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APPENDICES

Appendix A Temperature Profiles

Table A1 Pyrolysis conditions: Non-catalytic pyrolysis

Tire = 30.043 g, N_2 flow = 30 ml/min

Catalytic Temperature (T1): set value = 350 °C

Pyrolysis Temperature (T2): set value = 500 °C

Time (min)	T1	T2	Time (min)	T1	T2	Time (min)	T1	T2	Time (min)	T1	T2
2	38	28	**32**	358	501	**62**	350	501	**92**	348	497
4	40	45	**34**	343	493	**64**	353	499	**94**	348	501
6	60	76	**36**	353	505	**66**	350	499	**96**	350	499
8	87	115	**38**	354	496	**68**	348	501	**98**	354	499
10	122	166	**40**	347	505	**70**	349	501	**100**	345	499
12	163	222	**42**	348	496	**72**	354	499	**102**	343	500
14	208	283	**44**	351	502	**74**	360	500	**104**	344	499
16	249	342	**46**	340	500	**76**	352	499	**106**	350	501
18	289	408	**48**	345	501	**78**	350	503	**108**	349	500
20	333	446	**50**	345	499	**80**	346	501	**110**	354	500
22	296	471	**52**	350	498	**82**	351	499	**112**	352	500
24	323	505	**54**	352	500	**84**	349	501	**114**	354	500
26	347	501	**56**	357	500	**86**	347	498	**116**	352	501
28	362	488	**58**	353	498	**88**	352	500	**118**	353	499
30	348	495	**60**	347	503	**90**	348	501	**120**	353	499

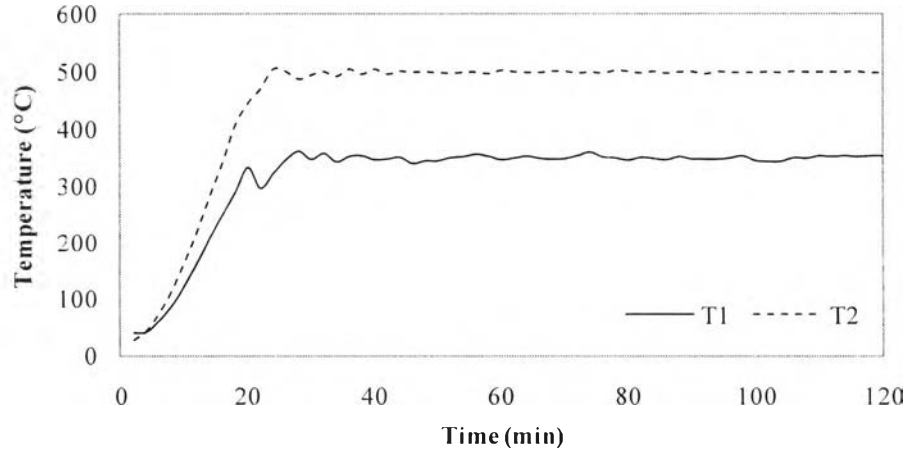

Figure A1 Temperature profiles of the non-catalytic pyrolysis.

Table A2 Pyrolysis conditions: Catalytic pyrolysis using Si-MCM-48

Tire = 30.020 g, N_2 flow = 30 ml/min

Catalytic Temperature (T1): set value = 350 °C

Pyrolysis Temperature (T2): set value = 500 °C

Time (min)	T1	T2	Time (min)	T1	T2	Time (min)	T1	T2	Time (min)	T1	T2
2	27	28	**32**	360	498	**62**	352	501	**92**	351	500
4	32	42	**34**	354	500	**64**	350	503	**94**	351	499
6	44	68	**36**	349	504	**66**	349	499	**96**	351	501
8	63	105	**38**	343	503	**68**	348	499	**98**	350	502
10	87	151	**40**	350	499	**70**	347	501	**100**	350	499
12	118	200	**42**	355	502	**72**	348	498	**102**	350	501
14	152	258	**44**	347	497	**74**	348	501	**104**	350	500
16	185	315	**46**	346	503	**76**	348	500	**106**	351	501
18	225	381	**48**	349	502	**78**	348	499	**108**	350	501
20	282	423	**50**	351	500	**80**	348	499	**110**	350	499
22	321	497	**52**	353	501	**82**	349	499	**112**	351	503
24	312	504	**54**	354	500	**84**	351	501	**114**	351	502
26	300	505	**56**	354	500	**86**	350	498	**116**	351	503
28	352	502	**58**	354	501	**88**	350	498	**118**	351	503
30	359	496	**60**	354	501	**90**	350	500	**120**	351	500

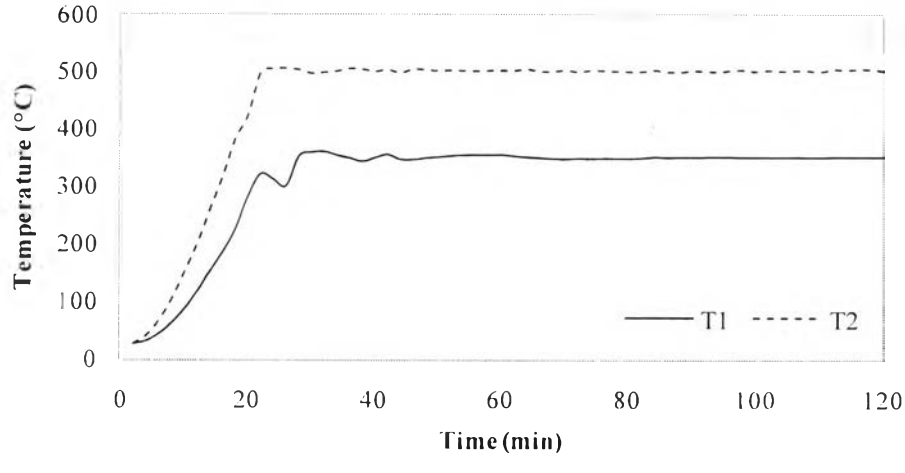

Figure A2 Temperature profiles of catalytic pyrolysis using Si-MCM-48.

Table A3 Pyrolysis conditions: Catalytic pyrolysis using Al-MCM-48 (82)

Tire = 30.009 g, N_2 flow = 30 ml/min

Catalytic Temperature (T1): set value = 350 °C

Pyrolysis Temperature (T2): set value = 500 °C

Time (min)	T1	T2	Time (min)	T1	T2	Time (min)	T1	T2	Time (min)	T1	T2
2	26	29	**32**	371	497	**62**	352	500	**92**	350	500
4	31	43	**34**	354	499	**64**	351	502	**94**	350	499
6	44	68	**36**	342	504	**66**	349	499	**96**	350	500
8	62	105	**38**	343	502	**68**	348	499	**98**	350	501
10	87	151	**40**	349	499	**70**	347	501	**100**	350	499
12	117	200	**42**	354	501	**72**	348	499	**102**	350	501
14	151	258	**44**	346	496	**74**	348	501	**104**	350	500
16	185	314	**46**	346	503	**76**	349	501	**106**	350	501
18	225	380	**48**	348	502	**78**	348	500	**108**	350	501
20	282	422	**50**	350	500	**80**	348	499	**110**	350	499
22	322	497	**52**	352	501	**82**	348	499	**112**	350	503
24	281	503	**54**	353	500	**84**	350	502	**114**	350	502
26	317	504	**56**	354	499	**86**	349	499	**116**	350	503
28	352	502	**58**	354	500	**88**	350	498	**118**	350	503
30	359	495	**60**	354	500	**90**	350	501	**120**	350	500

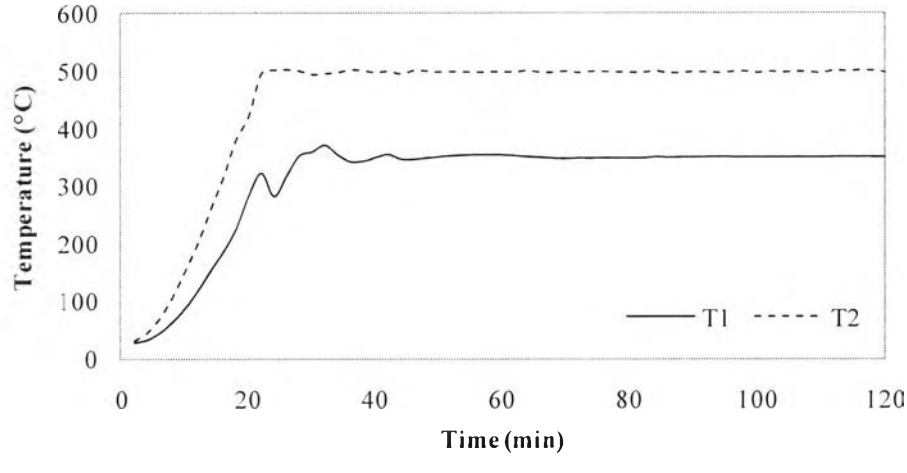

Figure A3 Temperature profiles of catalytic pyrolysis using Al-MCM-48 (82).

Table A4 Pyrolysis conditions: Catalytic pyrolysis using Al-MCM-48 (42)

Tire = 30.009 g, N_2 flow = 30 ml/min

Catalytic Temperature (T1): set value = 350 °C

Pyrolysis Temperature (T2): set value = 500 °C

Time (min)	T1	T2	Time (min)	T1	T2	Time (min)	T1	T2	Time (min)	T1	T2
2	25	24	**32**	367	494	**62**	342	502	**92**	351	501
4	31	35	**34**	357	501	**64**	346	502	**94**	351	500
6	44	57	**36**	344	504	**66**	352	500	**96**	351	500
8	62	93	**38**	347	504	**68**	356	500	**98**	349	501
10	86	134	**40**	354	498	**70**	355	500	**100**	349	500
12	118	186	**42**	358	500	**72**	354	500	**102**	351	500
14	148	241	**44**	349	497	**74**	352	499	**104**	350	501
16	185	295	**46**	347	501	**76**	350	500	**106**	349	501
18	224	353	**48**	354	501	**78**	351	500	**108**	349	499
20	262	414	**50**	357	500	**80**	350	500	**110**	349	500
22	326	459	**52**	356	498	**82**	348	501	**112**	351	500
24	275	497	**54**	347	500	**84**	349	499	**114**	352	499
26	314	505	**56**	353	500	**86**	349	501	**116**	349	500
28	354	500	**58**	360	499	**88**	350	500	**118**	349	501
30	378	497	**60**	357	499	**90**	351	500	**120**	348	500

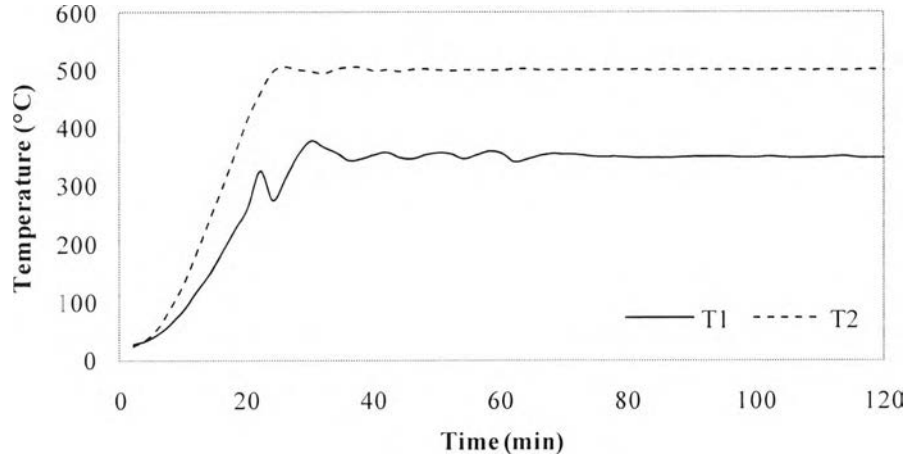

Figure A4 Temperature profiles of catalytic pyrolysis using Al-MCM-48 (42).

Table A5 Pyrolysis conditions: Catalytic pyrolysis using Al-MCM-48 (25)

Tire = 30.015 g, N_2 flow = 30 ml/min

Catalytic Temperature (T1): set value = 350 °C

Pyrolysis Temperature (T2): set value = 500 °C

Time (min)	T1	T2	Time (min)	T1	T2	Time (min)	T1	T2	Time (min)	T1	T2
2	27	27	**32**	353	507	**62**	353	498	**92**	345	499
4	31	40	**34**	357	495	**64**	346	500	**94**	344	501
6	41	65	**36**	348	497	**66**	350	503	**96**	344	500
8	58	97	**38**	342	505	**68**	353	498	**98**	345	500
10	79	140	**40**	342	500	**70**	355	500	**100**	347	502
12	105	188	**42**	343	499	**72**	351	499	**102**	352	500
14	135	242	**44**	345	500	**74**	352	502	**104**	355	497
16	162	295	**46**	350	501	**76**	354	499	**106**	354	500
18	194	352	**48**	355	500	**78**	356	499	**108**	351	501
20	256	410	**50**	358	499	**80**	355	501	**110**	348	501
22	338	456	**52**	345	496	**82**	355	500	**112**	345	500
24	317	497	**54**	339	502	**84**	355	500	**114**	344	500
26	356	505	**56**	343	503	**86**	352	500	**116**	343	498
28	369	498	**58**	350	500	**88**	350	500	**118**	344	501
30	348	500	**60**	355	500	**90**	347	500	**120**	344	500

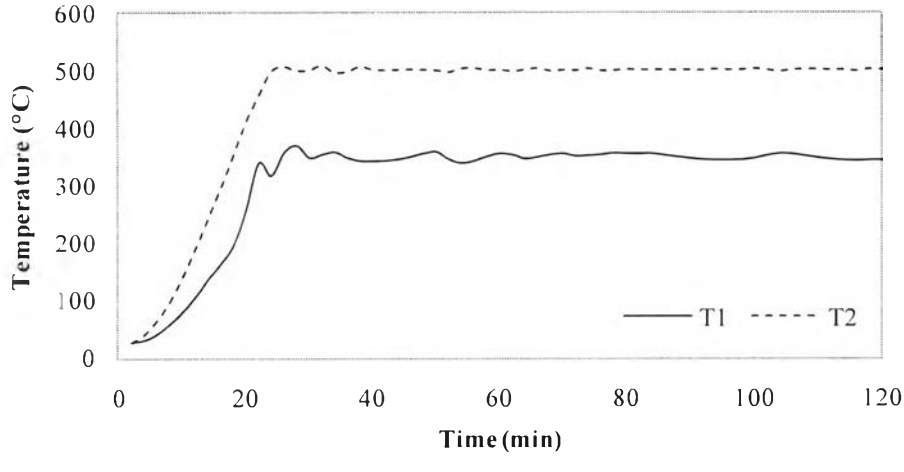

Figure A5 Temperature profiles of catalytic pyrolysis using Al-MCM-48 (25).

Table A6 Pyrolysis conditions: Catalytic pyrolysis using Si-MCM-48/HZSM-5

Tire = 30.016 g, N_2 flow = 30 ml/min

Catalytic Temperature (T1): set value = 350 °C

Pyrolysis Temperature (T2): set value = 500 °C

Time (min)	T1	T2	Time (min)	T1	T2	Time (min)	T1	T2	Time (min)	T1	T2
2	26	27	**32**	357	501	**62**	352	500	**92**	350	500
4	28	33	**34**	348	500	**64**	352	499	**94**	350	500
6	42	9	**36**	353	498	**66**	352	499	**96**	351	500
8	51	70	**38**	354	500	**68**	350	500	**98**	351	500
10	63	90	**40**	356	499	**70**	349	500	**100**	352	500
12	89	120	**42**	351	499	**72**	350	500	**102**	351	500
14	119	182	**44**	346	500	**74**	350	501	**104**	349	499
16	145	247	**46**	345	502	**76**	343	500	**106**	350	500
18	190	288	**48**	345	501	**78**	347	500	**108**	349	500
20	261	345	**50**	346	499	**80**	367	500	**110**	350	500
22	287	419	**52**	348	500	**82**	346	500	**112**	351	500
24	317	430	**54**	349	500	**84**	346	499	**114**	350	500
26	333	479	**56**	350	499	**86**	347	501	**116**	350	500
28	347	496	**58**	350	500	**88**	349	500	**118**	350	500
30	352	498	**60**	351	501	**90**	349	500	**120**	350	500

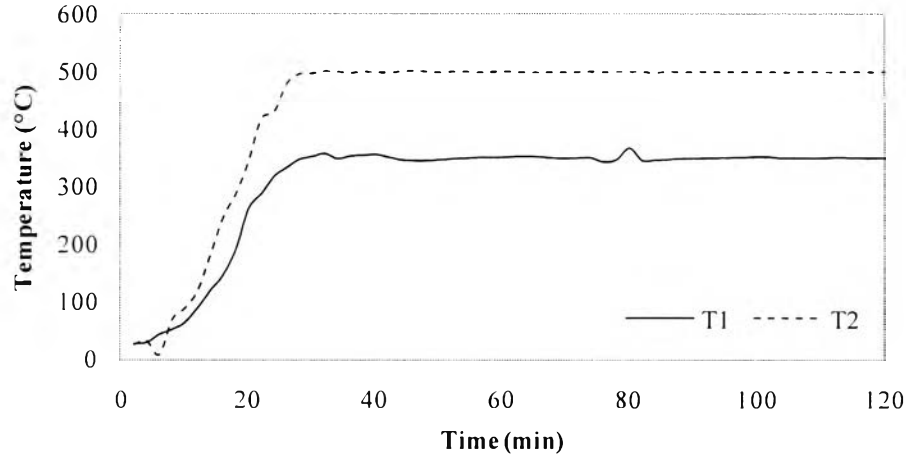

Figure A6 Temperature profiles of catalytic pyrolysis using Si-MCM-48/HZSM-5.

Table A7 Pyrolysis conditions: Catalytic pyrolysis using Si-MCM-48/HBETA

Tire = 30.004 g, N_2 flow = 30 ml/min

Catalytic Temperature (T1): set value = 350 °C

Pyrolysis Temperature (T2): set value = 500 °C

Time (min)	T1	T2	Time (min)	T1	T2	Time (min)	T1	T2	Time (min)	T1	T2
2	26	27	**32**	357	501	**62**	352	500	**92**	350	500
4	28	33	**34**	348	500	**64**	352	499	**94**	350	500
6	42	9	**36**	353	498	**66**	352	499	**96**	351	500
8	51	70	**38**	354	500	**68**	350	500	**98**	351	500
10	63	90	**40**	356	499	**70**	349	500	**100**	352	500
12	89	120	**42**	351	499	**72**	350	500	**102**	351	500
14	119	182	**44**	346	500	**74**	350	501	**104**	349	499
16	145	247	**46**	345	502	**76**	343	500	**106**	350	500
18	190	288	**48**	345	501	**78**	347	500	**108**	349	500
20	261	345	**50**	346	499	**80**	367	500	**110**	350	500
22	287	419	**52**	348	500	**82**	346	500	**112**	351	500
24	317	430	**54**	349	500	**84**	346	499	**114**	350	500
26	333	479	**56**	350	499	**86**	347	501	**116**	350	500
28	347	496	**58**	350	500	**88**	349	500	**118**	350	500
30	352	498	**60**	351	501	**90**	349	500	**120**	350	500

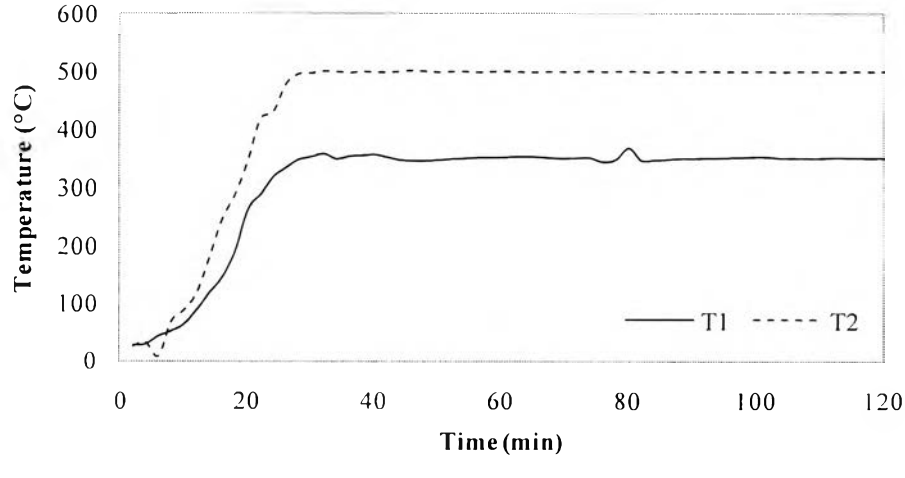

Figure A7 Temperature profiles of catalytic pyrolysis using Si-MCM-48/HBETA.

Table A8 Pyrolysis conditions: Catalytic pyrolysis using Si-MCM-48/HY

Tire = 30.008 g, N_2 flow = 30 ml/min

Catalytic Temperature (T1): set value = 350 °C

Pyrolysis Temperature (T2): set value = 500 °C

Time (min)	T1	T2	Time (min)	T1	T2	Time (min)	T1	T2	Time (min)	T1	T2
2	29	29	**32**	357	492	**62**	346	497	**92**	343	502
4	36	37	**34**	345	507	**64**	357	502	**94**	348	499
6	61	62	**36**	346	501	**66**	351	497	**96**	350	500
8	89	95	**38**	342	502	**68**	343	501	**98**	350	501
10	123	137	**40**	338	505	**70**	349	501	**100**	348	502
12	162	189	**42**	344	502	**72**	355	503	**102**	349	497
14	201	240	**44**	353	496	**74**	352	494	**104**	348	498
16	245	298	**46**	345	504	**76**	345	501	**106**	349	501
18	287	373	**48**	344	501	**78**	350	501	**108**	350	501
20	329	424	**50**	341	500	**80**	348	503	**110**	350	500
22	301	447	**52**	347	501	**82**	352	501	**112**	350	501
24	310	468	**54**	348	497	**84**	348	494	**114**	350	502
26	358	488	**56**	353	499	**86**	347	499	**116**	349	502
28	362	482	**58**	345	503	**88**	346	503	**118**	349	502
30	358	487	**60**	348	502	**90**	344	500	**120**	350	500

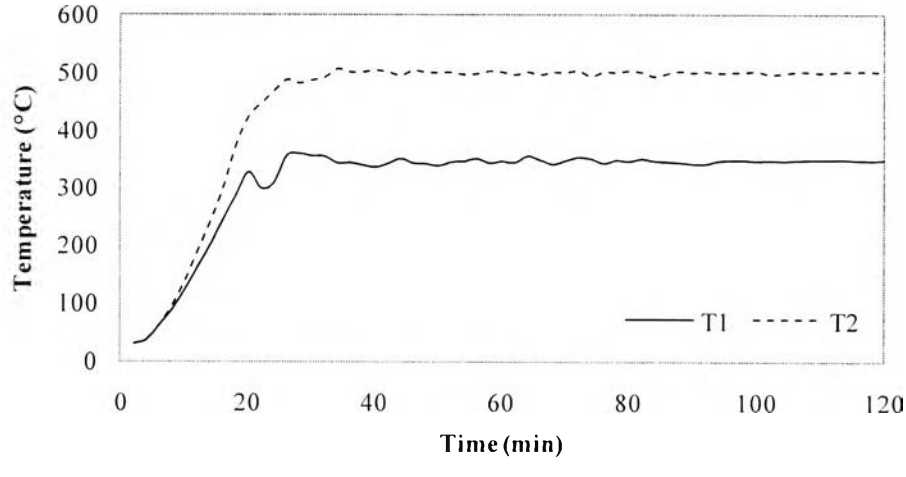

Figure A8 Temperature profiles of catalytic pyrolysis using Si-MCM-48/HY.

Appendix B Product Distribution

Table B1 Effect of mesoporous MCM-48 on product distribution (wt%)

	Non-Cat.	Si-MCM-48	Al-MCM-48 (82)	Al-MCM-48 (42)	Al-MCM-48 (25)
Gas	8.9	10.6	6.9	8.3	7.3
Liquid	46.2	38.9	43.3	43.3	43.8
Solid	44.9	43.7	43.2	43.1	42.9
Coke	-	6.8	6.6	5.4	6.0

Table B2 Effect of double beds of silica MCM-48 and zeolites on product distribution (wt%)

	Si-MCM-48/HZSM-5	Si-MCM-48/HBETA	Si-MCM-48/HY
Gas	11.2	5.7	5.6
Liquid	39.1	44.0	44.5
Solid	43.2	43.4	42.9
Coke	6.5	6.9	6.9

Table B3 Effect of mesoporous MCM-48 on product compositions (wt%)

	Non-Cat.	**Si-MCM-48**	**Al-MCM-48 (82)**	**Al-MCM-48 (42)**	**Al-MCM-48 (25)**
Gas Products					
Methane	2.0	2.3	1.5	1.6	1.4
Ethylene	0.8	1.0	0.7	0.7	0.6
Ethane	1.5	2.1	1.3	1.4	1.2
Propylene	0.9	1.1	0.8	0.9	0.7
Propane	0.8	1.2	0.7	0.8	0.7
Mixed-C_4	1.9	2.2	1.6	1.9	1.6
Mixed-C_5	1.0	0.8	0.8	01.0	0.7
Total	8.9	10.6	7.3	8.3	6.9
Petroleum Products					
Full range naphtha	13.4	19.7	20.4	16.1	18.8
Kerosene	11.3	10.5	12.9	12.8	12.0
Light gas oil	8.5	5.4	6.0	8.3	7.3
Heavy gas oil	7.0	2.5	2.8	4.5	4.4
Long residue	6.0	0.8	1.1	1.6	1.2
Total	46.2	38.9	43.3	43.3	43.8

Table B4 Effect of double beds of silica MCM-48 and zeolites on product compositions (wt%)

	Si-MCM-48/HZSM-5	**Si-MCM-48/HBETA**	**Si-MCM-48/HY**
Gas Products			
Methane	1.8	0.9	1.0
Ethylene	0.7	0.3	0.4
Ethane	1.5	0.7	0.9
Propylene	0.9	0.4	0.5
Propane	2.4	0.8	0.7
Mixed-C_4	2.8	1.8	1.4
Mixed-C_5	1.2	0.8	0.7
Total	11.2	5.7	5.6
Petroleum Products			
Full range naphtha	20.8	20.9	19.5
Kerosene	11.1	13.3	12.4
Light gas oil	5.2	6.7	7.8
Heavy gas oil	2.0	2.9	4.0
Long residue	0.0	0.3	0.8
Total	39.1	44.0	44.5

Appendix C Maltene Compositions

Table C1 Maltene compositions in mesoporous MCM-48 cases

	Non-Cat	Si-MCM-48	Al-MCM-48 (82)	Al-MCM-48 (42)	Al-MCM-48 (25)
P	2.94	3.52	4.01	4.02	4.16
Ole	9.39	10.08	8.04	8.75	6.95
Nap	15.53	13.52	10.21	10.24	7.49
Mono	47.74	54.26	56.22	53.18	56.31
Di	7.55	4.31	5.11	6.03	8.66
Poly	9.09	6.68	8.24	9.67	10.28
Polar	7.77	7.63	8.16	8.11	6.17

Table C2 Maltene compositions in double beds of silica MCM-48 and zeolite cases

	Si-MCM-48/HZSM-5	Si-MCM-48/HBETA	Si-MCM-48/HY
P	2.80	2.99	4.75
Ole	11.42	7.28	6.19
Nap	15.92	11.63	11.56
Mono	54.36	53.49	48.31
Di	5.61	8.31	8.07
Poly	4.95	9.31	13.17
Polar	4.93	6.99	7.95

P = Paraffins Ole = Olefins Nap = Naphthenes
Mono = Mono-aromatics Di = Di-aromatics Poly = Poly-aromatics
Polar = Polar-aromatics

Appendix D Sulfur-containing Compound Species in Oils

Table D1 Sulfur-containing compound species in oils in mesoporous MCM-48 cases

	Non-Cat	Si-MCM-48	Al-MCM-48 (82)	Al-MCM-48 (42)	Al-MCM-48 (25)
Thiophenes	0.74	0.96	0.69	0.62	0.62
Benzothiophenes	0.98	0.60	0.98	1.10	0.79
Dibenzothiophenes	0.05	0.02	0.02	0.03	0.03
Benzothiazoles	1.31	1.62	1.22	1.09	0.96
Isothiocyanates	0.59	0.34	0.56	0.56	0.36
Others	0.10	0.25	0.25	0.22	0.08

Table D2 Sulfur-containing compound species in oils in double beds of silica MCM-48 and zeolite cases.

	Si-MCM-48/HZSM-5	Si-MCM-48/HBETA	Si-MCM-48/HY
Thiophenes	0.7	0.8	0.5
Benzothiophenes	0.6	1.2	1.0
Dibenzothiophenes	0.0	0.1	0.1
Benzothiazoles	0.5	0.7	0.9
Isothiocyanates	0.0	0.3	0.4
Others	0.3	0.2	0.3

Appendix E Sulfur Analysis by Using S-Analyzer

Table E1 Effect of mesoporous MCM-48 on overall sulfur distribution (wt%)

	Non-Catalyst	Si-MCM-48	Al-MCM-48 (82)	Al-MCM-48 (42)	Al-MCM-48 (25)
Oil	29	16	26.14	24.05	21.89
Spent Catalyst	-	10	7.14	5.16	6.40
Gas	18	19	15.18	17.11	20.28
Char	53	55	51.53	53.68	51.44

Table E2 Effect of double beds of silica MCM-48 and zeolites on overall sulfur distribution (wt%)

	Si-MCM-48/HZSM-5	Si-MCM-48/HBETA	Si-MCM-48/HY
Oil	16.26	21.01	21.44
Spent Catalyst	20.16	14.06	12.84
Gas	11.19	13.71	14.79
Char	52.39	51.22	50.92

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Proceedings:

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