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Gold Nanoshells and Nanorings for Photo-Thermal Therapeutic Medicine

A. Duarte-Moller

Centro de Investigación en Materiales Avanzados (CIMAV), Laboratorio Nacional de Nanotecnología, Miguel de Cervantes No. 120, 31136 Chihuahua, Chihuahua, México.

Amongst the wide range of clinical imaging modalities available to clinicians today, advanced optical imaging systems such as optical coherence tomography (OCT), confocal reflectance endomicroscopy and diffuse optical tomography etc. offer promising clinical application particularly in the area of cancer imaging due to the high resolution they afford. However, these novel optical systems rely on scattering processes in tissue which can be rather indiscriminate in highlighting diseased states. The application of metallic nanoparticles such as gold nanoparticles as contrast agent in these reflectance-based imaging techniques is well appreciated, but limited to a narrow optical excitation range that are appropriate for use with only certain optical systems with matching optical wavelength [1-3].

The narrow optical excitation range is due to its rather invariable optical plasmon resonance, typically at 520 nm. Although its plasmon resonance is known to vary with size, the plasmon resonance of gold nanoparticles hardly changes by more than 60 nm before their sizes become impractical for biological applications. Gold nanoshells have the singular property to show an absorption band around the 760 nm, which is the same that the biological human optical window [4]. Here we discuss the production of gold nanoshells and the formation of gold nanorings by using of SiO_2 nanosphere template.

Hydrogen tetrachloroaurate ($HAuCl_4 \cdot 3H_2O$, 99.99%), 3-aminopropyltrimethoxysilane (APTMS, 95%) and tetraethyl orthosilicate (TEOS, 98%) were purchased from Sigma (USA), Triton X-100 (TX-100) was purchased from Aldrich, cyclohexane, n-hexanol, trisodium citrate, sodium brohydride ($NaBH_4$, 98%), ammonia water (NH_4OH, 25%), absolute ethanol and polyethylenimine (PEI) with average molecular weight 600,000 g mol−1 were obtained from Beijing. All reagents used were analytical grade and without further purification. The colloidal Au was prepared by rapidly adding 1.2mL of 1% trisodium citrate to 100mL of 0.01% $HAuCl_4$ aqueous solution when $HAuCl_4$ solution got a rolling boil under vigorous stirring. The color changed from pale to blue, then turned to burgundy. Boiling was continued for 15 min, stirring until it reached room temperature.

The method to obtain gold nanoshells by using the SiO_2 templates was very easy. Functionalized gold nanoaparticles were successfully assembled in the SiO_2 surface. The absorption wavelength was that required (NIR) for the optical human window.

Au/SiO_2 nanoshells can be converted to nanorings upon addition of excess $KAuCl_4$. Nanorings present a distinct particle geometry, with optical properties exhibiting characteristics of both nanorods and nanoshells. The gold nanoparticles, which are in the size range 4–5 nm, are used due that have a plasmon resonance with incoming radiation causing them to both absorb and scatter light. This effect can be harnessed to either destroy tissue by local heating or release payload molecules of therapeutic importance. Gold nanoparticles can also be conjugated to biologically active moieties, providing possibilities for targeting to particular tissues.

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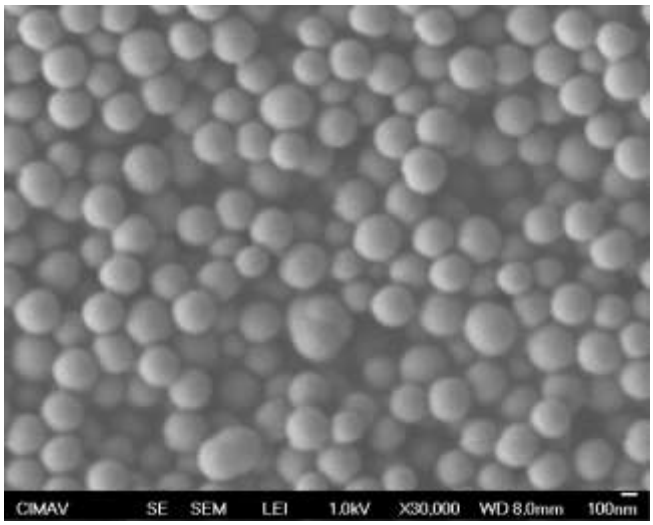

Figure 1. FESEM-SE micrograph of synthesized SiO_2 nanospheres. High uniformity can be observed among the particles.

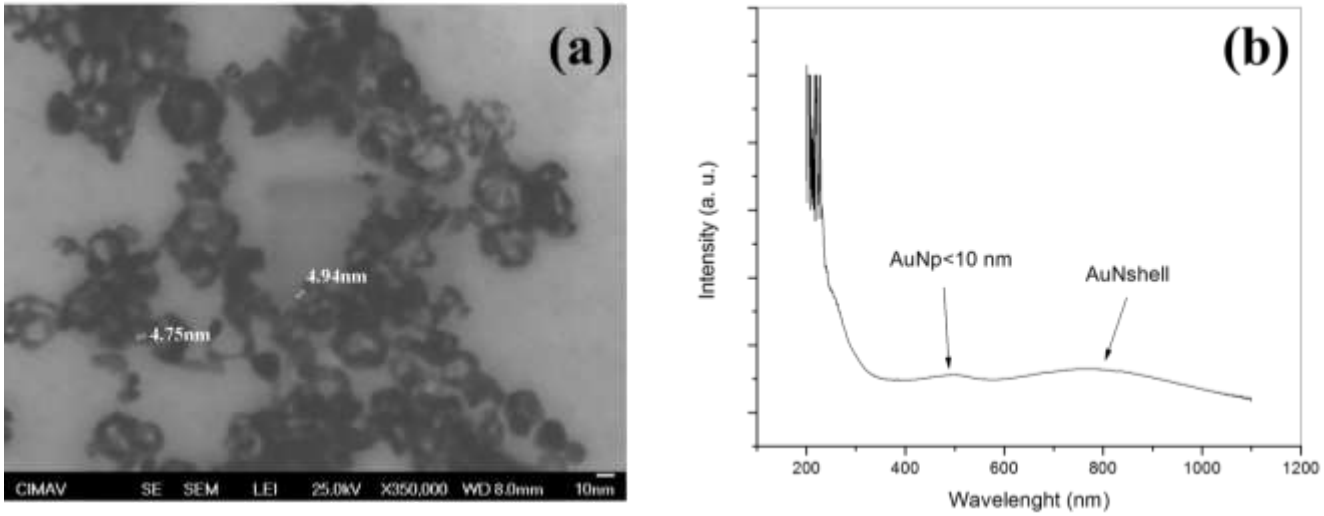

Figure 2. (a) FESEM-SE micrograph of the gold nanoshells with different shapes and sizes, including those nanorings formed in the experimental procedure. (b) Absorption spectra, when there is a border around the 500 nm, corresponding to the gold nanoparticles band and a band placed at 770 nm. This band is associated with that corresponding to the gold nanoshell.

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