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Controlling colloidal gold nanoparticles' optical properties

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Abstract – A new method to control the optical properties of colloidal gold nanoparticles in an organic dispersant has been investigated. Using different quantities of myristic acid during the syntheses processes, colloids with different linear and nonlinear optical responses were produced. Our results show that this approach can produce novel nanostructured materials with tunable optical properties that could be exploited in the development of optical and photonic applications.

Owing to the surface plasmon excitation and the enhancement of local field effects, metallic nanostructured solids and colloids may present large local and nonlocal nonlinear optical responses [1-3]. Several factors contribute to the enhancement of these effects, such as the particles size, shape and constituents. Due to these facts, there is a huge interest in the development of synthetic methods that produce stable colloids, with an effective control over the surface plasmon resonance (SPR) of metallic nanoparticles. In this work, we report on the successful use of myristic acid (MA) to modify the SPR of gold nanoparticles (AuNP) dispersed in castor oil. Furthermore, we demonstrate that the third-order nonlinear optical response of the resulting colloidal systems is also affected.

The colloids were prepared based on a methodology recently developed [4]. This method was modified by the addition of MA into the reaction medium. The amount of the MA employed was quantified in relation to the $HAuCl_4$ molar concentration. Changing the MA:gold molar ratio (MAAuR), different colloidal AuNP were obtained. The colloids were characterized by transmission electron microscopy (TEM), UV-VIS spectroscopy, and atomic absorption spectrometry. From TEM images, it was observed that as the MAAuR increased, AuNP with less spherical shapes and larger average diameters were obtained. Figure 1 presents a TEM image of the AuNP produced with MAAuR equal to 30:1. The influence of the MAAuR over the linear optical properties of the colloids can be seen in Figure 2. In these UV-VIS spectra, we can see that by increasing the relative amount of MA the SPR is shifted significantly to the red of the electromagnetic spectrum.

The Z-scan technique was employed to measure the nonlinear refraction and absorption of colloids containing AuNP of the same size and shape, but with different filling factors (FF). Using a Ti:sapphire laser (820 nm, 200 fs, 1 kHz), we investigated the nonlinear optical response of the colloids which were produced with a quantity of MAAuR equal to 10:1 [sample AG11 in Figure 2]. From this mother solution, we varied the AuNP FF adding castor oil to the colloid. The largest value of n_2 was equal to -3.96 x 10^{-13} cm^2/W for the system with FF = 22 x 10^{-6}. It was also observed that the modulus of n_2 increased linearly with the AuNP FF, but nor saturation of refraction, neither nonlinear absorption were detected in these systems. Our results suggest that using MA the optical properties of colloidal AuNP can be controlled and employed in the development of hybrid materials suitable for photonic applications.

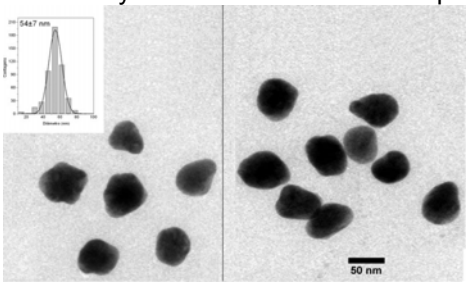

Figure 1: TEM images of AuNP produced using MAAuR equal to 30:1.

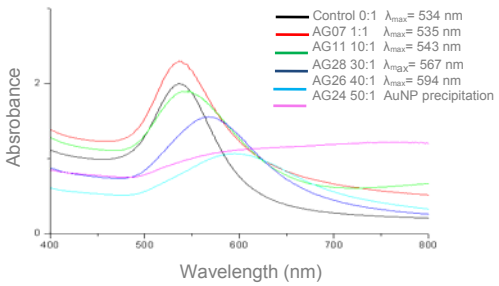

Figure 2: Absorption spectra of colloidal AuNP produced with different MAAuR.

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