Viscosity modelling of molten salts in heat transport and storage applications

Darya Ewaznezhad Fard, Michael Müller, Guixuan Wu

Institute of Energy and Climate Research (IEK-2), Forschungszentrum Jülich GmbH, Jülich, 52425, Germany, *email: d.ewaznezhad.fard@fz-juelich.de*

Concentrated solar power (CSP) plants are widely recognized as renewable technologies which have a significant role for the clean electricity generation in the present and future time since they utilize the sun's heat [1]. CSP technologies, as shown in Fig 1, concentrate the solar radiation beam onto a focal area containing a heat transfer fluid (HTF) and increase its temperature. Eventually, this energy can be transferred to steam and thus electricity is generated using a generator driven by a steam turbine. Thermal energy storage (TES) is utilized as a beneficial tool to integrate renewable energies and electricity generation [1, 2]. In recent years, molten salts have received much attention due to their specific properties in a wide range of applications making them promising candidates as HTFs in heat transport and storage applications. Therefore, noticeable efforts have been taken to develop an available database for transport properties of molten salts, e.g. the viscosity. Due to the high temperature or the presence of some hazardous species, running experiments in the entire temperature and compositional range is complicated if not impossible. It is therefore necessary to develop models that are capable of predicting, generating and analyzing the viscosity behavior of molten salts to be developed [2, 3]. In this work, temperature and composition dependence of viscosity of unary and higher order alkali and alkaline earth nitrates, chlorides and carbonates are evaluated and described using an Arrhenius-like model based on the associate species calculated from thermodynamic database, which was originally developed for oxide melts and now adapted for salt systems [4]. It is noteworthy that a good agreement for the temperature dependence of viscosity has been achieved for all unary molten salts. However, an excess viscosity induced by composition, i.e. due to formation of possible large clusters, might be required for some salt systems. Nevertheless, more experimental viscosity data is necessary, as well as evaluation of the validity of literature data, especially digitalized from existing equations.

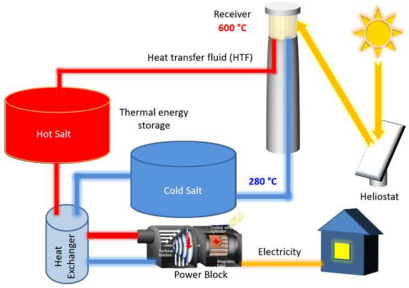

Figure 1. Scheme of a concentrated solar power plant

References:

1. Baharoon, D.A., et al., *Historical development of concentrating solar power technologies to generate clean electricity efficiently – A review 289.* Renewable and Sustainable Energy Reviews, 2015. **41**: p. 996-1027.
2. Kenisarin, M.M., *High-temperature phase change materials for thermal energy storage.* Renewable and Sustainable Energy Reviews, 2010. **14**(3): p. 955-970.
3. Liu, M., et al., *Review on concentrating solar power plants and new developments in high temperature thermal energy storage technologies.* Renewable and Sustainable Energy Reviews, 2016. **53**: p. 1411-1432.
4. Hack, K., et al., *A CALPHAD approach to modelling of slag viscosities.* Calphad, 2019. **65**: p. 101-110.