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Effects of Co/Ce molar ratio and Operating Temperature on Nanocatalyst Performance in the Fischer-Tropsch Synthesis

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Table S_1: Average crystalline size of iron-cobalt-cerium three metals nanocatalyst synthesized at various amount of Co and Ce molar ratios from XRD and SEM.

Sample number	Fe-Co-Ce Molar ratio	Average Crystalline size (nm) by XRD	SEM (nm)
1	1:1:1	4.5	25
2	1:1:1/2	4.7	26
3	1:1:1/4	5.7	32
4	1:1/2:1	7.9	37
5	1:1/4:1	7.2	47
6	Used catalyst	62.6	-

Table S_2: EDS data of iron-cobalt-cerium three metals nanocatalyst at various Co and Ce molar ratios.

Sample Fe:Co:Ce	Atomic % Weight %	O %	Fe %	Ce %	Co %
1:1:1		57.8	5.66	13.4	7.61
		24.5	8.39	50.0	11.9
1:1:1/2		62.2	8.12	8.86	7.78
		30.1	13.7	37.5	13.8
1:1:1/4		51.5	12.9	4.46	16.2
		24.9	21.8	18.8	28.9
1:1/2:1		59.2	12.9	10.7	6.43
		25.7	19.6	40.8	10.2
1:1/4:1		62.8	3.83	10.2	1.29
		33.5	7.13	47.9	2.53

Table S_3: Magnetic properties of iron-cobalt-cerium three metals nanocatalysts synthesized at various Co and Ce molar ratios.

Sample number	Fe-Co-Ce Molar ratio	Saturation magnetization (Ms)/emu g^{-1}	Coercivity (Hc) Oe	Residual Magnetization (Mr)/emu g^{-1}	(R= Mr/Ms)
1	1:1:1	7.768	75.28	2.449	0.315
2	1:1:1/2	10.078	449.5	2.637	0.261
3	1:1:1/4	19.050	393.6	5.018	0.263
4	1:1/2:1	9.715	970.1	3.945	0.406
5	1:1/4:1	11.497	45.17	2.831	0.246

Table S_4. Effect of 1:1:1 molar ratio of iron-cobalt-cerium three metals and operating temperature on nanocatalyst performance for product selectivity.

					Hydrocarbon Selectivity (%)								
Fe:Co:Ce Molar ratio	Operating Temperature (0C)	Operating Pressure (bar)	CO Conversion (%)	H_2 Conversion (%)	CH_4	C_2H_6	C_2H_4	C_3H_8	C_3H_6	C_4H_8	C_4H_{10}	C_5+	CO_2
1:1:1	270	2	78	89.2	62.4	4.24	0	6.9	20.11	0	5.7	0	0
	300	2	26.4	44.3	30.1	4.75	0.06	6.75	17.1	5.17	4.29	0	1.21
	330	2	34.3	58.5	47.6	8.34	1.67	6.54	17.6	3.54	2.9	5.19	2.33
	350	2	39	66.4	51.9	10.6	4.76	6.48	15.4	2.83	2.62	1.3	2.64
	380	2	43	71	54.8	11.2	5.99	5.39	14.1	1.14	1.74	1.2	2.86
	400	2	49.5	75.5	56.5	11.4	5.02	3.5	10.7	0.69	1.45	0.99	4.62

Table S_5. Effect of 1:1/2:1 molar ratio of iron-cobalt-cerium three metals and operating temperature on nanocatalyst performance for product selectivity.

					Hydrocarbon Selectivity (%)								
Fe:Co:Ce Molar ratio	Operating Temperature (0C)	Operating Pressure (bar)	CO Conversion (%)	H2 Conversion (%)	CH_4	C_2H_6	C_2H_4	C_3H_8	C_3H_6	C_4H_8	C_4H_{10}	C_5+	CO_2
1:1/2:1	270	2	76	81	60.1	5.3	0	0	21.39	3.98	0	9.23	0
	300	2	29	49.81	54.1	7.11	0.62	0	19.57	5.63	0	3.62	1.2
	330	2	35	59.2	62.2	7.53	1.03	0	20.1	5.15	0	2.29	1.6
	350	2	39.2	63.8	62.8	8.48	1.34	1.48	15.5	4.68	0.51	2	1.81
	380	2	47.9	72.6	63.2	8.87	7.16	1	14.76	1.47	0.2	1.2	2.1
	400	2	69.7	87.1	70.4	9.49	6.86	0.68	5.13	0.05	0	1.05	5.6

Table S_6. Effect of 1:1/4:1 molar ratio of iron-cobalt-cerium three metals and operating temperature on nanocatalyst performance for product selectivity.

					Hydrocarbon Selectivity (%)								
Fe:Co:Ce Molar ratio	Operating Temperature (0C)	Operating Pressure (bar)	CO Conversion (%)	H2 Conversion (%)	CH_4	C_2H_6	C_2H_4	C_3H_8	C_3H_6	C_4H_8	C_4H_{10}	C_5+	CO_2
1:1/4:1	270	2	81	87.1	72.4	0	0	0	0	0	0	0	0
	300	2	33.4	50.2	50.6	5.62	0.64	0	15.24	0	0	0	0.03
	330	2	35.7	54.8	58.5	7.8	1.07	0	15.14	2.96	0	0.021	1.35
	350	2	42.6	63.7	59.2	9.67	7.36	3.9	15.3	2.68	0	0.08	1.52
	380	2	45	68.3	60.3	10.5	7.1	2.2	12.42	1.23	0	0.97	2.23
	400	2	50.2	74.9	61.5	11.37	8.43	1.13	11.48	0.06	0	1.69	3.87

Table S_7. Effect of 1:1:1/2 molar ratio of iron-cobalt-cerium three metals and operating temperature on nanocatalyst performance for product selectivity.

					Hydrocarbon Selectivity (%)								
Fe:Co:Ce Molar ratio	Operating Temperature (0C)	Operating Pressure (bar)	CO Conversion (%)	H2 Conversion (%)	CH_4	C_2H_6	C_2H_4	C_3H_8	C_3H_6	C_4H_8	C_4H_{10}	C_5+	CO_2
1:1:1/2	270	2	78.9	87.1	73	9.27	0	0	0	0	0	7.63	0
	300	2	26.4	38.9	44.8	10.68	0	13.04	13	3.52	0	8.8	0
	330	2	30.6	46.1	47.6	11	0.04	6.06	19.57	4.52	3.23	5.6	1.98
	350	2	41.6	56.7	49.8	12.79	4.64	5.5	11.98	1.9	2.17	2.29	3.2
	380	2	47.3	62.8	56.7	12.95	2.98	4.93	8.17	1.25	0.51	1.61	6.72
	400	2	60.2	73.5	68.9	13.12	1.76	2.99	1.85	0.74	0	0.89	9.1

Table S_8. Effect of 1:1:1/4 molar ratio of iron-cobalt-cerium three metals and operating temperature on nanocatalyst performance for product selectivity.

					Hydrocarbon Selectivity (%)								
Fe:Co:Ce Molar ratio	Operating Temperature (0C)	Operating Pressure (bar)	CO Conversion (%)	H2 Conversion (%)	CH_4	C_2H_6	C_2H_4	C_3H_8	C_3H_6	C_4H_8	C_4H_{10}	C_5+	CO_2
1:1:1/4	270	2	72.7	74.7	46.3	10.13	0	19.79	9.29	0	8.97	5.16	0
	300	2	41.63	49.2	40.8	12.54	6.6	4.54	19.97	7.21	2.74	4.89	0.47
	330	2	49.3	54.8	47.3	12.76	4.28	4.7	15.79	4.05	2.78	4.2	3.74
	350	2	54	65.1	50.1	13.2	4.49	4.95	13.43	2.23	1.12	3.62	6.69
	380	2	58.2	69.6	57.7	13.86	1.61	4.52	8.92	1.02	0.78	2.19	8.3
	400	2	66.3	72.9	65.41	14.13	1.35	4.65	4.45	0.709	0	0.02	9.1