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APPENDICES

Appendix A Methodology for Interfacial Tension Measurement

The interfacial tension measurements of the selected system were carried out by using a Krüss spinning drop tensiometer (SITE 04). The denser liquid was filled into the capillary. The lighter phase (0.4 μL) was injected into the capillary through a septum using microsyringe, the rotating speed was increased. After a few seconds, the droplet appeared in the field of vision and the droplet length could be adjusted by altering the rotating speed. When the droplet length was more than 4 times its diameter, the diameter measurement was taken using a built-in microscope.

The interfacial tension was calculated according to equation A1.

$$IFT = 3.427 \times 10^{-7} (0.31 \times d)^3 n^2 \Delta \rho \qquad [Eq.A1]$$

where, d = diameter of the droplet; n = speed; $\Delta\rho$ = the density difference between the heavy phase and the light phase.

Appendix B Methodology for Preparation of Standard Solution for Calculation of the Retained Oil

Half grams (± 0.1 mg) of the colored oil was weighed into a 100-mL volumetric flask and diluted to volume using butan-1-ol. The standard stock solution of 5,000 mg/L or 0.5 % colored oil was obtained. The dilution of this stock was made to the required concentration into the 50-mL volumetric flask in order to construct the calibration curve. In this work, the standard curve of 100 – 2,000 ppm of colored oil was established.

Appendix C Methodology for Validation of the Dye-Tracer Technique

To ensure that the dye and the oily soil were removed by surfactant solutions in the same proportion as in the soil before washing, the 0.1 % w/v of dye solution in the oil (labeled as control soil solution) was prepared for loading on the fabric swatches. The soiled swatches were subsequently washed with a detergent solution. The residual oil was quantitatively extracted from the fabric using chloroform and recovered by evaporating the solvent in a rotovap apparatus. The extracted remaining soil after washing was diluted in butan-1-ol (labeled as experimental soil). The absorption peaks for the two samples were measured to see the agreement between the peak intensities at 518 nm (λ_{max} of solvent red 27).

Appendix D Phase Behavior Studies of DOWFAX 8390-AOT-Span 80 with Motor Oil

The selected surfactants systems for phase behavior studies were shown in Table D1.

Table D1 Surfactants and sodium chloride concentrations for the system containing Dowfax 8390/AOT/Span 80 with motor oil.

System	Surfactant concentration (% w/v)			NaCl concentration (% w/v)	Oil
	Dowfax (% w/v)	AOT (% w/v)	Span 80 (% w/v)		
AA	2.00	5.35	2.00	3.75-6.0	Motor oil
BB	1.25	3.00	2.00	3.75-6.0	Motor oil
CC	2.00	3.00	4.72	3.75-6.0	Motor oil
DD	2.00	3.00	2.00	8.75-11.0	Motor oil

The aim of this experimental part was to find the exact NaCl concentration where the supersolubilization and middle-phase microemulsion occurred. It was observed that at specified range of NaCl (Table D1), only Winsor Type III occurred. The differences in phase height of the middle phase of each system were also measured. As seen in Figure D1, the highest volume of the middle phase was found in system CC which indicated that highest solubilization was obtained, therefore system CC was selected in order to perform more salinity scan to get both Type I and Type III microemulsion.

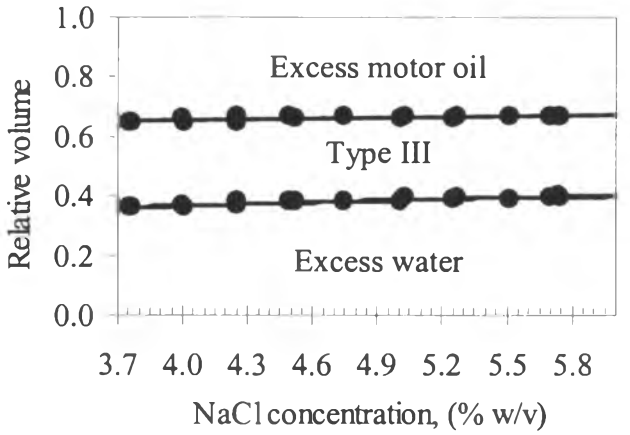

Figure D1 Middle phase microemulsion phase diagram for 2.0 % w/v Dowfax, 3.0 % w/v AOT, and 4.72 % w/v Span 80 (system CC) with varying sodium chloride concentration, the system was equilibrated at 25°C.

Figure D2 illustrates the use of salinity scan as an approach to drive Winsor Type I to Winsor Type III microemulsion by increasing salt concentration. This is because increasing electrolyte concentrations decreases the HLB of the surfactant system and is able to produce a middle-phase microemulsion system.

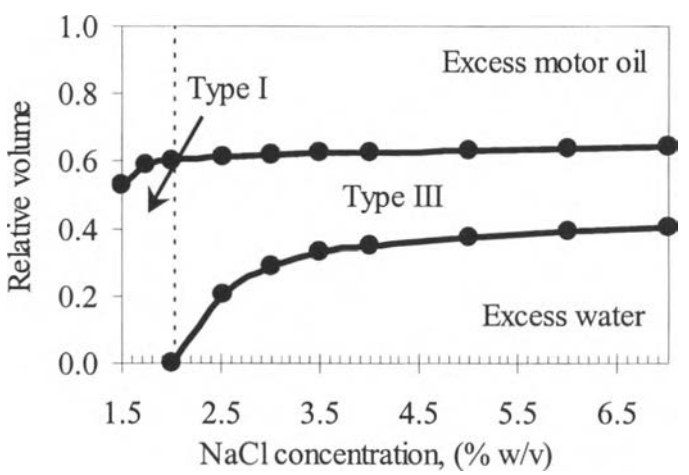

Figure D2 Middle phase microemulsion phase diagram for 2.0 % w/v Dowfax, 3.0 % w/v AOT, and 4.72 % w/v Span 80 with varying sodium chloride concentration at 30°C.

The second objective of this study was to determine the solubilization parameter of the Winsor Type I where supersolubilization occurred and Winsor Type III microemulsion in order to study the oil solubility enhancement. The plot between the solubilization parameter and sodium chloride concentration as seen in Figure D3 shows that supersolubilization was found at 2 % w/v NaCl and the solubilization parameter is almost 20 times (2.12 mL of motor oil/g of surfactants or 1.86 g of motor oil/g of surfactants) greater than the motor oil water solubility of 0.1%. Whereas, the oil solubility increased (2.71 mL of motor oil/g of surfactants or 2.38 g of motor oil/g of surfactants versus 0.1%) for the middle-phase system. It took 3 months for the system to reach the equilibrium at 30°C. For this experiment, the temperature was changed from 25°C to 30°C because it is more convenient to control the temperature in Thailand, not only for phase behavior study but also for detergency test.

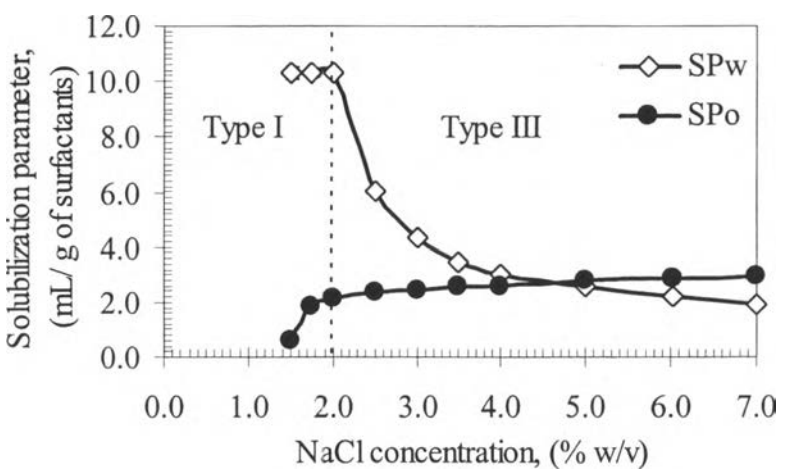

Figure D3 Solubilization parameter as a function of sodium chloride concentration for 2 % w/v Dowfax, 3 % w/v AOT, and 4.72 % w/v Span 80 (system CC) at 30°C.

Unfortunately, prior to addition of the motor oil, the aqueous phase (without Span 80) showed obvious phase separation at 3.5 % w/v upward of sodium chloride. The phase separation was confirmed by using optical microscope with 1,000 magnification. Dowfax concentration of each phase was analysed by using UV spectrophotometer, the absorbance was read at 236 nm. It was found that the bottom phase contained about 3% of Dowfax whereas the upper phase had about 1% of Dowfax. After adding Span 80, the phase separation also occurred with the upper phase of Span 80 on the surface at high salt concentration.

Therefore, this formulation could not be used for detergency test. In washing process if the surfactant solution is not homogeneous, Span 80 might attach to the fabric and cause difficulty in cleaning the fabric. To solve this problem, one way was the increase in Dowfax from 2 % w/v to 3-6 % w/v. Another way was using isopropanol with the concentration varying from 1 % w/v up to 20 % w/v. It was not succeeded by these two methods. However, Span 80 could be more soluble but not completely dissolved.

Due to very high hydrophilicity of Dowfax and the difference in solubility of the surfactants, phase separation took place.

Appendix E Phase Behavior Studies of DOWFAX 8390-AOT-Span 20 with Hexadecane and Motor Oil

The results of phase behavior studies of another two systems as seen in Table E1 were presented in Figure E1-E4.

Table E1 Surfactants and sodium chloride concentrations for the system containing Dowfax 8390/AOT/Span 20 with motor oil and hexadecane.

System	Surfactant concentration			Propylene glycol (% w/v)	NaCl concen-tration (% w/v)	Oil
	Dowfax (% w/v)	AOT (% w/v)	Span 20 (% w/v)			
E	1.2	3.6	4.8	10.0	0.8-1.75	Hexadecane
F	1.2	3.6	4.8	20.0	0.8-5.0	Motor oil

System E was not selected for detergency test because incomplete solubility of AOT.

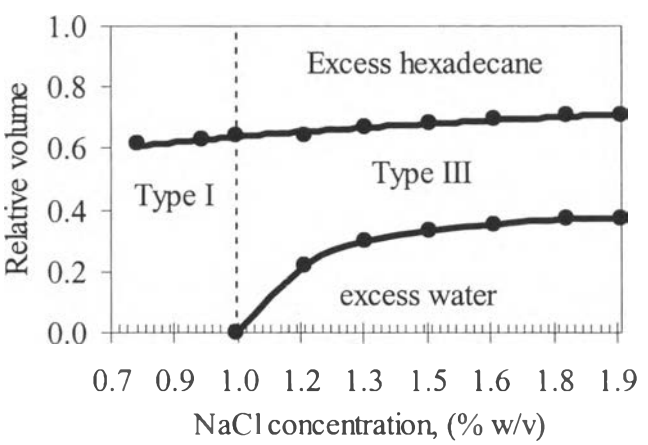

Figure E1 Middle phase microemulsion phase diagram for 1.2 % w/v Dowfax, 3.6 % w/v AOT, 4.8 % w/v Span 20 and 10 % w/v PG (system E) with varying sodium chloride concentration at 30°C.

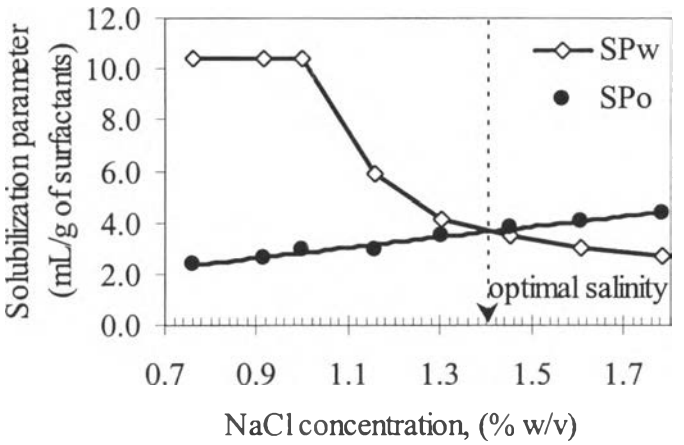

Figure E2 Solubilization parameter as a function of sodium chloride concentration for 1.2 % w/v Dowfax, 3.6 % w/v AOT, 4.8 % w/v Span 20 and 10 % w/v PG (system E with varying sodium chloride concentration at 30°C.

The solubilization parameter at supersolubilization was 2.98 mL of oil/g of surfactants while at optimum salinity (1.41% NaCl) the hexadecane solubility was 3.70 mL of oil/g of surfactants.

For the mixture of 1.2 % Dowfax/ 3.6 % AOT/ 4.8 % Span 20 with 20 % PG (system F), the width of middle phase was too narrow (low oil solubilization parameter) and the optimal salinity was quite high (see Figure E3 and E4).

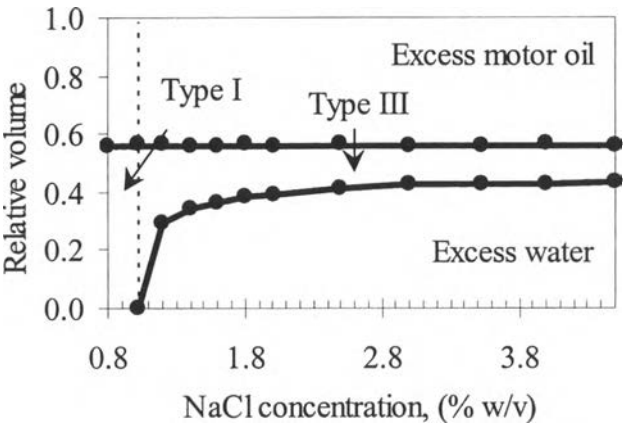

Figure E3 Middle phase microemulsion phase diagram for 1.2 % w/v Dowfax, 3.6 % w/v AOT, 4.8 % w/v Span 20 and 20 % w/v PG (system E) with varying sodium chloride concentration at 30°C.

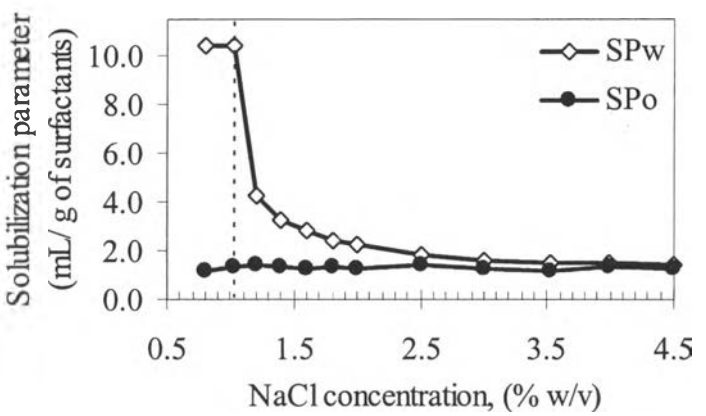

Figure E4 Solubilization parameter as a function of sodium chloride concentration for 1.2 % w/v Dowfax, 3.6 % w/v AOT, 4.8 % w/v Span 20 and 20 % w/v PG (system E) with varying sodium chloride concentration at 30°C.

The optimal salinity was more than 5%, and the SPo at supersolubilization was 1.32 mL of oil/g of surfactants.

Appendix F Relative Volume and Solubilization Parameter Results

Table F1 Effect of sodium chloride concentration on relative volume and solubilization parameter for system CC (Dowfax/AOT/Span 80) with motor oil.

NaCl	Relative volume of			M_s	SP_w	SP_o
(% w/v)	water	middle	oil	(g)	(mL/g)	(mL/g)
1.5078	0.5294	0.0000	0.4706	0.4864	10.2803	0.6047
1.7538	0.5882	0.0000	0.4118	0.4859	10.2901	1.8159
1.9995	0.6029	0.0000	0.3971	0.4862	10.2833	2.1172
2.5103	0.2072	0.4073	0.3855	0.4865	6.0179	2.3542
3.0136	0.2878	0.3317	0.3805	0.4857	4.3683	2.4604
3.4988	0.3303	0.2954	0.3743	0.4863	3.4902	2.5850
3.9997	0.3517	0.2729	0.3755	0.4858	3.0538	2.5634
5.0037	0.3755	0.2592	0.3654	0.4860	2.5622	2.7702
6.0096	0.3915	0.2482	0.3603	0.4859	2.2321	2.8753
7.0078	0.4055	0.2386	0.3559	0.4859	1.9449	2.9647

Table F2 Effect of sodium chloride concentration on relative volume and solubilization parameter for system A (Dowfax/AOT/Span 20) with hexadecane.

NaCl	Relative volume of			M_s	SP_w	SP_o
(% w/v)	water	middle	oil	(g)	(mL/g)	(mL/g)
0.7997	0.6010	0.0000	0.3990	0.7279	10.3038	2.0811
1.0029	0.6139	0.0000	0.3861	0.7190	10.4314	2.3755
1.1984	0.2426	0.3911	0.3663	0.7220	5.3483	2.7770
1.4008	0.3168	0.3267	0.3564	0.7188	3.8224	2.9959
1.6144	0.3515	0.3020	0.3465	0.7202	3.0934	3.1965
1.8048	0.3713	0.2921	0.3366	0.7290	2.6485	3.3616
2.0149	0.3861	0.2871	0.3267	0.7212	2.3682	3.6037
2.1989	0.3911	0.2871	0.3218	0.7199	2.2692	3.7133

Table F3 Effect of sodium chloride concentration on relative volume and solubilization parameter for system B (Dowfax/AOT/Span 20) with hexadecane.

NaCl	Relative volume of			M_s	SP_w	SP_o
(% w/v)	water	middle	oil	(g)	(mL/g)	(mL/g)
0.7996	0.5792	0.0000	0.4208	0.4798	10.4221	1.6502
1.0068	0.5938	0.0000	0.4062	0.4803	10.4103	1.9525
1.2136	0.2774	0.3331	0.3896	0.4799	4.6393	2.3014
1.3964	0.3435	0.2755	0.3811	0.4799	3.2614	2.4785
1.6076	0.3708	0.2631	0.3661	0.4962	2.6038	2.6979
1.8044	0.3851	0.2434	0.3714	0.4826	2.3797	2.6634
2.0140	0.3961	0.2353	0.3686	0.4787	2.1702	2.7450
2.2028	0.4072	0.2296	0.3632	0.4794	1.9361	2.8529

Table F4 Effect of sodium chloride concentration on relative volume and solubilization parameter for system C (Dowfax/AOT/Span 20) with motor oil.

NaCl	Relative volume of			M_s	SP_w	SP_o
(% w/v)	water	middle	oil	(g)	(mL/g)	(mL/g)
0.8110	0.6188	0.0000	0.3812	1.2024	6.2377	1.4822
1.0137	0.1163	0.5068	0.3770	1.1997	4.7979	1.5381
1.2230	0.2205	0.4064	0.3731	1.2011	3.4905	1.5852
1.3973	0.2606	0.3623	0.3771	1.1994	2.9946	1.5370
1.6020	0.2888	0.3331	0.3781	1.1995	2.6411	1.5249
1.7997	0.3103	0.3116	0.3781	1.2098	2.3516	1.5119
1.9997	0.3255	0.3018	0.3727	1.2026	2.1759	1.5883
2.9930	0.3659	0.2597	0.3744	1.2009	1.6746	1.5690
4.0070	0.3820	0.2528	0.3652	1.2013	1.4739	1.6831
5.0157	0.3889	0.2459	0.3652	1.2011	1.3874	1.6835
6.0070	0.3905	0.2529	0.3566	1.1990	1.3702	1.7943
7.0047	0.4002	0.2472	0.3527	1.2012	1.2465	1.8398

Table F5 Effect of sodium chloride concentration on relative volume and solubilization parameter for system D (Dowfax/AOT/Span 20) with motor oil.

NaCl	Relative volume of			M_s	SP_w	SP_o
(% w/v)	water	middle	oil	(g)	(mL/g)	(mL/g)
0.8168	0.6085	0.0000	0.3915	0.8001	6.2489	1.3925
1.0024	0.1650	0.4401	0.3949	0.8000	4.1727	1.3669
1.2004	0.2397	0.3747	0.3856	0.8013	3.1930	1.4275
1.3964	0.2742	0.3324	0.3933	0.7986	2.7849	1.3471
1.6136	0.3045	0.2915	0.4040	0.7996	2.4447	1.2011
1.8068	0.3238	0.2822	0.3940	0.8015	2.1988	1.3226
2.0132	0.3373	0.2680	0.3947	0.7998	2.0342	1.3161
2.1932	0.3475	0.2586	0.3939	0.8014	1.9026	1.3237
3.0032	0.3618	0.2455	0.3927	0.7989	1.7293	1.3434
4.0032	0.3798	0.2298	0.3904	0.8070	1.4890	1.3581
5.0036	0.3926	0.2236	0.3838	0.7995	1.3430	1.4537

Table F6 Effect of sodium chloride concentration on relative volume and solubilization parameter for system E (Dowfax/AOT/Span 20) with hexadecane.

NaCl	Relative volume of			M_s	SP_w	SP_o
(% w/v)	water	middle	oil	(g)	(mL/g)	(mL/g)
0.7632	0.6131	0.0000	0.3869	0.4817	10.3790	2.3472
0.9156	0.6260	0.0000	0.3740	0.4803	10.4097	2.6229
0.9980	0.0404	0.6028	0.3568	0.4811	10.3936	2.9763
1.1580	0.2176	0.4231	0.3593	0.4794	5.8901	2.9345
1.3028	0.3011	0.3667	0.3322	0.4797	4.1461	3.4985
1.4544	0.3308	0.3515	0.3178	0.4802	3.5247	3.7951
1.6076	0.3528	0.3436	0.3036	0.4814	3.0583	4.0798
1.7804	0.3709	0.3385	0.2905	0.4790	2.6944	4.3729
1.9100	0.3740	0.3314	0.2946	0.4806	2.6219	4.2735

Table F7 Effect of sodium chloride concentration on relative volume and solubilization parameter for system F (Dowfax/AOT/Span 20) with motor oil.

NaCl	Relative volume of			M_s	SP_w	SP_o
(% w/v)	water	middle	oil	(g)	(mL/g)	(mL/g)
0.8043	0.5560	0.0000	0.4440	0.7196	10.4223	1.1669
1.0213	0.5634	0.0000	0.4366	0.7208	10.4056	1.3607
1.2051	0.2967	0.2696	0.4337	0.7213	4.2283	1.3779
1.3973	0.3434	0.2195	0.4371	0.7216	3.2558	1.3068
1.5987	0.3631	0.1954	0.4416	0.7200	2.8528	1.2174
1.8024	0.3839	0.1814	0.4346	0.7206	2.4158	1.3609
2.0019	0.3916	0.1701	0.4383	0.7199	2.2581	1.2861
2.5021	0.4116	0.1552	0.4333	0.7197	1.8435	1.3911
2.9981	0.4233	0.1385	0.4382	0.7277	1.5817	1.2731
3.5205	0.4295	0.1284	0.4421	0.7208	1.4665	1.2053
3.9973	0.4278	0.1360	0.4362	0.7209	1.4560	1.3355
4.5045	0.4323	0.1268	0.4409	0.7221	1.4054	1.2286

Appendix G Interfacial Tension Results at NaCl Different Salinity for System A and C

Table G1 Interfacial tension at different NaCl concentration for system A.

NaCl (%)	Density measurement									IFT measurement					
	Oil			Middle phase			water			Middle phase/oil			Middle phase/water		
	wt (g)	Volume (μL)	ρ (g/mL)	wt (g)	Volume (μL)	ρ (g/mL)	wt (g)	Volume (μL)	ρ (g/mL)	d (mm)	speed (rpm)	IFT	d (mm)	speed (rpm)	IFT
0.80	0.1516	200	0.758	0.1906	200	0.953	-	-	-	1.370	1,607	0.0132	-	-	-
1.00	0.1522	200	0.761	0.1915	200	0.958	-	-	-	1.515	1,554	0.0168	-	-	-
	0.1522	200	0.761	0.1915	200	0.958	-	-	-	2.750	503	0.0106	-	-	-
1.20	0.1444	200	0.722	0.1911	200	0.956	0.1962	200	0.981	1.280	1,230	0.0076	-	-	-
	0.1444	200	0.722	0.1911	200	0.956	0.1962	200	0.981	1.230	1,499	0.0100	-	-	-
1.40	0.1495	200	0.748	0.1811	200	0.906	0.1967	200	0.984	1.540	990	0.0058	-	-	-
1.61	0.1564	200	0.782	0.1724	200	0.862	0.2036	200	1.018	1.555	1,070	0.0035	1.210	1,714	0.0083
	0.1564	200	0.782	0.1724	200	0.862	0.2036	200	1.018	1.370	1,473	0.0046	0.790	2,912	0.0067
1.80	0.1573	200	0.787	0.1767	200	0.884	0.2078	200	1.039	-	-	-	1.305	1,825	0.0118
	0.1573	200	0.787	0.1767	200	0.884	0.2078	200	1.039	-	-	-	1.205	2,119	0.0125
2.00	0.1620	200	0.810	0.1784	200	0.892	0.2072	200	1.036	1.315	1,386	0.0037	0.980	3,195	0.0141
	0.1620	200	0.810	0.1784	200	0.892	0.2072	200	1.036	1.165	1,344	0.0024	-	-	-

Table G2 Interfacial tension at different NaCl concentration for system C.

NaCl (%)	Density measurement									IFT measurement					
	Oil			Middle phase			water			Middle phase/oil			Middle phase/water		
	wt (g)	Volume (μL)	ρ (g/mL)	wt (g)	Volume (μL)	ρ (g/mL)	wt (g)	Volume (μL)	ρ (g/mL)	d (mm)	speed (rpm)	IFT	d (mm)	speed (rpm)	IFT
0.81	0.1340	150	0.893	0.1530	150	1.018	-	-	-	1.095	2958	0.0146	-	-	-
	0.1340	150	0.893	0.1530	150	1.018	-	-	-	1.230	3580	0.0169	-	-	-
1.01	0.0459	50	0.918	0.0516	50	1.032	-	-	-	0.920	3933	0.0140	-	-	-
	0.0459	50	0.918	0.0516	50	1.032	-	-	-	1.205	2798	0.0159	-	-	-
2.00	0.0459	50	0.918	0.0494	50	0.988	0.0505	50	1.010	1.350	2672	0.0126	1.455	3438	0.0082
	0.0459	50	0.918	0.0494	50	0.988	0.0505	50	1.010	1.290	2847	0.0124	1.340	3838	0.0080
2.99	0.0462	50	0.924	0.0497	50	0.994	0.0506	50	1.012	1.560	2160	0.0127	2.010	2874	0.0123
4.01	0.0460	50	0.920	0.0500	50	1.000	0.0519	50	1.038	1.265	2905	0.0140	1.585	3972	0.0244
	0.0460	50	0.920	0.0500	50	1.000	0.0519	50	1.038	1.215	3189	0.0149	1.560	4080	0.0245
5.02	0.0458	50	0.916	0.0498	50	0.996	0.0518	50	1.036	1.370	2605	0.0143	1.975	3603	0.0408
	0.0458	50	0.916	0.0498	50	0.996	0.0518	50	1.036	1.240	2998	0.0140	2.020	3477	0.0407

Appendix H Calibration Curve for Colored Hexadecane and Colored Motor Oil

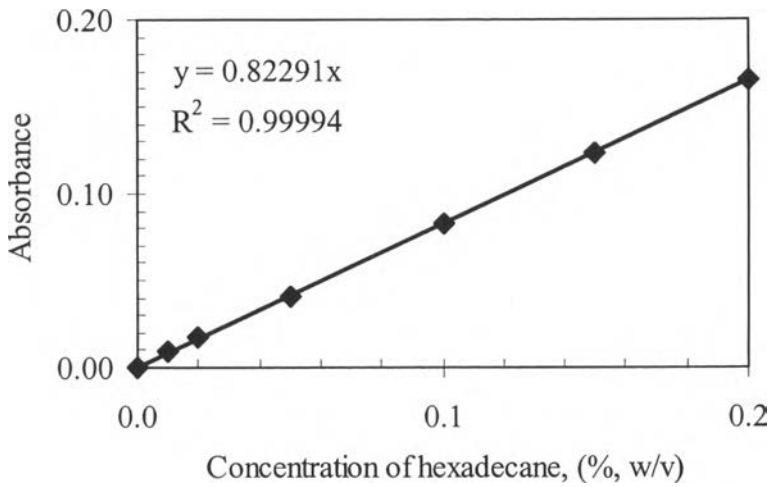

Figure H1 Relationship between colored hexadecane concentration and the absorbance measured at 520 nm.

Table H1 Relationship between colored hexadecane concentration and the absorbance measured at 520 nm.

Concentration of motor oil, (%, w/v)	0.01	0.02	0.05	0.10	0.15	0.20
Absorbance	0.009	0.017	0.041	0.082	0.123	0.165

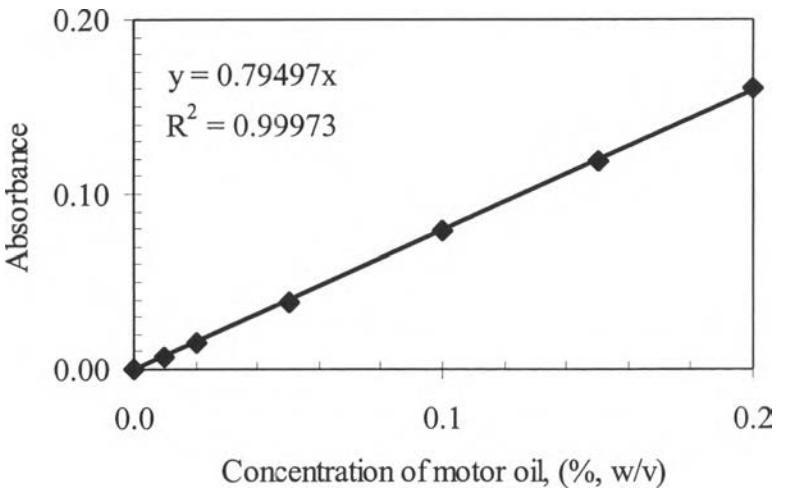

Figure H2 Relationship between colored motor oil concentration and the absorbance measured at 520 nm.

Table H2 Relationship between colored motor oil concentration and the absorbance measured at 520 nm.

Concentration of motor oil, (%, w/v)	0.01	0.02	0.05	0.10	0.15	0.20
Absorbance	0.007	0.015	0.038	0.079	0.119	0.160

Appendix I Hexadecane Removal from Cotton and Polyester Fabrics Using Formulation A at different NaCl concentration

Table I1 Hexadecane removal from cotton fabric based on spectrophotometric measurement.

Sample no.	NaCl (%, w/v)	Soil weight before washing (g)	Amount of applied soil (%)	Absorbance of extracted soil after washing	Amount of residual soil (%)	Soil removal (%)	Average soil removal (%)
1	0.80	0.0238	0.0952	0.033	0.0401	57.88	57.80
2	0.80	0.0230	0.0920	0.032	0.0389	57.73	
1	0.90	0.0247	0.0988	0.033	0.0401	59.41	59.87
2	0.90	0.0245	0.0980	0.032	0.0389	60.32	
1	1.00	0.0244	0.0976	0.031	0.0377	61.40	62.72
2	1.00	0.0245	0.0980	0.029	0.0352	64.04	
1	1.20	0.0238	0.0952	0.029	0.0348	63.49	63.69
2	1.20	0.0244	0.0976	0.029	0.0352	63.89	

Cont.

Table I1 (Continued)

Sample no.	NaCl (%, w/v)	Soil weight before washing (g)	Amount of applied soil (%)	Absorbance of extracted soil after washing	Amount of residual soil (%)	Soil removal (%)	Average soil removal (%)
1	1.40	0.0242	0.0968	0.028	0.0340	64.85	64.40
2	1.40	0.0236	0.0944	0.028	0.0340	63.96	
1	1.50	0.0245	0.0980	0.026	0.0311	68.26	68.27
2	1.50	0.0249	0.0996	0.026	0.0316	68.28	
1	1.60	0.0242	0.0968	0.025	0.0299	69.12	69.80
2	1.60	0.0247	0.0988	0.024	0.0292	70.48	
1	1.80	0.0236	0.0944	0.025	0.0301	68.08	68.28
2	1.80	0.0241	0.0964	0.025	0.0304	68.49	
1	2.00	0.0245	0.0980	0.027	0.0326	66.77	67.06
2	2.00	0.0242	0.0968	0.026	0.0316	67.36	

Remarks: After extraction, the volume of the extracted soil was made up to 25 mL with butan-1-ol.

Table I2 Hexadecane removal from polyester fabric based on spectrophotometric measurement.

Sample no.	NaCl (%, w/v)	Soil weight before washing (g)	Amount of applied soil (%)	Absorbance of extracted soil after washing	Amount of residual soil (%)	Soil removal (%)	Average soil removal (%)
1	0.80	0.0209	0.0836	0.053	0.0644	22.96	23.16
2	0.80	0.0222	0.0888	0.056	0.0681	23.37	
1	0.90	0.0221	0.0884	0.050	0.0608	31.27	31.88
2	0.90	0.0225	0.0900	0.050	0.0608	32.49	
1	1.00	0.0206	0.0824	0.045	0.0547	33.64	33.83
2	1.00	0.0221	0.0884	0.048	0.0583	34.02	
1	1.20	0.0220	0.0880	0.046	0.0559	36.48	36.93
2	1.20	0.0228	0.0912	0.047	0.0571	37.37	
1	1.40	0.0229	0.0916	0.044	0.0535	41.63	41.55
2	1.40	0.0218	0.0872	0.042	0.0510	41.47	

Cont.

Table I2 (Continued)

Sample no.	NaCl (%, w/v)	Soil weight before washing (g)	Amount of applied soil (%)	Absorbance of extracted soil after washing	Amount of residual soil (%)	Soil removal (%)	Average soil removal (%)
1	1.50	0.0217	0.0868	0.041	0.0498	42.60	42.23
2	1.50	0.0209	0.0836	0.040	0.0486	41.86	
1	1.60	0.0212	0.0848	0.040	0.0486	42.68	42.86
2	1.60	0.0208	0.0832	0.039	0.0474	43.04	
1	1.80	0.0215	0.0860	0.042	0.0510	40.65	40.64
2	1.80	0.0220	0.0880	0.043	0.0523	40.62	
1	2.00	0.0219	0.0876	0.045	0.0547	37.58	37.26
2	2.00	0.0212	0.0848	0.044	0.0535	36.95	

Remarks: After extraction, the volume of the extracted soil was made up to 25 mL with butan-1-ol.

Table I3 Hexadecane removal from cotton and polyester fabric based on reflectance measurement.

Sample no.	NaCl (%, w/v)	Reflectance value (R) measured at 520 nm					
		Cotton fabric			Polyester fabric		
		Before washing	After washing	Average Δ R	Before washing	After washing	Average Δ R
1	0.80	35.195	47.232	12.501	44.551	51.244	6.908
2	0.80	35.257	47.610		44.852	52.631	
3	0.80	36.124	49.236		45.316	51.567	
1	0.90	36.265	48.546	12.914	44.626	52.571	7.399
2	0.90	36.237	48.953		45.103	51.480	
3	0.90	35.709	49.454		44.108	51.982	
1	1.00	36.261	49.921	13.562	44.474	52.201	7.798
2	1.00	34.911	48.169		44.480	52.126	
3	1.00	35.045	48.813		44.344	52.364	

Cont.

Table I3 (Continued)

Sample no.	NaCl (%, w/v)	Reflectance value (R) measured at 520 nm					
		Cotton fabric			Polyester fabric		
		Before washing	After washing	Average Δ R	Before washing	After washing	Average Δ R
1	1.20	35.504	49.058	13.589	43.380	53.859	9.402
2	1.20	35.369	49.243		44.463	53.620	
3	1.20	35.091	48.431		44.621	53.191	
1	1.40	34.996	48.339	13.706	43.895	56.319	11.802
2	1.40	35.106	48.565		43.455	55.072	
3	1.40	34.926	49.243		44.832	56.197	
1	1.50	35.421	50.614	15.291	44.044	56.645	11.939
2	1.50	36.916	52.360		44.557	55.743	
3	1.50	36.012	51.247		43.445	55.475	
1	1.60	36.383	52.644	15.981	45.887	57.753	11.393
2	1.60	36.659	51.501		46.080	57.894	
3	1.60	36.383	53.223		46.617	57.117	

Table I3 (Continued)

Sample no.	NaCl (%, w/v)	Reflectance value (R) measured at 520 nm					
		Cotton fabric			Polyester fabric		
		Before washing	After washing	Average Δ R	Before washing	After washing	Average Δ R
1	1.80	36.531	52.384	15.462	46.125	57.966	44.434
2	1.80	36.583	52.114		46.593	57.530	
3	1.80	36.519	51.522		46.049	57.573	
1	2.00	35.662	51.109	15.170	45.950	56.508	11.077
2	2.00	35.427	50.580		45.716	57.086	
3	2.00	35.677	50.588		45.750	57.054	

Appendix J Motor Oil Removal from Cotton and Polyester Fabrics Using Formulation C at different NaCl concentration

Table J1 Motor oil removal from cotton fabric based on spectrophotometric measurement.

Sample no.	NaCl (%, w/v)	Soil weight before washing (g)	Amount of applied soil (%)	Absorbance of extracted soil after washing	Amount of residual soil (%)	Soil removal (%)	Average soil removal (%)
1	0.80	0.0236	0.0944	0.035	0.0440	53.36	53.54
2	0.80	0.0231	0.0924	0.034	0.0428	53.71	
1	1.60	0.0239	0.0956	0.035	0.0440	53.95	55.17
2	1.60	0.0238	0.0952	0.033	0.0415	56.40	
1	2.00	0.0236	0.0944	0.033	0.0415	56.03	57.27
2	2.00	0.0235	0.0940	0.031	0.0390	58.52	
1	3.30	0.0221	0.0884	0.032	0.0403	54.46	56.49
2	3.30	0.0235	0.0940	0.031	0.0390	58.52	

Cont.

Table J1 (Continued)

Sample no.	NaCl (%, w/v)	Soil weight before washing (g)	Amount of applied soil (%)	Absorbance of extracted soil after washing	Amount of residual soil (%)	Soil removal (%)	Average soil removal (%)
1	4.00	0.0221	0.0884	0.033	0.0415	53.04	54.36
2	4.00	0.0227	0.0908	0.032	0.0403	55.67	
1	5.00	0.0230	0.0920	0.035	0.0440	52.14	53.51
2	5.00	0.0230	0.0920	0.033	0.0415	54.88	

Remarks: After extraction, the volume of the extracted soil was made up to 25 mL with butan-1-ol.

Table J2 Motor oil removal from polyester fabric based on spectrophotometric measurement.

Sample no.	NaCl (%, w/v)	Soil weight before washing (g)	Amount of applied soil (%)	Absorbance of extracted soil after washing	Amount of residual soil (%)	Soil removal (%)	Average soil removal (%)
1	0.80	0.0223	0.0892	0.059	0.0742	16.80	16.33
2	0.80	0.0228	0.0912	0.061	0.0767	15.86	
1	1.60	0.0226	0.0904	0.059	0.0742	17.90	17.57
2	1.60	0.0228	0.0912	0.060	0.0755	17.24	
1	2.00	0.0226	0.0904	0.057	0.0717	20.68	21.03
2	2.00	0.0228	0.0912	0.057	0.0717	21.38	
1	3.30	0.0225	0.0900	0.057	0.0717	20.33	20.51
2	3.30	0.0226	0.0904	0.057	0.0717	20.68	
1	4.00	0.0247	0.0988	0.063	0.0792	19.79	19.90
2	4.00	0.0228	0.0912	0.058	0.0730	20.00	

Cont.

Table J2 (Continued)

Sample no.	NaCl (%, w/v)	Soil weight before washing (g)	Amount of applied soil (%)	Absorbance of extracted soil after washing	Amount of residual soil (%)	Soil removal (%)	Average soil removal (%)
1	5.00	0.0235	0.0940	0.060	0.0755	19.71	19.88
2	5.00	0.0236	0.0944	0.060	0.0755	20.05	

Remarks: After extraction, the volume of the extracted soil was made up to 25 mL with butan-1-ol.

Table J3 Motor oil removal from cotton and polyester fabric based on reflectance measurement.

Sample no.	NaCl (%, w/v)	Reflectance value (R) measured at 520 nm					
		Cotton fabric			Polyester fabric		
		Before washing	After washing	Average Δ R	Before washing	After washing	Average Δ R
1	0.80	33.954	44.517	10.988	35.197	41.421	5.572
2	0.80	33.672	44.713		35.954	41.001	
3	0.80	33.235	44.596		35.623	40.708	
1	1.60	32.819	44.233	11.422	35.699	40.737	5.606
2	1.60	32.542	44.158		35.045	41.107	
3	1.60	32.770	44.005		35.361	41.078	
1	2.00	32.640	44.229	11.617	35.116	41.136	5.770
2	2.00	33.796	46.242		35.345	40.735	
3	2.00	33.169	43.985		35.108	41.008	

Cont.

Table J3 (Continued)

Sample no.	NaCl (%, w/v)	Reflectance value (R) measured at 520 nm					
		Cotton fabric			Polyester fabric		
		Before washing	After washing	Average Δ R	Before washing	After washing	Average Δ R
1	3.00	33.078	44.229	11.251	35.384	41.010	5.671
2	3.00	32.457	43.977		35.153	40.895	
3	3.00	32.428	43.510		34.648	40.294	
1	4.00	32.770	43.900	10.804	34.684	40.564	5.699
2	4.00	32.962	43.623		35.298	40.825	
3	4.00	33.070	43.691		35.326	41.017	
1	5.00	33.364	44.039	10.367	35.432	40.916	5.660
2	5.00	33.624	43.891		35.156	40.990	
3	5.00	33.678	43.836		35.659	41.320	

Appendix K Results of Validation of Dye-Tracer Technique

Oil concentration of each sample was 1,000 ppm.

Sample	Absorbance	Oil concentration (ppm) calculated from calibration curve
Control soil solution of hexadecane.	0.083	996
Recovered hexadecane from cotton	0.081	984
Recovered hexadecane from polyester	0.080	972
Control soil solution of motor oil	0.080	1,006
Recovered motor oil from cotton	0.078	981
Recovered motor oil from polyester	0.078	981

This results shows that the concentration of dye in the soil left on the fabric after washing matches with the concentration of dye in the soil that was loaded.

CURRICULUM VITAE

Name: Ms. Porntip Pattayakorn

Date of Birth: October 14, 1969

Nationality: Thai

University Education:

1989-1991 Bachelor Degree of Science in Biotechnology, Chulalongkorn University, Bangkok, Thailand.

Working Experience:

1991-1994	Position:	Chemist
	Company name:	Unilever Thai Holdings, Ltd.
1994-1996	Position:	Quality Assurance Supervisor
	Company name:	Unilever Thai Holdings, Ltd.
1996-2000	Position:	Product Development Technologist
	Company name:	Unilever Thai Holdings, Ltd.