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MIXED IONIC ELECTRONIC CONDUCTING PEROVSKITES OXYGEN TRANSPORT MEMBRANE ON ALUMINA HOLLOW FIBRE SUBSTRATES FOR OXYGEN ENRICHMENT

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ABSTRACT

Currently, large scale of oxygen production for air separation unit (ASU) in carbon capture storage (CCS) is carried out using cryogenic distillation. It is a mature technology but has several drawbacks such as energy extensive and high operational cost due to very low temperature and high pressure operating conditions. Therefore, this thesis focuses on the fabrication of mixed ionic electronic conducting (MIEC) perovskite oxygen transport membrane (OTM) on alumina hollow fibre substrate for production of oxygen from air. One of the main advantages of using perovskite-based membrane is their unique characteristic that only allows oxygen to pass through at temperature higher than 600 °C, leading to an infinite selectivity of oxygen to other gas species. A series of MIEC perovskites; $SrCo_{0.8}Fe_{0.2}O_{3-\delta}$ (SCF), $La_{0.6}Sr_{0.4}Co_{0.8}Fe_{0.2}O_{3-\delta}$ (LSCF) and $La_{0.6}Sr_{0.4}Co_{0.2}Ni_{0.8}O_{3-\delta}$ (LSCNi) were prepared using Pechini sol-gel method and characterized using thermogravimetric analyzer (TGA), X-ray diffractometer (XRD) and Brunauer-Emmett-Teller (B.E.T.) surface area analyzer. Their oxygen adsorption/desorption properties were then investigated as a function of time and temperatures. It was found that the optimum oxygen sorption capacity and the best operating temperature for all MIEC perovskites were between 700 to 800 °C. LSCNi oxide was found able to adsorb the highest amount of oxygen, followed by LSCF and SCF during the oxygen-temperature programmed desorption (O_2-TPD) analysis. Thus, LSCF and LSCNi were selected for the development of MIEC OTM for further O_2 enrichment study. The alumina hollow fibre (AHF) was fabricated using phase-inversion and sintering process to obtain porous substrates. The effect of sintering temperature (1350 °C and 1450 °C) toward the porosity and mechanical strength were then investigated. 1450 AHF which refer to fibre sintered at 1450 °C was found to have better mechanical strength without sacrificing the porosity and thus was used as a substrates for OTM fabrication. The MIEC perovskite sol was deposited onto AHF using vacuum assisted technique and the viscosity of sol was carefully controlled to obtain a homogeneous and very thin coated perovskite. The physical and morphology of the prepared membranes were then characterized by using 3-point bending test, scanning electron microscope (SEM) and energy dispersive X-ray (EDX) prior to O_2 enrichment study. It was found that the oxygen flux increases when higher operating temperature and sweep gas flowrate were tested. LSCNi-AHF exhibits a maximum oxygen flux of 4.47 mL/cm^2.min at 950 °C; 150 mL/min as compared to LSCF-AHF (0.44 mL/cm^2.min). It can be concluded that the fabrication of MIEC perovskites OTM on alumina hollow fibre substrates were successfully prepared in this work. The performance of the OTMs were improved significantly owing to the new MIEC materials (LSCNi oxide) and microporous properties of alumina hollow fibre substrates.

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