SusMem

The production of membranes for sustainable and environmentally friendly applications is based on processes that use water-polluting, harmful and carcinogenic chemicals to process membrane materials that are difficult to recycle. In close cooperation with Covestro, the University of Twente and the RWTH Aachen University will evaluate the novel and sustainable thermoplastic high-performance polymer polyoxazolidinone (PRIOLON) as a membrane material. PRIOLON also dissolves in green solvents and can be processed into microporous hollow fiber membranes in the spinning process. In contrast to traditional organic solvents, green solvents are neither hazardous to water, health nor carcinogenic.

THE CONTEXT

One of the common methods for membrane fabrication is the so called non solvent induced phase separation (NIPS). In this process, a polymer (usually polyethersulfone or polyvinylidene fluoride) are dissolved in a suitable organic solvent to form a polymer solution. The polymer solution is immersed immersed in a non-solvent bath, causing the solvent to diffuse out and the non-solvent to diffuse in. This exchange leads to phase separation and solidification of the polymer, forming a membrane with a porous structure.

Due to growing environmental awareness, some of the toxic solvents commonly used for membrane fabrication, such as N-methyl-2-pyrrolidone (NMP) were recently added by the European Union to the list of substances of very high concern and their use is strongly restricted. The development towards green solvents includes, among other things, the substitution of toxic solvents with alternatives that have better EHS properties (environment, health, safety) and the use of "bio" solvents. However, the search for such solvents is complex, as they different types of solvents produce membranes with significantly different properties, even under the same fabrication conditions. The reason for this is the differences in thermodynamic interactions between polymer and solvent, and the differences in kinetics of solvent exchange during phase separation.

In the project SusMem, the University of Twente and the RWTH Aachen university will investigate the potential of the newly developed polymer PRIOLON as membrane material. The focus is to produce hollow fiber membranes from the new polymer and different types of green solvents.

Figure 1 Different processing forms of PRIOLON, from polymer solution to extruded materials.

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THE CHALLENGE

While there is extensive literature on the fabrication of polyethersulfone (PES) and polyvinylidene fluoride from conventional solvents such as NMP, only few publications are available on green solvents as this is only an emerging field. Moreover, no literature is available for PRIOLON as membranes material. It is widely known that solvents behave differently from polymer to polymer. Therefore, no assumptions can be initially made on the suitability of published green solvents on the PRIOLON.

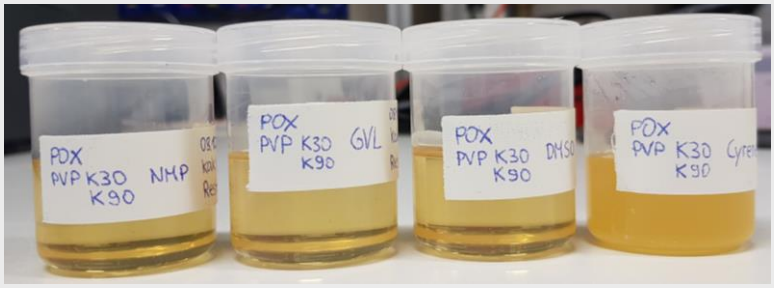

Figure 2 Polymers solutions prepared with different types of solvents (NMP, GVL, DMSO, Cyrene) and PRIOLON. GVL and Cyrene are considered green solvents.

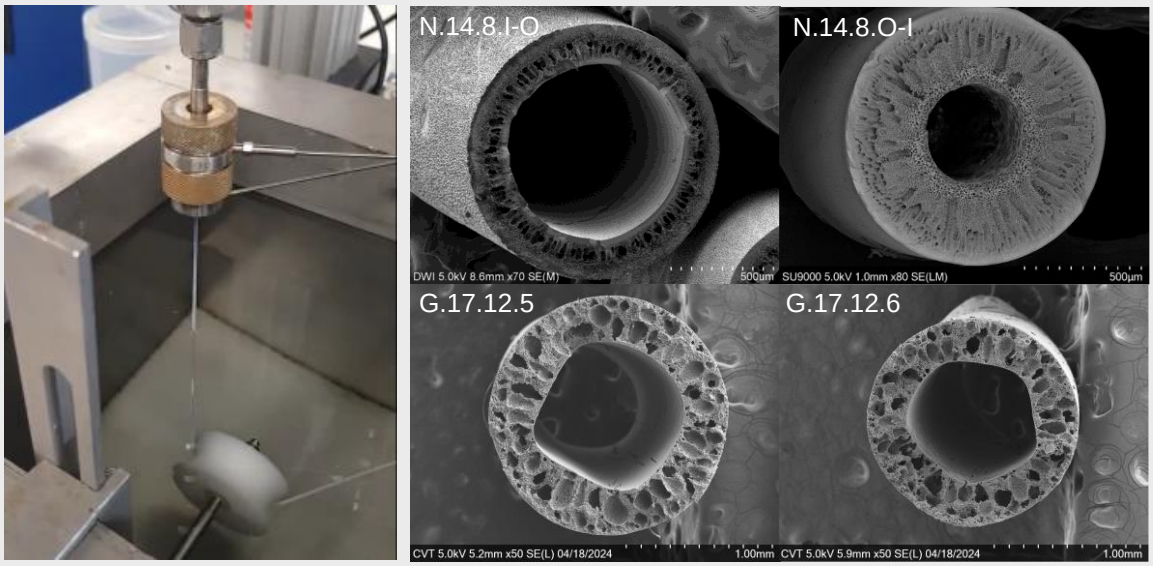

Figure 3 Left: Hollow fiber spinning . Right: Hollow fiber membranes produced with NMP (top) and GVL (bottom).

THE RESULTS

So far, hollow fiber membranes were successfully fabricated using conventional solvents (NMP) and the green solvent γ-Valerolactone (GVL). GVL is a sustainable organic solvent derived from biomass, specifically from the hydrogenation of levulinic acid. Both fibers produced from NPM and GVL demonstrate permeabilities and cut-offs in the ultrafiltration range. In contrast to NPM, the phase inversion of membranes produced with GVL as the solvent occurs more slowly. Even after several minutes, the membranes are not fully coagulated which leads to a difficult handling during spinning. For this reason, other types of solvents are being tested. One possibility is the combination of different types of solvents to overcome the limitations of single solvents. In the current pipeline are Agnique AMD 3L, PolarClean, and Cyrene.

CONCLUSION

PRIOLON Hollow fiber membranes were successfully fabricated with NMP and the green solvent GVL. The results obtained demonstrate the suitability of PRIOLON as membrane material. The combination the sustainable membrane material and a green solvent, opens the door for the production of more environmentally friendly membranes. In the remaining project time, the partners will focus on testing other different types of green solvents and improving spinning conditions.

TECHNIQUES USED

Hollow fiber spinning


Microscopy

Pure water permeability

Molecular weight cut-off


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