Specific heat capacity determination for aqueous solutions and colloids using an adaptation of the sapphire method

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Introduction

The aim of this work is to develop and validate a method of determining the constant pressure specific heat capacity (Cp'), applicable specifically for aqueous solutions or colloids. The method is based on the well-known sapphire method for differential scanning calorimetry (DSC) but relies on the use of closed crucibles and water as reference. This adaptation offers greater precision for water-based solutions and suspensions.

Sapphire method

The method developed in this work has been based on the traditional sapphire method[1]. This method requires three measurements:

- One of the blank: this measurement is used to correct the signals of references and samples
- One of the reference: this measurement is used to correct the obtained heat capacity
- One of the sample

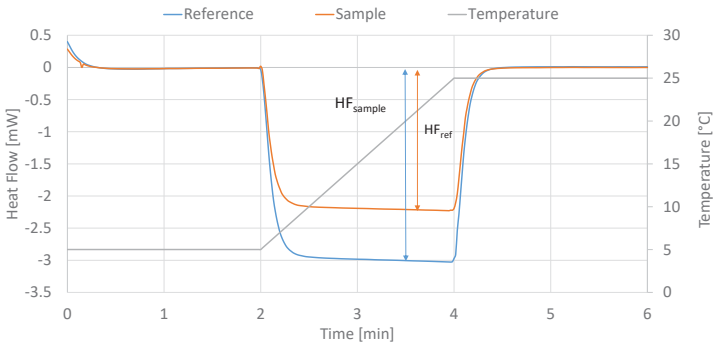

Fig. 1: Example of thermograms and the temperature ramp used for the sapphire method

Example of the obtained thermograms is given in **Fig. 1**. For each measurement, a specific temperature program is applied, with first an isothermal step, then a temperature ramp and another isothermal step.

Adaptation of the sapphire method

The principal adaptation was to replace the sapphire reference with a water one. Water has more similarities (physical state, specific heat capacity, …) with aqueous suspensions and colloids, which makes it a much better reference.

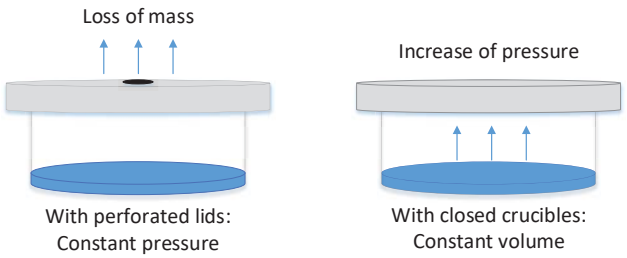

Fig. 2: Illustration of differences between closed and open crucibles

In addition, fully closed DSC crucibles were used. Indeed, a loss of mass due to perforated lids (see **Fig. 2**) and evaporation could cause a significant error on the observed specific heat capacity value. However, with closed crucibles, the determined value would be the specific heat capacity at constant volume (C_v'), which should be smaller than the constant pressure specific heat capacity (C_p'). This imprecision is assumed to be corrected by using water as reference.

Validation

The method was evaluated by determining the specific heat capacity of KCl aqueous solutions at four different temperatures. The measured values are compared with literature[2] in **Fig. 3**.

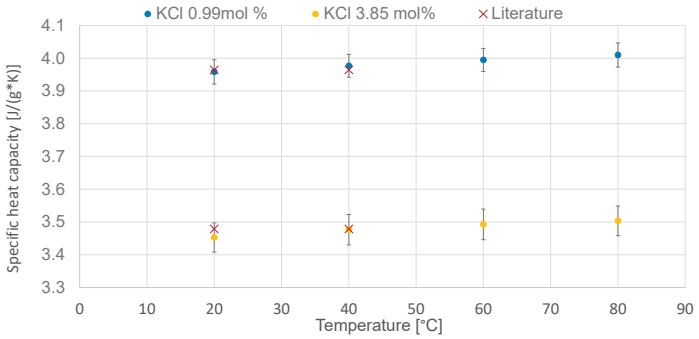

Fig. 3: Results obtained for the specific heat capacities of aqueous KCl solutions using the developed method

The relative errors obtained are less than 1% compared to the literature values, what shows satisfactory accuracy. The standard deviation calculated with three repeated measurements is low (about 0.05 J/(g*K)), which shows demonstrates measurement repeatability.

Conclusion

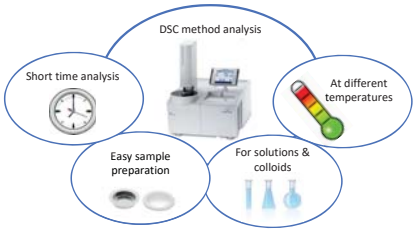

Fig. 4: Presentation of the advantages of the developed method

The developed method has several advantages, that are presented in **Fig. 4**. The precision of the approach seems to be satisfactory for several applications. The method is currently investigated, in collaboration with Dublin City University (Ireland), for the thermal characterization of nanoparticle colloids that can be used, for instance, in a coolant system.

[1] J. De Burh, R. Riesen, J. Widmann, and U. Jörimann, "Measuring specific heat capacity," *USER COM (Mettler Toledo)*, June, 1998.
[2] R. H. Perry, D. W. Green, and J. O. Maloney, *Perry's chemical engineers' handbook*. New York: McGraw-Hill, 1999.

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