Table G-2

Effect of Temperature on Yield and Selectivity for Carbon Monoxide Hydrogenation in the Diluted-Bed Reactor

Pressure = 2070 KPa; H_2/CO = 2/1; Space Velocity = 1 $cm^3 g^{-1} s^{-1}$

Activity		Product Distribution								Selectivity			
		Yields (%)								Olefin/Paraffin Ratio			
Temp. (K)	CO Conv. (%)	C_1	C_2	C_3	C_4	C_2-C_4	C_5^+	R-OH	CO_2	C_2	C_3	C_4	C_2-C_4
473	4.62	17.0	15.1	19.3	15.6	50.1	18.9	6.5	7.5	3.3	2.8	2.4	2.8
483	6.13	15.8	14.4	18.6	15.7	48.7	18.6	5.9	11.0	3.0	3.2	2.8	3.0
493	8.93	13.7	12.9	16.8	14.0	43.7	21.0	4.6	17.0	3.1	3.7	3.1	3.3

Table G-3

Effect of Temperature on Yield and Selectivity for Carbon Monoxide Hydrogenation in the Diluted-Bed Reactor

Pressure = 2760 KPa; H_2/CO = 2/1; Space Velocity = 0.5 $cm^3 g^{-1} s^{-1}$

Activity		Product Distribution								Selectivity			
		Yields (%)								Olefin/Paraffin Ratio			
Temp. (K)	CO Conv. (%)	C_1	C_2	C_3	C_4	C_2-C_4	C_5^+	R-OH	CO_2	C_2	C_3	C_4	C_2-C_4
463	4.93	16.3	15.9	20.3	16.7	52.9	19.0	4.7	7.0	2.5	2.3	2.0	2.3
473	8.55	14.5	14.8	19.4	16.1	50.3	20.7	4.5	10.0	2.9	2.6	2.2	2.5
483	14.07	12.6	13.2	17.5	14.7	45.4	22.4	3.5	16.2	3.2	3.1	2.6	2.9

Table G-4

Effect of Pressure on Yield and Selectivity for Carbon Monoxide Hydrogenation in the Diluted-Bed Reactor

Temperature = 483 K; H_2/CO = 2/1; Space Velocity = 1 $cm^3 g^{-1} s^{-1}$

Activity		Product Distribution								Selectivity			
		Yields (%)								Olefin/Paraffin Ratio			
Press. KPa	CO Conv. (%)	C_1	C_2	C_3	C_4	C_2-C_4	C_5^+	R-OH	CO_2	C_2	C_3	C_4	C_2-C_4
2070	6.25	15.6	14.9	19.0	16.0	49.9	18.0	6.0	10.6	3.2	3.1	2.7	3.0
2760	9.55	14.8	14.2	19.6	16.9	50.7	19.2	5.4	10.0	3.1	2.9	2.6	2.8
3450	12.35	13.4	13.6	20.3	17.8	51.7	21.0	4.4	9.5	3.0	2.8	2.4	2.7

Table G-5

Effect of Pressure on Yield and Selectivity for Carbon Monoxide Hydrogenation in the Diluted-Bed Reactor

Temperature = 463 K; H_2/CO = 2/1; Space Velocity = 0.5 $cm^3 g^{-1} s^{-1}$

Activity		Product Distribution								Selectivity			
		Yields (%)								Olefin/Paraffin Ratio			
Press. KPa	CO Conv. (%)	C_1	C_2	C_3	C_4	C_2-C_4	C_5^+	R-OH	CO_2	C_2	C_3	C_4	C_2-C_4
2070	3.30	18.0	16.6	19.9	14.9	51.4	18.0	4.3	8.2	2.6	2.6	2.1	2.4
2760	4.93	17.2	16.1	20.1	15.8	52.0	19.0	4.7	7.0	2.5	2.3	2.0	2.2
3450	5.60	16.9	15.9	20.4	16.8	53.1	19.1	4.7	6.3	2.1	2.1	1.9	2.0

Table G-6

Effect of Space Velocity on Yield and Selectivity for Carbon Monoxide Hydrogenation in the Diluted-Bed Reactor

Temperature = 473 K; Pressure = 2070 KPa; H_2/CO = 2/1

Activity		Product Distribution								Selectivity			
		Yield (%)								Olefin/Paraffin Ratio			
Space Velocity $cm^3 g^{-1} s^{-1}$	CO Conv. (%)	C_1	C_2	C_3	C_4	C_2-C_4	C_5^+	R-OH	CO_2	C_2	C_3	C_4	C_2-C_4
0.5	5.94	15.1	14.7	18.8	16.0	49.6	19.4	5.7	10.2	3.1	2.9	2.5	2.8
1.0	3.75	16.0	15.0	19.2	15.6	49.9	19.4	7.1	7.6	3.3	2.8	2.4	2.8
1.5	2.52	17.4	16.2	20.6	15.6	52.3	16.3	8.1	6.0	3.4	2.9	2.3	2.8

Table G-7

Effect of Space Velocity on Yield and Selectivity for Carbon Monoxide Hydrogenation in the Diluted-Bed Reactor

Temperature = 483 K; Pressure = 2760 KPa; H_2/CO = 2/1

Activity		Product Distribution								Selectivity			
Space Velocity $cm^3 g^{-1} s^{-1}$	CO Conv. (%)	Yield (%)								Olefin/Paraffin Ratio			
		C_1	C_2	C_3	C_4	C_2-C_4	C_5^+	R-OH	CO_2	C_2	C_3	C_4	C_2-C_4
0.5	14.07	12.6	13.2	17.5	14.7	45.4	22.4	3.5	16.2	3.2	3.1	2.6	2.9
1.0	8.28	13.8	14.2	18.6	15.5	48.4	21.6	4.6	11.5	3.3	3.0	2.5	2.9
1.5	6.20	15.7	14.9	19.2	16.0	50.1	19.0	5.4	9.8	3.2	3.0	2.6	2.9

Table G-8

Effect of Space Velocity on Yield and Selectivity for Carbon Monoxide Hydrogenation in the Diluted-Bed Reactor

Temperature = 463 K; Pressure = 3450 KPa; H_2/CO = 2/1

Activity		Product Distribution								Selectivity			
		Yield (%)								Olefin/Paraffin Ratio			
Space Velocity $cm^3g^{-1}s^{-1}$	CO Conv. (%)	C_1	C_2	C_3	C_4	C_2-C_4	C_5^+	R-OH	CO_2	C_2	C_3	C_4	C_2-C_4
0.5	5.40	17.8	15.8	19.6	16.6	52.0	18.0	5.7	6.5	2.0	2.1	2.0	2.0
1.0	3.85	19.5	16.8	20.3	15.9	53.0	15.4	6.4	5.6	2.0	2.1	1.9	2.0
1.5	2.02	21.2	17.8	21.3	15.1	54.2	12.1	5.8	4.8	2.1	2.1	1.7	2.0

Table G-9

Effect of H_2/CO Ratio on Yield and Selectivity for Carbon Monoxide Hydrogenation in the Diluted-Bed Reactor

Temperature = 473 K; Pressure = 2070 KPa; Space Velocity = 0.5 $cm^3 g^{-1} s^{-1}$

Activity		Product Distribution								Selectivity			
		Yield (%)								Olefin/Paraffin Ratio			
H_2/CO Ratio	CO Conv. (%)	C_1	C_2	C_3	C_4	C_2-C_4	C_5^+	R-OH	CO_2	C_2	C_3	C_4	C_2-C_4
1.5	4.87	13.5	14.7	19.1	15.8	49.6	19.1	5.0	12.7	3.5	3.1	2.7	3.1
2.0	5.85	15.1	15.3	19.3	15.9	50.5	18.1	5.0	11.3	3.2	3.0	2.6	2.9
2.5	6.88	15.8	15.7	19.6	15.9	51.2	17.6	4.7	10.8	3.1	2.9	2.5	2.8

Table G-10

Effect of H_2/CO Ratio on Yield and Selectivity for Carbon Monoxide Hydrogenation in the Diluted-Bed Reactor

Temperature = 483 K; Pressure = 3450 KPa; Space Velocity = 1 $cm^3 g^{-1} s^{-1}$

Activity		Product Distribution								Selectivity			
		Yield (%)								Olefin/Paraffin Ratio			
H_2/CO Ratio	CO Conv. (%)	C_1	C_2	C_3	C_4	C_2-C_4	C_5^+	R-OH	CO_2	C_2	C_3	C_4	C_2-C_4
1.5	9.86	12.1	13.0	17.7	15.5	46.2	24.1	4.5	13.0	3.3	2.9	2.5	2.8
2.0	11.56	12.9	13.5	18.0	15.5	47.0	23.1	4.8	12.1	3.1	2.8	2.4	2.7
2.5	13.70	14.4	13.9	18.4	15.8	48.1	23.1	4.2	10.2	2.7	2.7	2.3	2.6

APPENDIX H

CARBON MONOXIDE HYDROGENATION OVER IRON/MANGANESE CATALYSTS: DILUTED-BED, PSEUDO SLURRY REACTOR, PROCESS VARIABLE DATA

The process variable investigation in the dilute-bed, pseudo slurry reactor included a determination of the effects of reactor temperature, reactor pressure, space velocity, and hydrogen to carbon monoxide ratio on the activity (as measured by carbon monoxide conversion), product distribution (as measured by methane, C_2-C_4 hydrocarbon, C_5^+ hydrocarbons, alcohols, and carbon dioxide yields), and selectivity (as measured by the olefin to paraffin ratio of C_2-C_4 hydrocarbons). The data for the hydrogenation of carbon monoxide in the diluted-bed, pseudo slurry reactor obtained in the course of this research project are presented in Tables H-1 through H-16 of this appendix.

Table H-1

Effect of Temperature on Yield and Selectivity for Carbon Monoxide Hydrogenation in the Diluted-Bed, Pseudo Slurry Reactor

Pressure = 1400 KPa; H_2/CO = 2/1; Space Velocity = 1 $cm^3 g^{-1} s^{-1}$

Activity		Product Distribution								Selectivity			
		Yield (%)								Olefin/Paraffin Ratio			
Temp. (K)	CO Conv. (%)	C_1	C_2	C_3	C_4	C_2-C_4	C_5^+	R-OH	CO_2	C_2	C_3	C_4	C_2-C_4
475	1.76	15.4	12.9	18.3	16.4	47.7	24.4	4.4	8.1	1.7	3.1	2.5	2.4
491	3.11	18.0	14.0	17.9	15.1	47.1	17.1	1.4	16.4	1.5	3.6	2.8	2.5
500	4.62	15.8	13.0	17.6	13.4	44.0	16.1	4.2	19.9	1.5	4.0	3.1	2.6
504	5.40	14.8	12.4	17.0	12.9	42.3	15.6	4.2	23.1	1.5	4.2	3.2	2.8
513	6.83	14.2	11.5	15.8	11.5	38.8	14.9	1.8	30.3	1.6	4.6	3.4	2.9
525	10.53	13.1	10.9	14.8	11.1	36.8	14.4	3.5	32.3	1.6	5.0	3.6	3.0

Table H-2

Effect of Temperature on Yield and Selectivity for Carbon Monoxide Hydrogenation in the Diluted-Bed, Pseudo Slurry Reactor

Pressure = 2000 KPa; H_2/CO = 2/1; Space Velocity = 1 $cm^3 g^{-1} s^{-1}$

Activity		Product Distribution								Selectivity			
		Yield (%)								Olefin/Paraffin Ratio			
Temp. (K)	CO Conv. (%)	C_1	C_2	C_3	C_4	C_2-C_4	C_5^+	R-OH	CO_2	C_2	C_3	C_4	C_2-C_4
480	2.63	21.8	13.8	16.8	12.4	43.1	19.7	5.3	10.0	2.6	2.8	2.2	2.5
489	3.85	15.4	13.8	17.3	12.8	43.9	18.8	8.2	13.7	2.4	3.0	2.3	2.6
499	5.77	14.7	13.4	17.5	13.3	44.2	16.5	5.7	18.9	2.2	3.3	2.5	2.7
505	7.22	13.1	11.8	15.8	12.0	39.6	15.9	4.7	26.7	2.1	3.7	2.8	2.8
513	8.80	12.4	10.6	14.3	10.9	35.8	14.5	4.0	33.3	1.9	4.2	3.1	2.9
523	12.30	11.9	10.2	13.6	10.4	34.2	13.9	3.4	36.6	1.8	4.5	3.4	3.1

Table H-3

Effect of Temperature on Yield and Selectivity for Carbon Monoxide Hydrogenation in the Diluted-Bed, Pseudo Slurry Reactor

Pressure = 2600 KPa; H_2/CO = 2/1; Space Velocity = 1 $cm^3 g^{-1} s^{-1}$

Activity		Product Distribution								Selectivity			
		Yield (%)								Olefin/Paraffin Ratio			
Temp. (K)	CO Conv. (%)	C_1	C_2	C_3	C_4	C_2-C_4	C_5^+	R-OH	CO_2	C_2	C_3	C_4	C_2-C_4
456	0.49	33.3	23.0	20.1	9.82	52.9	2.7	5.6	5.4	2.3	2.1	1.7	2.1
465	1.07	22.9	18.2	18.9	11.8	48.8	13.3	9.4	5.6	2.2	2.2	1.8	2.1
474	2.18	20.4	17.3	20.9	14.5	52.7	14.2	5.4	7.2	1.8	2.4	1.9	2.1
488	4.52	17.1	15.4	19.7	14.4	49.5	15.9	6.2	11.3	2.0	2.8	2.2	2.3
495	6.00	15.7	14.0	18.4	13.9	46.3	17.0	5.8	15.1	2.1	3.1	2.4	2.5
510	9.02	14.3	13.0	17.1	12.8	43.0	16.7	5.1	21.0	2.2	3.5	2.7	2.8
521	14.74	11.5	11.5	16.7	12.5	40.8	16.3	5.3	25.1	2.5	4.0	3.0	3.2

Table H-4

Effect of Temperature on Yield and Selectivity for Carbon Monoxide Hydrogenation in the Diluted-Bed, Pseudo Slurry Reactor

Pressure = 3200 KPa; H_2/CO = 2/1; Space Velocity = 1 $cm^3 g^{-1} s^{-1}$

Activity		Product Distribution								Selectivity			
		Yield (%)								Olefin/Paraffin Ratio			
Temp. (K)	CO Conv. (%)	C_1	C_2	C_3	C_4	C_2-C_4	C_5^+	R-OH	CO_2	C_2	C_3	C_4	C_2-C_4
461	1.72	18.1	15.5	18.7	14.7	49.0	23.0	6.1	3.7	2.3	2.0	1.7	2.0
473	2.54	17.8	16.4	19.4	14.2	50.0	20.6	6.1	5.5	2.5	2.3	1.8	2.2
485	4.63	16.5	15.8	19.4	14.4	49.5	19.4	5.1	9.5	2.6	2.6	2.0	2.4
502	8.74	15.3	14.7	19.3	14.5	48.5	15.7	4.8	15.6	2.6	3.1	2.4	2.7
515	13.03	13.0	12.7	17.7	14.1	44.5	19.5	4.8	18.3	2.6	3.4	2.6	2.9
525	18.62	12.1	11.6	16.1	13.2	41.0	19.7	4.3	22.9	2.7	3.9	2.9	3.2

Table H-5

Effect of Temperature on Yield and Selectivity for Carbon Monoxide Hydrogenation in the Diluted-Bed, Pseudo Slurry Reactor

Pressure = 4400 KPa; H_2/CO = 2/1; Space Velocity = 1 $cm^3 g^{-1} s^{-1}$

Activity		Product Distribution								Selectivity			
		Yield (%)								Olefin/Paraffin Ratio			
Temp. (K)	CO Conv. (%)	C_1	C_2	C_3	C_4	C_2-C_4	C_5^+	R-OH	CO_2	C_2	C_3	C_4	C_2-C_4
467	1.98	18.2	17.3	20.6	14.6	52.6	16.3	8.0	5.0	2.3	2.0	1.6	2.0
471	2.77	16.4	16.1	20.0	15.0	51.0	19.3	7.4	5.8	2.4	2.1	1.65	2.0
481	5.08	13.9	15.7	20.7	16.6	53.0	20.1	8.0	7.1	2.5	2.2	1.7	2.1
489	6.43	12.8	15.3	20.1	16.3	51.7	19.1	6.2	10.1	2.8	2.4	1.9	2.3
497	8.51	12.2	14.7	18.3	14.9	47.9	19.5	4.6	15.8	3.0	2.7	2.0	2.6
510	13.36	11.5	12.2	16.9	13.8	43.0	21.7	5.25	18.6	3.2	3.2	2.4	2.9
521	18.86	10.8	11.7	16.6	13.6	41.9	19.1	4.7	23.6	3.4	3.5	2.7	3.2

Table H-6

Effect of Space Velocity on Yield and Selectivity for Carbon Monoxide Hydrogenation in the Diluted-Bed, Pseudo Slurry Reactor

Temperature = 503 K; Pressure = 1400 KPa; $H_2/CO = 2/1$

Activity		Product Distribution								Selectivity			
		Yield (%)								Olefin/Paraffin Ratio			
Space Velocity ($cm^3g^{-1}s^{-1}$)	CO Conv. (%)	C_1	C_2	C_3	C_4	C_2-C_4	C_5^+	R-OH	CO_2	C_2	C_3	C_4	C_2-C_4
0.5	7.88	12.3	11.0	15.1	12.1	38.2	17.2	4.3	28.0	1.9	4.5	3.3	3.1
1.0	4.41	14.3	12.7	16.4	12.2	41.3	18.1	3.7	22.6	1.95	4.4	3.4	3.1
1.5	3.47	15.3	13.6	17.5	12.9	44.0	16.5	3.3	20.9	2.0	4.4	3.4	3.1
2.0	3.18	14.6	12.8	17.2	14.2	44.3	21.0	3.7	16.4	2.0	4.3	3.3	3.1

Table H-7

Effect of Space Velocity on Yield and Selectivity for Carbon Monoxide Hydrogenation in the Diluted-Bed, Pseudo Slurry Reactor

Temperature = 503 K; Pressure = 2000 KPa; H_2/CO = 2/1

Activity		Product Distribution								Selectivity			
		Yield (%)								Olefin/Paraffin Ratio			
Space Velocity ($cm^3g^{-1}s^{-1}$)	CO Conv. (%)	C_1	C_2	C_3	C_4	C_2-C_4	C_5^+	R-OH	CO_2	C_2	C_3	C_4	C_2-C_4
0.5	9.20	12.4	11.1	14.5	11.0	36.7	16.4	3.3	31.3	2.1	4.1	3.2	3.1
1.0	5.22	13.2	12.3	16.2	12.3	40.8	17.6	3.8	24.7	2.2	4.0	3.1	3.1
1.5	4.23	13.7	12.7	17.0	13.2	42.8	18.0	3.9	21.6	2.3	3.9	3.1	3.1
2.0	3.64	13.3	12.4	16.6	13.0	42.0	21.9	5.1	17.7	2.5	3.8	3.0	3.1

Table H-8

Effect of Space Velocity in Yield and Selectivity for Carbon Monoxide Hydrogenation in the Diluted-Bed, Pseudo Slurry Reactor

Temperature = 503 K; Pressure = 2600 KPa; H_2/CO = 2/1

Activity		Product Distribution								Selectivity			
		Yield (%)								Olefin/Paraffin Ratio			
Space Velocity ($cm^3g^{-1}s^{-1}$)	CO Conv. (%)	C_1	C_2	C_3	C_4	C_2-C_4	C_5^+	R-OH	CO_2	C_2	C_3	C_4	C_2-C_4
0.5	11.65	13.4	13.4	16.5	11.1	41.0	18.1	4.4	23.2	2.8	3.5	2.7	3.0
1.0	6.86	13.7	14.1	17.8	13.5	45.4	18.3	5.4	17.1	2.9	3.4	2.6	3.0
1.5	5.52	14.7	14.2	18.2	14.3	46.7	18.4	5.7	14.6	3.1	3.3	2.6	3.0
2.0	4.96	17.8	17.1	19.1	12.1	48.2	17.7	4.2	12.1	3.1	3.2	2.7	3.0

Table H-9

Effect of Space Velocity on Yield and Selectivity for Carbon Monoxide Hydrogenation in the Diluted-Bed, Pseudo Slurry Reactor

Temperature = 503 K; Pressure = 3200 KPa; H_2/CO = 2/1

Activity		Product Distribution								Selectivity			
		Yield (%)								Olefin/Paraffin Ratio			
Space Velocity ($cm^3 g^{-1} s^{-1}$)	CO Conv. (%)	C_1	C_2	C_3	C_4	C_2-C_4	C_5^+	R-OH	CO_2	C_2	C_3	C_4	C_2-C_4
0.5	13.1	11.5	12.1	16.7	13.5	42.3	21.1	5.1	20.0	2.9	3.5	2.7	3.1
1.0	9.2	11.8	12.4	17.2	15.5	45.0	23.9	5.8	13.6	3.05	3.4	2.6	3.0
1.5	7.49	12.7	13.8	18.1	14.2	46.0	24.0	4.8	12.4	3.2	3.3	2.5	3.0
2.0	6.0	13.9	14.6	18.7	14.2	47.4	23.1	4.4	11.1	3.1	3.2	2.5	3.0