Antifouling properties of polymeric membranes

-Correlation between stability and enthalpy of mixing -

RAW MATERIALS

Introduction

Polymeric membranes are thin separating structures widely used in industry for wastewater treatments, CO_2 filtration during combustion processes or even as a battery separator. They can be easily produced at a low energy cost and without any use of solvents. However, the technology suffers from a well-known drawback limiting its industrial expansion: the membrane fouling. During this process, particles are deposited on the membrane surface resulting in a loss of performance. Blending the membrane with polymers is seen as an easy solution to address this issue but it requires high compatibility between the selected polymers. In this study, polymers compatibility for membrane blending can be evaluated by stability measurements using the Turbiscan Stability Index (TSI).

KEY **BENEFITS**

FAST

NO DILUTION

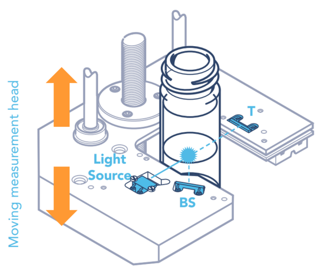
SENSITIVE

Reference

Zhang, J., Wang, Z., Wang, Q., Ma, J., Cao, J., Hu, W., & Wu, Z. (2017). "Relationship between polymers compatibility and casting solution stability in fabricating pvdf/pva membranes". Journal of Membrane Science, 537, 263-271.

Reminder of the technique

Turbiscan® technology provides a non-intrusive optical characterization of a native sample without dilution. The technology, based on Static Multiple Light Scattering (SMLS), consists on sending a light source (880nm) on a sample and acquiring backscattered (BS) and transmitted (T) signal over the whole sample height. By repeating this measurement over time with adapted frequency, the instrument enables to monitor physical stability.
The signal is directly linked to the particle concentration (φ) and size (d) by the Mie theory knowing refractive index of continuous (n_f) and dispersed phase (n_p):



$$BS = f(\varphi, d, n_p, n_f)$$

Materials and method

Polyvinylidene fluoride (PVDF) is used as the polymeric membrane matrix. To enhance the antifouling properties of the produced membrane, Poly(vinyl alcohol) (PVA) is blended at different concentration ratios to the PVDF solution before casting.
Four solutions with different PVDF/PVA concentrations are considered as shown in Table 1.

Polymer	Mass fraction [%]			
	A1	A2	A3	A4
PVDF	100	99.2	97.6	96
PVA	0.0	0.8	2.4	4.0

Table 1: Blending ratios of PVDF and PVA for membrane fabrication

The membranes are fabricated via immersion-precipitation method. During this process, compatibility of polymers can critically affect the properties and efficiency of the resulting membrane.
Indeed, an incompatibility between the polymer and the membrane matrix would result in a strong destabilization and consequently an inhomogeneous casting solution. Hence, it is primordial to control the stability of the casting solution before fabricating the membrane.
Each of the four casting solutions with different blending ratios of PVDF/PVA were analyzed with Turbiscan® technology for 325 minutes.

Results:

Relationship between stability of casting solution and compatibility of polymers

The stability of the four solutions was quantified thanks to the global Turbiscan stability index TSI computed automatically from the Turbiscan® software. This parameter adds all the variations detected in the sample (sedimentation, clarification, size variation, …). At a given ageing time, the higher is the TSI, the worse is the stability.

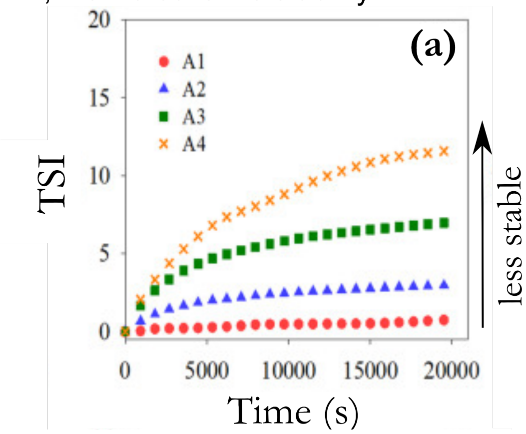


Figure 1: Global TSI evolution for the 4 casting solutions

Figure 1 shows the evolution of the TSI with time for the four casting solutions. It is clearly noticeable that the TSI is strongly increasing with the PVA concentration meaning that the global stability of the blend is decreasing.

The compatibility of the polymers is often quantified using the enthalpy of mixing ΔH_m. It is well established that the polymers are compatible when $\Delta H_m < 10$.

Thus, the TSI values were compared to the enthalpy of mixing ΔH_m in Figure 2. It can be established that the TSI is linearly linked to ΔH_m with an excellent regression coefficient.

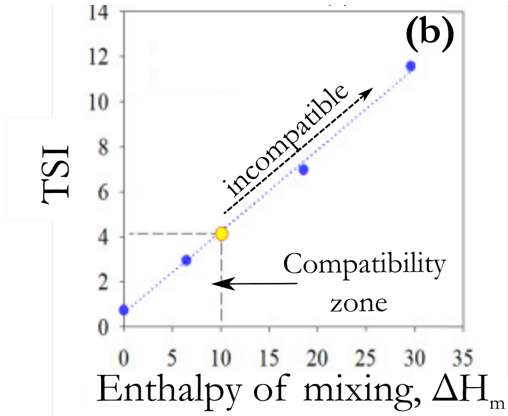


Figure 2: Relationship between TSI and enthalpy of mixing ΔH_m

As the stability of the casting solution is directly linked to the compatibility of the polymers, it is possible to determine the critical TSI corresponding to the limit of compatibility between polymers for membrane fabrication.

For blending PVDF with PVA polymers, compatibility the critical TSI value is 4,3 which corresponds to $\Delta H_m = 10$.

Turbiscan® allows to determine the optimal dosage of PVA to blend with the PVDF membrane matrix while keeping a sufficient compatibility between polymers. This ensures to fabricate polymeric membranes with enhanced antifouling performances.. Off course, prescreening of compatiblity can be performed with Turbiscan® technology for others polymers.

CONCLUSION

Turbiscan® technology can be of significant use for fast pre-screening of compatibility between polymers when fabricating antifouling membranes. A critical value of the Turbiscan Stability Index can be easily calculated for fast optimization of the appropriate concentration of casting solution to be used. Thus, assuring antifouling properties of polymeric membranes while maintaining a sufficient stability to ensure the homogeneity and the efficiency of the membrane.