

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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Avanzare Industrial Demonstrator

Safe by Design in Action

Goals: To reduce emissions to the workplace and reduce waste during synthesis, plus safe product for end users.

Safe by Design measures: Adaptation of wet phase synthesis in water, recycling of liquid waste into new batches, product distributed within liquid phase, exposure assessment performed and local ventilation system installed.

Outcomes: The company shifted to zero liquid waste and almost eliminated employee handling of graphene in powder form.

Avanzare is an advanced materials company from Spain which develops, produces and commercialises specialty additives for different materials, mainly plastics and rubber, across many different industries.

For the NanoReg2 project, Avanzare focused on scaling up powdered graphene and developing a process for its production in a liquid medium. Graphene has many desirable properties which make it suitable for many end-user markets, and the graphene from Avanzare has been selected by the European Space Agency (ESA) for use in aerospace applications.

There are four main properties Avanzare that targets for its graphene product. These include high electrical conductivity, high thermal conductivity, high rate of absorption for microwaves and finally, barrier properties. If the resulting product could achieve two of these four properties, commercial applications under consideration could include anti-static paints and coatings, electronically dissipative (ESD) paints and coatings, electrically conducting ATEX paints and coatings (for use within explosive atmospheres), coatings designed to prevent electric shock from lightning strikes, solar thermal collectors, and coatings which can absorb electromagnetic radiation.

Graphene in a liquid medium is suitable for many of the above applications across several markets. This is especially true for water-based paints and coatings, however a liquid medium is not a suitable form for all Avanzare's customers. Prior to NanoReg2, Avanzare was producing graphene on a scale of 8 kg/day. To be competitive price wise with other carbon nanomaterials by 2020, Avanzare needed to scale the production up to 250 kg/day. Choosing graphene for the Industrial Demonstrator presented Avanzare with an excellent opportunity to increase the graphene production to meet new demands, assess the occupational and environmental exposure during scale up and assess all risks using a Safe by Design approach.

avanzare

nanomaterials part of our everyday life



The Safety Approach of Avanzare

Graphene is considered to be a high aspect nanomaterial (HARN). HARNs are an interest point for the World Health Organisation (WHO), because they have the potential to be inhaled and are biopersistent. HARN are defined by the WHO to be materials with length greater than 5×10^{-6} m, a width less than 3×10^{-6} m and a length-to-width ratio (aspect ratio) greater than 3:1. The hazard profile of HARNs are influenced by their chemical composition, biopersistence, size, and shape. When no information is available that discredits biopersistence, it should be assumed that the nanomaterial is a potential concern to human health. Additionally, because of the platelet size and low aerodynamic diameters of graphene, it is possible that graphene could be a toxicological concern.

Prior to the start of the NanoReg2 project, Avanzare was not aware of Safe by Design, but had already applied safety concepts that would be considered as Safe by Design. Because some safety information data was missing, Avanzare classed graphene as a risk material, so all employees wear appropriate personal protective equipment (PPE). When the graphene production process was first considered, Avanzare's aim was to minimise the risk to both employees and the environment. It had proposed that graphene was retained in a liquid medium to reduce employee exposure and that the production process should be in a closed-circuit system. Avanzare used water as a solvent to minimize the impact on the environment and employee exposure compared to that from organic solvents. Thus, retrospectively, Avanzare had been employing a Safe by Design approach without recognising it as such.

Avanzare needed to comply with REACH requirements only if production exceeded one tonne per annum. Avanzare already followed the health and safety legislations set out by the Spanish Government. There was also regional legislation regarding environmental protection that Avanzare followed, as well as adhering to the recommended European Commission Code of Conduct on Responsible Nanosciences and Nanotechnologies Research, and the Second Regulatory Review on Nanomaterials.

Industrial Demonstrator Activities within NanoReg2

Avanzare focused its Industrial Demonstrator around the 'safe production' and 'safe use' pillars of Safe by Design. The ambition behind choosing these pillars included anticipating any regulatory changes that would prevent market access, plus enabling the company to produce safer products, ensure the safety of employees, consumers, and the environment, and to assess the risks before the production started. The goals within the NanoReg2 Industrial Demonstrator were to reduce emissions within the workplace, reduce waste during synthesis, and create a safe product for end users.

Avanzare carried out a screening risk assessment with two control banding models (SPM and Nanosafer 1.1) at project start, to identify any hotspots and where there was a lack of data. This assessment identified that the drying and packaging areas of the production stage were the most likely to present an exposure risk, due to the dustiness of graphene and a lack of local exhaust ventilation. These also indicated the need to test for nanomaterial stability, redox activity, oxidative stress and inflammation. Due to the characteristics of the nanomaterial, inhalation toxicity and dustiness were also identified as information gaps. During the inventory for life cycle analysis (LCA), it became evident that ecotoxicity end of life of the product information was also needed. Exposure was another parameter required for risk.

To reduce employee exposure in the hot spots identified by the control banding tools, Avanzare implemented different measures to reduce these chances. The first was the elimination of the drying step by delivering the graphene in liquid media for those applications for which it was compatible. For those applications that required dry graphene, a semi-automatic packing system was introduced that reduced exposure during this step. Avanzare also increased the dimensions of the packaging room, to lower the nanoparticle to air ratio. The third measure was the implementation of a Local Exhaust Ventilation (LEV) system at the drying step to further reduce employee exposure.

Outcomes from Safe by Design Implementation

The Industrial Demonstrators filled all the required data gaps for Avanzare. Toxicological testing showed that the graphene product and the liquid intermediate have similar hazard profiles, with a slightly raised tendency to produce inflammatory reactions for the liquid intermediate and a slightly greater (eco)toxicity for the powder graphene in fish cell lines.

The effectiveness of the SbD measures implemented were evaluated with three RA models: the Swiss precautionary Matrix (SPM), Nanosafer 1.1 for comparison and with the Weight of Evidence (WoE), and with LCA.

All the models indicated an improvement in the safety of the production process by a decrease in the exposure levels. However, there were differences between the results from the models. The weight of evidence model indicated the risk of exposure is low after SbD. Nanosafer however still gave a high potential exposure, while SPM indicated no difference. This may be due to an overestimation of the risk due to the high precautionary nature of the control banding tools.

LCA also measured an improvement in environmental impacts associated to indoor emissions of CNFs, although in general, the contribution of direct GNP emission to the global environmental impact is very low. This limited contribution was associated to two aspects: the emission in the use phase is expected to be low (according to tests performed) and the destruction ratio in end of life high, while the impacts related to GNP in production phase were low compared to the implications of material and energy consumption. The measured impact reduction in this SbD scenario was primarily linked to lower energy demand during production, due to the elimination of the high energy consumption drying step and reduced transportation volume requirements in distribution.

Summary

The initial goal for Avanzare was to reduce emissions to the workplace, reduce waste during synthesis, and create a safe product for end users.

Safe by Design measures implemented during the Industrial Demonstrator included the adaptation of wet phase synthesis in water, recycling of liquid waste into new batches, product distributed within liquid phase and a local ventilation system installed.

The outcome was that Avanzare shifted to zero liquid waste and almost eliminated employee handling of graphene in powder form.

Avanzare has not reported any barriers through the Demonstrator, either internal or external, and stated that it would consider Safe by Design again for its own products and processes. Decisions will be based on cost of SbD assessments and implementation, as each situation will be unique.