Ionanofluids Prepared from a Series of Ionic Liquids: Preparation, Heat Capacity Measurement and Advanced Data Analysis by Mathematical Gnostics

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Ionanofluids (INF), nanoparticles dispersed into an ionic liquid, are a novel class of alternative heat transfer fluid.[1-3] Addition of nanoparticles into a base ionic liquid is a prime reason for enhancement in thermophysical properties of ionanofluids,[4,5] however, due to very limited research on ionanofluids, further studies are required to understand change in isobaric heat capacity of ionanofluids as a function of type of the ions of base ionic liquids and type of nanoparticles. To this end, in the present work, isobaric heat capacity was measured as a function of temperature for the prepared ionanofluids samples. Moreover the influence of the size of the ion of ionic liquid on the isobaric heat capacity of ionanofluids was studied.

Ionanofluids samples were prepared by dispersing multi wall carbon nanotubes (MWCNT) into a series of imidazolium ion based ionic liquids ($[C_n\text{mim}][Tf_2N]$ where n=2, 4, 6, 8, 10 and 12). Stable samples of ionanofluids were prepared by mixing ionic liquids and MWCNT at 220 rpm, 1 mbar pressure and 50 °C temperature for two hours on the Rotavapor R-300. These mixtures were then submerged into the ultrasonic bath for up to 1 hour where they were converted to a viscous fluid or gel. Stability of the MWCNT dispersions in base ionic liquid for all gel like samples were observed and compared. Measurements of the heat capacity were carried out as a function of temperature (20 °C to 70 °C) for series of base ionic liquids and ionanofluids samples using a Tian-Calvet µDSC III Evo microcalorimeter by Setaram. The measured isobaric heat capacity data from the series of base ionic liquids were first compared with available literature data and then to the ionanofluids samples. A significant pattern was noted in the change of isobaric heat capacity for ionanofluids samples with respect to base ionic liquids.

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Furthermore, these experimental isobaric heat capacities data were assessed by a novel nonstatistical data analysis method named as mathematical gnostics (MG). MG marginal analysis was used to estimate most probable values and uncertainties from the measured data set.[6, 7]

References

1. Minea, A.A.; Murshed, S.M.S. A review on development of ionic liquid based nanofluids and their heat transfer behavior. *Renewable Sust. Energy Rev.* **2018**, *91*, 584–599.
2. Fukushima, T.; Aida, T. Ionic liquid for soft functional materials with carbon nano tubes. *Chem. Eur. J.* **2007**, *13* 5048–5058.
3. Murshed, S.M.S.; Nieto de Castro, C.A.; Lourenco, M.J.V.; Franca, J.; Ribeiro, A.P.C.; Vieira, S.I.C.; Queiros, C.S. Ionanofluids as novel fluids for advanced heat transfer applications. *World Academy of Science, Eng. and Tech.* **2011** 52.
4. Oster, K.; Hardacre, C.; Jacquemin, J.; Ribeiro, A.P.C.; Elsinawi, A. Understanding the heat capacity enhancement of ionic liquid based nanofluids (ionanofluids). *J. Mol. Liq.* **2018**, *253*, 326–339.
5. Nieto de Castro, C.A.; Murshed, S.M.S.; Lourenco, M.J.V.; Santos, F.J.V.; Lopes, M.L.M.; Franca, J.M.P. Enhanced thermal conductivty and specific heat capacity of carbon nanotubes ionanofluids. *Int. J. Therm. Sci.* **2012**, *62*, 34–39.
6. Bendová, M.; Čanji, M.; Wagner, Z.; Bogdanov, M.G. Ionic liquids as thermal energy storage materials: On the importance of reliable data analysis in assessing thermodynamic data. *J. Solut. Chem.* **2018**, *48*, 949–961.
7. Wagner, Z.; Bendová, M.; Rotrekl, J.; Velisek, P.; Storch. J.; Uchytil, P.; Setnickova, K.; Reznickova, J. Advanced analysis of isobaric heat capacities by mathematical gnostics. *J. Solut. Chem.* **2017**, *46*, 9–10.