Phosphonium-based ionic liquids for the formation of nanoparticles

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Abstract

Ionic liquids (ILs) are very good solvents for many applications. They have been also studied for the synthesis of nanomaterials, having different roles in the obtaining of the nanostructures. Many times ILs are used as mere stabilizing agents, acting as surfactants or co-surfactants in the formation of micelles or microemulsions, as well as in the dispersion medium [1,2]. The nanomaterials can be directly dispersed in the chosen solvent or they can be synthesized by chemical methods: carrying out reactions between two precursors at high temperatures and or pressures is the most common technique. The use of reducing agents to obtain noble-metal structures in the nanometric scale is also frequently used.

Some works present the preparation of nanomaterials with the ionic liquid as only medium of synthesis, in the absence of other solvents, [3,4]. Once more, several techniques can be used to form nanobjects inside the ionic liquid, such as thermolysis, reduction/oxidation (reactive techniques in general), ultrasounds, UV radiation... Recently, a new method based on the dissolution/reprecipitation of nanoparticles in ionic liquids was reported [5]. This technique avoids chemical reactions between precursors (the only solid used is the bulk product), high pressure or extreme temperatures

Despite inherent impurities of the ILs can alter and reduce the stability of nanoparticles, the metal nanoparticles dispersions are more stable in ionic liquids due to their microstructure and to possible interactions of the nanoparticles surface with the cation and/or anion of the molten salt [6]. Solvation and stabilization mechanisms allow the nanostructures to be stable without additional surface-active agents [7]. ILs act as supramolecular solvents, and spontaneous, well-defined, and extended ordering of nanoscale structures can take place within them [8]. Most studied ionic liquids for the preparation of nanomaterials are those based on an imidazolium ring cation. Their capability to control the size of nanoparticles depending on the length of the hydrocarbon chains was reported [9]. The influence of the cation was also studied [10]. Moreover, it was shown that tetralkylphosphonium ILs can act as both solving and stabilizing agents due to their long alkyl chains and obvious points of coordination with the particles [11,12].

In this work, several phosphonium-based ionic liquids were tested for the synthesis of different types of nanoparticles, (sulfides, metal oxides, silver derivatives) using the previously published method [5], see Figure 1. The nanoparticles were characterized by means of UV-vis absorption spectroscopy, X-ray powder diffraction, transmission electron microscopy and/or dynamic light scattering. The obtained nanoparticles are spherical, well-defined and with narrow size distributions. Depending on the ionic liquid and on the solid, different concentrations can be achieved.

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Figures

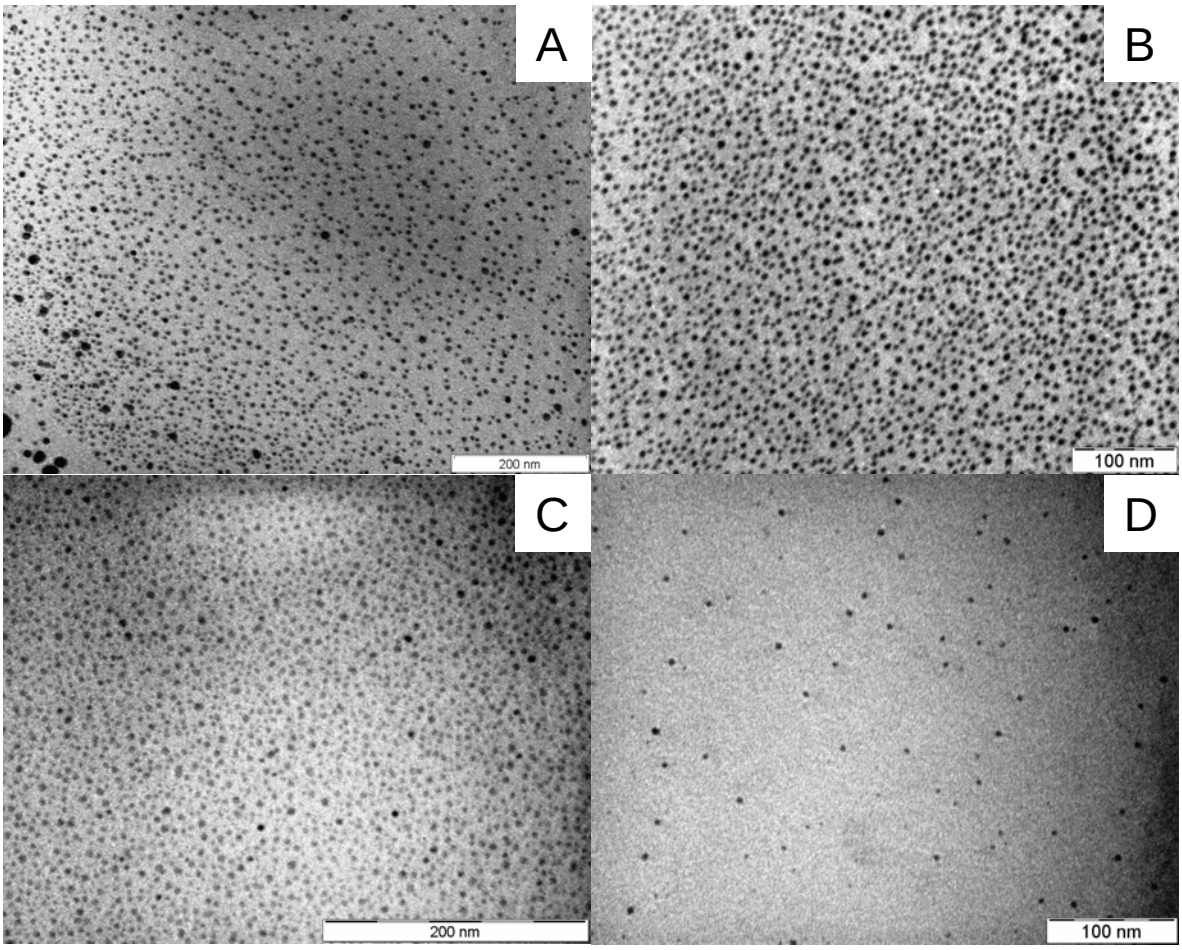

Figure 1. Nanoparticles of a) TiO_2, b) MnS, c) Fe_2O_3, d) CdS prepared in the ionic liquid trihexyl(tetradecyl)phosphonium chloride.