

## REFERENCES

- Benincasa, M., and Accorsini, F.R. (2008). *Pseudomonas aeruginosa* LBI production as an integrated process using the wastes from sunflower-oil refining as a substrate. Bioresource Technology, 99(9), 3843–3849.
- Benincasa, M., Contiero, J., Manresa, M.A., and Moraes, I.O. (2002). Rhamnolipid production by *Pseudomonas aeruginosa* LBI growing on soapstock as the sole carbon source. Journal of Food Engineering, 54, 283–288.
- Business Opportunity Center. (2003). Surfactant. Department of Industrial Promotion, 1-16.
- Chen, S. Y., Lu, W. B., Wei, Y. H., Chen, W. M., and Chang, J. S. (2007). Improved Production of Biosurfactant with Newly Isolated *Pseudomonas aeruginosa* S2. Biotechnol. Prog. 23, 661-666.
- Desai, J.D., and Banat, I.M. (1997). Microbial production of surfactants and their commercial potential. Microbiology and molecular biology, 61(1), 47-64.
- Fonseca, R.R., Silva, A.J.R., De França, F.P., Cardoso, V.L., and Sérvulo. (2007). Optimizing Carbon/Nitrogen Ratio for Biosurfactant Production by a *Bacillus subtilis* Strain. Applied Biochemistry and Biotechnology, 136–140, 471-486.
- Gautam, K.K., and Tyagi, V.K. (2006). Microbial surfactants: A review. Journal of Ore Science, 55(4), 155-166.
- Guerra-Santos, L.H., Kappeli, O., and Fiechter, A. (1984). *Pseudomonas aeruginosa* biosurfactant production in continuous culture with glucose as carbon source. Applied and Environmental Microbiology, 48(2), 301–305.
- Healy, M.G., Devine, C.M., Murphy, R. (1996). Microbial production of biosurfactants. Resources, conservation and recycling, 18, 41-57.
- Irvine, R.L., and Ketchum, Jr.L.H. (2004). The sequencing batch reactor and batch operation for the optimal treatment of wastewater. SBR Technologies Inc.
- Kappeli, O., and Finnerty, W.R. (1979). Partition of alkane by an extracellular vesicle derived from hexadecane grown *Acinetobacter*. J. Bacteriol. 1979, 140, 707–712.

- Kosaric, N. (1992). Biosurfactant in industry. Pure & Appl. Chem., 64(11), 1731-1737.
- Kretschmer, A., Bock, H. and Wagner, F. (1982). Chemical and physical characterization of interfacial active lipids from *Rhodococcus erythropolis* grown on n-alkane. Appl. Environ. Microbiol., 44, 864–870.
- Leung , G.L.W., and Tam N.F.Y. (1994). Operation strategy of a sequencing batch reactor for simultaneous removal of wastewater organic matter and nutrients. Resources, Conservation and Recycling, 11, 209-223.
- Mulligan, C.N. (2005). Environmental applications for biosurfactants. Environmental Pollution, 133, 183–198.
- Muthusamy, K., Gopalakrishnan, S., Ravi, T.K., and Sivachidambaram, P. (2008). Biosurfactants: Properties, commercial production and application. Current Science, 94(6), 736-747.
- Nitschke, M., Siddhartha, G.V.A.O.C., and Contiero, J. (2005). Rhamnolipid Surfactants: An Update on the General Aspects of These Remarkable Biomolecules. Biotechnology Progress, 21, 1593-1600.
- Ochsner, U.A., Reiser, J., Fiechter, A., and Witholt, B. (1995). American Society for Microbiology Production of *Pseudomonas aeruginosa* Rhamnolipid Biosurfactants in Heterologous Hosts. Applied and Environmental Microbiology, 61(9), 3503-3506.
- Oliveira, F.J.S., Vazquez, L., De Campos, N.P., and De França, F. (2006). Biosurfactants Production by *Pseudomonas aeruginosa* FR Using Palm Oil. Applied Biochemistry and Biotechnology, 129-132, 727-737.
- Parkinson, M. (1985). Biosurfactants. Biotechnology Advances, 3, 65-83.
- Pornsunthorntawee, O., Maksung, S., Huayyai O., Rujiravanit, R., and Chavadej, S. (2009). Biosurfactant production by *Pseudomonas aeruginosa* SP4 using sequencing batch reactors: Effects of oil loading rate and cycle time. Biore-source Technology, 100(2), 812-818
- Rashedi, H., Assadi, M.M., Jamshidi, E. and Bonakdarpour, B. (2006 a). Production of rhamnolipids by *Pseudomonas aeruginosa* growing on carbon sources. International Journal of Environmental Science and Technology, 3(3), 297-303.

- Rashedi, H., Jamshidi, E.M. Assadi, M., and Bonakdarpour, B. (2006 b). Biosurfactant production with glucose as a carbon source. Chemical and Biochemical Engineering, 20(1) 99–106.
- Robert, M., Mercade, M.E., Bosch, M.P., Parra, J.L., Espuny, M.J., Manresa, M.A., and Guinea, J. (1989). Effect of the carbon source on biosurfactant production by *Pseudomonas aeruginosa* 44T1. Biotechnology Letters, 11(12), 871–874.
- Santos, A.S., Sampaio, A.P.W., Vasquez, G.S., Anna, L.M.S., Pereira Jr.N., and Freire, D.M.G. (2002). Evaluation of different carbon and nitrogen sources in production of rhamnolipids by a strain of *Pseudomonas aeruginosa*. Applied Biochemical and Biotechnology, 98-100, 1025-1035.
- Shabtai, Y. (1990). Production of exopolysaccharides by *Acinetobacter* strains in a controlled fed-batch fermentation process using soap stock oil (SSO) as carbon source. Int. J. Biol. Macromol., 12, 145-152.
- Singh, A., Van Hamme, J.D., and Ward, O. P. (2007). Surfactants in microbiology and biotechnology:Part 2. Application aspects. Biotechnology Advances, 25, 99–121
- Singh, P. and Cameotra, S.S. (2004). Potential applications of microbial surfactants in biomedical sciences. Trends in Biotechnology, 22(3).
- Wei, Y.H., Choub, C.L., and Changb, J.S. (2005). Rhamnolipid production by indigenous *Pseudomonas aeruginosa* J4 originating from petrochemical wastewater. Biochemical Engineering Journal, 27, 146–154.
- Wu, J.Y., Yeh, K.L., Lu, W.B., Lin, C.L., and Chang, J.S. (2008). Rhamnolipid production with indigenous *Pseudomonas aeruginosa* EM1 isolated from oil-contaminated site. Bioresource Technology, 99, 1157-1164.
- Zhang, G.L., Wu, Y.T., Qian, X.P., and Meng, Q. (2005). Biodegradation of crude oil by *Pseudomonas aeruginosa* in the presence of rhamnolipids. Journal of Zhejiang University SCIENCE, 6B(8), 725-730.



**Table A3** Density of palm oil

No.	Density (g/ml)
1	0.88706
2	0.90063
3	0.90232
4	0.89938
5	0.88819
6	0.89114
7	0.88560
8	0.88370
9	0.88348
10	0.89430
Avg.	0.89158

**Table A4** Chemical oxygen demand (COD) of palm oil

Substance	No.	Surfactant sol <sup>n</sup> (ml)	DI water (ml)	Diluted COD (mg/l)	COD (mg/l)	Avg.COD (mg/l)
Surfactant solution	1	0.5	2.0	619.55	3097.75	3087.23
	2	0.5	2.0	615.5	3077.5	
	3	0.5	2.0	617.29	3086.45	

Substance	No.	Oil+Surfactant sol <sup>n</sup> (ml)	DI water (ml)	Diluted COD (mg/l)			COD (mg/l)	Actual COD (mg/l)
Surfactant + Palm oil	1	0.5	2	841.45	835.48	835.40	837.44	4187.22
	2	0.5	2	837.00	836.89	834.13	836.01	4180.03
	3	0.5	2	843.41	836.24	834.50	838.05	4190.25

Substance	No.	Palm Oil (g)	Palm Oil (ml)	DI water (ml)	Diluted COD (mg/l)	COD (mg/l)	Avg.COD (mg/l)
Palm oil	1	0.0099	0.0111	24.9888961	1,099.98	2,476,573.59	2,473,459.06
	2	0.0099	0.0111	24.9888961	1,092.80	2,460,400.57	
	3	0.0099	0.0111	24.9888961	1,103.02	2,483,403.03	

**Table A5** Chemical oxygen demand (COD) of glucose

No.	Glucose (g)	DI water (ml)	[Glucose] (g/ml)	Diluted COD (mg/l)				Avg. Diluted COD (mg/l)	Avg. COD (mg/l)
1	0.0102	50	0.000204	189.57	190.11	190.9	192.24	190.705	191.61
2	0.0102	50	0.000204	184.94	185.24	185.81	187.33	185.83	
3	0.0102	50	0.000204	197.71	198.56	197.34	199.55	198.29	

**Table A6** Total organic carbon (TOC) of palm oil

Substance	Sample No.	wt. of SFT (g)	RO water (ml)	[SFT] (%w/v)	TOC (mg/l)	Avg. TOC (mg/l)
SFT solution	1	0.5055	500	0.1011	582.2	584.65
	2	0.5055	500	0.1011	582.9	
	3	0.5055	500	0.1011	577.8	
	4	0.5055	500	0.1011	588.7	
	5	0.5055	500	0.1011	588.3	
	6	0.5055	500	0.1011	588	

Substance	Sample No.	wt. of SFT (g)	[SFT] (%w/v)	SFT solution (ml)	Palm oil (g)	Density Palm oil (g/ml)	Palm oil (ml)	[Palm oil] (%v/v)	TOC of Solution (mg/l)
Palm oil + SFT solution	7	0.5055	0.1011	100	0.087	0.89158	0.09758	0.09758	1149
	8	0.5055	0.1011	100	0.087	0.89158	0.09758	0.09758	1172
	9	0.5055	0.1011	100	0.087	0.89158	0.09758	0.09758	1125
	10	0.5055	0.1011	100	0.087	0.89158	0.09758	0.09758	1120
	11	0.5055	0.1011	100	0.087	0.89158	0.09758	0.09758	1118
	12	0.5055	0.1011	100	0.087	0.89158	0.09758	0.09758	1123

Substance	Sample No.	Palm oil (g)	Palm oil (ml)	Total solution (ml)	[Palm oil] (%v/v)	TOC (mg/l)		
						0.09758% v/v Palm oil	100% v/v Palm oil	Avg.
Palm oil	7	0.087	0.09758	100	0.09758	564.35	578,348.47	563,488.81
	8	0.087	0.09758	100	0.09758	587.35	601,918.98	
	9	0.087	0.09758	100	0.09758	540.35	553,753.16	
	10	0.087	0.09758	100	0.09758	535.35	548,629.14	
	11	0.087	0.09758	100	0.09758	533.35	546,579.53	
	12	0.087	0.09758	100	0.09758	538.35	551,703.56	



**Table A7** Total organic carbon (TOC) of glucose

Substance	Sample No.	wt. of Glucose (g)	RO water (ml)	[Glucose] (%w/v)	TOC (mg/l)	
					Avg.	Total Avg.
Glucose solution	1	0.1163	100	0.1163	472.3	470
	2	0.1163	100	0.1163	470.3	
	3	0.1163	100	0.1163	467.4	

**Table A8** Surface tension of the mineral medium in the different oil-to-glucose ratio of influent at an oil loading rate of 2 kg/m<sup>3</sup>d

Oil-to-glucose ratio	Surface tension (mN/m)					
	No.1	No.2	No.3	No.4	No.5	Avg.
Without glucose	71.63	71.76	71.70	71.63	71.59	71.66
60/1	71.64	71.53	71.38	71.10	71.68	71.47
40/1	71.88	71.79	71.93	71.81	71.93	71.87
30/1	70.91	70.80	70.72	70.92	71.00	70.87
20/1	71.75	71.79	71.88	71.71	71.88	71.80
10/1	71.82	71.78	71.89	71.74	71.79	71.80

**Table A9** Total nitrogen (TP) and total nitrogen (TN) of mineral medium and palm oil

Substances	No.	Volume of test (ml)		Diluted TP (mg/l)	Actual TP (mg/l)	Avg. TP (mg/l)	Diluted TN (mg/l)	Actual TN (mg/l)	Avg. TN (mg/l)
		Sample	DI water						
Palm oil	1	1	99	0.9	90	90	19	1,900	1,500
	2	1	99	0.8	80		13	1,300	
	3	1	99	1	100		13	1,300	
Glucose 0.1012 g/100 ml DI water	1	1	4	-	-	-	-	-	-
	2	1	4	-	-		-	-	
	3	1	4	-	-		-	-	
K <sub>2</sub> HPO <sub>4</sub> 0.1005 g/100 ml DI water	1	0.5	4.5	16.9	169	168	-	-	-
	2	0.5	4.5	16.7	167		-	-	
	3	0.5	4.5	16.8	168		-	-	
KH <sub>2</sub> PO <sub>4</sub> 0.0503 g/ 100 ml DI water	1	0.5	4.5	12.3	123	123.333	-	-	-
	2	0.5	4.5	12.3	123		-	-	
	3	0.5	4.5	12.4	124		-	-	
NaNO <sub>3</sub> 0.2003 g/ 100 ml DI water	1	0.1	0.4	-	-	-	57	285	290
	2	0.1	0.4	-	-		57	285	
	3	0.1	0.4	-	-		60	300	

**Table A10** COD and TOC of oil and mineral medium in the influent at different oil-to-glucose ratio (Oil loading rate of 2 kg/m<sup>3</sup>d)

Ratio	Oil (g)	Glucose (g)	COD(mg/l)			TOC(mg/l)		
			Palm oil	Mineral medium	Total	Palm oil	Mineral medium	Total
Without glucose	6	0.00	33290.91	0.00	33290.91	3792.07	0.00	3792.07
60/1	6	0.10	33290.91	93.93	33384.84	3792.07	39.62	3831.69
40/1	6	0.15	33290.91	140.89	33431.80	3792.07	59.43	3851.50
30/1	6	0.20	33290.91	187.85	33478.76	3792.07	79.24	3871.31
20/1	6	0.30	33290.91	281.78	33572.69	3792.07	118.87	3910.94
10/1	6	0.60	33290.91	563.56	33854.47	3792.07	237.73	4029.80

**Table A11** Composition of mineral medium with C/N of 16/1 and C/P of 14/1 at an oil loading rate of 2 kg/m<sup>3</sup>d

Ratio	Carbon(mg/l)			Total Nitrogen (mg/l)		Fill NaNO <sub>3</sub> in media (g/l)	C:N ratio
	Oil	Glucose	Total	Total	Wanted		
Without glucose	3792.07	0.00	3792.07	10.0944	226.9099	1.5672	16:1
60/1	3792.07	39.62	3831.69	10.0944	229.3863	1.5843	16:1
40/1	3792.07	59.43	3851.50	10.0944	230.6245	1.5929	16:1
30/1	3792.07	79.24	3871.31	10.0944	231.8626	1.6015	16:1
20/1	3792.07	118.87	3910.94	10.0944	234.3390	1.6186	16:1
10/1	3792.07	237.73	4029.80	10.0944	241.7682	1.6699	16:1

Ratio	Carbon(mg/l)			Total Phosphorous(mg/l)		Fill $K_2HPO_4$ in media (g/l)	Fill $KH_2PO_4$ in media (g/l)	C:P ratio
	Oil	Glucose	Total	Total	Wanted			
Without glucose	3792.07	0.00	3792.07	0.6057	270.2564	1.0778	0.3674	14:1
60/1	3792.07	39.62	3831.69	0.6057	273.0866	1.0891	0.3713	14:1
40/1	3792.07	59.43	3851.50	0.6057	274.5016	1.0947	0.3732	14:1
30/1	3792.07	79.24	3871.31	0.6057	275.9167	1.1004	0.3751	14:1
20/1	3792.07	118.87	3910.94	0.6057	278.7469	1.1117	0.3790	14:1
10/1	3792.07	237.73	4029.80	0.6057	287.2374	1.1455	0.3905	14:1

**Appendix B Experimental Data of Biosurfactant Production at an Oil Loading Rate of 2 kg/m<sup>3</sup>d with Different Oil-to-Glucose Ratio**

**1. Effect of Cycle Time on Biosurfactant Production.**

**1.1 Chemical Oxygen Demand (COD)**

**Table B1** Influent, effluent COD and COD removal on days 2-14 of operation in the SBR at oil-to-glucose ratio without glucose added

Day	Volume of test (ml)		Centrifuge				Avg. COD (mg/l)	Actual COD (mg/l)	Influent COD (mg/l)	% COD removal
	Sample	RO. Water	Diluted effluent COD (mg/l)							
			No.1	No.2	No.3	avg.				
0	-	-	-	-	-	-	-	-	-	
2	0.5	2	1189.80	1189.80	1189.90	1189.83	1190.51	5952.56	33290.91	82.12
			1195.80	1196.10	1196.10	1196.00				
			1186.10	1183.80	1187.20	1185.70				
4	0.5	2	1361.10	1381.20	1379.40	1373.90	1370.17	6850.83	33290.91	79.42
			1373.30	1368.00	1368.30	1369.87				
			1366.20	1366.00	1368.00	1366.73				
6	0.5	2	1165.50	1163.00	1162.70	1163.73	1190.50	5952.50	33290.91	82.12
			1183.70	1198.80	1195.80	1192.77				
			1214.80	1216.40	1213.80	1215.00				
8	0.5	2	1308.00	1307.80	1307.80	1307.87	1323.04	6615.22	33290.91	80.13
			1319.80	1319.00	1330.70	1323.17				
			1338.00	1338.10	1338.20	1338.10				
10	0.5	2	1216.50	1216.50	1216.30	1216.43	1207.33	6036.67	33290.91	81.87
			1200.90	1201.40	1202.10	1201.47				
			1204.50	1204.40	1203.40	1204.10				
12	0.5	2	1248.30	1247.50	1242.70	1246.17	1243.64	6218.22	33290.91	81.32
			1249.20	1248.40	1245.00	1247.53				
			1237.30	1237.30	1237.10	1237.23				
14	0.5	2	1239.30	1239.60	1240.00	1239.63	1250.11	6250.56	33290.91	81.22
			1243.50	1243.10	1242.80	1243.13				
			1264.10	1263.30	1275.30	1267.57				

**Table B2** Influent, effluent COD and COD removal on days 2-14 of operation in the SBR at 60/1 oil-to-glucose ratio

Day	Volume of test (ml)		Centrifuge				Avg. COD (mg/l)	Actual COD (mg/l)	Influent COD (mg/l)	% COD removal
			Diluted effluent COD (mg/l)							
	Sample	RO. Water	No.1	No.2	No.3	avg.				
0	-	-	-	-	-	-	-	-	-	
2	0.5	2	933.04	932.73	932.45	932.74	939.30	4696.51	33384.84	85.93
			946.50	946.48	946.42	946.47				
			938.78	938.74	938.58	938.70				
4	0.5	2	1057.30	1057.00	1057.40	1057.23	1063.74	5318.72	33384.84	84.07
			1062.90	1063.00	1063.60	1063.17				
			1070.90	1070.80	1070.80	1070.83				
6	0.5	2	1149.70	1152.90	1152.00	1151.53	1148.66	5743.28	33384.84	82.80
			1141.50	1141.50	1141.40	1141.47				
			1153.20	1153.10	1152.60	1152.97				
8	0.5	2	1120.90	1120.70	1120.50	1120.70	1124.29	5621.44	33384.84	83.16
			1136.60	1136.40	1141.80	1138.27				
			1114.00	1114.00	1113.70	1113.90				
10	0.5	2	1151.40	1151.40	1151.50	1151.43	1106.17	5530.83	33384.84	83.43
			1054.00	1054.10	1055.10	1054.40				
			1112.70	1112.60	1112.70	1112.67				
12	0.5	2	1161.50	1161.20	1161.90	1161.53	1145.32	5726.61	33384.84	82.85
			1132.20	1132.70	1132.10	1132.33				
			1142.10	1141.50	1142.70	1142.10				
14	0.5	2	1211.20	1211.70	1211.40	1211.43	1211.29	6056.44	33384.84	81.86
			1213.00	1213.60	1213.20	1213.27				
			1209.40	1208.90	1209.20	1209.17				

**Table B3** Influent, effluent COD and COD removal on days 2-14 of operation in the SBR at 40/1 oil-to-glucose ratio

Day	Volume of test (ml)		Centrifuge				Avg. COD (mg/l)	Actual COD (mg/l)	Influent COD (mg/l)	% COD removal
			Diluted effluent COD (mg/l)							
	Sample	RO. Water	No.1	No.2	No.3	avg.				
0	-	-	-	-	-	-	-	-	-	
2	0.5	2	1228.50	1228.90	1230.20	1229.20	1246.93	6234.67	33431.80	81.35
			1253.90	1257.30	1254.70	1255.30				
			1255.80	1256.20	1256.90	1256.30				
4	0.5	2	1102.60	1102.90	1102.70	1102.73	1103.03	5515.17	33431.80	83.50
			1110.90	1111.10	1111.90	1111.30				
			1094.70	1095.10	1095.40	1095.07				
6	0.5	2	1024.50	1024.00	1023.50	1024.00	1019.01	5095.06	33431.80	84.76
			1014.60	1014.40	1014.30	1014.43				
			1017.90	1018.80	1019.10	1018.60				
8	0.5	2	1056.40	1056.50	1056.50	1056.47	1051.82	5259.11	33431.80	84.27
			1045.50	1045.70	1045.80	1045.67				
			1053.30	1053.30	1053.40	1053.33				
10	0.5	2	844.15	844.31	844.29	844.25	844.05	4220.26	33431.80	87.38
			847.57	847.56	847.41	847.51				
			840.37	840.46	840.35	840.39				
12	0.5	2	966.47	966.48	966.42	966.46	966.54	4832.69	33431.80	85.54
			967.10	966.94	966.95	967.00				
			966.24	966.16	966.08	966.16				
14	0.5	2	1121.30	1121.40	1121.40	1121.37	1111.88	5559.39	33431.80	83.37
			1104.40	1104.60	1104.80	1104.60				
			1109.20	1109.50	1110.30	1109.67				

**Table B4** Influent, effluent COD and COD removal on days 2-14 of operation in the SBR at 30/1 oil-to-glucose ratio

Day	Volume of test (ml)		Centrifuge				Avg. COD (mg/l)	Actual COD (mg/l)	Influent COD (mg/l)	% COD removal
	Sample	RO. Water	Diluted effluent COD (mg/l)							
			No.1	No.2	No.3	avg.				
0	-	-	-	-	-	-	-	-	-	
2	0.5	2	1124.30	1124.20	1124.30	1124.27	1118.12	5590.61	33478.76	83.30
			1118.10	1118.30	1118.50	1118.30				
			1111.70	1111.70	1112.00	1111.80				
4	0.5	2	1146.10	1146.20	1146.40	1146.23	1167.82	5839.11	33478.76	82.56
			1178.90	1179.10	1179.20	1179.07				
			1177.70	1178.20	1178.60	1178.17				
6	0.5	2	1172.80	1172.70	1172.30	1172.60	1166.53	5832.67	33478.76	82.58
			1172.20	1172.00	1171.90	1172.03				
			1150.80	1150.10	1164.00	1154.97				
8	0.5	2	1218.30	1216.10	1215.70	1216.70	1188.63	5943.17	33478.76	82.25
			1151.40	1150.40	1150.20	1150.67				
			1197.00	1198.50	1200.10	1198.53				
10	0.5	2	1099.10	1099.40	1099.80	1099.43	1110.47	5552.33	33478.76	83.42
			1112.80	1111.60	1110.90	1111.77				
			1120.00	1120.40	1120.20	1120.20				
12	0.5	2	1163.70	1164.30	1163.90	1163.97	1176.39	5881.94	33478.76	82.43
			1169.10	1169.30	1180.30	1172.90				
			1192.30	1192.30	1192.30	1192.30				
14	0.5	2	1273.10	1270.40	1278.70	1274.07	1266.04	6330.22	33478.76	81.09
			1255.10	1251.40	1246.40	1250.97				
			1273.30	1272.50	1273.50	1273.10				



**Table B5** Influent, effluent COD and COD removal on days 2-14 of operation in the SBR at 20/1 oil-to-glucose ratio

Day	Volume of test (ml)		Centrifuge				Avg. COD (mg/l)	Actual COD (mg/l)	Influent COD (mg/l)	% COD removal
			Diluted effluent COD (mg/l)							
	Sample	RO. Water	No.1	No.2	No.3	avg.				
0	-	-	-	-	-	-	-	-	-	
2	0.5	2	879.21	879.54	879.63	879.46	903.26	4516.28	33572.69	86.55
			916.88	917.10	917.20	917.06				
			913.34	913.10	913.30	913.25				
4	0.5	2	1162.30	1163.20	1164.00	1163.17	1174.67	5873.33	33572.69	82.51
			1177.00	1179.00	1180.10	1178.70				
			1181.60	1182.00	1182.80	1182.13				
6	0.5	2	1271.80	1273.60	1273.20	1272.87	1195.54	5977.72	33572.69	82.19
			1165.10	1164.50	1163.70	1164.43				
			1151.90	1140.20	1155.90	1149.33				
8	0.5	2	1202.20	1202.10	1196.00	1200.10	1222.36	6111.78	33572.69	81.80
			1245.40	1249.20	1243.10	1245.90				
			1215.20	1218.70	1229.30	1221.07				
10	0.5	2	1212.20	1214.20	1213.40	1213.27	1087.74	5438.72	33572.69	83.80
			1234.9	1234.90	1235.20	1233.37				
			1226.70	1226.70	1226.40	1226.60				
12	0.5	2	1219.40	1219.20	1220.40	1219.67	1222.16	6110.78	33572.69	81.80
			1201.00	1201.80	1207.80	1203.53				
			1242.20	1242.70	1244.90	1243.27				
14	0.5	2	1518.70	1519.00	1519.00	1518.90	1468.74	7343.72	33572.69	78.13
			1442.20	1445.40	1442.10	1443.23				
			1444.50	1443.60	1444.20	1444.10				

**Table B6** Influent, effluent COD and COD removal on days 2-14 of operation in the SBR at 10/1 oil-to-glucose ratio

Day	Volume of test (ml)		Centrifuge				Avg. COD (mg/l)	Actual COD (mg/l)	Influent COD (mg/l)	% COD removal
			Diluted effluent COD (mg/l)							
	Sample	RO. Water	No.1	No.2	No.3	avg.				
0	-	-	-	-	-	-	-	-	-	
2	0.5	2	462.22	460.33	460.11	460.89	447.81	4478.14	33854.47	86.77
			430.09	436.75	432.10	432.98				
			455.81	446.77	446.15	449.58				
4	0.5	2	384.92	413.99	413.75	404.22	397.95	3979.46	33854.47	88.25
			417.53	385.63	385.87	396.34				
			393.25	393.25	393.32	393.27				
6	0.5	2	568.86	568.85	569.04	568.92	565.29	5652.90	33854.47	83.30
			561.77	561.96	562.01	561.91				
			565.06	565.09	564.97	565.04				
8	0.5	2	954.33	954.00	953.94	954.09	948.55	9485.47	33854.47	71.98
			926.95	926.99	926.93	926.96				
			964.80	964.55	964.43	964.59				
10	0.5	2	979.32	979.53	979.51	979.45	966.73	9667.31	33854.47	71.44
			951.93	951.78	951.85	951.85				
			968.84	968.88	968.94	968.89				
12	0.5	2	978.94	978.86	978.87	978.89	974.22	9742.18	33854.47	71.22
			973.73	973.87	973.90	973.83				
			969.89	969.96	969.94	969.93				
14	0.5	2	848.29	848.48	848.56	848.44	853.28	8532.80	33854.47	74.80
			860.43	860.14	860.20	860.26				
			851.14	851.14	851.14	851.14				

## 1.2 Suspended Solid (SS)

**Table B7** Effluent SS on days 4-14 of operation in the SBR at oil-to-glucose ratio without glucose added

Day	Vol.sample (ml)	wt.filter (g)	wt.filter+ SS (g)	Effluent SS (g)	Effluent SS (mg)	Effluent SS (mg/l)	Avg. Effluent SS (mg/l)
0	-	-	-	-	-	-	-
4	5	0.1241	0.1264	0.0023	2.3	460	420
	5	0.1244	0.1263	0.0019	1.9	380	
6	5	0.1236	0.1257	0.0021	2.1	420	430
	5	0.1238	0.126	0.0022	2.2	440	
8	5	0.1231	0.1253	0.0022	2.2	440	480
	5	0.1221	0.1247	0.0026	2.6	520	
10	5	0.1262	0.1279	0.0017	1.7	340	440
	5	0.124	0.1267	0.0027	2.7	540	
12	5	0.1251	0.1262	0.0011	1.1	220	480
	5	0.1232	0.1269	0.0037	3.7	740	
14	5	0.1245	0.1281	0.0036	3.6	720	560
	5	0.1253	0.1273	0.002	2	400	

**Table B8** Effluent SS on days 4-14 of operation in the SBR at 60/1 oil-to-glucose ratio

Day	Vol.sample (ml)	wt.filter (g)	wt.filter+ SS (g)	Effluent SS (g)	Effluent SS (mg)	Effluent SS (mg/l)	Avg. Effluent SS (mg/l)
0	-	-	-	-	-	-	-
4	5	0.1241	0.1272	0.0031	3.1	620	610
	5	0.1238	0.1268	0.003	3	600	
6	5	0.1238	0.1264	0.0026	2.6	520	560
	5	0.1259	0.1289	0.003	3	600	
8	5	0.1265	0.1298	0.0033	3.3	660	630
	5	0.1255	0.1285	0.003	3	600	
10	5	0.1252	0.1281	0.0029	2.9	580	600
	5	0.1247	0.1278	0.0031	3.1	620	
12	5	0.1233	0.1261	0.0028	2.8	560	600
	5	0.1246	0.1278	0.0032	3.2	640	
14	5	0.1242	0.1272	0.003	3	600	580
	5	0.1251	0.1279	0.0028	2.8	560	

**Table B9** Effluent SS on days 4-14 of operation in the SBR at 40/1 oil-to-glucose ratio

Day	Vol.sample (ml)	wt.filter (g)	wt.filter+ SS (g)	Effluent SS (g)	Effluent SS (mg)	Effluent SS (mg/l)	Avg. Effluent SS (mg/l)
4	5	0.1265	0.1349	0.0084	8.4	1,680	1,490
	5	0.1242	0.1307	0.0065	6.5	1,300	
6	5	0.1226	0.1297	0.0071	7.1	1,420	1,460
	5	0.1217	0.1292	0.0075	7.5	1,500	
8	5	0.1232	0.1308	0.0076	7.6	1,520	1,510
	5	0.1218	0.1293	0.0075	7.5	1,500	
10	5	0.1259	0.1334	0.0075	7.5	1,500	1,500
	5	0.1241	0.1316	0.0075	7.5	1,500	
12	5	0.1262	0.1336	0.0074	7.4	1,480	1,510
	5	0.1256	0.1333	0.0077	7.7	1,540	
14	5	0.1252	0.1329	0.0077	7.7	1,540	1,580
	5	0.1254	0.1335	0.0081	8.1	1,620	

**Table B10** Effluent SS on days 4-14 of operation in the SBR at 30/1 oil-to-glucose ratio

Day	Vol.sample (ml)	wt.filter (g)	wt.filter+ SS (g)	Effluent SS (g)	Effluent SS (mg)	Effluent SS (mg/l)	Avg. Effluent SS (mg/l)
4	5	0.1233	0.1414	0.0181	18.1	3,620	3,610
	5	0.1229	0.1409	0.018	18	3,600	
6	5	0.123	0.1399	0.0169	16.9	3,380	3,400
	5	0.1232	0.1403	0.0171	17.1	3,420	
8	5	0.1225	0.1414	0.0189	18.9	3,780	3,630
	5	0.1246	0.142	0.0174	17.4	3,480	
10	5	0.1243	0.1422	0.0179	17.9	3,580	3,640
	5	0.1231	0.1416	0.0185	18.5	3,700	
12	5	0.1236	0.1411	0.0175	17.5	3,500	3,530
	5	0.1222	0.14	0.0178	17.8	3,560	
14	5	0.1239	0.1419	0.018	18	3,600	3,680
	5	0.1226	0.1414	0.0188	18.8	3,760	

**Table B11** Effluent SS on days 4-14 of operation in the SBR at 20/1 oil-to-glucose ratio

Day	Vol.sample (ml)	wt.filter (g)	wt.filter+ SS (g)	Effluent SS (g)	Effluent SS (mg)	Effluent SS (mg/l)	Avg. Effluent SS (mg/l)
0	-	-	-	-	-	-	-
2	-	0	0	0	0	0	0
	-	0	0	0	0	0	
4	5	0.1225	0.1464	0.0239	23.9	4,780	4,690
	5	0.123	0.146	0.023	23	4,600	
6	5	0.1243	0.1457	0.0214	21.4	4,280	4,480
	5	0.1235	0.1469	0.0234	23.4	4,680	
8	5	0.1218	0.1449	0.0231	23.1	4,620	4,610
	5	0.1231	0.1461	0.023	23	4,600	
10	5	0.1237	0.1468	0.0231	23.1	4,620	4,580
	5	0.1242	0.1469	0.0227	22.7	4,540	
12	5	0.1239	0.1469	0.023	23	4,600	4,610
	5	0.1217	0.1448	0.0231	23.1	4,620	
14	5	0.1228	0.1459	0.0231	23.1	4,620	4,460
	5	0.1228	0.1443	0.0215	21.5	4,300	

**Table B12** Effluent SS on days 4-14 of operation in the SBR at 10/1 oil-to-glucose ratio

Day	Vol.sample (ml)	wt.filter (g)	wt.filter+ SS (g)	Effluent SS (g)	Effluent SS (mg)	Effluent SS (mg/l)	Avg. Effluent SS (mg/l)
4	5	0.1244	0.1588	0.0344	34.4	6,880	6,860
	5	0.1254	0.1596	0.0342	34.2	6,840	
6	5	0.126	0.1547	0.0287	28.7	5,740	5,800
	5	0.1262	0.1555	0.0293	29.3	5,860	
8	5	0.1249	0.1533	0.0284	28.4	5,680	5,790
	5	0.1242	0.1537	0.0295	29.5	5,900	
10	5	0.1258	0.1567	0.0309	30.9	6,180	6,170
	5	0.1257	0.1565	0.0308	30.8	6,160	
12	5	0.1242	0.1573	0.0331	33.1	6,620	6,590
	5	0.126	0.1588	0.0328	32.8	6,560	
14	5	0.1248	0.1563	0.0315	31.5	6,300	6,280
	5	0.1245	0.1558	0.0313	31.3	6,260	

### 1.3 Mixed Liquor Suspended Solid (MLSS)

**Table B13** Effluent MLSS on days 8-14 of operation in the SBR at oil-to-glucose ratio without glucose added

Day	Vol.sample	wt.filter	wt.filter+ MLSS	Effluent MLSS	Effluent MLSS	Effluent MLSS	Avg. effluent MLSS
	(ml)	(g)	(g)	(g)	(mg)	(mg/l)	(mg/l)
0	-	0	0	0	0	0	0
2	-	0	0	0	0	0	0
4	-	0	0	0	0	0	0
6	-	0	0	0	0	0	0
8	5	0.1221	0.1343	0.0122	12.2	2,440	2,660
	5	0.1211	0.1355	0.0144	14.4	2,880	
10	5	0.1256	0.1388	0.0132	13.2	2,640	2,720
	5	0.1251	0.1391	0.014	14	2,800	
12	5	0.124	0.1419	0.0179	17.9	3,580	3,520
	5	0.1255	0.1428	0.0173	17.3	3,460	
14	5	0.1247	0.1418	0.0171	17.1	3,420	2,760
	5	0.1284	0.1327	0.0043	4.3	860	

**Table B14** Effluent MLSS on days 8-14 of operation in the SBR at 60/1 oil-to-glucose ratio

Day	Vol.sample	wt.filter	wt.filter+ MLSS	Effluent MLSS	Effluent MLSS	Effluent MLSS	Avg. effluent MLSS
	(ml)	(g)	(g)	(g)	(mg)	(mg/l)	(mg/l)
0	-	0	0	0	0	0	0
2	-	0	0	0	0	0	0
4	-	0	0	0	0	0	0
6	-	0	0	0	0	0	0
8	5	0.1247	0.1411	0.0164	16.4	3,280	3,330
	5	0.1243	0.1412	0.0169	16.9	3,380	
10	5	0.1244	0.1391	0.0147	14.7	2,940	2,910
	5	0.1254	0.1398	0.0144	14.4	2,880	
12	5	0.1243	0.1392	0.0149	14.9	2,980	3,160
	5	0.1241	0.1408	0.0167	16.7	3,340	
14	5	0.1246	0.1398	0.0152	15.2	3,040	3,260
	5	0.1248	0.1422	0.0174	17.4	3,480	

**Table B15** Effluent MLSS on days 8-14 of operation in the SBR at 40/1 oil-to-glucose ratio

Day	Vol.sample	wt.filter	wt.filter+ MLSS	Effluent MLSS	Effluent MLSS	Effluent MLSS	Avg- effluent MLSS
	(ml)	(g)	(g)	(g)	(mg)	(mg/l)	(mg/l)
0	-	0	0	0	0	0	0
2	-	0	0	0	0	0	0
4	-	0	0	0	0	0	0
6	-	0	0	0	0	0	0
8	5	0.1219	0.1432	0.0213	21.3	4,260	4,290
	5	0.1213	0.1429	0.0216	21.6	4,320	
10	5	0.1259	0.1457	0.0198	19.8	3,960	3,960
	5	0.1255	0.1453	0.0198	19.8	3,960	
12	5	0.1247	0.157	0.0323	32.3	6,460	6,390
	5	0.1246	0.1562	0.0316	31.6	6,320	
14	5	0.1266	0.1575	0.0309	30.9	6,180	6,210
	5	0.1272	0.1584	0.0312	31.2	6,240	

**Table B16** Effluent MLSS on days 8-14 of operation in the SBR at 30/1 oil-to-glucose ratio

Day	Vol.sample	wt.filter	wt.filter+ MLSS	Effluent MLSS	Effluent MLSS	Effluent MLSS	Avg- effluent MLSS
	(ml)	(g)	(g)	(g)	(mg)	(mg/l)	(mg/l)
0	-	0	0	0	0	0	0
2	-	0	0	0	0	0	0
4	-	0	0	0	0	0	0
6	-	0	0	0	0	0	0
8	5	0.1247	0.1557	0.031	31	6,200	6,220
	5	0.1283	0.1595	0.0312	31.2	6,240	
10	5	0.1255	0.1642	0.0387	38.7	7,740	7,690
	5	0.1254	0.1636	0.0382	38.2	7,640	
12	5	0.1237	0.1679	0.0442	44.2	8,840	8,740
	5	0.1235	0.1667	0.0432	43.2	8,640	
14	5	0.1234	0.1612	0.0378	37.8	7,560	7,610
	5	0.1244	0.1627	0.0383	38.3	7,660	

**Table B17** Effluent MLSS on days 8-14 of operation in the SBR at 20/1 oil-to-glucose ratio

Day	Vol.sample	wt.filter	wt.filter+ MLSS	Effluent MLSS	Effluent MLSS	Effluent MLSS	Avg. effluent MLSS
	(ml)	(g)	(g)	(g)	(mg)	(mg/l)	(mg/l)
0	-	0	0	0	0	0	0
2	-	0	0	0	0	0	0
4	-	0	0	0	0	0	0
6	-	0	0	0	0	0	0
8	5	0.1263	0.1669	0.0406	40.6	8,120	8,120
	5	0.1251	0.1657	0.0406	40.6	8,120	
10	5	0.1251	0.1608	0.0357	35.7	7,140	7,090
	5	0.1222	0.1574	0.0352	35.2	7,040	
12	5	0.1254	0.1737	0.0483	48.3	9,660	9,480
	5	0.1241	0.1706	0.0465	46.5	9,300	
14	5	0.1247	0.1692	0.0445	44.5	8,900	8,920
	5	0.1257	0.1704	0.0447	44.7	8,940	

**Table B18** Effluent MLSS on days 8-14 of operation in the SBR at 10/1 oil-to-glucose ratio

Day	Vol.sample	wt.filter	wt.filter+ MLSS	Effluent MLSS	Effluent MLSS	Effluent MLSS	Avg. effluent MLSS
	(ml)	(g)	(g)	(g)	(mg)	(mg/l)	(mg/l)
0	-	0	0	0	0	0	0
2	-	0	0	0	0	0	0
4	-	0	0	0	0	0	0
6	-	0	0	0	0	0	0
8	5	0.125	0.1688	0.0438	43.8	8,760	8,810
	5	0.1231	0.1674	0.0443	44.3	8,860	
10	5	0.1238	0.1774	0.0536	53.6	10,720	10,590
	5	0.1243	0.1766	0.0523	52.3	10,460	
12	5	0.125	0.1778	0.0528	52.8	10,560	10,650
	5	0.1224	0.1761	0.0537	53.7	10,740	
14	5	0.1248	0.1865	0.0617	61.7	12,340	12,440
	5	0.1244	0.1871	0.0627	62.7	12,540	



## 1.4 pH

**Table B19** Influent and effluent pH in the SBRs with different oil-to-glucose ratios

### Influent pH

Palm oil	4.6
Mineral medium	7.3

### Effluent pH

Without glucose	
days	Effluent pH
2	7.66
4	7.7
6	7.95
8	8.04
10	8.29
12	8.08
14	8.06

60/1	
days	Effluent pH
2	7.52
4	7.56
6	7.52
8	7.54
10	7.58
12	7.65
14	7.58

40/1	
days	Effluent pH
2	7.36
4	7.3
6	7.68
8	7.83
10	7.97
12	7.9
14	7.89

30/1	
days	Effluent pH
2	7.3
4	8.06
6	7.95
8	7.8
10	7.74
12	7.45
14	7.54

20/1	
days	Effluent pH
2	7.32
4	7.45
6	7.49
8	7.61
10	7.57
12	7.68
14	7.38

10/1	
days	Effluent pH
2	7.69
4	7.68
6	7.7
8	7.91
10	8.95
12	7.97
14	7.85

### 1.5 Palm Oil Content

**Table B20** Effluent palm oil and oil removal on days 6-14 of operation in the SBR of 2 d/cycle at oil-to-glucose ratio without glucose added

Day	Volume of test (ml)			Wt.flask	Wt.flask	Wt. oil	Effluent	Effluent	Avg. effluent	Oil removal
	sample	1:1 HCl	DCM	(g)	+ oil		[oil]	[oil]		
					(g)	(g)	(g)	(g/500ml)	(g/l)	(g/l)
0	-	-	-	-	-	-	-	-	-	-
2	-	-	-	-	-	-	-	-	-	-
4	-	-	-	-	-	-	-	-	-	-
6	25	0.18	90	110.9725	111.0641	0.0916	1.832	3.664	3.818	36.37
	25	0.18	90	110.0482	110.1475	0.0993	1.986	3.972		
8	25	0.18	90	110.8688	110.9453	0.0765	1.53	3.06	3.216	46.40
	25	0.18	90	109.5488	109.6331	0.0843	1.686	3.372		
10	25	0.18	90	110.9743	111.0314	0.0571	1.142	2.284	2.414	59.77
	25	0.18	90	110.0492	110.1128	0.0636	1.272	2.544		
12	25	0.18	90	110.8712	110.9439	0.0727	1.454	2.908	2.904	51.60
	25	0.18	90	109.5515	109.624	0.0725	1.45	2.9		
14	25	0.18	90	110.9691	111.0407	0.0716	1.432	2.864	2.898	51.70
	25	0.18	90	110.0451	110.1184	0.0733	1.466	2.932		

**Table B21** Effluent palm oil and oil removal on days 6-14 of operation in the SBR of 2 d/cycle at 60/1 oil-to-glucose ratio

Day	Volume of test (ml)			Wt.flask (g)	Wt.flask + oil (g)	Wt. oil (g)	Effluent [oil] (g/500ml)	Effluent [oil] (g/l)	Avg. effluent [oil] (g/l)	Oil removal (%)
	sample	1:1 HCl	DCM							
0	-	-	-	-	-	-	-	-	-	-
2	-	-	-	-	-	-	-	-	-	-
4	-	-	-	-	-	-	-	-	-	-
6	25	0.18	90	100.2453	100.3125	0.0672	1.344	2.688	2.544	57.60
	25	0.18	90	107.1548	107.2148	0.06	1.2	2.4		
8	25	0.18	90	100.2463	100.3142	0.0679	1.358	2.716	2.724	54.60
	25	0.18	90	107.1499	107.2182	0.0683	1.366	2.732		
10	25	0.18	90	100.2423	100.2972	0.0549	1.098	2.196	2.544	57.60
	25	0.18	90	107.1456	107.2179	0.0723	1.446	2.892		
12	25	0.18	90	100.2507	100.3221	0.0714	1.428	2.856	2.582	56.97
	25	0.18	90	107.1532	107.2109	0.0577	1.154	2.308		
14	25	0.18	90	100.2412	100.3104	0.0692	1.384	2.768	2.506	58.23
	25	0.18	90	107.1468	107.2029	0.0561	1.122	2.244		

**Table B22** Effluent palm oil and oil removal on days 6-14 of operation in the SBR of 2 d/cycle at 40/1 oil-to-glucose ratio

Day	Volume of test (ml)			Wt.flask (g)	Wt.flask + oil (g)	Wt. oil (g)	Effluent [oil] (g/500ml)	Effluent [oil] (g/l)	Avg. effluent [oil] (g/l)	Oil removal (%)
	sample	1:1 HCl	DCM							
	0	-	-	-	-	-	-	-	-	-
2	-	-	-	-	-	-	-	-	-	-
4	-	-	-	-	-	-	-	-	-	-
6	25	0.18	90	112.8513	112.9077	0.0564	1.128	2.256	2.262	62.30
	25	0.18	90	112.8931	112.9498	0.0567	1.134	2.268		
8	25	0.18	90	112.1533	112.1904	0.0371	0.742	1.484	1.506	74.90
	25	0.18	90	108.3162	108.3544	0.0382	0.764	1.528		
10	25	0.18	90	112.8543	112.8817	0.0274	0.548	1.096	1.036	82.73
	25	0.18	90	112.8958	112.9202	0.0244	0.488	0.976		
12	25	0.18	90	112.1551	112.1917	0.0366	0.732	1.464	1.382	76.97
	25	0.18	90	108.3184	108.3509	0.0325	0.65	1.3		
14	25	0.18	90	112.8505	112.8857	0.0352	0.704	1.408	1.43	76.17
	25	0.18	90	112.893	112.9293	0.0363	0.726	1.452		

**Table B23** Effluent palm oil and oil removal on days 6-14 of operation in the SBR of 2 d/cycle at 30/1 oil-to-glucose ratio

Day	Volume of test (ml)			Wt.flask	Wt.flask	Wt. oil (g)	Effluent	Effluent	Avg.	Oil removal (%)
	sample	1:1 HCl	DCM	(g)	+ oil		[oil]	[oil]	effluent	
				(g)	(g)	(g/500ml)	(g/l)	(g/l)		
0	-	-	-	-	-	-	-	-	-	-
2	-	-	-	-	-	-	-	-	-	-
4	-	-	-	-	-	-	-	-	-	-
6	25	0.18	90	110.9771	111.0485	0.0714	1.428	2.856	2.73	54.50
	25	0.18	90	110.0517	110.1168	0.0651	1.302	2.604		
8	25	0.18	90	110.8737	110.9451	0.0714	1.428	2.856	2.896	51.73
	25	0.18	90	109.5543	109.6277	0.0734	1.468	2.936		
10	25	0.18	90	110.9981	111.0648	0.0667	1.334	2.668	3.11	48.17
	25	0.18	90	110.0527	110.1415	0.0888	1.776	3.552		
12	25	0.18	90	110.9214	110.9947	0.0733	1.466	2.932	3.268	45.53
	25	0.18	90	109.589	109.6791	0.0901	1.802	3.604		
14	25	0.18	90	110.9775	111.0593	0.0818	1.636	3.272	3.144	47.60
	25	0.18	90	110.0523	110.1277	0.0754	1.508	3.016		

**Table B24** Effluent palm oil and oil removal on days 6-14 of operation in the SBR of 2 d/cycle at 20/1 oil-to-glucose ratio

Day	Volume of test (ml)			Wt.flask	Wt.flask + oil	Wt. oil	Effluent [oil]	Effluent [oil]	Avg. effluent [oil]	Oil removal
	sample	1:1 HCl	DCM	(g)	(g)	(g)	(g/500ml)	(g/l)	(g/l)	(%)
	0	-	-	-	-	-	-	-	-	-
2	-	-	-	-	-	-	-	-	-	-
4	-	-	-	-	-	-	-	-	-	-
6	25	0.18	90	112.8572	112.9195	0.0623	1.246	2.492	2.436	59.40
	25	0.18	90	112.899	112.9585	0.0595	1.19	2.38		
8	25	0.18	90	112.1572	112.228	0.0708	1.416	2.832	2.966	50.57
	25	0.18	90	108.3206	108.3981	0.0775	1.55	3.1		
10	25	0.18	90	112.8588	112.9191	0.0603	1.206	2.412	2.92	51.33
	25	0.18	90	112.8998	112.9855	0.0857	1.714	3.428		
12	25	0.18	90	114.026	114.1034	0.0774	1.548	3.096	3.514	41.43
	25	0.18	90	108.3236	108.4219	0.0983	1.966	3.932		
14	25	0.18	90	112.8592	112.9428	0.0836	1.672	3.344	3.498	41.70
	25	0.18	90	112.8975	112.9888	0.0913	1.826	3.652		

**Table B25** Effluent palm oil and oil removal on days 6-14 of operation in the SBR of 2 d/cycle at 10/1 oil-to-glucose ratio

Day	Volume of test (ml)			Wt.flask (g)	Wt.flask + oil (g)	Wt. oil (g)	Effluent [oil] (g/500ml)	Effluent [oil] (g/l)	Avg. effluent [oil] (g/l)	Oil removal (%)
	sample	1:1 HCl	DCM							
0	-	-	-	-	-	-	-	-	-	-
2	-	-	-	-	-	-	-	-	-	-
4	-	-	-	-	-	-	-	-	-	-
6	25	0.18	90	110.8785	110.9233	0.0448	0.896	1.792	1.8	70.0
	25	0.18	90	109.5592	109.6044	0.0452	0.904	1.808		
8	25	0.18	90	110.9562	111.0294	0.0732	1.464	2.928	3.454	42.4
	25	0.18	90	110.0567	110.1562	0.0995	1.99	3.98		
10	25	0.18	90	110.8785	110.9637	0.0852	1.704	3.408	3.6	40.0
	25	0.18	90	109.5594	109.6542	0.0948	1.896	3.792		
12	25	0.18	90	110.9822	111.0851	0.1029	2.058	4.116	3.688	38.5
	25	0.18	90	110.0546	110.1361	0.0815	1.63	3.26		
14	25	0.18	90	110.8707	110.9542	0.0835	1.67	3.34	3.414	43.1
	25	0.18	90	109.5487	109.6359	0.0872	1.744	3.488		

## 1.6 Surface Tension

**Table B26** Surface tension and surface tension of 2 d/cycle at oil-to-glucose ratio without glucose added

Day	Surface tension (mN/m)						Surface tension reduction (%)
	No.1	No.2	No.3	No.4	No.5	avg.	
0	71.63	71.76	71.7	71.63	71.59	71.662	0
2	31.43	31.54	31.47	31.62	31.53	31.518	56.01853144
4	30.26	30.13	30.59	30.52	30.45	30.39	57.59258742
6	31.86	31.65	31.86	31.69	31.84	31.78	55.65292624
8	34.49	34.75	34.7	34.46	34.74	34.628	51.67871396
10	34.06	33.75	34.31	33.95	33.52	33.918	52.66947615
12	31.96	31.74	31.53	31.97	31.72	31.784	55.64734448
14	31.91	31.74	31.59	31.88	31.89	31.802	55.62222656

**Table B27** Surface tension and surface tension of 2 d/cycle at 60/1 oil-to-glucose ratio

Day	Surface tension (mN/m)						Surface tension reduction (%)
	No.1	No.2	No.3	No.4	No.5	avg.	
0	71.64	71.53	71.38	71.1	71.68	71.466	0
2	30.85	30.61	31.22	31.05	30.86	30.918	56.73746957
4	29.81	29.63	30.41	30.34	29.98	30.034	57.9744214
6	30.64	30.63	30.46	30.61	30.7	30.608	57.17124227
8	29.76	29.81	29.92	30.37	30.13	29.998	58.02479501
10	30.56	30.54	30.72	30.63	30.48	30.586	57.20202614
12	30.44	30.48	30.37	29.89	30.3	30.296	57.60781351
14	29.89	29.93	29.82	29.86	29.86	29.872	58.20110262



**Table B28** Surface tension and surface tension of 2 d/cycle at 40/1 oil-to-glucose ratio

Day	Surface tension (mN/m)						Surface tension reduction (%)
	No.1	No.2	No.3	No.4	No.5	avg.	
0	71.88	71.79	71.93	71.81	71.93	71.868	0
2	30.2	30.22	29.96	30.08	30.31	30.154	58.0425224
4	30.2	30.22	29.96	30.08	30.31	30.154	58.0425224
6	30.08	30.27	30.12	30.32	30.22	30.202	57.97573329
8	29.79	29.69	29.58	29.56	29.86	29.696	58.67980186
10	29.82	29.92	29.72	29.88	29.76	29.82	58.50726332
12	29.87	28.86	29.52	30.06	29.79	29.62	58.78555129
14	30.26	30.33	30.34	30.35	30.23	30.302	57.8365893

**Table B29** Surface tension and surface tension of 2 d/cycle at 30/1 oil-to-glucose ratio

Day	Surface tension (mN/m)						Surface tension reduction (%)
	No.1	No.2	No.3	No.4	No.5	avg.	
0	70.91	70.8	70.72	70.92	71	70.87	0
2	29.73	29.73	29.75	29.58	29.55	29.668	58.13743474
4	30.13	30.17	30.02	29.97	30.03	30.064	57.57866516
6	29.61	29.6	29.57	29.55	29.44	29.554	58.29829265
8	30.33	30.36	30.79	30.61	30.44	30.506	56.95498801
10	29.91	29.8	29.73	29.57	29.84	29.77	57.99350924
12	29.96	29.72	29.66	29.42	29.48	29.648	58.16565543
14	30.24	29.85	29.74	29.64	29.51	29.796	57.95682235

**Table B30** Surface tension and surface tension of 2 d/cycle at 20/1 oil-to-glucose ratio

Day	Surface tension (mN/m)						Surface tension reduction (%)
	No.1	No.2	No.3	No.4	No.5	avg.	
0	71.65	71.93	71.21	71.11	71.88	71.556	0
2	28.46	28.61	28.51	28.45	28.56	28.518	60.14589971
4	28.71	28.64	28.44	29.34	28.44	28.714	59.87198837
6	28.64	28.63	28.46	28.61	28.7	28.608	60.0201241
8	28.76	28.81	28.92	28.67	28.71	28.774	59.78813796
10	28.56	28.54	28.72	28.63	28.48	28.586	60.05086925
12	28.44	28.48	28.37	28.49	28.3	28.416	60.28844541
14	28.89	28.93	28.82	28.86	28.86	28.872	59.65118229

**Table B31** Surface tension and surface tension of 2 d/cycle at 10/1 oil-to-glucose ratio

Day	Surface tension (mN/m)						Surface tension reduction (%)
	No.1	No.2	No.3	No.4	No.5	avg.	
0	71.82	71.78	71.89	71.74	71.79	71.804	0
2	28.64	28.1	28.58	28.3	28.7	28.464	60.35875439
4	32.78	32.85	32.8	32.44	32.87	32.748	54.39251295
6	35.2	34.88	34.93	35.23	34.92	35.032	51.21163166
8	29.07	29.73	29.57	29.28	29.46	29.422	59.02456688
10	29.72	29.96	29.94	30.13	29.65	29.88	58.3867194
12	28.99	29.05	28.78	29.03	29.01	28.972	59.65127291
14	29.98	30.33	30	29.18	29.3	29.758	58.55662637

**Table B32** Surface tension and surface tension reduction at steady state operation

Oil-to-Glucose ratio	Surface Tension (mN/m)	Surface Tension Reduction (%)
Without glucose	33.03	53.90
60/1	30.19	57.76
40/1	29.86	58.45
30/1	29.93	57.77
20/1	30.31	57.78
10/1	29.51	58.90

**Table B33** Percent reduction of COD, oil and surface tension at steady state operation

Oil-to-Glucose ratio	COD removal (%)	Oil removal (%)	Surface Tension Reduction (%)
Without glucose	81.14	81.14	53.90
60/1	82.83	82.83	57.76
40/1	85.14	85.14	58.45
30/1	82.30	82.30	57.77
20/1	81.38	81.38	57.78
10/1	72.36	72.36	58.90

## 2. Measurement of Surface Tension and Determining Critical Micelle Dilution (CMD)

**Table B34** Surface tension of supernatant from *Pseudomonas aeruginosa* SP4 with aeration step during steady state cycle at 2 d/cycle

(hr)	1	2	3	4	5	6	7	8	9	10	Avg
0	66.45	66.32	65.98	66.74	66.63	66.92	65.41	66.37	66.40	66.08	66.33
2	65.12	65.98	65.91	65.88	65.80	65.64	65.72	65.32	65.19	65.85	65.64
4	61.22	59.76	60.02	61.41	61.69	62.11	61.96	61.82	61.39	59.94	61.13
6	33.84	34.26	33.97	35.33	36.23	35.47	33.52	34.15	35.60	35.44	34.78
8	34.79	32.30	32.12	32.18	32.80	33.02	32.81	32.52	32.18	32.58	32.73
10	31.17	32.22	32.13	31.61	31.49	32.13	31.75	31.64	31.51	31.73	31.74
12	30.29	31.33	33.69	33.67	32.65	31.52	31.23	31.19	31.23	31.22	31.80
14	30.17	30.24	30.26	30.86	30.00	31.04	30.72	31.26	30.56	31.45	30.66
16	30.91	29.45	31.19	29.36	30.11	30.01	29.75	29.84	29.62	29.63	29.99
18	31.23	31.07	30.38	30.95	29.45	30.68	30.23	29.45	30.95	30.81	30.52
20	29.61	30.29	29.76	29.31	29.06	29.85	29.20	30.13	29.24	29.36	29.58
22	29.75	30.53	29.92	29.24	29.49	29.32	29.58	29.05	29.60	28.85	29.53
24	28.76	28.72	30.48	30.28	29.64	30.13	30.07	29.91	29.80	29.73	29.75
26	29.87	29.55	29.44	28.94	29.73	29.73	29.75	29.60	29.57	28.93	29.51
28	29.60	28.63	28.59	28.64	28.56	28.83	28.74	28.73	29.55	28.66	28.85
30	28.74	29.25	29.10	29.61	29.52	29.59	29.50	28.67	29.55	28.49	29.20
32	29.79	29.87	29.86	28.86	29.72	28.64	28.56	29.69	29.88	29.52	29.44
34	29.64	29.32	28.51	28.64	28.59	29.58	29.48	29.36	28.91	28.76	29.08
36	29.97	30.44	30.67	30.78	29.33	30.65	30.97	29.81	29.40	29.69	30.17
38	29.51	28.81	28.79	28.81	29.32	30.13	29.25	29.19	29.15	28.83	29.18
40	28.75	28.80	29.47	29.51	29.43	28.83	29.37	29.29	28.83	29.74	29.20
42	28.87	29.17	29.61	29.83	29.81	29.10	28.72	28.80	28.63	28.66	29.12
44	28.08	28.01	29.58	29.48	29.36	29.27	28.99	28.91	27.99	28.03	28.77
46	29.27	28.83	30.02	29.47	30.75	28.69	28.76	29.66	29.31	29.71	29.45
48	29.05	29.91	29.36	29.73	29.67	29.69	29.36	29.81	30.01	29.58	29.62

**Table B34** The surface tension of serially dilutions of 2 d/cycle with 6, 10, 12, 18, 20, 24, 30, 36, 40, and 48 h of aeration time.

Time (hr)	Surface Tension (mN/m)						
	25:75	50:50	75:25	90:10	95:5	99:1	100:0
6	70.34	69.56	70.21	69.19	65.33	49.48	34.63
10	70.08	69.24	68.41	65.39	59.71	41.56	31.79
12	69.45	67.83	66.68	62.31	58.84	41.32	32.09
18	68.19	66.72	64.62	60.11	57.5	41.27	30.22
20	67.03	66.15	63.77	61.05	54.62	37.4	29.80
24	65.97	65.66	60.73	58.68	56.42	36.09	29.71
30	65.9	64.87	59.61	50.6	41.63	33.41	28.94
36	65.85	64.43	59.22	39.74	37.4	33.25	30.38
40	64.75	63.91	56.92	32.85	30.62	28.86	28.94
42	64.57	62.74	56.9	31.66	30.58	28.82	29.13
48	64.46	62.75	57.81	31.65	29.94	30.12	29.62

## CURRICULUM VITAE

**Name:** Mr. Sira Pansiripat

**Date of Birth:** March 14, 1985

**Nationality:** Thai

**University Education:**

2002-2006 Bachelor Degree of Engineering, Faculty of Engineering and Industrail Technology, Silpakorn University, Nakhon Prathom, Thailand

**Working Experience:**

2004	Position:	Internship Student
	Company name:	The Aromatics (Thailand) Public Co., Ltd.

**Proceedings:**

1. Pansiripat, S., Kitiyanan B., Chavadej, S., Rujiravanit, R., and Abe, M. (2009, April 22) Biosurfactant Production by *Pseudomonas aeruginosa* SP4 Using Sequencing Batch Reactors: Effect of Oil-to-Glucose Ratio. Proceedings of 15<sup>th</sup> PPC Symposium on Petroleum, Petrochems, and Polymers, Bangkok, Thailand.

**Presentations:**

1. Pansiripat, S., Kitiyanan B., Chavadej, S., Rujiravanit, R., and Abe, M. (2009, April 22) Biosurfactant Production by *Pseudomonas aeruginosa* SP4 Using Sequencing Batch Reactors: Effect of Oil-to-Glucose Ratio. Poster presented at the 15<sup>th</sup> PPC Symposium on Petroleum, Petrochems, and Polymers, Bangkok, Thailand.

