Development of High Performance Sodium and Chloride Selective Optode Devices

Hideaki Hisamoto
Department of Applied Chemistry, Keio University

Summary

Recently, we proposed a molecular design concept for the dyes called "multi-information dyes (MIDs)" for application to multi-dimensional optical chemical sensing. The MIDs used in the present investigation exhibit two kinds of spectral changes, which are a λmax shift based on a polarity change and an absorbance change based on protonation of the dye molecule.

Because the MID has plural spectral change properties, we here report the design of a novel unique "λmax-tunable" ion-selective optode as one of the applications of MIDs. Basically, the λmax-tuning was performed by varying the polarity of the membrane solvent. In the present investigation, the binary membrane solvent mixture of 2-nitrophenyl octylether (NPOE) and the newly synthesized NPOE derivative of NPOE-OH was used to continuously vary the polarity. The optodes were prepared as a PVC-less liquid membrane-type sensing plate which is similar to that recently reported by our group. Preliminary results clarified that the λmax tuning in the range from 649nm to 589nm and from 568nm to 540nm was possible for the optode using KD-M11 dye and KD-M9 dye, respectively, in an NPOE/NPOE-OH optode membrane system. This system was then applied to the neutral ionophore-based ion-selective optode (Na^+, Li^+, Ca^{2+}).

From a theoretical point of view, varying the polarity (hydrogen-bond donor ability) of the membrane solvent influences the equilibrium constant in the theoretical response equation for the optode. The ion-extraction equilibrium constant for the optode membrane using NPOE was increased by adding NPOE-OH. In an extreme situation (NPOE-OH 100%), the equilibrium constant was ca. 3 orders of magnitude larger than that in the optode based on NPOE. This fact suggests that the measurable range of the optode can be lowered upon addition of NPOE-OH in NPOE. Correlation between the mixing ratio of the two membrane solvents and the position of λmax and the equilibrium constants was examined in detail.

The λmax tuning technique is useful for preparing an optode system using a low cost light source such as a light emitting diode (LED) or a popular inexpensive laser.