Study of morphology and gas separation properties of polysulfone/titanium dioxide mixed matrix membranes

ABSTRACT

Polysulfone (PSf)-based mixed matrix membranes (MMMs) with the incorporation of titanium dioxide (TiO$_2$) nanoparticles were prepared. Distribution and agglomeration of TiO$_2$ in polymer matrix and also surface of membranes were observed by scanning electron microscopy, transmission electron microscopy, and energy dispersive X-ray. Variation in surface roughness of MMMs with different TiO$_2$ loadings was analyzed by atomic force microscopy. Physical properties of membranes before and after cross-linking were identified through thermal gravimetric analysis. At low TiO$_2$ loadings (≤3 wt%), both CO$_2$ and CH$_4$ permeabilities decreased and consequently gas selectivity improved and reached to 36.5 at 3 bar pressure. Interestingly, PSf/TiO$_2$ 3 wt% membrane did not allow to CH$_4$ molecules to pass through the membrane and this sample just had CO$_2$ permeability at 1 bar pressure. Gas permeability increased considerably at high filler contents (≥5 wt%) and CO$_2$ permeance reached to 37.7 GPU for PSf/TiO$_2$ 7 wt% at 7 bar pressure. It was detected that, critical nanoparticle aggregation has occurred at higher filler loadings (≥5 wt%), which contributed to formation of macropvoids and defects in MMMs. Accordingly, MMMs with higher gas permeance and lower gas selectivity were prepared in higher TiO$_2$ contents (≥5 wt%).

Keyword: Morphology; Gas separation properties; Polysulfone/titanium dioxide; Mixed matrix membranes (MMMs)