Mild heat treatment of a ceramic supported, ionic liquid membrane, for enhanced SO\textsubscript{2}/CO\textsubscript{2} and CO\textsubscript{2}/N\textsubscript{2} separation performance

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Supported ionic liquid membranes (SILMs) are promising candidates for cost-effective and efficient separation of acidic gases such as CO\textsubscript{2} and SO\textsubscript{2} from flue gas. This work deals with the study of SO\textsubscript{2}/CO\textsubscript{2} and CO\textsubscript{2}/N\textsubscript{2} separation performance of a mildly heat treated (180°C), SILM, developed by vacuum-assisted infiltration of the ionic liquid (IL) 1-methyl-3-octylimidazolium tricyanomethanide ([OMIM][TCM]) into the nanopores (10 nm) of a tubular ceramic composite membrane. The SILM was further subjected to a cyclic heat treatment process. The evolution of the permeation rates of CO\textsubscript{2}, SO\textsubscript{2} and N\textsubscript{2} along with their separation efficiency were investigated with real gas mixtures and interpreted in relation to the thermal stability and chemical structure of the embedded ionic liquid phase. In this context, the effect of temperature, trans-membrane pressure difference and feed composition on the gas permeation properties and CO\textsubscript{2}/N\textsubscript{2}, SO\textsubscript{2}/CO\textsubscript{2} separation performance was studied prior to and after completion of each heating cycle. The applied heat treatment significantly improved CO\textsubscript{2} and SO\textsubscript{2} permeances and especially SO\textsubscript{2}/CO\textsubscript{2} separation efficiency and SO\textsubscript{2} recovery. Indicatively, SO\textsubscript{2} permeance reached to 2.67×10\textsuperscript{-8} mol∙m\textsuperscript{-2}∙s\textsuperscript{-1}∙Pa\textsuperscript{-1} at 25°C, while CO\textsubscript{2}/N\textsubscript{2} and SO\textsubscript{2}/CO\textsubscript{2} selectivities as high as 50.4 and 250, respectively were achieved at ambient temperature. Thermal analysis contributed towards elucidating the physical state and thermal stability of the embedded ionic liquid, thereby assisting to better understand the acquired gas permeation properties. As confirmed by spectroscopic studies, confinement of the ionic liquid into the nanopores of the ceramic substrate substantially affected its thermal behavior and catalyzed thermal transformations to functionalized by-products that nest into the pores of the SILM. These by-products form stable chemical complexes with SO\textsubscript{2} and CO\textsubscript{2} molecules, drastically affecting the gas transport and separation efficiency of the SILM membrane.

Figure 1: Separation of CO\textsubscript{2} and SO\textsubscript{2} gases from dry flue gas by utilizing a ceramic SILM.

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Biography

Anastasios Labropoulos received his Chemistry Diploma from the Department of Chemistry, Aristotle University of Thessaloniki, Greece. He obtained his MSc and PhD Diplomas from the Department of Chemistry, National and Kapodistrian University of Athens (Greece). He joined the MESL Laboratory of the Institute of Nanoscience & Nanotechnology in the National Center for Scientific Research “Demokritos” (Athens, Greece). His overall research activities in MESL Laboratory have been focused on: (i) membrane fabrication and optimization for separation of gas mixtures, (ii) investigation of transport mechanisms of gases and vapors through porous materials, (iii) gas sorption in nanostructured materials and gas storage and (iv) characterization and performance evaluation of a wide range of nanoporous materials which are intended for energy, industrial and environmental applications. During the elaboration of his PhD thesis and as a Research Assistant, he has been involved in several European and national research projects.

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