A methodology to assess occupational exposure to MNMs by modelling

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Keywords: CFD modelling, occupational exposure, MNPs
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Despite the toxicological effects of certain construction and industry related manufactured nanomaterials (MNMs) (Lee *et al*, 2010) and the subsequent human exposure from their dispersion according to certain working situations (van Broekhuizen *et al*, 2011) there is a lack of modelling efforts towards understanding the relevant dispersion aspects and estimating the internal doses for workers.

In the present work different computational models, both in-house and commercial, are integrated in a single methodology in order to estimate occupational exposure to MNMs by inhalation.

In particular, the following three steps describe the modelling process. First, air velocity, pressure and temperature fields are calculated using the commercial computational fluid dynamics (CFD) package ANSYS CFX. The k-ε model is employed for turbulence modelling.

In the second step, the obtained airflow field is used to determine the dispersion of MNMs in space using the CFD-based in-house code of Pilou *et al* (2011). This is a three dimensional, fully Eulerian, mechanistic model that incorporates the effects of particle convection, Brownian and turbulent diffusion, and thermophoresis, as well as the effects of particles inertia and gravitational settling.

In the third and final step, the one dimensional, Eulerian, mechanistic model of Mitsakou *et al* (2006) is used for calculation of particle transport and deposition in the human respiratory tract. In particular, the concentration of particles at the breathing zone of the workers, obtained in the previous step, is the input to the model, and as a result the internal dose of MNMs in the different regions of the human lung is obtained.

The developed methodology is used in order to estimate occupational exposure to MNMs by inhalation in a realistic environment. In particular, we demonstrate the capabilities of the integrated model by determining the deposition of particles in the respiratory tract of workers in a MNMs production and handling site. Results of air flow field and particle distribution in the production site as well as internal doses of inhaled MNMs for the workers at different working stations will be given.

Overall, to the authors' opinion, the proposed integrated methodology could serve as a valuable support decision tool in order to minimize the risks of occupational exposure to potentially harmful MNMs.

This work is supported by project SCAFFOLD under Project No. 280535 of the European Commission.

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