Chemical sensor on the basis of materials possessing molecular memory created

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A chemical sensor on the basis of materials possessing molecular memory. Credit: Vita Nikitina

Scientists from the Faculty of Chemistry of the Lomonosov Moscow State University have developed a polymer-based electrochemical sensor with molecular imprinting aimed at detection of saccharides and hydroxy acids. The enzyme-free sensor allows measurement of glucose and lactic acid concentration. They have presented the results in *Sensors and Actuators B: Chemical*.

Vita Nikitina, a junior researcher at the Faculty of Chemistry of the Lomonosov Moscow State University and one of the project authors, shares: "Most sensors are electrochemical. This means that glucose concentration is measured in terms of current density, registered with the help of an enzyme electrode biosensor using a testing strip. However, enzyme usage for chemical detection of substances of interest in such devices has its disadvantages, mostly connected with low stability of enzymes and the necessity to provide special storage and operating conditions and biosensor disposability."

In their project, the chemists from the Lomonosov Moscow State University sought alternative enzyme-free devices. The sensor they developed is an electrode modified by a thin polymer layer. Such sensors are not only easy to produce, but also more stable in operation and storage. Moreover, reagents for their production are massively cheaper than enzymes.

Nikitina says, "In the structure of the polymer we synthesized on the surface of the electrode, there are functional groups, namely boronic acids, capable of detecting common low-molecular compounds like saccharides (glucose and fructose) and hydroxy acids (lactic and tartaric acids). In the project, we've shown how our sensors could be used for detection of these substances. A signal generated by the sensor is registered by electrochemical means similar to enzyme electrodes. However, unlike amperometric glucose meters, our device is based on another principle—namely, the change of polymer conductivity."

Generating an electrically conductive polymer coating on the surface of electrodes turns out to be a nontrivial task. Elaboration and thorough optimization of conditions and parameters of electropolymerization were key to the project. Polymers were synthesized under the current action, flowing through the working electrode, placed into an electrochemical cell with monomer solution. As a result of this electrochemical process, the water-insoluble polymer is deposited on the electrode surface.

The chemists have synthesized a polymer with the help of a molecular imprinting method. It implies formation of special regions (imprints) in the material, and these regions recognize only those molecules that have been used as templates during polymer synthesis. Such materials, possessing

molecular memory, could be applied as a sensitive layer of chemical sensors for detection of certain substances. Electrochemical polymerization of substituted aniline was conducted in the presence of template molecules—namely, hydroxy acids and saccharides. After polymerization, these molecules were removed from the polymer matrix. However, in its three-dimensional structure, some spaces (so called molecular imprints) were left. These imprints in terms of the form, size and orientation of functional groups are complementary to these template molecules. This effect, the "molecular memory" of a polymer, provides the material with the ability to detect compounds that have been used as templates.

In order to test the sensor, the researchers placed it into an electrochemical cell, where the analyzed sample is located. If there have been saccharides or hydroxy acids in the analyzed sample, than boronic acid groups of the polymer bind with them, resulting in the growth of polymer conductivity, which has been registered with the help of an electrochemical impedance spectroscopy technique.

Vita Nikitina says, "We've shown that it's possible to create multisensory systems on the basis of elaborated sensors with different selectivity. These systems allow the monitoring of concentration of various substances in biochemical processes. Such sensors could be used for detection of high-molecular substances and even whole cells, having structural fragments of saccharides or hydroxy acids."

More information: Vita N. Nikitina et al, Molecular imprinting of boronate functionalized polyaniline for enzyme-free selective detection of saccharides and hydroxy acids, *Sensors and Actuators B: Chemical* (2017). DOI: 10.1016/j.snb.2017.02.073

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