DESCRIPTION FOR THE GENERAL PUBLIC (IN ENGLISH)

IoNanofluids are fascinating "hybrid fluids" characterized by high thermal conductivity and heat capacity. They are stable systems consisting of nanoparticles (NPs) dispersed in ionic liquids (ILs). NPs, that is particles whose at least one of the dimensions is in the range from 1 nm to 100 nm, may form so-called nanofluids with various solvents, whereas ILs are chemicals of melting point below 100 ^{o}C and structurally are composed solely from ions. Hence, in contrast to "classic salts", ILs are liquids at room temperature. The main reason for those unusual properties of ILs is their molecular structure – they consist of large organic cations with low symmetry and inorganic or organic anions. Due to their molecular architecture ILs have many intriguing properties – they "stay" liquid in a wide temperature range up to 300 °C (water has a range of liquidity equal to 100 °C); they are non-flammable, non-evaporating, chemically and thermally stable – so they constitute attractive medium for heat transfer and storage. The "suspension" of even very small amounts of NPs in ILs can significantly increase thermal conductivity and heat capacity of the so-formed system as compared with the basic (non-modified) ILs. In this way, IoNanofluids combine the advantages of nanofluids and ILs, however, this is not a typical "averaging" of properties of the mixture since such "hybrid fluids" are characterized by non-linear dependences of physical properties on concentration of NPs and synergy of individual properties of the "components". The aim of this project is to form completely new IoNanofluids with reproducible parameters in the preparation, i.e. primarily with significantly improved stability and unprecedented thermal conductivity and heat capacity. As a dispersed phase, carbon nanostructures with longitudinal geometry, i.e. carbon nanotubes and "nanohelices", have been selected for the research since their thermal conductivity mechanism may resemble formation of complex three-dimensional network. For our investigations, thermally stable imidazolium ILs with the anion of tricyanomethanide, dicyanoimide and bis(trifluoromethyl sulfonyl)imide characterized by variable values of heat capacity and thermal conductivity as well as low viscosity were selected. This selection of components will allow us to study how the size of anions and cations, the size/morphology of NPs and the interactions between carbon NPs and the base IL will affect the thermophysical properties of IoNanofluids. In particular, the success of this project will depend on the method of preparation and purity of the starting materials which should lead to stable systems. This prerequisite will allow us to design IoNanofluids based on the "starting components" in the future. At the beginning, carbon nanostructures with high quality and low batch variability will be synthesized. In turn, preparation of IoNanofluids is delicate because it does not mean simple mixing of solid particles and liquids. IoNanofluids will be prepared using a two-step method, which can be based, for example, on dispersing NPs in ILs using sonication or high-shear mixing. This approach shall enable obtainment of stable systems in which no aggregation and hence the deposition of nanoparticles will occur. For example, IoNanofluids will be defined as stable, if nanoparticle would not precipitate and if their thermal conductivity which will be measured within one year interval does not differ by more than 2%. If necessary, the stability of IoNanofluids can be improved by controlled anchoring to the surface of carbon nanostructures of acidic functional groups capable of generating "stronger" interactions with ILs, and thus better dispersion of NPs. However, first of all, it is important to characterize the particle size distribution in IoNanofluids, not just the carbon nanostructures themselves. A particular scientific significance of this project will be to study the structure of IoNanofluids using cryogenic transmission microscopy (cryo-TEM). The cryo-TEM method allows direct imaging and characterization of IoNanofluids in the "natural state". The under-TEM observed objects will be transformed into glassy state by rapid cooling and further will be examined in the form of amorphous films. Other physicochemical properties of IoNanofluids, such as density, viscosity, heat capacity and high-pressure thermal conductivity under the pressure of 1-1000 atm. and at 20-177^{o}C will be also measured. The obtained results will allow to corelate thermophysical properties with the structure of IoNanofluids in order to discover the real mechanisms of stability and thermal conductivity in ILs and IoNanofluids. Our research will serve for more rational design of, for example, working fluids in solar collectors or cooling fluids circulating in supercomputers or car engines.