TECHNOLOGICAL SOLUTIONS TO MINIMISE OCCUPATIONAL EXPOSURE TO INCIDENTAL NANOPARTICLES

V. San Félix[(1)], E. Monfort[(1)], M. Viana[(2)], M. Macarulla[(3)], A. Mayor [(4)], E. Domingo [(5)], S. Font [(6)]

(1) Instituto de Tecnología Cerámica (ITC). Universitat Jaume I. Castelló. Spain.
(2)IDAEA-CSIC, Barcelona, Spain.
(3)Department of Project and Construction Engineering. UPC. Terrassa. Spain.
(4)Unimat Prevención. Castelló. Spain.
(5)Keraben. Nules. Spain.
(6)TmCOMAS. Blanes. Spain.

ABSTRACT

Assessment of exposure to nanomaterials in industrial workplaces is a widespread challenge because of the diversity of nanoparticle (NP) sources, which include manufactured nanomaterials (MNMs) and incidental nanoparticles (INPs) (SER 2012). While MNMs are intentionally designed and manufactured for specific purposes, INPs are unintentionally generated and released into workplace air during industrial activities. INPs can be generated during different high-energy processes such as burning fuels, plasma cutting, welding, metal grinding, laser ablation, iron casting, and firing (van Broekhuizen, 2012). These industrial processes can be defined as permanent releasers of INPs (up to several millions of NPs/cm^3) which may lead to chronic exposures if these sources are not recognized as such and if control measures are omitted or not adequately designed.

Currently, exposure assessment to INPs faces several barriers due to the lack of dedicated legislation. Only a set of non-binding recommendations, referred to as nano-reference values (NRVs) are available (van Broekhuizen, 2017).

Regarding risk assessment tools, the most promising methodology for exposure assessment in industrial settings is mass-balance modelling. This type of tool requires well-characterized particle emission and removal rates in industrial settings under actual operating conditions. Moreover, the large diversity of industrial processes and facilities that generate INPs requires the development of engineering controls which are easily adaptable to the needs of each industrial plant, and easy to monitor over time.

All these shortcomings must be addressed to meet EC legislation on health and safety of workers (Directive 89/391/EEC) regarding potential risks of nanomaterials at work, as well as for providing decision-makers, risk assessment authorities, professionals and workers, with tools and technologies for an appropriate solution to address the health and environmental risks of nanomaterials, and this is the rationale for developing the NanoHealth project, where a set of technological solutions are proposed, such as:

NANOHEALTH TOOL (NHT). To identify INP emission hotspots in industrial settings and simulation of INP dispersion across industrial plants, to select the most appropriate risk management measures (RMMs) and quantify the effective reductions in occupational exposure achieved.

NANOHEALTH PURIFIER (NHP): To develop a highly effective prototype capable of removing INPs and versatile enough to be easily implemented in industrial environments.

NANOHEALTH SERVICE (NHS): To design a service for the control and minimization of INPs in industrial settings, which will include guidelines and recommendations for health and safety departments and engineering teams.

The project is still under development and includes the study of different industrial scenarios in which high-temperature processing of ceramic materials takes place, although in this poster only the results obtained so far in the study of ceramic tile firing are presented.

1. NANOHEALTH TOOL (NHT)

An INP concentration reduced-order mass-balance grey-box model has been developed and evaluated through different tests, based on data collected from field campaigns in industrial plants under real operating conditions. Nanoparticles were characterised in terms of particle number concentrations (N) and size distributions (NanoScan SMPS (TSI Model 3910) and DiSCmini AG (TESTO)).

From this model, a Modelica library has been programmed to simulate INP concentrations and to evaluate the implementation of risk management measures for indoor air quality in industrial workplaces. This library translates the model's equation to a box-diagram system that can show the results in number concentration (#/cm^3 or #/m^3), reading data from external files or using signals from standard Modelica blocks to simulate continuous and discontinuous processes of particle generation and transport.

The Taylor diagram representation confirmed that the model can effectively describe INP concentration in systems with forced ventilation.

2. NANOHEALTH PURIFIER (NHP)

Detailed characterisation of INP emissions generated in the industrial processes mentioned above, allowed us to design a prototype air purifier to minimise INP occupational exposure and to assess the appropriateness of current NRVs. INP emissions near the emission sources and impacts on workers' areas were evaluated (Ostraat et al.(2015).

The experimental data showed that INPs were generated in the emission sources but were released into the workers' area due to the presence of leaks in the ceramic kilns, the INP concentrations being higher than the proposed NRVs ($4*10^4$ ♯/cm^3).

These results confirmed the need to test the NanoHealth air purifier in ceramic tile firing process to minimise INP concentrations. To this end, a prototype is being designed with a nominal flow rate of 12,000 m^3/h, to achieve a high number of air changes per hour (ACH) in the working area, and it incorporates a set of four stages for retaining from coarse particles to nanoparticles.

3. ACKNOWLEDGEMENTS

This study has been carried out within the LIFE NANOHEALTH project funded by the LIFE Programme of the European Union under project number LIFE20 ENV/ES/000187.

4. REFERENCES

[1] Ostraat, M., Engel, S., Swain, K.A., Kuhlbusch, T.A.J., Asbach, C. (2015). Harmonised Tiered Approach to Measure and Assess the Potential Exposure to Airborne Emissions of Engineered Nano-Objects and their Agglomerates and Aggregates at Workplaces *Series on the Safety of Manufactured Nanomaterials No. 55 - ENV/JM/MONO(2015)19*. Paris (France): OECD Environment, Health and Safety Publications.

[2] SER 2012, Provisional nano reference values for engineered nanomaterials, Advisory Report 12/01, Sociaal Economische Raad, Den Haag.

[3] Van Broekhuizen, P., Van Veelen, W. I. M., Streekstra, W. H., Schulte, P., & Reijnders, L. 2012. Exposure limits for nanoparticles: report of an international workshop on nano reference values. Annals of occupational hygiene 56 (5), 515-524.

[4] Van Broekhuizen, P., 2017. Applicability of provisional NRVs to PGNPs and FCNPs. BUREAU KLB.DOI:10.13140/RG2.2.18241.25445.