# A New Risk Management Strategy: Nanotechnology Workers’ Health Surveillance Program

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Since being exposed to engineered nanomaterials may risk nanotechnology workers’ health, it is of vital importance to plan effective risk management strategies to protect their health. Thus, a roadmap has recently been undertaken for the globally integrated health surveillance and epidemiological studies of nanotechnology workers. This roadmap has been devised in three main areas: exposure to nanomaterials, health and framework conditions for risk management, and study design.

With the rapid development of nanotechnologies, there is an increasing risk that workers may be exposed to engineered nanomaterials. As part of the responsible development of nanotechnologies it is important that the health of workers is protected by appropriate risk management strategies. Part of a cohesive strategy for the overall identification and management of potential risks from nanomaterials, is health surveillance of workers. It is crucial that health surveillance be proportionate, focused and most importantly is of value and to achieve this requires a multi-disciplinary approach.

## Health surveillance as part of an overall risk management strategy

Numerous organisations have proposed that health surveillance should be considered as part of an overall approach to managing risks from nanomaterials, including the International Organization for Standardization (ISO). In their guidelines for occupational risk management applied to engineered nanomaterials, suggested that, given current uncertainties relating to the hazards of nanomaterials, a prudent approach would be to collect at least some limited information about the materials being used and the duration of use (ISO 2012). Such information will help to build up a profile of potential exposures which could be important if any health effects are observed at a later date.

## A road map for health surveillance

In a recent paper Riediker et al. (2012) proposed a road map towards a globally harmonised approach for occupational health surveillance and epidemiological studies for workers in the nanomaterial industry. The roadmap was articulated around three key areas: exposure, health and framework conditions for risk management, and study design. The authors emphasised the need for harmonisation of methods for the conduct of occupational health studies, in order to improve risk management strategies and to evaluate the efficiency of protective measures, as well as harmonization and systematisation of exposure data recording. They also suggested the creation of exposure registries with worker health monitoring.

**Bio-monitoring of workers**

Efficient health monitoring for workers exposed to nanomaterials requires choosing sound biomarkers of exposure and/or effects. Bergamaschi et al. (2012) provided a review on the state of the art of biomarkers related to exposure to nanomaterials. In order to fulfil their preventive roles, biomarkers should be indicators of early biological changes prior to health alterations (on the pathway to disease) and that these biological changes should be reversible once the exposure is eliminated. This approach was laid out in a roadmap for biomarker research starting with ‘exploratory biomarkers’ derived from experimental studies (in vitro/ in vivo) determining possible heath response to exposures. Such exploratory biomarkers could be further validated, becoming so called ‘candidate biomarkers’, based their link to health effects through established controlled clinical studies culminating in ‘validated biomarkers’ whereby epidemiological studies demonstrate the link to disease.

As part of the development of biomarkers for nanomaterials, Bergamaschi et al. (2015) highlighted that it is critical to identify the mechanisms effects of toxicity along what is commonly referred to as the Adverse Outcome Pathway (AOP). This ideally requires data gathered from both epidemiological and experimental studies on nanomaterials toxicological effects. However, experimental and epidemiological studies indicate a similar hazard paradigm for nano and conventional particles and as such absence of nano specific biomarkers. Since one of the major routes of exposure to nanomaterials is the respiratory tract, Bergamaschi et al. suggested that biomarkers of lung and systemic inflammation are appropriate for nanomaterial exposure bio-monitoring with biomarkers of oxidative stress, inflammation and DNA damage also being used to monitor the health effects of nanomaterials. Other, more specific biomarkers such as those relating to neurotoxicity or other organs such as the liver or kidneys may also be required. Importantly, Bergamaschi et al. (2015) also highlighted the potential difficulties in translating laboratory data and workplace exposure scenarios. For example, aerosols in the workplace could be very different from those tested in the laboratory due to the way the aerosols are generated as well as potential adsorption of contaminants present in the workplace or even laboratory atmospheres.

### Bio-monitoring study: an example

A recent example of a biomonitoring study is a study on workers exposed to titanium dioxide (TiO2) aerosol containing a fraction of nanoparticles by Pelclova et al. (2012) where both exposure and health monitoring data were collected and analysed. In terms of exposure, large variations both in time and space of total aerosol concentration were observed. In terms of health, non-invasive methods were used by the mean of exhaled breath condensate (EBC) and fractional exhaled nitric oxide. The results indicated that exposure to the TiO2 aerosol lead to an increase in markers of lipid peroxidation (a marker of oxidative stress damage) as well as markers of oxidation of DNA and proteins in workers compared to controls. This may indicate a higher level of oxidative stress in exposed workers than non-exposed individuals. Moreover, the authors found that the exhaled breath condensate pH was decreased in workers while the fractional exhaled nitric oxide was increased. Altogether these data suggest that chronic exposure to TiO2 in this production plant induced early health effects that could be monitored with non-invasive techniques.

### Conclusion

Harmonisation and systematisation of both exposure and health monitoring studies of workers in the nanotechnology industry is considered to be a key element in ensuring the efficient and safe development of nanomaterials and nano-enabled products. SAFENANO provides rigorous onsite exposure assessments and also offer toxicological testing as part of its Scientific Services to support the responsible development and use of nanotechnology.

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