Adaptation of standard thermal analyzers and calorimeters to specific laboratory conditions – the space calorimeter

INTRODUCTION

Instrumentation may need to be adapted when meant to be used in unusual laboratory environment.
Among the most challenging laboratory conditions are those of the International Space Station (ISS)…
Calorimetry is a common technique for the characterization of water-in-oil emulsions that can be met in the petroleum or food industry fields. A phenomenon affecting the stability of emulsions is know as coalescence, which refers to the merging of small water droplets into larger ones. Gravity being one of the driver for coalescence, researchers from the European Space Agency initiated the FASES (Fundamental and Applied Studies on Emulsion Stability) project, to study the impact of the absence of gravity on emulsion stability. They consulted KEP Technologies to develop a calorimeter able to fit with the challenging conditions of a laboratory in space.

Key elements

Our skills in customized instrument design, our well recognized expertise in microcalorimetry, and the organization of our R&D service being structured to manage specific projects have been applied for a long time in such cases. The microcalorimeter was based on the design of MICROCALVET, an instrument already used in laboratories studying emulsions.

Technical achievements

The designed system allowed measuring heat flows as low as a few microwatts in a temperature range between -50°C and +50°C. It fitted with the harsh requirements in terms of size, operability, energy consumption of a use in the ISS. The microcalorimeter and its electronics have been delivered to the customer and then integrated in a wider testing platform.
The method involves the measurement of the heat effect of crystallization of the water droplets under cooling conditions. The shape and temperature of the exothermic peak of crystallization of the water droplets in the emulsion depends on the droplets average size and distribution. In case of emulsion destabilization, the peak is shifted to higher temperatures and may become broader (see figure 2).
The calorimeter have been used in the Fluid Space Laboratory of the ISS during several weeks before the module was detached from the ISS and burnt up in the atmosphere.

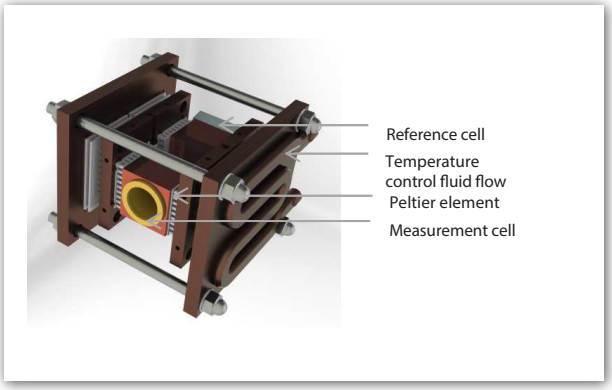

Figure 1 - Schematics of the designed microcalorimetric sensor

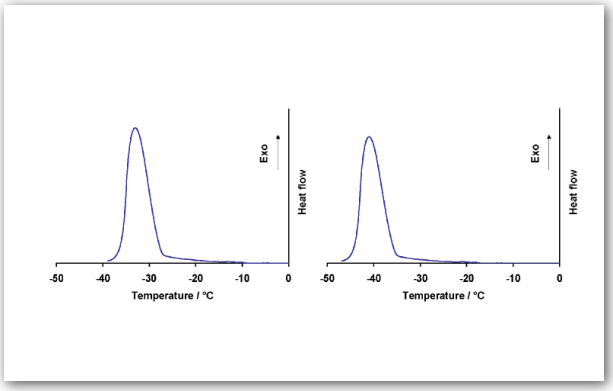

Figure 2 – Cooling profiles of water-in-oil emulsions the average size of the droplets are different but their distribution is similar.

Going further

Why not a thermal analysis instrument on another planet? The NASA already reproduced at the surface of the earth with thermal analysis some observations made at the surface of Mars by the Sample Analysis module of the Curiosity rover [1].

[1] ntrs.nasa.gov/archive/nasa/casi.ntrs.nasa.gov/20130009925.pdf