Sustainable High-Purity Nitrogen Production Using Perovskites

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Sustainable ammonia production is a key component in the transformation from fossil fuels towards renewable energy resources, as it does not only serve as a fertilizer, but also as a fuel. The required feedstocks, such as high purity nitrogen can be produced through solar-driven thermochemical air separation. Hence, it supports such transformation processes.

The applicability of these thermochemical cycles is governed by the properties of the required redox materials. A suitable material class is perovskites. To improve the efficiency of the process, it is crucial to investigate their structural stability, thermodynamics and kinetics and to understand the impact of structural changes on their thermodynamic and kinetic properties.

We present the impact of Sr-content in $Ca_{1-x}Sr_xMnO_{3-\delta}$ on these properties. We investigate the change in lattice parameters, bond angles and bond length by XRD. By means of in-situ high temperature XRD, DSC and dilatometry with varying oxygen concentration in the atmosphere, it is shown that increasing Sr-content strongly impacts changes of the crystal structure in dependence of temperature and surrounding atmosphere. The thermodynamic properties are analyzed by TGA in a temperature range of 873 - 1473K with oxygen partial pressures of 10^{-4} bar to 0.8 bar. An increasing Sr-content leads to faster oxidation kinetics, which is shown by TGA with varying oxidation temperatures. Moreover, we discuss that the structural changes of the material influence the reduction enthalpy and oxidation activation energy. This not only leads to a tunability of material properties, but can also be used to predict changes of these properties when only the structural changes are known. Finally, we demonstrate the successful production of high-purity nitrogen and present the reactor design. Figure 1 highlights the concept of the demonstration plant. The air is pre-purified by pressure swing adsorption. The thermochemical cycle is used to achieve very low oxygen concentrations of less than 10 ppm.

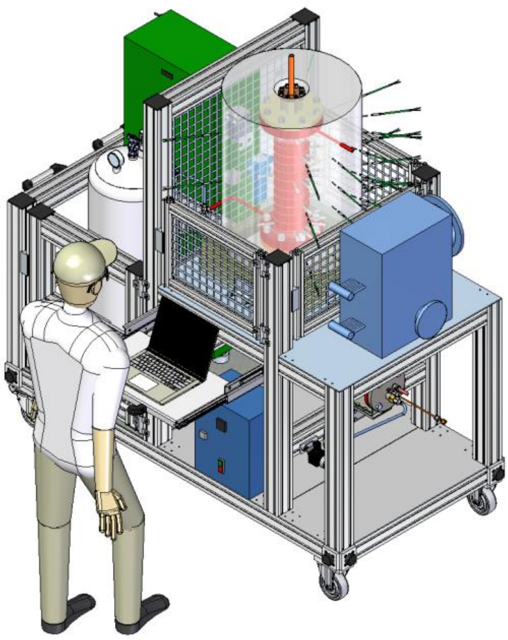

Figure 1: Demonstration plant for the production of high purity nitrogen using a pressure swing absorption and thermochemical cycle.

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