

REFERENCES

- Amaral, M.H., das Neves, J., Oliveira, A.Z., Bahia, M.F. (2008). Foamability of Detergent Solutions Prepared with Different Types of Surfactants and Waters. Journal of Surfactants and Detergents. 11, 275-278
- Ameri, M., Attwood, D., Collett, J.H., and Booth, C. (1997). Self-assembly of alcohol ethoxylate non-ionic surfactants in aqueous solution. J. Chem. Soc., Faraday Trans. 93(15), 2545-2551
- ASTM International Standard D 2024-65 (Reapproved 2003), "Cloud Point of Nonionic Surfactants," ASTM International, West Conshohocken, PA, 2003
- ASTM International Standard D 1173-53 (Reapproved 2001), "Foaming Properties of Surface-Active Agents," ASTM International, West Conshohocken, PA, 2001
- Balasuwatthi, P., Dechabumphen, N., Saiwan, C., and Scamehorn, J.F. (2004). Contact Angle of Surfactant Solutions on Precipitated Surfactant Surfaces. II. Effects of Surfactant Structure, Presence of a Subsaturated Surfactant, pH, and Counterion/Surfactant Ratio. Journal of Surfactants and Detergents. 7(4), 31-40
- Cox, M.F. (1989). Effect of Alkyl Carbon Chain Length and Ethylene Oxide Content on the Performance of Linear Alcohol Ethoxylates. JAOCS. 66(3), 367-374
- Fujiwara, M., Miyake, M., and Hama, I. (1994). Phase behavior of methoxypolyoxyethylene dodecanoate as compared to polyoxyethylene dodecyl ether and polyoxyethylene methyl dodecyl ether. Colloid and Polymer Science. 272(7), 797-802
- Gantz, G.M. (1967). Foaming, in Nonionic Surfactants; Schick M.J. (Ed) (1967) New Jersey: Edward Arnold.
- Garrett, P.R., and P.L. Gratton. (1995). Dynamic Surface Tensions, Foam and the Transition from Micellar Solution to Lamellar Phase Dispersion, Colloids Surf. A 103-127

- Genova, C., Schoenkaes, U., Smith, D., and Stolz, M. (2003). Effect of Hydrophobe Structure on Performance of Alcohol Ethoxylates. Journal of Surfactants and Detergents. 6(4), 365-372
- Goel, S.K. (1998). Selecting the Optimal Linear Alcohol Ethoxylate for Enhanced Oily Soil Removal. Journal of Surfactants and Detergents. 1(2), 213-219
- Goel, S.K. (2000). Phase Behavior and Detergency Study of Lauryl Alcohol Ethoxylates with High Ethylene Oxide Content. Journal of Surfactants and Detergents. 3(2), 221-227
- Gu, T., and Sjoblom, J. (1992). Surfactant structure and its relation to the Krafft point, cloud point and micellization: Some empirical relationships. Colloids and Surfaces. 64, 39-46
- Hama, I., Okamoto, T., Sasamoto, H., Nakamura, H. (1998) Method of producing an alkylene oxide adduct of a compound having one or more active hydrogen. US patent 5750796, Lion Corporation (Tokyo, JP)
- Hama, I., Sakaki, M., and Sasamoto, H. (1997). Effects of Ethoxylate Structure on Surfactant Properties of Ethoxylated Fatty Methyl Esters. JAOCS, 74(7), 823-827
- Hama, I., Sakaki, M., and Sasamoto, H. (1997). Nonionic Surfactant Properties of Methoxypolyoxyethylene Dodecanoate Compared with Polyoxyethylene Dodecylether. JAOCS, 74(7), 829-835
- Huibers, P.D.T., Shah, D.O, Katritzky, and A.R (1997) Note: Predicting Surfactant Cloud Point from Molecular Structure. Journal of Colloid and Interface Science. 193, 132-136
- Luangpirom, N., Dechabumphen, N., Saiwan, C., and Scamehorn, J.F. (2001). Contact Angle of Surfactant Solutions on Precipitated Surfactant Surfaces. Journal of Surfactants and Detergents. 4(4), 367-373
- Luepakdeesakoon, B., Saiwan, C., and Scamehorn, J.F. (2006). Contact angle of Surfactant Solutions on Precipitated Surfactant Surfaces. III. Effects of Unsaturated Anionic and Nonionic Surfactants and NaCl. Journal of Surfactants and Detergents. 9(2).

- Lunkenheimer, K., and Malysa, K., (2003). Simple and Generally Applicable method of Determination and Evaluation of Foam Properties. Journal of Surfactants and Detergents. 6(1), 69-74
- Mousli, R., and Tazerouti, A. (2007). Direct Method of Preparation of Dodecanesulfonamide Derivatives and Some Surface Properties. J Surfact Deterg. 10, 279-285
- Piispanen, P.S., Kjellin, U.R. M., Hedman, B., and Norin, T. (2003). Synthesis and Surface Measurements of Surfactants Derived from Dehydroabiatic Acid. Journal of Surfactants and Detergents. 6(2), 125-130
- Piispanen, P. S., Persson, M., Claesson, P., and Norin, T. (2004). Surface Properties of Surfactants Derived from Natural Products. Part 1: Syntheses and Structure/Property Relationships—Solubility and Emulsification. Journal of Surfactants and Detergents. 7(2), 147-159
- Piispanen, P. S., Persson, M., Claesson, P., and Norin, T. (2004). Surface Properties of Surfactants Derived from Natural Products. Part 2: Structure/Property Relationships—Foaming, Dispersion, and Wetting. Journal of Surfactants and Detergents. 7(2), 161-167
- Porter, M.R. (1994). Handbook of Surfactant, New York: Chapman & Hal.
- Rosen, M.J., Solash J. (1969). Factors Affecting Initial Foam Height in the Ross-Miles Foam Test. Journal of the American Oil Chemists' Society. 46, 399-402
- Rosen, M.J. (2004). Surfactants and Interfacial Phenomena. New Jersey: John Wiley & Sons.
- Satkowski, W.B., Huang, S.K., and Liss, R.L. (1967). Polyoxyethylene Alcohol, in Nonionic Surfactants; Schick M.J. (Ed) (1967) New Jersey: Edward Arnold.
- Sharma, S.C., Shresthal, L.K., and Aramaki, K. (2007). Foam Stability Study of Dilute Aqueous Nonionic Fluorinated Surfactant Systems. Journal of Nepal Chemistry Society. 22,47-54

Watcharasing S., Chavadej S., Rangsunvigit P., and Scamehorn J.F. (2004). Diesel Removal by Continuous Froth Flotation : Effects of Ultralow Interfacial Ten-sion and Foam Characteristics. M.S. Thesis in the Petrochemical Technology, The Petroleum and Petrochemical College, Chulalongkorn University.

APPENDICES

Appendix A Experimental Data of Critical Micelle Concentration (CMC)

1. Average Surface Tension of Single Fatty Alcohol Ethoxylates System for CMC Calculation

Surface tension versus concentration is measured by using the tensiometer (Krüss Easy Dyne). The best linear fit to the descending and horizontal lines of the plot is calculated, and their intersection is used to calculate for approximate CMC.

Table A1 Average surface tension as a function of concentration of $C_{12-14}EO_3$ single system at 25°C

Surfactant concentration (% wt/vol)	Surface tension (mN/m)
0.0002	42.1
0.0004	33.2
0.0006	30.3
0.0008	29
0.001	28.6
0.0012	28.2
0.0014	27.7
0.0016	27.7
0.0018	27.5
0.002	27.5
0.004	26.6
0.006	26.6
0.008	26.5
0.01	26.8
0.05	26.2

Table A2 Average surface tension as a function of concentration of C₁₂₋₁₄EO₅ single system at 25°C

Surfactant concentration (% wt/vol)	Surface tension (mN/m)
0.0002	59.7
0.0003	49.2
0.0005	42.8
0.0006	37.8
0.0007	36.3
0.0008	35.4
0.0009	34
0.001	31.8
0.0012	29.9
0.0014	28.9
0.002	28.3
0.004	27.8
0.006	27.7
0.008	27.5
0.01	27.5

Table A3 Average surface tension as a function of concentration of C₁₂₋₁₄EO₇ single system at 25°C

Surfactant concentration (% wt/vol)	Surface tension (mN/m)
0.0002	54.6
0.0003	51
0.0004	50.6
0.0005	47.8
0.0006	44.8
0.0007	43.2
0.0008	40.7
0.0009	39.5
0.0012	32.4
0.0014	30.9
0.002	30.1
0.004	30.5
0.006	29.6
0.008	29.5
0.01	29.4
0.02	29.5
0.04	29
0.06	29.1
0.08	28.7
0.1	28.8

Table A4 Average surface tension as a function of concentration of C₁₂₋₁₄EO₉ single system at 25°C

Surfactant concentration (% wt/vol)	Surface tension (mN/m)
0.0002	57.1
0.0003	55
0.0004	53.3
0.0005	50.8
0.0006	48.9
0.0007	47.7
0.0008	46.3
0.0009	43.4
0.0012	38
0.0014	36.5
0.002	35
0.004	31.8
0.006	31.8
0.008	32.7
0.01	32.4
0.02	32.4
0.04	32.2
0.06	32.2
0.08	32.2
0.1	32.3

2. Average Surface Tension of Single Nonylphenol Ethoxylates System for CMC Calculation

Table A5 Average surface tension as a function of concentration of NPE-6 single system at 25°C

Surfactant concentration (% wt/vol)	Surface tension (mN/m)
0.0002	46.9
0.0004	42.1
0.0006	37.2
0.001	32.1
0.0012	31.7
0.0014	30.1
0.0016	29.7
0.0018	29.4
0.002	29.8
0.004	29.1
0.006	29.4
0.008	29.6
0.01	29.5
0.05	29.7

Table A6 Average surface tension as a function of concentration of NPE-9 single system at 25°C

Surfactant concentration (% wt/vol)	Surface tension (mN/m)
0.0002	52.6
0.0003	49
0.0004	47.2
0.0005	47
0.0006	44.9
0.0007	43.6
0.0008	43
0.0009	42.2
0.001	41.1
0.002	36.1
0.004	31.1
0.006	31
0.008	31.1
0.01	31.3
0.02	31.3
0.04	31.2
0.06	31.2
0.08	31.2
0.1	31.2

APPENDICES

Appendix B Experimental Data of Foam Measurements

1. Ross–Miles Foam Test Results

The foam height is measured immediately after solution run out of the foam pipette and measured again at end of 5 minutes for estimating the foam characteristic.

Table B1 Foam height of single surfactant systems at concentration of 0.01 wt% and temperature of 49°C

Surfactant	Immediate Height (mm)	5–minute Height (mm)
C ₁₂₋₁₄ EO ₃	20.7	5.3
C ₁₂₋₁₄ EO ₅	23.8	18.7
C ₁₂₋₁₄ EO ₇	61.3	42.0
C ₁₂₋₁₄ EO ₉	71.7	58.0
NPE-6	22.3	13.0
NPE-9	55.3	43.0

Table B2 Foam height of single surfactant systems at concentration of 0.1 wt% and temperature of 49°C.

Surfactant	Immediate Height (mm)	5–minute Height (mm)
C ₁₂₋₁₄ EO ₃	24.3	5.3
C ₁₂₋₁₄ EO ₅	81.0	36.5
C ₁₂₋₁₄ EO ₇	132.5	64.8
C ₁₂₋₁₄ EO ₉	134.8	74.0
NPE-6	32.3	13.0
NPE-9	139.3	70.5

Table B3 Foam height of single surfactant systems at concentration of 1 wt% and temperature of 49°C

Surfactant	Immediate Height (mm)	5-minute Height (mm)
C ₁₂₋₁₄ EO ₃	34.5	8.0
C ₁₂₋₁₄ EO ₅	96.5	56.3
C ₁₂₋₁₄ EO ₇	204.8	116.5
C ₁₂₋₁₄ EO ₉	209.5	105.3
NPE-6	43.0	20.0
NPE-9	192.3	43.6

2. Pneumatic Foam Test Results

Foamability is defined as the ratio of maximum foam height to initial solution height, which is 7 cm. Foam stability ($t_{1/2}$) is the time required for the foam volume to collapse by half.

Table B4 Foam height of single surfactant systems at concentration of 0.01 wt% and room temperature

Surfactant	Maximum Foam Height (cm)	Foamability	Foam Stability, $t_{1/2}$ (min)
C ₁₂₋₁₄ EO ₃	29.5	4.2	20.0
C ₁₂₋₁₄ EO ₅	77.0	11.0	25.5
C ₁₂₋₁₄ EO ₇	76.0	10.9	70.5
C ₁₂₋₁₄ EO ₉	83.0	11.9	79.0
NPE-6	30.5	4.4	9.0
NPE-9	23.5	3.4	15.5

Table B5 Foam height of single surfactant systems at concentration of 0.1 wt% and room temperature

Surfactant	Maximum Foam Height (cm)	Foamability	Foam Stability, $t_{1/2}$ (min)
C ₁₂₋₁₄ EO ₃	46.5	6.6	21.5
C ₁₂₋₁₄ EO ₅	101.0	14.4	70.5
C ₁₂₋₁₄ EO ₇	101.0	14.4	105.3
C ₁₂₋₁₄ EO ₉	97.0	13.9	108.5
NPE-6	34.3	4.9	10.0
NPE-9	41.0	5.9	18.5

Table B6 Foam height of single surfactant systems at concentration of 1 wt% and room temperature

Surfactant	Maximum Foam Height (cm)	Foamability	Foam Stability, $t_{1/2}$ (min)
C ₁₂₋₁₄ EO ₃	>120.0	>17.1	
C ₁₂₋₁₄ EO ₅	97.5	13.9	82.0
C ₁₂₋₁₄ EO ₇	119.0	17.0	152.5
C ₁₂₋₁₄ EO ₉	102.3	14.6	139.3
NPE-6	54.0	7.7	16.0
NPE-9	50.5	7.2	22.0

3. Simple Shaking Foam Test Results

The foam height is measured immediately until 60 minutes for estimating the foam characteristics of each surfactant.

Table B7 Foam height of single $C_{12-14}EO_3$ systems at concentration of 0.01, 0.1, 1 wt% and room temperature from initial time to 60 minutes

Time (min)	Surfactant concentration (wt%)			Time (min)	Surfactant concentration (wt%)			Time (min)	Surfactant concentration (wt%)		
	0.01	0.1	1		0.01	0.1	1		0.01	0.1	1
0	12.5	13.8	18.8								
1	11.5	13.0	17.8	21	9.8	9.7	12.5	41	8.0	8.3	10.5
2	11.5	12.8	17.8	22	9.8	9.3	12.5	42	8.0	8.3	10.5
3	11.5	12.8	17.5	23	9.8	9.2	12.3	43	8.0	8.3	10.5
4	11.5	12.8	16.8	24	9.3	9.2	12.0	44	8.0	8.0	10.5
5	11.5	12.7	16.5	25	9.3	9.2	12.0	45	8.0	8.0	10.5
6	11.5	12.7	16.3	26	9.3	9.2	11.8	46	8.0	7.8	10.4
7	11.5	12.7	16.3	27	9.3	8.8	11.5	47	8.0	7.8	10.4
8	11.5	11.8	16.0	28	9.3	8.8	11.4	48	8.0	7.7	10.4
9	11.5	10.8	15.5	29	9.3	8.8	11.4	49	8.0	7.7	9.5
10	11.3	10.8	15.5	30	9.0	8.7	11.4	50	8.0	7.7	9.0
11	10.3	9.7	15.3	31	9.0	8.7	11.0	51	8.0	7.7	8.8
12	10.3	9.7	14.8	32	8.5	8.7	11.0	52	8.0	7.5	8.8
13	10.3	9.7	14.5	33	8.5	8.7	11.0	53	8.0	7.5	8.8
14	10.3	9.7	14.3	34	8.5	8.7	11.0	54	8.0	7.5	8.8
15	10.3	9.7	13.8	35	8.5	8.7	11.0	55	8.0	7.5	8.5
16	10.3	9.7	13.8	36	8.5	8.3	11.0	56	8.0	7.5	8.3
17	9.8	9.7	13.5	37	8.5	8.3	10.8	57	7.5	7.5	8.3
18	9.8	9.7	13.3	38	8.5	8.3	10.8	58	7.5	7.3	8.0
19	9.8	9.7	12.8	39	8.5	8.3	10.8	59	7.5	7.3	8.0
20	9.8	9.7	12.5	40	8.5	8.3	10.8	60	7.5	7.2	7.6

Table B8 Foam height of single C₁₂₋₁₄EO₅ systems at concentration of 0.01, 0.1, 1 wt% and room temperature from initial time to 60 minutes

Time (min)	Surfactant concentration (wt%)			Time (min)	Surfactant concentration (wt%)			Time (min)	Surfactant concentration (wt%)		
	0.01	0.1	1		0.01	0.1	1		0.01	0.1	1
0	14.0	25.3	28.5								
1	13.0	24.0	27.0	21	10.5	21.0	23.0	41	9.5	18.8	20.5
2	12.5	24.0	26.5	22	10.5	21.0	23.0	42	9.5	18.8	20.5
3	12.0	23.3	26.0	23	10.5	21.0	23.0	43	9.5	18.8	20.5
4	12.0	23.3	25.0	24	10.5	21.0	23.0	44	9.5	18.8	20.5
5	12.0	23.3	24.5	25	10.5	20.3	23.0	45	9.5	18.8	20.0
6	12.0	22.8	24.5	26	10.0	20.3	22.5	46	9.5	18.8	20.0
7	11.5	22.8	24.5	27	10.0	20.3	22.5	47	9.5	18.8	20.0
8	11.0	22.8	24.5	28	10.0	20.0	22.0	48	9.5	18.3	20.0
9	11.0	22.3	24.5	29	10.0	20.0	22.0	49	9.0	18.0	20.0
10	11.0	22.3	24.0	30	10.0	19.8	21.5	50	9.0	18.0	20.0
11	11.0	22.0	24.0	31	10.0	19.5	21.5	51	9.0	18.0	20.0
12	11.0	22.0	23.5	32	10.0	19.5	21.5	52	9.0	17.5	20.0
13	11.0	22.0	23.5	33	10.0	19.5	21.5	53	9.0	17.5	20.0
14	11.0	21.8	23.5	34	10.0	19.3	21.5	54	9.0	17.5	20.0
15	11.0	21.8	23.5	35	10.0	19.3	21.5	55	9.0	17.3	19.5
16	11.0	21.0	23.0	36	9.5	19.3	21.0	56	8.5	17.3	19.5
17	11.0	21.0	23.0	37	9.5	18.8	21.0	57	8.5	17.0	19.5
18	11.0	21.0	23.0	38	9.5	18.8	20.5	58	8.5	17.0	19.0
19	10.5	21.0	23.0	39	9.5	18.8	20.5	59	8.5	17.0	18.0
20	10.5	21.0	23.0	40	9.5	18.8	20.5	60	8.5	16.5	18.0

Table B9 Foam height of single C₁₂₋₁₄EO₇ systems at concentration of 0.01, 0.1, 1 wt% and room temperature from initial time to 60 minutes

Time (min)	Surfactant concentration (wt%)			Time (min)	Surfactant concentration (wt%)			Time (min)	Surfactant concentration (wt%)		
	0.01	0.1	1		0.01	0.1	1		0.01	0.1	1
0	17.0	27.7	35.3								
1	16.0	26.7	34.3	21	13.0	22.3	28.7	41	11.5	20.3	23.7
2	15.5	26.7	33.3	22	12.5	22.3	28.7	42	11.5	20.0	23.7
3	15.0	26.0	33.0	23	12.5	22.3	28.7	43	11.5	20.0	23.3
4	15.0	26.0	33.0	24	12.5	22.2	28.0	44	11.5	20.0	22.7
5	15.0	25.3	31.7	25	12.5	22.2	28.0	45	11.5	19.5	22.7
6	14.5	25.2	31.7	26	12.5	21.7	28.0	46	11.5	19.5	22.7
7	14.5	24.8	31.7	27	12.5	21.5	28.0	47	11.5	19.3	22.7
8	14.5	24.8	31.7	28	12.5	21.3	28.0	48	11.5	19.3	22.7
9	14.0	24.5	31.7	29	12.5	21.3	27.7	49	11.5	19.3	22.7
10	14.0	24.5	31.3	30	12.5	21.0	27.7	50	11.5	18.8	22.0
11	14.0	24.2	31.0	31	12.5	21.0	27.0	51	11.5	18.8	21.7
12	14.0	23.8	31.0	32	12.5	21.0	26.3	52	11.5	18.7	21.0
13	14.0	23.8	30.7	33	12.5	20.8	26.3	53	11.5	18.7	21.0
14	14.0	23.8	30.3	34	12.5	20.8	26.3	54	11.5	18.7	21.0
15	13.5	23.8	30.3	35	12.5	20.5	26.0	55	11.0	18.3	20.3
16	13.5	23.7	30.0	36	12.0	20.5	26.0	56	11.0	18.2	20.3
17	13.5	23.7	29.3	37	12.0	20.5	24.7	57	11.0	17.8	20.3
18	13.5	23.0	29.3	38	12.0	20.5	24.7	58	11.0	17.8	19.7
19	13.0	22.7	29.3	39	12.0	20.3	24.3	59	11.0	17.7	19.0
20	13.0	22.5	28.7	40	11.5	20.3	24.3	60	11.0	17.7	18.0

Table B10 Foam height of single C₁₂₋₁₄EO₉ systems at concentration of 0.01, 0.1, 1 wt% and room temperature from initial time to 60 minutes

Time (min)	Surfactant concentration (wt%)			Time (min)	Surfactant concentration (wt%)			Time (min)	Surfactant concentration (wt%)		
	0.01	0.1	1		0.01	0.1	1		0.01	0.1	1
0	20.0	26.0	38.5								
1	19.0	25.5	36.0	21	16.0	21.0	22.5	41	12.0	17.5	16.5
2	19.0	24.5	35.0	22	15.5	21.0	22.5	42	12.0	17.0	16.5
3	19.0	24.5	33.5	23	15.0	20.0	21.5	43	12.0	16.5	16.0
4	19.0	24.0	33.5	24	15.0	20.0	21.0	44	11.5	16.5	16.0
5	18.0	24.0	32.5	25	15.0	20.0	21.0	45	11.5	16.0	16.0
6	18.0	24.0	31.5	26	15.0	18.5	20.5	46	11.5	16.0	15.5
7	18.0	23.5	31.5	27	14.5	18.5	20.5	47	11.5	16.0	15.0
8	18.0	23.5	31.0	28	14.0	18.5	20.5	48	11.5	15.5	14.0
9	18.0	23.5	30.0	29	14.0	18.5	20.0	49	11.5	15.5	14.0
10	17.5	23.0	30.0	30	14.0	18.5	20.0	50	11.5	15.5	14.0
11	17.0	23.0	28.5	31	14.0	18.5	19.0	51	11.5	15.0	13.5
12	17.0	23.0	27.5	32	13.5	18.5	18.5	52	11.0	15.0	13.5
13	17.0	22.5	27.5	33	13.5	18.5	17.5	53	11.0	15.0	13.5
14	17.0	22.5	26.5	34	13.0	18.0	17.5	54	11.0	14.5	13.5
15	17.0	22.5	25.5	35	13.0	18.0	17.5	55	11.0	14.5	13.0
16	16.5	21.5	25.5	36	13.0	18.0	17.5	56	11.0	14.0	13.0
17	16.5	21.5	24.5	37	12.5	18.0	17.0	57	11.0	14.0	13.0
18	16.5	21.5	24.0	38	12.5	18.0	16.5	58	11.0	14.0	13.0
19	16.5	21.0	24.0	39	12.5	18.0	16.5	59	11.0	13.5	13.0
20	16.0	21.0	23.0	40	12.5	17.5	16.5	60	11.0	13.5	13.0

Table B11 Foam height of single NPE-6 systems at concentration of 0.01, 0.1, 1 wt% and room temperature from initial time to 60 minutes

Time (min)	Surfactant concentration (wt%)			Time (min)	Surfactant concentration (wt%)			Time (min)	Surfactant concentration (wt%)		
	0.01	0.1	1		0.01	0.1	1		0.01	0.1	1
0	8.0	10.4	16.8								
1	7.5	9.5	15.5	21	5.8	8.1	10.5	41	5.0	7.4	7.6
2	7.0	9.4	14.3	22	5.8	8.1	10.3	42	5.0	7.4	7.6
3	7.0	9.4	14.1	23	5.8	8.1	10.3	43	5.0	7.4	7.5
4	7.0	9.4	14.1	24	5.8	8.0	10.3	44	5.0	7.4	7.5
5	6.5	9.4	13.8	25	5.8	8.0	10.0	45	4.8	7.3	7.5
6	6.5	9.0	13.6	26	5.8	8.0	10.0	46	4.8	7.3	7.5
7	6.5	9.0	13.5	27	5.8	8.0	9.9	47	4.8	7.3	7.5
8	6.5	8.9	12.9	28	5.3	7.9	9.9	48	4.8	7.0	7.5
9	6.5	8.6	12.4	29	5.0	7.9	9.5	49	4.8	6.9	7.5
10	6.5	8.6	12.1	30	5.0	7.9	9.5	50	4.8	6.9	7.3
11	6.3	8.6	11.9	31	5.0	7.9	9.5	51	4.8	6.5	7.3
12	6.3	8.4	11.8	32	5.0	7.6	9.5	52	4.8	6.5	7.3
13	6.3	8.4	11.4	33	5.0	7.5	9.0	53	4.8	6.5	7.3
14	6.3	8.1	11.4	34	5.0	7.5	9.0	54	4.5	6.4	7.3
15	5.8	8.1	10.9	35	5.0	7.4	8.5	55	4.5	6.4	7.0
16	5.8	8.1	10.8	36	5.0	7.4	8.3	56	4.5	6.1	7.0
17	5.8	8.1	10.8	37	5.0	7.4	8.3	57	4.5	6.0	7.0
18	8.0	10.4	16.8	38	5.0	7.4	8.3	58	4.5	6.0	7.0
19	7.5	9.5	15.5	39	5.0	7.4	8.0	59	4.5	6.0	6.9
20	7.0	9.4	14.3	40	5.0	7.4	7.9	60	4.5	6.0	6.6

Table B12 Foam height of single NPE-9 systems at concentration of 0.01, 0.1, 1 wt% and room temperature from initial time to 60 minutes

Time (min)	Surfactant concentration (wt%)			Time (min)	Surfactant concentration (wt%)			Time (min)	Surfactant concentration (wt%)		
	0.01	0.1	1		0.01	0.1	1		0.01	0.1	1
0	17.0	25.0	33.7								
1	15.5	23.1	28.3	21	13.5	16.6	18.3	41	11.5	13.8	14.8
2	15.5	23.0	26.7	22	13.5	16.5	18.3	42	11.5	13.5	14.5
3	15.5	22.5	26.0	23	13.0	16.1	17.3	43	11.5	13.5	14.5
4	15.5	21.3	25.7	24	13.0	16.1	17.0	44	11.5	13.5	14.5
5	15.5	21.3	25.0	25	13.0	16.1	17.0	45	11.5	13.5	14.3
6	15.5	19.8	24.0	26	13.0	16.1	16.7	46	11.5	13.5	14.0
7	15.5	19.5	23.3	27	13.0	16.1	16.7	47	11.5	13.5	14.0
8	15.5	19.0	23.3	28	13.0	16.1	16.7	48	11.0	12.8	13.7
9	15.5	18.8	23.3	29	12.5	16.1	16.3	49	11.0	12.5	13.7
10	15.5	18.8	22.0	30	12.5	15.6	16.3	50	11.0	12.5	13.7
11	15.5	18.5	22.0	31	12.5	15.6	16.3	51	11.0	12.5	13.3
12	15.0	18.5	21.3	32	12.5	15.6	16.3	52	11.0	12.5	13.3
13	14.5	18.3	21.3	33	12.5	15.5	16.0	53	11.0	12.0	13.3
14	14.5	18.3	20.3	34	12.5	15.5	15.7	54	11.0	12.0	13.3
15	14.0	18.0	20.0	35	12.5	15.0	15.3	55	11.0	12.0	13.0
16	14.0	17.8	19.7	36	12.5	15.0	15.0	56	11.0	12.0	13.0
17	14.0	17.3	19.5	37	12.5	14.8	15.0	57	11.0	12.8	13.0
18	14.0	17.3	19.2	38	12.5	14.8	15.0	58	10.5	12.5	13.0
19	14.0	17.1	19.0	39	12.0	14.5	15.0	59	10.5	12.5	13.0
20	13.5	16.9	18.7	40	11.5	14.0	14.8	60	10.5	12.4	13.0

APPENDICES

Appendix C Experimental Data of Dynamic Surface Tension

1. Dynamic Surface Tension Results

The aqueous surfactant solutions were prepared at studied concentrations which consist of 0.01, 0.1 and 1 wt% of each surfactant. Dynamic surface tension measurements were carried out using a bubble pressure tensiometer (Krüss, BP2) and the temperature was maintained at 30°C.

Table C1 Dynamic surface tension data of C₁₂₋₁₄EO₃ at concentration of 0.01 wt%

No.	Surface age (ms)	Surface Tension (mN/m)	No.	Surface age (ms)	Surface Tension (mN/m)
1	8.8	71.1	21	19.1	72.4
2	9	71.9	22	19.4	73
3	9.6	71.6	23	19.8	72.8
4	9.8	71.9	24	20	72.3
5	10.4	71.6	25	20.5	72.9
6	10.6	72.9	26	21.4	72.6
7	11.3	73.9	27	21.8	72.3
8	11.8	73.6	28	23.3	72.4
9	12	74.3	29	24.3	72.1
10	12.1	74.1	30	25	72.5
11	12.4	73.8	31	25.9	72.4
12	12.5	74	32	27	72.1
13	13	73.4	33	27.6	72.3
14	13.1	72.8	34	28.4	72.4
15	13.6	73.2	35	30.1	72.2
16	14.7	73.1	36	30.4	72.2
17	15.2	72.6	37	30.7	72.1
18	16.7	72.8	38	32.2	72.1
19	17.6	72.9	39	34	71.9
20	18.3	72.6	40	34.6	71.8

No.	Surface age (ms)	Surface Tension (mN/m)	No.	Surface age (ms)	Surface Tension (mN/m)
41	35.8	71.8	79	84.6	70.4
42	36.2	71	80	86.6	70.3
43	36.8	71.8	81	90	70.3
44	38.1	72	82	90.4	70
45	38.4	71.6	83	91.7	70.2
46	39.5	71.4	84	93.2	70.2
47	40.2	71.6	85	95.8	70.1
48	41.3	71.8	86	97.8	69.9
49	41.8	71.6	87	99.5	70.2
50	43.7	71.3	88	101.5	70.1
51	45.2	71.6	89	102.6	70.1
52	45.9	71.4	90	104	70
53	46.1	71.5	91	108.1	69.9
54	47.5	71.4	92	110.7	69.8
55	48.2	71.4	93	112	69.9
56	49	71.1	94	115.1	69.4
57	49.6	71.4	95	116.1	69.4
58	52.1	71.4	96	120.8	69.6
59	52.2	71.3	97	123.4	69.1
60	53.7	70.4	98	125.8	69.8
61	54.2	71.2	99	126.8	69.4
62	56.7	71.3	100	129.6	68.4
63	58.1	70.9	101	134.4	69.6
64	61.1	71.1	102	136.1	69.4
65	62.7	70.9	103	143.8	69.6
66	64.2	71.1	104	145.1	69.2
67	65.5	70.9	105	149.5	69.4
68	67	70.6	106	150.6	69.4
69	68.2	70	107	153.7	69.1
70	68.9	70.3	108	154.6	69.1
71	71	70.8	109	159.3	69.1
72	71.5	70.4	110	161.6	69.2
73	74.9	70.6	111	164.8	69.1
74	76	70.6	112	166.6	69.1
75	77	70.6	113	167.5	68.7
76	78	70.1	114	169.7	69
77	78.7	70.4	115	174.3	69
78	82.4	70.4	116	176.5	69

No.	Surface age (ms)	Surface Tension (mN/m)	No.	Surface age (ms)	Surface Tension (mN/m)
117	184.7	68.9	149	399.1	66.9
118	189.1	68.8	150	421.4	67
119	193.8	68.6	151	438.6	66.9
120	199.6	68.9	152	468.4	66.4
121	200.6	68	153	486.1	65.5
122	212.5	68.5	154	537.5	66.2
123	216.3	68.6	155	547.4	66
124	220.7	68.5	156	589.6	64.6
125	228.2	68.5	157	605.4	65.4
126	229.2	68.2	158	637.5	65.6
127	231.6	68.4	159	671.8	65.4
128	241.9	68.1	160	689	65.1
129	251	68	161	732	65.3
130	255.8	67.9	162	762.4	65.3
131	262.3	68.1	163	835.4	64.7
132	269.7	68.1	164	886.3	64.4
133	275	68.1	165	928	63.7
134	285.5	68.1	166	978.6	64.1
135	293.9	68.1	167	1012.1	64.2
136	298.3	67.9	168	1189.4	63.6
137	300.2	67.6	169	1236.8	63.4
138	303.8	67.3	170	1277.6	62
139	314.7	67.6	171	1499.2	62.3
140	317.3	67.4	172	1858.7	60.8
141	324.9	67.4	173	2376.2	60.6
142	335.4	67.4	174	2901.1	59.4
143	349.2	67.3	175	3590.8	58.4
144	356.4	67.2	176	4695	56.9
145	358.7	67.2	177	5104.5	56.4
146	362.3	66.9	178	6227.3	55.4
147	378.6	66.1	179	7955.5	53.9
148	393.6	67.1	180	9036.1	52.8

Table C2 Dynamic surface tension data of C₁₂₋₁₄EO₃ at concentration of 0.1 wt%

No.	Surface age (ms)	Surface Tension (mN/m)	No.	Surface age (ms)	Surface Tension (mN/m)
1	8.2	69.9	27	39.2	59.9
2	8.9	69.4	28	41.5	59.2
3	9.1	69.4	29	45.2	58.2
4	9.6	68.9	30	49.5	57.6
5	10	68.5	31	51.5	57.5
6	10.1	68.3	32	51.7	57.6
7	11.2	67.8	33	62.3	55.8
8	12.5	67.1	34	78.4	54.2
9	12.9	67	35	98.7	52.3
10	13.2	66.8	36	119.8	50.7
11	14.6	66.4	37	150.7	49
12	14.9	66.1	38	190.2	47.1
13	15.7	65.4	39	239	45.2
14	16.4	65.5	40	300.5	43.2
15	18.1	65	41	379.9	41.3
16	19	64.6	42	476.1	39.6
17	19.7	64.7	43	599.8	37.9
18	21.4	64.1	44	756	36.5
19	21.9	63.9	45	953.9	35.2
20	22.6	63.6	46	1169.4	34
21	24.8	63.1	47	1491.1	32.9
22	27.3	62.4	48	1873.8	32
23	30.6	61.6	49	2281.1	31.3

Table C3 Dynamic surface tension data of C₁₂₋₁₄EO₃ at concentration of 1 wt%

No.	Surface age (ms)	Surface Tension (mN/m)	No.	Surface age (ms)	Surface Tension (mN/m)
1	9.2	53.9	36	23.6	49.9
2	9.4	52.8	37	24.2	49.7
3	9.6	53.5	38	24.5	50.1
4	10	53.9	39	25.1	49.4
5	10.2	53.6	40	25.3	50.4
6	10.3	53.5	41	25.5	48.8
7	10.6	54.2	42	26.2	49.6
8	11	53.3	43	26.7	49.7
9	11.3	53.9	44	28.1	49.8
10	11.6	53.2	45	28.9	48.9
11	11.9	53.1	46	29.3	49.4
12	12.4	52.2	47	30	48.7
13	12.6	52.5	48	30.9	48.9
14	13.1	52.7	49	31.5	49.3
15	13.6	52.2	50	32	49.1
16	13.8	52.4	51	32.2	48.9
17	14.2	50.7	52	33.4	48.3
18	14.7	52.4	53	33.7	48.8
19	15.3	51.2	54	35.1	48.7
20	15.7	52.1	55	36.4	48.7
21	16.1	51.8	56	36.5	48.8
22	16.4	51.6	57	37.2	48.7
23	16.5	51	58	37.7	48.9
24	16.9	51.6	59	38.9	47
25	17.1	51.7	60	39.3	47.9
26	17.3	50.8	61	40.8	48.7
27	17.8	50.6	62	42.6	48.7
28	18.1	51.7	63	43.3	48.3
29	19.2	50.4	64	43.7	48.1
30	19.7	51.3	65	45.2	48.1
31	20.1	49.9	66	46.1	47.1
32	21	50	67	46.8	48.1
33	21.3	50.4	68	47.8	47.7
34	21.9	49.7	69	48.6	47.9
35	22.4	50	70	50.1	47.9

No.	Surface age (ms)	Surface Tension (mN/m)	No.	Surface age (ms)	Surface Tension (mN/m)
71	51.4	47.3	108	131.8	44.4
72	52.3	47.5	109	133.7	44.5
73	53.8	47.1	110	139.3	43.7
74	55.8	47.7	111	141	43.7
75	57.1	47.7	112	143	43.4
76	59.9	47.6	113	146.2	43.6
77	61.8	47.5	114	148.2	43.3
78	62.4	47.4	115	151.2	43.9
79	65.3	47.3	116	152.3	43.2
80	65.4	46.9	117	152.7	43.7
81	66.2	46.9	118	158	42.9
82	69.7	47.1	119	159.1	42.9
83	70.6	47	120	162	43.1
84	72	46.7	121	165.3	43.2
85	73.8	46.9	122	169.3	42.2
86	76.2	46.9	123	173.6	42.6
87	77.5	46.8	124	178.3	41.9
88	79.6	46.6	125	183.2	42.4
89	81.4	46.5	126	187.5	42.1
90	83.3	46.8	127	190.1	42.1
91	83.9	46.5	128	193	41.9
92	85.8	46.4	129	195.7	42.1
93	89.8	46.1	130	197.2	41.6
94	90.6	45.9	131	200.8	41.5
95	91.8	45.5	132	203.9	41.6
96	94.2	45.9	133	207.2	41.5
97	95.9	46.3	134	210.2	40.9
98	97.9	45.8	135	211.9	41
99	100.8	45.7	136	221.9	41
100	103.2	45.6	137	223.1	40.8
101	105.5	45.9	138	226.9	40.7
102	111.1	45.4	139	235.8	40.3
103	114.5	45.2	140	239.2	40.1
104	115.9	45.2	141	248.7	40.1
105	119.6	45	142	249	39.9
106	121.1	44.8	143	262.3	39.6
107	127.2	45.1	144	272.1	39.4

No.	Surface age (ms)	Surface Tension (mN/m)	No.	Surface age (ms)	Surface Tension (mN/m)
145	281.1	38.9	170	600.9	33.1
146	286.4	38.6	171	624	32.6
147	295.8	38.1	172	627	32.1
148	301.6	37.9	173	649.4	32.2
149	315.9	37.9	174	702.4	32.2
150	316.1	37.8	175	730.3	32
151	331	37.5	176	767.2	31.5
152	349.4	37.2	177	808.4	31.4
153	356.1	36.8	178	899.9	30.8
154	357.9	36.7	179	979.8	30.4
155	370.1	36.1	180	998.5	30.4
156	378.8	36.2	181	1014.9	30
157	387.1	36.4	182	1109	29.7
158	392.6	35.9	183	1179.2	29.5
159	410.8	35.8	184	1213.6	29.4
160	419.4	35.6	185	1234.5	29.2
161	429.6	35.3	186	1428.4	28.7
162	459.1	34.8	187	1517.1	28.5
163	480.2	34.3	188	1623.9	28.2
164	497	34.2	189	1878.7	27.8
165	498.9	34.2	190	2400.4	27.1
166	512.5	34.1	191	2879.1	26.2
167	526.3	33.9	192	3678.9	26
168	549.4	33.9	193	4714.4	25.5
169	559.4	33.4	193	4714.4	25.5

Table C4 Dynamic surface tension data of C₁₂₋₁₄EO₅ at concentration of 0.01 wt%

No.	Surface age (ms)	Surface Tension (mN/m)	No.	Surface age (ms)	Surface Tension (mN/m)
1	8.2	72.4	39	39.1	70.9
2	8.6	71.9	40	39.3	70.9
3	8.7	71.6	41	41.4	70.7
4	9.6	72.1	42	45.4	70.6
5	9.9	72.5	43	49.6	70.3
6	11.6	74.1	44	49.7	70.3
7	12.5	73.6	45	49.7	70.1
8	12.6	73.4	46	53.4	70.1
9	14.1	73.1	47	62.1	69.6
10	14.3	73	48	62.6	69.6
11	15.1	72.9	49	78.7	68.7
12	15.4	72.9	50	98.9	67.7
13	15.6	72.8	51	103.3	67.5
14	16.4	72.9	52	120.2	66.8
15	17.9	72.9	53	144.6	65.9
16	18.9	72.6	54	150.6	65.8
17	19.7	72.5	55	160.6	65.5
18	20.1	72.4	56	162.9	65.5
19	21.1	72.3	57	174.6	65.1
20	22.4	72.1	58	189.9	64.7
21	23.4	72.1	59	238.9	63.4
22	23.5	72	60	300.8	62.2
23	24.4	71.9	61	380.9	61.1
24	24.8	71.9	62	480.5	59.9
25	26.5	71.9	63	600.7	58.8
26	26.9	71.7	64	764.2	57.7
27	28.1	71.6	65	954.1	56.6
28	29.1	71.5	66	1185.2	55.6
29	31.2	71.3	67	1475.7	54.5
30	31.6	71.3	68	1868	53.3
31	31.7	71.3	69	2285.4	52.2
32	31.9	71.3	70	2942.8	51
33	32.4	71.3	71	3636.1	49.9
34	35	71.1	72	4791.4	48.6
35	35.9	71.1	73	5207.4	48.1
36	37.5	71	74	5717	47.8
37	38.6	71	75	8129.3	46
38	38.8	70.9			

Table C5 Dynamic surface tension data of C₁₂₋₁₄EO₅ at concentration of 0.1 wt%

No.	Surface age (ms)	Surface Tension (mN/m)	No.	Surface age (ms)	Surface Tension (mN/m)
1	9.2	66.6	29	36	58.4
2	9.8	65.5	30	39.2	57.1
3	9.9	65.6	31	44.9	56.1
4	10	65.6	32	49.6	55.5
5	10	65.8	33	54.2	53.9
6	11	65.3	34	62.2	53.6
7	12.2	64.9	35	78.3	51.7
8	12.3	65.1	36	98.8	49.8
9	12.4	65.1	37	120.1	48.2
10	13.4	64.1	38	151	46.4
11	13.6	64.4	39	190.4	44.4
12	15.2	63.8	40	238.7	42.5
13	15.7	63.1	41	301.8	40.5
14	15.7	63.1	42	379.5	38.8
15	15.8	63.4	43	477.1	37.1
16	16.1	63.4	44	605	35.6
17	18.2	62.4	45	757	34.3
18	18.9	62.6	46	959.5	33.1
19	19.7	62	47	1165.3	32.2
20	20.2	62.4	48	1469.2	31.2
21	21.7	61.2	49	1874.6	30.3
22	24.8	60.5	50	2298.7	29.7
23	24.8	60.4	51	2969.9	28.9
24	24.8	60.6	52	3705.6	28.3
25	25.2	60.4	53	4590.7	27.8
26	31.2	59.4	54	4985.4	27.7
27	33.6	58.4	55	5473.4	27.5
28	33.6	58.7			

Table C6 Dynamic surface tension data of C₁₂₋₁₄EO₅ at concentration of 1 wt%

No.	Surface age (ms)	Surface Tension (mN/m)	No.	Surface age (ms)	Surface Tension (mN/m)
1	9.9	49.7	17	239.2	32
2	10	50.6	18	302.1	30.8
3	12.5	52.9	19	380.4	29.8
4	12.8	52.9	20	479.1	28.9
5	15.7	50.8	21	601.2	28.3
6	19.7	49.1	22	755.6	27.7
7	24.8	47.7	23	961.3	27.2
8	31.2	46	24	1172.3	26.9
9	39.3	44.2	25	1496.7	26.5
10	49.4	42.5	26	1857.8	26.2
11	62.2	40.6	27	2343.4	25.9
12	78.4	39.1	28	2996.1	25.6
13	99	37.4	29	3618.4	25.6
14	120	36.2	30	4608.9	25.4
15	151	34.7	31	5090.5	25.4
16	190.2	33.4	32	5711.4	25.3

Table C7 Dynamic surface tension data of C₁₂₋₁₄EO₇ at concentration of 0.01 wt%

No.	Surface age (ms)	Surface Tension (mN/m)	No.	Surface age (ms)	Surface Tension (mN/m)
1	9	67.5	37	42	66.8
2	10	70.1	38	42.4	66.8
3	12.2	70.6	39	43	66.7
4	12.4	70.6	40	43.1	66.6
5	14.5	70.5	41	45.1	66.6
6	14.8	70.4	42	49.2	66.1
7	15.6	70.4	43	49.6	66.1
8	16.6	70.2	44	50.2	66.1
9	16.8	70.3	45	60.8	65.1
10	19.7	69.7	46	62.3	65.1
11	20	69.6	47	78.5	64.1
12	20.9	69.6	48	79.8	64
13	22.9	69.2	49	85.4	63.7
14	23.5	69.2	50	98.8	63
15	23.8	69.1	51	119.6	62
16	24.1	69.2	52	151	60.7
17	24.8	69	53	190.1	59.5
18	26.9	68.6	54	239.1	58.1
19	28.1	68.4	55	300.6	56.8
20	29	68.2	56	378.7	55.5
21	29.4	68.2	57	479.5	54.1
22	30	68.3	58	604.3	52.9
23	31.2	68	59	757.2	51.9
24	32	67.9	60	952.5	50.7
25	32.2	67.9	61	1173.5	49.7
26	33.1	67.7	62	1500	48.5
27	33.2	67.8	63	1859.1	47.6
28	34	67.7	64	2323.9	46.6
29	36.5	67.4	65	2940.5	45.6
30	37	67.4	66	3763.7	44.6
31	37	67.4	67	4800.3	43.7
32	37.2	67.3	68	5136.4	43.4
33	38.2	67.2	69	5966.2	42.9
34	38.5	67.3	70	7647.8	41.9
35	39.4	67.1	71	8360	41.4
36	40.6	66.9			

Table C8 Dynamic surface tension data of C₁₂₋₁₄EO₇ at concentration of 0.01 wt%

No.	Surface age (ms)	Surface Tension (mN/m)	No.	Surface age (ms)	Surface Tension (mN/m)
1	9.2	60.8	23	62.3	45.2
2	9.8	60.7	24	78.5	43.2
3	10	60.4	25	98.9	41.4
4	10.4	60	26	119.6	40.1
5	12.4	59.1	27	150.7	38.6
6	12.6	59.2	28	190.2	37.2
7	15.6	57.9	29	239.3	35.9
8	19.7	55.5	30	301.1	34.9
9	20.4	55.6	31	380.6	33.9
10	24.9	53.5	32	476.7	33.2
11	25.3	53.7	33	604.7	32.5
12	25.4	53.9	34	756.9	32
13	25.5	53.6	35	954.6	31.6
14	27.7	52.5	36	1183.5	31.2
15	31.2	51.8	37	1473.5	30.9
16	32	51.5	38	1873.8	30.5
17	33.3	51.2	39	2284.2	30.2
18	34.7	50.7	40	2919.1	29.9
19	36.9	50.4	41	3590.1	29.6
20	39.3	49.8	42	4670.8	29.2
21	49.4	47.3	43	5060.3	29.2
22	51.8	46.7	44	6099.9	28.9

Table C9 Dynamic surface tension data of C₁₂₋₁₄EO₇ at concentration of 1 wt%

No.	Surface age (ms)	Surface Tension (mN/m)	No.	Surface age (ms)	Surface Tension (mN/m)
1	8.3	42	24	78.5	33.4
2	9.9	42	25	99	32.6
3	12.4	42	26	119.7	31.8
4	12.4	41.9	27	150.6	31.1
5	13.5	41.4	28	189.6	30.5
6	15.6	40.9	29	239.1	29.9
7	15.7	40.9	30	301.9	29.5
8	15.7	40.6	31	379.5	29.1
9	16.6	40.5	32	478.5	28.8
10	18.3	40.1	33	600.2	28.5
11	19.7	39.7	34	765.1	28.3
12	20.3	39.5	35	955.5	28
13	24.6	38.7	36	1166.4	27.9
14	24.8	38.9	37	1483	27.7
15	30.7	37.7	38	1894.9	27.6
16	30.8	37.8	39	2312.1	27.5
17	31.2	37.6	40	2943.6	27.4
18	34.4	37.3	41	3776.2	27.2
19	37.5	36.9	42	4519.5	27.2
20	38.3	36.8	43	4833.8	27.2
21	39.3	36.6	44	5186.3	27.1
22	49.5	35.5	45	6060.5	27
23	62.2	34.5	46	7250.3	27

Table C10 Dynamic surface tension data of C₁₂₋₁₄EO₉ at concentration of 0.01 wt%

No.	Surface age (ms)	Surface Tension (mN/m)	No.	Surface age (ms)	Surface Tension (mN/m)
1	9.7	66.9	37	25.4	65.8
2	9.9	67.6	38	25.9	65.9
3	10	67.7	39	26.1	65.7
4	10.5	68.6	40	26.4	65.8
5	10.9	68.6	41	26.6	65.7
6	11.2	68.9	42	26.9	65.7
7	12	68.5	43	27.3	65.6
8	12.1	68.4	44	28	65.5
9	12.2	68.4	45	28.3	65.4
10	12.4	68.2	46	28.5	65.4
11	12.5	68.2	47	29.6	65.3
12	13.4	67.7	48	30.2	65.2
13	15.4	67.3	49	30.4	65.2
14	15.5	67.4	50	30.9	65.1
15	15.6	67.4	51	31.2	65.1
16	16.3	67.3	52	31.6	65.1
17	17.5	67.1	53	31.6	65.1
18	18.1	66.9	54	31.8	65.1
19	18.6	66.9	55	32.4	65
20	19	66.9	56	32.9	65
21	19.7	66.7	57	33.5	64.7
22	19.9	66.6	58	34.4	64.7
23	20	66.6	59	34.6	64.8
24	20.5	66.4	60	35.5	64.5
25	20.6	66.4	61	36.9	64.4
26	20.8	66.5	62	37.4	64.4
27	21.7	66.3	63	37.9	64.3
28	21.8	66.3	64	38.7	64.2
29	22.1	66.2	65	39.3	64.2
30	22.2	66.2	66	40.2	63.9
31	22.4	66.2	67	40.7	64
32	22.9	66.2	68	42.3	63.8
33	23.1	66.1	69	43.5	63.7
34	24.5	66	70	44.7	63.5
35	24.8	65.9	71	46.6	63.4
36	25.2	65.9	72	49.2	63.1

No.	Surface age (ms)	Surface Tension (mN/m)	No.	Surface age (ms)	Surface Tension (mN/m)
73	49.5	63.1	90	379.7	53.6
74	50.7	63	91	479	52.7
75	52	62.9	92	605	51.7
76	54.9	62.7	93	759.4	50.7
77	60.6	62.2	94	962.4	49.9
78	62.5	62	95	1173.3	49.1
79	63.9	62	96	1496.6	48.1
80	64.6	61.9	97	1872.8	47.2
81	68.7	61.7	98	2288.1	46.4
82	77	61.2	99	2976.7	45.4
83	78.3	61.1	100	3745.1	44.6
84	98.9	59.9	101	4702.7	43.9
85	119.6	59	102	5148.3	43.5
86	150.8	57.8	103	5695.7	43.2
87	190.5	56.6	104	7355.8	42.2
88	239	55.5	105	8740.8	41.7
89	300.9	54.6			

Table C11 Dynamic surface tension data of C₁₂₋₁₄EO₉ at concentration of 0.1 wt%

No.	Surface age (ms)	Surface Tension (mN/m)	No.	Surface age (ms)	Surface Tension (mN/m)
1	9.4	57.9	26	85.5	41.2
2	9.9	58.2	27	98.5	40.4
3	10.7	57.8	28	120.1	39.3
4	11.8	57.2	29	150.9	38.3
5	12.5	56.3	30	174.4	37.7
6	12.7	56.6	31	189.9	37.3
7	14.4	55.7	32	239.7	36.4
8	15.6	54.7	33	300.7	35.8
9	16.3	54.7	34	386.4	35.1
10	18.1	54	35	481.4	34.7
11	19.7	53.4	36	602.7	34.2
12	20.2	53.1	37	754.8	33.8
13	21.6	52.4	38	954	33.5
14	24.8	51.2	39	1178.5	33.2
15	30	49.5	40	1288.2	33.1
16	30.7	49.4	41	1391.9	33
17	31.2	49.4	42	1497.4	32.9
18	31.8	49.2	43	1904.6	32.5
19	32.1	48.9	44	2298.5	32.3
20	38.4	47.3	45	2896	32
21	39.2	47	46	3676.9	31.7
22	42.2	46.4	47	4645.4	31.4
23	49.5	45.1	48	5107.4	31.2
24	62.3	43.3	49	5703.7	31.2
25	78.5	41.8	50	6493.7	31

Table C12 Dynamic surface tension data of C₁₂₋₁₄EO₉ at concentration of 1 wt%

No.	Surface age (ms)	Surface Tension (mN/m)	No.	Surface age (ms)	Surface Tension (mN/m)
1	9.8	41.8	24	78.5	35.4
2	9.9	42.7	25	98.5	34.7
3	11.8	42.8	26	119.8	34.2
4	12.5	42.3	27	150.9	33.7
5	13	42.5	28	184.3	33.3
6	14.4	42.2	29	189.9	33.2
7	15.6	41.7	30	239.1	32.9
8	16.1	41.5	31	300.6	32.4
9	19.7	40.9	32	378.6	32.2
10	21.3	40.7	33	476.7	31.9
11	24.9	40.2	34	601.5	31.7
12	25.5	40.2	35	760.8	31.6
13	27.7	39.9	36	955.6	31.4
14	27.8	39.8	37	1166.4	31.3
15	28.4	39.7	38	1494.4	31.2
16	31.2	39.2	39	1865.3	31.1
17	32.7	39.1	40	2270	31
18	35.1	38.7	41	2897.6	30.9
19	36.1	38.6	42	3753	30.9
20	37.2	38.4	43	4889.3	30.7
21	39.3	38.2	44	5471.1	30.7
22	49.4	37.3	45	6254.3	30.6
23	62.3	36.3	46	7441.6	30.5

Table C13 Dynamic surface tension data of NPE-6 at concentration of 0.01 wt%

No.	Surface age (ms)	Surface Tension (mN/m)	No.	Surface age (ms)	Surface Tension (mN/m)
1	9.4	73.5	36	25.5	72.4
2	10.1	71.9	37	25.8	72.4
3	10.2	73.6	38	26.2	72.4
4	11	73.4	39	26.7	72.3
5	11.2	74.1	40	27.8	72.3
6	11.5	74.2	41	28.4	72.1
7	11.7	74	42	30.3	72
8	11.9	73.5	43	31.7	72
9	12.4	73.2	44	31.9	72
10	13.1	73	45	33.7	71.8
11	13.3	73.3	46	34.2	71.7
12	13.4	73.1	47	34.5	71.8
13	13.8	73	48	35.4	71.8
14	14	72.9	49	36.3	71.5
15	14.5	72.6	50	36.7	71.7
16	15.3	72.9	51	37.5	71.7
17	15.4	73.1	52	38.9	71.7
18	15.6	73.1	53	39.5	71.4
19	16.7	72.7	54	40.3	71.1
20	16.9	73.1	55	41.4	71.5
21	17.5	73	56	41.9	71.4
22	17.6	73	57	43.6	71.6
23	18.8	72.6	58	44.3	71
24	19.4	72.5	59	46.6	71.5
25	19.7	72.9	60	47.8	71.1
26	20.6	72.6	61	48.5	71.1
27	21.4	72.6	62	49	71.1
28	21.5	72.6	63	49.9	71.2
29	21.8	72.5	64	51.5	71.2
30	22.8	72.5	65	51.9	70.7
31	23.9	72.5	66	52.9	70.9
32	24	72.5	67	53.6	71.1
33	24.8	71.9	68	55.2	70.9
34	24.9	72.4	69	55.8	70.8
35	25	72.4	70	57.5	70.9

No.	Surface age (ms)	Surface Tension (mN/m)	No.	Surface age (ms)	Surface Tension (mN/m)
71	58.9	70.8	108	119.5	68.2
72	60	70.4	109	120.5	69
73	61.3	70.5	110	122	68.9
74	62.5	70.6	111	124	68.9
75	64.5	70.3	112	126	68.9
76	66.3	70.5	113	128	68.4
77	66.8	70.3	114	131.2	68.8
78	67.9	70.3	115	137.6	68.7
79	70.2	70.1	116	141.5	68.6
80	72.7	70.1	117	144.3	68.1
81	74	70.1	118	147.5	68.6
82	74.6	70.1	119	149.4	67.4
83	76.7	70.1	120	150.8	67.9
84	78.8	70.1	121	152.7	68.2
85	79.2	69.9	122	152.9	68.4
86	79.6	69.9	123	157.3	68.4
87	80.2	69.9	124	159.7	68.3
88	81.9	69.9	125	161.7	68.2
89	83.6	69.7	126	162.4	68.2
90	87.8	70	127	164.2	68
91	89	69.6	128	172.5	68.1
92	89.8	69.6	129	174.8	67.9
93	91.9	69.6	130	180.9	67.9
94	93.4	69.4	131	184.1	67.9
95	95.5	69.6	132	189.4	67.9
96	97.5	69.4	133	193.3	67.8
97	99.8	69.6	134	197	67.7
98	102	69.6	135	197.2	67.7
99	103.3	69.5	136	204.7	67.7
100	104.9	69.1	137	206.5	67.6
101	106.8	69.3	138	209.9	67.6
102	107.4	69.1	139	214.8	67.5
103	109.1	69.1	140	224.2	67.1
104	111.2	69.1	141	228.4	67.4
105	114.9	68.9	142	238.6	67.2
106	116.2	68.9	143	241.1	66.9
107	118.6	68.9	144	245.4	67.1

No.	Surface age (ms)	Surface Tension (mN/m)	No.	Surface age (ms)	Surface Tension (mN/m)
145	247.6	67	172	594.1	64.9
146	250.2	67.1	173	600.7	64.6
147	254.2	66.9	174	643.9	64.6
148	259.5	67.1	175	710.3	64.4
149	264	66.9	176	731.8	64.1
150	268.1	66.9	177	754.8	63.9
151	275	66.9	178	826.3	63.6
152	278.8	66.4	179	854.2	63.2
153	285.5	66.9	180	953.3	63.2
154	289.9	66.6	181	1165.5	62.6
155	300.7	66.6	182	1245.1	62.4
156	308.5	66.7	183	1284.1	62.1
157	311.6	66	184	1384.9	61.9
158	318	66.1	185	1452.1	61.6
159	335.7	66.2	186	1495.1	60.9
160	352.3	65.9	187	1895.8	60.1
161	356.6	65.9	188	1990.9	60.3
162	372	66	189	2077.4	59.7
163	379.8	66.1	190	2313.7	59.1
164	382.9	65.9	191	2848.9	57.9
165	391	65.7	192	3696.5	56.4
166	401.7	65.9	193	4829.8	54.9
167	420.6	65.7	194	5150	54.2
168	467.9	65.5	195	5700.2	53.9
169	473.7	65.4	196	7246	51.5
170	485.7	65.2	197	9090.8	50
171	543.8	65.1			

Table C14 Dynamic surface tension data of NPE-6 at concentration of 0.1 wt%

No.	Surface age (ms)	Surface Tension (mN/m)	No.	Surface age (ms)	Surface Tension (mN/m)
1	9.2	65.4	36	49	62.4
2	10	66.4	37	51.6	62.9
3	10.5	64.9	38	52.8	61.6
4	11.1	57.9	39	55.3	62.4
5	12.4	67.4	40	57.4	62.7
6	12.6	64.4	41	57.7	60.6
7	12.9	65.3	42	61.2	62.9
8	14	65.9	43	64.5	61.1
9	14.8	60.8	44	67	59.7
10	15.7	67.3	45	71.7	60.9
11	16.1	64.5	46	75.9	59.6
12	17.2	63.6	47	78.8	59.2
13	18.4	66.4	48	79.5	57.8
14	19.1	65	49	82.5	57.4
15	19.9	62.4	50	85.1	57
16	21.8	65.1	51	90.4	59.5
17	22.6	66.4	52	92.8	59.5
18	23.1	63.4	53	95.2	60.4
19	25.1	64.8	54	98.4	58
20	25.6	63.5	55	99.1	56.6
21	26.4	64.9	56	101.7	58.1
22	27	64.1	57	104.9	55.1
23	28.5	62.4	58	107.8	58.8
24	30.1	64.4	59	109.6	57.8
25	32.4	65.4	60	115	54.4
26	32.8	60.9	61	122.8	57.9
27	34.9	64.1	62	126.2	58.9
28	35.7	63.8	63	127.7	56
29	37.5	63.6	64	131.5	53.6
30	38.9	63.6	65	137.4	57.3
31	40.6	62.4	66	140.7	52.2
32	41.3	60.5	67	145.2	56.1
33	45	60.1	68	149.7	55.1
34	45.7	62.6	69	154.7	54.6
35	47.6	60.5	70	157.7	57.1

No.	Surface age (ms)	Surface Tension (mN/m)	No.	Surface age (ms)	Surface Tension (mN/m)
71	159.1	55.4	105	555.9	48.6
72	161.1	54.4	106	606.2	48.7
73	163.4	56.1	107	624.5	48.2
74	170.3	53.9	108	637.7	47.9
75	176.9	56.3	109	660.5	48.6
76	178.3	53.6	110	731.3	48.1
77	184.6	54.3	111	772.1	47.6
78	189.3	53.1	112	805.5	46.8
79	192.3	54.3	113	847.1	47.3
80	206.3	54.4	114	854.4	47
81	207.9	54.1	115	906.4	46.4
82	213.8	54.2	116	953.4	46.1
83	219.8	54.9	117	1003.8	45.1
84	226.3	53.6	118	1081.5	43.7
85	239.4	54.5	119	1134.7	43.8
86	244.1	52.8	120	1177.3	41.9
87	255.7	53.7	121	1299.7	44.1
88	260.6	53.4	122	1316.3	42.2
89	278.1	54.2	123	1393.6	42.1
90	295.5	53	124	1472.6	41.8
91	304.4	51.6	125	1513.3	41.7
92	320.6	51.3	126	1550.1	41.2
93	334.1	52.2	127	1797.5	40.4
94	334.4	50.2	128	1858.4	39.9
95	368.8	52.4	129	1904.7	39.7
96	381.4	51.8	130	2041	39.5
97	405.8	51.1	131	2215.3	39.7
98	414.8	50.2	132	2290.9	38.6
99	434.6	49.9	133	2920.7	35.9
100	445	50.4	134	3605.4	35
101	476.5	49.7	135	4528.8	33.4
102	494.5	51	136	4847.3	32.8
103	495.3	48.7	137	5192.2	33.3
104	523.2	49.4	138	5732.8	32.4

Table C15 Dynamic surface tension data of NPE-6 at concentration of 1 wt%

No.	Surface age (ms)	Surface Tension (mN/m)	No.	Surface age (ms)	Surface Tension (mN/m)
1	8.7	53.6	36	21	51.8
2	8.8	53.5	37	21.3	52.2
3	9	53.9	38	21.9	51.7
4	9.2	53.6	39	22.1	52.4
5	9.5	53.6	40	22.3	51.7
6	9.6	53.8	41	22.7	52
7	9.8	54.2	42	22.9	52
8	10.1	53.8	43	23.6	52
9	10.4	53.9	44	23.7	51.7
10	10.6	53.9	45	24.7	51.4
11	11	53.6	46	24.8	51.5
12	11.5	53.9	47	25.3	51.4
13	12.2	53.4	48	25.6	51.5
14	12.3	53.6	49	26.1	50.7
15	12.7	53.9	50	26.8	51.1
16	12.8	53.6	51	27.2	51.1
17	13.1	53.3	52	27.4	50.6
18	13.4	53.4	53	27.8	50.9
19	13.7	53.4	54	28.2	50.8
20	14	53.8	55	28.4	49.8
21	14.4	53.4	56	29.4	49.6
22	15	53.4	57	29.8	51.1
23	15.5	53.6	58	30.1	50.4
24	15.8	53.1	59	31	50.7
25	16.2	53.6	60	31.2	50.4
26	16.6	52.9	61	31.4	50.3
27	16.8	52.9	62	31.9	49.7
28	17.1	52.6	63	32.4	50.7
29	17.8	52.9	64	32.8	50
30	18.2	53.1	65	33.3	49.6
31	18.3	53	66	34.3	50
32	18.9	52.6	67	34.5	48.8
33	19.6	52.4	68	35.4	50
34	19.7	52	69	35.9	49.7
35	20.6	52.5	70	37	49.4

No.	Surface age (ms)	Surface Tension (mN/m)	No.	Surface age (ms)	Surface Tension (mN/m)
71	39.1	48.7	108	86	42.4
72	40.7	49.1	109	87.4	42.2
73	41.2	48.7	110	89.9	41.9
74	42.3	48.7	111	90.3	41.7
75	43.1	48.3	112	91.7	41.6
76	44.8	48.4	113	92.9	41.6
77	45.1	48.1	114	95.1	41.3
78	45.8	47.9	115	96.3	41.2
79	46.4	48.1	116	97.5	40.9
80	47	47.8	117	98.5	40.4
81	48.1	47.4	118	101	40.3
82	49.3	47.8	119	103.5	40
83	49.8	47.6	120	105.8	39.8
84	51.9	47.5	121	107.5	39.7
85	53.8	46.9	122	110.3	39.3
86	54.4	46.7	123	111.8	39.2
87	55.9	47.1	124	113.9	38.9
88	57.5	46.6	125	116.8	38.6
89	58	46.4	126	118.7	38.5
90	59.5	46.4	127	120.1	38.3
91	60.6	46.1	128	122	38.5
92	61.1	46.1	129	123.7	37.9
93	62.3	45.8	130	126.8	37.7
94	63.7	45.9	131	129.8	37.6
95	64.2	45.6	132	135.1	37.2
96	65.2	45.6	133	137.2	36.8
97	66.5	45.8	134	139.7	36.9
98	68.6	45.1	135	140.6	36.6
99	69.9	44.5	136	143.8	36.5
100	70.9	44.6	137	145.6	36.4
101	73.4	44.2	138	147.8	36.4
102	75.2	43.9	139	150.9	36
103	76.3	43.9	140	153.4	35.8
104	77.8	43.8	141	154.2	35.8
105	78.4	43.6	142	154.9	35.7
106	80.2	43.4	143	155.1	35.7
107	83.4	43.4	144	160.6	35.5

No.	Surface age (ms)	Surface Tension (mN/m)	No.	Surface age (ms)	Surface Tension (mN/m)
145	163.6	35.4	178	292.3	32
146	163.8	35.2	179	301.8	31.9
147	170.7	35	180	324.5	31.7
148	174.1	34.9	181	330.8	31.6
149	175.3	34.8	182	332.2	31.6
150	178.7	34.6	183	341.8	31.6
151	181.2	34.6	184	354.2	31.4
152	183.8	34.4	185	359.3	31.4
153	184.9	34.4	186	369.4	31.3
154	188.1	34.3	187	379.8	31.2
155	190.6	34.2	188	393.5	31.1
156	198.7	34	189	398.1	31.1
157	201	33.9	190	407.8	31
158	208.1	33.7	191	421.9	30.9
159	209.1	33.7	192	444.4	30.8
160	210.8	33.7	193	480.5	30.7
161	217.1	33.4	194	513.5	30.6
162	222.8	33.2	195	555.1	30.5
163	227.4	33.2	196	570.4	30.4
164	230.6	33.1	197	587.8	30.3
165	237.1	32.9	198	604.1	30.2
166	241.1	32.9	199	762	29.9
167	243.1	32.9	200	955.9	29.5
168	245.4	32.8	201	1179.3	29.4
169	248.7	32.7	202	1481.2	29.1
170	250.7	32.6	203	1868.4	28.9
171	252.9	32.6	204	2315.8	28.7
172	260.8	32.4	205	2936.3	28.5
173	264.4	32.4	206	3731.6	28.3
174	268.8	32.4	207	4738.6	28.1
175	277.6	32.2	208	5238.9	28.1
176	281.3	32.2	209	5897.2	28
177	286.2	32.2			

Table C16 Dynamic surface tension data of NPE-9 at concentration of 0.01 wt%

No.	Surface age (ms)	Surface Tension (mN/m)	No.	Surface age (ms)	Surface Tension (mN/m)
1	9.3	68.4	36	34	67.4
2	9.6	69.2	37	34.2	67.3
3	10	69.9	38	34.7	67.3
4	11	71	39	34.9	67.2
5	11.8	70.4	40	35.4	67.2
6	12.4	70.2	41	36	67.1
7	12.9	69.8	42	36.7	67
8	14.3	69.4	43	39.2	66.8
9	15.7	69.5	44	39.3	66.8
10	15.9	69.4	45	40.8	66.6
11	15.9	69.4	46	41.1	66.6
12	16.7	69.3	47	43.3	66.4
13	18.1	69.1	48	45	66.3
14	18.7	69	49	47.1	66.1
15	18.8	69.1	50	49.4	65.9
16	19.7	68.9	51	49.4	65.9
17	20.1	68.9	52	50.5	65.8
18	20.3	68.9	53	52.8	65.6
19	22.7	68.5	54	58.5	65.3
20	22.8	68.5	55	62.2	65
21	23.4	68.4	56	66.5	64.9
22	24.1	68.4	57	75.2	64.3
23	24.8	68.2	58	76.1	64.2
24	25.9	68.1	59	78.3	64.1
25	26	68.1	60	96.9	63.1
26	26.7	68	61	99.4	63.1
27	27.4	67.9	62	120	62.1
28	27.5	68	63	149.1	60.9
29	28.6	67.9	64	151.2	60.9
30	30	67.7	65	160.6	60.6
31	30.4	67.7	66	190.2	59.6
32	31.1	67.6	67	238.9	58.5
33	31.2	67.6	68	301.7	57.4
34	33.3	67.4	69	378.5	56.5
35	33.8	67.4	70	479.6	55.5

No.	Surface age (ms)	Surface Tension (mN/m)	No.	Surface age (ms)	Surface Tension (mN/m)
71	599.8	54.8	78	2879.4	47.9
72	759.6	53.9	79	3724.4	46.6
73	967.9	52.9	80	4805.4	45
74	1169.1	52.2	81	5142.9	44.5
75	1494.3	51.2	82	6009	43.4
76	1853.4	50.1	83	7433.9	42.2
77	2344	49	84	8391	41.6

Table C17 Dynamic surface tension data of NPE-9 at concentration of 0.1 wt%

No.	Surface age (ms)	Surface Tension (mN/m)	No.	Surface age (ms)	Surface Tension (mN/m)
1	10	62.6	28	49.4	45.4
2	10	62.8	29	62.3	42
3	12.5	61.1	30	75.7	39.9
4	12.7	61	31	76.3	39.8
5	14	61.1	32	78.3	39.6
6	14.1	61.1	33	82.4	39.2
7	14.7	59.9	34	98.5	37.8
8	15.6	59.5	35	120	36.6
9	17.2	59.7	36	150.7	35.6
10	17.9	58.4	37	189.6	34.7
11	18.6	58.6	38	240.1	33.9
12	18.7	58.7	39	301.2	33.3
13	19.7	58.4	40	380.3	32.9
14	20.2	58.3	41	476.8	32.4
15	22	57.3	42	602.4	32.1
16	23.5	56.6	43	765	31.8
17	24.8	55.7	44	961.5	31.7
18	26.7	55.1	45	1175.2	31.4
19	29.4	53.6	46	1504.7	31.3
20	29.5	53.7	47	1870.1	31.1
21	31.2	52.8	48	2263	31
22	32	52.4	49	2868.5	30.8
23	32.4	52.3	50	3673.8	30.6
24	37.6	49.7	51	4713.6	30.4
25	37.7	49.8	52	5238.4	30.4
26	39.3	48.7	53	5919.8	30.3
27	39.9	48.7	54	8436.6	30.2

Table C18 Dynamic surface tension data of NPE-9 at concentration of 1 wt%

No.	Surface age (ms)	Surface Tension (mN/m)	No.	Surface age (ms)	Surface Tension (mN/m)
1	9.3	40.6	27	39.3	35.7
2	9.7	41.1	28	49.4	34.7
3	9.9	41.2	29	62.2	33.8
4	12.2	41.6	30	78.6	33.1
5	12.4	41.4	31	80.2	33.1
6	13.2	41.2	32	98.9	32.6
7	14.4	40.6	33	120	32.2
8	15.6	40.4	34	150.7	31.9
9	16.8	40.1	35	190.1	31.4
10	17.9	39.8	36	239.4	31.2
11	19.2	39.5	37	301.6	30.9
12	19.3	39.6	38	379.8	30.9
13	19.7	39.5	39	477.7	30.7
14	21.8	38.9	40	600.2	30.5
15	23.4	38.4	41	756.1	30.4
16	23.6	38.4	42	959.7	30.3
17	24.9	38.1	43	1165.1	30.2
18	25.4	38	44	1477.7	30.1
19	26	37.9	45	1882.6	30
20	27.5	37.5	46	2268.4	30
21	27.5	37.4	47	2862.1	29.9
22	31	36.9	48	3630.7	29.9
23	31.2	36.8	49	4587.2	29.8
24	32.3	36.7	50	5062	29.7
25	35	36.2	51	6459.1	29.7
26	38.3	35.7	52	7640.7	29.7

APPENDICES

Appendix D Experimental Data of Gel Range

1. Viscosity Test Results

The concentration of each surfactant is observed by rare eyes and measured the viscosity by Brookfield Viscometer Model DV-III.

Table D1 Viscosity behavior as a function of concentration of $C_{12-14}EO_3$ single system at 25°C

Surfactant Concentration (wt%)	Viscosity (cP)	Spindle No.	Rotational Speed (rpm)
5	6.6	21	250
10	38.6	21	250
15	214	21	250
20	980	27	250
25	1450	27	150
30	1580	27	150
35	3000	27	80
40	4750	27	50
45	11400	27	20
50	44700	27	5
55	46400	27	5
60	5000	27	45
65	8500	27	25
70	17500	27	13
75	7400	27	30
80	3175	27	75
85	52.8	21	250
90	37.4	21	250
95	27.6	21	250
100	21.6	21	250

Table D2 Viscosity behavior as a function of concentration of C₁₂₋₁₄EO₅ single system at 25°C

Surfactant Concentration (wt%)	Viscosity (cP)	Spindle No.	Rotational Speed (rpm)
5	8	21	250
10	33.2	21	250
15	49.8	21	250
20	70.4	21	250
25	150	21	250
30	178	21	250
35	287	21	150
40	42.4	21	250
45	201	21	250
50	1100	27	50
55	739	27	250
60	1500	27	150
65	4700	27	50
70	40200	27	5
75	41250	27	5
80	44000	27	5
85	7500	27	50
90	44	21	250
95	44.6	21	250
100	29.4	21	250

Table D3 Viscosity behavior as a function of concentration of C₁₂₋₁₄EO₇ single system at 25°C

Surfactant Concentration (wt%)	Viscosity (cP)	Spindle No.	Rotational Speed (rpm)
5	1.6	21	250
10	3.4	21	250
15	10.6	21	250
20	39	21	250
25	130	21	250
30	374	21	130
35	1470	21	30
40	276100	27	0.8
45	132500	27	1.7
50	278750	27	0.8
55	585000	27	0.4
60	41000	27	6
65	4650	27	50
70	1228	27	200
75	4750	27	50
80	7250	27	30
85	224	21	200
90	61.4	21	250
100	40.8	21	250

☐ = *hard gel (can not measure)*

Table D4 Viscosity behavior as a function of concentration of C₁₂₋₁₄EO₉ single system at 25°C

Surfactant Concentration (wt%)	Viscosity (cP)	Spindle No.	Rotational Speed (rpm)
5	-	-	-
10	-	-	-
15	-	-	-
20	3.8	21	250
25	7	21	250
30	143	21	250
35	139	21	250
40	5700	21	8
45	347000	27	0.7
50	371250	27	0.6
55	408000	27	0.6
60	490000	27	0.5
65	830000	27	0.3
70	4000	21	12
75	413	21	120
80	234	21	200
85	140	21	250
90	88.8	21	250
95	64.6	21	250
100	53.6	21	250

☒ = hard gel (can not measure), - = N/A

Table D5 Viscosity behavior as a function of concentration of NPE-6 single system at 25°C

Surfactant Concentration (wt%)	Viscosity (cP)	Spindle No.	Rotational Speed (rpm)
5	-	-	-
10	-	-	-
15	-	-	-
20	85	21	250
25	150	21	250
30	800	21	50
35	1600	27	150
40	20100	27	100
45	22000	27	10
50	24500	27	5
55	32000	27	5
60	17100	27	10
65	19100	27	10
70	55000	27	4
75	101250	27	2
80	44000	27	5
85	8384	27	28
90	247	21	200
95	247	21	200
100	209	21	200

- = N/A

Table D6 Viscosity behavior as a function of concentration of NPE-9 single system at 25°C

Surfactant Concentration (wt%)	Viscosity (cP)	Spindle No.	Rotational Speed (rpm)
5	-	-	-
10	-	-	-
15	-	-	-
20	58.4	21	250
25	133	21	250
30	437	21	110
35	777	21	62
40	1740	21	27
45	1850	27	130
50	6550	27	35
55	1523	27	200
60	1300	21	35
65	12500	27	18
70	11000	27	18
75	12000	27	20
80	3070	27	80
85	380	21	120
90	324	21	150
95	-	-	-
100	183	21	250

- = N/A

CURRICULUM VITAE

Name: Mr. Supoj Jirawatanaporn

Date of Birth: November 22, 1984

Nationality: Thai

University Education:

2003-2006 B.Eng. in Chemical Engineering, Faculty of Engineering, Mahidol University, Bangkok, Thailand.

2007-2008 M.S. in Petrochemical Technology, The Petroleum and Petrochemical College, Chulalongkorn University, Bangkok, Thailand.

Proceeding:

1. Jirawatanaporn, S., Kitiyanan, B., and Chavadej, S. (2009, April 22) Foam Properties of Alcohol Ethoxylates Derived Natural Products. Proceeding of the 15th PPC Symposium on Petroleum, Petrochems, and Polymers, Bangkok, Thailand.

Presentations:

1. Jirawatanaporn, S., Kitiyanan, B., and Chavadej, S. (2009, April 22) Foam Properties of Alcohol Ethoxylates Derived Natural Products. Poster presented at the 15th PPC Symposium on Petroleum, Petrochems, and Polymers, Bangkok, Thailand.

