Pd-based composite membrane and high pressure membrane module for pre-combustion CCS in IGCC

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The concerns about the increase of greenhouse gases in the atmosphere by use of fossil fuels as a primary energy source have encouraged research into various ways to capture and store CO\(_2\) before its emission. Pre-combustion carbon dioxide capture is developed in two phases: (1) the conversion of the fossil fuel in a mixture of H\(_2\) and CO\(_2\) through gasification or reforming followed by water-gas shift; (2) the separation of CO\(_2\) from the H\(_2\) at very high pressure. It is considered as a clean energy technology and under development in many countries like the USA, Canada, Japan, and Europe. The membranes are seen as an attractive technology for this technology because they can combine efficient production of hydrogen with capture of the remaining CO\(_2\). Storage of CO\(_2\) can be accomplished through compression in the deep ocean or underground. Hydrogen selective membranes allow for the selective permeation of hydrogen to the permeate side, while the high-pressure retentate stream consists primarily of CO\(_2\). Thus, subsequent CO\(_2\) compression for transport and storage requires low energy. Among many kinds of membrane, Pd and its alloy have attracted a great deal of attention due to their high hydrogen permeability and chemical compatibility with hydrocarbon-containing gas streams.

This study investigates configuration of a module for withstanding high pressure and temperature for CO\(_2\) capture from a coal gasifier. In order to increase the durability of the module at high pressure and temperature, a flange-type unit-cell module was installed in a high-pressure chamber. Hydrogen permeation and N\(_2\) leakage tests showed that H\(_2\)/N\(_2\) selectivity remained at ~4000 after ~300 hours at a pressure difference of 2000 kPa (~20 bar) and 673 K. A CO\(_2\) capturing test was carried out at 673 K and a pressure difference of 2000 kPa with a 40%CO\(_2\)+60%H\(_2\) feed gas mixture, which is similar to the composition in a coal gasifier after shift reaction and H\(_2\)O removal. It was shown that CO\(_2\) could be enriched up to 78-95% with a hydrogen recovery ratio of 82-97% when the feed flow rate was 0.05-0.17 Nm\(^3\) h\(^{-1}\) with a membrane surface area of 16. 6 cm\(^2\).

※ 키워드: Hydrogen; Pd Membrane; High-pressure Module; CO\(_2\) capture; Gasification
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