

Using electrokinetic leakage to probe internal fouling of ultrafiltration membranes

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Introduction

The zeta potential is a fundamental feature providing information about the electrokinetic charge of a solid. It is very sensitive to any change in surface electrical properties and so it can serve as a probe in various studies in materials science (adsorption, fouling, ageing...). For macroscopic solids the zeta potential can be inferred from streaming potential or streaming current measurements. Most recent studies on the electrokinetic characterization of membranes deal with measurements performed according to the so-called tangential mode, i.e. measurements are performed along the membrane skin layer. The reason is that the interpretation of transversal (i.e. through-pores) measurements could be quite complex in the case of asymmetric/composite membranes (Szymczyk *et al.*, 2001) and/or membranes with narrow pores (Fievet *et al.*, 2005). It has been shown, however, that complications in the interpretation of both tangential streaming potential (Yaroshchuk and Ribitsch, 2002) and streaming current (Yaroshchuk and Luxbacher, 2010; Szymczyk *et al.*, 2013) may arise when tangential measurements are carried out with membranes. In this work, we show that the electrokinetic leakage, i.e. the non-zero streaming current flowing through the membrane porous body when performing tangential electrokinetic measurements, can serve as a probe to detect internal fouling in porous membranes.

Material and Methods

Tangential streaming current measurements were performed with a symmetric cell in which two identical ultrafiltration (UF) membrane samples were inserted. The membrane skin layers thus formed the walls of a channel through which streaming current was measured. The cell configuration made it possible to vary the distance between the membrane skin layers without dismounting the cell channel (adjustable-gap cell). Two kinds of UF membranes (polyethersulfone and polyacrylonitrile) were used. The membranes were characterized before and after fouling (under various experimental conditions) by lipids.

Results and Discussion

Our results first revealed that significant electrokinetic leakage occurred through both pristine membranes as electrokinetic measurements were performed. The electrokinetic leakage detected through the polyacrylonitrile membrane was larger than through the polyethersulfone membrane, which was explained by the more hydrophilic character and the more porous structure of the polyacrylonitrile membrane. We showed that neglecting electrokinetic leakage in highly porous and hydrophilic membranes may lead to misleading conclusions regarding the surface charge of the membrane skin layer. Both polyethersulfone and polyacrylonitrile UF membranes were further fouled by filtering a model oil-in-water emulsion at different transmembrane pressure differences. The presence of lipids inside the membranes fouled under certain experimental conditions was found to weaken the electrokinetic leakage. Eventually it was shown that the penetration of foulant species inside the membrane pores could be highlighted by performing a series of tangential streaming current measurements at variable distances between membrane samples.

Conclusions

An electrokinetic leakage occurs through porous membranes when such materials are characterized by tangential electrokinetic measurements. This phenomenon is an issue in membrane characterization since it made it more difficult to determine the correct zeta potential of membrane skin layer. However, in this work it was shown for the first time that electrokinetic leakage could be used as a probe allowing characterization of fouling inside the membrane pores. Thanks to tangential streaming current measurements performed by varying the distance between the skin layers of two identical membranes it was possible to highlight the contribution of both internal and surface fouling in the case of UF membranes fouled by lipids.

References

- Fievet, P., Sbaï M. and Szymczyk A., *Analysis of the pressure-induced potential arising across selective multilayer membranes*, J. Membr. Sci. 264 (2005) 1-12.
- Szymczyk A., Labbez C., Fievet, P., Aoubiza, B. and Simon C., *Streaming potential through multilayer membranes*, AIChE J. 47 (2001) 2349-2358.
- Szymczyk A., Ibrahim Dirir Y., Picot M., Nicolas I. and Barrière F., *Advanced electrokinetic characterization of composite porous membranes*, J. Membr. Sci. 429 (2013) 44-51.
- Yaroshchuk A. and Ribitsch V., *Role of channel wall conductance in the determination of ζ -potential from electrokinetic measurements*, Langmuir 18 (2002) 2036-2038.
- Yaroshchuk A. and Luxbacher T., *Interpretation of electrokinetic measurements with porous films: role of electric conductance and streaming current within porous structure*, Langmuir 26 (2010) 10882–10889.