

REFERENCES

- Angarska, J.K., Tachev, K.D., Ivanov, I.B., Mchreteab, A., and Brose, G. Effect of Magnesium Ions on the Properties of Foam Films Stabilized with Sodium Dodecyl Sulfate. J. Colloid Interface Sci. 195 (1997) : 316-328.
- Bikerman, J.J. Foams : Theory and Industrial Application. New York: Reinhold Publishing, 1953.
- Blute, I., Jansson, M., Oh, S.G., and Shah, D.O. The Molecular Mechanism for Destabilization of Foams by Organic Ions. JAOCs 71, 1 (1994): 41-46.
- Chanin Chintanasathien. Precipitation in Solution Containing Mixture of Synthetic Anionic Surfactant and Soap. Master's Thesis, Chulalongkorn University, 1995.
- Client, J.H., Surfactant Aggregation. Glasgow : Blackie, 1992.
- Cohen, L., Moreno, A., and Berna, J.L. Influence of Anionic Concentration and Water Hardness on Foaming Properties of a Linear Alkylbenzene Sulfonate. J. Am. Oil Chem. Soc. 70, 1 (1993) : 75-78.
- Garrett, P.R. Defoaming : Theory and Industrial Applications. New York : Marcel Dekker, 1992.
- Grieves, R.B., and Bhattacharyya, D. Foam Columns for Countercurrent Surface-Active Solutes. J. Am. Oil Chem. Soc. 42(1965) : 174.
- Grieves, R.B., and Bhattacharyya, D. Foam Separation of Anionic; Stoichiometry. Sep. Sci. Tech. 7 (1992) : 115.
- Krit Kumpabooth. Surfactant Recovery from Water Using Foam Fractionation : Effect of Added Salt and Temperature. Master's Thesis, Chulalongkorn University, 1997.

- Matheson, K.L., Michael, F.C., and Dewey, L.S. Interactions Between Linear Alkylbenzene Sulfonates and Water Hardness Ions. I Effect of Calcium Ion on Surfactant Solubility and Implications for Detergency Performance. J. Am. Oil Chem. Soc. 62, 9 (1985) : 1391-1396.
- Noik, C., Baviere, M., and Defives, D. Anionic Surfactant Precipitation in Hard Water. J. Colloid Interface Sci. 115 (1987) : 36.
- Perrin, D.D., and Armarego, W.L.F. Purification of Laboratory Chemicals. 3rd ed. Oxford : Pergamon . 1988.
- Porter, M.R. Handbook of Surfactants. 2nd ed. Glasgow : Blackie Academic & Professional, 1994.
- Prud'homme, R.B. Foams: Theory, Measurements, and Applications. New York, Basel, Hongkong : Marcel Dekker, 1996.
- Ramesh Varadaraj et al., Influence of Hydrocarbon Chain Branching on Interfacial Properties of Properties of Sodium Dodecyl Sulfate. Langmuir 8 (1992) : 14-17.
- Robert Aveyard et al., Foam Breakdown by Hydrophobic particles and Nonpolar Oil. Langmuir 9 (1993) : 604-613.
- Rosen, M.J., Surfactant and Interfacial Phenomenon. 2nd ed. New York : Wiley, 1988.
- Scamehorn, J.F. Phenomenon in Mixed surfactant System. J.F. Scamehorn, ed. ACS Symposium Series 311. Washington D.C.: American chemical Society, 1986.
- Scamehorn, J.F., and Harwell, J.H. Precipitation of Surfactant Mixtures. Keizo Ogino and Masahiko, ed. New York: marcel Dekker, 1986.
- Schmidt, W.W., Durante, D.R., Gingell, R., and Harbell, J.W. Alcohol Ethoxycarboxylates-Mild, High-Foaming Surfactants for Personal-Care Products. J. Am. Oil Chem. Soc. 74,1 (1997) : 25-31.

Shiau Bor-Jier. Precipitation of ternary Mixtures of Surfactant. Master's Thesis. University of Oklahoma, 1990.

Stellner, K.L., and Scamehorn, J.F. Hardness tolerance of Anionic Surfactant Solutions. II Effect of Added Nonionic Surfactant. Langmuir 5 (1989): 77.

APPENDICES

APPENDIX A

Experimental data of CMC measurement

Table A-1 The measured mixture CMC value (CMC_{mix}) at different calcium concentration and different mole ratio for the mixture of soap and SDS

Mole fraction of soap in the mixture	CMC_{mix} (M)		
	Ca = 0 M	Ca = 0.0005 M	Ca = 0.001 M
0 (Pure SDS)	0.0080	0.0080	0.0070
0.2	0.0041	0.0030	0.0020
0.4	0.0045	0.0040	0.0033
0.6	0.0073	0.0070	0.0060
0.8	0.0150	0.0145	0.0102
1 (Pure soap)	0.3200	0.3000	0.2300

Table A-2 The calculated mixture CMC value (CMC_{mix}) at different calcium concentration and different mole ratio for the mixture of soap and SDS

Mole fraction of soap in the mixture	CMC_{mix} (M)		
	Ca = 0 M	Ca = 0.0005 M	Ca = 0.001 M
0 (Pure SDS)	0.0080	0.0080	0.0070
0.2	0.00994	0.00993	0.00868
0.4	0.0131	0.0131	0.0114
0.6	0.0193	0.0192	0.0167
0.8	0.0364	0.0361	0.0312
1 (Pure soap)	0.3200	0.3000	0.2300

Appendix B

Experimental data of foam test

Table B-1 The experimental data of the Ross-Miles test
at calcium concentration = 0 M. pH = 7, T = 30 C

Mole ratio of Concentration (M) SO/SDS	Mole ratio of Concentration (M)		Foam height (mm)			Stability index
	Soap	SDS	total	t = 0 min	t = 5 min	
100/0	0.03210	0.00000	0.03210	17	0	0.00
	0.05600	0.00000	0.05600	23	0	0.00
	0.09140	0.00000	0.09140	26	0	0.00
	0.11800	0.00000	0.11800	87	16	0.18
	0.30000	0.00000	0.30000	217	100	0.46
	0.42000	0.00000	0.42000	214	9	0.04
	0.51000	0.00000	0.51000	210	15	0.07
80/20	0.00284	0.00070	0.00354	146	130	0.89
	0.00392	0.00098	0.00490	163	148	0.91
	0.00605	0.00152	0.00757	186	183	0.98
	0.01000	0.00252	0.01252	196	194	0.99
	0.01300	0.00324	0.01624	194	190	0.98
	0.02140	0.00536	0.02676	196	195	0.99
	0.02850	0.00714	0.03564	192	189	0.98
60/40	0.00144	0.00096	0.00240	140	120	0.86
	0.00162	0.00108	0.00270	164	140	0.85
	0.00270	0.00180	0.00450	180	170	0.94
	0.00420	0.00280	0.00700	190	182	0.96
	0.00523	0.00348	0.00871	200	195	0.98
	0.00864	0.00576	0.01440	198	195	0.98
	0.01160	0.00770	0.01930	203	200	0.99
40/60	0.00041	0.00062	0.00103	132	84	0.64
	0.00066	0.00100	0.00166	138	115	0.83
	0.00098	0.00146	0.00244	150	143	0.95
	0.00150	0.00224	0.00374	173	170	0.98
	0.00190	0.00286	0.00476	196	190	0.97
	0.00225	0.00338	0.00563	187	184	0.98
	0.00579	0.00870	0.01449	186	182	0.98
20/80	0.00014	0.00056	0.00070	40	19	0.48
	0.00010	0.00080	0.00090	73	49	0.67
	0.00026	0.00104	0.00130	97	55	0.57
	0.00054	0.00216	0.00270	161	153	0.95
	0.00059	0.00238	0.00297	183	175	0.96
	0.00104	0.00416	0.00520	190	186	0.98
	0.00155	0.00620	0.00775	147	140	0.95
0/100	0.00000	0.00086	0.00086	109	76	0.70
	0.00000	0.00110	0.00110	122	87	0.71
	0.00000	0.00330	0.00330	176	175	0.99
	0.00000	0.00812	0.00812	196	190	0.97
	0.00000	0.01110	0.01110	202	195	0.97
	0.00000	0.03320	0.03320	198	196	0.99
	0.00000	0.07980	0.07980	188	180	0.96

Table B-2 The experimental data of the Ross-Miles test

at calcium concentration = 0.0005 M, pH = 7, T = 30 C

Mole ratio of SO/SDS	Concentration (M)		Foam height (mm)			Stability index
	Soap	SDS	total	t = 0 min	t = 5 min	
100/0	0.03210	0.00000	0.03210	1	0	0.00
	0.05600	0.00000	0.05600	1	0	0.00
	0.09140	0.00000	0.09140	1	0	0.00
	0.11800	0.00000	0.11800	1	0	0.00
	0.30000	0.00000	0.30000	179	50	0.28
	0.42000	0.00000	0.42000	216	12	0.06
	0.51000	0.00000	0.51000	239	225	0.94
	0.60000	0.00000	0.60000	240	226	0.94
80/20	0.00284	0.00070	0.00354	95	13	0.14
	0.00392	0.00098	0.00490	93	45	0.48
	0.00605	0.00152	0.00757	104	73	0.70
	0.01000	0.00252	0.01252	143	134	0.94
	0.01300	0.00324	0.01624	172	168	0.98
	0.02140	0.00536	0.02676	205	200	0.98
	0.02850	0.00714	0.03564	195	185	0.95
	60/40	0.00144	0.00096	0.00240	94	30
0.00162		0.00108	0.00270	96	45	0.47
0.00270		0.00180	0.00450	104	73	0.70
0.00420		0.00280	0.00700	110	90	0.82
0.00523		0.00348	0.00871	146	141	0.97
0.00864		0.00576	0.01440	205	200	0.98
0.01160		0.00770	0.01930	195	180	0.92
40/60		0.00041	0.00062	0.00103	75	9
	0.00066	0.00100	0.00166	105	20	0.19
	0.00098	0.00146	0.00244	85	25	0.29
	0.00150	0.00224	0.00374	92	31	0.34
	0.00190	0.00286	0.00476	90	49	0.54
	0.00225	0.00338	0.00563	110	90	0.82
	0.00579	0.00870	0.01449	195	188	0.96
	0.01000	0.01500	0.02500	208	201	0.97
20/80	0.00014	0.00056	0.00070	98	20	0.20
	0.00010	0.00080	0.00090	97	25	0.26
	0.00026	0.00104	0.00130	98	40	0.41
	0.00054	0.00216	0.00270	105	50	0.48
	0.00059	0.00238	0.00297	95	65	0.68
	0.00104	0.00416	0.00520	124	108	0.87
	0.00155	0.00620	0.00775	201	192	0.96
	0.00400	0.01600	0.02000	208	201	0.97
0/100	0.00000	0.00086	0.00086	62	29	0.47
	0.00000	0.00110	0.00110	65	32	0.49
	0.00000	0.00330	0.00330	103	75	0.73
	0.00000	0.00812	0.00812	212	202	0.95
	0.00000	0.01110	0.01110	194	190	0.98
	0.00000	0.03320	0.03320	193	190	0.98
	0.00000	0.07980	0.07980	195	193	0.99

Table B-3 The experimental data of the Ross-Miles test

at calcium concentration = 0.001 M, pH = 7, T = 30 C

Mole ratio of SO/SDS	Concentration (M)		Foam height (mm)			Stability index
	Soap	SDS	total	t = 0 min	t = 5 min	
100/0	0.03210	0.00000	0.03210	1	0	0.00
	0.05600	0.00000	0.05600	1	0	0.00
	0.09140	0.00000	0.09140	1	0	0.00
	0.11800	0.00000	0.11800	2	0	0.00
	0.30000	0.00000	0.30000	170	10	0.06
	0.42000	0.00000	0.42000	216	12	0.06
	0.51000	0.00000	0.51000	230	220	0.96
	0.60000	0.00000	0.60000	232	220	0.95
80/20	0.00284	0.00070	0.00354	90	16	0.18
	0.00392	0.00098	0.00490	88	18	0.20
	0.00605	0.00152	0.00757	85	63	0.74
	0.01000	0.00252	0.01252	126	115	0.91
	0.01300	0.00324	0.01624	140	129	0.92
	0.02140	0.00536	0.02676	215	210	0.98
	0.02850	0.00714	0.03564	200	195	0.98
	60/40	0.00144	0.00096	0.00240	78	28
0.00162		0.00108	0.00270	84	38	0.45
0.00270		0.00180	0.00450	86	65	0.76
0.00420		0.00280	0.00700	125	102	0.82
0.00523		0.00348	0.00871	120	100	0.83
0.00864		0.00576	0.01440	205	202	0.99
0.01160		0.00770	0.01930	215	208	0.97
40/60		0.00041	0.00062	0.00103	78	11
	0.00066	0.00100	0.00166	68	26	0.38
	0.00098	0.00146	0.00244	88	43	0.49
	0.00150	0.00224	0.00374	94	70	0.74
	0.00190	0.00286	0.00476	96	70	0.73
	0.00225	0.00338	0.00563	98	66	0.67
	0.00579	0.00870	0.01449	215	210	0.98
	0.01000	0.01500	0.02500	217	215	0.99
20/80	0.00014	0.00056	0.00070	74	16	0.22
	0.00010	0.00080	0.00090	74	16	0.22
	0.00026	0.00104	0.00130	74	17	0.23
	0.00054	0.00216	0.00270	110	85	0.77
	0.00059	0.00238	0.00297	98	80	0.82
	0.00104	0.00416	0.00520	105	77	0.73
	0.00155	0.00620	0.00775	166	157	0.95
	0.00400	0.01600	0.02000	168	160	0.95
0/100	0.00000	0.00086	0.00086	69	26	0.38
	0.00000	0.00110	0.00110	63	28	0.44
	0.00000	0.00330	0.00330	87	57	0.66
	0.00000	0.00812	0.00812	208	207	1.00
	0.00000	0.01110	0.01110	199	186	0.93
	0.00000	0.03320	0.03320	185	183	0.99
	0.00000	0.07980	0.07980	185	180	0.97

Table B-4 The experimental data of the Mixing test
at calcium concentration = 0 M, pH = 7, T = 30 C

Mole ratio of SO/SDS	Concentration (M)		Foam height (mm)			Stability index
	Soap	SDS	total	t = 0 min	t = 5 min	
100/0	0.03210	0.00000	0.03210	11	1	0.09
	0.05600	0.00000	0.05600	13	1	0.08
	0.09140	0.00000	0.09140	17	2	0.12
	0.11800	0.00000	0.11800	18	3	0.17
	0.30000	0.00000	0.30000	90	62	0.69
	0.42000	0.00000	0.42000	85	61	0.72
	0.51000	0.00000	0.51000	84	61	0.73
80/20	0.00284	0.00070	0.00354	74	61	0.82
	0.00392	0.00098	0.00490	82	68	0.83
	0.00605	0.00152	0.00757	89	70	0.79
	0.01000	0.00252	0.01252	96	76	0.79
	0.01300	0.00324	0.01624	95	75	0.79
	0.02140	0.00536	0.02676	96	76	0.79
	0.02850	0.00714	0.03564	95	75	0.79
60/40	0.00144	0.00096	0.00240	71	59	0.83
	0.00162	0.00108	0.00270	79	65	0.82
	0.00270	0.00180	0.00450	86	70	0.81
	0.00420	0.00280	0.00700	90	75	0.83
	0.00523	0.00348	0.00871	94	76	0.81
	0.00864	0.00576	0.01440	95	76	0.80
	0.01160	0.00770	0.01930	94	76	0.81
40/60	0.00041	0.00062	0.00103	38	34	0.89
	0.00066	0.00100	0.00166	47	40	0.85
	0.00098	0.00146	0.00244	78	65	0.83
	0.00150	0.00224	0.00374	88	71	0.81
	0.00190	0.00286	0.00476	94	75	0.80
	0.00225	0.00338	0.00563	92	75	0.82
	0.00579	0.00870	0.01449	92	75	0.82
20/80	0.00014	0.00056	0.00070	25	21	0.84
	0.00010	0.00080	0.00090	33	29	0.88
	0.00026	0.00104	0.00130	36	32	0.89
	0.00054	0.00216	0.00270	86	72	0.84
	0.00059	0.00238	0.00297	90	75	0.83
	0.00104	0.00416	0.00520	96	71	0.74
	0.00155	0.00620	0.00775	82	70	0.85
0/100	0.00000	0.00086	0.00086	26	22	0.85
	0.00000	0.00110	0.00110	32	26	0.81
	0.00000	0.00330	0.00330	90	76	0.84
	0.00000	0.00812	0.00812	95	79	0.83
	0.00000	0.01110	0.01110	98	78	0.80
	0.00000	0.03320	0.03320	86	71	0.83
	0.00000	0.07980	0.07980	85	70	0.82

Table B-5 The experimental data of the Mixing test
at calcium concentration = 0.0005 M, pH = 7, T = 30 C

Mole ratio of SO/SDS	Concentration (M)		Foam height (mm)			Stability index
	Soap	SDS	total	t = 0 min	t = 5 min	
100/0	0.03210	0.00000	0.03210	0	0	*
	0.05600	0.00000	0.05600	0	0	*
	0.09140	0.00000	0.09140	0	0	*
	0.11800	0.00000	0.11800	0	0	*
	0.30000	0.00000	0.30000	89	66	0.74
	0.42000	0.00000	0.42000	82	62	0.76
	0.51000	0.00000	0.51000	84	70	0.83
80/20	0.00284	0.00070	0.00354	28	24	0.86
	0.00392	0.00098	0.00490	25	21	0.84
	0.00605	0.00152	0.00757	21	19	0.90
	0.01000	0.00252	0.01252	40	30	0.75
	0.01300	0.00324	0.01624	86	70	0.81
	0.02140	0.00536	0.02676	95	74	0.78
	0.02850	0.00714	0.03564	96	76	0.79
60/40	0.00144	0.00096	0.00240	25	21	0.84
	0.00162	0.00108	0.00270	24	20	0.83
	0.00270	0.00180	0.00450	24	20	0.83
	0.00420	0.00280	0.00700	24	20	0.83
	0.00523	0.00348	0.00871	42	35	0.83
	0.00864	0.00576	0.01440	94	74	0.79
	0.01160	0.00770	0.01930	95	74	0.78
40/60	0.00041	0.00062	0.00103	28	24	0.86
	0.00066	0.00100	0.00166	32	29	0.91
	0.00098	0.00146	0.00244	34	29	0.85
	0.00150	0.00224	0.00374	20	18	0.90
	0.00190	0.00286	0.00476	28	26	0.93
	0.00225	0.00338	0.00563	36	30	0.83
	0.00579	0.00870	0.01449	95	75	0.79
	0.01000	0.01500	0.02500	97	76	0.78
20/80	0.00014	0.00056	0.00070	28	24	0.86
	0.00010	0.00080	0.00090	27	25	0.93
	0.00026	0.00104	0.00130	28	27	0.96
	0.00054	0.00216	0.00270	23	20	0.87
	0.00059	0.00238	0.00297	28	25	0.89
	0.00104	0.00416	0.00520	50	40	0.80
	0.00155	0.00620	0.00775	95	77	0.81
	0.00400	0.01600	0.02000	93	75	0.81
0/100	0.00000	0.00086	0.00086	15	10	0.67
	0.00000	0.00110	0.00110	13	10	0.77
	0.00000	0.00330	0.00330	18	15	0.83
	0.00000	0.00812	0.00812	91	75	0.82
	0.00000	0.01110	0.01110	94	73	0.78
	0.00000	0.03320	0.03320	94	73	0.78
	0.00000	0.07980	0.07980	94	71	0.76

* divided by zero

Table B-6 The experimental data of the Mixing test
at calcium concentration = 0.001 M, pH = 7, T = 30 C

Mole ratio of SO/SDS	Concentration (M)		Foam height (mm)			Stability index
	Soap	SDS	total	t = 0 min	t = 5 min	
100/0	0.03210	0.00000	0.03210	0	0	*
	0.05600	0.00000	0.05600	0	0	*
	0.09140	0.00000	0.09140	0	0	*
	0.11800	0.00000	0.11800	0	0	*
	0.30000	0.00000	0.30000	90	65	0.72
	0.42000	0.00000	0.42000	85	67	0.79
	0.51000	0.00000	0.51000	80	69	0.86
80/20	0.00284	0.00070	0.00354	31	28	0.90
	0.00392	0.00098	0.00490	30	27	0.90
	0.00605	0.00152	0.00757	26	19	0.73
	0.01000	0.00252	0.01252	29	24	0.83
	0.01300	0.00324	0.01624	55	44	0.80
	0.02140	0.00536	0.02676	96	76	0.79
	0.02850	0.00714	0.03564	97	77	0.79
60/40	0.00144	0.00096	0.00240	26	24	0.92
	0.00162	0.00108	0.00270	27	24	0.89
	0.00270	0.00180	0.00450	18	16	0.89
	0.00420	0.00280	0.00700	24	20	0.83
	0.00523	0.00348	0.00871	35	29	0.83
	0.00864	0.00576	0.01440	93	75	0.81
	0.01160	0.00770	0.01930	96	75	0.78
40/60	0.00041	0.00062	0.00103	25	21	0.84
	0.00066	0.00100	0.00166	28	23	0.82
	0.00098	0.00146	0.00244	23	18	0.78
	0.00150	0.00224	0.00374	35	29	0.83
	0.00190	0.00286	0.00476	23	20	0.87
	0.00225	0.00338	0.00563	26	23	0.88
	0.00579	0.00870	0.01449	85	69	0.81
	0.01000	0.01500	0.02500	86	70	0.81
20/80	0.00014	0.00056	0.00070	25	21	0.84
	0.00010	0.00080	0.00090	28	23	0.82
	0.00026	0.00104	0.00130	23	18	0.78
	0.00054	0.00216	0.00270	35	29	0.83
	0.00059	0.00238	0.00297	23	20	0.87
	0.00104	0.00416	0.00520	26	23	0.88
	0.00155	0.00620	0.00775	85	69	0.81
	0.00400	0.01600	0.02000	84	68	0.81
0/100	0.00000	0.00086	0.00086	15	12	0.80
	0.00000	0.00110	0.00110	13	10	0.77
	0.00000	0.00330	0.00330	16	12	0.75
	0.00000	0.00812	0.00812	92	72	0.78
	0.00000	0.01110	0.01110	92	74	0.80
	0.00000	0.03320	0.03320	90	72	0.80
	0.00000	0.07980	0.07980	90	71	0.79

* divided by zero

APPENDIX C
ADDITIONAL INFORMATION

Standard Deviation of Equipment

Standard deviation of Ross-Miles Reactor = 2.88

Standard deviation of Mixing Reactor = 1.30

Effect of Speed and Level of The Stirrer of the Mixing Method

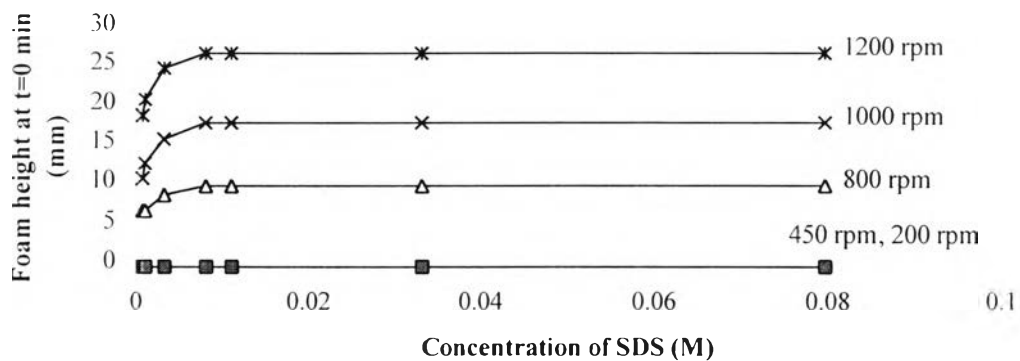


Figure C-1 Effect of stirrer speed of pure SDS.

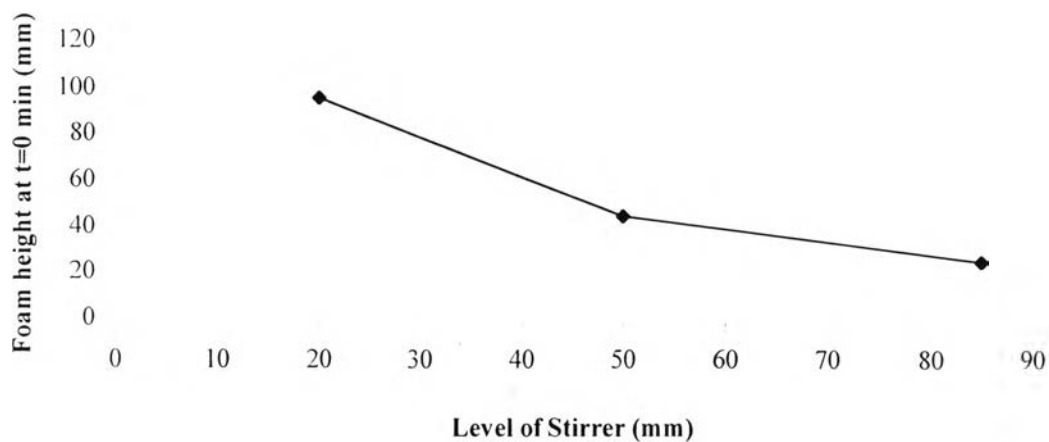


Figure C-2 Effect of level of Stirrer of 0.011 M SDS.

CURRICULUM VITAE

Name : Piyapon Hongpaya

Birth date : February 15, 1974

Nationality : Thai

University Education :

1992-1996 Bachelor's Degree of Science in Chemical
Engineering, Chemical Technology Department
Faculty of Science, Chulalongkorn University