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APPENDICES

Appendix A: Foaming property of the surfactant system 1 in the presence of water hardness.

Concentration of SDS = 4%wt. (0.122 M)

Concentration of coconut oil sodium soaps = 0.55%wt. (0.023 M)

Table A-1 The change of foam height with time of the surfactant system 1 at 50 ppm of bivalent ions (Ca^{2+} and Mg^{2+}) using Shaking method.

Time (min)	Foam height (cm)				
	Ca^{2+} and Mg^{2+}	with HCO_3^-		with HSO_4^-	
	50 ppm	50 ppm	100 ppm	50 ppm	100 ppm
0	7.65	6.61	6.55	6.66	7.30
1	7.65	6.50	5.25	6.54	7.25
2	7.65	6.31	4.05	6.45	7.21
3	7.53	5.59	3.65	6.33	6.15
4	7.38	5.13	3.15	5.23	3.98
5	7.33	4.26	2.95	3.74	3.26
6	7.25	3.74	2.62	2.79	2.43
7	6.68	3.29	2.55	2.29	2.40
8	5.93	2.96	2.25	2.01	2.40
9	5.10	2.43	2.10	1.76	2.29
10	4.55	2.17	2.00	1.60	2.00
11	3.65	1.93	1.85	1.43	1.85
12	3.08	1.66	1.70	1.39	1.64
13	2.55	1.59	1.55	1.23	1.61
14	2.13	1.40	1.35	1.16	1.60
15	1.93	1.33	1.25	1.06	1.53
16	1.65	1.23	1.20	1.01	1.50
17	1.50	1.19	1.20	0.96	1.39

Time (min)	Foam height (cm)				
	Ca^{2+} and Mg^{2+}	with HCO_3^-		with HSO_4^-	
	50 ppm	50 ppm	100 ppm	50 ppm	100 ppm
18	1.30	1.11	1.05	0.94	1.37
19	1.08	1.09	1.00	0.93	1.30
20	1.03	1.06	1.00	0.90	1.25
21	0.98	1.03	0.90	0.90	1.20
22	0.93	0.99	0.90	0.90	1.20
23	0.90	0.97	0.90	0.90	1.09
24	0.90	0.96	0.90	0.90	1.05
25	0.90	0.94	0.85	0.90	1.00

Table A-2 The change of foam height with time of the surfactant system 1 at 150 ppm of bivalent ions (Ca^{2+} and Mg^{2+}) using Shaking method.

Time (min)	Foam height (cm)				
	Ca^{2+} and Mg^{2+}	with HCO_3^-		with HSO_4^-	
	150 ppm	50 ppm	100 ppm	50 ppm	100 ppm
0	7.65	6.65	5.95	7.30	6.64
1	7.63	6.60	5.75	7.13	6.64
2	7.63	6.40	4.80	6.53	6.17
3	7.58	6.00	4.50	5.17	5.76
4	7.43	3.70	3.50	4.57	4.47
5	6.78	3.35	3.05	4.20	3.63
6	6.01	2.35	2.15	4.07	2.89
7	5.48	2.10	1.55	3.60	2.51
8	5.36	1.90	1.40	3.40	2.31
9	4.97	1.80	1.30	3.13	2.04
10	4.07	1.75	1.30	2.90	1.96
11	3.46	1.60	1.25	2.77	1.84
12	3.10	1.50	1.20	2.60	1.74
13	2.53	1.35	1.10	2.47	1.56
14	2.21	1.25	1.05	2.17	1.47
15	2.14	1.20	1.00	2.00	1.41
16	2.00	1.15	0.95	1.83	1.34
17	1.95	1.10	0.95	1.73	1.24
18	1.87	0.90	0.95	1.63	0.96
19	1.87	0.90	0.95	1.60	0.81
20	1.74	0.85	0.95	1.53	0.67
21	1.63	0.85	0.90	1.50	0.67
22	1.55	0.80	0.90	1.43	0.64
23	1.46	0.80	0.85	1.43	0.61
24	1.37	0.80	0.85	1.33	0.61
25	1.23	0.80	0.80	1.30	0.61

Table A-3 The change of foam height with time of the surfactant system 1 at 300 ppm of bivalent ions (Ca^{2+} and Mg^{2+}) using Shaking method.

Time (min)	Foam height (cm)				
	Ca^{2+} and Mg^{2+}	with HCO_3^-		with HSO_4^-	
	300 ppm	50 ppm	100 ppm	50 ppm	100 ppm
0	7.98	7.71	7.90	8.10	8.48
1	7.91	7.59	7.80	8.10	8.43
2	7.90	7.19	7.68	8.10	8.38
3	7.81	7.00	7.36	7.93	8.30
4	7.35	6.31	6.48	7.67	7.55
5	6.20	5.95	5.74	7.20	6.75
6	5.54	4.29	4.80	5.10	6.73
7	5.24	3.96	4.12	4.80	4.50
8	4.60	3.45	3.44	4.47	4.43
9	4.45	3.20	2.98	4.07	4.28
10	3.73	2.91	2.60	3.70	4.15
11	3.50	2.73	2.28	2.90	3.08
12	2.75	2.55	2.04	2.30	2.63
13	2.49	2.46	1.78	2.00	2.30
14	2.23	2.30	1.58	1.60	2.03
15	2.10	2.06	1.48	1.47	1.78
16	1.98	1.38	1.38	1.30	1.65
17	1.85	1.26	1.26	1.20	1.55
18	1.68	1.18	1.18	1.10	1.43
19	1.66	1.06	1.10	1.07	1.35
20	1.63	1.01	1.08	1.00	1.28
21	1.53	0.96	1.04	1.00	1.20
22	1.45	0.91	0.96	0.97	1.13
23	1.39	0.89	0.92	0.97	1.08
24	1.34	0.85	0.86	0.97	1.08
25	1.30	0.84	0.86	0.97	1.05

Appendix B: Foaming property of the surfactant system 2 in the presence of water hardness.

Concentration of SDS = 4%wt. (0.122 M)

Concentration of coconut oil sodium soaps = 0.55%wt. (0.0234 M)

Concentration of the synthetic of 12-15 carbon chain length detergent alcohol condensed with 7 moles of ethylene oxide = 2.40%wt. (4.69 mM)

Table B-1 The change of foam height with time of the surfactant system 2 at 50 ppm of bivalent ions (Ca^{2+} and Mg^{2+}) using Shaking method.

Time (min)	Foam height (cm)				
	Ca^{2+} and Mg^{2+}	with HCO_3^-		with HSO_4^-	
	50 ppm	50 ppm	100 ppm	50 ppm	100 ppm
0	7.83	7.86	7.79	7.59	8.24
1	7.80	7.83	7.71	7.56	8.16
2	7.79	7.79	7.71	7.50	8.14
3	7.76	7.75	7.70	7.50	8.10
4	7.70	7.75	7.68	7.47	8.08
5	7.70	7.75	7.68	7.47	8.02
6	7.69	7.75	7.66	7.47	7.72
7	7.69	7.75	7.66	7.47	7.66
8	7.67	7.75	7.65	7.46	7.60
9	7.67	7.75	7.65	7.46	7.60
10	7.67	7.75	7.64	7.44	7.60
11	7.67	7.75	7.63	7.43	7.56
12	7.67	7.75	7.61	7.40	7.52
13	7.67	7.75	7.61	7.40	7.46
14	7.66	7.74	7.40	7.37	7.44
15	7.66	7.74	7.13	7.37	7.44
16	7.66	7.73	6.73	7.37	7.42
17	7.66	7.73	6.73	7.30	7.30

Time (min)	Foam height (cm)				
	Ca^{2+} and Mg^{2+}	with HCO_3^-		with HSO_4^-	
	50 ppm	50 ppm	100 ppm	50 ppm	100 ppm
18	7.66	7.66	6.70	7.19	7.16
19	7.66	7.58	6.68	7.19	7.10
20	7.64	7.58	6.61	7.19	7.10
21	7.64	7.58	6.60	7.19	7.02
22	7.64	7.58	6.56	7.17	6.64
23	7.63	7.56	6.53	7.17	6.64
24	7.61	7.23	6.48	7.14	6.60
25	7.47	7.00	6.26	7.14	6.60

Table B-2 The change of foam height with time of the surfactant system 2 at 150 ppm of bivalent ions (Ca^{2+} and Mg^{2+}) using Shaking method.

Time (min)	Foam height (cm)				
	Ca^{2+} and Mg^{2+}	with HCO_3^-		with HSO_4^-	
	150 ppm	50 ppm	100 ppm	50 ppm	100 ppm
0	8.03	7.68	6.56	6.78	7.20
1	7.94	7.68	6.53	6.68	7.15
2	7.91	7.68	6.51	6.60	7.10
3	7.83	7.68	6.51	6.48	7.02
4	7.77	7.62	6.47	6.28	6.95
5	7.77	7.55	6.47	6.23	6.92
6	7.77	7.55	6.41	6.18	6.83
7	7.76	7.43	6.41	6.15	6.77
8	7.74	7.35	6.41	6.13	6.62
9	7.74	7.32	6.41	6.13	6.42
10	7.47	7.27	6.40	6.05	6.23
11	7.41	7.18	6.40	6.00	5.82
12	7.41	7.12	6.34	6.00	5.72
13	7.41	6.97	6.34	6.00	5.48
14	7.41	6.87	6.34	6.00	5.27
15	7.21	6.87	6.34	6.00	5.23
16	7.19	6.83	6.34	6.00	5.20
17	7.14	6.57	5.99	6.00	5.15
18	7.09	6.40	5.73	6.00	5.12
19	6.96	6.37	5.73	6.00	5.05
20	6.93	5.98	5.73	6.00	4.98
21	6.81	5.80	5.47	6.00	4.87
22	6.79	5.75	5.47	6.00	4.70
23	6.59	5.70	5.20	6.00	4.63
24	6.41	5.00	4.96	5.98	4.58
25	6.09	4.77	4.89	5.98	4.58

Table B-3 The change of foam height with time of the surfactant system 2 at 300 ppm of bivalent ions (Ca^{2+} and Mg^{2+}) using Shaking method.

Time (min)	Foam height (cm)				
	Ca^{2+} and Mg^{2+}	with HCO_3^-		with HSO_4^-	
	300 ppm	50 ppm	100 ppm	50 ppm	100 ppm
0	6.26	6.28	6.40	5.87	5.70
1	6.18	6.20	6.30	5.80	5.63
2	6.18	6.18	6.30	5.73	5.60
3	6.16	6.16	5.90	5.70	5.60
4	6.16	6.16	5.83	5.67	5.55
5	6.16	6.14	5.80	5.63	5.45
6	6.16	6.12	5.77	5.63	5.40
7	6.16	5.80	5.77	5.63	5.33
8	6.16	5.80	5.77	5.63	5.18
9	6.16	5.76	5.77	5.57	5.15
10	6.16	5.70	5.70	5.23	5.15
11	6.16	5.66	5.67	5.23	5.15
12	6.16	5.66	5.67	5.23	5.15
13	6.16	5.64	5.67	5.20	5.10
14	6.16	5.60	5.67	5.20	5.05
15	6.16	5.60	5.67	5.17	4.98
16	6.16	5.60	5.63	5.17	4.90
17	6.14	5.60	5.63	5.10	4.90
18	6.14	5.58	5.63	4.87	4.90
19	6.14	5.58	5.60	4.83	4.88
20	6.14	5.58	5.40	4.80	4.88
21	6.14	5.56	5.23	4.80	4.83
22	6.14	5.56	5.23	4.80	4.33
23	6.14	5.56	5.23	4.77	4.33
24	6.10	5.52	5.17	4.77	4.33
25	6.06	5.50	4.77	4.07	4.33

Appendix C: Foaming property of the surfactant system 3 in the presence of water hardness.

Concentration of SDS = 4.00%wt. (0.122 M)
Concentration of coconut oil sodium soaps = 0.55%wt (0.0234 M)
Concentration of the synthetic of 12-15 carbon chain length detergent alcohol condensed with 7 moles of ethylene oxide = 2.40%wt. (4.69 mM)
Concentration of DEGMBE = 2.80%wt. (17.26 mM)

Table C-1 The change of foam height with time of the surfactant system 3 at 50 ppm of bivalent ions (Ca^{2+} and Mg^{2+}) using Shaking method.

Time (min)	Foam height (cm)				
	Ca^{2+} and Mg^{2+}	with HCO_3^-		with HSO_4^-	
	50 ppm	50 ppm	100 ppm	50 ppm	100 ppm
0	9.80	9.59	8.56	9.77	8.28
1	9.79	9.53	8.46	9.73	8.13
2	9.74	9.45	8.41	9.67	7.78
3	9.71	9.45	8.23	9.64	7.75
4	9.71	9.40	8.20	9.64	7.73
5	9.70	9.40	8.11	9.64	7.70
6	9.70	9.19	7.56	9.60	7.68
7	9.70	9.13	7.48	9.59	7.68
8	9.69	8.94	7.43	9.36	7.68
9	9.69	8.74	7.10	9.36	7.68
10	9.69	8.43	6.23	9.34	7.68
11	9.69	8.28	6.04	9.34	7.63
12	9.69	8.23	5.78	9.34	7.60
13	9.69	8.16	5.58	9.29	7.53
14	9.69	8.06	5.35	9.21	7.48
15	9.69	8.05	5.18	9.11	7.38

Time (min)	Foam height (cm)				
	Ca^{2+} and Mg^{2+}	with HCO_3^-		with HSO_4^-	
	50 ppm	50 ppm	100 ppm	50 ppm	100 ppm
16	9.69	7.71	5.06	9.01	7.18
17	9.69	7.61	4.80	9.00	7.18
18	9.10	7.21	4.56	8.99	7.18
19	8.51	7.19	4.40	8.99	7.13
20	8.47	7.10	4.25	8.97	6.78
21	8.40	6.25	4.16	8.39	6.63
22	8.31	6.09	4.06	8.26	6.50
23	8.27	5.98	4.00	8.24	6.38
24	7.80	5.84	3.71	8.16	6.25
25	7.64	5.83	3.60	8.07	6.23

Table C-2 The change of foam height with time of the surfactant system 3 at 150 ppm of bivalent ions (Ca^{2+} and Mg^{2+}) using Shaking method.

Time (min)	Foam height (cm)				
	Ca^{2+} and Mg^{2+}	with HCO_3^-		with HSO_4^-	
	150 ppm	50 ppm	100 ppm	50 ppm	100 ppm
0	7.76	7.56	6.73	6.70	6.73
1	7.76	7.48	6.62	6.65	6.67
2	7.70	7.43	6.40	6.65	6.63
3	7.63	7.36	6.17	6.65	6.63
4	7.56	6.81	6.12	6.65	6.57
5	7.47	6.69	6.03	6.65	6.57
6	7.21	6.54	5.88	6.65	6.57
7	6.91	6.43	5.62	6.55	6.40
8	6.91	6.33	5.55	6.20	6.20
9	6.64	6.21	5.18	6.15	5.97
10	6.31	5.95	5.10	6.15	5.67
11	6.23	5.85	4.57	5.50	4.97
12	6.16	5.49	4.50	5.25	4.70
13	5.80	5.35	4.40	5.25	4.53
14	5.69	5.18	4.33	5.25	4.47
15	5.44	5.06	4.28	5.25	4.43
16	5.21	4.69	4.23	5.10	4.33
17	5.06	4.58	4.17	4.95	4.20
18	4.96	4.31	4.07	4.65	4.07
19	4.77	4.25	4.00	4.65	4.03
20	4.59	4.18	3.90	4.60	3.87
21	4.51	4.13	3.85	4.55	3.77
22	4.47	4.08	3.78	4.50	3.50
23	4.41	3.95	3.77	4.50	3.30
24	4.33	3.80	3.75	4.50	3.17
25	4.29	3.73	3.75	4.50	3.03

Table C-3 The change of foam height with time of the surfactant system 3 at 300 ppm of bivalent ions (Ca^{2+} and Mg^{2+}) using Shaking method.

Time (min)	Foam height (cm)				
	Ca^{2+} and Mg^{2+}	with HCO_3^-		with HSO_4^-	
	300 ppm	50 ppm	100 ppm	50 ppm	100 ppm
0	6.08	5.35	5.23	5.75	5.65
1	6.01	5.28	5.22	5.68	5.58
2	6.01	5.23	5.20	5.58	5.55
3	6.00	5.23	5.17	5.55	5.55
4	5.99	5.23	5.17	5.53	5.50
5	5.93	4.90	5.15	5.50	5.43
6	5.89	4.78	5.15	5.50	5.40
7	5.85	4.70	5.08	5.48	5.33
8	5.82	4.68	4.93	5.43	5.19
9	5.68	4.60	4.93	5.35	5.13
10	5.15	4.58	4.87	5.10	5.13
11	5.11	4.33	4.47	5.10	5.13
12	5.04	4.15	3.90	5.10	5.13
13	4.98	4.13	3.80	5.05	5.08
14	4.86	4.10	3.62	5.05	5.03
15	4.80	3.98	3.57	5.03	4.95
16	4.70	3.70	3.52	5.03	4.88
17	4.64	3.68	3.40	4.98	4.88
18	4.51	3.65	3.18	4.80	4.88
19	4.46	3.60	3.17	4.78	4.88
20	4.13	3.53	3.13	4.75	4.88
21	4.11	3.50	3.13	4.75	4.80
22	3.98	3.50	3.12	4.75	4.73
23	3.94	3.45	3.07	4.73	4.73
24	3.86	3.45	3.00	4.73	4.68
25	3.64	3.38	2.95	4.20	4.58

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