Kinetic and Thermodynamic Characterization of $CaCl_2/H_2O$ as Thermochemical Reaction System

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In thermochemical systems, reversible gas-solid reactions can be applied for the storage of thermal energy. Easily separable products and high reaction enthalpies are the key advantages of such reaction systems, leading to loss-free storage and high energy storage densities. Due to the dependence of the reaction temperature on the reaction gas pressure, heat transformation can be realized as well. Therefore, the thermal storage and upgrade of process waste heat is an interesting application of this technology.

In the relevant temperature range of 80°C to 200°C the reaction

$$CaCl_2 \cdot 2\ H_2O_{(s)} \rightleftharpoons CaCl_{2\,(s)} + 2\ H_2O_{(g)}$$

is reversible and stable over more than 20 cycles. This reaction system has been analyzed in detail by thermogravimetric experiments at different H_2O partial pressures in the relevant temperature range. The dependency of the vapor pressure on the reaction temperature was determined for the educt, intermediate and final products. The rate of reaction was modeled considering the multi-step reaction, showing reasonable kinetics in the relevant temperature range. Additionally, thermophysical properties such as density, permeability and thermal conductivity of the reaction bed as well as BET surface area and particle size distribution of the storage material were determined.

The presentation will outline the thermodynamic and kinetic characterization of the reaction system and evaluates their impact on the development of a storage reactor. Special attention will be paid to the change of thermophysical properties after de- and rehydration cycles.