

Fiber-Optic Chemical Sensor for Metal Ions and its Application to Seawater Industries

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Alkali and alkaline-earth metal ions in seawater are useful resources for chemical industries. Optical measurement of these ions through an optical fiber has several advantages over an electrochemical detection of ions. In this study, a fluorescent reagent sensitive to hydrophobicity around the reagent molecule is immobilized on a poly(vinyl chloride) (PVC) membrane, and it is used as an ion-sensing membrane in the fiber-optic chemical sensor. The constructed sensor is applied to real samples, and performances of the sensor are discussed.

Potassium Ion Sensor. Valinomycin was used as an ionophore for potassium ion. Dodecyl-acridine orange (dodecyl-AO⁺) was immobilized on the PVC membrane containing valinomycin, and it was attached on a distal end of an optical fiber. An argon-ion laser was introduced into the optical fiber as an exciting source, and fluorescence from the membrane was detected through the optical fiber. The sensor response was reversible to the potassium ion concentrations in the 0 ~ 100 mM range.

Response Mechanism. Potassium ion in a sample solution was extracted into a PVC membrane by valinomycin selectively. Positively charged dodecyl-AO⁺ in the PVC membrane was ion-exchanged with potassium ion, and moved toward the sample solution concomitantly. This movement lowered hydrophobicity around dodecyl-AO⁺. A fluorescence intensity of dodecyl-AO⁺ was well known to decrease with decrease of hydrophobicity around dodecyl-AO⁺. Thus the sensor signal decreased with increase of the potassium ion concentration in the sample solution.

Hexadecyl-AO⁺. The more lipophilic probe of hexadecyl-AO⁺ was synthesized. The response of the sensor using hexadecyl-AO⁺ was quite stable compared with that using dodecyl-AO⁺. Potassium ion in seawater was determined by the sensor, and the concentration of potassium ion was ca. 2 mM. Ionophores for ammonium and calcium ions were used instead of valinomycin, and fiber-optic sensors highly selective to these ions were also developed.