

การทำเซลล์จูลสำหรับให้แตกด้วยฟลูอิดไดซ์เบดสามวัฏภาคแบบใช้ใบกวน



น.ส. พิรดี สุนทรสถิตย์

ศูนย์วิทยทรัพยากร  
จุฬาลงกรณ์มหาวิทยาลัย

วิทยานิพนธ์นี้เป็นส่วนหนึ่งของการศึกษาตามหลักสูตรปริญญาวิศวกรรมศาสตรมหาบัณฑิต

สาขาวิชาวิศวกรรมเคมี ภาควิชาวิศวกรรมเคมี


คณะวิศวกรรมศาสตร์ จุฬาลงกรณ์มหาวิทยาลัย

ปีการศึกษา 2546

ISBN 974-17-4331-9

ลิขสิทธิ์ของจุฬาลงกรณ์มหาวิทยาลัย

MICROALGAE CELL DISRUPTION USING THREE-PHASE FLUIDIZED BED WITH AGITATOR



MISS PIRADEE SOONTORNSATID

ศูนย์วิทยทรัพยากร

A Thesis Submitted in Partial Fulfillment of the Requirements  
for the Degree of Master of Engineering in Chemical Engineering

Department of Chemical Engineering

Faculty of Engineering

Chulalongkorn University

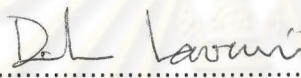
Academic Year 2003

ISBN 974-17-4331-9

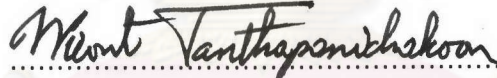
Thesis Title MICROALGAE CELL DISRUPTION USING THREE-PHASE  
FLUIDIZED BED WITH AGITATOR  
By Miss Piradee Soontornsatid  
Field of Study Chemical Engineering  
Thesis Advisor Associate Professor Tawatchai Charinpanitkul, D. Eng.  
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พริตี สุนทรสถิตย์ : การทำเซลล์จุลสาหร่ายให้แตกด้วยฟลูอิดไดซ์เบดสามวัฏภาคแบบใช้ไบน  
 กวน. (MICROALGAE CELL DISRUPTION USING THREE-PHASE FLUIDIZED BED  
 WITH AGITATOR) อ. ที่ปรึกษา : รศ.ดร. ธวัชชัย ชรินพานิชกุล, อ.ที่ปรึกษาร่วม : ดร.  
 อภาวรัตน์ มหาพันธ์ 119 หน้า. ISBN 974-17-4331-9

ศึกษาการทำเซลล์จุลสาหร่ายให้แตกด้วยฟลูอิดไดซ์เบดสามวัฏภาคแบบใช้ไบนกวนซึ่งประกอบ  
 ไปด้วย อากาศ, สารแขวนลอยสาหร่าย และ ลูกแก้ว (เส้นผ่านศูนย์กลาง 1 มม.) เป็นวัฏภาคของ  
 อากาศ ของเหลวและของแข็งตามลำดับ จุลสาหร่ายที่ใช้ได้แก่ *Chlorella ellipsoidea* TISTR 8260,  
*Chroococcus sp.* TISTR 8625 และ *Chlorococcum sp.* TISTR 8509 โดยมีความเข้มข้นอยู่ระหว่าง  
 $(9-15) \times 10^6$  เซลล์ต่อมิลลิลิตร ทำการศึกษาโดยปรับเปลี่ยนความเร็วอากาศ และ ความเร็วสาร  
 แขวนลอย อยู่ในช่วง 0-10 ชม.ต่อนาที และความเร็วรอบของไบนกวน 0-3000 รอบต่อนาที พิจารณา  
 ประสิทธิภาพการแตกของเซลล์จากเปอร์เซ็นต์เซลล์ที่ถูกทำลาย, อัตราการแตกของเซลล์, ปริมาตรของ  
 เซลล์และปริมาณคลอโรฟิลล์ เอ ที่เปลี่ยนแปลงไปตลอดเวลา และยืนยันการแตกของเซลล์ด้วยภาพถ่าย  
 จากกล้องจุลทรรศน์

จากผลการทดลองสามารถสรุปได้ว่าหากแยกศึกษาที่ละปัจจัยแล้ว แต่ละปัจจัยต่างให้  
 ประสิทธิภาพการแตกของเซลล์ใกล้เคียงกัน สำหรับความเร็วอากาศและความเร็วของเหลวค่า  
 ความเร็วที่ 10 ชม.ต่อนาทีจะให้ประสิทธิภาพการแตกของเซลล์สูงที่สุดที่ 41.8 and 38.5% แต่เมื่อ  
 เพิ่มความเร็วขึ้นพบว่าประสิทธิภาพการแตกของเซลล์กลับลดลง ในส่วนของความเร็วรอบการปั่นกวน  
 นั้นพบว่าที่ความเร็วรอบ 3000 รอบต่อนาทีให้ประสิทธิภาพการแตกของเซลล์สูงที่สุดที่ 38.5% และเมื่อ  
 นำทั้ง 3 ปัจจัยเข้าสู่ระบบพร้อมกันประสิทธิภาพการแตกของเซลล์จะมีค่าเพิ่มขึ้นสูงถึง 93.6% โดย  
 กลไกสำคัญที่มีอิทธิพลต่อการแตกของเซลล์คือ การบดกันระหว่างลูกบด การกระทบกันระหว่างลูก  
 บดและเซลล์รวมถึงแรงเฉือนที่เกิดขึ้นภายในระบบ

ภาควิชา.....วิศวกรรมเคมี.....ลายมือชื่อนิสิต.....  
 สาขาวิชา.....วิศวกรรมเคมี.....ลายมือชื่ออาจารย์ที่ปรึกษา.....  
 ปีการศึกษา...2546.....ลายมือชื่ออาจารย์ที่ปรึกษาร่วม.....

## 4370424321 : MAJOR CHEMICAL ENGINEERING

KEY WORD: CELL RUPTURED/ MICROALGAL/ FLUIDIZED BED

PIRADEE SOONTORNSATID: (MICROALGAE CELL DISRUPTION USING THREE-PHASE FLUIDIZED BED WITH AGITATOR) THESIS ADVISOR : ASSOC. PROF. TAWATCHAI CHARINPANITKUL, THESIS CO-ADVISER : DR. APARAT MAHAKHANT, 119 pp. ISBN: 974-17-4331-9

Microalgal cells disruption was investigated by using three-phase fluidized bed in which air, microalgal suspension and glass beads (diameter 1 mm) are treated as gas, liquid, and solid phases, respectively. An agitator was also employed to enhance the cell disruption performance. *Chlorella ellipsoidea* TISTR 8260, *Chroococcus* sp. TISTR 8625 and *Chlorococcum* sp. TISTR 8509 are used in this investigation within concentration range varied between  $(9-15) \times 10^6$  cells/cm<sup>3</sup>. Superficial gas and liquid velocities are varied from 0-40 cm/min, while agitation speed is varied between 0 and 3000 rpm. Percentage of cell ruptured, disruption rate, microalgal cell volume and amount of chlorophyll were measured to confirm the disruption performance of the equipment.

The results show that each single variable provides almost equal influence on the disruption of all microalgae. Superficial gas and liquid velocities at 10 cm/min show the highest value of cell disruption at 41.8 and 38.5%, respectively. An increase in superficial gas or liquid velocities resulted in a decrease in the percentage of cell disruption for all species investigated. Meanwhile, agitation speed of 3000 rpm provided the highest percentage of cell disruption at 38.5%. In the systems employing all disruption factors, namely, superficial gas and liquid velocities and agitation this cell disruption could be enhanced up to 93.6%. Based on the experimental results, dominating disruption mechanisms could be implied as; the grinding effect beads due to particle-particle interaction and particle-cell interaction, and shear stress due to the fluid flow.

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 Field of study ...Chemical...Engineering... Advisor's signature..... J. Chongmitth  
 Academic year.....2003..... Co-advisor's signature..... A. Mahakhant

## ACKNOWLEDGMENT

This thesis is the result of my attendance but its cannot be accomplished without support from many people. I would like to express my deepest gratitude to my thesis advisor, Assoc. Prof. Dr. Tawatchai Charinpanitkul and co-advisor, Dr. Aparat Mahakhant for their encouraging guidance, advice, discussion and helpful suggestions throughout the course of this work. I would like to acknowledge the member of my thesis committee, Prof. Dr. Wiwut Tanthapanichakoon and Ast. Prof. Dr. Prasert Pavasant for their invaluable suggestion and advises.

This thesis has been supported and funded by Thailand Reserch Fund (TRF) , Ministry of University Affairs (Thesis Grants For Graduate Students) and Microbiological Resources Center (MIRCEN), Thailand Institute of Scientific and Technological Research (TISTR).

Furthermore, special thanks are given to my friends at Satriwithaya School & KMITL & CU, senoir project, my brothers and sisters at TPTC lab and MIRCEN, for their help and cheer.

Finally, I wishes to belaud my mother, my brother and my grandparents for their invaluable love, support and inspiration all times.

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## NOMENCLATURES

$A$	:	the cross section area of column (m)
$A_p$	:	the projected area of particle measured in plane perpendicular to direction of motion of particle (-)
$Ar$	:	Archimedes number
$C$	:	amount of chlorophyll a at operating time ( $\mu\text{g chl/mL}$ )
$C_0$	:	amount of chlorophyll a at starting time ( $\mu\text{g chl/mL}$ )
$C_D$	:	drag coefficient (-)
$D_a$	:	diameter of impeller (m)
$D_c$	:	column diameter (m)
$d_p$	:	particle diameter (m)
$D_t$	:	diameter of tank (m)
$dP/dz$	:	the static pressure gradient.
$E$	:	the height of impeller above the column floor (m)
$g$	:	the gravitational acceleration ( $\text{m/s}^2$ )
$H$	:	the effective height of bed expansion (m)
$H$	:	the depth of liquid in column (m)
$J$	:	the width of baffles (m)
$L$	:	the length of impeller blades (m)
$L_0$	:	the height of bed at fixed bed (m)
$L_{mf}$	:	the height of bed at minimum fluidization (m)
$m$	:	the mass of particle (kg)
$N_{re,p}$	:	Reynolds number (-)
$N$	:	Impeller speed (rpm)
$P$	:	the operating pressure (psia)
$\Delta P$	:	pressure drop (psia)
$q$	:	the total volume of fluid throughput the CSTR ( $\text{m}^3$ )
$Re_{mfo}$	:	Reynolds number at minimum fluidization

$S$	:	the cross-section area of empty column (m)
$u_{mf}$	:	minimum fluidized bed velocity (m/s)
$u_t$	:	terminal velocity (m/s)
$U_g$	:	superficial gas velocity (cm/min)
$U_l$	:	superficial liquid velocity (cm/min)
$U_{mf}$	:	minimum fluidization velocity in a three-phase fluidize bed system (m/s)
$U_{mfo}$	:	minimum fluidization velocity for a liquid-solid system (m/s)
$V$	:	the total volume of the mill ( $m^3$ )
$W$	:	the weight of solid particle in the bed (kg).
$W$	:	the impeller width (m)
$\mu$	:	fluid viscosity (kg/ m.s)
$\rho_g$	:	gas density ( $kg/m^3$ )
$\rho_l$	:	liquid density ( $kg/m^3$ )
$\rho_s$	:	solid density ( $kg/m^3$ )
$\epsilon_g$	:	gas holdup (-)
$\epsilon_l$	:	liquid holdup (-)
$\epsilon_{mf}$	:	minimum porosity (-)
$\epsilon_s$	:	solid holdup (-)
$\phi_s$	:	the sphericity (-)
$\tau$	:	the mean residence time in the mill
$\sigma$	:	surface tension (mN/m)
$\nu_l$	:	kinematic liquid viscosity ( $m^2/s$ )
$\gamma_{av}$	:	average shear rate (1/s)