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- วิวัฒน์ ดัฒนะพานิชกุล. 2537. การศึกษาเบื้องต้นของภาพรวมของปัญหาน้ำมันหล่อลื่นที่ใช้แล้ว. เอกสารประกอบการสัมมนาทางวิชาการ เรื่องปัญหามลภาวะจากน้ำมันหล่อลื่นที่ใช้แล้ว และแนวทางแก้ไข. ศูนย์อบรมและวิจัยปิโตรเคมี คณะวิศวกรรมศาสตร์ จุฬาลงกรณ์มหาวิทยาลัย.

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ศูนย์วิทยทรัพยากร
จุฬาลงกรณ์มหาวิทยาลัย

APPENDIX



ศูนย์วิทยทรัพยากร
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APPENDIX A

EXPERIMENTAL DATA



ศูนย์วิทยทรัพยากร
จุฬาลงกรณ์มหาวิทยาลัย

Table A.1 Zinc content and %Extraction of various types of extractant
The initial zinc concentration was 867 ppm.

Types of extractant	Zinc content (ppm)	%Extraction (%)
Magnesium sulfate	837	3.46
Sodium thiosulfate	820	5.42
Sodium sulfate	817	5.77
Ammonium dihydrogen phosphate	804	7.27
Aluminium sulfate	764	11.88
Ammonium sulfate	743	14.30
Sodium metasulfate	731	15.69
Disodium hydrogen phosphate	604	30.33
Diammonium hydrogen phosphate	352	59.40
Ammonium persulfate	115	86.74

Table A.2 Zinc content and %Extraction at various concentrations of diammonium hydrogen phosphate.
The initial zinc concentration was 847 ppm.

Concentration (% wt/wt)	Zinc content (ppm)	%Extraction (%)
2	519	38.77
3	528	37.69
4	554	34.56
5	593	30.02
6	560	33.91
8	273	67.82
10	368	56.59
12	370	56.26
15	420	50.43
20	483	42.98

Table A.3 Zinc content and %Extraction of various types of surfactant.
The initial zinc concentration was 902 ppm.

Types of surfactant	Zinc content (ppm)	%Extraction (%)
Sodium lauryl sulfate	678	24.83
Sodium dodecyl benzene sulfonate	728	19.29
Sodium dioctylsulfosuccinate	776	13.97
Disodium laurethsulfosuccinate	756	16.19

Table A.4 Zinc content at various SDBS concentration without extractant in batch process.

The initial zinc concentration was 866 ppm.

Contact time (min)	zinc content at various SDBS concentration (ppm)			
	1%	2%	4%	8%
	0	866	866	866
5	735	692	660	641
10	712	681	657	632
20	711	679	645	628
30	706	675	644	630
40	700	670	646	602
50	696	665	641	599
60	694	667	640	595

Table A.5 %Extraction at various SDBS concentration without extractant in batch process. The initial zinc concentration was 866 ppm.

Contact time (min)	%Extraction at various SDBS concentration			
	1%	2%	4%	8%
0	0.00	0.00	0.00	0.00
5	15.13	20.09	23.79	25.98
10	17.78	21.36	24.13	27.02
20	17.90	21.59	25.52	27.48
30	18.48	22.06	25.64	27.25
40	19.17	22.63	25.40	30.48
50	19.63	23.21	25.98	30.83
60	19.86	22.98	26.10	31.29

Table A.6 Zinc content and %Extraction of extracting solution consisting of various types of surfactant and ammonium persulfate. The initial zinc concentration was 884 ppm.

Types of extractant	Zinc content (ppm)	%Extraction (%)
No surfactant	729	17.52
Sodium lauryl sulfate	626	29.20
Sodium dodecyl benzene sulfate	654	26.02
Sodium dioctylsulfosuccinate	652	26.23
Disodium laurethsulfosuccinate	589	33.40

Table A.7 Zinc content and %Extraction of extracting solution consisting of various SDBS concentrations and diammonium hydrogen phosphate
The initial zinc concentration was 847 ppm.

Concentration (% wt/wt)	Zinc content (ppm)	%Extraction (%)
0	311	63.28
1	176	79.22
2	99	88.31
4	128	84.89
6	37	95.63
8	6	99.29
10	0	100.00
12	0	100.00

Table A.8 Zinc content and %Extraction at various agitator speeds in batch process.

The initial zinc concentration was 873 ppm.

Agitator speed (rpm)	zinc content (ppm)	%Extraction (%)
400	358	58.98
500	350	59.92
600	320	63.33
700	336	61.53
800	316	63.80

Table A.9 Zinc content at various SDBS concentration in batch process.
The initial zinc concentration was 845 ppm.

Contact time (min)	zinc content at various SDBS conc. (ppm)				
	0%	1%	2%	4%	8%
0	845	845	845	845	845
5	598	217	181	231	55
10	565	55	156	40	51
20	580	184	161	39	20
30	391	177	148	90	0
40	375	168	145	50	13
50	378	173	159	43	11
60	382	183	150	41	9

Table A.10 %Extraction at various SDBS concentration in batch process.
The initial zinc concentration was 845 ppm.

Contact time (min)	%Extraction at various SDBS conc. (%)				
	0%	1%	2%	4%	8%
0	0.00	0.00	0.00	0.00	0.00
5	29.24	74.30	78.58	72.72	93.48
10	33.15	93.48	81.54	95.25	93.95
20	31.38	78.21	80.95	95.44	97.58
30	53.72	79.05	82.49	89.29	100.00
40	55.68	80.17	82.84	94.04	98.51
50	55.21	79.52	81.18	94.88	98.70
60	54.75	78.31	82.25	95.16	98.98

Table A.11 Zinc content at various phase ratios (extracting solution volume fraction : oil volume fraction) in batch process.
The initial zinc concentration was 845 ppm.

Phase ratio	Zinc content at various SDBS concentration (ppm)			
	1%	2%	4%	8%
1:1	179	115	30	6
1:2	599	451	341	112
1:3	577	493	436	220
1:4	656	580	670	423
1:5	634	608	751	488

Table A.12 %Extraction at various phase ratios (extracting solution volume fraction : oil volume fraction) in batch process.
The initial zinc concentration was 845 ppm.

Phase ratio	%Extraction at various SDBS concentration (%)			
	1%	2%	4%	8%
1:1	78.86	86.39	96.46	99.26
1:2	29.14	46.63	59.68	86.78
1:3	31.66	41.66	48.40	74.02
1:4	22.35	31.36	20.71	50.00
1:5	24.95	28.05	11.12	42.27

Table A.13 Zinc content at various initial zinc concentrations in batch process.

Initial zinc concentration (ppm)	Zinc content at various SDBS concentration (ppm)			
	1%	2%	4%	8%
113	10	0	0	0
239	0	9	0	0
499	45	68	0	0
772	152	184	31	0
1057	229	201	44	8
1287	512	289	176	24
1544	814	456	339	63

Table A.14 %Extraction at various initial zinc concentrations in batch process.

Initial zinc concentration (ppm)	%Extraction at various SDBS concentration (%)			
	1%	2%	4%	8%
113	98.82	100.00	100.00	100.00
239	100.00	98.93	100.00	100.00
499	94.67	91.95	100.00	100.00
772	82.01	78.22	96.33	100.00
1057	72.90	76.21	94.79	99.05
1287	39.41	65.80	79.17	97.16
1544	3.67	46.04	59.88	92.54

Table A.15 Zinc content at various agitator speeds in continuous process.

The initial zinc concentration was 842 ppm.

Operating contact time (min)	Zinc content at various agitator speed (ppm)			
	100 rpm	200 rpm	300 rpm	400 rpm
0	699	716	598	674
10	690	707	581	665
20	692	682	580	615
30	648	679	584	699
40	589	674	572	640
50	674	615	570	657
60	676	632	581	648
average	666.86	672.14	580.86	656.86

Table A.16 %Extraction at various agitator speeds in continuous process.

The initial zinc concentration was 842 ppm.

Operating contact time (min)	%Extraction at various agitator speed (ppm)			
	100 rpm	200 rpm	300 rpm	400 rpm
0	16.98	14.96	28.98	19.95
10	18.05	16.03	31.00	21.02
20	17.81	19.00	31.12	26.96
30	23.04	19.36	30.64	16.98
40	30.05	19.95	32.07	23.99
50	19.95	26.96	32.30	21.97
60	19.71	24.94	31.00	23.04
average	20.80	20.17	31.01	21.99

Table A.17 Zinc content at various SDBS concentrations in continuous process.
The initial zinc concentration was 802 ppm.

Operating contact time (min)	Zinc content at various SDBS concentrations (ppm)			
	0 %	0.1 %	0.5 %	1 %
0	624	492	453	379
10	535	347	313	283
20	545	402	342	235
30	601	388	296	199
40	625	353	297	263
50	654	369	321	221
60	642	361	305	241
average	603.71	387.43	332.43	260.14

Table A.18 %Extraction at various SDBS concentrations in continuous process.
The initial zinc concentration was 802 ppm.

Operating contact time (min)	%Extraction at various SDBS concentrations (ppm)			
	0 %	0.1 %	0.5 %	1 %
0	22.19	38.65	43.52	52.74
10	33.29	56.73	60.97	64.71
20	32.04	49.88	57.36	70.70
30	25.06	51.62	63.09	75.19
40	22.07	55.99	62.97	67.21
50	18.45	53.99	59.98	72.44
60	19.95	54.99	61.97	69.95
average	24.72	51.69	58.55	67.56

Table A.19 Zinc content at various phase ratios in continuous process.
The initial zinc concentration was 890 ppm.

Operating contact time (min)	Zinc content at various phase ratios (Extracting solution flow : Oil flow)				
	1:1	1:2	1:3	1:4	1:5
0	421	667	730	757	810
10	314	320	558	652	730
20	261	269	448	654	765
30	221	350	408	656	694
40	292	266	428	630	720
50	245	285	490	513	721
60	267	276	462	596	703
average	288.71	347.57	503.43	636.86	734.71

Table A.20 %Extraction at various phase ratios in continuous process.
The initial zinc concentration was 890 ppm.

Operating contact time (min)	Zinc content at various phase ratios (Extracting solution flow : Oil flow)				
	1:1	1:2	1:3	1:4	1:5
0	52.70	25.06	17.98	14.94	8.99
10	64.72	64.04	37.30	26.74	17.98
20	70.67	69.78	49.66	26.52	14.04
30	75.17	60.67	54.16	26.29	22.02
40	67.19	70.11	51.91	29.21	19.10
50	72.47	67.98	44.94	42.36	18.99
60	70.00	68.99	48.09	33.03	21.01
average	67.56	60.95	43.43	28.44	17.45

Table A.21 Zinc content at various initial zinc concentrations in continuous process.

Operating contact time (min)	Zinc content at various initial zinc concentrations (ppm)			
	153ppm	393ppm	706ppm	1467ppm
0	13	123	341	1098
10	15	64	256	646
20	10	112	312	755
30	11	129	366	1008
40	12	163	360	1040
50	15	158	327	1130
60	13	155	337	1077
average	12.71	129.14	328.43	964.86

Table A.22 %Extraction at various initial zinc concentrations in continuous process.

Operating contact time (min)	Zinc content at various initial zinc concentrations (ppm)			
	153ppm	393ppm	706ppm	1467ppm
0	91.50	68.70	51.70	25.15
10	90.20	83.72	63.74	55.96
20	93.46	71.50	55.81	48.53
30	92.81	67.18	48.16	31.29
40	92.16	58.52	49.01	29.11
50	90.20	59.80	53.68	22.97
60	91.50	60.56	52.27	26.58
average	91.69	67.14	53.48	34.23

Appendix B

Experiments for testing extractants and surfactants

The experimental procedure was followed as batch process experiments. This experiment was design for finding suitable extractant and surfactant used in further experiments. Ten types of extractant and four types of surfactant were studied.

For testing extractants, there were ten types of extractants, such as magnesium sulfate, sodium thiosulfate, sodium sulfate, ammonium dihydrogen phosphate, aluminium sulfate, ammonium sulfate, sodium metasulfate, disodium hydrogen phosphate, diammonium hydrogen phosphate, and ammonium persulfate. All of them were lab grade. Each extractants in concentration of 10% wt/wt was tested in batch process. After testing, the suitable extractant was considered by means of having high percentage of zinc extraction and giving optimum condition to operate and chosen to further study at concentration varied from 2 to 20% wt/wt in aqueous solution in order to find optimum concentration to used in batch and continuous processes.

For testing surfactants, there were four types of anionic surfactants, such as sodium lauryl sulfate, sodium dodecyl benzene sulfonate, sodium dioctylsulfosuccinate, and disodium laurethsulfosuccinate. Each surfactants in

concentration of 1% wt/wt was used. After testing, the suitable surfactant was considered by means of improving percentage of zinc extraction and giving optimum condition to operate and chosen to further study at concentration in the range of 1 to 8% wt/wt in aqueous solution without extractant and with extractant.



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APPENDIX C

EXPERIMENTAL CALCULATION

Calculation of percentage of zinc extraction and distribution coefficient could be shown as following formulae.

Percentage of zinc extraction (%Extraction)

$$\% \text{Extraction} = [(X_0 - X_i) / X_0] * 100$$

where

X_0 = initial zinc concentration in oil phase

X_i = final zinc concentration in oil phase

Distribution coefficient (K)

$$K = X_s / X_f$$

where

X_s = zinc content in extracting solution at equilibrium state

X_f = zinc content in oil at equilibrium state

VITA

Mr. Jaturaporn Bankaeng was born on May, 1972 in Bangkok, Thailand. He attended high school at Suankularb Wittayalai School and graduated in 1989. He received his Bachelor Degree of Science in Food Science and Technology from Kasetsart University, in 1993.



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