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Supporting Information

A Facile One-Pot Synthesis of Uniform Core-Shell Silver Nanoparticle@Mesoporous Silica Nanospheres

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Experimental section

Chemicals

Cetyltrimethylammonium bromide (CTAB, 99.0 %), formaldehyde solution (37.0 %), and ammonium nitrate (99.0 %) were purchased from Sinopharm Chemical Reagent Company. Tetraethyl orthosilicate (TEOS, 98 %) and absolute anhydrous ethanol (99.7 %) were purchased from Shanghai Chemical Company. Sodium hydroxide (96.0 %) was purchased from Shanghai Dahe Chemical Company. Silver nitrate (99.8 %) was purchased from Shanghai Shenbo Chemical Company. All chemicals were used without additional purification. Deionized water was used for all experiments.

Synthesis

The core-shell Ag@MSN mesoporous silica spheres were synthesized by a facile one-pot process using silver nitrate as a precursor, formaldehyde as a reducing agent,

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CTAB as the stabilizer and template, TEOS as a silica source, and sodium hydroxide as a basic catalyst. The synthesis compositions of silver nitrate: formaldehyde: sodium hydroxide: CTAB: TEOS: water (molar ratio) were in the range of 0.02-0.10: 0.3: 0.5-1.0: 0.27: 2.4: 2666. In a typical synthesis, 0.10 g of CTAB was dissolved in the solution containing 48 mL of water and 1.4 mL of 0.5 M NaOH. After stirring at 80 °C for 30 min, 0.3 mL of 1.0 M formaldehyde solution and 1.0 mL of 0.1 M silver nitrate aqueous solution were added. Then 0.5 g of TEOS was added with stirring. The products were filtered after stirring for 2 h, washed by ethanol and water, and then dried at 50 °C in vacuum. The surfactant template was removed by extraction in ethanol solution containing ammonium nitrate (6 g/L).

Characterization

X-ray diffraction (XRD) patterns were recorded on a Bruker D4 X-ray diffractometer with Ni-filtered Cu K α radiation (40 kV, 40 mA). Scanning electron microscopy (SEM) images were obtained on a Philips XL 30 microscope operated at 20 kV. Transmission electron microscopy (TEM) images were obtained with a JEM 2100F microscope operated at 200 kV. For TEM measurements, the samples were dispersed in ethanol, and then dipped and dried on Cu grids. Energy dispersive X-ray spectroscopy (EDX) was performed on a JEM 2100F EDX instrument. Nitrogen sorption isotherms were measured at 77 K by using a Micromeritics ASAP Tristar 3000 system. The samples were degassed at 180 °C for 6 h on a vacuum line. The surface area and pore size were obtained by using Brunauer-Emmett-Teller (BET) and Barrett-Joyner-Halenda (BJH) methods, respectively.

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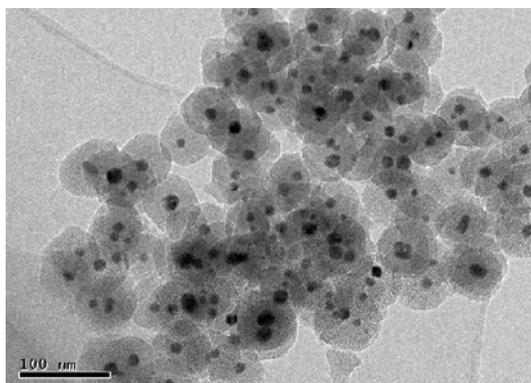


Fig. S1 Low-magnification TEM image of Ag@MSN nanospheres.

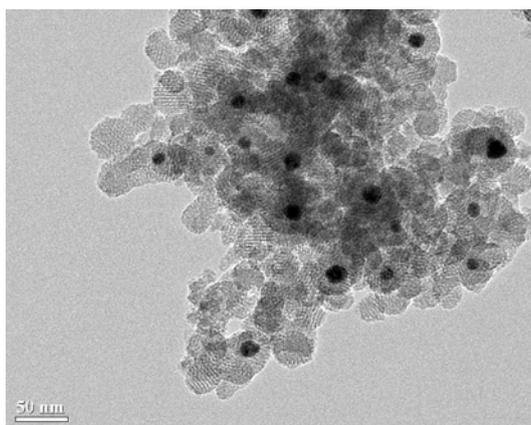


Fig. S2 TEM image of materials obtained using tetramethoxysilane (TMOS) as the silica source. The hydrolysis-condensation rate of TMOS is too fast to form uniform Ag@MSN core-shell structures. Many mesoporous silica nanoparticles without core-shell structures are observed.

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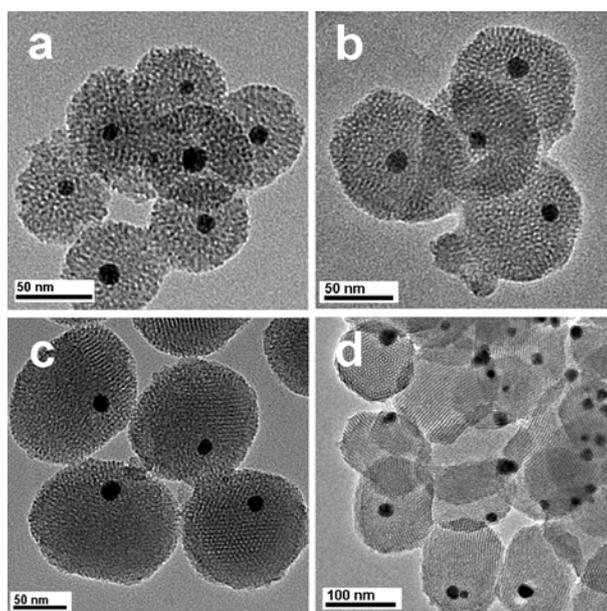


Fig. S3 TEM images of Ag@MSN nanocomposites with particle size of about (a) 60 nm, (b) 90 nm, (c) 120 nm, and (d) 140 nm. The samples were obtained by adjusting the volume of 0.5 M NaOH to (a) 1.2, (b) 1.4, (c) 1.6, and (d) 1.8 mL, respectively. The silver nanoparticles are located on the fringe of silica particles for the sample with the largest particle size.