REFERENCES

Ali, S.A., Ogunronbi, K.E., and Al-Khattaf, S.S. (2013) Kinetics of dealkylation–transalkylation of C9 alkyl-aromatics over zeolites of different structures. Chemical Engineering Research and Design, 91, 2601-2616.

Baerlocher, Ch. and McCusker, L.B. "Database of Zeolite Structures" International Zeolite Association. 10 Jan 2002. 2 June 2014 <http://www.iza-structure.org/databases>

Baran, R., Millot, Y., Onfroy, T., Krafft, J.M., and Dzwigaj, K. (2012) Influence of the nitric acid treatment on Al removal, framework composition and acidity of BEA zeolite investigated by XRD, FTIR and NMR. Microporous and Mesoporous Materials 163, 122-130.

Bi, J., Guo, X., Liu, M., and Wang, X. (2011) High effective dehydration of bio-ethanol into ethylene over nanoscale HZSM-5 zeolite catalysts. Catalysis Today, 149(1-2), 143–147.

Chen, Y., Wu, Y., Tao, L., Dai, B., Yang, M., Chen, Z., and Zhu, X. (2010) Dehydration reaction of bio-ethanol to ethylene over modified SAPO catalysts. Journal of Industrial and Engineering Chemistry, 16(5), 717-722.

Dergachev, A.A. and Lapidus, A.L. (2009) Catalytic aromatization of light alkanes. Russian Journal of General Chemistry, 79(6), 1244–1251.

Derouane, E.G., Nagy, J.B., Dejaifve, P., Van Hoof, J., Speckman, B.P., Védrine, J.C., and Naccache, C. (1978) Elucidation of mechanism of conversion of methanol and ethanol to hydrocarbons on a new type of synthesis zeolite. Journal of Catalysis, 53(1), 40-55.

Duan, C., Zhang, X., Zhou, R., Hua, Y., Zhang, L., and Chen J. (2013) Comparative studies of ethanol to propylene over HZSM-5/SAPO-34 catalysts prepared by hydrothermal synthesis and physical mixture. Fuel Processing Technology, 108, 31–40.

Dũng, N.A., Kaewkla, R., Wongkasemjit, S., and Jitkarnka, S. (2009) Light olefins and light oil production from catalytic pyrolysis of waste tire. Journal of Analytical and Applied Pyrolysis, 86, 281-286.

Egeblad, K., Christensen, C.H., Kustova, M., and Christensen, C.H. (2008) Templating mesoporous zeolites. Chemical Materials, 20(3), 946–960.

Furumoto, Y., Harada, Y., Tsunoji, N., Takahashi, A., Fujitani, T., Ide, Y., Sadakane, M., and Sano, T. (2011) Effect of acidity of ZSM-5 zeolite on conversion of ethanol to propylene. Applied Catalysis A: General, 399(1-2), 262–267.

González, M.D., Cesteros, Y., and Salagre, P. (2011) Comparison of dealumination of zeolites beta, mordenite and ZSM-5 by treatment with acid under microwave irradiation. Microporous and Mesoporous Materials, 144, 162-170.

Haveling, J., Nicolaides, C.P., and Scurrell, M.S. (1998) Catalysts and conditions for the highly efficient, selective and stable heterogeneous oligomerisation of ethylene. Applied Catalysis A: General, 173(10), 1-9.

Hulea, V. and Fajula, F. (2004) Ni-exchanged AlMCM-41—An efficient bifunctional catalyst for ethylene oligomerization. Journal of Catalysis, 225(1), 213-222.

Inaba, M., Murata, K., Saito, M., and Takahara, I. (2006) Ethanol conversion to aromatic hydrocarbons over several zeolite catalysts. Reaction Kinetics and Catalysis Letters, 88(1), 135–142.

Karlsson, A., Stocker, M., and Schmidt, R. (1999) Composites of micro- and mesoporous materials: simultaneous syntheses of MFI/MCM-41 like phases by a mixed template approach. Microporous and Mesoporous Materials, 27, 181-192.

Kittikarnchanaporn, J. (2014) Catalytic dehydration of Bio-ethanol to hydrocarbons : Oxide of P, Sb, and Bi . M.S. Thesis, The Petroleum and Petrochemical College, Chulalongkorn University, Bangkok, Thailand.

Li, H., He, S., Ma, K., Wu, Q., Jiao, Q., and Sun, K. (2013) Micro-mesoporous composite molecular sieves H-ZSM-5/MCM-41 for methanol dehydration to dimethyl ether: Effect of SiO2/Al2O3 ratio in H-ZSM-5. Applied Catalysis A General, 450, 152– 159.

Lin, H.P., Cheng, S., and Mou, C.Y. (1997) Effect of delayed neutralization on the synthesis of mesoporous MCM-41 molecular sieves. Microporous Materials, 10(1-3), 111-121.

Lindlar, B., Kogelbauer, A., and Prins, R. (2000) Chemical, structural, and catalytic characteristics of Al-MCM-41 prepared by pH-controlled synthesis Microporous and Mesoporous Materials, 38(2-3), 167-176.

Liu, Y., Zhang, W., and Pinnavaia, T.J. (2000) Steam-stable aluminosilicate mesostructures assembled from zeolite type Y seeds. Journal of American Chemical Society, 122, 8791-8792.

Liu, Y., Zhang, W., and Pinnavaia, T.J. (2001) Steam-stable MSU-S aluminosilicate mesostructure assembled from zeolite ZSM-5 and zeolite Beta-seeds. Angewandte Chemie International Edition, 40(7), 1255-1258.

Liu, Y. and Pinnavaia, T.J. (2004) Assembly of swormhole aluminosilicate mesostructures from zeolite seeds. Journal of Materials Chemistry, 14(7), 1099 –1103.

Lourenço, J.P., Fernandes, A., Henriques, C., and Ribeiro, M.F. (2006) Al-containing MCM-41 type materials prepared by different synthesis methods: Hydrothermal stability and catalytic properties. Microporous and Mesoporous Materials, 94(1-3), 56-65.

Luechinger, M., Frunz, L., Pirngruber, G.D., and Prins, R. (2003) A mechanistic explanation of the formation of high quality MCM-41 with high hydrothermal stability. Microporous and Mesoporous Materials, 64(1-3), 203-211.

Machado, N.R.C.F., Calsavara, V., Astrath, N.G.C., Matsuda, C.K., Junior, A.P., and Baesso, M.L. (2005) Obtaining hydrocarbons from ethanol over iron-modified ZSM-5 zeolites. Fuel, 84(16), 2064-2070.

Madeira, F.F., Gnep, N.S., Magnoux, P., Maury, S., and Cadran, N. (2009) Ethanol transformation over HFAU, HBEA and HMFI zeolites presenting similar brønsted acidity. Applied Catalysis A, 367(1-2), 39-46.

Madeira, F.F., Gnep, N.S., Magnoux, P., Vezin, H., Maury, S., and Cadran, N. (2010) Mechanistic insights on the ethanol transformation into hydrocarbons over HZSM-5 zeolite. Chemical Engineering Journal, 161(3), 403–408.

Madeira, F.F., Tayeb, K., Pinard, L., Vezin, H., and Maury, S. (2012) Ethanol transformation into hydrocarbons on ZSM-5 zeolites: Influence of Si/Al ratio on catalytic performances and deactivation rate: Study of the radical species role. Applied Catalysis A, General 443– 444, 171– 180.

Meng, T., Mao, D., Guo, Q., and Lu, G. (2012) The effect of crystal sizes of HZSM-5 zeolites in ethanol conversion to propylene. Catalysis Communications, 21, 52–57.

Mostafa, M.M.M., Rao, K.N., Harun, H.S., Basahel, S.N., and El-Maksod, I.H.A (2013) Synthesis and characterization of partiallyc rystalline nanosized ZSM-5 zeolites. Ceramics International, 39(1), 683-689.

Moreno, S. and Poncelet, G. (1997) Dealumination of small- and large-port mordenites: A comparative study. Microporous Materials, 12, 197-222.

Naik, S., Bui, V., Ryu, T., Miller, J., and Zmierczak, W. (2010) Al-MCM-41 as methanol dehydration catalyst. Applied Catalysis A: General, 381(1-2), 183–190.

Park, D.H., Kim, S.S., Pinnavaia, T.J., Tzompanzi, F., Prince, J., and Valente, J.S. (2011) Selective isobutene oligomerization by mesoporous MSU-S_{BEA} catalysts. Journal of Physical Chemistry, 115(13), 5809-5816.

Park, J.W. and Seo, G. (2009) IR study on methanol-to-olefin reaction over zeolites with different pore structures and acidities. Applied Catalysis A: General, 356(2), 180-188.

Pasomsub, S. (2013). Bio-Ethanol dehydration to liquid hydrocarbons. M.S. Thesis, The Petroleum and Petrochemical College, Chulalongkorn University, Bangkok, Thailand.

Perego, C. and Pollesel, P. (2009) Advances in aromatics processing using zeolite catalysts. Advances in Nanoporous Materials, 1, 97-149.

Pinard, L., H., S., Canaff, C., Madeira, F.F., Batonneau-Gener, I., Maury, S., Delpoux, O., Ben Tayeb, K., Pouilloux, Y., and Vezin, H (2013) Growth mechanism of coke on HBEA zeolite during ethanol transformation. Journal of Catalysis, 299, 284-297.

Ramasamy, K.K., Zhang, H., Sun, J., and Wang Y. (2014) Conversion of ethanol to hydrocarbons on hierarchical HZSM-5 zeolites. Catalysis Today, 238, 103-110.

Ramasamy, K.K. and Wang, Y. (2013) Catalyst activity comparison of alcohols over zeolites. Journal of Energy Chemistry, 22, 65-71.

Ramasamy, K.K. and Wang, Y. (2014) Ethanol conversion to hydrocarbons on HZSM-5: Effect of reaction conditions and Si/Al ratio on the product distributions. Catalysis Today, 237, 89-99.

Rashidi, H., Hamoule, T., Nikou, M.R.K., and Shariati, A. (2013) DME synthesis over MSU-S catalyst through methanol dehydration reaction. Iranian Journal of Oil & Gas Science and Technology, 2(4), 67-73.

Rownaghi, A., Rezaei, F., and Hedlund, J. (2011) Yield of gasoline-range hydrocarbons as a function of uniform ZSM-5 crystal size. Catalysis Communications, 14(1), 37–41.

Schwanke, A. J., Lopes, C.W., and Pergher, S.B.C. (2013) Synthesis of mesoporous material from chrysotile-derived silica. Materials Sciences and Applications, 4, 68-72.

Shen, Q., Zhu, X., Dong, J., and Zhu, Z. (2009) Hydrodealkylation of C9+ heavy aromatics to BTX over zeolite-supported nickel oxide and molybdenum oxide catalysts. Catalysis Letters, 129, 170-180.

Sujeerakulkai, S. and Jitkarnka, S. (2014) Bio-ethanol dehydration to hydrocarbons using Ga_2O_3/Beta zeolites with various Si/Al_2 ratios. Chemical Engineering Transactions, 39, 967-972.

Taguchi, A. and Schuth, F. (2005) Ordered mesoporous materials in catalysis. Microporous and Mesoporous Materials, 77(1), 1–45.

Takahara, I., Saito, M., Inaba, M., and Murata, K. (2005) Dehydration of ethanol into ethylene over solid acid catalysts. Catalysis Letters, 105(3-4), 249-252.

Takahashi, A., Xia, W., Nakamura, I., Shimada, H., and Fujitani, T. (2012) Effects of added phosphorus on conversion of ethanol to propylene over ZSM-5 catalysts. Applied Catalysis A: General, 423-424, 162-167.

Talukdar, A., Bhattacharyya, K., and Sivasanker, S. (1997) HZSM-5 catalysed conversion of aqueous ethanol to hydrocarbons. Applied Catalysis A: General, 148(2), 357-371.

Thanabodeekij, N., Sadthayanon, S., Gulari, E., and Wongkasemjit, S. (2006) Extremely high surface area of ordered mesoporous MCM-41 by atrane route. Materials Chemistry and Physics, 98, 131-137.

Trakarnpruk, W. (2013) Dehydration of ethanol over copper and cerium phosphotungstates supported on MCM-41. Mendeleev Communication, 23(3), 168-170.

Triantafyllidis, K.S., Iliopoulou, E.F., Antonakou, E.V., Lappas, A.A., Wang, H., and Pinnavaia, T.J. (2007) Hydrothermally stable mesoporous aluminosilicates (MSU-S) assembled from zeolite seeds as catalysts for biomass pyrolysis. Microporous and Mesoporous Materials, 99(1-2), 132–139.

Viswanadham, N., Saxena, S., Kumar, J., Sreenivasulu, P., and Nandan, D. (2012) Catalytic performance of nano crystalline H-ZSM-5 in ethanol to gasoline (ETG) reaction. Fuel, 95, 298–304.

Vu, D. V., Miyamoto, M., Nishiyama, N., Egashira, Y., and Ueyama, K. (2006) Selective formation of para-xylene over H-ZSM-5 coated with polycrystalline silicalite crystals. Journal of Catalysis, 243, 389-394.

Zhang, X., Wang, R., Yang, X., and Zhang, F. (2008) Comparison of four catalysts in the catalytic dehydration of ethanol to ethylene. Microporous and Mesoporous Materials, 116(1-3), 210-215.

APPENDICES

Appendix A Transmission Electron Microscopy Micrographs

TEM images were used to confirm the hexagonal structure of MSU-S_{ZSM-5} and MSU-S_{BEA} as shown in Figure A1 and Figure A2.

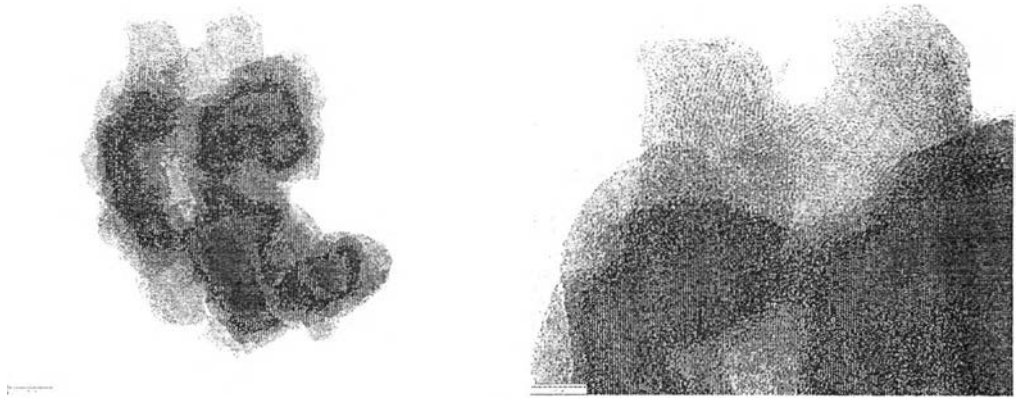

Figure A1 TEM images of MSU-S_{ZSM-5}

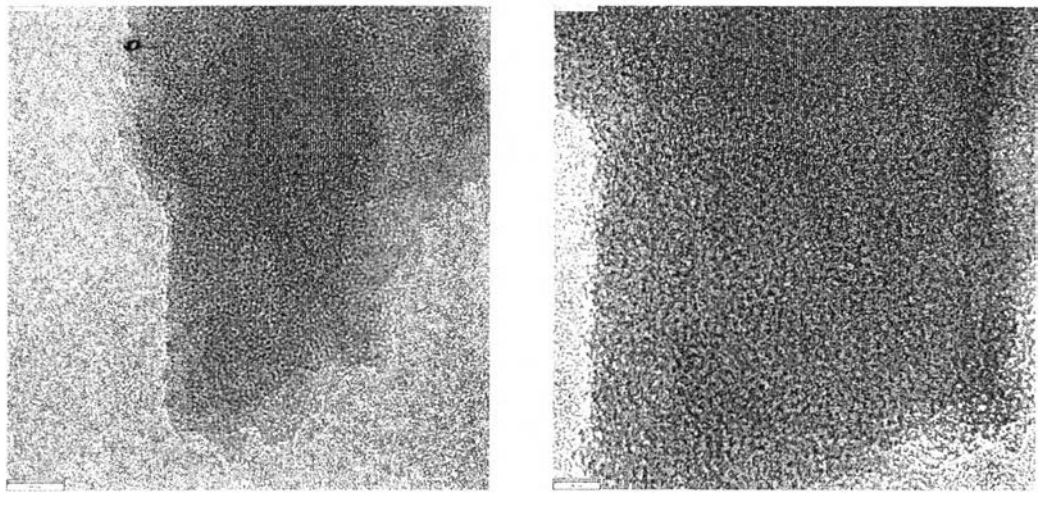

Figure A2 TEM images of MSU-S_{BEA}

Appendix B Product Distribution

Table B1 Product distributions from using HZSM-5, and HBeta catalysts at 8 h TOS.

Catalyst	HZSM-5	HBeta
Bio-ethanol Conversion	99.84	97.45
Product Yield (%wt)		
Gas	73.28	75.71
Oil	9.18	3.69
Water	17.54	20.60
Gas Composition (%wt)		
Methane	6.97	2.02
Carbon Dioxide	3.74	0.00
Ethylene	6.12	69.55
Ethane	6.75	5.93
Propane	65.74	2.57
Mixed C4	10.68	5.87
Oil Composition (%wt)		
Oxygenated	0.10	0.80
Non-Aromatics	1.57	2.41
Benzene	5.17	0.90
Toluene	26.36	9.58
o-Xylene	15.02	7.64
m-Xylene	9.14	10.90
p-Xylene	4.48	10.33
Ethylbenzene	4.11	5.66
C9 Aromatics	18.67	19.03
C10+ Aromatics	15.37	32.75

Table B2 Product distributions from using HB-S1, HB-S2, HB-S3, MSU-B-S1, MSU-B-S2, and MSU-B-S3 catalysts

Catalyst	HB-S1	HB-S2	HB-S3	MSU-B-S1	MSU-B-S2	MSU-B-S3
Bio-ethanol Conversion	99.6	99.53	99.49	99.80	99.97	99.87
Product Yield (%wt)						
Gas	82.45	83.00	80.13	75.52	72.81	83.22
Oil	1.64	1.12	1.18	1.26	1.64	0.82
Water	15.90	15.88	18.68	23.22	25.54	15.96
Gas Composition (%wt)						
Methane	0.99	0.81	0.41	0.00	0.00	0.00
Carbon Dioxide	0.00	0.00	0.00	0.00	0.00	0.00
Ethylene	83.59	86.30	91.98	99.70	99.91	98.95
Ethane	3.72	3.27	1.73	0.00	0.00	0.16
Propane	9.06	4.61	1.14	0.27	0.09	0.64
Mixed C4	2.63	2.25	1.28	0.03	0.00	0.24
Oil Composition (%wt)						
Oxygenated	0.25	5.06	8.84	2.27	2.49	2.45
Non-Aromatics	2.70	1.26	1.15	42.59	35.09	26.46
Benzene	0.39	2.53	6.72	0.14	0.06	0.10
Toluene	4.45	6.75	9.55	0.41	0.39	0.41
o-Xylene	4.24	3.54	3.44	1.92	1.40	1.19
m-Xylene	0.49	5.71	4.33	2.62	1.61	0.83
p-Xylene	28.89	17.61	16.82	1.43	0.54	0.57
Ethylbenzene	5.33	5.29	4.00	0.81	0.67	0.44
C9 Aromatics	21.62	22.09	24.91	11.86	12.98	16.39
C10+ Aromatics	31.64	30.17	20.23	35.96	44.75	51.16

Table B3 Product distributions from using MSU-Z-S1, MSU-Z-S2, MSU-Z-S3, and MSU-Z-S4 catalysts

Catalyst	MSU-Z-S1	MSU-Z-S2	MSU-Z-S3	MSU-Z-S4
Bio-ethanol Conversion	99.79	99.84	99.61	99.38
Product Yield (%wt)				
Gas	73.61	76.33	77.87	78.98
Oil	1.94	1.33	1.16	1.03
Water	24.45	22.34	20.97	19.99
Gas Composition (%wt)				
Methane	0.00	0.00	0.00	0.00
Carbon Dioxide	0.00	0.00	0.00	0.00
Ethylene	99.57	99.35	99.38	98.93
Ethane	0.21	0.32	0.35	0.75
Propane	0.22	0.27	0.24	0.27
Mixed C4	0.00	0.06	0.03	0.05
Oil Composition (%wt)				
Oxygenated	2.52	2.01	2.39	6.16
Non-Aromatics	1.29	0.45	1.16	0.56
Benzene	7.45	9.55	14.03	14.54
Toluene	1.34	1.59	1.42	1.49
o-Xylene	4.17	5.17	4.70	5.20
m-Xylene	3.15	3.59	3.37	3.99
p-Xylene	0.52	0.54	0.63	0.61
Ethylbenzene	1.20	1.51	1.36	1.29
C9 Aromatics	14.08	16.14	15.36	16.24
C10+ Aromatics	64.28	59.44	55.57	49.92

Table B4 Product distributions from using MSU-S_{BEA}, and MSU-S_{ZSM-5} catalysts at 8 h TOS

Catalyst	MSU-S_{BEA}	MSU-S_{ZSM-5}
Bio-ethanol Conversion	99.18	99.66
Product Yield (%wt)		
Gas	83.47	84.56
Oil	2.56	3.66
Water	13.97	11.78
Gas Composition (%wt)		
Methane	0.00	0.00
Carbon Dioxide	0.00	0.00
Ethylene	96.55	98.71
Ethane	0.50	0.55
Propane	2.18	0.74
Mixed C4	0.77	0.00
Oil Composition (%wt)		
Oxygenated	5.07	2.56
Non-Aromatics	44.22	1.55
Benzene	0.25	6.27
Toluene	0.88	7.10
o-Xylene	2.03	3.94
m-Xylene	3.82	3.88
p-Xylene	1.48	4.35
Ethylbenzene	0.96	1.32
C9 Aromatics	12.04	19.87
C10+ Aromatics	29.26	49.15

Table B5 Product distributions from using HB:MSU-B, and HZ:MSU-Z catalysts at 8 h TOS

Catalyst	HB:MSU-B	HZ:MSU-Z
Bio-ethanol Conversion	98.78	99.47
Product Yield (%wt)		
Gas	88.89	71.60
Oil	2.19	10.19
Water	8.89	18.21
Gas Composition (%wt)		
Methane	1.78	6.3
Carbon Dioxide	0.00	3.2
Ethylene	80.36	8.7
Ethane	5.16	5.9
Propylene	3.82	0.4
Propane	6.27	60.88
Mixed C4	2.81	14.6
Oil Composition (%wt)		
Oxygenated	0.55	0.26
Non-Aromatics	0.42	1.38
Benzene	3.63	6.62
Toluene	14.09	28.66
o-Xylene	9.48	12.96
m-Xylene	10.04	10.32
p-Xylene	6.69	10.76
Ethylbenzene	6.54	4.61
C9 Aromatics	25.77	12.67
C10+ Aromatics	22.79	11.74

Appendix C True Boiling Point Curves

Table C1 True boiling point curves of HZSM-5 and HBeta catalysts

%OFF	Boiling Point (°C)	
	HZSM-5	HBeta
0	75.4	76.6
5	76.2	105.1
10	76.5	105.6
15	104.8	106.8
20	105.5	135.1
25	105.8	138.0
30	106.1	138.1
35	106.3	138.6
40	106.5	141.5
45	106.7	143.1
50	106.8	159.0
55	107.1	159.7
60	137.9	165.0
65	138.5	166.8
70	138.9	181.1
75	139.2	190.2
80	143.0	206.8
85	158.1	220.7
90	165.9	250.7
95	226.0	267.6
100	254.0	280.8

Table C2 True boiling point curves of HB-S1, HB-S2, HB-S3, MSU-B-S1, MSU-B-S2, and MSU-B-S3 catalysts

%OFF	Boiling Point (°C)					
	HB-S1	HB-S2	HB-S3	MSU-B-S1	MSU-B-S2	MSU-B-S3
0	74.9	75.2	75.05	75.15	115.7	132.65
5	104.5	105	104.8	136.9	161.7	172.3
10	126.1	134.7	130.4	157.55	180.6	185.2
15	136.55	136.8	136.7	163.85	191.7	203.7
20	137.1	137.2	137.2	176.35	204.4	209.65
25	137.35	137.5	137.4	182.95	224.55	240.45
30	137.7	137.7	137.7	190.55	250.55	268.7
35	142.05	137.95	140	195.5	260.15	279.05
40	157.35	142.25	149.8	207.15	264.9	284.1
45	158	157.3	157.7	222.55	268.7	288.2
50	162.25	157.9	160.1	237.2	272.1	293.55
55	165.25	160.35	162.8	251.55	275.65	296.1
60	179.15	165.1	172.1	260	278.4	300.1
65	185.3	178.6	182.0	265.25	279	302.2
70	203.25	196.55	199.9	269.95	279.35	302.45
75	225.1	218.45	221.8	274.1	279.7	303.25
80	237.3	226.4	231.8	277.5	280.05	303.8
85	247.4	245.65	246.5	278.6	280.8	304.45
90	250.2	249.1	249.7	280.25	283.1	307.8
95	268.25	263.45	265.9	291.25	299.75	314.1
100	327.3	305.85	316.6	344.8	362.95	372.65

Table C3 True boiling point curves of MSU-Z-S1, MSU-Z-S2, MSU-Z-S3, and MSU-Z-S4 catalysts

%OFF	Boiling Point (°C)			
	MSU-Z-S1	MSU-Z-S2	MSU-Z-S3	MSU-Z-S4
0	71.95	69.6	69.6	69.9
5	103.1	78.4	97.7	82.3
10	136.35	134.65	136.2	135.35
15	156.15	141.55	156.35	140.8
20	159.8	158.55	163.55	157.25
25	164	164.05	164.6	163.6
30	170.55	172.3	178.05	164.55
35	178.3	179	182.7	177.2
40	182.65	183.55	184.6	181.15
45	184.3	190.5	191	183
50	190.6	191.3	191.65	189.45
55	191.15	192.25	196	191.5
60	191.7	199.4	201.8	196.25
65	197.45	208.05	208.55	200.85
70	206.25	222.75	222.7	210.5
75	212.3	234.4	227.75	223.75
80	223.55	251.6	248.2	243
85	243.5	271.2	267	263.35
90	265.55	284.8	282.3	278.9
95	287.5	303.7	300.2	296.3
100	339.15	347.95	349.45	326.75

Table C4 True boiling point curves of HZ-S1, HZ -S2, HZ -S3, and HZ -S4 catalysts

%OFF	Boiling Point (^{0}C)			
	HZ-S1	**HZ-S2**	**HZ-S3**	**HZ-S4**
0	75.5	75.75	74.65	74.4
5	76.4	76.7	75.75	75.55
10	77	104.95	104.65	104.3
15	105.45	106	105.5	104.9
20	106	106.4	105.95	105.2
25	106.35	106.75	106.25	105.5
30	106.65	107.05	106.55	105.7
35	106.85	107.3	106.75	105.9
40	107	107.5	107.05	106.1
45	107.2	107.75	107.3	136.5
50	107.4	137.8	138.05	137.4
55	137.5	138.7	138.7	137.9
60	138.65	139.25	139.15	138.25
65	139.1	139.55	139.45	138.5
70	139.45	139.9	139.75	138.9
75	139.8	143	143.25	142.65
80	143.6	143.9	157.35	157.6
85	159.75	160.2	165.15	164.7
90	169.85	166.45	173.15	177.35
95	217.65	201.7	220.55	220.95
100	268.4	258.5	271.8	271.05

Table C5 True boiling point curves of MSU-S_{BEA}, and MSU-S_{ZSM-5} catalysts

%OFF	Boiling Point (°C)	
	MSU-S_{BEA}	MSU-S_{ZSM-5}
0	87.7	75.1
5	134.6	90.5
10	155	136.8
15	162.1	140.6
20	169.4	158.6
25	179.8	161.7
30	186.6	165.2
35	189.8	165.9
40	197.9	175.6
45	208.5	181.2
50	222.5	183.9
55	240.9	185.6
60	253	192.2
65	260.2	192.9
70	264.8	195.0
75	269.6	201.8
80	275.3	210.2
85	276.9	226.0
90	277.5	251.6
95	278.7	288.4
100	291.8	337.9

Appendix D Petroleum Fractions

Table D1 Petroleum fractions of HZSM-5 and HBeta catalysts

Petroleum Fraction	Temperature (°C)	Catalysts	
		HZSM-5	HBeta
Gasoline	<149	82.6	37.3
Kerosene	149-232	13.0	34.4
Gas Oil	232-343	4.4	28.3
Light Vacuum Gas Oil	343-371	0.0	0.0

Table D2 Petroleum fractions of HB-S1, HB-S2, HB-S3, MSU-B-S1, MSU-B-S2, and MSU-B-S3 catalysts

Petroleum Fraction	Temperature (°C)	Catalysts					
		HB-S1	HB-S2	HB-S3	MSU-B-S1	MSU-B-S2	MSU-B-S3
Gasoline	<149	37.07	41.75	42.13	7.02	3.46	2.10
Kerosene	149-232	40.39	39.76	44.25	41.37	22.87	21.90
Gas Oil	232-343	22.54	18.49	13.62	51.61	72.23	73.62
Light Vacuum Gas Oil	343-371	0.00	0.00	0.00	0.00	1.44	2.38

Table D3 Petroleum fractions of MSU-Z-S1, MSU-Z-S2, MSU-Z-S3, and MSU-Z-S4 catalysts

Petroleum Fraction	Temperature (°C)	Catalysts			
		MSU-Z-S1	MSU-Z-S2	MSU-Z-S3	MSU-Z-S4
Gasoline	<149	12.73	17.21	12.73	18.02
Kerosene	149-232	69.6	57.18	63.91	59.44
Gas Oil	232-343	17.67	25.16	22.71	22.54
Light Vacuum Gas Oil	343-371	0.00	0.45	0.65	0.00

Table D4 Petroleum fractions of HZ-S1, HZ-S2, HZ-S3, and HZ-S4 catalysts

Petroleum Fraction	Temperature (°C)	Catalysts			
		HZ-S1	HZ -S2	HZ -S3	HZ -S4
Gasoline	<149	81.88	81.43	77.26	77.09
Kerosene	149-232	14.52	16.51	18.96	18.98
Gas Oil	232-343	3.6	2.06	3.78	3.93
Light Vacuum Gas Oil	343-371	0.00	0.00	0.00	0.00

Table D5 Petroleum fractions of MSU-S_{BEA}, and MSU-S_{ZSM-5} catalysts

Petroleum Fraction	Temperature (°C)	Catalysts	
		MSU-S_{BEA}	MSU-S_{ZSM-5}
Gasoline	<149	7.9	21.6
Kerosene	149-232	44.6	62.2
Gas Oil	232-343	47.5	16.2
Light Vacuum Gas Oil	343-371	0.00	0.0

Appendix E TGA Profiles

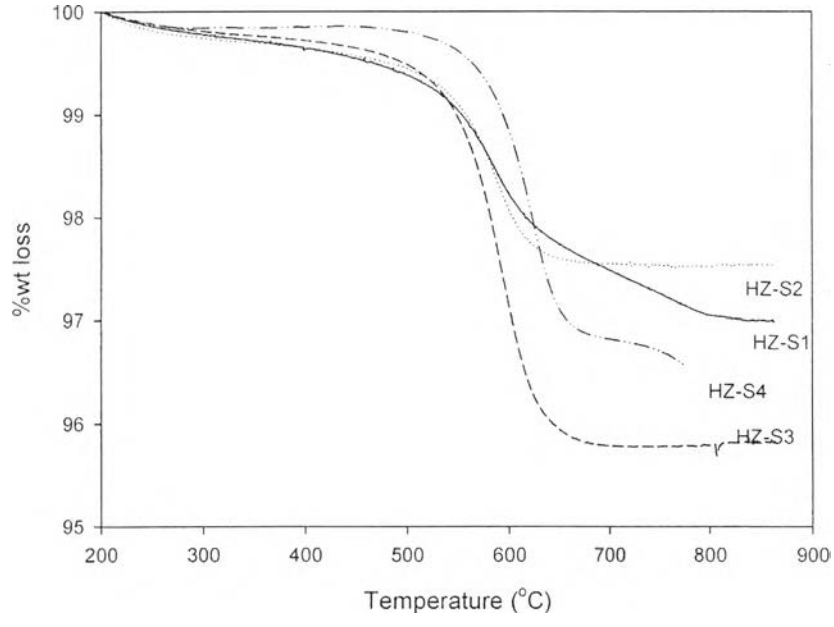

Figure E1 TGA profiles of HZ-S1, HZ-S2, HZ-S3, and HZ-S4.

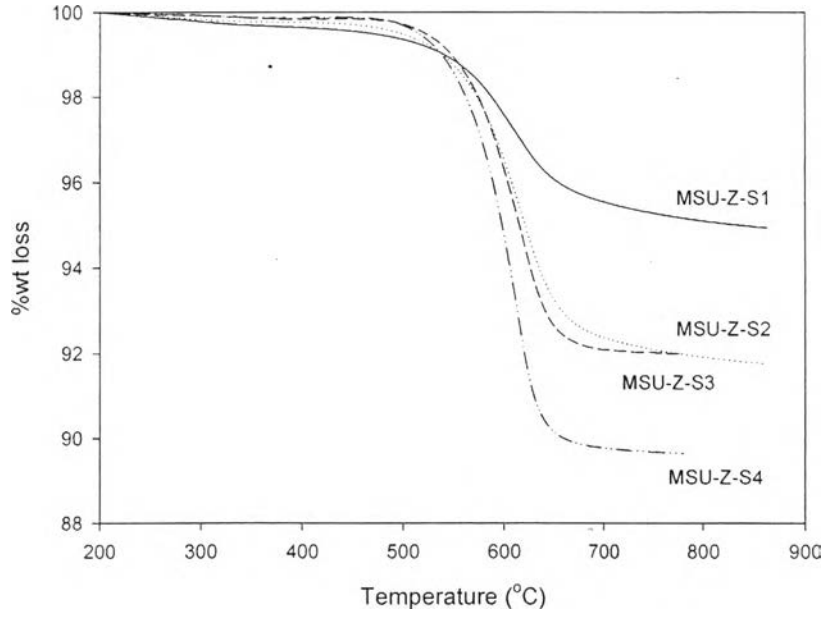

Figure E2 TGA profiles of MSU-Z-S1, MSU-Z -S2, MSU-Z -S3, and MSU-Z -S4.

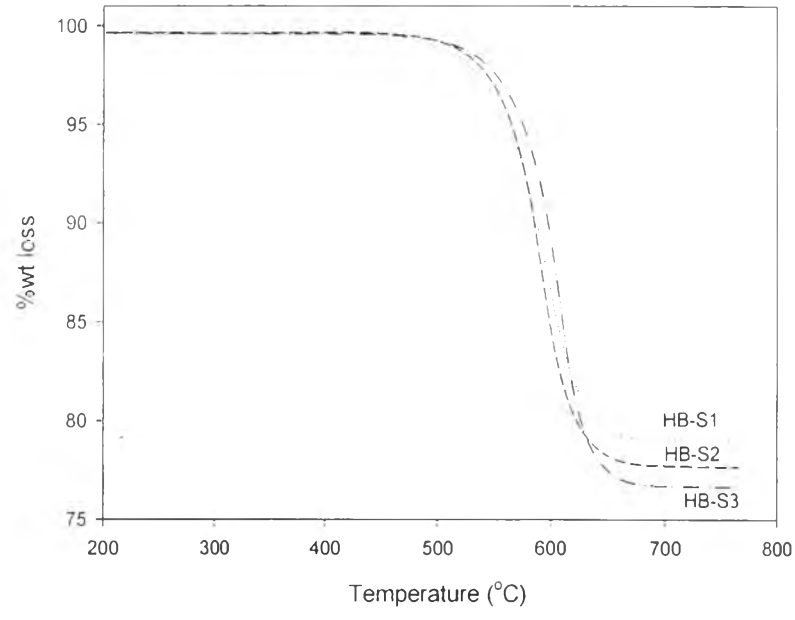

Figure E3 TGA profiles of HB-S1, HB-S2, and HB-S3.

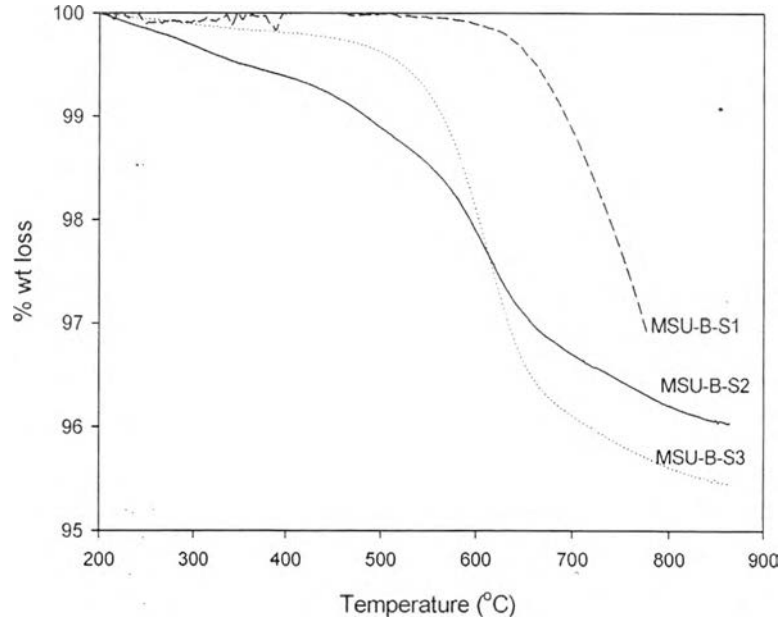

Figure E4 TGA profiles of MSU-B-S1, MSU-B-S2, and MSU-B-S3.

CURRICULUM VITAE

Name: Mr. Waranpong Choopun

Date of Birth: December 22, 1990

Nationality: Thai

University Education:

2009-2012 Bachelor Degree of Science (Industrial Chemistry), Faculty of Science, Chiang Mai University, Chiang Mai, Thailand

Work Experience:

March-May 2011 Position: Student Internship

Company name: Beer Thai 1991, Co., ltd.

Proceedings:

1. Choopun, W.; and Jitkarnka, S. (2015) Enhancing bio-kerosene and bio-gas oil production from bio-ethanol dehydration using the hierarchical mesoporous MSU-S_{ZSM5}. The Proceedings of The 18th Conference Process Integration, Modeling, and Optimization of Energy Saving and Pollution Reaction, Kuching, Sarawak, Malaysia
2. Choopun, W.; and Jitkarnka, S. (2015) Catalytic stability of the hierarchical mesoporous MSU-S_{ZSM-5} in bio-ethanol dehydration. The Proceedings of The 6th Research Symposium on Petrochemical and Materials Technology and The 21st PPC Symposium on Petroleum, Petrochemical, and Polymers, Bangkok, Thailand.

Presentation:

1. Choopun, W.; and Jitkarnka, S. (2015) Petrochemicals and fuels production using HBeta and hierarchical mesoporous MSU-S_{BEA} catalysts in bio-ethanol dehydration as a function of time-on-stream. Paper presented at Extended Abstract of The 5th Energy Science Technology, Karlsruhe Convention Centre, Karlsruhe, Germany.