$MgCl_2·6H_2O$-vermiculite composites for low and medium temperature thermochemical energy storage

ACTIVE BUILDING CENTRE RESEARCH PROGRAMME

Introduction

- Thermochemical energy storage surpasses sensible energy storage and latent energy storage due to large energy storage density, theoretically no heat loss, and small footprint.
- This work synthesized a novel composite $MgCl_2·6H_2O$-vermiculite (MC-VM) for low and medium heat storage for the first time.
- The energy storage density and mass change of MC-VM, as well as the morphology, were studied.

Methods

- Structural characterization: SEM, EDX
- Crystal form detection: XRD
- Dehydration/hydration enthalpy and mass change measurement: DSC, STA

Results and discussions

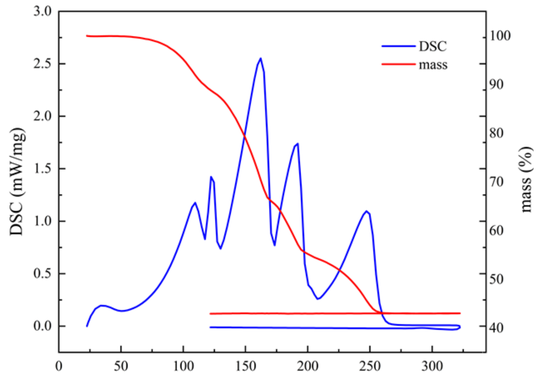

Fig. 1. The dehydration process of $MgCl_2·6H_2O$ measured by STA

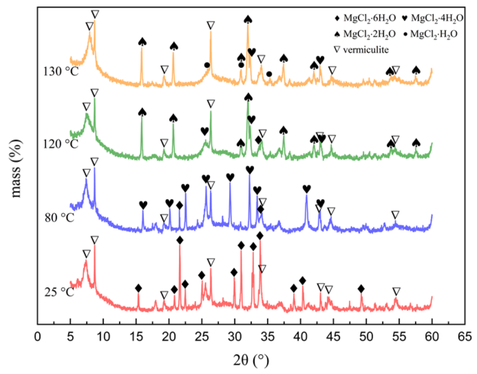

Fig. 2. Crystal form change of $MgCl_2·6H_2O$ during the dehydration process

- The first dehydration stage that $MgCl_2·6H_2O$ transferred to $MgCl_2·4H_2O$: at 71–120 °C;
- Most salt hydrates transferred to $MgCl_2·2H_2O$: at over 120 °C;
- Insufficient dehydration reaction caused by the agglomeration of $MgCl_2·6H_2O$.

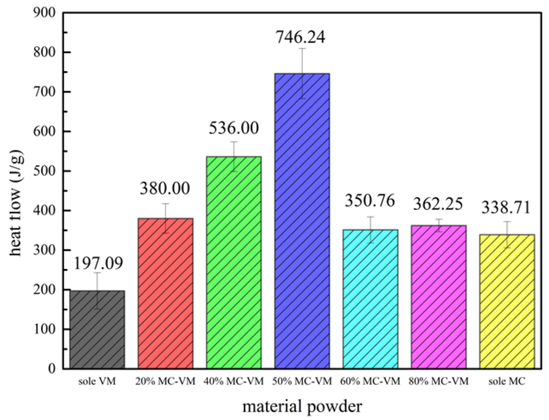

Fig. 3. Comparison of dehydration enthalpy values of sole VM, sole MC and 20%-80% MC-VM composite powders

- A series of composite $MgCl_2·6H_2O$-vermiculite (MC-VM) with different mass ratios were tested by DSC;
- The largest value of enthalpy of 50% MC-VM: 746.24 J/g;
- The matrix vermiculite helped increase mass transfer and promote $MgCl_2·6H_2O$ dehydrate more completely.

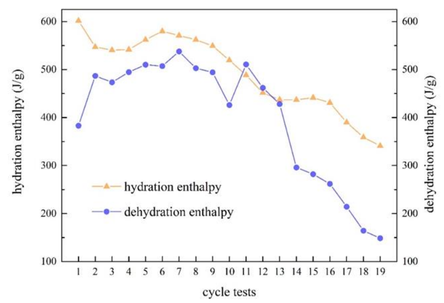

Fig. 4. Enthalpy change of 50% MC-VM during dehydration-hydration cycle tests measured by STA

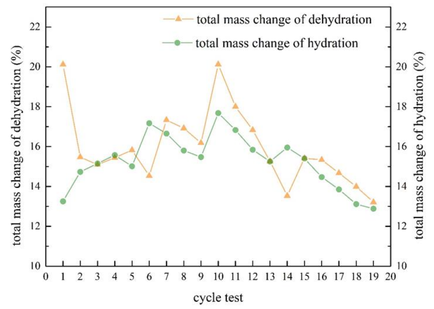

Fig. 5 Total mass change of 50% MC-VM during dehydration-hydration cycle tests measured by STA

- The largest hydration enthalpy in the first cycle value: 601.60 J/g;
- The hydration enthalpy decreased to 340.92 J/g after 19 cycle tests;
- The reason for enthalpy reduction: the agglomeration of $MgCl_2·6H_2O$ in the composite;
- The total mass change showed a downward trend: less and less water absorbed.

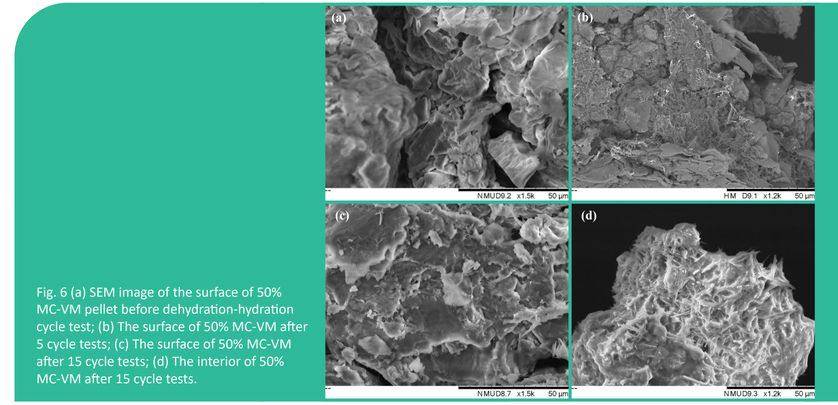

Fig. 6 (a) SEM image of the surface of 50% MC-VM pellet before dehydration-hydration cycle test; (b) The surface of 50% MC-VM after 5 cycle tests; (c) The surface of 50% MC-VM after 15 cycle tests; (d) The interior of 50% MC-VM after 15 cycle tests.

- The obvious layer structure of vermiculite in SEM images;
- Tiny $MgCl_2·6H_2O$ grains in the surface of the composite owing to the fully mixing with the abundant vermiculite particles;
- The fibre-like structure occurred after 5 cycle tests;
- The surface and interior of 50% MC-VM showed more fibres after 15 cycle tests.

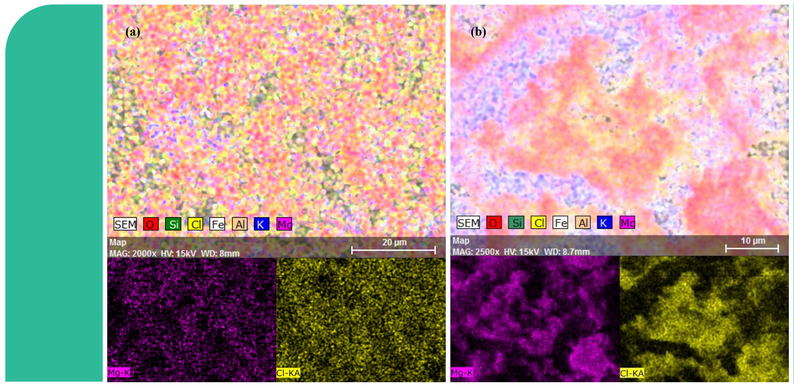

Fig. 7. (a) EDX images of the 50% MC-VM pellet before dehydration-hydration cycle test; (b) The 50% MC-VM after 15 dehydration-hydration cycle tests.

- Cl and Mg of the composite clustered together after 15 dehydration-hydration cycle tests, which might result from the easy-agglomeration characteristic of $MgCl_2·6H_2O$.

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