Abstract (w j. angielskim)

This paper presents the research results on the assessment of the possibility of using carbon nanotubes as a sorbent in passive sampling devices (CNTs-PSDs). The attached articles present the conducted experiments, which resulted in the development of a kinetic passive sampler containing carbon nanotubes as the receiving phase.

In the first stage of the research, analytical methods allowing the determination of selected micropollutants in water with the use of high-performance liquid chromatography and high-performance liquid chromatography coupled with mass spectrometry were developed and validated. Then, a semi-static calibration of passive samplers containing multi-walled carbon nanotubes with different outer diameter, length, specific surface, or the type of functional groups was carried out. Based on the obtained results, multi-walled carbon nanotubes modified with –COOH groups with an outer diameter < 8 nm (COOH8-CNTs) were selected as the best for the sampling of β-blockers and sulfonamides. In contrast, unmodified multi-walled carbon nanotubes with an outer diameter < 8 nm (8-CNTs) were selected as the best for the sampling of cytostatic drugs, non-steroidal anti-inflammatory drugs, tricyclic antidepressants, phenol derivatives and hormones. The curves of uptake of target compounds from water using the above-mentioned carbon nanotubes as sorbents were characterized by linearity, hence the developed passive samplers were defined as kinetic.

The next step was to select an appropriate eluent for the desorption of analytes retained on the surface of carbon nanotubes. Several types of solvents and their mixtures were tested to obtain the highest elution efficiency. It was shown that the highest extraction efficiency was obtained for all tested chemical compounds using the ACN:MeOH:CH_3COOH (1:1:1).

The following important stage of the research was to determine the influence of environmental factors on the sampling rate (R_s) of analytes by CNTs-PSDs. For this purpose, experiments were carried out in which the water surrounding the samplers was characterized by different physicochemical parameters, namely: different pH values, concentrations of dissolved humic acids and salinity. The influence of water mixing on the R_s values of analytes was also investigated. The obtained results indicate that the water pH, the presence of dissolved humic acids or salinity do not affect the sampling of hormones, cytostatic drugs, phenol derivatives, non-steroidal anti-inflammatory drugs, and tricyclic antidepressants using 8-CNTs-PSDs. However, in the case of sulfonamides uptake by COOH8-CNTs-PSDs, all the above-mentioned environmental factors influenced the R_s values. In the case of β-blockers, only the salinity of water above 7 PSU influenced the R_s of these analytes, the other factors did not cause significant changes in the sampling rate of these compounds. It was observed that the increase in the speed of mixing the matrix did not affect the R_s of the tested compounds. However, a decrease in the R_s value was noted for all analytes under static conditions compared to dynamic conditions.

The reliability of the applied calibration system was also assessed. For this purpose, the developed passive samplers were calibrated using the flow-through method (open system with a constant inflow of water spiked with analytes) and the semi-static method (closed system with gentle mixing of water spiked with analytes at the beginning of the experiment). There were no significant differences between the determined R_s obtained using the above-mentioned calibration methods, which proves that each of them is reliable and verifiable.

The last stage of the research carried out as part of this doctoral dissertation was the use of CNTs-PSDs in the monitoring of selected micropollutants in three types of surface waters, and then the regeneration of the used CNTs and their reuse in the passive extraction of the target analytes from treated sewage. The obtained results confirm the high potential of using CNTs-PSDs for the sampling and concentration of a wide range of chemical compounds that differ significantly in their physicochemical properties from the aquatic environment.

Keywords: passive samplers, carbon nanotubes, micropollutants, monitoring of the aquatic environment