

5 TABLES

Table 1. Run List for CO/H₂ Conversion

RUN	CATALYST		CATALYST DESCRIPTION	LOADING	TEMP (C)		CONDITIONS			FEED RATIO
	A	B			INLET	MAX	TOTA	PSIG	CO	
106	7923-2	None	Silica Gel (Davison)	0/6	310	310	1100	2250-675	47/47/6	
107	7923-4	CuZn/Al (33/64/3) Oxides (LT WGS)	Silica Gel (Davison)	3/3	310	310	1100	2250-675	47/47/6	
108	7923-4	CuZn/Al (33/64/3) Oxides (LT WGS)	Silica Gel (Davison)	3/3	310	310	1100	2250-675	47/47/6	
109	7923-6	CuZn/Al (33/64/3) Oxides (LT WGS)	Mg/Al Clay (USH)	3/3	310	310	1100	2250-675	47/47/6	
112	7923-10A	CuZn/Al (30/45/25) Oxides (Lab, Ne)	Silica Gel (Davison)	3/3	310	310	1100	2250	47/47/6	
113	7923-4	CuZn/Al (33/64/3) Oxides (LT WGS)	Silica Gel (Davison)	3/3	310	310	1100	2250	47/47/6	
114	7923-16A	ZnCr (75/25) Oxides (Lab)	Silica Gel (Davison)	3/3	450	450	1100	2250	47/47/6	
115	7923-18	CuZn/Al (30/45/25) Oxides (Lab)	Silica Gel (Davison)	3/3	310	310	1100	2250	47/47/6	
116	7923-20	CuZn/Al (30/45/25) Oxides (Lab)	Mg/Al Clay (USH)	3/3	310	310	1100	2250	47/47/6	
117	7923-20	CuZn/Al (30/45/25) Oxides (Lab)	Mg/Al Clay (Alcoa)	3/3	310	310	1100	2250	47/47/6	
118	7923-20	CuZn/Al (30/45/25) Oxides (Lab)	MgO (USH)	3/3	310	310	1100	2250	47/47/6	
119	7923-24	Zr/Zn/Mn/K (33/33/33) Oxides (Lab)	Silica Gel (Davison)	3/3	450	450	1100	2250	47/47/6	
124	7923-36	.14%Pd(.NO3)/.6%K/Zr/Zn/Mn Oxides	Silica Gel (Davison)	3/3	450	450	1100	2250	47/47/6	
125	7923-42A	.15%Pd(.NO3)/.8%K/Zr/Zn/Mn Oxides	Silica Gel (Davison)	3/3	450	450	1100	2250	47/47/6	
126	7923-20	CuZn/Al (30/45/25) Oxides (Lab)	Mg/Al Clay (Alcoa)	3/3	310	310	1100	2250	47/47/6	
127	7923-22	CuZn/Al (30/45/25) Oxides (Lab)	Mg/Al Clay (Alcoa)	3/3	230	230	1100	2250	47/47/6	
128	7923-42A	.15%Pd(.NO3)/.8%K/Zr/Zn/Mn Oxides	Silica Gel (Davison)	3/3	350	350	1100	2250	47/47/6	
129	7923-20	CuZn/Al (30/45/25) Oxides (Lab)	Mg/Al Clay (Alcoa)	3/3	310	310	1100	2250	47/47/6	
130	7923-44	.16%Pd(.NO3)/.6%K/Zr/Zn/Mn Oxides	None	3/0	450	450	1100	2250	47/47/6	
131	7923-46	.15%Pd(.NO3)/.8%K/Zr/Zn/Mn Oxides	None	3/0	450	450	1100	2250	47/47/6	
132	7923-42A	.15%Pd(.NO3)/.8%K/Zr/Zn/Mn Oxides	None	3/0	450	450	1100	2250	47/47/6	
133	7923-2	None	Silica Gel (Davison)	0/3	450	450	1100	2250	47/47/6	
134		Ceramic-Lined Reactor	a-Alumina Filled		450	450	1100	2250	47/47/6	
135		Ceramic-Lined Reactor	Empty		250-45	250-45	1100	2250	47/47/6	
136		Ceramic-Lined Reactor	Quartz Chips Filled		250-45	250-45	1100	2250	47/47/6	
137	7923-59A	CuZn/Al Oxide (ICI 51-3 catalyst)	Silica Gel (Davison)	3/3	230-31	230-31	1100	2250	47/47/6	
138	7923-20	CuZn/Al Oxide (Lab PPT)	Silica Gel (Davison)	3/3	230-31	230-31	1100	2250	47/47/6	
139	7923-20	CuZn/Al Oxide (Lab PPT)	5.0% K (KOH)/Al ₂ O ₃	3/3	310	310	1100	2250	47/47/6	
140	7923-20	CuZn/Al Oxide (Lab PPT)	5.3% K (KOH)/SiO ₂	3/3	310	310	1100	2250	47/47/6	
141	7923-20	CuZn/Al Oxide (Lab PPT)	Silica Gel (Davison)	3/3	310	310	1100	2250	47/47/6	
142	7923-85	CuZn/Al (31/42/27) Oxide (Lab PPT)	Silica Gel (Davison)	3/3	310	310	1100	2250	47/47/6	
143	7923-85	CuZn/Al (31/42/27) Oxide (Lab PPT)	.32% Ca (Mg/Al MOSS (Alcoa))	3/3	310	310	1100	2250	47/47/6	
144	7923-85	CuZn/Al (31/42/27) Oxide (Lab PPT)	.17% Na (Mg/Al MOSS (Alcoa))	3/3	310	310	1100	2250	47/47/6	
145	7923-85	CuZn/Al (31/42/27) Oxide (Lab PPT)	Silica Gel (Davison)	3/3	310	310	1100	2250	47/47/6	
146	7923-85	CuZn/Al (31/42/27) Oxide (Lab PPT)	.15% K (Mg/Al MOSS (Alcoa))	3/3	310	310	1100	2250	47/47/6	
147	7923-96	1.3% Cs (CsOOCH)/CuZn/Al Oxide	Silica Gel (Davison)	3/3	310	310	1100	2250	47/47/6	
148	None	a-Alumina/Quartz Chips		3/3	400	400	1100	2250	47/47/6	
149	7923-97	ZnCr Oxide (2.8/1)		3/3	400	400	1100	2250	47/47/6	
150	7923-62	0.1%Pd/0.5%K/Zr/Zn/Mn Oxide		3/3	400	400	1100	2250	47/47/6	
151	None	a-Alumina/Quartz Chips		3/3	310/400	310/400	1100	2250	N ₂ /CO/H	
152	7923-96	1.5% Cs (CsOOCH)/CuZn/Al Oxide		3/3	310	310	1100	2250	47/47/6	
153	7923-97	ZnCr Oxide (2.8/1)		3/3	400	400	1100	2250	47/47/6	

Table 2. Run List for Methanol and Methanol/Ethanol Conversion

RUN	CATALYST		CATALYST DESCRIPTION	CATALYST B	LOADING g	SIZE	TEMP (C)			CONDITIONS			FEED RATIO MeOH/EtOH/N ₂ (H ₂)
	A Book #	B Book #					INLET	MAX	TOTA	PSIG	MeOH WHS		
154			None (Quartz Chips/a-Alumina)				250.31			1100		2	1/0/2 N ₂
155	7923-85		CuZnAl (31/42/27) Oxide (Lab PPT)		5	20-40M	250			1100		2	1/0/2 N ₂
156	7887-11		Mg/Al Clay (Alcoa)		5	20-40M	250			1100		2	1/0/2 N ₂
157	7887-14		0.5%Cu / Mg/Al Clay (Alcoa)		5	20-40M	250			1100		2	1/0/2 N ₂
158	7887-18		0.5%Co / Mg/Al Clay (Alcoa)		5	20-40M	250			1100		2	1/0/2 N ₂
159	7923-81		Zn/Zr (50/50) Oxide (Lab PPT)		5	20-40M	250			1100		2	1/0/2 N ₂
160	7923-81		Ce/Zn/Min (33/33/33) Oxide (Lab PPT)		5	20-40M	250			1100		2	1/0/2 N ₂
161	7887-14		0.5%Cu / Mg/Al Clay (Alcoa)		5	20-40M	250			1100		2	1/0/2 H ₂
162	7923-81		Zn/Zr (50/50) Oxide (Lab PPT)		5	20-40M	250			1100		2	1/0/2 H ₂
163	7923-85		CuZnAl (31/42/27) Oxide (Lab PPT)		5	20-40M	250			1100		2	1/0/2 H ₂
164	7923-98		1.3%Cs / CuZnAl (30/45/25) Oxide (Lab PPT)		5	20-40M	250			1100		2	1/0/2 H ₂
165	7887-28		0.5%Ag / Mg/Al Clay (Alcoa)		5	20-40M	250			1100		2	1/0/2 H ₂
166	7923-55		Zr/Zn/Min (33/33/33) Oxide (Lab PPT)		5	20-40M	250			1100		2	1/0/2 H ₂
167	7887-34		5.0%Cu / Mg/Al Clay (Alcoa)		5	20-40M	250			1100		2	1/0/2 H ₂
174			None (Quartz Chips/a-Alumina)							30		2	1/0.1/2 N ₂
175	7923-6		Mg/Al Clay (Lab Prep 77)		5	20-40M	250			1100		2	1/0.1/2 H ₂
176	7887-11		Mg/Al Clay (Alcoa)		5	20-40M	250			100		2	1/0.1/2 H ₂
177	7887-11		Mg/Al Clay (Alcoa)		5	20-40M	350			100		2	1/0.1/2 N ₂
178	7923-28		MoO		5	20-40M	350			100		2	1/0.1/2 N ₂
179	7887-11		Mg/Al Clay (Alcoa)		5	20-40M	350			30		2	1/0.1/2 N ₂
173	7887-11		Mg/Al Clay (Alcoa)		25	20-40M	350			30		0.4	1/0.1/2 N ₂
174			None (Quartz Chips/a-Alumina)							30		2	1/0.1/2 N ₂
175	7923-6		Mg/Al Clay (Lab Prep 77)		5	20-40M	350			30		2	1/0.1/2 N ₂
176	7923-85		CuZnAl (31/42/27) Oxide (Lab PPT)		5	20-40M	350			30		2	1/0.1/2 N ₂
177	7923-85		CuZnAl (31/42/27) Oxide (Lab PPT)		5	20-40M	300			30		2	1/0.1/2 N ₂
178	7923-85		CuZnAl (31/42/27) Oxide (Lab PPT)		5	20-40M	250			30		2	1/0.1/2 N ₂
179	7923-16A		Zn/Cr (7.5/25) Oxide (Lab PPT)		5	20-40M	350			30		2	1/0.1/2 N ₂
180	7923-69		CuZn/Min (34/33/33) Oxide (Lab PPT)		5	20-40M	350			30		2	1/0.1/2 N ₂
181	7887-37		Zn/Al (74/26) Oxide (Lab PPT)		5	20-40M	350			30		2	1/0.1/2 N ₂
182	7887-39		CuZn/Al (11/63/26) Oxide (Lab PPT)		5	20-40M	350			30		2	1/0.1/2 N ₂
183	7887-41		Zn/Al (63/37) Oxide (Lab PPT)		5	20-40M	350			30		2	1/0.1/2 N ₂
184	7923-85		CuZn/Al (31/42/27) Oxide (Lab PPT)		10	20-40M	250			30		1	1/0.1/2 N ₂
185	7923-85		CuZn/Al (31/42/27) Oxide (Lab PPT)		5	20-40M	250			75		2	1/0.1/2 N ₂
186	7923-85		CuZn/Al (31/42/27) Oxide (Lab PPT)		2.5	20-40M	300			30		4	1/0.1/2 N ₂
187	7923-85		CuZn/Al (31/42/27) Oxide (Lab PPT)		10	20-40M	300			30		1	1/0.1/2 N ₂
188	7923-55		Zr/Zn/Min (34/34/32) Oxide		5	20-40M	350			30		2	1/0.1/2 N ₂
189	7923-62		0.2%Pd / Zn/Min/Zr (34/34/32) Oxide		5	20-40M	350			30		2	1/0.1/2 N ₂
190	7923-64		2.1%Pd / Zn/Min/Zr (34/34/32) Oxide		5	20-40M	350			30		2	1/0.1/2 N ₂

Table 2 (con't). Run List for Methanol and Methanol/Ethanol Conversion

RUN	CATALYST		CATALYST DESCRIPTION	CATALYST B	LOADING	SIZE	TEMP (C)		CONDITIONS			FEED RATIO
	A	B					INLET	MAX	TOTA	PSIG	WHS	
191	7923-85		Cu/Zn/Al (31/42/27) Oxide (Lab PPT)		5	20-40M	300	300	30	30	2	1/0.1/2 N2
192	7923-85		Cu/Zn/Al (31/42/27) Oxide (Lab PPT)		1.75	20-40M	300	300	30	30	5.7	1/0.1/2 N2
193	7923-72		2.0%Pd / Zn/Min (50/50) Oxide		5	20-40M	350	350	30	30	2	1/0.1/2 N2
194	7923-86		2.0%Pd / Zn/Min/Ce (33/33/33) Oxide		5	20-40M	350	350	30	30	2	1/0.1/2 N2
195	7887-42		Cu/Zn/Al (33/39/28) Oxide (Lab PPT)		5	20-40M	300	300	30	30	2	1/0.1/2 N2
196	7923-84		2.1%Pd / Zn/Min/Zr (34/34/32) Oxide		2.5	20-40M	350	350	30	30	4	1/0.1/2 N2
197	7923-84		2.1%Pd / Zn/Min/Zr (34/34/32) Oxide		1.75	20-40M	350	350	30	30	5.8	1/0.1/2 N2
198	7923-84		2.1%Pd / Zn/Min/Zr (34/34/32) Oxide		5	20-40M	350	350	30	30	2	1/0.1/2 N2
199	7887-48		None (Quartz Chips/s-Alumina)		5	20-40M	300	300	30	30	(2)	1/0.1/2 N2
200	7923-84		None (Glass Beads)		5	20-40M	300	300	30	30	(2)	1/0.1/2 N2
201	7887-56		2.1%Ag metal / Zn/Min/Zr (34/34/32) Oxide		5	20-40M	300	300	30	30	2	1/0.1/2 N2
202	7887-52		2.0%Ag / Zn/Min/Zr (34/34/32) Oxide		5	20-40M	350	350	30	30	2	1/0.1/2 N2
203	7887-50		2.0%Ag / Zn/Min/Zr (34/34/32) Oxide		5	20-40M	350	350	30	30	2	1/0.1/2 N2
204	7887-52		2.0%Pd / Zn/Min/Cr (34/33/33) Oxide		5	20-40M	350	350	30	30	2	1/0.1/2 N2
205	7887-48		2.0%Pd / Zn/Min/Zr (34/34/32) Oxide		5	20-40M	350	350	30	30	(2)	1/0.1/2 N2
206			None (Glass Beads)		5	20-40M	350	350	30	30	(2)	1/0.1/2 N2
207			None (Quartz Chips/s-Alumina)		5	20-40M	350	350	30	30	(2)	1/0.1/2 N2
208	7887-48		2.0%Pd / Zn/Min/Zr (34/34/32) Oxide		5	20-40M	350	350	30	30	2	1/0.1/2 N2
209	7887-50		2.0%Ag / Zn/Min/Zr (34/34/32) Oxide		5	20-40M	350	350	30	30	2	1/0.1/2 N2
210	7887-58		2.1%Ag metal / Zn/Min/Zr (34/34/32) Oxide		5	20-40M	350	350	30	30	2	1/0.1/2 N2
211	7887-48		2.0%Pd / Zn/Min/Zr (34/34/32) Oxide		5	20-40M	350	350	30	30	2	1/0.1/2 N2
212	7887-52		2.0%Pd / Zn/Min/Cr (34/33/33) Oxide		5	20-40M	350	350	30	30	2	1/0.1/2 N2
213	7887-58		2.0%Pd / Cu/Zn/Al (33/39/28) Oxide		5	20-40M	350	350	30	30	2	1/0.1/2 N2
214	7887-52		2.0%Pd / Zn/Min/Cr (34/33/33) Oxide		5	20-40M	350	350	30	30	2	1/0.1/2 N2
215	7923-95		Zn/Min/Cr (34/33/33) Oxide		5	20-40M	350	350	30	30	2	1/0.1/2 N2
216	7887-62		2.0%Pd / Zn/Min/Cr (34/33/33) Oxide		5	20-40M	350	350	30	30	2	1/0.1/2 N2
217	7887-64		2.0%Pd / Zn/Min (50/50) Oxide		5	20-40M	350	350	30	30	2	1/0.1/2 N2
218	7887-66		2.0%Pd / Zn/Min (50/50) Oxide		5	20-40M	350	350	30	30	2	1/0.1/2 N2
219	7887-68		2.0%Pd / Zn/Min/Ce (33/33/33) Oxide		5	20-40M	350	350	30	30	2	1/0.1/2 N2
220	7887-72		2.0%Pd / Zn/Al (7/4/26) Oxide		5	20-40M	350	350	30	30	2	1/0.1/2 N2
221	7887-70		2.0%Pd / Zn/Cr (7/4/26) Oxide		5	20-40M	350	350	30	30	2	1/0.1/2 N2
222	7887-90		2.0%Pd / Mn (100) Oxide		5	20-40M	350	350	30	30	2	1/0.1/2 N2
223	7887-78		2.0%Pd / Zn/Min/Cu (34/33/33) Oxide		5	20-40M	350	350	30	30	2	1/0.1/2 N2
224	7887-82		2.0%Pd / Zn/Min/La (34/32/34) Oxide		5	20-40M	350	350	30	30	2	1/0.1/2 N2
225	7887-84		2.0%Pd / Zn/Min/ZrK (34/34/32/6%) Oxide		5	20-40M	350	350	30	30	2	1/0.1/2 N2
226	7887-62		2.0%Pd / Zn/Min/Cr (34/33/33) Oxide		5	20-40M	350	350	30	30	2	1/0.1/2 N2
227	7887-66		2.0%Pd / Zr (100) Oxide		5	20-40M	350	350	30	30	2	1/0.1/2 N2
228	7887-90		2.0%Pd / Zn/Min/Cr (34/33/33) Oxide		5	20-40M	350	350	30	30	2	1/0.1/2 N2
229	7887-90		2.0%Pd / Zn/Min/Cr (34/33/33) Oxide		4	20-40M	350	350	30	30	2.5	1/0.1/2 N2
230	7887-80		2.0%Pd / Zn/Min/Cr (34/33/33) Oxide		3	20-40M	350	350	30	30	3.3	1/0.1/2 N2
231	7887-90		2.0%Pd / Zn/Min/Cr (34/33/33) Oxide		2	20-40M	350	350	30	30	5	1/0.1/2 N2
232	7887-90		2.0%Pd / Zn/Min/Cr (34/33/33) Oxide		1	20-40M	350	350	30	30	10	1/0.1/2 N2
233	7887-94		2.0%Pd / ZnO + SiO2 (1/1)		5	20-40M	300	300	30	30	2	1/0.1/2 N2
234	7887-89		2.0%Pd / Zn/Mg (50/50) Oxide + SiO2 (1/1)		5	20-40M	300	300	30	30	2	1/0.1/2 N2

Table 2 (con't). Run List for Methanol and Methanol/Ethanol Conversion

RUN	CATALYST		CATALYST DESCRIPTION	CATALYST B	LOADING #	SIZE	TEMP (C) INLET MAX	CONDITIONS			FEED RATIO MeOH/EtOH/N ₂ (1/2)
	A Book #	B Book #						TOTA PSIG	MeOH WHS		
235	7887-96		2.0%Pt / MgO		5	20-40M	300	30		2	1/0.1/2 N ₂
236	7887-96		2.0%Pt / MgO		5	20-40M	350	30		2	1/0.1/2 N ₂
237	7887-96		2.0%Pd / MgO		5	20-40M	350	30		2	1/0.1/2 N ₂
238	7887-94		2.0%Pt / ZnO + SiO ₂ (1/1)		5	20-40M	350	30		2	1/0.1/2 N ₂
239	7887-89		2.0%Pt / Zn/Mg (50/50) Oxide + SiO ₂ (1/1)		5	20-40M	350	30		2	1/0.1/2 N ₂
240	8125-8		2.0%Cu / TiO ₂		5	20-40M	350	30		2	1/0.1/2 N ₂
241	8125-10		2.0%Mo / TiO ₂		5	20-40M	350	30		2	1/0.1/2 N ₂
242	8285-12		2.0%Mo / Polyvinylpyridine (PVP425)		5	20-40M	350	30		2	1/0.1/2 N ₂
243	8285-13		2.0%Cu / Polyvinylpyridine (PVP425)		5	20-40M	350	30		2	1/0.1/2 N ₂
244	8285-16		2.0%Mo / Mg/Al MOSS (Alcoa)		5	20-40M	350	30		2	1/0.1/2 N ₂
245	8285-18		2.0%Cu / Mg/Al MOSS (Alcoa)		5	20-40M	350	30		2	1/0.1/2 N ₂
246	8285-14		2.0%Pd / Polyvinylpyridine (PVP425)		5	20-40M	350	30		2	1/0.1/2 N ₂
247	8285-22		2.0%Pd / Zn/Mn/Zr (33/33/33) Oxide		5	20-40M	350	30		2	1/0.1/2 N ₂
248	8285-24		2.0%Pd / Zn/Mn/Zr (33/33/33) Oxide		5	20-40M	350	30		2	1/0.1/2 N ₂
249	8285-26		2.0%Pd / Zn/Mn/Zr (33/33/33) Oxide		5	20-40M	350	30		2	1/0.1/2 N ₂
250	8285-32		2.0%Pd / Zn/Mn/Zr (33/33/33) Oxide		5	20-40M	350	30		2	1/0.1/2 N ₂
251	8285-34		2.0%Pd / Zn/Mn/Zr (45/45/10) Oxide		5	20-40M	350	30		2	1/0.1/2 N ₂
252	8285-36		2.0%Pd / Zn/Mn/Zr (45/45/10) Oxide		5	20-40M	350	30		2	1/0.1/2 N ₂
253	8285-38		2.0%Pd / NH ₂ -Terminated Polystyrene		5	20-40M	350	30		2	1/0.1/2 N ₂
254	8285-42		100% MnO ₂		5	20-40M	350	30		2	1/0.1/2 N ₂
255	8285-44		100% MnO ₂		5	20-40M	350	30		2	1/0.1/2 N ₂
256	8285-46		100% MnO ₂		5	20-40M	350	30		2	1/0.1/2 N ₂
257	8285-48		100% MnO ₂		5	20-40M	350	30		2	1/0.1/2 N ₂
258	8285-50		2.0%Pt / Zn/Mn/Zr (33/33/33) Oxide		5	20-40M	350	30		2	1/0.1/2 N ₂
259	8285-52		250ppm Co / MnO ₂		5	20-40M	350	30		2	1/0.1/2 N ₂
260	8285-36		2.0%Pt / Zn/Mn/Zr (45/45/10) Oxide		5	20-40M	350	30		2	1/0.1/2 N ₂
261	NO RUN										
262	NO RUN										
263	8285-56		2.0%Pd / Zn/Mn/Zr (45/10/45) Oxide		5	20-40M	350	30		2	1/0.1/2 N ₂
264	8285-60		2.0%Pd / MnO ₂ (Chemicals CIR 189)		5	20-40M	350	30		2	1/0.1/2 N ₂
265	8285-61		2.0%Pt / MnO ₂ (Chemicals CIR 189)		5	20-40M	350	30		2	1/0.1/2 N ₂
266	8285-64		2.0%Pd / Zn/Mn/Zr (10/45/45) Oxide (450C calc)		5	20-40M	350	30		2	1/0.1/2 N ₂
267	8285-63		2.0%Pt / MnO ₂ (Chemicals CDC 924)		5	20-40M	350	30		2	1/0.1/2 N ₂
268	8285-66		2.0%Pd / MnO ₂ (Chemicals CDC 924)		5	20-40M	350	30		2	1/0.1/2 N ₂
269	8285-68		2.0%Pt / Zn/Mn/Zr (10/45/45) Oxide (450C calc)		5	20-40M	350	30		2	1/0.1/2 N ₂
270	8285-69		2.0%Pd / Zn/Mn/Zr (20/60/20) Oxide (450C calc)		5	20-40M	350	30		2	1/0.1/2 N ₂
271	8285-70		2.0%Pt / Zn/Mn/Zr (20/60/20) Oxide (450C calc)		5	20-40M	350	30		2	1/0.1/2 N ₂
272	8285-76		2.0%Pt / Zn/Mn/Zr (60/20/20) Oxide (450C calc)		5	20-40M	350	30		2	1/0.1/2 N ₂
273	8285-77		2.0%Pt / Zn/Mn/Zr (45/10/45) Oxide		5	20-40M	350	30		2	1/0.1/2 N ₂
274	8285-76		2.0%Pt / Zn/Mn/Zr (60/20/20) Oxide		4	20-40M	350	30		2.5	1/0.1/2 N ₂
275	8285-76		2.0%Pt / Zn/Mn/Zr (60/20/20) Oxide		3	20-40M	350	30		3.3	1/0.1/2 N ₂
276	8285-76		2.0%Pt / Zn/Mn/Zr (60/20/20) Oxide		2	20-40M	350	30		5	1/0.1/2 N ₂
277	8285-76		2.0%Pt / Zn/Mn/Zr (60/20/20) Oxide		1	20-40M	350	30		10	1/0.1/2 N ₂
278	8285-82		2.0%Pt / Zn/Mn/Zr (10/45/45) Oxide		5	20-40M	350	30		2	1/0.1/2 N ₂
279	8285-80		2.0%Pt / Zn/Mn/Zr (20/20/60) Oxide		5	20-40M	350	30		2	1/0.1/2 N ₂
280	8285-83		2.0%Pd / Zn/Mn/Zr (10/45/45) Oxide		5	20-40M	350	30		2	1/0.1/2 N ₂
281	8285-84		2.0%Pt / Zn/Mn/Zr (20/60/20) Oxide		5	20-40M	350	30		2	1/0.1/2 N ₂
282	8285-85		2.0%Pd / Zn/Mn/Zr (20/60/20) Oxide		5	20-40M	350	30		2	1/0.1/2 N ₂

Table 2 (con't). Run List for Methanol and Methanol/Ethanol Conversion

RUN	CATALYST		CATALYST DESCRIPTION	CATALYST B	CATALYST A	LOADING	TEMP (C)		CONDITIONS			FEED RATIO MeOH:EtOH:N ₂ :Others
	A Book #	B Book #					INLET	MAX	TOTA	PSIG	WHS	
283	8265-91		2.0%Pt / ZnMnZr (20/20/60) Oxide			5	350	30	30	2	1/0.1/2 N ₂	
284	8265-96		0.5%Pt / ZnMnZr (60/20/20) Oxide			5	350	30	30	2	1/0.1/2 N ₂	
285	8265-87		1.0%Pt / ZnMnZr (60/20/20) Oxide			5	350	30	30	2	1/0.1/2 N ₂	
286	8265-88		5.0%Pt / ZnMnZr (60/20/20) Oxide			5	350	30	30	2	1/0.1/2 N ₂	
287	8265-89		2.0%Pt / ZnMnZr (10/45/45) Oxide		Caught @ 450C before impregnation	5	350	30	30	2	1/0.1/2 N ₂	
288	8265-90		2.0%Pt / ZnMnZr (20/20/60) Oxide		Caught @ 450C before impregnation	5	350	30	30	2	1/0.1/2 N ₂	
289	8265-50		2.0%Pt / ZnMnZr (33/33/33) Oxide			5	350	30	30	2	1/0.1/2 N ₂	
					HOS							
					0-16							
					24-40							
					48-64							
					72-88							
					96-112							
290	8265-92		2.0%Pt / ZnMnZr (10/45/45) Oxide			5	350	30	30	2	1/0.1/2 N ₂	
291	8265-76		2.0%Pt / ZnMnZr (60/20/20) Oxide			5	350	30	30	2	1/0.1/2 N ₂	
292	8265-92		2.0%Pt / ZnMnZr (10/45/45) Oxide			5	350	30	30	2	1/0.1/2 N ₂	
293	8265-50		2.0%Pt / ZnMnZr (33/33/33) Oxide			5	350	30	30	2	1/0.1/2 N ₂	
294	8265-92		2.0%Pt / TiO ₂			5	350	30	30	2	1/0.1/2 N ₂	
295	8265-94		0.5%Pt / ZnMnZr (60/20/20) Oxide			5	350	30	30	2	1/0.1/2 N ₂	
					HOS							
					0-16							
					16-32							
					32-48							
					48-64							
296	8265-95		2.0%Pt / ZnMnZr (60/20/20) Oxide			5	350	30	30	2	1/0.1/2 N ₂	
					0-16							
					16-32							
					32-48							
					48-64							
297	8265-95		2.0%Pt / ZnMnZr (60/20/20) Oxide			5	350	30	30	2	1/0.1/2 N ₂	
					0-16							
					16-32							
					32-48							
					48-64							
298			None (Glass Beads)			5	250	30	30	2	1/0.1/2 N ₂	
					0-16							
					40-48							
					48-56							
					56-64							
299	8265-95		2.0%Pt / ZnMnZr (60/20/20) Oxide			5	350	30	30	2	1/0.1/2 N ₂	
300	8265-95		2.0%Pt / ZnMnZr (60/20/20) Oxide			2.5	350	30	30	4	1/0.1/2 N ₂	
					Dirty Feed							
					Dirty Feed							
301	8265-97		2.0%Pt / ZnMnZr (60/20/20) Oxide			5	350	30	30	2	1/0.1/2 N ₂	
302	8265-98		2.0%Pt / ZnMnZr (60/20/20) Oxide			5	350	30	30	2	1/0.1/2 N ₂	
303	8265-98		2.0%Pt / ZnMnZr (60/20/20) Oxide			5	350	30	30	2	1/0.1/2 N ₂	
					Dirty Feed							
304	8265-98		2.0%Pt / ZnMnZr (60/20/20) Oxide			5	350	30	30	2	1/0.14/2 N ₂	
305	8265-98		2.0%Pt / ZnMnZr (60/20/20) Oxide			5	350	30	30	2	1/0.25/2 N ₂	
306	8265-98		2.0%Pt / ZnMnZr (60/20/20) Oxide			5	350	30	30	2	1/1.00/2 N ₂	
307	8265-98		2.0%Pt / ZnMnZr (60/20/20) Oxide			5	350	30	30	2	1/0.25/2 N ₂	

Table 3. High Temperature Blank Reactor Tests with CO/H₂ Feed

Conditions: 450°C, 1100 psig, 2250 hr⁻¹ CO GHSV, 1/1 CO/H₂ (molar)

	P700R133			P700R134			P700R135			P700R136		
	18 HOS SiO ₂ / 316SS Filler Blank/ 316SS Reactor	20 HOS	22 HOS	2 HOS α-Al ₂ O ₃ / Ceramic - Lined Reactor	6 HOS	14 HOS	23 HOS Empty Ceramic - Lined Reactor	25 HOS	27 HOS	23 HOS Quartz Chips / Ceramic - Lined Reactor	25 HOS	27 HOS
CONVERSION (% vs Ar)												
CO	9.41	8.70	8.37	6.51	5.52	6.69	2.45	2.70	3.38	7.29	6.26	4.47
H ₂	6.22	6.03	6.50	4.66	6.02	4.01	4.37	3.66	3.84	11.97	15.89	17.75
CO + H ₂	7.84	8.37	8.43	5.61	5.76	5.37	3.40	3.17	3.61	9.62	11.04	11.07
SELECTIVITY (mole %)												
C1OH	0.59	0.63	0.63	1.30	0.96	0.90	0.00	0.00	0.00	1.49	1.41	1.44
C2OH	0.40	0.39	0.41	0.00	0.00	0.00	0.00	0.00	0.00	0.26	0.29	0.33
nC3OH	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
iC3OH	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
nC4OH	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
iC4OH	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.21	0.09	0.08
nC5OH	0.46	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.21	0.10	0.00
iC5OH	0.35	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
C6+OH	0.00	0.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.09	0.00	0.00
DME	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
C1 Aldehyde	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
C2 Aldehyde	0.17	0.14	0.15	0.00	0.00	0.14	0.00	0.00	0.00	0.72	0.67	0.66
C3 Ald/Ketone	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
C4 Ald/Ketone	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
C5 Ald/Ketone	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
C6+ Ald/Ketone	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
C1	24.00	24.13	24.31	31.88	31.65	32.36	34.98	61.67	47.12	37.77	38.36	38.24
C2s	13.21	13.18	13.21	5.62	7.79	8.97	0.00	0.00	0.00	15.69	15.56	15.40
C3s	5.75	5.75	5.77	3.99	4.57	5.05	0.00	0.00	0.00	9.81	9.31	8.99
C4s	0.10	0.11	0.11	0.17	0.18	0.20	0.00	0.00	0.00	0.30	0.28	0.27
C5s	0.21	0.20	0.20	0.24	0.24	0.22	0.00	0.00	0.00	0.52	0.46	0.41
C6+s + UNKs	2.00	1.60	1.62	0.87	0.99	1.31	0.00	0.00	0.00	3.67	3.45	3.27
CO ₂	52.76	53.64	53.59	55.94	53.64	50.85	65.02	36.33	52.88	29.23	29.99	30.91
TOTAL	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

Table 4. Blank Reactor Tests with Methanol/Ethanol Feed

Blank Reactor Loading	Quartz/ α -Al ₂ O ₃	Glass Beads
Run Number	207	206
Conditions	350°C, 30 psig, 2 hr ⁻¹ MeOH WHSV, 10/1/2 MeOH/EtOH/N ₂ (molar)	
Conversion (%)		
MeOH	7.9	2.1
EtOH	12.1	2.5
Selectivities (mole %)		
nC ₃ OH	0.0	0.0
nC ₄ OH	0.0	0.0
iC ₄ OH	0.3	0.4
iC ₄ Aldehyde	0.1	0.0
Me iButyrate	0.0	0.0
Other Oxygenates	0.5	3.8
Others (No ID)	1.0	0.8
C ₁ -C ₂ Oxygenates	93.8	76.9
C ₁ -C ₄ Hydrocarbons	3.6	13.3
CO	0.0	0.0
CO ₂	0.8	4.9

Table 5. Blank Reactor Tests at High Temperature with Copper-Lined Reactor

Blank Reactor Loading	Glass Beads in Stainless Steel Reactor				Glass Beads in Copper-Lined Reactor			
	298				324			
Run Number	32-40	40-48	48-56	56-64	9-16	25-32	41-48	
Hours on Stream	30 psig, 2 hr ⁻¹ MeOH WHSV, 2/1 N ₂ /MeOH (molar)							
Conditions								
Temperature (°C)	250	350	450	500	350	400	450	
Conversion (%) MeOH	0.2	5.9	35.2	68.1	0.2	2.1	8.8	
Selectivities (mole %)								
nC ₃ OH	0.0	0.0	0.0	0.0	0.0	1.8	1.2	
nC ₄ OH	0.0	0.0	0.0	0.0	0.0	0.7	0.0	
iC ₄ OH	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
iC ₄ Aldehyde	0.0	0.0	0.0	0.0	0.0	0.6	0.0	
Me iButyrate	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
Other Oxygenates	0.0	0.0	0.0	0.0	7.8	1.2	0.3	
Others (No ID)	0.0	0.0	0.0	0.0	4.7	1.0	0.0	
C ₁ -C ₂ Oxygenates	0.0	0.0	0.0	0.0	87.5	54.6	35.0	
C ₁ -C ₄ Hydrocarbons	0.0	3.7	5.1	6.4	0.0	4.2	5.0	
CO	100.0	92.6	91.2	88.3	0.0	30.9	51.7	
CO ₂	0.0	2.0	2.1	4.2	0.0	5.0	6.8	

Table 6. Comparison of Lab Prepared and Commercial Cu/Zn/Al Methanol Synthesis Catalysts

Conditions: 310 °C, 1100 psig, 2250 hr⁻¹ CO GHSV, 1/1 H₂/CO (molar)

Run	113	137	138	141	145
Catalyst	Commercial Cu/Zn/Al Oxide	Commercial Cu/Zn/Al Oxide	Lab Prepared Cu/Zn/Al Oxide	Lab Prepared Cu/Zn/Al Oxide	Lab Prepared Cu/Zn/Al Oxide
Mixed with SiO ₂ (1:1 wt.)	ICI 52-1	ICI 51-3	7923-20	7923-20	7923-85
Conversions (%)					
CO	28.1	25.4	25.4	29.7	31.2
H ₂	37.6	34.4	39.1	40.2	40.6
Selectivities (mole %)					
C ₁ OH	64.0	54.3	57.1	54.3	46.0
C ₂ OH	2.7	3.2	2.2	2.4	2.5
C ₃ OHs	1.1	1.0	0.7	0.9	1.1
n-C ₄ OH	0.6	0.5	0.3	0.3	0.5
i-C ₄ OH	1.0	1.0	0.6	0.9	0.6
C ₅₊ OH	1.2	1.7	0.4	0.3	0.9
DME	1.4	3.8	6.6	6.5	7.5
C ₁ HCBN	1.4	1.6	1.2	1.3	1.1
C ₂₋₄ HCBNs	1.8	2.5	1.2	1.8	1.7
Others	12.2	15.4	3.6	3.4	7.7
CO ₂	12.6	15.0	26.1	27.9	30.4

Table 7. Evaluation of Methanol Synthesis Catalysts

Run Hours on Stream	113 8-16	115 8-16	114 8-16
Catalyst	Cu/Zn/Al Oxide	Cu/Zn/Al Oxide	Zn/Cr Oxide
	Commercial	Lab Prepared	Lab Prepared
Conditions			
Temperature (C)	310	310	450
Pressure (psig)	1100	1100	1100
CO GHSV (hr ⁻¹)	2250	2250	2250
H ₂ /CO (molar)	1/1	1/1	1/1
Conversions (%)			
CO	28.1	28.7	27.1
H ₂	37.6	38.7	24.6
Selectivities (%)			
C ₁ OH	64.0	65.9	0.1
C ₂ OH	2.7	3.0	0.1
C ₃ OHs	1.1	1.4	0.1
n-C ₄ OH	0.6	0.7	0.1
i-C ₄ OH	1.0	1.3	0.1
C ₅₊ OH	1.2	1.8	0.1
DME	1.4	4.1	0.0
C ₁ HCBN	1.4	1.7	26.7
C ₂₋₄ HCBNs	1.8	2.3	24.8
Others	12.2	4.1	6.5
CO ₂	12.6	13.7	41.4

Table 8. Cu/Zn/Al Oxide with Supported Potassium Co-Catalysts

Run Hours on Stream	141 8-16	139 8-16	140 8-16
Catalyst	Cu/Zn/Al Oxide + SiO ₂ 1:1 (wt.)	Cu/Zn/Al Oxide + K/Al ₂ O ₃ 1:1 (wt.)	Cu/Zn/Al Oxide + K/SiO ₂ 1:1 (wt.)
Conditions	Temperature (C) 310 Pressure (psig) 1100 CO GHSV (hr ⁻¹) 2250 H ₂ /CO (molar) 1/1		
Conversions (%)			
CO	29.7	27.5	13.5
H ₂	40.2	39.5	15.4
Selectivities (%)			
C ₁ OH	54.3	61.9	44.9
C ₂ OH	2.4	1.4	0.6
C ₃ OHs	0.9	0.6	0.3
n-C ₄ OH	0.3	0.2	0.1
i-C ₄ OH	0.9	0.7	0.2
C ₅₊ OH	0.3	0.6	1.1
DME	6.5	7.2	19.1
C ₁ HCBN	1.3	1.5	2.9
C ₂₋₄ HCBNs	1.4	1.3	2.8
Others	3.4	2.5	2.9
CO ₂	27.9	22.1	25.1

Table 9. Evaluation of Methanol Synthesis Catalysts

Run	115	116	117	118
Catalyst	Cu/Zn/Al Oxide + SiO ₂	Cu/Zn/Al Oxide + Mg/Al MOSS (Lab Prep)	Cu/Zn/Al Oxide + Mg/Al MOSS (Commercial)	Cu/Zn/Al Oxide + MgO (Lab Prep)
Conditions	310°C, 1100 psig, 2250 hr ⁻¹ CO GHSV, 1/1 CO/H ₂ (molar)			
Conversions (%)				
CO	28.7	34.5	34.9	29.4
H ₂	38.7	45.5	43.6	43.4
Selectivities (mole%)				
C ₁ OH	65.9	51.5	47.1	72.6
C ₂ OH	3.0	1.2	0.8	1.4
C ₃ OHs	1.4	0.9	0.5	0.9
n-C ₄ OH	0.7	0.2	0.1	0.2
i-C ₄ OH	1.3	1.6	0.9	1.1
C ₅₊ OH	1.8	1.1	0.7	0.8
DME	4.1	20.4	26.3	7.0
C ₁ HCBN	1.7	1.0	0.8	1.8
C ₂₋₄ HCBNs	2.3	0.7	0.6	1.2
Others	4.1	4.4	2.7	2.6
CO ₂	13.7	17.0	19.5	10.4

Table 10. Cu/Zn/Al Oxide with Mg/Al MOSS Co-Catalysts

Run Hours on Stream	145 8-16	144 8-16	146 8-16	143 8-16
Catalyst	Cu/Zn/Al Oxide + SiO ₂ 1:1 (wt.)	Cu/Zn/Al Oxide + 0.2% Na Mg/Al MOSS 1:1 (wt.)	Cu/Zn/Al Oxide + 0.2% K/ Mg/Al MOSS 1:1 (wt.)	Cu/Zn/Al Oxide + 0.3% Cs/ Mg/Al MOSS 1:1 (wt.)
Conditions	Temperature (C) 310 Pressure (psig) 1100 CO GHSV (hr ⁻¹) 2250 H ₂ /CO (molar) 1/1			
Conversions (%)				
CO	31.2	30.2	29.4	32.2
H ₂	40.6	43.1	39.5	41.5
Selectivities (%)				
C ₁ OH	46.0	41.8	40.5	41.1
C ₂ OH	2.5	0.4	0.5	0.5
C ₃ OHs	1.1	0.2	0.2	0.2
n-C ₄ OH	0.5	0.0	0.1	0.1
i-C ₄ OH	0.6	0.1	0.3	0.4
C ₅₊ OH	0.9	0.5	0.6	0.8
DME	7.5	23.3	23.9	21.5
C ₁ HCBN	1.1	0.6	0.7	0.8
C ₂₋₄ HCBNs	1.7	0.5	0.4	0.9
Others	7.7	2.1	2.4	3.1
CO ₂	30.4	30.5	30.4	30.6

Table 11. Cs Addition to Cu/Zn/Al Oxide

Run Hours on Stream	145 8-16	147 8-16	152 8-16
Catalyst	Cu/Zn/Al Oxide + SiO ₂ 1:1 (wt.)	1.3% Cs on Cu/Zn/Al Oxide + SiO ₂ 1:1 (wt.)	
Conditions	Temperature (C) 310 Pressure (psig) 1100 CO GHSV (hr ⁻¹) 2250 H ₂ /CO (molar) 1/1		
Conversions (%)			
CO	31.2	23.8	23.1
H ₂	40.6	37.3	35.4
Selectivities (%)			
C ₁ OH	46.0	63.2	62.9
C ₂ OH	2.5	2.1	2.2
C ₃ OHs	1.1	0.8	0.9
n-C ₄ OH	0.5	0.3	0.3
i-C ₄ OH	0.6	0.6	0.9
C ₅₊ OH	0.9	0.4	0.5
DME	7.5	6.7	7.7
C ₁ HCBN	1.1	1.0	1.2
C ₂₋₄ HCBNs	1.7	1.3	1.0
Others	7.7	3.7	1.5
CO ₂	30.4	20.2	20.9

Table 12. Evaluations of Pd/K on Zr/Zn/Mn Oxide Catalysts

Conditions: 1100 psig, 2250 hr⁻¹ CO GHSV, 1/1 H₂/CO (molar)

Run	124	125	128	132	130	150	131
Catalyst	0.14% Pd (Pd(NO ₃) ₂) on K/Zr/Zn/Mn (4.6%/1/1/1)	0.15% Pd (Pd(NO ₃) ₂) on K/Zr/Zn/Mn (0.8%/1/1/1)		0.18% Pd (PdCl ₂) on K/Zr/Zn/Mn (1.6%/1/1/1)	0.23% Pd (PdCl ₂) on K/Zr/Zn/Mn (0.4%/1/1/1)	0.23% Pd (PdCl ₂) on SiO ₂	
(Diluent)	SiO ₂	SiO ₂	SiO ₂	None	None	None	
Temperature (°C)	450	450	350	450	450	400	450
Conversions (%)							
CO	14.3	8.5	6.2	17.9	8.5	9.3	8.5
H ₂	14.3	12.6	2.6	13.2	12.6	10.9	12.6
Selectivities (mole %)							
MeOH	1.5	7.7	39.4	10.9	7.7	6.4	7.7
C ₂₊ Alcohols	2.0	0.2	0.8	1.6	0.2	1.1	0.2
DME	0.0	0.0	33.4	0.0	0.0	19.6	0.0
C ₁₋₄ HCBNs	33.2	43.1	4.3	34.8	43.1	19.3	43.1
CO ₂	40.9	45.4	20.1	44.9	45.4	48.1	45.4

Table 13. Catalyst Screening for Methanol Condensation

Plant 700 Runs 154-167

Conditions: 250 °C, 1100 psig, 2 hr⁻¹ MeOH WHSV,
1/2 MeOH/N₂ or H₂ (molar)

CATALYST	N ₂ Co-Feed		H ₂ Co-Feed	
	MeOH Conv. (%)	DME Select. (mole%)	MeOH Conv. (%)	DME Select. (mole%)
Blank	3.2	87		
Cu/Zn/Al (30/45/25)	8.3	45.4	2.1	83.4
Cu/Zn/Al (30/25/45) +1.3% Cs			1.9	92.2
Zr/Zn (50/50)	1.3	97.4	1.4	97.0
Zr/Zn/Mn (33/33/33)			1.4	89.3
Cs/Zn/Mn (33/33/33)	1.2	100.0		
Mg/Al MOSS	2.5	99.3		
Mg/Al MOSS +0.5% Cu	1.6	90.4	1.5	93.7
Mg/Al MOSS +5.0% Cu			1.9	89.3
Mg/Al MOSS +0.5% Co	1.5	98.5		
Mg/Al MOSS +0.5% Ag			1.7	96.4

Table 14. Evaluation of Mg/Al MOSS Catalyst for Methanol/Ethanol Condensation

Plant 700

Catalyst: Commercial Mg/Al MOSS (20-40 mesh)

Run	168	169	170	172	173
Conditions					
°C	250	250	350	350	350
psig	1100	100	100	30	30
hr ⁻¹ (MeOH)	2	2	2	2	0.4
EtOH/MeOH	0.1	0.1	0.1	0.1	0.1
Dil/MeOH	2 H ₂	2 H ₂	2 N ₂	2 N ₂	2 N ₂
Conversions (%)					
MeOH	-1.3	-0.1	7.9	6.5	21.6
EtOH	20.1	7.5	31.6	31.5	44.7
Selectivity (mole%, CO _x -free)					
C ₃ OH	0.0	7.6	7.2	10.1	4.8
n-C ₄ OH	4.1	1.4	0.2	0.8	0.6
i-C ₄ OHs	0.0	5.7	4.0	5.9	3.3
C ₅₊ OHs	0.0	0.6	0.7	1.2	0.5
DME	86.9	58.7	60.0	55.9	75.2
C ₁₋₃ ALD	0.0	11.3	9.3	9.6	0.8
C ₁ HCBN	4.3	1.6	1.5	1.9	1.2
C ₂₋₄ HCBN	4.7	3.8	1.4	1.3	9.6
Others	0.0	9.3	15.7	13.3	4.0

Table 15. Effect of Temperature on Performance of Cu/Zn/Al Oxide for Methanol/Ethanol Condensation

Plant 700

Catalyst: Cu/Zn/Al Oxide (30/45/25) 20-40 mesh

Conditions: 30 psig, 2 hr⁻¹ MeOH WHSV,
1/0.1/2 MeOH/EtOH/N₂ (molar)

Run	176	177	178
Temperature (°C)	350	300	250
Conversion %			
C ₁ OH	92.3	50.7	17.0
C ₂ OH	96.9	89.5	11.4
Selectivity mole%			
nC ₃ OH	0.4	0.8	7.4
nC ₄ OH	0.1	0.1	0.3
iC ₄ OH	4.5	13.4	8.7
tC ₄ OH	0.2	0.0	0.0
Me ₂ O	8.3	7.0	5.4
Et ₂ O	0.9	0.7	0.6
MeO _i C ₄	0.7	0.1	3.2
C ₂₋₃ ALD	1.1	1.3	13.0
iC ₄ ALD	6.6	6.9	2.2
ESTERS	3.3	10.5	12.5
C ₁₋₃ HCBN	3.2	2.5	1.3
CO	33.4	20.5	2.5
CO ₂	32.4	25.1	7.4
Others	4.9	11.1	35.5
Productivity g/kg cat/hr			
iC ₄ OH	26	56	21
C ₃₊ Oxygenates	76	121	43

Table 16. Evaluation of Methanol Synthesis Type Catalysts

Run	176	177	179	182	180	181	183
Catalyst	Cu/Zn/Al Oxide (31/42/27)	Cu/Zn/Al Oxide (31/42/27)	Zn/Cr Oxide (75/25)	Cu/Zn/Al Oxide (11/63/26)	Cu/Zn/Mn Oxide (34/33/33)	Zn/Al Oxide (74/26)	Zn/Al Oxide (63/37)
Temperature (°C)	350	300	350	350	350	350	350
Conversion (%)							
MeOH	97.6	67.3	14.9	62.3	50.8	15.5	17.7
EtOH	99.2	95.9	31.5	97.9	88.8	72.8	81.2
Selectivities (mole%)							
iC ₄ OH	2.0	5.8	2.8	7.5	5.5	1.1	2.0
iC ₄ Ald	2.2	2.3	0.4	6.0	7.2	0.2	0.2
Total C ₄₊ Oxy	5.9	12.7	6.2	21.4	14.6	9.8	8.9
CO	45.5	33.0	7.5	28.9	19.4	1.8	2.0
CO ₂	40.8	37.9	30.4	31.7	42.0	16.2	18.4
Productivities (g/kg cat/hr)							
iC ₄ OH	26	56	13	68	43	4	7
Total C ₄₊ Oxy	76	121	28	150	111	33	33

Conditions: 30 psig, 2 hr⁻¹ MeOH WHSV, 1/0.1/2 MeOH/EtOH/N₂

Table 17. Evaluation of Pd on Zn/Mn/Zr Oxide Catalysts

Run	176	177	188	189	190
Catalyst	Cu/Zn/Al Oxide (31/42/27)		Zn/Mn/Zr Oxide (34/34/32)	0.2%Pd on Zn/Mn/Zr Oxide (34/34/32)	2.1%Pd on Zn/Mn/Zr Oxide (34/34/32)
Temperature (°C)	350	300	350	350	350
Conversion (%)					
MeOH	97.6	67.3	8.6	30.3	47.9
EtOH	99.2	95.9	49.5	87.5	97.4
Selectivities (mole%)					
iC ₄ OH	2.0	5.8	12.9	7.6	10.3
iC ₄ Ald	2.2	2.3	0.2	7.4	10.4
Total C ₄₊ Oxy	5.9	12.7	18.1	20.8	25.0
CO	45.5	33.0	0.0	9.1	14.7
CO ₂	40.8	37.9	14.3	26.0	28.2
Productivities (g/kg cat/hr)					
iC ₄ OH	26	56	13	41	80
Total C ₄₊ Oxy	76	121	28	111	192

Conditions: 30 psig, 2 hr⁻¹ MeOH WHSV, 1/0.1/2 MeOH/EtOH/N₂

Table 18. Screening of 2% Pd on Mixed Metal Oxide Catalysts

Support Catalyst Number	Run	Conversion (%)		Selectivity (mole%)			Productivity (g/kg cat/hr)
		MeOH	EtOH	iC ₄ OH	Sum C ₄₊	CO _x	
Zn/Mn/Zr (34/34/32)	198	51	99	10	41	37	80 328
Zn/Mn/Cr (34/33/33)	212	79	100	10	36	57	110 399
Zn/Mn/Ce (33/33/33)	194	35	92	5	44	33	33 290
Cu/Zn/Al (33/39/28)	213	89	100	7	28	56	87 348
Zn/Mn (50/50)	193	42	95	7	21	40	50 150

Conditions: 350°C, 30 psig, 2 hr⁻¹ MeOH WHSV, 1/0.1/2 MeOH/EtOH/N₂

Table 19. Screening of 2% Pt on Mixed Metal Oxide Catalysts

Support Catalyst Number	Run	Conversion (%)		Selectivity (mole%)			Productivity (g/kg cat/hr)	
		MeOH	EtOH	iC ₄ OH	Sum C ₄₊	CO _x	iC ₄ OH	Sum C ₄₊
Zn/Mn/Zr (34/34/32) (45/45/10)	211	49	99	16	49	44	122	373
	252	56	100	12	42	48	100	350
Zn/Mn/Cr (34/33/33)	216	51	90	2	12	75	17	102
Zn/Mn/Ce (33/33/33)	219	50	100	12	46	48	91	349
Zn/Mn/La (34/32/34)	224	58	99	8	33	64	68	281
Zn/Mn/Cu (34/33/33)	223	32	95	7	37	37	37	196
Zn/Al (75/25)	220	74	100	7	30	57	74	317
Zn/Cr (75/25)	221	66	100	9	34	58	83	316
Zn/Zr (50/50)	217	10	57	2	32	53	4	64
Mn/Zr (50/50)	218	35	96	8	42	46	46	242

Conditions: 350 °C, 30 psig, 2 hr⁻¹ MeOH WHSV, 1/0.1/2 MeOH/EtOH/N₂

Table 20. Screening of Metals on Zr/Mn/Zr and Zn/Mn/Cr Oxides

Support Catalyst Number	Run	Conversion (%)		Selectivity (mole%)			Productivity (g/kg cat/hr)	
		MeOH	EtOH	iC ₄ OH	Sum C ₄₊	CO _x	iC ₄ OH	Sum C ₄₊
Zn/Mn/Zr (34/33/32)								
7887-48 (2% Pt)	211	49	99	16	49	44	122	374
7923-64 (2% Pd)	198	51	99	10	41	37	80	328
7887-50 (2% Ag)	209	11	67	13	45	26	37	128
7887-56 (2% Ag metal)	210	6	63	14	47	16	30	101
7923-55 (no metal)	188	9	50	13	18	14	13	18
Zn/Mn/Cr (34/33/33)								
7887-62 (2% Pt)	216	51	90	2	12	75	17	102
7887-52 (2% Pd)	212	79	100	10	36	57	110	399
7923-95 (no metal)	215	5	43	1	36	31	2	72

Conditions: 350°C, 30 psig, 2 hr⁻¹ MeOH WHSV, 1/0.1/2 MeOH/EtOH/N₂

Table 21. Overall Selectivities (mole %) of Most Promising Catalysts

Run	198	212	211	216
Catalyst	7923-64 2%Pd on Zn/Mn/Zr Oxide	7887-52 2% Pd on Zn/Mn/Cr Oxide	7887-48 2%Pt on Zn/Mn/Zr Oxide	7887-62 2%Pt on Zn/Mn/Cr Oxide
nC ₃ OH	0.7	0.1	0.6	2.0
nC ₄ OHs	0.2	1.1	0.4	0.1
iC ₄ OH	9.9	10.2	16.4	2.1
C ₅₊ OHs	0.8	1.1	0.9	0.5
iC ₄ Aldehyde	14.8	11.9	17.7	6.2
iC ₄ Methyl Ester	3.6	3.5	2.9	0.7
Other Oxygenates	2.2	3.3	1.0	1.1
C ₁₋₂ Aldehydes	0.0	0.0	0.6	0.0
C ₃ Aldehyde	0.8	0.3	0.7	6.6
DME	10.5	0.3	0.9	0.1
Methyl Formate	0.6	0.7	1.7	0.4
Methyl Acetate	2.4	2.0	1.3	2.7
C ₁₋₅ Hydrocarbons	6.0	3.5	1.6	1.6
CO	14.2	40.7	18.0	61.6
CO ₂	22.8	16.3	25.6	13.6
Others	10.5	5.0	9.7	0.7

Conditions: 350°C, 30 psig, 2 hr⁻¹ MeOH WHSV, 1/0.1/2 MeOH/EtOH/N₂

Table 22. Reproduction of 2% Pd and 2% Pt on Mixed Metal Oxide Catalyst Preparations

Support Catalyst Number	Run	Conversion (%)		Selectivity (mole%)			Productivity (g/kg cat/hr)		
		MeOH	EtOH	iC ₄ OH	Sum C ₄₊	CO _x	iC ₄ OH	Sum C ₄₊	Sum C ₄₊
Pd/Zn/Mn/Zr (34/34/32) Precipitation 1 Precipitation 2	198	51	99	8	41	37	62	328	
	247 250	45	97	7	38	48	52	273	
		25	80	1	49	33	6	214	
Pd/Zn/Mn/Cr (34/33/33) Precipitation 1 Impregnation 1 Impregnation 2 Precipitation 2	212 228 248	79	100	9	36	57	99	399	
		87	100	5	26	67	65	305	
		19	76	1	42	45	4	144	
Pt/Zn/Mn/Zr (34/34/32) Precipitation 1 Precipitation 2	211	47	99	14	49	44	102	373	
	258	57	100	11	54	47	92	356	
Pt/Zn/Mn/Cr (34/33/33) Precipitation 1 Precipitation 2	216	51	90	2	18	75	17	102	
	249	31	72	2	33	58	9	161	

Conditions: 350°C, 30 psig, 2 hr⁻¹ MeOH WHSV, 1/0.1/2 MeOH/EtOH/N₂

Table 23. Screening of 2% Pt on Single/Double Metal Oxide Catalysts

Support Catalyst Number	Run	Conversion (%)		Selectivity (mole%)			Productivity (g/kg cat/hr)	
		MeOH	EtOH	iC ₄ OH	Sum C ₄₊	CO _x	iC ₄ OH	Sum C ₄₊
ZnO / 10% SiO ₂ Binder 7887-94	238	37	95	7	36	52	44	224
MnO ₂ 7887-80	222	36	83	2	14	77	9	63
ZrO ₂ 7887-86	227	46	53	0	2	85	0	13
MgO 7887-96	236	100	100	0	0	91	0	0
TiO ₂ 8265-92	294	100	99	0	1	83	0	0
Zn/Mg (50/50)/10% SiO ₂ 7887-89	239	71	100	6	25	70	65	250

Conditions: 350°C, 30 psig, 2 hr⁻¹ MeOH WHSV, 1/0.1/2 MeOH/EtOH/N₂

Table 24. Screening of Other Potential Higher Alcohols Catalysts

Support Catalyst Number	Run	Conversion (%)		Selectivity (mole%)			Productivity (g/kg cat/hr)	
		MeOH	EtOH	iC ₄ OH	Sum C ₄₊	CO _x	iC ₄ OH	Sum C ₄₊
TiO ₂ 2% Cu 8125-8	240	11	31	14	53	11	28	106
	241	38	77	2	27	11	9	121
Mg/Al MOSS 2% Cu 8265-18	245	7	31	12	50	4	17	72
	244	14	34	8	24	11	19	56
Polyvinylpyridine 2% Cu 8265-12	242	-1	11	0	0	0	0	0
	243	3	-7	0	0	0	0	0
	246	10	-3	0	0	0	0	0

Conditions: 350°C, 30 psig, 2 hr⁻¹ MeOH WHSV, 1/0.1/2 MeOH/EtOH/N₂