17th International Conference on Inorganic Membranes
New Frontiers for Inorganic Membranes
July 1 - 5, 2024
Oceania Convention Center - Florianópolis - Brasil

Tuning mesoporous ceramic membranes with alkyl-based phosphonic acid molecules for solvent nanofiltration

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Nanofiltration (NF) membranes applied for the recovery of apolar solvents, and/or valuable molecules contained therein, require not only high chemical, thermal, and mechanical stabilities to withstand the operating conditions but also require favourable interactions between solvent, and solute. The desired stability can be achieved by using ceramic NF membranes. However, due to their hydrophilic nature a decrease in apolar solvent flux is observed compared to water flux [1]. To tackle this issue, the surface modification of mesoporous ceramic membrane with alkyl-based phosphonic acid molecules is a promising solution to tune the hydrophilic surface into hydrophobic/oleophilic one. Simultaneously it reduces the pore size of the membrane from the ultrafiltration to the nanofiltration range [1–4].

In this work, the possibility to functionalize mesoporous (pore diameter 5 nm) ceramic membranes with different alkyl-based phosphonic acid molecules will be presented. To tune the pore diameter, the length of the alkyl chain was varied between 12 and 18 carbon atoms. Two grafting methods were used: solution phase and solid-state grafting. Contact angle measurements were carried out as well as a dye retention/adsorption test. The results indicate no change in pore size with varying grafting density resulting from different grafting methods. Furthermore, it was found that the longer chains of 18 carbon atoms hindered other molecules from reaching the membrane surface thereby lowering the grafting density. The effect of the solute/solvent/membrane interaction was investigated by using different functional groups of the grafting agents.

With the large choice in possible grafting agents, this work shows an ideal method to form hydrophobic/oleophilic grafted ceramic membranes with improved performance. This results in membranes with a long lifetime, resistance to harsh conditions and tailor-made performance for a wide range of applications.

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