Submission from

Friends of the Earth Australia

To the Senate Community Affairs Committee:

Inquiry into workplace exposure to toxic dust

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The Friends of the Earth submission will be limited to addressing term of reference g: “the potential of emerging technologies, including nanoparticles, to result in workplace related harm”.

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Summary

- The similarities between health risks presented by workplace exposure to nanoparticles and asbestos have been noted by parties as diverse as global reinsurance giant Swiss Re and the Workers' Health International News (Hazards Magazine)
- Nanotechnology deals with the manipulation of matter in very small numbers of molecules, or at the atomic level. One nanometre is one billionth of a metre
- Nanotechnology is a rapidly expanding industry which may be worth as much as US $1 trillion world-wide within the next ten years
- There are now over 50 Australian companies focussed on nanotechnology. The Australian Research Council is funding more than 200 nanotechnology research projects. Key Australian research institutions including the CSIRO are also active in nanotechnology
- Very few toxicological studies have been published into the impacts of nanoparticles on human health and safety and the environment. However there is a growing body of evidence that nanoparticles are toxic, highly reactive and highly mobile
- Unlike larger particles, nanoparticles readily enter the blood stream following inhalation or ingestion. It also appears likely that nanoparticles can be absorbed through human skin. Once in the blood stream, nanoparticles are transported around the body and absorbed by tissues and vital organs including the heart, brain, liver, bone marrow and ovaries
- Irrespective of their chemical composition, nanoparticles are potent inducers of inflammatory lung injury
- No data exist on the incidence of Australian workplace exposure. However extrapolation from a recent UK survey gives estimates of:
    - as many as 700 people currently employed in activities in which they may be regularly exposed to synthetic nanoparticles
    - as many as 33,000 Australian workers exposed to fine powders through various powder handling processes, some of which contain synthetic nanoparticles
    - more than 300,000 Australian workers exposed to nanoparticles that are incidentally produced in high-energy industrial processes eg refining, welding
- There are critical knowledge gaps required to enable risk assessment, in particular to determine whether acceptable exposure limits exist
- There are no effective control methods to safeguard against exposure to nanoparticles and other nanomaterials
- There is an urgent need for a moratorium on the research, development and production of synthetic nanoparticles and other nanomaterials while regulations are developed to protect the health and safety of workers, the public and the environment from the harmful impacts of nanotechnology
- This regulatory regime must also ensure the safety of exposure levels for workers in high-energy industrial processes who are regularly exposed to incidentally-produced nanoparticles

The risk of government inaction: nanoparticle exposure the ‘new asbestos’

The human and financial costs associated with asbestos exposure-related disease are extremely high. In the UK alone, an estimated 3, 000 people a year continue to die from asbestos exposure-related disease[1]. In the US, since 1979 more than 43,000 people have died from asbestos-related diseases[2]. In the US, people are now dying at the rate of 10, 000 a year. Many times more have suffered serious illness.

Asbestos liability is by far the largest issue facing the global insurance industry today. Swiss Re states that the three waves of asbestos claims have cost US insurers and re-insurers approximately US$135 billion, with a fourth wave of potential claims estimated to be as great as an additional US$200 to $275 billion[3].

The similarities between the latent serious health risks presented by workplace exposure to nanoparticles and workplace exposure to asbestos have been noted by parties as diverse as Swiss Re and the Workers’ Health International News’ (Hazards Magazine). The parallels between these health risks and those associated with workplace exposure to silica dust have no doubt been made by other submissions to this inquiry and will not be detailed here.

As with exposure to asbestos or other toxic dusts, workplace exposure to nanoparticles has the potential to cause serious pulmonary disease (see following sections). However Swiss Re notes that the most important similarity between asbestos and nanoparticle exposure may be the lag time before the potential onset of serious harm to health – resulting in significant human and financial cost[4].

To safeguard against a repeat of the asbestos experience, the global reinsurer advocates a strict application of the precautionary principle in the regulation of nanotechnology. Swiss Re emphasizes that conservative regulation that puts health and safety first must be adopted, irrespective of uncertainties in scientific circles.

At a presentation in the UK last year the Head of the Science Strategy and Statistics Division of the UK Health and Safety Executive also recommended that rigorous regulation be developed to prevent nanoparticle exposure becoming the ‘new asbestos’. He noted that if regulators introduced “controls that are too lax, significant health effects [will] harm many people. The history of asbestos should warn all of society of the human and financial costs of this possibility”[5].

1 UK Trades Union Congress. 2005. Nanotechnology Factsheet. Available at http://www.tuc.org.uk/h_and_s/tuc-8350-f0.cfm

2 EWG Action Fund. 2004. Understanding asbestos. Available at http://www.ewg.org/reports/asbestos/facts/fact1.php

3 Swiss Re. 2004. Nanotechnology: Small matter, many unknowns. Available at http://www.swissre.com

4 Swiss Re. 2004. Nanotechnology: Small matter, many unknowns. Available at http://www.swissre.com

5 Health and Safety Laboratory, UK. 2004. “Nanomaterials at work: a risk to health at work?” In Report of Presentations at Plenary and Workshop Sessions and Summary of Conclusions. First International Symposium on Occupational Health Implications of Nanomaterials, held by the UK Health and Safety Laboratory and the US National Institute for Occupational Safety and Health. Available at www.hsl.gov.uk

However despite recommendations for rigorous regulations from eminent scientific bodies, national workers’ unions and global reinsurance agents, and strong words from government safety enforcement agencies, there is still a regulatory vacuum surrounding nanotechnology and workers’ health is still very much at risk.

Introduction to nanotechnology

The overwhelming majority of the general public – and much of government - remains unaware of what the term "nanotechnology" means. Significantly, so too do most of the hundreds of thousands of workers exposed to nanoparticles in the workplace. However research, development and industrial use of “nanotechnology" has been growing rapidly for the past decade and is already worth several billion dollars world-wide annually. Globally, hundreds of products containing nanomaterials are being manufactured and sold commercially.

Nanotechnology is the manipulation of matter at the atomic or molecular level. The term nanotechnology refers to engineered structures, materials and systems that operate at a scale of 100 nanometres or less[6]. One nanometre is one billionth of a metre; a human hair is about 80, 000 nm wide.

In the past, nano-sized particles have been produced incidentally as a by-product of fires, high-temperature industrial processes such as engine combustion and high energy welding or grinding. Hundreds of thousands of Australian workers are likely to be exposed to incidentally produced nanoparticles in their workplace (see below).

However now scientists have developed ways of manufacturing synthetic nanoparticles for use in a wide variety of products, from more reactive industrial catalysts, transparent sunscreens and cosmetics, self-cleaning toilets, long-lasting paints, targeted drug delivery, ‘smart’ surveillance equipment, ‘smart’ fertilisers, ‘smart’ packaging, to ‘nutritionally enhanced’ foods. Tens of thousands of Australian workers may be exposed to synthetic nanoparticles in their workplace – a number that will grow quickly as the nanotechnology industry expands.

Investment in the industry is forecast to grow to US$1 trillion by 2011-2015[7]. The US National Science Foundation estimates that in 2015 there will be 2 million workers employed in nanotechnology-related industries world wide; the number of people in secondary industries using nanotechnology-related materials and devices will be orders of magnitude greater.

6 The Royal Society and The Royal Academy of Engineering, UK. 2004. Nanoscience and nanotechnologies. Available at http://www.royalsoc.ac.uk/

7 Bainbridge, William S. and Mihail C. Roco. 2001. “Societal Implications of Nanoscience and Nanotechnology.” NSET Workshop report for the NSF. www.wtec.org/loyola/nano/NSET.Societal.Implications/

State of nanotechnology development in Australia

There are now over 50 Australian companies focussed on nanotechnology. Australian nanotech research spans materials, biotechnology, energy, environment, electronics, photonics, computing and surveillance.

The Australian Research Council currently funds more than 200 nanotechnology research projects[8]. Australian universities, CSIRO, the Australian Nuclear Science Technology Organisation and the Defence Science Technology Organisation are also active in nanotechnology research and development.

Multinational companies involved in Australian nanotechnology include Rio Tinto, AstraZeneca, BHP Billiton, Dow Chemical, DuPont, L'Oréal, Motorola, Orica, Revlon, and the US Government's Defence Advanced Research Projects Agency.

Australian nano products already on the market include: transparent sunscreens and cosmetics; colour-fast fabrics; self-cleaning windows; long-lasting paints and furniture varnishes; fuel catalysts; and automotive and aerospace components[9].

These products have been commercialised without a regulatory regime. The safety of nano-scale ingredients is not tested and products containing nanoparticles are not labelled.

8 Commonwealth of Australia, Invest Australia. 2005. Australian Nanotechnology: Capability & Commercial Potential, 2nd Edition. Available at http://investaustralia.hyperlink.net.au

9 Commonwealth of Australia, Invest Australia. 2005. Australian Nanotechnology: Capability & Commercial Potential, 2nd Edition. Available at http://investaustralia.hyperlink.net.au

Evidence of probable harm associated with workplace exposure to nanoparticles

The properties of matter change at the nano-scale, as the laws of classical physics give way to quantum effects. The physical properties of nano-sized particles can therefore be quite different from those of larger particles of the same substance. Altered properties can include colour, solubility, material strength, electrical conductivity and magnetic behaviour. Nano-sized particles also have a greater surface area relative to mass. This makes them much more chemically reactive.

The altered properties of nano-sized particles have created new possibilities for profitable products and applications. These altered properties also raise significant health and environmental risks that remain poorly studied, poorly understood and wholly unregulated. However the little peer-reviewed toxicological research that has been published regarding the health and environmental impacts of nanoparticle exposure is extremely concerning.

One risk that is clearly understood is the enhanced toxicity of nano-scale material[10]. Many studies have found a clear inverse relationship between toxicity of insoluble materials and particle size, irrespective of parent material [11].

The global reinsurance giant Swiss Re warns that at the nano-scale even normally harmless substances may become hazardous[12]. This renders toxicity tests of larger quantities of a substance irrelevant to determining the safety of nano-sized relatives – a fact that is yet to be reflected in the regulatory system.

Unlike larger microparticles, nanoparticles are highly mobile and readily enter the blood stream following inhalation or ingestion. It also appears likely that nanoparticles can penetrate human skin and gain access to the blood stream[13].

Inhaled nanoparticles penetrate the protective mucus lining of human lungs and have high rates of deposition in the deeper lungs[14]. Scavenger cells usually intercept foreign bodies and larger sized particles that make it past the mucus lung lining and into the deeper lung. However scientific studies have shown that these cells have difficulty recognising nano-scale particles, they are readily overloaded, and their action is impaired[15].

10 The Royal Society and The Royal Academy of Engineering, UK. 2004. Nanoscience and nanotechnologies. Available at http://www.royalsoc.ac.uk/

11 Institute of Occupational Medicine for the Health and Safety Executive. 2004. Nanoparticles: An occupational hygiene review. Available at http://www.hse.gov.uk

12 Swiss Re. 2004. Nanotechnology: Small matter, many unknowns. Available at http://www.swissre.com

13 Institute of Occupational Medicine for the Health and Safety Executive. 2004. Nanoparticles: An occupational hygiene review. Available at http://www.hse.gov.uk

14 Wichmann HE and Peters A. 2000. “Epidemiological evidence of the effects of ultrafine particle exposure”. Philos. Trans. R. Soc. Lond. A 358:2751–2769.

15 Wichmann HE and Peters A. 2000. “Epidemiological evidence of the effects of ultrafine particle exposure”. Philos. Trans. R. Soc. Lond. A 358:2751–2769.

Irrespective of their chemical composition, nanoparticles are potent inducers of inflammatory lung injury [16]. The UK Health and Safety Executive note that persistent lung inflammation as a result of exposure to nanoparticles (as with other toxic dust) is likely to lead to diseases such as fibrosis and cancer[17]. Organisations as diverse as The Workers' Health International News' (Hazards Magazine)[18] and Swiss Re global reinsurers[19] are making the comparison between exposure to nanoparticles and asbestos (see below).

Additional to causing direct lung damage, laboratory studies have repeatedly shown that nanoparticles cross from the deeper lungs to the blood stream. Once in the blood stream, nanoparticles are transported around the body and are absorbed by organs and tissues[20][21] including the brain, heart, liver, bone marrow, ovaries and muscles. Inhaled nanoparticles can travel directly to the brain along olfactory nerve cells[22]. This is of particular concern given recent findings that nanoparticles cause brain damage to fish[23] and dogs[24].

Ingested nanoparticles can be absorbed into the lymphatic system, and from there the blood stream, by intestinal tissue nodules known as "Peyer's plaques"[25]. As a general rule, the smaller the particle the greater is its absorption.

It has been shown that microparticles can penetrate human skin[26]. The UK Health and Safety Executive[27] note that skin penetration by nanoparticles is comparatively even

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16 US National Institute of Environmental Health Services.2003. Factsheet: Nanotechnology Safety Assessment: National Toxicology Program. Available at http://www.niehs.nih.gov/oc/factsheets/nano.htm

17 Institute of Occupational Medicine for the Health and Safety Executive. 2004. Nanoparticles: An occupational hygiene review. Available at http://www.hse.gov.uk

18 Workers Health International News. 2004. "Nanotech safety". Hazards Magazine. Issue 87 July-September. Available at http://www.hazards.org

19 Swiss Re. 2004. Nanotechnology: Small matter, many unknowns. Available at http://www.swissre.com

20 Oberdörster G, Sharp Z, Atuderoi V, Elder A, Gelein, R, Lunts A, Kreyling W, Cox C. 2002. "Extrapulmonary translocation of ultrafine carbon particles following whole-body inhalation exposure of rats." Journal of Toxicology and Environmental Health. Part A, 65:1531–1543

21 Kreyling WG, Semmler M, Erbe F, Mayer P, Takenaka S, Schulz H, Oberdörster G, Ziesenis A. 2002. "Translocation of ultrafine insoluble iridium particles from lung epithelium to extrapulmonary organs is size dependent but very low." Journal of Toxicology and Environmental Health. Part A, 65:1513–1530.

22 Oberdörster G, Sharp Z, Atudorei V, Elder A, Gelein R, Kreyling W, Cox C. 2004. "Translocation of inhaled ultrafine particles to the brain". Inhal Toxicol. 16(6-7):437-45.

23 Oberdörster E. 2004. Manufactured nanomaterials (fullerenes, C60) induce oxidative stress in the brain of juvenile largemouth bass. Environ. Health Perspect., 112, 1058-1062.

24 Cited in UK Trades Union Congress. 2005. Nanotechnology Factsheet. Available at http://www.tuc.org.uk/h_and_s/tuc-8350-f0.cfm

25 Swiss Re. 2004. Nanotechnology: Small matter, many unknowns. Available at http://www.swissre.com

26 Tinkle SS, Antonini JM, Roberts JR, Salmen R, DePree K, Adkins EJ. 2003. "Skin as a route of exposure and sensitisation in chronic beryllium disease", Environmental Health Perspectives. 111:1202-1208. Available at http://ehp.niehs.nih.gov/members/2003/5999/5999.html

more likely. Scientists have suggested that nanoparticles may penetrate into hair follicles and then enter the deeper skin, from where they could access the blood stream. Several pharmaceutical companies are believed to be developing nanoparticles for dermal penetration as a drug delivery route, based on their ability to gain access to the blood stream.

The duration of deposits of nanoparticles in vital organs is unknown, although there is some evidence to suggest they may accumulate in organs such as the liver[28]. The extent of damage they may do and what dose may cause a harmful effect remains unknown. However scientists have shown that even low levels of nanoparticles are toxic to human liver cells[29]. Other diseases of the liver suggest that the accumulation of even harmless foreign matter may also impair its function and result in harm.

Neuro-degenerative diseases such as Alzheimer's or Parkinson's are thought to be caused by a disruption of the iron concentration in the brain. However, iron oxide nanoparticles are already being used in a number of applications, for example magnetic resonance scans[30].

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27 Institute of Occupational Medicine for the Health and Safety Executive. 2004. Nanoparticles: An occupational hygiene review. Available at http://www.hse.gov.uk

28 Oberdörster G, Sharp Z, Atuderoi V, Elder A, Gelein, R, Lunts A, Kreyling W, Cox C. 2002. "Extrapulmonary translocation of ultrafine carbon particles following whole-body inhalation exposure of rats." Journal of Toxicology and Environmental Health. Part A, 65:1531–1543

29 Sayes C M, Fortner JD, Guo W, Lyon D, Boyd AM, Ausman KD, Tao YJ, Sitharaman B, Wilson LJ, Hughes JB, West JL, Colvin VL. 2004. "The differential cytotoxicity of water-soluble fullerenes". Nanolett. 4, 1881-1887.

30 Swiss Re. 2004. Nanotechnology: Small matter, many unknowns. Available at http://www.swissre.com

Likely incidence and sources of workplace exposure to nanoparticles

Current knowledge of worker exposure to nanoparticles is wholly inadequate for risk assessment purposes. The following discussion draws heavily on one of the few government investigations into workplace exposure to nanoparticles, undertaken last year by the UK government Health and Safety Executive[31].

The HSE report estimated the number of UK workers likely to be exposed to nanoparticles in the workplace. From these estimates, we have extrapolated possible incidence of Australian workplace exposure to nanoparticles, based on population comparisons. However variation in employment characteristics between the two nations makes it extremely desirable for a comprehensive Australian survey to be conducted.

A distinction is required between workplace exposure to incidentally produced nanoparticles (eg in welding or refining) and synthetic nanoparticles (eg in laboratories and factories that produce or handle products containing nanoparticles).

Exposure to incidentally produced nanoparticles

Nanoparticles are known to be an unwanted byproduct of thermal spraying and coating, metal production and refining, welding, soldering and high speed metal grinding[32]. Welding can generate large quantities of nanoparticles, usually in the form of a well defined plume of aggregated nanoparticles.

Extrapolating from the HSE survey, we estimate that more than 300,000 Australian workers may be exposed to nanoparticles that are incidentally produced in high-energy industrial processes.

The main exposure route for incidentally produced nanoparticles is via inhalation. Control methods exist that are thought to be reasonably effective against this, which are discussed below.

Exposure to synthetic nanoparticles

Despite the commercialisation of hundreds of products that contain nanomaterials, the main source of exposure to synthetic nanoparticles is still the workplace – laboratories and factories[33]. At this stage a greater proportion of people are likely to be involved in the research and development of nanoproducts and materials, rather than the secondary manufacturing of commercial nanoproducts, although this balance will change as industrial production expands.

31 Institute of Occupational Medicine for the Health and Safety Executive. 2004. Nanoparticles: An occupational hygiene review. Available at http://www.hse.gov.uk

32 Institute of Occupational Medicine for the Health and Safety Executive. 2004. Nanoparticles: An occupational hygiene review. Available at http://www.hse.gov.uk

33The Royal Society and The Royal Academy of Engineering, UK. 2004. Nanoscience and nanotechnologies. Available at http://www.royalsoc.ac.uk/

Australian organisations involved in nanotechnology include: university and government research organisations, new university spin-out companies, new private start-up companies, major multinational chemical and pharmaceutical groups.

Extrapolating from the HSE survey, we estimate that as many as 700 people are currently employed in activities in which they may be regularly exposed to synthetic nanoparticles in some form. This figure seems reasonable given that there are now over 50 Australian companies focussed on nanotechnology, and that the Australian Research Council is currently funding more than 200 nanotechnology research projects[34]. This number is likely to at least double over the next five years.

Again extrapolating from the HSE survey, as many as 33,000 Australian workers may be exposed to fine powders through various powder handling processes, including in the pharmaceutical and cosmetics industries. It is impossible to know how many of these people are handling powders comprising nano-scale materials, although the proportion of powders produced at the nano-scale is likely to increase.

Workers are exposed to nanoparticles during the research, development, handling and manufacture of nanotech products. Exposure also occurs in cleaning of research, production and handling facilities. As previously noted, exposure may be by inhalation, dermal or ingestion routes.

For a detailed discussion of routes of exposure, please refer to the HSE report.

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34 Commonwealth of Australia, Invest Australia. 2005. Australian Nanotechnology: Capability & Commercial Potential, 2nd Edition. Available at http://investaustralia.hyperlink.net.au

Key gaps in our understanding and other critical obstacles to providing worker protection from nanoparticle exposure

There are several critical gaps in our understanding that undermine our ability to provide satisfactory risk assessment and management of workplace exposure to nanoparticles. These are discussed in detail by the UK Health and Safety Executive[35], and in the report from the joint forum on workplace exposure to nanoparticles held by the UK Health and Safety Laboratory and the US National Institute for Occupational Health and Safety[36].

Critical gaps in our understanding include:

- inadequate understanding of nanoparticles and nanomaterials to enable risk assessment, in particular to determine whether acceptable exposure limits exist
- no consistent nomenclature and terminology for describing nanoparticles (eg whether to define nanoparticles by physical dimensions or behavioural properties)
- no effective methods to measure and assess workplace exposure to nanoparticles; no understanding of existing workplace exposure; no effort to share relevant information
- no effective control methods to safeguard against exposure to nanoparticles and other nanomaterials

Inadequate understanding of nanoparticles

Given the potential number of workers exposed to nanoparticle hazards we are confronted with numerous gaps in our knowledge about the behaviour of nanoparticles and their effect on the health and safety of workers.

We know very little about the release of nanoparticles from products containing nanomaterials during that product's life cycle, including its eventual destruction. The mobility and fate of various types of nanoparticles in the workplace and wider environment, and the extent of uptake and accumulation in the human body are both poorly understood.

Essentially, occupational health and safety experts know enough to recognise that nanoparticles are toxic, highly reactive, highly mobile, likely to be ineffectively controlled by current workplace practice and likely to result in harm to those exposed on a regular basis. However they have no idea how to manage the risks that are associated with workplace exposure to protect workers' health. This was admitted publicly by John Howard, head of the US government's National Institute for Occupational Safety and Health:

35 Institute of Occupational Medicine for the Health and Safety Executive. 2004. Nanoparticles: An occupational hygiene review. Available at http://www.hse.gov.uk

36 Health and Safety Laboratory, UK. 2004. "Nanomaterials at work: a risk to health at work?" In Report of Presentations at Plenary and Workshop Sessions and Summary of Conclusions. First International Symposium on Occupational Health Implications of Nanomaterials, held by the UK Health and Safety Laboratory and the US National Institute for Occupational Safety and Health. Available at www.hsl.gov.uk

"Very little is known currently about how dangerous nanomaterials are, or how we should protect workers in related industries. Research over the past few years has shown that nanometre-diameter particles are more toxic than larger particles on a mass basis. The combination of particle size unique structures, and unique physical and chemical properties, suggests that a great deal of care needs to be taken to ensure adequate worker protection when manufacturing and using nanomaterials. [However the behaviour of nanoparticles is] so far from our current understanding that we can not easily apply existing paradigms to protecting workers"[37].

This lack of understanding about how to manage risks associated with workplace exposure to nanoparticles is also made explicit in the UK HSE report. The report states clearly the significant gaps in understanding how to identify, quantify and assess risks associated with workplace exposure to nanoparticles and to subsequently establish and control acceptable exposure limits to safeguard workers' health[38].

No consistent nomenclature and terminology

The absence of a consistent nomenclature and terminology for describing nanoparticles is a barrier to developing and regulating acceptable exposure limits. There are no agreed definitions for nanoparticles, nanoparticle aerosols, or for the various types of nanoparticles which are produced. It is unclear whether parameters should be based on physical dimensions (e.g. length, diameter, surface area) or on behavioural properties such as diffusivity. It is unclear how to take account of agglomerated aerosols. Resolving these issues in conjunction with other regulators and experts will be vital to risk assessment and exposure measurement.

No effective methods to measure and assess workplace exposure

There are currently no effective methods to measure and assess exposure to nanoparticles in the workplace. For example to measure inhalation exposure, the most appropriate metric for assessment of exposure is particle surface area. However there are no effective methods to assess particle surface area in the workplace. Development of appropriate methods to evaluate dermal and ingestion exposure is also necessary.

There is insufficient information to judge whether exposure to the various forms of nanoparticles is occurring at significant levels in nanoparticle production processes. We have simply no knowledge of existing or acceptable nanoparticle exposure limits.

There is also no strategy in place for collecting, storing and disseminating information on workplace exposure. Databases and other information resources are required to collect information on toxicological assessment and exposure studies. Manufacturers of products containing nanoparticles should be required to publish details of the methodologies they have used in assessing the safety of their products, and to demonstrate how they have taken account that toxicological properties of

37 Smith, S. 2004. "Howard: Nanotechnology Represents an "Exciting Challenge" for EHS". Occupational Hazards. Available at http://www.occupationalhazards.com/articles/11779

38 Institute of Occupational Medicine for the Health and Safety Executive. 2004. Nanoparticles: An occupational hygiene review. Available at http://www.hse.gov.uk

nanoparticles may be different from larger forms. This was a key recommendation from the UK Royal Society and Royal Academy of Engineering in their 2004 report[39]. A publicly accessible database will be essential for storing such information.

No effective control methods to safeguard against exposure to nanoparticles and other nanomaterials

In the absence of knowing what – if any – acceptable limits to attach to workplace exposure to nanoparticles, and in the face of mounting concern over unsafe workplace exposure, the UK HSE issued an industry information sheet subsequent to its 2004 report recommending that workplace exposure should be avoided as much as possible:

"As the risks arising from exposure to many types of nanoparticles are not yet completely understood, control strategies should be based on the principle of reducing exposure as much as possible"[40].

This is a call echoed by the UK Royal Society and Royal Academy of Engineers in their 2004 report, which urged "factories and research laboratories [to] treat manufactured nanoparticles and nanotubes as if they were hazardous"[41].

However despite growing recognition from pre-eminent health experts that nanoparticle exposure presents serious risks to workers' health, no-one knows how to prevent such exposure from occurring.

In its 2004 report the HSE recommended the following strategies to contain nanoparticles in the workplace:

• Total enclosure of the process
• Partial enclosure with local exhaust ventilation
• Local exhaust ventilation
• General ventilation
• Limitation of numbers of workers and exclusion of others
• Reduction in periods of exposure
• Regular cleaning of wall and other surfaces
• Use of suitable personal protective equipment
• Prohibition of eating and drinking in contaminated areas

However in the same report the HSE acknowledged that it has no idea whether such practices would be at all effective in preventing worker exposure to nanoparticles, although it suggests they would be ineffective:

39 The Royal Society and The Royal Academy of Engineering, UK. 2004. Nanoscience and nanotechnologies. Available at http://www.royalsoc.ac.uk/

40 Health and Safety Executive, UK Government. 2004. Nanotechnology Information Note: Horizons Scanning Information Note No HSIN1. Available at http://www.hse.gov.uk/pubns/hsin1.pdf

41 The Royal Society and The Royal Academy of Engineering, UK. 2004. Nanoscience and nanotechnologies. Available at http://www.royalsoc.ac.uk/

"[The UK Health and Safety Executive] have identified no relevant research that has specifically sought to evaluate the effectiveness of engineering control systems [to protect workers from exposure] against new nanoparticle challenges. While most of these systems can in principle be used to control exposure, they do not always do so. There is no reason to expect that application of these methods to new nanoparticle generation processes will result in better control than that previously demonstrated in micro-scale powders and in gases."

The urgent need for a moratorium on the commercial production of nanoparticles while regulations are introduced to safeguard worker health

There is an urgent need for a moratorium on the research, development and production of nanoproducts while regulations are developed to protect the health and safety of workers, the public and the environment from the harmful impacts of nanotechnology. This regulatory regime must also ensure the safety of exposure levels for workers in high-energy industrial processes who are regularly exposed to incidentally-produced nanoparticles.

The Canadian-based action group on Erosion, Technology and Concentration (ETC) has been calling for a global moratorium on the production of synthetic nanoparticles since 2002. World-wide, ETC is the principle civil society group offering critical analysis of the introduction of nanotechnology, and warning governments of the risks of inaction[42].

The need to regulate workplace exposure is particularly urgent. There are tens of thousands of Australian workers who are likely to be exposed to synthetic nanoparticles, hundreds of thousands of workers exposed to incidentally produced nanoparticles, and a growing body of evidence that such exposure may relate in serious harm. Given the many uncertainties that continue to plague the development of adequate nanotechnology regulation, a moratorium on the research, development and manufacture of synthetic nanoparticles is essential until a comprehensive regulatory regime is developed and implemented.

There is currently no regulatory requirement for nanotechnology researchers or nanoparticle manufacturers to take into account the novel and toxic properties of nano-sized materials, or to protect their workers from exposure. For example, manufacturers of nano-sized titanium dioxide continue to rely on Material Safety Data Sheets and toxicological information based on bulk quantities of the material in question – which treat titanium dioxide as non-toxic.

The UK Royal Society and Royal Academy of Engineering have specifically recommended that nanoparticles and nanomaterials should be subject to new safety assessments as new substances[43]. Insurance groups such as Swiss Re and the Allianz Group[44] have called for new regulatory regimes and strong protective measures to manage nanotechnology's novel risks, especially in the workplace.

"The handling of nanotechnologically manufactured substances should be carefully assessed and accompanied by appropriate protective measures. This is particularly

42 See the action group on Erosion, Technology and Concentration website http://www.etcgroup.com

43 The Royal Society and The Royal Academy of Engineering, UK. 2004. Nanoscience and nanotechnologies. Available at http://www.royalsoc.ac.uk/

44 Allianz Group and OECD. 2005. Small sizes that matter: Opportunities and risks of Nanotechnologies: Report in co-operation with the OECD International Futures Programme. Available at http://www.allianz.com/Az_Cnt/az/_any/cma/contents/796000/saObj_796424_allianz_study_Nanotechnology_engl.pdf

important for individuals whose jobs expose them to nanoparticles on a regular basis. At the same time, no reasonable expense should be spared in clarifying the current uncertainties associated with nanotechnological risks"[45].

However despite these recommendations and the evidence that workplace exposure to nano-sized materials may result in serious harm, nanoparticles are still not subject to the more stringent controls that have seen many industrial substances banned outright and others subject to rigorous regulations designed to protect workers' health.

A moratorium would impose a short-term financial cost on nanotechnology companies and research institutions. However in the long term getting safety regulations right is more important. This could prevent huge human and financial costs, and waves of expensive compensation claims from injured persons, as has been seen with asbestos.

45 Swiss Re. 2004. Nanotechnology: Small matter, many unknowns. Available at http://www.swissre.com

Conclusion and recommendations

To prevent nanotechnology becoming the ‘new asbestos’ there is an urgent need for a moratorium on the research, development and production of nanoproducts while regulations are developed to protect the health and safety of workers, the public and the environment from the harmful impacts of nanotechnology.

Health and safety regulators, along with the scientific community, should use the moratorium to establish a regulatory framework for safe handling of nanomaterials to ensure the safety of workers and the environment. It is unacceptable for the health of workers to be further compromised during the period it takes to develop a comprehensive regulatory system.

The new regulatory regime must also ensure the safety of exposure levels for workers in high-energy industrial processes who are regularly exposed to incidentally-produced nanoparticles.

In order to develop an adequate regulatory framework, basic agreement needs to be reached on how to assess the toxicology of new nanomaterials. This will include the development of agreed nomenclature and measurement systems.

Products containing synthetic nanomaterials should be withdrawn from public sale. No new products containing synthetic nanomaterials should be commercially available until strong consumer safety regulations and a transparent labelling regime is in place.

Furthermore, mechanisms for genuine community consultation about the societal, ethical and socio-economic implications of commercialisation of nanotechnology must be established. Mechanisms should be developed for assessing the societal, livelihood and cultural implications of these products.

The Australian government should support calls for an International Convention for Evaluation of New Technologies, as advocated by the action group on Erosion, Technology and Concentration (ETC)[46]. The ICENT would provide an international framework to govern assessment of new technologies in a manner that will properly account for the concerns, values and expertise of the public and those who are usually marginalised from such decisions.

46 See the action group on Erosion, Technology and Concentration website http://www.etcgroup.com