Supporting Information

Room-temperature cold-welding of gold nanoparticles for enhancing the electrooxidation of carbon monoxide

Cai Liu,[a] Yong-Jun Li,[a] Shi-Gang Sun[b] and Edward S. Yeung[a]

[a] *State Key Lab of Chemo/Biosensing and Chemometrics, School of Chemistry and Chemical Engineering, Hunan University, Changsha 410082, China. Tel: 86- 731- 88821900; E-mail: liyongjunef@gmail.com*

[b] *State Key Lab for Physical Chemistry of Solid Surfaces, Department of Chemistry, Xiamen University, Xiamen 361005, China. Tel: 86-592- 2180181; E-mail:sgsun@xmu.edu.cn*

Experimental

Materials

Chloroauric acid trihydrate ($HAuCl_4 \cdot 3H_2O$), ethanol, toluene and potassium hydroxide (KOH) were purchased from Sinopharm Chemical Reagent Co. Ltd (China). Sodium citrate was obtained from Sanland-Chem International Inc. Indium-tin-oxide (ITO)-coated glass slides were supplied by Southern Glass Holding Co. Ltd (China), and were cleaned in acetone, ethanol and water successively before use.[1]

Fabrication of welded AuNP monolayer films

AuNPs with an average diameter of 18 nm were synthesized according to Frens' method.[2] The as-prepared Au aqueous colloid was used directly for the interfacial assembly as shown in Scheme 1. Typically, 10 mL of the Au aqueous colloid was transferred into a 25-mL beaker (inner diameter about 3.5 cm). Then, a mixture of ethanol and toluene with a selected volume ratio was injected into the Au aqueous colloid at a rate of 2.0 mL/min to obtain welded or isolated AuNPs at the water/toluene interface. After evaporation of toluene, AuNP monolayer films were formed and can be conveniently transferred onto other desired substrate surfaces for measurements after drying in air. Transfer of AuNP is easy to be done. Briefly, a piece of hydrophilic substrate was immersed into the solution at a certain inclined angle,

and then the film was deposited onto one side of the substrates by pulling the substrate slowly in the vertical direction, which is the same as our previous reports.[3]

Electrochemical measurements

All electrochemical measurements were carried out in a conventional three-electrode cell on CHI 660B electrochemical workstation (Shanghai, China). A Pt wire and a saturated calomel electrode (SCE) were used as the counter electrode and the reference electrode, respectively. After cleaning in 0.5 mol/L KOH solution, ITO glass coated with AuNP monolayer films was used as the working electrode by cycling the potential between -0.7 V and 0.7 V to estimate the electrochemically active area of the AuNP monolayer film. The electrocatalytic behavior of the resultant AuNP monolayer films for CO was evaluated in 0.5 mol/L KOH solution saturated with CO by cyclic voltammetry.[4]

Other Instruments

Transmission electron microscopy (TEM) characterization was carried out on a JEM-3010 with an accelerating voltage of 100 kV. Scanning electron microscopy (SEM) results were obtained on a LEO-1530 field emission scanning electron microscope with an accelerating voltage of 30 kV. Absorption spectra of AuNP monolayer films were measured on a Varian Cary 5000 UV-vis/NIR spectrophotometer. The injection rate of the mixture of ethanol and toluene was controlled by a KDS syringe pump (Stoelting Co.)

Fig. S1. Image of 18-nm AuNP monolayer film obtained by injecting the mixture with the ethanol:toluene volume ratio of 1:3 from the bottom of a 25-mL beaker (inner diameter, 3.5 cm) containing AuNP solution. The injected volume of ethanol was fixed at 2.75 mL.

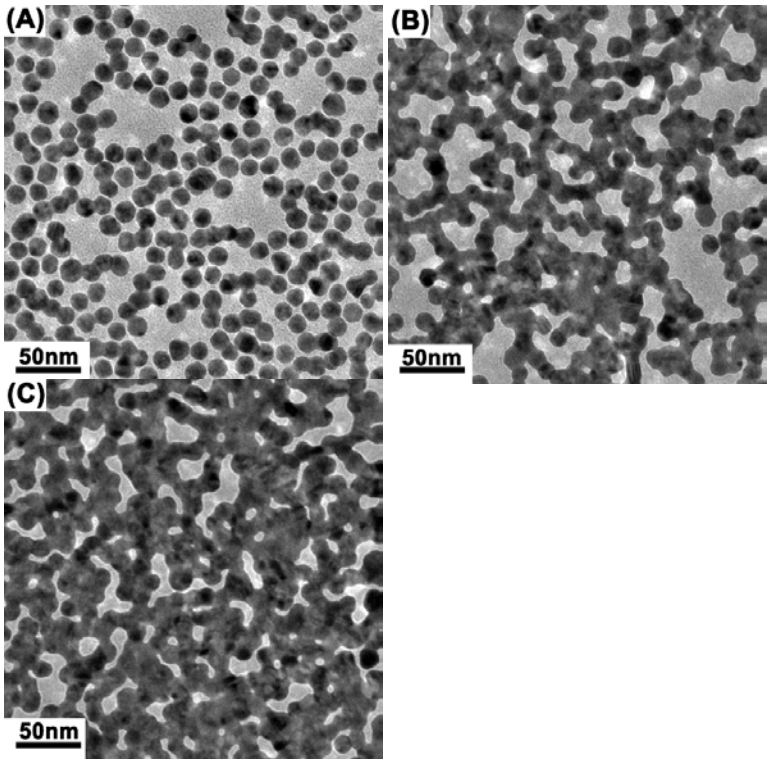

Fig. S2. TEM images of 18-nmAuNP monolayer films obtained by injecting mixtures with ethanol:toluene volume ratios of 1:2.5 (A), 1:1.25 (B) and 1:0.65 (C), respectively. The injected volume of toluene was fixed at 2 mL.

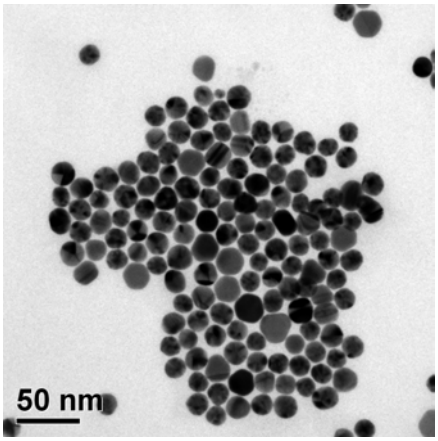

Fig. S3. TEM image of 18-nm AuNP solution dropped on a carbon-coated Cu grid.

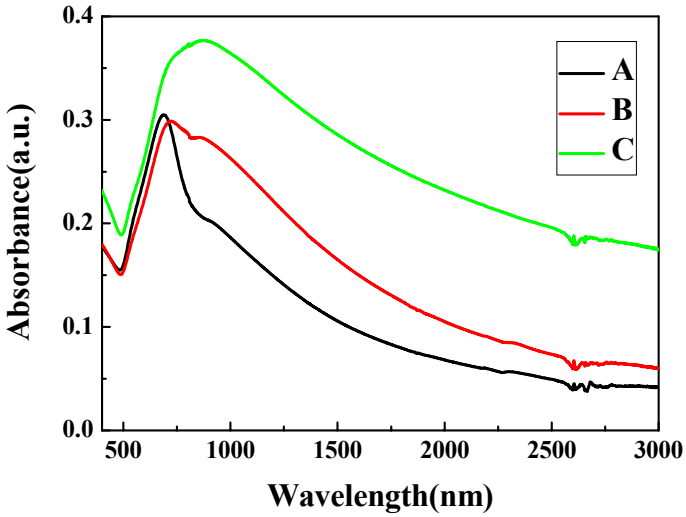

Fig. S4. Absorption spectra of 18-nm AuNP monolayer films obtained by injecting mixtures with ethanol:toluene volume ratios of 1:3 (A), 1:2 (B) and 1:1 (C), respectively. The injected volume of ethanol was fixed at 1.5 mL.

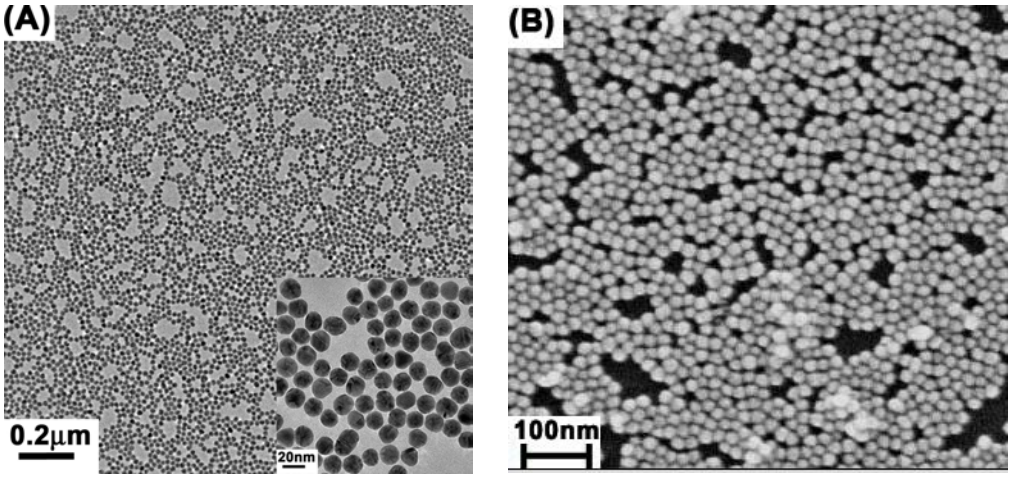

Fig. S5. TEM (A) and SEM (B) images of 18-nm AuNP monolayer films obtained by injecting a mixture with the ethanol:toluene volume ratio of 1:3. The injected volume of ethanol was 2.75 mL.

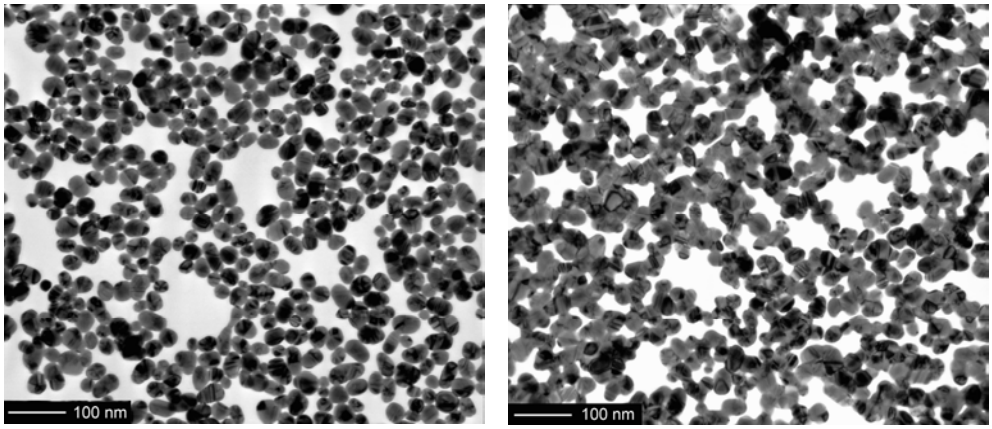

Fig. S6. TEM images of 30-nm AuNP monolayer film obtained by injecting the mixture with the ethanol:toluene volume of 1/3 (A) and 3/1 (B).

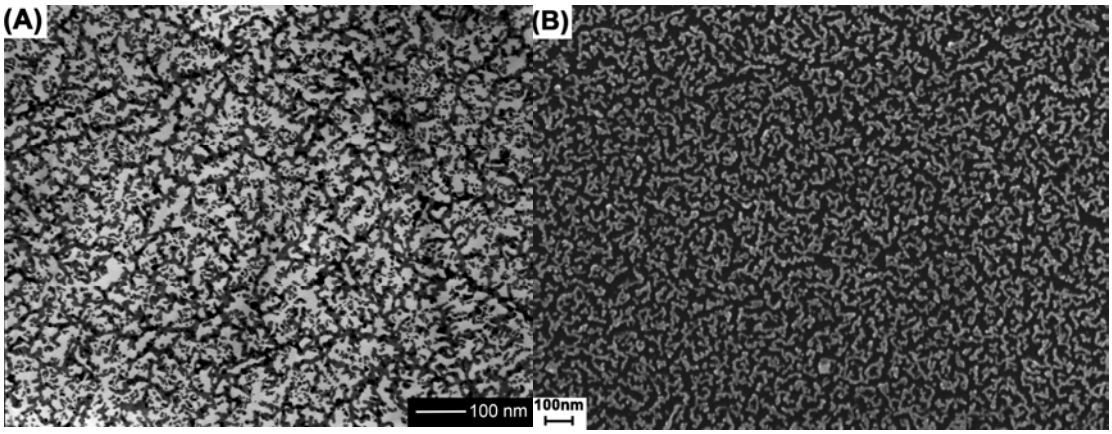

Fig. S7. TEM (A) and SEM (B) images of 3.5-nm AuNP monolayer film obtained by injecting the mixture with the ethanol:toluene volume ratio of 1/3. Note that 3.5-nm AuNP monolayer film always had a welding structure whatever the ethanol:toluene volume ratio was.

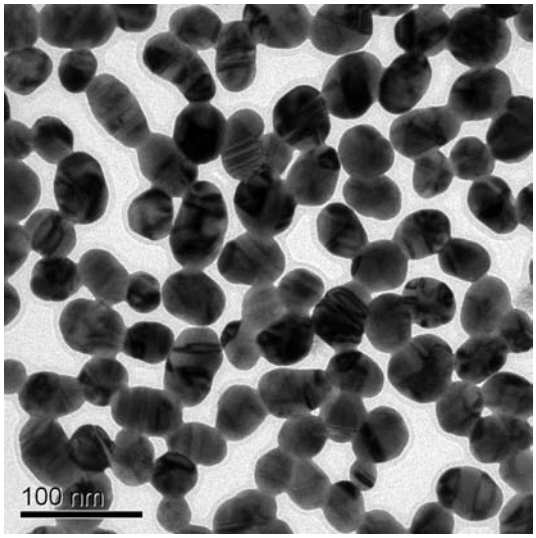

Fig. S8. TEM images of 59-nm AuNP monolayer film obtained by injecting the mixture with the ethanol:toluene volume ratio of 3/1.

References

1 C. M. Ruan, L. J. Yang and Y. B. Li, *Anal. Chem.*, 2002, **74**, 4814-4820.
2 G. Frens, *Nat. phys. Sci.*, 1973, **241**, 20-22.
3 (a) Y. J. Li, W. I. J. Huang and S. G. Sun, *Angew. Chem. Int. Ed.*, 2006, **45**, 2537-2539; (b) Y.-J. Li, C. Liu, M.-H. Yang, Y. He and E.S. Yeung, *J. Electroanal. Chem.* 2008, **622**, 103-108.
4 S. Kumar and S. Z. Zou, *J. Phys. Chem. B*, 2005, **109**, 15707-15713.