REFERENCES

Al-Sahhaf, T.A., Fahim, M.A., Elkilani, A.A. (2002) Retardation of asphaltene precipitation by addition of toluene, resins, deasphalted Oil, and Surfactants. Fluid Phase Equilibria, 194-197, 1045-1057.

Bell, R.P. (1973) The Proton in Chemistry, 2nd Edition. Chapman and Hall, London, Ostwald, W.Z. The Journal of Physical Chemistry, 3, 170.

Chang, C.H., and Fogler, H.S. (1994) Stabilization of Asphaltenes in Aliphatic Solvents Using Alkylbenzene-Derived Amphiphiles. 1. Effect of the chemical structure of amphiphiles on asphaltene stabilization, Langmiur Journal, 10, 1749-1757.

Chang, C.H., and Fogler, H.S. (1994) Stabilization of asphaltenes in aliphatic solvents using alkylbenzene-derived amphiphiles. 2. Study of the asphaltene-amphiphile interactions and structur

es using fourier transform infrared spectroscopy and small-angle X-ray scattering Techniques. Langmiur Journal, 10, 1758-1766.

EGE, S. (1984) Organic Chemistry, The University of Michigan, pp. 126.

Gonzâlez., G. and Middea, A. (1990) Peptization of asphaltene by various oil soluble amphiphiles. Colliods and Surfaces Journal, 52, pp.207-217.

Gunduz, T., Kilic, E., Atakol, O., and Kenar, A. (1987) Potentiometric titrations of symmetrical aliphatic diamines and their schiff bases in different solvents. Analyst Journal, 112.

Haji Akbari Balou, N., Masirisuk, P., Hoepfner, M.P. and Fogler H.S. (2013) A unified model for aggregation of asphaltenes. Energy&Fuels Journal, Articles ASAP.

LOW, L.K. (1988) Health effects of alkylbenzenes, Toxicol Ind Health. 4(1), 49-75.

Maqbool, T., Balgoa, A.T., and Fogler, H.S. (2009) Revisiting asphaltene instability in live crude oils. Energy&Fuels Journal, 21, 1248-1255.

Maqbool, T., Balgoa, A.T., and Fogler, H.S. (2009) Revisiting asphaltene precipitation from crude oils: a case of neglected kinetic effects. Energy&Fuels Journal, 23, 3681-3686.

Maqbool, T., Raha, S., Hoepfner, M.P., and Fogler, H.S. (2011) Modeling the aggregation of asphaltene nanoaggregates in crude oil-precipitant systems. Energy&Fuels Journal, 25, 1585-1596.

Mullins, O.C., Sheu, E.Y., Hammami, A., and Marshall, A.G. (2007) Asphaltenes, heavy oils, and petroleomics, XXII, NP, Springer.

Nazar, A.R., and Batandory, L. (2008) Investigation of asphaltene stability in the Iranian crude oils. Iranian Journal of Chemical Engineering, 5, 1.

Östlund, J.A., Nyden, M., Fogler, H.S., and Holmberg, K. (2004) Functional groups in fractionated asphaltenes and the adsorption of amphiphilic molecules. Colliods and Surfaces Journal, 234, 95-102.

Wattana, P. (2004) Pricipitation and Characterization of Petroleum Asphaltenes, PhD Thesis, the University of Michigan, Ann Arbor, Michigan, United States.

APPENDIX

Potential Values from Potentiometric Titration

As discussed in section 4.1, alkylbenzenes were measured in potentiometric titration to obtain pKa values. Each alkylbenzene was measure 3 times to get error values. All measured data between potential values and the volume of titrant is shown in this section. The calculated first derivative of data is also included.

Table 1 The first set of potentiometric titration data of dodecylbenzaldehyde at concentration 2.5 mM.

Volume (mL)	Cumulative volume	mV	ΔmV	ΔV	V Avg	ΔmV/ΔV
0	0	-189				
50	50	-101	88	50	25	1.76
50	100	-40	61	50	75	1.22
50	150	-1	39	50	125	0.78
50	200	171	172	50	175	3.44
50	250	267	96	50	225	1.92
50	300	337	70	50	275	1.4
50	350	380	43	50	325	0.86
50	400	422	42	50	375	0.84
50	450	452	30	50	425	0.6
50	500	488	36	50	475	0.72
half-equivalence point =		87.5	mL			
interpolation half point =		-55.25	mV			
pKa =		7.933725				

Table 2 The second set of potentiometric titration data of dodecylbenzaldehyde at concentration 2.5 mM.

Volume (mL)	Cumulative volume	mV	ΔmV	ΔV	V Avg	ΔmV/ΔV
0	0	-169				
50	50	-111	58	50	25	1.16
50	100	-48	63	50	75	1.26
50	150	2	50	50	125	1
50	200	185	183	50	175	3.66
50	250	271	86	50	225	1.72
50	300	308	37	50	275	0.74
50	350	356	48	50	325	0.96
50	400	400	44	50	375	0.88
50	450	451	51	50	425	1.02
50	500	479	28	50	475	0.56
half-equivalence point =		87.5	mL			
interpolation half point =		-63.75	mV			
pKa =		8.077375				

Table 3 The third set of potentiometric titration data of dodecylbenzaldehyde at concentration 2.5 mM.

Volume (mL)	Cumulative volume	mV	ΔmV	ΔV	V Avg	ΔmV/ΔV
0	0	-130				
50	50	-96	34	50	25	0.68
50	100	-61	35	50	75	0.7
50	150	25	86	50	125	1.72
50	200	204	179	50	175	3.58
50	250	266	62	50	225	1.24
50	300	308	42	50	275	0.84
50	350	348	40	50	325	0.8
50	400	392	44	50	375	0.88
50	450	431	39	50	425	0.78
50	500	463	32	50	475	0.64
half-equivalence point =		87.5	mL			
interpolation half point =		-69.75	mV			
pKa =		8.178775				

Table 4 The average values from three sets of potentiometric titration of dodecylbenzaldehyde

Set	pKa	HNP (mV)
1st	7.933725	-55.25
2nd	8.077375	-63.75
3rd	8.178775	-69.75
Average	8.063291667	-62.91666667
Standard average	0.123130544	7.285830998

Table 5 The first set of potentiometric titration data of nonylacetophenone at concentration 2.5 mM.

Volume (mL)	Cumulative volume	mV	ΔmV	ΔV	V Avg	ΔmV/ΔV
0	0	12				
50	50	90	78	50	25	1.56
50	100	255	165	50	75	3.3
50	150	433	178	50	125	3.56
50	200	513	80	50	175	1.6
50	250	573	60	50	225	1.2
50	300	591	18	50	275	0.36
50	350	606	15	50	325	0.3
50	400	614	8	50	375	0.16
50	450	621	7	50	425	0.14
50	500	626	5	50	475	0.1
half-equivalence point =		62.5	mL			
interpolation half point =		131.25	mV			
pKa =		4.781875				

Table 6 The second set of potentiometric titration data of nonylacetophenone at concentration 2.5 mM.

Volume (mL)	Cumulative volume	mV	ΔmV	ΔV	V Avg	ΔmV/ΔV
0	0	24				
50	50	104	80	50	25	1.6
50	100	217	113	50	75	2.26
50	150	420	203	50	125	4.06
50	200	520	100	50	175	2
50	250	575	55	50	225	1.1
50	300	598	23	50	275	0.46
50	350	610	12	50	325	0.24
50	400	617	7	50	375	0.14
50	450	622	5	50	425	0.1
50	500	627	5	50	475	0.1
half-equivalence point =		62.5	mL			
interpolation half point =		132.25	mV			
pKa =		4.764975				

Table 7 The third set of potentiometric titration data of nonylacetophenone at concentration 2.5 mM.

Volume (mL)	Cumulative volume	mV	ΔmV	ΔV	V Avg	ΔmV/ΔV
0	0	15				
50	50	100	85	50	25	1.7
50	100	221	121	50	75	2.42
50	150	428	207	50	125	4.14
50	200	518	90	50	175	1.8
50	250	573	55	50	225	1.1
50	300	589	16	50	275	0.32
50	350	611	22	50	325	0.44
50	400	617	6	50	375	0.12
50	450	619	2	50	425	0.04
50	500	623	4	50	475	0.08
half-equivalence point =		62.5	mL			
interpolation half point =		130.25	mV			
pKa =		4.798775				

Table 8 The average values from three sets of potentiometric titration of nonylacetophenone

Set	pKa	HNP (mV)
1st	4.781875	131.25
2nd	4.764975	132.25
3rd	4.798775	130.25
Average	4.781875	131.25
Standard average	0.0169	1

Table 9 The first set of potentiometric titration data of nonylaniline at concentration 2.5 mM.

Volume (mL)	Cumulative volume	mV	ΔmV	ΔV	V Avg	ΔmV/ΔV
0	0	-82				
100	100	50	132	100	50	1.32
100	200	170	120	100	150	1.2
100	300	230	60	100	250	0.6
100	400	252	22	100	350	0.22
100	500	264	12	100	450	0.12
100	600	272	8	100	550	0.08
100	700	278	6	100	650	0.06
100	800	282	4	100	750	0.04
half-equivalence point =		25	mL			
interpolation half point =		-49	mV			
pKa =		7.8281				

Table 10 The second set of potentiometric titration data of nonylaniline at concentration 2.5 mM.

Volume (mL)	Cumulative volume	mV	ΔmV	ΔV	V Avg	ΔmV/ΔV
0	0	-95				
50	50	-81	14	50	25	0.28
50	100	-55	26	50	75	0.52
50	150	-17	38	50	125	0.76
50	200	56	73	50	175	1.46
50	250	152	96	50	225	1.92
50	300	183	31	50	275	0.62
50	350	212	29	50	325	0.58
50	400	227	15	50	375	0.3
50	450	235	8	50	425	0.16
50	500	244	9	50	475	0.18
50	550	256	12	50	525	0.24
50	600	263	7	50	575	0.14
half-equivalence point =		112.5	mL			
interpolation half point =		-45.5	mV			
pKa =		7.76895				

Table 11 The third set of potentiometric titration data of nonylaniline at concentration 2.5 mM.

Volume (mL)	Cumulative volume	mV	ΔmV	ΔV	V Avg	ΔmV/ΔV
0	0	-90				
50	50	-78	12	50	25	0.24
-50	100	-50	28	50	75	0.56
50	150	-12	38	50	125	0.76
50	200	58	70	50	175	1.4
50	250	165	107	50	225	2.14
50	300	188	23	50	275	0.46
50	350	214	26	50	325	0.52
50	400	230	16	50	375	0.32
50	450	241	11	50	425	0.22
50	500	249	8	50	475	0.16
half-equivalence point =		112.5	mL			
interpolation half point =		-40.5	mV			
pKa =		7.68445				

Table 12 The average values from three sets of potentiometric titration of nonylaniline

Set	pKa	HNP (mV)
1st	7.8281	-49
2nd	7.76895	-45.5
3rd	7.68445	-40.5
Average	7.7605	-45
Standard average	0.072196832	4.272001873

Table 13 The first set of potentiometric titration data of nonylphenol at concentration 2.5 mM.

Volume (mL)	Cumulative volume	mV	ΔmV	ΔV	V Avg	ΔmV/ΔV
0	0	-68				
100	100	94	162	100	50	1.62
100	200	284	190	100	150	1.9
100	300	422	138	100	250	1.38
100	400	498	76	100	350	0.76
100	500	550	52	100	450	0.52
100	600	569	19	100	550	0.19
100	700	583	14	100	650	0.14
100	800	588	5	100	750	0.05
half-equivalence point =		75	mL			
interpolation half point =		53.5	mV			
pKa =		6.09585				

Table 14 The second set of potentiometric titration data of nonylphenol at concentration 2.5 mM.

Volume (mL)	Cumulative volume	mV	ΔmV	ΔV	V Avg	ΔmV/ΔV
0	0	-60				
50	50	-7	53	50	25	1.06
50	100	94	101	50	75	2.02
50	150	202	108	50	125	2.16
50	200	290	88	50	175	1.76
50	250	360	70	50	225	1.4
50	300	415	55	50	275	1.1
50	350	462	47	50	325	0.94
50	400	493	31	50	375	0.62
50	450	522	29	50	425	0.58
50	500	554	32	50	475	0.64
50	550	561	7	50	525	0.14
50	600	567	6	50	575	0.12
half-equivalence point =		62.5	mL			
interpolation half point =		6.25	mV			
pKa =		6.894375				

Table 15 The third set of potentiometric titration data of nonylphenol at concentration 2.5 mM.

Volume (mL)	Cumulative volume	mV	ΔmV	ΔV	V Avg	ΔmV/ΔV
0	0	-62				
50	50	0	62	50	25	1.24
50	100	88	88	50	75	1.76
50	150	208	120	50	125	2.4
50	200	291	83	50	175	1.66
50	250	348	57	50	225	1.14
50	300	409	61	50	275	1.22
50	350	460	51	50	325	1.02
half-equivalence point =		62.5	mL			
interpolation half point =		15.5	mV			
pKa =		6.73805				

Table 16 The average values from three sets of potentiometric titration of nonylphenol

Set	pKa	HNP (mV)
1st	6.09585	53.5
2nd	6.894375	6.25
3rd	6.73805	15.5
Average	6.576091667	25.08333333
Standard average	0.42318249	25.04038405

Table 17 The first set of potentiometric titration data of octyloxybenzonitrile at concentration 2.5 mM.

Volume (mL)	Cumulative volume	mV	ΔmV	ΔV	V Avg	ΔmV/ΔV
0	0	-30				
50	50	53	83	50	25	1.66
50	100	112	59	50	75	1.18
50	150	129	17	50	125	0.34
50	200	144	15	50	175	0.3
50	250	175	31	50	225	0.62
50	300	263	88	50	275	1.76
50	350	281	18	50	325	0.36
50	400	299	18	50	375	0.36
50	450	319	20	50	425	0.4
50	500	329	10	50	475	0.2
50	550	340	11	50	525	0.22
half-equivalence point =		137.5	mL			
interpolation half point =		124.75	mV			
pKa =		4.891725				

Table 18 The second set of potentiometric titration data of octyloxybenzonitrile at concentration 2.5 mM.

Volume (mL)	Cumulative volume	mV	ΔmV	ΔV	V Avg	ΔmV/ΔV
0	0	-12				
50	50	38	50	50	25	1
50	100	103	65	50	75	1.3
50	150	118	15	50	125	0.3
50	200	130	12	50	175	0.24
50	250	168	38	50	225	0.76
50	300	273	105	50	275	2.1
50	350	287	14	50	325	0.28
50	400	308	21	50	375	0.42
50	450	323	15	50	425	0.3
50	500	337	14	50	475	0.28
50	550	351	14	50	525	0.28
half-equivalence point =		137.5	mL			
interpolation half point =		114.25	mV			
pKa =		5.069175				

Table 19 The third set of potentiometric titration data of octyloxybenzonitrile at concentration 2.5 mM.

Volume (mL)	Cumulative volume	mV	ΔmV	ΔV	V Avg	ΔmV/ΔV
0	0	-45				
50	50	50	95	50	25	1.9
50	100	106	56	50	75	1.12
50	150	125	19	50	125	0.38
50	200	134	9	50	175	0.18
50	250	179	45	50	225	0.9
50	300	268	89	50	275	1.78
50	350	284	16	50	325	0.32
50	400	315	31	50	375	0.62
50	450	326	11	50	425	0.22
50	500	339	13	50	475	0.26
50	550	352	13	50	525	0.26
half-equivalence point =		137.5	mL			
interpolation half point =		120.25	mV			
pKa =		4.967775				

Table 20 The average values from three sets of potentiometric titration of octyloxybenzonitrile

Set	**pKa**	**HNP (mV)**
1st	4.891725	124.75
2nd	5.069175	114.25
3rd	4.967775	120.25
Average	4.976225	119.75
Standard average	0.089026274	5.267826876

CURRICULUM VITAE

Name: Mr. Pongkhun Siriprasurtsilp

Date of Birth: January 17, 1990

Nationality: Thai

University Education:

2007–2010 Bachelor Degree of Chemical Engineering, (Second Class Honor), King Mongkut's University of Technology North Bangkok, Bangkok, Thailand

Work Experience:

April – May 2010	Position:	Student Internship
	Company name:	Thaioil refinery

Proceeding:

1. Siriprasurtsilp, P.; Gasbarro N.; Malakul, P.; and Fogler, H.S. (2013, April 23) Effect of amphiphilic molecules on asphaltene precipitation. Proceedings of the 5th Research Symposium on Petrochemicals and Materials Technology and The 20th PPC Symposium on Petroleum, Petrochemicals, and Polymers, Bangkok, Thailand.