RESEARCH ARTICLE

A methodology on how to create a real-life relevant risk profile for a given nanomaterial

With large amounts of nanotoxicology studies delivering contradicting results and a complex, moving regulatory framework, potential risks surrounding nanotechnology appear complex and confusing. Many researchers and workers in different sectors are dealing with nanomaterials on a day-to-day basis, and have a requirement to define their assessment/management needs. This paper describes an industry-tailored strategy for risk assessment of nanomaterials and nano-enabled products, which builds on recent research outcomes. The approach focuses on the creation of a risk profile for a given nanomaterial (e.g., determine which materials and/or process operation pose greater risk, where these risks occur in the lifecycle, and the impact of these risks on society), using state-of-the-art safety assessment approaches/tools (ECETOC TRA, Stoffenmanager Nano and ISO/TS 12901-2:2014). The developed nanosafety strategy takes into account cross-sectoral industrial needs and includes (i) Information Gathering: Identification of nanomaterials and hazards by a demand-driven questionnaire and on-site company visits in the context of human and ecosystem exposures, considering all companies/parties/downstream users involved along the value chain; (ii) Hazard Assessment: Collection of all relevant and available information on the intrinsic properties of the substance (e.g., peer reviewed (eco)toxicological data, material safety data sheets), as well as identification of actual recommendations and benchmark limits for the different nano-objects in the scope of this projects; (iii) Exposure Assessment: Definition of industry-specific and application-specific exposure scenarios taking into account operational conditions and risk management measures; (iv) Risk Characterisation: Classification of the risk potential by making use of exposure estimation models (i.e., comparing estimated exposure levels with threshold levels); (v) Refined Risk Characterisation and Exposure Monitoring: Selection of individual exposure scenarios for exposure monitoring following the OECD Harmonized Tiered Approach to refine risk assessment; (vi) Risk Mitigation Strategies: Development of risk mitigation actions focusing on risk prevention.

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INTRODUCTION

In the last decade, nanotechnology entered the policy arena as a technology that is simultaneously threatening and promising.[1] The combination of size, structure and physical/chemical properties of nanomaterials (NMs) offer remarkable technological advances and innovations but may also entail new risks for human health and the environment.[2–4] Thus, an appropriate management of nano-related risks have been identified by the EU Commission as a vital empowering issue for the success of NMs and nanotechnologies.[5] One bottleneck that hinders the safe and sustainable development of nano-innovations in various industrial sectors is that nano-specific legislative

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measures at the EU level are currently vague; while a decade of research in nanotoxicology has failed to identify specific modes of action for nanomaterial toxicity,[6] the regulatory framework has been growing disorderly, creating an uncertain environment for industry.[7,8]

In the European Union, NMs are considered as a chemical substance and therefore fall in the existing regulatory framework of regulation 1907/2006[1] concerning the Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH). Since REACH does not explicitly integrate provisions regarding NMs, they are bound to registration like other substances. Since February 2012, registrants can voluntarily declare that their substance is in "nanomaterial form" and with the Second Regulatory Review on NMs produced by the Commission in the same year, the regulator promised improvements to the registration of such substances under REACH, including potential amendments of the Regulation's annexes. This process is currently under progress, but will not be ready for the 2018 registration deadline for substances manufactured or imported in amounts exceeding one ton a year as a two-year standstill period applies.

In addition, several pieces of sectoral European regulation directly target NMs and nanotechnology (e.g., food and novel foods, cosmetics, biocides, electronic waste, etc.). To support a harmonized understanding of what constitutes a nanomaterial, the European Commission has published a Recommendation for a Definition of a nanomaterial (696/2011)[2] which defines a nanomaterial as follows:

'2. 'Nanomaterial' means a natural, incidental or manufactured material containing particles, in an unbound state or as an aggregate or as an agglomerate and where, for 50% or more of the particles in the number size distribution, one or more external dimensions is in the size range 1 nm–100 nm. In specific cases and where warranted by concerns for the environment, health, safety or competitiveness the number size distribution threshold of 50% may be replaced by a threshold between 1 and 50%.'

While this definition has been taken up in most of the European and national legislation tackling NMs, there remains a variety of definitions (e.g. NMs for food, etc.). A review of this definition is also currently at work by the European Commission. Regulatory measures specific to NMs range from labelling requirements to additional testing and pre-market authorisation.

On top of this EU Framework, some EU Member States, including France, Belgium, Denmark and Sweden, have developed nanomaterial registers which condition the manufacturing, importation and distribution of NMs to their prior registration in a national database.

As a consequence, researchers are unsure how to work safely with NMs. Industry dealing with NMs has to cope with an unstable and unreliable framework to develop safe and legally compliant products, and consumer and public confidence of emerging nano-innovations may severely be affected.[9]

Another problem is that reliable toxicity information and data on the levels of NMs that the worker, consumer and environment may become exposed to are either limited or non-existent. Without such data, it is difficult to quantify exposures and it becomes even more difficult to effectively respond to any potential nano-related risks.[10,11]

Although relatively limited data are available, the fact remains that NMs and/or nano-enabled products may pose a risk depending on their potential hazard and exposure properties. Nonetheless, it cannot be concluded that nano-related risks are higher compared to conventional materials/bulk counterparts. Still, a strategic framework that can properly define the nature of nano-related risks is needed.[12–14]

According to legislation and the current knowledge, NMs have to be treated the same way as chemical substances, which means the standard information requirements and the Chemical Safety Assessment (CSA) described in the Annexes VII–X of the REACH regulation shall be applied. Quantitative risk estimation represents the most important feature of a CSA. Under REACH, risk estimation/characterisation is defined as the comparison of exposure levels and hazard levels leading to the calculation of a Risk Characterization Ratio (RCR). However, in the case of NMs quantitative risk assessment is not feasible due to the fact that presently neither agreed standardised, validated and specific methods for measuring personal exposure (i.e., breathing zone measurements) to engineered NMs are available nor are there validated models providing quantitative estimates of human (worker and consumer) or environmental exposure.[15] The technical limitations of currently available sampling and analytical methods may also raise issues and might not propose sufficient sensitivity to properly assess very low exposure levels.[16] The best available guidance for exposure measurement suggests that in addition to an appropriate characterisation of particle size distribution, measurements should at least encompass an assessment of mass, but where possible also include number and/or surface area concentration.[17,18]

Confronted with these limitations, it was decided that the most sensible course of action is to focus on (i) qualitative risk assessment covering all

[1] EC, 2006. Regulation (EC) 1907/2006 of the European Parliament and of the Council on the Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH), establishing a European Chemicals Agency, amending Directive 1999/45/EC and repealing Council Regulation (EEC) No 793/93 and Commission Regulation (EC) No 1488/94 as well as Council Directive 76/769/EEC and Commission Directives 91/155/EEC, 93/67/EEC, 93/105/EC and 2000/21/EC. OJ L; http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:02006R1907-20140410&from=EN.

[2] European Commission 2011 (2011/696/EU). Commission recommendation on the definition of nanomaterial. OJ L 275/38, 18 October 2011.

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