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APPENDICES

APPENDIX A Operating Temperatures

Table A1 Operating temperatures: Batch 1 (no Cat): 22-07-2009

1. Sample = 30 g , N2 flow rate = 30 ml/min
2. Char = 13.45 g
3. Pyrolysis oils = 9.55 g
4. Pyrolysis Gas = 8.00 g

Time (min)	T1	T2	Time (min)	T1	T2	Time (min)	T1	T2	Time (min)	T1	T2
2	32	26	32	379	523	62	303	504	92	308	496
4	53	38	34	370	503	64	307	494	94	312	507
6	96	69	36	364	505	66	302	504	96	313	496
8	112	82	38	354	502	68	297	498	98	315	505
10	162	128	40	341	485	70	306	506	100	314	500
12	215	179	42	337	470	72	306	499	102	315	503
14	251	221	44	335	453	74	311	505	104	315	494
16	301	285	46	324	441	76	308	501	106	314	500
18	318	375	48	321	452	78	307	492	108	305	495
20	323	402	50	317	497	80	301	502	110	302	505
22	346	379	52	317	506	82	304	500	112	298	498
24	347	481	54	309	498	84	306	494	114	309	502
26	364	492	56	304	493	86	301	503	116	310	495
28	377	488	58	303	501	88	297	503	118	313	506
30	377	519	60	300	500	90	299	504	120	313	502

* T1 is the catalytic temperature * T2 is the pyrolysis temperature

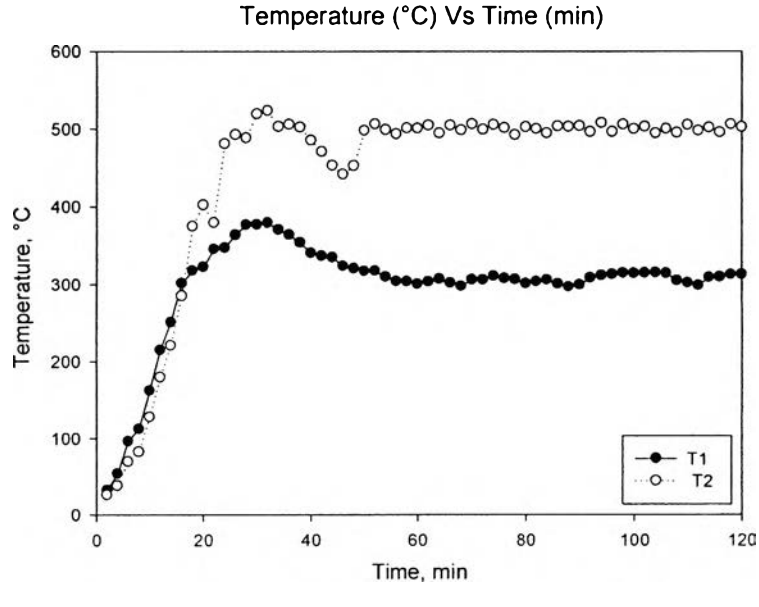


Table A2 Operating temperatures: Batch 2 (HMOR): 29-07-2009

1. Sample = 30.04 g , Catalyst = 7.51g, N2 flow rate = 30 ml/min
2. Char = 13.77 g
3. Pyrolysis oils = 7.22 g
4. Pyrolysis Gas = 9.05 g

Time (min)	T1	T2	Time (min)	T1	T2	Time (min)	T1	T2	Time (min)	T1	T2
2	31	32	32	350	501	62	339	505	92	314	500
4	45	54	34	353	507	64	338	499	94	312	502
6	55	68	36	355	497	66	336	502	96	310	502
8	75	103	38	355	505	68	332	505	98	309	501
10	101	142	40	356	501	70	331	498	100	309	505
12	139	194	42	356	504	72	329	501	102	307	495
14	177	248	44	357	496	74	327	496	104	306	502
16	220	321	46	356	501	76	325	504	106	305	502
18	290	409	48	356	502	78	323	505	108	303	498
20	312	454	50	354	506	80	322	498	110	303	501
22	341	503	52	352	497	82	320	505	112	301	505
24	345	509	54	350	505	84	319	498	114	300	500
26	347	502	56	349	499	86	317	501	116	300	504
28	347	497	58	345	503	88	316	498	118	306	499
30	350	504	60	342	499	90	314	506	120	308	508

* T1 is the catalytic temperature * T2 is the pyrolysis temperature

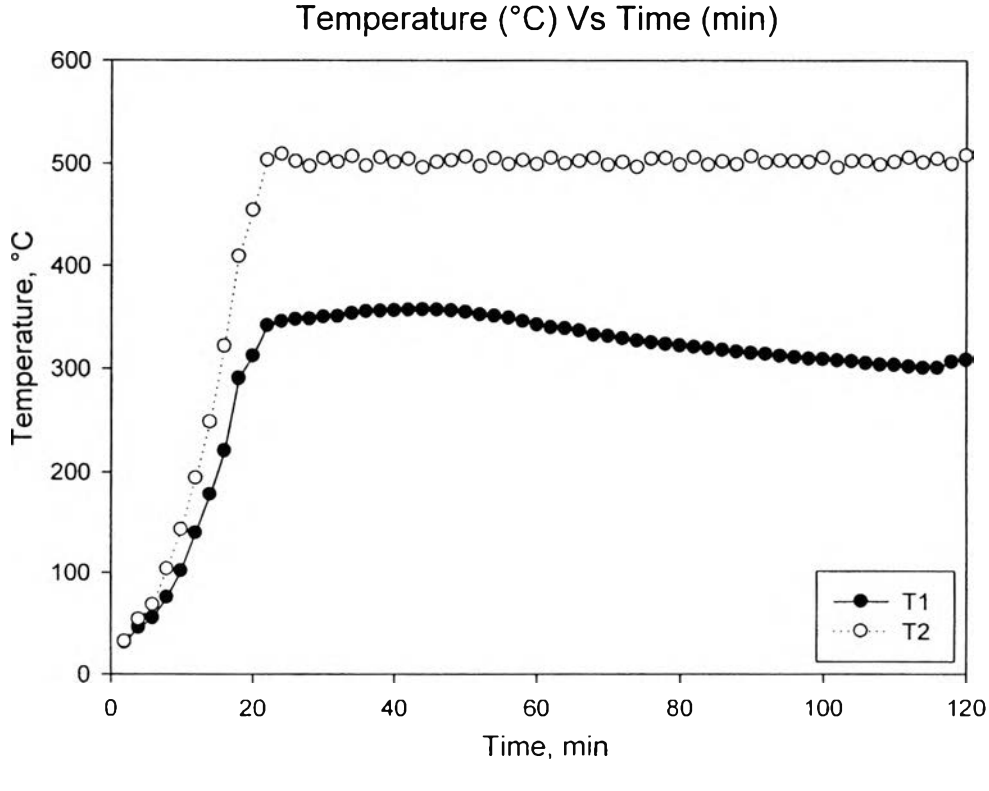


Table A3 Operating temperatures: Batch 3 (Ru/HMOR): 30-07-2009

1. Sample = 30 g , Catalyst = 7.5g, N2 flow rate = 30 ml/min
2. Char = 12.94g
3. Pyrolysis oils = 6.64 g
4. Pyrolysis Gas = 10.42 g

Time (min)	T1	T2	Time (min)	T1	T2	Time (min)	T1	T2	Time (min)	T1	T2
2	29	28	32	328	501	62	365	508	92	300	501
4	39	43	34	285	492	64	362	501	94	296	499
6	59	72	36	291	499	66	358	494	96	300	506
8	78	101	38	298	506	68	352	505	98	309	497
10	115	161	40	298	499	70	348	498	100	312	506
12	131	191	42	304	506	72	343	507	102	309	494
14	143	219	44	340	505	74	339	500	104	308	496
16	185	351	46	308	499	76	334	493	106	305	508
18	225	410	48	341	506	78	328	506	108	304	500
20	278	453	50	352	502	80	322	498	110	301	507
22	325	500	52	327	499	82	318	506	112	299	501
24	336	512	54	365	502	84	312	494	114	301	506
26	312	506	56	371	496	86	311	497	116	307	504
28	316	500	58	371	507	88	309	506	118	310	504
30	328	508	60	369	500	90	299	501	120	309	494

* T1 is the catalytic temperature * T2 is the pyrolysis temperature

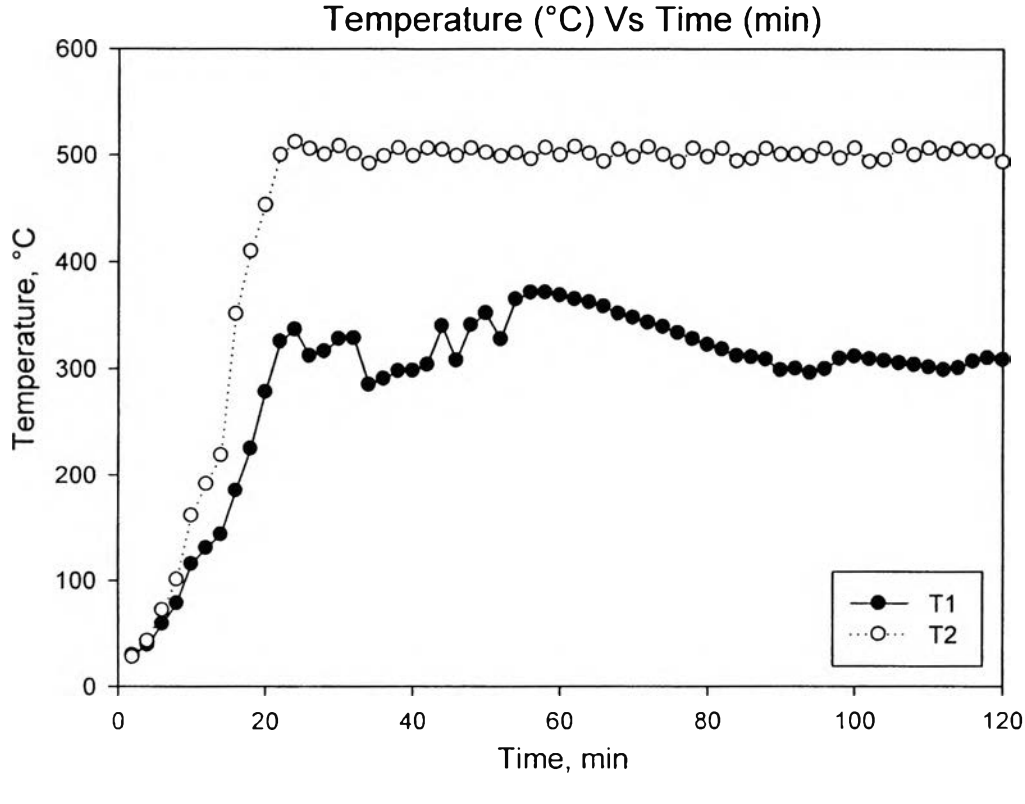


Table A4 Operating temperatures: Batch 4 (Kaolin): 31-07-2009

1. Sample = 30 g , Catalyst = 7.52g, N2 flow rate = 30 ml/min
2. Char = 13.68 g
3. Pyrolysis oils = 4.84 g
4. Pyrolysis Gas = 11.48 g

Time (min)	T1	T2	Time (min)	T1	T2	Time (min)	T1	T2	Time (min)	T1	T2
2	38	49	32	345	493	62	314	498	92	303	500
4	44	60	34	344	479	64	313	502	94	303	500
6	66	104	36	344	479	66	311	504	96	301	506
8	86	139	38	342	469	68	308	500	98	300	499
10	139	226	40	341	459	70	306	499	100	300	506
12	196	284	42	338	452	72	304	504	102	306	502
14	215	350	44	334	459	74	303	500	104	309	500
16	261	414	46	331	498	76	300	505	106	311	503
18	325	482	48	330	507	78	299	495	108	310	498
20	321	503	50	328	499	80	303	506	110	310	505
22	325	514	52	327	505	82	305	500	112	307	497
24	336	506	54	323	494	84	307	497	114	307	506
26	339	496	56	321	505	86	308	500	116	306	501
28	339	505	58	310	506	88	304	499	118	308	506
30	341	501	60	318	498	90	307	500	120	302	498

* T1 is the catalytic temperature * T2 is the pyrolysis temperature

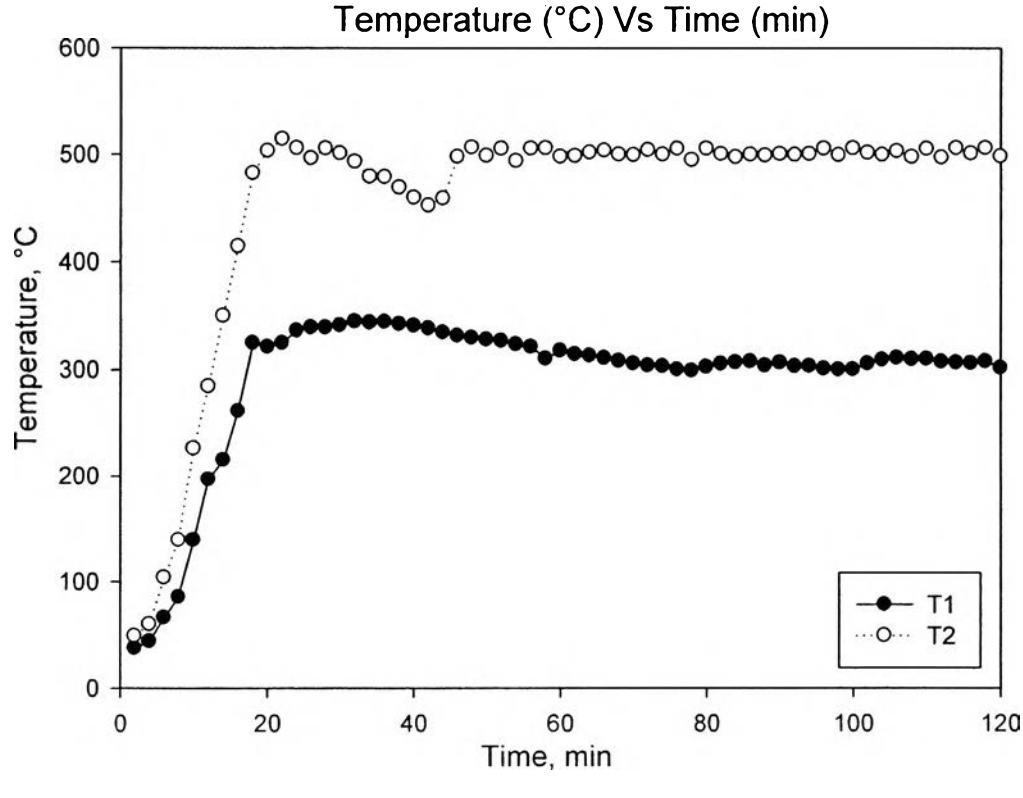


Table A5 Operating temperatures: Batch 5 (Alumina): 03-08-2009

1. Sample = 30 g , Catalyst = 7.50g, N2 flow rate = 30 ml/min
2. Char = 14.69 g
3. Pyrolysis oils = 7.15 g
4. Pyrolysis Gas = 8.16 g

Time (min)	T1	T2	Time (min)	T1	T2	Time (min)	T1	T2	Time (min)	T1	T2
2	29	29	32	358	501	62	317	502	92	302	501
4	39	49	34	358	503	64	315	504	94	301	497
6	54	75	36	356	493	66	313	498	96	300	500
8	74	110	38	352	497	68	312	505	98	297	498
10	111	174	40	349	503	70	303	503	100	307	501
12	141	220	42	346	505	72	301	504	102	310	493
14	178	275	44	343	494	74	299	498	104	311	506
16	224	345	46	339	501	76	314	497	106	309	498
18	273	425	48	338	498	78	314	507	108	308	499
20	322	459	50	334	505	80	312	498	110	307	505
22	328	513	52	331	493	82	310	498	112	306	498
24	328	512	54	328	504	84	308	498	114	304	503
26	335	501	56	326	498	86	305	501	116	303	493
28	344	501	58	323	501	88	305	498	118	302	506
30	357	500	60	320	493	90	305	505	120	301	497

* T1 is the catalytic temperature * T2 is the pyrolysis temperature

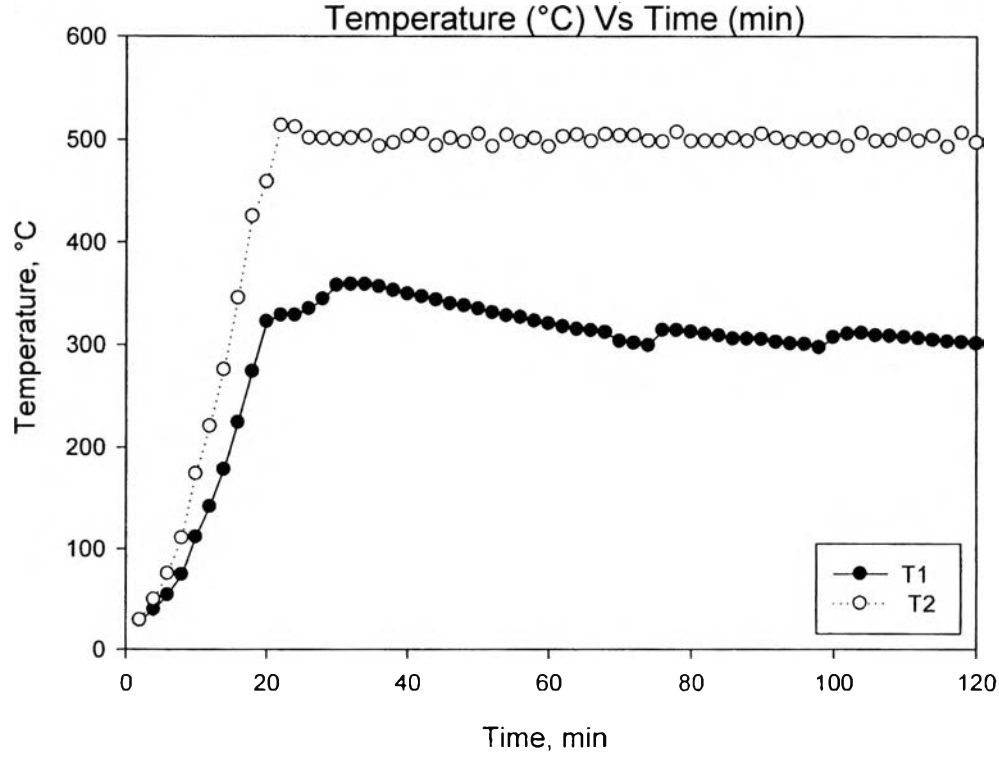


Table A6 Operating temperatures: Batch 6 (BC-20): 06-08-2009

1. Sample = 30.03 g , Catalyst = 7.50g , N2 flow rate = 30 ml/min
2. Char = 13.89 g
3. Pyrolysis oils = 5.86 g
4. Pyrolysis Gas = 10.28 g

Time (min)	T1	T2	Time (min)	T1	T2	Time (min)	T1	T2	Time (min)	T1	T2
2	30	27	32	359	494	62	321	504	92	305	507
4	39	35	34	359	485	64	318	496	94	305	502
6	57	55	36	357	491	66	316	500	96	302	504
8	78	82	38	356	508	68	313	502	98	301	500
10	101	111	40	353	500	70	310	503	100	298	495
12	137	156	42	351	504	72	307	498	102	303	507
14	179	208	44	350	500	74	304	505	104	310	500
16	218	266	46	346	489	76	303	502	106	312	506
18	277	364	48	341	505	78	300	506	108	311	495
20	324	458	50	337	499	80	298	499	110	311	495
22	339	516	52	334	506	82	301	505	112	310	507
24	345	513	54	332	500	84	309	503	114	308	501
26	356	499	56	328	494	86	309	506	116	307	508
28	351	507	58	327	500	88	309	503	118	305	499
30	356	501	60	324	504	90	307	495	120	304	495

* T1 is the catalytic temperature * T2 is the pyrolysis temperature

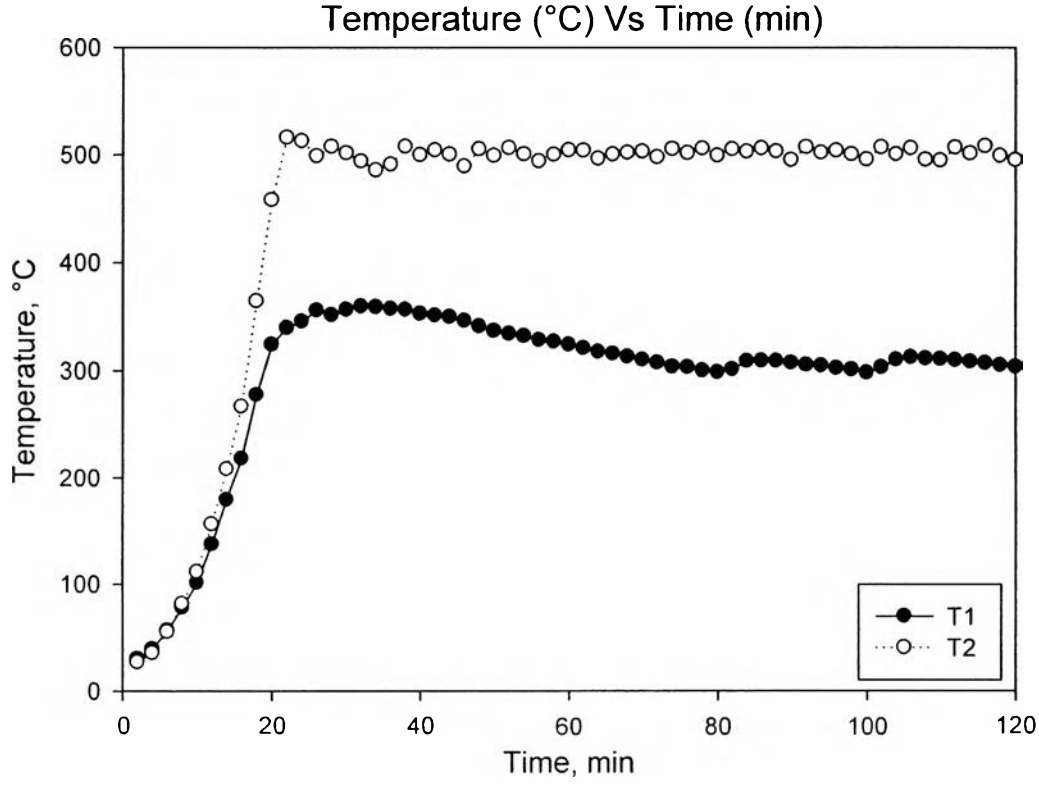


Table A7 Operating temperatures: Batch 7 (BC-30): 07-08-2009

1. Sample = 30.03 g , Catalyst = 7.52g, N2 flow rate = 30 ml/min
2. Char = 13.09 g
3. Pyrolysis oils = 6.93 g
4. Pyrolysis Gas = 10.01 g

Time (min)	T1	T2	Time (min)	T1	T2	Time (min)	T1	T2	Time (min)	T1	T2
2	28	28	32	369	492	62	328	502	92	296	493
4	35	40	34	372	504	64	325	496	94	295	506
6	50	66	36	372	498	66	318	506	96	303	505
8	64	91	38	371	507	68	313	499	98	311	498
10	86	135	40	367	496	70	309	506	100	314	504
12	118	189	42	363	506	72	305	500	102	313	495
14	153	244	44	362	502	74	300	496	104	311	508
16	110	299	46	357	504	76	301	502	106	308	500
18	231	382	48	354	497	78	306	498	108	304	504
20	290	441	50	351	504	80	310	506	110	302	498
22	329	490	52	348	497	82	311	498	112	300	507
24	348	509	54	346	498	84	308	504	114	298	501
26	363	501	56	346	496	86	307	499	116	303	499
28	368	505	58	342	505	88	304	506	118	311	504
30	370	490	60	336	500	90	301	502	120	311	498

* T1 is the catalytic temperature * T2 is the pyrolysis temperature

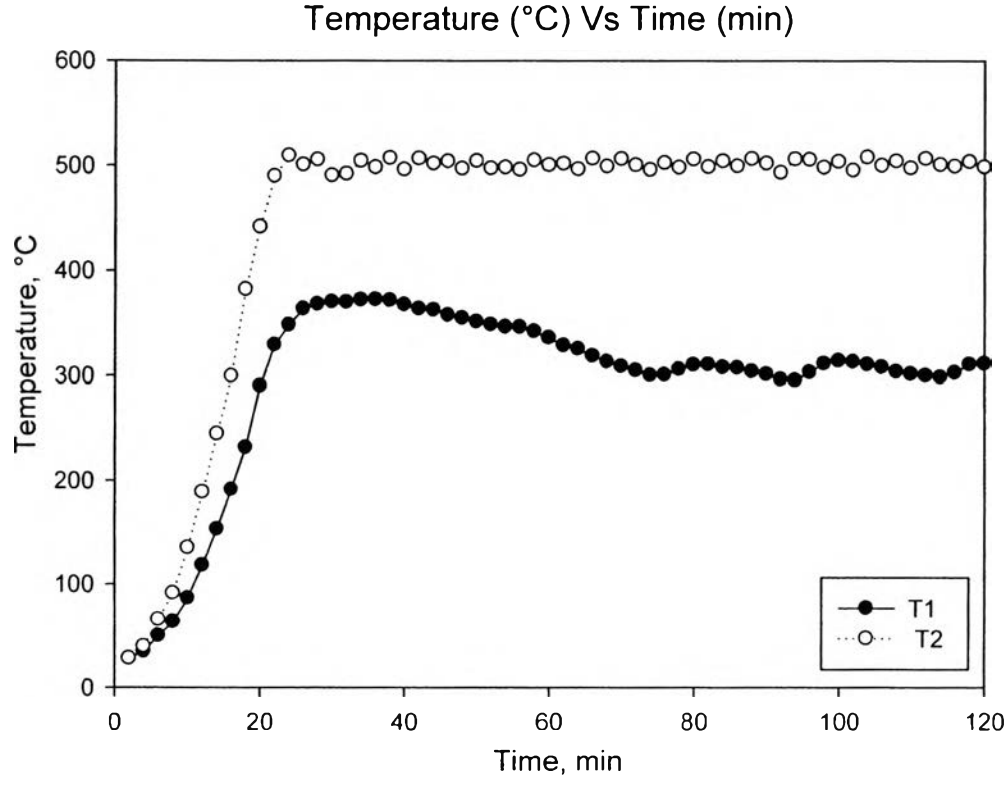


Table A8 Operating temperatures: Batch 8 (BC-40): 16-08-2009

1. Sample = 30.01 g , Catalyst = 7.50g , N2 flow rate = 30 ml/min
2. Char = 13.53 g
3. Pyrolysis oils = 5.30 g
4. Pyrolysis Gas = 11.18 g

Time (min)	T1	T2	Time (min)	T1	T2	Time (min)	T1	T2	Time (min)	T1	T2
2	28	29	32	334	495	62	301	499	92	311	507
4	37	47	34	333	505	64	298	505	94	310	502
6	52	80	36	332	501	66	300	497	96	308	505
8	69	116	38	329	506	68	308	506	98	307	500
10	92	162	40	328	496	70	308	498	100	304	501
12	120	218	42	327	505	72	308	505	102	304	503
14	154	280	44	324	503	74	306	497	104	301	505
16	200	355	46	323	504	76	304	505	106	300	503
18	242	419	48	319	501	78	303	497	108	297	494
20	325	482	50	316	500	80	300	501	110	308	505
22	319	514	52	312	502	82	298	504	112	309	503
24	319	509	54	310	504	84	298	505	114	310	502
26	325	502	56	308	501	86	302	498	116	309	504
28	326	502	58	303	506	88	310	505	118	307	494
30	328	504	60	307	505	90	311	499	120	305	506

* T1 is the catalytic temperature * T2 is the pyrolysis temperature

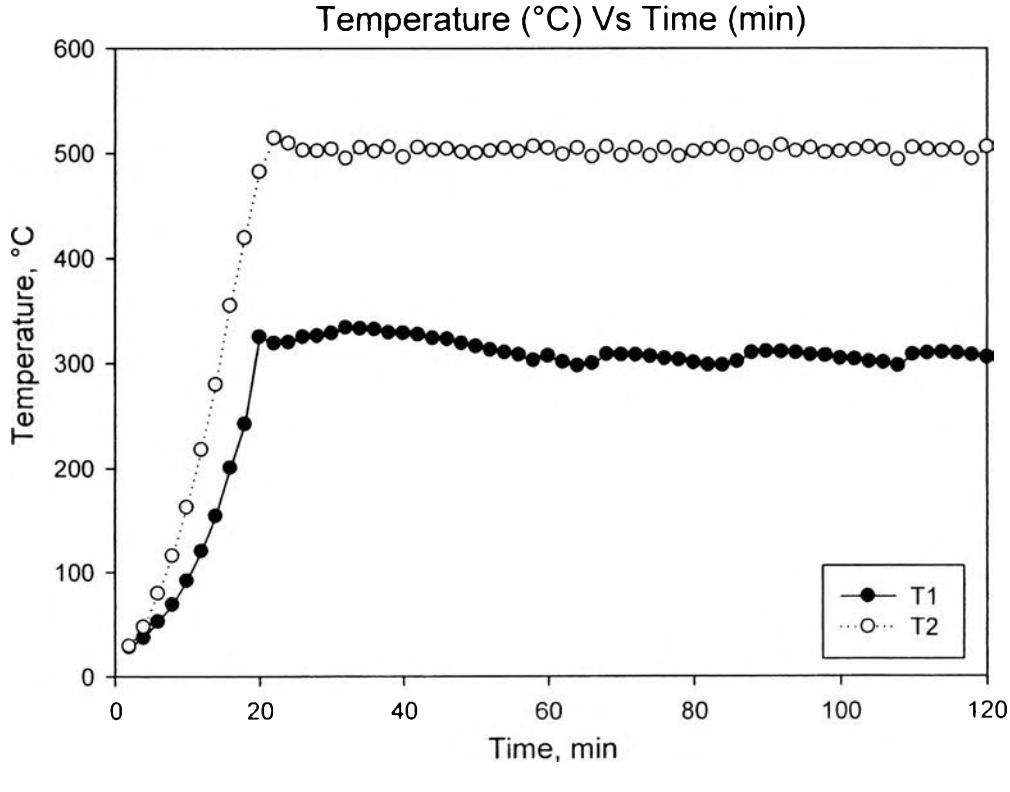


Table A9 Operating temperatures: Batch 9 (BC-50): 17-08-2009

1. Sample = 30.01 g , Catalyst = 7.53g, N2 flow rate = 30 ml/min
2. Char = 13.43 g
3. Pyrolysis oils = 5.59 g
4. Pyrolysis Gas = 10.99 g

Time (min)	T1	T2	Time (min)	T1	T2	Time (min)	T1	T2	Time (min)	T1	T2
2	29	29	32	355	492	62	302	505	92	310	494
4	37	44	34	354	503	64	300	498	94	308	503
6	50	68	36	350	504	66	300	499	96	306	504
8	66	99	38	349	504	68	304	499	98	304	500
10	90	149	40	345	499	70	310	501	100	301	499
12	120	207	42	339	487	72	311	498	102	299	494
14	163	283	44	334	494	74	310	501	104	300	506
16	185	320	46	332	506	76	309	494	106	307	499
18	265	428	48	326	498	78	305	501	108	308	506
20	280	439	50	321	502	80	304	497	110	307	499
22	317	499	52	317	494	82	301	501	112	304	496
24	320	512	54	313	506	84	297	501	114	302	505
26	333	505	56	310	500	86	295	504	116	300	498
28	343	506	58	307	504	88	301	500	118	296	503
30	348	502	60	304	495	90	309	504	120	297	494

* T1 is the catalytic temperature * T2 is the pyrolysis temperature

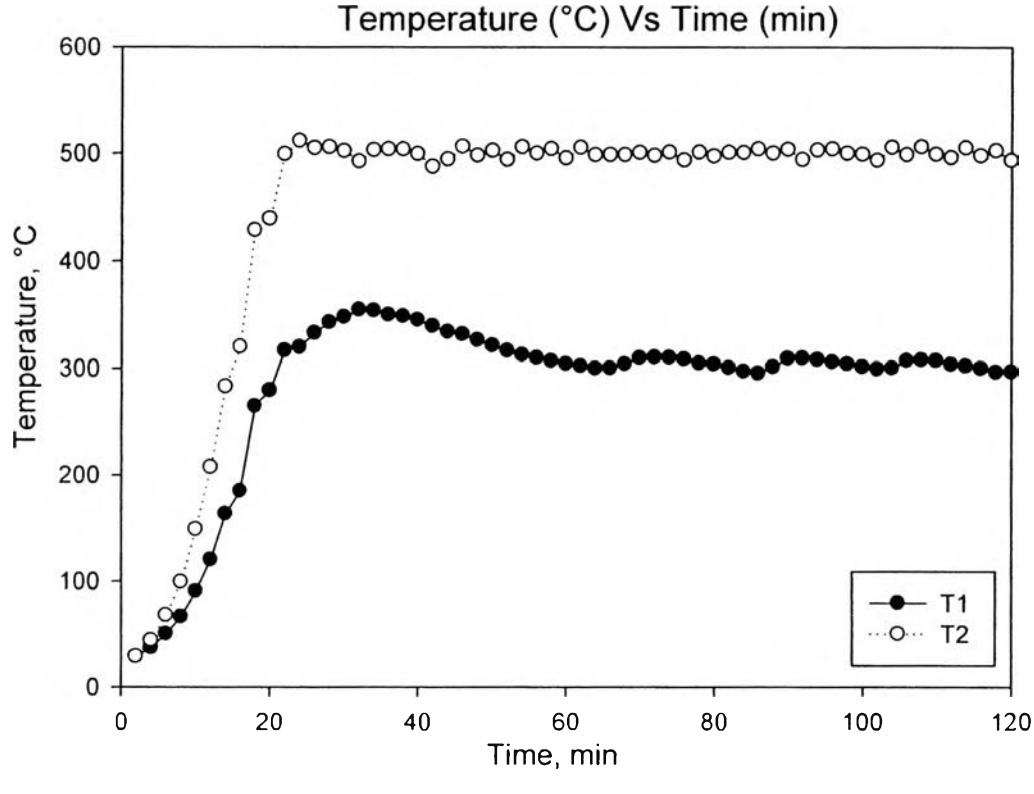


Table A10 Operating temperatures: Batch 10 (Pellet diameter 1.00mm): 14-09-2009

1. Sample = 30.05 g , Catalyst = 7.52g, N2 flow rate = 30 ml/min
2. Char = 13.39 g
3. Pyrolysis oils = 7.26 g
4. Pyrolysis Gas = 9.40 g

Time (min)	T1	T2	Time (min)	T1	T2	Time (min)	T1	T2	Time (min)	T1	T2
2	27	28	32	349	491	62	312	503	92	303	499
4	36	46	34	346	505	64	309	498	94	300	502
6	53	79	36	347	502	66	307	505	96	299	499
8	75	120	38	345	504	68	305	495	98	300	501
10	102	171	40	342	501	70	304	505	100	302	500
12	136	230	42	344	505	72	301	502	102	300	500
14	185	309	44	341	500	74	298	505	104	299	496
16	214	347	46	338	504	76	304	497	106	301	505
18	278	429	48	336	500	78	304	505	108	303	501
20	320	452	50	327	499	80	304	502	110	304	495
22	312	502	52	327	504	82	302	505	112	304	498
24	328	510	54	324	502	84	301	497	114	303	497
26	345	502	56	321	500	86	299	506	116	303	498
28	351	505	58	319	502	88	302	500	118	303	506
30	350	500	60	313	498	90	303	503	120	300	498

* T1 is the catalytic temperature * T2 is the pyrolysis temperature

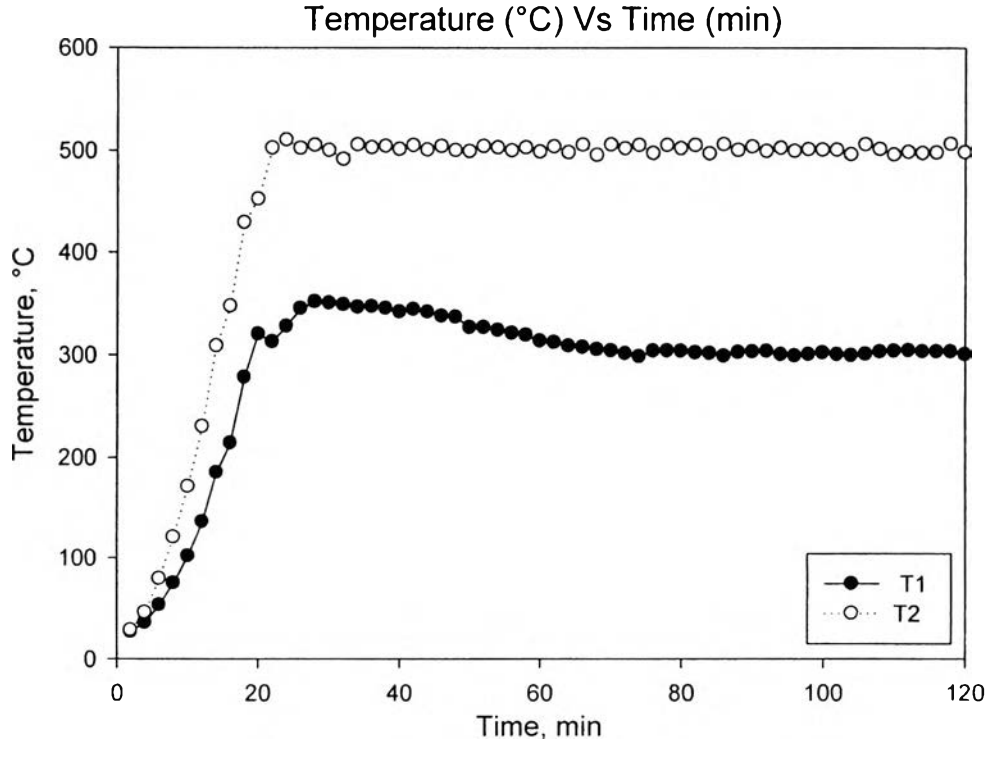


Table A11 Operating temperatures :Batch 11 (Pellet diameter 2.00mm): 17-09-2009

1. Sample = 30.02 g , Catalyst = 7.51g, N2 flow rate = 30 ml/min
2. Char = 13.46 g
3. Pyrolysis oils = 7.04 g
4. Pyrolysis Gas = 9.52 g

Time (min)	T1	T2	Time (min)	T1	T2	Time (min)	T1	T2	Time (min)	T1	T2
2	27	26	32	366	490	62	336	505	92	307	507
4	35	42	34	351	470	64	332	498	94	306	497
6	51	71	36	350	471	66	331	502	96	305	498
8	72	107	38	351	489	68	329	494	98	304	497
10	90	142	40	353	506	70	327	501	100	303	502
12	118	194	42	352	498	72	324	505	102	301	505
14	155	259	44	352	502	74	323	500	104	300	499
16	191	319	46	352	492	76	319	502	106	299	502
18	249	351	48	350	504	78	318	504	108	304	496
20	292	451	50	349	497	80	316	501	110	306	505
22	324	514	52	348	498	82	314	502	112	308	498
24	341	511	54	345	506	84	311	505	114	308	507
26	350	501	56	343	497	86	311	501	116	308	502
28	367	504	58	341	502	88	309	504	118	307	499
30	368	499	60	339	492	90	309	496	120	306	503

* T1 is the catalytic temperature * T2 is the pyrolysis temperature

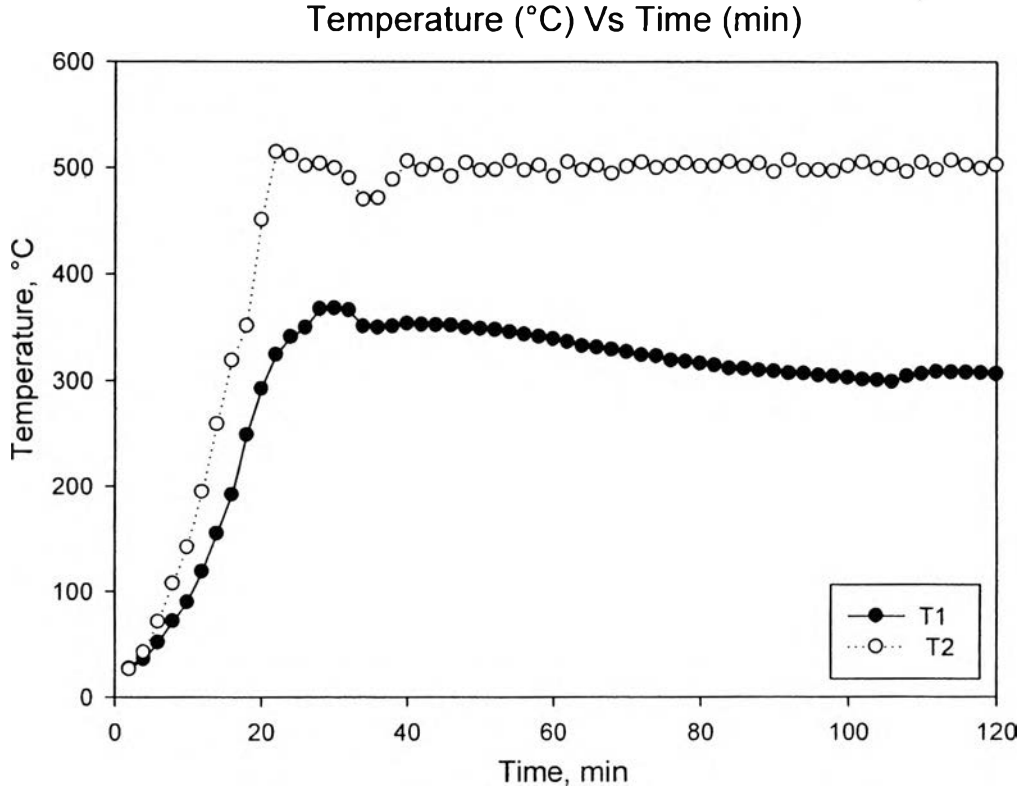


Table A12 Operating temperatures :Batch 12 (Pellet diameter 3.00mm): 06-10-2009

1. Sample = 30.01 g , Catalyst = 7.51g, N2 flow rate = 30 ml/min
2. Char = 13.50 g
3. Pyrolysis oils = 6.09 g
4. Pyrolysis Gas = 10.42 g

Time (min)	T1	T2	Time (min)	T1	T2	Time (min)	T1	T2	Time (min)	T1	T2
2	25	26	32	353	498	62	312	498	92	299	503
4	34	44	34	352	505	64	308	501	94	305	500
6	55	88	36	349	500	66	307	494	96	308	502
8	73	127	38	347	505	68	305	503	98	307	496
10	97	169	40	341	497	70	303	497	100	307	506
12	131	225	42	332	505	72	301	501	102	306	499
14	173	291	44	333	497	74	299	497	104	305	502
16	231	372	46	334	504	76	301	506	106	303	502
18	261	415	48	331	495	78	307	498	108	303	501
20	314	455	50	329	501	80	307	501	110	304	502
22	325	506	52	326	498	82	306	499	112	304	500
24	337	495	54	322	504	84	303	500	114	303	501
26	349	501	56	319	503	86	302	499	116	304	501
28	352	498	58	316	500	88	302	504	118	303	500
30	350	504	60	314	503	90	300	496	120	303	504

* T1 is the catalytic temperature * T2 is the pyrolysis temperature

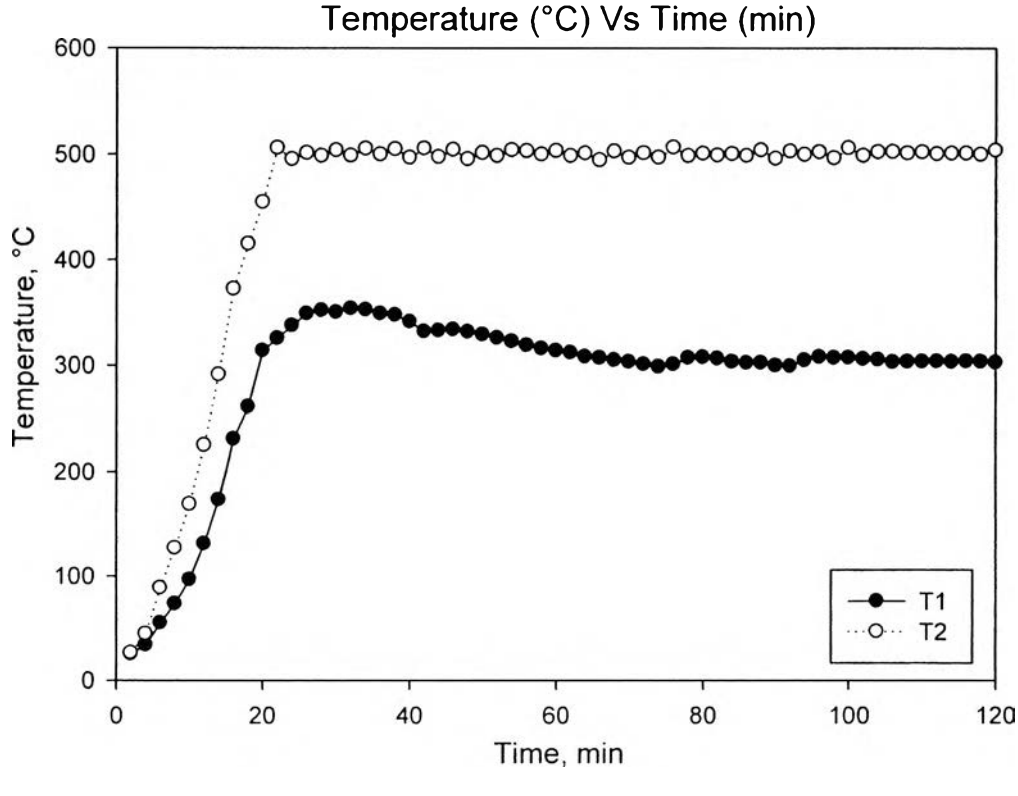


Table A13 Operating temperatures :Batch 13 (Pellet diameter 4.00mm): 12-10-2009

1. Sample = 30.00 g , Catalyst = 7.51g, N2 flow rate = 30 ml/min
2. Char = 13.18 g
3. Pyrolysis oils = 6.11 g
4. Pyrolysis Gas = 10.70 g

Time (min)	T1	T2	Time (min)	T1	T2	Time (min)	T1	T2	Time (min)	T1	T2
2	26	27	32	360	499	62	311	501	92	305	498
4	35	47	34	356	486	64	309	505	94	304	503
6	48	74	36	354	485	66	305	501	96	299	498
8	72	119	38	352	507	68	303	506	98	300	505
10	94	160	40	349	498	70	299	500	100	307	504
12	127	208	42	345	504	72	303	503	102	308	504
14	171	268	44	343	499	74	304	500	104	307	504
16	236	353	46	340	498	76	305	506	106	304	499
18	279	414	48	337	506	78	302	499	108	303	506
20	312	446	50	332	501	80	302	504	110	302	502
22	344	492	52	330	503	82	299	501	112	300	501
24	359	512	54	325	500	84	303	505	114	299	499
26	361	501	56	321	507	86	307	499	116	305	507
28	361	498	58	318	498	88	307	500	118	308	503
30	362	508	60	314	504	90	307	506	120	307	507

* T1 is the catalytic temperature * T2 is the pyrolysis temperature

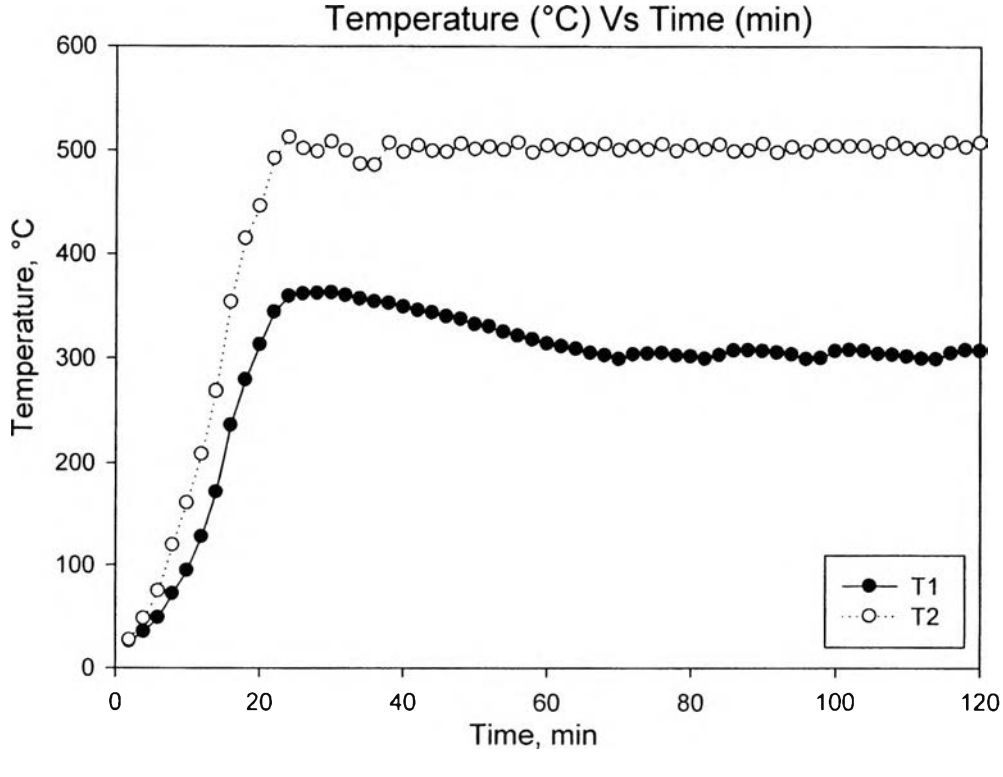


Table A14 Operating temperatures :Batch 14 (Flash Cat.): 06-10-2009

1. Sample = 30.01 g , Catalyst = 7.51g, N2 flow rate = 30 ml/min
2. Char = 13.50 g
3. Pyrolysis oils = 6.09 g
4. Pyrolysis Gas = 10.42 g

Time (min)	T1	T2	Time (min)	T1	T2	Time (min)	T1	T2	Time (min)	T1	T2
2	25	26	32	353	498	62	312	498	92	299	503
4	34	44	34	352	505	64	308	501	94	305	500
6	55	88	36	349	500	66	307	494	96	308	502
8	73	127	38	347	505	68	305	503	98	307	496
10	97	169	40	341	497	70	303	497	100	307	506
12	131	225	42	332	505	72	301	501	102	306	499
14	173	291	44	333	497	74	299	497	104	305	502
16	231	372	46	334	504	76	301	506	106	303	502
18	261	415	48	331	495	78	307	498	108	303	501
20	314	455	50	329	501	80	307	501	110	304	502
22	325	506	52	326	498	82	306	499	112	304	500
24	337	495	54	322	504	84	303	500	114	303	501
26	349	501	56	319	503	86	302	499	116	304	501
28	352	498	58	316	500	88	302	504	118	303	500
30	350	504	60	314	503	90	300	496	120	303	504

* T1 is the catalytic temperature * T2 is the pyrolysis temperature

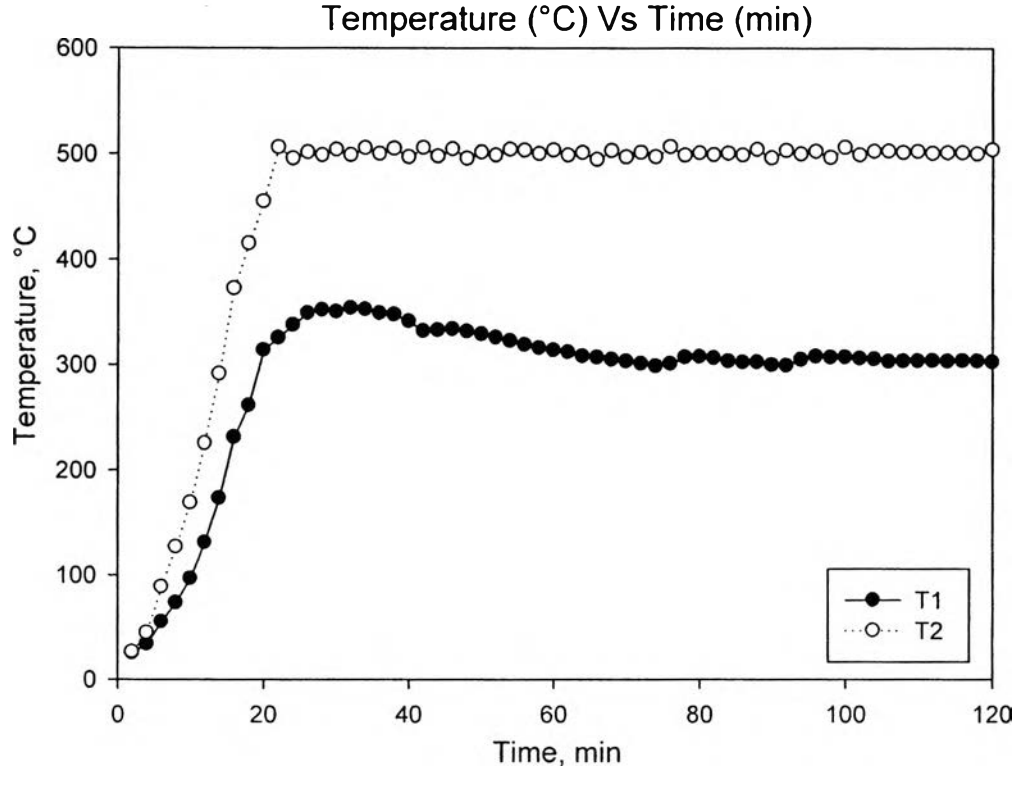


Table A15 Operating temperatures :Batch 15 (Spent Cat.1): 23-10-2009

1. Sample = 30.00 g , Catalyst = 7.50g, N2 flow rate = 30 ml/min
2. Char = 13.13 g
3. Pyrolysis oils = 7.95 g
4. Pyrolysis Gas = 8.92 g

Time (min)	T1	T2	Time (min)	T1	T2	Time (min)	T1	T2	Time (min)	T1	T2
2	29	35	32	334	495	62	308	500	92	311	501
4	40	54	34	335	502	64	303	496	94	308	505
6	54	76	36	337	503	66	301	508	96	306	504
8	82	124	38	340	502	68	297	499	98	302	501
10	104	161	40	339	500	70	305	507	100	302	498
12	137	216	42	337	507	72	309	498	102	301	506
14	180	282	44	334	499	74	308	501	104	297	499
16	225	346	46	333	503	76	309	499	106	302	502
18	290	425	48	328	507	78	305	503	108	308	505
20	317	479	50	329	506	80	301	495	110	311	497
22	324	515	52	323	500	82	299	503	112	310	505
24	331	511	54	320	502	84	299	503	114	307	505
26	335	501	56	314	504	86	310	508	116	305	500
28	332	503	58	314	504	88	312	502	118	304	507
30	334	503	60	309	503	90	311	503	120	300	500

* T1 is the catalytic temperature * T2 is the pyrolysis temperature

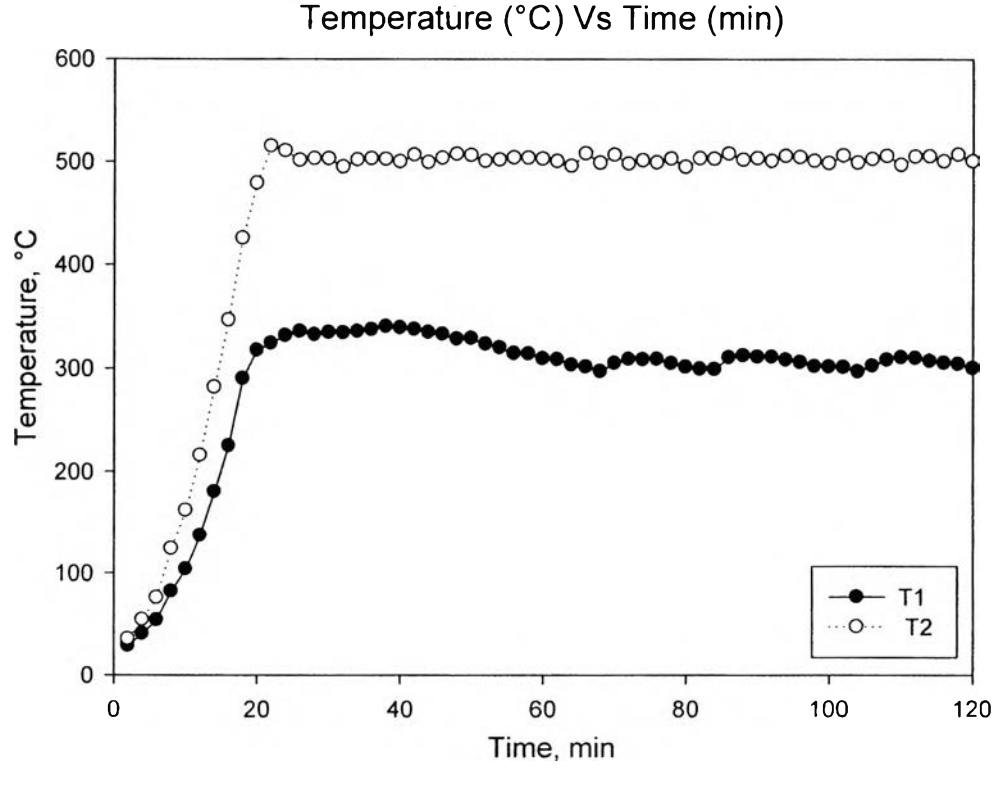
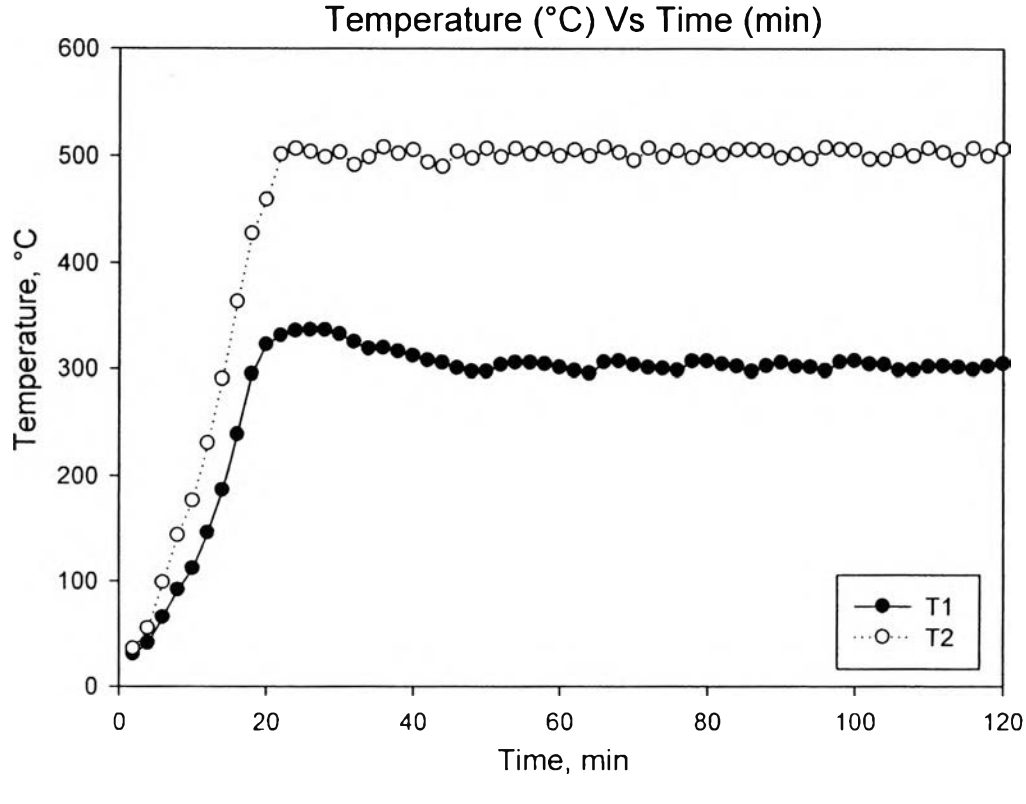


Table A16 Operating temperatures :Batch 16 (Spent Cat.2): 27-10-2009

1. Sample = 30.04 g , Catalyst = 7.50g, N2 flow rate = 30 ml/min
2. Char = 13.43 g
3. Pyrolysis oils = 8.42 g
4. Pyrolysis Gas = 8.56 g

Time (min)	T1	T2	Time (min)	T1	T2	Time (min)	T1	T2	Time (min)	T1	T2
2	30	35	32	325	491	62	298	505	92	302	501
4	41	55	34	318	498	64	296	499	94	301	497
6	65	98	36	319	507	66	306	507	96	298	507
8	91	143	38	316	501	68	307	502	98	306	505
10	112	176	40	312	505	70	304	495	100	307	505
12	146	230	42	308	493	72	301	506	102	304	496
14	186	290	44	305	489	74	300	498	104	304	496
16	239	363	46	300	503	76	299	504	106	299	504
18	295	427	48	297	497	78	307	498	108	299	499
20	322	459	50	297	506	80	307	504	110	302	507
22	331	501	52	303	498	82	304	501	112	302	502
24	335	506	54	306	506	84	302	505	114	301	496
26	336	503	56	306	501	86	298	505	116	299	506
28	336	498	58	304	506	88	303	504	118	302	499
30	332	503	60	301	499	90	306	497	120	305	506

* T1 is the catalytic temperature * T2 is the pyrolysis temperature



Appendix B Yields of Pyrolysis Products

Table B1 Weight percentage of pyrolysis products obtained from each separate component in the Ru/HMOR based catalysts

Catalyst / Products	No Cat.	HMOR	Kaolin	α-alumina
Gas	20.69	30.13	38.27	27.19
Liquid	34.35	24.03	16.13	23.85
Solid	44.89	45.84	45.60	48.96

Table B2 Weight percentage of pyrolysis products obtained from the Ru/HMOR based catalysts

Catalyst / Products	BC-20	BC-30	BC-40	BC-50	Ru/HMOR
Gas	34.23	33.33	37.25	36.62	33.63
Liquid	19.51	23.08	17.66	18.63	22.87
Solid	46.25	43.59	45.08	44.75	43.50

Table B3 Weight percentage of pyrolysis products obtained from the BC-20 catalyst with various pellet diameters

Pellet diameters / Products	1.00mm	2.00mm	3.00mm	4.00mm
Gas	31.28	32.45	34.72	35.71
Liquid	24.16	22.92	20.29	20.37
Solid	44.56	44.64	44.99	43.92

Table B4 Weight percentage of pyrolysis products from the catalyst deactivation testing

# of reuse / Products	1st cycle	2nd cycles	3rd cycles
Gas	30.34	29.73	28.50
Liquid	24.21	26.50	26.70
Solid	45.45	43.78	44.71

Appendix C The Pyrolysis Gas Compositions

Table C1 Weight percentage of gas product obtained from each separate component in the Ru/HMOR based catalysts

gas composition	Catalysts			
	No Cat.	HMOR	Kaolin	α-alumina
Methane	22.96	22.43	21.08	21.39
Ethylene	10.79	6.48	9.59	9.29
Ethane	17.71	18.12	17.69	16.65
Propylene	12.33	9.63	11.74	11.40
Propane	8.12	16.06	8.76	8.22
Mixed C4	21.01	20.61	20.88	18.97
Mixed C5	6.71	6.22	9.43	13.73
>C5	0.38	0.45	0.82	0.37

Table C2 Weight percentage of gas product obtained from the Ru/HMOR based catalysts

gas composition	Catalysts				
	BC-20	BC-30	BC-40	BC-50	Ru/HMOR
Methane	19.12	20.27	18.28	19.51	17.45
Ethylene	9.25	9.71	9.12	8.82	7.50
Ethane	16.71	18.41	16.94	16.83	16.94
Propylene	11.58	12.05	11.40	11.10	10.25
Propane	8.59	10.22	9.54	9.41	14.23
Mixed C4	19.83	22.82	19.55	19.35	20.64
Mixed C5	14.43	6.28	14.84	14.58	12.62
>C5	0.49	0.23	0.34	0.39	0.37

Table C3 Weight percentage of gas products obtained from the BC-20 catalyst with various pellet diameters

Gas composition	Pellet diameter (mm)			
	1.00 mm	2.00 mm	3.00 mm	4.00 mm
Methane	18.16	20.91	21.62	18.67
Ethylene	8.51	9.72	10.38	9.68
Ethane	16.59	17.86	19.22	17.79
Propylene	10.37	11.69	12.78	11.85
Propane	9.34	9.29	10.24	9.80
Mixed C4	18.83	20.50	22.53	20.32
Mixed C5	17.92	9.74	2.75	11.74
>C5	0.29	0.29	0.48	0.14

Table C4 Weight percentage of gas products from the catalyst deactivation testing

Gas composition	Pellet diameter (mm)		
	1st cycle	2nd cycles	3rd cycles
Methane	21.62	19.43	20.42
Ethylene	10.38	10.18	9.95
Ethane	19.22	18.16	18.13
Propylene	12.78	12.40	12.14
Propane	10.24	9.66	9.42
Mixed C4	22.53	22.04	21.42
Mixed C5	2.75	7.41	7.71
>C5	0.48	0.72	0.81

APPENDIX D Amount of Asphaltene in Pyrolysis Oil

Table D1 Amount of asphaltene in pyrolysis oil

No.	Parameter studied	detail	Asphaltene in oil (wt %)
1	Raw materials	No cat	0.0620
2		HMOR	0.0400
3		Kaolin	0.0400
4		α-alumina	0.0420
5	Compositions	BC-20	0.0178
6		BC-30	0.0178
7		BC-40	0.0159
8		BC-50	0.0159
9		BC-100	0.0360
10	Pellet diameter	1.00mm	0.0460
11		2.00mm	0.0420
12		3.00mm	0.0390
13		4.00mm	0.0410
14	Deactivation testing	1st cycle	0.0180
15		2nd cycle	0.0240
16		3rd cycle	0.0250

APPENDIX E Chemical Compositions of Maltenes

Table E1 Chemical compositions of maltenes obtained from each separate component in the Ru/HMOR based catalysts

Catalyst component / Chemical composition	No Cat.	HMOR	Kaolin	α-alumina
Saturated HC.	59.49	64.58	53.33	52.76
Mono-aromatic	13.08	12.10	16.41	16.08
Di-aromatic	6.15	4.75	8.46	6.28
Poly-aromatic	14.87	8.21	8.46	6.28
Polar-aromatic	5.38	5.83	9.23	3.77

Table E2 Chemical compositions of maltenes obtained from the Ru/HMOR based catalysts

Catalyst / Chemical composition	BC-20	BC-30	BC-40	BC-50	Ru/HMOR
Saturated HC.	53.57	54.25	54.77	57.47	58.81
Mono-aromatic	19.39	18.00	19.89	19.48	20.95
Di-aromatic	8.67	7.75	6.27	6.17	5.00
Poly-aromatic	15.56	16.75	16.08	13.96	13.10
Polar-aromatic	1.79	1.50	1.91	1.30	1.90

Table E3 Chemical compositions of maltenes obtained from the BC-20 catalyst with various pellet diameters

Pellet diameters / Chemical composition	1.00 mm	2.00 mm	3.00 mm	4.00 mm
Saturated HC.	47.33	45.27	43.53	40.20
Mono-aromatic	17.56	19.34	22.12	16.33
Di-aromatic	8.00	10.91	9.88	10.55
Poly-aromatic	13.11	14.40	10.35	22.36
Polar-aromatic	12.89	9.88	12.71	9.55

Table E4 Chemical compositions of maltenes from the catalyst deactivation testing

# of reuse / Chemical composition	1st cycle	2nd cycle	3rd cycle
Saturated HC.	43.53	42.05	40.31
Mono-aromatic	22.12	16.14	13.44
Di-aromatic	9.88	18.41	15.31
Poly-aromatic	10.35	12.95	15.31
Polar-aromatic	12.71	9.77	12.19

APPENDIX F True Boiling Point of Maltenes

Table F1 True boiling point of maltenes obtained from each separate component in the Ru/HMOR based catalyst

% Off	Boiling point (°C)			
	No cat	HMOR	Kaolin	α-alumina
0	27.5	29.7	22.2	22.0
5	162.3	152.3	112.4	111.8
10	173.8	157.0	151.4	150.1
15	189.8	167.9	155.5	155.0
20	199.2	171.6	157.7	157.4
25	208.0	182.8	160.6	161.8
30	214.3	190.1	169.2	169.4
35	222.4	197.1	171.5	171.1
40	230.5	203.9	179.9	176.0
45	238.6	210.6	187.8	185.1
50	249.3	216.4	198.6	191.3
55	259.7	222.7	209.0	201.3
60	271.0	230.0	220.2	209.0
65	282.2	237.3	232.0	219.0
70	294.7	247.6	246.4	230.3
75	310.5	258.9	262.8	245.3
80	327.8	272.2	279.4	263.8
85	347.9	287.7	299.0	283.8
90	372.1	311.7	325.6	310.7
95	400.7	351.8	365.4	350.6
100	464.9	425.2	452.2	428.0

Table F2 True boiling point of maltenes obtained from the Ru/HMOR based catalysts

% Off	Boiling point (°C)				
	BC-20	**BC-30**	**BC-40**	**BC-50**	**Ru/HMOR**
0	26.7	22.9	24.6	30.3	26.5
5	111.8	112.9	77.6	112.5	120.3
10	153.9	154.5	114.6	153.2	154.6
15	156.6	157.2	155.6	155.7	158.1
20	160.5	165.7	158.4	158.5	168.0
25	169.7	170.0	168.4	168.0	170.7
30	172.3	172.3	171.9	170.5	177.5
35	183.4	182.6	183.1	176.1	185.3
40	190.7	188.2	191.6	185.0	192.4
45	200.9	195.7	203.2	192.9	202.7
50	208.8	203.6	212.3	203.5	211.0
55	217.4	211.3	221.7	213.4	219.9
60	226.2	219.3	231.8	223.1	230.1
65	236.9	227.6	243.5	235.1	242.4
70	250.9	238.3	256.6	250.1	256.0
75	265.5	252.6	270.8	265.7	271.4
80	280.1	269.0	285.1	281.8	286.5
85	298.0	286.2	304.0	301.8	305.6
90	322.2	311.7	329.4	328.3	329.3
95	358.3	349.3	367.8	370.3	365.3
100	433.7	425.0	446.1	452.7	443.2

Table F3 True boiling point of maltenes obtained from the BC-20 catalyst with various pellet diameters

% Off	Boiling point (°C)			
	1.00 mm	**2.0 mm**	**3.00 mm**	**4.00 mm**
0	32.9	32.0	26.3	22.0
5	113.4	112.4	81.0	73.5
10	153.5	153.6	113.7	111.6
15	156.3	156.3	153.4	151.4
20	160.6	160.5	155.6	154.3
25	169.1	169.2	158.3	157.0
30	171.2	171.2	167.7	165.5
35	179.4	177.9	170.5	169.8
40	185.6	184.6	175.7	172.5
45	193.1	190.5	185.6	183.9
50	203.6	198.0	194.2	192.0
55	213.5	204.8	204.6	203.1
60	223.2	213.3	214.8	213.1
65	235.7	222.1	226.1	222.9
70	251.6	232.8	239.5	235.5
75	268.8	246.5	256.4	251.8
80	284.7	263.0	274.5	269.6
85	304.7	281.8	294.4	287.5
90	329.2	306.9	321.4	311.7
95	367.0	345.4	360.5	343.5
100	449.3	437.8	444.3	419.2

Table F4 True boiling point of maltenes from the catalyst deactivation testing

% Off	Boiling point (°C)		
	1st cycle	2nd cycle	3rd cycle
0	26.3	27.5	32.2
5	81.0	111.0	123.0
10	113.7	117.7	154.2
15	153.4	153.3	156.8
20	155.6	154.7	161.1
25	158.3	156.9	169.3
30	167.7	159.5	171.9
35	170.5	168.1	181.6
40	175.7	170.4	188.6
45	185.6	173.0	198.8
50	194.2	183.8	207.8
55	204.6	191.1	217.3
60	214.8	203.0	227.1
65	226.1	213.9	238.9
70	239.5	227.2	253.8
75	256.4	244.2	269.4
80	274.5	264.1	285.0
85	294.4	284.9	305.5
90	321.4	312.4	330.4
95	360.5	352.3	366.8
100	444.3	438.5	445.0

APPENDIX G True Boiling Point of Maltenes, Saturated Hydrocarbons, Mono-, Di-, Poly-, and Polar-aromatics in Maltenes

Table G1 Batch 1 (no Cat)

%off	Boiling point (°C)					
	Maltene	Saturated Hydrocarbons	Mono-aromatics	Di-aromatics	Poly-aromatics	Polar-aromatics
0	27.5	39.0	23.5	22.2	23.9	22.7
5	162.3	184.2	163.8	27.1	73.3	39.2
10	173.8	192.5	208.2	35.0	74.2	177.1
15	189.8	203.4	231.7	76.4	75.4	190.6
20	199.2	210.7	252.1	184.7	158.8	197.6
25	208.0	216.8	269.9	199.8	172.8	203.8
30	214.3	223.6	283.3	212.4	192.3	211.9
35	222.4	230.6	291.8	226.7	213.9	222.6
40	230.5	237.5	301.3	241.9	250.3	234.8
45	238.6	246.5	307.6	263.3	272.8	247.7
50	249.3	255.0	314.5	291.0	296.0	261.0
55	259.7	264.9	321.1	323.9	313.1	274.1
60	271.0	273.8	327.7	342.6	334.5	287.3
65	282.2	283.8	334.1	354.7	344.0	300.0
70	294.7	295.2	341.8	365.3	373.7	313.8
75	310.5	309.3	349.8	376.7	383.6	329.3
80	327.8	325.7	359.1	389.4	384.3	347.0
85	347.9	345.8	370.4	404.7	385.2	367.5
90	372.1	370.2	385.7	423.3	388.0	390.8
95	400.7	401.1	410.3	451.0	415.2	424.0
100	464.9	459.8	480.0	499.9	487.3	498.4

Table G2 Batch 2 (HMOR)

%off	Boiling point (°C)					
	Maltene	**Saturated Hydrocarbons**	**Mono-aromatics**	**Di-aromatics**	**Poly-aromatics**	**Polar-aromatics**
0	29.7	34.3	29.0	22.2	28.8	22.0
5	152.3	158.1	78.0	59.0	70.4	35.6
10	157.0	171.1	159.4	72.7	70.9	75.1
15	167.9	182.9	173.2	73.7	71.5	163.8
20	171.6	189.8	191.3	75.1	72.3	185.3
25	182.8	195.8	211.2	77.0	73.4	194.7
30	190.1	202.7	247.3	78.9	75.4	196.2
35	197.1	208.3	268.9	82.9	155.6	199.0
40	203.9	213.0	274.6	157.4	180.9	204.9
45	210.6	218.5	284.9	170.9	233.8	212.8
50	216.4	223.4	291.0	182.9	306.1	224.1
55	222.7	229.6	298.7	191.8	338.0	235.9
60	230.0	235.5	305.3	204.0	378.1	249.0
65	237.3	243.4	312.4	217.3	378.7	262.7
70	247.6	251.9	319.4	238.9	379.4	275.0
75	258.9	261.5	327.4	288.5	380.1	288.2
80	272.2	272.3	335.3	309.4	380.9	302.9
85	287.7	285.3	346.1	327.1	381.9	323.0
90	311.7	304.4	360.4	345.5	383.1	351.3
95	351.8	336.6	381.9	372.2	385.3	390.3
100	425.2	423.6	457.2	457.2	455.1	475.2

Table G3 Batch 3 (Ru/HMOR)

%off	Boiling point (°C)					
	Maltene	**Saturated Hydrocarbons**	**Mono-aromatics**	**Di-aromatics**	**Poly-aromatics**	**Polar-aromatics**
0	26.5	38.4	22.2	22.0	27.1	21.6
5	120.3	155.7	58.6	29.7	69.7	22.7
10	154.6	169.3	73.8	67.7	70.0	23.7
15	158.1	172.5	76.0	73.8	70.4	24.8
20	168.0	183.6	78.4	74.8	70.8	26.5
25	170.7	190.1	81.6	76.4	71.2	33.5
30	177.5	198.6	158.1	78.6	71.6	39.9
35	185.3	205.7	176.3	81.1	71.9	74.9
40	192.4	212.6	203.0	103.2	72.3	175.9
45	202.7	220.2	250.6	174.4	72.7	195.0
50	211.0	228.4	285.2	200.1	73.1	208.5
55	219.9	236.8	294.4	228.2	74.1	224.5
60	230.1	248.0	305.4	272.3	75.5	242.1
65	242.4	258.9	312.9	307.0	77.8	262.2
70	256.0	270.3	320.8	322.1	157.7	282.1
75	271.4	281.7	329.4	332.9	188.2	301.5
80	286.5	295.0	338.7	345.0	270.8	323.6
85	305.6	311.8	349.7	357.8	318.9	348.9
90	329.3	333.5	363.9	374.6	362.3	380.5
95	365.3	368.2	387.3	403.2	384.4	417.5
100	443.2	450.6	460.1	476.8	441.6	485.9

Table G4 Batch 4 (Kaolin)

%off	Boiling point (°C)					
	Maltene	**Saturated Hydrocarbons**	**Mono-aromatics**	**Di-aromatics**	**Poly-aromatics**	**Polar-aromatics**
0	22.2	33.7	30.9	25.8	23.5	20.3
5	112.4	70.1	70.3	70.2	70.8	22.0
10	151.4	72.3	72.0	71.9	71.2	29.0
15	155.5	74.2	73.6	73.0	71.6	74.2
20	157.7	78.0	75.7	74.8	71.9	162.4
25	160.6	104.7	79.3	76.9	72.3	174.8
30	169.2	158.9	90.3	81.7	72.7	192.3
35	171.5	169.8	213.0	154.4	73.1	206.5
40	179.9	175.5	230.0	158.2	73.5	221.5
45	187.8	185.3	242.9	168.8	73.8	239.6
50	198.6	194.5	250.5	171.5	74.2	260.6
55	209.0	203.6	261.4	183.0	74.6	279.6
60	220.2	213.6	271.4	199.0	75.0	295.0
65	232.0	222.4	279.2	245.8	75.6	311.7
70	246.4	234.8	289.2	274.8	77.8	329.0
75	262.8	250.4	300.2	293.3	156.2	349.3
80	279.4	267.1	314.7	310.0	196.6	374.5
85	299.0	283.9	331.2	327.8	300.9	385.3
90	325.6	309.0	354.7	348.9	327.0	387.6
95	365.4	346.2	388.9	380.6	358.5	410.0
100	452.2	433.2	465.5	456.9	446.7	477.5

Table G5 Batch 5 (Alumina)

%off	Boiling point (°C)					
	Maltene	**Saturated Hydrocarbons**	**Mono-aromatics**	**Di-aromatics**	**Poly-aromatics**	**Polar-aromatics**
0	22.0	55.4	35.8	24.2	26.9	23.5
5	111.8	156.5	72.3	72.6	70.1	155.3
10	150.1	169.8	75.1	74.6	70.5	155.7
15	155.0	173.8	80.9	78.5	70.9	156.1
20	157.4	183.8	170.4	171.7	71.3	156.4
25	161.8	189.5	191.9	232.0	71.8	157.1
30	169.4	196.4	209.2	246.2	72.5	162.6
35	171.1	201.7	211.9	254.9	73.5	182.4
40	176.0	206.9	219.6	264.7	75.4	192.6
45	185.1	212.7	228.5	272.5	113.1	194.7
50	191.3	218.0	231.9	279.1	226.1	201.9
55	201.3	223.0	240.2	287.4	269.6	203.0
60	209.0	230.6	247.7	293.2	287.9	209.4
65	219.0	238.1	255.1	302.4	301.6	213.5
70	230.3	248.3	264.3	311.5	311.8	223.2
75	245.3	259.0	274.5	321.9	322.6	236.5
80	263.8	271.4	285.0	333.3	335.8	245.5
85	283.8	286.3	298.9	347.2	347.6	269.3
90	310.7	309.7	319.9	365.3	366.3	297.0
95	350.6	346.6	352.1	390.2	386.9	345.6
100	428.0	433.3	347.5	457.8	456.9	453.6

Table G6 Batch 6 (BC-20)

%off	Boiling point (°C)					
	Maltene	**Saturated Hydrocarbons**	**Mono-aromatics**	**Di-aromatics**	**Poly-aromatics**	**Polar-aromatics**
0	26.7	31.8	21.8	23.9	38.6	22.0
5	111.8	113.0	72.8	72.3	60.5	70.2
10	153.9	167.5	79.6	72.8	61.5	70.6
15	156.6	171.6	217.2	73.5	62.6	71.0
20	160.5	182.4	244.7	74.5	63.6	71.4
25	169.7	189.2	253.6	77.0	64.7	72.1
30	172.3	196.7	263.7	86.1	65.8	73.5
35	183.4	203.4	270.8	247.9	66.8	77.0
40	190.7	210.6	275.3	277.5	67.9	191.7
45	200.9	216.9	282.4	290.6	69.0	194.6
50	208.8	223.1	288.1	299.4	69.4	200.9
55	217.4	230.9	293.4	306.5	69.7	222.0
60	226.2	239.0	300.9	313.8	70.1	248.4
65	236.9	249.6	308.1	320.5	70.5	275.3
70	250.9	260.2	316.5	328.4	70.9	298.8
75	265.5	271.4	325.5	336.3	71.3	326.9
80	280.1	283.1	335.0	346.3	72.6	364.6
85	298.0	298.6	347.9	357.9	74.6	383.3
90	322.2	320.5	364.8	372.9	109.7	384.5
95	358.3	353.8	388.6	397.1	285.3	388.0
100	433.7	436.3	458.2	464.5	406.6	479.9

Table G7 Batch7 (BC-30)

%off	Boiling point (°C)					
	Maltene	**Saturated Hydrocarbons**	**Mono-aromatics**	**Di-aromatics**	**Poly-aromatics**	**Polar-aromatics**
0	22.9	31.4	23.3	22.5	24.8	22.2
5	112.9	157.0	74.2	33.1	70.4	26.3
10	154.5	170.7	79.5	74.5	70.8	33.1
15	157.2	180.4	157.5	86.0	71.2	71.9
20	165.7	186.6	187.5	259.5	71.6	78.3
25	170.0	192.3	240.0	281.9	71.9	202.2
30	172.3	201.0	255.8	290.2	72.3	220.7
35	182.6	205.8	269.0	296.6	72.7	236.1
40	188.2	211.7	274.5	303.2	73.1	251.9
45	195.7	217.2	282.6	308.3	73.5	267.0
50	203.6	222.3	288.9	313.5	73.8	281.1
55	211.3	229.2	295.3	318.5	74.2	293.9
60	219.3	236.1	303.1	323.9	74.6	307.9
65	227.6	245.1	311.0	329.6	75.0	323.7
70	238.3	255.1	319.6	335.2	75.4	341.3
75	252.6	266.6	328.4	342.2	76.1	363.2
80	269.0	278.3	337.9	350.3	78.8	385.2
85	286.2	292.9	350.4	360.3	180.4	386.6
90	311.7	314.6	365.8	373.8	305.3	389.6
95	349.3	347.6	387.1	397.6	342.6	412.5
100	425.0	426.3	449.9	460.3	443.1	472.5

Table G8 Batch8 (BC-40)

%off	Boiling point (°C)					
	Maltene	**Saturated Hydrocarbons**	**Mono-aromatics**	**Di-aromatics**	**Poly-aromatics**	**Polar-aromatics**
0	24.6	35.4	26.3	22.9	23.5	22.5
5	77.6	79.0	77.0	57.7	71.3	29.5
10	114.6	156.7	117.0	75.7	72.0	71.2
15	155.6	168.8	160.0	80.9	72.4	74.2
20	158.4	172.1	171.1	165.5	72.8	74.8
25	168.4	182.3	184.4	188.2	73.2	76.3
30	171.9	189.1	202.1	207.4	73.5	181.0
35	183.1	197.7	234.7	231.3	73.9	200.1
40	191.6	204.5	257.7	270.1	74.3	211.1
45	203.2	212.6	271.9	287.4	74.7	226.6
50	212.3	219.6	279.6	296.6	75.1	242.2
55	221.7	227.2	288.6	305.7	76.1	258.7
60	231.8	235.9	297.1	312.6	80.8	273.1
65	243.5	246.7	305.7	319.7	194.1	287.1
70	256.6	257.9	315.6	327.5	261.8	299.7
75	270.8	270.0	326.0	335.3	312.7	314.7
80	285.1	282.5	336.9	345.2	337.9	331.9
85	304.0	299.0	351.4	356.8	370.2	352.5
90	329.4	322.9	368.8	372.6	385.2	379.9
95	367.8	361.3	394.7	400.9	388.2	418.5
100	446.1	448.4	460.2	475.9	467.3	486.3

Table G9 Batch9 (BC-50)

%off	Boiling point (°C)					
	Maltene	**Saturated Hydrocarbons**	**Mono-aromatics**	**Di-aromatics**	**Poly-aromatics**	**Polar-aromatics**
0	30.3	34.3	25.2	22.2	22.9	22.9
5	112.5	84.5	75.3	32.9	35.0	38.0
10	153.2	169.4	85.0	69.1	72.2	181.0
15	155.7	174.5	243.6	73.8	72.8	197.2
20	158.5	185.4	256.4	74.8	73.2	204.3
25	168.0	192.9	269.2	76.1	73.5	217.8
30	170.5	202.7	274.6	77.6	73.9	234.5
35	176.1	210.0	282.7	79.9	74.3	252.1
40	185.0	216.9	288.9	83.1	74.7	267.1
45	192.9	223.4	295.0	156.9	75.1	281.6
50	203.5	231.5	302.2	260.7	75.4	293.6
55	213.4	239.9	309.3	289.4	75.8	307.0
60	223.1	250.3	317.0	301.6	76.2	322.2
65	235.1	260.4	324.9	310.4	77.5	340.4
70	250.1	271.2	333.0	319.2	84.9	362.8
75	265.7	282.4	342.4	328.4	280.4	383.9
80	281.8	296.6	354.4	338.1	317.5	384.7
85	301.8	315.7	368.0	350.6	340.6	385.5
90	328.3	341.6	385.2	366.9	363.7	387.2
95	370.3	385.1	414.0	395.4	401.3	412.9
100	452.7	464.5	481.5	470.2	477.9	486.9

Table G10 Batch 10 (Pellet diameter 1.00mm)

%off	Boiling point (°C)					
	Maltene	Saturated Hydrocarbons	Mono-aromatics	Di-aromatics	Poly-aromatics	Polar-aromatics
0	32.9	71.4	35.6	23.5	24.2	22.7
5	113.4	157.8	169.8	81.4	176.1	71.8
10	153.5	170.3	207.0	190.1	236.9	158.5
15	156.3	179.4	227.9	245.0	276.9	166.0
20	160.6	185.5	239.1	266.2	289.3	176.0
25	169.1	192.5	249.8	275.6	296.1	193.3
30	171.2	201.9	259.3	284.6	303.5	197.1
35	179.4	208.9	267.3	291.2	308.4	202.5
40	185.6	215.4	272.3	297.7	312.3	213.0
45	193.1	221.9	278.6	303.3	316.1	228.7
50	203.6	230.4	285.3	308.8	321.5	244.8
55	213.5	239.4	291.3	315.2	327.8	262.2
60	223.2	250.8	298.8	320.7	333.8	276.1
65	235.7	261.8	306.1	327.1	337.2	287.9
70	251.6	273.1	315.4	332.1	343.2	298.9
75	268.8	284.8	325.1	339.2	350.7	312.9
80	284.7	299.3	335.1	348.0	359.2	330.3
85	304.7	318.4	349.7	359.6	370.3	351.3
90	329.2	341.8	368.4	374.8	385.7	383.3
95	367.0	379.6	396.2	401.3	411.3	401.8
100	449.3	450.0	465.1	470.0	480.0	482.2

Table G11 Batch 11 (Pellet diameter 2.00mm)

%off	Boiling point (°C)					
	Maltene	**Saturated Hydrocarbons**	**Mono-aromatics**	**Di-aromatics**	**Poly-aromatics**	**Polar-aromatics**
0	32.0	68.3	35.6	24.6	22.9	22.2
5	112.4	157.8	192.1	224.2	34.6	27.3
10	153.6	170.1	226.5	253.3	75.1	36.5
15	156.3	173.7	232.2	268.5	257.7	74.5
20	160.5	183.3	243.9	273.0	285.0	76.1
25	169.2	188.4	249.1	278.4	290.7	191.5
30	171.2	192.7	254.6	287.1	297.1	210.9
35	177.9	200.9	262.4	291.9	304.1	227.1
40	184.6	205.8	268.6	297.9	308.4	242.5
45	190.5	211.6	273.4	302.8	312.7	257.4
50	198.0	217.5	280.4	308.4	315.6	271.3
55	204.8	223.2	286.1	314.6	320.8	284.6
60	213.3	231.2	292.2	320.3	326.7	295.9
65	222.1	239.9	299.7	327.4	333.0	309.1
70	232.8	250.9	307.9	334.2	337.9	324.0
75	246.5	262.8	318.0	342.4	343.4	341.2
80	263.0	276.0	329.3	351.8	352.0	361.6
85	281.8	292.3	343.3	363.5	363.8	385.3
90	306.9	316.3	363.0	378.8	381.8	389.3
95	345.4	354.1	391.6	403.1	412.7	417.5
100	437.8	442.3	465.6	466.7	479.4	481.5

Table G12 Batch 12 (Pellet diameter 3.00mm)

%off	Boiling point (°C)					
	Maltene	**Saturated Hydrocarbons**	**Mono-aromatics**	**Di-aromatics**	**Poly-aromatics**	**Polar-aromatics**
0	26.3	60.0	32.0	28.0	25.0	22.5
5	81.0	83.0	72.9	71.5	71.6	35.4
10	113.7	158.0	75.7	73.1	72.0	74.4
15	153.4	169.4	80.7	75.7	72.4	77.3
20	155.6	173.2	156.6	81.4	72.8	157.5
25	158.3	182.6	170.7	157.4	73.2	158.7
30	167.7	189.2	185.3	170.7	73.8	161.3
35	170.5	198.0	192.6	184.4	74.9	175.3
40	175.7	203.6	208.8	201.3	77.7	195.0
45	185.6	212.4	212.8	225.4	160.4	203.4
50	194.2	219.5	224.8	244.9	190.2	208.3
55	204.6	227.6	231.4	259.6	251.9	215.2
60	214.8	237.9	243.6	272.2	276.8	228.4
65	226.1	251.0	254.2	283.7	292.6	246.1
70	239.5	264.1	265.2	293.1	304.7	266.0
75	256.4	277.7	278.0	306.1	315.7	285.6
80	274.5	294.2	290.9	320.2	327.5	305.5
85	294.4	317.1	309.6	335.7	341.0	326.9
90	321.4	349.6	333.4	356.9	357.7	354.6
95	360.5	393.4	372.5	384.5	385.3	388.2
100	444.3	460.3	459.5	452.0	462.5	465.1

Table G13 Batch 13 (Pellet diameter 4.00mm)

%off	Boiling point (°C)					
	Maltene	**Saturated Hydrocarbons**	**Mono-aromatics**	**Di-aromatics**	**Poly-aromatics**	**Polar-aromatics**
0	22.0	55.4	34.1	25.4	27.3	22.9
5	73.5	78.5	185.2	71.7	70.7	37.3
10	111.6	168.8	210.4	72.5	71.1	73.6
15	151.4	175.5	213.3	73.6	71.6	74.3
20	154.3	185.6	227.4	75.9	72.1	75.2
25	157.0	193.9	231.4	79.9	72.9	77.7
30	165.5	201.9	236.6	214.4	73.8	83.7
35	169.8	208.6	245.4	249.2	76.1	159.5
40	172.5	215.3	251.1	257.7	154.6	169.5
45	183.9	220.8	259.8	268.6	173.4	181.1
50	192.0	228.1	266.1	276.8	258.9	200.4
55	203.1	236.4	273.2	286.0	284.7	209.4
60	213.1	245.9	279.8	293.1	295.3	220.3
65	222.9	256.2	287.3	301.7	306.5	236.9
70	235.5	267.5	294.6	310.0	312.3	256.1
75	251.8	278.0	304.2	319.2	321.8	275.5
80	269.6	290.3	315.8	329.6	333.9	294.9
85	287.5	307.2	328.4	341.2	338.9	318.5
90	311.7	327.4	344.1	356.3	353.9	347.8
95	343.5	358.4	368.7	378.1	378.0	386.6
100	419.2	430.9	439.5	448.4	450.6	458.7

Table G14 Batch 14 (Flash Cat.)

%off	Boiling point (°C)					
	Maltene	**Saturated Hydrocarbons**	**Mono-aromatics**	**Di-aromatics**	**Poly-aromatics**	**Polar-aromatics**
0	26.3	60.0	32.0	28.0	25.0	22.5
5	81.0	83.0	72.9	71.5	71.6	35.4
10	113.7	158.0	75.7	73.1	72.0	74.4
15	153.4	169.4	80.7	75.7	72.4	77.3
20	155.6	173.2	156.6	81.4	72.8	157.5
25	158.3	182.6	170.7	157.4	73.2	158.7
30	167.7	189.2	185.3	170.7	73.8	161.3
35	170.5	198.0	192.6	184.4	74.9	175.3
40	175.7	203.6	208.8	201.3	77.7	195.0
45	185.6	212.4	212.8	225.4	160.4	203.4
50	194.2	219.5	224.8	244.9	190.2	208.3
55	204.6	227.6	231.4	259.6	251.9	215.2
60	214.8	237.9	243.6	272.2	276.8	228.4
65	226.1	251.0	254.2	283.7	292.6	246.1
70	239.5	264.1	265.2	293.1	304.7	266.0
75	256.4	277.7	278.0	306.1	315.7	285.6
80	274.5	294.2	290.9	320.2	327.5	305.5
85	294.4	317.1	309.6	335.7	341.0	326.9
90	321.4	349.6	333.4	356.9	357.7	354.6
95	360.5	393.4	372.5	384.5	385.3	388.2
100	444.3	460.3	459.5	452.0	462.5	465.1

Table G15 Batch 15 (Spent Cat.1)

%off	Boiling point (°C)					
	Maltene	Saturated Hydrocarbons	Mono-aromatics	Di-aromatics	Poly-aromatics	Polar-aromatics
0	27.5	70.6	38.6	23.9	33.9	19.5
5	111.0	155.7	156.5	77.5	66.8	20.5
10	117.7	168.2	172.2	173.6	67.9	21.6
15	153.3	171.1	192.3	226.3	69.0	22.7
20	154.7	179.1	212.9	252.8	69.4	23.7
25	156.9	184.5	229.1	268.4	69.7	24.8
30	159.5	190.5	234.8	273.8	70.1	25.8
35	168.1	199.2	245.8	281.9	70.5	27.3
40	170.4	205.4	253.8	289.5	70.9	38.8
45	173.0	212.5	261.8	295.1	71.3	167.9
50	183.8	219.6	269.2	302.1	71.6	173.2
55	191.1	227.7	275.8	308.4	72.0	185.5
60	203.0	237.5	283.5	315.6	72.4	201.2
65	213.9	249.4	291.3	322.9	72.8	214.7
70	227.2	261.5	300.2	330.7	73.2	236.9
75	244.2	274.2	311.2	339.3	73.5	264.8
80	264.1	288.1	324.0	349.2	73.9	293.1
85	284.9	307.1	338.7	361.3	74.3	326.1
90	312.4	330.4	359.5	376.5	75.6	365.1
95	352.3	367.4	387.3	400.6	78.5	408.9
100	438.5	448.6	461.3	465.8	388.1	471.0

Table G16 Batch 16 (Spent Cat.2)

%off	Boiling point (°C)					
	Maltene	**Saturated Hydrocarbons**	**Mono-aromatics**	**Di-aromatics**	**Poly-aromatics**	**Polar-aromatics**
0	32.2	25.0	30.1	26.1	23.1	21.2
5	123.0	68.3	70.8	70.6	58.1	23.5
10	154.2	73.8	73.2	73.2	72.8	26.9
15	156.8	75.5	74.8	74.7	73.2	31.6
20	161.1	77.2	76.6	76.7	73.6	37.3
25	169.3	80.0	79.7	78.9	74.2	74.5
30	171.9	84.9	83.9	84.0	74.8	168.3
35	181.6	170.6	213.5	255.0	75.9	191.6
40	188.6	185.6	237.9	275.1	77.8	211.2
45	198.8	198.2	262.0	290.2	80.4	231.5
50	207.8	207.8	283.2	302.4	86.0	246.7
55	217.3	218.0	309.7	314.7	255.0	262.3
60	227.1	226.2	341.2	327.6	292.0	277.1
65	238.9	238.0	366.7	341.4	307.8	292.4
70	253.8	251.6	382.3	356.9	314.0	308.8
75	269.4	265.4	394.0	373.3	325.6	326.7
80	285.0	280.0	404.5	389.2	336.7	346.1
85	305.5	298.4	415.2	404.1	344.6	368.6
90	330.4	323.6	429.0	419.1	362.1	391.6
95	366.8	362.3	450.7	442.8	393.7	420.2
100	445.0	449.2	500.9	499.7	474.7	477.5

APPENDIX H Carbon Number Distributions

Table H1 Carbon number distribution of maltenes obtained from each separate component in the Ru/HMOR based catalysts

Catalyst / No. carbon.	No Cat	HMOR	Kaolin	α-alumina
4	0.000	0.000	0.000	0.000
5	0.000	0.000	0.001	0.000
6	0.002	0.000	0.090	0.002
7	0.083	0.034	1.438	0.340
8	0.827	1.000	6.053	4.080
9	3.155	5.608	11.790	12.448
10	6.616	12.320	14.763	18.034
11	9.559	15.979	14.400	17.637
12	10.958	15.504	12.221	14.103
13	10.880	12.858	9.615	10.210
14	9.885	9.819	7.274	7.065
15	8.508	7.197	5.406	4.809
16	7.090	5.185	3.997	3.271
17	5.803	3.721	2.961	2.241
18	4.707	2.681	2.208	1.553
19	3.806	1.946	1.660	1.091
20	3.080	1.428	1.261	0.778
21	2.500	1.059	0.968	0.562
22	2.039	0.794	0.751	0.412
23	1.672	0.603	0.588	0.306
24	1.379	0.462	0.465	0.230
25	1.145	0.358	0.371	0.175
26	0.956	0.280	0.299	0.135
27	0.802	0.221	0.243	0.105
28	0.677	0.176	0.199	0.082
29	0.575	0.141	0.164	0.065
30	0.490	0.114	0.135	0.052
31	0.419	0.093	0.113	0.041
32	0.360	0.076	0.094	0.033
33	0.310	0.062	0.079	0.027
34	0.267	0.051	0.067	0.022
35	0.231	0.042	0.056	0.018
36	0.200	0.035	0.048	0.015
37	0.173	0.029	0.040	0.012
38	0.150	0.024	0.034	0.010
39	0.129	0.020	0.029	0.008
40	0.112	0.017	0.025	0.007
41	0.096	0.014	0.021	0.006
42	0.082	0.011	0.017	0.005
43	0.070	0.009	0.015	0.004
44	0.058	0.008	0.012	0.003
45	0.048	0.006	0.010	0.002
46	0.038	0.005	0.008	0.002
47	0.029	0.004	0.006	0.001
48	0.021	0.003	0.004	0.001
49	0.012	0.001	0.002	0.001
50	0.002	0.000	0.000	0.000

Table H2 Carbon number distribution of maltenes obtained from the Ru/HMOR based catalysts

Catalyst / No. carbon.	BC-20	BC-30	BC-40	BC-50	Ru/HMOR
4	0.000	0.000	0.000	0.000	0.000
5	0.000	0.000	0.051	0.000	0.000
6	0.032	0.001	0.411	0.054	0.036
7	0.740	0.191	1.814	1.041	0.753
8	4.011	2.622	4.795	4.976	3.919
9	9.329	9.282	8.488	10.580	9.013
10	13.223	15.374	11.213	14.073	12.811
11	14.076	16.781	12.099	14.317	13.757
12	12.717	14.641	11.423	12.519	12.564
13	10.475	11.359	9.905	10.066	10.463
14	8.204	8.309	8.154	7.740	8.280
15	6.262	5.920	6.513	5.825	6.381
16	4.729	4.184	5.121	4.350	4.861
17	3.565	2.962	4.000	3.248	3.693
18	2.696	2.113	3.123	2.438	2.813
19	2.053	1.523	2.445	1.844	2.156
20	1.576	1.111	1.925	1.407	1.665
21	1.221	0.821	1.526	1.085	1.297
22	0.955	0.613	1.219	0.845	1.020
23	0.754	0.464	0.981	0.664	0.809
24	0.600	0.355	0.796	0.527	0.647
25	0.483	0.275	0.650	0.422	0.522
26	0.391	0.215	0.535	0.341	0.425
27	0.319	0.169	0.444	0.277	0.348
28	0.263	0.134	0.370	0.227	0.288
29	0.217	0.108	0.310	0.188	0.239
30	0.181	0.087	0.262	0.156	0.199
31	0.151	0.070	0.222	0.130	0.167
32	0.127	0.057	0.188	0.109	0.141
33	0.107	0.047	0.161	0.092	0.119
34	0.091	0.039	0.137	0.077	0.101
35	0.077	0.032	0.118	0.065	0.086
36	0.065	0.026	0.101	0.055	0.073
37	0.055	0.022	0.087	0.047	0.062
38	0.047	0.018	0.075	0.040	0.053
39	0.040	0.015	0.064	0.034	0.045
40	0.034	0.013	0.055	0.029	0.039
41	0.029	0.010	0.047	0.024	0.033
42	0.024	0.009	0.040	0.020	0.028
43	0.020	0.007	0.034	0.017	0.023
44	0.017	0.006	0.028	0.014	0.019
45	0.014	0.005	0.023	0.012	0.016
46	0.011	0.004	0.018	0.009	0.013
47	0.008	0.003	0.014	0.007	0.010
48	0.006	0.002	0.010	0.005	0.007
49	0.003	0.001	0.005	0.003	0.004
50	0.001	0.000	0.001	0.001	0.001

Table H3 Carbon number distribution of maltenes obtained from the BC-20 catalyst with various pellet diameters

Pellet diameters / No. carbon.	1.00 mm	2.00 mm	3.00 mm	4.00 mm
4	0.000	0.000	0.000	0.000
5	0.000	0.000	0.000	0.000
6	0.045	0.140	0.084	0.081
7	0.944	2.627	1.381	1.392
8	4.755	10.279	5.914	6.053
9	10.405	17.109	11.650	11.932
10	14.052	18.050	14.696	14.966
11	14.404	15.038	14.405	14.556
12	12.638	11.130	12.266	12.295
13	10.173	7.791	9.673	9.622
14	7.822	5.334	7.330	7.241
15	5.882	3.637	5.455	5.355
16	4.387	2.493	4.037	3.941
17	3.272	1.726	2.993	2.907
18	2.452	1.211	2.233	2.159
19	1.852	0.862	1.680	1.618
20	1.412	0.622	1.276	1.225
21	1.087	0.455	0.980	0.937
22	0.845	0.337	0.760	0.724
23	0.664	0.253	0.596	0.566
24	0.526	0.192	0.471	0.447
25	0.421	0.148	0.377	0.356
26	0.339	0.114	0.303	0.286
27	0.276	0.090	0.246	0.231
28	0.226	0.071	0.201	0.189
29	0.186	0.056	0.166	0.155
30	0.155	0.045	0.137	0.128
31	0.129	0.036	0.114	0.107
32	0.108	0.029	0.096	0.089
33	0.091	0.024	0.080	0.074
34	0.076	0.019	0.068	0.063
35	0.065	0.016	0.057	0.053
36	0.055	0.013	0.048	0.045
37	0.046	0.011	0.041	0.038
38	0.039	0.009	0.035	0.032
39	0.033	0.007	0.029	0.027
40	0.028	0.006	0.025	0.023
41	0.024	0.005	0.021	0.019
42	0.020	0.004	0.018	0.016
43	0.017	0.003	0.015	0.014
44	0.014	0.003	0.012	0.011
45	0.011	0.002	0.010	0.009
46	0.009	0.001	0.008	0.007
47	0.007	0.001	0.006	0.005
48	0.005	0.001	0.004	0.004
49	0.003	0.000	0.002	0.002
50	0.001	0.002	0.000	0.000

Table H4 Carbon number distribution of maltenes from the catalyst deactivation testing

# of reuse / No. carbon.	1st cycle	2nd cycle	3rd cycle
4	0.000	0.000	0.000
5	0.000	0.000	0.000
6	0.084	0.035	0.065
7	1.381	1.219	1.057
8	5.914	6.917	4.746
9	11.650	14.486	9.947
10	14.696	17.598	13.338
11	14.405	16.004	13.804
12	12.266	12.526	12.312
13	9.673	9.100	10.096
14	7.330	6.392	7.908
15	5.455	4.439	6.053
16	4.037	3.087	4.589
17	2.993	2.163	3.475
18	2.233	1.532	2.641
19	1.680	1.099	2.021
20	1.276	0.800	1.559
21	0.980	0.589	1.213
22	0.760	0.440	0.953
23	0.596	0.333	0.756
24	0.471	0.255	0.605
25	0.377	0.197	0.488
26	0.303	0.154	0.397
27	0.246	0.121	0.326
28	0.201	0.096	0.269
29	0.166	0.077	0.223
30	0.137	0.062	0.186
31	0.114	0.051	0.156
32	0.096	0.041	0.132
33	0.080	0.034	0.111
34	0.068	0.028	0.095
35	0.057	0.023	0.080
36	0.048	0.019	0.069
37	0.041	0.016	0.058
38	0.035	0.013	0.050
39	0.029	0.011	0.042
40	0.025	0.009	0.036
41	0.021	0.008	0.031
42	0.018	0.006	0.026
43	0.015	0.005	0.022
44	0.012	0.004	0.018
45	0.010	0.003	0.015
46	0.008	0.003	0.012
47	0.006	0.002	0.009
48	0.004	0.001	0.006
49	0.002	0.001	0.003
50	0.000	0.000	0.001

Table H5 Carbon number distribution of saturated hydrocarbons obtained from the Ru/HMOR based catalysts

Catalyst / No. carbon.	BC-20	BC-30	BC-40	BC-50	Ru/HMOR
4	0.000	0.000	0.000	0.000	0.000
5	0.000	0.000	0.000	0.000	0.000
6	0.000	0.000	0.001	0.000	0.001
7	0.012	0.001	0.083	0.023	0.095
8	0.494	0.181	1.303	0.573	1.220
9	3.601	2.581	5.556	3.350	4.884
10	9.555	9.286	11.073	8.295	9.739
11	14.178	15.473	14.211	12.361	12.859
12	15.141	16.906	14.181	13.683	13.328
13	13.457	14.729	12.275	12.745	11.999
14	10.815	11.399	9.822	10.752	9.964
15	8.242	8.314	7.537	8.582	7.909
16	6.121	5.905	5.670	6.652	6.134
17	4.502	4.159	4.235	5.086	4.708
18	3.309	2.935	3.165	3.873	3.607
19	2.444	2.086	2.377	2.954	2.770
20	1.819	1.498	1.799	2.265	2.140
21	1.367	1.088	1.374	1.749	1.665
22	1.037	0.800	1.059	1.361	1.306
23	0.795	0.596	0.825	1.069	1.033
24	0.616	0.449	0.648	0.846	0.824
25	0.482	0.342	0.514	0.676	0.663
26	0.380	0.263	0.411	0.544	0.537
27	0.303	0.204	0.331	0.441	0.439
28	0.243	0.160	0.269	0.360	0.361
29	0.196	0.126	0.220	0.296	0.298
30	0.159	0.100	0.181	0.245	0.248
31	0.130	0.080	0.150	0.204	0.208
32	0.107	0.065	0.124	0.170	0.174
33	0.088	0.052	0.104	0.142	0.147
34	0.073	0.042	0.087	0.120	0.124
35	0.061	0.035	0.073	0.101	0.105
36	0.051	0.028	0.061	0.085	0.089
37	0.042	0.023	0.052	0.072	0.076
38	0.035	0.019	0.044	0.061	0.064
39	0.030	0.016	0.037	0.051	0.055
40	0.025	0.013	0.031	0.044	0.047
41	0.021	0.011	0.026	0.037	0.039
42	0.017	0.009	0.022	0.031	0.033
43	0.014	0.007	0.018	0.026	0.028
44	0.012	0.006	0.015	0.021	0.023
45	0.009	0.005	0.012	0.017	0.019
46	0.007	0.004	0.010	0.014	0.015
47	0.006	0.003	0.007	0.010	0.011
48	0.004	0.002	0.005	0.007	0.008
49	0.002	0.001	0.003	0.004	0.004
50	0.000	0.000	0.001	0.001	0.001

Table H6 Carbon number distribution of saturated hydrocarbons obtained from the BC-20 catalyst with various pellet diameters

Pellet diameters / No. carbon.	1.00 mm	2.00 mm	3.00 mm	4.00 mm
4	0.000	0.000	0.000	0.000
5	0.000	0.000	0.000	0.000
6	0.000	0.000	0.002	0.000
7	0.065	0.012	0.143	0.011
8	0.986	0.494	1.672	0.429
9	4.365	3.601	6.101	3.070
10	9.244	9.555	11.248	8.344
11	12.646	14.178	13.935	12.882
12	13.385	15.141	13.729	14.346
13	12.198	13.457	11.872	13.257
14	10.200	10.815	9.544	11.026
15	8.128	8.242	7.380	8.657
16	6.315	6.121	5.600	6.598
17	4.851	4.502	4.221	4.963
18	3.716	3.309	3.183	3.721
19	2.853	2.444	2.412	2.797
20	2.202	1.819	1.841	2.116
21	1.712	1.367	1.417	1.613
22	1.341	1.037	1.101	1.241
23	1.060	0.795	0.863	0.963
24	0.845	0.616	0.683	0.755
25	0.679	0.482	0.545	0.596
26	0.549	0.380	0.439	0.476
27	0.448	0.303	0.356	0.382
28	0.368	0.243	0.291	0.309
29	0.304	0.196	0.239	0.252
30	0.253	0.159	0.198	0.207
31	0.211	0.130	0.164	0.170
32	0.177	0.107	0.137	0.141
33	0.149	0.088	0.115	0.117
34	0.126	0.073	0.097	0.098
35	0.107	0.061	0.082	0.082
36	0.090	0.051	0.069	0.069
37	0.077	0.042	0.058	0.058
38	0.065	0.035	0.049	0.049
39	0.055	0.030	0.042	0.041
40	0.047	0.025	0.035	0.034
41	0.040	0.021	0.030	0.029
42	0.033	0.017	0.025	0.024
43	0.028	0.014	0.021	0.020
44	0.023	0.012	0.017	0.016
45	0.019	0.009	0.014	0.013
46	0.015	0.007	0.011	0.010
47	0.011	0.006	0.008	0.008
48	0.008	0.004	0.006	0.005
49	0.004	0.002	0.003	0.003
50	0.001	0.000	0.001	0.001

Table H7 Carbon number distribution of saturated hydrocarbons from the catalyst deactivation testing

# of reuse / No. carbon.	1st cycle	2nd cycle	3rd cycle
4	0.000	0.000	0.000
5	0.000	0.000	5.576
6	0.002	0.000	5.999
7	0.143	0.082	6.396
8	1.672	1.369	6.759
9	6.101	5.922	7.083
10	11.248	11.710	7.358
11	13.935	14.781	7.568
12	13.729	14.477	7.683
13	11.872	12.310	7.657
14	9.544	9.691	7.423
15	7.380	7.331	6.911
16	5.600	5.445	6.093
17	4.221	4.021	5.028
18	3.183	2.975	3.870
19	2.412	2.215	2.800
20	1.841	1.662	1.932
21	1.417	1.260	1.294
22	1.101	0.965	0.853
23	0.863	0.746	0.561
24	0.683	0.583	0.370
25	0.545	0.459	0.246
26	0.439	0.365	0.165
27	0.356	0.293	0.112
28	0.291	0.237	0.077
29	0.239	0.193	0.053
30	0.198	0.158	0.037
31	0.164	0.130	0.026
32	0.137	0.107	0.019
33	0.115	0.089	0.013
34	0.097	0.074	0.010
35	0.082	0.062	0.007
36	0.069	0.052	0.005
37	0.058	0.044	0.004
38	0.049	0.037	0.003
39	0.042	0.031	0.002
40	0.035	0.026	0.002
41	0.030	0.022	0.001
42	0.025	0.018	0.001
43	0.021	0.015	0.001
44	0.017	0.012	0.001
45	0.014	0.010	0.000
46	0.011	0.008	0.000
47	0.008	0.006	0.000
48	0.006	0.004	0.000
49	0.003	0.002	0.000
50	0.001	0.000	0.000

Table H8 Carbon number distribution of mono-aromatics obtained from the Ru/HMOR based catalysts

Catalyst / No. carbon.	BC-20	BC-30	BC-40	BC-50	Ru/HMOR
4	0.000	0.000	0.000	0.000	0.000
5	0.005	0.447	2.293	0.000	3.555
6	0.018	0.674	2.693	0.000	3.821
7	0.052	0.988	3.118	0.001	4.071
8	0.143	1.405	3.560	0.006	4.302
9	0.363	1.946	4.014	0.036	4.510
10	0.850	2.629	4.473	0.171	4.697
11	1.821	3.469	4.933	0.642	4.860
12	3.528	4.475	5.385	1.859	5.002
13	6.065	5.642	5.824	4.146	5.122
14	9.075	6.937	6.240	7.190	5.222
15	11.657	8.269	6.616	9.980	5.306
16	12.842	9.456	6.922	11.538	5.375
17	12.318	10.204	7.105	11.600	5.431
18	10.562	10.181	7.085	10.547	5.477
19	8.348	9.221	6.766	8.955	5.514
20	6.253	7.528	6.080	7.273	5.537
21	4.538	5.590	5.064	5.749	5.519
22	3.240	3.859	3.886	4.476	5.360
23	2.301	2.539	2.768	3.460	4.795
24	1.634	1.629	1.861	2.670	3.509
25	1.167	1.034	1.206	2.063	1.872
26	0.838	0.656	0.766	1.599	0.750
27	0.607	0.419	0.483	1.246	0.260
28	0.444	0.270	0.305	0.975	0.087
29	0.327	0.175	0.193	0.767	0.030
30	0.242	0.115	0.124	0.607	0.010
31	0.181	0.077	0.080	0.483	0.004
32	0.136	0.051	0.052	0.386	0.001
33	0.103	0.035	0.034	0.310	0.001
34	0.079	0.024	0.023	0.249	0.000
35	0.060	0.016	0.015	0.201	0.000
36	0.046	0.011	0.010	0.163	0.000
37	0.036	0.008	0.007	0.133	0.000
38	0.028	0.006	0.005	0.108	0.000
39	0.022	0.004	0.003	0.088	0.000
40	0.017	0.003	0.002	0.072	0.000
41	0.013	0.002	0.002	0.059	0.000
42	0.010	0.001	0.001	0.048	0.000
43	0.008	0.001	0.001	0.039	0.000
44	0.006	0.001	0.001	0.031	0.000
45	0.005	0.001	0.000	0.025	0.000
46	0.004	0.000	0.000	0.019	0.000
47	0.003	0.000	0.000	0.014	0.000
48	0.002	0.000	0.000	0.010	0.000
49	0.001	0.000	0.000	0.005	0.000
50	0.000	0.000	0.000	0.001	0.000

Table H9 Carbon number distribution of mono-aromatics obtained from the BC-20 catalyst with various pellet diameters

Pellet diameters / No. carbon.	1.00 mm	2.00 mm	3.00 mm	4.00 mm
4	0.000	0.000	0.000	0.000
5	0.017	0.000	1.205	0.000
6	0.049	0.000	1.937	0.000
7	0.127	0.000	2.975	0.005
8	0.308	0.000	4.348	0.053
9	0.694	0.012	6.006	0.355
10	1.446	0.173	7.766	1.547
11	2.758	1.196	9.305	4.412
12	4.758	4.299	10.241	8.564
13	7.303	9.102	10.320	12.117
14	9.841	13.031	9.562	13.523
15	11.573	14.268	8.236	12.797
16	11.949	13.145	6.699	10.876
17	11.022	10.895	5.230	8.653
18	9.305	8.490	3.976	6.628
19	7.373	6.398	2.978	4.979
20	5.604	4.745	2.217	3.710
21	4.157	3.499	1.650	2.762
22	3.046	2.584	1.232	2.064
23	2.222	1.916	0.925	1.552
24	1.623	1.431	0.700	1.176
25	1.191	1.078	0.534	0.898
26	0.879	0.818	0.411	0.692
27	0.653	0.626	0.318	0.537
28	0.489	0.483	0.249	0.420
29	0.369	0.375	0.196	0.331
30	0.280	0.294	0.155	0.263
31	0.214	0.231	0.123	0.210
32	0.165	0.183	0.099	0.168
33	0.128	0.146	0.079	0.136
34	0.099	0.117	0.064	0.110
35	0.078	0.094	0.052	0.089
36	0.061	0.075	0.042	0.073
37	0.048	0.061	0.035	0.059
38	0.038	0.049	0.028	0.049
39	0.030	0.040	0.023	0.040
40	0.024	0.033	0.019	0.033
41	0.019	0.026	0.015	0.027
42	0.015	0.021	0.013	0.022
43	0.012	0.017	0.010	0.018
44	0.009	0.014	0.008	0.014
45	0.007	0.011	0.007	0.011
46	0.006	0.008	0.005	0.009
47	0.004	0.006	0.004	0.007
48	0.003	0.004	0.003	0.005
49	0.002	0.002	0.001	0.003
50	0.000	0.000	0.000	0.001

Table H10 Carbon number distribution of mono-aromatics from the catalyst deactivation testing

# of reuse / No. carbon.	1st cycle	2nd cycle	3rd cycle
4	0.000	0.000	0.000
5	1.205	0.219	3.718
6	1.937	0.425	3.794
7	2.975	0.782	3.850
8	4.348	1.370	3.887
9	6.006	2.280	3.905
10	7.766	3.589	3.908
11	9.305	5.304	3.895
12	10.241	7.279	3.871
13	10.320	9.169	3.836
14	9.562	10.492	3.792
15	8.236	10.865	3.743
16	6.699	10.228	3.689
17	5.230	8.866	3.633
18	3.976	7.203	3.577
19	2.978	5.588	3.521
20	2.217	4.208	3.467
21	1.650	3.116	3.417
22	1.232	2.289	3.370
23	0.925	1.680	3.328
24	0.700	1.236	3.290
25	0.534	0.914	3.258
26	0.411	0.681	3.230
27	0.318	0.511	3.206
28	0.249	0.386	3.186
29	0.196	0.294	3.169
30	0.155	0.225	3.155
31	0.123	0.174	3.140
32	0.099	0.135	3.116
33	0.079	0.105	1.046
34	0.064	0.082	0.000
35	0.052	0.065	0.000
36	0.042	0.051	0.000
37	0.035	0.041	0.000
38	0.028	0.032	0.000
39	0.023	0.026	0.000
40	0.019	0.021	0.000
41	0.015	0.017	0.000
42	0.013	0.013	0.000
43	0.010	0.011	0.000
44	0.008	0.008	0.000
45	0.007	0.007	0.000
46	0.005	0.005	0.000
47	0.004	0.004	0.000
48	0.003	0.002	0.000
49	0.001	0.001	0.000
50	0.000	0.000	0.000

Table H11 Carbon number distribution of di-aromatics obtained from the Ru/HMOR based catalysts

Catalyst / No. carbon.	BC-20	BC-30	BC-40	BC-50	Ru/HMOR
4	0.000	0.000	0.000	0.000	0.000
5	0.542	0.004	1.783	3.700	4.755
6	0.768	0.010	2.134	4.055	5.360
7	1.059	0.026	2.513	4.290	5.703
8	1.424	0.063	2.916	4.413	5.813
9	1.871	0.144	3.339	4.443	5.740
10	2.407	0.310	3.774	4.397	5.537
11	3.035	0.631	4.218	4.294	5.250
12	3.759	1.220	4.665	4.151	4.916
13	4.578	2.238	5.112	3.981	4.563
14	5.488	3.875	5.554	3.796	4.210
15	6.477	6.262	5.988	3.605	3.870
16	7.512	9.259	6.413	3.413	3.549
17	8.521	12.188	6.821	3.226	3.252
18	9.348	13.902	7.196	3.047	2.980
19	9.727	13.547	7.487	2.877	2.734
20	9.328	11.379	7.570	2.718	2.512
21	8.003	8.482	7.194	2.570	2.313
22	6.051	5.826	6.077	2.434	2.135
23	4.074	3.814	4.306	2.309	1.976
24	2.519	2.439	2.524	2.194	1.833
25	1.482	1.547	1.283	2.089	1.706
26	0.852	0.984	0.606	1.993	1.592
27	0.488	0.630	0.279	1.905	1.489
28	0.281	0.407	0.129	1.823	1.396
29	0.163	0.265	0.060	1.748	1.311
30	0.096	0.175	0.029	1.677	1.234
31	0.057	0.117	0.014	1.611	1.162
32	0.034	0.079	0.007	1.547	1.096
33	0.021	0.053	0.003	1.486	1.034
34	0.013	0.037	0.002	1.426	0.975
35	0.008	0.025	0.001	1.366	0.918
36	0.005	0.018	0.000	1.306	0.864
37	0.003	0.012	0.000	1.245	0.810
38	0.002	0.009	0.000	1.182	0.758
39	0.001	0.006	0.000	1.116	0.705
40	0.001	0.004	0.000	1.047	0.653
41	0.001	0.003	0.000	0.975	0.600
42	0.000	0.002	0.000	0.898	0.546
43	0.000	0.002	0.000	0.816	0.490
44	0.000	0.001	0.000	0.728	0.433
45	0.000	0.001	0.000	0.634	0.374
46	0.000	0.001	0.000	0.532	0.311
47	0.000	0.000	0.000	0.423	0.246
48	0.000	0.000	0.000	0.304	0.176
49	0.000	0.000	0.000	0.176	0.101
50	0.000	0.000	0.000	0.035	0.020

Table H12 Carbon number distribution of di-aromatics obtained from the BC-20 catalyst with various pellet diameters

Pellet diameters / No. carbon.	1.00 mm	2.00 mm	3.00 mm	4.00 mm
4	0.000	0.000	0.000	0.000
5	0.019	0.000	4.552	0.763
6	0.044	0.000	4.831	1.073
7	0.094	0.000	5.087	1.469
8	0.192	0.001	5.315	1.963
9	0.373	0.007	5.515	2.564
10	0.691	0.042	5.686	3.279
11	1.223	0.203	5.828	4.112
12	2.072	0.783	5.940	5.059
13	3.358	2.345	6.020	6.108
14	5.175	5.329	6.062	7.224
15	7.504	9.193	6.055	8.329
16	10.053	12.355	5.978	9.270
17	12.154	13.524	5.800	9.797
18	12.969	12.692	5.481	9.617
19	12.083	10.709	4.989	8.577
20	9.915	8.437	4.323	6.871
21	7.348	6.378	3.535	4.977
22	5.076	4.715	2.724	3.335
23	3.363	3.450	1.990	2.125
24	2.183	2.517	1.394	1.319
25	1.408	1.840	0.950	0.811
26	0.910	1.352	0.637	0.500
27	0.592	1.000	0.425	0.310
28	0.388	0.744	0.283	0.194
29	0.257	0.558	0.189	0.123
30	0.172	0.421	0.128	0.079
31	0.116	0.320	0.086	0.051
32	0.079	0.245	0.059	0.034
33	0.055	0.188	0.041	0.022
34	0.038	0.145	0.028	0.015
35	0.027	0.113	0.020	0.010
36	0.019	0.088	0.014	0.007
37	0.013	0.069	0.010	0.005
38	0.010	0.054	0.007	0.003
39	0.007	0.043	0.005	0.002
40	0.005	0.034	0.004	0.002
41	0.004	0.027	0.003	0.001
42	0.003	0.021	0.002	0.001
43	0.002	0.017	0.001	0.001
44	0.001	0.013	0.001	0.000
45	0.001	0.010	0.001	0.000
46	0.001	0.008	0.001	0.000
47	0.001	0.006	0.000	0.000
48	0.000	0.004	0.000	0.000
49	0.000	0.002	0.000	0.000
50	0.000	0.000	0.000	0.000

Table H13 Carbon number distribution of di-aromatics from the catalyst deactivation testing

# of reuse / No. carbon.	1st cycle	2nd cycle	3rd cycle
4	0.000	0.000	0.000
5	4.552	0.050	1.877
6	4.831	0.103	2.144
7	5.087	0.203	2.417
8	5.315	0.380	2.693
9	5.515	0.682	2.968
10	5.686	1.170	3.237
11	5.828	1.923	3.498
12	5.940	3.021	3.749
13	6.020	4.518	3.986
14	6.062	6.380	4.208
15	6.055	8.407	4.413
16	5.978	10.186	4.598
17	5.800	11.202	4.759
18	5.481	11.108	4.889
19	4.989	9.971	4.981
20	4.323	8.214	5.021
21	3.535	6.336	4.996
22	2.724	4.669	4.888
23	1.990	3.346	4.685
24	1.394	2.362	4.381
25	0.950	1.658	3.981
26	0.637	1.164	3.509
27	0.425	0.821	2.997
28	0.283	0.582	2.485
29	0.189	0.415	2.007
30	0.128	0.299	1.585
31	0.086	0.216	1.230
32	0.059	0.158	0.942
33	0.041	0.116	0.715
34	0.028	0.086	0.540
35	0.020	0.064	0.406
36	0.014	0.048	0.306
37	0.010	0.036	0.230
38	0.007	0.027	0.173
39	0.005	0.021	0.131
40	0.004	0.016	0.099
41	0.003	0.012	0.075
42	0.002	0.009	0.057
43	0.001	0.007	0.043
44	0.001	0.005	0.033
45	0.001	0.004	0.025
46	0.001	0.003	0.018
47	0.000	0.002	0.013
48	0.000	0.001	0.009
49	0.000	0.001	0.005
50	0.000	0.000	0.001

Table H14 Carbon number distribution of poly-aromatics obtained from the Ru/HMOR based catalysts

Catalyst / No. carbon.	BC-20	BC-30	BC-40	BC-50	Ru/HMOR
4	0.000	0.000	0.000	0.000	0.000
5	0.000	0.004	10.794	3.700	4.755
6	0.000	0.010	12.178	4.055	5.360
7	0.000	0.026	11.991	4.290	5.703
8	0.002	0.063	10.851	4.413	5.813
9	0.006	0.144	9.324	4.443	5.740
10	0.021	0.310	7.769	4.397	5.537
11	0.065	0.631	6.363	4.294	5.250
12	0.186	1.220	5.169	4.151	4.916
13	0.496	2.238	4.187	3.981	4.563
14	1.218	3.875	3.396	3.796	4.210
15	2.722	6.262	2.765	3.605	3.870
16	5.421	9.259	2.262	3.413	3.549
17	9.309	12.188	1.863	3.226	3.252
18	13.310	13.902	1.544	3.047	2.980
19	15.501	13.547	1.289	2.877	2.734
20	14.797	11.379	1.084	2.718	2.512
21	11.985	8.482	0.918	2.570	2.313
22	8.643	5.826	0.783	2.434	2.135
23	5.805	3.814	0.672	2.309	1.976
24	3.756	2.439	0.581	2.194	1.833
25	2.393	1.547	0.505	2.089	1.706
26	1.521	0.984	0.442	1.993	1.592
27	0.972	0.630	0.388	1.905	1.489
28	0.626	0.407	0.343	1.823	1.396
29	0.408	0.265	0.304	1.748	1.311
30	0.268	0.175	0.271	1.677	1.234
31	0.179	0.117	0.242	1.611	1.162
32	0.120	0.079	0.216	1.547	1.096
33	0.082	0.053	0.194	1.486	1.034
34	0.056	0.037	0.175	1.426	0.975
35	0.039	0.025	0.157	1.366	0.918
36	0.027	0.018	0.141	1.306	0.864
37	0.019	0.012	0.127	1.245	0.810
38	0.013	0.009	0.114	1.182	0.758
39	0.010	0.006	0.102	1.116	0.705
40	0.007	0.004	0.091	1.047	0.653
41	0.005	0.003	0.080	0.975	0.600
42	0.004	0.002	0.071	0.898	0.546
43	0.003	0.002	0.062	0.816	0.490
44	0.002	0.001	0.053	0.728	0.433
45	0.001	0.001	0.045	0.634	0.374
46	0.001	0.001	0.036	0.532	0.311
47	0.001	0.000	0.028	0.423	0.246
48	0.001	0.000	0.020	0.304	0.176
49	0.000	0.000	0.011	0.176	0.101
50	0.000	0.000	0.002	0.035	0.020

Table H15 Carbon number distribution of poly-aromatics obtained from the BC-20 catalyst with various pellet diameters

Pellet diameters / No. carbon.	1.00 mm	2.00 mm	3.00 mm	4.00 mm
4	0.000	0.000	0.000	0.000
5	0.000	0.000	4.384	5.318
6	0.000	0.000	4.929	5.045
7	0.001	0.002	5.258	4.782
8	0.005	0.006	5.391	4.528
9	0.016	0.021	5.367	4.286
10	0.052	0.065	5.225	4.055
11	0.155	0.186	5.003	3.836
12	0.421	0.496	4.733	3.629
13	1.048	1.218	4.438	3.434
14	2.364	2.722	4.135	3.252
15	4.732	5.421	3.837	3.082
16	8.178	9.309	3.551	2.924
17	11.869	13.310	3.283	2.777
18	14.254	15.501	3.034	2.643
19	14.276	14.797	2.805	2.519
20	12.279	11.985	2.597	2.406
21	9.443	8.643	2.409	2.303
22	6.751	5.805	2.239	2.210
23	4.628	3.756	2.086	2.125
24	3.106	2.393	1.948	2.048
25	2.070	1.521	1.823	1.979
26	1.380	0.972	1.711	1.917
27	0.925	0.626	1.610	1.860
28	0.625	0.408	1.517	1.809
29	0.426	0.268	1.433	1.761
30	0.293	0.179	1.355	1.717
31	0.203	0.120	1.283	1.676
32	0.142	0.082	1.216	1.636
33	0.100	0.056	1.152	1.596
34	0.071	0.039	1.091	1.556
35	0.051	0.027	1.032	1.515
36	0.037	0.019	0.975	1.472
37	0.027	0.013	0.918	1.425
38	0.019	0.010	0.862	1.374
39	0.014	0.007	0.805	1.317
40	0.011	0.005	0.748	1.254
41	0.008	0.004	0.689	1.184
42	0.006	0.003	0.629	1.105
43	0.004	0.002	0.567	1.017
44	0.003	0.001	0.502	0.918
45	0.002	0.001	0.434	0.807
46	0.002	0.001	0.362	0.684
47	0.001	0.001	0.287	0.547
48	0.001	0.000	0.205	0.396
49	0.000	0.000	0.118	0.229
50	0.000	0.000	0.024	0.046

Table H16 Carbon number distribution of poly-aromatics from the catalyst deactivation testing

# of reuse / No. carbon.	1st cycle	2nd cycle	3rd cycle
4	0.000	0.000	0.000
5	4.384	0.004	4.570
6	4.929	0.010	4.868
7	5.258	0.026	5.016
8	5.391	0.063	5.036
9	5.367	0.144	4.956
10	5.225	0.310	4.804
11	5.003	0.631	4.604
12	4.733	1.220	4.373
13	4.438	2.238	4.127
14	4.135	3.875	3.877
15	3.837	6.262	3.632
16	3.551	9.259	3.396
17	3.283	12.188	3.172
18	3.034	13.902	2.963
19	2.805	13.547	2.770
20	2.597	11.379	2.592
21	2.409	8.482	2.430
22	2.239	5.826	2.282
23	2.086	3.814	2.148
24	1.948	2.439	2.026
25	1.823	1.547	1.916
26	1.711	0.984	1.815
27	1.610	0.630	1.724
28	1.517	0.407	1.640
29	1.433	0.265	1.563
30	1.355	0.175	1.492
31	1.283	0.117	1.425
32	1.216	0.079	1.361
33	1.152	0.053	1.301
34	1.091	0.037	1.242
35	1.032	0.025	1.185
36	0.975	0.018	1.128
37	0.918	0.012	1.070
38	0.862	0.009	1.012
39	0.805	0.006	0.952
40	0.748	0.004	0.890
41	0.689	0.003	0.826
42	0.629	0.002	0.758
43	0.567	0.002	0.687
44	0.502	0.001	0.611
45	0.434	0.001	0.531
46	0.362	0.001	0.445
47	0.287	0.000	0.353
48	0.205	0.000	0.254
49	0.118	0.000	0.146
50	0.024	0.000	0.029

Table H17 Carbon number distribution of polar-aromatics obtained from the Ru/HMOR based catalysts

Catalyst / No. carbon.	BC-20	BC-30	BC-40	BC-50	Ru/HMOR
4	0.000	0.000	0.000	0.000	0.000
5	4.457	2.101	3.980	0.158	6.810
6	5.225	2.425	4.313	0.403	6.586
7	5.705	2.761	4.629	0.862	6.355
8	5.913	3.104	4.923	1.576	6.120
9	5.898	3.447	5.191	2.503	5.884
10	5.720	3.784	5.428	3.524	5.648
11	5.436	4.108	5.629	4.484	5.414
12	5.090	4.412	5.788	5.251	5.183
13	4.717	4.687	5.894	5.755	4.956
14	4.341	4.923	5.935	5.988	4.731
15	3.976	5.108	5.895	5.983	4.507
16	3.632	5.232	5.757	5.799	4.281
17	3.314	5.280	5.508	5.492	4.051
18	3.024	5.245	5.142	5.115	3.811
19	2.761	5.118	4.668	4.707	3.558
20	2.526	4.899	4.113	4.295	3.287
21	2.315	4.597	3.517	3.898	2.998
22	2.127	4.227	2.924	3.525	2.691
23	1.960	3.810	2.373	3.183	2.372
24	1.811	3.370	1.888	2.872	2.050
25	1.678	2.931	1.480	2.592	1.736
26	1.559	2.511	1.149	2.342	1.443
27	1.452	2.125	0.886	2.117	1.178
28	1.356	1.780	0.681	1.917	0.947
29	1.269	1.479	0.523	1.738	0.753
30	1.190	1.221	0.402	1.578	0.592
31	1.117	1.004	0.310	1.434	0.463
32	1.049	0.822	0.239	1.303	0.361
33	0.986	0.672	0.185	1.185	0.280
34	0.926	0.549	0.144	1.078	0.217
35	0.870	0.448	0.112	0.980	0.169
36	0.815	0.365	0.088	0.889	0.131
37	0.762	0.298	0.069	0.806	0.102
38	0.710	0.243	0.054	0.728	0.079
39	0.659	0.198	0.043	0.656	0.062
40	0.608	0.161	0.034	0.588	0.048
41	0.557	0.131	0.027	0.524	0.038
42	0.506	0.106	0.021	0.464	0.029
43	0.454	0.086	0.017	0.406	0.023
44	0.400	0.069	0.013	0.350	0.018
45	0.344	0.054	0.010	0.295	0.014
46	0.286	0.042	0.008	0.242	0.010
47	0.226	0.031	0.006	0.188	0.008
48	0.161	0.021	0.004	0.133	0.005
49	0.093	0.012	0.002	0.076	0.003
50	0.019	0.002	0.000	0.015	0.001

Table H18 Carbon number distribution of polar-aromatics obtained from the BC-20 catalyst with various pellet diameters

Pellet diameters / No. carbon.	1.00 mm	2.00 mm	3.00 mm	4.00 mm
4	0.000	0.000	0.000	0.000
5	0.020	1.972	1.130	8.307
6	0.244	2.378	2.272	8.003
7	1.186	2.818	3.963	7.692
8	3.129	3.285	5.990	7.376
9	5.539	3.768	7.893	7.056
10	7.552	4.253	9.193	6.729
11	8.678	4.722	9.648	6.394
12	8.913	5.154	9.318	6.045
13	8.504	5.524	8.453	5.676
14	7.734	5.803	7.332	5.281
15	6.820	5.966	6.169	4.854
16	5.899	5.992	5.090	4.395
17	5.046	5.872	4.153	3.909
18	4.291	5.611	3.371	3.406
19	3.640	5.229	2.732	2.905
20	3.090	4.758	2.219	2.426
21	2.629	4.236	1.808	1.988
22	2.243	3.700	1.480	1.602
23	1.922	3.181	1.219	1.275
24	1.654	2.700	1.009	1.006
25	1.429	2.269	0.841	0.789
26	1.241	1.893	0.704	0.617
27	1.082	1.572	0.593	0.482
28	0.947	1.301	0.503	0.377
29	0.833	1.075	0.428	0.295
30	0.734	0.887	0.366	0.232
31	0.649	0.732	0.314	0.183
32	0.575	0.605	0.270	0.145
33	0.511	0.500	0.233	0.115
34	0.454	0.413	0.202	0.091
35	0.404	0.342	0.175	0.073
36	0.360	0.283	0.152	0.058
37	0.320	0.235	0.132	0.047
38	0.284	0.195	0.114	0.038
39	0.252	0.161	0.099	0.030
40	0.222	0.134	0.085	0.024
41	0.195	0.110	0.074	0.020
42	0.170	0.091	0.063	0.016
43	0.147	0.075	0.053	0.013
44	0.126	0.061	0.045	0.010
45	0.105	0.048	0.037	0.008
46	0.085	0.038	0.030	0.006
47	0.066	0.028	0.023	0.005
48	0.046	0.019	0.016	0.003
49	0.026	0.011	0.009	0.002
50	0.005	0.002	0.002	0.000

Table H19 Carbon number distribution of polar-aromatics from the catalyst deactivation testing

# of reuse / No. carbon.	1st cycle	2nd cycle	3rd cycle
4	0.000	0.000	0.000
5	1.130	6.389	3.799
6	2.272	6.986	4.086
7	3.963	7.257	4.354
8	5.990	7.230	4.600
9	7.893	6.969	4.818
10	9.193	6.546	5.007
11	9.648	6.031	5.160
12	9.318	5.477	5.275
13	8.453	4.925	5.344
14	7.332	4.398	5.362
15	6.169	3.912	5.320
16	5.090	3.472	5.213
17	4.153	3.080	5.034
18	3.371	2.734	4.783
19	2.732	2.432	4.464
20	2.219	2.168	4.090
21	1.808	1.939	3.675
22	1.480	1.739	3.241
23	1.219	1.566	2.810
24	1.009	1.414	2.398
25	0.841	1.282	2.020
26	0.704	1.167	1.683
27	0.593	1.065	1.391
28	0.503	0.975	1.142
29	0.428	0.895	0.934
30	0.366	0.823	0.761
31	0.314	0.758	0.619
32	0.270	0.700	0.504
33	0.233	0.646	0.409
34	0.202	0.597	0.333
35	0.175	0.551	0.271
36	0.152	0.509	0.221
37	0.132	0.468	0.180
38	0.114	0.430	0.146
39	0.099	0.393	0.119
40	0.085	0.358	0.097
41	0.074	0.324	0.079
42	0.063	0.291	0.064
43	0.053	0.258	0.052
44	0.045	0.225	0.042
45	0.037	0.192	0.033
46	0.030	0.158	0.026
47	0.023	0.124	0.019
48	0.016	0.088	0.013
49	0.009	0.051	0.007
50	0.002	0.010	0.001

APPENDIX I Petroleum Fractions of Derived Oils

Table I1 Petroleum fractions of derived oils obtained from each separate component in Ru/HMOR based catalysts

Catalyst / Fraction	No Cat	HMOR	Kaolin	α-alumina
Naphtha	20.00	38.00	38.00	35.00
Kerosene	30.00	32.00	29.00	28.00
Light Gas Oil	22.00	18.00	17.00	16.00
Heavy Gas Oil	18.00	8.00	11.00	15.00
Residues	10.00	4.00	5.00	6.00

Table I2 Petroleum fractions of derived oils obtained from the Ru/HMOR based catalysts

Catalyst / Fraction	BC-20	BC-30	BC-40	BC-50	Ru/HMOR
Naphtha	44.00	47.00	44.00	48.00	43.50
Kerosene	26.00	27.00	23.50	22.00	24.50
Light Gas Oil	15.00	14.00	16.50	15.00	16.00
Heavy Gas Oil	11.00	8.00	11.00	10.00	11.50
Residues	4.00	4.00	5.00	5.00	4.50

Table I3 Petroleum fractions of derived oils obtained from the BC-20 catalyst with various pellet diameters

Pellet diameters / Fraction	1.00 mm	2.00 mm	3.00 mm	4.00 mm
Naphtha	48.00	50.00	53.00	52.00
Kerosene	22.00	26.00	20.00	22.00
Light Gas Oil	14.00	12.00	13.00	14.00
Heavy Gas Oil	11.00	8.00	10.00	9.00
Residues	5.00	4.00	4.00	3.00

Table I4 Petroleum fractions of derived oils from the catalyst deactivation testing

# of reuse / Fraction	1st cycle	2nd cycle	3rd cycle
Naphtha	53.00	50.00	46.00
Kerosene	20.00	20.00	24.00
Light Gas Oil	13.00	15.00	14.00
Heavy Gas Oil	10.00	11.00	11.00
Residues	4.00	4.00	5.00

APPENDIX J Effectiveness Factor Calculations

Catalyst diameter (mm)	ε_P	D_{TA}^e (cm^2s^{-1})	R_P (cm)	ϕ	η
1.0	0.38	0.0000110	0.05	2.90	0.42
2.0	0.52	0.0001644	0.10	1.50	0.63
3.0	0.60	0.0004926	0.15	1.30	0.68
4.0	0.68	0.0006943	0.20	1.46	0.65

Thiele modulus is defined by Eq. (8)

$$\phi = \frac{R_P}{2}\sqrt{\frac{k}{D_{TA}^e}} \tag{8}$$

The effective transition diffusivity, D_{TA}^e is defined by Eq. (9)

$$\frac{1}{D_{TA}^e} = \frac{1}{D_{AB}^e} + \frac{1}{D_{KA}^e} \tag{9}$$

The Knudsen diffusivity, D_{KA}^e is calculated from Eq. (10)

$$D_{KA} = (9.7 \times 10^3) \cdot R_{pore} \cdot \left(\frac{T}{M_A}\right)^{1/2} \tag{10}$$

The superscript *e* refer to the *effective* diffusivity, which can be calculated from Eq. (11)

$$D^e = \frac{\varepsilon_P}{\tau} D \tag{11}$$

The effectiveness factor can be approximated from Figure 4.22.

APPENDIX K Metal Dispersion Calculations

	Weight (g)	%Ru	Ru (mol)	Total metal (mol)	Total metal A. (atom)
Sample used	0.05	0.7	6.92E-05	6.92E-05	2.09E+18
Mw of Ru (g/mol)	101.07				
Calibration factor (mol/mVs) F_c = 1*20*10^-6/303/0.08205784/V.					

Peaks	Chemisorbed H_2 (mVs)	
1	12746.933	V1
2	11586.933	V2
3	11006.933	V3
4	10366.933	V4
5	8626.9333	V5
6	5386.9333	V6
7	3476.9333	V7
8	3326.9333	V8
9	2216.9333	V9
10	2063.1333	V10
11	1776.9333	V11
Total H_2 chemisorbed (mVs) = V, and V = $\sum$(V1:V11)		72584
Total Chemisorbed (mol) = $V_m = V * F_c$		1.15E-06
Total H_2 chemisorbed (atom) = $V_a = V_m * N_A$		1.39E+18

Dispersion:

$$\mathbf{D(\%) = (V_a / V_0) * 100\% = (1.39E+18)/(2.09E+18) * 100 = 66.67\%}$$

APPENDIX L Mean Particle Size Calculation from Dispersion

Relationship between specific surface area and dispersion:

$$S_{Sp}\ (m^2 / g) = a_m * (N_A / M) * D$$

Ruthenium: $M = 101.07$ g/mol

$a_m = 6.35 * 10^{-20}$ m^2/atom

$N_A = 6.022 * 10^{23}$ mol^{-1}

$\rho = 12.3$ g / cm^3

Relationship between specific surface area and mean particle size:

$$S_{Sp} = 6000 / \rho d_{VA}$$

With d_{VA} in nanometers, ρ in g / cm^3, and S_{Sp} = m^2 / g

Dispersion (%)	specific surface area (m^2/g)	mean particle size (nm)
66.67	2.52E+02	1.93
64.33	2.43E+02	2.00
62.14	2.35E+02	2.07

CURRICULUM VITAE

Name: Ms. Palida Sritana

Date of Birth: January 1, 1986

Nationality: Thai

University Education:

2004-2008 Bachelor Degree of Science (Industrial Chemistry), Faculty of Science, Chiangmai University, Chiangmai, Thailand

Working Experience:

2007 Position: Internship Student
Company name: Thaioil Public Company Limited, Refinery, Sriracha, Thailand.

Proceedings:

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