Biotechnological potential of 2D MXene materials - opportunities and challenges

A. M. Jastrzębska [1,a], **A. Szuplewska** [1], **A. Rozmysłowska-Wojciechowska** [1]

[1] *Warsaw University of Technology, Faculty of Materials Science and Engineering, Woloska 141, 02-507 Warsaw, Poland*
[a] *agnieszka.jastrzebska@pw.edu.pl*

The past few years have witnessed significant development in the chemistry and potential biological applications of two-dimensional (2D) materials. Innovative 2D carbides, nitrides and carbonitrides of early transition metals, called MXenes, have been extensively studied for several years on their applications in human health protection. The recent advances include biotechnological and biomedical applications such as anticancer treatment, photothermal therapy, drug delivery platforms, or nano-drugs without any additional modification. These can be combined with bioimaging, magnetic resonance or photoacoustic techniques.

It is currently accepted that the specific functionalities of the MXenes can result in a wide spectrum of bio-activities. MXenes are currently being carefully studied in this context, with strong attention to mechanisms of action and biocompatibility features. We already know that MXenes exhibit different cellular effects which multiple external or internal factors can additionally induce. These effects are in turn strictly dependent on MXenes structure, chemical composition, and surface characteristics which positively support their interesting potential in nano-therapies. MXenes are promising anticancer agents that can inhibit the proliferation of cancer cells, induce oxidative stress, and even influence cell functioning and cell cycle by causing programmed cellular death (apoptosis).

On the other hand, such a wide range of bio-activities may inevitably cause unexpected toxicological effects that require a broader understanding. The obtained results clearly indicate that in this respect, the surface chemistry of MXenes has a significant impact on their biological properties. This is closely related to the synthesis methods and oxidizing properties, leading to potentially toxic superficial metal oxides. In the case of MXenes, the challenge now relates not only to obtain the needed biological properties but above all, to understand and maintain (stabilize) them in the desired environment. The presented studies will shed some light on the issues raised above and also outline new directions in toxicology of the MXene phases. They are focused on elucidating antiproliferative, pro-oxidative, and pro-apoptotic mechanisms of action. The specific features of MXenes such as a high degree of morphological anisotropy, specific chemical functionalities, surface oxides, and unique surface charges, undoubtedly define their biological properties.

Acknowledgments: *The presented results were accomplished thanks to the funds allotted by the National Science Centre, within the framework of the research project 'SONATA BIS 7' no. UMO-2017/26/E/ST8/01073.*