Computational Risk Assessment of ionic liquids Before their use in new technologies (CRAB)

Ionic liquids (ILs) is an exciting group of new chemical substances that have the greatest potential to improve the development of organic chemistry and chemical technology. These compounds may be used in many research fields, in various chemical processes including the synthesis and catalysis, separation technics, or they can be used as electrolytes or functional fluids. However, industrial applications of ionic liquids could face many difficulties. Recently, ionic liquids were considered as “green chemicals” - safe for human and environmentally friendly. Nowadays, however, a number of research studies prove that they can be toxic. Thus, it is necessary to perform an evaluation of ILs’ potential impact on living organisms (including humans) before they are introduced on a large scale in the industrial processes.

Experimental studies considering the risk assessment are often very time-consuming and expensive, so it is not possible to conduct a comprehensive evaluation of exposure assessment for the chemicals. In this case computational methods such as quantitative structure activity/properties relationship (QSAR/QSPR) could be used as an alternative to expensive experiments. These methods are currently the "gold standard" in risk assessment for new groups of chemicals and are recommended by many international regulations, including European REACH chemical management system. However ionic liquids require separate treatment of the modeling of QSAR/QSPR (existing methodology requires the development of specific solutions for the ILs). The subject of research in the presented project was the adaptation of computational algorithms currently used in the chemical risk assessment to the specificity of ionic liquids (CRAB methodology) and gathering reliable information regarding the mechanisms of transport and deposit of ionic liquids and their impact on the human health.

Within the project, a methodology for calculating ionic liquid structure descriptors useful for the development of QSAR/QSPR models has been developed. A set of computational algorithms for modeling the transport processes and persistence of ionic liquids in the aquatic environment and soil (based on multicomponent environmental models (MM)) and for modeling the ILs toxicity (based on the QSAR method) were also developed.

Based on the developed algorithms, the **RExIL (Risk Explorer of Ionic Liquids)** software has been developed. This software allows for the initial, fast assessment of toxicity and physicochemical properties of ionic liquids. **RExIL can be successfully used in the process of designing new, safe ionic liquids and thus allowing to reduce the time-consuming experimental researches.** Potentially toxic/environmentally hazardous ionic liquids can be eliminated at the designing stage, before they are synthesized (in accordance with the **CRAB idea - Computational Risk Assessment Before**). This is a very important issue especially taking into account the growing use of ILs in the new technologies, eg. the use of ILs in solar batteries, which are intended to protect the environment and human (reducing environmental pollution caused by the use of fossil fuels as a source of energy), can also become a source human exposure to toxic ionic liquids.

Moreover, developed within the project QSAR/QSPR models indicated which structural features of ionic liquids are responsible for the toxicity/physicochemical properties of these compounds may have the great impact in solving significant problems of future threats of ILs to individual ecosystems and human health. The proposed computational tools for comprehensive risk assessment of ionic liquids have a very practical dimension in the light of the legal regulations (eg. REACH Regulation) and the act on the protection of laboratory animals, where the emphasis is on the safety of using compounds as well as on the development of computational methods as an alternative to time-consuming and costly experimental research (sometimes doubtful from an ethical point of view). Research results will add value to the process of creating an innovative product, guaranteeing a high level of consumer health protection and limiting the number of experimental tests carried out on animals.