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In situ monitoring of membrane fouling in spiral-wound RO modules by UTDR with a sound intensity modeling

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ABSTRACT

The ultrasonic time-domain reflectometry (UTDR) technique with a new signal analysis protocol-sound intensity calculation and modeling was developed to detect the calcium-sulfate fouling in a commercial spiral-wound reverse osmosis (RO) membrane module. The fouling experiments were carried out with 2.0 g/L calcium sulfate solution. A 2.25 MHz focused transducer was used and mounted on the outside of the module housing. Results show that the ultrasound is capable to penetrate through the multiple layers of membrane. The systematic changes on the ultrasonic reflected signals with fouling time were observed by UTDR. The total sound intensity of the response signals obtained declined with the fouling time and reached a minimum at about 25 h of fouling, and then increased in the following time. The changes in the total sound intensity were correlated to the deposition and formation of the fouling. The entire acoustic spectra were divided into three sections according to the arrival time. The subsection sound intensity indicated that the fouling layers deposited on the membranes in regular order from inner to outer of the spiral-wound module. Gravimetric and scanning electron microscopy (SEM) analyses revealed the membranes near the pure water tube of the module suffered from much severely fouling. Overall, this study demonstrates that the UTDR with a suitable signal analysis protocol can provide valuable insight concerning fouling in a spiral-wound membrane module.

Keywords: Ultrasonic time-domain reflectometry (UTDR); Reverse osmosis; Spiral-wound membrane module; Membrane fouling; Sound intensity

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