Temperature cycling stability of Phase Change Materials

Introduction

Some materials have the capacity to store and release large amounts of energy by changing their physical sate: they are called Phase Change Materials (PCM). They can be used for instance to minimize the need of air conditioning and heating: incorporated into walls of buildings, they absorb heat when outside temperature is high, and release it when temperature decreases. This keeps the house into a "comfort temperature zone". Another utilization of the PCM is the use of residual heat from exothermic reaction in industry as a source of energy. An application fitting phase change temperature and a large melting enthalpy are two obvious requirements for these materials. However, there is another important parameter: the cycling stability, in order to use the PCM as many times for storage and release of heat as required by an application [1].

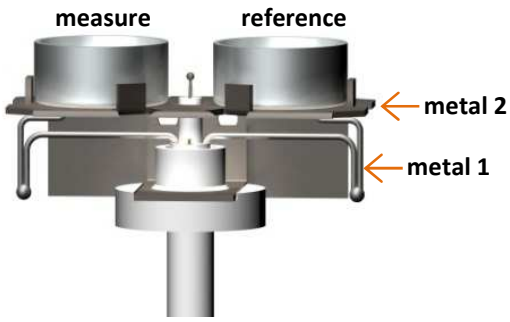

Figure 1 – Plate of the DSC 131evo

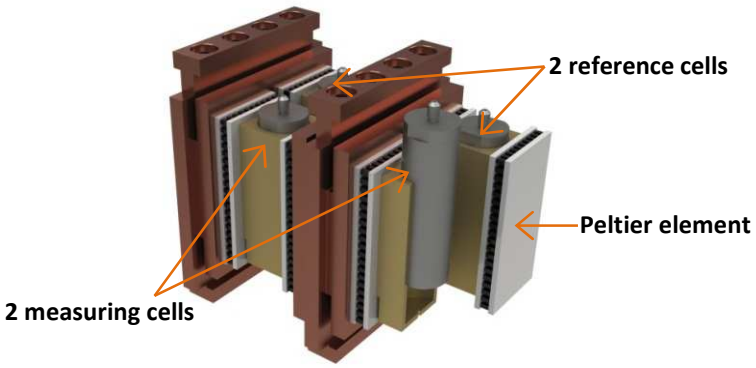

Figure 2 – The four wells of the µSC

Experimental

Two PCM samples have been cycled in order to check their thermal stability after several phase changing: a mixture of paraffins and a dicarboxilic acid (sebacic acid) [2].

The DSC 131evo (*Figure 1*) is a flexible and powerful Differential Scanning Calorimeter, with fast heating and cooling performances. It allows to perform up to 100 melting/crystallizations of samples in 24 hours.

The µSC (*Figure* 2) is a state of the art multi-cells micro-calorimeter, with a wide operating temperature range (from -40 to 200°C). The very high sensitivity of the µSC enables transition studies to be performed on small but still representative quantities of products and at very low programming speeds.

The dicarboxylic acid is heated and cooled between 100 and 150°C at 10°C.min^{-1} by DSC131evo. On ***Figure 3*** are presented the 1st, 20th, 60th, 100th, 140th and 200th heating thermograms.

The mixture of paraffin is heated and cooled between -20°C and 50°C at 5°C.min^{-1} a hundred times using the DSC131evo. Then, using the 2 measuring wells of the µSC, a simultaneous analysis of a fresh sample and an aged one is done at 0.05°C.min^{-1} (similar to the real condition of use in building's walls).

Results

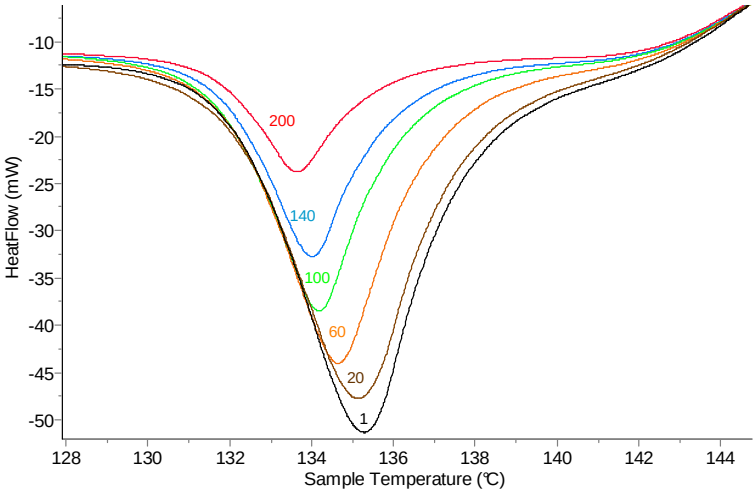

Figure 3 – Superimposition of peaks linked to the melting of sebacic acid (numbers of cycling are indicated)

Experiments run with the DSC131evo on the sebacic acid show that there is a constant decrease of the latent heat of melting linked to the number of cycling done on this compound (***Figure 3***). Latent heat of crystallization presents a similar decrease (curves not showed here). This lost of energy is certainly due to a degradation of the sample at high temperature.

Due to its thermal instability, sebacic acid can not be considered as an interesting PCM.

The slow scan rate, and the two measuring wells of the microcalorimeter µSC allow to precisely obtain the latent heats of melting and crystallization of a fresh and an aged sample of paraffin .

A hundred successive phase changes did not affect the capacity of storage of this material, the latent heat of melting is still 158 $J.g^{-1}$ (***Figure 4***). However, the difference in melting temperature observed is significant (0.7°C). It will be necessary to test on longer term (at least 1000 cycles) to ensure the effectiveness of this type of material over a very long period of time.

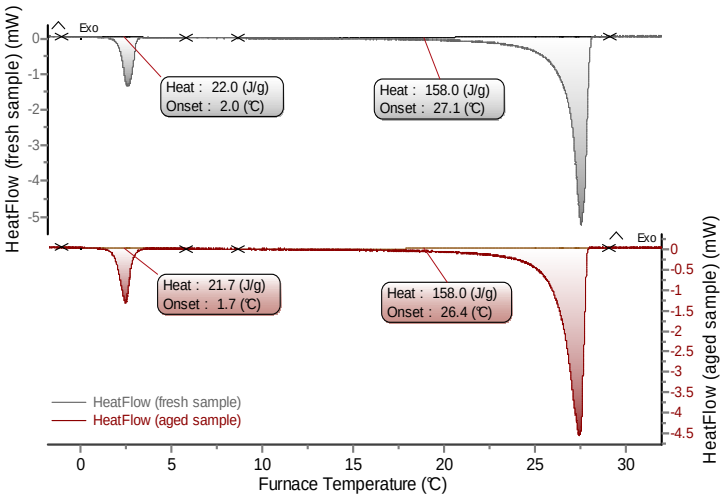

Figure 4 – Simultaneous analysis of a fresh and an aged sample of paraffins

Conclusions

Characterization of PCM could be done at low temperature rate using the new micro-calorimeter µSC; they can undergo an accelerated ageing using the DSC131evo in order to determine their cycling stability.

[1] H. Mehling, L.F. Cabeza, *Heat and Cold storage with PCM – An up to date introduction into basics and applications*, Springer, 2008
[2] D. Haillot, T. Bauer, U. Kröner, R. Tamme, *Thermal analysis of phase change materials in the temperature range 120-150°C*, Thermochimica Acta 513,p.49-59, 2011, Elsevier

µSC
-40°C to 200°C

DSC131 Evo
-170°C to 700°C

www.setaram.com
sales@setaram.com

SETARAM Instrumentation
KEP Technologies