# Abstract for the general public

The anthropogenic influence on the distribution of toxic elements in the environment increases the risk of human exposure to them. In the general case, modern inorganic analytical chemistry focuses on conscious elemental control processes, i.e., qualitative and quantitative analysis of the elements in environmental samples, their separation, preconcentration, purification, and recovery. Numerous metals are very harmful to our health, even at very low (trace or ultratrace) concentrations. Thus, it is necessary to find novel procedures to isolate and determine metal ions at such levels. Modern spectrometry techniques allow determining elements on trace and ultratrace concentrations. However, the presence of a sample matrix worsens the detection limits, which causes the analysis to be unreliable. Recently, solid adsorbents based on carbon materials have been of this interest in the scope of the above issue due to their promising adsorption properties. Nevertheless, their application is often limited since their low adsorption properties or lack of selectivity toward metal ions in the presence of organic matrix or high salinity water samples. The fullerenes are particularly interesting materials due to their attractive spherical shape and exceptional physicochemical properties. However, the hydrophobic interactions of fullerenes in aqueous solutions preclude their potential use in the adsorption of metal ions. These properties, however, can be improved by modifying their structures with suitable functional groups.

The proposed scientific project aims to introduce novel modifications of fullerenes for efficient and selective adsorption of toxic metal ions from aqueous solutions. The studies will consider the modifications of $C_{60}$ and $C_{70}$ fullerenes using amino acids, peptides, and dendrimers. The modified structure of buckyballs using the abovementioned organic compounds will improve their dispersibility due to the presence of a high amount of hydrophilic functional groups on the modified carbonous structure. Because of the small sizes of fullerene nanoparticles, it is expected that obtained modifications will characterize by high solubility. Therefore, the studies on binding the acquired modifications to the solid phases, which could stabilize the fullerenes in an aqueous solution, will be conducted. Since the different purposes in the application of modified fullerenes in adsorption and determination of metal ions, carbon nanomaterials (graphene oxide (GO), carbon nanotubes (CNT)) and silica will be applied as a solid phase to which the tested fullerenes will be attached. The modified fullerenes seated on the GO or CNT will be dedicated for the dispersive extraction methods, whereas in the case of silica, for the column extraction.

In the next part, the structures of obtained fullerene modifications will be confirmed and thoroughly characterized using microscopic and spectrometric techniques. In addition, studies of their adsorption properties will be conducted. Thus, the following parameters will be considered, i.e., the effect of pH, adsorbent dose, adsorption time, ionic strength, also the influence of organic matrix and coexisting ions. Moreover, the adsorption kinetics and isotherms will be studied, allowing us to understand better the ions complexation mechanisms which occur on the modified fullerenes. These results will have a significant contribution to the expansion of current knowledge on the adsorption of metal ions on modified fullerenes, and thus they will open the path for their further studies and applications in analytical chemistry.

Thoroughly studied modified fullerenes will be used to develop new ultrasensitive microanalytical methods for the preconcentration and determination of trace and ultratrace metal ions. The procedures will be based on direct measurements of the adsorbents containing the preconcentrated elements using energy-dispersive X-ray fluorescence spectrometry and total-reflection X-ray fluorescence spectrometry. The proposed techniques allow performing measurements of solid samples directly, therefore eliminating the elution step, which is necessary for other spectrometric techniques. The developed and verified methods using selective fullerenes will enable adsorption of the elements in high salinity water samples and/or in the presence of organic matrix, using micro-doses of adsorbents. In addition, the procedures will allow lowering the detection limits of XRF techniques down to pg/mL level, which is achievable only by using expensive techniques, which consume high amounts of reagents at the sample preparation step and the measurements, and also often fails in the analysis of the samples with a complex matrix.