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APPENDIX A

Samples of Calculation

A.1 Porosity

From equation 3.1

$$log\left(\frac{\Delta P}{\rho_b v^2}\right)\left(\frac{D_p}{L}\right) = -log\left(\frac{D_p v \rho_b}{\mu}\right) + log\left(\frac{150(1-\epsilon)^2}{\epsilon^3}\right)$$

The bed porosity, ϵ, is obtained from the intercept of the plot between $log\left(\frac{\Delta P}{\rho_b v^2}\right)\left(\frac{D_p}{L}\right)$ against $log\left(\frac{D_p v \rho_b}{\mu}\right)$.

For bed length, L, 10 cm, the plot is represented in Figure A.1.

- Intercept, $log\left(\frac{150(1-\epsilon)^2}{\epsilon^3}\right) = 2.48$

Thus,

$$\epsilon = 0.48$$

A.2 Pellet Density

From equation 3.2

$$\rho_s = \frac{\rho_b}{1-\epsilon}$$

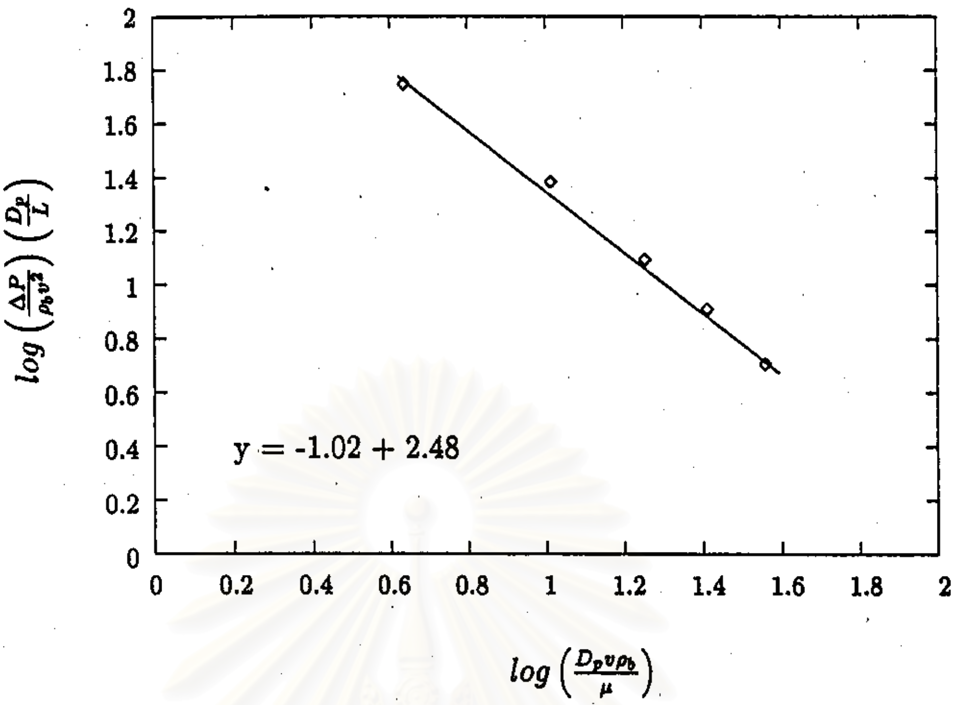

Figure A.1: The plot between $log\left(\frac{\Delta P}{\rho_b v^2}\right)\left(\frac{D_p}{L}\right)$ against $log\left(\frac{D_p v \rho_b}{\mu}\right)$

For bed length, L, 10 cm,

- Bulk density, ρ_b = 0.54 g/cm^3

Thus,

$$\rho_s = \frac{0.54}{1-0.48} = 1.04 \quad g/cm^3$$

A.3 Adsorption Isotherms

The equilibrium adsorption capacity, q_i, corresponding to the feed concentration , c_i was determined from the experimental breakthrough curve based on the following material balance.

In : $Qt_e c_i$

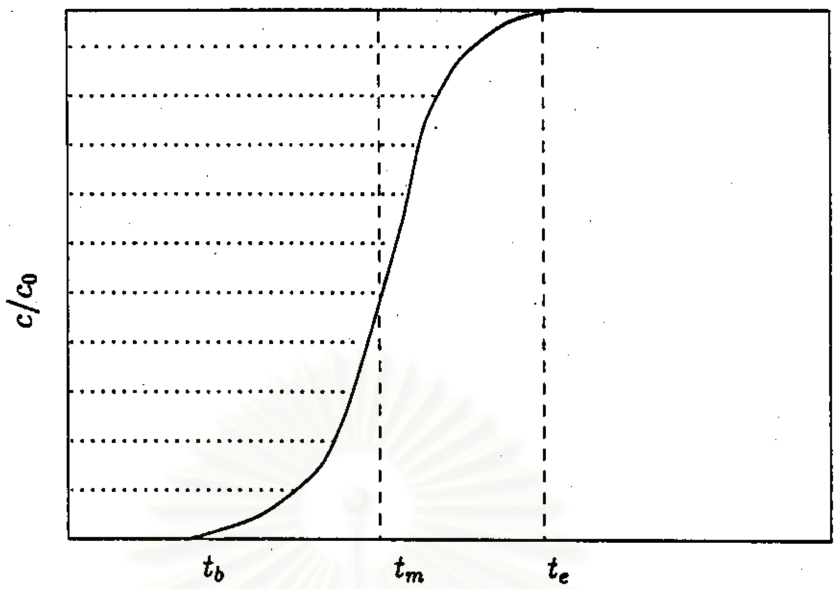

Figure A.2: Sketch of breakthrough curve

Out : $Q(t_e - t_m)$

Accumulation (W) : $AL\,(\epsilon c_i + (1-\epsilon)\rho_s q_i)$

Therefore,

$$W = Qt_m c_i = AL\,(\epsilon c_i + (1-\epsilon)\rho_s q_i) \quad \text{(A.1)}$$

in which t_m is the mean residence time, W is represented by the shaded area, A_s,in Firure A.2, and can be obtained by the use of the following equation

$$W = A_s \times N \quad \text{(A.2)}$$

where N is molar flow rate. For 19.89%V/V acetylene in feed :

- Column length,L = 8 cm

- Cross section area, $A = 0.16 \quad cm^2$.
- Bed porosity, $\epsilon = 0.49$
- Bed pressure, $P = 1.99 \quad atm$
- Bed temperature, $T = 323 \quad K$
- Pellet density, $\rho_s = 1.04 \quad g/cm^3$
- Feed concentration, $c_i = \frac{P_i}{RT}$

: $P_i = P \times y_i = 1.99 \times 0.19 = 0.39$ atm $= 38.51$ kPa

: Acetylene concentration in cylinder = 98%

: R = 82.06 cm^3.atm/mol.K , T = 323 K

Thus,

$$c_i = \left(\frac{0.39}{82.06 \times 323}\right) \times 0.98 = 1.44 \times 10^{-5} \quad mol/cm^3$$

- Molar flow rate, $N = \frac{P_i Q}{RT}$

: Total flow rate, $Q = 2.50 \quad cm^3/s$

Thus,

$$N = \left(\frac{0.39 \times 2.50}{82.06 \times 323}\right) \times 0.98 = 3.68 \times 10^{-5} \quad mol/s$$

- Shaded area integrated from the experimental curve, $A_s = 49.13$ s

Thus,

$$W = 49.13 \times 3.6 \times 10^{-5} = 1.81 \times 10^{-3} \quad \text{mol}$$

Substituting all these value into equation A.1, gaves rises to

$$q_i = 2.65 \times 10^{-3} \quad \text{mol/g} = 2.65 \quad \text{mmol/g}$$

A.4 Concentration Profile

The breakthrough results from 2 cm long bed of 60-80 mesh YAO, 20%V/V acetylene in feed mixture with a superficial of 15 cm/s is illustrated in Figure A.3.

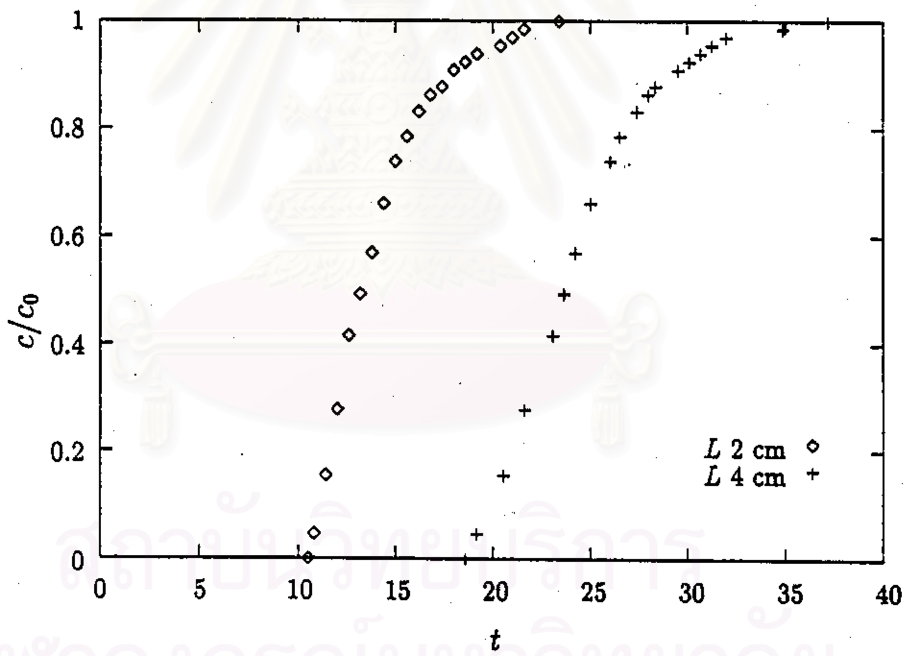

Figure A.3: An experimental breakthrough curve of acetylene 20%V/V from 2 cm long bed of YAO at the superficial velocity of 15 cm/s .

At $c/c_0 = 0.49$

- $L_1 = 2$ cm

- $t_{b2} = 10.82$ sec

- $t_{2,0.49} = 13.20$ sec

From equation 4.3,

$$w_{L_1,c/c_0} = \frac{L_1}{t_{L_1,c/c_0}}$$

Thus,

$$w_{2,0.49} = \frac{2}{13.20} = 0.152 \quad \text{cm/s}$$

From equation 4.4

$$S_{L_1,c/c_0} = w_{L_1,c/c_0} t_{bL_1}$$

Thus,

$$S_{2,0.49} = 0.152 \times 10.82 = 1.645 \quad \text{cm}$$

Similarly, the axial position of another dimensionless concentration is determined in the same manner as above. Therefore, the complete concentration profile is illustrated in Figure A.4. For 4 cm long bed of YAO at the corresponding dimensionless concentration,

- $L_2 = 4$ cm

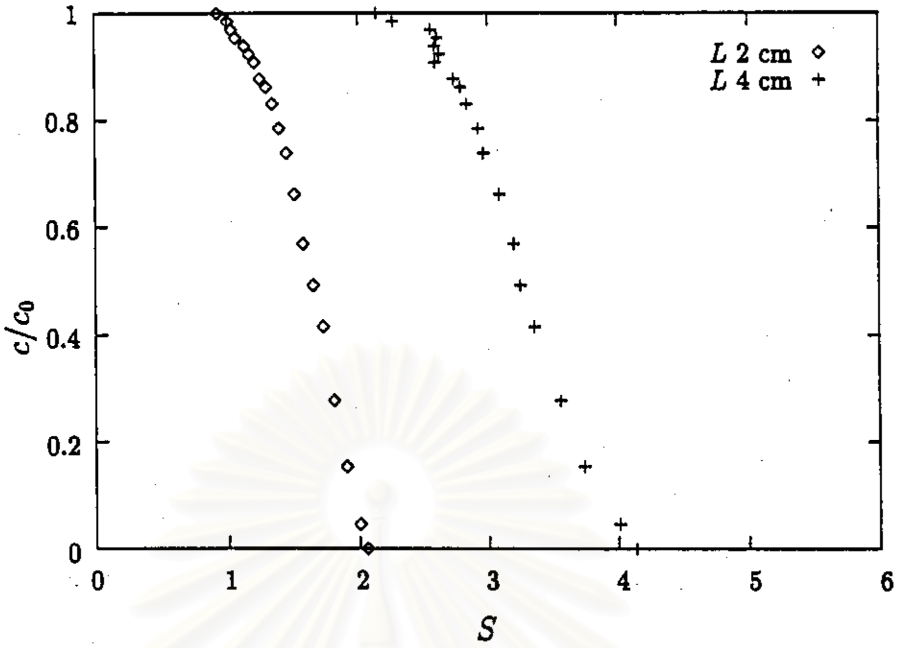

Figure A.4: The concentration profile of acetylene 20%V/V from 2 cm long bed of YAO at the superficial velocity of 15 cm/s .

- $t_{b4} \quad = \quad 19.18 \quad \text{sec}$

- $t_{4,0.49} \quad = \quad 23.64 \quad \text{sec}$

From equation 4.5

$$S_{L_2,c/c_0} = S_{L_1,c/c_0} + \left(\frac{L_2-L_1}{t_{L_2,c/c_0}-t_{L_1,c/c_0}}\right)(t_{bL_2}-t_{bL_1})$$

Thus,

$$S_{1,0.49} = 1.645 + \frac{4-2}{23.64-13.20}(19.18-10.82) = 3.247 \quad \text{cm}$$

Similarly, the axial position of another dimensionless concentration is determined in the same manner as above. The complete concentration profile is also illustrated in Figure A.4.

A.5 Mass Transfer Coefficient

A.5.1 Film Mass Transfer Coefficient

The appropriate dimensionless group characterizing external fluid film mass transfer coefficient, $k_f a$ is the Sherwood number, defined as

$$Sh = \frac{k_f D_p}{D_{AB}} \tag{A.3}$$

From equation 2.15

$$Sh = 2.0 + 1.1 Sc^{1/3} Re^{0.6} \quad ; \quad 3 < Re < 10^4$$

in which

$$Sc = \frac{\mu_{mix}}{D_{AB}\rho_{mix}} \tag{A.4}$$

and

$$Re = \frac{D_p v \rho_{mix}}{\mu_{mix}(1-\epsilon)} \tag{A.5}$$

- The density of mixed gas, $\rho_{mix} = \frac{PM_{mix}}{RT}$

  : Molecular weight of mixed gas, $M_{mix} = \sum_{i=1}^{n} y_i M_{mix}$

- The viscosity of mixed gas, $\mu_{mix} = \mu_{r,mix}\mu_{c,mix}$

  : The reduced viscousity, $\mu_{r,mix}$, can be read from the plot of $\mu_{r,mix}$ as a fucntion of reduced temperature, $T_{r,mix}$, at several values of the reduced pressure, $P_{r,mix}$, as represented in Transport Phenomena pp.16 (Figure 1.3-1). $P_{r,mix}$ and $T_{r,mix}$ is determined by the use of equation 2.11 and equation 2.12, respectively. In the same manner as $P_{r,mix}$ and $T_{r,mix}$, critical viscousity, $\mu_{c,mix}$, can be estimated from the following equation.

$$\mu_{c,mix} = \sum_{i=1}^{n} y_i \mu_c \tag{A.6}$$

- D_{AB} is calculated by the use of equation 2.7

For 20%V/V acetylene in feed with velocity of 15 cm/s, the physical property of acetylene-helium mixtures can be evaluated from the property of pure acetylene and helium represented in table 3.2 and table 3.3.

- Bed length, L = 2 cm
- Bed porosity, ϵ = 0.49
- Bed pressure, P = 1.99 atm
- Bed temperature, T = 323 K
- Particle diameter, D_p = 0.02 cm
- Superficial velocity, v = 15 cm/s
- The molecular weight of acetylene-helium mixture

$$M_{mix} = 0.20 \times 26.03 + 0.80 \times 4.00 = 8.41 \quad \text{g/cm}^3$$

- The density of acetylene-helium mixture

$$\rho_{mix} = \frac{1.99 \times 8.41}{82.06 \times 323} = 6.31 \times 10^{-4} \quad \text{g/cm}^3$$

- Critical temperature of acetylene-helium mixture

$$T_{c,mix} = 0.20 \times 309.50 + 0.80 \times 5.26 = 66.11 \quad K$$

: Reduced temperature of acetylene-helium mixture, $T_r = \frac{323}{66.11} = 4.89$

- Critical pressure of acetylene-helium mixture

$$P_{c,mix} = 0.20 \times 61.60 + 0.80 \times 2.26 = 14.13 \quad atm$$

: Reduced pressure of acetylene-helium mixture, $P_r = \frac{1.99}{14.13} = 0.14$

- Critical viscousity of acetylene-helium mixture

$$\mu_{c,mix} = 0.20 \times 2.37 \times 10^{-4} + 0.80 \times 2.54 \times 10^{-5} = 6.77 \times 10^{-5} \quad g/cm.s$$

- Reduced viscousity of acetylene-helium read from Figure 1.3-1 in Transport Phenomena, $\mu_{r,mix} = 1.70$

Thus,

$$\mu_{mix} = 1.70 \times 6.77 \times 10^{-5} = 1.15 \times 10^{-4} \quad g/cm.s$$

- Diffusivity coefficient, D_{AB} calculated from equation 2.7 $= 0.37 \quad cm^2/s$

Then,

$$Sc = \frac{1.15\times10^{-4}}{0.37\times6.31\times10^{-4}} = 0.49$$

$$Re = \frac{0.02\times15\times6.31\times10^{-4}}{1.15\times10^{-4}\times(1-0.49)} = 3.28$$

Substituting Sc and Re into equation 2.15, gave rise to

$$Sh = 2.0 + 1.1 \times 0.49^{1/3} \times 3.28^{0.6} = 3.77$$

Thus, based on equation A.3, $k_f = 69.76$ cm/s

- The mass transfer area per unit bed volume, $a = \frac{6(1-\epsilon)}{D_p} = 153 \quad \mathrm{cm}^{-1}$

Then,

$$k_f a = 69.76 \times 153 = 1.07 \times 10^4 \quad \mathrm{s}^{-1}$$

A.5.2 Pore Mass Transfer Coefficient

The pore mass trasfer coefficient were calculated from the correlation purposed by A.Gorius, M. Bailly and D. Tondeur [9], as followed. They take into account non-linear isotherms, general mass transfer limitations.

$$k_P a = \frac{v_i}{L}\left(\frac{S_b}{\lambda f(x_f)}\right)^{\frac{1}{2}} \tag{A.7}$$

where x_f was the dimensionless concentration at the breakthrough point, which equal 0.1 in the present study, S_b was the slope of an experimental breakthrough curve at x_f. The term λ and $f(x_f)$ were calculated by the following equation

$$\lambda = \frac{1-\epsilon}{\epsilon}\frac{q}{c} \tag{A.8}$$

$$f(x_f) = \frac{f_{eq}(x_f)}{q} \tag{A.9}$$

in which q was calculated from the mean residence time of the experimental breakthrough curve. Subscript eq denote the equilibrium condition.

From an experimental breakthrough curve of 20%V/V acetylene in feed :

- Column length, L = 2 cm
- Cross section area, A = 0.16 cm^2.
- Bed porosity, ϵ = 0.49
- Bed pressure, P = 1.99 atm
- Bed temperature, T = 323 K
- Pellet density, ρ_s = 1.04 g/cm^3
- Feed concentration, $c_i = \frac{P_i}{RT}$

: $P_i = P \times y_i = 1.99 \times 0.20 = 0.40$ atm

Thus,

$$c_i = \left(\frac{0.40}{82.06 \times 323}\right) \times 0.98 = 1.49 \times 10^{-5} \quad mol/cm^3$$

- Interstitial velocity, $v_i = \frac{v}{\epsilon}$

: Superficial velocity, v = 15.69 cm/s

Thus,

$$v_i = \left(\frac{15.69}{0.16 \times 0.49}\right) = 32.02 \quad cm/s$$

- Slope of breakthrough curve readed from the experimental curve, S_b = 0.01

- Equilibrium adsorption capacity calculated from the experimental breakthrough curve, $q_i = 2.67 \times 10^{-3}$ mol/g

- The term λ were calculated as followed

$$\lambda = \left(\frac{1-0.49}{0.49}\right) \times \left(\frac{2.67\times10^{-3}}{1.49\times10^{-5}}\right) \times 1.04 = 193.97$$

- The term $f(x_f)$ were calculated by the use of the equation A.9

: $x_f = 0.1$

: $f_{eq}(x_f)$ were estimated from the following Freudlich isotherms

$$f_{eq}(x_f) = K_F P_i^{\left(\frac{1}{n}\right)} = 2.89 \times 10^{-4} P_i^{\frac{1}{1.65}} \qquad \text{(A.10)}$$

where P_i at $x_f = P_i \times x_f = 0.40 \times 0.10 = 0.04$ atm $= 4.05$ kPa

Thus,

$$f_{eq}(x_f) = (2.89 \times 10^{-4}) \times 4.05^{\frac{1}{1.65}} = 6.75 \times 10^{-4} \quad \text{mol/g}$$

and hence,

$$f(x_f) = \frac{6.75\times10^{-4}}{2.67\times10^{-3}} = 0.25$$

Then, substituting the values of v_i, L, S_b, λ and $f(x_f)$ into equation A.7, gave rise to

$$k_P a \quad = \quad \frac{32.02}{2}\left(\frac{0.01}{193.97\times 0.25}\right)^{\frac{1}{2}} \quad = \quad 0.23 \quad s^{-1}$$

APPENDIX B

Breakthrough Curve of Various Bed Lengths

B.1 Breakthrough Data

Table B.1: An experimental breakthrough curve of acetylene 20%V/V at the superficial velocity of 15 cm/s.

c/c_0	t (s)				
	L 2 cm	L 4 cm	L 6 cm	L 8 cm	L 10 cm
0.000	10.500	18.600	32.250	41.700	57.900
0.046	10.800	19.182	33.055	42.942	59.712
0.154	11.400	20.538	34.996	44.892	61.127
0.277	12.000	21.601	36.233	46.766	63.100
0.415	12.600	23.060	37.775	48.001	64.706
0.492	13.200	23.642	38.518	49.422	66.505
0.569	13.800	24.223	39.171	50.342	67.490
0.662	14.400	25.002	40.248	51.797	68.977
0.738	15.000	26.028	41.095	53.165	70.300
0.785	15.600	26.529	41.871	54.000	71.045
0.831	16.200	27.402	42.532	54.600	72.482
0.862	16.800	27.983	43.117	55.200	72.751
0.877	17.400	28.348	43.652	55.800	74.335
0.908	18.000	29.511	44.889	57.434	75.070
0.923	18.600	30.092	45.254	58.062	75.720
0.938	19.200	30.674	45.563	58.689	76.634
0.954	20.400	31.255	46.145	59.317	77.323
0.969	21.000	31.985	47.326	59.945	78.285
0.985	21.600	34.874	48.563	61.145	78.715
1.000	23.400	37.200	49.200	61.800	80.816

Table B.2: An experimental breakthrough curve of acetylene 33%V/V at the superficial velocity of 15 cm/s.

c/c_0	t (s)				
	L 2 cm	L 4 cm	L 6 cm	L 8 cm	L 10 cm
0.000	8.700	15.000	27.300	33.900	45.900
0.058	9.000	15.733	28.429	36.176	49.847
0.208	9.600	16.933	29.403	37.691	51.496
0.367	10.200	18.001	31.136	39.194	52.756
0.517	10.800	18.603	32.214	40.202	54.384
0.625	11.400	19.203	33.008	42.175	55.738
0.725	12.000	19.803	33.963	43.679	57.153
0.775	12.600	20.401	34.588	44.487	58.045
0.833	13.200	21.800	35.575	45.220	59.233
0.867	13.800	22.600	36.400	46.020	60.340
0.892	14.400	23.400	37.092	46.958	61.533
0.908	15.000	24.000	37.800	47.615	62.400
0.925	15.600	24.600	38.400	48.682	63.645
0.942	16.200	25.800	40.025	49.949	64.835
0.950	16.800	26.400	40.650	50.546	65.490
0.958	17.400	27.000	41.275	51.223	67.225
0.967	18.000	28.200	42.400	52.802	67.860
0.975	18.600	29.400	44.175	53.669	69.645
0.983	19.800	30.600	44.950	55.264	71.470
0.992	20.400	31.200	47.300	57.638	75.625
1.000	23.400	34.200	52.200	61.437	75.600

Table B.3: An experimental breakthrough curve of acetylene 60%V/V at the superficial velocity of 15 cm/s.

c/c_0	t (s)				
	L 2 cm	L 4 cm	L 6 cm	L 8 cm	L 10 cm
0.000	6.600	13.050	19.650	31.800	20.278
0.087	7.200	13.744	21.587	29.232	38.666
0.390	7.800	14.602	22.830	30.654	40.032
0.603	8.400	15.183	23.489	31.584	41.568
0.747	9.000	15.749	24.170	32.636	43.119
0.805	9.600	16.323	24.771	33.358	44.063
0.845	10.200	16.905	25.440	34.189	45.052
0.874	10.800	17.952	26.463	35.013	46.031
0.895	11.400	18.607	27.187	35.737	46.810
0.906	12.000	19.118	27.654	36.225	47.442
0.921	12.600	19.759	28.383	37.196	48.551
0.928	13.200	19.867	28.493	37.587	49.346

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	L 2 cm	L 4 cm	L 6 cm	L 8 cm	L 10 cm
0.939	13.800	20.465	29.238	38.462	49.976
0.942	14.400	21.065	29.724	38.662	50.118
0.949	15.000	21.665	30.314	39.444	51.324
0.957	15.600	22.266	30.903	40.162	52.462
0.960	16.200	22.867	31.451	40.669	53.094
0.964	16.800	23.469	31.987	41.107	53.589
0.968	17.400	23.969	32.404	41.564	54.353
0.971	18.000	24.491	32.881	42.104	55.120
0.975	18.600	24.998	33.493	42.875	55.840
0.978	19.200	25.413	34.136	43.808	56.579
0.982	19.800	26.253	34.906	44.526	57.754
0.986	20.400	27.298	36.001	45.532	58.855
0.993	21.000	28.433	38.017	48.782	61.430
0.996	21.600	29.798	39.657	50.424	63.350
1.000	22.200	31.633	41.846	52.628	67.774

Table B.4: An experimental breakthrough curve of acetylene 20%V/V at the superficial velocity of 5 cm/s.

c/c_0	t (s)				
	L 2 cm	L 4 cm	L 6 cm	L 8 cm	L 10 cm
0.000	26.400	64.200	100.950	138.000	174.150
0.014	27.000	64.784	101.351	138.567	174.582
0.027	27.600	65.367	101.868	139.134	174.875
0.055	28.200	66.267	102.768	140.034	176.203
0.082	28.800	67.101	103.088	140.803	177.597
0.110	29.400	67.241	103.882	141.712	178.531
0.151	30.000	68.310	104.959	142.319	178.664
0.205	30.600	69.318	105.871	143.236	179.815
0.247	31.200	69.826	106.405	143.803	180.600
0.301	31.800	70.479	107.277	144.600	181.200
0.356	32.400	71.143	107.873	145.200	181.801
0.397	33.000	71.641	108.364	145.800	182.400
0.452	33.600	72.419	108.695	146.400	183.001
0.507	34.200	73.048	109.353	147.000	184.296
0.548	34.800	73.581	110.192	148.362	184.907
0.589	35.400	74.073	110.786	148.993	185.647
0.616	36.000	74.365	111.160	149.507	186.045
0.658	36.600	75.137	111.561	150.074	186.805
0.699	37.200	75.781	112.323	150.662	187.471
0.726	37.800	76.364	112.858	151.229	188.047
0.753	38.400	76.948	113.392	151.201	188.844
0.767	39.000	77.240	113.659	151.800	189.210

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	L 2 cm	L 4 cm	L 6 cm	L 8 cm	L 10 cm
0.781	39.600	77.663	113.926	152.400	189.000
0.808	40.200	78.715	114.460	153.000	190.545
0.836	40.800	79.397	115.389	154.595	191.248
0.863	42.000	80.400	116.458	155.564	192.247
0.890	43.800	81.600	117.615	156.395	193.495
0.904	44.400	82.800	119.133	157.297	194.246
0.918	45.000	83.400	119.662	157.800	195.148
0.932	47.400	84.423	120.949	158.564	196.093
0.945	48.000	85.595	122.012	159.197	198.296
0.959	49.800	88.948	123.981	160.048	199.985
0.973	51.000	89.850	126.035	161.063	199.801
0.986	54.600	93.592	127.271	163.332	202.800
1.000	55.200	95.058	128.526	163.678	207.200

Table B.5: An experimental breakthrough curve of acetylene 33%V/V at the superficial velocity of 5 cm/s.

c/c_0	t (s)				
	L 2 cm	L 4 cm	L 6 cm	L 8 cm	L 10 cm
0.000	24.600	52.200	83.100	113.250	140.400
0.008	25.200	52.809	83.409	113.409	140.972
0.031	25.800	53.738	84.338	114.338	149.643
0.063	26.400	54.012	85.238	116.474	151.309
0.126	27.000	54.973	86.250	117.475	152.088
0.213	27.600	56.257	87.001	117.739	152.402
0.307	28.200	57.000	87.602	118.667	153.837
0.402	28.800	57.601	88.203	119.520	154.639
0.488	29.400	58.201	88.804	120.330	155.405
0.567	30.000	58.801	90.095	121.227	156.060
0.638	30.600	59.401	90.819	122.155	156.917
0.693	31.200	60.001	91.533	123.116	157.584
0.748	31.800	60.601	92.299	124.200	158.477
0.780	32.400	61.201	92.868	124.800	159.065
0.811	33.000	62.083	93.787	124.982	159.827
0.827	33.600	62.400	94.096	126.000	160.208
0.858	34.200	63.687	95.230	127.630	161.055
0.866	34.800	63.600	95.539	127.939	161.341
0.882	35.400	64.200	96.317	128.717	162.425
0.898	36.000	64.800	97.377	129.777	163.084
0.906	36.600	65.400	97.687	130.087	163.540
0.921	37.200	67.011	98.811	131.211	164.683
0.937	38.400	68.249	100.649	133.049	166.054
0.953	39.600	69.487	101.887	134.287	167.400
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	L 2 cm	L 4 cm	L 6 cm	L 8 cm	L 10 cm
0.961	41.400	71.117	103.011	135.411	169.200
0.969	42.000	72.449	104.773	137.173	171.000
0.984	43.800	75.506	107.400	141.487	174.600
0.992	47.400	79.668	109.200	145.087	178.200
1.000	48.000	82.200	112.800	147.000	181.800

Table B.6: An experimental breakthrough curve of acetylene 60%V/V at the superficial velocity of 5 cm/s.

c/c_0	t (s)				
	L 2 cm	L 4 cm	L 6 cm	L 8 cm	L 10 cm
0.000	19.950	34.200	47.400	73.800	84.600
0.004	20.400	34.800	48.926	75.659	85.613
0.011	21.000	42.600	63.335	90.215	104.192
0.046	21.600	43.477	68.400	94.435	120.698
0.140	22.200	44.280	69.603	95.407	121.919
0.305	22.800	45.002	70.389	96.196	122.448
0.488	23.400	45.604	71.197	97.012	123.250
0.628	24.000	46.205	71.944	97.765	124.026
0.712	24.600	46.803	72.650	98.504	124.713
0.775	25.200	47.401	73.534	99.418	125.548
0.814	25.800	48.700	74.386	100.345	126.379
0.825	26.400	48.600	74.728	100.693	126.709
0.860	27.000	50.100	76.174	102.000	127.800
0.877	27.600	51.150	77.279	103.403	129.112
0.898	28.200	52.200	78.678	104.748	130.845
0.912	28.800	53.100	79.542	105.889	132.163
0.923	29.400	53.800	80.581	106.935	133.152
0.933	30.000	54.900	81.640	108.000	134.480
0.940	30.600	55.500	82.613	109.354	135.399
0.947	31.200	56.100	83.811	110.574	137.116
0.951	31.800	56.400	84.503	110.922	137.587
0.954	32.400	57.000	84.898	112.082	137.917
0.958	33.000	57.600	85.377	112.838	138.493
0.961	33.600	58.500	86.581	113.535	139.152
0.965	34.200	58.800	87.274	114.463	141.011
0.968	34.800	59.400	87.966	115.857	141.669
0.972	35.400	60.000	89.118	117.038	142.328
0.975	36.600	61.200	90.503	116.400	143.362
0.979	37.200	60.000	91.566	120.638	145.093
0.982	37.800	62.400	92.947	121.974	146.716
0.986	39.600	64.200	95.259	121.800	148.328
0.989	42.000	66.600	96.483	125.747	149.646
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	L 2 cm	L 4 cm	L 6 cm	L 8 cm	L 10 cm
0.993	43.200	70.800	96.986	128.419	150.964
0.996	48.600	71.400	100.654	133.528	153.905
1.000	51.600	78.000	102.937	136.200	157.200

B.2 Breakthrough Curve

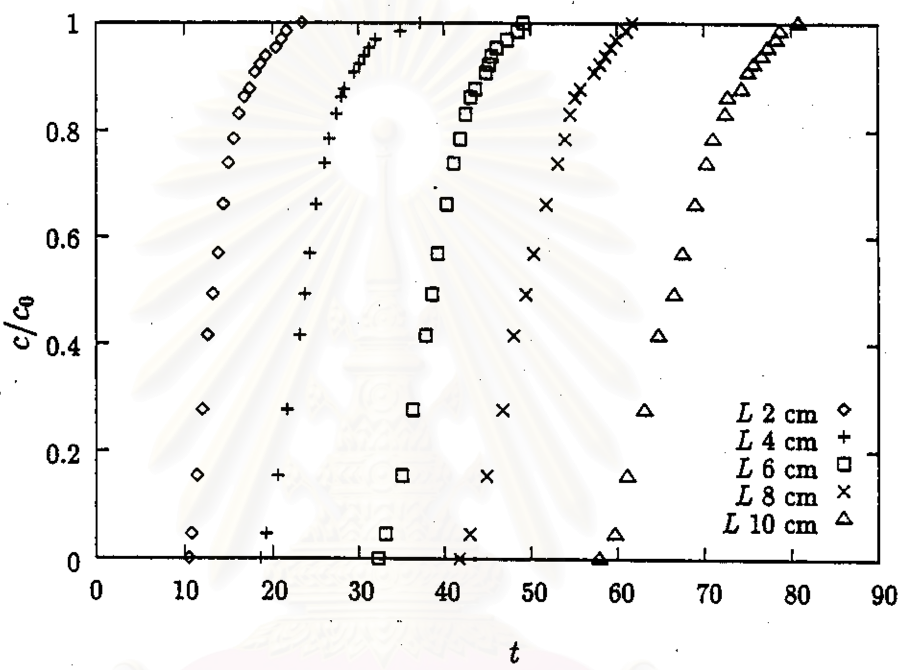

Figure B.1: An experimental breakthrough curve of acetylene 20%V/V at the superficial velocity of 15 cm/s.

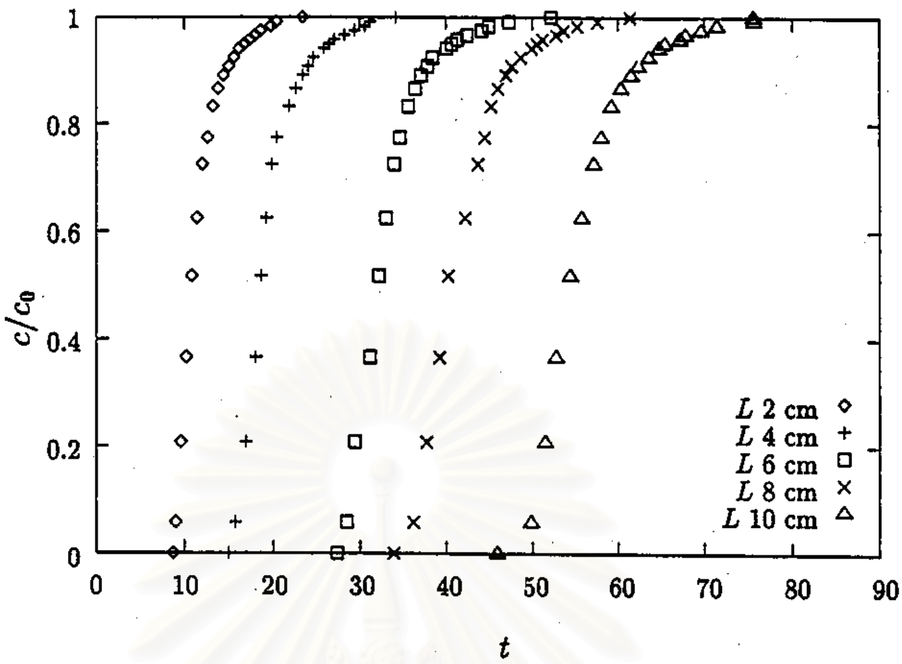

Figure B.2: An experimental breakthrough curve of acetylene 33%V/V at the superficial velocity of 15 cm/s.

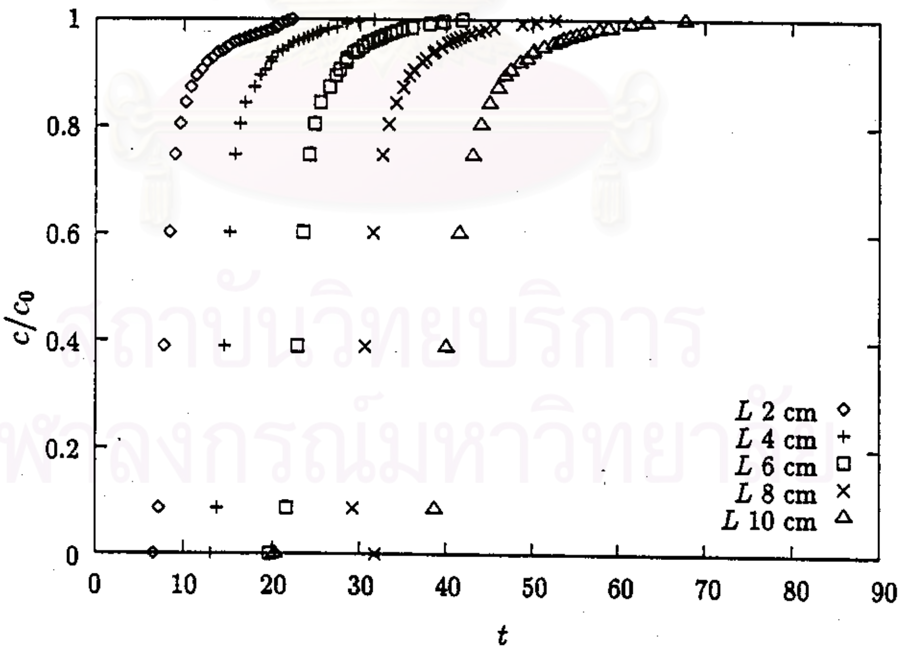

Figure B.3: An experimental breakthrough curve of acetylene 60%V/V at the superficial velocity of 15 cm/s.

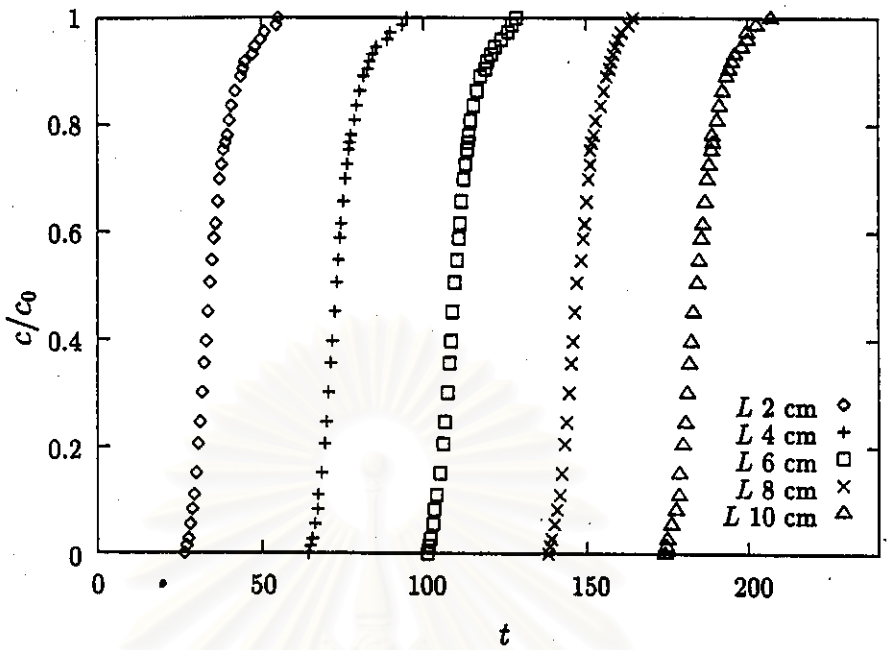

Figure B.4: An experimental breakthrough curve of acetylene 20%V/V at the superficial velocity of 5 cm/s.

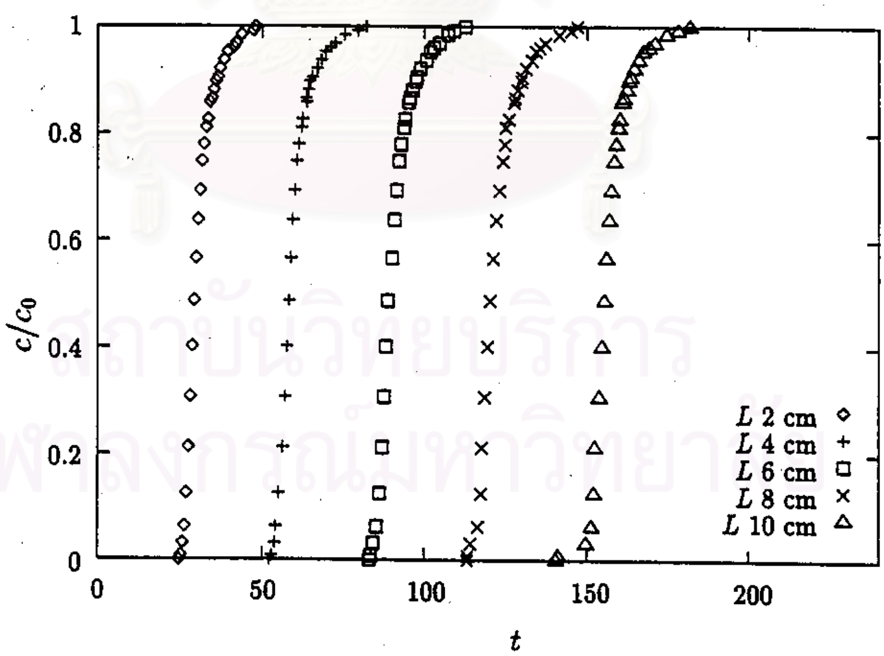

Figure B.5: An experimental breakthrough curve of acetylene 33%V/V at the superficial velocity of 5 cm/s.

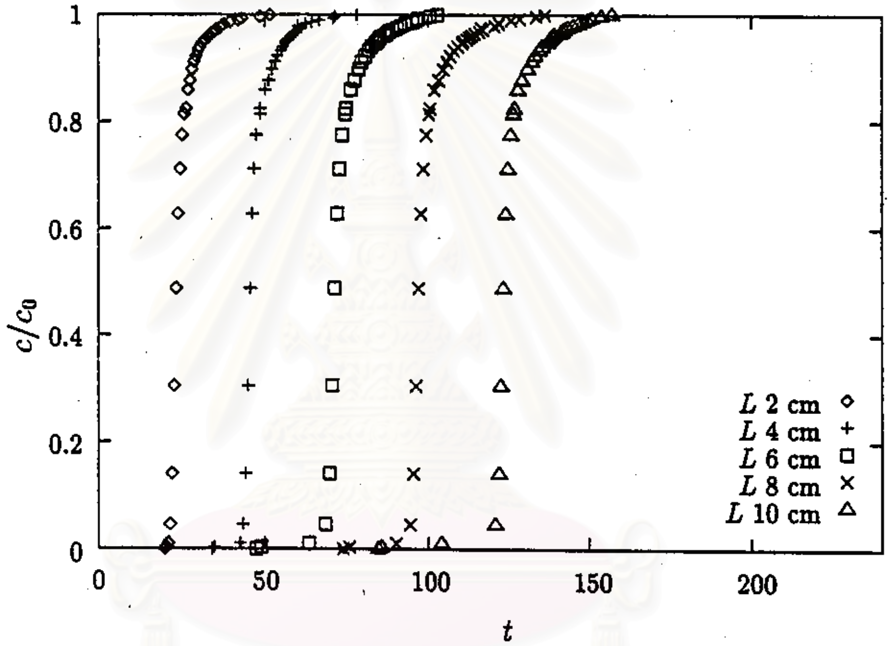

Figure B.6: An experimental breakthrough curve of acetylene 60%V/V at the superficial velocity of 5 cm/s.

APPENDIX C

Concentration Profile of Various Bed Lengths

Table C.1: The concentration profile of acetylene 20%V/V at the superficial velocity of 15 cm/s.

c/c_0	S (cm)				
	L 2 cm	L 4 cm	L 6 cm	L 8 cm	L 10 cm
0.000	2.061	4.137	6.173	8.266	10.332
0.046	2.004	4.010	6.013	8.013	10.011
0.154	1.898	3.739	5.661	7.659	9.722
0.277	1.804	3.555	5.454	7.332	9.383
0.415	1.718	3.353	5.214	7.148	9.153
0.492	1.645	3.247	5.133	6.932	8.893
0.569	1.568	3.198	5.054	6.811	8.765
0.662	1.503	3.089	4.912	6.624	8.574
0.738	1.443	2.968	4.812	6.450	8.406
0.785	1.387	2.926	4.737	6.368	8.333
0.831	1.336	2.837	4.674	6.312	8.186
0.862	1.288	2.792	4.628	6.265	8.174
0.877	1.244	2.738	4.596	6.223	8.031
0.908	1.202	2.596	4.334	5.778	7.517
0.923	1.164	2.627	4.392	5.893	7.725
0.938	1.127	2.593	4.389	5.861	7.665
0.954	1.061	2.610	4.406	5.844	7.642
0.969	1.031	2.562	4.291	5.724	7.490
0.985	1.002	2.269	3.945	5.376	7.161
1.000	0.925	2.144	4.083	5.577	7.280

Table C.2: The concentration profile of acetylene 33%V/V at the superficial velocity of 15 cm/s.

c/c_0	S (cm)				
	L 2 cm	L 4 cm	L 6 cm	L 8 cm	L 10 cm
0.000	2.059	4.177	6.232	8.305	10.368
0.058	1.990	3.972	5.963	7.730	9.604
0.208	1.866	3.686	5.713	7.365	9.124
0.367	1.756	3.467	5.391	7.090	8.871
0.517	1.659	3.369	5.226	6.940	8.642
0.625	1.571	3.282	5.113	6.606	8.386
0.725	1.493	3.203	4.988	6.397	8.188
0.775	1.422	3.132	4.914	6.297	8.077
0.833	1.357	2.909	4.744	6.163	7.880
0.867	1.298	2.814	4.646	6.069	7.746
0.892	1.244	2.727	4.573	5.960	7.613
0.908	1.194	2.677	4.509	5.903	7.527
0.925	1.148	2.631	4.463	5.794	7.410
0.942	1.106	2.496	4.273	5.652	7.266
0.950	1.066	2.456	4.230	5.614	7.219
0.958	1.030	2.419	4.190	5.566	7.050
0.967	0.995	2.303	4.084	5.400	7.007
0.975	0.963	2.199	3.909	5.351	6.826
0.983	0.905	2.140	3.902	5.229	6.700
0.992	0.878	2.114	3.684	5.008	6.308
1.000	0.766	2.001	3.405	4.888	6.577

Table C.3: The concentration profile of acetylene 60%V/V at the superficial velocity of 15 cm/s.

c/c_0	S (cm)				
	L 2 cm	L 4 cm	L 6 cm	L 8 cm	L 10 cm
0.000	2.105	4.125	6.594	8.676	10.347
0.087	1.930	3.914	5.670	7.370	9.035
0.390	1.781	3.684	5.305	7.045	8.666
0.603	1.654	3.563	5.159	6.813	8.340
0.747	1.544	3.463	5.017	6.572	8.119
0.805	1.447	3.375	4.920	6.439	7.990
0.845	1.362	3.295	4.808	6.310	7.844
0.874	1.286	3.090	4.669	6.156	7.669
0.895	1.219	3.007	4.569	6.079	7.502
0.906	1.158	2.970	4.540	6.031	7.447
0.921	1.103	2.904	4.444	5.880	7.419
0.928	1.052	2.998	4.479	5.897	7.321

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	L 2 cm	L 4 cm	L 6 cm	L 8 cm	L 10 cm
0.939	1.007	2.952	4.382	5.835	7.245
0.942	0.965	2.910	4.380	5.877	7.186
0.949	0.926	2.872	4.345	5.761	7.143
0.957	0.891	2.836	4.313	5.678	7.072
0.960	0.858	2.802	4.300	5.651	7.043
0.964	0.827	2.771	4.293	5.647	7.008
0.968	0.798	2.775	4.320	5.636	7.015
0.971	0.772	2.774	4.329	5.618	7.018
0.975	0.747	2.781	4.290	5.578	7.001
0.978	0.724	2.823	4.250	5.550	6.996
0.982	0.702	2.717	4.173	5.449	6.824
0.986	0.681	2.556	4.028	5.307	6.647
0.993	0.662	2.392	3.631	4.938	6.451
0.996	0.643	2.201	3.446	4.746	6.172
1.000	0.626	1.969	3.292	4.408	6.008

Table C.4: The concentration profile of acetylene 20%V/V at the superficial velocity of 5 cm/s.

c/c_0	S (cm)				
	L 2 cm	L 4 cm	L 6 cm	L 8 cm	L 10 cm
0.000	2.128	4.140	6.126	8.137	10.134
0.014	2.081	4.093	6.090	8.092	10.097
0.027	2.036	4.049	6.049	8.049	10.069
0.055	1.993	3.990	5.990	7.990	9.986
0.082	1.905	3.936	5.965	7.940	9.902
0.110	1.889	3.920	5.930	7.899	9.860
0.151	1.873	3.858	5.850	7.845	9.831
0.205	1.836	3.800	5.797	7.792	9.766
0.247	1.801	3.769	5.765	7.758	9.720
0.301	1.767	3.733	5.717	7.714	9.686
0.356	1.734	3.697	5.684	7.681	9.653
0.397	1.703	3.670	5.658	7.650	9.622
0.452	1.672	3.631	5.643	7.620	9.592
0.507	1.643	3.600	5.611	7.590	9.525
0.548	1.615	3.575	5.569	7.525	9.500
0.589	1.587	3.553	5.542	7.495	9.465
0.616	1.561	3.543	5.527	7.474	9.449
0.658	1.535	3.508	5.512	7.451	9.417
0.699	1.510	3.481	5.479	7.426	9.387
0.726	1.487	3.458	5.458	7.404	9.365
0.753	1.463	3.436	5.439	7.412	9.329
0.767	1.441	3.429	5.434	7.390	9.320

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	L 2 cm	L 4 cm	L 6 cm	L 8 cm	L 10 cm
0.781	1.419	3.416	5.430	7.370	9.343
0.808	1.398	3.372	5.414	7.352	9.275
0.836	1.377	3.347	5.375	7.282	9.252
0.863	1.338	3.318	5.342	7.254	9.222
0.890	1.283	3.294	5.321	7.251	9.197
0.904	1.266	3.245	5.255	7.229	9.176
0.918	1.249	3.229	5.242	7.207	9.140
0.932	1.185	3.239	5.238	7.227	9.151
0.945	1.171	3.193	5.198	7.208	9.054
0.959	1.128	3.070	5.154	7.165	8.973
0.973	1.102	3.059	5.125	7.125	8.989
0.986	1.029	2.979	5.075	7.045	8.874
1.000	1.018	2.925	5.040	7.002	7.900

Table C.5: The concentration profile of acetylene 33%V/V at the superficial velocity of 5 cm/s.

c/c_0	S (cm)				
	L 2 cm	L 4 cm	L 6 cm	L 8 cm	L 10 cm
0.000	2.126	4.157	6.143	8.147	10.743
0.008	2.076	4.106	6.112	8.125	10.683
0.031	2.027	4.034	6.039	8.053	10.049
0.063	1.998	4.011	5.973	7.896	9.937
0.126	1.976	3.941	5.900	7.823	9.879
0.213	1.895	3.851	5.847	7.812	9.846
0.307	1.855	3.801	5.807	7.751	9.755
0.402	1.816	3.762	5.768	7.696	9.704
0.488	1.779	3.725	5.731	7.647	9.657
0.567	1.744	3.690	5.651	7.591	9.615
0.638	1.709	3.655	5.609	7.536	9.564
0.693	1.676	3.623	5.569	7.481	9.527
0.748	1.645	3.591	5.527	7.421	9.477
0.780	1.614	3.561	5.499	7.390	9.448
0.811	1.585	3.512	5.450	7.386	9.410
0.827	1.557	3.503	5.439	7.332	9.393
0.858	1.529	3.430	5.376	7.240	9.349
0.866	1.503	3.449	5.371	7.235	9.346
0.882	1.478	3.424	5.335	7.199	9.290
0.898	1.453	3.357	5.283	7.165	9.246
0.906	1.429	3.324	5.276	7.140	9.205
0.921	1.406	3.286	5.216	7.080	9.187
0.937	1.362	3.240	5.134	6.998	9.134
0.953	1.321	3.196	5.091	6.955	9.084

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	L 2 cm	L 4 cm	L 6 cm	L 8 cm	L 10 cm
0.961	1.263	3.150	5.074	6.938	9.025
0.969	1.245	3.086	4.985	6.849	8.933
0.984	1.194	2.962	4.886	6.658	8.787
0.992	1.103	2.841	4.919	6.602	8.731
1.000	1.090	2.729	4.734	6.500	8.526

Table C.6: The concentration profile of acetylene 60%V/V at the superficial velocity of 5 cm/s.

c/c_0	S (cm)				
	L 2 cm	L 4 cm	L 6 cm	L 8 cm	L 10 cm
0.000	2.168	5.240	9.019	10.991	15.856
0.004	2.120	5.160	8.691	10.641	15.921
0.011	2.086	4.086	6.492	8.439	12.199
0.046	2.060	4.003	6.005	8.004	10.005
0.140	1.995	3.987	5.901	7.918	9.900
0.305	1.897	3.869	5.834	7.851	9.853
0.488	1.849	3.820	5.769	7.786	9.789
0.628	1.802	3.774	5.712	7.729	9.730
0.712	1.758	3.730	5.660	7.677	9.682
0.775	1.716	3.688	5.597	7.614	9.625
0.814	1.677	3.559	5.530	7.547	9.566
0.825	1.638	3.610	5.519	7.537	9.557
0.860	1.602	3.497	5.410	7.446	9.483
0.877	1.567	3.426	5.335	7.337	9.381
0.898	1.534	3.358	5.287	7.286	9.273
0.912	1.502	3.303	5.240	7.271	9.207
0.923	1.471	3.265	5.128	7.145	9.150
0.933	1.442	3.200	5.065	7.105	9.089
0.940	1.414	3.172	5.011	7.017	9.034
0.947	1.386	3.144	4.945	6.962	8.942
0.951	1.360	3.140	4.915	6.892	8.863
0.954	1.335	3.114	4.903	6.839	8.873
0.958	1.311	3.090	4.886	6.903	8.952
0.961	1.287	3.045	4.822	6.783	8.835
0.965	1.265	3.044	4.796	6.778	8.757
0.968	1.243	3.022	4.769	6.736	8.772
0.972	1.222	3.001	4.714	6.683	8.761
0.975	1.182	2.961	4.664	6.822	8.771
0.979	1.163	3.083	4.663	6.677	8.826
0.982	1.144	2.924	4.557	6.561	8.684
0.986	1.092	2.872	4.478	6.595	8.576
0.989	1.030	2.809	4.479	6.473	8.672

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	L 2 cm	L 4 cm	L 6 cm	L 8 cm	L 10 cm
0.993	1.001	2.587	4.492	6.510	8.840
0.996	0.890	2.810	4.515	6.554	9.133
1.000	0.838	2.496	4.497	6.383	8.885

APPENDIX D

Breakthrough Curve of Various Adsorbent Sizes

D.1 Breakthrough Data

Table D.1: An experimental breakthrough curve of acetylene 20%V/V using 60-80, 40-60 and 30-40 mesh.

c/c_0	t (s)		
	60-80 mesh	40-60 mesh	30-40 mesh
0.000	32.250	30.450	30.000
0.046	33.055	32.074	31.420
0.154	34.996	33.615	32.927
0.277	36.233	35.199	33.686
0.415	37.775	36.702	34.935
0.492	38.518	37.307	35.859
0.569	39.171	37.952	36.639
0.662	40.248	39.349	37.854
0.738	41.095	39.767	38.896
0.785	41.871	40.635	39.742
0.831	42.532	41.538	40.621
0.862	43.117	42.915	41.228
0.877	43.652	43.635	41.907
0.908	44.889	44.532	42.752
0.923	45.254	44.787	43.103
0.938	45.563	45.802	44.872
0.954	46.145	47.294	45.461
0.969	47.326	47.778	47.791
0.985	48.563	50.605	49.621
1.000	49.200	54.557	55.314

Table D.2: An experimental breakthrough curve of acetylene 33%V/V using 60-80, 40-60 and 30-40 mesh.

c/c_0	t (s)		
	60-80 mesh	40-60 mesh	30-40 mesh
0.000	27.300	26.400	26.250
0.058	28.429	27.511	27.242
0.208	29.403	28.492	28.431
0.367	31.136	29.829	30.009
0.517	32.214	30.972	30.659
0.625	33.008	31.741	31.259
0.725	33.963	32.665	31.953
0.775	34.588	33.267	32.639
0.833	35.575	34.226	33.324
0.867	36.400	34.517	34.414
0.892	37.092	35.165	34.957
0.908	37.800	35.838	35.432
0.925	38.400	36.391	35.863
0.942	40.025	37.918	36.893
0.950	40.650	39.099	37.184
0.958	41.275	39.699	37.431
0.967	42.400	40.777	38.361
0.975	44.175	42.468	38.868
0.983	44.950	44.535	40.727
0.992	47.300	46.465	41.701
1.000	52.200	50.437	42.612

Table D.3: An experimental breakthrough curve of acetylene 60%V/V using 60-80, 40-60 and 30-40 mesh.

c/c_0	t (s)		
	60-80 mesh	40-60 mesh	30-40 mesh
0.000	19.650	19.200	18.450
0.087	21.587	21.751	20.859
0.390	22.830	23.444	22.452
0.603	23.489	24.206	23.196
0.747	24.170	24.483	23.467
0.805	24.771	25.430	24.392
0.845	25.440	26.153	25.098
0.874	26.463	26.535	25.471
0.895	27.187	26.894	25.821
0.906	27.654	27.268	26.185
0.921	28.383	28.038	26.937
0.928	28.493	28.285	27.177

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	60-80 mesh	40-60 mesh	30-40 mesh
0.939	29.238	28.440	27.328
0.942	29.724	28.678	27.561
0.949	30.314	29.162	28.032
0.957	30.903	29.634	28.493
0.960	31.451	30.012	28.860
0.964	31.987	30.361	29.201
0.968	32.404	30.844	29.672
0.971	32.881	31.187	30.005
0.975	33.493	31.849	30.649
0.978	34.136	32.635	31.415
0.982	34.906	33.233	31.997
0.986	36.001	34.202	32.938
0.993	38.017	34.502	33.230
0.996	39.657	35.924	34.613
1.000	41.846	36.925	35.585

D.2 Breakthrough Curve

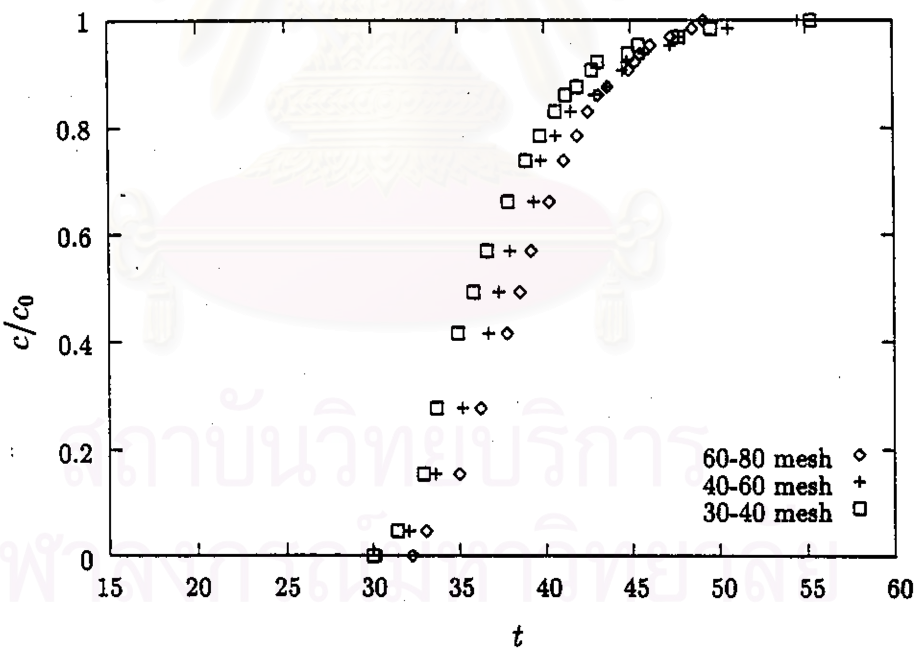

Figure D.1: An experimental breakthrough curve of acetylene 20%V/V using 60-80, 40-60 and 30-40 mesh YAO.

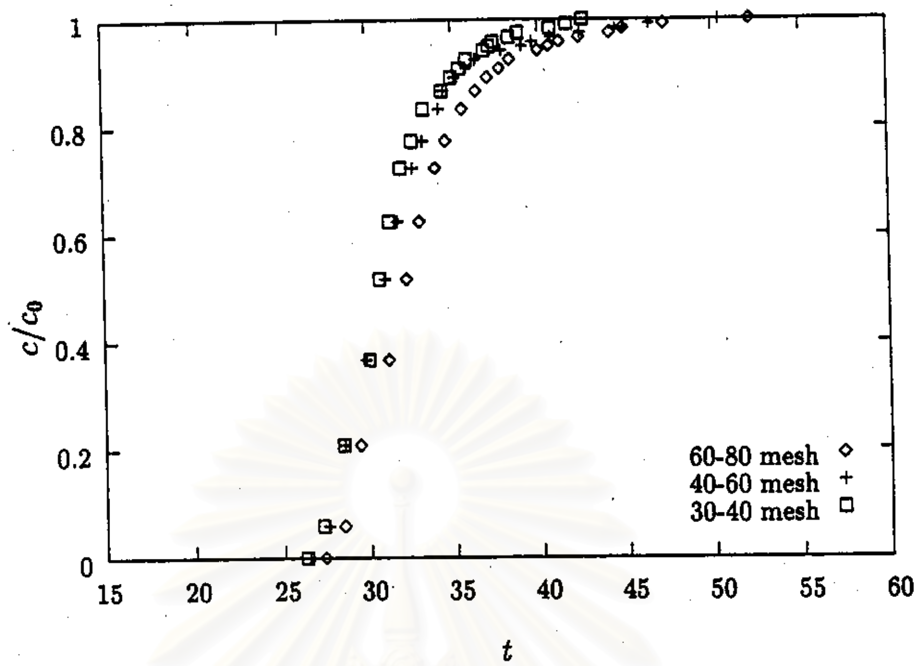

Figure D.2: An experimental breakthrough curve of acetylene 33%V/V using 60-80, 40-60 and 30-40 mesh YAO.

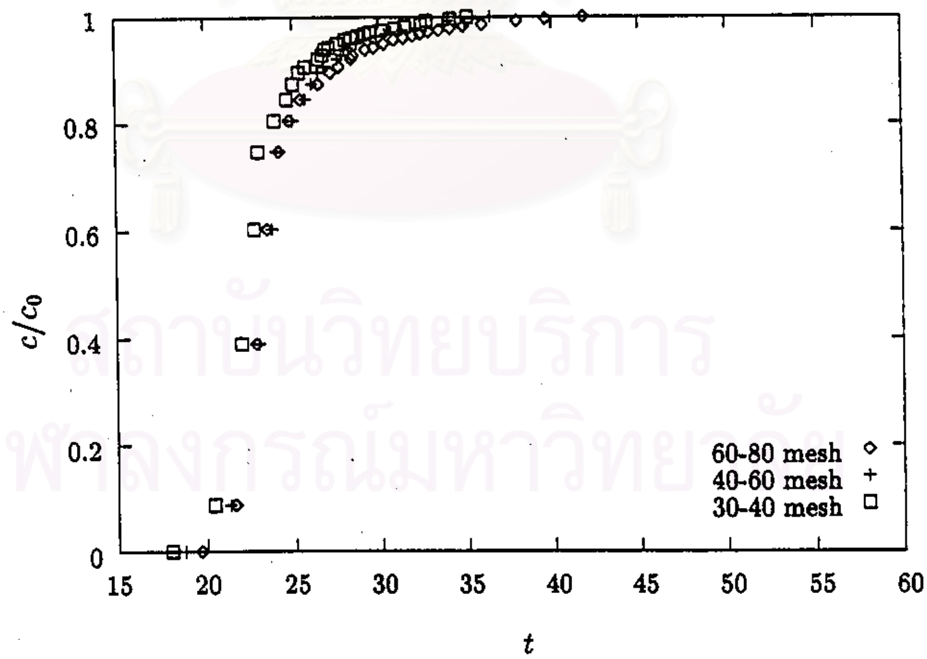

Figure D.3: An experimental breakthrough curve of acetylene 60%V/V using 60-80, 40-60 and 30-40 mesh YAO.

APPENDIX E

Concentration Profile of Various Adsorbent Sizes

Table E.1: The concentration profile of acetylene 20%V/V using 60-80, 40-60 and 30-40 mesh.

c/c_0	S (cm)		
	60-80 mesh	40-60 mesh	30-40 mesh
0.000	6.173	6.331	6.295
0.046	6.013	6.010	6.010
0.154	5.661	5.735	5.735
0.277	5.454	5.477	5.606
0.415	5.214	5.252	5.405
0.492	5.133	5.167	5.266
0.569	5.054	5.079	5.154
0.662	4.912	4.899	4.989
0.738	4.812	4.848	4.855
0.785	4.737	4.744	4.752
0.831	4.674	4.641	4.649
0.862	4.628	4.492	4.580
0.877	4.596	4.418	4.506
0.908	4.334	4.329	4.417
0.923	4.392	4.304	4.381
0.938	4.389	4.209	4.208
0.954	4.406	4.076	4.154
0.969	4.291	4.035	3.951
0.985	3.945	3.809	3.806
1.000	4.083	3.533	3.414

Table E.2: The concentration profile of acetylene 33%V/V using 60-80, 40-60 and 30-40 mesh.

c/c_0	S(cm)		
	60-80 mesh	40-60 mesh	30-40 mesh
0.000	6.232	6.216	6.194
0.058	5.963	5.965	5.969
0.208	5.713	5.760	5.719
0.367	5.391	5.502	5.418
0.517	5.226	5.299	5.303
0.625	5.113	5.170	5.202
0.725	4.988	5.024	5.089
0.775	4.914	4.933	4.982
0.833	4.744	4.795	4.879
0.867	4.646	4.755	4.725
0.892	4.573	4.667	4.651
0.908	4.509	4.579	4.589
0.925	4.463	4.510	4.534
0.942	4.273	4.328	4.407
0.950	4.230	4.197	4.373
0.958	4.190	4.134	4.344
0.967	4.084	4.025	4.239
0.975	3.909	3.864	4.183
0.983	3.902	3.685	3.992
0.992	3.684	3.532	3.899
1.000	3.405	3.254	3.816

Table E.3: The concentration profile of acetylene 60%V/V using 60-80, 40-60 and 30-40 mesh.

c/c_0	S (cm)		
	60-80 mesh	40-60 mesh	30-40 mesh
0.000	6.594	6.460	6.452
0.087	5.670	5.702	5.707
0.390	5.305	5.291	5.302
0.603	5.159	5.124	5.132
0.747	5.017	5.066	5.073
0.805	4.920	4.877	4.880
0.845	4.808	4.743	4.743
0.874	4.669	4.674	4.674
0.895	4.569	4.612	4.610
0.906	4.540	4.549	4.546
0.921	4.444	4.424	4.419
0.928	4.479	4.385	4.380

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	60-80 mesh	40-60 mesh	30-40 mesh
0.939	4.382	4.361	4.356
0.942	4.380	4.325	4.319
0.949	4.345	4.253	4.247
0.957	4.313	4.185	4.178
0.960	4.300	4.133	4.125
0.964	4.293	4.085	4.077
0.968	4.320	4.021	4.012
0.971	4.329	3.977	3.967
0.975	4.290	3.894	3.884
0.978	4.250	3.801	3.789
0.982	4.173	3.732	3.720
0.986	4.028	3.626	3.614
0.993	3.631	3.595	3.582
0.996	3.446	3.453	3.439
1.000	3.292	3.359	3.345

APPENDIX F

Breakthrough Curve of Various Superficial Velocities

F.1 Breakthrough Data

Table F.1: An experimental breakthrough curve of acetylene 60%V/V at various superficial velocities

c/c_0	t (s)					
	v 5 cm/s	v 10 cm/s	v 15 cm/s	v 20 cm/s	v 25 cm/s	v 30 cm/s
0.000	60.300	28.450	16.150	13.400	10.050	7.900
0.004	61.504	28.768	16.600	14.106	10.306	8.197
0.007	66.962	31.335	20.200	16.012	12.007	9.374
0.011	68.750	33.463	21.400	15.871	12.071	9.441
0.044	72.627	34.392	22.000	16.412	12.612	9.935
0.132	73.409	35.096	22.600	16.892	13.094	10.392
0.324	74.325	35.802	23.200	17.489	13.684	10.955
0.515	75.001	36.423	23.800	18.094	14.240	11.490
0.673	75.602	37.019	24.400	18.656	14.693	12.142
0.765	76.201	37.708	25.000	19.112	15.439	12.711
0.816	77.440	38.434	25.600	19.779	15.979	13.437
0.849	78.327	39.155	26.200	20.479	16.659	13.894
0.868	78.986	39.649	26.800	20.888	17.188	14.488
0.890	80.022	40.436	27.400	21.385	17.735	15.150
0.908	81.035	41.251	28.000	22.179	18.529	15.891
0.919	81.553	41.869	28.600	22.541	18.941	16.249
0.930	82.241	42.351	29.200	22.965	19.576	16.663
0.941	83.518	42.976	29.800	24.012	19.835	17.553
0.952	84.312	44.200	30.400	24.571	21.247	18.443
0.956	84.715	44.549	31.000	24.888	21.176	18.740
0.963	85.800	45.190	31.600	25.047	22.324	19.066
0.971	86.400	46.000	32.200	26.318	23.118	20.253

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	v 5 cm/s	v 10 cm/s	v 15 cm/s	v 20 cm/s	v 25 cm/s	v 30 cm/s
0.974	87.000	46.600	32.800	26.953	23.753	20.846
0.982	89.174	47.995	33.400	28.224	25.112	22.033
0.985	89.876	47.800	34.600	28.859	25.659	22.653
0.989	91.257	49.474	35.200	29.494	26.788	23.840
0.996	94.438	51.874	36.400	31.929	28.165	26.220
1.000	97.200	57.200	38.200	32.200	29.400	28.000

F.2 Breakthrough Curve

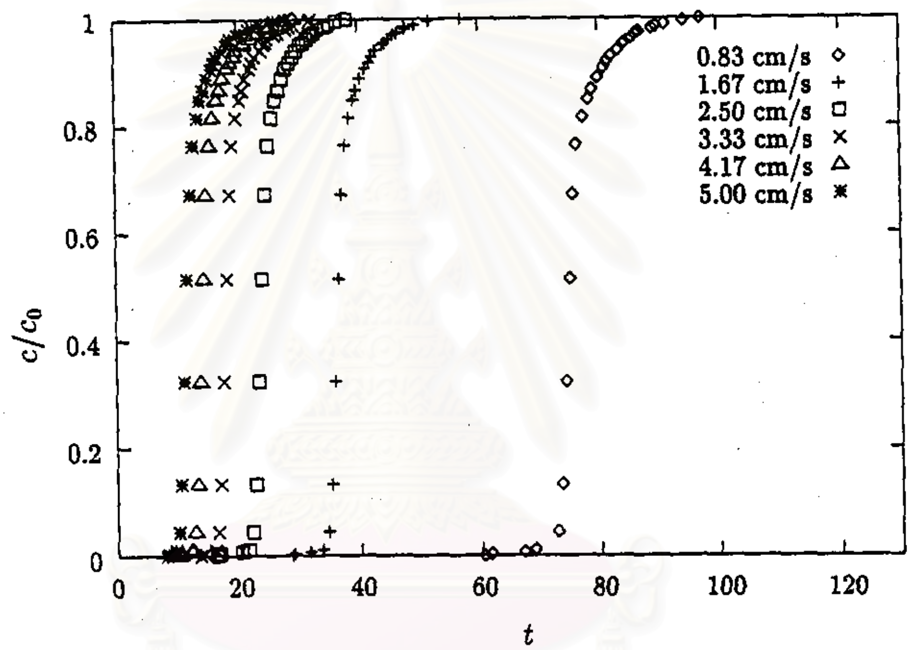

Figure F.1: An experimental breakthrough curve of 60%V/V acetylene at various superficial velocity.

APPENDIX G

Concentration Profile of Various Superficial Velocities

Table G.1: Concentration profile of acetylene 60%V/V at various superficial velocities

c/c_0	S (cm)					
	v 5 cm/s	v 10 cm/s	v 15 cm/s	v 20 cm/s	v 25 cm/s	v 30 cm/s
0.000	7.299	7.363	8.300	7.443	7.695	7.739
0.004	7.156	7.282	8.075	7.071	7.504	7.459
0.007	6.573	6.685	6.636	6.229	6.441	6.523
0.011	6.402	6.260	6.264	6.284	6.407	6.476
0.044	6.060	6.091	6.093	6.077	6.132	6.154
0.132	5.996	5.969	5.931	5.904	5.906	5.884
0.324	5.922	5.851	5.778	5.703	5.651	5.581
0.515	5.869	5.751	5.632	5.512	5.431	5.321
0.673	5.822	5.659	5.494	5.346	5.263	5.035
0.765	5.776	5.555	5.362	5.219	5.009	4.810
0.816	5.684	5.450	5.236	5.042	4.840	4.550
0.849	5.619	5.350	5.116	4.870	4.642	4.400
0.868	5.573	5.283	5.002	4.775	4.499	4.220
0.890	5.500	5.181	4.892	4.664	4.361	4.036
0.908	5.432	5.078	4.787	4.497	4.174	3.847
0.919	5.397	5.003	4.687	4.425	4.083	3.763
0.930	5.352	4.946	4.591	4.343	3.950	3.669
0.941	5.270	4.874	4.498	4.154	3.899	3.483
0.952	5.221	4.739	4.410	4.059	3.640	3.315
0.956	5.196	4.702	4.324	4.007	3.652	3.263
0.963	5.130	4.635	4.242	3.982	3.464	3.207
0.971	5.094	4.554	4.163	3.790	3.345	3.019
0.974	5.059	4.495	4.087	3.700	3.256	2.933
0.982	4.936	4.365	4.013	3.534	3.080	2.775

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	v 5 cm/s	v 10 cm/s	v 15 cm/s	v 20 cm/s	v 25 cm/s	v 30 cm/s
0.985	4.897	4.382	3.874	3.456	3.014	2.699
0.989	4.823	4.234	3.808	3.382	2.887	2.565
0.996	4.661	4.038	3.683	3.124	2.746	2.332
1.000	4.528	3.662	3.509	3.097	2.630	2.184

APPENDIX H

Breakthrough Curve and Concentration Profile of Unpacked and Sand Packed Column

H.1 Breakthrough and Concentration Profile Data

Table H.1: An experimental breakthrough curve and the concentration profile of unpackd column at superficial velocity 15 cm/s .

c/c_0	t (s)	S (cm)	c/c_0	t (s)	S (cm)
0.000	0.390	6.152	0.797	0.399	6.007
0.014	0.400	6.000	0.855	0.400	6.002
0.087	0.400	6.000	0.884	0.397	6.041
0.188	0.400	5.998	0.913	0.400	5.996
0.304	0.395	6.070	0.928	0.401	5.987
0.420	0.398	6.034	0.942	0.400	6.000
0.522	0.400	6.001	0.957	0.401	5.981
0.623	0.397	6.040	0.971	0.394	6.084
0.696	0.397	6.039	0.986	0.419	5.720
0.754	0.400	6.000	1.000	0.390	6.159

Table H.2: An experimental breakthrough curve and the concentration profile of unpackd column at superficial velocity 5 cm/s .

c/c_0	t (s)	S (cm)	c/c_0	t (s)	S (cm)
0.000	1.200	6.003	0.644	1.205	5.977
0.014	1.207	5.970	0.671	1.200	6.003
0.041	1.202	5.993	0.699	1.203	5.989
0.068	1.202	5.993	0.712	1.210	5.953
0.096	1.200	6.003	0.726	1.210	5.954
0.123	1.202	5.993	0.753	1.201	6.000
0.164	1.201	5.997	0.767	1.205	5.976
0.205	1.201	5.997	0.781	1.203	5.990
0.260	1.201	5.999	0.808	1.210	5.956
0.288	1.202	5.995	0.836	1.210	5.953
0.329	1.200	6.003	0.849	1.201	6.000
0.370	1.201	5.998	0.863	1.201	6.000
0.397	1.201	5.997	0.877	1.201	5.998
0.438	1.200	6.003	0.890	1.200	6.001
0.479	1.201	5.999	0.918	1.201	5.998
0.507	1.200	6.003	0.932	1.201	6.000
0.534	1.201	5.998	0.945	1.200	6.001
0.562	1.200	6.003	0.973	1.213	5.937
0.589	1.205	5.977	0.986	1.201	6.000
0.616	1.200	6.003	1.000	1.200	6.003

Table H.3: An experimental breakthrough curve and the concentration profile of sand packd column at superficial velocity 15 cm/s .

c/c_0	t (s)	S (cm)	c/c_0	t (s)	S (cm)
0.000	0.420	5.652	0.818	0.397	5.976
0.015	0.400	5.934	0.833	0.414	5.730
0.076	0.392	6.050	0.864	0.400	5.934
0.152	0.405	5.861	0.894	0.425	5.588
0.242	0.400	5.938	0.909	0.421	5.633
0.333	0.400	5.933	0.924	0.401	5.923
0.439	0.402	5.906	0.939	0.401	5.914
0.515	0.395	6.013	0.955	0.402	5.906
0.591	0.394	6.027	0.970	0.409	5.810
0.667	0.403	5.888	0.985	0.455	5.212
0.727	0.407	5.834	1.000	0.409	5.809
0.773	0.399	5.951			

Table H.4: An experimental breakthrough curve and the concentration profile of sand packd column at superficial velocity 5 cm/s .

c/c_0	t (s)	S (cm)	c/c_0	t (s)	S (cm)
0.000	1.260	5.719	0.643	1.201	5.999
0.043	1.201	5.999	0.671	1.205	5.979
0.071	1.201	6.002	0.686	1.201	6.002
0.100	1.201	6.002	0.700	1.172	6.149
0.129	1.204	5.987	0.729	1.191	6.051
0.157	1.204	5.987	0.757	1.193	6.039
0.180	1.195	6.031	0.786	1.200	6.004
0.214	1.208	5.965	0.800	1.200	6.005
0.243	1.208	5.968	0.814	1.191	6.050
0.271	1.206	5.975	0.829	1.190	6.054
0.314	1.208	5.965	0.843	1.188	6.066
0.357	1.199	6.009	0.857	1.218	5.916
0.386	1.196	6.025	0.871	1.210	5.958
0.414	1.196	6.028	0.900	1.225	5.881
0.457	1.198	6.016	0.929	1.200	6.005
0.486	1.196	6.025	0.914	1.247	5.779
0.543	1.201	5.999	0.957	1.200	6.005
0.571	1.203	5.992	0.971	1.200	6.005
0.600	1.210	5.954	0.986	1.171	6.152
0.629	1.207	5.970	1.000	1.200	6.005

H.2 Breakthrough Curve and Concentration Profile

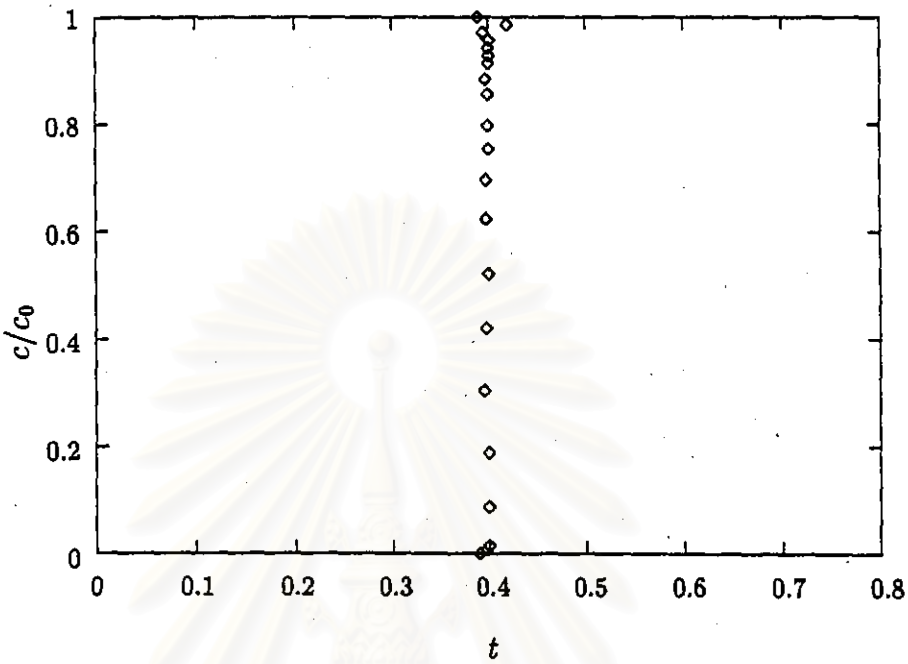

Figure H.1: An experimental breakthrough curve of unpacked column at superficial velocity 15 cm/s.

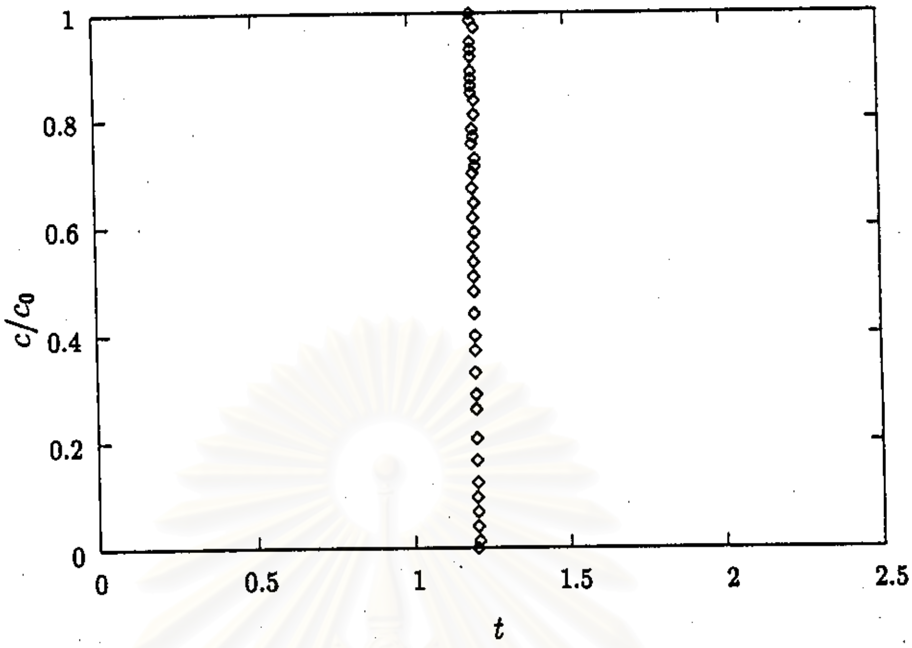

Figure H.2: An experimental breakthrough curve of unpacked column at superficial velocity 5 cm/s.

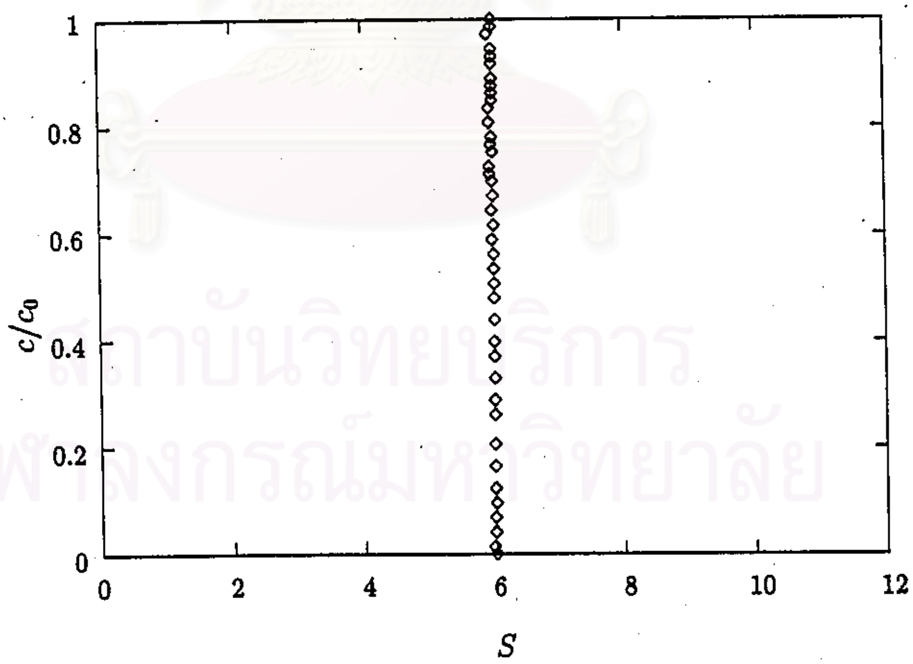

Figure H.3: The concentration profile of unpacked column at superficial velocity 5 cm/s.

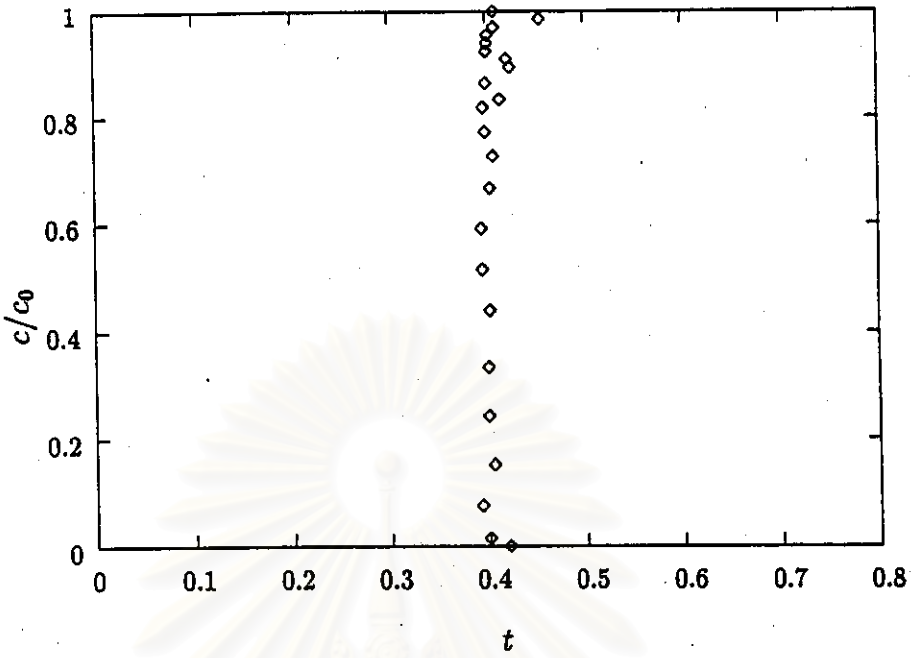

Figure H.4: An experimental breakthrough curve of sand packed column at superficial velocity 15 cm/s

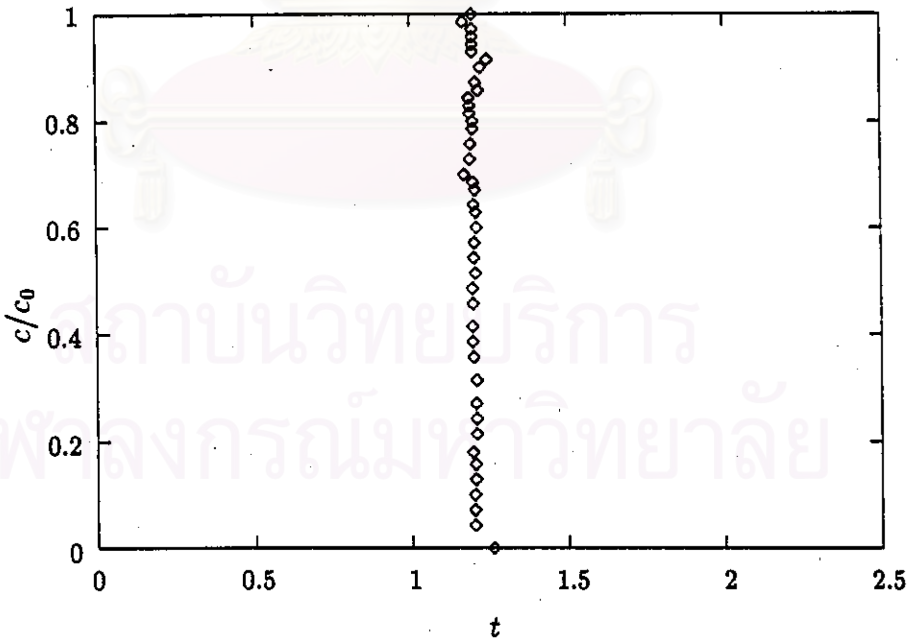

Figure H.5: An experimental breakthrough curve of sand packed column at superficial velocity 5 cm/s.

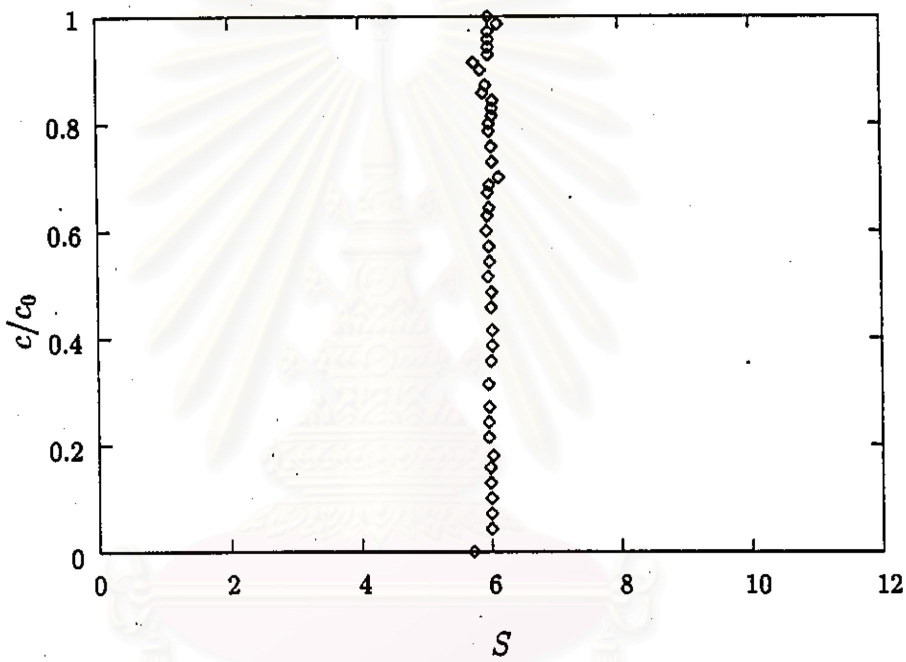

Figure H.6: The concentration profile of sand packed column at superficial velocity 5 cm/s.

CURRICULUM VITAE

Miss Chananchida Bungrapue was born in December, 1973 in Bangkok. She graduate high school from Samsen Wittayalai School in 1992. She recieved Bachelor's Degree of Chemical Technology, Faculty of Science from Chulalongkorn University in 1995. Subsequently, she completed the requirements for Master's Degree in Chemical Engineering at the Department of Chemical Engineering, Faculty of Engineering, Chulalongkorn University in 1997.