Novel cellulose-based biosorbents in water treatment technologies: role of the intermolecular and surface interactions

One of the biggest challenges of the modern world is the purification of water for consumption purposes. Water contaminated with solid particles, microorganisms, toxins, dissolved elements and inorganic compounds (e.g. heavy metals, i.e. lead, cadmium, mercury, iron and others), arsenic, chlorine, fluorine, dissolved organic substances (pesticides, plant and animal residues, and fragments thereof) and any other natural or man-made chemicals, each year takes a deadly harvest in the form of hundreds of lives. Recent decades have brought a lot of discussion about water scarcity and related threats. Water has no substitute; there is no alternative for it; it cannot be replaced.

An extremely important problem at this point is water pollution with plastics, in particular those whose sizes are known as micro-, sub-micro and nanometric. Polymer micro- and nanomaterials (micro-/nanoplastics) are formed most often from larger waste, but can also come from cleaning products, cosmetics, and medicines or fabrics. Contamination with this material type is dangerous not only because of the scale of their occurrence and difficulties in removing them, but also by supporting the transfer of other toxic substances. It is also important that despite the progress in spreading awareness of this problem, which has been going on for several years (understanding the need for recycling, increasing consumer awareness, or even facts such as the introduction of the *zero waste* life philosophy), the plastics market is growing every year, resulting in production of huge amount of polymer wastes. The problem of contamination of water with plastics smaller than micrometers is a problem more and more often raised by governmental, non-governmental organizations and scientific units. Information campaigns (WHO, UNICEF, UN, European Commission), scientific research on the pollution of water resources, their detection, analysis and environmental effects caused by them, legislation (including the ban on the use of micro- and nanoparticles in cosmetic products), and media campaigns make the problem more and more visible and there is a chance that it will attract the attention of many research centers.

The main goal of this project is to develop a method of removing micro- and nanomaterials from aqueous solutions using ionic liquid functionalized cellulose nanostructures. For this purpose, appropriate ionic liquids will be designed, which will then be attached to properly prepared substrates (cellulose nanostructures). The obtained materials will be subjected to structural characteristics and physicochemical, and then used in the process of water purification from standard solutions of nano-/ submicro-/micromaterials. The point of reference mustn't be an in-depth analysis of the type of pollution, but only a quantitative analysis of the removal of a given type of pollution by the appropriate material. The process of water purification from reference aqueous solutions of plastic materials (i.e. micro- and nanoplastics: including PET, PVC, PTFE, and PS) will be carried out in two variants: (1) adsorption of plastic particles directly from contaminated solutions and (2) direct filtration of aqueous solutions particles through the adsorbent both by gravity and under reduced pressure. An important part of the project will also be the assessment of the interactions between the pollution and the obtained sorbent. The number of the obtained systems will allow, first of all, the creation of a wide library of materials, and will allow further modeling and design of the purification process of micro/sub-micro and nanoplastics.

The main benefit of the project will be the development of a material that removes micro- and nanoplastics, and the determination of the role of surface and intermolecular interactions affecting the effective purification of aqueous solutions. The newly designed materials could significantly contribute to the development of water purification techniques, and the determination of the impurity/sorbent interactions will allow for a better understanding of the removal of small polymer systems, and thus their more effective removal from the environment. The complementarity of the infrastructure located in the NanoBioMedical Center of the Adam Mickiewicz University, the selection of staff responsible for the implementation of the project, as well as extensive scientific cooperation in many research networks will allow for a timely and reliable implementation of the proposed project at the highest scientific level. The result of the project will be published in articles in scientific journals with a high impact factor (i.e. *ACS Applied Materials and Interfaces*, *Science of the Total Environment*, *Journal of Hazardous Materials* or *Environmental Science: Nano*), as well as presentations at international and national conferences devoted to ionic liquids, nanotechnology and environmental protection. It is also planned to disseminate the information about the project in the popular science context: both through popular science articles and social media.