Nanotechnology

Introduction

Nanotechnology is the use of structures of 100 nanometres (nm) or smaller.

- A nanometre is a billionth of a metre.
- A human hair is about 50 000 nm in diameter.
- As an example, if a marble were one nanometre in diameter, a metre would be the size of the earth.

Nanoparticles commonly have unique physical, chemical, biological and toxicological behaviour, quite different from the larger (macro) form of the same material.

Nanoparticles can exist in nature, such as the structures on the wing of a butterfly, the skin of a shark or the surface of the lotus leaf. Throughout history, people have been exposed to nanoparticles such as smoke, dust, ash and fine clays through air, food or water.

This bulletin focuses on manufactured nanoparticles and contains information for people at workplaces using nanoparticles in research or manufacturing, using products incorporating nanoparticles, or importing or supplying nanoparticles to workplaces.

Nanotechnology may lead to scientific advances in areas such as medicine, consumer products, coatings and manufacturing. This area of scientific development is relatively new, and information on health hazards is incomplete. As such, a conservative approach to risk management is recommended until further information is available.

Types of manufactured nanoparticles

Some types of nanoparticles include:

- **Non-engineered nanoparticles**, such as metals, oxides, ceramics or organics produced by processes such as pyrolysis or physical methods (eg milling). These may be used in reasonably large quantities for applications such as coatings, cosmetics and composite materials.
- **Engineered nanoparticles** are designed to have a particular structure. For example:
  - **Carbon nanotubes** – cylindrical tubes of carbon on a nano scale, with unique properties such as strength, conductivity and high surface area. These could be used in coatings, electronics or construction.
  - **Fullerenes** – ball shaped carbon structures (which looks a bit like a soccer ball on a nano scale). These could be used for medical, lubrication or coating applications.
  - **Quantum dots** – Semiconductor materials with unique electronic, optical, magnetic and catalytic properties.

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What the law says

Occupational health and safety legislation places a duty on the **employer** to provide a safe workplace and safe systems of work. Additionally, there are particular regulations governing the use of hazardous substances in workplaces, for example the requirement to obtain material safety data sheets (MSDS), conduct risk assessments, train staff, and implement effective control measures. There are no occupational safety and health laws that specifically mention nanoparticles, however many nanoparticles are hazardous substances.

People manufacturing or importing substances for use at a workplace have a duty to classify the substance as to whether it is hazardous or not. If it is hazardous, there is also a duty to ensure that a compliant MSDS has been prepared and provided to workplaces using the substance, and that containers are properly labelled. Manufacturers and importers should note that a nanomaterial may have a different hazard classification than the same substance at a larger size.

If the manufacturer/importer is unsure whether the substance is hazardous, a conservative approach is recommended.

Workers have a duty to look after their own safety and health at work, avoid harming others, and follow instructions in relation to safety and health matters.

Risk management

Identifying hazards

It is well known that many particles, including nanoparticles, can cause ill health (eg coal dust, welding fume, asbestos). Due to their small size, nanoparticles can reach parts of the body which normal size particles may not reach. There is also more chance that they may move to other parts within the body.

Nanoparticles composed of substances that are known to be carcinogenic, mutagenic or cause reproductive harm in their larger form should be considered to be more toxic in their nano form.

- When identifying hazards, be aware that nanoparticles may be much more reactive and more flammable than the larger form. **Importers/manufacturers** of nanoparticles or mixtures containing nanoparticles should ensure that the label and MSDS make reference to the nano form of the material. Information on the size and shape of the particles, the proportion of nanoparticles, dustiness, solubility, reactivity, flammability and toxicity should be provided on the MSDS if known.
- **People running businesses using nanoparticles** should ensure that they have reviewed the label and MSDS for the substance, and also consider any other information they have about the substance.

Assessing health and safety risks

Assessing risks helps to identify any high priority issues for prompt action. Workers should be involved in the assessment, and a record of the risk assessment must be kept.

The risk of exposure through inhalation and skin contact should be considered. Nanoparticles that are insoluble and dusty may be more easily inhaled and harder for the body to process.

Factors to consider as part of the risk assessment include:

- Nature of the task and likelihood of dust or mist generation/inhalation or skin contact (eg high pressure spray applications generally present a higher risk than manual wet handling methods)
- Whether the nanoparticle is bound in a non-friable solid matrix
- Particle size, shape and solubility
- Toxicity – of the nanoparticle (if known) or the larger form of the substance
- Quantity used
- Frequency and duration of use
- Number of people who may be exposed
- Flammability/reactivity
- Current controls
- Occasional tasks (eg cleaning/emptying dust collection systems, spill cleanup) should be assessed also

Tools to assist in the assessment are available from Workplace Health and Safety Queensland (search ‘nanotechnology control banding’) and Safe Work Australia (search ‘nanotechnology assessment tool’).

Controlling health and safety risks

Using the hierarchy of controls

Where practical, the risk should be removed by eliminating the substance or substituting a safer alternative. For example, information on designing engineered nanoparticles for lower toxicity is available from Safe Work Australia (search ’nanomaterials substitution‘).

Where these options are not practical, processes may be fully enclosed to minimise exposure. This option is suitable where aerosols are generated, such as when manufacturing certain nanoparticles.

The next preferred option is to use engineering controls, such as working in a fumehood, or under other local exhaust ventilation. Engineering controls can also be used to reduce the risk of liquid splashing, eg using a pump rather than decanting.

Procedural or administrative controls can also help minimise risks, usually in addition to a higher level control such as an engineering control. These controls may include limiting access to particular areas, restricting higher risk tasks to trained and authorised people, documenting safe work procedures, and conducting atmospheric monitoring.

Personal protective equipment (PPE) is the least preferred control and should be used with higher level controls. Respiratory protective equipment should be selected in accordance with AS/NZS 1715, and high efficiency filters should be selected to protect against nanoparticles (due to their size). Respirators should be fit tested for each individual.

Controls should be checked regularly to ensure they continue to provide adequate protection, and should be reviewed if the risks change (such as when a new procedure or task is introduced).

Information, instruction, training and supervision
The importer/manufacturer of the nanomaterial should provide clear advice on appropriate controls in the MSDS and on the label.

The employer must provide workers with information and training on:

- The names of hazardous (or potentially hazardous) substances they use;
- The nature of the hazard (if known) (refer to information from the MSDS and label);
- Safe work procedures;
- Use of control measures including PPE;
- Any other relevant data available, such as air monitoring results.

Training records must be maintained.

Supervision provided to workers must be appropriate to their experience, knowledge and to the task.

Health surveillance
Where a substance, including a nanomaterial, has been linked to a known health effect, and there is a suitable medical test available to check for such an effect, occupational safety and health regulations require the employer to provide health surveillance to workers who could be affected (at no cost to the workers). Information on the substance should be provided to the medical practitioner. The medical practitioner should provide the employer and worker with a report indicating the results of the health surveillance.

For some nanoparticles, there may be insufficient information on health effects for health surveillance to be effectively targeted.

Air monitoring
Air monitoring may be useful in:

- Identifying the source of nanoparticle emissions;
- Assessing the effectiveness of controls;
- Checking compliance against exposure standards or exposure guidelines;

Air monitoring may be on the basis of particle mass, number of particles, or surface area. Such monitoring is a specialised area and subject to ongoing technical improvements. Details of instruments for different types of monitoring are available in ‘Nanotechnologies Part 2: Guide to safe handling and disposal of manufactured nanomaterials’ and ‘Nanotechnologies Part 3: Guide to assessing airborne exposure in occupational settings relevant to nanomaterials’ – available from the British Standards Institution (and available for review from the WorkSafe WA library). A consultant (such as an occupational hygienist) may be used to conduct air monitoring unless in-house expertise is available.

Fires, explosions or spills

Due to the very small particle size, nanomaterials can more easily form dust clouds than the corresponding larger particle, and, for combustible particles, these dust clouds may be easier to ignite. The dust cloud may also be very difficult to see (air monitoring may assist in identifying emissions). Dust explosions can be extremely powerful.

Nanomaterials are also generally more reactive than the corresponding larger particle, and care should be taken to prevent hazardous reactions which could cause a fire or explosion.

Specific fire prevention controls may include:

- separation of hazardous processes from other work areas
- ventilation systems (especially local exhaust ventilation near the source),
- dust collection equipment
- pressure relief vents on equipment where a dust explosion could occur
- separation of heat and ignition sources from combustible dusts
- spark detection systems
- wet or damp work methods
- cleaning program (including areas where dust may be unseen) – wet methods rather than sweeping

There should be a documented emergency plan, indicating the actions to be taken in the event of a fire/explosion and the responsible people, and there should also be information on the suitability of extinguishing agents (for example, some nanomaterials may react with water). Workers with emergency duties should be trained in relation to those duties. Emergency equipment should be regularly inspected and maintained.

The employer should develop procedures for spill management. Methods and equipment should be appropriate to the quantities present and the risks. As a minimum, spill areas should be restricted to essential personnel wearing the necessary PPE, and measures should be taken to prevent the material being spread around the workplace (for example, absorbent mats can be used to exit the affected area). Wet cleanup methods are preferred, provided the nanomaterial does not react with water. All contaminated materials should be stored as indicated in the section below on Disposal.

Disposal

Nanomaterial contaminated waste should not be disposed of with general waste. Wastes containing nanomaterials may include:

- pure nanomaterials;
- items contaminated with nanomaterials such as wipes and disposable PPE;
- liquids containing nanomaterials; and
- friable solids containing nanomaterials.

Store nanomaterial waste in sealed containers or in sealed, double waste bags. Waste materials should be labelled to indicate the contents and any known or suspected hazards.

Contact the Department of Environment and Conservation to identify a waste facility able to dispose of nanomaterial waste.

Further information

WorkSafe WA, '*Hazardous or combustible dusts, fumes and fibres*' www.worksafe.gov.au go to: worksafe→guides→dust, fumes and fibres

The British Standards Institution, http://shop.bsigroup.com/ has a number of guides and standards including:

- *PAS 130 Guidance on the labelling of manufactured nanoparticles and products containing manufactured nanoparticles PD 6699-1:2007 Nanotechnologies. Good practice guide for specifying manufactured nanomaterials*
- *PD 6699-2:2007 Nanotechnologies. Guide to safe handling and disposal of manufactured nanomaterials*
- *PD 6699-3:2010 Nanotechnologies. Guide to assessing airborne exposure in occupational settings relevant to nanomaterials* (available for purchase from the website, or for review from the WorkSafe WA library) (browse by subject 'nanotechnology')

Department of Justice, Workplace Health and Safety Queensland, '*Nanomaterial Control Banding Tool Worksheet'*, available from www.deir.qld.gov.au (search 'nanotechnology control banding').

The US Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health (NIOSH) '*Current Intelligence Bulletin 60 - Interim Guidance for Medical Screening and Hazard Surveillance for Workers Potentially Exposed to Engineered Nanoparticles*' 2009, available from www.cdc.gov/niosh/ (search 'bulletin 60' or go to 'topics, nanotechnology')

Safe Work Australia publications are available from www.safeworkaustralia.gov.au and include:

- *Work health and safety assessment tool for handling engineered nanomaterials*
- *Durability of carbon nanotubes and their potential to cause inflammation*
- *Engineered Nanomaterials: Investigating substitution and modification options to reduce potential hazards*
- *Engineered Nanomaterials: Feasibility of establishing exposure standards and using control banding in Australia*
- *An Evaluation of MSDS and Labels associated with the use of Engineered Nanomaterials*
- *Developing Workplace Detection and Measurement Techniques for Carbon Nanotubes*
- *Engineered Nanomaterials: Evidence on the effectiveness of workplace controls to prevent exposure*
- *Engineered Nanomaterials: a review of the toxicology and health hazards*
- *A Review of the Potential Occupational Health and Safety Implications of Nanotechnology (Archived)*

The US Occupational Safety and Health Administration (OSHA) has a nanotechnology page with many useful links, and also a Bulletin on *Combustible Dust in Industry: Preventing and Mitigating the Effects of Fire and Explosions* available from www.osha.gov search for title.

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