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APPENDIX A

A.1 Periodic Table of the Elements

Table A.1 Periodic table of the elements (54)

Period	Group IA	Group IIA	Group IIIB	Group IVB	Group VB	Group VIB	Group VIIB	Group VIII			Group IB	Group IIB	Group IIIA	Group IVA	Group VA	Group VIA	Group VIIA	Group 0
1 1s	1 H																1 H	2 He
2 2s2p	3 Li	4 Be											5 B	6 C	7 N	8 O	9 F	10 Ne
3 3s3p	11 Na	12 Mg											13 Al	14 Si	15 P	16 S	17 Cl	18 Ar
4 4s3d4p	19 K	20 Ca	21 Sc	22 Ti	23 V	24 Cr	25 Mn	26 Fe	27 Co	28 Ni	29 Cu	30 Zn	31 Ga	32 Ge	33 As	34 Se	35 Br	36 Kr
5 5s4d5p	37 Rb	38 Sr	39 Y	40 Zr	41 Nb	42 Mo	43 Tc	44 Ru	45 Rh	46 Pd	47 Ag	48 Cd	49 In	50 Sn	51 Sb	52 Te	53 I	54 Xe
6 6s(4f)5d6p	55 Ca	56 Ba	57* La	72 Hf	73 Ta	74 W	75 Re	76 Os	77 Ir	78 Pt	79 Au	80 Hg	81 Tl	82 Pb	83 Bi	84 Po	85 At	86 Rn
7 7s(5f)6d	87 Fr	88 Ra	89† Ac															

*Lanthanide series 4f	58 Ce	59 Pr	60 Nd	61 Pm	62 Sm	63 Eu	64 Gd	65 Tb	66 Dy	67 Ho	68 Er	69 Tm	70 Yb	71 Lu
†Actinide series 5f	90 Th	91 Pa	92 U	93 Np	94 Pu	95 Am	96 Cm	97 Bk	98 Cf	99 Es	100 Fm	101 Md	102 No	103 Lw

A.2 Vapor Pressure of Alcohols (C_1OH - C_4OH)

<u>Antonie's Equation</u>

Equation (1.) $$Log_{10}P = A - \frac{B}{(C+t)}$$

Equation (2.) $$Log_{10}P = -\frac{52.23B}{T} + C$$

P = P mm.Hg

t = t°C

T = t+273.15 K

Table A.2 Constant for Antonie's Equation (60)

Substance	A	B	C	Remark
CH_3OH	7.87863	1473.11	230	Eq.(1.)
C_2H_5OH	8.04494	1554.3	222.65	Eq.(1.)
n-C_3H_7OH	7.99733	1569.7	209.5	Eq.(1.)
n-C_4H_9OH	-	46.774	9.1362	Eq.(2.)

A.3 Constant for Find Heat of Capacity

Heat of capacity of hydrocarbon (C_p)

By ; $Cp = A + BT + CT^2 + DT^3$

Where ; A,B,C,D are Showed in Table A.3

Table A.3 Constant for find heat of capacity. (60)

Substance	A	B	C	D
H_2	6.483	2.215E-3	-3.298E-6	1.826E-9
N_2	7.44	-0.324E-2	6.400E-6	-2.790E-9
CH_4	4.598	1.245E-2	2.860E-6	-2.703E-9
C_2H_6	1.292	4.254E-2	-1.657E-5	2.081E-9
CH_4	0.909	3.740E-2	-1.994E-5	4.192E-9
C_2H_4	-1.009	7.315E-2	-3.789E-5	7.678E-9
C_3H_6	0.886	5.602E-2	-2.771E-5	5.266E-9
C_4H_{10}	2.266	7.913E-2	-2.647E-5	-0.674E-9
i-C_4H_{10}	-0.332	9.189E-2	-4.409E-5	6.195E-9
i-C_4H_8	-0.715	8.436E-2	-4.754E-5	1.066E-8
cis-2-C_4H_8	0.105	7.054E-2	-2.431E-5	-0.147E-9
tran-2-C_4H_8	4.375	6.123E-2	-1.675E-5	-2.147E-9
C_4H_6	-0.403	8.165E-2	-5.589E-5	1.513E-8

A.4 Physical Constant for Light Olefins

Some physical properties of light olefins is showed in Figure A.1, Figure A.2, and Figure A.3

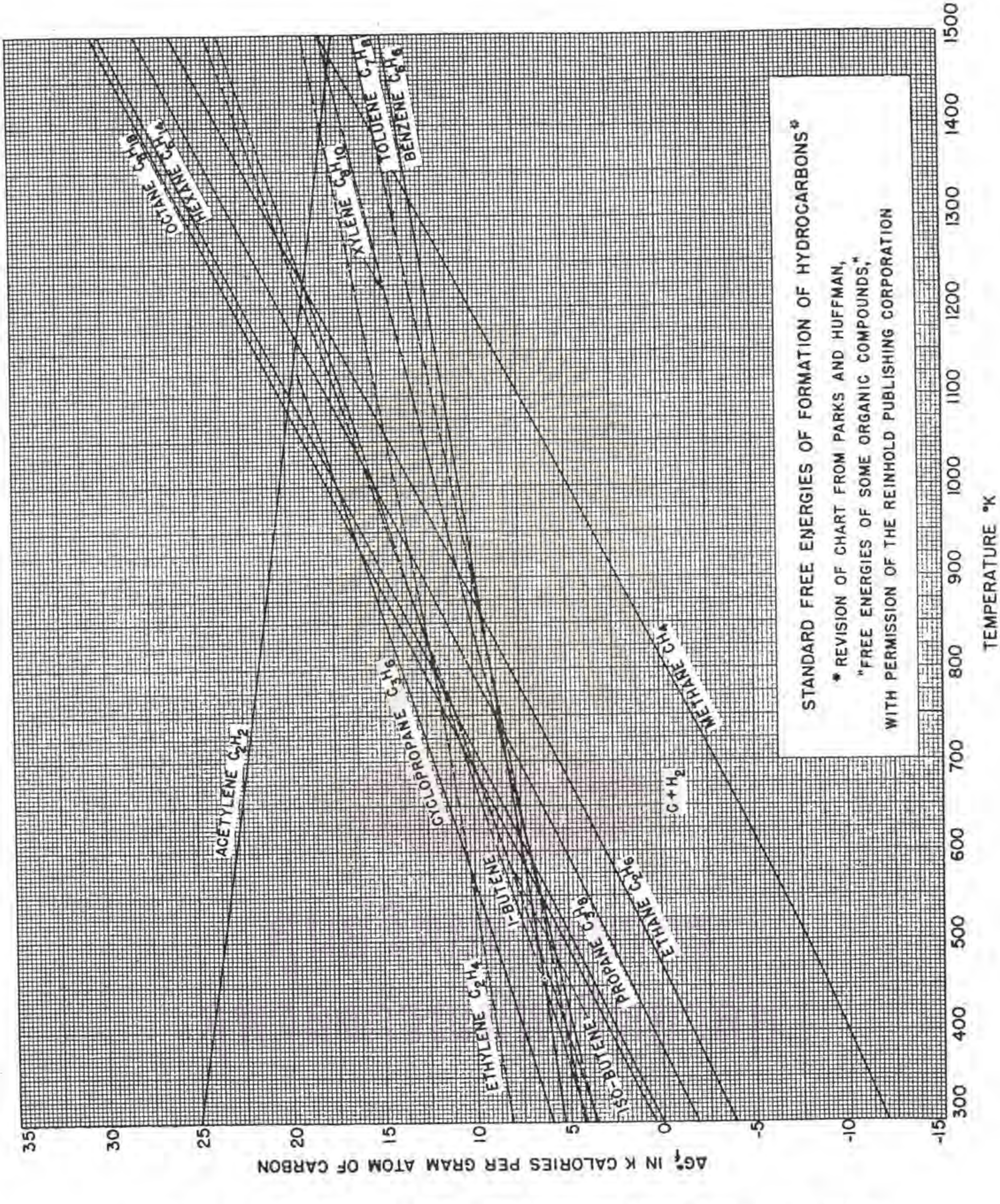


Figure A.1 Standard Free Energies of Formation of Hydrocarbons (61).

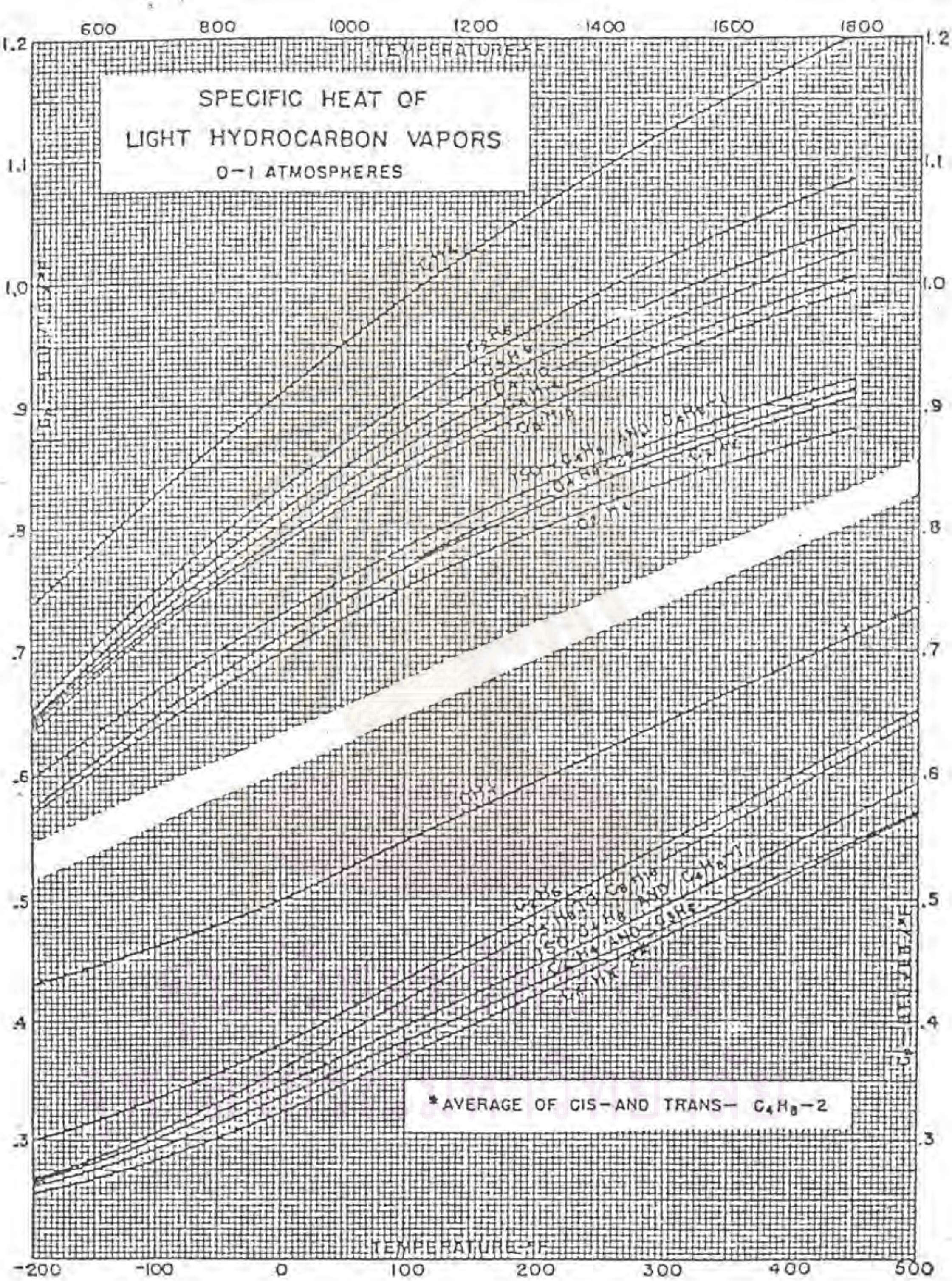


Figure A.2 Specific Heat of Light Olefin Vapors (61).

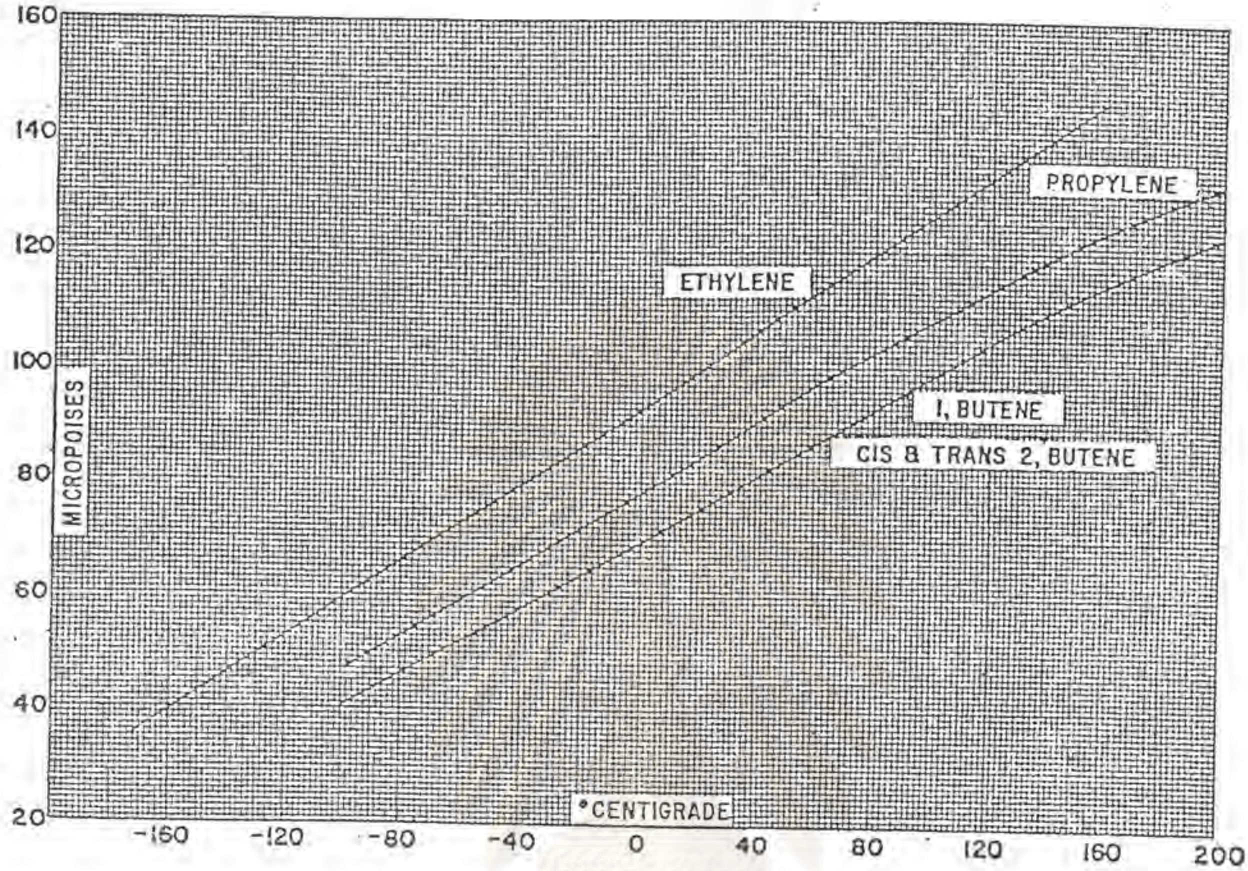


Figure A.3 Viscosity of Light Olefin Vapors (61).

APPENDIX B

B.1 Sample of Calculation for Volume of Catalyst

$$V = \frac{(\pi D_r^2)h}{4}$$

D_r = Inside Diameter of Reactor = 0.5 cm.

h = Height of Catalyst = 4 cm.

V = Volume of Catalyst Packing

$$V = \frac{[\pi(0.5)^2](4)}{4}$$

$$V = 0.785 \quad cm^3$$

B.2 Sample of Calculation for Gas Flowrate

For : the space velocity requirement = 5000 hr^{-1}

Definition : $S.V. = \frac{\text{Volumetric flowrate of He gas at S.T.P.}}{\text{Volume of catalyst}}$

Hence ; Volumetric flowrate of He at S.T.P.

= [S.V.]xVolume of catalyst

$= 5000 \times 0.785 = 3925 \quad \frac{cm^3}{hr}$

find the volumetric flowrate at t = 30° C

Table B.1 Example of Experimental Data

Catalyst = HM-10;Reactant = CH_3OH;Run No. = 632

Temperature = 300°C ; S.V. = 5000 hr^{-1}

Substance	Raw Data Gas Fraction Area/1cm³	gm/cm³	Liquid Fraction Area/ 1	gm/ 1	Total Grams	% Conversion =31.4 % Selectivity
CH_3OH	-	-	110	$9.5933x10^{-9}$	$2.1585x10^{-3}$	
C_2H_5OH						
C_3H_7OH						
C_4H_9OH						
C_2H_4	9681	$1.006x10^{-6}$	-	-	$2.2635x10^{-4}$	22.91
C_3H_6	7093	$6.5391x10^{-7}$	-	-	$1.4713x10^{-4}$	14.89

Reaction Involved :-

<u>Methanol</u> : $2CH_3OH \text{-----------}> C_2H_4 + 2H_2O$

$3CH_3OH \text{-----------}> C_3H_6 + 3H_2O$

<u>Ethanol</u> : $C_2H_5OH \text{-----------}> C_2H_4 + H_2O$

$3C_2H_5OH \text{----------}> 2C_3H_6 + 3H_2O$

<u>Propanol</u> : $2C_3H_7OH \text{----------}> 3C_2H_4 + 2H_2O$

$C_3H_7OH \text{-----------}> C_3H_6 + H_2O$

<u>Butanol</u> : $C_4H_9OH \text{-----------}> 2C_2H_4 + H_2O$

$3C_4H_9OH \text{----------}> 4C_3H_6 + 3H_2O$

From, Ideal gas'law

$$\frac{P_t \times V_t}{T_t} = \frac{P_{S.T.P} \times V_{S.T.P.}}{T_{S.T.P.}}$$

But, $P_t = P_{S.T.P}$ and $V_{S.T.P.} = 3925 \ cm^3/hr$

$$So,\ V_t = \frac{V_{S.T.P.}}{T_{S.T.P.}} \times T_t = \frac{3925 \times (273 + 30)}{(273)}$$

$$V_t = 4356.3 \ CM^3/hr$$

∴Volumetric flowrate at 30°C = 72.6 cm³/min.

B.3 Sample of Calculation for Percentage of MeOH Conversion.

<u>Definition</u>

$$\%\ MeOH\ conversion = \left[\frac{MeOH_{Input} - MeOH_{output}}{MeOH_{Input}}\right] \times 100$$

wt.of $MeOH_{Input}$ = $3.1465 \times 10^{0-3}$ g.(4 μl)

wt.of $MeOH_{output}$ = 2.1585×10^{-3} g.

$$\therefore\ \%\ MeOH\ conversion = \left[\frac{(3.1465 \times 10^{-3} - 2.1585 \times 10^{-3})}{(3.1465 \times 10^{-3})}\right] \times 100$$

$$= 31.40\ \%$$

B.4 Sample of Calculation for Percentage of MeOH Conversion to Light Olefins

<u>Definition</u>

$$\%\ Yield\ of\ C_{2-3} = \left[\frac{Wt.of C_2H_4 + Wt.of C_3H_6}{Wt.of\ MeOH\ Input}\right] \times 100$$

By;

Wt.of C_2H_4 = Total wt.of Ethylene in 225 cm^3 Bulb

Wt.of C_3H_6 = Total wt.of Propylene in 225 cm^3 Bulb

So,wt.of C_2H_4 = 2.2635×10^{-4} g

wt.of C_3H_6 = 1.4713×10^{-4} g

$$\therefore \%\text{Yield of } C_{2-3} = \left[\frac{(2.2635\times10^{-4} + 1.4713\times10^{-4})}{3.1465\times10^{-3}}\right] \times 100$$

$$= 11.87 \quad \%$$

$$\%\ \text{Selectivity of } C_2H_4 = \frac{\text{wt.of } C_2H_4 \quad \times \quad 100}{\text{wt.of } MeOH_{Reacted}}$$

But wt.of $MeoH_{Reacted}$ = wt.of $MeOH_{Input}$ – wt.of $MeOH_{output}$

$$= 3.1465\times10^{3} - 2.1585\times10^{-3}$$

$$= 9.880\times10^{-4}$$

$$\text{So, } \%\ \text{Selectivity of } C_2H_4 = \frac{2.2635\times10^{-4}}{9.880\times10^{-4}} \times 100$$

$$= 22.91 \quad \%$$

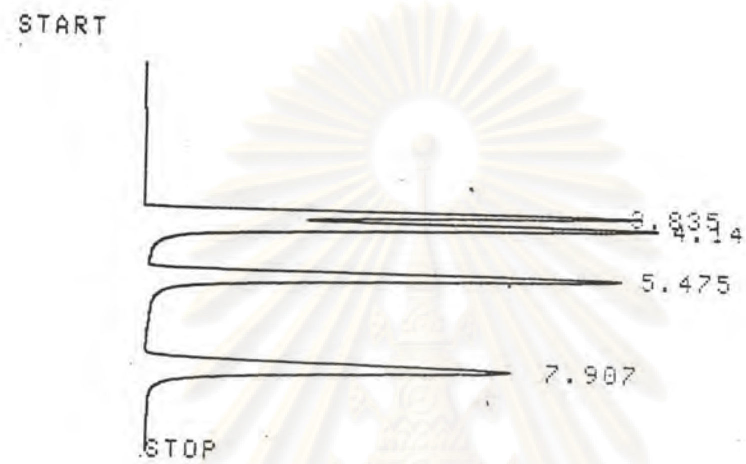
In the same ; For % Selectivity of C_3H_6 = $\dfrac{\text{wt.of } C_3H_6 \times 100}{\text{wt.of } MeOH_{Reacted}}$

$$= \frac{1.4713\times10^{-4}}{9.880\times10^{-4}} \times 100$$

$$= 14.89\ \%$$

APPENDIX C

C.1 Standard Calibration Curve for Alcohols ($C_1{}^{OH}$-$C_4{}^{OH}$)



CHROMATOPAC C-R6A
SAMPLE NO 0
REPORT NO 6

FILE 0
METHOD 41

PKNO	TIME	AREA	MK	IDNO	CONC	NAME
1	3.835	4976			19.699	
2	4.14	6917	V		27.3835	
3	5.475	6786			26.8655	
4	7.907	6580			26.0519	
	TOTAL	25258			100	

ZERO
S.TEST

Figure C.1 Standard GC-Analysis Peak of Alcohols ($C_1{}^{OH}$-$C_4{}^{OH}$) [(3 mm.O.D.x6 m.) 10% PEG -20 M on Chromasorb P-AW 60/80 mesh]

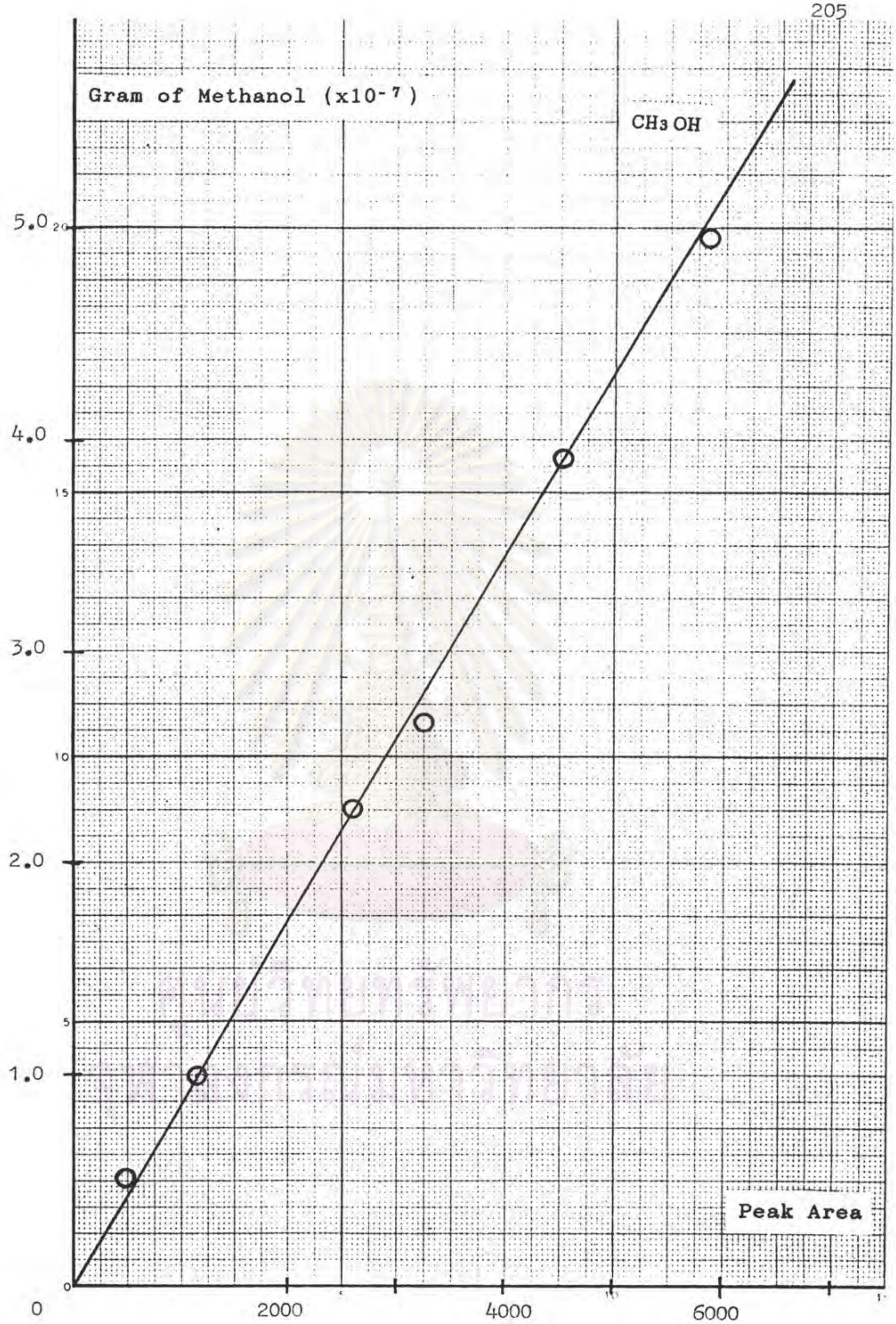


Figure C.2 Calibration Curve for Methanol

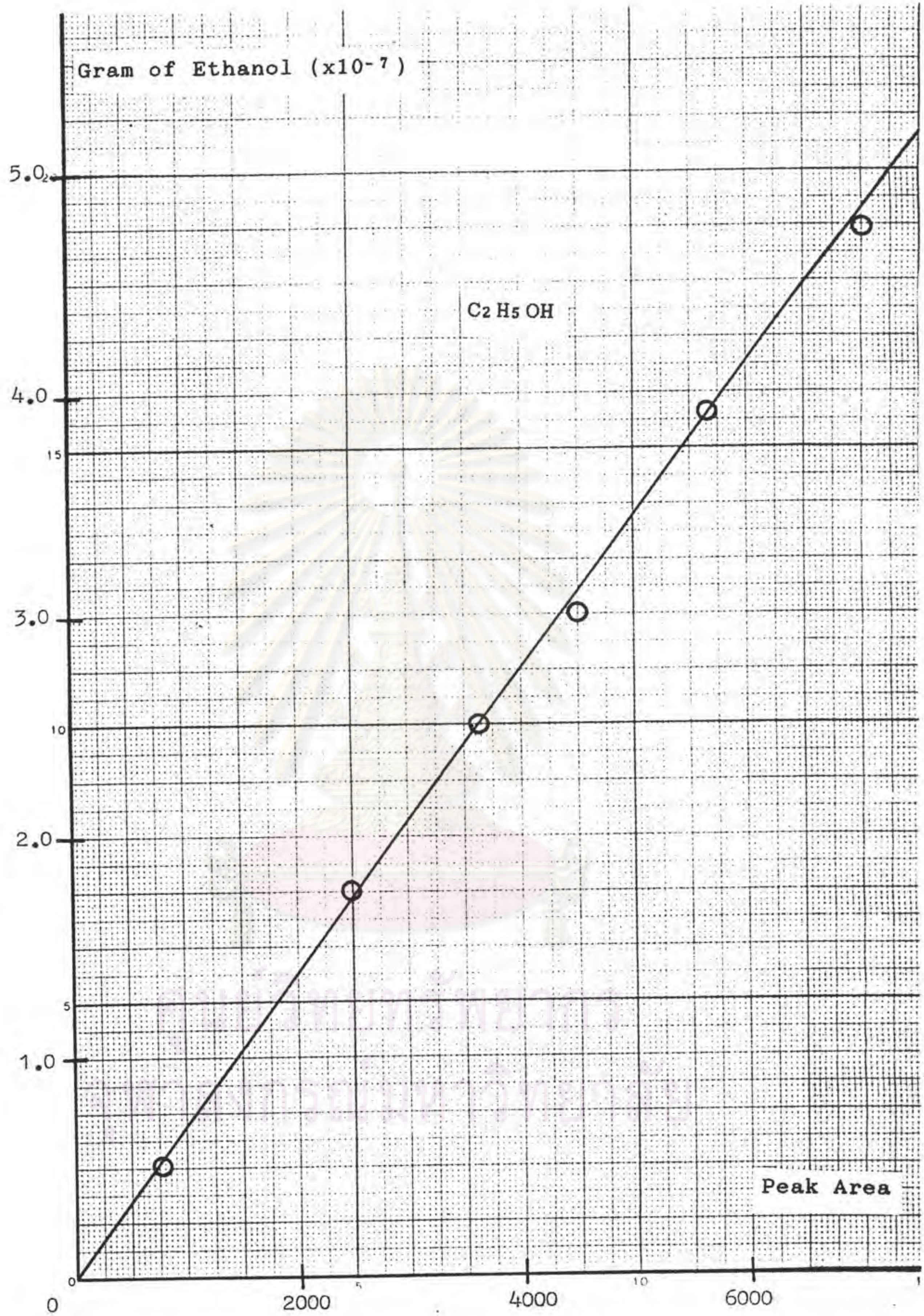


Figure C.3 Calibration Curve for Ethanol

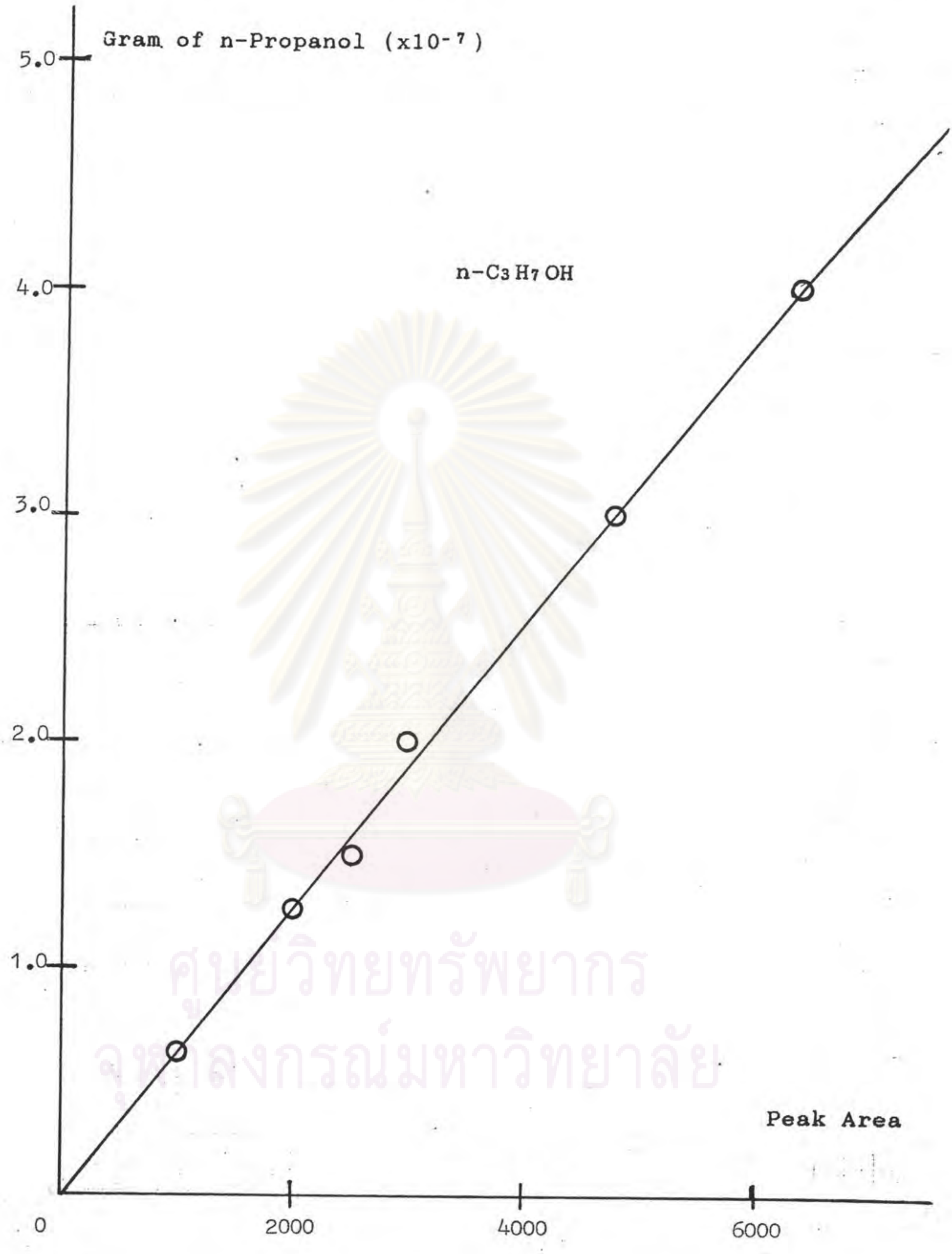


Figure C.4 Calibration Curve for n-Propanol

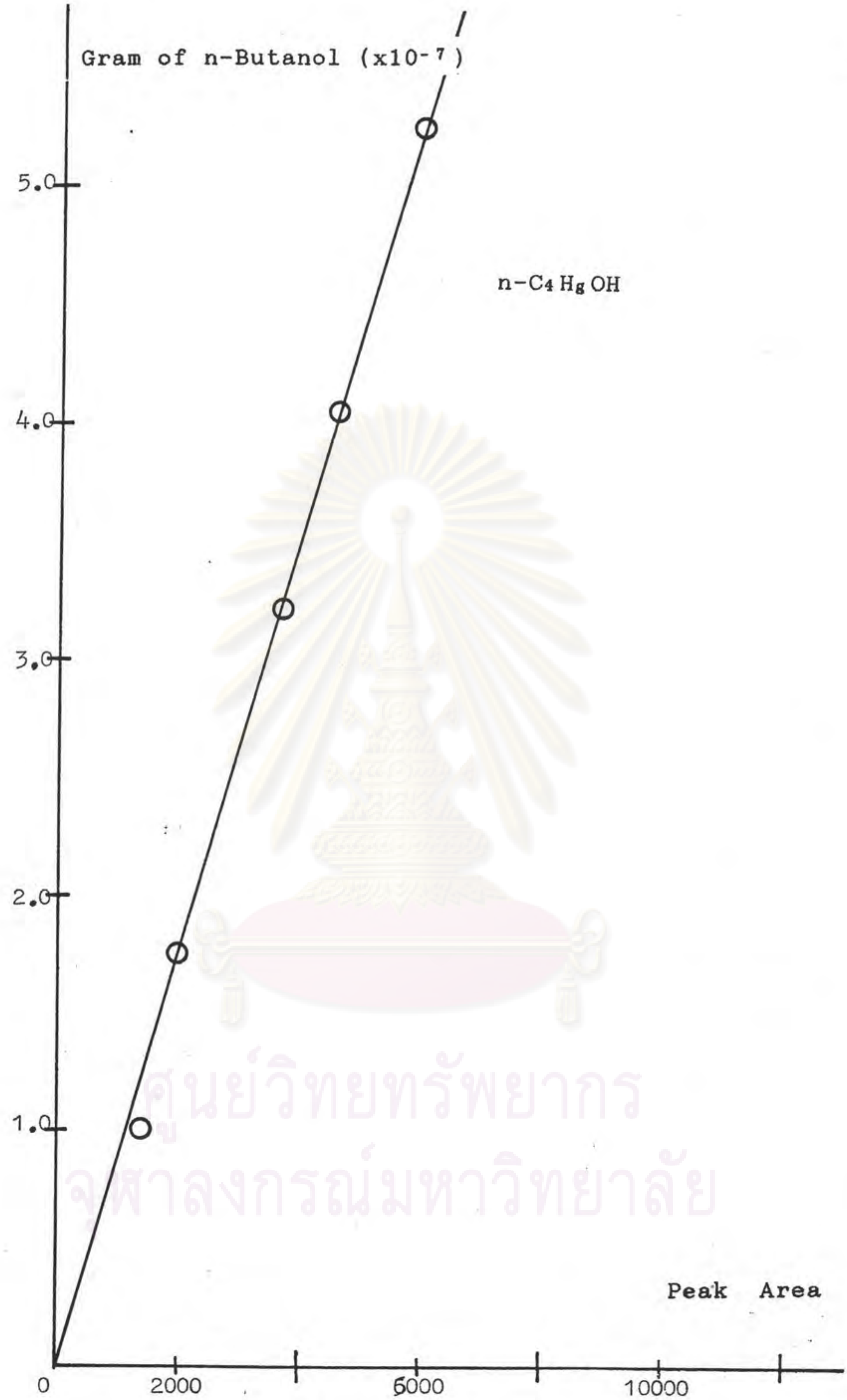
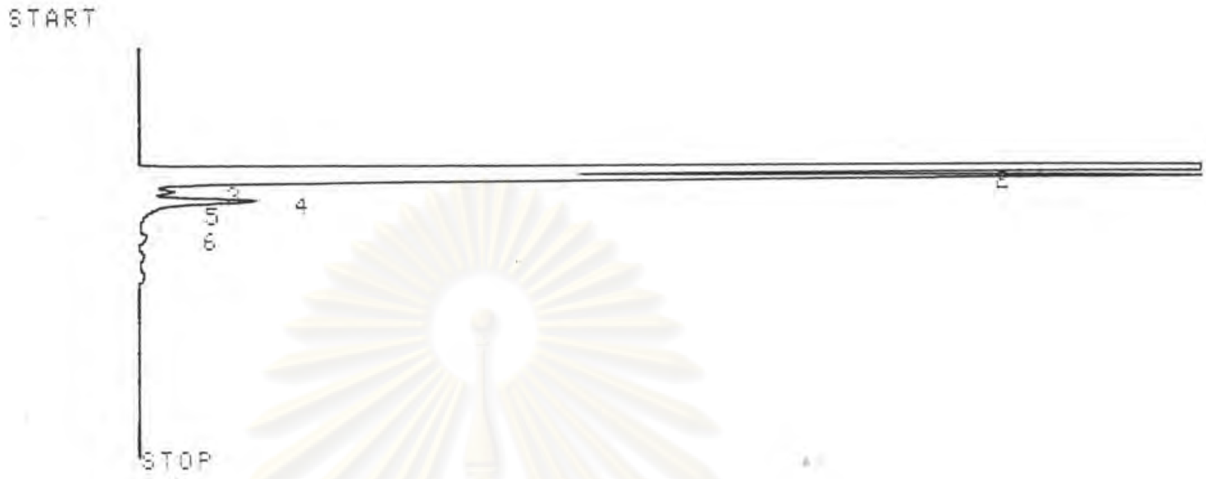


Figure C.5 Calibration Curve for n-Butanol

C.2 Standard Calibration Curve for Light Olefins



CHROMATOPAC C-R6A FILE 0
SAMPLE NO 0 METHOD 241
REPORT NO 14

PKNO	TIME	AREA	MK	IDNO	CONC	NAME
1	3.268	34027			77.8764	
2	3.492	8056	V		18.4369	
3	3.783	283	V		0.6479	
4	4.042	1213	V		2.7761	
5	4.317	64	V		0.1456	
6	4.95	51			0.1172	
	TOTAL	43693			100	

Figure C.6 Standard GC-Analysis Peak of Light Olefins [(3 mm.O.D.x6 m.) 5% SE-30 on Supelcoport 80/100 mesh.]

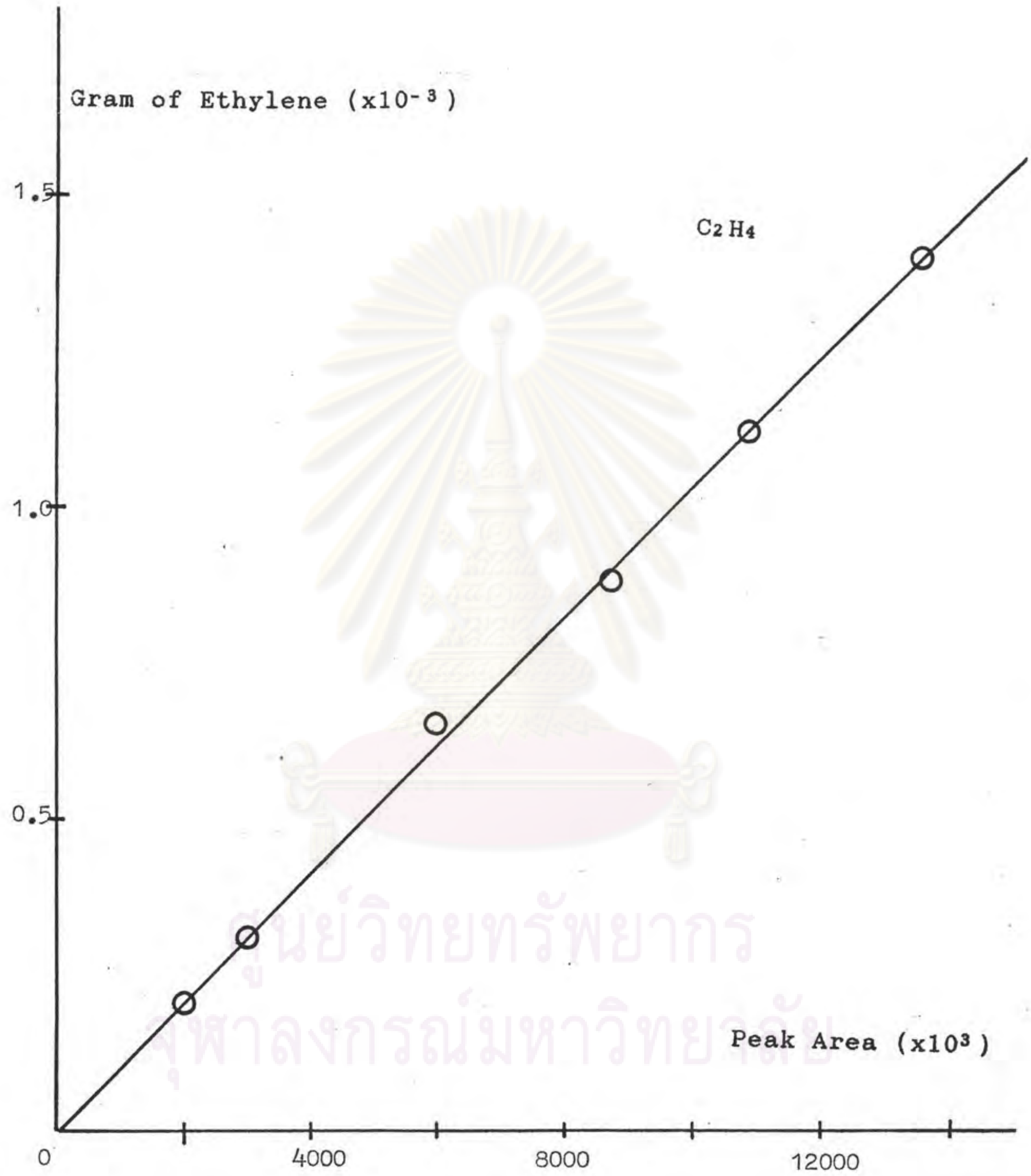


Figure C.7 Calibration Curve for Ethylene

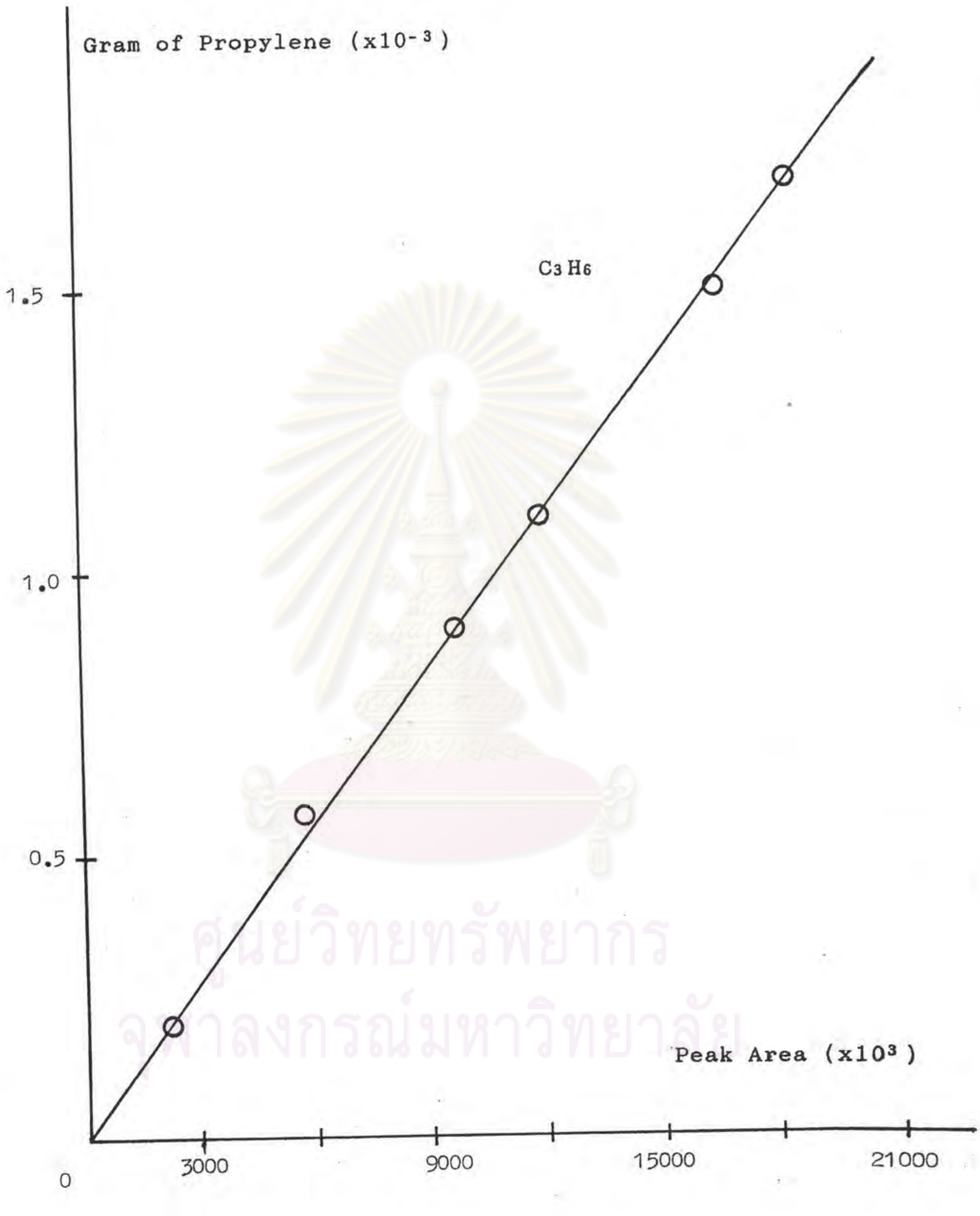


Figure C.8 Calibration Curve for Propylene

APPENDIX D

D.1 Definitions

Catalyst

- A catalyst is that of a substance that in small amount causes a large change.
- A catalyst is a substance that increases the rate of reaction without being appreciably consumed in the process.

Catalyst Activity

- The activity of a catalyst refers to the rate at which it causes the reaction to proceed to chemical equilibrium

Catalyst Selectivity

- The selectivity of a catalyst is a measure of the extent to which it accelerates the reaction to form one or more of the desired products that are usually intermediates, instead of those formed by reaction to the overall state of lowest free energy.
- Selectivity is usually defined as the percentage of the consumed reactant that forms the desired product. It is usually a function of degree of conversion and reaction conditions.

Negative Catalyst (Inhibitor)

- A negative catalyst is a substance which decreases the rate of reaction.

Turnover Number

- The turnover number is the number of molecules that react per site per unit time.

Sites (Active Center)

- Sites that reaction takes place only on specific locations on the catalyst

- A site may be a group or cluster of neighboring atoms on the catalyst surface;sometimes it may actually be a species adsorbed onto the catalyst.

D.2 Condition for GC-9APF

1. The following calibration curves obtained from Shimadzu Gas Chromatography Model 9 APF (FID) with the operations:

Injector/Detector Temperature	= 80°C
Column Temperature	= 40°C
Range	= 10^{-3}
Carrier gas	= Nitrogen
Regulator Pressure of N_2	= 6 kg/cm^2
Regulator Pressure of H_2	= 2.5 kg/cm^2
Column A Pressure	= 2.5 kg/cm^2
Air Pressure	= 0.5 kg/cm^2
H_2 Pressure	= 0.6 kg/cm^2

Carrier gas flowrate = 30 ml/min

Detector = FID

Column A = (3 mm.O.D.x6 m.)5% SE-30 on Supelcoport 80/100 mesh

Column A detected = C_2H_4, C_3H_6, 1-C_4H_8, i-C_4H_8

2. The following calibration curves obtained from Shimadzu Gas Chromatography Model 9APF (FID) with the operations :

Injector/Detector Temperature = 160°C

Column Temperature = 120°C

Range = 10^{-3}

Carrier gas = Nitrogen

Regulator Pressure of N_2 = 6 kg/cm^2

Regulator Pressure of H_2 = 2.5 kg/cm^2

Column B Pressure = 4.0 kg/cm^2

Air Pressure = 0.5 kg/cm^2

H_2 Pressure = 0.6 kg/cm^2

Carrier gas flowrate = 50 ml/min

Detector = FID

Column B = (3 mm.O.D.x6 m.)10% PEG-20 M on Chromasorb P-AW 60/80 mesh

Column B detected = CH_3OH, C_2H_5OH, C_3H_7OH, C_4H_9OH, ethers.

APPENDIX E

E.1 Data for Study of Reactivity of Methanol

Reaction Condition : Catalyst HM - 10, CH_3OH = 4 ul

Space Velolcity (hr^{-1})	Temperature (°C)	C_1^{OH} output (g)	$C_2H_4^{=}$ output (g)	$C_3H_6^{=}$ output (g)
	200	2.6006×10^{-3}	8.7975×10^{-5}	6.6825×10^{-5}
	250	1.5862×10^{-3}	1.2820×10^{-4}	2.5481×10^{-4}
1500	300	1.4332×10^{-3}	2.3232×10^{-4}	3.3514×10^{-4}
	350	8.7850×10^{-4}	3.4568×10^{-4}	3.3317×10^{-4}
	200	2.9854×10^{-3}	2.5882×10^{-5}	3.1689×10^{-5}
	250	1.8671×10^{-3}	2.3843×10^{-4}	2.2179×10^{-4}
3000	300	1.7192×10^{-3}	2.1506×10^{-4}	1.9036×10^{-4}
	350	1.2586×10^{-3}	3.8159×10^{-4}	2.7413×10^{-4}
	200	3.0637×10^{-3}	1.8891×10^{-5}	1.4168×10^{-5}
	250	2.4360×10^{-3}	1.5503×10^{-4}	9.2183×10^{-5}
5000	300	2.1585×10^{-3}	2.2635×10^{-4}	1.4713×10^{-3}
	350	1.4159×10^{-3}	5.2635×10^{-4}	1.7386×10^{-4}

E.2 Data for Study of Reactivity of Ethanol

Reaction Condition : catalyst HM - 10 : C_2H_5OH = 4 μl

Space Velocity (hr^{-1})	Temperature (°C)	C_2OH output (g)	C_2H_4 output (g)	C_3H_6 output
1500	200	2.1065×10^{-3}	6.2813×10^{-4}	0
	250	8.8402×10^{-4}	1.0614×10^{-3}	0
	300	7.8330×10^{-4}	1.7684×10^{-3}	1.2965×10^{-4}
	350	4.9726×10^{-4}	1.7416×10^{-3}	3.0867×10^{-4}
3000	200	2.6353×10^{-3}	3.1225×10^{-4}	0
	250	1.8154×10^{-3}	1.1385×10^{-3}	0
	300	1.4409×10^{-3}	1.1760×10^{-3}	0
	350	8.6981×10^{-4}	2.0837×10^{-3}	4.6058×10^{-5}
5000	200	2.7648×10^{-3}	1.1087×10^{-4}	0
	250	2.2015×10^{-3}	7.2975×10^{-4}	10611×10^{-5}
	300	1.8943×10^{-3}	9.0516×10^{-4}	2.1974×10^{-4}
	350	1.2585×10^{-3}	3.3441×10^{-4}	3.0964×10^{-4}

E.3 Data for Study of Reactivity of n - Propanol

Reaction Condition : Catalyst HM - 10 ; n - $C_3H_7{}^{OH}$ = 4 ul

Space Velocity (hr^{-1})	Temperature (°C)	$C_3{}^{OH}$ output (g)	C_2H_4 output	C_3H_6 output (g)
	200	1.8944×10^{-3}	1.2972×10^{-6}	7.8995×10^{-4}
	250	2.1541×10^{-4}	4.3695×10^{-6}	1.7739×10^{-3}
1500	300	2.4061×10^{-4}	8.1701×10^{-6}	1.6270×10^{-3}
	350	1.9194×10^{-4}	3.0231×10^{-5}	1.5115×10^{-3}
	200	1.9920×10^{-3}	1.7123×10^{-6}	8.5093×10^{-4}
	250	1.6062×10^{-3}	5.0290×10^{-7}	1.0845×10^{-3}
3000	300	1.2719×10^{-3}	1.6830×10^{-6}	1.1351×10^{-3}
	350	6.4300×10^{-4}	9.5850×10^{-6}	1.0137×10^{-3}
	200	2.6524×10^{-3}	1.2510×10^{-6}	2.2574×10^{-4}
	250	2.0898×10^{-3}	3.5303×10^{-6}	3.9533×10^{-4}
5000	300	1.6332×10^{-3}	1.6026×10^{-5}	4.7760×10^{-4}
	350	1.1535×10^{-3}	8.0021×10^{-5}	7.0739×10^{-4}

E.4 Data for Study of Reactivity of n - Butanol

Reaction Condition : Catalyst = HM - 10 ; n - $C_4H_9{}^{OH}$ = 4 μl

Space Velocity (hr^{-1})	Temperature (°C)	C_4 ^{OH} output (g)	C_2H_4 output (g)	C_3H_6 output (g)
1500	200	8.3875×10^{-4}	1.2398×10^{-6}	1.7114×10^{-5}
	250	2.0497×10^{-4}	3.5078×10^{-6}	7.6421×10^{-5}
	300	3.4520×10^{-4}	7.8773×10^{-6}	1.4927×10^{-4}
	350	1.8903×10^{-4}	3.1982×10^{-5}	2.7266×10^{-4}
3000	200	1.7799×10^{-3}	0	5.0041×10^{-5}
	250	1.6221×10^{-3}	9.3490×10^{-7}	1.4562×10^{-5}
	300	9.6434×10^{-4}	1.1217×10^{-5}	9.2026×10^{-5}
	350	3.1754×10^{-4}	2.0276×10^{-5}	1.3588×10^{-4}
5000	200	2.4421×10^{-3}	4.2323×10^{-6}	4.6591×10^{-5}
	250	2.0172×10^{-3}	1.5454×10^{-5}	1.5207×10^{-4}
	300	1.0733×10^{-3}	5.0684×10^{-5}	4.0250×10^{-4}
	350	9.0903×10^{-4}	1.0665×10^{-4}	5.3351×10^{-4}

E.5 Data for Study of Reactivity of Methanol

Reaction condition : catalyst HY-5.6 ; CH_3OH = 4 μl

Space Velocity (hr^{-1})	Temperature (° C)	C_1^{OH} output (g)	C_2H_4 output (g)	C_3H_6 output (g)
1500	200	$2.8294x10^{-3}$	$4.6761x10^{-7}$	0
	250	$2.6519x10^{-3}$	$4.3488x10^{-6}$	$4.5844x10^{-6}$
	300	$2.4345x10^{-3}$	$2.1229x10^{-5}$	$2.7901x10^{-5}$
	350	$1.5575x10^{-3}$	$8.6857x10^{-5}$	$1.4763x10^{-4}$
3000	200	$3.0455x10^{-3}$	$2.6377x10^{-7}$	0
	250	$2.9734x10^{-3}$	$1.2388x10^{-6}$	$2.7813x10^{-6}$
	300	$2.812x10^{-3}$	$2.6887x10^{-6}$	$3.1323x10^{-6}$
	350	$2.4760x10^{-3}$	$1.5267x10^{-5}$	$4.1073x10^{-5}$
5000	200	$3.1433x10^{-3}$	0	0
	250	$3.1323x10^{-3}$	$7.4817x10^{-7}$	$7.8826x10^{-7}$
	300	$3.1028x10^{-3}$	$5.1436x10^{-6}$	$5.5386x10^{-6}$
	350	$2.9832x10^{-3}$	$1.9803x10^{-5}$	$2.0599x10^{-5}$

E.6 Data for Study of Reactivity of Ethanol

Reaction condition : catalyst HY-5.6; C_2H_5OH = 4 μl

Space Velocity	Temperature	C_2OH output	C_2H_4 output	C_3H_6 output
(hr^{-1})	(^{o} C)	(g)	(g)	(g)
	200	$2.6467x10^{-3}$	$3.1139x10^{-4}$	0
	250	$2.1627x10^{-3}$	$6.1110x10^{-4}$	0
1500	300	$1.5653x10^{-3}$	$9.6943x10^{-4}$	0
	350	$7.1637x10^{-4}$	$1.4887x10^{-3}$	0
	200	$2.9479x10^{-3}$	$1.2751x10^{-4}$	$1.1409x10^{-6}$
	250	$2.7231x10^{-3}$	$2.6456x10^{-4}$	$1.6595x10^{-6}$
3000	300	$2.5258x10^{-3}$	$2.6545x10^{-4}$	$2.6967x10^{-6}$
	350	$2.2334x10^{-3}$	$5.6005x10^{-4}$	$3.5679x10^{-6}$
	200	$3.0454x10^{-3}$	$5.0636x10^{-5}$	0
	250	$2.8986x10^{-3}$	$1.5761x10^{-4}$	0
5000	300	$2.7379x10^{-3}$	$2.5552x10^{-4}$	0
	350	$2.3878x10^{-3}$	$4.6536x10^{-4}$	$8.5050x10^{-7}$

E.7 Data for Study of Reactivity of n-Propanol

Reaction condition : catalyst HY-5.6 ; $n-C_3H_7OH$ = 4   1

Space Velocity (hr^{-1})	Temperature ($_oC$)	$n-C_3^{OH}$ output (g)	C_2H_4 output (g)	C_3H_6 output (g)
	200	$2.4363x10^{-3}$	0	$5.0806x10^{-4}$
	250	$1.5644x10^{-3}$	$1.6834x10^{-6}$	$1.0996x10^{-3}$
1500	300	$8.6291x10^{-4}$	$2.8056x10^{-6}$	$1.4731x10^{-3}$
	350	$1.4082x10^{-4}$	$9.8665x10^{-6}$	$1.6439x10^{-3}$
	200	$2.8771x10^{-3}$	$3.8245x10^{-7}$	$2.1348x10^{-4}$
	250	$2.4035x10^{-3}$	$7.2479x10^{-7}$	$5.3223x10^{-4}$
3000	300	1.92910^{-3}	$1.7301x10^{-6}$	$7.7687x10^{-4}$
	350	$1.4268x10^{-3}$	$5.1436x10^{-6}$	$8.9946x10^{-4}$
	200	$3.0497x10^{-3}$	0	$1.0135x10^{-4}$
	250	$2.572x10^{-3}$	0	$3.2889x10^{-4}$
5000	300	$2.1708x10^{-3}$	0	$7.2544x10^{-4}$
	350	$1.9451x10^{-3}$	$1.1223x10^{-6}$	$5.7336x10^{-4}$

E.8 Data for Study of Reactivity of n-Butanol

Reaction condition : catalyst HY-5.6 ; n-C_4H_9OH = 4 μl

Space Velocity (hr^{-1})	Temperature (°C)	n-C_4OH output (g)	C_2H_4 output (g)	C_3H_6 output (g)
1500	200	$2.3464x10^{-3}$	$3.1330x10^{-6}$	$1.7342x10^{-5}$
	250	$9.3571x10^{-4}$	$2.6653x10^{-6}$	$8.5983x10^{-5}$
	300	$3.9823x10^{-4}$	$5.0501x10^{-6}$	$1.4035x10^{-4}$
	350	$1.1745x10^{-4}$	$1.5291x10^{-5}$	$2.0980x10^{-4}$
3000	200	$2.7167x10^{-3}$	$3.0135x10^{-6}$	$3.2345x10^{-5}$
	250	$1.9768x10^{-3}$	$5.3775x10^{-6}$	$5.0034x10^{-5}$
	300	$1.2233x10^{-3}$	$7.2011x10^{-6}$	$1.2160x10^{-4}$
	350	$7.8247x10^{-4}$	$1.1414x10^{-5}$	$1.9300x10^{-4}$
5000	200	$3.0641x10^{-3}$	$8.6507x10^{-7}$	$1.8255x10^{-6}$
	250	$1.9973x10^{-3}$	$5.4435x10^{-7}$	$1.0953x10^{-5}$
	300	$1.6105x10^{-3}$	$1.5197x10^{-7}$	$3.6281x10^{-5}$
	350	$1.6782x10^{-3}$	$1.9640x10^{-6}$	$5.8955x10^{-5}$

E.9 Chemical Equilibrium for the Reaction with the Change in Gibbs Free Energy (ΔG_r)

	ΔGf	473 (K)	523 (K)	573 (K)	623 (K)
CH_3OH	$-201.86 + 1.2542 \times 10^{-1} (T) + 2.0345 \times 10^{-5} (T^2)$	-137.99	-130.70	-123.31	-115.83
C_2H_5OH	$-236.102 + 2.1904 \times 10^{-1} (T) + 2.5659 \times 10^{-5} (T^2)$	-126.75	-114.53	-102.17	- 89.68
C_3H_7OH	$-259.317 + 3.1232 \times 10^{-1} (T) + 3.3063 \times 10^{-5} (T^2)$	-104.19	- 86.93	- 69.50	- 51.91
C_4H_9OH	$-276.72 + 4.0989 \times 10^{-1} (T) + 3.91 \times 10^{-5} (T^2)$	- 74.09	- 51.65	- 29.02	- 6.18
C_2H_4	$51.75 + 4.933 \times 10^{-4} (T) + 1.7284 \times 10^{-5} (T^2)$	78.95	82.28	85.69	89.19
C_3H_6	$19.41 + 1.3685 \times 10^{-1} (T) + 2.5749 \times 10^{-5} (T^2)$	89.90	98.03	106.28	114.66
H_2O	$-241.74 + 4.174 \times 10^{-4} (T) + 7.428 \times 10^{-6} (T^2)$	-220.34	-217.88	-215.38	-212.85

	$\Delta G_r = \Delta G_{f,\ product} - \Delta G_{f,\ reactant}$	473 (K)	523 (K)	573 (K)	623 (K)
C_1^{OH}	$[(C_2H_4) + 2(H_2O)] - [2(CH_3OH)]$	- 85.75	- 92.08	- 98.45	-104.85
	$[(C_3H_6) + 3(H_2O)] - [3(CH_3OH)]$	-157.15	-164.51	-169.93	-176.40
C_2^{OH}	$[(C_2H_4) + (H_2O)] - [(C_2H_5OH)]$	- 14.64	- 21.07	- 27.52	- 33.98
	$[2(C_3H_6) + 3(H_2O)] - [3(C_2G_5OH)]$	-100.97	-113.99	-127.07	-140.19
$n\text{-}C_3^{OH}$	$[3(C_2H_4) + (H_2O)] - [2(C_3H_7OH)]$	+ 4.55	- 15.06	- 34.69	- 54.31
	$[(C_3H_6) + (H_2O)] - [(C_3H_7OH)]$	- 26.65	- 32.92	- 39.60	- 46.28
$n\text{-}C_4^{OH}$	$[2(C_2H_4) + (H_2O)] - [(C_4H_9OH)]$	+ 11.65	- 1.67	- 14.98	- 28.29
	$[4(C_3H_6) + 3(H_2O)] - [3(C_4H_9OH)]$	- 79.15	-106.57	-133.96	-161.37

VITA

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