Engineered nanomaterial mechanisms of interactions with living systems and the environment: a universal framework for safe nanotechnology

Results in Brief

‘Safety by design’ for responsible nanotechnology

The EU-funded NANOMILE project has helped unlock the promise of nanotechnology by developing a tool to better assess the environmental impact of nanomaterials, keeping it safe.

Nanotechnology has long been touted as a game changer for meeting the needs of modern life, with implications ranging across sectors from health to housing. With estimates that nanotechnology is integrated into half of newly designed advanced materials and manufacturing processes, there is an increasing requirement to better understand its environmental impact, especially on living systems. While research efforts have focused on issues around potential health effects, investigation into the
actual mechanisms still remains under-researched.

The EU funded NANOMILE project set out to fill this knowledge gap by studying environmental transformation within the nanomaterial life cycle and across a wide range of target species and nanomaterials, focusing on mechanistic effects to identify harmful properties that could be avoided to ensure safer applications. The project developed a computational model capable of predicting hazards from nanomaterials.

Developing hazard and risk assessment tools

NANOMILE first created a testing and selection platform which enabled the team to apply a high throughput screening process to the selected manufactured nanomaterials (MNMs), ascertaining their toxicity. As the project coordinator Professor Eugenia Valsami-Jones recalls, ‘We tested more than a hundred MNMs. To challenge prevailing ideas, we used several criteria for the MNMs, including size, lifecycle, possible mode of action and relevance to commercial products. As we also wanted to be systematic, we produced property libraries where we experimented with variants around a single property. This enabled us to methodically test various hypotheses.’

An example of how the project set out to test various hypotheses systematically was by ageing the selected MNMs under different scenarios. Nanoparticles were aged through exposure to air and light, as well as within simulated real-life conditions, such as that experienced by antimicrobial nanoparticles (for example silver) within washing machines simulating their fate in textiles. These efforts have resulted in the creation of what could be the largest systematically tested nanomaterials characterisation data-set in the world.

The next stage for the team was the development of computational models based on the established nanomaterial behaviour, and supplemented with image analysis to maximise the predictive potential of the model. As Prof Valsami-Jones explains, ‘The modelling is based on an approach called Quantitative Nanoparticle Activity Relationship which essentially identifies the relationship between nanoparticle characteristics and biological activity before predicting the behaviour of other similar nanomaterials.’

The actual model interface enables researchers to input or select variables such as nanoparticle type (for example metal) or shape, identify an analysis to run, before the system displays a prediction for likely hazard. As the professor concludes, ‘Although our models are still at the early stage of development, we were able to make the first important step towards predictive nanotoxicology.’

Supporting regulation for safe and responsible nanotechnology
The project results contribute significantly to understanding the risks which MNMs might pose to health and the environment based on a better appreciation of the mechanisms involved in toxicity. Indeed, NANOMILE has already played its part in wider efforts to develop a regulatory framework for the sustainable applications of nanotechnology, by initiating or contributing to ISO standards. An example being the standard for MNMs toxicokinetics, which measures uptake, transport, transformation and elimination of nanomaterials in a biological context.

In conjunction with industry partners the project has also already generated a number of market-ready methodologies for MNM hazard assessment, for example with the release of the Vitrocell Air-Liquid Interface (ALI) platform which mimics lung exposure to nanomaterials.

These efforts should help unlock the full potential of nanotechnology which has been valued by some as reaching into the trillions of euros over the coming years.

**Keywords**

NANOMILE, nanomaterials, nanotechnology, risk assessment, computer modelling, ISO, advanced materials, environmental impact, hazard prediction, nanotoxicology, toxicity

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**NANOMILE**

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