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EDITORIAL

Preface

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Topical issue “Solid-state potentiometric sensors”

Development of chemical sensors is an interdisciplinary endeavor that can be both challenging and rewarding. Potentiometric sensors represent one of the most attractive chemical sensors available today for continuous determination of pH, various ions and gases. This may be related to the small size, portability, low-energy consumption and relatively low cost of potentiometric sensors and the associated instrumentation. The development of solid-state potentiometric sensors and solid-state reference electrodes are in line with the current trends in analytical chemistry concerning microfabrication and mass-production of durable chemical sensors that may ultimately be integrated into miniaturized total analysis systems (μ-TAS). Not only miniaturized electrodes, but also conventional-size solid-state potentiometric sensors that require little or no maintenance are very attractive from the user’s perspective. Recent advances in the field of solid-state potentiometric sensors are highlighted in this topical issue of the Journal of Solid State Electrochemistry.

Some potentiometric sensors, such as gas sensors based on solid electrolytes and solid-contact ion sensors based on inorganic salt or single crystal membranes, are true solid-state sensors. In this issue, however, also potentiometric sensors based on polymeric membranes are regarded as “solid-state” sensors despite the well-known fact that the major component of a typical plasticized poly(vinyl chloride)-based ion-selective membrane is an non-volatile organic liquid. One reason for this choice is that the physical appearance of plasticized polymer membranes is solid rather than liquid. Another reason is that solvent polymeric ion-selective membranes are frequently used nowadays in combination with solid-state ion-to-electron transducers, such as conducting polymers and other solid electroactive materials. Furthermore, the discovery of the low detection limit that can be achieved also for solid-contact electrodes based on polymeric ion-selective membranes emphasizes the importance of plasticized polymer membranes in the field of modern solid-state electrochemistry.

This topical issue contains four authoritative reviews providing an overview of the field of solid-state potentiometric sensors. Ernö Lindner and Róbert Gyurcsányi review several important quality control criteria for solid-contact, solvent polymeric membrane ion-selective electrodes. Many important issues are discussed and clarified in this review. Solid-state potentiometric gas sensors based on the chemical modulation of the work function of organic semiconductors are reviewed by Jiri Janata and Mira Josowicz. In this review, fundamental differences between sensors based on chemically sensitive field-effect transistors (CHEMFET) and organic field-effect transistors (OFET) are pointed out. Solid-state potentiometric gas sensors based on solid electrolytes are reviewed by Pawel Pasierb and Mietek Rekas. The construction details, working mechanism and performance of different types of potentiometric sensors for detection of gases such as O_2, H_2, CO_2, SO_x, NO_x, CH_x, and CO are described. Finally, important issues related to solid-state reference electrodes for potentiometric sensors are reviewed by Ulrich Guth et al. The investigation of all-solid-state reference electrodes is still in an early state and will most probably gain more attention in the near future.

Several original papers are devoted to solid-contact electrodes based on conducting polymers as ion-to-electron

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transducers. Roland de Marco et al. describe the synthesis and characterization of high integrity solid-contact polymeric ion sensors. By using various surface analysis and electrochemical characterization methods it is concluded that poly(3-octylthiophene) is a suitable solid-contact material that can prevent the formation of a detrimental water layer at the interface between the solid-contact and the ion-selective membrane. Tom Lindfors compares the light sensitivity and potential stability of several conducting polymers that are commonly used in solid-contact ion-selective electrodes. The potential of poly(3-octylthiophene) was found to be significantly more sensitive to light than polypyrrole, poly(3,4-ethylenedioxythiophene) and polyaniline. Krzysztof Maksymiuk et al. study the influence of galvanostatic polarization on ion concentration profiles in solid-contact ion-selective sensors by using laser ablation inductively coupled plasma mass spectrometry, while all-plastic ion sensors with polyaniline and poly(3,4-ethylenedioxythiophene) as solid-contact materials are described by Agata Michalska et al. Furthermore, a procedure for the construction of an all-plastic electrochemical cell comprising miniaturized planar indicator and reference electrodes is described by Andrzej Lewenstam et al. In this unique approach, all electrodes are based on conducting polymers and contain no internal electrolyte.

In addition to conducting polymers, also other solid-contact materials are of great interest in potentiometric sensors. Philippe Bühlmann et al. show that subnanomolar detection limits can be achieved with ion-selective electrodes with three-dimensionally ordered macroporous carbon as the solid contact. A solid-contact ionophore-based electrode for determination of pH in acidic media is described by Konstantin Mikhelson et al. In this case, the ion-to-electron transducer contains carbon black and an electron-ion-exchanger resin that stabilizes the electrode potential. The influence of the transducer on the potential response and stability of solid-contact anion-selective membrane electrodes based on metalloporphyrin ionophores is discussed by Łukasz Górski et al. Highly lipophilic electrode substrates (graphite paste with mineral oil) help to prevent the formation of an aqueous layer underneath the ion-sensing membrane. Patrycja Ciosek et al. present the construction of an integrated microelectrode array by using low-temperature cofired ceramics (LTCC) technology. The microelectrodes are covered with polymeric membranes with various selectivities and used as an “electronic tongue”.

A chronopotentiometric method is proposed by Róbert Gyurcsányi et al. for the determination of the diffusion coefficients of free ionophore in solvent polymeric membranes. Interestingly, the chronopotentiometric method is more robust and more widely applicable than the previously reported chronoamperometric and optical methods. Winfried Vonau et al. describe a new solid-state glass electrode based on a semiconducting zinc oxide thin film as intermediate layer between the pH-sensitive glass membrane and the solid electronic conductor. The pH and ion sensitivity of a field-effect electrolyte–insulator–semiconductor (EIS) sensor covered with polyelectrolyte multilayers is studied by Arshak Poghossian et al. Furthermore, an enzyme-free glucose-sensitive field-effect transistor based on interactions between glucose and phenylboronic acid is proposed by Yuji Miyahara et al.

I would like to thank all authors, co-authors, and reviewers that have contributed to this topical issue. I am convinced that your expertise has resulted in an excellent issue on this timely and exciting topic of solid-state potentiometric sensors. I am also most grateful to Prof. Fritz Scholz (Editor-in-Chief) for inviting me to edit this issue and to Dr. Michael Hermes for always providing an answer to my endless stream of technical questions.