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Nonlinear optical responses of metallic nanoparticles dispersed in ionic liquids

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Abstract – Hybrid organic-metallic colloids consisting of Au and Ag nanoparticles dispersed in two different ionic liquids were synthesized. Both media presented large nonlinear optical responses owing to the thermal and the electronic contribution to the nonlinear refractive index enhanced by the presence of the metallic particles. Our results indicate that these systems are promising candidates to the development of nonlinear optical applications.

Hybrid nanostructured organic-metallic colloidal systems are among the most promising systems for the development of optical and photonic devices due to the fact that they can present improved physical and chemical characteristics in comparison with the separated organic or metallic constituents. For instance, the presence of metallic nanoparticles enhances significantly the third-order nonlinear response [1] and the thermo-optical effect [2] of colloidal systems. However, the choice of the dispersant, stabilizer and particles is still a matter of research in order to obtain more stable hybrid materials with suitable optical properties. Among the myriad of organic materials, ionic liquids (IL), presents very interesting properties such as an ionic-covalent molecular structure, different molecular architectures, low melting point, negligible vapor pressure, excellent thermal and chemical stability, which suggests that they can be very interesting systems to the development of hybrid media aiming applications in optics and photonics [3,4]. In this work, we report on the investigation of the nonlinear optical response of colloids consisting of Au and Ag nanoparticles (AuNP and AgNP) dispersed in two different IL.

Roughly spherical AuNP and AgNP were produced and dispersed in BMI.PF_6 and BMI.BF_4 ionic liquids, respectively. They were characterized by transmission electron microscopy, UV-VIS absorption spectroscopy, X-ray diffraction and atomic absorption. In figures 1 and 2, the TEM images of the AuNP and AgNP are shown respectively. The average diameter of the AuNP was estimated roughly as 10.1 nm, while for the AgNP this quantity was 2.8 nm.

Using the Z-scan technique with a Ti-Sapphire laser (820 nm, 200 fs, 1 kHz), large nonlinear responses were observed for both colloidal systems. The thermal and electronic contributions to the nonlinear refractive indexes of both colloids were investigated. A typical experimental result for the AuNP colloid is shown in figure 3. Nonlinear absorption was not detected in these systems. Our results suggest that electronic effects associated with the metallic nanoparticles give the main contribution for the observed nonlinear response. The obtained results show that these new hybrid systems are promising materials to be exploited in the development of nonlinear optical applications.

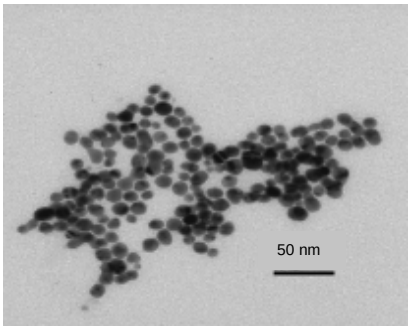

Figure 1: TEM image of the AuNP colloid.

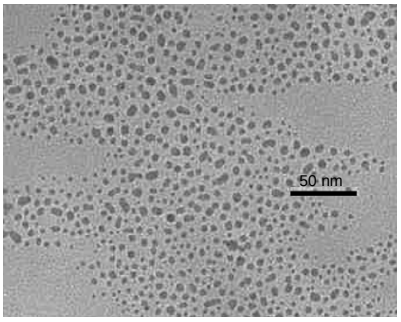

Figure 2: TEM image of the AgNP colloid.

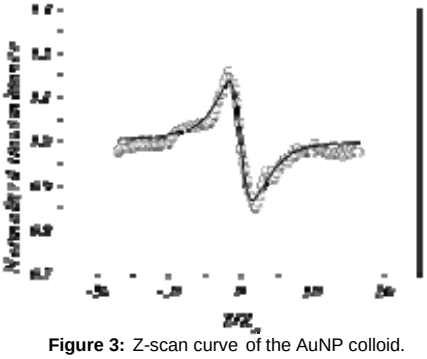

Figure 3: Z-scan curve of the AuNP colloid.

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