High-Yield Synthesis of Gold Nanoribbons by Using Binary Surfactants

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Materials

Gold chloride trihydrate ($HAuCl_4 \cdot 3H_2O$), L-ascorbic acid ($C_6H_8O_6$, > 99.7%) and sodium borohydride ($NaBH_4$, > 99%) were obtained from Sigma-Aldrich, cetyltrimethyl ammonium bromide (CTAB, $C_{19}H_{42}BrN$, >98%) and sodium oleate (NaOL, $C_{18}H_{33}NaO_2$, >97%) were purchased from TCI. Milli-Q water with the resistance of 18.2 MΩ was used for the preparation of all solutions.

Synthesis of gold nanoribbons

A seeded growth method is employed for the synthesis of gold nanoribbons. It is important to note that all the glasswares used for the synthesis of gold nanoribbons must be cleaned in aqua regia, followed by a complete cleaning with ultra-pure water. In a typical synthesis, the seed solution was prepared by rapidly injecting 0.6 mL of fresh and ice-cold aqueous $NaBH_4$ solution (0.01 M) into an aqueous mixture solution containing 0.25 mL of $HAuCl_4$ (0.01 M) and 7.5 mL of CTAB (0.1M), followed by rapid stirring for 2 min. The resultant seed solution was kept at 35 °C for 1 h and diluted 10 times with ultrapure water before use. For the growth solution, 0.23 g of CTAB solution and 0.0485 g of NaOL were first dissolved in 38.4 mL ultrapure water at temperature of 35 °C, followed by the addition of 0.25 mL of $HAuCl_4$ (0.01 M). The colorless solution changed to yellowish immediately. After the yellowish faded, indicating that the Au^{3+} was pre-reduced into Au^{+}, 3.8 mL of L-ascorbic acid (0.1 M) was added into the growth solution, followed by the addition of 0.02 mL of the diluted seed solution. After that, the solution was kept for 30 s under magnetic stirring and then the solution was left to be undisturbed overnight. The samples were collected by centrifugation and washed three times using ultrapure water.

Characterization

Transmission electron microscopy (TEM) images were collected with LaB6 TEM (TECNAI G2, FEI), operating at 200 KV. High resolution transmission electron microscope (HRTEM) images of the prepared gold nanoribbonswere obtained at 200 KV by using the model of Tecnai G2 F20 from FEI, USA. Scanning electron microscope (SEM) images were taken at 5 KV by using Supra 55 from Carl Zeiss. Raman spectra were recorded using a JobinYvon Raman confocal system (HR800) equipped with an integral microscope (Olympus). For SERS measurements, a diode laser with emission wavelength of 633 nm was used and focused onto the samples through a 50x objective. The samples were irradiated with laser power of 0.6 mW (633 nm excitation) and an exposition time of 20 s. X-ray diffraction (XRD) was measured on an Empyrean diffractometer with a Cu K_α radiation. For the XRD measurement, the obtained gold nanoribbons were centrifuged at first; the suspension was dropped onto a clean silicon slide, followed by drying in air. The thickness of gold nanoribbons was measured using Dimension FastScan™ atomic force microscopy (AFM) from Bruker (Germany). Silica substrate was used for the tapping mode operation with a scan rate of 1 Hz and the value of samples/line was 256.

UV-vis spectrum was measured using LAMBDA 750 (USA) in the range of 300-1200 nm. The optical microscope picture was obtained by using Laica DM4000M (German).

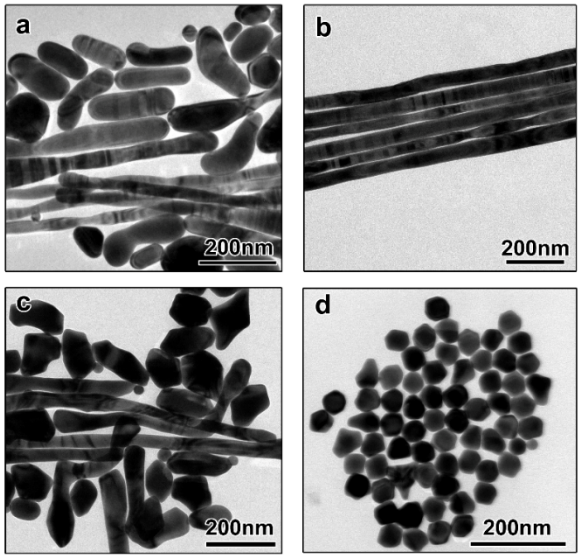

Figure S1. Effects of CTAB on the gold nanoribbons synthesis. (**a**) [CTAB] = 7.5 mM; (**b**) [CTAB] = 15 mM; (**c**) [CTAB] = 30 mM; (**d**) [CTAB] = 45 mM. [NaOL] = 3.8 mM, [L-Ascorbic acid] = 9 mM, the volume of seed is 20 μL, and the growth time is 18 hours.

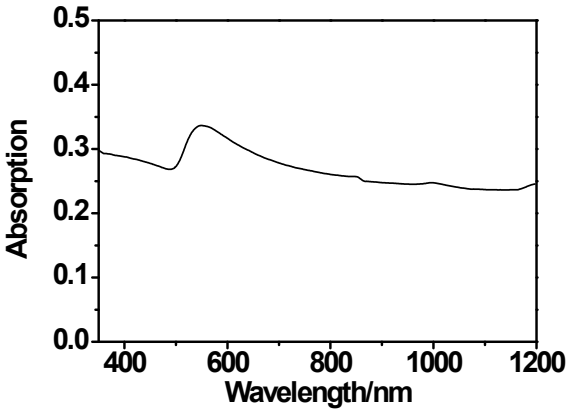

Figure S2. Typical UV-vis spectrum from the gold nanoribbons. [CTAB] = 15 mM, [NaOL] = 3.8 mM, [L-Ascorbic acid] = 9 mM, the volume of seed is 20 μL, and the growth time is 18 hours.

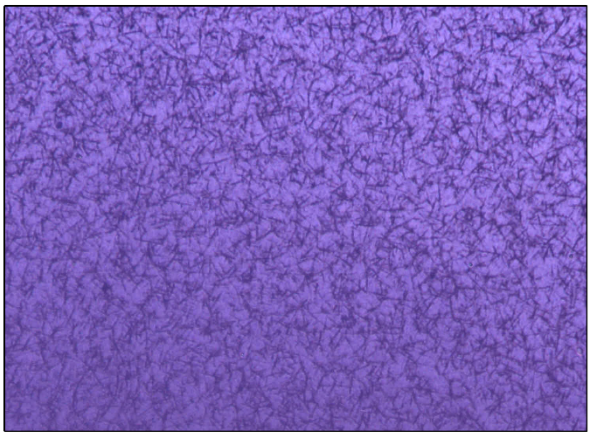

Figure S3. Optical microscope image from the obtained gold nanoribbons. [CTAB] = 15 mM, [NaOL] = 3.8 mM, [ascorbic acid] = 9 mM, the volume of seed is 20 μL, and the growth time is 18 hours.

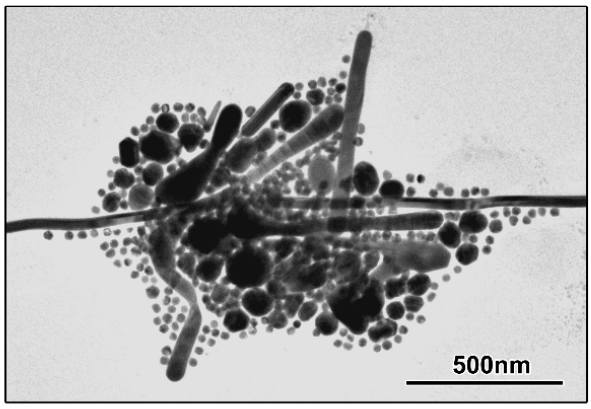

Figure S4. TEM image from the obtained products using citrate-capped seeds. [CTAB] = 15 mM, [NaOL] = 3.8 mM, [ascorbic acid] = 9 mM, the volume of seed is 20 μL, and the growth time is 18 hours.