Supplementary Materials

Dynamic Pyrolysis Characteristics, Kinetics and Products Analysis of Waste Tire Catalytic Pyrolysis with Ni/Fe-ZSM-5 Catalysts Using TG-IR-GC/MS

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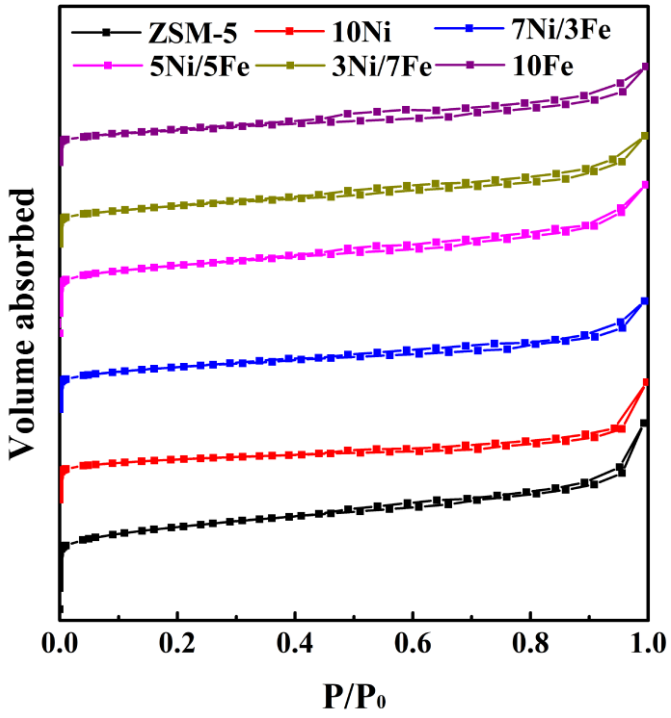

Figure S1. N_2 adsorption-desorption isotherms of parent and modified ZSM-5.

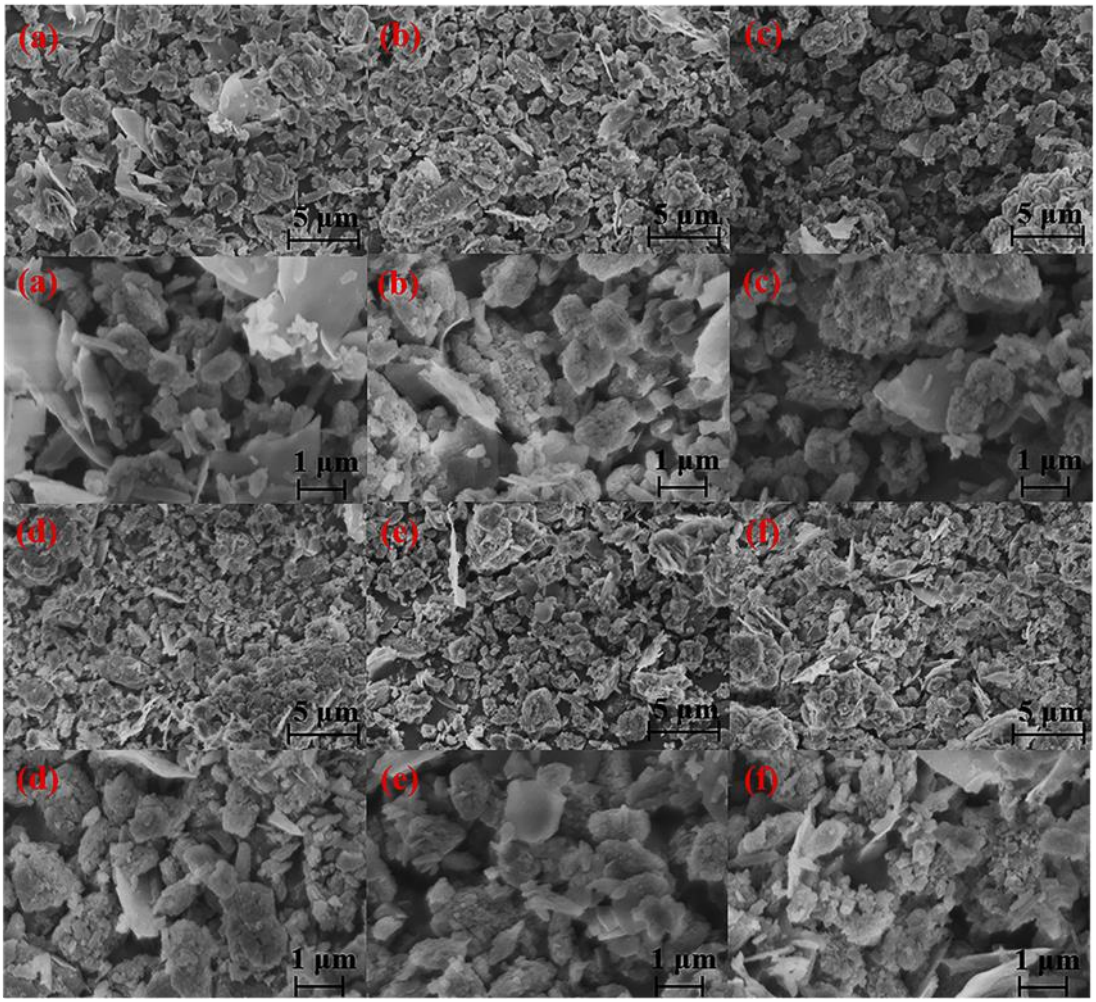

Figure S2. The SEM images of parent and modified catalysts (**a**) ZSM-5; (**b**) 10Ni; (**c**) 7Ni/3Fe; (**d**) 5Ni/5Fe; (**e**) 3Ni/7Fe; (**f**) 10Fe.

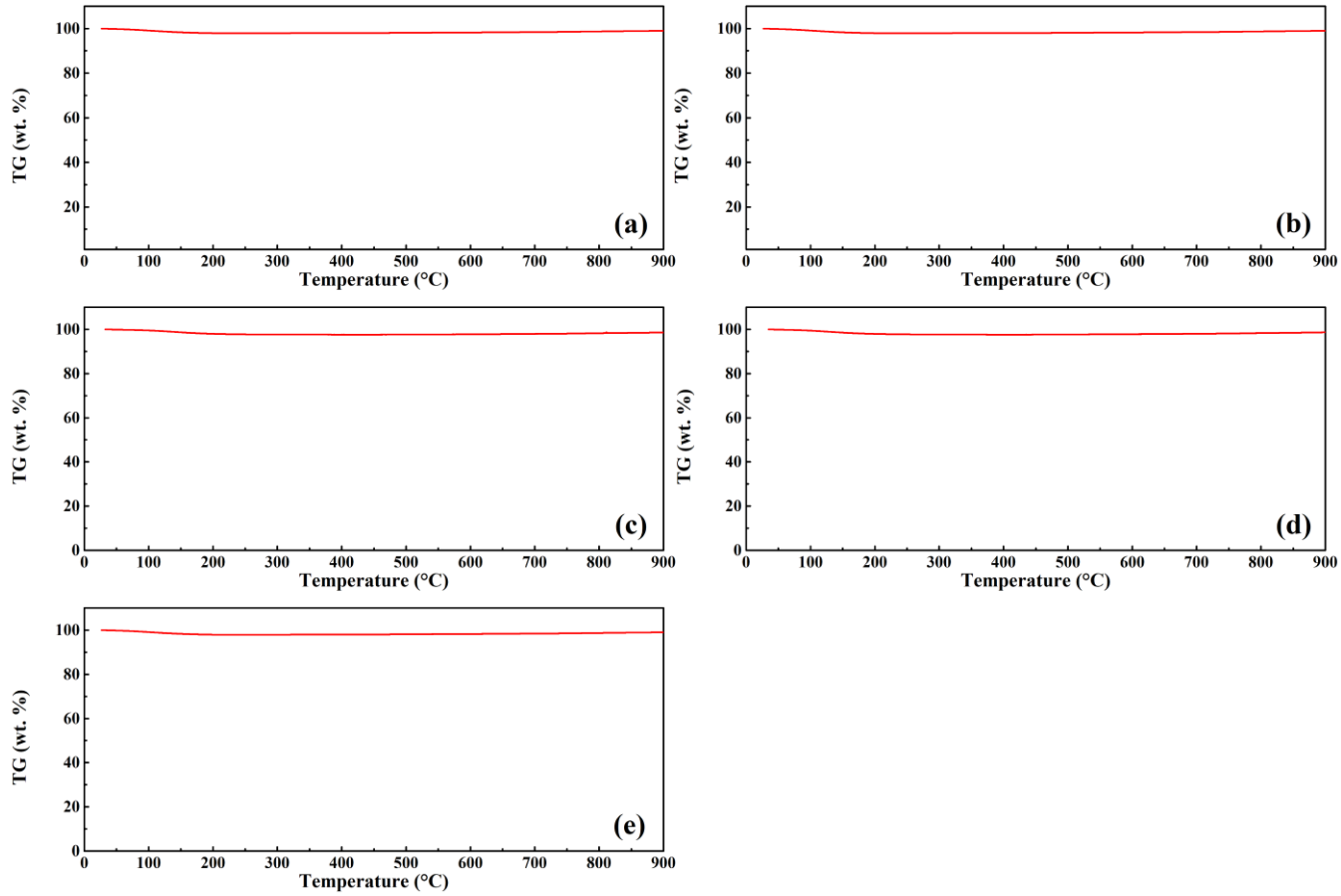

Figure S3. The TG curves of parent and modified catalysts heated from room temperature to 900 °C at the heating rate of 10 °C/min (**a**) 10Ni; **(b**) 7Ni/3Fe; (**c**) 5Ni/5Fe; (**d**) 3Ni/7Fe; (**e**) 10Fe.

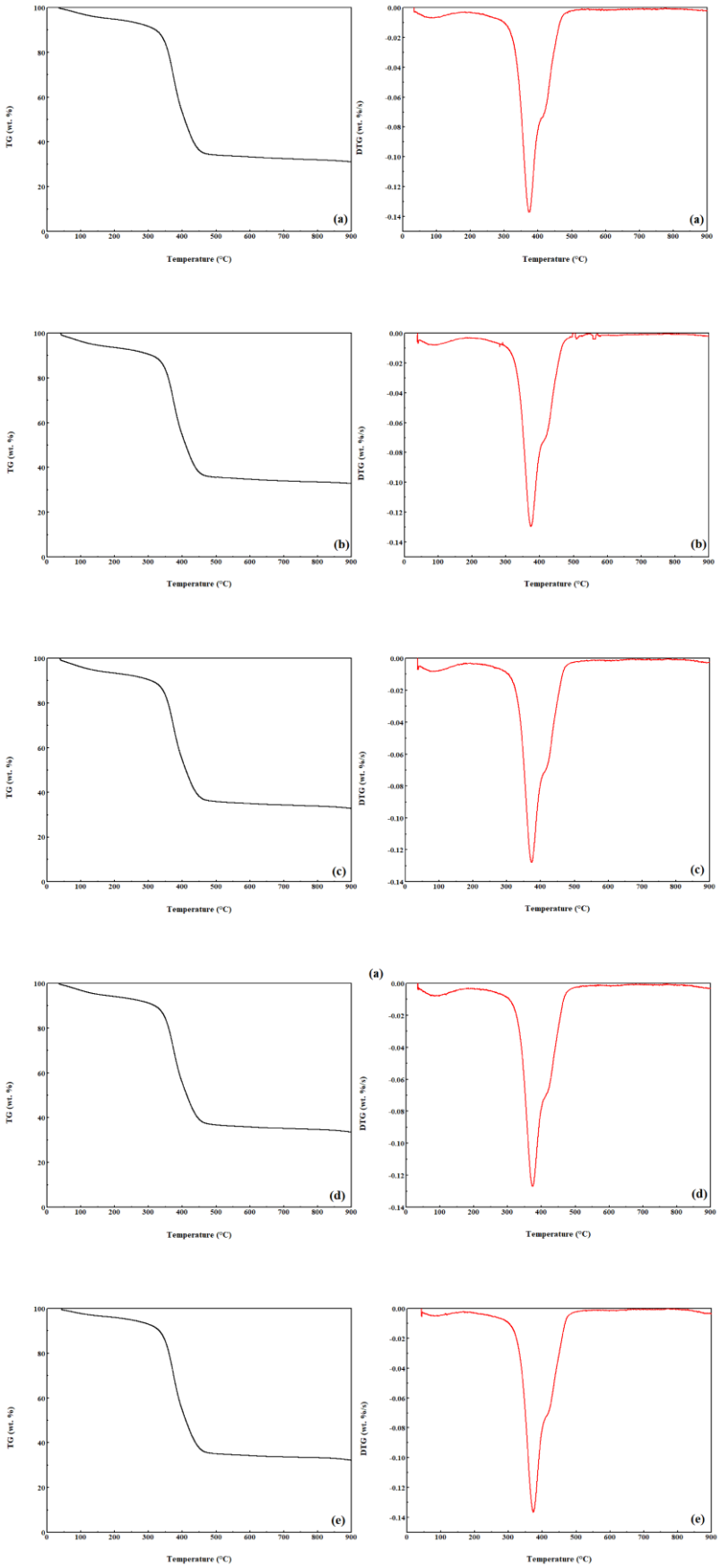

Figure S4. The TG and DTG curves of modified catalysts at the heating rate of 10 °C/min (**a**) 10Ni; (**b**) 7Ni/3Fe; (**c**) 5Ni/5Fe; (**d**) 3Ni/7Fe; (**e**) 10Fe.

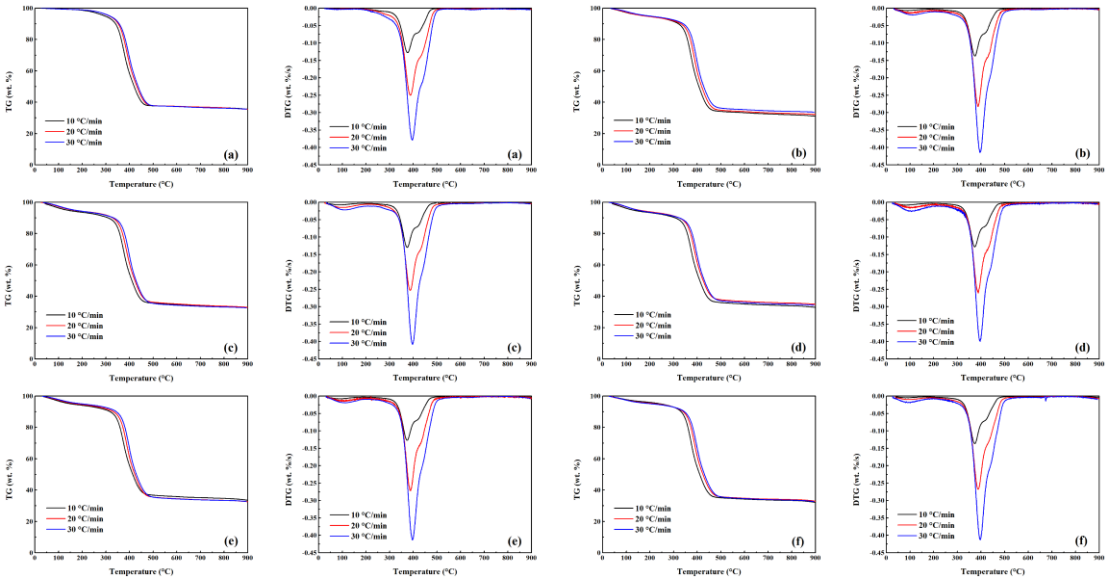

Figure S5. The TG and DTG curves of WT pyrolysis with no catalyst and five synthesized catalysts at three different heating rates of 10, 20 and 30 °C/min (**a**) No catalyst; (**b**) 10Ni; (**c**) 7Ni/3Fe; (**d**) 5Ni/5Fe; (**e**) 3Ni/7Fe; (**f**) 10Fe.

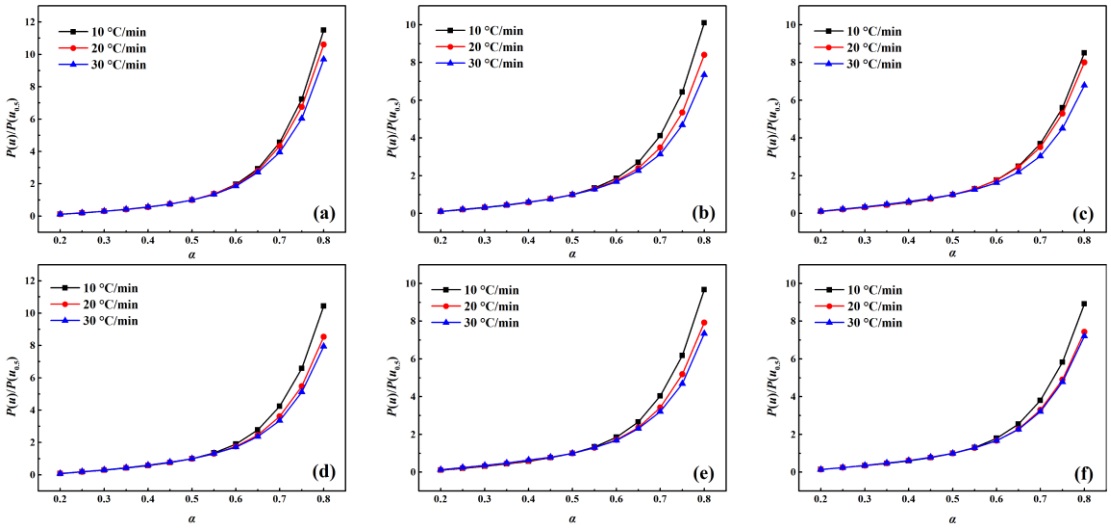

Figure S6. $P(u)/P(u_{0.5})$ versus α for WT pyrolysis with no catalyst and five synthesized catalysts at three different heating rates of 10, 20 and 30 °C/min (**a**) No catalyst; (**b**) 10Ni; (**c**) 7Ni/3Fe; (**d**) 5Ni/5Fe; (**e**) 3Ni/7Fe; (**f**) 10Fe.

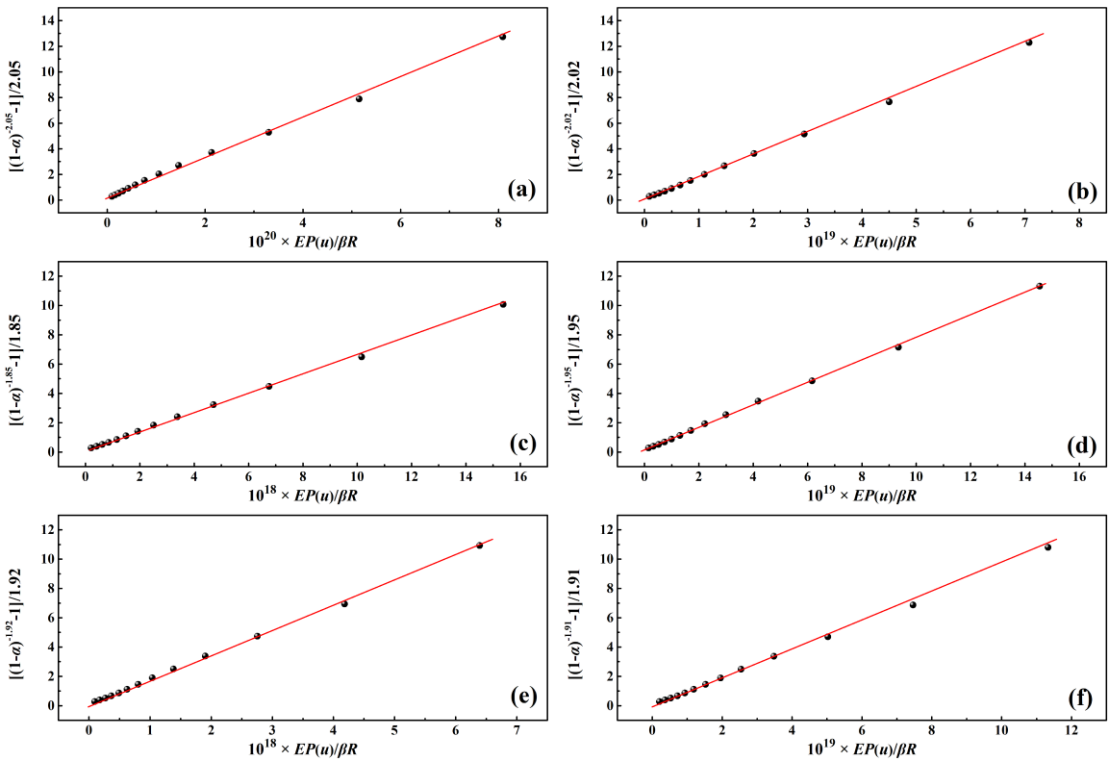

Figure S7. Plots of $[(1-\alpha)^{(1-n)}-1]/(n-1)$ versus $EP(u)/\beta R$ for WT pyrolysis with no catalyst and five synthesized catalysts (**a**) No catalyst; (**b**) 10Ni; (**c**) 7Ni/3Fe; (**d**) 5Ni/5Fe; (**e**) 3Ni/7Fe; (**f**) 10Fe.

Table S1. Correlations of all samples with Starink's method.

α	No catalyst	10Ni	7Ni/3Fe	5Ni/5Fe	3Ni/7Fe	10Fe
	R^2	R^2	R^2	R^2	R^2	R^2
0.20	0.9932	0.9991	0.9983	0.9975	0.9995	0.9976
0.25	0.9946	0.999	0.9964	0.9994	0.9992	0.9981
0.30	0.9988	0.9996	0.9956	0.9998	1.0000	0.9988
0.35	0.9985	0.9994	0.9942	0.9999	0.9998	0.9993
0.40	0.9991	0.9986	0.998	0.9998	1.0000	0.9997
0.45	0.9976	1.0000	0.999	1.0000	1.0000	0.9983
0.50	0.9985	0.9993	0.9995	0.9999	0.9999	0.999
0.55	0.9956	0.9994	1.0000	0.9999	0.9999	0.9981
0.60	0.9972	0.9991	0.9987	1.0000	1.0000	0.9961
0.65	0.9980	0.9981	0.9972	0.9998	0.9995	0.9946
0.70	0.9915	0.9993	0.9947	1.0000	0.9997	0.9935
0.75	0.9894	0.9997	0.9936	0.9997	0.9998	0.99
0.80	0.9937	0.9998	0.9933	0.9994	0.9995	0.9897

Table S2. Correlations of all samples with KAS method.

α	No catalyst	10Ni	7Ni/3Fe	5Ni/5Fe	3Ni/7Fe	10Fe
	R^2	R^2	R^2	R^2	R^2	R^2
0.20	0.9932	0.9991	0.9982	0.9975	0.9995	0.9976
0.25	0.9946	0.999	0.9963	0.9994	0.9992	0.9981

0.30	0.9988	0.9996	0.9955	0.9998	1.0000	0.9988
0.35	0.9985	0.9994	0.9942	0.9999	0.9998	0.9993
0.40	0.9991	0.9986	0.9980	0.9998	1.0000	0.9997
0.45	0.9976	1.0000	0.9990	1.0000	1.0000	0.9983
0.50	0.9985	0.9993	0.9995	0.9999	0.9999	0.9990
0.55	0.9956	0.9994	1.0000	0.9999	0.9999	0.9981
0.60	0.9971	0.9991	0.9987	1.0000	1.0000	0.9961
0.65	0.9980	0.9981	0.9972	0.9998	0.9995	0.9945
0.70	0.9915	0.9993	0.9946	1.0000	0.9997	0.9935
0.75	0.9894	0.9997	0.9936	0.9997	0.9998	0.9899
0.80	0.9937	0.9998	0.9933	0.9994	0.9995	0.9897

Table S3. Activation energies of all samples with KAS method.

α	No catalyst	10Ni	7Ni/3Fe	5Ni/5Fe	3Ni/7Fe	10Fe
	E (kJ/mol)	E (kJ/mol)	E (kJ/mol)	E (kJ/mol)	E (kJ/mol)	E (kJ/mol)
0.20	213.40	184.13	161.56	190.93	152.85	196.66
0.25	215.74	180.55	169.90	181.62	161.42	182.51
0.30	212.23	185.51	177.07	185.52	169.11	180.38
0.35	215.07	185.68	176.19	184.22	173.29	177.24
0.40	215.31	187.06	176.79	186.39	174.36	182.30
0.45	217.76	195.99	181.58	188.71	185.16	180.69
0.50	217.45	193.51	188.34	193.38	191.59	185.18
0.55	220.22	202.38	193.95	199.43	197.37	187.05
0.60	229.35	213.59	204.51	213.75	210.93	199.60
0.65	233.73	231.93	213.40	227.68	223.43	209.71
0.70	248.02	257.23	228.28	247.39	329.29	220.69
0.75	258.35	271.15	233.67	253.24	260.05	227.97
0.80	257.36	271.69	235.28	260.64	261.53	231.88
Ave	227.23	212.34	195.43	208.68	206.95	197.07