

Tuning the catalytic selectivity in biomass-derived succinic acid

hydrogenation on FeO_x-modified Pd catalysts

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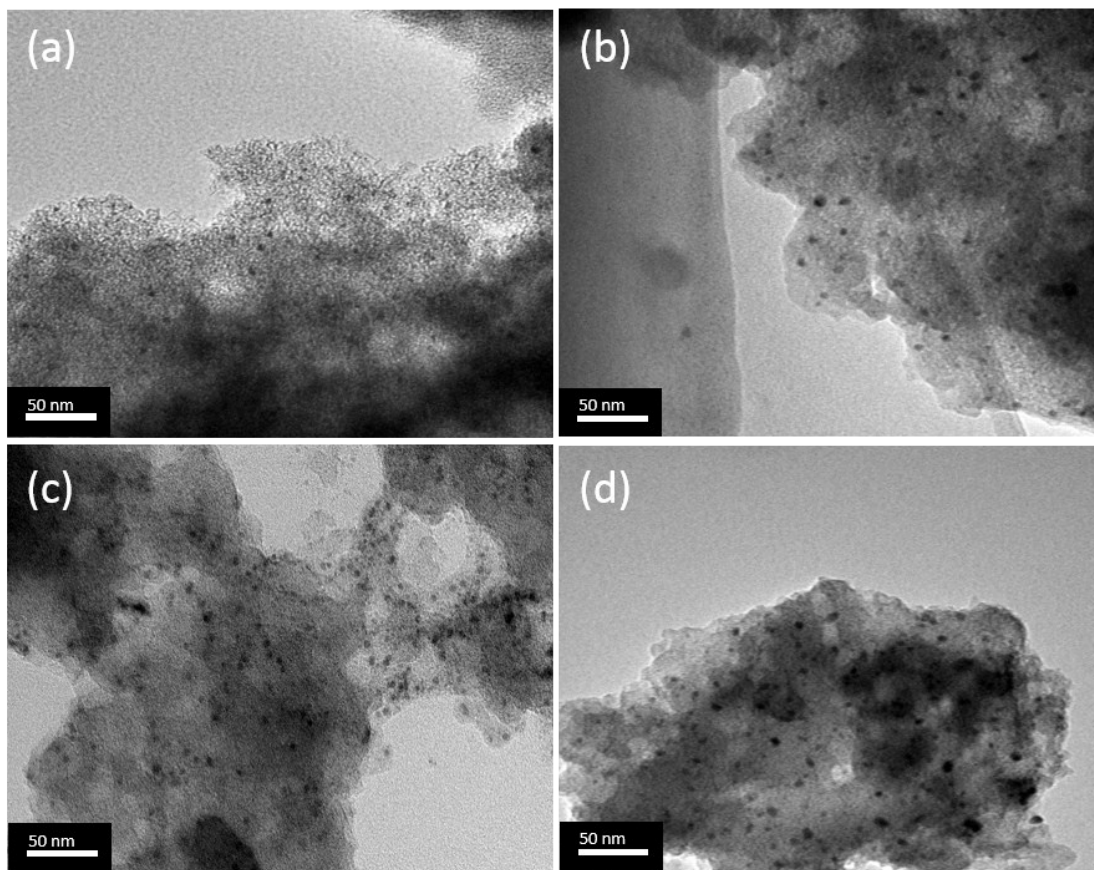


Fig. S1 TEM images of Pd-FeO_x/C catalysts: (a) Pd/C, (b) Pd-1FeO_x/C, (c) Pd-5FeO_x/C and (d) Pd-10FeO_x/C.

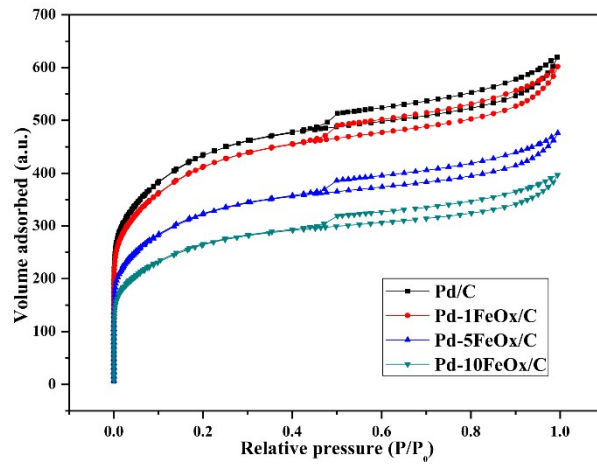


Fig. S2 Nitrogen sorption isotherms at 77.3 K.

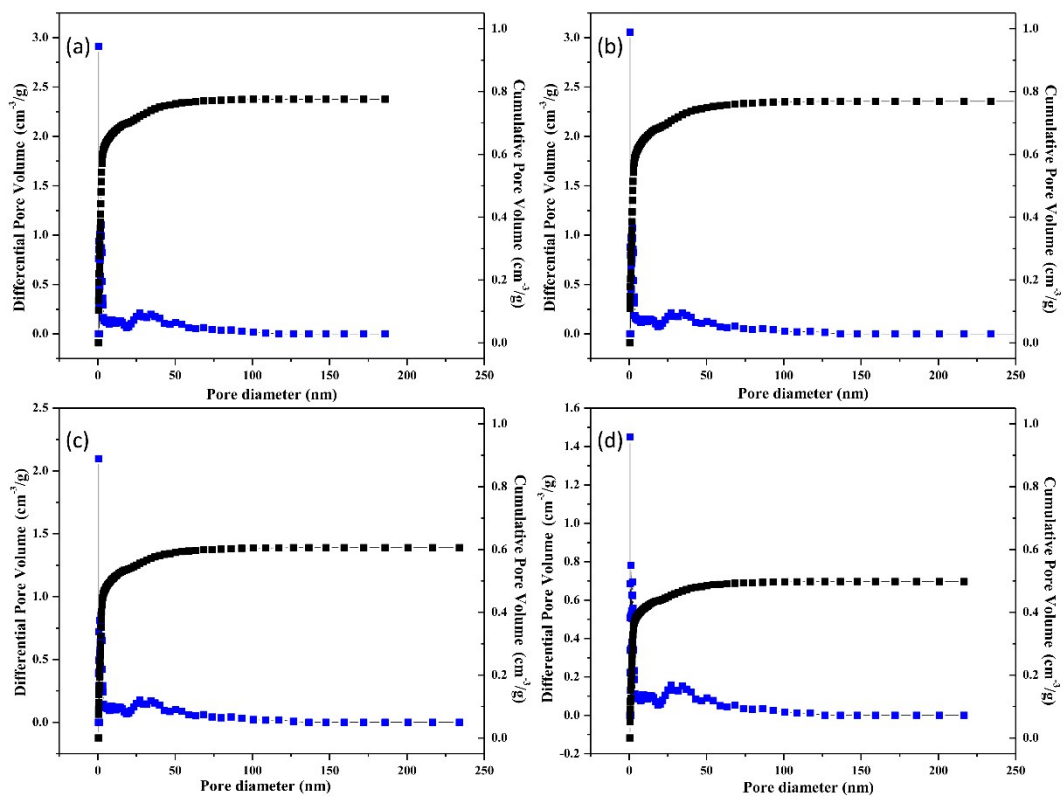


Fig. S3 Pore size distributions of Pd-FeO_x/C catalysts: (a) Pd/C, (b) Pd-1FeO_x/C, (c) Pd-5FeO_x/C and (d) Pd-10FeO_x/C.

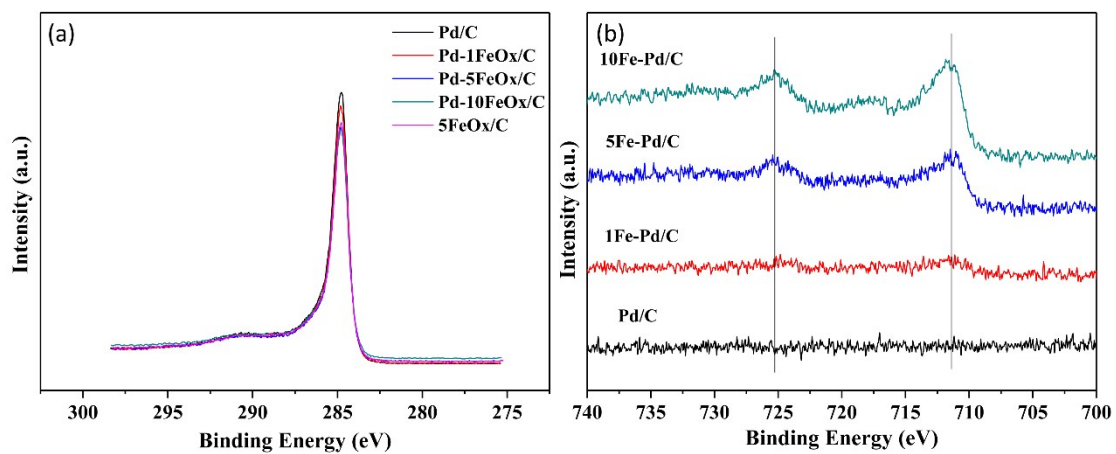


Fig. S4 XPS spectra of Pd-FeO_x/C catalysts: (a) C 1s spectra, (b) Fe 2p spectra.

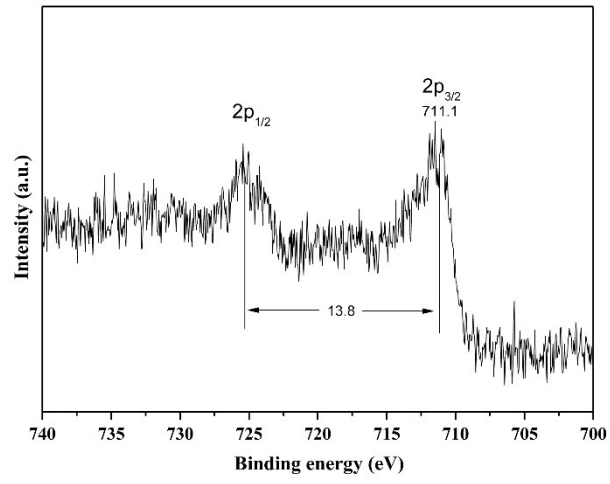


Fig. S5 Fe 2p spectrum of Pd-5FeO_x/C catalysts

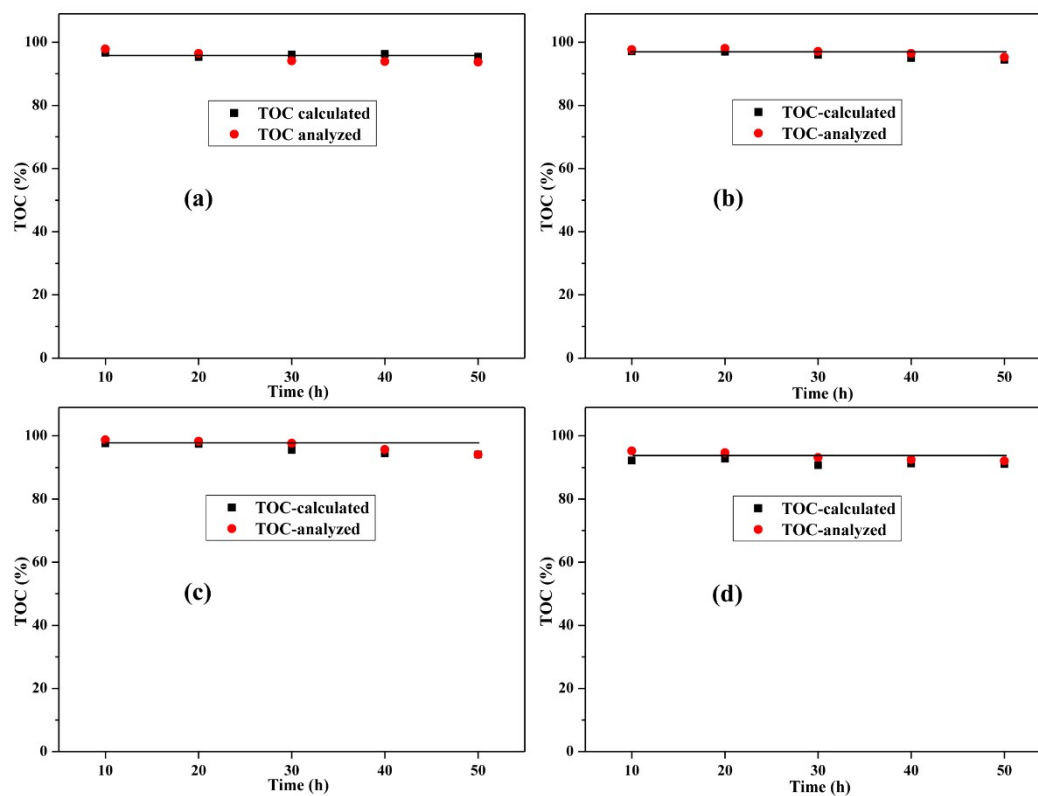


Fig. S6 Evolution of TOC in aqueous solution as a function of time. (a) Pd/C, (b) Pd-1FeO_x/C, (c) Pd-5FeO_x/C and (d) Pd-10FeO_x/C.

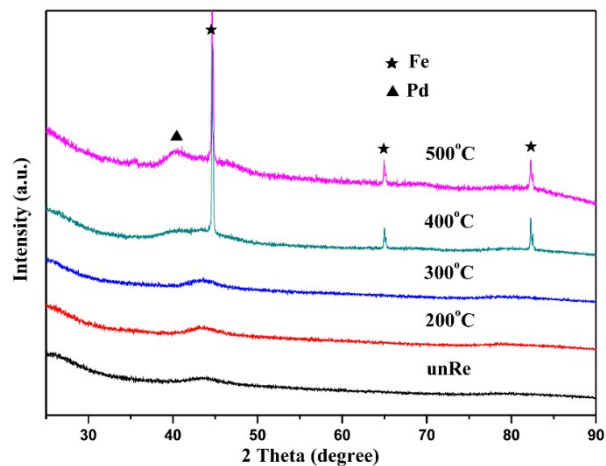


Fig. S7 XRD patterns of Pd-FeO_x/C reduced at different temperatures.

Fig. S7 shows the XRD patterns of Pd-5FeO_x/C reduced at different temperatures. No peaks belonged to Fe and Pd species could be observed at the reduction temperature of 200°C and 300°C. However, obvious sharp peaks belonged to Fe could be observed at 400°C, indicating that FeO_x was reduced to Fe at 400°C. Meanwhile, peak located at about 40° which belonged to Pd emerged at a higher temperature (above 400°C) which indicated the particle size of Pd increased as we elevated the reduction temperature.

Table S1 SA hydrogenation over Pd-5FeO_x/C reduced at different temperatures^a

Entry	Reduction temperature (°C)	Conv. (%)	Selectivity (%)				
			THF	GBL	BDO	PA	BA
1	200	87.7	3.2	65.3	21.6	1.8	5.3
2	300	83.3	5.9	74.8	10.3	1.5	4.0
3	400	60.2	6.6	84.5	0	2.2	3.6
4	500	56.7	8.0	76.5	0	5.6	3.3

^a Reaction conditions: T = 200°C; P = 5 MPa H₂ (RT); reaction time = 10 h.

Conv.: conversion, SA: succinic acid, THF: tetrahydrofuran, GBL: γ -butyrolactone, BDO: 1,4-butanediol, PA: propionic acid and BA: butyric acid.

We also investigated the catalytic activity of Pd-5FeO_x/C reduced at different temperatures in the SA hydrogenation. The results were shown in Table S1. SA conversion decreased over the catalysts reduced at a higher temperature (above 200°C). The decline of catalytic activity might attribute to the increase of metal particles size and the changes in the Fe chemical state. The results demonstrated the significant role of the interaction between FeO_x species and Pd in the SA hydrogenation. Selectivity to BDO decreased while the selectivity to THF increased slightly with the elevating of reduction temperature. Therefore, 200°C was used instead of a higher temperature in this research.