Electronic Supplementary Material (ESI) for RSC Advances.
This journal is © The Royal Society of Chemistry 2014

Supporting Information

Are microorganisms indispensable in green microbial nanomaterial synthesis?

Lihong Liu, Zongping Shao, Ha Ming Ang, Moses O. Tadé, Shaomin Liu*

Experimental Section

Nanoparticle synthesis

Chloroauric acid ($HAuCl_4 \cdot 3H_2O$) was purchased from Sigma Aldrich Company and dissolved in deionized water to get 20 mM stock solutions. The dehydrated culture media named Lysogeny Broth, Tryptic Soy Broth and Yeast Mold Broth, in powder form were purchased from BD Company. Yeast Extract and Peptone in powder form were also provided by BD Company. We bought dextrose from Kanto Chemical Co. Inc.
The dehydrated culture media as well as pure yeast extract, peptone and dextrose were dispersed in deionized (DI) water and autoclaved at 121°C for 15 min. In a typical procedure for the nanoparticle preparation, 5 mL aqueous solution of metal salts was added to 5 mL broth to get initial ion concentrations of 0.5 to 5.0 mM. The pH of the broth was adjusted by adding HCl or NaOH. The mixture was then placed inside a shaker at room temperature or 37°C (100 rpm) to react for a desired period of time. Graphene oxide (GO) was prepared with a modified Hummers method.[1] The reduction of GO was carried out by mixing with pH 12 YM broth and executed at room temperature, 37 °C or 121 °C. The Au-rGO composites were prepared as follows: aqueous solution of GO (0.25 mg/mL, 1 mL) was added to the chloroauric acid solution (10 mM, 1 mL) under stirring then followed by addition of 2 mL pH 12 YM broth. The mixture was stirring for 8 h at 37 °C. The final product was separated by means of centrifugation at 8000 rpm for 20 m and washed with DI water to remove unreacted gold ions.

Structural characterization of nanoparticles

The course of the nanoparticle formation was monitored by UV-visible spectroscopy (GBC Scientific Equipment). The synthesized nanoparticles were characterized by a dynamic light scattering (DLS) using Nano-ZS90 analyzer (Malvern). The particle size and polydispersity were determined from the DLS measurements. For transmission electron microscopy (TEM), a drop of solution was placed on carbon-coated copper grids and air dried. X-ray diffraction analysis was performed using a Bruker D8 Advance X-ray Diffractometer with Cu Kα (λ = 1.54Å) radiation. The diffracted intensities were recorded from 10° to 65° 2θ angles. The Raman spectra were acquired with a Dilor Labram 1B dispersive Raman spectrometer using a 633 nm excitation line, delivering 0.02 mW of laser power on the sample. Spectra were recorded with 50 s accumulation times.

SERS test

For the SERS experiments, 10 μL (0.1 mM) Rhodamine 6G chloride solution was mixed with 10 μL Au or Au/rGO solution, after incubation for 3 h, 2 μL mixture was dropped on glass coverslip and dried in air. SERS spectra were acquired by using the same Raman spectrometer.

1. Results

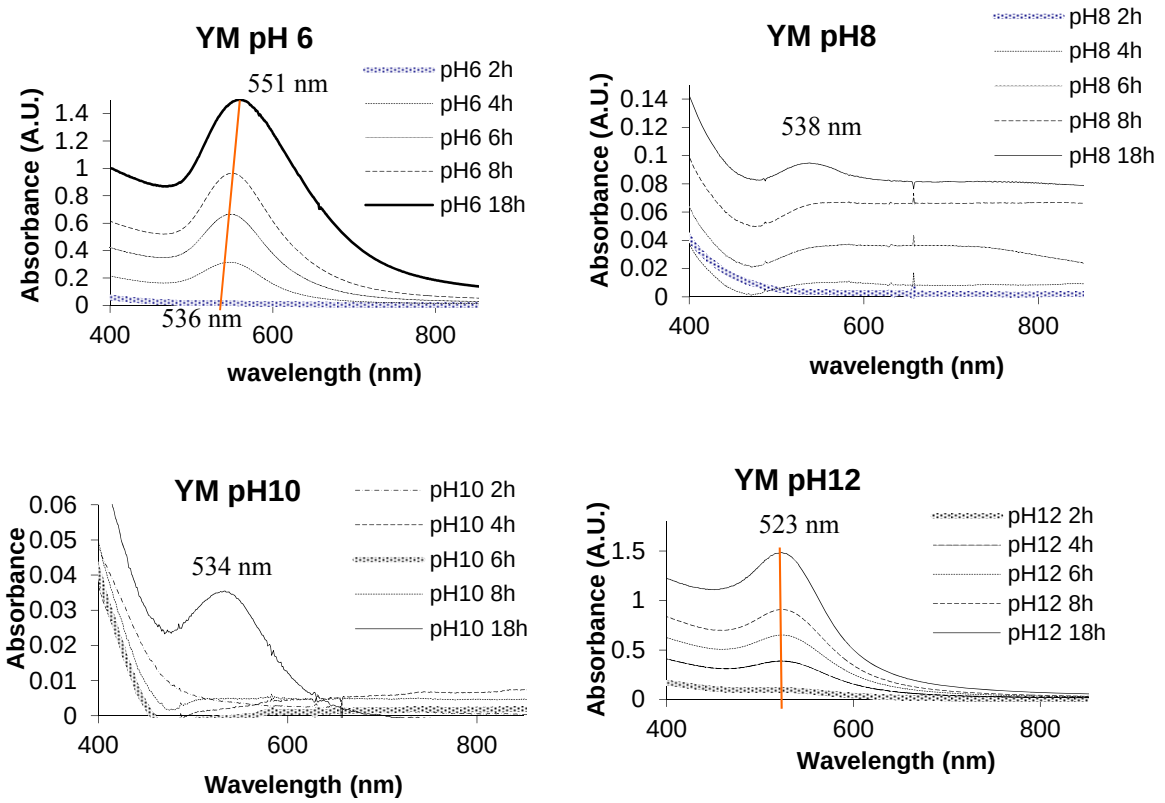


Figure S1. UV-vis spectra of gold nanoparticles synthesized at 37 °C in YM broth of differenct pH values. .

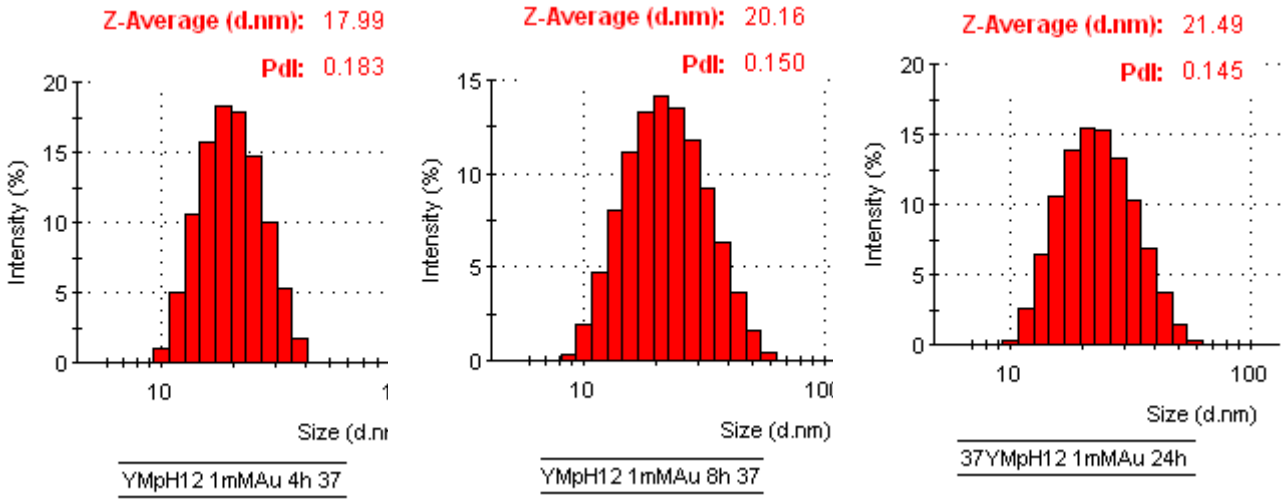


Figure S2. Dynamic Light Scattering (DLS) analysis of AuNPs formed by adding 1 mM Au^{3+} in YM broth (pH 12) at 37°C.

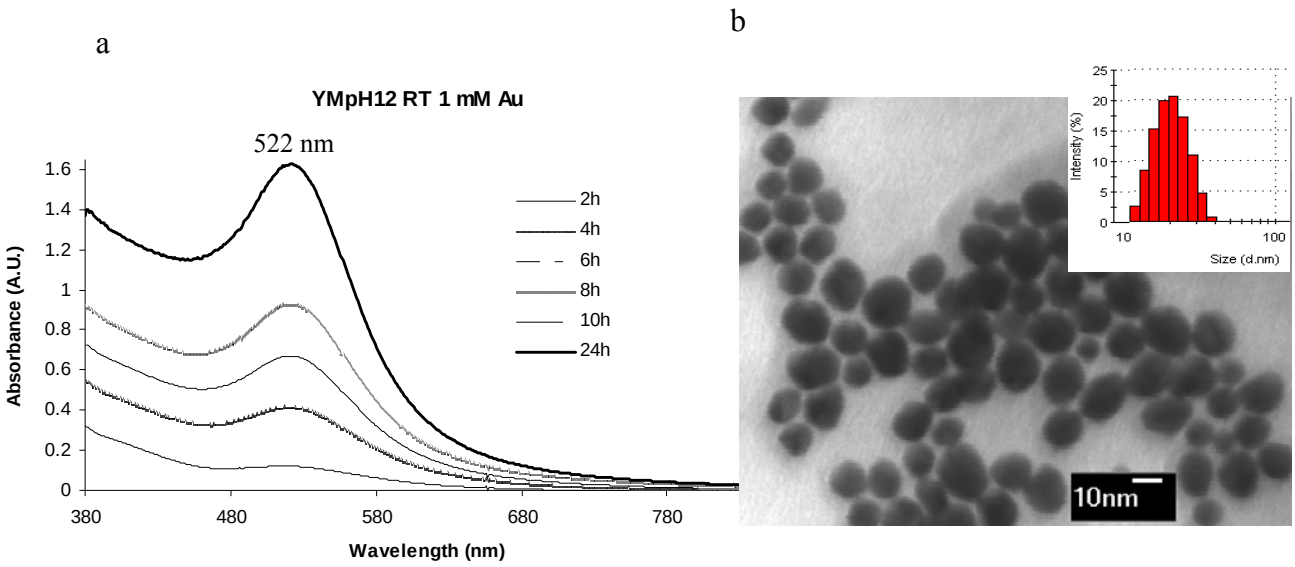


Figure S3. The UV-Vis absorption spectra of 1 mM [Au^{3+}] reduced by YM broth at room temperature (a). The TEM (b) and particle size distribution of Au nanoparticles.

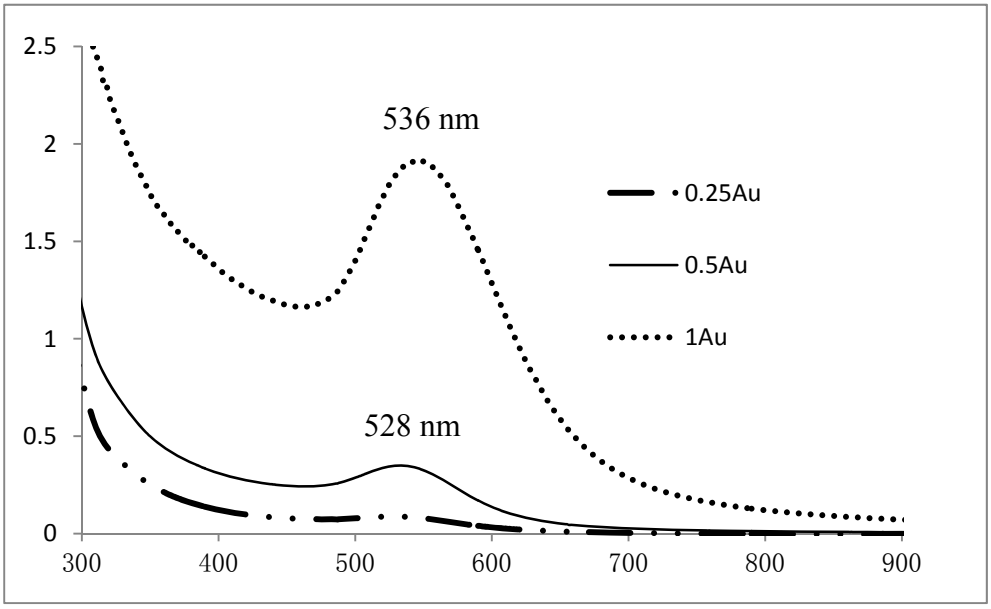
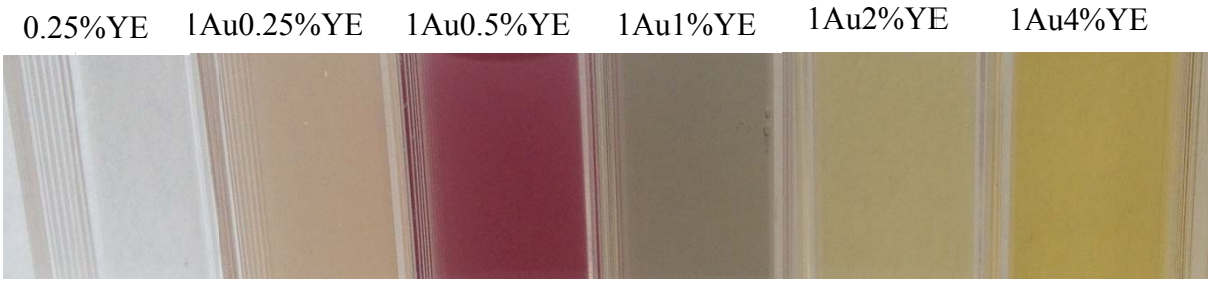


Figure S4. The UV-vis absorption spectra of 0.25, 0.5 and 1 mM [Au^{3+}] reduced by pH12 peptone at room temperature for 8 days.

a



b

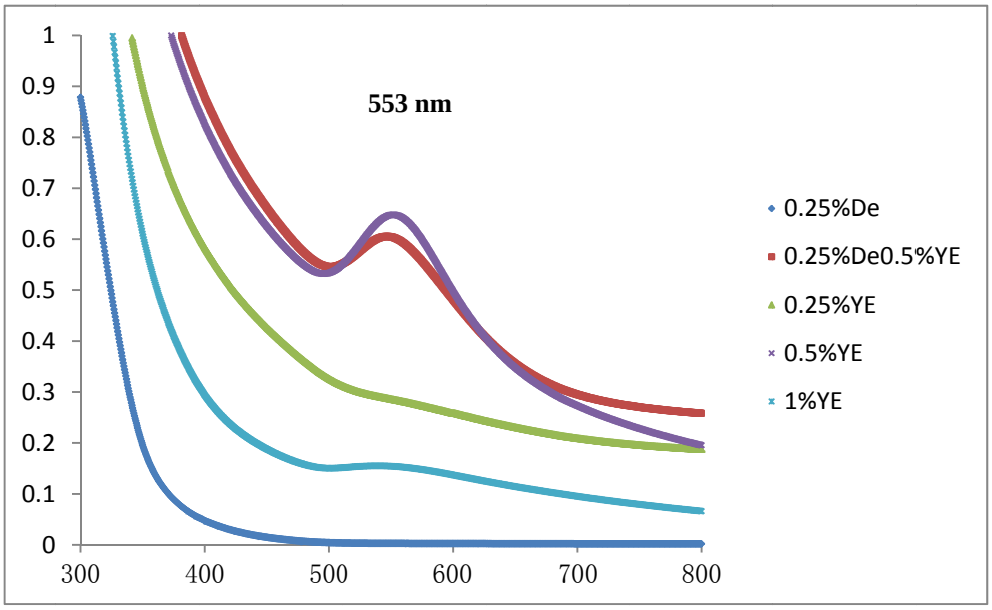


Figure S5. Photographs of 1 mM $HAuCl_4$ reduced in 0.25% to 4 % yeast extract (YE) solution at room temperature for 24 h. The UV-vis absorption spectra of 1 mM [Au^{3+}] reduced by autoclaved dextrose (De) and YE (b).

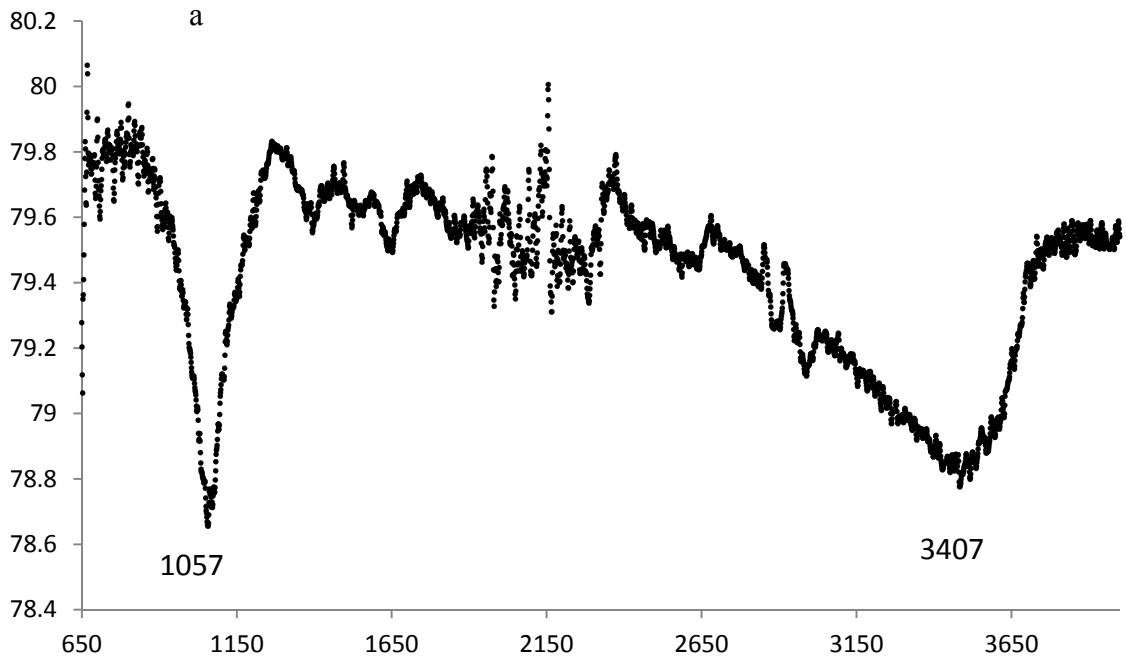


Figure S6. FTIR spectra of 1 mM [Au^{3+}] reduced by 0.25% dextrose (pH12, a) and solid dextrose (b).

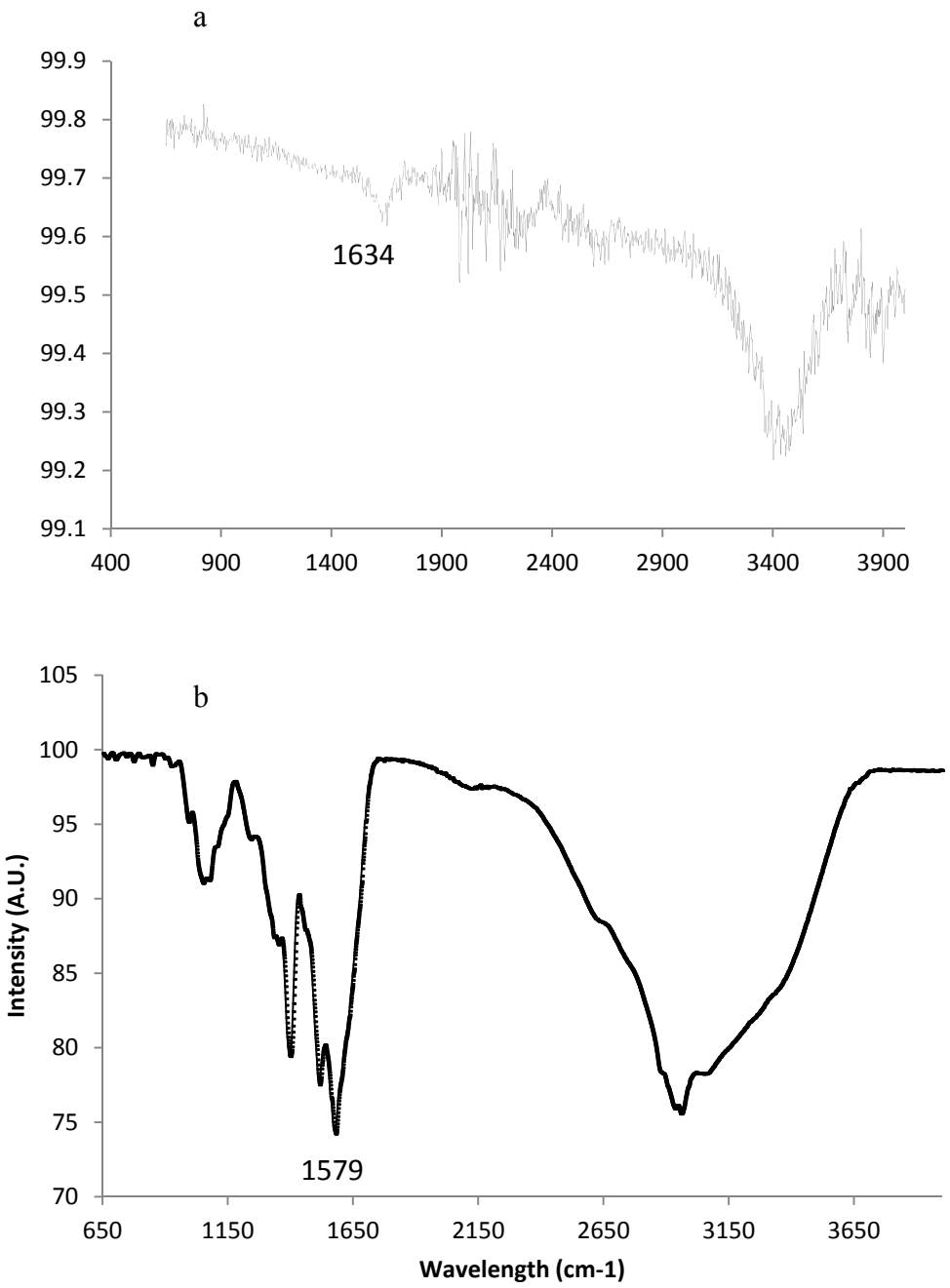


Figure S7. FTIR spectrum of 1 mM [Au^{3+}] reduced by yeast mold broth (pH 12, a). The characteristic peaks of dehydrated YM broth powder were displayed in spectrum b.

References:

1 W. S. Hummers, R. E. Offeman, *J. Am. Chem. Soc*. 1958, 80, 1339.