Investigations on a two step thermochemical water splitting cycle using mixed iron oxides for solar hydrogen production

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A thermochemical cycle converts water into hydrogen and oxygen in typically 2-4 consecutive chemical reactions. The advantages in comparison to direct thermolysis of water are that thermochemical cycles operate at more moderate temperatures and avoid the need of high temperature separation of hydrogen and oxygen.
Investigations in the EU project Hydrosol focus on a two step thermochemical cycle using mixed iron oxides as a metal oxide redox system. A reactor concept has been developed in which the metal oxide is fixed on multi-channeled honeycomb ceramic supports capable of adsorbing solar irradiation. In the solar furnace of DLR coated honeycomb structures are tested in a solar reactor with respect to their water splitting capability and their long term stability. A recent test campaign focused on the hydrogen production capability of different coating materials and on the influence of operational parameters like water splitting temperature and oxygen content in the regenerating gas.
At the same time thermodynamic investigations on Ni-Fe-O_2 and Zn-Fe-O_2 systems have been performed with commercial software. The influence of oxidation and reduction temperature, partial pressure of oxygen during the reduction step and the composition of the metal oxide on the thermodynamic equilibrium composition has been investigated. The results found in the experimental campaign in the solar furnace and the results from the thermodynamic calculations have been compared.
The thermodynamic calculations predict a decrease in hydrogen production with an increase in oxidation temperature from 800 to 1200 °C. The experimental results found in the solar furnace show a converse behavior. This leads to the conclusion, that the reaction monitored in the solar furnace is not controlled by the thermodynamic equilibrium but more likely by the kinetics. To examine the kinetics of the oxidation and the reduction step a test rig has been built up on a laboratory scale. In this test rig coated honeycombs and metal oxide powders can be tested under constant conditions. Parameters like temperature and water concentration can be varied and their influence on the kinetics can be investigated.