

Highly dispersed PtCo supported on mesoporous carbon nanospheres for efficient hydrogenation of furfural to furfuryl alcohol

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Experimental section

Materials

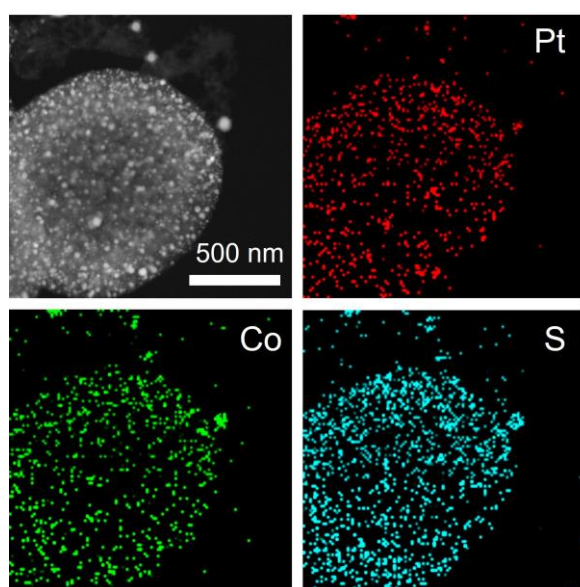
Resorcinol (AR), tetrapropoxysilane (TPOS, AR), hydrofluoric acid (HF, 35-38wt%), ethanol (99.9%), H₂PtCl₆ (99%), furfural (FFA, AR), furfuryl alcohol (FOL, AR), methanol (AR, ≥99.5%), ethanol (≥99.7%), isopropyl alcohol (IPA, AR), n-butanol (AR, ≥99.5%) were purchased from Aladdin Reagent (Shanghai) Co., Ltd. Formaldehyde (37wt%), NH₄OH (28-30wt%), FeCl₃ (97%), Cu(NO₃)₂·3H₂O (99%), CoCl₂·6H₂O (99%), sodium thioglycolate (STG, 97%) were purchased from Sinopharm Chemical Reagent Co. Ltd., China. All the chemicals were used as received without further purification. Deionized water (18.2 MΩ/cm) used in all experiments was prepared by passing through an ultra-pure purification system. Characterization.

The morphologic structures of samples were observed using scanning electron microscopy (SEM, TESCAN/MAIA3, Czech) and Transmission electron microscopy (TEM, JEM-2100F). X-ray diffraction (XRD) spectra were collected on a Rigaku Miniflex diffractometer using Cu-Kα as a radiation source ($\lambda = 0.154$ nm). The N₂ sorption was carried out with Quantachrome Autosorb-iQ to measure Brunauer-

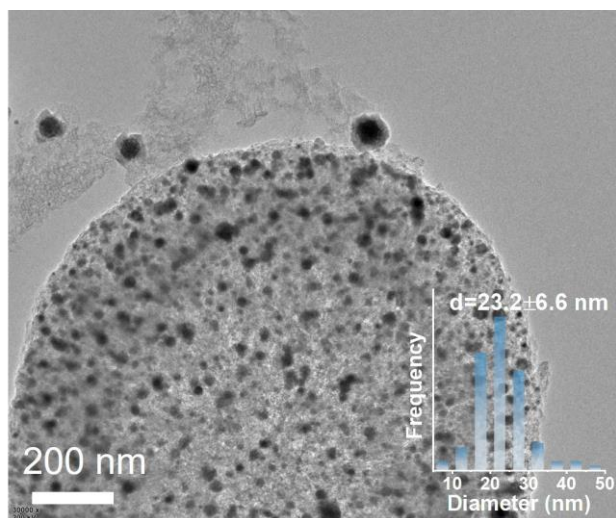
Emmett-Teller (BET) surface area and pore size distribution. The BET method was employed for the determination of the specific surface area of the catalysts and the Barrett-JoynerHalenda (BJH) model was employed to analyze the pore size distribution and pore volume. The XPS spectra were investigated using an Escalab 250Xi equipped with Al K radiation. NMR determination was performed on nuclear magnetic resonance (NMR, 400 MHz) equipment. The metal loadings of samples were determined with ICP-OES (Prodigy plus).

Catalytic performance tests

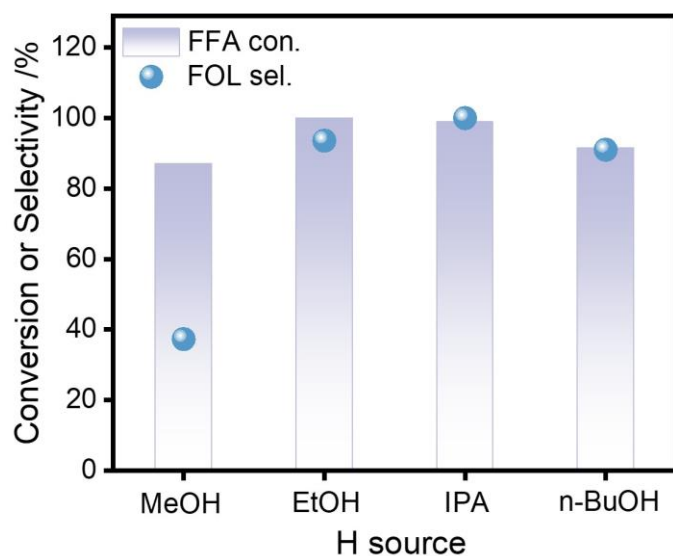
The selective hydrogenation of furfural (FFA) was carried out in a sealed stainless-steel autoclave reactor under magnetic stirring. In a typical catalytic run, 20 mg of catalyst and 0.5 mmol of FFA were dispersed in 15 mL of isopropanol as the solvent. The reactor was subsequently sealed and heated to the target reaction temperature, and the reaction proceeded under the autogenous pressure generated during heating. Upon completion of the reaction, the catalyst was removed by filtration, and the liquid-phase products were analyzed by gas chromatography-mass spectrometry (GC-MS) using an Agilent 8860 GC system coupled with a 5977B mass spectrometer. The recyclability of the catalyst was assessed over multiple consecutive runs. Following each cycle, the spent catalyst was recovered by centrifugation, washed thoroughly with isopropanol to remove any adsorbed species, dried under vacuum, and reloaded into the reactor under identical experimental conditions.



Supplementary Figure 1. HAADF-STEM image and the corresponding EDS elemental mapping of PtCo/S/MCS catalyst.

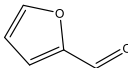
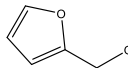
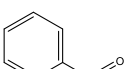
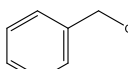
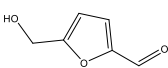
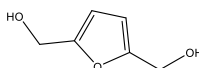


Supplementary Figure 2. TEM image of PtCo/S/MCS with the inset showing the particle size distribution.



Supplementary Figure 3. Catalytic performances of FFA hydrogenation with various solvents. Reaction conditions: 20 mg of catalyst, 0.5 mmol of FFA, 15 mL of solvent, 170 °C, 4 h.

Supplementary Table 1. Catalytic hydrogenation of different carbonyl compounds over the as-prepared PtCo-S/MCS catalyst^a

Entry	Substrates	Products	Con./ %	Sel./%
1			98.9	100
2			72.3	90.2
3			65	89

^aReaction conditions: 20 mg of catalyst, 0.5 mmol of substrates, 15 mL of IPA, 170 °C, 4 h, 900 rpm.

The hydrogenation of a series of carbonyl-containing compounds was also investigated to evaluate the applicability of the PtCo-S/MCS catalyst. As shown in Supplementary Table 1, selectivities toward the corresponding alcohol products above 85% were achieved in all cases, indicating the potential applicability of PtCo-S/MCS in the catalytic upgrading of biomass-derived carbonyl compounds.