Biofouling of Reverse Osmosis Membranes: Measurements and Mechanisms

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The mechanisms of biofouling and the specific contributions of the various biofilm components to the deterioration of reverse osmosis (RO) membrane performance are not well understood. In this presentation we describe experimental results that elucidate the specific roles of biofilm growth and extracellular polymeric substances (EPS) in RO membrane biofouling. Biofilm growth dynamics on the RO membrane surface are visualized using confocal microscopy, in which active cells, dead cells, and EPS are monitored. We propose that the biofilm deteriorates the membrane performance by increasing both the trans-membrane osmotic pressure and hydraulic resistance. By comparing the decrease in permeate flux and salt rejection upon fouling with dead bacterial cells and upon biofilm growth on the membrane surface, we can distinguish between these two fouling mechanisms. Bacterial cells on the membrane hinder the back diffusion of salt, which results in elevated osmotic pressure on the membrane surface, and therefore a decrease in permeate flux and salt rejection. We refer to this mechanism as "biofilm-enhanced osmotic pressure". On the other hand, EPS contributes to water flux decline by increasing hydraulic resistance, without additional contribution to the decrease in salt rejection. Scanning electron microscope imaging, confocal microscopy, atomic force microscope (AFM) measurements, and gene expression data further support our proposed biofouling mechanisms.