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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:
$SrBr_2 \cdot H_2O$ (s) + $\Delta H \rightleftharpoons SrBr_2$ (s) + H_2O (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 °C to 250 °C. 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 °C). 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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