Development of porous structures and dense membranes based on perovskite materials for thermochemical production of solar fuels

Solar-driven thermochemical splitting of CO$_2$ and H$_2$O by exploiting the redox properties of ceramic oxides is an enticing route for the massive production of synthetic fuels without emission of greenhouse gases and with a complete recycling of chemical intermediates. The implementation of a relevant thermochemical cycling gives access to the separate production of CO (and/or H$_2$) and O$_2$ with redox materials exhibiting fast redox kinetics and good cycling stability at high temperature. Concentrated solar energy is used as a renewable and pollution-free heat source to reach the required temperatures during redox reactions (1000 to 1400 °C). The development of active redox catalysts is thus a real challenge for the implementation of this attractive technology in the field of energy production. Perovskite oxides (ABO$_{3-\delta}$) appear as relevant materials for this application [1], thanks to their attractive redox properties, durability and reliability. In addition to the optimization of their formulation, structure and microstructure, the design and shaping of the catalysts are also key challenges for their efficient integration in thermochemical splitting solar reactors.

In this work, we are focusing on the fabrication (powder synthesis and sintering), characterization (crystalline structure, ion conductivity, oxygen transport kinetics, stability upon cycling at high temperature, etc.) and optimization of both porous reactive structures and dense membranes based on these materials. A detailed study of the materials physicochemical properties is carried out with a special attention devoted to dilatometric studies in an environmental chamber simulating the operating process conditions. The optimized samples are integrated in dedicated solar reactor prototypes at the PROMES lab (PROcéédés, Matériaux et Energie Solaire - Odeillo) where their thermochemical performance during CO$_2$ splitting are tested.


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