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KINETICS STUDY ON MIXED IONIC-ELECTRONIC CONDUCTING MEMBRANES FOR CO_2 THERMOCHEMICAL REDUCTION

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ABSTRACT

Mixed ionic-electronic conducting (MIEC) membranes are dense ceramic membranes that allow oxygen permeation with high selectivity at elevated temperatures of 500 – 1000ºC. They can be utilized to separate oxygen from air or reaction products (e.g., water splitting products) and to provide oxygen feedstock for applications such as oxy-fuel combustion and biomass gasification. Various membrane materials with high oxygen permeability and good stability have been studied in the literature, such as $Ba_{0.5}Sr_{0.5}Co_{0.8}Fe_{0.2}O_{3-\delta}$ perovskite membranes. In this talk, a kinetics model will be presented to examine the rate-limiting steps in the MIEC membrane-supported CO_2 reduction process. In this process, pure CO_2 undergoes thermochemical reduction to produce CO on the feed side of the membrane (i.e., high oxygen partial pressure side), while the oxygen incorporates into the membrane surface as lattice oxygen [1]. The lattice oxygen diffuses across the membrane in the form of oxygen ions, driven by the chemical potential gradient. Once the lattice oxygen reaches the sweep side (i.e., low oxygen partial pressure side), it can be utilized to reform methane to produce syngas.

A resistance-network model is constructed, considering the mass diffusion, surface reactions and charged species diffusion, based on the experimental data on $La_{0.9}Ca_{0.1}FeO_{3-\delta}$ membranes with various configurations and catalysts. Results show that the surface reactions are the rate-limiting steps under the operating conditions tested; a transition of the rate-limiting steps was observed from the surface reaction on the feed side to that on the sweep sides when temperature rises [2]. The Thiele Modulus of the porous catalytic layers on both sides of the membranes are in the orders of magnitude of 0.1-1 [3]. Hence, the mass diffusion in the porous layers is also an important step to be enhanced for high CO_2 reduction rates.

Reference:

[1] Wu, X.Y. et al., 2019, *Prog. Energy Combust. Sci.*, **74**, 1–30.

[2] Wu, X.Y. et al., 2018, *ChemSusChem*, **11**(2), 483–493.

[3] Wu, X.Y. et al., 2019, *Proc. Combust. Inst.*, **37**(4), 5517–5524.

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