

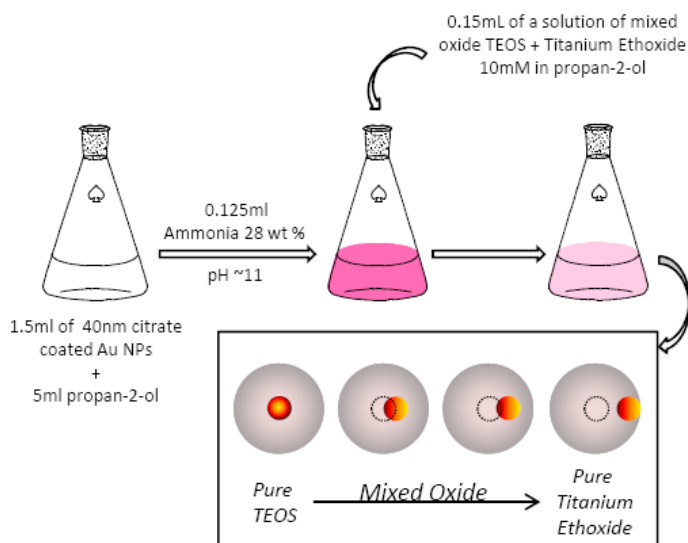
Supplementary Informations

Materials: Gold (III) chloride trihydrate ($\text{HAuCl}_4 \cdot 3\text{H}_2\text{O}$ $\geq 99.9\%$ trace basis), Sodium citrate dihydrate ($\geq 99\%$), Ammonium hydroxide 28wt% in H_2O ($\geq 99\%$), Acetylacetone ($\geq 99\%$), Titanium (IV) ethoxide, propan-2-ol ($\geq 99.8\%$) were purchased from Sigma-Aldrich. Tetraethylorthosilicate (TEOS, ≥ 99.9) was purchased from Johnson Matthey.

Characterization of the particles: Nanoparticles were characterized by transmission electron microscopy (TEM) and infra-red spectroscopy. The TEM images were carried out with a TOPCON EM002B operating at 200KV and a JEOL 2200FS transmission electron (fitted with omega filter and field emission gun) was employed for EELS measurements (Electron Energy Loss Spectrometry and Imaging) with an energy resolution of 0.8 eV obtained with 10 seconds exposure time and a 5 eV energy slit placed at the Si L_{2,3} (99 eV) and Ti L_{2,3} (455 eV) core loss edges. The extinction spectra were performed on a SAFAS instrument. The infrared spectra are obtained using a Nicolet Magna 560 Fourier transform-infrared spectrometer in the range of 1400-400 cm^{-1} .

Seeded growth of 40nm gold nanoparticles: A 50mL sample of aqueous $\text{HAuCl}_4 \cdot 3\text{H}_2\text{O}$ (1mM) was prepared in a 250mL flask. The solution was brought to boil under reflux while being stirred and 5mL of 38.8mM aqueous solution of sodium citrate was added. Then the reaction was allowed to run until the solution reached a wine red color, indicating the formation of gold seed nanoparticles of about 15nm diameter. Gold nanoparticles 40nm-diameter was prepared according to the Frens method. Typically, 125mL of a freshly prepared aqueous solution of $\text{HAuCl}_4 \cdot 3\text{H}_2\text{O}$ (0.25mM) was heated to boil under reflux and magnetic stirring. Then 1.125mL of as prepared 15nm gold nanoparticles and 0.56mL of sodium citrate solution (38.8mM) were injected. The solution went through a slow color change from purple to pink. The mixture was then boiled for 30 minutes then 5mL of additional sodium citrate solution (38.8mM) was added into the boiling solution as extra stabilizer and the mixture was heated for another 1 hour.

Preparation of silica-titania mixed oxide coated Au nanoparticles: Since Titanium ethoxide ($\text{Ti}(\text{OEt})_4$) is not very stable, it was mixed with Acetylacetone (acac) to form $\text{Ti}(\text{OEt})_2(\text{acac})_2$. Silica-titania coated gold nanoparticles were prepared following the procedure proposed by Liu et al. typically 1.5mL of 40nm citrate coated gold nanoparticles was mixed with 5mL of propan-2-ol under vigorous shaking. After adjusting the pH to 11 by adding 0.125mL of ammonia hydroxide 28 wt%, 0.15mL of a solution of mixed oxide (TEOS + $\text{Ti}(\text{OEt})_2(\text{acac})_2$ titanium ethoxide) in propan-2-ol was added to the mixed solution four times within 6 hours at an interval of 2 hours. After shaking for 18 hours at room temperature, the reaction mixture was washed with propan-2-ol by centrifugation three times at 3500rpm for 5 minutes and the precipitate was collected and redispersed into ethanol for characterization.



Scheme 1 Synthesis of core-shell nanoparticles. At the second step, the ratio TEOS/Titanium Ethoxide added in the 40nm citrate coated NPs lead to different core-shell structure (Insert).