INDO SWISS JOINT RESEARCH PROGRAMME (ISJRP)

JOINT RESEARCH PROJECT

ABSTRACT

Grant No.: 138852

DEVELOPMENT OF NOVEL, CATALYTICALLY ACTIVE, DOPED CERIA, OPTIMIZED FOR SOLAR THERMOCHEMICAL CYCLES THAT CONVERT WATER AND CARBON DIOXIDE DIRECTLY INTO SYNGAS, HYDROCARBONS, METHANOL OR OTHER OXYGENATED LIQUID FUELS BY CONCENTRATED SOLAR RADIATION

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PROJECT ABSTRACT

Thermochemical cycles are means to convert concentrated solar radiation into storable and transportable chemicals, so called "solar fuels". In these cycles, a metal oxide is thermally reduced at ultra high temperatures by exposing it to concentrated solar radiation. During the reduction a low valent oxide (or metal) is formed while oxygen is released. At a lower temperature the initial oxide is reformed in a separate step by (re)oxidation. Oxygen consumed in this latter step is provided by e.g. water or carbon dioxide and hydrogen or carbon monoxide is formed, respectively. If both reactants are present simultaneously, syngas i.e. a mixture of hydrogen and carbon monoxide results. Chemical plants must then be in place that further convert syngas to useful fuels such as methanol or liquid hydrocarbons via a Fischer-Tropsch process.

The goal of this project is to develop novel doped cerium oxides (ceria) as material optimized with a dual purpose for the application in thermochemical cycles. First, doped ceria acts as an intermediate storage of redox equivalents. These are used in the low temperature step to reduce water and / or carbon dioxide to hydrogen and / or carbon monoxide. The dopant should increase the number of redox equivalents that can be stored per amount of ceria to allow a more efficient use of the oxide. Second, the dopant performs as catalyst and is responsible that liquid products are directly formed instead of syngas in the low temperature step. Thus, the catalyst must ensure the preferential formation of e.g. methanol, higher hydrocarbons or other oxygenated liquid fuels and avoid the formation of hydrogen and carbon monoxide (syngas). If the second goal is achieved the additional infrastructure needed to e.g. convert syngas via a Fischer-Tropsch process to liquid hydrocarbons is avoided and the solar process becomes economically more competitive.

In this project the synthesis of doped ceria, initially in the form of powders, at a later stage in the form of larger, porous blocks is developed. Important physico-chemical properties such as the optimum reduction temperature, the number of redox equivalents the samples can store, and the rate constants of the reduction and (re)oxidation reaction are determined in order to optimize the material for our purposes. A theoretical understanding of the role of the dopants will result. The projet will provide us with the basic information needed to initiate the development of specifically designed solar reactors to apply the ceria-based thermochemical cycle on a larger scale to harvest solar energy.