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APPENDICES

Appendix A Stock HSSs Solution, Mobile Phase, Diluent C, Titrant, and Indicator Preparation Calculation

HPLC Mobile Phase Preparation

Mobile phase: 0.05 M of KH_2PO_4

Adjusted pH to 2.6 by adding H_3PO_4

Acid dissociation: $H_3PO_4 \Leftrightarrow H^+ + H_2PO_4^-$ ($pK_{a1} = 2.13966$),

Buffer preparation calculation

$$K_{a1} = \frac{[H^+][H_2PO_4^-]}{[H_3PO_4]}$$

$$-\log(K_{a1}) = -\log[H^+] - \log\frac{[H_2PO_4^-]}{[H_3PO_4]}$$

$$pK_{a1} = pH - \log\frac{[H_2PO_4^-]}{[H_3PO_4]}$$

$$\log\frac{[H_2PO_4^-]}{[H_3PO_4]} = pH - pK_{a1}$$

$$\frac{[H_2PO_4^-]}{[H_3PO_4]} = 10^{(pH - pKa1)}$$

$$[H_2PO_4^-] = [H_3PO_4][10^{(pH - pKa1)}]$$

$$[0.05] = [H_3PO_4]\left[10^{(2.6-2.13966)}\right]$$

$$\therefore [H_3PO_4] = 0.0173\ M$$

Adding H_3PO_4 0.0173 M

Prepare 0.05 M KH_2PO_4

0.05 mol in 1 L = 0.05 mol x 136.0857 g/mol KH_2PO_4 = **6.8045 g KH_2PO_4 in 1 L DI water**

Adding H_3PO_4

0.0173 M = 0.0173 mol/L = 0.0173 mol/L x 97.9953 g/mol H_3PO_4 = 1.6953 g H_3PO_4 in 1 L DI water

85.7 wt% purityH_3PO_4 = 1.6953g/0.857 = 1.9945 g H_3PO_4 = 1.9945 g H_3PO_4/ 1.685 g/mL = **1.1837 mL H_3PO_4 in 1 L DI water.**

HSS 1,000 ppm Without MEA Stock Solution Preparation

Formate 1,000 ppm solution was prepared by 491 uL of formic acid 85 wt% dissolved in 500 mL of DI water.

$$\frac{1{,}000\ mgFormate}{10^6\ mgWater} \times \frac{100\ mgSol.}{85\ mgFormate} = \frac{1{,}176.4706\ mgSol.}{10^6\ mgWater}$$

$$1{,}176.4706\ mg\ in\ 1{,}000\ mLWater = 588.2353\ mg\ in\ 500\ mLWater$$

$$588.2353\ mg \times \frac{1\ mL}{1.198\ g} \times \frac{g}{1{,}000\ mg} = 0.491\ mL = 491\ uL\ of\ Formic\ acid$$

Acetate 1,000 ppm solution was prepared by 478 uL of acetic acid 99.7 wt% dissolved in 500 mL of DI water.

$$\frac{1{,}000\ mgAcetate}{10^6\ mgWater} \times \frac{100\ mgSol.}{99.7\ mgAcetate} = \frac{1{,}003.009\ mgSol.}{10^6\ mgWater}$$

$$1{,}003.009\ mg\ in\ 1{,}000\ mLWater = 501.5045\ mg\ in\ 500\ mLWater$$

$$501.5045\ mg \times \frac{1\ mL}{1.05\ g} \times \frac{g}{1{,}000\ mg} = 0.4776\ mL = 478\ uL\ of\ Acetic\ acid$$

Glycolate 1,000 ppm solution was prepared by 0.5051 g of sodium glycolate in 500 mL of DI water.

$$\frac{1{,}000\ mgGlycolate}{10^6\ mgWater} \times \frac{100\ mgSol.}{99\ mgGlycolate} = \frac{1{,}010.1010\ mgSol.}{10^6\ mgWater}$$

$$1{,}010.1010\ mg\ in\ 1{,}000\ mLWater = 505.0505\ mg\ in\ 500\ mLWater$$
$$= 0.5051\ g\ of\ Glycolate$$

Oxalate 1,000 ppm solution was prepared by 0.5051 g of sodium oxalate in 500 mL of DI water.

$$\frac{1{,}000\ mgOxalate}{10^6\ mgWater} \times \frac{100\ mgSol.}{99\ mgOxalate} = \frac{1{,}010.1010\ mgSol.}{10^6\ mgWater}$$

$$1{,}010.1010\ mg\ in\ 1{,}000\ mLWater = 505.0505\ mg\ in\ 500\ mLWater$$
$$= 0.5051\ g\ of\ Oxalate$$

Monoethanolamine 5 Molar (30 wt%) Preparation

5 M of MEA

$$\frac{5\ mol}{1\ L} = \frac{5\ mol\ MEA}{1\ L\ water} \times 61.08 \frac{g\ MEA}{mol\ MEA} = \frac{305.4\ g\ MEA}{1\ L\ water} \times \frac{1\ L\ water}{1{,}000\ g\ water}$$

$$= \frac{305.4\ g\ MEA}{1{,}000\ g\ water} \times 100 \approx 30.54\%wt$$

$$305.4\ g\ MEA \times \frac{1\ mL\ MEA}{1.02\ g\ MEA} = 311.5\ mL\ MEA$$

So, 5 M of MEA was prepared by adding **305.4 g or 311.5 mL of MEA into 1 L DI water**.

HSS 1,000 ppm with MEA Stock Solution Preparation

Formate 1,000 ppm solution was prepared by 98.2 uL of formic acid 85wt% mixed with 31.15 mL of MEA and then adjusted volume by DI water to 100 mL.

Glycolate 1,000 ppm solution was prepared by 0.1010 g of sodium glycolate mixed with 31.15 mL of MEA and then adjusted volume by DI water to 100 mL.

Oxalate 1,000 ppm solution was prepared by 0.1010 g of sodium oxalate mixed with 31.15 mL of MEA and then adjusted volume by DI water to 100 mL.

NaOH Preparation

2 M of NaOH for converting extractant-Cl to extractant-OH.

$$\frac{2\ mol}{1\ L} = \frac{2\ mol\ C}{1\ L\ water} \times 39.997 \frac{g\ NaOH}{mol\ NaOH}$$

$$= \frac{79.994\ g\ NaOH}{1\ L\ water} \times \frac{100}{99} \%puri = \frac{80.802\ g\ C}{1\ L\ water}$$

So, 2 M of NaOH was prepared by dissolving **80.802 g of pellet NaOH into 1 L of DI water.**

4 M of diluent NaOH for HSS back extraction.

$$\frac{4\ mol}{1\ L} = \frac{4\ mol\ NaOH}{1\ L\ water} \times 39.997 \frac{g\ NaOH}{mol\ NaOH} = \frac{159.998\ g\ NaOH}{1\ L\ water} \times \frac{100}{99} \%purity$$

$$= \frac{161.604\ g\ NaOH}{1\ L\ water}$$

So, 4 M NaOH was prepared by dissolving **161.604 g of pellet NaOH into 1 L of DI water.**

Sodium chromate indicator preparation

0.25 M of Na_2CrO_4 used as an indicator in Mohr's titration method.

$$\frac{0.25\ mol}{1\ L} = \frac{0.25\ mol\ Na_2CrO_4}{1\ L\ water} \times 161.97 \frac{g\ Na2CrO4}{mol\ Na2CrO4} = \frac{40.4925\ g\ Na2CrO4}{1\ L\ water}$$

$$= \frac{4.0493\ g\ Na2CrO4}{100\ mL\ water}$$

So, 0.25 M of Na_2CrO_4 was prepared by dissolving **4.0493 g of solid Na_2CrO_4 into 100 mL of DI water.**

Silver nitrate preparation

0.05 M of $AgNO_3$ used in Mohr's titration method for measuring Cl^- in extractant B.

$$\frac{0.05\ mol}{1\ L} = \frac{0.05\ mol\ AgNO_3}{1\ L\ water} \times 169.87 \frac{g\ AgNO_3}{mol\ AgNO_3} = \frac{8.4935\ g\ AgNO_3}{1\ L\ water}$$

$$= \frac{0.8494\ g\ AgNO_3}{100\ mL\ water}$$

So, 0.0500 M of $AgNO_3$ was prepared by dissolving **0.8494 g of solid $AgNO_3$ into 100 mL of DI water.**

Appendix B Conversion of Extractant-Cl to Extractant-OH. 1 M of Extractant-OH Preparation Calculation

Extractant as purchased is in the form of chloride (extractant-Cl). It was converted to hydroxide form by reaction,

Extractant-Cl + NaOH = Extractant-OH + NaCl

Table B1 Conversion of extractant-Cl to be extractant-OH measured by Mohr's method titration

Batch No.	1st titration				2nd titration				3rd titration				Avg. Conversion (%)
	Weight of B (g)	Vol. of $AgNO_3$ (ml)	Chloride (%)	Conversion (%)	Weight of B* (g)	Vol. of $AgNO_3$ (ml)	Chloride (%)	Conversion (%)	Weight of B (g)	Vol. of $AgNO_3$ (ml)	Chloride (%)	Conversion (%)	
1	0.1096	1.45	26.73	73.27	0.1132	1.5	26.78	73.22	0.1168	1.545	26.73	73.27	73.25
2	0.1055	1.36	26.05	73.95	0.113	1.46	26.11	73.89	0.0995	1.29	26.20	73.80	73.88
3	0.1021	1.5	29.69	70.31	0.0956	1.41	29.80	70.20	0.1021	1.46	28.90	71.10	70.54
4	0.1049	1535	29.57	70.43	0.1079	1.595	29.87	70.13	0.1049	1.515	29.19	70.81	70.46
5	0.1059	1.475	28.15	71.85	0.1058	1.45	27.69	72.31	0.1029	1.5	29.46	70.54	71.57

*Extractant-OH mixed with extractant-Cl remaining.

Table B2 Average conversion of extractant-OH after evaporation of water

After evaporation					Avg. Conversion (%)
No. titration	Weight of B* (g)	Vol. of $AgNO_3$** (mL)	Chloride (%)	Conversion (%)	
1	0.1176	2.27	36.80	63.20	63.48
2	0.1140	2.175	36.37	63.63	
3	0.1080	2.05	36.19	63.81	
4	0.1075	2.07	36.71	63.29	

*Extractant-OH mixed with extractant-Cl remaining.

**The actual concentration of $AgNO_3$ is 0.0472 M, which titrated with standard 0.05 M NaCl.

Calculation Example of Conversion from extractant-Cl to extractant-OH

Extractant-Cl + NaOH = Extractant-OH + NaCl

Molecular weight of extractant-Cl is 404.16 g/mol. One mole of extractant-Cl consists of one mole of Cl^- ion and one mole of extractant ion and produces one mole of extractant-OH. If the conversion is incomplete, there is extractant-OH and extractant-Cl remaining which extractant-Cl remaining can be determined by titration of Cl^- in extractant-Cl with Ag^+. The reation is one t one.

Know that Cl^- and Ag^+ have reaction at the mole ratio of 1:1.

From 1st titration of batch no. 1 in Table B1

1.45 mL of 0.0500 M of $AgNO_3$ was consumed = $\frac{0.05mol}{1000mL} \times 1.45mL$

= 0.0000725 mol Ag^+

= 0.0000725 mol Cl^- remaining in the sample

= 0.0000725 mol extractant-Cl

= 0.0000725 mol extractant-Cl $\times \frac{404.16\ g\ extractant-Cl}{1\ mol\ extractant-Cl}$

= 0.0293 g extractant-Cl (weight of extractant-Cl remaining)

Sample weight of 0.1096 g is a mixture of extractant-OH and extractant-Cl.

Calculate how much extractant-Cl is remaining,

$\frac{0.0293g}{0.1096g} \times 100 = 26.73$wt% extractant-Cl remaining

Therefore, the conversion is 100 – 26.73 = 73.27 wt% extractant-OH

Average Molecular Weight of Extractant After Converting

Molecular weight of extractant-Cl is 404.16 g/mol.

Molecular weight of Chloride (Cl^-) = 35.45 g/mol

Molecular weight of Hydroxide (OH^-) = 15.95 + 1 = 16.95 g/mol

Then, molecular weight of extractant-OH is (=404.16 – 35.45 + 16.95) = 385.66 g/mol

$Mw_{avg} = (Mw_B)(X_B) + (Mw_A)(X_A)$; where X_i = mass fraction

Then, Mw_{avg} = (385.66)(0.6348) + (404.16)(1-0.6348) = 392.4162 g/mol

The average molecular weight of extractant B is 392.4162 g/mol.

1 M of Extractant B Preparation Calculation

From the average molecular weight of extractant B, 392.4162 g/mol,

Therefore, 1 M of B in diluents with a total volume of 10 mL was calculated by

$$\frac{1\ mol}{1{,}000\ mL} \times \frac{392.4162\ g\ B}{mol} \times 10\ mL = 3.9241\ g\ B$$

1 M of B is equal to **3.9241 g of B adjusted volume to 10 mL by adding diluents.**

Later, the total volume of 6 mL was used instead, due to saving the extractant consumption.

So, 1 M of B in diluents with a total volume of 6 mL was calculated by

$$\frac{1\ mol}{1{,}000\ mL} \times \frac{392.4162\ g\ B}{mol} \times 6\ mL = 2.3545 g\ B$$

1 M of B is equal to **2.3545 g of B adjusted volume to 6 mL by adding diluents.**

Table B3 Example of preparation extractant in various diluents

Chemical	MW (g/mole)	Density (g/mL)	1M in 10 mL (g)	1M in 6 mL (g)
Avg. Extractant	392.4162	0.818	3.9241	2.3545
1-octanol	130.23	0.824	4.2848	2.5709
2-ethyl-hexanol	130.23	0.833	4.3316	2.5990
1-heptanol	102.17	0.8136	4.2307	2.5384
1-hexanol	116.2	0.8187	4.2572	2.5543
1-pentanol	88.15	0.8144	4.2349	2.5409

Table B4 1 M of average extractant B preparation for 1,000 HSSs without MEA extraction

1st HSSs w/o MEA extraction			
Weight of B (g)	**Diluents**		**Total vol. (mL)**
3.9248	1-octanol	4.1300g	10
3.9352	2-ethyl-hexanol	4.2500g	10
3.9378	1-heptanol	4.1167g	10
3.9295	1-hexanol	4.0271g	10
3.9390	1-pentanol	4.1002g	10
2nd HSSs w/o MEA extraction			
Weight of B (g)	**Diluents**		**Total vol. (mL)**
3.9401	1-octanol	4.2396g	10
3.9288	2-ethyl-hexanol	4.0624g	10
3.9305	1-heptanol	4.1201g	10
3.9384	1-hexanol	4.2947g	10
3.9400	1-pentanol	5.0700g	10
3rd HSSs w/o MEA extraction			
Weight of B (g)	**Diluents**		**Total vol. (mL)**
3.9201	1-octanol	4.1920g	10
3.9212	2-ethyl-hexanol	4.3708g	10
3.9411	1-heptanol	4.7401g	10
3.9302	1-hexanol	3.9795g	10
3.9324	1-pentanol	4.0443g	10

Note: All of extractant concentration was prepared at 1 M in each diluent.

Volume ratio of extracntant in diluents to HSSs aqueous solution is 1:1

Table B5 1st of 1 M of extractant B preparation for 1,000 ppm HSS with 30 wt% of MEA extraction

1st HSS with **30 wt%** *MEA extraction at room temperature (30 °C)*					
with Formate + 30 wt% MEA			**with Glycolate, Oxalate + 30 wt% MEA**		
Weight of B (g)	**Diluents**	**Total Vol. (mL)**	**Weight of B (g)**	**Diluents**	**Total Vol. (mL)**
3.9297	2-ethyl-hexanol 4.1842g	10	3.9364	2-ethyl-hexanol 4.3582g	10
3.9341	1-octanol 4.1275g	10	3.9328	1-octanol 4.1608g	10
2.3652	1-heptanol 2.3012g	6	2.3415	1-heptanol 2.2081g	6
2.3492	1-hexanol 2.2716g	6	2.3615	1-hexanol 2.1462g	6
2.3645	1-pentanol 2.3752g	6	2.3528	1-pentanol 2.2244g	6
1st HSS with **30 wt%** *MEA extraction at 60 °C*					
with Formate + 30 wt% MEA			**with Glycolate, Oxalate + 30 wt% MEA**		
Weight of B (g)	**Diluents**	**Total Vol. (mL)**	**Weight of B (g)**	**Diluents**	**Total Vol. (mL)**
2.3674	2-ethyl-hexanol 2.3970g	6	2.3542	2-ethyl-hexanol 2.2586g	6
2.358	1-octanol 2.2958g	6	2.3638	1-octanol 2.1631g	6
2.3632	1-heptanol 2.192g	6	2.3628	1-heptanol 2.0874g	6
2.3562	1-hexanol 2.084g	6	2.3506	1-hexanol 2.1918g	6
2.3551	1-pentanol 2.1536g	6	2.3511	1-pentanol 2.1607g	6

Table B6 2nd of 1 M of extractant B preparation for 1,000 ppm HSS with 30 wt% of MEA extraction

2nd HSS with **30 wt%** *MEA extraction at room temperature (30 °C)*					
with Formate + 30 wt% MEA			**with Glycolate, Oxalate + 30 wt% MEA**		
Weight of B (g)	**Diluents**	**Total Vol. (mL)**	**Weight of B (g)**	**Diluents**	**Total Vol. (mL)**
2.3689	2-ethyl-hexanol 2.4378g	6	2.3627	2-ethyl-hexanol 2.1711g	6
2.3718	1-octanol 2.0109g	6	2.3703	1-octanol 2.3163g	6
2.3512	1-heptanol 2.3455g	6	2.3522	1-heptanol 2.3038g	6
2.3514	1-hexanol 2.5112g	6	2.3582	1-hexanol 2.4456g	6
2.3493	1-pentanol 2.4735g	6	2.349	1-pentanol 2.3701g	6
2nd HSS with **30 wt%** *MEA extraction at 60 °C*					
with Formate + 30 wt% MEA			**with Glycolate, Oxalate + 30 wt% MEA**		
Weight of B (g)	**Diluents**	**Total Vol. (mL)**	**Weight of B (g)**	**Diluents**	**Total Vol. (mL)**
2.3453	2-ethyl-hexanol 2.6511g	6	2.3469	2-ethyl-hexanol 2.3379g	6
2.3479	1-octanol 2.3381g	6	2.364	1-octanol 2.2607g	6
2.3654	1-heptanol 2.3838g	6	2.3743	1-heptanol 2.3142g	6
2.3663	1-hexanol 2.4407g	6	2.3563	1-hexanol 2.3766g	6
2.3667	1-pentanol 2.5388g	6	2.3595	1-pentanol 2.3253g	6

Table B7 3rd of 1 M of extractant B preparation for 1.000 ppm HSS with 30 wt% of MEA extraction

3rd HSS with 30 wt% MEA extraction at room temperature (30 °C)					
with Formate + 30 wt% MEA			**with Glycolate, Oxalate + 30 wt% MEA**		
Weight of B (g)	**Diluents**	**Total Vol. (mL)**	**Weight of B (g)**	**Diluents**	**Total Vol. (mL)**
2.3578	2-ethyl-hexanol 2.4468g	6	2.3583	2-ethyl-hexanol 2.4921g	6
2.3523	1-octanol 2.4841g	6	2.3635	1-octanol 2.4494g	6
2.3585	1-heptanol 2.5258g	6	2.3608	1-heptanol 2.5335g	6
2.3501	1-hexanol 2.5348g	6	2.3490	1-hexanol 2.5130g	6
2.3594	1-pentanol 2.3597g	6	2.3495	1-pentanol 2.578g	6
3rd HSS with 30 wt% MEA extraction at 45 °C					
with Formate + 30 wt% MEA			**with Glycolate, Oxalate + 30 wt% MEA**		
Weight of B (g)	**Diluents**	**Total Vol. (mL)**	**Weight of B (g)**	**Diluents**	**Total Vol. (mL)**
2.356	2-ethyl-hexanol 2.4835g	6	2.3588	2-ethyl-hexanol 2.4669g	6
2.3625	1-octanol 2.4717g	6	2.3651	1-octanol 2.5206g	6
2.3523	1-heptanol 2.4997g	6	2.3495	1-heptanol 2.5690g	6
2.3542	1-hexanol 2.5150g	6	2.3505	1-hexanol 2.7085g	6
2.3602	1-pentanol 2.5101g	6	2.3556	1-pentanol 2.6010g	6

Appendix C Extraction of HSSs Solution without MEA Presence with Diluents Alone (without Extractant B)

Extraction efficiency in every section was calculated based on the HSS concentration before extracted and remaining HSS concentration.

Example from 1st Extraction of formate by 1-octanol

Formate concentration before extraction was 896.92 ppm

Remaining formate concentration was 803.96 ppm

Thus, extracted formate by 1-octanol was 896.92 – 803.96 = 92.96 ppm

$$\frac{92.96\ ppm}{896.92\ ppm} \times 100 = 10.36\ \%$$

Table C1 HPLC Analysis of the 1st Extraction of HSSs

	Retention time (min)				Peak Area				Peak Height (μV)			
	Formate	**Acetate**	**Glycolate**	**Oxalate**	**Formate**	**Acetate**	**Glycolate**	**Oxalate**	**Formate**	**Acetate**	**Glycolate**	**Oxalate**
Before extraction	9.869	16.288	9.444	7.471	6320944	3720460	3217780	52760714	294217	131750	155645	3182344
1-Octanol	9.89	16.336	9.47	7.499	5487572	2613767	3119662	54620206	262161	93219	150718	3249220
2-ethyl-hexanol	9.868	16.327	9.447	7.476	5470825	2477505	3167114	52844637	258735	88965	150360	3209330
1-heptanol	9.866	16.33	9.446	7.474	5267709	2422189	3083266	54144295	251610	86461	148137	3274825
1-hexanol	9.874	16.336	9.454	7.485	5058609	2200670	3089041	54455115	243802	79053	146796	3292731
1-pentanol	9.863	16.323	9.445	7.478	5059600	2188177	2955770	55650178	239024	75618	143579	32358026

Table C1(cont.)

	Concentration (ppm)				Extraction efficiency (%)			
	Formate	**Acetate**	**Glycolate**	**Oxalate**	**Formate**	**Acetate**	**Glycolate**	**Oxalate**
Before extraction	896.92	982.22	926.00	1391.30	-	-	-	-
1-Octanol	803.96	685.53	886.75	1465.68	10.36	30.21	4.24	0.00
2-ethyl-hexanol	794.02	652.77	905.74	1394.66	11.47	33.54	2.19	0.00
1-heptanol	773.36	633.49	872.20	1446.64	13.78	35.50	5.81	0.00
1-hexanol	750.71	576.45	874.51	1459.07	16.30	41.31	5.56	0.00
1-pentanol	736.86	550.00	821.20	1506.88	17.85	44.00	11.32	0.00

Table C2 HPLC Analysis of the 2nd Extraction of HSSs

	Retention time (min)				Peak Area				Peak Height (μV)			
	Formate	**Acetate**	**Glycolate**	**Oxalate**	**Formate**	**Acetate**	**Glycolate**	**Oxalate**	**Formate**	**Acetate**	**Glycolate**	**Oxalate**
Before extraction	9.872	16.266	9.449	7.482	5982370	3669856	3178088	52187899	289889	129869	152597	3278749
1-Octanol	9.881	16.342	9.461	7.482	5651612	2657120	3183891	55900949	265269	94692	152440	3376530
2-ethyl-hexanol	9.88	16.344	9.46	7484	5458804	2585227	3163266	53674684	263390	92529	151418	3311147
1-heptanol	9.89	16.361	9.471	7.494	5301639	2462534	3091610	54512978	253855	88077	148155	3342509
1-hexanol	9.881	16.359	9.463	7.486	5190275	2264337	3062405	54752051	246508	80951	146927	3336101
1-pentanol	9.876	16.351	9.458	7.485	5103189	2153573	3038352	56275489	239457	76036	144846	3356714

Table C2(cont.)

	Concentration (ppm)				Extraction efficiency (%)			
	Formate	**Acetate**	**Glycolate**	**Oxalate**	**Formate**	**Acetate**	**Glycolate**	**Oxalate**
Before extraction	884.37	967.73	910.13	1368.39	-	-	-	-
1-Octanol	812.97	696.87	912.45	1516.91	8.07	27.99	0.00	0.00
2-ethyl-hexanol	807.52	680.22	904.20	1427.86	8.69	29.71	0.65	0.00
1-heptanol	779.87	645.94	875.53	1461.39	11.82	33.25	3.80	0.00
1-hexanol	758.56	591.07	863.85	1470.95	14.23	38.92	5.08	0.00
1-pentanol	738.11	553.22	854.23	1531.89	16.54	42.83	6.14	0.00

Table C3 HPLC Analysis of 3rd Extraction of HSSs

	Retention time (min)				Peak Area				Peak Height (μV)			
	Formate	**Acetate**	**Glycolate**	**Oxalate**	**Formate**	**Acetate**	**Glycolate**	**Oxalate**	**Formate**	**Acetate**	**Glycolate**	**Oxalate**
Before extraction	9.85	16.14	9.429	7.489	5985147	3672596	3158823	51167206	291112	131349	153820	3177360
1-Octanol	9.859	16.25	9.441	7.484	5408497	2540314	3167553	52922122	259882	91442	150359	3219771
2-ethyl-hexanol	9.853	16.245	9.434	7.477	5633395	2571688	3215184	52645599	263024	92195	152648	3219725
1-heptanol	9.842	16.222	9.426	7.472	5295325	2435403	3103864	52429093	253345	87840	148609	3197871
1-hexanol	9.862	16.27	9.446	7.485	5232410	2239402	3098140	54440560	247627	80614	148861	3279002
1-pentanol	9.854	16.208	9.439	7.497	5054999	2101878	3002267	52683343	239809	75700	145435	3180788

Table C3(cont.)

	Concentration (ppm)				Extraction efficiency (%)			
	Formate	**Acetate**	**Glycolate**	**Oxalate**	**Formate**	**Acetate**	**Glycolate**	**Oxalate**
Before extraction	887.91	979.13	902.42	1327.56	-	-	-	-
1-Octanol	797.35	671.85	905.91	1397.75	10.20	31.38	0.00	0.00
2-ethyl-hexanol	806.46	677.64	924.96	1386.69	9.17	30.79	0.00	0.00
1-heptanol	778.39	644.11	880.44	1378.03	12.34	34.22	2.44	0.00
1-hexanol	761.81	588.47	878.15	1458.49	14.20	39.90	2.69	0.00
1-pentanol	739.14	550.63	839.80	1388.20	16.76	43.76	6.94	0.00

Table C4 Average extraction efficiency of diluents alone

Diluents	Extraction efficiency (%)			
	Formate (%)	**Acetate (%)**	**Glycolate (%)**	**Oxalate (%)**
1-Octanol	9.55±1.28	29.86 ± 1.72	1.41 ± 2.45	0.00 ± 0.00
2-ethyl-hexanol	9.78 ± 1.49	31.35 ± 1.97	0.95 ± 1.12	0.00 ± 0.00
1-heptanol	12.64 ± 1.02	34.32 ± 1.13	4.02 ± 1.70	0.00 ± 0.00
1-hexanol	14.91 ± 1.20	40.04 ± 1.20	4.45 ± 1.54	0.00 ± 0.00
1-pentanol	17.05 ± 0.70	43.53 ± 0.62	8.13 ± 2.79	0.00 ± 0.00

Appendix D Extraction of HSSs Solution without MEA Presence with Extractant in Various Diluents

Table D1 HPLC Analysis of HSS without MEA from the 1st extraction

	Retention time (min)				Peak Area				Peak Height (μV)			
	Formate	**Acetate**	**Glycolate**	**Oxalate**	**Formate**	**Acetate**	**Glycolate**	**Oxalate**	**Formate**	**Acetate**	**Glycolate**	**Oxalate**
Before extraction	10.11	16.54	9.67	7.66	6,688,698	3,684,003	3,543,034	46,450,426	302243	135588	166634	3155105
B in 1-Octanol	9.86	16.03	9.47	7.69	242,932	407,707	376,623	146,177	13417	8314	15579	15523
B in 2-ethyl-hexanol	9.81	15.65	9.43	7.70	234,203	190,199	330,224	116,233	10935	4781	13261	12741
B in 1-heptanol	9.88	16.13	9.48	7.68	270,301	321,147	422,259	134,119	14426	7816	18094	14201
B in 1-hexanol	9.91	16.25	9.50	7.71	339,964	302,212	398,776	180,679	14962	8659	18685	18026
B in 1-pentanol	9.90	16.20	9.49	7.70	301,825	299,839	452,553	236,090	15685	7824	19174	19589

Table D1(cont.)

	Concentration (ppm)				Extraction efficiency (%)			
	Formate	**Acetate**	**Glycolate**	**Oxalate**	**Formate**	**Acetate**	**Glycolate**	**Oxalate**
Before extraction	1,300	1,100	1,021.75	929	-	-	-	-
B in 1-Octanol	9.87	116.27	71.83	2.92	99.24	89.43	92.97	99.69
B in 2-ethyl-hexanol	8.12	51.01	57.91	2.33	99.38	95.36	94.33	99.75
B in 1-heptanol	15.35	90.30	85.52	2.68	98.82	91.79	91.63	99.71
B in 1-hexanol	29.28	84.62	78.48	3.61	97.75	92.31	92.32	99.61
B in 1-pentanol	21.65	83.91	94.61	4.72	98.33	92.37	90.74	99.49

Table D2 HPLC Analysis of HSS without MEA from the 2nd extraction

	Retention time (min)				Peak Area				Peak Height (μV)			
	Formate	**Acetate**	**Glycolate**	**Oxalate**	**Formate**	**Acetate**	**Glycolate**	**Oxalate**	**Formate**	**Acetate**	**Glycolate**	**Oxalate**
Before extraction	9.89	16.18	9.45	7.50	6,549,807	3,602,744	3,458,479	46,519,679	292126	130393	161974	3184288
B in 1-Octanol	9.74	16.16	9.32	7.52	340,560	332,432	562,754	85,690	15812	10272	19150	12937
B in 2-ethyl-hexanol	9.75	16.09	9.32	7.55	219,116	181,061	348,125	32,903	9853	5841	13386	4589
B in 1-heptanol	9.76	16.21	9.34	7.54	301,636	288,926	477,814	51,138	14170	9653	18230	7770
B in 1-hexanol	9.68	16.54	9.32	7.72	253,067	131,697	349,293	124,488	11024	4032	13687	9755
B in 1-pentanol	9.80	16.32	9.38	7.54	449,357	412,431	725,563	423,980	22085	15457	27575	37792

Table D2(cont.)

	Concentration (ppm)				Extraction efficiency (%)			
	Formate	**Acetate**	**Glycolate**	**Oxalate**	**Formate**	**Acetate**	**Glycolate**	**Oxalate**
Before extraction	1,270	1,075	996.40	930	-	-	-	-
B in 1-Octanol	29.40	93.68	127.67	1.71	97.69	91.29	87.19	99.82
B in 2-ethyl-hexanol	5.11	48.27	63.28	0.66	99.60	95.51	93.65	99.93
B in 1-heptanol	21.61	80.63	102.19	1.02	98.30	92.50	89.74	99.89
B in 1-hexanol	11.90	33.46	63.63	2.49	99.06	96.89	93.61	99.73
B in 1-pentanol	51.16	16.32	176.51	8.48	95.97	98.48	82.29	99.09

Table D3 Analysis of HSS without MEA from the 3rd extraction

	Retention time (min)				Peak Area				Peak Height (μV)			
	Formate	**Acetate**	**Glycolate**	**Oxalate**	**Formate**	**Acetate**	**Glycolate**	**Oxalate**	**Formate**	**Acetate**	**Glycolate**	**Oxalate**
Before extraction	9.89	16.18	9.45	7.50	6,549,807	3,602,744	3,458,479	46,519,679	292126	130393	161974	3184288
B in 1-Octanol	9.78	16.19	9.36	7.56	352,859	316,369	546,552	50,603	16439	10748	20446	7927
B in 2-ethyl-hexanol	9.74	16.05	9.31	7.56	230,024	180,617	350,193	37,010	9671	5899	14166	4639
B in 1-heptanol	9.77	16.09	9.35	7.56	377,380	309,370	590,336	98,769	17366	9301	21838	12796
B in 1-hexanol	9.75	16.11	9.33	7.55	339,823	290,166	517,379	130,031	16546	9393	20614	15856
B in 1-pentanol	9.80	16.25	9.37	7.58	364,468	299,544	519,386	112,977	16229	11120	20997	13301

Table D3(cont.)

	Concentration (ppm)				Extraction efficiency (%)			
	Formate	**Acetate**	**Glycolate**	**Oxalate**	**Formate**	**Acetate**	**Glycolate**	**Oxalate**
Before extraction	1,270	1,075	996.40	930	-	-	-	-
B in 1-Octanol	31.85	88.86	122.81	1.01	97.49	91.73	87.67	99.89
B in 2-ethyl-hexanol	7.29	48.14	63.90	0.74	99.43	95.52	93.59	99.92
B in 1-heptanol	36.76	86.76	135.94	1.98	97.11	91.93	86.36	99.79
B in 1-hexanol	29.25	81.00	114.06	2.60	97.70	92.47	88.55	99.72
B in 1-pentanol	34.18	83.82	114.66	2.26	97.31	92.20	88.49	99.76

Table D4 Average HSS extraction efficiency without MEA solution

Diluents	Extraction efficiency (%)			
	Formate (%)	Acetate (%)	Glycolate (%)	Oxalate (%)
1-Octanol	94.87 ± 0.62	93.01 ± 1.06	85.97 ± 3.222	99.92 ± 0.04
2-ethyl-hexanol	96.57 ± 0.16	96.05 ± 0.53	90.43 ± 0.494	99.95 ± 0.04
1-heptanol	94.84 ± 0.64	93.62 ± 0.83	85.94 ± 2.684	99.92 ± 0.04
1-hexanol	95.23 ± 0.94	94.75 ± 2.04	88.13 ± 2.591	99.87 ± 0.03
1-pentanol	93.94 ± 1.25	91.78 ± 2.86	83.92 ± 4.344	99.77 ± 0.14

Appendix E Results from HSSs with 30 wt% MEA Extraction at Room Temperature, 45 °C, and 60 °C; and Extraction Efficiency Calculation

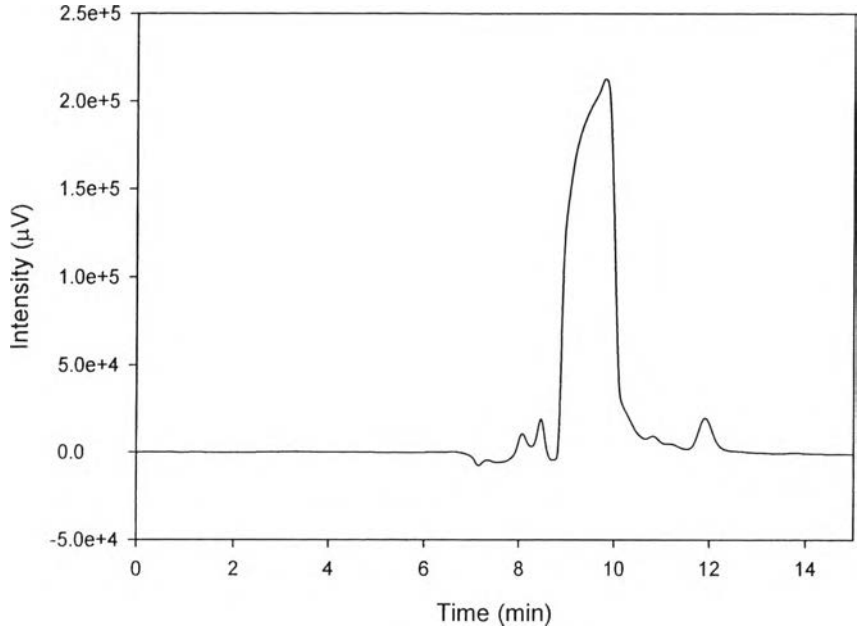

Figure E1. Chromatogram of background of 3 wt% MEA solution.

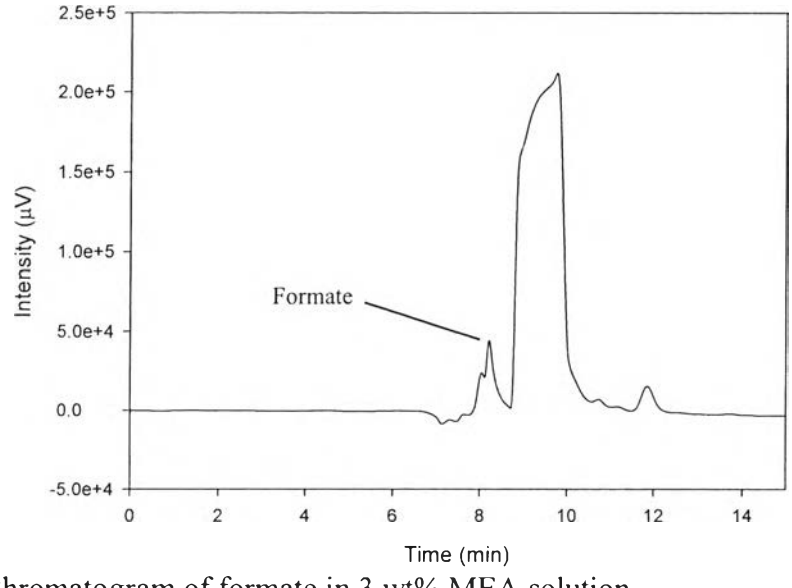

Figure E2. Chromatogram of formate in 3 wt% MEA solution.

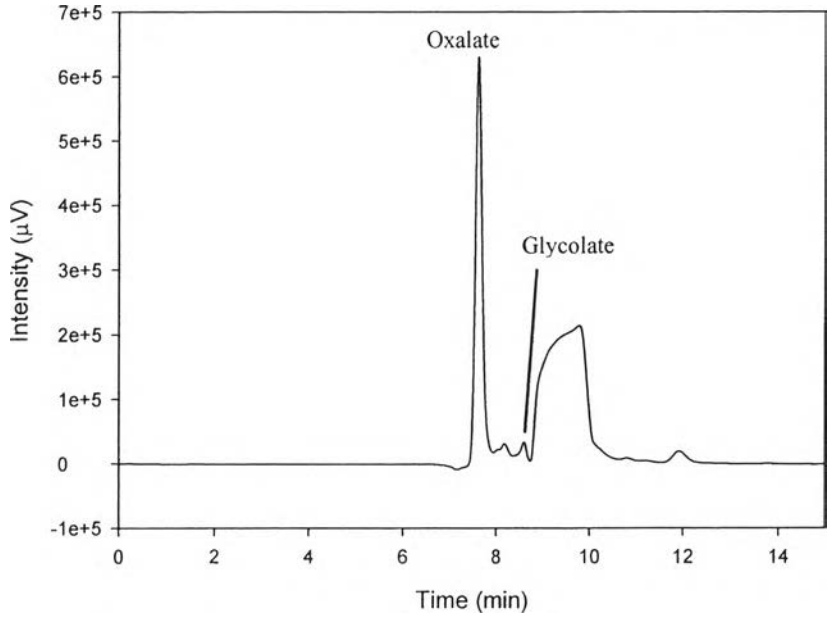

Figure E3. Chromatogram of oxalate and glycolate in 3 wt% MEA solution.

Note that the MEA has the noise in the background when analyzed by HPLC at the same retention time of formate and glycolate. The average height of the noise peaks are 24,151 and 20,398 for formate and glycolate, respectively. The results obtained from chromatograms must be deducted by the noises.

Example: Peak height of formate before extraction was 45,944, deducted the noise in the background 45,944 – 24,151 = 21,793 Example: Peak height of formate extracted by extractant B in 1-octanol was 13,592. Assuming all the degradation compounds of MEA (noise) were equally extracted as HSSs. Then compare the extracted by

$$\frac{(21{,}793)}{(45{,}944)} \times 13{,}592 = 6{,}447.21$$

Table E1 1st HSSs with 30 wt% MEA extraction at room temperature (30 °C)

	Retention time (min)			Height			Height (deducted noise)		
	Formate	**Glycolate**	**Oxalate**	**Formate**	**Glycolate**	**Oxalate**	**Formate**	**Glycolate**	**Oxalate**
Before extraction	8.388	8.268	7.817	76,768.00	51,372.00	610,179.00	52,617.00	30,974.00	610,179.00
B in 1-Octanol	8.086	8.254	7.864	13,592.00	9,456.00	167.00	6,447.21	5,701.36	167.00
B in 2-ethyl-hexanol	7.99	8.232	7.597	17,914.00	9,710.00	1,386.00	8,497.30	5,854.50	1,386.00
B in 1-heptanol	8.263	8.23	7.867	30,806.00	11,135.00	1,484.00	21,114.52	6,713.69	1,484.00
B in 1-hexanol	8.294	8.249	7.843	10,417.00	9,835.00	1,016.00	7,139.84	5,929.87	1,016.00
B in 1-pentanol	8.275	8.224	7.838	21,763.00	7,596.00	1,411.00	14,916.42	4,579.90	1,411.00

Table E1(cont.) 1st HSSs with 30 wt% MEA extraction at room temperature (30 °C)

	Concentration (ppm)			Extraction efficiency (%)		
	Formate	**Glycolate**	**Oxalate**	**Formate**	**Glycolate**	**Oxalate**
Before extraction	52.62	154.96	121.84	-	-	-
B in 1-Octanol	6.45	43.76	0.00	70.42	71.76	99.99
B in 2-ethyl-hexanol	8.50	44.44	0.00	61.01	71.32	99.99
B in 1-heptanol	21.11	48.22	0.10	59.87	68.88	99.91
B in 1-hexanol	7.14	44.77	0.01	86.43	71.11	99.99
B in 1-pentanol	14.92	38.83	0.09	71.65	74.94	99.93

Table E2 2nd HSSs with 30 wt% MEA extraction at room temperature (30 °C)

	Retention time (min)			Height			Height (deducted noise)		
	Formate	**Glycolate**	**Oxalate**	**Formate**	**Glycolate**	**Oxalate**	**Formate**	**Glycolate**	**Oxalate**
Before extraction	8.388	8.268	7.817	76,768.00	51,372.00	610,179.00	52,617.00	30,974.00	610,179.00
B in 1-Octanol	8.058	8.238	7.863	28,149.00	11,458.00	1,301.00	18,366.48	6,908.43	1,301.00
B in 2-ethyl-hexanol	8.067	8.236	-	20,563.00	10,371.00	-	13,416.81	6,253.04	-
B in 1-heptanol	8.273	8.236	7.856	26,640.00	9,428.00	953.00	18,259.13	5,684.48	953.00
B in 1-hexanol	8.272	8.238	7.843	21,767.00	9,790.00	1,205.00	14,919.16	5,902.74	1,205.00
B in 1-pentanol	8.286	8.292	7.917	26,596.00	9,483.00	2,943.00	18,228.97	5,717.64	2,943.00

Table E2(cont.) 2nd HSSs with 30 wt% MEA extraction at room temperature (30 °C)

	Concentration (ppm)			Extraction efficiency (%)		
	Formate	**Glycolate**	**Oxalate**	**Formate**	**Glycolate**	**Oxalate**
Before extraction	52.62	154.96	121.84	-	-	-
B in 1-Octanol	18.37	49.08	0.07	59.49	68.33	99.95
B in 2-ethyl-hexanol	13.42	46.19	0.00	70.41	70.19	99.99
B in 1-heptanol	18.26	43.69	0.00	65.30	71.81	99.99
B in 1-hexanol	14.92	44.65	0.05	71.65	71.19	99.96
B in 1-pentanol	18.23	43.84	0.39	65.36	71.71	99.67

Table E3 3rd HSSs with 30 wt% MEA extraction at room temperature (30 °C)

	Retention time (min)			Height			Height (deducted noise)		
	Formate	**Glycolate**	**Oxalate**	**Formate**	**Glycolate**	**Oxalate**	**Formate**	**Glycolate**	**Oxalate**
Before extraction	8.334	8.324	7.773	43,900.00	31,922.00	597,054.00	19,749.00	11,524.00	597,054.00
B in 1-Octanol	8.213	8.231	7.8	12,120.00	11,191.00	845.00	5,452.34	4,040.01	845.00
B in 2-ethyl-hexanol	8.217	8.23	7.793	12,822.00	9,317.00	524.00	5,768.15	3,363.48	524.00
B in 1-heptanol	8.226	8.215	7.743	17,139.00	10,633.00	507.00	7,710.21	3,838.57	507.00
B in 1-hexanol	8.233	8.231	7.802	11,393.00	13,661.00	1,107.00	5,125.29	4,931.69	1,107.00
B in 1-pentanol	8.226	8.23	7.797	16,740.00	13,483.00	1,477.00	7,530.71	4,867.43	1,477.00

Table E3(cont.) 3rd HSSs with 30 wt% MEA extraction at room temperature (30 °C)

	Concentration (ppm)			Extraction efficiency (%)		
	Formate	**Glycolate**	**Oxalate**	**Formate**	**Glycolate**	**Oxalate**
Before extraction	19.75	159.14	119.22	-	-	-
B in 1-Octanol	5.45	36.46	0.00	72.39	77.09	99.99
B in 2-ethyl-hexanol	5.77	33.48	0.00	70.79	78.96	99.99
B in 1-heptanol	7.71	35.57	0.00	60.96	77.65	99.99
B in 1-hexanol	5.13	40.38	0.03	74.05	74.63	99.98
B in 1-pentanol	7.53	40.10	0.10	61.87	74.80	99.92

Table E4 HSSs with 30 wt% MEA extraction at 45 °C

	Retention time (min)			Height			Height (deducted noise)		
	Formate	**Glycolate**	**Oxalate**	**Formate**	**Glycolate**	**Oxalate**	**Formate**	**Glycolate**	**Oxalate**
Before extraction	8.288	8.284	7.840	64,945.00	42,586.00	606,745.00	40,794.00	22,188.00	606,745.00
B in 1-Octanol	8.212	8.208	-	10,201.00	11,051.00	-	6,655.88	4,632.85	-
B in 2-ethyl-hexanol	8.283	8.268	7.874	13,511.00	19,259.00	2,406.00	8,486.68	10,034.25	2,406.00
B in 1-heptanol	8.215	8.226	7.82	10,144.00	9,757.00	1,025.00	6,618.69	4,090.37	1,025.00
B in 1-hexanol	8.277	8.204	7.81	17,987.00	9,629.00	1,866.00	11,298.20	4,036.71	1,866.00
B in 1-pentanol	8.292	8.212	7.83	18,167.00	10,359.00	2,493.00	11,411.26	4,342.75	2,493.00

Table E4(cont.) HSSs with 30 wt% MEA extraction at 45 °C

	Concentration (ppm)			Extraction efficiency (%)		
	Formate	**Glycolate**	**Oxalate**	**Formate**	**Glycolate**	**Oxalate**
Before extraction	40.79	206.06	121.16	-	-	-
B in 1-Octanol	6.66	39.06	0.00	85.32	83.23	99.99
B in 2-ethyl-hexanol	8.49	62.83	0.29	79.20	69.51	99.76
B in 1-heptanol	6.62	36.68	0.01	85.40	84.25	99.99
B in 1-hexanol	11.30	36.44	0.18	72.30	84.36	99.85
B in 1-pentanol	11.41	37.79	0.30	72.03	83.78	99.75

Table E5 HSSs with 30 wt% MEA extraction at 60 °C

	Retention time (min)			Height			Height (deducted noise)		
	Formate	**Glycolate**	**Oxalate**	**Formate**	**Glycolate**	**Oxalate**	**Formate**	**Glycolate**	**Oxalate**
Before extraction	8.288	8.284	7.840	64,945.00	42,586.00	606,745.00	40,794.00	22,188.00	606,745.00
B in 1-Octanol	8.251	8.078	-	20,116.00	14,765.00	-	12,635.49	6,189.85	-
B in 2-ethyl-hexanol	8.053	8.07	-	19,358.00	15,525.00	-	12,630.58	6,508.46	-
B in 1-heptanol	8.052	8.269	-	25,027.00	15,288.00	-	16,329.46	7,965.30	741.00
B in 1-hexanol	8.042	8.267	7.876	13,809.00	14,767.00	741.00	9,010.01	7,965.30	232.00
B in 1-pentanol	8.267	8.264	7.863	17,841.00	18,725.00	232.00	11,206.49	7,693.85	741.00

Table E5(cont.) HSSs with 30 wt% MEA extraction at 60 °C

	Concentration (ppm)			Extraction efficiency (%)		
	Formate	Glycolate	Oxalate	Formate	Glycolate	Oxalate
Before extraction	40.79	206.06	121.16	-	-	-
B in 1-Octanol	12.64	45.91	0.00	69.03	80.29	99.99
B in 2-ethyl-hexanol	12.63	47.32	0.00	72.14	79.69	99.99
B in 1-heptanol	16.33	53.73	0.00	63.99	73.93	99.99
B in 1-hexanol	9.01	52.53	0.00	80.13	74.51	99.99
B in 1-pentanol	11.21	61.61	0.00	72.53	70.10	99.99

Table E6 HSS in 30 wt% MEA extraction efficiency deviation, extracted by extractant in various diluents at room temperature (30 °C)

Diluents	Extraction efficiency (%)		
	Formate (%)	Glycolate (%)	Oxalate (%)
1-Octanol	67.43 ± 6.95	72.44 ± 4.49	99.98 ± 0.03
2-ethyl-hexanol	67.40 ± 5.54	74.81 ± 7.04	99.99 ± 0.00
1-heptanol	62.04 ± 2.87	73.07 ± 4.94	99.96 ± 0.04
1-hexanol	77.37 ± 7.93	73.65 ± 4.33	99.98 ± 0.02
1-pentanol	66.29 ± 4.96	74.86 ± 3.11	99.84 ± 0.15

Table E7 Deviation of the formate extraction efficiency by extractant in various diluents affected by temperature at 45 °C and 60 °C

Diluents	Formate 30°C (wt%)	Formate 45°C (wt%)	Deviation from 30°C (wt%)	Formate 60°C (wt%)	Deviation from 30°C (wt%)
1-octanol	67.43±6.95	66.30		69.03	
2-ethyl-1-hexanol	67.40±5.54	79.20	+6.25	72.14	
1-heptanol	62.04±2.87	66.49	+1.57	63.99	
1-hexanol	77.37±7.93	72.30		80.13	
1-pentanol	66.29±4.96	72.03	+0.78	72.53	+1.28

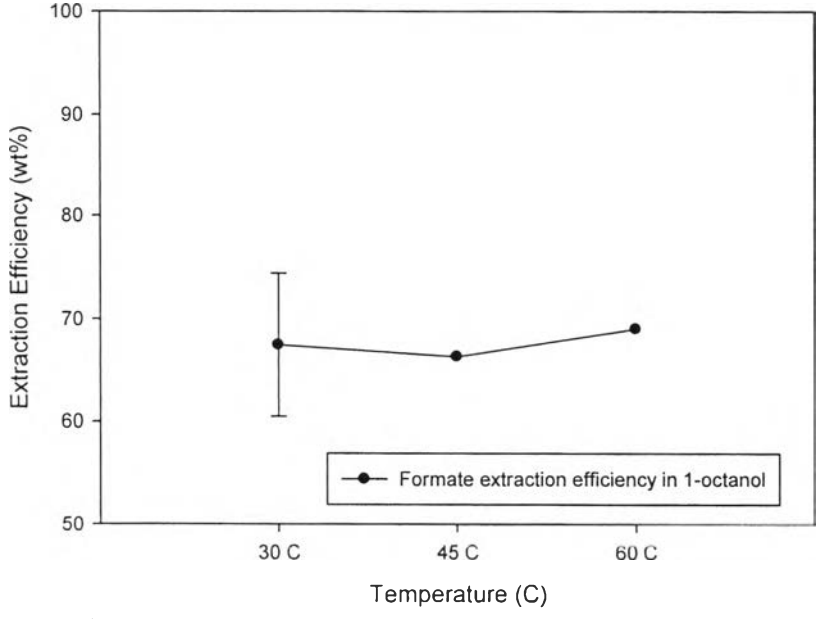

Figure E4. Effect of formate extraction in 1-octanol diluents, varied temperature.

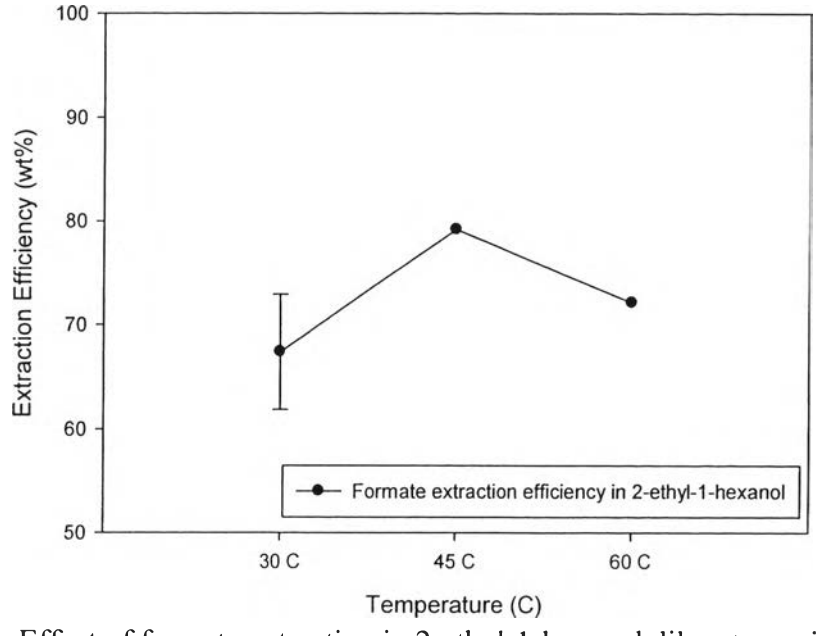

Figure E5. Effect of formate extraction in 2-ethyl-1-hexanol diluents, varied temperature.

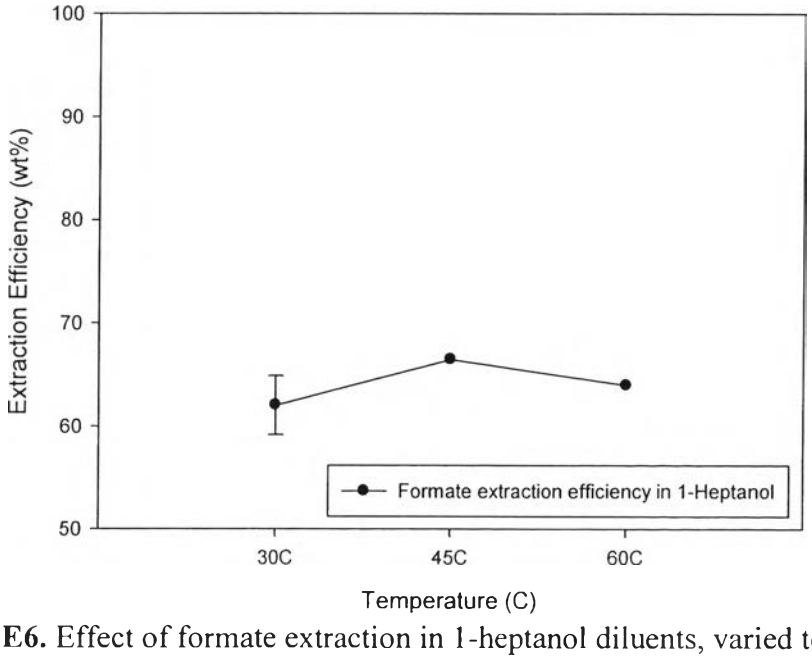

Figure E6. Effect of formate extraction in 1-heptanol diluents, varied temperature.

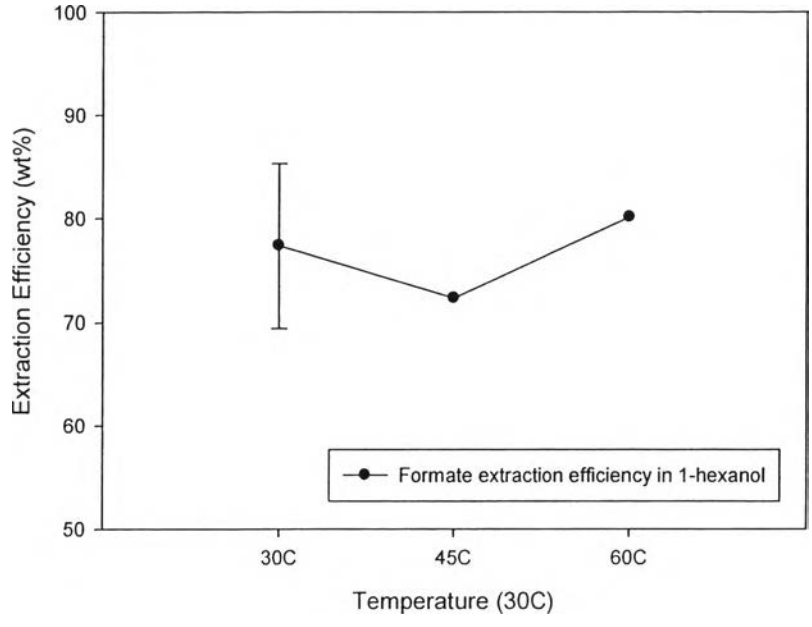

Figure E7. Effect of formate extraction in 1-hexanol diluents, varied temperature.

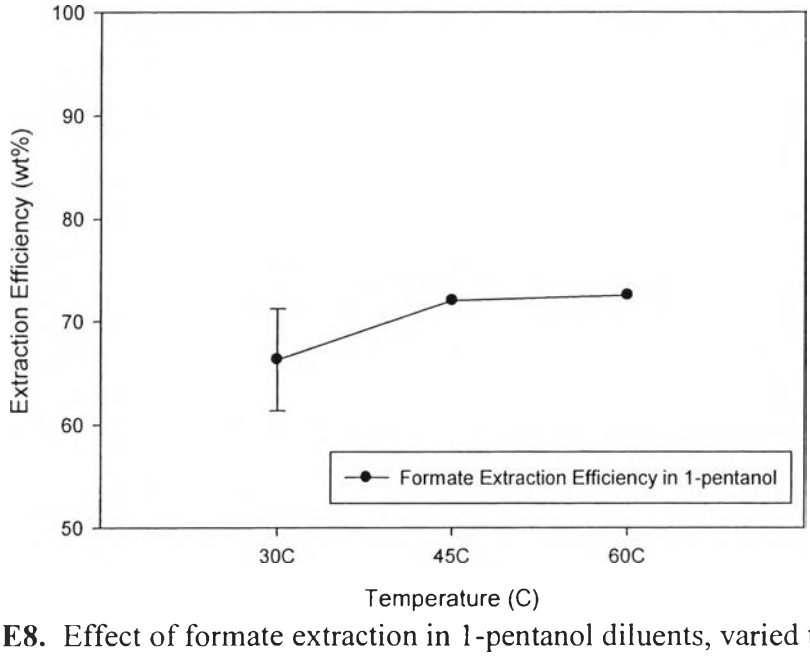

Figure E8. Effect of formate extraction in 1-pentanol diluents, varied temperature.

Table E8 Deviation of the glycolate extraction efficiency by extractant in various diluents affected by temperature at 45 °C and 60 °C

Diluents	Glycolate 30C (wt%)	Glycolate 45C (wt%)	Deviation from 30C (wt%)	Glycolate 60C (wt%)	Deviation from 30C (wt%)
1-octanol	72.44±4.49	77.23	+0.30	72.33	
2-ethyl-1-hexanol	74.81±7.04	69.51		71.31	
1-heptanol	73.07±4.94	78.52	+0.51	73.93	
1-hexanol	73.65±4.33	78.65	+0.67	74.51	
1-pentanol	74.86±3.11	77.92		70.10	-1.65

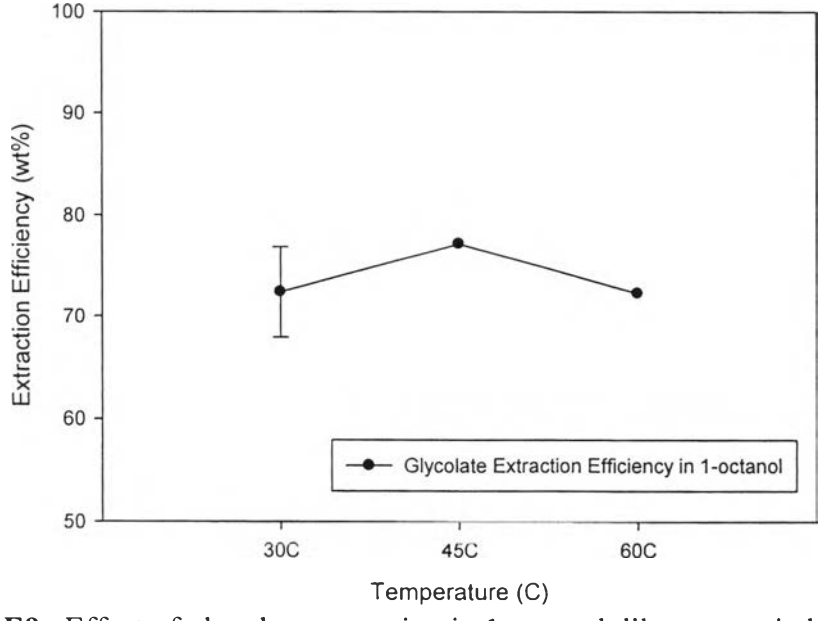

Figure E9. Effect of glycolate extraction in 1-octanol diluents, varied temperature.

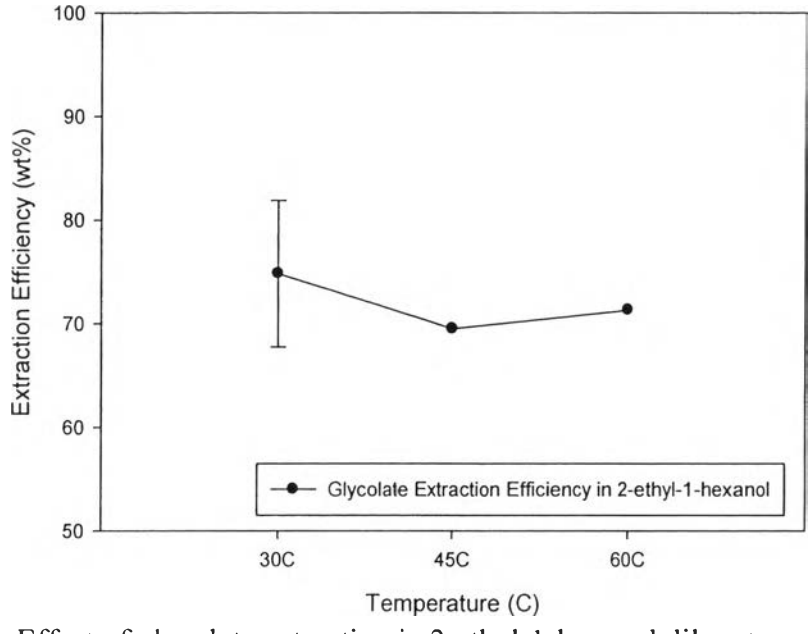

Figure E10. Effect of glycolate extraction in 2-ethyl-1-hexanol diluents, varied temperature.

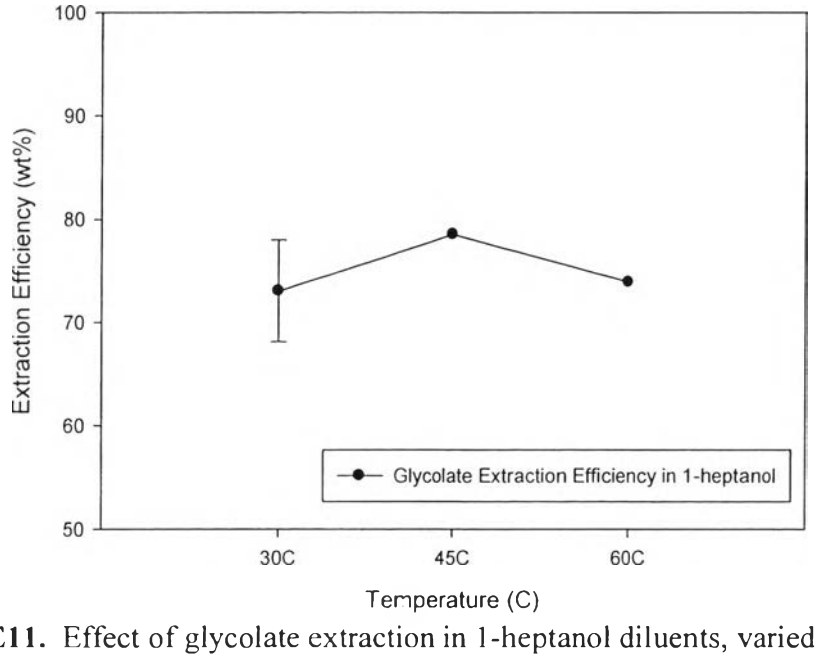

Figure E11. Effect of glycolate extraction in 1-heptanol diluents, varied temperature.

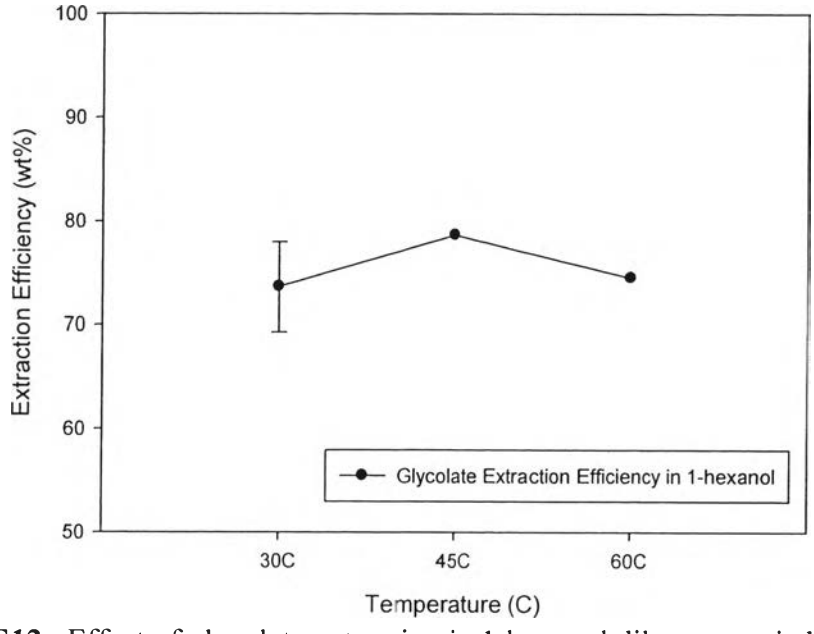

Figure E12. Effect of glycolate extraction in 1-hexanol diluents, varied temperature.

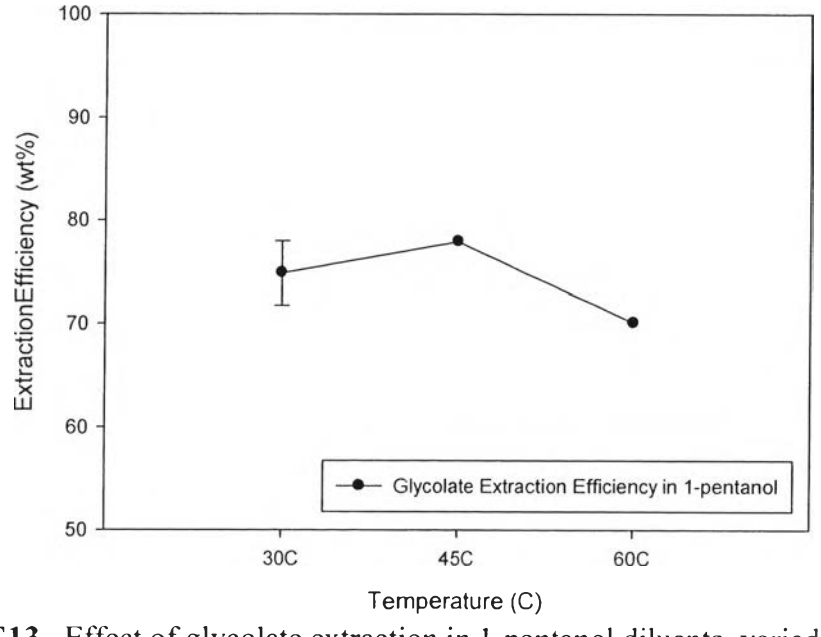

Figure E13. Effect of glycolate extraction in 1-pentanol diluents, varied temperature.

Table E9 Deviation of the oxalate extraction efficiency by extractant in various diluents affected by temperature at 45 °C and 60 °C

Diluents	Oxalate 30°C (wt%)	Oxalate 45°C (wt%)	Deviation from 30°C (wt%)	Oxalate 60°C (wt%)	Deviation from 30°C (wt%)
1-octanol	99.98±0.03	99.99		99.99	
2-ethyl-1-hexanol	99.99±0.00	99.76	-0.23	99.99	
1-heptanol	99.96±0.04	99.99		99.99	
1-hexanol	99.98±0.02	99.85	-0.11	99.99	
1-pentanol	99.92±0.15	99.74	-0.17	99.99	+0.06

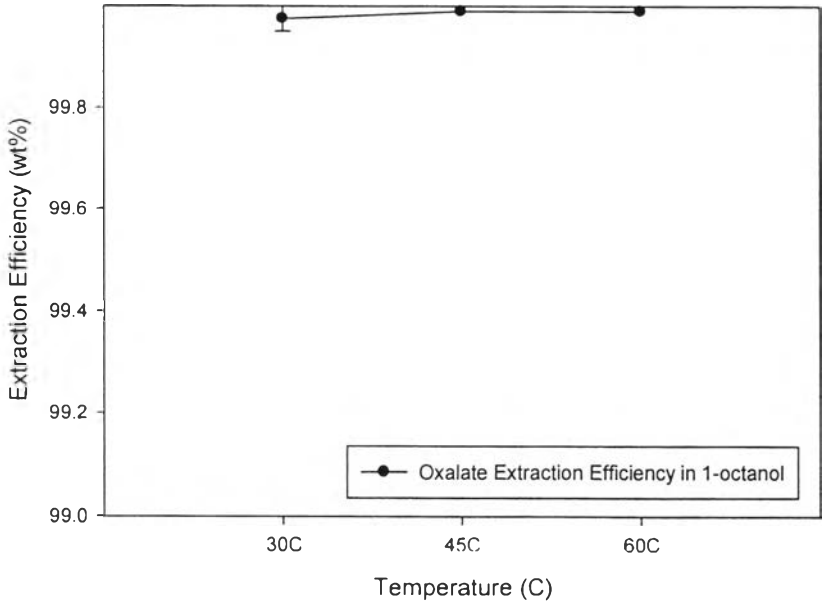

Figure E14. Effect of oxalate extraction in 1-octanol diluents, varied temperature.

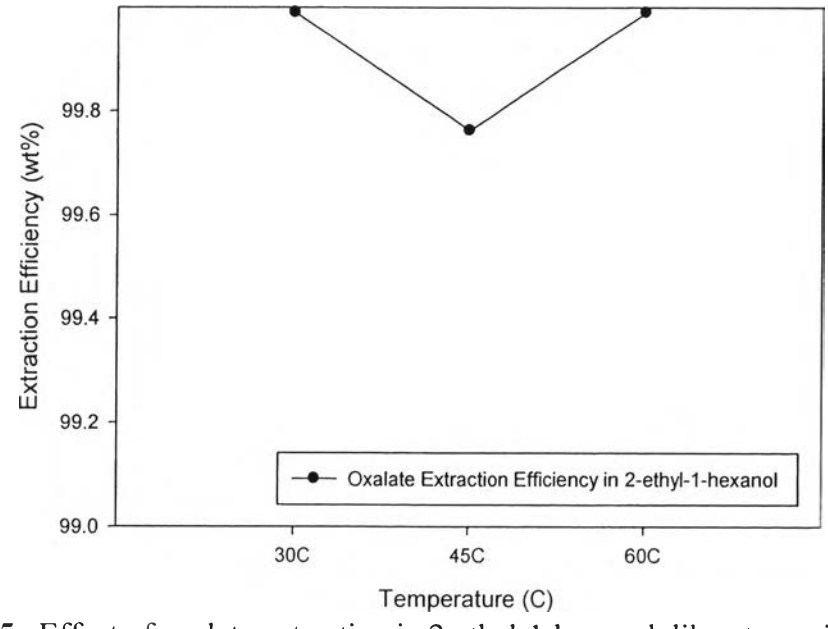

Figure E15. Effect of oxalate extraction in 2-ethyl-1-hexanol diluents, varied temperature.

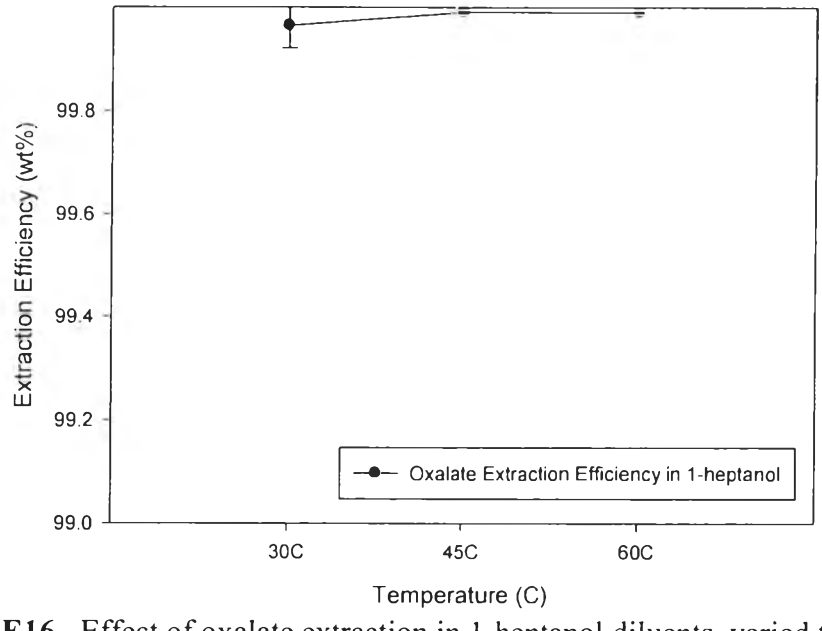

Figure E16. Effect of oxalate extraction in 1-heptanol diluents, varied temperature.

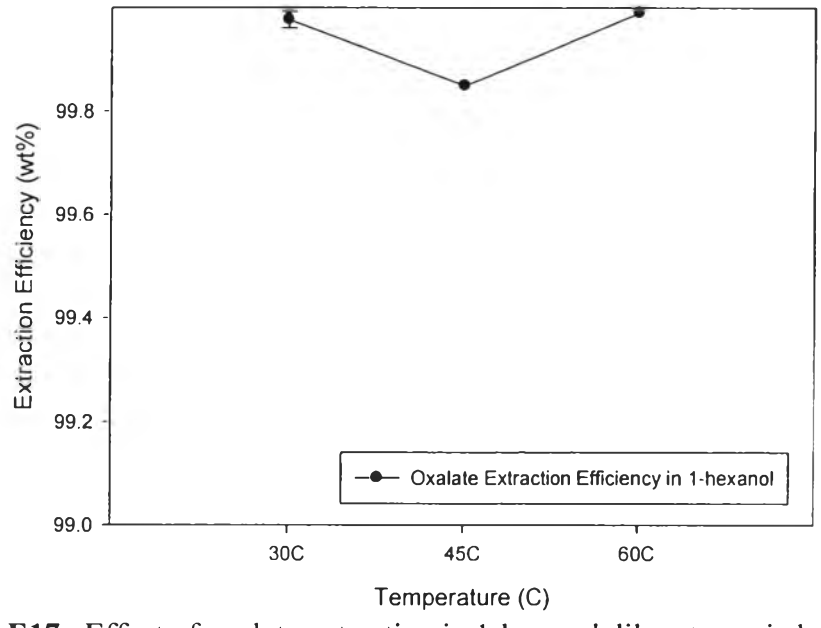

Figure E17. Effect of oxalate extraction in 1-hexanol diluents, varied temperature.

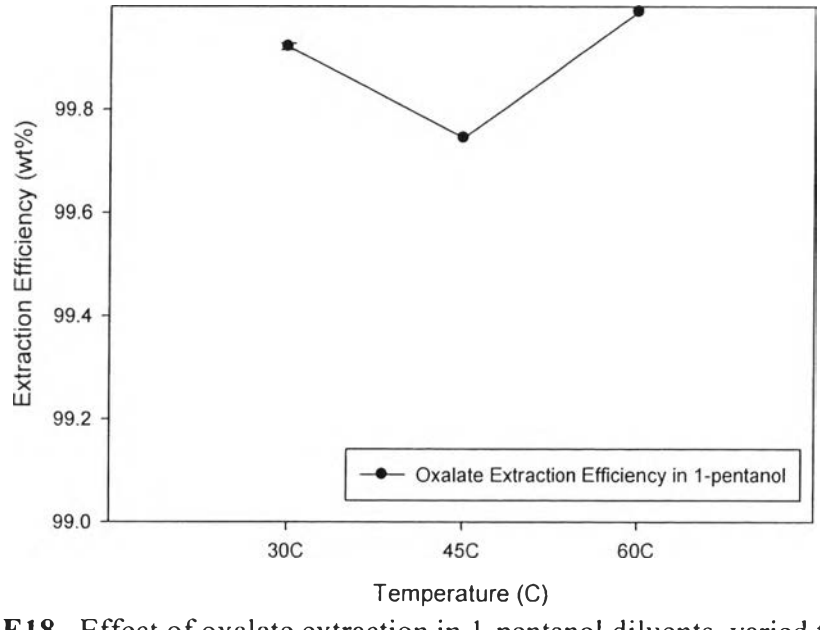

Figure E18. Effect of oxalate extraction in 1-pentanol diluents, varied temperature.

Appendix F Regeneration of used extractant in various diluents at room temperature (30 °C), 45, and 60 °C; and regeneration efficiency calculation

Regeneration efficiency was calculated based on the extractant results of the previous HSS in MEA extraction. The extraction efficiency of HSS with MEA was calculated the HSS concentration left in solution, thus the extracted HSS can be calculated by
HSS concentration before extraction – HSS concentration remaining = Extracted HSS concentration

Example: From 1st formate extraction with 30 wt% MEA at room temperature in 1-octanol.

HSS concentration before extraction = 526.2 ppm
HSS concentration remaining = 64.5 ppm
∴ Extracted HSS concentration = 526.2 – 64.5 = 441.25 ppm

Note: In HSS with MEA extraction, the aqueous solution was diluted 10 times. The HSS concentration before extraction was calculated based on no dilution, which means it must multiply by 10.

The regeneration efficiency was calculated by using a peak height which obtained from chromatogram. The HSS concentration was diluted 20 times to avoid hydroxide overloading. The regenerated concentration was calculated based on no dilution, then multiplied by 20 to make it equal to the concentration before extraction from previous part, and then divided by extracted HSS concentration.

$$\frac{Regenerated\ HSS\ Conc}{Extracted\ HSS\ Conc} \times 100 = Regeneration\ Efficiency\ (wt\%)$$

Example: From 1st formate extraction with 30 wt% MEA at room temperature in 2-ethyl-1-hexanol.

$$\frac{352.46}{441.25} \times 100 = 79.89\ wt\%$$

Table F1 Regeneration of extractant in 1st HSS extraction with 30 wt% MEA at room temperature (30 °C)

	Remaining Concentration after extracted (ppm)			Extracted Concentration (ppm)		
	Formate	**Glycolate**	**Oxalate**	**Formate**	**Glycolate**	**Oxalate**
Before extraction	526.2	1549.6	1218.4	-	-	-
B in 1-Octanol	64.5	437.6	15.34	461.7	1112	1203.06
B in 2-ethyl-hexanol	85.0	444.4	0	441.25	1105.2	1218.4
B in 1-heptanol	211.1	482.2	1	315.1	1067.4	1217.4
B in 1-hexanol	71.4	447.7	0.1	454.8	1101.9	1218.3
B in 1-pentanol	149.2	388.3	0.9	377	1161.3	1217.5

Table F1 (Cont.) Regeneration of extractant in 1st HSS extraction with 30 wt% MEA at room temperature (30 °C)

	Retention time (min)			Height			Back-extraced Concentration (ppm)		
	Formate	**Glycolate**	**Oxalate**	**Formate**	**Glycolate**	**Oxalate**	**Formate**	**Glycolate**	**Oxalate**
B in 1-Octanol	8.438	8.518	7.741	25515	12972	264622	510.30	1515.12	1054.61
B in 2-ethyl-hexanol	8.488	8.517	7.745	17623	11633	266007	352.46	1397.28	1060.15
B in 1-heptanol	8.488	8.592	7.749	18507	10594	262691	370.14	1305.85	1046.89
B in 1-hexanol	8.482	8.592	7.749	18547	10688	260745	370.94	1314.12	1039.10
B in 1-pentanol	8.478	8.54	7.748	18701	11335	260118	374.02	1371.06	1036.59

Table F1 (Cont.) Regeneration of extractant in 1st HSS extraction with 30 wt% MEA at room temperature (30 °C)

	Regen Efficiency (%)		
	Formate	**Glycolate**	**Oxalate**
B in 1-Octanol	110.53	136.25	86.56
B in 2-ethyl-hexanol	79.89	126.43	87.01
B in 1-heptanol	117.47	122.34	85.99
B in 1-hexanol	81.56	119.26	85.29
B in 1-pentanol	99.21	118.06	85.14

Table F2 Regeneration of extractant in 2nd HSS extraction with 30 wt% MEA at room temperature (30 °C)

	Remaining Concentration after extracted (ppm)			Extracted Concentration (ppm)		
	Formate	**Glycolate**	**Oxalate**	**Formate**	**Glycolate**	**Oxalate**
Before extraction	526.2	1549.65	1218.42	-	-	-
B in 1-Octanol	183.7	490.8	0.7	342.50	1058.85	1217.72
B in 2-ethyl-hexanol	134.2	461.9	0	392.00	1087.75	1218.42
B in 1-heptanol	182.6	436.9	0	343.60	1112.75	1218.42
B in 1-hexanol	149.2	446.5	0.5	377.00	1103.15	1217.92
B in 1-pentanol	182.3	438.4	3.9	343.90	1111.25	1214.52

Table F2(Cont.) Regeneration of extractant in 2nd HSS extraction with 30 wt% MEA at room temperature (30 °C)

	Retention time (min)			Height			Back-extraced Concentration (ppm)		
	Formate	**Glycolate**	**Oxalate**	**Formate**	**Glycolate**	**Oxalate**	**Formate**	**Glycolate**	**Oxalate**
B in 1-Octanol	8.564	8.515	7.752	15100	12408	307336	302.00	1465.48	1225.47
B in 2-ethyl-hexanol	8.538	8.481	7.744	14891	11102	303015	297.82	1350.56	1208.18
B in 1-heptanol	8.536	8.467	7.749	13440	13735	327996	268.80	1582.26	1308.11
B in 1-hexanol	8.544	8.494	7.752	13064	10379	314880	261.28	1286.93	1255.64
B in 1-pentanol	8.5278	8.492	7.764	15278	15580	341631	305.56	1744.62	1362.65

Table F2(Cont.) Regeneration of extractant in 2nd HSS extraction with 30 wt% MEA at room temperature (30 °C)

	Regen Efficiency (%)		
	Formate	**Glycolate**	**Oxalate**
B in 1-Octanol	88.18	138.40	100.64
B in 2-ethyl-hexanol	75.97	124.16	99.16
B in 1-heptanol	78.23	142.19	107.36
B in 1-hexanol	69.31	116.66	103.10
B in 1-pentanol	88.85	157.00	112.20

Table F3 Regeneration of extractant in 3rd HSS extraction with 30 wt% MEA at room temperature (30 °C)

	Remaining Concentration after extracted (ppm)			Extracted Concentration (ppm)		
	Formate	**Glycolate**	**Oxalate**	**Formate**	**Glycolate**	**Oxalate**
Before extraction	197.5	1591.4	1192.2	-	-	-
B in 1-Octanol	54.5	364.6	0	143	1226.8	1192.2
B in 2-ethyl-hexanol	57.7	334.8	0	139.8	1256.6	1192.2
B in 1-heptanol	77.1	355.7	0	120.4	1235.7	1192.2
B in 1-hexanol	51.3	403.8	0.3	146.2	1187.6	1191.9
B in 1-pentanol	75.3	401	1	122.2	1190.4	1191.2

Table F3(Cont.) Regeneration of extractant in 3rd HSS extraction with 30 wt% MEA at room temperature (30 °C)

	Retention time (min)			Height			Back-extraced Concentration (ppm)		
	Formate	**Glycolate**	**Oxalate**	**Formate**	**Glycolate**	**Oxalate**	**Formate**	**Glycolate**	**Oxalate**
B in 1-Octanol	8.516	8.348	7.744	16338	29668	382016	326.76	2984.36	1524.19
B in 2-ethyl-hexanol	8.437	8.377	7.756	18541	25439	338940	370.82	2612.21	1351.88
B in 1-heptanol	8.477	8.351	7.737	18856	26378	432498	377.12	2694.84	1726.11
B in 1-hexanol	8.473	8.368	7.749	19897	23235	445776	397.94	2418.26	1779.23
B in 1-pentanol	8.46	8.35	7.75	22073	25985	497508	441.46	2660.26	1986.15

Table F3(Cont.) Regeneration of extractant in 3rd HSS extraction with 30 wt% MEA at room temperature (30 °C)

	Regen Efficiency (%)		
	Formate	**Glycolate**	**Oxalate**
B in 1-Octanol	228.50	243.26	127.85
B in 2-ethyl-hexanol	265.25	207.88	113.39
B in 1-heptanol	313.22	218.08	144.78
B in 1-hexanol	272.19	203.63	149.28
B in 1-pentanol	361.26	223.48	166.74

Table F4 Regeneration of extractant in HSS extraction with 30 wt% MEA at 45 °C

	Remaining Concentration after extracted (ppm)			Extracted Concentration (ppm)		
	Formate	**Glycolate**	**Oxalate**	**Formate**	**Glycolate**	**Oxalate**
Before extraction	407.9	2060.6	1211.6	-	-	-
B in 1-Octanol	66.6	390.6	0	341.3	1670	1211.6
B in 2-ethyl-hexanol	84.9	628.3	2.9	323	1432.3	1208.7
B in 1-heptanol	66.2	366.8	0.1	341.7	1693.8	1211.5
B in 1-hexanol	113	364.4	1.8	294.9	1696.2	1209.8
B in 1-pentanol	114.1	377.9	3	293.8	1682.7	1208.6

Table F4(Cont.) Regeneration of extractant in HSS extraction with 30 wt% MEA at 45 °C

	Retention time (min)			Height			Back-extraced Concentration (ppm)		
	Formate	**Glycolate**	**Oxalate**	**Formate**	**Glycolate**	**Oxalate**	**Formate**	**Glycolate**	**Oxalate**
B in 1-Octanol	8.466	8.445	7.754	20192	27905	298854	403.84	2829.22	1191.54
B in 2-ethyl-hexanol	8.531	8.501	7.752	14879	11972	282136	297.58	1427.12	1124.67
B in 1-heptanol	8.481	8.455	7.752	19075	22629	295150	381.50	2364.93	1176.72
B in 1-hexanol	8.549	8.43	7.753	14844	23125	325256	296.88	2408.58	1297.15
B in 1-pentanol	8.529	8.443	7.762	16078	24095	297055	321.56	2493.94	1184.34

Table F4(Cont.) Regeneration of extractant in HSS extraction with 30 wt% MEA at 45 °C

	Regen Efficiency (%)		
	Formate	**Glycolate**	**Oxalate**
B in 1-Octanol	118.32	169.41	98.34
B in 2-ethyl-hexanol	92.13	99.64	93.05
B in 1-heptanol	111.65	139.62	97.13
B in 1-hexanol	100.67	142.00	107.22
B in 1-pentanol	109.45	148.21	97.99

Table F5 Regeneration of extractant in HSS extraction with 30 wt% MEA at 60 °C

	Remaining Concentration after extracted (ppm)			Extracted Concentration (ppm)		
	Formate	**Glycolate**	**Oxalate**	**Formate**	**Glycolate**	**Oxalate**
Before extraction	407.9	2060.6	1211.6	-	-	-
B in 1-Octanol	126.4	459.1	0	281.5	1601.5	1211.6
B in 2-ethyl-hexanol	126.3	473.2	0	281.6	1587.4	1211.6
B in 1-heptanol	163.3	537.3	0	244.6	1523.3	1211.6
B in 1-hexanol	90.1	525.3	0	317.8	1535.3	1211.6
B in 1-pentanol	112.1	616.1	0	295.8	1444.5	1211.6

Table F5(Cont) Regeneration of extractant in HSS extraction with 30 wt% MEA at 60 °C

	Retention time (min)			Height			Back-extraced Concentration (ppm)		
	Formate	**Glycolate**	**Oxalate**	**Formate**	**Glycolate**	**Oxalate**	**Formate**	**Glycolate**	**Oxalate**
B in 1-Octanol	8.503	8.49	7.765	19493	17330	254894	389.86	1898.62	1015.70
B in 2-ethyl-hexanol	8.48	8.505	7.775	20290	17702	247712	405.80	1931.36	986.97
B in 1-heptanol	8.478	8.519	7.767	23995	14914	291352	479.90	1686.01	1161.53
B in 1-hexanol	8.477	8.522	7.764	21277	13313	282061	425.54	1545.12	1124.37
B in 1-pentanol	8.503	8.534	7.789	19493	13464	297425	389.86	1558.41	1185.82

Table F5(Cont) Regeneration of extractant in HSS extraction with 30 wt% MEA at 60 °C

	Regen Efficiency (%)		
	Formate	**Glycolate**	**Oxalate**
B in 1-Octanol	138.49	118.55	83.83
B in 2-ethyl-hexanol	144.11	121.67	81.46
B in 1-heptanol	196.20	110.68	95.87
B in 1-hexanol	133.90	100.64	92.80
B in 1-pentanol	131.80	107.89	97.87

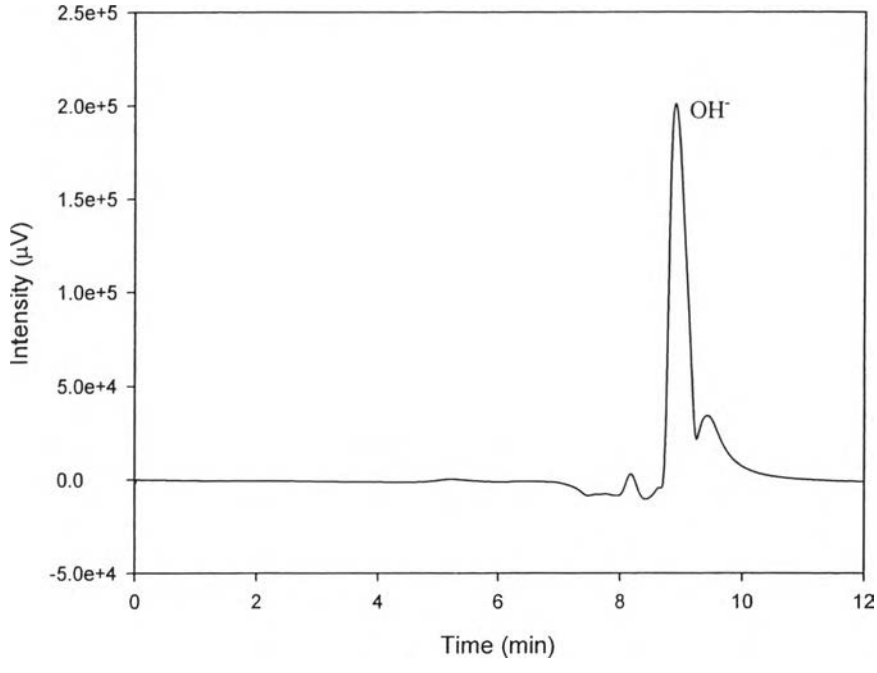

Figure F1 Chromatogram of blank 0.2 M NaOH.

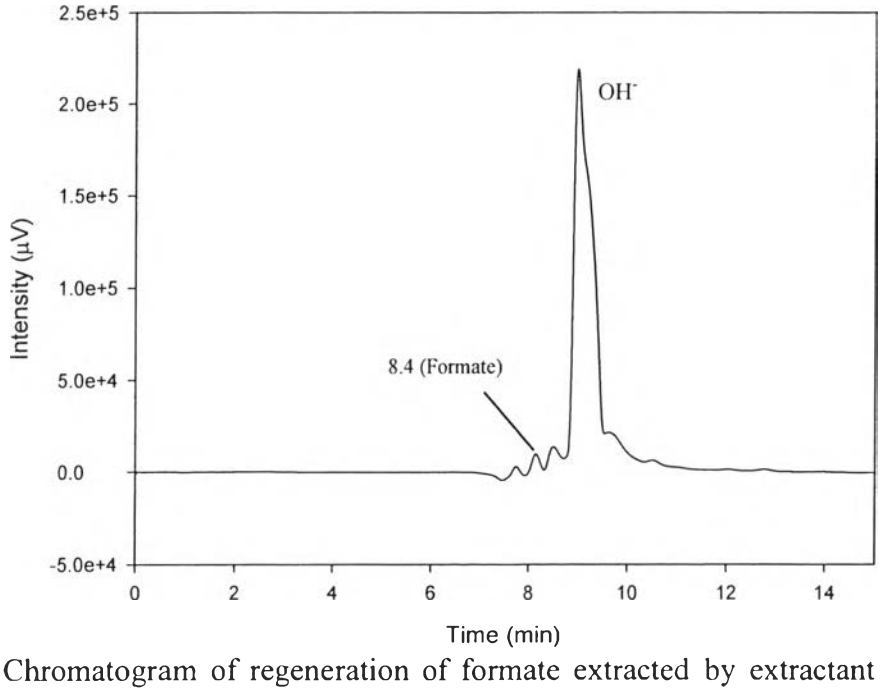

Figure F2 Chromatogram of regeneration of formate extracted by extractant in 2-ethyl-1-hexanol at room temperature.

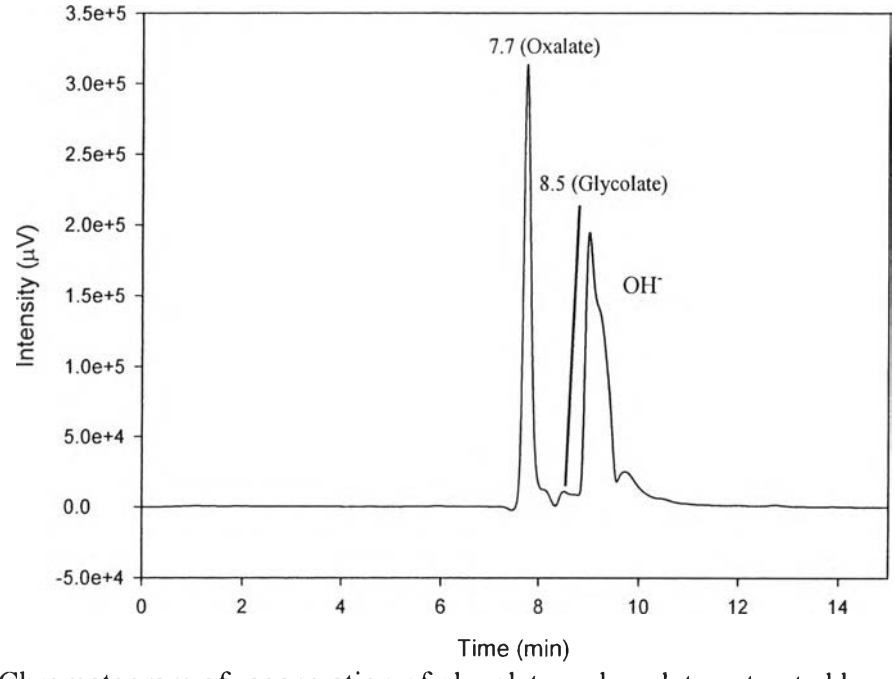

Figure F3 Chromatogram of regeneration of glycolate and oxalate extracted by extractant in 1-hexanol at room temperature.

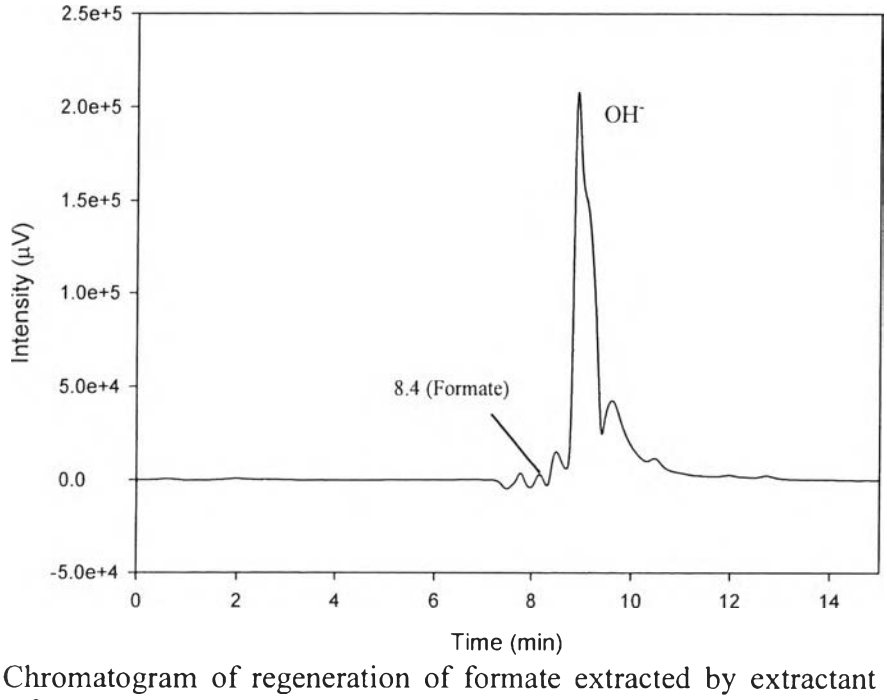

Figure F4 Chromatogram of regeneration of formate extracted by extractant in 2-ethyl-1-hexanol at 45 °C.

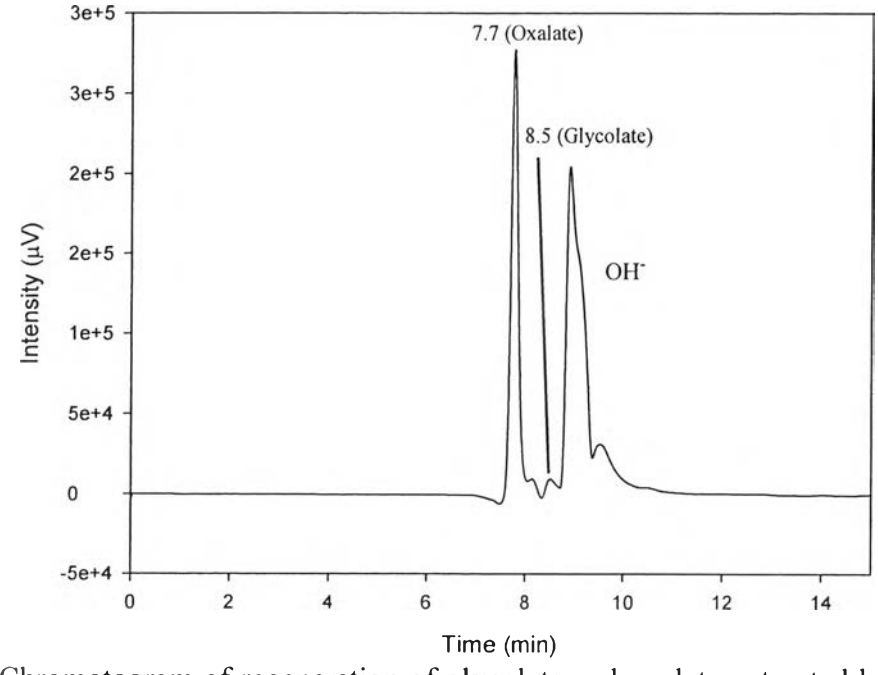

Figure F5 Chromatogram of regeneration of glycolate and oxalate extracted by extractant in 1-heptanol at 45 °C.

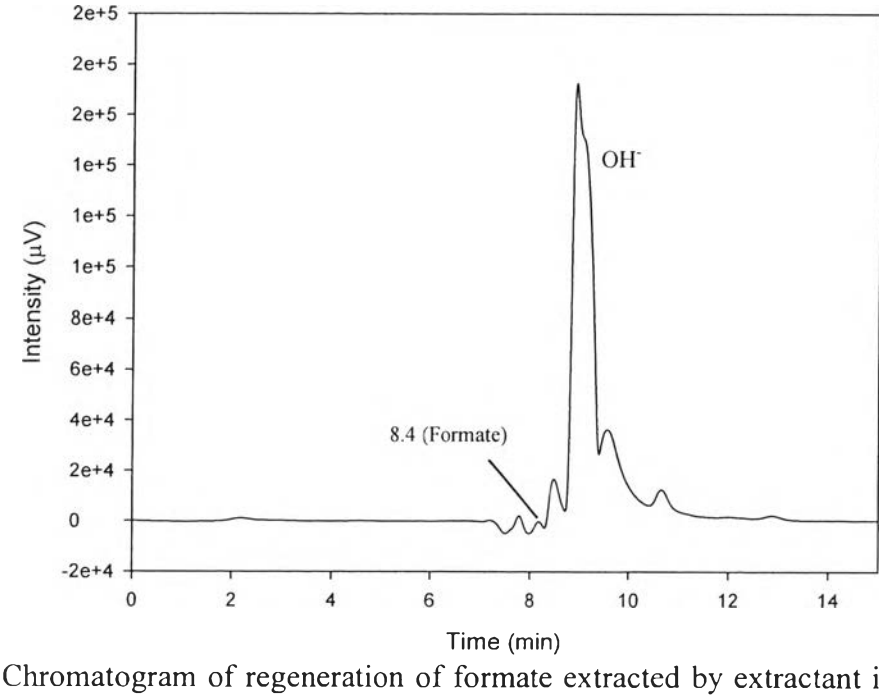

Figure F6 Chromatogram of regeneration of formate extracted by extractant in 1-octanol at 60 °C.

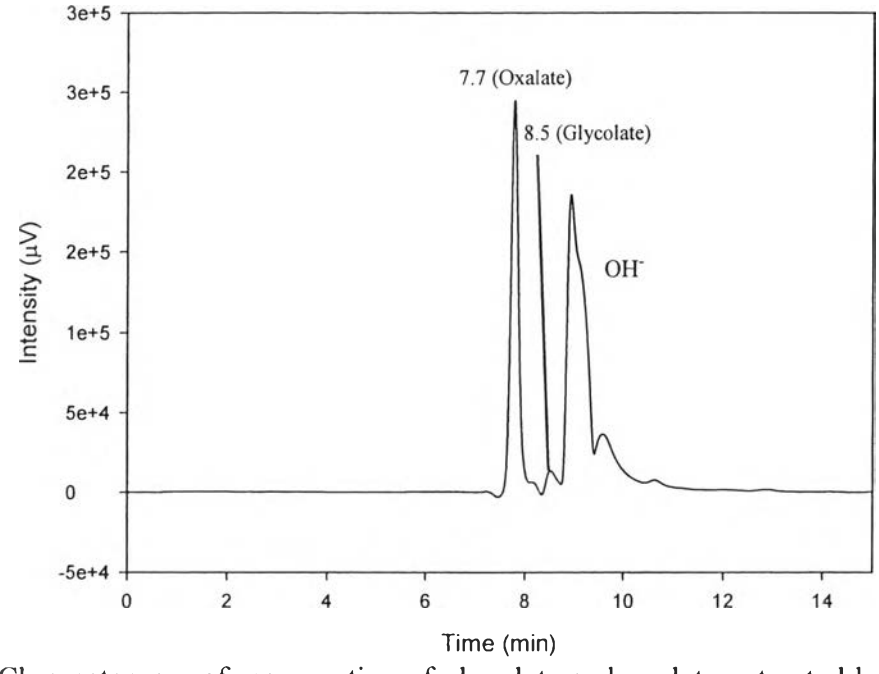

Figure F7 Chromatogram of regeneration of glycolate and oxalate extracted by extractant in 1-pentanol at 60 °C.

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1. Suppaibulsuk, P.; Saiwan, C.; and Supap, T. (2013, April 23). Effect of Organic Diluents on Separation of Heat Stable Salts (HSSs) Generated During Carbon Dioxide Absorption Using Amine Solution. Proceedings of the 4th Research Symposium on Petrochemical and Materials Technology and 19th PPC Symposium on Petroleum, Petrochemical, and Polymers, Bangkok, Thailand.

2. Suppaibulsuk, P.; Saiwan, C.; and Supap, T. (2013, September 29- October 2). Effect of Organic Solvents on Separation of Heat Stable Salts (HSSs) Generated During Carbon Dioxide Absorption Using Amine Solution. Proceedings of the PRES13: 16th Conference Process Integration, Modelling and Optimisation for Energy Saving and Pollution Reduction, Rhode, Greece.