In-situ monitoring of inorganic and microbial synergistic fouling during nanofiltration by UTDR

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ABSTRACT
This study describes an ultrasonic time-domain reflectometry (UTDR) as a non-invasive real-time technique for in-situ monitoring of the early-stage CaSO₄ and microbial synergistic fouling on nanofiltration (NF) membranes. The fouling experiments were carried out with 1.0 g/L and 1.5 g/L calcium sulfate solution at the operating pressure of 0.7 MPa, the temperature of 25±0.5°C and the flow rate of 0.13 cm/s. The number of bacteria incubated from lake was 5×10⁶ cell/ml. A commercial nanofiltration membrane was utilized in this study. The permeate flux, rejection and ultrasonic measurements were made at regular intervals during cross-flow NF. Results show that the flux obtained in the experiment with bacteria declined subtly slower than that without bacteria in the early phase, and then declined to the same level in the later phase of the fouling process. The rejection obtained in the experiment with bacteria was higher than that without. Furthermore, the acoustic measurements indicate that the fouling layer obtained with bacteria was thicker and looser than that without bacteria under the condition of low concentration solution. However, the layer becomes thicker and denser under the condition of high concentration solution. It implies that bacteria could accelerate deposition of inorganic scaling on NF membrane. Independent measurement such as flux-decline date, SEM analysis and weight measurement corroborate the ultrasonic measurement. Overall, this study suggests that the ultrasonic technique, due to its powerful capabilities and its use in monitoring devices, can be of great significance in the membrane industry.

Keywords: Nanofiltration; Membrane fouling; CaSO₄ and microbial synergistic fouling; Ultrasonic time-domain reflectometry

1. Introduction
Nanofiltration (NF) has been paid more attention as the optimized step in water treatment technology. Having characteristics half-way between ultrafiltration (UF) and reverse osmosis (RO), NF requires a much lower operating pressure than RO, offers higher permeate flux compared to that of RO, and allows rejection of multivalent ions and dissolved organic compounds [1–3]. These advantages have popularized the application of NF technologies in drinking water treatment and wastewater effluents reclamation as an alternative for RO. However, like other membrane processes, fouling is always a big challenge to the membrane operation.

Numerous investigations were performed to study the membrane fouling mechanism in order to support much more important theoretic date for the optimization of membrane operation. Foulants can be categorized into several groups such as sparingly soluble (inorganic) salts, organic substances, colloidal and particulate matter and biological growth [4]. In drinking water treatment, colloidal and organic substances are the main foulants of all. Hence, many researchers have studied the membrane fouling of organic substances and colloidal [1–5]. The fouling