Investigation of Fouling Mechanism and Development of Anti-fouling Processes in Membrane Desalination System

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Membrane fouling always degrades its performance in membrane desalination system, and biofouling due to growth of microorganisms on the membrane surface is the most serious problem. The aims of this study is to elucidate acid-shock and heat-shock effects on anti-biofouling using ATP measurement and other analysis methods for sea water characterization and to develop long term operation processes in membrane desalination system.

The ATP in microorganisms should be distinguished from ATP which exists outside in sea water (Free ATP) in order to get information of microorganism population. Two methods are proposed to measure the ATP in microorganisms in sea water, one is extraction of ATP from membrane-entrapped microorganisms (Membrane ATP) and the other is Cell ATP, which is subtraction of directly-measured ATP by mixing sea water and luciferase reagent without extraction (Free ATP) from directly-measured ATP with extraction (Total ATP), and utility of the methods were investigated. Conditions of ATP-extraction for microorganisms which grow on a membrane surface during membrane desalination process were also investigated. These ATP analysis allowed quick information on the microorganism population, and enabled characterization of sea water and membrane condition in combination with SDI, the turbidity, E260 and seasonal factors. This analysis is effective to control a membrane desalination system. Simulation studies based on the cake-filtration model clarified that SDI of monodisperse spherical particle suspension can not exceed 6. In fact, SDI of sea water sometimes exceeds 6, and then E260 is usually high. This indicates that organic compounds affect MF flux decline by adsorption on membrane pore surface.

Acid-shock and heat-shock were examined as anti-biofouling methods. Sterilization effects of acid-shock were preliminarily examined by ATP extraction from acid-added sea water and acid-treated MF membrane after dead-end filtration of sea water, and in both cases the ATP was largely decreased. Continuous crossflow MF of sea water was also carried out. The acid-shock decreased ATP on the membrane and increased the flux, whose influence still remained after one week. Heat-shock experiments were performed for 2-3 weeks to supply heated sea water directly to NF crossflow membrane cell. The heat-shock was effective to decrease ATP on NF membrane surfaces especially in spring and summer. It was not effective in winter because of low activity of microorganisms. The heat-shock effect on anti-biofouling was clearly proved with use of a heat exchanger in front of a NF membrane cell to cool down the heated sea water to eliminate heat-deterioration of the membrane.