



Classification of Carbon Nanotubes as Hazardous Chemicals

INFORMATION SHEET

Background

Carbon nanotubes are carbon sheets rolled to form either a seamless cylinder, known as single-walled carbon nanotubes (SWCNTs), or many cylinders stacked one inside the other, known as multi-walled carbon nanotubes (MWCNTs). The lengths of these tubes generally range from several hundred nanometers (nm) to several micrometers (μm), though tubes in the millimetre range have also been reported. Their diameter is dependent on the number of walls and is usually less than 100 nm.

As a result of their physical and chemical properties, carbon nanotubes have potential use in a variety of industrial and biomedical applications including:

- catalysts
- biosensors
- composite materials with improved mechanical and electrical properties, and
- drug carriers.

Human health hazard assessment and classification of carbon nanotubes

The potential for carbon nanotubes to be hazardous to health if inhaled has been extensively reported. In order to assist manufacturers and importers to formally classify carbon nanotubes, Safe Work Australia commissioned the National Industrial Chemicals Notification and Assessment Scheme (NICNAS) to undertake a human health hazard assessment and classification of carbon nanotubes.

The criteria in both the *Approved criteria for classifying hazardous substances* (Approved Criteria) and the *Globally Harmonised System of Classification and Labelling of Chemicals* (GHS) were used by NICNAS to determine the appropriate classification for carbon nanotubes. Findings are presented in the report entitled *Human Health Hazard Assessment and Classification of Carbon Nanotubes*.

All health endpoints that need to be considered for classification were examined. The report recommends classification as hazardous for repeated or prolonged inhalation exposure and for carcinogenicity. For all other endpoints, the report found that carbon nanotubes either; (a) were not classified as hazardous, or (b) cannot be classified as insufficient data is available.

Carcinogenicity classification

The assessment by NICNAS noted that MWCNTs have been shown to induce mesothelioma in rodents after a single intraperitoneal or intrascrotal exposure. The carcinogenic potential of carbon nanotubes is not solely determined by the length of the individual carbon nanotubes, but by their ability to present as a fibre with pathogenic dimensions, either as the individual fibre or through aggregation.

Based on the limited data available on mesothelioma formation in animal studies and difficulty in conclusively determining whether a specific MWCNT can present as a fibre of pathogenic dimensions, the report recommends that all MWCNTs should be considered as hazardous and classified for carcinogenicity as follows in accordance with:

- **Approved Criteria** – Classification: Carcinogen Category 3, Harmful (Xn). Risk Phrase: R40 Limited evidence of a carcinogenic effect
- **GHS** – Classification: Carcinogen Category 2. Hazard Statement: Suspected of causing cancer

The report notes that there are no studies demonstrating that SWCNTs cause mesothelioma. Neither is there evidence to suggest SWCNTs will behave any differently to MWCNTs with respect to the potential to form granulomas or mesotheliomas given they have been shown to be durable and have shown to elicit a fibre pathogenic response through the ability to form rigid fibre-like structures through aggregation inside the body. Hence the report considers it is prudent taking a precautionary approach to consider the above

recommended classification for MWCNTs according to the Approved Criteria or GHS as also being applicable to SWCNTs.

Repeated or prolonged inhalation exposure classification

The NICNAS assessment noted two 90-day repeat dose inhalation toxicity studies in rodents have shown that MWCNTs can cause fibrosis and granulomas at very low doses. The adverse effects are likely due to lung overload, but the doses at which these effects were observed are significantly below the classification cut-off under both the Approved Criteria and the GHS. This can therefore be considered to be an intrinsic property of these particles. Hence, the report considers that inhaling MWCNTs repeatedly, even at very low doses, could be harmful to humans and MWCNTs should be classified for repeated or prolonged inhalation exposure in accordance with:

- **Approved Criteria** – Classification: Harmful (Xn). Risk Phrase: R48/20 Danger of serious damage to health by prolonged exposure through inhalation
- **GHS** – Classification: Specific target organ toxicity following repeated exposure Category 2. Hazard Statement: May cause damage to lungs/respiratory system through prolonged or repeated inhalation exposure

Although there are no supportive data for SWCNTs, given the adverse effects have been postulated due to lung overloading SWCNTs are not expected to behave differently to MWCNTs. Therefore, the report recommends that the above classification should also be applied on a precautionary basis to SWCNTs until data to the contrary become available, particularly as the applicability of the pathogenic fibre hypothesis to granuloma and fibrosis induction is not clear.

Regulations

Australia's work health and safety (WHS) legislation aims to protect the health and safety of researchers and other workers developing, manufacturing or using carbon nanotubes, including those used in manufactured products. General duties under the legislation apply to working with carbon nanotubes as they do to technologies, substances, chemicals and materials generally. These general duties require risks to be minimised.

There are also specific WHS Regulations for workplace hazardous chemicals, which cover carbon nanotubes in the same way as other chemicals if they are classifiable as hazardous.

The recommended classification of carbon nanotubes by NICNAS in this report has implications for duty holders under the WHS Regulations.

Manufacturers and importers

Manufacturers and importers of hazardous chemicals have an obligation under the WHS legislation to classify substances, mixtures and articles and communicate their hazards on labels and safety data sheets (SDS). They also have an obligation to amend the SDS, and also the label, whenever necessary to ensure that it contains correct, current information.

Manufacturers and importers of carbon nanotubes should consider the recommended classification in the report, as well as any other data on the hazards as they come to light. The Hazardous Substances Information System (HSIS) maintained by Safe Work Australia includes the recommended carbon nanotubes classification information to assist manufacturers and importers. Safety data sheets and labels should contain the relevant GHS hazard pictogram, signal word, hazard and precautionary statements. A sample of relevant GHS label elements is:

Pictogram – Chronic health hazards



Signal Word - Warning

Hazard Statements:

H351 Suspected of causing cancer by inhalation

H373 May cause damage to the lungs/respiratory system through prolonged or repeated exposure by inhalation

Precautionary Statements include:

P202 Do not handle until all safety precautions have been read and understood

P260 Do not breathe dust

Persons conducting businesses or undertakings

Persons conducting business or undertaking (PCBUs) involved in handling carbon nanotubes and products containing carbon nanotubes must ensure that workers are made aware of the hazards of those materials. PCBUs must ensure that appropriate risk controls are put in place to eliminate or minimise exposure and ensure that workers are made aware of these risk controls.

Risk management approach

The general risk management process is illustrated in Figure 1. Details are in the model Code of Practice: *How to Manage Work Health and Safety Risks* and for chemicals generally in the Code of Practice: *Managing Risks of Hazardous Chemicals in the Workplace*. It can be applied to working safely with carbon nanotubes.



Specific guidance on risk management for carbon nanotubes is available in the document published by Safe Work Australia entitled *Safe Handling and Use of Carbon Nanotubes*. This was developed on the basis that carbon nanotubes are likely to be classified as hazardous and the controls recommended are consistent with the classifications determined in the *Human Health Hazard Assessment and Classification of Carbon Nanotubes*. The approach to choosing controls for working with carbon nanotubes is the same as for working with chemicals generally, i.e. following the hierarchy of controls and minimising exposure.

Effectiveness of Controls

Measurement data have shown that exposure to carbon nanotubes can be minimised by using conventional control methods such as process enclosure and local exhaust ventilation, where the equipment is appropriately designed for the process involving carbon nanotubes.

Measurements to assess exposure can be undertaken using the approaches described in the research report recently published by Safe Work Australia entitled *Measurements of Particle Emissions from Nanotechnology Processes, with Assessment of Measuring Techniques and Workplace Controls*.

More information

Information on nanotechnology work health and safety is available on the Safe Work Australia website including:

- *Human Health Hazard Assessment and Classification of Carbon Nanotubes*
- *Safe Handling and Use of Carbon Nanotubes*
- *Measurements of Particle Emissions from Nanotechnology Processes, with Assessment of Measuring Techniques and Workplace Controls*

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