# How to test membrane robustness regarding particles

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## Short Introduction

Thanks to the improvement in membrane resistance, low pressure membranes are now used for the treatment of complex water such as surface water, sea water and produced water in oil & gas applications, with or without pre-treatment. Consequently, the polymeric micro and ultrafiltration membranes are exposed to effluents increasingly concentrated in particles leading to abrasion and/or erosion risks. While membrane chemical and mechanical ageing have been widely studied, only few studies deal with abrasion of hollow fiber membranes (Lai et al. 2014). The objective of this study is to define a methodology to classify hollow fibre membranes according to their abrasion resistance.

## Material and Methods

Brown corundum ($Al_2O_3$, $\rho$=4 $g.cm^{-3}$ at 20°C, hardness=9 Mohs) and glass powder ($SiO_2$, $\rho$=2,5 $g.cm^{-3}$ at 20°C, hardness=6 Mohs) supplied by Mineralex were used in this study to mimic particles in complex effluents. These particles have been selected for their high abrasive potential (angular shaped particles). They are mainly used as an anti-slip agent in paints. Commercial PVDF membranes were tested corresponding to two homogenous ultrafiltration membranes (i.e. asymmetric membranes), one composite ultrafiltration membrane and one homogeneous microfiltration membrane (i.e. symmetric membrane).

Two accelerated testing methods were compared to evaluate the abrasion resistance of the membranes with synthetic effluents made of particles and water. The first one was based on a biphasic system including water and particles movement along the fibers simulating abrasion (Barkoula et al., 2002). In the second one, the abrasion occurred in a three-phase system with particles, water and air, simulating membrane cleanings. To setup the abrasion test, a tailor-made lab-scale module is filled with the abrasive solution (50 $g.L^{-1}$). Air is continuously introduced at the bottom of the lab-scale module using air compressor. Air bubbles induce turbulence within the lab-scale module and allow the particles to shake in water.

## Results and Discussion

Among parameters used to monitor membrane abrasion, Log Removal Value (LRV) appears to be the most promising as presented Figure 1. Moreover, no clear correlation was established between the abrasion rate of the membrane and the other monitored parameters (i.e. permeability, air integrity test, mechanical properties and bubble point), which is consistent with Ji et al (2015) conclusions.

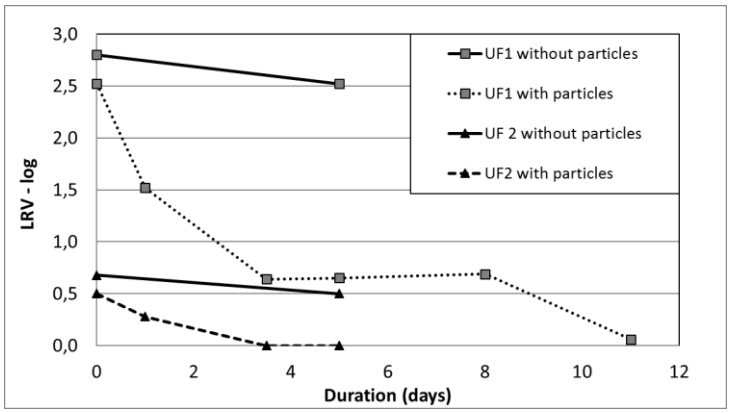


**Figure 1.** LRV measurement during abrasion test in tree-phase system (UF1 homogeneous ultrafiltration membrane – UF2 composite ultrafiltration membrane)

Scanning Electron Microscopy (SEM) images show advanced damages on the membrane external layer after 15 days of abrasion using three-phase system. Indeed, the whole surface is modified, with the formation of many folds (Figure 2). Similar modification on the external layer is observed on membranes from industrial site after xxx months (Figure 3).

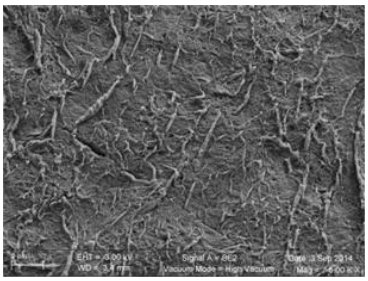

**Figure 2.** SEM image of the external layer of the tested membrane after accelerated ageing (X 5000)

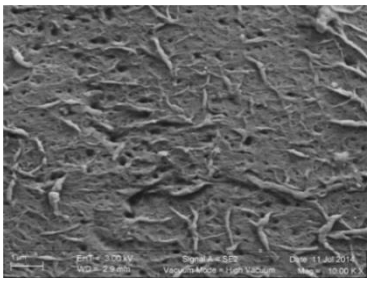

**Figure 3.** SEM image of the external layer of the same membrane coming from an industrial site (X 10 000)

## Conclusions

Different experimental conditions have been tested in order to simulate abrasion with highly variable response time. Three-phase tests (water, air and particles), allowed (i) to obtain a rapid abrasion similar to the membrane behaviours observed on industrial sites and (ii) to classify hollow fibre membranes according to their abrasion resistance.

## References

Barkoula, N.M., Karger-Kocsis, J., *Processes and influencing parameters of the solid particle erosion of polymers and their composite,* J. Mater. Sci. 37 (2002), 3807–3820

Ji J., Zhou S., Lai C. Y., Wang B., Li K., *PVDF/palygorskite composite ultrafiltration membranes with enhanced abrasion resistance and flux,* J. Membr. Sci. 495 (2015) 91 -100.

Lai C. Y., Groth A., Gray S., Duke M., *Enhanced abrasion resistant PVDF/nanoclay hollow fibre composite membranes for water treatment,* J. Membr. Sci. 449 (2014) 146 -157.