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Appendix A

EXPERIMENTAL DATA

Part I Data of Equilibrium Concentration

Data No.	gm of CH_3COOH/gm of MIBK	gm of CH_3COOH/gm of H_2O
1	0.1168	0.1347
2	0.1560	0.2013
3	0.1936	0.2262
4	0.2153	0.2552
5	0.3347	0.3287
6	0.1354	0.1796
7	0.1746	0.2231
8	0.2174	0.2569
9	0.2506	0.3109

Part II Physical Properties of MIBK-Water-Acetic Acid

MIBK $CH_3COCH_2(CH_3)_2$

Solubility : very slightly soluble in water

Density : 0.8277 gm/cc at 30°C

Interfacial Tension : 10.3 dyne/cm

Acetic acid (CH_3COOH)

Solubility : infinity

Density : 1.048 gm/cc

Water Density : 1 gm/cc at 30°C

Solubility : Very slightly soluble in MIBK

Part III Experimental Runs

Experimental run No.1 Total cycle time 18 seconds

Volume flow ratio (H/L) H_2O to MIBK 0.693-0.714

Run No.	Vol.flow rate (lit/hr)		Vol. flow ratio	Conc.of acetic acid				Controlled cyclic period			
	H_2O phase	MIBK phase		H_2O		MIBK		MIBK flow	MIBK coales	H_2O flow	H_2O coales
	(lit/hr)	(lit/hr)	H/L	inlet (gm/cc)	outlet (gm/cc)	inlet (gm/cc)	outlet (gm/cc)	(sec)	(sec)	(sec)	(sec)
1	12	16.8	6.714	0	0.0965	0.0854	0.0135	1	7.5	1	8.5
2	15.40	22.00	0.700	0	0.1028	0.0854	0.0144	1	7.5	1	8.5
3	18.10	26.00	0.696	0	0.1000	0.0854	0.0162	1	7.5	1	8.5
4	16.90	24.00	0.704	0	0.099	0.0854	0.0162	1	7.5	1	8.5
5	19.60	27.60	0.71	0	0.1028	0.0854	0.0162	1	7.5	1	8.5
6	20.80	30.00	0.093	0	0.1118	0.0854	0.0144	1	7.5	1	8.5

Experimental run No.2 Total cycle time 18 seconds

Volume flow ratio H_2O to MIBK 0.85-0.859

Run No.	Vol. flow rate (lit/hr) H_2O phase (lit/hr)	Vol. flow rate (lit/hr) MIBK phase (lit/hr)	Vol. flow ratio H/L	Conc. of acetic acid H_2O inlet (gm/cc)	Conc. of acetic acid H_2O outlet (gm/cc)	Conc. of acetic acid MIBK inlet (gm/cc)	Conc. of acetic acid MIBK outlet (gm/cc)	Controlled cyclic period MIBK flow (sec)	Controlled cyclic period MIBK coales (sec)	Controlled cyclic period H_2O flow (sec)	Controlled cyclic period H_2O coales (sec)
1	18.20	21.40	0.85	0	0.0837	0.0845	0.0126	1	7.5	1	8.5
2	18.80	22.00	0.854	0	0.0880	0.0845	0.0135	1	7.5	1	8.5
3	19.60	23.00	0.852	0	0.0865	0.0845	0.0126	1	7.5	1	8.5
4	20.60	24.20	0.851	0	0.0865	0.0845	0.0117	1	7.5	1	8.5
5	22.00	25.60	0.859	0	0.0855	0.0845	0.0108	1	7.5	1	8.5
6	22.80	26.60	0.857	0	0.0865	0.0845	0.0117	1	7.5	1	8.5

Experimental run No.3 Total cycle time 18 seconds

Volume flow ratio H_2O to MIBK 0.98-1.02

Run No.	Vol.flow rate (lit/hr) H_2O phase (lit/hr)	Vol.flow rate (lit/hr) MIBK phase (lit/hr)	Vol. flow ratio H/L	Conc. of acetic acid H_2O inlet (gm/cc)	Conc. of acetic acid H_2O outlet (gm/cc)	Conc. of acetic acid MIBK inlet (gm/cc)	Conc. of acetic acid MIBK outlet (gm/cc)	Controlled cyclic period MIBK flow (sec)	Controlled cyclic period MIBK coales (sec)	Controlled cyclic period H_2O flow (sec)	Controlled cyclic period H_2O coales (sec)
1	20.00	2.00	1.00	0	0.0827	0.0864	0.0117	1	7.5	1	8.5
2	20.60	21.00	0.98	0	0.0827	0.0864	0.0099	1	7.5	1	8.5
3	22.00	22.00	1.00	0	0.0827	0.0864	0.0117	1	7.5	1	8.5
4	23.20	22.00	1.02	0	0.0790	0.0864	0.0117	1	7.5	1	8.5
5	23.60	23.20	1.02	0	0.0755	0.0864	0.0108	1	7.5	1	8.5
6	24.00	24.00	1.00	0	0.0817	0.0864	0.0117	1	7.5	1	8.5

Experimental run No.5 Total cycle time 18 seconds

Volume flow ratio 0.811-0.89

Run No.	Vol. flow rate (lit/hr)		Vol. flow ratio	Conc. of acetic acid				Controlled cyclic period			
	H_2O phase (lit/hr)	MIBK phase (lit/hr)	H/L	H_2O inlet (gm/cc)	H_2O outlet (gm/cc)	MIBK inlet (gm/cc)	MIBK outlet (gm/cc)	MIBK flow (sec)	MIBK coales (sec)	H_2O flow (sec)	H_2O coales (sec)
1	14.16	16.6	0.853	0	0.0695	0.0846	0.0108	1.0	8.4	1.3	7.3
2	14.92	17.40	0.857	0	0.0675	0.0864	0.0117	1.0	8.4	1.3	7.3
3	15.08	18.60	0.811	0	0.0685	0.0864	0.0117	1.0	8.4	1.3	7.3
4	16.20	18.20	0.890	0	0.0675	0.0864	0.009	1.0	8.4	1.3	7.3
5	16.94	16.854	0.847	0	0.072	0.0864	0.009	1.0	8.4	1.3	7.3
6	19.26	22.00	0.875	0	0.0685	0.0846	0.0108	1.0	8.4	1.3	7.3

Experimental run No.6 Total cycle time 13.2 seconds

Run No.	Vol.flow rate (lit/hr) H O phase (lit/hr)	Vol.flow rate (lit/hr) MIBK phase (lit/hr)	Vol. flow ratio H/L	Conc.of acetic acid H_2O inlet (gm/cc)	Conc.of acetic acid H_2O outlet (gm/cc)	Conc.of acetic acid MIBK inlet (gm/cc)	Conc.of acetic acid MIBK outlet (gm/cc)	Controlled cyclic period MIBK flow (sec)	Controlled cyclic period MIBK coales (sec)	Controlled cyclic period H_2O flow (sec)	Controlled cyclic period H_2O coales (sec)
1	19.091	39.00	0.49	0	0.101	0.082	0.0396	0.9	5.7	0,9	5.7
2	21.818	35.454	0.62	0	0.0737	0.082	0.0342	0.9	5.7	0.9	5.7
3	24.545	31.909	6.77	0	0.111	0.082	0.0296	0.9	5.7	0.9	5.7
4	27.273	28.364	0.96	0	0.091	0.082	0.971	0.9	5.7	0.9	5.7
5	30.000	24.818	1.21	0	0.081	0.082	0.0117	0.9	5.7	0.9	5.7
6	32.727	21.273	1.54	0	0.0699	0.082	0.0072	0.9	5.7	0.9	5.7

Experimental run No.7 Total cycle time 11.8 seconds

Run No.	Vol. flow rate (lit/hr)		Vol. flow ratio H/L	Conc. of acetic acid				Controlled cyclic period			
	H_2O phase (lit/hr)	MIBK phase (lit/hr)		H_2O		MIBK		MIBK flow (sec)	MIBK coales (sec)	H_2O flow (sec)	H_2O coales (sec)
				inlet (gm/cc)	outlet (gm/cc)	inlet (gm/cc)	outlet (gm/cc)				
1	18.305	39.661	0.46	0	0.108	0.082	0.0405	0.8	5.1	0.8	5.1
2	24.407	31.729	0.77	0	0.103	0.082	0.026	0.8	5.1	0.8	5.1
3	27.458	27.763	0.99	0	0.074	0.082	0.0135	0.8	5.1	0.8	5.1
4	28.983	24.407	1.19	0	0.074	0.082	0.0099	0.8	5.1	0.8	5.1
5	30.508	23.797	1.28	0	0.086	0.082	0.0153	0.8	5.1	0.8	5.1

Experimental run No.8 Vary fraction open of H_2O to MIBK flow

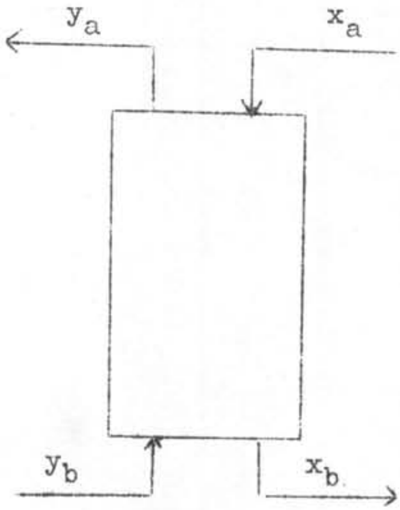
Total cycle time 18 seconds

Run No.	Vol. flow rate (lit/hr)		Vol. flow ratio H/L	Conc. of acetic acid				Controlled cyclic period			
	H_2O phase (lit/hr)	MIBK phase (lit/hr)		H_2O		MIBK		MIBK flow (sec)	MIBK coales (sec)	H_2O flow (sec)	H_2O coales (sec)
				inlet (gm/cc)	outlet (gm/cc)	inlet (gm/cc)	outlet (gm/cc)				
1	20.3	26.5	0.76	0	0.103	0.081	0.0234	1.4	7.8	1.0	7.8
2	20.5	26.4	0.78	0	0.099	0.081	0.0202	1.3	7.8	1.1	7.8
3	20.0	26.0	0.77	0	0.083	0.081	0.0144	1.2	7.8	1.2	7.8
4	20.4	26.3	0.77	0	0.081	0.081	0.0135	1.1	7.8	1.3	7.8
5	20.1	26.0	0.77	0	0.0665	0.081	0.0095	1.0	7.8	1.4	7.8
6	20.5	26.5	0.77	0	0.077	0.081	0.0117	0.9	7.8	1.5	7.8

Appendix B

SAMPLE OF CALCULATIONS

1. To Determine the Composition of Feed



Since concentration input of feed $= 0.081 \dfrac{\text{gm acetic acid}}{\text{cc of solution}}$

Density of acetic acid $= 1.048$ gm/cc.

Density of MIBK $= 0.8277$ "

$\therefore$ Volume of acetic per c.c. of solution $= 0.081/1.048$ c.c.

$\therefore$ Volume of MIBK in 1 c.c. of solution $= 1 - \dfrac{0.081}{1.048}$ c.c.

$\therefore$ Weight of MIBK in 1 c.c. of solution $= 0.8277(1 - \dfrac{0.081}{1.048})$ gm.

$= 0.76$ gm.

$$\therefore \frac{\text{Weight of acetic acid}}{\text{Weight of MIBK}} = y_b = \frac{0.081}{0.76} = 0.106$$

2. To Determine the Output Condition of Raffinate

Since concentration of raffinate output = 0.0144 $\frac{\text{gm acid}}{\text{c.c.}}$

$\therefore$ Volume of acid/c.c.of solution $= \frac{0.0144}{1.048}$ c.c.

$\therefore$ Volume of MIBK in 1 c.c.of solution = 1-(0.0144/1.048) c.c.

$\therefore$ Wt of MFBK in 1 c.c. solution = 0.8277(1-0.0144/1.048)gm.

= 0.81 gm.

$$\therefore \frac{\text{Wt.of acetic acid}}{\text{Wt. of MIBK}} = y_a = \frac{0.0144}{0.81} = 0.0176$$

3. To Determine the Input Condition of Extract Phase

Since there is no acetic acid in water.

$$\therefore \frac{\text{Weight of acetic acid}}{\text{Weight of water}} = x_a = 0$$

4. To Determine the Output Condition of Extract Phase

Since concentration of output of extract = 0.083 gm/c.c.

$\therefore$ Volume of acetic acid/c.c.of solution = 0.083/1.048 c.c.

$\therefore$ Volume of water in 1 c.c. solution = 1-(0.083/1.048) c.c.

$\therefore$ Wt.of water in 1c.c. solution = 1(1-0.083/1.048 gm.

= 0.921 gm.

$$\therefore \frac{\text{Weight of acetic acid}}{\text{Weight of water}} = x_b = \frac{0.083}{0.921} = 0.0901$$

5. To Determine the Number of Ideal Stage

From $x_a = 0.00$

$x_b = 0.0901$

$y_a = 0.0176$

$y_b = 0.106$

$$N = \frac{\log \dfrac{x_b^* - x_b}{x_a^* - x_a}}{\log \dfrac{x_b^* - x_a^*}{x_b - x_a}} \quad \text{.............. A}$$

$$\text{or } N = \frac{\log \left(\dfrac{y_b - y_b^*}{y_a - y_a^*} \right)}{\log \left(\dfrac{y_b - y_a}{y_b^* - y_a} \right)} \quad \text{.............. B}$$

Equilibrium line and operating line are ploted by using wt. of acetic acid/wt. of MIBK as ordinate, and wt. acetic/wt. of H_2O as abcissa. Assume equilibrium line and operating line are straight as shown in graph.

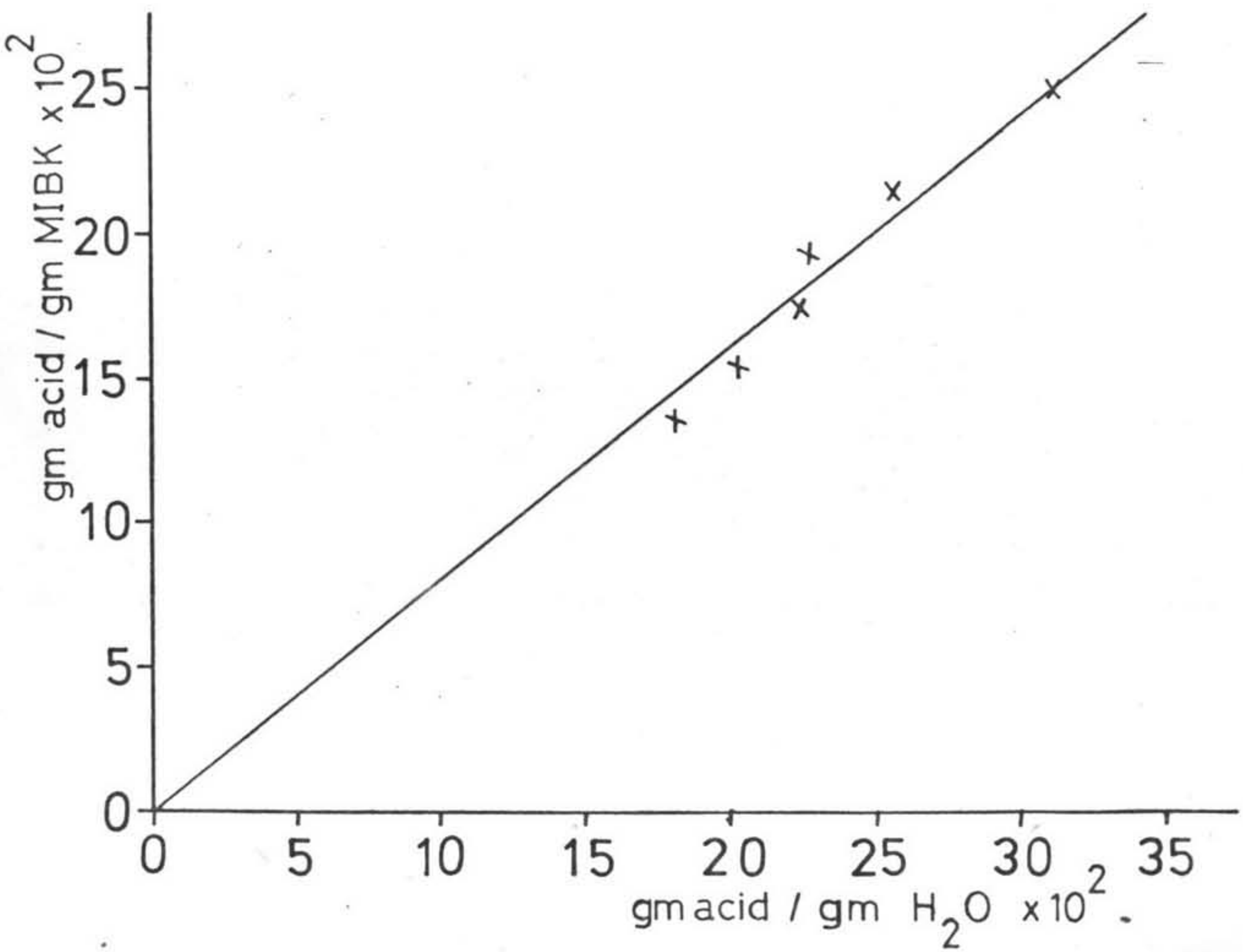
Then we get $x_b^* = 0.1312$

$x_a^* = 0.02$

Substitute in (A) obtained

$$N = \frac{\log \dfrac{0.1312 - 0.0901}{0.02 - 0.00}}{\log \dfrac{0.1312 - 0.02}{0.0901 - 0.00}}$$

$$= 3.422$$



Equilibrium line

6. To Determine the Number of Transfer Unit.

From equation; the number of over all transfer unit

$$NTUR_o = \frac{\ln\left[\frac{y_b - x_{a/m}}{y_a - x_{a/m}}\left(1 - \frac{1}{\varepsilon}\right) + \frac{1}{\varepsilon}\right]}{\left(1 - \frac{1}{\varepsilon}\right)}$$

ϵ = **diffusion coefficient**

$= m\ Ef/R_f$

$$m = \left[\frac{\text{wt. of } \hat{a}/\text{wt. of } H_2O}{\text{wt. of } \hat{a}/\text{wt. of MIBK}}\right] \text{ at equilibrium}$$

$$= \frac{1}{\text{Slope of equilibrium line}}$$

E_f = wt.of solute free water (gm/hr)

R_f = wt.of solute free MIBK (gm/hr)

E_f = 20,000×0.921 = 18420 gm/hr

R_f = 26,000×0.76 = 19240 gm/hr

m = 1.25 (slope of equilibrium line = 0.8)

$$\therefore \varepsilon = \frac{18420 \times 1.25}{19240}$$

$= 1.1967$

$$\therefore NTUR_o = \frac{\ln\left[\frac{0.106}{0.0176}\left(1 - \frac{1}{1.1967}\right) + \frac{1}{1.1967}\right]}{\left(1 - \frac{1}{1.1967}\right)}$$

$= 3.6612$

7. To Determine Height of Transfer Unit

Since, Height of column = (NTUR)($HTUR_o$)

$$\therefore \quad HTUR_o = \frac{\text{Height of Column}}{NTUR_o}$$

$$= \frac{39}{3.6612}$$

$$= 10.65$$

VITA

Mr. Samran Thungtong was born on 13 November 1942 at Chachoeng Sao Province. He received Bachelor Degree of Science in the field of Chemical Engineering with Second Class Honors from Faculty of Science, Chulalongkorn University in 1967.

He has been joining the teaching staff in the Department of Chemical Engineering, Faculty of Science, Chulalongkorn University. The subjects which he had taught are: Industrial Stoichiometry, Economic Process Industries, Thermodynamics, Unit Operation Laboratory, Physical Chemistry Laboratory and Fuel Testing Laboratory.