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## APPENDICES

### APPENDIX A Operating Temperature Profiles (°C)

**Table A1** Pyrolysis conditions: Non-catalytic Pyrolysis

Pyrolysis oils = 12.66 g

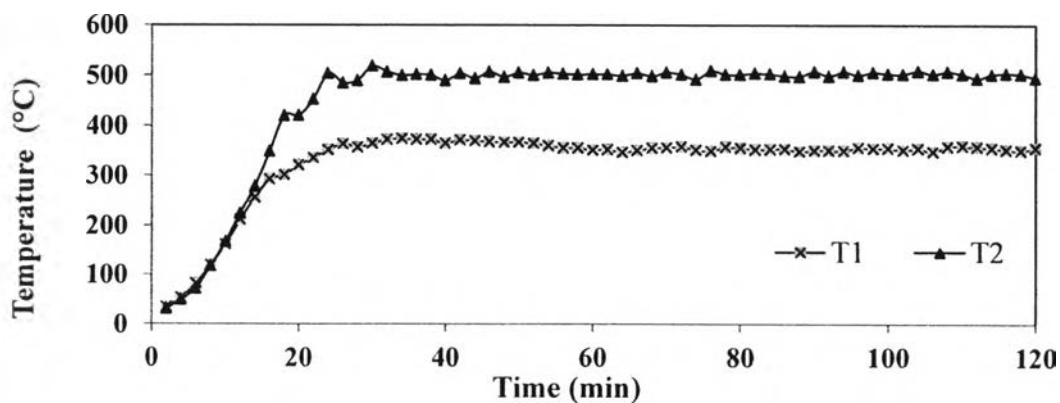
Pyrolysis gas = 3.91 g

Carbon black = 13.43 g

Time (min)	T1	T2	Time (min)	T1	T2	Time (min)	T1	T2	Time (min)	T1	T2
2	34.6	31.3	32	372.0	507.0	62	352.3	502.2	92	350.1	498.9
4	53.3	49.4	34	373.6	499.9	64	346.7	499.5	94	349.5	507.1
6	82.0	72.0	36	372.1	501.7	66	350.0	504.2	96	355.6	500.4
8	119.2	118.0	38	371.7	500.7	68	355.2	498.4	98	354.0	506.2
10	161.1	167.3	40	364.4	489.7	70	355.8	505.9	100	354.3	502.9
12	211.8	224.8	42	371.0	503.6	72	357.4	501.8	102	350.7	502.2
14	255.8	278.9	44	369.2	493.8	74	351.3	492.4	104	353.8	508.7
16	292.1	348.7	46	367.5	507.2	76	348.9	508.9	106	347.8	502.3
18	301.3	419.6	48	366.3	496.9	78	356.7	501.8	108	357.9	507.3
20	321.0	420.1	50	366.1	505.2	80	355.0	501.7	110	358.7	502.2
22	335.3	452.8	52	364.5	500.7	82	352.3	504.3	112	357.1	494.0
24	351.3	503.3	54	359.7	505.4	84	352.7	502.8	114	354.3	501.8
26	363.0	485.1	56	355.4	503.1	86	353.0	498.4	116	351.3	503.9
28	356.6	490.2	58	355.0	501.8	88	348.2	497.8	118	349.4	502.4
30	364.4	518.4	60	351.0	502.1	90	350.3	507.3	120	355.1	495.2

\*T1 = Catalytic temperature

\*\*T2 = Pyrolysis temperature



**Figure A1** Temperature profiles of non-catalytic pyrolysis.

**Table A2** Pyrolysis conditions: Catalytic Pyrolysis using KL zeolite

Pyrolysis oils = 10.40 g

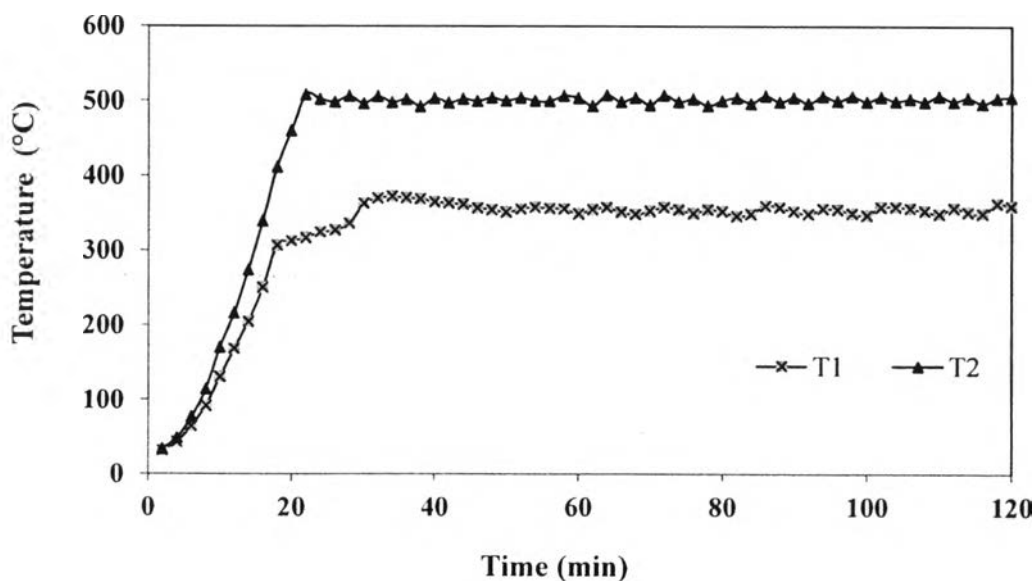
Pyrolysis gas = 5.63 g

Carbon black = 13.97 g

Time (min)	T1	T2	Time (min)	T1	T2	Time (min)	T1	T2	Time (min)	T1	T2
2	31.3	33.7	32	369.5	505.5	62	354.9	493.3	92	348.8	496.8
4	42.9	48.2	34	372.1	497.9	64	357.7	507.4	94	356.0	506.1
6	64.2	76.8	36	370.2	502.1	66	351.2	498.5	96	354.7	499.8
8	91.7	114.5	38	368.7	492.5	68	348.4	504.1	98	349.9	506.0
10	130.7	170.2	40	364.9	503.3	70	352.7	494.5	100	347.4	499.0
12	168.6	216.3	42	363.0	497.2	72	357.5	507.2	102	358.2	505.4
14	204.4	273.5	44	361.5	502.2	74	354.8	498.4	104	358.6	499.5
16	249.9	339.3	46	357.0	499.5	76	349.7	502.5	106	356.3	502.7
18	306.4	411.1	48	354.4	504.0	78	354.9	493.4	108	353.2	498.6
20	312.2	460.0	50	350.8	499.8	80	352.2	500.0	110	348.7	506.1
22	316.4	507.8	52	355.3	503.8	82	346.2	504.0	112	357.0	499.1
24	324.2	502.1	54	357.8	499.8	84	348.7	496.6	114	351.0	504.1
26	326.8	498.1	56	356.0	499.4	86	359.9	506.6	116	349.3	496.3
28	336.0	505.9	58	355.4	506.3	88	357.5	498.5	118	362.5	503.7
30	362.5	496.4	60	349.1	503.6	90	352.3	504.6	120	359.4	504.7

\*T1 = Catalytic temperature

\*\*T2 = Pyrolysis temperature

**Figure A2** Temperature profiles of catalytic pyrolysis (KL zeolite).

**Table A3** Pyrolysis conditions: Catalytic Pyrolysis using 1%MoO<sub>3</sub>/KL

Pyrolysis oils = 12.57 g

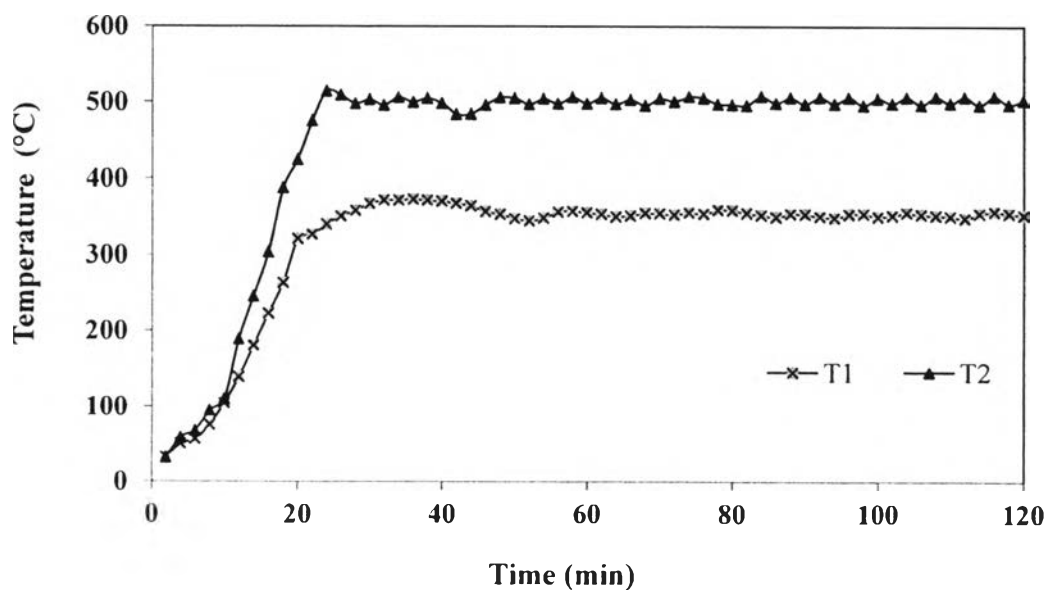
Pyrolysis gas = 4.61 g

Carbon black = 12.82 g

Time (min)	T1	T2	Time (min)	T1	T2	Time (min)	T1	T2	Time (min)	T1	T2
2	32.7	39.1	32	382.1	495.2	62	366.6	501.1	92	353.3	499.9
4	49.3	63.7	34	380.0	505.7	64	365.1	499.1	94	355.5	500.8
6	74.7	103.6	36	381.1	497.5	66	364.3	498.8	96	357.7	501.2
8	108.8	151.1	38	383.8	495.1	68	359.0	499.7	98	354.9	500.5
10	146.0	204.8	40	381.2	498.2	70	358.9	500.3	100	353.8	499.7
12	193.3	264.7	42	380.7	500.6	72	357.4	501.2	102	351.4	498.8
14	238.1	319.4	44	377.9	498.5	74	353.3	501.0	104	350.9	497.7
16	291.7	381.8	46	376.7	500.4	76	353.0	503.7	106	350.8	498.3
18	340.0	447.0	48	373.4	501.1	78	348.8	503.4	108	350.1	500.3
20	376.4	487.3	50	370.0	500.3	80	349.2	502.3	110	349.9	502.5
22	370.0	493.8	52	368.8	499.7	82	350.0	501.1	112	352.8	503.4
24	363.0	501.9	54	367.2	499.1	84	348.4	499.5	114	355.8	500.0
26	367.7	502.1	56	368.7	498.3	86	349.8	498.2	116	353.8	501.7
28	371.0	503.9	58	369.0	499.2	88	349.9	497.3	118	350.9	501.7
30	380.0	500.0	60	367.1	500.4	90	349.2	498.7	120	348.9	498.6

\*T1 = Catalytic temperature

\*\*T2 = Pyrolysis temperature

**Figure A3** Temperature profiles of catalytic pyrolysis (1%MoO<sub>3</sub>/KL).



**Table A4** Pyrolysis conditions: Catalytic Pyrolysis using 2%MoO<sub>3</sub>/KL

Pyrolysis oils = 12.14 g

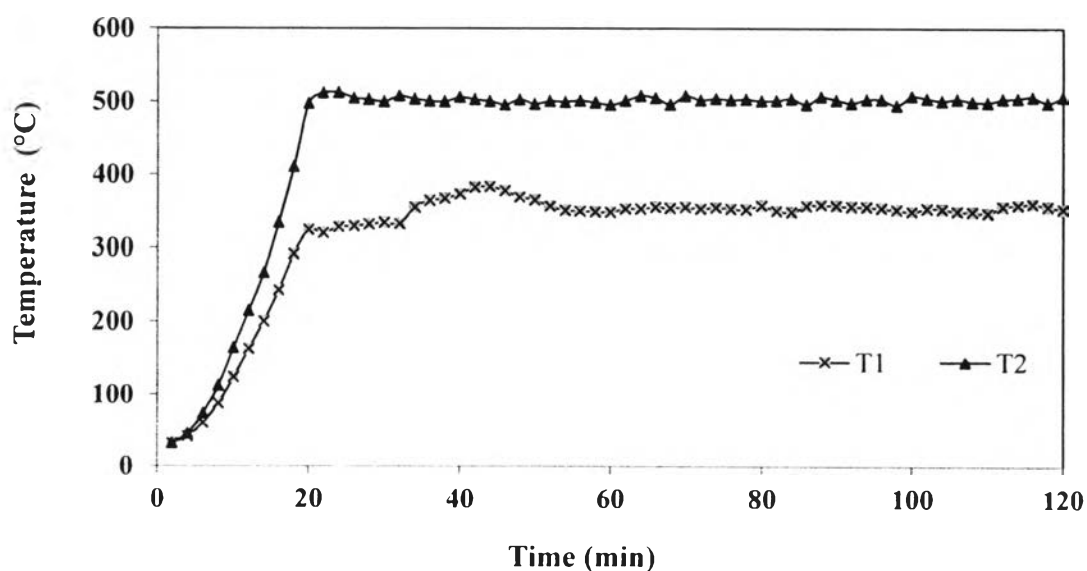
Pyrolysis gas = 4.66 g

Carbon black = 13.20 g

Time (min)	T1	T2	Time (min)	T1	T2	Time (min)	T1	T2	Time (min)	T1	T2
2	30.0	30.7	32	383.8	505.5	62	352.2	502.3	92	349.6	499.2
4	50.7	60.3	34	383.6	495.1	64	353.0	501.2	94	351.0	498.5
6	70.8	90.8	36	380.0	498.2	66	351.1	502.5	96	349.9	499.9
8	101.7	125.6	38	377.0	500.3	68	350.0	503.7	98	347.4	498.2
10	140.5	185.4	40	373.0	500.0	70	350.3	503.5	100	349.6	501.3
12	190.8	256.7	42	371.1	500.3	72	349.8	502.1	102	348.8	503.4
14	243.3	308.8	44	368.0	499.6	74	348.8	501.3	104	349.7	502.1
16	292.5	368.2	46	366.7	500.1	76	349.7	500.2	106	349.5	502.8
18	357.0	422.0	48	360.5	501.1	78	348.5	499.7	108	349.9	503.0
20	356.6	450.3	50	358.7	499.8	80	349.9	499.2	110	350.0	502.6
22	354.3	469.0	52	357.6	498.9	82	350.0	498.2	112	351.1	501.2
24	352.0	500.8	54	355.2	500.0	84	351.1	498.5	114	350.3	500.8
26	360.5	503.6	56	353.4	499.8	86	350.2	498.6	116	349.6	500.1
28	366.5	504.9	58	351.1	500.7	88	352.3	497.6	118	349.8	500.0
30	373.9	498.2	60	353.7	500.0	90	353.4	499.4	120	349.8	499.7

\*T1 = Catalytic temperature

\*\*T2 = Pyrolysis temperature

**Figure A4** Temperature profiles of catalytic pyrolysis (2%MoO<sub>3</sub>/KL).

**Table A5** Pyrolysis conditions: Catalytic Pyrolysis using 3%MoO<sub>3</sub>/KL

Pyrolysis oils = 12.48 g

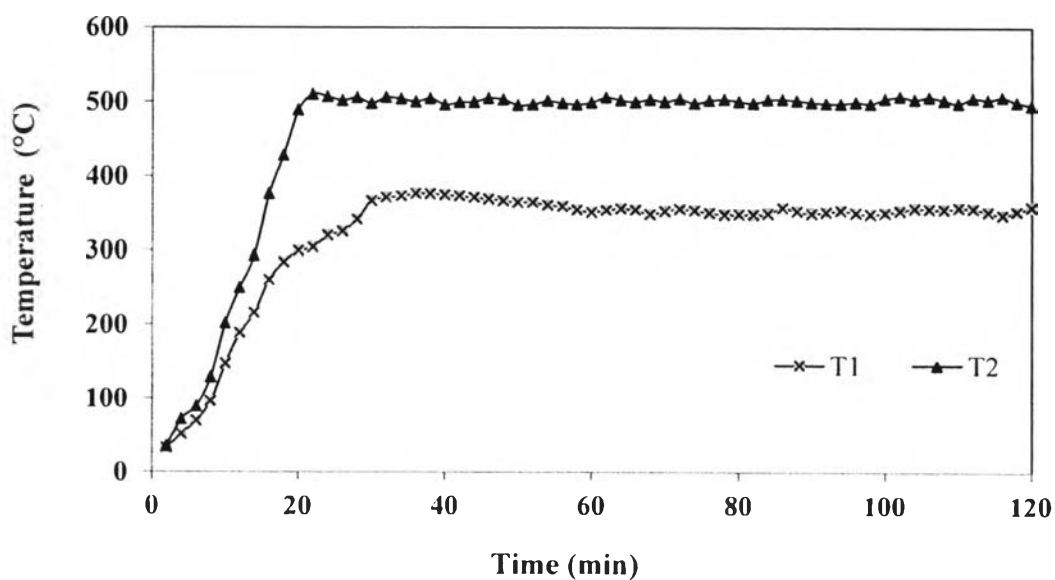
Pyrolysis gas = 4.59 g

Carbon black = 12.93 g

Time (min)	T1	T2	Time (min)	T1	T2	Time (min)	T1	T2	Time (min)	T1	T2
2	31.0	31.9	32	363.3	505.1	62	358.7	502.4	92	349.8	501.3
4	49.1	58.6	34	353.1	494.8	64	358.5	503.5	94	349.7	503.0
6	68.7	87.6	36	362.7	500.0	66	358.8	502.6	96	348.8	502.8
8	90.3	122.4	38	363.4	508.1	68	358.7	501.5	98	349.7	503.5
10	114.0	154.2	40	364.7	499.9	70	358.0	502.3	100	348.8	502.8
12	152.4	200.7	42	364.3	500.0	72	357.7	501.6	102	349.7	501.8
14	192.7	264.7	44	364.8	499.6	74	355.7	502.8	104	348.3	502.0
16	240.0	320.6	46	361.9	498.5	76	352.2	501.1	106	348.0	502.9
18	292.4	380.4	48	362.0	500.3	78	351.1	499.3	108	349.6	501.4
20	303.8	405.6	50	361.9	499.0	80	350.0	498.8	110	349.8	499.0
22	317.0	435.6	52	360.5	500.1	82	350.5	498.0	112	350.3	498.7
24	320.5	474.2	54	359.7	501.4	84	351.1	498.9	114	351.1	499.0
26	324.1	503.7	56	359.2	500.0	86	353.0	499.0	116	352.3	500.0
28	340.2	499.9	58	359.0	502.4	88	351.3	500.6	118	351.8	499.7
30	346.8	500.5	60	358.9	503.3	90	350.0	500.9	120	352.4	500.2

\*T1 = Catalytic temperature

\*\*T2 = Pyrolysis temperature

**Figure A5** Temperature profiles of catalytic pyrolysis (3%MoO<sub>3</sub>/KL).

**Table A6** Pyrolysis conditions: Catalytic Pyrolysis using 5%MoO<sub>3</sub>/KL

Pyrolysis oils = 10.69 g

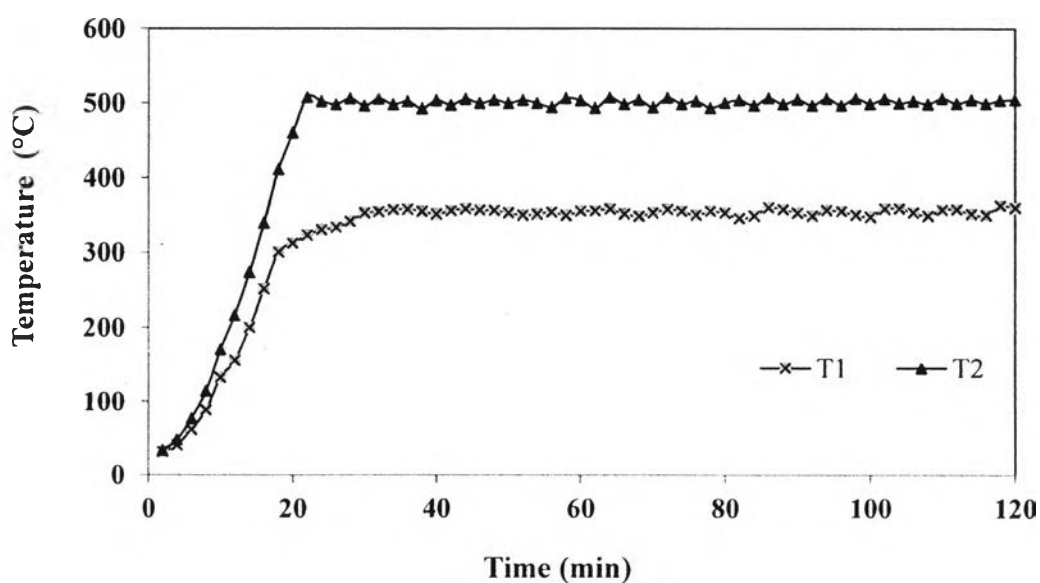
Pyrolysis gas = 6.23 g

Carbon black = 13.08 g

Time (min)	T1	T2	Time (min)	T1	T2	Time (min)	T1	T2	Time (min)	T1	T2
2	31.4	35.6	32	345.2	492.1	62	353.3	502.0	92	348.9	501.1
4	43.4	49.9	34	361.7	500.1	64	353.9	503.2	94	349.6	503.3
6	62.5	80.2	36	367.6	501.5	66	352.0	501.3	96	348.7	501.3
8	90.1	121.8	38	357.9	498.6	68	351.2	502.1	98	348.9	503.5
10	128.1	172.3	40	368.7	497.5	70	350.3	503.4	100	349.9	503.3
12	171.3	231.1	42	369.1	500.2	72	350.1	501.8	102	350.0	499.0
14	220.3	296.3	44	372.1	499.3	74	350.7	499.9	104	350.2	498.4
16	275.5	358.7	46	367.2	500.2	76	350.0	498.8	106	350.4	497.9
18	327.7	425.3	48	365.1	500.6	78	351.1	498.3	108	351.6	498.2
20	345.4	464.9	50	362.6	501.6	80	352.9	499.3	110	352.0	501.1
22	334.4	499.3	52	361.4	499.8	82	351.3	500.0	112	350.2	500.2
24	336.0	501.3	54	359.2	499.6	84	350.0	502.2	114	350.5	500.7
26	339.0	499.6	56	356.2	498.0	86	349.9	501.4	116	351.3	501.4
2	31.4	35.6	32	345.2	492.1	62	353.3	502.0	92	348.9	501.1
4	43.4	49.9	34	361.7	500.1	64	353.9	503.2	94	349.6	503.3

\*T1 = Catalytic temperature

\*\*T2 = Pyrolysis temperature

**Figure A6** Temperature profiles of catalytic pyrolysis (5%MoO<sub>3</sub>/KL).

**Table A7** Pyrolysis conditions: Catalytic Pyrolysis using 10%MoO<sub>3</sub>/KL

Pyrolysis oils = 10.71 g

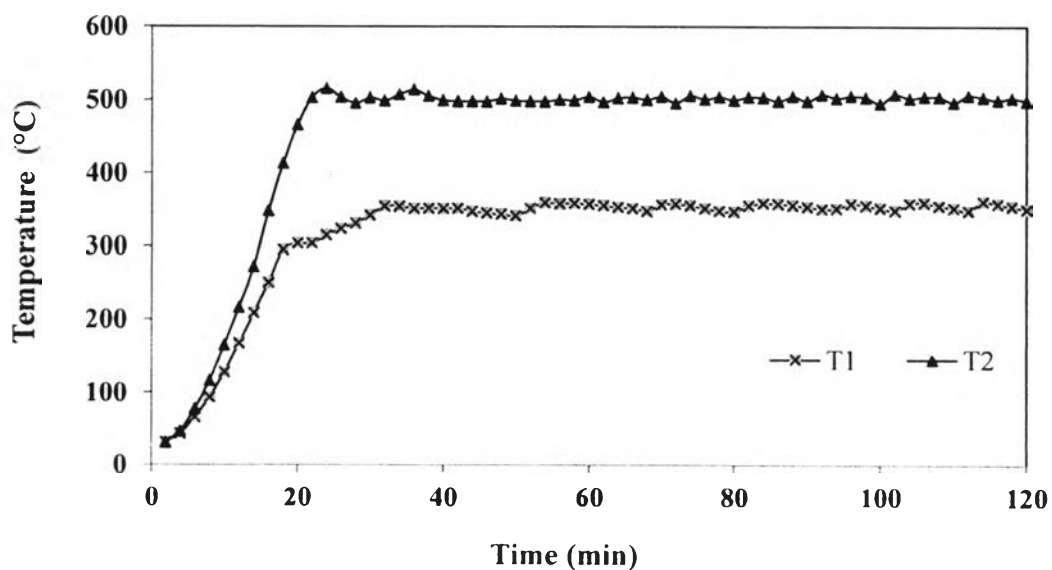
Pyrolysis gas = 6.21 g

Carbon black = 13.08 g

Time (min)	T1	T2	Time (min)	T1	T2	Time (min)	T1	T2	Time (min)	T1	T2
2	30.4	30.4	32	355.0	501.4	62	351.0	498.8	92	349.1	500.0
4	38.8	43.4	34	357.5	499.0	64	350.0	498.6	94	348.9	500.3
6	54.5	64.9	36	361.0	499.1	66	350.2	499.4	96	349.5	499.8
8	78.7	106.1	38	363.3	499.5	68	350.1	500.1	98	347.9	498.7
10	109.9	153.4	40	365.4	499.3	70	350.4	500.3	100	350.4	499.2
12	147.9	208.1	42	366.7	498.3	72	349.9	500.7	102	350.0	499.2
14	186.6	264.4	44	365.9	500.0	74	349.2	501.3	104	350.8	500.0
16	234.5	332.7	46	363.1	501.1	76	348.9	503.2	106	350.7	501.4
18	279.6	386.2	48	360.0	500.3	78	347.5	502.5	108	350.8	502.4
20	335.5	439.1	50	359.1	502.8	80	348.6	503.7	110	351.1	502.3
22	345.5	484.2	52	358.9	502.5	82	349.6	504.0	112	351.9	501.8
24	347.0	510.2	54	357.1	501.6	84	350.0	503.3	114	350.2	503.3
26	346.2	502.0	56	355.0	500.8	86	351.1	502.1	116	350.7	501.3
28	348.2	502.8	58	354.1	499.1	88	351.3	501.6	118	349.7	500.0
30	350.5	506.6	60	353.2	499.7	90	350.1	502.8	120	349.9	500.2

\*T1 = Catalytic temperature

\*\*T2 = Pyrolysis temperature

**Figure A7** Temperature profiles of catalytic pyrolysis (10%MoO<sub>3</sub>/KL).

**Table A8** Pyrolysis conditions: Catalytic Pyrolysis using 0.25%Re/KL

Pyrolysis oils = 10.50 g

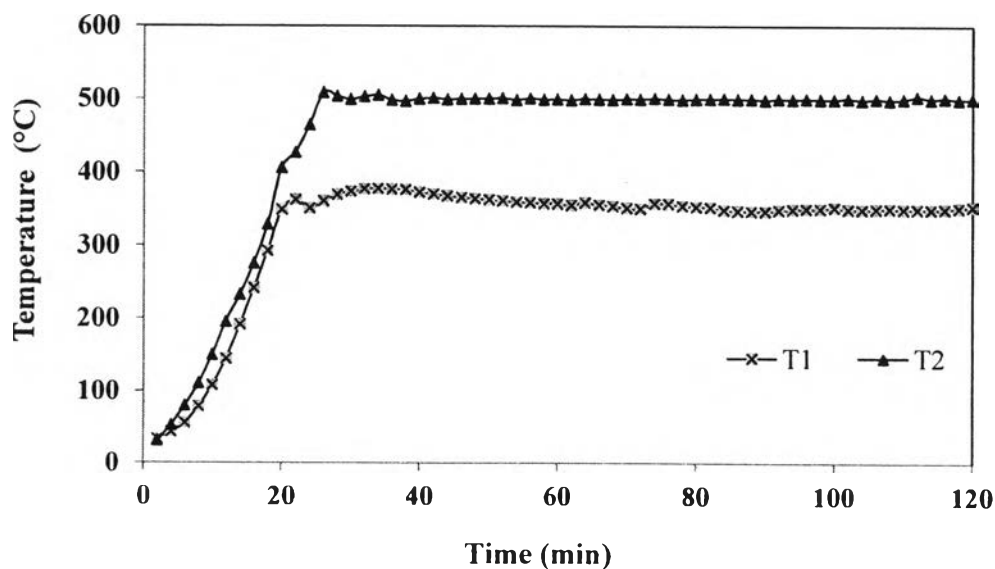
Pyrolysis gas = 6.25 g

Carbon black = 13.25 g

Time (min)	T1	T2	Time (min)	T1	T2	Time (min)	T1	T2	Time (min)	T1	T2
2	30.5	30.6	32	354.9	501.4	62	352.5	500.9	92	350.1	499.2
4	41.2	45.0	34	356.1	499.7	64	350.4	500.3	94	348.6	500.4
6	60.0	70.8	36	360.0	494.7	66	351.3	498.8	96	347.3	499.9
8	89.0	107.4	38	363.7	499.2	68	357.9	500.8	98	347.2	499.8
10	108.9	150.5	40	365.5	500.9	70	357.1	499.1	100	347.5	500.6
12	154.0	195.3	42	367.1	501.2	72	354.9	499.2	102	348.7	499.2
14	193.0	244.5	44	364.9	500.7	74	352.5	499.5	104	349.2	500.0
16	241.0	291.3	46	362.2	501.1	76	350.9	500.0	106	349.4	500.5
18	288.0	354.4	48	360.0	500.1	78	345.3	499.4	108	349.0	499.9
20	330.0	403.2	50	359.1	499.9	80	358.2	501.0	110	348.2	499.7
22	338.8	448.3	52	355.8	503.3	82	358.0	500.6	112	349.0	500.5
24	341.9	495.1	54	354.4	500.1	84	356.6	501.0	114	349.8	501.2
26	345.9	506.6	56	352.5	500.3	86	353.3	499.5	116	349.9	500.6
28	350.7	499.1	58	350.4	501.4	88	352.9	500.4	118	350.3	499.2
30	352.7	504.4	60	351.1	499.4	90	354.4	502.1	120	350.0	500.1

\*T1 = Catalytic temperature

\*\*T2 = Pyrolysis temperature



**Figure A8** Temperature profiles of catalytic pyrolysis (0.25%Re/KL).

**Table A9** Pyrolysis conditions: Catalytic Pyrolysis using 0.50%Re/KL

Pyrolysis oils = 10.32 g

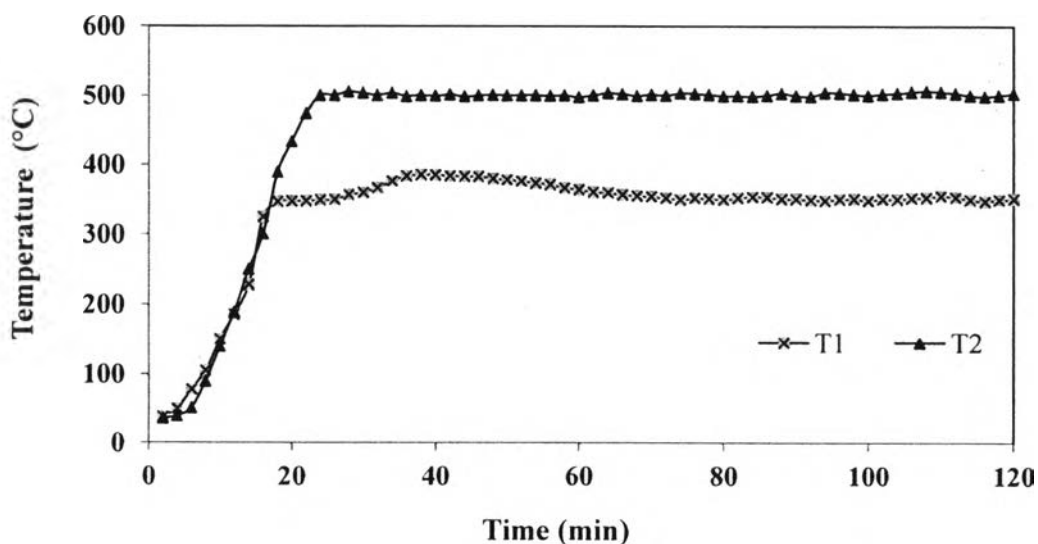
Pyrolysis gas = 6.47 g

Carbon black = 13.21 g

Time (min)	T1	T2	Time (min)	T1	T2	Time (min)	T1	T2	Time (min)	T1	T2
2	30.2	30.9	32	357.7	503.4	62	357.7	501.0	92	350.0	500.0
4	43.2	47.7	34	358.9	502.3	64	355.0	502.9	94	349.9	500.2
6	63.7	78.0	36	360.1	501.0	66	354.0	503.2	96	349.5	500.7
8	91.1	117.5	38	362.3	502.4	68	353.3	502.1	98	350.0	501.3
10	127.1	168.0	40	364.5	501.3	70	352.0	500.2	100	348.7	502.1
12	173.3	231.1	42	365.5	500.0	72	351.1	501.3	102	349.8	503.3
14	214.4	283.0	44	368.9	501.3	74	352.2	503.4	104	347.9	502.9
16	274.5	351.6	46	368.6	502.3	76	353.8	502.4	106	349.7	499.9
18	328.9	421.2	48	368.5	500.2	78	355.6	501.5	108	350.0	501.0
20	349.9	464.3	50	365.0	500.1	80	354.8	499.2	110	351.1	500.3
22	350.6	499.3	52	361.9	499.2	82	353.2	499.6	112	352.0	500.2
24	357.8	501.3	54	360.4	499.2	84	353.0	498.7	114	350.3	501.5
26	356.6	502.0	56	361.0	498.7	86	352.9	499.2	116	350.1	502.4
28	354.8	505.5	58	359.9	497.5	88	351.0	499.3	118	350.3	502.1
30	355.1	504.3	60	358.7	498.6	90	351.3	500.1	120	349.5	503.1

\*T1 = Catalytic temperature

\*\*T2 = Pyrolysis temperature

**Figure A9** Temperature profiles of catalytic pyrolysis (0.50%Re/KL).

**Table A10** Pyrolysis conditions: Catalytic Pyrolysis using 0.75%Re/KL

Pyrolysis oils = 10.93 g

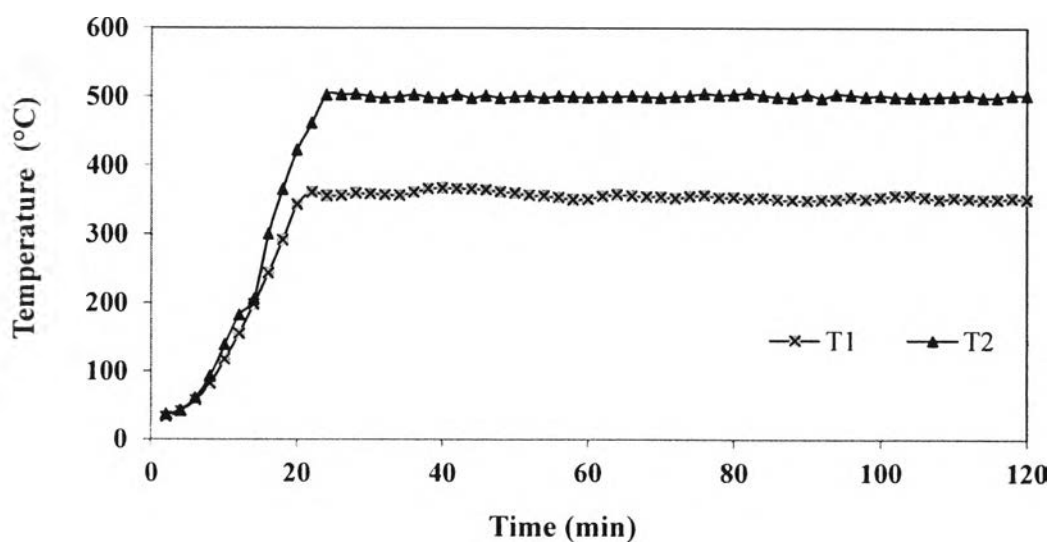
Pyrolysis gas = 6.07 g

Carbon black = 13.00g

Time (min)	T1	T2	Time (min)	T1	T2	Time (min)	T1	T2	Time (min)	T1	T2
2	30.2	30.1	32	361.4	499.5	62	361.2	499.9	92	352.3	503.2
4	41.9	46.3	34	363.9	499.7	64	356.8	499.7	94	353.4	502.5
6	61.4	73.8	36	365.7	500.7	66	352.2	498.9	96	354.9	503.5
8	85.6	114.5	38	364.0	501.5	68	349.3	501.9	98	355.4	501.3
10	129.0	170.0	40	366.6	499.6	70	351.9	498.9	100	353.2	500.3
12	175.5	231.0	42	373.5	500.8	72	350.0	499.9	102	351.2	499.8
14	220.8	288.5	44	367.9	500.1	74	350.2	500.2	104	350.5	498.3
16	273.4	353.9	46	370.3	499.6	76	350.8	500.0	106	349.7	497.9
18	320.0	420.1	48	371.6	500.3	78	349.9	498.9	108	348.7	499.2
20	333.1	503.0	50	371.5	499.5	80	349.7	499.7	110	349.2	500.2
22	334.7	500.6	52	369.5	500.2	82	348.7	499.0	112	349.9	500.4
24	347.9	500.9	54	368.5	501.2	84	349.2	499.2	114	350.2	500.9
26	350.3	499.8	56	366.0	501.2	86	350.5	500.3	116	350.2	502.4
28	355.4	503.2	58	363.2	499.1	88	350.3	501.2	118	350.2	501.9
30	360.5	498.8	60	362.1	500.5	90	351.7	503.4	120	349.9	502.8

\*T1 = Catalytic temperature

\*\*T2 = Pyrolysis temperature



**Figure A10** Temperature profiles of catalytic pyrolysis (0.75%Re/KL).

**Table A11** Pyrolysis conditions: Catalytic Pyrolysis using 1%Re/KL

Pyrolysis oils = 11.06 g

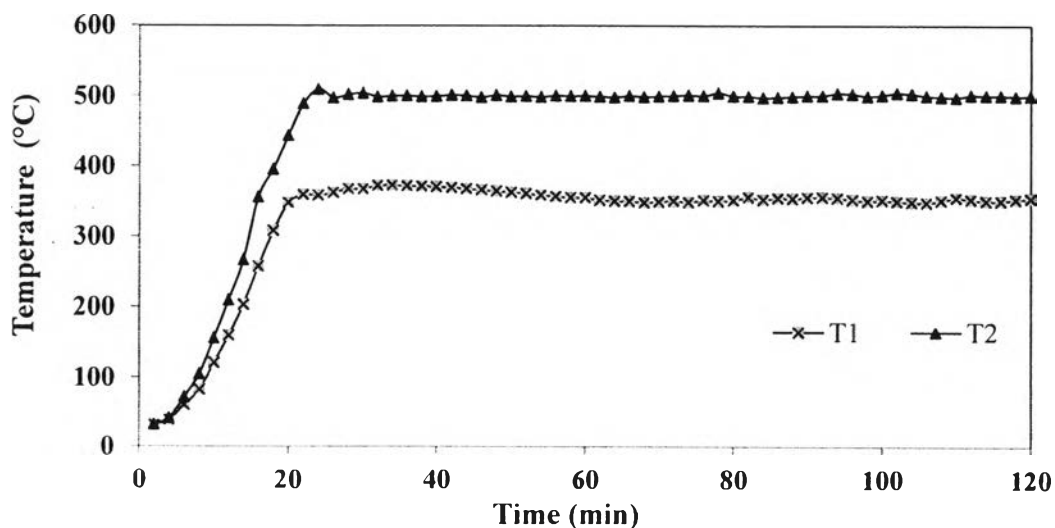
Pyrolysis gas = 6.11 g

Carbon black = 12.83 g

Time (min)	T1	T2	Time (min)	T1	T2	Time (min)	T1	T2	Time (min)	T1	T2
2	29.7	30.4	32	357.8	497.7	62	350.0	499.8	92	350.5	500.4
4	43.6	52.1	34	354.6	500.7	64	349.0	499.2	94	350.7	503.3
6	59.5	78.4	36	357.4	501.9	66	349.7	500.2	96	349.9	500.1
8	88.1	123.8	38	359.1	498.9	68	347.9	499.7	98	350.1	499.3
10	121.5	175.5	40	359.7	501.3	70	349.8	499.9	100	349.7	500.0
12	161.9	239.6	42	359.2	497.8	72	350.0	500.5	102	359.9	499.9
14	201.5	281.4	44	358.2	501.4	74	349.9	501.1	104	350.0	500.2
16	253.5	347.5	46	355.0	499.9	76	350.1	501.7	106	350.1	499.1
18	299.6	410.8	48	352.6	501.4	78	349.0	502.2	108	350.8	498.2
20	331.1	456.9	50	348.9	499.8	80	350.0	502.1	110	357.0	500.2
22	336.1	507.1	52	354.6	501.6	82	350.2	501.1	112	355.9	501.2
24	345.4	503.8	54	360.0	500.5	84	350.4	502.6	114	351.5	498.6
26	352.7	504.4	56	358.5	498.9	86	349.8	501.8	116	347.1	501.3
28	354.9	502.0	58	354.4	500.0	88	348.6	499.2	118	352.1	502.4
30	356.9	504.9	60	349.1	498.2	90	350.0	499.0	120	350.6	499.9

\*T1 = Catalytic temperature

\*\*T2 = Pyrolysis temperature

**Figure A11** Temperature profiles of catalytic pyrolysis (1%Re/KL).



**Table A12** Pyrolysis conditions: Catalytic Pyrolysis using 0.25%Re-1%MoO<sub>3</sub>/KL

Pyrolysis oils = 12.22 g

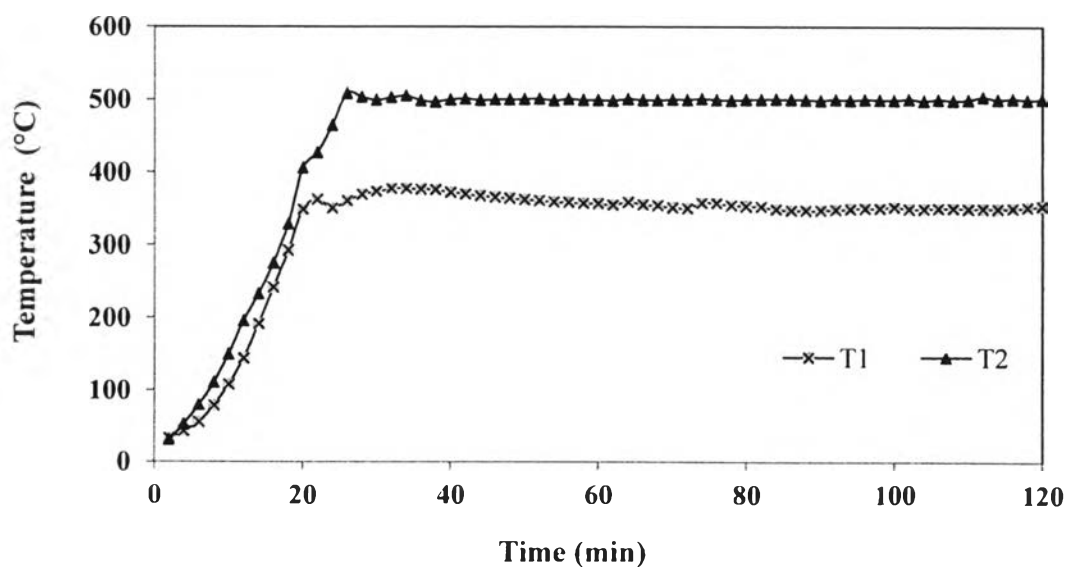
Pyrolysis gas = 5.13 g

Carbon black = 12.65 g

Time (min)	T1	T2	Time (min)	T1	T2	Time (min)	T1	T2	Time (min)	T1	T2
2	32.7	30.6	32	377.0	502.6	62	354.9	498.6	92	348.6	500.3
4	42.5	52.3	34	377.4	504.8	64	358.6	500.4	94	349.4	499.5
6	54.9	79.6	36	376.3	498.3	66	355.5	499.5	96	350.4	500.3
8	78.2	110.6	38	375.9	496.7	68	353.9	499.1	98	350.2	499.6
10	107.8	149.7	40	372.0	499.9	70	351.1	500.1	100	352.1	499.3
12	143.8	195.6	42	369.9	501.2	72	350.4	499.9	102	349.5	500.8
14	191.2	232.6	44	367.3	499.1	74	357.6	501.0	104	349.2	498.5
16	241.5	275.3	46	365.5	500.0	76	357.1	499.8	106	350.1	500.1
18	292.3	328.7	48	363.7	500.2	78	354.1	498.8	108	350.4	498.7
20	348.5	405.7	50	362.2	500.4	80	352.9	500.0	110	349.5	499.7
22	362.1	426.8	52	361.0	500.9	82	352.3	500.2	112	349.7	503.4
24	350.3	464.6	54	359.3	498.7	84	348.8	500.5	114	349.2	500.0
26	360.3	508.5	56	358.3	500.7	86	347.3	500.0	116	350.1	501.2
28	369.0	503.3	58	357.1	499.1	88	347.2	499.9	118	351.3	499.5
30	373.2	499.1	60	356.6	499.4	90	347.0	498.7	120	353.2	500.4

\*T1 = Catalytic temperature

\*\*T2 = Pyrolysis temperature

**Figure A12** Temperature profiles of catalytic pyrolysis (0.25%Re-1%MoO<sub>3</sub>/KL).

**Table A13** Pyrolysis conditions: Catalytic Pyrolysis using 0.50%Re-1%MoO<sub>3</sub>/KL

Pyrolysis oils = 12.44 g

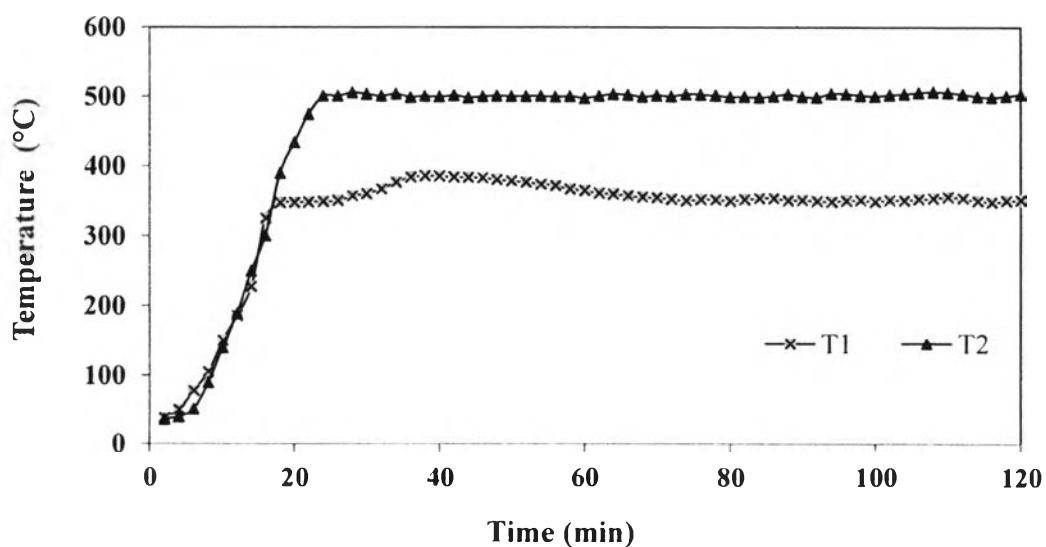
Pyrolysis gas = 4.80 g

Carbon black = 12.76 g

Time (min)	T1	T2	Time (min)	T1	T2	Time (min)	T1	T2	Time (min)	T1	T2
2	37.5	35.2	32	366.6	500.4	62	361.0	500.5	92	349.6	498.7
4	49.8	39.4	34	376.6	503.5	64	359.7	503.4	94	348.9	503.9
6	77.7	50.9	36	383.5	498.9	66	357.3	502.3	96	350.3	503.7
8	105.3	89.7	38	385.3	500.3	68	355.5	499.5	98	351.1	501.6
10	149.8	139.9	40	384.9	499.5	70	354.4	501.3	100	348.8	500.0
12	185.4	188.7	42	383.7	501.4	72	352.2	500.0	102	351.1	502.3
14	227.2	249.7	44	383.1	498.5	74	350.1	503.4	104	350.5	503.5
16	324.9	300.3	46	382.7	500.0	76	352.1	502.8	106	352.2	505.3
18	346.9	389.4	48	380.0	500.8	78	351.3	501.2	108	353.3	506.4
20	347.5	433.4	50	378.2	500.1	80	349.9	499.2	110	355.5	505.3
22	348.0	474.2	52	376.6	500.2	82	352.1	499.5	112	353.7	503.2
24	349.0	500.3	54	373.4	500.6	84	353.9	498.7	114	349.9	499.8
26	350.0	500.3	56	371.7	499.5	86	353.8	500.2	116	348.0	498.6
28	356.9	505.4	58	366.5	500.2	88	350.8	503.3	118	350.0	500.4
30	360.1	503.4	60	364.5	497.6	90	351.1	499.7	120	351.2	503.3

\*T1 = Catalytic temperature

\*\*T2 = Pyrolysis temperature

**Figure A13** Temperature profiles of catalytic pyrolysis (0.50%Re-1%MoO<sub>3</sub>/KL).

**Table A14** Pyrolysis conditions: Catalytic Pyrolysis using 0.75%Re-1%MoO<sub>3</sub>/KL

Pyrolysis oils = 12.27 g

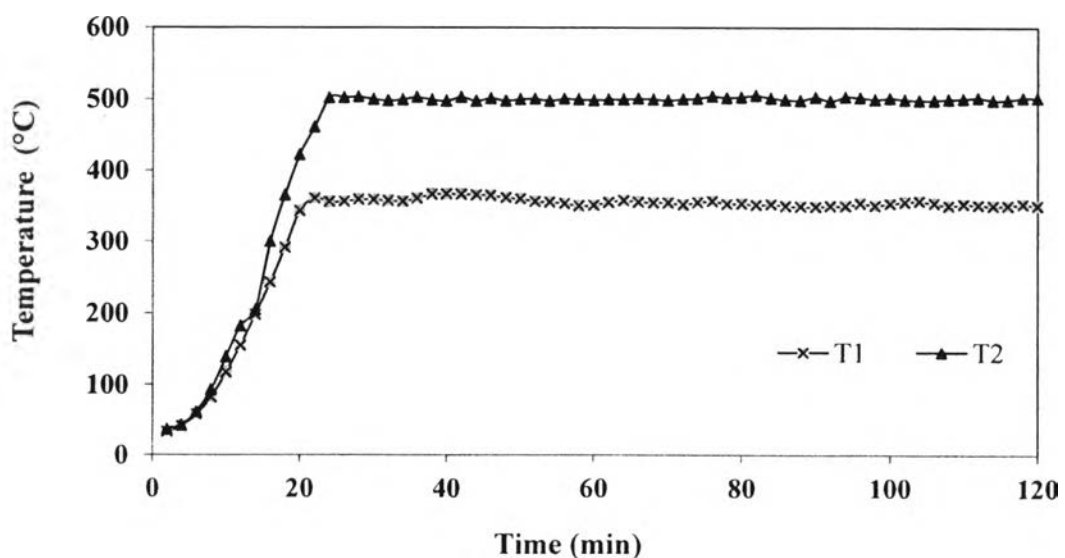
Pyrolysis gas = 4.84 g

Carbon black = 12.89 g

Time (min)	T1	T2	Time (min)	T1	T2	Time (min)	T1	T2	Time (min)	T1	T2
2	32.8	36.6	32	357.0	498.0	62	355.0	499.8	92	349.9	497.8
4	40.8	42.6	34	356.3	499.7	64	357.6	499.9	94	350.1	503.3
6	57.3	61.3	36	360.6	502.8	66	355.4	501.1	96	353.4	502.7
8	81.9	93.0	38	366.0	499.2	68	354.6	500.0	98	350.7	499.9
10	117.4	139.0	40	366.7	497.6	70	354.4	498.5	100	353.3	501.9
12	154.6	182.4	42	366.2	502.8	72	352.0	500.3	102	355.5	499.5
14	197.9	204.9	44	365.5	497.6	74	355.0	501.2	104	356.5	498.8
16	242.6	300.0	46	364.3	501.4	76	356.7	504.4	106	353.4	498.7
18	291.1	365.3	48	361.3	497.8	78	352.9	502.3	108	350.1	500.1
20	342.8	422.3	50	359.6	500.0	80	353.3	503.2	110	352.2	500.7
22	360.7	461.1	52	356.3	500.8	82	351.3	505.5	112	351.1	502.3
24	355.6	502.2	54	355.4	497.9	84	352.3	501.7	114	349.9	498.7
26	356.2	502.7	56	353.2	500.7	86	350.0	499.5	116	350.2	499.1
28	359.0	503.3	58	350.1	499.8	88	349.1	498.7	118	352.1	502.1
30	358.4	500.0	60	350.8	498.7	90	348.8	503.1	120	350.0	502.1

\*T1 = Catalytic temperature

\*\*T2 = Pyrolysis temperature

**Figure A14** Temperature profiles of catalytic pyrolysis (0.75%Re-1%MoO<sub>3</sub>KL).

**Table A15** Pyrolysis conditions: Catalytic Pyrolysis using 1%Re-1%MoO<sub>3</sub>/KL

Pyrolysis oils = 11.72 g

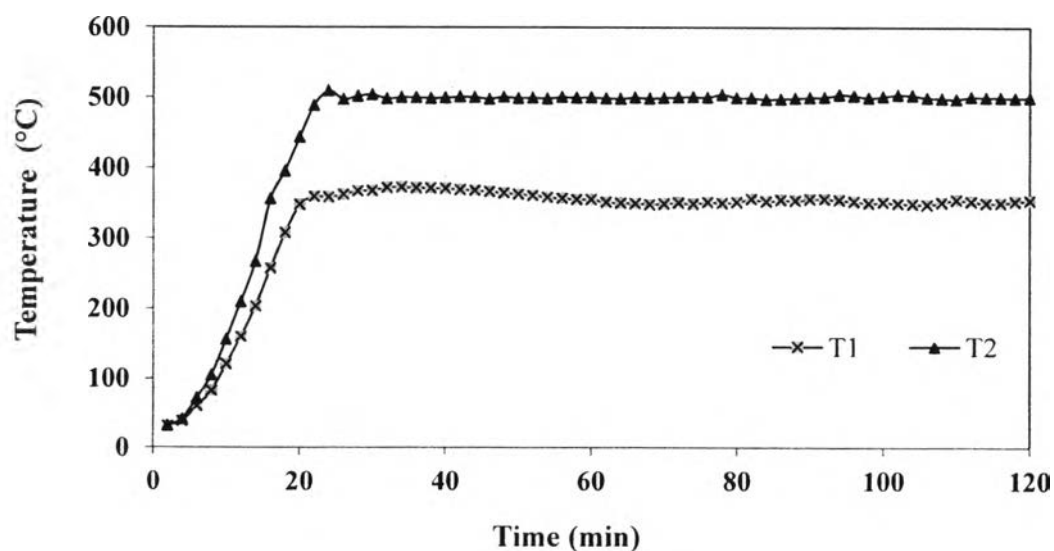
Pyrolysis gas = 5.35 g

Carbon black = 12.93 g

Time (min)	T1	T2	Time (min)	T1	T2	Time (min)	T1	T2	Time (min)	T1	T2
2	31.0	31.2	32	371.8	498.5	62	351.1	499.0	92	355.5	500.4
4	37.9	41.2	34	372.2	500.0	64	349.8	498.3	94	354.4	504.0
6	59.8	71.9	36	371.3	500.1	66	349.7	500.1	96	352.1	503.0
8	82.3	104.8	38	371.0	499.0	68	347.9	498.7	98	350.0	499.5
10	120.3	155.8	40	370.2	499.5	70	349.2	499.5	100	351.1	501.4
12	159.3	209.6	42	368.7	501.0	72	350.2	500.5	102	349.4	504.2
14	202.7	266.6	44	367.5	500.4	74	348.7	501.1	104	348.7	503.1
16	257.0	355.6	46	365.8	498.0	76	351.3	500.2	106	347.8	499.8
18	307.5	395.3	48	364.2	501.0	78	350.0	504.3	108	350.8	498.7
20	347.1	443.4	50	362.3	499.0	80	351.1	499.7	110	354.4	497.8
22	358.7	488.7	52	360.7	499.8	82	355.5	499.5	112	352.1	501.1
24	357.7	509.3	54	358.1	498.5	84	352.1	497.5	114	350.0	500.3
26	361.9	497.4	56	356.4	500.4	86	354.4	498.0	116	349.9	500.3
28	366.9	501.9	58	354.9	499.8	88	353.3	499.2	118	352.3	499.2
30	367.1	504.0	60	354.6	500.1	90	355.4	500.3	120	353.5	499.9

\*T1 = Catalytic temperature

\*\*T2 = Pyrolysis temperature

**Figure A15** Temperature profiles of catalytic pyrolysis (1%Re-1%MoO<sub>3</sub>/KL).

## APPENDIX B Pyrolysis Product Distribution

**Table B1** The weight percentage of pyrolysis products (wt%)

	Pyrolytic oil	Pyrolytic gas	Char
<b>Non catalyst</b>	42.19	13.04	44.77
<b>KL zeolite</b>	34.67	18.77	46.56

<b>%wtMoO<sub>3</sub>/KL</b>			
1% MoO <sub>3</sub> /KL	41.90	15.37	42.73
2% MoO <sub>3</sub> /KL	40.47	15.53	44.00
3% MoO <sub>3</sub> /KL	41.60	15.30	43.10
5% MoO <sub>3</sub> /KL	35.63	20.77	43.60
10% MoO <sub>3</sub> /KL	35.70	20.70	43.60

<b>%wtRe/KL</b>			
0.25% Re/KL	35.00	20.83	44.17
0.50% Re/KL	34.40	21.57	44.03
0.75% Re/KL	36.44	20.23	43.33
1% Re/KL	36.87	20.37	42.76

<b>%wtRe-1MoO<sub>3</sub>/KL</b>			
0.25%Re-1%MoO <sub>3</sub> /KL	40.73	17.10	42.17
0.50%Re-1% MoO <sub>3</sub> /KL	41.47	16.00	42.53
0.75%Re-1% MoO <sub>3</sub> /KL	40.90	16.13	42.97
1%Re-1% MoO <sub>3</sub> /KL	39.07	17.83	43.10









### APPENDIX C Pyrolysis Gas Compositions

**Table C1** Compositions of gas product at different MoO<sub>3</sub> amounts loaded on KL zeolite (%wt)

Composition	Non-catalyst	KL	%MoO <sub>3</sub> /KL				
			1%	2%	3%	5%	10%
Methane	22.95	21.72	22.49	22.98	22.04	22.46	22.01
Ethylene	10.03	9.170	8.579	8.598	8.726	8.983	8.950
Ethane	18.12	18.34	19.35	18.90	18.95	19.67	19.47
Propylene	11.46	11.29	10.52	10.52	10.68	10.95	10.92
Propane	8.540	9.236	10.25	9.534	10.09	10.21	10.17
C4	19.55	20.30	20.27	20.23	20.29	19.27	19.38
C5	8.712	9.550	7.883	8.479	8.455	7.797	8.303
C6	0.539	0.363	0.608	0.680	0.699	0.610	0.725
C7	0.015	0.009	0.008	0.017	0.016	0.009	0.015
C8	0.093	0.019	0.027	0.063	0.058	0.033	0.066

**Table C2** Compositions of gas product at different Re amounts loaded on KL zeolite (%wt)

Composition	Non-catalyst	KL	%Re/KL			
			0.25%	0.50%	0.75%	1%
Methane	22.95	21.72	21.74	22.83	21.05	22.74
Ethylene	10.03	9.170	8.606	9.299	9.003	8.014
Ethane	18.12	18.34	18.78	18.79	17.46	19.21
Propylene	11.46	11.29	10.57	11.10	10.83	10.07
Propane	8.540	9.236	9.739	9.655	9.220	10.17
C4	19.55	20.30	20.32	19.95	21.49	20.28
C5	8.712	9.550	9.445	7.784	9.943	8.905
C6	0.539	0.363	0.703	0.567	0.871	0.529
C7	0.015	0.009	0.018	0.007	0.020	0.009
C8	0.093	0.019	0.075	0.018	0.113	0.059

**Table C3** Compositions of gas product at different Re amounts loaded on 1%MoO<sub>3</sub>/KL catalysts (%wt)

Composition	Non-catalyst	KL	%Re-1%MoO <sub>3</sub> /KL			
			0.25%	0.50%	0.75%	1.00%
<b>Methane</b>	22.95	21.72	21.81	22.08	22.59	22.60
<b>Ethylene</b>	10.03	9.170	8.305	8.405	8.487	8.416
<b>Ethane</b>	18.12	18.34	18.67	18.95	19.53	19.53
<b>Propylene</b>	11.46	11.29	10.21	10.40	10.51	10.51
<b>Propane</b>	8.540	9.236	10.03	10.27	10.41	10.53
<b>C4</b>	19.55	20.30	20.12	20.68	20.54	20.34
<b>C5</b>	8.712	9.550	10.17	8.500	7.401	7.546
<b>C6</b>	0.539	0.363	0.615	0.696	0.491	0.491
<b>C7</b>	0.015	0.009	0.010	0.009	0.007	0.007
<b>C8</b>	0.093	0.019	0.049	0.023	0.028	0.023

## APPENDIX D Maltene Analysis

**Table D1** Chemical compositions in maltenes (wt%)

	<b>Saturated Hydrocarbons</b>	<b>Mono-Aromatics</b>	<b>Di-Aromatics</b>	<b>Poly-Aromatics</b>	<b>Polar-Aromatics</b>
<b>Non-catalyst</b>	54.67	11.58	15.15	14.34	4.27
<b>KL zeolite</b>	60.04	12.20	12.04	11.48	4.23

<b>wt%MoO<sub>3</sub>/KL</b>					
1%MoO <sub>3</sub> /KL	59.84	19.95	11.14	5.70	3.37
2%MoO <sub>3</sub> /KL	57.89	21.58	11.05	5.79	3.68
3%MoO <sub>3</sub> /KL	59.08	19.04	12.04	5.47	4.38
5%MoO <sub>3</sub> /KL	57.14	18.10	13.81	6.90	4.05
10%MoO <sub>3</sub> /KL	58.23	16.88	14.29	7.14	3.46

<b>wt%Re/KL</b>					
0.25%Re/KL	62.47	20.00	7.12	5.75	4.66
0.50%Re/KL	58.00	23.91	7.90	5.41	4.78
0.75%Re/KL	57.52	26.39	6.33	5.80	3.96
1%Re/KL	56.16	26.85	7.67	4.93	4.38

<b>wt%Re-1%MoO<sub>3</sub>/KL</b>					
0.25%Re-1%MoO <sub>3</sub> /KL	73.89	16.45	3.39	2.61	3.66
0.50%Re-1%MoO <sub>3</sub> /KL	71.43	17.31	3.57	4.12	3.57
0.75%Re-1%MoO <sub>3</sub> /KL	68.27	21.60	3.20	4.27	2.67
1%Re-1%MoO <sub>3</sub> /KL	66.85	22.64	2.70	4.31	3.50

**Table D2** Chemical compositions in maltenes (%Yield)

	<b>Saturated Hydrocarbons</b>	<b>Mono- Aromatics</b>	<b>Di- Aromatics</b>	<b>Poly- Aromatics</b>	<b>Polar- Aromatics</b>
<b>Non-catalyst</b>	23.06	4.89	6.39	6.05	1.80
<b>KL zeolite</b>	20.82	4.23	4.17	3.98	1.47
<b>wt%MoO<sub>3</sub>/KL</b>					
1%MoO <sub>3</sub> /KL	25.07	8.36	4.67	2.39	1.41
2%MoO <sub>3</sub> /KL	23.43	8.73	4.47	2.34	1.49
3%MoO <sub>3</sub> /KL	24.58	7.92	5.01	2.28	1.82
5%MoO <sub>3</sub> /KL	20.36	6.45	4.92	2.46	1.44
10%MoO <sub>3</sub> /KL	20.79	6.03	5.10	2.55	1.24
<b>wt%Re/KL</b>					
0.25%Re/KL	21.86	7.00	2.49	2.01	1.63
0.50%Re/KL	19.95	8.22	2.72	1.86	1.64
0.75%Re/KL	20.96	9.61	2.31	2.11	1.44
1%Re/KL	20.71	9.90	2.83	1.82	1.62
<b>wt%Re- 1MoO<sub>3</sub>/KL</b>					
0.25%Re-1%MoO <sub>3</sub> /KL	30.10	6.70	1.38	1.06	1.49
0.50%Re-1%MoO <sub>3</sub> /KL	29.62	7.18	1.48	1.71	1.48
0.75%Re-1%MoO <sub>3</sub> /KL	27.92	8.83	1.31	1.75	1.09
1%Re-1%MoO <sub>3</sub> /KL	26.11	8.85	1.05	1.68	1.37

**Table D3** Petroleum fractions of Maltenes (wt%)

	<b>Naphtha</b>	<b>Kerosene</b>	<b>Light Gas Oil</b>	<b>Heavy Gas Oil</b>	<b>Long Residue</b>
<b>Non-catalyst</b>	31.7	25.0	19.3	15.8	8.2
<b>KL zeolite</b>	46.7	27.7	15.0	6.7	4.0

<b>wt%MoO<sub>3</sub>/KL</b>					
1% MoO <sub>3</sub> /KL	25	30	25	14	6
2% MoO <sub>3</sub> /KL	29	29	25	11	6
3% MoO <sub>3</sub> /KL	28	28	24	14	6
5% MoO <sub>3</sub> /KL	37	31	16	10	6
10% MoO <sub>3</sub> /KL	40	31	14.5	10.5	4

<b>wt%Re/KL</b>					
0.25% Re/KL	40.0	28.0	20.0	8.0	4.0
0.50% Re/KL	42.0	31.0	15.0	7.0	5.0
0.75% Re/KL	46.0	31.0	11.0	7.0	5.0
1% Re/KL	31.0	26.0	21.0	14.0	8.0

<b>wt%Re-1%MoO<sub>3</sub>/KL</b>					
0.25%Re-1%MoO <sub>3</sub> /KL	28.0	23.0	25.0	16.0	8.0
0.50%Re-1%MoO <sub>3</sub> /KL	29.0	24.0	23.0	16.0	8.0
0.75%Re-1%MoO <sub>3</sub> /KL	32.0	26.5	21.5	12.5	7.5
1%Re-1%MoO <sub>3</sub> /KL	28.0	29.0	25.0	13.0	5.0

**Table D4** Petroleum fractions of Maltenes (%Yield)

	<b>Naphtha</b>	<b>Kerosene</b>	<b>Light Gas Oil</b>	<b>Heavy Gas Oil</b>	<b>Long Residue</b>
<b>Non-catalyst</b>	13.36	10.55	8.16	6.68	3.45
<b>KL zeolite</b>	16.18	9.59	5.20	2.31	1.39
<b>wt%MoO<sub>3</sub>/KL</b>					
1%MoO <sub>3</sub> /KL	10.48	12.57	10.48	5.87	2.51
2%MoO <sub>3</sub> /KL	11.74	11.74	10.12	4.45	2.43
3%MoO <sub>3</sub> /KL	11.65	11.65	9.98	5.82	2.50
5%MoO <sub>3</sub> /KL	13.18	11.05	5.70	3.56	2.14
10%MoO <sub>3</sub> /KL	14.28	11.07	5.18	3.75	1.43
<b>wt%Re/KL</b>					
0.25%Re/KL	14.00	9.80	7.00	2.80	1.40
0.50%Re/KL	14.45	10.66	5.16	2.41	1.72
0.75%Re/KL	16.76	11.29	4.01	2.55	1.82
1%Re/KL	11.43	9.59	7.74	5.16	2.95
<b>wt%Re-1MoO<sub>3</sub>/KL</b>					
0.25%Re-1%MoO <sub>3</sub> /KL	11.41	9.37	10.18	6.52	3.26
0.50%Re-1%MoO <sub>3</sub> /KL	12.03	9.95	9.54	6.63	3.32
0.75%Re-1%MoO <sub>3</sub> /KL	13.09	10.84	8.79	5.11	3.07
1%Re-1%MoO <sub>3</sub> /KL	10.94	11.33	9.77	5.08	1.95

## APPENDIX E Coke Formation (wt%)

Catalyst	Coke (wt%)
<b>KL zeolite</b>	18.07
<b>wt%MoO<sub>3</sub>/KL</b>	
1%MoO <sub>3</sub> /KL	19.93
2%MoO <sub>3</sub> /KL	20.21
3%MoO <sub>3</sub> /KL	19.33
5%MoO <sub>3</sub> /KL	20.88
10%MoO <sub>3</sub> /KL	22.88
<b>wt%Re/KL</b>	
0.25%Re/KL	18.59
0.50%Re/KL	18.55
0.75%Re/KL	18.81
1%Re/KL	18.10
<b>wt%Re-1%MoO<sub>3</sub>/KL</b>	
0.25%Re-1%MoO <sub>3</sub> /KL	17.25
0.50%Re-1%MoO <sub>3</sub> /KL	18.28
0.75%Re-1%MoO <sub>3</sub> /KL	18.86
1%Re-1%MoO <sub>3</sub> /KL	20.04

## APPENDIX F Asphaltene Yields

Catalyst	Asphaltene/Oil ratio (g/g Oil)
Non catalyst	0.0023
KL zeolite	0.0007

wt%MoO <sub>3</sub> /KL	
1%MoO <sub>3</sub> /KL	0.0002
2%MoO <sub>3</sub> /KL	0.0004
3%MoO <sub>3</sub> /KL	0.0002
5%MoO <sub>3</sub> /KL	0.0002
10%MoO <sub>3</sub> /KL	0.0002

wt%Re/KL	
0.25%Re/KL	0.0001
0.50%Re/KL	0.0002
0.75%Re/KL	0.0003
1%Re/KL	0.0003

wt%Re-1%MoO <sub>3</sub> /KL	
0.25%Re-1%MoO <sub>3</sub> /KL	0.0002
0.50%Re-1%MoO <sub>3</sub> /KL	0.0002
0.75%Re-1%MoO <sub>3</sub> /KL	0.0001
1%Re-1%MoO <sub>3</sub> /KL	0.0002



**APPENDIX G Sulfur Content (wt%)**

	<b>Sulfur Content (wt%)</b>	
	<b>Catalyst</b>	<b>Pyrolytic Oil</b>
<b>Non-catalyst</b>	-	1.31
<b>KL zeolite</b>	0.41	0.88

<b>wt%MoO<sub>3</sub>/KL</b>		
1% MoO <sub>3</sub> /KL	0.75	1.02
2% MoO <sub>3</sub> /KL	0.88	1.02
3% MoO <sub>3</sub> /KL	0.83	1.04
5% MoO <sub>3</sub> /KL	1.02	0.89
10% MoO <sub>3</sub> /KL	0.98	0.90

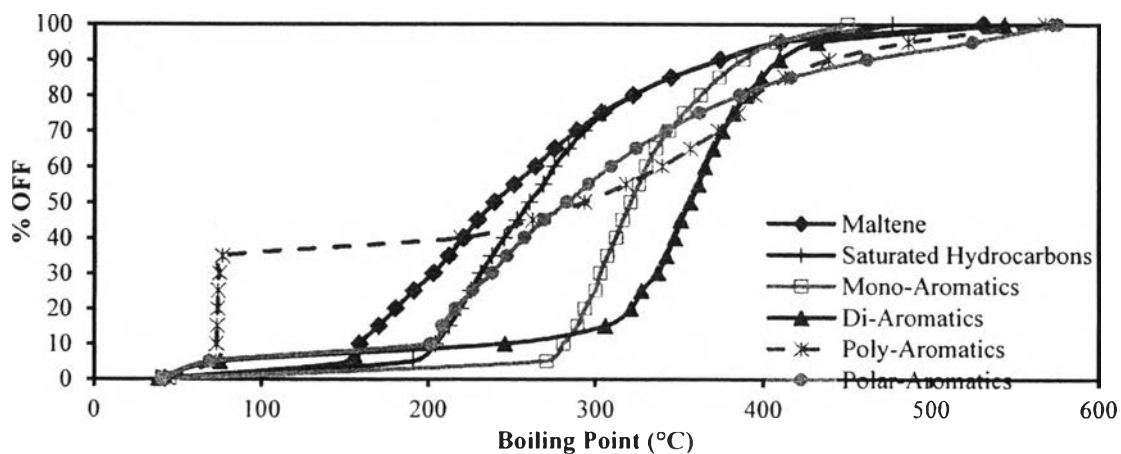
<b>wt%Re/KL</b>		
0.25% Re/KL	0.34	0.94
0.50% Re/KL	0.39	0.85
0.75% Re/KL	0.49	0.85
1% Re/KL	0.44	1.03

<b>wt%Re-1%MoO<sub>3</sub>/KL</b>		
0.25% Re-1% MoO <sub>3</sub> /KL	0.55	1.10
0.50% Re-1% MoO <sub>3</sub> /KL	0.62	1.06
0.75% Re-1% MoO <sub>3</sub> /KL	0.64	1.01
1% Re-1% MoO <sub>3</sub> /KL	0.69	1.02

## APPENDIX H True Boiling Point Curves (°C)

**Table H1** True Boiling Point Curves : Non-catalyst

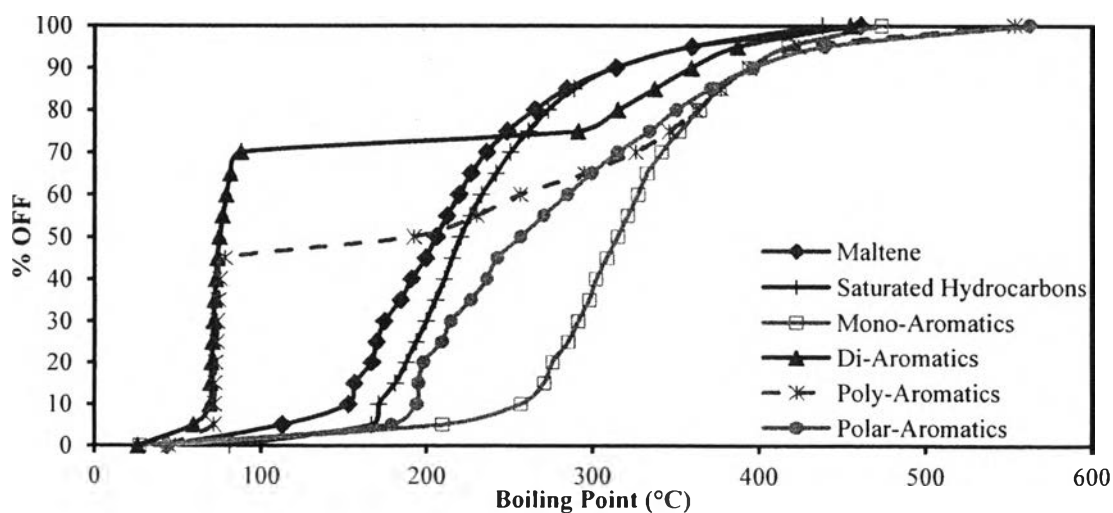
% Off	Boiling Point (°C)					
	Maltene	Saturated Hydrocarbons	Mono-Aromatics	Di-Aromatics	Poly-Aromatics	Polar-Aromatics
0	42.2	37.1	45.2	38.4	43.5	40.7
5	154.9	191.1	270.8	75.5	72.6	69.0
10	158.4	204.7	280.9	246.1	73.0	201.9
15	170.3	212.8	289.4	306.2	73.4	208.7
20	180.6	219.6	293.8	321.6	73.8	216.9
25	191.7	225.9	300.3	327.9	74.2	227.0
30	203.5	231.6	303.2	337.5	74.8	238.6
35	212.7	238.4	307.5	342.7	76.5	247.2
40	221.4	245.6	312.6	347.5	219.8	257.8
45	229.8	253.4	316.6	351.3	262.6	269.6
50	239.8	260.6	321.4	356.7	293.5	283.1
55	251.6	269.0	326.4	361.7	318.4	296.0
60	264.1	275.5	330.7	365.4	340.1	309.8
65	275.6	284.0	336.4	370.4	356.6	324.7
70	288.9	293.6	344.1	375.9	373.1	342.4
75	303.7	306.1	353.0	382.4	385.3	362.2
80	322.6	323.0	363.0	389.8	395.1	386.1
85	345.1	345.4	373.9	399.2	413.3	416.9
90	374.3	375.3	388.1	410.2	439.1	461.8
95	410.6	410.1	408.4	432.6	486.3	524.8
100	531.3	476.9	450.3	543.9	568.3	575.3



**Figure H1** True boiling point curves (°C) for non-catalytic pyrolysis.

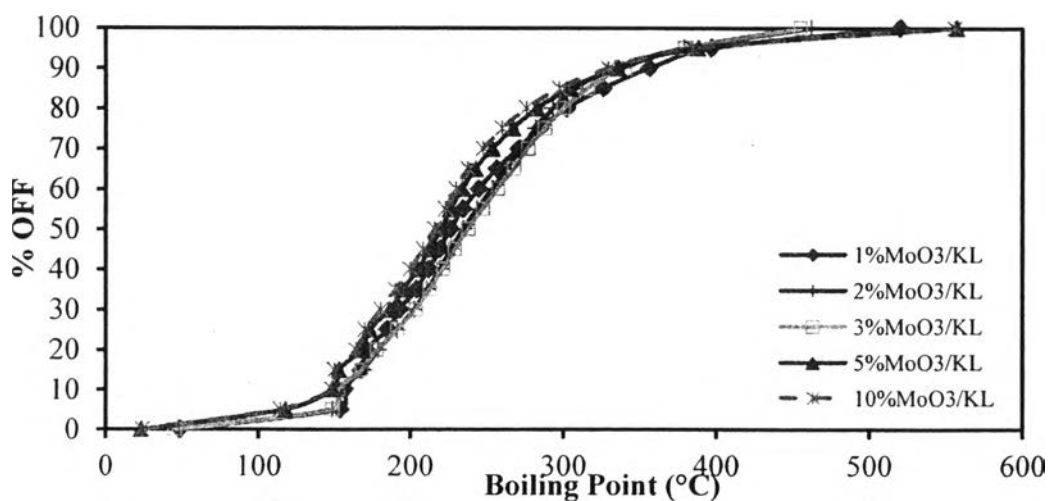
**Table H2** True Boiling Point Curves : KL zeolite

% Off	Boiling Point (°C)					
	Maltene	Saturated Hydrocarbons	Mono-Aromatics	Di-Aromatics	Poly-Aromatics	Polar-Aromatics
0	44.1	81.3	27.3	26.3	45.0	44.3
5	112.8	166.9	209.7	59.8	71.9	178.9
10	152.9	171.3	256.9	69.7	72.3	194.3
15	156.6	181.3	270.9	70.2	72.6	195.3
20	167.1	187.9	275.9	70.7	73.0	198.3
25	170.0	193.8	285.5	71.2	73.4	209.5
30	174.9	200.1	291.6	71.7	73.8	214.7
35	184.5	205.6	298.3	72.4	74.5	226.8
40	191.1	210.9	302.5	73.1	75.6	236.4
45	199.8	215.6	309.1	74.1	78.5	242.7
50	205.9	220.5	315.5	75.4	192.5	257.0
55	212.5	226.6	321.4	77.2	230.3	270.7
60	219.7	233.1	327.6	79.5	256.6	285.1
65	226.7	241.9	332.9	81.8	295.3	299.9
70	236.3	250.6	341.6	88.0	326.1	315.4
75	248.6	261.5	352.5	291.7	346.2	334.4
80	265.3	273.3	364.5	315.5	362.3	350.6
85	284.6	289.1	376.7	337.6	377.4	371.1
90	314.2	313.9	394.5	359.6	394.5	396.9
95	359.7	359.2	417.8	387.7	423.6	439.7
100	461.1	438.0	473.7	455.0	553.6	562.5

**Figure H2** True boiling point curves (°C) for KL zeolite.

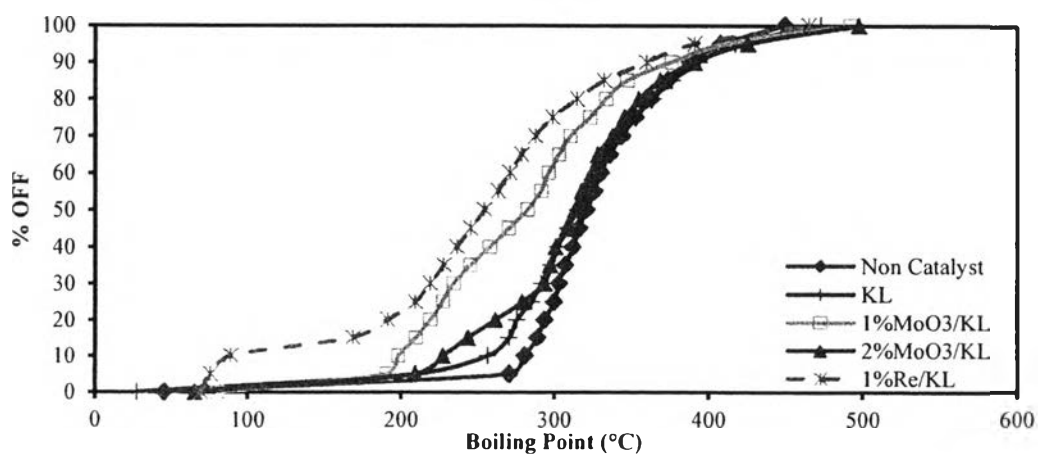
**Table H3** True Boiling Point Curves : Maltene obtained from MoO<sub>3</sub>/KL Catalysts

% Off	Boiling Point (°C)				
	1%MoO <sub>3</sub> /KL	2%MoO <sub>3</sub> /KL	3%MoO <sub>3</sub> /KL	5%MoO <sub>3</sub> /KL	10%MoO <sub>3</sub> /KL
0	48.8	47.8	45.3	23.7	24.2
5	154.4	149.2	149.0	118.3	114.6
10	157.3	153.4	152.7	149.3	148.7
15	167.9	169.3	168.3	153.5	150.6
20	171.7	179.2	178.5	168.2	164.6
25	185.1	191.5	191.6	173.7	170.5
30	193.2	202.7	203.8	186.8	181.0
35	203.9	211.1	212.8	195.0	190.2
40	212.0	219.3	221.5	205.2	199.8
45	219.3	226.6	229.3	212.5	208.3
50	226.3	235.0	238.0	220.0	215.8
55	234.6	243.8	247.6	226.2	222.9
60	244.9	253.7	257.6	234.3	229.8
65	256.7	262.9	268.1	242.8	238.0
70	271.0	273.0	277.4	254.1	248.0
75	284.6	282.1	287.9	267.5	260.3
80	302.4	293.3	300.2	283.2	276.2
85	326.3	308.3	316.0	304.7	297.4
90	356.6	334.0	340.2	336.1	329.6
95	397.1	379.2	379.5	388.4	384.5
100	520.5	462.3	455.2	557.5	556.1

**Figure H3** True boiling point curves (°C) for maltene obtained from MoO<sub>3</sub>/KL Catalysts.

**Table H4** True Boiling Point Curves : Comparison of Mono-aromatics (non-catalyst, KL, 1%MoO<sub>3</sub>/KL, 2%MoO<sub>3</sub>/KL, and 1%Re/KL)

% Off	Boiling Point (°C)				
	Non Catalyst	KL	1%MoO <sub>3</sub> /KL	2%MoO <sub>3</sub> /KL	1%Re/KL
0	45.2	27.3	80.5	65.8	69.2
5	270.8	209.7	190.6	209.1	75.8
10	280.9	256.9	198.4	227.8	89.1
15	289.4	270.9	210.0	244.0	168.6
20	293.8	275.9	219.5	262.0	191.4
25	300.3	285.5	227.7	279.4	209.3
30	303.2	291.6	234.9	293.5	219.2
35	307.5	298.3	245.7	297.6	228.3
40	312.6	302.5	258.6	301.1	236.9
45	316.6	309.1	270.9	308.5	245.8
50	321.4	315.5	283.0	314.2	255
55	326.4	321.4	291.7	318.4	263.8
60	330.7	327.6	296.6	325.0	271.4
65	336.4	332.9	303.5	328.8	278.9
70	344.1	341.6	311.0	338.0	287.9
75	353.0	352.5	323.8	345.9	299.2
80	363.0	364.5	334.3	355.4	315.4
85	373.9	376.7	348.0	369.3	332.9
90	388.1	394.5	376.4	391.5	360.3
95	408.4	417.8	411.0	426.2	391.3
100	450.3	473.7	492.5	498.1	465.8



**Figure H4** True boiling point curves (°C) for comparison of Mono-aromatics (non-catalyst, KL, 1%MoO<sub>3</sub>/KL, 2%MoO<sub>3</sub>/KL, and 1%Re/KL).

Table H5 True Boiling Point Curves : 0.25%Re/KL

% Off	Boiling Point (°C)					
	Maltene	Saturated Hydrocarbons	Mono-Aromatics	Di-Aromatics	Poly-Aromatics	Polar-Aromatics
0	32.0	165.6	51.0	31.1	33.9	30.3
5	113.0	187.2	73.7	72.2	71.7	171.9
10	145.1	197.2	79.6	73.8	72.7	192.5
15	148.1	204.1	214.0	76.3	74.7	193.9
20	161.4	210.0	230.3	80.4	163.3	194.3
25	167.6	213.7	242.7	241.0	243.7	194.9
30	179.3	218.8	245.3	260.2	272.1	202.5
35	189.6	224.3	253.0	269.9	287.0	209.4
40	199.7	229.3	258.5	274.8	295.3	219.8
45	207.8	234.7	263.4	277.1	305.1	226.1
50	215.4	241.6	268.2	285.9	311.6	236.2
55	223.8	247.5	272.1	292.4	320.2	247.4
60	232.4	253.9	276.8	299.5	328.9	263.9
65	243.3	260.9	283.2	302.7	337.9	279.1
70	253.7	268.0	288.9	314.2	346.9	298.6
75	264.7	276.1	296.3	322.3	355.4	320.3
80	276.0	285.3	306.7	330.9	365.3	343.4
85	290.7	297.2	322.4	348.2	376.1	369.3
90	312.8	318.8	341.2	372.5	389.4	393.1
95	354.4	359.3	372.3	405.5	410.4	423.1
100	451.7	452.2	453.3	488.3	498.6	521.1

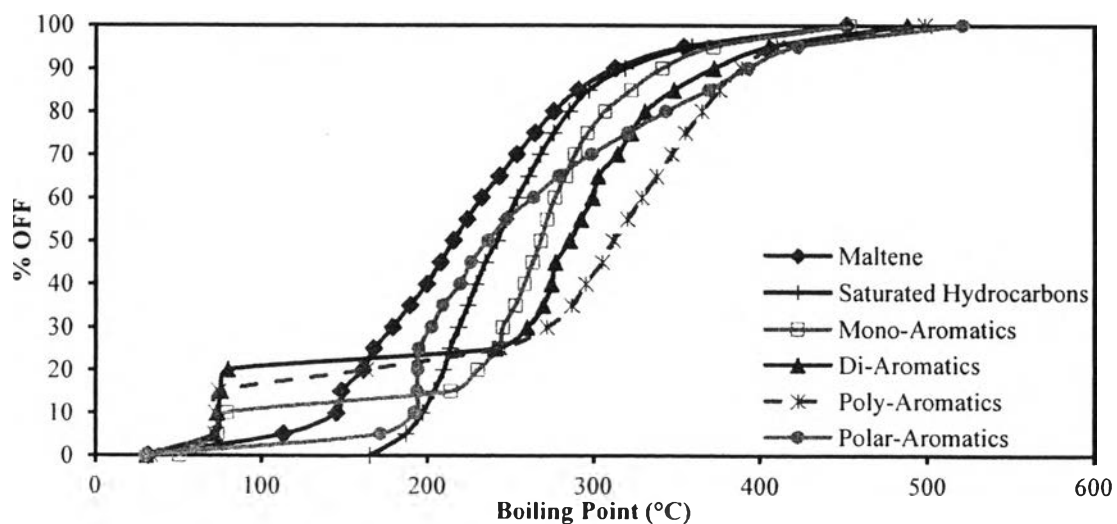


Figure H5 True boiling point curves (°C) for 0.25%Re/KL.

**Table H6** True Boiling Point Curves : 0.50%Re/KL

% Off	Boiling Point (°C)					
	Maltene	Saturated Hydrocarbons	Mono-Aromatics	Di-Aromatics	Poly-Aromatics	Polar-Aromatics
0	24.8	65.6	73.2	74.4	22.5	22.3
5	115.3	80.3	212.1	189.4	26.1	24.4
10	148.7	149.4	228.6	206.2	32.0	27.3
15	150.6	168.2	234.4	219.2	40.7	31.1
20	162.8	175.3	243.3	232.3	225.6	36.0
25	170.0	187.1	249.7	247.1	251.7	41.7
30	178.1	193.7	255.5	271.0	275.9	209.1
35	188.4	203.5	262.8	288.0	305.0	227.7
40	196.8	208.7	270.9	298.0	327.9	240.5
45	206.2	214.3	277.4	307.1	342.8	252.1
50	214.0	220.2	285.5	314.9	354.2	263.7
55	221.1	224.6	293.3	323.2	364.5	275.4
60	227.3	230.3	303.1	332.6	373.8	288.8
65	235.1	236.1	312.3	342.9	383.0	303.9
70	243.4	243.1	323.2	354.8	392.5	321.3
75	254.3	251.3	334.0	367.7	403.1	342.3
80	267.7	261.1	347.5	381.8	415.1	367.6
85	284.8	274.0	365.7	397.9	429.6	396.3
90	311.2	294.3	385.6	417.0	449.1	431.5
95	359.1	337.3	416.4	446.4	482.0	483.4
100	554.4	451.7	506.6	525.7	565.6	569.3

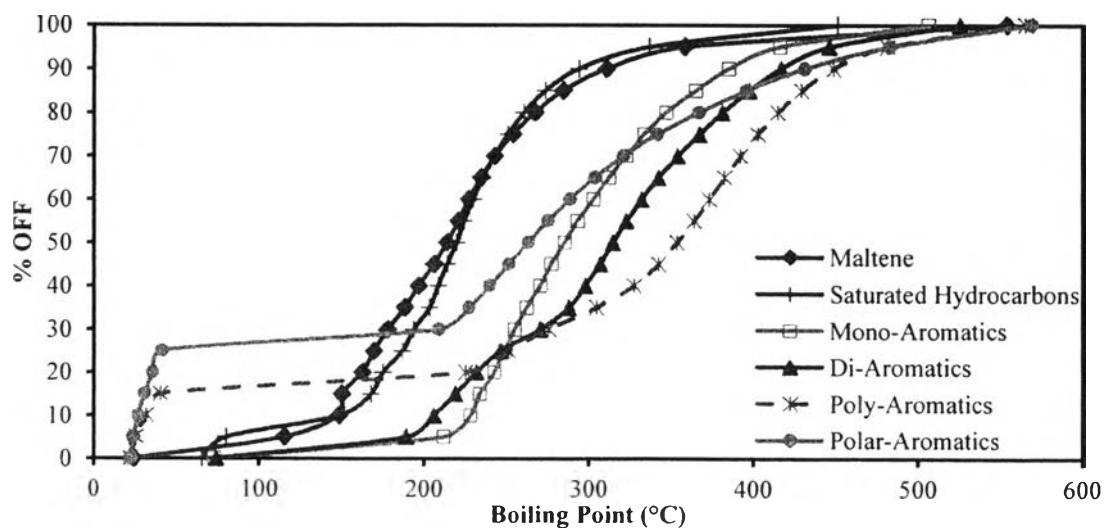
**Figure H6** True boiling point curves (°C) for 0.50%Re/KL.

Table H7 True Boiling Point Curves : 0.75%Re/KL

% Off	Boiling Point (°C)					
	Maltene	Saturated Hydrocarbons	Mono-Aromatics	Di-Aromatics	Poly-Aromatics	Polar-Aromatics
0	34.9	99.4	72.3	27.1	23.2	23.1
5	145.9	180.7	189.0	253.3	74.2	36.6
10	148.3	192.5	211.0	273.7	262.8	173.3
15	163.1	203.6	224.4	285.1	289.8	194.4
20	169.6	212.2	234.9	290.1	302.7	201.3
25	185.1	218.7	246.8	292.8	308.3	210.2
30	196.4	224.7	255.4	296.2	315.4	218.9
35	207.5	231.8	264.3	300.8	323.6	231.2
40	217.7	239.3	271.4	302.8	331.7	240.5
45	226.7	247.1	275.9	307.6	339.3	251.0
50	237.1	254.9	282.6	313.1	347	265.0
55	248.9	263.0	287.5	316.0	353.6	278.4
60	260.4	270.3	292.2	321.8	361.5	291.4
65	271.5	277.4	299.2	328.2	368.5	306.7
70	281.8	284.7	304.1	336.5	376.0	323.4
75	291.8	293.9	313.0	350.6	383.8	342.8
80	303.3	303.8	323.6	366.3	392.7	365.3
85	319.6	318.7	336.8	383.6	403.6	389.4
90	344.8	340.9	361.4	404.2	418.2	414.6
95	389.1	384.3	392.3	429.6	447.1	453.8
100	480.8	464.4	466.4	511.8	550.5	560.6

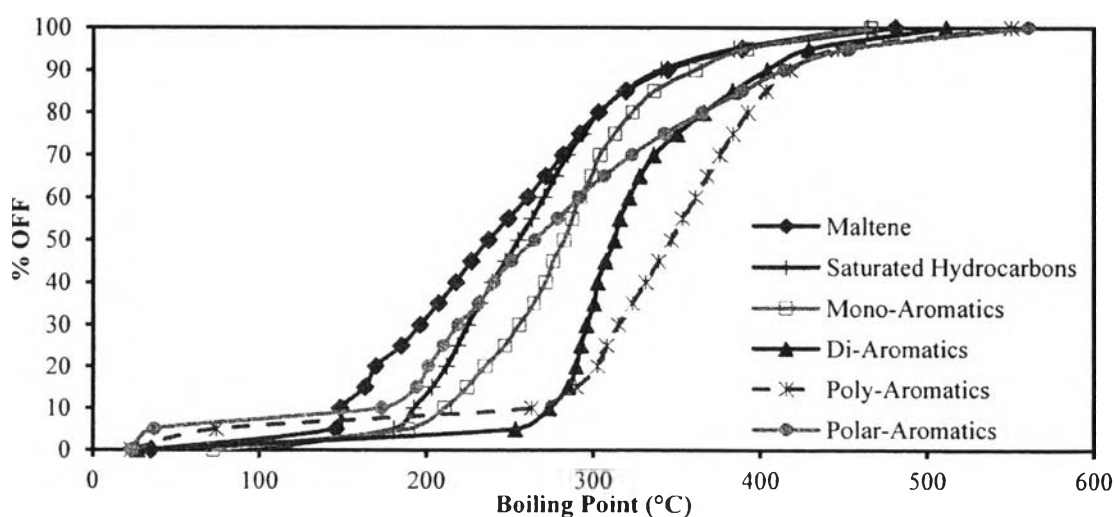
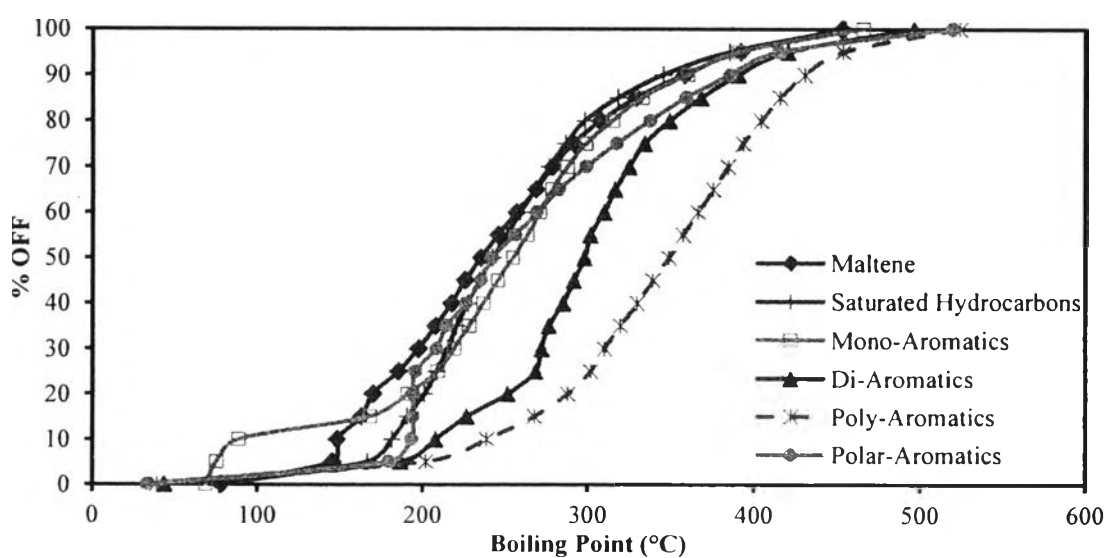


Figure H7 True boiling point curves (°C) for 0.75%Re/KL.



**Table H8** True Boiling Point Curves : 1%Re/KL

% Off	Boiling Point (°C)					
	Maltene	Saturated Hydrocarbons	Mono-Aromatics	Di-Aromatics	Poly-Aromatics	Polar-Aromatics
0	78.6	77.3	69.2	44.5	39.4	33.5
5	145.8	166.9	75.8	187.3	202.3	180.1
10	148.6	181.9	89.1	208.0	238.9	193.6
15	163.4	191.0	168.6	226.8	268.1	194.1
20	170.3	201.5	191.4	252.0	288.3	194.5
25	185.7	208.8	209.3	268.8	302.0	196.0
30	197.7	215.1	219.2	272.3	310.4	208.6
35	208.1	220.6	228.3	276.8	319.9	214.6
40	217.6	227.5	236.9	285.5	330.0	226.6
45	225.7	234.6	245.8	291.8	339.3	235.4
50	235.3	242.6	255.0	298.5	349	242.2
55	245.7	251.3	263.8	302.1	357.6	256.7
60	257.1	259.4	271.4	310.2	366.6	269.6
65	269.0	268.4	278.9	316.9	375.7	283.0
70	278.9	276.9	287.9	325.1	384.7	299.3
75	291.5	286.8	299.2	334.2	393.9	317.5
80	308.0	298.6	315.4	349.5	404.8	337.6
85	329.3	318.4	332.9	368.5	416.0	359.4
90	358.4	345.6	360.3	391.0	430.8	385.9
95	392.2	385.7	391.3	420.7	453.6	415.5
100	453.1	455.3	465.8	496.7	524.0	519.7

**Figure H8** True boiling point curves (°C) for 1%Re/KL.

**Table H9** True Boiling Point Curves : 0.25%Re-1%MoO<sub>3</sub>/KL

% Off	Boiling Point (°C)					
	Maltene	Saturated Hydrocarbons	Mono-Aromatics	Di-Aromatics	Poly-Aromatics	Polar-Aromatics
0	110.4	40.0	31.8	23.5	23.1	171.9
5	146.1	154.1	211.3	39.2	40.2	199.5
10	149.5	171.7	228.6	273.3	249.4	205.5
15	167.6	187.3	244.6	289.8	279.1	214.6
20	183.0	199.8	255.4	295.6	300.3	227.7
25	194.2	207.7	267.5	302.1	314.8	239.6
30	206.6	215.3	272.8	306.1	326.2	248.1
35	216.6	222.6	278.7	309.9	338.2	260.8
40	225.7	230.7	285.7	315.3	347.0	272.6
45	235.8	238.7	291.0	318.8	355.4	283.9
50	246.9	248.0	296.6	324.6	363.9	295.6
55	258.3	256.7	301.5	331.2	371.3	308.5
60	268.9	265.9	306.4	339.2	378.7	321.9
65	276.9	272.9	314.3	350.5	386.0	337.7
70	286.4	281.5	321.7	361.1	393.5	354.5
75	297.0	290.1	329.7	373.6	401.8	372.3
80	310.6	299.4	340.4	387.3	411.1	389.8
85	328.9	314.3	358.4	403.9	422.4	407.4
90	356.5	334.6	379.0	421.6	438.3	427.4
95	391.7	376.2	410.2	451.2	468.7	457.5
100	459.4	463.8	492.1	558.0	553.0	531.2

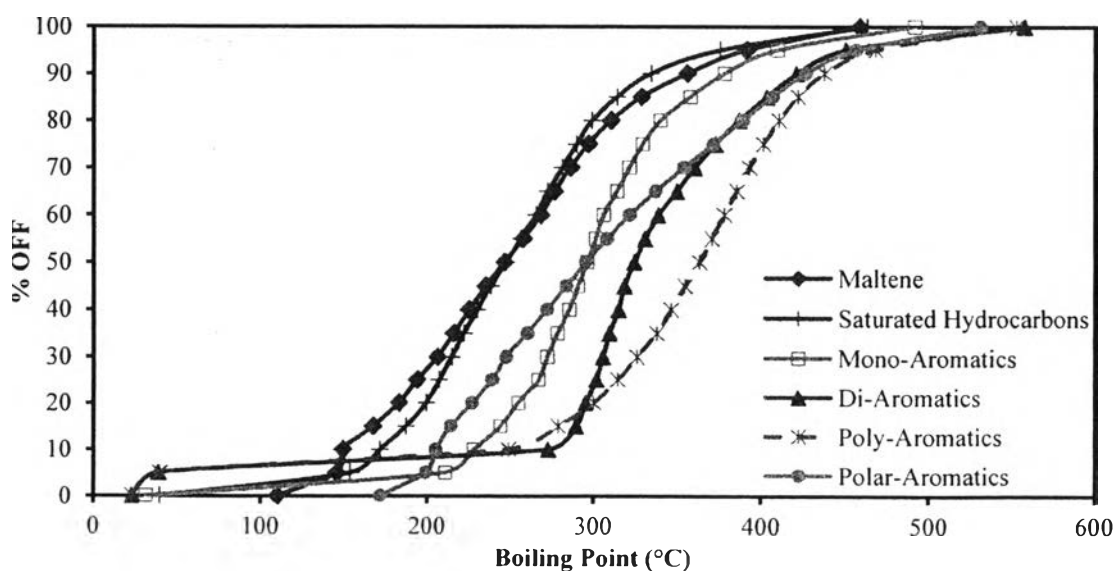
**Figure H9** True boiling point curves (°C) for 0.25%Re-1%MoO<sub>3</sub>/KL.

Table H10 True Boiling Point Curves : 0.50%Re-1%MoO<sub>3</sub>/KL

% Off	Boiling Point (°C)					
	Maltene	Saturated Hydrocarbons	Mono-Aromatics	Di-Aromatics	Poly-Aromatics	Polar-Aromatics
0	23.7	42.6	33.0	23.3	22.7	73.7
5	107.9	158.4	211.4	43.4	29.0	75.9
10	149.3	172.0	228.7	278.2	39.8	160.3
15	159.3	199.0	244.7	290.5	74.7	192.6
20	172.4	200.5	255.6	296.3	214.9	201.9
25	188.9	208.3	267.7	302.0	304.4	210.4
30	203.5	216.2	272.8	306.2	314.7	220.4
35	214.7	223.2	278.6	310.2	329.4	233.4
40	224.5	231.3	285.6	315.4	339.4	242.3
45	234.4	239.6	290.9	319.1	348.0	252.0
50	245.0	249.1	296.2	324.9	355.7	264.7
55	256.5	257.9	301.3	331.6	364.6	276.5
60	267.7	267.2	305.8	340.2	372.2	288.4
65	277.4	273.9	313.7	350.5	379.5	302.2
70	287.6	282.5	320.7	360.9	387.5	317.0
75	299.2	291.0	328.9	372.8	395.6	334.4
80	313.1	300.5	338.9	385.9	404.8	353.3
85	332.1	315.3	356.5	401.9	415.6	375.2
90	360.8	335.7	377.4	419.0	432.1	398.8
95	405.6	376.6	409.0	446.7	475.2	430.8
100	532.4	460.1	490.0	551.9	566.1	497.6

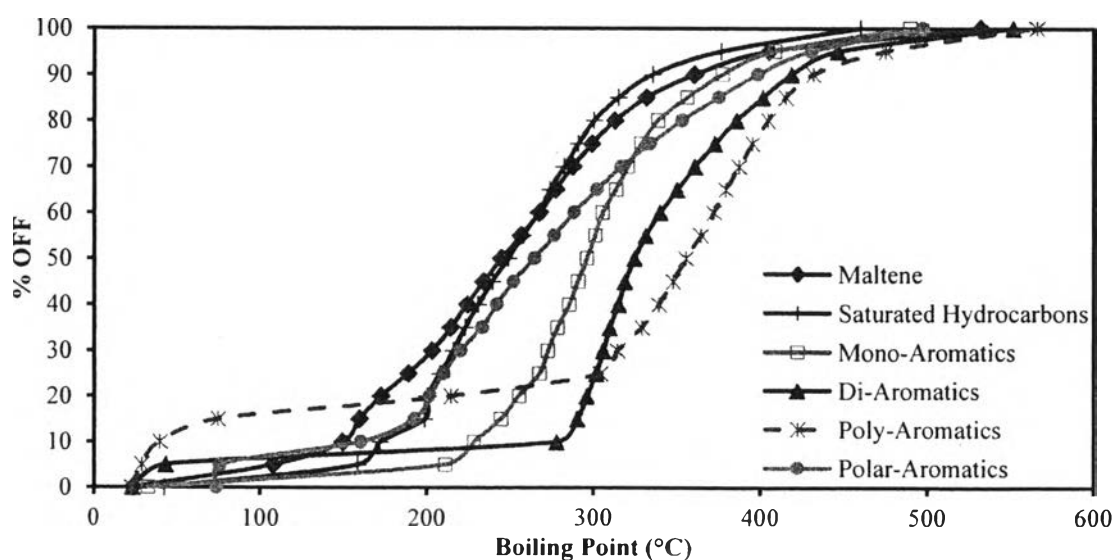
Figure H10 True boiling point curves (°C) for 0.50%Re-1%MoO<sub>3</sub>/KL.

Table H11 True Boiling Point Curves : 0.75%Re-1%MoO<sub>3</sub>/KL

% Off	Boiling Point (°C)					
	Maltene	Saturated Hydrocarbons	Mono-Aromatics	Di-Aromatics	Poly-Aromatics	Polar-Aromatics
0	22.9	31.6	157.9	22.7	22.5	22.5
5	45.7	165.0	189.3	29.0	30.1	29.2
10	148.8	182.7	214.5	40.4	72.9	41.3
15	152.9	192.1	244.0	220.7	247.0	201.5
20	169.4	203.5	269.1	254.2	270.1	211.9
25	182.6	210.5	274.9	291.1	288.6	223.3
30	194.6	216.6	280.9	310.9	305.2	235.9
35	206.3	223.3	288.5	322.5	321.0	247.1
40	215.8	230.0	293.9	332.9	337.4	258.5
45	224.5	236.9	299.9	343.3	349.2	271.3
50	233.6	245.1	305.3	353.1	360.3	285.7
55	243.0	253.1	312.0	361.8	370.1	299.9
60	254.0	260.7	319.3	371.1	378.6	316.2
65	264.6	269.5	327.3	380.5	386.8	334.9
70	275.3	276.4	335.3	390.6	395.4	354.9
75	286.4	285.4	346.8	401.9	405.1	375.3
80	300.2	296.3	361.6	413.6	416.2	395.9
85	319.7	311.6	377.3	428.6	429.8	417.5
90	350.5	339.1	397.6	449.0	449.2	442.7
95	397.6	390.9	426.1	484.5	483.3	482.5
100	527.2	493.0	500.3	564.3	561.1	563.8

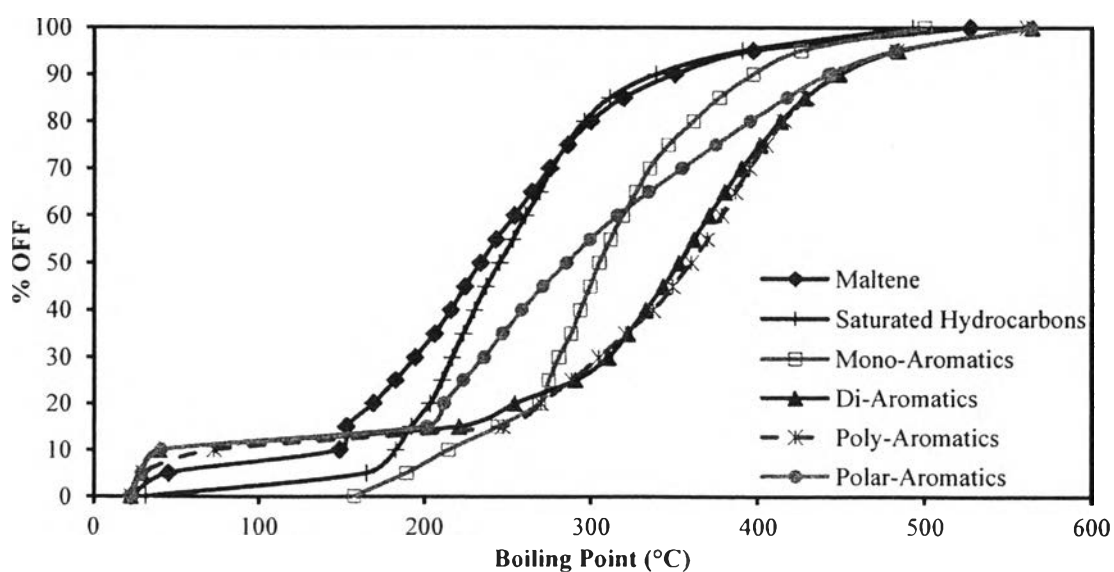
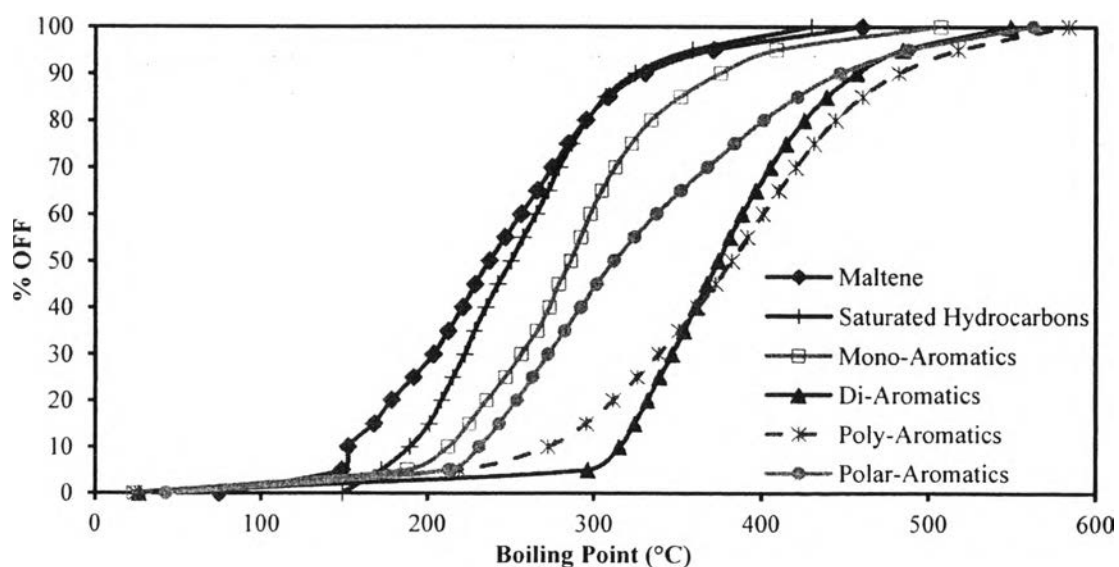
Figure H11 True boiling point curves (°C) for 0.75%Re-1%MoO<sub>3</sub>/KL.

Table H12 True Boiling Point Curves : 1%Re-1%MoO<sub>3</sub>/KL

% Off	Boiling Point (°C)					
	Maltene	Saturated Hydrocarbons	Mono-Aromatics	Di-Aromatics	Poly-Aromatics	Polar-Aromatics
0	74.6	149.4	23.7	27.1	24.6	43.2
5	148.9	172.6	188.1	296.6	219.2	213.1
10	152.7	189.6	212.8	315.4	272.6	231.4
15	168.2	201.3	225.5	324.8	295.6	243.5
20	178.7	208.6	236.0	332.7	311.9	254.2
25	191.8	215.6	247.4	340.0	326.5	263.7
30	203.9	222.7	256.9	347.3	339.5	272.8
35	212.8	228.6	266.4	354.5	351.3	282.6
40	221.4	235.5	273.6	361.2	362.6	292.4
45	229.0	242.8	279.2	368.0	373.1	302.0
50	237.6	250.7	286.3	374.7	382.8	312.5
55	247.1	257.9	292.2	381.6	392.1	324.5
60	256.8	265.7	298.1	388.9	401.3	338.0
65	266.4	272.8	304.9	397.0	410.9	352.5
70	275.3	279.3	313.0	405.7	421.0	368.3
75	284.6	286.9	322.8	415.2	432.2	384.3
80	295.3	296.2	334.7	426.3	445.1	401.8
85	309.0	307.1	352.4	439.9	460.9	422.2
90	331.0	325.0	376.0	457.6	482.6	447.7
95	371.9	359.4	409.4	485.0	517.8	488.5
100	461.0	430.8	507.6	549.4	584.0	562.9

Figure H12 True boiling point curves (°C) for 1%Re-1%MoO<sub>3</sub>/KL.

## APPENDIX I Carbon Number Distributions

**Table II** Carbon number distributions of maltene for Non-catalyst, KL, and MoO<sub>3</sub>/KL catalysts

No. Carbon	Non-catalyst	KL	1%MoO <sub>3</sub> /KL	2%MoO <sub>3</sub> /KL	3%MoO <sub>3</sub> /KL	5%MoO <sub>3</sub> /KL	10%MoO <sub>3</sub> /KL
5	0.0006	0.0000	0.0000	0.1081	0.1245	0.0509	0.0464
6	0.0406	0.0004	0.0110	0.3565	0.4028	0.2880	0.2880
7	0.5105	0.1124	0.3300	1.0109	1.1062	1.1826	1.2578
8	2.3022	2.0630	2.2690	2.4167	2.5368	3.4432	3.7726
9	5.4335	8.5156	6.4120	4.7858	4.8051	7.1421	7.8424
10	8.5285	15.2254	10.5906	7.7841	7.5163	10.9368	11.8087
11	10.3619	17.1867	12.6831	10.4645	9.8395	13.0940	13.7672
12	10.7218	15.1644	12.5464	11.8801	11.0505	13.0638	13.3417
13	10.0350	11.7652	11.0884	11.7573	10.9819	11.5030	11.4299
14	8.8261	8.5606	9.1799	10.5001	9.9633	9.3510	9.0705
15	7.4756	6.0525	7.3273	8.7322	8.4811	7.2481	6.8881
16	6.1941	4.2402	5.7394	6.9354	6.9229	5.4749	5.1141
17	5.0726	2.9757	4.4602	5.3602	5.5077	4.0876	3.7631
18	4.1334	2.1042	3.4622	4.0845	4.3204	3.0438	2.7677
19	3.3660	1.5040	2.6956	3.0958	3.3682	2.2732	2.0449
20	2.7471	1.0882	2.1103	2.3475	2.6237	1.7082	1.5224
21	2.2510	0.7974	1.6637	1.7873	2.0491	1.2942	1.1439
22	1.8539	0.5918	1.3218	1.3692	1.6081	0.9895	0.8680
23	1.5356	0.4446	1.0586	1.0568	1.2698	0.7637	0.6654
24	1.2796	0.3379	0.8546	0.8222	1.0094	0.5950	0.5152
25	1.0727	0.2597	0.6953	0.6450	0.8081	0.4678	0.4027
26	0.9045	0.2016	0.5699	0.5099	0.6514	0.3710	0.3176
27	0.7669	0.1580	0.4704	0.4063	0.5287	0.2966	0.2527
28	0.6537	0.1249	0.3907	0.3260	0.4319	0.2389	0.2026
29	0.5598	0.0995	0.3265	0.2634	0.3548	0.1938	0.1635
30	0.4815	0.0798	0.2742	0.2140	0.2931	0.1581	0.1329
31	0.4156	0.0644	0.2314	0.1749	0.2433	0.1298	0.1086
32	0.3599	0.0522	0.1960	0.1435	0.2028	0.1070	0.0892
33	0.3125	0.0426	0.1666	0.1183	0.1697	0.0886	0.0735
34	0.2719	0.0349	0.1420	0.0979	0.1424	0.0736	0.0609
35	0.2370	0.0286	0.1213	0.0813	0.1198	0.0614	0.0505
36	0.2067	0.0236	0.1038	0.0676	0.1010	0.0513	0.0421
37	0.1803	0.0195	0.0889	0.0563	0.0852	0.0429	0.0351
38	0.1571	0.0161	0.0762	0.0470	0.0720	0.0359	0.0293
39	0.1368	0.0133	0.0652	0.0392	0.0608	0.0301	0.0245
40	0.1188	0.0110	0.0557	0.0327	0.0513	0.0252	0.0204
41	0.1027	0.0091	0.0475	0.0273	0.0432	0.0211	0.0170
42	0.0884	0.0075	0.0403	0.0226	0.0362	0.0176	0.0142
43	0.0754	0.0062	0.0339	0.0187	0.0302	0.0145	0.0117
44	0.0635	0.0050	0.0282	0.0153	0.0249	0.0119	0.0096
45	0.0525	0.0040	0.0231	0.0123	0.0202	0.0096	0.0077
46	0.0422	0.0031	0.0184	0.0097	0.0160	0.0076	0.0061
47	0.0323	0.0024	0.0140	0.0073	0.0121	0.0057	0.0046
48	0.0226	0.0016	0.0097	0.0050	0.0083	0.0039	0.0031
49	0.0128	0.0009	0.0055	0.0028	0.0047	0.0022	0.0018
50	0.0026	0.0002	0.0011	0.0006	0.0009	0.0004	0.0004

**Table I2** Carbon number distributions of maltene for Re/KL catalysts

<b>No. Carbon</b>	<b>0.25%Re/KL</b>	<b>0.50%Re/KL</b>	<b>0.75%Re/KL</b>	<b>1%Re/KL</b>
5	0.2054	0.1142	0.1250	0.0041
6	0.7107	0.4644	0.4788	0.1045
7	1.9899	1.5314	1.4087	0.8206
8	4.4171	3.9571	3.1895	2.8993
9	7.7231	7.8213	5.6582	6.0205
10	10.7793	11.8217	8.1167	8.8328
11	12.3953	14.0576	9.7915	10.3551
12	12.2426	13.8091	10.3389	10.5166
13	10.8331	11.8317	9.9045	9.7511
14	8.9042	9.2756	8.8646	8.5406
15	6.9898	6.8997	7.5808	7.2245
16	5.3453	4.9934	6.2974	5.9885
17	4.0362	3.5735	5.1417	4.9108
18	3.0359	2.5545	4.1601	4.0090
19	2.2876	1.8351	3.3541	3.2717
20	1.7329	1.3294	2.7051	2.6762
21	1.3223	0.9729	2.1878	2.1980
22	1.0175	0.7199	1.7771	1.8145
23	0.7899	0.5387	1.4513	1.5064
24	0.6188	0.4076	1.1921	1.2580
25	0.4889	0.3116	0.9851	1.0569
26	0.3896	0.2406	0.8189	0.8931
27	0.3129	0.1875	0.6846	0.7588
28	0.2531	0.1474	0.5755	0.6480
29	0.2061	0.1168	0.4862	0.5560
30	0.1688	0.0931	0.4126	0.4791
31	0.1390	0.0747	0.3515	0.4144
32	0.1151	0.0603	0.3006	0.3595
33	0.0956	0.0489	0.2577	0.3127
34	0.0797	0.0398	0.2215	0.2725
35	0.0666	0.0326	0.1907	0.2379
36	0.0558	0.0267	0.1644	0.2078
37	0.0469	0.0219	0.1418	0.1815
38	0.0394	0.0181	0.1223	0.1585
39	0.0331	0.0149	0.1053	0.1381
40	0.0278	0.0123	0.0906	0.1201
41	0.0233	0.0101	0.0776	0.1040
42	0.0194	0.0083	0.0662	0.0896
43	0.0161	0.0068	0.0560	0.0765
44	0.0132	0.0055	0.0468	0.0645
45	0.0107	0.0044	0.0385	0.0534
46	0.0084	0.0034	0.0307	0.0429
47	0.0064	0.0026	0.0234	0.0329
48	0.0044	0.0018	0.0163	0.0230
49	0.0025	0.0010	0.0092	0.0131
50	0.0005	0.0002	0.0018	0.0026

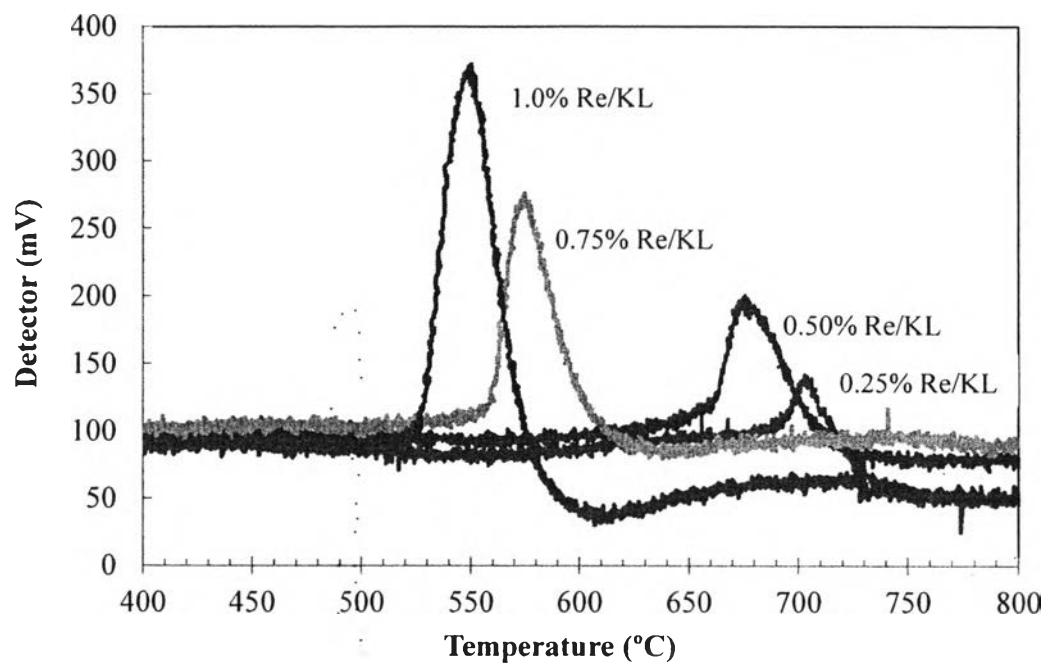
**Table I3** Carbon number distributions of maltene for %Re-1%MoO<sub>3</sub>/KL catalysts

No. Carbon	0.25%Re- 1%MoO <sub>3</sub> /KL	0.50%Re- 1%MoO <sub>3</sub> /KL	0.75%Re- 1%MoO <sub>3</sub> /KL	1%Re- 1%MoO <sub>3</sub> /KL
5	1.7854	0.7781	0.2590	0.3758
6	2.5198	1.3591	0.6838	0.8118
7	3.4365	2.2371	1.5825	1.6210
8	4.5188	3.4521	3.1664	2.9649
9	5.7074	4.9607	5.4183	4.9066
10	6.8892	6.5935	7.9032	7.2510
11	7.9014	8.0637	9.8997	9.4757
12	8.5658	9.0601	10.8397	10.9267
13	8.7492	9.3835	10.6307	11.2070
14	8.4214	9.0329	9.5859	10.3981
15	7.6701	8.1778	8.1408	8.9191
16	6.6598	7.0556	6.6419	7.2305
17	5.5649	5.8759	5.2857	5.6472
18	4.5192	4.7765	4.1486	4.3136
19	3.5991	3.8244	3.2362	3.2582
20	2.8322	3.0367	2.5222	2.4520
21	2.2153	2.4034	1.9707	1.8478
22	1.7297	1.9027	1.5471	1.3988
23	1.3523	1.5103	1.2219	1.0658
24	1.0609	1.2038	0.9715	0.8181
25	0.8361	0.9644	0.7779	0.6330
26	0.6625	0.7769	0.6272	0.4936
27	0.5279	0.6293	0.5090	0.3880
28	0.4231	0.5127	0.4158	0.3071
29	0.3409	0.4198	0.3416	0.2448
30	0.2761	0.3455	0.2822	0.1964
31	0.2247	0.2856	0.2342	0.1584
32	0.1837	0.2370	0.1952	0.1284
33	0.1507	0.1974	0.1633	0.1046
34	0.1241	0.1649	0.1370	0.0855
35	0.1025	0.1381	0.1153	0.0701
36	0.0848	0.1159	0.0972	0.0577
37	0.0703	0.0974	0.0820	0.0476
38	0.0584	0.0819	0.0693	0.0393
39	0.0485	0.0688	0.0585	0.0324
40	0.0403	0.0578	0.0493	0.0268
41	0.0334	0.0485	0.0415	0.0221
42	0.0276	0.0405	0.0348	0.0182
43	0.0227	0.0336	0.0290	0.0149
44	0.0185	0.0276	0.0239	0.0121
45	0.0148	0.0223	0.0194	0.0097
46	0.0116	0.0176	0.0153	0.0076
47	0.0087	0.0133	0.0116	0.0057
48	0.0060	0.0092	0.0080	0.0039
49	0.0034	0.0052	0.0045	0.0022
50	0.0007	0.0010	0.0009	0.0004



**Table I4** Carbon number distributions of mono-aromatics for non-catalyst, KL, 1%MoO<sub>3</sub>/KL, 2%MoO<sub>3</sub>/KL, and 1%Re/KL

No. Carbon	Non-catalyst	KL	1%MoO <sub>3</sub> /KL	2%MoO <sub>3</sub> /KL	1%Re/KL
5	0.0003	0.0000	0.0308	0.0447	0.2310
6	0.0012	0.0000	0.1017	0.0899	0.4809
7	0.0041	0.0000	0.2965	0.1721	0.9425
8	0.0130	0.0000	0.7575	0.3148	1.7333
9	0.0381	0.0001	1.6773	0.5515	2.9737
10	0.1042	0.0018	3.1921	0.9282	4.7148
11	0.2657	0.0311	5.2053	1.5039	6.8279
12	0.6332	0.2866	7.3092	2.3490	8.9284
13	1.4080	1.4363	8.9561	3.5363	10.4645
14	2.9000	4.2317	9.7662	5.1157	10.9976
15	5.4409	8.1335	9.6944	7.0601	10.4629
16	9.0456	11.3606	8.9571	9.1766	9.1621
17	12.8673	12.6765	7.8562	11.0265	7.5322
18	15.2037	12.1682	6.6472	11.9938	5.9254
19	14.8175	10.5997	5.4934	11.6235	4.5327
20	12.1894	8.6927	4.4754	10.0125	3.4134
21	8.8382	6.8770	3.6180	7.7741	2.5528
22	5.9137	5.3328	2.9160	5.5781	1.9074
23	3.7877	4.0951	2.3505	3.8001	1.4293
24	2.3806	3.1344	1.8988	2.5142	1.0768
25	1.4902	2.4008	1.5394	1.6419	0.8166
26	0.9369	1.8449	1.2533	1.0694	0.6238
27	0.5941	1.4242	1.0252	0.6991	0.4801
28	0.3808	1.1052	0.8426	0.4602	0.3721
29	0.2468	0.8624	0.6957	0.3056	0.2905
30	0.1618	0.6766	0.5769	0.2048	0.2282
31	0.1072	0.5337	0.4803	0.1385	0.1804
32	0.0718	0.4230	0.4013	0.0946	0.1434
33	0.0485	0.3368	0.3364	0.0651	0.1145
34	0.0331	0.2692	0.2827	0.0452	0.0918
35	0.0228	0.2160	0.2381	0.0316	0.0739
36	0.0158	0.1738	0.2009	0.0223	0.0597
37	0.0110	0.1403	0.1697	0.0158	0.0484
38	0.0078	0.1135	0.1434	0.0113	0.0393
39	0.0055	0.0919	0.1211	0.0082	0.0319
40	0.0039	0.0745	0.1022	0.0059	0.0260
41	0.0028	0.0604	0.0860	0.0043	0.0211
42	0.0021	0.0489	0.0721	0.0032	0.0171
43	0.0015	0.0394	0.0601	0.0023	0.0139
44	0.0011	0.0316	0.0495	0.0017	0.0111
45	0.0008	0.0249	0.0402	0.0013	0.0088
46	0.0006	0.0193	0.0318	0.0009	0.0068
47	0.0004	0.0143	0.0240	0.0006	0.0051
48	0.0003	0.0098	0.0166	0.0004	0.0035
49	0.0001	0.0054	0.0093	0.0002	0.0019
50	0.0000	0.0011	0.0019	0.0000	0.0004

**APPENDIX J Temperature Programmed Reduction of Re/KL**

**Figure J** TPR profiles of different loading percentages of Re/KL catalysts.

## CURRICULUM VITAE

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**Proceedings:**

1. Mahanin, R. and Jitkarnka, S. (2011, April 26) Catalytic Pyrolysis of Waste Tire over KL-based Catalysts: The Effect of MoO<sub>3</sub> and Re. Proceedings of The 2<sup>nd</sup> Research Symposium on Petroleum, Petrochemicals, and Advanced Materials, and The 17<sup>th</sup> PPC Symposium on Petroleum, Petrochemicals, and Polymers, Queen Sirikit National Convention Center, Bangkok, Thailand.

