

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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Grupo Antolin Industrial Demonstrator

Safe by Design in Action

Goal: To reduce emissions in the workplace and select safer nanomaterials for scale up.

Safe by Design measures: Automation of collection methods plus nanomaterial optimisation of specific surface area, crystallinity and surface functionalisation through production method comparisons.

Outcomes: Reduced occupational exposure and selection of production method for safest nanomaterial.

Grupo Antolin is a multi-national company headquartered in Spain, with its division Advanced Carbon Materials (ACM) developing, producing and marketing carbon nanofibres (CNF) and graphene derivatives. GANF and GAtam carbon nanofibres are produced for use within plastic parts for automotive applications. When the NanoReg2 project commenced, Grupo Antolin was at the pilot plant stage of production.

Currently, the industrially produced carbon nanofibres from Grupo Antolin are the only known nanofibres which are synthesised using a chemical vapour deposition (CVD) method alongside a floating catalyst composed of nickel (as well as a sulphur co-catalyst). Both types of carbon nanofibres produced by Grupo Antolin are synthesised in this way, which means that they have similar grades and few metal impurities. The two fibre types have slightly different structural properties and significantly different surface properties.

Whilst the method is known to produce high-quality carbon nanofibres, it was believed that the GAtam was more scalable because higher flow rate can be used to introduce the precursor gases and catalyst to the reaction furnace, compared to GANF. Thus, the main aim from a market and production perspective for becoming involved with the NanoReg2 project was to see which of these two carbon nanofibres should be scaled up to 1 tonne per year for use in reinforced polymer applications. This included comparing the safety studies between the two materials in addition to aspects impacting the production scale-up.



Aims for Implementing Safe by Design

Prior to the NanoReg2 project, Grupo Antolin was not familiar with the concept of Safe by Design. Although no Safe by Design measures had previously been undertaken, preliminary toxicological *in-vitro* studies had been completed on the GANF carbon nanofibres. Results showed that the GANF carbon nanofibres are non-corrosive and non-irritant to the skin or eye and are non-mutagenic. Other studies demonstrated no inflammatory effects in human keratinocytes, nor any ill-effects on human respiratory cells. Additional studies were required for the GAtam carbon nanofibres to compare toxicological properties and the risks/safety issues associated with each nanofibre for a more informed selection of a candidate for scale up.

The overall aim in this Industrial Demonstrator was to understand implementation of Safe by Design for these carbon nanofiber products and also for future products. It would compare the two and their production processes for risk and sustainability, select the best one for scaling up and finally advise the safest scale up. This included determination of any safety issues during the production, storage and cleaning stages of the production process.

SbD implementation included i) preliminary risk assessments to identify safety hotspots during the production process ii) filling gaps in human and environmental risk information and to design and iii) implementing measures to eliminate or at least reduce them.

It also included evaluation of the effectiveness of measures using risk assessment (RA) control banding tools (as a comparison with the initial situation) and also SUNDs and Weight of Evidence (WoE) for a fuller assessment. Sustainability was assessed using life cycle analysis (LCA) to give an assessment of impacts beyond those from the RA models. Finally, the company aimed to reduce the exposure of employees and complete any missing data and knowledge gaps for risk and regulatory aspects associated with both materials.

Industrial Demonstrator Activities

During the course of the project, Grupo Antolin focused on the 'safe nanomaterials' and 'safe production' pillars of Safe by Design. For the identification of hot spots and gaps a screening risk assessment was performed with two tools: the Swiss Precautionary Matrix (SPM) and Nanosafer 1.1. The SPM assessed the risk for employees and the environment at different stages of the nanomaterials' production life cycles, reviewing catalyst production and dosing, production of the carbon nanofibres, their surface treatment, dispersion in liquid media and storage.

Nanosafer 1.1. assessed the handling of powders and point source emissions, using multiple control bands to assess the hazards, exposure and risk. Stages of the production assessed included CNF production, dispersion in liquid media and storage. When unknown for the CNF, data of the bulk material (graphite) were used. The SRA and the inventory performed for the LCA indicated some data gaps that needed to be filled and that included (eco)toxicity, exposure and use and end of life tests (ageing).

Safe by Design measures implemented included process automation and selection of safest and more sustainable nanomaterials. Their impact was assessed with SUNDs and WoE models and with LCA for sustainability aspects. In the WoE model, the assessment endpoint was the environmental and/or human value to be protected, while the measurement endpoints were a set of information used to evaluate the assessment endpoint. A hazard and exposure index was calculated using all the evidence provided from the study.

Outcomes from Safe by Design implementation

The Industrial Demonstrator outcomes contributed to changed company practice. For example, Grupo Antolin implemented an automatic pneumatic transport instrument which cleans itself, reducing the likelihood of employee exposure to the nanomaterials, an outcome linked to reduced occupational exposure.

Life cycle assessment (LCA) indicated that the method for producing GAtam was more energy efficient and presented a lower environmental impact than the GANF method. More data is needed before Grupo Antolin makes an informed decision about which carbon nanofibre to scale up.

Another area of process change was at the surface treatment stage of carbon nanofibre production. An automated transport system now moves CNFs to a silo which discharges them to a ductless fume hood with ventilation, ensuring no exposure to employees. Additionally, the ventilation in areas where the nanofibres were stored, weighed and dispersed was also improved. Further improvements towards the implementation of an automated gravimetric dosing system for the dispersion and packaging stages are set to be put in force after the end of NanoReg2, to further reduce the occupational exposure at different stages of the production life cycle. The outcome further improved occupational exposure conditions.

For the two carbon nanofibres under consideration, results from the testing in NanoReg2 have shown that their hazards are similar, although there are some differences in important properties such as specific surface area (SSA) and in end points such as inflammatory markers at different times during *in vivo* studies. Both nanofibres appear to present the same level of exposure risk throughout the production life-cycle. The Nanosafer 1.1. method suggested that the levels of exposure of GAtam at the storage and dispersion stages was slightly higher than GANF.

Overall, Grupo Antolin was highly satisfied with the NanoReg2 project and the introduction of Safe by Design to its processes. The knowledge gained will be of significant use to the company. Barriers to SbD introduction included time required to understand the risk assessment tools and implement the methods. Time and cost of changing production processes were also a challenge to plan and implement, particularly in the limited time constraints of the NanoReg2 project. As a result of the useful knowledge gained throughout the NanoReg2 project, Grupo Antolin will continue to apply Safe by Design approaches in the future.

Summary

Grupo Antolin started the Industrial Demonstrator with the aims to reduce employee exposure during production and select the production process delivering the nanomaterial with the safest profile.

Safe by Design measures implemented to achieve company aims included automation of nanomaterial collection methods, and comparison of production methods for nanomaterials with reduced SSA and surface functionalisation.

The Industrial Demonstrator for Grupo Antolin resulted in reduced employee exposure through automated nanomaterials handling and fully informed selection of an optimum production process.