REFERENCES

Abalos, A., Pinazo, A., Infante, M.R., Casals, M., García, F., and Manresa, A. (2001) Physicochemical and antimicrobial properties of new rhamnolipids produced by *Pseudomonas aeruginosa* AT10 from soybean oil refinery wastes. Langmuir, 17, 1367-1371.

Abalos, A., Viñas, M., Sabaté, J., Manresa, M.A., and Solanas, A.M. (2004) Enhanced biodegradation of Casablanca crude oil by a microbial consortium in presence of a rhamnolipid produced by *Pseudomonas aeruginosa* AT10. Biodegradation, 15, 249-260.

Altankov, G., Grinnell, F., and Groth, T. (1996) Studies on the biocompatibility of materials: fibroblast recognization of substratum-bound fibronectin on surfaces varying in wettability. Journal of Biomedical Materials Research, 30, 385-391.

Amiji, M., and Park, K. (1992) Prevention of protein adsorption and platelet adhesion on surfaces by PEO/PPO/PEO triblock copolymers. Biomaterials, 13, 682-692.

Arino, S., Marchal, R., and Vandecasteele, J.P. (1996) Identification and production of a rhamnolipid biosurfactant by a *Pseudomonas* species. Applied and Environmental Microbiology, 45, 162-168.

Bai, G., Brusseau, M.L., and Miller, R.M. (1997) Biosurfactant-enhanced removal of residual hydrocarbon from soil. Journal of Contaminant Hydrology, 25, 157-170.

Banat, I.M., Makkar, R.S., and Cameotra, S.S. (2000) Potential commercial applications of microbial surfactants. Applied and Environmental Microbiology, 53, 495-508.

Baxter, A., Dillon, M., Taylor, K.D.A., and Roberts, G.A.F. (1992) Improved method for i.r. determination of the degree of *N*-acetylation of chitosan. International Journal of Biological Macromolecules, 14, 1661-1669.

Benerjee, P., Irvine, D.J., Mayes, A.M., and Griffith, L.G. (2000) Polymer latexes for cell-resistant and cell-interactive surfaces. Journal of Biomedical Materials Research, 50, 331-339.

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.

Benincasa, M., Abalos, A., Oliveira, I., and Manresa, A. (2004) Chemical structure, surface properties, and biological activities of the biosurfactant produced by *Pseudomonas aeruginosa* LBI from soapstock. Antonio van Leeuwenhoek, 85, 1-8.

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, 3843-3849.

Berry, C.C., Campbell, G., Spadiccino, A., Robertson, M., and Curtis, A.S.G. (2004) The influence of microscale topography on fibroblast attachment and motility. Biomaterials, 25, 5781-5788.

Brandani, P., and Stroeve, P. (2003) Adsorption and desorption of PEO-PPO-PEO triblock copolymers on a self-assembled hydrophobic surface. Macromolecules, 36, 9492-9501.

Brien, J.O., Wilson, I., Orton, T., and Pognan, F. (2000) Investigation of the alamar blue (resazurin) fluorescent dye for the assessment of mammalian cell cytotoxicity. European Journal of Biochemistry, 267, 5421-5426.

Burger, M.M., Glaser, L., and Burton, R.M. (1963) The enzymatic synthesis of rhamnose-containing glycolipids by extracts of *Pseudomonas aeruginosa*. Journal of Biological Chemistry, 238, 2595-2602.

Burger, M.M., Glaser, L., Burton, R.M. (1966) Formation of rhamnolipids of *Pseudomonas aeruginosa*. Methods in Enzymology, 8, 441-445.

Cameotra, S.S., and Makkar, R.S. (2004) Recent applications of biosurfactants as biological and immunological molecules. Current Opinion in Microbiology, 7, 262-266.

Campos-García, J., Caro, A.D., Nájera, R., Miller-Maier R.M., Al-Tahhan, R.A., and Soberón-Chávez (1998) The *Pseudomonas aeruginosa rhlG* gene encodes a NADPH-dependent b-ketoacyl reductase which is specifically involved in rhamnolipid synthesis. Journal of Bateriology, 180, 4442-4451.

Cassidy, D.P., Hudak, A.J., Werkema, D.D., Atekwana, E.A., Rossbach, S., Duris, J.W., Atekwana, E.A., and Sauck, W.A. (2002) *In situ* rhamnolipid production at an abandoned petroleum refinery. Soil and sediment contamination, 11, 769-787.

Champion, J.T., Gilkey, J.C., Lamparski, H., Reitrer, J., and Miller, R.M. (1995) Electron microscopy of rhamnolipid (biosurfactant) morphology: Effects of pH, cadmium, and octadecane. Journal of Colloid and Interface Science, 170, 569-574.

Chayabutra, C., and Ju, L-K. (2001) Polyhydroxyalkanoic acids and rhamnolipids are synthesized sequentially in hexadecane fermentation by *Pseudomonas aeruginosa* ATCC 10145. Biotechnology Progress, 17, 419-423.

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. Biotechnology Progress, 23, 661-666.

Choquet, D., Felsenfeld, D.P., and Sheetz, M. (1997) Extracellular matrix rigidity causes strengthening of intergrin-cytoskeleton linkages. Cell, 88, 39-48.

Chou, L., Firth, J.D., Uitto, V.-J., and Brunette, D.M. (1998) Effects of titanium substratum and grooved surface topography on metalloproteinase-2 expression in human fibroblasts. Journal of Biomedical Materials Research, 39, 437-445.

Chung, T.-W., Liu, D.-Z., Wang, S.-Y., and Wang, S.-S. (2003) Enhancement of the growth of human endothelial cells by surface roughness at nanometer scale. Biomaterials, 24, 4655-4661.

Clifford, J.S., Ioannidis, M.A., and Legge, R.L. (2007) Enhanced aqueous solubilization of tetrachloroethylene by a rhamnolipid biosurfactant.Journal of Colloid and Interface Science, 305, 361-365.

Cooper, D.G., and Goldenberg, B.G. (1987) Surface-active agents from two *Bacillus* species. Applied and Environmental Microbiology, 53, 224-229.

Costa, S.G.V.A.O., Nitschke, M., Haddad, R., Eberlin, M.N., and Contiero, J. (2006) Production of *Pseudomonas aeruginosa* LBI rhamnolipids following growth on Brazillian native oils. Process Biochemistry, 41, 483-488.

Desai, J.D., and Banat, I.M. (1997) Microbial production of surfactants and their commercial potential. Microbiology and Molecular Biology Reviews, 61, 47-64.

Déziel, E., Lépine, F., Dennie, D., Boismenu, D., Mamer, O.A., and Villemur, R. (1999) Liquid chromatography/mass spectrometry analysis of mixtures of rhamnolipids produced by *Pseudomonas aeruginosa* strain 57RP grown on mannitol or naphthalene. Biochimica et Biophysica Acta, 1440, 244-252.

Déziel, E., Lépine, F., Milot, S., and Villemur, R. (2000) Mass spectrometry monitoring of rhamnolipids fron a growing culture of *Pseudomonas aeruginosa* strain 57RP. Biochimica et Biophysica Acta, 1485, 145-152.

Finnerty, W.R., (1994) Biosurfactants in environmental biotechnology. Environmental Biotechnology, 5, 291-295.

Fox, S.L., and Bala, G.A. (2000) Production of surfactant from *Bacillus subtilis* ATCC 21332 using potato substrates. Bioresource Technology, 75, 235-240.

Gunther, N.W., Nuñez, A., Fett, W., and Solaiman, D.K.Y. (2005) Production of rhamnolipids by *Pseudomonas chlororaphis*, a nonpathogenic bacterium. Applied and Environmental Microbiology, 71, 2288-2293.

Guerra-Santos, L., Kappeli, O., Fiechter, A. (1984) *Pseudomonas aeruginosa* biosurfactant production in continuous culture with glucose as sole carbon source. Applied and Environmental Microbiology, 48, 301-305.

Healy, M.G., Devine, C.M., and Murphy, R. (1996) Microial production of biosurfactants. Resources, conservation and recycling, 18, 41-57.

Herman, D.C., Artiola, J.F., Miller, R.M. (1995) Removal of cadmium, lead, and zinc from soil by a rhamnolipid biosurfactant. Environmental Science and Technology, 29, 2280-2285.

Jarvis, F.G., and Johnson, M.J. (1949) A glyco-lipid produced by *Pseudomonas aeruginosa*. Journal of the American Chemical Society, 71, 4124-4126.

Jeong, H.-S., Lim, D.-J., Hwang, S.-H., Ha, S.D., Kong, J.Y. (2004) Rhamnolipid production by *Pseudomonas aeruginosa* immobilised in polyvinyl alcohol beads. Biotechnology Letters, 26, 35-39.

Jones, G.E., Arumugham, R.G., and Tanzer, M.L. (1995) Fibronectin glycosylation modulates fibroblast adhesion and spreading. The Journal of Cell Biology, 103(5), 1663-1670.

Kapur, R., Lilien, J., Picciolo, G.L., and Black, J. (1996) Human monocyte morphology is affected by local substrate charge heterogeneity. Journal of Biomedical Materials Research, 32, 133-142.

Kausaite, A., van Dijk, M., Castrop, J., Ramanavicience, A., Baltrus, J.P., Acaite, J., and Ramanavicius, A. (2007) SPR label-free monitoring of antibody antigen interactions in real-time. Biochemistry and Molecular Biology Education, 35, 57-63.

Kennedy, S.B., Washburn, N.R., Simon, C.G., Jr., and Amis, E.J. (2006) Combinatorial screen of the effect of surface energy on fibronectin-mediated osteoblast adhesion, spreading, and proliferation. Biomaterials, 27, 3817-3824.

Khang, G., Lee, S.J., Lee, J.H., Kim, Y.S., and Lee, H.B. (1999) Interaction of fibroblast cells on poly(lactide-*co*-glycolide) surface with wettability chemogradient. Biomedical Materials and Engineering, 9, 179-187.

Kim, H.S., Jeon, J.W., Kim, B.H., Ahn, C.Y., Oh, H.M., and Yoon, B.D. (2006) Extracellular production of a glycolipid biosurfactant, mannosylerythritol lipid, by *Candida* sp. SY16 using fed-batch fermentation. Applied Microbiology and Biotechnology, 70, 391-396.

Kosaric, N., Cairns, W.L., and Gray, N.C.C. (Eds.). (1987) Biosurfactants and Biotechnology. New York: Marcel Dekker.

Lam, K.H., Schakenraad, J.M., Groen, H., Esselbrugge, H., Dijkstra, P.J., Feijin, J., and Nieuwenhuis, P. (1995) The inflammatory response against poly(L-

lactic acid): a semi-quantitative study with monoclonal antibodies. Journal of Biomedical Materials Research, 29, 929-942.

Lampin, M., Warocquier-Clérout, R., Legris, C., Degrange, M., and Sigot-Luizard, M.F. (1997) Correlation between substratum roughness and wettability, cell adhesion, and cell migration. Journal of Biomedical Materials Research, 36, 99-108.

Lang, S., and Wagner, F. (1987) Structure and properties of biosurfactants. In N. Kosaric, W.L. Cairns, and N.C.C. Gray (Eds.), Biosurfactants and Biotechnology (pp. 21-45). New York: Marcel Dekker.

Lee, J.H., Lee, J.W., Khang, G., and Lee, H.B. (1997) Interaction of cells on chargeable functional group gradient surfaces. Biomaterials, 18, 351-358.

Lee, Y., Lee, S.Y., and Yang, J.-W. (1999) Production of rhamnolipid biosurfactant by fed-batch culture of *Pseudomonas aeruginosa* using glucose as a sole carbon source. Bioscience, Biotechnology, and Biochemistry, 63, 946-947.

Lee, K.Y., and Mooney, J.Y. (2001) Hydrogels for tissue engineering. Chemical Reviews, 101(7), 1869-1879.

Levchenko, A.A., Argo, B.P., Vidu, R., Talroze, R.V., and Stroeve, P. (2002) Kinetics of sodium dodecyl sulfate adsorption on and desorption from self-assembled monolayers measured by surface plasmon resonance. Langmuir, 18, 8464-8471.

Lo, C.-M., Wang, H.-B., Dembo, M., and Wang, Y.-L. (2000) Cell movement is guided by the rigidity of the substrate. Biophysical Journal, 79, 144-152.

Maier, R.M., and Soberón-Chavéz, G. (2000) *Pseudomonas aeruginosa* rhamnolipids: biosynthesis and potential applications. Applied Microbiology and Biotechnology, 54, 625-633.

Mata-Sandoval, J.C., Karns, J., and Torrent, A. (1999) High-performance liquid chromatography method for the characterization of rhamnolipid mixtures produced by *Pseudomonas aeruginosa* UG2 corn oil. Journal of Chromatography A, 864, 211-220.

Mata-Sandoval, J.C., Karns, J., Torrents, A. (2000) Effect of rhamnolipids produced by *Pseudomonas aeruginosa* UG2 on the solubilization of pesticides. Environmental Science and Technology, 34, 4923-4930.

Mata-Sandoval, J.C., Karns, J., and Torrent, A. (2001) Effect of nutritional and environmental conditions on the production and composition of rhamnolipids by *P. aeruginosa* UG2. Microbiology Research, 155, 249-256.

Matsufuji, M., Nakata, K., and Yoshimoto, A. (1997) High production of rhamnolipids by *Pseudomonas aeruginosa* growing on ethanol. Biotechnology Letters, 19, 1213-1215.

Mercadé, M.E., Manresa, M.A., Robert, M., Espuny, M.J., de Andrés, C., and Guinea, J. (1993) Olive oil mill effluent (OOME). New substrate for biosurfactant production. Bioresource Technology, 43, 1-6.

Miller, C.E., Meyer, W.H., Knoll, W., and Wegner, G. (1992) Surface plasmon resonance as a technology to study adsorption to aluminum oxide surfaces. Ber Bunsenges Phys Chem, 96, 869-879.

Monteiro, S.A., Sassaki, G.L., de Souza, L.M., Meira, J.A., de Araujo, J.M., Mitchell, D.A., Ramos, L.P., and Krieger, N. (2007) Molecular and structural characterization of the biosurfactant produced by *Pseudomonas aeruginosa* DAUPE 614. Chemistry and Physics of Lipids, 147, 1-13.

Mulligan, C.N., Mahmourides, G., and Gibbs B.F. (1989) The influence of phosphate metabolism on biosurfactant production by *Pseudomonas aeruginosa*. Journal of Biotechnology, 12, 199-210.

Mulligan, C.N., Yong, R.N., and Gibbs, B.F. (2001) Surfactant-enhanced remediation of contaminated soil: a review. Engineering Geology, 60, 371-380.

Mulligan, C.N., and Wang, S. (2006) Remediation of a heavy metal-contaminated soil by a rhamnolipid foam. Engineering Geology, 85, 75-81.

Nitschke, M., Ferraz, C., and Pastore, G.M. (2004) Selection of microorganisms for biosurfactant production using agroindustrial wastes. Brazillian Journal of Microbiology, 35, 81-85.

Nitschke, M., Costa, S.G.V.A.O., and Contiero, J. (2005) Rhamnolipid surfactants: an update on the general aspects of these remarkable biomolecules. Biotechnology Progress, 21, 1593-1600.

Nitschke, M., and Pastore, G.M. (2006) Production and properties of a surfactant obtained from *Bacillus subtilis* grown on cassava wastewater. Bioresource Technology, 97, 336-341.

Noordman, W.H., Brusseau, M.L., and Janssen, D.B. (2000) Adsorption of a multicomponent rhamnolipid surfactant to soil. Environmental Science and Technology, 34, 832-838.

Noordman, W.H., Wachter, J.H.J., de Boer, G.J. and Janssen, D.B. (2002) The enhancement by surfactants of hexadecane by *Pseudomonas aeruginosa* varies with substrate availability. Journal of Biotechnology, 94, 195-212.

Paisanjit, S. (2006) Isolation of biosurfactant-producing bacteria relating to the activity of oil recovery. M.S. Thesis, The Petroleum and Petrochemical College, Chulalongkorn University, Bangkok, Thailand.

Patel, R.M., and Desai, A.J. (1997) Biosurfactant production by *Pseudomonas aeruginosa* GS3 from molasses. Letters in Applied Microbiology, 25, 91-94.

Patel, S., Thakar, R.G., Wong, J., McLeod, S.D., and Li, S. (2006) Control of cell adhesion on poly(methyl methacrylate). Biomaterials, 27, 2890-2897.

Pelham, R.J., and Wang, Y.-L. (1997) Cell locomotion and focal adhesions are regulated by substrate flexibility. Proceeding of the National Academy of Sciences of the United States of America, 94, 13661-13665.

Plumb, J.A., Milroy, R., and Kaye, S.B. (1989) Effects of the pH dependence of 3-(4,5-dimethylthiazol-2yl)-2,5-diphenylterazolium bromide-formazan absorption on chemosensitivity determined by a novel tetrazolium based assay. Cancer Research, 49, 4435-4440.

Qiu, Q., Sayer, M., Kawaja, M., Shen, X., and Davies, J.E. (1998) Attachment, morphology, and protein expression of rat marrow stromal cells cultured on charged substrate surfaces. Journal of Biomedical Materials Research, 42, 117-127.

Rahim, R., Ochsner, U.A., Olvera, C., Graninger, M., Messner, P., Lam, J.S., Soberón-Chávez, G. (2001) Cloning and functional characterization of the *Pseudomonas aeruginosa rhlC* gene that encodes rhamnosyltransferase 2, an enzyme responsible for di-rhamnolipid biosynthesis. Molecular Microbiology, 40, 708-718.

Rahman, K.S.M., Rahman, T.J., McClean, S., Marchant, R., and Banat, I.M. (2002) Rhamnolipid biosurfactant production by strains of *Pseudomonas aeruginosa* using low-cost raw materials. Biotechnology Progress, 18, 1277-1281.

Ratner, B.D., Hoffman, A.S., Schoen, F.J., and Lemons J.E. (Eds.) (2004) Biomaterials Science. China: Elsevier Inc.

Rendell, N.B., Taylor, G.W., Somerville, M., Todd, H., Wilson, R., and Cole, P.J. (1990) Characterisation of *Pseudomonas* rhamnolipids. Biochimica et Biophysica Acta, 1045, 189-193.

Robert, M., Mercadé, M.E., Bosch, M.P., Parra, J.L., Espuny, M.J., Manresa, M.A., and Guinea, J. (1989) Effect of carbon source on biosurfactant production by *Pseudomonas aeruginosa* 44T1. Biotechnology Letters, 11, 871-874.

Rodrigues, L., van der Mei, H., Banat, I.M., Teixeira, J., and Oliveira, R. (2005) Inhibition of microbial adhesion to silicone rubber treated with biosurfacatant from *Streptococcus thermophilus* A. Federation of European Microbiological Societies Immunological Medical Microbiology, 46, 107-112.

Rodrigues, L.R., Teixeira, J.A., van der Mei, H.C., and Oliveira, R. (2006) Physicochemical and functional characterization of a biosurfactant produced by *Lactococcus lactis* 53. Colloids and Surfaces B: Biointerfaces, 49, 79-86.

Rosen, M.J. (Eds.) (2004) Surfactant and Interfacial Phenomena. Hoboken, N.J.: Wiley-Interscience.

Ruardy, T.G., Schakenraad, J.M., van der Mei, H.C., and Busscherl, H.J. (1995) Adhesion and spreading of human skin fibroblasts on physicochemically characterized gradient surfaces. Journal of Biomedical Materials Research, 29, 1415-1423.

Sakai, K., Smith, E.G., Webber, G.B., Schatz, C., Wanless, E.J., Bütün, V., Armes, S.P., and Biggs, S. (2006) pH-Responsive diblock copolymer micelles at the silica/aqueous interfaces: adsorption kinetics and equilibrium studies. Journal of Physical Chemistry B, 110, 14744-14753.

Sánchez, M., Aranda, F.J., Espuny, M.J., Marqués, A., Teruel, J.A., Manresa, Á., and Ortiz, A. (2007) Aggregation behaviour of a dirhamnolipid biosurfactant secreted by *Pseudomonas aeruginosa* in aqueous media. Journal of Colloid and Interface Science, 307, 246-253.

Santa Anna, L.M., Sebastian, G.V., Menezes, E.P., Alves, T.L.M., Santos, A.S., Pereira, N., and Freire, D.M.G. (2002) Production of biosurfactants from *Pseudomonas aeruginosa* PA1 isolated in oil environments. Brazilian Journal of Chemical Engineering, 19, 159-166.

Santiago, L.Y., Nowak, R.W., Rubin, J.P., and Marra, K.G. (2006) Peptide-surface modification of poly(caprolactone) with laminin-derived sequences for adipose-derived stem cell applications. Biomaterials, 27, 2962-2969.

Schakenraad, J.M., Busscher, H.J., Wildevuur, C.R.H., and Arends, J. (1986) The influence of substratum surface free energy on growth and spreading of human fibroblasts in the presence and absence of serum proteins. Journal of Biomedical Materials Research, 20, 773-784.

Schenk, T., Schuphan, I., and Schmidt, B. (1995) High-performance liquid chromatographic determination of the rhamnolipids produced by *Pseudomonas aeruginosa*. Journal of Chromatography A, 693, 7-13.

Schuler, M., Owen, G. Rh., Hamilton, D.W., de Wild, M., Textor, M., Brunette, D.M., and Tosatti, S.G.P. (2006) Biomimectic modification of titanium dental implant model surfaces using the RGDSP-peptide Sequence: a cell morphology structure. Biomaterials, 27, 4003-4015.

Shu, X.Z., Ghosh, K., Liu, Y., Palumbo, F.S., Luo, Y., Clark, R.A., and Prestwich, G.D. (2004) Attachment and spreading of fibroblasts on an RGD peptide-modified injectable hyaluronan hydrogel. Journal of Biomedical Materials Research, 68A, 365-375.

Sim, L., Ward, O.P., and Li, Z.Y. (1997) Production and characterization of a biosurfactant isolated from *Pseudomonas aeruginosa* UW-1. Journal of Industrial Microbiology and Biotechnology, 19, 232-238.

Smetana, K., Jr., Vacík, J., Součková, D., Krčová, and Šulc, J. (1990) The influence of hydrogel functional groups on cell behavior. Journal of Biomedical Materials Research, 24, 463-470.

Stipcevic, T., Piljac, T., and Isseroff, R.R. (2005) Di-rhamnolipid from *Pseudomonas aeuroginosa* displays differential effects on human keratinocyte and fibroblast cultures. Journal of Dermatological Science, 40, 141-143.

Stipcevic, T., Piljac, A., and Piljac, G. (2006) Enhanced healong of full-thickness burn wounds using di-rhamnolipid. Burns, 32, 24-34.

Syldatk, C., Lang, S., Matulovic, U., and Wagner, F. (1985) Production of four interfacial active rhamnolipids from *n*-alkane or glycerol by resting cells of *Pseudomonas* species DSM 2874. Zeitschrift für Naturforschung, 40c, 61-67.

Tang, Z.G., Black, R.A., Curran, J.M., Hunt, J.A., Rhodes, N.P., and Williams, D.F. (2004) Surface properties and biocompatibility of solvent-cast poly(ε-caprolactone) films. Biomaterials, 25, 4741-4748.

Tegoulia, V.A., and Cooper, S.L. (2000) Leukocyte adhesion on model surfaces under flow: effects of surface chemistry, protein adsorption, and shear rate. Journal of Biomedical Materials Research, 50, 291-301.

Thanomsub, B., Pumeechockchai, W., Limtrakul, A., Arunrattiyakorn, P., Petchleelaha, W., and Nitoda, T. (2006) Chemical structures and biological activities of rhamnolipids produced by *Pseudomonas aeruginosa* B189 isolated from milk factory waste. Bioresource Technology, 97, 2457-2461.

Thanpitcha, T., Sirivat, A., Jamieson, A.M., and Rujiravanit, R. (2006) Preparation and characterization of polyaniline/chitosan blend film. Carbohydrate Polymers, 64, 560-568.

Torrens, J.L., Herman, D.C., and Miller-Maier, R.M. (1998) Biosurfactant (rhamnolipid) sorption and the impact on rhamnolipid-facilitated removal of

cadmium from various soils under saturated flow conditions. Environmental Science and Technology, 32, 776-781.

Trummler, K., Effenberger, F., and Syldatk, C. (2003) An integrated microbial/enzymatic process for production of rhamnolipids and L-(+)-rhamnose from rapeseed oil with *Pseudomonas* sp. DSM 2874. European Journal of Lipid Science and Technology, 105, 563-571.

Urum, K., Pekdemir, T., Ross, D., and Grigson, S. (2005) Crude oil contaminated soil washing in air sparging assisted stirred tank reactor using biosurfactants. Chemosphere, 60, 334-343.

van der Valk, P., van Pelt, A.J., Busscher, H.J., de Jong, H.P., Wildevuur, Ch.R.H., and Arends, J. (1983) Interaction of fibroblasts and polymer surfaces: relationship between surface free energy and fibroblast spreading. Journal of Biomedical Materials Research, 17, 807-817.

Velraeds, M.M., van der Mei, H.C., Reid, G., and Busscher, H.J. (1997) Inhibition of initial adhesion of uropathocenic *Enterococcus faecalis* to solid substrata by an adsorbed biosurfactant layer from *Lactobacillus acidophilus*. Urology, 49(5), 790-794.

Vernon, R.B., Gooden, M.D., Lara, S.L., and Wight, T.N. (2005) Microgrooved fibrillar collagen membranes as scaffolds for cell support and alignment. Biomaterials, 26, 3131-3140.

Wagner, P., Hegner, M., Güntherodt, H.-J., and Semenza, G. (1995) Formation and *in situ* modification of monolayers chemisorbed on ultraflat template-stripped gold surfaces. Langmuir, 11, 3867-3875.

Wan, Y., Wang, Y., Liu, Z., Qu, X., Han, B., Bei, J., and Wang, S. (2005) Adhesion and proliferation of OCT-1 osteoblast-like cells on micro- and nano-scale topography structured poly(L-lactide). Biomaterials, 26, 4453-4459.

Wang, W., Bo, S., Li, S., and Qin, W. (1991) Determination of the Mark- Houwink equation for chitosans with different degrees of deacetylation. International Journal of Biological Macromolecules, 13, 281–285.

Webb, K., Hlady, V., and Tresco, P.A. (1998) Relative importance of surface wettability and charged functional groups on NIH 3T3 fibroblast attachment,

spreading, and cytoskeletal organization. Journal of Biomedical Materials Research, 41, 422-430.

Webb, K., Hlady, V., and Tresco, P.A. (2000) Relationships among cell attachment, spreading, cytoskeletal organization, and migration rate for anchorage-dependent cells on model surfaces. Journal of Biomedical Materials Research, 49, 362-368.

Wei, Y.-H., Chou, C.-L., and Chang, J.-S. (2005) Rhamnolipid production by indigenous *Pseudomonas aeruginosa* J4 originating from petrochemical wastewater. Biochemical Engineering Journal, 27, 146-154.

Whang, L.-M., Liu, P.-W.G., Ma, C.-C., and Cheng, S.-S. (2008) Application of biosurfactants, rhamnolipid, and surfactin, for enhanced biodegradation of diesel-contaminated water and soil. Journal of Hazardous Materials, 151, 155-163.

Wongpanit, P., Sanchavanakit, N., Pavasant, P., Bunaprasert, T., Tabata, Y., and Rujiravanit, R. (2007) Preparation and characterization of chitin whisker-reinforced silk fibroin nanocomposite sponges. European Polymer Journal, 43, 4123-4135.

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.

Yakimov, M.M., Fredrickson, H.L., and Timmis, K.N. (1996) Effect of heterogeneity of hydrophobic moieties on surface activity of lichenysin A, a lipopeptide biosurfactant from *Bacillus licheniformis* BAS50. Biotechnology Applied Biochemical, 23, 13-18.

Yateem, A., Balba, M.T., Al-Shayji, Y., and Al-Awadhi, N. (2002) Isolation and characterization of biosurfactant-producing bacteria from oil-contaminated soil. Soil and Sediment Contamination, 11, 41-55.

Zhang, Y., and Miller, R.M. (1992) Enhancement of octadecane dispersion and biodegradation by a *Pseudomonas* rhamnolipid surfactant (biosurfactant). Applied and Environmental Microbiology, 58, 3276-3282.

Zhang, Y., Maier, W.J., and Miller, R.M. (1997) Effect of rhamnolipids on the dissolution, bioavailability, and biodegradation of phenanthrene. Environmental Science and Technology, 31, 2211-2217.

APPENDICES

Appendix A Structural and Physicochemical Characterization of Crude Biosurfactant produced by *Pseudomonas aeruginosa* SP4 isolated from Petroleum-contaminated Soil

Table A1 Diameter of the clear zones on the oil surface obtained from oil displacement testing with the crude biosurfactant produced by *P. aeruginosa* SP4 and its fractions compared with Pluronic F-68 and SDS at a surfactant concentration of 20 mg/ml

Sample	Diameter of Clear Zone (cm)		
	I	II	III
PLURONIC F-68	3.0	2.6	2.4
SDS	11.2	12.0	11.6
BIOSURFACTANT	10.3	10.5	10.5
FRACTION A	10.5	10.6	10.5
FRACTION B	11.1	11.5	12.0
FRACTION C	13.0	13.6	13.0
FRACTION D	13.0	12.4	12.6
FRACTION E	10.6	11.0	10.0
FRACTION F	12.8	12.7	12.4

Table A2 Surface tension versus concentrations of the crude biosurfactant produced by *P. aeruginosa* SP4 compared with Pluronic F-68 and SDS

Concentration (mg/l)	Surface Tension (mN/m)								
	Pluronic F-68			SDS			Biosurfactant		
	I	II	III	I	II	III	I	II	III
0.3	56.0	55.8	55.6	69.6	69.7	69.8	56.0	56.6	56.6
0.6	54.1	54.2	54.3	67.6	67.5	67.6	55.6	55.3	55.4
1.3	53.2	53.0	53.4	65.1	65.2	65.1	53.3	53.6	53.1
2.5	52.1	52.2	52.1	63.9	63.0	63.2	50.4	50.6	50.3
5	51.4	51.6	51.4	61.3	61.4	61.1	49.4	49.5	49.3
10	51.2	51.3	51.4	57.9	57.9	57.9	47.8	48.0	47.7
20	51.3	51.4	51.1	53.5	53.7	53.4	44.8	45.0	44.7
40	50.9	50.9	51.0	48.2	48.1	48.0	41.5	41.4	41.3
80	51.0	50.9	51.0	41.9	41.7	41.5	36.4	36.8	36.8
160	50.8	50.7	50.8	37.0	36.9	37.0	35.0	35.0	35.0
320	46.7	46.7	46.8	33.0	32.9	33.0	32.5	32.5	32.3
640	45.0	45.0	45.0	30.5	30.7	30.6	30.6	30.7	30.2
1,280	44.0	44.0	44.1	28.5	28.6	28.8	30.1	30.3	30.2
2,560	42.8	42.8	42.9	28.8	28.7	28.6	29.4	29.1	28.8

Table A3 Emulsification activity (E_{24}) of the crude biosurfactant produced by *P. aeruginosa* SP4 compared with Pluronic F-68 and SDS

Sample	Emulsification Activity (%)								
	Pluronic F-68			SDS			Biosurfactant		
	I	II	III	I	II	III	I	II	III
PENTANE	50.8	52.3	50.8	80.9	81.6	79.6	16.2	14.7	14.7
HEXANE	47.6	49.2	47.6	63.6	65.2	63.6	18.5	18.5	18.2
HEPTANE	51.6	53.1	50.0	87.8	86.7	86.7	13.4	13.4	12.2
TOLUENE	51.5	52.9	52.2	84.9	84.3	80.8	27.9	25.0	25.0
1-CHLORO BUTANE	75.8	73.0	75.8	76.1	77.6	74.6	14.7	11.8	13.2
PALM OIL	76.2	77.7	76.2	75.0	73.5	70.6	90.3	91.4	93.6
CRUDE OIL	54.6	52.7	50.9	56.5	54.8	53.2	57.9	59.7	56.1
SOYBEAN OIL	40.0	38.5	40.0	65.2	63.8	67.7	58.1	60.3	60.3
COCONUT OIL	49.2	47.6	49.2	74.6	73.1	74.6	54.6	54.2	54.7
OLIVE OIL	73.0	71.4	73.0	75.8	74.2	75.8	43.3	46.9	46.9

Table A4 Surface tension of the crude biosurfactant as compared with Pluronis F-68 and SDS after heat treatment at 30°C with different heating times

Time (min)	Surface Tension (mN/m)					
	I	II	III	IV	V	VI
Pluronic F-68						
0	45.0	45.0	45.0	45.1	45.2	45.3
20	45.1	45.2	45.3	45.0	45.2	45.2
40	44.9	44.8	45.0	45.1	45.2	45.0
60	45.7	45.6	45.7	45.4	45.5	45.7
80	45.0	44.9	45.0	44.9	45.0	45.1
100	45.9	45.8	45.7	45.7	45.7	45.8
120	44.9	44.8	44.6	45.0	44.9	45.0
SDS						
0	28.6	28.6	28.7	28.9	28.7	28.8
20	28.4	28.3	28.4	28.6	28.5	28.6
40	28.3	28.4	28.2	28.6	28.4	28.6
60	28.5	28.4	28.5	28.4	28.5	28.6
80	28.1	28.2	28.1	28.3	28.3	28.3
100	28.5	28.6	28.7	28.5	28.5	28.7
120	28.2	28.3	28.1	28.3	28.2	28.1
Biosurfactant						
0	30.4	30.5	30.5	30.3	30.4	30.3
20	30.7	30.6	30.6	30.6	30.5	30.5
40	30.6	30.8	30.7	30.8	30.6	30.8
60	30.7	30.7	30.7	30.8	30.8	30.7
80	30.5	30.6	30.6	30.4	30.6	30.4
100	30.5	30.6	30.5	30.7	30.5	30.6
120	30.5	30.6	30.4	30.6	30.5	30.6

Table A5 Surface tension of the crude biosurfactant as compared with Pluronis F-68 and SDS after heat treatment at 50°C with different heating times

Time (min)	Surface Tension (mN/m)					
	I	II	III	IV	V	VI
Pluronic F-68						
0	45.0	45.0	45.0	45.1	45.2	45.3
20	45.9	45.8	45.9	45.7	45.7	45.8
40	45.4	45.4	45.4	45.5	45.3	45.3
60	45.3	45.3	45.3	45.4	45.2	45.2
80	45.9	45.9	45.9	45.7	45.8	45.7
100	45.3	45.4	45.3	45.4	45.5	45.5
120	45.9	45.9	45.9	45.7	45.8	45.7
SDS						
0	28.6	28.6	28.7	28.9	28.7	28.8
20	28.6	28.5	28.7	28.5	28.5	28.7
40	28.6	28.9	28.7	28.6	28.6	28.9
60	28.4	28.7	28.6	28.5	28.9	28.8
80	28.5	28.4	28.4	28.3	28.2	28.1
100	28.3	28.2	28.1	28.5	28.4	28.2
120	28.6	28.1	28.2	28.3	28.5	28.6
Biosurfactant						
0	30.4	30.5	30.4	30.4	30.4	30.5
20	30.7	30.7	30.8	30.7	30.7	30.7
40	30.5	30.6	30.5	30.5	30.5	30.5
60	30.3	30.4	30.3	30.4	30.4	30.3
80	30.2	30.3	30.2	30.2	30.3	30.3
100	30.2	30.2	30.3	30.3	30.2	30.3
120	30.7	30.9	30.6	30.4	30.4	30.9

Table A6 Surface tension of the crude biosurfactant as compared with Pluronis F-68 and SDS after heat treatment at 70°C with different heating times

Time (min)	Surface Tension (mN/m)					
	I	II	III	IV	V	VI
Pluronic F-68						
0	45.0	45.0	45.0	45.1	45.2	45.3
20	45.4	45.5	45.5	45.6	45.6	45.5
40	45.8	45.7	45.8	45.9	45.8	45.8
60	45.4	45.3	45.3	45.4	45.3	45.4
80	45.4	45.3	45.5	45.4	45.5	45.3
100	45.5	45.5	45.4	45.3	45.4	45.5
120	45.7	45.8	45.7	45.7	45.6	45.7
SDS						
0	28.6	28.6	28.7	28.9	28.7	28.8
20	28.5	28.6	28.8	28.5	28.6	28.7
40	28.5	28.6	28.5	28.5	28.6	28.8
60	28.4	28.5	28.3	28.6	28.8	28.6
80	28.5	28.6	28.5	28.6	28.5	28.6
100	28.2	28.3	28.3	28.4	28.6	28.6
120	28.2	28.1	28.2	27.9	28.1	28.3
Biosurfactant						
0	30.4	30.5	30.4	30.3	30.4	30.4
20	30.4	30.4	30.4	30.4	30.5	30.3
40	30.4	30.6	30.5	30.5	30.5	30.4
60	30.6	30.6	30.7	30.7	30.5	30.5
80	30.9	30.8	30.8	30.8	30.8	30.9
100	30.8	30.9	30.8	30.6	30.8	30.6
120	30.4	30.6	30.3	30.3	30.5	30.3

Table A7 Surface tension of the crude biosurfactant as compared with Pluronis F-68 and SDS after heat treatment at 90°C with different heating times

Time	Surface Tension (mN/m)					
(min)	I	II	III	IV	V	VI
Pluronic F-68						
0	45.0	45.0	45.0	45.1	45.2	45.3
20	45.0	45.0	45.1	45.0	45.1	45.1
40	44.9	44.9	45.0	44.9	45.0	45.0
60	45.2	45.3	45.2	45.3	45.4	45.3
80	45.4	45.4	45.4	45.5	45.6	45.5
100	45.6	45.6	45.7	45.8	45.7	45.5
120	45.4	45.4	45.5	45.4	45.6	45.3
SDS						
0	28.6	28.6	28.7	28.9	28.7	28.8
20	28.2	28.3	28.6	28.2	28.6	28.3
40	28.6	28.7	28.8	28.8	28.8	28.9
60	28.9	28.8	28.6	28.9	28.7	28.8
80	28.6	28.8	28.5	28.6	28.8	28.8
100	28.6	28.7	28.6	28.6	28.7	28.8
120	28.8	28.8	29.0	28.9	29.0	28.9
Biosurfactant						
0	30.8	30.9	30.9	30.9	30.9	31.0
20	31.6	31.6	31.4	31.4	31.6	31.5
40	31.5	31.3	31.5	31.4	31.4	31.5
60	31.0	30.8	30.9	30.9	30.8	30.9
80	31.0	31.1	31.1	31.0	31.0	31.1
100	31.2	31.2	31.0	31.1	31.1	31.2
120	31.3	31.4	31.4	31.3	31.3	31.4

Table A8 Effect of autoclave treatment (15 minutes at 121°C) on surface tension of the crude biosurfactant as compared with Pluronic F-68 and SDS

Sample	Surface Tension (mN/m)					
	I	II	III	IV	V	VI
Before Autoclaving						
PLURONIC F-68	45.0	45.0	45.0	45.1	45.2	45.3
SDS	28.6	28.6	28.7	28.9	28.7	28.8
BIOSURFACTANT	30.4	30.5	30.5	30.3	30.4	30.3
After Autoclaving						
PLURONIC F-68	46.5	46.5	46.4	46.3	46.3	46.5
SDS	35.1	34.8	34.8	34.9	35.0	35.1
BIOSURFACTANT	31.7	31.5	31.8	31.5	31.7	31.5

Table A9 Effect of pH on surface activity of Pluronis F-68

pH	Surface Tension (mN/m)					
	I	II	III	IV	V	VI
3	46.2	46.4	46.5	46.5	46.6	46.2
4	47.0	47.0	47.1	46.8	46.9	47.0
5	46.0	46.1	46.1	46.1	46.1	46.0
6	46.0	45.9	45.9	46.1	46.1	46.0
7	45.0	45.0	45.0	45.1	45.2	45.0
8	44.4	44.5	44.5	44.4	44.4	44.4
9	43.2	43.2	43.3	43.5	43.5	43.2
10	43.8	43.8	43.9	43.9	43.8	43.8
11	43.9	43.9	44.0	43.8	43.9	43.9

Table A10 Effect of pH on surface activity of SDS

pH	Surface Tension (mN/m)					
	I	II	III	IV	V	VI
3	29.2	29.2	29.3	29.4	29.3	29.2
4	29.4	29.6	29.6	29.5	29.6	29.4
5	29.7	29.6	29.6	29.7	29.8	29.7
6	29.5	29.5	29.5	29.6	29.6	29.5
7	29.6	29.7	29.7	29.7	29.8	29.6
8	29.4	29.6	29.6	29.5	29.6	29.4
9	29.5	29.6	29.7	29.6	29.7	29.5
10	29.7	29.7	29.8	29.7	29.8	29.7
11	29.8	29.8	29.9	29.8	29.9	29.8

Table A11 Effect of pH on surface activity of the crude biosurfactant produced by *P. aeruginosa* SP4

pH	Surface Tension (mN/m)					
	I	II	III	IV	V	VI
3	29.0	29.1	29.1	29.1	29.0	29.0
4	29.2	29.3	29.2	29.2	29.3	29.2
5	30.3	30.2	30.2	30.2	30.0	30.3
6	31.3	31.3	31.0	31.3	31.0	31.3
7	31.9	32.2	32.1	31.9	31.8	31.9
8	31.9	31.9	32.2	32.3	32.3	31.9
9	32.0	31.9	32.0	32.0	32.1	32.0
10	32.0	31.9	32.1	32.0	32.2	32.0
11	31.6	31.9	31.5	31.5	31.8	31.6

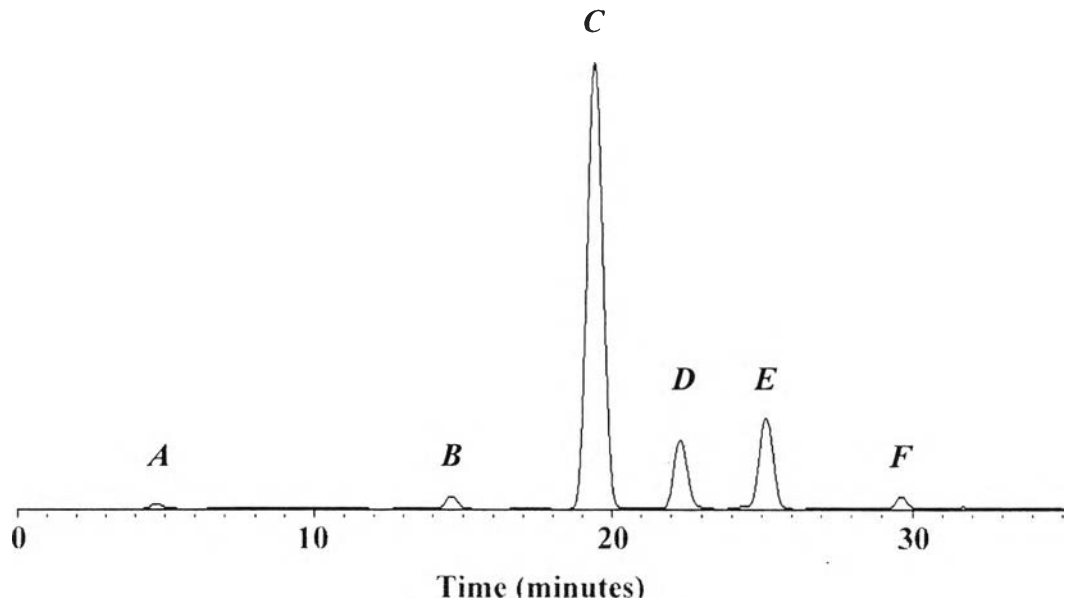

Figure A1 HPLC-ELSD chromatogram of the crude biosurfactant produced by *P. aeruginosa* SP4.

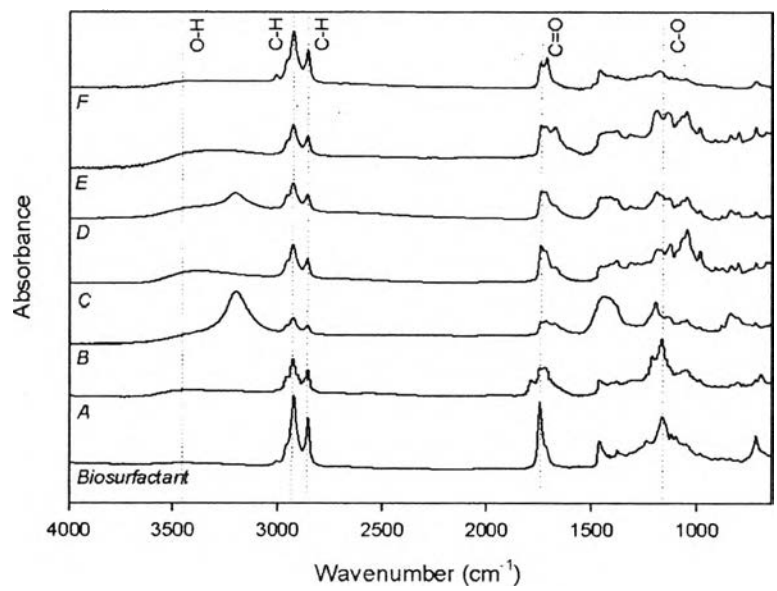

Figure A2 ATR-FTIR spectra of the crude biosurfactant produced by *P. aeruginosa* SP4 and its fractions.

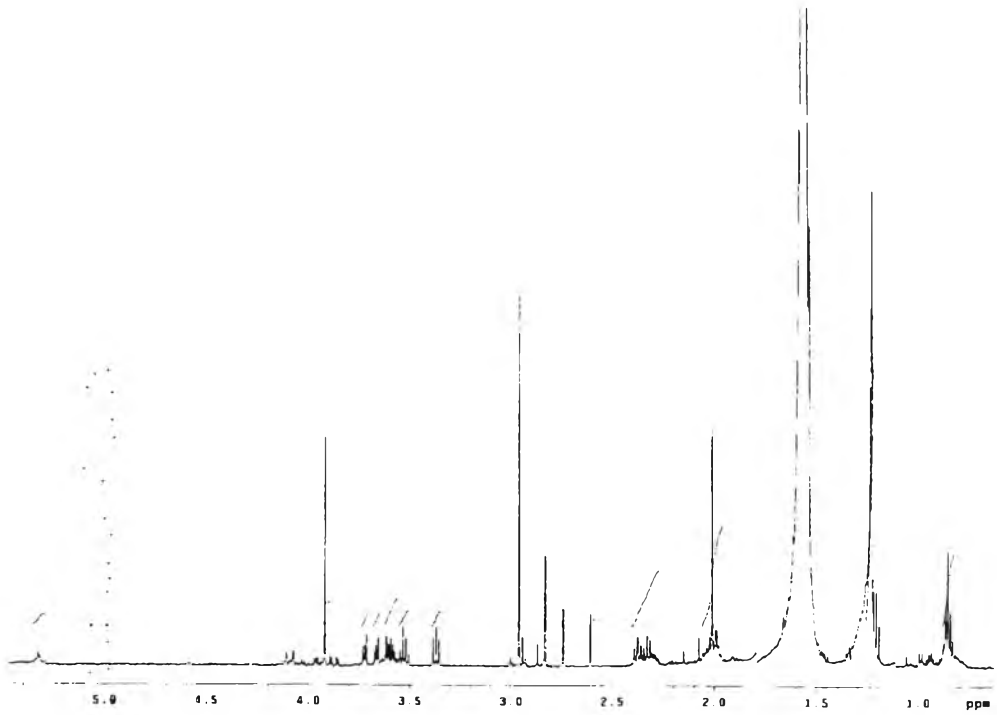

Figure A3 ^{1}H NMR spectrum of fraction A fractionated from the crude biosurfactant produced by *P. aeruginosa* SP4.

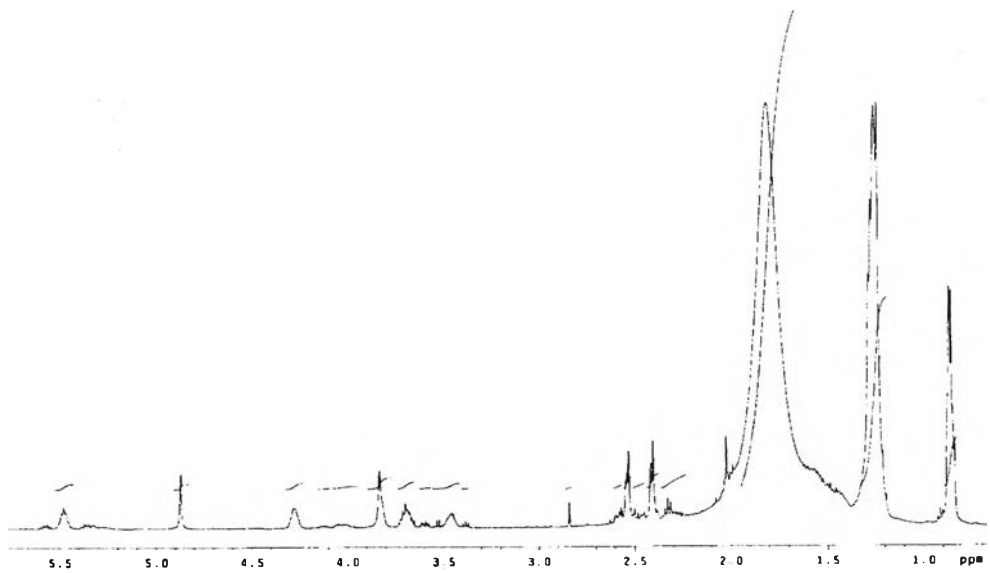

Figure A4 ^{1}H NMR spectrum of fraction B fractionated from the crude biosurfactant produced by *P. aeruginosa* SP4.

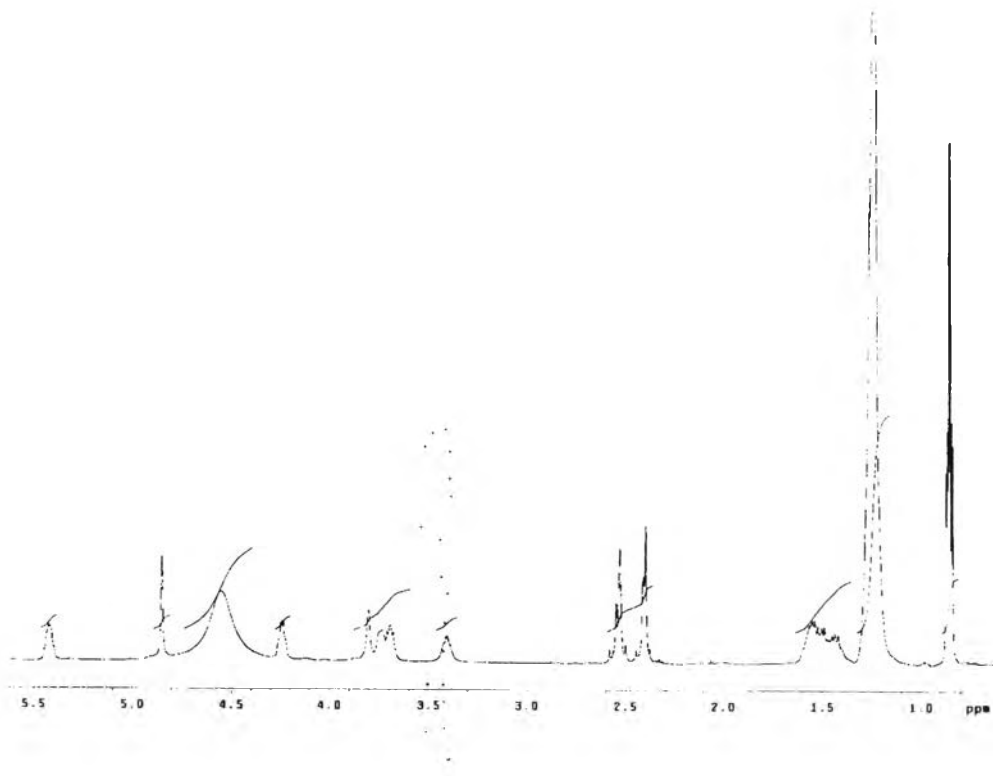

Figure A5 ^{1}H NMR spectrum of fraction C fractionated from the crude biosurfactant produced by *P. aeruginosa* SP4.

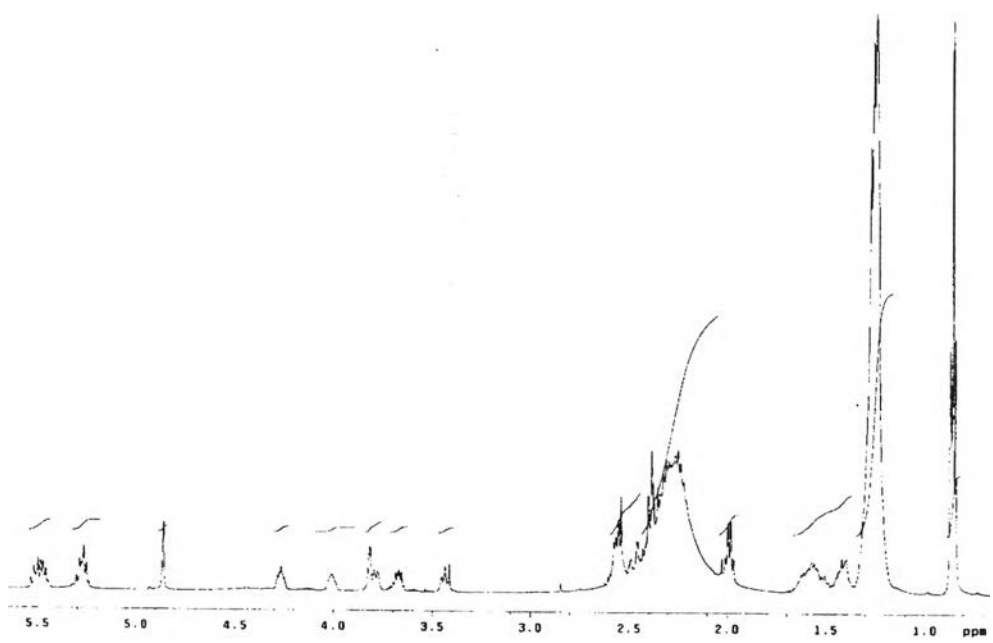

Figure A6 ^{1}H NMR spectrum of fraction D fractionated from the crude biosurfactant produced by *P. aeruginosa* SP4.

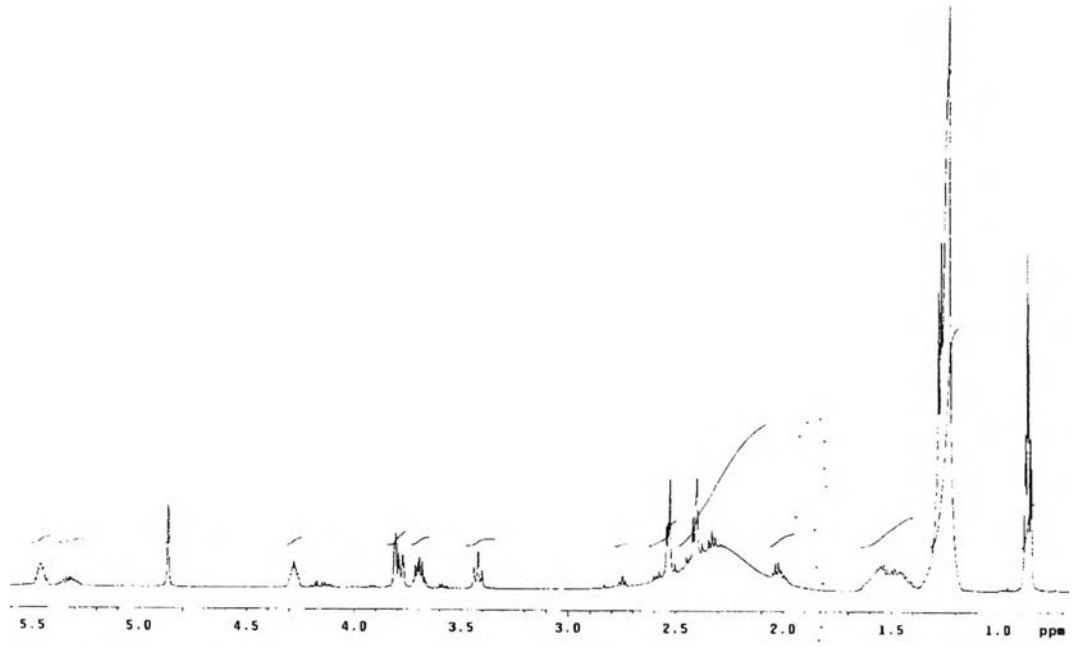

Figure A7 ^{1}H NMR spectrum of fraction E fractionated from the crude biosurfactant produced by *P. aeruginosa* SP4.

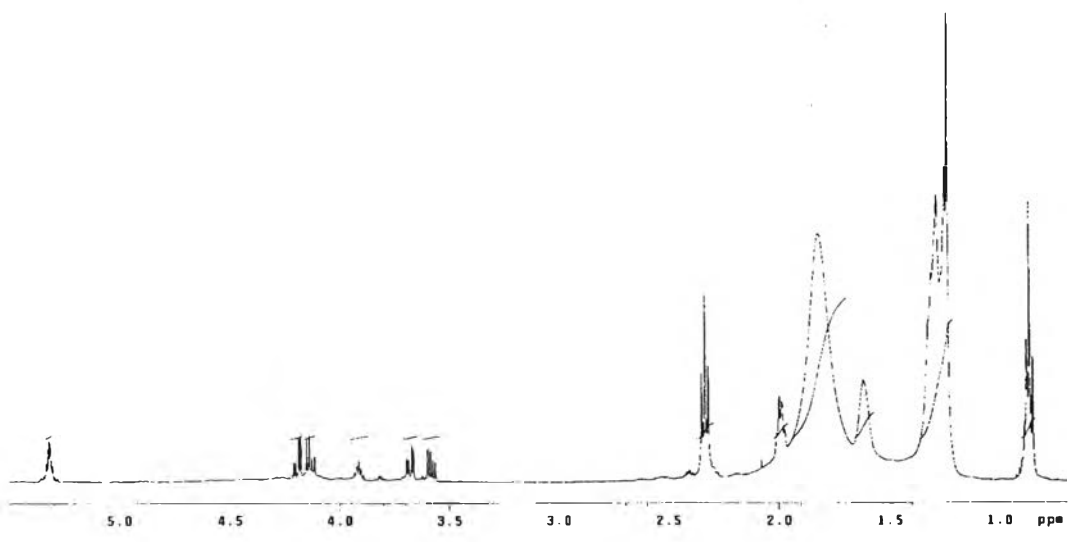

Figure A8 ^{1}H NMR spectrum of fraction F fractionated from the crude biosurfactant produced by *P. aeruginosa* SP4.

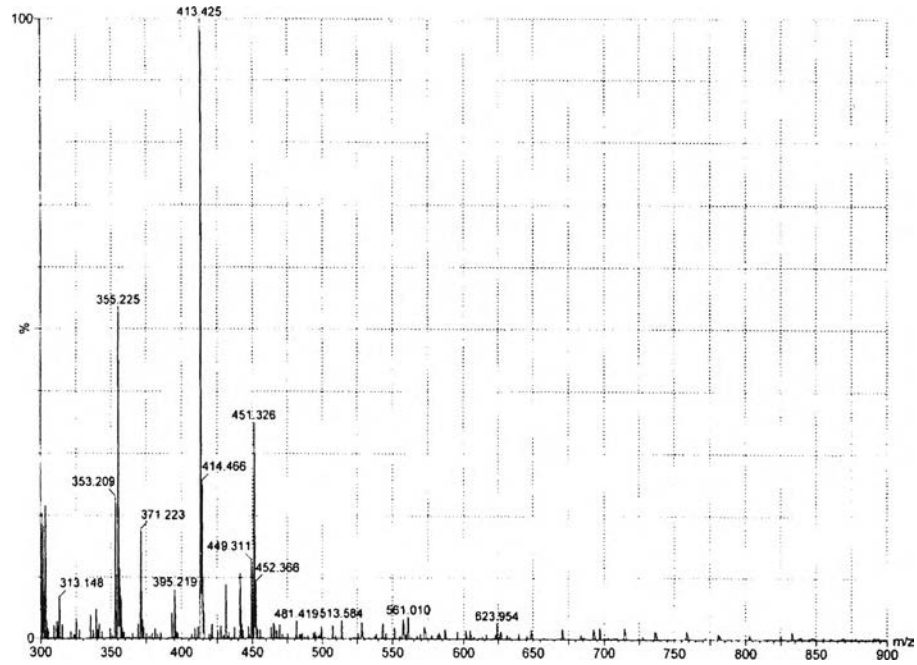

Figure A9 Mass spectrum of fraction A fractionated from the crude biosurfactant produced by *P. aeruginosa* SP4.

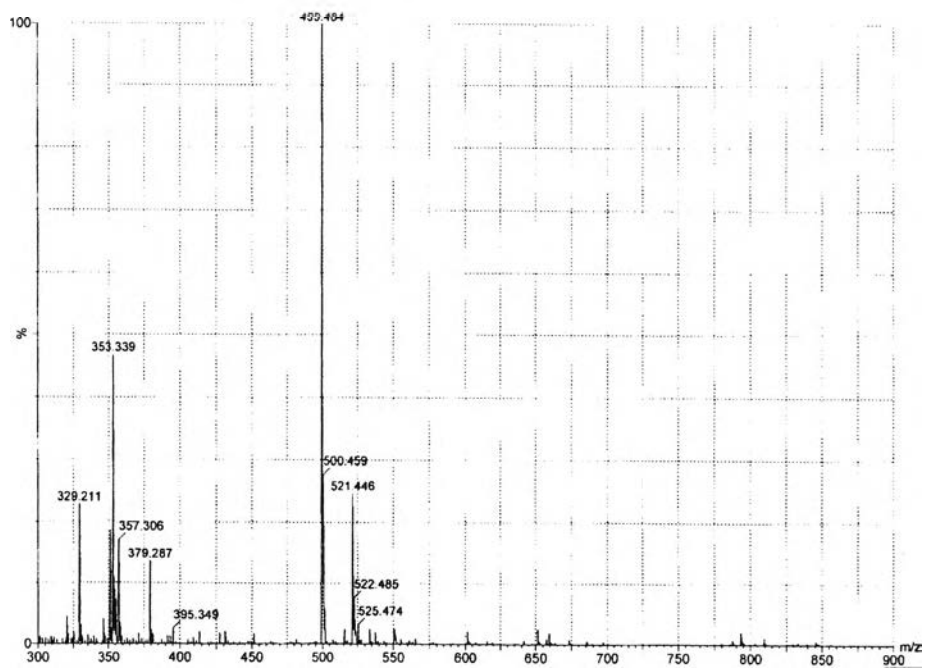

Figure A10 Mass spectrum of fraction B fractionated from the crude biosurfactant produced by *P. aeruginosa* SP4.

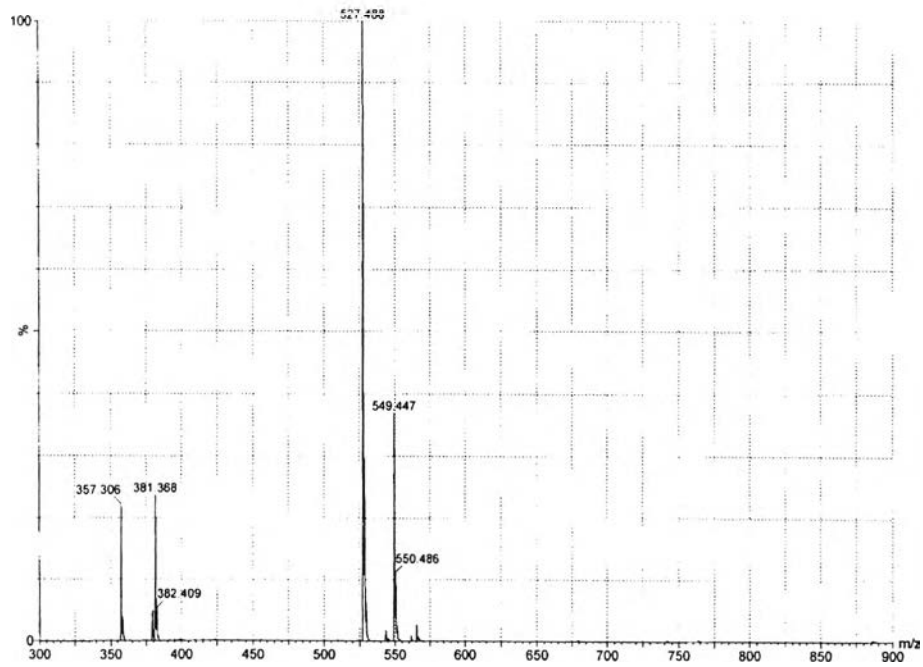

Figure A11 Mass spectrum of fraction C fractionated from the crude biosurfactant produced by *P. aeruginosa* SP4.

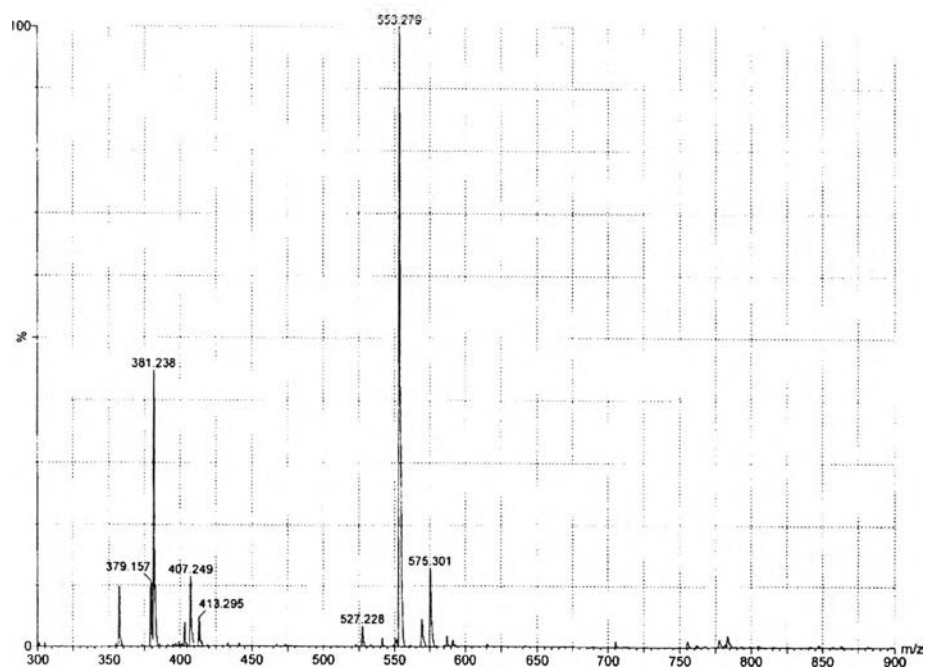

Figure A12 Mass spectrum of fraction D fractionated from the crude biosurfactant produced by *P. aeruginosa* SP4.

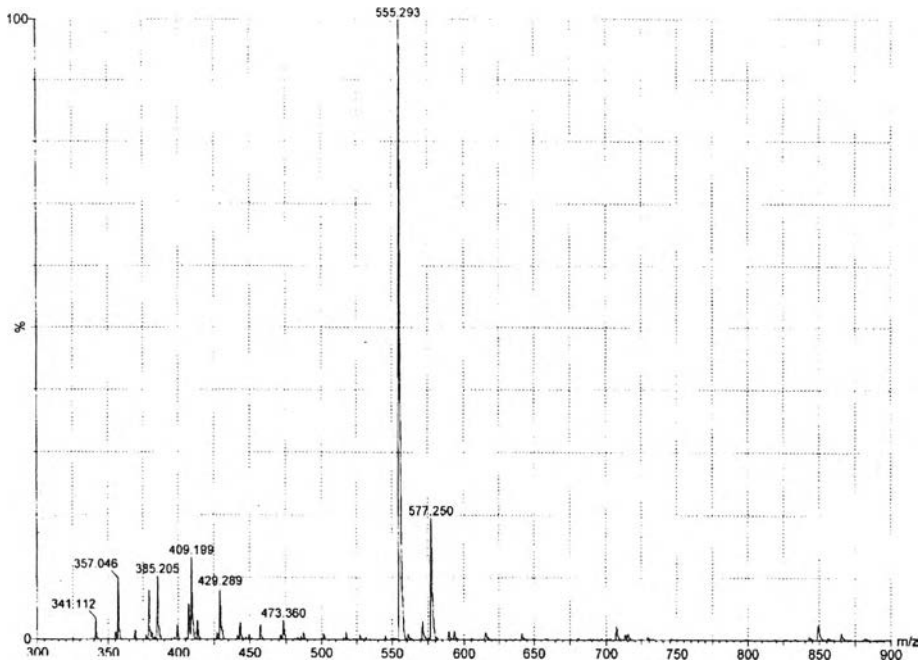

Figure A13 Mass spectrum of fraction E fractionated from the crude biosurfactant produced by *P. aeruginosa* SP4.

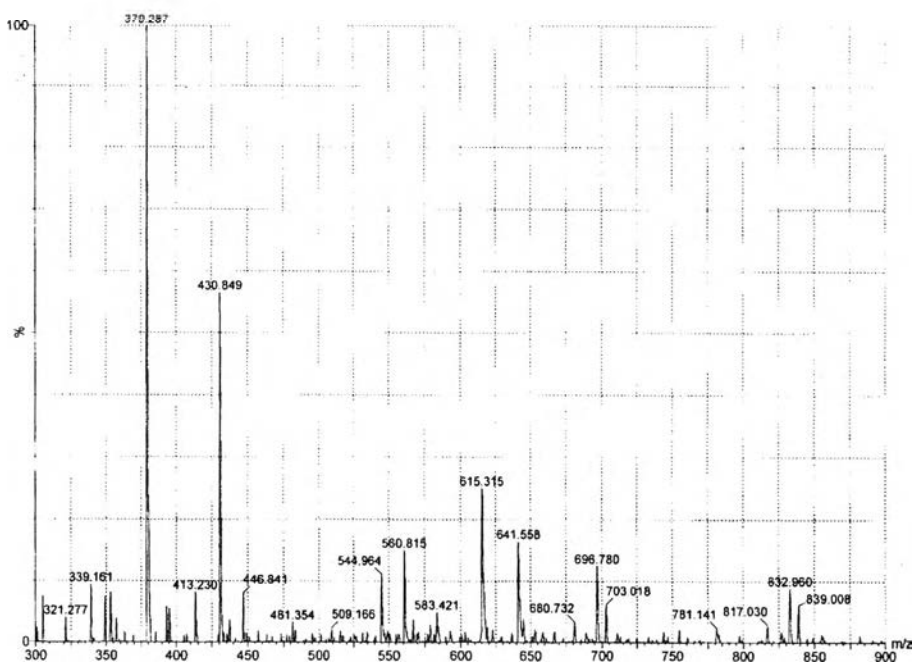

Figure A14 Mass spectrum of fraction F fractionated from the crude biosurfactant produced by *P. aeruginosa* SP4.

Appendix B Solution Properties and Vesicle Formation of Rhamnolipid Biosurfactants produced by *Pseudomonas aeruginosa* SP4

Table B1 Surface tension *versus* rhamnolipid biosurfactant concentration in a PBS solution

Concentration (mg/l)	Surface Tension (mN/m)		
	I	II	III
0.3	64.5	64.5	64.5
0.6	64.6	64.5	64.5
1.3	64.5	64.5	64.6
2.5	64.7	64.8	64.8
5	64.2	64.1	64.3
10	64.4	64.5	64.5
20	65.0	65.1	65.1
40	64.6	64.6	64.6
80	45.1	45.0	45.0
160	41.5	41.5	41.5
320	34.3	34.3	34.3
640	30.3	30.3	30.3
1,280	29.3	29.3	29.2
2,560	29.3	29.3	29.2

Table B2 Surface tension *versus* rhamnolipid biosurfactant concentration in a PBS solution containing NaCl

Concentration (mg/l)	Surface Tension (mN/m)								
	PBS + 0.1 M NaCl			PBS + 0.2 M NaCl			PBS + 0.4 M NaCl		
	I	II	III	I	II	III	I	II	III
0.3	64.8	64.8	64.8	65.7	65.7	65.9	62.3	62.3	62.3
0.6	64.1	64.1	64.2	66.5	66.5	66.5	62.3	62.3	62.3
1.3	65.5	65.5	65.6	66.5	66.5	66.4	62.7	62.8	62.8
2.5	65.7	65.6	65.6	65.5	65.5	65.5	62.8	62.8	62.9
5	64.6	64.6	64.5	65.5	65.6	65.7	62.4	62.4	62.4
10	64.2	64.3	64.2	64.3	64.3	64.4	62.7	62.8	62.7
20	64.5	64.6	64.5	64.2	64.1	64.1	62.9	62.9	62.9
40	64.0	63.9	63.9	65.0	65.0	65.0	62.4	62.4	62.4
80	59.3	59.4	59.2	42.3	42.3	42.3	43.6	43.7	43.6
160	39.8	39.8	39.8	38.8	38.7	38.7	35.6	35.6	35.6
320	34.7	34.8	34.8	33.7	33.8	33.7	32.2	32.2	32.2
640	29.9	29.8	29.8	30.3	30.3	30.3	30.8	30.8	30.8
1,280	29.9	29.8	29.8	28.6	28.6	28.6	29.5	29.5	29.4
2,560	29.9	29.4	29.5	28.8	28.7	28.4	28.9	28.9	28.9

Table B3 Surface tension *versus* rhamnolipid biosurfactant concentration in a PBS solution containing C_2H_5OH

Concentration (mg/l)	Surface Tension (mN/m)								
	PBS + 0.1 M C_2H_5OH			PBS + 0.2 M C_2H_5OH			PBS + 0.4 M C_2H_5OH		
	I	II	III	I	II	III	I	II	III
0.3	64.5	64.5	64.6	63.3	63.4	63.4	58.6	58.7	58.7
0.6	64.2	64.2	64.0	62.4	62.3	62.3	59.6	59.8	59.6
1.3	64.4	64.4	64.4	63.3	63.3	63.4	59.9	59.7	59.8
2.5	64.9	64.9	64.8	63.4	63.4	63.3	59.2	59.6	59.4
5	64.1	64.1	64.2	63.4	63.4	63.3	58.4	58.6	58.7
10	64.1	64.2	64.2	63.4	63.3	63.3	57.3	57.5	57.5
20	64.8	64.9	64.8	63.4	63.4	63.6	57.9	58.0	57.8
40	64.3	64.3	64.3	63.9	63.8	63.9	58.8	58.9	58.6
80	43.8	43.9	43.8	42.6	42.6	42.4	58.7	58.8	58.9
160	41.9	41.9	41.8	41.6	41.8	41.8	39.1	39.1	39.2
320	39.9	39.8	39.9	39.1	39.1	39.3	35.0	35.0	35.0
640	29.8	29.8	29.9	34.8	34.8	34.7	32.5	32.5	32.5
1,280	29.4	29.3	29.5	29.5	29.5	29.4	28.9	29.0	28.9
2,560	28.3	28.4	28.4	28.5	29.0	28.6	28.4	28.4	28.4

Table B4 Turbidity (absorbance at 600 nm) of the biosurfactant solution at different concentrations prepared in a PBS solution

Concentration (mg/l)	Turbidity (Absorbance at 600 nm)		
	I	II	III
0.31	0.12	0.12	0.12
0.63	0.17	0.16	0.16
1.25	0.15	0.14	0.14
2.50	0.16	0.16	0.17
5	0.15	0.15	0.14
10	0.18	0.17	0.18
20	0.18	0.18	0.18
40	0.19	0.19	0.19
80	0.19	0.20	0.20
160	0.42	0.42	0.43
320	0.62	0.61	0.62
640	1.07	1.07	1.07
1,280	2.38	2.37	2.38
2,560	3.67	3.67	3.67

Table B5 Turbidity (absorbance at 600 nm) of the biosurfactant solution at different concentrations prepared in a PBS solution containing NaCl

Concentration (mg/l)	Turbidity (Absorbance at 600 nm)								
	PBS + 0.1 M NaCl			PBS + 0.2 M NaCl			PBS + 0.4 M NaCl		
	I	II	III	I	II	III	I	II	III
0.31	0.19	0.20	0.20	0.22	0.22	0.22	0.20	0.20	0.20
0.63	0.17	0.17	0.17	0.16	0.17	0.17	0.17	0.18	0.17
1.25	0.17	0.18	0.17	0.17	0.17	0.16	0.20	0.20	0.20
2.50	0.17	0.17	0.17	0.17	0.17	0.17	0.19	0.19	0.18
5	0.20	0.20	0.19	0.16	0.17	0.17	0.16	0.17	0.17
10	0.20	0.19	0.19	0.22	0.21	0.22	0.22	0.23	0.23
20	0.24	0.23	0.24	0.24	0.23	0.23	0.19	0.18	0.18
40	0.28	0.29	0.29	0.29	0.29	0.29	0.20	0.20	0.21
80	0.35	0.35	0.35	0.33	0.33	0.33	0.20	0.20	0.20
160	0.42	0.42	0.42	0.39	0.39	0.38	0.33	0.33	0.33
320	0.61	0.61	0.60	0.53	0.52	0.52	0.37	0.38	0.38
640	0.96	0.96	0.95	0.76	0.76	0.76	0.64	0.65	0.65
1,280	1.81	1.81	1.81	1.34	1.33	1.33	1.17	1.18	1.17
2,560	3.51	3.51	3.49	2.73	2.73	2.74	2.36	2.35	2.36

Table B6 Turbidity (absorbance at 600 nm) of the biosurfactant solution at different concentrations prepared in a PBS solution containing C_2H_5OH

Concentration (mg/l)	Turbidity (Absorbance at 600 nm)								
	PBS + 0.1 M C_2H_5OH			PBS + 0.2 M C_2H_5OH			PBS + 0.4 M C_2H_5OH		
	I	II	III	I	II	III	I	II	III
0.31	0.17	0.18	0.17	0.17	0.18	0.19	0.17	0.16	0.16
0.63	0.20	0.20	0.20	0.17	0.16	0.17	0.17	0.17	0.18
1.25	0.23	0.23	0.23	0.17	0.17	0.17	0.18	0.19	0.18
2.50	0.20	0.20	0.20	0.18	0.19	0.19	0.17	0.17	0.18
5	0.21	0.20	0.21	0.19	0.20	0.19	0.18	0.19	0.18
10	0.22	0.22	0.22	0.20	0.20	0.21	0.15	0.14	0.16
20	0.26	0.26	0.26	0.27	0.27	0.28	0.18	0.17	0.17
40	0.26	0.26	0.26	0.26	0.27	0.26	0.18	0.19	0.18
80	0.36	0.37	0.36	0.35	0.34	0.35	0.19	0.19	0.20
160	0.40	0.39	0.39	0.36	0.34	0.35	0.27	0.28	0.26
320	0.59	0.59	0.59	0.41	0.42	0.43	0.34	0.34	0.35
640	0.95	0.95	0.95	0.60	0.60	0.60	0.50	0.50	0.51
1,280	1.50	1.50	1.50	1.74	1.75	1.73	1.50	1.49	1.50
2,560	2.99	2.99	2.99	2.53	2.54	2.54	2.25	2.25	2.24

Table B7 Electrical conductivity of the biosurfactant solution at different concentrations prepared in a PBS solution

Concentration (mg/l)	Electrical Conductivity (mS)		
	I	II	III
0.31	5.79	5.74	5.88
0.63	6.30	6.36	6.31
1.25	6.32	6.35	6.38
2.50	6.25	6.52	6.71
5	6.74	6.59	6.96
10	6.85	6.97	6.74
20	7.09	7.09	7.09
40	7.45	7.44	7.41
80	7.87	7.73	7.96
160	6.87	6.81	6.82
320	6.24	6.37	6.37
640	6.02	6.04	6.07
1,280	5.98	5.89	5.83
2,560	5.85	5.96	6.05

Table B8 Electrical conductivity of the biosurfactant solution at different concentrations prepared in a PBS solution containing NaCl

Concentration (mg/l)	Electrical Conductivity (mS)								
	PBS + 0.1 M NaCl			PBS + 0.2 M NaCl			PBS + 0.4 M NaCl		
	I	II	III	I	II	III	I	II	III
0.31	9.87	9.88	9.81	9.87	9.86	9.82	14.70	14.64	14.64
0.63	10.04	10.05	10.06	10.90	10.86	11.02	16.64	16.65	16.61
1.25	10.21	10.22	10.17	13.32	13.43	13.23	17.54	17.65	17.45
2.50	10.50	10.44	10.63	15.15	15.04	15.30	18.90	18.80	19.05
5	10.06	10.18	10.26	17.01	17.15	16.91	20.08	20.01	20.10
10	10.08	10.01	10.01	17.98	18.02	17.88	21.04	21.56	21.46
20	10.14	10.02	9.98	17.99	17.78	18.18	21.22	20.96	22.92
40	10.13	10.10	10.22	18.97	19.12	17.78	21.41	20.93	22.33
80	10.61	10.66	10.68	19.33	20.46	20.15	21.78	21.77	21.76
160	9.61	9.65	9.70	18.00	18.01	18.06	21.44	21.59	21.31
320	8.43	8.47	8.40	14.19	14.14	14.11	18.58	18.68	18.43
640	6.98	6.82	6.77	12.05	12.10	12.01	14.08	14.02	14.04
1,280	6.82	6.72	6.96	10.52	10.52	10.57	12.24	12.22	12.26
2,560	6.71	6.73	6.74	10.26	10.17	10.34	12.30	12.26	12.23

Table B9 Electrical conductivity of the biosurfactant solution at different concentrations prepared in a PBS solution containing C_2H_5OH

Concentration (mg/l)	Electrical Conductivity (μS)								
	PBS + 0.1 M C_2H_5OH			PBS + 0.2 M C_2H_5OH			PBS + 0.4 M C_2H_5OH		
	I	II	III	I	II	III	I	II	III
0.31	4.67	4.62	4.67	4.84	4.98	4.75	6.71	6.78	6.71
0.63	4.86	4.93	4.72	4.91	5.01	4.88	6.91	7.20	6.76
1.25	4.99	4.82	5.00	5.07	5.08	5.09	7.26	7.29	7.20
2.50	5.51	5.55	5.52	5.65	5.52	5.45	7.54	7.59	7.51
5	5.95	6.01	6.88	6.01	5.91	6.14	7.61	7.64	7.80
10	6.17	6.34	5.97	6.14	6.25	5.97	7.68	7.98	7.37
20	6.25	6.14	6.38	6.38	6.14	6.58	7.81	8.08	7.68
40	6.41	6.43	6.41	6.53	6.56	6.60	7.94	8.04	8.06
80	6.65	6.60	6.69	6.60	6.63	6.67	8.06	8.22	7.80
160	5.95	5.90	5.99	6.80	6.80	6.89	8.22	8.45	8.00
320	5.27	5.23	5.26	5.74	5.77	5.71	6.64	6.68	6.60
640	4.91	4.78	5.17	5.17	5.18	5.16	5.87	5.96	5.75
1,280	4.71	4.73	4.71	4.80	4.80	4.79	5.37	5.10	5.63
2,560	4.53	4.55	4.59	4.62	4.66	4.64	4.94	4.82	4.90

Table B10 Scattered light intensity of the biosurfactant solution at different concentrations prepared in a PBS solution, a PBS solution containing NaCl, and a PBS solution containing C_2H_5OH

Concentration (mg/l)	Average Count Rate (kcps)						
	PBS	0.1 M NaCl	0.2 M NaCl	0.4 M NaCl	0.1 M C_2H_5OH	0.2 M C_2H_5OH	0.4 M C_2H_5OH
0.3	24.4	73.4	11.6	33.4	11.9	38.1	17.5
0.6	26.6	82.2	11.5	32.2	22.7	38.8	15.3
1.3	28.6	89.2	13.5	32.3	18.0	38.6	28.1
2.5	32.8	91.2	21.8	32.5	20.6	58.0	29.3
5	37.2	97.9	21.5	35.7	33.7	90.3	32.5
10	42.4	100.2	20.0	42.7	46.8	153.1	61.6
20	65.5	131.9	46.9	35.8	11.9	38.1	17.5
40	183.4	434.2	123.9	151.6	22.7	38.8	15.3
80	468.6	462.5	670.4	549.9	703.1	532.8	469.4
160	465.6	423.4	499.7	499.4	458.8	1,100	1,000
320	471.6	425.0	482.1	497.4	440.9	468.7	489.0
640	478.0	428.8	480.4	488.8	439.0	445.5	420.3
1,280	475.6	422.5	477.0	488.0	443.2	440.0	425.5
2,560	470.3	421.2	475.5	488.4	445.2	441.4	428.4

Table B11 Contribution of the various-sized biosurfactant vesicles at different concentrations prepared in a PBS solution

Concentration (mg/l)	Contribution of Aggregate (%)	
	50-250 nm	>250 nm
160	59.1	40.9
320	37.5	62.5
640	20.1	79.9
1,280	0	100
2,560	0	100

Table B12 Contribution of the various-sized biosurfactant vesicles at different concentrations prepared in a PBS solution containing NaCl: (a) 50-250 nm and (b) >250 nm

Concentration (mg/l)	Contribution of Aggregate (%)					
	PBS + 0.1 M NaCl		PBS + 0.2 M NaCl		PBS + 0.4 M NaCl	
	(a)	(b)	(a)	(b)	(a)	(b)
160	42.5	57.5	24.6	75.4	10.0	90.0
320	50.6	49.4	25.2	74.8	50.6	49.5
640	57.0	43.0	30.5	69.5	46.8	53.2
1,280	0	100	0	100	54.0	46.0
2,560	0	100	0	100	42.6	57.4

Table B13 Contribution of the various-sized biosurfactant vesicles at different concentrations prepared in a PBS solution containing C_2H_5OH: (a) 50-250 nm and (b) >250 nm

Concentration (mg/l)	Contribution of Aggregate (%)					
	PBS + 0.1 M C_2H_5OH		PBS + 0.2 M C_2H_5OH		PBS + 0.4 M C_2H_5OH	
	(a)	(b)	(a)	(b)	(a)	(b)
160	20.9	79.1	66.4	33.6	37.1	62.9
320	4.2	95.8	39.0	61.0	100	0
640	0	100	21.9	78.1	100	0
1,280	0	100	0	100	100	0
2,560	0	100	0	100	100	0

Table B14 Encapsulation efficiency (E%) of the biosurfactant vesicle formed in a PBS solution in the absence and presence of the additives at a biosurfactant concentration of 1,280 mg/l

Medium	Encapsulation Efficiency (%)		
	I	II	III
PBS	9.6	7.8	12.5
PBS + 0.1 M NaCl	6.4	8.2	7.7
PBS + 0.2 M NaCl	6.7	5.0	7.5
PBS + 0.4 M NaCl	5.8	6.1	6.2
PBS + 0.1 M C_2H_5OH	11.4	17.0	14.6
PBS + 0.2 M C_2H_5OH	13.2	18.3	17.1
PBS + 0.4 M C_2H_5OH	32.0	31.7	29.4

Appendix C Preparation and Characterization of Rhamnolipid Vesicles as Potential Nanocarrier Systems

Table C1 Solution turbidity (absorbance at 600 nm) of the rhamnolipid solution prepared in a PBS solution (pH 7.4) at a biosurfactant concentration of 0.13 wt.% at different cholesterol concentrations

Cholesterol Concentration (μM)	Turbidity (Absorbance at 600 nm)		
	I	II	III
0	0.99	0.99	0.99
25	0.99	0.99	0.99
50	0.99	0.99	0.99
100	0.71	0.71	0.71
200	0.65	0.65	0.65
400	0.60	0.60	0.60

Table C2 Zeta potential of the rhamnolipid solution prepared in a PBS solution (pH 7.4) at a biosurfactant concentration of 0.13 wt.% at different cholesterol concentrations

Cholesterol Concentration (μM)	Zeta Potential (mV)		
	I	II	III
0	-29.8	-29.9	-27.1
25	-28.6	-28.5	-28.5
50	-27.2	-25.4	-26.9
100	-17.2	-21.9	-20.4
200	-16.5	-16.1	-14.3
400	-13.2	-13.6	-13.2

Table C3 Size of the rhamnolipid vesicle prepared in a PBS solution (pH 7.4) at a biosurfactant concentration of 0.13 wt.% at different cholesterol concentrations obtained from the DLS measurement

Cholesterol Concentration (μM)	Hydrodynamic Diameter (nm)				
	I	II	III	IV	V
0	297.1	288.0	313.0	294.6	298.2
25	262.8	258.5	294.6	269.2	286.7
50	261.4	263.9	263.2	268.2	270.0
100	250.9	241.9	242.2	259.3	256.6
200	234.9	239.8	240.1	220.4	255.1
400	213.7	210.5	203.2	206.5	210.9

Table C4 Size of the rhamnolipid vesicle prepared in a PBS solution (pH 7.4) at a biosurfactant concentration of 0.13 wt.% at different cholesterol concentrations obtained from the TEM technique

Cholesterol Concentration (μM)	Vesicle Diameter (nm)							
	I	II	III	IV	V	VI	VII	VIII
0	813	829	811	808	782	723	923	780
25	634	663	638	656	608	699	702	712
50	554	547	501	508	515	498	494	488
100	443	449	462	494	395	361	354	514
200	399	372	411	414	420	409	404	415
400	339	300	289	346	337	353	365	340

Table C5 Encapsulation efficiency (*E*%) of the rhamnolipid vesicles formed in a PBS solution (pH 7.4) at a biosurfactant concentration of 0.13 wt.% at various cholesterol concentrations and initial Sudan III concentrations

Cholesterol Concentration (μM)	Encapsulation Efficiency (%)								
	8.8 Mm Sudan III			17.5 μM Sudan III			35 μM Sudan III		
	I	II	III	I	II	III	I	II	III
0	46.8	45.9	45.1	20.5	19.5	19.6	6.6	6.8	7.5
25	68.9	67.0	70.5	33.2	31.8	33.2	16.0	17.7	19.9
50	70.0	78.2	80.8	35.0	35.2	32.8	21.3	22.5	23.3
100	91.1	82.5	90.8	54.6	59.8	57.5	23.6	22.3	21.7
200	65.0	65.7	66.5	39.0	36.6	37.2	10.1	10.6	11.0
400	60.1	50.0	46.9	26.2	27.8	24.8	11.3	12.8	11.1

Appendix D Surface-modified Polymeric Films by Rhamnolipid Biosurfactant from *Pseudomonas aeruginosa* SP4 for Biomedical Applications

Table D1 Adsorption isotherms of the rhamnolipid biosurfactant onto either silk fibroin or chitosan films from the SPR analysis

Concentration (mM)	Adsorbed Mass (μmol/m^2)							
	Silk Fibroin Film				Chitosan Film			
	I	II	III	IV	I	II	III	IV
0.03	0.16	0.26	0.07	0.08	0.13	0.15	0.12	0.16
0.06	0.25	0.13	0.18	0.08	0.24	0.19	0.16	0.24
0.12	0.79	0.21	0.43	0.43	0.25	0.19	0.14	0.44
0.24	1.25	0.65	0.98	0.96	0.60	0.56	0.51	0.35
0.49	3.16	2.47	2.47	2.37	0.74	0.75	0.74	0.72
0.97	3.66	4.52	4.03	4.11	2.25	2.17	1.80	1.70
1.95	4.16	4.69	4.04	4.66	2.31	2.33	2.69	1.98
3.90	4.58	4.43	4.59	4.17	2.39	2.33	2.50	2.47

(a) The adsorption of the biosurfactant onto the silk fibroin film:

From the SPR data, the adsorbed amount of the biosurfactant on the silk fibroin film was 4.5 μmol/m^2.

$$4.5\ \mu mol/m^2 = 4.5 \times 10^{-6} \times 6.02 \times 10^{23}\ molecules/\ m^2$$

$$= 2.7 \times 10^{18}\ molecules/\ m^2$$

If the bilayer topography was assumed, one biosurfactant molecule should occupy $2 \times (2.7 \times 10^{18})^{-1}\ m^2$.

$$2 \times (2.7 \times 10^{18})^{-1}\ m^2 = 2 \times (3.7 \times 10^{-19})\ m^2$$

$$= 7.41 \times 10^{-19}\ m^2$$

$$= 74.1\ Å^2$$

Therefore, based on the assumption of bilayer topography, a surface area per molecule of 74.1 Å^2 was obtained.

(b) The adsorption of the biosurfactant onto the chitosan film:

From the SPR data, the adsorbed amount of the biosurfactant on the chitosan film was 2.3 μmol/m^2.

$$2.3\ \mu mol/m^2 = 2.3 \times 10^{-6} \times 6.02 \times 10^{23}\ molecules/\ m^2$$

$$= 1.4 \times 10^{18}\ molecules/\ m^2$$

If the monolayer topography was assumed, one biosurfactant molecule should occupy $(1.4 \times 10^{18})^{-1}\ m^2$.

$$(1.4 \times 10^{18})^{-1}\ m^2 = 7.14 \times 10^{-19}\ m^2$$

$$= 71.4\ Å^2$$

Therefore, based on the assumption of monolayer topography, a surface area per molecule of 71.4 $Å^2$ was obtained.

Table D2 Adsorption isotherms of the rhamnolipid biosurfactant onto either silk fibroin or chitosan films from the QCM-D experiment

Concentration (mM)	Adsorbed Mass (μmol/m^2)					
	I	II	III	IV	V	VI
Silk Fibroin Film						
0.03	2.9	2.9	2.9	2.9	2.9	2.9
0.06	13.8	13.8	13.8	13.8	13.8	13.8
0.12	29.0	29.0	29.0	29.1	29.0	29.0
0.24	34.3	34.3	34.3	34.3	34.3	34.3
0.49	37.0	37.0	37.0	37.0	37.0	37.0
0.97	38.8	38.8	38.8	38.8	38.8	38.8
1.95	39.8	39.8	39.8	39.8	39.8	39.8
3.90	39.9	39.9	39.9	39.9	39.9	39.9
Chitosan Film						
0.03	7.1	7.1	7.1	7.1	7.1	7.1
0.06	25.4	25.4	25.4	25.4	25.4	25.4
0.12	50.7	50.7	50.7	50.8	51.2	51.7
0.24	96.7	96.8	96.8	96.9	96.8	96.8
0.49	112.5	112.5	112.5	112.5	112.5	112.6
0.97	127.4	127.4	127.4	127.4	127.4	127.4
1.95	135.1	135.1	135.1	135.1	135.1	135.1
3.90	137.5	137.5	137.5	137.5	137.4	137.4

Table D3 The changes in the third overtone of the resonance frequency from the QCM-D experiment as a function of the biosurfactant concentration

Concentration (mM)	Frequency (Hz)					
	I	II	III	IV	V	VI
Silk Fibroin Film						
0.03	-8.2	-8.2	-8.6	-8.6	-8.1	-8.1
0.06	-39.5	-39.5	-39.5	-39.5	-39.5	-39.5
0.12	-83.3	-83.3	-83.3	-83.3	-83.3	-83.3
0.24	-98.3	-98.3	-98.3	-98.3	-98.3	-98.3
0.49	-106.1	-106.1	-106.0	-106.0	-106.0	-106.0
0.97	-111.3	-111.3	-111.3	-111.3	-111.3	-111.3
1.95	-114.0	-114.0	-114.0	-114.0	-114.0	-114.0
3.90	-114.3	-114.3	-114.3	-114.2	-114.2	-114.2
Chitosan Film						
0.03	-20.3	-20.3	-20.4	-20.4	-20.4	-20.4
0.06	-72.7	-72.7	-72.7	-72.7	-72.7	-72.8
0.12	-145.2	-145.2	-145.3	-145.3	-145.3	-145.3
0.24	-277.1	-277.1	-277.1	-277.2	-277.2	-277.3
0.49	-322.1	-322.1	-322.1	-322.1	-322.2	-322.2
0.97	-365.1	-365.1	-365.2	-365.2	-365.2	-365.2
1.95	-387.2	-387.2	-387.2	-387.2	-387.2	-387.2
3.90	-394.3	-394.2	-394.1	-394.0	-393.9	-393.8

Table D4 The changes in the third overtone of the dissipation from the QCM-D experiment as a function of the biosurfactant concentration

Concentration (mM)	Dissipation (10^{-6})					
	I	II	III	IV	V	VI
Silk Fibroin Film						
0.03	2.2	2.2	2.2	2.2	2.2	2.2
0.06	8.9	8.9	8.9	8.9	8.9	8.9
0.12	16.3	16.2	16.2	16.2	16.3	16.3
0.24	17.1	17.1	17.1	17.1	17.1	17.1
0.49	17.7	17.7	17.7	17.7	17.7	17.7
0.97	18.0	18.0	18.0	18.0	18.0	18.0
1.95	19.0	19.0	19.0	19.0	19.0	19.0
3.90	19.1	19.1	19.0	19.0	19.0	19.0
Chitosan Film						
0.03	4.2	4.2	4.2	4.2	4.2	4.2
0.06	13.6	13.6	13.6	13.6	13.6	13.6
0.12	25.0	25.0	25.0	25.0	25.0	25.0
0.24	28.1	27.3	26.5	25.7	24.9	24.2
0.49	27.2	27.3	27.3	27.3	27.3	27.3
0.97	30.2	30.2	30.2	30.2	30.2	30.2
1.95	35.6	35.6	35.6	35.6	35.6	35.6
3.90	37.9	37.9	37.8	37.8	37.8	37.7

Table D5 Water content percentages within the adsorbed layers of either silk fibroin or chitosan films as a function of the biosurfactant concentration

Concentration (mM)	Water Content (%)	
	Silk Fibroin Film	Chitosan Film
0.03	95.1	98.0
0.06	98.8	99.2
0.12	98.4	99.5
0.24	97.2	99.5
0.49	92.9	99.3
0.97	89.5	98.4
1.95	89.0	98.3
3.90	88.8	98.2

Table D6 Water contact angles of either silk fibroin or chitosan films as a function of the biosurfactant concentration

Concentration (mM)	Water Contact Angle (°)					
	Silk Fibroin Film			Chitosan Film		
	I	II	III	I	II	III
0	49.6	50.8	50.6	71.0	71.4	71.2
0.03	59.4	57.5	54.2	72.1	71.9	72.9
0.06	60.0	59.6	58.1	73.6	73.4	74.0
0.12	62.7	62.7	62.0	75.6	75.0	75.8
0.24	67.7	67.6	66.3	76.8	79.8	78.9
0.49	69.9	72.0	73.5	82.6	83.2	82.7
0.97	76.3	72.7	76.7	83.2	85.3	83.2
1.95	76.2	76.4	77.5	85.1	83.8	83.6
3.90	76.7	77.5	76.5	85.1	83.5	86.5

Table D7 Surface roughness (R_a) of unmodified silk fibroin, surface-modified silk fibroin films, unmodified chitosan, and surface-modified chitosan

Sample	Surface Roughness (nm)			
	I	II	III	IV
UNMODIFIED-SILK FIBROIN FILM	2.43	3.06	1.33	1.01
SURFACE-MODIFIED SILK FIBROIN FILM	4.34	3.51	1.66	1.26
UNMODIFIED-CHITOSAN FILM	1.57	1.25	1.50	1.18
SURFACE-MODIFIED CHITOSAN FILM	1.63	1.28	1.98	1.56

Table D8 Growth of human dermal fibroblasts on unmodified and surface-modified polymeric films

Sample	Fluorescent Intensity		
	I	II	III
Incubation Time of 1 day			
CONTROL	646	649	730
UNMODIFIED-SILK FIBROIN FILM	729	719	774
SURFACE-MODIFIED SILK FIBROIN FILM	728	760	708
UNMODIFIED-CHITOSAN FILM	689	744	717
SURFACE-MODIFIED CHITOSAN FILM	675	669	647
Incubation Time of 3 days			
CONTROL	1129	1131	1222
UNMODIFIED-SILK FIBROIN FILM	1470	1403	1585
SURFACE-MODIFIED SILK FIBROIN FILM	1357	1476	1240
UNMODIFIED-CHITOSAN FILM	1103	1190	1157
SURFACE-MODIFIED CHITOSAN FILM	1106	1236	1178
Incubation Time of 5 days			
CONTROL	2424	2541	2462
UNMODIFIED-SILK FIBROIN FILM	2800	2794	2947
SURFACE-MODIFIED SILK FIBROIN FILM	2420	2476	2669
UNMODIFIED-CHITOSAN FILM	2199	2359	2137
SURFACE-MODIFIED CHITOSAN FILM	2397	2485	2411

Table D9 Growth of human dermal keratinocytes on unmodified and surface-modified polymeric films

Sample	Optical Density (Absorbance at 570 nm)			
	1 day		7 days	
	I	II	I	II
CONTROL	0.29	0.31	0.69	0.74
UNMODIFIED-SILK FIBROIN FILM	0.27	0.28	0.62	0.63
SURFACE-MODIFIED SILK FIBROIN FILM	0.25	0.27	0.62	0.67
UNMODIFIED-CHITOSAN FILM	0.20	0.22	0.55	0.52
SURFACE-MODIFIED CHITOSAN FILM	0.25	0.24	0.60	0.60

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Publications:

1. Pornsunthorntawee, O.; Wongpanit, P.; Chavedj, S.; Abe, M.; and Rujiravanit, R. (2008) Structural and physicochemical characterization of crude biosurfactant produced by *Pseudomonas aeruginosa* SP4 isolated from petroleum-contaminated soil. Bioresource Technology, 99, 1589-1595.
2. Pornsunthorntawee, O.; Arttaweeporn, N.; Paisanjit, S.; Somboonthanate, P.; Abe, M.; Rujiravanit, R.; and Chavadej, S. (2008) Isolation and comparison of biosurfactants produced by *Bacillus subtilis* PT2 and *Pseudomonas aeruginosa* SP4 for microbial surfactant-enhanced oil recovery. Biochemical Engineering Journal, 42, 172-179.
3. Pornsunthorntawee, O.; Maksung, S.; Huayyai, O.; Rujiravanit, R.; Chavadej, S. (2009) Biosurfactant production by *Pseudomonas aeruginosa* SP4 using sequencing batch reactors: effects of oil loading rate and cycle time. Bioresource Technology, 100, 812-818.
4. Pornsunthorntawee, O.; Chavadej, S.; and Rujiravanit, R. (2009) Solution properties and vesicle formation of rhamnolipid biosurfactants produced by *Pseudomonas aeruginosa* SP4. Colloids and Surfaces B: Biointerfaces, 72, 6-15.
5. Sarachat, T.; Pornsunthorntawee, O.; Chavadej, S.; and Rujiravanit, R. (2010) Purification and concentration of a rhamnolipid biosurfactant produced by

Pseudomonas aeruginosa SP4 using foam fractionation. Bioresource Technology, 101, 324-330.

6. Pansiripat, S.; Pornsunthorntawee, O.; Rujiravanit, R.; Kitiyanan, B.; Somboonthanate, P.; and Chavadej, S. (2010) Biosurfactant production by *Pseudomonas aeruginosa* SP4 using sequencing batch reactors: effect of oil-to-glucose ratio. Biochemical Engineering Journal, 49, 185-191.
7. Pornsunthorntawee, O.; Wongpanit, P.; and Rujiravanit, R. (2010) Rhamnolipid biosurfactants: production and their potential in environmental biotechnology. In R. Sen (Eds.), Biosurfactants (pp. 211-221). Texas: Landes Bioscience.

Proceedings:

1. Pornsunthorntawee, O.; Wongpanit, P.; Chavadej, S.; Abe, M.; and Rujiravanit, R. (2007, June 25-28) Structural and physicochemical characterization of crude biosurfactant produced by *Pseudomonas aeruginosa* SP4. Proceedings of the 2nd International Conference on Advanced in Petrochemicals and Polymers (ICAPP 2007), Bangkok, Thailand.
2. Pornsunthorntawee, O.; Chavadej, S.; and Rujiravanit, R. (2008, August 19-20) Preparation, characterization, and vesicle morphology of biosurfactant produced by *Pseudomonas aeruginosa* SP4. Proceedings of the Thai-Japan Joint Symposium on Advances in Materials Science and Environmental Technology, Bangkok, Thailand.
3. Worakitsiri, P.; Pornsunthorntawee, O.; Chavadej, S.; Weder, C.; and Rujiravanit, R (2009, August 23-25) Biosurfactant mediated synthesis of conductive polymer. Proceedings of the 4th International Symposium in Science and Technology at Kansai University 2009, Osaka, Japan.

Presentations:

1. Rujiravanit, R.; Pornsunthorntawee, O.; Wongpanit, P.; and Chavadej, S. (2006, September 13-15) Preparation and characterization of surfactant-modified polymeric films for potential use in biomedical applications. Paper presented at The 59th Division Meeting on Colloid and Surface Chemistry, Supporo, Japan.
2. Pornsunthorntawee, O.; Chavadej. S.; Abe, M.; and Rujiravanit, R. (2008, August 17-22) Aggregation behaviors and microstructures of rhamnolipid biosurfactant

produced by *Pseudomonas aeruginosa* SP4 in aqueous media. Paper presented at The 17th International Symposium on Surfactants in Solution (SIS 2008), Berlin, Germany.

3. Pornsunthorntawee, O.; Arttaweeporn, N.; Paisanjit, S.; Abe, M.; Rujiravanit, R.; and Chavadej, S. (2008, August 17-22) Comparison of surface activity and efficiency in oil recovery of biosurfactants produced by *Bacillus subtilis* PT2 and *Pseudomonas aeruginosa* SP4. Paper presented at The 17th International Symposium on Surfactants in Solution (SIS 2008), Berlin, Germany.
4. Pornsunthorntawee, O.; Wongpanit, P.; Chavadej, S.; and Rujiravanit, R. (2009, April 20-24) Surface modification of biopolymeric films via adsorption of rhamnolipid biosurfactant produced by *Pseudomonas aeruginosa* SP4. Paper presented at The 17th POLYCHAR World Forum on Advanced Materials, Rouen, France.