Preparation of SiO_2/Au/TiO_2 Core-Shell Nanoparticles and Their Photocatalytic Properties

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Titanium dioxide (TiO_2) is a very attractive photocatalyst in practical applications such as water splitting and photodegradation of organic pollutants, due to its chemical stability and non-toxicity. However, TiO_2 has a wide band gap of 3.2 eV, which limits their photocatalytic activity under the ultraviolet light. Therefore, it is important to endow TiO_2 with photocatalytic activity under the visible light. Noble metal nanoparticles absorb visible light due to the localized surface plasmon resonance (LSPR), in which light absorption and/or amplification of the electric field have been shown to depend strongly on the particle size, shape and local dielectric environment. Gold nanoshells are a type of spherical nanoparticles consisting of dielectric core such as SiO_2 particles covered by a thin Au shell. These nanoshells can absorb the light of broad wavelengths ranging from the visible to the near-infrared region depending on the core/shell thicknesses. If gold nanoshells/titania composite particles are prepared, the light source available for the photocatalyst can be extended from the conventional ultraviolet region to the visible and the near-infrared regions, leading to an effective use of sunlight energy.

The SiO_2/Au core-shell nanoparticles were prepared by the deposition-precipitation (DP) process and the seed-mediated growth method [1, 2]. Firstly the surface of SiO_2 particles was functionalized with amino groups by 3-aminopropyltriethoxysilane (APTES). Subsequently Au nanoparticles were deposited on the APTES-grafted SiO_2 surfaces by controlling temperature, pH, and reaction time (70 ^{o}C, pH 8, 1 h). Using the Au-supported SiO_2 particles as seed solution, the Au particles grew and formed a uniform shell on the SiO_2 surfaces. Finally addition of titanium tetrabutoxide (TTBO) in the mixed butanol/acetonitrile solvents to aqueous Au nanoshells dispersion gave rise to the formation of TiO_2 shell [3, 4]. The TEM image (Figure 1) reveals that SiO_2/Au (120 diam. / 20 nm thickness) core-shell nanoparticles are covered by a uniform TiO_2 layer of 20-nm thick. The UV-vis extinction spectra (Figure 2) indicates a broad absorption from the visible to the infrared due to the Au nanoshell, as well as the UV absorption by TiO_2 shell. Photocatalytic properties of as-prepared SiO_2/Au/TiO_2 samples were evaluated by oxidation of 2-propanol under visible light (λ>420 nm). A high photocatalytic activity was observed under the visible light for the SiO_2/Au/TiO_2 core-shell NPs.

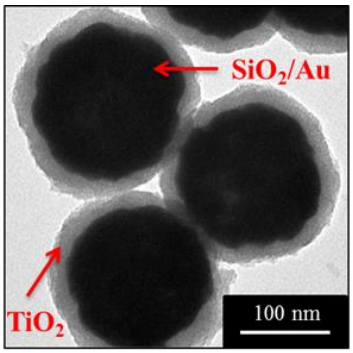

Figure 1. TEM image of SiO_2/Au/TiO_2 core-shell NPs.

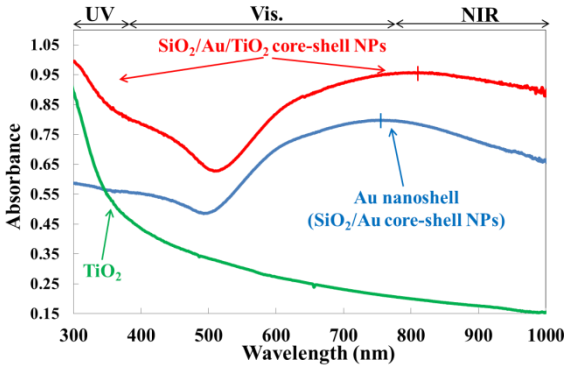

Figure 2. UV-vis extinction spectra.

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