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Atmospheric-Pressure Plasma-Enhanced Chemical Vapor Deposition of Microporous Silica Membranes  
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Abstract

Microporous silica membranes with high permselectivity are fabricated by atmospheric-pressure plasma-enhanced chemical vapor deposition (AP-PECVD) using hexamethyldisiloxane as the precursor in plasma working gases of pure argon, and mixture of argon with oxygen or nitrogen. A silica membrane grown using plasma composed of a mixture of argon and nitrogen displays highly efficient gas separation, with selectivities for He/N<sub>2</sub> and He/SF<sub>6</sub> of 196 and 820, respectively, and He permeance of  $1.1 \times 10^{-7}$  mol m<sup>-2</sup> s<sup>-1</sup> Pa<sup>-1</sup> at 50 °C. Characterization of the membranes by FTIR and X-ray photoelectron spectroscopies reveals a relatively high concentration of carbon remains in the membrane grown using a mixture of argon and nitrogen. Annealing at elevated temperature after plasma deposition improves the permselectivity of the membranes. After annealing at 300 °C, the permeance of He at 50 °C increased to  $4.0 \times 10^{-7}$  mol m<sup>-2</sup> s<sup>-1</sup> Pa<sup>-1</sup> with no marked decrease of selectivity (He/N<sub>2</sub> = 98, He/SF<sub>6</sub> = 770). The annealed membrane also exhibits remarkable permselectivity for CO<sub>2</sub>, showing selectivities for CO<sub>2</sub>/N<sub>2</sub> and CO<sub>2</sub>/CH<sub>4</sub> of 46 and 166, respectively, with CO<sub>2</sub> permeance of  $1.9 \times 10^{-7}$  mol m<sup>-2</sup> s<sup>-1</sup> Pa<sup>-1</sup> at 50 °C. AP-

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