Supporting information

Carbon-based catalysts for Fischer Tropsch synthesis

Yanping Chen*[a], Jiatong Wei[a,c], Melis S. Duyar [d], Vitaly V. Ordomsky*[b], Andrei Y. Khodakov[b] and Jian Liu*[a,d]

[a]State Key Laboratory of Catalysis, iChEM, Dalian Institute of Chemical Physics, Chinese Academy of Sciences, Dalian 116023, Liaoning, China.

Email: chenyp@dicp.ac.cn

vitaly.ordomsky@univ-lille.fr

jian.liu@surrey.ac.uk

[b]Univ. Lille, CNRS, Centrale Lille, ENSCL, Univ. Artois, UMR 8181 – UCCS – Unité de Catalyse et Chimie du Solide, F-59000 Lille, France

[c]Institute of Chemistry for Functionalized Materials, School of Chemistry and Chemical Engineering, Liaoning Normal University, 850 Huanghe Road, Dalian 116029, China.

[d]DICP-Surrey Joint Centre for Future Materials, Department of Chemical and Process Engineering, and Advanced Technology Institute, University of Surrey, Guildford, Surrey GU2 7XH, UK.

Table S1 Catalytic data of representative activated carbon supported cobalt catalysts for Fischer Tropsch synthesis.

Catalysts	Reaction conditions				CO conv. /%	C sel./%					MTY/10^{-5} mol_{CO} g_{Co}^{-1} s^{-1}	Ref
	T/ ℃	H_2/ CO	P/ MPa	GHSV/L $g_{cat}^{-1}h^{-1}$		CO_2	CH_4	C_2-C_4	CH_5+	ROH		
15Co/AC					65.2	2.1	22.6	19.2	36.0	20.1	0.36	1
15Co-0.2Al_2O_3/AC					68.5	2.0	21.0	11.9	37.4	27.7	0.38	1
15Co-0.9Al_2O_3/AC	220	3	2	0.2	79.0	2.4	14.8	8.7	52.4	21.7	0.44	1
15Co-1.9Al_2O_3/AC					84.9	2.9	13.2	6.2	58.9	18.8	0.47	1
15Co-3.8Al_2O_3/AC					82.8	4.1	16.8	7.5	56.6	15.0	0.46	1
15Co/AC					13.5	8.6	31.7	37.5	–	22.2	0.56	2
15Co-0.1La/AC					16.8	6.5	27.2	32.8	–	33.5	0.69	2
15Co-0.5La/AC	222	1.5	2	0.2	21.4	5.1	23.8	32.2	–	38.9	0.88	2
15Co-1.0La/AC					16.9	6.1	24.2	31.8	–	37.9	0.70	2
15Co-2.0La/AC					8.0	7.4	31.4	24.1	–	37.1	0.33	2
15Co/AC					31.7	0.8	53.9(C_1-C_4)[a]		25.1	20.2	0.44	3
15Co-0.1Li/AC	220	3	2	0.5	18.7	1.4	44.8(C_1-C_4)		26.1	27.7	0.26	3
15Co-1.0Li/AC					14.2	1.9	38.8(C_1-C_4)		26.8	32.5	0.20	3
15Co-2.0Li/AC					11.9	2.2	29.3(C_1-C_4)		34.2	34.3	0.16	3
15Co/AC					24.2	0.4	43.0(C_1-C_4)		39.1	17.5	2.67	4
15Co-0.5Fe/AC					27.4	0.7	44.0(C_1-C_4)		35.0	20.2	3.02	4
15Co-1Fe/AC	220	3	2	4.0	24.8	1.0	55.0(C_1-C_4)		23.1	20.9	2.73	4
15Co-3Fe/AC					14.8	1.7	58.3(C_1-C_4)		17.8	22.3	1.63	4
15Co-5Fe/AC					16.4	1.6	57.8(C_1-C_4)		20.0	20.6	1.81	4
15Co/AC					64.3	1.5	37.7(C_1-C_4)		45.3	15.4	1.59	5
15Co-0.05Ca/AC	220	3	2	0.9	56.2	1.4	32.7(C_1-C_4)		42.5	23.5	1.39	5
15Co-0.1Ca/AC					49.0	0.7	29.9(C_1-C_4)		38.8	30.6	1.22	5
15Co-0.5Ca/AC					24.7	1.3	48.0(C_1-C_4)		21.4	29.3	0.61	5
15Co-1Zr-0.5La/AC-H					55.0	3.7	75.6(Hydrocarbons)			21.7	0.76	6
15Co-1Zr-0.5La/AC-S					21.5	6.4	71.1(Hydrocarbons)			22.5	0.30	6
15Co-0.5La/AC	225	3	2	0.5	58.0	2.0	77.6(Hydrocarbons)			20.4	0.80	6
15Co/AC					74.0	4.4	82.4(Hydrocarbons)			13.2	1.02	6
15Co-1Zr-0.5La/Al					84.0	12.3	83.4(Hydrocarbons)			4.5	1.16	6
15Co/AC					28.9	0.6	23.1	23.5	32.0	20.8	1.59	7
15Co-1Cr/AC					35.0	0.5	21.3	22.7	36.6	18.9	1.93	7
15Co-2Cr/AC	220	3	2	2.0	47.0	0.6	20.8	21.7	41.4	15.5	2.59	7
15Co-3Cr/AC					45.6	0.5	18.1	20.3	42.5	18.6	2.51	7
15Co-5Cr/AC					30.1	0.8	20.4	24.5	35.8	18.5	1.66	7
10Co-0.5Mn-0.1La/AC					14.8	0.9	11.7	35.0	31.0	21.4	1.22	8
10Co-0.5Mn-0.5La/AC					20.8	2.0	10.2	33.6	29.4	24.5	1.72	8
10Co-1Mn-0.1La/AC	220	3	2	2.0	21.0	1.1	9.4	32.6	34.1	22.9	1.74	8
10Co-1Mn-0.5La/AC					23.0	2.5	9.0	31.3	32.1	25.1	1.90	8
10Co-1Mn-1La/AC					14.7	3.1	12.0	34.4	25.3	25.2	1.22	8

10Co-0.5Mn-1La/AC					8.3	2.5	18.3	34.4	18.0	26.8	0.69	8
10Co/AC					49.7	–	18.5	18.2	63.3	–	1.12	9
10Co-4Zr/AC					86.4	–	14.2	14.8	71.0	–	1.11	9
10Co-4Zr-0.1La/AC					90.7	–	13.7	14.2	72.1	–	0.68	9
10Co-4Zr-0.2La/AC	250	3	2	0.5	92.3	–	11.5	13.8	74.7	–	1.12	9
10Co-4Zr-0.3La/AC					87.9	–	12.1	14.6	73.3	–	1.11	9
10Co-4Zr-0.5La/AC					85.1	–	14.4	15.2	70.4	–	0.68	9
10Co-4Zr-1.0La/AC					75.9	–	16.7	17.1	66.2	–	1.12	9
15Co/AC					38.9	–	20.4	18.2	61.4	–	0.54	10
15Co-0.5V/AC					45.3	–	12.1	15.9	72	–	0.62	10
15Co-1V/AC	220	3	2	0.5	56.5	–	13.9	17.5	68.6	–	0.78	10
15Co-2V/AC					73.1	–	15.3	18.8	65.9	–	1.01	10
15Co-4V/AC					87.4	–	18.4	18.7	62.9	–	1.20	10
								C_2+ paraffins[b]	Olefin	ROH		
15Co/AC					47.5	0.7	22.9	47.1	14.7	14.6	2.62	11
15Co0.5Mn/AC	220	3	2	2.0	40.5	1.8	8.6	29.0	41.4	19.2	2.23	11
15Co1Mn/AC					29.1	2.4	8.1	29.6	38.5	21.4	1.60	11
15Co2Mn/AC					14.3	3.1	9.7	25.7	41.7	19.8	0.79	11

GHSV=Gas hourly space velocity(L g_{cat}^{-1} h^{-1}); TOS=Time on stream(h); CO conv.=CO conversion(%); C_2-C_4=Hydrocarbons with carbon number of 2-4; CH_5+=Hydrocarbons with carbon number above 5; ROH=Alcohol selectivity; MTY=Cobalt time yield($10^{-5}mol_{CO}$ g_{Co}^{-1} s^{-1}); [a]C_1-C_4=Hydrocarbons with carbon number of 1-4; [b]C_2+ Paraffins=Paraffins with carbon number above 2.

Table S2 Catalytic data of representative carbon nanotubes, carbon nanofibers, and carbon spheres supported and MOF-derived cobalt catalysts for Fischer Tropsch synthesis.

Catalysts	Reaction conditions				CO conv. /%	CO_2 sel. /%	CH sel. /%			MTY/ $10^{-5}mol_{CO}$ g_{Co}^{-1} s^{-1}	Ref
	T/ ℃	H_2/ CO	P/ MPa	GHSV/L $g_{cat}^{-1}h^{-1}$			CH_4	C_2-C_4	CH_5+		
10Co/CNT					22.0	–	16.0	9.0	75.0	3.27	12
10Co/CNT-cold acid	220	2	2	3.6	35.0	–	21.0	6.0	73.0	5.21	12
10Co/CNT-hot acid					50.0	–	25.0	7.0	68.0	7.44	12
15Co/CNT-CSTR	220	2	2.5	–	45.0	–	10.0	10.0	80.0	1.49	13

25Co/CNT-CSTR					68.0	–	10.0	8.0	82.0	1.35	13
35Co/CNT-CSTR					77.0	–	9.0	6.0	85.0	1.09	13
15Co/CNT	225	0.8	2	3.8	25.9	–	30.6	7.4	62.0	2.74	14
15Co-in-CNT					26.1	–	25.9	7.5	66.6	2.76	14
15Co-out-CNT					23.2	–	31.1	8.8	60.1	2.46	14
15Co-out-CNT-300					9.0	–	12.4	3.0	84.6	0.95	14
15Co/CNF					23.0	–	35.1	8.7	56.2	2.43	14
15Co/CMC					4.4	–	2.0	1.2	96.8	0.47	14
13.2Co/CNT-IM	225	0.8	2	3.8	25.9	–	30.6	7.4	62.1	3.11	15
4.3Co/CNT-DP					9.9	–	23.5	4.4	72.1	3.65	15
5.2Co/CS-IM					2.6	–	0.6	0.3	99.1	0.79	15
1.5Co/CS-IM					3.7	–	4.0	1.2	94.8	3.92	15
9Co/CNT-H_2O	220	2	2	2.0	29.0	–	4.0	5.0	91.0	2.66	16
9Co/CNT-EtOH					42.0	–	5.0	5.0	90.0	3.86	16
9Co/CNT-PrOH					37.0	–	6.0	6.0	88.0	3.40	16
9Co/CNT-GPO-H_2O					16.0	–	11.0	7.0	82.0	1.47	16
9Co/CNT-GPO-EtOH					21.0	–	11.0	7.0	82.0	1.93	16
9Co/CNT-GPO-PrOH					20.0	–	10.0	7.0	83.0	1.84	16
15Co/CNT-Al_2O_3	220	0.1	2	–	18.8	–	48.4	20.3	29.1	–	17
15Co/CNT-MgO					12.2	–	34.3	25.8	41.3	–	17
15Co/Al_2O_3					12.6	–	60.3	19.4	17.9	–	17
15Co/MgO					16.1	–	22.7	35.2	38.0	–	17
15Co/FM	220	2	2	0.1	54.0	–	22.0	10.0	68.0	1.10	18
15Co/CNT					38.0	–	14.0	4.0	82.0	0.67	18
15Co/CNF					20.0	–	0.0	6.0	94.0	0.20	18
10Co/MWCNT	220	2	2	5.0	27.2	–	6.0	6.6	87.4	5.60	19
10Co/MWCNT-HNO_3-10					34.4	–	5.8	9.8	84.4	7.10	19
10CoMWCNT-HNO_3-50					33.6	–	10.2	14.8	75.0	6.90	19
12Co/CNF	220	0.1	2	9.4	–	–	44.0	34.0	22.0	2.90	20
12Co0.15Mn/CNF					–	–	32.0	38.0	30.0	3.80	20
12Co0.6Mn/CNF					–	–	22.0	38.0	40.0	2.70	20
12Co1.2Mn/CNF					–	–	19.0	37.0	44.0	1.50	20
12Co2.4Mn/CNF					–	–	18.0	34.0	48.0	0.30	20
9.5Co/CNF	220	2	2	–	60.0	–	18.0	8.0	74.0	4.10	21
9.5Co0.028Mn/CNF					60.0	–	14.0	8.0	78.0	5.10	21
9.5Co0.13Mn/CNF					60.0	–	15.0	8.0	77.0	6.80	21
9.5Co0.3Mn/CNF					60.0	–	20.0	14.0	66.0	5.80	21
9.5Co1.1Mn/CNF					60.0	–	21.0	27.0	52.0	2.70	21
11Co/CNF-L	220	2	0.1	–	2.0	–	40.0	37.0	23.0	0.64	22
15Co/CNF-H					2.0	–	20.0	27.0	53.0	1.24	22
14.8Co@C-400	270	2	2	3.6	20.1	17.1	21.2	45.1	33.7	2.02	23
14.8Co@C-600					78.6	15.3	13.6	29.6	56.8	7.90	23

14.8Co@C-800					60.3	18.9	15.3	31.8	52.9	6.07	23
10Co/HCS					26.0	–	13.4	7.9	78.7	2.70	24
10Co/N-HCS-600	220	1	2	5.4	30.0	–	18.5	18.3	63.2	3.10	24
10Co/N-HCS-900					34.0	–	15.7	8.5	75.8	3.50	24
79Co1K/C					4.0	–	37.0	44.0	12.0	1.12	25
70Co5K/C	300	4	1	36.0	1.0	–	27.0	22.0	16.0	0.32	25
70Co10K/C					1.0	–	27.0	44.0	4.0	0.32	25
50Co@C-0CTAB					35.6	1.8	26.0	10.9	63.1	2.00	26
51Co@C-2CTAB					34.2	1.2	23.3	11.9	64.8	1.86	26
50Co@C-4CTAB	230	2	2	6.8	36.2	1.9	26.7	11.2	62.1	2.04	26
51Co@C-8CTAB					40.1	1.8	26.2	11.3	62.5	2.21	26
49Co@C-16CTAB					30.7	1.8	24.3	10.6	65.1	1.76	26
5Co@MIL-53(Al)-MW1					50.0	4.5	12.3	13.3	74.4	2.37	27
5Co@MIL-53(Al)-MW2	240	2	2	0.67	50.0	6.3	22.0	20.7	57.3	2.71	27
5Co@MIL-53(Al)-SV					24.0	5.5	13.3	19.0	67.7	1.19	27
33Co/C-450					17.0	–	56.0	10.0	34.0	1.19	28
44Co/C-500					60.0	–	27.0	13.0	60.0	3.13	28
50Co/C-550					50.0	–	27.0	14.0	59.0	2.32	28
50Co/C-600	235	1	2	5.6	49.0	–	32.0	15.0	53.0	2.25	28
57Co/C-700					30.0	–	38.0	19.0	43.0	1.21	28
63Co/C-800					17.0	–	31.0	20.0	49.0	0.62	28
63Co/C-900					5.0	–	33.0	20.0	47.0	0.18	28
25Co@C-400					12.6	6.9	27.4	20.3	52.3	4.45	29
32Co@C-450					18.6	6.5	21.9	17.7	60.4	32.10	29
32Co@C-500	260	3	2	–	14.4	4.8	13.0	11.6	75.4	25.40	29
30Co@C-550					16.8	4.7	11.7	10.7	77.6	18.60	29
28Co@C-600					13.2	4.9	10.3	7.7	82.0	8.97	29
5%Co@MIL-53(Al)					23.8	5.5	13.3	13.5	73.2	11.80	30
10%Co@MIL-53(Al)	240	2	2	0.7	47.1	4.7	14.8	11.9	73.3	11.70	30
15%Co@MIL-53(Al)					60.2	2.0	14.2	10.7	75.1	10.00	30
15%Co@Al_2O_3					62.7	2.3	15.7	12.6	71.7	10.40	30
Co@C					–	1.0	51.0	32.0	17.0	–	31
Co-2Si@C	300	3	2	48.0	–	2.0	53.0	32.0	15.0	–	31
Co-4Si@C					–	3.0	70.0	20.0	10.0	–	31
52Co@C-550	230	3	2	3.0	10.0	5.0	20.0	10.0	65.0	1.91	32
30Co@NC-550					30.0	8.0	24.0	36.0	32.0	9.92	32
Co@C-Ar	220	3	2	3.0	6.0	–	20.0	15.0	65.0	–	33
Co@C-C_2H_2					10.0	–	15.0	5.0	80.0	–	33
49Co@SiO_2-773					13.7	–	6.5	6.3	87.2	4.00	34
51Co@SiO_2-873	210	2	1	24.0	15.8	–	5.3	4.2	90.5	4.40	34
50Co@SiO_2-973					10.9	–	5.8	4.7	89.5	3.30	34

CO_2 sel.=CO_2 selectivity (%); CH sel.=Hydrocarbon selectivity without CO_2.

Table S3 Catalytic data of representative activated carbon, carbon nanotubes, carbon nanofibers, carbon spheres, MOF-derived and other carbon materials support iron catalysts for Fischer Tropsch synthesis.

Catalysts	Reaction conditions				CO conv. /%	CO_2 sel. /%	CH sel./%				O/P	MTY/10^{-5} mol_{CO} g_{Fe}^{-1} s^{-1}	Ref
	T/ ℃	H_2/ CO	P/ MPa	GHSV/ L g_{cat}^{-1} h^{-1}			CH_4	$C_2^{=}$-$C_4^{=}$	C_2^0-C_4^0	C_5+			
10Fe/AC	320	2	1	3.0	61.6	42.1	23.8	16.0	22.8	37.4	0.7	11.5	35
10Fe-10Mn-2K/AC					96.8	44.5	14.3	27.5	4.8	53.3	5.7	18.0	35
10Fe-22Mn-4K/AC					93.8	47.7	16.7	26.0	7.4	49.9	3.5	17.5	35
10Fe-29Mn-5K/AC					85.0	48.0	22.7	39.4	8.1	29.7	4.9	15.8	35
16Fe/AC	200	2	2	16.0	32.2	5.1	9.3	12.9(C_2-C_4)[a]		77.8	–	10.4	36
12.5Fe-1K/AC					62.0	13.7	9.2	18.7(C_2-C_4)		72.1	–	25.6	36
8.5Fe-0.9K/AC					87.2	18.8	9.7	20.0(C_2-C_4)		70.3	–	34.9	36
14Fe-1.8K/AC					86.1	19.0	7.9	14.6(C_2-C_4)		77.5	–	31.7	36
15.7Fe/AC	260	3	0.9	3.0	29.4	30.1	18.4	51.1(C_2-C_4)		30.6	–	3.7	37
15.7Fe-0.9K/AC					50.7	45.5	7.8	41.7(C_2-C_4)		50.5	–	6.3	37
15.7Fe-2K/AC					35.5	44.7	7.2	44.0(C_2-C_4)		48.8	–	4.4	37
15.7Fe-0.9K/AC	260	3	–	–	50.7	45.5	7.8	41.7(C_2-C_4)		50.5	–	6.3	38
15.7Fe-0.8Cu-0.9K/AC					30.7	41.9	8.9	37.3(C_2-C_4)		53.8	–	3.8	38
15.7Fe-2Cu-0.9K/AC					28.1	44.6	8.1	37.9(C_2-C_4)		54.0	–	3.5	38
15.7Fe-0.9K/AC					85.7	47.5	8.6	34.9(C_2-C_4)		56.5	–	10.7	38
10Fe/CNT	340	2	1	9.0	24.3	27.3	24.2	8.1	27.2	40.5	0.3	13.6	39
10Fe/g-C_3N_4-silica					77.8	35.0	4.8	18.0	2.9	74.3	6.3	43.4	39
10Fe/g-C_3N_4					96.5	33.4	11.1	12.6	9.7	66.7	1.3	53.8	39
20Fe/AC					17.2	21.9	17.5	6.3	31.4	44.8	0.2	4.8	39
10Fe/CNT	275	2	2	1.9	60.0	33.6	41.2	18.6(C_2-C_4)		40.2	–	4.7	40

10Fe/CNT-cold acid					61.0	33.6	38.9	18.9(C_2-C_4)		42.2	–	4.8	40
10Fe/CNT-hot acid					74.0	37.1	23.7	23.5(C_2-C_4)		52.8	–	5.8	40
10Fe/CNT-hot acid-silica					86.0	33.3	8.7	21.2(C_2-C_4)		70.2	–	6.8	40
12Fe-in-CNT	270	2.5	2	20.0	86.0	38.9	25.6	38.2(C_2-C_4)		36.2	–	6.1	41
12Fe-out-CNT					78.0	39.5	40.5	35.7(C_2-C_4)		23.8	–	5.4	41
10Fe0.25Ru/CNT	275	0.8	2	4.6	28.0	5.5	14.7	31.4(C_2-C_4)		53.9	–	5.3	42
10Fe0.25Ru0.2K/CNT					25.0	10.0	14.5	39.3(C_2-C_4)		46.1	–	4.8	42
10Fe0.25Ru0.6Cu/CNT					23.0	6.1	16.8	51.7(C_2-C_4)		31.4	–	4.4	42
10Fe0.25Ru0.2K0.6Cu/CNT					23.0	2.1	11.4	22.4(C_2-C_4)		66.2	–	4.4	42
10Fe-in-CNT	270	5.1	2	20.0	40.0	18.0	12.0	41.0	18.0	29.0	2.3	33.1	43
10Fe-out-CNT					29.0	12.0	15.0	54.0	12.0	19.0	4.5	24.0	43
5.6Fe-in-CNT	300	0.5	0.9	15.0	–	22.2	30.5	39.6	11.9	18.0	3.3	12.7	44
5.6Fe_xN-in-CNT					–	38.0	27.2	35.2	15.1	22.5	2.3	96.1	44
5.2Fe_xN-out-CNT					–	34.5	31.8	37.9	12.1	18.2	3.1	61.2	44
5.5FeN/CNT	300	0.5	0.9	15.0	20.5	38.0	27.2	35.2	15.1	22.5	2.3	96.0	45
6.5FeN0.4Mn/CNT					10.7	31.8	21.6	42.1	7.5	28.8	5.6	43.8	45
6.4FeN0.7Mn/CNT					11.8	36.1	23.6	43.9	8.3	24.2	5.3	48.4	45
6.6FeN1.6Mn/CNT					11.1	34.3	20.8	43.2	8.0	28.0	5.4	44.3	45
5.6FeN0.7Mn0.1K/CNT					8.8	31.3	21.6	43.1	7.0	28.3	6.2	41.8	45
5.8FeN0.7Mn0.3K/CNT					11.9	38.4	20.0	43.6	7.0	29.4	6.2	54.0	45
Fe_3O_4/CNT	300	1	2	6.0	60.2	36.4	11.0	24.2	15.5	49.3	1.6	36.4	46
$Fe_{2.98}Mn_{0.02}O_4$/CNT					60.5	36.4	10.0	27.5	13.2	49.3	2.1	36.3	46
$Fe_{2.97}Mn_{0.03}O_4$/CNT					61.8	38.0	8.7	27.6	12.5	51.5	2.2	36.5	46
$Fe_{2.93}Mn_{0.07}O_4$/CNT					56.2	38.9	7.1	29.9	9.3	53.8	3.2	34.9	46
$Fe_{2.86}Mn_{0.14}O_4$/CNT					43.9	37.2	6.1	31.5	8.7	53.8	3.6	27.5	46
$Fe_{2.73}Mn_{0.27}O_4$/CNT					30.7	36.3	5.6	30.5	8.7	55.3	3.5	19.6	46
$Fe_{2.5}Mn_{0.5}O_4$/CNT					25.2	33.2	5.6	30.3	8.0	56.1	3.8	18.8	46
20Fe-CNT-NH_3	340	2.5	1	50.0	48.3	22.5	–	–	–	–	–	76.8	47
20Fe-CNT-HNO_3					26.5	11.5	–	–	–	–	–	41.7	47
40Fe-CNT-NH_3					81.9	40.3	–	–	–	–	–	70.5	47
40Fe-CNT-HNO_3					0.0	24.0	–	–	–	–	–	38.5	47
10Fe-NCNT	300	0.1	1	4.2	14.4	18.6	22.2	46.7	5.7	25.4	8.2	2.7	48
10Fe-CNT-HNO_3					9.1	16.8	30.6	36.4	7.8	25.2	4.7	1.6	48
10Fe-NCNT-K					16.5	23.6	17.3	54.6	5.9	22.2	9.3	2.8	48
10Fe/AC					4.8	9.9	17.4	30.6	7.5	44.5	4.1	1.0	48
2Fe/CNF	340	2	1	–	9.0	32.0	34.0	13.0	46.0	7.0	0.3	3.8	49
10Fe/CNF					11.0	46.0	59.0	4.0	34.0	0.0	0.1	1.3	49
20Fe/CNF					10.0	42.0	43.0	21.0	32.0	0.0	0.7	0.6	49

10FeNaS/CNF					86.0	47.0	8.0	52.0	7.0	28.0	7.4	5.5	49
20FeNaS/CNF					87.0	42.0	10.0	37.0	23.0	28.0	1.6	3.2	49
12Fe/CNF					88.0	42.0	13.0	52.0	12.0	18.0	4.3	3.0	50
6Fe/α-Al_2O_3					77.0	46.0	24.0	35.0	21.0	10.0	1.7	–	50
12Fe/α-Al_2O_3					81.0	41.0	17.0	39.0	19.0	14.0	2.1	–	50
25Fe/α-Al_2O_3					80.0	40.0	11.0	53.0	6.0	21.0	8.8	–	50
8Fe/β-SiC	340	2	1	–	77.0	42.0	35.0	19.0	39.0	4.0	0.5	–	50
13Fe/γ-Al_2O_3					10.0	20.0	49.0	33.0	11.0	1.0	3.0	–	50
72Fe-Ti-Zn-K					79.0	41.0	24.0	28.0	29.0	10.0	1.0	–	50
32Fe-Cu-K-SiO_2					79.0	37.0	26.0	36.0	12.0	18.0	3.0	–	50
63Bulk Fe					97.0	34.0	30.0	32.0	18.0	14.0	1.7	–	50
Fe_3C@C					73.2	30.4	21.8	30.6	26.7	20.9	1.1	–	51
Fe_3C@C-Na					12.6	27.6	19.5	32.1	4.6	43.8	7.0	–	51
Fe_3C@C-Mg	340	1	1	16.0	21.2	25.3	19.6	31.6	8.1	40.7	3.9	–	51
Fe_3C@C-Ca					28.5	33.8	19.2	35.1	9.7	36.0	3.6	–	51
Fe_3C@C-K					27.6	25.0	18.2	32.1	9.5	40.2	3.4	–	51
9Fe@CMK-3-300	340	1	2	–	13.0	–	18.7	50.4	4.8	26.1	10.5	–	52
14Fe@CMK-3-500					14.8	–	13.4	54.6	4.9	27.1	11.1	–	52
6Fe-Na-CMK-3					3.9	–	23.4	48.0	4.7	23.9	10.2	7.6	53
8Fe-Na-2S-CMK-3	340	1	2	–	12.1	–	19.6	56.0	6.1	18.3	9.2	16.2	53
10Fe-Na-3S-CMK-3					11.3	–	18.2	56.0	5.9	19.9	9.5	15.5	53
34Fe@C-400	340	2	1	30.0	74.0	47.0	15.0	16.0	30.0	39.0	0.5	38.0	54
38Fe@C-500					76.0	46.0	15.0	14.0	29.0	42.0	0.5	36.0	54
42Fe@C-600					74.0	46.0	14.0	13.0	30.0	43.0	0.4	31.0	54
53Fe@C-900					53.0	45.0	13.0	17.0	30.0	40.0	0.6	19.0	54
38Fe@C	340	1.5	1	–	70.0	43.0	20.0	27.0(C_2-C_4)		53.0	–	–	55
38Fe@C/Al					68.0	43.0	21.0	29.0(C_2-C_4)		50.0	–	–	55
25Fe@C/Al					33.0	33.0	19.0	34.0(C_2-C_4)		47.0	–	–	55
15Fe@C/Al					7.0	19.0	20.0	45.0(C_2-C_4)		35.0	–	–	55
34Fe-Na-S/C-micro	340	1	2	–	35.0	–	17.0	49.0	5.0	29.0	9.8	8.0	56
34Fe-Na-S/C-Xero					51.0	–	19.0	47.0	6.0	28.0	7.8	15.0	56
34Fe-Na-S/C-Aero					35.0	–	12.0	50.0	4.0	34.0	12.5	8.0	56
25Fe@C	340	2	1	60.0	59.0	46.8	14.6	15.9	12.7	56.8	1.3	49.0	57
31Fe@C					70.0	47.0	15.0	15.8	12.0	57.2	1.3	44.0	57
38Fe@C					72.0	47.4	15.5	14.6	14.4	55.5	1.0	38.0	57
34Fe@C	300	2	1	36.0	33.8	33.7	11.5	18.3	6.8	63.4	2.7	15.0	58
32Fe@NC					81.8	42.9	15.1	21.4	12.8	50.7	1.7	32.0	58
11Fe/PANI	350	2	1	9.0	79.0	44.0	24.0	47.0	14.0	15.0	3.4	40.1	59
10Fe/SiO_2					50.0	45.0	29.0	25.0	25.0	21.0	1.0	27.9	59
10Fe/CNT					75.0	44.0	25.0	29.0	31.0	15.0	0.9	41.9	59
10Fe/AC					62.0	41.0	30.0	28.0	25.0	17.0	1.1	34.6	59
11Fe/N-AC					73.0	42.0	27.0	36.0	19.0	18.0	1.9	37.0	59
18Fe/rGO	340	2	1	–	60.0	50.0	48.0	31.0	20.0	6.3	1.6	33.3	60
18Fe-0.5K/rGO					60.0	50.0	31.0	51.0	14.0	3.3	3.6	55.6	60

18Fe-1K/rGO					60.0	50.0	26.0	62.0	7.9	4.4	7.8	64.6	60
18Fe-1.5K/rGO					60.0	50.0	22.0	67.0	6.8	5.0	9.9	27.1	60
17Fe-2K/rGO					60.0	50.0	20.0	68.0	6.2	6.7	11.0	22.0	60
20.3Fe/rGO					58.0	40.9	42.3	33.2	23.2	1.1	1.4	34.2	61
20.3Fe-6.3Mg/rGO					59.0	40.7	35.6	33.0	26.9	4.5	1.2	24.7	61
20.3Fe-6.3Mg-0.5K/rGO					59.0	40.5	31.4	49.2	13.5	5.9	3.6	106.0	61
20.3Fe-6.3Mg-1K/rGO	340	2	1	–	59.0	41.1	27.1	58.8	7.7	6.4	7.6	107.6	61
20.3Fe-6.3Mg-2K/rGO					59.0	40.8	20.3	65.0	6.2	8.5	10.5	133.8	61
20.3Fe-6.3Mg-5K/rGO					59.0	40.5	19.6	64.2	5.9	10.3	10.9	61.7	61
20.3Fe-2K/rGO					59.0	49.0	22.0	63.7	6.4	7.9	10.0	54.5	61
Fe_xO_y/CNS	350	2	1	–	72.6	–	29.9	53.5	41.2	16.6	3.35	188.2	62
Fe_xO_y/CNT					42.1	–	29.7	61.0	33.1	9.0	1.19	86.1	62
3Fe/C	300	2	2.1	16.0	32	20.6	20.4	6.2	26.7	26.0	0.2	76.9	63
6Fe/C–Si-02					21	13.8	19.4	7.7	19.4	39.6	0.4	22.8	63
10Fe/C–Si-04					74	30.9	10.8	14.0	10.5	33.7	1.3	51.6	63
8Fe/C–Si-06					41	20.1	15.5	13.8	16.5	34.1	0.8	36.7	63
10Fe/C–Si-08					39	21.4	19.2	16.8	14.0	28.7	1.2	27.3	63
10Fe/Si					26	12.5	20.0	15.9	10.9	41.9	1.5	17.9	63

$C_2^=$-$C_4^=$=Olefins with carbon number of 2-4; C_2^0-C_4^0=Paraffins with carbon number of 2-4; O/P=Olefins/Paraffins ratio with carbon number of 2-4; MTY=Iron time yield ($10^{-5}mol_{CO}\ g_{Fe}^{-1}\ s^{-1}$).
[a]C_2-C_4=Hydrocarbons with carbon number of 2-4;

References

1. Y. Pei, Y. Ding, H. Zhu, J. Zang, X. Song, W. Dong, T. Wang and Y. Lu, *Catal. Lett.*, 2014, **144**, 1433-1442.
2. G. Jiao, Y. Ding, H. Zhu, X. Li, J. Li, R. Lin, W. Dong, L. Gong, Y. Pei and Y. Lu, *Appl. Catal. A-Gen.*, 2009, **364**, 137-142.
3. 76 Y. Pei, Y. Ding, j. Zang, X. Song, W. Dong, H. Zhu, T. Wang and W. Chen, *Chin. J. Catal.*, 2013, **33**, 808-812.
4. H. Du, H. Zhu, T. Liu, Z. Zhao, X. Chen, W. Dong, W. Lu, W. Luo and Y. Ding, *Catal. Today*,

2017, **281**, 549-558.
5. H. Du, H. Zhu, X. Chen, W. Dong, W. Lu, W. Luo, M. Jiang, T. Liu and Y. Ding, *Fuel*, 2016, **182**, 42-49.
6. V. M. Lebarbier, D. Mei, D. H. Kim, A. Andersen, J. L. Male, J. E. Holladay, R. Rousseau and Y. Wang, *J.Phsy.Chem.C.*, 2011, **115**, 17440-17451.
7. Z. Zhao, W. Lu, C. Feng, X. Chen, H. Zhu, R. Yang, W. Dong, M. Zhao, Y. Lyu, T. Liu, Z. Jiang and Y. Ding, *J. Catal.*, 2019, **370**, 251-264.
8. Z. Zhao, W. Lu, H. Zhu, W. Dong, Y. Lyu, T. Liu, X. Chen, Y. Wang and Y. Ding, *J. Catal.*, 2018, **361**, 156-167.
9. T. Wang, Y. Ding, Y. Lü, H. Zhu and L. Lin, *J.Nat.Gas.Chem.*, 2008, **17**, 153-158.
10. T. Wang, Y. Ding, J. Xiong, L. Yan, H. Zhu, Y. Lu and L. Lin, *Catal. Lett.*, 2006, **107**, 47-52.
11. Z. Zhao, W. Lu, R. Yang, H. Zhu, W. Dong, F. Sun, Z. Jiang, Y. Lyu, T. Liu, H. Du and Y. Ding, *ACS Catal.*, 2017, **8**, 228-241.
12. M. Trépanier, A. Tavasoli, A. K. Dalai and N. Abatzoglou, *Fuel Process. Technol.*, 2009, **90**, 367-374.
13. A. Tavasoli, R. M. M. Abbaslou, M. Trepanier and A. K. Dalai, *Appl. Catal. A-Gen.*, 2008, **345**, 134-142.
14. H. Xiong, M. A. M. Motchelaho, M. Moyo, L. L. Jewell and N. J. Coville, *Catal. Today*, 2013, **214**, 50-60.
15. H. Xiong, M. A. M. Motchelaho, M. Moyo, L. L. Jewell and N. J. Coville, *J. Catal.*, 2011, **278**, 26-40.
16. T. O. Eschemann, W. S. Lamme, R. L. Manchester, T. E. Parmentier, A. Cognigni, M. Rønning and K. P. de Jong, *J. Catal.*, 2015, **328**, 130-138.
17. M. Zaman, A. Khodadi and Y. Mortazavi, *Fuel Process. Technol.*, 2009, **90**, 1214-1219.
18. A. C. Ghogia, S. Cayez, B. F. Machado, A. Nzihou, P. Serp, K. Soulantica and D. Pham Minh, *ChemCatChem*, 2019, **12**, 1117-1128.
19. H. Zhang, C. Lancelot, W. Chu, J. Hong, A. Y. Khodakov, P. A. Chernavskii, J. Zheng and D. Tong, *J. Mater. Chem.*, 2009, **19**.
20. G. L. Bezemer, U. Falke, A. J. van Dillen and K. P. de Jong, *Chem. Commun.*, 2005, 731-733.
21. G. Bezemer, P. Radstake, U. Falke, H. Oosterbeek, H. Kuipers, A. Vandillen and K. Dejong, *J. Catal.*, 2006, **237**, 152-161.
22. G. L. Bezemer, P. Radstake, V. Koot, A. Van Dillen, J. Geus and K. De Jong, *J. Catal.*, 2006, **237**, 291-302.
23. H. Qin, S. Kang, Y. Wang, H. Liu, Z. Ni, Y. Huang, Y. Li and X. Li, *ACS Sustain. Chem. Eng.*, 2016, **4**, 1240-1247.
24. M. W. Dlamini, T. N. Phaahlamohlaka, D. O. Kumi, R. Forbes, L. L. Jewell and N. J. Coville, *Catal. Today*, 2020, **342**, 99-110.
25. Z. Wang, G. Laddha, S. Kanitkar and J. J. Spivey, *Catal. Today*, 2017, **298**, 209-215.
26. Y. Chen, X. Li, M. U. Nisa, J. Lv and Z. Li, *Fuel*, 2019, **241**, 802-812.
27. V. I. Isaeva, O. L. Eliseev, R. V. Kazantsev, V. V. Chernyshev, A. L. Tarasov, P. E. Davydov, A. L. Lapidus and L. M. Kustov, *Polyhedron*, 2019, **157**, 389-395.
28. Q.-X. Luo, L.-P. Guo, S.-Y. Yao, J. Bao, Z.-T. Liu and Z.-W. Liu, *J. Catal.*, 2019, **369**, 143-156.
29. C. Zhang, X. Guo, Q. Yuan, R. Zhang, Q. Chang, K. Li, B. Xiao, S. Liu, C. Ma, X. Liu, Y. Xu, X. Wen, Y. Yang and Y. Li, *ACS Catal.*, 2018, **8**, 7120-7130.

30. V. I. Isaeva, O. L. Eliseev, R. V. Kazantsev, V. V. Chernyshev, P. E. Davydov, B. R. Saifutdinov, A. L. Lapidus and L. M. Kustov, *Dalton Trans*, 2016, **45**, 12006-12014.
31. Y. Pei, Z. Li and Y. Li, *AlChE J.*, 2017, **63**, 2935-2944.
32. B. Qiu, C. Yang, W. Guo, Y. Xu, Z. Liang, D. Ma and R. Zou, *J. Mater. Chem. A*, 2017, **5**, 8081-8086.
33. N. Li, C.-p. Ma, C.-h. Zhang, Y. Yang and Y.-w. Li, *J. Fuel Chem. Technol.*, 2019, **47**, 428-437.
34. X. Sun, A. I. O. Suarez, M. Meijerink, T. van Deelen, S. Ould-Chikh, J. Zecevic, K. P. de Jong, F. Kapteijn and J. Gascon, *Nat Commun*, 2017, **8**, 1680.
35. Z. Tian, C. Wang, Z. Si, L. Ma, L. Chen, Q. Liu, Q. Zhang and H. Huang, *Appl. Catal. A-Gen.*, 2017, **541**, 50-59.
36. P. A. Chernavskii, G. V. Pankina, R. V. Kazantsev and O. L. Eliseev, *ChemCatChem*, 2018, **10**, 1313-1320.
37. W. Ma, E. L. Kugler and D. B. Dadyburjor, *Energ. Fuel.*, 2007, **21**, 1832-1842.
38. W. Ma, E. L. Kugler and D. B. Dadyburjor, *Energ. Fuel.,* 2011, **25**, 1931-1938.
39. H. Park, D. H. Youn, J. Y. Kim, W. Y. Kim, Y. H. Choi, Y. H. Lee, S. H. Choi and J. S. Lee, *ChemCatChem*, 2015, **7**, 3488-3494.
40. R. M. Malek Abbaslou, A. Tavasoli and A. K. Dalai, *Appl. Catal. A-Gen.*, 2009, **355**, 33-41.
41. R. M. M. Abbaslou, A. Tavassoli, J. Soltan and A. K. Dalai, *Appl. Catal. A-Gen.*, 2009, **367**, 47-52.
42. M. C. Bahome, L. L. Jewell, K. Padayachy, D. Hildebrandt, D. Glasser, A. K. Datye and N. J. Coville, *Appl. Catal. A-Gen.*, 2007, **328**, 243-251.
43. W. Chen, Z. Fan, X. Pan and X. Bao, *J. Am. Chem. Soc.*, 2008, **130**, 9414-9419.
44. 170 Z. Yang, S. Guo, X. Pan, J. Wang and X. Bao, *Energy Environ. Sci.*, 2011, **4**, 4500-4503.
45. Z. Yang, X. Pan, J. Wang and X. Bao, *Catal. Today*, 2012, **186**, 121-127.
46. J.-D. Xu, K.-T. Zhu, X.-F. Weng, W.-Z. Weng, C.-J. Huang and H.-L. Wan, *Catal. Today*, 2013, **215**, 86-94.
47. H. J. Schulte, B. Graf, W. Xia and M. Muhler, *ChemCatChem*, 2012, **4**, 350-355.
48. J. Lu, L. Yang, B. Xu, Q. Wu, D. Zhang, S. Yuan, Y. Zhai, X. Wang, Y. Fan and Z. Hu, *ACS Catal.*, 2014, **4**, 613-621.
49. H. M. Torres Galvis, J. H. Bitter, T. Davidian, M. Ruitenbeek, A. I. Dugulan and K. P. de Jong, *J. Am. Chem. Soc.*, 2012, **134**, 16207-16215.
50. H. M. Torres Galvis, J. H. Bitter, C. B. Khare, M. Ruitenbeek, A. I. Dugulan and K. P. de Jong, *Science*, 2012, **335**, 835-838.
51. X. Zhao, S. Lv, L. Wang, L. Li, G. Wang, Y. Zhang and J. Li, *Mol. Catal.*, 2018, **449**, 99-105.
52. M. Oschatz, T. W. van Deelen, J. L. Weber, W. S. Lamme, G. Wang, B. Goderis, O. Verkinderen, A. I. Dugulan and K. P. de Jong, *Catal. Sci. Technol.*, 2016, **6**, 8464-8473.
53. M. Oschatz, W. S. Lamme, J. Xie, A. I. Dugulan and K. P. de Jong, *ChemCatChem*, 2016, **8**, 2846-2852.
54. T. A. Wezendonk, V. P. Santos, M. A. Nasalevich, Q. S. Warringa, A. I. Dugulan, A. Chojecki, A. C. Koeken, M. Ruitenbeek, G. Meima and H.-U. Islam, *ACS Catal.*, 2016, **6**, 3236-3247.
55. L. Oar-Arteta, M. J. Valero-Romero, T. Wezendonk, F. Kapteijn and J. Gascon, *Catal. Sci. Technol.*, 2018, **8**, 210-220.
56. M. Oschatz, S. Krause, N. A. Krans, C. Hernandez Mejia, S. Kaskel and K. P. de Jong, *Chem.Commun.*, 2017, **53**, 10204-10207.

57. V. P. Santos, T. A. Wezendonk, J. J. Jaen, A. I. Dugulan, M. A. Nasalevich, H. U. Islam, A. Chojecki, S. Sartipi, X. Sun, A. A. Hakeem, A. C. Koeken, M. Ruitenbeek, T. Davidian, G. R. Meima, G. Sankar, F. Kapteijn, M. Makkee and J. Gascon, *Nat Commun*, 2015, **6**, 6451.
58. B. An, K. Cheng, C. Wang, Y. Wang and W. Lin, *ACS Catal.*, 2016, **6**, 3610-3618.
59. B. Gu, S. He, W. Zhou, J. Kang, K. Cheng, Q. Zhang and Y. Wang, *J. Energ. Chem.*, 2017, **26**, 608-615.
60. Y. Cheng, J. Lin, K. Xu, H. Wang, X. Yao, Y. Pei, S. Yan, M. Qiao and B. Zong, *ACS Catal.*, 2015, **6**, 389-399.
61. Y. Cheng, J. Lin, T. Wu, H. Wang, S. Xie, Y. Pei, S. Yan, M. Qiao and B. Zong, *Appl. Catal., B*, 2017, **204**, 475-485.
62. Y. Zhou, S. Natesakhawat, T. D. Nguyen-Phan, D. R. Kauffman, C. M. Marin, K. Kisslinger, R. Lin, H. L. Xin, E. Stavitski and K. Attenkofer, *ChemCatChem*, 2019, **11**, 1625-1632.
63. V. Subramanian, V. V. Ordomsky, B. Legras, K. Cheng, C. Cordier, P. A. Chernavskii and A. Y. Khodakov, *Catal. Sci. Technol.*, 2016, **6**, 4953-4961.