PASSIL – an innovative passive sampling technique using ionic liquids

The main objective of this project is to investigate the possible use of ionic liquids (ILs) as the acceptor phase in passive sampling in order to monitor the presence of polar organic pollutants in water environments. Ionic liquids are salts that are liquid at temperatures below 100°C, which distinguishes them from standard salts. ILs have specific physicochemical properties, interesting from the point of view of chemical analysis, as they are non-volatile and non-flammable. Passive sampling extraction is a technique in which analytes (chemical compounds which are the subject of investigation) pass freely (by diffusion) from an aqueous phase, which is also known as a donor phase, to an acceptor phase, solid or liquid. This distinguishes it from commonly used active extraction techniques, in which a sample is taken at a specific time and place, and passed through a solid sorbent in a laboratory using a pump.

In the case of passive sampling, a dosimeter is inserted directly in the environment, and after a predetermined time it is removed, and its contents are analyzed. Both of these extraction techniques have advantages and disadvantages. Passive sampling is more appropriate from the point of view of environmental monitoring and quality assessment, because the results are a time-weighted average concentration of impurities, in contrast to the results from active extractions – which are only momentary snapshots of the concentrations.
To date, the passive extractions of polar compounds in an aqueous medium have been processed using a solid phase acceptor. Because of the unique properties of ionic liquids, we decided to explore their use in passive sampling, which is an innovative idea. It is worth noting that the Department of Environmental Analyses at the University of Gdańsk has already been extensively dealing with the subject of ionic liquids, developing analytical methods and analyzing environmental pollution, in particular residues of pharmaceuticals in water matrices. This project is therefore well supported by a research group with good knowledge and wide experience of existing research trends related to this subject.

The main hypothesis in the research project presented here is that ionic liquids can be successfully used as a receiving phase in passive sampling for the determination of polar impurities in aquatic environments. To prove this hypothesis, a series of experiments in the field of basic research were planned. It should be mentioned that preliminary studies have already been carried out, and their positive result was a prerequisite for the further exploration of this PASSIL (Ionic Liquids' Passive Sampling) technique. A special disk dosimeter has already been designed, composed of two screw rings, between which is placed a membrane, and an ionic liquid inside them.

The project is divided into three parts. Polar analytes, selected pharmaceuticals and phenol derivatives have been taken as models for the experiments, because these compounds are currently regarded as pollutants in aqueous environments. In the first part of the project, experiments will be carried out to verify how the efficiency of extraction of selected analytes may be affected by the ionic liquid used, the type of membranes and experimental conditions (temperature, salinity, amount of dissolved organic matter and stirring rate). A static system will be applied, which means that the dosimeter is immersed in a vessel through which the solution in the donor phase will not flow. During the experiments, samples from the donor phase will be taken every two days to check the loss of analytes. Desorption experiments will also be carried out to check how the analyte can be extracted from the interior of the dosimeter. Highly zoomed photographs of the membranes - which have been impregnated with the ionic liquids - will be taken to test the effect of the ionic liquid on the structure of the semi-permeable membrane material. The results from this part of the experiment will determine which ionic liquids are the most appropriate for PASSIL and how this new technique can be affected by different experimental conditions.

In the second part of the project, a so-called calibration of the dosimeter will be carried out. This is a procedure to determine the values of factors specific to each analyte, which in later use of PASSIL can be used to determine the time-weighted average concentrations of environmental pollution. Because of the fact that PASSIL is a new unexplored extraction technique, three calibration techniques will be compared to see which one produces the best results. A dynamic system will be constructed at this part of the experiment, which means that the aqueous phase of the donor phase flows through the vessel with a submerged dosimeter. A peristaltic pump and circulating bath with thermostats will be purchased for these experiments. These will be used to better reflect real environmental conditions. Finally, the results will be collected and correlated, which will either confirm or deny the research hypothesis.

The successful completion of this project will result in the delivery of an innovative tool which could be used to assess the state of the environment, in particular to determine its quality as well as the sources and pathways of any organic polar environmental pollutants. It is worth noting that the project fits into the current trend of what is called green chemistry, in other words chemistry which is friendly to the environment. Its implementation will make a significant contribution to the development of science, in particular analytical and environmental chemistry.