Structure and morphology of gold nanoparticles synthesised in imidazolium ionic liquid.

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The study of metal nanoparticles has been an extremely active area in recent years because of their application in different fields of physics, chemistry, material science, medicine and biology, as a result of their unique electronic, optical, chemical and catalytic properties. The intrinsic properties of metal nanoparticles are mainly determined by their size, shape, composition, stability, crystallinity and structure. In principle, one could control any of these parameters to fine-tune the properties of these nanoparticles [1-3].Therefore, there is an increasing interest in the development of studies on the synthesis and stabilisation techniques for obtaining stable nanoparticles of controlled size and shape. Gold nanoparticles have been thoroughly studied in recent years due to their current and many potential applications in biology, medicine and other fields and in particular for catalysis applications.
To synthesise gold nanoparticles, fast chemical reduction routes are among the most commonly used. We propose to use ionic liquids (Imidazolium family) which can be used simultaneously as solvent, stabiliser and structure directing agent in order to tailor the properties of the nanoparticles [3].

The understanding of the nanoparticles formation mechanisms, their interactions between the NPs and the ionic liquid, and how this leads to their stabilisation, without losing their properties, is primordial.

In this context, the project will consist in studying the effects of the synthesis conditions, the chain length, the nature of the anion and the concentration of the ionic liquid, of the imidazolium family, on the formation of the gold nanoparticles and further understand the influence on their stability, size, shape and size distribution.

- The self-organisation of the ionic liquids in solution will first be studied by Small and Wide Angle X-ray Scattering in order to determine its phase diagram and thus understand how they organise to form macro structures as a function of concentration (Figure 1).

- Second, the interaction of gold with the ionic liquid will be studied by Small and Wide Angle X-ray Scattering (SAXS/WAXS), X-ray Absorption Spectroscopy (XAS) and UV-visible spectroscopy. In particular the reduction character of the different ionic liquids on gold will be examined, that is their capability of reducing gold from Au^{3+} to Au^{+}. The effects of the concentration, anion and chain length of the ionic liquid on the latter process will be established.

- Finally, *in situ* SAXS/WAXS, XAS and UV-visible spectroscopies experiments, which will be carried out at the LNLS facility, will enable to follow *in situ* the formation of the gold nanoparticles, synthesized by chemical reduction. *Ex situ* scanning electron and transmission electron microscopies (SEM and TEM) experiments, which will be carried out at the LN-NANO, will complement the X-ray studies (Figure 2).

The results obtained on the self-organisation of the ionic liquids in solution, plus the understanding of the interactions of gold with the ionic liquid combined to the *in situ* measurements will enable us to understand the mechanisms of formation of gold nanoparticles and correlate the synthesis conditions to the final nanoparticles' properties.

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2. SAFAVI A. & ZEINALI S. Synthesis of highly stable gold nanoparticles using conventional and germinal ionic liquids. Colloids and Surfaces A: Physicochemical Engineering Aspects 362, 121–126 (2010).
3. SUN Y. & XIA Y. Shape-Controlled Synthesis of Gold and Silver Nanoparticles. Science. 298, 2176-2179, (2002).

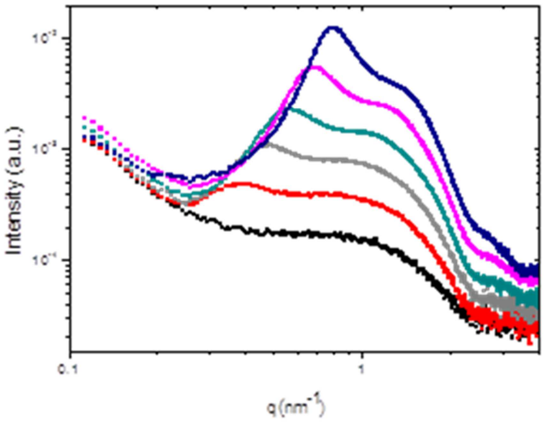

Figure 1: SAXS (LNLS) curves of Hexadecyl-3-methylimidazolium chloride solutions at concentrations of 10 (black), 25 (red), 50 (blue), 100 (green) and 200 (pink) and 500 mM (yellow), three diffraction peaks are observed, characteristic of the self-organisation of the objects as a function of concentration.

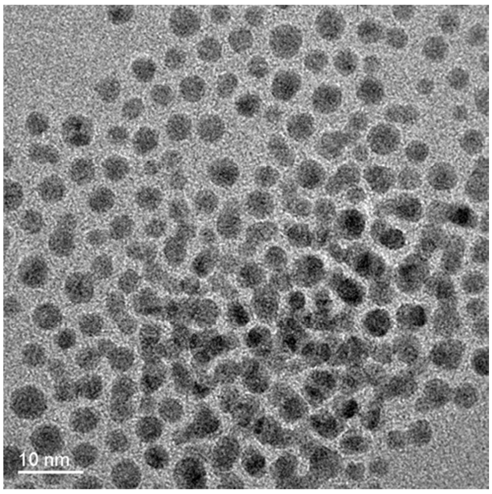

Figure 2: HRTEM (LN-NANO) micrographs of gold nanoparticles synthesised in 100 mM hexadecyl-3-methylimidazolium chloride.