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APPENDICES

APPENDIX A. TEMPERATURE PROFILES

Table A1 Pyrolysis conditions: Non-catalyst

Tire = 30.0666 g, N_2 flow = 30 ml/min

Catalytic Temperature (T1) = 350 °C

Pyrolysis Temperature (T2) = 500 °C

Time (min)	T1	T2	Time (min)	T1	T2	Time (min)	T1	T2	Time (min)	T1	T2
2	28.4	26.9	32	344.8	535.8	62	351.1	500.3	92	343.5	500.0
4	39.3	40.9	34	354.8	523.3	64	348.7	500.3	94	339.9	500.8
6	56.4	63.9	36	343.5	508.6	66	349.6	499.7	96	339.8	499.7
8	79.5	94.7	38	360.1	499.5	68	349.4	500.4	98	339.7	499.3
10	111.2	136.9	40	363.3	504.2	70	347.6	500.9	100	338.1	500.8
12	148.2	183.4	42	365.2	498.7	72	348.0	499.6	102	338.0	499.2
14	190.5	236.1	44	359.4	500.3	74	348.3	500.5	104	337.3	500.7
16	235.0	293.5	46	350.7	491.1	76	347.4	499.9	106	337.6	500.2
18	269.6	357.2	48	348.5	500.5	78	348.0	499.7	108	337.0	500.1
20	322.4	412.5	50	349.1	501.0	80	346.8	501.4	110	335.7	500.7
22	265.7	407.6	52	347.0	499.9	82	346.5	499.9	112	335.5	499.6
24	289.7	458.8	54	347.9	499.1	84	344.9	499.6	114	336.2	500.0
26	311.4	511.5	56	348.4	499.8	86	344.6	499.1	116	335.8	499.8
28	326.7	468.4	58	348.3	501.2	88	344.6	499.9	118	332.7	500.3
30	325.3	544.8	60	349.4	498.8	90	342.7	499.8	120	333.0	500.4

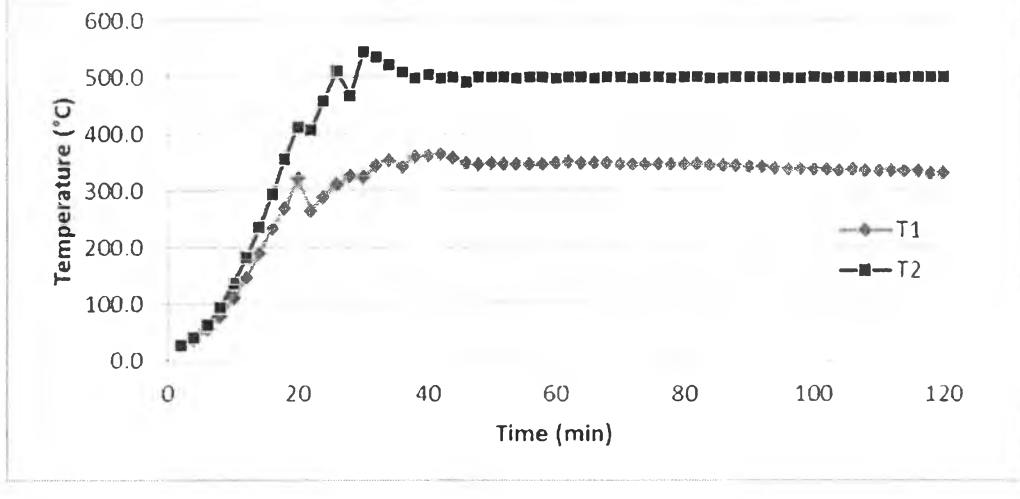

Figure A1 Temperature profiles of non-catalytic pyrolysis case.

Table A2 Pyrolysis conditions: HBETA

Tire = 30.0015 g, N_2 flow = 30 ml/min

Catalytic Temperature (T1) = 350 °C

Pyrolysis Temperature (T2) = 500 °C

Time (min)	T1	T2	Time (min)	T1	T2	Time (min)	T1	T2	Time (min)	T1	T2
2	24.2	24.4	32	391.3	506.6	62	365.5	500.1	92	353.8	499.8
4	29.9	37.1	34	397.7	501.3	64	364.9	499.1	94	353.8	499.8
6	39.6	55.5	36	383.9	472.9	66	364.2	499.1	96	350.2	500.0
8	59.1	87.7	38	372.2	458.4	68	363.6	499.8	98	350.0	500.0
10	90.6	168.1	40	366.5	466.5	70	364.8	501.5	100	350.1	500.2
12	107.7	173.3	42	364.2	494.4	72	363.7	499.9	102	351.8	500.4
14	135.1	218.1	44	365.1	504.3	74	363.6	499.9	104	351.0	500.3
16	182.0	290.1	46	367.0	497.4	76	360.4	501.3	106	347.6	500.1
18	265.7	401.2	48	365.4	503.0	78	358.4	500.7	108	348.9	500.0
20	281.3	415.0	50	365.1	495.5	80	357.6	500.5	110	348.6	500.0
22	313.2	448.8	52	365.5	498.7	82	356.8	500.5	112	350.0	500.0
24	260.7	494.9	54	365.7	500.0	84	356.5	500.4	114	350.1	499.8
26	310.1	509.6	56	365.5	500.0	86	354.3	499.7	116	349.9	499.7
28	344.5	505.6	58	365.6	500.1	88	353.8	499.7	118	349.8	500.1
30	375.2	498.8	60	365.4	500.1	90	353.9	499.8	120	348.9	500.3

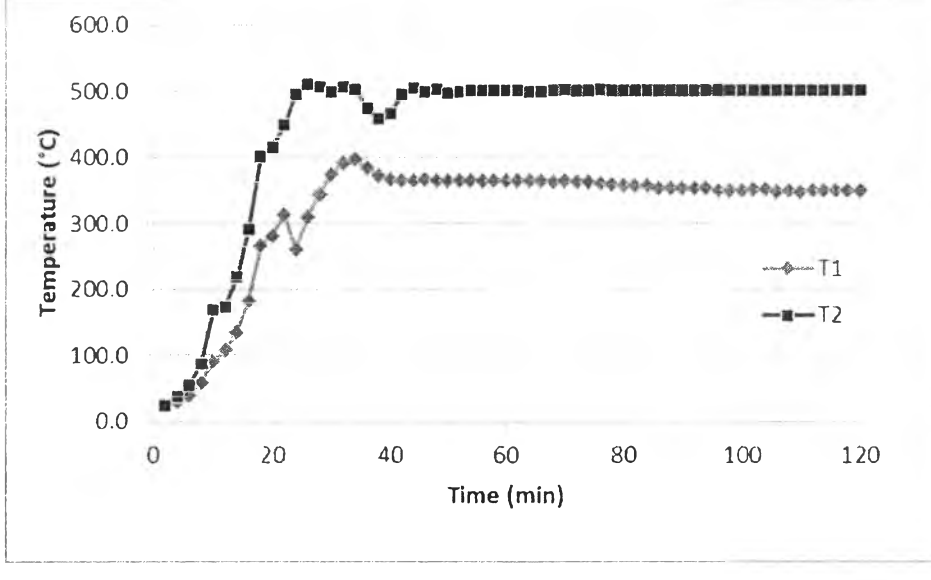

Figure A2 Temperature profiles of waste tire pyrolysis with HBETA catalyst.

Table A3 Pyrolysis conditions: 5Ni/HBETA

Tire = 30.0009 g, N_2 flow = 30 ml/min

Catalytic Temperature (T1) = 350 °C

Pyrolysis Temperature (T2) = 500 °C

Time (min)	T1	T2	Time (min)	T1	T2	Time (min)	T1	T2	Time (min)	T1	T2
2	27.3	26.1	32	319.4	497.8	62	348.2	496.8	92	344.3	499.8
4	31.4	34.6	34	323.4	491.9	64	351.0	499.2	94	346.7	499.3
6	42.7	54.4	36	327.8	487.0	66	351.1	498.7	96	344.2	497.4
8	61.4	83.8	38	332.6	473.8	68	352.0	499.1	98	343.8	500.6
10	93.8	128.1	40	343.9	462.1	70	350.4	500.9	100	346.7	500.4
12	115.4	160.5	42	344.9	459.7	72	349.1	500.3	102	346.8	500.5
14	153.3	222.9	44	348.0	447.3	74	347.9	499.1	104	345.4	500.3
16	184.6	277.8	46	347.4	441.6	76	347.3	499.2	106	345.0	499.9
18	221.2	352.4	48	347.4	445.0	78	346.5	500.4	108	344.4	499.7
20	289.5	413.8	50	346.0	480.7	80	343.2	499.8	110	344.2	500.0
22	310.9	467.3	52	346.6	497.1	82	343.0	498.2	112	342.8	500.4
24	333.7	510.3	54	348.7	507.7	84	344.4	498.2	114	342.6	500.3
26	337.6	510.8	56	346.8	497.4	86	341.1	498.1	116	340.7	500.5
28	316.4	500.2	58	351.6	501.0	88	342.4	498.3	118	340.0	500.8
30	312.6	506.0	60	348.2	495.6	90	345.2	499.7	120	339.6	500.2

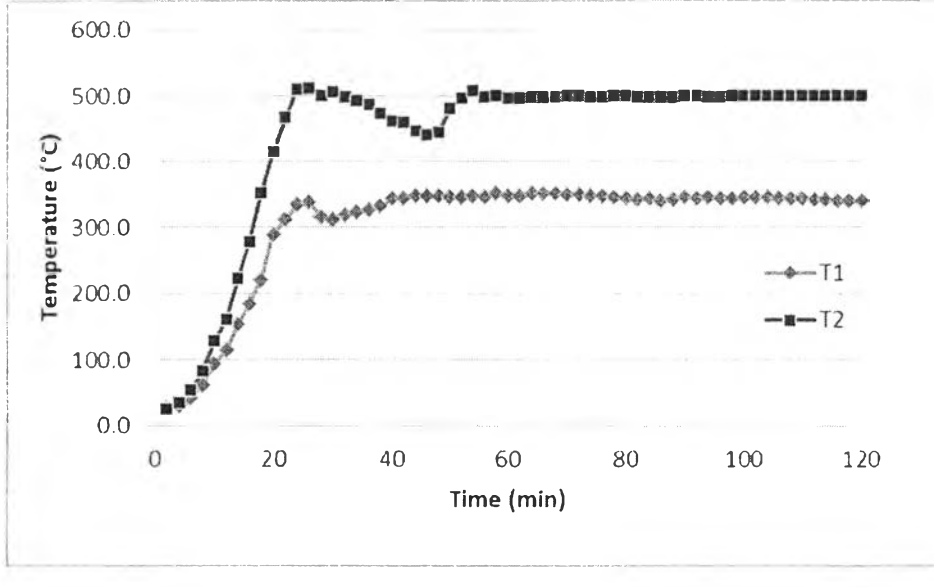

Figure A3 Temperature profiles of waste tire pyrolysis with 5Ni/HBETA.

Table A4 Pyrolysis conditions: 5Ni10Mo/HBETA

Tire = 30.085 g, N_2 flow = 30 ml/min

Catalytic Temperature (T1) = 350 °C

Pyrolysis Temperature (T2) = 500 °C

Time (min)	T1	T2	Time (min)	T1	T2	Time (min)	T1	T2	Time (min)	T1	T2
2	25.4	25.3	32	352.0	509.7	62	354.8	500.5	92	341.7	500.2
4	34.2	35.3	34	379.8	503.9	64	353.7	500.7	94	342.4	500.3
6	56.8	64.5	36	347.5	497.4	66	354.3	500.4	96	340.8	500.4
8	75.3	89.7	38	350.8	504.8	68	352.0	500.9	98	337.8	500.3
10	106.1	127.1	40	372.0	496.9	70	351.7	501.7	100	336.9	499.4
12	144.2	172.1	42	353.3	495.7	72	351.4	501.3	102	338.4	499.7
14	185.4	223.9	44	355.9	499.3	74	350.8	500.8	104	339.7	499.3
16	230.6	280.8	46	358.3	500.4	76	350.5	502.6	106	340.6	499.3
18	282.0	339.7	48	351.1	497.9	78	348.2	500.7	108	339.2	499.7
20	305.8	419.0	50	351.8	501.8	80	347.7	498.8	110	338.8	499.5
22	306.2	446.8	52	352.4	500.8	82	348.4	499.7	112	338.4	499.3
24	258.5	479.1	54	352.8	500.6	84	348.0	499.8	114	338.3	499.8
26	273.0	509.4	56	351.9	501.0	86	346.7	497.6	116	337.7	499.7
28	298.0	490.4	58	354.5	501.2	88	345.4	498.3	118	337.5	500.4
30	330.7	515.7	60	355.4	500.5	90	342.8	500.4	120	337.3	500.6

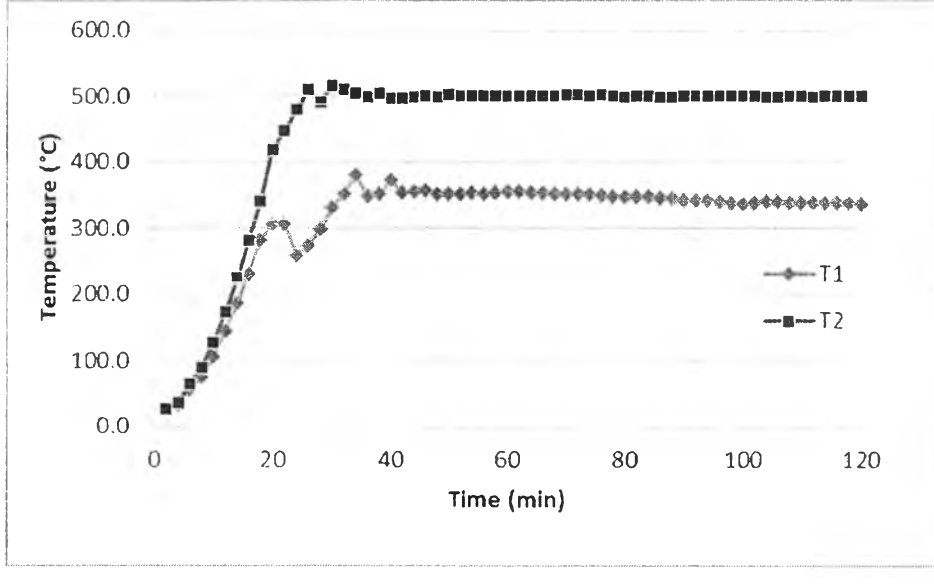

Figure A4 Temperature profiles of waste tire pyrolysis with 5Ni10Mo/HBETA.

Table A5 Pyrolysis conditions: 5Ni20Mo/HBETA

Tire = 30.0014 g, N_2 flow = 30 ml/min

Catalytic Temperature (T1) = 350 °C

Pyrolysis Temperature (T2) = 500 °C

Time (min)	T1	T2	Time (min)	T1	T2	Time (min)	T1	T2	Time (min)	T1	T2
2	24.2	23.9	32	307.8	499.3	62	338.5	499.7	92	340.7	499.6
4	35.5	43.8	34	320.8	504.8	64	338.2	500.2	94	338.5	500.4
6	44.3	60.4	36	337.1	495.9	66	339.6	500.3	96	336.3	500.3
8	66.6	96.9	38	342.0	498.7	68	340.2	500.4	98	335.4	500.0
10	89.8	130.1	40	336.7	498.2	70	338.7	500.0	100	334.3	500.2
12	118.3	177.4	42	334.0	500.6	72	336.2	500.6	102	336.8	500.3
14	158.5	234.0	44	335.7	500.4	74	338.4	499.8	104	338.4	500.0
16	204.0	294.1	46	338.9	499.4	76	339.3	499.8	106	339.2	500.0
18	253.4	371.9	48	337.9	500.5	78	340.2	500.1	108	339.6	500.2
20	299.8	416.7	50	341.6	500.4	80	342.4	500.0	110	338.2	500.7
22	280.4	453.7	52	344.5	499.6	82	340.5	499.8	112	339.4	500.4
24	288.8	497.3	54	344.3	499.7	84	340.7	499.8	114	340.3	500.3
26	301.1	501.1	56	342.2	499.7	86	343.3	500.0	116	338.6	500.5
28	296.9	496.5	58	342.7	500.4	88	340.6	500.1	118	337.4	500.6
30	299.6	503.4	60	340.6	500.3	90	340.5	499.4	120	336.0	500.7

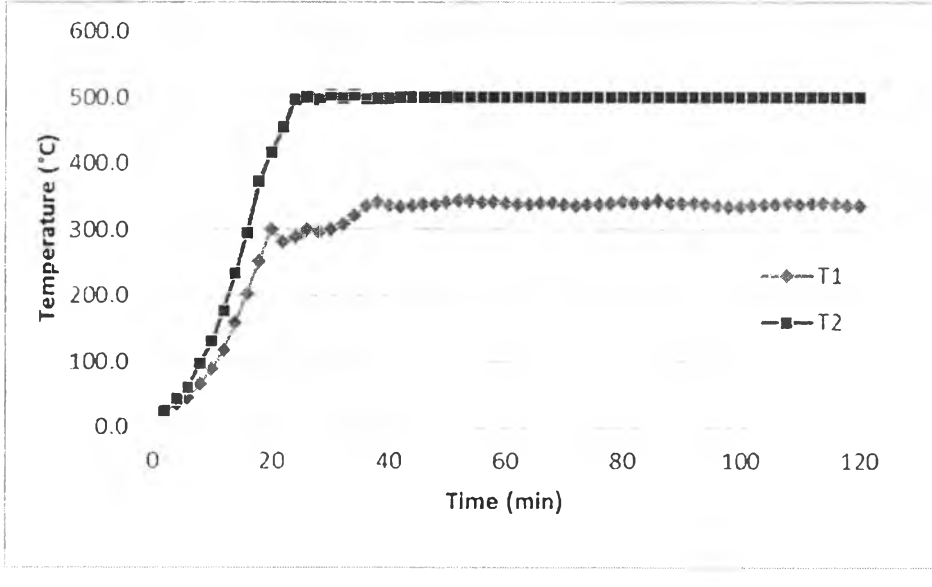

Figure A5 Temperature profiles of waste tire pyrolysis with 5Ni20Mo/HBETA.

Table A6 Pyrolysis conditions: 5Ni10W/HBETA

Tire = 30.0019 g, N_2 flow = 30 ml/min

Catalytic Temperature (T1) = 350 °C

Pyrolysis Temperature (T2) = 500 °C

Time (min)	T1	T2	Time (min)	T1	T2	Time (min)	T1	T2	Time (min)	T1	T2
2	25.7	25.2	32	333.7	499.6	62	352.5	499.8	92	350.5	500.6
4	31.5	36.3	34	344.1	506.1	64	350.6	498.3	94	349.8	500.5
6	43.4	56.2	36	353.4	502.2	66	351.2	499.5	96	349.7	500.4
8	63.6	88.0	38	356.2	503.4	68	350.8	499.7	98	348.6	500.3
10	89.5	127.5	40	354.3	500.0	70	352.4	499.6	100	346.2	500.9
12	124.3	174.2	42	354.0	502.4	72	353.3	499.5	102	347.3	500.0
14	164.6	229.8	44	353.8	503.5	74	350.6	499.7	104	348.2	501.2
16	204.5	281.8	46	353.9	502.6	76	350.5	499.8	106	346.4	501.3
18	251.2	335.7	48	351.7	501.7	78	350.4	499.9	108	345.3	501.1
20	298.6	410.3	50	350.0	500.8	80	350.2	499.6	110	342.0	500.8
22	299.2	450.4	52	350.3	500.9	82	350.0	500.0	112	343.5	500.0
24	267.9	484.7	54	350.4	500.5	84	349.9	500.5	114	344.6	500.5
26	276.4	481.2	56	350.0	500.4	86	349.8	500.3	116	341.7	500.4
28	307.0	527.7	58	352.8	500.5	88	348.7	500.5	118	340.6	500.4
30	307.8	513.7	60	354.6	499.7	90	348.5	500.7	120	339.7	501.1

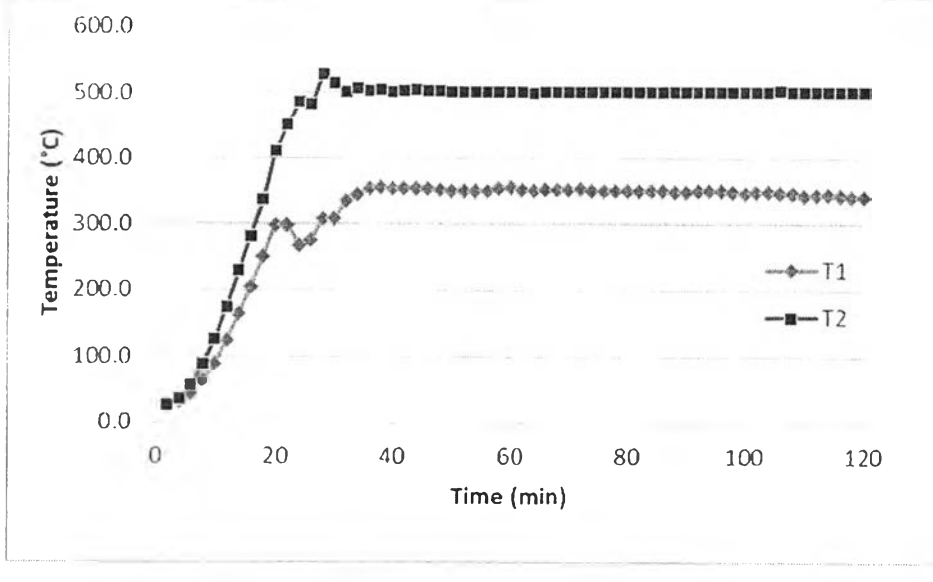

Figure A6 Temperature profiles of waste tire pyrolysis with 5Ni10W/HBETA.

Table A7 Pyrolysis conditions: 5Ni20W/HBETA

Tire = 30.0003 g, N_2 flow = 30 ml/min

Catalytic Temperature (T1) = 350 °C

Pyrolysis Temperature (T2) = 500 °C

Time (min)	T1	T2	Time (min)	T1	T2	Time (min)	T1	T2	Time (min)	T1	T2
2	26.8	27.0	32	322.9	519.5	62	346.7	500.0	92	342.7	499.8
4	35.8	46.5	34	332.2	502.7	64	340.3	500.0	94	343.5	499.7
6	46.1	61.9	36	333.2	506.2	66	340.2	500.2	96	344.8	499.9
8	70.3	100.6	38	333.9	501.6	68	340.7	500.4	98	342.6	500.0
10	91.4	131.5	40	346.9	494.5	70	341.5	500.6	100	341.7	500.0
12	128.8	183.9	42	348.1	498.2	72	342.6	500.7	102	343.4	499.9
14	162.2	232.9	44	348.5	500.5	74	342.2	500.0	104	347.8	499.7
16	209.4	291.1	46	350.3	498.8	76	342.0	500.4	106	346.5	499.4
18	257.5	346.2	48	352.8	499.1	78	341.3	500.3	108	346.9	499.3
20	303.8	419.4	50	350.3	500.5	80	340.4	500.1	110	347.8	499.2
22	328.5	444.0	52	353.5	499.2	82	340.7	500.2	112	348.4	499.5
24	262.4	484.0	54	353.8	499.9	84	340.9	500.4	114	346.5	499.6
26	275.6	471.3	56	353.6	499.0	86	342.4	500.3	116	345.3	499.5
28	291.2	522.0	58	350.8	498.8	88	343.5	500.0	118	344.4	499.5
30	311.2	529.4	60	350.9	499.7	90	343.9	500.3	120	344.8	499.4

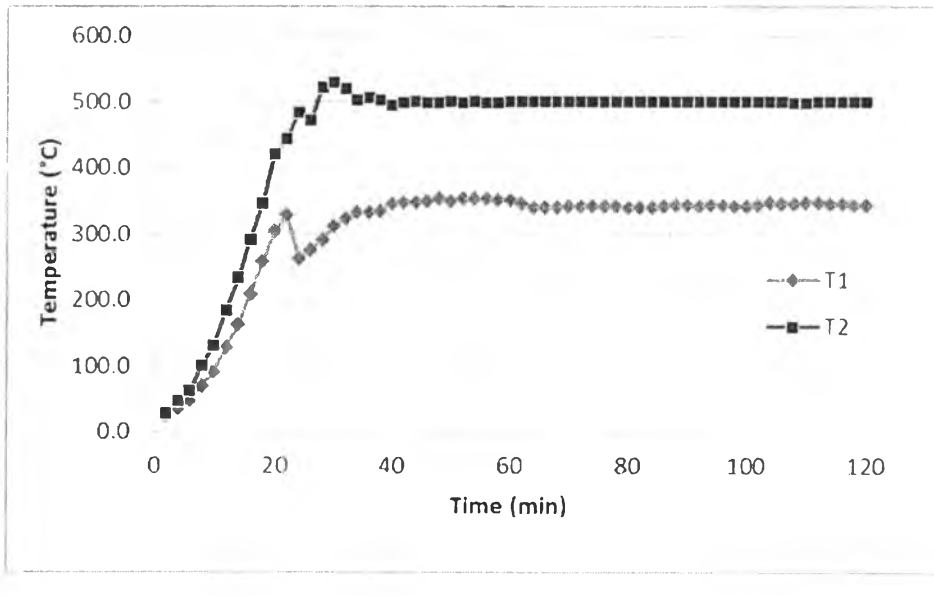

Figure A7 Temperature profiles of waste tire pyrolysis with 5Ni20W/HBETA.

Table A8 Pyrolysis conditions: 5Co/HBETA

Tire = 30.0013 g, N_2 flow = 30 ml/min

Catalytic Temperature (T1) = 350 °C

Pyrolysis Temperature (T2) = 500 °C

Time (min)	T1	T2	Time (min)	T1	T2	Time (min)	T1	T2	Time (min)	T1	T2
2	39.7	50.0	32	353.1	484.9	62	348.2	502.6	92	347.6	500.8
4	57.1	76.9	34	353.1	473.5	64	349.7	500.8	94	347.4	500.6
6	94.6	128.1	36	356.5	464.2	66	348.6	501.6	96	346.9	500.5
8	114.1	152.5	38	355.3	473.9	68	347.5	500.7	98	346.8	500.4
10	145.3	196.6	40	355.4	477.6	70	346.8	499.8	100	345.0	499.6
12	198.0	274.8	42	355.9	484.4	72	346.3	499.9	102	346.3	499.8
14	233.6	330.6	44	350.6	500.3	74	345.9	499.4	104	346.7	500.5
16	298.2	407.5	46	343.9	506.3	76	346.7	500.4	106	346.5	500.4
18	239.5	438.6	48	347.8	507.4	78	348.3	500.3	108	346.8	499.8
20	291.8	485.1	50	348.2	505.2	80	349.6	500.0	110	347.2	500.9
22	281.8	509.5	52	347.5	504.8	82	350.3	502.4	112	345.4	499.8
24	298.6	503.3	54	348.6	504.7	84	350.0	502.8	114	344.3	500.2
26	324.8	503.2	56	349.7	503.6	86	348.5	501.9	116	342.1	500.1
28	342.0	503.9	58	348.6	502.9	88	347.6	501.5	118	341.7	499.9
30	351.5	488.0	60	347.3	503.0	90	346.8	501.4	120	340.6	499.7

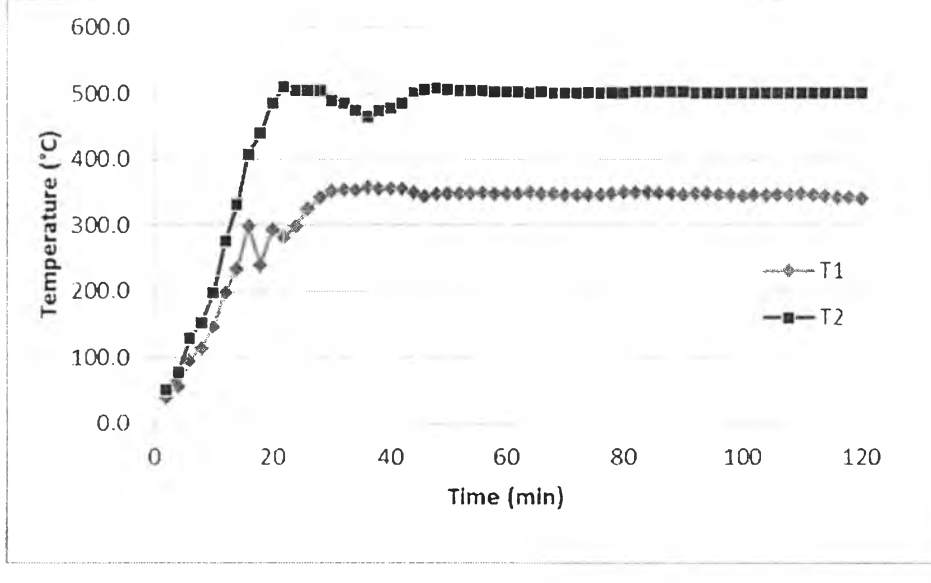

Figure A8 Temperature profiles of waste tire pyrolysis with 5Co/HBETA.

Table A9 Pyrolysis conditions: 5Co20Mo/HBETA

Tire = 30.0666 g, N_2 flow = 30 ml/min

Catalytic Temperature (T1) = 350 °C

Pyrolysis Temperature (T2) = 500 °C

Time (min)	T1	T2	Time (min)	T1	T2	Time (min)	T1	T2	Time (min)	T1	T2
2	26.8	25.8	32	361.6	487.7	62	358.5	500.3	92	348.5	499.9
4	33.1	36.6	34	353.7	477.9	64	357.4	500.2	94	347.6	500.2
6	46.7	57.1	36	349.1	483.3	66	355.3	500.2	96	346.5	499.8
8	64.9	86.0	38	346.9	506.3	68	352.0	500.0	98	346.4	499.7
10	91.6	128.6	40	344.6	499.7	70	350.0	499.8	100	346.4	500.0
12	118.4	170.9	42	349.3	505.4	72	349.9	499.7	102	345.0	500.1
14	164.8	237.1	44	355.5	497.0	74	349.8	499.7	104	347.3	500.2
16	206.7	290.5	46	353.9	494.4	76	348.5	499.9	106	346.2	500.2
18	271.8	387.5	48	356.6	498.4	78	350.3	500.3	108	345.4	500.1
20	315.9	404.5	50	359.7	500.3	80	350.2	500.2	110	343.3	499.9
22	333.7	458.0	52	359.8	500.2	82	350.1	500.3	112	342.8	499.9
24	350.9	499.1	54	360.0	500.6	84	350.0	500.6	114	342.5	499.8
26	357.0	505.4	56	360.3	500.5	86	350.2	500.5	116	342.7	499.9
28	359.5	500.5	58	361.1	500.4	88	350.4	500.4	118	342.3	500.0
30	361.0	501.4	60	359.5	500.7	90	351.0	500.3	120	342.0	500.1

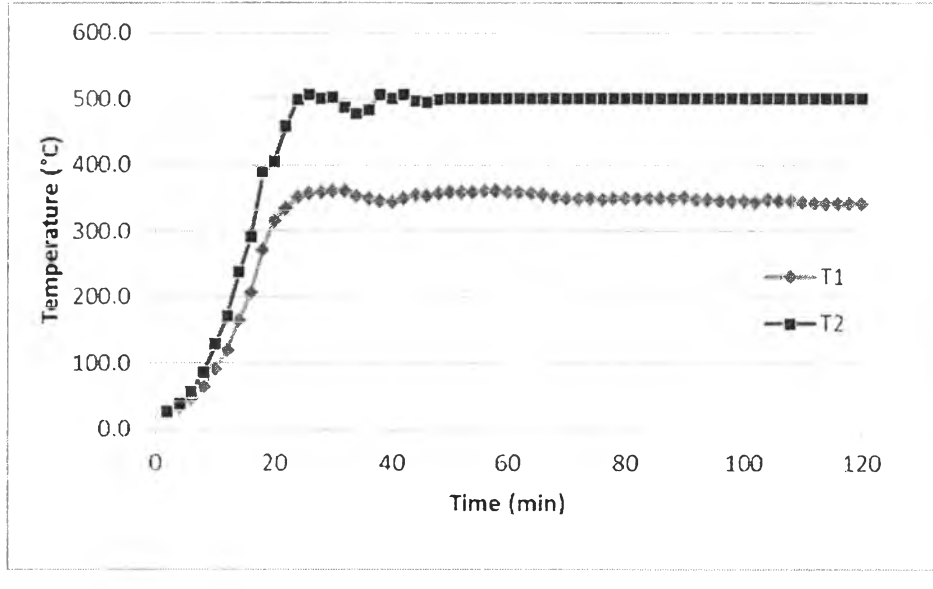

Figure A9 Temperature profiles of waste tire pyrolysis with 5Co20MO/HBETA.

Table A10 Pyrolysis conditions: 5Co20W/HBETA

Tire = 30.0015 g, N_2 flow = 30 ml/min

Catalytic Temperature (T1) = 350 °C

Pyrolysis Temperature (T2) = 500 °C

Time (min)	T1	T2	Time (min)	T1	T2	Time (min)	T1	T2	Time (min)	T1	T2
2	43.8	30.4	32	314.2	544.6	62	354.4	499.5	92	346.3	499.9
4	59.7	35.9	34	340.2	530.4	64	353.8	499.7	94	347.2	499.8
6	68.7	43.3	36	366.7	512.2	66	353.7	499.9	96	347.5	499.8
8	88.4	60.2	38	364.3	510.4	68	352.7	500.0	98	347.6	499.7
10	119.7	90.7	40	361.8	505.8	70	350.4	500.2	100	347.3	499.8
12	150.0	124.9	42	358.7	500.3	72	348.9	500.4	102	347.8	499.9
14	182.3	170.0	44	357.6	500.2	74	347.6	500.3	104	347.9	500.0
16	228.7	228.0	46	355.4	500.4	76	346.5	500.3	106	348.4	500.0
18	271.7	280.4	48	353.2	500.7	78	344.3	500.3	108	347.3	500.2
20	307.1	342.3	50	350.7	499.8	80	344.0	500.4	110	347.6	500.3
22	325.4	406.0	52	354.3	499.6	82	343.1	500.5	112	348.5	500.4
24	343.5	444.3	54	353.7	499.5	84	343.0	500.3	114	348.6	500.4
26	320.6	476.1	56	353.0	499.7	86	344.7	500.1	116	349.3	500.3
28	323.4	485.9	58	353.8	500.3	88	345.4	500.1	118	349.6	500.3
30	311.5	520.7	60	354.0	500.7	90	345.5	500.0	120	350.3	500.2

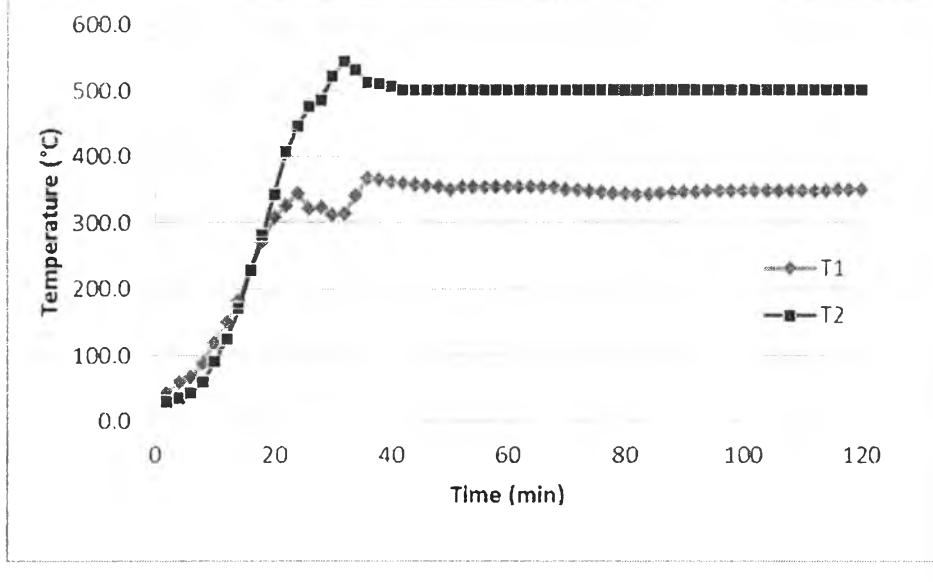

Figure A10 Temperature profiles of waste tire pyrolysis with 5Co20W/HBETA.

Appendix B Yields of Pyrolysis Products

Table B1 Weight percentage of pyrolysis products obtained from Ni/HBETA and NiMo/HBETA catalysts

Product	Non-cat	HBETA	5Ni/ HBETA	5Ni10Mo/ HBETA	5Ni20Mo/ HBETA
Gas	23.7	26.5	18.2	19.6	26.5
Liquid	36.3	30.2	33.2	32.5	30.0
Solid	40.0	4.02	39.0	38.9	37.7
Coke	0.00	3.11	9.63	8.9	5.71
G/L ratio	0.65	0.88	0.55	0.60	0.88

Table B2 Weight percentage of pyrolysis products obtained from Ni/HBETA and NiW/HBETA catalysts

Product	Non-cat	HBETA	5Ni/ HBETA	5Ni10W/ HBETA	5Ni20W/ HBETA
Gas	23.7	26.5	18.2	20.7	24.8
Liquid	36.3	30.2	33.2	31.2	29.6
Solid	40.0	4.02	39.0	39.3	39.3
Coke	0.00	3.11	9.63	8.80	6.29
G/L ratio	0.65	0.88	0.55	0.66	0.84

Table B3 Weight percentage of pyrolysis products obtained from modified Co/HBETA catalysts

Product	Non-cat	HBETA	5Co/ HBETA	5Co20Mo/ HBETA	5Co20W/ HBETA
Gas	23.7	26.5	27.2	25.2	25.7
Liquid	36.3	30.2	25.4	26.2	28.9
Solid	40.0	4.02	39.0	41.3	38.9
Coke	0.00	3.11	8.43	7.32	6.52
G/L ratio	0.65	0.88	1.07	0.96	0.89

Appendix C The Pyrolysis Gas Compositions

Table C1 Weight percentage of gas products obtained from Ni/HBETA and NiMo/HBETA catalysts

Gas composition	Catalysts				
	Non Cat.	HBETA	5Ni/HBETA	5Ni10Mo/ HBETA	5Ni20Mo/ HBTEA
Methane	21.51	15.77	15.94	17.67	19.14
Ethylene	14.64	8.46	8.90	10.42	10.88
Ethane	14.21	11.38	11.59	13.40	14.36
Propylene	11.66	9.37	9.23	10.04	9.77
Propane	7.04	9.15	7.64	8.27	8.32
Mixed C4	15.14	27.04	29.14	22.60	19.72
Mixed C5	15.80	18.84	17.53	17.59	17.81

Table C2 Weight percentage of gas products obtained from the NiW/HBETA and modified Co/HBETA catalysts

Gas composition	Catalysts				
	5Ni10W/ HBETA	5Ni20W/ HBETA	5Co/HBETA	5Co20Mo/ HBETA	5Co20W/ HBTEA
Methane	17.63	19.46	18.73	19.80	18.45
Ethylene	10.44	11.59	9.83	11.01	11.62
Ethane	12.90	13.85	13.72	14.27	13.57
Propylene	9.72	10.21	9.66	10.04	10.39
Propane	7.92	7.59	8.50	8.01	7.64
Mixed C4	23.07	19.84	23.49	19.74	20.59
Mixed C5	18.32	17.45	16.07	17.13	17.75

Appendix D Amount of Asphaltene in Pyrolysis Oils

Table D1 Amount of asphaltene in pyrolysis oils

Catalysts	Asphaltene (wt%)
Non-cat	0.470
HBETA	0.250
5Ni/HBETA	0.015
5Ni10Mo/HBETA	0.011
5Ni20Mo/HBETA	0.011
5Ni10W/HBETA	0.018
5Ni20W/HBETA	0.022
5Co/HBETA	0.038
5Co20Mo/HBETA	0.014
5Co20W/HBETA	0.023

Appendix E Chemical Compositions of Maltenes

Table E1 Chemical compositions of maltenes obtained from Ni/HBETA and NiMo/HBETA catalysts

Catalyst component / Chemical composition	Non Cat.	HBETA	5Ni/HBETA	5Ni10Mo/ HBETA	5Ni20Mo/ HBETA
Saturated HC.	44.94	45.05	41.61	47.28	48.58
Mono-aromatic	19.01	18.95	13.8	20.34	23.45
Di-aromatic	12.91	12.89	9.55	10.03	7.65
Poly-aromatic	12.73	12.72	22.29	13.47	12.28
Polar-aromatic	10.41	10.39	12.75	8.88	8.04

Table E2 Chemical compositions of maltenes obtained from NiW/HBETA and modified Co/HBETA catalysts

Catalyst component / Chemical composition	5Ni10W/ HBETA.	5Ni20W/ HBETA	5Co/HBETA	5Co20Mo/ HBETA	5Co20W/ HBETA
Saturated HC.	45.49	47.62	45.1	52.12	63.84
Mono-aromatic	19.44	19.34	18.04	20.44	13.75
Di-aromatic	7.64	8.63	10.26	7.55	5.84
Poly-aromatic	19.1	16.37	18.35	9.76	7.91
Polar-aromatic	8.33	8.04	8.24	10.13	8.66

Appendix F Petroleum Fractions of Derived Oils

Table F1 Petroleum fractions of derived oils obtained from Ni/HBETA and NiMo/HBETA catalysts

Catalyst / Fraction	Non Cat.	HBETA	5Ni/HBETA	5Ni10Mo/ HBETA	5Ni20Mo/ HBETA
Naphtha	45.48	34.48	45.77	40.23	47.4
Kerosene	14.85	20.56	16.37	21.29	16.87
Light Gas Oil	11.39	15.37	13.07	13.01	12.51
Heavy Gas Oil	12.26	13.09	13.96	11.92	12.44
Residues	16.03	16.5	10.83	13.55	10.78

Table F2 Petroleum fractions of derived oils obtained from NiW/HBETA and modified Co/HBETA catalysts

Catalyst / Fraction	5Ni10W/ HBETA.	5Ni20W/ HBETA	5Co/HBETA	5Co20Mo/ HBETA	5Co20W/ HBETA
Naphtha	45.48	45.8	48.53	52.17	47.82
Kerosene	14.85	19.59	18.17	15.3	21.95
Light Gas Oil	11.39	12.4	11.63	11.03	13.18
Heavy Gas Oil	12.26	11.28	11.83	11.47	10.41
Residues	16.03	10.93	9.84	10.03	6.64

Appendix G Sulfur in Derived Oils and Sulfur deposition on Spent Catalysts

Table G1 Sulfur in derived oils and sulfur deposition on spent catalysts

Catalysts	Sulfur in oil (%wt)	Sulfur on spent cat (%wt)
Non-cat	1.36	0
HBETA	1.27	0.374
5Ni/HBETA	1.016	0.8675
5Ni10Mo/HBETA	1.205	0.777
5Ni20Mo/HBETA	0.8165	0.2675
5Ni10W/HBETA	1.195	0.715
5Ni20W/HBETA	0.9635	0.915
5Co/HBETA	1.0565	0.715
5Co20Mo/HBETA	0.558	0.79
5Co20W/HBETA	0.51	0.445

Appendix H Sulfur distribution

Table H1 Sulfur distribution (%wt) in the pyrolytic products obtained from using each catalyst

Catalyst	Gas	Oil	Char	Coke
Non-cat	32.3	20.2	47.6	0
HBETA	25.1	22.8	45.2	6.88
5Ni/HBETA	22.0	0.99	57.3	19.7
5Ni10Mo/HBETA	25.6	21.1	37.8	15.6
5Ni20Mo/HBETA	24.4	15.9	43.9	15.8
5Ni10W/HBETA	16.0	55.1	23.5	5.37
5Ni20W/HBETA	18.6	18.2	44.4	18.7
5Co/HBETA	17.5	23.2	43.6	15.6
5Co20Mo/HBETA	9.55	9.44	64.3	16.7
5Co20W/HBETA	9.63	18.3	62.9	9.17

APPENDIX I Carbon Number Distribution of polar-aromatics

Table I1 Carbon Number Distribution of polar-aromatics obtained from Ni/HBETA and NiMo/HBETA catalysts

No.Carbon	Non-catalytic	HBETA	5Ni/HBETA	5Ni10Mo/ HBETA	5Ni20Mo/ HBETA
1	0.000	0.000	0.000	0.000	0.000
2	0.000	0.000	0.000	0.000	0.000
3	0.000	0.000	0.000	0.000	0.000
4	0.000	0.002	0.003	0.009	0.015
5	0.007	0.023	0.036	0.084	0.140
6	0.023	0.034	0.053	0.112	0.179
7	0.058	0.048	0.074	0.144	0.221
8	0.116	0.066	0.100	0.179	0.265
9	0.194	0.086	0.131	0.217	0.311
10	0.287	0.111	0.168	0.258	0.358
11	0.384	0.139	0.209	0.301	0.405
12	0.477	0.171	0.257	0.345	0.453
13	0.560	0.206	0.309	0.392	0.500
14	0.629	0.245	0.366	0.439	0.546
15	0.684	0.288	0.428	0.487	0.592
16	0.725	0.333	0.495	0.536	0.637
17	0.752	0.383	0.565	0.585	0.680
18	0.769	0.435	0.639	0.635	0.722
19	0.777	0.491	0.716	0.686	0.763
20	0.778	0.550	0.795	0.737	0.801
21	0.773	0.612	0.874	0.789	0.835
22	0.765	0.678	0.953	0.842	0.865
23	0.754	0.748	1.028	0.896	0.888
24	0.741	0.822	1.096	0.950	0.902
25	0.728	0.898	1.154	1.003	0.902
26	0.713	0.977	1.196	1.054	0.887
27	0.698	1.058	1.218	1.098	0.853
28	0.682	1.139	1.216	1.130	0.799
29	0.667	1.216	1.187	1.141	0.728
30	0.651	1.286	1.132	1.120	0.644
31	0.635	1.342	1.054	1.058	0.553
32	0.619	1.380	0.958	0.951	0.462
33	0.602	1.391	0.851	0.806	0.377
34	0.585	1.370	0.740	0.644	0.302
35	0.566	1.314	0.632	0.487	0.238
36	0.547	1.224	0.532	0.352	0.186
37	0.526	1.108	0.442	0.247	0.144
38	0.504	0.973	0.364	0.170	0.111
39	0.480	0.832	0.297	0.116	0.085
40	0.454	0.695	0.241	0.079	0.066
41	0.426	0.569	0.195	0.054	0.050
42	0.396	0.458	0.156	0.037	0.039
43	0.363	0.363	0.125	0.025	0.030

44	0.327	0.285	0.099	0.018	0.023
45	0.288	0.220	0.078	0.012	0.017
46	0.245	0.167	0.060	0.008	0.013
47	0.197	0.121	0.045	0.006	0.010
48	0.144	0.082	0.031	0.004	0.006
49	0.084	0.046	0.017	0.002	0.004
50	0.017	0.009	0.003	0.000	0.001

Table I2 Carbon Number Distribution of polar-aromatics obtained from NiW/HBETA and modified Co catalysts

No.Carbon	5Ni10W/ HBETA.	5Ni20W/ HBETA	5Co/HBETA	5Co20Mo/ HBETA	5Co20W/ HBETA
1	0.000	0.000	0.000	0.000	0.000
2	0.000	0.000	0.000	0.000	0.000
3	0.000	0.000	0.000	0.000	0.000
4	0.000	0.001	0.013	0.008	0.014
5	0.007	0.020	0.126	0.080	0.142
6	0.023	0.051	0.163	0.110	0.202
7	0.058	0.103	0.202	0.144	0.273
8	0.116	0.174	0.245	0.183	0.354
9	0.194	0.258	0.289	0.226	0.442
10	0.287	0.349	0.334	0.274	0.532
11	0.384	0.436	0.380	0.324	0.618
12	0.477	0.515	0.427	0.378	0.695
13	0.560	0.582	0.474	0.433	0.758
14	0.629	0.636	0.521	0.490	0.802
15	0.684	0.676	0.567	0.547	0.826
16	0.725	0.703	0.613	0.604	0.830
17	0.752	0.721	0.658	0.659	0.817
18	0.769	0.729	0.703	0.711	0.789
19	0.777	0.731	0.747	0.760	0.750
20	0.778	0.728	0.791	0.803	0.704
21	0.773	0.721	0.835	0.839	0.655
22	0.765	0.711	0.878	0.868	0.604
23	0.754	0.699	0.920	0.888	0.554
24	0.741	0.687	0.960	0.899	0.506
25	0.728	0.673	0.993	0.900	0.461
26	0.713	0.660	1.015	0.890	0.420
27	0.698	0.646	1.017	0.870	0.381
28	0.682	0.632	0.991	0.842	0.346
29	0.667	0.618	0.925	0.805	0.314
30	0.651	0.605	0.817	0.761	0.285
31	0.635	0.591	0.677	0.712	0.258
32	0.619	0.576	0.525	0.659	0.234
33	0.602	0.562	0.383	0.605	0.212
34	0.585	0.546	0.268	0.550	0.192
35	0.566	0.530	0.181	0.496	0.174
36	0.547	0.513	0.120	0.444	0.157
37	0.526	0.495	0.079	0.395	0.142

38	0.504	0.475	0.052	0.349	0.128
39	0.480	0.453	0.034	0.306	0.115
40	0.454	0.430	0.023	0.267	0.102
41	0.426	0.404	0.015	0.231	0.091
42	0.396	0.376	0.010	0.199	0.080
43	0.363	0.346	0.007	0.170	0.070
44	0.327	0.312	0.005	0.143	0.061
45	0.288	0.275	0.003	0.118	0.051
46	0.245	0.234	0.002	0.095	0.042
47	0.197	0.188	0.002	0.073	0.033
48	0.144	0.138	0.001	0.052	0.024
49	0.084	0.081	0.001	0.030	0.014
50	0.017	0.017	0.000	0.006	0.003

APPENDIX J Distribution of sulfur compounds in petroleum fractions

Table J1 Distribution of sulfur compounds in petroleum fractions from Ni/HBETA and NiMo/HBETA catalysts

	Noncat	HBETA	5Ni/HBETA	5Ni10Mo/HBETA	5Ni20Mo/HBETA
Gasoline C5-C9	33.8	47.3	55.3	43.8	45.0
Kerosene C10-C13	55.6	50.0	44.3	53.4	45.1
Gas oil C14-C20	10.6	2.70	0.34	2.84	8.35
LVGO C21-C23	0	0	0	0	0
HVGO C24-C50	0	0	0	0	0

Table J2 Distribution of sulfur compounds in petroleum fractions from NiW/HBETA and modified Co/HBETA catalysts

	5Ni10W/ HBETA.	5Ni20W/ HBETA	5Co/HBETA	5Co20Mo/ HBETA	5Co20W/ HBETA
Gasoline C5-C9	20.9	36.8	41.6	59.3	53.3
Kerosene C10-C13	70.4	60.3	31.3	39.7	44.3
Gas oil C14-C20	8.68	2.81	27.1	0.99	2.33
LVGO C21-C23	0	0	0	0	0
HVGO C24-C50	0	0	0	0	0

APPENDIX K Sulfur compounds in oils from all catalysts.

Table K1 Sulfur compounds in oil from the non-catalytic case

Name	Formular	Area %
Thiophene, 2-(1-methylethyl)-	C7H10S	1.3839
Benzenethiol	C6H6S	0.30196
Thiophene, 2-(1,1-dimethylethyl)-	C8H12S	0.72133
Thiophene, 2-methyl-5-propyl-	C8H12S	0.65462
Thiophene, 2-butyl-	C8H12S	1.7774
Thiophene, 3,4-diethyl-	C8H12S	0.85483
Thiophene, 2,5-diethyl-	C8H12S	0.74795
Benzenethiol, 3-methyl-	C7H8S	0.47752
Thiophene, 2-(2-butenyl)-, (E)-	C8H10S	1.0302
Benzo[b]thiophene	C8H6S	3.317
4-Isopropylthiophenol	C9H12S	0.62165
2-Benzothiophene	C8H6S	0.086677
Thiophene, 2-hexyl-	C10H16S	1.2257
3-Methylbenzothiophene	C9H8S	5.8476
Benzo[b]thiophene, 2-methyl-	C9H8S	2.1865
Benzo[b]thiophene, 2-methyl-	C9H8S	6.0267
Benzo[b]thiophene, 2,5-dimethyl-	C3H6S3	4.7837
Benzo[b]thiophene, 7-ethyl-	C10H10S	5.3197
Benzo[b]thiophene, 2,7-dimethyl-	C10H10S	13.322
Benzo[b]thiophene, 3,6-dimethyl-	C10H10S	3.5151
5-Ethylbenzo[b]thiophene	C10H10S	1.6039
Sulfide, 1-butynyl phenyl	C10H10S	2.6537
Benzene, 1-methyl-4-[(methylthio)ethynyl)	C10H10S	0.23545
Benzo[b]thiophene, 3,5-dimethyl-	C10H10S	0.28446
Benzo[b]thiophene, 2-ethyl-7-methyl-	C11H12S	7.0944
1509 Thiophene, 2-(phenylmethyl)-	C11H12S	1.9931
Benzo[b]thiophene, 2,5,7-trimethyl	C11H12S	5.2206
Benzo[b]thiophene, 7-ethyl-2-methyl-	C11H12S	0.90472
Benzo[b]thiophene, 2-ethyl-5-methyl-	C11H12S	0.51927
Benzo[b]thiophene, 2,3-diethyl-	C12H14S	0.92551
Benzo[b]thiophene, 2,7-diethyl-	C12H14S	5.422
Benzo[b]thiophene, 2-ethyl-5,7-dimethyl-	C12H14S	0.23737
Benzo[b]thiophene, 7-ethyl-2-propyl-	C13H16S	0.79963
Dibenzothiophene	C12H8S	1.6837
Naphtho[2,1-b]thiophene	C12H8S	0.72667
4-Methylnaphtho[1,2-b]thiophene	C13H10S	1.4757
Thioxanthene	C13H10S	0.51407

1-Methyldibenzothiophene	C13H10S	0.92092
Dibenzothiophene, 4-methyl-	C13H10S	0.27743
3-Ethyldibenzothiophene	C14H12S	0.20139
2,8-Dimethyldibenzo(b,d)thiophen	C14H12S	0.72166
2,7-Dimethyldibenzothiophene	C14H12S	2.6001
2,6-Dimethyldibenzothiophene	C14H12S	0.6658
1,7-Dimethyldibenzothiophene	C14H12S	1.6922
3,7-Dimethyldibenzothiophene	C14H12S	1.0677
1-Propene-2-thiol, 1,1-diphenyl-	C15H14S	0.7001
Phenaleno[1,9-bc]thiophene	C14H8S	0.71894
Benzene, 1,1'-[(methylthio)ethenylidene]bis-	C15H14S	1.0859
1-Methylphenanthro[4,5-bcd]thiophen	C15H10S	0.18375
Benzo[b]naphtho[2,1-d]thiophene	C16H10S	0.40427
Benzo[b]naphtho[2,3-d]thiophene, 9,10-dihydro-7-methyl-	C17H14S	0.18342
Benzo[b]naphtho[2,3-d]thiophene, 8-methyl-	C17H12S	0.38749
Benzo[b]naphtho[2,3-d]thiophene, 7-methyl-	C17H12S	0.2458
Benzo[b]naphtho[2,3-d]thiophene, 6-methyl-	C17H12S	0.519
Benzo[b]naphtho[2,3-d]thiophene, 7,8-dimethyl-	C18H14S	0.3114
Benzo[b]naphtho[2,3-d]thiophene, 6,8-dimethyl-	C18H14S	0.44024

Table K2 Sulfur compounds in oil from the HBETA

Name	Formular	Area %
Thiophene, 2-ethyl-	C6H8S	1.2523
3,4-Dimethylthiophene	C6H8S	0.78954
3,4-Dimethylthiophene	C6H8S	0.23426
Thiophene, 2,3-dimethyl-	C6H8S	0.53712
Thiophene, 2-ethenyl-	C6H8S	0.43584
Thiophene, 2-propyl-	C7H10S	0.38807
Thiophene, 2-(1-methylethyl)-	C7H10S	4.8594
Thiophene, 2-pentyl-	C9H14S	0.52506
Benzenethiol	C6H6S	0.44069
Thiophene, 2-ethyl-5-methyl-	C7H10S	1.2388
Thiophene, 2-ethyl-5-isopentyl-	C11H18S	3.8925
Thiophene, 2-ethyl-5-isopentyl-	C7H10S	1.0587
Thiophene, 3-(1,1-dimethylethyl)-	C8H12S	2.4641
2-(2-Methylvinyl)thiophene	C7H8S	0.33676
Thiophene, 2-methyl-5-propyl-	C8H12S	3.32
Thiophene, 2,5-diethyl-	C8H12S	1.7162
Thiophane, propyl-	C7H14S	0.70504
Thiophene, 2-butyl-	C8H12S	2.9736
2-Cyclopropylthiophene	C7H8S	0.40986

Thiophene, 3,4-diethyl-	C8H12S	2.5851
Benzenethiol, 3-methyl-	C7H8S	0.4555
Thiophene, 2-(2-butenyl)-, (E)-	C8H10S	0.3285
2-(2,2-Dimethylvinyl)thiophene	C8H10S	0.21536
Thiophene, 2-ethyl-5-propyl-	C9H14S	1.8186
Benzo[b]thiophene	C8H6S	4.252
Cyclopenta[b]thiapyran	C8H6S	0.31413
Thiophene, 2-butyl-5-ethyl-	C10H16S	0.36168
Benzo[b]thiophene, 2,3-dihydro-	C8H8S	0.15498
Thiophene, 2-hexyl-	C10H16S	0.98213
Benzo[c]thiophene, 1,3-dihydro-	C8H8S	0.084461
Benzo[b]thiophene, 2-methyl-	C9H8S	5.8021
Benzo[b]thiophene, 2,3-dihydro-3-methyl-	C9H10S	0.46764
3-Methylbenzothiophene	C9H8S	2.4307
Benzo[b]thiophene, 6-methyl-	C9H8S	4.3574
1,3,5-Trithiane	C3H6S3	0.26965
Benzo[b]thiophene, 4-methyl-	C9H8S	0.09372
Benzo[b]thiophene, 7-ethyl-2-propyl-	C13H16S	0.30923
Benzo[b]thiophene, 2,7-dimethyl-	C10H10S	3.1123
Thiophene, 3-phenyl-	C10H8S	1.0649
Benzo[b]thiophene, 2,5-dimethyl-	C10H10S	10.518
2-Naphthalenethiol	C10H8S	0.20708
Benzo[b]thiophene, 3,5-dimethyl-	C10H10S	1.5001
Sulfide, 1-butynyl phenyl	C10H10S	3.5218
Benzo[b]thiophene, 7-ethyl-	C10H10S	1.2833
Thiophene, 2-ethyl-5-hexyl-	C12H20S	0.41594
Benzene, 1-methyl-4-[(methylthio)ethynyl]-	C10H10S	0.12458
Benzo[b]thiophene, 2,5,7-trimethyl-	C11H12S	0.28492
Benzo[b]thiophene, 2-ethyl-7-methyl-	C11H12S	4.1862
Thiophene, 2-(phenylmethyl)-	C11H10S	1.4046
Benzo[b]thiophene, 7-ethyl-2-methyl-	C11H12S	2.93
Benzo[b]thiophene, 2-ethyl-5-methyl-	C11H12S	2.0045
Benzo[b]thiophene, 2,7-diethyl-	C12H14S	5.4802
Benzo[b]thiophene, 2-ethyl-5,7-dimethyl-	C12H14S	0.56488
Benzo[b]thiophene, 2,3-diethyl-	C12H14S	0.75581
1-(3'-Isopropylphenylthio)prop-1-yne	C12H14S	1.2209
Dibenzothiophene	C12H8S	0.95114
Naphtho[2,1-b]thiophene	C12H8S	0.35733
Dibenzothiophene, 4-methyl-	C13H10S	0.84746
Thioxanthene	C13H10S	0.88184
Dibenzothiophene, 3-methyl-	C13H10S	0.82545
3,7-Dimethyldibenzothiophene	C14H12S	0.27283

Naphtho[2,3-b]thiophene, 4,9-dimethyl-	C14H12S	0.55332
2,8-Dimethyldibenzo(b,d)thiophene	C14H12S	1.27
Benzene, 1,1'-[(methylthio)ethenylidene]bis-	C15H14S	0.24675
Phenaleno[1,9-bc]thiophene	C14H8S	0.15181
1-Methylphenanthro[4,5-bcd]thiophene	C15H10S	0.051208
Benzo[b]naphtho[2,1-d]thiophene	C16H10S	0.14965

Table K3 Sulfur compounds in oil from the 5Ni/HBETA

Name	Formular	Area %
Thiophene, 3-ethyl-	C6H8S	1.7596
Thiophene, 2,3-dimethyl-	C6H8S	1.0605
Thiophene, 2-ethyl-	C6H8S	0.95381
3,4-Dimethylthiophene	C6H8S	3.8054
Thiophene, 2-ethenyl-	C6H8S	0.4838
Thiophene, 2-propyl-	C7H10S	3.3226
Thiophene, 2-ethyl-5-methyl-	C7H10S	3.8432
Thiophene, 2-methyl-	C5H6S	1.0738
Thiophene, 2-(1-methylethyl)-	C7H10S	4.5751
Thiophene, 2,3,4-trimethyl-	C7H10S	0.71607
Thiophene, 3,4-diethyl-	C8H12S	3.0513
Thiophene, 2,5-diethyl-	C8H12S	3.7543
Thiophene, 3-(1,1-dimethylethyl)- s	C8H12S	0.23458
Thiophene, 2-(2-butenyl)-, (E)-	C8H10S	0.41476
Thiophene, 2-ethyl-5-propyl-	C9H14S	1.9101
Thiophene, 2-pentyl-	C9H14S	2.2997
Benzo[b]thiophene	C8H6S	5.9478
Thiophene, 2-hexyl-	C10H16S	0.85554
Benzo[b]thiophene, 4-methyl-	C9H8S	8.0273
3-Methylbenzothiophene	C9H8S	3.3749
Benzo[b]thiophene, 2-methyl-	C9H8S	4.73
Benzo[b]thiophene, 3,5-dimethyl-	C10H10S	4.0408
Benzo[b]thiophene, 7-ethyl-	C10H10S	4.3055
Thiophene, 2-phenyl-	C10H8S	1.4734
Benzo[b]thiophene, 2,7-dimethyl-	C10H10S	10.665
Benzene, [(2-methylenecyclopropyl)thio]-	C10H10S	1.5189
5-Ethylbenzo[b]thiophene	C10H10S	0.75248
Benzo[b]thiophene, 2,5-dimethyl-	C10H10S	2.0977
Sulfide, 1-butynyl phenyl	C10H10S	3.6283
Benzo[b]thiophene, 2-propyl-	C11H12S	1.5614
Benzo[b]thiophene, 2-ethyl-7-methyl-	C11H12S	5.7761

Benzo[b]thiophene, 2-ethyl-5-methyl-	C11H12S	1.41
Benzo[b]thiophene, 7-ethyl-2-methyl-	C11H12S	1.6927
Benzo[b]thiophene, 2,5,7-trimethyl-	C11H12S	0.66887
Benzo[b]thiophene, 2,7-diethyl-	C12H14S	2.7722
Dibenzothiophene	C12H8S	0.54115
Dibenzothiophene, 3-methyl-	C13H10S	0.55795
Dibenzothiophene, 4,6-dimethyl-	C14H12S	0.34362

Table K4 Sulfur compounds in oil from the 5Ni10Mo/HBETA

Name	Formular	Area %
Thiophene, 3-methyl-	C5H6S	0.065908
Thiophene, 3-ethyl-	C6H8S	0.24339
Thiophene, 2-ethyl-	C6H8S	0.45417
Thiophene, 2,5-dimethyl-	C6H8S	0.70518
Thiophene, 2,3-dimethyl-	C6H8S	0.47666
3,4-Dimethylthiophene	C6H8S	0.043939
Thiophene, 2-propyl-	C7H10S	1.3565
Thiophene, 2-(1-methylethyl)-	C7H10S	2.8534
Thiophene, 2-ethyl-5-methyl-	C7H10S	1.9022
2-Cyclopropylthiophene	C7H8S	0.082358
Thiophene, 2,3,4-trimethyl-	C7H10S	0.28026
Thiophene, 3,4-diethyl-	C8H12S	1.0848
Thioxylenol	C8H10S	0.11497
Thiophene, 2-methyl-5-propyl-	C8H12S	1.7651
Thiophene, 2,5-diethyl-	C8H12S	1.0163
Thiophene, 2-butyl-	C8H12S	0.76882
Thiophene, 2-(1,1-dimethylethyl)-	C8H12S	1.0377
Thiophene, 3-(1,1-dimethylethyl)-	C8H12S	0.85651
2-Undecanethiol, 2-methyl-	C12H26S	5.225
2-(2,2-Dimethylvinyl)thiophene	C8H10S	0.15685
2-(2-Methylcyclopropyl)thiophene	C8H10S	0.035463
Thiophene, 2-(2-butenyl)-, (E)-	C8H10S	0.33586
Thiophene, 2-ethyl-5-propyl-	C9H14S	1.1911
Thiophene, 2-pentyl-	C9H14S	1.9079
Thiophene, 2-butyl-5-ethyl-	C10H16S	0.14096
Benzo[b]thiophene	C8H6S	4.7727
Cyclopenta[c]thiapyran	C8H6S	0.036522
Benzo[b]thiophene, 2,3-dihydro-	C8H8S	0.045425
Benzo[b]thiophene, 6-methyl-	C9H8S	5.5181
3-Methylbenzothiophene	C9H8S	8.6978
Benzo[b]thiophene, 5-methyl-	C9H8S	0.075819

Thiophene, 3-(2-butenyl)-, (E)-	C8H10S	0.29645
Benzo[b]thiophene, 2-methyl	C9H8S	0.081073
5-Ethylbenzo[b]thiophene	C10H10S	0.25447
Benzo[b]thiophene, 2,5-dimethyl-	C10H10S	4.1758
2,3'-Bithiophene	C8H6S2	0.06296
Benzo[b]thiophene, 7-ethyl-	C10H10S	3.2722
Thiophene, 3,5-dimethyl-2-(methylthio)-	C7H10S2	0.51219
Thiophene, 3-phenyl-	C10H8S	1.5796
Benzo[b]thiophene, 2,7-dimethyl-	C10H10S	8.7947
Benzo[b]thiophene, 3,6-dimethyl-	C10H10S	2.9185
Benzo[b]thiophene, 2-propyl-	C11H12S	0.11761
Benzo[b]thiophene, 3,5-dimethyl	C10H10S	0.13532
Benzo[b]thiophene, 7-ethyl-2-methyl-	C11H12S	0.6288
2-(2-Methyl-propenyl)-indan-1-thiol	C13H16S	1.8614
Benzo[b]thiophene, 2-ethyl-5-methyl-	C11H12S	9.4555
Benzo[b]thiophene. 2,5,7-trimethyl-	C11H12S	7.1923
2,2'-Methylenedithiophene	C9H8S2	0.044851
Benzo[b]thiophene, 2-ethyl-7-methyl-	C11H12S	0.68148
Benzo[b]thiophene, 2,3-diethyl-	C12H14S	0.53493
Thiophene, 2-(phenylmethyl)-	C11H10S	0.18615
Benzo[b]thiophene, 2,7-diethyl-	C12H14S	1.3287
1-(3'-Isopropylphenylthio)prop-1-yne	C12H14S	1.1255
Benzo[b]thiophene, 2-ethyl-5,7-dimethyl-	C12H14S	0.6053
Benzo[b]thiophene, 7-ethyl-2-propyl-	C13H16S	0.65559
Dibenzothiophene	C12H8S	0.68396
Naphtho[2,3-b]thiophene	C12H8S	0.27258
Dibenzothiophene, 4-methyl-	C13H10S	0.56505
Thioxanthene	C13H10S	0.9002
Dibenzothiophene, 3-methyl-	C13H10S	0.096096
3-Ethyldibenzothiophene	C14H12S	0.29154
2,6-Dimethyldibenzothiophene	C14H12S	0.54872
2,8-Dimethyldibenzo(b,d)thiophene	C14H12S	0.49847
1,7-Dimethyldibenzothiophene	C14H12S	1.9498
Benzenemethanethiol, à-methyl-à-phenyl-	C14H12S	0.74708
3,7-Dimethyldibenzothiophene	C14H12S	0.21421
Benzene, 1,1'-[(methylthio)ethenylidene]bis-	C15H14S	0.34029
Phenaleno[1,9-bc]thiophene	C14H8S	0.15321
1-Propene-2-thiol, 1,1-diphenyl-	C15H14S	0.63522
Dibenzo[b,d]thiophene, 1,3,6,7-tetramethyl-	C16H16S	0.18715
1-Methylphenanthro[4,5-bcd]thiophene	C15H10S	0.098732
Benzo[b]naphtho[2,3-d]thiophene	C16H10S	0.071665
Benzo[b]naphtho[2,3-d]thiophene, 9,10-dihydro-7-methyl-	C17H14S	0.093494

Benzo[b]naphtho[2,3-d]thiophene, 8-methyl-	C17H12S	0.078489
Benzo[b]naphtho[2,3-d]thiophene, 6-methyl-	C17H12S	0.099274
Benzo[b]naphtho[2,3-d]thiophene, 7-methyl-	C17H12S	0.19718
10-Methylphenanthro[2,1-b]thiophene	C17H12S	0.051016
Benzo[b]naphtho[2,3-d]thiophene, 7,8-dimethyl-	C18H14S	0.25917
Benzo[b]naphtho[2,3-d]thiophene, 6,8-dimethyl-	C18H14S	0.15026

Table K5 Sulfur compounds in oil from the 5Ni20Mo/HBETA

Name	Formular	Area %
Thiophene, 3-methyl-	C5H6S	0.28628
Thiophene, 2,3-dihydro-5-methyl-	C5H8S	0.044205
Thiophene, 2-ethyl-	C6H8S	0.3744
3,4-Dimethylthiophene	C6H8S	0.71775
Thiophene, 2,5-dimethyl-	C6H8S	1.3384
Thiophene, 2,3-dimethyl-	C6H8S	0.4776
Thiophene, 2,4-dimethyl-	C6H8S	0.11911
Benzenemethanethiol	C7H8S	0.32385
Thiophene, 2-propyl-	C7H10S	1.3698
Thiophene, 2-(1-methylethyl)-	C7H10S	5.6684
Thiophene, 2-ethenyl-	C6H6S	0.18096
Benzenethiol	C6H6S	0.22613
2-Cyclopropylthiophene	C7H8S	0.16463
Thiophene, 2,3,4-trimethyl-	C7H10S	0.27521
Thiophene, 3-(1,1-dimethylethyl)-	C8H12S	3.2032
Benzenethiol, 2-methyl-	C7H8S	0.48393
Thiophene, 2-methyl-5-propyl-	C8H12S	2.7137
Thiophene, 2,5-diethyl-	C8H12S	1.6593
2-(2-Methylvinyl)thiophene	C7H8S	0.33295
Thiophene, 3,4-diethyl-	C8H12S	0.97356
Benzenethiol, 4-methyl-	C7H8S	0.12633
4-Ethylthiophenol	C8H10S	0.22001
Thiophene, 3-(2-butenyl)-, (E)-	C8H10S	0.22618
2-Undecanethiol, 2-methyl-	C12H26S	1.3886
Thiophene, 2-ethyl-5-propyl-	C9H14S	0.84194
2H-Cyclopenta[b]thiophene, hexahydro-, cis-	C7H12S	0.13296
2-(2,2-Dimethylvinyl)thiophene	C8H10S	0.046161
2-(2-Methylcyclopropyl)thiophene	C8H10S	0.10047
Thiophene, 2-(2-butenyl)-, (E)-	C8H10S	0.47786
Thiophene, 2-(3-methylbutyl)-	C9H14S	2.2398
Benzenethiol	C6H6S	0.4568

Benzo[c]thiophene, 1,3-dihydro-	C8H8S	0.048462
4-Isopropylthiophenol	C9H12S	0.15515
Thiophene, 2-butyl-5-ethyl-	C10H16S	0.19805
Benzo[b]thiophene	C8H6S	4.3353
Cyclopenta[c]thiapyran	C8H6S	0.11426
(1-(Methylthio)propyl)benzene	C10H14S	0.15889
Thieno[3,2-b]thiophene	C6H4S2	0.030575
Benzo[b]thiophene, 2-ethyl-	C10H10S	0.25075
2-Benzothiophene	C8H6S	0.014034
Thiophene, 2,5-dipropyl-	C10H16S	0.28305
Thiophene, 2-butyl-5-ethyl-	C10H16S	0.49285
Benzo[b]thiophene, 2,3-dihydro-	C8H8S	0.05785
Thiophene, 2-hexyl-	C10H16S	0.33191
3-Methylbenzothiophene	C9H8S	2.2105
Thiophane, propyl-	C7H14S	0.10036
Benzo[b]thiophene, 2-methyl-	C9H8S	3.2984
Benzo[b]thiophene, 4-methyl-	C9H8S	7.8127
Benzo[b]thiophene, 6-methyl-	C9H8S	0.10875
1,3,5-Trithiane	C3H3S3	0.056406
Benzene, (butylthio)-	C10H14S	0.35863
Benzene, 1-ethynyl-2-(methylthio)-	C9H8S	0.46213
Benzo[b]thiophene, 2,5-dimethyl-	C10H10S	3.0792
5-Ethylbenzo[b]thiophene	C10H10S	3.1465
Thiophene, 2-phenyl-	C10H8S	1.4921
Benzo[b]thiophene, 2,7-dimethyl-	C10H10S	11.443
Thiophene, 3-phenyl-	C10H8S	0.55434
Benzo[b]thiophene, 7-ethyl-	C10H10S	0.18026
Benzo[b]thiophene, 2-propyl-	C11H12S	0.082578
Benzo[b]thiophene, 3,5-dimethyl-	C10H10S	0.15644
Benzo[b]thiophene, 7-ethyl-2-methyl-	C11H12S	0.43512
Benzo[b]thiophene, 2-ethyl-5-methyl-	C11H12S	4.7322
2,2'-Methylenedithiophene	C9H8S2	0.07184
Benzo[b]thiophene, 2-ethyl-7-methyl-	C11H12S	10.618
Thiophene, 2-(phenylmethyl)-	C11H10S	0.30162
Benzo[b]thiophene, 2,5,7-trimethyl-	C12H14S	0.80042
Benzo[b]thiophene, 2,3-diethyl-	C12H14S	0.60334
1-(3'-Isopropylphenylthio)prop-1-yne	C12H14S	0.84118
Benzo[b]thiophene, 2-ethyl-5,7-dimethyl-	C12H14S	0.40098
3-Octylthiophene	C12H20S	0.23347
Benzo[b]thiophene, 2,7-diethyl-	C12H14S	0.088815
Dibenzothiophene	C12H8S	0.06945
Azuleno(2,1-b)thiophene	C12H8S	0.065008

2H-Naphtho[1,8-bc]thiophene, 2-methyl-	C12H10S	0.016618
4-Methylnaphtho[1,2-b]thiophene	C13H10S	0.99455
Dibenzothiophene, 4-methyl-	C13H10S	1.2519
Thioxanthene	C13H10S	0.22371
Dibenzothiophene, 3-methyl-	C13H10S	0.1425
2,6-Dimethyldibenzothiophene	C14H12S	0.46104
3-Ethyldibenzothiophene	C14H12S	0.28412
2,7-Dimethyldibenzothiophene	C14H12S	1.0783
2,8-Dimethyldibenzo(b,d)thiophene	C14H12S	1.3063
Naphtho[2,3-b]thiophene, 4,9-dimethyl-	C14H12S	0.98797
1,7-Dimethyldibenzothiophene	C14H12S	0.45435
Benzene, 1,1'-[(methylthio)ethenylidene]bis-	C15H14S	0.70153
1-Propene-2-thiol, 1,1-diphenyl-	C15H14S	0.53519
Phenaleno[1,9-bc]thiophene	C14H8S	0.30638
1-Methylphenanthro[4,5-bcd]thiophene	C15H10S	0.18746
Dibenzo[b,d]thiophene, 1,3,6,7-tetramethyl-	C16H16S	0.18504
Naphthalene, 1-(phenylthio)-	C16H12S	0.074809
Benzo[b]naphtho[2,1-d]thiophene	C16H10S	0.22958
Benzo[b]naphtho[1,2-d]thiophene	C16H10S	0.037677
Benzo[b]naphtho[2,3-d]thiophene, 9,10-dihydro-7-methyl-	C17H14S	0.12749
Phenanthro(2,1-b)thiophene	C16H10S	0.038635
Benzo[b]naphtho[2,3-d]thiophene	C16H10S	0.050455
3-Methylbenzo[b]naphtho[2,1-d]thiophene	C17H12S	0.16535
Benzo[b]naphtho[2,3-d]thiophene, 6-methyl-	C17H12S	0.19187
Benzo[b]naphtho[2,3-d]thiophene, 7-methyl-	C17H12S	0.34346
Benzo[b]naphtho[2,3-d]thiophene, 8-methyl-	C17H12S	0.066765
Benzo[b]naphtho[2,3-d]thiophene, 7,8-dimethyl-	C18H14S	0.22175
Benzo[b]naphtho[2,3-d]thiophene, 6,8-dimethyl-	C18H14S	0.31188

Table K6 Sulfur compounds in oil from the 5Ni10W/HBETA

Name	Formular	Area %
Benzenethiol	C6H6S	0.056432
Thiophene, 2,5-diethyl-	C8H12S	0.14443
Benzenethiol, 3-methyl-	C7H8S	0.14815
Thiophene, 3-(2-butenyl)-, (E)-	C8H10S	0.13508
Thiophene, 3,4-diethyl-	C8H12S	0.088356
2-(1-Methylcyclopropyl)thiophene	C8H10S	0.21837
Thiophene, 2-ethyl-5-propyl-	C9H14S	0.90962
Thioxylenol	C8H10S	0.6051
Thiophene, 2-(2-butenyl)-, (E)-	C8H10S	0.29566
Benzo[c]thiophene, 1,3-dihydro-	C8H8S	0.076342
Thiophene, 2-butyl-5-ethyl-	C10H16S	0.33101
Benzo[b]thiophene	C8H6S	5.6564
Thieno[2,3-b]thiophene	C6H4S2	0.022889
Benzo[b]thiophene	C8H6S	0.077786
2-(2,2-Dimethylcyclopropyl)thiophene	C9H12S	0.19075
1,3-Dithiolane, 2-benzyl-2-methyl-	C11H14S2	0.51838
Thiophene, 2-hexyl-	C10H16S	0.44807
Thiophene, 2-ethyl-5-isopentyl-	C11H18S	0.057258
3-Methylbenzothiophene	C9H8S	11.959
Thieno[2,3-b]thiophene,2-methyl-	C7H6S2	0.039306
Benzo[b]thiophene, 2-methyl-	C9H8S	0.16195
Benzo[b]thiophene, 7-ethyl-	C10H10S	0.27807
Benzo[b]thiophene, 7-ethyl-	C10H10S	5.8473
5-Ethylbenzo[b]thiophene	C10H10S	4.2353
2,3'-Bithiophene	C8H6S2	0.10155
Thiophene, 3-phenyl-	C10H8S	2.8433
Benzo[b]thiophene, 2,5-dimethyl-	C10H10S	16.027
Benzo[b]thiophene, 7-ethyl-	C10H10S	2.3179
Benzo[b]thiophene, 3,6-dimethyl-	C10H10S	1.7578
Thiophene, 2-(phenylmethyl)-	C11H10S	0.083622
Benzene, 1-methyl-4-[(methylthio)ethynyl]-	C10H10S	0.51844
Benzo[b]thiophene, 2-propyl-	C11H12S	0.091565
Benzo[b]thiophene, 3,5-dimethyl-	C10H10S	0.26508
Benzo[b]thiophene, 2-ethyl-5-methyl-	C11H12S	3.879
Benzo[b]thiophene, 2-ethyl-7-methyl-	C11H12S	11.472
Thiophene, 2-(phenylmethyl)-	C11H10S	4.4741
Benzo[b]thiophene, 7-ethyl-2-methyl-	C11H12S	0.49489
Benzo[b]thiophene, 2,5,7-trimethyl-	C11H12S	1.7929
Benzo[b]thiophene, 2,3-diethyl-	C12H14S	1.0095

Benzo[b]thiophene, 2,7-diethyl-	C12H14S	0.87935
1-(3'-Isopropylphenylthio)prop-1-yne	C12H14S	1.7053
Benzo[b]thiophene, 2-ethyl-5,7-dimethyl-	C12H14S	0.70809
2H-Naphtho[1,8-bc]thiophene, 2-methyl-	C12H10S	0.064921
Dibenzothiophene	C12H8S	1.5387
Naphtho[2,3-b]thiophene	C12H8S	0.33652
Azuleno(2,1-b)thiophene	C12H8S	0.080123
Dibenzothiophene, 4-methyl-	C13H10S	1.2779
Dibenzothiophene, 3-methyl-	C13H10S	1.3947
4-Methylnaphtho[1,2-b]thiophene	C13H10S	1.8272
Thiophene, 2,5-bis(1,1-dimethylethyl)-	C12H20S	0.34948
Dibenzothiophene, 4-methyl-	C13H10S	0.24923
3-Ethyldibenzothiophene	C14H12S	0.57109
Thioxanthene	C13H10S	0.41023
2,6-Dimethyldibenzothiophene	C14H12S	1.5812
Naphtho[2,3-b]thiophene, 4,9-dimethyl-	C13H10S	0.86924
2,8-Dimethyldibenzo(b,d)thiophene	C14H12S	1.5689
2,7-Dimethyldibenzothiophene	C14H12S	1.4822
1,7-Dimethyldibenzothiophene	C14H12S	0.43278
Phenaleno[1,9-bc]thiophene	C14H8S	0.34307
1-Methylphenanthro[4,5-bcd]thiophene	C15H10S	0.14226
Dibenzo[b,d]thiophene, 1,3,6,7-tetramethyl-	C16H16S	0.30936
Naphthalene, 1-(phenylthio)-	C16H12S	0.19305
Benzo[b]naphtho[1,2-d]thiophene	C16H10S	0.22382
Benzo[b]naphtho[2,1-d]thiophene	C16H10S	0.061634
Benzo[b]naphtho[2,3-d]thiophene, 6-methyl-	C17H12S	0.14409
Benzo[b]naphtho[2,3-d]thiophene, 7-methyl-	C17H12S	0.29639
2-Methylbenzo[b]naphtho[2,1-d]thiophene	C17H12S	0.30537
Benzo[b]naphtho[2,3-d]thiophene, 8-methyl-	C17H12S	0.040702
Benzo[b]naphtho[2,3-d]thiophene, 7,8-dimethyl-	C18H14S	0.37427
Benzo[b]naphtho[2,3-d]thiophene, 6,8-dimethyl-	C18H14S	0.21088
Benzo[1,2-b:4,3-b']dithiophene, 1-phenyl-	C16H10S2	0.034534

Table K7 Sulfur compounds in oil from the 5Ni20W/HBETA

Name	Formular	Area %
Thiophene, 2-propyl-	C7H10S	1.6508
Thiophene, 3-(2-butenyl)-, (E)-	C8H10S	0.75517
Benzene, 1-methyl-4-(methylthio)-	C8H10S	0.6447
Thiophene, 2-(2-butenyl)-, (E)-	C8H10S	0.76275
Cyclopenta[b]thiapyran	C8H6S	8.5159
Benzo[b]thiophene	C8H6S	0.10186
Thiophene, 2-hexyl-	C9H12S	0.7494
3-Methylbenzothiophene	C9H8S	12.643
Benzo[b]thiophene, 2-methyl-	C9H8S	10.815
Benzo[b]thiophene, 5-methyl-	C9H8S	0.20731
Benzo[b]thiophene, 2,7-dimethyl-	C10H10S	4.9473
Benzo[b]thiophene, 2,5-dimethyl-	C10H10S	19.54
Benzo[b]thiophene, 3,5-dimethyl-	C10H10S	4.0104
Benzo[b]thiophene, 7-ethyl-	C10H10S	2.7658
Benzene, 1-methyl-4-[(methylthio)ethynyl]-	C10H10S	0.43026
5-Ethylbenzo[b]thiophene	C10H10S	0.18847
Benzo[b]thiophene, 3,6-dimethyl-	C10H10S	0.26846
Benzo[b]thiophene, 2-ethyl-7-methyl-	C11H12S	15.36
Benzo[b]thiophene, 2,5,7-trimethyl-	C11H12S	4.2285
Thiophene, 2-(phenylmethyl)-	C11H12S	1.957
Benzo[b]thiophene, 7-ethyl-2-methyl-	C11H12S	0.35598
Benzo[b]thiophene, 2,7-diethyl-	C11H12S	1.1364
Benzo[b]thiophene, 2,3-diethyl-	C12H14S	1.3007
Benzo[b]thiophene, 2-ethyl-5,7-dimethyl-	C12H14S	0.57394
Dibenzothiophene	C12H14S	0.80826
Naphtho[2,3-b]thiophene	C12H8S	0.23176
Thioxanthene	C12H8S	0.71868
Dibenzothiophene, 4-methyl-	C13H10S	1.219
2,8-Dimethyldibenzo(b,d)thiophene	C13H10S	0.30012
Naphtho[2,3-b]thiophene, 4,9-dimethyl-	C14H12S	0.37407
2,6-Dimethyldibenzothiophene	C14H12S	0.44958
2,7-Dimethyldibenzothiophene	C14H12S	1.7681
Benzo[b]naphtho[2,3-d]thiophene, 6-methyl-	C17H12S	0.12027
Benzo[b]naphtho[2,3-d]thiophene, 6,8-dimethyl-	C18H14S	0.10182

Table K8 Sulfur compounds in oil from the 5Co/HBETA

Name	Formular	Area %
Thiophene, 3-methyl-	C5H6S	0.20927
Thiophene, 2-methyl-	C5H6S	0.033568
Thiophene, 2,3-dihydro-5-methyl-	C5H8S	0.079121
Thiophene, tetrahydro-2-methyl-	C5H10S	0.0707
Thiophene, 3-ethyl-	C6H8S	0.32928
Thiophene, 2,4-dimethyl-	C6H8S	0.65544
Thiophene, 2,5-dimethyl-	C6H8S	1.0406
Thiophene, 2,3-dimethyl-	C6H8S	0.90204
3,4-Dimethylthiophene	C6H8S	0.25383
Thiophene, 2-ethenyl-	C6H6S	0.073738
Benzenethiol	C6H6S	0.027971
Thiophene, 2-(1-methylethyl)-	C7H10S	0.063034
Thiophene, 2-propyl-	C7H10S	1.9822
Thiophene, 2-ethyl-5-methyl-	C7H10S	6.0893
Benzenethiol	C6H6S	0.17697
Thiophene, 2,3,4-trimethyl-	C7H10S	0.80644
2-(2-Methylvinyl)thiophene	C7H8S	0.71331
2-Cyclopropylthiophene	C7H8S	0.48268
Thiophene, 2,5-diethyl-	C8H12S	1.8473
3,4-Dimethylthiophenol	C8H10S	0.26613
Thiophene, 2-methyl-5-propyl-	C8H12S	1.693
Thiophene, 3-(1,1-dimethylethyl)-	C8H12S	1.485
Thiophene, 2-butyl-	C8H12S	0.98095
Thiophene, 3,4-diethyl-	C8H12S	2.596
Thiophene, 2,5-diethyl-	C8H12S	1.7759
Benzenethiol, 4-methyl-	C7H8S	0.20403
Thiophene, 2-(2-butenyl)-, (E)-	C8H10S	0.42422
Thiophene, 2-ethyl-5-propyl-	C9H14S	0.34168
2-(1-Methylcyclopropyl)thiophene	C8H10S	0.15356
Benzene, 1-methyl-2-(methylthio)-	C8H10S	0.05592
Thiophene, 3-(2-butenyl)-, (E)-	C8H10S	0.55453
Thiophene, 2-pentyl-	C9H14S	0.89239
2,4,6-Trimethylbenzenethiol	C9H12S	0.46517
Benzo[b]thiophene, 2,3-diethyl-	C12H14S	0.15314
Benzo[b]thiophene, 2,3-dihydro-	C8H8S	0.25457
Benzo[c]thiophene, 1,3-dihydro-	C8H8S	0.046369
Thiophene, 2-butyl-5-ethyl-	C10H16S	0.19103
Benzo[b]thiophene	C8H6S	5.4253

Benzo[b]thiophene, 2-ethyl-5,7-dimethyl-	C12H14S	0.49669
Thiophene, 2,5-dipropyl-	C10H16S	0.29897
2,6-Dimethylbenzenethiol, S-methyl-	C9H12S	0.17108
Benzo[c]thiophene, 1,3-dihydro-	C8H8S	0.067707
Thieno[2,3-b]thiophene,2-methyl-	C7H6S2	0.062438
3-Methylbenzothiophene	C9H8S	7.5658
Benzo[b]thiophene, 4-methyl-	C9H8S	0.13764
Benzo[b]thiophene, 2-methyl-	C9H8S	0.09047
5-Ethylbenzo[b]thiophene	C10H10S	2.3181
Benzo[b]thiophene, 2,7-dimethyl-	C10H10S	1.8579
Benzo[b]thiophene, 7-ethyl-	C10H10S	1.0988
Thiophene, 2-(phenylmethyl)-	C11H10S	0.35903
Benzo[b]thiophene, 2,7-diethyl-	C12H14S	0.50321
Thiophene, 2,5-bis(1,1-dimethylethyl)-	C12H20S	0.068152
Benzo[b]thiophene, 7-ethyl-2-propyl-	C13H16S	0.53342
2,2'-Methylenedithiophene	C9H8S2	0.039628
Benzo[b]thiophene, 2-ethyl-7-methyl-	C11H12S	4.8
Benzo[b]thiophene, 2-ethyl-5,7-dimethyl-	C12H14S	0.15181
Benzo[b]thiophene, 2,5,7-trimethyl-	C11H12S	1.1378
Benzo[b]thiophene, 2-ethyl-5-methyl-	C11H12S	0.30388
Benzo[b]thiophene, 2,3-diethyl-	C12H14S	0.99292
Benzo[b]thiophene, 2,3-diethyl-	C12H12S	0.10687
Dibenzothiophene	C12H8S	2.1514
Thiophene, 2,4-bis(1,1-dimethylethyl)-	C12H20S	0.61947
Thiophene, 3-(1-methyl-1-phenylethyl)-	C13H14S	0.32156
Naphtho[2,3-b]thiophene	C12H8S	0.80565
Naphtho[2,3-b]thiophene	C12H20S	0.47844
Azuleno(2,1-b)thiophene	C12H8S	0.70818
Naphtho[2,3-c]thiophene, 1,3-dihydro-	C12H10S	0.084495
2H-Naphtho[1,8-bc]thiophene, 2-methyl-	C12H10S	0.22129
Naphtho[2,1-b]thiophene	C12H8S	0.53779
Dibenzothiophene, 4-methyl-	C13H10S	1.782
4-Methylnaphtho[1,2-b]thiophene	C13H10S	2.4993
Thioxanthene	C13H10S	1.7229
Dibenzothiophene, 3-methyl-	C13H10S	2.0271
Thiophene, 2,5-bis(1,1-dimethylethyl)-	C12H20S	1.8379
1,3,6,8-Tetrahydro-2,7-dithiapyrene	C14H12S2	0.65903
1-Methyldibenzothiophene	C13H10S	0.12349
2,8-Dimethyldibenzo(b,d)thiophene	C14H12S	0.82438
2,6-Dimethyldibenzothiophene	C14H12S	4.0212
Naphtho[2,3-b]thiophene, 4,9-dimethyl-	C14H12S	1.7768
3,7-Dimethyldibenzothiophene	C14H12S	2.1106

Dibenzothiophene, 4,6-dimethyl-	C14H12S	0.69613
2,7-Dimethyldibenzothiophene	C14H12S	2.3386
1-Propene-2-thiol, 1,1-diphenyl-	C15H14S	2.3986
Benzene, 1,1'-[(methylthio)ethenylidene]bis-	C15H14S	1.2451
Phenaleno[1,9-bc]thiophen	C14H8S	0.18527
1-Methylphenanthro[4,5-bcd]thiophene	C15H10S	0.65511
Naphthalene, 1-(phenylthio)-	C16H12S	0.57957
[1,2]Dithiolo[1,5-b][1,2]dithiole-7-SIV, 2-phenyl-	C11H8S3	0.21709
Thioxanthene, 9-(tetrahydrothiopyranyliden-4-yl)-	C18H16S2	1.2825
[1]Benzothieno[4,5-b][1]benzothiophene	C14H8S2	0.077581
Anthra(1,2-b)thiophene	C16H10S	0.17416
Benzo[b]naphtho[2,3-d]thiophene, 9,10-dihydro-7-methyl-	C17H14S	1.1033
5-Methylbenzo[b]naphtho[2,1-d]thiophene	C17H12S	0.53992
Benzo[b]naphtho[2,3-d]thiophene, 8-methyl-	C17H12S	0.54611
2-Methylbenzo[b]naphtho[2,1-d]thiophene	C17H12S	0.51464
Benzo[b]naphtho[2,3-d]thiophene, 6-methyl-	C17H12S	1.1454
Benzo[b]naphtho[2,3-d]thiophene, 7-methyl-	C17H12S	0.49881
Benzo[b]naphtho[2,3-d]thiophene, 7,8-dimethyl-	C18H14S	0.8759
Benzo[b]naphtho[2,3-d]thiophene, 6,8-dimethyl-	C18H14S	1.2936
1-Phenyldibenzothiophene	C18H12S	0.1179

Table K9 Sulfur compounds in oil from the 5Co20Mo/HBETA

Name	Formular	Area %
Thiophene, 3-methyl-	C5H6S	0.44732
Thiophene, tetrahydro-2-methyl-	C5H10S	0.14753
Thiophene, 2-ethyl-	C6H8S	5.9651
hiophene, 3-ethyl-	C6H8S	0.48902
Thiophene, 2,5-dimethyl-	C6H8S	3.1995
3,4-Dimethylthiophene	C6H8S	1.2588
Thiophene, 2,3-dimethyl-	C6H8S	0.30549
Thiophene, 2,4-dimethyl-	C6H8S	0.080151
Thiophene, 2-propyl-	C7H10S	2.8832
Thiophene, 2-(1-methylethyl)-	C7H10S	1.8302
Benzenethiol	C6H6S	0.17433
Thiophene, 2,3,4-trimethyl-	C7H10S	0.95458
Thiophene, 2-(1,1-dimethylethyl)-	C8H12S	2.1411
2-(2-Methylvinyl)thiophene	C7H8S	0.75802
Thiophene, 2,5-diethyl-	C8H12S	4.7442
Thiophene, 2-butyl-	C8H12S	2.0099
Thiophene, 3,4-diethyl-	C8H12S	2.198

Thiophene, 3-(1,1-dimethylethyl)-	C8H12S	2.3957
2-Cyclopropylthiophene	C7H8S	0.1039
2-Methyl-2-tert-butyl-1,3-dithiane	C9H18S2	0.17272
2-(1-Methylcyclopropyl)thiophene	C8H10S	0.2106
Thiophene, 2-(2-butenyl)-, (E)-	C8H10S	1.0047
2-(2-Methylcyclopropyl)thiophene	C8H10S	0.15859
Thiophene, 2-ethyl-5-propyl-	C9H14S	3.3108
Thiophene, 2-(3-methylbutyl)-	C9H14S	2.8953
Benzo[c]thiophene, 1,3-dihydro-	C8H8S	0.13839
Thiophene, 2-butyl-5-ethyl-	C10H16S	0.20829
Benzo[b]thiophene	C8H6S	5.1874
Cyclopenta[c]thiapyran	C8H6S	0.047973
Thiophene, 2,5-dipropyl-	C10H16S	0.35301
Thiophene, 2-decyl-	C14H24S	0.3561
Benzo[c]thiophene, 1,3-dihydro-	C8H8S	0.076742
Thiophene, 2-hexyl-	C10H16S	0.26151
Benzo[b]thiophene, 4-methyl-	C9H8S	2.1435
Benzo[b]thiophene, 2-methyl-	C9H8S	2.5447
3-Methylbenzothiophene	C9H8S	8.6615
Thiophene, 3-(2-butenyl)-, (E)-	C8H10S	0.59688
Benzo[b]thiophene, 6-methyl-	C9H8S	0.060442
5-Ethylbenzo[b]thiophene	C10H10S	0.25286
Benzo[b]thiophene, 2,5-dimethyl-	C10H10S	1.7813
Benzo[b]thiophene, 3,6-dimethyl-	C10H10S	1.8203
Benzo[b]thiophene, 7-ethyl-	C10H10S	2.2646
Thiophene, 2-phenyl-	C10H8S	1.7276
Benzo[b]thiophene, 2,7-dimethyl-	C10H10S	10.763
Thiophene, 3-phenyl-	C10H8S	0.53344
Thiophene, 2-(phenylmethyl)-	C11H10S	0.056907
Benzene, 1-methyl-4-[(methylthio)ethynyl]-	C10H10S	0.20371
Benzo[b]thiophene, 2-ethyl-	C10H10S	0.13468
Benzo[b]thiophene, 3,5-dimethyl-	C10H10S	0.089203
Benzo[b]thiophene, 2-ethyl-7-methyl-	C11H10S	7.5199
2,2'-Methylenedithiophene	C9H8S2	0.049977
Thiophene, 2-(phenylmethyl)-	C11H10S	0.87599
Benzo[b]thiophene, 2,5,7-trimethyl-	C11H12S	0.22061
Thiophene, 2-heptyl-	C11H18S	0.1194
Benzo[b]thiophene, 2,3-diethyl-	C12H14S	0.95355
Benzo[b]thiophene, 2,7-diethyl-	C12H14S	2.6856
Benzo[b]thiophene, 2-ethyl-5,7-dimethyl-	C12H14S	0.21898
Dibenzothiophene	C12H8S	0.53259
Naphtho[2,1-b]thiophene	C12H8S	0.21884

Dibenzothiophene, 4-methyl-	C13H10S	0.39435
Thioxanthene	C13H10S	0.74036
4-Methylnaphtho[1,2-b]thiophene	C13H10S	0.11929
Benzenemethanethiol, à-methyl-à-phenyl-	C14H14S	1.2414
2,6-Dimethyldibenzothiophene	C14H12S	0.36482
3-Ethyldibenzothiophene	C14H12S	0.12095
2,8-Dimethyldibenzo(b,d)thiophene	C14H12S	0.51835
Dibenzothiophene, 4,6-dimethyl-	C14H12S	0.81934
Naphtho[2,3-b]thiophene, 4,9-dimethyl-	C14H12S	0.56719
2,7-Dimethyldibenzothiophene	C14H12S	0.18961
1-Propene-2-thiol, 1,1-diphenyl-	C15H14S	0.37085
Phenaleno[1,9-bc]thiophene	C14H8S	0.12921
Benzene, 1,1'-[(methylthio)ethenylidene]bis-	C15H14S	0.53897
1-Methylphenanthro[4,5-bcd]thiophene	C15H10S	0.044741
Benzo[b]naphtho[1,2-d]thiophene	C16H10S	0.071602
Benzo[b]naphtho[2,3-d]thiophene, 6,8-dimethyl-	C18H14S	0.056702
Disulfide, bis(1,1,3,3-tetramethylbutyl)	C16H34S2	0.21404

Table K10 Sulfur compounds in oil from the 5Co20W/HBETA

Name	Formular	Area %
Thiophene, 2-ethyl-	C6H8S	5.0174
3,4-Dimethylthiophene	C6H8S	0.6326
Thiophene, 2,3-dimethyl-	C6H8S	0.82492
Thiophene, 3-ethyl-	C6H8S	0.90173
Thiophene, 2-propyl-	C7H10S	0.55649
Thiophene, 2-(1-methylethyl)-	C7H10S	1.7938
Thiophene, 2,3,4-trimethyl-	C7H10S	5.9381
2-Cyclopropylthiophene	C7H8S	0.21768
Benzenethiol, 4-methyl-	C7H8S	0.9675
Thiophene, 2-methyl-5-propyl-	C8H12S	1.5116
Thiophene, 3-(1,1-dimethylethyl)-	C8H12S	0.83911
Thiophene, 3,4-diethyl-	C8H12S	2.3687
Thiophene, 2-(2-butenyl)-, (E)-	C8H10S	0.61846
2H-Cyclopenta[b]thiophene, hexahydro-, cis-	C7H12S	0.22956
2-(1-Methylcyclopropyl)thiophene	C8H10S	0.19416
Thiophene, 3-(2-butenyl)-, (E)-	C8H10S	0.4043
Thiophene, 2-pentyl-	C9H14S	2.7055
Thioxylenol	C8H10S	0.82324
Benzo[c]thiophene, 1,3-dihydro-	C8H8S	0.12386

Benzo[b]thiophene	C8H6S	6.992
Cyclopenta[c]thiapyran	C8H6S	0.062481
Thiophene, 2-hexyl-	C10H16S	0.21357
Thiophene, 2-decyl-	C14H14S	1.2583
3-Methylbenzothiophene	C9H8S	3.7484
Benzo[b]thiophene, 6-methyl-	C9H8S	4.4757
Benzo[b]thiophene, 2-methyl-	C9H8S	10.591
Thiophene, 2-(1-methylethyl)-	C7H10S	0.80111
Benzo[b]thiophene, 7-ethyl-	C10H10S	0.35674
Benzo[b]thiophene, 2,7-dimethyl-	C10H10S	3.7061
5-Ethylbenzo[b]thiophene	C10H10S	5.2293
Benzo[b]thiophene, 2,5-dimethyl-	C10H10S	23.623
Thiophene, 3-phenyl-	C10H8S	0.52773
Benzo[b]thiophene, 3,5-dimethyl-	C10H10S	0.14158
Benzo[b]thiophene, 2-ethyl-7-methyl-	C11H12S	6.4446
Benzo[b]thiophene, 7-ethyl-2-methyl-	C11H12S	1.6176
Benzo[b]thiophene, 2,5,7-trimethyl-	C11H12S	0.2451
Benzo[b]thiophene, 2-ethyl-5-methyl-	C11H12S	0.68044
Benzo[b]thiophene, 2-ethyl-5,7-dimethyl-	C12H14S	0.24514
Dibenzothiophene	C12H8S	0.4605
Dibenzothiophene, 4-methyl-	C13H10S	0.41413
1-Methyldibenzothiophene	C13H10S	0.42579
Dibenzothiophene, 4,6-dimethyl-	C14H12S	0.099645
3,7-Dimethyldibenzothiophene	C14H12S	0.22059
1,7-Dimethyldibenzothiophene	C14H12S	0.75096

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Presentations:

Yotin, P and Jitkarnka, S. (2013, April 23) Impact of HBETA as Cracking and Desulfurization Abilities of NiW/HBETA Catalysts in Waste Tire Pyrolysis presented at the 4th Research Symposium on Petrochemical and Materials Technology and the 19th PPC Symposium on Petroleum, Petrochemicals, and Polymers, Bangkok, Thailand.