Supplementary Information for:

Promoted $PtFe/SiO_2$ catalyst with low Pt concentration for propane dehydrogenation

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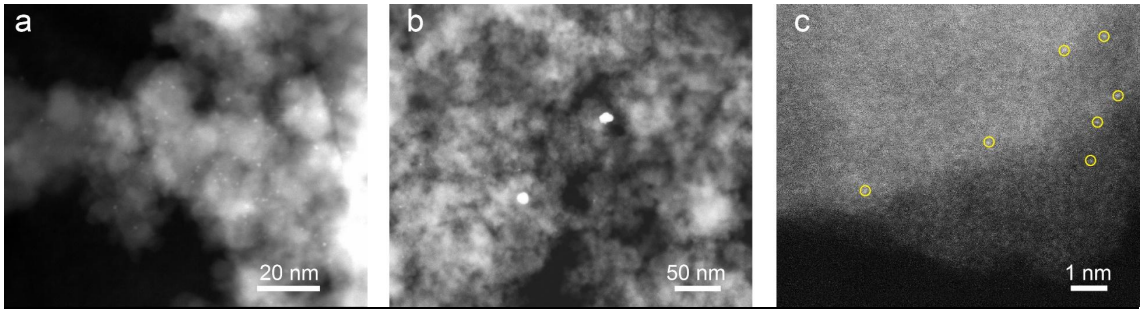

Figure S1. Aberration-corrected HAADF-STEM images. (a) $PtFe/SiO_2$ and (b, c) Pt/SiO_2 catalyst.

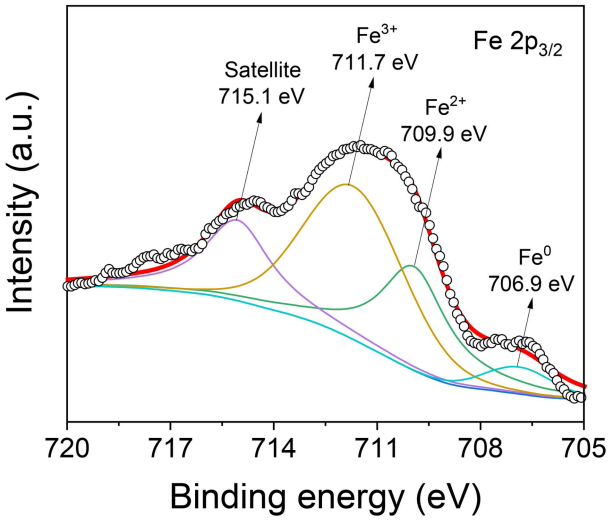

Figure S2. XPS spectra of Fe 2*p* for $PtFe/SiO_2$ after *quasi in situ* pretreated in a hydrogen flow at 600 °C for 3 h.

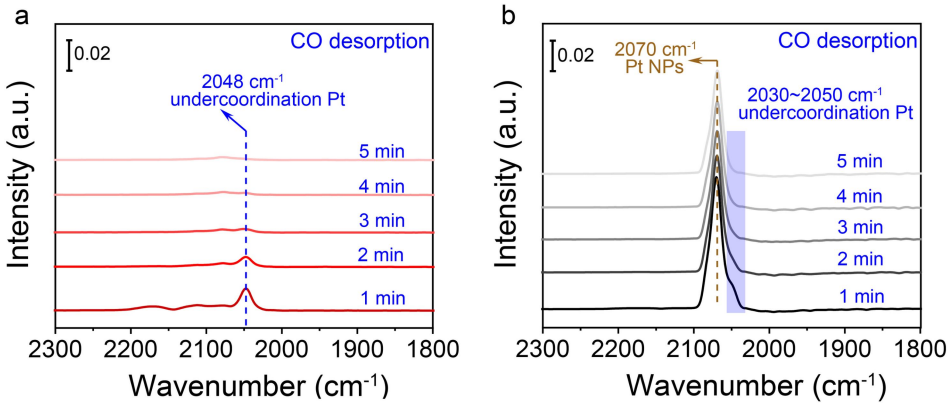

Figure S3. DRIFTS spectra of CO desorption. (a) $PtFe/SiO_2$ and (b) Pt/SiO_2 catalysts.

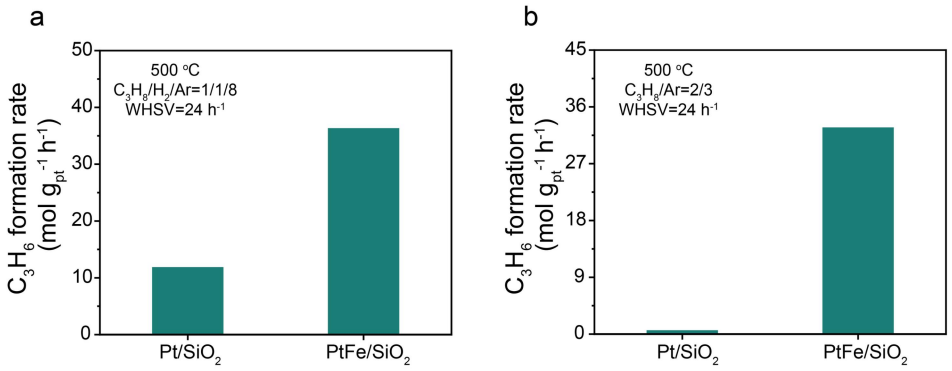

Figure S4. Catalytic performances toward PDH. (a) C_3H_6 formation rate at 10 h of reaction for Pt/SiO_2 and $PtFe/SiO_2$ (500 °C, $C_3H_8/H_2/Ar$ = 1/1/8, WHSV = 24 h^{-1}); (b) C_3H_6 formation rate at 10 h of reaction for Pt/SiO_2 and $PtFe/SiO_2$ (500 °C, C_3H_8/Ar =2/3, WHSV = 24 h^{-1}).

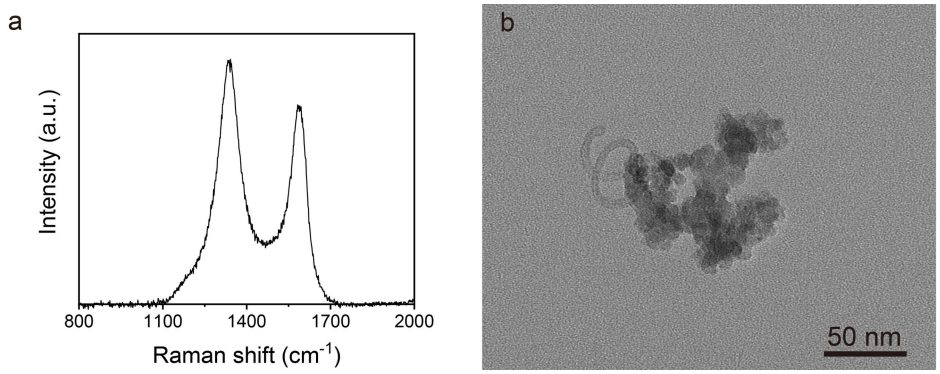

Figure S5. (a) Raman spectrum and (b) TEM image of $PtFe/SiO_2$ catalyst after reaction for 100 h.

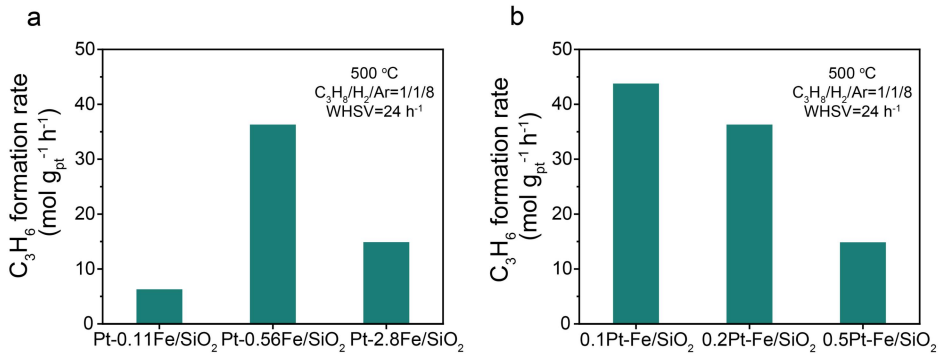

Figure S6. Catalytic performances toward PDH. (a) C_3H_6 formation rate at 10 h of reaction for Pt-0.11Fe/SiO_2, Pt-0.56Fe/SiO_2 and Pt-2.8Fe/SiO_2 (500 °C, $C_3H_8/H_2/Ar$ = 1/1/8, WHSV = 24 h^{-1}); (b) C_3H_6 formation rate at 10 h of reaction for 0.1Pt-Fe/SiO_2, 0.2Pt-Fe/SiO_2 and 0.5Pt-Fe/SiO_2 (500 °C, $C_3H_8/H_2/Ar$ = 1/1/8, WHSV = 24 h^{-1}).

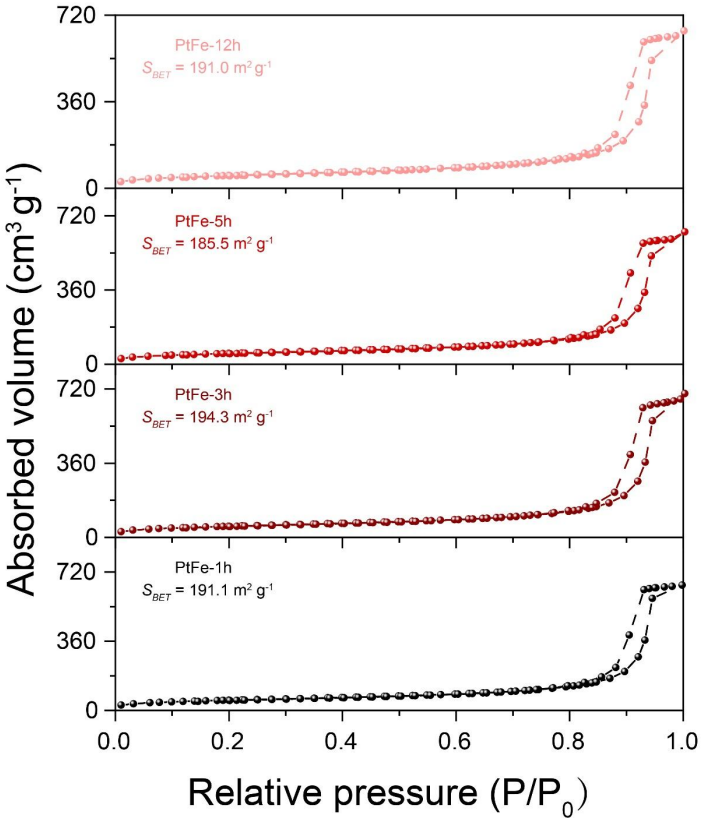

Figure S7. N_2 sorption isotherms of the PtFe/SiO_2 catalysts with different H_2 reduction time.

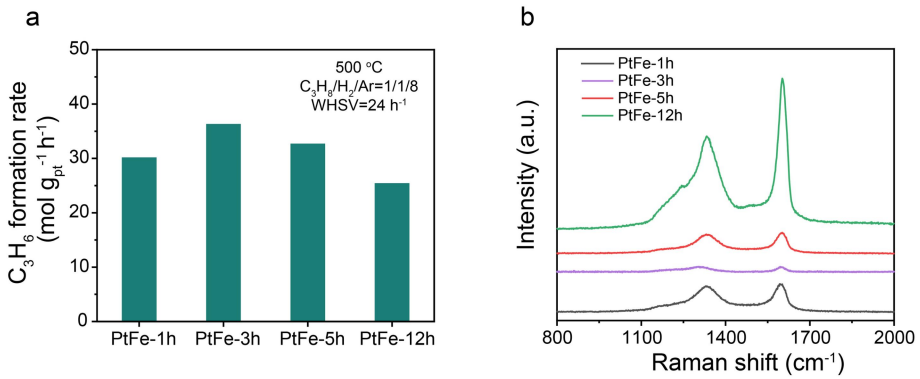

Figure S8. Catalytic performances toward PDH. (a) C_3H_6 formation rate at 10 h of reaction for PtFe-1h, PtFe-3h, PtFe-5h and PtFe-12h (500 °C, $C_3H_8/H_2/Ar$ = 1/1/8, WHSV = 24 h^{-1}); (b) Raman spectra of catalysts after 10 h reaction.

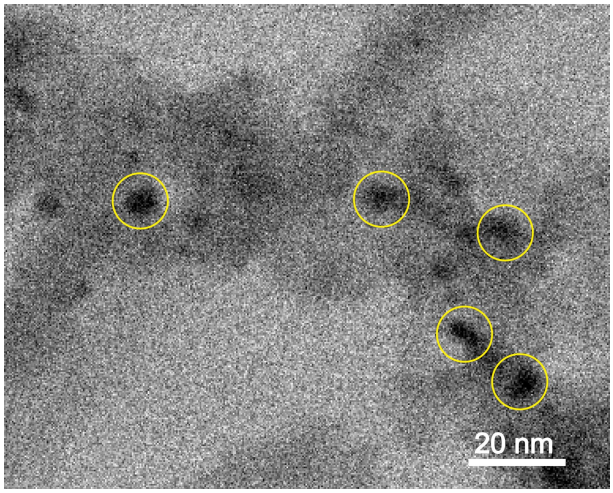

Fig.S9. HR-TEM image of PtFe-12h.

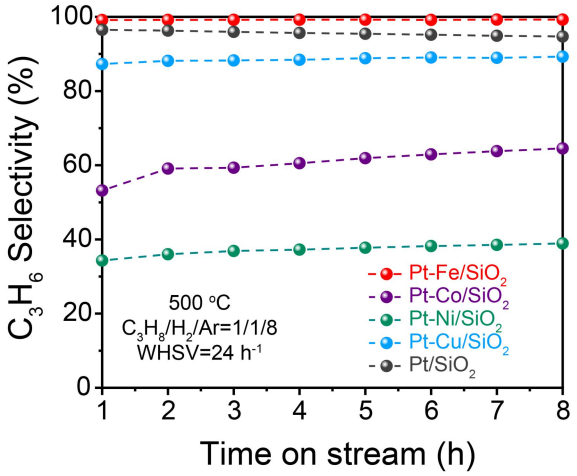

Figure S10. Time-dependent C_3H_6 selectivity of the Pt-M catalysts (M = Fe, Co, Ni or Cu).

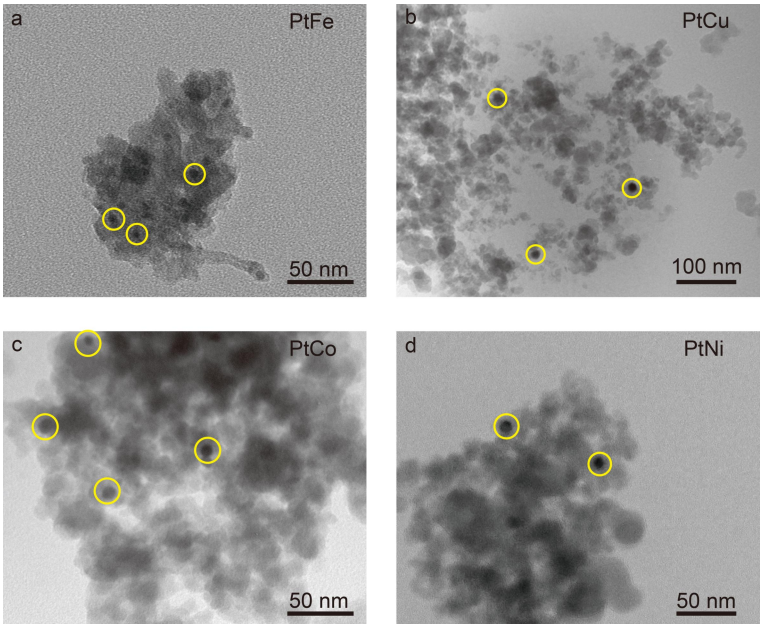

Figure S11. TEM images of Pt-M/SiO_2 (M = Fe、Cu、Co and Ni) after PDH reaction for 20 h.

Supplementary Table S1 | Summary of the catalytic performance of PtIn@S-1 and other reported Pt-based catalysts for PDH.

Catalyst	Temp. (℃)	Pt (wt%)	[a]WHSV (h^{-1})	Gas composition (%)	C_3H_8 Conv. (%)	Equilibrium Conv. (%)	C_3H_6 Sel. (%)	Operation time (h)	Catalyst life τ (h)	[b]ratio	[c]Initial C_3H_6 formation rate ($mol_{propylene}\ g_{Pt}^{-1}\ h^{-1}$)	Ref.
$Ga^{\delta+}Pt^0/SiO_2$	550	4.37	2.1	C_3H_8:Ar=1:4	40.7	53.18	63.5	20	217	0.77	0.26	1
HEI (PtCoCu) (GeGaSn)/Ca−SiO_2	600	1	2	C_3H_8:H_2:He =2.5:1.3:3.7	33	52	98.1	720	4146	0.63	1.34	2
PtGa–Ca–Pb/SiO_2	600	3	5.9	C_3H_8:H_2:He=2:1:3	37.6	52.4	98.3	720	3067	0.72	1.51	3
K-PtSn@MFI	600	0.42	1.8	C_3H_8:N_2=5:16	20	69.19	97	67	72	0.29	1.73	4
0.5Pt/2.5Zn, Na-ZSM-5	555	0.5	2.6	pure C_3H_8	23.9	32.87	67.5	44	161	0.73	1.74	5
Zn10Pt0.1/HZ	550	0.1	0.2	C_3H_8/N_2=5/95	56.2	74.95	78	20	62	0.75	1.82	6
Zn10Pt0.1/HZ	600	0.1	0.2	C_3H_8:N_2=5:95	80	88.32	56	20	14	0.91	1.86	6
PtGa–Pb/SiO_2	600	3	9.8	C_3H_8:He=2.5:5.0	31.6	64.55	97.9	160	149	0.49	2.10	3
0.3Pt/0.5Sn-Si-Beta	550	0.26	1	C_3H_8:Ar=1:19	27.5	74.95	99.1	12	101	0.37	2.18	7
PtSn/Al_2O_3	580	1	4.7	C_3H_8:He=16:84	23	66.5	99	8	8	0.35	2.22	8
PtGa–Ca–Pb/SiO_2	600	3	9.8	C_3H_8:He=2.5:5.0	37.8	64.55	98	160	233	0.59	2.51	3
PtGa–Ca–Pb/SiO_2	580	3	11	pure C_3H_8	36.6	45.42	98	252	465	0.81	2.73	3
Pt/Al_2O_3	580	0.5	4.7	C_3H_8:He=16:84	16.5	66.5	86	8	5	0.25	2.77	8
LaPt/SSF	580	1	3.5	C_3H_8:Ar=1:4	44.4	64.73	92	33	86	0.69	2.97	9
CePt/SSF	580	1	3.5	C_3H_8:Ar=1:4	44.9	64.73	92	33	108	0.69	3.00	9
0.1Pt-2Zn/Si-Beta	550	1	2.4	C_3H_8:He=1:9	65	64.36	98	150	126	1.01	3.17	10

InPt/SSF	580	1	3.5	C_3H_8:Ar=1:4	46.9	64.73	98	33	135	0.72	3.34	9
FePt/SSF	580	1	3.5	C_3H_8:Ar=1:4	56.8	64.73	90	33	64	0.88	3.72	9
$PtSn/SiO_2$	580	1	4.7	pure C_3H_8	40.4	40.8	99	30	263	0.99	3.90	8
$PtZn_4$@S-1-H	550	0.72	3.6	C_3H_8:N_2=1:3	47.4	49.52	93.2	216.7	759	0.96	4.59	11
PtSnAl0.1/SBA-15	590	0.5	2.4	C_3H_8:Ar=1:5	55.1	71.03	97.8	6	9	0.78	5.37	12
PtSnAl0.2/SBA-15	590	0.5	2.4	C_3H_8:Ar=1:5	55.9	71.03	98.5	6	10	0.79	5.49	12
0.6PtSn/1.5In-Al	600	0.6	3.1	C_3H_8:H_2:Ar = 8:7:35	55	59.8	96	53	101	0.92	5.66	13
Pt-Sn-6/$MgAl_2O_4$	580	0.39	2.4	C_3H_8:H_2:He =2:2:16	45	58.4	99	90	359	0.77	5.69	14
PtZn4@S-1-H	600	0.72	3.6	C_3H_8:N_2=1:3	66.7	66.9	90.8	58.3	60	1.00	6.29	11
PtGa–Pb/SiO_2	600	3	30.7	C_3H_8:H_2:He =3.9:5:40	30	68.2	99.6	96	1159	0.44	6.35	15
$PtSn/SiO_2$	580	1	4.7	C_3H_8:He=16:84	66.2	66.5	99.4	8	101	1.00	6.42	8
$Ga^{\delta+}Pt^0/SiO_2$	550	4.37	43.7	C_3H_8:Ar=1:4	36.5	53.18	90.9	20	45	0.69	6.89	1
$Pt^0Zn^{\delta+}/SiO_2$	550	3.05	35.4	C_3H_8:Ar=1:4	30.2	53.18	98.1	30	37	0.57	7.14	16
PtSn/2Mg-SBA-15	580	1	8.25	C_3H_8:Ar=7:3	43	46.24	97.5	6	29	0.93	7.18	17
PtIn/Mg(Al)O-600	620	0.6	3.1	C_3H_8:H_2:Ar = 8:7:35	69	68	98	30	37	1.01	7.26	18
Pt/0.5Sn-SBA-15	580	1	8.25	C_3H_8:Ar=7:3	43.8	46.24	97.3	6	26	0.95	7.30	19
Pt/Sn-ZSM-5	600	0.32	1.8	C_3H_8:N_2=1.5:5	70	69.8	99	24	23	1.00	8.09	20
$PtGa/SiO_2$	600	3	29.5	C_3H_8:He=2.5:5.0	43.4	64.55	97.1	20	19	0.67	8.61	3
PtGa–Ca/SiO_2	600	3	29.5	C_3H_8:He=2.5:5.0	43	64.55	98.3	20	26	0.67	8.63	3

$PtSn/SiO_2$	500	3	47	C_3H_8:N_2=1:4	27	33.71	99.5	6	38	0.80	8.74	21
$PtCu/Al_2O_3$	520	0.1	3.8	C_3H_8:H_2 = 1:1	13.1	9.2	87	120	2000	1.42	8.99	22
PtLa/mz-deGa	580	1	11	pure C_3H_8	42	45.42	95	480	380	0.92	9.11	23
PtY/mz-deGa	580	1	11	pure C_3H_8	42	45.42	96	312	119	0.92	9.21	23
$PtGa/SiO_2$	600	3	30.7	C_3H_8:H_2:He =3.9:5:40	44.7	68.2	98.8	50	54	0.66	9.39	15
1.5Ga0.1Pt@S-1	600	0.09	1.2	C_3H_8:N_2=1:19	45.9	88.32	92.1	24	129	0.52	11.70	24
PtSnIn/1.5Ca-Al	600	0.3	3.1	C_3H_8:H_2:Ar = 8:7:35	60.1	59.8	96.6	100	93	1.01	12.46	25
PtZn@S-1	600	0.41	5.9	C_3H_8:H_2:N_2 =1:1:2	46.6	49.1	98.5	90	324	0.95	13.72	26
$Ga^{\delta+}Pt^0/SiO_2$	550	4.37	98.4	C_3H_8:Ar=1:4	31.9	53.18	99	20	27	0.60	14.77	1
$Pt/Mg(Sn)(Al)O@Al_2O_3$	550	0.5	14	C_3H_8:H_2:Ar = 1:0.5:2	29.4	33.2	93.7	240	3062	0.89	16.02	27
0.3PtZn0.5@S-1	600	0.23	6.5	C_3H_8:N_2=11:19	31	61.2	97	5	16	0.51	17.65	28
$Pt^0Zn^{\delta+}/SiO_2$	550	3.05	82.6	C_3H_8:Ar=1:4	35.3	53.18	97.6	30	73	0.66	19.38	16
$Pt/Mg(Sn)(Al)O@Al_2O_3$	600	0.5	14	C_3H_8:H_2:Ar =1:0.5:2	48.3	55.1	86.4	48	224	0.88	24.26	27
0.04Pt-0.36Zn-DeAlBEA	600	0.04	1.2	C_3H_8:He=1:3	41	66.9	99.5	160	301	0.61	25.41	29
$PtSn/Al_2O_3$ sheet	590	0.35	9.4	C_3H_8:H_2:N_2 =1:1.25:4	48.7	50	99.1	24	143	0.97	26.92	30
$PtZn_4$@S-1-H	550	0.72	26.8	C_3H_8:N_2=1:3	40	49.52	99.1	105.9	121	0.81	30.64	11

$PtZn_4$@S-1-H	550	0.72	53.7	C_3H_8:N_2=1:3	34.7	49.52	99.1	10.3	41	0.70	53.26	11
K-PtSn@MFI-600H_2-22 h	600	0.4	29.5	C_3H_8:He=24:76	38.7	70	97	25	77	0.55	57.49	31
$PtZn_4$@S-1-H	550	0.72	109.4	C_3H_8:N_2=1:3	21.2	49.52	98.3	10.3	14	0.43	65.75	11
Pt0.1Zn0.17/SiO_2	600	0.1	9.4	C_3H_8:H_2 = 2:1	36	40.2	97	160	433	0.90	68.16	32
$PtZn_4$/SiO_2	600	0.1	11	C_3H_8:H_2 = 2:1	34.7	36	96	160	500	0.96	76.09	32
K-PtSn@MFI-600H_2-22 h	550	0.4	118.1	pure C_3H_8	20	31.38	97	70	351	0.64	118.94	31
PtFe-3h	500	0.2	3	C_3H_8:H_2:Ar=1:1:8	27.15	21.1	48.26	10	50	1.29	4.02	This work
PtFe-3h	500	0.2	6	C_3H_8:H_2:Ar=1:1:8	21.00	21.1	80.33	10	7664	1.00	10.35	
PtFe-3h	500	0.2	12	C_3H_8:H_2:Ar=1:1:8	20.06	21.1	90.08	10	247	0.95	22.16	
PtFe-3h	500	0.2	24	C_3H_8:H_2:Ar=1:1:8	16.40	21.1	98.23	10	83	0.78	39.52	
PtFe-3h	500	0.2	24	C_3H_8: Ar=2:3	16.45	21.1	98.99	10	42	0.78	39.94	
PtFe-3h	500	0.2	48	C_3H_8:H_2:Ar=1:1:8	15.31	21.1	97.40	10	42	0.73	72.75	

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