Capacitive sensing of amphetamine-type stimulants based on immobilized molecular imprinted polymers

Beloglazova N., Graniczewska K., De Rycke E., Pütz M., Hauser F.M., De Saeger S.

Ghent University, Faculty of Pharmaceutical Sciences, Laboratory for Food Analysis, Ottergemsesteenweg 460, 9000 Ghent, Belgium

natalia.beloglazova@ugent.be

Abstract: The threat of synthetic drugs is one of the most significant current drug problems worldwide. Amphetamine-Type Stimulants (ATS) are globally the second most widely used drugs after cannabis. ATS production contributes to environmental pollution, so there is a demand to develop robust and sensitive sensors that can detect ATS and in environmental water samples.

Why Amphetamine-type stimulants?

The graph presenting capacitance changes (df) of the MIP functionalized electrode in function of concentration (µM) for separate injections of N-formylamphetamine (N-FA), methamphetamine (MAM), and phenazone (ZP).

Why capacitive biosensor?

Difference between capacitance changes (df) of the MIP and NIP functionalized electrodes in function of N-FA concentration (µM); difference in sensitivity according to implemented initiative (A) AIBN MIP (B) 9-phenyl-651 MIP. The measurements with use of regeneration buffer between each injection was performed in triplicate.

Choice of the optimal MIP

The working electrode consists of several layers that contribute to the system’s total capacitance. The electrode’s gold surface is first insulated to improve surface-charge deviation; then, recognition elements are bound to this layer. If analyte binds, the electrochemical double layer will be displaced further away from the gold surface. Assuming a good insulation, the insulating and receptor layers will contribute the least to the total capacitance. Hence, the partial capacitance of the analyte and the electrochemical double layer will be the most pronounced. Binding of analyte typically leads to a measurable decrease of the total capacitance.

Construction of working electrode

An automated flow-injection system was used to simulate continuously flowing systems, using a peristaltic pump to maintain a buffer or carrier solution flow. It is connected to an injection loop via a 3-port valve, and the loop is connected to a 9-port valve. This latter allows injection of up to six different samples, and a regeneration solution, into the continuous flow system. An inline degasser unit removes air bubbles from the solution before it is introduced into the flow cell.

Automated flow-injection system

Comparison of electrodes insulation with the use of cyclic voltammetry recorded in 10 mM K3[Fe(CN)6] in 0.1 M KCl. The potential was swept in the range between -300 and 800 mV vs Ag/AgCl with a sweep rate of 100 mV/s; electrodes (a) bare, (b) modified with MIPs, (c) modified with IA and MIPs, (d) MIPs electropolymerization with tyramine, (e) after treatment with 3-mercaptopropionic acid.

Synthesis of MIPs

MIPs are polymers that have been processed using the molecular imprinted technique which leaves cavities in polymer matrix with affinity to a chosen "template" molecule.

Molecular structure: (a) template, N-formylamphetamine (N-FA); (b) cross-linker, ethylene glycol dimethacrylate (EGDMA); (c) monomer, 2-hydroxyethyl methacrylate (HEMA); (d) functional monomer, itaconic acid (IA).

Synthesis of MIPs

MIPs can be prepared by precipitation polymerization, (c) MIPs for N-FA prepared using in situ polymerization, (d) commercial MIPs for methamphetamine.