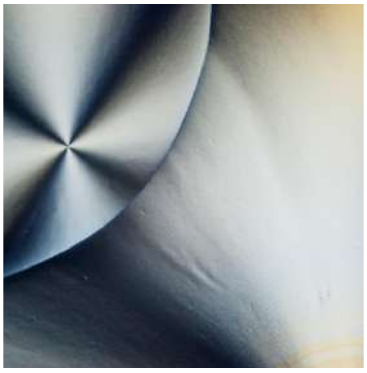
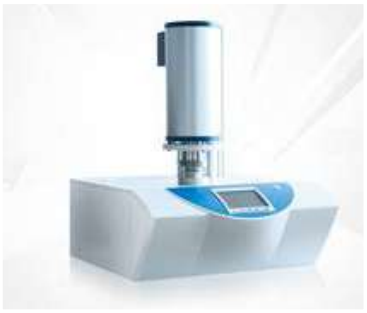


High temperature differencial scanning calorimeter

Thermal analysis of phase change materials (PCM) - inorganic salt



HDSC PT1600

Introduction

Phase change materials (PCM) and latent heat storage has become an important research topic during the latest decades. In times of green energy politics, there are a lot of projects for energy storage and optimization of energy usage. Thermal analysis can help to investigate these materials regarding their behavior and capability for latent heat storage.

Methods

Using a high-temperature-DSC for analysis of such materials is a common technique. In this application, the HDSC was used for measurements of salt powder that changes its phase during heating. Most salts have a very high crystallization and melting enthalpy and are therefore used as heat storage materials.

The DSC signal in general is generated by heating a pan containing a sample and an empty reference pan using the same heat source. Subtracting the heat flow signals of the two pans from each other, results in endothermic or exothermic peaks if the sample temperature changes due to thermal effects.

The DSC measurement therefore gives the melting and crystallization temperature and enthalpy and can also determine Cp values and in case of latent heat storage materials, also the change of the Cp value before and after the phase change.

Table 1. Experimental Conditions

Instrument	HDSC PT 1600
Heating rate	10 K/min
Sample mass	15 mg
Sample pan	open alumina pan
Purge gas	Nitrogen 6 l/h

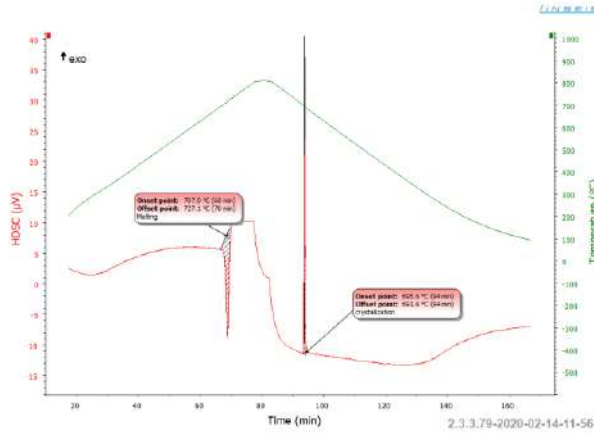


Figure 1. HDSC diagram of $CeBr_3$; Sample weight: 15 mg, heating rate: 10 K/min. Cooling rate 10K/min

Experimental

Cerbromide ($CeBr_3$) powder was measured on a single furnace HDSC PT1600 under the conditions shown in Table 1. Open alumina pans were used in order to avoid reaction between the molten sample and the crucible and/or sensor. The sample was heated and cooled with constant speed of 10 K/min to investigate melting and crystallization.

Results

Cerbromide is a white salt that crystallizes in a hexagonal structure and has a considerable high melting enthalpy. It is frequently used as a radiation detector however here it is taken as a phase change material to demonstrate the behavior of molten salts as latent heat storage compound. During melting, which can be seen as endothermic effect at 722°C in fig. 1, the $CeBr_3$ shows a significant shift in the heat capacity. The baseline of the liquid substance is shifted from the DSC baseline in ist solid state. The difference in Cp represents the latent heat that can be stored within the crystal. During cooling, there is a typical, very sharp crystallisation peak with very high enthalpy that is typical for such salts. The heat energy that is released during crystallisation is considerable high and represents the stored heat that can be released by initialising a crystallisation.

Conclusion

$CeBr_3$ has a very high crystallization and melting temperature and therefore is of course not used very frequently as a latent heat storage material. However the general effect of such materials can be demonstrated quite well. Most PCMs have melting and crystallisation points close to room temperature and are already liquid or given as an undercooled liquid close to room temperature. By initialising a crystallisaition, for example by a local change in density that can be applied by a local force, the stored latent heat can be released as the crystallization starts. After that, the material can be heated again to obtain again the undercooled liquid state.