

Gold-gold sulfide nanostructures for hyperthermal therapeutics

María Ana Huergo

Introduction

The study of matter at the nanometer size allows the development of new strategies for biomedical applications. For example, hyperthermal therapeutics for cancer treatment, which causes cell death by means of a local temperature increase¹.

Gold nanostructures (NS) have attracted wide attention in biomedicine due to their ease of bio-conjugation, their oxide-free surfaces, good biocompatibility and unique optical properties, as they exhibit particle plasmon resonances at optical frequencies. Among them, nanowires, hollow nanospheres and core-shell nanoparticles are of special interest because of their optical properties in the near infrared region (NIR). These NS are promising for cancer ablation therapy applications because NIR is the optimal range for transmission through tissue with minimal damage. Therefore, they can be used as heat sources for hyperthermia applications. In the last years, besides nanowires and core-shell SiO₂/Au nanoparticles, interest has grown in gold/gold-sulfide nanoparticles due to their more effective radiation absorbance. However, at present, the nature and optical properties of these nanostructures is still a matter of study. Indeed, while some authors propose that these NS have a core-shell structure², with a thin gold shell surrounding a gold(I)-sulfide core, others think that these are not spherical NS, but nanowires, nanotriangles³, etc, and yet others believe that the absorption at 800 nm is due to the formation of nanoparticle aggregates⁴. In this perspective, the controversy about the NIR surface plasma resonance (SPR) has not yet been thoroughly solved.

Objectives

1. The synthesis of stable NSs by the reduction of HAuCl₄ with Na₂S, with a SPR peak in the NIR region.
2. The physico-chemical characterization of the NS by UV-visible-NIR spectroscopy (UVS), Atomic Force Microscopy (AFM), X-Ray Photoelectrons Spectroscopy (XPS).

Results

This kind of NS has a particular formation kinetic since two different SPR peaks appear, which shift with time and finally merge. In fact, the UVS analysis shows a stable SPR peak around 525 nm, and a second one, that shifts from 600 nm to the NIR region (800-1000 nm), followed by a blue-shift. This dramatic change in the second SPR peak is probably due to a change in the NS size. This time evolution can be stopped with different reagents, such as phosphate buffer or Na₂S, which stabilize the NS within the desired SPR peak.

The AFM images show that more than one NS population is formed, one of them having sizes between 20-35 nm, and the second one seem to be solid gold nanoparticles of about 5-15 nm. The purification of the obtained NS by means of several centrifugation cycles, and the comparison of spectra and AFM images suggest that the NS responsible for the second SPR peak are predominant in the pellet and correspond to the larger NS population.

Conclusions

It is possible to synthesize stable Au-Au₂S NS, with superficial SPR in the NIR region. This NS can be purified and stabilized for several months. The combination of sequential centrifugation cycles, UVS analysis and AFM observation of supernatant and pellets show that the small NP would be responsible for the 525 nm peak, while the biggest NS would originate de NIR peak.

Bibliography

1. Wust, P.; Schlag, P. M.; *et al*, *The Lancet Oncology* **2002**, 3, (8), 487-497.
2. Halas, N.; *et al*, *Proceedings National Academy of Sciences* **2003**, 100, (23), 13549-54.
3. Melancon, M. ; Zhou, M.; Li, C., *Accounts of Chemical Research* **2011**, 44, (10), 947-56.
4. Mikhlin, Y.; Krylov, A. *et al*, *Phys. Chem. Chem. Phys.* **2009**, 11, (26), 5445-5454.