Supporting Information

Porous Nanopeapod Pd Catalyst with Excellent Stability and Efficiency

Chemicals

Palladium acetate, sodium dodecyl sulfate (SDS), hexadecyl trimethyl ammonium bromide (CTAB), tetraethyl orthosilicate (TEOS), and nitrobenzene were bought from Sigma-Aldich and used without further purification. Carbon nanotubes with diameters between 20 and 40 nm (CNTs) were purchased from Shenzhen Nanotech Port Co. Ltd(NTP) and the other chemicals were obtained from Sinopharm Chemical Reagent Co., Ltd.

Experimental section

1. Deposition of Pd nanoparticles on carbon nanotubes (CNT-Pd)

In the typical procedures, 30 mg of CNTs (MWCNTs) were suspended in 60 mL of 0.05 M aqueous SDS solution and sonicated for 20 min. Afterwards, 60 mg of palladium acetate were added to the CNTs/SDS dispersion and the mixture was refluxed for 6 h. After cooling to room termperature, the mixture was filtered through a 0.2 μm PTFE membrane filter, washed extensively with ethanol to remove the excess surfactant, and dried in vaccum at 80 ^{o}C.

2. Deposition of the mesoporous silica layer on CNT/Pd (CNT/Pd@m-SiO_2)

A modified synthesis method to form the silica coating on CNT/Pd was adopted.[1] In the typical synthesis, 100 mg of CNT/Pd and 0.3 g of CTAB were dispersed in 9 mL of deionized water and the mixture was sonicated for one hour. The mixture was added to 24 mL of anhydrous ethanol and sonicated for another 0.5 h to form a stable dispersion. 0.6 mL of $NH_3·H_2O$ (25～28 wt%) were added and a TEOS solution (0.3 mL TEOS in 12 ml ethanol) was then added dropwise under stirring, followed by stirring for another 12 h. Finally, the mixture was centrifuged and washed with ethanol and a uniform and thick layer of silica was produced on the CNT/Pd@m-SiO_2.

3. Peapod Pd@m-C/SiO_2

The CNT/Pd@m-SiO_2 was annealed at 800 °C in Ar for 18 h. After cooling to room temperature, the peapod Pd@m-C/SiO_2 was obtained.

4. Catalytic reduction of nitrobenzene with H_2

The hydrogenation reactions were conducted in an autoclave at 80 °C. In the typical catalytic reaction, 10 mg of the catalyst, 10 mL of ethanol, and 5 mmol of nitrobenzene were introduced into the autoclave at a H_2 pressure of 4 Mpa and the reaction proceeded for 5 min. After the reaction, the catalyst was seperated by centrifugation and washed for future use.

Evaluation of Pd leaching

In the assessment of leaching of Pd species, after filtration of the catalyst, no color appeared from the solution. After the IPC measurement, no Pd species were detected from the solution.

5. Catalytic reduction of NO with NH_3

The NH_3-SCR stability tests were performed in a fixed-bed quartz reactor using 0.2 g of the catalyst (20～40 mesh). The gas mixture was composed of 500 ppm NO, 500 ppm NH_3, 3 vol. % O_2, and N_2 balance. The gas velocity was 20000 h^{-1} while the total flow rate of the gas was 250 mL/min. The reaction temperature was 200 °C. The concentration of the feeding and tail gases were was determined on the SIGNAL MEASUREMEN flue gas analyzer.

6. Characterization

X-ray diffraction (XRD) was conducted on a Philips diffractometer using Cu K_α radiation. Transmission electron microscopy (TEM) and high-resolution transmission electron microscopy (HR-TEM) were performed on the FEI Tecnai F30 transmission electron microscope at 200 kV. The N_2 adsorption/desorption isotherms were acquired at the liquid nitrogen temperature (77 K) on a Micromeritics ASAP 2010M instrument and the specific surface area was calculated by the Brunauer–Emmett–Teller (BET) method. The pore size distribution was determined by the Barret–Joner–Halenda (BJH) method.

1. M. Zhang, Y. Wu, X. Feng, X. He,L. Chen, Y. Zhang. Journal of Materials Chemistry. 2010, 20, 5835-42.

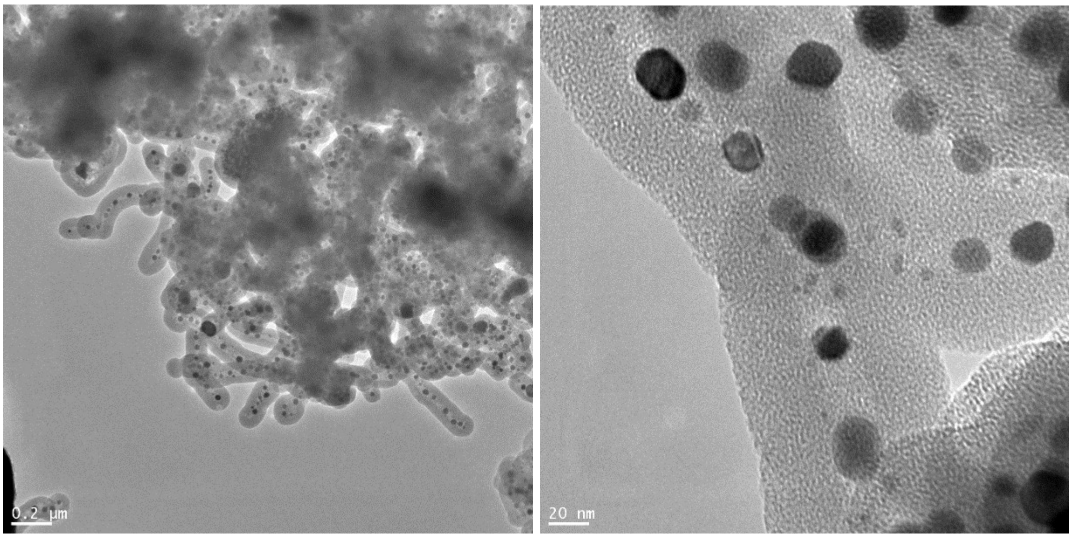

Figure S1. TEM images of the Pd@m-C/SiO_2 catalyst in low and high-magnification.

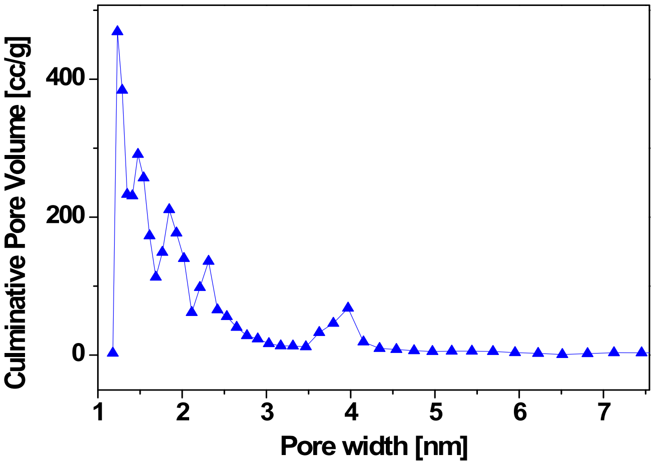

Figure S2. Pore size distributions of the Pd@m-C/SiO_2 catalyst.