

FAST FACTS

Duration:

42 Months

Completion Date:

February 2019

Total Funding:

€10 Million

Partners:

42 across 15+ countries

Objective:

Establish Safe by Design as a fundamental pillar in the development of nanomaterials or nano-enabled products

Outcomes:

- Nanomaterial
- grouping strategy
- Associated
- integrated testing
- strategy

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Nanomakers Industrial Demonstrator

Safe by Design in Action

Goal: To reduce the impact of human and ecological toxicity

Safe by Design measures: Increased nanoparticle size and undertake a coating step.

Outcomes: Reinforce the strategy towards improving product performance and raw materials use.

Nanomakers is a French company that produces a wide range of silicon-based nanomaterials for use in mechanical reinforcement and lithium-ion batteries. During the NanoReg2 project, the focus of the Industrial Demonstrator was the final stage of the value chain, for products intended for production on a large scale and sold to customers. Three nanomaterials were selected for inclusion in this Demonstrator:

- Pure silicon nanoparticles with a diameter of 40 nm diameter (named Si 40 nm)
- Silicon nanoparticles coated with an amorphous carbon shell and 40 nm in diameter (named SiQC 40 nm)
- Silicon nanoparticles coated with an amorphous carbon shell and 75 nm in diameter (named SiQC 75 nm)

The nanoparticles in this study were designed to be used alongside graphite in the anode of lithium-ion batteries to provide enhanced battery performance. The silicon nanoparticles were synthesised using Nanomakers' own patented laser pyrolysis method, which uses a combination of gaseous silane precursors and a high-power CO₂ laser to break up and recombine the atoms in the reaction chamber to form crystalline silicon nanoparticles.



The Safety Approach from Nanomakers

Prior to the NanoReg2 project, Nanomakers was aware of Safe by Design, but was using an existing internal approach based on non-contact strategies, safe industrial production and product risk evaluations. Regarding French regulations, Nanomakers conformed to French environmental regulation for manufacturing tools plus the international transport regulation for chemicals, neither of which are specific to nanomaterials. REACH registration was not yet necessary due to sub-tonne material production. The safety tools used by Nanomakers prior to the NanoReg2 Industrial Demonstrator involved grouping the bulk chemical materials together before undertaking flammability and dustiness tests.

It was determined that the risk of exposure and physical hazards was most likely to occur through accidental means. As a result, Nanomakers aimed to assess human and environmental risks. Another focus was to compare the product impacts using selected criteria and find a tool that can compare all relevant parameters, enabling prioritisation of action.

The three products chosen for the demonstrator had the same end-use application, similar functionalities and equivalent risk profiles. Therefore, the main driver in choosing between them was their application performance, with the aim to find factors that could influence the final choice of product going forward.

Industrial Demonstrator Activities within NanoReg2

To develop a safer silicon-based nanomaterial, Nanomakers opted to address the 'safe product' and 'safe use' pillars of Safe by Design. It implemented three risk assessment tools; the Swiss Precautionary Matrix (SPM), NanoRiskCat and NanoSafer 1.1, plus life cycle assessments, risk assessments and socio-economic analyses. The study was based on four main steps.

Step 1 was the comparison of the physical hazards, ecotoxicity and toxicity of each of the products, as it became apparent early in the process that all the hazards had to be characterised due to a lack of information in the literature.

Step 2 used the data collected in the first stage and applied it to various risk assessments, with an attempt to link the physicochemical properties of the nanoparticles to the main hazard properties. The risk assessments had to be adapted for the study, and they were supported by the life cycle analysis and socio-economic analyses.

Step 3 took all data generated from steps one and two to propose and develop a safer nanomaterial by applying Safe by Design concepts and then characterising the potential hazards of the new nanomaterial to validate the use of Safe by Design. In this instance, because Nanomakers focused on two pillars, specific assessments had to be used, especially for the 'safe use' pillar, which included using the life cycle assessment and socio-economic analyses to evaluate the product against existing technologies.

Step 4 of the Demonstrator was to identify the electrochemical performances of the safer nanomaterial and to provide a comparison against other products and their properties. This was primarily done through risk assessment tools.



Outcomes from Safe by Design Actions

Not all the required data gaps were filled during the NanoReg2 Industrial Demonstrator, as it was not possible for human toxicity and the long-term effect on humans within the timeframe and budget of the project. However, it has been possible to use data from existing models to predict the effects in humans and fill in some gaps with Nanomakers own flammability and dustiness data. Whilst the Safe by Design approach did not fulfil all its needs at this point, it enabled Nanomakers to gain a better understanding of its products, and has helped to reinforce its strategy towards improving product performance and raw materials use.

From the different products chosen for the Demonstrator, results indicated that the final performance is more important than the risk, as many risks appear to be low and comparable. Nanomakers chose to pursue the SiO₂ 40 nm nanoparticles and it has now produced a range that is more efficient for battery applications, as well as optimising some of the production parameters to lower the risk at the production stage. Risk Assessment was carried out following data generation, with the recommendation that inhalation exposure should be minimised (with little difference between the three nanomaterials). The main benefit for Nanomakers was associated with size and particle coating, which primarily dictate the performance of the nanoparticles. Nanomakers has continued efforts to improve the product performances, in addition to optimisation of raw materials with high impacts.

Nanomakers identified one barrier during the Demonstrator within its organisation, the need to obtain production data for each type of product, with this data not always readily available. Outside the company, it found the timeframe to be incompatible with industrial product development and sometimes found it difficult to communicate with other partners. As Nanomakers was implementing Safe by Design before the project, but without recognising it as such, it will continue to use Safe by Design in future projects within a suitable context for industrial development.

Summary

Nanomakers was using Safe by Design principles within production development prior to the NanoReg2 Industrial Demonstrator, without being aware of the term SbD.

Through the NanoReg2 project, Nanomakers extended its application of SbD to reduce human and ecological impact, however the products' low toxicity shifted the focus on the raw material use and the product performance optimisation.

The full range of Safe by Design protocols brought into the company through the Demonstrator are not sustainable commercially, however Nanomakers will continue to apply SbD principles in future development.