Reverse osmosis membranes oxidation by hypochlorite and chlorine dioxide: spectroscopic techniques vs. Fujiwara test

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The aim of this work was the study of degradation of a commercial polyamide membrane by two commonly employed oxidants for disinfection in seawater desalination, hypochlorite, and chlorine dioxide. A conventional reverse osmosis (RO) membrane is a thin film composite membrane composed of three different layers, a polyester support web, a microporous polysulfone interlayer, and a thin cross-linked polyamide barrier layer on the top surface, which is the active layer of the RO membrane. The degree of membrane degradation in seawater was evaluated in terms of decline in membrane performance calculated from permeability and salt rejection. In order to establish a relationship between the hydraulic properties and spectroscopic data, infrared and X-ray photoemission techniques (ATR-FTIR and XPS) were employed. The obtained results were compared with the Fujiwara test which is usually performed in membrane autopsies to check the degradation of polyamides with halogens. The chemical degradation of the surface active layer was analyzed using infrared spectroscopy (ATR-FTIR) by monitoring the changes in the characteristic infrared bands of the polyamide. It is possible to calculate the transmittance bands ratio between peak at 1540 cm\(^{-1}\) (due to amide II) and peak at 1585 cm\(^{-1}\) (due to the polysulfone layer) in order to get the comparison of the degraded membranes with a virgin membrane. The amide II band was selected to evaluate the degradation process, because it is the first band that reduces its transmittance value when the degradation process begins. Once the ratio is obtained for the degraded membrane and considering the value obtained from the virgin membrane as the reference point, a new index is calculated named as degradation index. The higher the parameter is, the greater the chemical attacks the polyamide layer. X-ray spectroscopy (XPS) measures the elemental composition and the chemical state of the elements that exist in the surface of a solid. Evaluation of the binding energy is possible to determine if the halogens are attached to the polyamide structure. It was concluded in this work that both spectroscopic techniques ATR-FTIR and XPS could detect the membrane degradation process earlier than Fujiwara test.