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Low-melting ionic liquids for lunar telescope

The project follows the paper published in Nature [1], concerned with using ionic liquids to construct a liquid mirror for a lunar telescope, to be erected on Moon. A range of ionic liquids was synthesised and examined, in order to produce a secondary or tertiary mixture of exceptionally low melting point/glass transition. This part of the research focused on influence of the anion.

Ionic liquids were tested using various mass spectrometry techniques in order to see what different ion formations occur when cation of ionic liquid is constant and the anion is varied. The ionic liquids examined in Swansea where: 1-ethyl-3-methylimidazolium ethyl sulphate, 1-ethyl-3-methylimidazolium chloride, 1-ethyl-3-methylimidazolium bis[(trifluoromethyl)sulfonyl]amide and 1-ethyl-3-methylimidazolium trifluoromethanesulfonate. Several methods of analysis were used for each of the above ionic liquids. These included Fast Atom Bombardment, Liquid Secondary Ion Mass Spectrometry, Electro spray, Matrix assisted Laser Desorption Ionization, Electron Ionization, Chemical Ionization. The analysis provided insight into speciation of the ionic liquids and ion-ion interaction (clustering), and very useful information regarding the possible decomposition route. All results were obtained in a satisfactory timeframe and with good resolution.

This research is to be continued, and new ionic liquids are to be synthesised, in the search of the ideal eutectic mixture for the liquid mirror.

Speciation of the chloroindate ionic liquids

Preliminary experiments according to speciation of the chlorometallate ionic liquids for catalytic applications were carried out. Chlorides of the Group 13 metals (aluminium, gallium, indium) form ionic liquids with organic chlorides. In the case of aluminium(III) and gallium(III) chlorides, when excess of the metal chloride is added (χ_{MCl3}>0.5), the ionic liquid contains Lewis acidic $[M_2Cl_7]^-$ anions. In the case of indium(III) chloride, the excessive metal chloride precipitates as a white solid; however, such mixture still possesses Lewis acidic properties and acts as a mild Lewis catalyst [2]. This fragment of the speciation research aimed at finding out, using various techniques - POM, DSC, EXAFS, ^{221}In NMR (liquid and solid state), FAB MS) - whether trace amounts of $[In_2Cl_7]^-$ were found in the system.

1-Octyl-3-methylimidazolium chloride in the mixture with indium(III) chloride (χ_{MCl3} = 0.45 and 0.55) were analysed using FAB MS. Interestingly, in the composition where indium(III) chloride was excessive, formation of $[In_2Cl_7]^-$ was observed in the conditions of experiment. This was unexpected, as it was not possible to observe formation of the binuclear anion using any other technique. It was established, based on all employed techniques and literature Raman data [3], that this anion is not responsible for the catalytic properties of the system, as it is not stable in the liquid phase. However, it is possible to form it in the specific conditions (*e.g.* FAB MS experiments), and it may play some part in the dynamic equilibrium between the solid indium(III) chloride and the chloroindate ionic liquids. This data are to be published soon in the form of a journal paper. All results were obtained in a satisfactory timeframe and with good resolution.

1. Borra, E.F., et al., *Deposition of metal films on an ionic liquid as a basis for a lunar telescope.* Nature, 2007. **447**(7147): p. 979-981.
2. Gunaratne, N., T.J. Lotz, and K.R. Seddon, *ALKYLATION OF HYDROXYARENES WITH OLEFINS, ALCOHOLS AND ETHERS IN IONIC LIQUIDS*. 2006.
3. Yang, J.Z., et al., *Studies on an ionic liquid prepared from InCl3 and 1-methyl-3-butylimidazolium chloride.* Thermochimica Acta, 2004. **412**(1-2): p. 1-5.