Catalytic conversion of hydrocarbons using oxygen-selective microtubular membranes for hydrogen production

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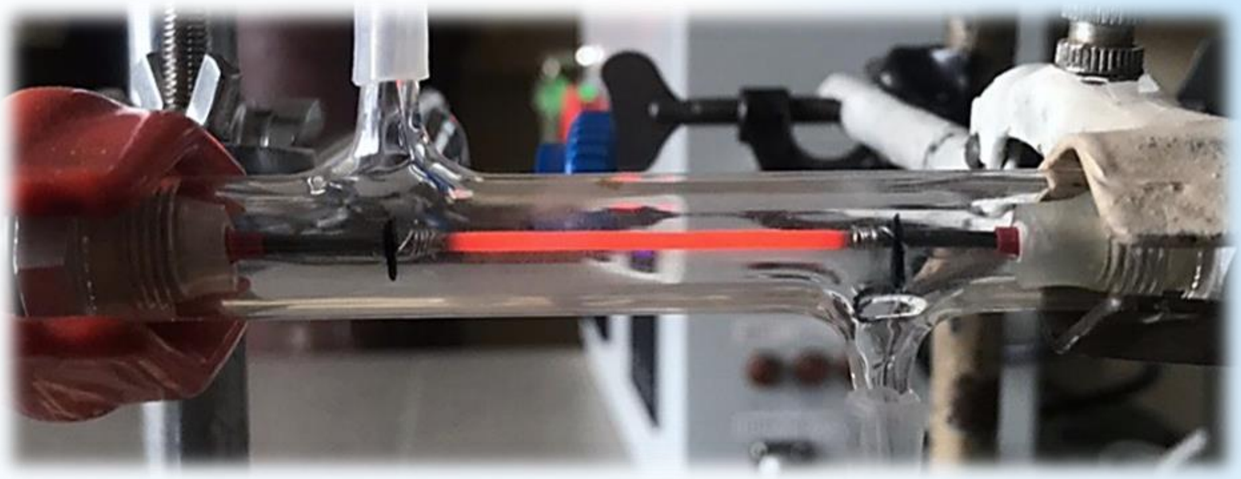
Introduction

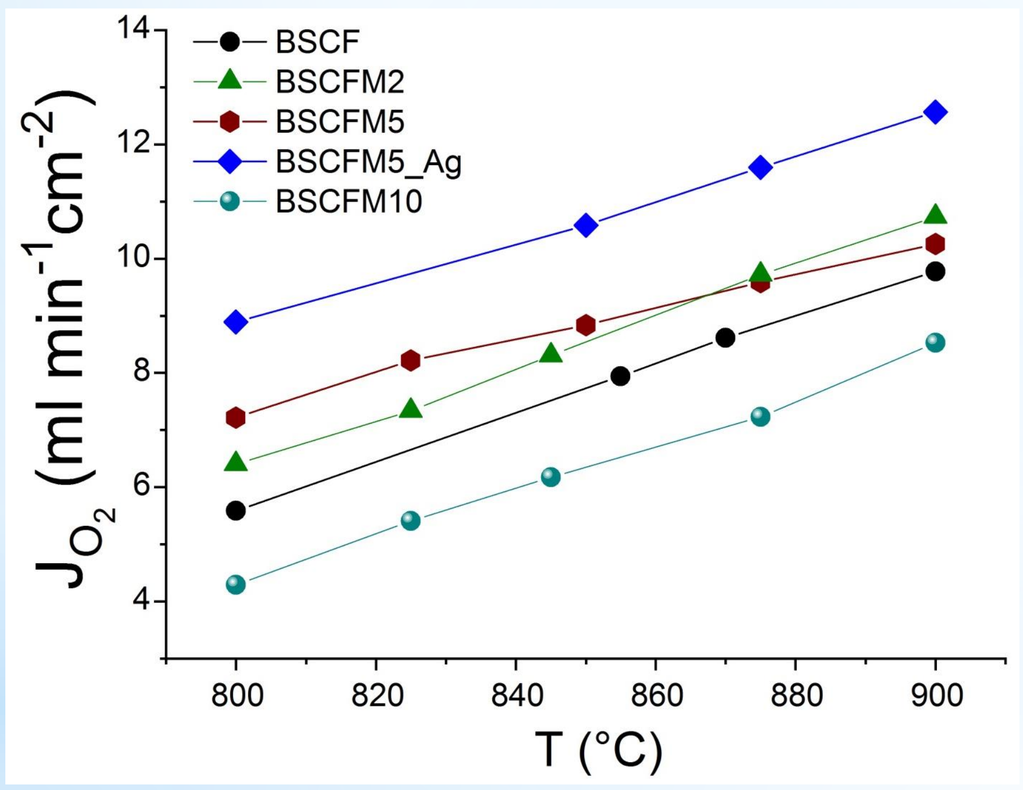
One of the important things in modern hydrogen energetics is studying the ceramic perovskite-type membranes with mixed ion-electronic conductivity. They have 100% oxygen selectivity and are easily integrated into high-temperature processes, that allows using them in the membrane catalytic oxidation reactors [1].

The study is devoted to the research of catalytic conversion processes on microtubular oxygen-permeable $Ba_{0.5}Sr_{0.5}Co_{0.8-x}Fe_{0.2}Mo_xO_{3-z}$ (BSCFMx) membranes using direct AC heating technique.



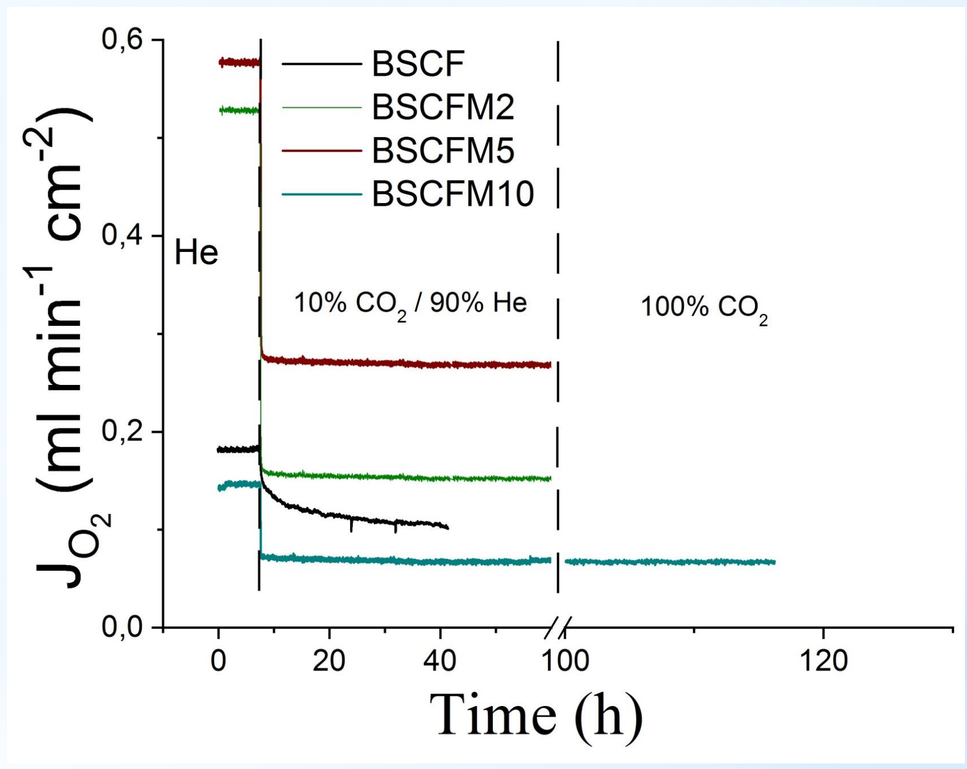
Microtubular membrane reactor for hydrocarbons conversion

Permeability tests

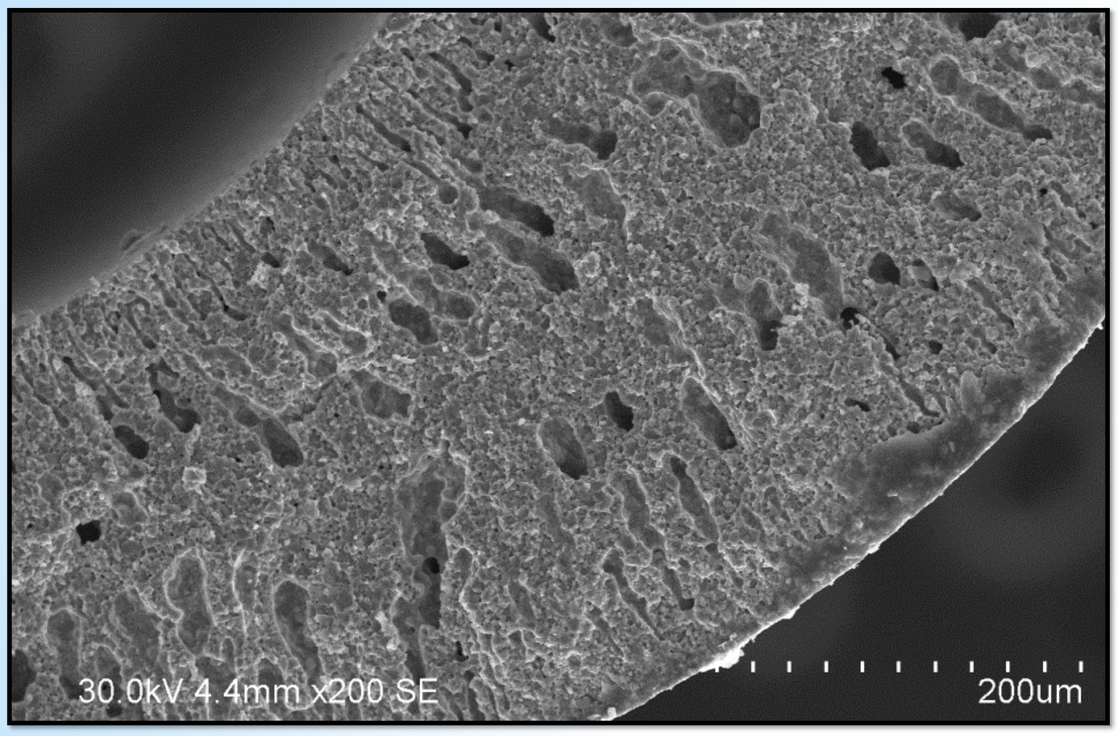


Oxygen fluxes across BSCFMx (x=0; 2; 5; 10 at%) and BSCFM5_Ag (Ag-coating) membranes as a function of temperature. Conditions: sweep flow rate: 90 ml min^{-1}; feed flow rate: 150 ml min^{-1}; $pO_{2.1}$=0.2 atm

CO_2 stability

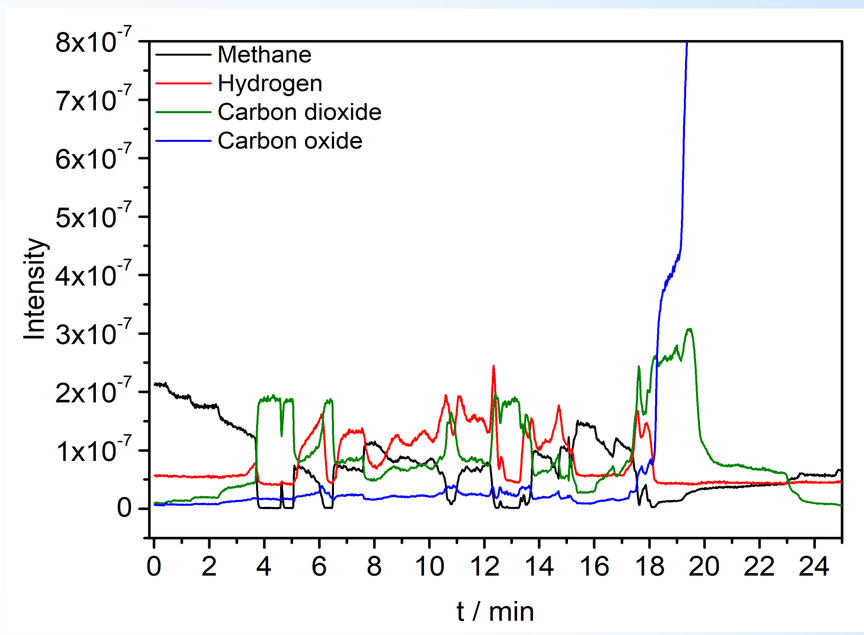


Time dependence of oxygen fluxes across BSCFMx (x=0; 2; 5; 10 at%) membranes in the presence of CO_2 at 650°C. Conditions: sweep flow rate: 90 ml min^{-1}; feed flow rate: 150 ml min^{-1}; $pO_{2.1}$=0.21 atm



SEM image of the membrane's cross-sections fabricated by phase inversion technique

Catalytic conversion



Mass-spectrometry of conversion products across BSCFM10 with Ni catalyst. Conditions: T = 750°C, sweep flow rate: 90 ml min^{-1}; feed flow rate: 150 ml min^{-1}; $pO_{2.1}$=0.21 atm

Results and discussion

In the work, [2] new possibilities were studied that open up to study the mechanism of oxygen permeability and [3] the features of practically important processes that occur when using direct heating of membranes with electric current.

Permeability tests with different sweep gases (He, CO_2) have shown that BSCFM10 membranes can be used for POM reactor. Initial results were achieved for methane catalytic conversion for BSCFM10 membranes with Ni catalyst (1% H_2).

References

1. Buwmeester H.J.M., Burggraf A.J. // In: Gellings P.J., Bouwmeester H.J.M. (Eds.), The CRC Handbook of Solid State Electrochem. CRC Press. – 1997. – P. 481-482.
2. Popov M. et. al. // Catalysis Today – 2019. – V. 323. – P. 167-170.
3. Popov M. et. al. // Materials Today: Proceedings – 2017. – V. 4. – P. 11381-11384.