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Anthony Szymczyk, V Drevet, S. Liu, E Clavijo Rivera, L Villafaña López, et al.. Using electrokinetic leakage to probe internal fouling of ultrafiltration membranes. Euromembrane, Jul 2018, Valencia, Spain. hal-02352407

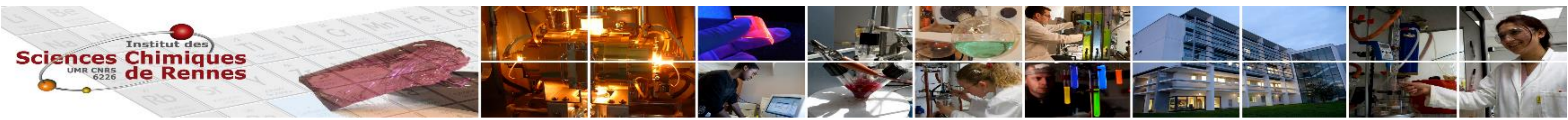
HAL Id: hal-02352407

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Submitted on 6 Nov 2019

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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

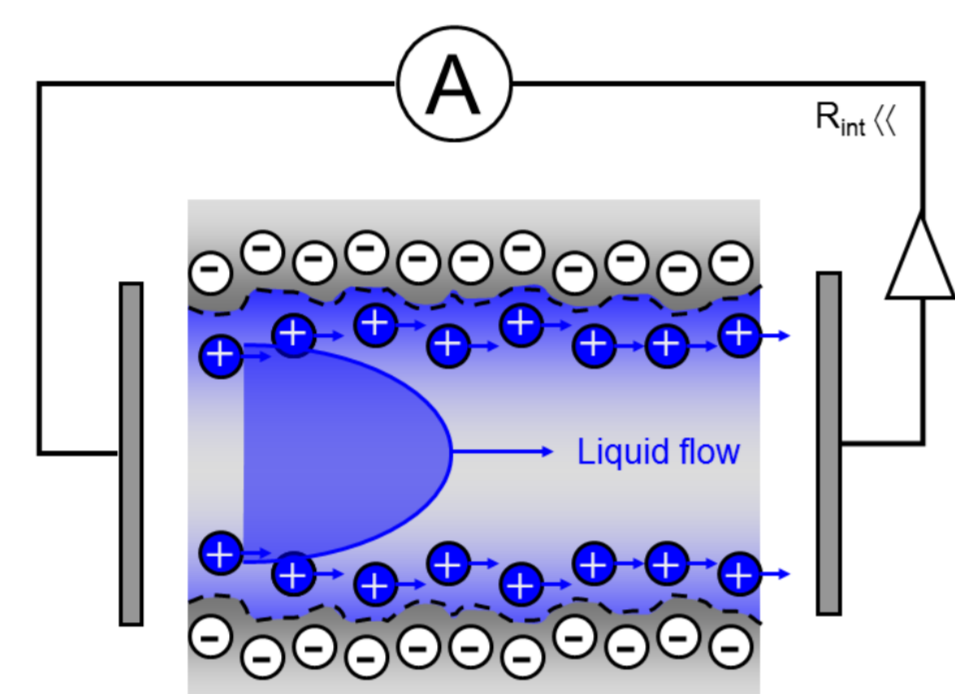
Soaking in vegetable oil

Solution for membrane characterization

KCl (0.001 M; pH 4.60 ± 0.05)

Membrane characterization

Streaming current (I_s)



For dense membranes

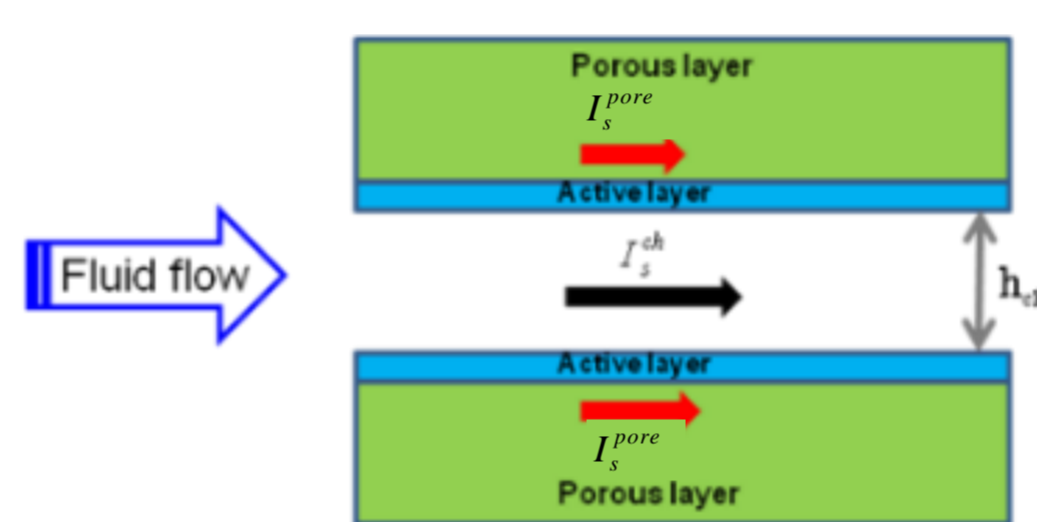
$$I_s = \frac{Wh_{ch}\epsilon_0\epsilon_r\Delta P}{\eta L} \zeta_{surf}$$

W: Sample width
L: Sample length
 h_{ch} : Distance between membrane surfaces (gap)
 ΔP : Applied pressure difference

ϵ_0 : Vacuum permittivity
 ϵ_r : Solution dielectric constant
 η : Solution dynamic viscosity
 ζ_{surf} : Surface zeta potential

For porous membranes

$$I_s = \frac{Wh_{ch}\epsilon_0\epsilon_r\Delta P}{\eta L} \zeta_{surf} + 2I_s^{pore}$$

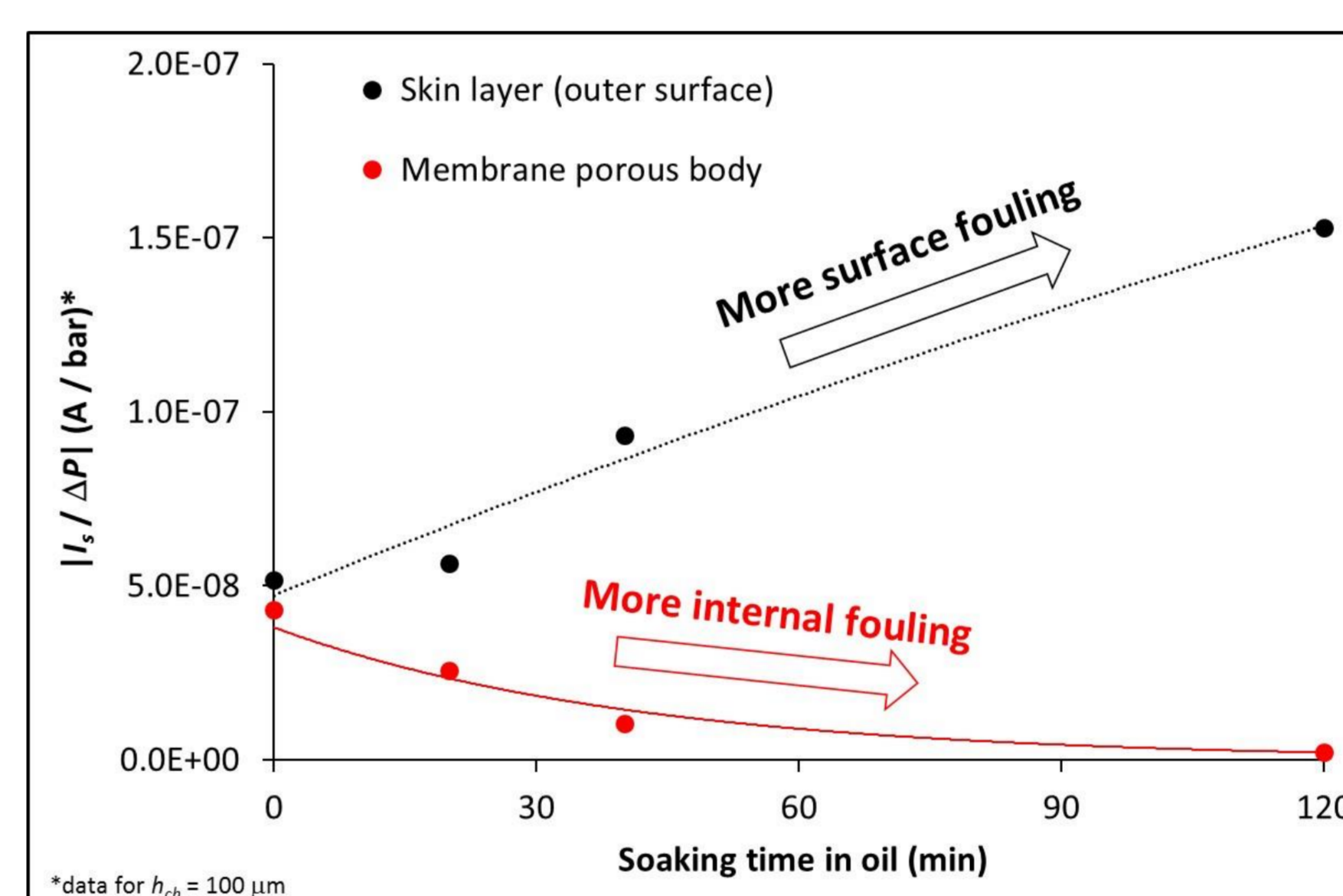
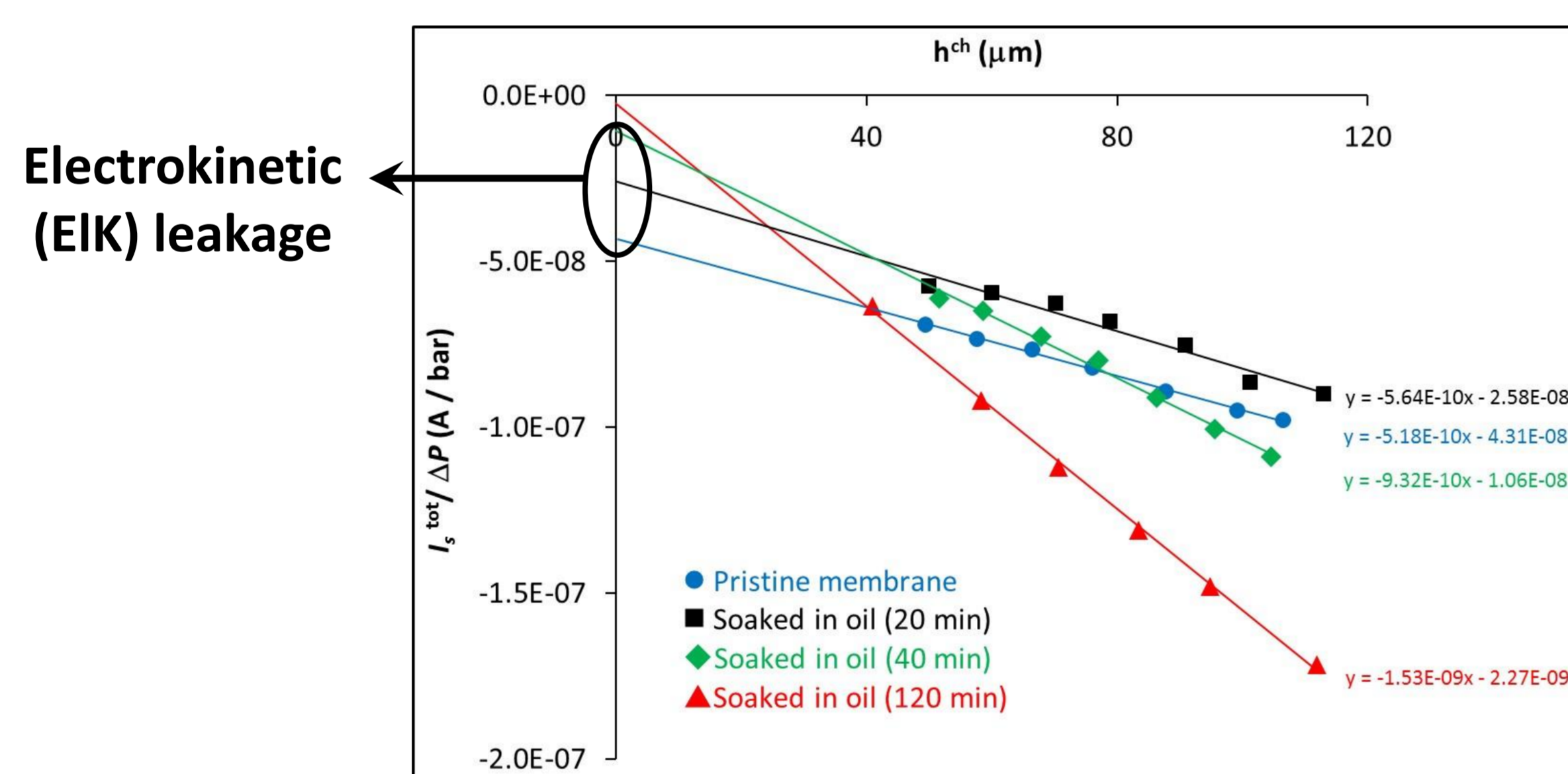


Electrokinetic leakage

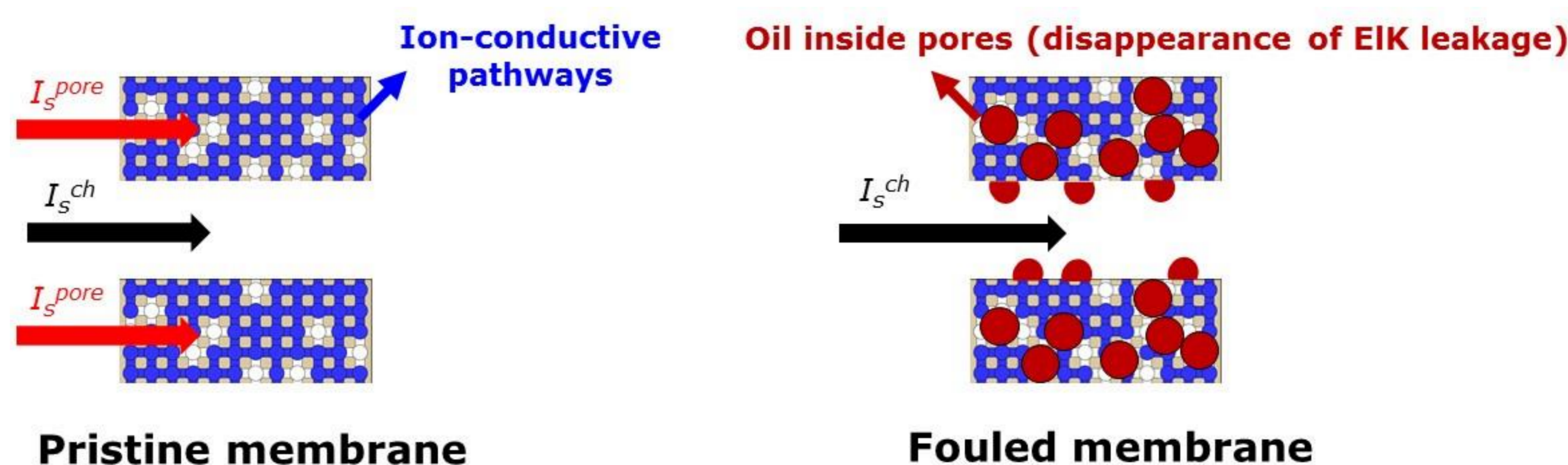
$$I_s^{tot} = I_s^{ch} + 2I_s^{pore} = \frac{Wh_{ch}\epsilon_0\epsilon_r\Delta P}{\eta L} \zeta_{surf} + \frac{2Wh^{eff}\epsilon_0\epsilon_r\Delta P}{\eta L} \zeta_{pore}$$

I_s^{tot} : Total streaming current (= experimental signal)
 I_s^{ch} : Streaming current flowing between the membrane surfaces
 I_s^{pore} : Streaming current flowing through the porous structure of a single sample
 h^{eff} : Effective thickness on which the electrokinetic leakage occurs
 ζ_{pore} : Pore zeta potential

Results



- Streaming current measurements performed by varying the distance between the membrane surfaces revealed significant electrokinetic (EIK) leakage through the pristine membranes.
- Neglecting EIK leakage may lead to misleading conclusions regarding the surface charge of membrane skin layers ($I_s^{tot} \neq I_s^{ch}$).
- After soaking the membranes in oil, both I_s^{ch} and I_s^{pore} were affected → Tangential streaming current measurements allow highlighting both surface and internal fouling.
- Internal fouling by hydrophobic species can be put in evidence through the reduction of the EIK leakage (the ion-conductive pathways inside the membrane porous body are cut).



References

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