Toxicological features of new two-dimensional nanomaterials from the MBenes family

The tremendous advancement in the field of nanotechnology has been accompanied by much slower progress in the understanding of its impact on the environment. The large-scale production, leaching out from the enriched products, accidental spills during production, and poor disposal of wastes might result in significant release and accumulation of nanomaterials in the natural environment [1]. The best example of unexpected catastrophic nano-impact on the environment is the phenomenon of nano-plastics that corresponds to the claimed 'discovery of the century'. As correctly predicted, plastics changed the everyday lives of people. However, although the promises were fulfilled, the benefits were unfortunately counterbalanced by catastrophic environmental problems, which emerged unexpectedly only half a century later [2]. Hence, exploring the ecotoxicity of new types of nanostructures, including two-dimensional (2D), is of fundamental importance [3]. The scarce knowledge about their properties and potential interactions with the target environments results in the inability to assess the risks associated with their industrial use. The increasing number of some threats and the general lack of dedicated assessment methods for 2D nanomaterials' features is also a huge problem [1]. According to the conclusions of the 2013 report, '*Nanosafety in Europe 2015-2025: Towards Safe and Sustainable Nanomaterials and Nanotechnology Innovations*' [4], as well as conclusions of the '*2019 Global Summit on Regulatory Science*' (GSRS19, 2019, Sept. 24-26) hosted by the European Commission's Joint Research Center (JRC) and U.S. National Nanotechnology Initiative (NNI) [5], the current nanosafety activities for the upcoming new 'Horizon Europe' will concentrate on specific research priorities. These are environmental and human-related hazards, emerging nanomaterials and potential risks thereof, social and natural science research to support balanced risk governance of new nanomaterials, nanoinformatics, exposure assessment at both environment and human population levels, and standardization of methodologies.

Therefore, the scientific aim of the Opus 18 project is to define, recognize, and finally enable to control the toxicological features of an innovative group of nano-laminated (layered) two-dimensional (2D) structures of early transition metal borides (2D MBene phases), prepared of their respective MAB phases. In particular, the project focuses on defining experimentally, and theoretically the toxicity-generating as well as toxicity-mitigating key features of the 2D MBenes as well as elucidating, and verifying their mechanisms of action in relation to investigated types of model organisms (mammalian cells *in vitro*, microorganisms, algae, seed plants, invertebrates, and vertebrates from a variety of ecosystems). The project objective is also the development of the acute and chronic toxicity testing methods, specifically tailored to 2D MBene phases, as well as the development of efficient methods of controlling their potential toxicity. The obtained results boosted by international collaborations from the opposite ends of the world (USA, Russia) concentrated in the middle (Poland), will be of high scientific value, mostly first-principles, with significant innovation potential. Therefore, also patentation of the most significant results of some commercialization potential is planned within the project. Documented effects of project realization will be publications in highly-ranked JCR journals, and high-impact communicates at national and international removed scientific conferences, especially focused on MBene and MXene structures. The additional result will be the formation of a solid, interdisciplinary, and international scientific research team, which will involve qualified post-docs and contractors personnel with scientific and practical experience due to meet the high requirements of this project as well as Ph.D., Master, and Bachelor students.

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[3] A. Montagner et al. 2D Mater. 4, 2017, 012001;
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[5] https://ec.europa.eu/jrc