Porous media for thermochemical energy storage: experimental investigation on structural changes of reactive materials

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The use of gas-solid reactions for thermochemical energy storage has been widely discussed in literature. Still, the question of handling a reacting solid on a technically relevant scale is not solved yet: structural changes within the porous solid media need to be considered when designing high-power storage reactors for commercial applications.

In an experimental study, we have successfully demonstrated the applicability of strontium bromide and water vapor as a reacting couple:

\[ \text{SrBr}_2\cdot\text{H}_2\text{O} (s) + \Delta\text{H} \rightleftharpoons \text{SrBr}_2 (s) + \text{H}_2\text{O} (g) \]

A sample mass of around 100 g of hydrated salt was investigated with regard to its use as thermochemical energy storage material in the temperature range of 200 ℃ to 250 ℃. In our experimental work, we found that the macroscopic and the microscopic properties of the solid bulk material change considerably during the first reaction cycles: the primary particles agglomerated, and the overall volume of the porous bulk significantly increased within 27 dehydration/re-hydration cycles. Structural changes in the porous media influence the progression of the gas-solid reaction: A change in bulk material permeability directly affects the vapor mass transfer. Furthermore, the observed structural changes can lead to a reduced bulk thermal conductivity and thus have a negative effect on the thermal performance of a storage reactor.

The aim of our work is to enhance the understanding of the decisive factors for the thermal power of a thermochemical reactor and to quantify their impact in wide pressure and temperature ranges (1 kPa – 0.6 MPa, 100 – 320 ℃). Our main objective is the consideration of aging effects of the reactive bulk material when deriving layout rules for the design of high-performance reactors.

References

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