

Supporting Information Available

Facile water-based synthesis and catalytic properties of platinum-gold alloy nanocubes

Gengtao Fu, Linfei Ding, Yu Chen,* Jun Lin, Yawen Tang, and Tianhong Lu

Jiangsu Key Laboratory of New Power Batteries, Jiangsu Collaborative Innovation Center of Biomedical Functional Materials, College of Chemistry and Materials Science, Nanjing Normal University, Nanjing 210046, P. R. China.

*Corresponding author. Tel: +86–25–85891651; fax: +86–25–83243286.

E-mail address: ndchenyu@gmail.com

Experimental section

Reagents and chemicals

Polyallylamine hydrochloride (PAH, shown in Scheme S1, weight-average molecular weight 15 0000) was supplied from Nitto Boseki Co., Ltd. (Tokyo, Japan). Hydrogen hexachloroplatinate(IV) hydrate ($\text{H}_2\text{PtCl}_6 \cdot 6\text{H}_2\text{O}$), hydrogen tetrachloroaurate(III) tetrahydrate ($\text{HAuCl}_4 \cdot 4\text{H}_2\text{O}$), formaldehyde solution (HCHO, 40%) and 4-nitrophenol (4-NP) and were purchased from Sinopharm Chemical Reagent Co., Ltd. (Shanghai, China). Other reagents were of analytical reagent grade and used without further purification. All the aqueous solutions were prepared with Millipore water with a resistivity of 18.2 M Ω . The solution pH was adjusted by the addition of dilute NaOH or HCl solution.

Synthesis of the Pt-Au nanocubes (Pt-Au ANCs)

In a typical synthesis, the appropriate amount of 0.05 M H_2PtCl_6 , 0.05 M HAuCl_4 and 0.50 M PAH (molarity of PAH given with respect to the repeating unit) were added into 4.0 mL of water with continued stirring (molar ratio of PAH monomer to total metal species was 10:1). After adjusting solution pH to 3.0, 2.0 mL of formaldehyde solution (40%) was added into the homogeneous solution. Then, the mixture solution was transferred to a 20-mL Teflon-lined stainless-steel autoclave, and was then heated at 120 °C for 6 hours. After being cooled to room temperature, the obtained Pt-Au nanocubes (Pt-Au ANCs) were separated by centrifugation at 15000 rpm for 15 min, washed several times with water, and then dried at 60 °C for 5 hours in a vacuum dryer.

Catalytic reduction of 4-nitrophenol (4-NP)

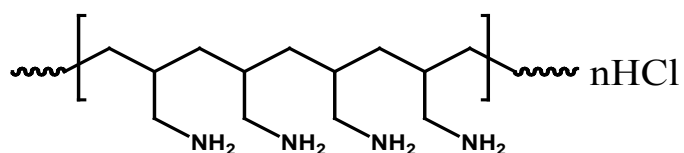
Typically, 1.0 mL of 0.1 M NaBH_4 and 2 mL of 1.0×10^{-5} M 4-NP solutions were first put in a quartz cuvette having 1-cm path length. Then, 40 μL of Pt-Au ANCs aqueous solution (1.0 g L^{-1}) was added into the mixture solution. The reduction

progress of 4-NP was then monitored by recording the time-dependent absorption UV-vis spectra of the reaction at a regular time interval of 4 min. For comparison, commercial Pt black was also used as heterogeneous catalysts for the reduction of 4-NP.

Instruments

Transmission electron microscopy (TEM) images were taken using a JEOL JEM-2100F transmission electron microscopy operated at 200 kV. X-Ray Powder Diffraction (XRD) data was obtained with a Model D/max-rC X-ray diffractometer using Cu K_α radiation source ($\lambda=1.5406 \text{ \AA}$) and operating at 40 kV and 100 mA. The composition of the catalysts was determined using the energy dispersive spectrum (EDS) techniques. High-resolution X-ray photoelectron spectroscopy (XPS) was carried out on a Thermo VG Scientific ESCALAB 250 spectrometer with an Al K α radiator, and the vacuum in the analysis chamber was maintained at about 10^{-9} mbar. The binding energy was calibrated by means of the C 1s peak energy of 284.6 eV. Fourier Transform infrared (FT-IR) spectra were recorded on a Nicolet 520 SXFTIR spectrometer. The pH measurements were carried out a Mettler Toledo Delta320 Digital pH-meter.

Experimental Data



Scheme S1. Structure of the polyallylamine hydrochloride (PAH).

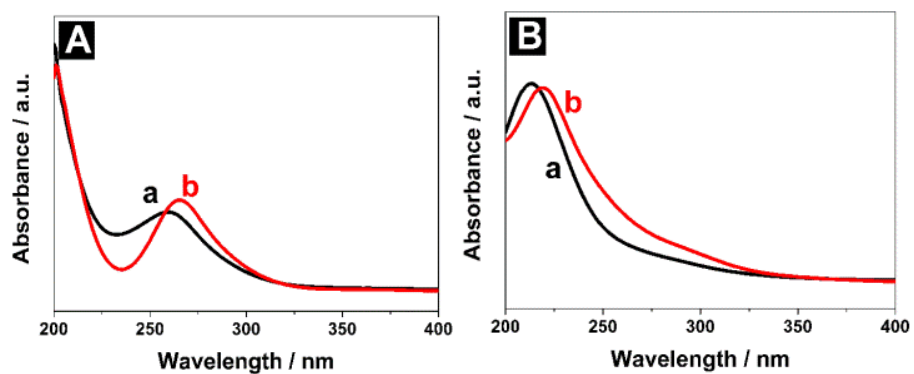


Fig. S1 (A) UV-vis absorption spectra of (a) H_2PtCl_6 solution, and (b) the mixture solution of PAH and H_2PtCl_6 (molar ratio of PAH monomer to H_2PtCl_6 is 10:1). (B) UV-vis absorption spectra of (a) HAuCl_4 solution, and (b) the mixture solution of PAH and HAuCl_4 (molar ratio of PAH monomer to HAuCl_4 is 10:1).

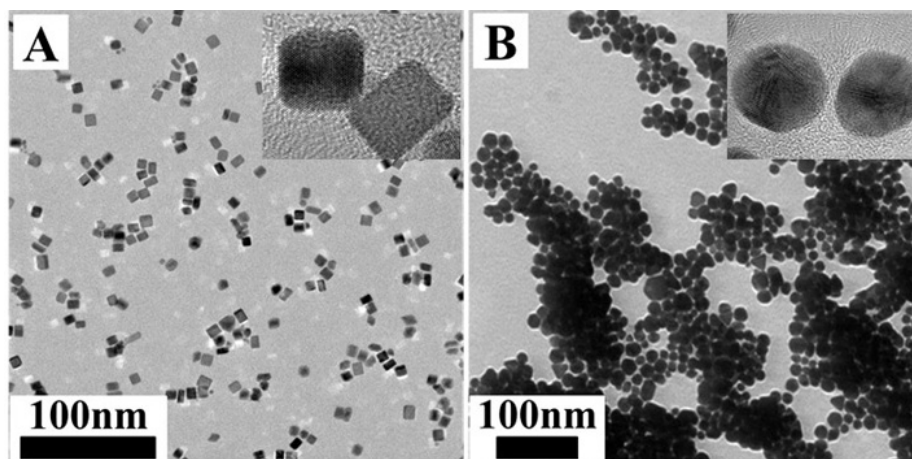


Fig. S2 TEM image of the single-component (A) Pt nanoparticles and (B) Au nanoparticles prepared under the same condition as in Fig. 3, the up-right inset in Fig. S2 are corresponding magnified TEM images.

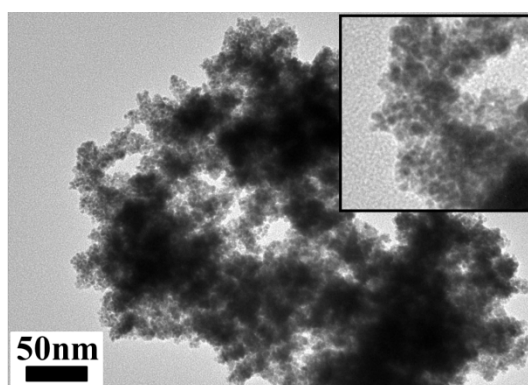


Fig. S3 TEM image of the Pt-Au nanoparticles prepared under the same condition as in Figure 3 except the exclusion of PAH.