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APPENDIX A

SAMPLE OF CALCULATIONS

A-1 Calculation of Si/Metal Atomic Ratio for Metallosilicates Preparation

The calculations is based on weight of Sodium Silicate ($Na_2O.SiO_2.H_2O$) in G2 and S2 solutions.

Molecular Weight of Si = 28.0855

Molecular Weight of SiO_2 = 60.0843

Weight percent of SiO_2 in Sodium Silicate = 28.5

Using Sodium Silicate 69 g with 45 g of water as a G2 and S2 solution.

$$\text{mole of Si used} = \text{wt.} \times \frac{(\%)}{100} \times \frac{(\text{M.W. of Si})}{(\text{M.W. of } SiO_2)} \times \frac{(1\ \text{mole})}{(\text{M.W. of Si})} \quad \text{(A-1.1)}$$

$$= 69 \times (28.5/100) \times (1/60.0843)$$

$$= 0.3273 \ \text{mole}$$

ZSM-5 Catalyst

For example, to prepare ZSM-5 at Si/Al atomic ratio of 40 by using $AlCl_3$ for aluminium source.

Si/Al atomic ratio of 40

mole of AlCl3 required = 0.3273/40 = 8.1825×10^{-3} mole

amount of $AlCl_3$ = $8.1825 \times 10^{-3} \times 133.3405$

= 1.0911 g

Fe-silicate and Fe.Al-silicate Catalyst

For example, to prepare Fe-silicate with Si/Fe atomic ratio of 40 by using $Ga_2(SO_4)_3.nH_2O$ for aluminium source.

Molecular Weight of Fe = 69.723

Molecular Weight of $Fe(NO_3)_3.9H_2O$ = 742.4042

Si/Ga atomic ratio of 40

mole of $Fe(NO_3)_3.9H_2O$ = 0.3273/40 = 8.1825×10^{-3} mole

amount of $Fe(NO_3)_3.9H_2O$ = $(8.1825 \times 10^{-3} \times 404)/2$

= 3.0374 g

Zn-silicate and Zn.Al-silicate Catalyst

For example, to prepare Zn-silicate with Si/Ga atomic ratio of 40 by using $ZnSO_4.7H_2O$ for aluminium source.

Molecular Weight of Zn = 65.39 Molecular Weight of

$ZnSO_4.7H_2O$ = 287.54

Si/Zn atomic ratio of 40

mole of $ZnSO_4.7H_2O$ required = 0.3273/40 = 8.1825×10^{-3} mole

amount of $ZnSO_4.7H_2O$ = $8.1825 \times 10^{-3} \times 287.54$

= 2.353 g

This is the amount of $AlCl_3$, $Fe(NO_3)_3.9H_2O$ and/or $ZnSO_4.7H_2O$ used in G1 and S1 solutions.

A-2 Calculation of Metal Ion-Exchanged ZSM-5 and Metallosilicates

Platinum ion-exchange

Determine the amount of Pt into catalyst = 0.5 wt.%

The catalyst use = X g

So that: from the equation

Pt/(X+Pt) = 0.5/100

100 x Pt = 0.5 x (X+Pt)

(100-0.5) x Pt = 0.5 x X

thus Pt = (0.5 x X)/(100-0.5) g

use $Pt(NH_3)4Cl_2.H_2O$ (Molecular Weight = 352.13, 55 % Pt)

weight of $Pt(NH_3)_4Cl_2.H_2O$ = [0.5 x X/(100-0.5)] x [100/55] g

For other metal ion-exchange

Determine the amount of metal loaded into catalyst = 0.5 wt.%

The catalyst use = X g

So that : from the equation

Me/(X+Me) = 0.5/100

100 x Me = 0.5 x (X+Me)

(100-0.5) x Me = 0.5 x X

thus weight of metal, Me = 0.5 x X/(100-0.5) g

Various metal salt used for ion-exchange

Metal salt	M.W.	% metal	Weight of metal salt(g)
$ZnSO_4.7H_2O$	287.54	21.98	[0.5 x X/(100-0.5)]x[100/21.98]
$Fe(NO_3)_3.9H_2O$	404.00	13.82	[0.5 x X/(100-0.5)]x[100/13.82]

A-3 Calculation of Reaction Flow Rate.

The catalyst used = 0.2113 g

packed catalyst into quartz reactor (inside diameter = 0.6 cm)

determine the average high of catalyst bed = H cm. So that,

Volume of catalyst = $\pi \times (0.3)^2 \times h$ cc-cat.

used Gas Hourly Space Velocity (GHSV) = 2000 h^{-1}

$$\text{GHSV} = \frac{\text{Volumetric flow rate}^1}{\text{Volume of catalyst}}$$

Volumetric flow rate[1] = 2000 x Volume of catalyst

= $2000 \times \pi \times (0.3)^2 \times H$ cc/h

= $(2000 \times \pi \times (0.3)^2 \times H)/60$ cc/min.

at STP condition:

Volumetric f low rate = Volumetric flow rate[1] x (273.15 + t)/273.15

where t = room temperature, °C.

A-4 Calculation of Conversion and Hydrocarbon Distribution of Aromatization Reaction

Methanol aromatization activity was evaluated in term of the conversion of Methanol into other hydrocarbons.

For example : H-Zn.Al-silicate (Si/Zn = 40, Si/Al = 40)

Reaction condition : Reaction temperature 500 °C, GHSV = 2000 h^{-1},

feed 20 % methanol N_2 balanced, 1 h time on stream.

From Figure A-4.1

<u>Porapak Q</u> (TCD)

area of feed methanol = 628261

From Figure A-4.2

<u>Porapak Q</u> (TCD)

(ratio of CH_4 : CO_2 = 1 : 1.35; this value for each G.C.)

area of CH_4 = 45605 = 45605/1 = 45605

area of CO_2 = 19845 = 19845/1.35 = 147004

area of methanol = 628261

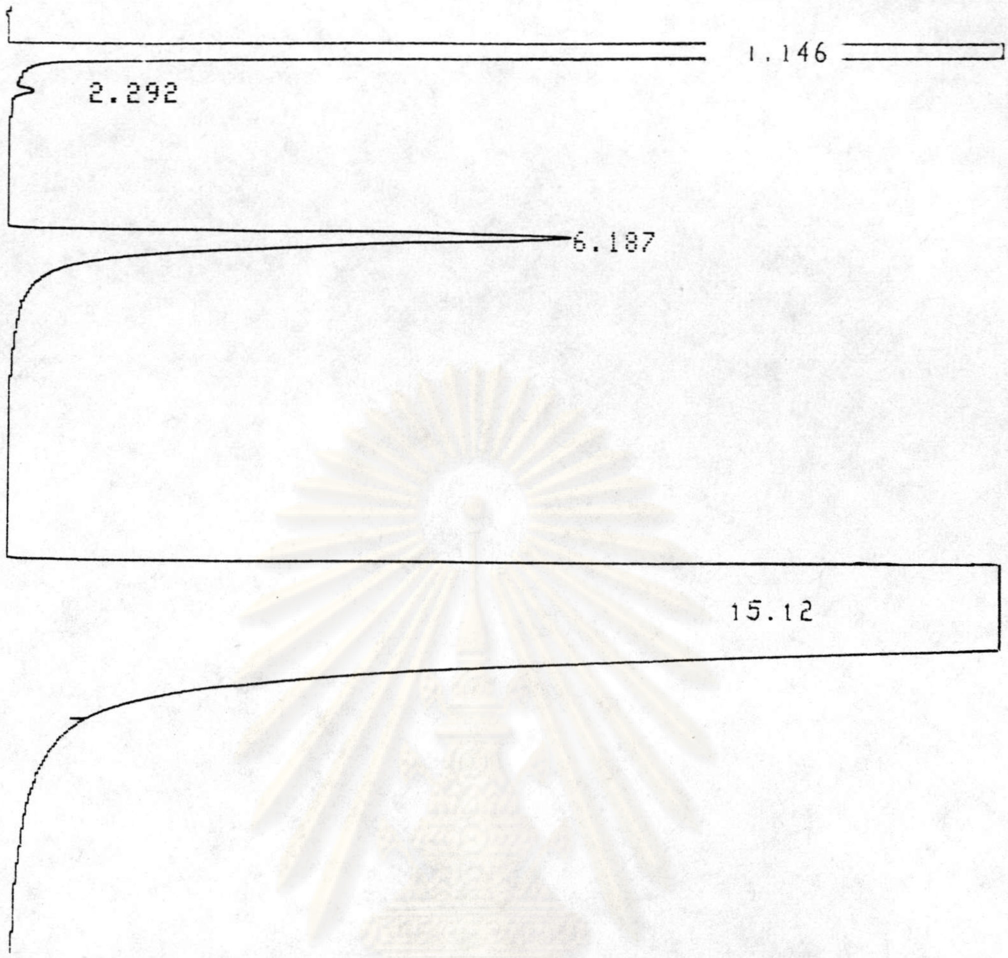
CO_2 = CH_4 * a

a = CO_2/CH_4 = 45605/19845 = 3.22

$$\text{Methanol conversion(\%)} = \frac{([\text{Methanol}]_{in}-[\text{Methanol}]_{out}) \times 100}{[\text{Methanol}]_{in}}$$

$$= \frac{(628261-0) \times 100}{628261}$$

$$= 100\ \%$$

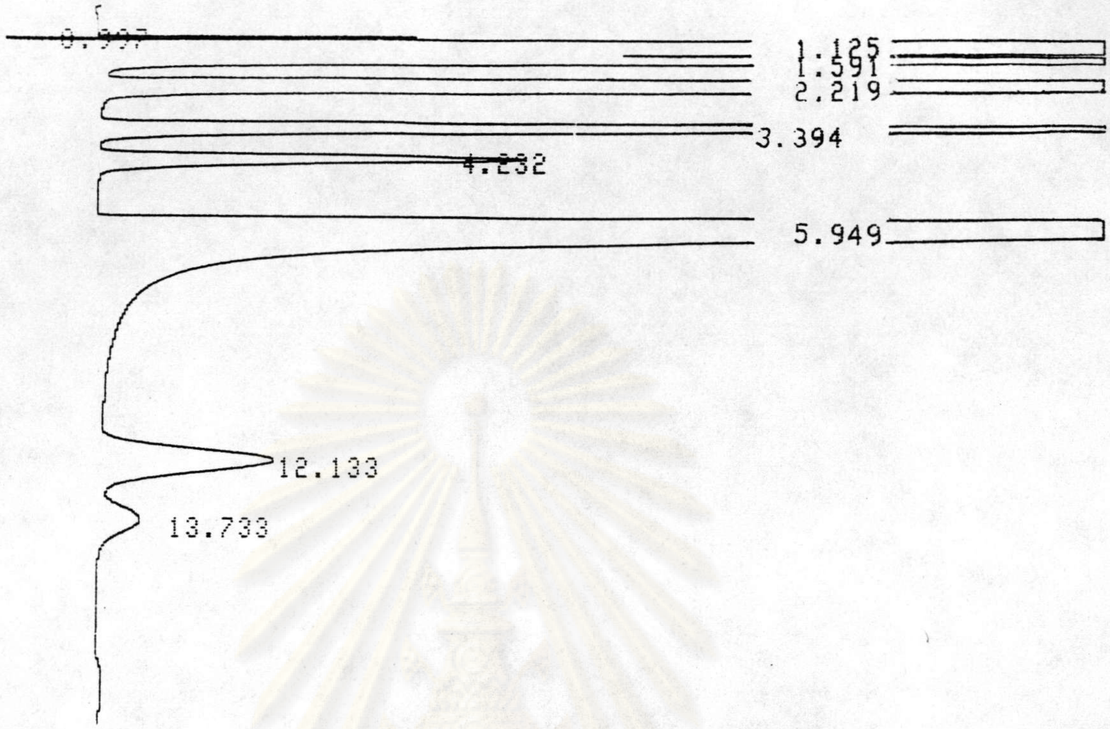


CHROMATOGRAM 1 MEMORIZED

C-R5A CHROMATOPAC
CHANNEL NO 1 FILE 0
SAMPLE NO 0 METHOD 41
REPORT NO 1

PKNO	TIME	AREA	MK	IDNO	CONC	NAME
1	1.146	2493336			79.4318	
2	2.292	174			0.0055	
3	6.187	17194			0.5478	
4	15.12	628261			20.0149	MeOH
	TOTAL	3138964			100	

Figure A-4.1 Peaks of feed from Porapak Q (TCD)



CHROMATOGRAM 1 MEMORIZED

C-R5A CHROMATOPAC
CHANNEL NO 1 FILE 0
SAMPLE NO 0 METHOD 41
REPORT NO 2

PKNO	TIME	AREA	MK	IDNO	CONC	NAME
1	0.997	3872			0.1611	
2	1.125	2038083			84.7804	
3	1.591	45605	V		1.8971	CH_4
4	2.219	198456	V		8.2554	CO_2
5	3.394	20266			0.843	
6	4.232	6733			0.2801	
7	5.949	81745			3.4004	
8	12.133	7302			0.3038	
9	13.733	1894	V		0.0788	
	TOTAL	2403955			100	

Figure A-4.2 Peaks of product from Porapak Q (TCD)

From Figure A-4.3

MS-5A (TCD)

(ratio of $CH_4 : CO_2$ = 1 : 1.13)

area of CH_4 = 12279 = 12279 = 12279

area of CO = 0 = 0/1.13 = 0

CO_2 = CH_4 * b

b = CO/CH_4 = 0/12279 = 0

From Figure A-4.4

VZ-10 (FID)

area of CH_4 = 45496

area of CO_2 = a * area of CH_4 = 3.22 * 45496 = 146653

area of CO_2 = b * area of CH_4 = 0 * 45496 = 0

area of C_2-C_4 paraffin = 24000

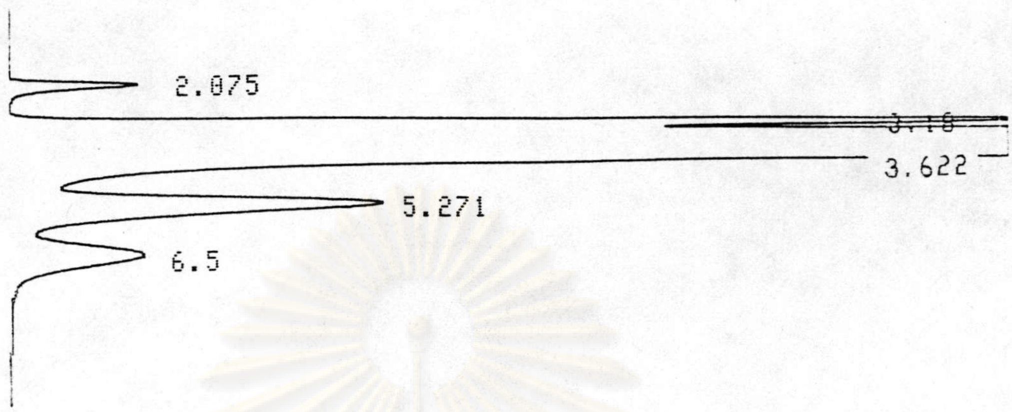
area of $C_2^=$ = 50265

area of $C_3^=$ = 22063

area of $C_4^=$ = 0

area of C_1-C_4(paraffin, olefin)+CO_2+CO = 141824+146653+0

= 288477



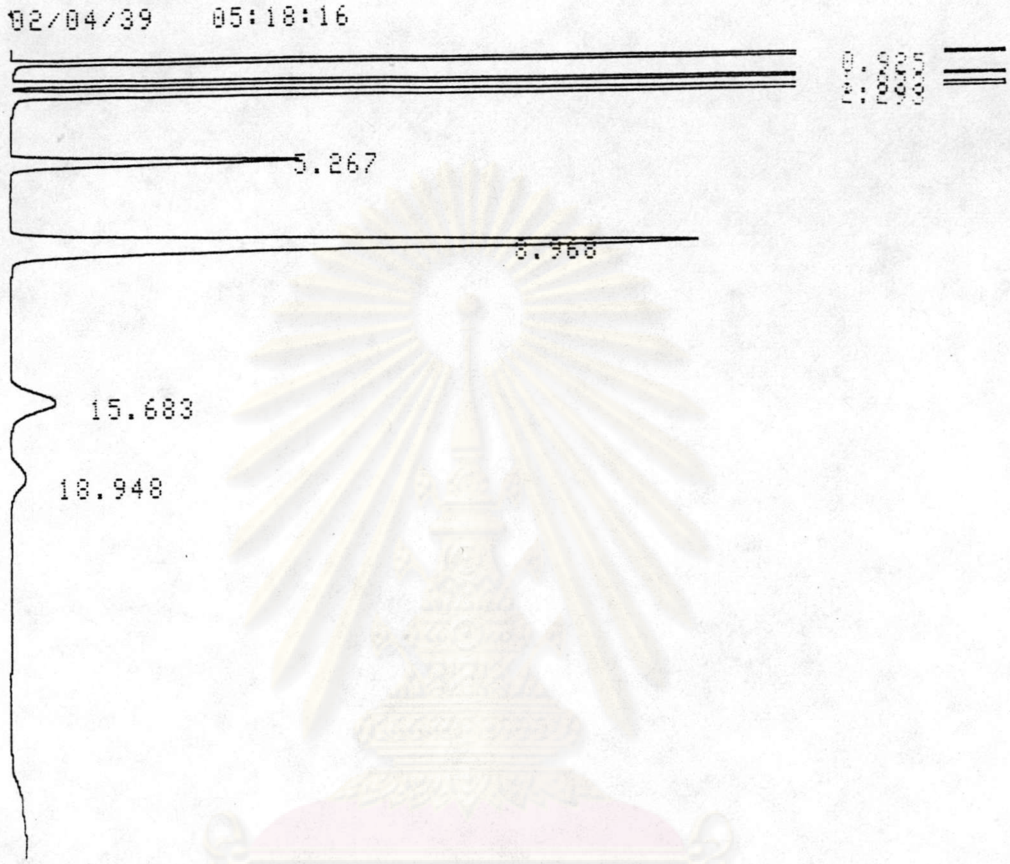
CHROMATOGRAM 1 MEMORIZED

C-R5A CHROMATOPAC
CHANNEL NO 1 FILE 0
SAMPLE NO 0 METHOD 41
REPORT NO 3

PKNO	TIME	AREA	MK	IDNO	CONC	NAME
1	2.075	1705			0.3889	
2	3.18	16231			3.7022	
3	3.622	402806	V		91.8764	
4	5.271	12279	V		2.8007	CH_4
5	6.5	5400	V		1.2318	
	TOTAL	438421			100	

CHROMATOGRAM 101 MEMORIZED

Figure A-4.3 Peaks of product from MS-5A (TCD)



PKNO	TIME	AREA	MK	IDNO	CONC	NAME
1	0.925	45496			32.0795	C_1
2	1.833	15197			10.7151	C_2
3	2.293	50265			35.442	$C_{2=}$
4	5.267	5358			3.7776	C_3
5	8.968	22063			15.5567	$C_{3=}$
6	15.683	2511			1.7707	C_4
7	18.948	934			0.6583	$C_{4=}$
	TOTAL	141824			100	

Figure A-4.4 Peaks of product from VZ-10 (FID)

From Figure A-4.5

Silicon OV-1 (1h)

determine all of hydrocarbon area into 3 parts

first part are the area of C_1-C_4(p,o)+CO_2+CO = 25935

second part are the area of C_5^+ = 6825

third part are the area of aromatics = 29511

So that : compared the area from VZ-10 to the area of OV-1

$$\text{area of } CO_2\text{(OV-1)} = \frac{\text{area of } CO_2\text{(VZ-10) x area of } C_1\text{-}C_4\text{(p,o)+}CO_2\text{+CO(OV-1)}}{\text{area of } C_1\text{-}C_4\text{(p,o)+}CO_2\text{+CO(OV-1)}}$$

= (146653*25935)/288477

= 13185

where p = paraffin; o = olefin

The same calculation of CO_2

CO = 0

C_1 = 4090

C_2-C_4(p) = 2158

$C_2^=$ = 4519

$C_3^=$ = 1984

$C_4^=$ = 0

Hence : Product Distribution (C-wt. %)

C_1 = (area of C_1 * 100)/total area of OV-1

= (4090*100)/62271 = 6.57 %

C_2 - C_4(p) = (2158*100)/62271 = 3.46 %

$C_2^=$	=	(4519*100)/62271	=	7.26 %
$C_3^=$	=	(1984*100)/62271	=	3.19 %
$C_4^=$	=	(0*100)/62271	=	0 %
C_5^+	=	(6825*100)/62271	=	10.96 %
Benzene	=	(1060*100)/62271	=	1.70 %
Toluene	=	(5038*100)/62271	=	8.09 %
Xylene	=	(16736*100)/62271	=	26.88 %
Other Aromatics	=	(6677*100)/62271	=	10.72 %
CO_2	=	(13185*100)/62271	=	21.17 %
CO	=	(0*100)/62271	=	0 %

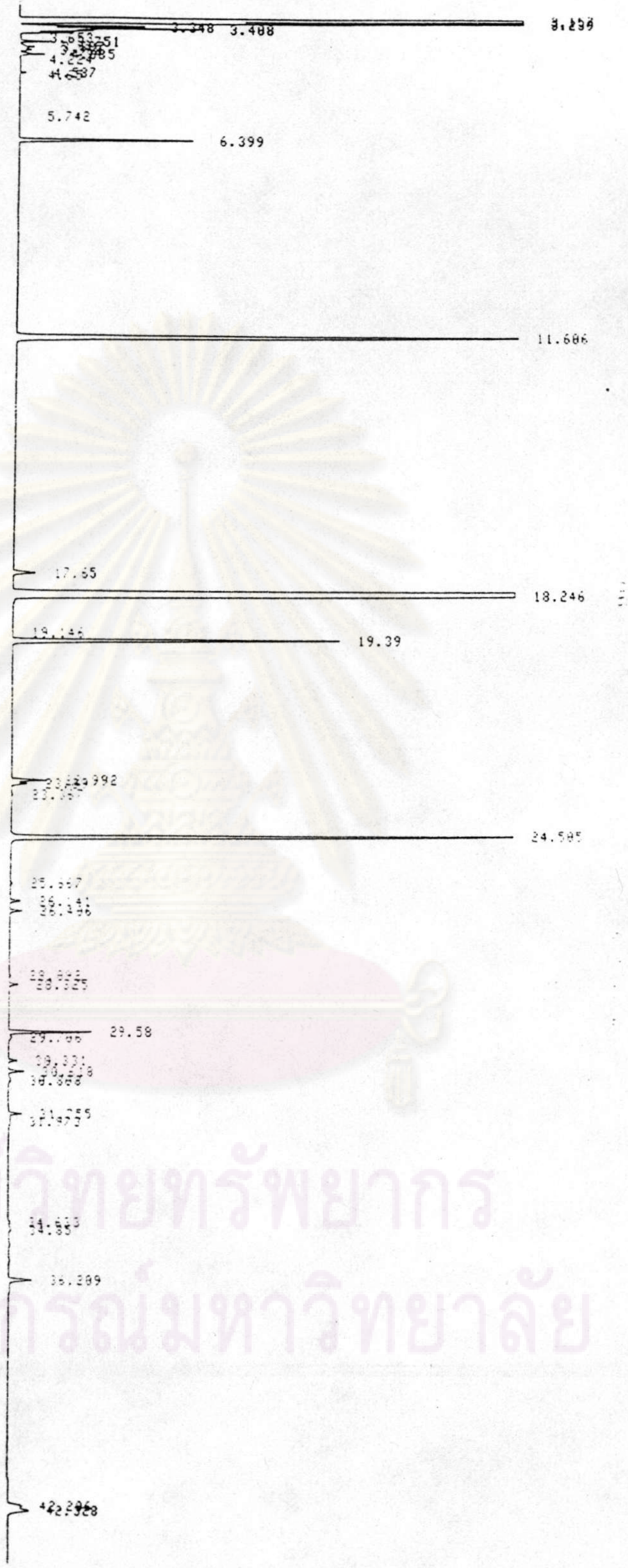


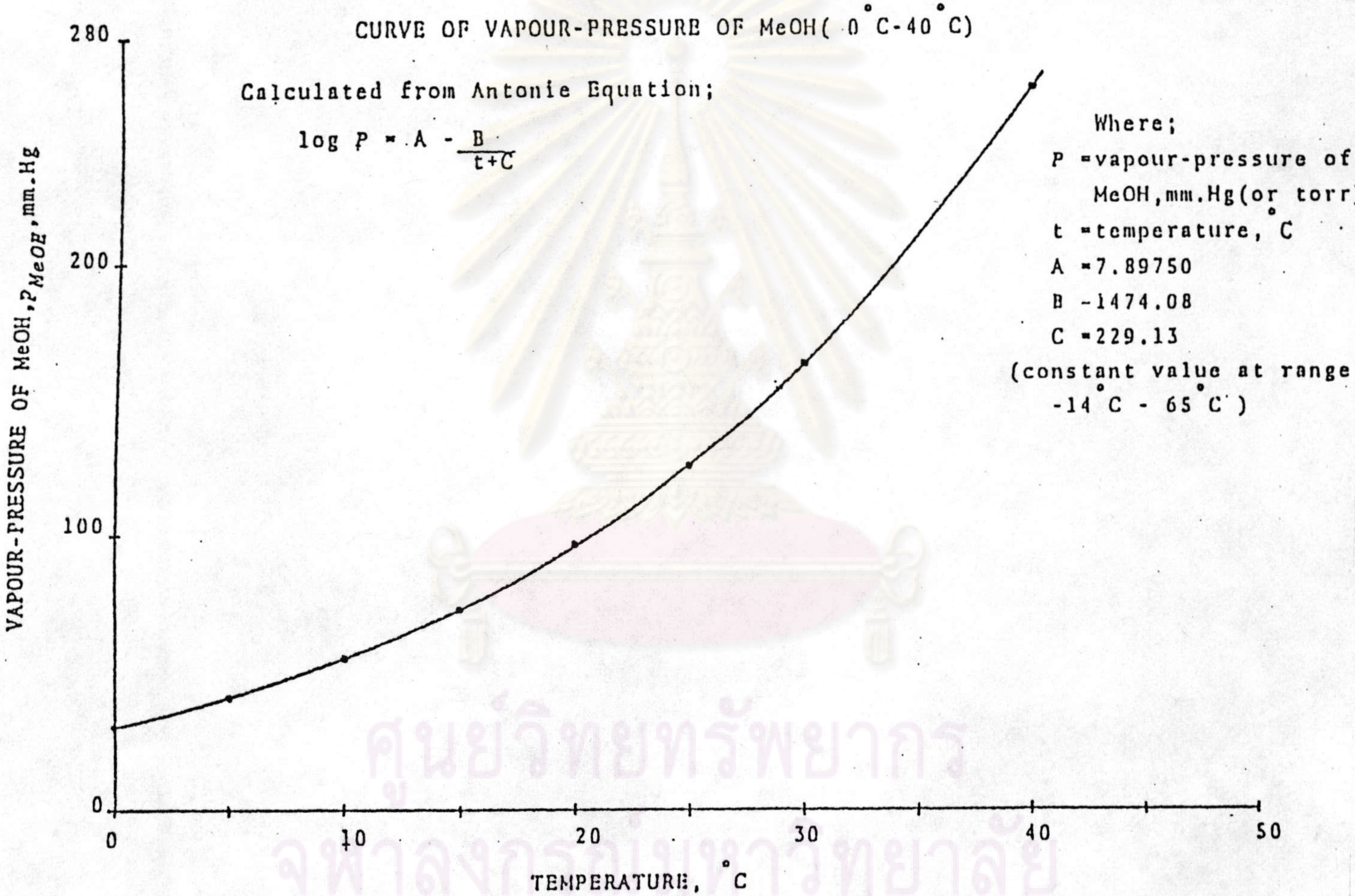
Figure A-4.5 Peaks of product from Silicon OV-1 (FID)

PKNO	TIME	AREA	MK	IDNO	CONC	NAME
1	3.157	19487			34.6912	
2	3.239	4533	V		8.0704	
3	3.348	537	V		0.9561	CO, CO_2, C_1-C_4, MeOH, DME
4	3.408	1378	V		2.4527	
5	3.653	16	V		0.0281	
6	3.751	127	V		0.2269	
7	3.887	129	V		0.2295	
8	3.968	56	V		0.0992	
9	4.085	144	V		0.2562	
10	4.224	13			0.0231	C_{5+}
11	4.587	40			0.0707	
12	6.399	1060			1.8865	Benzene
13	11.606	5038			8.9691	Toluene
14	17.65	187			0.3333	
15	18.246	14293			25.4444	Xylene
16	19.146	15			0.0265	
17	19.39	2443			4.3488	Xylene
18	22.992	264			0.4707	
19	23.09	112	V		0.1991	
20	23.367	24	V		0.043	
21	24.505	4305			7.6633	
22	25.667	21			0.0375	
23	26.141	80			0.1428	
24	26.406	93	V		0.1652	
25	28.092	17			0.031	
26	28.325	69			0.123	Aromatic
27	29.58	542			0.9657	
28	29.706	42	V		0.0746	
29	30.331	71			0.1272	
30	30.618	124	V		0.2205	
31	30.808	52	V		0.0917	
32	31.755	94			0.1667	
33	31.973	21	V		0.0373	
34	34.633	18			0.0322	
35	34.85	42	V		0.075	
36	36.209	211			0.3749	
37	42.206	183			0.326	
38	42.328	292	V		0.52	
	TOTAL	56173			100	

Figure A-4.5 Continue.

APPENDIX B

VAPOR PRESSURE CURVE OF METHANOL AT VARIOUS TEMPERATURE



Figture B-1 Curve of pressure of MeOH related to temperature

VITA

Miss Supawadee Chaisawadi was born in Bangkok, Thailand on July 11, 1968. She received her Bachelor Degree of Science from Department of Chemistry, Faculty of Science, Kasetsart University in 1991.