

## **IN-SITU MONITORING OF RO MEMBRANES USING ELECTRICAL IMPEDANCE SPECTROSCOPY: THRESHOLD FLUXES AND FOULING**

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Electrical impedance spectroscopy (EIS) was employed to monitor RO membranes in-situ during crossflow filtration using a membrane module fitted with suitable electrodes. EIS spectra can be analyzed in terms of layers and processes that are associated with different electrical time constants. One such layer identified in the spectra is the AC diffusion polarization layer that forms at the surface of the membrane within the concentration polarization layer. The conductance, ( $G_{DP}$ ) of this layer provides an indication of the nature of the material accumulating very close to the surface. When the feed water contained inorganic foulants such as silica, the value of  $G_{DP}$  gradually decreased as the silica (a poorly conducting material) accumulated on the surface. However, once a more integrated cake forms, the value of  $G_{DP}$  rises as the decrease in the mass transport coefficient due to the cake, leads to an increase in the salt concentration in this region; the so called cake enhanced concentration polarization (CECP) effect. The inflection point of  $G_{DP}$  vs time was itself dependent on the value of the flux (decreasing with increases in flux) and crossflow velocity (increasing with increasing crossflow). This mimics the variation of the "critical" flux observed in porous membranes such as MF. It would thus appear that the inflection point for  $G_{DP}$  corresponds to a threshold phenomenon where accumulation changes to cake formation and that it is a relatively well defined phenomenon, at least under controlled experimental conditions. This threshold flux could also be discerned in flux-step experiments where the differential rate changes in TMP (transmembrane pressure) vs time displayed a similar inflection. The threshold flux so determined was indeed very close to that determined from the  $G_{DP}$  profiles.

The concept of a "Threshold" flux, its relation to cake formation and its detection using EIS could be used for in-situ monitoring of RO membranes to optimize performance of plants. That could either be achieved using a "Canary" crossflow membrane module (fitted with suitable electrodes) connected in a side stream of a RO train or by suitable modification of the spiral wound modules themselves. Field trials to evaluate the economics of this have begun.