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HIGHLY SELECTIVE IONOPHORE FOR LITHIUM IONS. 14-CROWN-4 DERIVATIVE BEARING A LONG ALIPHATIC CHAIN

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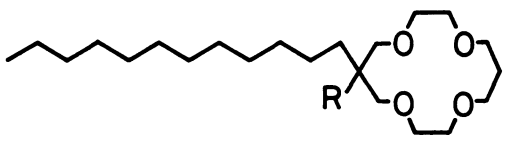
The 14-crown-4 derivative, 3-dodecyl-3-methyl-1,5,8,12-tetraoxacyclotetradecane, has proved to be highly Li^+-selective. In the ion-selective polymeric membrane electrode based on the crown ether was attained marked preference of Li^+ over alkali and alkaline-earth metal ions, NH_4^+, and H^+.

Crown ethers, when incorporated into membranes, can behave as ionophores selective for particular metal ions. Especially important is their use as neutral carriers for ion-selective electrodes. Lithium-selective electrodes should be very useful for monitoring of Li^+ activity in biological systems, *e.g.*, Li^+ determination during therapy of maniacal psychosis.[1-3] It seems likely that Li^+ is complexed preferentially by some of crown-4 derivatives, macrocyclic polyethers containing four oxygen atoms with different ring sizes. Several crown-4 derivatives have been attempted for their usefulness as neutral carriers of Li^+-selective electrodes,[4,5] but the ion selectivities are insufficient for practical use. We have synthesized highly lipophilic crown-4 derivatives with 13- through 16-member rings and investigated their Li^+ selectivities. The 14-crown-4 derivatives were found to be most selective for Li^+ when they were utilized for neutral carriers of polymeric membrane electrodes. We report here on the excellent Li^+ selectivities of the highly lipophilic 14-crown-4 derivatives, 1 and 2.

The crown ethers were synthesized by the cyclization reaction of 2-dodecyl-2-methyl- or 2-dodecyl-propane-1,3-diol with 3,7-dioxanonane-1,9-diol ditosylate in refluxing dioxane. The polymeric membranes were prepared with 1% (in weight) crown ether, 70% *o*-nitrophenyl octyl ether (NPOE), 28% poly(vinyl chloride) (PVC), 0.7% potassium tetrakis(*p*-chlorophenyl)borate. The EMF measurements were carried out at 25 °C, the composition of the electrochemical cell being Ag|AgCl| 1 mol dm^{-3} LiCl|PVC membrane|sample solution|0.1 mol dm^{-3} NH_4NO_3|4 mol dm^{-3} KCl| AgCl|Ag. The potentiometric selectivity coefficients, which were determined by



1 : R = CH_3

2 : R = H

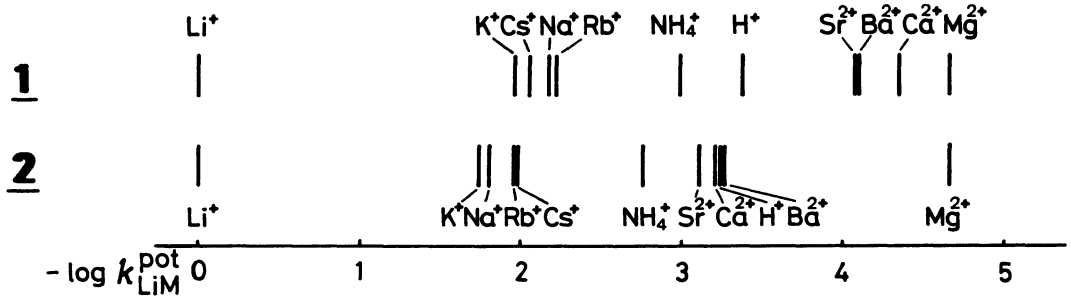


Fig. 1. Potentiometric selectivity coefficients $\log k^{Pot}_{LiM}$ for PVC - NPOE membranes containing lipophilic 14-crown-4 derivatives 1 and 2. Constant concentrations: 5×10^{-2} mol dm^{-3} for alkali metal ions and H^+, 5×10^{-1} mol dm^{-3} for alkaline-earth metal ions and NH_4^+.

a mixed solution method (the fixed interference method), are illustrated in Fig. 1.

High preference of Li^+ over Na^+ in Li^+-selective electrodes is a most important prerequisite for determination of Li^+ activity in biological systems. It is worth noting that dodecyl-methyl-14-crown-4 1 possesses extremely high Li^+ selectivity with respect to Na^+ ($k^{Pot}_{LiNa} = 7 \times 10^{-3}$). Dodecyl-14-crown-4 2, though still highly Li^+-selective, is not so high in the Li^+ selectivity as the dodecyl-methyl derivative. The Li^+ preference of 1 is equivalent or even superior to that for a previous acyclic neutral carrier,[6] which, to the best of our knowledge, had been the most excellent Li^+ ionophore. Moreover, the combined use of a small quantity of a powerful ligand, trioctylphosphine oxide[7] and the crown ether in the PVC membrane electrode enhanced the selectivity a little more ($k^{Pot}_{LiNa} = 2 \times 10^{-3}$). Also, the crown ether based Li^+-selective electrode offered a drastic improvement in the interference by H^+ (or H_3O^+), from which the electrode of the acyclic neutral carrier suffered seriously.[6] The selectivity for Li^+ relative to K^+ is sufficient for the practical use and the interference by Mg^{2+} and Ca^{2+} is almost negligible. The electrodes based on the crown ether showed near-Nernstian response (58 mV per ten-time activity change) in the wide activity range of 1×10^{-5} - 1 mol dm^{-3} Li^+. Thus, the Li^+-selective PVC membrane electrode based on the lipophilic 14-crown-4 derivative 1 is an attractive candidate for monitoring Li^+ activity in biological systems.

References

1) D. Samuel and Z. Gottesfeld, Endeavour, 32, 122 (1973).
2) A. Amdisen, Dan. Medic. Bull., 22, 277 (1975).
3) M Canessa, N. Adragna, H. S. Solomon, T. M. Connolly, and D. C. Tosteson, New England J. Medic., 302, 772 (1980).
4) K. M. Aalmo and J. Krane, Acta chem. Scand., Ser. A, 36, 227 (1982).
5) U. Olsher, J. Am. Chem. Soc., 104, 4006 (1982).
6) A. F. Zhukov, D. Erne, D. Ammann, M. Guggi, E. Pretsch, and W. Simon, Anal. Chim. Acta, 131, 117 (1981).
7) M. Katahira, T. Imatoh, and N. Ishibashi, 32nd Annual Meeting of the Japan Society for Analytical Chemistry, Niigata, 1983, Abstr., No. 1D06.

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