ELECTROCHEMICAL SENSOR DEVELOPMENT FOR MELAMINE DETECTION

Ernestas Brazys[1], Vilma Ratautaitė[2], Arūnas Ramanavičius[1,2]

[1]Department of Physical Chemistry, Institute of Chemistry, Faculty of Chemistry and Geosciences, Vilnius University, Lithuania

[2]Department of Nanotechnology, State Research Institute Center for Physical Sciences and Technology (FTMC), Lithuania

ernestas.brazys@chgf.stud.vu.lt

Melamine is a compound usually used in the plastics industry to produce melamine–formaldehyde resins. It contains a large amount of nitrogen (66 % by mass). The worldwide outbreaks of misuse by unethical manufacturers of this property and adding melamine to dairy products to inflate measured protein levels are described in the literature. One of them was in 2008 when melamine-containing milk caused urinary stones in children under the age of 3 in China [1]. It was established that melamine is nephrotoxic to humans and the consumption of it can cause renal diseases. Therefore, melamine was limited to 2.5 ppm in dairy products by the responsible authorities, including the European Community and the US Foods and Drug Administration. To enforce these regulations, a wide variety of methods have been developed to detect melamine. In this presentation, melamine detection by employing molecularly imprinted polypyrrole is demonstrated [2].

The typical molecular imprinting procedure consists of a few steps: 1) self-assembly of monomer, cross-linker, and template molecules to form pre-polymerization complexes; 2) chemical or electrochemical polymerization; 3) the polymerization step is then followed by the removal of the template, which generates the binding sites in the structure of the polymer, which are specific or complementary to the template molecules [3]. This characteristic can be used in the development of sensors for specific detection [4].

In this study, the melamine-imprinted polypyrrole-based (MIP) sensor was developed [2]. The pre-polymeric mixture contained 50 mM of pyrrole as a monomer and 5 mM of melamine as a template in a 10 mM PBS solution, pH 7.4. The polymeric layer was deposited electrochemically directly on the surface of a graphite electrode by a sequence of potential pulses. The template molecules were extracted by washing the polymer in 1 M H_2SO_4 solution for 60 min. In comparison, an electrode was modified with a non-imprinted polypyrrole layer (NIP). Further, both MIP and NIP layers were modified with 3.5 nm, 6 nm, and 13 nm diameter gold nanoparticles (AuNPs), and gold (I) complexes during the polymer preparation step.

The properties of all polypyrrole films were evaluated by differential pulse voltammetry (DPV) using a 10 mM PBS solution (pH 7.4) with 5 mM $K_3[Fe(CN)_6]/K_4[Fe(CN)_6]$ redox probe. The interaction between melamine and polymer layers was assessed by the comparison of oxidation peak currents of the aforementioned system and calculating the apparent imprinting factor. The most optimum results were achieved by MIP modified with 0.05 nM AuNPs with a diameter of 3.5 nm.

[1] A. K. C. Hau et al. Melamine toxicity and the kidney. JASN, 20 (2009).
[2] E. Brazys et al. Molecularly imprinted polypyrrole-based electrochemical melamine sensors. Microchem. J., 199 (2024).
[3] V. Ratautaite et al. Electrochemical sensors based on l-tryptophan molecularly imprinted polypyrrole and polyaniline. J. Electroanal. Chem., 917 (2022).
[4] V. Ratautaite et al. Evaluation of the interaction between SARS-CoV-2 spike glycoproteins and the molecularly imprinted polypyrrole. Talanta, 253 (2023).