High temperature thermodynamic and thermo-physical properties of liquids for nuclear fuels applications

Nuclear materials are subjected to extreme temperature under nominal, transient or accidental conditions that impose to study their properties at high temperature. Even under nominal conditions, irradiated UO_2 or MOx fuels may undergo very high temperatures that may generate a local melting of the fuel pellets due to the interactions between melted uranium, low melting temperature fission products and iron from structural materials.

The thermodynamic and thermo-physical properties of such liquid phases are paramount; these parameters strongly influence the high temperature behavior and corrosion resistance of fuel pins inside the nuclear core.

However, literature data on high temperature liquids are scarce and affected by large uncertainties. These discrepancies are due to many experimental difficulties related to the chemical interaction between liquid samples and crucible, redox chemistry and high temperature measurements.

In the framework of the acquisition of fundamental data on high temperature liquid for nuclear applications, a PhD project is proposed aiming at the development of a dedicated experimental setup capable to obtain thermodynamic and thermo-physical data on rather complex Fe-containing liquid mixtures.

In particular, the experimental setup will be based on a laser heating technique coupled with aerodynamic levitation. This device will be complementary to the one already existing in JRC-Karlsruhe that does not use any levitation technique but a self-crucible method. Furthermore, the setup will be equipped with a series of monitoring devices: pyrometer, wide-band infrared detector, thermal infrared camera and high-speed visible camera. This device will make it possible to determine some local phenomena during phase transitions.

A first version of the experimental setup has already been used on oxide samples. The obtained results are promising and motivate to pursue these investigations and to improve the existing set-up. In a first step, the chemical systems of interest will be Fe-Zr-O based liquids as surrogates of the interaction between the oxide fuel and structural materials. Then, the sensitivity of these melts towards temperature and oxygen potential will be investigated. The final perspective of the PhD will be to adapt the developed experimental device to U-containing liquids for specific nuclear fuel applications.

Useful information

PhD Salary: ≈1600 € per month
Location: CEA center of Saclay www-centre-saclay.cea.fr/
PhD will start in October 2018

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