Challenges on the Determination of the Thermophysical Properties of Molten Eutectic Li, Na and K Carbonate Mixtures for Thermal Storage Applications

Maria José V. Lourenço[1, S, C], Mafalda S. Gil[1], Rafael A.S. Taranta[1], J.F. Chainho[1], Valentim M.B. Nunes[2] and Carlos Nieto de Castro[1]

[1]*Centro de Química Estrutural, Institute of Molecular Sciences, Departamento de Química e Bioquímica, Faculdade de Ciências da Universidade de Lisboa, Lisboa, Portugal*
[2]*Centro de Investigação em Cidades Inteligentes, Instituto Politécnico de Tomar, Tomar, Portugal*
mjlourenco@ciencias.ulisboa.pt

The need for efficient and cheap renewable energies led to the development of Concentrated Solar Plants (CSP), due to their dispatchability, by using thermal storage units based on mixtures of molten nitrate salts. However, their corrosiveness and temperature operational zones led to exploration of the use of molten carbonate and chloride eutectics for the future of energy storage in CSP, the first looking more reliable due to materials compatibility issues [1,2].

A project to measure thermal, chemical and thermophysical stability of a Li-Na-K-carbonate eutectic mixture, was started in Lisbon. The salt was prepared from pure reagent precursors (Li_2CO_3, Na_2CO_3, K_2CO_3) and the mixing involves melting, solidification, and drying. The mixture characterization was carried out by thermogravimetry and differential thermal analysis (TG-DTA), in the range T_{amb} -800 °C. The properties were enhanced by preparing dispersions of nanoparticles in the salt media, the nanosalts, namely TiO_2, MgO and SiO_2 [3].

Existing methods for their preparation (at room temperature, obtaining a solid composite of nanoparticles in the solid salt followed by melting at higher temperatures or at temperatures above the melting point of a base salt eutectic mixture) will be discussed, and a new technique, which guarantees the chemical and long-term stability of the dispersions, will be discussed. Thermal conductivity (transient hot-strip) [4,5], viscosity (oscillating cup technique) [6,7] and melting points and heat capacity (DSC) were the techniques chosen for the measurement. Preliminary measurements will be presented.

References

1. Ong, T-C., Sarvghad, M., Bell, S., Will G., Steinberg, T.A., Yin, Y., Andersson, G., Lewis, D. Review on the challenges of salt phase change materials for energy storage in concentrated solar power facilities. App. Ther. Eng., 2023, 122034 (in press).
2. Nunes, V.M.B., Lourenco, M.J.V., Santos, F.J.V., Nieto de Castro, C.A. Molten alkali carbonates as alternative engineering fluids for high temperature applications. Appl. Energy, 2019, 242, 1626-1633.
3. Navarrete, N., Gimeno-Furió, A., Forner-Escrig, J., Enrique Juliá, J., Mondragón, R. Colloidal stability of molten salt –based nanofluids: Dynamic Light Scattering tests at high temperature conditions. Powder Technol., 2019, 352, 1–10.
4. Nieto de Castro, C.A., Lourenço, M.J.V. Towards the Correct Measurement of Thermal Conductivity of Ionic Melts and Nanofluids. Energies 2020, 13, 99.
5. Lourenço, M.J.V., Alves, M., Serra, J.M., Nieto de Castro, C.A., Buschmann, M.B. The Thermal Conductivity of Near-Eutectic Galinstan ($Ga_{68.4}In_{21.5}Sn_{10}$) Molten Alloy", Int. J. Thermophys., 2023, in press.
6. Nunes, V.B., Santos, F.J.V., Nieto de Castro, C.A. A High Temperature Viscometer for Molten Materials. Int. J. Thermophys. 1998, 19, 427-435.
7. Nunes, V.M.B., Lourenço, M.J.V., Santos, F.J.V., Nieto de Castro, C.A. Measurements on of the Viscosity of Molten Lithium Nitrate by the Oscillating-cup Method. Int. J. Thermophys., 2017, 38:13.