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Materials Engineering Forum

- The Materials Engineering and Metallurgy Committee of the Polish Academy of Sciences
- Polish Materials Science Society

Ion-selective electrodes and ion-sensors - engineering analytical tools

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The ion-selective electrode is an electrochemical sensor that allows specific determination of ions in a biological, environmental, ori ndustrial origin matrix. Measurement of pH and ions such assodium, potassium, chloride, bicarbonate, ammonia, calcium, magnesium, fluoride, nitrate, silver, cadmium, and leadarenowavailable. The lecture will showthe essential material and physicochemicalprinciples, milestones, and challenges in electrochemical ion sensing.

Each ion-selective electrode is based on a process of ion-to-electron coupling, i.e., the ion to be determined and electron to serve amplified for information on ion quantity. The ions are sensed by a membrane, a crucial part of the electrode. The membranes contain activesites inducing sensitivity to preferred ions, and they are made from glass, crystals, or plastics. Partition of the ions between the sample and membrane is responsible for signal formation. Nernst-type equations describe the signal taken in an open circuit (zero-current) under equilibrium. Nernst-Planck-Poisson equations extended the signal theory, which can be applied for non-zero current signals, as well as time and space domains. Non-equilibrium signals and responses over a short time are thus engaged in a routine fast sample through put analysis.

The internal contact is conventionally made by the internal solution containing the preferred ions, chlorides, and silver chloride electrode. To integrate the ion-selective electrodes, the internal solution was eliminated and substituted by a so-called solid contact. Conducting polymers were first proposed as the suitable material, and a new class of ion-selective electrodes, called ion-sensors, was established. Now a plethora of different contacts made of nanocarbon, metal structures, or functionalized composites is offered. Consequently, the ion-sensors can be miniaturized, positioned in the multi electrode platforms, 3D-printed, sterilized, and made ready for use.

The ion-sensors today are reliable, robust, and price-attractive tools for many analytical applications. Clinical measurements in blood, drinking water, process liquids, and waste water control are most attractive applications.

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Chemo-resistive gas sensors – materials' aspects

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Chemo-resistive gas sensors are the electronic devices that exhibit significant changes in their electrical resistance upon admission of certain oxidizing or reducing chemical species. Metal oxides such as SnO_2, MoO_3, TiO_2, CuO, are well-known materials usually applied as gas sensors. These materials can be synthesized in different forms ranging from bulk ceramics to thin films. Thin-film technology has contributed significantly to the development of reliable chemical sensors as it is easily controllable and results in reproducible parameters of the deposited layers. Moreover, it is compatible with interdigitated transducer IDT electrodes which provide electrical contacts to the resistance measuring units. Emerging nanotechnology has led to a revolution in chemical sensing especially as far as different forms of nanomaterials have demonstrated better response, sensitivity and selectivity. Moreover, the nanostructured sensors can operate much faster due to better kinetics of responses at room temperature. The aim of this contribution is to review the most recent work performed in the field of chemo-resistive gas sensor with a special emphasis on the materials' aspect.