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Adaptive pores in next generation membranes

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Motivation

Petroleum extraction unavoidably generates large volumes of produced water. The environmentally acceptable discharge of produced water is a current challenge to the petroleum industry. Therefore, there is an urgent need for treatment of produced water. Among many different techniques, membrane separation processes have become an emerging technology due to high oil removal efficiency and relatively facile operational process. However, membrane fouling which results in flux decline and rejection deterioration, is the main drawback of this technique. As a result, improvement of anti-fouling properties of polymeric membranes has attracted a lot of attention recently.

Approach

In this work the novel **Slippery Liquid Infiltrated Membranes (SLIM)** with adaptive pores will be used to reduce fouling deposition in treatment of produced water. The principle of liquid infiltration is based on well-matched solid and liquid surface energies, combined with the microtextural roughness. The **Infusion Liquid (IL)** fills the spaces within the texture (pores) and forms a continuous overlying film. The capillary-stabilized liquid in the micro- or nanometer-sized pores leads to a reversible gate mechanism which can coordinate multiphase transport (see Figure 1) [1, 2].

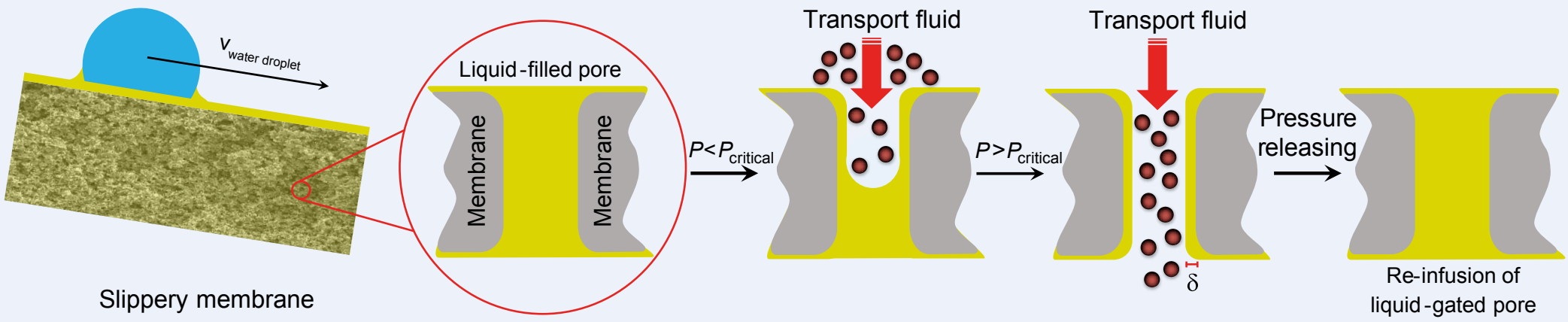

Fig 1. Schematic illustration of SLIM and gating mechanism of adaptive pores (from left to right). In this figure, δ is the liquid film thickness lining the pore and $P_{critical}$ is the pressure required to open up the liquid-filled pore.

Technological challenges

In order to ensure constant experimental conditions, model synthetic produced water (oil/water emulsion) will be used. The main technological challenges in the application of **SLIM** for oil/water separation include determination of optimal operating conditions, stability assessment of the liquid-lined pores, and **SLIM**s reuse.
The critical pressure of the individual components of the emulsion and **SLIM**s properties such as surface slipperiness and others will be studied to address technological challenges.
The performance and stability of **SLIM**s for oil/water separation will be investigated by performing:

- long term separation experiments
- experiments at high shear conditions
- separation tests in the presence of surfactants

Research goals

In order to accomplish the intended approach of the project, **SLIM** will be fabricated and characterized and various aspects, such as re-infusion of the liquid-lined pores will be evaluated. An extended experimental data set obtained at various experimental conditions, will be at first used to better understand the gating mechanism and then to validate the theoretical description.
Fouling and anti-fouling properties of **SLIM** will be investigated by performing filtration experiments. The performance of the membrane will be evaluated by considering the effect of operating parameters such as salinity, pH and temperature.

[1] X. Hou, Y. Hu, A. Grinthal, M. Khan, J. Aizenberg, Nature 2015, 519, 70.
[2] H. Bazyar, S. Javadpour, R. G. H. Lammertink, Advanced Materials Interfaces 2016, 3, 10.1002/admi.201600025.

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