SOLAR HEATING & COOLING PROGRAMME
INTERNATIONAL ENERGY AGENCY

2023 HIGHLIGHTS

Task 67 – Compact Thermal Energy Storage Materials Within Components Within Systems

THE ISSUE

In general, thermal storage leads to a better use of renewable sources, increases thermal systems efficiency, or improves the thermal comfort in buildings. For example, with thermal energy storage the use of solar heat can be extended to periods in which there is less or not sufficient sunshine. Compact thermal energy storage materials have special characteristics that enable storage applications beyond the commonly used water thermal storages. Heat can be stored in a more compact way. Thermochemical storage materials (TCMs) can store heat at a large range of temperatures and over a long period, virtually without losses. Phase change materials (PCMs) can store heat at specific temperatures and with high energy density, providing constant temperature heat sinks or sources.

There is a broad range of possible applications for compact thermal energy storage: from keeping temperatures of transported goods constant to the seasonal storage of solar thermal energy in dwellings.

The challenge is to couple the compact thermal storage materials development work to the targeted applications. The material performance needs to be understood, materials need to be tested in application boundary conditions and the material performance, in combination with properly designed components, should be tuned to the desired system performance in the application.

OUR WORK

The purpose of this joint Task with the Energy Storage TCP is to push forward the compact thermal energy storage (CTES) technology developments to accelerate the market introduction of these technologies through the international collaboration of experts from materials research, components development and system integration, and industry and research organizations.

The main objectives of the Task are to 1) better understand the factors that influence the storage density and the performance degradation of CTES materials, 2) characterize these materials in a reliable and reproducible manner, 3) develop methods to effectively determine the State of Charge of a CTES, and 3) increase the knowledge base on how to design optimized heat exchangers and reactors for CTES technologies.

Participating Countries

Austria

Canada

Denmark

France

Germany *

Italy

Netherlands

Norway

Portugal

Slovenia *

Spain

Switzerland

Türkiye *

United Kingdom

United States *

** Participating through IEA Energy Storage TCP*

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KEY RESULTS IN 2023

Reliable and reproducible determination of material properties

The determination of material properties is not straightforward. Measurement of the properties should give consistent results; therefore, standardized procedures need to be developed and tested via round-robin tests. In this Task, 38 organizations from 15 countries are collaborating in 4 round-robin test groups: Thermal conductivity and thermal diffusivity, Specific heat capacity, Enthalpy change, and Density and Viscosity determination.

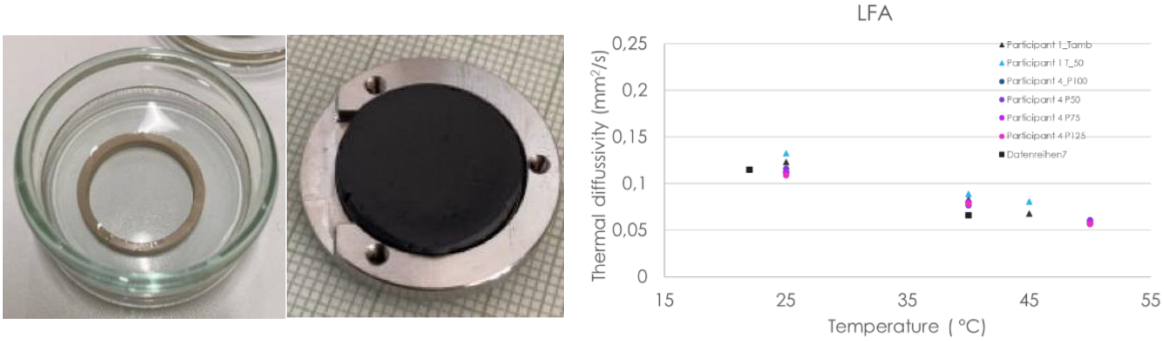

Figure 1: (a) Sample preparation of the paraffin samples for Laser Flash measurements in the liquid phase and solidified with graphite coating. (b) Laser Flash results for thermal diffusivity of 4 different participants.

For the thermal conductivity and diffusivity, the first round robin was done with a paraffine PCM CAS No. 8002-74-2 (melting temperature between 53 °C – 58 °C) in the solid phase. Several methods (Laser Flash, Transient Hot Bridge, Hot Wire, Hot Disk, Guarded Hot Plate, and Guarded Heat Flow meter) were applied, and procedures from the former Task and existing standards were used as the basis for the measurements. Results show already a good comparability. Additional results for transient plane source methods, hot wire and guarded hot plate were received. Now that this data is compared, a second round with refined procedures is planned for the next project phase.

Stability of PCM and TCM

For a reliable duration and long storage component lifetime, a better understanding of the stability of PCM and TCM during their service lifetime and recommendations for an application-oriented investigation of this stability are needed. The first step to this understanding is to get an overview and understanding of the different degradation mechanisms. To this end, several mapping methods have been discussed and tried. For example, **Error! Reference source not found.** shows one mapping type with input on TCM stability provided by Peter Weinberger of TU Vienna. The first line indicates that material stability might change over time or the number of cycles. Different causes for the changes are listed in the second line, and the third line lists the possible measurement techniques for the changes. The fourth line then gives possible solutions to overcome or prevent the degradation.

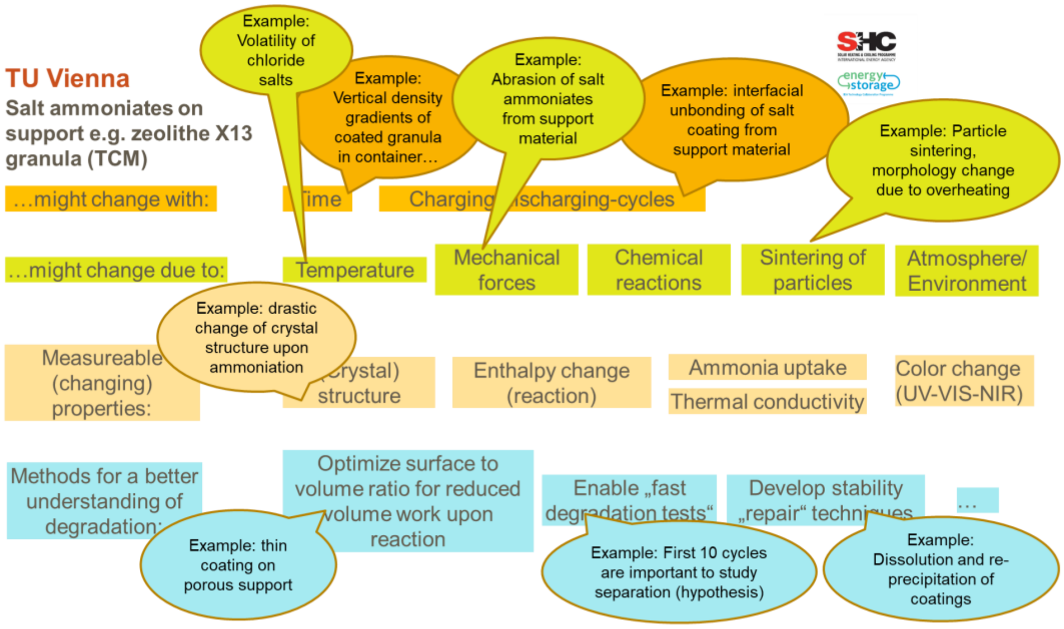

Figure 2: First presentation type to map CTES material stability, with salt ammoniates/zeolite X13 as an example.

An alternative type of presentation was developed by Ángel Serrano of CIC energiGUNE. This approach connects the degradation mechanisms (e.g., phase separation, corrosion, polymorphism) with their effect on the performance of the CTES component (e.g., change in transition enthalpy or thermal conductivity) and system level (e.g., change in power or capacity). The degradation mechanisms are, in turn, specified in more detail by their dependence on application conditions in this approach, called "aging agents" (e.g., time, heating/cooling rate, atmosphere). **Error! Reference source not found.** illustrates this approach for the material class plastic crystals, which are used as solid-solid PCM.

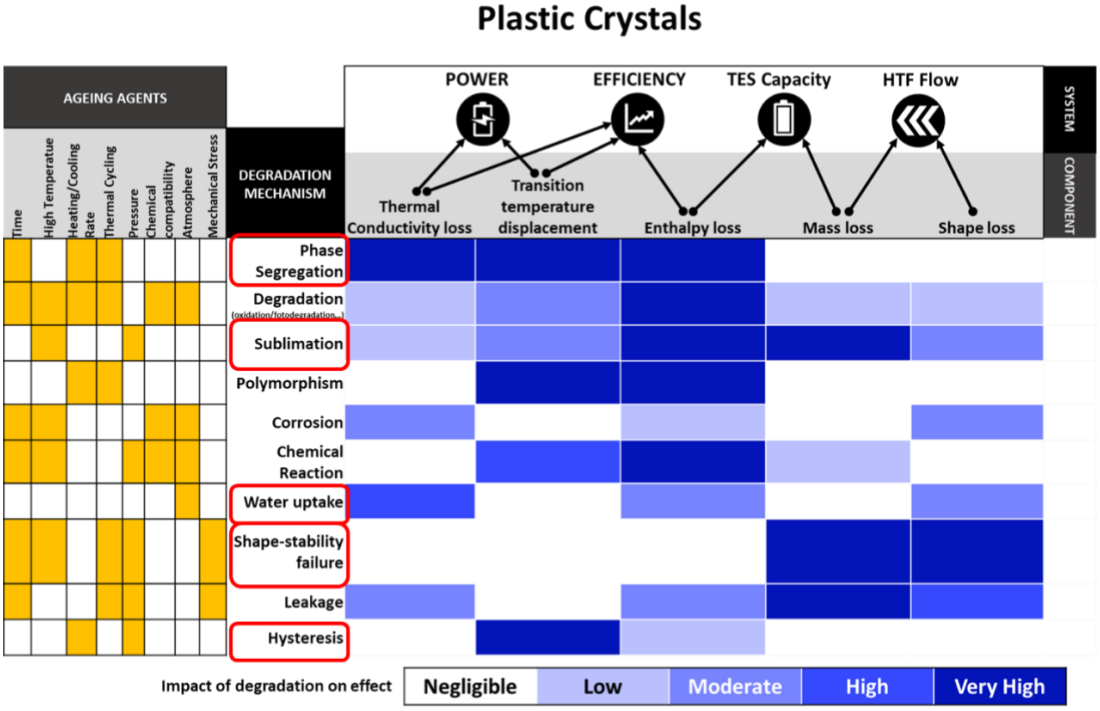

Figure 3: First presentation type to map CTES material stability, with salt ammoniates/zeolite X13 as an example.