Membrane fouling monitoring by advanced thermal conductivity sensing of the fouling layer

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Introduction

The development of fouling monitoring has the potential to enable efficient control membrane processes to optimize operation and cleaning. The measurement of thermal conductivity by 3ω sensing has proven efficient in other applications. The aim of this study is to show the potential of 3ω sensing for membrane fouling monitoring.

Methods

A Platinum wire (20 μm diameter) was attached to a ceramic ultrafiltration membrane (HTM UF from LiqTech) and alternating currents of varying frequencies (ω) were applied while logging voltage during filtrations. By Fourier transformation, the amplitude of the signal at three times the frequency, $U_{3\omega}$, was collected. $U_{3\omega}$ is inversely proportional to thermal conductivity, i.e. it increases when an insulating deposit forms around the wire. The signal was measured online in water at varying crossflow, and with acrylic and milk fouling layers on the membrane.

Results

The $U_{3\omega}$ signal of membrane in water decreased at higher crossflow velocities due to thermal convection. This was more pronounced at lower frequencies due higher signal penetration depth (Figure 1, left). Signals from a membrane in water with different amounts of acrylic deposit shows higher signal with layer thickness, explained by its insulating effect. The signal increases with higher frequency (lower penetration depth) as the thermal conductivity is measured within the layer at high frequencies. Signals collected during filtration of milk showed an increasing signal during fouling of the membrane. After cleaning, the permeability and signal were restored (Figure 1, right).

Discussion

3ω sensing is a promising method for fouling monitoring as it enables sensing changes in crossflow and fouling formation by measuring thermal conductivity. The penetration depth changes with frequency, which enables to distinguish between fouling thickness, type of fouling and crossflow.

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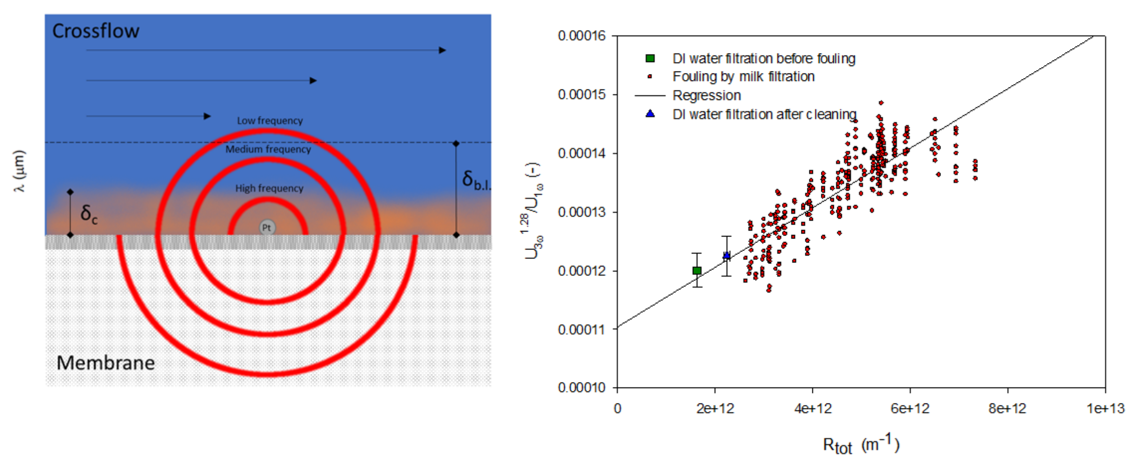

Figure 1: Conceptual drawing (left) and signal vs. filtration resistance before and during milk filtration and after cleaning (right).