

Microencapsulation of Salts for Enhanced Thermochemical Storage Materials

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ABSTRACT SUMMARY

Thermochemical storage is a new and emerging long-term thermal storage for residential use (cooling, heating & domestic hot water generation), offering high thermal storage density without the need for thermal insulation during storage (Fig. 1). However, existing materials for thermochemical storage either suffer from practical issues like limited physical and mechanical stability and severe corrosivity (salt hydrates), or thermal storage capacities that are too low to substantially cover seasonal storage adequately (zeolites and silicagel).

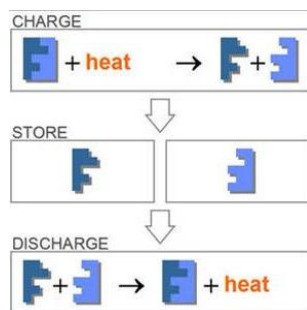


Figure 1. Thermochemical storage principle

To overcome the corrosion and stability problems with salt hydrate thermochemical materials and to make them more suitable for use in thermochemical reactor systems, microencapsulation is proposed. A suitable encapsulation material was assessed, having an open structure for good vapor transport, being capable of high loading fraction and therefore still a high storage density, and being flexible, stable and cheap. Initial experiments yield promising results on this material exhibiting high storage capacity, good reversibility and ease of use. Surprisingly, lower dehydration temperatures as compared to the non-encapsulated material were found, enabling the use of other salt hydrates with higher dehydration temperatures.

INTRODUCTION

As Europe moves more and more towards low and zero-carbon buildings, challenges arise in the management of building integrated renewable energy technologies. Electricity generating renewable energy sources (like windmills or PV) have the benefit of electrical connection and financial mechanisms allowing feed-in to the network. Thermal technologies (like solar collectors in combination with solar boilers or phase change materials) do not have long-term storage capability. This approach provides little benefit in winter, e.g. for space heating purposes. Wouldn't it be nice to be able to store the summer heat in a loss-free fashion for use in winter time in some sort of "thermal battery"? A material for such a thermal battery is being developed in our laboratories.

EXPERIMENTAL METHODS

Design and development are basically an iterative approach to ensure the transition from an innovative thermal energy storage idea into an effective and marketable technology.

As mentioned, our seasonal thermal storage working principle is based on thermochemical reactions. Therefore, investigations are done in the fields of corrosion, physical stability of the active composite materials, thermal and mass-transport properties, all at different temperatures and pressure levels. Used materials are CaCl_2 ^{1,2} and encapsulated CaCl_2 . Encapsulation was achieved by using a Büchi Spray Dryer and different salt to polymeric material ratios. Material properties are investigated using Differential Scanning Calorimetry (DSC) as well as with Thermo-Gravimetric Analyses (TGA). Prior to TGA measurements, samples are equilibrated at constant humidity and temperature to ensure hydration to the

$\text{CaCl}_2 \cdot 6\text{H}_2\text{O}$ form. Bulk-properties like heat- and mass-transport in a fixed reactor bed, as well as corrosivity and mechanical stability are investigated in dedicated reactor set-ups.

RESULTS AND DISCUSSION

In Fig. 2, TGA results for encapsulated and non-encapsulated CaCl_2 are given. The data shows that the encapsulated CaCl_2 is fully dehydrated at much lower temperatures than non-encapsulated CaCl_2 , approx. 125°C vs 210°C . The higher residual weight of the encapsulated CaCl_2 is caused by the polymeric encapsulation material.

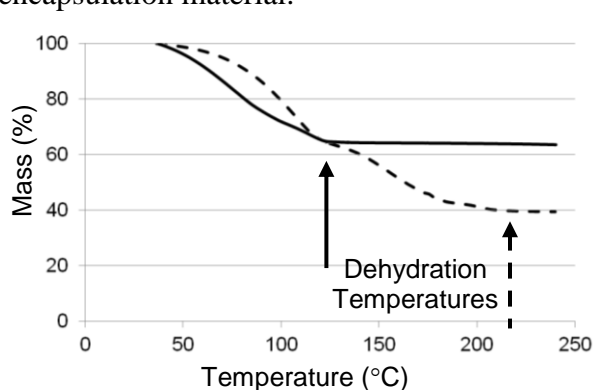


Figure 2. TGA of encapsulated CaCl_2 (continuous line) and CaCl_2 (dashed line), showing reduction of dehydration temperature for the encapsulated CaCl_2 .

In Fig. 3, the mass (%) is plotted against the temperature for different heating cycles of a single sample of encapsulated material. It shows that maximum water content in the enhanced material is approx.. 40% w/w, and also that the hydration/dehydration reactions are reversible and occur with almost no hysteresis.

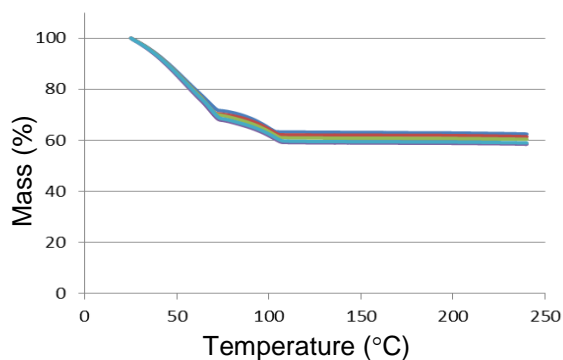


Figure 3. TGA of 5 subsequent cycles of dehydration of encapsulated CaCl_2 , showing less than 5% variation.

In addition, no deterioration of the enhanced material could be found, even upon multiple loading and unloading cycles. The material stays present as a solid throughout the measurements, even at elevated temperatures.

It can be seen from DSC measurements (not depicted) that although the energy contents is somewhat lower than that of CaCl_2 (~50% due to the presence of composite material), a large thermal response is obtained on dehydration upon temperature increase. This shows that the thermal storage capacity of the obtained composite is still intact.

CONCLUSION

Experiments on novel encapsulated active materials for thermochemical storage are promising; a new material has been assessed, showing good thermal behavior and reliable cycling properties while maintaining its physical shape during operation. In addition, temperature ranges for the new material are more suitable for use in a thermal storage system in combination with solar collectors due to lower dehydration temperatures, enabling its introduction in the built environment.

REFERENCES

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