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Characterization of High-Durable Ceramic Ion-Exchange Membrane for Microfluidic Molecular Separation Device

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Extended Abstract

Over the past few decades, membrane separation techniques were a most suitable process for selective molecular/ion separation for molecular biology, gas separation, and seawater desalination because of its productivity and ability to industrialization. However, it still has some disadvantages such as low efficiency, high energy consumption, and molecular weight cut-off according to the performance of membranes.[1] Molecular separation techniques based on ion concentration polarization rises novel molecular separation technique which shows high ion/molecular separation performances without regard to molecular weight.[2] Although it shows dramatical ion/molecular separation performances, low mechanical stiffness and durability of polymer ion-exchange membranes have been criticized to construct high-throughput ion/molecular separation system.[3] In this paper, we present fabrication method and performance of high-durable ceramic ion-exchange membrane for high-throughput microfluidic molecular separation device based on ion concentration polarization. The proposed ceramic ion-exchange membrane consists of aluminum oxyhydroxide(AlOOH) for the ion-exchange region and nanoporous alumina for the supporting platform of AlOOH. Ceramic ion-exchange membrane fabricated by an aluminum anodic oxidation process and hydrothermal synthesis of AlOOH from nanoporous alumina. Polished pure aluminum was anodized and boiled in a steam chamber for the synthesis of AlOOH from nanoporous alumina. After the synthesis of AlOOH, remained aluminum and barrier layer of nanoporous alumina were removed by wet etching process. PDMS (polydimethylsiloxane) microfluidic device was fabricated which has two outlet ports of separated molecules containing water and pure water branched from the inlet port of polar molecule aqueous solution. Microfluidic device also has electrolyte chamber to generate ion concentration polarization which separated from mainstream channels by the ceramic ion-exchange membrane. Finally, a ceramic ion-exchange membrane was embedded in the microfluidic device across mainstream channels and electrolyte chamber. Methyl blue of polar molecules separation from methyl blue aqueous solution was carried out for verification. 1 mM of methyl blue aqueous solution was injected to inlet port as 4 μl/min of flow rate under 100 V/cm of the electric field. When the electric field was applied to the system, methyl blue molecules in the injected solution were repelled by electrical repulsive force of ion-depletion zone. And also, methyl blue-enriched solution and methyl blue-eliminated solution were collected from each outlet port. According to experimental results, methyl blue molecules were perfectly separated from methyl blue aqueous solution and molarity of collected pure water was 0 M. We verified the excellent performance of proposed ceramic ion exchange membrane and it would be constructed as stacked microchannel array for the high-throughput system. This work was supported by the Basic Science Research Program through the National Research Foundation of Korea (NRF) funded by the Ministry of Education (2017R1D1A1B03034696) and by the Human Resources Development program (No.20154030200950) of the Korea Institute of Energy Technology Evaluation and Planning (KETEP) grant funded by the Korea government Ministry of Trade, Industry and Energy.

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