Working Safely with Manufactured Nanomaterials

Guidance for Workers

Employment,
Social Affairs
and Inclusion

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- *relaying the views of the stakeholders and society at large.*

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What are nanomaterials and nano-enabled products?

The term 'nanomaterial' is used generally to describe a material that has at least one dimension smaller than 100 nanometres (nm). To put this into perspective, a human hair or a sheet of paper are approximately 100,000 nm thick (Figure 1). Various definitions have been proposed to define a 'nanomaterial', with that most widely applicable in Europe being the European Commission Recommendation 2011/696/EU.

Nanomaterials occur in nature, may be inadvertently generated during industrial processing or combustion (i.e. process generated nano particles, PGNP) or are specifically produced to make use of the properties they possess when in a 'nano' form. This latter group comprises the so called manufactured (or engineered) nanomaterials (MNM) which may in turn be used to produce 'nano-enabled products' showing enhanced functionality.

While several substances that have been used in large quantities by industry for decades are now considered to fall within the European Union's definition of a nanomaterial, there is a rapidly expanding range of other MNMs that are moving from the research and development stage in laboratories to larger scale applications in industry and use in consumer products. For example, the range of European industries using MNMs now include sectors as diverse as agriculture, electronics, medicines and medical technology, construction, automotive production, textiles, food processing and cosmetics.

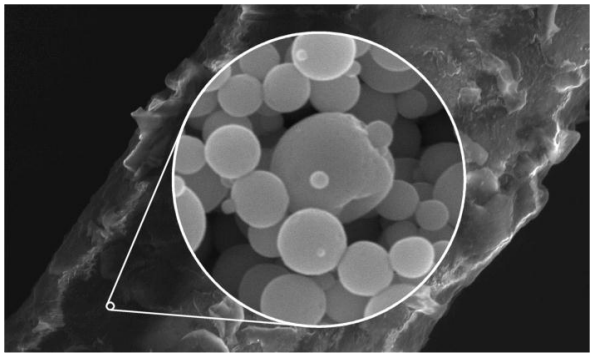

Figure 1: Nanoparticles on a human hair (Photograph courtesy of Prof R Dorey, Cranfield University**)**

This guidance is specifically intended to provide employees working with MNM and nano-enabled products with an introduction to the issues surrounding - and approaches to working safely with MNMs. A more technically-focused companion guidance (intended to assist employers and Health and Safety Managers when they are undertaking risk assessment and deciding on risk management needs) is also freely available and may be of interest to employees who wish to learn more on this topic.

What is the basis for current concerns about manufactured nanomaterials ?

The reason why manufactured nanomaterials (MNMs) are of such interest to industry and offer potentially significant benefits to society is that they sometimes possess very different properties to the same substances when in the macro scale – for example,

they may potentially be more reactive or have increased strength. However, these same differences mean that they may potentially interact differently with biological systems, for example they may be more readily absorbed or pass more readily across the body's physiological barriers.

Concerns have been identified about the possible hazards which nanomaterials may present because of their different physicochemical properties and the different ways they may interact with the bodies of humans and animals (see Box 1).

Box 1. Nature of Concerns about Nanomaterials

Physical Hazards: At the nano-scale materials may show different physicochemical properties than their macro form. For example, they may have significantly lower melting point or phase transition temperature, show altered electrical conductivity and magnetic properties and/or differences in chemical reactivity. Such properties may potentially result in an altered hazard profile. Physicochemical changes of particular concern include potential increase in flammability, self-heating properties and dust explosivity. While carbon-based or metallic materials are most likely to possess these qualities, others could pose unexpected physical hazards.

Human Health: Nanoparticles may interact with biological systems differently from larger particles of the same material. For example, nanoparticles may show altered rates of absorption into the body through inhalation, ingestion or skin contact and, once absorbed, may reach parts of the body that larger particles are unable to. Also, the same mass of nanoparticles will have a very much higher surface area that an equal mass of a macro form with the same chemical composition and crystalline structure; this larger surface area may be reflected in increased biological reactivity resulting in, for a given mass, the nanoparticle form appearing to show a greater toxic dose-response. The toxicity shown by a nanoparticle may also be influenced by the presence of surface coatings or the materials tendency to from agglomerations.

Currently, there is uncertainty as to the extent to which the various characteristics of nanoparticles influence toxicity. Research has suggested that in some cases the physical properties of a nanomaterial (e.g. size, shape, crystal structure, surface coating, surface reactivity) may be important in determining the nature and extent of toxicity. Particular concern has focussed on the potential consequences of inhalation of some types of nanomaterials – particularly those of fibre-like shape and/or showing persistence and poor solubility in biological fluids. There is also concern that inhaled nanoparticles may be very readily absorbed through the lungs and transported to other parts of the body where they could potentially cause a toxic effect. Skin contact with nanomaterials could also lead to adverse consequences. However, available evidence suggests that nanomaterials are not generally expected to be absorbed across healthy skin but, in the absence of data about the specific nanomaterial being handled, good occupational hygiene practice should always be observed to minimise skin contact. Oral ingestion is not generally a concern in the workplace. However, ingestion of nanomaterials could occur if good occupational hygiene practice was not observed (i.e. it is important to change clothes and hand-wash before eating). It is also possible that nanomaterials could be ingested as a result of inhaled particles being swallowed during the body's natural clearing processes from the nose, throat and lungs.

Although some have queried if the existing European worker health and safety regulatory system is adequate to ensure the safe management of the potential risks that may be associated with the use or presence of nanomaterials in the workplace, an extensive review of work-related legislation concluded that, in general, the existing regulatory system applies to nanomaterials. Nonetheless, with support from the European Commission, in order to provide further assistance to employers and their workforces, this and other focused guidance documents have been made available at the European level to address issues that may be raised by the presence of nanomaterials in the workplace. Other guidance materials have also been produced by various bodies including some Member States, examples of which are identified at the end of this document.

Do I need to treat all manufactured nanomaterials as special cases?

The reason why particular care is necessary when working with MNMs is that some - but not all - nanomaterials may show different properties to what would be predicted based on a chemically-identical substance in the form of larger (macro) particles (see Box 1).

Given the newness of much of the nanotechnology field, it is not yet possible to lay down detailed systematic rules by which one should identify and fully characterise all the potential hazards that might be posed by MNMs. Hence, it is particularly important that each nanomaterial that is manufactured or used by a company is well characterised as part of a workplace risk assessment exercise using, where possible, a **case-by-case** approach. A similar case-by-case approach is also needed to define what are the appropriate risk management measures that need to be implemented, so as to ensure that the risk management measures fully guard against all potential hazards so that the nanomaterial can be used safely. This is particularly the case for manufactured nanomaterials that may be produced by more than one process (e.g. carbon nanotubes) since the different production processes may result in notionally the same material but that can exhibit different properties. Overall, in the light of the scientific uncertainties, it is strongly advised that a **precautionary approach** is adopted when using nanomaterials.

Consequently, employers should consider each manufactured nanomaterial used on, where possible, a case-by-case basis to establish what are the appropriate risk management requirements. It is equally important that all workers ensure they fully understand and comply with the risk management measures established for each procedure or task that may bring employees into contact with a manufactured nanomaterial or nano-enabled product.

Where a substance in any form is classified under CLP as hazardous or where it has been identified as having hazardous properties that indicate it should be so classified, namely according to the definition of a 'hazardous chemical agent' as per art. 2 (b) (iii) of the Chemical Agents Directive 98/24/EC (CAD), or if the substance has an established Occupational Exposure Limit (OEL), then if used in a nano-form, your employer should ensure that – as the minimum requirement – all risk reduction measures appropriate for the classification or that are necessary to achieve the OEL are in place. Where using the substance in nano-form, however, the employer should, where possible, undertake an additional case-by-case assessment for each particular nanoform to decide

if it is appropriate or not to introduce even more stringent risk management measures to address any uncertainties regarding nanomaterial-specific properties.

How can I tell if I am using nanomaterials or nano-enabled products, and how may I be exposed?

Some products advertise that they contain nanomaterials as this may offer a technical or commercial advantage but for some other products manufacturers might not want to openly advertise this, either for confidentiality reasons or, potentially, to avoid raising public concern. It can therefore be difficult to tell with certainty if a particular substance or product contains nano-forms. In order to establish if there are nanomaterials present, you should look for information on the product labels, in the safety data sheets and in the technical specifications. These may identify whether one or more nanomaterials are present (e.g. in some industrial sectors, inclusion of specific labelling is now required in Europe by legislation) but in other cases such checks may not clearly establish the material's status. If you still have concerns that the material or product may contain nano-forms but there is no labelling to confirm this, ask your safety manager or safety representative. In such circumstances, they should be able to either advise you directly or seek confirmation from the supplier whether or not nanomaterials are present. You can also look for information on the Internet (see final section of Guidance).

In the workplace you may be exposed to a chemical (in nanoform or not) through:

- inhalation (breathing the substance in);
- dermal absorption (contact with the skin), or
- ingestion (swallowing).

Inhalation can occur when solid particles become airborne or when mist particles are generated from liquids, for example during the spraying of products. Nanoparticles are not normally released when bound to a surface as part of a coating. However, if you were to cut, abrade or grind a treated surface, this might release free nanoparticles. Skin contact can occur when handling a powder, suspension or liquid, or when exposed to a dusty atmosphere or mists containing nanoparticles. Ingestion may occur if you do not follow good personal hygiene and safety practice rules (such as washing hands with soap and water before taking a work-break or at the end of the workday) or as a result of wearing personal protective clothing outside of work areas.

What actions are necessary to enable safe working with manufactured nanomaterials and nano-enabled products?

As previously stated, nanomaterials are not covered by a specific regulation(s) but are all subject to the same EU and national legislation that deals with working safely with conventional chemicals and mixtures. In addition the European Commission has

clearly stated that it is necessary to assess the risks posed by individual nanomaterials, where possible, on a case-by-case basis.

Therefore your employer should have undertaken a specific risk assessment on each nanomaterial present in the workplace, so as to establish what risk management measures are necessary for the various activities you undertake in the workplace.

In designing control measures, a hierarchy of options (Box 2) will have been considered, with the appropriate measures being selected based on the risk assessment outcome.

Some examples of the commonly used risk management measures are given in Box 3.

Box 2. Hierarchy of Risk Management Controls Options

Isolate or Enclose

Operations which involve the likely release of MNMs into the air should be performed in contained installations or in facilities that can be operated remotely from a protected area

Engineering Control

Processes where there is a potential for creating dusts or aerosols of MNMs should be carried out in areas with efficient local exhaust or extraction ventilation.

Wet cutting is recommended for cutting solid articles (e.g. nano-enabled products) containing MNMs.

Administrative Control

Working procedures and staff assignment to tasks should be developed so as to ensure safe handling of MNMs;

Adequate training and information should be provided to individual workers;

. An Emergency Management Plan should be established.

Personal Protective Equipment (PPE)

PPE should be regarded as a 'last resort' control measure or a supplemental option to be used in conjunction with other measures.

Box 3 Typical Risk Management Measures used with Manufactured Nanomaterials

Technical measures:

If MNMs have a tendency to become airborne, try to work in containment wherever possible such as using a fume hood or glove-box or local exhaust ventilation;
Where used, ventilation systems should use HEPA-filters and be regularly maintained and serviced;
On construction sites, optimum use should be made of natural ventilation (by opening doors and windows and minimising any shielding of the work place, etc.);
If working in the open air, try to position potentially MNM-generating activities downwind;
Unintentional dispersion of MNMs after use may be prevented by fixing them in a resin, liquid, etc.;
MNMs should be disposed of as Chemical Waste;

Organisational measures:

There should be a **specially trained employee** in the company with advanced knowledge on how to handle MNM safely;
Workers using MNM should expect to be provided with adequate instruction and information on working safely with MNMs;
The number of different handlings per material/product should be minimised;
Work places involving the use of MNMs should be shielded from other areas wherever possible and access limited to staff specifically trained in the safe handling of nanomaterials;

Personal protective measures:

If you are working with MNM, your employer should provide you with clear user instructions on the safe and proper use of the personal protective equipment prescribed;
Disposable gloves (preferably non-woven) should be used (examples include nitrile, latex and neoprene gloves);
Safety goggles should always be used during activities where dispersion of a MNM is possible;
Protective clothing (preferably non-woven, e.g. made of **Tyvek**) should be used;
Where use of a respirator is necessary, **this should be of at least FFP3-respiratory grade (with a NPF of 30 or higher**).

Further information sources

Any guidance on nanomaterials should be regarded as a 'living document' as it represents the knowledge of nanomaterials and understanding of health and safety issues pertaining to them **at the time of drafting**; this particular Guidance was 1st drafted in June 2013.

Since nanotechnology is a rapidly evolving area and novel forms are increasingly entering the workplace, our knowledge of the properties and characteristics of particular nanomaterials and the extent to which these may be a cause of potential concern to humans and the wider environment, is constantly evolving. Hence, it is important that both employers and employees seek to keep up-to-date in this field, particularly with regard to what constitutes best practice to ensure occupational health and safety.

Additional Guidance Materials have also been published by individual European States; examples are listed below:

Austria

AGES (undated): Österreichisches NanoInformationsPortal "nanoinformation". Österreichische Agentur für Gesundheit und Ernährungssicherheit GmbH., Austria. Available at Internet site http://nanoinformation.at/arbeitswelt.html.

AUVA (undated): Merkblatt M 310 Nanotechnologien - Arbeits- und Gesundheitsschutz. Allgemeine Unfallversicherungsanstalt, Austria. Available at Internet site http://www.auva.at/portal27/portal/auvaportal/start/startWindow?action=2&p_menuid=15&p_tabid=1

Bundesministerium für Arbeit (2010): Leitfaden für das Risikomanagement beim Umgang mit Nanomaterialien am Arbeitsplatz. Bundesministerium für Arbeit, Soziales und Konsumentenschutz, Zentral-Arbeitsinspektorat, Wien, Austria.

Denmark

Depa (2011): NanoRiskCat (NRC) - A Conceptual Decision Support Tool for Nanomaterials. Danish Environmental Protection Agency (DEPA), Denmark. Available at Internet site http://www.mst.dk/Publikationer/Publications/2011/12/978-87-92779-11-3.htm

France

ANSES (2008): Development of a specific Control Banding Tool for Nanomaterials. French Agency for Food, Environmental and Occupational Health & Safety, France. Available at Internet site http://www.anses.fr/fr

INRS (undated): Nanomaterials: definitions, toxicological risk, characterisation of occupational exposure and prevention measures. Institut national de recherche et de

sécurité, France. Available at Internet site http://en.inrs.fr/inrs-pub/inrs01.nsf/IntranetObject-accesParReference/Breve%20Occupational%20Risks%20Associated%20to%20Nanomaterials%20EN/$File/print.html

INRS (2012): Recommendations for characterizing potential emissions and exposure to aerosols released from nanomaterials in workplace operations. Institut national de recherche et de sécurité, France. Available at Internet site http://www.hst.fr/inrs-pub/inrs01.nsf/IntranetObject-accesParReference/HST_ND%202355/$File/ND2355.pdf

INRS (2012): Nanomaterials. Risk prevention in laboratories. Institut national de recherche et de sécurité, France. Available at Internet site http://www.inrs.fr/accueil/dms/inrs/CataloguePapier/ED/TI-ED-6115/ed6115.pdf

INRS (2011): Nanomaterials. Air filtration and protection of employees. Institut national de recherche et de sécurité, France. Available at Internet site http://www.inrs.fr/accueil/dms/inrs/CataloguePapier/ED/TI-ED-138/ed138.pdf

Germany

BauA/VCI (2012): Empfehlung für die Gefährdungsbeurteilung bei Tätigkeiten mit Nanomaterialien am Arbeitsplatz. Bundesanstalt für Arbeitsschutz und Arbeitsmedizin (BAuA) / Verband der Chemischen Industrie e.V. (VCI), Germany. Available at Internet site: http://www.baua.de/de/Publikationen/Fachbeitraege/Gd4.html;jsessionid=DD88F6A90D67E05F1DB49896C57C96E9.1_cid380.

BGI/GUV (2011): Sicheres Arbeiten in Laboratorien Grundlagen und Handlungshilfen.
BG Rohstoffe und chemische Industrie. Arbeitskreis Laboratorien, Fachausschuss Chemie, DGUV & Ausschuss für Gefahrstoffe. Available at Internet site http://bgi850-0.vur.jedermann.de/index.jsp.

BMAS (2013): Hergestellte Nanomaterialien. Bekanntmachungen zu Gefahrstoffen (BekGS 527). Bundesministerium für Arbeit und Soziales. Available at Internet site http://www.baua.de/de/Themen-von-A-Z/Gefahrstoffe/TRGS/Bekanntmachung-527.html

Italy

INAIL (2011): Exposure to engineered nanomaterials and occupational health and safety effects. Department of Occupational Medicine, Italian National Institute for Occupational Safety and Prevention, Italy. Available at Internet site: *www.ispesl.it/nanotecnologie/documenti/WB_NANO_network.pdf.*

The Netherlands

Delft University of Technology (TU Delft):
Nanosafety Guidelines

Dutch Ministry of Social Affairs and Employment:
Guidance working safely with nanomaterials and nanoproducts, the guide for employers and employees (PDF-Datei, 654 KB)
Stoffenmanager Nano Modul

Rijksinstituut voor Volksgezondheid en Milieu (RIVM):
Nanotechnology Workplace
Provisional nano-reference values: Applicability of the concept and of published methods

Social and Economic Council of the Netherlands (SER):
Advisory report "Nanoparticles in the Workplace: Health and Safety Precautions"

Sweden

Arbetsmiljöverket (2011): Carbon nanotubes - Exposure, toxicology and protective measures in the work environment. Arbetsmiljöverket, Sweden. Available at Internet site www.av.se/publikationer/rapporter/

Switzerland

Bundesamt für Gesundheit (BAG):
InfoNano

Bundesamt für Gesundheit (BAG) und Bundesamt für Umwelt (BAFU):
Vorsorgeraster synthetische Nanomaterialien

Innovationsgesellschaft mbH St. Gallen und TÜV SÜD:
CENARIOS® - Zertifizierbares Risikomanagement- und Monitoringsystem für die Nanotechnologie - Faktenblatt (PDF-Datei, 271 KB)

Interessengemeinschaft Detailhandel Schweiz (IG DHS) in Zusammenarbeit mit der Innovationsgesellschaft:
Code of Conduct Nanotechnologien

Schweizerische Unfallversicherungsanstalt (SUVA):
Nanopartikel an Arbeitsplätzen
Grenzwerte am Arbeitsplatz 2013 (PDF-Datei, 1 MB)
(siehe Kapitel 1.8.3 Nanopartikel und ultrafeine Partikel)
Factsheet "Nanopartikel und ultrafeine Partikel am Arbeitsplatz" (2012) (PDF-Datei, 101 KB)

Staatssekretariat für Wirtschaft (SECO):
Sicherheitsdatenblatt (SDB): Leitfaden für synthetische Nanomaterialien (2012)

Textilverband Schweiz (TVS) und Eidgenössische Materialprüfungs- und Forschungsanstalt (Empa):
Projekt "NanoSafe Textiles"
Leitfaden nano textiles (PDF-Datei, 3 MB)

Nanomaterialien in Textilien - Umwelt-, Gesundheits- und Sicherheits-Aspekte (PDF-Datei, 1 MB)

UK

HSE (2013): Using Nanomaterials at work. Health and Safety Execuutive, UK. Available at Internet site http://www.hse.gov.uk/nanotechnology/publications.htm.

Key points to note regarding the use of nanomaterials in the workplace

What are nanomaterials?

- Nanomaterials are materials with one or more dimensions below 100 nanometers (i.e. less than a thousandth the width of a human hair);
- NMs occur naturally, can be generated during processing or combustion or may be deliberately manufactured (the so called manufactured or engineered nanomaterials);
- The focus of this guidance are manufactured nanomaterials and the use of products containing them.

What are the concerns about manufactured nanomaterials?

- Some nanomaterials may have properties that differ from the same material when in conventional form;
- These differences may result in altered physicochemical risks (e.g. flammability, explosivity) or increase uncertainties regarding the extent of potential health effects;
- Though some nanomaterials have been used safely for decades, other manufactured forms are new and have characteristics that are not yet fully defined.
- In nano-enabled products, the nanomaterials are normally bound within a matrix so there is no risk of exposure. However, if cut, abraded or ground, this might release free nanoparticles.

Are manufactured nanomaterials safe to use in the workplace?

- Since materials in nanoform may show properties different from when in conventional form, there is a need to consider if occupational health and safety (OSH) measures are adequately protective;
- Hence, your employer should undertake a specific risk assessment on each nanomaterial present in the workplace to establish what risk management measures are necessary;
- Various control measures are appropriate when working with nanomaterials – these are described in this document.

IF YOU ARE UNCERTAIN IF NANOMATERIALS ARE USED IN YOUR WORKPLACE OR UNSURE WHAT OCCUPATIONAL HEALTH AND SAFETY MEASURES ARE REQUIRED, ASK YOUR SAFETY REPRESENTATIVE OR EMPLOYER FOR FURTHER INFORMATION!