Implementation of Safe-by-Design (SbD) and Safer and Sustainable by Design (SSbD) within the Health, Safety and Environment (HSE) Platform in South Africa

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The focus of the HSE Platform is to ensure the safety of those who encounter or apply nanomaterials (NMs) in occupational, and environmental settings and also from consumer products to mitigate its risks.

1. Safe by Design (SbD)

The aim is to conduct the risk assessment of the nanomaterials by assessing occupational, consumer and environmental exposures as well as the development of predictive tools to ensure safer innovation of nanotechnology in South Africa with safe by design (SbD) approach (Figure 1).

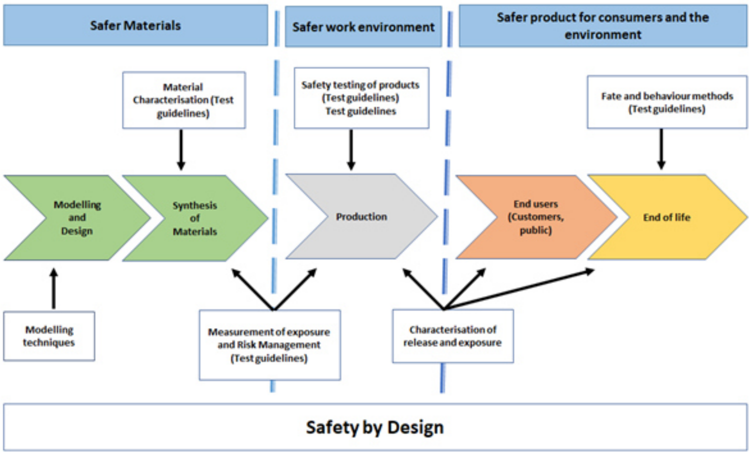

Figure 1: Safety by design

2. Safer Materials:

For Heman Health: For the early development and design phases of a new nanomaterial or nano-enabled product it is essential to identify the hazards of the nanomaterials synthesized. This involves the basic toxicological information to establish the

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relationship between designed nanomaterial properties, their interactions with biological systems and environmental systems, and effects at the cellular and molecular level. The development and use of validated assays is therefore a critical issue that needs to be addressed prior to their implementation to confirm or negate the toxicity of nanomaterials in this initial stage of SbD. Within this part of the SbD, in silico models computational modelling and were implemented since nanoparticles of various shapes, sizes, materials (elements) chemical properties etc. can be designed in a virtual environment and tested without any detrimental consequences (Ngake et al., 2022; Nqayi et al., 2022). Moreover, nanoQSAR modelling was developed to tailor metal oxides is the success of various synthetic methods in influencing the formation of desired faceted surfaces for toxicity prediction (Thwala et al., 2022; Nqayi et al., 2022). For safety testing, dissolution of nanoparticles as a measure of biodurability and persistence was assessed to provide an insight on the behaviour of these particles in biological and environmental surroundings (Mbanga et a., 2021; 2022a; 2022b; 2023). Participation in Round Robin on OECD Test guidelines on dissolution was also conducted. Moreover, the assessment of lysosomal membrane permeabilization (LMP) as a prediction of the long-term toxic effects of nanoparticles is established as well as a new work item proposal was made to ISO. Within this project, the methodologies the methodology to assess free radicals using cyclic voltammetry is also established. Finally, culturing and characterizing representative alveolar- and bronchial-barrier co-culture models, at the ALI to investigate systemic translocation was also established.

For Environmental health: Nanomaterials synthesised in research laboratories and in industrial settings were tested for their environmental exposure (aqueous and diet) using aquatic model organisms (macroinvertebrates and fish). Bioassays are conducted in the National Bioassay Facility at NWU using zebrafish and daphnia as model organisms.

3. Safer Work Environment:

The important of exposure assessments has been influenced by a rapid increase in the mass production of nanomaterials and their application in various fields of work including water treatment, food technology, pharmaceutical applications and human care products. This development has also evoked increasing societal and industrial concerns regarding incidental release of nanoparticles which may threaten employee's safety. Exposure assessment was therefore conducted in South African research laboratories and also in industrial settings during the synthesis and handling of nanomaterials.

Safer product for consumer and the environment:

The section above has demonstrated that applications of nanoparticles can improve the efficiency of a wide range of consumer and industrial products. However, unlocking this potential requires a responsible and co-ordinated approach to ensure that potential challenges are being addressed in parallel with the development and use of nanotechnology. Safety assessment of nanomaterials should be incorporated in the early developmental stages of nano-enabled products rather than later where a nanomaterial has reached the market.

4. Safer and Sustainable by Design (SSbD)

The SSbD approach addresses the safety and sustainability of the material/product and associated processes through the whole life cycle.

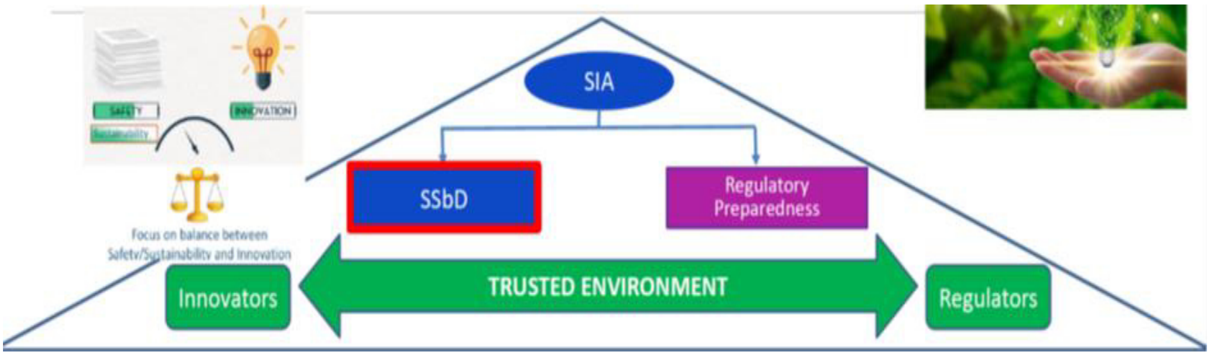

Figure 2: Safe and Sustainable by Design

The SSbD concept refers to identifying and minimising the risks and uncertainties concerning humans and the environment an early phase of the innovation process: Hazard, Exposure. And End of life

Stakeholder Engagement Plan:

A plan to guide the engagement process between the project team with various stakeholders/parties throughout the life of the DSI Nano HSE Risk project. This is to assist in developing safer nanotechnology and enable the risk assessment of nanomaterials synthesized in South Africa to facilitate their exports internationally and support government in areas requiring regulatory solutions for nanotechnology. A case in point, SabinanoTubesTM was chosen to implement the SSbD approach. This industry said to be supplying carbon nanotubes (CNTs) and graphene and graphene oxide. In addition, they seem to produce a large list of nanomaterials including different metal based nanoparticles. Sabinano indicated that they recognise the importance of research and innovation for the sustainability of the company. They also indicate that the founder and partners of the company have solid experience in nanotechnology research and its applications. They also mention the importance of sustainable development with the application of green chemistry and engineering principles to nanotechnology (green nanotechnology) and to use a renewable energy source (e.g. solar, wind, biomass).

5. References

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