REFERENCES

Arayawongkul, S. (2002). Characterization of polystyrene produced by admicellar polymerization. M.S.Thesis, The Petroleum and Petrochemical College Chulalongkorn University.

Barraza, H.J., Hwa, M.J., Blakley, K., O'Rear. E.A., and Grady, B.P. (2001). Wetting behavior of elastomer-modified glass fibers. Langmuir, in press.

Brady, P.V. (1996). Physics and Chemistry of Mineral Surfaces. CRC Press.

Chaisirimahamorakot, S. (2001). Modification of silica surface for rubber reinforcement using a continuous admicellar polymerization system. M.S. Thesis, The Petroleum and Petrochemical College, Chulalongkorn University.

Chakraverty, A., Mishra, P., and Banerjee, H.D. (1988). Investigation of combustion of raw and acid-leached rice husk for production of pure amorphous white silica. Journal of Materials Science, 23, 21-24.

Chuayjuljit, S., Eiumnoh, S., and Potiyaraj, P. (2001). Using silica from rice husk as a reinforcing filler in natural rubber. Journal of Science Research Chulalongkorn University, 26(2), 127-138.

Cutler, I.B. (1974). Production of silicon nitride from rice hulls. U.S. Patent 3,855,395.

Fuad, M.Y.A., Ismail, Z., Ishak, Z.A., and Omar, A.K.M. (1995). Application of rice husk ash as fillers in polypropylene: effect of titanate, zirconate and silane coupling agents. European Polymer Journal, 31(9), 885-893.

Gächter, R. and Müller, H. (1984). Plastics Additives Handbook. 2nd edition. New York: Hanser Publishers, Munich Vienna.

Genetti, W.B., Yuan, W.L., Grady, B.P., O'Rear, E.A., Lai, C.L., and Glatzhofer, D.T. (1998). Journal of Materials Science, 33, 3085-3093.

Grady, B.P., O'Rear, E.A., Penn, L.S., and Pedicini, A. (1998). Polymerization of styrene-isoprene on glass cloth for use in composite manufacture. Polymer composite, 19(5), 579-587.

James, J. and Rao, M. S. (1986). Characterization of silica in rice husk ash. American Ceramic Society Bulletin, 65(8), 1177-1180.

Khunthon, S., Tangwiwat, S., and Roengsumran, S. (1997). The application of rice husk ash for silica production. Journal of Metals, Materials and Minerals, 7 (1),21-30.

Kitiyanan, B., O'Haver, J. H., Harwell, J. H., and Osuwan, S. (1996). Absolubilization of styrene and isoprene in cetyltrimethylammonium bromide admicelle on precipitated silica. Langmuir, 12, 2162-2168.

Leela-Adisorn, U. (1992). Preparation and Characterization of High-grade Silica from Rice Husk. M.S. Thesis, Chulalongkorn University.

Nakata, Y., Suzuki, M., Okutai, T., Kikuche. M., and Akiyama, T. (1989). Preparation and properties of SiO_2 from rice hulls. Journal of the Ceramic Society of Japan, 97, 842.

Nontasorn, P. (2002). Improvement of Natural Rubber Properties by Modification of Silica Surface Using a Continuous Admicellar Polymerization System. M.S. Thesis, The Petroleum and Petrochemical College, Chulalongkorn University.

O'Haver, J.H., Harwell, J.H., O'Rear, E.A., Waddell, W.H., Snodgrass, L.J., and Parker, J.R. (1993). Formation of ultrathin polystyrene films in adsorbed surfactant bilayers on silica. Materials Research Society Symposium Proceedings, 304, 161-166.

O' Rear, E.A., Wu, J., and Harwell, J.H. (1987). Two-dimensional reaction solvent: surfactant bilayers in the formation of ultrathin films. Langmuir, 3(4), 531-537.

Pradubmook, T. (2001). Effect pH on Adsolubilization of Tolulene and Acetophenone into Adsorbed Surfactant on Precipitated Silica. M.S. Thesis, The Petroleum and Petrochemical College, Chulalongkorn University.

Rosen, M.J. (1989). Surfactants and Interfacial Phenomena. 2nd edition. New York: John Wiley and Sons.

Real, C., Alcala, M.D., and Criado, J.M. (1996). Preparation of silica from rice husks. Journal of American Ceramic Society, 79(8), 2012-2016.

Sun, L. and Gong, K. (2001). Silicon-based materials from rice husks and their applications: A Review Industrial Engineering Chemical Research, 40, 5861-5877.

Waddell, W.H., O'Haver, J.H., Evans, L.R., and Harwell, J.H. (1995). Organic polymer-surface modified precipitated silica. Journal of Applied Polymer Science, 55, 1627-1641.

Wu, J., Harwell, J.H., and O'Rear, E.A. (1987). Two-dimensional solvents: kinetics of styrene polymerization in admicelles at or near saturation. The Journal of Physical Chemistry, 91(3), 623-634.

Yalçin, N., and Sevinç, V. (2001). Studies on silica obtained from rice husk. Ceramics International, 27, 219.

APPENDIX A CTAB Adsorption Measurement.

Adsorption Isotherm

Observed the amount of carbon from TOC (ppm)
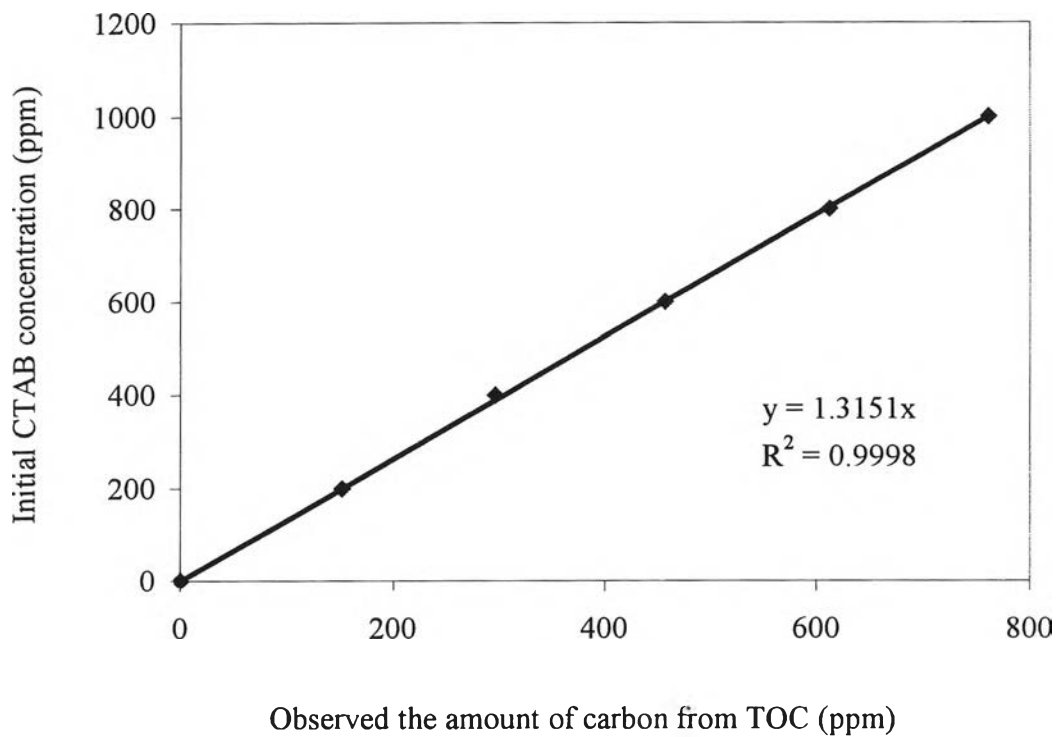
Figure A1 Calibration curve of CTAB solution by Total Organic Carbon analyzer (TOC).

Table A1 Data from adsorption isotherm of CTAB on rice husk silica at pH 8, 30°C.

Adsorbed CTAB (μmol/g silica)	Equilibrium Concentration (μM)
67.74	4681.48
70.72	3482.06

Table A1 (Continued)

Adsorbed CTAB (μmol/g silica)	Equilibrium Concentration (μM)
63.98	2900.39
65.41	2489.76
64.71	2132.18
60.22	1869.49
63.91	1402.21
57.38	1190.40
48.33	1041.73
45.26	893.43
41.57	835.69
30.08	748.01
20.12	622.08
9.27	518.16
8.60	159.96

Table A2 Data from adsorption isotherm of CTAB on commercial silica (Hi-Sil$^{®}$ 255) at pH 8, 30°C.

Adsorbed CTAB (μmol/g silica)	Equilibrium Concentration (μM)
574.50	10637.42
573.14	9421.41

Cont…

Table A2 (Continued)

Adsorbed CTAB (µmol/g silica)	Equilibrium Concentration (µM)
579.72	8006.93
579.81	6754.84
581.80	6080.07
577.58	5560.47
603.10	4297.55
580.84	4228.99
600.09	3122.67
611.58	2210.48
570.15	1996.14
574.99	625.33
539.77	255.80
493.47	163.17
443.94	151.62
394.16	146.10
344.48	138.02
294.54	136.58
244.79	130.26
144.59	135.24
582.18	1195.45

APPENDIX B Calculation of CTAB Adsorption Isotherm.

Surfactant Adsorption Isotherm Calculation

CTAB adsorption isotherm was constructed by plotting the amount of CTAB adsorbed per gram silica versus equilibrium concentration of CTAB.

Conditions: Silica 0.5 g: Solution 20 ml

1. To convert the amount of carbon from TOC (ppm) to equlibrium concentration of CTAB (ppm); Equation from TOC: $Y = 1.3151X$

    Where:

    X = The amount of carbon from TOC (ppm) = 1297.4 ppm

    Y = equlibrium concentration of CTAB (ppm) = $1.3151 \times 1297.4 = 1706.21$ ppm

2. Finding CTAB adsorbed concentration (ppm).

    [Adsorbed CTAB] = [Initial CTAB]-[Equilibrium CTAB]

    [Initial CTAB] = 2323.43 ppm.

    [Equilibrium CTAB] = 1706.21 ppm.

    [Adsorbed CTAB] = 2323.43-1706.21 = 617.22 ppm.

3. To convert unit of ppm to micromolar of [Adsorbed CTAB]

    Concentration (μM) = (Concentration (ppm)$\times$1000)/ Molecular weight

    Adsorbed CTAB (μM) = (617.22$\times$1000)/364.46 = 1693.52 μM

4. To convert adsorption concentration to moles of adsorption.

    Mole = (concentration x volume)/1000

    Adsorbed (μmoles) = (Adsorbed (μM) x volume of solution)/1000

    Adsorbed (μmoles) = (1693.52 x 20)/1000 = 33.87 μmoles

5. Finding CTAB adsorbed per gram silica.

    CTAB adsorbed (μmoles/g silica) = Adsorbed (μmoles)/ the amount of silica (g)

    CTAB adsorbed (μmoles/g silica) = 33.87/0.5 = 67.74

Appendix C Calculation of Amount of CTAB, Styrene, and AIBN for Admicellar Polymerization

Condition: Silica 20 g: Solution 250 ml

        CTAB: Molecular weight = 364.46 $gmol^{-1}$

        Styrene: Molecular weight = 104.15 $gmol^{-1}$, Density = 0.906 g/ml

        AIBN: Molecular weight = 164.21 $gmol^{-1}$

C1 CTAB Loading Calculation

Table C1 Calculation of initial CTAB concentration for CTAB adsorption at 50 and 560 μmol/g silica in the system

CTAB adsorption		Equilibrium CTAB concentration		Initial CTAB loading in the system (μmol)	Total weight of CTAB (g)
(μmol/g)	(μmol/20g)	(μM)	(μmol in 250 ml)		
50	1000	1000	250	1250	0.4556
560	11200	850	212.5	11412.5	4.1594

C2 Styrene and AIBN Loading Calculation at Ratio of CTAB: Styrene: AIBN = 1: 2: 2

Table C2 Calculation of initial styrene and AIBN loading for CTAB adsorption at 50 and 560 μmol/g silica in the system

Total CTAB (μmol)	Total styrene (μmol)	Styrene loading (g)	Total AIBN (μmol)	AIBN loading (g)
1250	2500	0.2874	2500	0.4105
11412.5	22825	2.6239	22825	3.7481

APPENDIX D Data of Gel Permeation Chromatography

Weight average molecular weight of polystyrene was measured using gel permeation chromatography at National Metal and Materials Technology Center (MTEC).

Instrument: Gel Permeation Chromatography, Water 150-CV

Test conditions:

Eluent:	Tetrahydrofuran
Flow rate:	1.0 ml/min
Injection volume:	100 μl
Temperature:	30 °C
Column set:	Plgel 10 μm mixed B 2 columns (MW resolving rang = 500-10,000,000)
Polymer standard:	Polystyrene
Calibration method:	Polystyrene standard calibration (MW 5,460-1,290,000)
Detector:	Refractive index detector

Sample Information

SampleName	Rice Husk Silica	Sample Type	Broad Unknown
Vial	6	Date Acquired	27/02/2003 1:05:44 PM
Injection	1	Acq Method Set	MethR_THF_30C_1
Injection Volume	100.00 ul	Processing Method	R_THF_30C_1
Channel	SATIN	Date Processed	27/02/2003 1:55:57 PM
Run Time	22.0 Minutes		
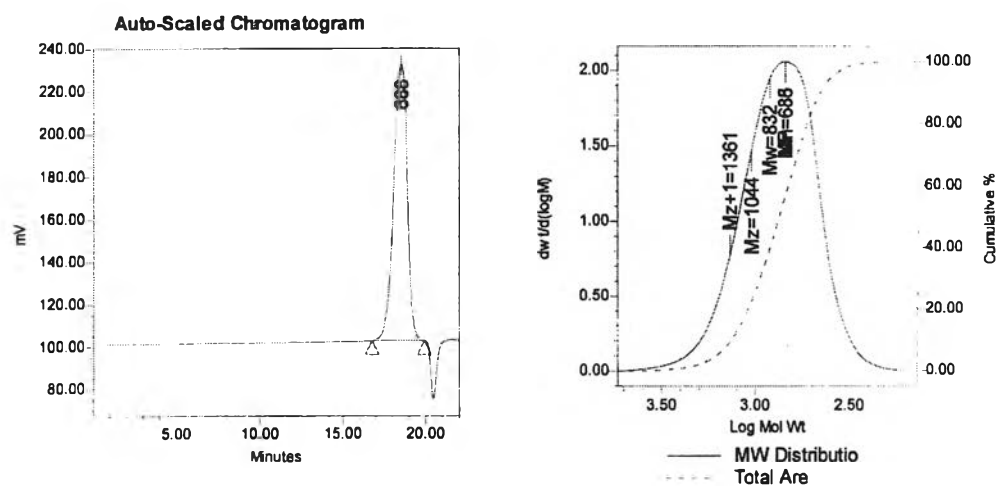
Peak Results

	Name	Mn	Mw	MP	Mz	Mz+1	Polydispersity
1	Peak3	685	832	688	1044	1361	1.214860

Figure D1 GPC result of extracted polystyrene from modified rice husk silica.

Sample Information

SampleName	Commercial Silica (Hi-Sil 255)	Sample Type	Broad Unknown
Vial	7	Date Acquired	27/02/2003 1:31:28 PM
Injection	1	Acq Method Set	MethR_THF_30C_1
Injection Volume	100.00 ul	Processing Method	R_THF_30C_1
Channel	SATIN	Date Processed	27/02/2003 1:56:02 PM
Run Time	22.0 Minutes		

Auto-Scaled Chromatogram
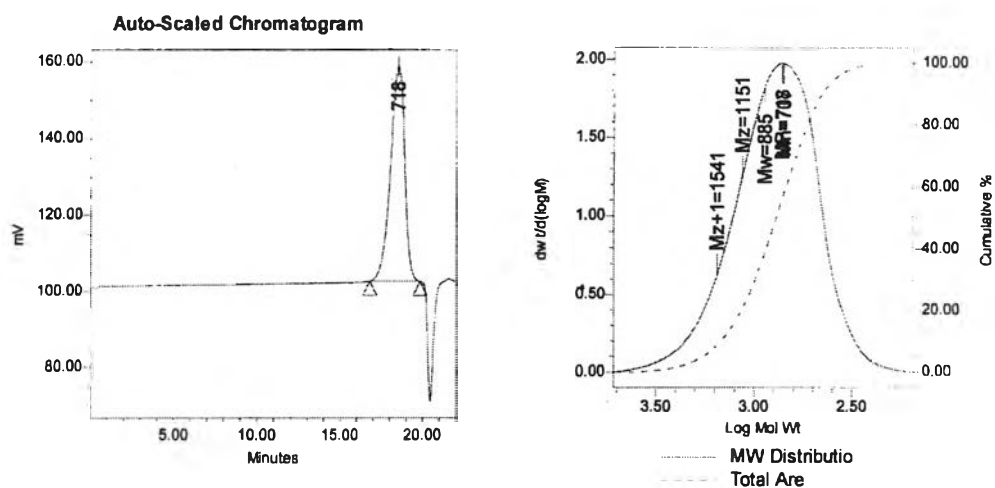
Peak Results

	Name	Mn	Mw	MP	Mz	Mz+1	Polydispersity
1	Peak3	707	885	718	1151	1541	1.252009

Figure D2 GPC result of extracted polystyrene from modified commercial silica (Hi-Sil®255).

CURRICURUM VITAE

Name: Mr. Thanawat Ou-udomying

Date of Birth: July 21, 1980

Nationality: Thai

University Education:

1997-2000   Bachelor Degree of Science (Petrochemicals and Polymeric Materials), Faculty of Industrial Technology, Silpakorn University, Nakorn Pathom, Thailand.