Development of concentration sensor of carbon dioxide dissolved in sea water

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Summary

Recently, the global warming with the increase in the artificial CO_2 emission becomes serious problem. Ocean is a largest storage of carbon, however there are many unclear points on carbon cycle in the ocean. One of the causes is the difficulty of CO_2 measurement in ocean. Since the conventional method for measurement of CO_2 in seawater required considerable time and high skill, therefore knowledge of the distribution of CO_2 is limited. To clarify the carbon circulation in the ocean, the development of the method for measuring of the CO_2 is required, which can be measured conveniently and continuously. An optical fiber sensor for pCO_2 in sea water was developed and the behavior of the sensor was studied experimentally and theoretically. The sensor consists of optical fibers, a gas permeable membrane and a fluorescence indicator solution. Since CO_2 molecular moves between seawater and fluorescence indicator through a gas permeation membrane, and pCO_2 in the fluorescence indicator becomes equilibrium to that of sea water. A fluorescence indicator is HPTS (1-Hydroxypyrene-3, 6, 8-Trisulfonic Acid Trisodium Salt) having a pH dependency. When the CO_2 dissolves to HPTS solution, pH changes. Therefore, it is possible to detect of pCO_2 in sea water as a change of the fluorescence.

A theoretical model for the pCO_2 optical sensor was considering CO_2 transmission rate of gas permeable membrane, diffusion of CO_2 and HCO_3^-, reaction rate of CO_2 hydration and the electroneutrality in the indicator solution. The model accurately reproduced the behavior of the sensor required experimentally. As a result of the model, it was clarified that the transmission rate of a gas permeation membrane and the diffusion of CO_2 in the indicator solution limited the response time of the CO_2 sensor. Therefore, the response time within 5 minutes was achieved when the diffusion length of the indicator solution was less than 0.2.