HEALTH, SAFETY & ENVIRONMENTAL (HSE) MANAGEMENT

From core-shell production to final parts

Development of a complete workflow for producing and using a novel nanomodified Ti-based alloy for additive manufacturing (AM) in special applications

DEVELOPMENT OF CORE-SHELL NANOPARTICLES → POWDER FOR AM: SLM AND EBM → DEVELOPMENT OF AM PROCESS: SLM AND EBM → DEVELOPMENT OF AM POST-PROCESS → MATERIAL AND PROCESS QUALIFICATION → LIGTHWEIGHT STRUCTURAL METALLIC PARTS

The concept **Safe-by-Design** is developed as a way to incorporate **HSE** aspects in an **early stage** of the **innovation process** in order to **guarantee safety** at the workplace, for consumers, and the environment!

STEP 1: Nanomaterial identification

- By consortium partners, and VITO (in biological systems*)

STEP 2: Exposure assessment

- On-site visits for description of **exposure scenarios (ES)** and **exposure measurements (EM)**:

Lab-scale core-shell production (ES+EM), pilot-scale core-shell production (ES+EM), AM (ES), powder manufacture (ES; table 1), high kinetic processing and hot extrusion process (ES+EM; photo 1); other processes in line with project development*

- **NP release simulation*** in test chambers
- **Modelling*** (industrial scale, environment)

Activities	Gas atomization (VIGA); Pressure process (lab scale); Hot isostatic pressure (HIP)
Technical measures & operational conditions	Local exhaust ventilation for weighing balance; Fume cupboard for pressure process; VIGA, calcination, and HIP are contained
Personal protection	VIGA: short gloves, respiratory mask, overall Weighing: FFP3 mask, short nitrile gloves, lab coat
Environment	No direct release to surface water/soil /waste water; Release to air and possible deposition
Recommendations	First engineering controls than PPE, FP3 mask, long gloves; Separate nano-waste (label, bag-in-bag); clean with HEPA vacuum clearner followed by wet cleaning

Table 1: Example of ES during powder manufacture at CEIT

Photo 1: Exposure measurements during high kinetic processing at Zoz

STEP 3: Hazard assessment

- **Samples**: SiC (50 and 500 nm); SiC@TiO2 (50 and 500 nm); TiO2 (50 nm)
- In vitro **human hazard** testing: EYE, SKIN*, LUNG*

Bovine Corneal Opacity and Permeability (BCOP) test for EYE irritation (OECD TG437, photo 2): result: 'No prediction can be made' for all samples; further testing using SkinEthic™ HCE (OECD TG492)*

- **Ecotoxicity** testing*: Algae growth inhibition test (OECD TG201) and Daphnia acute immobilisation test (OECD TG202)

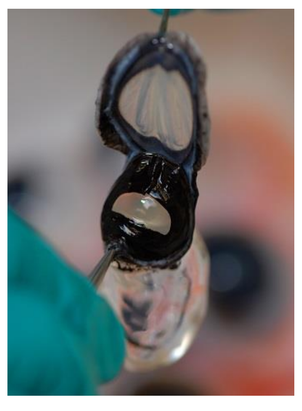

Photo 2 left-right: Excised cornea for BCOP experiment

STEP 4: Risk assessment*

- Comparison exposure values with (proposed) occupational exposure limits
- Identification residual health risk
- Comparison of emissions to the environment and PNEC values

STEP 5: Risk management*

- Recommendations for safe use (NP general, plant-specific)

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SLM: selective laser melting; EBM: electron beam melting; PPE: personal protective equipment; HCE: human corneal epithelium; PNEC: predicted no-effect concentration; *To be performed