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Mesoporous CeO_2-ZrO_2-γ-Al_2O_3 nanocomposite membranes exhibiting remarkable hydrothermal stability

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ABSTRACT

The CeO_2-ZrO_2-γ-Al_2O_3 nanocomposite was synthesized through the sol-gel route by mixing a boehmite sol (AlOOH) with an appropriate amount of metal nitrates. By using this multicomponent sol, crack and pinhole free mesoporous membranes were successfully fabricated on an asymmetric porous α-Al_2O_3 support through dip coating process. The hydrothermal (up to 75% steam) stability of the mesoporous membranes was studied in terms of hydrogen gas permeance at 500°C, phase structure, surface microstructure and pore size distribution. The pore size distribution measurements were conducted directly on the membranes by a nano-permporometer. Among the tested samples with different molar compositions of CeO_2-ZrO_2-γ-Al_2O_3, only the mesoporous CeO_2-ZrO_2-γ-Al_2O_3 membrane with a molar ratio of 10:10:80 mol% was found to be the most effective membrane under the hydrothermal condition at 500°C. The ternary CeO_2-ZrO_2-γ-Al_2O_3 system retained its structure (order and porosity) after crystallization on an α-Al_2O_3 porous support and subsequent hydrothermal treatment for over 50 h. The hydrothermal test indicates that the mesoporous membrane developed in this study is viable to be used as an intermediate layer for fabricating a multilayer hydrogen separation membrane reactor for the methane steam reforming reaction.

Keywords: Mesoporous membrane; Ce-Zr solid solution; γ-Al_2O_3; Gas permeance; Hydrothermal stability

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