Closed-Loop Processing of Solvent-resistant Membranes from Commercially Available Polymers

Aristizábal, S.L[a,b], Ramírez-Martínez, M[a,b], Upadhyaya, L[b], Li, X[b], Nunes, S. P[a,b,c]*

[a] Environmental Science and Engineering Program, King Abdullah University of Science and Technology (KAUST), 23955-6900 Thuwal, Saudi Arabia

[b] Advanced Membranes and Porous Materials (AMPM) Center, King Abdullah University of Science and Technology (KAUST), 23955-6900 Thuwal, Saudi Arabia

[c] Chemical Science Program, King Abdullah University of Science and Technology (KAUST), 23955-6900 Thuwal, Saudi Arabia

*Corresponding author: suzana.nunes@kaust.edu.sa, +966544700052

Abstract:

The search for processable and recyclable materials is being promoted by the growing plastic waste generation awareness, stringent environmental legislation, and recognition of the advantage of the circular economy. Membrane-based separation processes have the potential to substitute traditional energy-intensive separation methods with a lower carbon footprint. However, in terms of the membrane materials, the apparently antagonistic requirements of long-term operation under challenging conditions such as exposure to organic solvents or high temperatures but easy solution-processability are hard to fulfil. Most commercial membranes cannot withstand long-term separations under organic solvents due to their poor chemical stability. Examples such as polyimides, polyacrylonitriles, and polybenzimidazoles must be crosslinked to provide them the required stability in such conditions, and those polymers that are solvent-resistant without crosslinking are almost impossible to process into membranes and fibers. While membrane technology contributes to a more environmentally benign separation, further improvement can be done in terms of the end-of-life process of the materials. This work consists of a modification strategy for commercially available polymers that can be modified to enable processability and turned into solvent-resistant membranes. The resulting membranes are stable in NMP, DMF, THF, and DMSO, and are tested in organic solvent nanofiltration. Then, after the membrane performance, the membranes can be regenerated again to the soluble materials for further reprocessing and testing. This approach is applied to commercial polymers under mild conditions without compromising the polymer chemical properties. It takes into account the end-of-life of the material contributing to a more sustainable process.

Keywords: solvent-resistant membrane, organic solvent nanofiltration, chemical modification, sustainability, re-processability.