World Academy of Science, Engineering and Technology
International Journal of Chemical and Materials Engineering
Vol:10, No:08, 2016

Experimental Study of Hydrogen and Water Vapor Extraction from Helium with Zeolite Membranes for Tritium Processes

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Abstract : The Tritium Laboratory Karlsruhe (TLK) has identified zeolite membranes as most promising for tritium processes in the future fusion reactors. Tritium diluted in purge gases or gaseous effluents, and present in both molecular and oxidized forms, can be pre-concentrated by a stage of zeolite membranes followed by a main downstream recovery stage (e.g., catalytic membrane reactor). Since 2011 several membrane zeolite samples have been tested to measure the membrane performances in the separation of hydrogen and water vapor from helium streams. These experiments were carried out in the ZIMT (Zeolite Inorganic Membranes for Tritium) facility where mass spectrometry and cold traps were used to measure the membranes' performances. The membranes were tested at temperatures ranging from 25 °C up to 130 °C, at feed pressures between 1 and 3 bar, and typical feed flows of 2 l/min. During this experimental campaign, several zeolite-type membranes were studied: a hollow-fiber MFI nanocomposite membrane purchased from IRCELYON (France), and tubular MFI-ZSM5, NaA and H-SOD membranes purchased from Institute for Ceramic Technologies and Systems (IKTS, Germany). Among these membranes, only the MFI-based showed relevant performances for the H2/He separation, with rather high permeances (~0.5 – 0.7 µmol/sm2Pa for H2 at 25 °C for MFI-ZSM5), however with a limited ideal selectivity of around 2 for H2/He regardless of the feed concentration. Both MFI and NaA showed higher separation performances when water vapor was used instead; for example, at 30 °C, the separation factor for MFI-ZSM5 is approximately 10 and 38 for 0.2% and 10% H2O/He, respectively. The H-SOD evidenced to be considerably defective and therefore not considered for further experiments. In this contribution, a comprehensive analysis of the experimental methods and results obtained for the separation performance of different zeolite membranes during the past four years in inactive environment is given. These results are encouraging for the experimental campaign with molecular and oxidized tritium that will follow in 2017.

Keywords : gas separation, nuclear fusion, tritium processes, zeolite membranes
Conference Title : ICIMA 2016 : International Conference on Inorganic Membranes and Applications
Conference Location : Barcelona, Spain
Conference Dates : August 11-12, 2016