Table 1. List of Co-based FT Catalysts Formulated

CAT. NO.	wt% Co	wt% M	wt% Prom.	Support	Basis	Prepared
Co.001	20%	1% Re	1% La_2O_3 0.13% K	γ-alumina	U.S. Pat. 4,880,763	P
Co.002	20%	0.43% Ru	1% La_2O_3	γ-alumina	U.S. Pat. 4,413,064	P
Co.003	20%	0.5% Ru	1% La_2O_3	γ-alumina	U.S. Pat. 4,413,064	P
Co.004	20%	0.43% Ru	1% La_2O_3	γ-alumina	Reproduce Co.002	P
Co.005	20%	0	0	γ-alumina	Base Catalyst	P
Co.005A	20%	0.4% Ru	0	γ-alumina	Ru added to calcined Co.005 by IW impreg.	P
Co.006	12%	0.75% Re	0	Titania	U.S. Pat. 4,794,009	P
Co.007	20%	0	0	Titania	Base Catalyst	P
Co.008	20%	0	0	Silica	UK Pat. Appl. GB 2 125 062 A (Kneaded with excess liquid)	P
Co.009	20%	0.5% Ru	0	γ-alumina	Ru-Promoted Catalyst (use Ru Chloride, single-step aquaous IW)	P
Co.010	20%	0	0	γ-alumina	Base Catalyst (non-calcined)	P
Co.010A	20%	0.4% Ru	0	γ-alumina	Ru added to dried Co.010 by IW impreg.	P
Co.011	20%	0	0	Silica	UK Pat. Appl. GB 2 125 062 A (Kneaded)	P
Co.012	20%	0	0	Silica	Base Catalyst (Inc. Wetness)	P
Co.013	20%	0	0	Titania	Base Catalyst like Co.007, but all aqueous	P
Co.014	12%	0.5% Ru	0	Titania	Ru-Promoted Catalyst (aqueous IW co-impregnation)	P
Co.015	20%	0.43% Ru	1% La_2O_3	γ-Alumina	Similar to Co.002, but all aqueous	P
Co.016	20%	0.43% Ru	1% La_2O_3	γ-Alumina	Similar to Co.015, but calcined after Co impregnation	P

Table 1. List of Co-based FT Catalysts Formulated (Contd.)

CAT. NO.	wt% Co	wt% M	wt% Prom.	Support	Basis	Prepared
Co.017	20%	0.5% Ru	1% La_2O_3	γ-Alumina	Similar to Co.003, but all aqueous	P
Co.018	20%	0.5% Ru	0	γ-Alumina	Ru-Promoted Catalyst (single-step, aqueous IW)	P
Co.019	20%	0.5% Ru	0	Silica	Ru-Promoted Catalyst (single-step, aqueous IW)	P
Co.020	0	0.5% Ru	0	γ-Alumina	Ru Base Catalyst	P
Co.020A	20%	0.4% Ru	0	γ-Alumina	Co added to dried Co.020 by IW impreg.	P
Co.020B	20%	0.4% Ru	0	γ-Alumina	Co added to reduced Co.020 by IW impreg.	P
Co.020C	20%	0.4% Ru	0	γ-Alumina	Co added to calcined Co.020 by IW impreg.	P
Co.021	20%	0	0.7% Zr	Silica	U.K. Pat. Appl. GB 2 125 062 A (single-step)	P
Co.022	20%	0	0.7% Zr	Silica	U.K. Pat. Appl. GB 2 125 062 A (multiple-steps)	P
Co.023	20%	0	1.4% Zr	Silica	U.K. Pat. Appl. GB 2 125 062 A (multiple-steps)	P
Co.024	20%	0	8.5% Zr	Silica	Eur. Pat. Appl. 0 167 215 A2 (non-aqueous Zr pre-impregnation)	P
Co.025	20%	0	8.5% Zr	Silica	Similar to Co.024 but aqueous Zr pre-impregnation	P
Co.026	20%	0	0	Silica (Davison Grade 59)	Similar to Co.012 but different grade silica	P
Co.027	20%	0.5% Ru	0	Silica (Davison Grade 59)	Similar to Co.019 but different grade silica	P
C0.028	20%	0.5% Ru	0.5% K	γ-alumina	Ru- and K-Promoted Catalyst (single-step IW)	P
Co.029	30%	0.5% Ru	0.5% K	γ-alumina	Similar to Co.028 but 30% Co	P

Table 1. List of Co-based FT Catalysts Formulated (Contd.)

CAT. NO.	wt% Co	wt% M	wt% Prom.	Support	Basis	Prepared
Co.030	20%	0	0.1% Zr	γ-alumina	Zr-Promoted Catalyst (single-step aqueous IW)	P
Co.031	20%	0	1.4% Zr	γ-alumina	Zr-Promoted Catalyst (single-step aqueous IW)	P
Co.032	20%	0	8.5% Zr	γ-alumina	Zr-Promoted Catalyst (aqueous IW co-impregnation)	P
Co.033	20%	0	8.5% Zr	γ-alumina	multiple-steps, aqueous IW, Co pre-impregnation	P
Co.034	20%	0	8.5% Zr	γ-alumina	multiple-steps, aqueous IW, Zr pre-impregnation	P
Co.035	20%	0	8.5% Zr	Silica	Zr-Promoted Catalyst (single-step aqueous, kneaded)	P
Co.036	20%	0	8.5% Zr	Silica	multiple-steps, aq. Co pre-impreg. by kneading, aqueous IW Zr impreg.	P
Co.037	12%	0	0	Titania	Similar to Co.013, but TiO_2 mainly anatase	P
C0.038	12%	0.5% Ru	0	Titania	Similar to Co.014, but TiO_2 mainly anatase	P
Co.039	12%	0	0	Titania	Similar to Co.007, but only 12% Co	P
Co.040	12%	0	0	Titania	Similar to Co.013, but only 12% Co	P
Co.041	20%	0.5% Ru	8.5% Zr	Silica	Similar to Co.025, but Ru-promoted	P
Co.042	0	0	8.5% Zr	Silica	Blank Zr-promoted SiO_2	P
Co.043	20%	0.5% Ru	8.5% Zr 0.5% K	Silica	Similar to Co.041, but K-promoted	P
Co.044	20%	0	15% Zr	Silica	Similar to Co.025, but 15% Zr	P
Co.045	20%	0	4% Zr	Silica	Similar to Co.025, but 4% Zr	P
Co.046	12%	0.75% Re	4% SiO_2	Titania	Similar to Co.006, but SiO_2-promoted	-

Table 1. List of Co-based FT Catalysts Formulated (Contd.)

CAT. NO.	wt% Co	wt% M	wt% Prom.	Support	Basis	Prepared
Co.047	20%	0.5% Ru	0.3% K	γ-alumina	Similar to Co.028, but 0.3% K	P
Co.048	20%	0.5% Ru	8.5% Zr 0.3% K	Silica	Similar to Co.043, but 0.3% K	P
Co.049	20%	0.5% Ru	0.1% K	γ-alumina	Similar to Co.047, but 0.1% K	P
Co.050	20%	0.5% Ru	8.5% Zr 0.1% K	Silica	Similar to Co.048, but 0.1% K	P
Co.051	0	0.5% Ru	0	Titania (R)		P
Co.052	0	0.5% Ru	0	Titania (A)		P
Co.053	20%	0.5% Ru	0	γ-alumina	Similar to Co.018 (New Batch)	P
Co.054	20%	0	8.5% Zr 0.3% K	Silica	Similar to Co.043, but without Ru	P
Co.055	20%	1% Re	1% La_2O_3	γ-alumina	Similar to Co.001, but without K	P
Co.056	20%	0	8.5% La_2O_3	Silica	Similar to Co.025, but La instead of Zr	P
CAL.01 (97E-13E)	20%	0.5% Ru	0	γ-alumina	Similar to Co.018 (Calsicat Prep.)	P
CAL.02 (97E-16B)	20%	0.5% Ru	0	γ-alumina	Similar to CAL.01 (New Batch)	P
CAL.03 (97E-13F	20%	0.5% Ru	0	γ-alumina	2-step impreg., Simlar to CAL.02	P
CAL.04 (97E-50C)	20%	0.5% Ru	0.3% K	γ-alumina	Similar to Co.047 Stand. Calc. in Air	P
CAL.05 (97E-50D)	20%	0.5% Ru	0.3% K	γ-alumina	Similar to Co.047 Stand. Calc. in N_2	P
CAL.06 (97E-51A)	20%	0.5% Ru	0.3% K	γ-alumina	Similar to Co.047 Red. and Pas. in Air	P
CAL.07 (97E-51B)	20%	0.5% Ru	0.3% K	γ-alumina	Similar to Co.047 Red. and Protected in Paraffin (51.3% Cat. Conc.)	P
CAL.08 (97E-51C)	20%	0.5% Ru	0.3% K	γ-alumina	Similar to Co.047 Calc., Red. and Protected in Paraffin (54.4% Cat. Conc.)	P

Table 2. List of Water-Gas Shift Catalysts and F-T Catalysts with WGS Function

CAT. NO.	wt% Co	wt% M	wt% Prom.	Support	Basis	Prepared
WGS.01	0	5.0% Cu	0	γ-alumina	single-step, aqu. IW	P
WGS.02	0	5.0% Cu	10% Zn	γ-alumina	single-step, aqu. IW	P
WGS.03	0	5.0% Cu	4.0% Cr	γ-alumina	single-step, aqu. IW	P
WGS.04	0	0	4.0% Cr	γ-alumina	single-step, aqu. IW	P
WGS.05	0	0	4.0% Mn	γ-alumina	single-step, aqu. IW	P
WGS.06	0	5.0% Cu	4.0% Mn	γ-alumina	single-step, aqu. IW	P
WGS.07	0	4.0% Fe	0	γ-alumina	single-step, aqu. IW	P
WGS.08	0	4.0% Fe	4.0% Cr	γ-alumina	single-step, aqu. IW	P
WGS.09	0	5.0% Cu	4.0% Cr	γ-alumina	Similar to WGS.03	-
CoW.01	20%	5.0% Cu	10% Zn	γ-alumina	multiple-steps, aqu. IW, Cu,Zn pre-impr.	P
CoW.02	20%	5.0% Cu	4.0% Cr	γ-alumina	multiple-steps, aqu. IW, Cu,Cr pre-impr.	P
CoW.03	10%	5.0% Cu	4.0% Cr	γ-alumina	similar to CoW.02 (10% Co only)	P
CoW.04	10%	10% Cu	8.0% Cr	γ-alumina	similar to CoW.03; 10% Cu and 8% Cr	P
CoW.05	20%	5.0% Cu	4.0% Cr	γ-alumina	similar to CoW.02 with support calcined at 750°C	P
CoW.06	20%	5.0% Cu	4.0% Cr	Silica	multiple-steps, aqu. IW, Cu,Cr pre-impr.	P
CoW.07	20%	5.0% Cu	4.0% Cr	Silica	similar to CoW.06, but with support calcined at 750°C	P

Table 3. Summary of Physical Properties

CATALYST	Composition	BET Surface Area (m^2/g)	Pore Volume (cc/g)	Average Pore Dia. (Å)	Average Part. Size (μm)
Vista-B Al_2O_3	(0-400 mesh)	299	1.69	269	24
Vista-B Al_2O_3	Calcined 500°C	240	0.49	82	
Vista-B Al_2O_3	Calcined 600°C	206	0.49	95	
Vista-B Al_2O_3	Calcined 600°C	174	0.47	109	
Davison SiO_2	(0-400 mesh)	219	0.51	89	121
Degussa P25 TiO_2	(as received)	47	0.40	335	6
Degussa P25 TiO_2	Dried 60°C, Calc. 350°C/16hrs	46	0.48	419	51
Degussa P25 TiO_2	Dried 60°C, Calc. 650°C/16hrs	12	0.17	573	212
Co.001	20Co/1Re/ $1La_2O_3$/0.13K/A	191	0.31	66	42 40
Co.002	20Co/0.43Ru/ $1La_2O_3$/A	149	0.33	89	74
Co.003	20Co/0.5Ru/ $1La_2O_3$/A	122	0.26	87	77
Co.004	20Co/0.43Ru/ $1La_2O_3$/A				
Co.005	20Co/A	173	0.34	81	65 86
Co.006	12Co/0.75Re/T	16	-	-	
Co.007	20Co/T	11	0.10	372	
Co.008	20Co/S	181	1.06	234	
Co.009	20Co/0.5/A				
Co.010	20Co/A				
Co.011	20Co/S	211	1.07	203	107
Co.012	20Co/S	211	-	-	105
Co.013	20Co/T				
Co.014	12Co/0.5Ru/T	15	0.12	328	
Co.015	20Co/0.43Ru/ $1La_2O_3$/A	141	-	-	67

Table 3. Summary of Physical Properties (contd.)

CATALYST	Composition	BET Surface Area (m^2/g)	Pore Volume (cc/g)	Average Pore Dia. (Å)	Average Part. Size (μm)
Co.016	20CoB/0.43Ru/ $1La_2O_3$/A	116	-	-	79
Co.017	20Co/0.5Ru/ $1La_2O_3$/A	123	-	-	73
Co.018	20Co/0.5Ru/A	158	-	-	69
Co.019	20Co/0.5Ru/S				110
Co.021	20Co/0.7Zr/S	213	1.12	210	
Co.023	20Co/1.4Zr/S	213	-	-	
Co.024	20Co/8.5Zr/S	215	1.08	202	
Co.025	20Co/8.5Zr/S	208	0.97	187	
Co.026	20Co/S(59)	184	-	-	
Co.027	20Co/S(59)	189	-	-	
Co.028	20Co/0.5Ru/0.5K/A	161	0.33	82	
Co.029	30Co/0.5Ru/0.5K/A	140	-	-	
Co.032	20Co/8.5Zr/A	155	0.30	77	
Co.034	20Co/8.5Zr/A	150	0.31	83	
Co.035	20Co/8.5Zr/S	207	1.21	233	
Co.036	20Co/8.5Zr/S	209	-	-	
Co.037	12Co/T(A)	38	-	-	
Co.039	12Co/T(R)	13	-	-	
Co.041	20Co/0.5Ru/8.5Zr/S	214	-	-	-
Co.047	20Co/0.5Ru/0.3K/A	162	0.31-	78	
CAL.01	20Co/0.5Ru/A	178	0.34	76	
CAL.02	20Co/0.5Ru/A	158	-	-	
CAL.03	20Co/0.5Ru/A	158	-	-	
CAL.04	20Co/0.5Ru/0.3K/A	151			
CAL.05	20Co/0.5Ru/0.3K/A	163			
CAL.06	20Co/0.5Ru/0.3K/A	162			
CAL.07	20Co/0.5Ru/0.3K/A	-			

Table 3. Summary of Physical Properties (contd.)

CATALYST	Composition	BET Surface Area (m^2/g)	Pore Volume (cc/g)	Average Pore Dia. (Å)	Average Part. Size (μm)
CAL.08	20Co/0.5Ru/0.3K/A	-			

Table 4. H_2 Chemisorption and TPR Results

Catalyst	H_2 Chemisorption[a]				H_2 TPR	
	Total (μ mol H_2/g cat)	Irrevers. (μ mol H_2 /g cat)	Average d_p[b] (nm)	% Disp.	%Co Red.[c] (TPR calc. Cat.)	% Red.[d] (stand. red.)
Co.001	174±5	157±5		10.2		
Co.002	155	130		9.1		
Co.003	165	140		9.6		
Co.004[1] " [2]	205 65	185 56		12.1 4		
Co.005	48	42	20	2.8	89	58
Co.005a	129	110	11	7.6	92	84
Co.006	44	32	19	4	80	
Co.007	33	23	36	2.0	78	78
Co.008						
Co.009	133	109	13	7.8	98	
Co.010						
Co.010a	124	100	12.5	7.3	91	89
Co.011	82	70	15.6	4.8	75	75
Co.012	89	74	15	5.2	80	80
Co.013	21	17	79	1.2	97	
Co.014	38	30	21	3.7	79	
Co.015	146	124	11.7	8.6	94	94
Co.016	163	146	10.5	9.6	96	96
Co.017	202	183	8.5	11.9	97	97
Co.018	185	165	9.2	11	97	94

Table 4. H_2 Chemisorption[a] and TPR Results (contd.)

Catalyst	H_2 Chemisorption[a]				TPR	
	Total (μ mol H_2/g cat)	Irrev. (μ mol H_2/g cat)	Average d_p[b] (nm)	% Disp.	%Co Red.[c] (TPR calc. Cat.)	% Red.[d] (stand. red.)
Co.018Cl					95	
Co.019	112	92		6.6		
Co.020						
Co.020a	153	126	10	9.1	88	
Co.020b	134	113	11	7.9	86	
Co.020c	115	100	13	6.8	88	
Co.021	74	50		4.3		
Co.022	141	122		8.3	80	
Co.023	158	136		9.3	81	
Co.024	87	72		5.1	91	
Co.025	93	77		5.5	75	
Co.026						
Co.027						
Co.028	170	148		10		
Co.029	175	155		7		
Co.030						
Co.031	71	51	20	4.2	82	
Co.032	55	39	26	3.2	85	
Co.033	43	32	31	2.5	79	
Co.034	114	91	14	6.7	96	
Co.035	125	115	11	7.2	82	
Co.036	122	98		7.2		

Table 4. H_2 Chemisorption[a] and TPR Results (contd.)

Catalyst	H_2 Chemisorption[a]				TPR	
	Total (μ mol H_2/g cat)	Irrev. (μ mol H_2/g cat)	Average d_p[b] (nm)	% Disp.	%Co Red.[c] (TPR calc. Cat.)	% Red.[d] (stand. red.)
Co.037	21	3	48	2	99	
Co.038	45	35	21	4.3	91	
Co.039	19	16	40	1.8	72	
Co.040	14	11		1.4		
Co.041	70	55		4		
Co.042						
Co.043	137	116		8		
Co.053						
CAL.01	-	-	58[e]	4.4[e]		
CAL.02	-	-	63[e]	5.1[e]		
CAL.03	-	-	57[e]	4.2[e]		
CAL.04			55[e]			
CAL.05			56[e]			
CAL.06			57[e]			
CAL.07			-			
CAL.08			-			

(a) static H_2 chemisorption at 100°C
(b) Est. assuming $H_{tot}/Co_s = 1$, 5.46×10^{-20} m^2/Co_s, and $d_p = 5/S_{Co}/\rho$
S_{Co} is based on amt. Co reducible during standard reduction
(c) % Co reducible from TPR of calcined catalysts up to 900°C
(d) % Co reduced after standard reduction procedure
(e) Based on CO chemisorption
(f) Catalyst Co.018-Cl is chlorinated.

Table 5. Summary of Fixed Bed Reaction Results

Catalyst	Run	Prep	CO Conv (%)	Rate g CH2/ g cat/hr	R-C6+ g CH2/ g cat/hr	R (CO) mol/mol Co/s	wt% CH4	alpha	C3-C5 Ole/ Par	CO2 (%) (CO)	CO2 g/g cat/hr	E act. kcal/ mol	Comment
Co.001	4	(1)	2.6	0.116	0.056	6.8E-04	19.6	0.76	8.61	0.4	0.061		NSH**
Co.002	4	(2)	6.7	0.258	0.082	1.5E-03	26.1	0.64	1.97	0.1	0.012		NS*
Co.003	1	(3)	5.5	0.185	0.044	1.1E-03	30.8	0.57	4.22			28.9	old startup
Co.004	1	(2) s	4.3	0.291	0.086	1.7E-03	30.4	0.62	2.77	0.1	0.025	25.9	NSH
"	2	u	11.2	0.517	0.155	3.0E-03	28.9	0.61	1.02	0.1	0.038		NSH
"	2h	u	47.6	0.548	0.211	3.2E-03	21.9	0.64	0 .40	2.3	0.090		NSH, high conv. study
"	2a	f	3.8	0.177	0.063	1.0E-03	25.5	0.65	3.02	0.1	0.024		NSH,calc.after run2,T surge
"	3	u	6.7	0.499	0.153	2.9E-03	27.8	0.61	1.45	0.1	0.036		NSH
"	3h	u	27.0	0.506	0.164	3.0E-03	27.3	0.62	0.46	0.8	0.048		NSH, high conv. study
"	4	u	1.8	0.427	0.241	2.5E-03	24.0	0.79	2.40	0.1	0.078		NSH, 10 atm
"	5	f	4.5	0.288	0.150	1.7E-03	19.4	0.75	7.84	0.1	0.027		NSH
Co.005	2	(1)	3.3	0.087	0.037	5.1E-04	21.4	0.66	3.40	0.1	0.005		NS
"	2a		2.5	0.066	0.021	3.9E-04	25.9	0.59	4.92	0.1	0.004		CO:H2:Ar = 1:2:2
"	2b		2.4	0.064	0.021	3.7E-04	26.3	0.60	6.22	0.1	0.006		+ H2O (eq. 7.5% CO conv.)
"	3		3.3	0.077	0.024	4.5E-04	28.4	0.62	2.29	0.1	0.013		NSH
"	4		4.0	0.069	0.021	4.0E-04	30.0	0.62	2.16	0.2	0.009	25.1	NSH
"	5		3.9	0.171	0.084	1.0E-03	26.8	0.76	2.59	0.1	0.018		NSH, 10 atm
"	6		2.1	0.129	0.044	7.6E-04	25.7	0.64	5.53	0.1	0.017		NSH
"	7		6.7	0.084	0.040	4.9E-04	18.8	0.70	1.95	0.1	0.003		S2
Co.005a	1	(4a)	3.2	0.227	0.067	1.3E-03	30.0	0.60	3.05	0.1	0.034		NSH
Co.005b	1	(1)	2.4	0.040	0.024	2.3E-04	13.9	0.74	0.55	0.4	0.023		S2,1/4WGS.03+3/4Co.005
Co.005c	1	(1)	5.7	0.071	0.031	4.1E-04	20.3	0.68	0.21	1.8	0.076		S2,1/2WGS.03+1/2Co.005
Co.006	1	(5)	2.7	0.052	0.007	5.1E-04	45.0	0.49	1.90	0.1	0.006		NSH
Co.007	1	(5)	3.2	0.024	0.003	1.4E-04	49.8	0.50	0.72	0.2	0.004		NSH
Co.009	1	(1)	4.9	0.346	0.090	2.0E-03	31.1	0.57	1.69	0.1	0.020		NSH
"	2		4.9	0.338	0.091	2.0E-03	31.1	0.58	1.64	0.1	0.026		NSH
Co.010a	1	(4b) s	3.5	0.246	0.076	1.4E-03	29.5	0.62	2.58	0.2	0.040		NSH
"	2		4.1	0.262	0.080	1.5E-03	30.0	0.61	2.31	0.1	0.022		NSH
Co.011	2	(6b)	2.9	0.094	0.037	5.5E-04	22.4	0.61	4.83	0.3	0.030		slow CO startup (60 min)
Co.012	1		3.8	0.083	0.027	4.8E-04	26.3	0.64	4.40			22.5	slow CO startup (60 min)
"	2		4.4	0.085	0.030	5.0E-04	29.1	0.64	1.93	0.3	0.018		NSH
"	3		2.1	0.081	0.026	4.7E-04	28.6	0.66	3.57	0.4	0.049		NSH
"	4		2.5	0.105	0.035	6.2E-04	28.4	0.61	4.94	0.4	0.023		NSH
Co.014	1	(1)	1.5	0.028	0.009	2.8E-04	32.3	0.63	4.70	0.1	0.003		NSH
"	2		2.6	0.034	0.013	3.3E-04	27.7	0.69	10.8	0.1	0.011	26.0	NSH
Co.015	1	(4) s	6.8	0.211	0.063	1.2E-03	26.7	0.60	3.30	0.1	0.011		slow CO startup (120 min)
"	2	f	7.0	0.388	0.135	2.3E-03	26.4	0.64	1.39	0.1	0.011		NSH
Co.016	1	(4a) s	5.2	0.161	0.035	9.4E-04	33.6	0.56	6.85				slow CO startup (30 min)
"	2	f	5.1	0.291	0.112	1.7E-03	25.1	0.68	2.48	0.1	0.01		NSH

Table 5. Summary of Fixed Bed Reaction Results (Continued)

Catalyst	Run	Prep	CO Conv (%)	Rate g CH2/ g cat/hr	R-C6+ g CH2/ g cat/hr	R (Co) mol/mol Co/s	wt% CH4	alpha	C3-C5 Ole/ Par	CO2 (%)	CO2 g/g cat/hr	E act. kcal/ mol	Comment
Co.017	2	(1) s	4.6	0.139	0.066	8.2E-04	22.0	0.69	3.72	0.1	0.012		NS
"	2a	s	3.7	0.111	0.043	6.5E-04	25.9	0.64	4.19	0.1	0.011		CO:H2:Ar = 1:2:2
"	2b	s	3.4	0.102	0.039	6.0E-04	26.9	0.65	4.39	0.1	0.013		+ H2O (eq. 7.5% CO conv.)
Co.018	2	s	3.4	0.170	0.068	1.0E-03	27.2	0.69	2.24	0.1	0.013		NS
"	2a	s	2.7	0.133	0.041	7.8E-04	33.2	0.64	2.52	0.1	0.011		CO:H2:Ar = 1:2:2
"	2b	s	3.0	0.147	0.045	8.6E-04	33.6	0.63	2.41	0.1	0.015		+ H2O (eq. 7.5% CO conv.)
"	3	s	4.1	0.290	0.086	1.7E-03	30.0	0.62	2.34	0.1	0.022		NSH
"	4	s	3.6	0.340	0.180	2.0E-03	25.4	0.80	1.92	0.1	0.041		NSH, 10 atm
"	5	f	7.5	0.470	0.136	2.8E-03	29.0	0.60	1.93	0.3	0.055		NSH
"	6	f	6.5	0.409	0.147	2.4E-03	24.6	0.64	2.42				NSH,S2"
Co.018Cl	1	(1)	4.5	0.320	0.075	1.9E-03	33.5	0.57	1.45	0.1	0.018		NSH
Co.019	1	(1)s	4.4	0.088	0.047	5.2E-04	15.2	0.74	7.61				NS
"	2	s	2.2	0.085	0.046	4.9E-03	18.9	0.73	8.59	0.3	0.040		NSH
"	3	s	3.4	0.142	0.071	8.3E-04	19.3	0.72	6.74	0.2	0.025		NSH
"	3h	f	16.7	0.172	0.091	1.0E-03	18.2	0.74	1.77	1.0	0.034		NSH, high conv. study
Co.020a	1	(4) s	4.6	0.343	0.085	2.0E-03	33.5	0.57	1.70	0.1	0.024		NSH
"	2		4.4	0.315	0.086	1.8E-03	31.2	0.59	1.96	0.1	0.028		NSH
Co.020b	1	(4b) s	4.4	0.311	0.084	1.8E-03	31.7	0.58	1.81	0.2	0.051		NSH
Co.020c	1	(4a) s	4.0	0.287	0.083	1.7E-03	30.4	0.60	2.38	0.1	0.017		NSH
Co.021	1	(6b)	3.4	0.109	0.032	6.4E-04	27.3	0.62	2.78	0.1	0.012	28.2	NSH
"	2		3.6	0.114	0.035	6.7E-04	28.0	0.56	2.69	0.1	0.012		NSH
Co.022	1	(6c)	3.8	0.121	0.037	7.1E-04	26.7	0.55	2.91	0.1	0.015	30.1	NSH
Co.023	1	(6c)	3.8	0.123	0.038	7.2E-04	28.3	0.56	3.18	0.2	0.023	29.5	NSH
Co.024	1	(7)	5.1	0.165	0.047	9.7E-04	32.8	0.62	2.08	0.5	0.055		NSH
"	2		5.7	0.182	0.060	1.1E-03	28.7	0.62	2.25	0.3	0.035		NSH
Co.025	1	(4)	5.0	0.160	0.062	9.4E-04	23.5	0.63	4.13	0.2	0.019	26.9	NSH
Co.026	1	(1)	4.4	0.129	0.043	5.0E-04	26.9	0.62	2.65	0.2	0.022		NSH
"	1h		22.9	0.170	0.072	6.6E-04	22.6	0.67	0.64	1.5	0.037		NSH, high conv. study
Co.027	1	(1)	4.2	0.169	0.068	6.6E-04	23.0	0.65	3.44	0.2	0.026		NSH
"	1h		17.8	0.180	0.085	7.0E-04	19.4	0.71	0.96	1.2	0.011		NSH, high conv. study
Co.028	1	(4)	3.8	0.146	0.076	5.7E-04	18.2	0.76	7.63	0.2	0.031		NSH
"	2		4.3	0.167	0.105	6.5E-04	14.7	0.80	13.2	0.2	0.030	28.4	NSH
"	3		4.5	0.206	0.126	8.0E-04	15.5	0.79	13.4	0.2	0.037		NSH, re-calc. in flow air
Co.029	1	(4)	2.8	0.173	0.105	6.7E-04	15.3	0.79	25.9	0.2	0.026		NSH
Co.031	1	(1)	1.9	0.060	0.022	3.5E-04	26.1	0.64	4.65	0.3	0.031		NSH
Co.032	1	(1)	3.3	0.183	0.079	1.1E-03	22.0	0.70	5.28	0.1	0.022		NSH
Co.033	1	(1)	1.3	0.073	0.027	4.3E-04	24.1	0.67	7.36	0.1	0.020		NSH
Co.034	1	(4)	5.0	0.275	0.107	1.6E-03	24.0	0.67	4.29	0.1	0.018		NSH
Co.035	2	(6)	4.6	0.147	0.068	8.6E-04	22.0	0.69	4.84	0.2	0.019		NSH
Co.036	2	(6c)	3.9	0.125	0.045	7.3E-04	28.9	0.67	4.20	0.1	0.013		NSH
Co.037	1	(4a)	2.7	0.053	0.011	5.2E-04	32.8	0.59	2.82				NSH
Co.038	1	(4a)	4.5	0.051	0.018	4.9E-04	25.1	0.68	4.63	0.3	0.013	24.2	NSH

Table 5. Summary of Fixed Bed Reaction Results (Continued)

Catalyst	Run	Prep	CO Conv (%)	Rate g CH2/ g cat/hr	R-C6+ g CH2/ g cat/hr	R (Co) mol/mol Co/s	wt% CH4	alpha	C3-C5 Ole/ Par	CO2 (%)	CO2 g/g cat/hr	E act. kcal/ mol	Comment
Co.039	1	(5)	1.1	0.021	0.004	2.0E-04	57.2	0.64	0.84	0.2	0.010	25.6	NSH, cracking in the line
"	2		3.9	0.049	0.007	4.7E-04	42.4	0.48	0.95	0.2	0.009		NSH
Co.040	1	(4a)	1.9	0.037	0.004	3.7E-04	45.2	0.53	1.79	0.2	0.007		NSH
"	2		2.8	0.033	0.004	2.0E-04	44.6	0.46	1.12	0.2	0.007		NSH
Co.041	1	(4)	3.5	0.136	0.042	8.0E-04	40.7	0.69	1.47	0.6	0.079		NSH, cracking in the line
Co.043	1	(4a)	4.6	0.104	0.062	6.1E-04	15.3	0.78	12.1	0.6	0.048		NSH, 2.5 hr on-stream
"	2		3.7	0.078	0.045	4.6E-04	16.3	0.78	7.75	0.5	0.035	35.1	NSH
Co.047	1	(4)	6.4	0.263	0.128	1.5E-03	21.3	0.73	7.20	0.3	0.040	26.6	NSH
Co.048	1	(4)	3.5	0.162	0.094	9.5E-04	16.3	0.77	17.1	0.2	0.027	28.0	NSH
Co.049	1	(4)	7.1	0.366	0.153	2.1E-03	23.4	0.69	5.63	0.3	0.043		NSH
"	2		6.0	0.388	0.160	2.3E-03	23.3	0.68	5.93	0.3	0.056		NSH, re-calcined in flow air
"	3	f	6.7	0.410	0.158	2.4E-03	25.2	0.69	4.64	0.3	0.059		NSH
"	3h	f	44.9	0.457	0.178	2.7E-03	26.5	0.67	0.67	3.8	0.131		NSH,HCS
Co.053	1	(1)	7.0	0.408	0.127	2.4E-03	27.3	0.62	3.07	0.2	0.049		NSH
"	1h		28.5	0.417	0.145	2.4E-03	26.8	0.64	0.79	1.6	0.081		NSH, high conv. study
"	2	f	6.6	0.433	0.174	2.5E-03	23.4	0.63	2.35	0.2	0.052		NSH
"	3		7.8	0.453	0.143	2.7E-03	27.6	0.62	1.67	0.1	0.027		NSH
"	3h		31.5	0.457	0.164	2.7E-03	25.4	0.65	0.52	0.9	0.044		NSH, high conv. study
"	4	u	6.1	0.426	0.142	2.5E-03	28.3	0.65	1.41	0.2	0.030		NSH
Co.054	1	(1)	1.2	0.041	0.023	2.4E-04	17.8	0.79	16.3	0.2	0.014		NSH
Co.055	1	(1) f	9.1	0.490	0.159	2.9E-03	28.9	0.63	1.31	0.2	0.034		NSH
"	2	u	4.9	0.290	0.105	1.7E-03	25.7	0.65	1.49	0.2	0.022		NSH, T serge
"	3	u	11.0	0.611	0.193	3.6E-03	29.4	0.60	1.02	0.2	0.033		NSH
CAL.01	1	(1)	4.8	0.181	0.068	1.1E-03	24.4	0.66	5.86	0.3	0.036		NSH, temp. surge (startup)
"	2		7.4	0.491	0.142	2.9E-03	28.7	0.61	2.06	0.4	0.083		NSH
"	3		2.5	0.164	0.053	9.6E-04	25.6	0.63	4.97	0.2	0.052		NSH, HT, re-reduced
"	4		7.3	0.483	0.103	2.8E-03	35.8	0.57	1.21	0.2	0.098		NSH, HT, re-calcined
CAL.02	1	(1)	6.1	0.379	0.121	2.2E-03	27.3	0.63	3.04	0.2	0.040		NSH
CAL.03	1	(1)	7.3	0.459	0.133	2.7E-03	29.0	0.60	2.59	0.2	0.048		NSH
CAL.04	1	(1)	4.1	0.234	0.123	1.4E-03	19.1	0.71	8.98	0.2	0.026		NSH
CAL.05	1	(1)	4.7	0.274	0.134	1.6E-03	20.8	0.75	6.85	0.2	0.026		NSH
CAL.06	1	(1)	5.8	0.267	0.135	1.6E-03	20.7	0.74	5.50	0.2	0.021		NSH
CoW.01	1	(4a)	1.2	0.016	0.003	9.5E-05	30.2	0.58	3.78	0.2	0.006		NSH, reduced at 230 °C
"	1		0.5	0.007	0.001	3.4E-05	42.1	0.51	0.95	0.1	0.003		NSH, re-reduced at 350 °C
"	2		0.2	0.006	0.000	3.4E-05	40.9	0.51	11.3	0.1	0.006		NSH, reduced at 350 °C
CoW.02	1	(4a)	0.3	0.009	0.002	5.4E-05	25.6	0.60	4.94	0.1	0.008		NSH, reduced at 230 °C
CoW.03	1	(4a)											NSH, negligible activity
CoW.04	1	(4a)											S2, negligible activity
CoW.05	1	(4c)	2.8	0.035	0.006	2.1E-04	33.1	0.55	0.66	0.2	0.008		S2, reduced at 350 °C
"	2	u	4.7	0.058	0.011	3.4E-04	34.8	0.50	0.85	0.2	0.009		S2
CoW.06	1	(4a)	3.3	0.041	0.012	2.4E-04	26.0	0.59	2.21	0.2	0.007		S2, reduced at 250 °C
"	2	u	2.6	0.032	0.004	1.9E-04	39.3	0.46	0.99	0.3	0.012		S2
"	2		17.0	0.207	0.004	1.2E-03	68.7	0.32	0.37	1.7	0.07		S2, rxn. at 280 °C
UOP	1	(1)	7.8	0.298	0.104	1.7E-03	22.6	0.61	1.29	0.2	0.023		NSH

Table 5. Summary of Fixed Bed Reaction Results (Continued)

All the reactions are carried out at 220 deg. C , 1 atm , and with H2:CO=2

All the catalysts are reduced and passivated before loading into reactor, then rereduced in-situ

All catalysts are calcined at UPARC (static) : except where specified in prep. column

s : calcined at Pitt, static

f : calcined at Pitt, flow

u : uncalcined

In some cases, "re-calcined" means calcination of the calcined catalyst from UPARC for a longer period

(1) single step, aqueous incipient wetness
(2) Two step impregnation: aqueous incipient wetness of Co + acetone/ethanol impregnation of Ru, La
(3) three step, with calcination after each step, acetone incipient wetness
(4) two step, aqueous incipient wetness, (a) intermediate calcination, (b) intermediate reduction, (c) intermediate calcination 750 °C
(5) single step, acetone impregnation
(6) single step, aqueous kneading, (a) = 150%, (b) = 110% of pore volume
(6c) aqueous kneading for Co, calcined, then aqueous incipient wetness for Zr
(7) Two step impregnation :organic incipient wetness + aqueous incipient wetness

* New startup
** New startup, heated inlet
" was done in the second system
~ Davison Grade 59 Silica, if not specified, S refers Davison Grade 952 Silica
# corrected overheated line on 3/6/1994
Cl chlorinated (see Co.018Cl)

Table 6

DATE: 09/30/94

COMPARISON OF CONVERSION AND SELECTIVITY OF

METHANE REDUCTION CATALYSTS AT STARTUP CONDITIONS

Period No.	Temp.	Pres.	H2/CO Ratio
1	240 C	450psi	2.0

Run No	Cat. No	Cat. wt,g	Conv. %	Prod. Rate	Selectivities %CH4	%C2	%C3+	%CO2	Alpha GC	Alpha Liq	Catalyst Prom%	Composit. Metal%	Suppt
M-4	SBCR												
3	Co.002	15.2	29.4	1.42	17.3	2.3	79.4	1.01	0.73	0.82	1.0La	0.43Ru	Al
14	BlendA	20.0	29.3	1.41	10.1	1.6	86.3	2.02	0.77	0.86	5.0Cu	4.0Cr	Al
15	Co.034	13.0	27.5	1.54	10.4	1.6	87.2	0.80	0.78	0.84	8.5Zr	0.0	Al
16	CAL.04	16.1	26.3	1.34	7.1	1.3	90.3	1.38	0.80	0.85	0.3K	0.5Ru	Al
17	CAL.08	15.0	16.9	0.93	5.9	0.8	91.7	1.36	0.82	0.88	0.3K	0.5Ru	Al
18	CAL.07	15.0	20.6	1.03	7.7	1.2	90.0	1.09	0.81	0.88	0.3K	0.5Ru	Al
19	CAL.05	15.7	26.6	1.22	7.3	1.3	90.2	1.19	0.82	0.86	0.3K	0.5Ru	Al
20	CAL.06	15.0	5.6	0.26	3.1	2.1	92.0	2.86	0.80	0.90	0.3K	0.5Ru	Al
21	CO.004	15.9	39.3	1.80	15.2	2.3	81.2	1.38	0.74	0.80	1.0La	0.43Ru	Al

Note: Catalysts for all runs except Run 8 screened thru 150 x 400 mesh.
Blend A contains 15.0 gm of Cat. No. Co.005 plus 5.0 gm of Cat. No. WGS.03.
Cat. Nos. CAL.07 and CAL.08 were prereduced and wax coated.
H2 to CO ratio for Runs 16 and 17 was 1.76/1.0.
Cat. No. CAL.06 was H2 reduced and air stabilized.

Table 7

DATE: 09/30/94

COMPARISON OF CONVERSION AND SELECTIVITY OF

CALSICAT PRODUCED CATALYSTS AT STARTUP CONDITIONS

Period No.	Temp.	Pres.	H2/CO Ratio
1	240 C	450psi	2.0

a) Total flow is ca.15 L/min. STP, or 3 cm/sec linear gas flow.
Flows: N2-563 SLH, H2-225 SLH, CO-112.5 SLH
b) Conversion is total CO conversion over the period (%).
c) Conversion and selectivities are calculated using N2 as an internal standard in the GC analysis of the offgas.
d) Prod. rate: Rate for production of total hydrocarbons C1+ (kg/kg cat.,hr).
e) Alpha: Based on GC analysis of offgas and liquid product.

Run No	Cat. No	Cat. wt,g	Conv. %	Prod. Rate	Selectivities %CH4	%C2	%C3+	%CO2	Alpha GC	Alpha Liq	Catalyst Prom%	Composit. Metal%	Suppt
M-4 SBCR													
10	CAL.02	15.9	34.5	1.58	12.9	2.0	83.9	1.23	0.75	0.81	0.0	0.5Ru	Al
11	CAL.03	15.6	29.7	1.39	13.5	2.1	83.4	1.08	0.74	0.86	0.0	0.5Ru	Al
16	CAL.04	16.1	26.3	1.34	7.1	1.3	90.3	1.38	0.80	0.85	0.3K	0.5Ru	Al
17	CAL.08	15.0	16.9	0.93	5.9	0.8	91.7	1.36	0.82	0.88	0.3K	0.5Ru	Al
18	CAL.07	15.0	20.6	1.03	7.7	1.2	90.0	1.09	0.81	0.88	0.3K	0.5Ru	Al
19	CAL.05	15.7	26.6	1.22	7.3	1.3	90.2	1.19	0.82	0.86	0.3K	0.5Ru	Al
20	CAL.06	15.0	5.6	0.26	3.1	2.1	92.0	2.86	0.80	0.90	0.3K	0.5Ru	Al
M-3 SBCR													
12	C0.018	15.6	33.8	1.56	9.7	2.0	86.6	1.68	0.75	0.85	0.0	0.5Ru	Al
23	CO.047	15.8	28.2	1.29	7.7	1.5	89.3	1.47	0.79	0.84	0.3K	0.5Ru	Al

Note: Catalysts for all runs except Runs 17,18,& 20 screened thru 150 x 400 mesh.
Catalyst CAL.04 was calcined in air; Catalyst CAL.05 processed in N2.
Cat. No. CAL.06 was H2 reduced and air stabilized before charging.
Cat. Nos. CAL.08 and CAL.07 were prereduced and wax coated. CAL.08 was calcined in N2 ; CAL.07 was reduced in H2 without prior calcination.
H2 to CO ratio for Runs 16 and 17 was 1.76/1.
Cat. Nos. Co.018 & Co.047 were prepared by Pitt. Shown for comparison.

Table 8

HIGH SYNGAS CONVERSION TEST: RUN 29-M3

Period No.	Temp. °C	Pressure psi	H_2/CO Ratio	CO Conv. %	Prod.Rate $KgC_1+/Kg, Hr$	Selectivities % CH_4	Selectivities % C_3+
1	240	450	2.0	42.0	1.19	15.8	79.5
2	220	450	2.0	20.5	0.59	5.7	89.0
3	240	450	2.0	39.2	1.13	15.8	79.2
4	240	450	1.0	18.4	0.79	5.3	90.6
5	240	600	1.0	19.7	0.85	4.6	92.9
6	240	600	2.0	40.8	1.17	14.8	81.4
7	240	450	2.0 (1)	31.5	0.45	21.0	72.2
8	260	450	2.0 (1)	31.0	0.44	36.4	52.6
9	240	450	2.0	18.0	0.55	23.0	72.1
10	240	450	2.0 (2)	21.6	0.98	14.4	82.4

Notes:

(1) Feed gas composition: N_2-80%, H_2-13.5%, CO-6.5%
(2) Feed gas composition: N_2-40%, H_2-40%, CO-20%
All other periods: N_2-60%, H_2-33%, CO-17%

Table 9

SBCR CATALYST EXTRACTIONS

Catalyst No. (Support)	Run No.	Charge (H_2 Reduced) wt, gm	Recovered (Oxidized) wt, gm	Charge Particle Size, mvd, microns	Charge Particle Size at 10% microns	Recovered Particle Size, mvd, microns	Recovered Particle Size at 10% microns	Reduction in Particle Size, %
Co.001 (Al)	1	14.5	12.63	42.02	24.25	41.06	23.62	2.3
Co.001 (Al)	2	16.5	15.18	42.02	24.25	40.09	22.86	4.6
Co.005 (Al)	3	19.5	18.41	85.66	30.46	64.53	31.27	24.7
Co.002 (Al)	4	20.1	20.4	73.61	32.86	71.19	33.50	3.3
Co.003 (Al)	5	15.1	14.54	76.81	34.40	72.57	34.25	5.5
Co.011 (Si)	6	15.3	16.03	107.09 (1)	53.19	94.02	40.44	12.2
Co.012 (Si)	7	15.8	14.73	105.22 (1)	51.33	101.37	44.44	3.7
Co.015 (Al)	8	15.0	15.52	75.63 (1)	33.15	74.68	32.68	1.3
Co.011 (Si)	9	15.0	15.92	79.88 (2)	48.31	72.44	36.31	9.3
Co.016 (Al)	10	15.5	15.72	64.60 (2)	32.16	64.38	32.78	0.3
Co.017 (Al)	11	15.0	15.09	73.14 (3)	36.29	69.95	35.62	4.4
Co.018 (Al)	12	15.6	16.97	62.89 (3)	32.56	68.16	34.74	--
Co.016 (Al)	13	14.7	13.30	67.69 (3)	35.05	64.79	34.20	4.3
Co.019 (Si)	14	15.2	15.00	92.63 (3)	42.73	84.39	36.52	8.9
Co.005 (Al)	15	14.7	15.30	80.62 (3)	45.07	71.90	36.79	10.8
Co.002 (Al)	16	15.4	14.98	73.61 (3)	32.86	67.62	32.67	8.1
Co.002 (Al)	1 (M4)	15.0	11.00	73.61 (3)	32.86	66.26	35.75	10.0
Co.025 (Si)	17	15.6	14.60	87.19 (3)	47.35	78.31	36.27	10.2
Co.004 (Al)	18	15.0	15.25	78.12 (3)	44.15	66.86	33.83	14.4
Co.021 (Si)	19	15.6	16.06	86.18 (3)	46.54	77.95	35.59	9.55
Co.041 (Si)	20	15.8	17.02	87.48 (3)	49.26	68.74	26.72	17.0
Co.021 (Si)	3 (M4)	15.2	15.1	73.61 (3)	24.46	71.38	32.33	3.03
Co.024 (Al)	4 (M4)	15.4	(4)	--	--	--	--	--
Co.035 (Si)	5 (M4)	15.4	14.08	89.14 (3)	49.29	74.76	31.67	19.2
Co.028 (Al)	6 (M4)	15.4	15.7	80.83 (3)	44.81	71.83	36.34	11.1

(1) Screened through 100x400 mesh screens.
(2) Screened through 170x400 mesh screens.
(3) Screened through 150x400 mesh screens.
(4) Did not filter, too waxy

Note: The charge weights are in the hydrogen-reduced state and the recovered weights are in the oxidized state. The particle size is reported as the mean volume diameter (mvd) as measured by a Microtrac particle size analyzer.

Table 9
(Continued)

SBCR CATALYST EXTRACTIONS

Catalyst No. (Support)	Run No.	Charge (H_2 Reduced) wt, gm	Recovered (Oxidized) wt, gm	Charge Particle Size, mvd, microns	Charge Particle Size at 10% microns	Recovered Particle Size, mvd. microns	Recovered Particle Size at 10% microns	Reduction in Particle Size, %
Co.014 (Ti)	21	15.1	15.1	111.70 (1)	32.65	106.66	33.49	4.51
Co.040 (Ti)	22	14.5	8.5	(5)	(5)	130.40	51.40	--
Co.047 (Al)	23	15.8	16.95	83.42 (3)	44.41	76.46	39.02	8.34
Co.049 (Al)	24	15.6	16.54	81.3 (3)	42.39	70.11	35.87	13.8
Co.047 (Al)	25	15.6	16.69	79.36 (3)	41.72	69.09	36.16	12.94
Co.031 (Al)	26	15.9	15.37	75.48 (3)	38.34	68.42	35.39	9.35
Co.029 (Al)	27	15.9	18.28	76.39 (3)	39.56	68.72	36.04	10.04
Co.043 (Si)	7 (M4)	15.4	15.1	(5)	(5)	85.51	40.20	--
Co.006 (Ti)	8 (M4)	15.0	9.09	121.38 (1)	52.80	99.31	38.62	18.2
Co.048 (Si)	9 (M4)	15.4	15.85	82.40 (3)	40.94	70.69	25.53	14.2
CAL.02 (Al)	10 (M4)	15.9	16.42	74.40 (3)	37.79	65.89	34.14	11.44
Co.053 (Al)	12 (M4)	15.9	16.95	82.02 (3)	43.10	69.53	35.76	15.23
Co.054 (Si)	13 (M4)	15.7	17.09	101.17 (3)	57.54	82.37	37.89	18.58
Blend A (Al)	14 (M4)	20.0	14.61	86.23 (3)	46.36	77.43	42.81	10.21
Co.034 (Al)	15 (M4)	13.0	9.52	(5)	(5)	88.26	45.28	--
CAL.04 (Al)	16 (M4)	16.1	21.78	71.54 (3)	36.28	66.50	32.82	7.05
CAL.08 (Al)	17 (M4)	15.0 (6)	14.27	63.12	25.60	62.80	26.03	0.51
CAL.07 (Al)	18 (M4)	14.5 (6)	13.37	--	--	67.02	28.12	--
CAL.05 (Al)	19 (M4)	15.7	5.62	72.75	36.90	71.62	36.55	1.55
CAL.06 (Al)	20 (M4)	15.0	(7)	72.62	37.33	--	--	--
Co.053 (Al)	29 (M3)	25.2	25.8	75.63	40.80	71.09	38.20	6.00
Co.004 (Al)	21 (M4)	15.9	15.04	81.38	41.82	72.88	37.61	10.44

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(1) Screened through 100x400 mesh screens.
(3) Screened through 150x400 mesh screens.
(5) Insufficient feed sample.
(6) Wax coated.
(7) Lost catalyst.