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APPENDICES

APPENDIX A

Experimental Data of Contact Angle Study with Time

Table A1 The advancing contact angle of saturated CaC_{12} solution containing NaDS at [NaDS] = 0 mM, solution volume = 20 μL.

Time (min)	Advancing contact angle (θ_A)
0.00	82.3
0.25	82.0
0.50	81.8
1.00	81.7
5.00	81.6
10.00	81.4
15.00	81.3
20.00	81.1

Table A2 The advancing contact angle of saturated CaC_{12} solution containing NaDS at [NaDS] = 5 mM, solution volume = 20 μL.

Time (min)	Advancing contact angle (θ_A)
0.00	47.2
0.25	47.0
0.50	46.4
1.00	46.3
5.00	46.3
10.00	46.1
15.00	45.8
20.00	45.5

Table A3 The advancing contact angle of saturated CaC_{12} solution containing NaDS at [NaDS] = 10 mM, solution volume = 20 μL.

Time (min)	Advancing contact angle (θ_A)
0.00	40.5
0.25	40.3
0.50	40.1
1.00	40.0
5.00	39.9
10.00	40.0
15.00	38.5
20.00	38.1

Table A4 The advancing contact angle of saturated CaC_{12} solution containing NaDS at [NaDS] = 100 mM, solution volume = 20 μL.

Time (min)	Advancing contact angle (θ_A)
0.00	40.6
0.25	40.1
0.50	39.9
1.00	39.9
5.00	39.8
10.00	39.5
15.00	38.6
20.00	38.1

APPENDIX B

Experimental Data of Contact angle for mixed surfactant system

Table B1 The contact angle of saturated CaC_{12} containing NaDS..
[NaDS] = 0 mM.

Volume (μL)	Advancing contact angle (θ_A)	Receding contact angle (θ_R)
20	81.5	31.0
30	81.6	35.1
40	81.3	48.5
50	81.7	52.4
60	81.8	59.6
70	82.0	69.0
Average	81.7	

Table B2 The contact angle of saturated CaC_{12} containing NaDS.
[NaDS] = 0.5 mM.

Volume (μL)	Advancing contact angle (θ_A)	Receding contact angle (θ_R)
20	70.8	22.8
30	71.4	33.0
40	72.1	42.6
50	72.5	48.9
60	72.4	56.5
70	73.0	65.6
Average	72.0	

Table B3 The contact angle of saturated CaC_{12} containing NaDS.
[NaDS] = 1.0 mM.

Volume (μL)	Advancing contact angle (θ_A)	Receding contact angle (θ_R)
20	69.6	15.4
30	70.0	23.1
40	69.7	33.6
50	68.9	41.4
60	70.1	53.2
70	68.7	58.2
Average	69.5	

Table B4 The contact angle of saturated CaC_{12} containing NaDS.
[NaDS] = 1.5 mM.

Volume (μL)	Advancing contact angle (θ_A)	Receding contact angle (θ_R)
20	66.2	14.9
30	66.4	22.9
40	66.3	32.7
50	66.5	40.6
60	66.1	54.0
70	66.2	57.6
Average	66.3	

Table B5 The contact angle of saturated CaC_{12} containing NaDS. [NaDS] = 2.0 mM.

Volume (μL)	Advancing contact angle (θ_A)	Receding contact angle (θ_R)
20	63.5	5.1
30	64.0	15.4
40	62.5	26.2
50	62.8	36.1
60	62.8	43.3
70	63.5	46.0
Average	63.2	

Table B6 The contact angle of saturated CaC_{12} containing NaDS. [NaDS] = 2.5 mM.

Volume (μL)	Advancing contact angle (θ_A)	Receding contact angle (θ_R)
20	61.5	6.1
30	61.2	15.6
40	61.1	24.9
50	60.9	35.2
60	61.3	42.4
70	61.2	45.5
Average	61.2	

Table B7 The contact angle of saturated CaC_{12} containing NaDS. [NaDS] =3.0 mM.

Volume (μL)	Advancing contact angle (θ_A)	Receding contact angle (θ_R)
20	59.0	11.4
30	58.8	21.6
40	59.4	30.1
50	60.2	39.0
60	58.9	47.2
70	58.7	54.4
Average	59.2	

Table B8 The contact angle of saturated CaC_{12} containing NaDS. [NaDS] = 3.5 mM.

Volume (μL)	Advancing contact angle (θ_A)	Receding contact angle (θ_R)
20	57.5	12.1
30	58.0	22.4
40	57.1	29.5
50	57.2	38.8
60	57.3	46.5
70	57.0	51.1
Average	57.4	

Table B9 The contact angle of saturated CaC_{12} containing NaDS.
[NaDS] = 4.0 mM.

Volume (μL)	Advancing contact angle (θ_A)	Receding contact angle (θ_R)
20	54.5	6.2
30	53.9	15.1
40	54.5	21.5
50	54.8	30.1
60	53.6	39.4
70	55.0	46.2
Average	54.4	

Table B10 The contact angle of saturated CaC_{12} containing NaDS.
[NaDS] = 4.5 mM.

Volume (μL)	Advancing contact angle (θ_A)	Receding contact angle (θ_R)
20	49.5	9.5
30	49.0	14.1
40	48.8	20.2
50	49.4	30.4
60	49.1	36.4
70	49.0	45.2
Average	49.1	

Table B11 The contact angle of saturated CaC_{12} containing NaDS.
[NaDS] = 5.0 mM.

Volume (μL)	Advancing contact angle (θ_A)	Receding contact angle (θ_R)
20	46.8	6.1
30	46.1	12.4
40	46.3	17.3
50	46.5	26.0
60	46.2	32.2
70	46.6	39.1
Average	46.3	

Table B12 The contact angle of saturated CaC_{12} containing NaDS.
[NaDS] = 5.5 mM.

Volume (μL)	Advancing contact angle (θ_A)	Receding contact angle (θ_R)
20	43.6	5.5
30	43.5	11.2
40	42.9	14.1
50	43.0	20.8
60	42.9	29.9
70	43.9	35.6
Average	43.3	

Table B13 The contact angle of saturated CaC_{12} containing NaDS.
[NaDS] = 6.0 mM.

Volume (μL)	Advancing contact angle (θ_A)	Receding contact angle (θ_R)
20	40.5	5.1
30	40.1	10.4
40	39.8	13.2
50	39.5	20.5
60	40.8	29.6
70	40.1	33.3
Average	40.1	

Table B14 The contact angle of saturated CaC_{12} containing NaDS.
[NaDS] = 6.5 mM.

Volume (μL)	Advancing contact angle (θ_A)	Receding contact angle (θ_R)
20	37.0	5.7
30	35.9	11.1
40	36.0	14.2
50	36.5	20.5
60	35.9	28.8
70	36.4	34.0
Average	36.3	

Table B15 The contact angle of saturated CaC_{12} containing NaDS. [NaDS] =7.0 mM.

Volume (μL)	Advancing contact angle (θ_A)	Receding contact angle (θ_R)
20	36.5	3.1
30	37.2	5.5
40	37.1	10.2
50	36.8	19.4
60	36.5	21.0
70	37.0	29.1
Average	36.9	

Table B16 The contact angle of saturated CaC_{12} containing NaDS. [NaDS] = 7.5 mM.

Volume (μL)	Advancing contact angle (θ_A)	Receding contact angle (θ_R)
20	36.8	4.4
30	37.8	9.5
40	36.8	12.1
50	37.2	20.3
60	37.6	21.5
70	36.8	30.0
Average	37.2	

Table B17 The contact angle of saturated CaC_{12} containing NaDS. [NaDS] = 8.0 mM.

Volume (μL)	Advancing contact angle (θ_A)	Receding contact angle (θ_R)
20	38.0	4.5
30	37.7	8.3
40	36.5	16.2
50	36.9	21.2
60	37.0	28.1
70	36.7	31.0
Average	37.1	

Table B18 The contact angle of saturated CaC_{12} containing NaDS. [NaDS] = 8.5 mM.

Volume (μL)	Advancing contact angle (θ_A)	Receding contact angle (θ_R)
20	37.5	4.6
30	37.8	9.6
40	37.1	13.4
50	37.6	21.5
60	37.0	23.6
70	37.5	32.4
Average	37.4	

Table B19 The contact angle of saturated CaC_{12} containing NaDS.
[NaDS] = 9.0 mM.

Volume (μL)	Advancing contact angle (θ_A)	Receding contact angle (θ_R)
20	38.5	6.1
30	38.9	10.2
40	37.5	18.1
50	37.8	22.0
60	38.2	30.0
70	38.2	36.1
Average	38.2	

Table B20 The contact angle of saturated CaC_{12} containing NaDS.
[NaDS] = 9.5 mM.

Volume (μL)	Advancing contact angle (θ_A)	Receding contact angle (θ_R)
20	39.4	7.0
30	39.5	11.4
40	39.2	19.2
50	39.1	21.9
60	39.3	30.4
70	39.2	35.1
Average	39.3	

Table B21 The contact angle of saturated CaC_{12} containing NaDS.
[NaDS] =10.0 mM.

Volume (μL)	Advancing contact angle (θ_A)	Receding contact angle (θ_R)
20	41.0	6.8
30	40.1	9.9
40	39.9	16.4
50	39.7	23.2
60	39.6	28.5
70	39.9	30.0
Average	40.0	

Table B22 The contact angle of saturated CaC_{12} containing NaDS.
[NaDS] = 11.0 mM.

Volume (μL)	Advancing contact angle (θ_A)	Receding contact angle (θ_R)
20	40.2	6.4
30	40.1	10.5
40	39.7	17.2
50	40.1	22.8
60	39.9	28.8
70	39.9	30.4
Average	40.0	

Table B23 The contact angle of saturated CaC_{12} containing NaDS.
[NaDS] =12.0 mM.

Volume (μL)	Advancing contact angle (θ_A)	Receding contact angle (θ_R)
20	40.0	6.1
30	40.5	9.6
40	40.3	15.9
50	39.5	24.0
60	39.8	29.1
70	40.3	31.0
Average	40.1	

Table B24 The contact angle of saturated CaC_{12} containing NaDS.
[NaDS] = 13.0 mM.

Volume (μL)	Advancing contact angle (θ_A)	Receding contact angle (θ_R)
20	40.1	6.5
30	40.0	10.2
40	39.9	16.4
50	39.8	25.5
60	40.0	30.1
70	40.3	31.5
Average	40.0	

Table B25 The contact angle of saturated CaC_{12} containing NaDS. [NaDS] =14.0 mM.

Volume (μL)	Advancing contact angle (θ_A)	Receding contact angle (θ_R)
20	40.0	5.9
30	40.1	12.4
40	40.3	22.1
50	40.2	30.1
60	40.4	30.5
70	39.9	35.4
Average	40.0	

Table B26 The contact angle of saturated CaC_{12} containing NaDS. [NaDS] = 15.0 mM.

Volume (μL)	Advancing contact angle (θ_A)	Receding contact angle (θ_R)
20	40.0	5.9
30	41.1	10.0
40	39.4	15.6
50	39.5	23.4
60	40.5	29.3
70	40.1	31.4
Average	40.1	

Table B27 The contact angle of saturated CaC_{12} containing NaDS.
[NaDS] = 20.0 mM.

Volume (μL)	Advancing contact angle (θ_A)	Receding contact angle (θ_R)
20	40.4	6.4
30	40.2	11.5
40	39.9	16.2
50	40.0	21.8
60	39.9	29.9
70	40.6	31.6
Average	40.2	

Table B28 The average advancing contact angle of saturated CaC_{12} with varying NaDS concentration.

NaDS concentration (mM)	Advancing contact angle (θ_A)
0.0	81.7
0.5	72.0
1.0	69.5
1.5	66.3
2.0	63.2
2.5	61.2
3.0	59.2
3.5	57.4
4.0	54.4
4.5	49.1
5.0	46.3
5.5	43.3
6.0	40.1
6.5	36.3
7.0	36.9
7.5	37.2
8.0	37.1
8.5	37.4
9.0	38.2
9.5	39.3
10.0	40.0
11.0	40.0
12.0	40.1
13.0	40.0

NaDS concentration (mM)	Advancing contact angle (θ_A)
14.0	40.0
15.0	40.1
20.0	40.2

APPENDIX C

Experimental Data of the CMC of Aqueous Solution of NaDS and Saturated CaC_{12} Solution with NaDS.

Table C1 The measured liquid/vapor surface tension of mixed solution of saturated CaC_{12} and NaDS and aqueous solution of NaDS as a function of NaDS concentration.

NaDS concentration (mM)	Surface tension of aqueous solution of NaDS (mN/m)	Surface tension of mixed surfactant , γ_{LV} (mN/m)
0	63.2	59.0
0.5	59.9	57.2
1.0	59.7	54.0
1.5	53.2	50.2
2.0	52.7	45.0
2.5	50.1	41.5
3.0	46.1	37.0
3.5	42.6	35.9
4.0	40.9	34.2
4.5	39.5	33.7
5.0	38.4	32.5
5.5	37.0	31.0
6.0	36.0	30.6
6.5	35.5	30.1
7.0	36.0	30.3
7.5	35.0	30.8
8.0	34.7	31.0

NaDS concentration (mM)	Surface tension of aqueous solution of NaDS (mN/m)	Surface tension of mix surfactant , γ_{LV} (mN/m)
8.5	34.8	31.1
9.0	35.0	31.2
9.5	35.4	31.0
10.0	35.8	31.4
11.0	35.5	32.1
12.0	34.4	32.5
13.0	35.1	32.5
14.0	35.2	32.6
15.0	36.8	32.8
20.0	35.7	32.5

APPENDIX D

The Experimental Data of NaDS Adsorption Study

The surface concentration Γ_s, in micromoles/m^2, of the surfactant can be calculated when a_s, the surface area per unit mass of the solid adsorbent, in m^2/g, (the specific surface area), is known (Rosen, 1989).

$$\Gamma_s = \frac{(C_i - C_e)V}{a_s \times m}$$

where C_i is the molar concentration ,in moles/liter, of the solution before adsorption, C_e is molar concentration of surfactant at adsorption equilibrium, and V is the volume of the solution, in liters.

Weight of precipitate CaC_{12} (m)	= 0.5 g
Surface area of CaC_{12} precipitate (a_s)	= 3.457 g/m^2
Volume of mix surfactant solution (V)	= 20 mL
Temperature	= 30 °C

Table D1. Adsorption of NaDS on CaC_{12} with equilibrium NaDS concentration.

Initial NaDS concentration (mM)	Equilibrium NaDS concentration (mM)	NaDS adsorption (μmole/g)	NaDS adsorption (μmole/m^2)
1.0	0.65	13.99	4.05
1.5	0.95	22.02	6.37
2.0	1.43	22.99	6.65
2.5	1.74	30.60	8.85

Initial NaDS concentration (mM)	Equilibrium NaDS concentration (mM)	NaDS adsorption (μmole/g)	NaDS adsorption (μmole/m^2)
3.0	2.26	31.39	9.08
3.5	2.67	33.07	9.56
4.0	3.00	40.04	11.58
4.5	3.55	38.09	11.02
5.0	3.97	41.50	12.01
5.5	4.22	51.13	14.79
6.0	4.59	56.49	16.34
6.5	4.87	65.37	18.91
7.0	5.45	62.08	17.96
7.5	5.80	67.80	19.61
8.0	6.24	70.59	20.42
8.5	6.78	68.86	19.92
9.0	7.30	68.02	19.68
9.5	7.75	70.20	20.31
10.0	8.16	73.49	21.26
20.0	15.58	176.69	51.11
30.0	20.88	364.40	105.41
40.0	26.89	524.47	151.71
50.0	32.31	707.63	204.70
60.0	36.76	929.37	268.84
70.0	42.94	1082.29	313.07
80.0	45.00	1399.20	404.74
90.0	48.01	1679.56	485.84
100.0	49.14	2034.57	588.54

APPENDIX E

Correlation of Measured Contact Angle and Liquid/Vapor Surface Tension to Young's Equation and Calculation of Solid/Liquid Surface Tension.

Table E 1 The contact angle as a function of reciprocal of liquid/vapor surface tension.

Cos θ_A	$1/\gamma_{LV}$ (m/mN)
0.1444	0.0169
0.2470	0.0175
0.3502	0.0185
0.3987	0.0199
0.4509	0.0222
0.4924	0.0.241
0.5120	0.0.270
0.5678	0.0279
0.5821	0.0292
0.6547	0.0297
0.6909	0.0308
0.7278	0.0323
0.7649	0.0327
0.8059	0.0332

Table E2 The reduction of solid/liquid surface tension as a function of NaDS concentration and NaDS adsorption.

NaDS concentration (mM)	NaDS adsorption (μmol/g)	$\gamma_{SL}^{o} - \gamma_{SL}$ (mN/m)
0.0	-	0.0
0.5	-	-1.8
1.0	14.72064	-5.0
1.5	23.01873	-8.8
2.0	24.13803	-14.0
2.5	32.11436	-17.5
3.0	32.92115	-22.0
3.5	34.77952	-23.1
4.0	42.05937	-24.8
4.5	39.70279	-25.3
5.0	43.54549	-26.5
5.5	53.65271	-28.0
6.0	58.93114	-28.4
6.5	68.49463	-28.9

CURRICULUM VITAE

Name: Piyada Balasuwatthi

Date of Birth: 12 July 1977

Nationality: Thai

University Educaition:

1995-1998 Bachelor's Degree of Engineering in Chemical Engineering, Srinakarinwirot University.