Conclusions

The following conclusions may be drawn from the present work.

1. Ion exchange of the three isopropanol synthesis catalysts (NaY, offretite/erionite, mordenite) was carried out as follows:

a) The mixture of catalyst powder and 1 Molar NH_4NO_3 solution was heated at 80° C for 2 hours.

b) The catalyst powder was washed with distilled water.

c) Repeat steps a) and b) one more time.

d) The catalyst was dried in an oven at 120° C for 24 hours.

e) The catalyst was calcined for 15 hours by heating in atmospheric air at approximately 500°C. The catalyst thus obtained was pelletized to have a bulk density about .866 gm/cc, then crushed and screened between mesh # 10 and # 15 for use in isopropanol synthesis experiments.

2. The experimental apparatus for isopropanol synthesis, which was mounted within a frame of angular steel, was fabricated using stainless steel Swagelok parts. The maximum design pressure was 100 atg. and the maximum design temperature 400° C. The heating furnace was made of refractory bricks inset with heating wires and temperature control was done using 2 slidacs. Leak tests with N_2 was carried out at 1, 2 , 5, 10-100 atg.

3. In the experiments, isopropanol was synthesized from propylene and water at the feed mole ratio of 1/4-10. Experiments were carried out at 45, 75 and 105 psig, while varying the temperature from 150 to 300°C and the space velocity from 2000 to 8000 hr^{-1} 2 ml. of catalyst was packed in the 1/2" O.D. tubular reactor. Analyses of the product gases and liquid were performed using gas chromatography

(Shimadzu GC model 8AIT and GC 8AIF). Both equipped with porapak Q column.

4. From the experimental results obtained in this study, it may be concluded that the effects of temperature, pressure, space velocity on isopropanol synthesis were as follows.

4.1 For catalyst no.1, a ternary H-Y catalyst of $SiO_2/Al_2O_3/Na_2O$ = 66.7 : 20.3 : 12.3, total C_3H_6 conversion generally increased with temperature but decreased as space velocity and pressure increaed. Isopropanol selectivity increased remarkable with temperature up to an optimum temperature (around 250°C), above which it instead decreased. Space time yield of isopropanol usually increased with temperature up to the optimum temperature (around 250°C) but decreased as pressure increased. Optimum space velocity was around 5000 hr^{-1}, above or below which STY decreased.

4.2 For catalyst no.2, an offretite/erionite catalyst of $SiO_2/Al_2O_3/Na_2O/K_2O$ = 70.8 : 15.6 : 2.36 : 11.2, total C_3H_6 conversion usually increased with temperature but decreased as space velocity increased and slightly decreased as pressure decreased. Isoprepanol selectivity generally increased with pressure up to an optimum pressure 45 psig but decreased against space velocity. The selectivity generally increased with temperature up to a certain optimum temperature (around 210°C), above which it then decreased. Space time yield of isopropanol was also found to increase with temperature up to an optimum value (around 210°C) above which it then decreased. The optimum pressure and space velocity were 45 psig and 5000 hr^{-1}, below which the STY then decreased.

4.3 For catalyst no.3, Na mordenite, with $SiO_2/Al_2O_3/Na_2O$ = 87.7 : 7.3 : 5.1. It was found by Dr.Wiwut Tanthapanichakoon that, in general the total conversion of C_3H_6 increased with temperature up to an optimum temperature (around 280°C) above which it then decreased, and isopropanol selectivity had the same temperature dependency as C_3H_6 conversion, the optimum temperature again around 280°C. Both pressure and space velocity had no remarkable effects on the space time yield of isopropanol.

4.4 It was seen that although all the three catalysts had qualitatively, the same effect of temperature, pressure and space velocity on isopropanol synthesis, their quantitative effects on the yields of the main and side product differed remarkably. Catalyst no.2 converted more C_3H_6 to isopropanol than catalyst no.1 and no.3 under the same pressure, temperature and space velocity. Catalyst no.2 also converted some C_3H_6 to sec $-C_4H_8$ but catalyst no.1 and no.3 did not

4.5 Of the three studied catalyst no.2 was most suitable for isopropanol synthesis.

Future Work

As the next step of study we should improve the catalyst performance by searching for a promoter, such as an oxide of centain alkali metal or alkali earth metal. Once the best catalyst has been found, then more study on the physical properties, such as pore size distribution BET surface area, etc. before and after the reaction should be investigated to see how they affect the performance of the catalyst. The results of such study can then be used to further optimize the catalyst performance.

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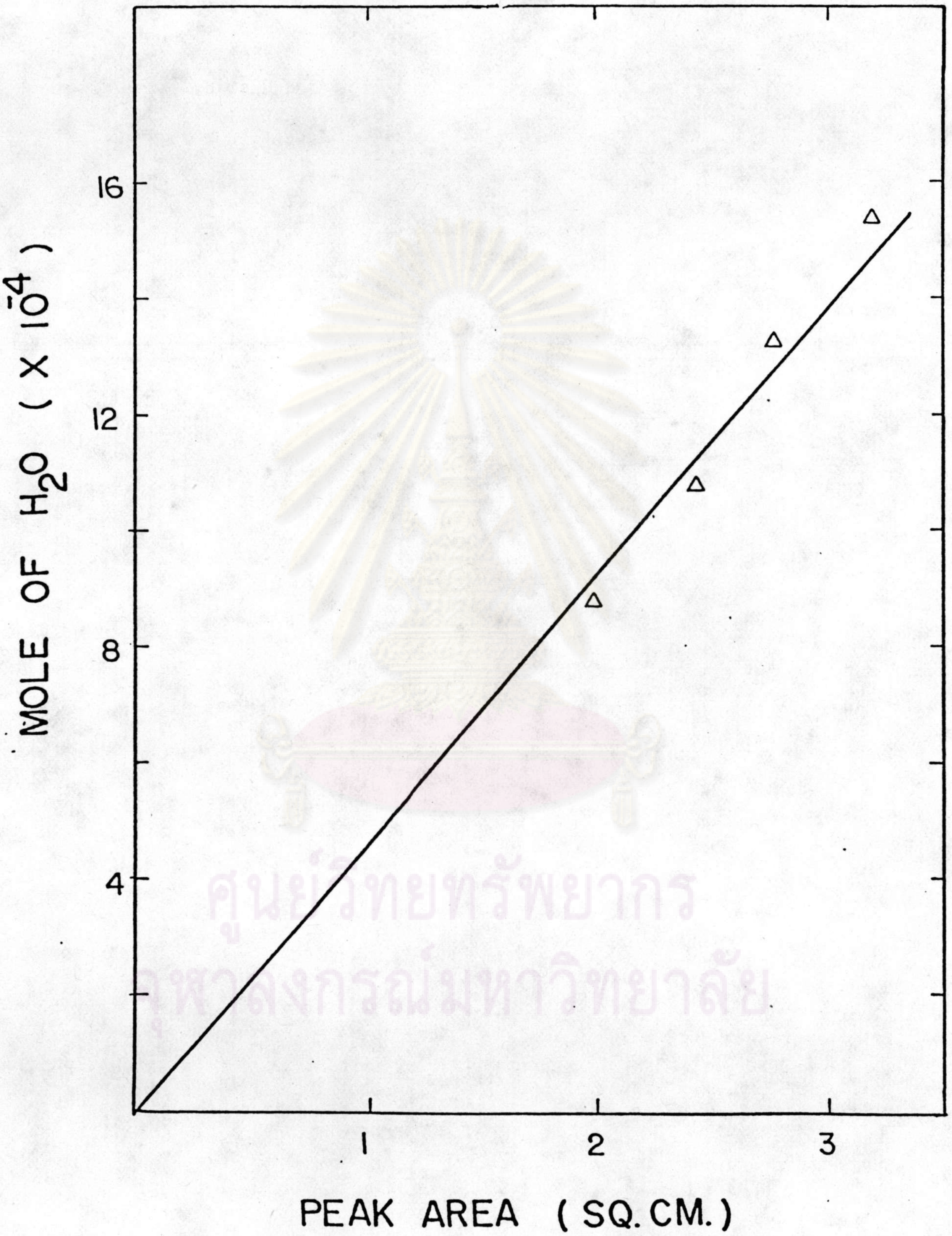
APPENDIX A

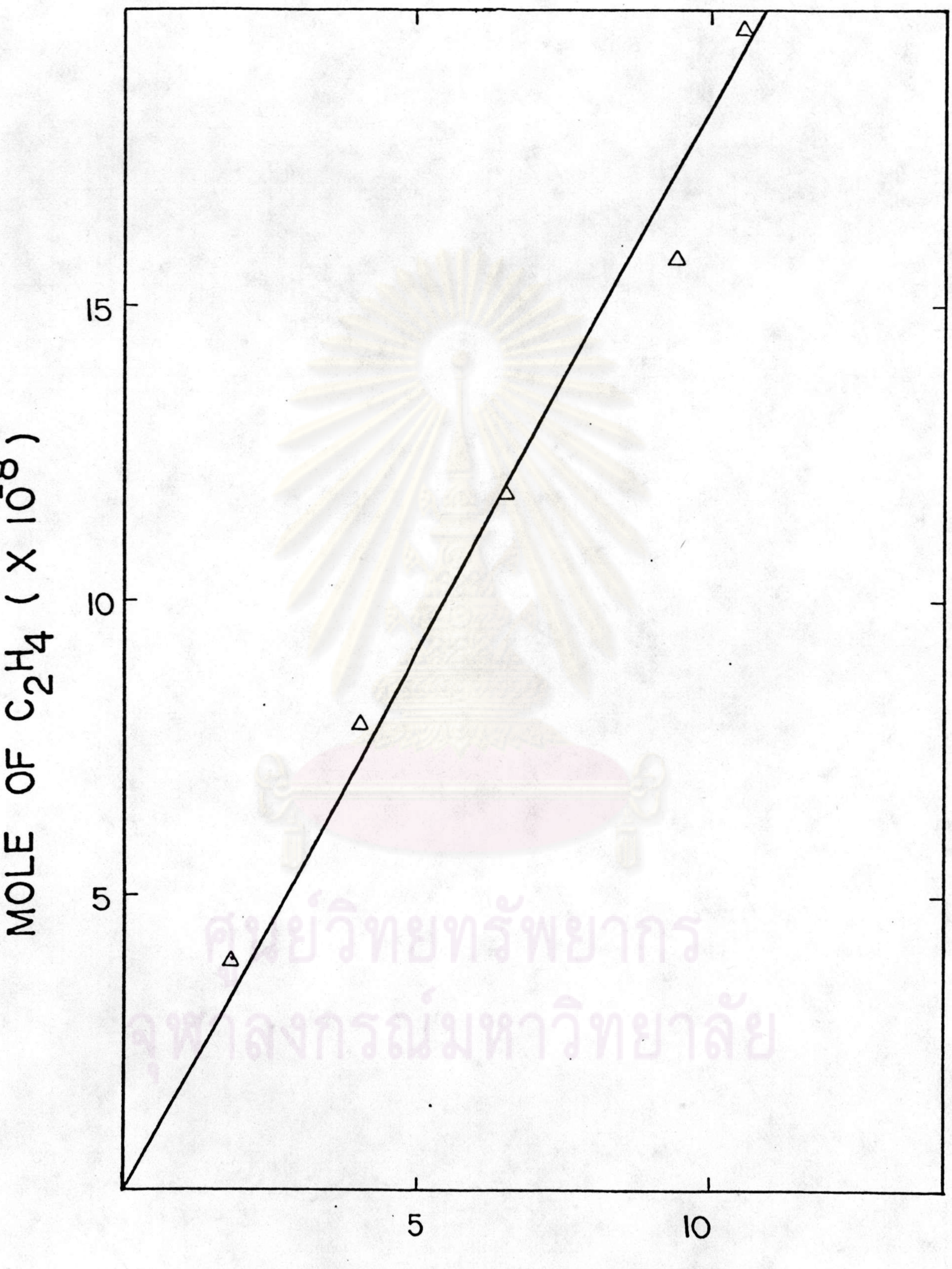
The following calibration curves obtained from Shimadzu Gas Chromatography model 8AIT (TCD) with the operations:

Inj/Det temperature	: 150 °C
Column temperature	: 125 °C
Carrier gas	: Argon
Carrier gas pressure of PQ column	: 3.5 atg
Flow rate of carrier gas in PQ column	: 10 ml/25 sec
PQ detected	: C_3H_6, H_2O
Polarity PQ	: +

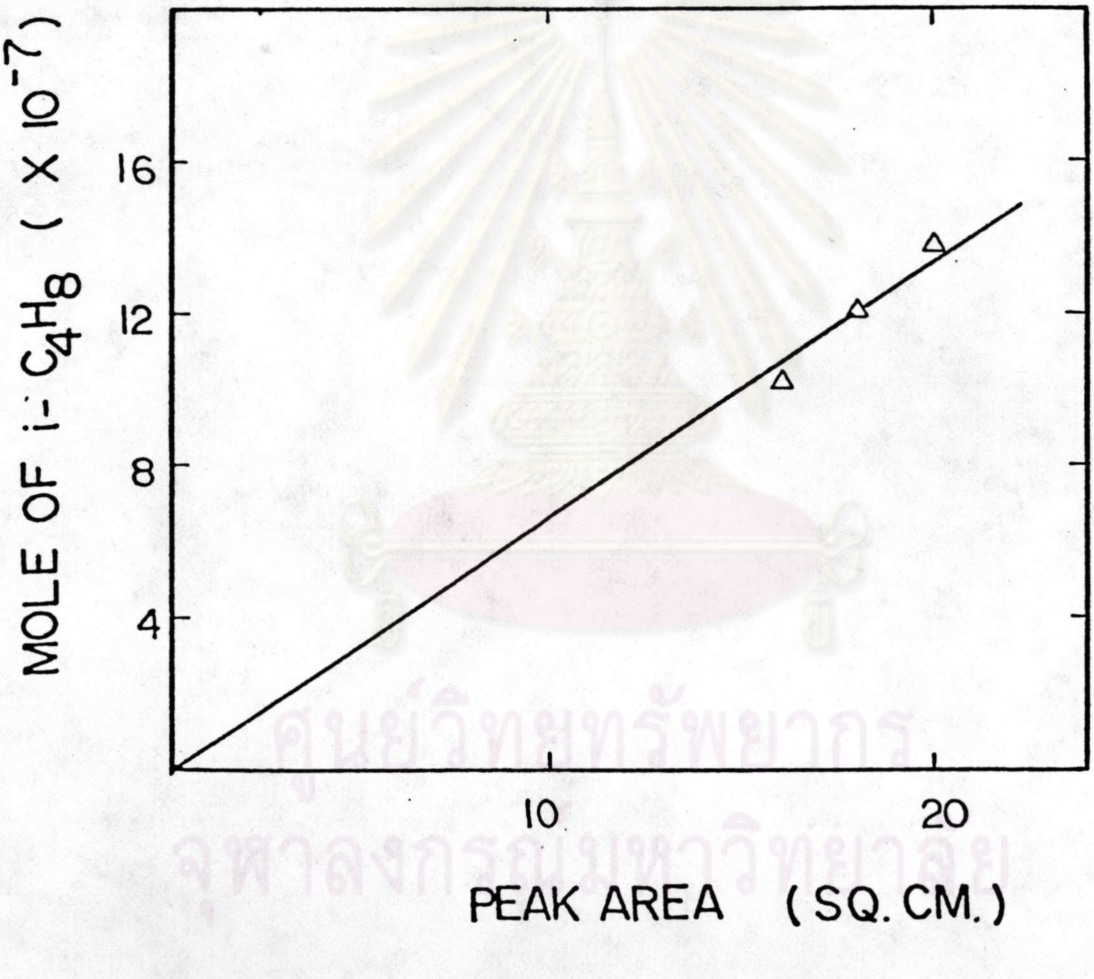
From Shimadzu Gas Chromatography model 8ATF (FID) with the operations:

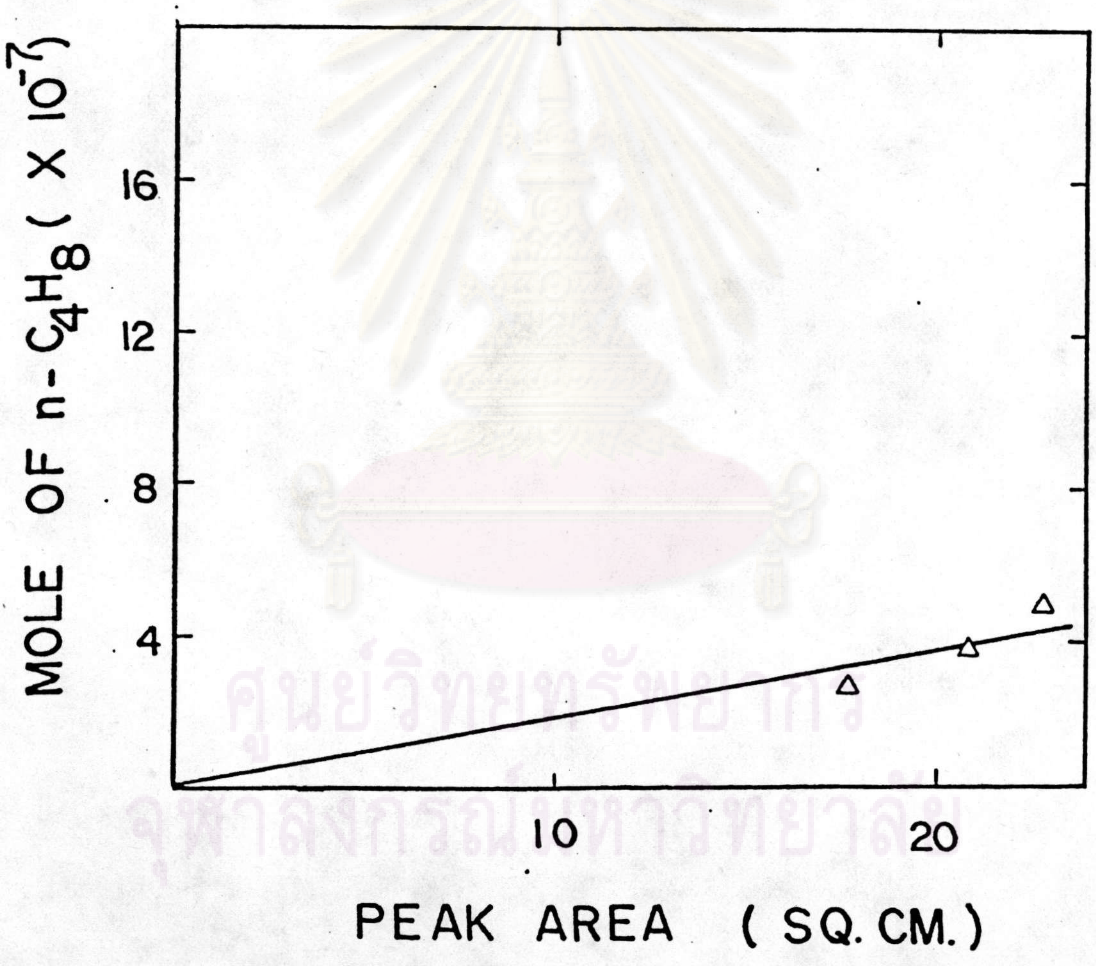
Inj/Detect temperature	: 200 °C
Column temperature	: 180 °C
Carrier gas	: Nitrogen
Carrier gas pressure of PQ column	: 2.5 atg
Air pressure	: 0.1 - 0.2 kg/cm^2
H_2 pressure	: .9 - 1 kg/cm^2
PQ detected	: C_2H_4, C_2H_5OH, i-C_3H_7OH, n-C_3H_7OH, t-C_4H_9OH, 2-C_4H_9OH and n-C_4H_9OH
Polarity PQ	: +

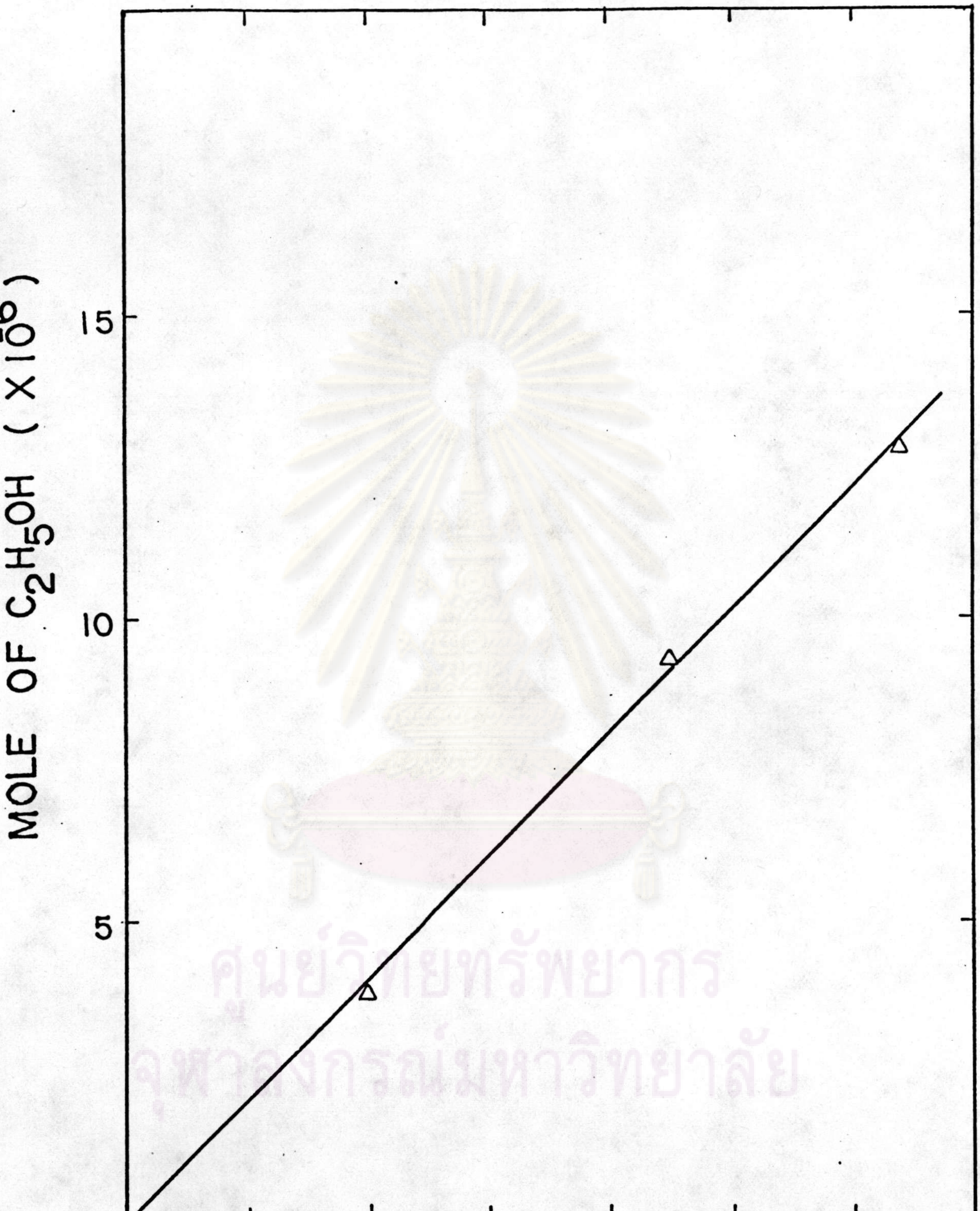

MOLE OF H2O (X 10-4)
16
12
8
4
1
2
3
PEAK AREA (SQ. CM.)

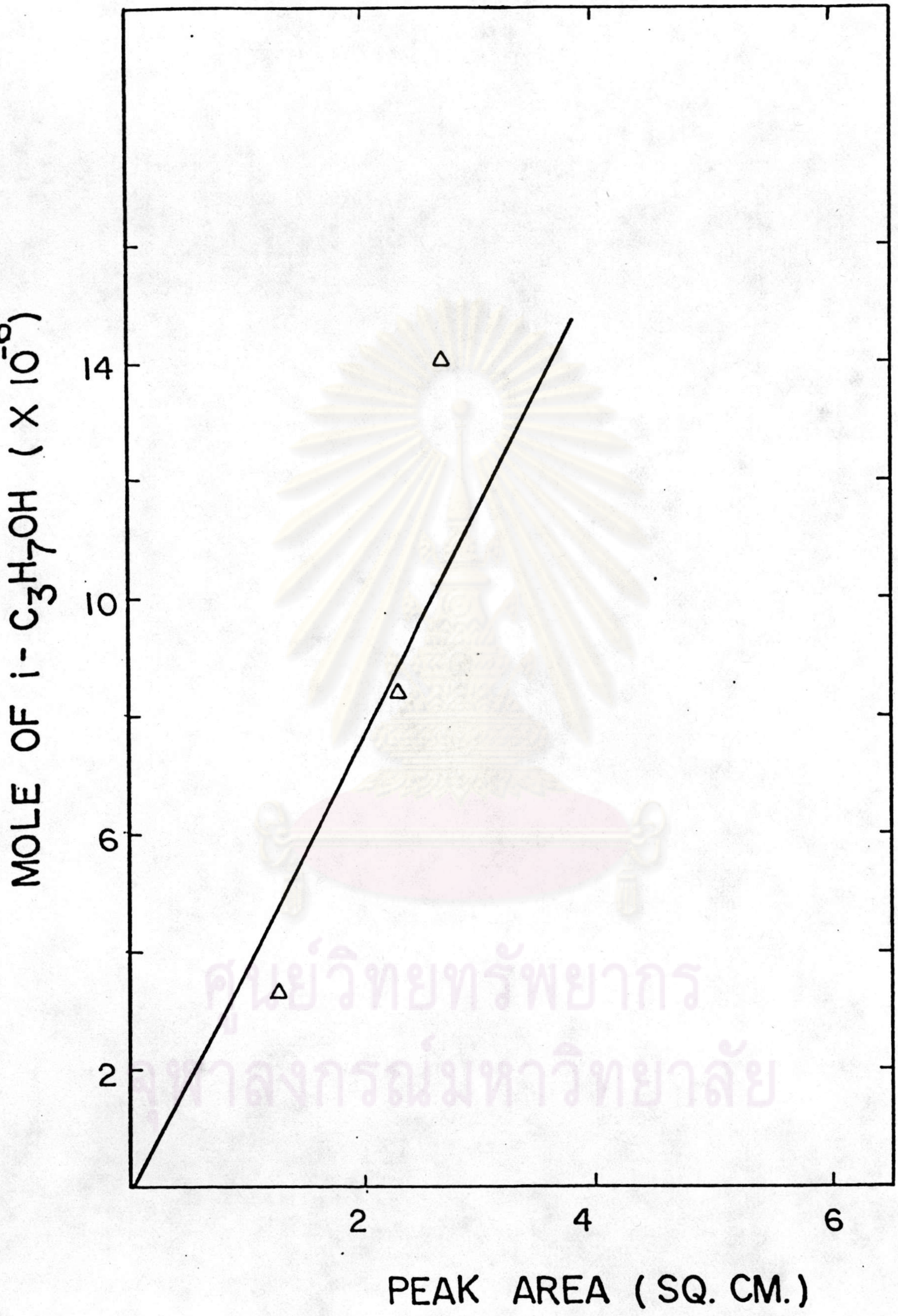


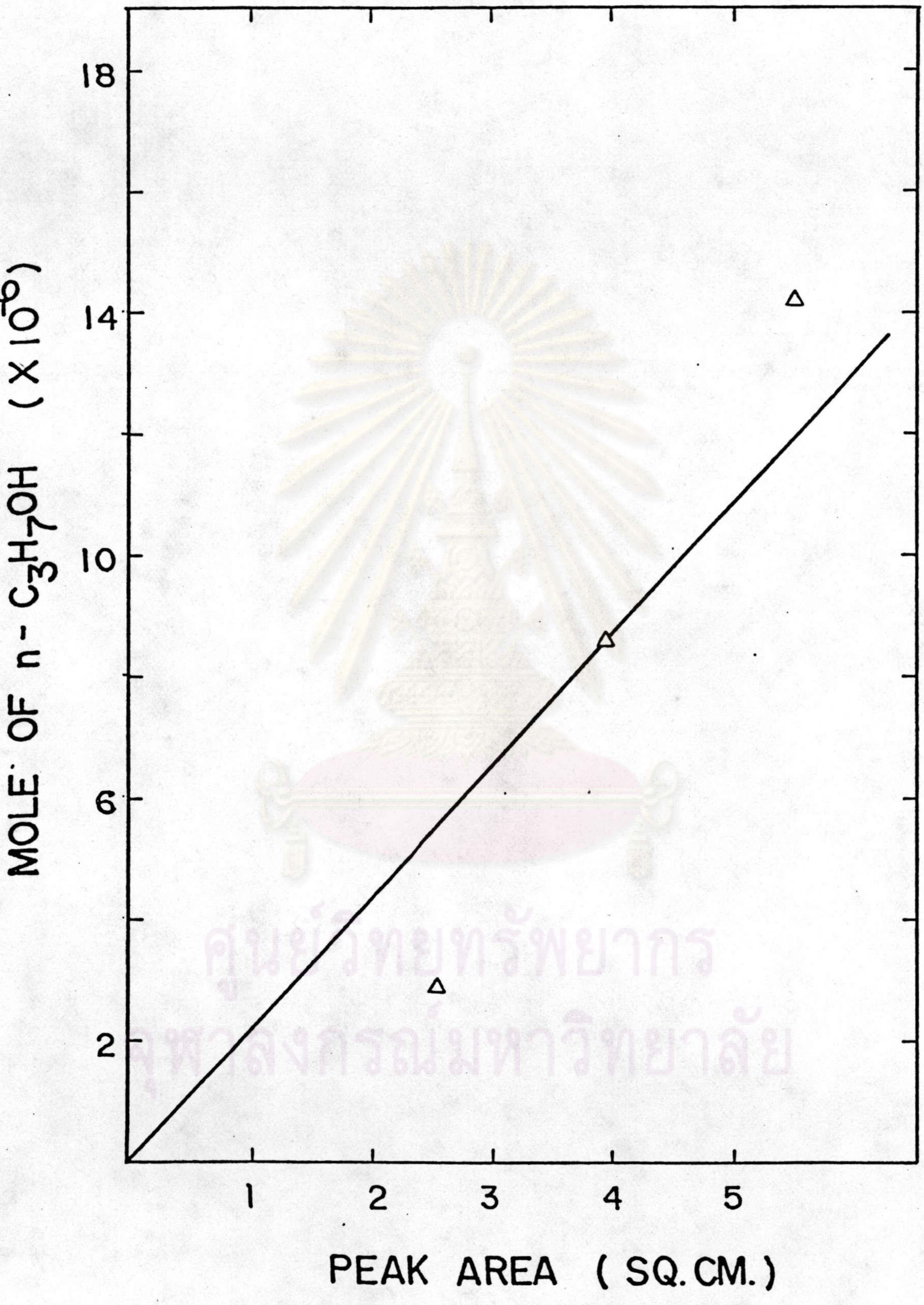
MOLE OF C_2H_4 (X 10^{-8})
15
10
5
5
10
PEAK AREA (SQ. CM.)

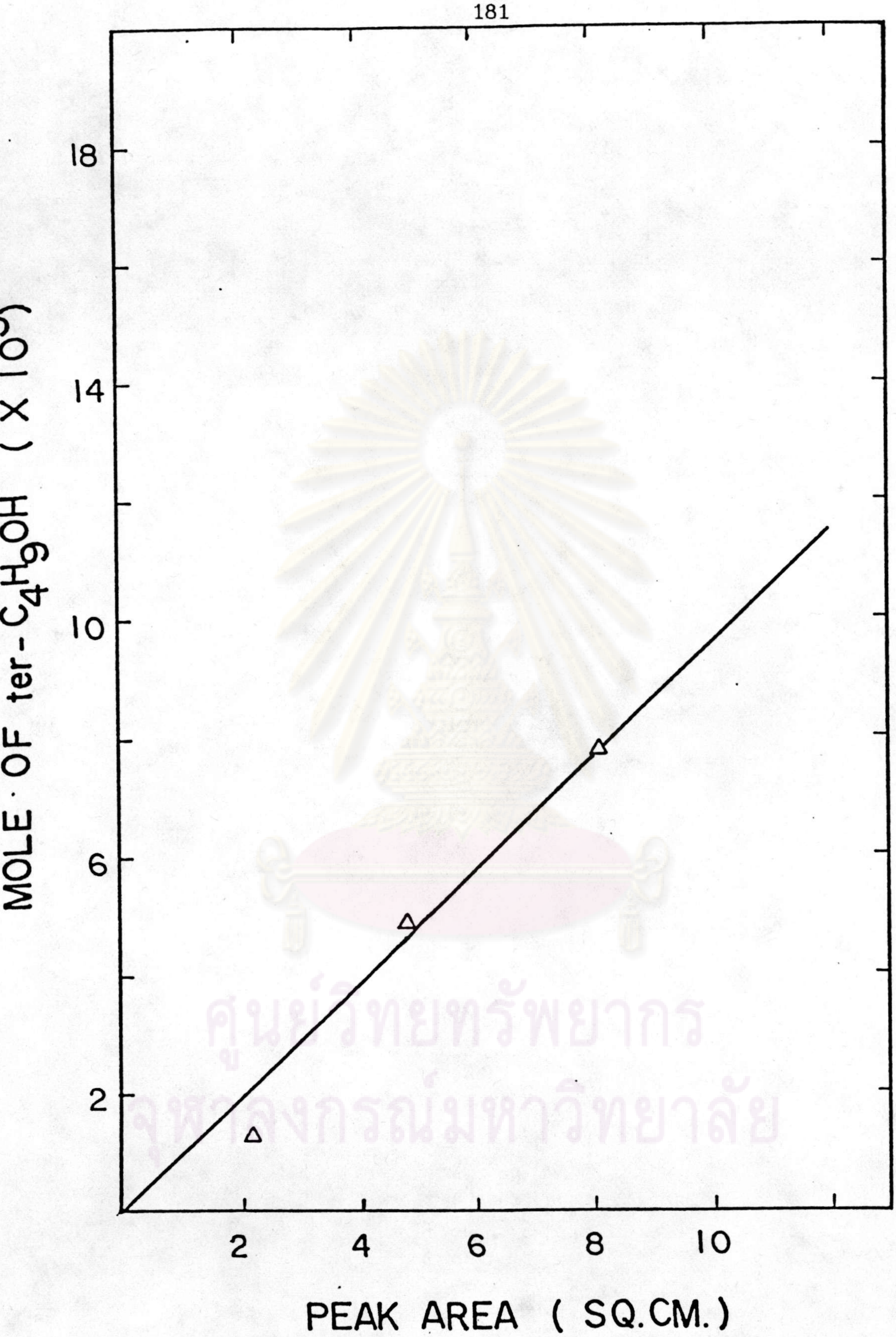

MOLE OF i- C_4H_8 (X 10^{-7})
4
8
12
16
10
20
PEAK AREA (SQ. CM.)

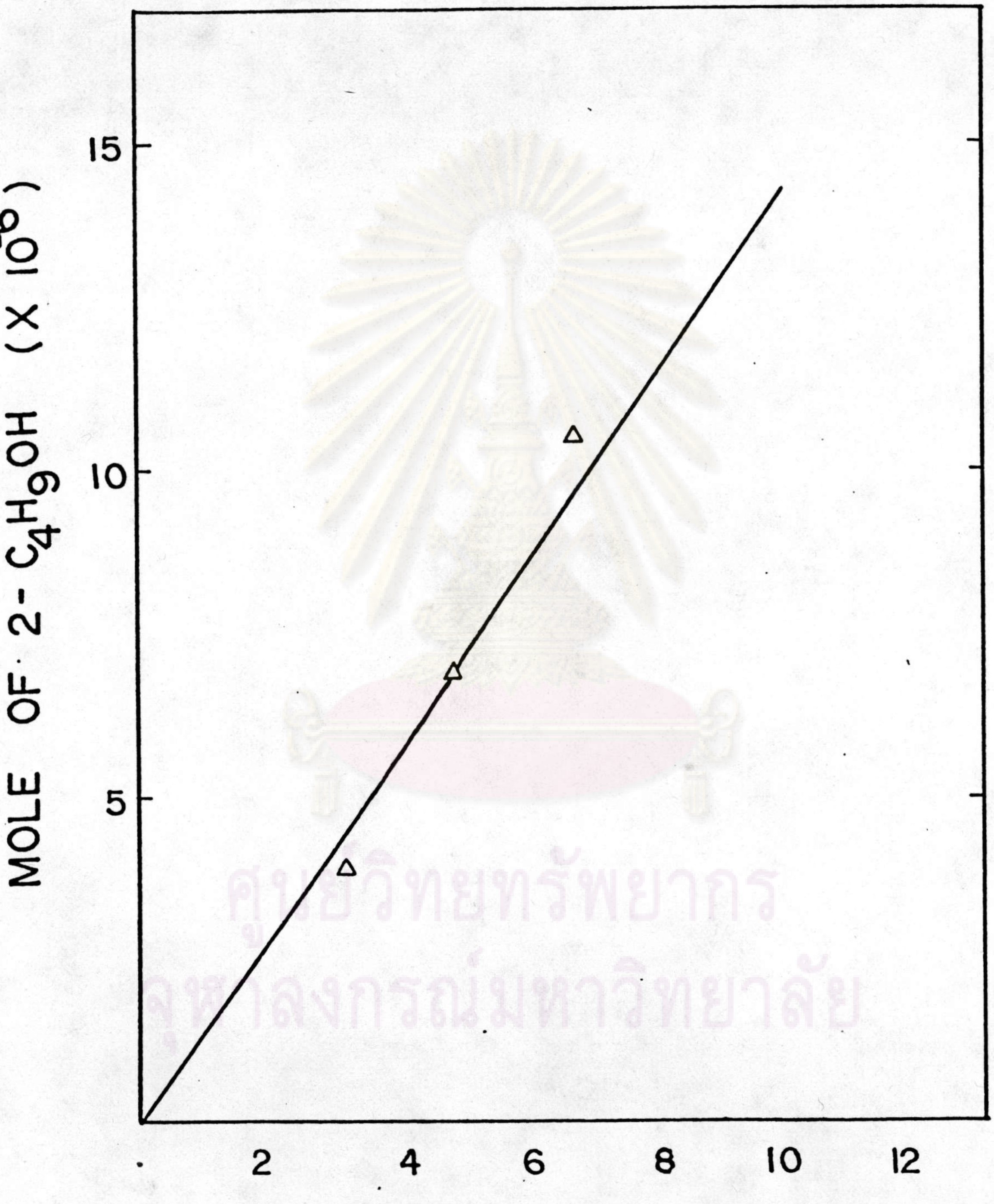

MOLE OF n-C_4H_8 (X 10^{-7})
16
12
8
4
10
20
PEAK AREA (SQ. CM.)


MOLE OF C_2H_5OH ($\times 10^{-6}$)
15
10
5
.25
.5
.75
1
1.25
1.5
PEAK AREA (SQ.CM.)


MOLE OF i- C3H7OH (X 10-6)
14
10
6
2
2
4
6
PEAK AREA (SQ. CM.)


MOLE OF n - C_3H_7OH (X 10^{-6})
18
14
10
6
2
1
2
3
4
5
PEAK AREA (SQ. CM.)


MOLE OF ter-C4H9OH (X 10-5)
18
14
10
6
2
2
4
6
8
10
PEAK AREA (SQ.CM.)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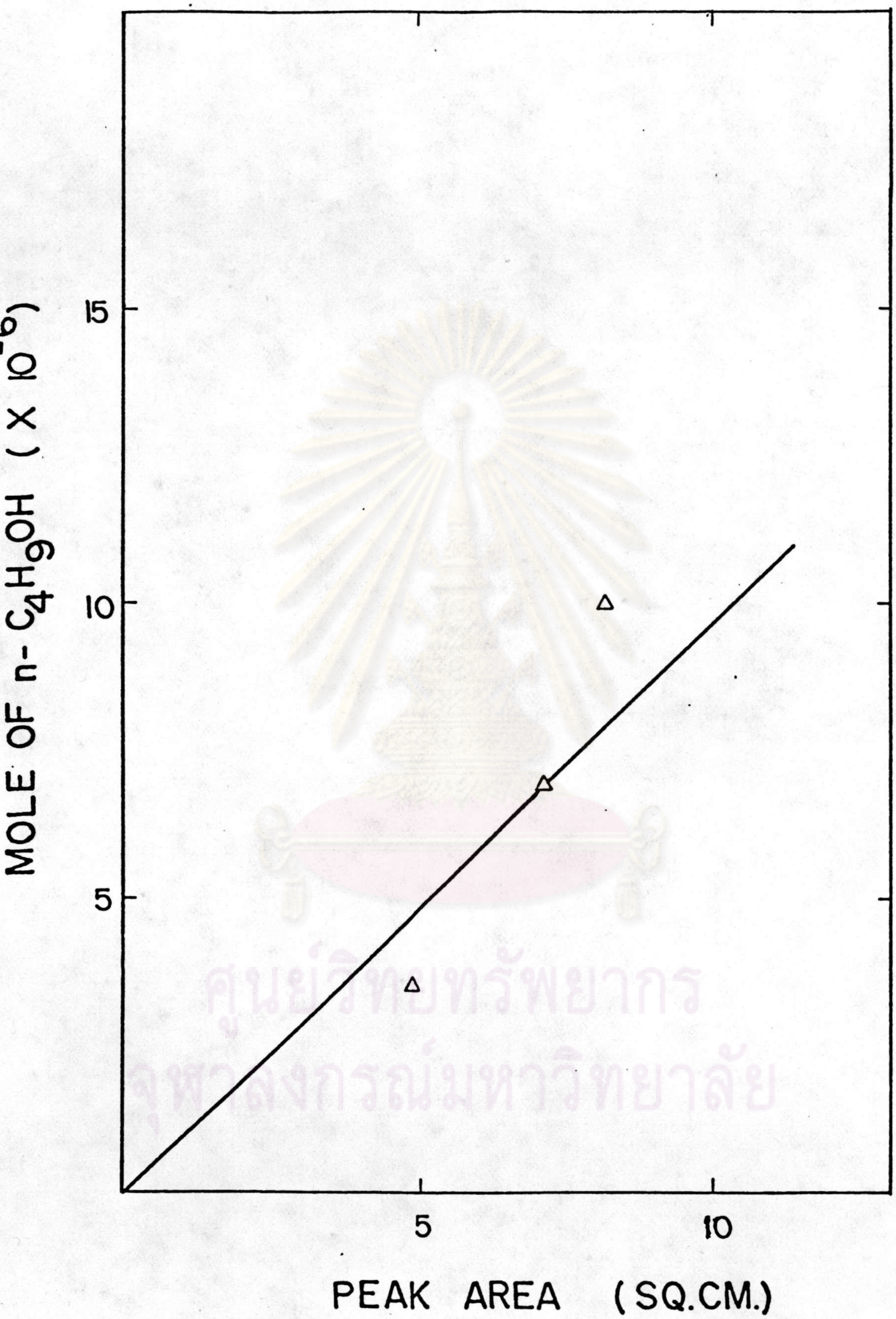
10
5
2
4
6
8
10
12
PEAK AREA (SQ.CM.)


MOLE OF n- C_4H_9OH (X 10^{-6})
15
10
5
5
10
PEAK AREA (SQ.CM.)

APPENDIX B

EXPERIMENTAL RESULTS OF CATALYST NO.1

Catalyst no.1 (H-Y)

Reaction Conditions:

P = 45 psig

GHSV = 2000 hr^{-1}

T = 150-280 °C

Reaction Temperature (°C)		150	200	230	250	280
Product Selectivity (%)	C_2H_4	7.31	3.62	-	-	-
	$i-C_4H_8$	.53	.22	1.49	6.62	8.75
	$n-C_4H_8$	.34	.33	.45	.97	2.19
	C_2H_5OH	2.48	17.69	4.62	24.44	21.13
	$i-C_3H_7OH$	78.95	73.11	79.21	42.16	51.85
	$n-C_3H_7OH$	4.29	2.23	.73	1.96	1.69
	$t-C_4H_9OH$	3.72	.22	.95	3.73	3.67
	$2-C_4H_9OH$	1.4	1.67	5.57	13.49	7.97
	$n-C_4H_9OH$	.95	.85	6.97	6.59	2.7
	Total	100.0	100.0	100.0	100.0	100.0
Conversion of C_3H_6 (%) in Feed		.79	1.33	2.32	2.86	1.67
Space Time Yield of $i-C_3H_7OH$ (mol/l-cat.hr.)		.11	.17	.33	.22	.15

Catalyst no.1 (H-Y)

Reaction Conditions:

P = 45 psig

GHSV = 5000 hr^{-1}

T = 200-300 °C

Reaction Temperature (°C)		200	230	250	280	300
Product Selectivity (%)	C_2H_4	4.72	3.49	3.13	2.22	-
	$i-C_4H_8$	-	-	0.42	4.42	10.86
	$n-C_4H_8$	-	-	.08	.04	.12
	C_2H_5OH	3.28	2.47	2.5	13.01	19.40
	$i-C_3H_7OH$	91.59	93.95	88.68	62.49	49.14
	$n-C_3H_7OH$	-	-	.58	1.36	.61
	$t-C_4H_9OH$	-	.07	.5	2.07	4.65
	$2-C_4H_9OH$	.39	-	2.56	8.94	15.16
	$n-C_4H_9OH$	-	-	1.52	5.41	-
	Total	100.0	100.0	100.0	100.0	100.0
Conversion of C_3H_6 (%) in Feed		2.18	3.02	4.3	4.53	5.80
Space Time Yield of $i-C_3H_7OH$ (mol/l-cat.hr.)		.64	.90	1.21	.90	.91

Catalyst no.1 (H-Y)

Reaction Conditions:

P = 45 psig

GHSV = 8000 hr^{-1}

T = 150-280 °C

Reaction Temperature (°C)		.150	200	230	250	280
Product Selectivity (%)	C_2H_4	36.42	42.09	6.22	-	3.46
	i-C_4H_8	9.83	3.33	.45	.18	1.05
	n-C_4H_8	.65	3.97	.31	.01	.31
	C_2H_5OH	-	4.02	8.86	7.32	10.8
	i-C_3H_7OH	12.77	34.62	83.03	89.85	81.66
	n-C_3H_7OH	17.12	5.39	.64	.48	.68
	t-C_4H_9OH	23.18	6.55	.47	.50	.59
	2-C_4H_9OH	-	-	-	.63	.39
	n-C_4H_9OH	-	-	-	1.02	1.04
	Total	100.0	100.0	100.0	100.0	100.0
Conversion of C_3H_6 (%) in Feed		.31	.22	1.47	2.78	1.60
Space Time Yield of i-C_3H_7OH (mol/l-cat.hr.)		.02	.03	.54	1.11	.53

Catalyst no.1 (H-Y)

Reaction Conditions:

P = 75 psig

GHSV = 2000 hr^{-1}

T = 200-300 °C

Reaction Temperature (°C)		200	230	250	280	300
Product Selectivity (%)	C_2H_4	-	2.87	3.22	-	-
	$i\text{-}C_4H_8$	2.5	3.7	.14	.17	4.36
	$n\text{-}C_4H_8$	.74	.49	.02	2.43	.42
	C_2H_5OH	30.06	9.37	19.74	66.03	17.07
	$i\text{-}C_3H_7OH$	51.24	70.80	66.76	15.44	15.18
	$n\text{-}C_3H_7OH$	4.06	2.53	3.19	.79	2.82
	$t\text{-}C_4H_9OH$	2.35	1.64	3.34	5.26	2.46
	$2\text{-}C_4H_9OH$	4.25	1.65	4.31	4.32	54.60
	$n\text{-}C_4H_9OH$	4.78	1.86	3.28	5.62	2.53
	Total	100.0	100.0	100.0	100.0	100.0
Conversion of C_3H_6 (%) in Feed		1.84	4.93	9.46	17.19	2.25
Space Time Yield of $i\text{-}C_3H_7OH$ (mol/l-cat.hr.)		.17	.64	.67	.47	.06

Catalyst no.1 (H-Y)

Reaction Conditions:

P = 75 psig

GHSV = 5000 hr^{-1}

T = 180-280 °C

Reaction Temperature (°C)		180	200	230	250	280
Product Selectivity (%)	C_2H_4	-	2.61	.29	.33	-
	$i-C_4H_8$	-	.31	3.50	.47	9.27
	$n-C_4H_8$	-	-	.36	.08	1.46
	C_2H_5OH	37.41	28.9	52.45	45.53	31.87
	$i-C_3H_7OH$	62.58	66.0	39.13	51.25	34.94
	$n-C_3H_7OH$	-	.38	.88	1.69	10.22
	$t-C_4H_9OH$	-	.89	1.30	.55	7.89
	$2-C_4H_9OH$	-	.31	.67	.51	2.86
	$n-C_4H_9OH$	-	.49	.93	.38	1.44
	Total	100.0	100.0	100.0	100.0	100.0
Conversion of C_3H_6 (%) in Feed		3.01	5.91	7.64	10.46	3.86
Space Time Yield of $i-C_3H_7OH$ (mol/l-cat.hr.)		.77	.55	1.09	.48	1.01

Catalyst no.1 (H-Y)

Reaction Conditions:

P = 75 psig

GHSV = 8000 hr^{-1}

T = 150-280 °C

Reaction Temperature (°C)		150	180	200	230	250	280
Product Selectivity (%)	C_2H_4	3.98	2.54	11.95	3.09	2.92	1.56
	$i-C_4H_8$	5.52	5.70	2.67	1.11	5.63	13.12
	$n-C_4H_8$	.89	.57	-	.04	.59	2.04
	C_2H_5OH	-	19.14	4.12	46.87	63.24	34.83
	$i-C_3H_7OH$	11.08	37.12	74.30	48.04	18.18	13.12
	$n-C_3H_7OH$	18.73	13.97	1.75	.38	3.08	12.11
	$t-C_4H_9OH$	17.84	8.73	1.52	.46	2.56	10.68
	$2-C_4H_9OH$	12.85	7.80	2.29	-	1.4	2.91
	$n-C_4H_9OH$	19.07	4.44	1.36	-	2.35	9.50
	Total	100.0	100.0	100.0	100.0	100.0	100.0
Conversion of C_3H_6 (%) in Feed		1.17	.72	1.25	10.87	18.20	25.90
STY of C_3H_7OH (mol/1-cat.hr.)		.06	.11	.41	2.33	1.41	1.52

Catalyst no.1 (H-Y)

Reaction Conditions:

p = 105 psig

GHSV = 2000 hr^{-1}

T = 200-300 °C

Reaction Temperature (°C)		200	230	250	280	300
Product Selectivity (%)	C_2H_4	56.29	-	-	3.42	5.28
	$i\text{-}C_4H_8$	.04	24.29	.08	11.44	8.43
	$n\text{-}C_4H_8$	-	-	-	.52	.08
	C_2H_5OH	18.41	7.14	2.38	11.42	28.75
	$i\text{-}C_3H_7OH$	23.33	67.44	32.37	45.84	44.11
	$n\text{-}C_3H_7OH$	1.24	.10	.03	3.08	2.01
	$t\text{-}C_4H_9OH$	-	.09	.03	4.92	3.1
	$2\text{-}C_4H_9OH$	.68	.45	65.04	11.96	5.47
	$n\text{-}C_4H_9OH$	-	.44	.05	7.36	2.73
	Total	100.0	100.0	100.0	100.0	100.0
Conversion of C_3H_6 (%) in Feed		.35	3.84	10.75	4.28	4.26
STY of $i\text{-}C_3H_7OH$ (mol/l-cat.hr.)		.01	.39	.52	.29	.28

Catalyst no.1 (H-Y)

Reaction Conditions:

P = 105 psig

GHSV = 5000 hr^{-1}

T = 200-300 °C

Reaction Temperature (°C)		200	230	250	280	300
Product Selectivity (%)	C_2H_4	-	-	-	-	-
	i-C_4H_8	37.4	17.79	4.74	8.41	14.93
	n-C_4H_8	2.06	2.97	1.01	1.68	2.4
	C_2H_5OH	2.58	1.56	22.52	29.19	41.96
	i-C_3H_7OH	48.58	33.06	60.07	43.0	22.81
	n-C_3H_7OH	-	8.21	-	3.8	5.72
	ter-C_4H_9OH	-	7.05	-	3.7	4.13
	sec-C_4H_9OH	7.38	12.15	4.81	4.79	3.27
	n-C_4H_9OH	1.98	17.36	6.82	5.39	4.74
	Total	100.0	100.0	100.0	100.0	100.0
Conversion of C_3H_6 (%) in Feed		.23	.27	1.34	1.64	2.18
Space Time Yield of i-C_3H_7OH (mol/l-cat.hr.)		.03	.01	.27	.22	.16

Catalyst no.1 (H-Y)

Reaction Conditions:

P = 105 psig

GHSV = 8000 hr^{-1}

T = 200-300 °C

Reaction Temperature (°C)		200	230	250	280	300
Product Selectivity (%)	C_2H_4	31.68	-	-	2.64	-
	$i-C_4H_8$	-	1.38	1.21	2.39	3.06
	$n-C_4H_8$	-	.27	.15	1.07	.98
	C_2H_5OH	-	22.55	54.10	34.59	45.69
	$i-C_3H_7OH$	68.31	74.49	42.43	48.04	39.06
	$n-C_3H_7OH$	-	-	.66	3.12	2.88
	$ter-C_4H_9OH$	-	-	.57	3.38	3.33
	$sec-C_4H_9OH$	-	.85	.44	3.06	2.23
	$n-C_4H_9OH$	-	.44	.40	1.72	2.26
	Total	100.0	100.0	100.0	100.0	100.0
Conversion of C_3H_6 (%) in Feed		.36	1.01	4.41	1.29	2.34
Space Time Yield of $i-C_3H_7OH$ (mol/l-cat.hr.)		.11	.38	.95	.32	.47

EXPERIMENTAL RESULTS OF CATALYST NO.2

Catalyst no. 2 (offretite/erionite)

Reaction Conditions:

P = 45 psig

GHSV = 2000 hr^{-1}

T = 150-250 °C

Reaction Temperature (°C)		150	180	210	230	250
Product Selectivity (%)	C_2H_4	-	-	-	-	-
	$i-C_4H_8$	42.45	9.33	11.91	19.11	18.54
	$n-C_4H_8$	7.17	.49	.60	1.85	3.13
	$2-C_4H_8$	14.19	1.46	1.72	4.71	6.24
	C_2H_5OH	3.49	4.42	-	1.40	3.85
	$i-C_3H_7OH$	9.20	32.72	45.47	29.23	33.95
	$n-C_3H_7OH$	1.53	6.89	4.37	7.25	8.67
	$t-C_4H_9OH$	4.61	18.59	12.21	15.83	17.73
	$2-C_4H_9OH$	11.56	27.07	13.98	12.20	4.46
	$n-C_4H_9OH$	5.65	-	9.7	8.42	4.39
	Total	100.0	100.0	100.0	100.0	100.0
Conversion of C_3H_6 (%) in Feed		.82	2.18	2.05	3.01	1.87
Space Time Yield of $i-C_3H_7OH$ (mol/l-cat.hr.)		.01	.11	.14	.13	.09

Catalyst no.2 (offretite/erionite)

Reaction Conditions:

P = 45 psig

GHSV = 5000 hr^{-1}

T = 150-280 °C

Reaction Temperature (°C)		150	180	210	230	250	280
Product Selectivity (%)	C_2H_4	3.0	3.33	1.49	3.1	5.18	.92
	$i\text{-}C_4H_8$	.47	1.50	.85	1.93	3.64	4.92
	$n\text{-}C_4H_8$	.06	.04	3.42	5.92	12.0	19.35
	$2\text{-}C_4H_8$	-	-	1.80	2.94	4.64	6.90
	C_2H_5OH	11.67	7.32	14.76	10.40	10.82	9.58
	$i\text{-}C_3H_7OH$	80.24	77.92	69.52	59.69	45.57	15.38
	$n\text{-}C_3H_7OH$	.19	3.18	1.85	3.99	2.06	20.61
	$t\text{-}C_4H_9OH$	.23	2.11	3.98	3.95	6.48	13.98
	$2\text{-}C_4H_9OH$	3.66	3.52	1.34	3.88	5.26	1.47
	$n\text{-}C_4H_9OH$	.44	.88	.95	4.14	4.3	6.84
	Total	100.0	100.0	100.0	100.0	100.0	100.0
Conversion of C_3H_6 (%) in Feed		3.59	2.25	10.36	18.02	9.41	16.65
STY of $i\text{-}C_3H_7OH$ (mol/l-cat.hr.)		.94	.56	2.29	3.42	1.36	.81

Catalyst no.2 (offretite/erionite)

Reaction Conditions:

P = 45 psig

GHSV = 8000 hr^{-1}

T = 150-250 °C

Reaction Temperature (°C)		150	180	210	230	250
Product Selectivity (%)	C_2H_4	-	-	-	-	-
	i-C_4H_8	8.7	1.78	6.49	.82	8.81
	n-C_4H_8	3.19	.50	.16	.33	1.18
	2-C_4H_8	-	-	-	.98	2.58
	C_2H_5OH	7.87	5.88	3.56	12.54	-
	i-C_3H_7OH	80.22	91.83	88.16	80.06	60.84
	n-C_3H_7OH	-	-	.15	-	3.37
	t-C_4H_9OH	-	-	.46	-	6.57
	2-C_4H_9OH	-	-	1.00	5.25	15.42
	n-C_4H_9OH	-	-	-	-	1.19
	Total	100.0	100.0	100.0	100.0	100.0
Conversion of C_3H_6 (%) in Feed		.06	.38	2.83	2.04	1.94
Space Time Yield of i-C_3H_7OH (mol/l-cat.hr.)		.02	.18	1.27	.83	.60

Catalyst no.2 (offretite/erionite)

Reaction Conditions:

P = 75 psig

GHSV = 2000 hr^{-1}

T = 150-250 °C

Reaction Temperature (°C)		150	180	210	230	250
Product Selectivity (%)	C_2H_4	-	-	-	-	-
	$i\text{-}C_4H_8$	-	-	.49	16.87	23.08
	$n\text{-}C_4H_8$	-	-	-	.45	1.04
	$2\text{-}C_4H_8$	-	-	-	1.75	2.18
	C_2H_5OH	-	29.93	44.06	27.66	6.1
	$i\text{-}C_3H_7OH$	100.0	70.07	54.97	13.95	3.97
	$n\text{-}C_3H_7OH$	-	-	-	5.23	9.41
	$t\text{-}C_4H_9OH$	-	-	.47	10.48	13.98
	$2\text{-}C_4H_9OH$	-	-	-	18.63	23.96
	$n\text{-}C_4H_9OH$	-	-	-	4.92	16.23
	Total	100.0	100.0	100.0	100.0	100.0
Conversion of C_3H_6 (%) in Feed		.06	.43	2.12	3.48	8.50
Space Time Yield of $i\text{-}C_3H_7OH$ (mol/l-cat.hr.)		8.97×10^{-1}	.04	.17	.07	.05

Catalyst no.2 (offretite/erionite)

Reaction Conditions:

P = 75 psig

GHSV = 5000 hr^{-1}

T = 150-250 °C

Reaction Temperature (°C)		150	180	210	230	250
Product Selectivity (%)	C_2H_4	22.28	9.54	1.76	-	.51
	$i-C_4H_8$	12.02	15.49	.64	6.82	23.64
	$n-C_4H_8$	2.00	1.28	.85	.46	1.34
	$2-C_4H_8$	-	-	-	1.49	3.46
	C_2H_5OH	-	-	9.58	25.58	-
	$i-C_3H_7OH$	38.18	65.27	51.36	18.05	4.40
	$n-C_3H_7OH$	-	8.4	2.07	4.90	10.74
	$t-C_4H_9OH$	25.50	-	8.94	9.41	19.67
	$2-C_4H_9OH$	-	-	12.86	18.26	18.96
	$n-C_4H_9OH$	-	-	11.90	14.99	20.24
	Total	100.0	100.0	100.0	100.0	100.0
Conversion of C_3H_6 (%) in Feed		.08	.20	5.16	5.86	15.92
Space Time Yield of $i-C_3H_7OH$ (mol/l-cat.hr.)		$9.3x10^{-3}$	.04	.85	.34	.22

Catalyst no.2 (offretite/erionite)

Reaction Conditions:

P = 75 psig

GHSV = 8000 hr^{-1}

T = 150-250 °C

Reaction Temperature (°C)		150	180	210	230	250
Product Selectivity (%)	C_2H_4	-	-	-	-	-
	$i\text{-}C_4H_8$	5.31	-	.22	-	2.17
	$n\text{-}C_4H_8$	.88	-	.05	-	.54
	$2\text{-}C_4H_8$	-	-	-	-	-
	C_2H_5OH	15.55	-	6.49	2.07	2.38
	$i\text{-}C_3H_7OH$	78.23	100	93.22	97.93	88.83
	$n\text{-}C_3H_7OH$	-	-	-	-	-
	$t\text{-}C_4H_9OH$	-	-	-	-	2.68
	$2\text{-}C_4H_9OH$	-	-	-	-	3.36
	$n\text{-}C_4H_9OH$	-	-	-	-	-
	Total	100.0	100.0	100.0	100.0	100.0
Conversion of C_3H_6 (%) in Feed		.19	.65	3.00	1.42	.93
Space Time Yield of $i\text{-}C_3H_7OH$ (mol/l-cat.hr.)		.08	.33	1.42	.71	.04

Catalyst no.2 (offretite/erionite)

Reaction Conditions:

P = 105 psig

GHSV = 2000 hr^{-1}

T = 150-250 °C

Reaction Temperature (°C)		150	180	210	230	250
Product Selectivity (%)	C_2H_4	-	-	-	-	-
	$i\text{-}C_4H_8$	1.69	12.29	14.61	8.35	16.42
	$n\text{-}C_4H_8$	-	.33	.50	.12	.34
	$2\text{-}C_4H_8$	-	.98	1.50	.71	1.56
	C_2H_5OH	-	8.96	3.56	36.74	3.12
	$i\text{-}C_3H_7OH$	98.30	4.31	17.63	20.75	.49
	$n\text{-}C_3H_7OH$	-	8.01	6.09	3.53	8.82
	$t\text{-}C_4H_9OH$	-	17.14	13.18	7.85	17.3
	$2\text{-}C_4H_9OH$	-	37.81	26.45	17.52	36.04
	$n\text{-}C_4H_9OH$	-	10.15	16.45	4.40	15.80
	Total	100.0	100.0	100.0	100.0	100.0
Conversion of C_3H_6 (%) in Feed		$9x10^{-3}$	2.16	1.07	5.07	3.36
Space Time Yield of $i\text{-}C_3H_7OH$ (mol/l-cat.hr.)		$1.0x10^{-3}$	.01	.03	.16	$2.4x10^{-3}$

Catalyst no.2 (offretite/erionite)

Reaction Conditions:

P = 105 psig

GHSV = 5000 hr^{-1}

T = 150-250 °C

Reaction Temperature (°C)		150	180	210	230	250
Product Selectivity (%)	C_2H_4	-	-	-	-	-
	$i-C_4H_8$	2.41	16.08	.94	.61	2.58
	$n-C_4H_8$	-	3.01	.14	-	.15
	$2-C_4H_8$	-	-	-	-	.44
	C_2H_5OH	-	21.78	1.91	6.93	2.75
	$i-C_3H_7OH$	97.58	50.94	93.71	90.54	45.96
	$n-C_3H_7OH$	-	8.17	.23	.79	1.45
	$t-C_4H_9OH$	-	-	-	1.11	1.87
	$2-C_4H_9OH$	-	-	3.03	-	28.47
	$n-C_4H_9OH$	-	-	-	-	16.3
	Total	100.0	100.0	100.0	100.0	100.0
Conversion of C_3H_6 (%) in Feed		$8.6x10^{-3}$	.08	1.72	1.33	2.19
Space Time Yield of $i-C_3H_7OH$ (mol/l-cat.hr.)		$2.7x10^{-3}$	.01	.51	.38	.32

Catalyst no.2 (offretite/erionite)

Reaction Conditions:

P = 105 psig

GHSV = 8000 hr^{-1}

T = 150-250 °C

Reaction Temperature (°C)		150	180	210	230	250
Product Selectivity (%)	C_2H_4	-	-	-	-	-
	$i-C_4H_8$	-	3.09	.25	1.09	2.96
	$n-C_4H_8$	-	.39	.06	.18	1.58
	$2-C_4H_8$	-	-	-	-	-
	C_2H_5OH	14.60	10.23	4.30	6.04	2.79
	$i-C_3H_7OH$	85.40	86.28	95.38	92.67	73.43
	$n-C_3H_7OH$	-	-	-	-	5.52
	$t-C_4H_9OH$	-	-	-	-	3.59
	$2-C_4H_9OH$	-	-	-	-	10.10
	$n-C_4H_9OH$	-	-	-	-	-
	Total	100.0	100.0	100.0	100.0	100.0
Conversion of C_3H_6 (%) in Feed		.15	.22	2.66	.92	.40
Space Time Yield of $i-C_3H_7OH$ (mol/l-cat.hr.)		.06	.84	1.13	.38	.13

EXPERIMENTAL RESULTS OF CATALYST NO.3

Catalyst no.3 (mordenite)

Reaction Conditions:

P = 45 psig

GHSV = 2000 hr^{-1}

T = 200-300 °C

Reaction Temperature (°C)		200	230	260	280	300
Product Selectivity (%)	C_2H_4	7.1	.64	.88	.58	2.42
	i-C_4H_8	2.94	.35	2.21	1.57	7.26
	n-C_4H_8	.49	.07	.68	.47	3.01
	C_2H_5OH	20.34	3.05	4.22	31.90	13.68
	i-C_3H_7OH	63.45	95.00	88.61	63.77	65.34
	n-C_3H_7OH	3.00	.41	2.27	1.08	5.25
	t-C_4H_9OH	.91	.08	.42	.21	1.19
	2-C_4H_9OH	1.17	.09	.45	.23	1.12
	n-C_4H_9OH	.50	.06	.23	.13	.68
	Total	100.0	100.0	100.0	100.0	100.0
Conversion of C_3H_6 (%) in Feed		1.29	11.09	10.95	17.77	8.62
Space Time Yield of i-C_3H_7OH (mol/l-cat.hr.)		.056	.72	.67	.78	.39

Catalyst no.3 (mordenite)

Reaction Conditions:

P = 45 psig

GHSV = 5000 hr^{-1}

T = 200-300 °C

Reaction Temperature (°C)		200	230	260	280	300
Product Selectivity (%)	C_2H_4	75.77	59.05	11.34	1.10	4.21
	i-C_4H_8	1.08	2.42	3.63	2.46	13.56
	n-C_4H_8	1.44	2.16	3.18	.28	.87
	C_2H_5OH	2.04	1.91	3.72	20.08	5.16
	i-C_3H_7OH	19.11	23.94	73.43	70.86	58.13
	n-C_3H_7OH	.53	1.13	1.47	1.12	3.91
	t-C_4H_9OH	-	.86	1.20	1.09	3.21
	2-C_4H_9OH	-	.81	1.45	.96	3.70
	n-C_4H_9OH	-	7.69	.54	2.00	7.21
	Total	100.0	100.0	100.0	100.0	100.0
Conversion of C_3H_6 (%) in Feed		.51	.62	1.03	4.04	3.18
Space Time Yield of i-C_3H_7OH (mol/l-cat.hr.)		.02	.03	.17	.65	.42

Catalyst no.3 (mordenite)

Reaction Conditions:

P = 45 psig

GHSV = 8000 hr^{-1}

T = 200-300 °C

Reaction Temperature (°C)		200	230	260	280	300
Product Selectivity (%)	C_2H_4	5.71	8.43	6.07	3.19	3.71
	$i-C_4H_8$	3.20	6.88	2.74	3.02	4.58
	$n-C_4H_8$	.91	1.89	.91	1.91	4.41
	C_2H_5OH	54.65	6.47	6.01	4.97	8.95
	$2-C_3H_7OH$	33.49	55.85	82.09	83.44	73.23
	$n-C_3H_7OH$	1.07	1.53	1.11	1.35	1.63
	$t-C_4H_9OH$	.84	-	.36	.76	1.06
	$2-C_4H_9OH$	-	13.62	.44	.77	1.45
	$n-C_4H_9OH$	-	5.28	.23	.55	.93
	Total	100.0	100.0	100.0	100.0	100.0
Conversion of C_3H_6 (%) in Feed		.50	.56	1.33	2.34	12.77
Space Time Yield of $i-C_3H_7OH$ (mol/l-cat.hr.)		.06	.12	.41	.73	.48

Catalyst no.3 (mordenite)

Reaction Conditions:

P = 75 psig

GHSV = 2000 hr^{-1}

T = 200-300 °C

Reaction Temperature (°C)		200	230	260	280	300
Product Selectivity (%)	C_2H_4	47.36	10.51	18.63	2.66	19.5
	$i\text{-}C_4H_8$	10.30	23.70	15.21	23.00	14.02
	$n\text{-}C_4H_8$	1.91	4.99	5.94	9.24	7.45
	C_2H_5OH	2.29	10.72	10.30	13.32	5.90
	$i\text{-}C_3H_7OH$	15.88	20.65	19.42	27.43	41.17
	$n\text{-}C_3H_7OH$	5.99	13.31	11.94	12.15	4.85
	$t\text{-}C_4H_9OH$	1.52	5.15	4.74	3.80	2.60
	$2\text{-}C_4H_9OH$	11.96	6.03	7.63	5.14	1.68
	$n\text{-}C_4H_9OH$	2.72	4.90	6.14	3.88	2.78
	Total	100.0	100.0	100.0	100.0	100.0
Conversion of C_3H_6 (%) in Feed		.79	1.80	1.52	3.35	3.80
Space Time Yield of $i\text{-}C_3H_7OH$ (mol/l-cat.hr.)		.02	.07	.05	.16	.28

Catalyst no.3 (mordenite)

Reaction Conditions:

P = 75 psig

GHSV = 5000 hr^{-1}

T = 200-300 °C

Reaction Temperature (°C)		200	230	260	280	300
Product Selectivity (%)	C_2H_4	-	-	-	.89	-
	$i-C_4H_8$	31.92	11.16	2.41	2.35	8.94
	$n-C_4H_8$	4.85	2.29	1.75	1.17	6.48
	C_2H_5OH	9.09	9.11	6.14	9.34	7.71
	$i-C_3H_7OH$	31.60	67.25	85.39	83.45	63.76
	$n-C_3H_7OH$	12.44	3.75	2.53	2.01	7.71
	$t-C_4H_9OH$	4.77	1.16	.66	.30	2.10
	$2-C_4H_9OH$	1.74	2.91	.80	.13	2.02
	$n-C_4H_9OH$	3.55	2.32	.61	.34	1.24
	Total	100.0	100.0	100.0	100.0	100.0
Conversion of C_3H_6 (%) in Feed		1.21	1.80	3.30	5.98	2.40
Space Time Yield of $i-C_3H_7OH$ (mol/l-cat.hr.)		.04	.14	.29	.53	.16

Catalyst no. 3 (mordenite)

Reaction Conditions:

P = 75 psig

GHSV = 8000 hr^{-1}

T = 200-300 °C

Reaction Temperature (°C)		200	230	260	280	300
Product Selectivity (%)	C_2H_4	-	-	2.46	1.14	.84
	$i\text{-}C_4H_8$	3.7	3.9	1.38	1.73	4.84
	$n\text{-}C_4H_8$	-	-	.39	.88	4.84
	C_2H_5OH	15.90	11.41	5.14	6.18	4.37
	$i\text{-}C_3H_7OH$	76.80	83.40	89.18	87.94	78.66
	$n\text{-}C_3H_7OH$	3.46	1.27	1.11	1.32	3.55
	$t\text{-}C_4H_9OH$	-	-	.31	.39	1.07
	$2\text{-}C_4H_9OH$	-	-	-	.39	1.13
	$n\text{-}C_4H_9OH$	-	-	-	-	.87
	Total	100.0	100.0	100.0	100.0	100.0
Conversion of C_3H_6 (%) in Feed		.27	.31	1.09	2.01	1.07
Space Time Yield of $i\text{-}C_3H_7OH$ (mol/l-cat.hr.)		.10	.12	.46	.84	.40

Catalyst no.3 (mordenite)

Reaction Conditions:

P = 105 psig

GHSV = 2000 hr^{-1}

T = 200-300 °C

Reaction Temperature (°C)		200	230	260	280	300
Product Selectivity (%)	C_2H_4	-	3.23	5.15	2.41	1.27
	i-C_4H_8	.35	.16	5.30	15.15	16.97
	n-C_4H_8	.47	.03	.07	3.08	3.49
	C_2H_5OH	17.12	47.81	40.55	.56	17.95
	i-C_3H_7OH	71.68	34.83	33.80	53.48	16.28
	n-C_3H_7OH	10.27	6.27	5.84	1.78	18.88
	t-C_4H_9OH	-	1.64	1.49	4.42	4.14
	2-C_4H_9OH	-	4.64	3.68	14.46	17.50
	n-C_4H_9OH	-	1.36	3.45	4.61	3.47
	Total	100.0	100.0	100.0	100.0	100.0
Conversion of C_3H_6 (%) in Feed		6.6×10^{-3}	1.76	2.45	3.69	6.82
Space Time Yield of i-C_3H_7OH (mol/l-cat.hr.)		4.7×10^{-4}	.06	.08	.20	.11

Catalyst no.3 (mordenite)

Reaction Conditions:

P = 105 psig

GHSV = 5000 hr^{-1}

T = 200-300 °C

Reaction Temperature (°C)		200	230	260	280	300
Product Selectivity (%)	C_2H_4	7.67	4.69	2.50	.38	1.87
	$i-C_4H_8$	2.76	4.49	21.96	7.82	22.72
	$n-C_4H_8$	-	-	3.00	1.62	9.14
	C_2H_5OH	10.64	7.55	10.06	5.73	8.24
	$i-C_3H_7OH$	67.37	73.50	24.24	71.05	31.73
	$n-C_3H_7OH$	5.07	4.73	16.35	5.37	19.41
	$t-C_4H_9OH$	1.64	1.79	6.72	2.09	2.24
	$2-C_4H_9OH$	2.95	1.07	8.62	4.18	2.85
	$n-C_4H_9OH$	1.86	2.13	6.50	1.71	1.80
	Total	100.0	100.0	100.0	100.0	100.0
Conversion of C_3H_6 (%) in Feed		.49	.79	.74	4.60	3.05
Space Time Yield of $i-C_3H_7OH$ (mol/l-cat.hr.)		.10	.19	.06	1.04	.21

Catalyst no.3 (mordenite)

Reaction Conditions:

P = 105 psig

GHSV = 8000 hr^{-1}

T = 200-300 °C

Reaction Temperature (°C)		200	230	260	280	300
Product Selectivity (%)	C_2H_4	69.89	26.51	7.54	11.15	1.82
	$i-C_4H_8$	4.18	12.72	8.26	13.53	22.03
	$n-C_4H_8$	2.39	3.63	3.35	5.17	11.18
	C_2H_5OH	1.85	2.81	3.4	4.61	2.23
	$i-C_3H_7OH$	14.46	45.59	72.78	54.50	26.02
	$n-C_3H_7OH$	7.19	5.07	3.01	6.16	14.93
	$t-C_4H_9OH$	-	.96	.66	2.01	5.56
	$2-C_4H_9OH$	-	1.82	.37	2.43	9.89
	$n-C_4H_9OH$	-	1.40	.59	1.38	6.39
	Total	100.0	100.0	100.0	100.0	100.0
Conversion of C_3H_6 (%) in Feed		.36	.95	2.77	3.7	5.81
Space Time Yield of $i-C_3H_7OH$ (mol/l-cat.hr)		.03	.22	1.02	1.02	.77

VITA

Miss Arunwan Punyaporn was born on January 1, 1962 in Samuthsakorn, Thailand. She graduated with a Bachelor Degree of Science in Chemical Technology from Chulalongkorn University in 1984.