PREPARATION AND THERMOPHYSICAL CHARACTERIZATION OF [$P_{6,6,6,14}$]Cl WITH AgI IONANOFLUID

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Introduction: Due to the need of a higher energetic efficiency to reduce the costs of the productive processes in the worldwide industry, new technologies are being developed to optimize the energy consumption. Cooling/heating fluids with good thermal properties allow a more efficient heat transfer. This implies working with lower flows of fluid, reducing the costs of the process. With this aim, the heat conduction of base fluids has been enhanced with solid additives suspended in them, since solid particles have a higher thermal conductivity than that of the fluid [1]. However, solid particles in suspension show sedimentation and erosion problems. Thanks to nanotechnology, nanoparticles can be introduced into traditional fluids, resulting in nanofluids [2].

The emergence of Ionic Liquids (ILs) as solvents with very attractive properties suggests the use of these molten salts as base fluids for the synthesis of nanofluids. These Ionic Liquids often have a very good thermal stability and are usually liquid in a wide range of temperatures. But above all, the property that makes them interesting is their low vapor pressure, being not volatile and allowing working at high temperatures without air pollution phenomena. The use of ILs as base fluids to which nanoparticles are added results in the Ionic Nanofluids (Ionanofluids).

Ionanofluids, or nanofluids in general, can be made by dispersion of commercially acquired nanoparticles in the base fluid. Nonetheless, by synthesizing the nanoparticles directly in the fluid, the stability of the dispersion is enhanced. In this work, we report the preparation of an Ionanofluid consisting on silver iodide nanoparticles formed inside an Ionic Liquid (trihexyl(tetradecyl)phosphonium chloride, [$P_{6,6,6,14}$]Cl). For its synthesis, only the Ionic Liquid and the bulk powder of the material of the target nanoparticle are used [3]. Once prepared, the nanodispersion was both physically (density, refractive index and viscosity) and thermally (thermal conductivity and specific heat capacity) characterized.

Experimental: The solid precursor is placed into a round-bottom flask with Ionic Liquid and the mixture is heated up to 120 ºC and vigorously stirred for 4 hours under an inert

atmosphere of argon. The concentration of the nanoparticles in the Ionanofluid is 1% (w/w).

In order to study the size and morphology of nanoparticles, they were precipitated from the Ionanofluid. Transmission electron microscopy (TEM) and X-ray powder diffraction (XRPD) techniques were used.

The nanofluid densities were measured in an Anton Paar DMA 5000 densimeter with viscosity correction and with self-control of temperature using the Peltier effect. Refractive indices were measured in an ATAGO RX-5000 refractometer. The kinematic viscosities were determined by Ubbelohde micro-viscometer. For the thermal characterization, thermal conductivities were measured with a F5-Technologie Lambda System and specific heat capacities with a DSC Q2000 (TA Instruments).

Results and discussion: Silver iodide nanoparticles were prepared inside the Ionic Liquid trihexyl(tetradecyl)phosphonium chloride ([$P_{6,6,6,14}$]Cl), conforming a Ionanofluid. The first evidence of the formation of this nanodispersion is the change of the fluid to a characteristic yellow-greenish color. The nanodispersion was stored for several weeks, showing a great stability.

To characterize the nanoparticles they were precipitated from the Ionanofluid. They were studied in the TEM (Figure 1a), showing spherical, well defined and non-agglomerated nanoparticles in the range of 2-20 nm. The XRPD pattern in Figure1b confirmed the hexagonal structure of the particles and, thus, any structural change took place during the formation of the nanomaterial from the bulky powder.

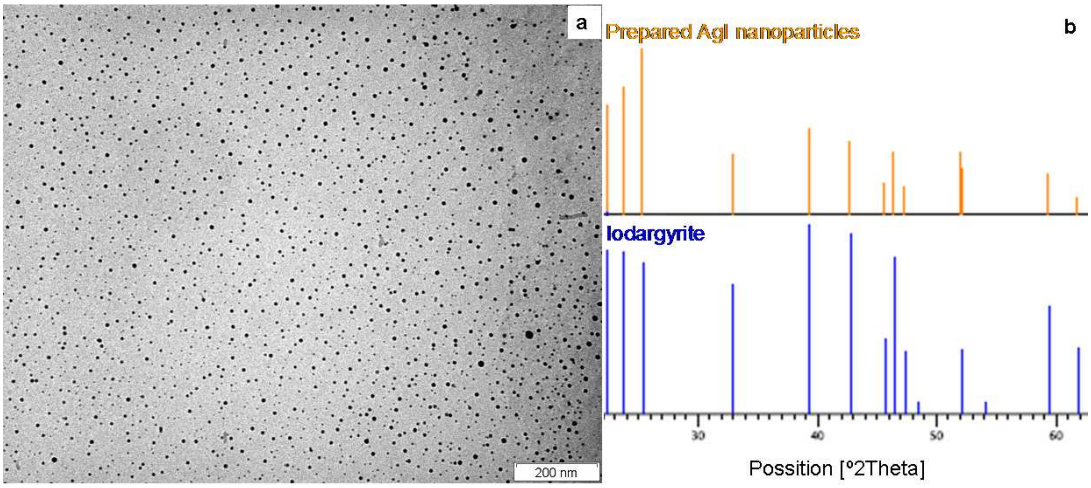

Figure 1. a) TEM image and b) XRPD pattern of the AgI nanoparticles.

When measuring the physical properties of the Ionanofluid (density, refractive index and viscosity) a slight increase of the value is found compared to the values of the fluid base in the two first cases. This increase tends to be constant with the temperature (293.15-323.15 K), as it can be seen in Figure 2. No relevant variations appear in the case of the viscosity.

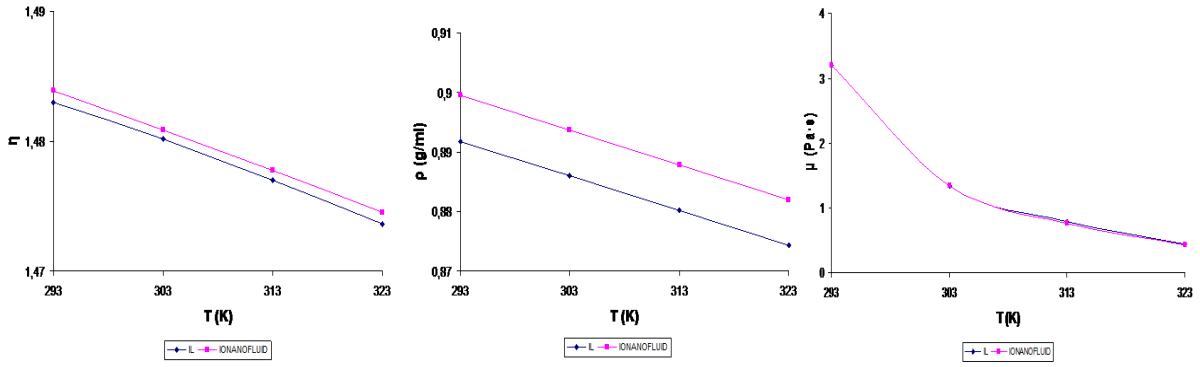

Figure 2. Refractive index, density and viscosity of the Ionanofluid and the Ionic Liquid at different temperatures.

Thermal conductivities were measured in the range of temperatures between 298.15 and 423.15 K and specific heat capacities were measured in the range of temperatures between 373.15 and 473.15 K. Both properties are compared to those of the IL (Figure 3). As showed in Figure 3, thermal conductivity has a linear dependence with temperature.

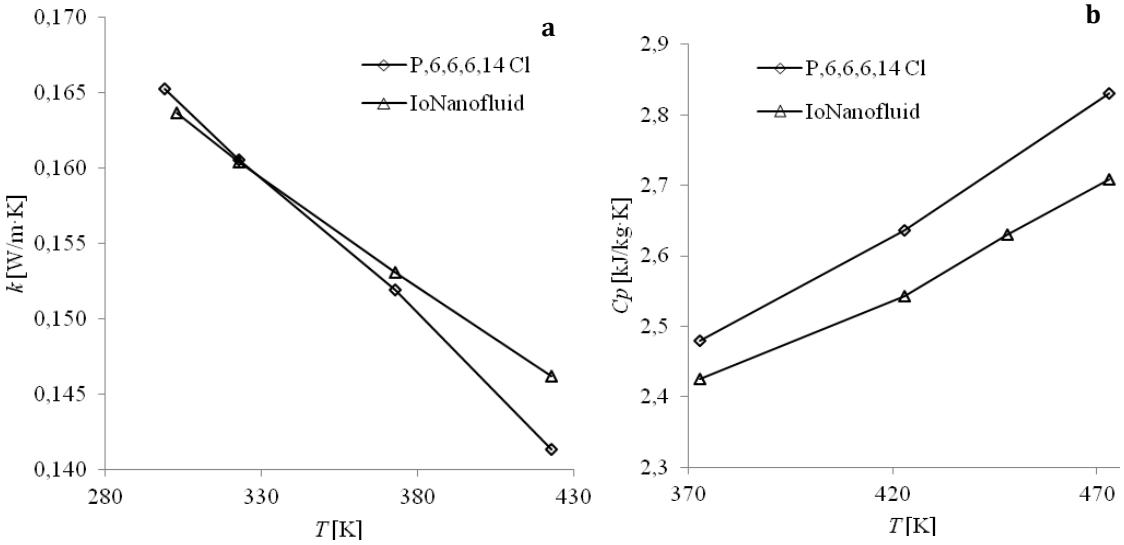

Figure 3. Thermal conductivity (a) and specific heat capacity (b) of the Ionanofluid and the Ionic Liquid at different temperatures.

Conclusions: An Ionanofluid of silver iodide nanoparticles within the Ionic Liquid trihexyl(tetradecyl)phosphonium chloride has been prepared. The used method allows a fabrication without atmospheric pollution problems since Ionic Liquids are non-volatile. The obtained nanoparticles were spherical and well defined with sizes between 2 and 20 nm. The refractive index and density of the nanofluid is slightly higher than those of the Ionic Liquid due to the effect of the nanoparticles, nontheless their influence on the high viscosity of the Ionic Liquid is negligible. Heat capacities of Ionanofluid were found to be lower than those of the Ionic Liquid. At high temperatures the thermal conductivity of the Ionanofluid showed an enhancement over the Ionic Liquid.

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