Title: Are 2D materials safe for our skin? A toxicological perspective.

Abstract:
Two-dimensional materials (2DM), including graphene-based materials (GBMs), hexagonal boron nitride (hBN), molybdenum disulfide (MoS_2), black phosphorus (BP), and others, have gained significant attention across scientific and industrial domains due to their exceptional physico-chemical characteristics. As their production and commercial application expand, it becomes increasingly important to assess their potential risks for human health, generating solid data to support safety evaluation and regulation.

Among the various possible exposure routes, dermal contact represents a particularly relevant way of contact with humans, both in occupational settings for workers and through consumer-facing products incorporating 2DM. To investigate this aspect, we evaluated the skin toxicity potential of selected 2DM using both conventional *in vitro* systems (e.g., cultured keratinocytes) and more advanced models (e.g., 3D human epidermis and *in vivo* models). In several cases, the application of Test Guidelines given by the Organization for Economic Cooperation and Development (OECD) enabled the collection of reproducible toxicological data suitable for regulatory purposes.

This work provided insights into the skin-related adverse effects potentially induced by 2DM — such as irritation, corrosion, and sensitization — after a direct cutaneous contact and contributed to elucidate their mode of action at the epidermal level. Overall, our findings support the development of safer applications of 2DM technologies through a better understanding of their biological interactions with the skin.

Short bio:

Prof. Marco Pelin graduated in Pharmaceutical Chemistry and Technology at the University of Trieste (Italy) in 2007 and earned his PhD in Chemical and Pharmaceutical Sciences and Technologies in 2012, with a focus on skin toxicology. He was appointed tenure-track Assistant Professor in 2021 and has become Associate Professor of Toxicology and Pharmacotherapy at the same University since 2024.

His research focuses on hazard characterization of nanomaterials and natural substances, particularly in relation to skin toxicity, within the framework of several national and EU-funded projects. He currently serves as EU coordinator of the ERA-NET Safe2energy project (SAF€RA2022 call) and as principal investigator in the Italian Tox-IT project (PRIN 2022). He also participated in multiple EU (including the H2020 Graphene Flagship) and national research projects, both as principal investigator and as a member of the University of Trieste team.

Prof. Pelin is a member of the Italian Society of Toxicology (SITOX), Italian Society of Pharmacology (SIF), the Innovative Advanced Materials Initiative (IAM-I), the National Interuniversity Consortium of Materials Science and Technology (INSTM) and he has been recently involved in the activities of the OECD Working Party on Manufactured Nanomaterials (WPMN). He is co-author of ~70 peer-reviewed publications (31 as first, corresponding, or last author; h-index: 26, >2100 citations – SCOPUS) and in over 100 national and international conference contributions.