CURRENT STATUS AND FUTURE PROSPECTS OF IONANOFLUIDS

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Introduction: The concept of *Ionanofluids* was first introduced by Nieto de Castro and co-workers from the Centre for Molecular Sciences and Materials, Faculty of Sciences of the University of Lisbon [1]. The term *Ionanofluids* represents a novel class of heat transfer fluids which is engineered by suspending nanoparticles in ionic liquids (IL). This is basically a specific type of nanofluids where conventional heat transfer fluids such as water, ethylene glycol and engine oil are commonly used as base fluids [2]. Before discussing ionanofluids it is important to brief about ionic liquids used as base fluids in ionanofluids. The topic “ionic liquids” has received immense attention from researcher, engineers and industries due to their fascinating thermophysical and phase-equilibria properties, the versatility of their synthesis, and manageable to be tailored for a given application. Ionic liquids have proven to be safe and sustainable alternatives for many applications in industry and chemical manufacturing. Their solvent properties as well as their heat transfer, heat storage and surface properties make them possible to use in a high plethora of applications [3, 4]. On the other side, nanoparticles offer numerous advantages over any other sizes (micro or macro) of particles as heat transfer enhancer of the host fluids and as stability of the suspensions.

If nanoparticulates in any shapes and structures are dispersed in ionic liquids, “bucky gels” (i.e., actually ionanofluids) are formed. As ionic liquids are highly flexible such that they can be designed for target-oriented properties or task, suspending small quantity of nanomaterials in ionic liquids can offer exciting thermal features like high thermal conductivity, and heat capacity as well as other thermophysical and electrochemical properties.

Our primary studies showed that ionanofluids possess higher thermal conductivity, larger volumetric heat capacity and better heat transfer fluids for heat exchangers compared to their base ionic liquids. Figure 1 shows picture of a sample ionanofluid ([C_4mim][NTf2]+MWCNT).

Figure1. Sample ionanofluids.

Thermal Conductivity and Heat Capacity of Ionanofluids: Since the concept of "ionanofluids" is very new, except research works by this group no other work on this novel class of fluids is so far available in the literature. Recent studies by Prof Nieto de Castro and his group [5-6] revealed that ionanofluids containing multi-walled carbon nanotubes (MWCNT) in various ionic liquids possess enhanced thermal conductivity and specific heat capacity compared to their base ionic liquids and these properties further increase with increasing concentration of MWCNT.

Figure 2 shows that the thermal conductivity of MWCNT/[C_2mim][$EtSO_4$]-based ionanofluids increases considerably over base ionic liquids (i.e., [C_2mim][$EtSO_4$] with the concentration of MWCNT [7]. Maximum enhancement of thermal conductivity of 25% is observed at 71°C and at 3 wt% concentration of MWCNT in this ionic liquid (Figure 2). For several other types of MWCNT-ionanofluids the enhancement of thermal conductivity was found to be in the range of 2 to 35%. However, the effect of temperature on the enhancement of thermal conductivity of this [C_2mim][$EtSO_4$]-based ionanofluids is not significant.

Besides thermal conductivity, specific heat capacity of ionanofluids is very important for their practical applications in numerous fields. Specific heat capacity of MWCNT-ionanofluids was also investigated in our previous study. It was found that the specific heat capacity of ionanofluids increased significantly with increasing temperature in the range of 50-90 ºC [6, 7]. There was also little increase in specific heat capacity of ionanofluids with concentration of MWCNT. Nevertheless, any increase in heat capacity of such suspensions or fluids is of great importance for their practical applications as heat transfer fluids.

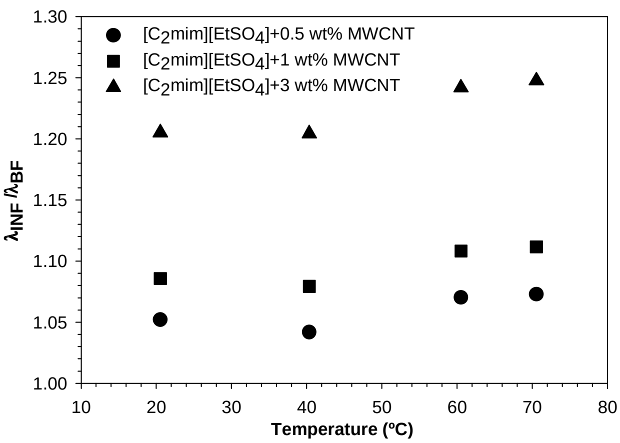

Figure2. Temperature and concentration-dependent thermal conductivity of MWCNT-ionanofluids [7].

Recently, França [8] performed simulation to estimate reference heat transfer area using two ionic liquids, ([C_4mim][NTf2] and [C_2mim][EtSO4]) as well as their ionanofluids containing 1 wt% of MWCNT in a shell and tube heat exchanger. It was found that there is a decrease (up to 2.5%) in reference heat transfer area due to the addition of MWCNT in the base ILs. This indicates that ionanofluids will perform better than ionic liquids in heat transfer in devices like heat exchangers. Based on the findings of another very recent study on solar absorbance and thermal emissivity [9], a new and fascinating area of application for ionanofluids was innovated since ionanofluids was found to be usable for the development of new pigments for solar energy applications.

Conclusions: Ionanofluids are found to exhibit superior thermophysical properties particularly thermal conductivity and heat capacity compared to their base ionic liquids. These properties further increase with concentration of nanoparticles. Temperature also found to have positive impact on specific heat capacity of ionanofluids. These new fluids are also demonstrated to be better heat transfer fluids for heat exchangers or other heat transfer devices than ionic liquids. With these exciting features including high thermal conductivity, high heat capacity, non-volatile, designable and green solvent, ionanofluids can be used as advanced heat transfer fluids in numerous cooling technologies, chemical engineering and green energy-based applications. Another new and fascinating area of application for ionanofluids is that they could be used for the development of new pigments for solar applications. As a recent topic ionanofluids research is still in its very early stage and plenty of potentials are to be explored in the future.

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