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Supporting information

Synthesis of gold and palladium nanoshells by in situ generation of seeds on silica nanoparticle cores

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Synthesis of gold nanoshells on ~200 nm silica cores:

SiO_2 core nanoparticle formation

Silica core nanoparticles were formed by adding 75.0 mL 200 proof ethanol to 25 mL of water and 3.5 mL of 9M NH_4OH mixture. After stirring this solution for 5 minutes, 3.0 mL of TEOS was added. After stirring for 20 minutes, the solution changed color from clear to white. Stirring was continued for additional 8 hours before the solution was finally centrifuged at 4000 rpm for 25 minutes, washed with absolute ethanol, and sonicated for 5 minutes. Washing cycles was repeated 2 times.

Formation of TSPEI monolayer

5 mL of the silica core solution was diluted to 90 mL with absolute ethanol. To that solution 10 mL of TSPEI was added while stirring. This solution was refluxed with stirring for 1 hour, followed by stirring for an additional hour without refluxing. The solution was left to sit overnight before it was centrifuged at 4000 rpm for 25 minutes, washed with 95% ethanol, and sonicated for 5 minutes. Washing cycles were repeated 4 times and the functionalized silica nanoparticle cores were then left as pellet overnight.

Adsorption of $[AuCl_4]^-$

The silica/TSPEI nanoparticle pellet was redispersed in 30mL freshly prepared 10 mM aqueous HAuCl4 solution and agitated for approximately five minutes. The centrifuge tube containing the solution was wrapped in aluminum foil for dark-aging and allowed to sit at room temperature for

8 hours. The solution was then centrifuged at 4000 rpm for 25 minutes, washed with water, and sonicated for 5 minutes. The washing process was repeated 4 more times. After the last washing cycle, 15 mL of the solution was transferred to another centrifuge tube.

In situ formation of Au-seeds with L-ascorbic acid as reducing agent

15 mL of silica/TSPEI/Au seeded nanoparticle solution was centrifuged to obtain a pellet. 2% (w/v) ascorbic acid solution was made by dissolving 0.6000g of L-ascorbic acid in 30 mL of water. The pellet was redispersed in the ascorbic acid solution and the tube was wrapped in aluminum foil to sit at room temperature overnight. The solution was then centrifuged at 4000 rpm for 25 minutes, washed with water, and sonicated for 5 minutes. The washing process was repeated 4 times.

Synthesis of Au-Nanoshells

A 25 mM $HAuCl_4$ solution was made by dissolving 0.0594 g of $HAuCl_4$ in 6.99 mL of water. This solution was wrapped in aluminum foil, and allowed to sit overnight in the refrigerator. 0.75 mL of the 25 mM $HAuCl_4$ solution was transferred into a beaker and 0.0143 g of K_2CO_3 was added, along with 50 mL of water. This solution, termed as the growth solution was stirred until it became clear. The beaker was wrapped in aluminum foil, and allowed to sit overnight. 9.0 mL of the growth solution was added to 100 μL of the silica/TSPEI/Au seeded nanoparticle solution while stirring. After five minutes, 80 μL of formaldehyde was added to the mixture. This solution was stirred for 1.5 hours and finally was allowed to sit at room temperature for 24 hours. This solution was eventually centrifuged at 4000 rpm for 25 minutes and washed with water without any sonication. This washing process was also repeated 4 times.

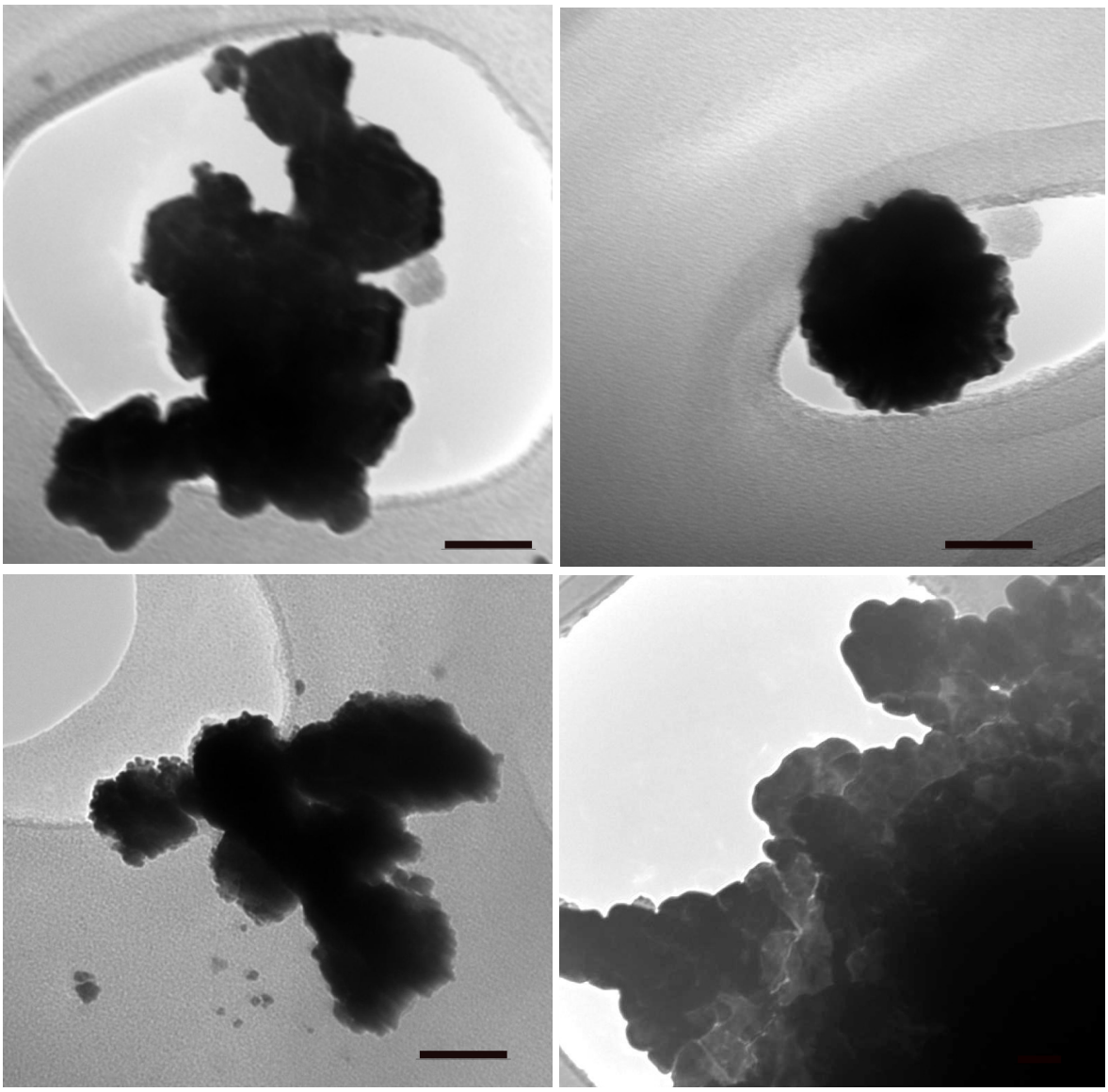

Fig. S1: Different TEM images of gold nanoshells of ~28 nm shell thickness on ~ 40 nm diameter silica cores showing individual nanoshell and aggregated structures. Scale bars are 50 nm.

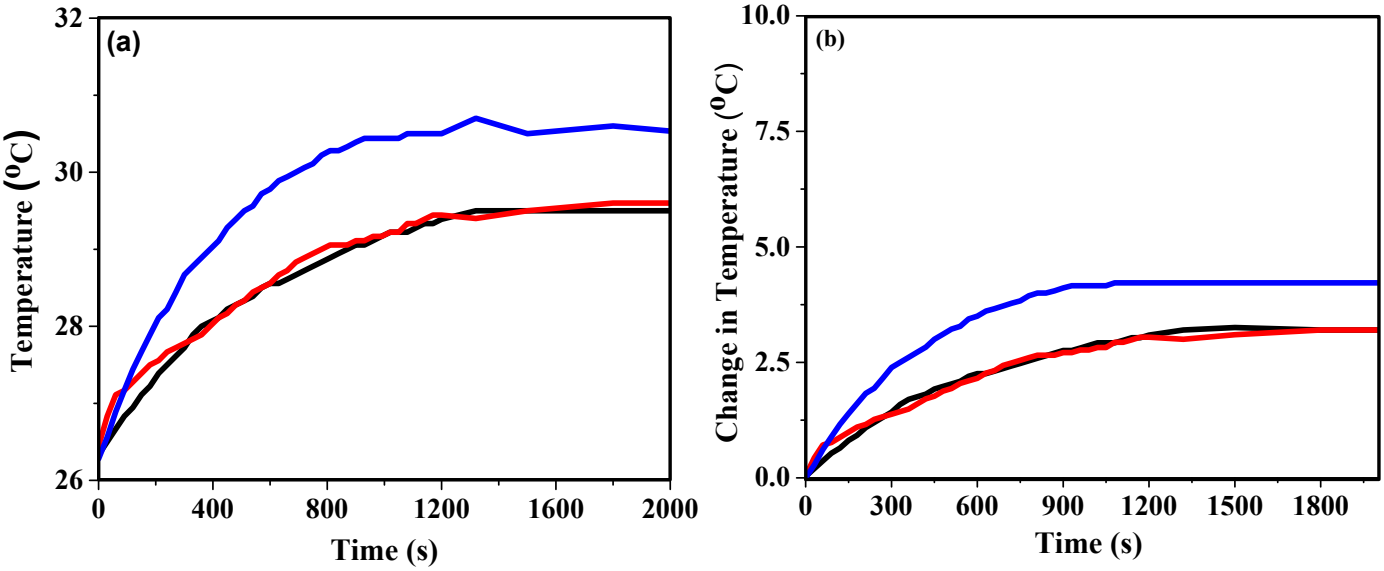

Fig. S2: (a) Comparative time-dependent temperature profile of water (black), aqueous suspension of ~200 nm silica nanoparticle cores (red) and aqueous dispersion of palladium nanoshells with shell thickness ~12 nm (blue) under illumination of an 808 nm laser. (b) Data in (a) plotted as a function of change in temperature (ΔT) against time. For photothermal experiment, 3 mL of aqueous dispersion of Pd nanoshell (0.53 mg mL^{-1} Pd concentration) is exposed to 808 nm laser.

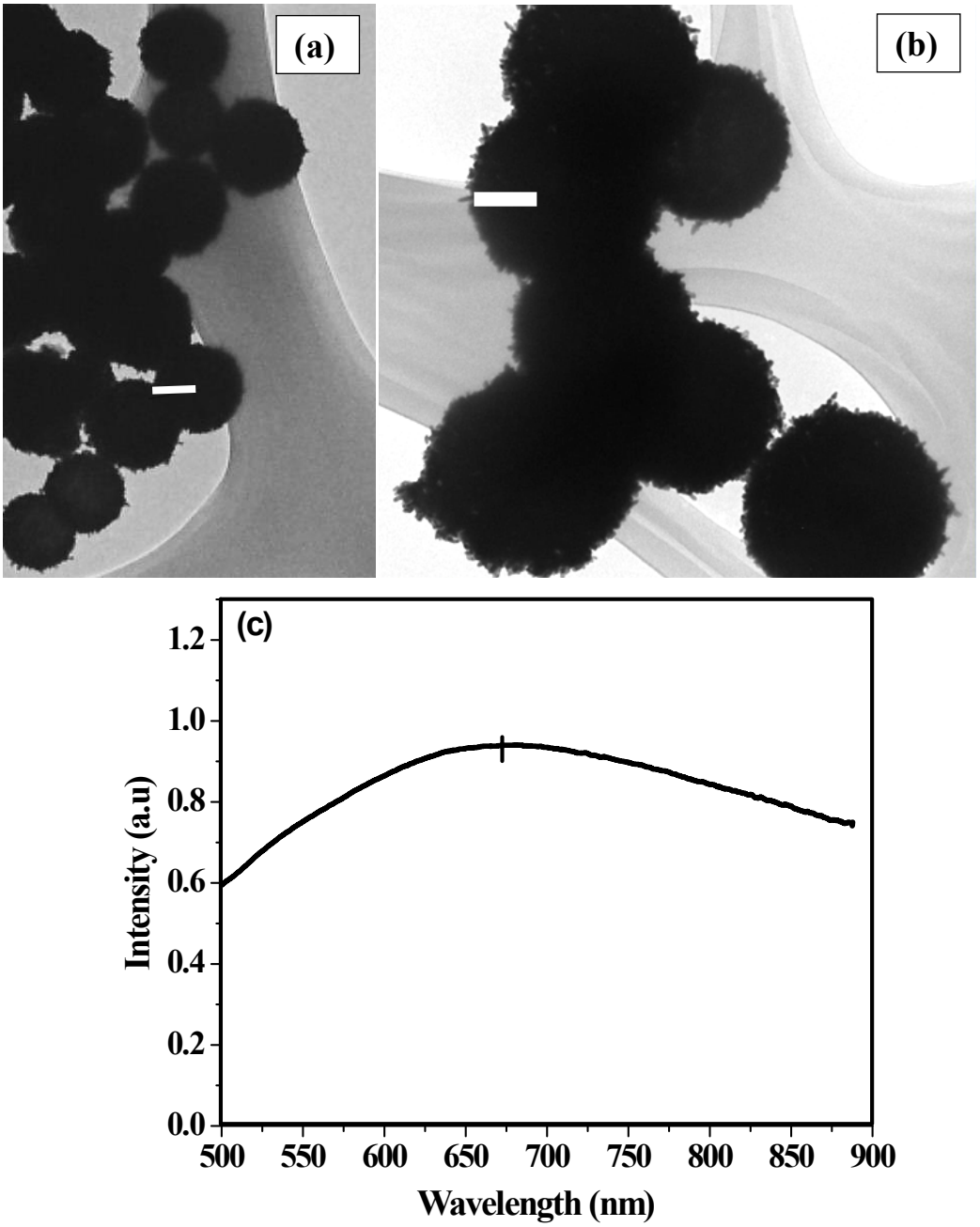

Fig. S3: TEM images of gold nanoshell, ~23.6 nm thick, on ~200 nm diameter silica core (a) low magnification, (b) higher magnification. Scale bars are 100 nm. (c) UV-Vis spectrum of aqueous dispersion of gold nanoshells on ~200 nm diameter silica core. Hash mark indicates the peak of the spectra.