Capacitive readout of ion-selective electrode by electronic control for high precision measurements

Pitchnaree Kraikaew, Sunil Kumar Sailapu, Stéphane Jeanneret, Eric Bakker

Department of Inorganic and Analytical Chemistry, University of Geneva, Quai Ernest-Ansermet 30, CH-1211 Geneva, Switzerland

Pitchnaree.Kraikaew@unige.ch

Constant potential coulometric readout of ion-selective electrode is known to improve sensitivity by producing a current signal that is easier to identify than that of direct potentiometric measurement. The current spike is measured and integrated, giving charge information that is proportional to logarithmic ion activity. The general coulometric readout utilizes an ion-to-electron transducing material as a capacitive layer for solid-contact ion selective electrode (SC-ISE).[1] In this case, the charge transfer process may be limited by the capacitive behavior of the transducer, resulting in a long response time and a current drift from the zero baseline. We presented recently for the first-time the use of an electronic capacitor instead of a solid-contact material to overcome the main drawbacks of constant potential capacitive readout.[2] The capacitor can be simply adapted to amplify the current signal so that it is optimally suitable for each application. Importantly, the current baseline drift is minimized owing to the ideally capacitive behavior of electronic capacitor. In that work, the electronic capacitor is discharged after each sample measurement by sequentially introducing a reference solution, which is required for a certain time to acquire again a zero potential difference.

To improve this method for practical use, we report the use of an electronic circuit to automate the control of the capacitive readout principle.[3] The open-circuit potential (OCP) of the reference solution is measured and stored by the potentiostat. In this method, the OCP value can be applied directly to the sample solution resulting in a sharp current spike. Discharging the capacitor is executed by short circuiting after each chronoamperometric measurement. Hence, the reference solution is no longer needed, resulting in shorter response time. Furthermore, the development of a portable device for constant-potential coulometry is presented. A small potentiostat along with dedicated electronic circuits are integrated and fitted in a small box (18.5 cm width $\times$ 10.7 cm length $\times$ 3.6 cm height with a weight of 370 g). A range of capacitors (22 – 220 µF) are integrated in the device, which can be automatically chosen by the control software. The device, the so-called PotentioCap, was evaluated in standard pH solutions and stabilized seawater samples using a hydrogen-selective electrode placed in series with a capacitor. The results of transient current and integrated charge over time correlates well with that from capacitive readout using a benchtop potentiostat with an external electronic circuit.

[1] E. Hupa, U. Vanamo, J. Bobacka, *Electroanalysis*, 2015, 27, 591-4.
[2] P. Kraikaew, S. Jeanneret, Y. Soda, T. Cherubini, E. Bakker, *ACS Sensors* **2020**, 5, 650-4.
[3] P. Kraikaew, S.K. Sailapu, E. Bakker, *Sensor Actuat. B-Chem.* **2021**, 344, 130282.