Ceramic Hollow Fibers for Oxygen Separation in a CO_2 Plasma

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Chemical transformations of carbon dioxide (CO_2) into value-added chemicals like carbon monoxide (CO) and synthetic fuels have been regarded as an attractive approach to enable energy storage and reduce the greenhouse effect. In the last decade, microwave plasma torches have attracted great interest in the field of gas conversion and can be used successfully to dissociate CO_2 into CO and oxygen radicals.

However, the O_2, produced by recombination of oxygen radicals, must be removed from the gas mixture. The current work shows that ceramic hollow fibers prepared from the oxygen conducting materials can ensure an effective separation process. Moreover, in the case of oxygen separation, the thermodynamically forced recombination back to CO_2 can be prevented, leading to further improved CO_2 conversion.

In preliminary tests, single hollow fibers with different chemical compositions were investigated. First, they were tested for their permeability and thermal stability in the plasma atmosphere, including on-off plasma cycles to subject the fibers to high-temperature loads.

One promising candidate is the oxygen conducting material $La_{0.6}Ca_{0.4}Co_{0.8}Fe_{0.2}O_{3-\delta}$. In a successive step, several fibers were arranged in arrays to increase both the active membrane surface and the amount of the separated oxygen. Next, a clamping system for a multi-fiber array was created and placed in the plasma flame. A temperature profile of the fibers was determined via a thermal camera. Finally, the oxygen permeation in the hollow fiber arrays was measured independently to investigate the effects of the plasma parameters and the positioning of the fibers on the overall permeation process.