

Modern potentiometer for analytical chemistry.

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Commentary

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Potential difference sensors based on liquid or polymer membrane materials have successfully integrated sensor devices into clinical laboratories for automated analysis of physiological samples of key electrolytes such as potassium, sodium, calcium, chloride and pH. This is an ever-evolving, well-established technology. This important success story in the field of electrochemical sensor technology took place in the 1970s and 1980s, after which the technology was considered mature and significant progress was impossible.

One of the decisive turning points in the field of potential difference sensors in the early 1990s was the introduction of heparin-selective electrodes by the group of Meyerhoff and Yang. The importance of sensors for the widely used anticoagulant heparin and its antidote protamine was the driving force behind the development. In the early stages of research, the underlying sensor mechanism was not yet understood. The following description of the reaction mechanism as a non-equilibrium ion exchange / backdiffusion process has helped open the field of non-classical potentiometric measurements.

At the same time, the success of optical sensors in achieving low detection limits down to the nanomolar range raises questions about unattractive detection limits beyond the micromolar range of the same material. It has been shown that the detection limit of the potential difference sensor is also determined by the non-equilibrium diffusion process through the membrane. This can be explained by some similarities with the polyion sensor above. By understanding and eliminating the unwanted zero-current ion flow of ions from the membrane to the sample solution, we were able to reduce the detection limit of ISE to ultra-trace levels. Then, research was continued to miniaturize and simplify the manufacturing process by incorporating suitable solids instead of aqueous internal contact, and potentiometric measurements determine ultra-small total ion content in small sample volumes. It was very helpful to do. It turned out to be a good technology. This is particularly attractive when the ion detection step is combined, for example, with a bioanalytical assay using soluble nanoparticle labeling. Other recent trends have focused on actively controlling ion transport through potential or current control, bringing the IES field closer to that of traditional voltammetry sensors. The improved search for lower detection limits also revived the search for better molecular receptors and the characterization of their binding behavior to ISE membranes. New methods have been proposed to determine the ion exchange selectivity underlying such membranes, resulting in ion selectivity up to 10 orders of magnitude better than initially described in conventional protocols. Many methods have also

been introduced to determine the complex formation constants of lipophilic receptors directly at the organic sensor stage. These developments, along with the correct theoretical treatment of ion exchange and diffusion behavior of such membrane systems, form a solid foundation for further development in this fascinating field. Applications Clinical analysis and pH measurement are the main practical applications of ISE. The physiological range of related ions is so narrow that the accuracy and accuracy should be better than 23%. This is very difficult given the small sample size and complex media such as whole blood. Due to the high charge z (70 or +30 for heparin or protamine), the sensitivity and the slope of the corresponding sensor response function ($59.2 / z \text{ mV} / 10$) are usually negligibly small and non-classical. Potentiometric titration should be used to evaluate these clinically important polyions. Recently, various practical applications of ISE with improved detection limits are currently being developed. Their usefulness for trace metal analysis in drinking water was demonstrated by good agreement with the results of ICPMS measurements. A new application for miniaturized ISE is potential difference biosensing with nanoparticle marking. This was demonstrated in a sandwich immunoassay based on the capture of gold nanoparticles and the deposition and subsequent dissolution of silver. In contrast to most techniques currently used to study host-guest interactions, potentiometric methods are not limited to medium-intensity complexes. They are relatively simple and far less sophisticated than other methods, so they are expected to become more prevalent in this area in the future.

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