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Fluorescence imaging for biofoulants detection and monitoring of biofouled strength in reverse osmosis membrane

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Biofouling is a crucial issue, and it causes seawater reverse osmosis membrane to deteriorate the performance of desalination. In this study, excitation emission matrix (EEM) fluorescence spectroscopy and parallel factor analysis (PARAFAC) were used to monitor the strength of biofouling on the fouled membrane which was obtained from real plant. Based on EEM and PARAFAC results of raw seawater, feed water, permeate, brine and fouled membrane, three components were identified as the major peaks: (1) microbial product-like materials at Ex/Em = 280/370 nm, (2) humic-like substances at Ex/Em = 330/420 nm, and (3) aromatic proteins at Ex/Em = 240/320 nm. Using the fluorescence intensity changes, the effects of replacing fouled RO membranes were found to be most significant at one of the components (Ex/Em = 270–300/350–380 nm) which could be considered the substances desorbed from fouled RO membrane. Compared to the data for salt rejection, this component monitoring of the brine EEM image is shown to be more sensitive than conductivity monitoring for predicting the biofouling strength during the desalination process.

1. Introduction

Technology using membrane-based desalination processes, *e.g.*, reverse osmosis (RO) processes, have continued to receive considerable attention because of their relatively high energy savings compared to traditional thermal processes. Currently, RO systems are a proven technology in desalination plant designs.[1] However, due to intrinsic characteristics of the membrane itself, all RO membranes have the same difficulty during process operation—membrane fouling. Once an RO membrane is fouled, the flux of water production drops and more pressure is required in order to maintain water production levels; fouling also requires frequent chemical cleaning and ultimately shortens the membrane lifetime.[2]

Membrane foulants can be classified as inorganic compounds, colloidal or particulate matter, dissolved organics, chemical reactants, and microorganisms or their byproducts.[2] Among the diverse types of fouling, biofouling is thought to be a major factor because it only requires a few microorganisms to develop into a biofilm, whereas other foulants can usually be removed using a series of pretreatment steps. Furthermore, microorganisms are ubiquitous in most water systems and tend to adhere to surfaces and then multiply on any surface that comes in contact with the water treatment system. Once attached to the membrane surface, microorganisms subsequently grow and increase the amount of extracellular polymeric substances (EPS; polysaccharides together with proteins and other cellular compounds) required in order to survive and form a mature biofilm, occasionally even in extremely oligotrophic environments such as seawater.[3] These EPS compounds are high-molecular weight complexes, and include carbohydrates, proteins, nucleic acids, lipids, and other polymeric compounds that can be secreted by microorganisms into their aggregates.[4]

It has also been reported that the proteins and humic-like substances of EPS compounds generate fluorescence signals because they contain an aromatic structure with functional groups.[5,6] This fluorescence, emission spectra when molecules re-emit absorbed light at a different wavelength, can be measured *via* fluorescence spectroscopy. In previous studies, fluorescence spectroscopy has been shown to be sensitive and subsequently used to identify the type of dissolved organic matter (DOM) in fields that include marine and fresh water environments.[7,8] Indeed, a great deal of research has been conducted in attempts to classify and characterize the DOM type using a fluorescence excitation emission matrix (EEM), in

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