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APPENDICES

Appendix A Experimental data of microemulsion formation

1. Interfacial tension (IFT)

The interfacial tension of each phase of microemulsion is calculated by following formulation :

$$\text{IFT} = e (Vd)^3 n^2 \Delta\rho \quad (\text{A.1})$$

Where

$$e = 3.427 \times 10^{-4} \text{ (mN cm}^3 \text{ min}^2 \text{/m g mm}^3 \text{)}$$

$$V = 0.31 \text{ (mm/sdv)}$$

d = measured drop diameter (sdv)

n = number of revolution (rpm)

$\Delta\rho$ = density difference of two liquids (g/cm³)

2. Experimental data of interfacial tension

Table A-1 Interfacial tension as a function of MES concentration at an oil to water volumetric ratio of 1:1

Concentration	top	bottom	d (mm)	speed(n) (rpm)	heavy phase (g)	light phase (g)	ρ heavy (g/mL)	ρ light (g/mL)	$\Delta\rho$	IFT (mN/m)
0.1	5.220	1.891	3.329	6500	0.25017	0.17749	1.00068	0.88745	0.11323	1.8019
0.2	5.317	1.902	3.415	6513	0.24932	0.22379	0.99728	0.89516	0.10212	1.7613
0.4	5.529	1.990	3.539	5812	0.25120	0.22411	1.0048	0.89644	0.10836	1.6564
0.6	5.247	2.000	3.247	5541	0.25257	0.17819	1.01028	0.8910	0.11933	1.2805
0.8	5.248	2.020	3.228	5013	0.25236	0.17778	1.00944	0.8889	0.12054	1.0402
1.0	5.211	2.050	3.161	4893	0.25147	0.17919	1.00588	0.89595	0.10993	0.8487
2.0	5.202	2.115	3.087	4458	0.25106	0.17903	1.00424	0.89515	0.10909	0.6511
3.0	5.244	2.124	3.120	4015	0.25161	0.17884	1.00644	0.8942	0.11224	0.5610
4.0	5.255	2.010	3.245	3249	0.25334	0.17925	1.01336	0.89625	0.11711	0.4313
5.0	5.252	2.202	3.050	3012	0.25210	0.1750	1.00840	0.8750	0.13340	0.3506
6.0	5.293	1.762	3.531	4087	0.25156	0.17895	1.00624	0.89475	0.11149	0.8370
8.0	5.244	2.012	3.232	5012	0.25169	0.17811	1.00676	0.89055	0.11621	1.0062
10.0	5.284	1.992	3.292	5621	0.2521	0.17795	1.00840	0.88975	0.11865	1.3654

Table A-2 Interfacial tension as a function of NaCl concentration with the concentration of 5% MES at an oil to water volumetric ratio 1:1

% NaCl	top	bottom	d (mm)	speed(n) (rpm)	heavy phase (g)	light phase (g)	ρ heavy (g/mL)	ρ light (g/mL)	$\Delta\rho$	IFT (mN/m)
0.0	5.252	2.202	3.050	3012	0.25210	0.17500	1.00840	0.87500	0.13340	0.35056
0.1	5.352	2.025	3.327	3412	0.25039	0.23115	1.00156	0.92460	0.07696	0.33685
0.2	5.391	1.968	3.423	3458	0.24935	0.23188	0.9974	0.92752	0.06988	0.34215
0.3	5.332	2.151	3.181	3310	0.25349	0.22975	1.01396	0.91900	0.09496	0.34189
0.4	5.390	2.092	3.298	3089	0.25387	0.23015	1.01548	0.92060	0.09488	0.33156
0.5	5.381	1.992	3.389	3187	0.25365	0.23195	1.01460	0.92780	0.08680	0.35035
0.6	5.342	2.397	2.945	3650	0.25394	0.22876	1.01576	0.91504	0.10072	0.34991
0.7	5.502	2.277	3.225	3569	0.25264	0.23264	1.01056	0.93056	0.08000	0.34896
0.8	5.445	2.276	3.169	3722	0.25036	0.23168	1.00144	0.92672	0.07472	0.33632
0.9	5.285	2.255	3.030	3856	0.25005	0.22975	1.00020	0.91900	0.08120	0.34289
1	5.452	2.072	3.380	3120	0.25421	0.23119	1.01684	0.92476	0.09208	0.35337

Table A-3 Interfacial tension as a function of Ethylene oxide groups and concentration of Alcohol ethoxylate at an oil to water volumetric ratio 1:1

Concentration	Interfacial tension (IFT) (mN/m)			
	3 EO group Alcohol ethoxylate	5 EO group Alcohol ethoxylate	7 EO group Alcohol ethoxylate	8 EO group Alcohol ethoxylate
0.5	0.9801	0.4412	0.3290	0.3053
1	1.0520	0.3306	0.2768	0.2768
5	0.4472	0.1374	0.1909	0.1618
10	0.2942	0.2125	0.4935	0.3829
15	*	0.3015	0.5504	1.5051

* This IFT value cannot be measured because of its high viscosity

Table A-4 Interfacial tension as a function of LAS concentration at an oil to water volumetric ratio 1:1

Concentration	top	bottom	d (mm)	speed(n) (rpm)	heavy phase (g)	light phase (g)	ρ heavy (g/mL)	ρ light (g/mL)	$\Delta\rho$	IFT (mN/m)
0.05	5.419	2.342	3.077	8425	0.20886	0.18926	1.04430	0.94630	0.09800	2.0689
0.1	5.602	2.560	3.042	8004	0.20688	0.18949	1.03440	0.94745	0.08695	1.6009
0.2	5.410	2.418	2.992	7102	0.20658	0.18666	1.03290	0.93330	0.09960	1.3737
0.4	5.362	2.475	2.887	6843	0.20106	0.18076	1.00530	0.90380	0.10150	1.1676
0.6	5.333	2.487	2.846	6184	0.20631	0.18819	1.03155	0.94095	0.09060	0.8154
0.8	5.345	2.420	2.925	6139	0.20511	0.18865	1.02555	0.94325	0.08230	0.7925
1.0	5.351	2.415	2.936	6279	0.20195	0.18721	1.00975	0.93605	0.07370	0.7508
2.0	5.319	2.438	2.881	5746	0.20472	0.18733	1.02360	0.93665	0.08695	0.7009
3.0	5.255	2.397	2.858	5550	0.20245	0.18411	1.01225	0.92055	0.09170	0.6732
4.0	5.318	2.322	2.996	5145	0.20087	0.18411	1.00435	0.92055	0.08380	0.6090
5.0	5.304	2.385	2.919	5049	0.20632	0.18803	1.03160	0.94015	0.09145	0.5920
6.0	5.160	2.355	2.805	5278	0.20300	0.18456	1.01500	0.92280	0.09220	0.5787
7.0	5.277	2.525	2.752	5111	0.20697	0.18716	1.03485	0.93580	0.09905	0.5506
8.0	5.233	2.541	2.692	5005	0.20990	0.18845	1.04950	0.94225	0.10725	0.5351
9.0	5.303	2.485	2.818	4882	0.20498	0.18782	1.02490	0.93910	0.08580	0.4672
10.0	5.164	2.545	2.619	4665	0.20803	0.18634	1.04015	0.93170	0.10845	0.4329

Table A-5 Interfacial tension as a function of MES concentration with fixed 5 %wt/v concentration of 5 EO group Alcohol ethoxylate at an oil to water volumetric ratio 1:1

Concentration	top	bottom	d (mm)	speed(n) (rpm)	heavy phase (g)	light phase (g)	ρ heavy (g/mL)	ρ light (g/mL)	$\Delta\rho$	IFT (mN/m)
0	5.216	2.435	2.781	3174	0.19934	0.18692	0.99670	0.93460	0.06210	0.1374
1	5.225	2.526	2.699	3324	0.19704	0.18484	0.98520	0.92420	0.06100	0.1353
2	5.480	2.682	2.798	3140	0.19533	0.18298	0.97665	0.91490	0.06175	0.1362
3	5.111	2.293	2.818	3625	0.20207	0.19325	1.01035	0.96625	0.04410	0.1324
4	5.398	2.699	2.699	3100	0.20061	0.18710	1.00305	0.93550	0.06755	0.1303
5	5.290	2.695	2.595	3008	0.20008	0.18501	1.00040	0.92505	0.07535	0.1216
6	5.311	2.442	2.869	3405	0.20204	0.19228	1.01020	0.96140	0.04880	0.1364
7	5.443	2.352	3.091	3500	0.20353	0.19631	1.01765	0.98155	0.03610	0.1333
8	5.343	2.475	2.868	3200	0.20230	0.19176	1.01150	0.95880	0.05270	0.1300
9	5.324	2.433	2.891	3412	0.19708	0.18772	0.98540	0.93860	0.04680	0.1344
10	5.267	2.504	2.763	3385	0.19983	0.18918	0.99915	0.94590	0.05325	0.1314

Table A-6 Interfacial tension as a function of % NaCl concentration with formulation of 5% MES and 5% AE at an oil to water volumetric ratio 1:1

Concentration	top	bottom	d (mm)	speed(n) (rpm)	heavy phase (g)	light phase (g)	ρ heavy (g/mL)	ρ light (g/mL)	$\Delta\rho$	IFT (mN/m)
0	5.290	2.695	2.595	3008	0.20008	0.18501	1.00040	0.92505	0.07535	0.1216
0.1	5.223	2.554	2.669	3015	0.19779	0.18428	0.98895	0.92140	0.06755	0.1192
0.2	5.257	2.522	2.735	2990	0.20273	0.18998	1.01365	0.94990	0.06375	0.1190
0.3	5.144	2.462	2.682	2959	0.19740	0.18497	0.98700	0.92485	0.06215	0.1072
0.4	5.261	2.584	2.677	3080	0.20055	0.18856	1.00275	0.94280	0.05995	0.1114
0.5	5.233	2.791	2.442	3176	0.20008	0.18501	1.00040	0.92505	0.07535	0.1130
0.6	5.230	2.459	2.771	3335	0.20398	0.19365	1.01990	0.96825	0.05165	0.1248
0.7	5.353	2.517	2.836	3260	0.20118	0.19112	1.00590	0.95560	0.05030	0.1245
0.8	5.210	2.365	2.845	3227	0.20536	0.19508	1.02680	0.97540	0.05140	0.1258
0.9	5.292	2.701	2.591	3457	0.19862	0.18681	0.99310	0.93405	0.05905	0.1253
1.0	5.386	2.781	2.605	3504	0.19843	0.18740	0.99215	0.93700	0.05515	0.1222

Table A-7 Interfacial tension as a function of % active surfactant concentration of the mixture of 5% MES and 5% AE at an oil to water volumetric ratio 1:1

Concentration	top	bottom	d (mm)	speed(n) (rpm)	heavy phase (g)	light phase (g)	ρ heavy (g/mL)	ρ light (g/mL)	$\Delta\rho$	IFT (mN/m)
0.3	5.241	2.648	2.593	3987	0.19789	0.18437	0.98945	0.92185	0.06760	0.1913
0.4	5.227	2.554	2.673	3367	0.20273	0.18984	1.01250	0.94920	0.06330	0.1399
0.5	5.147	2.429	2.718	2959	0.19742	0.18417	0.98710	0.92085	0.06625	0.1189
0.6	5.302	2.610	2.692	3142	0.20055	0.18871	1.00275	0.94355	0.05920	0.1164
0.7	5.311	2.648	2.663	3185	0.19987	0.18773	0.99935	0.93865	0.06070	0.1187
0.8	5.330	2.605	2.725	3354	0.20146	0.19162	1.00730	0.95810	0.04920	0.1143
0.9	5.313	2.554	2.759	3260	0.20097	0.19106	1.00485	0.95530	0.04955	0.1129
1.0	5.307	2.563	2.744	3288	0.20489	0.19522	1.02445	0.97610	0.04835	0.1103
1.2	5.295	2.677	2.618	3307	0.19854	0.18687	0.99270	0.93435	0.05835	0.1169
1.4	5.315	2.722	2.593	3489	0.19845	0.18797	0.99225	0.93985	0.05240	0.1135

Appendix B Experimental data of Detergency Experiment

1. %Detergency

The detergency performance can be determined by %Detergency calculated from the following equation:

$$\%Detergency = [(A-B)/(C_0-B)] \times 100$$

where A = average reflectance of the soiled swatches after washing

B = average reflectance of the soiled swatches before washing

C₀ = average reflectance of the unsoiled swatches before washing

2. %Oil Removal

The oil removal is calculated from the calibration curve for colored palm oil.

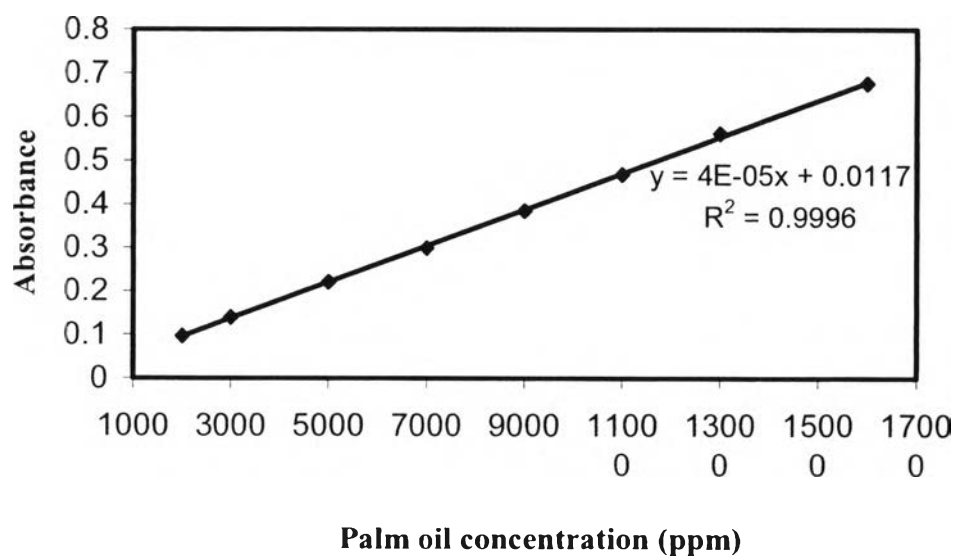


Figure B-1 Relationship between colored palm oil concentration and the absorbance measured at 520 nm

Table B-1 Relationship between colored palm oil concentration and the absorbance measured at 520 nm

Palm oil concentration (ppm)	Absorbance
2000	0.096
3000	0.139
5000	0.221
7000	0.299
9000	0.385
11000	0.469
13000	0.562
16000	0.677

3. Experimental data of detergency performance

Table B-2 %Detergency of MES at different concentration

Surfactant concentration (%wt/v)	Sample No.	Reflectance of the unsoiled swatches before washing (Co)	Reflectance of the soiled swatches before washing (B)	Reflectance of the soiled swatches after washing (A)	%Detergency	Average %Detergency
0	1	84.9100	56.1900	59.1000	10.1323	10.2220
	2	84.8900	56.2000	59.1900	10.4217	
	3	84.9200	56.3400	59.2300	10.1120	
1	1	84.9500	56.6400	67.7900	39.3854	37.3122
	2	84.8200	56.5000	67.1600	37.6412	
	3	84.9100	56.5800	66.4700	34.9100	
2	1	84.9200	56.6000	67.5000	38.4887	38.6157
	2	84.9500	56.4900	67.5500	38.8616	
	3	84.8900	56.5500	67.4600	38.4968	
3	1	84.9300	56.6100	67.9400	40.0071	40.9743
	2	84.8800	56.5900	68.1000	40.6858	
	3	84.7900	56.5400	68.4700	42.2301	
4	1	84.8000	56.4700	68.8500	43.6993	44.5429
	2	84.9500	56.6300	69.6400	45.9393	
	3	84.8700	56.5000	68.9800	43.9901	

Table B-2 %Detergency of MES at different concentration (Cont.)

Surfactant concentration (%wt/v)	Sample No.	Reflectance of the unsoiled swatches before washing (Co)	Reflectance of the soiled swatches before washing (B)	Reflectance of the soiled swatches after washing (A)	%Detergency	Average %Detergency
5	1	84.9400	56.5200	71.3000	52.0056	50.9865
	2	84.9000	56.6400	71.2300	51.6277	
	3	84.8200	56.6200	70.5300	49.3262	
6	1	84.8700	56.5900	71.1100	51.3437	51.2361
	2	84.9400	56.4900	70.9500	50.8260	
	3	84.9000	56.6300	71.2000	51.5387	
7	1	84.9300	56.8400	71.1200	50.8366	51.0341
	2	84.8800	56.3800	70.8800	50.8772	
	3	84.7900	56.3400	70.9600	51.3884	
8	1	84.8000	56.0400	70.7900	51.2865	50.9918
	2	84.9500	56.5300	71.2200	51.6890	
	3	84.8700	56.8300	70.8500	50.0000	
9	1	84.9200	56.1900	70.8300	50.9572	50.9574
	2	84.9500	56.1900	70.7500	50.6259	
	3	84.8900	56.1900	70.9100	51.2892	
10	1	84.9400	56.1400	70.8900	51.2153	51.0507
	2	84.9000	56.4500	70.9400	50.9315	
	3	84.8200	56.4700	70.9300	51.0053	

Table B-3 %Detergency of 5 EO group Alcohol ethoxylate at different concentration

Surfactant concentration (%wt/v)	Sample No.	Reflectance of the unsoiled swatches before washing (Co)	Reflectance of the soiled swatches before washing (B)	Reflectance of the soiled swatches after washing (A)	%Detergency	Average %Detergency
0	1	84.9100	56.1900	59.1000	10.1323	10.2220
	2	84.8900	56.2000	59.1900	10.4217	
	3	84.9200	56.3400	59.2300	10.1120	
1	1	84.9500	56.6400	70.6200	49.3818	50.7647
	2	84.8200	56.5000	70.7800	50.4237	
	3	84.9100	56.5800	71.4500	52.4885	
2	1	84.9200	56.6000	71.5000	52.6130	52.9716
	2	84.9500	56.4900	71.6800	53.3732	
	3	84.8900	56.5500	71.5500	52.9287	
3	1	84.9300	56.6100	72.7100	56.8503	56.8938
	2	84.8800	56.5900	72.6500	56.7692	
	3	84.7900	56.5400	72.6600	57.0619	
4	1	84.8000	56.4700	73.0200	58.4186	58.2686
	2	84.9500	56.6300	73.1000	58.1568	
	3	84.8700	56.5000	73.0200	58.2305	

Table B-3 %Detergency of 5 EO group Alcohol ethoxylate at different concentration (**Cont.**)

Surfactant concentration (%wt/v)	Sample No.	Reflectance of the unsoiled swatches before washing (Co)	Reflectance of the soiled swatches before washing (B)	Reflectance of the soiled swatches after washing (A)	%Detergency	Average %Detergency
5	1	84.9400	56.5200	73.6000	60.0985	60.0609
	2	84.9000	56.6400	73.7200	60.4388	
	3	84.8200	56.6200	73.4400	59.6454	
6	1	84.8700	56.5900	73.6000	60.1485	60.0931
	2	84.9400	56.4900	73.7200	60.5624	
	3	84.9000	56.6300	73.4700	59.5684	
7	1	84.9500	56.5700	73.6000	60.0070	60.1113
	2	84.8500	56.5900	73.7300	60.6511	
	3	84.9100	56.5400	73.4700	59.6757	
8	1	84.9200	56.4700	73.4600	59.7188	60.1382
	2	84.9500	56.6300	73.6100	59.9576	
	3	84.8900	56.4400	73.7200	60.7381	
9	1	84.9300	56.6200	73.4600	59.4843	59.8678
	2	84.8800	56.6400	73.7500	60.5878	
	3	84.7900	56.6200	73.3900	59.5314	
10	1	84.8000	56.5900	73.2600	59.0925	60.0030
	2	84.9500	56.4900	73.7200	60.5411	
	3	84.8700	56.6300	73.6800	60.3754	

Table B-4 %Detergency of LAS at different concentration

Surfactant concentration (%wt/v)	Sample No.	Reflectance of the unsoiled swatches before washing (Co)	Reflectance of the soiled swatches before washing (B)	Reflectance of the soiled swatches after washing (A)	%Detergency	Average %Detergency
0	1	84.91	56.19	59.10	10.1323	10.2220
	2	84.89	56.20	59.19	10.4217	
	3	84.92	56.34	59.23	10.1120	
1	1	84.95	59.75	65.12	21.3095	20.7547
	2	84.85	60.35	65.02	19.0612	
	3	84.91	59.56	65.11	21.8935	
2	1	84.92	59.56	65.87	24.8817	24.7685
	2	84.95	59.7	65.79	24.1188	
	3	84.89	59.48	65.91	25.3050	
3	1	84.93	59.27	66.34	27.5526	27.1121
	2	84.88	59.33	66.45	27.8669	
	3	84.79	60.25	66.61	25.9169	
4	1	84.80	58.42	66.47	30.5155	30.4842
	2	84.95	58.49	66.6	30.6500	
	3	84.87	58.39	66.41	30.2870	

Table B-4 %Detergency of LAS at different concentration

Surfactant concentration (%wt/v)	Sample No.	Reflectance of the unsoiled swatches before washing (Co)	Reflectance of the soiled swatches before washing (B)	Reflectance of the soiled swatches after washing (A)	%Detergency	Average %Detergency
5	1	84.93	58.19	66.87	32.4607	32.1492
	2	84.88	59.56	67.68	32.0695	
	3	84.79	58.19	66.68	31.9173	
6	1	84.80	59.56	68.01	33.4786	35.1077
	2	84.95	57.45	67.46	36.4000	
	3	84.87	58.66	67.95	35.4445	
7	1	84.95	58.55	69.14	40.1136	40.8378
	2	84.82	58.14	69.23	41.5667	
	3	84.91	59.22	69.71	40.8330	
8	1	84.92	60.84	70.85	41.5698	41.3151
	2	84.95	59.38	70.02	41.6113	
	3	84.89	61.34	70.94	40.7643	
9	1	84.94	60.04	70.49	41.9679	41.2149
	2	84.90	59.53	70.11	41.7028	
	3	84.82	61.83	71.02	39.9739	
10	1	84.87	59.34	70.01	41.7940	41.9072
	2	84.94	59.34	70.09	41.9922	
	3	84.90	59.48	70.14	41.9355	

Table B-6 %Detergency of various MES concentration at fixed 5% AE concentration

Surfactant concentration (%wt/v)	Sample No.	Reflectance of the unsoiled swatches before washing (Co)	Reflectance of the soiled swatches before washing (B)	Reflectance of the soiled swatches after washing (A)	%Detergency	Average %Detergency
0	1	84.9100	56.1900	59.1000	10.1323	10.2220
	2	84.8900	56.2000	59.1900	10.4217	
	3	84.9200	56.3400	59.2300	10.1120	
1	1	84.9900	56.6300	71.2800	51.6573	51.6242
	2	84.8500	56.7400	71.3600	52.0100	
	3	84.8900	57.1000	71.3300	51.2055	
2	1	84.9300	56.5800	71.6100	53.0159	52.9248
	2	84.9700	56.8700	71.6800	52.7046	
	3	84.8500	56.6900	71.6300	53.0540	
3	1	84.9500	56.5800	72.7700	57.0673	56.5724
	2	84.9100	56.8900	72.6300	56.1742	
	3	84.9000	56.6400	72.6000	56.4756	
4	1	84.8600	56.9700	73.4100	58.9459	58.3160
	2	84.7900	56.9500	73.1100	58.0460	
	3	84.9200	56.6400	73.0300	57.9562	

Table B-6 %Detergency of various MES concentration at fixed 5% AE concentration (**Cont.**)

Surfactant concentration (%wt/v)	Sample No.	Reflectance of the unsoiled swatches before washing (Co)	Reflectance of the soiled swatches before washing (B)	Reflectance of the soiled swatches after washing (A)	%Detergency	Average %Detergency
5	1	84.9500	56.6900	73.6500	60.0142	60.1430
	2	84.8200	56.8900	73.7300	60.2936	
	3	84.8000	56.7400	73.6100	60.1212	
6	1	84.7700	56.6200	73.7700	60.9236	60.3155
	2	84.9600	56.4700	73.8000	60.8284	
	3	84.9300	56.8700	73.4800	59.1946	
7	1	84.8900	56.5500	73.6000	60.1623	60.4169
	2	84.8200	56.5100	73.7200	60.7912	
	3	84.8800	56.6200	73.6600	60.2972	
8	1	84.9100	56.4800	73.7900	60.8864	60.4151
	2	84.9300	56.6800	73.6300	60.0000	
	3	84.9700	56.5400	73.7000	60.3588	
9	1	84.9300	56.6500	73.6800	60.2192	60.5587
	2	84.8700	56.7000	73.7800	60.6319	
	3	84.9600	56.6000	73.8500	60.8251	
10	1	84.6900	56.4400	73.7100	61.1327	60.8808
	2	84.7300	56.4800	73.7200	61.0265	
	3	84.9800	56.4100	73.6900	60.4830	

Table B-7 %Detergency of various active surfactant concentration at the mixture of 5% MES and 5% AE

Active surfactant concentration (%wt/v)	Sample No.	Reflectance of the unsoiled swatches before washing (Co)	Reflectance of the soiled swatches before washing (B)	Reflectance of the soiled swatches after washing (A)	%Detergency	Average %Detergency
0	1	84.9100	56.1900	59.1000	10.1323	10.2220
	2	84.8900	56.2000	59.1900	10.4217	
	3	84.9200	56.3400	59.2300	10.1120	
0.30	1	84.8900	56.7200	71.1600	51.2602	51.3037
	2	84.9100	56.7900	71.3500	51.7781	
	3	84.8700	56.8000	71.0800	50.8728	
0.40	1	84.9000	58.7400	73.2900	55.6193	56.4332
	2	84.8800	58.7100	73.5700	56.7826	
	3	84.9300	58.6900	73.6200	56.8979	
0.50	1	84.8500	58.5500	74.4100	60.3042	60.0556
	2	84.7900	58.6100	74.3900	60.2750	
	3	84.9100	58.7300	74.3300	59.5875	
0.60	1	84.8500	58.5600	74.3700	60.1369	59.9572
	2	84.8700	58.4500	74.3000	59.9924	
	3	84.9100	58.5300	74.2900	59.7422	

Table B-7 %Detergency of various active surfactant concentration of the mixture of 5% MES and 5% AE (Cont.)

Active surfactant concentration (%wt/v)	Sample No.	Reflectance of the unsoiled swatches before washing (Co)	Reflectance of the soiled swatches before washing (B)	Reflectance of the soiled swatches after washing (A)	%Detergency	Average %Detergency
0.70	1	84.8900	59.9100	75.0400	60.5927	60.4367
	2	84.7700	59.9900	75.0100	60.5157	
	3	84.8300	60.0400	74.9700	60.2016	
0.80	1	84.9400	58.6400	74.4700	60.1901	60.3078
	2	84.9100	59.3200	74.7600	60.3361	
	3	84.8900	59.2100	74.7200	60.3972	
0.90	1	84.8800	59.5600	74.7700	60.0711	60.5851
	2	84.9300	58.8700	74.5900	60.3223	
	3	84.9000	58.7600	74.8000	61.3619	
1.00	1	84.8800	57.6500	74.2400	60.9254	60.5930
	2	84.9100	57.4900	74.1700	60.8315	
	3	84.9000	57.8600	74.0900	60.0222	
1.20	1	84.8000	57.7400	74.1000	60.4582	60.7356
	2	84.7700	57.9100	74.1500	60.4617	
	3	84.7500	57.5500	74.2200	61.2868	
1.40	1	84.8800	57.5400	74.0500	60.3877	60.5822
	2	84.8100	56.9800	73.9200	60.8696	
	3	84.8400	57.0500	73.8600	60.4894	

Table B-8 %Detergency of various active surfactant concentration of commercial detergent

Active surfactant concentration (%wt/v)	Sample No.	Reflectance of the unsoiled swatches before washing (Co)	Reflectance of the soiled swatches before washing (B)	Reflectance of the soiled swatches after washing (A)	%Detergency	Average %Detergency
0	1	84.9100	56.1900	59.1000	10.1323	10.2220
	2	84.8900	56.2000	59.1900	10.4217	
	3	84.9200	56.3400	59.2300	10.1120	
0.30	1	84.8700	55.5800	62.3600	23.1478	23.1744
	2	84.9400	55.2700	62.3200	23.7614	
	3	84.9000	56.8200	63.1700	22.6140	
0.40	1	84.9500	58.7500	65.4100	25.4198	26.7104
	2	84.8500	59.6500	67.0700	29.4444	
	3	84.9100	58.6700	65.3000	25.2668	
0.50	1	84.9300	58.8000	67.6200	33.7543	36.9076
	2	84.8800	59.2700	69.5400	40.1015	
	3	84.7900	57.3400	67.4600	36.8670	
0.60	1	84.9300	59.7000	68.3600	34.3242	31.4208
	2	84.8800	60.3600	67.4100	28.7520	
	3	84.7900	61.3500	68.6600	31.1860	

Table B-8 %Detergency of various active surfactant concentration of commercial detergent (Cont.)

Active surfactant concentration (%wt/v)	Sample No.	Reflectance of the unsoiled swatches before washing (Co)	Reflectance of the soiled swatches before washing (B)	Reflectance of the soiled swatches after washing (A)	%Detergency	Average %Detergency
0.70	1	84.8000	59.9000	67.9900	32.3083	32.5517
	2	84.9500	60.3500	68.2600	32.2200	
	3	84.8700	60.6100	68.6300	33.1268	
0.80	1	84.9500	58.4200	68.6200	38.4470	37.1046
	2	84.8200	59.7500	68.6900	35.6602	
	3	84.9100	58.9200	68.5900	37.2066	
0.90	1	84.9200	59.3400	69.2600	38.7803	40.2814
	2	84.9500	58.2900	70.4200	45.4989	
	3	84.8900	58.6900	68.2700	36.5649	
1.00	1	84.9200	60.1400	70.3200	41.0815	42.4330
	2	84.9500	57.4000	69.4500	43.7387	
	3	84.8900	57.7000	69.2500	42.4789	
1.20	1	84.8000	55.3600	69.4300	47.7921	42.4813
	2	84.9500	57.1900	68.2700	39.9135	
	3	84.8700	58.1200	68.7500	39.7383	
1.40	1	84.9400	57.3100	68.5700	40.7528	42.4856
	2	84.9000	56.7100	68.4400	41.6105	
	3	84.8200	54.8600	68.3700	45.0935	

Table B-9 %Oil Removal of MES at different concentration

Surfactant concentration (%wt/v)	Sample No.	Reflectance of extracted soil before washing	Amount of applied soiled (%)	Reflectance of extracted soil after washing	Amount of residual soiled (%)	Soil removal (%)	Average soil removal (%)
0	1	0.3400	82.0750	0.3060	73.5750	10.3564	10.5885
	2	0.3420	82.5750	0.3050	73.3250	11.2019	
	3	0.3350	80.8250	0.3020	72.5750	10.2072	
1	1	0.3350	80.8250	0.1910	44.8250	44.5407	44.6526
	2	0.3410	82.3250	0.1950	45.8250	44.3365	
	3	0.3400	82.0750	0.1920	45.0750	45.0807	
2	1	0.3400	82.0750	0.1770	41.3250	49.6497	49.5463
	2	0.3390	81.8250	0.1780	41.5750	49.1903	
	3	0.3350	80.8250	0.1740	40.5750	49.7989	
3	1	0.3410	82.3250	0.1650	38.3250	53.4467	53.2095
	2	0.3380	81.5750	0.1640	38.0750	53.3252	
	3	0.3390	81.8250	0.1660	38.5750	52.8567	
4	1	0.3380	81.5750	0.1520	35.0750	57.0028	57.2363
	2	0.3370	81.3250	0.1500	34.5750	57.4854	
	3	0.3420	82.5750	0.1530	35.3250	57.2207	
5	1	0.3350	80.8250	0.1400	32.0750	60.3155	60.5552
	2	0.3410	82.3250	0.1410	32.3250	60.7349	
	3	0.3400	82.0750	0.1410	32.3250	60.6153	

Table B-9 %Oil Removal of MES at different concentration (Cont.)

Surfactant concentration (%wt/v)	Sample No.	Reflectance of extracted soil before washing	Amount of applied soiled (%)	Reflectance of extracted soil after washing	Amount of residual soiled (%)	Soil removal (%)	Average soil removal (%)
6	1	0.3370	81.3250	0.1380	31.5750	61.1743	60.6616
	2	0.3350	80.8250	0.1400	32.0750	60.3155	
	3	0.3390	81.8250	0.1410	32.3250	60.4950	
7	1	0.3380	81.5750	0.1410	32.3250	60.3739	60.6623
	2	0.3370	81.3250	0.1390	31.8250	60.8669	
	3	0.3360	81.0750	0.1390	31.8250	60.7462	
8	1	0.3400	82.0750	0.1400	32.0750	60.9199	61.0430
	2	0.3370	81.3250	0.1390	31.8250	60.8669	
	3	0.3410	82.3250	0.1390	31.8250	61.3422	
9	1	0.3380	81.5750	0.1390	31.8250	60.9868	61.3092
	2	0.3390	81.8250	0.1380	31.5750	61.4115	
	3	0.3400	82.0750	0.1380	31.5750	61.5291	
10	1	0.3360	81.0750	0.1390	31.8250	60.7462	61.2525
	2	0.3380	81.5750	0.1370	31.3250	61.5998	
	3	0.3390	81.8250	0.1380	31.5750	61.4115	

Table B-10 %Oil Removal of 5 EO group AE at different concentration

Surfactant concentration (%wt/v)	Sample No.	Reflectance of extracted soil before washing	Amount of applied soiled (%)	Reflectance of extracted soil after washing	Amount of residual soiled (%)	Soil removal (%)	Average soil removal (%)
0	1	0.3400	82.0750	0.3060	73.5750	10.3564	10.5885
	2	0.3420	82.5750	0.3050	73.3250	11.2019	
	3	0.3350	80.8250	0.3020	72.5750	10.2072	
1	1	0.3340	80.5750	0.1350	30.8250	61.7437	62.6363
	2	0.3350	80.8250	0.1310	29.8250	63.0993	
	3	0.3320	80.0750	0.1300	29.5750	63.0659	
2	1	0.3400	82.0750	0.1230	27.8250	66.0981	66.0612
	2	0.3380	81.5750	0.1240	28.0750	65.5838	
	3	0.3350	80.8250	0.1200	27.0750	66.5017	
3	1	0.3390	81.8250	0.1130	25.3250	69.0498	69.6817
	2	0.3370	81.3250	0.1100	24.5750	69.7817	
	3	0.3350	80.8250	0.1080	24.0750	70.2134	
4	1	0.3350	80.8250	0.1010	22.3250	72.3786	72.3325
	2	0.3340	80.5750	0.1010	22.3250	72.2929	
	3	0.3380	81.5750	0.1020	22.5750	72.3261	
5	1	0.3370	81.3250	0.0930	19.8740	75.5623	75.5287
	2	0.3360	81.0750	0.0920	19.8210	75.5523	
	3	0.3350	80.8250	0.0910	19.8250	75.4717	

Table B-10 %Oil Removal of 5 EO group AE at different concentration (Cont.)

Surfactant concentration (%wt/v)	Sample No.	Reflectance of extracted soil before washing	Amount of applied soiled (%)	Reflectance of extracted soil after washing	Amount of residual soiled (%)	Soil removal (%)	Average soil removal (%)
6	1	0.3370	81.3250	0.090	19.575	75.9299	76.2245
	2	0.3320	80.0750	0.087	18.825	76.4908	
	3	0.3330	80.3250	0.088	19.075	76.2527	
7	1	0.3350	80.8250	0.087	18.825	76.7089	76.6706
	2	0.3380	81.5750	0.090	19.575	76.0037	
	3	0.3390	81.8250	0.086	18.575	77.2991	
8	1	0.3380	81.5750	0.087	18.825	76.9231	76.3925
	2	0.3360	81.0750	0.089	19.325	76.1640	
	3	0.3350	80.8250	0.089	19.325	76.0903	
9	1	0.3410	82.3250	0.089	19.325	76.5260	76.7439
	2	0.3380	81.5750	0.088	19.075	76.6166	
	3	0.3360	81.0750	0.086	18.575	77.0891	
10	1	0.3330	80.3250	0.087	18.825	76.5640	76.7301
	2	0.3380	81.5750	0.085	18.325	77.5360	
	3	0.3350	80.8250	0.089	19.325	76.0903	

Table B-11 %Oil Removal of various MES concentration at fixed 5% AE

Surfactant concentration (%wt/v)	Sample No.	Reflectance of extracted soil before washing	Amount of applied soiled (%)	Reflectance of extracted soil after washing	Amount of residual soiled (%)	Soil removal (%)	Average soil removal (%)
0	1	0.3400	82.0750	0.3060	73.5750	10.3564	10.5885
	2	0.3420	82.5750	0.3050	73.3250	11.2019	
	3	0.3350	80.8250	0.3020	72.5750	10.2072	
1	1	0.3370	81.3250	0.1340	30.5750	62.4039	62.9111
	2	0.3320	80.0750	0.1300	29.5750	63.0659	
	3	0.3310	79.8250	0.1290	29.3250	63.2634	
2	1	0.3360	81.0750	0.1210	27.3250	66.2966	66.4346
	2	0.3330	80.3250	0.1190	26.8250	66.6044	
	3	0.3400	82.0750	0.1220	27.5750	66.4027	
3	1	0.3380	81.5750	0.1070	23.8250	70.7937	70.6275
	2	0.3390	81.8250	0.1050	23.3250	71.4940	
	3	0.3350	80.8250	0.1100	24.5750	69.5948	
4	1	0.3360	81.0750	0.0840	18.0750	77.7058	76.8113
	2	0.3320	80.0750	0.0870	18.8250	76.4908	
	3	0.3370	81.3250	0.0890	19.3250	76.2373	
5	1	0.3340	80.5750	0.0730	15.3250	80.9805	80.5847
	2	0.3380	81.5750	0.0740	15.5750	80.9071	
	3	0.3410	82.3250	0.0780	16.5750	79.8664	

Table B-11 %Oil Removal of various MES concentration at fixed 5% AE (Cont.)

Surfactant concentration (%wt/v)	Sample No.	Reflectance of extracted soil before washing	Amount of applied soiled (%)	Reflectance of extracted soil after washing	Amount of residual soiled (%)	Soil removal (%)	Average soil removal (%)
6	1	0.3360	81.0750	0.0730	15.3250	81.0977	80.8367
	2	0.3370	81.3250	0.0770	16.3250	79.9262	
	3	0.3320	80.0750	0.0710	14.8250	81.4861	
7	1	0.3340	80.5750	0.0750	15.8250	80.3599	80.4196
	2	0.3360	81.0750	0.0720	15.0750	81.4061	
	3	0.3350	80.8250	0.0780	16.5750	79.4927	
8	1	0.3400	82.0750	0.0730	15.3250	81.3281	80.7009
	2	0.3370	81.3250	0.0760	16.0750	80.2336	
	3	0.3370	81.3250	0.0750	15.8250	80.5410	
9	1	0.3360	81.0750	0.0740	15.5750	80.7894	80.7704
	2	0.3330	80.3250	0.0730	15.3250	80.9213	
	3	0.3380	81.5750	0.0750	15.8250	80.6007	
10	1	0.3370	81.3250	0.0720	15.0750	81.4633	80.9467
	2	0.3390	81.8250	0.0770	16.3250	80.0489	
	3	0.3400	82.0750	0.0730	15.3250	81.3281	

Table B-12 %Oil Removal of active surfactant concentration at the mixture of 5% MES and 5% AE

Active surfactant concentration (%wt/v)	Sample No.	Reflectance of extracted soil before washing	Amount of applied soiled (%)	Reflectance of extracted soil after washing	Amount of residual soiled (%)	Soil removal (%)	Average soil removal (%)
0	1	0.3400	82.0750	0.3060	73.5750	10.3564	10.5885
	2	0.3420	82.5750	0.3050	73.3250	11.2019	
	3	0.3350	80.8250	0.3020	72.5750	10.2072	
0.3	1	0.3390	81.8250	0.1160	26.0750	68.1332	68.2664
	2	0.3410	82.3250	0.1150	25.8250	68.6304	
	3	0.3380	81.5750	0.1160	26.0750	68.0356	
0.4	1	0.3400	82.0750	0.0830	17.8250	78.2821	78.2737
	2	0.3370	81.3250	0.0810	17.3250	78.6966	
	3	0.3380	81.5750	0.0840	18.0750	77.8425	
0.5	1	0.3390	81.8250	0.0760	16.0750	80.3544	80.3954
	2	0.3410	82.3250	0.0780	16.5750	79.8664	
	3	0.3390	81.8250	0.0740	15.5750	80.9655	
0.6	1	0.3370	81.3250	0.0750	15.8250	80.5410	80.4990
	2	0.3380	81.5750	0.0740	15.5750	80.9071	
	3	0.3390	81.8250	0.0770	16.3250	80.0489	

Table B-12 %Oil Removal of active surfactant concentration at the mixture of 5% MES and 5% AE (Cont.)

Active surfactant concentration (%wt/v)	Sample No.	Reflectance of extracted soil before washing	Amount of applied soiled (%)	Reflectance of extracted soil after washing	Amount of residual soiled (%)	Soil removal (%)	Average soil removal (%)
0.7	1	0.3370	81.3250	0.0740	15.5750	80.8484	80.8296
	2	0.3340	80.5750	0.0730	15.3250	80.9805	
	3	0.3390	81.8250	0.0750	15.8250	80.6599	
0.8	1	0.3400	82.0750	0.0730	15.3250	81.3281	80.8229
	2	0.3380	81.5750	0.0740	15.5750	80.9071	
	3	0.3370	81.3250	0.0760	16.0750	80.2336	
0.9	1	0.3400	82.0750	0.0750	15.8250	80.7189	80.6601
	2	0.3380	81.5750	0.0740	15.5750	80.9071	
	3	0.3390	81.8250	0.0760	16.0750	80.3544	
1.0	1	0.3390	81.8250	0.0750	15.8250	80.6599	80.6607
	2	0.3410	82.3250	0.0760	16.0750	80.4737	
	3	0.3370	81.3250	0.0740	15.5750	80.8484	
1.2	1	0.3360	81.0750	0.0750	15.8250	80.4810	80.6203
	2	0.3400	82.0750	0.0760	16.0750	80.4143	
	3	0.3390	81.8250	0.0740	15.5750	80.9655	
1.4	1	0.3390	81.8250	0.0740	15.5750	80.9655	80.6403
	2	0.3370	81.3250	0.0750	15.8250	80.5410	
	3	0.3400	82.0750	0.0760	16.0750	80.4143	

Table B-13 %Oil Removal of active surfactant concentration of commercial detergent

Active surfactant concentration (%wt/v)	Sample No.	Reflectance of extracted soil before washing	Amount of applied soiled (%)	Reflectance of extracted soil after washing	Amount of residual soiled (%)	Soil removal (%)	Average soil removal (%)
0	1	0.3400	82.0750	0.3060	73.5750	10.3564	10.5885
	2	0.3420	82.5750	0.3050	73.3250	11.2019	
	3	0.3350	80.8250	0.3020	72.5750	10.2072	
0.3	1	0.3410	82.3250	0.2830	67.8250	17.6131	17.1931
	2	0.3380	81.5750	0.2820	67.5750	17.1621	
	3	0.3390	81.8250	0.2840	68.0750	16.8042	
0.4	1	0.3410	82.3250	0.2730	65.3250	20.6499	19.9767
	2	0.3360	81.0750	0.2750	65.8250	18.8097	
	3	0.3390	81.8250	0.2720	65.0750	20.4705	
0.5	1	0.3400	82.0750	0.2610	62.3250	24.0634	23.4771
	2	0.3390	81.8250	0.2650	63.3250	22.6092	
	3	0.3400	82.0750	0.2620	62.5750	23.7588	
0.6	1	0.3380	81.5750	0.2440	58.0750	28.8078	27.7208
	2	0.3360	81.0750	0.2480	59.0750	27.1354	
	3	0.3350	80.8250	0.2470	58.8250	27.2193	

Table B-13 %Oil Removal of active surfactant concentration of commercial detergent (Cont.)

Active surfactant concentration (%wt/v)	Sample No.	Reflectance of extracted soil before washing	Amount of applied soiled (%)	Reflectance of extracted soil after washing	Amount of residual soiled (%)	Soil removal (%)	Average soil removal (%)
0.7	1	0.3330	80.3250	0.2380	56.5750	29.5674	31.3804
	2	0.3420	82.5750	0.2350	55.8250	32.3948	
	3	0.3380	81.5750	0.2330	55.3250	32.1790	
0.8	1	0.3410	82.3250	0.2290	54.3250	34.0115	34.0455
	2	0.3420	82.5750	0.2280	54.0750	34.5141	
	3	0.3360	81.0750	0.2270	53.8250	33.6109	
0.9	1	0.3400	82.0750	0.2180	51.5750	37.1611	37.1843
	2	0.3390	81.8250	0.2170	51.3250	37.2747	
	3	0.3350	80.8250	0.2150	50.8250	37.1172	
1.0	1	0.3380	81.5750	0.1990	46.8250	42.5988	42.6724
	2	0.3370	81.3250	0.1980	46.5750	42.7298	
	3	0.3420	82.5750	0.2010	47.3250	42.6885	
1.2	1	0.3350	80.8250	0.1960	46.0750	42.9941	42.9199
	2	0.3410	82.3250	0.1990	46.8250	43.1218	
	3	0.3400	82.0750	0.2000	47.0750	42.6439	
1.4	1	0.3380	81.5750	0.1960	46.0750	43.5182	43.0663
	2	0.3340	80.5750	0.1950	45.8250	43.1275	
	3	0.3360	81.0750	0.1980	46.5750	42.5532	

Table B-14 %Oil Removal of LAS at different concentration

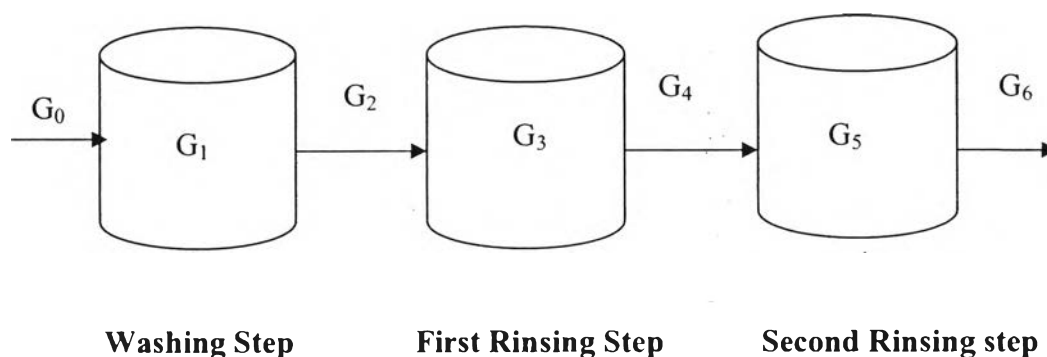
Active surfactant concentration (%wt/v)	Sample No.	Reflectance of extracted soil before washing	Amount of applied soiled (%)	Reflectance of extracted soil after washing	Amount of residual soiled (%)	Soil removal (%)	Average soil removal (%)
0	1	0.3400	82.0750	0.3060	73.5750	10.3564	10.5885
	2	0.3420	82.5750	0.3050	73.3250	11.2019	
	3	0.3350	80.8250	0.3020	72.5750	10.2072	
1	1	0.3380	81.5750	0.2840	63.1200	22.6234	22.6634
	2	0.3370	81.3250	0.2850	63.1900	22.2994	
	3	0.3420	82.5750	0.2830	63.5270	23.0675	
2	1	0.3380	81.5750	0.2790	59.5560	26.9923	26.5631
	2	0.3340	80.5750	0.2700	59.1450	26.5963	
	3	0.3360	81.0750	0.2710	59.9140	26.1005	
3	1	0.3350	80.8250	0.2510	57.1510	29.2904	30.1599
	2	0.3410	82.3250	0.2550	57.0020	30.7598	
	3	0.3400	82.0750	0.2540	57.1000	30.4295	
4	1	0.3400	82.0750	0.2300	54.5750	33.5059	32.9948
	2	0.3390	81.8250	0.2320	55.0750	32.6917	
	3	0.3350	80.8250	0.2290	54.3250	32.7869	
5	1	0.3330	80.3250	0.2220	52.5750	34.5472	36.0839
	2	0.3420	82.5750	0.2180	51.5750	37.5416	
	3	0.3380	81.5750	0.2200	52.0750	36.1630	

Table B-14 %Oil Removal of LAS at different concentration (Cont.)

Active surfactant concentration (%wt/v)	Sample No.	Reflectance of extracted soil before washing	Amount of applied soiled (%)	Reflectance of extracted soil after washing	Amount of residual soiled (%)	Soil removal (%)	Average soil removal (%)
6	1	0.3410	82.3250	0.2120	50.0750	39.1740	39.3321
	2	0.3420	82.5750	0.2110	49.8250	39.6609	
	3	0.3360	81.0750	0.2090	49.3250	39.1613	
7	1	0.3400	82.0750	0.1930	45.3250	44.7761	45.2282
	2	0.3390	81.8250	0.1910	44.8250	45.2185	
	3	0.3400	82.0750	0.1900	44.5750	45.6899	
8	1	0.3380	81.5750	0.1850	43.3250	46.8894	45.8955
	2	0.3360	81.0750	0.1890	44.3250	45.3284	
	3	0.3350	80.8250	0.1880	44.0750	45.4686	
9	1	0.3410	82.3250	0.1850	43.3250	47.3732	47.4106
	2	0.3380	81.5750	0.1840	43.0750	47.1958	
	3	0.3390	81.8250	0.1830	42.8250	47.6627	
10	1	0.3410	82.3250	0.1820	42.5750	48.2842	47.8132
	2	0.3360	81.0750	0.1800	42.0750	48.1036	
	3	0.3390	81.8250	0.1850	43.3250	47.0516	

Appendix C Experimental data of Residual Surfactant Adsorption on Fabric after Rinsing Determination

The amount of residual surfactant adsorption on the fabric after rinsing can be calculated from mass balance principle



Where

G_0 is the initial weight of prepared surfactant

G_1 is the weight of surfactant after washing, obtained from titration method

G_2 , $(G_0 - G_1)$, is the weight of residual surfactant on the fabric after washing

G_3 is the weight of surfactant after first rinsing, obtained from titration method

G_4 , $(G_2 - G_3)$, is the weight of residual surfactant on the fabric after first rinsing

G_5 is the weight of surfactant after second rinsing, obtained from titration method

G_6 , $(G_4 - G_5)$, is the weight of residual surfactant on the fabric after second or last rinsing

Table C-1 Titration of MES at 5%wt/v optimum concentration

Cleaning step	Standard surfactant		Sample surfactant		Weight of anionic sample surfactant (gram)	Weight of total sample surfactant (gram)	
	Used volume (V_1) (μL)	Concentration (M_1), (mol/L)	Used volume (V_2) (μL)	Concentration (M_2) (mol/L)			
Washing	77	0.005	3	0.1283	49.1145	49.1145	G ₁
Rinsing 1	20	0.005	70	1.429E-03	0.5467	0.5467	G ₃
Rinsing 2	1	0.005	540	9.259E-06	3.544E-03	3.544E-03	G ₅

Table C-2 Titration of LAS at 7%wt/v optimum concentration

Cleaning step	Standard surfactant		Sample surfactant		Weight of anionic sample surfactant (gram)	Weight of total sample surfactant (gram)	
	Used volume (V_1) (μL)	Concentration (M_1), (mol/L)	Used volume (V_2) (μL)	Concentration (M_2) (mol/L)			
Washing	81	0.005	2	0.2025	69.6600	69.6600	G ₁
Rinsing 1	20	0.005	1000	1.000E-04	0.0344	0.0344	G ₃
Rinsing 2	10	0.005	5200	9.615E-06	0.00331	0.00331	G ₅

Table C-3 Titration of mixed system 5% MES and 5% AE at 0.5% active surfactant concentration

Cleaning step	Standard surfactant		Sample surfactant		Weight of anionic sample surfactant (gram)	Weight of total sample surfactant (gram)	
	Used volume (V_1) (μL)	Concentration (M_1), (mol/L)	Used volume (V_2) (μL)	Concentration (M_2) (mol/L)			
Washing	20	0.005	17.5	0.0057	2.2537	4.5074	G ₁
Rinsing 1	5	0.005	120	2.083E-04	0.0822	0.1643	G ₃
Rinsing 2	0.2	0.005	7000	1.429E-07	5.634E-05	1.1269E-04	G ₅

Table C-4 Titration of commercial detergent at 1% active surfactant concentration

Cleaning step	Standard surfactant		Sample surfactant		Weight of anionic sample surfactant (gram)	Weight of total sample surfactant (gram)	
	Used volume (V_1) (μL)	Concentration (M_1), (mol/L)	Used volume (V_2) (μL)	Concentration (M_2) (mol/L)			
Washing	57	0.005	14.5	0.0197	6.3879	9.5819	G1
Rinsing 1	5	0.005	430	5.814E-05	1.8895E-02	0.0283	G3
Rinsing 2	0.2	0.005	6500	1.538E-07	5.0000E-05	7.500E-05	G5

Table C-5 Calculation of the amount of residual surfactant adsorption on the fabric at different surfactant types

Types of surfactants	Optimum concentration (%wt/v)	G ₀ (gram)	G ₁ (gram)	G ₂ (gram)	G ₃ (gram)	G ₄ (gram)	G ₅ (gram)	G ₆ (gram)	Amount of residual surfactant per Fabric area (g/in. ²)
Single system of MES	5.0	50.0	49.1145	0.8855	0.5467	0.3388	3.544E-03	0.3353	0.009313
Single system of LAS	7.0	70.0	69.6600	0.3400	0.0344	0.3056	3.310E-03	0.3023	0.008397
Mixed system of MES and AE	0.50	5.0	4.5074	0.4926	0.1643	0.3283	1.127E-04	0.3282	0.009116
Commercial detergent	1.0	10.0	9.5819	0.4181	0.0283	0.3898	7.500E-05	0.3897	0.010826

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