Supporting the development of sustainable nano-based formulations for the restoration of modern and contemporary works of art

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Currently there is a lack of methodologies for the conservation of modern/contemporary artworks, many of which will not be accessible in short time due to extremely fast degradation processes. In this context, the application of nanotechnology already showed promising results and more solutions are currently being explored in the frame of the NANORESTART (NANOmaterials for the REStoration of works of ART) H2020 project. In particular, the project aims at developing nano-based formulations to ensure long term protection and security of modern/contemporary cultural heritage, taking into account environmental and human risks, feasibility and materials costs. Specifically, it focuses on: (i) tools for controlled cleaning, such as highly retentive gels for the confinement of enzymes and nanostructured fluids based on green surfactants; (ii) the strengthening and protection of surfaces by using nanocontainers, nanoparticles and supramolecular systems/assemblies; (iii) nanostructured substrates and sensors for enhanced molecules detection. To support the developers of new materials in designing safer and sustainable products, a four steps strategy was designed and is currently adopted in the project. First, a list of potential ingredients (along with their Material Safety Data Sheets) is collected for each proposed innovative formulation together with its composition (as ranges of percentage in weight for each ingredient). This allows to apply the self-classification approach included in the EU Classification, Labelling and Packaging (CLP) regulation with the aim to classify each formulation according to a set of human health and environmental hazards and to advise the material developers about weight thresholds that should not be exceeded in order to avoid specific hazards. Secondly, information on conventional counterparts already in the market (including their Safety Data Sheets) are collected to prioritize the most promising new formulations: on these products physico-chemical characterization in environmental and biological media as well as (eco)toxicological testing are performed. Toxicity tests are carried on according to internationally standardized testing protocols (ISO and OECD) and EU REACH regulation requirements [e.g. in vitro: SOS-ChromoTest and UMU-ChromoTest; in vivo: MicrotoxTM, microalgae (Pseudokirchneriella subcapita) and Daphnia magna]. Physico-chemical characterization includes spectroscopic and light scattering techniques [Inductively Coupled Plasma-Mass Spectrometry (ICP-MS), analytical centrifuge (Dispersion Analyser) and Dynamic Light Scattering (DLS)]. Estimated toxicity are then compared to the results of the self-classification approach in order to identify possible nano-specific hazards. Results support the third step, when environmental impacts along the life-cycle of the formulations are assessed (in particular in application and post-applications stages). Finally, in the fourth and last step, environmental impact assessment results are combined with technical (e.g. stability, compatibility, re-treatability), economic (e.g. market price) and social (e.g. ethical) criteria in order to derive a conclusion on the overall sustainability of the innovative nano-based products.

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