# การผลิตกระแสไฟฟ้าจากน้ำเสียแป้งมันด้วยเซลล์เชื้อเพลิงจุลชีพแบบช่องเดี่ยว

นางนัทกาญจน์ ประเสริฐสังข์

วิทยานิพนธ์นี้เป็นส่วนหนึ่งของการศึกษาตามหลักสูตรปริญญาวิศวกรรมศาสตรดุษฎีบัณฑิต
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# ELECTRICITY GENERATION FROM CASSAVA WASTEWATER BY A SINGLE CHAMBER MICROBIAL FUEL CELL

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A Dissertation Submitted in Partial Fulfillment of the Requirements
for the Degree of Doctor of Philosophy Program in Environmental Engineering
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นัทกาญจน์ ประเสริฐสังข์ : การผลิตกระแสไฟฟ้าจากน้ำเสียแป้งมันด้วยเซลล์เชื้อเพลิงจุลชีพแบบช่องเดี่ยว. (Electricity Generation from Cassava Wastewater by a Single Chamber Microbial Fuel Cell) อ. ที่ปรึกษาวิทยานิพนธ์หลัก: รศ.ดร. ชวลิต รัตนธรรมสกุล, อ.ที่ปรึกษาวิทยานิพนธ์ร่วม: รศ.ดร.อลิศรา เรืองแสง, 235 หน้า.

งานวิจัยนี้ศึกษาผลกระทบของภาระบรรทุกอินทรีย์ พีเอช และอุณหภูมิต่อการบำบัดน้ำเสียแป้งมันสำปะหลังและพลังงานที่ได้จากกเซลล์เชื้อเพลิงจุลชีพแบบช่องเดี่ยว งานวิจัยแบ่งเป็นสองส่วนภายใต้การควบคุมอุณหภูมิ 45 และ 30 องศาเซลเซียส โดยส่วนแรกควบคุมค่าพีเอชที่ 7.0 ในการกำจัดซีโอดีและพลังงานที่ได้ต่อผลของภาระบรรทุกอินทรีย์ 0.56, 1.44, 2.79, 4.14 และ 6.25 กก.ซีโอดี/ลบ.ม.-วัน ส่วนที่สองศึกษาผลของค่าพีเอชที่ 5.0, 5.5, 6.0, 6.5, 7.5, 8.0, 8.5 และ 9.0 ต่อการกำจัดซีโอดีและพลังงานที่ได้เมื่อควบคุมภาระบรรทุกอินทรีย์เป็น 0.56 กก.ซีโอดี/ลบ.ม.-วัน

เมื่อควบคุมค่าพีเอชเป็น 7.0 พบว่าประสิทธิภาพการกำจัดซีโอดีสูงสุดเมื่อภาระบรรทุกอินทรีย์เป็น 0.56 กก.ซีโอดี/ลบ.ม.-วัน ภายใต้อุณหภูมิทั้งสองค่า โดยมีประสิทธิภาพการกำจัดซีโอดีเป็นร้อยละ 91.44 ± 0.72 และ 90.72± 0.87 ที่ 30 องศาเซลเซียส และ 45 องศาเซลเซียส ตามลำดับ ขณะที่ค่าพลังงานสูงสุดได้จากภาระบรรทุกอินทรีย์ 6.25 กก.ซีโอดี/ลบ.ม.-วัน เป็น 28.68 วัตต์/ลบ.ม. ที่ 30 องศาเซลเซียส และ 27.85 วัตต์/ลบ.ม.ที่ 45 องศาเซลเซียส ค่าประสิทธิภาพของคูลอมบ์สูงสุดได้จากภาระบรรทุกอินทรีย์ 0.56 กก.ซีโอดี/ลบ.ม.-วัน โดยเป็นร้อยละ 30.2 ที่ 30 องศาเซลเซียส และร้อยละ 28.5 ที่ 45 องศาเซลเซียส ทั้งนี้พบว่าอุณหภูมิมีผลกระทบต่อการส่งผ่านของอิเล็กตรอนจากแอโทดไปยังแคโทด ที่อุณหภูมิต่ำอิเล็กตรอนจะส่งผ่านได้ดีกว่าที่อุณหภูมิสูงเนื่องจากผลกระทบของอุณหภูมิที่สูงขึ้นทำให้ความต้านทานของอุปกรณ์ไฟฟ้าสูงขึ้นด้วย ดังนั้นพลังงานที่ได้จึงลดลงเมื่ออุณหภูมิเพิ่มขึ้น

ภาระบรรทุกอินทรีย์เป็น 0.56 กก.ซีโอดี/ลบ.ม.-วัน พบว่าการกำจัดซีโอดีสูงสุดได้จากค่าพีเอช 7.5 ของอุณหภูมิทั้งสองค่า โดยมีประสิทธิภาพการกำจัดซีโอดีเป็นร้อยละ 96.77 ± 0.93 และ 95.93 ± 1.44 ที่ 30 องศาเซลเซียส และ 45 องศาเซลเซียส ตามลำดับ ขณะที่ค่าพลังงานสูงสุดได้จากค่าพีเอช 8.5 เป็น 30.30 วัตต์/ลบ.ม. ที่ 30 องศาเซลเซียส และ 26.06 วัตต์/ลบ.ม.ที่ 45 องศาเซลเซียส ค่าประสิทธิภาพของคูลอมบ์สูงสุดได้จากค่าพีเอช 8.5 โดยเป็นร้อยละ 52.9 ที่ 30 องศาเซลเซียส และ 50.6 ที่ 45 องศาเซลเซียส

กลุ่มจุลชีพในช่องแอโนดจากเซลล์เชื้อเพลิงจุลชีพแบบช่องเดี่ยวที่อุณหภูมิ 30 องศาเซลเซียส แบ่งเป็นสี่กลุ่มได้แก่ Gammaproteobacteria, Betaprotobacteria, Bacteroidetes และ Firmicutes ขณะที่อุณหภูมิ 45 องศาเซลเซียส แบ่งได้เป็นสามกลุ่มได้แก่ Gammaproteobacteria, Betaprotobacteria และ Firmicutes โดยกลุ่มจุลชีพที่พบมีหลายประเภท ได้แก่ กลุ่มแบคทีเรียทำหน้าที่หมักในระบบไร้อากาศ กลุ่มแบคทีเรียผลิตอิเล็กตรอนออกภายนอกเซลล์ แบคทีเรียย่อยสลายมีเทน แบคทีเรียย่อยสลายซัลเฟต และกลุ่มแบคทีเรียกึ่งใช้อากาศ

ภาควิชา....วิศวกรรมสิ่งแวดล้อม ........ลายมือชื่อนิสิต..................................................
สาขาวิชา...วิศวกรรมสิ่งแวดล้อม........ลายมือชื่อ อ.ที่ปรึกษาวิทยานิพนธ์หลัก.................
ปีการศึกษา.............2554................ลายมือชื่อ อ.ที่ปรึกษาวิทยานิพนธ์ร่วม .................

# # 5071837021 : MAJOR ENVIRONMENTAL ENGINEERING

KEYWORDS : SINGLE CHAMBER MICROBIAL FUEL CELL / CASSAVA WASTEWATER TREATMENT / ELECTRICITY GENERATION / ORGANIC LOADING / TEMPERATURE/ pH

NATTAKARN PRASERTSUNG : ELECTRICITY GENERATION FROM CASSAVA WASTEWATER BY A SINGLE CHAMBER MICROBIAL FUEL CELL. ADVISOR : ASSOC. PROF. CHAWALIT RATTANATHAMASKUL, Ph.D., CO-ADVISOR : ASSOC. PROF. ALISSARA REANGSANG, Ph.D., 235 pp.

This study examined the effects of the organic loading rate (OLR), pH and the temperature in cassava wastewater treatment and the power generated by a single microbial fuel cell. The study was divided into two parts under temperature of 45°C and 30 °C. The first part was examined the effect of OLR of 0.56, 1.44, 2.79, 4.14 to 6.25 kg-COD/$m^3$-d at pH 7.0 to remove COD and generate electricity. The second part was examined the effect of pH at 5.0, 5.5, 6.0, 6.5, 7.5, 8.0, 8.5 and 9.0 on OLR of 0.56 kg-COD/$m^3$-d to remove COD and generate electricity.

When controlled pH 7.0, the efficiency of COD removal was achieved at maximum from the OLR of 0.56 kg-COD/$m^3$-d at both temperatures. The efficiency of COD removal was 91.44 ± 0.72% and 90.72± 0.87% at 30 °C and 45 °C respectively. The maximum of power density was obtained from OLR of 6.25 kg-COD/$m^3$-d, which the value was 28.68 W/$m^3$ at 30 °C and 27.85 W/$m^3$ at 45 °C. The maximum of coulombic efficiency was obtained from the OLR of 0.56 kg-COD/$m^3$-d which was 30.2% at 30 °C and 28.5% at 45 °C. The temperature affected on the electron transferring from anode to cathode. At the lower temperature, electron was able to transfer from anode to cathode more effectively than at higher temperature. High temperature caused high electrical resistant, so the power output decreased when temperature increased.

At OLR of 0.56 kg-COD/$m^3$-d, the maximum efficiency of COD removal was achieved at a pH of 7.5 at both temperatures. The efficiency of COD removal was as 96.77 ± 0.93% and 95.93± 1.44% at 30 °C and 45 °C respectively. The maximum of power density obtained from pH 8.5 which the values were 30.30 W/$m^3$ at 30 °C and 26.06 W/$m^3$ at 45 °C. The maximum of coulombic efficiency was obtained from pH 8.5 which was 52.9% at 30 °C and 50.6% at 45 °C.

The microbial communities in the anode of a single chamber microbial fuel cell under 30°C could be divided into four groups as Gammaproteobacteria, Betaprotobacteria, Bacteroidetes and Firmicutes. While under 45°C operation, the microbial communities could be divided into three groups as Gammaproteobacteria, Betaprotobacteria and Firmicutes. The microbial communities included several fermentative bacteria, exocellular electron-transfer, methane oxidizers, sulfate-reducing bacteria and groups of facultative bacteria.

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| Department : ENVIRONMENTAL ENGINEERING | Student's Signature |
| Field of Study : ENVIRONMENTAL ENGINEERING | Advisor's Signature |
| Academic Year : 2011 | Co-advisor's Signature |

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# CHAPTER I

# BACKGROUND AND OBJECTIVES

## 1.1 Thesis title

Electricity Generation from Cassava Wastewater by a Single Chamber Microbial Fuel Cell

## 1.2 Key words

Single chamber microbial fuel cell, SCMFC
Electricity generation
Cassava wastewater
Wastewater treatment
pH

## 1.3 Motivation

Electricity is necessary to grow a country's industries and economy, but supplies such as fossil fuels, oil, natural gas, biomass, etc. are limited, and they also cause climate change. Meanwhile, clean energy can be thermally generated by streams. Due to the high price of oil and the greenhouse effect, many countries are interested in clean and renewable energy from sources such as heat energy, sound energy, light energy, and mechanical energy. In Thailand electricity can be generated from dams, wind, solar cells and the thermal process. Electricity Generation Authority of Thailand (EGAT) reported that electricity generation in 2008 was 12% from dams, 44% from natural gas, and the remainder from private electricity generation. Many countries are focusing on how to produce energy from other sources in order to reduce costly fossil fuel consumption. It is common knowledge that energy comes from carbon sources. Recently, it has been found that high strength wastewater should no longer be considered a waste product, as it is also a carbon source and can therefore be changed into energy. Anaerobic wastewater treatment is a common way to indirectly change wastewater into electricity by producing biogas which can be used as a fuel to thermodynamically generate electricity.

Cassava is considered one of the economic plants in Thailand. Because of its usefulness in power generation, cassava plantations are promoted in many parts of Thailand. Native starch from cassava produced high quantities and concentrations of wastewater. The typical process for treating cassava wastewater is anaerobic digestion followed by an oxidation pond to reach the regulation requirement of effluent industrial wastewater (COD $\leq$ 400 mg/L). Scaling up wastewater treatment plants is a problem because cassava wastewater contains a large quantity of organic and suspended solids. Treatment plants therefore require a large land area, and setting up electricity generation by biogas from anaerobic digestion as fuel through thermodynamic processes is costly.

In microbial fuel cells, electricity is produced by the electrochemical processes of microorganisms oxidizing organic compounds. The oxidation process releases electrons from cells, and anode electrodes accept these electrons anaerobically (Logan, 2007). In recent years, microbial fuel cells research has tremendously grown both in studies and in actual application (Pant, et al., 2010). Many studies have found that electricity can be generated from organic substrates in various sources such as domestic waste (Liu, et al., 2004), composite vegetable waste (Mohan, et al., 2010), various food industry wastes (Cercado-Quezada, et al., 2010), starch processing (Lu, et al., 2009; Kaewkannetra, et al., 2011), brewery wastewater (Wang, et al., 2008; Wen, et al., 2010), cheese whey (Antonopoulou, et al., 2010) , palm oil mill effluent (Cheng, et al., 2010), sewage sludge (Zhang, et al., 2011), decolorization in wastewater treatment (Sun, et al., 2009), and leachate wastewater (Gálvez, et al., 2009). These studies have shown that microbial fuel cells can be used to treat wastewater and simultaneously produce electricity in various conditions. The optimized conditions depend on the characteristics of the wastewater, reactor architectures including the type of cathode, anode, and connection wire, environmental conditions such as pH, temperature, conductivity, and quantity and the source of the sludge. Wastewater design engineering must focus on the necessary parameters for high COD removal efficiency and produce electricity without adding any power to the system.

To enhance the performance of MFCs, optimal conditions in designing cassava wastewater treatment by a microbial fuel cell system in term of COD loading rate (OLR), pH, and temperature were investigated. This study examined various OLRs of cassava wastewater treatment at mesophilic temperature (30°C) and high temperature (45°C) using batch flow-mode in a single-chamber microbial fuel cell. The efficiency of treatment was evaluated in terms of total COD removal, power density generation, and coulombic efficiency.

## 1.4 Objectives of study

1. To study the effect of temperature on electricity generation from cassava wastewater by a single chamber microbial fuel cell.
2. To study the effect of COD loading on electricity generation from cassava wastewater by a single chamber microbial fuel cell.
3. To examine the efficiency in electrical generation in a single-chamber microbial fuel cell with high strength wastewater from cassava wastewater.
4. To study the effect of pH on electricity generation from cassava wastewater by a single chamber microbial fuel cell.

## 1.5 Scope of study

This study was setup as lab-scale at the laboratory in the Civil and Environment Department, Faculty of Science and Engineering, Kasertsart University Chalermprakiat Sakon Nakhon Province Campus, Sakon Nakhon Province, Thailand. The scopes of this study are the followings:

1. The wastewater used in the study was actual wastewater from Roi-Ed Flour factory, Roi-Ed Province, Thailand.
2. Seed was collected from UASB wastewater treatment plant of Roi-Ed flour factory, Roi-Ed Province, Thailand.
3. A single-chamber microbial fuel cell was made from polyvinyl chloride. The total volume was 150mL. Spacing between the anode and cathode was 4 cm. The diameter of anode and cathode was 7 cm, with a surface area of 38.5 $cm^2$. The cathode was coated by 0.5 $mg/cm^2$ of Pt. and PEM on the side to contact the wastewater, and another side was coated by four layers of Teflon layers to prevent water penetration.
4. Temperature control boxes were used to maintain mesophilic and high temperatures of 30$^{\circ}$C and 45$^{\circ}$C. The initial COD in the SCMFC was varied from 1,000 mg/L., 2500 mg/L, 5,000 mg/L., 7500 mg/L., and 10,000 mg/L. while pH was fixed at 7.0 in all experiments.
5. COD loading was chosen to achieve the highest efficiency of COD removal to study the effects of the initial pH at 5.0, 5.5, 6.0, 6.5, 7.5, 8.0, 8.5, and 9.0.
6. Electrical potential, SCOD, VFA, pH, alkalinity, and microbial communities were studied at the end of each experiment.
7. Microbial communities were analyzed in the SCMFC at both temperatures by molecular based techniques using PCR-DGGE method.

## 1.6 Benefits of study

1. Determine the feasibility of electricity generation from cassava wastewater by a single-chamber microbial fuel cell.
2. Determine the effects of temperature on electricity generation from cassava wastewater by a single-chamber microbial fuel cell.

3. Determine the effects of COD loading on electricity generation from cassava wastewater by a single-chamber microbial fuel cell.
4. Determine the effects of pH on electricity generation from cassava wastewater by a single-chamber microbial fuel cell.

# CHAPTER II

# LITERATURE REVIEW

## 2.1 Principle of biological wastewater treatment

Wastewater treatment transforms the carbon in wastewater into a reduced of power form with oxidation and reduction reaction or redox reaction. The process of redox transfers electrons from a reducing agent to an oxidizing agent. The reducing agent in wastewater is organic matter and the oxidizing agent is a chemical in the wastewater such as oxygen, nitrate, sulfate or carbon dioxide. The redox reactions and their namely in wastewater treatment are as shown in Table 2.1. The electron transfers in the redox reaction produce power which uses microorganism growth to produce new cells and increase their quantity, and some of the power is lost in heat power form. Organic matter can be the carbon source for power production and the substrate of bacteria which are most common in microorganism communities. Because there are many types of agents to oxidize the electron, there are differences in reactions depending on the type of oxidizing agent. The substrate reduction of inner bacteria can be categorized into two processes, fermentation and aspiration. Fermentation is the redox reaction of organic substrate without an electron acceptor outside the cell, and respiration reaction is the redox reaction of organic substrate with a final electron acceptor outside the cell. The respiration reaction can be categorized into two types, aerobic respiration and anaerobic respiration, as described below.

1. Aerobic respiration is oxidation-reduction reaction with oxygen as the final electron acceptor.
2. Anaerobic respirations oxidation-reduction reaction with a final electron acceptor other than oxygen, such as nitrate or sulfate.

Table 2.1: The oxidation-reduction reaction in wastewater treatment

| List | Electron acceptors | | | | |
|---|---|---|---|---|---|
| | Oxygen | Organic matter | Nitrate | Sulfate | Carbon dioxide |
| The end product | Carbon dioxide | Organic matter | Nitrogen | Sulfide | Methane |
| Type of reaction | Aerobic oxidation | Fermentation | Denitrification | Sulfate Reduction | Methanogenesis |

### 2.1.1 Anaerobic operations

The principle step of anaerobic biochemical operations is shown in Figure 2.1.

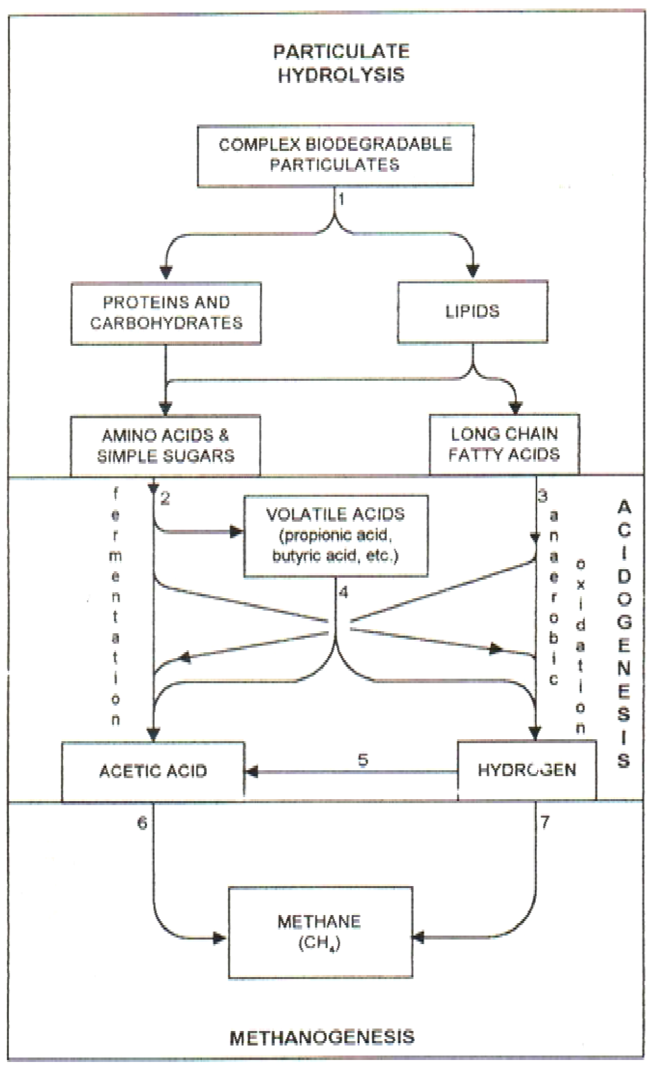



Figure 2.1: Steps of anaerobic operation (Graddy, et al., 1999)

Before insoluble organic materials are consumed, they must be solubilized. The large soluble organic molecules must be reduced in size to facilitate transport across the cell membrane. The reactions responsible for solubilization and size reduction are usually hydrolytic and are catalyzed by extracellular enzymes produced by bacteria such as cellulases, amylases, and proteases. They are all grouped together as hydrolysis reactions. The enzymes are produced by fermentative bacteria that are an importance component of the second step, acidogenesis.

Acidogenesis is carried out by members of the domain bacteria. Amino acids and sugars are degraded by fermentative reactions in which organic compound serve as both electron donors and acceptors. The principal products of reaction are intermediately degradative products such as propionic and butyric acids and direct methane precursors, acetic acid, and $H_2$. The $H_2$ production from fermentative reactions is small and originates from the dehydrogenation of pyruvate by mechanisms that are different products of the bulk of the $H_2$ produced. In contrast, most of the $H_2$ produced comes from the oxidation of volatile and long chain fatty acids to acetic acid and arises from the transfer of electrons from reduced carriers directly to hydrogen ions, in a process call anaerobic oxidation. Because of the thermodynamics of this reaction, it is inhibited by high partial pressures of $H_2$, whereas the production of $H_2$ pyruvate is not.

The production of $H_2$ by anaerobic oxidation is important to the proper functioning of anaerobic processes. First, $H_2$ is one of the primary substrates from which methane is formed. Second, if $H_2$ were not formed, acidogenesis would not result in the oxidized product, with acetic acid being the major soluble organic product. Rather, the only reactions that could occur would be fermentative, in which electrons released during the oxidation of one organic compound are passed to another organic compound that serves as the electron acceptor, yielding a mixture of oxidized and reduced organic products. Consequently, the energy level of the soluble organic matter would not change significantly because all of the electrons originally present would still be in solution in organic form. When $H_2$ is formed as the reduced product, however, it can escape from the liquid phase because it is gas, thereby causing a reduction in the energy content of the liquid. In actuality, the $H_2$ does not escape. The gas is used as the substrate for methane production, but because methane is removed as a gas the same thing is accomplished. Finally, if $H_2$ formation did not occur and reduced organic products were formed, they would accumulate in the liquid because they cannot be used as substrates for methane production. Only acetic acid, $H_2$, methanol and methylamines can be used. As shown by reaction 5, some $H_2$ can be combined with carbon dioxide by $H_2$-oxidizing acetogens to form acetic acid, but since the acetic can serve as a substrate for methanogens, the impact of this reaction is thought to be small.

The products of the acidogenic reactions, acetic acid and $H_2$, are used by methanogens, which are members of the domain Archaer, to produce methane gas. Two groups are involved:

(1) Aceticlastic methanogens, which split acetic into methane and carbon dioxide.

(2) $H_2$-oxidizing methanogens, which reduce carbon dioxide.

### 2.1.2 Factors affecting the performance of anaerobic digestion

Speech, (1995) said that high loading rate was one of the most important advantages of the anaerobic process, and was also one of the most fundamental of all operational considerations. Table 2.2 lists the factors that control the allowable loading rate.

Table 2.2: Factors controlling allowable loading rates in aerobic treatment (Speech, 1995)

| Item | Factors |
|---|---|
| 1 | Concentration of viable biomass which can be retained in the anaerobic reactor |
| 2 | Mass transfer between the incoming wastewater and the retained biomass |
| 3 | Biomass proximity for metabolism of $H_2$ intermediate |
| 4 | Each metabolism of the organic pollutant |
| 5 | Temperature within the reactor |
| 6 | Level of toxicity in the wastewater |
| 7 | Elevated Ks |
| 8 | pH |
| 9 | Reactor configuration/staging |

#### 2.1.1.1 Temperature

Temperature can exert an effect on biological reactors in two ways, by influencing the rate of enzymatically catalyzed reactions and by affecting the rate of diffusion substrate to the cells. The biomass growth and substrate use are proportional with the yield. Temperature can influence the value of the yield as shown in Figure 2.2. It influences growth and substrate use in quantitatively different ways. This is an importance factor in anaerobic operations.

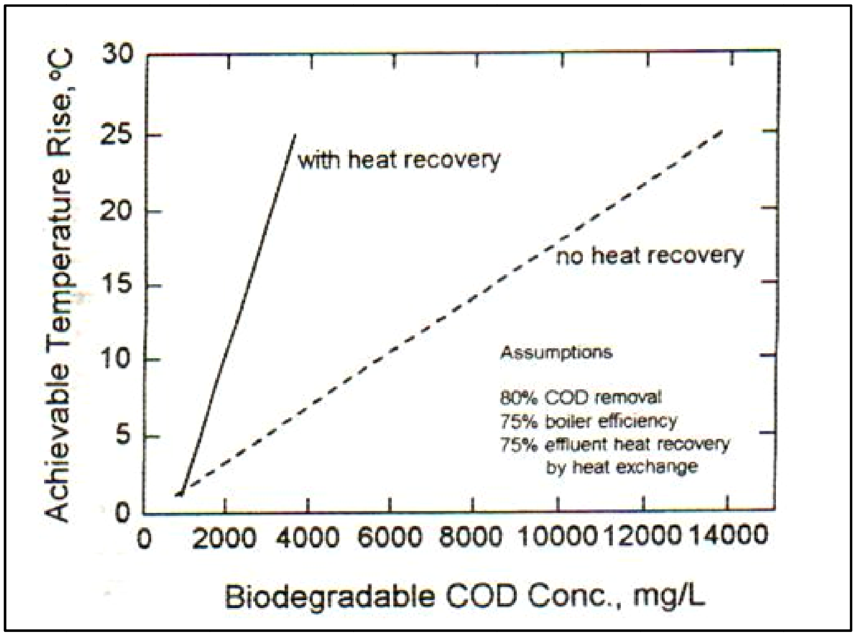



Figure 2.2: Achievable temperature rise (Graddy, et al. 1999)

The anaerobic process is more sensitive to temperature variation than its aerobic counterpart. Particularly noteworthy is the finding that methane conversion of acetate to $CH_4$ is more temperature-dependent than the acetate forming biomass. An increase in the concentration of volatile acids may accompany a lowered temperature because the metabolism rate of the acidogens is affected less than the methanogens. This VFA increase, associated with a lower temperature, can potentially exceed the buffer capacity of the system, with corresponding catastrophic drop in pH. Thus a temperature decrease can have drastic repercussions on the process, operating almost to maximum capacity. Temperature sensitivity increases with loading rate. The temperature effect on substrate removal rate is of primary interest in using the anaerobic process, but other temperature-dependent constants include specific growth rate decay, biomass yield, Ks, and propionate degradation.

2.1.1.2 pH

Methanogens prefer nearly neutral pH conditions with a generally accepted optimum range of 6.5-8.2 (Speech, 1995). Conditions above or below range of 6.5-8.2 decrease the rate of methane production rather steeply. Figure 2.3 shows an acceptable range of 6.0-8.0 with indicating the relative acetate use rate. The sharp drop in the activity above pH 8.0 may be related to a shift in $NH_4$-N to a toxic level.

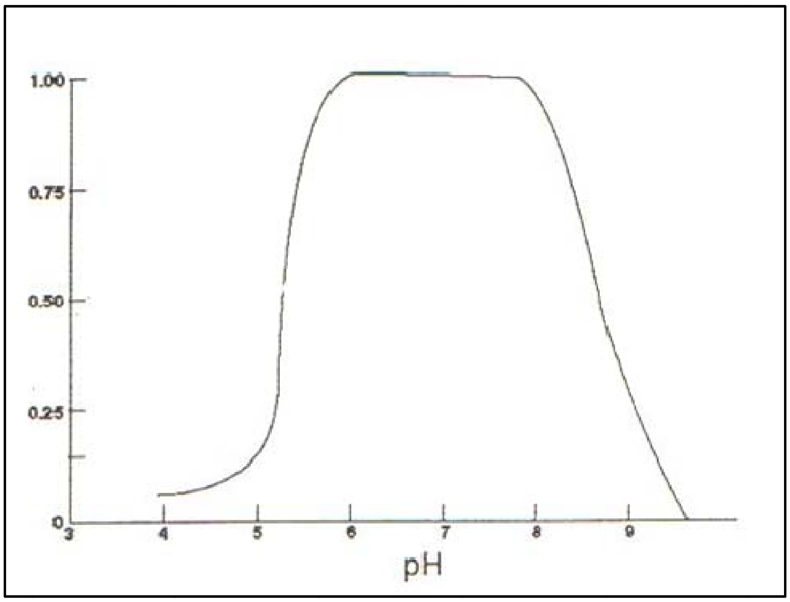



**Figure 2.3: The relative activity of methanogens to pH (Speech, 1995)**

Microorganisms can grow only at a specific pH which does not have a wide range. For example, methane-producing bacteria with anaerobic digestion grow well at pH 6.7 to 7.7. Figure 2.4 shows the production of methane gas and total biogas at laboratory scale by anaerobic digestion using formate acid as the substrate. As shown in this figure, the maximum production of biogas is at neutral pH.

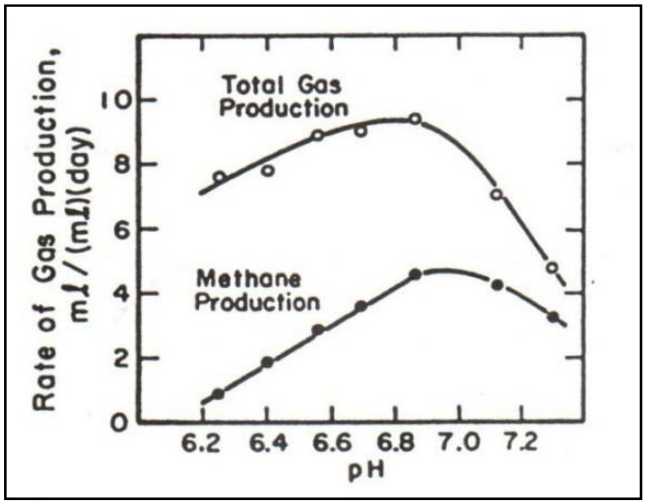



Figure 2.4: Effect of pH to total gas production and methane production from formic acid (Theera, 1996)

2.1.1.3 Toxicity

Chemicals which are toxic to the microorganisms are volatile fatty acids, free ammonia, proton ions, sulfide and heavy metals.

a. Volatile fatty acids: The concentration of volatile fatty acid that affects microorganisms in an anaerobic process depends on the pH. Acetic acid and butyric acid are not significantly to hydrogen-producing microorganisms at neutral pH. Propionic acid is toxic to microorganisms when its concentration nears 1,000 mg/L.

b. Ammonia: In sewage sludge digestion, most of the toxicity is due to ammonia. The sewage sludge contains a high level of protein, and protein hydrolysis releases nitrogen in the form of ammonium ions ($NH_4^+$) or free ammonia ($NH_3$). The dominant forms of nitrogen contained depend on the pH solution. Ammonia and ammonium ions are highly toxic to bacteria at levels above 150 mg N/L and 3,000 mg N/L, respectively.

c. Metal ions: The processes to remove proton ions and metal ions from wastewater are toxic to bacteria growth because that processes need to add high alkalinity. The toxic reaction is complex, as there are many kinds of proton ions in wastewater treatment such as sodium, potassium, calcium and manganese. Table 2.3 shows how the toxicity of proton ions inhibits anaerobic processes.

Table 2.3: Concentrations of metal ions that inhibit anaerobic processes (Theera, 1996)

| Proton | Concentration (mg/L) | | |
|---|---|---|---|
| | Low inhibition | Medium inhibition | High inhibition |
| Sodium | 100-200 | 3,500-5,500 | 8,000 |
| Potassium | 200-400 | 2,500-4,500 | 12,000 |
| Calcium | 100-200 | 1,500-4,500 | 8,000 |
| Magnesium | 75-150 | 1,000-1,500 | 3,000 |

d. Sulfide: Sulfide production from anaerobic processes is by sulfate reduction of protein hydrolysis in influent solution. If the sulfide concentration is more than 200 mg S/L it highly inhibits the metabolic process of methane-producing bacteria until production fails. Methane-producing bacteria can tolerate a sulfide concentration of not more than 100 mg S/L. A concentration of 100 to 200 mg S/L of sulfide slightly inhibits methane production. Sulfide in the form of solution inhibits bacteria growth, while sulfide in metal insoluble form cannot affect bacteria.

e. Heavy metals: Heavy metals in soluble form are toxic to anaerobic bacteria. Table 2.4 lists the heavy metal concentrations that inhibit the growth of anaerobic bacteria by 50%. However the concentration of heavy metal can be reduced to nontoxic levels by the precipitation process.

Table 2.4: The concentration of soluble heavy metal to inhibit 50% production of anaerobic digestion (Theera, 1996)

| Heavy metal | Approximate concentration (mg/L) |
|---|---|
| $Fe^{2+}$ | 1-10 |
| $Zn^{2+}$ | $10^{-4}$ |
| $Cd^{2+}$ | $10^{-7}$ |
| $Cu^{+}$ | $10^{-12}$ |
| $Cu^{2+}$ | $10^{-16}$ |

### 2.1.1.4 Organic loading rate

In the process of completely mixing an aerobic system without return sludge, the organic loading rate is relative to sludge retention time. For anaerobic digestion from sewage sludge, the organic loading affects the efficiency of substrate reduction. The relationship between organic loading and the efficiency of COD removal is shown in Table 2.5.

Table 2.5: The relationship between organic loading and efficiency of COD removal (Van den Berge and Kennedy, 1982 referred by Pollution control department, 2003)

| Type of reactor | COD loading (kg COD/$m^3$-d) | COD removal (%) |
|---|---|---|
| Anaerobic Contact | 1-6 | 80-95 |
| Upflow Filter | 1-10 | 80-95 |
| FB/EB | 1-20 | 80-87 |
| Downflow Filter | 5-15 | 75-88 |
| UASB | 5-30 | 85-95 |

Sludge retention time of a completely mixed reactor without return sludge is equal to hydraulic detention time ($\tau$). Organic loading relates to hydraulic detention time as per the curve in Figure 2.5. Figure 2.5 shows that the organic loading of sewage sludge in sludge digestion must not more than 6.4 kg/kg VS-$m^3$ and hydraulic detention time is 10-15 days.

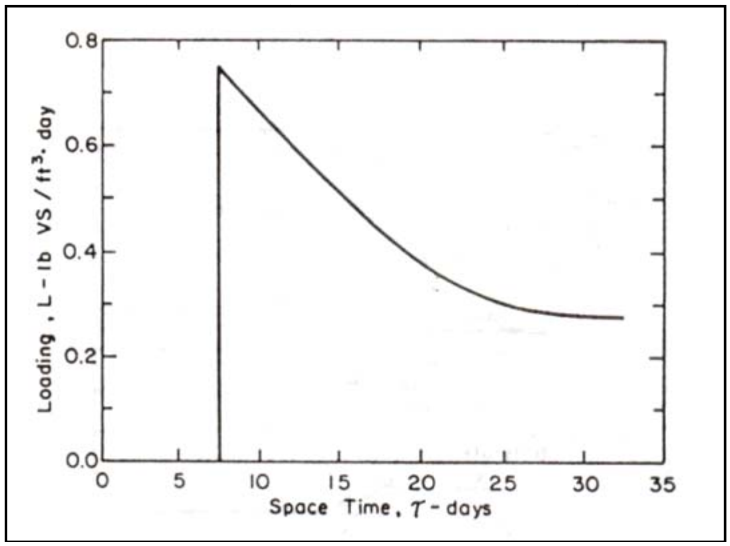



Figure 2.5: The curve between organic loading and hydraulic detention time of sludge digestion from sewage

2.2 Energetic overview

Microorganisms require these 4 factors for growth:

a) Carbon source
b) Inorganic nutrient
c) Energy
d) Reducing power

Microorganism derives energy and reducing power from oxidation reduction, which involves the removal of electrons from the substrate with their ultimate transfer to the terminal electron acceptor. So the available energy in the substrate depends on its oxidation state, which is indicative of the electrons available for removal as the substrate is oxidized. Highly reduced compounds have more electrons and higher standard free energy than highly oxidized compounds, regardless of whether they are organic or inorganic. In wastewater treatment using COD as a substrate, compounds with high COD:C ratio are highly reduced, whereas those with low COD:C ratio are more oxidized. The carbon in methane is the most highly reduced state possible, with a COD:C ratio of 5.33 mg COD/mg C, but carbon dioxide is the most highly oxidized state with a COD:C ratio of 0 mg COD/mg C. Thus all organic compounds will have a COD:C ratio between 0 and 5.33 mg COD/mg C.

Heterotrophic bacteria oxidize the carbon in organic compounds through their catabolic pathways, converting them to metabolic intermediates of the central amphibolic pathways that are in a higher oxidation state than either starting compound. The metabolic intermediates are used in anabolic pathways for cell synthesis with a higher oxidation state than the cell materials. Those electrons arise from the original substrate during its catabolism and are transferred to the anabolic pathways through the use of carriers such as nicotiaminde adenine dicleotide (Biffinger, et al., 2011) and nicotiaminde adenine dicleotide phosphate (NADP) which alternate between the oxidized (NAD and NADP) and reduced (NADH and NADPH) state. Thus NAD and NADP serve as electron acceptors for catabolic reactions, in which NADH and NADPH are form electron reductions. The availability of NADH and NADPH is called reducing power.

Biosynthetic reactions also require energy in a form that can be used in coupled reactions to join the amphibolic intermediate and form new compounds. That energy is provided by adenosine triphosphate (ATP) and to a lesser degree by other nucleotides. ATP is generated by phosphorylation adenosine diphosphate (ADP). When ATP is used to provide energy in biosynthetic reactions and ADP is released to reuse, ATP can be formed from two types of phosphorylation reactions, substrate level phosphorylation and electron transport phosphorylation.

During substrate level phosphorylation, ATP is formed directly by coupled reactions within a catabolic pathway. Only small amounts of ATP can be generated in this way. Great amounts can be generated during electron transport phosphorylation, which occurs when electrons removed during oxidation of the substrate and pass through the electron transport chain to the terminal electron acceptor, setting up a proton-motive force. The magnitude of the proton moving force, and consequently the amount of ATP that can be generated, depend on both the organisms and the performance of the terminal electron acceptor.

### 2.3 Effects of growth environment on ATP generation

Electron transport chains are found in bacteria and Eucarya. They are highly organized and are localized within membranes. They contain flavoproteins and cytochromes which accept electrons from NADH and pass them to the terminal acceptor. The electron transport chain in Eucarya is located in the mitochondria and is remarkably uniform from species to species. The electron transport chain in bacteria is located in the cytoplasmic membrane and exhibits considerable variety among individual species in the identity of the individual components and the presence or absence of sections of the chain. The electron transport chain is determined by the bacteria's standard oxidation-reduction potential. Table 2.6 presents the potentials for the array of couples found in mitochondrial electron transport chains. The transfer is in the direction of increasing redox potential until the final reduction with the terminal acceptor is catalyzed by the appropriate enzyme. When the environment is aerobic, oxygen serves as the terminal acceptor and the enzyme is an oxidase.

ATP generation is associated with the transfer of electrons down the electron transport chain through electron transport phosphorylation, although it is not directly coupled to a specific biochemical reaction that occurs during that transfer.

Table 2.6: The standard oxidation-reduction potential of a number of redox couples of interest in biological systems (Graddy, et al., 1999)

| Redox couple | $E^{0'}$ (mV) |
|---|---|
| $H_2$/ $2H^+$+$2e^-$ | -420 |
| Ferredoxin reduction / oxidation | -410 |
| NADPH / $NADP^+$ | -324 |
| NADH / $NAD^+$ | -320 |
| Flavoproteins reduction / oxidation | -300 to 0 |
| Cytochromes reduction / oxidation | +30 |
| Uquinone reduction / oxidation | +100 |
| Cytochromes c reduction / oxidation | +254 |
| Cytochromes a reduction / oxidation | +385 |
| $O_2$ / $1/2O_2$+$2e^-$ | +820 |

In the absence of molecular oxygen, other terminal acceptors may accept electrons from the electron transport chain. Their redox potential, as well as those of various donors are given in Table 2.7. In order for ATP to be generated by electron transport phosphorylation, the oxidation-reduction potential for the donor redox couple must be smaller than the potential for the acceptor redox couple, there must be at least one site of proton translocation in the electron transport chain between the final acceptor and the point where the donor contributes its electrons, and the associated free energy change ($\Delta G^{0'}$) must exceed 44 kJ. Nitrate and nitrite are important terminal electron acceptors in biochemical operations performing denitrification. Under strictly anaerobic conditions, when neither oxygen nor nitrogen oxides are present, many bacteria generate their ATP through substrate level phosphorylation associated with fermentation in which the oxidation of organic substrate is coupled to the reduction of another. The second substrate is generally a product of the catabolic pathway leading from the oxidized substrate with the result that the fermentation pathway is internally balanced, with neither a net production nor a net requirement for reducing power.

Table 2.7: The standard oxidation-reduction potential of various acceptor and donor redox couples (Graddy, et al., 1999)

| Redox couple | $E^{0'}$ (mV) |
|---|---|
| Acceptor | |
| $1/2O_2$ / $H_2O$ | +820 |
| $NO_3^-/NO_2^-$ | +433 |
| $NO_2^-/NO$ | +350 |
| Fumarate/Succinate | +33 |
| $SO_4^-/SO_3^-$ | -60 |
| $CO_2$ / $CH_4$ | -244 |
| Donor | |
| $H_2/2H^+$ | -420 |
| $HCOOH/HCO_3^-$ | -416 |
| $NADH/NAD^+$ | -320 |
| Lactate/Pyruvate | -197 |
| Malate/Oxaloacetate | -172 |
| Succinate/Fumarate | +33 |

Several types of fermentation reactions are listed in Table 2.8. Because ATP generation occurs only by substrate level phosphorylation and a large part of the available electrons in the original substrate end up in the reduced organic products, bacteria receive relatively little energy in this mode of growth, and thus have low yield per unit of substrate processed.

Table 2.8: Type of fermentation of various microorganisms (Graddy, et al., 1999)

| Type of fermentation | Product | Organisms |
|---|---|---|
| Alcoholic | Ethanol, $CO_2$ | Yeast |
| Lactic acid | Lactic acid | *Streptococcus, Lactobacillus* |
| Mixed acid | Lactic acid, acetic acid, Ethanol, $CO_2$, $H_2$ | *Escherichia, Salmonella* |
| Butanediol | Butanediol, ethanol, Lactic acid, acetic acid, $CO_2$, $H_2$ | *Aerobactor, Seratia* |
| Butyric acid | Butanediol, ethanol, Lactic acid, acetic acid, $CO_2$, $H_2$ | *Clostridium butyricum* |
| Acetone-butanol | Acetone, butanol, ethanol | *Clostridium acetobutylicum* |
| Propionic acid | Propionic acid | *Propionibacterium* |

## 2.4 Microbial fuel cell

A fuel cell is a device that converts the chemical energy from a fuel into electricity through a chemical reaction with an oxidizing agent such as oxygen. The most common fuel is hydrogen, although other hydrocarbons such as natural gas and alcohols like methanol are sometimes used. Fuel cells work similar to batteries but the difference is the fuel can produce electricity as long as fuel inputs are supplied. The important key assemblies of the fuel cell are the anode, cathode, ion-conducting material, catalyst and electrolyte. Fuel cells can be classified by the electrolyte or the supplied fuel. Factors that enhance the performance of a microbial fuel cell depend on the efficiency of its parts.

Fuel cells that use bacteria as a catalyst are called microbial fuel cells (Mohan et al. 2008). Bacteria can produce electricity by oxidizing organic matter in anaerobic digestion. When the microorganisms digest the organic substrate, they released electrons outside their cells into the electrolyte. These electrons move to the anode electrode and then are transferred to the cathode electrode by a conducting wire. At the cathode electrode, protons from the anode chamber can move to the cathode by salt bridge or proton exchange membrane to combine with electrons and oxygen (or another oxidizing agent) to produce $H_2O$ (or another form).

The performance of microbial fuel cells depends on 3 processes. The first is the process of the oxidizing organic substrate by microbes and the release of electrons outside their cells. The second process is electron transfer to anode and cathode electrodes, so the anode chamber should not have another competitive electron acceptor such as oxygen, nitrate, sulfate, etc. The last process depends on the ability of the cathode electrode to use electrons and produce the chemical product in a reduced form. If the fuel of the process is carbohydrate, the reaction in the anode and cathode are as defined in equations 2.1 to 2.3 (Rismani-Yazdi, et al., 2008).

Anode:

$C_6H_{12}O_6 + 6H_2O \longrightarrow 6CO_2 + 24H^+ + 24e^-$ ..........................................................(2.1)

Cathode:

$6O_2 + 24H^+ + 24e^- \longrightarrow 12H_2O$ ..........................................................(2.2)

$O_2 + 4H^+ + 4e^- \longrightarrow 2H_2O$ ($E^0 = 0.816V$) ..........................................................(2.3)

The ideal microbial fuel cell can produce electricity as long as organic matter is supplied. The ideal potential ($E_{thermo}$ (V)) is as the thermodynamic of the Nernst equation shown in equation 2.4.

$$E_{thermo} = E^0 - \frac{RT}{nF}\ln(\pi) \qquad (2.4)$$

Where

| | | |
|---|---|---|
| $E^0$ | = | The standard cell potential (V) |
| $R$ | = | The ideal gas constant (8.314 J/mol- K) |
| T | = | The temperature (K) |
| n | = | The number of electrons transferred in the reaction |

| | | |
|---|---|---|
| F | = | Faraday's constant (96,485 C /mol) |
| $\pi$ | = | The chemical activity of products divided by those of reactants |
| | = | $\frac{[product]^p}{[reactant]^r}$ |
| [product] | = | The concentration of product |
| [reactant] | = | The concentration of reactant |
| p | = | Mole of product |
| r | = | Mole of reactant |

All reactions are written in the direction of chemical reduction, so the products are always the reduced species, and the reactants are the oxidized species. As a condition, temperature is 298 K, and the chemical concentration is 1 mol/L for liquids and 1 bar for gases. All values of $E^0$ are calculated with respect to that of hydrogen under standard conditions, which is defined to be $E^0$ ($H_2$) = 0 V, referred to as a normal hydrogen electrode (NHE). The standard potential for all chemicals is obtained with $\pi$ = 1 relative to the hydrogen electrode.

In biological systems the reported potentials are usually adjusted to neutral pH, because the cytoplasm of most cells is at pH 7. For a hydrogen reaction as equation 2.5, at a temperature of 298 K, the potential at standard conditions is shown in equation 2.6.

$$2H^+ + 2e^- \rightarrow H_2 \quad \text{..........(2.5)}$$

$$E^{0\prime} = 0 - \frac{\left(8.31\frac{J}{mol-K}\right)(298\ K)}{(2)(96{,}485\frac{C}{mol})}\ln\frac{[1\ bar]}{[10^{-7}M]^2} = -0.414\ V \quad \text{..........(2.6)}$$

Where $E^{0'}$ = The standard cell potential of adjusted pH (V)

There is a potential need to adjust for temperature, partial pressure, and pH if different from the above conditions. If pH increases, temperature and partial pressure also increase. Chemicals that oxidize by $H^+$ have more negative potentials while those that are reduced by $H_2$ have more positive potentials. The half reaction for oxygen is shown in equation 2.7 and $E^0$ ($O_2$) = 1.229 V so the adjusted value for oxygen at a pH of 7 and a temperature of 298 K is 0.805 V. Table 2.9 shows anode and cathode potentials for different anodic and cathodic reactions at a temperature of 298 K.

$$\frac{1}{2}O_2 + 2H^+ \rightarrow H_2O \qquad (2.7)$$

Table 2.9: Anode and cathode potentials for different anodic and cathodic reactions at a temperature of 298 K (Logan, (2007) referred to Heilmann and Logan, (2006))

| Electrode | Reaction | $E^0$ (V) | Conditions | $E^{'}$(V) |
|---|---|---|---|---|
| <u>Anode</u> | | | | |
| A-1 | $2H^+ + 2e^- \rightarrow H_2$ | 0.000 | pH=7 | -0.414 |
| A-2 | $2HCO_3^- + 9H^+ + 8e^- \rightarrow CH_3COOH^- + 4H_2O$ | 0.187 | $HCO_3^-$= 5 mM<br>$CH_3COO^-$= 16.9 mM<br>pH=7 | -0.300 |
| A-3 | $2HCO_3^- + 9H^+ + 8e^- \rightarrow CH_3COOH^- + 4H_2O$ | 0.187 | $HCO_3^-$= 5 mM<br>$CH_3COO^-$= 5 mM<br>pH=7 | -0.296 |
| A-4 | $CO_2 + HCO_3^- + 8H^+ + 8e^- \rightarrow CH_3COOH^- + 3H_2O$ | 0.130 | pH=7 | -0.284 |
| A-5 | $6CO_2 + 24H^+ + 24e^- \rightarrow C_6H_{12}O_6 + 6H_2O$ | 0.014 | pH=7 | -0.428 |
| <u>Cathode</u> | | | | |
| C-1 | $O_2 + 4H^+ + 4e^- \rightarrow 2H_2O$ | 1.129 | $pO_2$=0.2, pH=7 | 0.805 |
| C-2 | $O_2 + 4H^+ + 4e^- \rightarrow 2H_2O$ | 1.129 | $pO_2$=0.2, pH=10 | 0.627 |
| C-3 | $O_2 + 2H^+ + 4e^- \rightarrow H_2O_2$ | 0.695 | $pO_2$=0.2,<br>$H_2O_2$= 5mM pH=10 | 0.328 |
| C-4 | $O_2 + 2H^+ + 4e^- \rightarrow H_2O_2$ | 0.695 | $pO_2$=0.2,<br>$H_2O_2$= 0.22mM pH=7 | 0.370 |
| C-5 | $Fe(CN)_6^{-3} + e^- \rightarrow Fe(CN)_6^{-4}$ | 0.361 | $Fe(CN)_6^{-3}$= $Fe(CN)_6^{-4}$ | 0.361 |
| C-6 | $MnO_2(s) + 4H^+ + 2e^- \rightarrow Mn^{2+} + 2H_2O$ | 1.229 | $Mn^{2+}$= 5 mM, pH=7 | 0.470 |
| C-7 | $MnO_4^- + 4H^+ + 3e^- \rightarrow MnO_2 + 2H_2O$ | 1.70 | $MnO_4^-$=10 mM, pH=3.5 | 1.385 |
| <u>Cathode</u> | | | | |
| C-8 | $Fe^{3-} + e^- \rightarrow Fe^{2+}$ | 0.77 | $Fe^{3+}$=$Fe^{2+}$, T=303 K<br>(Low pH) | 0.78 |
| C-9 | $Fe^{3-} + e^- \rightarrow Fe^{2+}$ | 0.77 | $Fe^{3+}$=$Fe^{2+}$, T=303 K<br>(Neutral pH) | 0.20 |

The activity of a pure liquid or a solid is constant, so here the activity of water is unity. Because $E^{0'}(O_2) > E^{0'}(H_2)$, oxygen is reduced by hydrogen. When the voltage is positive, the reaction is exothermic. The calculations can also be expressed in terms of the change in Gibbs free energy, $G_r^0$, [J], as per equation 2.8.

$$E^0 = \frac{\Delta G^0}{nF} \quad (2.8)$$

Where

| | | |
|---|---|---|
| $E^0$ | = | The standard cell potential (V) |
| *R* | = | The ideal gas constant (8.314 J/mol- K) |
| $\Delta G^0$ | = | Gibbs free energy |
| *n* | = | The number of electrons transferred in the reaction (dimensionless) |
| F | = | Faraday's constant (96,485 C /mol) |

The reaction is exothermic when $\Delta G_r^0$ is negative. The total cell potential that can be produced by any fuel cell is the difference in the anode and cathode potentials, as per equations 2.9 and 2.10.

$$\mathrm{E_{emf}} = \mathrm{E_{Cat}} - \mathrm{E_{An}} \quad (2.9)$$

$$\mathrm{E'_{emf}} = \mathrm{E'_{Cat}} - \mathrm{E'_{An}} \quad (2.10)$$

*Anode potentials*

If thermodynamics limit overall power production, we can expect that the measured anode potential will approach that of the calculated maximum potentials. The maximum voltage is produced in open circuit mode, so the maximum potential should be close to the voltage in open circuit mode.

*Cathode potentials*

For an MFC using oxygen, the cathode potential is the maximum potential ($E^{0'}$ =0.805 V). The reduction of oxygen to water requires four electron transfers but that may not always be achieved. It is also possible that oxygen reduction results in hydrogen peroxide production, and this is only a two-electron transfer reaction. The standard for hydrogen peroxide evaluation is 0.695 V but under conditions reasonable for MFCs as in Table 2.6, which shows a result in 0.425 V. The production of hydrogen peroxide is problematic as it is a strong oxidizer and can result in degradation of the electrode or membrane. However, hydrogen peroxide's disinfectant properties are useful in limiting biofilm production at the cathode or degrading organics.

*Anode potentials and enzyme potentials*

While the potential of the anode and cathode set the limits for the maximum voltage achievable for power generation, using the potentials for these substrates does not fully consider the biochemical basis for power generation. Bacteria that use oxygen and many alternate electron acceptors such as iron use the citric acid cycle to oxidize the substrate, resulting in the production of three different electron carriers (NADH, FADH, and GTP). The ATP yield under aerobic conditions is the highest achievable due to the largest potential between NADH and oxygen. Under aerobic conditions when glucose is first oxidized to pyruvate (producing a net of 2 ATP), each pyruvate is decarboxylated to acetyl-CoA (producing 1 NADH as 3 ATP), and then the Citric Acid Cycle (CAC) is used to completely oxidize the pyruvate producing 1 GTP (producing 1 ATP), 4 NADH (12 ATP),and 1 FADH (2 ATP). With oxygen it is 15 ATP from each pyruvate in the CAC (total of 30 ATP), plus 6 ATP from pyruvate oxidation, plus 2 ATP from glycolysis, netting a maximum of 38 ATP under aerobic conditions. ATP is generated due to the pumping of protons across inner cell membranes by the respiratory enzymes. When they flow back to ATPase, ATP is generated from ADP.

When oxygen is used as the terminal electron acceptor, a total of five protons are pumped across the inner membrane for *Paracoccus denitrificans* or *Escherichia coli*. When nitrate is used as the terminal electron acceptor by *E. coli*, only four protons are pumped across the inner cell membrane and thus the yield of ATP will be less with nitrate than with oxygen. This because there is less energy available with nitrate than with oxygen, as indicated by a lower redox potential for nitrate ($NO_3^-/1/2N_2$, $E^{0'}$=0.74 V) than for oxygen ($1/2O_2/H_2O$, $E^{0'}$=0.82 V under the same conditions), as can be seen in Table 2.10. Less energy means fewer protons can pump across inner cell membranes.

**Table 2.10: Potential of different couples (pH=7, temperature is assumed to be 303 K) (Madigan and Martinkov, (2006) was referred by Logan, (2007))**

| Couple | Potential (V) | Couple | Potential (V) |
|---|---|---|---|
| $CO_2$/glucose, 24e$^-$ | -0.43 | $S_4O_6^{2-}/S_2O_3^{2-}$, 2e$^-$ | 0.024 |
| $2H^+/H_2$, 2e$^-$ | -0.42 | Fermarate,succinate, 2e$^-$ | 0.030 |
| $CO_2$/methanol, 6e$^-$ | -0.38 | Cytochrome $b_{ox}/_{red}$, 1e$^-$ | 0.035 |
| $NAD^+$/NADH, 2e$^-$ | -0.32 | Ubiquinonone$_{ox}/_{red}$, 2e$^-$ | 0.11 |
| $CO_2$/acetate, 8e$^-$ | -0.28 | $Fe^{3+}/Fe^{2+}$, 1e$^-$ | 0.20 |
| $S^0/H_2S$, 2e$^-$ | -0.22 | Cytochrome $c_{ox}/_{red}$, 1e$^-$ | 0.25 |
| Pyruvate/lactate, 2e$^-$ | -0.19 | Cytochrome $a_{ox}/_{red}$, 1e$^-$ | 0.39 |
| | | $NO_3^-/NO_2^-$, 2e$^-$ | 0.42 |
| | | $NO_3^-/1/2N_2^-$, 5e$^-$ | 0.74 |
| | | $Fe^{3+}/Fe^{2+}$, 1e$^-$(pH=2) | 0.76 |
| | | $1/2O_2/H_2O$, 2e$^-$ | 0.82 |

*Role of communities versus enzymes in setting anode potentials*

The cell potentials can be determined by the relative $NAD^+$ in the oxidized and reduced form, thus these factors affect the microbial ecology in MFC. One microorganism is able to achieve a certain $NADH/NAD^+$ ratio compared to another, setting a limit on the potential that a specific microbial species can set relative to the circuit. Thus the anode potential could vary among bacteria, setting different power generation levels for different strains of bacteria. Since one goal in using bacteria is to obtain the most energy possible from degradation of the substrate, it is easy to see that a high $NADH/NAD^+$ ratio benefits the microbe. A low ratio for the concentration of reduced to oxidized species is desirable for the terminal enzyme that transfers the electrons to the anode electrode.

The competition between the two bacteria results in the following: one of the species sets a lower potential or they both achieve the same potential and co-exist. The resistance of the circuit used by the bacteria to transfer electrons also affects the final potential that the bacteria can achieve, so this is a factor in competition as well. As bacteria are pushed out further from the anode, as they grow and new cells are formed, the length of the wire or connection to the anode surface will grow more distant and thus, these bacteria will begin to compete less effectively for electrode space. Then these bacteria will die, be forced to move to a new more advantageous location on the electrode, or switch metabolism to some other kind of electron acceptor or switch to a fermentation metabolism.

*Voltage generation by fermentative bacteria*

Bacteria that produce energy from substrate fermentation obtain energy by substrate level phosphorylation, taking a substrate and producing a variety of different end products as in Figure 2.6.

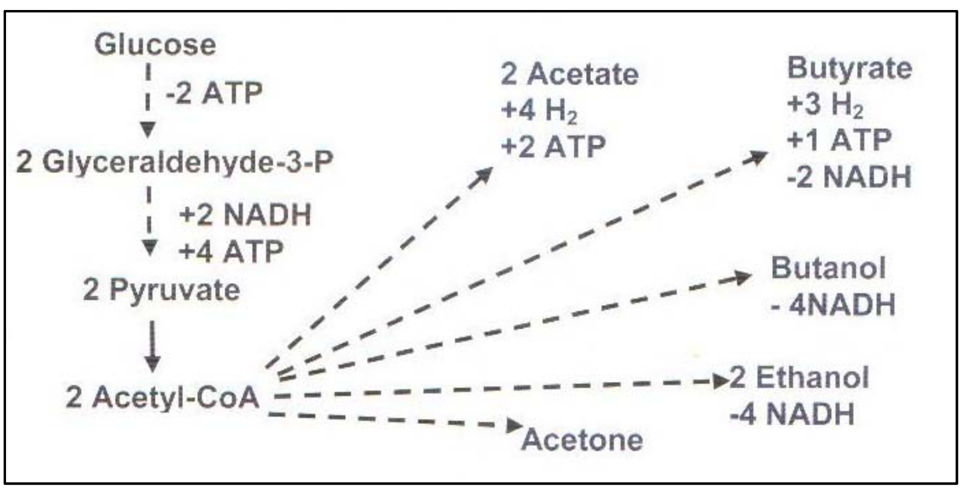



Figure 2.6: Different fermentation pathways used by *Clostridium acetobutylicum* (ATCC 824) to generate ATP or regenerate NADH (Girbal, et al., (1995) was referred by Logan, (2007))

As shown in Figure 2.6, when a microbe makes acetate, it can produce the most ATP from fermentation. However, it also produces NADH which must be converted back to $NAD^+$ to sustain the reaction. One possible way for cells to generate $NAD^+$ from NADH is by a reversible hydrogenase that produces hydrogen. The potential of a $NADH/NAD^+$ couple can be compared to that of hydrogen couple ($2H^+/H_2$) under the same conditions of pH 7 where the hydrogen couple has a potential of E0' = -0.421 V. Under these standard conditions (1 M concentration of each soluble species, and 1 bar pressure for $H_2$), NADH cannot transfer these electrons through a hydrogenase to form $H_2$ as the process is thermodynamically unfavorable (E = -0.421 V- (-0.320 V) = -0.09 V). However, as indicated above the relative concentrations of $NADH/NAD^+$ can vary within the cell, allowing the potential to change.

### 2.5 The resistance in the MFC operation

The maximum cell voltage for a single chamber microbial fuel cell is E0'=1.1 V, which is calculated for the acetate and oxygen couple as in Table 2.6. The OCV produced by the MFC is always less than that predicted by the maximum potential calculations for the cell due to the bacteria enzymes, as shown in Figure 2.7.

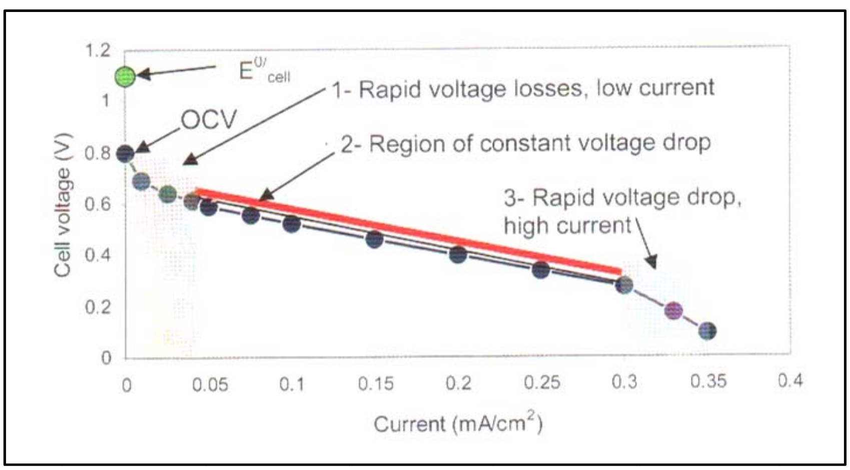



Figure 2.7: Characteristics of a polarization curve, showing regions where different types of losses reduce the useful current and the region of the constant voltage drop (Logan, 2007)

In Figure 2.7 there are 3 characteristics regions of voltage decrease in MFC:

1. A rapid voltage drop current flows through the circuit (at high internal resistance)
2. A nearly linear decrease in voltage
3. A second rapid voltage decrease at high current densities

The cell voltage produced at any specific current is considered to be the result of voltage losses due to electrode overpotential and ohmic losses as in equation 2.11.

$$E_{emf} = E^0 - (\sum OP_{An} + |\sum OP_{Cat}| + IR_{\Omega}) \qquad (2.11)$$

| | | |
|---|---|---|
| Where $E_{emf}$ | = | The intrinsic maximum possible potential due to the chemical reactions at the anode and cathode (Volt) |
| $\sum OP_{An}$ | = | The overpotential of the anode (Volt) |
| $\lvert\sum OP_{Cat}\rvert$ | = | The overpotential of the cathode (Volt) |
| $IR_{\Omega}$ | = | Ohmic losses (Volt) |

Overpotentials of the electrode are most evident at low current densities where the voltage rapidly decrease, but it must be recognized that their magnitude at any specific point is current dependent. Electrode overpotentials are thought to arise from three basic losses:

1. Activation
2. Bacteria metabolism
3. Mass transport

Activation losses are due to energy lost (as heat) in initiating the oxidation or reduction reaction, and the energy loss through the transfer of an electron from the cell terminal protein or enzyme to the anode surface such as the nanowire, mediator, or terminal cytochrome at the cell surface. These losses are especially apparent at low current densities as shown in the first region of Figure 2.6. They could be reduced by using an improved catalyst at the cathode or different bacteria on the anode, or by improving the electron transfer between bacteria and the anode.

Voltage losses due to the bacteria metabolism are inevitable as these losses are a consequence of the bacteria deriving energy from substrate oxidation. In practice, the actual voltage output of the microbial fuel cell is less than the theoretical voltage because of unavoidable losses such as overpotentials. The three major irreversible effects on the efficiency of microbial fuel cell are activation losses, ohmic losses and mass transport losses. The real operational voltage output ($V_{op}$) of an MFC can be determined by subtracting the voltage losses associated with each compartment from the thermodynamically predicted voltage as in equation 2.12.

$$V_{op} = E_{thermo} - [(\eta_{act} + \eta_{ohmic} + \eta_{conc})_{cathode} + (\eta_{act} + \eta_{ohmic} + \eta_{conc})_{anode}] \qquad (2.12)$$

Where

| | | |
|---|---|---|
| $V_{op}$ | = | The operational voltage output |
| $E_{thermo}$ | = | The thermodynamically predicted voltage |
| $\eta_{act}$ | = | The activation loss due to reaction kinetics |
| $\eta_{ohmic}$ | = | The ohmic loss from ionic and electronic resistances |
| $\eta_{conc}$ | = | The concentration loss due to mass transport limitations |

## 2.6 Materials for microbial fuel cell

### 2.6.1 Anode materials

The anode materials for an MFC should be highly conductive, non-corrosive, high specific surface area (area per volume), high porosity, non-fouling, inexpensive, and easily made and scaled up. A simple test with a voltmeter is sufficient to make the first evaluation of the material by measuring its resistance. Placing the voltmeter electrodes on the surface about 1 cm apart and reading the resistance produces an immediate classification of the material's conductivity. The electrons produced by bacteria will need to flow from the point of generation on the surface of the materials to the collection point that contacts the wire, where only a few ohms of added internal resistance can greatly reduce power. In addition, bacteria must be able to attach to the material and achieve good electrical connection.

*a) Carbon cloth, paper, foams, and reticulated vitreous carbon (RVC)*

Carbon-based electrodes in paper, cloth, and foam form are commonly used for MFC anodes. These materials (Figure2.8) have high conductivity and appear to be well suited for bacterial growth.

Carbon paper is stiff and slightly brittle but it is easy to connect to a wire. It should be sealed to the wire using epoxy, with all exposed surface of the wire covered or sealed with epoxy as well. Copper wire can be used but it corrodes over time, releasing copper into the solution (which can be toxic to bacteria). Stainless steel and titanium wires work better in MFCs. Carbon paper is commonly available in plain and wet-proofed versions, with plain paper suggested for anode applications.

Carbon cloth is more flexible and appears to have greater porosity than carbon paper.

Carbon foams are much thicker than the cloths, conferring more space for bacterial growth. They have not been as extensively used in MFC studies. The conductivity of the material is excellent at 200 S/cm ($5x10^{-3}$ $\Omega$/cm). It is quite porous (97%) with different effective pore sizes specified by the manufacturer. The main disadvantages of these materials are that they are quite brittle.

There are few direct comparisons of the effectiveness of these different carbonaceous materials in power generation.

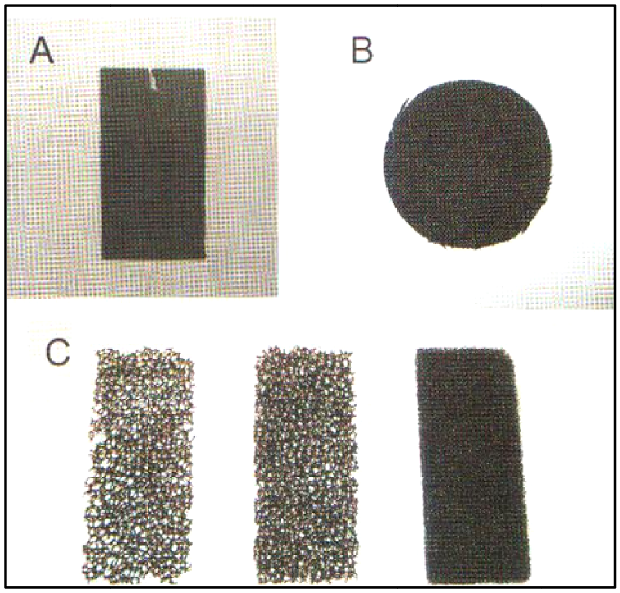



Figure 2.8 : (A) carbon paper, (B) carbon cloth (C) RVC in difference types (Logan, 2007)

*b) Graphite rods, felt, foams, plate and sheets.*

There are many graphite materials to choose from for MFC electrodes which vary greatly in price, composition, and surface area, as shown in Figure 2.9.

Graphite rods have been used in several MFC studies, as they are highly conductive and have a relatively defined surface area (low internal porosity). They have been extensively used in electrochemical study. High performance graphite rods can be purchased from a number of vendors. Before they are used they are often sanded lightly to increase surface area for bacterial growth. A common graphite rod is pencil lead, which is quite conductive (0.2 $\Omega$/cm).

Graphite sheets can be purchased in a variety of thicknesses and, like pencil lead, are soft and will mark paper. Because these sheets are flat, they are an excellent surface to use for microscope-based analysis of electrochemically active biofilm. However graphite sheets are not porous and thus produce less power per geometric surface area than felts or foams.

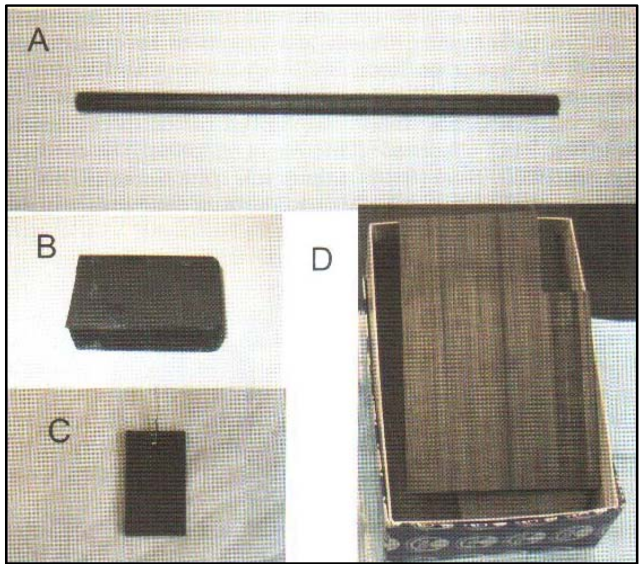



**Figure 2.9: (A) graphite rod, (B) graphite plate, (C) thinner graphite electrode, (D) sheet shown with square electrode cut out (Logan, 2007)**

c) Graphite granules

Graphite granules, shown in Figure 2.10, are chunks of graphite that resemble pencil lead in their appearance and are available from some different sources. The granules are conductive (0.5-1.0 Ω/granule). Due to the shape of the granules and the bad porosity, they can connect at only a small fraction of their total surface area.

d) Graphite fiber and brushes

The highest specific surface area and porosities for anodes can be achieved using graphite fiber brush electrodes. These brushes can be made from carbon fibers produced by different manufacturers using conventional industrial brush machines. The core of the wire can be made from a non-corrosive metal such as titanium wire.

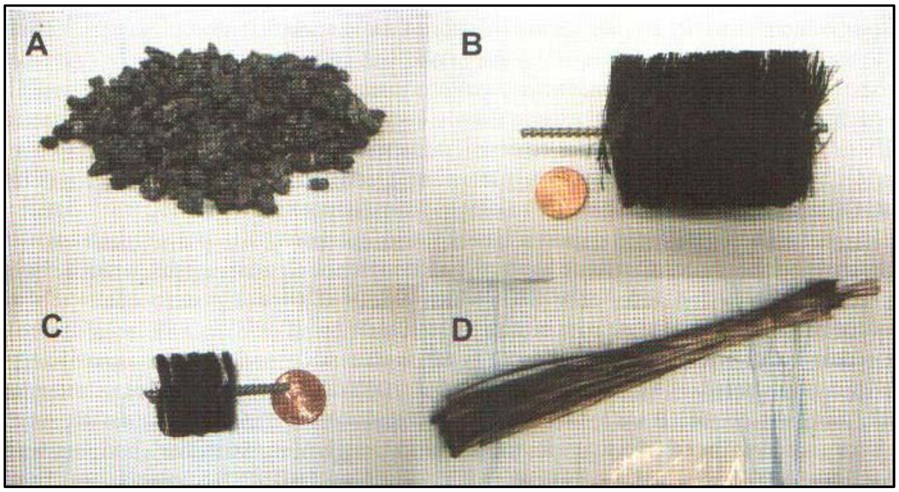



Figure 2.10: (A) graphite granules, (B) large graphite brush, (C) small graphite brush, (D) section of a tow of graphite (Logan, 2007)

e) Conductive polymers

The use of conductive polymer materials as anodes has not been well investigated in MFC studies. Logan, (2007) showed that the polymers were not as effective as carbon paper or granules.

f) Metal and metal coating

The use of various metal and metal coatings on carbon materials has not been well examined for MFCs. Adding metal to the electrode increases power, but the additional power resulting from the galvanic increases due to the potential of the metal or other reasons have not been well examined. Metal coatings can use materials such as $Fe_3O_4$, $Fe_3O^{4+}$, $Ni^{2+}$, and $Mm^{4+}$.Metals that can be used as electrodes include stainless 304, aluminum oxide, tungsten, titanium, and iron oxide. Stainless 304, aluminum oxide, and titanium inhibit electricity production, while tungsten and iron oxide decrease the start up times.

g) Non-metallic treatments and modification of anodes to increase power

Several approaches have been used to increase anode performance using different non-metallic materials. Anodes are modified by treatment with carbon cloth using 5%$NH_3$ gas in a helium carrier gas at 700°C (for 1 hour), bonding a mediator of neutral red on woven graphite electrode.

### 2.6.2 Cathode materials

The design of the cathode is the single greatest challenge for making an MFC a useful and scalable technology. The chemical reaction that occurs at the cathode is difficult to engineer because the electrons, protons, and oxygen must all meet with the catalyst in a tri-phase reaction (solid catalyst, air, and water). The catalyst must be on a conductive surface, but must be exposed to both water and air so that protons and electrons in these different phases can reach the same point. Oxygen can diffuse into water, but the solubility of oxygen in the water is only 4.6 $x10^{-6}$ at 25°C (mole fraction basis) compared to 0.21 in the air. Proton solubility in membranes or binders such as Nafion can be high, producing a low pH, but the proton concentration in water is limited by pH ranges tolerated by bacteria, which are near neutral (pH nearly 7.0). Lower pH can be used in the cathode chamber, but these can result in voltage losses across the membrane.

The same materials that have been described above for use as anode have also been use as cathodes. Thus, studies have use carbon paper, cloth, graphite, woven graphite, graphite granules, brushes, etc. The main difference when these materials are use as cathode is that catalyst is usually but not always needed. Solid phase and liquid catalyst have been used, creating a wide range of possible materials and chemicals to facilitate current generation.

### 2.6.2.1 Carbon-based cathodes

a) Carbon cathode with platinum catalysts

The most commonly used material for a cathode is commercially available carbon paper pre-loaded with platinum catalyst on one side, available from different manufacturers. When used in the MFC, the side containing the catalyst faces the water, with the uncoated side facing the air. It is also possible to purchase plain carbon cloth and apply the catalyst in the laboratory. Figure 2.11 shows the cathode carbon cloth.

b) Catalyst binders

When catalyst is applied to carbon it must be held there using materials that allow the transfer of protons, electrons, and oxygen. Nafion is therefore often chosen, although materials such as polytetrafluoroethylene suspension (PTFE) can also be used.

c) Diffusion layers

When air cathode microbial fuel cells do not contain a cation exchange membrane, Coulombic efficiency (CE) is reduced due to the high oxygen flux through the cathode. In addition, there can be substantial water loss through the air-facing side. In some reactors, that can result in the appearance of gas in the head space which could be composed of carbon dioxide, methane, nitrogen, and oxygen depending on operational conditions. Obviously, the occurrence of an air phase in the anode chamber is to be avoided because the oxygen in the air may reduce the CE and affect the power generation if the redox potentials become too high in the anode chamber. To avoid these problems of water loss and low CE, the air-facing side of the cathode is coated with hydrophobic material. While Nafion can also serve the same purpose, it is used on the water side of the cathode.

d) Carbon cathodes with non platinum catalysts

Logan, (2007) referred to Park and Zeikus, (2002), who made the first to experiment with non-precious-metal, carbon-based air cathodes in MFCs. They made a ferric cathode by forming the plate out of ferric sulfate (3% w/w), fine graphite (60%), kaolin (36% as a binder), and nickel chloride (1%), then baking at 1,100°C for 12 hours under $N_2$ gas. These iron cathodes produced up to 3.8 times as much power as plain woven graphite cathodes, but they did not compare to Pt-based cathodes of similar dimensions.

e) Plain carbon cathodes

The efficiency of a catalyst is often assessed by comparing current or power densities to those with plain carbon electrodes of the same surface area. Oxygen reduction still proceeds in the absence of the catalyst, but the rate is reduced. In general, current and power reduce by a factor of 10 or more with plain carbon materials. However if the cathode surface area is substantially increased, it is possible to achieve much higher power densities.

f) Tubular carbon-coated cathodes

Logan, (2007) referred to Riemers, (2006), who tested sediment MFC with 1-mm long carbon brush cathodes. Riemers (2006) reached power densities of 34 mW/$m^2$ by positioning the MFC over deep ocean water in Monterey Canyon in California. Power decreased over time due to the sulfide built up on the anode with no indication of reduced cathode performance.

g) Tubular carbon-coated cathodes

MFCs require high surface area and high porosity typical in wastewater reactors. The tubular ultra-filtration membranes provide high surface areas for filtering the treated water (180 to 6,800 $m^2/m^3$). Logan, (2007) referred to Zuo, et al., (2007), who developed a tubular cathode by applying a conductive graphite paint material, to a hydrophilic tubular ultrafiltration membrane (polysulfone membrane on a composite polyester carrier) that had an inner diameter of 14.4 mm. and a wall thickness of 0.6 mm.

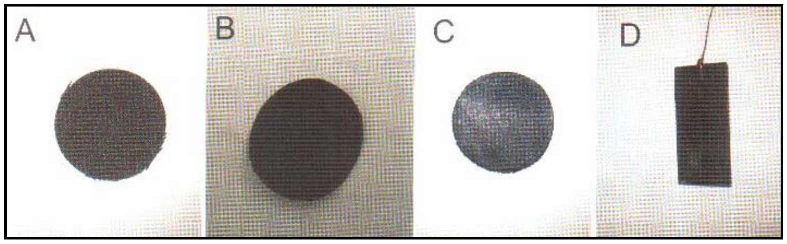



Figure 2.11: (A) plain carbon cloth, (B) carbon cloth coated with Pt, (C) carbon cloth coated with diffusion layer, (D) square cathode used in two chambers (Logan, 2007)

2.6.2.2 Other cathodes and catalysts

a) Aqueous catholytes

When oxygen is not used at the cathode, no catalyst is needed and therefore plain carbon cathodes can be used. Several different aqueous catholyte have been tested. The most common is ferricyanide or hexacyanoferate which is reduced according to equation 2.13

$$\mathrm{Fe(CN)_6^{3-}} + \mathrm{e^-} \rightarrow \mathrm{Fe(CN)_6^{4-}} \quad (2.13)$$

Permanganate and iron have also been used as catholytes. The main disadvantage of catholytes like ferric cyanide is that they must be chemically regenerated or replaced.

b) Pt and Pt-coated metals

Pt electrodes are not practical for large scale applications due to their prohibitive cost, but they provide useful benchmarks on the performance of the system. While Pt can be used in MFC tests, the formation of an oxide layer (PtO) on the Pt surface can reduce electron activity over time.

c) Metal other than Pt

Cathodes made of several different metals have been examined for use in various types of MFCs, but not all of them can be used.

d) Biocathodes

A biocathode uses bacteria as the catholyte in the cathode chamber. When stainless steel containing sea water biofilm was used for a HFC (hydrogen fuel cell), power was increased by a factor of 30 compared to the same system after cleaning the biofilm on the cathode (Bergel, et al., (2005) was referred to by Logan, (2007)). A system using bacteria to re-oxidize Mn can also be used as biocathodes.

### 2.6.3 Membranes and separators

Membranes are primarily used in two-chambered MFCs as a method for keeping the anode and cathode liquids separate. The solution in the cathode chamber cannot be allowed to mix with the solution in the anode chamber. This membrane needs to be permeable so that protons produced at the anode can pass to the cathode. The disadvantages of membranes in MFCs are their high cost and sometimes decreased system performance due to increasing internal resistance as shown in Table 2.11.

Table 2.11: Internal resistance of cation, anion, and ultrafiltration membrane tested in bottle (B-MFCs) and cube MFC(C-MFC) (Logan, (2007) referred to Kim, et al., (2007))

| Membrane | Internal resistance (Ω) | |
|---|---|---|
| | B-MFC | C-MFC |
| No membrane | 1,230 ± 44 | 84 ± 3 |
| CEM (Nafion) | 1,272 ± 24 | 84 ± 4 |
| CEM (CEMI-7000) | 1,308 ± 18 | 84 ± 3 |
| AEM (AMI-7001) | 1,239 ± 27 | 88± 3 |
| UF-0.5K | 6,009±58 | 1,814±15 |
| UF-3K | 1,233 ± 46 | 91± 3 |

The internal resistance attributable to the membrane can be measured by placing difference membranes into the reactor and measuring internal resistance according to the method described in Appendix A.

a) Cation exchange membrane

The most commonly used cation exchange membrane (CEM) is Nafion 117 (Dupont Corp., available from Ion Power, Inc., shown in Figure 2.12). This membrane was developed for high proton concentrations (low pH) under conditions where the water content is carefully controlled. However, this material becomes completely flooded with the water in an MFC, producing a pH reflective of the solution's properties (neutral pH). So it does not function according to its intended purpose in an MFC as it cannot operate under its designed conditions.

Nafion is also referred to as a PEM on the basis that it is designed to transfer protons ($H^+$), but in an MFC it preferentially conducts other positively charged species ($Na^+$, $K^+$, $NH_4^+$, $Ca^{2+}$, and $Mg^{2+}$) that are present at typically 105 times higher concentrations than protons in solution at neutral pH (Logan, (2007) referred to Rozendal, et al., (2006)). The competitive transport of cations other than protons significantly affects MFC performance. When substrate is degraded, protons are produced at the anode and consumed at the cathode. If protons cannot migrate at a sufficient rate from the anode to the cathode, the pH will decrease at the anode and increase at the cathode while charge balance is maintained by the migration of other cations. The pH decrease at the anode affects bacterial respiration and thus current generation. At the cathode, the pH can rapidly rise, which can lead to mass transfer and limited proton transport to the catalyst. A well buffered solution can offset these pH changes in the biofilm which may affect power generation. Calculations based on oxygen reduction at the cathode show that an increase in pH will affect the cathode potential.

A CEM membrane (CMI-7000) made by Membrane International Inc., NJ, has been used in several MFC studies, mostly those with ferricyanide as the catalysts

(Logan, (2007) referred to He, et al., (2005); Robeay, et al., (2005b); Robeay, et al., (2003); Robeay, et al., (2005c)). This membrane is much thicker and stiffer than the Nafion 117 (0.046 cm) and in general appears to be structurally stronger. There are many manufacturers of CEMs which could be used in MFCs, but these have not been compared for their performance in MFC applications.

Anion exchange membranes (AEM) work as CEMs but in a different way. The AEM can increase in the cathode chamber more than the PEM of a two-chamber microbial fuel cell using phosphate buffer (Kim, et al., (2007b), was referred by Logan, (2007)). $PO_4^{3-}$ were being transported across the membrane and that pH was better maintained in the anode chamber.

A bipolar membrane consists of an anion and cation membrane joined in series. As voltage develops, rather than protons passing the membrane water is split, resulting in transport of anions ($OH^-$) to the anode and cations ($H^+$) to the cathode to balance the charge. The energy needed for the water splitting reaction is presumed to be small because water is split into ionic species, $H^+$ and $OH^-$ (not electrolyzed into $H_2$ and $O_2$). A bipolar membrane is used to maintain low pH in the cathode chamber and near neutral pH in the anode chamber. For a completely selective bipolar membrane, it was calculated that 0.83 V needed to be overcome (Hurwitz and Didiani, (2001), was referred by Logan, (2007)) for a 100% selective membrane with one molar acid and base solutions (△pH=14) using equation 2.14

$$\Delta V = \frac{-2.3RT}{F}\Delta pH \qquad (2.14)$$

Where

| | | |
|---|---|---|
| $\Delta V$ | = | The difference potential (V) |
| $R$ | = | The ideal gas constant (8.314 J/mol- K) |
| $\Delta pH$ | = | The difference voltage |
| T | = | Temperature (Kelvin) |
| F | = | Faraday's constant (96,485 C /mol) |

b) Other separators and membranes

The observation that cations or anions can help to maintain a charge in an MFC opened the door to new possibilities for using different types of membranes in MFCs. The main function of the membrane is to keep solutions isolated while allowing charge transfer, presumably via small ions. Thus, an ultrafiltration (UF) membrane (especially those developed for wastewater applications) may be suitable for use in MFCs. These membranes have tiny pores, with many membranes available that have molecular weight cutoff values below 1,000 daltons (1K). UF membranes have appreciable flow through them only under high pressure, and thus under relatively low hydrostatic pressure in tanks.

### 2.6.4 Long term operations

The long term stabilities of MFC are due to the biofilm formed on the surface of electrode materials and membranes. The parameters that affect power generation are operation, temperature, ionic strength, and pH variation.

Logan, (2007) referred to Change, et al., (2006c), who used batch mode operation in MFC with Pt catalysts bond using two different binder materials (Nafion and PTFE). MFC-fed batch tests were conducted for 35 cycles, spanning 31 days, with glucose as the substrate. In the MFC using the Nafion binder, voltage varied between 0.5 V and 0.6 V but decreased slightly over time. The maximum power density decreased from 480 ± 20 mW/m$^2$ (based on the first three cycles) to 400 ± 10 mW/m$^2$ (last three cycles). The CE increased over the same period from 8.9 ± 0.4% to 18.6 ± 0.5%. This suggests that proton conduction, oxygen conduction, and oxygen diffusion were impaired over time. The development of a biofilm on the cathode could be reducing the effective diffusivity of protons from the anode to the cathode. The biofilm caused a reduction of substrate and oxygen diffusivities near the cathode, reducing over substrate loss due to bacteria aerobic growth sustained by oxygen diffusion into the reactor.

When PTPE was used as the binder instead of Nafion, the same generation pattern was observed with decreased maximum power densities and increased CE over time. The maximum voltages and power densities with PTFE were not as high as with Nafion, but changes with time were reduced as well. The maximum power decreased by only 9%, or from 360 ± 10 $mW/m^2$ (cycle 2-4) to 331 ± 3 $mW/m^2$ (last three cycles). The CE increased from 9.5 ± 1.5% to 13.1 ± 0.3%. This changing of binder materials affected the overall process.

Membrane fouling on the surface of the electrode in the MFC can limit the chemical diffusivities through it. This can reduce proton transport or charge transfer as well as oxygen or substrate diffusion between the chambers. When using ferric ions as the catholyte, the CEM quickly became fouled due to iron precipitation on the membrane (Figure 2.12) (Logan, (2007), referring to Heijne, et al., (2006)). This problem was solved by replacing the CEM with a bipolar membrane.

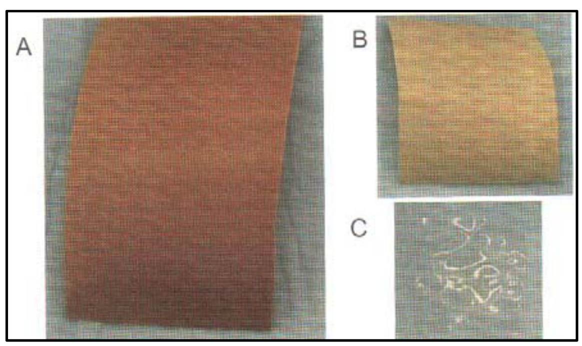



**Figure 2.12: Fouling of a Nafion 117 membrane due to a pH rise in the cathode chamber, causing ferric iron precipitation (Logan, 2007)**

## 2.7 The features of MFC

### 2.7.1 The Two-Chamber Microbial Fuel Cell

The physical layout of a two-chamber microbial fuel cell is shown in Figure 2.13.

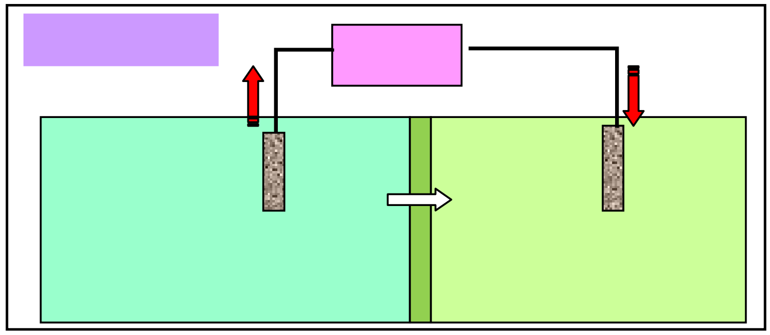


Figure 2.13: The principle of a two-chamber microbial fuel cell

The two-chamber fuel cell was the first method to develop the microbial fuel cell to generate electricity. Its advantage is easy of assembly. The disadvantages of the two-chamber are power input in aeration at the cathode chamber and high internal resistant due to its architecture. Its potential output is less and its maximum power density is not as high as the type and loading of any organic cell. Logan, et al., (2005) and Min, et al., (2005) used acetate or cysteine as the organic supply, and the maximum power density was 40 $mW/m^2$. Consist with this, Mohan, et al., (2008) used various substrates for loading, and the maximum power density is not different. Nevertheless the sizing of electrodes and proton exchange membrane affects the maximum power density (Oh and Logan, 2005).

### 2.7.2 A Single-Chamber Microbial Fuel Cell

The principle of a-single microbial fuel cell is shown in Figure 2.14.

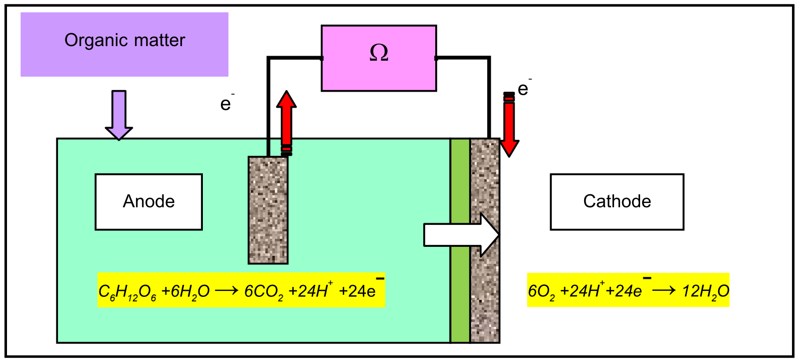



Figure 2.14: A single-chamber microbial fuel cell

The distinct advantage of a single-chamber microbial fuel cell is its low internal resistance, so its maximum power density output is more than that of a two-chamber microbial fuel cell and is directly related to its loading and the type of organic used. Liu, et al., (2005b) and Liu and Logan, (2004) used acetate and glucose as the organic substrate in a single-chamber microbial fuel cell; the maximum power density was 506 mW/m$^2$ and 494 mW/m$^2$ respectively. With domestic wastewater and butyrate the maximum power density was 146 mW/m$^2$ and 305 mW/m$^2$. With ethanol as a substrate power output was 488 mW/m$^2$ (Kim, et al., 2007). These studies show that the power outputs differed from those of other substrates.

## 2.8 Factors affecting the performance of MFC

The procedure to produce electricity by could divide into 3 processes as the substrate oxidation, the transportation of electron and proton and the usage electron at the cathode electrode. The factors influent efficiency the microbial fuel cell can be list as Table 2.12.

Table 2.12: Factors affecting the efficiency of a microbial fuel cell

| Factors | Oxidized substrate | Transfer electrons | Using electrons |
|---|---|---|---|
| Microbial communities | √ | - | - |
| Substrate | √ | - | - |
| Temperature | √ | √ | - |
| Mediator | - | √ | - |
| Proton exchange membrane and separators | - | √ | - |
| Electrode distances | - | √ | - |
| Internal and external resistant | - | √ | - |
| Electrodes | √ | √ | √ |
| Catalyst | - | - | √ |

### 2.8.1 Microbial communities

There are many types of bacteria that can produce electrons outside the cell. Iron-reducing bacteria such as *Shewanella* and *Geobactor* a recalled exoelectrogens bacteria (Feng, et al., 2008). However the diversion of microbial communities results from the substrate and the environment in the system (Patrick, et al., 2011). Other species of exoelectrogens used in microbial fuel cell are in Table 2.13.

Table 2.13: Microbes used in microbial fuel cells (Sammers, 2006)

| Organisms | References |
|---|---|
| *E. coli* | Sell, et al., (1989) |
| *Alcaligenes eutrophus* | Choi ,et al., (2003) |
| *Bacillus subtilis* | Kim, et al. (2000) |
| *Bacillus subtilis* | Kim, et al. (2000) |
| *Proteus vulgaris* | Rabaey, et al., (2003) |
| Mixed culture from anaerobic sludge | Tender, et al. (2002) |
| *Desulfuromonas acetoxidant* | Bond,et al. (2002) |
| Mixed culture from marine sediments | Chaudhuri and Lovley, (2003) |
| *Rhodoferax ferric reductions* | Bond and Lovley, (2003) |
| *Geobactor sulferreducence* | Park and Zeikus, (2003) |
| *Mixed culture from anaerobic sludge* | Kim, et al. (2002) |
| *Shewanella putrefaciens* | Yakishita, et al., (1998) |
| *Anabaena variabillis* | Sell, et al., (1989) |
| Mixed culture | Choi, et al., (2003) |
| Activated sludge | Kim, et al., (2000) |
| *Mixed culture from wastewater* | Rabaey, et al., (2003) |
| Anaerobic sludge | Tender, et al., (2002) |
| *Clostridium beijerinckii* | Bond, et al., (2002) |
| Secondary Anaerobic sludge from digester | Chaudhuri and Lovley, (2003) |
| Mixed anaerobic culture | Bond and Lovley, (2003) |
| anaerobic mixed consortia | Park and Zeikus, (2003) |

### 2.8.2 Electrodes

The electrodes affect the performance of the microbial fuel cell as described in section 2.6.1 and section 2.6.2. Lowy, et al., (2006) reported that coating the cathode with a high oxidizing agent is more efficient. The oxidizing agent usually used is $Mn^{4+}$, $Fe_3O_4$, or $Ni^{2+}$. Cheng and Logan, (2007) coated the cathode with ammonia used a 200 mM phosphate buffer as mediator; startup period was reduced, and the maximum power density was as high as 1,970 mW/m$^2$. Mohanakrishna, et al., (2012) used carbon based multi walled nano-tubes (MWCNT) and nano-powder (CNP) as the electrode, and the results showed 148% and 57% enhancement in power generation, respectively, compared to plain graphite anode (MFCP). Rismani-Yazdi, et al., (2008) and Logan, (2007) mentioned that the reaction at the cathode is limited in microbial fuel cells because of 3 major losses: activation losses, ohmic losses, and mass transport losses.

### 2.8.3 Substrates

Many studies have found that electricity can be generated from organic substrate from various sources such as domestic waste (Liu, et al., 2004), composite vegetable waste (Mohan, et al., 2010), various food industry wastes (Cercado-Quezada, et al., 2010), starch processing (Lu, et al., 2009); Kaewkannetra, et al., 2011)), brewery wastewater (Wang, et al., 2008; Wen, et al., 2010), cheese whey (Antonopoulou, et al., 2010), palm oil mill effluent (Cheng, et al., 2010), sewage sludge (Zhang, et al., 2011), decolorization in wastewater treatment (Sun, et al., 2009), and leachate wastewater (Gálvez, et al., 2009). Min and Angelidaki, (2008) used municipal waste as fuel in a microbial fuel cell system; their output voltage was $0.428 \pm 0.003$ volts. This is less than that of high strength wastewater (BOD/COD $\approx$ 0.3), used by Kim, et al., (2007); the power was 0.716 volt and 0.731 volt when the organic loading was 1.165 kg COD/$m^3$-day and 1.404 kg COD/$m^3$-day, respectively.

### 2.8.4 Temperatures

Controlling the temperature of the anode chamber affects the kinetics of reduction and proton transferred. Ahn and Logan, (2010) used domestic wastewater under two different temperatures ($23 \pm 3^{\circ}$C and $30 \pm 1^{\circ}$C) and flow modes (fed-batch and continuous) in single-chamber air–cathode microbial fuel cells (MFCs). They showed that the COD removal was slightly larger at mesophilic temperatures (33% removal) than ambient temperatures (23% removal). The CE and energy recoveries were 26% and 0.214 Whr/g COD removal for mesophilic reactors, and 38% and 0.314 Whr/g COD removal for ambient reactors.

### 2.8.5 Mediator

Cheng and Logan, (2007) found that the mediator can enhance the power generation from MFC. They compared two mediators in MFCs, NaCl and phosphate buffered nutrient solution (PBS). Their results showed that the power was higher when using PBS than when using NaCl due to the effects of chloride ions. Rismani-Yazdi, et al., (2008) discovered that the mediator inhibited the reversibility of the redox reaction and decreased the overpotentials. The mediator enhanced the reaction of the electron acceptor at cathode but it was not stable. Ferric cyanide is always used as the mediator in MFCs and the redox reaction is as shown in equation 2.14, equation 2.15, and Figure 2.15.

$$[Fe(CN)_6]^{3-}+e^{x}\rightarrow[Fe(CN)_6]^{4-}\ (E^{0}=0.358\ V) \qquad (2.14)$$

$$O_2+4[Fe(CN)_6]^{4-}+4H^{+}\rightarrow[Fe(CN)_6]^{3-}+2H_2O \qquad (2.15)$$

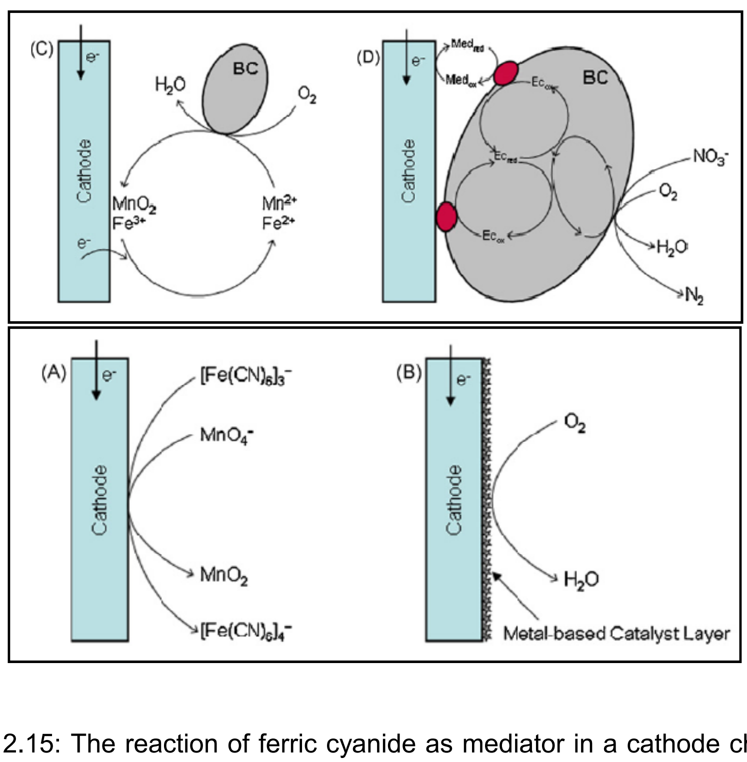



Figure 2.15: The reaction of ferric cyanide as mediator in a cathode chamber

### 2.8.6 Internal and external resistance

There are several factors affecting the internal resistant of an MFC. One cause of internal resistance is the distance between the anode and the cathode. At 3.0 cm, the voltage is 0.428 V (Min and Angelidaki, 2008) while at 2 cm it is 0.8 V (Cheng and Logan, 2007). As the distance increases, internal resistance increases.

External resistance also affects the circuit voltage output. Rismani-Yazdi, et al., (2011) concluded that external resistance affects the performance of MFCs by controlling the flow of electrons from the anode to the cathode. They tested four external resistances (20, 249, 480, and 1,000 Ω) by operating parallel MFCs independently at constant circuit loads for 10 weeks. A maximum power density of 66 $mW/m^2$ was achieved by the 20 Ω MFCs, while the MFCs with 249, 480, and 1000 Ω of external resistance produced 57.5, 27, and 47 $mW/m^2$, respectively.

## 2.9 Other studies of the microbial fuel cell

### 2.9.1 Applications in various substrates

Rezaei, et al., (2009) used chitin as the substrate in MFCs. The power generation from chitin and the magnitude of power density depended on the particles sizes. They operated for 33 days. The power increased as the particle diameter was increased from 0.28 to 0.78 mm. The CE also increased with particle size, from 18% to 56%. The minimum power density achieved with 0.78 mm particles was 176 $mW/m^2$ while the maximum power density from the 0.28 mm particles was 272 $mW/m^2$.

Sun, et al., (2009) applied the microfiltration membrane SCMFC to generate electricity from readily biodegradable organic substrates accompanied by decolorization of azo dye in batch mode operation. They found that accelerated decolorization of active brilliant red X-3B (ABRX3) was achieved in the MFC as compared to traditional anaerobic technology. The inhibition of electricity generation by SCMFC using azo dye was at a high concentration of 300 mg/L of ABRX3, and they noted that the voltage can be recovered to the original level after replacement with anodic medium not containing azo dye.

Bakhshian, et al., (2011) found that a dual-chamber microbial fuel cell using suspended lactase in the cathode chamber in the absence of any mediators decolorized RB221 and also improved oxygen reduction reaction in the cathode. They used molasses as the substrate in the anode chamber. The aims of their study showed that the capability of an MFC for simultaneous molasses and dye removal had an efficiency of 87% in the cathode chamber and 84% COD removal for molasses was observed in the anode chamber.

Chae, et al., (2009) evaluated four microbial fuel cells (MFCs) which they inoculated with anaerobic sludge and fed four different substrates for over one year. They found that the CE and power output varied with different substrates, while the bacterial viability was similar. Acetate-fed MFC showed the highest CE (72.3%), followed by butyrate (43.0%), propionate (36.0%), and glucose (15.0%). They explained the use of glucose as the substrate and its low CE as being due to its fermentable nature, implying its consumption by diverse non-electricity-generating bacteria.

Luo, et al., (2010) investigated furfural as an inhibitor in the ethanol fermentation process using lignocellulosic hydrolysates as raw materials. They demonstrated that electricity was successfully generated using furfural as the sole fuel in both the ferricyanide-cathode MFC and the air-cathode MFC. In the ferricyanide-cathode MFC, the maximum power densities reached 45.4, 81.4, and 103W/m$^3$, respectively, when 10,00 mg/L of glucose, a mixture of 200 mg/L glucose and 5 mM furfural, and 6.68 mM furfural were used as the fuels in the anode solution. The corresponding CEs were 4.0, 7.1, and 10.2% for the three treatments, respectively. With pure furfural as the fuel, the removal efficiency of furfural reached up to 95% within 12 hours. In the air-cathode MFC using 6.68 mM furfural as the fuel, the maximum values of power density and CE were 18 W/m$^3$ and 30.3%, respectively, and the COD removal was about 68% at the end of the experiment, at about 30 hours. Increase in furfural concentrations from 6.68 to 20 mM resulted in increase in the maximum power densities from 361 to 368 mW/m$^2$, and decrease in CEs from 30.3 to 20.6%. These results indicate that some toxic and biorefractory organics such as furfural might still be suitable resources for electricity generation using MFC technology.

Li, et al., (2010) demonstrated the effects of nitrobenzene (NB) on electricity generation and simultaneous biodegradation of NB with two types of microbial fuel cells (MFCs): a ferricyanide-cathode MFC with NB as the anodic reactant and an NB-cathode MFC. They compared to controls without NB. The presence of NB in the anode of the first MFC decreased maximum voltage outputs, maximum power densities, and Coulombic efficiencies. No electricity was generated from the first MFC using NB as the sole fuel; however, the second MFC using NB as the electron acceptor generated electricity successfully with a maximum voltage of 400 mV. NB was degraded completely within 24 hours in both anode and cathode chambers.

Cheng, et al., (2010) integrated a system of two-stage microbial fuel cells and immobilized biological aerated filters (I-BAFs) to treat palm oil mill effluent (POME) at laboratory scale. They tested by replacing the conventional two-stage upflow anaerobic sludge blanket (UASB) with a newly proposed upflow membrane-less microbial fuel cell (UML-MFC) in the integrated system. Significant improvements in $NH_3$–N removal were observed and direct electricity generation implemented in both $MFC_1$ and $MFC_2$. Moreover, the coupled iron-carbon micro-electrolysis in the cathode of $MFC_2$ further enhanced the treatment efficiency of organic compounds. They found that the I-BAFs played a major role in further removal of $NH_3$–N and COD. For influent COD and $NH_3$–N of 10,000 and 125 mg/L, respectively, the final effluents of COD and $NH_3$–N were below 350 and 8 mg/L, with removal rates higher than 96.5% and 93.6%.

Cercado-Quezada, et al., (2010) used three food-industry wastes: fermented apple juice (FAJ), wine lees, and yogurt waste (YW), for evaluation in combination with two sources of inoculums, anaerobic sludge and garden compost, to produce electricity in microbial fuel cells. They found that in the preliminary potentiostatic studies, YW was able to provide up to 250 $mA/m^2$. Wine lees were definitely not suitable, and FAJ was not able to start an MFC by means of its endogenous microflora. Both FAJ and YW were suitable for producing electricity when anaerobic sludge or compost leachate was used as the inoculums source. When they used Sludge-MFCs, YW performed better (232 mA/$m^2$), and when they used compost leachate MFCs, the power density of FAJ was 209 mA/$m^2$ and YW was144 mA/$m^2$, but YW provided stable power.

Morris, et al., (2009) applied MFCs to enhance subsurface bioremediation of contaminants such as petroleum hydrocarbons by providing an inexhaustible source of terminal electron acceptors to a groundwater environment that was likely depleted in thermodynamically favorable electron acceptors such as oxygen and nitrate. Their results indicate that anaerobic biodegradation of diesel range organics (Morrisa et al. ,2009) were significantly enhanced in an MFC (82% removal efficiency) as compared to an anaerobically incubated control cell (31% removal efficiency) over 21 days at 30˚C, and provided the power of 31 mW/$m^2$ cathode during diesel degradation. The microbial consortium on the anode of a diesel-degrading MFC was characterized by cloning and sequencing 16S rRNA genes. The majority of the clone sequences showed more than 98% similarity to bacteria capable of denitrification, such as *Citrobacter* sp., *Pseudomonas sp*., and *Stenotrophomonas* sp. The remaining clone sequences showed high similarity with organisms capable of using a wide range of electron acceptors, including sulfate, arsenate, and chlorinated inorganics. In particular, *Shewanella* sp. and *Alishewanella* sp. were found to be typically capable of using multiple electron acceptors. They suggested that MFC technology may be used to improve biodegradation of petroleum contaminants in anoxic environments, thus eliminating the need to amend terminal electron acceptors such as oxygen.

### 2.9.2 Architectures

Deng, et al., (2010)constructed an activated carbon fiber felt (ACFF) cathode lacking metal catalysts in an upflow microbial fuel cell (UMFC) as in Figure2.16. The maximum power density with the ACFF cathode was 315mW/$m^2$, compared to lower values with cathodes made of plain carbon paper (67 mW/$m^2$), carbon felt (77 mW/$m^2$), or platinum-coated carbon paper (124 mW/$m^2$, 0.2 mg-Ptc/$m^2$). When they added platinum to the ACFF cathode (0.2 mg-Ptc/$m^2$), the maximum power density increased to

391mWm$^2$, and increasing the cathode surface and shaping it into a tubular form further increased it to 784 mW/m$^2$. With the ACFF cut into granules, the maximum power was 481 mW/m$^2$ (0.5 cm granules), and 667 mW/m$^2$ (1.0 cm granules). They noted that ACFF cathodes lacking metal catalysts can be used to substantially increase power production in UMFC compared to traditional materials lacking a precious metal catalyst.

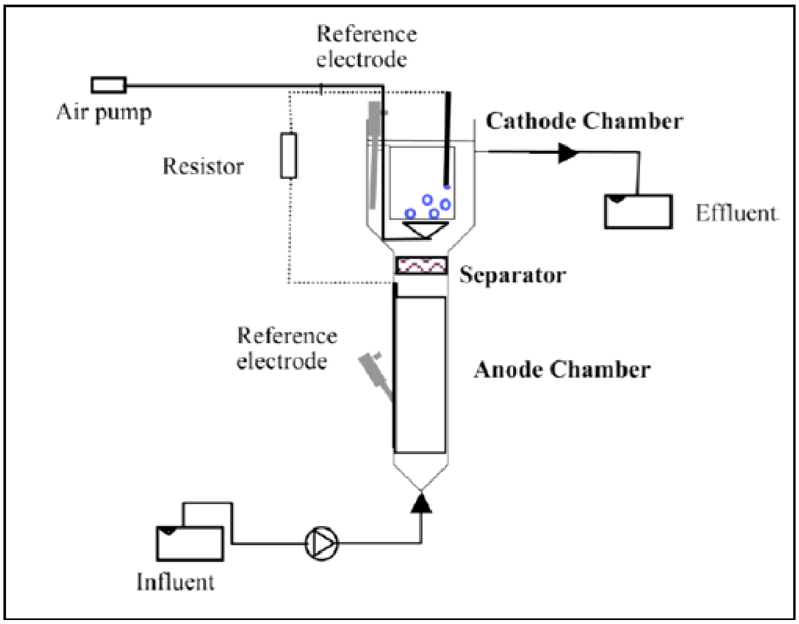



Figure 2.16: The schematic construction of UMFC (Deng, et al., 2010)

Mohan, et al., (2008) used glass wool as the proton exchange membrane (PEM) in an SCMFC (Figure2.17) with an acidogenic mixed culture, and OLRs of 2.64 and 3.54 kg COD/m$^3$ with pH 6 and 7 using non-coated plain graphite electrodes. They found that higher current density was observed at acidophilic conditions than at neutral conditions, while the highest efficiency of COD removal was observed at neutral pH.

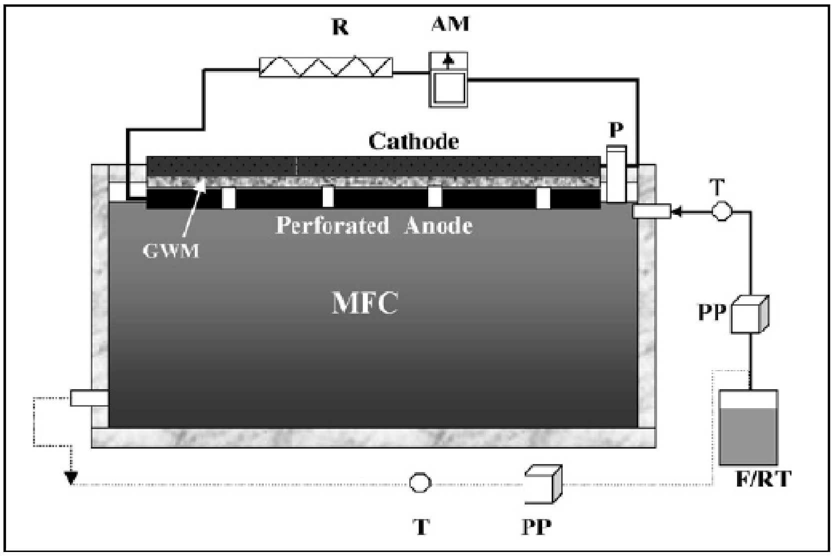



Figure 2.17: The schematic details of the experiment setup microbial fuel cell (Mohan, et al., 2008)

Li, et al., (2009) assembled an overflow-type wetted-wall MFC (WWMFC) as in Figure2.18. They used it to generate power from an acetate-based system. The maximum power density of 18.21 W/$m^3$ was obtained and showed a saturation-type relationship as a function of initial COD, with a maximum power density ($P_{max}$) of 18.82 W/$m^3$ and a saturation constant (Ks) of 227.4 mg/l. They found that forced air flowing through the cathode chamber had a negligible effect on power generation but affected the influent flow rate. The overflow type wet wall's maximum power density increased by 72.8% when the influent flow rate increased from 5 to 30 ml/min.

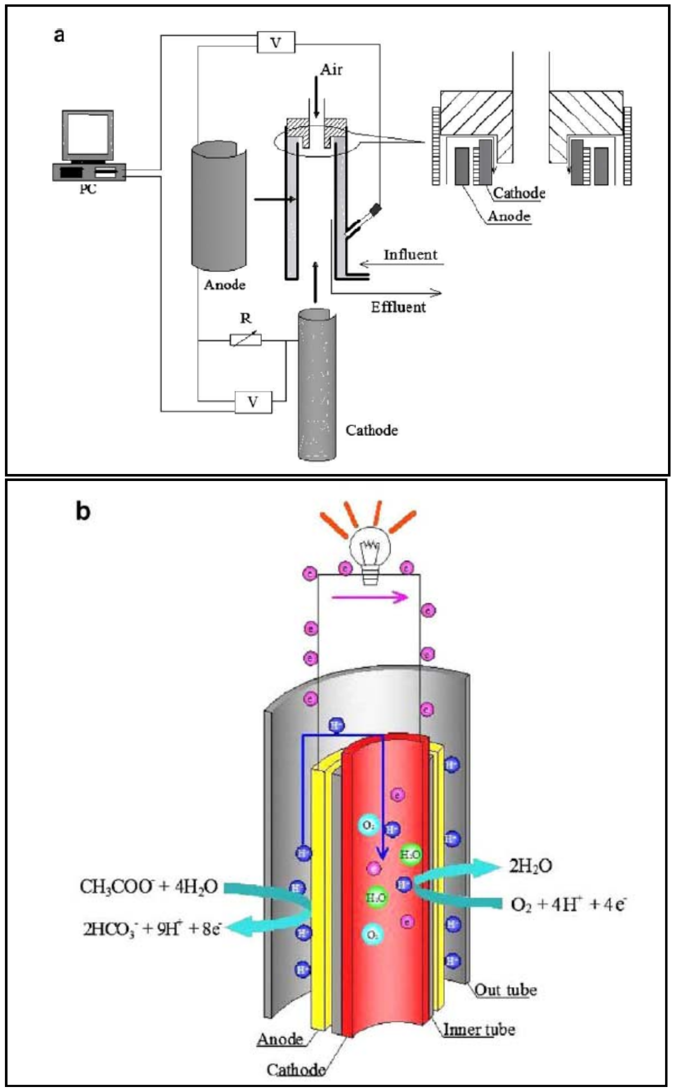



Figure 2.18: (a) The schematic of the main structure of WWMFC, (b) proton transfer mechanism in WWMFC (Li, et al., 2009)

Feng, et al., (2010) designed and operated a baffled air-cathode microbial fuel cell (BAFMFC) as in Figure 2.19 under continuous flow using glucose as substrate. They obtained an average voltage of 652 mV under the external resistance of 1000 $\Omega$ (30°C). They got the maximum power density as 15.2 W/m$^3$ with the chemical oxygen demand (COD) removal rate of 88.0%. The overall resistance from the MFC was 13.7 $\Omega$ while ohmic internal resistance was 10.8 $\Omega$. Average COD removal rate was 69.7-88.0% as the COD loading varied from 4.11 kg-COD/$m^3$-d to 16.0 kg-COD/$m^3$-d. The power achieved 10.7 W/$m^3$ and the COD removal rate was 89.1 when using liquid from a corn stover steam explosion process (COD of 7,160 ± 50 mg/L). They showed that a BAFMFC could be comparable to the traditional anaerobic baffled reactor in COD removal rate for high-concentration wastewater and have an advantage in energy harvest from wastewater.

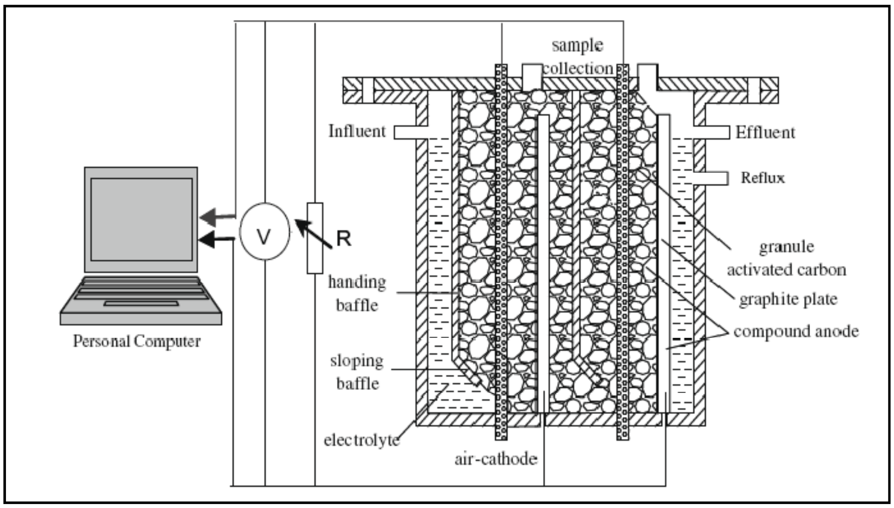



Figure 2.19 : The configuration of BAFMFC (Feng, et al., 2010)

### 2.9.3 Applications

Cha, et al. (2010) used submerged a SCMFC into an aeration tank in an activated sludge process (Figure 2.20). Among four different electrode materials, the MFC with a graphite felt (GF) anode and a GF cathode showed the highest power density of 16.7 W/$m^3$ and the lowest internal resistance of 17 $\Omega$. When aeration was stopped, the cell voltage of the MFC dropped rapidly and reached 30 mV, and immediately returned to around 200 mV after being aerated again. The SCMFCs were sensitive to mixing intensity; with a very low concentration of 0.2 mg-$O_2$/L, the circuit voltage remained at 200 mV.

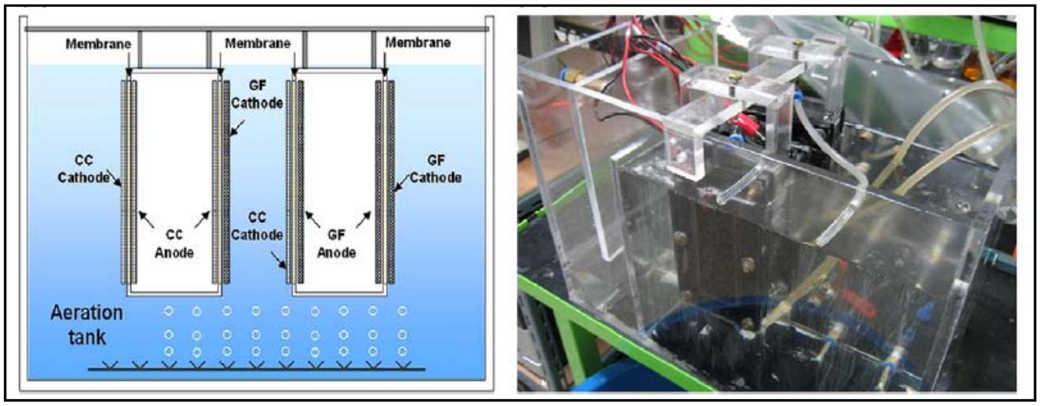



Figure 2.20: The configuration of an SCMFC (Cha, et al., 2010)

Lorenzo, et al., (2009) used SCMFC as a biosensor. They found that the relationship between the BOD concentration and power output was linear up to 350,000 mg/L of BOD concentration, which was very highly reproducible and stable over 7 months of operation.

Borole, et al., (2009) designed microbial fuel cells (MFC) based on a flow-through anode with minimal dead volume and a high electrode surface area per unit volume. They focused on promoting biofilm formation via a combination of forced flow through the anode, carbon limitation, and step-wise reduction of external resistance. The result was the development of exoelectrogenic biofilm communities dominated by *Anaeromusa* sp. This was the first report to identify this organism from the *Veillonellaceae* family in MFCs. The power density of the resulting MFC using a ferricyanide cathode reached 300W/$m^3$.

Yan, et al., (2012) used synthetic wastewater to remove nitrogen in the air cathode of a single-chamber MFC. They found that MFCs could use nitrification and denitrification simultaneously, without extra energy input for aeration. The air cathode of a single-chamber MFC was pre-enriched with a nitrifying biofilm. Diethylamine-functionalized polymer (DEA) was used as the Pt catalyst binder on the cathode. MFCs with the DEA binder had an ammonia removal efficiency of up to 96.8% and a maximum power density of 900 ± 25 $mW/m^2$, compared to 90.7% and 945 ± 42 $mW/m^2$ with a Nafion binder.

Fuentes-Albarra´n, et al., (2012) used two different MFC designs (parallel plate and tank reactor) to test with non-catalyzed carbon electrodes and natural inocula by synthetic wastewater. They found that that power and current densities can be boosted by systematically decreasing the catholyte resistance (by additions of NaCl or $Na_2SO_4$) and dissolved oxygen concentration. The power output from the parallel plate cell configuration was as high as 2,867$mW/m^3$.

Lee, et al., (2012) applied a pure culture, an autotrophic denitrifier, *Pseudomonas* sp. *C27*, to start up a two-chambered MFC using sulfide as the sole electron donor. Their experimental results revealed that the MFC can successfully convert sulfide to elementary sulfur with electricity generation at a maximum power density of 29.3 $mW/m^2$ with no use of external organic carbon sources.

Wei, et al., (2012) studied the effects of hydraulic retention time (HRT) and substrate concentration on a two-chambered microbial fuel cell (MFC) which was operated in continuous flow mode using enriched hydrogen-producing mixed bacteria as the anodic inoculums and artificial sucrose wastewater as a substrate. Their results showed that when the substrate concentration was high, this system exhibited rapid start-up and continuous and stable power output over a long period. They reported that HRT and substrate concentration had a great effect on the electricity-generation characteristics of the MFC. They noted that the optimum HRT was 8 h, and the maximum power density was produced using a sucrose concentration of 3.5 g/L.

Lefebvre, et al., (2012) studied the effects of the high salinity of wastewater-generated electricity in microbial fuel cells that used acetate as a substrate. They found that adding up to 20 g/L of NaCl enhanced the overall performance of the system, reducing the internal resistance by 33% and increasing the maximum power production by 30%. They noted that the Coulombic efficiency started to be affected at a much lower NaCl concentration of 10 g/L, showing that the anodophilic bacteria are sensitive to NaCl at relatively low concentrations.

Zhuang, et al., (2012) constructed a tubular air-cathode microbial fuel cell (MFC) stack with high scalability and low material cost for simultaneous real wastewater treatment and bioelectricity generation under continuous flow mode. They tested two organic loading rates 1.2 and 4.9 kg-COD/$m^3$-d on five non-Pt MFCs connected in series and parallel circuit modes treating swine wastewater. They achieved 83.8% COD removal and 90.8% $NH_4$ –N removal at 1.2 kg-COD/$m^3$ -d, and 77.1% COD removal and 80.7% $NH_4$ -N removal at 4.9 kg-COD/$m^3$-d.

# CHAPTER III

# METHODOLOGIES

## 3.1 Experimental planning

This study investigated the potential of using wastewater from a cassava factory to generate electricity by a single chamber microbial fuel cell in semi-batch mode operation. The purposes of this research were to study the effects of COD loading and pH at mesophilic and high temperatures on electricity generation and COD removal. The laboratory was set up at faculty of Science and Engineering, Kasetsart University Chalermprakait Sakon Nakhon province campus. The study was divided into two parts as follows:

### 3.1.1 Part 1

Part 1 investigated the effects of COD loading on electricity generation using a single chamber microbial fuel cell at mesophilic (30°C) and high temperature (45°C) conditions. The COD influent was varied from 1,000, 2,500, 5,000, 7,500, and 10,000 mg/L. while pH was fixed at 7.0 in all experiments.

### 3.1.2 Part 2

Part 2 investigated the effect of pH on electricity generation using a single chamber microbial fuel cell at temperatures of 30°C and 45°C while COD loading was kept at the optimum concentration that obtained from part 1. The pH feed was varied from 5.0 to 9.0 with an interval of 0.5. The microbial communities were analyzed at 30°C and 45°C at the end of the experiments.

Table 3.1: The experimental procedure

| Experiment | | SCOD | Temp. | pH | Independent | Dependent | Control |
|---|---|---|---|---|---|---|---|
| Part | No. | (mg./L.) | (°C) | | parameters | parameters | parameters |
| 1 | 1 | 1,000 | 30 | 7.0 | TCOD | Volt, SCOD, | Temperature, |
| | 2 | 2,500 | | 7.0 | | VFA, pH, | initial pH, |
| | 3 | 5,000 | | 7.0 | | Alkalinity | initial MLSS |
| | 4 | 7,500 | | 7.0 | | | |
| | 5 | 10,000 | | 7.0 | | | |
| | 6 | 1,000 | 45 | 7.0 | TCOD | Volt, SCOD, | Temperature, |
| | 7 | 2,500 | | 7.0 | | VFA, pH, | initial pH, |
| | 8 | 5,000 | | 7.0 | | Alkalinity | initial MLSS |
| | 9 | 7,500 | | 7.0 | | | |
| | 10 | 10,000 | | 7.0 | | | |
| 2 | 11 | 1,000 | 30 | 5.0 | pH | Volt, SCOD, | Temperature, |
| | 12 | 1,000 | | 5.5 | | VFA, pH, | initial COD, |
| | 13 | 1,000 | | 6.0 | | Alkalinity, | initial MLSS |
| | 14 | 1,000 | | 6.5 | | Microbial | |
| | 15 | 1,000 | | 7.5 | | | |
| | 16 | 1,000 | | 8.0 | | | |
| | 17 | 1,000 | | 8.5 | | | |
| | 18 | 1,000 | | 9.0 | | | |
| | 19 | 1,000 | 45 | 5.0 | pH | Volt, SCOD, | Temperature, |
| | 20 | 1,000 | | 5.5 | | VFA, pH, | initial COD, |
| | 21 | 1,000 | | 6.0 | | Alkalinity, | initial MLSS |
| | 22 | 1,000 | | 6.5 | | Microbial | |
| | 23 | 1,000 | | 7.5 | | communities | |
| | 24 | 1,000 | | 8.0 | | | |
| | 25 | 1,000 | | 8.5 | | | |
| | 26 | 1,000 | | 9.0 | | | |

## 3.2 Wastewater

Cassava wastewater used in the experiment was from the last pond before feeding into the wastewater treatment plant of the cassava factory in Roi-ed province, Thailand. The characteristics of cassava wastewater were shown in table 3.2

The concentration of COD was diluted by tap water to be 1,000, 2,500, 5,000, 7,500, and 10,000 mg./L. The pH was adjusted by adding 0.02 N NaOH.

Table 3.2: The characteristics of cassava wastewater

| Parameters | Unit | Value |
|---|---|---|
| TCOD | mg/L | 14,500-21,800 |
| pH | - | 3.84-3.92 |
| TP | mg/L | 54 |
| TKN | mg/L | 160 |
| $SO_4^{2-}$ | mg/L | 18,000-22,000 |
| Conductivity | mS/cm | 2.77 |

## 3.3 Reactor and Materials

3.3.1 Reactor (Single Chamber Microbial Fuel Cell)

The SCMFS was made at faculty of Science and Engineering, Kasetsart University Chalermprakait Sakon Nakhon province campus (as per Figure 3.1).

| | | |
|---|---|---|
| Type | : | Polyvinyl chloride ∅ 3 inches |
| Working volume | : | 150 mL |
| Inlet port | : | On the top of the reactor ∅ ¼ inches |
| Outlet port | : | At the bottom of the reactor ∅ ¼ inches |

3.3.2 Anode electrode

| | | |
|---|---|---|
| Type | : | Carbon cloth A-1 from Clean Fuel Cell Energy, LLC, |
| Size | : | ∅ 7 cm. |

3.3.3 Cathode electrode

Type : Carbon cloth B-1 (standard wet-proofing) coated with Pt. 0.5 $mg/m^2$, from Clean Fuel Cell Energy, LLC,

Size : ∅ 7 cm.

3.3.4 Proton Exchange Membrane, PEM

Type : Nafion® solution 5% wt. from Clean Fuel Cell Energy, LLC.

Operated : Coated on cathode surface.

3.3.5 Electrical wire

Type : Copper wire

3.3.6 External resistance

Size : 100 Ohms

3.3.7 Temperature controlling

Temperature range : From 30°C to 50°C

3.3.8 Data-logger

Specification : keep data every 30 minutes.


Figure 3.1: A single chamber microbial fuel cell used in the study

## 3.4 Controls, operations and calculation

### 3.4.1 Seeding preparation

The seeds used in the experimental were from UASB of the cassava wastewater treatment plant of Roi-ed Flour factory, Roi-ed province, Thailand. The inoculums used in the SCMFC were from the UASB of the cassava wastewater treatment plant. The inoculums were prepared before use in the SCMFC by drying in daylight for 2 days. Then heating at 60°C for 1 hour to suppress methanogens bacteria after that it was cooled to room temperature and it was ground and sieved through 1 mm.

### 3.4.2 Experimental control

#### 3.4.2.1 Part1

A single chamber microbial fuel cell was assembled as per Figure 3.1. Temperature was set to 30°C and 45°C by the temperature controlling boxes. The anode and cathode were connected with an external resistance of 100 ohms. The circuit voltage was collected every 30 minutes by the data logger. The MLSS in the anode chamber was kept at 3,000 mg/L (MLVSS of 2,650 mg/L) by adding dry seed for 450 mg in 150 mL of cassava wastewater in anode chamber. The SCMFC in this study was operated in semi-batch operation. The first batch fed 150 mL of cassava wastewater into the inlet port of anode chamber. It operated for 22 hours. Then 80 mL of wastewater was withdrawn at the end of the batch at the outlet port. The processes of filling and withdrawing required 2 hours. The temperature was maintained at 30°C and 45°C by a temperature controlling box. TCOD, pH, MLSS, and MLVSS were analyzed using the standard method examining water and wastewater (AWWA, WEF, 1998).

#### 3.4.2.2 Part 2

The configuration and seeding of SCMFC were the same in part 2 of the experiment as in part 1. The pH of wastewater was controlled by feeding 0.02 N NaOH. The pH was set as per Table 4.1 (experiment numbers 11 to 26).

### 3.4.3 Samples and parameters analysis

Sampling points and samples analysis methods were set as per Table 3.3.

Table 3.3 Sampling point and sample analysis methods

| Sampling point | Parameter | Analysis method |
|---|---|---|
| Influent | TCOD | Close Reflux Method |
| | SCOD | Close Reflux Method |
| | TKN | Total Kjeldahl (Titrimetric) Method |
| | $PO_4^{3-}$ | Ascorbic acid-molybdate Method |
| | pH | pH meter |
| | $SO_4^{3-}$ | Turbidimetric method |
| Effluent | SCOD | Close Reflux Method |
| | pH | pH meter |

### 3.4.4 Power and coulombic efficiency calculation

The power from SCMFC was calculated according to P= $(V^2)$/R, where P= Power (W), V=Volt (V) and R=Resistant (Ohm). The coulombic efficiency (CE) was calculated by measuring current relative to the theoretical current on the basis of consumed COD as equation (3.1)

$$CE=8I/((F)(Q)(\Delta COD)) \qquad (3.1)$$

Where I = Current (A)

F = Faraday Constant (96,485 C/mol)

Q = Wastewater quantity ($m^3$)

$\Delta COD$ = COD removal ($g/m^3$)

The internal resistance was calculated from polarization slope method (see Appendix a).

### 3.4.5 Microbial study

PCR-DGGE method was used to study the microbial communities of a single microbial fuel cell. The conditions of PCR-DGGE method was set as following.

1. *Sample collection*

The samples for microbial study were collected from the SCMFC reactor for 10 mL.

2. *DNA extraction*

Total genomic DNA was extracted from the samples using SDS-based method as described previously by Zhou, et al., (1996) (Universal primer). Briefly, 1 g of sample was suspended in lysis buffer (1 M Tris-HCl pH 8.0, 5M NaCl and 0.5 M EDTA pH 8.0). Lysozyme and protinase K was added to final concentration 10 mg/mL and the mixture was incubated at 37 °C for 1 hour. Subsequently, SDS was added to a final concentration of 2%, followed by incubation for 30 minutes at 70°C. The supernatant was harvested and transferred to a fresh microfuge tube after centrifugation at 10,000 rpm for 10 minutes. And then the supernatant was extracted with 1 volume of chloroform: isoamyl alcohol (24:1). The DNA was precipitated from the aqueous phase with 0.6 volume of isopropanal and after being dried, was resuspended in 50 µL of sterile deionized water.

3. *Polymerase Chain Reaction (PCR) method*

The DNA was used as a template for amplification of the partial 16S rDNA fragment of the domain *Bacteria* using Taq DNA polymerase (Invitrogen, USA) according to the manufacture's protocol with 338F-GC (5'-CGCCCGGGGCGCGCCCCG GGCGGGGCGGGGGCACGGGGGG AACTCCTACGGGAGGCAGC-3') and 518R (5'-ATTACCGCGGCTGCTGG-3') (Òvreas, et al., 1997). PCR reactions were performed in a Perkin-Elmer GeneAmp PCR System 9700 (Applied Biosystem). The thermal program was as follows: 95 °C for 5 min, followed by 30 cycles of 95 °C for 30 seconds, 60 °C for

30 seconds, and 72 °C for 50 seconds, and a final extension at 72 °C for 7 minutes. The presence of PCR products was confirmed by analyzing 5 μL of product on a 1% agarose gel stained with ethidium bromide.

*4. DNA fragment detection*

DGGE was performed using a DGGE-2000 system apparatus (CBS Scientific Company, Del Mar, CA.). The PCR product generated by the 338F-GC and 518R primers were loaded onto 7.5% (wt/vol) polyacrylamide gels with a denaturing gradient ranging from 40–60% denaturants (100% denaturant contains 7 M urea and 40% [vol/vol] formamide in 1X TAE). Electrophoresis was performed at 60 °C for 14 hours, 90 V. After that, the gel was stained with SYBR Gold nucleic acid stain (Invitrogen, USA) for 30 minutes. The images were visualized on a UV transilluminator and captured using Biovision CN 1000/26M (Vilber Lourmat, France).

*5. DNA sequencing*

The target DGGE bands were excised, resuspended in 20 μL of MilliQ water, and stored at 4° C overnight. The DNA fragments recovered from the gel were used as templates for reamplification using primer set without GC-clamp. The amplified PCR products were purified and sequenced by 1$^{st}$ BASE, Malasia. Sequences were compared with available databases by use of the BLAST search program from the NCBI to determine their approximate phylogenetic affiliations (Altschul, et al., 1990).

# CHAPTER IV

# RESULTS AND DISCUSSIONS

## 4.1 Effect of OLR

In the first part of this study, we examined the effect of organic loading rate (OLR) on the performance of a single chamber microbial fuel cell (SCMFC) for producing electricity and treating organic substances. The performance of the microbial fuel cell was evaluated for the efficiency of COD removal, power generation and the internal resistance, as described bellows.

### 4.1.1 The performance of power generation

When the anode chamber of an SCMFC was filled with cassava wastewater, the initial voltage was 0.12-0.40 V, depending on the OLR. It took 4 hours to reach the constant after that it dropped close to the initial value again when the effluent was withdrawn and the new wastewater was filled. The initial circuit voltage of the latter batch was higher than the previous batch and also of the maximum circuit voltage. Table 4.1 show the average of circuit voltage at different OLRs. Figure 4.1 (a) to (f) show the circuit voltage in terms of operating time in various OLRs.

Table 4.1: The average circuit voltage output from a SCMFC

| Temperature | Unit | OLR (kg-COD/$m^3$-d) | | | | |
|---|---|---|---|---|---|---|
| | | 0.56 | 1.44 | 2.79 | 4.14 | 6.25 |
| 30°C | Volt | $0.66 \pm 0.03$ | $0.59 \pm 0.03$ | $0.54 \pm 0.03$ | $0.49 \pm 0.02$ | $0.35 \pm 0.01$ |
| 45°C | Volt | $0.65 \pm 0.03$ | $0.56 \pm 0.02$ | $0.53 \pm 0.02$ | $0.47 \pm 0.02$ | $0.33 \pm 0.01$ |

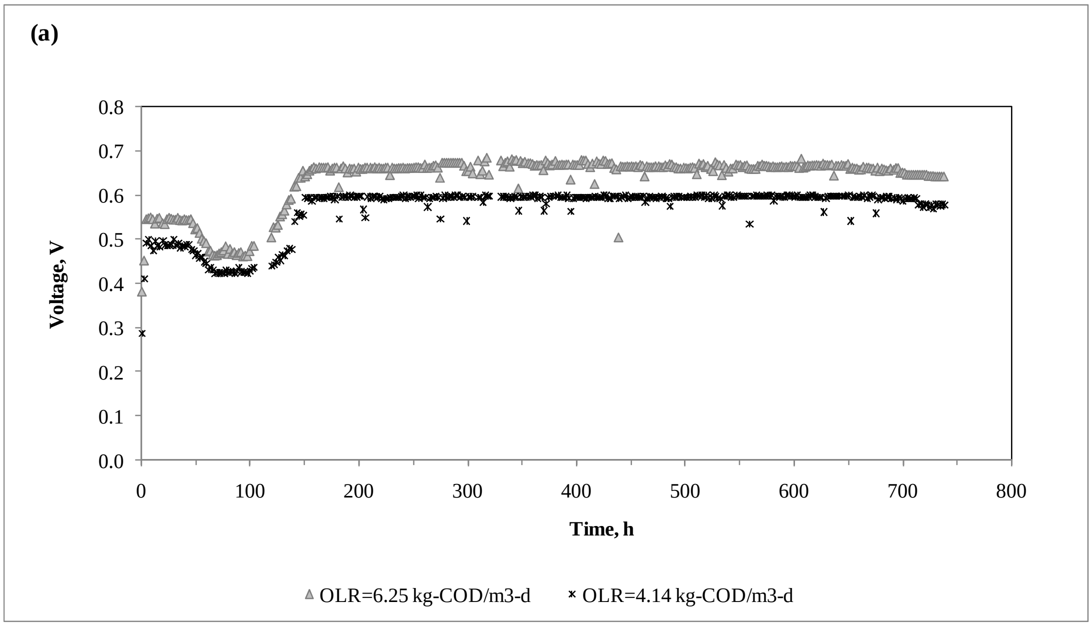



Figure 4.1 (a): The circuit voltage output from 6.25 and 4.14 kg-COD/$m^3$-d at 30°C

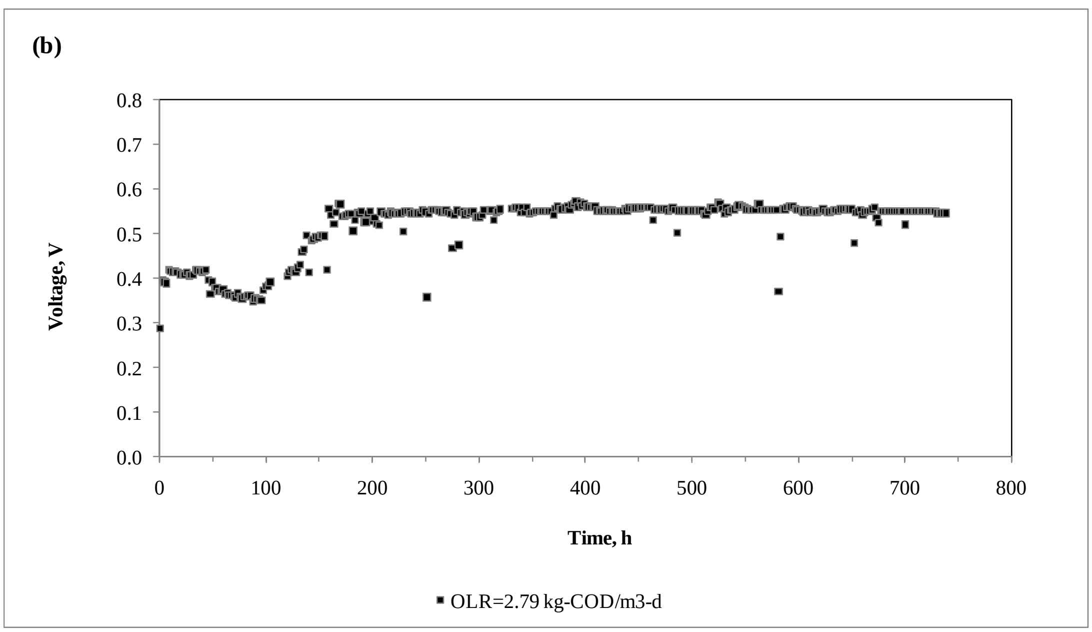



Figure 4.1 (b): The circuit voltage output from 2.79 kg-COD/$m^3$-d at 30°C

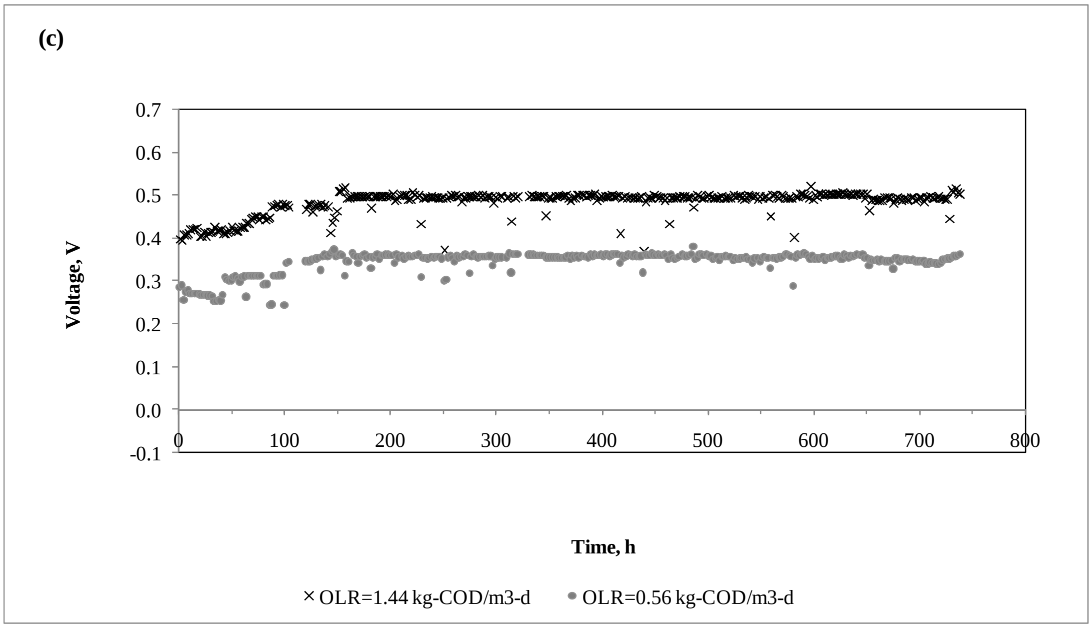



Figure 4.1 (c): The circuit voltage output from 1.44 and 0.56 kg-COD/m$^3$-d at 30°C

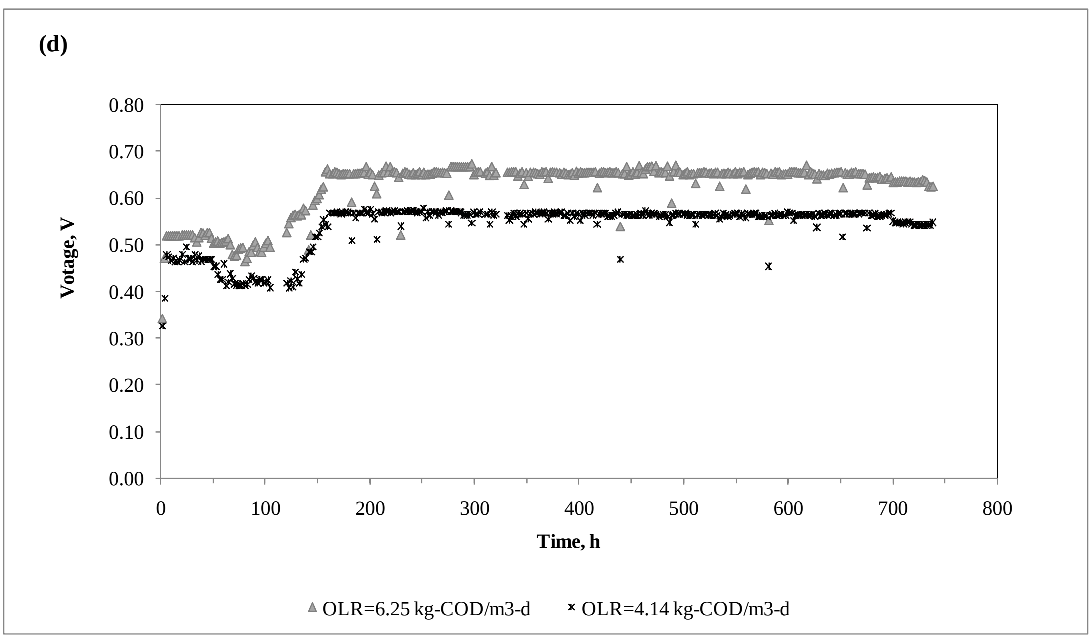



Figure 4.1 (d): The circuit voltage output from 6.25 and 4.14 kg-COD/m$^3$-d at 45°C

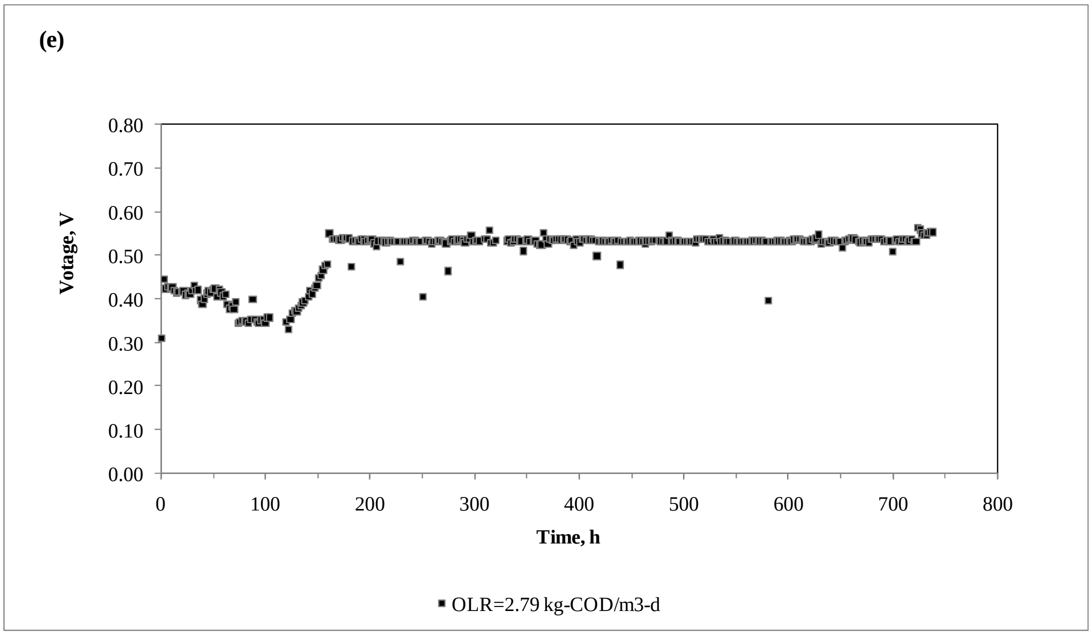



Figure 4.1 (e): The circuit voltage output from 2.79 kg-COD/$m^3$-d at 45°C

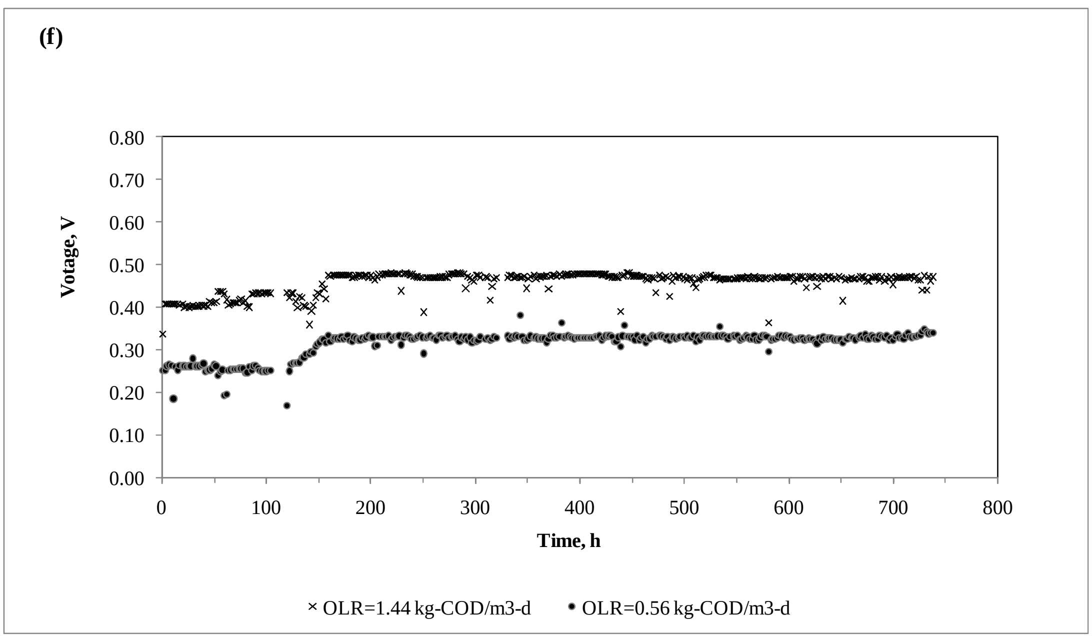



Figure 4.1 (f): The circuit voltage output from 1.44 and 0.56 kg-COD/$m^3$-d at 45°C

From Figure 4.1 (a) and 4.1 (d), the circuit voltage at high OLR (6.25 kg-COD/$m^{3-}$d) was constant for a period of time (from the 1st batch cycle to the 2th batch cycle), then decreased when the operating time increased (from the 2st batch cycle to the 5th batch cycle). From the 5st batch cycle to the 8th batch cycle, the circuit voltage increased and reached to the constant. The constant of circuit voltage at the first stage was from the clean electrode. The decreasing of circuit voltage at the second stage was from voltage losses due slime or biofilm starting form at the cathode surface. The increasing of circuit voltage at the latter stage was from the increasing of microbial activities. The circuit voltage was constant from the 8th batch cycle to the end of experiment. At the last batch cycle, the circuit voltage slightly decreased. The decreasing of circuit voltage was from the mass transfer losses, oxygen leakage to anode chamber. The mass transfer losses increased when the biofilm was formed on the cathode surface. This biofilm inhibited the transferring of protons to cathode and some of protons were accumulated in the anode chamber. The protons accumulation in cathode chamber was showed by the decreasing of pH in the effluent. In addition, organic matters at high OLR were accumulated more than at low OLR (the wastewater was filled and withdrawn every day).

From Figure 4.1 (c) and 4.1 (f), the circuit voltage at low OLR (0.56 kg-COD/$m^{3-}$d) was constant for a period of time (from the 1st batch cycle to the 6th batch cycle). From the 6st batch cycle to the 7th batch cycle, the circuit voltage increased and reached to the constant through the end of the 7th batch cycle. The occurrence of circuit voltage at low OLR was different from at high OLR. The different state was from effects of the mass transfer losses and the food per microorganism ratio (F/M). The organic matter accumulation in anode chamber at low OLR was lower than at high OLR because the concentration of wastewater at low OLR was lower than that of high OLR. Addition, the wastewater was filled and withdrawn every day. The mass transfer losses at low OLR was lower than that of high OLR so, the circuit voltage did not decrease. When considered to the F/M ratio, the F/M ratio at low OLR (0.21 kg-COD/$m^3$-d) was lower than that of high OLR (2.36 kg-COD/$m^3$-d). COD was reduced at low FM ratio better than at high F/M ratio. The relation of circuit voltage and COD removal was a direct variation in microbial fuel cell (Lorenzo, et al., 2009). At low OLR, the circuit voltage reached to the constant faster than that of high OLR.

In this part of the study, the pH in the effluent did not adversely affect to the kinetic energy of the microorganism because pH in the effluent from anode chamber did not drop below 6.5 (Speech, 1995). The alkalinity in the influent wastewater was used as buffer in anode chamber. Sodium hydroxide solution (alkalinity) was added in influent wastewater to keep the initial pH feed of 7.0. The minimum concentration of alkalinity in the effluent was found at the lowest OLR (more than 200 mg/L as $CaCO_3$). Table 4.2 shows the average of pH and alkalinity in the effluent.

Table 4.2: pH in the effluent from the SCMFC

| Parameter | Temperature (°C) | OLR (kg-COD/m$^3$-d) | | | | |
|---|---|---|---|---|---|---|
| | | 0.56 | 1.44 | 2.79 | 4.14 | 6.25 |
| pH | 30 | 6.85 ± 0.14 | 6.96 ± 0.11 | 6.78 ± 0.11 | 6.94 ± 0.11 | 6.88 ± 0.15 |
| | 45 | 6.75 ± 0.13 | 6.80 ± 0.18 | 6.99 ± 0.09 | 6.99 ± 0.10 | 6.85 ± 0.14 |
| Alkalinity* | 30 | 209 ± 44 | 1,408± 356 | 1,705 ± 547 | 2,348 ± 430 | 2,572 ± 828 |
| | 45 | 206 ± 38 | 1,288± 336 | 1,873 ± 602 | 2,295 ± 554 | 2,683 ± 1,117 |

* Unit is mg/L as $CaCO_3$

The operating time increased, the microorganism try to acclimate with the environment. They increased their cell number, some of them formed to be a biofilm on the surface of cathode (Figure 4.2 (a)). This biofilm increased the mass transfer losses in SCMFC but this loss was not the major loss, because the circuit voltage slightly decreased. Most of microorganisms formed as granules and attached at the surface of the anode (Figure 4.2 (b)). However the effects of granules at the surface of anode enhanced the power generation because the granules at anode surface decreased the distance of electron shutter from solution to anode surface. The competition between the activities of the granules at anode surface and the biofilm at cathode surface was responded by the values of the circuit voltage or the total loss. In this study, the circuit voltage did not drop in significant so, the electron lost by the biofilm was not the major affect on decreasing the circuit voltage.

Figure 4.2: The biofilm was formed on the surface of electrode: (a) cathode, (b) anode.

Other factors enhancing the performance of SCMFC was on the characteristics of wastewater such as the solution conductivity. Our study implied that the power generation increased with increasing the solution conductivity (the solution conductivity increased with the OLR). The solution conductivity in the effluent of 30°C was 0.047 ± 0.003, 1.67 ± 0.22, 3.63 ± 0.30, 4.32 ± 0.34 and 5.70 ± 0.31 mS/cm as the OLR of 0.56, 1.05, 1.44, 2.76 and 6.25 kg-COD/$m^3$-d, respectively and the solution conductivity at 45°C condition was 0.047 ± 0.008, 1.71 ± 0.17, 3.57 ± 0.21, 4.27 ± 0.33 and 5.55 ± 0.22 mS/cm for the same OLR values. The results of the solution conductivity in the effluent were shown in Figure 4.3.

The solution conductivity increased from 46.74 μS/cm to 5.70 mS/cm and the power density increased by 71.46% (data at 30°C). This result conformed to those of using the result beer brewery wastewater as substrate by SCMFC (Feng, et al., 2008). While Mohan and Das, (2009a) examined the effect of ionic strength, cation exchange and inoculum age on the power generation in a mediator MFC with methylene blue as electron mediator.

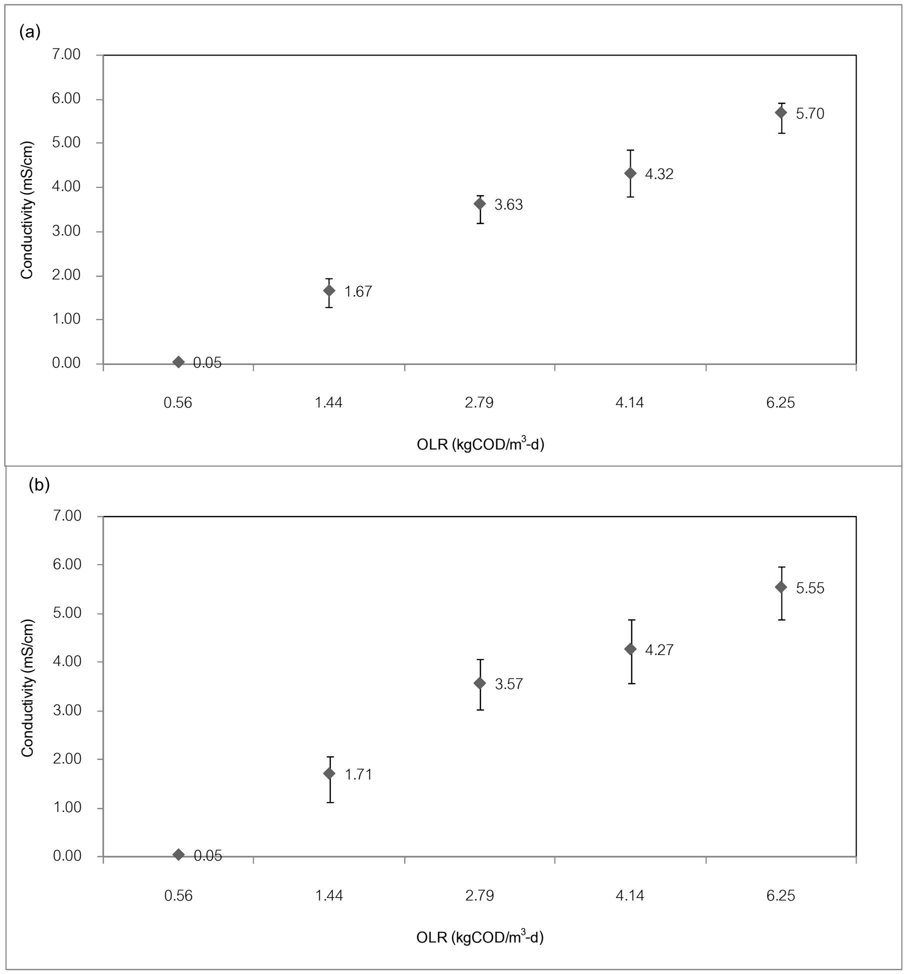



Figure 4.3: The solution conductivity in the effluent (a) at 30°C, (b) at 45°C

The results of this study showed that cassava wastewater could generate power by SCMFC effectively. The power achieved from the experimental was shown in Figure 4.4. The result illustrated that the microbial fuel cell could generate electricity using cassava wastewater as substrate. The OLRs of 0.56, 1.44, 2.79, 4.14 and 6.25 kg-COD/$m^3$-d could generate the power outputs of 8.2, 16.0, 19.8, 22.9 and 28.7 W/$m^3$ respectively at operating temperature of 30°C. While the values of power generation at 45°C were 7.18, 14.49, 18.49, 20.85 and 27.85 W/$m^3$, respectively as the same results of OLR at 30°C. The increased power occurred from increasing OLR or influent COD concentration.

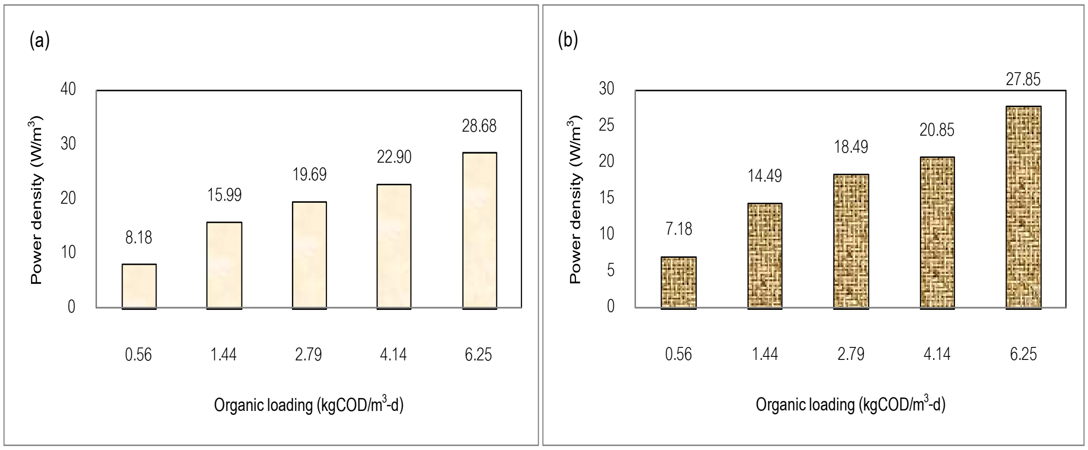



Figure 4.4: The power density from cassava wastewater by SCMFC

(a) at 30°C, (b) at 45°C

The statistical evaluation was presented the effect of OLR on the power generation from SCMFC. The different OLRs were compared by applying two-way ANOVA (analysis of variance) method followed by F-test using SPSS (Statistical Package for social Science) with a 0.05 significance level. The comparison test showed in table 4.3.

Table 4.3: Statistical results for power generation

| Variable loading | Degree of freedom | p-value | Conclusions |
|---|---|---|---|
| Loading | 4 | 0.000 | Significant |
| Temperature | 1 | 0.004 | Significant |

The F-statistic is interpreted in a practical way though the p-value with a confidence level of 0.95%. When p-value lower than 0.05 were considered statistically significant (factor is dependent on the response variable) and p-value higher than 0.05 were statistically insignificant (factor is independent of the response variable). According to the statistical results of Table 4.3, OLRs and temperature are significant on the power generation with 95% confidence level.

Table 4.4 showed the comparisons of power generation from MFC with this study.

Table 4.4: The comparisons of power generation by OLR from MFC in previous study with this study

| Substrate | OLR ($kgCOD/m^3$-d) | Power density base on anode surface or anode volume | Reference |
|---|---|---|---|
| Cassava wastewater | 0.56 | 8.18 $W/m^3$ | This study |
| | 1.44 | 16.01 $W/m^3$ | |
| | 2.79 | 19.75 $W/m^3$ | |
| | 4.14 | 22.90 $W/m^3$ | |
| | 6.25 | 28.67 $W/m^3$ | |
| Domestic wastewater | - | 1.06 $mW/m^3$ | Liu, et al., 2004 |
| Vegetable-based waste | 0.56 | 2.81 $W/m^3$ | Cercado-Quezada, et al., 2010 |
| Corn starch wastewater | 0.54 | 1.41 $W/m^3$ | Wen, et al., 2010 |
| Cassava wastewater | 2.67 | 18.2 $W/m^3$ | Kaewkannetra, et al., 2011 |
| Brewery wastewater | 4.08-4.43 | 0.83 $W/m^3$ | Antonopoulou, et al., 2010 |
| Synthetic wastewater | 0.91 | 160.36 $mA/m^2$ | Raghavulu, et al., (2011) |
| | 1.43 | 282.83 $mA/m^2$ | |
| Domestic wastewater | 54 | 12.8 $W/m^3$ | Ahn and Logan, (2010) |
| Composite waste vegetables | 0.70 | 0.93 $W/m^3$ | Mohan, et al., (2010) |
| Chocolate industry | 0.49 | 6.6 $W/m^3$ | Patil, et al., (2009) |

### 4.1.2 COD removal efficiency

In order to examine the effects of OLR on the fixed volume of a single chamber microbial fuel cell, the COD influent concentration must be varies. Table 4.5 showed summary of the COD concentration, COD removal efficiency at the end of experiment.

Table 4.5: The efficiency of COD removal

| Temp (°C) | OLR (kg-COD/$m^3$-d) | | | | |
|---|---|---|---|---|---|
| | 0.56 | 1.44 | 2.79 | 4.14 | 6.25 |
| 30 | 91.44± 0.72 | 86.14± 1.99 | 79.47± 2.16 | 78.37± 2.04 | 73.67± 2.99 |
| 45 | 90.72± 0.87 | 82.45± 1.34 | 76.83± 3.60 | 75.87± 2.61 | 70.74± 1.72 |

The efficiency of COD removal decreased when the OLR increased. At high OLR (6.25 kg-COD/$m^3$-d) it took more time to reach the constant of COD in the effluent than at low OLR (0.56 kg-COD/$m^3$-d) (Figure 4.5 (a) and Figure 4.5 (b)), because at high OLR the ratio of F/M ratio at the beginning operation in the anode chamber was lower than at low OLR, thus the microorganism was insufficient for reducing the organic matter, which meant a low efficiency of COD removal. The F/M ratio at the beginning was 2.36, 1.56, 1.05, 0.54 and 0.21 kg-COD/kg-VSS-d as the OLR of 0.56, 1.05, 1.44, 2.76 and 6.25 kg-COD/$m^3$-d, respectively.

At high OLR (6.25 kg-COD/$m^3$-d), there was only 30% of COD removal efficiency at the first stage of operation. However, the microorganisms survived by increasing their quantity to balance with the food in the chamber and achieved a steady state after 400 hours. At a steady state (the COD in the effluent was quite stable), the efficiency of COD removal increased to 73.7%. At the low OLR condition (0.56 kg-COD/$m^3$-d), the time using to reach steady state was only 250 hours. This study could explain that the microbial needed time to acclimatize when operating on high OLR. Comparing the efficiency of COD removal between low OLR and high OLR shows that COD removal efficiency decreased when the OLR increased, in both temperature conditions.

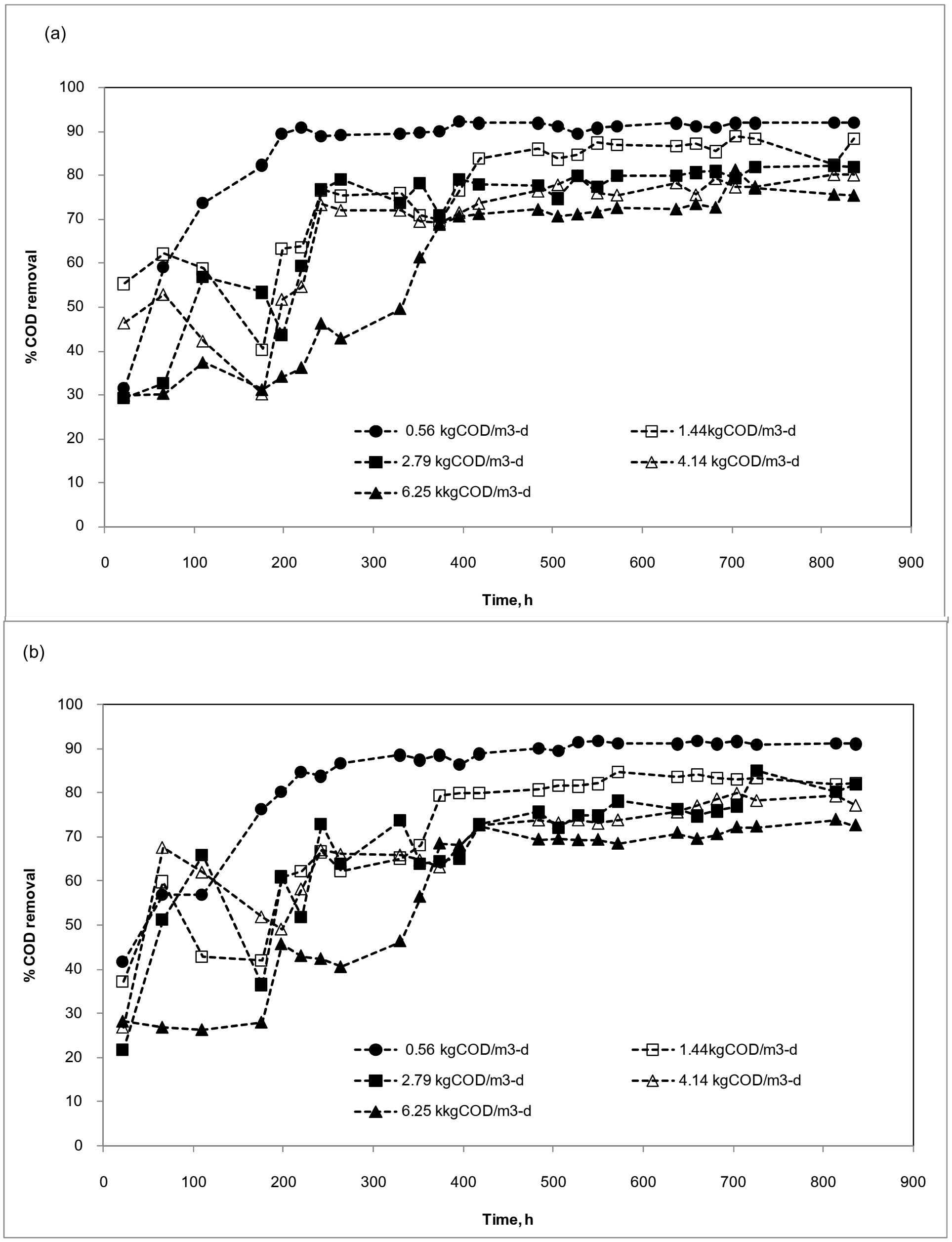



Figure 4.5: The efficiency of COD removal as the function of time (a) at 30°C, (b) at 45°C

The statistical evaluation was presented the effect of OLR on the efficiency of COD removal from SCMFC. The different OLRs were compared by applying two-way ANOVA (analysis of variance) method followed by F-test using SPSS (Statistical Package for social Science) with a 0.05 significance level. The comparison test showed in table 4.6.

Table 4.6: Statistical results for COD removal

| Variable loading | Degree of freedom | p-value | Conclusions |
|---|---|---|---|
| Loading | 4 | 0.000 | Significant |
| Temperature | 1 | 0.007 | Significant |

The F-statistic is interpreted in a practical way though the p-value with a confidence level of 0.95%. When p-value lower than 0.05 were considered statistically significant (factor is dependent on the response variable) and p-value higher than 0.05 were statistically insignificant (factor is independent of the response variable). According to the statistical results of Table 4.6, OLRs and temperature are significant on the efficiency of COD removal with 95% confidence level.

The results from our study are similar to those of Feng, et al., (2008) and Sharma and Li, (2010). Table 4.7 showed the comparison of the efficiency of COD removal in various substrates from microbial fuel cell.

Table 4.7: The comparisons of COD removal efficiency from MFC in previous study with this study

| Substrate | OLR (kg-COD/$m^3$-d) | %COD removal efficiency | Reference |
|---|---|---|---|
| Cassava wastewater | 0.56 | 91.44±0.72 | This study |
| | 1.44 | 86.14±1.99 | |
| | 2.79 | 79.47±2.16 | |
| | 4.14 | 78.37±2.04 | |
| | 6.25 | 73.67±2.99 | |
| Domestic wastewater | - | 70 | Liu, et al., 2004 |
| Vegetable-based waste | 0.56 | 62.86 | Cercado-Quezada, et al., 2010 |

Table 4.7 (Cont): The comparisons of COD removal efficiency from MFC in previous study with this study

| Substrate | OLR ($kg\text{-}COD/m^3\text{-}d$) | %COD removal efficiency | Reference |
|---|---|---|---|
| Corn starch wastewater | 0.54 | 98.0 | Wen, et al., 2010 |
| Cassava wastewater | 2.67 | 88.0 | Kaewkannetra, et al., 2011 |
| Brewery wastewater | 4.08-4.43 | 45.1-49.4 | Antonopoulou, et al., 2010 |
| Synthetic wastewater | 0.91 | - | Raghavulu, et al., (2011) |
| | 1.43 | - | |
| Domestic wastewater | 54 | >89 | Ahn and Logan, (2010) |
| Composite waste vegetables | 0.70 | 62.86 | Mohan, et al., (2010) |

### 4.1.3 Coulombic efficiency

Coulombic efficiency (CE) represents the conversion efficiency of the organic carbon to electricity by microorganism activities in an SCMFC. This study found that the CE decreased when the OLR increased, at both temperature conditions (Figure 4.6). At 30°C, the highest OLR (6.25 $kg\text{-}COD/m^3\text{-}d$), CE was found to be 6.2%, which was lower than the findings of Kaewkannetra, et al., (2011) due to the lower hydraulic retention time in the anode chamber of our study (45 hours in our study and 168 hours in Kaewkannetra, et al., (2011). CE value increased when operating time increasing.

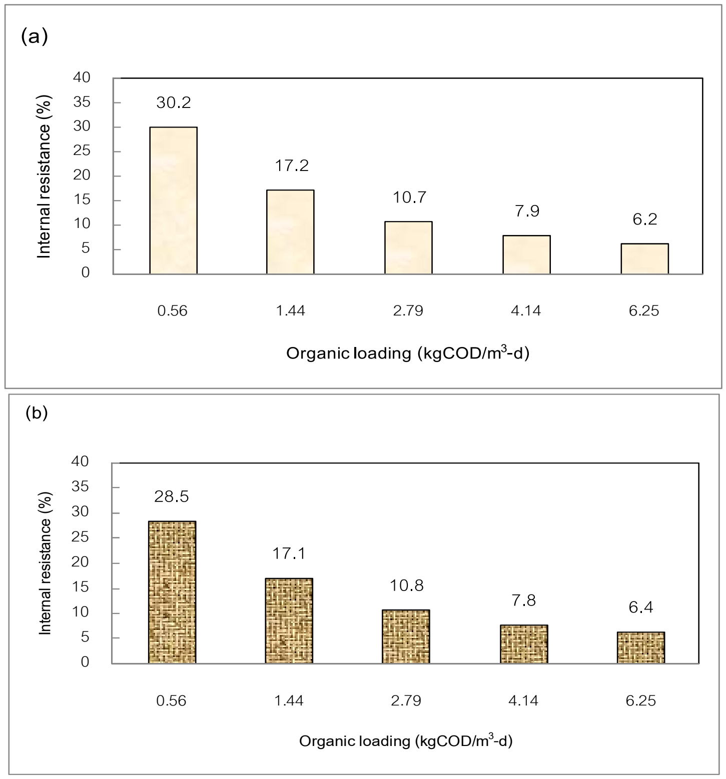



Figure 4.6: Coulombic efficiency: (a) at 30°C, (b) at 45°C

Low CE occurred at high OLR because there was a high concentration of other electron acceptors such as sulfate in the wastewater which caused the loss of electrons. Sulfate in cassava wastewater was from sulfuric acid, which was added in the production processes. We also found that sulfate concentration in the influent of cassava wastewater was very high at 1,038, 2,894, 6,052, 9,124 and 11,572 mg/L for OLRs of 0.56, 1.44, 2.79, 4.14, and 6.25 kg-COD/$m^3$-d, respectively. The sulfate in the effluent was quite constant.

Moreover, sulfate removal loading reduced when the OLR increased in both temperature conditions as shown in Table 4.8.

Table 4.8: Sulfate removal in terms of OLR

| Temp | Item | OLR (kg-COD/$m^3$-d) | | | | |
|---|---|---|---|---|---|---|
| | | 0.56 | 1.44 | 2.79 | 4.14 | 6.25 |
| 30°C | Sulfate influent (mg/L.) | 1,038 | 2,894 | 5,652 | 8,524 | 12,972 |
| | Sulfate effluent (mg/L.) | 61 | 112 | 170 | 327 | 987 |
| | % Sulfate removal | 94.16 | 96.15 | 96.99 | 96.16 | 92.39 |
| | Sulfate removal loading (kg/$m^3$-d) | 0.52 | 1.48 | 2.92 | 4.37 | 6.39 |
| 45°C | Sulfate influent (mg/L.) | 1,038 | 2,894 | 5,652 | 8,524 | 12,972 |
| | Sulfate effluent (mg/L.) | 58 | 217 | 274 | 549 | 1,417 |
| | % Sulfate removal | 94.42 | 92.50 | 95.14 | 93.56 | 89.08 |
| | Sulfate removal loading (kg/$m^3$-d) | 0.52 | 1.43 | 2.87 | 4.25 | 6.16 |

From Table 4.8, the maximum sulfate removal loading occurred at the highest OLR. The amount of sulfate removal was used as an electron acceptor by substrate reduction.

Theoretically, COD of 64 mg will reduce 96 mg of sulfate to sulfide 1 mole, or 1 mg of sulfate will use COD of 0.67 mg. The amounts of COD consumed by sulfate reduction in theory at 30°C are 652, 1,855, 3,654, 5,465, and 7,990 mg/L, and at 45°C the figures are 653, 1,785, 3,585, 5,317, and 7,704 mg/L, for OLR values of 0.56, 1.44, 2.79, 4.14, and 6.25 kg-COD/$m^3$-d, respectively.

The percentages of COD consumed by sulfate reduction were 68.39, 79.55, 87.87, 89.87, and 92.57% of total COD removal at 30°C operating temperature as shown in Table 4.9.

Table 4.9: COD removal and the theoretical COD consumed by sulfate reduction

| Temp | Items | OLR (kg-COD/$m^3$-d) | | | | |
|---|---|---|---|---|---|---|
| | | 0.56 | 1.44 | 2.79 | 4.14 | 6.25 |
| 30°C | COD influent (mg/L) | 1,042 | 2,707 | 5,233 | 7,759 | 11,717 |
| | COD effluent (mg/L) | 89 | 375 | 1074 | 1679 | 3085 |
| | COD removal (mg/L) | 953 | 2,332 | 4,159 | 6,080 | 8,632 |
| | COD theoretically was consumed by sulfate (mg/L) | 652 | 1,855 | 3,654 | 5,465 | 7,990 |
| | %COD theoretically was consumed by sulfate | 68.39 | 79.55 | 87.87 | 89.87 | 92.57 |
| | %COD available to produce electricity | 31.61 | 20.45 | 12.13 | 10.13 | 7.43 |
| 45°C | COD influent (mg/L) | 1,042 | 2,707 | 5,233 | 7,759 | 11,717 |
| | COD effluent (mg/L) | 108 | 475 | 1212 | 1872 | 3428 |
| | COD removal (mg/L) | 943 | 2,232 | 4,021 | 5,887 | 8,289 |
| | COD theoretically was consumed by sulfate (mg/L) | 653 | 1,785 | 3,585 | 5,317 | 7,704 |
| | %COD theoretically was consumed by sulfate | 69.98 | 79.96 | 89.17 | 90.31 | 92.94 |
| | %COD available to produce electricity | 30.02 | 20.04 | 10.83 | 9.69 | 7.06 |

The COD lost by sulfate reduction caused a lower CE while the maximum CE resulted from the lower OLR. The percentage of COD available for producing electricity is close to the CE value at both temperatures (Figure 4.6). These results indicate that the amount of sulfate reduction affects the generation of electricity by SCMFC.

The correlation between high CE and COD removal efficiency is caused by the high ability of microorganisms to reduce the substrate and produce electricity. High CE and COD removal efficiency are more common in diluted wastewater than in high strength wastewater. However, the OLR was not significant on CE in our study because there are many factors enhancing the current while COD do not remove effectively. The statistical evaluation was presented the effect of OLR on the CE from SCMFC (Table 4.10).

Table 4.10: Statistical results for CE

| Variable loading | Degree of freedom | p-value | Conclusions |
|---|---|---|---|
| Loading | 4 | 0.170 | No significant |
| Temperature | 1 | 0.374 | No significant |

### 4.1.4 The polarization curve and internal resistance

In a plot of current density and voltage curve, the polarization slope method was used to examine the internal resistance and maximum power density by varying the external resistance from 30 $\Omega$ to 996 $\Omega$ (Table 4.11). Figures 4.7 and 4.8 show the maximum power density with OLR. The internal resistances of 30°C were 115, 64, 55, 52, and 38 $\Omega$ and the internal resistances of 45°C were 134, 83, 59, 59 and 48 $\Omega$ at OLR of 0.56, 1.44, 2.79, 4.14 and 6.25 kg-COD/$m^3$-d, respectively.

Table 4.11: The internal resistance of the SCMFC

| Temperature | Unit | OLR (kg-COD/$m^3$-d) | | | | |
|---|---|---|---|---|---|---|
| | | 0.56 | 1.44 | 2.79 | 4.14 | 6.25 |
| 30°C | ohm | 115 | 64 | 55 | 52 | 38 |
| 45°C | ohm | 134 | 83 | 59 | 59 | 48 |

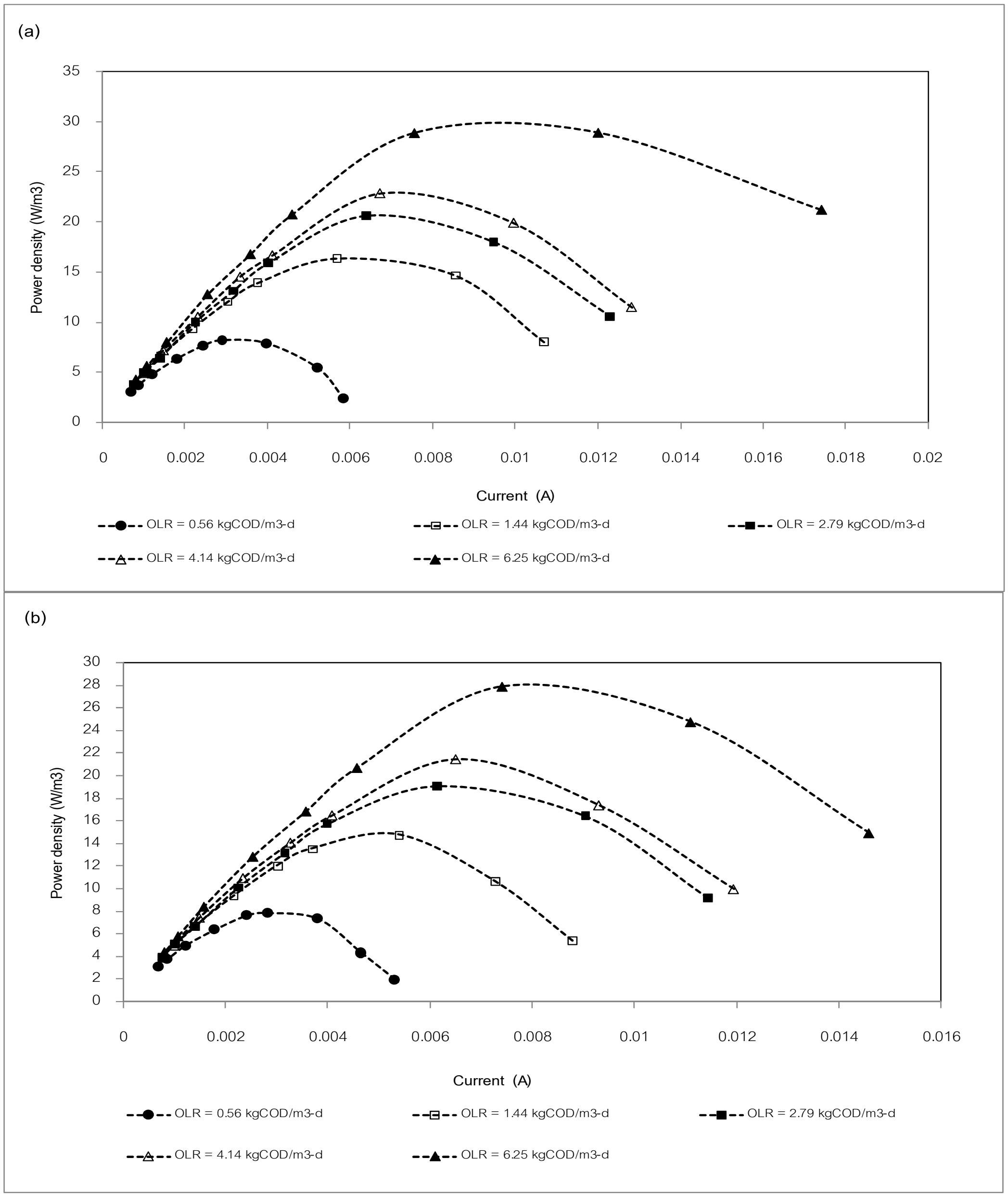



Figure 4.7: The polarization curve: (a) at 30°C, (b) at 45°C

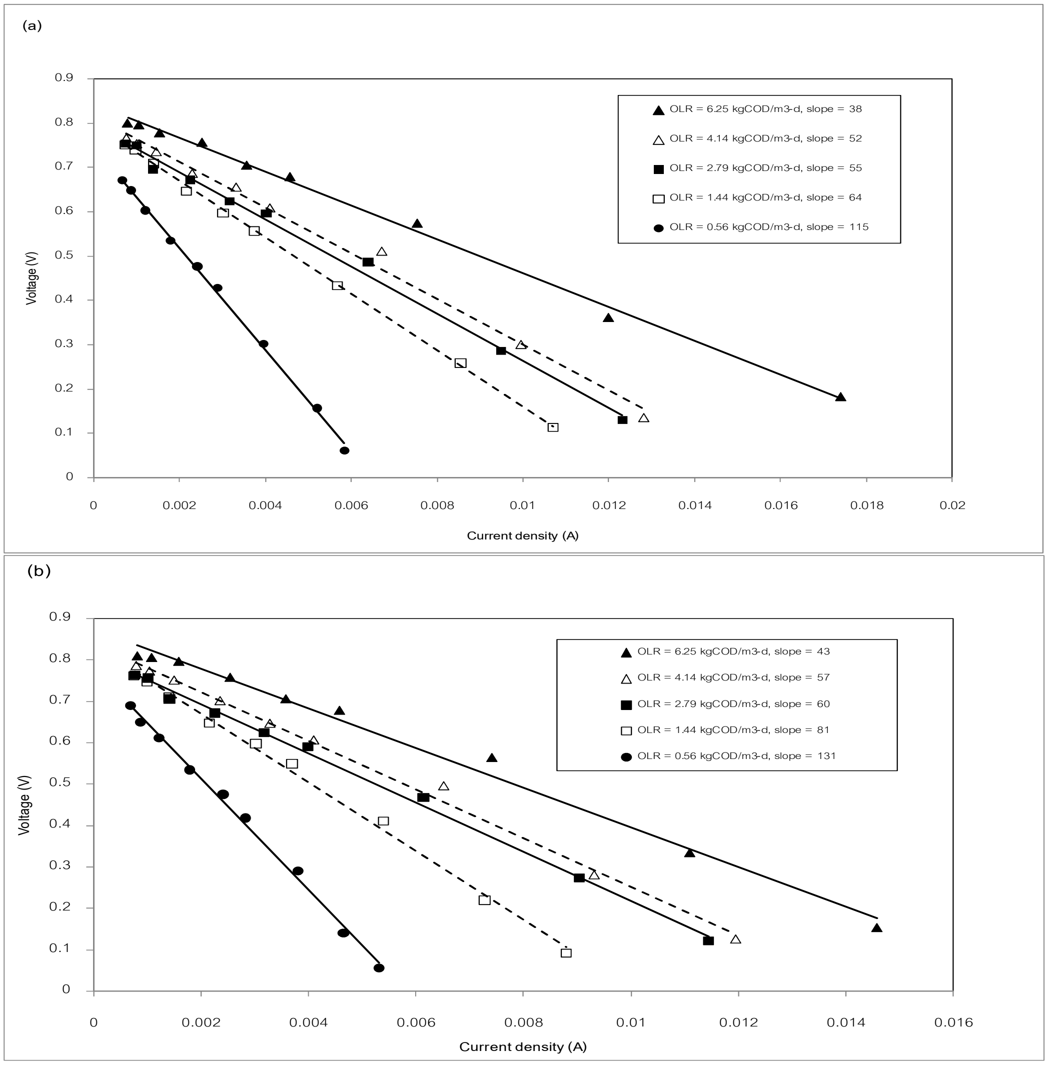



Figure 4.8: The slope from the polarization curve method: (a) at 30°C, (b) at 45°C

The maximum internal resistance of this study was obtained from the lowest OLR of 0.56 kg-COD/$m^3$-d. A high concentration of COD influent as well as a high solution conductivity cause high power production and lower internal resistance, similar to the previous reported from Mohan and Das, (2009a). Decreasing anolyte conductivity might be the result of increasing the internal resistance to the flow of electrons in the anolytes thereby increasing the ohmic losses (Behera and Ghangrekar, 2009). The conductivity of our study increased from 0.047mS/cm to 5.67 mS/cm. This caused internal resistance to decrease from 115 Ω to 38 Ω, which is a 67% decrease of the internal resistance at 30°C operation. The conductivity of the effluent at both temperatures is shown in Figure 4.9.

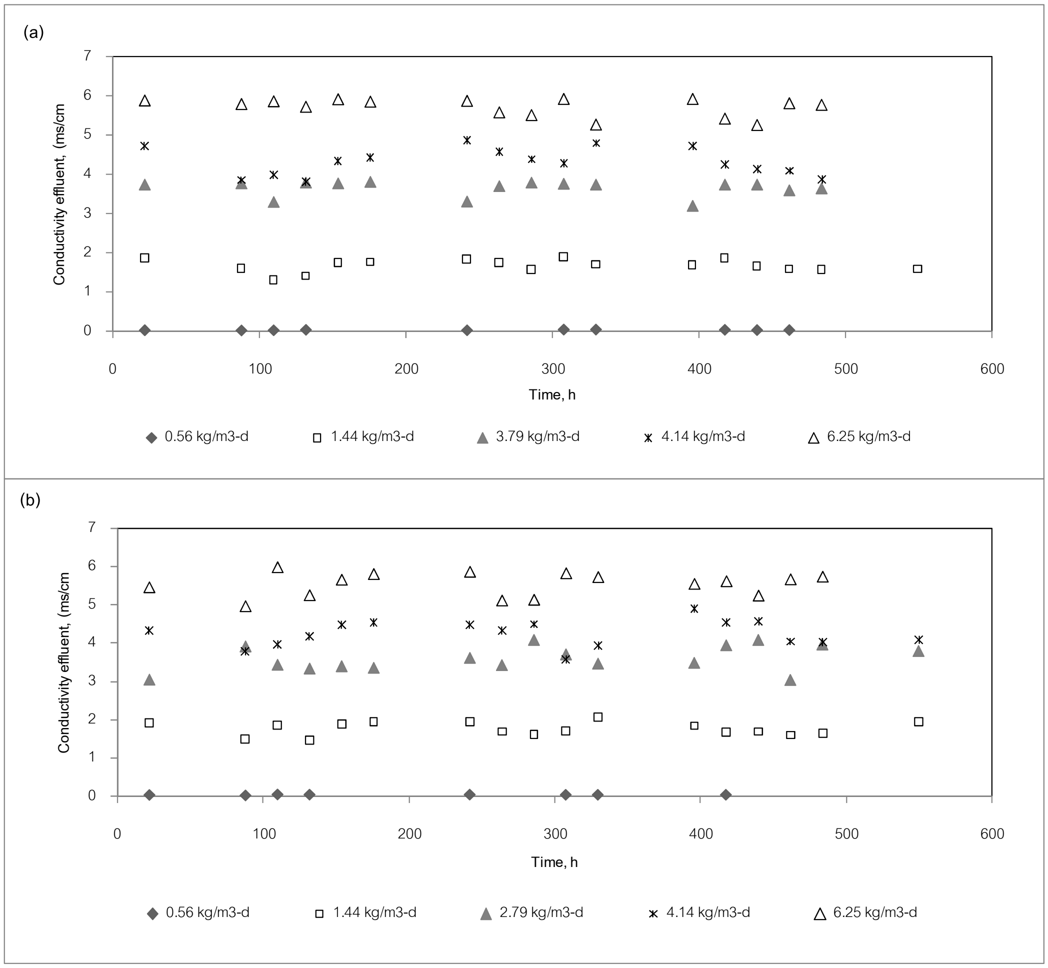



Figure 4.9: The conductivity of the effluent: (a) at 30°C, (b) at 45°C

The result of statistical test from our study was show in Table 4.12. In this work, OLRs and temperature were select as independent variables. In the same way, internal resistant was used as dependent variable. The statistical evaluation was presented the effect of OLR on the internal resistant from SCMFC (Table 4.12). From the results, OLRs and temperature were considered significant to the internal resistant from microbial fuel cell.

Table 4.12: Statistical results for internal resistant

| Variable loading | Degree of freedom | p-value | Conclusions |
|---|---|---|---|
| Loading | 4 | 0.000 | Significant |
| Temperature | 1 | 0.019 | Significant |

## 4.2 Effect of pH fed

The fed pH is the most influential parameter on the mechanisms of the microorganisms. This is especially true in anaerobic wastewater treatment because the anaerobic digestion produces fatty acids, causing the pH to decrease; however, excess alkalinity can act as a buffer in the system. MFC performance was highly sensitive to the feeding pH because there were two major factors in evaluating its efficiency, power generation and organic matter removal. The inoculums used in this experiment were from the end of part 1 of the experiment (pH was controlled as 7.0).

### 4.2.1 Performance of power generation

The circuit voltage output from alkaline wastewater feed (pH 8.0-9.0) was the maximum, followed by neutral wastewater feed (pH 6.5-7.5), with the lowest circuit voltage coming from acidic wastewater feed (pH 5.0-6.0). The circuit voltage outputs from pH 5.0, 5.5, 6.0, 6.5, 7.0, 7.5, 8.0, 8.5 and 9.0 at 30$^{\circ}$C are 0.399±0.020, 0.330±0.017, 0.290±0.028, 0.258±0.007, 0.350±0.028, 0.415±0.022, 0.501±0.018, 0.674±0.038 and 0.577±0.026 V., respectively. While the values from 45$^{\circ}$C are 0.366±0.006, 0.309±0.022, 0.264±0.010, 0.234±0.016, 0.328±0.037, 0.386±0.035, 0.461±0.024, 0.625±0.044 and 0.535±0.033 V, respectively at the same pHS of 30$^{\circ}$C. Figures 4.10 through Figure 4.12 show the circuit voltage in a function of time.

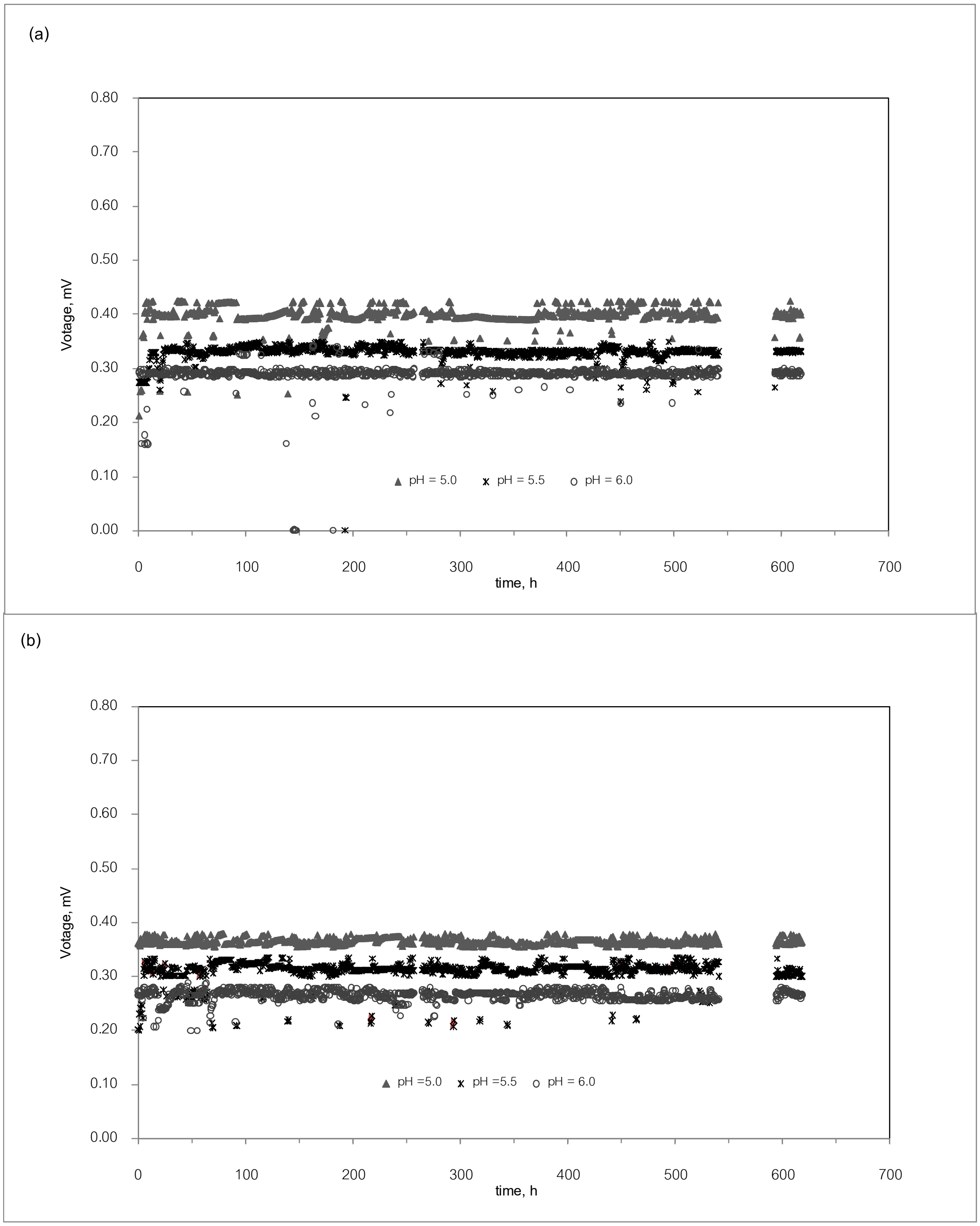



Figure 4.10: The circuit voltage of acidic wastewater feed: (a) at 30°C, (b) at 45°C

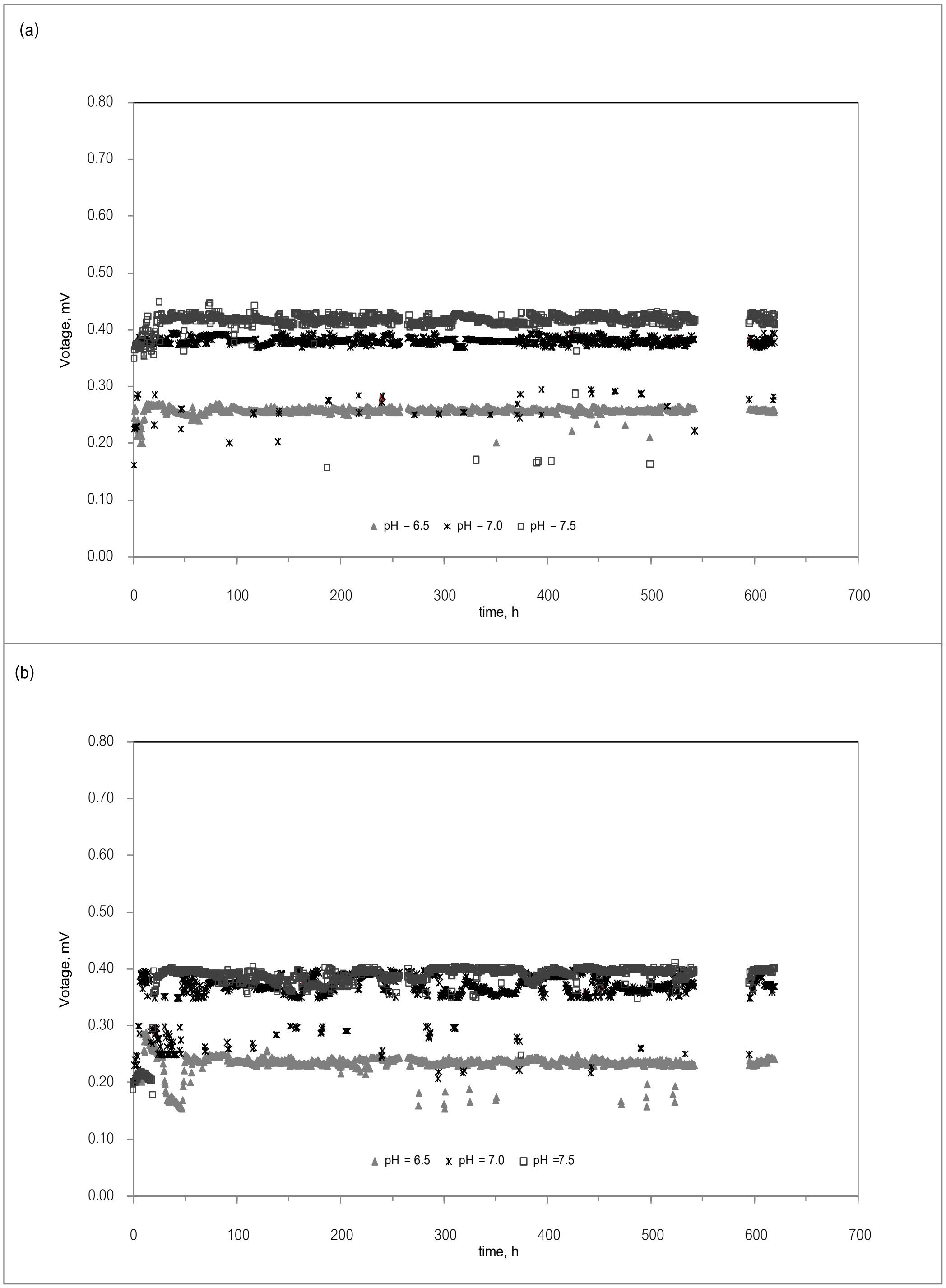



Figure 4.11: The circuit voltage of neutral wastewater feed: (a) at 30˚C, (b) at 45˚C

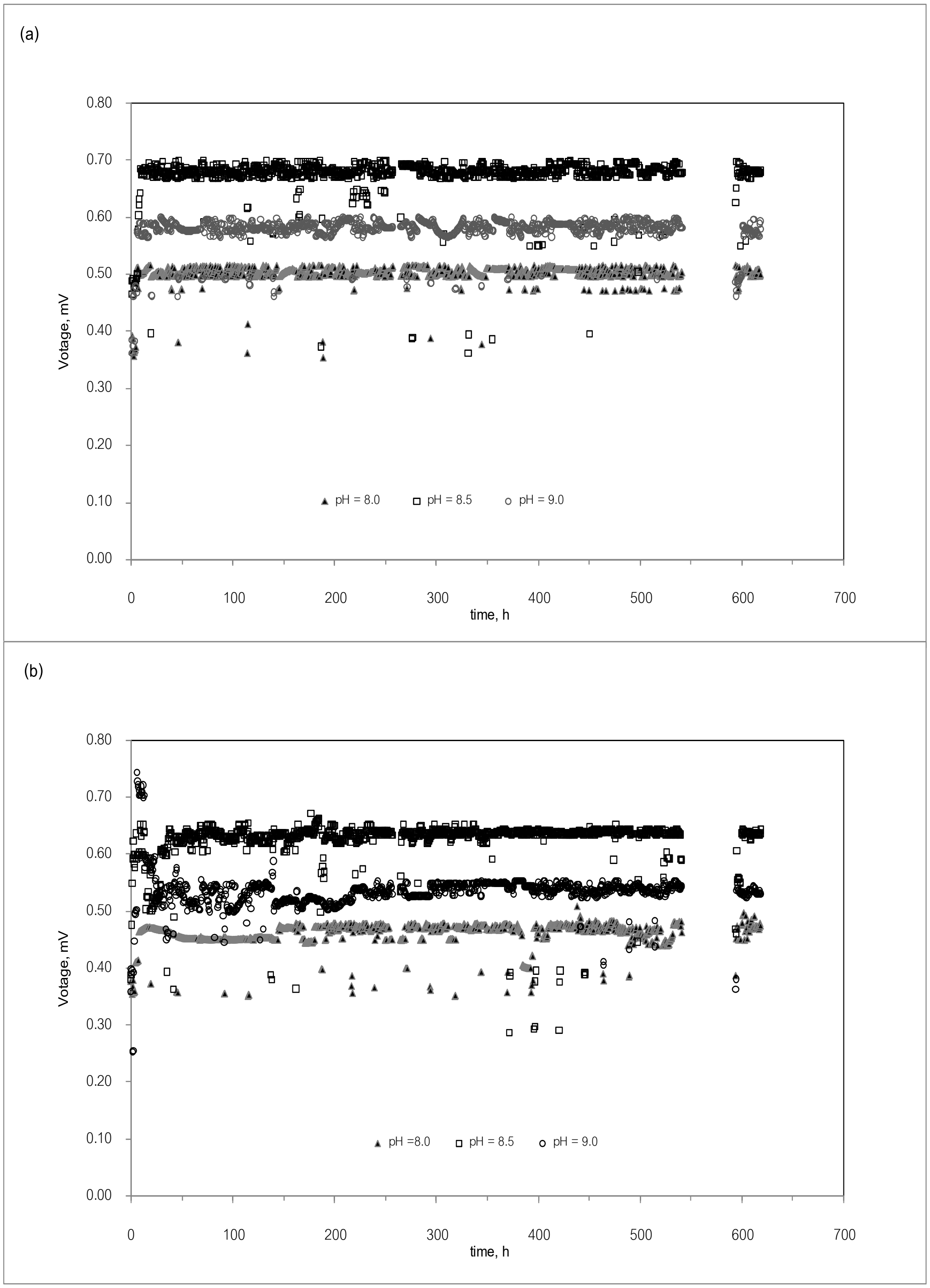



Figure 4.12: The circuit voltage of alkaline wastewater feed: (a) at 30°C, (b) at 45°C

The power generated from those feed pHs were not different at the initial operation, but as batch number increased the initial of circuit voltage changed. The values of circuit voltage from acidic and alkaline feed were higher than that from the neutral condition because those of two pH feeds have higher conductivity than that of at neutral feed. The final circuit voltages from various pH feeds were almost constant since the end of batch cycle number 2 through the end of operation (600 hours). The average of circuit voltage was used to calculate the value of power density as equation 3.1. The power densities are summarized in Figure 4.13.

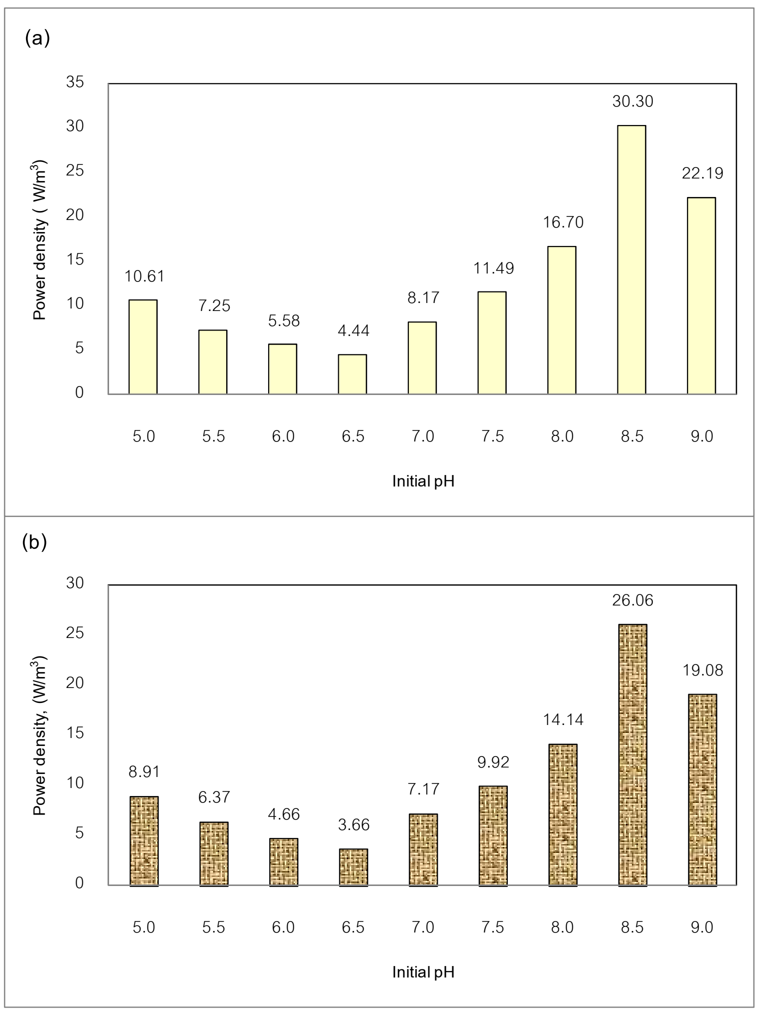



Figure 4.13: The power density from cassava wastewater by SCMFC in terms of pH feed: (a) at 30°C, (b) at 45°C

The maximum power output as a function of pH feed was obtained by varying the pH from 8.5 to 9.0 and then 8.0. The lowest power output occurred when the pH was 6.5 (in the neutral range). The reason for this lower power output is low solution conductivity and a pH that favors the growth of methanogens.

The solution conductivity in the effluent at 30°C was 50 $\pm$ 8.84, 35 $\pm$ 2.97, 24 $\pm$ 3.02, 15 $\pm$ 2.03, 47 $\pm$3 .50, 62 $\pm$ 4.20, 83 $\pm$ 6.41, 111 $\pm$ 8.48, and 159 $\pm$ 17.11μs/cm for pH values of 5.0, 5.5, 6.0, 6.5, 7.0, 7.5, 8.0, 8.5, and 9.0, respectively, while the conductivity figures at 45°C were 48 $\pm$ 2.88, 33 $\pm$ 3.04, 25 $\pm$ 2.81, 16 $\pm$ 9.51, 46 $\pm$ 7.58, 60 $\pm$ 5.91, 76 $\pm$ 5.21, 104 $\pm$ 5.56, and 185 $\pm$ 11.85, respectively. But the solution's conductivity was not the only factor to influence the power generation of the SCMFC.

High alkaline feed (pH 9.0) suppresses methanogens and thereby also supports maximum power output, and there was available alkalinity as a buffer of $H^+$ which occurred in the anode. In acidic conditions, meanwhile, there was less buffering to neutralize $H^+$, so in that environment there was a high concentration of $H^+$, and that high concentration was a driving force to balance all ions in the MFC as an electrochemical reaction. This drive force enhanced electron flow from the anode to the cathode and caused more $H^+$ to pass through the cathode. This increased power output from acidic conditions was from the electrochemical processes rather than that of the biochemical processes. In contrast, the power output at neutral feed from the biochemical processes was more than that of the electrochemical processes.

The statistical evaluation was presented the effect of pH on the power generation from SCMFC. The different pHs were compared by applying two-way ANOVA (analysis of variance) method followed by F-test using SPSS (Statistical Package for social Science) with a 0.05 significance level. The comparison test showed in table 4.13. In this work, pHs and temperature were select as independent variables. In the same way, power generation was used as dependent variable. The statistical evaluation was presented the effect of pHs on the power generation from SCMFC (Table 4.13). From the results, pHs and temperature were considered significant to the power generation from microbial fuel cell.

Table 4.13: Statistical results for power generation

| Variable loading | Degree of freedom | p-value | Conclusions |
|---|---|---|---|
| pH | 8 | 0.000 | Significant |
| Temperature | 1 | 0.008 | Significant |

Table 4.14 show the comparisons of power obtained from this study and others researchers.

Table 4.14: The comparisons of power generation from MFC in previous study with this study

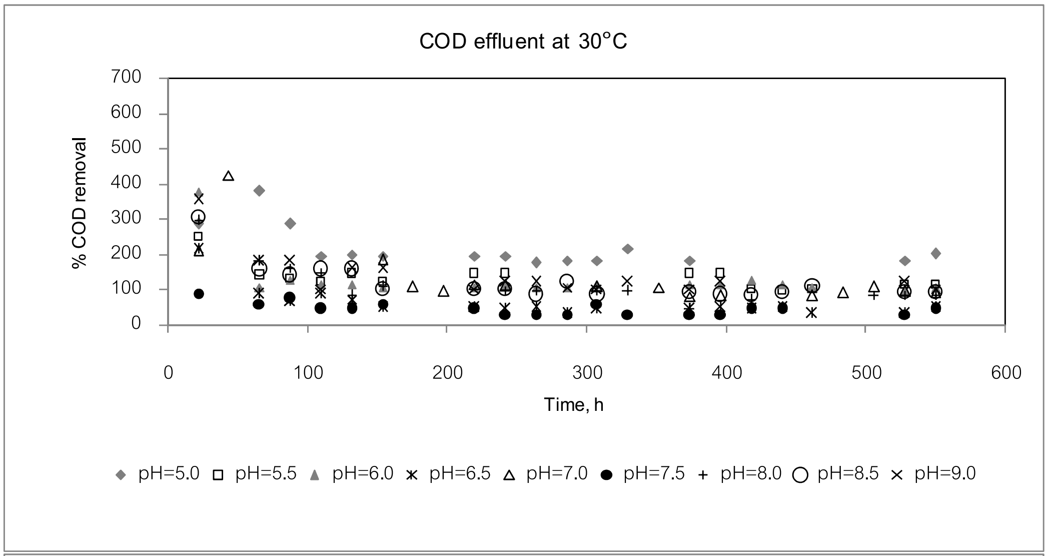
| Substrate | pH | Power density base on anode surface or anode volume | Reference |
|---|---|---|---|
| Cassava wastewater | 5.0 | 10.61 $W/m^3$ | This study |
| | 6.0 | 5.58 $W/m^3$ | |
| | 7.0 | 8.17 $W/m^3$ | |
| | 8.0 | 16.70 $W/m^3$ | |
| | 9.0 | 22.19 $W/m^3$ | |
| Acetate | 6.0 | 600 $mW/m^2$ | Behera and Ghangrekar, (2009) |
| | 8.0 | 158 $mW/m^2$ | |
| Vegetable-based waste | 7.0 | 2.81$W/m^3$ | Cercado-Quezada, et al., (2010) |
| Corn starch wastewater | 7.0 | 1.41$W/m^3$ | Wen, et al., (2010) |
| Cassava wastewater | 5.5±0.2 | 18.2 $W/m^3$ | Kaewkannetra, et al., (2011) |
| Synthetic wastewater | 6.0 | 12.70 $W/m^2$ | Raghavulu, et al., (2009) |
| | 7.0 | 12.01 $W/m^2$ | |
| | 8.0 | 11.58 $W/m^2$ | |
| Synthetic wastewater | 6.0 | | Raghavulu, et al., (2011) |
| Composite waste vegetables | 7.0 | 0.93$W/m^3$ | Mohan, et al., (2010b) |
| Domestic wastewater | - | 1.06 $mW/m^3$ | Liu, et al., (2004) |

### 4.2.2 COD removal efficiency

The pH of cassava wastewater is one of major parameters affecting its biological treatment processes. Since sulfuric acid is added during starch production, the pH in raw wastewater is very low at 4.0.

The results above show that the best condition for producing electricity from and treatment for cassava wastewater in a single chamber microbial fuel cell is an OLR of 0.56 kg-COD/$m^3$-d. This section examines the best feed pH for generating electricity and reducing organic compounds. The raw wastewater of cassava was adjusted by adding 0.1 N NaOH to increase the pH from 4.0 to 5.0, 5.5, 6.0, 6.5, 7.0, 7.5, 8.0, and 9.0 while the organic loading was fixed as 0.56 kg-COD/$m^3$-d.

When cassava wastewater was fed into the anode at various pHs, the effluent was taken to analyze the COD concentration. The early batch cycles showed that COD removal was quite low but increased gradually in latter batches to reach a constant. However the number of batch cycles to reach the constant in COD effluent for each feed pH was different due to the ability of microorganisms and equipment in that chamber. This was true for both temperatures. Figure 4.14 (a) and (b) shows the results of COD in the effluent when operated for 550 hours at 30°C and 45°C.



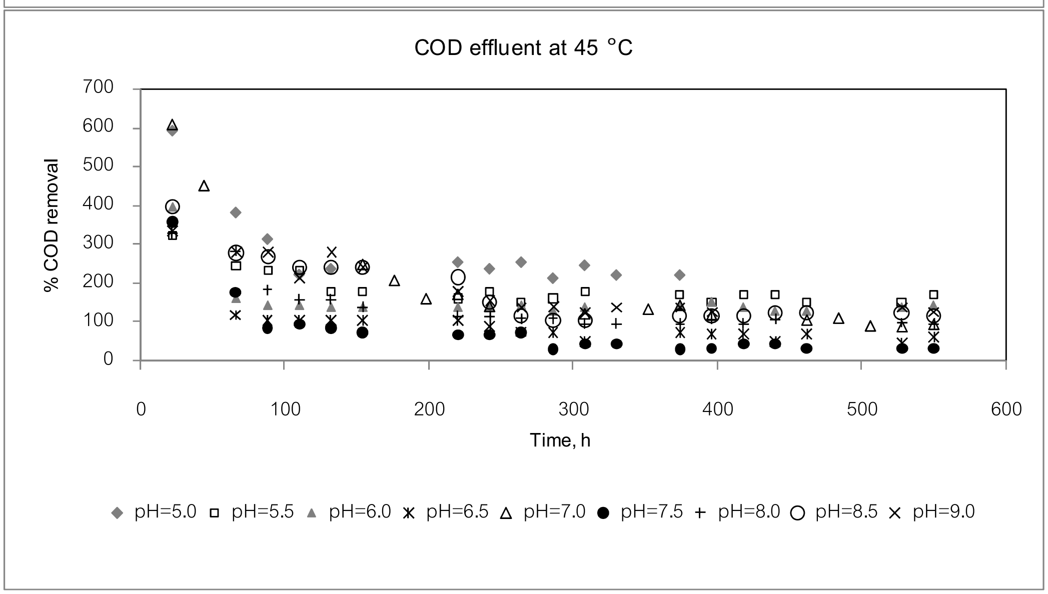




Figure 4.14: COD in the effluent in terms of pH feed (a) at 30°C, (b) at 45°C

The tendency of COD concentration in the effluent from SCMFC at 30°C and 45°C was lower than the standard of the Industrial Department of Thailand (400 mg/L). When focused on the range of the feed pH, the results showed that the efficiency of COD removal of acidic feed varied and was lower than that of neutral feed and alkaline feed, and that the maximum COD removal efficiency was obtained from neutral feed followed by alkaline feed as shown in Figures 4.15 and 4.16.

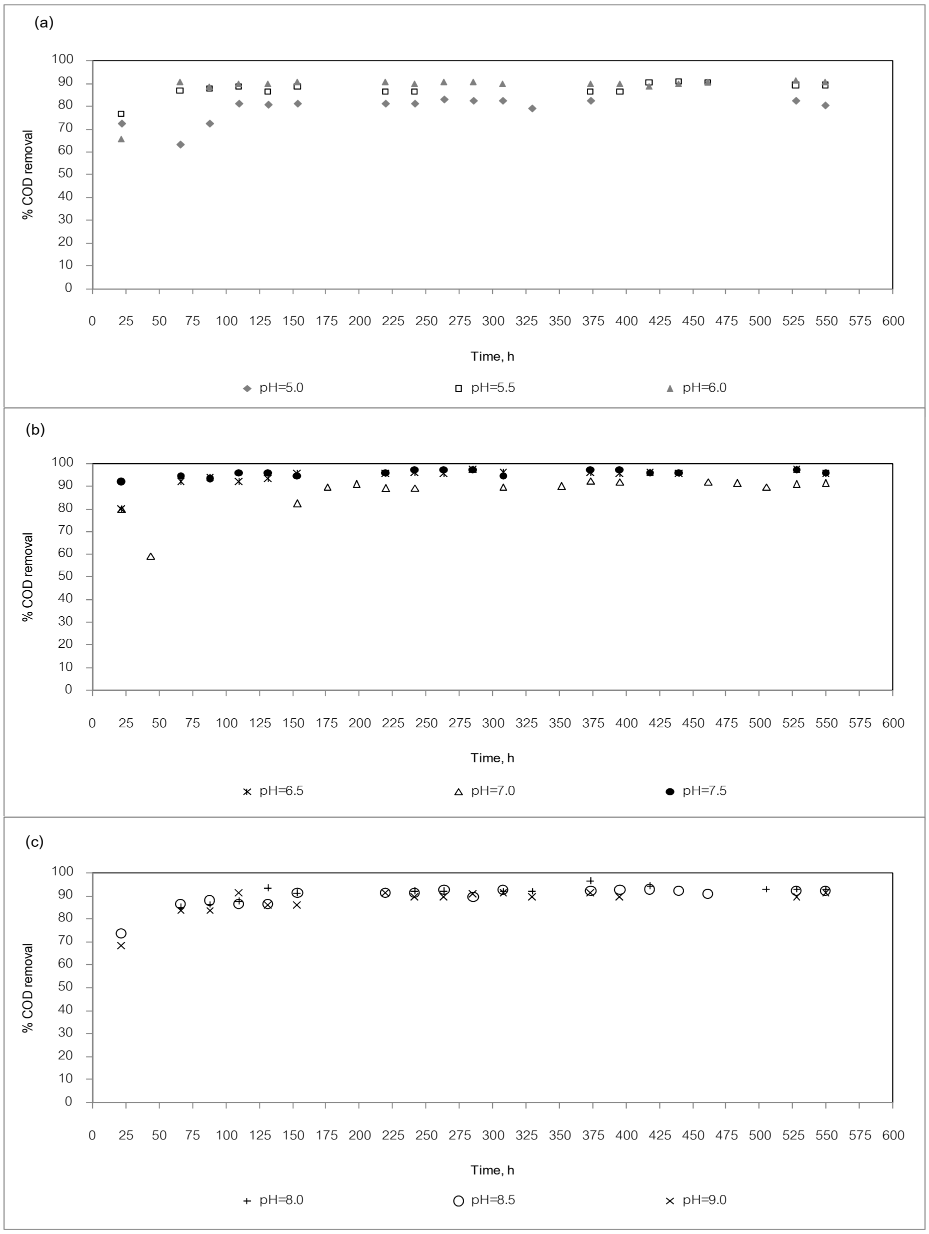



Figure 4.15: Efficiency for COD removal at 30°C: (a) at acidic feed, (b) at neutral feed, (c) at alkaline feed

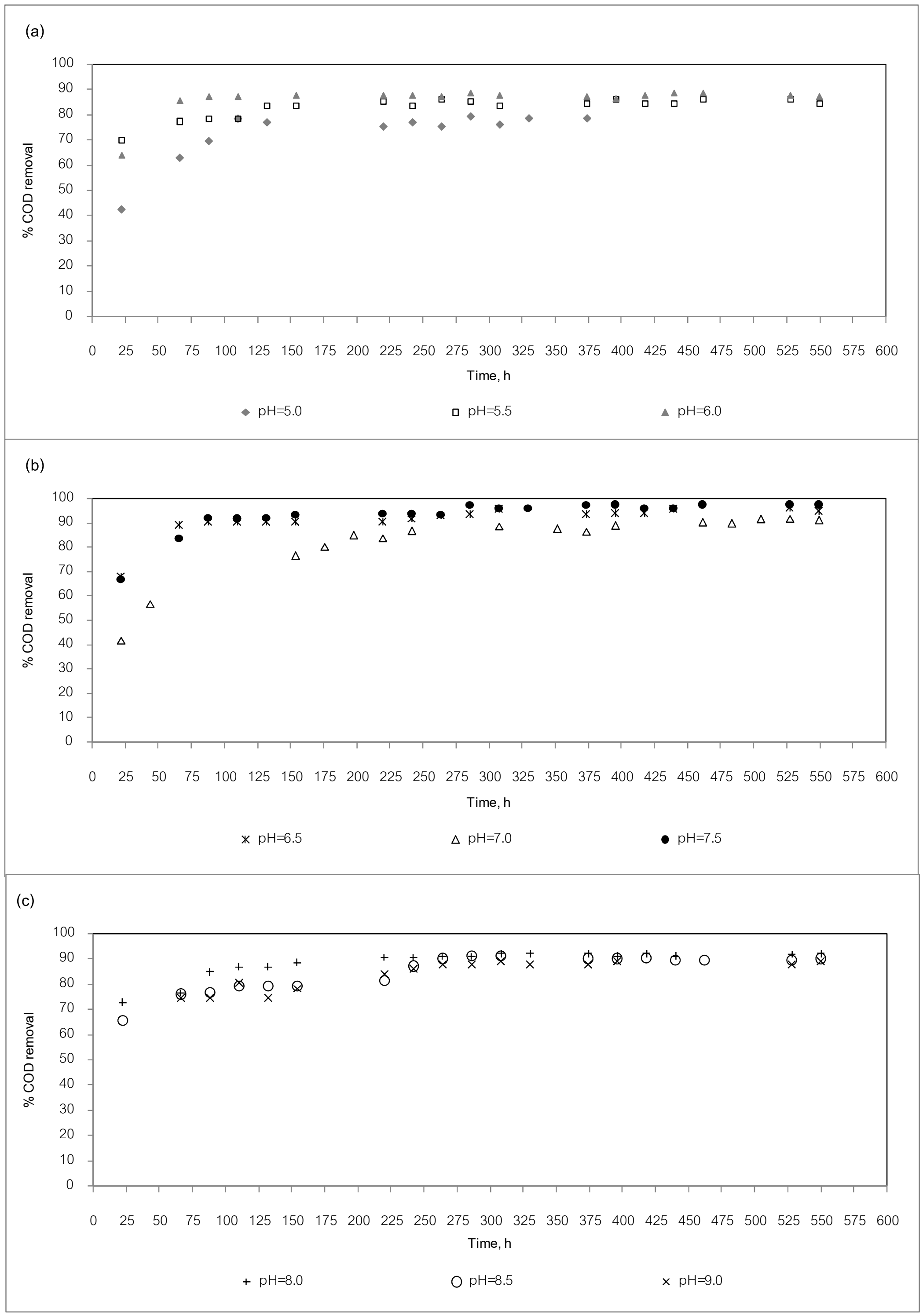



Figure 4.16: Efficiency for COD removal at 45°C: (a) at acidic feed, (b) at neutral feed, (c) at alkaline feed

The efficiency for COD removal at neutral feed (pH of 6.5-7.5) was the most favorable to microorganisms for substrate reduction, followed by alkaline feed (pH of 8.0-9.0), with acidic feed (pH of 5.0-6.0) being the worst at both temperatures.

Table 4.15 and Figure 4.15 show the COD removal efficiency of a single chamber microbial fuel cell by the effect of pH influent.

Table 4.15: The efficiency for COD removal as function of pH feed and temperature

| Temperature | pH | $COD_{inf}$ (mg/L) | $COD_{eff}$(mg/L) | %COD removal |
|---|---|---|---|---|
| | 5.0 | 1,027 | 193±7.6 | 81.19±1.10 |
| | 5.5 | 1,064 | 124±7.5 | 88.37±2.04 |
| | 6.0 | 1,086 | 110±10.8 | 89.88±0.68 |
| | 6.5 | 1,045 | 44±9.1 | 95.84±0.65 |
| 30°c | 7.0 | 1,045 | 89±7.7 | 91.46±1.10 |
| | 7.5 | 1,082 | 35±7.2 | 96.77±0.93 |
| | 8.0 | 1,181 | 85±6.9 | 92.83±1.37 |
| | 8.5 | 1,142 | 96±8.9 | 91.63±1.10 |
| | 9.0 | 1,103 | 113±11.0 | 89.78±0.86 |
| | 5.0 | 1,027 | 234±9.2 | 77.21±1.42 |
| | 5.5 | 1,064 | 162±9.9 | 84.77±0.98 |
| | 6.0 | 1,086 | 136±6.7 | 87.48±0.66 |
| | 6.5 | 1,045 | 97±12.0 | 90.69±1.80 |
| 45°c | 7.0 | 1,045 | 108±6.4 | 89.62±2.23 |
| | 7.5 | 1,082 | 44±6.8 | 95.93±1.44 |
| | 8.0 | 1,181 | 102±4.6 | 91.39±0.64 |
| | 8.5 | 1,142 | 127±4.1 | 88.89±2.63 |
| | 9.0 | 1,103 | 137±7.5 | 87.55±1.49 |

Table 4.15 shows the maximum and minimum efficiency of COD removal from the feed pHs of 7.5 (96.77% at 30°C; 95.93% at 45°C) and 5.0 (81.19% at 30°C; 77.21% at 45°C), respectively. At neutral feed, wastewater promoted the activities of microorganisms for

using substrate better than in acidic or alkaline conditions. At neutral feed, the pH value in the effluent was close to neutral, but it slightly decreased as in Table 4.16.

In the early batch cycles, the amount of alkalinity can be used as a buffer for neutralization with $H^+$ which was in the wastewater influent only; in the later batch cycles, it decreased by neutralization with the accumulating protons in the anode chamber. Thus the pH in the effluent decreased with a number of batch cycle increasing and might be toxic to microorganisms. The pH in the effluent of pH 5.0 feed was quite especially in the latter batch. At low pH, it inhibited microorganism activities, so the COD removal efficiency was lower than in other conditions.

Alkaline feed of wastewater favored the microbial activities in a single chamber microbial fuel cell rather that feeding with acidic wastewater feed. This condition has enough alkalinity and the pH did not strongly inhibit the activities of the microorganisms however, it was favored less than in neutral conditions.

Table 4.16: The pH in the effluent

| Temp | pH | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 5.0 | 5.5 | 6.0 | 6.5 | 7.0 | 7.5 | 8.0 | 8.5 | 9.0 |
| 30°C | 4.81±0.05 | 5.39±0.07 | 5.76±0.12 | 6.36±0.10 | 6.75±0.09 | 7.35±0.06 | 7.73±0.10 | 8.21±0.09 | 8.68±0.12 |
| 45°C | 4.77±0.06 | 5.34±0.12 | 5.75±0.21 | 6.37±0.09 | 6.66±0.20 | 7.31±0.09 | 7.77±0.11 | 8.34±0.07 | 8.78±0.15 |

The statistical evaluation was presented the effect of pH on the efficiency of COD removal from SCMFC. The different pHs were compared by applying two-way ANOVA (analysis of variance) method followed by F-test using SPSS (Statistical Package for social Science) with a 0.05 significance level. The comparison test showed in Table 4.17. In this work, pHs and temperature were select as independent variables. In the same way, efficiency of COD removal was used as dependent variable. The statistical evaluation was presented the effect of pHs on the COD removal from SCMFC. From the results, pHs and temperature were considered significant to efficiency of COD removal from microbial fuel cell.

Table 4.17: Statistical results for efficiency of COD removal

| Variable loading | Degree of freedom | p-value | Conclusions |
|---|---|---|---|
| pH | 8 | 0.000 | Significant |
| Temperature | 1 | 0.000 | Significant |

COD removal was more efficient at neutral conditions than in alkaline conditions, followed by acidic conditions. This agrees with Raghavulu, et al., (2009); Jadhav and Ghangrekar, (2009); Martin, et al., (2010). Table 4.18 shows the comparison of COD removal efficiency from MFC of this study with other studies.

Table 4.18: The comparisons of COD removal efficiency by the effect of pH feed from MFC in previous study with this study

| Substrate | pH | % COD removal efficiency | Reference |
|---|---|---|---|
| Cassava wastewater | 5.0 | 81.19 | This study |
| | 6.0 | 89.88 | |
| | 7.0 | 91.44 | |
| | 8.0 | 92.83 | |
| | 9.0 | 89.78 | |
| | 6.0 | 47.80 | |
| | 7.0 | 58.98 | |
| | 8.0 | 55.76 | |
| Chemical wastewater | 6.0 | 47.80 | Raghavulu, et al., (2009) |
| | 7.0 | 58.98 | |
| | 8.0 | 55.76 | |
| Synthetic wastewater | 7.0 | 82.3 | Martin, et al., (2010) |
| | 6.25 | 76.6 | |

### 4.2.3 Coulombic efficiency

The coulombic efficiency by the effect of pH feed in this study is shown in Table 4.19

**Table 4.19: Coulombic efficiency in terms of pH feed**

| Temperature | Unit | pH | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | 5.0 | 5.5 | 6.0 | 6.5 | 7.0 | 7.5 | 8.0 | 8.5 | 9.0 |
| 30°C | % | 39.3 | 28.8 | 24.4 | 21.2 | 30.2 | 32.5 | 37.5 | 52.9 | 47.8 |
| 45°C | % | 37.9 | 28.1 | 22.8 | 19.5 | 28.7 | 30.5 | 35.0 | 50.6 | 45.5 |

Table 4.19 shows that the maximum CE at pH of 8.5 of alkaline feed was as high as 52.6% and 50.6% at the temperatures of 30°C and 45°C, respectively, while the minimum CE obtained from lower temperature and higher temperature operation at pH of 6.5 of neutral feed were 21.2% and 19.5% respectively. The alkaline feed (pH 7.5-9.0) achieved the maximum CE followed by acidic feed and the minimum CE was obtained at pH of 6.5 of neutral feed; these circumstances occurred at both operating temperatures.

From the results of Table 4.19, the CE at extremely acidic feed and extremely alkaline feed were both higher than the CE at neutral feed. The higher CE was achieved from the extremes of pH feed because at that solubility, the flow of ions was high, promoting power generation by the SCMFC. On the other hand, that condition was not favored the microorganisms reducing the substrate, so substrate was only slightly removed. These two reasons enhanced coulombic efficiency.

The effects of sulfate in these experiments were significant on CE which depended on the pH feed. The sulfate removal loading was at 0.32 to 0.52 kg/$m^3$-d at 30°C and 0.30 to 0.52 kg/$m^3$-d at 45°C. The details of sulfate reduction are shown in Table 4.20 and Figure 4.28.

Table 4.20: Sulfate removal in terms of pH feed

| Temp | Item | pH | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | 5.0 | 5.5 | 6.0 | 6.5 | 7.0 | 7.5 | 8.0 | 8.5 | 9.0 |
| 30°C | Sulfate influent (mg/L.) | 998 | 1,065 | 1,010 | 995 | 1,027 | 1,145 | 1,150 | 984 | 1,035 |
| | Sulfate effluent (mg/L.) | 305 | 333 | 366 | 318 | 61 | 425 | 336 | 378 | 364 |
| | % Sulfate removal | 69.43 | 68.72 | 63.74 | 68.08 | 94.06 | 62.85 | 70.82 | 61.54 | 64.86 |
| Sulfate removal loading ($kg/m^3$-d) | | 0.37 | 0.39 | 0.34 | 0.36 | 0.52 | 0.38 | 0.43 | 0.32 | 0.36 |
| 45°C | Sulfate influent (mg/L.) | 998 | 1,065 | 1,010 | 995 | 1,027 | 1,145 | 1,150 | 984 | 1,035 |
| | Sulfate effluent (mg/L.) | 296 | 352 | 314 | 348 | 58 | 328 | 354 | 418 | 394 |
| | % Sulfate removal | 70.36 | 66.96 | 68.93 | 65.01 | 94.35 | 71.34 | 69.24 | 57.53 | 61.92 |
| Sulfate removal loading ($kg/m^3$-d) | | 0.37 | 0.38 | 0.37 | 0.34 | 0.52 | 0.44 | 0.42 | 0.30 | 0.34 |

The maximum of sulfate removal was at pH 7.0. The sulfate removed was used as electron acceptors in sulfate reduction processes.

Theoretical COD consumption by sulfate reduction, as in section 4.1.3 of this report, was 462, 488, 429, 452, 644, 480, 543, 404 and 448 mg/L at 30°C and 793, 902, 950, 948, 934, 1,038, 1,079, 1,015 and 966 mg/L at 45°C for pH feeds of 5.0, 5.5, 6.0, 6.5, 7.0, 7.5, 8.0, 8.5, and 9.0 respectively.

The percentage of COD consumed by sulfate reduction was 55.41%, 51.89%, 43.97%, 45.09%, 67.58%, 45.82%, 49.53%, 38.58%, and 45.19% of total COD removal at 30 °C operation and 59.04%, 52.71%, 48.85%, 45.49%, 69.20%, 52.46%, 49.19%, 37.18%, and 44.24% at 45°C operation (Table 4.21).

Table 4.21: COD removal and theoretical of COD consumed by sulfate reduction

| Temp | Item | pH | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | 5.0 | 5.5 | 6.0 | 6.5 | 7.0 | 7.5 | 8.0 | 8.5 | 9.0 |
| 30°C | COD in the influent (mg/L) | 1,027 | 1,064 | 1,086 | 1,045 | 1,042 | 1,082 | 1,181 | 1,142 | 1,103 |
| | COD in the effluent (mg/L) | 193 | 124 | 110 | 44 | 89 | 35 | 85 | 96 | 113 |
| | COD removal (mg/L) | 834 | 940 | 976 | 1,002 | 953 | 1,047 | 1,096 | 1,046 | 990 |
| | COD theoretically consumed by sulfate(mg/L) | 462 | 488 | 429 | 452 | 644 | 480 | 543 | 404 | 448 |
| | %COD theoretically consumed by sulfate | 55.41 | 51.89 | 43.97 | 45.09 | 67.58 | 45.82 | 49.53 | 38.58 | 45.19 |
| | %COD removal available to produce electricity | **44.59** | **48.11** | **56.03** | **54.91** | **32.42** | **54.18** | **50.47** | **61.42** | **54.81** |
| 45°C | COD in the influent (mg/L) | 1,027 | 1,064 | 1,086 | 1,045 | 1,042 | 1,082 | 1,181 | 1,142 | 1,103 |
| | COD in the effluent (mg/L) | 234 | 162 | 136 | 97 | 108 | 44 | 102 | 127 | 137 |
| | COD removal (mg/L) | 793 | 902 | 950 | 948 | 934 | 1,038 | 1,079 | 1,015 | 966 |
| | COD theoretically consumed by sulfate(mg/L) | 468 | 475 | 464 | 431 | 646 | 545 | 531 | 377 | 427 |
| | %COD theoretically consumed by sulfate | 59.04 | 52.71 | 48.85 | 45.49 | 69.20 | 52.46 | 49.19 | 37.18 | 44.24 |
| | %COD removal available to produce electricity | **40.96** | **47.29** | **51.15** | **54.51** | **30.80** | **47.54** | **50.81** | **62.82** | **55.76** |

The statistical evaluation was presented the effect of pH on CE from SCMFC. The different pHs were compared by applying two-way ANOVA (analysis of variance) method followed by F-test using SPSS (Statistical Package for social Science) with a 0.05 significance level. The comparison test showed in Table 4.22. In this work, pHs and temperature were select as independent variables. In the same way, CE value was used as dependent variable. The statistical evaluation was presented the effect of pHs on the CE from SCMFC. From the results, pHs and temperature were considered significant to CE from microbial fuel cell.

Table 4.22: Statistical results for CE

| Variable loading | Degree of freedom | p-value | Conclusions |
|---|---|---|---|
| pH | 8 | 0.000 | Significant |
| Temperature | 1 | 0.000 | Significant |

### 4.2.4 Polarization curve and internal resistance

The slope of the polarization curve in the variation of pH feed was the internal resistance. The internal resistant was summarized as in Table 4.23. Figure 4.17 and Figure 4.18 show the polarization curve.

Table 4.23: Internal resistance from the SCMFC

| Temperature | Unit | pH | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | 5.0 | 5.5 | 6.0 | 6.5 | 7.0 | 7.5 | 8.0 | 8.5 | 9.0 |
| 30°C | Ohm | 115 | 132 | 142 | 152 | 115 | 119 | 71 | 46 | 55 |
| 45°C | Ohm | 140 | 145 | 158 | 168 | 134 | 128 | 83 | 50 | 65 |

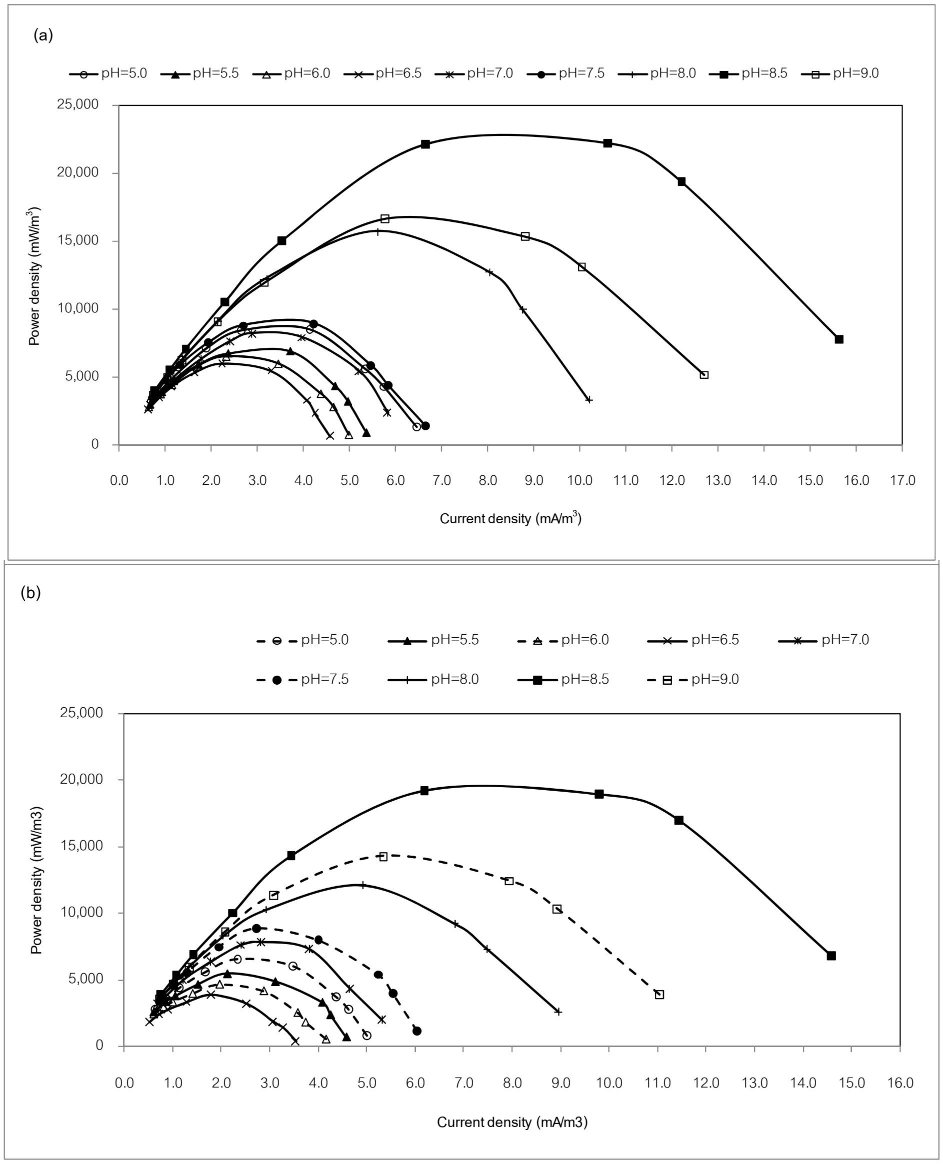



Figure 4.17 (a): The polarization curve at 30°C, (b): The polarization curve at 45°C

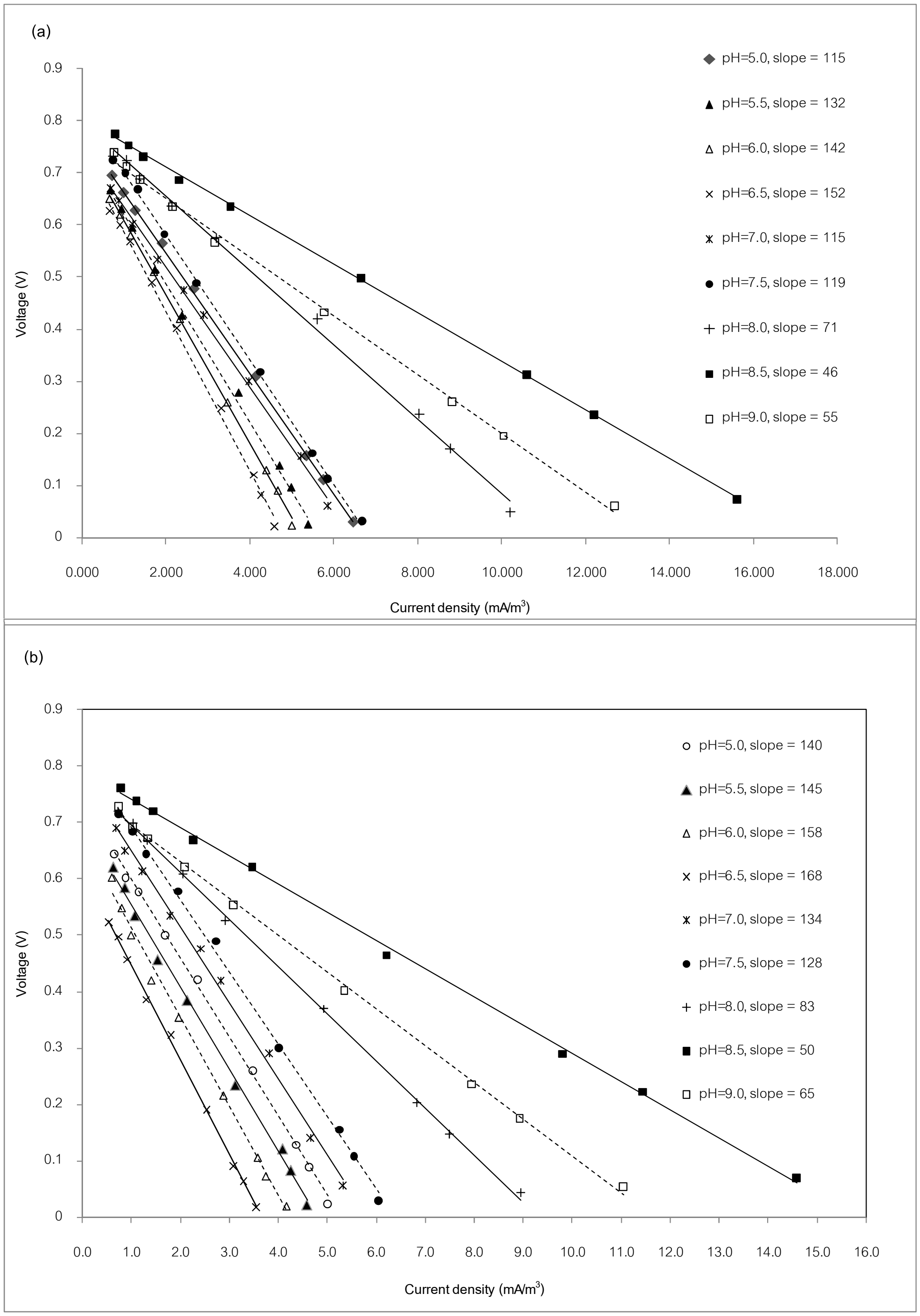



Figure 4.18 (a): The slope from the polarization curve method at 30°C, (b): The slope from the polarization curve method at 45°C

The maximum internal resistance of this study was obtained from the pH feed of 6.5 at both operating temperatures (152 $\Omega$ at 30°C, 168 $\Omega$ at 45°C). At a pH of 6.5, COD might be removed by methanogenesis more than exoelectrogenesis and the solution conductivity was low, thus the current was low too.

The minimum internal resistance was achieved at pH 8.5 (46 $\Omega$ at 30°C, 50 $\Omega$ at 45°C). At pH 8.5, the solution conductivity was high and the pH did not inhibit exoelectrogens activities. The solution conductivity at pH 9.0 was higher than at pH 8.0, but the internal resistant at pH 8.0 was lower than at pH 9.0, because the pH 9.0 might inhibit the exoelectrogens.

The solution's conductivity at both operation temperatures are shown in Figure 4.19.

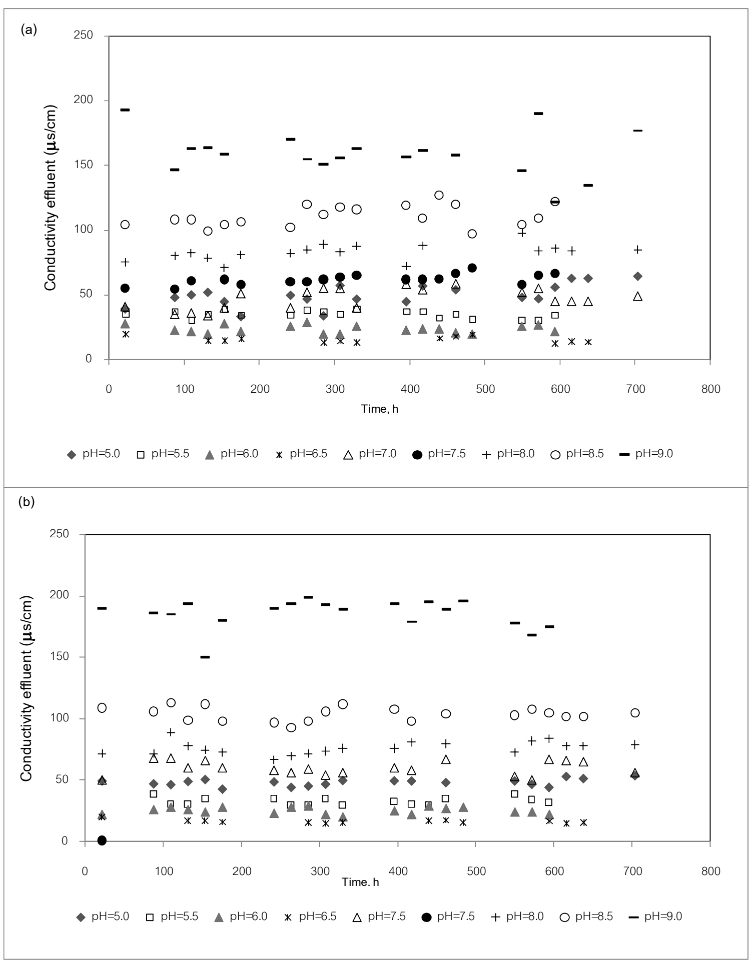



Figure 4.19: The conductivity of the effluent in terms of pH feed: (a) at 30°C, (b) at 45°C

The statistical evaluation was presented the effect of pH on the internal resistant in SCMFC. The different pHs were compared by applying two-way ANOVA (analysis of variance) method followed by F-test using SPSS (Statistical Package for social Science) with a 0.05 significance level. The comparison test showed in Table 4.24. In this work, pHs and temperature were select as independent variables. In the same way, internal resistant was used as dependent variable. The statistical evaluation was presented the effect of pHs on the internal resistant from SCMFC. From the results, pHs and temperature were considered significant to internal resistant from microbial fuel cell.

Table 4.24: Statistical results for internal resistant

| Variable loading | Degree of freedom | p-value | Conclusions |
|---|---|---|---|
| pH | 8 | 0.000 | Significant |
| Temperature | 1 | 0.000 | Significant |

### 4.3 Effects of temperature

#### 4.3.1 Performance of power generation

Temperature affects the resistivity of electronic equipment such as wire, electrode. The size of the impact can be determined with equation (4.1).

$$\frac{R_1}{R_2} = K\left(\frac{T_1}{T_2}\right) \qquad (4.1)$$

Where $T_1$ = Temperature 1, °C

$T_2$ = Temperature 2, °C

$R_1$ = Resistance at temperature 1, Ohm

$R_2$ = Resistance at temperature 2, Ohm

K = Resistance constant of material (234 for copper wire)

From equation 4.1, the resistance of copper wire at 45°C was 5.6% higher than at 30 °C. The power obtained from our study was not significantly different as shown in Figure 4.20, however the power at 30°C was slightly higher than at 45°C.

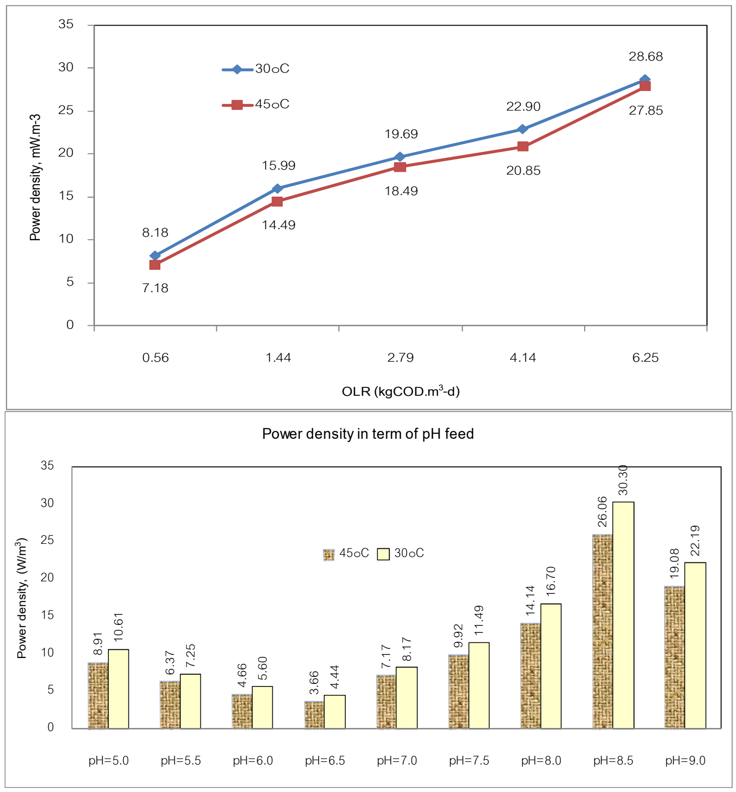



Figure 4.20: Conductivity in the effluent in terms of temperature: (a) In terms of OLR, (b) in terms of pH feed

### 4.3.2 COD removal efficiency

Temperature can affect the kinetic energy of microorganisms as illustrated using Arrhenius's equation (4.2). As the temperature increases, the rate of constant increases. In the activity of substrate reduction by microorganisms, the application of Arrhenius's equation is shown by equation 4.3.

$$k = Ae^{\frac{-E_A}{RT}} \qquad (4.2)$$

Where k = Rate coefficient

| | | |
|---|---|---|
| A | = | Constant value |
| $E_A$ | = | Activation energy ($8.314 \times 10^{-3}$ kJ $mol^{-1}K^{-1}$) |
| $R_2$ | = | Universal gas constant |
| T | = | Temperature (Kelvin) |

$$k_2 = k_1\theta^{(T_1-T_2)} \qquad (4.3)$$

| | | | |
|---|---|---|---|
| Where | $k_1$ | = | Rate coefficient at temperature 1 |
| | $k_2$ | = | Rate coefficient at temperature 2 |
| | $\theta$ | = | Constant value |
| | $T_1$-$T_2$ | = | Difference between temperatures 1 and 2 |

From equation 4.3, if the temperature increased from 30°C to 45°C, the rate of substrate use increased from 11.8 to 32.56 g VSS/g VSS-d which was 2.75 times ($\theta$ = 1.07, and $\mu_m$ of 20 °C = 6 g VSS/g VSS-d). Our study showed that the effect of OLR on COD removal at two temperatures did not different significantly. The percent of variation of COD removal only varied from 0.78% to 3.98% at the two temperatures. This study shows that the main factor affecting substrate reduction in terms of OLR was the ratio of food per microorganisms (F/M) rather than the effect of temperature. When considering the effect of pH in terms of temperature, we found that the COD removal at 30°C was slightly more than at 45°C, 0.87% to 4.90%. The different values depended on pH feed. There was a narrow gap of COD removal efficiency at low OLR (0.56 kg-COD/$m^3$-d) between 30°C and 45°C. This result might be caused by low organic loading; the available substrate was a limitation. The efficiency of COD removal in terms of temperature is shown in Figure 4.21.

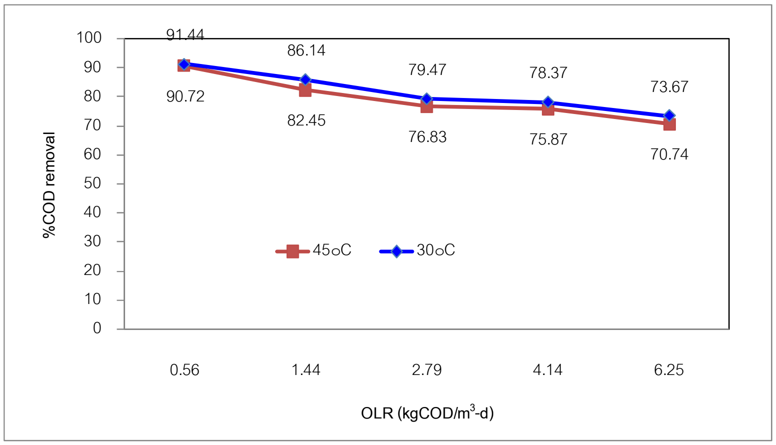



Figure 4.21: The efficiency of COD removal in terms of temperature: (a) in terms of OLR

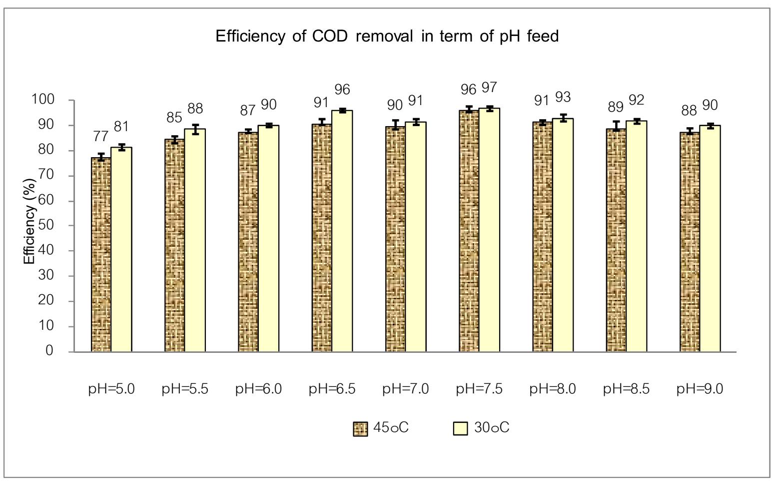



Figure 4.21: The efficiency of COD removal in terms of temperature: (b) in terms of pH feed

### 4.3.3 Coulombic efficiency and internal resistance

The effect of temperature on coulombic efficiency was similar to the efficiency of COD removal or the internal resistance. The tendency of coulombic efficiency on the effect of temperature was not different in the OLR and pH feed. CE was higher at 30°C than at 45°C (Figures 4.22 and 4.23). This could be because the microorganisms were more acclimated to 30°C than to 45°C and at temperature 45 °C is poor for microorganism growth. Moreover, electrical resistance is higher at high temperature than at low temperature.

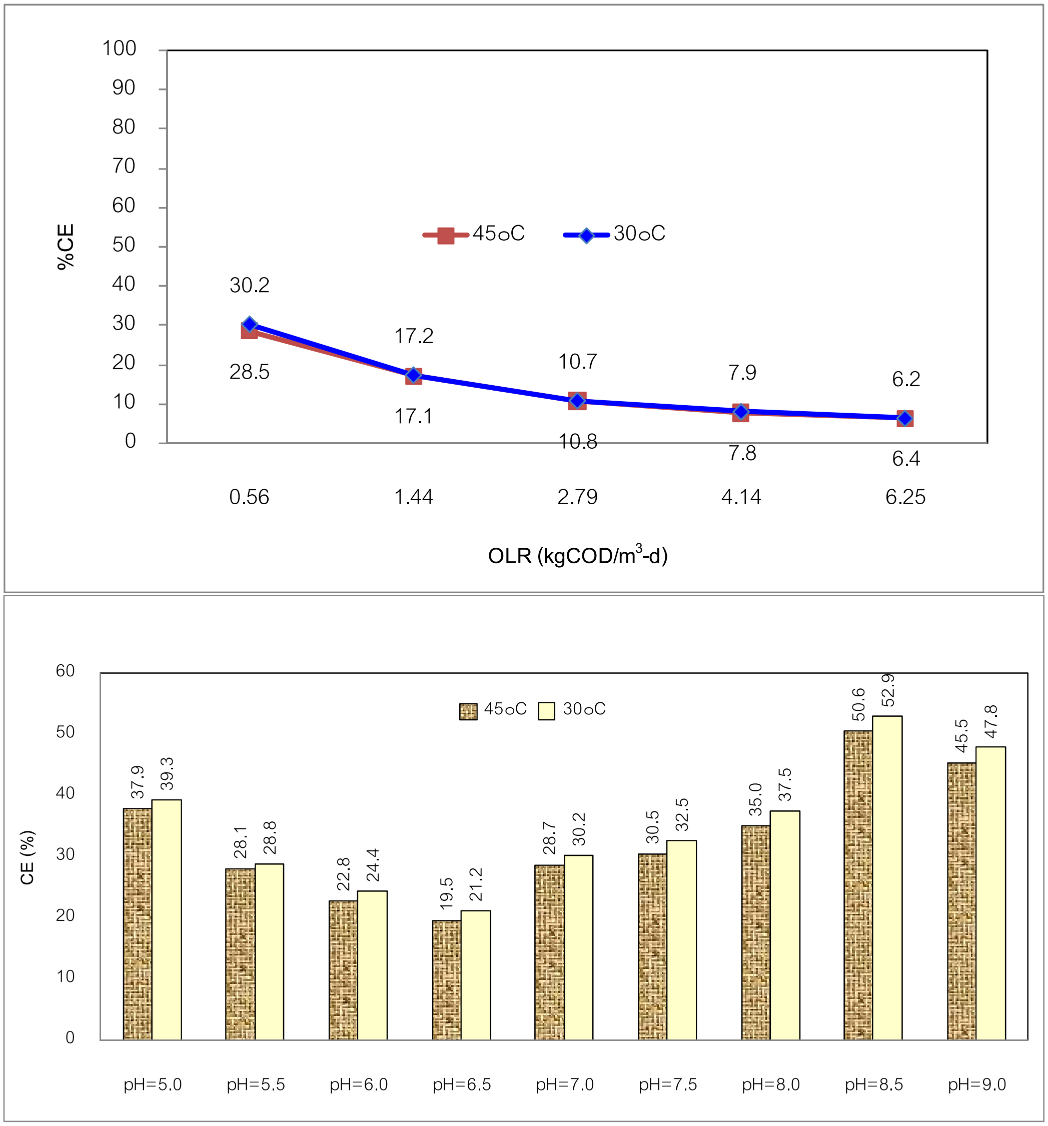



Figure 4.22: The effect of temperature on coulombic efficiency:

(a) in terms of OLR, (b) in terms of pH feed

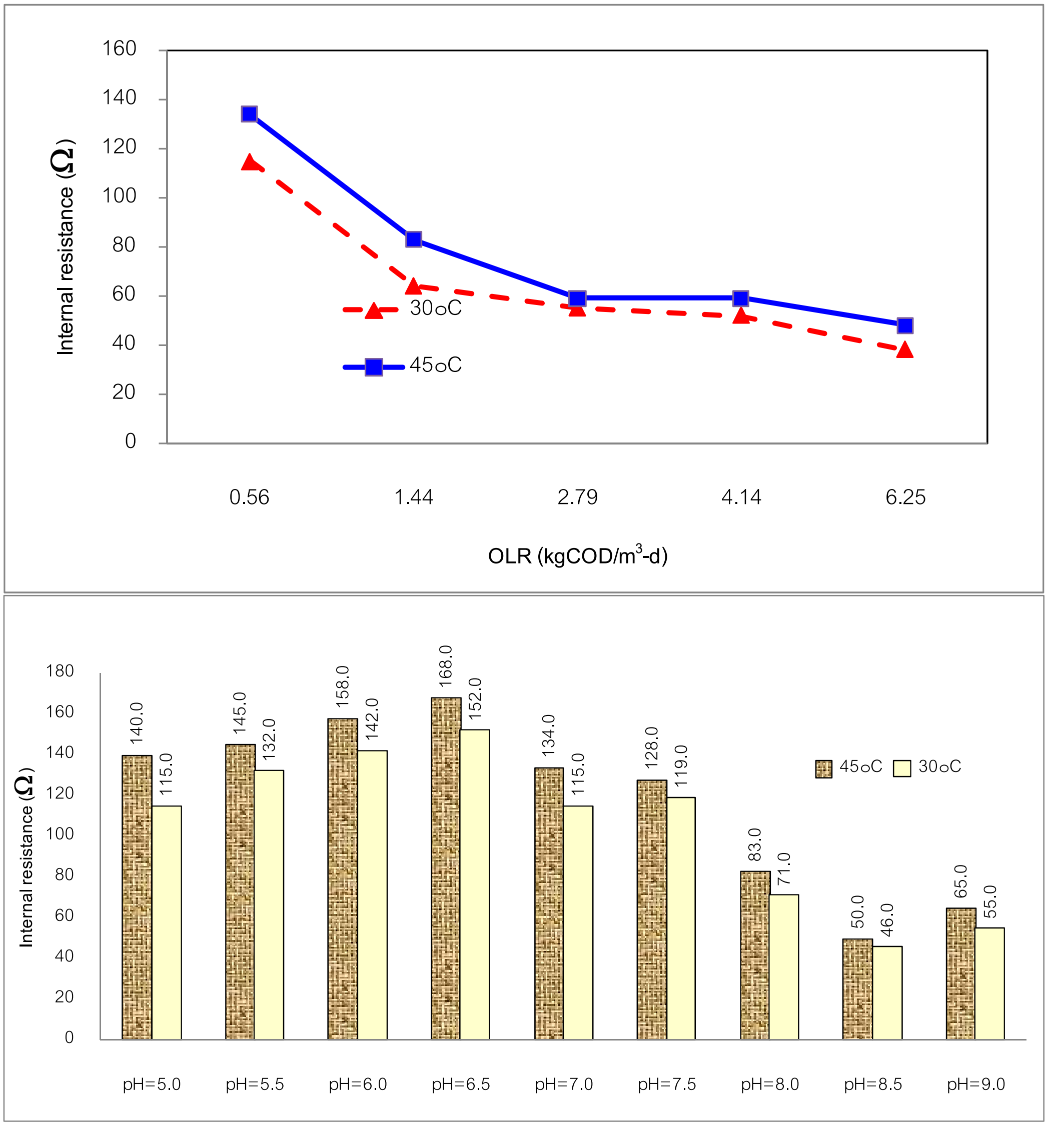



Figure 4.23: The internal resistance: (a) in terms of OLR, (b) in terms of pH feed

## 4.4 Microbial communities

Bacteria samples were collected from the bottom of the anode chamber at the end of batch on both operating temperatures (0.56 kg-COD/$m^3$-d, pH of 7.0). Based on the PCR-DGGE method, the structures of the microbial communities in the anodes of the coupled MFCs at both operating temperatures were determined using DGGE analysis. Figure 4.24 presents the DGGE profiles of the microorganisms in anode chamber. Each band on the

DGGE profile represents a specific species in the microbial community, and the staining intensity of a band represents the relative abundance of the corresponding microbial species. There was diversity of the microbial community at both temperatures operation. The bands were cut for 5 bands of both temperatures operation to study the microbial community. The band number of 23, 24, 25, 26 and 31 at 30°C and 7, 9, 10, 15 and 20 at 45 °C were cut for sequencing analysis.

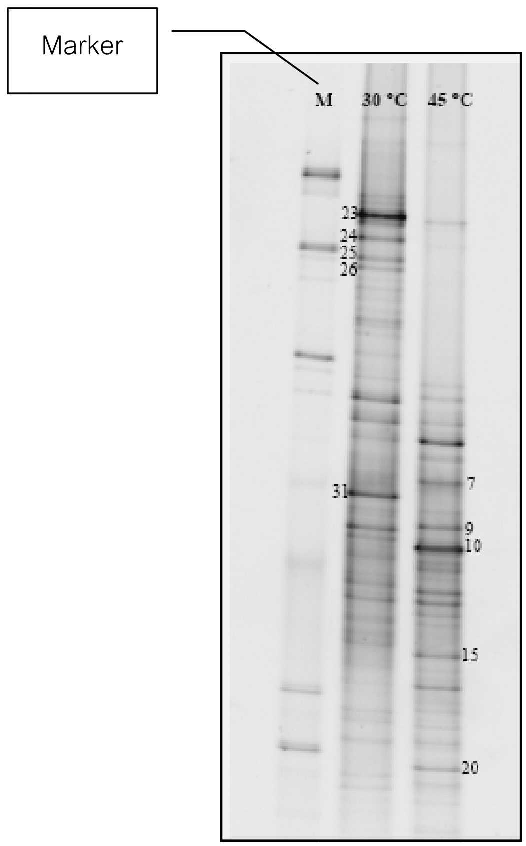



**Figure 4.24: PCR-DGGE fingerprints for bacterial communities in MFC. Each lane contains PCR-amplified 16S rRNA gene fragments from 30°C and 45°C. Lanes labeled M contain a reference fingerprint used to correct for differences in fragment migration across the gel.**

At both operating temperatures, a number of bands from the gels were cut for sequence analysis as shown in Table 4.25 - 4.26, Figure 4.25 - 4.26. At 30°C the population could be assigned to four groups: Gammaproteobacteria, Betaprotobacteria, Bacteroidetes and Firmicutes. At 45°C the population could be assigned to three groups: Gammaproteobacteria, Betaprotobacteria and Firmicutes. These population groups are similar to those found by Hou, et al., (2012).

Table 4.25: The sequencing results from 30°C

| DGGE band | Phylogenetic affiliation | Closest relative (accession no.) | Similarity (%) |
|---|---|---|---|
| 30-24 | Firmicutes | *Lysinibacillus* sp. *YC12 (JQ446580)* | 100 |
| | | *Bacillus* sp. *YC8 (JQ446579)* | 100 |
| | | *Lysinibacillus fusiformis* strain *KNUC423 (JQ071512)* | 100 |
| 30-23 | Firmicutes | *Lysinibacillus* sp. *YC12 (JQ446580)* | 99 |
| | | *Bacillus* sp. *YC8 (JQ446579)* | 99 |
| | | *Lysinibacillus fusiformis* strain *KNUC423 (JQ071512)* | 99 |
| 30-25 | Bacteroidetes | *Uncultured bacterium clone 265MICC biofilm (JF342101)* | 96 |
| | | *Uncultured bacterium clone ABRB03 (HQ224792)* | 95 |
| | | *Uncultured bacteroidetes bacterium clone RBE2CI-87 (EF111175)* | 95 |
| 30-26 | Betaproteobacteria | *Uncultured bacterium clone nbw388g05c1 (GQ096482)* | 90 |
| | | *Uncultured bacterium clone 8484F020996 (JN199259)* | 90 |
| | | *Acidovorax* sp. *KBT209 (AB547157)* | 90 |
| 30-31 | Gammaproteobacteria | *Stenotrophomonas* sp. *GCDP4_I (JQ072086)* | 98 |
| | | *Stenotrophomonas acidaminiphila* strain *CCUG 54933 (GU945535)* | 98 |
| | | *Uncultured Xanthomonadales bacterium clone MFC63F02 (FJ823918)* | 98 |

Table 4.26: The sequencing results from 45°C

| DGGE band | Phylogenetic affiliation | Closest relative (accession no.) | Similarity (%) |
|---|---|---|---|
| 45-7 | Betaproteobacteria | *Uncultured bacterium clone: PLLA-4 (AB596952)* | 98 |
| | | *Comamonas sp. EB172 (EU847238)* | 98 |
| | | *Comamonas terrigena strain: NBRC 12685 (AB680315)* | 97 |
| 45-10 | Betaproteobacteria | *Soil bacterium Peni-S1T-M1LLLSSL-3 (EU515501)* | 98 |
| | Gammaproteobacteria | *Silanimonaslenta strain L-bf-PMW-29.5 (FR774582)* | 97 |
| | Betaproteobacteria | *Burkholderia phytofirmans isolate PSB48 (HQ242761)* | 97 |
| 45-9 | Gammaproteobacteria | *Uncultured bacterium clone CVMbac91 (JF922902)* | 99 |
| | | *Silanimona slenta* strain *L-bf-PMW-29.5 (FR774582)* | 99 |
| | Betaproteobacteria | *Burkholderia multivorans* strain *103104 (FJ932759)* | 97 |
| 45-15 | Betaproteobacteria | *Uncultured Burkholderia* sp. *clone AG12P* | 92 |
| | | *Burkholderia sp. TSH27* | 90 |
| | | *Burkholderia vietnamiensis* | 89 |
| 45-20 | Firmicutes | *Uncultured bacterium clone env_seq_267-3 (GQ983135)* | 99 |
| | | *Uncultured Firmicutes bacterium clone BM70 (JN412195)* | 96 |
| | | *Clostridium* sp. *6-31 (FJ808611)* | 96 |

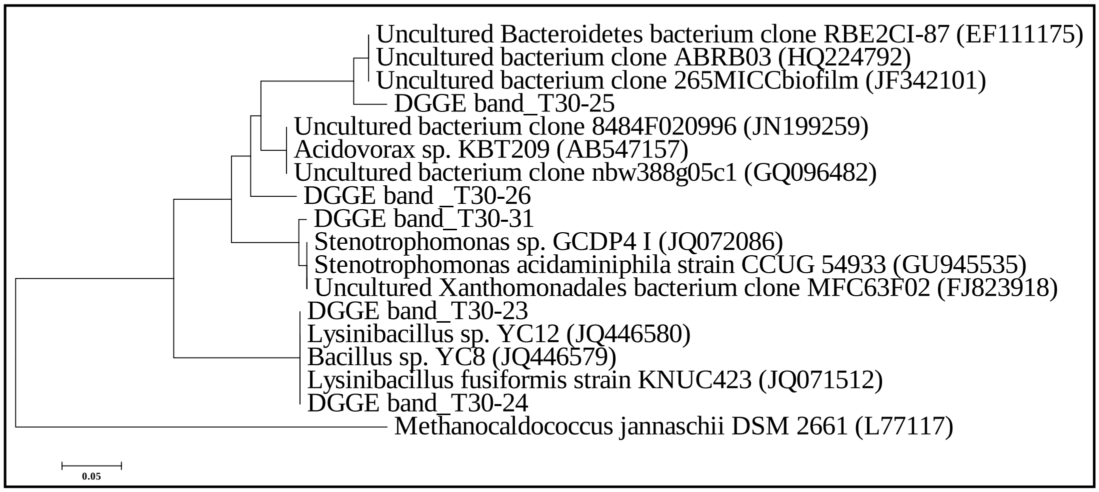



Figure 4.25: Phylogenetic tree recovered from sludge in anode chamber at 30°C

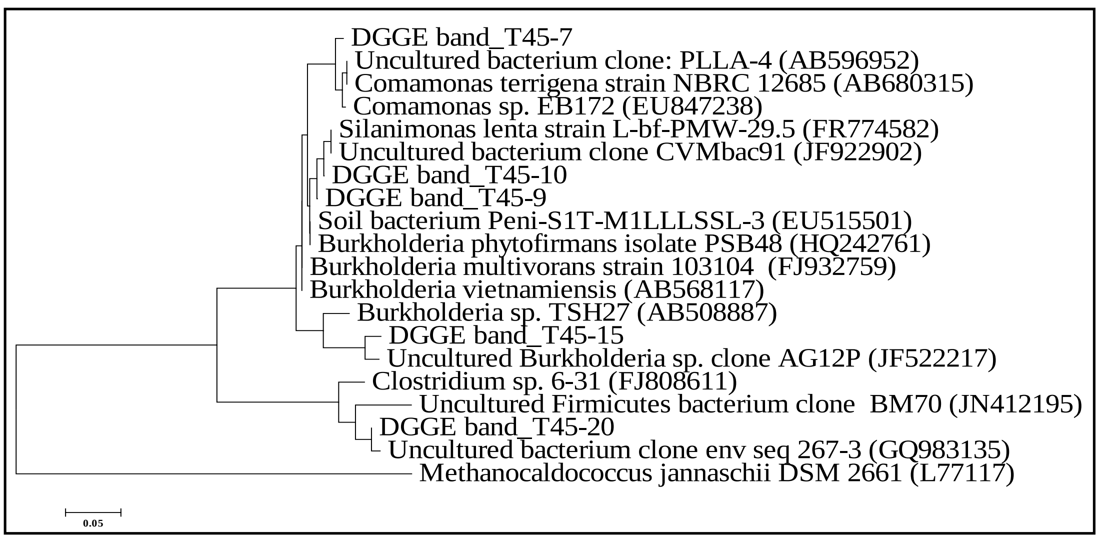



Figure 4.26: Phylogenetic tree recovered from sludge in anode chamber at 45°C

The Bacteroidetes mainly included several fermentative bacteria which were induced by the anaerobic environment. They were found in 30°C operation. We found new bacteria but could not define the specific species. Firmicutes was reported to be integral members of the MFC bacterial community, indicating their exocellular electron transfer. Some Gammaproteobacteria are methane oxidizers and sulfate-reducing bacteria. They were observed in the MFCs at both operating temperature. The Betaproteobacteria included several groups of aerobic or facultative bacteria. That was possibly due to oxygen diffused into anode chamber, which might support aerobic facultative growth.

Comparison of the bacterial communities in the MFCs from this study and previous study is shown in Table 4.26.

Table 4.27: Comparison of the bacterial communities in the MFCs from this study and previous study

| Substrate | Conditions | Phylogenetic affiliation | Reference |
|---|---|---|---|
| Cassava wastewater | pH = 7.0, 30°C, Single chamber | Firmicutes, Bacteroidetes, Betaproteobacteria, Gammaproteobacteria | This study |
| | pH = 7.0, 45°C, Single chamber MFC | Firmicutes, Betaproteobacteria Gammaproteobacteria | |
| Acetate | pH = 7.0, 28°C, Two chamber MFC | Betaproteobacteria, Alfaproteobacteria Deltaproteobacteria, Bacteria | Chae, et.al., (2009) |
| Propionate | | Gammaproteobacteria, Betaproteobacteria, Alfaproteobacteria Deltaproteobacteria, Firmicutes | |
| Butyrate | | Betaproteobacteria, Alfaproteobacteria Deltaproteobacteria, Firmicutes | |
| Glucose | | Betaproteobacteria, Deltaproteobacteria Firmicutes, Clorobia, Actinobacteria Bacteria | |
| Chocolate industry | pH = 7.0, 28°C, Two chamber MFC | Betaproteobacteria, Proteobacteria Alfaproteobacteria, Unclassified bacteria Nitrospora, Firmicutes, Spirochate Bacteroides, Gammaproteobacteria | Patil, et.al., (2009) |
| Glucose and indole wastewater | 30°C, Single chamber MFC | *Enterobacter* sp., Uncultured *Geobacter* sp., Unculture bacterium, *Desulfovibrio* sp. | Luo, et.al., (2010) |
| Diesel wastewater | 30°C, Two chamber MFC | *Citrobacter* sp., *Pseudomonas* sp., *Stenotrophomonas* sp., *Shewanella* sp. and *Alishewanella* sp. | Morris, et.al., (2009) |
| Acetate | 30°C, Single chamber MFC | *Azospira* sp., *Acidovorax* sp., *Comamonas* sp. | Borole, et.al., (2009) |

# CHAPTER V

# CONCLUSIONS

The results of the study and conclusions were list as the following;

1. Cassava wastewater can be treated effectively by a single microbial fuel cell at 30°C and 45°C temperature with COD removal efficiency of 91.44 ± 0.72% and 90.72 ± 0.87%, respectively at the OLR of 0.56 kg-COD/$m^3$-d and pH 7.0 both of temperatures operation.
2. The performance of COD removal decreased when increased the OLR. As the OLR of 6.25 kg-COD/$m^3$-d, the COD removal was 73.67± 2.99% and 70.74± 1.72% % of temperature at 30°C and 45°C temperature respectively.
3. At pH 7.0, the average power density of 8.18 W/$m^3$ and 7.19 W/$m^3$ could be obtained at OLR of 0.56 kg-COD/$m^3$-d and obtained from OLR of 6.25 kg-COD/$m^3$-d was 28.66 W/$m^3$ and 27.81 W/$m^3$.
4. CE and internal resistance of cassava wastewater treatment by microbial fuel cell were increased when decreasing the OLR. The maximum CE achieved from OLR of 0.56 kg-COD/$m^3$-d as 30.2 % and 28.5% at 30°C and 45°C respectively.
5. At the OLR of 0.56 kg-COD/$m^3$-d, cassava wastewater could be treated effectively at 30°C and 45°C temperature with the maximum COD removal efficiency of 96.77 ± 0.93% and 95.93 ± 1.44% respectively at the pH of 7.5.
6. The performance of COD removal depended on the pH feed. As the pH of 5.0, the COD removal was 81.19±1.10% and 77.21±1.42% % of temperature at 30°C and 45°C temperature respectively.
7. At the OLR of 0.56 kg-COD/$m^3$-d, the average power density of 30.30 W/$m^3$ and 26.06 W/$m^3$ could be obtained at pH of 8.5 at 30°C and 45°C temperature, respectively and obtained from pH of 6.5 was 4.44 W/$m^3$ and 3.66 W/ $m^3$ at 30°C and 45°C temperature, respectively.

8. CE and internal resistance of cassava wastewater treatment by microbial fuel cell were different with pH feed. The maximum of coulombic efficiency was obtained from pH 8.5 which was 52.9% at 30 °C and 50.6% at 45 °C.
9. The microbial communities in the anode of a single chamber microbial fuel cell under 30°C could be divided into four groups as Gammaproteobacteria, Betaprotobacteria, Bacteroidetes and Firmicutes.
10. Under 45°C operation, the microbial communities could be divided into three groups as Gammaproteobacteria, Betaprotobacteria and Firmicutes.
11. The microbial communities included several fermentative bacteria, exocellular electron-transfer, methane oxidizers, sulfate-reducing bacteria and groups of facultative bacteria.

Suggestions for the future works

1. To examine the continuous in feeding operation mode of cassava wastewater.
2. Improvement the others materials for cathode or anode to lower their cost.
3. Scaling up the microbial fuel cells.

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# Appendices

# Appendix A

## BASIC OF POWER GENERATION AND EXPERIMENTAL SET-UP

# Power generation

## A.1 Power calculation

The principle of calculation the power generated from MFC is the general power calculation as euation A.1

$$P = IE_{MFC} \qquad \text{(A.1)}$$

Where P = Power generation from MFC (Watt)

I = Current (Ampere)

$E_{MFC}$ = Circuit voltage (Volt)

The current is proporsion of external resistant as in equation A.2

$$I = \frac{E_{MFC}}{R_{ext}} \qquad \text{(A.2)}$$

Where, I = Current (Ampere)

$E_{MFC}$ = Circuit voltage output from MFC (Volt)

$R_{ext}$ = External resistant (ohm)

Because the current generation from MFC is a few so the power can calculate by the circuit voltage as in equation A.3

$$P = \frac{E_{MFC}^2}{R_{ext}} \qquad \text{(A.3)}$$

Where P = Power generation from MFC (Watt)

$E_{MFC}$ = Circuit voltage output from MFC (Volt)

$R_{ext}$ = External resistant (ohm)

Comparision the power generation from MFC considered into the surface area of anode electrode or volume of solubility in anode chamber. This concept is from the electron generated by substrate degradation by microorganism and the anode electrode is served as electron acceptor in redox reaction. So the comparision of power generation from MFC is as equation A.4 or A.5

$$P = \frac{E_{MFC}^2}{A_{An}R_{ext}} \quad \text{(A.4)}$$

$$P = \frac{E_{MFC}^2}{V_{An}R_{ext}} \quad \text{(A.5)}$$

Where P = Power generation from MFC (Watt/$m^2$ or Watt/$m^3$)

$E_{MFC}$ = Circuit voltage output from MFC (Volt)

$R_{ext}$ = External resistant (ohm)

$A_{An}$ = Surface area of anode electrode ($m^2$)

$V_{An}$ = Volume of solubility in anode chamber ($m^3$)

**A.2 Calculation of internal resistant**

The less of power generation from MFC is due to high internal resistant of MFC. The resistant of MFC is as the series of external resistant and internal resistant. So the power generation from MFC due to their internal resistant and external resistant is as equation A.6.

$$P = \frac{E_{MFC}^2}{R_{ext}+R_{int}} \quad \text{(A.6)}$$

Where P = Power generation from MFC (Watt)

$E_{MFC}$ = Circuit voltage output from MFC (Volt)

$R_{ext}$ = External resistant (ohm)

$R_{int}$ = Internal resistant (ohm)

The power generation from MFC is the maximum when there are not connect to external resistant which call as open circuit (OCV). Calculation the maximum power generation from MFC is as in equation A.7

$$P_t = \frac{OCV^2}{R_{ext}+R_{int}} \qquad \text{(A.7)}$$

Where $P_t$ = Power generation from MFC (Watt)

OCV = Open circuit voltage (volt)

$R_{ext}$ = External resistant (ohm)

$R_{int}$ = Internal resistant (ohm)

The objective of MFC is focus on the maximum of power generation and determine by equation A.8

$$P_{max} = \frac{(OCV^2)(R_{ext})}{(R_{ext}+R_{int})^2} \qquad \text{(A.8)}$$

Where $P_{max}$ = The maximum power generation from MFC (watt)

OCV = Open circuit voltage (volt)

$R_{ext}$ = External resistant (ohm)

$R_{int}$ = Internal resistant (ohm)

### A.3 Coulombic efficiency

Coulombic efficiency (CE) is the term of recovery of electron transferred in MFC system. The goal of MFC system is seek to axtract as much of electrons stored in the biomass as possible as current and to recover as much energy as possible from the system. CE defined as the fraction of electron recovered as current versus that in the starting organic matter. The oxidation of a substrate occurs with the removal of electrons, with the moles of electron defined for each substrate base on writing out a half reactio and an ampare is defined as the transfer of 1 coulomb of charge per second. So CE can determine by equation A.9

$$C_E = \frac{(M_s)\int_0^{tb} I dt}{(F)(b_{es})(V_{An})(\Delta C)} \quad \text{(A.9)}$$

Where $C_E$ = Coulombic efficiency (%)

$M_S$ = Molecular weight of substrate (g/mol)

I = Output current (A = C/s)

F = Faraday's constant (96,485 C/mol)

$V_{An}$ = Volume of solubility in anode chamber ($m^3$)

$\Delta C$ = Substrate reducing ($g/m^3$)

$t_b$ = Time (s)

$b_{es}$ = Available electron transfered in substrate (mol)

From the equation A.9, if substrate is wastewater which defined as COD and operated in continueous mode, the CE is as equation A.10

$$C_E = \frac{8I}{(F)(Q)(\Delta COD)} \quad \text{(A.10)}$$

Where I = Current (A = C/s)

F = Faraday's constant (96,485 C/mol)

Q = Flowrate of wastewater in anod chamber ($m^3/s$)

$\Delta COD$ = COD removal ($g/m^3$)

8 = The fraction of $M_s$ to $b_{es}$ (In this condition, $M_{O2}$=32 g/mol, $b_{es}$=4)

A.4 Efficiency of energy from MFC

Efficiency of energy from MFC is the fraction of power output versus the heat in wastewater as in equation A. 11

$$\eta_{MFC} = \frac{\int_0^{tb} E_{MFC} I dt}{(n_s)(\Delta H)}(100) \quad \text{(A.11)}$$

Where $\eta_{MFC}$ = Efficiency of energy (%)

$n_S$ = Amount of substrate added (mol)

$\Delta H$ = The heat of combustion (J/mol)

From equetion A.11, if the substrate is wastewater which is defined as COD and operate in contineuous mode, so the efficiency of power from MFC is as equation A.12

$$\eta_{MFC} = \frac{(E)(I)}{(Q)(\Delta H)(\Delta COD)} \quad \text{(A.12)}$$

Where I = Current (A = C/s)

E = Maximum circuit voltage (Volt)

Q = Flowrate of wastewater in anod chamber ($m^3$/s)

$\Delta COD$ = COD removal (g/$m^3$)

$\Delta H$ = 14.7 (KJ/g COD)(Shizas and Bagley, 2004)

General of MFC system, there are efficiency of power as the range from 2% to 50% when easily biodegradable substrates are used and comparision to electric energy efficiency for thermal conversion of methane is less than 40% (Logan, 2006).

## A.5 Polarization and power density curves.

The OCV measured for an MFC is the maximum voltage that can be obtained with the system, with the limitation imposed by the specific bacterial community and the obtained OCP of the cathode. For an MFC, as with any power source, the objective is to maximize power output and therefore to obtain the highest current density under condition of the maximum potential. The OCV is only achieved under the condition where there is infinite resistance.

A polarization curve is used to characterize current as a function of voltage. By changing the circuit external resistant, the new voltage is obtained, and hence a new different resistances on the circuit, measuring the voltage at each resistance. The current is calcutated by fraction of circuit voltage versus external resistant or current density normalizing by an electrode surface area or volume of solubility in anode chamber. Then plot the voltage versus current to obtain the polarization curve. This curve show how well the MFC maintains a voltage as a fuction of current production and the maximum power from the polarization curve is deviced for comparision of power output and internal resistant from MFC.

## A.6 MFC internal resistance

There is a direct linear relationship between the voltage produced and current density, which can be express as equation A.13.

$$E_{emf} = OCV^{*} - IR_{int} \qquad \text{(A.13)}$$

Where $E_{emf}$ = The intrinsic maximum possible potential due to the chemical reactions at the anode and cathode (Volt)

OCV* = Opened circuit voltage of y-intercept of the equation A.13 (volt)

I = Current (Ampere)

$R_{int}$ = Summation of internal resistant (Volt)

There are different methods to evaluate the internal resistance MFC as follow;

1. Polarization slope,
2. Power density peak,
3. Electrochemical impedence spectroscopy (EIS) using Nyquist plot
4. Current interrupt method

*Polarization slpoe method*

The slope of a plot of current versus measure voltage from equation A.13 is $R_{int}$. As long as the polarization curve is linear, the internal resistance is easily obtained over the region of interest from the slope from the polarization curve.

*Power density peak method*

As the equation of A.8, The maximum power occurs at the point of internal resistance equal to external resistance. Thus the internal resistance identify by noting the external resistance that produced the peak power output.

*Electrochemical impedance spectroscopy method (EIS)*

This method is preferred compared to the above two methods as the dynamic response of the system is measured and nedd to potentiostat with EIS software to obtain data. EIS is base on superimposing a sinusoidal signal with small amplitude on the applied potential of working electrode. By varying the frequency of the sinusoidal signal over a wide range, detailed information can be obtained on the system by plotting the measure electrode impedance.

*Current interupt method (EIS)*

The current interrupt method requires the use of a potentiostat, and accurate determination of the potential after interrupting the current requires a very fast recording of the potential. The MFC should be operated under steady conditions where there are no concentration losses. To apply the method, the electrical circuit is opened producing zero current and initial steep rises in voltage. This is followed by a slower and further increase of the potential which will eventually reach the OCV.

The ohmic losses are proporsional to the current as in equation A.14.

$$E_{emf} = E^0 - (\sum OP_{An} + |\sum OP_{Cat}| + IR_{\Omega}) \quad \text{(A.14)}$$

| | | |
|---|---|---|
| Where $E_{emf}$ | = | The intrinsic maximum possible potential due to the chemical reactions at the anode and cathode (Volt) |
| $\sum OP_{An}$ | = | The overpotential of the anode (Volt) |
| $\|\sum OP_{Cat}\|$ | = | The overpotential of the cathode (Volt) |
| $IR_{\Omega}$ | = | Ohmic losses (Volt) |

When the current is interrupted the ohmic losses instantaneously disappear. This produces the steep rise in the potential that is proporsional to $R_{\Omega}$ and the current that was produced before the interruption. The ohmic resistant is obtained using Ohms law, as $R_{\Omega} = E_R/I$. The electrode over potential thas that occurred during currents generation are evidenced by the additional slower increase of the potential as it approaches the OCV.

A.7 Experimental set up

This study was performed in a lab-scale experimental set-up at the faculty of Science and Engineering at Kasertsart Chalermprakait Sakon Nakhon province campus, Thailand. Most parameters were analyzed at Kasertsart Chalermprakait Sakon Nakhon province campus, and some were analyzed at the National Center for Genetic Engineering and Biotechnology (BIOTEC)Thailand. The wastewater was examined using the standard method for examining water and wastewater (APHA, 1998). The SCMFC and laboratory set-up are shown in Figure A.1.

Figure A.1: The experimental set-up

In July 2009, an SCMFC was set up and connected to the data logger and equipments. it was initially difficult to control leakage. The leakage occurred at the contact surface between the end of the acrylic tube and the cover at both sides (anode and cathode).  When we cut the acrylic tube it was hard to smooth the cutting surface and that rough surface cause easy leakage. We solved this problem by using the O-ring to fit with its covers. The other problems were from anode electrode and the connection wire. That anode was made from a carbon cloth which could float in the aqueous solution and sometimes it touched the cathode electrode which was installed at the opposite side, causing a short circuit (the voltage was show as 0 V). The connection wire was easily torn due to the corrosion by the wastewater. Figure A.2 (a), (b) and (c) show the first SCMFC, the anode with a connection wires and parts of SCMFC.

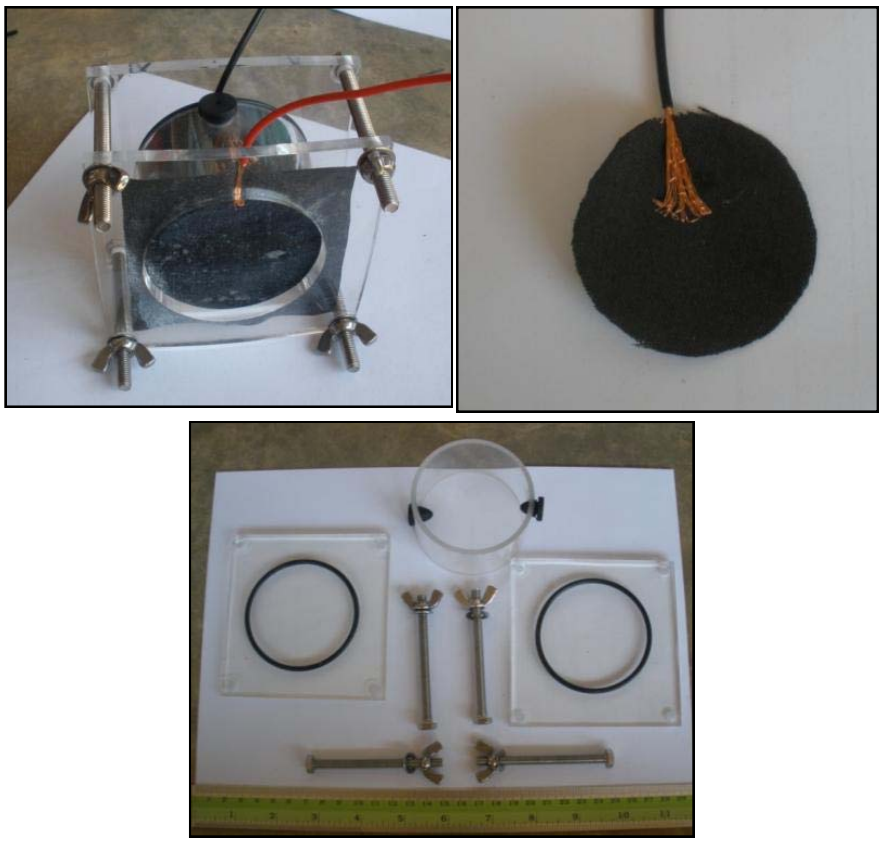

Figure A.2: The first SCMFC

(a) Configuration of the first SCMFC (b) anode electrode (c) parts of SCMFC

From April, 2011 to December, 2011, the new SCMFC was set up in a new experiment that amended the problems of the previous experiment. The reactor was made from polyvinyl chloride of 3-inch diameter. The anode electrode was fixed by the aluminum screen which was easy for installation and connection (Figure A.3).

Figure A.3: New SCMFC

(a) Configuration of the new SCMFC (b) anode electrode (c) cathode electrode

# Appendix B

# DATAS FROM THE STUDY

# DATA FROM THE STUDY

## The result of part 1

COD in the effluent of Part 1

| Hour | 45°C | | | | | 30°C | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 0.56 $kg/m^3$-d | 1.44 $kg/m^3$-d | 2.79 $kg/m^3$-d | 4.14 $kg/m^3$-d | 6.25 kg/m3-d | 0.56 $kg/m^3$-d | 1.44 $kg/m^3$-d | 2.79 $kg/m^3$-d | 4.14 $kg/m^3$-d | 6.25 kg/m3-d |
| 22 | 608 | 1,700 | 4,090 | 5,683 | 8,432 | 712 | 1,208 | 3,692 | 4,156 | 8,215 |
| 66 | 451 | 1,089 | 2,550 | 2,515 | 8,592 | 425 | 1,027 | 3,514 | 3,652 | 8,167 |
| 110 | 451 | 1,551 | 1,787 | 2,951 | 8,656 | 273 | 1,118 | 2,259 | 4,475 | 7,338 |
| 176 | 248 | 1,574 | 3,324 | 3,738 | 8,459 | 184 | 1,613 | 2,439 | 5,410 | 8,066 |
| 198 | 207 | 1,062 | 2,046 | 3,954 | 6,377 | 108 | 994 | 2,951 | 3,738 | 7,710 |
| 220 | 160 | 1,023 | 2,518 | 3,246 | 6,689 | 95 | 984 | 2,125 | 3,511 | 7,475 |
| 242 | 171 | 905 | 1,416 | 2,557 | 6,768 | 114 | 630 | 1,220 | 2,066 | 6,295 |
| 264 | 140 | 1,023 | 1,889 | 2,636 | 6,984 | 112 | 669 | 1,102 | 2,164 | 6,689 |
| 330 | 121 | 944 | 1,377 | 2,648 | 6,295 | 108 | 650 | 1,377 | 2,164 | 5,902 |
| 352 | 133 | 864 | 1,889 | 2,736 | 5,115 | 106 | 787 | 1,141 | 2,361 | 4,525 |
| 374 | 121 | 560 | 1,859 | 2,859 | 3,699 | 102 | 820 | 1,534 | 2,391 | 3,654 |
| 396 | 143 | 543 | 1,823 | 2,481 | 3,744 | 80 | 630 | 1,101 | 2,202 | 3,432 |
| 418 | 118 | 541 | 1,416 | 2,116 | 3,219 | 84 | 436 | 1,159 | 2,042 | 3,368 |
| 484 | 105 | 524 | 1,282 | 2,031 | 3,595 | 84 | 380 | 1,177 | 1,826 | 3,252 |
| 506 | 110 | 495 | 1,462 | 2,080 | 3,579 | 92 | 442 | 1,328 | 1,714 | 3,429 |
| 528 | 90 | 502 | 1,313 | 2,030 | 3,612 | 108 | 415 | 1,052 | 1,552 | 3,377 |
| 550 | 88 | 486 | 1,323 | 2,091 | 3,602 | 96 | 343 | 1,191 | 1,859 | 3,323 |
| 572 | 94 | 415 | 1,147 | 2,029 | 3,705 | 92 | 353 | 1,052 | 1,895 | 3,206 |
| 638 | 95 | 446 | 1,240 | 1,892 | 3,416 | 84 | 361 | 1,052 | 1,680 | 3,243 |
| 660 | 88 | 432 | 1,323 | 1,780 | 3,580 | 92 | 346 | 1,020 | 1,890 | 3,102 |
| 682 | 95 | 453 | 1,264 | 1,658 | 3,453 | 95 | 395 | 1,006 | 1,604 | 3,196 |
| 704 | 89 | 459 | 1,209 | 1,559 | 3,268 | 84 | 302 | 1,085 | 1,756 | 2,192 |
| 726 | 96 | 454 | 791 | 1,688 | 3,253 | 84 | 316 | 949 | 1,744 | 2,688 |
| 814 | 94 | 490 | 1,042 | 1,610 | 3,068 | 82 | 474 | 941 | 1,534 | 2,853 |
| 836 | 95 | 480 | 949 | 1,772 | 3,218 | 83 | 316 | 953 | 1,542 | 2,876 |

Note. 1. The unit of COD as mg/L

pH in the effluent of part 1

| Hour | 45 °C | | | | | 30 °C | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 0.56 $kg/m^3$-d | 1.44 $kg/m^3$-d | 2.79 $kg/m^3$-d | 4.14 $kg/m^3$-d | 6.95 kg/m3-d | 0.56 $kg/m^3$-d | 1.44 $kg/m^3$-d | 2.79 $kg/m^3$-d | 4.14 $kg/m^3$-d | 6.95 kg/m3-d |
| 22 | 7.09 | 7.06 | 6.74 | 6.85 | 6.85 | 6.84 | 6.63 | 7.01 | 7.01 | 6.99 |
| 44 | | 6.81 | 7.03 | 6.9 | 6.66 | | 6.61 | 6.99 | 6.99 | 7.07 |
| 66 | | 6.92 | 6.94 | 6.92 | 7.09 | | 7.02 | 7.08 | 7.08 | 7.08 |
| 88 | 6.63 | 6.99 | 6.89 | 7.08 | 7.08 | 6.64 | 7.04 | 7.08 | 7.08 | 7.06 |
| 154 | 7.09 | 7.02 | 6.78 | 6.8 | 6.61 | 6.66 | 6.67 | 7.09 | 7.09 | 6.75 |
| 176 | 6.84 | 7.09 | 6.64 | 6.89 | 6.93 | 6.68 | 6.78 | 7.08 | 7.08 | 6.69 |
| 198 | | 6.64 | 6.7 | 7.08 | 7.08 | | 6.64 | 6.83 | 6.83 | 6.87 |
| 220 | | 6.88 | 6.79 | 6.99 | 7.05 | | 7.04 | 7.09 | 7.09 | 6.68 |
| 242 | 6.67 | 7.01 | 6.87 | 6.92 | 6.84 | 6.84 | 6.61 | 7.08 | 7.08 | 6.83 |
| 308 | 6.84 | 6.73 | 6.73 | 6.94 | 6.63 | 6.74 | 6.91 | 6.97 | 6.97 | 7.06 |
| 330 | 6.96 | 6.91 | 6.68 | 7.06 | 7.03 | 7.07 | 6.62 | 7.08 | 7.08 | 7.08 |
| 352 | | 6.88 | 6.8 | 7.02 | 6.83 | | 7.09 | 6.84 | 6.75 | |
| 374 | | 7.03 | 6.84 | 6.93 | 6.66 | | 6.88 | 6.83 | 6.83 | 6.82 |
| 396 | 6.83 | | 6.68 | 7.04 | 7.04 | 6.84 | 7.09 | 7.01 | 7.01 | 6.62 |
| 462 | 6.78 | 7.09 | 6.89 | 6.96 | 6.73 | 6.68 | 6.64 | 6.88 | 6.88 | 6.89 |
| 484 | | 7.04 | 6.71 | 6.89 | 6.94 | | 6.75 | 6.94 | 6.94 | 6.83 |
| 506 | | 7.04 | 6.64 | 6.76 | 6.93 | | 6.93 | 6.94 | 6.94 | 6.86 |
| 528 | | 7.02 | 6.98 | 6.65 | 7 | | 6.77 | 7.02 | 7.02 | 6.89 |
| 550 | 6.89 | 6.96 | 6.75 | 7.04 | 6.93 | 6.68 | 6.68 | 6.94 | 6.94 | 7.02 |
| 616 | 6.87 | 7.05 | 6.86 | 7.09 | 7.06 | 6.85 | 7.07 | 7.09 | 7.09 | 6.85 |
| 638 | 6.76 | 6.91 | 6.83 | 6.93 | 6.85 | 6.87 | 6.78 | 7.09 | 7.09 | 6.99 |
| 660 | | 6.94 | 6.98 | 7.07 | 6.87 | | 6.98 | 7.06 | 7.06 | 6.75 |
| 682 | | 6.87 | 6.84 | | 7.04 | | 7.04 | | | 6.85 |
| 792 | | 6.9 | 6.73 | 6.97 | 6.97 | | | | | 7.05 |
| 814 | | 7.08 | 6.63 | 7.02 | 7.09 | | 6.83 | 6.99 | 6.99 | 6.86 |

Sulfate in the effluent of part 1

| Hour | 45 °C | | | | | 30 °C | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 0.56 kg/m³-d | 1.44 kg/m³-d | 2.79 kg/m³-d | 4.14 kg/m³-d | 6.25 kg/m³-d | 0.56 kg/m³-d | 1.44 kg/m³-d | 2.79 kg/m³-d | 4.14 kg/m³-d | 6.25 kg/m³-d |
| 22 | 77 | 271 | 358 | 737 | 1,698 | 74 | 124 | 200 | 365 | 1,053 |
| 44 | | 193 | 253 | 517 | 1,463 | | 102 | 174 | 320 | 1,042 |
| 66 | | 205 | 260 | 557 | 1,452 | | 94 | 178 | 302 | 890 |
| 88 | 71 | 222 | 254 | 592 | 1,331 | 53 | 163 | 183 | 315 | 1,065 |
| 154 | 24 | 228 | 266 | 542 | 1,357 | 57 | 105 | 178 | 292 | 932 |
| 176 | 88 | 203 | 275 | 503 | 1,381 | 52 | 99 | 161 | 294 | 910 |
| 198 | | 228 | 256 | 508 | 1,312 | | 101 | 183 | 359 | 1,000 |
| 220 | | 206 | 274 | 548 | 1,343 | | 97 | 156 | 333 | 1,065 |
| 242 | 33 | 233 | 272 | 528 | 1,495 | 49 | 117 | 150 | 355 | 1,049 |
| 308 | 35 | 194 | 263 | 551 | 1,334 | 36 | 88 | 150 | 325 | 896 |
| 330 | 45 | 227 | 272 | 510 | 1,346 | 82 | 97 | 150 | 296 | 937 |
| 352 | | 236 | 275 | 527 | 1,341 | | 107 | 159 | 302 | |
| 374 | | 220 | 276 | 570 | 1,460 | | 114 | 163 | 311 | 1,075 |
| 396 | 68 | | 270 | 513 | 1,435 | 61 | 94 | 195 | 321 | 1,037 |
| 462 | 57 | 229 | 253 | 564 | 1,407 | 44 | 118 | 172 | 319 | 1,015 |
| 484 | | 195 | 284 | 558 | 1,396 | | 99 | 189 | 292 | 890 |
| 506 | | 240 | 255 | 561 | 1,414 | | 116 | 161 | 373 | 869 |
| 528 | | 223 | 270 | 542 | 1,391 | | 123 | 173 | 329 | 1,009 |
| 550 | 82 | 225 | 294 | 547 | 1,351 | 98 | 118 | 163 | 346 | 1,074 |
| 616 | | 209 | | 550 | 1,498 | | 111 | 169 | 372 | 918 |
| 638 | | 203 | 287 | 550 | 1,488 | | 111 | 168 | 341 | 871 |
| 660 | | 197 | 281 | 519 | 1,402 | | 120 | 155 | 310 | 1,047 |
| 682 | | 222 | 277 | 512 | 1,440 | | 142 | 170 | 364 | 997 |
| 792 | | 204 | 277 | 561 | 1,438 | | 116 | 188 | 335 | 1,050 |
| 814 | | 200 | 287 | 566 | 1,440 | | | | 308 | |

Note. 1. The unit of sulfate as mg/L

Alkalinity in the effluent of part 1

| ชั่วโมง | 45 °C | | | | | 30 °C | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 0.56 kg/m$^3$-d | 1.44 kg/m$^3$-d | 2.79 kg/m$^3$-d | 4.14 kg/m$^3$-d | 6.25 kg/m$^3$-d | 0.56 kg/m$^3$-d | 1.44 kg/m$^3$-d | 2.79 kg/m$^3$-d | 4.14 kg/m$^3$-d | 6.25 kg/m$^3$-d |
| 22 | 180 | 1,885 | 3,000 | 3,160 | 6,300 | 180 | 1,850 | 3,000 | 3,010 | 2,850 |
| 44 | | 1,527 | 2,000 | 2,360 | 2,880 | | 1,100 | 1,580 | 2,340 | 2,000 |
| 66 | | 1,760 | 2,460 | 1,990 | 2,780 | | 1,680 | 2,090 | 2,980 | 1,660 |
| 88 | 250 | 1,380 | 1,260 | 1,740 | 2,620 | 180 | | | | |
| 154 | 180 | | | | | 250 | | | | |
| 176 | 180 | | | | | 250 | 1,700 | 1,460 | 2,340 | 3,240 |
| 198 | | 980 | 1,780 | 1,940 | 1,660 | | 1,820 | 1,560 | 1,920 | 2,660 |
| 220 | | 1,180 | 1,660 | 2,420 | 2,660 | | 1,740 | 1,580 | 2,000 | 4,020 |
| 242 | 250 | 1,480 | 2,640 | 3,260 | 2,620 | 180 | 1,100 | 1,880 | 2,160 | 3,920 |
| 308 | 160 | 1,460 | 2,880 | 3,340 | 2,780 | 200 | 860 | 1,580 | 2,880 | 3,000 |
| 330 | 250 | 1,060 | 1,980 | 2,020 | 3,300 | 240 | 1,260 | 1,420 | 2,200 | 1,460 |
| 352 | | 980 | 1,520 | 1,900 | 2,240 | | 1,760 | 1,340 | 1,660 | |
| 374 | | 1,180 | 1,620 | 2,140 | 2,680 | | 1,270 | 1,350 | 2,060 | 2,620 |
| 396 | 250 | | | | | 250 | | | | |
| 462 | 180 | | | | | 240 | | | | |
| 484 | | | | | | | | | | |
| 506 | | | | | | | | | | |
| 528 | | | | | | | | | | |
| 550 | 180 | | | | | 120 | | | | |
| 616 | | | | | | | | | | |
| 638 | | | | | | | | | | |
| 660 | | 1,710 | 1,280 | 1,760 | 1,420 | | 980 | 2,460 | 2,000 | 1,920 |
| 682 | | 840 | 1,350 | | 2,320 | | 1,180 | | 2,500 | 3,000 |
| 792 | | 940 | 1,320 | 1,960 | 1,920 | | | | 2,820 | 2,120 |
| 814 | | 960 | 1,340 | 2,140 | 2,060 | | | 870 | | 1,540 |

Note. 1. The unit of alkalinity as mg /L as $CaCO_3$

Conductivity in the effluent of part 1

| ชั่วโมง | 45 °C | | | | | 30 °C | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 0.56 kg/m$^3$-d | 1.44 kg/m$^3$-d | 2.79 kg/m$^3$-d | 4.14 kg/m$^3$-d | 6.25 kg/m$^3$-d | 0.56 kg/m$^3$-d | 1.44 kg/m$^3$-d | 2.79 kg/m$^3$-d | 4.14 kg/m$^3$-d | 6.25 kg/m$^3$-d |
| 22 | 0.043 | 1.92 | 3.05 | 4.34 | 5.46 | 0.0409 | 1.87 | 3.75 | 4.73 | 5.88 |
| 44 | | 1.6 | 3.25 | 4.41 | 5.35 | | 1.95 | 3.2 | 4.22 | 5.31 |
| 66 | | 1.58 | 3.63 | 3.94 | 4.9 | | 1.43 | 3.5 | 3.99 | 5.88 |
| 88 | 0.03 | 1.49 | 3.92 | 3.81 | 4.96 | 0.035 | 1.61 | 3.78 | 3.86 | 5.79 |
| 154 | 0.056 | 1.85 | 3.44 | 3.97 | 5.99 | 0.04 | 1.31 | 3.3 | 3.99 | 5.86 |
| 176 | 0.052 | 1.46 | 3.34 | 4.18 | 5.25 | 0.051 | 1.42 | 3.8 | 3.81 | 5.72 |
| 198 | | 1.89 | 3.4 | 4.49 | 5.66 | | 1.75 | 3.78 | 4.34 | 5.91 |
| 220 | | 1.94 | 3.36 | 4.54 | 5.81 | | 1.77 | 3.82 | 4.44 | 5.85 |
| 242 | 0.04 | 1.3 | 3.45 | 4.86 | 5.79 | 0.04 | 1.8 | 3.4 | 3.95 | 5.52 |
| 308 | 0.045 | 1.13 | 3.69 | 4.2 | 5.58 | 0.055 | 1.54 | 3.78 | 4.35 | 5.83 |
| 330 | 0.054 | 1.94 | 3.62 | 4.49 | 5.87 | 0.04 | 1.84 | 3.31 | 4.88 | 5.87 |
| 352 | | 1.69 | 3.43 | 4.33 | 5.11 | | 1.75 | 3.71 | 4.58 | 5.58 |
| 374 | | 1.61 | 4.09 | 4.5 | 5.13 | | 1.59 | 3.8 | 4.39 | 5.51 |
| 396 | 0.048 | 1.71 | 3.71 | 3.59 | 5.83 | 0.058 | 1.91 | 3.77 | 4.28 | 5.92 |
| 462 | 0.048 | 2.07 | 3.47 | 3.95 | 5.73 | 0.059 | 1.71 | 3.75 | 4.8 | 5.27 |
| 484 | | 1.94 | 3.49 | 3.89 | 5.58 | | 1.72 | 4 | 4.57 | 5.62 |
| 506 | | 1.84 | 3.46 | 4.69 | 5.56 | | 1.58 | 3.76 | 4.45 | 5.87 |
| 528 | | 1.84 | 3.49 | 4.9 | 5.55 | | 1.69 | 3.2 | 4.73 | 5.92 |
| 550 | 0.049 | 1.67 | 3.95 | 4.53 | 5.62 | 0.052 | 1.88 | 3.75 | 4.26 | 5.42 |
| 616 | | 1.69 | 4.09 | 4.56 | 5.24 | 0.045 | 1.67 | 3.75 | 4.14 | 5.26 |
| 638 | | 1.6 | 3.04 | 4.05 | 5.67 | 0.045 | 1.6 | 3.6 | 4.09 | 5.81 |
| 660 | | 1.64 | 3.97 | 4.04 | 5.74 | | 1.58 | 3.65 | 3.88 | 5.77 |
| 682 | | 1.82 | 3.91 | | 5.98 | | 1.39 | | 4.82 | 5.82 |
| 792 | | 1.7 | 3.28 | 4.22 | 5.79 | | | | 4.18 | 5.56 |
| 814 | | 1.95 | 3.8 | 4.1 | | | 1.6 | | | |

Note. 1. The unit of conductivity as mS/cm

The circuit voltage (V) from of the experiment of part 1

| t (h) | 45°C | | | | | 30°C | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 6.25 kg/m$^3$-d | 4.14 kg/m$^3$-d | 2.79 kg/m$^3$-d | 1.44 kg/m$^3$-d | 0.56 kg/m$^3$-d | 6.25 kg/m$^3$-d | 4.14 kg/m$^3$-d | 2.79 kg/m$^3$-d | 1.44 kg/m$^3$-d | 0.56 kg/m$^3$-d |
| 0.00 | 0.432 | 0.143 | 0.366 | 0.445 | 0.362 | 0.510 | 0.309 | 0.239 | 0.298 | 0.242 |
| 0.50 | 0.583 | 0.150 | 0.340 | 0.445 | 0.367 | 0.390 | 0.416 | 0.262 | 0.289 | 0.283 |
| 1.53 | 0.596 | 0.186 | 0.357 | 0.445 | 0.371 | 0.380 | 0.502 | 0.279 | 0.289 | 0.283 |
| 2.03 | 0.633 | 0.188 | 0.382 | 0.445 | 0.348 | 0.394 | 0.521 | 0.298 | 0.297 | 0.282 |
| 2.53 | 0.649 | 0.231 | 0.400 | 0.445 | 0.359 | 0.406 | 0.590 | 0.310 | 0.307 | 0.284 |
| 3.03 | 0.664 | 0.242 | 0.403 | 0.445 | 0.407 | 0.449 | 0.638 | 0.308 | 0.320 | 0.287 |
| 3.53 | 0.664 | 0.243 | 0.422 | 0.445 | 0.367 | 0.469 | 0.624 | 0.315 | 0.330 | 0.288 |
| 4.03 | 0.664 | 0.210 | 0.407 | 0.445 | 0.362 | 0.468 | 0.624 | 0.331 | 0.337 | 0.241 |
| 4.53 | 0.664 | 0.241 | 0.417 | 0.445 | 0.362 | 0.440 | 0.602 | 0.334 | 0.343 | 0.289 |
| 5.03 | 0.664 | 0.271 | 0.412 | 0.445 | 0.347 | 0.461 | 0.623 | 0.348 | 0.343 | 0.242 |
| 5.53 | 0.664 | 0.243 | 0.411 | 0.445 | 0.376 | 0.498 | 0.600 | 0.344 | 0.343 | 0.254 |
| 6.03 | 0.664 | 0.256 | 0.411 | 0.445 | 0.367 | 0.561 | 0.634 | 0.346 | 0.350 | 0.277 |
| 6.53 | 0.664 | 0.287 | 0.408 | 0.445 | 0.353 | 0.615 | 0.617 | 0.351 | 0.353 | 0.278 |
| 7.03 | 0.664 | 0.256 | 0.406 | 0.445 | 0.350 | 0.623 | 0.639 | 0.357 | 0.351 | 0.276 |
| 7.53 | 0.664 | 0.240 | 0.410 | 0.445 | 0.355 | 0.659 | 0.606 | 0.364 | 0.350 | 0.273 |
| 8.03 | 0.664 | 0.238 | 0.400 | 0.445 | 0.309 | 0.684 | 0.617 | 0.383 | 0.353 | 0.273 |
| 8.53 | 0.664 | 0.218 | 0.396 | 0.445 | 0.289 | 0.678 | 0.624 | 0.367 | 0.354 | 0.275 |
| 9.03 | 0.664 | 0.215 | 0.395 | 0.445 | 0.313 | 0.684 | 0.612 | 0.369 | 0.362 | 0.276 |
| 9.53 | 0.664 | 0.206 | 0.405 | 0.445 | 0.285 | 0.677 | 0.625 | 0.368 | 0.358 | 0.276 |
| 10.03 | 0.664 | 0.203 | 0.400 | 0.445 | 0.257 | 0.677 | 0.601 | 0.381 | 0.324 | 0.272 |
| 10.53 | 0.664 | 0.175 | 0.399 | 0.445 | 0.362 | 0.677 | 0.599 | 0.404 | 0.323 | 0.276 |
| 11.03 | 0.664 | 0.194 | 0.397 | 0.445 | 0.328 | 0.677 | 0.633 | 0.408 | 0.324 | 0.269 |
| 11.53 | 0.664 | 0.121 | 0.401 | 0.445 | 0.266 | 0.677 | 0.624 | 0.409 | 0.328 | 0.269 |
| 12.03 | 0.664 | 0.176 | 0.394 | 0.445 | 0.305 | 0.677 | 0.629 | 0.407 | 0.327 | 0.268 |
| 12.53 | 0.664 | 0.189 | 0.389 | 0.445 | 0.317 | 0.677 | 0.614 | 0.411 | 0.325 | 0.270 |
| 13.03 | 0.664 | 0.187 | 0.393 | 0.445 | 0.305 | 0.677 | 0.625 | 0.421 | 0.327 | 0.268 |
| 13.53 | 0.664 | 0.208 | 0.382 | 0.445 | 0.314 | 0.677 | 0.627 | 0.426 | 0.329 | 0.269 |
| 14.03 | 0.664 | 0.235 | 0.382 | 0.486 | 0.295 | 0.677 | 0.641 | 0.427 | 0.327 | 0.268 |
| 14.53 | 0.664 | 0.266 | 0.378 | 0.486 | 0.292 | 0.677 | 0.642 | 0.421 | 0.328 | 0.269 |
| 15.03 | 0.664 | 0.234 | 0.390 | 0.485 | 0.266 | 0.677 | 0.632 | 0.425 | 0.330 | 0.269 |
| 15.53 | 0.664 | 0.226 | 0.388 | 0.485 | 0.296 | 0.677 | 0.645 | 0.433 | 0.330 | 0.269 |
| 16.03 | 0.664 | 0.219 | 0.392 | 0.485 | 0.269 | 0.677 | 0.650 | 0.443 | 0.330 | 0.271 |

| t (h) | 45°C | | | | | 30°C | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 6.25 kg/m$^3$-d | 4.14 kg/m$^3$-d | 2.79 kg/m$^3$-d | 1.44 kg/m$^3$-d | 0.56 kg/m$^3$-d | 6.25 kg/m$^3$-d | 4.14 kg/m$^3$-d | 2.79 kg/m$^3$-d | 1.44 kg/m$^3$-d | 0.56 kg/m$^3$-d |
| 16.53 | 0.664 | 0.205 | 0.393 | 0.485 | 0.266 | 0.677 | 0.644 | 0.440 | 0.332 | 0.267 |
| 17.03 | 0.651 | 0.185 | 0.350 | 0.485 | 0.280 | 0.604 | 0.564 | 0.236 | 0.153 | 0.218 |
| 18.47 | 0.667 | 0.206 | 0.482 | 0.487 | 0.266 | 0.647 | 0.632 | 0.298 | 0.281 | 0.269 |
| 19.17 | 0.667 | 0.261 | 0.554 | 0.485 | 0.266 | 0.644 | 0.631 | 0.319 | 0.295 | 0.270 |
| 19.67 | 0.667 | 0.272 | 0.586 | 0.485 | 0.266 | 0.678 | 0.652 | 0.334 | 0.288 | 0.267 |
| 20.17 | 0.667 | 0.254 | 0.608 | 0.485 | 0.266 | 0.683 | 0.644 | 0.341 | 0.313 | 0.267 |
| 20.67 | 0.667 | 0.289 | 0.591 | 0.485 | 0.266 | 0.678 | 0.648 | 0.347 | 0.318 | 0.267 |
| 21.17 | 0.667 | 0.287 | 0.587 | 0.485 | 0.266 | 0.680 | 0.636 | 0.345 | 0.308 | 0.270 |
| 21.67 | 0.667 | 0.279 | 0.593 | 0.485 | 0.323 | 0.676 | 0.647 | 0.361 | 0.314 | 0.270 |
| 22.17 | 0.667 | 0.259 | 0.598 | 0.485 | 0.318 | 0.677 | 0.656 | 0.361 | 0.307 | 0.269 |
| 22.67 | 0.667 | 0.280 | 0.607 | 0.485 | 0.322 | 0.677 | 0.650 | 0.357 | 0.302 | 0.267 |
| 23.17 | 0.667 | 0.298 | 0.601 | 0.485 | 0.306 | 0.677 | 0.641 | 0.363 | 0.311 | 0.268 |
| 23.67 | 0.667 | 0.338 | 0.605 | 0.485 | 0.298 | 0.677 | 0.631 | 0.369 | 0.317 | 0.257 |
| 24.17 | 0.667 | 0.340 | 0.603 | 0.485 | 0.266 | 0.677 | 0.637 | 0.365 | 0.322 | 0.266 |
| 24.67 | 0.667 | 0.351 | 0.606 | 0.485 | 0.280 | 0.677 | 0.640 | 0.363 | 0.326 | 0.267 |
| 25.17 | 0.667 | 0.353 | 0.593 | 0.484 | 0.266 | 0.677 | 0.654 | 0.368 | 0.324 | 0.267 |
| 25.67 | 0.667 | 0.349 | 0.599 | 0.484 | 0.266 | 0.677 | 0.655 | 0.363 | 0.333 | 0.267 |
| 26.17 | 0.667 | 0.334 | 0.593 | 0.484 | 0.358 | 0.677 | 0.648 | 0.358 | 0.336 | 0.266 |
| 26.67 | 0.667 | 0.316 | 0.599 | 0.484 | 0.300 | 0.677 | 0.643 | 0.359 | 0.330 | 0.266 |
| 27.17 | 0.667 | 0.333 | 0.591 | 0.484 | 0.266 | 0.677 | 0.644 | 0.362 | 0.330 | 0.264 |
| 27.67 | 0.667 | 0.314 | 0.592 | 0.484 | 0.284 | 0.677 | 0.636 | 0.369 | 0.332 | 0.265 |
| 28.17 | 0.667 | 0.314 | 0.586 | 0.525 | 0.290 | 0.677 | 0.633 | 0.374 | 0.344 | 0.265 |
| 28.67 | 0.667 | 0.318 | 0.594 | 0.484 | 0.279 | 0.677 | 0.634 | 0.374 | 0.349 | 0.265 |
| 29.17 | 0.667 | 0.325 | 0.589 | 0.525 | 0.387 | 0.677 | 0.634 | 0.375 | 0.347 | 0.262 |
| 29.67 | 0.667 | 0.346 | 0.589 | 0.484 | 0.281 | 0.677 | 0.625 | 0.372 | 0.355 | 0.264 |
| 30.17 | 0.667 | 0.343 | 0.589 | 0.484 | 0.290 | 0.677 | 0.616 | 0.375 | 0.354 | 0.264 |
| 30.67 | 0.662 | 0.346 | 0.574 | 0.484 | 0.266 | 0.677 | 0.613 | 0.375 | 0.355 | 0.265 |
| 31.17 | 0.659 | 0.356 | 0.570 | 0.484 | 0.266 | 0.677 | 0.616 | 0.374 | 0.356 | 0.264 |
| 31.67 | 0.653 | 0.359 | 0.577 | 0.484 | 0.266 | 0.677 | 0.619 | 0.375 | 0.360 | 0.265 |
| 32.17 | 0.657 | 0.363 | 0.566 | 0.484 | 0.266 | 0.677 | 0.625 | 0.379 | 0.360 | 0.265 |
| 32.67 | 0.650 | 0.353 | 0.554 | 0.484 | 0.266 | 0.677 | 0.628 | 0.377 | 0.361 | 0.264 |
| 33.17 | 0.647 | 0.348 | 0.554 | 0.484 | 0.266 | 0.677 | 0.624 | 0.385 | 0.365 | 0.265 |
| 33.67 | 0.651 | 0.353 | 0.563 | 0.525 | 0.266 | 0.677 | 0.632 | 0.387 | 0.357 | 0.263 |

| t (h) | 45°C | | | | | 30°C | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 6.25 kg/m$^3$-d | 4.14 kg/m$^3$-d | 2.79 kg/m$^3$-d | 1.44 kg/m$^3$-d | 0.56 kg/m$^3$-d | 6.25 kg/m$^3$-d | 4.14 kg/m$^3$-d | 2.79 kg/m$^3$-d | 1.44 kg/m$^3$-d | 0.56 kg/m$^3$-d |
| 34.17 | 0.668 | 0.335 | 0.562 | 0.525 | 0.266 | 0.677 | 0.617 | 0.379 | 0.361 | 0.250 |
| 34.67 | 0.655 | 0.345 | 0.560 | 0.525 | 0.266 | 0.677 | 0.615 | 0.386 | 0.371 | 0.250 |
| 35.17 | 0.658 | 0.354 | 0.558 | 0.525 | 0.266 | 0.677 | 0.611 | 0.383 | 0.367 | 0.253 |
| 35.67 | 0.658 | 0.376 | 0.550 | 0.484 | 0.220 | 0.677 | 0.601 | 0.383 | 0.366 | 0.251 |
| 36.17 | 0.647 | 0.365 | 0.538 | 0.484 | 0.263 | 0.677 | 0.602 | 0.386 | 0.366 | 0.218 |
| 36.67 | 0.654 | 0.357 | 0.532 | 0.525 | 0.240 | 0.677 | 0.592 | 0.383 | 0.365 | 0.251 |
| 37.17 | 0.653 | 0.361 | 0.536 | 0.484 | 0.213 | 0.677 | 0.604 | 0.381 | 0.372 | 0.253 |
| 37.67 | 0.655 | 0.372 | 0.532 | 0.525 | 0.301 | 0.677 | 0.605 | 0.385 | 0.369 | 0.252 |
| 38.17 | 0.656 | 0.361 | 0.539 | 0.484 | 0.289 | 0.677 | 0.596 | 0.379 | 0.366 | 0.251 |
| 38.67 | 0.647 | 0.354 | 0.523 | 0.525 | 0.301 | 0.677 | 0.593 | 0.375 | 0.365 | 0.254 |
| 39.17 | 0.632 | 0.342 | 0.521 | 0.484 | 0.275 | 0.677 | 0.587 | 0.380 | 0.365 | 0.252 |
| 39.67 | 0.655 | 0.354 | 0.507 | 0.484 | 0.278 | 0.677 | 0.596 | 0.383 | 0.367 | 0.253 |
| 40.17 | 0.633 | 0.371 | 0.506 | 0.484 | 0.281 | 0.677 | 0.576 | 0.385 | 0.364 | 0.253 |
| 40.67 | 0.651 | 0.377 | 0.506 | 0.484 | 0.301 | 0.677 | 0.564 | 0.387 | 0.368 | 0.253 |
| 41.17 | 0.626 | 0.397 | 0.494 | 0.484 | 0.290 | 0.677 | 0.570 | 0.381 | 0.235 | 0.252 |
| 41.67 | 0.510 | 0.488 | 0.380 | 0.404 | 0.271 | 0.520 | 0.449 | 0.328 | 0.446 | 0.252 |
| 43.65 | 0.520 | 0.495 | 0.398 | 0.404 | 0.263 | 0.618 | 0.536 | 0.336 | 0.447 | 0.251 |
| 44.15 | 0.519 | 0.504 | 0.404 | 0.444 | 0.282 | 0.527 | 0.631 | 0.329 | 0.444 | 0.267 |
| 44.65 | 0.536 | 0.496 | 0.417 | 0.484 | 0.288 | 0.529 | 0.625 | 0.334 | 0.445 | 0.262 |
| 45.15 | 0.541 | 0.498 | 0.421 | 0.484 | 0.296 | 0.534 | 0.643 | 0.326 | 0.450 | 0.262 |
| 45.65 | 0.532 | 0.499 | 0.430 | 0.484 | 0.295 | 0.655 | 0.640 | 0.330 | 0.453 | 0.304 |
| 46.15 | 0.526 | 0.516 | 0.440 | 0.484 | 0.297 | 0.658 | 0.642 | 0.327 | 0.454 | 0.306 |
| 46.65 | 0.511 | 0.499 | 0.438 | 0.484 | 0.282 | 0.670 | 0.639 | 0.332 | 0.456 | 0.305 |
| 47.15 | 0.518 | 0.499 | 0.446 | 0.484 | 0.300 | 0.671 | 0.641 | 0.335 | 0.453 | 0.307 |
| 47.65 | 0.518 | 0.504 | 0.443 | 0.484 | 0.288 | 0.666 | 0.640 | 0.336 | 0.454 | 0.303 |
| 48.15 | 0.518 | 0.540 | 0.448 | 0.484 | 0.304 | 0.670 | 0.641 | 0.336 | 0.459 | 0.301 |
| 48.65 | 0.525 | 0.520 | 0.460 | 0.484 | 0.266 | 0.571 | 0.643 | 0.337 | 0.462 | 0.299 |
| 49.15 | 0.537 | 0.530 | 0.453 | 0.484 | 0.312 | 0.666 | 0.639 | 0.340 | 0.465 | 0.298 |
| 49.65 | 0.556 | 0.537 | 0.456 | 0.484 | 0.278 | 0.576 | 0.592 | 0.344 | 0.459 | 0.300 |
| 50.15 | 0.552 | 0.536 | 0.459 | 0.484 | 0.290 | 0.603 | 0.598 | 0.340 | 0.456 | 0.298 |
| 50.65 | 0.566 | 0.549 | 0.460 | 0.525 | 0.297 | 0.606 | 0.593 | 0.336 | 0.453 | 0.298 |
| 51.15 | 0.561 | 0.555 | 0.455 | 0.525 | 0.266 | 0.600 | 0.594 | 0.338 | 0.456 | 0.302 |
| 51.65 | 0.544 | 0.554 | 0.447 | 0.525 | 0.275 | 0.612 | 0.601 | 0.339 | 0.450 | 0.304 |

| t (h) | 45°C | | | | | 30°C | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 6.25 kg/m$^3$-d | 4.14 kg/m$^3$-d | 2.79 kg/m$^3$-d | 1.44 kg/m$^3$-d | 0.56 kg/m$^3$-d | 6.25 kg/m$^3$-d | 4.14 kg/m$^3$-d | 2.79 kg/m$^3$-d | 1.44 kg/m$^3$-d | 0.56 kg/m$^3$-d |
| 52.15 | 0.538 | 0.556 | 0.442 | 0.525 | 0.294 | 0.615 | 0.599 | 0.334 | 0.456 | 0.300 |
| 52.65 | 0.547 | 0.553 | 0.432 | 0.444 | 0.273 | 0.612 | 0.591 | 0.336 | 0.453 | 0.304 |
| 53.15 | 0.562 | 0.535 | 0.434 | 0.444 | 0.278 | 0.669 | 0.593 | 0.337 | 0.453 | 0.304 |
| 53.65 | 0.538 | 0.549 | 0.440 | 0.444 | 0.270 | 0.666 | 0.587 | 0.337 | 0.455 | 0.305 |
| 54.15 | 0.532 | 0.563 | 0.453 | 0.444 | 0.266 | 0.668 | 0.585 | 0.339 | 0.457 | 0.308 |
| 54.65 | 0.534 | 0.565 | 0.449 | 0.444 | 0.275 | 0.664 | 0.593 | 0.338 | 0.456 | 0.307 |
| 55.15 | 0.528 | 0.568 | 0.454 | 0.444 | 0.290 | 0.653 | 0.597 | 0.338 | 0.454 | 0.307 |
| 55.65 | 0.534 | 0.580 | 0.454 | 0.444 | 0.283 | 0.657 | 0.597 | 0.343 | 0.458 | 0.309 |
| 56.15 | 0.544 | 0.576 | 0.451 | 0.444 | 0.277 | 0.658 | 0.562 | 0.342 | 0.459 | 0.309 |
| 56.65 | 0.547 | 0.582 | 0.448 | 0.444 | 0.278 | 0.657 | 0.569 | 0.343 | 0.460 | 0.308 |
| 57.15 | 0.540 | 0.574 | 0.446 | 0.444 | 0.296 | 0.659 | 0.583 | 0.339 | 0.463 | 0.306 |
| 57.65 | 0.545 | 0.576 | 0.448 | 0.484 | 0.269 | 0.661 | 0.536 | 0.340 | 0.464 | 0.308 |
| 58.15 | 0.539 | 0.584 | 0.448 | 0.484 | 0.269 | 0.661 | 0.563 | 0.340 | 0.461 | 0.305 |
| 58.65 | 0.532 | 0.582 | 0.441 | 0.484 | 0.282 | 0.655 | 0.515 | 0.342 | 0.467 | 0.309 |
| 59.15 | 0.531 | 0.585 | 0.437 | 0.484 | 0.268 | 0.653 | 0.577 | 0.343 | 0.465 | 0.309 |
| 59.65 | 0.521 | 0.584 | 0.437 | 0.444 | 0.227 | 0.657 | 0.588 | 0.342 | 0.461 | 0.300 |
| 60.15 | 0.523 | 0.609 | 0.432 | 0.484 | 0.219 | 0.646 | 0.591 | 0.334 | 0.466 | 0.297 |
| 60.65 | 0.537 | 0.593 | 0.433 | 0.444 | 0.218 | 0.644 | 0.587 | 0.339 | 0.463 | 0.300 |
| 61.15 | 0.532 | 0.613 | 0.440 | 0.484 | 0.272 | 0.643 | 0.586 | 0.335 | 0.465 | 0.302 |
| 61.65 | 0.535 | 0.610 | 0.433 | 0.484 | 0.281 | 0.645 | 0.586 | 0.339 | 0.466 | 0.306 |
| 62.15 | 0.545 | 0.621 | 0.420 | 0.484 | 0.286 | 0.641 | 0.565 | 0.339 | 0.473 | 0.307 |
| 62.65 | 0.531 | 0.616 | 0.414 | 0.484 | 0.290 | 0.534 | 0.486 | 0.337 | 0.476 | 0.308 |
| 63.15 | 0.534 | 0.624 | 0.416 | 0.484 | 0.292 | 0.533 | 0.527 | 0.336 | 0.477 | 0.309 |
| 63.65 | 0.521 | 0.611 | 0.409 | 0.484 | 0.294 | 0.522 | 0.558 | 0.333 | 0.474 | 0.309 |
| 64.15 | 0.529 | 0.621 | 0.407 | 0.444 | 0.295 | 0.523 | 0.551 | 0.334 | 0.474 | 0.309 |
| 64.65 | 0.506 | 0.633 | 0.408 | 0.484 | 0.296 | 0.523 | 0.580 | 0.332 | 0.474 | 0.309 |
| 65.15 | 0.504 | 0.621 | 0.405 | 0.484 | 0.295 | 0.514 | 0.573 | 0.331 | 0.476 | 0.309 |
| 65.65 | 0.415 | 0.468 | 0.350 | 0.404 | 0.190 | 0.407 | 0.524 | 0.271 | 0.367 | 0.261 |
| 67.65 | 0.423 | 0.468 | 0.350 | 0.404 | 0.244 | 0.493 | 0.556 | 0.270 | 0.366 | 0.262 |
| 68.15 | 0.407 | 0.497 | 0.373 | 0.444 | 0.244 | 0.492 | 0.519 | 0.297 | 0.409 | 0.261 |
| 68.65 | 0.413 | 0.506 | 0.368 | 0.444 | 0.244 | 0.495 | 0.553 | 0.290 | 0.405 | 0.309 |
| 69.15 | 0.460 | 0.575 | 0.404 | 0.484 | 0.298 | 0.487 | 0.589 | 0.300 | 0.452 | 0.309 |
| 69.65 | 0.470 | 0.606 | 0.424 | 0.484 | 0.298 | 0.487 | 0.590 | 0.307 | 0.453 | 0.311 |

| t (h) | 45°C | | | | | 30°C | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 6.25 kg/m$^3$-d | 4.14 kg/m$^3$-d | 2.79 kg/m$^3$-d | 1.44 kg/m$^3$-d | 0.56 kg/m$^3$-d | 6.25 kg/m$^3$-d | 4.14 kg/m$^3$-d | 2.79 kg/m$^3$-d | 1.44 kg/m$^3$-d | 0.56 kg/m$^3$-d |
| 70.15 | 0.471 | 0.592 | 0.422 | 0.484 | 0.298 | 0.491 | 0.591 | 0.329 | 0.491 | 0.310 |
| 70.65 | 0.488 | 0.593 | 0.421 | 0.484 | 0.298 | 0.494 | 0.596 | 0.326 | 0.490 | 0.311 |
| 71.15 | 0.481 | 0.580 | 0.422 | 0.484 | 0.299 | 0.491 | 0.601 | 0.326 | 0.494 | 0.310 |
| 71.65 | 0.488 | 0.564 | 0.430 | 0.484 | 0.299 | 0.486 | 0.599 | 0.333 | 0.494 | 0.311 |
| 72.15 | 0.482 | 0.558 | 0.430 | 0.484 | 0.299 | 0.483 | 0.596 | 0.336 | 0.492 | 0.311 |
| 72.65 | 0.493 | 0.555 | 0.434 | 0.484 | 0.299 | 0.476 | 0.595 | 0.340 | 0.491 | 0.311 |
| 73.15 | 0.495 | 0.566 | 0.413 | 0.484 | 0.299 | 0.483 | 0.600 | 0.336 | 0.494 | 0.311 |
| 73.65 | 0.490 | 0.549 | 0.417 | 0.484 | 0.299 | 0.486 | 0.596 | 0.332 | 0.495 | 0.311 |
| 74.15 | 0.485 | 0.549 | 0.406 | 0.484 | 0.299 | 0.477 | 0.588 | 0.335 | 0.498 | 0.311 |
| 74.65 | 0.487 | 0.539 | 0.420 | 0.485 | 0.299 | 0.531 | 0.582 | 0.331 | 0.498 | 0.311 |
| 75.15 | 0.497 | 0.530 | 0.416 | 0.485 | 0.299 | 0.498 | 0.587 | 0.329 | 0.496 | 0.311 |
| 75.65 | 0.505 | 0.540 | 0.425 | 0.485 | 0.299 | 0.496 | 0.589 | 0.333 | 0.498 | 0.311 |
| 76.15 | 0.503 | 0.542 | 0.428 | 0.485 | 0.299 | 0.499 | 0.586 | 0.332 | 0.500 | 0.310 |
| 76.65 | 0.514 | 0.542 | 0.429 | 0.485 | 0.299 | 0.486 | 0.585 | 0.329 | 0.506 | 0.311 |
| 77.15 | 0.498 | 0.547 | 0.419 | 0.485 | 0.299 | 0.454 | 0.583 | 0.325 | 0.507 | 0.311 |
| 77.65 | 0.486 | 0.534 | 0.424 | 0.485 | 0.299 | 0.453 | 0.584 | 0.326 | 0.505 | 0.310 |
| 78.15 | 0.467 | 0.535 | 0.429 | 0.485 | 0.286 | 0.458 | 0.577 | 0.327 | 0.500 | 0.310 |
| 78.65 | 0.471 | 0.537 | 0.426 | 0.485 | 0.284 | 0.451 | 0.577 | 0.334 | 0.503 | 0.310 |
| 79.15 | 0.468 | 0.528 | 0.416 | 0.485 | 0.285 | 0.448 | 0.590 | 0.329 | 0.507 | 0.310 |
| 79.65 | 0.468 | 0.523 | 0.414 | 0.485 | 0.285 | 0.448 | 0.582 | 0.330 | 0.503 | 0.310 |
| 80.15 | 0.466 | 0.539 | 0.415 | 0.485 | 0.286 | 0.448 | 0.585 | 0.327 | 0.505 | 0.311 |
| 80.65 | 0.465 | 0.538 | 0.423 | 0.485 | 0.287 | 0.450 | 0.582 | 0.323 | 0.509 | 0.310 |
| 81.15 | 0.475 | 0.544 | 0.418 | 0.486 | 0.287 | 0.439 | 0.581 | 0.329 | 0.508 | 0.310 |
| 81.65 | 0.462 | 0.541 | 0.418 | 0.486 | 0.289 | 0.435 | 0.593 | 0.323 | 0.509 | 0.310 |
| 82.15 | 0.458 | 0.535 | 0.423 | 0.486 | 0.278 | 0.427 | 0.585 | 0.327 | 0.508 | 0.290 |
| 82.65 | 0.488 | 0.537 | 0.415 | 0.484 | 0.223 | 0.437 | 0.591 | 0.328 | 0.509 | 0.290 |
| 83.15 | 0.468 | 0.544 | 0.414 | 0.484 | 0.222 | 0.441 | 0.590 | 0.332 | 0.511 | 0.313 |
| 83.65 | 0.466 | 0.549 | 0.415 | 0.484 | 0.280 | 0.438 | 0.589 | 0.330 | 0.515 | 0.290 |
| 84.15 | 0.477 | 0.556 | 0.422 | 0.484 | 0.285 | 0.440 | 0.595 | 0.330 | 0.513 | 0.290 |
| 84.65 | 0.489 | 0.551 | 0.421 | 0.484 | 0.291 | 0.435 | 0.592 | 0.328 | 0.514 | 0.290 |
| 85.15 | 0.488 | 0.565 | 0.423 | 0.484 | 0.293 | 0.429 | 0.602 | 0.330 | 0.516 | 0.290 |
| 85.65 | 0.484 | 0.544 | 0.421 | 0.484 | 0.293 | 0.421 | 0.608 | 0.326 | 0.520 | 0.290 |
| 86.15 | 0.479 | 0.558 | 0.425 | 0.484 | 0.293 | 0.433 | 0.609 | 0.320 | 0.524 | 0.291 |

| t (h) | 45°C | | | | | 30°C | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 6.25 kg/m$^3$-d | 4.14 kg/m$^3$-d | 2.79 kg/m$^3$-d | 1.44 kg/m$^3$-d | 0.56 kg/m$^3$-d | 6.25 kg/m$^3$-d | 4.14 kg/m$^3$-d | 2.79 kg/m$^3$-d | 1.44 kg/m$^3$-d | 0.56 kg/m$^3$-d |
| 86.65 | 0.494 | 0.525 | 0.431 | 0.484 | 0.293 | 0.422 | 0.608 | 0.320 | 0.518 | 0.291 |
| 87.15 | 0.504 | 0.522 | 0.429 | 0.484 | 0.295 | 0.423 | 0.598 | 0.320 | 0.523 | 0.291 |
| 87.65 | 0.506 | 0.524 | 0.427 | 0.484 | 0.295 | 0.428 | 0.598 | 0.320 | 0.524 | 0.291 |
| 88.15 | 0.510 | 0.521 | 0.425 | 0.484 | 0.296 | 0.427 | 0.594 | 0.322 | 0.524 | 0.291 |
| 88.65 | 0.513 | 0.520 | 0.423 | 0.484 | 0.296 | 0.422 | 0.596 | 0.324 | 0.524 | 0.291 |
| 89.15 | 0.510 | 0.513 | 0.422 | 0.484 | 0.297 | 0.418 | 0.590 | 0.325 | 0.524 | 0.291 |
| 89.65 | 0.498 | 0.421 | 0.315 | 0.363 | 0.184 | 0.352 | 0.453 | 0.324 | 0.366 | 0.243 |
| 91.65 | 0.496 | 0.390 | 0.341 | 0.363 | 0.185 | 0.357 | 0.475 | 0.355 | 0.408 | 0.243 |
| 92.15 | 0.494 | 0.458 | 0.378 | 0.404 | 0.185 | 0.382 | 0.484 | 0.354 | 0.448 | 0.243 |
| 92.65 | 0.477 | 0.472 | 0.410 | 0.404 | 0.239 | 0.384 | 0.507 | 0.263 | 0.488 | 0.243 |
| 93.15 | 0.479 | 0.483 | 0.434 | 0.444 | 0.239 | 0.378 | 0.515 | 0.292 | 0.489 | 0.243 |
| 93.65 | 0.478 | 0.517 | 0.441 | 0.484 | 0.292 | 0.402 | 0.515 | 0.319 | 0.490 | 0.291 |
| 94.15 | 0.471 | 0.552 | 0.441 | 0.484 | 0.292 | 0.405 | 0.571 | 0.325 | 0.531 | 0.291 |
| 94.65 | 0.475 | 0.559 | 0.442 | 0.484 | 0.291 | 0.400 | 0.564 | 0.317 | 0.532 | 0.311 |
| 95.15 | 0.468 | 0.537 | 0.442 | 0.484 | 0.291 | 0.405 | 0.571 | 0.321 | 0.532 | 0.311 |
| 95.65 | 0.485 | 0.541 | 0.430 | 0.484 | 0.291 | 0.397 | 0.577 | 0.321 | 0.532 | 0.311 |
| 96.15 | 0.499 | 0.543 | 0.429 | 0.484 | 0.290 | 0.400 | 0.579 | 0.318 | 0.536 | 0.311 |
| 96.65 | 0.498 | 0.552 | 0.441 | 0.484 | 0.291 | 0.412 | 0.576 | 0.307 | 0.539 | 0.311 |
| 97.15 | 0.489 | 0.560 | 0.443 | 0.525 | 0.291 | 0.412 | 0.572 | 0.305 | 0.541 | 0.311 |
| 97.65 | 0.502 | 0.562 | 0.443 | 0.525 | 0.291 | 0.410 | 0.565 | 0.302 | 0.541 | 0.311 |
| 98.15 | 0.501 | 0.554 | 0.439 | 0.525 | 0.292 | 0.411 | 0.573 | 0.300 | 0.540 | 0.311 |
| 98.65 | 0.508 | 0.544 | 0.434 | 0.525 | 0.291 | 0.406 | 0.570 | 0.295 | 0.539 | 0.311 |
| 99.15 | 0.507 | 0.551 | 0.435 | 0.484 | 0.291 | 0.405 | 0.570 | 0.295 | 0.537 | 0.311 |
| 99.65 | 0.504 | 0.561 | 0.426 | 0.484 | 0.292 | 0.398 | 0.565 | 0.301 | 0.538 | 0.311 |
| 100.15 | 0.509 | 0.552 | 0.427 | 0.525 | 0.292 | 0.398 | 0.561 | 0.306 | 0.538 | 0.311 |
| 100.65 | 0.518 | 0.539 | 0.416 | 0.525 | 0.292 | 0.391 | 0.553 | 0.304 | 0.538 | 0.311 |
| 101.15 | 0.513 | 0.566 | 0.422 | 0.484 | 0.293 | 0.381 | 0.555 | 0.306 | 0.539 | 0.311 |
| 101.65 | 0.506 | 0.567 | 0.418 | 0.484 | 0.293 | 0.390 | 0.545 | 0.310 | 0.541 | 0.311 |
| 102.15 | 0.494 | 0.576 | 0.420 | 0.525 | 0.293 | 0.388 | 0.534 | 0.305 | 0.540 | 0.311 |
| 102.65 | 0.492 | 0.591 | 0.416 | 0.525 | 0.293 | 0.379 | 0.530 | 0.308 | 0.541 | 0.311 |
| 103.15 | 0.494 | 0.597 | 0.423 | 0.484 | 0.293 | 0.390 | 0.541 | 0.304 | 0.544 | 0.311 |
| 103.65 | 0.484 | 0.593 | 0.423 | 0.484 | 0.294 | 0.391 | 0.535 | 0.305 | 0.546 | 0.311 |
| 104.15 | 0.480 | 0.588 | 0.418 | 0.484 | 0.294 | 0.392 | 0.539 | 0.309 | 0.547 | 0.311 |

| t (h) | 45°C | | | | | 30°C | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 6.25 kg/m$^3$-d | 4.14 kg/m$^3$-d | 2.79 kg/m$^3$-d | 1.44 kg/m$^3$-d | 0.56 kg/m$^3$-d | 6.25 kg/m$^3$-d | 4.14 kg/m$^3$-d | 2.79 kg/m$^3$-d | 1.44 kg/m$^3$-d | 0.56 kg/m$^3$-d |
| 104.65 | 0.413 | 0.361 | 0.288 | 0.364 | 0.188 | 0.535 | 0.425 | 0.376 | 0.476 | 0.244 |
| 118.95 | 0.460 | 0.374 | 0.312 | 0.393 | 0.182 | 0.537 | 0.476 | 0.416 | 0.479 | 0.243 |
| 119.45 | 0.496 | 0.323 | 0.308 | 0.377 | 0.222 | 0.578 | 0.530 | 0.435 | 0.482 | 0.245 |
| 119.95 | 0.651 | 0.376 | 0.323 | 0.435 | 0.225 | 0.623 | 0.580 | 0.445 | 0.487 | 0.292 |
| 120.45 | 0.655 | 0.382 | 0.328 | 0.453 | 0.286 | 0.638 | 0.591 | 0.456 | 0.487 | 0.341 |
| 120.95 | 0.643 | 0.371 | 0.335 | 0.471 | 0.291 | 0.655 | 0.598 | 0.455 | 0.489 | 0.341 |
| 121.45 | 0.644 | 0.396 | 0.347 | 0.450 | 0.295 | 0.649 | 0.612 | 0.468 | 0.486 | 0.341 |
| 121.95 | 0.655 | 0.416 | 0.367 | 0.442 | 0.297 | 0.647 | 0.624 | 0.489 | 0.492 | 0.342 |
| 122.45 | 0.651 | 0.431 | 0.387 | 0.457 | 0.298 | 0.649 | 0.618 | 0.479 | 0.493 | 0.342 |
| 122.95 | 0.656 | 0.426 | 0.379 | 0.451 | 0.299 | 0.666 | 0.621 | 0.486 | 0.491 | 0.342 |
| 123.45 | 0.651 | 0.431 | 0.390 | 0.431 | 0.300 | 0.670 | 0.620 | 0.498 | 0.490 | 0.343 |
| 123.95 | 0.653 | 0.400 | 0.389 | 0.405 | 0.301 | 0.665 | 0.625 | 0.475 | 0.494 | 0.343 |
| 124.45 | 0.656 | 0.426 | 0.394 | 0.412 | 0.302 | 0.666 | 0.622 | 0.475 | 0.494 | 0.343 |
| 124.95 | 0.655 | 0.414 | 0.392 | 0.403 | 0.303 | 0.504 | 0.617 | 0.463 | 0.492 | 0.344 |
| 125.45 | 0.654 | 0.427 | 0.395 | 0.418 | 0.303 | 0.514 | 0.621 | 0.461 | 0.491 | 0.344 |
| 125.95 | 0.654 | 0.434 | 0.397 | 0.402 | 0.303 | 0.511 | 0.321 | 0.438 | 0.494 | 0.343 |
| 126.45 | 0.655 | 0.425 | 0.413 | 0.408 | 0.303 | 0.511 | 0.330 | 0.441 | 0.495 | 0.344 |
| 126.95 | 0.654 | 0.424 | 0.409 | 0.427 | 0.304 | 0.524 | 0.323 | 0.409 | 0.498 | 0.344 |
| 127.45 | 0.655 | 0.420 | 0.399 | 0.462 | 0.305 | 0.516 | 0.328 | 0.428 | 0.498 | 0.344 |
| 127.95 | 0.669 | 0.444 | 0.400 | 0.468 | 0.305 | 0.510 | 0.331 | 0.428 | 0.496 | 0.344 |
| 128.45 | 0.645 | 0.417 | 0.397 | 0.473 | 0.306 | 0.531 | 0.323 | 0.444 | 0.498 | 0.344 |
| 128.95 | 0.654 | 0.431 | 0.407 | 0.460 | 0.305 | 0.513 | 0.325 | 0.444 | 0.500 | 0.345 |
| 129.45 | 0.652 | 0.411 | 0.404 | 0.470 | 0.306 | 0.518 | 0.323 | 0.469 | 0.506 | 0.345 |
| 129.95 | 0.653 | 0.411 | 0.405 | 0.466 | 0.306 | 0.522 | 0.322 | 0.508 | 0.507 | 0.346 |
| 130.45 | 0.655 | 0.416 | 0.401 | 0.447 | 0.306 | 0.538 | 0.319 | 0.503 | 0.505 | 0.346 |
| 130.95 | 0.655 | 0.421 | 0.394 | 0.443 | 0.306 | 0.416 | 0.322 | 0.511 | 0.500 | 0.346 |
| 131.45 | 0.651 | 0.442 | 0.391 | 0.447 | 0.306 | 0.539 | 0.328 | 0.512 | 0.503 | 0.346 |
| 131.95 | 0.650 | 0.433 | 0.375 | 0.465 | 0.307 | 0.450 | 0.332 | 0.505 | 0.507 | 0.347 |
| 132.45 | 0.655 | 0.428 | 0.377 | 0.489 | 0.307 | 0.640 | 0.331 | 0.526 | 0.503 | 0.347 |
| 132.95 | 0.654 | 0.439 | 0.379 | 0.511 | 0.307 | 0.661 | 0.329 | 0.531 | 0.505 | 0.348 |
| 133.45 | 0.655 | 0.432 | 0.363 | 0.490 | 0.307 | 0.659 | 0.325 | 0.532 | 0.509 | 0.348 |
| 133.95 | 0.650 | 0.426 | 0.362 | 0.491 | 0.307 | 0.562 | 0.333 | 0.529 | 0.508 | 0.348 |
| 134.45 | 0.650 | 0.441 | 0.388 | 0.489 | 0.308 | 0.638 | 0.337 | 0.525 | 0.509 | 0.349 |

| t (h) | 45°C | | | | | 30°C | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 6.25 kg/m$^3$-d | 4.14 kg/m$^3$-d | 2.79 kg/m$^3$-d | 1.44 kg/m$^3$-d | 0.56 kg/m$^3$-d | 6.25 kg/m$^3$-d | 4.14 kg/m$^3$-d | 2.79 kg/m$^3$-d | 1.44 kg/m$^3$-d | 0.56 kg/m$^3$-d |
| 134.95 | 0.650 | 0.423 | 0.387 | 0.488 | 0.308 | 0.668 | 0.332 | 0.538 | 0.508 | 0.349 |
| 135.45 | 0.667 | 0.427 | 0.382 | 0.515 | 0.308 | 0.544 | 0.342 | 0.551 | 0.509 | 0.349 |
| 135.95 | 0.656 | 0.431 | 0.378 | 0.496 | 0.308 | 0.648 | 0.335 | 0.553 | 0.511 | 0.350 |
| 136.45 | 0.651 | 0.434 | 0.375 | 0.519 | 0.308 | 0.661 | 0.336 | 0.572 | 0.515 | 0.350 |
| 136.95 | 0.650 | 0.456 | 0.381 | 0.487 | 0.306 | 0.638 | 0.338 | 0.575 | 0.513 | 0.351 |
| 137.45 | 0.404 | 0.383 | 0.315 | 0.392 | 0.302 | 0.524 | 0.422 | 0.318 | 0.514 | 0.255 |
| 138.82 | 0.423 | 0.413 | 0.337 | 0.393 | 0.302 | 0.560 | 0.541 | 0.357 | 0.516 | 0.270 |
| 139.32 | 0.461 | 0.437 | 0.372 | 0.424 | 0.303 | 0.574 | 0.579 | 0.371 | 0.520 | 0.290 |
| 139.82 | 0.483 | 0.438 | 0.379 | 0.435 | 0.303 | 0.582 | 0.590 | 0.379 | 0.524 | 0.324 |
| 140.32 | 0.503 | 0.463 | 0.380 | 0.424 | 0.304 | 0.605 | 0.592 | 0.385 | 0.518 | 0.339 |
| 140.82 | 0.519 | 0.458 | 0.381 | 0.466 | 0.304 | 0.594 | 0.589 | 0.386 | 0.476 | 0.346 |
| 141.32 | 0.522 | 0.458 | 0.376 | 0.489 | 0.304 | 0.599 | 0.590 | 0.393 | 0.479 | 0.349 |
| 141.82 | 0.526 | 0.449 | 0.373 | 0.474 | 0.304 | 0.593 | 0.591 | 0.398 | 0.482 | 0.354 |
| 142.32 | 0.528 | 0.442 | 0.365 | 0.499 | 0.304 | 0.594 | 0.592 | 0.401 | 0.487 | 0.354 |
| 142.82 | 0.530 | 0.452 | 0.370 | 0.480 | 0.304 | 0.581 | 0.593 | 0.401 | 0.487 | 0.354 |
| 143.32 | 0.542 | 0.448 | 0.379 | 0.497 | 0.338 | 0.605 | 0.594 | 0.410 | 0.489 | 0.359 |
| 143.82 | 0.539 | 0.449 | 0.367 | 0.490 | 0.337 | 0.601 | 0.592 | 0.410 | 0.486 | 0.359 |
| 144.32 | 0.542 | 0.438 | 0.379 | 0.509 | 0.340 | 0.618 | 0.594 | 0.410 | 0.492 | 0.344 |
| 144.82 | 0.532 | 0.443 | 0.377 | 0.553 | 0.346 | 0.613 | 0.596 | 0.408 | 0.493 | 0.349 |
| 145.32 | 0.532 | 0.420 | 0.381 | 0.526 | 0.355 | 0.608 | 0.592 | 0.410 | 0.491 | 0.352 |
| 145.82 | 0.529 | 0.419 | 0.378 | 0.512 | 0.357 | 0.622 | 0.594 | 0.414 | 0.490 | 0.353 |
| 146.32 | 0.537 | 0.420 | 0.383 | 0.538 | 0.364 | 0.632 | 0.592 | 0.418 | 0.494 | 0.355 |
| 146.82 | 0.544 | 0.397 | 0.395 | 0.513 | 0.365 | 0.615 | 0.597 | 0.418 | 0.494 | 0.356 |
| 147.32 | 0.538 | 0.403 | 0.404 | 0.488 | 0.363 | 0.606 | 0.592 | 0.418 | 0.492 | 0.358 |
| 147.82 | 0.543 | 0.420 | 0.396 | 0.525 | 0.364 | 0.607 | 0.593 | 0.423 | 0.491 | 0.359 |
| 148.32 | 0.536 | 0.410 | 0.403 | 0.539 | 0.365 | 0.621 | 0.591 | 0.423 | 0.494 | 0.361 |
| 148.82 | 0.542 | 0.429 | 0.391 | 0.552 | 0.331 | 0.626 | 0.595 | 0.423 | 0.495 | 0.362 |
| 149.32 | 0.547 | 0.414 | 0.404 | 0.536 | 0.325 | 0.626 | 0.593 | 0.423 | 0.498 | 0.364 |
| 149.82 | 0.546 | 0.433 | 0.398 | 0.534 | 0.331 | 0.633 | 0.597 | 0.417 | 0.498 | 0.365 |
| 150.32 | 0.556 | 0.425 | 0.391 | 0.549 | 0.334 | 0.647 | 0.594 | 0.422 | 0.496 | 0.367 |
| 150.82 | 0.560 | 0.435 | 0.391 | 0.567 | 0.331 | 0.655 | 0.594 | 0.425 | 0.498 | 0.368 |
| 151.32 | 0.556 | 0.440 | 0.384 | 0.534 | 0.330 | 0.662 | 0.592 | 0.427 | 0.500 | 0.369 |
| 151.82 | 0.547 | 0.441 | 0.387 | 0.528 | 0.335 | 0.661 | 0.593 | 0.430 | 0.506 | 0.371 |

| t (h) | 45°C | | | | | 30°C | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 6.25 kg/m$^3$-d | 4.14 kg/m$^3$-d | 2.79 kg/m$^3$-d | 1.44 kg/m$^3$-d | 0.56 kg/m$^3$-d | 6.25 kg/m$^3$-d | 4.14 kg/m$^3$-d | 2.79 kg/m$^3$-d | 1.44 kg/m$^3$-d | 0.56 kg/m$^3$-d |
| 152.32 | 0.544 | 0.431 | 0.369 | 0.506 | 0.332 | 0.664 | 0.594 | 0.427 | 0.507 | 0.359 |
| 152.82 | 0.544 | 0.407 | 0.352 | 0.512 | 0.333 | 0.662 | 0.593 | 0.434 | 0.505 | 0.360 |
| 153.32 | 0.536 | 0.417 | 0.352 | 0.526 | 0.330 | 0.667 | 0.592 | 0.435 | 0.500 | 0.361 |
| 153.82 | 0.542 | 0.419 | 0.341 | 0.518 | 0.332 | 0.668 | 0.592 | 0.437 | 0.503 | 0.353 |
| 154.32 | 0.543 | 0.406 | 0.337 | 0.520 | 0.326 | 0.678 | 0.592 | 0.435 | 0.507 | 0.355 |
| 154.82 | 0.548 | 0.411 | 0.340 | 0.491 | 0.325 | 0.667 | 0.594 | 0.435 | 0.503 | 0.354 |
| 155.32 | 0.540 | 0.414 | 0.332 | 0.498 | 0.324 | 0.671 | 0.597 | 0.433 | 0.505 | 0.356 |
| 155.82 | 0.543 | 0.424 | 0.329 | 0.530 | 0.319 | 0.671 | 0.593 | 0.435 | 0.509 | 0.357 |
| 156.32 | 0.549 | 0.422 | 0.334 | 0.515 | 0.319 | 0.666 | 0.596 | 0.435 | 0.508 | 0.358 |
| 156.82 | 0.543 | 0.424 | 0.334 | 0.516 | 0.322 | 0.661 | 0.593 | 0.436 | 0.509 | 0.359 |
| 157.32 | 0.541 | 0.425 | 0.332 | 0.537 | 0.322 | 0.662 | 0.590 | 0.435 | 0.508 | 0.360 |
| 157.82 | 0.547 | 0.418 | 0.333 | 0.555 | 0.326 | 0.675 | 0.590 | 0.434 | 0.509 | 0.360 |
| 158.32 | 0.543 | 0.417 | 0.337 | 0.554 | 0.327 | 0.669 | 0.597 | 0.433 | 0.511 | 0.361 |
| 158.82 | 0.544 | 0.413 | 0.342 | 0.549 | 0.326 | 0.664 | 0.597 | 0.432 | 0.515 | 0.357 |
| 159.32 | 0.540 | 0.418 | 0.344 | 0.558 | 0.327 | 0.662 | 0.594 | 0.432 | 0.513 | 0.357 |
| 159.82 | 0.541 | 0.413 | 0.337 | 0.543 | 0.324 | 0.663 | 0.593 | 0.434 | 0.514 | 0.357 |
| 160.32 | 0.539 | 0.399 | 0.336 | 0.546 | 0.322 | 0.662 | 0.588 | 0.434 | 0.516 | 0.357 |
| 160.82 | 0.537 | 0.406 | 0.337 | 0.526 | 0.319 | 0.662 | 0.592 | 0.432 | 0.520 | 0.357 |
| 161.32 | 0.438 | 0.383 | 0.328 | 0.363 | 0.314 | 0.514 | 0.445 | 0.367 | 0.524 | 0.290 |
| 162.57 | 0.456 | 0.420 | 0.346 | 0.420 | 0.316 | 0.477 | 0.484 | 0.418 | 0.518 | 0.309 |
| 163.07 | 0.490 | 0.452 | 0.381 | 0.476 | 0.316 | 0.521 | 0.528 | 0.478 | 0.413 | 0.315 |
| 163.57 | 0.477 | 0.476 | 0.382 | 0.473 | 0.333 | 0.556 | 0.558 | 0.491 | 0.463 | 0.334 |
| 164.07 | 0.525 | 0.507 | 0.427 | 0.433 | 0.320 | 0.592 | 0.577 | 0.543 | 0.491 | 0.340 |
| 164.57 | 0.561 | 0.538 | 0.459 | 0.475 | 0.334 | 0.662 | 0.592 | 0.554 | 0.492 | 0.344 |
| 165.07 | 0.591 | 0.568 | 0.489 | 0.474 | 0.321 | 0.656 | 0.592 | 0.553 | 0.494 | 0.344 |
| 165.57 | 0.624 | 0.567 | 0.520 | 0.474 | 0.319 | 0.669 | 0.593 | 0.579 | 0.494 | 0.350 |
| 166.07 | 0.651 | 0.567 | 0.549 | 0.473 | 0.335 | 0.666 | 0.589 | 0.549 | 0.494 | 0.342 |
| 166.57 | 0.651 | 0.566 | 0.550 | 0.473 | 0.320 | 0.658 | 0.593 | 0.541 | 0.493 | 0.343 |
| 167.07 | 0.651 | 0.566 | 0.536 | 0.476 | 0.329 | 0.639 | 0.597 | 0.538 | 0.494 | 0.353 |
| 167.57 | 0.652 | 0.566 | 0.536 | 0.476 | 0.334 | 0.642 | 0.593 | 0.537 | 0.493 | 0.351 |
| 168.07 | 0.652 | 0.566 | 0.535 | 0.476 | 0.325 | 0.660 | 0.593 | 0.534 | 0.494 | 0.356 |
| 168.57 | 0.651 | 0.567 | 0.536 | 0.476 | 0.327 | 0.661 | 0.592 | 0.521 | 0.494 | 0.363 |
| 169.07 | 0.650 | 0.567 | 0.536 | 0.475 | 0.327 | 0.658 | 0.592 | 0.523 | 0.495 | 0.353 |

| t (h) | 45°C | | | | | 30°C | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 6.25 kg/m$^3$-d | 4.14 kg/m$^3$-d | 2.79 kg/m$^3$-d | 1.44 kg/m$^3$-d | 0.56 kg/m$^3$-d | 6.25 kg/m$^3$-d | 4.14 kg/m$^3$-d | 2.79 kg/m$^3$-d | 1.44 kg/m$^3$-d | 0.56 kg/m$^3$-d |
| 169.57 | 0.651 | 0.567 | 0.535 | 0.476 | 0.328 | 0.658 | 0.594 | 0.524 | 0.495 | 0.354 |
| 170.07 | 0.653 | 0.567 | 0.535 | 0.476 | 0.327 | 0.659 | 0.594 | 0.528 | 0.495 | 0.353 |
| 170.57 | 0.655 | 0.567 | 0.536 | 0.476 | 0.328 | 0.660 | 0.592 | 0.547 | 0.496 | 0.357 |
| 171.07 | 0.652 | 0.568 | 0.536 | 0.475 | 0.327 | 0.659 | 0.592 | 0.542 | 0.496 | 0.338 |
| 171.57 | 0.650 | 0.568 | 0.535 | 0.476 | 0.326 | 0.660 | 0.593 | 0.558 | 0.495 | 0.341 |
| 172.07 | 0.656 | 0.568 | 0.534 | 0.476 | 0.327 | 0.658 | 0.593 | 0.568 | 0.495 | 0.347 |
| 172.57 | 0.655 | 0.568 | 0.535 | 0.476 | 0.327 | 0.661 | 0.592 | 0.566 | 0.495 | 0.353 |
| 173.07 | 0.655 | 0.566 | 0.534 | 0.476 | 0.328 | 0.658 | 0.592 | 0.556 | 0.497 | 0.361 |
| 173.57 | 0.655 | 0.566 | 0.534 | 0.476 | 0.326 | 0.658 | 0.594 | 0.559 | 0.497 | 0.353 |
| 174.07 | 0.654 | 0.566 | 0.534 | 0.472 | 0.326 | 0.660 | 0.592 | 0.557 | 0.497 | 0.357 |
| 174.57 | 0.652 | 0.566 | 0.534 | 0.476 | 0.326 | 0.661 | 0.593 | 0.565 | 0.496 | 0.341 |
| 175.07 | 0.653 | 0.566 | 0.534 | 0.475 | 0.328 | 0.659 | 0.593 | 0.566 | 0.496 | 0.349 |
| 175.57 | 0.651 | 0.569 | 0.534 | 0.475 | 0.330 | 0.659 | 0.665 | 0.546 | 0.496 | 0.355 |
| 176.07 | 0.651 | 0.569 | 0.539 | 0.475 | 0.325 | 0.660 | 0.594 | 0.539 | 0.496 | 0.362 |
| 176.57 | 0.650 | 0.566 | 0.534 | 0.475 | 0.332 | 0.661 | 0.592 | 0.538 | 0.495 | 0.354 |
| 177.07 | 0.651 | 0.566 | 0.538 | 0.475 | 0.327 | 0.658 | 0.595 | 0.537 | 0.496 | 0.354 |
| 177.57 | 0.651 | 0.566 | 0.539 | 0.400 | 0.334 | 0.660 | 0.596 | 0.527 | 0.496 | 0.352 |
| 178.07 | 0.652 | 0.566 | 0.538 | 0.475 | 0.331 | 0.656 | 0.593 | 0.532 | 0.496 | 0.355 |
| 178.57 | 0.651 | 0.566 | 0.538 | 0.476 | 0.327 | 0.654 | 0.595 | 0.538 | 0.494 | 0.357 |
| 179.07 | 0.651 | 0.566 | 0.538 | 0.475 | 0.329 | 0.658 | 0.596 | 0.532 | 0.495 | 0.359 |
| 179.57 | 0.651 | 0.568 | 0.537 | 0.475 | 0.329 | 0.659 | 0.592 | 0.544 | 0.495 | 0.360 |
| 180.07 | 0.651 | 0.568 | 0.538 | 0.475 | 0.334 | 0.661 | 0.590 | 0.545 | 0.495 | 0.361 |
| 180.57 | 0.651 | 0.569 | 0.537 | 0.475 | 0.328 | 0.658 | 0.595 | 0.541 | 0.495 | 0.361 |
| 181.07 | 0.651 | 0.569 | 0.538 | 0.475 | 0.332 | 0.660 | 0.596 | 0.536 | 0.496 | 0.361 |
| 181.57 | 0.652 | 0.569 | 0.537 | 0.475 | 0.333 | 0.658 | 0.598 | 0.531 | 0.495 | 0.361 |
| 182.07 | 0.652 | 0.568 | 0.537 | 0.475 | 0.320 | 0.659 | 0.589 | 0.545 | 0.507 | 0.339 |
| 182.57 | 0.651 | 0.568 | 0.539 | 0.475 | 0.334 | 0.660 | 0.588 | 0.544 | 0.495 | 0.350 |
| 183.07 | 0.651 | 0.568 | 0.538 | 0.475 | 0.325 | 0.659 | 0.596 | 0.548 | 0.495 | 0.358 |
| 183.57 | 0.651 | 0.568 | 0.539 | 0.475 | 0.335 | 0.661 | 0.593 | 0.541 | 0.502 | 0.357 |
| 184.07 | 0.651 | 0.568 | 0.538 | 0.475 | 0.326 | 0.659 | 0.594 | 0.539 | 0.496 | 0.355 |
| 184.57 | 0.651 | 0.567 | 0.537 | 0.475 | 0.323 | 0.660 | 0.596 | 0.544 | 0.495 | 0.354 |
| 185.07 | 0.488 | 0.408 | 0.387 | 0.354 | 0.267 | 0.531 | 0.445 | 0.407 | 0.360 | 0.280 |
| 186.18 | 0.522 | 0.454 | 0.428 | 0.388 | 0.305 | 0.568 | 0.488 | 0.445 | 0.388 | 0.278 |

| t (h) | 45°C | | | | | 30°C | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 6.25 kg/m$^3$-d | 4.14 kg/m$^3$-d | 2.79 kg/m$^3$-d | 1.44 kg/m$^3$-d | 0.56 kg/m$^3$-d | 6.25 kg/m$^3$-d | 4.14 kg/m$^3$-d | 2.79 kg/m$^3$-d | 1.44 kg/m$^3$-d | 0.56 kg/m$^3$-d |
| 186.68 | 0.558 | 0.476 | 0.459 | 0.428 | 0.313 | 0.575 | 0.525 | 0.472 | 0.421 | 0.303 |
| 187.18 | 0.591 | 0.507 | 0.474 | 0.469 | 0.320 | 0.617 | 0.544 | 0.505 | 0.468 | 0.328 |
| 187.68 | 0.625 | 0.536 | 0.516 | 0.471 | 0.323 | 0.662 | 0.592 | 0.527 | 0.502 | 0.350 |
| 188.18 | 0.651 | 0.569 | 0.532 | 0.476 | 0.323 | 0.666 | 0.592 | 0.543 | 0.496 | 0.355 |
| 188.68 | 0.651 | 0.566 | 0.531 | 0.477 | 0.324 | 0.649 | 0.597 | 0.545 | 0.496 | 0.354 |
| 189.18 | 0.652 | 0.568 | 0.532 | 0.470 | 0.330 | 0.658 | 0.593 | 0.528 | 0.495 | 0.353 |
| 189.68 | 0.651 | 0.567 | 0.534 | 0.473 | 0.327 | 0.659 | 0.593 | 0.546 | 0.503 | 0.357 |
| 190.18 | 0.651 | 0.567 | 0.534 | 0.474 | 0.324 | 0.658 | 0.598 | 0.532 | 0.502 | 0.356 |
| 190.68 | 0.651 | 0.568 | 0.531 | 0.473 | 0.329 | 0.661 | 0.592 | 0.543 | 0.496 | 0.355 |
| 191.18 | 0.651 | 0.556 | 0.533 | 0.474 | 0.327 | 0.663 | 0.596 | 0.545 | 0.496 | 0.354 |
| 191.68 | 0.652 | 0.568 | 0.532 | 0.475 | 0.330 | 0.653 | 0.594 | 0.546 | 0.497 | 0.353 |
| 192.18 | 0.651 | 0.566 | 0.531 | 0.475 | 0.328 | 0.663 | 0.590 | 0.546 | 0.496 | 0.353 |
| 192.68 | 0.651 | 0.566 | 0.532 | 0.476 | 0.327 | 0.660 | 0.591 | 0.545 | 0.496 | 0.361 |
| 193.18 | 0.653 | 0.567 | 0.533 | 0.475 | 0.325 | 0.658 | 0.595 | 0.544 | 0.496 | 0.361 |
| 193.68 | 0.652 | 0.569 | 0.531 | 0.476 | 0.325 | 0.659 | 0.592 | 0.545 | 0.495 | 0.361 |
| 194.18 | 0.652 | 0.568 | 0.536 | 0.476 | 0.328 | 0.650 | 0.594 | 0.545 | 0.495 | 0.353 |
| 194.68 | 0.652 | 0.568 | 0.530 | 0.475 | 0.326 | 0.655 | 0.596 | 0.545 | 0.496 | 0.359 |
| 195.18 | 0.652 | 0.566 | 0.531 | 0.475 | 0.325 | 0.649 | 0.593 | 0.549 | 0.496 | 0.347 |
| 195.68 | 0.650 | 0.569 | 0.521 | 0.475 | 0.325 | 0.656 | 0.593 | 0.546 | 0.495 | 0.355 |
| 196.18 | 0.651 | 0.566 | 0.524 | 0.470 | 0.325 | 0.665 | 0.595 | 0.546 | 0.495 | 0.356 |
| 196.68 | 0.653 | 0.567 | 0.531 | 0.473 | 0.326 | 0.661 | 0.592 | 0.546 | 0.496 | 0.357 |
| 197.18 | 0.653 | 0.568 | 0.535 | 0.473 | 0.328 | 0.659 | 0.597 | 0.526 | 0.496 | 0.356 |
| 197.68 | 0.654 | 0.568 | 0.529 | 0.475 | 0.326 | 0.659 | 0.594 | 0.545 | 0.496 | 0.354 |
| 198.18 | 0.655 | 0.567 | 0.523 | 0.474 | 0.331 | 0.658 | 0.593 | 0.546 | 0.497 | 0.359 |
| 198.68 | 0.654 | 0.567 | 0.531 | 0.475 | 0.333 | 0.659 | 0.592 | 0.544 | 0.497 | 0.358 |
| 199.18 | 0.653 | 0.574 | 0.535 | 0.473 | 0.327 | 0.658 | 0.596 | 0.526 | 0.497 | 0.358 |
| 199.68 | 0.653 | 0.569 | 0.530 | 0.475 | 0.329 | 0.658 | 0.596 | 0.535 | 0.498 | 0.358 |
| 200.18 | 0.652 | 0.570 | 0.531 | 0.475 | 0.327 | 0.659 | 0.589 | 0.536 | 0.497 | 0.358 |
| 200.68 | 0.650 | 0.571 | 0.532 | 0.471 | 0.329 | 0.659 | 0.593 | 0.545 | 0.498 | 0.358 |
| 201.18 | 0.666 | 0.568 | 0.531 | 0.475 | 0.331 | 0.659 | 0.593 | 0.545 | 0.497 | 0.358 |
| 201.68 | 0.656 | 0.568 | 0.531 | 0.476 | 0.332 | 0.656 | 0.594 | 0.543 | 0.496 | 0.358 |
| 202.18 | 0.653 | 0.567 | 0.531 | 0.473 | 0.333 | 0.660 | 0.593 | 0.542 | 0.497 | 0.358 |
| 202.68 | 0.650 | 0.568 | 0.534 | 0.465 | 0.334 | 0.659 | 0.594 | 0.544 | 0.498 | 0.358 |

| t (h) | 45°C | | | | | 30°C | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 6.25 kg/m$^3$-d | 4.14 kg/m$^3$-d | 2.79 kg/m$^3$-d | 1.44 kg/m$^3$-d | 0.56 kg/m$^3$-d | 6.25 kg/m$^3$-d | 4.14 kg/m$^3$-d | 2.79 kg/m$^3$-d | 1.44 kg/m$^3$-d | 0.56 kg/m$^3$-d |
| 203.18 | 0.650 | 0.568 | 0.534 | 0.469 | 0.334 | 0.652 | 0.595 | 0.549 | 0.498 | 0.358 |
| 203.68 | 0.650 | 0.567 | 0.534 | 0.476 | 0.335 | 0.661 | 0.592 | 0.544 | 0.498 | 0.358 |
| 204.18 | 0.667 | 0.566 | 0.534 | 0.476 | 0.331 | 0.655 | 0.592 | 0.525 | 0.497 | 0.358 |
| 204.68 | 0.655 | 0.573 | 0.534 | 0.475 | 0.332 | 0.659 | 0.593 | 0.546 | 0.496 | 0.357 |
| 205.18 | 0.654 | 0.574 | 0.533 | 0.476 | 0.331 | 0.661 | 0.596 | 0.527 | 0.496 | 0.357 |
| 205.68 | 0.655 | 0.580 | 0.534 | 0.475 | 0.331 | 0.654 | 0.598 | 0.546 | 0.495 | 0.357 |
| 206.18 | 0.654 | 0.566 | 0.532 | 0.475 | 0.331 | 0.661 | 0.592 | 0.527 | 0.502 | 0.357 |
| 206.68 | 0.650 | 0.574 | 0.532 | 0.476 | 0.331 | 0.659 | 0.591 | 0.544 | 0.495 | 0.357 |
| 207.18 | 0.650 | 0.566 | 0.535 | 0.469 | 0.331 | 0.658 | 0.595 | 0.536 | 0.503 | 0.357 |
| 207.68 | 0.654 | 0.566 | 0.535 | 0.470 | 0.331 | 0.661 | 0.593 | 0.541 | 0.495 | 0.357 |
| 208.18 | 0.651 | 0.578 | 0.528 | 0.474 | 0.331 | 0.660 | 0.594 | 0.538 | 0.495 | 0.357 |
| 208.68 | 0.650 | 0.566 | 0.536 | 0.475 | 0.331 | 0.659 | 0.592 | 0.544 | 0.496 | 0.358 |
| 209.18 | 0.495 | 0.383 | 0.397 | 0.314 | 0.309 | 0.508 | 0.436 | 0.372 | 0.377 | 0.290 |
| 210.33 | 0.530 | 0.417 | 0.415 | 0.348 | 0.310 | 0.545 | 0.468 | 0.406 | 0.431 | 0.329 |
| 210.83 | 0.569 | 0.455 | 0.448 | 0.388 | 0.310 | 0.577 | 0.481 | 0.437 | 0.451 | 0.340 |
| 211.33 | 0.593 | 0.478 | 0.480 | 0.430 | 0.310 | 0.628 | 0.535 | 0.480 | 0.513 | 0.359 |
| 211.83 | 0.608 | 0.510 | 0.520 | 0.471 | 0.310 | 0.660 | 0.548 | 0.518 | 0.489 | 0.360 |
| 212.33 | 0.607 | 0.541 | 0.522 | 0.471 | 0.331 | 0.659 | 0.594 | 0.544 | 0.496 | 0.360 |
| 212.83 | 0.647 | 0.571 | 0.533 | 0.471 | 0.331 | 0.650 | 0.594 | 0.546 | 0.496 | 0.361 |
| 213.33 | 0.655 | 0.570 | 0.530 | 0.472 | 0.332 | 0.661 | 0.597 | 0.541 | 0.498 | 0.361 |
| 213.83 | 0.649 | 0.571 | 0.532 | 0.476 | 0.332 | 0.660 | 0.594 | 0.548 | 0.497 | 0.352 |
| 214.33 | 0.650 | 0.566 | 0.531 | 0.476 | 0.332 | 0.655 | 0.598 | 0.551 | 0.499 | 0.353 |
| 214.83 | 0.652 | 0.566 | 0.530 | 0.477 | 0.332 | 0.660 | 0.593 | 0.552 | 0.498 | 0.354 |
| 215.33 | 0.648 | 0.572 | 0.533 | 0.477 | 0.332 | 0.661 | 0.593 | 0.545 | 0.498 | 0.354 |
| 215.83 | 0.653 | 0.567 | 0.532 | 0.477 | 0.332 | 0.661 | 0.592 | 0.544 | 0.498 | 0.356 |
| 216.33 | 0.647 | 0.567 | 0.531 | 0.477 | 0.332 | 0.659 | 0.595 | 0.544 | 0.498 | 0.356 |
| 216.83 | 0.650 | 0.568 | 0.531 | 0.477 | 0.332 | 0.658 | 0.593 | 0.546 | 0.497 | 0.348 |
| 217.33 | 0.656 | 0.568 | 0.533 | 0.478 | 0.332 | 0.659 | 0.592 | 0.546 | 0.498 | 0.349 |
| 217.83 | 0.654 | 0.568 | 0.533 | 0.477 | 0.333 | 0.659 | 0.597 | 0.544 | 0.498 | 0.350 |
| 218.33 | 0.651 | 0.569 | 0.528 | 0.477 | 0.332 | 0.660 | 0.595 | 0.544 | 0.499 | 0.351 |
| 218.83 | 0.651 | 0.568 | 0.531 | 0.478 | 0.332 | 0.659 | 0.597 | 0.545 | 0.498 | 0.352 |
| 219.33 | 0.655 | 0.567 | 0.532 | 0.478 | 0.333 | 0.659 | 0.593 | 0.545 | 0.488 | 0.353 |
| 219.83 | 0.667 | 0.572 | 0.529 | 0.478 | 0.332 | 0.661 | 0.594 | 0.541 | 0.499 | 0.354 |

| t (h) | 45°C | | | | | 30°C | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 6.25 $kg/m^3$-d | 4.14 $kg/m^3$-d | 2.79 $kg/m^3$-d | 1.44 $kg/m^3$-d | 0.56 $kg/m^3$-d | 6.25 $kg/m^3$-d | 4.14 $kg/m^3$-d | 2.79 $kg/m^3$-d | 1.44 $kg/m^3$-d | 0.56 $kg/m^3$-d |
| 220.33 | 0.654 | 0.571 | 0.532 | 0.478 | 0.332 | 0.660 | 0.592 | 0.545 | 0.484 | 0.356 |
| 220.83 | 0.650 | 0.569 | 0.532 | 0.478 | 0.333 | 0.659 | 0.596 | 0.542 | 0.488 | 0.357 |
| 221.33 | 0.654 | 0.578 | 0.533 | 0.479 | 0.332 | 0.658 | 0.594 | 0.545 | 0.499 | 0.358 |
| 221.83 | 0.654 | 0.569 | 0.531 | 0.479 | 0.334 | 0.658 | 0.594 | 0.547 | 0.489 | 0.356 |
| 222.33 | 0.654 | 0.569 | 0.532 | 0.479 | 0.327 | 0.659 | 0.595 | 0.549 | 0.496 | 0.361 |
| 222.83 | 0.654 | 0.566 | 0.532 | 0.479 | 0.328 | 0.660 | 0.594 | 0.550 | 0.505 | 0.350 |
| 223.33 | 0.656 | 0.566 | 0.531 | 0.479 | 0.328 | 0.659 | 0.595 | 0.552 | 0.494 | 0.361 |
| 223.83 | 0.666 | 0.566 | 0.533 | 0.479 | 0.325 | 0.660 | 0.596 | 0.545 | 0.490 | 0.354 |
| 224.33 | 0.652 | 0.570 | 0.532 | 0.479 | 0.327 | 0.660 | 0.597 | 0.546 | 0.487 | 0.353 |
| 224.83 | 0.652 | 0.566 | 0.532 | 0.479 | 0.328 | 0.658 | 0.592 | 0.544 | 0.486 | 0.355 |
| 225.33 | 0.650 | 0.571 | 0.531 | 0.479 | 0.329 | 0.659 | 0.596 | 0.544 | 0.493 | 0.354 |
| 225.83 | 0.655 | 0.571 | 0.531 | 0.478 | 0.330 | 0.659 | 0.590 | 0.544 | 0.506 | 0.354 |
| 226.33 | 0.669 | 0.571 | 0.531 | 0.479 | 0.330 | 0.659 | 0.592 | 0.544 | 0.510 | 0.353 |
| 226.83 | 0.668 | 0.570 | 0.531 | 0.478 | 0.330 | 0.659 | 0.595 | 0.546 | 0.506 | 0.356 |
| 227.33 | 0.652 | 0.569 | 0.532 | 0.478 | 0.331 | 0.658 | 0.596 | 0.545 | 0.500 | 0.353 |
| 227.83 | 0.656 | 0.571 | 0.532 | 0.478 | 0.332 | 0.659 | 0.588 | 0.547 | 0.501 | 0.358 |
| 228.33 | 0.647 | 0.571 | 0.530 | 0.479 | 0.332 | 0.660 | 0.594 | 0.546 | 0.509 | 0.357 |
| 228.83 | 0.656 | 0.571 | 0.532 | 0.479 | 0.332 | 0.660 | 0.593 | 0.544 | 0.498 | 0.351 |
| 229.33 | 0.653 | 0.570 | 0.531 | 0.478 | 0.333 | 0.659 | 0.593 | 0.545 | 0.495 | 0.358 |
| 229.83 | 0.654 | 0.570 | 0.532 | 0.479 | 0.333 | 0.661 | 0.589 | 0.544 | 0.494 | 0.356 |
| 230.33 | 0.644 | 0.571 | 0.536 | 0.479 | 0.333 | 0.658 | 0.594 | 0.544 | 0.492 | 0.352 |
| 230.83 | 0.656 | 0.569 | 0.533 | 0.479 | 0.333 | 0.659 | 0.598 | 0.545 | 0.500 | 0.353 |
| 231.33 | 0.656 | 0.570 | 0.531 | 0.479 | 0.333 | 0.660 | 0.595 | 0.544 | 0.513 | 0.352 |
| 231.83 | 0.644 | 0.569 | 0.531 | 0.479 | 0.333 | 0.660 | 0.589 | 0.545 | 0.499 | 0.361 |
| 232.33 | 0.667 | 0.570 | 0.531 | 0.479 | 0.333 | 0.660 | 0.595 | 0.546 | 0.497 | 0.352 |
| 232.83 | 0.656 | 0.571 | 0.532 | 0.479 | 0.333 | 0.660 | 0.592 | 0.546 | 0.512 | 0.361 |
| 233.33 | 0.487 | 0.519 | 0.440 | 0.399 | 0.312 | 0.608 | 0.561 | 0.475 | 0.397 | 0.308 |
| 235.33 | 0.520 | 0.540 | 0.485 | 0.439 | 0.313 | 0.644 | 0.593 | 0.505 | 0.433 | 0.306 |
| 235.83 | 0.622 | 0.571 | 0.514 | 0.480 | 0.324 | 0.658 | 0.597 | 0.536 | 0.471 | 0.315 |
| 236.33 | 0.656 | 0.570 | 0.523 | 0.480 | 0.321 | 0.658 | 0.593 | 0.550 | 0.493 | 0.334 |
| 236.83 | 0.656 | 0.570 | 0.533 | 0.480 | 0.321 | 0.661 | 0.594 | 0.547 | 0.491 | 0.340 |
| 237.33 | 0.653 | 0.569 | 0.531 | 0.479 | 0.329 | 0.660 | 0.594 | 0.547 | 0.492 | 0.351 |
| 237.83 | 0.654 | 0.569 | 0.531 | 0.479 | 0.334 | 0.659 | 0.591 | 0.550 | 0.495 | 0.351 |

| t (h) | 45°C | | | | | 30°C | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 6.25 kg/m$^3$-d | 4.14 kg/m$^3$-d | 2.79 kg/m$^3$-d | 1.44 kg/m$^3$-d | 0.56 kg/m$^3$-d | 6.25 kg/m$^3$-d | 4.14 kg/m$^3$-d | 2.79 kg/m$^3$-d | 1.44 kg/m$^3$-d | 0.56 kg/m$^3$-d |
| 238.33 | 0.653 | 0.570 | 0.531 | 0.479 | 0.334 | 0.659 | 0.595 | 0.547 | 0.492 | 0.351 |
| 238.83 | 0.655 | 0.569 | 0.533 | 0.479 | 0.334 | 0.659 | 0.593 | 0.548 | 0.494 | 0.351 |
| 239.33 | 0.656 | 0.570 | 0.532 | 0.479 | 0.334 | 0.659 | 0.593 | 0.549 | 0.492 | 0.351 |
| 239.83 | 0.651 | 0.571 | 0.532 | 0.478 | 0.335 | 0.660 | 0.591 | 0.547 | 0.491 | 0.351 |
| 240.33 | 0.651 | 0.571 | 0.531 | 0.478 | 0.335 | 0.658 | 0.594 | 0.548 | 0.494 | 0.350 |
| 240.83 | 0.654 | 0.572 | 0.532 | 0.478 | 0.335 | 0.658 | 0.592 | 0.547 | 0.493 | 0.351 |
| 241.33 | 0.655 | 0.572 | 0.532 | 0.477 | 0.335 | 0.658 | 0.593 | 0.548 | 0.494 | 0.350 |
| 241.83 | 0.669 | 0.587 | 0.533 | 0.477 | 0.335 | 0.661 | 0.592 | 0.549 | 0.491 | 0.350 |
| 242.33 | 0.652 | 0.582 | 0.532 | 0.477 | 0.335 | 0.659 | 0.593 | 0.547 | 0.493 | 0.350 |
| 242.83 | 0.650 | 0.572 | 0.531 | 0.477 | 0.335 | 0.660 | 0.593 | 0.547 | 0.491 | 0.351 |
| 243.33 | 0.650 | 0.571 | 0.532 | 0.477 | 0.330 | 0.659 | 0.593 | 0.544 | 0.495 | 0.350 |
| 243.83 | 0.652 | 0.571 | 0.532 | 0.477 | 0.334 | 0.660 | 0.590 | 0.544 | 0.498 | 0.350 |
| 244.33 | 0.648 | 0.570 | 0.532 | 0.476 | 0.331 | 0.659 | 0.594 | 0.544 | 0.492 | 0.353 |
| 244.83 | 0.651 | 0.553 | 0.533 | 0.476 | 0.333 | 0.659 | 0.591 | 0.545 | 0.495 | 0.355 |
| 245.33 | 0.650 | 0.571 | 0.532 | 0.476 | 0.326 | 0.659 | 0.594 | 0.546 | 0.495 | 0.353 |
| 245.83 | 0.652 | 0.571 | 0.521 | 0.472 | 0.335 | 0.659 | 0.591 | 0.545 | 0.494 | 0.379 |
| 246.33 | 0.652 | 0.571 | 0.533 | 0.471 | 0.328 | 0.661 | 0.593 | 0.544 | 0.498 | 0.383 |
| 246.83 | 0.648 | 0.570 | 0.531 | 0.471 | 0.325 | 0.658 | 0.594 | 0.545 | 0.498 | 0.355 |
| 247.33 | 0.654 | 0.572 | 0.533 | 0.471 | 0.326 | 0.660 | 0.597 | 0.546 | 0.495 | 0.352 |
| 247.83 | 0.650 | 0.570 | 0.533 | 0.476 | 0.328 | 0.659 | 0.594 | 0.546 | 0.494 | 0.352 |
| 248.33 | 0.654 | 0.570 | 0.532 | 0.471 | 0.325 | 0.661 | 0.593 | 0.547 | 0.498 | 0.353 |
| 248.83 | 0.649 | 0.570 | 0.533 | 0.471 | 0.327 | 0.661 | 0.593 | 0.546 | 0.491 | 0.353 |
| 249.33 | 0.650 | 0.570 | 0.532 | 0.472 | 0.328 | 0.659 | 0.591 | 0.545 | 0.494 | 0.353 |
| 249.83 | 0.651 | 0.569 | 0.532 | 0.472 | 0.334 | 0.667 | 0.593 | 0.547 | 0.491 | 0.353 |
| 250.33 | 0.652 | 0.569 | 0.532 | 0.471 | 0.329 | 0.658 | 0.597 | 0.545 | 0.492 | 0.354 |
| 250.83 | 0.651 | 0.568 | 0.533 | 0.471 | 0.332 | 0.660 | 0.598 | 0.545 | 0.491 | 0.354 |
| 251.33 | 0.651 | 0.569 | 0.531 | 0.471 | 0.331 | 0.659 | 0.594 | 0.544 | 0.493 | 0.355 |
| 251.83 | 0.651 | 0.580 | 0.530 | 0.471 | 0.332 | 0.659 | 0.594 | 0.544 | 0.495 | 0.356 |
| 252.33 | 0.651 | 0.581 | 0.533 | 0.470 | 0.324 | 0.660 | 0.591 | 0.553 | 0.492 | 0.352 |
| 252.83 | 0.651 | 0.578 | 0.532 | 0.470 | 0.332 | 0.660 | 0.592 | 0.547 | 0.491 | 0.354 |
| 253.33 | 0.656 | 0.569 | 0.531 | 0.470 | 0.334 | 0.660 | 0.593 | 0.551 | 0.492 | 0.354 |
| 253.83 | 0.655 | 0.570 | 0.532 | 0.469 | 0.331 | 0.659 | 0.590 | 0.552 | 0.491 | 0.352 |
| 254.33 | 0.655 | 0.570 | 0.531 | 0.468 | 0.331 | 0.661 | 0.594 | 0.552 | 0.491 | 0.352 |

| t (h) | 45°C | | | | | 30°C | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 6.25 kg/m$^3$-d | 4.14 kg/m$^3$-d | 2.79 kg/m$^3$-d | 1.44 kg/m$^3$-d | 0.56 kg/m$^3$-d | 6.25 kg/m$^3$-d | 4.14 kg/m$^3$-d | 2.79 kg/m$^3$-d | 1.44 kg/m$^3$-d | 0.56 kg/m$^3$-d |
| 254.83 | 0.656 | 0.570 | 0.531 | 0.468 | 0.331 | 0.660 | 0.597 | 0.547 | 0.493 | 0.351 |
| 255.33 | 0.650 | 0.570 | 0.531 | 0.468 | 0.330 | 0.660 | 0.596 | 0.548 | 0.493 | 0.349 |
| 255.83 | 0.655 | 0.569 | 0.536 | 0.469 | 0.334 | 0.666 | 0.597 | 0.548 | 0.494 | 0.352 |
| 256.33 | 0.655 | 0.569 | 0.531 | 0.469 | 0.332 | 0.659 | 0.593 | 0.547 | 0.491 | 0.355 |
| 256.83 | 0.654 | 0.574 | 0.532 | 0.469 | 0.333 | 0.666 | 0.594 | 0.551 | 0.492 | 0.357 |
| 257.33 | 0.655 | 0.578 | 0.405 | 0.388 | 0.291 | 0.661 | 0.596 | 0.358 | 0.371 | 0.299 |
| 259.33 | 0.654 | 0.581 | 0.457 | 0.429 | 0.315 | 0.666 | 0.593 | 0.422 | 0.411 | 0.299 |
| 259.83 | 0.649 | 0.579 | 0.489 | 0.448 | 0.320 | 0.665 | 0.590 | 0.482 | 0.451 | 0.300 |
| 260.33 | 0.655 | 0.565 | 0.515 | 0.469 | 0.327 | 0.665 | 0.598 | 0.512 | 0.484 | 0.301 |
| 260.83 | 0.650 | 0.557 | 0.533 | 0.469 | 0.329 | 0.662 | 0.598 | 0.544 | 0.491 | 0.301 |
| 261.33 | 0.650 | 0.562 | 0.532 | 0.469 | 0.332 | 0.663 | 0.594 | 0.548 | 0.492 | 0.351 |
| 261.83 | 0.650 | 0.571 | 0.531 | 0.470 | 0.331 | 0.660 | 0.597 | 0.548 | 0.491 | 0.351 |
| 262.33 | 0.655 | 0.561 | 0.531 | 0.470 | 0.332 | 0.658 | 0.593 | 0.548 | 0.498 | 0.352 |
| 262.83 | 0.651 | 0.570 | 0.533 | 0.469 | 0.333 | 0.662 | 0.590 | 0.552 | 0.494 | 0.353 |
| 263.33 | 0.652 | 0.560 | 0.533 | 0.469 | 0.335 | 0.668 | 0.596 | 0.551 | 0.493 | 0.353 |
| 263.83 | 0.651 | 0.564 | 0.531 | 0.469 | 0.331 | 0.659 | 0.597 | 0.547 | 0.499 | 0.354 |
| 264.33 | 0.650 | 0.561 | 0.531 | 0.469 | 0.330 | 0.659 | 0.597 | 0.551 | 0.496 | 0.355 |
| 264.83 | 0.650 | 0.562 | 0.531 | 0.469 | 0.333 | 0.659 | 0.598 | 0.551 | 0.499 | 0.355 |
| 265.33 | 0.650 | 0.565 | 0.533 | 0.469 | 0.331 | 0.659 | 0.590 | 0.550 | 0.494 | 0.355 |
| 265.83 | 0.650 | 0.562 | 0.531 | 0.469 | 0.332 | 0.659 | 0.598 | 0.552 | 0.494 | 0.355 |
| 266.33 | 0.651 | 0.560 | 0.535 | 0.469 | 0.330 | 0.667 | 0.595 | 0.552 | 0.494 | 0.353 |
| 266.83 | 0.652 | 0.570 | 0.525 | 0.468 | 0.330 | 0.659 | 0.593 | 0.551 | 0.497 | 0.351 |
| 267.33 | 0.655 | 0.561 | 0.532 | 0.469 | 0.327 | 0.660 | 0.593 | 0.550 | 0.496 | 0.349 |
| 267.83 | 0.655 | 0.563 | 0.527 | 0.469 | 0.325 | 0.661 | 0.592 | 0.552 | 0.497 | 0.342 |
| 268.33 | 0.652 | 0.564 | 0.531 | 0.469 | 0.333 | 0.658 | 0.597 | 0.550 | 0.498 | 0.343 |
| 268.83 | 0.655 | 0.569 | 0.532 | 0.468 | 0.330 | 0.668 | 0.593 | 0.552 | 0.498 | 0.343 |
| 269.33 | 0.646 | 0.564 | 0.533 | 0.468 | 0.329 | 0.664 | 0.592 | 0.547 | 0.495 | 0.343 |
| 269.83 | 0.655 | 0.569 | 0.533 | 0.469 | 0.386 | 0.664 | 0.590 | 0.547 | 0.498 | 0.358 |
| 270.33 | 0.651 | 0.566 | 0.524 | 0.470 | 0.329 | 0.667 | 0.590 | 0.547 | 0.491 | 0.353 |
| 270.83 | 0.655 | 0.569 | 0.532 | 0.469 | 0.325 | 0.660 | 0.571 | 0.549 | 0.495 | 0.356 |
| 271.33 | 0.654 | 0.569 | 0.530 | 0.469 | 0.333 | 0.659 | 0.594 | 0.547 | 0.493 | 0.355 |
| 271.83 | 0.653 | 0.568 | 0.532 | 0.470 | 0.328 | 0.658 | 0.594 | 0.548 | 0.496 | 0.354 |
| 272.33 | 0.653 | 0.568 | 0.533 | 0.470 | 0.326 | 0.658 | 0.595 | 0.547 | 0.493 | 0.353 |

| t (h) | 45°C | | | | | 30°C | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 6.25 kg/m$^3$-d | 4.14 kg/m$^3$-d | 2.79 kg/m$^3$-d | 1.44 kg/m$^3$-d | 0.56 kg/m$^3$-d | 6.25 kg/m$^3$-d | 4.14 kg/m$^3$-d | 2.79 kg/m$^3$-d | 1.44 kg/m$^3$-d | 0.56 kg/m$^3$-d |
| 272.83 | 0.655 | 0.564 | 0.534 | 0.470 | 0.335 | 0.661 | 0.590 | 0.547 | 0.495 | 0.352 |
| 273.33 | 0.649 | 0.564 | 0.533 | 0.470 | 0.326 | 0.659 | 0.590 | 0.548 | 0.493 | 0.353 |
| 273.83 | 0.652 | 0.564 | 0.531 | 0.470 | 0.327 | 0.659 | 0.594 | 0.549 | 0.493 | 0.353 |
| 274.33 | 0.648 | 0.571 | 0.531 | 0.470 | 0.327 | 0.658 | 0.592 | 0.551 | 0.494 | 0.353 |
| 274.83 | 0.654 | 0.569 | 0.533 | 0.470 | 0.334 | 0.661 | 0.592 | 0.547 | 0.483 | 0.354 |
| 275.33 | 0.653 | 0.569 | 0.536 | 0.471 | 0.326 | 0.658 | 0.592 | 0.552 | 0.492 | 0.355 |
| 275.83 | 0.656 | 0.570 | 0.533 | 0.471 | 0.327 | 0.658 | 0.597 | 0.551 | 0.498 | 0.356 |
| 276.33 | 0.653 | 0.562 | 0.532 | 0.471 | 0.328 | 0.659 | 0.596 | 0.547 | 0.491 | 0.354 |
| 276.83 | 0.655 | 0.567 | 0.532 | 0.470 | 0.330 | 0.664 | 0.592 | 0.551 | 0.493 | 0.355 |
| 277.33 | 0.652 | 0.568 | 0.531 | 0.470 | 0.327 | 0.661 | 0.595 | 0.547 | 0.494 | 0.356 |
| 277.83 | 0.654 | 0.570 | 0.533 | 0.470 | 0.335 | 0.658 | 0.596 | 0.547 | 0.495 | 0.358 |
| 278.33 | 0.650 | 0.570 | 0.535 | 0.470 | 0.332 | 0.660 | 0.597 | 0.548 | 0.492 | 0.359 |
| 278.83 | 0.654 | 0.570 | 0.532 | 0.471 | 0.332 | 0.665 | 0.595 | 0.547 | 0.493 | 0.361 |
| 279.33 | 0.647 | 0.570 | 0.533 | 0.470 | 0.334 | 0.666 | 0.592 | 0.549 | 0.498 | 0.352 |
| 279.83 | 0.656 | 0.570 | 0.532 | 0.470 | 0.334 | 0.659 | 0.597 | 0.550 | 0.497 | 0.352 |
| 280.33 | 0.669 | 0.568 | 0.536 | 0.470 | 0.333 | 0.661 | 0.594 | 0.547 | 0.497 | 0.361 |
| 280.83 | 0.652 | 0.571 | 0.526 | 0.470 | 0.335 | 0.661 | 0.592 | 0.544 | 0.495 | 0.357 |
| 281.33 | 0.505 | 0.440 | 0.377 | 0.354 | 0.319 | 0.507 | 0.470 | 0.368 | 0.386 | 0.320 |
| 282.48 | 0.538 | 0.481 | 0.407 | 0.389 | 0.323 | 0.571 | 0.480 | 0.410 | 0.413 | 0.317 |
| 282.98 | 0.572 | 0.512 | 0.447 | 0.431 | 0.325 | 0.604 | 0.530 | 0.455 | 0.444 | 0.316 |
| 283.48 | 0.606 | 0.543 | 0.464 | 0.477 | 0.329 | 0.638 | 0.543 | 0.467 | 0.495 | 0.316 |
| 283.98 | 0.649 | 0.565 | 0.512 | 0.476 | 0.326 | 0.671 | 0.595 | 0.502 | 0.492 | 0.339 |
| 284.48 | 0.666 | 0.571 | 0.532 | 0.477 | 0.330 | 0.638 | 0.598 | 0.548 | 0.494 | 0.352 |
| 284.98 | 0.666 | 0.571 | 0.531 | 0.478 | 0.334 | 0.671 | 0.566 | 0.548 | 0.492 | 0.355 |
| 285.48 | 0.666 | 0.571 | 0.532 | 0.478 | 0.332 | 0.671 | 0.592 | 0.541 | 0.496 | 0.354 |
| 285.98 | 0.666 | 0.563 | 0.534 | 0.478 | 0.334 | 0.671 | 0.595 | 0.548 | 0.492 | 0.354 |
| 286.48 | 0.666 | 0.563 | 0.533 | 0.478 | 0.333 | 0.671 | 0.594 | 0.529 | 0.491 | 0.352 |
| 286.98 | 0.666 | 0.570 | 0.534 | 0.478 | 0.333 | 0.671 | 0.597 | 0.548 | 0.494 | 0.360 |
| 287.48 | 0.666 | 0.570 | 0.534 | 0.477 | 0.332 | 0.671 | 0.598 | 0.551 | 0.496 | 0.360 |
| 287.98 | 0.666 | 0.570 | 0.534 | 0.477 | 0.331 | 0.671 | 0.596 | 0.534 | 0.493 | 0.359 |
| 288.48 | 0.666 | 0.570 | 0.534 | 0.477 | 0.329 | 0.671 | 0.597 | 0.547 | 0.491 | 0.358 |
| 288.98 | 0.666 | 0.570 | 0.536 | 0.477 | 0.330 | 0.671 | 0.593 | 0.546 | 0.494 | 0.356 |
| 289.48 | 0.666 | 0.569 | 0.531 | 0.478 | 0.333 | 0.671 | 0.592 | 0.475 | 0.494 | 0.355 |

| t (h) | 45°C | | | | | 30°C | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 6.25 kg/m$^3$-d | 4.14 kg/m$^3$-d | 2.79 kg/m$^3$-d | 1.44 kg/m$^3$-d | 0.56 kg/m$^3$-d | 6.25 kg/m$^3$-d | 4.14 kg/m$^3$-d | 2.79 kg/m$^3$-d | 1.44 kg/m$^3$-d | 0.56 kg/m$^3$-d |
| 289.98 | 0.666 | 0.569 | 0.534 | 0.478 | 0.333 | 0.671 | 0.594 | 0.541 | 0.492 | 0.351 |
| 290.48 | 0.666 | 0.570 | 0.531 | 0.478 | 0.334 | 0.671 | 0.592 | 0.544 | 0.497 | 0.350 |
| 290.98 | 0.666 | 0.569 | 0.534 | 0.478 | 0.334 | 0.671 | 0.595 | 0.551 | 0.496 | 0.349 |
| 291.48 | 0.666 | 0.569 | 0.533 | 0.479 | 0.327 | 0.671 | 0.596 | 0.546 | 0.499 | 0.353 |
| 291.98 | 0.666 | 0.570 | 0.534 | 0.479 | 0.329 | 0.671 | 0.593 | 0.549 | 0.496 | 0.355 |
| 292.48 | 0.666 | 0.569 | 0.534 | 0.480 | 0.327 | 0.671 | 0.593 | 0.549 | 0.494 | 0.354 |
| 292.98 | 0.666 | 0.569 | 0.534 | 0.479 | 0.327 | 0.671 | 0.592 | 0.532 | 0.497 | 0.354 |
| 293.48 | 0.666 | 0.570 | 0.535 | 0.479 | 0.320 | 0.671 | 0.594 | 0.550 | 0.494 | 0.354 |
| 293.98 | 0.666 | 0.570 | 0.535 | 0.479 | 0.325 | 0.671 | 0.595 | 0.531 | 0.494 | 0.354 |
| 294.48 | 0.666 | 0.569 | 0.534 | 0.479 | 0.324 | 0.671 | 0.595 | 0.551 | 0.498 | 0.355 |
| 294.98 | 0.666 | 0.570 | 0.534 | 0.479 | 0.324 | 0.671 | 0.592 | 0.549 | 0.499 | 0.355 |
| 295.48 | 0.666 | 0.569 | 0.536 | 0.479 | 0.330 | 0.671 | 0.594 | 0.543 | 0.498 | 0.355 |
| 295.98 | 0.666 | 0.569 | 0.533 | 0.479 | 0.325 | 0.671 | 0.590 | 0.545 | 0.499 | 0.355 |
| 296.48 | 0.666 | 0.565 | 0.533 | 0.478 | 0.322 | 0.671 | 0.594 | 0.532 | 0.493 | 0.354 |
| 296.98 | 0.666 | 0.565 | 0.534 | 0.478 | 0.330 | 0.671 | 0.597 | 0.552 | 0.492 | 0.354 |
| 297.48 | 0.666 | 0.564 | 0.533 | 0.478 | 0.326 | 0.671 | 0.597 | 0.547 | 0.493 | 0.354 |
| 297.98 | 0.666 | 0.564 | 0.534 | 0.478 | 0.325 | 0.671 | 0.595 | 0.531 | 0.492 | 0.355 |
| 298.48 | 0.666 | 0.565 | 0.532 | 0.474 | 0.325 | 0.671 | 0.592 | 0.550 | 0.493 | 0.355 |
| 298.98 | 0.666 | 0.565 | 0.533 | 0.472 | 0.333 | 0.671 | 0.593 | 0.547 | 0.498 | 0.355 |
| 299.48 | 0.666 | 0.564 | 0.527 | 0.444 | 0.331 | 0.671 | 0.597 | 0.546 | 0.495 | 0.355 |
| 299.98 | 0.666 | 0.564 | 0.534 | 0.444 | 0.328 | 0.671 | 0.597 | 0.538 | 0.496 | 0.355 |
| 300.48 | 0.666 | 0.564 | 0.535 | 0.444 | 0.328 | 0.671 | 0.595 | 0.549 | 0.495 | 0.355 |
| 300.98 | 0.666 | 0.564 | 0.534 | 0.470 | 0.325 | 0.671 | 0.591 | 0.549 | 0.496 | 0.355 |
| 301.48 | 0.666 | 0.563 | 0.536 | 0.471 | 0.325 | 0.671 | 0.594 | 0.548 | 0.495 | 0.355 |
| 301.98 | 0.666 | 0.564 | 0.531 | 0.468 | 0.327 | 0.671 | 0.589 | 0.545 | 0.493 | 0.355 |
| 302.48 | 0.666 | 0.563 | 0.521 | 0.469 | 0.328 | 0.671 | 0.593 | 0.547 | 0.493 | 0.355 |
| 302.98 | 0.666 | 0.563 | 0.536 | 0.469 | 0.329 | 0.671 | 0.590 | 0.547 | 0.494 | 0.356 |
| 303.48 | 0.666 | 0.564 | 0.536 | 0.469 | 0.330 | 0.671 | 0.596 | 0.548 | 0.495 | 0.355 |
| 303.98 | 0.666 | 0.564 | 0.534 | 0.469 | 0.330 | 0.671 | 0.590 | 0.544 | 0.493 | 0.355 |
| 304.48 | 0.666 | 0.563 | 0.532 | 0.470 | 0.332 | 0.671 | 0.590 | 0.549 | 0.495 | 0.356 |
| 304.98 | 0.666 | 0.563 | 0.534 | 0.511 | 0.333 | 0.671 | 0.592 | 0.547 | 0.499 | 0.356 |
| 305.48 | 0.472 | 0.446 | 0.459 | 0.363 | 0.317 | 0.484 | 0.414 | 0.386 | 0.381 | 0.293 |
| 308.07 | 0.536 | 0.470 | 0.480 | 0.383 | 0.316 | 0.529 | 0.414 | 0.445 | 0.414 | 0.318 |

| t (h) | 45°C | | | | | 30°C | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 6.25 kg/m$^3$-d | 4.14 kg/m$^3$-d | 2.79 kg/m$^3$-d | 1.44 kg/m$^3$-d | 0.56 kg/m$^3$-d | 6.25 kg/m$^3$-d | 4.14 kg/m$^3$-d | 2.79 kg/m$^3$-d | 1.44 kg/m$^3$-d | 0.56 kg/m$^3$-d |
| 308.57 | 0.588 | 0.505 | 0.514 | 0.404 | 0.320 | 0.562 | 0.477 | 0.467 | 0.469 | 0.336 |
| 309.07 | 0.635 | 0.537 | 0.530 | 0.460 | 0.321 | 0.670 | 0.509 | 0.503 | 0.484 | 0.343 |
| 309.57 | 0.650 | 0.568 | 0.531 | 0.460 | 0.323 | 0.642 | 0.541 | 0.536 | 0.495 | 0.348 |
| 310.07 | 0.650 | 0.568 | 0.534 | 0.468 | 0.323 | 0.653 | 0.541 | 0.548 | 0.495 | 0.353 |
| 310.57 | 0.654 | 0.569 | 0.531 | 0.461 | 0.320 | 0.654 | 0.597 | 0.545 | 0.498 | 0.352 |
| 311.07 | 0.655 | 0.565 | 0.535 | 0.474 | 0.320 | 0.650 | 0.598 | 0.549 | 0.496 | 0.352 |
| 311.57 | 0.654 | 0.565 | 0.532 | 0.474 | 0.321 | 0.633 | 0.595 | 0.536 | 0.492 | 0.353 |
| 312.07 | 0.655 | 0.563 | 0.533 | 0.472 | 0.322 | 0.647 | 0.596 | 0.535 | 0.497 | 0.353 |
| 312.57 | 0.654 | 0.563 | 0.531 | 0.476 | 0.327 | 0.666 | 0.594 | 0.535 | 0.497 | 0.353 |
| 313.07 | 0.655 | 0.563 | 0.529 | 0.472 | 0.325 | 0.665 | 0.593 | 0.537 | 0.497 | 0.353 |
| 313.57 | 0.655 | 0.564 | 0.533 | 0.474 | 0.323 | 0.662 | 0.592 | 0.542 | 0.497 | 0.353 |
| 314.07 | 0.656 | 0.565 | 0.532 | 0.475 | 0.325 | 0.655 | 0.591 | 0.548 | 0.497 | 0.353 |
| 314.57 | 0.656 | 0.564 | 0.531 | 0.468 | 0.327 | 0.638 | 0.595 | 0.545 | 0.496 | 0.353 |
| 315.07 | 0.654 | 0.565 | 0.532 | 0.469 | 0.331 | 0.643 | 0.593 | 0.554 | 0.497 | 0.353 |
| 315.57 | 0.655 | 0.569 | 0.533 | 0.470 | 0.333 | 0.648 | 0.596 | 0.552 | 0.496 | 0.353 |
| 316.07 | 0.654 | 0.569 | 0.532 | 0.474 | 0.333 | 0.682 | 0.593 | 0.553 | 0.497 | 0.352 |
| 316.57 | 0.656 | 0.570 | 0.530 | 0.474 | 0.335 | 0.681 | 0.597 | 0.545 | 0.496 | 0.352 |
| 317.07 | 0.667 | 0.569 | 0.532 | 0.471 | 0.331 | 0.681 | 0.592 | 0.551 | 0.496 | 0.352 |
| 317.57 | 0.653 | 0.564 | 0.536 | 0.471 | 0.326 | 0.676 | 0.594 | 0.551 | 0.492 | 0.352 |
| 318.07 | 0.670 | 0.565 | 0.535 | 0.474 | 0.329 | 0.681 | 0.592 | 0.552 | 0.493 | 0.352 |
| 318.57 | 0.667 | 0.564 | 0.535 | 0.472 | 0.328 | 0.662 | 0.597 | 0.550 | 0.496 | 0.361 |
| 319.07 | 0.656 | 0.564 | 0.541 | 0.471 | 0.328 | 0.663 | 0.595 | 0.551 | 0.496 | 0.361 |
| 319.57 | 0.655 | 0.565 | 0.535 | 0.469 | 0.328 | 0.645 | 0.593 | 0.551 | 0.495 | 0.361 |
| 320.07 | 0.654 | 0.564 | 0.533 | 0.475 | 0.327 | 0.646 | 0.590 | 0.552 | 0.495 | 0.361 |
| 320.57 | 0.526 | 0.472 | 0.423 | 0.329 | 0.274 | 0.470 | 0.429 | 0.378 | 0.349 | 0.293 |
| 330.15 | 0.561 | 0.506 | 0.431 | 0.379 | 0.309 | 0.536 | 0.446 | 0.407 | 0.389 | 0.293 |
| 330.65 | 0.598 | 0.543 | 0.455 | 0.417 | 0.323 | 0.603 | 0.502 | 0.428 | 0.439 | 0.317 |
| 331.15 | 0.622 | 0.566 | 0.486 | 0.439 | 0.326 | 0.611 | 0.509 | 0.503 | 0.475 | 0.331 |
| 331.65 | 0.655 | 0.556 | 0.514 | 0.469 | 0.327 | 0.676 | 0.592 | 0.549 | 0.487 | 0.349 |
| 332.15 | 0.653 | 0.566 | 0.529 | 0.473 | 0.328 | 0.678 | 0.598 | 0.548 | 0.494 | 0.360 |
| 332.65 | 0.667 | 0.568 | 0.528 | 0.448 | 0.326 | 0.675 | 0.597 | 0.547 | 0.497 | 0.360 |
| 333.15 | 0.652 | 0.566 | 0.528 | 0.476 | 0.333 | 0.669 | 0.596 | 0.547 | 0.497 | 0.360 |
| 333.65 | 0.656 | 0.564 | 0.529 | 0.475 | 0.331 | 0.651 | 0.595 | 0.549 | 0.496 | 0.360 |

| t (h) | 45°C | | | | | 30°C | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 6.25 kg/m$^3$-d | 4.14 kg/m$^3$-d | 2.79 kg/m$^3$-d | 1.44 kg/m$^3$-d | 0.56 kg/m$^3$-d | 6.25 kg/m$^3$-d | 4.14 kg/m$^3$-d | 2.79 kg/m$^3$-d | 1.44 kg/m$^3$-d | 0.56 kg/m$^3$-d |
| 334.15 | 0.653 | 0.564 | 0.529 | 0.467 | 0.333 | 0.675 | 0.595 | 0.548 | 0.495 | 0.360 |
| 334.65 | 0.648 | 0.563 | 0.529 | 0.467 | 0.331 | 0.682 | 0.595 | 0.548 | 0.494 | 0.359 |
| 335.15 | 0.650 | 0.563 | 0.528 | 0.469 | 0.331 | 0.665 | 0.596 | 0.550 | 0.493 | 0.359 |
| 335.65 | 0.648 | 0.562 | 0.531 | 0.469 | 0.330 | 0.674 | 0.596 | 0.550 | 0.496 | 0.359 |
| 336.15 | 0.656 | 0.564 | 0.534 | 0.469 | 0.331 | 0.655 | 0.596 | 0.549 | 0.496 | 0.359 |
| 336.65 | 0.653 | 0.564 | 0.534 | 0.469 | 0.329 | 0.644 | 0.597 | 0.553 | 0.496 | 0.359 |
| 337.15 | 0.655 | 0.566 | 0.529 | 0.468 | 0.331 | 0.667 | 0.596 | 0.554 | 0.498 | 0.359 |
| 337.65 | 0.656 | 0.565 | 0.506 | 0.469 | 0.334 | 0.674 | 0.597 | 0.555 | 0.498 | 0.359 |
| 338.15 | 0.656 | 0.564 | 0.512 | 0.469 | 0.328 | 0.672 | 0.595 | 0.554 | 0.496 | 0.359 |
| 338.65 | 0.655 | 0.563 | 0.532 | 0.469 | 0.333 | 0.677 | 0.595 | 0.555 | 0.496 | 0.359 |
| 339.15 | 0.655 | 0.564 | 0.532 | 0.469 | 0.331 | 0.667 | 0.595 | 0.555 | 0.497 | 0.359 |
| 339.65 | 0.655 | 0.562 | 0.532 | 0.468 | 0.330 | 0.668 | 0.595 | 0.553 | 0.496 | 0.358 |
| 340.15 | 0.656 | 0.551 | 0.532 | 0.468 | 0.331 | 0.666 | 0.595 | 0.555 | 0.498 | 0.358 |
| 340.65 | 0.655 | 0.552 | 0.535 | 0.476 | 0.325 | 0.664 | 0.595 | 0.555 | 0.499 | 0.358 |
| 341.15 | 0.655 | 0.551 | 0.531 | 0.473 | 0.334 | 0.667 | 0.595 | 0.557 | 0.496 | 0.358 |
| 341.65 | 0.654 | 0.566 | 0.525 | 0.471 | 0.330 | 0.662 | 0.595 | 0.557 | 0.497 | 0.358 |
| 342.15 | 0.654 | 0.556 | 0.532 | 0.468 | 0.335 | 0.666 | 0.595 | 0.557 | 0.495 | 0.358 |
| 342.65 | 0.655 | 0.561 | 0.529 | 0.474 | 0.333 | 0.672 | 0.595 | 0.557 | 0.495 | 0.358 |
| 343.15 | 0.654 | 0.568 | 0.526 | 0.471 | 0.335 | 0.668 | 0.595 | 0.557 | 0.496 | 0.358 |
| 343.65 | 0.655 | 0.565 | 0.533 | 0.469 | 0.328 | 0.675 | 0.595 | 0.557 | 0.495 | 0.358 |
| 344.15 | 0.655 | 0.568 | 0.530 | 0.475 | 0.330 | 0.680 | 0.595 | 0.557 | 0.493 | 0.358 |
| 344.65 | 0.656 | 0.567 | 0.532 | 0.469 | 0.329 | 0.675 | 0.592 | 0.557 | 0.495 | 0.358 |
| 345.15 | 0.668 | 0.564 | 0.535 | 0.475 | 0.327 | 0.673 | 0.593 | 0.558 | 0.495 | 0.358 |
| 345.65 | 0.654 | 0.567 | 0.532 | 0.468 | 0.334 | 0.675 | 0.592 | 0.557 | 0.496 | 0.358 |
| 346.15 | 0.654 | 0.561 | 0.532 | 0.474 | 0.333 | 0.661 | 0.593 | 0.558 | 0.496 | 0.358 |
| 346.65 | 0.655 | 0.561 | 0.536 | 0.470 | 0.334 | 0.662 | 0.592 | 0.547 | 0.497 | 0.358 |
| 347.15 | 0.656 | 0.566 | 0.531 | 0.471 | 0.333 | 0.667 | 0.592 | 0.548 | 0.496 | 0.358 |
| 347.65 | 0.655 | 0.555 | 0.532 | 0.472 | 0.332 | 0.670 | 0.592 | 0.547 | 0.496 | 0.358 |
| 348.15 | 0.655 | 0.551 | 0.533 | 0.472 | 0.334 | 0.674 | 0.593 | 0.547 | 0.496 | 0.358 |
| 348.65 | 0.646 | 0.566 | 0.536 | 0.471 | 0.333 | 0.679 | 0.593 | 0.558 | 0.497 | 0.358 |
| 349.15 | 0.656 | 0.566 | 0.535 | 0.471 | 0.333 | 0.681 | 0.594 | 0.547 | 0.497 | 0.358 |
| 349.65 | 0.656 | 0.565 | 0.534 | 0.468 | 0.332 | 0.676 | 0.592 | 0.547 | 0.496 | 0.358 |
| 350.15 | 0.654 | 0.563 | 0.534 | 0.474 | 0.385 | 0.680 | 0.592 | 0.547 | 0.496 | 0.358 |

| t (h) | 45°C | | | | | 30°C | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 6.25 kg/m$^3$-d | 4.14 kg/m$^3$-d | 2.79 kg/m$^3$-d | 1.44 kg/m$^3$-d | 0.56 kg/m$^3$-d | 6.25 kg/m$^3$-d | 4.14 kg/m$^3$-d | 2.79 kg/m$^3$-d | 1.44 kg/m$^3$-d | 0.56 kg/m$^3$-d |
| 350.65 | 0.653 | 0.565 | 0.534 | 0.470 | 0.381 | 0.675 | 0.595 | 0.547 | 0.497 | 0.358 |
| 351.15 | 0.656 | 0.564 | 0.532 | 0.473 | 0.333 | 0.668 | 0.592 | 0.548 | 0.496 | 0.358 |
| 351.65 | 0.653 | 0.564 | 0.530 | 0.474 | 0.332 | 0.665 | 0.592 | 0.547 | 0.498 | 0.358 |
| 352.15 | 0.654 | 0.564 | 0.534 | 0.471 | 0.331 | 0.673 | 0.593 | 0.558 | 0.497 | 0.358 |
| 352.65 | 0.655 | 0.564 | 0.533 | 0.469 | 0.331 | 0.678 | 0.592 | 0.559 | 0.497 | 0.358 |
| 353.15 | 0.525 | 0.434 | 0.393 | 0.345 | 0.324 | 0.445 | 0.414 | 0.373 | 0.350 | 0.290 |
| 354.72 | 0.561 | 0.470 | 0.451 | 0.397 | 0.324 | 0.510 | 0.486 | 0.413 | 0.394 | 0.333 |
| 355.22 | 0.595 | 0.506 | 0.476 | 0.429 | 0.322 | 0.567 | 0.520 | 0.482 | 0.411 | 0.338 |
| 355.72 | 0.629 | 0.543 | 0.509 | 0.472 | 0.323 | 0.613 | 0.564 | 0.544 | 0.452 | 0.353 |
| 356.22 | 0.654 | 0.566 | 0.533 | 0.475 | 0.323 | 0.670 | 0.596 | 0.545 | 0.497 | 0.357 |
| 356.72 | 0.653 | 0.557 | 0.532 | 0.473 | 0.323 | 0.670 | 0.594 | 0.545 | 0.497 | 0.353 |
| 357.22 | 0.655 | 0.567 | 0.531 | 0.473 | 0.323 | 0.671 | 0.595 | 0.545 | 0.497 | 0.357 |
| 357.72 | 0.653 | 0.567 | 0.531 | 0.444 | 0.324 | 0.675 | 0.595 | 0.546 | 0.493 | 0.352 |
| 358.22 | 0.656 | 0.567 | 0.532 | 0.449 | 0.324 | 0.675 | 0.593 | 0.546 | 0.493 | 0.352 |
| 358.72 | 0.654 | 0.568 | 0.532 | 0.472 | 0.325 | 0.671 | 0.592 | 0.546 | 0.494 | 0.352 |
| 359.22 | 0.669 | 0.564 | 0.531 | 0.470 | 0.325 | 0.670 | 0.592 | 0.546 | 0.493 | 0.352 |
| 359.72 | 0.645 | 0.555 | 0.535 | 0.466 | 0.328 | 0.670 | 0.594 | 0.547 | 0.492 | 0.352 |
| 360.22 | 0.653 | 0.569 | 0.533 | 0.472 | 0.329 | 0.669 | 0.592 | 0.547 | 0.493 | 0.352 |
| 360.72 | 0.655 | 0.564 | 0.532 | 0.470 | 0.330 | 0.670 | 0.593 | 0.547 | 0.492 | 0.352 |
| 361.22 | 0.654 | 0.565 | 0.533 | 0.472 | 0.333 | 0.431 | 0.593 | 0.548 | 0.493 | 0.352 |
| 361.72 | 0.655 | 0.565 | 0.530 | 0.472 | 0.333 | 0.404 | 0.595 | 0.549 | 0.491 | 0.352 |
| 362.22 | 0.656 | 0.563 | 0.534 | 0.473 | 0.332 | 0.425 | 0.596 | 0.549 | 0.492 | 0.352 |
| 362.72 | 0.654 | 0.564 | 0.533 | 0.474 | 0.329 | 0.670 | 0.596 | 0.549 | 0.496 | 0.352 |
| 363.22 | 0.654 | 0.565 | 0.534 | 0.473 | 0.330 | 0.670 | 0.596 | 0.549 | 0.497 | 0.352 |
| 363.72 | 0.655 | 0.564 | 0.533 | 0.475 | 0.329 | 0.670 | 0.597 | 0.549 | 0.497 | 0.352 |
| 364.22 | 0.667 | 0.564 | 0.534 | 0.470 | 0.331 | 0.669 | 0.594 | 0.549 | 0.498 | 0.352 |
| 364.72 | 0.655 | 0.579 | 0.533 | 0.473 | 0.330 | 0.668 | 0.595 | 0.550 | 0.497 | 0.352 |
| 365.22 | 0.653 | 0.563 | 0.532 | 0.471 | 0.331 | 0.669 | 0.594 | 0.550 | 0.497 | 0.352 |
| 365.72 | 0.653 | 0.569 | 0.532 | 0.466 | 0.330 | 0.670 | 0.595 | 0.550 | 0.498 | 0.352 |
| 366.22 | 0.667 | 0.567 | 0.530 | 0.471 | 0.327 | 0.670 | 0.597 | 0.552 | 0.498 | 0.352 |
| 366.72 | 0.668 | 0.563 | 0.531 | 0.470 | 0.328 | 0.668 | 0.598 | 0.551 | 0.496 | 0.352 |
| 367.22 | 0.667 | 0.568 | 0.533 | 0.473 | 0.328 | 0.669 | 0.597 | 0.553 | 0.498 | 0.352 |
| 367.72 | 0.651 | 0.567 | 0.524 | 0.472 | 0.327 | 0.668 | 0.598 | 0.549 | 0.498 | 0.352 |

| t (h) | 45°C | | | | | 30°C | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 6.25 kg/m$^3$-d | 4.14 kg/m$^3$-d | 2.79 kg/m$^3$-d | 1.44 kg/m$^3$-d | 0.56 kg/m$^3$-d | 6.25 kg/m$^3$-d | 4.14 kg/m$^3$-d | 2.79 kg/m$^3$-d | 1.44 kg/m$^3$-d | 0.56 kg/m$^3$-d |
| 368.22 | 0.651 | 0.563 | 0.533 | 0.468 | 0.327 | 0.670 | 0.588 | 0.549 | 0.496 | 0.352 |
| 368.72 | 0.654 | 0.564 | 0.532 | 0.468 | 0.326 | 0.671 | 0.593 | 0.549 | 0.498 | 0.352 |
| 369.22 | 0.651 | 0.565 | 0.534 | 0.472 | 0.327 | 0.664 | 0.593 | 0.549 | 0.498 | 0.352 |
| 369.72 | 0.651 | 0.565 | 0.523 | 0.471 | 0.327 | 0.665 | 0.598 | 0.549 | 0.497 | 0.352 |
| 370.22 | 0.652 | 0.564 | 0.533 | 0.473 | 0.329 | 0.671 | 0.598 | 0.549 | 0.499 | 0.352 |
| 370.72 | 0.667 | 0.563 | 0.533 | 0.474 | 0.329 | 0.665 | 0.597 | 0.551 | 0.495 | 0.352 |
| 371.22 | 0.653 | 0.564 | 0.522 | 0.473 | 0.328 | 0.665 | 0.592 | 0.550 | 0.495 | 0.352 |
| 371.72 | 0.656 | 0.566 | 0.524 | 0.472 | 0.328 | 0.666 | 0.592 | 0.550 | 0.496 | 0.352 |
| 372.22 | 0.654 | 0.566 | 0.521 | 0.472 | 0.329 | 0.665 | 0.595 | 0.550 | 0.498 | 0.352 |
| 372.72 | 0.667 | 0.568 | 0.532 | 0.473 | 0.328 | 0.665 | 0.594 | 0.551 | 0.493 | 0.352 |
| 373.22 | 0.655 | 0.567 | 0.522 | 0.473 | 0.327 | 0.665 | 0.594 | 0.550 | 0.496 | 0.352 |
| 373.72 | 0.654 | 0.568 | 0.552 | 0.473 | 0.328 | 0.666 | 0.595 | 0.550 | 0.499 | 0.352 |
| 374.22 | 0.653 | 0.568 | 0.534 | 0.473 | 0.327 | 0.666 | 0.593 | 0.549 | 0.498 | 0.352 |
| 374.72 | 0.667 | 0.567 | 0.534 | 0.473 | 0.327 | 0.666 | 0.592 | 0.549 | 0.494 | 0.352 |
| 375.22 | 0.653 | 0.566 | 0.536 | 0.473 | 0.292 | 0.666 | 0.597 | 0.549 | 0.493 | 0.352 |
| 375.72 | 0.655 | 0.567 | 0.536 | 0.473 | 0.299 | 0.666 | 0.594 | 0.549 | 0.491 | 0.356 |
| 376.22 | 0.654 | 0.566 | 0.533 | 0.473 | 0.333 | 0.666 | 0.593 | 0.549 | 0.492 | 0.356 |
| 376.72 | 0.655 | 0.564 | 0.535 | 0.468 | 0.341 | 0.666 | 0.595 | 0.549 | 0.496 | 0.353 |
| 377.22 | 0.656 | 0.568 | 0.532 | 0.476 | 0.344 | 0.667 | 0.589 | 0.550 | 0.493 | 0.357 |
| 377.72 | 0.501 | 0.404 | 0.384 | 0.340 | 0.236 | 0.515 | 0.424 | 0.380 | 0.360 | 0.299 |
| 379.45 | 0.528 | 0.451 | 0.416 | 0.398 | 0.291 | 0.551 | 0.421 | 0.405 | 0.374 | 0.315 |
| 379.68 | 0.563 | 0.505 | 0.448 | 0.427 | 0.332 | 0.628 | 0.486 | 0.478 | 0.415 | 0.327 |
| 380.18 | 0.620 | 0.565 | 0.511 | 0.474 | 0.335 | 0.641 | 0.565 | 0.548 | 0.474 | 0.349 |
| 380.68 | 0.654 | 0.566 | 0.536 | 0.472 | 0.335 | 0.677 | 0.579 | 0.554 | 0.493 | 0.357 |
| 381.18 | 0.654 | 0.566 | 0.532 | 0.474 | 0.333 | 0.676 | 0.594 | 0.558 | 0.491 | 0.351 |
| 381.68 | 0.655 | 0.565 | 0.534 | 0.474 | 0.334 | 0.666 | 0.592 | 0.560 | 0.491 | 0.348 |
| 382.18 | 0.656 | 0.568 | 0.534 | 0.475 | 0.335 | 0.665 | 0.594 | 0.563 | 0.493 | 0.355 |
| 382.68 | 0.655 | 0.565 | 0.534 | 0.475 | 0.335 | 0.671 | 0.593 | 0.559 | 0.494 | 0.352 |
| 383.18 | 0.656 | 0.567 | 0.535 | 0.475 | 0.331 | 0.666 | 0.592 | 0.556 | 0.494 | 0.360 |
| 383.68 | 0.656 | 0.568 | 0.533 | 0.475 | 0.331 | 0.665 | 0.595 | 0.554 | 0.495 | 0.358 |
| 384.18 | 0.654 | 0.554 | 0.536 | 0.475 | 0.333 | 0.664 | 0.596 | 0.549 | 0.491 | 0.356 |
| 384.68 | 0.654 | 0.569 | 0.534 | 0.474 | 0.330 | 0.666 | 0.596 | 0.555 | 0.501 | 0.356 |
| 385.18 | 0.653 | 0.567 | 0.535 | 0.474 | 0.367 | 0.667 | 0.595 | 0.554 | 0.499 | 0.353 |

| t (h) | 45°C | | | | | 30°C | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 6.25 kg/m$^3$-d | 4.14 kg/m$^3$-d | 2.79 kg/m$^3$-d | 1.44 kg/m$^3$-d | 0.56 kg/m$^3$-d | 6.25 kg/m$^3$-d | 4.14 kg/m$^3$-d | 2.79 kg/m$^3$-d | 1.44 kg/m$^3$-d | 0.56 kg/m$^3$-d |
| 385.68 | 0.653 | 0.565 | 0.536 | 0.474 | 0.365 | 0.668 | 0.596 | 0.554 | 0.501 | 0.352 |
| 386.18 | 0.653 | 0.564 | 0.535 | 0.473 | 0.331 | 0.668 | 0.598 | 0.551 | 0.500 | 0.351 |
| 386.68 | 0.654 | 0.566 | 0.536 | 0.472 | 0.331 | 0.667 | 0.597 | 0.553 | 0.500 | 0.350 |
| 387.18 | 0.653 | 0.566 | 0.536 | 0.476 | 0.331 | 0.666 | 0.596 | 0.557 | 0.501 | 0.349 |
| 387.68 | 0.653 | 0.565 | 0.535 | 0.476 | 0.330 | 0.675 | 0.596 | 0.558 | 0.499 | 0.349 |
| 388.18 | 0.654 | 0.565 | 0.536 | 0.476 | 0.333 | 0.676 | 0.597 | 0.559 | 0.501 | 0.348 |
| 388.68 | 0.653 | 0.567 | 0.536 | 0.476 | 0.332 | 0.676 | 0.597 | 0.556 | 0.501 | 0.356 |
| 389.18 | 0.653 | 0.567 | 0.534 | 0.476 | 0.334 | 0.666 | 0.596 | 0.561 | 0.502 | 0.355 |
| 389.68 | 0.655 | 0.568 | 0.534 | 0.476 | 0.330 | 0.665 | 0.596 | 0.562 | 0.501 | 0.355 |
| 390.18 | 0.656 | 0.569 | 0.534 | 0.473 | 0.332 | 0.677 | 0.592 | 0.558 | 0.499 | 0.355 |
| 390.68 | 0.651 | 0.568 | 0.535 | 0.473 | 0.363 | 0.666 | 0.598 | 0.559 | 0.499 | 0.353 |
| 391.18 | 0.653 | 0.568 | 0.534 | 0.473 | 0.335 | 0.667 | 0.598 | 0.557 | 0.500 | 0.355 |
| 391.68 | 0.655 | 0.568 | 0.534 | 0.472 | 0.332 | 0.668 | 0.592 | 0.556 | 0.499 | 0.355 |
| 392.18 | 0.654 | 0.565 | 0.536 | 0.476 | 0.331 | 0.666 | 0.592 | 0.551 | 0.495 | 0.354 |
| 392.68 | 0.654 | 0.561 | 0.536 | 0.476 | 0.330 | 0.666 | 0.592 | 0.552 | 0.495 | 0.353 |
| 393.18 | 0.655 | 0.566 | 0.535 | 0.476 | 0.335 | 0.666 | 0.592 | 0.556 | 0.494 | 0.354 |
| 393.68 | 0.656 | 0.560 | 0.535 | 0.476 | 0.335 | 0.667 | 0.594 | 0.556 | 0.495 | 0.355 |
| 394.18 | 0.647 | 0.569 | 0.536 | 0.476 | 0.333 | 0.667 | 0.593 | 0.562 | 0.493 | 0.354 |
| 394.68 | 0.653 | 0.561 | 0.536 | 0.476 | 0.333 | 0.667 | 0.594 | 0.564 | 0.499 | 0.352 |
| 395.18 | 0.648 | 0.567 | 0.535 | 0.476 | 0.333 | 0.623 | 0.593 | 0.563 | 0.495 | 0.361 |
| 395.68 | 0.648 | 0.567 | 0.535 | 0.476 | 0.331 | 0.665 | 0.594 | 0.565 | 0.494 | 0.360 |
| 396.18 | 0.653 | 0.566 | 0.534 | 0.476 | 0.333 | 0.667 | 0.593 | 0.568 | 0.499 | 0.360 |
| 396.68 | 0.650 | 0.567 | 0.534 | 0.476 | 0.334 | 0.666 | 0.593 | 0.566 | 0.499 | 0.360 |
| 397.18 | 0.652 | 0.566 | 0.536 | 0.476 | 0.334 | 0.665 | 0.593 | 0.571 | 0.500 | 0.358 |
| 397.68 | 0.651 | 0.566 | 0.532 | 0.476 | 0.330 | 0.666 | 0.594 | 0.572 | 0.500 | 0.358 |
| 398.18 | 0.650 | 0.554 | 0.531 | 0.476 | 0.334 | 0.668 | 0.593 | 0.572 | 0.500 | 0.357 |
| 398.68 | 0.651 | 0.551 | 0.531 | 0.476 | 0.332 | 0.668 | 0.597 | 0.572 | 0.500 | 0.356 |
| 399.18 | 0.655 | 0.569 | 0.534 | 0.476 | 0.331 | 0.667 | 0.597 | 0.565 | 0.500 | 0.351 |
| 399.68 | 0.667 | 0.568 | 0.535 | 0.476 | 0.330 | 0.667 | 0.597 | 0.561 | 0.502 | 0.337 |
| 400.18 | 0.656 | 0.566 | 0.534 | 0.476 | 0.327 | 0.667 | 0.592 | 0.560 | 0.501 | 0.361 |
| 400.68 | 0.654 | 0.566 | 0.534 | 0.476 | 0.330 | 0.668 | 0.592 | 0.560 | 0.502 | 0.359 |
| 401.18 | 0.554 | 0.452 | 0.444 | 0.358 | 0.284 | 0.499 | 0.466 | 0.565 | 0.364 | 0.285 |
| 403.18 | 0.583 | 0.513 | 0.485 | 0.398 | 0.318 | 0.531 | 0.497 | 0.567 | 0.430 | 0.297 |

| t (h) | 45°C | | | | | 30°C | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 6.25 kg/m$^3$-d | 4.14 kg/m$^3$-d | 2.79 kg/m$^3$-d | 1.44 kg/m$^3$-d | 0.56 kg/m$^3$-d | 6.25 kg/m$^3$-d | 4.14 kg/m$^3$-d | 2.79 kg/m$^3$-d | 1.44 kg/m$^3$-d | 0.56 kg/m$^3$-d |
| 403.68 | 0.622 | 0.544 | 0.507 | 0.438 | 0.328 | 0.564 | 0.530 | 0.568 | 0.466 | 0.334 |
| 404.18 | 0.649 | 0.559 | 0.522 | 0.479 | 0.328 | 0.634 | 0.561 | 0.568 | 0.488 | 0.356 |
| 404.68 | 0.646 | 0.568 | 0.527 | 0.479 | 0.328 | 0.667 | 0.593 | 0.569 | 0.493 | 0.357 |
| 405.18 | 0.655 | 0.567 | 0.531 | 0.479 | 0.328 | 0.668 | 0.592 | 0.577 | 0.494 | 0.357 |
| 405.68 | 0.656 | 0.567 | 0.531 | 0.479 | 0.328 | 0.665 | 0.592 | 0.571 | 0.494 | 0.359 |
| 406.18 | 0.656 | 0.567 | 0.535 | 0.479 | 0.328 | 0.667 | 0.592 | 0.562 | 0.492 | 0.358 |
| 406.68 | 0.656 | 0.566 | 0.533 | 0.478 | 0.328 | 0.665 | 0.592 | 0.560 | 0.492 | 0.360 |
| 407.18 | 0.654 | 0.567 | 0.532 | 0.478 | 0.328 | 0.668 | 0.598 | 0.563 | 0.494 | 0.352 |
| 407.68 | 0.655 | 0.565 | 0.531 | 0.478 | 0.328 | 0.667 | 0.593 | 0.564 | 0.495 | 0.339 |
| 408.18 | 0.653 | 0.564 | 0.531 | 0.478 | 0.328 | 0.667 | 0.593 | 0.566 | 0.495 | 0.359 |
| 408.68 | 0.646 | 0.568 | 0.531 | 0.478 | 0.328 | 0.665 | 0.593 | 0.557 | 0.495 | 0.360 |
| 409.18 | 0.655 | 0.566 | 0.531 | 0.478 | 0.328 | 0.668 | 0.593 | 0.553 | 0.495 | 0.352 |
| 409.68 | 0.655 | 0.568 | 0.531 | 0.478 | 0.328 | 0.667 | 0.593 | 0.558 | 0.495 | 0.357 |
| 410.18 | 0.655 | 0.552 | 0.529 | 0.478 | 0.328 | 0.666 | 0.593 | 0.560 | 0.494 | 0.356 |
| 410.68 | 0.652 | 0.551 | 0.533 | 0.478 | 0.328 | 0.667 | 0.593 | 0.560 | 0.495 | 0.357 |
| 411.18 | 0.655 | 0.568 | 0.532 | 0.478 | 0.328 | 0.667 | 0.594 | 0.564 | 0.496 | 0.357 |
| 411.68 | 0.654 | 0.568 | 0.531 | 0.478 | 0.328 | 0.666 | 0.593 | 0.566 | 0.496 | 0.358 |
| 412.18 | 0.653 | 0.568 | 0.535 | 0.478 | 0.328 | 0.666 | 0.594 | 0.559 | 0.496 | 0.359 |
| 412.68 | 0.655 | 0.567 | 0.534 | 0.478 | 0.328 | 0.665 | 0.594 | 0.557 | 0.496 | 0.360 |
| 413.18 | 0.656 | 0.566 | 0.534 | 0.478 | 0.328 | 0.677 | 0.593 | 0.557 | 0.496 | 0.356 |
| 413.68 | 0.653 | 0.565 | 0.531 | 0.478 | 0.328 | 0.677 | 0.593 | 0.558 | 0.496 | 0.352 |
| 414.18 | 0.654 | 0.564 | 0.536 | 0.478 | 0.328 | 0.677 | 0.593 | 0.558 | 0.496 | 0.360 |
| 414.68 | 0.650 | 0.565 | 0.536 | 0.478 | 0.328 | 0.675 | 0.593 | 0.551 | 0.497 | 0.359 |
| 415.18 | 0.654 | 0.565 | 0.531 | 0.479 | 0.328 | 0.683 | 0.593 | 0.550 | 0.497 | 0.352 |
| 415.68 | 0.653 | 0.567 | 0.531 | 0.479 | 0.328 | 0.680 | 0.594 | 0.556 | 0.497 | 0.353 |
| 416.18 | 0.654 | 0.567 | 0.533 | 0.479 | 0.328 | 0.677 | 0.592 | 0.557 | 0.497 | 0.355 |
| 416.68 | 0.656 | 0.566 | 0.529 | 0.479 | 0.328 | 0.676 | 0.592 | 0.561 | 0.498 | 0.355 |
| 417.18 | 0.654 | 0.566 | 0.535 | 0.479 | 0.328 | 0.675 | 0.592 | 0.560 | 0.498 | 0.361 |
| 417.68 | 0.653 | 0.568 | 0.535 | 0.479 | 0.328 | 0.680 | 0.597 | 0.561 | 0.499 | 0.359 |
| 418.18 | 0.654 | 0.568 | 0.535 | 0.479 | 0.328 | 0.676 | 0.592 | 0.559 | 0.498 | 0.358 |
| 418.68 | 0.654 | 0.568 | 0.535 | 0.479 | 0.328 | 0.670 | 0.592 | 0.560 | 0.499 | 0.360 |
| 419.18 | 0.653 | 0.567 | 0.535 | 0.479 | 0.328 | 0.670 | 0.592 | 0.560 | 0.499 | 0.358 |
| 419.68 | 0.655 | 0.568 | 0.533 | 0.478 | 0.328 | 0.668 | 0.592 | 0.562 | 0.495 | 0.360 |

| t (h) | 45°C | | | | | 30°C | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 6.25 kg/m$^3$-d | 4.14 kg/m$^3$-d | 2.79 kg/m$^3$-d | 1.44 kg/m$^3$-d | 0.56 kg/m$^3$-d | 6.25 kg/m$^3$-d | 4.14 kg/m$^3$-d | 2.79 kg/m$^3$-d | 1.44 kg/m$^3$-d | 0.56 kg/m$^3$-d |
| 420.18 | 0.655 | 0.567 | 0.534 | 0.478 | 0.328 | 0.669 | 0.592 | 0.551 | 0.496 | 0.360 |
| 420.68 | 0.654 | 0.555 | 0.534 | 0.478 | 0.328 | 0.671 | 0.592 | 0.549 | 0.495 | 0.358 |
| 421.18 | 0.655 | 0.566 | 0.534 | 0.478 | 0.328 | 0.678 | 0.592 | 0.549 | 0.496 | 0.360 |
| 421.68 | 0.655 | 0.563 | 0.534 | 0.478 | 0.328 | 0.671 | 0.592 | 0.549 | 0.496 | 0.358 |
| 422.18 | 0.655 | 0.564 | 0.534 | 0.478 | 0.328 | 0.662 | 0.593 | 0.549 | 0.496 | 0.360 |
| 422.68 | 0.654 | 0.566 | 0.534 | 0.478 | 0.328 | 0.669 | 0.592 | 0.548 | 0.496 | 0.358 |
| 423.18 | 0.656 | 0.566 | 0.535 | 0.478 | 0.335 | 0.654 | 0.593 | 0.551 | 0.496 | 0.357 |
| 423.68 | 0.656 | 0.564 | 0.534 | 0.478 | 0.333 | 0.655 | 0.593 | 0.551 | 0.498 | 0.361 |
| 424.18 | 0.656 | 0.567 | 0.533 | 0.478 | 0.333 | 0.669 | 0.593 | 0.549 | 0.498 | 0.359 |
| 424.68 | 0.655 | 0.568 | 0.533 | 0.478 | 0.333 | 0.669 | 0.592 | 0.549 | 0.497 | 0.359 |
| 425.18 | 0.553 | 0.445 | 0.447 | 0.437 | 0.280 | 0.570 | 0.476 | 0.551 | 0.361 | 0.286 |
| 427.18 | 0.587 | 0.473 | 0.476 | 0.477 | 0.321 | 0.587 | 0.559 | 0.551 | 0.380 | 0.321 |
| 427.68 | 0.621 | 0.544 | 0.498 | 0.477 | 0.332 | 0.624 | 0.597 | 0.550 | 0.410 | 0.341 |
| 428.18 | 0.641 | 0.557 | 0.521 | 0.477 | 0.331 | 0.665 | 0.594 | 0.555 | 0.458 | 0.352 |
| 428.68 | 0.654 | 0.565 | 0.531 | 0.477 | 0.332 | 0.670 | 0.598 | 0.550 | 0.497 | 0.354 |
| 429.18 | 0.656 | 0.563 | 0.532 | 0.477 | 0.331 | 0.675 | 0.592 | 0.549 | 0.494 | 0.355 |
| 429.68 | 0.653 | 0.565 | 0.531 | 0.477 | 0.334 | 0.675 | 0.592 | 0.551 | 0.492 | 0.356 |
| 430.18 | 0.653 | 0.563 | 0.530 | 0.477 | 0.335 | 0.677 | 0.593 | 0.553 | 0.496 | 0.353 |
| 430.68 | 0.655 | 0.565 | 0.531 | 0.477 | 0.334 | 0.669 | 0.592 | 0.552 | 0.498 | 0.354 |
| 431.18 | 0.655 | 0.566 | 0.530 | 0.477 | 0.332 | 0.670 | 0.598 | 0.552 | 0.494 | 0.360 |
| 431.68 | 0.656 | 0.565 | 0.531 | 0.477 | 0.325 | 0.669 | 0.592 | 0.553 | 0.495 | 0.352 |
| 432.18 | 0.655 | 0.565 | 0.533 | 0.477 | 0.334 | 0.670 | 0.598 | 0.555 | 0.496 | 0.353 |
| 432.68 | 0.655 | 0.564 | 0.533 | 0.477 | 0.332 | 0.668 | 0.593 | 0.550 | 0.499 | 0.353 |
| 433.18 | 0.656 | 0.565 | 0.531 | 0.477 | 0.326 | 0.668 | 0.593 | 0.549 | 0.499 | 0.356 |
| 433.68 | 0.655 | 0.566 | 0.533 | 0.477 | 0.329 | 0.668 | 0.593 | 0.550 | 0.491 | 0.355 |
| 434.18 | 0.654 | 0.565 | 0.532 | 0.477 | 0.325 | 0.677 | 0.592 | 0.549 | 0.491 | 0.352 |
| 434.68 | 0.656 | 0.566 | 0.533 | 0.476 | 0.331 | 0.676 | 0.592 | 0.549 | 0.495 | 0.354 |
| 435.18 | 0.653 | 0.567 | 0.531 | 0.476 | 0.333 | 0.677 | 0.598 | 0.550 | 0.491 | 0.353 |
| 435.68 | 0.653 | 0.568 | 0.531 | 0.476 | 0.334 | 0.677 | 0.597 | 0.550 | 0.495 | 0.360 |
| 436.18 | 0.653 | 0.566 | 0.531 | 0.476 | 0.333 | 0.676 | 0.597 | 0.552 | 0.493 | 0.354 |
| 436.68 | 0.655 | 0.562 | 0.531 | 0.472 | 0.330 | 0.668 | 0.592 | 0.550 | 0.494 | 0.356 |
| 437.18 | 0.653 | 0.561 | 0.531 | 0.472 | 0.330 | 0.677 | 0.592 | 0.549 | 0.493 | 0.356 |
| 437.68 | 0.654 | 0.561 | 0.531 | 0.472 | 0.334 | 0.676 | 0.598 | 0.549 | 0.494 | 0.358 |

| t (h) | 45°C | | | | | 30°C | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 6.25 kg/m$^3$-d | 4.14 kg/m$^3$-d | 2.79 kg/m$^3$-d | 1.44 kg/m$^3$-d | 0.56 kg/m$^3$-d | 6.25 kg/m$^3$-d | 4.14 kg/m$^3$-d | 2.79 kg/m$^3$-d | 1.44 kg/m$^3$-d | 0.56 kg/m$^3$-d |
| 438.18 | 0.655 | 0.562 | 0.533 | 0.472 | 0.335 | 0.677 | 0.593 | 0.549 | 0.492 | 0.358 |
| 438.68 | 0.655 | 0.562 | 0.531 | 0.472 | 0.331 | 0.678 | 0.592 | 0.549 | 0.492 | 0.357 |
| 439.18 | 0.654 | 0.561 | 0.533 | 0.472 | 0.332 | 0.669 | 0.598 | 0.548 | 0.493 | 0.360 |
| 439.68 | 0.656 | 0.562 | 0.531 | 0.472 | 0.335 | 0.668 | 0.201 | 0.549 | 0.492 | 0.355 |
| 440.18 | 0.650 | 0.561 | 0.531 | 0.471 | 0.333 | 0.676 | 0.198 | 0.549 | 0.491 | 0.353 |
| 440.68 | 0.656 | 0.561 | 0.531 | 0.471 | 0.333 | 0.668 | 0.192 | 0.549 | 0.491 | 0.361 |
| 441.18 | 0.653 | 0.560 | 0.531 | 0.471 | 0.331 | 0.678 | 0.593 | 0.549 | 0.494 | 0.358 |
| 441.68 | 0.653 | 0.561 | 0.533 | 0.471 | 0.331 | 0.670 | 0.592 | 0.550 | 0.494 | 0.358 |
| 442.18 | 0.654 | 0.562 | 0.533 | 0.471 | 0.326 | 0.670 | 0.596 | 0.549 | 0.494 | 0.360 |
| 442.68 | 0.655 | 0.561 | 0.533 | 0.471 | 0.325 | 0.670 | 0.596 | 0.549 | 0.493 | 0.358 |
| 443.18 | 0.655 | 0.561 | 0.533 | 0.471 | 0.320 | 0.668 | 0.597 | 0.549 | 0.491 | 0.359 |
| 443.68 | 0.654 | 0.562 | 0.530 | 0.471 | 0.320 | 0.671 | 0.597 | 0.549 | 0.492 | 0.353 |
| 444.18 | 0.654 | 0.561 | 0.533 | 0.471 | 0.321 | 0.668 | 0.596 | 0.553 | 0.491 | 0.358 |
| 444.68 | 0.656 | 0.562 | 0.533 | 0.470 | 0.320 | 0.672 | 0.594 | 0.549 | 0.494 | 0.354 |
| 445.18 | 0.655 | 0.566 | 0.531 | 0.470 | 0.320 | 0.672 | 0.597 | 0.549 | 0.494 | 0.355 |
| 445.68 | 0.656 | 0.566 | 0.531 | 0.470 | 0.319 | 0.660 | 0.596 | 0.549 | 0.493 | 0.354 |
| 446.18 | 0.656 | 0.566 | 0.533 | 0.470 | 0.326 | 0.674 | 0.597 | 0.550 | 0.493 | 0.352 |
| 446.68 | 0.653 | 0.566 | 0.533 | 0.470 | 0.328 | 0.671 | 0.597 | 0.552 | 0.494 | 0.360 |
| 447.18 | 0.653 | 0.567 | 0.533 | 0.470 | 0.332 | 0.668 | 0.597 | 0.553 | 0.495 | 0.359 |
| 447.68 | 0.654 | 0.568 | 0.533 | 0.470 | 0.330 | 0.656 | 0.597 | 0.555 | 0.495 | 0.355 |
| 448.18 | 0.655 | 0.567 | 0.531 | 0.470 | 0.330 | 0.681 | 0.597 | 0.555 | 0.496 | 0.355 |
| 448.68 | 0.655 | 0.568 | 0.531 | 0.470 | 0.332 | 0.680 | 0.597 | 0.552 | 0.496 | 0.353 |
| 449.18 | 0.506 | 0.444 | 0.446 | 0.388 | 0.280 | 0.481 | 0.428 | 0.406 | 0.329 | 0.288 |
| 450.07 | 0.539 | 0.468 | 0.478 | 0.390 | 0.309 | 0.504 | 0.471 | 0.431 | 0.367 | 0.318 |
| 450.57 | 0.572 | 0.531 | 0.506 | 0.421 | 0.320 | 0.596 | 0.510 | 0.467 | 0.436 | 0.323 |
| 451.07 | 0.608 | 0.563 | 0.522 | 0.470 | 0.321 | 0.630 | 0.597 | 0.526 | 0.466 | 0.351 |
| 451.57 | 0.652 | 0.563 | 0.531 | 0.472 | 0.330 | 0.664 | 0.596 | 0.556 | 0.494 | 0.358 |
| 452.07 | 0.652 | 0.564 | 0.532 | 0.473 | 0.333 | 0.664 | 0.592 | 0.556 | 0.484 | 0.360 |
| 452.57 | 0.650 | 0.563 | 0.532 | 0.474 | 0.325 | 0.663 | 0.592 | 0.556 | 0.496 | 0.360 |
| 453.07 | 0.651 | 0.565 | 0.533 | 0.475 | 0.331 | 0.662 | 0.593 | 0.557 | 0.497 | 0.360 |
| 453.57 | 0.651 | 0.565 | 0.533 | 0.474 | 0.334 | 0.664 | 0.595 | 0.556 | 0.493 | 0.361 |
| 454.07 | 0.651 | 0.565 | 0.532 | 0.475 | 0.358 | 0.662 | 0.597 | 0.556 | 0.492 | 0.357 |
| 454.57 | 0.652 | 0.565 | 0.532 | 0.476 | 0.334 | 0.664 | 0.596 | 0.556 | 0.492 | 0.360 |

| t (h) | 45°C | | | | | 30°C | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 6.25 kg/m$^3$-d | 4.14 kg/m$^3$-d | 2.79 kg/m$^3$-d | 1.44 kg/m$^3$-d | 0.56 kg/m$^3$-d | 6.25 kg/m$^3$-d | 4.14 kg/m$^3$-d | 2.79 kg/m$^3$-d | 1.44 kg/m$^3$-d | 0.56 kg/m$^3$-d |
| 455.07 | 0.651 | 0.564 | 0.532 | 0.476 | 0.321 | 0.664 | 0.592 | 0.556 | 0.494 | 0.353 |
| 455.57 | 0.651 | 0.566 | 0.531 | 0.476 | 0.335 | 0.662 | 0.592 | 0.556 | 0.493 | 0.360 |
| 456.07 | 0.666 | 0.563 | 0.531 | 0.481 | 0.332 | 0.662 | 0.597 | 0.557 | 0.493 | 0.357 |
| 456.57 | 0.647 | 0.563 | 0.532 | 0.482 | 0.333 | 0.662 | 0.593 | 0.557 | 0.494 | 0.358 |
| 457.07 | 0.648 | 0.563 | 0.532 | 0.481 | 0.360 | 0.662 | 0.594 | 0.557 | 0.495 | 0.360 |
| 457.57 | 0.648 | 0.565 | 0.530 | 0.481 | 0.330 | 0.664 | 0.592 | 0.556 | 0.497 | 0.355 |
| 458.07 | 0.649 | 0.563 | 0.532 | 0.480 | 0.332 | 0.663 | 0.589 | 0.557 | 0.492 | 0.361 |
| 458.57 | 0.648 | 0.565 | 0.532 | 0.475 | 0.335 | 0.661 | 0.596 | 0.557 | 0.495 | 0.354 |
| 459.07 | 0.651 | 0.564 | 0.532 | 0.475 | 0.330 | 0.662 | 0.592 | 0.557 | 0.496 | 0.356 |
| 459.57 | 0.655 | 0.565 | 0.531 | 0.474 | 0.328 | 0.669 | 0.592 | 0.557 | 0.498 | 0.356 |
| 460.07 | 0.651 | 0.564 | 0.532 | 0.474 | 0.330 | 0.663 | 0.592 | 0.557 | 0.499 | 0.359 |
| 460.57 | 0.650 | 0.560 | 0.533 | 0.474 | 0.333 | 0.662 | 0.593 | 0.556 | 0.496 | 0.358 |
| 461.07 | 0.652 | 0.564 | 0.533 | 0.474 | 0.333 | 0.662 | 0.594 | 0.556 | 0.495 | 0.358 |
| 461.57 | 0.654 | 0.563 | 0.533 | 0.473 | 0.334 | 0.662 | 0.594 | 0.557 | 0.496 | 0.357 |
| 462.07 | 0.656 | 0.563 | 0.531 | 0.473 | 0.332 | 0.664 | 0.595 | 0.556 | 0.497 | 0.356 |
| 462.57 | 0.651 | 0.563 | 0.531 | 0.473 | 0.332 | 0.663 | 0.594 | 0.556 | 0.494 | 0.360 |
| 463.07 | 0.652 | 0.564 | 0.531 | 0.473 | 0.322 | 0.663 | 0.593 | 0.556 | 0.494 | 0.359 |
| 463.57 | 0.655 | 0.562 | 0.531 | 0.473 | 0.322 | 0.662 | 0.593 | 0.556 | 0.493 | 0.360 |
| 464.07 | 0.650 | 0.562 | 0.531 | 0.473 | 0.324 | 0.662 | 0.592 | 0.557 | 0.493 | 0.359 |
| 464.57 | 0.653 | 0.563 | 0.531 | 0.473 | 0.326 | 0.663 | 0.592 | 0.557 | 0.492 | 0.357 |
| 465.07 | 0.656 | 0.562 | 0.530 | 0.473 | 0.322 | 0.662 | 0.592 | 0.556 | 0.494 | 0.359 |
| 465.57 | 0.653 | 0.563 | 0.532 | 0.473 | 0.329 | 0.663 | 0.592 | 0.557 | 0.493 | 0.361 |
| 466.07 | 0.654 | 0.564 | 0.532 | 0.473 | 0.335 | 0.664 | 0.594 | 0.557 | 0.494 | 0.357 |
| 466.57 | 0.653 | 0.563 | 0.532 | 0.473 | 0.333 | 0.661 | 0.592 | 0.557 | 0.494 | 0.359 |
| 467.07 | 0.653 | 0.563 | 0.532 | 0.473 | 0.329 | 0.661 | 0.593 | 0.557 | 0.485 | 0.359 |
| 467.57 | 0.668 | 0.562 | 0.531 | 0.473 | 0.332 | 0.664 | 0.592 | 0.557 | 0.486 | 0.360 |
| 468.07 | 0.668 | 0.563 | 0.533 | 0.473 | 0.325 | 0.662 | 0.593 | 0.557 | 0.493 | 0.358 |
| 468.57 | 0.652 | 0.564 | 0.533 | 0.473 | 0.329 | 0.663 | 0.592 | 0.557 | 0.492 | 0.358 |
| 469.07 | 0.653 | 0.565 | 0.533 | 0.472 | 0.332 | 0.665 | 0.589 | 0.557 | 0.484 | 0.360 |
| 469.57 | 0.654 | 0.563 | 0.533 | 0.473 | 0.330 | 0.665 | 0.589 | 0.557 | 0.485 | 0.360 |
| 470.07 | 0.654 | 0.565 | 0.532 | 0.473 | 0.328 | 0.667 | 0.594 | 0.557 | 0.486 | 0.360 |
| 470.57 | 0.654 | 0.565 | 0.532 | 0.473 | 0.330 | 0.662 | 0.593 | 0.557 | 0.492 | 0.357 |
| 471.07 | 0.655 | 0.563 | 0.531 | 0.473 | 0.331 | 0.663 | 0.596 | 0.557 | 0.493 | 0.361 |

| t (h) | 45°C | | | | | 30°C | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 6.25 kg/m$^3$-d | 4.14 kg/m$^3$-d | 2.79 kg/m$^3$-d | 1.44 kg/m$^3$-d | 0.56 kg/m$^3$-d | 6.25 kg/m$^3$-d | 4.14 kg/m$^3$-d | 2.79 kg/m$^3$-d | 1.44 kg/m$^3$-d | 0.56 kg/m$^3$-d |
| 471.57 | 0.650 | 0.562 | 0.533 | 0.472 | 0.332 | 0.662 | 0.597 | 0.557 | 0.491 | 0.358 |
| 472.07 | 0.652 | 0.563 | 0.531 | 0.472 | 0.332 | 0.664 | 0.596 | 0.557 | 0.492 | 0.358 |
| 472.57 | 0.654 | 0.564 | 0.531 | 0.473 | 0.330 | 0.665 | 0.598 | 0.557 | 0.491 | 0.357 |
| 473.07 | 0.653 | 0.564 | 0.531 | 0.473 | 0.330 | 0.665 | 0.593 | 0.557 | 0.495 | 0.358 |
| 473.57 | 0.505 | 0.442 | 0.446 | 0.326 | 0.286 | 0.512 | 0.463 | 0.399 | 0.398 | 0.288 |
| 474.88 | 0.561 | 0.472 | 0.487 | 0.367 | 0.319 | 0.540 | 0.483 | 0.428 | 0.432 | 0.318 |
| 475.38 | 0.572 | 0.505 | 0.516 | 0.409 | 0.331 | 0.601 | 0.534 | 0.458 | 0.463 | 0.343 |
| 475.88 | 0.606 | 0.545 | 0.533 | 0.464 | 0.331 | 0.640 | 0.572 | 0.491 | 0.495 | 0.350 |
| 476.38 | 0.650 | 0.564 | 0.531 | 0.464 | 0.328 | 0.662 | 0.590 | 0.552 | 0.493 | 0.357 |
| 476.88 | 0.667 | 0.565 | 0.532 | 0.464 | 0.326 | 0.664 | 0.592 | 0.552 | 0.493 | 0.359 |
| 477.38 | 0.667 | 0.565 | 0.532 | 0.467 | 0.326 | 0.663 | 0.594 | 0.553 | 0.499 | 0.353 |
| 477.88 | 0.667 | 0.565 | 0.533 | 0.469 | 0.328 | 0.662 | 0.596 | 0.553 | 0.493 | 0.347 |
| 478.38 | 0.667 | 0.563 | 0.532 | 0.470 | 0.328 | 0.662 | 0.593 | 0.553 | 0.493 | 0.350 |
| 478.88 | 0.667 | 0.563 | 0.532 | 0.469 | 0.327 | 0.661 | 0.594 | 0.554 | 0.492 | 0.352 |
| 479.38 | 0.667 | 0.563 | 0.533 | 0.465 | 0.325 | 0.663 | 0.596 | 0.554 | 0.494 | 0.350 |
| 479.88 | 0.654 | 0.564 | 0.532 | 0.471 | 0.333 | 0.665 | 0.593 | 0.554 | 0.496 | 0.350 |
| 480.38 | 0.667 | 0.565 | 0.532 | 0.472 | 0.330 | 0.662 | 0.594 | 0.554 | 0.492 | 0.351 |
| 480.88 | 0.668 | 0.565 | 0.532 | 0.469 | 0.334 | 0.662 | 0.593 | 0.554 | 0.493 | 0.348 |
| 481.38 | 0.669 | 0.565 | 0.533 | 0.467 | 0.333 | 0.664 | 0.590 | 0.554 | 0.492 | 0.352 |
| 481.88 | 0.668 | 0.565 | 0.534 | 0.465 | 0.325 | 0.663 | 0.594 | 0.554 | 0.486 | 0.349 |
| 482.38 | 0.655 | 0.565 | 0.533 | 0.470 | 0.330 | 0.668 | 0.592 | 0.554 | 0.497 | 0.348 |
| 482.88 | 0.656 | 0.565 | 0.533 | 0.467 | 0.332 | 0.662 | 0.592 | 0.554 | 0.494 | 0.350 |
| 483.38 | 0.654 | 0.566 | 0.534 | 0.470 | 0.334 | 0.664 | 0.595 | 0.554 | 0.498 | 0.349 |
| 483.88 | 0.654 | 0.565 | 0.533 | 0.469 | 0.329 | 0.663 | 0.594 | 0.553 | 0.492 | 0.351 |
| 484.38 | 0.653 | 0.565 | 0.533 | 0.475 | 0.332 | 0.668 | 0.589 | 0.553 | 0.495 | 0.351 |
| 484.88 | 0.668 | 0.565 | 0.534 | 0.434 | 0.332 | 0.664 | 0.592 | 0.556 | 0.496 | 0.353 |
| 485.38 | 0.654 | 0.565 | 0.534 | 0.474 | 0.331 | 0.663 | 0.597 | 0.552 | 0.499 | 0.357 |
| 485.88 | 0.653 | 0.565 | 0.534 | 0.472 | 0.330 | 0.662 | 0.598 | 0.552 | 0.495 | 0.357 |
| 486.38 | 0.655 | 0.561 | 0.534 | 0.468 | 0.332 | 0.664 | 0.593 | 0.552 | 0.496 | 0.360 |
| 486.88 | 0.654 | 0.560 | 0.533 | 0.475 | 0.335 | 0.663 | 0.592 | 0.553 | 0.495 | 0.361 |
| 487.38 | 0.655 | 0.566 | 0.533 | 0.473 | 0.334 | 0.666 | 0.598 | 0.553 | 0.498 | 0.361 |
| 487.88 | 0.669 | 0.579 | 0.533 | 0.475 | 0.327 | 0.664 | 0.598 | 0.553 | 0.492 | 0.356 |
| 488.38 | 0.653 | 0.560 | 0.533 | 0.470 | 0.332 | 0.664 | 0.594 | 0.553 | 0.495 | 0.352 |

| t (h) | 45°C | | | | | 30°C | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 6.25 kg/m$^3$-d | 4.14 kg/m$^3$-d | 2.79 kg/m$^3$-d | 1.44 kg/m$^3$-d | 0.56 kg/m$^3$-d | 6.25 kg/m$^3$-d | 4.14 kg/m$^3$-d | 2.79 kg/m$^3$-d | 1.44 kg/m$^3$-d | 0.56 kg/m$^3$-d |
| 488.88 | 0.655 | 0.561 | 0.533 | 0.465 | 0.334 | 0.662 | 0.597 | 0.550 | 0.496 | 0.356 |
| 489.38 | 0.654 | 0.563 | 0.533 | 0.473 | 0.331 | 0.663 | 0.590 | 0.550 | 0.497 | 0.354 |
| 489.88 | 0.654 | 0.564 | 0.533 | 0.468 | 0.332 | 0.663 | 0.594 | 0.553 | 0.499 | 0.355 |
| 490.38 | 0.654 | 0.565 | 0.533 | 0.466 | 0.335 | 0.662 | 0.593 | 0.552 | 0.498 | 0.354 |
| 490.88 | 0.654 | 0.565 | 0.532 | 0.469 | 0.332 | 0.661 | 0.593 | 0.552 | 0.493 | 0.356 |
| 491.38 | 0.669 | 0.565 | 0.532 | 0.467 | 0.334 | 0.663 | 0.593 | 0.552 | 0.494 | 0.356 |
| 491.88 | 0.653 | 0.564 | 0.532 | 0.471 | 0.332 | 0.664 | 0.593 | 0.551 | 0.495 | 0.353 |
| 492.38 | 0.655 | 0.563 | 0.532 | 0.470 | 0.330 | 0.662 | 0.592 | 0.552 | 0.495 | 0.354 |
| 492.88 | 0.653 | 0.565 | 0.531 | 0.472 | 0.327 | 0.666 | 0.592 | 0.557 | 0.493 | 0.356 |
| 493.38 | 0.656 | 0.563 | 0.533 | 0.466 | 0.276 | 0.663 | 0.593 | 0.550 | 0.494 | 0.353 |
| 493.88 | 0.656 | 0.565 | 0.532 | 0.465 | 0.279 | 0.663 | 0.592 | 0.552 | 0.493 | 0.354 |
| 494.38 | 0.654 | 0.564 | 0.532 | 0.465 | 0.333 | 0.664 | 0.593 | 0.552 | 0.494 | 0.360 |
| 494.88 | 0.667 | 0.560 | 0.533 | 0.470 | 0.333 | 0.662 | 0.590 | 0.552 | 0.495 | 0.360 |
| 495.38 | 0.654 | 0.563 | 0.531 | 0.466 | 0.327 | 0.662 | 0.593 | 0.552 | 0.494 | 0.359 |
| 495.88 | 0.654 | 0.564 | 0.532 | 0.468 | 0.334 | 0.662 | 0.592 | 0.552 | 0.495 | 0.358 |
| 496.38 | 0.654 | 0.560 | 0.530 | 0.468 | 0.332 | 0.663 | 0.593 | 0.553 | 0.494 | 0.354 |
| 496.88 | 0.470 | 0.448 | 0.450 | 0.425 | 0.280 | 0.569 | 0.474 | 0.401 | 0.370 | 0.277 |
| 498.30 | 0.481 | 0.478 | 0.469 | 0.416 | 0.317 | 0.603 | 0.501 | 0.459 | 0.430 | 0.301 |
| 498.80 | 0.533 | 0.510 | 0.375 | 0.437 | 0.325 | 0.632 | 0.538 | 0.489 | 0.465 | 0.331 |
| 499.30 | 0.538 | 0.565 | 0.515 | 0.452 | 0.331 | 0.644 | 0.592 | 0.520 | 0.494 | 0.349 |
| 499.80 | 0.589 | 0.563 | 0.532 | 0.459 | 0.330 | 0.668 | 0.594 | 0.550 | 0.491 | 0.348 |
| 500.30 | 0.654 | 0.564 | 0.531 | 0.465 | 0.325 | 0.667 | 0.593 | 0.550 | 0.491 | 0.349 |
| 500.80 | 0.653 | 0.565 | 0.532 | 0.472 | 0.335 | 0.666 | 0.594 | 0.550 | 0.492 | 0.350 |
| 501.30 | 0.652 | 0.563 | 0.532 | 0.471 | 0.334 | 0.666 | 0.593 | 0.550 | 0.492 | 0.358 |
| 501.80 | 0.655 | 0.563 | 0.530 | 0.474 | 0.330 | 0.662 | 0.594 | 0.550 | 0.499 | 0.352 |
| 502.30 | 0.669 | 0.565 | 0.531 | 0.468 | 0.327 | 0.667 | 0.594 | 0.550 | 0.497 | 0.350 |
| 502.80 | 0.654 | 0.565 | 0.531 | 0.471 | 0.328 | 0.665 | 0.593 | 0.550 | 0.497 | 0.353 |
| 503.30 | 0.655 | 0.563 | 0.532 | 0.467 | 0.328 | 0.658 | 0.593 | 0.550 | 0.497 | 0.352 |
| 503.80 | 0.670 | 0.565 | 0.533 | 0.468 | 0.327 | 0.662 | 0.594 | 0.550 | 0.496 | 0.360 |
| 504.30 | 0.651 | 0.565 | 0.533 | 0.471 | 0.328 | 0.660 | 0.593 | 0.550 | 0.493 | 0.355 |
| 504.80 | 0.656 | 0.565 | 0.531 | 0.470 | 0.328 | 0.659 | 0.594 | 0.550 | 0.495 | 0.355 |
| 505.30 | 0.655 | 0.566 | 0.532 | 0.471 | 0.327 | 0.660 | 0.594 | 0.550 | 0.493 | 0.349 |
| 505.80 | 0.654 | 0.565 | 0.533 | 0.472 | 0.329 | 0.659 | 0.596 | 0.550 | 0.492 | 0.361 |

| t (h) | 45°C | | | | | 30°C | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 6.25 kg/m$^3$-d | 4.14 kg/m$^3$-d | 2.79 kg/m$^3$-d | 1.44 kg/m$^3$-d | 0.56 kg/m$^3$-d | 6.25 kg/m$^3$-d | 4.14 kg/m$^3$-d | 2.79 kg/m$^3$-d | 1.44 kg/m$^3$-d | 0.56 kg/m$^3$-d |
| 506.30 | 0.655 | 0.566 | 0.532 | 0.470 | 0.329 | 0.659 | 0.596 | 0.550 | 0.494 | 0.353 |
| 506.80 | 0.655 | 0.563 | 0.531 | 0.472 | 0.334 | 0.661 | 0.597 | 0.550 | 0.496 | 0.352 |
| 507.30 | 0.666 | 0.565 | 0.532 | 0.465 | 0.335 | 0.660 | 0.592 | 0.550 | 0.494 | 0.355 |
| 507.80 | 0.655 | 0.565 | 0.532 | 0.470 | 0.332 | 0.658 | 0.593 | 0.550 | 0.492 | 0.357 |
| 508.30 | 0.652 | 0.565 | 0.532 | 0.464 | 0.335 | 0.666 | 0.593 | 0.550 | 0.494 | 0.358 |
| 508.80 | 0.656 | 0.564 | 0.532 | 0.472 | 0.333 | 0.658 | 0.592 | 0.550 | 0.496 | 0.359 |
| 509.30 | 0.652 | 0.564 | 0.532 | 0.470 | 0.335 | 0.663 | 0.593 | 0.550 | 0.491 | 0.359 |
| 509.80 | 0.650 | 0.564 | 0.532 | 0.470 | 0.331 | 0.661 | 0.592 | 0.550 | 0.496 | 0.361 |
| 510.30 | 0.652 | 0.563 | 0.531 | 0.465 | 0.329 | 0.659 | 0.593 | 0.550 | 0.496 | 0.353 |
| 510.80 | 0.656 | 0.563 | 0.531 | 0.465 | 0.326 | 0.659 | 0.592 | 0.550 | 0.495 | 0.347 |
| 511.30 | 0.669 | 0.565 | 0.532 | 0.467 | 0.325 | 0.664 | 0.588 | 0.550 | 0.497 | 0.353 |
| 511.80 | 0.653 | 0.566 | 0.532 | 0.466 | 0.330 | 0.659 | 0.592 | 0.550 | 0.499 | 0.355 |
| 512.30 | 0.652 | 0.563 | 0.531 | 0.457 | 0.332 | 0.660 | 0.594 | 0.550 | 0.499 | 0.354 |
| 512.80 | 0.655 | 0.566 | 0.531 | 0.465 | 0.333 | 0.659 | 0.592 | 0.550 | 0.495 | 0.354 |
| 513.30 | 0.649 | 0.564 | 0.531 | 0.468 | 0.333 | 0.659 | 0.592 | 0.550 | 0.492 | 0.355 |
| 513.80 | 0.656 | 0.563 | 0.530 | 0.464 | 0.334 | 0.659 | 0.594 | 0.550 | 0.494 | 0.356 |
| 514.30 | 0.667 | 0.563 | 0.531 | 0.470 | 0.335 | 0.659 | 0.594 | 0.550 | 0.498 | 0.347 |
| 514.80 | 0.647 | 0.564 | 0.532 | 0.468 | 0.330 | 0.658 | 0.592 | 0.550 | 0.495 | 0.356 |
| 515.30 | 0.653 | 0.563 | 0.532 | 0.467 | 0.335 | 0.660 | 0.592 | 0.550 | 0.495 | 0.349 |
| 515.80 | 0.650 | 0.563 | 0.532 | 0.470 | 0.329 | 0.660 | 0.596 | 0.550 | 0.492 | 0.348 |
| 516.30 | 0.668 | 0.563 | 0.532 | 0.465 | 0.326 | 0.669 | 0.598 | 0.550 | 0.492 | 0.348 |
| 516.80 | 0.656 | 0.563 | 0.531 | 0.470 | 0.325 | 0.658 | 0.596 | 0.551 | 0.498 | 0.350 |
| 517.30 | 0.653 | 0.564 | 0.531 | 0.471 | 0.330 | 0.659 | 0.595 | 0.551 | 0.499 | 0.353 |
| 517.80 | 0.651 | 0.565 | 0.531 | 0.467 | 0.331 | 0.661 | 0.594 | 0.551 | 0.491 | 0.351 |
| 518.30 | 0.651 | 0.565 | 0.531 | 0.471 | 0.414 | 0.658 | 0.594 | 0.551 | 0.491 | 0.353 |
| 518.80 | 0.651 | 0.564 | 0.532 | 0.459 | 0.411 | 0.658 | 0.594 | 0.551 | 0.492 | 0.352 |
| 519.30 | 0.650 | 0.564 | 0.532 | 0.459 | 0.328 | 0.659 | 0.595 | 0.551 | 0.493 | 0.353 |
| 519.80 | 0.652 | 0.563 | 0.532 | 0.456 | 0.334 | 0.660 | 0.594 | 0.551 | 0.494 | 0.354 |
| 520.30 | 0.651 | 0.563 | 0.532 | 0.466 | 0.334 | 0.661 | 0.593 | 0.551 | 0.493 | 0.357 |
| 520.80 | 0.518 | 0.441 | 0.411 | 0.360 | 0.263 | 0.548 | 0.448 | 0.418 | 0.398 | 0.283 |
| 522.28 | 0.551 | 0.441 | 0.457 | 0.402 | 0.301 | 0.602 | 0.503 | 0.429 | 0.469 | 0.287 |
| 522.78 | 0.591 | 0.504 | 0.479 | 0.417 | 0.321 | 0.635 | 0.519 | 0.464 | 0.511 | 0.316 |
| 523.28 | 0.625 | 0.534 | 0.508 | 0.473 | 0.327 | 0.668 | 0.565 | 0.502 | 0.493 | 0.334 |

| t (h) | 45°C | | | | | 30°C | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 6.25 kg/m$^3$-d | 4.14 kg/m$^3$-d | 2.79 kg/m$^3$-d | 1.44 kg/m$^3$-d | 0.56 kg/m$^3$-d | 6.25 kg/m$^3$-d | 4.14 kg/m$^3$-d | 2.79 kg/m$^3$-d | 1.44 kg/m$^3$-d | 0.56 kg/m$^3$-d |
| 523.78 | 0.653 | 0.565 | 0.528 | 0.464 | 0.332 | 0.671 | 0.596 | 0.535 | 0.494 | 0.343 |
| 524.28 | 0.653 | 0.563 | 0.535 | 0.464 | 0.332 | 0.670 | 0.592 | 0.536 | 0.495 | 0.348 |
| 524.78 | 0.653 | 0.563 | 0.535 | 0.464 | 0.331 | 0.670 | 0.596 | 0.542 | 0.497 | 0.355 |
| 525.28 | 0.653 | 0.563 | 0.535 | 0.464 | 0.329 | 0.661 | 0.596 | 0.544 | 0.496 | 0.352 |
| 525.78 | 0.653 | 0.564 | 0.536 | 0.467 | 0.330 | 0.659 | 0.595 | 0.547 | 0.491 | 0.357 |
| 526.28 | 0.654 | 0.566 | 0.536 | 0.464 | 0.328 | 0.657 | 0.597 | 0.549 | 0.494 | 0.353 |
| 526.72 | 0.654 | 0.565 | 0.535 | 0.465 | 0.325 | 0.665 | 0.598 | 0.550 | 0.492 | 0.354 |
| 527.22 | 0.653 | 0.565 | 0.535 | 0.454 | 0.340 | 0.662 | 0.597 | 0.553 | 0.493 | 0.352 |
| 527.72 | 0.653 | 0.566 | 0.535 | 0.457 | 0.329 | 0.657 | 0.593 | 0.556 | 0.495 | 0.368 |
| 528.22 | 0.654 | 0.565 | 0.535 | 0.470 | 0.334 | 0.665 | 0.593 | 0.558 | 0.496 | 0.354 |
| 528.72 | 0.654 | 0.563 | 0.535 | 0.469 | 0.333 | 0.668 | 0.593 | 0.557 | 0.494 | 0.356 |
| 529.22 | 0.654 | 0.563 | 0.535 | 0.471 | 0.323 | 0.648 | 0.593 | 0.555 | 0.496 | 0.361 |
| 529.72 | 0.656 | 0.564 | 0.536 | 0.472 | 0.324 | 0.664 | 0.592 | 0.559 | 0.497 | 0.368 |
| 530.22 | 0.654 | 0.564 | 0.536 | 0.468 | 0.323 | 0.661 | 0.593 | 0.559 | 0.496 | 0.355 |
| 530.72 | 0.655 | 0.565 | 0.536 | 0.471 | 0.334 | 0.661 | 0.598 | 0.557 | 0.493 | 0.353 |
| 531.22 | 0.654 | 0.564 | 0.536 | 0.473 | 0.334 | 0.659 | 0.595 | 0.559 | 0.493 | 0.368 |
| 531.72 | 0.654 | 0.565 | 0.536 | 0.473 | 0.334 | 0.663 | 0.592 | 0.556 | 0.491 | 0.354 |
| 532.22 | 0.655 | 0.564 | 0.536 | 0.473 | 0.329 | 0.658 | 0.596 | 0.555 | 0.493 | 0.356 |
| 532.72 | 0.654 | 0.564 | 0.536 | 0.474 | 0.333 | 0.664 | 0.592 | 0.553 | 0.493 | 0.353 |
| 533.22 | 0.655 | 0.564 | 0.536 | 0.475 | 0.328 | 0.666 | 0.593 | 0.555 | 0.495 | 0.354 |
| 533.72 | 0.652 | 0.564 | 0.531 | 0.475 | 0.326 | 0.662 | 0.592 | 0.557 | 0.491 | 0.355 |
| 534.22 | 0.653 | 0.563 | 0.531 | 0.475 | 0.330 | 0.664 | 0.596 | 0.559 | 0.496 | 0.348 |
| 534.72 | 0.653 | 0.564 | 0.531 | 0.475 | 0.333 | 0.658 | 0.592 | 0.569 | 0.499 | 0.345 |
| 535.22 | 0.653 | 0.563 | 0.531 | 0.475 | 0.335 | 0.656 | 0.595 | 0.559 | 0.497 | 0.344 |
| 535.72 | 0.653 | 0.565 | 0.531 | 0.475 | 0.319 | 0.666 | 0.595 | 0.564 | 0.493 | 0.345 |
| 536.22 | 0.653 | 0.563 | 0.531 | 0.475 | 0.332 | 0.658 | 0.596 | 0.567 | 0.499 | 0.351 |
| 536.72 | 0.653 | 0.564 | 0.532 | 0.476 | 0.333 | 0.652 | 0.597 | 0.565 | 0.496 | 0.351 |
| 537.22 | 0.653 | 0.563 | 0.536 | 0.469 | 0.331 | 0.660 | 0.597 | 0.562 | 0.490 | 0.349 |
| 537.72 | 0.653 | 0.563 | 0.536 | 0.469 | 0.334 | 0.670 | 0.592 | 0.555 | 0.492 | 0.349 |
| 538.22 | 0.652 | 0.563 | 0.536 | 0.469 | 0.334 | 0.661 | 0.592 | 0.553 | 0.496 | 0.349 |
| 538.72 | 0.652 | 0.564 | 0.535 | 0.470 | 0.332 | 0.672 | 0.595 | 0.555 | 0.498 | 0.349 |
| 539.22 | 0.651 | 0.564 | 0.534 | 0.470 | 0.331 | 0.667 | 0.594 | 0.544 | 0.498 | 0.347 |
| 539.72 | 0.652 | 0.565 | 0.536 | 0.469 | 0.334 | 0.667 | 0.593 | 0.552 | 0.495 | 0.347 |

| t (h) | 45°C | | | | | 30°C | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 6.25 kg/m$^3$-d | 4.14 kg/m$^3$-d | 2.79 kg/m$^3$-d | 1.44 kg/m$^3$-d | 0.56 kg/m$^3$-d | 6.25 kg/m$^3$-d | 4.14 kg/m$^3$-d | 2.79 kg/m$^3$-d | 1.44 kg/m$^3$-d | 0.56 kg/m$^3$-d |
| 540.22 | 0.652 | 0.565 | 0.531 | 0.469 | 0.332 | 0.667 | 0.594 | 0.554 | 0.496 | 0.351 |
| 540.72 | 0.654 | 0.565 | 0.531 | 0.468 | 0.332 | 0.668 | 0.592 | 0.544 | 0.498 | 0.349 |
| 541.22 | 0.654 | 0.564 | 0.532 | 0.469 | 0.333 | 0.667 | 0.594 | 0.550 | 0.495 | 0.349 |
| 541.72 | 0.654 | 0.565 | 0.531 | 0.469 | 0.332 | 0.667 | 0.589 | 0.551 | 0.496 | 0.342 |
| 542.22 | 0.653 | 0.565 | 0.531 | 0.468 | 0.333 | 0.667 | 0.596 | 0.550 | 0.494 | 0.351 |
| 542.72 | 0.654 | 0.563 | 0.531 | 0.469 | 0.334 | 0.665 | 0.590 | 0.557 | 0.492 | 0.351 |
| 543.22 | 0.655 | 0.564 | 0.531 | 0.468 | 0.332 | 0.667 | 0.592 | 0.547 | 0.491 | 0.351 |
| 543.72 | 0.655 | 0.564 | 0.531 | 0.468 | 0.331 | 0.667 | 0.593 | 0.543 | 0.490 | 0.351 |
| 544.22 | 0.655 | 0.564 | 0.532 | 0.472 | 0.331 | 0.665 | 0.594 | 0.543 | 0.487 | 0.350 |
| 544.72 | 0.524 | 0.454 | 0.458 | 0.364 | 0.255 | 0.503 | 0.474 | 0.398 | 0.390 | 0.281 |
| 546.33 | 0.598 | 0.483 | 0.479 | 0.400 | 0.293 | 0.549 | 0.505 | 0.428 | 0.439 | 0.315 |
| 546.83 | 0.653 | 0.545 | 0.518 | 0.410 | 0.316 | 0.634 | 0.512 | 0.489 | 0.477 | 0.334 |
| 547.33 | 0.650 | 0.565 | 0.531 | 0.466 | 0.319 | 0.665 | 0.596 | 0.552 | 0.487 | 0.347 |
| 547.83 | 0.652 | 0.560 | 0.531 | 0.467 | 0.334 | 0.666 | 0.597 | 0.552 | 0.494 | 0.353 |
| 548.33 | 0.653 | 0.560 | 0.532 | 0.465 | 0.333 | 0.665 | 0.597 | 0.553 | 0.495 | 0.348 |
| 548.83 | 0.652 | 0.561 | 0.532 | 0.467 | 0.333 | 0.665 | 0.598 | 0.553 | 0.495 | 0.351 |
| 549.33 | 0.653 | 0.560 | 0.532 | 0.466 | 0.333 | 0.665 | 0.597 | 0.553 | 0.491 | 0.351 |
| 549.83 | 0.652 | 0.565 | 0.532 | 0.466 | 0.334 | 0.660 | 0.597 | 0.553 | 0.499 | 0.348 |
| 550.33 | 0.652 | 0.564 | 0.532 | 0.466 | 0.329 | 0.658 | 0.597 | 0.553 | 0.499 | 0.351 |
| 550.83 | 0.652 | 0.565 | 0.532 | 0.466 | 0.332 | 0.649 | 0.596 | 0.553 | 0.498 | 0.351 |
| 551.33 | 0.653 | 0.564 | 0.532 | 0.466 | 0.328 | 0.659 | 0.597 | 0.553 | 0.497 | 0.347 |
| 551.83 | 0.651 | 0.564 | 0.532 | 0.466 | 0.331 | 0.651 | 0.598 | 0.553 | 0.497 | 0.348 |
| 552.33 | 0.651 | 0.564 | 0.533 | 0.466 | 0.330 | 0.659 | 0.597 | 0.566 | 0.497 | 0.349 |
| 552.83 | 0.652 | 0.565 | 0.533 | 0.466 | 0.333 | 0.659 | 0.598 | 0.559 | 0.498 | 0.348 |
| 553.33 | 0.654 | 0.560 | 0.533 | 0.465 | 0.333 | 0.659 | 0.592 | 0.559 | 0.499 | 0.349 |
| 553.83 | 0.654 | 0.560 | 0.532 | 0.465 | 0.327 | 0.659 | 0.592 | 0.560 | 0.496 | 0.342 |
| 554.33 | 0.655 | 0.560 | 0.532 | 0.465 | 0.330 | 0.661 | 0.598 | 0.562 | 0.492 | 0.348 |
| 554.83 | 0.652 | 0.561 | 0.532 | 0.466 | 0.333 | 0.659 | 0.592 | 0.561 | 0.494 | 0.349 |
| 555.33 | 0.651 | 0.561 | 0.533 | 0.466 | 0.334 | 0.659 | 0.592 | 0.562 | 0.493 | 0.350 |
| 555.83 | 0.652 | 0.561 | 0.530 | 0.466 | 0.332 | 0.659 | 0.593 | 0.562 | 0.495 | 0.349 |
| 556.33 | 0.652 | 0.561 | 0.533 | 0.466 | 0.331 | 0.659 | 0.593 | 0.563 | 0.492 | 0.347 |
| 556.83 | 0.654 | 0.565 | 0.532 | 0.467 | 0.334 | 0.660 | 0.594 | 0.562 | 0.487 | 0.348 |
| 557.33 | 0.654 | 0.565 | 0.531 | 0.467 | 0.334 | 0.659 | 0.598 | 0.562 | 0.491 | 0.352 |

| t (h) | 45°C | | | | | 30°C | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 6.25 kg/m$^3$-d | 4.14 kg/m$^3$-d | 2.79 kg/m$^3$-d | 1.44 kg/m$^3$-d | 0.56 kg/m$^3$-d | 6.25 kg/m$^3$-d | 4.14 kg/m$^3$-d | 2.79 kg/m$^3$-d | 1.44 kg/m$^3$-d | 0.56 kg/m$^3$-d |
| 557.83 | 0.651 | 0.564 | 0.530 | 0.467 | 0.333 | 0.667 | 0.597 | 0.561 | 0.491 | 0.352 |
| 558.33 | 0.651 | 0.560 | 0.532 | 0.468 | 0.330 | 0.666 | 0.597 | 0.561 | 0.493 | 0.349 |
| 558.83 | 0.652 | 0.561 | 0.532 | 0.467 | 0.335 | 0.665 | 0.594 | 0.560 | 0.495 | 0.347 |
| 559.33 | 0.650 | 0.561 | 0.532 | 0.467 | 0.335 | 0.667 | 0.598 | 0.559 | 0.499 | 0.339 |
| 559.83 | 0.655 | 0.565 | 0.532 | 0.467 | 0.333 | 0.666 | 0.597 | 0.558 | 0.496 | 0.342 |
| 560.33 | 0.650 | 0.565 | 0.532 | 0.468 | 0.333 | 0.667 | 0.597 | 0.553 | 0.496 | 0.348 |
| 560.83 | 0.650 | 0.560 | 0.532 | 0.467 | 0.322 | 0.668 | 0.596 | 0.554 | 0.496 | 0.361 |
| 561.33 | 0.656 | 0.565 | 0.531 | 0.468 | 0.323 | 0.666 | 0.596 | 0.554 | 0.495 | 0.361 |
| 561.83 | 0.651 | 0.565 | 0.531 | 0.468 | 0.335 | 0.666 | 0.596 | 0.553 | 0.491 | 0.350 |
| 562.33 | 0.654 | 0.560 | 0.531 | 0.469 | 0.320 | 0.662 | 0.596 | 0.553 | 0.497 | 0.351 |
| 562.83 | 0.654 | 0.560 | 0.531 | 0.469 | 0.320 | 0.663 | 0.597 | 0.553 | 0.494 | 0.348 |
| 563.33 | 0.654 | 0.560 | 0.531 | 0.469 | 0.325 | 0.662 | 0.597 | 0.553 | 0.494 | 0.340 |
| 563.83 | 0.654 | 0.560 | 0.531 | 0.469 | 0.324 | 0.662 | 0.597 | 0.552 | 0.494 | 0.355 |
| 564.33 | 0.654 | 0.565 | 0.531 | 0.468 | 0.327 | 0.666 | 0.596 | 0.552 | 0.494 | 0.354 |
| 564.83 | 0.655 | 0.560 | 0.532 | 0.469 | 0.327 | 0.665 | 0.597 | 0.552 | 0.494 | 0.351 |
| 565.33 | 0.653 | 0.560 | 0.532 | 0.469 | 0.323 | 0.667 | 0.597 | 0.552 | 0.493 | 0.350 |
| 565.83 | 0.653 | 0.565 | 0.531 | 0.469 | 0.326 | 0.664 | 0.596 | 0.552 | 0.495 | 0.352 |
| 566.33 | 0.653 | 0.564 | 0.532 | 0.469 | 0.329 | 0.665 | 0.597 | 0.552 | 0.494 | 0.351 |
| 566.83 | 0.653 | 0.560 | 0.532 | 0.470 | 0.329 | 0.665 | 0.596 | 0.552 | 0.496 | 0.350 |
| 567.33 | 0.654 | 0.560 | 0.531 | 0.470 | 0.328 | 0.666 | 0.595 | 0.552 | 0.494 | 0.352 |
| 567.83 | 0.656 | 0.561 | 0.531 | 0.470 | 0.329 | 0.665 | 0.596 | 0.552 | 0.492 | 0.350 |
| 568.33 | 0.655 | 0.561 | 0.531 | 0.470 | 0.330 | 0.667 | 0.597 | 0.552 | 0.492 | 0.348 |
| 568.83 | 0.555 | 0.486 | 0.469 | 0.384 | 0.291 | 0.557 | 0.469 | 0.552 | 0.364 | 0.303 |
| 570.83 | 0.582 | 0.514 | 0.492 | 0.422 | 0.320 | 0.597 | 0.501 | 0.552 | 0.407 | 0.298 |
| 571.33 | 0.618 | 0.557 | 0.531 | 0.467 | 0.333 | 0.659 | 0.532 | 0.552 | 0.450 | 0.328 |
| 571.83 | 0.652 | 0.564 | 0.531 | 0.470 | 0.325 | 0.662 | 0.565 | 0.552 | 0.495 | 0.343 |
| 572.33 | 0.652 | 0.564 | 0.533 | 0.468 | 0.331 | 0.660 | 0.596 | 0.557 | 0.493 | 0.349 |
| 572.83 | 0.651 | 0.564 | 0.530 | 0.470 | 0.330 | 0.665 | 0.596 | 0.564 | 0.496 | 0.351 |
| 573.33 | 0.650 | 0.565 | 0.532 | 0.471 | 0.330 | 0.657 | 0.597 | 0.565 | 0.500 | 0.351 |
| 573.83 | 0.650 | 0.565 | 0.532 | 0.471 | 0.334 | 0.657 | 0.597 | 0.565 | 0.502 | 0.351 |
| 574.33 | 0.653 | 0.566 | 0.532 | 0.469 | 0.328 | 0.657 | 0.596 | 0.565 | 0.500 | 0.351 |
| 574.83 | 0.654 | 0.566 | 0.532 | 0.469 | 0.325 | 0.657 | 0.597 | 0.565 | 0.500 | 0.349 |
| 575.33 | 0.653 | 0.565 | 0.531 | 0.468 | 0.326 | 0.657 | 0.596 | 0.564 | 0.501 | 0.351 |

| t (h) | 45°C | | | | | 30°C | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 6.25 kg/m$^3$-d | 4.14 kg/m$^3$-d | 2.79 kg/m$^3$-d | 1.44 kg/m$^3$-d | 0.56 kg/m$^3$-d | 6.25 kg/m$^3$-d | 4.14 kg/m$^3$-d | 2.79 kg/m$^3$-d | 1.44 kg/m$^3$-d | 0.56 kg/m$^3$-d |
| 575.83 | 0.653 | 0.565 | 0.531 | 0.468 | 0.331 | 0.657 | 0.596 | 0.564 | 0.492 | 0.350 |
| 576.33 | 0.654 | 0.565 | 0.531 | 0.468 | 0.326 | 0.657 | 0.596 | 0.558 | 0.495 | 0.349 |
| 576.83 | 0.655 | 0.565 | 0.531 | 0.467 | 0.326 | 0.657 | 0.596 | 0.551 | 0.495 | 0.355 |
| 577.33 | 0.655 | 0.564 | 0.533 | 0.467 | 0.327 | 0.657 | 0.597 | 0.551 | 0.496 | 0.350 |
| 577.83 | 0.655 | 0.564 | 0.533 | 0.468 | 0.328 | 0.657 | 0.597 | 0.551 | 0.499 | 0.350 |
| 578.33 | 0.656 | 0.565 | 0.533 | 0.469 | 0.329 | 0.663 | 0.596 | 0.551 | 0.492 | 0.351 |
| 578.83 | 0.641 | 0.565 | 0.533 | 0.469 | 0.332 | 0.663 | 0.596 | 0.552 | 0.493 | 0.353 |
| 579.33 | 0.655 | 0.565 | 0.533 | 0.470 | 0.334 | 0.664 | 0.597 | 0.552 | 0.491 | 0.353 |
| 579.83 | 0.655 | 0.561 | 0.533 | 0.469 | 0.332 | 0.664 | 0.596 | 0.552 | 0.493 | 0.354 |
| 580.33 | 0.655 | 0.561 | 0.530 | 0.468 | 0.333 | 0.665 | 0.596 | 0.552 | 0.499 | 0.355 |
| 580.83 | 0.655 | 0.561 | 0.530 | 0.469 | 0.334 | 0.664 | 0.597 | 0.552 | 0.493 | 0.353 |
| 581.33 | 0.655 | 0.566 | 0.533 | 0.468 | 0.325 | 0.663 | 0.597 | 0.552 | 0.498 | 0.353 |
| 581.83 | 0.655 | 0.560 | 0.533 | 0.468 | 0.326 | 0.663 | 0.597 | 0.551 | 0.498 | 0.350 |
| 582.33 | 0.654 | 0.560 | 0.533 | 0.469 | 0.332 | 0.664 | 0.597 | 0.552 | 0.491 | 0.350 |
| 582.83 | 0.653 | 0.560 | 0.533 | 0.468 | 0.332 | 0.662 | 0.597 | 0.552 | 0.498 | 0.353 |
| 583.33 | 0.656 | 0.560 | 0.531 | 0.468 | 0.325 | 0.667 | 0.597 | 0.552 | 0.496 | 0.354 |
| 583.83 | 0.656 | 0.560 | 0.531 | 0.469 | 0.327 | 0.666 | 0.597 | 0.552 | 0.496 | 0.354 |
| 584.33 | 0.656 | 0.561 | 0.531 | 0.467 | 0.331 | 0.665 | 0.596 | 0.552 | 0.496 | 0.357 |
| 584.83 | 0.656 | 0.560 | 0.531 | 0.467 | 0.329 | 0.665 | 0.597 | 0.552 | 0.497 | 0.359 |
| 585.33 | 0.650 | 0.560 | 0.533 | 0.467 | 0.330 | 0.665 | 0.597 | 0.552 | 0.491 | 0.360 |
| 585.83 | 0.647 | 0.560 | 0.532 | 0.467 | 0.330 | 0.664 | 0.598 | 0.552 | 0.491 | 0.356 |
| 586.33 | 0.656 | 0.561 | 0.532 | 0.469 | 0.332 | 0.665 | 0.598 | 0.552 | 0.494 | 0.364 |
| 586.83 | 0.655 | 0.561 | 0.533 | 0.469 | 0.333 | 0.664 | 0.597 | 0.550 | 0.493 | 0.359 |
| 587.33 | 0.655 | 0.561 | 0.532 | 0.468 | 0.334 | 0.665 | 0.597 | 0.552 | 0.492 | 0.359 |
| 587.83 | 0.656 | 0.561 | 0.532 | 0.468 | 0.333 | 0.664 | 0.597 | 0.552 | 0.493 | 0.363 |
| 588.33 | 0.656 | 0.560 | 0.532 | 0.468 | 0.333 | 0.666 | 0.598 | 0.552 | 0.492 | 0.357 |
| 588.83 | 0.656 | 0.561 | 0.531 | 0.468 | 0.334 | 0.664 | 0.598 | 0.552 | 0.494 | 0.355 |
| 589.33 | 0.653 | 0.561 | 0.531 | 0.468 | 0.334 | 0.664 | 0.597 | 0.552 | 0.493 | 0.357 |
| 589.83 | 0.656 | 0.562 | 0.533 | 0.468 | 0.333 | 0.663 | 0.597 | 0.553 | 0.494 | 0.359 |
| 590.33 | 0.651 | 0.562 | 0.531 | 0.468 | 0.330 | 0.664 | 0.597 | 0.553 | 0.492 | 0.359 |
| 590.83 | 0.655 | 0.561 | 0.531 | 0.468 | 0.331 | 0.662 | 0.598 | 0.553 | 0.492 | 0.354 |
| 591.33 | 0.652 | 0.561 | 0.531 | 0.468 | 0.332 | 0.662 | 0.598 | 0.553 | 0.492 | 0.353 |
| 591.83 | 0.646 | 0.561 | 0.531 | 0.468 | 0.332 | 0.664 | 0.597 | 0.553 | 0.492 | 0.357 |

| t (h) | 45°C | | | | | 30°C | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 6.25 kg/m$^3$-d | 4.14 kg/m$^3$-d | 2.79 kg/m$^3$-d | 1.44 kg/m$^3$-d | 0.56 kg/m$^3$-d | 6.25 kg/m$^3$-d | 4.14 kg/m$^3$-d | 2.79 kg/m$^3$-d | 1.44 kg/m$^3$-d | 0.56 kg/m$^3$-d |
| 592.33 | 0.652 | 0.566 | 0.530 | 0.469 | 0.334 | 0.662 | 0.596 | 0.550 | 0.494 | 0.356 |
| 592.83 | 0.652 | 0.560 | 0.533 | 0.469 | 0.333 | 0.662 | 0.596 | 0.553 | 0.494 | 0.356 |
| 593.33 | 0.551 | 0.454 | 0.396 | 0.363 | 0.297 | 0.563 | 0.470 | 0.370 | 0.402 | 0.286 |
| 595.33 | 0.588 | 0.485 | 0.500 | 0.403 | 0.311 | 0.594 | 0.501 | 0.401 | 0.440 | 0.311 |
| 595.83 | 0.619 | 0.515 | 0.518 | 0.427 | 0.322 | 0.628 | 0.533 | 0.431 | 0.457 | 0.335 |
| 596.33 | 0.652 | 0.545 | 0.531 | 0.467 | 0.329 | 0.662 | 0.565 | 0.462 | 0.497 | 0.341 |
| 596.83 | 0.652 | 0.563 | 0.532 | 0.465 | 0.325 | 0.661 | 0.596 | 0.493 | 0.496 | 0.351 |
| 597.33 | 0.652 | 0.563 | 0.532 | 0.468 | 0.325 | 0.662 | 0.595 | 0.523 | 0.495 | 0.366 |
| 597.83 | 0.652 | 0.564 | 0.533 | 0.469 | 0.329 | 0.662 | 0.595 | 0.554 | 0.495 | 0.361 |
| 598.33 | 0.651 | 0.564 | 0.532 | 0.469 | 0.329 | 0.662 | 0.595 | 0.554 | 0.493 | 0.360 |
| 598.83 | 0.650 | 0.564 | 0.532 | 0.469 | 0.327 | 0.662 | 0.595 | 0.555 | 0.494 | 0.358 |
| 599.33 | 0.656 | 0.564 | 0.532 | 0.469 | 0.328 | 0.662 | 0.596 | 0.562 | 0.501 | 0.358 |
| 599.83 | 0.656 | 0.564 | 0.532 | 0.469 | 0.321 | 0.662 | 0.595 | 0.559 | 0.500 | 0.359 |
| 600.33 | 0.656 | 0.565 | 0.532 | 0.469 | 0.322 | 0.663 | 0.596 | 0.559 | 0.500 | 0.357 |
| 600.83 | 0.656 | 0.565 | 0.532 | 0.470 | 0.326 | 0.662 | 0.595 | 0.554 | 0.502 | 0.357 |
| 601.33 | 0.656 | 0.565 | 0.532 | 0.468 | 0.324 | 0.664 | 0.595 | 0.554 | 0.502 | 0.361 |
| 601.83 | 0.655 | 0.563 | 0.531 | 0.467 | 0.326 | 0.664 | 0.595 | 0.557 | 0.503 | 0.358 |
| 602.33 | 0.655 | 0.566 | 0.532 | 0.468 | 0.329 | 0.664 | 0.595 | 0.557 | 0.499 | 0.357 |
| 602.83 | 0.655 | 0.563 | 0.532 | 0.471 | 0.330 | 0.663 | 0.597 | 0.558 | 0.502 | 0.360 |
| 603.33 | 0.655 | 0.563 | 0.532 | 0.469 | 0.333 | 0.664 | 0.594 | 0.557 | 0.502 | 0.357 |
| 603.83 | 0.655 | 0.563 | 0.533 | 0.468 | 0.331 | 0.664 | 0.594 | 0.558 | 0.501 | 0.360 |
| 604.33 | 0.656 | 0.564 | 0.532 | 0.469 | 0.334 | 0.664 | 0.592 | 0.558 | 0.500 | 0.359 |
| 604.83 | 0.655 | 0.563 | 0.533 | 0.468 | 0.335 | 0.661 | 0.593 | 0.559 | 0.499 | 0.361 |
| 605.33 | 0.655 | 0.563 | 0.533 | 0.470 | 0.335 | 0.664 | 0.592 | 0.559 | 0.498 | 0.359 |
| 605.83 | 0.656 | 0.565 | 0.532 | 0.465 | 0.330 | 0.664 | 0.593 | 0.559 | 0.498 | 0.353 |
| 606.33 | 0.649 | 0.564 | 0.533 | 0.468 | 0.335 | 0.662 | 0.594 | 0.559 | 0.498 | 0.359 |
| 606.83 | 0.650 | 0.565 | 0.533 | 0.470 | 0.334 | 0.663 | 0.598 | 0.559 | 0.497 | 0.360 |
| 607.33 | 0.650 | 0.564 | 0.533 | 0.468 | 0.331 | 0.663 | 0.597 | 0.559 | 0.496 | 0.361 |
| 607.83 | 0.650 | 0.563 | 0.533 | 0.469 | 0.330 | 0.663 | 0.597 | 0.560 | 0.495 | 0.360 |
| 608.33 | 0.650 | 0.566 | 0.533 | 0.468 | 0.333 | 0.664 | 0.597 | 0.560 | 0.494 | 0.360 |
| 608.83 | 0.650 | 0.563 | 0.532 | 0.469 | 0.330 | 0.662 | 0.597 | 0.560 | 0.491 | 0.354 |
| 609.33 | 0.650 | 0.568 | 0.532 | 0.469 | 0.333 | 0.662 | 0.597 | 0.560 | 0.488 | 0.354 |
| 609.83 | 0.650 | 0.568 | 0.531 | 0.469 | 0.334 | 0.662 | 0.597 | 0.559 | 0.490 | 0.355 |

| t (h) | 45°C | | | | | 30°C | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 6.25 kg/m$^3$-d | 4.14 kg/m$^3$-d | 2.79 kg/m$^3$-d | 1.44 kg/m$^3$-d | 0.56 kg/m$^3$-d | 6.25 kg/m$^3$-d | 4.14 kg/m$^3$-d | 2.79 kg/m$^3$-d | 1.44 kg/m$^3$-d | 0.56 kg/m$^3$-d |
| 610.33 | 0.652 | 0.568 | 0.531 | 0.469 | 0.333 | 0.662 | 0.596 | 0.551 | 0.488 | 0.348 |
| 610.83 | 0.652 | 0.563 | 0.531 | 0.470 | 0.334 | 0.664 | 0.596 | 0.555 | 0.521 | 0.347 |
| 611.33 | 0.650 | 0.568 | 0.532 | 0.469 | 0.332 | 0.662 | 0.596 | 0.552 | 0.503 | 0.356 |
| 611.83 | 0.650 | 0.566 | 0.532 | 0.470 | 0.331 | 0.663 | 0.596 | 0.550 | 0.500 | 0.356 |
| 612.33 | 0.651 | 0.568 | 0.532 | 0.469 | 0.330 | 0.662 | 0.597 | 0.551 | 0.497 | 0.348 |
| 612.83 | 0.650 | 0.568 | 0.532 | 0.470 | 0.332 | 0.663 | 0.596 | 0.551 | 0.488 | 0.355 |
| 613.33 | 0.650 | 0.567 | 0.532 | 0.469 | 0.331 | 0.663 | 0.597 | 0.550 | 0.496 | 0.356 |
| 613.83 | 0.650 | 0.568 | 0.532 | 0.470 | 0.330 | 0.663 | 0.593 | 0.552 | 0.488 | 0.356 |
| 614.33 | 0.649 | 0.568 | 0.532 | 0.470 | 0.330 | 0.664 | 0.592 | 0.552 | 0.502 | 0.348 |
| 614.83 | 0.656 | 0.567 | 0.533 | 0.470 | 0.333 | 0.664 | 0.595 | 0.551 | 0.499 | 0.348 |
| 615.33 | 0.656 | 0.567 | 0.532 | 0.469 | 0.335 | 0.664 | 0.593 | 0.552 | 0.500 | 0.349 |
| 615.83 | 0.656 | 0.567 | 0.532 | 0.470 | 0.325 | 0.663 | 0.598 | 0.551 | 0.497 | 0.357 |
| 616.33 | 0.656 | 0.568 | 0.532 | 0.469 | 0.331 | 0.663 | 0.594 | 0.550 | 0.495 | 0.350 |
| 616.83 | 0.655 | 0.568 | 0.531 | 0.472 | 0.326 | 0.663 | 0.598 | 0.550 | 0.495 | 0.351 |
| 617.33 | 0.538 | 0.432 | 0.433 | 0.357 | 0.257 | 0.503 | 0.500 | 0.439 | 0.373 | 0.319 |
| 618.62 | 0.597 | 0.461 | 0.475 | 0.397 | 0.297 | 0.571 | 0.557 | 0.459 | 0.419 | 0.334 |
| 619.37 | 0.625 | 0.491 | 0.510 | 0.442 | 0.324 | 0.670 | 0.593 | 0.516 | 0.481 | 0.351 |
| 619.87 | 0.655 | 0.552 | 0.534 | 0.459 | 0.325 | 0.660 | 0.594 | 0.547 | 0.503 | 0.350 |
| 620.37 | 0.654 | 0.552 | 0.536 | 0.465 | 0.324 | 0.658 | 0.597 | 0.548 | 0.502 | 0.351 |
| 620.87 | 0.652 | 0.561 | 0.536 | 0.466 | 0.323 | 0.659 | 0.598 | 0.549 | 0.502 | 0.349 |
| 621.37 | 0.653 | 0.561 | 0.535 | 0.468 | 0.325 | 0.683 | 0.592 | 0.550 | 0.502 | 0.353 |
| 621.87 | 0.655 | 0.562 | 0.535 | 0.467 | 0.326 | 0.681 | 0.593 | 0.550 | 0.502 | 0.351 |
| 622.37 | 0.653 | 0.562 | 0.536 | 0.467 | 0.328 | 0.660 | 0.594 | 0.550 | 0.499 | 0.350 |
| 622.87 | 0.654 | 0.564 | 0.534 | 0.469 | 0.327 | 0.661 | 0.594 | 0.551 | 0.500 | 0.355 |
| 623.37 | 0.668 | 0.561 | 0.534 | 0.467 | 0.329 | 0.677 | 0.593 | 0.551 | 0.499 | 0.355 |
| 623.87 | 0.654 | 0.565 | 0.536 | 0.466 | 0.326 | 0.660 | 0.594 | 0.551 | 0.500 | 0.354 |
| 624.37 | 0.653 | 0.563 | 0.535 | 0.471 | 0.326 | 0.668 | 0.597 | 0.552 | 0.503 | 0.355 |
| 624.87 | 0.668 | 0.565 | 0.536 | 0.469 | 0.327 | 0.663 | 0.597 | 0.552 | 0.503 | 0.356 |
| 625.37 | 0.667 | 0.564 | 0.534 | 0.472 | 0.326 | 0.665 | 0.592 | 0.552 | 0.502 | 0.353 |
| 625.87 | 0.654 | 0.563 | 0.536 | 0.471 | 0.329 | 0.662 | 0.594 | 0.547 | 0.502 | 0.347 |
| 626.37 | 0.651 | 0.562 | 0.535 | 0.468 | 0.329 | 0.666 | 0.592 | 0.547 | 0.502 | 0.359 |
| 626.87 | 0.654 | 0.563 | 0.535 | 0.467 | 0.329 | 0.666 | 0.596 | 0.547 | 0.502 | 0.347 |
| 627.37 | 0.655 | 0.561 | 0.534 | 0.466 | 0.329 | 0.666 | 0.594 | 0.548 | 0.502 | 0.360 |

| t (h) | 45°C | | | | | 30°C | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 6.25 kg/m$^3$-d | 4.14 kg/m$^3$-d | 2.79 kg/m$^3$-d | 1.44 kg/m$^3$-d | 0.56 kg/m$^3$-d | 6.25 kg/m$^3$-d | 4.14 kg/m$^3$-d | 2.79 kg/m$^3$-d | 1.44 kg/m$^3$-d | 0.56 kg/m$^3$-d |
| 627.87 | 0.653 | 0.565 | 0.534 | 0.472 | 0.330 | 0.666 | 0.594 | 0.548 | 0.500 | 0.351 |
| 628.37 | 0.654 | 0.561 | 0.534 | 0.470 | 0.328 | 0.665 | 0.595 | 0.548 | 0.501 | 0.360 |
| 628.87 | 0.650 | 0.566 | 0.532 | 0.467 | 0.328 | 0.665 | 0.592 | 0.548 | 0.501 | 0.355 |
| 629.37 | 0.655 | 0.565 | 0.533 | 0.465 | 0.323 | 0.671 | 0.595 | 0.547 | 0.501 | 0.356 |
| 629.87 | 0.654 | 0.563 | 0.532 | 0.466 | 0.324 | 0.665 | 0.598 | 0.547 | 0.501 | 0.352 |
| 630.37 | 0.652 | 0.563 | 0.532 | 0.468 | 0.324 | 0.665 | 0.597 | 0.548 | 0.501 | 0.357 |
| 630.87 | 0.667 | 0.563 | 0.533 | 0.472 | 0.326 | 0.666 | 0.592 | 0.547 | 0.500 | 0.354 |
| 631.37 | 0.648 | 0.565 | 0.532 | 0.445 | 0.327 | 0.667 | 0.593 | 0.547 | 0.501 | 0.352 |
| 631.87 | 0.669 | 0.564 | 0.532 | 0.445 | 0.326 | 0.666 | 0.597 | 0.547 | 0.501 | 0.353 |
| 632.37 | 0.656 | 0.563 | 0.532 | 0.471 | 0.328 | 0.665 | 0.593 | 0.548 | 0.500 | 0.354 |
| 632.87 | 0.666 | 0.563 | 0.532 | 0.445 | 0.328 | 0.666 | 0.593 | 0.548 | 0.501 | 0.356 |
| 633.37 | 0.653 | 0.564 | 0.531 | 0.471 | 0.330 | 0.665 | 0.595 | 0.549 | 0.501 | 0.352 |
| 633.87 | 0.650 | 0.563 | 0.531 | 0.469 | 0.328 | 0.666 | 0.594 | 0.549 | 0.501 | 0.355 |
| 634.37 | 0.650 | 0.562 | 0.533 | 0.468 | 0.325 | 0.666 | 0.594 | 0.549 | 0.499 | 0.355 |
| 634.87 | 0.654 | 0.563 | 0.531 | 0.466 | 0.325 | 0.665 | 0.592 | 0.549 | 0.501 | 0.352 |
| 635.37 | 0.655 | 0.560 | 0.533 | 0.469 | 0.326 | 0.666 | 0.594 | 0.549 | 0.501 | 0.352 |
| 635.87 | 0.656 | 0.562 | 0.532 | 0.471 | 0.326 | 0.666 | 0.593 | 0.549 | 0.501 | 0.356 |
| 636.37 | 0.654 | 0.567 | 0.531 | 0.470 | 0.325 | 0.666 | 0.592 | 0.549 | 0.501 | 0.355 |
| 636.87 | 0.656 | 0.571 | 0.531 | 0.469 | 0.325 | 0.666 | 0.592 | 0.553 | 0.501 | 0.352 |
| 637.37 | 0.655 | 0.561 | 0.532 | 0.470 | 0.325 | 0.665 | 0.597 | 0.553 | 0.502 | 0.352 |
| 637.87 | 0.652 | 0.565 | 0.536 | 0.472 | 0.326 | 0.665 | 0.594 | 0.554 | 0.501 | 0.356 |
| 638.37 | 0.652 | 0.563 | 0.535 | 0.467 | 0.325 | 0.666 | 0.593 | 0.547 | 0.501 | 0.353 |
| 638.87 | 0.649 | 0.570 | 0.536 | 0.468 | 0.323 | 0.666 | 0.597 | 0.549 | 0.502 | 0.355 |
| 639.37 | 0.668 | 0.564 | 0.536 | 0.469 | 0.322 | 0.665 | 0.592 | 0.549 | 0.502 | 0.352 |
| 639.87 | 0.651 | 0.561 | 0.534 | 0.469 | 0.321 | 0.665 | 0.594 | 0.549 | 0.502 | 0.349 |
| 640.37 | 0.651 | 0.560 | 0.534 | 0.469 | 0.326 | 0.665 | 0.597 | 0.548 | 0.491 | 0.348 |
| 640.87 | 0.651 | 0.563 | 0.536 | 0.468 | 0.324 | 0.665 | 0.596 | 0.548 | 0.492 | 0.348 |
| 642.17 | 0.552 | 0.496 | 0.428 | 0.357 | 0.273 | 0.666 | 0.477 | 0.457 | 0.337 | 0.314 |
| 642.67 | 0.571 | 0.536 | 0.437 | 0.398 | 0.316 | 0.669 | 0.509 | 0.487 | 0.364 | 0.328 |
| 643.17 | 0.593 | 0.555 | 0.473 | 0.415 | 0.326 | 0.666 | 0.543 | 0.496 | 0.420 | 0.335 |
| 643.67 | 0.622 | 0.561 | 0.524 | 0.456 | 0.325 | 0.667 | 0.592 | 0.548 | 0.461 | 0.350 |
| 644.17 | 0.650 | 0.564 | 0.547 | 0.471 | 0.325 | 0.666 | 0.594 | 0.547 | 0.501 | 0.349 |
| 644.67 | 0.652 | 0.566 | 0.546 | 0.468 | 0.328 | 0.667 | 0.592 | 0.547 | 0.502 | 0.359 |

| t (h) | 45°C | | | | | 30°C | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 6.25 $kg/m^3$-d | 4.14 $kg/m^3$-d | 2.79 $kg/m^3$-d | 1.44 $kg/m^3$-d | 0.56 $kg/m^3$-d | 6.25 $kg/m^3$-d | 4.14 $kg/m^3$-d | 2.79 $kg/m^3$-d | 1.44 $kg/m^3$-d | 0.56 $kg/m^3$-d |
| 645.17 | 0.652 | 0.564 | 0.548 | 0.468 | 0.328 | 0.667 | 0.592 | 0.548 | 0.501 | 0.359 |
| 645.67 | 0.653 | 0.565 | 0.528 | 0.466 | 0.326 | 0.666 | 0.592 | 0.548 | 0.502 | 0.359 |
| 646.17 | 0.652 | 0.563 | 0.529 | 0.466 | 0.320 | 0.667 | 0.593 | 0.549 | 0.502 | 0.351 |
| 646.67 | 0.649 | 0.563 | 0.525 | 0.467 | 0.323 | 0.667 | 0.596 | 0.549 | 0.501 | 0.358 |
| 647.17 | 0.647 | 0.563 | 0.526 | 0.469 | 0.326 | 0.666 | 0.597 | 0.549 | 0.502 | 0.357 |
| 647.67 | 0.648 | 0.564 | 0.529 | 0.470 | 0.332 | 0.666 | 0.597 | 0.553 | 0.502 | 0.357 |
| 648.17 | 0.649 | 0.568 | 0.531 | 0.468 | 0.328 | 0.666 | 0.597 | 0.553 | 0.501 | 0.359 |
| 648.67 | 0.648 | 0.563 | 0.532 | 0.471 | 0.331 | 0.665 | 0.596 | 0.553 | 0.500 | 0.351 |
| 649.17 | 0.650 | 0.566 | 0.532 | 0.469 | 0.331 | 0.666 | 0.597 | 0.553 | 0.502 | 0.357 |
| 649.67 | 0.653 | 0.563 | 0.527 | 0.470 | 0.332 | 0.667 | 0.596 | 0.553 | 0.499 | 0.360 |
| 650.17 | 0.649 | 0.564 | 0.529 | 0.469 | 0.330 | 0.667 | 0.597 | 0.553 | 0.501 | 0.358 |
| 650.67 | 0.647 | 0.565 | 0.531 | 0.466 | 0.327 | 0.668 | 0.597 | 0.553 | 0.501 | 0.357 |
| 651.17 | 0.651 | 0.565 | 0.532 | 0.466 | 0.329 | 0.658 | 0.596 | 0.549 | 0.501 | 0.358 |
| 651.67 | 0.655 | 0.564 | 0.533 | 0.468 | 0.326 | 0.650 | 0.597 | 0.549 | 0.502 | 0.358 |
| 652.17 | 0.651 | 0.564 | 0.533 | 0.473 | 0.328 | 0.644 | 0.596 | 0.549 | 0.499 | 0.360 |
| 652.67 | 0.653 | 0.563 | 0.529 | 0.473 | 0.328 | 0.643 | 0.596 | 0.549 | 0.500 | 0.353 |
| 653.17 | 0.651 | 0.566 | 0.528 | 0.474 | 0.327 | 0.667 | 0.596 | 0.553 | 0.502 | 0.353 |
| 653.67 | 0.651 | 0.566 | 0.528 | 0.475 | 0.327 | 0.667 | 0.596 | 0.554 | 0.500 | 0.355 |
| 654.17 | 0.651 | 0.564 | 0.528 | 0.470 | 0.323 | 0.666 | 0.597 | 0.554 | 0.500 | 0.355 |
| 654.67 | 0.650 | 0.565 | 0.527 | 0.472 | 0.330 | 0.665 | 0.596 | 0.553 | 0.502 | 0.358 |
| 655.17 | 0.648 | 0.563 | 0.533 | 0.466 | 0.325 | 0.664 | 0.597 | 0.554 | 0.501 | 0.357 |
| 655.67 | 0.647 | 0.564 | 0.533 | 0.465 | 0.325 | 0.666 | 0.597 | 0.554 | 0.493 | 0.351 |
| 656.17 | 0.652 | 0.563 | 0.533 | 0.464 | 0.322 | 0.670 | 0.595 | 0.553 | 0.502 | 0.359 |
| 656.67 | 0.653 | 0.565 | 0.533 | 0.465 | 0.329 | 0.665 | 0.595 | 0.553 | 0.502 | 0.360 |
| 657.17 | 0.654 | 0.563 | 0.533 | 0.468 | 0.321 | 0.666 | 0.596 | 0.554 | 0.499 | 0.357 |
| 657.67 | 0.654 | 0.566 | 0.533 | 0.466 | 0.329 | 0.667 | 0.595 | 0.554 | 0.500 | 0.358 |
| 658.17 | 0.655 | 0.564 | 0.533 | 0.470 | 0.325 | 0.666 | 0.595 | 0.554 | 0.502 | 0.357 |
| 658.67 | 0.654 | 0.563 | 0.532 | 0.469 | 0.325 | 0.666 | 0.596 | 0.554 | 0.503 | 0.358 |
| 659.17 | 0.655 | 0.564 | 0.532 | 0.469 | 0.325 | 0.666 | 0.596 | 0.554 | 0.502 | 0.358 |
| 659.67 | 0.655 | 0.563 | 0.532 | 0.470 | 0.325 | 0.665 | 0.597 | 0.554 | 0.502 | 0.358 |
| 660.17 | 0.656 | 0.563 | 0.532 | 0.464 | 0.325 | 0.665 | 0.596 | 0.554 | 0.502 | 0.358 |
| 660.67 | 0.655 | 0.563 | 0.532 | 0.466 | 0.325 | 0.665 | 0.597 | 0.554 | 0.503 | 0.359 |
| 661.17 | 0.655 | 0.564 | 0.531 | 0.469 | 0.325 | 0.666 | 0.596 | 0.554 | 0.503 | 0.357 |

| t (h) | 45°C | | | | | 30°C | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 6.25 kg/m³-d | 4.14 kg/m³-d | 2.79 kg/m³-d | 1.44 kg/m³-d | 0.56 kg/m³-d | 6.25 kg/m³-d | 4.14 kg/m³-d | 2.79 kg/m³-d | 1.44 kg/m³-d | 0.56 kg/m³-d |
| 661.67 | 0.653 | 0.563 | 0.531 | 0.472 | 0.325 | 0.666 | 0.596 | 0.554 | 0.500 | 0.359 |
| 662.17 | 0.656 | 0.563 | 0.530 | 0.471 | 0.325 | 0.664 | 0.597 | 0.554 | 0.491 | 0.358 |
| 662.67 | 0.655 | 0.565 | 0.530 | 0.471 | 0.325 | 0.665 | 0.597 | 0.554 | 0.492 | 0.350 |
| 663.17 | 0.653 | 0.564 | 0.532 | 0.472 | 0.325 | 0.663 | 0.597 | 0.554 | 0.492 | 0.357 |
| 663.67 | 0.654 | 0.565 | 0.530 | 0.469 | 0.326 | 0.667 | 0.597 | 0.554 | 0.492 | 0.357 |
| 664.17 | 0.656 | 0.564 | 0.531 | 0.469 | 0.325 | 0.662 | 0.597 | 0.554 | 0.502 | 0.352 |
| 664.67 | 0.655 | 0.565 | 0.531 | 0.469 | 0.325 | 0.668 | 0.597 | 0.553 | 0.503 | 0.350 |
| 665.17 | 0.653 | 0.565 | 0.531 | 0.469 | 0.325 | 0.665 | 0.596 | 0.553 | 0.492 | 0.351 |
| 666.37 | 0.548 | 0.427 | 0.390 | 0.333 | 0.266 | 0.538 | 0.445 | 0.386 | 0.363 | 0.286 |
| 666.87 | 0.577 | 0.477 | 0.414 | 0.397 | 0.298 | 0.564 | 0.485 | 0.405 | 0.405 | 0.326 |
| 667.37 | 0.621 | 0.517 | 0.516 | 0.415 | 0.316 | 0.658 | 0.541 | 0.477 | 0.462 | 0.333 |
| 667.87 | 0.655 | 0.556 | 0.524 | 0.461 | 0.321 | 0.660 | 0.580 | 0.527 | 0.479 | 0.344 |
| 668.37 | 0.668 | 0.563 | 0.528 | 0.469 | 0.330 | 0.657 | 0.560 | 0.534 | 0.494 | 0.346 |
| 668.87 | 0.667 | 0.565 | 0.529 | 0.460 | 0.325 | 0.659 | 0.594 | 0.537 | 0.488 | 0.343 |
| 669.37 | 0.654 | 0.565 | 0.532 | 0.463 | 0.325 | 0.660 | 0.594 | 0.547 | 0.488 | 0.346 |
| 669.87 | 0.654 | 0.567 | 0.533 | 0.465 | 0.328 | 0.661 | 0.597 | 0.544 | 0.489 | 0.345 |
| 670.37 | 0.655 | 0.567 | 0.532 | 0.465 | 0.327 | 0.659 | 0.592 | 0.547 | 0.489 | 0.346 |
| 670.87 | 0.651 | 0.567 | 0.535 | 0.465 | 0.330 | 0.664 | 0.595 | 0.546 | 0.489 | 0.343 |
| 671.37 | 0.650 | 0.567 | 0.533 | 0.465 | 0.325 | 0.659 | 0.593 | 0.547 | 0.489 | 0.345 |
| 671.87 | 0.650 | 0.563 | 0.534 | 0.471 | 0.328 | 0.660 | 0.594 | 0.548 | 0.489 | 0.347 |
| 672.37 | 0.652 | 0.563 | 0.536 | 0.464 | 0.333 | 0.657 | 0.592 | 0.550 | 0.489 | 0.346 |
| 672.87 | 0.652 | 0.564 | 0.537 | 0.466 | 0.325 | 0.659 | 0.594 | 0.554 | 0.489 | 0.345 |
| 673.37 | 0.651 | 0.565 | 0.537 | 0.465 | 0.331 | 0.659 | 0.592 | 0.552 | 0.488 | 0.345 |
| 673.87 | 0.648 | 0.565 | 0.537 | 0.464 | 0.330 | 0.655 | 0.593 | 0.549 | 0.488 | 0.346 |
| 674.37 | 0.655 | 0.565 | 0.538 | 0.465 | 0.330 | 0.661 | 0.592 | 0.548 | 0.489 | 0.346 |
| 674.87 | 0.668 | 0.565 | 0.539 | 0.464 | 0.330 | 0.656 | 0.594 | 0.546 | 0.488 | 0.343 |
| 675.37 | 0.655 | 0.566 | 0.538 | 0.469 | 0.330 | 0.656 | 0.596 | 0.542 | 0.488 | 0.347 |
| 675.87 | 0.653 | 0.569 | 0.538 | 0.465 | 0.330 | 0.654 | 0.592 | 0.544 | 0.488 | 0.343 |
| 676.37 | 0.656 | 0.567 | 0.536 | 0.467 | 0.337 | 0.657 | 0.595 | 0.548 | 0.488 | 0.343 |
| 676.87 | 0.649 | 0.566 | 0.538 | 0.466 | 0.331 | 0.656 | 0.593 | 0.547 | 0.488 | 0.347 |
| 677.37 | 0.653 | 0.566 | 0.538 | 0.466 | 0.328 | 0.657 | 0.592 | 0.547 | 0.488 | 0.345 |
| 677.87 | 0.656 | 0.566 | 0.537 | 0.460 | 0.326 | 0.659 | 0.596 | 0.548 | 0.488 | 0.347 |
| 678.37 | 0.648 | 0.566 | 0.536 | 0.467 | 0.331 | 0.660 | 0.589 | 0.549 | 0.488 | 0.344 |

| t (h) | 45°C | | | | | 30°C | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 6.25 kg/m$^3$-d | 4.14 kg/m$^3$-d | 2.79 kg/m$^3$-d | 1.44 kg/m$^3$-d | 0.56 kg/m$^3$-d | 6.25 kg/m$^3$-d | 4.14 kg/m$^3$-d | 2.79 kg/m$^3$-d | 1.44 kg/m$^3$-d | 0.56 kg/m$^3$-d |
| 678.87 | 0.667 | 0.565 | 0.533 | 0.466 | 0.332 | 0.659 | 0.594 | 0.546 | 0.487 | 0.346 |
| 679.37 | 0.656 | 0.566 | 0.534 | 0.467 | 0.325 | 0.663 | 0.598 | 0.548 | 0.488 | 0.346 |
| 679.87 | 0.656 | 0.566 | 0.532 | 0.462 | 0.329 | 0.659 | 0.584 | 0.553 | 0.487 | 0.345 |
| 680.37 | 0.654 | 0.566 | 0.531 | 0.462 | 0.331 | 0.661 | 0.584 | 0.552 | 0.487 | 0.343 |
| 680.87 | 0.656 | 0.566 | 0.531 | 0.467 | 0.337 | 0.658 | 0.594 | 0.554 | 0.495 | 0.344 |
| 681.37 | 0.651 | 0.566 | 0.531 | 0.465 | 0.331 | 0.661 | 0.592 | 0.549 | 0.495 | 0.344 |
| 681.87 | 0.652 | 0.566 | 0.533 | 0.467 | 0.330 | 0.661 | 0.592 | 0.547 | 0.495 | 0.345 |
| 682.37 | 0.650 | 0.567 | 0.529 | 0.472 | 0.336 | 0.658 | 0.595 | 0.552 | 0.495 | 0.345 |
| 682.87 | 0.655 | 0.566 | 0.530 | 0.472 | 0.330 | 0.661 | 0.594 | 0.553 | 0.494 | 0.347 |
| 683.37 | 0.652 | 0.566 | 0.529 | 0.471 | 0.333 | 0.661 | 0.595 | 0.554 | 0.495 | 0.344 |
| 683.87 | 0.650 | 0.566 | 0.533 | 0.472 | 0.325 | 0.658 | 0.593 | 0.554 | 0.495 | 0.343 |
| 684.37 | 0.653 | 0.567 | 0.534 | 0.470 | 0.328 | 0.658 | 0.595 | 0.558 | 0.492 | 0.345 |
| 684.87 | 0.650 | 0.568 | 0.532 | 0.469 | 0.326 | 0.661 | 0.593 | 0.557 | 0.491 | 0.344 |
| 685.37 | 0.652 | 0.568 | 0.533 | 0.470 | 0.328 | 0.659 | 0.598 | 0.559 | 0.492 | 0.344 |
| 685.87 | 0.656 | 0.568 | 0.532 | 0.472 | 0.324 | 0.660 | 0.596 | 0.560 | 0.492 | 0.345 |
| 686.37 | 0.666 | 0.568 | 0.533 | 0.471 | 0.327 | 0.659 | 0.596 | 0.535 | 0.488 | 0.346 |
| 686.87 | 0.652 | 0.566 | 0.533 | 0.469 | 0.329 | 0.658 | 0.593 | 0.538 | 0.492 | 0.344 |
| 687.37 | 0.650 | 0.566 | 0.533 | 0.469 | 0.336 | 0.659 | 0.596 | 0.536 | 0.492 | 0.346 |
| 687.87 | 0.656 | 0.568 | 0.533 | 0.472 | 0.338 | 0.659 | 0.595 | 0.539 | 0.492 | 0.347 |
| 688.37 | 0.647 | 0.566 | 0.533 | 0.468 | 0.330 | 0.659 | 0.596 | 0.542 | 0.492 | 0.343 |
| 688.87 | 0.652 | 0.566 | 0.533 | 0.470 | 0.331 | 0.663 | 0.593 | 0.547 | 0.491 | 0.345 |
| 690.63 | 0.528 | 0.436 | 0.410 | 0.361 | 0.257 | 0.503 | 0.458 | 0.425 | 0.381 | 0.326 |
| 691.13 | 0.588 | 0.496 | 0.475 | 0.369 | 0.222 | 0.563 | 0.529 | 0.458 | 0.408 | 0.328 |
| 691.63 | 0.636 | 0.566 | 0.517 | 0.436 | 0.243 | 0.660 | 0.550 | 0.514 | 0.454 | 0.351 |
| 692.13 | 0.643 | 0.567 | 0.525 | 0.458 | 0.328 | 0.661 | 0.591 | 0.550 | 0.514 | 0.350 |
| 692.63 | 0.642 | 0.567 | 0.530 | 0.461 | 0.326 | 0.660 | 0.589 | 0.550 | 0.490 | 0.351 |
| 693.13 | 0.646 | 0.551 | 0.532 | 0.472 | 0.325 | 0.657 | 0.592 | 0.550 | 0.493 | 0.351 |
| 693.63 | 0.640 | 0.560 | 0.533 | 0.467 | 0.326 | 0.657 | 0.592 | 0.550 | 0.494 | 0.343 |
| 694.13 | 0.644 | 0.561 | 0.534 | 0.470 | 0.334 | 0.658 | 0.595 | 0.550 | 0.495 | 0.351 |
| 694.63 | 0.643 | 0.562 | 0.535 | 0.470 | 0.334 | 0.653 | 0.593 | 0.550 | 0.494 | 0.352 |
| 695.13 | 0.645 | 0.562 | 0.536 | 0.472 | 0.325 | 0.666 | 0.594 | 0.550 | 0.491 | 0.343 |
| 695.63 | 0.646 | 0.563 | 0.534 | 0.471 | 0.325 | 0.657 | 0.593 | 0.550 | 0.492 | 0.352 |
| 696.13 | 0.643 | 0.563 | 0.535 | 0.468 | 0.333 | 0.659 | 0.593 | 0.550 | 0.495 | 0.343 |

| t (h) | 45°C | | | | | 30°C | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 6.25 $kg/m^3$-d | 4.14 $kg/m^3$-d | 2.79 $kg/m^3$-d | 1.44 $kg/m^3$-d | 0.56 $kg/m^3$-d | 6.25 $kg/m^3$-d | 4.14 $kg/m^3$-d | 2.79 $kg/m^3$-d | 1.44 $kg/m^3$-d | 0.56 $kg/m^3$-d |
| 696.63 | 0.644 | 0.564 | 0.536 | 0.469 | 0.331 | 0.659 | 0.593 | 0.550 | 0.489 | 0.343 |
| 697.13 | 0.645 | 0.564 | 0.536 | 0.472 | 0.326 | 0.653 | 0.593 | 0.550 | 0.490 | 0.344 |
| 697.63 | 0.645 | 0.565 | 0.531 | 0.470 | 0.332 | 0.649 | 0.586 | 0.550 | 0.490 | 0.347 |
| 698.13 | 0.643 | 0.565 | 0.536 | 0.470 | 0.334 | 0.660 | 0.594 | 0.550 | 0.490 | 0.347 |
| 698.63 | 0.643 | 0.565 | 0.536 | 0.471 | 0.327 | 0.656 | 0.590 | 0.550 | 0.488 | 0.348 |
| 699.13 | 0.643 | 0.560 | 0.536 | 0.468 | 0.334 | 0.655 | 0.594 | 0.550 | 0.487 | 0.348 |
| 699.63 | 0.645 | 0.560 | 0.530 | 0.470 | 0.333 | 0.653 | 0.583 | 0.550 | 0.487 | 0.347 |
| 700.13 | 0.645 | 0.560 | 0.536 | 0.470 | 0.325 | 0.660 | 0.594 | 0.550 | 0.489 | 0.348 |
| 700.63 | 0.644 | 0.561 | 0.535 | 0.471 | 0.326 | 0.654 | 0.595 | 0.550 | 0.490 | 0.348 |
| 701.13 | 0.643 | 0.560 | 0.536 | 0.470 | 0.328 | 0.657 | 0.592 | 0.550 | 0.488 | 0.348 |
| 701.63 | 0.644 | 0.560 | 0.530 | 0.471 | 0.331 | 0.658 | 0.590 | 0.550 | 0.490 | 0.347 |
| 702.13 | 0.640 | 0.560 | 0.531 | 0.470 | 0.333 | 0.659 | 0.592 | 0.550 | 0.489 | 0.348 |
| 702.63 | 0.645 | 0.561 | 0.536 | 0.463 | 0.334 | 0.653 | 0.595 | 0.550 | 0.490 | 0.348 |
| 703.13 | 0.644 | 0.562 | 0.535 | 0.466 | 0.331 | 0.659 | 0.593 | 0.550 | 0.488 | 0.348 |
| 703.63 | 0.646 | 0.562 | 0.535 | 0.470 | 0.331 | 0.660 | 0.593 | 0.550 | 0.490 | 0.346 |
| 704.13 | 0.642 | 0.562 | 0.536 | 0.472 | 0.333 | 0.660 | 0.594 | 0.550 | 0.488 | 0.346 |
| 704.63 | 0.639 | 0.562 | 0.536 | 0.471 | 0.333 | 0.659 | 0.590 | 0.550 | 0.489 | 0.347 |
| 705.13 | 0.641 | 0.562 | 0.536 | 0.469 | 0.330 | 0.659 | 0.594 | 0.550 | 0.492 | 0.347 |
| 705.63 | 0.641 | 0.563 | 0.530 | 0.469 | 0.331 | 0.657 | 0.593 | 0.550 | 0.493 | 0.344 |
| 706.13 | 0.640 | 0.563 | 0.531 | 0.468 | 0.334 | 0.663 | 0.593 | 0.550 | 0.494 | 0.347 |
| 706.63 | 0.642 | 0.563 | 0.532 | 0.461 | 0.330 | 0.656 | 0.592 | 0.550 | 0.494 | 0.345 |
| 707.13 | 0.640 | 0.563 | 0.533 | 0.469 | 0.333 | 0.667 | 0.593 | 0.550 | 0.492 | 0.345 |
| 707.63 | 0.646 | 0.564 | 0.533 | 0.470 | 0.331 | 0.657 | 0.594 | 0.550 | 0.494 | 0.348 |
| 708.13 | 0.646 | 0.564 | 0.531 | 0.470 | 0.334 | 0.663 | 0.593 | 0.550 | 0.492 | 0.348 |
| 708.63 | 0.642 | 0.565 | 0.533 | 0.469 | 0.335 | 0.660 | 0.589 | 0.550 | 0.495 | 0.349 |
| 709.13 | 0.641 | 0.563 | 0.530 | 0.472 | 0.323 | 0.660 | 0.593 | 0.550 | 0.495 | 0.349 |
| 709.63 | 0.641 | 0.564 | 0.533 | 0.469 | 0.325 | 0.660 | 0.592 | 0.550 | 0.494 | 0.348 |
| 710.13 | 0.640 | 0.565 | 0.531 | 0.469 | 0.326 | 0.657 | 0.592 | 0.550 | 0.488 | 0.349 |
| 710.63 | 0.640 | 0.565 | 0.532 | 0.467 | 0.325 | 0.660 | 0.594 | 0.550 | 0.487 | 0.342 |
| 711.13 | 0.640 | 0.566 | 0.533 | 0.467 | 0.326 | 0.653 | 0.592 | 0.550 | 0.487 | 0.344 |
| 711.63 | 0.643 | 0.565 | 0.531 | 0.471 | 0.327 | 0.656 | 0.593 | 0.550 | 0.490 | 0.344 |
| 712.13 | 0.640 | 0.566 | 0.531 | 0.470 | 0.327 | 0.652 | 0.592 | 0.550 | 0.489 | 0.344 |
| 712.63 | 0.644 | 0.567 | 0.532 | 0.471 | 0.329 | 0.648 | 0.590 | 0.550 | 0.490 | 0.344 |

| t (h) | 45°C | | | | | 30°C | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 6.25 kg/m$^3$-d | 4.14 kg/m$^3$-d | 2.79 kg/m$^3$-d | 1.44 kg/m$^3$-d | 0.56 kg/m$^3$-d | 6.25 kg/m$^3$-d | 4.14 kg/m$^3$-d | 2.79 kg/m$^3$-d | 1.44 kg/m$^3$-d | 0.56 kg/m$^3$-d |
| 713.13 | 0.645 | 0.566 | 0.531 | 0.471 | 0.330 | 0.653 | 0.590 | 0.550 | 0.488 | 0.346 |
| 715.13 | 0.554 | 0.503 | 0.492 | 0.341 | 0.279 | 0.588 | 0.527 | 0.458 | 0.448 | 0.285 |
| 715.63 | 0.587 | 0.538 | 0.497 | 0.401 | 0.286 | 0.619 | 0.558 | 0.489 | 0.456 | 0.314 |
| 716.13 | 0.613 | 0.550 | 0.509 | 0.453 | 0.323 | 0.650 | 0.585 | 0.519 | 0.494 | 0.344 |
| 716.63 | 0.643 | 0.554 | 0.525 | 0.466 | 0.332 | 0.650 | 0.589 | 0.550 | 0.497 | 0.350 |
| 717.13 | 0.645 | 0.557 | 0.530 | 0.465 | 0.331 | 0.649 | 0.589 | 0.550 | 0.492 | 0.351 |
| 717.63 | 0.645 | 0.561 | 0.531 | 0.470 | 0.334 | 0.650 | 0.590 | 0.550 | 0.492 | 0.355 |
| 718.13 | 0.643 | 0.561 | 0.533 | 0.469 | 0.331 | 0.649 | 0.590 | 0.550 | 0.495 | 0.343 |
| 718.63 | 0.645 | 0.562 | 0.533 | 0.471 | 0.331 | 0.649 | 0.590 | 0.550 | 0.492 | 0.343 |
| 719.13 | 0.645 | 0.562 | 0.534 | 0.469 | 0.331 | 0.648 | 0.588 | 0.550 | 0.498 | 0.345 |
| 719.63 | 0.644 | 0.562 | 0.534 | 0.470 | 0.337 | 0.650 | 0.591 | 0.550 | 0.484 | 0.345 |
| 720.13 | 0.644 | 0.560 | 0.536 | 0.468 | 0.339 | 0.648 | 0.591 | 0.550 | 0.484 | 0.346 |
| 720.63 | 0.643 | 0.562 | 0.527 | 0.471 | 0.336 | 0.648 | 0.591 | 0.550 | 0.494 | 0.346 |
| 721.13 | 0.643 | 0.558 | 0.530 | 0.470 | 0.335 | 0.648 | 0.591 | 0.550 | 0.495 | 0.337 |
| 721.63 | 0.646 | 0.558 | 0.531 | 0.470 | 0.335 | 0.648 | 0.588 | 0.550 | 0.493 | 0.339 |
| 722.13 | 0.646 | 0.560 | 0.531 | 0.470 | 0.329 | 0.648 | 0.590 | 0.550 | 0.492 | 0.339 |
| 722.63 | 0.645 | 0.561 | 0.533 | 0.471 | 0.327 | 0.648 | 0.591 | 0.550 | 0.495 | 0.341 |
| 723.13 | 0.645 | 0.560 | 0.534 | 0.472 | 0.328 | 0.648 | 0.589 | 0.550 | 0.488 | 0.339 |
| 723.63 | 0.646 | 0.560 | 0.535 | 0.472 | 0.334 | 0.648 | 0.592 | 0.550 | 0.485 | 0.339 |
| 724.13 | 0.646 | 0.560 | 0.531 | 0.470 | 0.329 | 0.648 | 0.590 | 0.550 | 0.494 | 0.339 |
| 724.63 | 0.645 | 0.560 | 0.532 | 0.469 | 0.329 | 0.648 | 0.589 | 0.550 | 0.493 | 0.339 |
| 725.13 | 0.644 | 0.561 | 0.534 | 0.470 | 0.328 | 0.648 | 0.591 | 0.550 | 0.493 | 0.338 |
| 725.63 | 0.644 | 0.561 | 0.534 | 0.469 | 0.329 | 0.648 | 0.589 | 0.550 | 0.492 | 0.338 |
| 726.13 | 0.645 | 0.561 | 0.535 | 0.469 | 0.326 | 0.648 | 0.591 | 0.550 | 0.497 | 0.342 |
| 726.63 | 0.645 | 0.561 | 0.534 | 0.471 | 0.325 | 0.648 | 0.589 | 0.550 | 0.496 | 0.341 |
| 727.13 | 0.644 | 0.562 | 0.535 | 0.470 | 0.326 | 0.648 | 0.588 | 0.550 | 0.491 | 0.340 |
| 727.63 | 0.643 | 0.557 | 0.535 | 0.469 | 0.334 | 0.648 | 0.591 | 0.550 | 0.490 | 0.340 |
| 728.13 | 0.645 | 0.557 | 0.535 | 0.469 | 0.334 | 0.648 | 0.590 | 0.550 | 0.493 | 0.340 |
| 728.63 | 0.644 | 0.557 | 0.536 | 0.469 | 0.331 | 0.648 | 0.589 | 0.550 | 0.492 | 0.342 |
| 729.13 | 0.644 | 0.557 | 0.535 | 0.472 | 0.340 | 0.648 | 0.586 | 0.550 | 0.493 | 0.347 |
| 729.63 | 0.646 | 0.558 | 0.535 | 0.469 | 0.340 | 0.648 | 0.587 | 0.550 | 0.493 | 0.339 |
| 730.13 | 0.644 | 0.558 | 0.531 | 0.469 | 0.340 | 0.648 | 0.587 | 0.550 | 0.492 | 0.340 |
| 730.63 | 0.644 | 0.558 | 0.532 | 0.468 | 0.338 | 0.648 | 0.590 | 0.550 | 0.491 | 0.337 |

| t (h) | 45°C | | | | | 30°C | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 6.25 kg/m$^3$-d | 4.14 kg/m$^3$-d | 2.79 kg/m$^3$-d | 1.44 kg/m$^3$-d | 0.56 kg/m$^3$-d | 6.25 kg/m$^3$-d | 4.14 kg/m$^3$-d | 2.79 kg/m$^3$-d | 1.44 kg/m$^3$-d | 0.56 kg/m$^3$-d |
| 731.13 | 0.643 | 0.559 | 0.532 | 0.468 | 0.334 | 0.648 | 0.590 | 0.550 | 0.494 | 0.342 |
| 731.63 | 0.643 | 0.559 | 0.532 | 0.468 | 0.333 | 0.648 | 0.588 | 0.550 | 0.493 | 0.338 |
| 732.13 | 0.646 | 0.559 | 0.532 | 0.471 | 0.332 | 0.648 | 0.588 | 0.550 | 0.495 | 0.338 |
| 732.63 | 0.645 | 0.559 | 0.533 | 0.470 | 0.332 | 0.648 | 0.589 | 0.550 | 0.489 | 0.338 |
| 733.13 | 0.645 | 0.559 | 0.534 | 0.471 | 0.331 | 0.648 | 0.591 | 0.550 | 0.493 | 0.339 |
| 733.63 | 0.644 | 0.559 | 0.536 | 0.468 | 0.340 | 0.648 | 0.591 | 0.550 | 0.498 | 0.338 |
| 734.13 | 0.644 | 0.559 | 0.535 | 0.472 | 0.331 | 0.648 | 0.591 | 0.550 | 0.496 | 0.338 |
| 734.63 | 0.643 | 0.560 | 0.536 | 0.471 | 0.331 | 0.648 | 0.589 | 0.550 | 0.495 | 0.342 |
| 735.13 | 0.643 | 0.559 | 0.529 | 0.463 | 0.333 | 0.648 | 0.590 | 0.550 | 0.494 | 0.339 |
| 735.63 | 0.643 | 0.558 | 0.528 | 0.466 | 0.330 | 0.648 | 0.588 | 0.550 | 0.491 | 0.339 |
| 736.13 | 0.644 | 0.562 | 0.530 | 0.468 | 0.333 | 0.648 | 0.589 | 0.550 | 0.491 | 0.341 |
| 736.63 | 0.642 | 0.557 | 0.531 | 0.471 | 0.340 | 0.648 | 0.587 | 0.550 | 0.495 | 0.342 |
| 737.13 | 0.644 | 0.562 | 0.529 | 0.469 | 0.331 | 0.648 | 0.590 | 0.550 | 0.491 | 0.341 |
| 737.63 | 0.642 | 0.560 | 0.528 | 0.471 | 0.331 | 0.648 | 0.587 | 0.550 | 0.493 | 0.342 |
| 738.13 | 0.643 | 0.561 | 0.531 | 0.472 | 0.331 | 0.648 | 0.587 | 0.550 | 0.492 | 0.347 |
| 738.63 | 0.643 | 0.560 | 0.530 | 0.468 | 0.331 | 0.648 | 0.591 | 0.550 | 0.492 | 0.339 |
| 739.13 | 0.643 | 0.560 | 0.531 | 0.463 | 0.338 | 0.648 | 0.589 | 0.550 | 0.496 | 0.340 |

Circuit voltage in various external resistance of part 1

| Temp | OLR (kg/m$^3$-d) | External resistance ($\Omega$) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | 10.5 | 30.1 | 76 | 148 | 197 | 298 | 502 | 746 | 996 |
| 45°C | 0.56 | 0.055 | 0.140 | 0.290 | 0.418 | 0.475 | 0.534 | 0.612 | 0.650 | 0.690 |
| | 1.44 | 0.092 | 0.219 | 0.410 | 0.548 | 0.597 | 0.646 | 0.708 | 0.746 | 0.760 |
| | 2.79 | 0.120 | 0.272 | 0.467 | 0.591 | 0.624 | 0.671 | 0.706 | 0.756 | 0.763 |
| | 4.14 | 0.125 | 0.280 | 0.495 | 0.605 | 0.645 | 0.700 | 0.750 | 0.771 | 0.785 |
| | 6.25 | 0.153 | 0.334 | 0.564 | 0.678 | 0.705 | 0.757 | 0.796 | 0.805 | 0.809 |
| 30°C | 0.56 | 0.061 | 0.157 | 0.301 | 0.428 | 0.476 | 0.534 | 0.602 | 0.648 | 0.670 |
| | 1.44 | 0.112 | 0.258 | 0.432 | 0.556 | 0.597 | 0.646 | 0.708 | 0.740 | 0.750 |
| | 2.79 | 0.129 | 0.285 | 0.486 | 0.595 | 0.624 | 0.671 | 0.696 | 0.750 | 0.753 |
| | 4.14 | 0.134 | 0.300 | 0.511 | 0.608 | 0.655 | 0.686 | 0.735 | 0.753 | 0.766 |
| | 6.25 | 0.182 | 0.361 | 0.574 | 0.679 | 0.705 | 0.756 | 0.777 | 0.796 | 0.799 |

# The result of part 2

COD in the effluent of Part 2

| Hour | 45°C | | | | | | | | | 30°C | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | pH 5.0 | pH 5.5 | pH 6.0 | pH 6.5 | pH 7.0 | pH 7.5 | pH 8.0 | pH 8.5 | pH 9.0 | pH 5.0 | pH 5.5 | pH 6.0 | pH 6.5 | pH 7.0 | pH 7.5 | pH 8.0 | pH 8.5 | pH 9.0 |
| 22 | 590 | 323 | 395 | 333 | 608 | 359 | 325 | 395 | | 286 | 250 | 377 | 214 | 210 | 89 | 295 | 305 | 354 |
| 44 | | | | | 451 | | | | | | | | | 425 | | | | |
| 66 | 381 | 244 | 159 | 117 | | 177 | 281 | 277 | 281 | 381 | 141 | 105 | 86 | | 59 | 181 | 159 | 181 |
| 88 | 313 | 232 | 141 | 104 | | 86 | 181 | 268 | 281 | 286 | 132 | 128 | 68 | | 74 | 162 | 141 | 181 |
| 110 | 222 | 232 | 141 | 104 | | 95 | 157 | 241 | 214 | 195 | 123 | 114 | 86 | | 44 | 149 | 159 | 102 |
| 132 | 237 | 177 | 136 | 104 | | 86 | 157 | 241 | 281 | 200 | 146 | 114 | 72 | | 44 | 83 | 159 | 159 |
| 154 | | 177 | 136 | 104 | 248 | 72 | 138 | 241 | 241 | 195 | 123 | 105 | 50 | 184 | 59 | 108 | 102 | 159 |
| 176 | | | | | 207 | | | | | | | | | 108 | | | | |
| 198 | | | | | 160 | | | | | | | | | 95 | | | | |
| 220 | 254 | 159 | 136 | 104 | 171 | 68 | 114 | 215 | 178 | 195 | 146 | 105 | 50 | 114 | 44 | | 102 | 102 |
| 242 | 237 | 177 | 136 | 89 | 140 | 68 | 114 | 150 | 154 | 195 | 146 | 114 | 44 | 112 | 30 | 98 | 102 | 121 |
| 264 | 254 | 150 | 141 | 74 | | 72 | 108 | 116 | 137 | 176 | | 105 | 50 | | 30 | 98 | 86 | 121 |
| 286 | 213 | 159 | 126 | 72 | | 30 | 108 | 105 | 138 | 182 | | 105 | 32 | | 30 | | 123 | 106 |
| 308 | 246 | 177 | 136 | 50 | 121 | 44 | 95 | 105 | 122 | 182 | | 114 | 44 | 108 | 59 | 95 | 86 | 102 |
| 330 | 221 | | | | | 44 | 95 | | 136 | 217 | | | | | 30 | 95 | | 121 |
| 352 | | | | | 133 | | | | | | | | | 106 | | | | |
| 374 | 221 | 168 | 141 | 72 | 143 | 30 | 95 | 116 | 136 | 182 | 146 | 114 | 44 | 80 | 30 | 45 | 92 | 102 |
| 396 | | 150 | 150 | 68 | 118 | 32 | 107 | 116 | 124 | | 146 | 114 | 50 | 84 | 30 | | 86 | 121 |
| 418 | | 168 | 136 | 68 | | 44 | 95 | 115 | | | 102 | 126 | 44 | | 44 | 71 | 85 | |
| 440 | | 168 | 126 | 50 | | 44 | 107 | 123 | | | 98 | 114 | 50 | | 44 | | 92 | |
| 462 | | 150 | 126 | 68 | 105 | 32 | | 123 | | | 102 | 105 | 32 | 84 | | | 109 | |
| 484 | | | | | 110 | | | | | | | | | 92 | | | | |
| 506 | | | | | 90 | | | | | | | | | 108 | | 85 | | |
| 528 | | 150 | 136 | 44 | 88 | 32 | 98 | 123 | 137 | 182 | 114 | 98 | 32 | 96 | 30 | 85 | 92 | 121 |
| 550 | | 168 | 141 | 59 | 94 | 32 | 95 | 116 | 124 | 203 | 114 | 105 | 50 | 92 | 44 | 85 | 92 | 102 |
| 572 | | | | 50 | | | | | | 203 | | | | | 30 | | | |
| 594 | 221 | | | 30 | | | | | | 195 | | | | | 30 | | | |
| 616 | | | | 44 | | | | | | 195 | | | | | 30 | | | |
| 638 | 237 | | | 44 | | | | | | 195 | | | | | 30 | | | |

pH in the effluent of part 2

| Hour | 45°C | | | | | | | | | 30°C | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | pH 5.0 | pH 5.5 | pH 6.0 | pH 6.5 | pH 7.0 | pH 7.5 | pH 8.0 | pH 8.5 | pH 9.0 | pH 5.0 | pH 5.5 | pH 6.0 | pH 6.5 | pH 7.0 | pH 7.5 | pH 8.0 | pH 8.5 | pH 9.0 |
| 22 | 5.01 | | 5.86 | 6.21 | 6.09 | 7.22 | 7.94 | 8.42 | 8.84 | 5.08 | 5.31 | 5.7 | 6.46 | 6.84 | 7.43 | 7.84 | 8.21 | 8.75 |
| 44 | | | | 6.27 | | | | | | | | | 6.27 | | | | | |
| 66 | | | | 6.39 | | | | | | | | | 6.39 | | | | | |
| 88 | 5.03 | 5.39 | 5.89 | | 6.63 | 7.34 | 7.86 | 8.49 | 8.83 | 5.12 | 5.32 | 5.88 | | 6.64 | 7.36 | 7.75 | 8.12 | 8.75 |
| 110 | 5.1 | 5.45 | 5.94 | | 6.56 | 7.13 | 7.64 | 8.34 | 8.92 | 5.01 | 5.45 | 5.76 | | 6.84 | 7.35 | 7.68 | 8.19 | 8.86 |
| 132 | 5.07 | 5.32 | 5.92 | 6.45 | 6.67 | 7.24 | 7.78 | 8.43 | 8.88 | 5.05 | 5.42 | 5.79 | 6.32 | 6.75 | | 7.62 | 8.27 | 8.54 |
| 154 | 5.19 | 5.47 | 5.92 | 6.45 | 6.59 | 7.26 | 7.67 | 8.24 | 8.83 | 5.19 | 5.34 | 5.76 | 6.43 | 6.66 | 7.39 | 7.84 | 8.21 | 8.54 |
| 176 | 5.04 | | 5.82 | 6.35 | 6.84 | 7.36 | 7.78 | | 8.79 | 5.13 | 5.49 | 5.87 | 6.24 | 6.68 | 7.36 | 7.68 | 8.26 | 8.56 |
| 198 | | | | 6.44 | | | | | | | | | 6.32 | | | | | |
| 220 | | | | 6.28 | | | | | | | | | 6.23 | | | | | |
| 242 | 5.19 | 5.42 | 5.97 | | 6.67 | 7.16 | 7.81 | 8.38 | 8.79 | 5.14 | 5.25 | 5.79 | | 6.84 | 7.36 | 7.86 | 8.28 | 8.74 |
| 264 | 5.04 | 5.12 | 5.95 | | 6.84 | 7.34 | 7.87 | 8.37 | 8.99 | 5.19 | 5.26 | 5.81 | | 6.74 | 7.32 | 7.71 | 8.48 | 8.51 |
| 286 | 5.01 | 5.41 | 5.79 | 6.39 | 6.85 | 7.46 | 7.78 | 8.31 | 8.87 | 5.16 | 5.45 | 5.83 | 6.45 | 6.68 | 7.28 | 7.83 | 8.13 | 8.57 |
| 308 | 5.12 | 5.35 | 5.62 | 6.34 | 6.84 | 7.35 | 7.98 | 8.41 | 8.81 | 5.12 | 5.39 | 5.71 | 6.47 | 6.74 | 7.22 | 7.69 | 8.28 | 8.66 |
| 330 | 5.07 | 5.15 | 5.99 | 6.49 | 6.96 | 7.41 | 7.66 | 8.34 | 8.94 | 5.07 | 5.49 | 5.86 | 6.28 | 6.57 | 7.31 | 7.96 | 8.22 | 8.67 |
| 352 | | | | 6.24 | | | | | | | | | 6.48 | | | | | |
| 374 | | | | 6.29 | | | | | | | | | 6.47 | | | | | |
| 396 | 5.01 | 5.49 | 5.73 | | 6.83 | 7.42 | 7.87 | 8.42 | 8.74 | 5.19 | 5.38 | 5.86 | | 6.84 | 7.39 | 7.56 | 8.17 | 8.59 |
| 418 | 5.09 | 5.42 | 5.96 | | 6.71 | 7.34 | 7.78 | 8.36 | 8.83 | 5.09 | 5.44 | 5.83 | | 6.89 | 7.39 | 7.57 | 8.15 | 8.68 |
| 440 | | 5.41 | 5.05 | 6.49 | | 7.26 | | 8.25 | | | 5.33 | 5.37 | 6.22 | 6.75 | | 7.82 | | |
| 462 | 5.02 | 5.18 | 5.82 | 6.36 | 6.78 | 7.34 | 7.85 | 8.28 | 8.79 | 5.05 | 5.41 | 5.76 | 6.41 | 6.68 | 7.36 | 7.74 | 8.11 | 8.67 |
| 484 | | | 5.96 | 6.38 | | 7.34 | | 8.29 | | | 5.43 | 5.75 | 6.26 | | 7.38 | | 8.14 | |
| 506 | | | | 6.49 | | | | | | | | | 6.34 | | | | | |
| 528 | | | | 6.42 | | | | | | | | | 6.25 | | | | | |
| 550 | 5.03 | 5.45 | 5.82 | | 6.39 | 7.37 | 7.87 | 8.34 | 8.29 | 5.07 | 5.45 | 5.69 | | 6.68 | 7.48 | 7.79 | 8.29 | 8.73 |
| 572 | 5.07 | 5.45 | 5.89 | | 6.77 | 7.33 | 7.69 | 8.25 | 8.69 | 5.07 | 5.45 | 5.87 | | 6.87 | 7.41 | 7.65 | 8.11 | 8.89 |
| 594 | 5.03 | 5.29 | 5.93 | 6.46 | 6.93 | 7.34 | 7.81 | | 8.98 | 5.11 | 5.47 | 5.89 | 6.49 | 6.72 | 7.25 | 7.74 | 8.28 | 8.85 |
| 616 | 5.09 | | | 6.46 | 6.87 | | 7.59 | | 8.87 | 5.16 | | | 6.49 | 6.85 | | 7.78 | | |
| 638 | 5.09 | | | 6.38 | 6.76 | | 7.66 | | 8.78 | 5.16 | | | 6.24 | 6.87 | | | | 8.79 |

Note. 1. The unit less

Sulfate in the effluent of part 2

| Hour | 45°C | | | | | | | | | 30°C | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | pH 5.0 | pH 5.5 | pH 6.0 | pH 6.5 | pH 7.0 | pH 7.5 | pH 8.0 | pH 8.5 | pH 9.0 | pH 5.0 | pH 5.5 | pH 6.0 | pH 6.5 | pH 7.0 | pH 7.5 | pH 8.0 | pH 8.5 | pH 9.0 |
| 22 | 942 | | 770 | 685 | 77 | 820 | 678 | 1,100 | 874 | 738 | 872 | 755 | 630 | 74 | 712 | 793 | 760 | 609 |
| 44 | | | | 280 | | | | | | | | | 260 | | | | | |
| 66 | | | | 270 | | | | | | | | | 410 | | | | | |
| 88 | 270 | 340 | | | 71 | 360 | 445 | 435 | 400 | 287 | 260 | 260 | | 53 | 435 | 219 | 410 | 430 |
| 110 | 165 | 440 | 375 | | 24 | 355 | 355 | 450 | 415 | 208 | 245 | 225 | | 57 | 470 | 225 | 310 | 546 |
| 132 | 185 | 480 | 185 | 280 | 88 | 230 | 303 | 450 | 418 | 160 | 175 | 335 | 369 | 52 | | 234 | 410 | 176 |
| 154 | 189 | 245 | 225 | 402 | | 280 | 348 | 325 | 483 | 115 | 400 | 465 | 279 | | 475 | 272 | 340 | 232 |
| 176 | 325 | | 225 | 436 | | 240 | 380 | 285 | 380 | 261 | 290 | 425 | 322 | | 376 | 232 | 330 | |
| 198 | | | | 316 | 33 | | | | | | | | 237 | 49 | | | | |
| 220 | | | | 481 | 35 | | | | | | | | 462 | 36 | | | | |
| 242 | 188 | 280 | 410 | | 45 | 438 | 482 | 445 | 350 | 133 | 450 | 470 | | 82 | 324 | 261 | 395 | 330 |
| 264 | 235 | 277 | 210 | | | 210 | 436 | 455 | 358 | 133 | 320 | 295 | | | 320 | 334 | 280 | 217 |
| 286 | 234 | 295 | 260 | 364 | | 394 | 241 | 345 | 345 | 100 | 265 | 355 | 228 | | 420 | 346 | 305 | 441 |
| 308 | 295 | 425 | 275 | 261 | 68 | 340 | 141 | 165 | 153 | 313 | 310 | 370 | 255 | 61 | 465 | 310 | 420 | 310 |
| 330 | 214 | | 426 | 492 | 57 | 215 | 300 | 240 | 459 | 483 | 315 | 405 | 112 | 44 | 320 | 291 | 330 | 392 |
| 352 | | | | 228 | | | | | | | | | 239 | | | | | |
| 374 | | | | 218 | | | | | | | | | 197 | | | | | |
| 396 | | 450 | 240 | | | 208 | 420 | 305 | 340 | 376 | 440 | 265 | | | 380 | 380 | 405 | 295 |
| 418 | 365 | 300 | 410 | | 82 | 253 | 285 | 440 | 425 | 470 | 470 | 345 | | 98 | 415 | 275 | 375 | 490 |
| 440 | | 260 | 210 | 400 | | 220 | | 375 | | | 384 | 290 | 213 | | 450 | | 345 | |
| 462 | | 410 | 354 | 240 | | 315 | 340 | 320 | | 358 | 169 | 166 | 228 | | 415 | | 315 | 395 |
| 484 | | | 250 | 320 | | 265 | | 340 | | | 272 | 431 | 380 | | 389 | | 348 | |
| 506 | | | | 530 | | | | | | | | | 255 | | | | | |
| 528 | | | | 330 | | | | | | | | | 228 | | | | | |
| 550 | 245 | 450 | 230 | | | 385 | 445 | 515 | 490 | 315 | 174 | 374 | | | 480 | 485 | 460 | 320 |
| 572 | 309 | 275 | 280 | | 270 | 380 | 280 | 533 | 210 | 285 | 186 | 360 | | 435 | 385 | 265 | 275 | 355 |
| 594 | 330 | | | 287 | 353 | | 475 | | 265 | 242 | | | 362 | 430 | | 225 | | 410 |
| 616 | 195 | | | 385 | 367 | | 255 | | 215 | 470 | | | 433 | 509 | | 400 | | |
| 638 | 315 | | | 358 | 313 | | 255 | | 445 | 319 | | | 242 | 429 | | | | 270 |

Note. 1. The unit of sulfate as mg/L

Alkalinity in the effluent of part 2

| Hour | 45°C | | | | | | | | | 30°C | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | pH 5.0 | pH 5.5 | pH 6.0 | pH 6.5 | pH 7.0 | pH 7.5 | pH 8.0 | pH 8.5 | pH 9.0 | pH 5.0 | pH 5.5 | pH 6.0 | pH 6.5 | pH 7.0 | pH 7.5 | pH 8.0 | pH 8.5 | pH 9.0 |
| 22 | 120 | | 250 | 400 | 480 | 550 | 620 | 730 | 720 | 180 | 150 | 200 | 360 | 490 | 550 | 690 | 730 | 750 |
| 44 | | | | 340 | | | | | | | | | 380 | | | | | |
| 66 | | | | 370 | | | | | | | | | 340 | | | | | |
| 88 | 120 | 220 | 280 | | 420 | 600 | 650 | 720 | 770 | 130 | 200 | 200 | | 460 | 570 | 660 | 730 | 770 |
| 110 | 150 | 220 | 300 | | 460 | 580 | 690 | 720 | 770 | 150 | 200 | 250 | | 460 | 560 | 630 | 730 | 770 |
| 132 | 160 | 260 | 300 | 360 | 470 | 600 | 700 | 720 | 800 | 110 | 220 | 250 | 340 | 460 | | 690 | 740 | 770 |
| 154 | 180 | 200 | 300 | 350 | 470 | 600 | 680 | 730 | 780 | 120 | 200 | 200 | 360 | 460 | 580 | 660 | 750 | 770 |
| 176 | 100 | | 300 | 380 | 490 | 550 | 690 | 710 | 720 | 100 | 150 | 350 | 380 | 500 | 550 | 640 | 710 | |
| 198 | | | | 380 | | | | | | | | | 380 | | | | | |
| 220 | | | | 380 | | | | | | | | | 310 | | | | | |
| 242 | 170 | 200 | 350 | | 420 | 590 | 700 | 720 | 780 | 110 | 150 | 250 | | 460 | 580 | 600 | 750 | 750 |
| 264 | 120 | 200 | 320 | | 460 | 520 | 620 | 740 | 780 | 160 | 200 | 250 | | 490 | 570 | 660 | 730 | 770 |
| 286 | 140 | 180 | 320 | 390 | 450 | 600 | 700 | 730 | 780 | 100 | 200 | 300 | 380 | 490 | 560 | 630 | 710 | 770 |
| 308 | 120 | 200 | 300 | 380 | 420 | 600 | 670 | 720 | 790 | 140 | 250 | 250 | 330 | 490 | 550 | 630 | 720 | 760 |
| 330 | 120 | 180 | 280 | 340 | 430 | 540 | 690 | 730 | 770 | 120 | 200 | 300 | 380 | 470 | 580 | 600 | 720 | 770 |
| 352 | | | | 340 | | | | | | | | | 360 | | | | | |
| 374 | | | | 340 | | | | | | | | | 380 | | | | | |
| 396 | 130 | 200 | 280 | | 420 | 580 | 660 | 710 | 790 | 150 | 200 | 300 | | 440 | 580 | 660 | 750 | 750 |
| 418 | 160 | 160 | 280 | | 470 | 550 | 650 | 760 | 790 | 170 | 200 | 300 | | 420 | 550 | 630 | 720 | 730 |
| 440 | | 150 | 290 | 320 | | 600 | | 720 | | | 200 | 300 | 360 | | 550 | | 740 | |
| 462 | 170 | 180 | 280 | 350 | 490 | 590 | 680 | 730 | 770 | 130 | 200 | 300 | 320 | 450 | 580 | | 730 | 770 |
| 484 | | | 280 | 360 | | 620 | | 730 | | | 150 | 300 | 320 | | 520 | | 750 | |
| 506 | | | | 360 | | | | | | | | | 380 | | | | | |
| 528 | | | | 360 | | | | | | | | | 360 | | | | | |
| 550 | 170 | 250 | 250 | | 450 | 580 | 620 | 720 | 760 | 180 | 190 | 300 | | 420 | 550 | 670 | 740 | 770 |
| 572 | 180 | 200 | 250 | | 450 | 600 | 660 | 730 | 750 | 150 | 250 | 250 | | 450 | 600 | 650 | 730 | 750 |
| 594 | 160 | 200 | 250 | 380 | 460 | 620 | 640 | 740 | 740 | 170 | 250 | 300 | 380 | 440 | 550 | 660 | 750 | 750 |
| 616 | 160 | | | 360 | 480 | | 670 | | 750 | 170 | | | 340 | 480 | | 630 | | |
| 638 | 160 | | | 360 | 490 | | 650 | | 740 | 160 | | | 380 | 440 | | | | 730 |

Note. 1. The unit of alkalinity as mg/L as $CaCO_3$

Conductivity in the effluent of part 2

| Hour | 45°C | | | | | | | | | 30°C | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | pH 5.0 | pH 5.5 | pH 6.0 | pH 6.5 | pH 7.0 | pH 7.5 | pH 8.0 | pH 8.5 | pH 9.0 | pH 5.0 | pH 5.5 | pH 6.0 | pH 6.5 | pH 7.0 | pH 7.5 | pH 8.0 | pH 8.5 | pH 9.0 |
| 22 | 49.5 | | 22 | 20 | 43 | 50 | 72 | 109 | 190 | 39 | 35 | 28 | 19.5 | 40.9 | 55.1 | 75 | 104 | 193 |
| 44 | | | | 17.1 | | | | | | | | | 18.3 | | | | | |
| 66 | | | | 18.2 | | | | | | | | | 16.4 | | | | | |
| 88 | 47.2 | 39 | 26 | | 30 | 68 | 72 | 106 | 186 | 48 | 37 | 23 | | 35 | 54.4 | 80.1 | 108 | 147 |
| 110 | 46.5 | 31 | 28 | | 26 | 68 | 89 | 113 | 185 | 50 | 30 | 22 | | 36 | 61 | 82.4 | 108 | 163 |
| 132 | 49.1 | 31 | 26 | 17 | 28 | 60 | 78 | 99 | 194 | 52 | 35 | 20 | 14.5 | 34 | | 78.3 | 99 | 164 |
| 154 | 50.7 | 35 | 24 | 16.8 | 56 | 66 | 75 | 112 | 150 | 44.7 | 39 | 28 | 14.5 | 40 | 62 | 70.7 | 104 | 159 |
| 176 | 42.9 | | 28 | 15.6 | 52 | 60 | 73 | 98 | 180 | 33 | 34 | 22 | 16.1 | 51 | 58 | 81 | 106 | |
| 198 | | | | 15 | | | | | | | | | 14.8 | | | | | |
| 220 | | | | 13.7 | | | | | | | | | 17.6 | | | | | |
| 242 | 48.8 | 35 | 23 | | 40 | 58 | 67 | 97 | 190 | 49.7 | 34 | 26 | | 40 | 60 | 82 | 102 | 170 |
| 264 | 44.3 | 30 | 28 | | 59 | 56 | 70 | 93 | 194 | 46.8 | 38 | 29 | | 52 | 60 | 85 | 120 | 155 |
| 286 | 45.4 | 30 | 29 | 15.2 | 37 | 59 | 72 | 98 | 199 | 33.6 | 37 | 20 | 12.9 | 55.1 | 62 | 89 | 112 | 151 |
| 308 | 46.9 | 35 | 22 | 14.4 | 45 | 54 | 74 | 106 | 193 | 57.4 | 35 | 20 | 14.2 | 55 | 64 | 83 | 118 | 156 |
| 330 | 49.9 | 30 | 20 | 15.3 | 54 | 56 | 76 | 112 | 189 | 46.7 | 39 | 26 | 13.1 | 40 | 65 | 87.7 | 116 | 163 |
| 352 | | | | 13.4 | | | | | | | | | 15.2 | | | | | |
| 374 | | | | 16.1 | | | | | | | | | 14.5 | | | | | |
| 396 | 49.7 | 33 | 25 | | 48 | 60 | 76 | 108 | 194 | 44.7 | 37 | 23 | | 58.2 | 62 | 72 | 119 | 157 |
| 418 | 49.5 | 31 | 22 | | 50 | 58 | 81 | 98 | 179 | 57 | 37 | 24 | | 54 | 62 | 88 | 109 | 162 |
| 440 | | 30 | 29 | 16.7 | 46 | | | | 195 | | 31.9 | 24 | 16.3 | | 62.1 | | 127 | |
| 462 | 48.2 | 35 | 27 | 17.1 | 48 | 67 | 80 | 104 | 189 | 54 | 35 | 21 | 17.6 | 58.6 | 67 | | 120 | 158 |
| 484 | | | 28 | 15.2 | 49 | | | | 196 | | 31 | 20 | 19.1 | | 71 | | 97 | |
| 506 | | | | 16.6 | | | | | | | | | 15.2 | | | | | |
| 528 | | | | 12.9 | | | | | | | | | 13.3 | | | | | |
| 550 | 49.5 | 39 | 24 | | 49 | 53 | 73 | 103 | 178 | 48 | 30 | 26 | | 52 | 58 | 98 | 104 | 146 |
| 572 | 46.8 | 34.4 | 24 | | 53 | 50 | 82 | 108 | 168 | 47 | 30 | 27 | | 55 | 65 | 84 | 109 | 190 |
| 594 | 44.3 | 32 | 22 | 16.5 | 54 | 67 | 84 | 105 | 175 | 56 | 34.2 | 22 | 12.3 | 45 | 67 | 86 | 122 | 122 |
| 616 | 53.1 | | | 14.4 | | 66 | 78 | 102 | | 63 | | | 13.8 | 45 | | 84 | | |
| 638 | 51.5 | | | 15.5 | | 65 | 78 | 102 | | 63 | | | 13.4 | 45 | | | | 135 |

Note. 1. The unit of conductivity as µS/cm

The circuit voltage from of the experiment of part 2

| Hour | 45°C | | | | | | | | | 30°C | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | pH 5.0 | pH 5.5 | pH 6.0 | pH 6.5 | pH 7.0 | pH 7.5 | pH 8.0 | pH 8.5 | pH 9.0 | pH 5.0 | pH 5.5 | pH 6.0 | pH 6.5 | pH 7.0 | pH 7.5 | pH 8.0 | pH 8.5 | pH 9.0 |
| 0.00 | 0.362 | 0.202 | 0.265 | 0.206 | 0.202 | 0.188 | 0.377 | 0.382 | 0.360 | 0.212 | 0.275 | 0.293 | 0.244 | 0.162 | 0.350 | 0.365 | 0.490 | 0.384 |
| 0.50 | 0.362 | 0.202 | 0.272 | 0.206 | 0.202 | 0.201 | 0.360 | 0.389 | 0.399 | 0.275 | 0.275 | 0.295 | 0.257 | 0.225 | 0.364 | 0.391 | 0.466 | 0.362 |
| 1.00 | 0.360 | 0.200 | 0.265 | 0.206 | 0.200 | 0.201 | 0.364 | 0.477 | 0.390 | 0.257 | 0.275 | 0.288 | 0.263 | 0.227 | 0.371 | 0.387 | 0.490 | 0.374 |
| 1.50 | 0.361 | 0.231 | 0.270 | 0.206 | 0.231 | 0.202 | 0.355 | 0.550 | 0.397 | 0.259 | 0.275 | 0.298 | 0.260 | 0.229 | 0.374 | 0.386 | 0.492 | 0.460 |
| 2.00 | 0.357 | 0.207 | 0.272 | 0.207 | 0.207 | 0.201 | 0.369 | 0.594 | 0.254 | 0.259 | 0.275 | 0.161 | 0.232 | 0.229 | 0.373 | 0.356 | 0.477 | 0.463 |
| 2.50 | 0.371 | 0.241 | 0.265 | 0.208 | 0.241 | 0.205 | 0.379 | 0.625 | 0.255 | 0.259 | 0.275 | 0.291 | 0.226 | 0.229 | 0.374 | 0.363 | 0.477 | 0.473 |
| 3.00 | 0.364 | 0.249 | 0.263 | 0.207 | 0.249 | 0.206 | 0.357 | 0.600 | 0.394 | 0.360 | 0.277 | 0.290 | 0.213 | 0.280 | 0.375 | 0.366 | 0.484 | 0.382 |
| 3.50 | 0.361 | 0.231 | 0.265 | 0.210 | 0.231 | 0.208 | 0.359 | 0.584 | 0.449 | 0.361 | 0.275 | 0.292 | 0.241 | 0.286 | 0.371 | 0.368 | 0.480 | 0.478 |
| 4.00 | 0.362 | 0.247 | 0.257 | 0.211 | 0.247 | 0.213 | 0.360 | 0.578 | 0.498 | 0.364 | 0.275 | 0.300 | 0.224 | 0.389 | 0.374 | 0.372 | 0.491 | 0.478 |
| 4.50 | 0.363 | 0.223 | 0.223 | 0.212 | 0.223 | 0.212 | 0.410 | 0.600 | 0.496 | 0.357 | 0.275 | 0.288 | 0.221 | 0.377 | 0.366 | 0.498 | 0.493 | 0.468 |
| 5.00 | 0.365 | 0.315 | 0.275 | 0.213 | 0.300 | 0.214 | 0.411 | 0.638 | 0.502 | 0.402 | 0.274 | 0.177 | 0.223 | 0.377 | 0.373 | 0.511 | 0.499 | 0.576 |
| 5.50 | 0.361 | 0.301 | 0.280 | 0.217 | 0.300 | 0.217 | 0.412 | 0.593 | 0.503 | 0.406 | 0.275 | 0.160 | 0.222 | 0.381 | 0.370 | 0.500 | 0.502 | 0.572 |
| 6.00 | 0.368 | 0.318 | 0.267 | 0.208 | 0.288 | 0.216 | 0.412 | 0.600 | 0.744 | 0.421 | 0.275 | 0.689 | 0.200 | 0.376 | 0.372 | 0.511 | 0.579 | 0.574 |
| 6.50 | 0.379 | 0.329 | 0.280 | 0.203 | 0.379 | 0.218 | 0.413 | 0.600 | 0.729 | 0.420 | 0.275 | 0.289 | 0.233 | 0.375 | 0.378 | 0.475 | 0.605 | 0.569 |
| 7.00 | 0.373 | 0.313 | 0.268 | 0.207 | 0.393 | 0.220 | 0.414 | 0.600 | 0.723 | 0.424 | 0.275 | 0.225 | 0.226 | 0.379 | 0.382 | 0.498 | 0.622 | 0.590 |
| 7.50 | 0.371 | 0.311 | 0.267 | 0.205 | 0.391 | 0.218 | 0.414 | 0.600 | 0.719 | 0.391 | 0.283 | 0.162 | 0.212 | 0.381 | 0.390 | 0.499 | 0.633 | 0.589 |
| 8.00 | 0.378 | 0.328 | 0.266 | 0.203 | 0.378 | 0.219 | 0.465 | 0.604 | 0.713 | 0.402 | 0.289 | 0.160 | 0.200 | 0.377 | 0.393 | 0.499 | 0.643 | 0.590 |
| 8.50 | 0.379 | 0.329 | 0.269 | 0.202 | 0.379 | 0.216 | 0.466 | 0.599 | 0.705 | 0.408 | 0.284 | 0.160 | 0.241 | 0.383 | 0.399 | 0.498 | 0.686 | 0.570 |
| 9.00 | 0.366 | 0.316 | 0.274 | 0.207 | 0.366 | 0.216 | 0.466 | 0.653 | 0.705 | 0.423 | 0.299 | 0.291 | 0.257 | 0.378 | 0.355 | 0.499 | 0.682 | 0.568 |
| 9.50 | 0.375 | 0.315 | 0.269 | 0.285 | 0.395 | 0.215 | 0.467 | 0.643 | 0.595 | 0.409 | 0.301 | 0.290 | 0.355 | 0.384 | 0.367 | 0.499 | 0.676 | 0.568 |
| 10.00 | 0.363 | 0.313 | 0.268 | 0.212 | 0.398 | 0.217 | 0.467 | 0.633 | 0.710 | 0.409 | 0.316 | 0.293 | 0.243 | 0.384 | 0.372 | 0.501 | 0.681 | 0.587 |
| 10.50 | 0.377 | 0.327 | 0.263 | 0.258 | 0.377 | 0.218 | 0.468 | 0.600 | 0.720 | 0.408 | 0.323 | 0.292 | 0.263 | 0.383 | 0.397 | 0.501 | 0.684 | 0.569 |
| 11.00 | 0.368 | 0.318 | 0.271 | 0.273 | 0.388 | 0.216 | 0.468 | 0.605 | 0.705 | 0.409 | 0.328 | 0.292 | 0.266 | 0.384 | 0.400 | 0.501 | 0.677 | 0.567 |
| 11.50 | 0.362 | 0.332 | 0.264 | 0.255 | 0.382 | 0.215 | 0.469 | 0.600 | 0.710 | 0.422 | 0.331 | 0.292 | 0.268 | 0.377 | 0.403 | 0.502 | 0.682 | 0.589 |
| 12.00 | 0.360 | 0.310 | 0.277 | 0.282 | 0.395 | 0.215 | 0.470 | 0.600 | 0.722 | 0.424 | 0.330 | 0.292 | 0.270 | 0.379 | 0.414 | 0.504 | 0.684 | 0.588 |
| 12.50 | 0.371 | 0.311 | 0.265 | 0.288 | 0.391 | 0.215 | 0.470 | 0.653 | 0.701 | 0.391 | 0.330 | 0.292 | 0.261 | 0.381 | 0.417 | 0.506 | 0.676 | 0.570 |
| 13.00 | 0.370 | 0.320 | 0.274 | 0.287 | 0.390 | 0.212 | 0.471 | 0.640 | 0.704 | 0.424 | 0.330 | 0.292 | 0.261 | 0.379 | 0.424 | 0.507 | 0.688 | 0.573 |
| 13.50 | 0.376 | 0.326 | 0.278 | 0.271 | 0.376 | 0.213 | 0.471 | 0.642 | 0.599 | 0.391 | 0.327 | 0.293 | 0.261 | 0.381 | 0.398 | 0.508 | 0.688 | 0.570 |
| 14.00 | 0.364 | 0.304 | 0.278 | 0.276 | 0.354 | 0.210 | 0.472 | 0.575 | 0.578 | 0.404 | 0.330 | 0.295 | 0.269 | 0.379 | 0.388 | 0.510 | 0.682 | 0.569 |
| 14.50 | 0.375 | 0.315 | 0.207 | 0.272 | 0.395 | 0.209 | 0.472 | 0.599 | 0.591 | 0.402 | 0.330 | 0.291 | 0.269 | 0.377 | 0.376 | 0.510 | 0.674 | 0.590 |
| 15.00 | 0.362 | 0.332 | 0.278 | 0.274 | 0.382 | 0.208 | 0.472 | 0.505 | 0.592 | 0.404 | 0.330 | 0.292 | 0.268 | 0.379 | 0.366 | 0.511 | 0.685 | 0.566 |

| Hour | 45°C | | | | | | | | | 30°C | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | pH 5.0 | pH 5.5 | pH 6.0 | pH 6.5 | pH 7.0 | pH 7.5 | pH 8.0 | pH 8.5 | pH 9.0 | pH 5.0 | pH 5.5 | pH 6.0 | pH 6.5 | pH 7.0 | pH 7.5 | pH 8.0 | pH 8.5 | pH 9.0 |
| 15.50 | 0.379 | 0.329 | 0.276 | 0.278 | 0.379 | 0.209 | 0.473 | 0.527 | 0.588 | 0.402 | 0.330 | 0.293 | 0.267 | 0.377 | 0.370 | 0.512 | 0.685 | 0.566 |
| 16.00 | 0.363 | 0.333 | 0.265 | 0.267 | 0.383 | 0.207 | 0.473 | 0.527 | 0.589 | 0.399 | 0.322 | 0.291 | 0.265 | 0.389 | 0.378 | 0.512 | 0.683 | 0.565 |
| 16.50 | 0.371 | 0.311 | 0.207 | 0.273 | 0.291 | 0.207 | 0.472 | 0.526 | 0.595 | 0.398 | 0.315 | 0.285 | 0.269 | 0.388 | 0.392 | 0.514 | 0.696 | 0.566 |
| 17.00 | 0.362 | 0.272 | 0.268 | 0.262 | 0.272 | 0.207 | 0.473 | 0.536 | 0.585 | 0.401 | 0.301 | 0.291 | 0.269 | 0.376 | 0.363 | 0.514 | 0.697 | 0.588 |
| 18.42 | 0.374 | 0.314 | 0.265 | 0.258 | 0.294 | 0.180 | 0.473 | 0.501 | 0.581 | 0.401 | 0.291 | 0.290 | 0.268 | 0.376 | 0.356 | 0.515 | 0.397 | 0.590 |
| 18.92 | 0.368 | 0.268 | 0.219 | 0.262 | 0.268 | 0.298 | 0.473 | 0.574 | 0.595 | 0.402 | 0.281 | 0.288 | 0.268 | 0.377 | 0.371 | 0.495 | 0.689 | 0.588 |
| 19.42 | 0.372 | 0.312 | 0.237 | 0.262 | 0.292 | 0.383 | 0.373 | 0.566 | 0.575 | 0.257 | 0.261 | 0.288 | 0.267 | 0.232 | 0.387 | 0.496 | 0.684 | 0.463 |
| 19.92 | 0.370 | 0.310 | 0.240 | 0.257 | 0.390 | 0.398 | 0.373 | 0.594 | 0.578 | 0.361 | 0.278 | 0.288 | 0.267 | 0.286 | 0.395 | 0.496 | 0.683 | 0.461 |
| 20.42 | 0.358 | 0.308 | 0.243 | 0.269 | 0.358 | 0.359 | 0.472 | 0.502 | 0.570 | 0.399 | 0.283 | 0.288 | 0.267 | 0.379 | 0.389 | 0.497 | 0.676 | 0.585 |
| 20.92 | 0.360 | 0.300 | 0.240 | 0.264 | 0.350 | 0.364 | 0.472 | 0.514 | 0.581 | 0.399 | 0.298 | 0.288 | 0.267 | 0.379 | 0.403 | 0.498 | 0.672 | 0.588 |
| 21.42 | 0.366 | 0.316 | 0.238 | 0.258 | 0.286 | 0.363 | 0.472 | 0.505 | 0.573 | 0.398 | 0.301 | 0.288 | 0.268 | 0.378 | 0.415 | 0.498 | 0.676 | 0.587 |
| 21.92 | 0.363 | 0.313 | 0.240 | 0.260 | 0.298 | 0.373 | 0.472 | 0.524 | 0.587 | 0.395 | 0.311 | 0.288 | 0.268 | 0.385 | 0.417 | 0.499 | 0.680 | 0.587 |
| 22.42 | 0.367 | 0.317 | 0.242 | 0.255 | 0.287 | 0.377 | 0.472 | 0.509 | 0.592 | 0.398 | 0.317 | 0.288 | 0.267 | 0.378 | 0.426 | 0.499 | 0.677 | 0.588 |
| 22.92 | 0.360 | 0.310 | 0.240 | 0.244 | 0.295 | 0.382 | 0.472 | 0.524 | 0.589 | 0.399 | 0.327 | 0.288 | 0.269 | 0.379 | 0.426 | 0.499 | 0.686 | 0.589 |
| 23.42 | 0.378 | 0.313 | 0.238 | 0.252 | 0.278 | 0.387 | 0.471 | 0.515 | 0.597 | 0.398 | 0.336 | 0.298 | 0.269 | 0.378 | 0.426 | 0.501 | 0.695 | 0.588 |
| 23.92 | 0.365 | 0.275 | 0.238 | 0.254 | 0.275 | 0.389 | 0.471 | 0.522 | 0.555 | 0.400 | 0.337 | 0.288 | 0.270 | 0.380 | 0.449 | 0.502 | 0.687 | 0.576 |
| 24.42 | 0.360 | 0.302 | 0.238 | 0.253 | 0.250 | 0.389 | 0.471 | 0.519 | 0.558 | 0.399 | 0.334 | 0.292 | 0.270 | 0.379 | 0.380 | 0.502 | 0.673 | 0.578 |
| 24.92 | 0.378 | 0.313 | 0.239 | 0.253 | 0.278 | 0.389 | 0.470 | 0.520 | 0.547 | 0.399 | 0.333 | 0.297 | 0.267 | 0.379 | 0.411 | 0.503 | 0.671 | 0.581 |
| 25.42 | 0.362 | 0.324 | 0.242 | 0.253 | 0.252 | 0.389 | 0.470 | 0.522 | 0.533 | 0.396 | 0.333 | 0.292 | 0.267 | 0.386 | 0.418 | 0.503 | 0.692 | 0.580 |
| 25.92 | 0.360 | 0.302 | 0.241 | 0.250 | 0.250 | 0.390 | 0.470 | 0.525 | 0.530 | 0.397 | 0.335 | 0.293 | 0.267 | 0.377 | 0.426 | 0.504 | 0.680 | 0.578 |
| 26.42 | 0.363 | 0.263 | 0.245 | 0.252 | 0.263 | 0.389 | 0.470 | 0.530 | 0.524 | 0.397 | 0.337 | 0.290 | 0.268 | 0.377 | 0.428 | 0.504 | 0.683 | 0.577 |
| 26.92 | 0.360 | 0.302 | 0.247 | 0.249 | 0.250 | 0.393 | 0.469 | 0.523 | 0.527 | 0.399 | 0.338 | 0.300 | 0.269 | 0.379 | 0.421 | 0.496 | 0.680 | 0.577 |
| 27.42 | 0.360 | 0.302 | 0.248 | 0.248 | 0.250 | 0.395 | 0.469 | 0.524 | 0.528 | 0.400 | 0.336 | 0.288 | 0.269 | 0.380 | 0.415 | 0.496 | 0.679 | 0.576 |
| 27.92 | 0.360 | 0.302 | 0.247 | 0.246 | 0.250 | 0.393 | 0.469 | 0.527 | 0.527 | 0.397 | 0.336 | 0.288 | 0.270 | 0.377 | 0.418 | 0.496 | 0.680 | 0.576 |
| 28.42 | 0.360 | 0.302 | 0.267 | 0.245 | 0.250 | 0.395 | 0.469 | 0.533 | 0.529 | 0.397 | 0.335 | 0.288 | 0.260 | 0.377 | 0.420 | 0.505 | 0.674 | 0.600 |
| 28.92 | 0.360 | 0.302 | 0.256 | 0.234 | 0.250 | 0.394 | 0.469 | 0.547 | 0.533 | 0.397 | 0.335 | 0.288 | 0.261 | 0.377 | 0.418 | 0.503 | 0.689 | 0.599 |
| 29.42 | 0.360 | 0.302 | 0.258 | 0.220 | 0.250 | 0.396 | 0.469 | 0.608 | 0.548 | 0.395 | 0.336 | 0.288 | 0.261 | 0.385 | 0.419 | 0.503 | 0.691 | 0.598 |
| 29.92 | 0.363 | 0.303 | 0.257 | 0.222 | 0.353 | 0.397 | 0.468 | 0.606 | 0.546 | 0.400 | 0.334 | 0.288 | 0.261 | 0.380 | 0.419 | 0.503 | 0.681 | 0.596 |
| 30.42 | 0.364 | 0.314 | 0.256 | 0.204 | 0.299 | 0.398 | 0.468 | 0.605 | 0.529 | 0.399 | 0.333 | 0.288 | 0.257 | 0.379 | 0.416 | 0.503 | 0.699 | 0.595 |
| 30.92 | 0.362 | 0.302 | 0.256 | 0.199 | 0.352 | 0.397 | 0.468 | 0.606 | 0.508 | 0.397 | 0.336 | 0.288 | 0.251 | 0.377 | 0.420 | 0.502 | 0.675 | 0.594 |
| 31.42 | 0.367 | 0.317 | 0.260 | 0.187 | 0.287 | 0.398 | 0.468 | 0.601 | 0.512 | 0.399 | 0.335 | 0.288 | 0.254 | 0.379 | 0.418 | 0.500 | 0.682 | 0.593 |
| 31.92 | 0.360 | 0.315 | 0.261 | 0.183 | 0.280 | 0.400 | 0.468 | 0.606 | 0.531 | 0.407 | 0.339 | 0.294 | 0.257 | 0.387 | 0.417 | 0.499 | 0.678 | 0.592 |
| 32.42 | 0.360 | 0.301 | 0.266 | 0.182 | 0.250 | 0.399 | 0.468 | 0.607 | 0.520 | 0.396 | 0.337 | 0.298 | 0.263 | 0.376 | 0.419 | 0.498 | 0.672 | 0.590 |

| Hour | 45°C | | | | | | | | | 30°C | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | pH 5.0 | pH 5.5 | pH 6.0 | pH 6.5 | pH 7.0 | pH 7.5 | pH 8.0 | pH 8.5 | pH 9.0 | pH 5.0 | pH 5.5 | pH 6.0 | pH 6.5 | pH 7.0 | pH 7.5 | pH 8.0 | pH 8.5 | pH 9.0 |
| 32.92 | 0.363 | 0.263 | 0.267 | 0.170 | 0.263 | 0.400 | 0.468 | 0.612 | 0.511 | 0.397 | 0.341 | 0.299 | 0.265 | 0.377 | 0.417 | 0.497 | 0.671 | 0.590 |
| 33.42 | 0.360 | 0.302 | 0.269 | 0.171 | 0.250 | 0.400 | 0.468 | 0.611 | 0.532 | 0.397 | 0.338 | 0.298 | 0.266 | 0.377 | 0.419 | 0.499 | 0.677 | 0.589 |
| 33.92 | 0.360 | 0.302 | 0.270 | 0.170 | 0.250 | 0.400 | 0.468 | 0.599 | 0.541 | 0.397 | 0.337 | 0.285 | 0.267 | 0.377 | 0.419 | 0.499 | 0.670 | 0.588 |
| 34.42 | 0.366 | 0.316 | 0.268 | 0.169 | 0.286 | 0.399 | 0.467 | 0.603 | 0.470 | 0.396 | 0.337 | 0.300 | 0.266 | 0.376 | 0.422 | 0.496 | 0.671 | 0.590 |
| 34.92 | 0.362 | 0.317 | 0.270 | 0.167 | 0.282 | 0.400 | 0.467 | 0.600 | 0.451 | 0.396 | 0.336 | 0.299 | 0.264 | 0.376 | 0.425 | 0.495 | 0.689 | 0.578 |
| 35.42 | 0.360 | 0.302 | 0.269 | 0.171 | 0.250 | 0.402 | 0.467 | 0.395 | 0.543 | 0.424 | 0.335 | 0.287 | 0.263 | 0.394 | 0.426 | 0.512 | 0.672 | 0.579 |
| 35.92 | 0.367 | 0.267 | 0.272 | 0.175 | 0.267 | 0.402 | 0.466 | 0.614 | 0.463 | 0.424 | 0.338 | 0.299 | 0.263 | 0.394 | 0.429 | 0.511 | 0.679 | 0.581 |
| 36.42 | 0.363 | 0.273 | 0.272 | 0.172 | 0.273 | 0.404 | 0.466 | 0.617 | 0.456 | 0.425 | 0.334 | 0.299 | 0.262 | 0.395 | 0.429 | 0.508 | 0.682 | 0.581 |
| 36.92 | 0.362 | 0.262 | 0.272 | 0.177 | 0.262 | 0.404 | 0.465 | 0.629 | 0.463 | 0.425 | 0.334 | 0.298 | 0.261 | 0.395 | 0.429 | 0.505 | 0.675 | 0.582 |
| 37.42 | 0.364 | 0.314 | 0.273 | 0.176 | 0.264 | 0.404 | 0.465 | 0.632 | 0.545 | 0.422 | 0.335 | 0.296 | 0.261 | 0.392 | 0.424 | 0.501 | 0.674 | 0.580 |
| 37.92 | 0.364 | 0.264 | 0.276 | 0.175 | 0.264 | 0.396 | 0.465 | 0.646 | 0.528 | 0.424 | 0.336 | 0.298 | 0.261 | 0.394 | 0.420 | 0.500 | 0.677 | 0.578 |
| 38.42 | 0.362 | 0.272 | 0.278 | 0.173 | 0.272 | 0.396 | 0.464 | 0.636 | 0.520 | 0.424 | 0.337 | 0.291 | 0.260 | 0.394 | 0.424 | 0.497 | 0.677 | 0.575 |
| 38.92 | 0.360 | 0.302 | 0.279 | 0.172 | 0.250 | 0.396 | 0.464 | 0.644 | 0.538 | 0.425 | 0.337 | 0.294 | 0.258 | 0.395 | 0.423 | 0.474 | 0.673 | 0.595 |
| 39.42 | 0.360 | 0.302 | 0.278 | 0.171 | 0.250 | 0.395 | 0.463 | 0.638 | 0.541 | 0.424 | 0.334 | 0.288 | 0.257 | 0.394 | 0.423 | 0.471 | 0.676 | 0.592 |
| 39.92 | 0.360 | 0.302 | 0.280 | 0.170 | 0.250 | 0.397 | 0.463 | 0.639 | 0.546 | 0.425 | 0.333 | 0.288 | 0.257 | 0.395 | 0.422 | 0.513 | 0.677 | 0.593 |
| 40.42 | 0.360 | 0.302 | 0.278 | 0.168 | 0.250 | 0.398 | 0.462 | 0.624 | 0.509 | 0.425 | 0.331 | 0.290 | 0.256 | 0.395 | 0.424 | 0.499 | 0.681 | 0.590 |
| 41.82 | 0.360 | 0.302 | 0.264 | 0.167 | 0.250 | 0.399 | 0.462 | 0.364 | 0.461 | 0.423 | 0.291 | 0.257 | 0.255 | 0.393 | 0.424 | 0.510 | 0.684 | 0.588 |
| 42.32 | 0.360 | 0.302 | 0.267 | 0.165 | 0.350 | 0.395 | 0.461 | 0.491 | 0.548 | 0.395 | 0.298 | 0.299 | 0.255 | 0.375 | 0.421 | 0.496 | 0.692 | 0.586 |
| 42.82 | 0.360 | 0.302 | 0.265 | 0.165 | 0.350 | 0.395 | 0.461 | 0.536 | 0.552 | 0.423 | 0.317 | 0.285 | 0.254 | 0.393 | 0.422 | 0.497 | 0.671 | 0.590 |
| 43.32 | 0.360 | 0.302 | 0.269 | 0.163 | 0.350 | 0.396 | 0.460 | 0.606 | 0.550 | 0.399 | 0.333 | 0.285 | 0.253 | 0.374 | 0.424 | 0.497 | 0.697 | 0.589 |
| 43.82 | 0.360 | 0.302 | 0.274 | 0.162 | 0.350 | 0.398 | 0.460 | 0.622 | 0.568 | 0.400 | 0.347 | 0.299 | 0.253 | 0.375 | 0.422 | 0.498 | 0.692 | 0.588 |
| 44.32 | 0.360 | 0.302 | 0.269 | 0.161 | 0.350 | 0.399 | 0.459 | 0.631 | 0.529 | 0.403 | 0.348 | 0.294 | 0.253 | 0.378 | 0.423 | 0.499 | 0.673 | 0.587 |
| 44.82 | 0.357 | 0.257 | 0.268 | 0.160 | 0.257 | 0.398 | 0.359 | 0.632 | 0.574 | 0.360 | 0.332 | 0.293 | 0.253 | 0.260 | 0.429 | 0.500 | 0.670 | 0.461 |
| 45.32 | 0.363 | 0.313 | 0.259 | 0.159 | 0.298 | 0.398 | 0.358 | 0.621 | 0.577 | 0.256 | 0.344 | 0.299 | 0.253 | 0.226 | 0.428 | 0.380 | 0.675 | 0.494 |
| 45.82 | 0.375 | 0.310 | 0.281 | 0.158 | 0.275 | 0.395 | 0.358 | 0.625 | 0.539 | 0.361 | 0.349 | 0.299 | 0.253 | 0.261 | 0.428 | 0.380 | 0.700 | 0.493 |
| 46.32 | 0.361 | 0.251 | 0.287 | 0.157 | 0.251 | 0.395 | 0.357 | 0.622 | 0.545 | 0.362 | 0.331 | 0.296 | 0.253 | 0.377 | 0.427 | 0.500 | 0.689 | 0.491 |
| 46.82 | 0.363 | 0.318 | 0.250 | 0.156 | 0.383 | 0.398 | 0.457 | 0.633 | 0.533 | 0.402 | 0.320 | 0.294 | 0.252 | 0.377 | 0.422 | 0.500 | 0.689 | 0.581 |
| 47.32 | 0.361 | 0.271 | 0.265 | 0.155 | 0.371 | 0.398 | 0.457 | 0.631 | 0.535 | 0.401 | 0.324 | 0.286 | 0.251 | 0.376 | 0.388 | 0.500 | 0.687 | 0.580 |
| 47.82 | 0.363 | 0.318 | 0.265 | 0.170 | 0.383 | 0.400 | 0.456 | 0.622 | 0.544 | 0.403 | 0.330 | 0.287 | 0.251 | 0.378 | 0.362 | 0.499 | 0.690 | 0.579 |
| 48.32 | 0.358 | 0.258 | 0.250 | 0.194 | 0.358 | 0.400 | 0.456 | 0.621 | 0.548 | 0.402 | 0.330 | 0.288 | 0.251 | 0.377 | 0.398 | 0.497 | 0.671 | 0.579 |
| 48.82 | 0.361 | 0.261 | 0.250 | 0.203 | 0.361 | 0.398 | 0.456 | 0.629 | 0.555 | 0.403 | 0.333 | 0.287 | 0.251 | 0.378 | 0.417 | 0.474 | 0.675 | 0.579 |
| 49.32 | 0.365 | 0.265 | 0.200 | 0.222 | 0.365 | 0.397 | 0.455 | 0.630 | 0.531 | 0.403 | 0.332 | 0.286 | 0.251 | 0.378 | 0.416 | 0.472 | 0.683 | 0.578 |
| 49.82 | 0.363 | 0.318 | 0.265 | 0.236 | 0.383 | 0.397 | 0.455 | 0.627 | 0.533 | 0.402 | 0.335 | 0.292 | 0.251 | 0.377 | 0.417 | 0.510 | 0.677 | 0.578 |

| Hour | 45°C | | | | | | | | | 30°C | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | pH 5.0 | pH 5.5 | pH 6.0 | pH 6.5 | pH 7.0 | pH 7.5 | pH 8.0 | pH 8.5 | pH 9.0 | pH 5.0 | pH 5.5 | pH 6.0 | pH 6.5 | pH 7.0 | pH 7.5 | pH 8.0 | pH 8.5 | pH 9.0 |
| 50.32 | 0.363 | 0.273 | 0.250 | 0.250 | 0.373 | 0.397 | 0.455 | 0.631 | 0.537 | 0.402 | 0.339 | 0.293 | 0.251 | 0.377 | 0.418 | 0.507 | 0.674 | 0.578 |
| 50.82 | 0.367 | 0.317 | 0.250 | 0.249 | 0.387 | 0.398 | 0.455 | 0.629 | 0.529 | 0.402 | 0.341 | 0.288 | 0.250 | 0.377 | 0.427 | 0.498 | 0.676 | 0.577 |
| 51.32 | 0.360 | 0.310 | 0.250 | 0.248 | 0.395 | 0.399 | 0.454 | 0.621 | 0.529 | 0.405 | 0.301 | 0.289 | 0.251 | 0.380 | 0.420 | 0.499 | 0.677 | 0.577 |
| 51.82 | 0.359 | 0.259 | 0.250 | 0.247 | 0.359 | 0.399 | 0.454 | 0.624 | 0.517 | 0.400 | 0.303 | 0.289 | 0.250 | 0.375 | 0.418 | 0.511 | 0.682 | 0.577 |
| 52.32 | 0.365 | 0.275 | 0.250 | 0.246 | 0.375 | 0.399 | 0.454 | 0.624 | 0.526 | 0.402 | 0.327 | 0.292 | 0.250 | 0.377 | 0.422 | 0.498 | 0.679 | 0.577 |
| 52.82 | 0.377 | 0.312 | 0.250 | 0.245 | 0.377 | 0.399 | 0.454 | 0.629 | 0.519 | 0.401 | 0.329 | 0.293 | 0.250 | 0.376 | 0.420 | 0.495 | 0.684 | 0.576 |
| 53.32 | 0.370 | 0.320 | 0.265 | 0.244 | 0.390 | 0.399 | 0.453 | 0.640 | 0.545 | 0.397 | 0.304 | 0.293 | 0.250 | 0.377 | 0.429 | 0.504 | 0.681 | 0.576 |
| 53.82 | 0.360 | 0.270 | 0.265 | 0.243 | 0.370 | 0.399 | 0.453 | 0.637 | 0.547 | 0.422 | 0.326 | 0.291 | 0.250 | 0.392 | 0.423 | 0.507 | 0.689 | 0.576 |
| 54.32 | 0.378 | 0.313 | 0.265 | 0.241 | 0.378 | 0.399 | 0.453 | 0.640 | 0.540 | 0.422 | 0.326 | 0.291 | 0.250 | 0.392 | 0.423 | 0.508 | 0.682 | 0.576 |
| 54.82 | 0.377 | 0.312 | 0.200 | 0.240 | 0.377 | 0.399 | 0.453 | 0.645 | 0.542 | 0.406 | 0.331 | 0.292 | 0.249 | 0.386 | 0.417 | 0.511 | 0.677 | 0.576 |
| 55.32 | 0.379 | 0.314 | 0.265 | 0.201 | 0.379 | 0.399 | 0.453 | 0.637 | 0.502 | 0.408 | 0.332 | 0.290 | 0.241 | 0.388 | 0.429 | 0.496 | 0.676 | 0.576 |
| 55.82 | 0.365 | 0.265 | 0.250 | 0.239 | 0.365 | 0.399 | 0.453 | 0.641 | 0.502 | 0.406 | 0.330 | 0.291 | 0.245 | 0.386 | 0.422 | 0.510 | 0.676 | 0.576 |
| 56.32 | 0.362 | 0.317 | 0.265 | 0.219 | 0.382 | 0.399 | 0.453 | 0.640 | 0.512 | 0.409 | 0.331 | 0.291 | 0.264 | 0.389 | 0.420 | 0.501 | 0.684 | 0.576 |
| 56.82 | 0.361 | 0.271 | 0.250 | 0.234 | 0.371 | 0.399 | 0.453 | 0.637 | 0.516 | 0.404 | 0.323 | 0.293 | 0.257 | 0.379 | 0.423 | 0.513 | 0.675 | 0.576 |
| 57.32 | 0.366 | 0.316 | 0.265 | 0.241 | 0.386 | 0.399 | 0.453 | 0.636 | 0.519 | 0.403 | 0.331 | 0.289 | 0.255 | 0.378 | 0.425 | 0.511 | 0.676 | 0.576 |
| 57.82 | 0.360 | 0.301 | 0.269 | 0.244 | 0.350 | 0.399 | 0.453 | 0.629 | 0.516 | 0.401 | 0.325 | 0.288 | 0.244 | 0.376 | 0.427 | 0.513 | 0.678 | 0.576 |
| 58.32 | 0.373 | 0.313 | 0.264 | 0.245 | 0.393 | 0.399 | 0.453 | 0.640 | 0.514 | 0.399 | 0.329 | 0.291 | 0.244 | 0.374 | 0.427 | 0.502 | 0.679 | 0.576 |
| 58.82 | 0.362 | 0.262 | 0.276 | 0.245 | 0.362 | 0.398 | 0.453 | 0.609 | 0.519 | 0.402 | 0.324 | 0.291 | 0.245 | 0.377 | 0.428 | 0.496 | 0.681 | 0.576 |
| 59.32 | 0.362 | 0.272 | 0.273 | 0.245 | 0.372 | 0.399 | 0.453 | 0.626 | 0.510 | 0.399 | 0.319 | 0.291 | 0.245 | 0.374 | 0.429 | 0.499 | 0.682 | 0.577 |
| 59.82 | 0.380 | 0.315 | 0.272 | 0.244 | 0.380 | 0.399 | 0.453 | 0.625 | 0.505 | 0.399 | 0.318 | 0.293 | 0.245 | 0.374 | 0.422 | 0.508 | 0.680 | 0.577 |
| 60.32 | 0.360 | 0.302 | 0.272 | 0.243 | 0.350 | 0.398 | 0.453 | 0.607 | 0.513 | 0.403 | 0.321 | 0.298 | 0.244 | 0.378 | 0.416 | 0.512 | 0.687 | 0.577 |
| 60.82 | 0.358 | 0.258 | 0.273 | 0.242 | 0.358 | 0.396 | 0.453 | 0.636 | 0.519 | 0.405 | 0.327 | 0.299 | 0.244 | 0.385 | 0.421 | 0.509 | 0.680 | 0.577 |
| 61.32 | 0.377 | 0.312 | 0.274 | 0.241 | 0.377 | 0.397 | 0.453 | 0.632 | 0.515 | 0.401 | 0.327 | 0.298 | 0.244 | 0.376 | 0.424 | 0.513 | 0.683 | 0.577 |
| 61.82 | 0.357 | 0.257 | 0.274 | 0.240 | 0.357 | 0.398 | 0.453 | 0.630 | 0.518 | 0.406 | 0.326 | 0.299 | 0.242 | 0.386 | 0.422 | 0.497 | 0.684 | 0.577 |
| 62.32 | 0.361 | 0.261 | 0.276 | 0.239 | 0.361 | 0.398 | 0.453 | 0.635 | 0.514 | 0.406 | 0.327 | 0.297 | 0.241 | 0.386 | 0.422 | 0.506 | 0.670 | 0.577 |
| 62.82 | 0.364 | 0.311 | 0.284 | 0.239 | 0.354 | 0.397 | 0.453 | 0.633 | 0.508 | 0.406 | 0.329 | 0.288 | 0.240 | 0.386 | 0.424 | 0.498 | 0.675 | 0.577 |
| 63.32 | 0.360 | 0.302 | 0.287 | 0.238 | 0.350 | 0.399 | 0.453 | 0.621 | 0.518 | 0.409 | 0.329 | 0.289 | 0.254 | 0.389 | 0.424 | 0.514 | 0.684 | 0.577 |
| 63.82 | 0.359 | 0.259 | 0.254 | 0.238 | 0.359 | 0.395 | 0.453 | 0.631 | 0.523 | 0.409 | 0.333 | 0.289 | 0.253 | 0.389 | 0.415 | 0.513 | 0.673 | 0.577 |
| 64.32 | 0.362 | 0.272 | 0.262 | 0.238 | 0.372 | 0.393 | 0.453 | 0.621 | 0.516 | 0.408 | 0.334 | 0.286 | 0.252 | 0.388 | 0.425 | 0.510 | 0.673 | 0.578 |
| 64.82 | 0.366 | 0.266 | 0.267 | 0.237 | 0.366 | 0.393 | 0.453 | 0.632 | 0.516 | 0.421 | 0.334 | 0.286 | 0.253 | 0.391 | 0.417 | 0.508 | 0.678 | 0.578 |
| 66.82 | 0.360 | 0.332 | 0.214 | 0.226 | 0.353 | 0.393 | 0.453 | 0.639 | 0.503 | 0.409 | 0.339 | 0.292 | 0.251 | 0.389 | 0.416 | 0.510 | 0.680 | 0.579 |
| 67.32 | 0.361 | 0.325 | 0.227 | 0.238 | 0.352 | 0.392 | 0.453 | 0.636 | 0.506 | 0.406 | 0.335 | 0.294 | 0.250 | 0.386 | 0.416 | 0.506 | 0.683 | 0.579 |
| 67.82 | 0.378 | 0.315 | 0.239 | 0.237 | 0.365 | 0.391 | 0.451 | 0.644 | 0.504 | 0.421 | 0.331 | 0.293 | 0.250 | 0.391 | 0.418 | 0.513 | 0.670 | 0.579 |

| Hour | 45°C | | | | | | | | | 30°C | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | pH 5.0 | pH 5.5 | pH 6.0 | pH 6.5 | pH 7.0 | pH 7.5 | pH 8.0 | pH 8.5 | pH 9.0 | pH 5.0 | pH 5.5 | pH 6.0 | pH 6.5 | pH 7.0 | pH 7.5 | pH 8.0 | pH 8.5 | pH 9.0 |
| 68.32 | 0.363 | 0.322 | 0.242 | 0.236 | 0.352 | 0.392 | 0.451 | 0.651 | 0.503 | 0.421 | 0.337 | 0.290 | 0.250 | 0.391 | 0.421 | 0.496 | 0.676 | 0.580 |
| 68.82 | 0.362 | 0.214 | 0.247 | 0.245 | 0.264 | 0.393 | 0.456 | 0.652 | 0.519 | 0.361 | 0.333 | 0.288 | 0.259 | 0.376 | 0.420 | 0.510 | 0.696 | 0.490 |
| 69.32 | 0.365 | 0.206 | 0.247 | 0.244 | 0.256 | 0.393 | 0.453 | 0.628 | 0.556 | 0.358 | 0.333 | 0.287 | 0.259 | 0.393 | 0.421 | 0.474 | 0.693 | 0.491 |
| 69.82 | 0.362 | 0.205 | 0.268 | 0.243 | 0.255 | 0.395 | 0.453 | 0.636 | 0.525 | 0.361 | 0.333 | 0.285 | 0.259 | 0.376 | 0.421 | 0.514 | 0.692 | 0.492 |
| 70.32 | 0.364 | 0.306 | 0.269 | 0.242 | 0.356 | 0.395 | 0.453 | 0.639 | 0.543 | 0.403 | 0.340 | 0.292 | 0.258 | 0.378 | 0.422 | 0.502 | 0.700 | 0.586 |
| 70.82 | 0.356 | 0.314 | 0.256 | 0.241 | 0.364 | 0.393 | 0.453 | 0.607 | 0.542 | 0.407 | 0.339 | 0.293 | 0.257 | 0.387 | 0.422 | 0.512 | 0.592 | 0.589 |
| 71.32 | 0.355 | 0.319 | 0.268 | 0.244 | 0.369 | 0.393 | 0.452 | 0.626 | 0.548 | 0.409 | 0.332 | 0.286 | 0.257 | 0.389 | 0.426 | 0.513 | 0.692 | 0.573 |
| 71.82 | 0.356 | 0.322 | 0.265 | 0.242 | 0.372 | 0.392 | 0.452 | 0.621 | 0.545 | 0.420 | 0.333 | 0.291 | 0.257 | 0.390 | 0.444 | 0.499 | 0.681 | 0.592 |
| 72.32 | 0.364 | 0.325 | 0.266 | 0.241 | 0.375 | 0.393 | 0.452 | 0.638 | 0.544 | 0.420 | 0.332 | 0.287 | 0.256 | 0.390 | 0.447 | 0.511 | 0.678 | 0.594 |
| 72.82 | 0.369 | 0.326 | 0.267 | 0.240 | 0.376 | 0.393 | 0.452 | 0.640 | 0.537 | 0.421 | 0.330 | 0.292 | 0.264 | 0.391 | 0.428 | 0.511 | 0.679 | 0.595 |
| 73.32 | 0.362 | 0.327 | 0.271 | 0.250 | 0.377 | 0.393 | 0.451 | 0.644 | 0.536 | 0.421 | 0.333 | 0.287 | 0.264 | 0.391 | 0.447 | 0.513 | 0.683 | 0.596 |
| 73.82 | 0.365 | 0.328 | 0.270 | 0.249 | 0.378 | 0.391 | 0.451 | 0.641 | 0.536 | 0.421 | 0.331 | 0.297 | 0.264 | 0.391 | 0.411 | 0.507 | 0.683 | 0.595 |
| 74.32 | 0.376 | 0.328 | 0.273 | 0.249 | 0.378 | 0.391 | 0.451 | 0.639 | 0.530 | 0.421 | 0.334 | 0.296 | 0.264 | 0.391 | 0.416 | 0.503 | 0.680 | 0.596 |
| 74.82 | 0.377 | 0.328 | 0.272 | 0.249 | 0.378 | 0.391 | 0.451 | 0.651 | 0.520 | 0.422 | 0.334 | 0.294 | 0.263 | 0.392 | 0.423 | 0.496 | 0.684 | 0.594 |
| 75.32 | 0.378 | 0.328 | 0.272 | 0.248 | 0.378 | 0.393 | 0.451 | 0.607 | 0.519 | 0.392 | 0.332 | 0.292 | 0.263 | 0.382 | 0.421 | 0.507 | 0.683 | 0.596 |
| 75.82 | 0.378 | 0.329 | 0.272 | 0.248 | 0.379 | 0.393 | 0.451 | 0.653 | 0.518 | 0.421 | 0.332 | 0.292 | 0.263 | 0.391 | 0.425 | 0.509 | 0.680 | 0.590 |
| 76.32 | 0.378 | 0.329 | 0.276 | 0.247 | 0.379 | 0.393 | 0.451 | 0.643 | 0.511 | 0.421 | 0.335 | 0.292 | 0.262 | 0.391 | 0.422 | 0.512 | 0.684 | 0.586 |
| 76.82 | 0.378 | 0.329 | 0.273 | 0.247 | 0.379 | 0.391 | 0.451 | 0.638 | 0.504 | 0.421 | 0.331 | 0.296 | 0.262 | 0.391 | 0.423 | 0.497 | 0.680 | 0.581 |
| 77.32 | 0.379 | 0.330 | 0.268 | 0.246 | 0.380 | 0.393 | 0.451 | 0.653 | 0.500 | 0.421 | 0.333 | 0.295 | 0.262 | 0.391 | 0.420 | 0.514 | 0.680 | 0.567 |
| 77.82 | 0.379 | 0.330 | 0.270 | 0.246 | 0.380 | 0.393 | 0.451 | 0.637 | 0.542 | 0.421 | 0.331 | 0.290 | 0.260 | 0.391 | 0.431 | 0.502 | 0.683 | 0.590 |
| 78.32 | 0.379 | 0.330 | 0.273 | 0.246 | 0.380 | 0.393 | 0.451 | 0.642 | 0.546 | 0.421 | 0.329 | 0.292 | 0.260 | 0.391 | 0.422 | 0.497 | 0.679 | 0.578 |
| 78.82 | 0.380 | 0.330 | 0.266 | 0.246 | 0.380 | 0.389 | 0.451 | 0.635 | 0.538 | 0.422 | 0.329 | 0.291 | 0.270 | 0.392 | 0.424 | 0.510 | 0.678 | 0.595 |
| 79.32 | 0.380 | 0.330 | 0.279 | 0.245 | 0.380 | 0.388 | 0.451 | 0.653 | 0.535 | 0.422 | 0.331 | 0.291 | 0.269 | 0.392 | 0.425 | 0.512 | 0.671 | 0.583 |
| 79.82 | 0.380 | 0.330 | 0.266 | 0.250 | 0.380 | 0.388 | 0.451 | 0.653 | 0.538 | 0.422 | 0.328 | 0.290 | 0.268 | 0.392 | 0.432 | 0.501 | 0.670 | 0.573 |
| 80.32 | 0.360 | 0.331 | 0.273 | 0.249 | 0.381 | 0.393 | 0.451 | 0.652 | 0.535 | 0.422 | 0.332 | 0.294 | 0.266 | 0.392 | 0.423 | 0.501 | 0.693 | 0.566 |
| 80.82 | 0.360 | 0.331 | 0.271 | 0.248 | 0.381 | 0.393 | 0.451 | 0.652 | 0.537 | 0.422 | 0.328 | 0.292 | 0.261 | 0.392 | 0.422 | 0.505 | 0.682 | 0.586 |
| 81.32 | 0.360 | 0.331 | 0.270 | 0.248 | 0.381 | 0.393 | 0.451 | 0.639 | 0.538 | 0.422 | 0.334 | 0.291 | 0.269 | 0.392 | 0.432 | 0.506 | 0.679 | 0.579 |
| 81.82 | 0.361 | 0.331 | 0.271 | 0.247 | 0.381 | 0.377 | 0.451 | 0.637 | 0.549 | 0.422 | 0.334 | 0.293 | 0.269 | 0.392 | 0.422 | 0.509 | 0.671 | 0.596 |
| 82.32 | 0.361 | 0.331 | 0.271 | 0.247 | 0.381 | 0.392 | 0.451 | 0.638 | 0.455 | 0.423 | 0.332 | 0.290 | 0.270 | 0.393 | 0.424 | 0.513 | 0.672 | 0.591 |
| 82.82 | 0.361 | 0.331 | 0.266 | 0.246 | 0.381 | 0.393 | 0.451 | 0.643 | 0.545 | 0.423 | 0.330 | 0.290 | 0.269 | 0.393 | 0.422 | 0.495 | 0.676 | 0.587 |
| 83.32 | 0.361 | 0.331 | 0.270 | 0.248 | 0.381 | 0.388 | 0.451 | 0.644 | 0.543 | 0.423 | 0.331 | 0.286 | 0.268 | 0.393 | 0.422 | 0.499 | 0.695 | 0.583 |
| 83.82 | 0.361 | 0.331 | 0.277 | 0.246 | 0.381 | 0.393 | 0.451 | 0.640 | 0.548 | 0.423 | 0.338 | 0.299 | 0.258 | 0.393 | 0.423 | 0.508 | 0.688 | 0.580 |
| 84.32 | 0.361 | 0.331 | 0.280 | 0.250 | 0.381 | 0.392 | 0.451 | 0.634 | 0.546 | 0.423 | 0.334 | 0.285 | 0.257 | 0.393 | 0.416 | 0.509 | 0.682 | 0.575 |

| Hour | 45°C | | | | | | | | | 30°C | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | pH 5.0 | pH 5.5 | pH 6.0 | pH 6.5 | pH 7.0 | pH 7.5 | pH 8.0 | pH 8.5 | pH 9.0 | pH 5.0 | pH 5.5 | pH 6.0 | pH 6.5 | pH 7.0 | pH 7.5 | pH 8.0 | pH 8.5 | pH 9.0 |
| 84.82 | 0.361 | 0.331 | 0.268 | 0.249 | 0.381 | 0.379 | 0.451 | 0.634 | 0.544 | 0.422 | 0.341 | 0.297 | 0.257 | 0.392 | 0.413 | 0.512 | 0.675 | 0.573 |
| 85.32 | 0.361 | 0.331 | 0.268 | 0.249 | 0.381 | 0.383 | 0.451 | 0.635 | 0.508 | 0.422 | 0.336 | 0.297 | 0.256 | 0.392 | 0.412 | 0.496 | 0.670 | 0.572 |
| 85.82 | 0.361 | 0.331 | 0.279 | 0.249 | 0.381 | 0.377 | 0.451 | 0.630 | 0.512 | 0.423 | 0.332 | 0.299 | 0.255 | 0.393 | 0.413 | 0.507 | 0.683 | 0.569 |
| 86.32 | 0.361 | 0.331 | 0.279 | 0.249 | 0.381 | 0.377 | 0.451 | 0.636 | 0.520 | 0.423 | 0.334 | 0.299 | 0.260 | 0.393 | 0.419 | 0.510 | 0.681 | 0.567 |
| 86.82 | 0.361 | 0.332 | 0.265 | 0.249 | 0.382 | 0.378 | 0.451 | 0.642 | 0.520 | 0.422 | 0.332 | 0.295 | 0.256 | 0.392 | 0.419 | 0.512 | 0.671 | 0.565 |
| 87.32 | 0.361 | 0.319 | 0.279 | 0.249 | 0.369 | 0.379 | 0.451 | 0.634 | 0.523 | 0.422 | 0.333 | 0.295 | 0.256 | 0.392 | 0.417 | 0.497 | 0.683 | 0.566 |
| 87.82 | 0.361 | 0.317 | 0.274 | 0.249 | 0.367 | 0.379 | 0.451 | 0.632 | 0.536 | 0.422 | 0.337 | 0.298 | 0.256 | 0.392 | 0.417 | 0.499 | 0.684 | 0.589 |
| 88.32 | 0.362 | 0.318 | 0.271 | 0.249 | 0.368 | 0.393 | 0.451 | 0.641 | 0.539 | 0.422 | 0.336 | 0.299 | 0.255 | 0.392 | 0.417 | 0.503 | 0.689 | 0.588 |
| 88.82 | 0.369 | 0.318 | 0.271 | 0.249 | 0.368 | 0.393 | 0.451 | 0.638 | 0.529 | 0.422 | 0.339 | 0.297 | 0.259 | 0.392 | 0.417 | 0.496 | 0.695 | 0.587 |
| 90.82 | 0.367 | 0.321 | 0.215 | 0.239 | 0.271 | 0.393 | 0.451 | 0.625 | 0.493 | 0.422 | 0.331 | 0.254 | 0.258 | 0.392 | 0.415 | 0.498 | 0.686 | 0.586 |
| 91.32 | 0.368 | 0.312 | 0.274 | 0.244 | 0.362 | 0.399 | 0.456 | 0.622 | 0.522 | 0.390 | 0.341 | 0.293 | 0.258 | 0.380 | 0.415 | 0.499 | 0.674 | 0.575 |
| 91.82 | 0.368 | 0.209 | 0.277 | 0.249 | 0.259 | 0.393 | 0.355 | 0.630 | 0.446 | 0.250 | 0.338 | 0.294 | 0.257 | 0.200 | 0.419 | 0.503 | 0.682 | 0.490 |
| 92.32 | 0.369 | 0.209 | 0.278 | 0.240 | 0.259 | 0.393 | 0.356 | 0.630 | 0.470 | 0.395 | 0.340 | 0.289 | 0.256 | 0.375 | 0.418 | 0.497 | 0.688 | 0.492 |
| 92.82 | 0.370 | 0.313 | 0.266 | 0.235 | 0.363 | 0.378 | 0.456 | 0.633 | 0.530 | 0.391 | 0.344 | 0.292 | 0.255 | 0.381 | 0.417 | 0.505 | 0.676 | 0.576 |
| 93.32 | 0.360 | 0.318 | 0.268 | 0.235 | 0.368 | 0.384 | 0.454 | 0.632 | 0.537 | 0.391 | 0.341 | 0.290 | 0.264 | 0.381 | 0.410 | 0.510 | 0.677 | 0.575 |
| 93.82 | 0.361 | 0.323 | 0.267 | 0.235 | 0.373 | 0.392 | 0.452 | 0.633 | 0.548 | 0.391 | 0.340 | 0.288 | 0.264 | 0.381 | 0.420 | 0.515 | 0.684 | 0.575 |
| 94.32 | 0.362 | 0.325 | 0.280 | 0.235 | 0.375 | 0.393 | 0.452 | 0.631 | 0.511 | 0.391 | 0.340 | 0.327 | 0.264 | 0.381 | 0.419 | 0.499 | 0.671 | 0.575 |
| 94.82 | 0.359 | 0.325 | 0.280 | 0.236 | 0.375 | 0.392 | 0.450 | 0.625 | 0.507 | 0.391 | 0.342 | 0.287 | 0.264 | 0.381 | 0.419 | 0.508 | 0.670 | 0.575 |
| 95.32 | 0.359 | 0.326 | 0.279 | 0.236 | 0.376 | 0.392 | 0.452 | 0.631 | 0.503 | 0.391 | 0.340 | 0.288 | 0.264 | 0.381 | 0.420 | 0.511 | 0.680 | 0.598 |
| 95.82 | 0.363 | 0.326 | 0.268 | 0.237 | 0.376 | 0.393 | 0.452 | 0.625 | 0.502 | 0.392 | 0.346 | 0.326 | 0.264 | 0.382 | 0.418 | 0.513 | 0.681 | 0.579 |
| 96.32 | 0.368 | 0.327 | 0.278 | 0.237 | 0.377 | 0.392 | 0.452 | 0.630 | 0.500 | 0.392 | 0.339 | 0.325 | 0.264 | 0.382 | 0.392 | 0.515 | 0.681 | 0.575 |
| 96.82 | 0.363 | 0.327 | 0.277 | 0.237 | 0.377 | 0.393 | 0.451 | 0.626 | 0.547 | 0.392 | 0.345 | 0.295 | 0.264 | 0.382 | 0.377 | 0.496 | 0.679 | 0.576 |
| 97.32 | 0.375 | 0.328 | 0.275 | 0.237 | 0.378 | 0.394 | 0.451 | 0.630 | 0.502 | 0.392 | 0.343 | 0.292 | 0.263 | 0.382 | 0.401 | 0.497 | 0.677 | 0.595 |
| 97.82 | 0.375 | 0.328 | 0.270 | 0.238 | 0.378 | 0.393 | 0.451 | 0.626 | 0.504 | 0.392 | 0.336 | 0.326 | 0.263 | 0.382 | 0.415 | 0.497 | 0.672 | 0.597 |
| 98.32 | 0.376 | 0.329 | 0.276 | 0.238 | 0.379 | 0.393 | 0.451 | 0.630 | 0.509 | 0.392 | 0.341 | 0.294 | 0.263 | 0.382 | 0.421 | 0.496 | 0.682 | 0.577 |
| 98.82 | 0.376 | 0.321 | 0.274 | 0.238 | 0.371 | 0.393 | 0.451 | 0.637 | 0.510 | 0.390 | 0.344 | 0.295 | 0.262 | 0.380 | 0.416 | 0.514 | 0.676 | 0.568 |
| 99.32 | 0.377 | 0.322 | 0.273 | 0.238 | 0.372 | 0.384 | 0.451 | 0.628 | 0.546 | 0.390 | 0.342 | 0.294 | 0.262 | 0.380 | 0.420 | 0.511 | 0.679 | 0.598 |
| 99.82 | 0.377 | 0.322 | 0.279 | 0.238 | 0.372 | 0.393 | 0.451 | 0.633 | 0.549 | 0.392 | 0.342 | 0.294 | 0.261 | 0.382 | 0.419 | 0.509 | 0.677 | 0.583 |
| 100.32 | 0.378 | 0.323 | 0.274 | 0.238 | 0.373 | 0.393 | 0.451 | 0.626 | 0.501 | 0.392 | 0.346 | 0.326 | 0.260 | 0.382 | 0.416 | 0.500 | 0.676 | 0.572 |
| 100.82 | 0.378 | 0.323 | 0.268 | 0.239 | 0.373 | 0.392 | 0.451 | 0.626 | 0.501 | 0.392 | 0.342 | 0.327 | 0.260 | 0.382 | 0.420 | 0.515 | 0.679 | 0.578 |
| 101.32 | 0.379 | 0.324 | 0.270 | 0.238 | 0.374 | 0.392 | 0.451 | 0.632 | 0.501 | 0.392 | 0.336 | 0.293 | 0.260 | 0.382 | 0.419 | 0.510 | 0.680 | 0.574 |
| 101.82 | 0.361 | 0.324 | 0.269 | 0.238 | 0.374 | 0.393 | 0.451 | 0.621 | 0.544 | 0.392 | 0.339 | 0.295 | 0.260 | 0.382 | 0.416 | 0.503 | 0.675 | 0.579 |
| 102.32 | 0.362 | 0.324 | 0.271 | 0.239 | 0.374 | 0.395 | 0.451 | 0.630 | 0.545 | 0.392 | 0.341 | 0.293 | 0.260 | 0.382 | 0.416 | 0.512 | 0.695 | 0.576 |

| Hour | 45°C | | | | | | | | | 30°C | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | pH 5.0 | pH 5.5 | pH 6.0 | pH 6.5 | pH 7.0 | pH 7.5 | pH 8.0 | pH 8.5 | pH 9.0 | pH 5.0 | pH 5.5 | pH 6.0 | pH 6.5 | pH 7.0 | pH 7.5 | pH 8.0 | pH 8.5 | pH 9.0 |
| 102.82 | 0.362 | 0.325 | 0.272 | 0.238 | 0.375 | 0.394 | 0.451 | 0.627 | 0.502 | 0.392 | 0.343 | 0.294 | 0.259 | 0.382 | 0.417 | 0.495 | 0.673 | 0.579 |
| 103.32 | 0.363 | 0.324 | 0.272 | 0.238 | 0.374 | 0.377 | 0.451 | 0.631 | 0.504 | 0.392 | 0.341 | 0.293 | 0.259 | 0.382 | 0.416 | 0.498 | 0.679 | 0.584 |
| 103.82 | 0.363 | 0.323 | 0.269 | 0.238 | 0.373 | 0.383 | 0.451 | 0.627 | 0.503 | 0.392 | 0.341 | 0.294 | 0.259 | 0.382 | 0.418 | 0.513 | 0.677 | 0.591 |
| 104.32 | 0.364 | 0.323 | 0.270 | 0.238 | 0.373 | 0.383 | 0.451 | 0.641 | 0.507 | 0.392 | 0.344 | 0.292 | 0.259 | 0.382 | 0.409 | 0.507 | 0.677 | 0.575 |
| 104.82 | 0.364 | 0.323 | 0.278 | 0.237 | 0.373 | 0.377 | 0.451 | 0.639 | 0.511 | 0.392 | 0.347 | 0.290 | 0.257 | 0.382 | 0.416 | 0.497 | 0.677 | 0.584 |
| 105.32 | 0.364 | 0.323 | 0.266 | 0.237 | 0.373 | 0.377 | 0.452 | 0.641 | 0.512 | 0.392 | 0.342 | 0.292 | 0.257 | 0.382 | 0.417 | 0.513 | 0.672 | 0.570 |
| 105.82 | 0.365 | 0.323 | 0.271 | 0.236 | 0.373 | 0.383 | 0.452 | 0.652 | 0.513 | 0.392 | 0.345 | 0.292 | 0.257 | 0.382 | 0.418 | 0.510 | 0.675 | 0.578 |
| 106.32 | 0.364 | 0.324 | 0.267 | 0.237 | 0.374 | 0.379 | 0.452 | 0.654 | 0.513 | 0.393 | 0.345 | 0.290 | 0.256 | 0.383 | 0.418 | 0.506 | 0.674 | 0.586 |
| 106.82 | 0.363 | 0.324 | 0.277 | 0.237 | 0.374 | 0.383 | 0.452 | 0.645 | 0.512 | 0.393 | 0.343 | 0.290 | 0.256 | 0.383 | 0.415 | 0.503 | 0.685 | 0.565 |
| 107.32 | 0.363 | 0.324 | 0.275 | 0.236 | 0.374 | 0.384 | 0.452 | 0.639 | 0.516 | 0.393 | 0.340 | 0.292 | 0.256 | 0.383 | 0.416 | 0.501 | 0.670 | 0.590 |
| 107.82 | 0.363 | 0.324 | 0.265 | 0.236 | 0.374 | 0.384 | 0.452 | 0.630 | 0.518 | 0.393 | 0.343 | 0.294 | 0.256 | 0.383 | 0.420 | 0.514 | 0.672 | 0.580 |
| 108.32 | 0.363 | 0.324 | 0.269 | 0.236 | 0.374 | 0.385 | 0.452 | 0.642 | 0.527 | 0.393 | 0.348 | 0.290 | 0.256 | 0.383 | 0.420 | 0.512 | 0.672 | 0.576 |
| 108.82 | 0.363 | 0.324 | 0.279 | 0.235 | 0.374 | 0.381 | 0.452 | 0.645 | 0.523 | 0.393 | 0.349 | 0.288 | 0.256 | 0.383 | 0.417 | 0.510 | 0.674 | 0.573 |
| 109.32 | 0.364 | 0.324 | 0.266 | 0.235 | 0.374 | 0.362 | 0.452 | 0.640 | 0.521 | 0.393 | 0.344 | 0.290 | 0.255 | 0.383 | 0.415 | 0.499 | 0.680 | 0.588 |
| 109.82 | 0.364 | 0.325 | 0.276 | 0.243 | 0.375 | 0.358 | 0.452 | 0.642 | 0.520 | 0.393 | 0.349 | 0.289 | 0.255 | 0.383 | 0.407 | 0.498 | 0.691 | 0.588 |
| 110.32 | 0.364 | 0.325 | 0.266 | 0.244 | 0.375 | 0.395 | 0.453 | 0.644 | 0.522 | 0.393 | 0.346 | 0.288 | 0.255 | 0.383 | 0.410 | 0.497 | 0.690 | 0.566 |
| 110.82 | 0.364 | 0.325 | 0.270 | 0.243 | 0.375 | 0.398 | 0.452 | 0.641 | 0.524 | 0.393 | 0.342 | 0.289 | 0.260 | 0.383 | 0.416 | 0.512 | 0.692 | 0.579 |
| 111.32 | 0.364 | 0.325 | 0.274 | 0.243 | 0.375 | 0.398 | 0.453 | 0.636 | 0.529 | 0.393 | 0.349 | 0.287 | 0.260 | 0.383 | 0.430 | 0.511 | 0.697 | 0.579 |
| 111.82 | 0.364 | 0.325 | 0.266 | 0.240 | 0.375 | 0.384 | 0.452 | 0.653 | 0.534 | 0.393 | 0.341 | 0.287 | 0.259 | 0.383 | 0.430 | 0.512 | 0.692 | 0.579 |
| 112.32 | 0.364 | 0.326 | 0.268 | 0.241 | 0.376 | 0.398 | 0.452 | 0.654 | 0.535 | 0.393 | 0.350 | 0.288 | 0.259 | 0.383 | 0.418 | 0.511 | 0.687 | 0.579 |
| 113.67 | 0.365 | 0.311 | 0.277 | 0.235 | 0.376 | 0.398 | 0.452 | 0.608 | 0.480 | 0.393 | 0.330 | 0.298 | 0.259 | 0.383 | 0.373 | 0.361 | 0.618 | 0.579 |
| 114.17 | 0.365 | 0.326 | 0.278 | 0.235 | 0.376 | 0.381 | 0.452 | 0.626 | 0.533 | 0.393 | 0.330 | 0.326 | 0.259 | 0.383 | 0.406 | 0.412 | 0.618 | 0.579 |
| 114.67 | 0.375 | 0.326 | 0.255 | 0.234 | 0.376 | 0.373 | 0.452 | 0.637 | 0.528 | 0.393 | 0.330 | 0.288 | 0.258 | 0.383 | 0.412 | 0.513 | 0.677 | 0.581 |
| 115.17 | 0.375 | 0.271 | 0.268 | 0.233 | 0.271 | 0.396 | 0.351 | 0.656 | 0.514 | 0.352 | 0.330 | 0.288 | 0.258 | 0.252 | 0.418 | 0.504 | 0.683 | 0.493 |
| 115.67 | 0.375 | 0.259 | 0.277 | 0.233 | 0.259 | 0.406 | 0.354 | 0.641 | 0.546 | 0.354 | 0.330 | 0.288 | 0.258 | 0.254 | 0.427 | 0.512 | 0.673 | 0.481 |
| 116.15 | 0.376 | 0.261 | 0.277 | 0.233 | 0.261 | 0.397 | 0.353 | 0.627 | 0.521 | 0.353 | 0.335 | 0.288 | 0.259 | 0.383 | 0.443 | 0.495 | 0.683 | 0.481 |
| 116.65 | 0.376 | 0.319 | 0.256 | 0.233 | 0.369 | 0.376 | 0.453 | 0.622 | 0.534 | 0.393 | 0.333 | 0.295 | 0.259 | 0.383 | 0.428 | 0.502 | 0.559 | 0.587 |
| 117.15 | 0.376 | 0.324 | 0.269 | 0.232 | 0.374 | 0.380 | 0.454 | 0.623 | 0.542 | 0.394 | 0.339 | 0.287 | 0.258 | 0.384 | 0.424 | 0.498 | 0.682 | 0.580 |
| 117.65 | 0.376 | 0.328 | 0.267 | 0.232 | 0.378 | 0.383 | 0.454 | 0.624 | 0.538 | 0.394 | 0.337 | 0.286 | 0.259 | 0.384 | 0.422 | 0.502 | 0.680 | 0.593 |
| 118.15 | 0.361 | 0.329 | 0.269 | 0.231 | 0.379 | 0.388 | 0.453 | 0.622 | 0.506 | 0.395 | 0.333 | 0.288 | 0.258 | 0.370 | 0.421 | 0.508 | 0.675 | 0.590 |
| 118.65 | 0.359 | 0.330 | 0.268 | 0.230 | 0.365 | 0.386 | 0.452 | 0.621 | 0.544 | 0.395 | 0.333 | 0.287 | 0.258 | 0.370 | 0.421 | 0.512 | 0.675 | 0.594 |
| 119.15 | 0.361 | 0.331 | 0.279 | 0.230 | 0.366 | 0.382 | 0.452 | 0.633 | 0.546 | 0.395 | 0.333 | 0.288 | 0.258 | 0.370 | 0.420 | 0.496 | 0.679 | 0.577 |
| 119.65 | 0.369 | 0.332 | 0.267 | 0.239 | 0.367 | 0.383 | 0.451 | 0.631 | 0.550 | 0.396 | 0.330 | 0.288 | 0.257 | 0.371 | 0.420 | 0.506 | 0.686 | 0.579 |

| Hour | 45°C | | | | | | | | | 30°C | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | pH 5.0 | pH 5.5 | pH 6.0 | pH 6.5 | pH 7.0 | pH 7.5 | pH 8.0 | pH 8.5 | pH 9.0 | pH 5.0 | pH 5.5 | pH 6.0 | pH 6.5 | pH 7.0 | pH 7.5 | pH 8.0 | pH 8.5 | pH 9.0 |
| 120.15 | 0.364 | 0.333 | 0.277 | 0.239 | 0.368 | 0.387 | 0.451 | 0.631 | 0.549 | 0.396 | 0.335 | 0.287 | 0.257 | 0.371 | 0.420 | 0.509 | 0.690 | 0.578 |
| 120.65 | 0.378 | 0.334 | 0.269 | 0.239 | 0.369 | 0.388 | 0.451 | 0.629 | 0.543 | 0.396 | 0.334 | 0.293 | 0.257 | 0.371 | 0.419 | 0.512 | 0.686 | 0.581 |
| 121.15 | 0.379 | 0.335 | 0.267 | 0.238 | 0.370 | 0.388 | 0.454 | 0.629 | 0.541 | 0.397 | 0.330 | 0.286 | 0.256 | 0.372 | 0.418 | 0.495 | 0.692 | 0.580 |
| 121.65 | 0.360 | 0.315 | 0.278 | 0.238 | 0.365 | 0.390 | 0.454 | 0.628 | 0.545 | 0.397 | 0.332 | 0.285 | 0.257 | 0.372 | 0.418 | 0.497 | 0.686 | 0.580 |
| 122.15 | 0.361 | 0.335 | 0.266 | 0.237 | 0.370 | 0.388 | 0.455 | 0.628 | 0.548 | 0.396 | 0.338 | 0.287 | 0.257 | 0.371 | 0.417 | 0.499 | 0.687 | 0.579 |
| 122.65 | 0.362 | 0.315 | 0.275 | 0.237 | 0.365 | 0.393 | 0.455 | 0.627 | 0.546 | 0.397 | 0.336 | 0.294 | 0.257 | 0.372 | 0.417 | 0.500 | 0.692 | 0.578 |
| 123.15 | 0.363 | 0.316 | 0.267 | 0.245 | 0.366 | 0.395 | 0.455 | 0.626 | 0.544 | 0.397 | 0.337 | 0.285 | 0.257 | 0.372 | 0.417 | 0.500 | 0.689 | 0.579 |
| 123.65 | 0.364 | 0.316 | 0.279 | 0.235 | 0.366 | 0.392 | 0.454 | 0.625 | 0.540 | 0.397 | 0.337 | 0.288 | 0.256 | 0.372 | 0.417 | 0.500 | 0.680 | 0.578 |
| 124.15 | 0.365 | 0.317 | 0.267 | 0.245 | 0.367 | 0.388 | 0.455 | 0.634 | 0.536 | 0.397 | 0.331 | 0.288 | 0.256 | 0.372 | 0.416 | 0.501 | 0.690 | 0.579 |
| 124.65 | 0.365 | 0.317 | 0.272 | 0.245 | 0.367 | 0.388 | 0.455 | 0.633 | 0.544 | 0.397 | 0.331 | 0.287 | 0.257 | 0.372 | 0.416 | 0.501 | 0.686 | 0.580 |
| 125.15 | 0.365 | 0.317 | 0.274 | 0.245 | 0.367 | 0.387 | 0.455 | 0.633 | 0.547 | 0.398 | 0.333 | 0.288 | 0.256 | 0.373 | 0.416 | 0.501 | 0.684 | 0.581 |
| 125.65 | 0.365 | 0.317 | 0.266 | 0.244 | 0.367 | 0.389 | 0.456 | 0.633 | 0.549 | 0.398 | 0.334 | 0.290 | 0.256 | 0.373 | 0.416 | 0.501 | 0.672 | 0.580 |
| 126.15 | 0.366 | 0.317 | 0.267 | 0.244 | 0.367 | 0.391 | 0.456 | 0.632 | 0.550 | 0.399 | 0.337 | 0.289 | 0.257 | 0.374 | 0.417 | 0.501 | 0.677 | 0.581 |
| 126.65 | 0.366 | 0.318 | 0.258 | 0.244 | 0.368 | 0.388 | 0.456 | 0.633 | 0.451 | 0.399 | 0.347 | 0.295 | 0.255 | 0.374 | 0.416 | 0.500 | 0.676 | 0.596 |
| 127.15 | 0.367 | 0.318 | 0.268 | 0.243 | 0.368 | 0.389 | 0.456 | 0.633 | 0.547 | 0.399 | 0.336 | 0.286 | 0.255 | 0.374 | 0.417 | 0.499 | 0.678 | 0.581 |
| 127.65 | 0.367 | 0.318 | 0.268 | 0.235 | 0.368 | 0.387 | 0.456 | 0.634 | 0.543 | 0.399 | 0.343 | 0.294 | 0.264 | 0.374 | 0.416 | 0.497 | 0.675 | 0.581 |
| 128.15 | 0.367 | 0.318 | 0.266 | 0.240 | 0.368 | 0.387 | 0.456 | 0.635 | 0.532 | 0.400 | 0.331 | 0.300 | 0.261 | 0.375 | 0.416 | 0.496 | 0.676 | 0.582 |
| 128.65 | 0.367 | 0.318 | 0.268 | 0.255 | 0.368 | 0.388 | 0.456 | 0.620 | 0.545 | 0.400 | 0.330 | 0.294 | 0.257 | 0.375 | 0.416 | 0.495 | 0.671 | 0.584 |
| 129.15 | 0.367 | 0.318 | 0.258 | 0.258 | 0.368 | 0.385 | 0.456 | 0.621 | 0.543 | 0.401 | 0.331 | 0.295 | 0.257 | 0.376 | 0.416 | 0.515 | 0.670 | 0.584 |
| 129.65 | 0.368 | 0.319 | 0.260 | 0.231 | 0.369 | 0.386 | 0.455 | 0.620 | 0.542 | 0.401 | 0.334 | 0.293 | 0.258 | 0.376 | 0.416 | 0.513 | 0.692 | 0.579 |
| 130.15 | 0.368 | 0.319 | 0.268 | 0.231 | 0.369 | 0.386 | 0.455 | 0.621 | 0.469 | 0.401 | 0.331 | 0.286 | 0.256 | 0.376 | 0.416 | 0.512 | 0.688 | 0.578 |
| 130.65 | 0.368 | 0.319 | 0.250 | 0.235 | 0.369 | 0.381 | 0.455 | 0.622 | 0.547 | 0.402 | 0.341 | 0.287 | 0.256 | 0.377 | 0.416 | 0.510 | 0.680 | 0.578 |
| 131.15 | 0.368 | 0.319 | 0.258 | 0.236 | 0.369 | 0.384 | 0.455 | 0.623 | 0.545 | 0.402 | 0.339 | 0.285 | 0.257 | 0.377 | 0.416 | 0.507 | 0.680 | 0.578 |
| 131.65 | 0.368 | 0.319 | 0.256 | 0.239 | 0.369 | 0.383 | 0.455 | 0.623 | 0.548 | 0.403 | 0.337 | 0.300 | 0.255 | 0.378 | 0.416 | 0.498 | 0.683 | 0.578 |
| 132.15 | 0.368 | 0.320 | 0.263 | 0.238 | 0.370 | 0.383 | 0.455 | 0.624 | 0.549 | 0.403 | 0.347 | 0.293 | 0.265 | 0.378 | 0.416 | 0.514 | 0.687 | 0.579 |
| 132.65 | 0.369 | 0.320 | 0.258 | 0.236 | 0.370 | 0.385 | 0.455 | 0.631 | 0.551 | 0.404 | 0.344 | 0.295 | 0.256 | 0.379 | 0.416 | 0.511 | 0.700 | 0.580 |
| 133.15 | 0.369 | 0.317 | 0.263 | 0.235 | 0.367 | 0.382 | 0.455 | 0.632 | 0.551 | 0.404 | 0.342 | 0.294 | 0.257 | 0.379 | 0.416 | 0.506 | 0.686 | 0.580 |
| 133.65 | 0.369 | 0.334 | 0.256 | 0.245 | 0.369 | 0.384 | 0.455 | 0.633 | 0.545 | 0.404 | 0.342 | 0.294 | 0.257 | 0.379 | 0.415 | 0.501 | 0.685 | 0.585 |
| 134.15 | 0.369 | 0.334 | 0.261 | 0.244 | 0.369 | 0.380 | 0.455 | 0.634 | 0.544 | 0.405 | 0.337 | 0.286 | 0.255 | 0.380 | 0.415 | 0.512 | 0.672 | 0.588 |
| 134.65 | 0.369 | 0.335 | 0.265 | 0.242 | 0.370 | 0.378 | 0.455 | 0.621 | 0.546 | 0.405 | 0.337 | 0.294 | 0.256 | 0.385 | 0.416 | 0.499 | 0.673 | 0.589 |
| 135.15 | 0.370 | 0.335 | 0.266 | 0.241 | 0.370 | 0.379 | 0.455 | 0.623 | 0.547 | 0.406 | 0.344 | 0.292 | 0.265 | 0.386 | 0.416 | 0.497 | 0.674 | 0.575 |
| 135.65 | 0.370 | 0.315 | 0.257 | 0.241 | 0.365 | 0.378 | 0.455 | 0.624 | 0.547 | 0.406 | 0.344 | 0.292 | 0.264 | 0.386 | 0.415 | 0.505 | 0.675 | 0.577 |
| 136.15 | 0.367 | 0.316 | 0.269 | 0.240 | 0.366 | 0.376 | 0.455 | 0.626 | 0.544 | 0.406 | 0.341 | 0.294 | 0.262 | 0.386 | 0.415 | 0.503 | 0.685 | 0.577 |

| Hour | 45°C | | | | | | | | | 30°C | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | pH 5.0 | pH 5.5 | pH 6.0 | pH 6.5 | pH 7.0 | pH 7.5 | pH 8.0 | pH 8.5 | pH 9.0 | pH 5.0 | pH 5.5 | pH 6.0 | pH 6.5 | pH 7.0 | pH 7.5 | pH 8.0 | pH 8.5 | pH 9.0 |
| 136.65 | 0.364 | 0.316 | 0.269 | 0.239 | 0.366 | 0.374 | 0.455 | 0.627 | 0.541 | 0.406 | 0.333 | 0.293 | 0.261 | 0.386 | 0.414 | 0.502 | 0.682 | 0.580 |
| 137.75 | 0.364 | 0.316 | 0.258 | 0.239 | 0.286 | 0.386 | 0.455 | 0.389 | 0.542 | 0.407 | 0.334 | 0.161 | 0.261 | 0.387 | 0.406 | 0.502 | 0.678 | 0.581 |
| 138.25 | 0.365 | 0.316 | 0.272 | 0.238 | 0.286 | 0.363 | 0.455 | 0.380 | 0.540 | 0.407 | 0.332 | 0.297 | 0.259 | 0.387 | 0.406 | 0.500 | 0.682 | 0.584 |
| 138.55 | 0.365 | 0.316 | 0.274 | 0.237 | 0.286 | 0.390 | 0.455 | 0.639 | 0.541 | 0.408 | 0.336 | 0.297 | 0.257 | 0.388 | 0.422 | 0.499 | 0.574 | 0.587 |
| 139.05 | 0.365 | 0.217 | 0.278 | 0.235 | 0.367 | 0.366 | 0.452 | 0.623 | 0.569 | 0.253 | 0.335 | 0.285 | 0.256 | 0.203 | 0.424 | 0.497 | 0.573 | 0.494 |
| 139.55 | 0.366 | 0.217 | 0.275 | 0.240 | 0.367 | 0.373 | 0.453 | 0.609 | 0.563 | 0.353 | 0.343 | 0.293 | 0.257 | 0.253 | 0.425 | 0.496 | 0.689 | 0.461 |
| 140.05 | 0.366 | 0.220 | 0.279 | 0.239 | 0.370 | 0.380 | 0.452 | 0.629 | 0.589 | 0.356 | 0.348 | 0.291 | 0.257 | 0.256 | 0.416 | 0.496 | 0.695 | 0.468 |
| 140.55 | 0.366 | 0.325 | 0.269 | 0.238 | 0.375 | 0.384 | 0.451 | 0.645 | 0.501 | 0.402 | 0.350 | 0.291 | 0.258 | 0.377 | 0.428 | 0.499 | 0.692 | 0.576 |
| 141.05 | 0.366 | 0.333 | 0.277 | 0.237 | 0.383 | 0.385 | 0.451 | 0.636 | 0.510 | 0.405 | 0.345 | 0.293 | 0.256 | 0.380 | 0.427 | 0.507 | 0.693 | 0.576 |
| 141.55 | 0.366 | 0.316 | 0.268 | 0.237 | 0.386 | 0.388 | 0.450 | 0.636 | 0.513 | 0.407 | 0.331 | 0.294 | 0.257 | 0.387 | 0.411 | 0.509 | 0.690 | 0.569 |
| 142.05 | 0.367 | 0.313 | 0.260 | 0.236 | 0.393 | 0.387 | 0.450 | 0.639 | 0.515 | 0.408 | 0.335 | 0.293 | 0.256 | 0.388 | 0.413 | 0.511 | 0.699 | 0.569 |
| 142.55 | 0.367 | 0.313 | 0.266 | 0.235 | 0.393 | 0.388 | 0.450 | 0.637 | 0.518 | 0.410 | 0.328 | 0.288 | 0.256 | 0.390 | 0.409 | 0.514 | 0.686 | 0.599 |
| 143.05 | 0.370 | 0.312 | 0.269 | 0.239 | 0.392 | 0.381 | 0.450 | 0.637 | 0.516 | 0.421 | 0.333 | 0.290 | 0.260 | 0.391 | 0.406 | 0.471 | 0.691 | 0.580 |
| 143.55 | 0.375 | 0.312 | 0.262 | 0.239 | 0.392 | 0.382 | 0.450 | 0.633 | 0.514 | 0.423 | 0.330 | 0.292 | 0.255 | 0.393 | 0.410 | 0.472 | 0.692 | 0.587 |
| 144.05 | 0.363 | 0.313 | 0.263 | 0.238 | 0.393 | 0.383 | 0.451 | 0.636 | 0.515 | 0.424 | 0.333 | 0.000 | 0.256 | 0.394 | 0.409 | 0.473 | 0.680 | 0.583 |
| 144.55 | 0.366 | 0.312 | 0.266 | 0.237 | 0.362 | 0.383 | 0.451 | 0.639 | 0.511 | 0.396 | 0.336 | 0.296 | 0.256 | 0.376 | 0.414 | 0.474 | 0.687 | 0.576 |
| 145.05 | 0.373 | 0.305 | 0.262 | 0.236 | 0.355 | 0.382 | 0.468 | 0.635 | 0.512 | 0.397 | 0.335 | 0.001 | 0.255 | 0.377 | 0.415 | 0.475 | 0.696 | 0.590 |
| 145.55 | 0.373 | 0.311 | 0.264 | 0.236 | 0.361 | 0.381 | 0.474 | 0.639 | 0.514 | 0.399 | 0.335 | 0.000 | 0.255 | 0.379 | 0.417 | 0.496 | 0.693 | 0.587 |
| 146.05 | 0.372 | 0.314 | 0.262 | 0.240 | 0.364 | 0.381 | 0.476 | 0.638 | 0.514 | 0.395 | 0.331 | 0.000 | 0.256 | 0.385 | 0.412 | 0.497 | 0.676 | 0.578 |
| 146.55 | 0.372 | 0.312 | 0.265 | 0.239 | 0.362 | 0.383 | 0.467 | 0.634 | 0.515 | 0.397 | 0.333 | 0.000 | 0.256 | 0.387 | 0.411 | 0.498 | 0.672 | 0.575 |
| 147.05 | 0.373 | 0.310 | 0.263 | 0.239 | 0.360 | 0.381 | 0.475 | 0.638 | 0.514 | 0.398 | 0.330 | 0.296 | 0.260 | 0.388 | 0.410 | 0.499 | 0.678 | 0.569 |
| 147.55 | 0.362 | 0.315 | 0.266 | 0.238 | 0.365 | 0.382 | 0.474 | 0.637 | 0.515 | 0.400 | 0.331 | 0.299 | 0.260 | 0.390 | 0.409 | 0.500 | 0.697 | 0.580 |
| 148.05 | 0.355 | 0.312 | 0.268 | 0.237 | 0.362 | 0.372 | 0.473 | 0.640 | 0.518 | 0.402 | 0.336 | 0.287 | 0.259 | 0.377 | 0.410 | 0.501 | 0.676 | 0.581 |
| 148.55 | 0.361 | 0.313 | 0.271 | 0.236 | 0.363 | 0.370 | 0.472 | 0.637 | 0.515 | 0.403 | 0.337 | 0.295 | 0.258 | 0.378 | 0.410 | 0.501 | 0.675 | 0.583 |
| 149.05 | 0.364 | 0.310 | 0.266 | 0.235 | 0.360 | 0.371 | 0.472 | 0.640 | 0.519 | 0.405 | 0.339 | 0.291 | 0.258 | 0.380 | 0.410 | 0.502 | 0.678 | 0.577 |
| 149.55 | 0.362 | 0.312 | 0.260 | 0.245 | 0.362 | 0.369 | 0.472 | 0.636 | 0.520 | 0.407 | 0.338 | 0.291 | 0.257 | 0.382 | 0.410 | 0.502 | 0.688 | 0.576 |
| 150.05 | 0.360 | 0.306 | 0.265 | 0.244 | 0.356 | 0.366 | 0.471 | 0.638 | 0.522 | 0.408 | 0.336 | 0.295 | 0.257 | 0.383 | 0.408 | 0.503 | 0.694 | 0.572 |
| 150.55 | 0.365 | 0.305 | 0.255 | 0.243 | 0.355 | 0.365 | 0.471 | 0.605 | 0.519 | 0.407 | 0.332 | 0.291 | 0.256 | 0.382 | 0.408 | 0.503 | 0.694 | 0.575 |
| 151.05 | 0.362 | 0.304 | 0.260 | 0.230 | 0.354 | 0.364 | 0.471 | 0.606 | 0.519 | 0.409 | 0.339 | 0.287 | 0.253 | 0.384 | 0.407 | 0.504 | 0.680 | 0.570 |
| 151.55 | 0.363 | 0.315 | 0.258 | 0.244 | 0.300 | 0.364 | 0.471 | 0.637 | 0.519 | 0.421 | 0.343 | 0.300 | 0.255 | 0.376 | 0.406 | 0.504 | 0.679 | 0.577 |
| 152.05 | 0.360 | 0.315 | 0.269 | 0.244 | 0.300 | 0.363 | 0.471 | 0.638 | 0.518 | 0.422 | 0.336 | 0.287 | 0.259 | 0.377 | 0.414 | 0.505 | 0.671 | 0.568 |
| 152.55 | 0.362 | 0.303 | 0.265 | 0.245 | 0.353 | 0.361 | 0.473 | 0.606 | 0.517 | 0.422 | 0.336 | 0.287 | 0.262 | 0.377 | 0.412 | 0.504 | 0.694 | 0.570 |
| 153.05 | 0.356 | 0.303 | 0.257 | 0.241 | 0.353 | 0.362 | 0.473 | 0.610 | 0.522 | 0.424 | 0.338 | 0.293 | 0.259 | 0.379 | 0.412 | 0.505 | 0.688 | 0.575 |

| Hour | 45°C | | | | | | | | | 30°C | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | pH 5.0 | pH 5.5 | pH 6.0 | pH 6.5 | pH 7.0 | pH 7.5 | pH 8.0 | pH 8.5 | pH 9.0 | pH 5.0 | pH 5.5 | pH 6.0 | pH 6.5 | pH 7.0 | pH 7.5 | pH 8.0 | pH 8.5 | pH 9.0 |
| 153.55 | 0.355 | 0.306 | 0.259 | 0.235 | 0.356 | 0.383 | 0.473 | 0.621 | 0.521 | 0.424 | 0.339 | 0.285 | 0.258 | 0.379 | 0.412 | 0.506 | 0.673 | 0.578 |
| 154.05 | 0.364 | 0.308 | 0.259 | 0.242 | 0.358 | 0.382 | 0.473 | 0.630 | 0.523 | 0.424 | 0.341 | 0.295 | 0.259 | 0.379 | 0.410 | 0.506 | 0.675 | 0.576 |
| 154.55 | 0.365 | 0.306 | 0.258 | 0.238 | 0.356 | 0.388 | 0.473 | 0.622 | 0.523 | 0.390 | 0.341 | 0.295 | 0.259 | 0.380 | 0.411 | 0.506 | 0.678 | 0.584 |
| 155.05 | 0.365 | 0.307 | 0.256 | 0.235 | 0.357 | 0.388 | 0.473 | 0.621 | 0.521 | 0.390 | 0.341 | 0.290 | 0.258 | 0.380 | 0.429 | 0.507 | 0.677 | 0.584 |
| 155.55 | 0.363 | 0.305 | 0.270 | 0.232 | 0.355 | 0.387 | 0.473 | 0.624 | 0.523 | 0.391 | 0.342 | 0.294 | 0.257 | 0.381 | 0.430 | 0.507 | 0.678 | 0.584 |
| 156.05 | 0.363 | 0.302 | 0.268 | 0.231 | 0.352 | 0.388 | 0.473 | 0.628 | 0.524 | 0.391 | 0.339 | 0.291 | 0.260 | 0.381 | 0.429 | 0.507 | 0.685 | 0.584 |
| 156.55 | 0.356 | 0.314 | 0.269 | 0.234 | 0.299 | 0.389 | 0.473 | 0.632 | 0.520 | 0.391 | 0.341 | 0.292 | 0.259 | 0.381 | 0.429 | 0.507 | 0.679 | 0.576 |
| 157.05 | 0.358 | 0.311 | 0.268 | 0.234 | 0.296 | 0.387 | 0.472 | 0.626 | 0.518 | 0.391 | 0.343 | 0.293 | 0.259 | 0.381 | 0.430 | 0.507 | 0.670 | 0.589 |
| 157.55 | 0.356 | 0.313 | 0.269 | 0.233 | 0.298 | 0.388 | 0.472 | 0.623 | 0.520 | 0.391 | 0.334 | 0.295 | 0.257 | 0.381 | 0.429 | 0.507 | 0.682 | 0.581 |
| 158.05 | 0.357 | 0.313 | 0.279 | 0.232 | 0.298 | 0.387 | 0.473 | 0.628 | 0.521 | 0.391 | 0.334 | 0.293 | 0.257 | 0.381 | 0.427 | 0.509 | 0.684 | 0.584 |
| 158.55 | 0.365 | 0.313 | 0.279 | 0.232 | 0.398 | 0.399 | 0.472 | 0.633 | 0.520 | 0.391 | 0.337 | 0.290 | 0.256 | 0.381 | 0.426 | 0.507 | 0.677 | 0.586 |
| 159.05 | 0.362 | 0.301 | 0.265 | 0.231 | 0.351 | 0.399 | 0.472 | 0.629 | 0.520 | 0.392 | 0.344 | 0.290 | 0.264 | 0.382 | 0.425 | 0.507 | 0.679 | 0.590 |
| 159.55 | 0.364 | 0.314 | 0.258 | 0.230 | 0.399 | 0.398 | 0.472 | 0.634 | 0.521 | 0.392 | 0.342 | 0.285 | 0.262 | 0.382 | 0.426 | 0.506 | 0.679 | 0.577 |
| 160.05 | 0.361 | 0.302 | 0.256 | 0.235 | 0.352 | 0.398 | 0.471 | 0.636 | 0.520 | 0.392 | 0.340 | 0.292 | 0.261 | 0.382 | 0.426 | 0.506 | 0.680 | 0.581 |
| 160.55 | 0.363 | 0.300 | 0.257 | 0.234 | 0.350 | 0.397 | 0.471 | 0.641 | 0.519 | 0.393 | 0.343 | 0.287 | 0.260 | 0.383 | 0.425 | 0.505 | 0.675 | 0.581 |
| 161.67 | 0.363 | 0.315 | 0.257 | 0.234 | 0.400 | 0.385 | 0.470 | 0.608 | 0.520 | 0.395 | 0.331 | 0.236 | 0.259 | 0.370 | 0.410 | 0.505 | 0.634 | 0.579 |
| 162.17 | 0.363 | 0.301 | 0.262 | 0.233 | 0.351 | 0.387 | 0.480 | 0.365 | 0.520 | 0.396 | 0.332 | 0.340 | 0.258 | 0.371 | 0.423 | 0.504 | 0.672 | 0.582 |
| 162.67 | 0.361 | 0.260 | 0.270 | 0.233 | 0.360 | 0.368 | 0.480 | 0.639 | 0.535 | 0.406 | 0.334 | 0.343 | 0.258 | 0.386 | 0.409 | 0.495 | 0.699 | 0.586 |
| 163.17 | 0.364 | 0.264 | 0.268 | 0.232 | 0.364 | 0.378 | 0.466 | 0.638 | 0.537 | 0.404 | 0.341 | 0.341 | 0.257 | 0.379 | 0.423 | 0.498 | 0.672 | 0.572 |
| 163.67 | 0.362 | 0.270 | 0.269 | 0.231 | 0.370 | 0.385 | 0.478 | 0.630 | 0.502 | 0.410 | 0.341 | 0.291 | 0.256 | 0.390 | 0.427 | 0.499 | 0.645 | 0.579 |
| 164.17 | 0.360 | 0.312 | 0.278 | 0.231 | 0.377 | 0.392 | 0.466 | 0.654 | 0.509 | 0.396 | 0.348 | 0.298 | 0.259 | 0.376 | 0.419 | 0.495 | 0.678 | 0.591 |
| 164.67 | 0.365 | 0.318 | 0.266 | 0.234 | 0.388 | 0.385 | 0.478 | 0.636 | 0.515 | 0.397 | 0.345 | 0.212 | 0.259 | 0.387 | 0.426 | 0.501 | 0.601 | 0.591 |
| 165.17 | 0.361 | 0.318 | 0.277 | 0.234 | 0.388 | 0.389 | 0.475 | 0.637 | 0.512 | 0.402 | 0.343 | 0.290 | 0.258 | 0.377 | 0.410 | 0.505 | 0.605 | 0.587 |
| 165.67 | 0.360 | 0.318 | 0.272 | 0.233 | 0.388 | 0.389 | 0.476 | 0.631 | 0.510 | 0.406 | 0.350 | 0.298 | 0.257 | 0.381 | 0.408 | 0.509 | 0.649 | 0.587 |
| 166.17 | 0.364 | 0.318 | 0.274 | 0.233 | 0.388 | 0.381 | 0.479 | 0.633 | 0.510 | 0.420 | 0.336 | 0.290 | 0.258 | 0.375 | 0.415 | 0.498 | 0.680 | 0.587 |
| 166.67 | 0.360 | 0.317 | 0.274 | 0.232 | 0.382 | 0.384 | 0.473 | 0.634 | 0.508 | 0.391 | 0.336 | 0.286 | 0.256 | 0.381 | 0.414 | 0.506 | 0.699 | 0.586 |
| 167.17 | 0.377 | 0.317 | 0.276 | 0.232 | 0.382 | 0.361 | 0.472 | 0.640 | 0.506 | 0.394 | 0.341 | 0.286 | 0.256 | 0.384 | 0.428 | 0.509 | 0.672 | 0.584 |
| 167.67 | 0.368 | 0.317 | 0.276 | 0.231 | 0.382 | 0.363 | 0.473 | 0.641 | 0.509 | 0.400 | 0.350 | 0.291 | 0.255 | 0.375 | 0.428 | 0.514 | 0.686 | 0.584 |
| 168.17 | 0.368 | 0.318 | 0.267 | 0.230 | 0.383 | 0.367 | 0.451 | 0.640 | 0.507 | 0.407 | 0.341 | 0.289 | 0.264 | 0.387 | 0.421 | 0.511 | 0.675 | 0.584 |
| 168.67 | 0.368 | 0.319 | 0.266 | 0.235 | 0.384 | 0.369 | 0.475 | 0.641 | 0.506 | 0.424 | 0.348 | 0.286 | 0.264 | 0.394 | 0.424 | 0.496 | 0.673 | 0.584 |
| 169.17 | 0.368 | 0.316 | 0.266 | 0.234 | 0.381 | 0.370 | 0.452 | 0.641 | 0.510 | 0.401 | 0.335 | 0.293 | 0.264 | 0.376 | 0.418 | 0.511 | 0.684 | 0.586 |
| 169.67 | 0.362 | 0.316 | 0.262 | 0.233 | 0.381 | 0.370 | 0.474 | 0.642 | 0.515 | 0.420 | 0.338 | 0.296 | 0.264 | 0.375 | 0.425 | 0.513 | 0.681 | 0.586 |
| 170.17 | 0.362 | 0.316 | 0.263 | 0.232 | 0.381 | 0.370 | 0.452 | 0.642 | 0.516 | 0.354 | 0.340 | 0.296 | 0.264 | 0.384 | 0.412 | 0.496 | 0.694 | 0.588 |

| Hour | 45°C | | | | | | | | | 30°C | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | pH 5.0 | pH 5.5 | pH 6.0 | pH 6.5 | pH 7.0 | pH 7.5 | pH 8.0 | pH 8.5 | pH 9.0 | pH 5.0 | pH 5.5 | pH 6.0 | pH 6.5 | pH 7.0 | pH 7.5 | pH 8.0 | pH 8.5 | pH 9.0 |
| 170.67 | 0.362 | 0.318 | 0.265 | 0.232 | 0.383 | 0.370 | 0.452 | 0.642 | 0.520 | 0.362 | 0.341 | 0.296 | 0.262 | 0.377 | 0.415 | 0.498 | 0.698 | 0.589 |
| 171.17 | 0.363 | 0.320 | 0.262 | 0.231 | 0.385 | 0.372 | 0.446 | 0.642 | 0.516 | 0.368 | 0.343 | 0.296 | 0.262 | 0.388 | 0.420 | 0.496 | 0.691 | 0.590 |
| 171.67 | 0.364 | 0.316 | 0.258 | 0.230 | 0.386 | 0.372 | 0.445 | 0.642 | 0.519 | 0.356 | 0.350 | 0.296 | 0.261 | 0.376 | 0.421 | 0.496 | 0.689 | 0.592 |
| 172.17 | 0.361 | 0.312 | 0.256 | 0.240 | 0.392 | 0.371 | 0.445 | 0.642 | 0.521 | 0.357 | 0.346 | 0.296 | 0.261 | 0.382 | 0.418 | 0.498 | 0.688 | 0.595 |
| 172.67 | 0.361 | 0.317 | 0.261 | 0.239 | 0.387 | 0.375 | 0.446 | 0.643 | 0.520 | 0.362 | 0.340 | 0.289 | 0.261 | 0.387 | 0.412 | 0.497 | 0.693 | 0.597 |
| 173.17 | 0.361 | 0.314 | 0.257 | 0.238 | 0.394 | 0.374 | 0.446 | 0.644 | 0.520 | 0.366 | 0.345 | 0.289 | 0.260 | 0.391 | 0.374 | 0.497 | 0.676 | 0.600 |
| 173.67 | 0.363 | 0.311 | 0.280 | 0.237 | 0.396 | 0.374 | 0.446 | 0.645 | 0.522 | 0.369 | 0.336 | 0.289 | 0.260 | 0.394 | 0.411 | 0.496 | 0.689 | 0.577 |
| 174.17 | 0.365 | 0.317 | 0.280 | 0.236 | 0.387 | 0.373 | 0.448 | 0.642 | 0.525 | 0.371 | 0.334 | 0.298 | 0.259 | 0.376 | 0.410 | 0.495 | 0.681 | 0.580 |
| 174.67 | 0.366 | 0.320 | 0.278 | 0.235 | 0.385 | 0.372 | 0.448 | 0.637 | 0.526 | 0.373 | 0.330 | 0.295 | 0.258 | 0.378 | 0.425 | 0.513 | 0.692 | 0.583 |
| 175.17 | 0.372 | 0.320 | 0.266 | 0.235 | 0.390 | 0.372 | 0.448 | 0.638 | 0.527 | 0.373 | 0.339 | 0.289 | 0.262 | 0.378 | 0.427 | 0.511 | 0.699 | 0.586 |
| 175.67 | 0.367 | 0.314 | 0.275 | 0.236 | 0.394 | 0.371 | 0.447 | 0.639 | 0.526 | 0.374 | 0.331 | 0.287 | 0.263 | 0.379 | 0.429 | 0.511 | 0.674 | 0.587 |
| 176.17 | 0.374 | 0.319 | 0.278 | 0.238 | 0.389 | 0.373 | 0.447 | 0.640 | 0.525 | 0.375 | 0.327 | 0.285 | 0.258 | 0.380 | 0.411 | 0.505 | 0.673 | 0.588 |
| 176.67 | 0.361 | 0.312 | 0.280 | 0.234 | 0.397 | 0.375 | 0.447 | 0.673 | 0.526 | 0.375 | 0.326 | 0.291 | 0.257 | 0.380 | 0.414 | 0.505 | 0.670 | 0.589 |
| 177.17 | 0.367 | 0.313 | 0.278 | 0.236 | 0.398 | 0.373 | 0.449 | 0.639 | 0.526 | 0.375 | 0.328 | 0.288 | 0.257 | 0.380 | 0.414 | 0.496 | 0.683 | 0.589 |
| 177.67 | 0.365 | 0.300 | 0.279 | 0.237 | 0.350 | 0.372 | 0.447 | 0.640 | 0.524 | 0.391 | 0.331 | 0.290 | 0.259 | 0.381 | 0.414 | 0.495 | 0.680 | 0.589 |
| 178.17 | 0.370 | 0.314 | 0.265 | 0.240 | 0.399 | 0.371 | 0.446 | 0.642 | 0.525 | 0.403 | 0.331 | 0.300 | 0.261 | 0.378 | 0.415 | 0.515 | 0.672 | 0.586 |
| 178.67 | 0.374 | 0.305 | 0.266 | 0.239 | 0.355 | 0.374 | 0.446 | 0.644 | 0.523 | 0.421 | 0.332 | 0.287 | 0.261 | 0.376 | 0.416 | 0.514 | 0.697 | 0.582 |
| 179.17 | 0.369 | 0.315 | 0.276 | 0.237 | 0.395 | 0.372 | 0.449 | 0.636 | 0.523 | 0.420 | 0.334 | 0.287 | 0.261 | 0.375 | 0.417 | 0.514 | 0.672 | 0.581 |
| 179.67 | 0.362 | 0.307 | 0.276 | 0.235 | 0.357 | 0.368 | 0.449 | 0.637 | 0.523 | 0.409 | 0.340 | 0.296 | 0.262 | 0.384 | 0.417 | 0.498 | 0.685 | 0.584 |
| 180.17 | 0.363 | 0.304 | 0.278 | 0.235 | 0.354 | 0.368 | 0.473 | 0.639 | 0.525 | 0.407 | 0.334 | 0.289 | 0.262 | 0.382 | 0.416 | 0.496 | 0.689 | 0.587 |
| 180.67 | 0.360 | 0.301 | 0.278 | 0.234 | 0.351 | 0.370 | 0.450 | 0.651 | 0.523 | 0.405 | 0.338 | 0.287 | 0.261 | 0.380 | 0.416 | 0.495 | 0.685 | 0.589 |
| 181.17 | 0.364 | 0.317 | 0.277 | 0.233 | 0.287 | 0.369 | 0.474 | 0.653 | 0.524 | 0.403 | 0.331 | 0.000 | 0.261 | 0.378 | 0.417 | 0.498 | 0.696 | 0.566 |
| 181.67 | 0.355 | 0.320 | 0.274 | 0.233 | 0.290 | 0.369 | 0.475 | 0.656 | 0.523 | 0.401 | 0.330 | 0.286 | 0.257 | 0.376 | 0.420 | 0.497 | 0.690 | 0.567 |
| 182.17 | 0.375 | 0.311 | 0.274 | 0.232 | 0.296 | 0.369 | 0.474 | 0.657 | 0.521 | 0.400 | 0.333 | 0.299 | 0.261 | 0.375 | 0.420 | 0.497 | 0.693 | 0.569 |
| 182.67 | 0.357 | 0.314 | 0.280 | 0.231 | 0.299 | 0.369 | 0.474 | 0.659 | 0.519 | 0.399 | 0.333 | 0.285 | 0.260 | 0.389 | 0.420 | 0.497 | 0.685 | 0.571 |
| 183.17 | 0.364 | 0.304 | 0.272 | 0.234 | 0.354 | 0.367 | 0.474 | 0.661 | 0.518 | 0.398 | 0.332 | 0.290 | 0.258 | 0.388 | 0.420 | 0.497 | 0.689 | 0.572 |
| 183.67 | 0.361 | 0.305 | 0.274 | 0.234 | 0.355 | 0.367 | 0.474 | 0.661 | 0.519 | 0.397 | 0.340 | 0.296 | 0.258 | 0.387 | 0.417 | 0.515 | 0.696 | 0.572 |
| 184.17 | 0.367 | 0.311 | 0.274 | 0.234 | 0.361 | 0.371 | 0.475 | 0.663 | 0.520 | 0.396 | 0.335 | 0.295 | 0.257 | 0.386 | 0.417 | 0.514 | 0.688 | 0.572 |
| 184.67 | 0.370 | 0.307 | 0.270 | 0.233 | 0.357 | 0.371 | 0.474 | 0.664 | 0.520 | 0.400 | 0.338 | 0.285 | 0.255 | 0.380 | 0.417 | 0.495 | 0.683 | 0.571 |
| 184.77 | 0.361 | 0.305 | 0.280 | 0.232 | 0.355 | 0.404 | 0.473 | 0.650 | 0.521 | 0.399 | 0.330 | 0.340 | 0.261 | 0.379 | 0.416 | 0.514 | 0.700 | 0.572 |
| 186.28 | 0.364 | 0.309 | 0.211 | 0.232 | 0.359 | 0.389 | 0.473 | 0.500 | 0.520 | 0.398 | 0.330 | 0.290 | 0.257 | 0.378 | 0.158 | 0.515 | 0.374 | 0.572 |
| 186.78 | 0.364 | 0.308 | 0.278 | 0.231 | 0.358 | 0.380 | 0.474 | 0.568 | 0.518 | 0.397 | 0.330 | 0.327 | 0.256 | 0.377 | 0.408 | 0.514 | 0.598 | 0.571 |
| 187.28 | 0.365 | 0.210 | 0.275 | 0.230 | 0.360 | 0.393 | 0.399 | 0.645 | 0.520 | 0.397 | 0.330 | 0.330 | 0.258 | 0.277 | 0.430 | 0.501 | 0.681 | 0.569 |

| Hour | 45°C | | | | | | | | | 30°C | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | pH 5.0 | pH 5.5 | pH 6.0 | pH 6.5 | pH 7.0 | pH 7.5 | pH 8.0 | pH 8.5 | pH 9.0 | pH 5.0 | pH 5.5 | pH 6.0 | pH 6.5 | pH 7.0 | pH 7.5 | pH 8.0 | pH 8.5 | pH 9.0 |
| 187.78 | 0.361 | 0.208 | 0.271 | 0.240 | 0.358 | 0.398 | 0.399 | 0.635 | 0.517 | 0.396 | 0.330 | 0.298 | 0.260 | 0.276 | 0.425 | 0.381 | 0.678 | 0.569 |
| 188.28 | 0.357 | 0.208 | 0.262 | 0.239 | 0.358 | 0.369 | 0.398 | 0.579 | 0.517 | 0.425 | 0.330 | 0.290 | 0.256 | 0.275 | 0.414 | 0.353 | 0.688 | 0.569 |
| 188.78 | 0.365 | 0.320 | 0.269 | 0.239 | 0.370 | 0.403 | 0.474 | 0.595 | 0.517 | 0.424 | 0.330 | 0.295 | 0.251 | 0.394 | 0.421 | 0.498 | 0.672 | 0.568 |
| 189.28 | 0.359 | 0.316 | 0.268 | 0.238 | 0.366 | 0.401 | 0.475 | 0.558 | 0.514 | 0.395 | 0.330 | 0.289 | 0.255 | 0.385 | 0.411 | 0.499 | 0.676 | 0.567 |
| 189.78 | 0.358 | 0.308 | 0.273 | 0.237 | 0.358 | 0.399 | 0.474 | 0.624 | 0.510 | 0.401 | 0.330 | 0.289 | 0.253 | 0.386 | 0.413 | 0.499 | 0.679 | 0.590 |
| 190.28 | 0.360 | 0.321 | 0.276 | 0.236 | 0.371 | 0.394 | 0.475 | 0.572 | 0.511 | 0.422 | 0.330 | 0.286 | 0.260 | 0.372 | 0.419 | 0.506 | 0.681 | 0.566 |
| 190.78 | 0.358 | 0.325 | 0.273 | 0.235 | 0.375 | 0.366 | 0.450 | 0.628 | 0.510 | 0.401 | 0.330 | 0.287 | 0.253 | 0.376 | 0.412 | 0.508 | 0.680 | 0.589 |
| 191.28 | 0.358 | 0.316 | 0.265 | 0.244 | 0.366 | 0.363 | 0.450 | 0.626 | 0.510 | 0.393 | 0.330 | 0.297 | 0.263 | 0.383 | 0.423 | 0.509 | 0.680 | 0.588 |
| 191.78 | 0.360 | 0.321 | 0.262 | 0.244 | 0.371 | 0.399 | 0.452 | 0.634 | 0.510 | 0.410 | 0.330 | 0.296 | 0.263 | 0.385 | 0.414 | 0.510 | 0.684 | 0.589 |
| 192.28 | 0.366 | 0.316 | 0.267 | 0.243 | 0.366 | 0.376 | 0.479 | 0.632 | 0.508 | 0.405 | 0.000 | 0.300 | 0.263 | 0.380 | 0.417 | 0.511 | 0.680 | 0.587 |
| 192.78 | 0.358 | 0.318 | 0.270 | 0.242 | 0.368 | 0.381 | 0.479 | 0.631 | 0.505 | 0.400 | 0.247 | 0.287 | 0.263 | 0.390 | 0.426 | 0.510 | 0.682 | 0.587 |
| 193.28 | 0.361 | 0.322 | 0.267 | 0.241 | 0.372 | 0.384 | 0.479 | 0.631 | 0.504 | 0.397 | 0.246 | 0.299 | 0.262 | 0.387 | 0.425 | 0.510 | 0.682 | 0.584 |
| 193.78 | 0.375 | 0.311 | 0.261 | 0.240 | 0.361 | 0.390 | 0.467 | 0.639 | 0.504 | 0.393 | 0.337 | 0.295 | 0.261 | 0.383 | 0.413 | 0.512 | 0.683 | 0.590 |
| 194.28 | 0.366 | 0.313 | 0.263 | 0.239 | 0.363 | 0.375 | 0.474 | 0.642 | 0.503 | 0.391 | 0.332 | 0.287 | 0.262 | 0.381 | 0.413 | 0.501 | 0.680 | 0.577 |
| 194.78 | 0.361 | 0.322 | 0.261 | 0.238 | 0.372 | 0.395 | 0.474 | 0.634 | 0.514 | 0.391 | 0.333 | 0.299 | 0.261 | 0.381 | 0.410 | 0.510 | 0.680 | 0.572 |
| 195.28 | 0.366 | 0.329 | 0.261 | 0.237 | 0.379 | 0.385 | 0.463 | 0.643 | 0.519 | 0.392 | 0.332 | 0.289 | 0.260 | 0.382 | 0.421 | 0.498 | 0.679 | 0.565 |
| 195.78 | 0.368 | 0.332 | 0.261 | 0.236 | 0.382 | 0.381 | 0.473 | 0.631 | 0.518 | 0.392 | 0.331 | 0.286 | 0.260 | 0.382 | 0.418 | 0.503 | 0.680 | 0.568 |
| 196.28 | 0.362 | 0.334 | 0.258 | 0.235 | 0.384 | 0.371 | 0.471 | 0.651 | 0.514 | 0.392 | 0.332 | 0.300 | 0.260 | 0.382 | 0.415 | 0.511 | 0.675 | 0.568 |
| 196.78 | 0.361 | 0.316 | 0.265 | 0.234 | 0.386 | 0.375 | 0.476 | 0.654 | 0.513 | 0.392 | 0.330 | 0.287 | 0.260 | 0.382 | 0.424 | 0.512 | 0.686 | 0.569 |
| 197.28 | 0.363 | 0.317 | 0.257 | 0.234 | 0.387 | 0.382 | 0.466 | 0.634 | 0.512 | 0.392 | 0.331 | 0.297 | 0.259 | 0.382 | 0.424 | 0.512 | 0.682 | 0.570 |
| 197.78 | 0.362 | 0.318 | 0.268 | 0.232 | 0.388 | 0.381 | 0.467 | 0.638 | 0.510 | 0.392 | 0.331 | 0.296 | 0.259 | 0.382 | 0.429 | 0.512 | 0.688 | 0.587 |
| 198.28 | 0.379 | 0.319 | 0.278 | 0.231 | 0.389 | 0.374 | 0.475 | 0.655 | 0.508 | 0.392 | 0.331 | 0.289 | 0.259 | 0.382 | 0.412 | 0.511 | 0.682 | 0.573 |
| 198.78 | 0.362 | 0.319 | 0.259 | 0.231 | 0.389 | 0.374 | 0.477 | 0.631 | 0.507 | 0.392 | 0.327 | 0.289 | 0.258 | 0.382 | 0.410 | 0.510 | 0.671 | 0.593 |
| 199.28 | 0.364 | 0.320 | 0.268 | 0.243 | 0.390 | 0.374 | 0.480 | 0.651 | 0.505 | 0.391 | 0.327 | 0.290 | 0.258 | 0.381 | 0.415 | 0.511 | 0.682 | 0.579 |
| 199.78 | 0.366 | 0.311 | 0.268 | 0.228 | 0.391 | 0.371 | 0.470 | 0.632 | 0.505 | 0.391 | 0.334 | 0.289 | 0.257 | 0.381 | 0.416 | 0.511 | 0.683 | 0.581 |
| 200.28 | 0.367 | 0.312 | 0.259 | 0.217 | 0.392 | 0.385 | 0.480 | 0.651 | 0.507 | 0.391 | 0.326 | 0.291 | 0.262 | 0.381 | 0.416 | 0.499 | 0.674 | 0.580 |
| 200.78 | 0.368 | 0.311 | 0.255 | 0.231 | 0.391 | 0.382 | 0.480 | 0.626 | 0.506 | 0.391 | 0.326 | 0.293 | 0.257 | 0.381 | 0.412 | 0.498 | 0.676 | 0.582 |
| 201.28 | 0.369 | 0.311 | 0.256 | 0.238 | 0.391 | 0.384 | 0.475 | 0.629 | 0.506 | 0.391 | 0.327 | 0.299 | 0.262 | 0.381 | 0.426 | 0.496 | 0.681 | 0.589 |
| 201.78 | 0.369 | 0.311 | 0.255 | 0.241 | 0.391 | 0.383 | 0.472 | 0.620 | 0.513 | 0.390 | 0.328 | 0.290 | 0.264 | 0.380 | 0.422 | 0.504 | 0.676 | 0.584 |
| 202.28 | 0.370 | 0.311 | 0.258 | 0.241 | 0.391 | 0.381 | 0.470 | 0.621 | 0.512 | 0.390 | 0.330 | 0.293 | 0.251 | 0.380 | 0.424 | 0.502 | 0.684 | 0.585 |
| 202.78 | 0.371 | 0.311 | 0.256 | 0.241 | 0.391 | 0.393 | 0.474 | 0.622 | 0.513 | 0.390 | 0.333 | 0.292 | 0.251 | 0.380 | 0.425 | 0.500 | 0.671 | 0.596 |
| 203.28 | 0.372 | 0.311 | 0.278 | 0.239 | 0.391 | 0.382 | 0.467 | 0.622 | 0.509 | 0.391 | 0.337 | 0.291 | 0.251 | 0.381 | 0.420 | 0.499 | 0.672 | 0.595 |
| 203.78 | 0.371 | 0.311 | 0.258 | 0.237 | 0.391 | 0.388 | 0.468 | 0.621 | 0.509 | 0.390 | 0.339 | 0.291 | 0.251 | 0.380 | 0.415 | 0.496 | 0.675 | 0.589 |

| Hour | 45°C | | | | | | | | | 30°C | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | pH 5.0 | pH 5.5 | pH 6.0 | pH 6.5 | pH 7.0 | pH 7.5 | pH 8.0 | pH 8.5 | pH 9.0 | pH 5.0 | pH 5.5 | pH 6.0 | pH 6.5 | pH 7.0 | pH 7.5 | pH 8.0 | pH 8.5 | pH 9.0 |
| 204.28 | 0.371 | 0.311 | 0.265 | 0.236 | 0.391 | 0.384 | 0.469 | 0.629 | 0.512 | 0.391 | 0.340 | 0.290 | 0.251 | 0.381 | 0.410 | 0.514 | 0.681 | 0.590 |
| 204.78 | 0.371 | 0.311 | 0.255 | 0.235 | 0.291 | 0.372 | 0.476 | 0.622 | 0.511 | 0.391 | 0.343 | 0.296 | 0.251 | 0.381 | 0.424 | 0.512 | 0.680 | 0.591 |
| 205.28 | 0.371 | 0.311 | 0.266 | 0.235 | 0.291 | 0.390 | 0.473 | 0.622 | 0.511 | 0.391 | 0.347 | 0.297 | 0.251 | 0.381 | 0.420 | 0.508 | 0.675 | 0.593 |
| 205.78 | 0.371 | 0.311 | 0.257 | 0.235 | 0.291 | 0.384 | 0.472 | 0.623 | 0.512 | 0.393 | 0.344 | 0.296 | 0.250 | 0.383 | 0.420 | 0.506 | 0.678 | 0.594 |
| 206.28 | 0.371 | 0.311 | 0.268 | 0.234 | 0.291 | 0.388 | 0.479 | 0.620 | 0.513 | 0.393 | 0.345 | 0.296 | 0.251 | 0.383 | 0.422 | 0.498 | 0.672 | 0.587 |
| 206.78 | 0.371 | 0.312 | 0.257 | 0.237 | 0.292 | 0.370 | 0.475 | 0.625 | 0.517 | 0.393 | 0.340 | 0.296 | 0.250 | 0.383 | 0.415 | 0.496 | 0.683 | 0.592 |
| 207.28 | 0.371 | 0.312 | 0.260 | 0.235 | 0.392 | 0.374 | 0.452 | 0.626 | 0.517 | 0.394 | 0.344 | 0.298 | 0.264 | 0.384 | 0.422 | 0.513 | 0.676 | 0.593 |
| 207.78 | 0.371 | 0.311 | 0.268 | 0.236 | 0.391 | 0.376 | 0.475 | 0.628 | 0.518 | 0.394 | 0.348 | 0.299 | 0.264 | 0.384 | 0.415 | 0.511 | 0.678 | 0.599 |
| 208.28 | 0.371 | 0.312 | 0.267 | 0.234 | 0.392 | 0.379 | 0.453 | 0.637 | 0.516 | 0.395 | 0.336 | 0.288 | 0.262 | 0.385 | 0.423 | 0.512 | 0.676 | 0.596 |
| 208.78 | 0.371 | 0.312 | 0.270 | 0.234 | 0.392 | 0.375 | 0.474 | 0.626 | 0.518 | 0.395 | 0.345 | 0.286 | 0.262 | 0.370 | 0.414 | 0.504 | 0.677 | 0.598 |
| 210.78 | 0.371 | 0.312 | 0.262 | 0.233 | 0.392 | 0.384 | 0.479 | 0.640 | 0.524 | 0.399 | 0.343 | 0.234 | 0.258 | 0.374 | 0.424 | 0.500 | 0.674 | 0.595 |
| 211.28 | 0.372 | 0.312 | 0.272 | 0.230 | 0.392 | 0.379 | 0.479 | 0.624 | 0.522 | 0.399 | 0.344 | 0.286 | 0.259 | 0.374 | 0.413 | 0.497 | 0.682 | 0.596 |
| 211.78 | 0.372 | 0.312 | 0.274 | 0.231 | 0.392 | 0.376 | 0.472 | 0.639 | 0.520 | 0.401 | 0.341 | 0.286 | 0.259 | 0.376 | 0.415 | 0.496 | 0.674 | 0.594 |
| 212.28 | 0.371 | 0.312 | 0.274 | 0.232 | 0.392 | 0.373 | 0.473 | 0.644 | 0.519 | 0.402 | 0.343 | 0.289 | 0.258 | 0.377 | 0.413 | 0.503 | 0.675 | 0.597 |
| 212.78 | 0.372 | 0.313 | 0.276 | 0.231 | 0.393 | 0.383 | 0.473 | 0.643 | 0.519 | 0.403 | 0.342 | 0.296 | 0.258 | 0.378 | 0.413 | 0.501 | 0.670 | 0.596 |
| 213.28 | 0.372 | 0.312 | 0.271 | 0.231 | 0.392 | 0.394 | 0.472 | 0.635 | 0.518 | 0.404 | 0.342 | 0.287 | 0.258 | 0.379 | 0.415 | 0.500 | 0.680 | 0.597 |
| 213.78 | 0.372 | 0.312 | 0.271 | 0.242 | 0.392 | 0.397 | 0.479 | 0.641 | 0.520 | 0.405 | 0.332 | 0.292 | 0.258 | 0.385 | 0.414 | 0.499 | 0.683 | 0.597 |
| 214.28 | 0.372 | 0.313 | 0.275 | 0.230 | 0.393 | 0.399 | 0.470 | 0.637 | 0.522 | 0.406 | 0.334 | 0.295 | 0.258 | 0.386 | 0.414 | 0.498 | 0.679 | 0.596 |
| 214.78 | 0.372 | 0.312 | 0.269 | 0.226 | 0.392 | 0.399 | 0.479 | 0.640 | 0.523 | 0.408 | 0.331 | 0.294 | 0.256 | 0.388 | 0.413 | 0.497 | 0.678 | 0.597 |
| 215.28 | 0.372 | 0.312 | 0.280 | 0.228 | 0.392 | 0.397 | 0.479 | 0.644 | 0.519 | 0.409 | 0.335 | 0.293 | 0.257 | 0.389 | 0.412 | 0.496 | 0.676 | 0.596 |
| 215.78 | 0.372 | 0.313 | 0.273 | 0.228 | 0.393 | 0.398 | 0.471 | 0.622 | 0.517 | 0.420 | 0.333 | 0.295 | 0.256 | 0.390 | 0.410 | 0.497 | 0.677 | 0.591 |
| 216.28 | 0.372 | 0.312 | 0.278 | 0.228 | 0.392 | 0.396 | 0.479 | 0.635 | 0.519 | 0.422 | 0.327 | 0.292 | 0.256 | 0.392 | 0.415 | 0.495 | 0.679 | 0.592 |
| 216.78 | 0.372 | 0.214 | 0.265 | 0.226 | 0.364 | 0.397 | 0.369 | 0.644 | 0.531 | 0.399 | 0.334 | 0.291 | 0.256 | 0.284 | 0.415 | 0.497 | 0.679 | 0.490 |
| 217.28 | 0.373 | 0.217 | 0.270 | 0.225 | 0.367 | 0.395 | 0.387 | 0.650 | 0.519 | 0.394 | 0.334 | 0.291 | 0.255 | 0.254 | 0.413 | 0.507 | 0.626 | 0.493 |
| 217.78 | 0.372 | 0.228 | 0.269 | 0.225 | 0.378 | 0.396 | 0.356 | 0.639 | 0.523 | 0.403 | 0.335 | 0.292 | 0.260 | 0.378 | 0.413 | 0.513 | 0.636 | 0.492 |
| 218.28 | 0.372 | 0.333 | 0.276 | 0.245 | 0.383 | 0.398 | 0.464 | 0.636 | 0.535 | 0.424 | 0.341 | 0.291 | 0.259 | 0.394 | 0.409 | 0.471 | 0.646 | 0.575 |
| 218.78 | 0.373 | 0.315 | 0.272 | 0.243 | 0.385 | 0.397 | 0.476 | 0.639 | 0.539 | 0.397 | 0.337 | 0.290 | 0.259 | 0.387 | 0.412 | 0.472 | 0.699 | 0.589 |
| 219.28 | 0.372 | 0.317 | 0.267 | 0.220 | 0.387 | 0.402 | 0.480 | 0.639 | 0.541 | 0.401 | 0.342 | 0.288 | 0.258 | 0.376 | 0.409 | 0.496 | 0.681 | 0.580 |
| 219.78 | 0.372 | 0.318 | 0.275 | 0.241 | 0.388 | 0.400 | 0.471 | 0.633 | 0.540 | 0.403 | 0.341 | 0.286 | 0.258 | 0.378 | 0.423 | 0.500 | 0.682 | 0.581 |
| 220.28 | 0.373 | 0.319 | 0.267 | 0.242 | 0.389 | 0.391 | 0.475 | 0.566 | 0.541 | 0.402 | 0.342 | 0.287 | 0.259 | 0.377 | 0.415 | 0.504 | 0.695 | 0.597 |
| 220.78 | 0.372 | 0.320 | 0.270 | 0.241 | 0.390 | 0.403 | 0.476 | 0.628 | 0.540 | 0.403 | 0.335 | 0.286 | 0.259 | 0.378 | 0.409 | 0.499 | 0.636 | 0.597 |
| 221.28 | 0.364 | 0.310 | 0.259 | 0.241 | 0.390 | 0.396 | 0.473 | 0.621 | 0.541 | 0.401 | 0.343 | 0.291 | 0.258 | 0.376 | 0.430 | 0.514 | 0.649 | 0.577 |
| 221.78 | 0.367 | 0.311 | 0.269 | 0.241 | 0.391 | 0.403 | 0.476 | 0.632 | 0.540 | 0.399 | 0.333 | 0.291 | 0.258 | 0.389 | 0.410 | 0.502 | 0.672 | 0.584 |

| Hour | 45°C | | | | | | | | | 30°C | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | pH 5.0 | pH 5.5 | pH 6.0 | pH 6.5 | pH 7.0 | pH 7.5 | pH 8.0 | pH 8.5 | pH 9.0 | pH 5.0 | pH 5.5 | pH 6.0 | pH 6.5 | pH 7.0 | pH 7.5 | pH 8.0 | pH 8.5 | pH 9.0 |
| 222.28 | 0.378 | 0.311 | 0.268 | 0.241 | 0.391 | 0.396 | 0.475 | 0.622 | 0.539 | 0.401 | 0.339 | 0.290 | 0.258 | 0.376 | 0.419 | 0.503 | 0.682 | 0.568 |
| 222.78 | 0.363 | 0.312 | 0.267 | 0.242 | 0.392 | 0.398 | 0.474 | 0.627 | 0.538 | 0.391 | 0.335 | 0.298 | 0.257 | 0.381 | 0.422 | 0.503 | 0.680 | 0.576 |
| 223.28 | 0.365 | 0.312 | 0.267 | 0.226 | 0.392 | 0.397 | 0.474 | 0.626 | 0.541 | 0.390 | 0.336 | 0.298 | 0.259 | 0.380 | 0.423 | 0.502 | 0.681 | 0.582 |
| 223.78 | 0.367 | 0.312 | 0.261 | 0.238 | 0.392 | 0.396 | 0.468 | 0.638 | 0.540 | 0.404 | 0.335 | 0.291 | 0.264 | 0.379 | 0.417 | 0.503 | 0.684 | 0.589 |
| 224.28 | 0.368 | 0.313 | 0.263 | 0.215 | 0.393 | 0.399 | 0.474 | 0.624 | 0.541 | 0.421 | 0.342 | 0.289 | 0.260 | 0.371 | 0.415 | 0.502 | 0.688 | 0.596 |
| 224.78 | 0.369 | 0.313 | 0.264 | 0.243 | 0.393 | 0.397 | 0.475 | 0.639 | 0.540 | 0.400 | 0.350 | 0.290 | 0.264 | 0.385 | 0.417 | 0.502 | 0.696 | 0.600 |
| 225.28 | 0.370 | 0.313 | 0.255 | 0.226 | 0.393 | 0.404 | 0.465 | 0.629 | 0.538 | 0.401 | 0.340 | 0.290 | 0.265 | 0.386 | 0.418 | 0.502 | 0.694 | 0.579 |
| 225.78 | 0.370 | 0.313 | 0.260 | 0.227 | 0.393 | 0.399 | 0.474 | 0.643 | 0.538 | 0.401 | 0.347 | 0.292 | 0.250 | 0.386 | 0.414 | 0.503 | 0.689 | 0.581 |
| 226.28 | 0.371 | 0.313 | 0.265 | 0.229 | 0.393 | 0.404 | 0.469 | 0.637 | 0.539 | 0.395 | 0.343 | 0.293 | 0.264 | 0.380 | 0.429 | 0.502 | 0.673 | 0.584 |
| 226.78 | 0.371 | 0.313 | 0.267 | 0.228 | 0.393 | 0.397 | 0.473 | 0.637 | 0.540 | 0.399 | 0.349 | 0.292 | 0.263 | 0.379 | 0.427 | 0.501 | 0.685 | 0.587 |
| 227.28 | 0.372 | 0.313 | 0.263 | 0.228 | 0.393 | 0.396 | 0.471 | 0.640 | 0.542 | 0.395 | 0.350 | 0.291 | 0.262 | 0.380 | 0.413 | 0.501 | 0.644 | 0.565 |
| 227.78 | 0.372 | 0.313 | 0.261 | 0.226 | 0.393 | 0.396 | 0.479 | 0.576 | 0.543 | 0.400 | 0.347 | 0.287 | 0.261 | 0.380 | 0.414 | 0.502 | 0.637 | 0.569 |
| 228.28 | 0.372 | 0.313 | 0.270 | 0.225 | 0.393 | 0.399 | 0.466 | 0.635 | 0.543 | 0.400 | 0.345 | 0.286 | 0.261 | 0.380 | 0.427 | 0.501 | 0.696 | 0.575 |
| 228.78 | 0.373 | 0.313 | 0.260 | 0.244 | 0.393 | 0.400 | 0.479 | 0.628 | 0.543 | 0.421 | 0.325 | 0.290 | 0.259 | 0.371 | 0.428 | 0.500 | 0.648 | 0.576 |
| 229.28 | 0.373 | 0.314 | 0.263 | 0.244 | 0.394 | 0.399 | 0.471 | 0.635 | 0.541 | 0.410 | 0.326 | 0.289 | 0.259 | 0.390 | 0.425 | 0.501 | 0.699 | 0.580 |
| 229.78 | 0.373 | 0.314 | 0.258 | 0.244 | 0.394 | 0.399 | 0.477 | 0.629 | 0.540 | 0.409 | 0.335 | 0.293 | 0.258 | 0.389 | 0.427 | 0.502 | 0.686 | 0.581 |
| 230.28 | 0.373 | 0.314 | 0.269 | 0.244 | 0.394 | 0.398 | 0.479 | 0.628 | 0.534 | 0.408 | 0.330 | 0.292 | 0.258 | 0.388 | 0.411 | 0.502 | 0.644 | 0.582 |
| 230.78 | 0.373 | 0.314 | 0.267 | 0.244 | 0.394 | 0.398 | 0.479 | 0.644 | 0.533 | 0.407 | 0.335 | 0.300 | 0.257 | 0.387 | 0.414 | 0.502 | 0.638 | 0.582 |
| 231.28 | 0.373 | 0.314 | 0.264 | 0.244 | 0.394 | 0.397 | 0.472 | 0.642 | 0.530 | 0.406 | 0.342 | 0.295 | 0.257 | 0.386 | 0.411 | 0.502 | 0.625 | 0.582 |
| 231.78 | 0.373 | 0.314 | 0.259 | 0.244 | 0.394 | 0.399 | 0.479 | 0.652 | 0.531 | 0.405 | 0.345 | 0.291 | 0.257 | 0.380 | 0.429 | 0.502 | 0.623 | 0.581 |
| 232.28 | 0.373 | 0.314 | 0.258 | 0.244 | 0.394 | 0.396 | 0.471 | 0.651 | 0.531 | 0.404 | 0.337 | 0.290 | 0.255 | 0.379 | 0.417 | 0.502 | 0.696 | 0.581 |
| 232.78 | 0.373 | 0.314 | 0.267 | 0.244 | 0.394 | 0.403 | 0.475 | 0.654 | 0.528 | 0.404 | 0.349 | 0.294 | 0.260 | 0.379 | 0.416 | 0.502 | 0.692 | 0.580 |
| 234.78 | 0.373 | 0.315 | 0.268 | 0.244 | 0.395 | 0.393 | 0.470 | 0.637 | 0.533 | 0.364 | 0.341 | 0.218 | 0.258 | 0.379 | 0.416 | 0.503 | 0.681 | 0.577 |
| 235.28 | 0.374 | 0.315 | 0.255 | 0.244 | 0.395 | 0.393 | 0.468 | 0.654 | 0.534 | 0.403 | 0.335 | 0.252 | 0.257 | 0.378 | 0.421 | 0.503 | 0.681 | 0.577 |
| 235.78 | 0.374 | 0.315 | 0.264 | 0.244 | 0.395 | 0.400 | 0.466 | 0.652 | 0.532 | 0.404 | 0.349 | 0.291 | 0.256 | 0.379 | 0.426 | 0.504 | 0.690 | 0.577 |
| 236.28 | 0.374 | 0.315 | 0.256 | 0.244 | 0.395 | 0.400 | 0.468 | 0.636 | 0.533 | 0.403 | 0.341 | 0.294 | 0.256 | 0.378 | 0.426 | 0.504 | 0.694 | 0.576 |
| 236.78 | 0.374 | 0.315 | 0.260 | 0.244 | 0.395 | 0.398 | 0.476 | 0.637 | 0.534 | 0.403 | 0.335 | 0.299 | 0.256 | 0.378 | 0.425 | 0.504 | 0.683 | 0.576 |
| 237.28 | 0.374 | 0.315 | 0.258 | 0.244 | 0.395 | 0.394 | 0.470 | 0.642 | 0.526 | 0.403 | 0.343 | 0.300 | 0.265 | 0.378 | 0.420 | 0.504 | 0.681 | 0.575 |
| 237.78 | 0.374 | 0.315 | 0.260 | 0.244 | 0.395 | 0.389 | 0.470 | 0.624 | 0.530 | 0.404 | 0.341 | 0.299 | 0.265 | 0.379 | 0.416 | 0.504 | 0.670 | 0.599 |
| 238.28 | 0.374 | 0.310 | 0.259 | 0.243 | 0.395 | 0.391 | 0.470 | 0.643 | 0.529 | 0.404 | 0.344 | 0.289 | 0.263 | 0.379 | 0.422 | 0.505 | 0.673 | 0.598 |
| 238.78 | 0.374 | 0.314 | 0.268 | 0.243 | 0.394 | 0.386 | 0.471 | 0.642 | 0.532 | 0.403 | 0.347 | 0.297 | 0.262 | 0.378 | 0.422 | 0.505 | 0.694 | 0.598 |
| 239.28 | 0.374 | 0.246 | 0.250 | 0.243 | 0.246 | 0.376 | 0.366 | 0.642 | 0.537 | 0.422 | 0.338 | 0.299 | 0.262 | 0.272 | 0.421 | 0.510 | 0.689 | 0.578 |
| 239.78 | 0.374 | 0.248 | 0.237 | 0.243 | 0.248 | 0.377 | 0.450 | 0.642 | 0.530 | 0.399 | 0.337 | 0.298 | 0.261 | 0.284 | 0.420 | 0.508 | 0.676 | 0.588 |

| Hour | 45°C | | | | | | | | | 30°C | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | pH 5.0 | pH 5.5 | pH 6.0 | pH 6.5 | pH 7.0 | pH 7.5 | pH 8.0 | pH 8.5 | pH 9.0 | pH 5.0 | pH 5.5 | pH 6.0 | pH 6.5 | pH 7.0 | pH 7.5 | pH 8.0 | pH 8.5 | pH 9.0 |
| 240.28 | 0.374 | 0.306 | 0.248 | 0.241 | 0.256 | 0.389 | 0.478 | 0.638 | 0.530 | 0.406 | 0.331 | 0.297 | 0.261 | 0.391 | 0.420 | 0.496 | 0.680 | 0.582 |
| 240.78 | 0.375 | 0.315 | 0.250 | 0.241 | 0.365 | 0.389 | 0.478 | 0.641 | 0.535 | 0.408 | 0.331 | 0.293 | 0.260 | 0.383 | 0.417 | 0.498 | 0.672 | 0.588 |
| 241.28 | 0.375 | 0.318 | 0.250 | 0.240 | 0.388 | 0.385 | 0.478 | 0.642 | 0.535 | 0.422 | 0.338 | 0.296 | 0.260 | 0.377 | 0.421 | 0.495 | 0.678 | 0.580 |
| 241.78 | 0.375 | 0.315 | 0.246 | 0.240 | 0.365 | 0.385 | 0.469 | 0.636 | 0.549 | 0.408 | 0.347 | 0.296 | 0.260 | 0.388 | 0.415 | 0.505 | 0.675 | 0.580 |
| 242.28 | 0.375 | 0.321 | 0.269 | 0.240 | 0.371 | 0.390 | 0.458 | 0.640 | 0.554 | 0.420 | 0.335 | 0.296 | 0.259 | 0.390 | 0.415 | 0.497 | 0.682 | 0.586 |
| 242.78 | 0.375 | 0.323 | 0.267 | 0.240 | 0.373 | 0.391 | 0.478 | 0.642 | 0.543 | 0.421 | 0.344 | 0.297 | 0.259 | 0.391 | 0.419 | 0.499 | 0.677 | 0.577 |
| 243.28 | 0.375 | 0.315 | 0.267 | 0.241 | 0.365 | 0.384 | 0.473 | 0.641 | 0.534 | 0.421 | 0.336 | 0.286 | 0.259 | 0.391 | 0.419 | 0.499 | 0.682 | 0.595 |
| 243.78 | 0.375 | 0.322 | 0.268 | 0.231 | 0.372 | 0.385 | 0.478 | 0.639 | 0.526 | 0.421 | 0.338 | 0.285 | 0.260 | 0.391 | 0.416 | 0.505 | 0.696 | 0.594 |
| 244.28 | 0.360 | 0.324 | 0.227 | 0.233 | 0.374 | 0.384 | 0.478 | 0.639 | 0.533 | 0.421 | 0.336 | 0.295 | 0.261 | 0.391 | 0.418 | 0.506 | 0.700 | 0.592 |
| 244.78 | 0.374 | 0.314 | 0.247 | 0.236 | 0.364 | 0.376 | 0.467 | 0.639 | 0.540 | 0.421 | 0.350 | 0.294 | 0.259 | 0.391 | 0.417 | 0.505 | 0.648 | 0.591 |
| 245.28 | 0.361 | 0.319 | 0.247 | 0.235 | 0.369 | 0.382 | 0.480 | 0.639 | 0.541 | 0.422 | 0.349 | 0.290 | 0.257 | 0.392 | 0.411 | 0.505 | 0.694 | 0.589 |
| 245.78 | 0.363 | 0.312 | 0.250 | 0.238 | 0.362 | 0.381 | 0.478 | 0.641 | 0.541 | 0.422 | 0.341 | 0.292 | 0.262 | 0.392 | 0.411 | 0.500 | 0.686 | 0.588 |
| 246.28 | 0.356 | 0.311 | 0.267 | 0.240 | 0.361 | 0.384 | 0.471 | 0.635 | 0.544 | 0.423 | 0.336 | 0.294 | 0.255 | 0.393 | 0.411 | 0.506 | 0.682 | 0.586 |
| 246.78 | 0.365 | 0.312 | 0.248 | 0.242 | 0.362 | 0.389 | 0.471 | 0.639 | 0.539 | 0.424 | 0.326 | 0.293 | 0.265 | 0.394 | 0.429 | 0.506 | 0.674 | 0.585 |
| 247.28 | 0.368 | 0.305 | 0.246 | 0.242 | 0.355 | 0.359 | 0.471 | 0.640 | 0.537 | 0.395 | 0.334 | 0.292 | 0.256 | 0.375 | 0.427 | 0.507 | 0.675 | 0.584 |
| 247.78 | 0.365 | 0.312 | 0.268 | 0.241 | 0.392 | 0.387 | 0.478 | 0.644 | 0.535 | 0.397 | 0.340 | 0.295 | 0.257 | 0.377 | 0.410 | 0.511 | 0.699 | 0.584 |
| 248.28 | 0.361 | 0.314 | 0.267 | 0.241 | 0.399 | 0.388 | 0.470 | 0.638 | 0.532 | 0.398 | 0.335 | 0.292 | 0.255 | 0.378 | 0.426 | 0.512 | 0.647 | 0.583 |
| 248.78 | 0.363 | 0.311 | 0.265 | 0.241 | 0.396 | 0.385 | 0.476 | 0.638 | 0.531 | 0.396 | 0.332 | 0.293 | 0.264 | 0.376 | 0.410 | 0.495 | 0.645 | 0.582 |
| 249.28 | 0.365 | 0.312 | 0.247 | 0.240 | 0.397 | 0.382 | 0.474 | 0.643 | 0.528 | 0.420 | 0.331 | 0.288 | 0.255 | 0.390 | 0.427 | 0.502 | 0.698 | 0.582 |
| 249.78 | 0.362 | 0.311 | 0.267 | 0.240 | 0.396 | 0.383 | 0.450 | 0.641 | 0.527 | 0.404 | 0.331 | 0.292 | 0.255 | 0.379 | 0.428 | 0.501 | 0.699 | 0.582 |
| 250.28 | 0.364 | 0.310 | 0.267 | 0.241 | 0.395 | 0.380 | 0.474 | 0.637 | 0.528 | 0.403 | 0.328 | 0.287 | 0.255 | 0.378 | 0.423 | 0.502 | 0.688 | 0.581 |
| 250.78 | 0.364 | 0.314 | 0.267 | 0.238 | 0.394 | 0.389 | 0.450 | 0.640 | 0.530 | 0.400 | 0.332 | 0.288 | 0.260 | 0.375 | 0.419 | 0.501 | 0.678 | 0.581 |
| 251.28 | 0.369 | 0.312 | 0.248 | 0.241 | 0.392 | 0.390 | 0.451 | 0.637 | 0.532 | 0.398 | 0.333 | 0.292 | 0.260 | 0.373 | 0.423 | 0.502 | 0.685 | 0.581 |
| 251.78 | 0.362 | 0.313 | 0.266 | 0.242 | 0.393 | 0.387 | 0.473 | 0.644 | 0.528 | 0.400 | 0.327 | 0.291 | 0.260 | 0.375 | 0.423 | 0.504 | 0.675 | 0.581 |
| 252.28 | 0.361 | 0.314 | 0.269 | 0.242 | 0.394 | 0.385 | 0.473 | 0.635 | 0.534 | 0.399 | 0.325 | 0.294 | 0.259 | 0.374 | 0.423 | 0.503 | 0.676 | 0.581 |
| 252.78 | 0.362 | 0.302 | 0.266 | 0.243 | 0.352 | 0.386 | 0.471 | 0.640 | 0.534 | 0.399 | 0.333 | 0.293 | 0.256 | 0.374 | 0.422 | 0.505 | 0.678 | 0.581 |
| 253.28 | 0.365 | 0.328 | 0.267 | 0.243 | 0.378 | 0.389 | 0.474 | 0.638 | 0.539 | 0.400 | 0.332 | 0.291 | 0.255 | 0.375 | 0.419 | 0.505 | 0.682 | 0.581 |
| 253.78 | 0.372 | 0.334 | 0.270 | 0.243 | 0.384 | 0.360 | 0.472 | 0.639 | 0.531 | 0.400 | 0.333 | 0.291 | 0.257 | 0.375 | 0.416 | 0.496 | 0.676 | 0.581 |
| 254.28 | 0.364 | 0.316 | 0.268 | 0.243 | 0.386 | 0.387 | 0.451 | 0.639 | 0.546 | 0.400 | 0.331 | 0.292 | 0.257 | 0.375 | 0.416 | 0.496 | 0.683 | 0.581 |
| 254.78 | 0.361 | 0.311 | 0.266 | 0.243 | 0.391 | 0.386 | 0.452 | 0.642 | 0.549 | 0.401 | 0.333 | 0.294 | 0.256 | 0.376 | 0.415 | 0.499 | 0.683 | 0.581 |
| 255.28 | 0.362 | 0.318 | 0.270 | 0.244 | 0.388 | 0.388 | 0.451 | 0.641 | 0.549 | 0.402 | 0.334 | 0.286 | 0.257 | 0.377 | 0.419 | 0.510 | 0.684 | 0.582 |
| 255.78 | 0.361 | 0.334 | 0.269 | 0.245 | 0.384 | 0.388 | 0.452 | 0.640 | 0.541 | 0.403 | 0.334 | 0.285 | 0.255 | 0.378 | 0.418 | 0.510 | 0.675 | 0.582 |
| 256.28 | 0.360 | 0.312 | 0.267 | 0.244 | 0.392 | 0.387 | 0.452 | 0.636 | 0.543 | 0.404 | 0.330 | 0.299 | 0.255 | 0.379 | 0.418 | 0.511 | 0.684 | 0.582 |

| Hour | 45°C | | | | | | | | | 30°C | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | pH 5.0 | pH 5.5 | pH 6.0 | pH 6.5 | pH 7.0 | pH 7.5 | pH 8.0 | pH 8.5 | pH 9.0 | pH 5.0 | pH 5.5 | pH 6.0 | pH 6.5 | pH 7.0 | pH 7.5 | pH 8.0 | pH 8.5 | pH 9.0 |
| 256.78 | 0.374 | 0.311 | 0.268 | 0.244 | 0.396 | 0.390 | 0.451 | 0.635 | 0.532 | 0.405 | 0.334 | 0.300 | 0.264 | 0.380 | 0.421 | 0.513 | 0.679 | 0.583 |
| 264.65 | 0.372 | 0.312 | 0.271 | 0.244 | 0.397 | 0.387 | 0.451 | 0.535 | 0.544 | 0.405 | 0.331 | 0.290 | 0.264 | 0.385 | 0.409 | 0.496 | 0.600 | 0.583 |
| 265.15 | 0.373 | 0.313 | 0.274 | 0.244 | 0.398 | 0.401 | 0.450 | 0.564 | 0.536 | 0.406 | 0.342 | 0.292 | 0.262 | 0.386 | 0.415 | 0.497 | 0.694 | 0.584 |
| 265.65 | 0.374 | 0.315 | 0.261 | 0.244 | 0.395 | 0.376 | 0.451 | 0.622 | 0.535 | 0.407 | 0.349 | 0.285 | 0.261 | 0.387 | 0.426 | 0.497 | 0.694 | 0.585 |
| 266.15 | 0.362 | 0.311 | 0.263 | 0.245 | 0.396 | 0.387 | 0.450 | 0.634 | 0.543 | 0.407 | 0.335 | 0.332 | 0.260 | 0.387 | 0.405 | 0.498 | 0.693 | 0.585 |
| 266.65 | 0.378 | 0.320 | 0.273 | 0.231 | 0.390 | 0.394 | 0.452 | 0.639 | 0.543 | 0.408 | 0.333 | 0.327 | 0.260 | 0.388 | 0.409 | 0.510 | 0.691 | 0.586 |
| 267.15 | 0.364 | 0.313 | 0.268 | 0.244 | 0.393 | 0.384 | 0.454 | 0.639 | 0.541 | 0.408 | 0.333 | 0.291 | 0.260 | 0.388 | 0.412 | 0.511 | 0.692 | 0.587 |
| 267.65 | 0.366 | 0.311 | 0.267 | 0.230 | 0.396 | 0.383 | 0.451 | 0.654 | 0.543 | 0.408 | 0.332 | 0.291 | 0.259 | 0.388 | 0.411 | 0.513 | 0.692 | 0.588 |
| 268.15 | 0.371 | 0.312 | 0.262 | 0.245 | 0.397 | 0.381 | 0.451 | 0.642 | 0.536 | 0.408 | 0.332 | 0.294 | 0.259 | 0.388 | 0.410 | 0.512 | 0.693 | 0.589 |
| 268.65 | 0.368 | 0.311 | 0.257 | 0.244 | 0.396 | 0.381 | 0.451 | 0.638 | 0.538 | 0.407 | 0.332 | 0.293 | 0.259 | 0.387 | 0.411 | 0.512 | 0.693 | 0.589 |
| 269.15 | 0.364 | 0.310 | 0.270 | 0.243 | 0.390 | 0.381 | 0.473 | 0.636 | 0.530 | 0.404 | 0.332 | 0.292 | 0.259 | 0.379 | 0.408 | 0.501 | 0.695 | 0.590 |
| 269.65 | 0.372 | 0.317 | 0.263 | 0.243 | 0.387 | 0.381 | 0.452 | 0.639 | 0.533 | 0.402 | 0.333 | 0.289 | 0.258 | 0.377 | 0.408 | 0.502 | 0.692 | 0.592 |
| 270.15 | 0.361 | 0.216 | 0.264 | 0.243 | 0.366 | 0.382 | 0.400 | 0.638 | 0.551 | 0.350 | 0.333 | 0.293 | 0.257 | 0.250 | 0.407 | 0.514 | 0.690 | 0.492 |
| 270.65 | 0.362 | 0.213 | 0.264 | 0.242 | 0.363 | 0.380 | 0.400 | 0.637 | 0.552 | 0.351 | 0.333 | 0.333 | 0.257 | 0.251 | 0.409 | 0.475 | 0.693 | 0.477 |
| 271.15 | 0.363 | 0.270 | 0.265 | 0.241 | 0.370 | 0.384 | 0.400 | 0.640 | 0.552 | 0.391 | 0.334 | 0.296 | 0.256 | 0.381 | 0.411 | 0.515 | 0.692 | 0.583 |
| 271.65 | 0.375 | 0.274 | 0.264 | 0.241 | 0.374 | 0.384 | 0.400 | 0.635 | 0.550 | 0.391 | 0.334 | 0.293 | 0.255 | 0.381 | 0.413 | 0.496 | 0.692 | 0.585 |
| 272.15 | 0.361 | 0.313 | 0.278 | 0.241 | 0.363 | 0.383 | 0.471 | 0.639 | 0.526 | 0.402 | 0.334 | 0.292 | 0.256 | 0.377 | 0.408 | 0.503 | 0.693 | 0.585 |
| 272.65 | 0.370 | 0.325 | 0.256 | 0.240 | 0.375 | 0.384 | 0.478 | 0.638 | 0.526 | 0.397 | 0.334 | 0.293 | 0.255 | 0.387 | 0.407 | 0.514 | 0.694 | 0.580 |
| 273.15 | 0.373 | 0.330 | 0.269 | 0.240 | 0.380 | 0.384 | 0.476 | 0.638 | 0.526 | 0.399 | 0.334 | 0.294 | 0.259 | 0.379 | 0.408 | 0.499 | 0.692 | 0.575 |
| 273.65 | 0.361 | 0.313 | 0.269 | 0.240 | 0.393 | 0.383 | 0.469 | 0.639 | 0.526 | 0.398 | 0.334 | 0.292 | 0.259 | 0.378 | 0.411 | 0.496 | 0.694 | 0.574 |
| 274.15 | 0.362 | 0.308 | 0.257 | 0.239 | 0.358 | 0.382 | 0.476 | 0.640 | 0.527 | 0.397 | 0.334 | 0.290 | 0.259 | 0.377 | 0.410 | 0.501 | 0.695 | 0.569 |
| 274.65 | 0.361 | 0.306 | 0.260 | 0.240 | 0.356 | 0.381 | 0.470 | 0.638 | 0.527 | 0.396 | 0.335 | 0.292 | 0.259 | 0.376 | 0.412 | 0.501 | 0.691 | 0.567 |
| 275.15 | 0.370 | 0.315 | 0.261 | 0.161 | 0.365 | 0.381 | 0.478 | 0.631 | 0.527 | 0.396 | 0.335 | 0.331 | 0.258 | 0.376 | 0.407 | 0.499 | 0.693 | 0.565 |
| 275.65 | 0.367 | 0.316 | 0.226 | 0.183 | 0.366 | 0.381 | 0.479 | 0.633 | 0.527 | 0.396 | 0.334 | 0.328 | 0.259 | 0.376 | 0.407 | 0.515 | 0.388 | 0.588 |
| 276.15 | 0.366 | 0.317 | 0.227 | 0.239 | 0.367 | 0.383 | 0.472 | 0.620 | 0.528 | 0.396 | 0.334 | 0.292 | 0.262 | 0.376 | 0.408 | 0.515 | 0.390 | 0.586 |
| 276.65 | 0.363 | 0.318 | 0.270 | 0.239 | 0.368 | 0.382 | 0.472 | 0.622 | 0.528 | 0.396 | 0.334 | 0.294 | 0.259 | 0.376 | 0.407 | 0.515 | 0.689 | 0.585 |
| 277.15 | 0.370 | 0.314 | 0.248 | 0.235 | 0.364 | 0.383 | 0.477 | 0.625 | 0.528 | 0.398 | 0.334 | 0.290 | 0.258 | 0.378 | 0.408 | 0.496 | 0.688 | 0.584 |
| 277.65 | 0.364 | 0.321 | 0.248 | 0.239 | 0.371 | 0.384 | 0.477 | 0.628 | 0.528 | 0.398 | 0.334 | 0.294 | 0.260 | 0.378 | 0.414 | 0.496 | 0.689 | 0.582 |
| 278.15 | 0.363 | 0.317 | 0.246 | 0.240 | 0.367 | 0.385 | 0.479 | 0.631 | 0.528 | 0.400 | 0.334 | 0.294 | 0.260 | 0.380 | 0.413 | 0.497 | 0.690 | 0.581 |
| 278.65 | 0.365 | 0.318 | 0.264 | 0.240 | 0.368 | 0.381 | 0.479 | 0.634 | 0.528 | 0.397 | 0.334 | 0.326 | 0.262 | 0.387 | 0.413 | 0.515 | 0.690 | 0.579 |
| 279.15 | 0.360 | 0.330 | 0.265 | 0.239 | 0.380 | 0.381 | 0.480 | 0.636 | 0.528 | 0.398 | 0.335 | 0.294 | 0.262 | 0.388 | 0.415 | 0.495 | 0.689 | 0.578 |
| 279.65 | 0.373 | 0.317 | 0.265 | 0.239 | 0.387 | 0.381 | 0.478 | 0.639 | 0.528 | 0.399 | 0.335 | 0.290 | 0.260 | 0.389 | 0.406 | 0.514 | 0.690 | 0.577 |
| 280.15 | 0.358 | 0.315 | 0.265 | 0.238 | 0.400 | 0.384 | 0.473 | 0.642 | 0.528 | 0.402 | 0.335 | 0.325 | 0.259 | 0.377 | 0.406 | 0.515 | 0.691 | 0.576 |

| Hour | 45°C | | | | | | | | | 30°C | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | pH 5.0 | pH 5.5 | pH 6.0 | pH 6.5 | pH 7.0 | pH 7.5 | pH 8.0 | pH 8.5 | pH 9.0 | pH 5.0 | pH 5.5 | pH 6.0 | pH 6.5 | pH 7.0 | pH 7.5 | pH 8.0 | pH 8.5 | pH 9.0 |
| 280.65 | 0.356 | 0.312 | 0.266 | 0.238 | 0.397 | 0.383 | 0.473 | 0.635 | 0.528 | 0.403 | 0.335 | 0.333 | 0.259 | 0.378 | 0.405 | 0.495 | 0.690 | 0.575 |
| 281.88 | 0.365 | 0.312 | 0.267 | 0.238 | 0.392 | 0.359 | 0.475 | 0.550 | 0.528 | 0.405 | 0.273 | 0.298 | 0.257 | 0.380 | 0.424 | 0.513 | 0.691 | 0.599 |
| 282.38 | 0.366 | 0.314 | 0.266 | 0.240 | 0.299 | 0.384 | 0.474 | 0.639 | 0.528 | 0.405 | 0.292 | 0.294 | 0.256 | 0.380 | 0.415 | 0.513 | 0.691 | 0.598 |
| 282.88 | 0.367 | 0.314 | 0.269 | 0.239 | 0.364 | 0.383 | 0.474 | 0.634 | 0.528 | 0.406 | 0.310 | 0.296 | 0.255 | 0.381 | 0.412 | 0.511 | 0.676 | 0.597 |
| 283.38 | 0.368 | 0.303 | 0.267 | 0.231 | 0.353 | 0.383 | 0.474 | 0.638 | 0.528 | 0.404 | 0.314 | 0.293 | 0.255 | 0.379 | 0.421 | 0.511 | 0.694 | 0.597 |
| 283.88 | 0.364 | 0.304 | 0.266 | 0.232 | 0.354 | 0.398 | 0.471 | 0.651 | 0.528 | 0.400 | 0.304 | 0.288 | 0.259 | 0.375 | 0.426 | 0.512 | 0.673 | 0.596 |
| 284.38 | 0.361 | 0.315 | 0.266 | 0.232 | 0.300 | 0.396 | 0.450 | 0.642 | 0.528 | 0.397 | 0.319 | 0.294 | 0.259 | 0.387 | 0.428 | 0.512 | 0.679 | 0.595 |
| 284.88 | 0.367 | 0.314 | 0.266 | 0.233 | 0.279 | 0.397 | 0.450 | 0.651 | 0.528 | 0.399 | 0.322 | 0.288 | 0.256 | 0.379 | 0.411 | 0.511 | 0.681 | 0.595 |
| 285.38 | 0.368 | 0.316 | 0.266 | 0.232 | 0.281 | 0.398 | 0.453 | 0.641 | 0.528 | 0.398 | 0.329 | 0.292 | 0.256 | 0.378 | 0.414 | 0.512 | 0.683 | 0.594 |
| 285.88 | 0.380 | 0.319 | 0.267 | 0.233 | 0.284 | 0.398 | 0.454 | 0.644 | 0.528 | 0.398 | 0.335 | 0.291 | 0.256 | 0.378 | 0.413 | 0.511 | 0.685 | 0.593 |
| 286.38 | 0.367 | 0.317 | 0.256 | 0.232 | 0.287 | 0.397 | 0.451 | 0.643 | 0.528 | 0.396 | 0.330 | 0.298 | 0.264 | 0.376 | 0.407 | 0.514 | 0.680 | 0.593 |
| 286.88 | 0.365 | 0.320 | 0.257 | 0.233 | 0.290 | 0.402 | 0.452 | 0.636 | 0.528 | 0.395 | 0.333 | 0.292 | 0.263 | 0.375 | 0.407 | 0.514 | 0.680 | 0.592 |
| 287.38 | 0.362 | 0.314 | 0.257 | 0.232 | 0.394 | 0.401 | 0.450 | 0.635 | 0.528 | 0.398 | 0.328 | 0.285 | 0.262 | 0.378 | 0.408 | 0.515 | 0.680 | 0.592 |
| 287.88 | 0.372 | 0.312 | 0.258 | 0.231 | 0.392 | 0.403 | 0.472 | 0.635 | 0.528 | 0.397 | 0.329 | 0.295 | 0.261 | 0.377 | 0.410 | 0.511 | 0.697 | 0.591 |
| 288.38 | 0.364 | 0.314 | 0.258 | 0.232 | 0.394 | 0.401 | 0.470 | 0.637 | 0.528 | 0.397 | 0.326 | 0.292 | 0.261 | 0.377 | 0.412 | 0.509 | 0.691 | 0.591 |
| 288.88 | 0.364 | 0.313 | 0.258 | 0.232 | 0.393 | 0.403 | 0.472 | 0.638 | 0.528 | 0.395 | 0.330 | 0.299 | 0.259 | 0.375 | 0.413 | 0.513 | 0.680 | 0.591 |
| 289.38 | 0.363 | 0.313 | 0.258 | 0.233 | 0.393 | 0.403 | 0.471 | 0.639 | 0.528 | 0.424 | 0.335 | 0.290 | 0.259 | 0.394 | 0.414 | 0.512 | 0.693 | 0.590 |
| 289.88 | 0.364 | 0.312 | 0.258 | 0.233 | 0.392 | 0.404 | 0.480 | 0.636 | 0.528 | 0.424 | 0.335 | 0.290 | 0.258 | 0.394 | 0.413 | 0.511 | 0.692 | 0.590 |
| 290.38 | 0.365 | 0.311 | 0.258 | 0.232 | 0.391 | 0.403 | 0.472 | 0.640 | 0.528 | 0.423 | 0.333 | 0.289 | 0.258 | 0.393 | 0.415 | 0.513 | 0.691 | 0.589 |
| 290.88 | 0.379 | 0.319 | 0.256 | 0.232 | 0.389 | 0.401 | 0.478 | 0.632 | 0.528 | 0.422 | 0.332 | 0.291 | 0.257 | 0.392 | 0.414 | 0.515 | 0.685 | 0.589 |
| 291.38 | 0.361 | 0.311 | 0.257 | 0.233 | 0.391 | 0.402 | 0.476 | 0.620 | 0.528 | 0.409 | 0.335 | 0.285 | 0.256 | 0.389 | 0.413 | 0.496 | 0.690 | 0.588 |
| 291.88 | 0.364 | 0.313 | 0.256 | 0.233 | 0.393 | 0.400 | 0.475 | 0.623 | 0.528 | 0.408 | 0.331 | 0.292 | 0.257 | 0.388 | 0.414 | 0.497 | 0.686 | 0.588 |
| 292.38 | 0.367 | 0.313 | 0.257 | 0.234 | 0.393 | 0.405 | 0.476 | 0.624 | 0.527 | 0.404 | 0.332 | 0.292 | 0.257 | 0.379 | 0.414 | 0.498 | 0.685 | 0.587 |
| 292.88 | 0.370 | 0.314 | 0.257 | 0.234 | 0.394 | 0.400 | 0.475 | 0.626 | 0.527 | 0.404 | 0.331 | 0.295 | 0.255 | 0.379 | 0.414 | 0.499 | 0.693 | 0.587 |
| 293.38 | 0.374 | 0.314 | 0.256 | 0.234 | 0.394 | 0.404 | 0.476 | 0.629 | 0.527 | 0.402 | 0.329 | 0.291 | 0.260 | 0.377 | 0.415 | 0.501 | 0.691 | 0.586 |
| 293.88 | 0.372 | 0.207 | 0.256 | 0.233 | 0.207 | 0.401 | 0.368 | 0.630 | 0.549 | 0.351 | 0.332 | 0.290 | 0.260 | 0.251 | 0.413 | 0.387 | 0.679 | 0.484 |
| 294.38 | 0.374 | 0.219 | 0.256 | 0.233 | 0.219 | 0.401 | 0.362 | 0.634 | 0.545 | 0.353 | 0.331 | 0.294 | 0.259 | 0.253 | 0.415 | 0.497 | 0.671 | 0.485 |
| 294.88 | 0.373 | 0.312 | 0.255 | 0.233 | 0.377 | 0.404 | 0.465 | 0.636 | 0.538 | 0.393 | 0.325 | 0.290 | 0.259 | 0.383 | 0.413 | 0.498 | 0.679 | 0.593 |
| 295.38 | 0.373 | 0.317 | 0.270 | 0.233 | 0.387 | 0.405 | 0.472 | 0.639 | 0.550 | 0.393 | 0.331 | 0.295 | 0.257 | 0.383 | 0.412 | 0.502 | 0.679 | 0.586 |
| 295.88 | 0.372 | 0.301 | 0.270 | 0.233 | 0.351 | 0.401 | 0.471 | 0.639 | 0.550 | 0.392 | 0.327 | 0.294 | 0.257 | 0.382 | 0.412 | 0.502 | 0.679 | 0.596 |
| 296.38 | 0.371 | 0.306 | 0.269 | 0.234 | 0.356 | 0.400 | 0.474 | 0.645 | 0.544 | 0.393 | 0.330 | 0.294 | 0.258 | 0.383 | 0.413 | 0.502 | 0.683 | 0.592 |
| 296.88 | 0.369 | 0.304 | 0.269 | 0.232 | 0.354 | 0.404 | 0.471 | 0.635 | 0.550 | 0.393 | 0.325 | 0.290 | 0.258 | 0.383 | 0.413 | 0.505 | 0.671 | 0.589 |
| 297.38 | 0.371 | 0.305 | 0.269 | 0.232 | 0.355 | 0.405 | 0.474 | 0.644 | 0.543 | 0.393 | 0.334 | 0.293 | 0.257 | 0.383 | 0.413 | 0.504 | 0.677 | 0.587 |

| Hour | 45°C | | | | | | | | | 30°C | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | pH 5.0 | pH 5.5 | pH 6.0 | pH 6.5 | pH 7.0 | pH 7.5 | pH 8.0 | pH 8.5 | pH 9.0 | pH 5.0 | pH 5.5 | pH 6.0 | pH 6.5 | pH 7.0 | pH 7.5 | pH 8.0 | pH 8.5 | pH 9.0 |
| 297.88 | 0.373 | 0.310 | 0.268 | 0.232 | 0.360 | 0.401 | 0.468 | 0.640 | 0.543 | 0.393 | 0.327 | 0.288 | 0.256 | 0.383 | 0.411 | 0.497 | 0.678 | 0.585 |
| 298.38 | 0.373 | 0.305 | 0.268 | 0.232 | 0.355 | 0.401 | 0.466 | 0.653 | 0.538 | 0.393 | 0.326 | 0.299 | 0.257 | 0.383 | 0.412 | 0.497 | 0.671 | 0.582 |
| 298.88 | 0.374 | 0.303 | 0.268 | 0.240 | 0.353 | 0.403 | 0.475 | 0.636 | 0.543 | 0.393 | 0.331 | 0.299 | 0.258 | 0.383 | 0.419 | 0.497 | 0.678 | 0.580 |
| 299.38 | 0.374 | 0.310 | 0.268 | 0.239 | 0.360 | 0.401 | 0.466 | 0.641 | 0.550 | 0.393 | 0.329 | 0.286 | 0.257 | 0.383 | 0.419 | 0.498 | 0.676 | 0.579 |
| 299.88 | 0.357 | 0.317 | 0.268 | 0.164 | 0.367 | 0.402 | 0.467 | 0.643 | 0.534 | 0.393 | 0.326 | 0.285 | 0.263 | 0.383 | 0.419 | 0.499 | 0.675 | 0.578 |
| 300.38 | 0.369 | 0.316 | 0.267 | 0.155 | 0.366 | 0.404 | 0.474 | 0.636 | 0.533 | 0.393 | 0.333 | 0.300 | 0.263 | 0.383 | 0.417 | 0.500 | 0.673 | 0.576 |
| 300.88 | 0.377 | 0.316 | 0.267 | 0.185 | 0.366 | 0.400 | 0.473 | 0.638 | 0.549 | 0.393 | 0.334 | 0.296 | 0.260 | 0.383 | 0.418 | 0.500 | 0.684 | 0.574 |
| 301.38 | 0.367 | 0.313 | 0.266 | 0.239 | 0.363 | 0.404 | 0.475 | 0.639 | 0.551 | 0.393 | 0.332 | 0.285 | 0.256 | 0.383 | 0.418 | 0.512 | 0.681 | 0.574 |
| 301.88 | 0.361 | 0.311 | 0.266 | 0.234 | 0.361 | 0.404 | 0.474 | 0.644 | 0.549 | 0.393 | 0.331 | 0.288 | 0.261 | 0.383 | 0.418 | 0.513 | 0.683 | 0.574 |
| 302.38 | 0.356 | 0.303 | 0.266 | 0.234 | 0.353 | 0.401 | 0.466 | 0.643 | 0.528 | 0.394 | 0.330 | 0.289 | 0.262 | 0.384 | 0.415 | 0.513 | 0.683 | 0.573 |
| 302.88 | 0.364 | 0.309 | 0.266 | 0.236 | 0.359 | 0.400 | 0.466 | 0.645 | 0.533 | 0.394 | 0.327 | 0.286 | 0.255 | 0.384 | 0.415 | 0.514 | 0.674 | 0.572 |
| 303.38 | 0.365 | 0.306 | 0.265 | 0.240 | 0.356 | 0.399 | 0.468 | 0.637 | 0.544 | 0.394 | 0.327 | 0.287 | 0.265 | 0.384 | 0.405 | 0.500 | 0.670 | 0.570 |
| 303.88 | 0.360 | 0.305 | 0.266 | 0.243 | 0.355 | 0.399 | 0.469 | 0.640 | 0.544 | 0.393 | 0.328 | 0.298 | 0.264 | 0.383 | 0.413 | 0.501 | 0.670 | 0.570 |
| 304.38 | 0.355 | 0.303 | 0.266 | 0.245 | 0.353 | 0.398 | 0.477 | 0.635 | 0.550 | 0.394 | 0.334 | 0.300 | 0.265 | 0.384 | 0.414 | 0.503 | 0.679 | 0.569 |
| 304.88 | 0.363 | 0.303 | 0.266 | 0.237 | 0.353 | 0.398 | 0.477 | 0.637 | 0.538 | 0.393 | 0.335 | 0.287 | 0.263 | 0.383 | 0.406 | 0.504 | 0.685 | 0.568 |
| 306.25 | 0.360 | 0.305 | 0.266 | 0.238 | 0.355 | 0.352 | 0.479 | 0.640 | 0.550 | 0.394 | 0.270 | 0.252 | 0.264 | 0.384 | 0.412 | 0.511 | 0.558 | 0.568 |
| 306.75 | 0.367 | 0.306 | 0.267 | 0.239 | 0.356 | 0.389 | 0.480 | 0.645 | 0.543 | 0.394 | 0.332 | 0.297 | 0.262 | 0.384 | 0.419 | 0.512 | 0.572 | 0.568 |
| 307.25 | 0.366 | 0.305 | 0.269 | 0.239 | 0.355 | 0.362 | 0.470 | 0.642 | 0.550 | 0.394 | 0.333 | 0.292 | 0.263 | 0.384 | 0.407 | 0.514 | 0.685 | 0.567 |
| 307.75 | 0.366 | 0.302 | 0.255 | 0.235 | 0.352 | 0.390 | 0.480 | 0.638 | 0.543 | 0.394 | 0.333 | 0.300 | 0.261 | 0.384 | 0.416 | 0.511 | 0.699 | 0.567 |
| 308.25 | 0.363 | 0.313 | 0.269 | 0.238 | 0.398 | 0.404 | 0.470 | 0.640 | 0.543 | 0.394 | 0.339 | 0.293 | 0.261 | 0.384 | 0.420 | 0.513 | 0.673 | 0.566 |
| 308.75 | 0.361 | 0.313 | 0.269 | 0.237 | 0.298 | 0.396 | 0.472 | 0.644 | 0.534 | 0.394 | 0.345 | 0.286 | 0.260 | 0.384 | 0.424 | 0.496 | 0.682 | 0.566 |
| 309.25 | 0.363 | 0.312 | 0.270 | 0.237 | 0.297 | 0.396 | 0.472 | 0.651 | 0.547 | 0.395 | 0.303 | 0.285 | 0.259 | 0.385 | 0.425 | 0.498 | 0.683 | 0.566 |
| 309.75 | 0.359 | 0.311 | 0.269 | 0.237 | 0.296 | 0.397 | 0.471 | 0.644 | 0.542 | 0.395 | 0.348 | 0.293 | 0.258 | 0.385 | 0.426 | 0.499 | 0.684 | 0.566 |
| 310.25 | 0.356 | 0.312 | 0.268 | 0.236 | 0.297 | 0.405 | 0.474 | 0.643 | 0.547 | 0.396 | 0.341 | 0.293 | 0.257 | 0.371 | 0.427 | 0.507 | 0.670 | 0.566 |
| 310.75 | 0.355 | 0.313 | 0.268 | 0.237 | 0.298 | 0.405 | 0.475 | 0.644 | 0.550 | 0.396 | 0.336 | 0.293 | 0.257 | 0.371 | 0.427 | 0.509 | 0.671 | 0.566 |
| 311.25 | 0.363 | 0.303 | 0.268 | 0.237 | 0.353 | 0.402 | 0.474 | 0.636 | 0.547 | 0.396 | 0.332 | 0.293 | 0.256 | 0.371 | 0.426 | 0.511 | 0.671 | 0.566 |
| 311.75 | 0.363 | 0.301 | 0.268 | 0.238 | 0.351 | 0.405 | 0.475 | 0.637 | 0.550 | 0.396 | 0.334 | 0.293 | 0.255 | 0.371 | 0.426 | 0.495 | 0.671 | 0.567 |
| 312.25 | 0.365 | 0.301 | 0.268 | 0.238 | 0.351 | 0.401 | 0.451 | 0.637 | 0.542 | 0.396 | 0.334 | 0.286 | 0.259 | 0.371 | 0.426 | 0.497 | 0.671 | 0.566 |
| 312.75 | 0.356 | 0.302 | 0.269 | 0.238 | 0.352 | 0.402 | 0.451 | 0.640 | 0.550 | 0.396 | 0.330 | 0.291 | 0.258 | 0.371 | 0.428 | 0.500 | 0.672 | 0.567 |
| 313.25 | 0.355 | 0.303 | 0.269 | 0.230 | 0.353 | 0.403 | 0.451 | 0.639 | 0.547 | 0.396 | 0.334 | 0.286 | 0.258 | 0.371 | 0.427 | 0.501 | 0.670 | 0.567 |
| 313.75 | 0.362 | 0.307 | 0.269 | 0.230 | 0.357 | 0.405 | 0.452 | 0.634 | 0.547 | 0.396 | 0.334 | 0.291 | 0.259 | 0.371 | 0.426 | 0.502 | 0.681 | 0.568 |
| 314.25 | 0.363 | 0.306 | 0.269 | 0.230 | 0.356 | 0.401 | 0.452 | 0.623 | 0.550 | 0.396 | 0.334 | 0.292 | 0.259 | 0.371 | 0.427 | 0.502 | 0.683 | 0.568 |
| 314.75 | 0.363 | 0.304 | 0.269 | 0.239 | 0.354 | 0.401 | 0.452 | 0.627 | 0.550 | 0.396 | 0.330 | 0.290 | 0.259 | 0.371 | 0.426 | 0.503 | 0.681 | 0.568 |

| Hour | 45°C | | | | | | | | | 30°C | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | pH 5.0 | pH 5.5 | pH 6.0 | pH 6.5 | pH 7.0 | pH 7.5 | pH 8.0 | pH 8.5 | pH 9.0 | pH 5.0 | pH 5.5 | pH 6.0 | pH 6.5 | pH 7.0 | pH 7.5 | pH 8.0 | pH 8.5 | pH 9.0 |
| 315.25 | 0.362 | 0.305 | 0.269 | 0.238 | 0.355 | 0.404 | 0.452 | 0.630 | 0.543 | 0.396 | 0.326 | 0.288 | 0.260 | 0.371 | 0.426 | 0.495 | 0.681 | 0.568 |
| 315.75 | 0.361 | 0.308 | 0.269 | 0.238 | 0.358 | 0.405 | 0.453 | 0.633 | 0.534 | 0.396 | 0.322 | 0.291 | 0.259 | 0.371 | 0.426 | 0.496 | 0.680 | 0.569 |
| 316.25 | 0.362 | 0.311 | 0.269 | 0.240 | 0.361 | 0.405 | 0.452 | 0.636 | 0.528 | 0.396 | 0.322 | 0.291 | 0.260 | 0.371 | 0.424 | 0.496 | 0.679 | 0.569 |
| 316.75 | 0.363 | 0.313 | 0.269 | 0.230 | 0.363 | 0.403 | 0.475 | 0.639 | 0.550 | 0.396 | 0.324 | 0.294 | 0.255 | 0.371 | 0.424 | 0.497 | 0.678 | 0.570 |
| 317.25 | 0.363 | 0.313 | 0.269 | 0.230 | 0.363 | 0.403 | 0.451 | 0.643 | 0.538 | 0.396 | 0.323 | 0.289 | 0.260 | 0.371 | 0.424 | 0.497 | 0.678 | 0.571 |
| 317.75 | 0.361 | 0.315 | 0.269 | 0.230 | 0.365 | 0.401 | 0.475 | 0.637 | 0.529 | 0.396 | 0.322 | 0.292 | 0.259 | 0.371 | 0.424 | 0.496 | 0.678 | 0.572 |
| 318.25 | 0.361 | 0.216 | 0.269 | 0.230 | 0.216 | 0.405 | 0.351 | 0.650 | 0.550 | 0.355 | 0.330 | 0.299 | 0.259 | 0.255 | 0.423 | 0.497 | 0.676 | 0.474 |
| 318.75 | 0.362 | 0.221 | 0.269 | 0.231 | 0.221 | 0.401 | 0.352 | 0.654 | 0.550 | 0.355 | 0.334 | 0.298 | 0.259 | 0.255 | 0.422 | 0.497 | 0.677 | 0.475 |
| 319.25 | 0.363 | 0.324 | 0.269 | 0.232 | 0.374 | 0.404 | 0.451 | 0.637 | 0.550 | 0.395 | 0.334 | 0.299 | 0.259 | 0.370 | 0.423 | 0.508 | 0.677 | 0.575 |
| 319.75 | 0.357 | 0.324 | 0.269 | 0.234 | 0.374 | 0.403 | 0.475 | 0.638 | 0.549 | 0.395 | 0.334 | 0.286 | 0.259 | 0.385 | 0.421 | 0.509 | 0.677 | 0.577 |
| 320.25 | 0.356 | 0.333 | 0.269 | 0.234 | 0.383 | 0.401 | 0.473 | 0.642 | 0.543 | 0.395 | 0.335 | 0.287 | 0.259 | 0.385 | 0.421 | 0.511 | 0.677 | 0.578 |
| 320.75 | 0.364 | 0.318 | 0.269 | 0.232 | 0.388 | 0.404 | 0.472 | 0.636 | 0.545 | 0.395 | 0.331 | 0.293 | 0.258 | 0.385 | 0.421 | 0.512 | 0.676 | 0.579 |
| 321.25 | 0.355 | 0.318 | 0.269 | 0.231 | 0.388 | 0.405 | 0.474 | 0.638 | 0.543 | 0.395 | 0.332 | 0.291 | 0.258 | 0.385 | 0.422 | 0.511 | 0.677 | 0.580 |
| 321.75 | 0.358 | 0.328 | 0.268 | 0.231 | 0.378 | 0.405 | 0.474 | 0.643 | 0.545 | 0.394 | 0.333 | 0.292 | 0.257 | 0.384 | 0.422 | 0.509 | 0.677 | 0.581 |
| 322.25 | 0.361 | 0.326 | 0.268 | 0.231 | 0.376 | 0.401 | 0.471 | 0.636 | 0.543 | 0.394 | 0.334 | 0.296 | 0.257 | 0.384 | 0.424 | 0.503 | 0.677 | 0.582 |
| 322.75 | 0.363 | 0.328 | 0.268 | 0.240 | 0.378 | 0.401 | 0.474 | 0.639 | 0.550 | 0.394 | 0.333 | 0.295 | 0.257 | 0.384 | 0.423 | 0.500 | 0.678 | 0.583 |
| 323.25 | 0.363 | 0.331 | 0.268 | 0.239 | 0.381 | 0.404 | 0.472 | 0.639 | 0.548 | 0.394 | 0.332 | 0.296 | 0.257 | 0.384 | 0.424 | 0.498 | 0.678 | 0.585 |
| 323.75 | 0.365 | 0.327 | 0.268 | 0.239 | 0.377 | 0.404 | 0.474 | 0.638 | 0.533 | 0.394 | 0.334 | 0.297 | 0.257 | 0.384 | 0.424 | 0.474 | 0.679 | 0.588 |
| 324.25 | 0.366 | 0.329 | 0.268 | 0.189 | 0.379 | 0.403 | 0.472 | 0.636 | 0.544 | 0.394 | 0.332 | 0.292 | 0.256 | 0.384 | 0.423 | 0.471 | 0.679 | 0.589 |
| 324.75 | 0.361 | 0.326 | 0.268 | 0.167 | 0.376 | 0.401 | 0.472 | 0.638 | 0.548 | 0.394 | 0.333 | 0.291 | 0.253 | 0.384 | 0.424 | 0.513 | 0.680 | 0.590 |
| 325.25 | 0.364 | 0.323 | 0.268 | 0.239 | 0.373 | 0.401 | 0.472 | 0.641 | 0.544 | 0.393 | 0.333 | 0.293 | 0.257 | 0.383 | 0.425 | 0.510 | 0.697 | 0.593 |
| 325.75 | 0.364 | 0.321 | 0.268 | 0.241 | 0.371 | 0.403 | 0.471 | 0.642 | 0.545 | 0.393 | 0.332 | 0.294 | 0.259 | 0.383 | 0.421 | 0.508 | 0.688 | 0.595 |
| 326.25 | 0.363 | 0.323 | 0.268 | 0.235 | 0.373 | 0.403 | 0.470 | 0.644 | 0.544 | 0.393 | 0.327 | 0.294 | 0.265 | 0.383 | 0.421 | 0.505 | 0.673 | 0.598 |
| 326.75 | 0.368 | 0.322 | 0.268 | 0.239 | 0.372 | 0.402 | 0.477 | 0.638 | 0.548 | 0.393 | 0.330 | 0.292 | 0.264 | 0.383 | 0.423 | 0.498 | 0.671 | 0.578 |
| 327.25 | 0.368 | 0.321 | 0.268 | 0.240 | 0.371 | 0.353 | 0.479 | 0.640 | 0.548 | 0.393 | 0.331 | 0.293 | 0.262 | 0.383 | 0.422 | 0.495 | 0.696 | 0.580 |
| 327.75 | 0.378 | 0.320 | 0.268 | 0.235 | 0.370 | 0.354 | 0.478 | 0.653 | 0.550 | 0.393 | 0.328 | 0.297 | 0.263 | 0.383 | 0.422 | 0.498 | 0.674 | 0.580 |
| 328.25 | 0.376 | 0.321 | 0.268 | 0.238 | 0.371 | 0.356 | 0.476 | 0.640 | 0.544 | 0.393 | 0.327 | 0.286 | 0.262 | 0.383 | 0.422 | 0.497 | 0.670 | 0.583 |
| 330.23 | 0.378 | 0.320 | 0.267 | 0.238 | 0.370 | 0.351 | 0.470 | 0.639 | 0.549 | 0.393 | 0.258 | 0.251 | 0.262 | 0.383 | 0.171 | 0.495 | 0.673 | 0.584 |
| 330.73 | 0.361 | 0.321 | 0.255 | 0.237 | 0.371 | 0.387 | 0.477 | 0.631 | 0.550 | 0.392 | 0.334 | 0.286 | 0.262 | 0.382 | 0.420 | 0.499 | 0.363 | 0.587 |
| 331.23 | 0.377 | 0.314 | 0.259 | 0.240 | 0.364 | 0.385 | 0.476 | 0.635 | 0.550 | 0.392 | 0.332 | 0.294 | 0.261 | 0.382 | 0.414 | 0.497 | 0.395 | 0.567 |
| 331.73 | 0.379 | 0.318 | 0.257 | 0.238 | 0.368 | 0.398 | 0.469 | 0.632 | 0.533 | 0.392 | 0.332 | 0.297 | 0.261 | 0.382 | 0.413 | 0.495 | 0.674 | 0.572 |
| 332.23 | 0.376 | 0.313 | 0.256 | 0.238 | 0.363 | 0.397 | 0.469 | 0.641 | 0.533 | 0.392 | 0.328 | 0.291 | 0.259 | 0.382 | 0.416 | 0.514 | 0.682 | 0.571 |
| 332.73 | 0.363 | 0.312 | 0.270 | 0.239 | 0.362 | 0.400 | 0.469 | 0.637 | 0.533 | 0.392 | 0.326 | 0.287 | 0.259 | 0.382 | 0.417 | 0.513 | 0.676 | 0.574 |

| Hour | 45°C | | | | | | | | | 30°C | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | pH 5.0 | pH 5.5 | pH 6.0 | pH 6.5 | pH 7.0 | pH 7.5 | pH 8.0 | pH 8.5 | pH 9.0 | pH 5.0 | pH 5.5 | pH 6.0 | pH 6.5 | pH 7.0 | pH 7.5 | pH 8.0 | pH 8.5 | pH 9.0 |
| 333.23 | 0.361 | 0.310 | 0.269 | 0.237 | 0.360 | 0.404 | 0.469 | 0.639 | 0.533 | 0.392 | 0.331 | 0.294 | 0.257 | 0.382 | 0.418 | 0.511 | 0.684 | 0.579 |
| 333.73 | 0.363 | 0.311 | 0.269 | 0.240 | 0.361 | 0.401 | 0.470 | 0.643 | 0.533 | 0.392 | 0.334 | 0.291 | 0.258 | 0.382 | 0.418 | 0.510 | 0.681 | 0.579 |
| 334.23 | 0.362 | 0.316 | 0.269 | 0.239 | 0.366 | 0.405 | 0.467 | 0.636 | 0.533 | 0.392 | 0.331 | 0.297 | 0.256 | 0.382 | 0.418 | 0.510 | 0.684 | 0.581 |
| 334.73 | 0.361 | 0.314 | 0.269 | 0.230 | 0.364 | 0.402 | 0.469 | 0.641 | 0.550 | 0.392 | 0.320 | 0.286 | 0.256 | 0.382 | 0.419 | 0.509 | 0.685 | 0.583 |
| 335.23 | 0.370 | 0.310 | 0.269 | 0.230 | 0.360 | 0.401 | 0.469 | 0.643 | 0.539 | 0.392 | 0.326 | 0.286 | 0.256 | 0.382 | 0.420 | 0.508 | 0.681 | 0.586 |
| 335.73 | 0.361 | 0.310 | 0.269 | 0.231 | 0.360 | 0.403 | 0.468 | 0.654 | 0.550 | 0.392 | 0.329 | 0.292 | 0.255 | 0.382 | 0.420 | 0.507 | 0.685 | 0.586 |
| 336.23 | 0.370 | 0.313 | 0.269 | 0.232 | 0.363 | 0.399 | 0.469 | 0.640 | 0.550 | 0.392 | 0.328 | 0.294 | 0.259 | 0.382 | 0.419 | 0.506 | 0.671 | 0.586 |
| 336.73 | 0.361 | 0.315 | 0.269 | 0.232 | 0.365 | 0.405 | 0.469 | 0.639 | 0.550 | 0.392 | 0.334 | 0.296 | 0.258 | 0.382 | 0.420 | 0.505 | 0.684 | 0.583 |
| 337.23 | 0.364 | 0.318 | 0.269 | 0.232 | 0.368 | 0.400 | 0.470 | 0.654 | 0.539 | 0.391 | 0.331 | 0.295 | 0.259 | 0.381 | 0.418 | 0.505 | 0.681 | 0.580 |
| 337.73 | 0.368 | 0.320 | 0.270 | 0.232 | 0.370 | 0.401 | 0.479 | 0.642 | 0.549 | 0.391 | 0.329 | 0.286 | 0.258 | 0.381 | 0.419 | 0.504 | 0.681 | 0.573 |
| 338.23 | 0.363 | 0.319 | 0.256 | 0.232 | 0.369 | 0.401 | 0.479 | 0.644 | 0.538 | 0.391 | 0.325 | 0.292 | 0.257 | 0.381 | 0.418 | 0.504 | 0.671 | 0.585 |
| 338.73 | 0.362 | 0.318 | 0.256 | 0.232 | 0.368 | 0.401 | 0.479 | 0.641 | 0.545 | 0.391 | 0.325 | 0.294 | 0.256 | 0.381 | 0.419 | 0.503 | 0.683 | 0.596 |
| 339.23 | 0.360 | 0.314 | 0.256 | 0.232 | 0.364 | 0.401 | 0.479 | 0.644 | 0.550 | 0.391 | 0.322 | 0.292 | 0.256 | 0.381 | 0.418 | 0.502 | 0.683 | 0.573 |
| 339.73 | 0.361 | 0.313 | 0.256 | 0.233 | 0.363 | 0.402 | 0.471 | 0.640 | 0.551 | 0.391 | 0.323 | 0.294 | 0.265 | 0.381 | 0.419 | 0.501 | 0.683 | 0.584 |
| 340.23 | 0.366 | 0.314 | 0.256 | 0.235 | 0.364 | 0.400 | 0.480 | 0.639 | 0.550 | 0.391 | 0.334 | 0.292 | 0.256 | 0.381 | 0.418 | 0.500 | 0.681 | 0.583 |
| 340.73 | 0.364 | 0.313 | 0.256 | 0.232 | 0.363 | 0.404 | 0.478 | 0.639 | 0.538 | 0.391 | 0.328 | 0.291 | 0.256 | 0.381 | 0.416 | 0.499 | 0.671 | 0.592 |
| 341.23 | 0.360 | 0.312 | 0.256 | 0.232 | 0.362 | 0.403 | 0.477 | 0.639 | 0.550 | 0.391 | 0.327 | 0.293 | 0.265 | 0.381 | 0.417 | 0.499 | 0.680 | 0.593 |
| 341.73 | 0.360 | 0.314 | 0.255 | 0.234 | 0.364 | 0.402 | 0.468 | 0.632 | 0.550 | 0.391 | 0.327 | 0.292 | 0.263 | 0.381 | 0.416 | 0.498 | 0.679 | 0.597 |
| 342.23 | 0.363 | 0.313 | 0.255 | 0.234 | 0.363 | 0.400 | 0.470 | 0.633 | 0.550 | 0.391 | 0.325 | 0.295 | 0.265 | 0.381 | 0.416 | 0.498 | 0.691 | 0.588 |
| 342.73 | 0.365 | 0.313 | 0.255 | 0.234 | 0.363 | 0.404 | 0.476 | 0.633 | 0.552 | 0.391 | 0.329 | 0.291 | 0.263 | 0.381 | 0.417 | 0.497 | 0.680 | 0.579 |
| 343.23 | 0.368 | 0.312 | 0.270 | 0.233 | 0.362 | 0.403 | 0.477 | 0.623 | 0.528 | 0.391 | 0.327 | 0.291 | 0.261 | 0.381 | 0.414 | 0.497 | 0.694 | 0.580 |
| 343.73 | 0.360 | 0.211 | 0.270 | 0.234 | 0.361 | 0.402 | 0.393 | 0.627 | 0.528 | 0.351 | 0.327 | 0.294 | 0.261 | 0.251 | 0.411 | 0.497 | 0.699 | 0.480 |
| 344.23 | 0.369 | 0.209 | 0.270 | 0.233 | 0.359 | 0.404 | 0.394 | 0.630 | 0.555 | 0.351 | 0.325 | 0.294 | 0.260 | 0.251 | 0.411 | 0.377 | 0.696 | 0.478 |
| 344.73 | 0.368 | 0.308 | 0.268 | 0.233 | 0.358 | 0.402 | 0.477 | 0.632 | 0.528 | 0.391 | 0.325 | 0.291 | 0.260 | 0.381 | 0.411 | 0.497 | 0.698 | 0.576 |
| 345.23 | 0.364 | 0.307 | 0.268 | 0.233 | 0.357 | 0.404 | 0.476 | 0.635 | 0.550 | 0.391 | 0.333 | 0.292 | 0.261 | 0.381 | 0.411 | 0.496 | 0.696 | 0.575 |
| 345.73 | 0.363 | 0.306 | 0.267 | 0.232 | 0.356 | 0.400 | 0.476 | 0.621 | 0.550 | 0.391 | 0.323 | 0.285 | 0.256 | 0.381 | 0.411 | 0.496 | 0.685 | 0.570 |
| 346.23 | 0.364 | 0.306 | 0.267 | 0.231 | 0.356 | 0.399 | 0.476 | 0.621 | 0.551 | 0.391 | 0.325 | 0.293 | 0.260 | 0.381 | 0.411 | 0.495 | 0.694 | 0.589 |
| 346.73 | 0.363 | 0.305 | 0.267 | 0.240 | 0.355 | 0.399 | 0.477 | 0.621 | 0.550 | 0.391 | 0.327 | 0.290 | 0.260 | 0.381 | 0.409 | 0.495 | 0.676 | 0.566 |
| 347.23 | 0.362 | 0.305 | 0.267 | 0.230 | 0.355 | 0.397 | 0.475 | 0.639 | 0.546 | 0.391 | 0.328 | 0.293 | 0.259 | 0.381 | 0.409 | 0.495 | 0.677 | 0.589 |
| 347.73 | 0.364 | 0.303 | 0.267 | 0.239 | 0.353 | 0.399 | 0.477 | 0.630 | 0.551 | 0.391 | 0.321 | 0.294 | 0.259 | 0.381 | 0.410 | 0.495 | 0.684 | 0.566 |
| 348.23 | 0.363 | 0.304 | 0.267 | 0.238 | 0.354 | 0.395 | 0.476 | 0.636 | 0.551 | 0.391 | 0.321 | 0.294 | 0.259 | 0.381 | 0.410 | 0.495 | 0.681 | 0.589 |
| 348.73 | 0.363 | 0.303 | 0.267 | 0.238 | 0.353 | 0.398 | 0.477 | 0.638 | 0.551 | 0.391 | 0.328 | 0.295 | 0.259 | 0.381 | 0.411 | 0.510 | 0.682 | 0.585 |
| 349.23 | 0.362 | 0.304 | 0.267 | 0.238 | 0.354 | 0.399 | 0.470 | 0.621 | 0.551 | 0.391 | 0.333 | 0.286 | 0.259 | 0.381 | 0.411 | 0.510 | 0.679 | 0.581 |

| Hour | 45°C | | | | | | | | | 30°C | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | pH 5.0 | pH 5.5 | pH 6.0 | pH 6.5 | pH 7.0 | pH 7.5 | pH 8.0 | pH 8.5 | pH 9.0 | pH 5.0 | pH 5.5 | pH 6.0 | pH 6.5 | pH 7.0 | pH 7.5 | pH 8.0 | pH 8.5 | pH 9.0 |
| 349.73 | 0.361 | 0.304 | 0.267 | 0.170 | 0.354 | 0.403 | 0.469 | 0.623 | 0.551 | 0.391 | 0.328 | 0.288 | 0.201 | 0.381 | 0.413 | 0.510 | 0.681 | 0.583 |
| 350.23 | 0.359 | 0.304 | 0.267 | 0.175 | 0.354 | 0.403 | 0.469 | 0.641 | 0.550 | 0.391 | 0.324 | 0.286 | 0.257 | 0.381 | 0.411 | 0.510 | 0.679 | 0.582 |
| 350.73 | 0.358 | 0.305 | 0.267 | 0.241 | 0.355 | 0.395 | 0.470 | 0.635 | 0.550 | 0.391 | 0.328 | 0.286 | 0.258 | 0.381 | 0.411 | 0.510 | 0.681 | 0.583 |
| 351.23 | 0.357 | 0.305 | 0.267 | 0.240 | 0.355 | 0.399 | 0.469 | 0.638 | 0.551 | 0.391 | 0.326 | 0.286 | 0.259 | 0.381 | 0.410 | 0.509 | 0.684 | 0.580 |
| 351.73 | 0.356 | 0.305 | 0.267 | 0.241 | 0.355 | 0.399 | 0.468 | 0.640 | 0.552 | 0.391 | 0.332 | 0.289 | 0.258 | 0.381 | 0.412 | 0.509 | 0.683 | 0.578 |
| 352.23 | 0.356 | 0.308 | 0.267 | 0.243 | 0.358 | 0.399 | 0.468 | 0.638 | 0.550 | 0.391 | 0.325 | 0.287 | 0.257 | 0.381 | 0.414 | 0.509 | 0.671 | 0.578 |
| 354.70 | 0.355 | 0.309 | 0.256 | 0.243 | 0.359 | 0.377 | 0.469 | 0.592 | 0.550 | 0.391 | 0.334 | 0.260 | 0.259 | 0.381 | 0.426 | 0.509 | 0.386 | 0.577 |
| 355.20 | 0.365 | 0.311 | 0.246 | 0.241 | 0.361 | 0.396 | 0.475 | 0.637 | 0.550 | 0.391 | 0.333 | 0.291 | 0.258 | 0.381 | 0.414 | 0.509 | 0.691 | 0.577 |
| 355.70 | 0.363 | 0.313 | 0.245 | 0.241 | 0.363 | 0.400 | 0.469 | 0.636 | 0.550 | 0.391 | 0.330 | 0.295 | 0.259 | 0.381 | 0.409 | 0.509 | 0.683 | 0.576 |
| 356.20 | 0.364 | 0.313 | 0.262 | 0.240 | 0.363 | 0.405 | 0.468 | 0.640 | 0.550 | 0.391 | 0.326 | 0.291 | 0.258 | 0.381 | 0.411 | 0.509 | 0.685 | 0.600 |
| 356.70 | 0.363 | 0.313 | 0.266 | 0.238 | 0.363 | 0.398 | 0.470 | 0.638 | 0.552 | 0.391 | 0.326 | 0.290 | 0.257 | 0.381 | 0.411 | 0.509 | 0.674 | 0.599 |
| 357.20 | 0.364 | 0.309 | 0.269 | 0.239 | 0.359 | 0.395 | 0.470 | 0.637 | 0.551 | 0.390 | 0.334 | 0.287 | 0.256 | 0.380 | 0.412 | 0.509 | 0.678 | 0.598 |
| 357.70 | 0.364 | 0.310 | 0.265 | 0.239 | 0.360 | 0.395 | 0.476 | 0.639 | 0.550 | 0.390 | 0.332 | 0.292 | 0.259 | 0.380 | 0.412 | 0.509 | 0.678 | 0.597 |
| 358.20 | 0.364 | 0.309 | 0.258 | 0.239 | 0.359 | 0.400 | 0.476 | 0.637 | 0.550 | 0.390 | 0.328 | 0.295 | 0.259 | 0.380 | 0.413 | 0.509 | 0.695 | 0.595 |
| 358.70 | 0.365 | 0.311 | 0.276 | 0.239 | 0.361 | 0.398 | 0.470 | 0.639 | 0.550 | 0.390 | 0.331 | 0.287 | 0.258 | 0.380 | 0.414 | 0.508 | 0.679 | 0.594 |
| 359.20 | 0.355 | 0.310 | 0.257 | 0.238 | 0.360 | 0.398 | 0.475 | 0.639 | 0.550 | 0.390 | 0.329 | 0.287 | 0.258 | 0.380 | 0.413 | 0.508 | 0.680 | 0.595 |
| 359.70 | 0.355 | 0.311 | 0.266 | 0.239 | 0.361 | 0.397 | 0.475 | 0.642 | 0.550 | 0.390 | 0.324 | 0.287 | 0.255 | 0.380 | 0.412 | 0.508 | 0.695 | 0.596 |
| 360.20 | 0.358 | 0.310 | 0.260 | 0.239 | 0.360 | 0.398 | 0.470 | 0.635 | 0.550 | 0.390 | 0.321 | 0.290 | 0.265 | 0.380 | 0.413 | 0.509 | 0.696 | 0.596 |
| 360.70 | 0.359 | 0.308 | 0.257 | 0.239 | 0.358 | 0.397 | 0.469 | 0.636 | 0.550 | 0.390 | 0.331 | 0.290 | 0.264 | 0.380 | 0.412 | 0.509 | 0.696 | 0.595 |
| 361.20 | 0.361 | 0.308 | 0.265 | 0.240 | 0.358 | 0.396 | 0.468 | 0.639 | 0.550 | 0.390 | 0.326 | 0.292 | 0.263 | 0.380 | 0.413 | 0.509 | 0.690 | 0.595 |
| 361.70 | 0.363 | 0.309 | 0.267 | 0.237 | 0.359 | 0.397 | 0.468 | 0.639 | 0.550 | 0.390 | 0.327 | 0.291 | 0.263 | 0.380 | 0.413 | 0.508 | 0.672 | 0.593 |
| 362.20 | 0.363 | 0.308 | 0.261 | 0.238 | 0.358 | 0.395 | 0.470 | 0.639 | 0.550 | 0.390 | 0.326 | 0.291 | 0.264 | 0.380 | 0.409 | 0.509 | 0.681 | 0.595 |
| 362.70 | 0.363 | 0.308 | 0.267 | 0.236 | 0.358 | 0.405 | 0.476 | 0.644 | 0.550 | 0.390 | 0.332 | 0.288 | 0.263 | 0.380 | 0.409 | 0.509 | 0.694 | 0.594 |
| 363.20 | 0.359 | 0.306 | 0.269 | 0.236 | 0.356 | 0.395 | 0.470 | 0.640 | 0.553 | 0.390 | 0.333 | 0.290 | 0.263 | 0.380 | 0.409 | 0.509 | 0.674 | 0.593 |
| 363.70 | 0.360 | 0.307 | 0.257 | 0.236 | 0.357 | 0.404 | 0.469 | 0.644 | 0.550 | 0.390 | 0.329 | 0.288 | 0.262 | 0.380 | 0.408 | 0.509 | 0.674 | 0.592 |
| 364.20 | 0.359 | 0.307 | 0.266 | 0.235 | 0.357 | 0.403 | 0.470 | 0.643 | 0.550 | 0.390 | 0.324 | 0.286 | 0.261 | 0.380 | 0.410 | 0.509 | 0.673 | 0.593 |
| 364.70 | 0.361 | 0.310 | 0.268 | 0.234 | 0.360 | 0.403 | 0.475 | 0.643 | 0.550 | 0.390 | 0.321 | 0.290 | 0.261 | 0.380 | 0.408 | 0.509 | 0.673 | 0.593 |
| 365.20 | 0.360 | 0.310 | 0.265 | 0.235 | 0.360 | 0.403 | 0.476 | 0.642 | 0.550 | 0.390 | 0.327 | 0.294 | 0.261 | 0.380 | 0.406 | 0.509 | 0.678 | 0.592 |
| 365.70 | 0.361 | 0.308 | 0.273 | 0.234 | 0.358 | 0.402 | 0.478 | 0.644 | 0.550 | 0.390 | 0.320 | 0.293 | 0.261 | 0.380 | 0.407 | 0.509 | 0.675 | 0.591 |
| 366.20 | 0.360 | 0.308 | 0.267 | 0.234 | 0.358 | 0.399 | 0.478 | 0.644 | 0.550 | 0.390 | 0.335 | 0.292 | 0.261 | 0.380 | 0.407 | 0.509 | 0.675 | 0.593 |
| 366.70 | 0.358 | 0.309 | 0.262 | 0.234 | 0.359 | 0.402 | 0.479 | 0.641 | 0.551 | 0.390 | 0.332 | 0.293 | 0.260 | 0.380 | 0.407 | 0.509 | 0.688 | 0.591 |
| 367.20 | 0.358 | 0.308 | 0.259 | 0.234 | 0.358 | 0.400 | 0.470 | 0.642 | 0.552 | 0.390 | 0.335 | 0.291 | 0.260 | 0.380 | 0.405 | 0.509 | 0.684 | 0.592 |
| 367.70 | 0.359 | 0.308 | 0.258 | 0.232 | 0.358 | 0.401 | 0.479 | 0.644 | 0.551 | 0.390 | 0.332 | 0.294 | 0.258 | 0.380 | 0.405 | 0.509 | 0.672 | 0.591 |

| Hour | 45°C | | | | | | | | | 30°C | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | pH 5.0 | pH 5.5 | pH 6.0 | pH 6.5 | pH 7.0 | pH 7.5 | pH 8.0 | pH 8.5 | pH 9.0 | pH 5.0 | pH 5.5 | pH 6.0 | pH 6.5 | pH 7.0 | pH 7.5 | pH 8.0 | pH 8.5 | pH 9.0 |
| 368.20 | 0.358 | 0.308 | 0.260 | 0.231 | 0.358 | 0.400 | 0.479 | 0.642 | 0.551 | 0.390 | 0.335 | 0.294 | 0.258 | 0.380 | 0.405 | 0.510 | 0.685 | 0.591 |
| 368.70 | 0.358 | 0.308 | 0.272 | 0.240 | 0.358 | 0.400 | 0.477 | 0.643 | 0.550 | 0.391 | 0.329 | 0.294 | 0.258 | 0.381 | 0.415 | 0.509 | 0.679 | 0.591 |
| 369.20 | 0.356 | 0.307 | 0.269 | 0.238 | 0.357 | 0.402 | 0.479 | 0.639 | 0.551 | 0.391 | 0.331 | 0.291 | 0.257 | 0.381 | 0.414 | 0.509 | 0.673 | 0.590 |
| 369.70 | 0.357 | 0.274 | 0.269 | 0.237 | 0.274 | 0.400 | 0.358 | 0.638 | 0.541 | 0.351 | 0.331 | 0.290 | 0.257 | 0.251 | 0.413 | 0.506 | 0.679 | 0.490 |
| 370.20 | 0.357 | 0.316 | 0.272 | 0.239 | 0.281 | 0.400 | 0.394 | 0.638 | 0.540 | 0.370 | 0.327 | 0.291 | 0.256 | 0.270 | 0.412 | 0.498 | 0.680 | 0.493 |
| 370.70 | 0.360 | 0.313 | 0.276 | 0.239 | 0.363 | 0.401 | 0.476 | 0.637 | 0.540 | 0.394 | 0.331 | 0.291 | 0.256 | 0.384 | 0.411 | 0.512 | 0.681 | 0.590 |
| 371.20 | 0.360 | 0.320 | 0.265 | 0.239 | 0.370 | 0.402 | 0.476 | 0.642 | 0.546 | 0.391 | 0.331 | 0.291 | 0.256 | 0.381 | 0.412 | 0.472 | 0.672 | 0.576 |
| 371.70 | 0.358 | 0.323 | 0.267 | 0.237 | 0.373 | 0.402 | 0.478 | 0.288 | 0.541 | 0.421 | 0.330 | 0.292 | 0.256 | 0.376 | 0.412 | 0.499 | 0.675 | 0.570 |
| 372.20 | 0.358 | 0.322 | 0.268 | 0.235 | 0.222 | 0.402 | 0.478 | 0.387 | 0.544 | 0.420 | 0.334 | 0.292 | 0.256 | 0.245 | 0.411 | 0.502 | 0.671 | 0.575 |
| 372.70 | 0.359 | 0.324 | 0.273 | 0.235 | 0.274 | 0.400 | 0.477 | 0.393 | 0.543 | 0.401 | 0.331 | 0.294 | 0.257 | 0.286 | 0.412 | 0.506 | 0.680 | 0.591 |
| 373.20 | 0.358 | 0.327 | 0.272 | 0.236 | 0.377 | 0.400 | 0.469 | 0.637 | 0.542 | 0.404 | 0.320 | 0.294 | 0.260 | 0.389 | 0.410 | 0.504 | 0.678 | 0.599 |
| 373.70 | 0.358 | 0.330 | 0.279 | 0.240 | 0.380 | 0.250 | 0.476 | 0.636 | 0.542 | 0.402 | 0.328 | 0.289 | 0.260 | 0.387 | 0.429 | 0.501 | 0.672 | 0.576 |
| 374.20 | 0.358 | 0.325 | 0.278 | 0.235 | 0.375 | 0.396 | 0.469 | 0.637 | 0.542 | 0.401 | 0.323 | 0.294 | 0.259 | 0.386 | 0.430 | 0.501 | 0.671 | 0.566 |
| 374.70 | 0.358 | 0.328 | 0.262 | 0.236 | 0.378 | 0.396 | 0.469 | 0.638 | 0.545 | 0.399 | 0.324 | 0.291 | 0.259 | 0.384 | 0.411 | 0.499 | 0.675 | 0.574 |
| 375.20 | 0.357 | 0.334 | 0.263 | 0.240 | 0.384 | 0.393 | 0.468 | 0.637 | 0.539 | 0.396 | 0.330 | 0.293 | 0.258 | 0.381 | 0.413 | 0.498 | 0.670 | 0.578 |
| 375.70 | 0.364 | 0.335 | 0.270 | 0.240 | 0.385 | 0.393 | 0.465 | 0.640 | 0.544 | 0.398 | 0.333 | 0.292 | 0.258 | 0.378 | 0.413 | 0.496 | 0.678 | 0.580 |
| 376.20 | 0.361 | 0.320 | 0.264 | 0.240 | 0.390 | 0.392 | 0.473 | 0.638 | 0.531 | 0.396 | 0.332 | 0.294 | 0.257 | 0.376 | 0.412 | 0.512 | 0.684 | 0.586 |
| 376.70 | 0.363 | 0.316 | 0.270 | 0.238 | 0.386 | 0.391 | 0.472 | 0.642 | 0.553 | 0.423 | 0.334 | 0.292 | 0.256 | 0.373 | 0.412 | 0.512 | 0.681 | 0.589 |
| 378.70 | 0.360 | 0.315 | 0.270 | 0.238 | 0.395 | 0.389 | 0.471 | 0.640 | 0.554 | 0.406 | 0.333 | 0.266 | 0.257 | 0.386 | 0.411 | 0.505 | 0.681 | 0.586 |
| 379.20 | 0.363 | 0.313 | 0.265 | 0.238 | 0.393 | 0.390 | 0.471 | 0.639 | 0.554 | 0.405 | 0.335 | 0.289 | 0.256 | 0.385 | 0.412 | 0.496 | 0.672 | 0.583 |
| 379.70 | 0.362 | 0.331 | 0.271 | 0.242 | 0.381 | 0.388 | 0.479 | 0.643 | 0.554 | 0.405 | 0.331 | 0.286 | 0.257 | 0.380 | 0.410 | 0.499 | 0.674 | 0.581 |
| 380.20 | 0.364 | 0.311 | 0.267 | 0.243 | 0.376 | 0.388 | 0.475 | 0.643 | 0.554 | 0.403 | 0.331 | 0.286 | 0.257 | 0.378 | 0.412 | 0.496 | 0.676 | 0.578 |
| 380.70 | 0.377 | 0.311 | 0.277 | 0.243 | 0.376 | 0.379 | 0.472 | 0.637 | 0.554 | 0.402 | 0.333 | 0.286 | 0.257 | 0.377 | 0.411 | 0.499 | 0.684 | 0.575 |
| 381.20 | 0.380 | 0.311 | 0.278 | 0.242 | 0.376 | 0.381 | 0.471 | 0.639 | 0.554 | 0.402 | 0.331 | 0.287 | 0.256 | 0.377 | 0.410 | 0.498 | 0.684 | 0.573 |
| 381.70 | 0.365 | 0.313 | 0.269 | 0.242 | 0.378 | 0.380 | 0.469 | 0.642 | 0.554 | 0.401 | 0.329 | 0.286 | 0.256 | 0.376 | 0.430 | 0.496 | 0.681 | 0.570 |
| 382.20 | 0.378 | 0.312 | 0.275 | 0.243 | 0.377 | 0.379 | 0.468 | 0.640 | 0.554 | 0.400 | 0.331 | 0.286 | 0.255 | 0.395 | 0.429 | 0.514 | 0.680 | 0.569 |
| 382.70 | 0.364 | 0.314 | 0.271 | 0.243 | 0.379 | 0.378 | 0.466 | 0.643 | 0.554 | 0.399 | 0.333 | 0.294 | 0.256 | 0.394 | 0.426 | 0.512 | 0.683 | 0.567 |
| 383.20 | 0.365 | 0.316 | 0.266 | 0.241 | 0.381 | 0.377 | 0.465 | 0.635 | 0.555 | 0.398 | 0.321 | 0.286 | 0.256 | 0.393 | 0.427 | 0.506 | 0.680 | 0.565 |
| 383.70 | 0.370 | 0.317 | 0.268 | 0.240 | 0.387 | 0.377 | 0.464 | 0.637 | 0.555 | 0.398 | 0.333 | 0.287 | 0.262 | 0.393 | 0.426 | 0.504 | 0.683 | 0.590 |
| 384.20 | 0.366 | 0.311 | 0.266 | 0.243 | 0.391 | 0.376 | 0.458 | 0.637 | 0.555 | 0.396 | 0.325 | 0.286 | 0.260 | 0.391 | 0.426 | 0.503 | 0.673 | 0.588 |
| 384.70 | 0.366 | 0.320 | 0.266 | 0.244 | 0.390 | 0.375 | 0.406 | 0.638 | 0.555 | 0.399 | 0.329 | 0.286 | 0.261 | 0.379 | 0.428 | 0.500 | 0.673 | 0.587 |
| 385.20 | 0.368 | 0.317 | 0.268 | 0.243 | 0.387 | 0.375 | 0.406 | 0.639 | 0.555 | 0.398 | 0.331 | 0.286 | 0.262 | 0.378 | 0.418 | 0.498 | 0.674 | 0.585 |
| 385.70 | 0.365 | 0.316 | 0.277 | 0.241 | 0.386 | 0.375 | 0.405 | 0.642 | 0.555 | 0.397 | 0.333 | 0.292 | 0.262 | 0.377 | 0.409 | 0.495 | 0.682 | 0.584 |

| Hour | 45°C | | | | | | | | | 30°C | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | pH 5.0 | pH 5.5 | pH 6.0 | pH 6.5 | pH 7.0 | pH 7.5 | pH 8.0 | pH 8.5 | pH 9.0 | pH 5.0 | pH 5.5 | pH 6.0 | pH 6.5 | pH 7.0 | pH 7.5 | pH 8.0 | pH 8.5 | pH 9.0 |
| 386.20 | 0.375 | 0.315 | 0.272 | 0.241 | 0.385 | 0.373 | 0.404 | 0.636 | 0.545 | 0.397 | 0.323 | 0.291 | 0.259 | 0.377 | 0.425 | 0.474 | 0.685 | 0.583 |
| 386.70 | 0.373 | 0.320 | 0.268 | 0.240 | 0.385 | 0.373 | 0.403 | 0.641 | 0.545 | 0.398 | 0.332 | 0.292 | 0.261 | 0.378 | 0.421 | 0.472 | 0.683 | 0.582 |
| 387.20 | 0.361 | 0.320 | 0.271 | 0.244 | 0.385 | 0.383 | 0.403 | 0.644 | 0.545 | 0.398 | 0.334 | 0.292 | 0.261 | 0.378 | 0.406 | 0.507 | 0.679 | 0.581 |
| 387.70 | 0.376 | 0.318 | 0.272 | 0.245 | 0.383 | 0.382 | 0.402 | 0.642 | 0.545 | 0.397 | 0.321 | 0.292 | 0.261 | 0.377 | 0.426 | 0.507 | 0.678 | 0.581 |
| 388.20 | 0.376 | 0.318 | 0.280 | 0.241 | 0.383 | 0.382 | 0.402 | 0.642 | 0.545 | 0.395 | 0.324 | 0.292 | 0.262 | 0.375 | 0.411 | 0.507 | 0.677 | 0.580 |
| 388.70 | 0.376 | 0.318 | 0.262 | 0.241 | 0.383 | 0.390 | 0.402 | 0.644 | 0.545 | 0.425 | 0.333 | 0.292 | 0.262 | 0.395 | 0.166 | 0.505 | 0.673 | 0.579 |
| 389.20 | 0.378 | 0.316 | 0.255 | 0.245 | 0.381 | 0.381 | 0.402 | 0.644 | 0.545 | 0.423 | 0.335 | 0.291 | 0.260 | 0.393 | 0.423 | 0.505 | 0.675 | 0.578 |
| 389.70 | 0.377 | 0.318 | 0.277 | 0.241 | 0.383 | 0.390 | 0.401 | 0.635 | 0.545 | 0.424 | 0.330 | 0.292 | 0.259 | 0.394 | 0.420 | 0.499 | 0.681 | 0.578 |
| 390.20 | 0.379 | 0.314 | 0.278 | 0.245 | 0.379 | 0.380 | 0.401 | 0.645 | 0.545 | 0.423 | 0.331 | 0.287 | 0.258 | 0.393 | 0.169 | 0.498 | 0.681 | 0.577 |
| 390.70 | 0.361 | 0.319 | 0.258 | 0.244 | 0.389 | 0.388 | 0.401 | 0.637 | 0.545 | 0.421 | 0.331 | 0.288 | 0.259 | 0.391 | 0.415 | 0.498 | 0.672 | 0.577 |
| 391.20 | 0.367 | 0.315 | 0.273 | 0.243 | 0.385 | 0.389 | 0.401 | 0.636 | 0.545 | 0.422 | 0.334 | 0.293 | 0.259 | 0.392 | 0.406 | 0.496 | 0.551 | 0.577 |
| 391.70 | 0.371 | 0.319 | 0.255 | 0.241 | 0.384 | 0.388 | 0.400 | 0.636 | 0.545 | 0.421 | 0.332 | 0.295 | 0.259 | 0.391 | 0.411 | 0.497 | 0.678 | 0.576 |
| 392.20 | 0.370 | 0.317 | 0.279 | 0.241 | 0.382 | 0.386 | 0.401 | 0.638 | 0.545 | 0.409 | 0.325 | 0.294 | 0.259 | 0.389 | 0.417 | 0.496 | 0.671 | 0.577 |
| 392.70 | 0.367 | 0.316 | 0.267 | 0.241 | 0.381 | 0.395 | 0.401 | 0.641 | 0.545 | 0.404 | 0.324 | 0.293 | 0.259 | 0.379 | 0.427 | 0.495 | 0.681 | 0.576 |
| 393.20 | 0.366 | 0.265 | 0.269 | 0.241 | 0.365 | 0.386 | 0.358 | 0.640 | 0.545 | 0.350 | 0.323 | 0.292 | 0.258 | 0.250 | 0.422 | 0.504 | 0.681 | 0.584 |
| 393.70 | 0.365 | 0.267 | 0.270 | 0.242 | 0.367 | 0.386 | 0.370 | 0.641 | 0.544 | 0.370 | 0.324 | 0.293 | 0.257 | 0.295 | 0.417 | 0.503 | 0.673 | 0.580 |
| 394.20 | 0.365 | 0.310 | 0.256 | 0.241 | 0.360 | 0.394 | 0.423 | 0.641 | 0.536 | 0.402 | 0.332 | 0.292 | 0.257 | 0.377 | 0.416 | 0.499 | 0.681 | 0.584 |
| 394.70 | 0.365 | 0.303 | 0.270 | 0.235 | 0.353 | 0.394 | 0.422 | 0.642 | 0.546 | 0.396 | 0.331 | 0.289 | 0.258 | 0.371 | 0.413 | 0.470 | 0.682 | 0.590 |
| 395.20 | 0.363 | 0.333 | 0.272 | 0.240 | 0.383 | 0.394 | 0.378 | 0.642 | 0.535 | 0.404 | 0.328 | 0.290 | 0.257 | 0.379 | 0.420 | 0.473 | 0.688 | 0.597 |
| 395.70 | 0.363 | 0.302 | 0.276 | 0.235 | 0.352 | 0.394 | 0.471 | 0.636 | 0.535 | 0.395 | 0.324 | 0.291 | 0.257 | 0.375 | 0.413 | 0.515 | 0.683 | 0.577 |
| 396.20 | 0.363 | 0.317 | 0.261 | 0.234 | 0.367 | 0.393 | 0.472 | 0.294 | 0.530 | 0.395 | 0.331 | 0.293 | 0.257 | 0.370 | 0.414 | 0.497 | 0.671 | 0.588 |
| 396.70 | 0.361 | 0.314 | 0.273 | 0.235 | 0.399 | 0.393 | 0.472 | 0.297 | 0.542 | 0.398 | 0.335 | 0.293 | 0.256 | 0.373 | 0.416 | 0.508 | 0.675 | 0.573 |
| 397.20 | 0.363 | 0.334 | 0.276 | 0.240 | 0.384 | 0.391 | 0.472 | 0.378 | 0.535 | 0.398 | 0.323 | 0.292 | 0.256 | 0.373 | 0.416 | 0.509 | 0.677 | 0.571 |
| 397.70 | 0.379 | 0.308 | 0.259 | 0.234 | 0.358 | 0.392 | 0.475 | 0.397 | 0.544 | 0.409 | 0.327 | 0.291 | 0.260 | 0.389 | 0.414 | 0.474 | 0.680 | 0.581 |
| 398.20 | 0.369 | 0.319 | 0.267 | 0.231 | 0.389 | 0.391 | 0.479 | 0.641 | 0.535 | 0.410 | 0.330 | 0.291 | 0.256 | 0.390 | 0.415 | 0.504 | 0.683 | 0.581 |
| 398.70 | 0.365 | 0.319 | 0.277 | 0.232 | 0.389 | 0.391 | 0.454 | 0.636 | 0.536 | 0.421 | 0.325 | 0.291 | 0.256 | 0.391 | 0.415 | 0.502 | 0.682 | 0.587 |
| 399.20 | 0.364 | 0.319 | 0.272 | 0.232 | 0.389 | 0.391 | 0.461 | 0.643 | 0.544 | 0.397 | 0.334 | 0.292 | 0.259 | 0.377 | 0.415 | 0.473 | 0.552 | 0.571 |
| 399.70 | 0.362 | 0.319 | 0.277 | 0.231 | 0.389 | 0.399 | 0.466 | 0.641 | 0.534 | 0.396 | 0.327 | 0.292 | 0.255 | 0.376 | 0.414 | 0.499 | 0.672 | 0.588 |
| 400.20 | 0.361 | 0.319 | 0.268 | 0.231 | 0.389 | 0.400 | 0.462 | 0.645 | 0.553 | 0.399 | 0.326 | 0.290 | 0.256 | 0.389 | 0.412 | 0.510 | 0.551 | 0.588 |
| 400.70 | 0.365 | 0.319 | 0.274 | 0.231 | 0.389 | 0.397 | 0.471 | 0.642 | 0.542 | 0.406 | 0.334 | 0.290 | 0.255 | 0.381 | 0.413 | 0.500 | 0.678 | 0.580 |
| 402.70 | 0.367 | 0.319 | 0.263 | 0.237 | 0.389 | 0.398 | 0.470 | 0.643 | 0.547 | 0.366 | 0.331 | 0.260 | 0.259 | 0.386 | 0.169 | 0.499 | 0.673 | 0.496 |
| 403.20 | 0.360 | 0.319 | 0.267 | 0.238 | 0.389 | 0.397 | 0.471 | 0.640 | 0.541 | 0.421 | 0.333 | 0.290 | 0.258 | 0.371 | 0.429 | 0.511 | 0.684 | 0.576 |
| 403.70 | 0.363 | 0.319 | 0.267 | 0.239 | 0.389 | 0.396 | 0.469 | 0.636 | 0.527 | 0.409 | 0.332 | 0.293 | 0.258 | 0.389 | 0.429 | 0.510 | 0.678 | 0.578 |

| Hour | 45°C | | | | | | | | | 30°C | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | pH 5.0 | pH 5.5 | pH 6.0 | pH 6.5 | pH 7.0 | pH 7.5 | pH 8.0 | pH 8.5 | pH 9.0 | pH 5.0 | pH 5.5 | pH 6.0 | pH 6.5 | pH 7.0 | pH 7.5 | pH 8.0 | pH 8.5 | pH 9.0 |
| 404.20 | 0.363 | 0.319 | 0.271 | 0.232 | 0.389 | 0.398 | 0.470 | 0.642 | 0.542 | 0.421 | 0.330 | 0.291 | 0.257 | 0.371 | 0.428 | 0.501 | 0.553 | 0.584 |
| 404.70 | 0.362 | 0.319 | 0.259 | 0.236 | 0.389 | 0.396 | 0.452 | 0.644 | 0.542 | 0.396 | 0.331 | 0.288 | 0.258 | 0.376 | 0.427 | 0.500 | 0.679 | 0.587 |
| 405.20 | 0.367 | 0.319 | 0.265 | 0.235 | 0.389 | 0.405 | 0.456 | 0.625 | 0.553 | 0.397 | 0.328 | 0.288 | 0.257 | 0.377 | 0.428 | 0.510 | 0.672 | 0.584 |
| 405.70 | 0.364 | 0.319 | 0.274 | 0.235 | 0.389 | 0.405 | 0.458 | 0.637 | 0.545 | 0.397 | 0.329 | 0.291 | 0.257 | 0.382 | 0.428 | 0.504 | 0.681 | 0.588 |
| 406.20 | 0.364 | 0.319 | 0.258 | 0.234 | 0.389 | 0.403 | 0.459 | 0.643 | 0.540 | 0.398 | 0.333 | 0.285 | 0.256 | 0.378 | 0.422 | 0.503 | 0.680 | 0.579 |
| 406.70 | 0.358 | 0.319 | 0.273 | 0.233 | 0.389 | 0.401 | 0.458 | 0.642 | 0.555 | 0.405 | 0.330 | 0.285 | 0.257 | 0.390 | 0.427 | 0.511 | 0.679 | 0.571 |
| 407.20 | 0.369 | 0.319 | 0.280 | 0.233 | 0.389 | 0.401 | 0.454 | 0.637 | 0.550 | 0.400 | 0.331 | 0.299 | 0.255 | 0.385 | 0.422 | 0.514 | 0.678 | 0.579 |
| 407.70 | 0.369 | 0.319 | 0.270 | 0.233 | 0.389 | 0.402 | 0.456 | 0.642 | 0.541 | 0.398 | 0.333 | 0.297 | 0.255 | 0.383 | 0.427 | 0.510 | 0.683 | 0.593 |
| 408.20 | 0.369 | 0.319 | 0.259 | 0.233 | 0.389 | 0.401 | 0.453 | 0.644 | 0.532 | 0.398 | 0.333 | 0.297 | 0.253 | 0.383 | 0.426 | 0.500 | 0.682 | 0.583 |
| 408.70 | 0.369 | 0.319 | 0.272 | 0.233 | 0.389 | 0.401 | 0.455 | 0.642 | 0.542 | 0.400 | 0.334 | 0.297 | 0.252 | 0.385 | 0.417 | 0.513 | 0.684 | 0.592 |
| 409.20 | 0.369 | 0.319 | 0.274 | 0.232 | 0.389 | 0.399 | 0.459 | 0.642 | 0.541 | 0.401 | 0.334 | 0.295 | 0.265 | 0.386 | 0.428 | 0.514 | 0.684 | 0.588 |
| 409.70 | 0.369 | 0.319 | 0.266 | 0.231 | 0.389 | 0.400 | 0.471 | 0.643 | 0.533 | 0.404 | 0.334 | 0.295 | 0.265 | 0.389 | 0.418 | 0.513 | 0.680 | 0.592 |
| 410.20 | 0.369 | 0.319 | 0.277 | 0.230 | 0.389 | 0.399 | 0.476 | 0.636 | 0.528 | 0.404 | 0.323 | 0.294 | 0.264 | 0.389 | 0.415 | 0.501 | 0.697 | 0.598 |
| 410.70 | 0.369 | 0.319 | 0.269 | 0.230 | 0.389 | 0.399 | 0.471 | 0.643 | 0.538 | 0.399 | 0.320 | 0.295 | 0.264 | 0.384 | 0.425 | 0.510 | 0.693 | 0.590 |
| 411.20 | 0.369 | 0.319 | 0.267 | 0.231 | 0.389 | 0.399 | 0.476 | 0.642 | 0.549 | 0.397 | 0.335 | 0.294 | 0.263 | 0.382 | 0.425 | 0.515 | 0.696 | 0.596 |
| 411.70 | 0.369 | 0.319 | 0.261 | 0.230 | 0.389 | 0.396 | 0.474 | 0.643 | 0.535 | 0.397 | 0.332 | 0.295 | 0.263 | 0.382 | 0.419 | 0.512 | 0.695 | 0.593 |
| 412.20 | 0.369 | 0.319 | 0.268 | 0.244 | 0.389 | 0.398 | 0.479 | 0.639 | 0.527 | 0.398 | 0.334 | 0.298 | 0.262 | 0.378 | 0.414 | 0.511 | 0.687 | 0.578 |
| 412.70 | 0.369 | 0.319 | 0.264 | 0.243 | 0.389 | 0.398 | 0.479 | 0.639 | 0.532 | 0.396 | 0.333 | 0.294 | 0.262 | 0.376 | 0.423 | 0.513 | 0.673 | 0.565 |
| 413.20 | 0.369 | 0.319 | 0.264 | 0.242 | 0.389 | 0.398 | 0.478 | 0.637 | 0.537 | 0.424 | 0.333 | 0.297 | 0.261 | 0.374 | 0.422 | 0.513 | 0.685 | 0.584 |
| 413.70 | 0.369 | 0.319 | 0.268 | 0.242 | 0.389 | 0.395 | 0.477 | 0.637 | 0.533 | 0.399 | 0.335 | 0.296 | 0.262 | 0.379 | 0.423 | 0.513 | 0.687 | 0.589 |
| 414.20 | 0.369 | 0.319 | 0.255 | 0.243 | 0.389 | 0.396 | 0.471 | 0.637 | 0.537 | 0.397 | 0.333 | 0.298 | 0.262 | 0.382 | 0.423 | 0.495 | 0.686 | 0.588 |
| 414.70 | 0.369 | 0.319 | 0.268 | 0.242 | 0.389 | 0.396 | 0.477 | 0.637 | 0.533 | 0.399 | 0.330 | 0.297 | 0.262 | 0.379 | 0.420 | 0.513 | 0.687 | 0.589 |
| 415.20 | 0.369 | 0.319 | 0.273 | 0.241 | 0.389 | 0.393 | 0.471 | 0.635 | 0.537 | 0.397 | 0.328 | 0.295 | 0.261 | 0.382 | 0.421 | 0.495 | 0.681 | 0.588 |
| 415.70 | 0.369 | 0.319 | 0.271 | 0.240 | 0.389 | 0.395 | 0.477 | 0.635 | 0.533 | 0.399 | 0.329 | 0.300 | 0.262 | 0.379 | 0.421 | 0.513 | 0.686 | 0.589 |
| 416.20 | 0.369 | 0.319 | 0.276 | 0.239 | 0.389 | 0.394 | 0.471 | 0.639 | 0.537 | 0.397 | 0.325 | 0.295 | 0.260 | 0.382 | 0.420 | 0.495 | 0.695 | 0.588 |
| 416.70 | 0.369 | 0.325 | 0.271 | 0.239 | 0.375 | 0.393 | 0.477 | 0.638 | 0.544 | 0.395 | 0.333 | 0.293 | 0.260 | 0.375 | 0.414 | 0.509 | 0.670 | 0.587 |
| 417.20 | 0.369 | 0.318 | 0.273 | 0.239 | 0.368 | 0.392 | 0.477 | 0.637 | 0.542 | 0.399 | 0.324 | 0.293 | 0.260 | 0.384 | 0.419 | 0.509 | 0.676 | 0.587 |
| 417.70 | 0.369 | 0.323 | 0.267 | 0.240 | 0.373 | 0.392 | 0.478 | 0.640 | 0.553 | 0.398 | 0.326 | 0.288 | 0.260 | 0.393 | 0.420 | 0.509 | 0.675 | 0.587 |
| 418.20 | 0.369 | 0.313 | 0.266 | 0.239 | 0.363 | 0.391 | 0.478 | 0.640 | 0.552 | 0.397 | 0.326 | 0.294 | 0.261 | 0.377 | 0.420 | 0.509 | 0.673 | 0.587 |
| 418.70 | 0.369 | 0.316 | 0.278 | 0.238 | 0.366 | 0.391 | 0.480 | 0.639 | 0.546 | 0.424 | 0.328 | 0.286 | 0.259 | 0.374 | 0.419 | 0.509 | 0.681 | 0.587 |
| 419.20 | 0.369 | 0.318 | 0.268 | 0.238 | 0.368 | 0.391 | 0.478 | 0.639 | 0.542 | 0.420 | 0.330 | 0.288 | 0.258 | 0.370 | 0.419 | 0.509 | 0.681 | 0.587 |
| 419.70 | 0.369 | 0.319 | 0.277 | 0.236 | 0.369 | 0.393 | 0.475 | 0.640 | 0.547 | 0.402 | 0.325 | 0.285 | 0.260 | 0.377 | 0.419 | 0.509 | 0.673 | 0.587 |
| 420.20 | 0.369 | 0.313 | 0.268 | 0.237 | 0.363 | 0.393 | 0.478 | 0.638 | 0.540 | 0.402 | 0.324 | 0.286 | 0.259 | 0.377 | 0.418 | 0.509 | 0.685 | 0.587 |

| Hour | 45°C | | | | | | | | | 30°C | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | pH 5.0 | pH 5.5 | pH 6.0 | pH 6.5 | pH 7.0 | pH 7.5 | pH 8.0 | pH 8.5 | pH 9.0 | pH 5.0 | pH 5.5 | pH 6.0 | pH 6.5 | pH 7.0 | pH 7.5 | pH 8.0 | pH 8.5 | pH 9.0 |
| 420.70 | 0.369 | 0.312 | 0.272 | 0.236 | 0.362 | 0.392 | 0.470 | 0.292 | 0.544 | 0.403 | 0.325 | 0.287 | 0.258 | 0.378 | 0.417 | 0.509 | 0.697 | 0.587 |
| 421.20 | 0.369 | 0.312 | 0.264 | 0.236 | 0.362 | 0.390 | 0.477 | 0.377 | 0.542 | 0.393 | 0.326 | 0.293 | 0.258 | 0.383 | 0.416 | 0.509 | 0.699 | 0.587 |
| 421.70 | 0.369 | 0.302 | 0.266 | 0.236 | 0.352 | 0.391 | 0.475 | 0.396 | 0.541 | 0.395 | 0.323 | 0.297 | 0.260 | 0.385 | 0.416 | 0.509 | 0.686 | 0.587 |
| 422.20 | 0.369 | 0.302 | 0.272 | 0.235 | 0.352 | 0.391 | 0.479 | 0.635 | 0.543 | 0.393 | 0.322 | 0.291 | 0.259 | 0.383 | 0.417 | 0.509 | 0.695 | 0.587 |
| 422.70 | 0.369 | 0.301 | 0.270 | 0.231 | 0.351 | 0.391 | 0.477 | 0.641 | 0.551 | 0.398 | 0.332 | 0.295 | 0.222 | 0.393 | 0.416 | 0.509 | 0.688 | 0.587 |
| 423.20 | 0.369 | 0.314 | 0.264 | 0.244 | 0.399 | 0.391 | 0.476 | 0.636 | 0.551 | 0.400 | 0.332 | 0.297 | 0.258 | 0.395 | 0.416 | 0.509 | 0.687 | 0.587 |
| 423.70 | 0.369 | 0.305 | 0.275 | 0.237 | 0.355 | 0.390 | 0.478 | 0.640 | 0.546 | 0.406 | 0.332 | 0.299 | 0.257 | 0.386 | 0.415 | 0.509 | 0.680 | 0.587 |
| 424.20 | 0.369 | 0.314 | 0.278 | 0.237 | 0.399 | 0.390 | 0.476 | 0.639 | 0.554 | 0.398 | 0.323 | 0.286 | 0.251 | 0.383 | 0.415 | 0.509 | 0.683 | 0.587 |
| 426.30 | 0.369 | 0.312 | 0.276 | 0.230 | 0.397 | 0.388 | 0.477 | 0.636 | 0.551 | 0.404 | 0.289 | 0.291 | 0.250 | 0.389 | 0.288 | 0.509 | 0.695 | 0.587 |
| 426.80 | 0.369 | 0.305 | 0.257 | 0.235 | 0.355 | 0.364 | 0.479 | 0.640 | 0.552 | 0.406 | 0.282 | 0.290 | 0.256 | 0.391 | 0.362 | 0.509 | 0.682 | 0.587 |
| 427.30 | 0.365 | 0.314 | 0.261 | 0.239 | 0.399 | 0.377 | 0.477 | 0.639 | 0.555 | 0.406 | 0.304 | 0.293 | 0.258 | 0.391 | 0.398 | 0.509 | 0.684 | 0.587 |
| 427.80 | 0.368 | 0.302 | 0.270 | 0.230 | 0.352 | 0.404 | 0.480 | 0.636 | 0.541 | 0.406 | 0.311 | 0.299 | 0.259 | 0.391 | 0.417 | 0.509 | 0.695 | 0.587 |
| 428.30 | 0.363 | 0.306 | 0.260 | 0.250 | 0.356 | 0.404 | 0.476 | 0.636 | 0.546 | 0.400 | 0.305 | 0.290 | 0.255 | 0.385 | 0.416 | 0.509 | 0.695 | 0.587 |
| 428.80 | 0.363 | 0.309 | 0.260 | 0.240 | 0.359 | 0.401 | 0.477 | 0.637 | 0.544 | 0.398 | 0.323 | 0.294 | 0.264 | 0.383 | 0.417 | 0.509 | 0.695 | 0.587 |
| 429.30 | 0.366 | 0.305 | 0.260 | 0.238 | 0.355 | 0.405 | 0.478 | 0.636 | 0.549 | 0.406 | 0.333 | 0.290 | 0.265 | 0.391 | 0.418 | 0.509 | 0.699 | 0.587 |
| 429.80 | 0.368 | 0.301 | 0.255 | 0.237 | 0.351 | 0.403 | 0.473 | 0.638 | 0.542 | 0.398 | 0.334 | 0.290 | 0.265 | 0.383 | 0.427 | 0.509 | 0.698 | 0.587 |
| 430.30 | 0.369 | 0.313 | 0.273 | 0.234 | 0.398 | 0.403 | 0.471 | 0.639 | 0.542 | 0.396 | 0.335 | 0.299 | 0.264 | 0.381 | 0.420 | 0.509 | 0.695 | 0.587 |
| 430.80 | 0.363 | 0.314 | 0.271 | 0.233 | 0.399 | 0.403 | 0.477 | 0.636 | 0.544 | 0.403 | 0.333 | 0.291 | 0.255 | 0.388 | 0.418 | 0.507 | 0.695 | 0.589 |
| 431.30 | 0.362 | 0.313 | 0.277 | 0.236 | 0.393 | 0.405 | 0.475 | 0.637 | 0.551 | 0.398 | 0.341 | 0.300 | 0.264 | 0.383 | 0.422 | 0.507 | 0.701 | 0.588 |
| 431.80 | 0.362 | 0.311 | 0.274 | 0.238 | 0.396 | 0.402 | 0.471 | 0.638 | 0.548 | 0.399 | 0.338 | 0.297 | 0.263 | 0.384 | 0.420 | 0.507 | 0.695 | 0.583 |
| 432.30 | 0.362 | 0.311 | 0.255 | 0.237 | 0.396 | 0.403 | 0.473 | 0.638 | 0.539 | 0.399 | 0.343 | 0.297 | 0.263 | 0.384 | 0.429 | 0.507 | 0.695 | 0.588 |
| 432.80 | 0.362 | 0.314 | 0.279 | 0.237 | 0.394 | 0.404 | 0.475 | 0.635 | 0.527 | 0.401 | 0.336 | 0.296 | 0.260 | 0.386 | 0.423 | 0.507 | 0.695 | 0.585 |
| 433.30 | 0.361 | 0.314 | 0.278 | 0.237 | 0.394 | 0.402 | 0.476 | 0.636 | 0.528 | 0.402 | 0.337 | 0.296 | 0.259 | 0.387 | 0.423 | 0.507 | 0.695 | 0.584 |
| 433.80 | 0.364 | 0.311 | 0.270 | 0.235 | 0.396 | 0.403 | 0.479 | 0.640 | 0.536 | 0.401 | 0.347 | 0.297 | 0.259 | 0.386 | 0.417 | 0.507 | 0.695 | 0.584 |
| 434.30 | 0.365 | 0.302 | 0.272 | 0.235 | 0.352 | 0.404 | 0.473 | 0.640 | 0.540 | 0.404 | 0.343 | 0.287 | 0.258 | 0.389 | 0.429 | 0.507 | 0.695 | 0.586 |
| 434.80 | 0.364 | 0.315 | 0.272 | 0.236 | 0.400 | 0.403 | 0.471 | 0.637 | 0.535 | 0.398 | 0.300 | 0.290 | 0.258 | 0.383 | 0.422 | 0.507 | 0.695 | 0.577 |
| 435.30 | 0.362 | 0.313 | 0.274 | 0.239 | 0.398 | 0.401 | 0.472 | 0.635 | 0.529 | 0.406 | 0.345 | 0.292 | 0.257 | 0.391 | 0.420 | 0.507 | 0.695 | 0.582 |
| 435.80 | 0.355 | 0.303 | 0.267 | 0.238 | 0.353 | 0.401 | 0.471 | 0.637 | 0.532 | 0.399 | 0.342 | 0.285 | 0.256 | 0.379 | 0.423 | 0.507 | 0.695 | 0.575 |
| 436.30 | 0.364 | 0.301 | 0.261 | 0.237 | 0.351 | 0.401 | 0.471 | 0.640 | 0.544 | 0.397 | 0.335 | 0.297 | 0.256 | 0.377 | 0.425 | 0.507 | 0.695 | 0.572 |
| 436.80 | 0.362 | 0.311 | 0.264 | 0.234 | 0.361 | 0.404 | 0.471 | 0.636 | 0.537 | 0.422 | 0.338 | 0.287 | 0.255 | 0.372 | 0.427 | 0.507 | 0.692 | 0.579 |
| 437.30 | 0.356 | 0.307 | 0.261 | 0.235 | 0.357 | 0.405 | 0.478 | 0.640 | 0.532 | 0.423 | 0.339 | 0.299 | 0.255 | 0.373 | 0.427 | 0.507 | 0.673 | 0.574 |
| 437.80 | 0.359 | 0.305 | 0.264 | 0.233 | 0.355 | 0.400 | 0.477 | 0.640 | 0.533 | 0.422 | 0.339 | 0.290 | 0.255 | 0.372 | 0.428 | 0.507 | 0.677 | 0.573 |
| 438.30 | 0.355 | 0.301 | 0.264 | 0.232 | 0.351 | 0.403 | 0.510 | 0.638 | 0.548 | 0.402 | 0.344 | 0.287 | 0.253 | 0.377 | 0.429 | 0.498 | 0.683 | 0.587 |

| Hour | 45°C | | | | | | | | | 30°C | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | pH 5.0 | pH 5.5 | pH 6.0 | pH 6.5 | pH 7.0 | pH 7.5 | pH 8.0 | pH 8.5 | pH 9.0 | pH 5.0 | pH 5.5 | pH 6.0 | pH 6.5 | pH 7.0 | pH 7.5 | pH 8.0 | pH 8.5 | pH 9.0 |
| 438.80 | 0.361 | 0.301 | 0.255 | 0.231 | 0.351 | 0.401 | 0.476 | 0.640 | 0.544 | 0.392 | 0.342 | 0.287 | 0.254 | 0.382 | 0.422 | 0.498 | 0.684 | 0.589 |
| 439.30 | 0.363 | 0.302 | 0.255 | 0.232 | 0.352 | 0.401 | 0.467 | 0.636 | 0.548 | 0.396 | 0.335 | 0.287 | 0.252 | 0.376 | 0.416 | 0.507 | 0.681 | 0.590 |
| 439.80 | 0.364 | 0.301 | 0.255 | 0.232 | 0.351 | 0.404 | 0.479 | 0.637 | 0.537 | 0.398 | 0.333 | 0.287 | 0.253 | 0.388 | 0.421 | 0.498 | 0.694 | 0.584 |
| 440.30 | 0.373 | 0.300 | 0.255 | 0.234 | 0.350 | 0.401 | 0.478 | 0.643 | 0.547 | 0.409 | 0.337 | 0.289 | 0.251 | 0.384 | 0.424 | 0.511 | 0.671 | 0.569 |
| 440.80 | 0.361 | 0.300 | 0.255 | 0.233 | 0.350 | 0.404 | 0.475 | 0.642 | 0.542 | 0.423 | 0.342 | 0.291 | 0.251 | 0.378 | 0.422 | 0.497 | 0.680 | 0.570 |
| 441.30 | 0.361 | 0.218 | 0.255 | 0.233 | 0.218 | 0.405 | 0.493 | 0.640 | 0.474 | 0.370 | 0.343 | 0.292 | 0.251 | 0.295 | 0.422 | 0.498 | 0.694 | 0.593 |
| 441.80 | 0.374 | 0.228 | 0.264 | 0.232 | 0.228 | 0.405 | 0.489 | 0.638 | 0.474 | 0.363 | 0.345 | 0.290 | 0.251 | 0.288 | 0.424 | 0.503 | 0.692 | 0.566 |
| 442.30 | 0.374 | 0.327 | 0.263 | 0.232 | 0.377 | 0.401 | 0.477 | 0.640 | 0.525 | 0.403 | 0.341 | 0.289 | 0.265 | 0.378 | 0.424 | 0.500 | 0.699 | 0.571 |
| 442.80 | 0.361 | 0.330 | 0.262 | 0.245 | 0.380 | 0.404 | 0.477 | 0.639 | 0.526 | 0.399 | 0.342 | 0.292 | 0.264 | 0.389 | 0.415 | 0.511 | 0.693 | 0.574 |
| 443.30 | 0.362 | 0.330 | 0.261 | 0.231 | 0.380 | 0.405 | 0.469 | 0.639 | 0.534 | 0.399 | 0.337 | 0.290 | 0.264 | 0.389 | 0.425 | 0.497 | 0.681 | 0.584 |
| 443.80 | 0.365 | 0.317 | 0.255 | 0.231 | 0.387 | 0.401 | 0.473 | 0.641 | 0.530 | 0.406 | 0.334 | 0.293 | 0.263 | 0.381 | 0.417 | 0.496 | 0.582 | 0.588 |
| 444.30 | 0.363 | 0.314 | 0.262 | 0.230 | 0.394 | 0.404 | 0.473 | 0.638 | 0.535 | 0.400 | 0.332 | 0.291 | 0.263 | 0.390 | 0.416 | 0.499 | 0.694 | 0.588 |
| 444.80 | 0.363 | 0.310 | 0.265 | 0.244 | 0.390 | 0.404 | 0.465 | 0.636 | 0.535 | 0.400 | 0.330 | 0.294 | 0.264 | 0.380 | 0.425 | 0.472 | 0.681 | 0.576 |
| 445.30 | 0.361 | 0.311 | 0.264 | 0.244 | 0.391 | 0.403 | 0.470 | 0.389 | 0.527 | 0.400 | 0.338 | 0.291 | 0.263 | 0.375 | 0.429 | 0.499 | 0.677 | 0.598 |
| 445.80 | 0.361 | 0.302 | 0.264 | 0.244 | 0.352 | 0.403 | 0.466 | 0.394 | 0.532 | 0.399 | 0.339 | 0.291 | 0.263 | 0.379 | 0.427 | 0.509 | 0.681 | 0.595 |
| 446.30 | 0.357 | 0.310 | 0.263 | 0.243 | 0.360 | 0.401 | 0.475 | 0.391 | 0.540 | 0.396 | 0.342 | 0.290 | 0.263 | 0.376 | 0.426 | 0.512 | 0.679 | 0.578 |
| 446.80 | 0.355 | 0.313 | 0.264 | 0.244 | 0.363 | 0.401 | 0.473 | 0.640 | 0.537 | 0.399 | 0.342 | 0.289 | 0.234 | 0.379 | 0.427 | 0.505 | 0.671 | 0.589 |
| 447.30 | 0.361 | 0.315 | 0.265 | 0.239 | 0.365 | 0.401 | 0.468 | 0.637 | 0.531 | 0.398 | 0.341 | 0.288 | 0.257 | 0.378 | 0.427 | 0.496 | 0.698 | 0.570 |
| 447.80 | 0.361 | 0.326 | 0.255 | 0.237 | 0.376 | 0.402 | 0.479 | 0.639 | 0.526 | 0.424 | 0.342 | 0.289 | 0.255 | 0.394 | 0.429 | 0.509 | 0.672 | 0.577 |
| 448.30 | 0.362 | 0.329 | 0.255 | 0.240 | 0.379 | 0.403 | 0.477 | 0.640 | 0.525 | 0.425 | 0.338 | 0.291 | 0.262 | 0.395 | 0.422 | 0.506 | 0.692 | 0.584 |
| 449.73 | 0.361 | 0.316 | 0.279 | 0.239 | 0.386 | 0.389 | 0.468 | 0.636 | 0.533 | 0.416 | 0.239 | 0.236 | 0.251 | 0.391 | 0.421 | 0.471 | 0.680 | 0.585 |
| 450.23 | 0.360 | 0.314 | 0.270 | 0.238 | 0.399 | 0.368 | 0.483 | 0.638 | 0.549 | 0.424 | 0.265 | 0.288 | 0.252 | 0.394 | 0.423 | 0.497 | 0.396 | 0.591 |
| 450.73 | 0.360 | 0.302 | 0.257 | 0.237 | 0.352 | 0.395 | 0.470 | 0.650 | 0.535 | 0.406 | 0.292 | 0.291 | 0.252 | 0.386 | 0.424 | 0.511 | 0.682 | 0.588 |
| 451.23 | 0.368 | 0.315 | 0.258 | 0.241 | 0.365 | 0.396 | 0.467 | 0.637 | 0.540 | 0.423 | 0.314 | 0.292 | 0.251 | 0.393 | 0.426 | 0.495 | 0.681 | 0.585 |
| 451.73 | 0.378 | 0.327 | 0.260 | 0.240 | 0.377 | 0.400 | 0.465 | 0.635 | 0.533 | 0.395 | 0.304 | 0.291 | 0.262 | 0.375 | 0.426 | 0.505 | 0.679 | 0.588 |
| 452.23 | 0.377 | 0.328 | 0.260 | 0.240 | 0.378 | 0.399 | 0.473 | 0.639 | 0.539 | 0.397 | 0.298 | 0.294 | 0.263 | 0.377 | 0.419 | 0.507 | 0.686 | 0.595 |
| 452.73 | 0.360 | 0.318 | 0.260 | 0.243 | 0.388 | 0.399 | 0.478 | 0.641 | 0.539 | 0.398 | 0.312 | 0.294 | 0.263 | 0.378 | 0.427 | 0.504 | 0.681 | 0.589 |
| 453.23 | 0.360 | 0.310 | 0.258 | 0.231 | 0.395 | 0.395 | 0.469 | 0.644 | 0.533 | 0.398 | 0.318 | 0.294 | 0.262 | 0.388 | 0.428 | 0.501 | 0.672 | 0.588 |
| 453.73 | 0.367 | 0.312 | 0.257 | 0.230 | 0.397 | 0.397 | 0.465 | 0.643 | 0.532 | 0.400 | 0.326 | 0.290 | 0.262 | 0.380 | 0.426 | 0.504 | 0.674 | 0.570 |
| 454.23 | 0.374 | 0.315 | 0.256 | 0.232 | 0.400 | 0.397 | 0.478 | 0.644 | 0.536 | 0.398 | 0.327 | 0.292 | 0.263 | 0.388 | 0.427 | 0.498 | 0.676 | 0.580 |
| 454.38 | 0.370 | 0.310 | 0.256 | 0.232 | 0.360 | 0.396 | 0.468 | 0.645 | 0.530 | 0.400 | 0.331 | 0.294 | 0.262 | 0.390 | 0.424 | 0.500 | 0.550 | 0.588 |
| 454.88 | 0.371 | 0.318 | 0.256 | 0.232 | 0.368 | 0.398 | 0.477 | 0.641 | 0.536 | 0.405 | 0.333 | 0.288 | 0.261 | 0.380 | 0.422 | 0.507 | 0.684 | 0.587 |
| 455.38 | 0.362 | 0.321 | 0.256 | 0.236 | 0.371 | 0.396 | 0.476 | 0.644 | 0.536 | 0.407 | 0.331 | 0.291 | 0.261 | 0.382 | 0.422 | 0.498 | 0.672 | 0.593 |

| Hour | 45°C | | | | | | | | | 30°C | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | pH 5.0 | pH 5.5 | pH 6.0 | pH 6.5 | pH 7.0 | pH 7.5 | pH 8.0 | pH 8.5 | pH 9.0 | pH 5.0 | pH 5.5 | pH 6.0 | pH 6.5 | pH 7.0 | pH 7.5 | pH 8.0 | pH 8.5 | pH 9.0 |
| 455.88 | 0.360 | 0.328 | 0.256 | 0.236 | 0.378 | 0.396 | 0.478 | 0.636 | 0.537 | 0.407 | 0.335 | 0.291 | 0.260 | 0.382 | 0.420 | 0.499 | 0.673 | 0.587 |
| 456.38 | 0.363 | 0.333 | 0.256 | 0.236 | 0.383 | 0.398 | 0.484 | 0.643 | 0.534 | 0.407 | 0.330 | 0.297 | 0.258 | 0.382 | 0.423 | 0.495 | 0.673 | 0.570 |
| 456.88 | 0.365 | 0.334 | 0.256 | 0.238 | 0.384 | 0.397 | 0.477 | 0.640 | 0.532 | 0.420 | 0.325 | 0.293 | 0.257 | 0.375 | 0.421 | 0.508 | 0.671 | 0.575 |
| 457.38 | 0.376 | 0.332 | 0.256 | 0.239 | 0.382 | 0.398 | 0.482 | 0.642 | 0.526 | 0.405 | 0.333 | 0.293 | 0.257 | 0.380 | 0.423 | 0.504 | 0.674 | 0.572 |
| 457.88 | 0.379 | 0.312 | 0.256 | 0.238 | 0.397 | 0.395 | 0.477 | 0.643 | 0.534 | 0.409 | 0.334 | 0.287 | 0.258 | 0.384 | 0.421 | 0.501 | 0.675 | 0.577 |
| 458.38 | 0.366 | 0.303 | 0.256 | 0.235 | 0.353 | 0.398 | 0.467 | 0.638 | 0.527 | 0.422 | 0.333 | 0.289 | 0.258 | 0.377 | 0.420 | 0.499 | 0.673 | 0.573 |
| 458.88 | 0.364 | 0.303 | 0.256 | 0.234 | 0.353 | 0.397 | 0.469 | 0.645 | 0.529 | 0.424 | 0.333 | 0.290 | 0.257 | 0.379 | 0.418 | 0.505 | 0.671 | 0.575 |
| 459.38 | 0.362 | 0.305 | 0.256 | 0.235 | 0.355 | 0.398 | 0.480 | 0.638 | 0.537 | 0.408 | 0.338 | 0.289 | 0.257 | 0.383 | 0.416 | 0.513 | 0.683 | 0.567 |
| 459.88 | 0.365 | 0.306 | 0.256 | 0.235 | 0.356 | 0.398 | 0.477 | 0.640 | 0.532 | 0.421 | 0.338 | 0.289 | 0.257 | 0.376 | 0.415 | 0.499 | 0.682 | 0.568 |
| 460.38 | 0.377 | 0.302 | 0.256 | 0.233 | 0.352 | 0.399 | 0.478 | 0.640 | 0.534 | 0.408 | 0.337 | 0.290 | 0.257 | 0.383 | 0.412 | 0.497 | 0.681 | 0.571 |
| 460.88 | 0.378 | 0.310 | 0.256 | 0.233 | 0.360 | 0.398 | 0.471 | 0.642 | 0.538 | 0.410 | 0.335 | 0.289 | 0.257 | 0.385 | 0.413 | 0.496 | 0.681 | 0.572 |
| 461.38 | 0.368 | 0.315 | 0.256 | 0.234 | 0.365 | 0.396 | 0.473 | 0.642 | 0.543 | 0.420 | 0.333 | 0.288 | 0.255 | 0.375 | 0.411 | 0.499 | 0.694 | 0.575 |
| 461.88 | 0.360 | 0.313 | 0.256 | 0.234 | 0.363 | 0.399 | 0.473 | 0.642 | 0.545 | 0.408 | 0.336 | 0.292 | 0.255 | 0.383 | 0.429 | 0.498 | 0.681 | 0.578 |
| 462.38 | 0.362 | 0.309 | 0.256 | 0.233 | 0.359 | 0.401 | 0.468 | 0.640 | 0.548 | 0.407 | 0.332 | 0.291 | 0.258 | 0.382 | 0.429 | 0.513 | 0.680 | 0.584 |
| 462.88 | 0.365 | 0.313 | 0.256 | 0.233 | 0.363 | 0.400 | 0.470 | 0.640 | 0.554 | 0.408 | 0.334 | 0.289 | 0.258 | 0.383 | 0.427 | 0.470 | 0.681 | 0.584 |
| 463.38 | 0.360 | 0.315 | 0.256 | 0.234 | 0.365 | 0.398 | 0.465 | 0.644 | 0.534 | 0.406 | 0.331 | 0.292 | 0.259 | 0.381 | 0.427 | 0.515 | 0.681 | 0.588 |
| 463.88 | 0.368 | 0.220 | 0.256 | 0.235 | 0.370 | 0.398 | 0.391 | 0.642 | 0.406 | 0.406 | 0.332 | 0.291 | 0.258 | 0.291 | 0.425 | 0.508 | 0.683 | 0.590 |
| 464.38 | 0.361 | 0.222 | 0.256 | 0.236 | 0.372 | 0.399 | 0.379 | 0.644 | 0.413 | 0.409 | 0.331 | 0.290 | 0.259 | 0.294 | 0.424 | 0.497 | 0.684 | 0.586 |
| 464.88 | 0.378 | 0.321 | 0.255 | 0.235 | 0.371 | 0.399 | 0.476 | 0.643 | 0.538 | 0.409 | 0.332 | 0.293 | 0.260 | 0.384 | 0.424 | 0.506 | 0.683 | 0.583 |
| 465.38 | 0.363 | 0.319 | 0.262 | 0.234 | 0.369 | 0.397 | 0.472 | 0.641 | 0.529 | 0.409 | 0.335 | 0.291 | 0.259 | 0.384 | 0.425 | 0.500 | 0.685 | 0.588 |
| 465.88 | 0.364 | 0.320 | 0.264 | 0.233 | 0.370 | 0.397 | 0.472 | 0.643 | 0.536 | 0.420 | 0.331 | 0.291 | 0.257 | 0.375 | 0.423 | 0.511 | 0.682 | 0.585 |
| 466.38 | 0.362 | 0.321 | 0.262 | 0.233 | 0.371 | 0.397 | 0.468 | 0.645 | 0.543 | 0.425 | 0.330 | 0.290 | 0.258 | 0.380 | 0.421 | 0.470 | 0.671 | 0.583 |
| 466.88 | 0.362 | 0.327 | 0.261 | 0.230 | 0.377 | 0.398 | 0.479 | 0.640 | 0.531 | 0.421 | 0.328 | 0.293 | 0.258 | 0.376 | 0.422 | 0.507 | 0.671 | 0.589 |
| 467.38 | 0.363 | 0.322 | 0.264 | 0.231 | 0.372 | 0.396 | 0.472 | 0.643 | 0.544 | 0.421 | 0.329 | 0.292 | 0.257 | 0.376 | 0.420 | 0.507 | 0.672 | 0.588 |
| 467.88 | 0.363 | 0.320 | 0.255 | 0.232 | 0.370 | 0.399 | 0.466 | 0.642 | 0.541 | 0.421 | 0.328 | 0.295 | 0.256 | 0.376 | 0.420 | 0.506 | 0.672 | 0.585 |
| 468.38 | 0.365 | 0.320 | 0.255 | 0.231 | 0.370 | 0.399 | 0.473 | 0.643 | 0.544 | 0.421 | 0.330 | 0.291 | 0.257 | 0.376 | 0.418 | 0.500 | 0.671 | 0.588 |
| 468.88 | 0.356 | 0.319 | 0.255 | 0.231 | 0.369 | 0.399 | 0.475 | 0.641 | 0.549 | 0.424 | 0.333 | 0.290 | 0.257 | 0.379 | 0.419 | 0.499 | 0.674 | 0.587 |
| 469.38 | 0.362 | 0.323 | 0.255 | 0.235 | 0.373 | 0.399 | 0.471 | 0.641 | 0.539 | 0.423 | 0.331 | 0.286 | 0.257 | 0.378 | 0.418 | 0.500 | 0.675 | 0.583 |
| 469.88 | 0.360 | 0.323 | 0.255 | 0.232 | 0.373 | 0.399 | 0.472 | 0.644 | 0.544 | 0.421 | 0.332 | 0.286 | 0.256 | 0.376 | 0.416 | 0.506 | 0.679 | 0.583 |
| 470.38 | 0.365 | 0.321 | 0.255 | 0.168 | 0.371 | 0.399 | 0.483 | 0.644 | 0.537 | 0.423 | 0.335 | 0.286 | 0.257 | 0.378 | 0.419 | 0.499 | 0.677 | 0.582 |
| 470.88 | 0.363 | 0.319 | 0.255 | 0.163 | 0.369 | 0.397 | 0.483 | 0.644 | 0.544 | 0.391 | 0.333 | 0.287 | 0.262 | 0.381 | 0.416 | 0.495 | 0.680 | 0.579 |
| 471.38 | 0.359 | 0.316 | 0.255 | 0.238 | 0.366 | 0.396 | 0.477 | 0.640 | 0.544 | 0.423 | 0.331 | 0.288 | 0.257 | 0.378 | 0.415 | 0.496 | 0.681 | 0.585 |
| 471.88 | 0.363 | 0.316 | 0.255 | 0.239 | 0.366 | 0.404 | 0.480 | 0.645 | 0.542 | 0.391 | 0.333 | 0.289 | 0.257 | 0.381 | 0.415 | 0.498 | 0.682 | 0.583 |

| Hour | 45°C | | | | | | | | | 30°C | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | pH 5.0 | pH 5.5 | pH 6.0 | pH 6.5 | pH 7.0 | pH 7.5 | pH 8.0 | pH 8.5 | pH 9.0 | pH 5.0 | pH 5.5 | pH 6.0 | pH 6.5 | pH 7.0 | pH 7.5 | pH 8.0 | pH 8.5 | pH 9.0 |
| 472.38 | 0.365 | 0.318 | 0.255 | 0.239 | 0.368 | 0.404 | 0.484 | 0.641 | 0.537 | 0.395 | 0.330 | 0.289 | 0.257 | 0.370 | 0.415 | 0.513 | 0.681 | 0.590 |
| 474.18 | 0.370 | 0.318 | 0.258 | 0.231 | 0.368 | 0.374 | 0.484 | 0.591 | 0.546 | 0.398 | 0.262 | 0.294 | 0.233 | 0.373 | 0.420 | 0.500 | 0.558 | 0.590 |
| 474.68 | 0.362 | 0.318 | 0.259 | 0.234 | 0.368 | 0.393 | 0.468 | 0.636 | 0.544 | 0.395 | 0.275 | 0.298 | 0.258 | 0.385 | 0.410 | 0.499 | 0.598 | 0.596 |
| 475.18 | 0.361 | 0.316 | 0.265 | 0.235 | 0.366 | 0.393 | 0.478 | 0.643 | 0.551 | 0.393 | 0.284 | 0.295 | 0.258 | 0.383 | 0.414 | 0.470 | 0.684 | 0.599 |
| 475.68 | 0.369 | 0.313 | 0.266 | 0.235 | 0.363 | 0.399 | 0.474 | 0.628 | 0.554 | 0.399 | 0.328 | 0.297 | 0.257 | 0.374 | 0.418 | 0.510 | 0.681 | 0.588 |
| 476.18 | 0.370 | 0.310 | 0.261 | 0.235 | 0.360 | 0.401 | 0.479 | 0.653 | 0.542 | 0.399 | 0.333 | 0.287 | 0.257 | 0.374 | 0.420 | 0.514 | 0.679 | 0.593 |
| 476.68 | 0.361 | 0.314 | 0.258 | 0.234 | 0.364 | 0.402 | 0.481 | 0.643 | 0.554 | 0.396 | 0.340 | 0.297 | 0.257 | 0.371 | 0.421 | 0.507 | 0.672 | 0.590 |
| 477.18 | 0.377 | 0.313 | 0.255 | 0.237 | 0.363 | 0.400 | 0.466 | 0.637 | 0.542 | 0.395 | 0.344 | 0.296 | 0.259 | 0.385 | 0.418 | 0.508 | 0.698 | 0.586 |
| 477.68 | 0.362 | 0.316 | 0.274 | 0.237 | 0.366 | 0.402 | 0.481 | 0.638 | 0.541 | 0.403 | 0.345 | 0.299 | 0.260 | 0.378 | 0.413 | 0.506 | 0.698 | 0.584 |
| 478.18 | 0.360 | 0.311 | 0.270 | 0.239 | 0.361 | 0.404 | 0.475 | 0.638 | 0.555 | 0.402 | 0.326 | 0.287 | 0.256 | 0.377 | 0.415 | 0.496 | 0.697 | 0.581 |
| 478.68 | 0.360 | 0.312 | 0.261 | 0.238 | 0.362 | 0.400 | 0.470 | 0.637 | 0.549 | 0.404 | 0.330 | 0.290 | 0.257 | 0.379 | 0.412 | 0.508 | 0.698 | 0.567 |
| 479.18 | 0.369 | 0.314 | 0.258 | 0.241 | 0.364 | 0.401 | 0.467 | 0.635 | 0.541 | 0.402 | 0.350 | 0.293 | 0.257 | 0.377 | 0.422 | 0.499 | 0.699 | 0.580 |
| 479.68 | 0.363 | 0.310 | 0.259 | 0.241 | 0.360 | 0.403 | 0.469 | 0.645 | 0.542 | 0.404 | 0.332 | 0.293 | 0.258 | 0.379 | 0.427 | 0.500 | 0.681 | 0.587 |
| 480.18 | 0.363 | 0.312 | 0.258 | 0.239 | 0.362 | 0.403 | 0.471 | 0.645 | 0.539 | 0.404 | 0.327 | 0.289 | 0.258 | 0.379 | 0.423 | 0.508 | 0.698 | 0.570 |
| 480.68 | 0.361 | 0.312 | 0.258 | 0.238 | 0.362 | 0.404 | 0.463 | 0.644 | 0.534 | 0.407 | 0.325 | 0.296 | 0.256 | 0.387 | 0.420 | 0.512 | 0.682 | 0.570 |
| 481.18 | 0.369 | 0.311 | 0.257 | 0.237 | 0.361 | 0.404 | 0.473 | 0.638 | 0.535 | 0.420 | 0.333 | 0.297 | 0.256 | 0.390 | 0.424 | 0.515 | 0.684 | 0.585 |
| 481.68 | 0.366 | 0.321 | 0.257 | 0.237 | 0.371 | 0.404 | 0.470 | 0.639 | 0.543 | 0.421 | 0.328 | 0.297 | 0.256 | 0.391 | 0.422 | 0.514 | 0.678 | 0.576 |
| 482.18 | 0.366 | 0.312 | 0.257 | 0.236 | 0.362 | 0.404 | 0.465 | 0.642 | 0.542 | 0.424 | 0.329 | 0.297 | 0.256 | 0.394 | 0.424 | 0.471 | 0.675 | 0.578 |
| 482.68 | 0.368 | 0.315 | 0.256 | 0.235 | 0.365 | 0.402 | 0.465 | 0.642 | 0.542 | 0.424 | 0.318 | 0.286 | 0.256 | 0.394 | 0.419 | 0.474 | 0.683 | 0.579 |
| 483.18 | 0.368 | 0.314 | 0.256 | 0.234 | 0.364 | 0.405 | 0.473 | 0.642 | 0.541 | 0.424 | 0.318 | 0.291 | 0.257 | 0.394 | 0.412 | 0.495 | 0.682 | 0.595 |
| 483.68 | 0.368 | 0.317 | 0.256 | 0.235 | 0.367 | 0.401 | 0.470 | 0.642 | 0.541 | 0.399 | 0.316 | 0.294 | 0.256 | 0.379 | 0.409 | 0.500 | 0.687 | 0.597 |
| 484.18 | 0.366 | 0.312 | 0.256 | 0.237 | 0.362 | 0.402 | 0.467 | 0.643 | 0.539 | 0.395 | 0.319 | 0.295 | 0.257 | 0.385 | 0.411 | 0.501 | 0.688 | 0.598 |
| 484.68 | 0.363 | 0.314 | 0.256 | 0.236 | 0.364 | 0.401 | 0.465 | 0.644 | 0.535 | 0.399 | 0.320 | 0.289 | 0.258 | 0.379 | 0.409 | 0.504 | 0.687 | 0.577 |
| 485.18 | 0.360 | 0.311 | 0.256 | 0.235 | 0.361 | 0.404 | 0.471 | 0.642 | 0.539 | 0.398 | 0.329 | 0.300 | 0.259 | 0.388 | 0.413 | 0.507 | 0.685 | 0.584 |
| 485.68 | 0.364 | 0.312 | 0.265 | 0.236 | 0.362 | 0.401 | 0.468 | 0.642 | 0.536 | 0.398 | 0.315 | 0.290 | 0.260 | 0.388 | 0.426 | 0.509 | 0.679 | 0.576 |
| 486.18 | 0.363 | 0.314 | 0.255 | 0.238 | 0.364 | 0.350 | 0.464 | 0.643 | 0.538 | 0.402 | 0.315 | 0.291 | 0.259 | 0.377 | 0.412 | 0.512 | 0.676 | 0.600 |
| 486.68 | 0.366 | 0.312 | 0.260 | 0.239 | 0.362 | 0.403 | 0.464 | 0.644 | 0.540 | 0.404 | 0.316 | 0.291 | 0.257 | 0.379 | 0.426 | 0.505 | 0.696 | 0.596 |
| 487.18 | 0.361 | 0.314 | 0.255 | 0.236 | 0.364 | 0.404 | 0.465 | 0.644 | 0.542 | 0.404 | 0.317 | 0.293 | 0.258 | 0.379 | 0.415 | 0.509 | 0.680 | 0.596 |
| 487.68 | 0.362 | 0.312 | 0.255 | 0.235 | 0.362 | 0.401 | 0.465 | 0.644 | 0.539 | 0.406 | 0.315 | 0.288 | 0.258 | 0.381 | 0.413 | 0.473 | 0.697 | 0.597 |
| 488.18 | 0.364 | 0.310 | 0.255 | 0.236 | 0.360 | 0.402 | 0.441 | 0.644 | 0.535 | 0.407 | 0.321 | 0.287 | 0.258 | 0.382 | 0.411 | 0.508 | 0.678 | 0.595 |
| 488.68 | 0.360 | 0.308 | 0.256 | 0.235 | 0.358 | 0.403 | 0.468 | 0.644 | 0.533 | 0.404 | 0.318 | 0.291 | 0.257 | 0.379 | 0.426 | 0.509 | 0.675 | 0.593 |
| 489.18 | 0.362 | 0.260 | 0.268 | 0.237 | 0.260 | 0.403 | 0.385 | 0.645 | 0.434 | 0.402 | 0.318 | 0.292 | 0.258 | 0.287 | 0.411 | 0.499 | 0.675 | 0.593 |
| 489.68 | 0.362 | 0.262 | 0.275 | 0.235 | 0.262 | 0.405 | 0.388 | 0.645 | 0.483 | 0.403 | 0.328 | 0.288 | 0.257 | 0.288 | 0.412 | 0.506 | 0.675 | 0.587 |

| Hour | 45°C | | | | | | | | | 30°C | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | pH 5.0 | pH 5.5 | pH 6.0 | pH 6.5 | pH 7.0 | pH 7.5 | pH 8.0 | pH 8.5 | pH 9.0 | pH 5.0 | pH 5.5 | pH 6.0 | pH 6.5 | pH 7.0 | pH 7.5 | pH 8.0 | pH 8.5 | pH 9.0 |
| 490.18 | 0.361 | 0.313 | 0.274 | 0.234 | 0.363 | 0.403 | 0.469 | 0.644 | 0.549 | 0.424 | 0.316 | 0.292 | 0.258 | 0.379 | 0.417 | 0.471 | 0.697 | 0.600 |
| 490.68 | 0.361 | 0.313 | 0.269 | 0.235 | 0.363 | 0.400 | 0.449 | 0.636 | 0.533 | 0.423 | 0.326 | 0.287 | 0.256 | 0.378 | 0.415 | 0.513 | 0.697 | 0.596 |
| 491.18 | 0.362 | 0.317 | 0.263 | 0.234 | 0.367 | 0.402 | 0.445 | 0.637 | 0.537 | 0.423 | 0.327 | 0.289 | 0.258 | 0.378 | 0.422 | 0.508 | 0.697 | 0.575 |
| 491.68 | 0.365 | 0.314 | 0.261 | 0.232 | 0.364 | 0.401 | 0.448 | 0.637 | 0.540 | 0.422 | 0.328 | 0.287 | 0.258 | 0.377 | 0.424 | 0.513 | 0.696 | 0.575 |
| 492.18 | 0.364 | 0.312 | 0.263 | 0.238 | 0.362 | 0.395 | 0.456 | 0.637 | 0.544 | 0.407 | 0.328 | 0.286 | 0.258 | 0.382 | 0.427 | 0.506 | 0.697 | 0.578 |
| 492.68 | 0.367 | 0.313 | 0.264 | 0.231 | 0.363 | 0.395 | 0.472 | 0.637 | 0.537 | 0.403 | 0.329 | 0.286 | 0.259 | 0.378 | 0.425 | 0.496 | 0.696 | 0.581 |
| 493.18 | 0.362 | 0.308 | 0.255 | 0.230 | 0.358 | 0.399 | 0.469 | 0.637 | 0.540 | 0.402 | 0.326 | 0.292 | 0.257 | 0.377 | 0.425 | 0.500 | 0.697 | 0.584 |
| 493.68 | 0.364 | 0.310 | 0.255 | 0.239 | 0.360 | 0.398 | 0.443 | 0.637 | 0.544 | 0.403 | 0.326 | 0.291 | 0.259 | 0.378 | 0.427 | 0.495 | 0.697 | 0.578 |
| 494.18 | 0.361 | 0.311 | 0.256 | 0.238 | 0.361 | 0.396 | 0.453 | 0.637 | 0.547 | 0.402 | 0.334 | 0.293 | 0.258 | 0.377 | 0.415 | 0.508 | 0.697 | 0.579 |
| 494.68 | 0.362 | 0.310 | 0.256 | 0.175 | 0.360 | 0.396 | 0.454 | 0.637 | 0.545 | 0.406 | 0.350 | 0.295 | 0.257 | 0.381 | 0.415 | 0.510 | 0.698 | 0.597 |
| 495.18 | 0.364 | 0.316 | 0.256 | 0.159 | 0.366 | 0.396 | 0.468 | 0.637 | 0.547 | 0.422 | 0.331 | 0.286 | 0.256 | 0.377 | 0.422 | 0.471 | 0.698 | 0.584 |
| 495.68 | 0.362 | 0.315 | 0.256 | 0.198 | 0.365 | 0.398 | 0.468 | 0.638 | 0.547 | 0.423 | 0.335 | 0.288 | 0.262 | 0.378 | 0.420 | 0.471 | 0.698 | 0.575 |
| 496.18 | 0.364 | 0.314 | 0.256 | 0.237 | 0.364 | 0.399 | 0.473 | 0.637 | 0.542 | 0.392 | 0.334 | 0.290 | 0.261 | 0.382 | 0.423 | 0.508 | 0.696 | 0.597 |
| 497.92 | 0.362 | 0.311 | 0.273 | 0.237 | 0.361 | 0.374 | 0.462 | 0.447 | 0.549 | 0.355 | 0.295 | 0.236 | 0.211 | 0.390 | 0.164 | 0.508 | 0.505 | 0.598 |
| 498.42 | 0.360 | 0.323 | 0.259 | 0.240 | 0.373 | 0.389 | 0.461 | 0.555 | 0.549 | 0.403 | 0.271 | 0.299 | 0.261 | 0.378 | 0.424 | 0.506 | 0.570 | 0.596 |
| 498.92 | 0.358 | 0.319 | 0.262 | 0.233 | 0.369 | 0.390 | 0.455 | 0.631 | 0.547 | 0.407 | 0.275 | 0.290 | 0.260 | 0.387 | 0.430 | 0.511 | 0.692 | 0.598 |
| 499.42 | 0.360 | 0.318 | 0.261 | 0.234 | 0.368 | 0.384 | 0.460 | 0.637 | 0.546 | 0.420 | 0.279 | 0.290 | 0.260 | 0.370 | 0.422 | 0.507 | 0.677 | 0.587 |
| 499.92 | 0.362 | 0.323 | 0.258 | 0.235 | 0.373 | 0.396 | 0.472 | 0.643 | 0.546 | 0.424 | 0.331 | 0.290 | 0.259 | 0.374 | 0.426 | 0.510 | 0.688 | 0.596 |
| 500.42 | 0.363 | 0.328 | 0.261 | 0.235 | 0.378 | 0.397 | 0.459 | 0.640 | 0.541 | 0.398 | 0.331 | 0.290 | 0.259 | 0.378 | 0.412 | 0.474 | 0.672 | 0.585 |
| 500.92 | 0.363 | 0.329 | 0.274 | 0.236 | 0.379 | 0.398 | 0.461 | 0.644 | 0.543 | 0.398 | 0.332 | 0.290 | 0.259 | 0.383 | 0.416 | 0.474 | 0.679 | 0.595 |
| 501.42 | 0.367 | 0.332 | 0.261 | 0.237 | 0.367 | 0.398 | 0.456 | 0.636 | 0.543 | 0.402 | 0.333 | 0.290 | 0.257 | 0.387 | 0.423 | 0.495 | 0.678 | 0.584 |
| 501.92 | 0.364 | 0.335 | 0.262 | 0.235 | 0.370 | 0.405 | 0.458 | 0.637 | 0.539 | 0.404 | 0.333 | 0.293 | 0.256 | 0.389 | 0.424 | 0.473 | 0.678 | 0.588 |
| 502.42 | 0.362 | 0.334 | 0.262 | 0.234 | 0.369 | 0.399 | 0.460 | 0.638 | 0.536 | 0.407 | 0.330 | 0.294 | 0.255 | 0.392 | 0.421 | 0.495 | 0.679 | 0.576 |
| 502.92 | 0.363 | 0.319 | 0.262 | 0.236 | 0.369 | 0.399 | 0.459 | 0.637 | 0.534 | 0.420 | 0.332 | 0.285 | 0.260 | 0.375 | 0.425 | 0.501 | 0.680 | 0.593 |
| 503.42 | 0.358 | 0.320 | 0.262 | 0.237 | 0.370 | 0.399 | 0.453 | 0.637 | 0.539 | 0.423 | 0.334 | 0.289 | 0.260 | 0.378 | 0.420 | 0.497 | 0.680 | 0.585 |
| 503.92 | 0.360 | 0.312 | 0.259 | 0.235 | 0.392 | 0.399 | 0.454 | 0.636 | 0.538 | 0.390 | 0.333 | 0.285 | 0.259 | 0.380 | 0.425 | 0.473 | 0.680 | 0.591 |
| 504.42 | 0.361 | 0.320 | 0.261 | 0.234 | 0.370 | 0.396 | 0.454 | 0.637 | 0.537 | 0.392 | 0.332 | 0.294 | 0.257 | 0.382 | 0.427 | 0.495 | 0.680 | 0.591 |
| 504.92 | 0.360 | 0.318 | 0.261 | 0.237 | 0.368 | 0.399 | 0.455 | 0.636 | 0.532 | 0.392 | 0.335 | 0.286 | 0.256 | 0.382 | 0.432 | 0.515 | 0.679 | 0.593 |
| 505.42 | 0.366 | 0.320 | 0.260 | 0.238 | 0.370 | 0.395 | 0.450 | 0.636 | 0.539 | 0.393 | 0.333 | 0.293 | 0.256 | 0.383 | 0.428 | 0.515 | 0.676 | 0.592 |
| 505.92 | 0.365 | 0.316 | 0.260 | 0.237 | 0.366 | 0.397 | 0.449 | 0.636 | 0.537 | 0.394 | 0.331 | 0.293 | 0.256 | 0.384 | 0.417 | 0.513 | 0.674 | 0.577 |
| 506.42 | 0.364 | 0.334 | 0.259 | 0.236 | 0.369 | 0.399 | 0.475 | 0.645 | 0.536 | 0.397 | 0.333 | 0.290 | 0.265 | 0.372 | 0.426 | 0.514 | 0.672 | 0.597 |
| 506.92 | 0.361 | 0.332 | 0.260 | 0.232 | 0.367 | 0.397 | 0.460 | 0.635 | 0.537 | 0.401 | 0.333 | 0.292 | 0.255 | 0.376 | 0.422 | 0.508 | 0.671 | 0.596 |
| 507.42 | 0.363 | 0.331 | 0.260 | 0.231 | 0.366 | 0.397 | 0.467 | 0.645 | 0.538 | 0.396 | 0.332 | 0.294 | 0.255 | 0.371 | 0.412 | 0.510 | 0.671 | 0.593 |

| Hour | 45°C | | | | | | | | | 30°C | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | pH 5.0 | pH 5.5 | pH 6.0 | pH 6.5 | pH 7.0 | pH 7.5 | pH 8.0 | pH 8.5 | pH 9.0 | pH 5.0 | pH 5.5 | pH 6.0 | pH 6.5 | pH 7.0 | pH 7.5 | pH 8.0 | pH 8.5 | pH 9.0 |
| 507.92 | 0.369 | 0.315 | 0.261 | 0.240 | 0.365 | 0.397 | 0.443 | 0.644 | 0.533 | 0.399 | 0.333 | 0.291 | 0.264 | 0.374 | 0.421 | 0.507 | 0.685 | 0.590 |
| 508.42 | 0.368 | 0.317 | 0.261 | 0.240 | 0.367 | 0.399 | 0.463 | 0.644 | 0.537 | 0.397 | 0.336 | 0.293 | 0.255 | 0.372 | 0.417 | 0.509 | 0.684 | 0.579 |
| 508.92 | 0.363 | 0.313 | 0.262 | 0.239 | 0.368 | 0.397 | 0.464 | 0.644 | 0.536 | 0.397 | 0.334 | 0.293 | 0.264 | 0.372 | 0.417 | 0.470 | 0.683 | 0.579 |
| 509.42 | 0.378 | 0.313 | 0.263 | 0.239 | 0.368 | 0.397 | 0.465 | 0.644 | 0.541 | 0.399 | 0.335 | 0.292 | 0.264 | 0.374 | 0.415 | 0.510 | 0.683 | 0.578 |
| 509.92 | 0.379 | 0.314 | 0.262 | 0.240 | 0.369 | 0.398 | 0.470 | 0.643 | 0.543 | 0.399 | 0.334 | 0.292 | 0.264 | 0.374 | 0.415 | 0.497 | 0.683 | 0.578 |
| 510.42 | 0.362 | 0.320 | 0.264 | 0.233 | 0.370 | 0.398 | 0.469 | 0.644 | 0.540 | 0.400 | 0.336 | 0.293 | 0.263 | 0.375 | 0.410 | 0.500 | 0.682 | 0.571 |
| 510.92 | 0.365 | 0.310 | 0.266 | 0.232 | 0.365 | 0.396 | 0.445 | 0.643 | 0.539 | 0.400 | 0.337 | 0.295 | 0.263 | 0.375 | 0.426 | 0.497 | 0.682 | 0.589 |
| 511.42 | 0.364 | 0.320 | 0.267 | 0.230 | 0.375 | 0.397 | 0.443 | 0.642 | 0.539 | 0.402 | 0.336 | 0.287 | 0.263 | 0.377 | 0.429 | 0.505 | 0.681 | 0.590 |
| 511.92 | 0.369 | 0.334 | 0.271 | 0.232 | 0.369 | 0.404 | 0.447 | 0.641 | 0.533 | 0.401 | 0.332 | 0.287 | 0.263 | 0.376 | 0.421 | 0.498 | 0.681 | 0.588 |
| 512.42 | 0.370 | 0.331 | 0.276 | 0.231 | 0.366 | 0.395 | 0.469 | 0.641 | 0.531 | 0.401 | 0.333 | 0.289 | 0.262 | 0.376 | 0.423 | 0.499 | 0.681 | 0.584 |
| 512.92 | 0.372 | 0.330 | 0.270 | 0.232 | 0.365 | 0.395 | 0.445 | 0.641 | 0.535 | 0.403 | 0.332 | 0.296 | 0.261 | 0.378 | 0.412 | 0.499 | 0.681 | 0.582 |
| 513.42 | 0.370 | 0.315 | 0.273 | 0.232 | 0.370 | 0.405 | 0.468 | 0.640 | 0.533 | 0.406 | 0.333 | 0.289 | 0.262 | 0.386 | 0.415 | 0.499 | 0.690 | 0.578 |
| 513.92 | 0.368 | 0.311 | 0.267 | 0.240 | 0.366 | 0.404 | 0.470 | 0.639 | 0.535 | 0.405 | 0.335 | 0.289 | 0.261 | 0.380 | 0.415 | 0.510 | 0.690 | 0.577 |
| 514.42 | 0.370 | 0.319 | 0.262 | 0.239 | 0.374 | 0.398 | 0.470 | 0.638 | 0.484 | 0.406 | 0.331 | 0.296 | 0.262 | 0.266 | 0.420 | 0.508 | 0.689 | 0.582 |
| 514.92 | 0.366 | 0.317 | 0.261 | 0.238 | 0.372 | 0.396 | 0.466 | 0.638 | 0.439 | 0.406 | 0.332 | 0.296 | 0.261 | 0.266 | 0.421 | 0.498 | 0.689 | 0.583 |
| 515.42 | 0.364 | 0.334 | 0.264 | 0.237 | 0.369 | 0.396 | 0.468 | 0.637 | 0.534 | 0.407 | 0.334 | 0.296 | 0.259 | 0.387 | 0.419 | 0.500 | 0.689 | 0.568 |
| 515.92 | 0.362 | 0.319 | 0.255 | 0.237 | 0.374 | 0.400 | 0.468 | 0.636 | 0.529 | 0.407 | 0.333 | 0.298 | 0.258 | 0.387 | 0.412 | 0.514 | 0.689 | 0.584 |
| 516.42 | 0.361 | 0.319 | 0.255 | 0.238 | 0.374 | 0.395 | 0.454 | 0.636 | 0.540 | 0.391 | 0.332 | 0.297 | 0.258 | 0.381 | 0.410 | 0.498 | 0.688 | 0.492 |
| 516.92 | 0.365 | 0.302 | 0.256 | 0.238 | 0.352 | 0.404 | 0.474 | 0.645 | 0.544 | 0.399 | 0.333 | 0.297 | 0.258 | 0.374 | 0.412 | 0.498 | 0.688 | 0.587 |
| 517.42 | 0.367 | 0.318 | 0.256 | 0.236 | 0.373 | 0.398 | 0.441 | 0.645 | 0.532 | 0.397 | 0.332 | 0.299 | 0.258 | 0.372 | 0.413 | 0.498 | 0.688 | 0.578 |
| 517.92 | 0.373 | 0.326 | 0.256 | 0.237 | 0.376 | 0.395 | 0.470 | 0.644 | 0.528 | 0.423 | 0.334 | 0.285 | 0.258 | 0.378 | 0.411 | 0.498 | 0.687 | 0.579 |
| 518.42 | 0.373 | 0.307 | 0.256 | 0.237 | 0.357 | 0.402 | 0.468 | 0.643 | 0.539 | 0.400 | 0.336 | 0.286 | 0.258 | 0.375 | 0.409 | 0.498 | 0.687 | 0.588 |
| 518.92 | 0.374 | 0.317 | 0.256 | 0.231 | 0.367 | 0.403 | 0.467 | 0.642 | 0.538 | 0.401 | 0.337 | 0.286 | 0.257 | 0.376 | 0.406 | 0.499 | 0.687 | 0.566 |
| 519.42 | 0.370 | 0.312 | 0.256 | 0.231 | 0.362 | 0.397 | 0.468 | 0.641 | 0.528 | 0.396 | 0.334 | 0.297 | 0.257 | 0.371 | 0.405 | 0.496 | 0.687 | 0.587 |
| 519.92 | 0.370 | 0.311 | 0.257 | 0.232 | 0.361 | 0.401 | 0.466 | 0.640 | 0.530 | 0.393 | 0.334 | 0.287 | 0.255 | 0.383 | 0.412 | 0.497 | 0.686 | 0.583 |
| 520.42 | 0.370 | 0.319 | 0.257 | 0.180 | 0.384 | 0.403 | 0.470 | 0.639 | 0.532 | 0.421 | 0.332 | 0.286 | 0.259 | 0.376 | 0.411 | 0.512 | 0.686 | 0.566 |
| 522.17 | 0.364 | 0.310 | 0.263 | 0.167 | 0.390 | 0.406 | 0.441 | 0.645 | 0.541 | 0.425 | 0.257 | 0.290 | 0.255 | 0.380 | 0.424 | 0.495 | 0.570 | 0.590 |
| 522.63 | 0.361 | 0.274 | 0.262 | 0.195 | 0.374 | 0.412 | 0.441 | 0.637 | 0.545 | 0.422 | 0.301 | 0.336 | 0.262 | 0.377 | 0.405 | 0.506 | 0.577 | 0.583 |
| 523.13 | 0.360 | 0.310 | 0.265 | 0.239 | 0.375 | 0.381 | 0.445 | 0.561 | 0.547 | 0.408 | 0.335 | 0.299 | 0.256 | 0.383 | 0.429 | 0.512 | 0.684 | 0.581 |
| 523.63 | 0.365 | 0.270 | 0.260 | 0.232 | 0.370 | 0.363 | 0.446 | 0.587 | 0.554 | 0.400 | 0.330 | 0.291 | 0.257 | 0.375 | 0.422 | 0.474 | 0.692 | 0.577 |
| 524.13 | 0.371 | 0.259 | 0.262 | 0.234 | 0.359 | 0.372 | 0.442 | 0.639 | 0.543 | 0.396 | 0.332 | 0.291 | 0.257 | 0.386 | 0.426 | 0.499 | 0.683 | 0.570 |
| 524.63 | 0.369 | 0.264 | 0.267 | 0.235 | 0.364 | 0.382 | 0.450 | 0.644 | 0.526 | 0.402 | 0.334 | 0.293 | 0.257 | 0.377 | 0.410 | 0.499 | 0.674 | 0.569 |
| 525.13 | 0.367 | 0.263 | 0.256 | 0.235 | 0.363 | 0.384 | 0.446 | 0.636 | 0.532 | 0.404 | 0.333 | 0.291 | 0.265 | 0.379 | 0.413 | 0.504 | 0.673 | 0.587 |

| Hour | 45°C | | | | | | | | | 30°C | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | pH 5.0 | pH 5.5 | pH 6.0 | pH 6.5 | pH 7.0 | pH 7.5 | pH 8.0 | pH 8.5 | pH 9.0 | pH 5.0 | pH 5.5 | pH 6.0 | pH 6.5 | pH 7.0 | pH 7.5 | pH 8.0 | pH 8.5 | pH 9.0 |
| 525.63 | 0.364 | 0.253 | 0.260 | 0.234 | 0.353 | 0.377 | 0.449 | 0.637 | 0.531 | 0.395 | 0.335 | 0.291 | 0.264 | 0.375 | 0.413 | 0.499 | 0.672 | 0.588 |
| 526.13 | 0.369 | 0.255 | 0.260 | 0.233 | 0.355 | 0.383 | 0.444 | 0.605 | 0.535 | 0.397 | 0.332 | 0.293 | 0.263 | 0.387 | 0.407 | 0.499 | 0.677 | 0.590 |
| 526.63 | 0.369 | 0.254 | 0.255 | 0.232 | 0.354 | 0.384 | 0.440 | 0.595 | 0.538 | 0.403 | 0.332 | 0.285 | 0.264 | 0.378 | 0.412 | 0.498 | 0.677 | 0.577 |
| 527.13 | 0.362 | 0.314 | 0.260 | 0.239 | 0.399 | 0.386 | 0.445 | 0.635 | 0.537 | 0.407 | 0.333 | 0.288 | 0.263 | 0.382 | 0.414 | 0.499 | 0.677 | 0.575 |
| 527.63 | 0.368 | 0.314 | 0.255 | 0.238 | 0.394 | 0.388 | 0.446 | 0.594 | 0.541 | 0.397 | 0.334 | 0.293 | 0.262 | 0.387 | 0.417 | 0.499 | 0.674 | 0.576 |
| 528.13 | 0.376 | 0.314 | 0.255 | 0.236 | 0.394 | 0.397 | 0.441 | 0.594 | 0.541 | 0.407 | 0.331 | 0.293 | 0.259 | 0.382 | 0.419 | 0.497 | 0.674 | 0.575 |
| 528.63 | 0.357 | 0.330 | 0.256 | 0.233 | 0.380 | 0.399 | 0.443 | 0.594 | 0.544 | 0.404 | 0.332 | 0.290 | 0.259 | 0.379 | 0.416 | 0.497 | 0.673 | 0.587 |
| 529.13 | 0.367 | 0.318 | 0.256 | 0.233 | 0.388 | 0.386 | 0.448 | 0.636 | 0.548 | 0.407 | 0.331 | 0.293 | 0.260 | 0.382 | 0.424 | 0.498 | 0.682 | 0.577 |
| 529.63 | 0.362 | 0.323 | 0.256 | 0.233 | 0.373 | 0.389 | 0.450 | 0.639 | 0.546 | 0.407 | 0.330 | 0.286 | 0.259 | 0.382 | 0.425 | 0.496 | 0.689 | 0.574 |
| 530.13 | 0.361 | 0.321 | 0.256 | 0.233 | 0.371 | 0.392 | 0.454 | 0.638 | 0.546 | 0.408 | 0.334 | 0.289 | 0.258 | 0.383 | 0.425 | 0.496 | 0.681 | 0.574 |
| 530.63 | 0.364 | 0.310 | 0.258 | 0.231 | 0.390 | 0.395 | 0.453 | 0.642 | 0.541 | 0.391 | 0.335 | 0.295 | 0.258 | 0.381 | 0.423 | 0.498 | 0.681 | 0.577 |
| 531.13 | 0.370 | 0.313 | 0.259 | 0.231 | 0.398 | 0.384 | 0.455 | 0.636 | 0.539 | 0.398 | 0.332 | 0.289 | 0.257 | 0.373 | 0.426 | 0.508 | 0.688 | 0.576 |
| 531.63 | 0.364 | 0.315 | 0.260 | 0.234 | 0.400 | 0.387 | 0.458 | 0.640 | 0.545 | 0.397 | 0.332 | 0.297 | 0.256 | 0.372 | 0.423 | 0.498 | 0.686 | 0.582 |
| 532.13 | 0.375 | 0.250 | 0.265 | 0.233 | 0.250 | 0.385 | 0.461 | 0.637 | 0.541 | 0.398 | 0.331 | 0.299 | 0.256 | 0.373 | 0.426 | 0.500 | 0.685 | 0.578 |
| 532.63 | 0.370 | 0.312 | 0.271 | 0.231 | 0.362 | 0.384 | 0.477 | 0.639 | 0.546 | 0.424 | 0.331 | 0.299 | 0.256 | 0.379 | 0.421 | 0.515 | 0.695 | 0.591 |
| 533.13 | 0.359 | 0.308 | 0.276 | 0.231 | 0.358 | 0.387 | 0.482 | 0.644 | 0.549 | 0.424 | 0.331 | 0.300 | 0.258 | 0.379 | 0.424 | 0.471 | 0.693 | 0.595 |
| 533.63 | 0.364 | 0.316 | 0.272 | 0.231 | 0.366 | 0.391 | 0.480 | 0.638 | 0.554 | 0.422 | 0.333 | 0.298 | 0.259 | 0.377 | 0.426 | 0.511 | 0.694 | 0.598 |
| 534.13 | 0.363 | 0.319 | 0.268 | 0.232 | 0.369 | 0.393 | 0.482 | 0.637 | 0.554 | 0.422 | 0.334 | 0.285 | 0.257 | 0.377 | 0.421 | 0.513 | 0.699 | 0.595 |
| 534.63 | 0.363 | 0.319 | 0.263 | 0.232 | 0.369 | 0.391 | 0.477 | 0.636 | 0.551 | 0.392 | 0.333 | 0.288 | 0.265 | 0.382 | 0.423 | 0.513 | 0.697 | 0.593 |
| 535.13 | 0.365 | 0.322 | 0.263 | 0.231 | 0.372 | 0.394 | 0.479 | 0.636 | 0.555 | 0.392 | 0.335 | 0.290 | 0.264 | 0.382 | 0.422 | 0.470 | 0.697 | 0.598 |
| 535.63 | 0.364 | 0.321 | 0.260 | 0.232 | 0.371 | 0.396 | 0.478 | 0.645 | 0.554 | 0.390 | 0.333 | 0.294 | 0.263 | 0.380 | 0.421 | 0.473 | 0.697 | 0.598 |
| 536.13 | 0.364 | 0.324 | 0.264 | 0.234 | 0.374 | 0.393 | 0.479 | 0.644 | 0.546 | 0.390 | 0.334 | 0.294 | 0.263 | 0.380 | 0.420 | 0.471 | 0.697 | 0.597 |
| 536.63 | 0.374 | 0.327 | 0.255 | 0.233 | 0.377 | 0.393 | 0.480 | 0.642 | 0.547 | 0.394 | 0.326 | 0.289 | 0.264 | 0.384 | 0.413 | 0.498 | 0.697 | 0.591 |
| 537.13 | 0.374 | 0.322 | 0.255 | 0.231 | 0.372 | 0.398 | 0.478 | 0.642 | 0.541 | 0.393 | 0.327 | 0.297 | 0.263 | 0.383 | 0.414 | 0.499 | 0.677 | 0.594 |
| 537.63 | 0.380 | 0.323 | 0.256 | 0.231 | 0.373 | 0.403 | 0.479 | 0.640 | 0.549 | 0.392 | 0.335 | 0.298 | 0.263 | 0.382 | 0.417 | 0.496 | 0.678 | 0.595 |
| 538.13 | 0.368 | 0.323 | 0.256 | 0.231 | 0.373 | 0.394 | 0.479 | 0.639 | 0.548 | 0.395 | 0.326 | 0.298 | 0.260 | 0.390 | 0.419 | 0.474 | 0.695 | 0.590 |
| 538.63 | 0.363 | 0.328 | 0.256 | 0.235 | 0.378 | 0.399 | 0.483 | 0.638 | 0.541 | 0.395 | 0.326 | 0.297 | 0.261 | 0.385 | 0.417 | 0.475 | 0.679 | 0.588 |
| 539.13 | 0.361 | 0.324 | 0.256 | 0.234 | 0.374 | 0.400 | 0.481 | 0.636 | 0.542 | 0.394 | 0.325 | 0.296 | 0.261 | 0.384 | 0.418 | 0.496 | 0.678 | 0.582 |
| 539.63 | 0.370 | 0.328 | 0.257 | 0.230 | 0.378 | 0.397 | 0.478 | 0.636 | 0.544 | 0.394 | 0.327 | 0.286 | 0.261 | 0.384 | 0.415 | 0.497 | 0.679 | 0.582 |
| 540.13 | 0.363 | 0.326 | 0.257 | 0.232 | 0.376 | 0.398 | 0.475 | 0.593 | 0.541 | 0.395 | 0.328 | 0.287 | 0.261 | 0.385 | 0.416 | 0.498 | 0.677 | 0.583 |
| 540.63 | 0.365 | 0.326 | 0.257 | 0.233 | 0.376 | 0.399 | 0.483 | 0.592 | 0.544 | 0.393 | 0.326 | 0.300 | 0.261 | 0.383 | 0.415 | 0.503 | 0.679 | 0.581 |
| 541.13 | 0.360 | 0.300 | 0.257 | 0.231 | 0.370 | 0.397 | 0.464 | 0.590 | 0.546 | 0.422 | 0.332 | 0.299 | 0.261 | 0.222 | 0.416 | 0.502 | 0.679 | 0.581 |
| 593.90 | 0.362 | 0.300 | 0.256 | 0.231 | 0.250 | 0.378 | 0.387 | 0.470 | 0.363 | 0.357 | 0.266 | 0.291 | 0.260 | 0.277 | 0.412 | 0.515 | 0.627 | 0.485 |

| Hour | 45°C | | | | | | | | | 30°C | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | pH 5.0 | pH 5.5 | pH 6.0 | pH 6.5 | pH 7.0 | pH 7.5 | pH 8.0 | pH 8.5 | pH 9.0 | pH 5.0 | pH 5.5 | pH 6.0 | pH 6.5 | pH 7.0 | pH 7.5 | pH 8.0 | pH 8.5 | pH 9.0 |
| 594.40 | 0.358 | 0.300 | 0.266 | 0.240 | 0.350 | 0.396 | 0.453 | 0.463 | 0.382 | 0.396 | 0.294 | 0.294 | 0.260 | 0.381 | 0.416 | 0.497 | 0.652 | 0.462 |
| 594.90 | 0.366 | 0.300 | 0.267 | 0.234 | 0.350 | 0.381 | 0.473 | 0.608 | 0.538 | 0.400 | 0.332 | 0.293 | 0.260 | 0.375 | 0.417 | 0.496 | 0.699 | 0.471 |
| 595.40 | 0.369 | 0.334 | 0.262 | 0.233 | 0.384 | 0.383 | 0.475 | 0.552 | 0.541 | 0.406 | 0.333 | 0.294 | 0.261 | 0.386 | 0.427 | 0.513 | 0.678 | 0.484 |
| 595.90 | 0.369 | 0.313 | 0.258 | 0.233 | 0.398 | 0.387 | 0.471 | 0.556 | 0.542 | 0.406 | 0.333 | 0.292 | 0.260 | 0.386 | 0.427 | 0.471 | 0.685 | 0.489 |
| 596.40 | 0.362 | 0.303 | 0.255 | 0.234 | 0.363 | 0.394 | 0.451 | 0.560 | 0.538 | 0.405 | 0.333 | 0.295 | 0.260 | 0.380 | 0.426 | 0.471 | 0.674 | 0.482 |
| 596.90 | 0.361 | 0.303 | 0.274 | 0.233 | 0.363 | 0.398 | 0.451 | 0.558 | 0.536 | 0.404 | 0.334 | 0.291 | 0.259 | 0.379 | 0.429 | 0.475 | 0.697 | 0.488 |
| 597.40 | 0.364 | 0.304 | 0.271 | 0.233 | 0.364 | 0.368 | 0.451 | 0.559 | 0.534 | 0.396 | 0.333 | 0.292 | 0.259 | 0.371 | 0.427 | 0.511 | 0.680 | 0.489 |
| 597.90 | 0.377 | 0.305 | 0.261 | 0.231 | 0.375 | 0.400 | 0.451 | 0.559 | 0.536 | 0.400 | 0.332 | 0.294 | 0.260 | 0.375 | 0.428 | 0.495 | 0.695 | 0.497 |
| 598.40 | 0.362 | 0.303 | 0.265 | 0.234 | 0.368 | 0.401 | 0.451 | 0.553 | 0.534 | 0.399 | 0.330 | 0.294 | 0.260 | 0.374 | 0.428 | 0.497 | 0.550 | 0.492 |
| 598.90 | 0.363 | 0.304 | 0.280 | 0.233 | 0.379 | 0.400 | 0.451 | 0.550 | 0.532 | 0.401 | 0.331 | 0.286 | 0.260 | 0.376 | 0.426 | 0.497 | 0.672 | 0.494 |
| 599.40 | 0.363 | 0.301 | 0.271 | 0.231 | 0.381 | 0.401 | 0.477 | 0.640 | 0.533 | 0.401 | 0.331 | 0.296 | 0.259 | 0.376 | 0.426 | 0.497 | 0.675 | 0.497 |
| 599.90 | 0.378 | 0.301 | 0.275 | 0.234 | 0.386 | 0.399 | 0.479 | 0.638 | 0.532 | 0.402 | 0.333 | 0.293 | 0.261 | 0.377 | 0.427 | 0.500 | 0.680 | 0.498 |
| 600.40 | 0.364 | 0.303 | 0.275 | 0.234 | 0.383 | 0.401 | 0.480 | 0.636 | 0.535 | 0.396 | 0.332 | 0.287 | 0.260 | 0.371 | 0.428 | 0.502 | 0.682 | 0.585 |
| 600.90 | 0.378 | 0.303 | 0.270 | 0.232 | 0.383 | 0.399 | 0.494 | 0.645 | 0.534 | 0.398 | 0.332 | 0.289 | 0.261 | 0.373 | 0.426 | 0.508 | 0.680 | 0.583 |
| 601.40 | 0.376 | 0.302 | 0.276 | 0.239 | 0.377 | 0.400 | 0.496 | 0.643 | 0.530 | 0.394 | 0.332 | 0.289 | 0.261 | 0.384 | 0.428 | 0.505 | 0.685 | 0.585 |
| 601.90 | 0.376 | 0.301 | 0.274 | 0.238 | 0.381 | 0.399 | 0.498 | 0.642 | 0.531 | 0.401 | 0.334 | 0.292 | 0.259 | 0.376 | 0.422 | 0.504 | 0.689 | 0.566 |
| 602.40 | 0.360 | 0.303 | 0.265 | 0.236 | 0.388 | 0.402 | 0.450 | 0.639 | 0.531 | 0.402 | 0.334 | 0.300 | 0.257 | 0.377 | 0.421 | 0.509 | 0.681 | 0.571 |
| 602.90 | 0.360 | 0.304 | 0.274 | 0.237 | 0.389 | 0.402 | 0.450 | 0.637 | 0.530 | 0.403 | 0.332 | 0.291 | 0.258 | 0.378 | 0.417 | 0.509 | 0.680 | 0.577 |
| 603.40 | 0.360 | 0.312 | 0.278 | 0.235 | 0.392 | 0.402 | 0.466 | 0.631 | 0.527 | 0.398 | 0.332 | 0.294 | 0.257 | 0.373 | 0.420 | 0.506 | 0.675 | 0.579 |
| 603.90 | 0.360 | 0.311 | 0.273 | 0.236 | 0.391 | 0.402 | 0.493 | 0.637 | 0.535 | 0.395 | 0.331 | 0.294 | 0.258 | 0.370 | 0.421 | 0.506 | 0.560 | 0.581 |
| 604.40 | 0.364 | 0.314 | 0.273 | 0.238 | 0.394 | 0.403 | 0.469 | 0.640 | 0.526 | 0.396 | 0.331 | 0.292 | 0.257 | 0.371 | 0.418 | 0.503 | 0.673 | 0.579 |
| 604.90 | 0.363 | 0.304 | 0.271 | 0.238 | 0.389 | 0.402 | 0.472 | 0.640 | 0.525 | 0.400 | 0.333 | 0.296 | 0.259 | 0.375 | 0.423 | 0.505 | 0.685 | 0.576 |
| 605.40 | 0.363 | 0.303 | 0.269 | 0.240 | 0.388 | 0.399 | 0.453 | 0.640 | 0.532 | 0.400 | 0.334 | 0.293 | 0.259 | 0.375 | 0.427 | 0.514 | 0.684 | 0.580 |
| 605.90 | 0.363 | 0.301 | 0.268 | 0.239 | 0.386 | 0.399 | 0.483 | 0.640 | 0.531 | 0.397 | 0.331 | 0.294 | 0.260 | 0.372 | 0.414 | 0.511 | 0.671 | 0.578 |
| 606.40 | 0.364 | 0.315 | 0.270 | 0.239 | 0.395 | 0.399 | 0.465 | 0.640 | 0.530 | 0.395 | 0.332 | 0.294 | 0.259 | 0.370 | 0.412 | 0.508 | 0.684 | 0.579 |
| 606.90 | 0.360 | 0.315 | 0.272 | 0.237 | 0.395 | 0.399 | 0.468 | 0.639 | 0.539 | 0.392 | 0.333 | 0.293 | 0.259 | 0.382 | 0.410 | 0.502 | 0.684 | 0.579 |
| 607.40 | 0.368 | 0.313 | 0.269 | 0.237 | 0.398 | 0.400 | 0.465 | 0.637 | 0.538 | 0.395 | 0.334 | 0.291 | 0.260 | 0.385 | 0.429 | 0.508 | 0.670 | 0.579 |
| 607.90 | 0.379 | 0.313 | 0.269 | 0.236 | 0.398 | 0.399 | 0.477 | 0.632 | 0.538 | 0.396 | 0.335 | 0.293 | 0.260 | 0.371 | 0.430 | 0.509 | 0.683 | 0.578 |
| 608.40 | 0.361 | 0.302 | 0.267 | 0.237 | 0.372 | 0.399 | 0.481 | 0.626 | 0.538 | 0.425 | 0.331 | 0.286 | 0.258 | 0.395 | 0.422 | 0.496 | 0.684 | 0.590 |
| 608.90 | 0.366 | 0.303 | 0.266 | 0.236 | 0.373 | 0.399 | 0.481 | 0.628 | 0.535 | 0.410 | 0.334 | 0.291 | 0.260 | 0.385 | 0.413 | 0.498 | 0.685 | 0.566 |
| 609.40 | 0.363 | 0.315 | 0.271 | 0.235 | 0.400 | 0.400 | 0.486 | 0.626 | 0.537 | 0.398 | 0.334 | 0.295 | 0.259 | 0.373 | 0.414 | 0.496 | 0.670 | 0.567 |
| 609.90 | 0.363 | 0.301 | 0.265 | 0.240 | 0.371 | 0.400 | 0.470 | 0.635 | 0.537 | 0.400 | 0.335 | 0.299 | 0.260 | 0.375 | 0.413 | 0.500 | 0.684 | 0.570 |
| 610.40 | 0.377 | 0.301 | 0.264 | 0.238 | 0.371 | 0.400 | 0.473 | 0.638 | 0.537 | 0.401 | 0.330 | 0.287 | 0.259 | 0.376 | 0.425 | 0.499 | 0.684 | 0.568 |

| Hour | 45°C | | | | | | | | | 30°C | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | pH 5.0 | pH 5.5 | pH 6.0 | pH 6.5 | pH 7.0 | pH 7.5 | pH 8.0 | pH 8.5 | pH 9.0 | pH 5.0 | pH 5.5 | pH 6.0 | pH 6.5 | pH 7.0 | pH 7.5 | pH 8.0 | pH 8.5 | pH 9.0 |
| 610.90 | 0.361 | 0.306 | 0.268 | 0.244 | 0.371 | 0.402 | 0.475 | 0.639 | 0.544 | 0.392 | 0.330 | 0.286 | 0.259 | 0.382 | 0.422 | 0.500 | 0.677 | 0.569 |
| 611.40 | 0.368 | 0.305 | 0.266 | 0.236 | 0.375 | 0.402 | 0.472 | 0.636 | 0.545 | 0.398 | 0.331 | 0.291 | 0.257 | 0.378 | 0.419 | 0.496 | 0.679 | 0.596 |
| 611.90 | 0.369 | 0.307 | 0.266 | 0.245 | 0.372 | 0.400 | 0.491 | 0.640 | 0.544 | 0.407 | 0.335 | 0.293 | 0.256 | 0.387 | 0.414 | 0.498 | 0.683 | 0.596 |
| 612.40 | 0.372 | 0.308 | 0.267 | 0.245 | 0.373 | 0.401 | 0.493 | 0.639 | 0.540 | 0.405 | 0.334 | 0.292 | 0.257 | 0.380 | 0.420 | 0.500 | 0.683 | 0.571 |
| 612.90 | 0.371 | 0.303 | 0.263 | 0.244 | 0.373 | 0.400 | 0.471 | 0.639 | 0.535 | 0.403 | 0.333 | 0.294 | 0.258 | 0.378 | 0.419 | 0.500 | 0.685 | 0.572 |
| 613.40 | 0.374 | 0.307 | 0.266 | 0.244 | 0.372 | 0.399 | 0.475 | 0.635 | 0.541 | 0.405 | 0.333 | 0.291 | 0.257 | 0.385 | 0.425 | 0.506 | 0.684 | 0.573 |
| 613.90 | 0.369 | 0.309 | 0.267 | 0.243 | 0.374 | 0.399 | 0.475 | 0.644 | 0.534 | 0.404 | 0.334 | 0.294 | 0.257 | 0.379 | 0.411 | 0.496 | 0.685 | 0.576 |
| 614.40 | 0.368 | 0.309 | 0.267 | 0.242 | 0.374 | 0.396 | 0.474 | 0.637 | 0.532 | 0.404 | 0.333 | 0.293 | 0.257 | 0.379 | 0.417 | 0.500 | 0.678 | 0.574 |
| 614.90 | 0.366 | 0.308 | 0.262 | 0.243 | 0.373 | 0.402 | 0.475 | 0.640 | 0.531 | 0.406 | 0.333 | 0.287 | 0.257 | 0.386 | 0.414 | 0.507 | 0.679 | 0.573 |
| 615.40 | 0.375 | 0.309 | 0.265 | 0.244 | 0.374 | 0.395 | 0.471 | 0.639 | 0.531 | 0.403 | 0.332 | 0.292 | 0.258 | 0.378 | 0.413 | 0.506 | 0.682 | 0.570 |
| 615.90 | 0.375 | 0.311 | 0.266 | 0.244 | 0.361 | 0.402 | 0.474 | 0.638 | 0.532 | 0.401 | 0.331 | 0.293 | 0.255 | 0.376 | 0.411 | 0.508 | 0.680 | 0.569 |
| 616.40 | 0.363 | 0.313 | 0.264 | 0.243 | 0.363 | 0.396 | 0.474 | 0.636 | 0.532 | 0.400 | 0.333 | 0.297 | 0.260 | 0.395 | 0.428 | 0.508 | 0.679 | 0.569 |
| 616.90 | 0.363 | 0.300 | 0.260 | 0.242 | 0.370 | 0.404 | 0.469 | 0.636 | 0.530 | 0.356 | 0.334 | 0.287 | 0.260 | 0.276 | 0.423 | 0.508 | 0.679 | 0.566 |
| 617.40 | 0.362 | 0.300 | 0.264 | 0.241 | 0.370 | 0.404 | 0.473 | 0.635 | 0.536 | 0.358 | 0.333 | 0.295 | 0.260 | 0.283 | 0.411 | 0.496 | 0.680 | 0.588 |
| 617.90 | 0.363 | 0.300 | 0.265 | 0.242 | 0.370 | 0.403 | 0.480 | 0.638 | 0.532 | 0.404 | 0.332 | 0.290 | 0.255 | 0.379 | 0.425 | 0.497 | 0.679 | 0.593 |
| 618.40 | 0.365 | 0.300 | 0.264 | 0.242 | 0.370 | 0.403 | 0.476 | 0.645 | 0.531 | 0.399 | 0.333 | 0.290 | 0.259 | 0.394 | 0.410 | 0.499 | 0.683 | 0.580 |

Circuit voltage in various external resistance of part 2

| Temp | pH | External resistance (Ω) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | 10.5 | 30.1 | 76 | 148 | 197 | 298 | 502 | 746 | 996 |
| 45°C | 5.0 | 0.024 | 0.090 | 0.129 | 0.261 | 0.422 | 0.501 | 0.577 | 0.602 | 0.645 |
| | 5.5 | 0.022 | 0.083 | 0.121 | 0.234 | 0.384 | 0.456 | 0.534 | 0.584 | 0.620 |
| | 6.0 | 0.020 | 0.073 | 0.106 | 0.216 | 0.354 | 0.420 | 0.500 | 0.548 | 0.602 |
| | 6.5 | 0.017 | 0.064 | 0.091 | 0.190 | 0.324 | 0.386 | 0.457 | 0.498 | 0.524 |
| | 7.0 | 0.056 | 0.140 | 0.290 | 0.418 | 0.475 | 0.534 | 0.612 | 0.650 | 0.690 |
| | 7.5 | 0.029 | 0.108 | 0.155 | 0.300 | 0.490 | 0.578 | 0.645 | 0.684 | 0.716 |
| | 8.0 | 0.043 | 0.146 | 0.202 | 0.369 | 0.526 | 0.608 | 0.668 | 0.698 | 0.720 |
| | 8.5 | 0.070 | 0.223 | 0.290 | 0.465 | 0.622 | 0.669 | 0.720 | 0.739 | 0.762 |
| | 9.0 | 0.053 | 0.174 | 0.235 | 0.401 | 0.554 | 0.621 | 0.672 | 0.692 | 0.729 |
| 30°C | 5.0 | 0.031 | 0.112 | 0.158 | 0.310 | 0.478 | 0.565 | 0.628 | 0.662 | 0.695 |
| | 5.5 | 0.026 | 0.097 | 0.139 | 0.279 | 0.427 | 0.515 | 0.596 | 0.632 | 0.668 |
| | 6.0 | 0.024 | 0.091 | 0.130 | 0.260 | 0.420 | 0.510 | 0.580 | 0.620 | 0.650 |
| | 6.5 | 0.022 | 0.083 | 0.121 | 0.248 | 0.403 | 0.489 | 0.569 | 0.599 | 0.627 |
| | 7.0 | 0.061 | 0.157 | 0.301 | 0.428 | 0.476 | 0.534 | 0.602 | 0.648 | 0.672 |
| | 7.5 | 0.032 | 0.114 | 0.162 | 0.318 | 0.489 | 0.582 | 0.668 | 0.700 | 0.725 |
| | 8.0 | 0.049 | 0.171 | 0.238 | 0.421 | 0.576 | 0.638 | 0.690 | 0.725 | 0.734 |
| | 8.5 | 0.075 | 0.238 | 0.314 | 0.499 | 0.637 | 0.687 | 0.732 | 0.754 | 0.776 |
| | 9.0 | 0.061 | 0.196 | 0.261 | 0.433 | 0.568 | 0.637 | 0.688 | 0.713 | 0.741 |

# BIOGRAPHY FOR NATTAKARN PRASERTSUNG

**Date of birth** : 16 October 1972 **Place of birth** : Roi ed Province, Thailand

**Education** : 1995, B.Eng. (Environmental Engineering), Chulalongkorn University

: 2004, M.Eng. (Environmental Engineering), Chulalongkorn University

: 2004, B.Sc Occupational Health, Shukhothai Thammatirath University, Bangkok, Thailand

**Employment record**

| | |
|---|---|
| Jun. 2005 – now ; | Lecturer at Kasetsart University Chalermphrakiat Sakon Nakhon Province Campus in Faculty of Science and Engineering. |
| May. 2002 – May. 2005 | Civil and Environmental Engineer at Eastern Water Resources Development and Management Public Company limited. |
| Jul. 1995 – Apr. 2001 | Civil and Environmental Engineer at Thammasorn Company Limited. |