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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, 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 dealt with measurements performed according to the so-called tangential mode, i.e., measurements performed along the membrane skin layer. The main reason is that the interpretation of transversal (i.e., through-pores) measurements can 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.

Materials and Methods

Membrane
Polyacrylonitrile (PAN) 500 kD (Orelis)

Membrane fouling
Soaking in vegetable oil

Solution for membrane characterization
KCl (0.001 M; pH 4.60 ± 0.05)

Membrane characterization
Streaming current ($I_s$)

For dense membranes

\[ I_s = \frac{W_0 \varepsilon \varepsilon_0 \Delta P}{nL} \]

W: Sample width
L: Sample length
$n$: Distance between membrane surfaces (gap)
$\Delta P$: Applied pressure difference

For porous membranes

\[ I_s = \frac{W_0 \varepsilon \varepsilon_0 \Delta P}{nL} \]

Electrokinetic leakage

I_{tot} = I_s^p + 2I_s^o

I_s^p: Streaming current flowing between the membrane surfaces
I_s^o: Streaming current flowing through the porous structure of a single sample

References


