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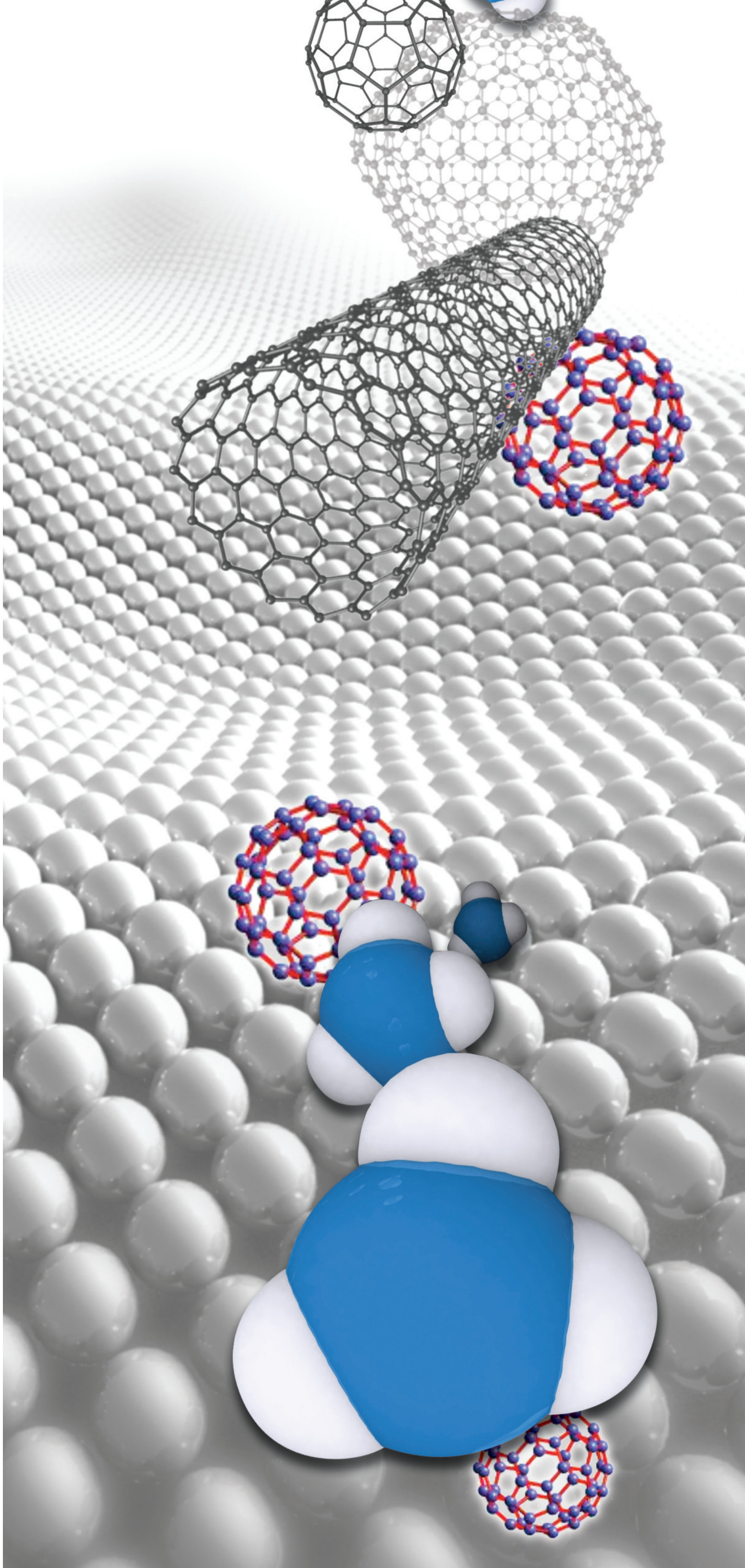

Nanomaterials in South Africa and occupational health

Human disease due to exposure to nanoparticles

Back to basics – the chest radiograph in silica associated tuberculosis

The transformation of nursing in South Africa: a personal reflection

SASOHN

SASOM South African Society of Occupational Medicine FOUNDED IN 1948

SAIOH

MMPA SOUTH AFRICA

Official Journal of *The SA Society of Occupational Health Nursing Practitioners, The SA Society of Occupational Medicine, The Southern African Institute for Occupational Hygiene* and the *Mine Medical Professionals' Association.*

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From the Editor . . .

Linda Grainger, Editor

The final issue for this year has a sub-theme of nanoparticles and nanotechnology in relation to occupational health. This is an increasingly common topic in journals and conferences, although it is the first time that it has been featured in our journal.

In addition to naturally occurring nanoparticles, such as those produced during forest fires, there are two other sources of nanoparticles. Engineered nanoparticles, which are intentionally produced, and incidental or ultrafine particles which are typically byproducts of processes such as combustion and vaporisation.[1] The former are designed with very specific properties or compositions, such as shape, size, surface properties and chemistry, whereas incidental nanoparticles are generated in a fairly uncontrolled manner and tend to be physically and chemically heterogeneous compared with engineered nanoparticles.[1]

Nanotechnology, which has been defined as "... the manipulation of matter on a near-atomic scale to produce new structures, materials, and devices . . ." has the potential for unprecedented scientific advancement for many sectors, like medicine, consumer products, energy, materials, and manufacturing. It can be used to improve existing technologies and enhance the effectiveness of new applications.[1] Consequently, there is rapid and ongoing growth in research and new products. However, along with the apparently unlimited possibilities of nanotechnology and engineered nanoparticles "... they bring with them new challenges to understanding, predicting, and managing potential safety and health risks to workers.[1] The uncertainties are great ". . . because the characteristics of nanoparticles may be different from those of larger particles with the same chemical composition".[1] We have insufficient knowledge of their toxicity and effects on humans following exposure.

Gulumian, Masoka and Savolainen's informative paper describes the major classes of engineered nanoparticles and nanomaterials, their potential health effects in mammalian systems, and recommendations on the safe handling of nanomaterials in laboratory or work environments. They emphasise the need for a "precautionary approach" with respect to risk management of all nanomaterials. The second paper on the topic is by Phillips, Murray and Davies, who have reviewed the literature concerning human disease attributable to exposure to engineered and incidental nanoparticles.

This issue also contains a useful article by Solomon and Rees on the chest radiograph in silica associated tuberculosis (TB). Reminding us that silicosis increases the risk of TB, they warn that its presence complicates the radiological features of TB which may then be atypical. Given the increased prevalence of TB in HIV positive silica exposed workers, and that such people are commonly smear-negative, the chest radiograph plays an important role in identifying TB. Practitioners will find it useful as it highlights the radiological features in reading chest radiographs for TB in the presence of silicosis.

The last article is a transcript of an interesting presentation given by Brookes to mark the International Year of the Nurse. She recounts her personal reflection on the transformation of nursing in South Africa. Given the significant role which she played in the events that culminated in these changes and her long career in nursing, her experiences and views are most worthwhile. She closes with a set of challenges to South African occupational health nurses for 2010 and beyond.

On the news front, SASOHN members elected Karen Michell as their President for 2011 to 2012. We congratulate you Karen and wish you well in another term of office. Reports on the annual MMPA Congress and SASOHN conferences are to be found on these societies' pages.

In May 2010, the National Department of Health published the guidelines for tuberculosis preventive therapy among HIV infected individuals.[2] Since about 70% of new adult cases of tuberculosis in South Africa are co-infected with HIV and because TB is the commonest cause of morbidity and mortality in HIV-positive people, TB preventive therapy must be offered to them. TB preventive therapy is the administration of one or more anti-tuberculosis drugs to individuals with latent TB infection to prevent progression to active TB disease. Although, maximum benefits from such therapy are achieved in HIV-infected persons who have TB infection as demonstrated by a positive tuberculin skin test, benefit has also been shown among those without a positive tuberculin test result. Access the guidelines at the web address indicated in the reference.[2]

Also from the Department of Health, the General Regulations of the Medicines and Related Substances have been amended, as published in May 2010. View these at the website given.[3]

As the year draws to a close, the Editorial Board, the Production team of Technique Publishing and I, wish you the readers a well-earned and restful break over the festive season. We thank you, our advertisers, the authors and reviewers for their support during 2010 and wish you all the best for 2011.

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1. National Institute of Occupational Safety and Health. Approaches to safe nanotechnology. Managing the health and safety concerns associated with engineered nanomaterials. DHHS (NIOSH) Publication No. 2009–125. Atlanta: NIOSH; 2009. Accessed on 11 November 2010. Available at: http://www.cdc.gov/niosh/docs/2009-125/.
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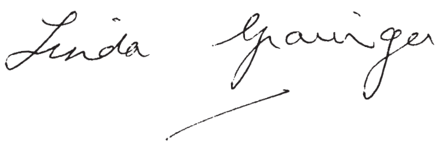

Legislation update

On 17 September 2010, the Minister of Labour published the **Lift, Escalator and Passenger Conveyor Regulations** in terms of the OHS Act 85 of 1993 under GNR.828 in *Government Gazette* 33561. The Minister further incorporated Safety Standards as prescribed by the safety specifications for lifts, escalator and passenger conveyors published by the South African Bureau of Standards, published under GNR.828 in *Government Gazette* 33561. These regulations come into effect on 30 November 2010 (except section 6 (7) which concerns the registration of inspection service providers with the accreditation authority, comes into effect on 1 December 2012).

Fiona Omar, Managing Editor (Legislative Materials and Tax), fiona.omar@lexisnexis.co.za

Upcoming events

INTERNATIONAL CONFERENCES

Date	Place	Topic	More information
4 – 6 April 2011	Rhodes University, Grahamstown	ODAM2011 10th Int. Symp. on Factors in Organisational Design and Management	E-mail: a.todd@ru.ac.za www.ODAM2011.net
9 – 12 Aug 2011	Boston, Massachusetts, USA	5th International Conference on Nanotechnology Occupational and Environmental Health	www.uml.edu/nano/nanoehs/Contact_Us.html
25 – 27 Aug 2011	Birchwood Hotel, Boksburg, South Africa	African Regional Association of Occupational Health (ARAOH) Congress	SASOM National Office Tel: +27 (0)12 803 7418 E-mail: info@sasom.org
11 – 15 Sept 2011	Istanbul, Turkey	XIX World Congress On Safety and Health at Work – Building a culture of prevention for a healthy and safe future.	E-mail: info@safety2011turkey.org
18–24 Mar 2012	Monterry, Mexico	30th ICOH Congress– Occupational Health For All: Research, Training and Good Practices	E-mail: admin@icohcongress2012.org

LOCAL CONFERENCES

Date	Topic	Region	Target	Cost	ContactName
11 March 2011	Occupational medicine "Off the beaten track"	Kimberley	OH&S practitioners	To be announced	Jenny Acutt Tel/Fax: +27 (0)12 803 7418 E-mail: info@sasom.org
18 March 2011	Occupational medicine "Off the beaten track"	East London	OH&S practitioners	To be announced	Jenny Acutt Tel/Fax: +27 (0)12 803 7418 E-mail: info@sasom.org

2010 SAIOH COUNCIL AND CERTIFICATION BOARD MEETINGS AND EXAMINATION DATES

4 February 2011	OHPC meeting/Oral assessment
4 March 2011	National Council meeting/Written assessments

HEALTH AWARENESS DAYS, WEEKS AND MONTHS

DAY TOPIC

DECEMBER

Prevention of Injuries Month

Breast Cancer Awareness Month

Day	Topic
1	World AIDS Day
3	International Day of Disabled Persons
5	International Volunteers Day
9	World Patient Safety Day
10	International Human Rights Day

Upcoming features

The four special issues scheduled for 2011 are:

- **May/June 2011** Work and vision;
- **July/August 2011** Managing chronic diseases of lifestyle in the OH setting;
- **September/October 2011** Respiratory health;
- **November/December 2011** Infections of relevance to OH.

Nanomaterials in South Africa and occupational health

[1,2] Mary Gulumian, [1]Xolani Masoka, and [4]Kai Savolainen

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[2]Haematology and Molecular Medicine, University of the Witwatersrand, Johannesburg
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Abstract

Uncertainties exist as to whether the desirable properties of nanotechnologies used in numerous applications should also be reason for concern. These uncertainties arise due to gaps in knowledge of the toxicity and potential health effects through possible exposure of workers to nanomaterials. For these reasons, governments and international agencies have published guidelines for safe handling of nanomaterials during research and production and have also recommended that a "precautionary approach" should be taken in the risk management of all nanomaterials. This paper describes the major classes of engineered nanoparticles and nanomaterials, their potential health effects in mammalian systems, and recommendations on the safe handling of nanomaterials in laboratory or work environments.

Key words: nanotechnology, nanoparticles, exposure assessment, adverse health effects, precautionary approach.

Introduction

Nanotechnologies, defined as the design, characterisation, production and application of structures, devices and systems by controlling shape and size at the nanometre scale, are set to revolutionise some of the fundamental features of everyday life. These include applications in fields of medicine, manufacturing, energy production, water purification, and remediation of contaminated environments.[1] Because of these huge potential benefits, nanotechnologies have attracted governments and major industrial companies worldwide resulting in commitment of significant resources towards supporting research and development.[2] These roleplayers have also recognised that the applications of engineered nanomaterials may potentially pose risks to health and the environment.

Nanoparticles are defined as particles that have structural features with at least one dimension of 100 nm or less, and exhibit novel characteristics in comparison to counterpart bulk materials. Nanoparticles may also differ from their larger counterparts by their propensity to aggregate or agglomerate. Nanomaterials (NMs) are generally classified in terms of the dimensions of their constituent nanostructures.[3] Primarily there are three classes of NMs. Nanomaterials with 1-D nanometric dimensions, examples of which include surface coatings used in lithographic depositing of nano-scale layers of materials on silicon wafers in the development of computer chips or the thin films such as surface treatments for glass used in filling microscopic depressions and production of surfaces that prevent dirt from attaching. Nanomaterials with 2-D nanometric dimensions include nanotubes, nanowires, fibres and fibrils and finally, NMs with 3-D nanometric dimensions comprise of engineered quantum dots, nanocrystals, fullerenes, and particles of metals such as gold and silver or of metallic oxides such as titanium and zinc oxides.

The objectives of this paper are to provide a summary description of the major classes of engineered nanoparticles and nanomaterials, a brief description of their potential health effects in mammalian systems, and recommendations on the safe handling of nanomaterials in laboratory or work environments.

Classes of engineered nanoparticles, applications, toxicity and health effects

Nanoparticles exist widely in the natural environment from sources such as photochemical and volcanic activities, or are created by plants and algae. They are also generated from anthropogenic processes as non-intentional by-products of combustion, welding fumes, and vaporisation and from diesel and petrol-fuelled vehicles. Other frequently used terms to describe these types of incidental nanoparticles are "ultrafines" in the air[4] and "colloid" for particles with slightly different size range particularly in the soil and water environment.[5] Although some reference to incidental nanoparticles present in the general and working environments is made, they are outside the focus of this paper. Examples of research and reviews on the toxicity and health effects of naturally occurring nanoparticles are available in the literature.[6,7] Also, the comparability of engineered nanoparticles (ENPs) to incidental ultrafine particles make it more probable that behaviour, properties and health effects of the latter will be similar to the former.[8]

Differences in shape, size, surface charge, and chemical composition mostly due to the mode of their production are used to define ENPs.[9] The most dominant types of ENPs currently being fabricated or researched nationally and internationally are described as well as the current knowledge on their hazards (toxicity and health effects) based on laboratory studies. Such background information on nanoparticles is intended to provide a basis for appreciating the novel, complex, and numerous challenges nanotechnology is likely to pose for occupational health, which may be distinctive from their larger counterparts.

Carbon nanoparticles: Fullerenes

Fullerenes are carbon-based allotropes which are hollow sphere-, ellipsoid-, tube-, or plane-shaped.

C_{60} fullerenes

Fullerenes in the form of spherical cages are generally regarded as buckyballs, named after Buckminster Fuller, the

Continued on page 6

PROGRAMME IN SAFETY MANAGEMENT

This course focuses on the science of Safety Management and the safety responsibilities of both line managers and staff safety practitioners. This programme introduces line managers and safety practitioners to the very basics in safety management. Such basics comprise the sciences of safety management and the roles of line and staff functionaries pertaining to safety risk assessment, safety management in industry and the analysis of safety incidents.

The focus and contents of the programme is unique in the sense that it prepares both managers and safety practitioners for performing their roles and functions on a professional and scientific basis. The program focus on meeting the needs of line managers and staff safety practitioners in achieving their legal responsibilities and professional accountability in making the workplace and the work procedures as safe as possible for all involved.

Specifically, the course is aimed at... aspirant managers, shop stewards, supervisors, inspectors, safety representatives/practitioners/managers, training officials and occupational hygienists.

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- **PSMP015** Introduction to Safety Management
- **PSMP026** Assess Safety Risk
- **PSMP038** Manage Safety in the Workplace
- **PSMP049** Analyse Safety Incidents

DURATION: 12 months

COST: The fee per candidate is R 5500. This includes all study material, examinations fees, et cetera. Registration without payment in full (or other prior approved arrangement) is not permissible.

REGISTRATION REQUIREMENTS: A Senior Certificate, equivalent qualification or appropriated experience.

NEXT REGISTRATION DATE: 29 November 2010 - 5 March 2011

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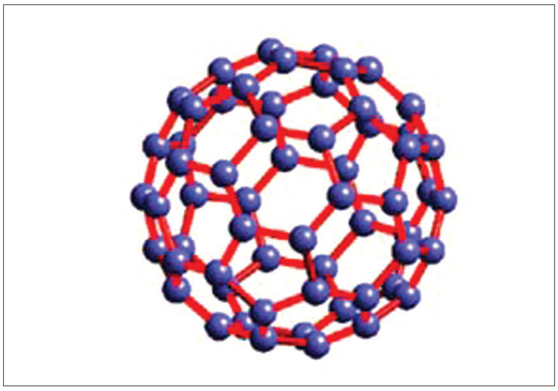

Figure 1. Schematic presentation of buckyballs (C_{60})
(Source: Office of Basic Energy Science/U.S. Dept. of Energy. Available at: http://ieeeghn.org/wiki/index.php/Image:Buckyballs_and_Nanotubes_1.jpg)

inventor of the geodesic dome,[10] is schematically shown in Figure 1. They contain between 28 to 100 or more carbon atoms. The most widely studied form is C_{60} – which contains 60 carbon atoms.

Carbon nanotubes

Cylindrical shaped fullerenes are called carbon nanotubes (CNTs) or buckytubes. CNTs are hexagonal networks of hollow cylinders of carbon atoms loaded with a wide variety of molecules (Figure 2).

Double-walled carbon nanotubes (DWCNTs) are a unique form of CNTs comprising of two coaxial single-walled carbon nanotubes (SWCNTs). Both of these forms are typically a few nanometres in diameter and several micrometres long (Figure 3).

Multiple concentric tubes, referred to as multi-walled carbon nanotubes (MWCNTs) (Figure 4), have significant diameters (up to 20 nm) and lengths (greater than 1 mm) [11] and are thermally stable. MWCNTs are manufactured in the presence of a metal catalyst, and the final product content depends on the synthesis conditions and effectiveness of the subsequent purification processes.

Applications

Carbon fullerenes display unique physical properties such as high tensile strength, flexibility, high conductivity, large surface area, unique electronic properties, and potentially high molecular adsorption capacity. These properties make them suitable for novel applications in consumer products including cosmetics, lubricants, food supplements, building materials, clothing treatment, electronics and fuel cells.[12] The water soluble derivatives of C_{60} are increasingly becoming central for emerging biomedical technological applications.[13]

DWCNTs exhibit the electrical and thermal stability of MWCNTs as well as the flexibility of SWCNTs.[14] They are also used in drug delivery systems of therapeutic agents for chemotherapy, gene therapy and radiotherapy, where the latter functions are dependent on the functional groups present on CNTs.[15]

Toxicity and health effects

In vitro, C_{60} fullerenes were toxic to human dermal fibroblasts and human liver carcinoma cells,[16] mutagenic to *Salmonella typhimurium* and genotoxic to human lymphocytes.[17] *In vivo,* oral administration of C_{60} did not result in its efficient absorption but intravenous injection produced rapid distribution including its penetration of the blood-brain barrier. This has raised concerns about their potential chronic toxic effects.[18] Acute and chronic toxicities of some C_{60} derivatives were found to be non-toxic at low doses, but they could cause nephropathy at higher doses.[19]

Potential health effects of carbon nanotubes are of concern due to their similarity to asbestos fibres. Intraperitoneal exposure of rats to unrefined (containing iron) SWCNTs resulted in asbestos-like, length-dependent, pathogenic behaviour including inflammation and formation of granulomas[20] and intraperitoneal administration of *p53* heterozygous mice with MWCNT induced mesotheliomas.[21]

Quantum dots

Quantum dots (QDs) (Figure 5) are nano-crystalline semi-conductors that emit or absorb light of specific wavelengths depending on their size.[11] Generally, QDs are fabricated from group II-VI or group III-V elements of the periodic table.

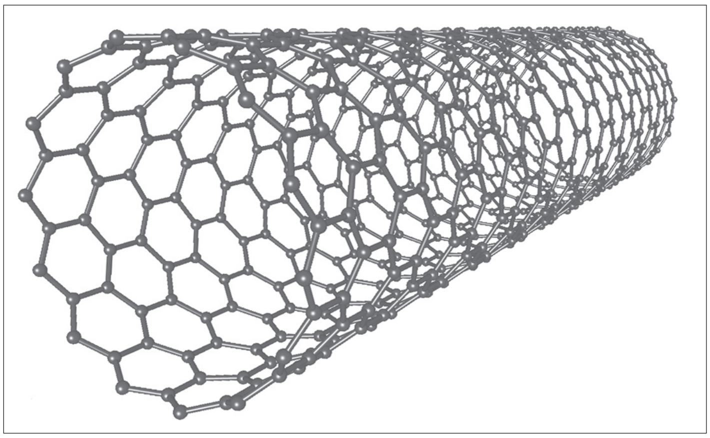

Figure 2. Single-walled carbon nanotube (SWNT)
(Source: Wikipedia, available at http://upload.wikimedia.org/wikipedia/commons/f/f8/Eight_Allotropes_of_Carbon.png)

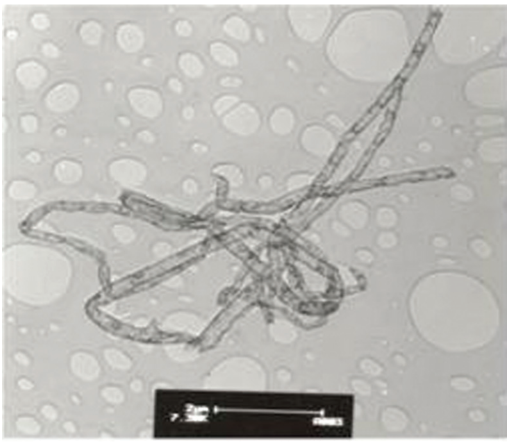

Figure 3. Double-walled nanotubes
(Courtesy of Professor Sunny Iyuke, University of the Witwatersrand)

“Nanoparticles are defined as particles that have structural features with at least one dimension of 100 nm or less . . .”

Of the various methods of synthesising QDs, the most commonly used are wet chemical colloidal processes. Newly synthesised QDs are inherently hydrophobic in nature – and are “functionalised” using secondary coatings to improve their solubility. Structurally, QDs for biological applications consist of a metalloid crystalline core, and a “cap” of ZnS and “shell” of different compositions such as functionalised silica or linkers including mercaptoacetic acid, dihydrolipoic acid (DHLA),[22] or modified polyacrylic acid.[23] The purpose of the cap or shell is to shield the core, and render the QDs readily bioavailable.[24]

Applications

Quantum dots were first developed in the form of semi-conductors, insulators, metals, magnetic materials, and metallic oxides. Their biological application capability has also been demonstrated and novel applications including fluorescent labelling,[25] and photodynamic therapy have been proposed.[26]

Toxicity and health effects

Release of QD precursor core materials such as cadmium and selenium was one of the mechanisms involved in their toxicity – and is directly related to the accessibility of the core cadmium atoms to the surrounding medium. This in turn was shown to be linked to the permeability to oxygen and protons of different extra layers of materials that are added to the core (shell and ligands) on QD). As such, it was proposed that a shell will reduce QD toxicity by delaying the oxidation of the core.[27]

Figure 4. Multi-walled carbon nanotube (MWCNT) with diameter of 88 nm)
(Courtesy of Professor Sunny Iyuke, University of the Witwatersrand)

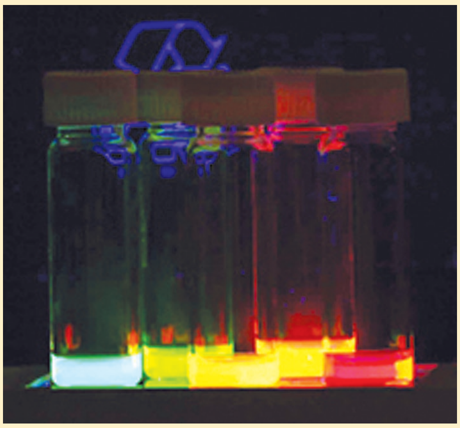

Figure 5. Colloidal quantum dots irradiated with a UV light. Different sized quantum dots emit different colour light due to quantum confinement
(Source: Wikipedia, available at: http://upload.wikimedia.org/wikipedia/en/f/f4/QD_mini_rainbow.jpg)

Inorganic nanoparticles

Inorganic nanoparticles primarily consist of pure metals, metal oxides or metallic composition. Examples include gold, silver, aluminium, titanium, silica, tungsten, manganese, copper, molybdenum and palladium nanoparticles. They are synthesised in various geometries such as spherical, nanoshells, nanorods, tripods, tetrapods, nanocages or for example, star-shaped or nanorice-shaped gold nanoparticles[28,29] (Figure 6).

Gold nanoparticles of different shapes are synthesised by various methodologies. Gold nanocages for example, are synthesised through the deposition of gold on the surface of silver nanocubes – with the subsequent oxidation and removal of the interior silver, together with alloying and dealloying, to produce hollow and, eventually, porous structures of gold nanocages[30]. Silver nanoparticles are synthesised either using traditional or non-traditional methods (Figure 7).[31]

Titanium dioxide nanoparticles are among the most widely used metal oxide-based nanoparticles or nanotubes (Figure 8). Their synthesis and other nanomaterials has recently been reviewed.[32] Notably, nano-TiO_2 is either available in pure anatase, pure rutile, or as mixtures of anatase and rutile. In general, anatase nano-TiO_2 is more photocatalytic than the rutile form; whereas nanoscale rutile is less photoreactive than either anatase, rutile mixtures or anatase alone. Mesoporous forms of nanoparticles include mesoporous silica represented in Figure 9.

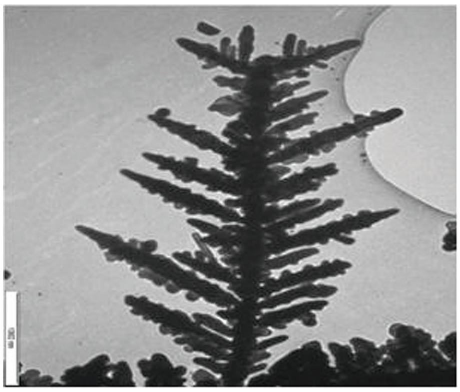

Figure 7. Synthesis of silver nanodendrites

(Source: Mdluli PS and Revaprasadu N., Materials Letters 63 (2009) 447–450)
(Courtesy of Dr Robert Tshikhudo, Mintek, South Africa)

Applications

At nanoscale, inorganic nanoparticles display novel mechanical, electrical, magnetic and optical properties owing to dominant quantum effects that do not exist in larger dimensions. These properties make them ideal for enhancing cancer detection, cancer treatment, cellular imaging, medical biosensing and in drug and biomolecule delivery applications.[33] For example, nanosilver coatings are used on textiles and coatings on implants due to their strong antibacterial activity properties. Nanosilver is also used for treating wounds and burns, or marketed as a water disinfectant and room spray.[34] Nanocrystalline titanium dioxide is used in applications ranging from self-cleaning glass to low-cost solar cells,[35] environmental remediation and wastewater purification[36] as well as in cosmetic applications.[37] Mesoporous silica nanoparticles modified with trimethylammonium groups are an efficient near-infrared contrast agent for optical imaging *in vivo*,[38] and functionalised mesoporous silica for photodynamic therapy of cancer cells.[39]

Toxicity and health effects

Functional groups with cationic side chains of gold nanoparticles are toxic to mammalian and bacterial cells[40] whereas the toxicity of anionic surface modifier has been found to be dependent on the property of functional group present. Gold nanoparticles with citrate and biotin surface modifier have not revealed obvious toxicity, whereas glucose and cysteine have been found to be toxic.[41]

A 28-day inhalation exposure study to silver nanoparticles in both male and female Sprague-Dawley rats did not show any significant changes in body weight during the study period.[42] However, a subchronic 90-day inhalation study found that lungs and liver are the major target tissues for

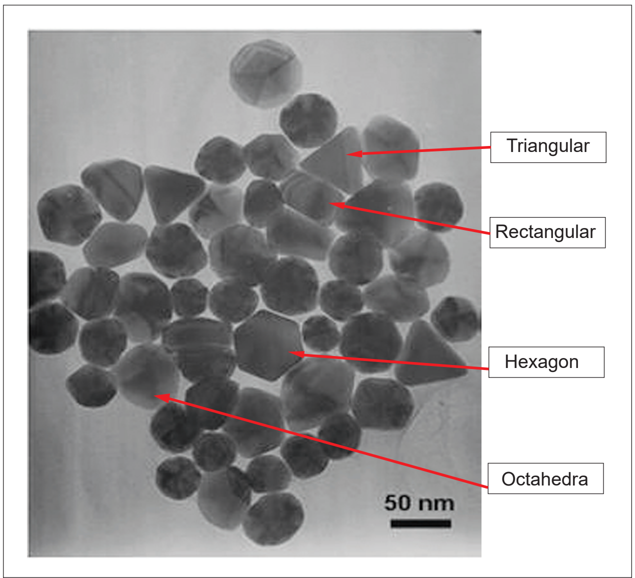

Figure 6. Mixtures of gold nanostructures

(Courtesy of Dr Robert Tshikhudo, Mintek, South Africa)

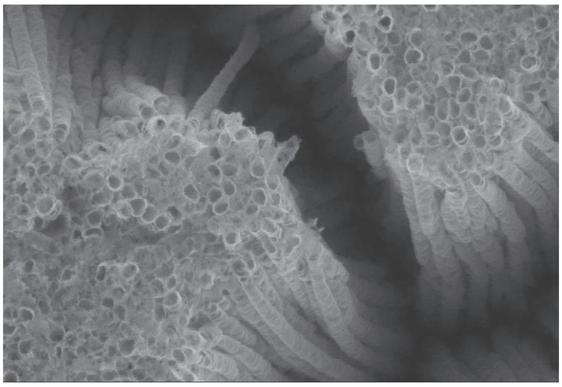

Figure 8. An electron microscope image of electrochemically grown TiO_2 nanotubes. 10 000 times smaller than the width of a human hair, the tubes are filled with organic polymer in a new technique for "growing" solar cells with the potential to be cheaper than current solar cells

(Source: Argonne National Laboratory, available at: http://en.wikipedia.org/wiki/File:TiO2nanotube.jpg)

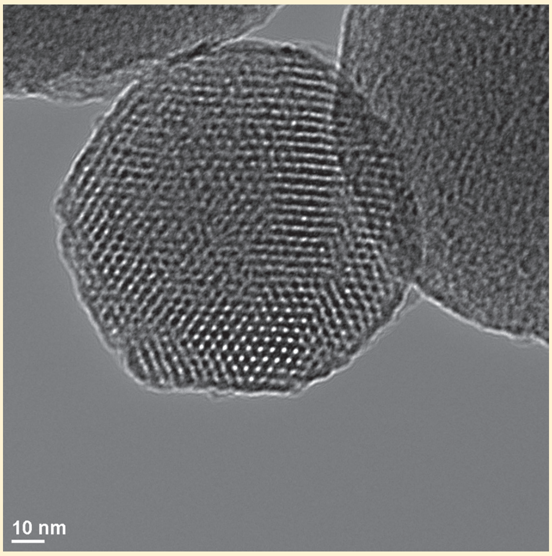

Figure 9. Transmission electron microscopy (TEM) of a mesoporous silica nanoparticle

(Source: Dr. Victor Lin group/Iowa State University, available at: http://en.wikipedia.org/wiki/File:Mesopourus_silica_closeup.jpg)

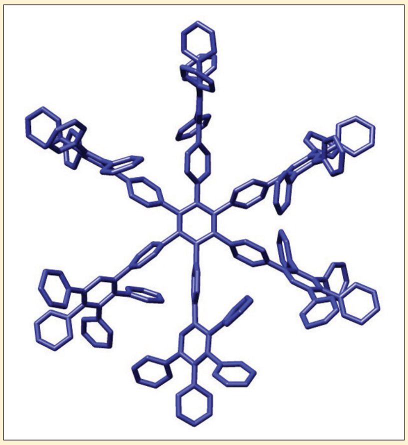

Figure 10. Picture of a first-generation polyphenylene dendrimer

(Source: Bauer et al., Wikipedia, available at: http://en.wikipedia.org/wiki/File:Dendrimer_ChemEurJ_2002_3858.jpg)

"Differences in shape, size, surface charge, and chemical composition mostly due to the mode of their production are used to define ENPs."

prolonged silver nanoparticle accumulation. Bile-duct hyperplasia was noted in both the male and female animals with a higher accumulation of silver nanoparticles in the female kidneys.[43]

Size and the crystalline nature[7] of the TiO_2 nanoparticles determined their toxicity where inert particles as TiO_2 can become biologically active when nano-scaled with the highly crystalline anatase to be more toxic than a mixture of rutile and anatase.

Organic nanoparticles

Polymers used for controlled drug release include the well-known poly(esters) and several examples include polylactic acid (PLA), polyglycolic acid (PGA), or PLGA, a copolymer of PLA and PGA; poly(ortho esters), such as 3,9-diethylidene-2,4,8,10-tetraoxaspiro[5,5]undecane (DETOSU]-based poly(ortho esters); poly(anhidrides) such as sebacic acid (SA), *p*-(carboxyphenoxy)propane (CPP) and *p*(carboxyphenoxy)hexane (CPH) based poly(anhydrides); poly(amides) or poly(amino acids) such as poly(lactic acid-co-lysine) (PLAL); and finally phosphorous-containing polymers.[44]

The highly branched and symmetrical molecules known as dendrimers (Figure 10) are the most recently recognised members of the polymer family because of their unique branched topologies which confer them with properties that differ substantially from those of counterpart linear polymers.

Applications

Polymeric nanoparticle drug delivery systems encapsulate a variety of therapeutic compounds. For example, biodegradable polymer nanoparticles, consisting of PLA, PGA or a copolymer of PLA and PGA, have been investigated for the delivery of proteins and genes, vaccines and anticancer drugs.[45-47] Dendrimer applications include catalysis[48] and molecular encapsulation for light harvesting.[49]

Toxicity and health effects

When using nanoparticles as a vehicle for drug delivery, the health effects of the residual material after drug delivery should be considered. It is therefore desirable to use biodegradable nanoparticles. Poly(ester) nanoparticles are regarded as nontoxic and biodegradable [50]; however, surface modified PLGA such as chitosin-PLGA nanoparticles are toxic to certain cell types.[51] Cationic dendrimers are more cytotoxic and haemolytic than anionic or PEGylated dendrimers.[52]

Occupational exposure to nanoparticles

Similar to other countries, nanoparticles are produced in South Africa by universities and other research groups, small emerging companies, and established major international organisations. There are two basic processes for synthesising nanomaterials. The top-down or mechanical method where the reduction of particle size is achieved by attrition using either lithography or precision engineering processes. The bottom-up method uses gas phase, vapour deposition and colloidal or liquid phase methodologies starting with atoms, ions and/or molecules. An alternative to chemical and physical processes involving the use of microorganisms has recently been investigated.[53]

The UK's Health and Safety Executive (HSE) concluded that all four main groups of nanoparticle production processes may result in exposure through inhalation, dermal or ingestion routes.[11] It stated that exposure via inhalation may occur mainly with gas-phase processes. In addition, particle generation of respirable and inhalable concentrations may result during powder handling activities, product recovery and subsequent processing during all the four production methods.[54] A recent review characterised exposure and summarised the published workplace air measurements on manufactured nanomaterials or objects.[55] A case study on a series of seven previously healthy young women who developed serious heart and lung disease, with fatal outcomes in some cases, after working at a print plant exposed to a chemical "paste" mixture containing undefined "nanoparticles" of approximately 30 nanometres in diameter was also reported.[56]

Exposure assessment in the workplace

As discussed earlier, engineered nanomaterials are diverse in their physical, chemical, and biological nature, as are the processes used in their research, material development, production, or use. Therefore, nanomaterials present new challenges to understanding, predicting, and managing potential health risks to workers. Unfortunately, very little information is available to verify exposure and disease endpoints. Consequently, international agencies, scientists, and regulators have been assessing present knowledge and identifying gaps and research needs about worker exposure as well as defining safe uses of the different engineered nanoparticles. For example, the HSE[11] and others[57] have reviewed processes for the development and manufacture of nanoparticle products and have considered sources and routes of exposure, levels of exposure, numbers exposed, knowledge gaps and future trends.

Traditionally, the dose of particles administered to the lung, e.g. in an instillation or inhalation situation, is measured in mass. However, current evidence suggests that surface area is the most appropriate metric to use to assess exposure by inhalation to most nanoparticles. Ideally a personal sampler should be available which could assess this metric but presently no such methods are available. It has been recommended that where possible, mass, number and surface area of particles should be measured.[58]

Studies have been published on assessing exposure to nanoparticles during their formulation/manufacturing phase using different methodologies. For example, using Condensation Nuclear Counter (CNC) and Scanning Mobility Particle Sizer (SMPS), Thomassen et al.[59] illustrated elevated ultrafine particles in a primary aluminium smelter. Using FMPS, APS, SMPS and Dust Trak, for real-time particle number concentration, size distribution and surface area concentrations, Bello et al., [60] showed that dry cutting of base and CNT containing composites without emission controls resulted in high airborne exposures. Also, using an SMPS and Dust Trak, for real-time size, mass and number concentrations, in a developmental production facility and also in a research facility for metal oxide nanoparticles, Demou et al.[61] demonstrated real-time worker exposure during gas-phase nanoparticle manufacturing. Using scanning transmission electron microscopy with an energy-dispersive X-ray analyser to measure number, composition, and aspect ratio of MWCNTs, an increased release of MWCNTs from the blending equipment in a research laboratory was demonstrated.[62] There are also easy-to-use portable devices capable of detecting ENPs especially in the workplace air.[63,64]

A key challenge in quantitative exposure assessment of nanoparticles is the inability to distinguish nanoparticles of interest from background airborne particulate matter. Therefore, in addition to the assessment of mass, number and size distribution using the aforementioned methodologies, Ono-Ogosarawa and co-workers[65] highlighted the importance of chemical analysis of nanomaterials as part of quantitative exposure assessment of nanomaterials.

Recently the National Institute for Occupational Safety and Health (NIOSH) developed a Nanoparticle Emission Assessment Technique (NEAT) for the identification and measurement of potential inhalation exposure to engineered nanomaterials, which involves three steps; identification of potential sources of emissions, particle number concentration analysis, and collection of filter based samples.[66] In addition, control banding (CB) strategies have also been proposed as simplified solutions for controlling worker exposures to nanoparticles where it has been argued that in the absence of firm toxicological and exposure data, the CB Nanotool may provide a useful approach for assessing the risk of nanomaterial operations.[67]

Protection devices against nanoparticles and nanomaterials

While international efforts are in progress and national programmes are just being established, the paucity of data on toxicity as well as environmental and health effects hinders the ability to conduct timely and proper risk assessment. Therefore, it is imperative to minimise exposure and treat all new nanomaterials as potentially hazardous. This is in line with the paradigm that health and environmental risk is a function of exposure and hazard. In addition, as with any inhalation hazard, potential health risks from nanoparticles are a function of the magnitude (concentration) and duration of the exposure.[68]

Investigations were therefore conducted to assess suitability of laboratory environments and practices in protecting researchers during their activities with nanoparticles. For example, the use of respiratory protection is normally recommended when engineering and administrative controls cannot keep exposure of workers by inhalation below regulatory limits. Due to gaps in information on toxicity and health effects of nanoparticles, it is recommended that personal protection practices, including respiratory protection, be implemented as a matter of course.[69]

Respirators: NIOSH[70] has emphasised that presently, there are no specific exposure limits for airborne nanoparticles and therefore, in determining the need for respirators, they propose considering current exposure limits or guidelines for larger particles of similar composition with one total inward leakage (TIL). For example, they refer to a study[71] on four NIOSH certified N95 filtering facepiece respirator models where a TIL of 80-200 nm was observed. NIOSH also indicates that further studies are being conducted to determine if nanoparticle face seal leakage is consistent with the leakage observed with larger particles and gases/vapours. They discuss the respirator selection logic (RSL) for protection against particular hazards. The certification performance testing of the two classes of most commonly used NIOSH recommended respirators is most affected by particle size. As light scattering photometry is used to assess particle penetration through the filter, the instrumentation used in this certification test is not able to measure the light scattering of all particles less than 100 nm.[72]

The most penetrating particle size (MPPS) for most NIOSH recommended respirators has been determined to be particles less than 0.3 µm. However, in practice, MPPS can vary for a given respirator depending on among other things, the filter media and condition of the respirator.[73] Different studies indicate that the MPPS for most N95 respirator models is in the 40-nm range.[74,75] Laboratory studies[76] showed mean penetration levels for 40-nm particles for the N95 models tested in the range of 1.4% to 5.2% suggesting that these respirators would be protective against nanoparticles.[75] NIOSH has also established that respirators that performed better using the NIOSH certification test also had higher filter efficiencies against monodispersed 40-nm particles. This observation is backed by the fact that changes in filtration performance follow a consistent trend as a function of particle size; namely, that filtration efficiency will increase as particle size decreases, a trend that will continue until the particles are so small that they will start to behave like vapour molecules.[73] At the molecular size, i.e. less than 2 nm, particles are subject to thermal rebound effects thereby increasing their penetration through a filter.[77] Based on these findings it is expected that NIOSH certified respirators should provide desired levels of protection provided they are properly selected and fit tested as part of a complete respiratory protection programme.[73] It is also recommended that in the event of the presence of a large percentage of particles in the MPPS range respirators with higher filtration levels (e.g. P100) should be considered over the standard N95 series.

Protective clothing and gloves: Many factors contribute to the effectiveness of protective clothing.[69] The current two basic test methods are penetration tests on material swatches to determine barrier efficiency and system level aerosol testing to determine product ensemble integrity. Not many studies have been published on the effectiveness of protective clothing against nanoparticles. Golanski et al.[78] showed that protective clothing made of cotton and polyester (woven), and high density polyethylene textile (non-woven) were efficient in protecting workers against TIO_2 and Pt nanoparticles, with the latter being more protective than the former. They also showed that nitrile, latex and neoprene gloves are all efficient against penetration by TiO_2 and Pt nanoparticles.[78]

Fume hoods: The efficacy of laboratory fume hoods in protecting the researchers from nanoparticle exposure were investigated where variable factors studied included hood design, transfer method, and face velocity/sash location and material type. The test results indicated that the handling of dry powders consisting of nano-sized particles inside laboratory fume hoods can result in a significant release of airborne nanoparticles from the fume hood into the laboratory environment and the researcher's breathing zone. Many variables affected the extent of particle release.[79]

General hygiene measures: The effectiveness of protective control using conventional industrial hygiene measures (including installation of a fan, cleaning and re-arrangement of the workplace) for MWCNT in a research facility was demonstrated (Figures 11 and 12).[62]

Figure 11. A nanoparticle production worker wearing a personal air sampler and hearing, respiratory, and dermal protection during a pouring operation

(Source: NIOSH, available at: http://www.cdc.gov/niosh/docs/2008-112/pdfs/2008-112.pdf)

Guidelines on the safe handling of nanoparticles in the work place and in research laboratories

It is probable that exposure to nanoparticles will occur during the research and development stage of nanomaterials. In 2008, the European Commission published a code of conduct and principles of good practice for researchers involved in the development of nanomaterials.[80] Some key principles were that research activities should be conducted in accordance with the precautionary principle, anticipating potential environmental, health and safety impacts and taking due precautions. This in turn, implies that the responsibility of the assessment of toxicity of newly manufactured nanoparticles remains with the producers.

Recently a number of documents and guidelines have been published by NIOSH related to safe handling of nanoparticles at the workplace,[81] and to the management of health and safety concerns associated with ENPs.[73] They emphasise the importance of minimising exposure of workers to nanomaterials by controlling airborne nanoaerosols through engineering control techniques. The implementation of a risk management programme to minimise exposure by evaluating the hazard posed by the nanomaterials based on the available physicochemical properties, and also, the toxicity and health effects of the nanomaterials was recommended. Other suggested measures included control techniques like source enclosure and effective local exhaust ventilation system to capture airborne nanoparticles with the use of a high-efficiency (HEPA) filter system, cleaning the work areas using HEPA vacuum pickup, and use of wet wiping methods. However, they indicate that no guidelines are yet available on the selection of clothing or other apparel for the prevention of dermal exposure to nanoaerosols.

Similarly, in Germany, Wacker Chemie AG and the German Chemical Industry Association jointly published a guidance document for handling and use of nanomaterials at the workplace to support companies towards achieving sustainable and responsible development of nanotechnology-based applications.[82] In the UK, the HSE published guidance specifically addressing the safe handling of CNTs, and also stated that a "precautionary approach" should be taken in the risk management of all CNTs. The use of HEPA filters or suitable effective exhaust ventilation is also recommended.[83] In addition, the Organisation for Economic Cooperation and Development (OECD) is involved in activities to provide sound guidelines on exposure assessment and mitigation for nanotechnology in the workplace.[57] All of these organisations recommend that until further information on the possible health risks and extent of occupational exposure to nanomaterials becomes available, interim precautionary measures should be developed and implemented. In Europe, under the Registration, Evaluation Authorisation and Restructure of Chemical Substances (REACH) legislation, the need for re-examination of existing legislation and, if needed, its revision has been identified. In addition, a number of documents on REACH application relevant to the regulatory aspects of nanomaterials has been published.[84] Controlling of exposure and risk management issues of ENPs have also recently been discussed by Savolainen et al.[85]

With emerging information suggesting that exposure to some ENPs can cause adverse health effects in laboratory animals, NIOSH has recently formulated interim guidance relevant to medical screening for nanotechnology workers.[4] While this document acknowledges the lack of sufficient scientific and medical evidence to recommend the specific medical screening of workers potentially exposed

Figure 12. A flat plate test system for measuring respirator filter penetration of 3 to 20 nm silver particles

(Source: NIOSH, available at: http://www.cdc.gov/niosh/docs/2007-123/pdfs/2007-123.pdf)

to ENPs, it also emphasises that this does not preclude specific medical screening by employers interested in taking precautions beyond existing industrial hygiene measures. Subsequently interim recommendations were made for the workplaces where workers may be exposed to ENPs in the course of their work to take prudent measures to control exposures to ENPs, conduct hazard surveillance as the basis for implementing controls, and continue the use of established medical surveillance approaches.

Conclusions and recommendations

The South African government has shown appreciation for the potential application of nanotechnology in the fields of energy, water purification and better drug delivery systems and has therefore established and initiated numerous activities in the country on nanotechnology at universities, scientific councils and commercial companies.

Similar to any new technology, concerns have been expressed that the very properties of nanoscale particles being exploited in certain applications might also cause undesirable health and environmental impacts. Until now, various studies demonstrated that at least some ENPs will be more toxic per unit of mass than their larger counterpart parent bulk chemicals. This toxicity is related to the greater surface area of and the chemical reactivity of the surface which could be increased or decreased by the use of surface coatings. It also seems likely that nanoparticles will penetrate cells more readily than larger particles. Therefore, it is imperative that the full extent of effects of these nanoparticles and nanomaterials on human and environment be systematically investigated.

Lessons learned

1. Engineered nanoparticles are defined by differences in their shape, size, surface charge, and chemical composition mostly due to the mode of their production.
2. Nanoparticles that deposit in the lung produce greater adverse inflammatory and fibrotic response when compared with larger-sized counterpart bulk parent chemicals.
3. Inhaled nanoparticles may evade phagocytosis, cross cell membranes, and redistribute to other sites of the body, causing systemic health effects.
4. The small size of nanoparticles confers advantageous properties which may also make them behave differently in biological systems from their larger sized counterparts. Therefore, nanoparticles are likely to be more toxic than their larger-sized counterparts, and surface reactivity of nanoparticles may determine this toxicity.
5. An integrated effort is needed to estimate health hazards of newly generated nanoparticles during their development. Hazard identification of nanoparticles and nanoparticle toxicology is still at a developmental stage with most studies focusing on acute toxicity. Long-term toxicity and examination of chronic exposure are critical in understanding the toxicology of nanoparticles *in vivo* that can be used for No Observed Adverse Effect Level (NOAEL) determination – which in turn will assist in undertaking their comprehensive health risk assessment.
6. The precautionary principle is recommended in mitigating the potential health effects of nanomaterials. In this regard a number of organisations, e.g. NIOSH, HSE, OECD, have come up with guidelines for the safe handling of nanoparticles in the workplace.

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Human disease due to exposure to nanoparticles

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Abstract

The rapid progress and growth in the field of nanotechnology has raised concerns about the toxicity of nanoparticles. This paper reviews the literature concerning human disease attributable to exposure to nanoparticles and is illustrated with nanoparticles in a product on sale in South Africa. Nanotoxicology studies *in vitro* and in rodents have shown nanoparticles to be more biologically active than their larger counterparts. These studies also show that nanoparticles may be rapidly transported to many organs of the body. Documented examples of disease in humans attributable to nanoparticles are rare. The explanation for this is not known but nanoparticles tend to aggregate and, perhaps, larger aggregated particles are not as biologically active as individual particles. In the examples of human disease due to nanoparticles presented here, workers were exposed to massive doses of particles without basic occupational hygiene measures being taken. The effects of nanoparticles on humans may be systemic and present diagnostic difficulties as the effects of exposure to low doses and the long-term effects of exposure to nanoparticles are unknown.

Key words: nanoparticles, toxicity, human disease, workplace exposure

Introduction

Nanoparticles, which are sometimes called ultrafine particles, are defined as particles having at least one dimension of 100 nanometres or less. This means nanoparticles are smaller than bacteria and are the size of viruses. They are smaller than the resolution limit (approximately 250 nm) of light microscopes but can be visualized using electron microscopy.

Nanoparticles can be classified into three main types – naturally occurring, manmade incidental and engineered. Naturally occurring nanoparticles are produced by forest fires and volcanoes and have been around since our planet was formed. Manmade incidental nanoparticles result from industrial processes such as smelting and the burning of fossil fuels. These processes are important in South Africa where mining and the beneficiation of minerals is important to the economy. However, it is the engineered nanoparticles and the technologies associated with them that are set to change the world as we know it.[1] The prediction that nanotechnology will transform life in a more dramatic fashion than the industrial revolution of the 18th and 19th centuries is underpinned by an exponential increase in the number of patents being taken out on nanoparticles, the number of scientific articles written about nanoparticles and the increasing number of consumer goods that contain nanoparticles.[2-3] The application and potential of these particles in areas such as medicine, computers, energy, coatings, lubricants and consumer goods has caused much excitement.

Along with this excitement have come warnings about the possible adverse health effects that nanoparticles may have on human health and in particular on those who will be working with these particles. Such fears seem reasonable given that the properties that make nanoparticles so useful: small size, relatively large surface area and reactivity, may make them more toxic than larger particles of similar chemical makeup.[4,5]

Although nanotechnologies are evolving, there are already many products currently available that contain nanoparticles. Sunscreens and cosmetics containing nanoparticles of zinc oxide and titanium dioxide are readily available in shops and as these products are applied to the skin, there have been concerns raised over their potential adverse health effects.[6,7]

Because of concerns about the potential adverse health effects of nanoparticles, there have been calls for research into risk assessment, legislation and toxicology.[8] Recently, there have been numerous toxicology studies of nanoparticles using cell cultures and rodent models. These laboratory studies have been extensively reviewed[9] and support the hypothesis that *in vitro* and in rodents, nanoparticles are more toxic than their larger counterparts.[4] Despite these concerns there is very little evidence in the literature to suggest that human disease can be attributed to exposure to nanoparticles. This paper reviews the literature and examines silver nanoparticles that can be bought by South Africans.

Methodology

The literature was searched online using PubMed and a combination of key words: nanoparticles, nanotubes, human, disease, toxicology.

A silver based, liquid, tonic was purchased online. Aliquots of 5 ml were filtered using a gold coated polycarbonate filter with a pore size of 0.2 µm. The filter was examined at magnifications up to 100 000 times, using a Jeol JSM 5600 scanning electron microscope equipped with Thermo Noran energy dispersive X-ray spectroscopy capabilities. For transmission electron microscopy (TEM), a drop of the liquid tonic was put onto a formvar and carbon coated copper grid and allowed to dry before being examined in a Jeol JEM 1200 EX2 TEM at magnifications of up to 300 000 times.

"Occupational health professionals must be aware of the potential adverse effects of nanoparticles . . ."

In vitro and animal toxicology studies

In rodents, raised cytokines and inflammation of the respiratory tract has been demonstrated following intratracheal instillation of engineered metal and carbon based nanoparticles.[9-11] Animal studies show that the nanoparticles whether administered orally, intravenously or via inhalation, can be distributed to many organs including the liver, spleen, kidney, lung, brain and testes.[9] Nanoparticles that are administered intratracheally have been shown to reach other organs via the blood.[12] Various mechanisms by which nanoparticles cross the epithelial cells lining the alveoli, the basement membranes and the endothelial cells to enter the blood stream have been proposed. Consensus is that this can happen very rapidly.[13-15] Alternatively, the particles can reach other organs through ingestion and transportation by macrophages.[13] Direct olfactory transport of inhaled nanoparticles can bypass the blood brain barrier. Nanoparticles can be conveyed along cell processes of olfactory neurons through the cribriform plate to synaptic junctions with neurons of the olfactory bulb and released into the central nervous system.[16,17]

Since nanoparticles have the potential to be transported to different organs of the body, the potential exists for their use in drug delivery systems. This useful ability also confers the potential of nanoparticles to produce a wide spectrum of disease.[4]

Carbon nanotubes have been shown to produce inflammation, granulomas and fibrosis of the lungs in rodents.[4,18] The analogy between high aspect ratio carbon nanotubes and asbestos fibres has been made, raising the concern that they may cause an adverse health effect such as mesothelioma, which only manifests many years after exposure. Carbon nanotubes administered intraperitoneally to mice have been shown to induce pathological changes including the development of mesothelioma.[19,20]

Particles may cause adverse changes in cell culture, but this cannot always be extrapolated to human disease. Testing glass fibres *in vitro*, for example, produces oxidative stress similar to that produced by asbestos fibres. But, because of their relative lack of biopersistence, glass fibres do not produce the spectrum of disease seen in humans exposed to asbestos.[21] Similarly, the results of animal studies may not be directly extrapolated to humans. Cellulose fibres injected into the peritoneal cavity of a rat can produce tumours, including mesothelioma[22], but these fibres are not seen to cause tumours following exposure in humans.

Human disease following nanoparticle exposure

Evidence for the toxicity of nanoparticles in humans is limited but compelling. Searching the PubMed database revealed only two reports describing disease following exposure to nanoparticles in the workplace. A recent report from China[23] describes lung disease in a cluster of workers in the printing industry. The workers were involved in a process of spraying a coating onto boards. For a period of 5 to 13 months, they were all exposed to the spray which contained 30 nm diameter particles of polyacrylic ester. The seven workers, previously healthy, young females, who had never smoked, were admitted to hospital with shortness of breath. On admission they had clinical findings of pleural and pericardial effusions. Examination of lung biopsies and chest fluid from these women showed

30 nm particles in their pulmonary epithelial cells. Within 21 months of developing symptoms, two of the workers had died of respiratory failure.[23] Although nanoparticles were not monitored in the working environment, engineered nanoparticles were identified from the work process and in the lungs of workers. The disease process appeared to be confined to the respiratory tract.

The concerns around nanoparticles led us to re-examine in detail[24] a case reported in 1994.[25] A previously healthy, non-smoking, 38-year-old male was exposed to a nanoparticulate spray of nickel while operating a metal arc process for approximately 90 minutes without personal protective equipment. He died of acute respiratory distress syndrome (ARDS) 13 days post-exposure. The nickel particles were recreated in a simulation of the process and nanoparticles of nickel were identified using scanning electron microscopy. Transmission electron microscopy identified 4 to 25 nm particles in his lung macrophages. In hospital, the patient excreted large amounts of nickel in his urine (780 µg/L). At autopsy there was histological evidence of tubular necrosis of the kidney. The nanoparticles of nickel were inhaled and produced an acute respiratory distress syndrome along with other systemic effects.[24] Metallic nickel is allergenic but is not regarded as being particularly toxic. This case report supports the concept that nanoparticles are more reactive and therefore more likely to produce adverse health effects than larger particles of the same chemical. It also reminds us that nanoparticles are not new and that there are many industrial operations such as metal arc spraying that may produce incidental nanoparticles. South Africa is a uniquely mineral rich country with a modern economy built on the exploitation of minerals. Associated with the mining and beneficiation of minerals are a range of industrial processes with the potential to generate manmade incidental nanoparticles. A careful investigation of the workers engaged in these industries, which include welding, metal spraying and smelting might reveal more evidence of nanoparticle associated disease.

In the two examples above, nanoparticles were identified in the work process and the lungs making a compelling case that the disease was due to nanoparticulate inhalation. One other possible example of disease following inhalation of nanoparticles was found in the literature; however the presence of nanoparticles has been assumed rather than proven. Incidental nanoparticles can be produced in combustion processes such as the burning of fossil fuels. In December 1952 the City of London in England, was engulfed in smog, a combination of fog contaminated with smoke, mainly from coal fires and diesel engines. The smog persisted for a period of five days, bringing the city to a standstill. In the aftermath it was noted that there was an extraordinarily high number of deaths due to respiratory and cardiovascular complications. These deaths occurred over 50 years ago and have never been fully explained. An investigation was carried out recently using tissue from patients who died with an autopsy diagnosis including either chronic obstructive pulmonary disease or congestive heart failure following the 1952 smog episode. Electron microscopic examination of archived lung tissue showed fine particles of carbon, lead, tin, zinc and antimony in lung macrophages.[26] Some of the fine particles identified were nanoparticles raising the possibility of their involvement in lung and cardiovascular disease. The concept that particulate air pollution exacerbates respiratory illness and deaths from cardiovascular disease has been proposed.[27] There is evidence of a possible mechanism, whereby exposure to particulate air pollution may alter haematological parameters, making red blood cells more adhesive.[28]

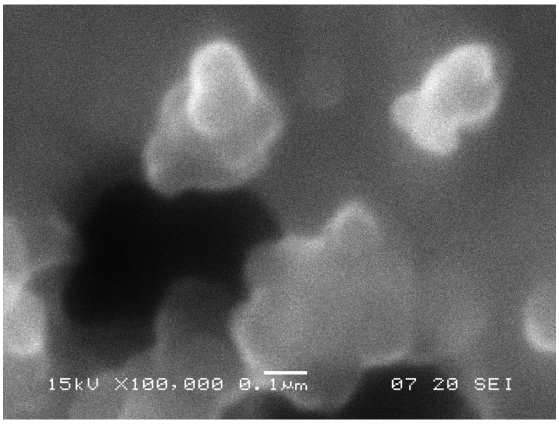

Figure 1. Scanning electron micrograph of clusters of colloidal silver from a general tonic manufactured and sold in South Africa. The particles are ovoid rather than spherical. Using a Thermo Noran energy dispersive X-ray spectroscopy system, energy peaks for silver (Lα = 2.984) were detected from the particles.

South Africa is investing in more coal fired power stations and has a petrochemical industry based on coal. The emphasis on environmental pollution with PM_{10} (particles less than 10 microns) may need to be shifted to concentrate more on the ultrafine or nanoparticulate range less than 100 nanometres in size. Exposure to lesser concentrations may produce more subtle outcomes and affect organs other than those of the respiratory and cardiovascular system.

Just one other example of disease due to the ingestion of nanoparticles was found in the literature. Silver has been used as a medicine since ancient times and medical products containing nanoparticles of silver have been developed because of their antibacterial properties and wound healing properties.[29,30] Recently, colloidal silver

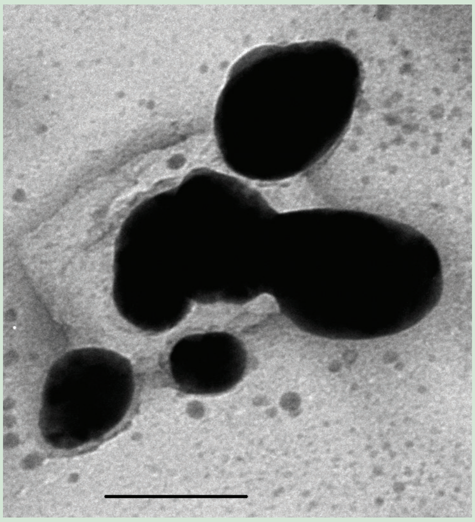

Figure 2. A transmission electron micrograph of electron dense, silver, nanoparticles from the commercially obtained tonic used for Figure 1. The ovoid shape of the silver particles is confirmed. The individual silver particles are less than 100 nm in diameter and tend to occur in small clusters. The scale bar represents 50 nm.

may see an increase in an old disease caused by alternative medicines that contain silver nanoparticles.

In the examples cited above, the adverse health effects caused by exposure to nanoparticles produced extreme heath outcomes. Lower level exposures may produce more subtle disease processes. Occupational health professionals must be aware of the potential adverse health effects of nanoparticles and the fact that the disease they cause may be unusual and systemic. Also, the disease may occur in clusters or amongst a specific cohort of workers. Currently, there are no accepted medical screening measures or biological indicators that are specific for nanoparticle exposure.

In South Africa, alternative medicines, cosmetics and sun screens containing engineered nanoparticles can be bought by consumers and universities and research institutes are producing novel nanoparticles such as gold-based chemo-therapeutics. However, industries that make or use engineered nanoparticles on a large scale have yet to be developed. The large scale manufacture of engineered nanoparticles may or may not materialise in South Africa but incidental manmade nanoparticles are not new. Existing

"Although nanotechnologies are evolving, there are already many products currently available that contain nanoparticles."

products have become popular as alternative medicines and are used as a general tonic, cleanser or specific treatment for conditions such as arthritis. These products are manufactured in South Africa and are commercially available without a prescription. Using electron microscopy they are seen to contain nanoparticles of silver less than 100 nm diameter (Figures 1 and 2). There are reports of cases of argyria due to nanoparticles of silver ingested as an alternative medicine.[31-32]

Argyria patients have a systemic deposition of silver in internal organs and the skin. Their skin develops a permanent bluish grey colour, especially in sun exposed areas. The colouration has been misdiagnosed as cyanosis resulting in patients undergoing unnecessary investigations.[32] The development of argyria due to ingestion of silver medicines has been known for some time.[33] Physician-directed use of silver containing products has declined with the availability of effective pharmacological alternatives and argyria is rarely seen. The recent interest in self medicating with colloidal silver products and their availability through the Internet

industrial processes have the potential to produce incidental nanoparticles. The emergence of new nanotechnologies has increased awareness of nanoparticles which might give impetus to revisiting industrial processes capable of producing incidental nanoparticles.

A challenge facing occupational health professionals is the monitoring of nanoparticles in the workplace. While instruments capable of measuring nanoparticles exist, they have limitations of lack of specificity, lack of portability, complexity of use and high cost. Strategies for measuring and identifying nanoparticles in the workplace are being developed.[34,35] However, without affordable convenient monitoring devices risk assessments cannot be conducted and monitoring cannot take place and new standards and exposure limits cannot be set. Since nanoparticles owe their unique characteristics to their small size, relatively large surface area and low mass, air measurements based on the mass of nanoparticulate dust would seem to be inappropriate.

Toxicology studies *in vitro* and in animals have demonstrated mechanisms whereby nanoparticles might cause disease in humans. However, reports in the literature of disease in humans attributable to nanoparticles are sparse and have been reviewed here in detail. Why are we not seeing more evidence of disease in humans due to nanoparticles? Are cases being missed or misdiagnosed? This would seem unlikely given the current interest in nanoparticles and their toxicology. There may be difficulty in identifying nanoparticles as they can only be visualised using electron microscopy.

It has long been recognised that workers in the silicon alloy industry can develop a rapidly progressive form of silicosis.[36] The process of manufacturing a silicon alloy involves the heating of quartz and metal in a furnace. The process emits a smoke or fume which contains silicon dioxide particles. When freshly formed these particles are less than 300 nm in diameter and are below the limit of detection using light microscopy techniques. These fume particles rapidly aggregate to form larger particles which may not be respirable (Figure 3). In a study of 14 silicon alloy workers with pneumoconiosis, it was found that they all worked in the casting bay in the immediate vicinity of the furnaces, where the fume particles have had less chance to aggregate.[37] Silicon alloy workers' disease may be due to small particles of silicon dioxide with affected workers being exposed to the fume before it has time to aggregate.

The aggregation of nanoparticles is an important consideration in assessing their impact on human health.[38] Aggregation has a profound impact on particle size and structure and experimental evidence suggests that particles with the same chemical composition but different sizes may exhibit different properties.[39] The aggregation of nanoparticles may have toxicologic implications[40] and there is a growing consensus that nanoparticle aggregation is an important factor in understanding the health implications for nanoparticles.[41]

The aggregation of nanoparticles may be preventing human disease by changing the size, shape and surface properties of the particles. In the workplace, this may limit the area of risk and thus, in this reduced area, only a small proportion of the workforce may be exposed.

Conclusion and recommendation

There is a great deal of current research being conducted on the toxicology of engineered nanoparticles, which are usually chemically pure. Industrial processes currently operating in South Africa produce mixtures of incidental manmade nanoparticles that may include a variety of chemicals. Exposure to these complex mixtures of

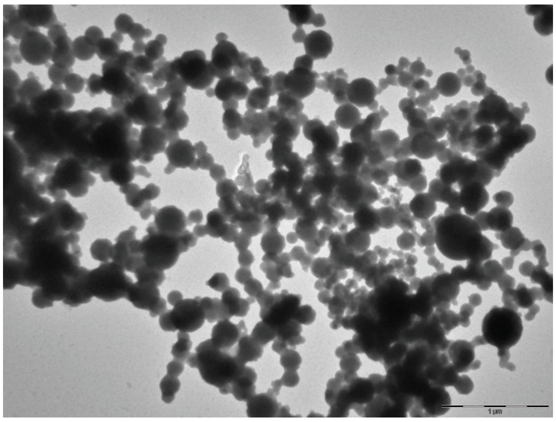

Figure 3. Transmission electron micrograph showing fume from a silicon ferro-alloy smelting process. Some of the particles have diameters less than 100 nm. The particles are seen to occur as large aggregates. The scale bar represents 1 µm (1000 nm).

particles may produce a variety of adverse health effects, which may be difficult to attribute accurately to a workplace exposure. Industrial fumes need to be revisited with particular reference to nanoparticles as their long-term effects on workers are unknown.

Lessons learned

1. Occupational health professionals need to be aware of nanoparticles and their potential to be more toxic than their larger counterparts.
2. Reports of disease attributable to exposure to nanoparticles are rare but when they occur they can be acute and catastrophic.
3. Incidental manmade nanoparticles are being produced by industrial process in South Africa. Identifying, monitoring and controlling nanoparticles present challenges to occupational hygienists.
4. Aggregation of nanoparticles may protect some workers from exposure, which may be limited to groups of workers or certain areas of the industrial plant.
5. The effects of exposure to nanoparticles may be systemic and the long-term effects of exposure to low doses are unknown.

Acknowledgements

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"Particles may cause adverse changes in cell culture, but this cannot always be extrapolated to human disease."

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An introduction to the toxicology of endocrine disruptors

The last article in a series of three.

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INTRODUCTION

The series introduced the readers to the consequences of exposures in the workplace by xenobiotics, phyto-oestrogens, xeno-oestrogens, drugs, biologicals and chemicals that can be associated with short- to long-term health effects or even death. In principle, there is agreement that such compounds in high or low doses at chronic intervals may cause developmental, reproductive, and tumorigenic effects. Nevertheless, persistent chemicals with a high potential of accumulation remain a topic of concern in ecotoxicology and human toxicology and can only be properly addressed when medical practitioners understand and accept that toxicology cannot be evaluated in isolation but is the combination of research and information throughout the multidisciplinary phases of science.

BACKGROUND TO HORMONES AND HORMONE ACTION

Endocrinology, as is the case with most of the modern medical sciences, is an everchanging discipline. The impact of molecular and cell biology has radically transformed our understanding of endocrine physiology and pathology. Today, the focus is more on how hormones act than on factors that influence hormone levels. Moreover, advancement made in technology has led to the recognition that many chemicals (hazardous/non-hazardous) can behave like/mimic hormones.

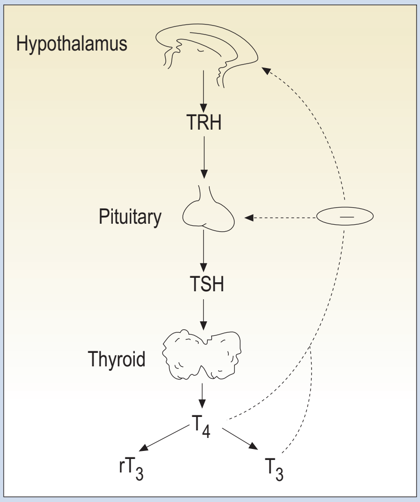

Figure 1. The classical feedback system: control of thyroid hormone release. When thyroid hormone levels are inadequate, the repressive effect of triiodothronine (T_3) and thyroxine (T_4) on the hypothalamus and pituitary is removed. Thyrotropin releasing hormone (TRH) release stimulates thyrotropin (TSH, which in turn activates thyroxine synthesis in the thyroid gland. As soon as the triiodothyronine and thyroxine levels are adequate, inhibition of release of thyrotropin-releasing hormone and thyrotropin occurs

BASIC ENDOCRINE PHYSIOLOGY AND PATHOLOGY

1. The functions of hormones

Hormonal function involves four broad domains: reproductive, growth and development, maintenance of the internal environment, and utilisation/storage of energy. The distinguishing characteristic of the endocrine system is the feedback control of hormone production. The paradigm for feedback control is the interaction of the pituitary gland with the thyroid, adrenals and gonads. Hormones produced in the peripheral endocrine organs feedback on the hypothalamic-pituitary system, thus regulating the production of the tropic hormones that control the peripheral endocrine gland (Figure 1). Virtually all hormones are controlled

Table 1. Occupational exposure to oestrogenic chemicals (Case reports) *(Source: Degen at al., 2000)*

Example/agent	Persons	Effect	References
Manufacture of oral contraceptives	Male workers[a]	Gynaecomastia	Harrington et al. 1978 Willems 1981
DDT[c] application	Female workers[a]	Cycle irregularities	Singer 1949
Kepon manufacture	Crop dusters[a]	Oligospermia	Ecobichon 1996
	Male workers[a]	"Kepon-shakes" – impotence, reduced sperm counts and motility	
Cream with ?? (ER-active)	Embalmer[b]	Gynaecomastia, hypogonadotropic hypogonadism	Finkelstein et al. 1988
Stilbene derivatives[d]	Male workers[a]	Impotence	Quinn et al. 1990
DAS manufacture	Male workers[a]	Impotence, decreased libido	Grajewski et al. 1996

[a] Insufficient protection at work
[b] No use of gloves
[c] Technical product with p,p′-DDT and o,p-DDT in a xylene base
[d] Intermediates for the synthesis of optical brightening agents

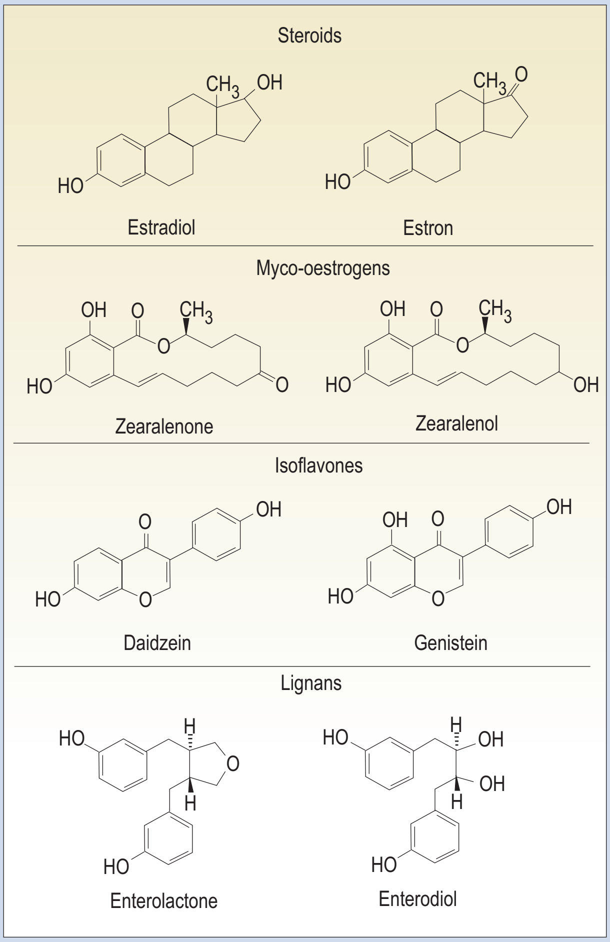

Figure 2. Structures of naturally occurring compounds with oestrogenic activity (Degen et al., 2000). Environmental oestrogens with oestrogenic activity are very often the result of improper dietary regiment. Dietary exposure to chemicals (phyto-oestrogenes) are usually classified as 'weak' oestrogens, these compounds are known to affect the endocrine system when consumed in sufficient amounts

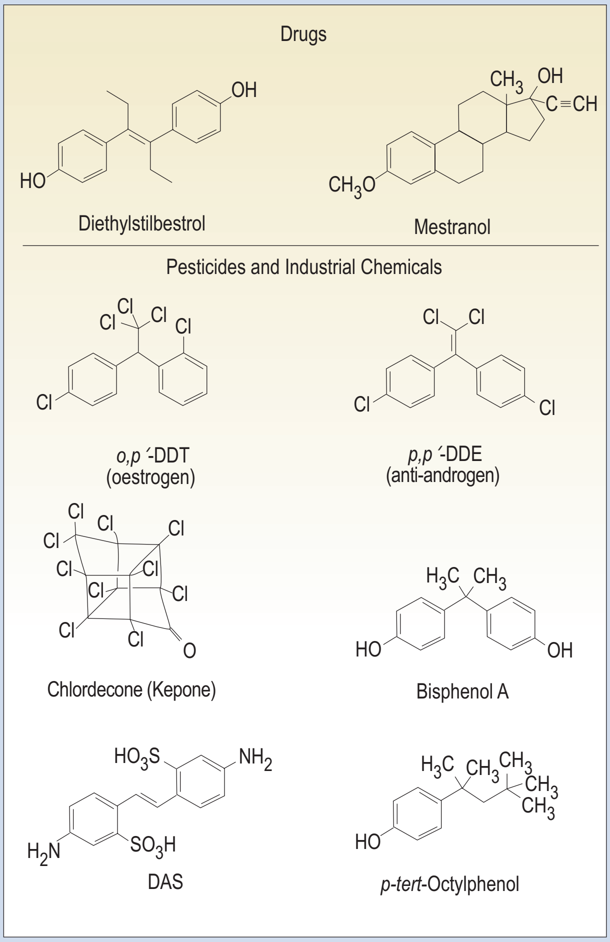

Figure 3. Examples of synthetic chemicals with different oestrogenic activities, which, when exposed to on chronic basis will result in irreversible damage in children throughout their developmental stages (Degen et al., 2000)

by some type of feedback mechanism / control, some by cations (calcium on parathyroid hormone), some by metabolites (glucose on insulin and glucagon), some by other hormones (somatostatin on insulin and glucagon), and some by osmolality on extracellular fluid volume (vasopressin, renin and aldosterone).

2. Environmental endocrine disruptors

Endocrine disruption by external agents in the environment has become a very hot topic over the past few years. Active research has led to a focus shift from hormone activity to xeno-oestrogens, i.e. environmental chemicals with oestrogenic activity. An endocrine disruptor is an exogenous substance or mixture that alters function(s) of the endocrine system and consequently causes adverse effect in an intact organism or its progeny, or in vulnerable populations and is not considered a toxicological endpoint per se, but a function change that may lead to adverse outcomes (Damstra, et al., 2002).

2.1. Endocrine disruptors – naturally occurring environmental phyto-oestrogens

In principle, it has been accepted that such chemicals ("hazard"), in high doses, may cause developmental, reproductive and tumorigenic effects. Some chemicals with known hormone-like properties are listed in Figure 2 and have been associated with hormonal activities (Tyler et al. 1998; Tyler and Routledge 1998; van der Kraak, 1998). However, the complex regulation of the endocrine system, variations in endogenous sex hormone levels, and exposure to naturally occurring compounds (phyto-oestrogens) with hormone-like activity complicate the picture to the extent that cause and effect relationships are difficult to establish (Figure 2). For instance, an endocrine effect can result from interaction with the receptor molecules, but also from interference with endogenous hormone synthesis, secretion, transport, metabolism or elimination (Kavlock et al. 1996).

2.2. Endocrine disruptors – occupational exposure to synthetic oestrogens

Exposure to synthetic oestrogens is not a new concept and has been recognised by international legislation, which requires classification and labelling of dangerous substances with respect to risks for fertility and development. Table 1 provides some guidelines observed in humans when working with chemicals as illustrated in Figure 3.

In the past, the production of oral contraceptives resulted in

“. . . persistent chemicals with a high potential of accumulation . . . can only be properly addressed when medical practitioners understand and accept that toxicology . . . is the combination of research and information throughout the multidisciplinary phases of science.”

some male workers developing gynaecomastia and complaints about loss of libido, whereas female counterparts complained of irregular menstruation (Harrington et al. 1978, Willems 1981). Another historical example is oligospermia in workers with high exposure to DDT (Singer 1949). However, we also know that throughout the developmental stages in children, the exposure to xeno-oestrogens will result in irreversible damage (Figure 3).

3. Endocrine disruptor mode of action

The fundamental hormonal signalling system is based on a feedback system involving the hypothalamic/pituitary/gonad axis as schematically depicted in Figure 4. From the diagram, it can be seen that feedback can be modulated in two basic ways: agonist or antagonist of the respective oestrogen and androgen receptors, and interference with steroid biosynthesis and metabolism, particularly the important terminal step such as the conversion of testosterone into more potent dihydrotestosterone by 5α-reductase.

Chemicals of different origin which act to mimic oestrogens or act as anti-androgens may be detrimental to reproduction and development in humans and animals. The diagram (Figure 4) demonstrates the binding site normally associated with persistence and bio-accumulating chemicals such as DDT, dieldrin, endosulfan, etc. However, to what extent xeno-oestrogens and xenoanti-androgens can indeed exert adverse effects on humans remains somewhat controversial.

CONCLUSION

The rapidity and extent of advancements made in endocrinology have made it increasingly difficult for physicians to take full advantage of information available for the understanding, diagnosis and treatment of clinical disorders caused by hazardous substances associated with occupational toxicology. Without clear guidance and more fundamental research, clinicians and occupational medical practitioners need to be prudent and follow a common-sense and high index of suspicion approach.

The main focus of this three-part article was to introduce the reader to the old and new in immunotoxicology and provide a condensed introduction to the subject matter. This should lead to further reading and publication of current and local research.

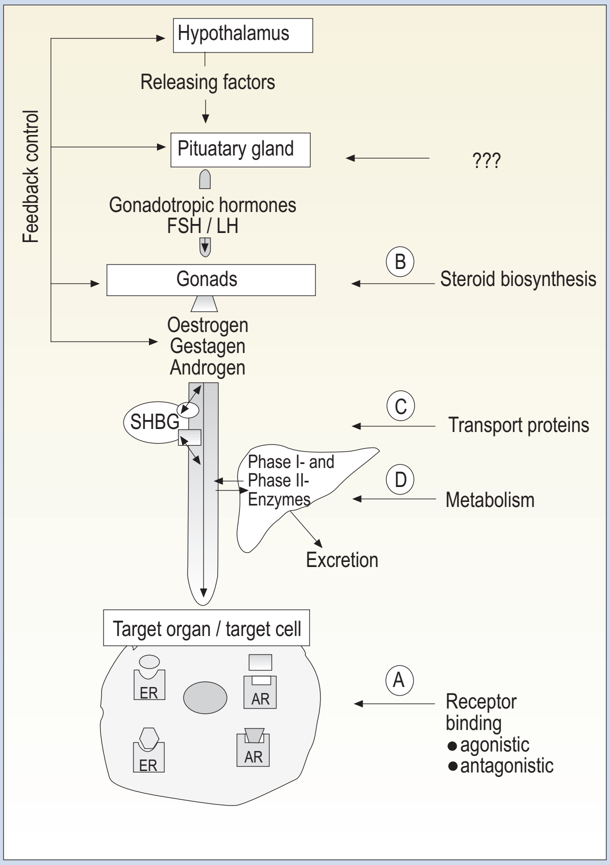

Figure 4. Schematic diagram of hormone signalling components. Chemicals (oestrogens) can interfere by different mechanisms (A to D) with the sex hormone system

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Back to Basics – the chest radiograph in silica associated tuberculosis

Abstract

Silicosis increases the risk of tuberculosis (TB) but its presence complicates the radiological features of TB and they may not be typical. Additionally, HIV infection rates may be high in silica exposed populations and the prevalence of smear-negative pulmonary TB is higher in these groups. Consequently the chest radiograph – along with symptoms and other investigations – is important in identifying TB. The radiological features in reading chest radiographs for TB in the presence of silicosis are highlighted in the article to promote the earlier investigation of suspect cases.

Key words: tuberculosis, silicosis, radiological features, chest radiographs, tuberculosis detection

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Introduction

Silicosis increases the risk of tuberculosis (TB) and the disease is common in individuals with the pneumoconiosis, particularly in settings with high background rates and when the silicosis is advanced. Consequently, TB should be considered in all cases of silicosis both for individual treatment and to reduce transmission. But, the presence of silicosis complicates the radiological features of TB and they may not be typical. Additionally, HIV infection rates may be high in silica exposed populations and the prevalence of smear-negative pulmonary TB is higher in these groups. Consequently the chest radiograph – along with symptoms and other investigations – is important in identifying TB. This article briefly summarises the epidemiology of silica and TB and highlights some of the radiological features in reading chest radiographs for TB in the presence of silicosis to promote the earlier investigation of suspect cases.

Background epidemiology

Exposure to silica is very common around the world with millions of people over-exposed in a large range of industries.[1] Silicosis burdens are high in some settings in southern Africa. For example, about 20% of long-service gold miners have the disease[2]; 22–36% of living ex-miners[3,4,5] and cumulative prevalences can exceed 50% in miners followed to death.[6] The proportion of miners with silicosis coming to autopsy at the National Institute for Occupational Health has increased markedly from 1975 to 2007: 3% to 32% in black miners and 18% to 22% in white miners.[7]

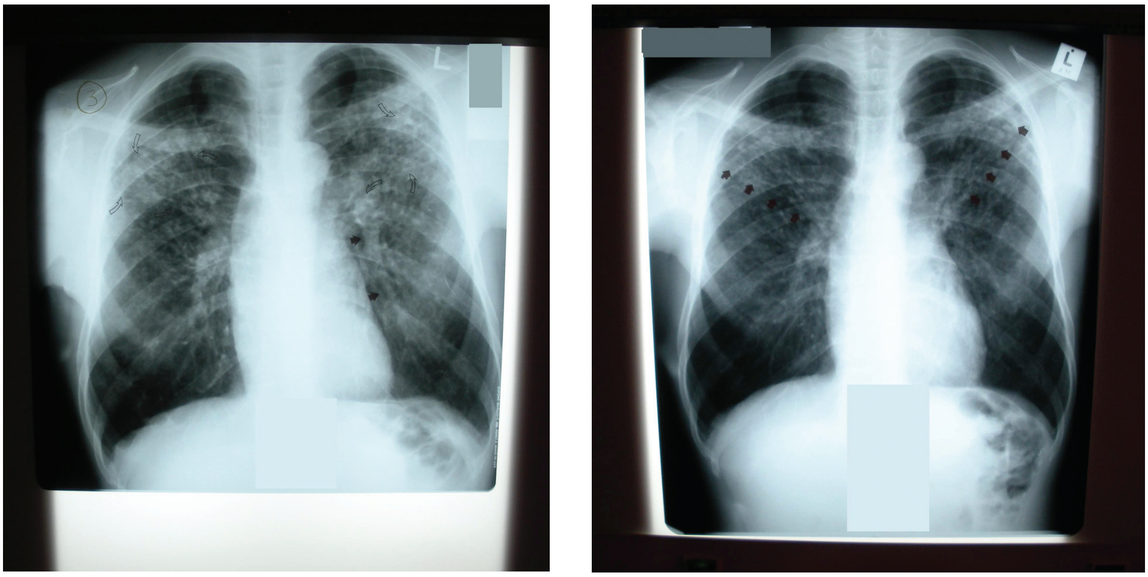
A major concern related to silicosis is the associated increased risk of TB, which approaches or equals that conferred by HIV infection.[8] A seven-year follow-up of gold miners before the HIV epidemic found a relative risk of TB in men with silicosis compared to those without of 2.8 (95% CI 1.9-4.1), and the incidence of TB rose with increasing severity of silicosis: 2.2% per annum in mild silicosis to 6.3% per annum in those with advanced disease.[9] The HIV epidemic has worsened the situation both because of the high HIV prevalences in southern African workforces and because there is a multiplicative interaction for TB between silicosis and HIV; the risk of TB is higher than the sum of each risk combined.[10] Importantly, silica exposure is associated with TB even in the absence of silicosis[11,12] and the increased risk of active TB is lifelong.[11] Consequently, very high burdens of TB have been described in silica-exposed populations: for example incidences between 3000 to 7000/100 000/year in gold miners[13]; and a prevalence of radiological TB of 6.5% in children (less than 10 to 18 years) living – and possibly working – in a community processing agate in India.[14] In addition to miners, significantly increased risks for TB have been reported in stone crushers, foundry workers, construction, and stone masons.[15]

The importance of the chest X-ray

Sputum staining and culture remain the major modalities for the detection of active TB in workers exposed to silica, but the chest X-ray has an important place. Some of the reasons are:

1. an increased prevalence of smear-negative TB is found in HIV infected populations, but importantly patients with smear-negative disease can still transmit the infection[16];
2. chest X-ray has been shown to greatly increase the sensitivity of screening for TB among HIV infected gold miners[17];
3. active TB case detection, including regular chest X-rays, is recommended, resources permitting, for silica exposed workers partly because TB case-fatality rates have been found to be lower in workers detected by active radiological screening compared to self-presentation[18]; and
4. significant prevalences of multidrug resistant TB have been found among silica exposed miners: in the most recent study 4.3%[19]; and in earlier studies 2.3%[20] and 5.8%.[21]

Early diagnosis is important in reducing transmission.



Florid examples of the nodular arrangement along the broncho-vascular bundles of silicosis and tuberculosis

The chest radiograph is thus valuable but only if radiological features of TB are identified, and these features may not be typical in patients with silicosis. Unfortunately, clinico-pathological studies show that high percentages of patients with active TB are not diagnosed in life. Data on 350 miners showed that clinicians failed to diagnose active TB in 65% of cases coming to autopsy.[22] A study in four settings (two South African platinum mine hospitals, a South African teaching hospital and a London teaching hospital) found that PTB was missed in life in 51% of those patients who came to autopsy.[23] Many omissions may explain the delayed, incorrect and missed diagnosis of TB but one contributing factor is probably failure to detect the radiologic features of TB on the chest radiograph, especially when atypical.

The radiological features of silicosis and tuberculosis in silicosis

Typically silicosis manifests radiologically as bilateral, uniformly distributed and sized, small rounded nodules (opacities) between 1–3 mm in size in the upper halves of the lungs.[1] In very early disease the opacities may appear first in the right upper zone. As silicosis advances the opacities may extend to the lower zones of the lungs and increase in size.

Radiographic TB might well be considered in three forms:

1. the typical and well-known active TB;
2. recurrent TB in a scarred lung following cure of a previous episode of the disease; and
3. an indolent (smouldering) state, particularly found in the nodular presentation of TB and silicosis.

Hence the radiologic features are numerous, but what follows highlights the features to look out for in silica-exposed workers, particularly those with silicosis because especially in the indolent form sputum smear and even culture may remain persistently negative. The reason for this is that nodular TB and silicosis are sited in the interstitial compartment of the lung, and they accordingly lack airway contact. The chest radiograph therefore becomes extremely important.

In assessing the chest radiograph of silica exposed workers it is essential to have chronological details of exposure. The appearance of nodules unusually soon after first exposure should alert the reader to the likely possibility of TB. "Unusually soon" is difficult to define as very high levels of exposure produce silicosis in under 10 years, but this period would be the exception and should not be accepted as silicosis without further clinical investigation.

Sudden changes in radiological features, for example from one year to the next, are unusual in silicosis and should alert the practitioner to possible TB. Aspects of the radiologic presentation of silicosis and TB have been described elsewhere[24,25] so are summarised here. In TB concurrent with silicosis the bilateral uniform profusion of nodular silicosis on the chest X-ray is likely to be disorganised giving way to a mixed pattern. A florid or subtle arrangement of nodules along a broncho-vascular bundle is a not uncommon feature. Regional aggregation of irregular-sized nodules on a background of established silicosis is highly suspicious of associated TB. Nodules in unexpected sites, for example the supra-clavicular region, are questionable, as typically silicosis spares these areas, unless very profuse. Variable profusions and opacities which are not evenly distributed in both lungs are suspect. Large opacities (i.e. radiologic opacities >1 cm) in silicosis require special attention as their appearance is often TB-associated. A miliary or peri-bronchioloar nodular superimposition on the silicotic nodular changes is often subtle and missed by the unwary with the possible fatal outcome associated with untreated miliary TB or non-recognition of bronchogenic disseminated TB. Mediastinal lymphadenopathy is rarely found in silicosis[26].

"... in the indolent form sputum smear and even culture may remain persistently negative."

This finding on the X-ray in HIV positive patients is associated with smear-negative TB.[16]

Conclusion

The subtle or florid changes of TB are regularly superimposed on the radiographic appearance of silicosis. Knowledge of the kaleidoscopic features of pulmonary TB is essential in evaluating the chest radiograph of workers exposed to silica dust. Casual readers are likely to be at a disadvantage. Reading skill depends on the quality of X-rays, reading conditions and reading experience of chest radiographs in silicosis associated TB possibly with HIV present. Preferably well trained, knowledgeable and experienced chest readers are required to protect the worker from the consequence of missed active TB. Although the TB may be active the likelihood of a negative smear is high. The abnormal radiographic features should encourage the clinician to take a more aggressive approach in attempts to prove the existence of an active treatable TB.

Lessons learned

- **Silicosis complicates the radiological features of TB and they may not be typical.**
- **Although the TB may be active the likelihood of a negative smear is high.**
- **It is essential to have chronological details of exposure.**
- **The appearance of nodules unusually soon after first exposure could indicate TB.**
- **The bilateral uniform profusion of nodular silicosis on the chest X-ray is likely to be disorganised giving way to a mixed pattern.**
- **Mediastinal lymphadenopathy is rarely found in silicosis.**

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The transformation of nursing in South Africa: a personal reflection

Transcript of paper delivered to OHNs in Port Natal for the International Day of the Nurse on 11 May 2010 by Heidi Brookes (D.Tech.)

Colleagues, thank you for inviting me to give this talk – it is a great honour and privilege.

This is an auspicious year as it is "The International Year of the Nurse" celebrating 100 years since the death of Florence Nightingale (1829-2010) – who, like many occupational health nurses (OHNs), was a great innovator. She, as have many South African (SA) nurse leaders, used her friendship with politicians and highly placed doctors, to influence the position of nurses. Some such nurses were Sister Henrietta Stockdale, the founder of professional nursing in South Africa, and also the initiators of the Nursing Act 45 of 1944 when the South African Nursing Council (SANC) and the South African Nursing Association (SANA) were established to place nursing squarely in the hands of nurses. At that time all race groups could belong to the same branch but as apartheid took hold and despite vigorous protest, especially in Johannesburg, same race branches were established.

SANA and SANC were pristinely White. Under Professor Charlotte Searle and her board and with Miss Radloff, the Executive Director of SANA, government policy at that time was extended into nursing structures. Professor Searle always claimed to "have the ear of the Minister of Health." Independent homelands such as the Transkei, Ciskei and Bophutatswana as well as some self-governing states willingly or unwillingly formed their own associations. However, this was a very painful process for nurses in KwaZulu (KZ). Mrs Dorothy Dlomo, Chief Nursing Officer of the nurses in KwaZulu, did not want to break away from SANA and was "tricked" into signing away KZ nurses powers by signing a homeland document in 1978. She came to visit the Natal nurses for help and was part of a KZ government delegation to visit the then National Minister of Health in Cape Town. He was extremely rude to this eminent nurse. We obtained legal opinion from a Constitutional lawyer at the University of Natal and were told that this could prove to be unconstitutional. All four SANA branches in Durban agreed to attack this at their national congresses but unfortunately nurse informants foiled us and the National Board sought legal opinion, which opinion was opposite to ours and we were out-manoeuvred and out-voted.

At this time our Durban, District and Coastal Branch was very active in demanding rights for nurses. One of the local politicians, a professional nurse, was a member of our branch committee and a politician, who was also a lawyer, and gave us free legal advice. Three of our branch committee were summoned to Pretoria by the SANA Board for a disciplinary hearing; Eileen Brannigan, myself and Morag Grant (nee Veitch). However they found little fault with us as they chastised us for minutes written by the previous branch chairman. We were also told that our demand for a 54% salary increase was too little as they might be demanding more. Our meetings were open to the press. At this time Eileen Brannigan, Margaret Harrison and others called an open meeting attended by over 500 nurses in the Shepstone Building, University of Natal, in an attempt to democratise SANA.

The Nursing Association continued to follow the patterns of the SA Government and Parliament and when the Tricameral Parliament was established SANA's all White Central Board then altered its constitution to include one Indian and one Coloured professional nurse, namely our own Hani Allee and Mrs Bosch from the Eastern Cape. In 1988 Hani Allee became the first, other than White, Chairman of the Natal Regional Board and continued to serve on SANA's Central Board. One part of our history, for which I am rightly proud, was when in 1988 SANA's Board voted for equality of pay for nurses of all race groups rather than for a large salary increase. We also asked that nurses no longer be differentiated according to race. We were congratulated on being the first professionals to ensure equal pay. Despite this our colleagues of colour were severely handicapped in regard to some conditions of service such as pensions.

With the release of Nelson Mandela in 1990, I was reminded by one of my ex-colleagues that we stood to sing Nkosi Sikelel' iAfrika at a nursing gathering to reflect our joy at his release. In 1994 the Transitional Nursing Association was formed and Dr Yoliswa Mbele became the Chairman of the KwaZulu-Natal (KZN) Board. The Durban office was staffed by Thembi Ngomezulu and then Kuki Ndlovu and there was also an office in Zululand. Professor Dudu Nzimande of the University of Zululand and Professor Marie Muller from the Rand Afrikaans University were the President and Vice President respectively. The Chief Executive Officer of SANA at that time was Eileen Brannigan and that post was taken over by Thembeka Gwagwa.

In 1996 DENOSA was established with both a professional and a trade union function. Professor Nzimande was the first President of DENOSA and only a year after DENOSA's formation DENOSA once again became a member of the International Council of Nurses (ICN). Thembeka Gwagwa became Executive Director with the name changing to Secretary General and Cassim Lekhoathi became the Provincial Secretary, the new nomenclature. In order to strengthen its bargaining powers DENOSA affiliated with COSATU. Five years after DENOSA was established, in 2001 in Taipei, South Africa won the right to host the 24th Quadrennial Congress of ICN at the ICC, Durban. This was to be the first time an ICN Congress was to be held in Africa and in 2005 in Yokohoma, Japan, a handover to South Africa as the next host nation was undertaken. Mayor Obed Mlaba and our MEC for Health were present to welcome nurses representing 131 nations – currently 133 countries are affiliated to ICN. The Congress was held in 2009 – run by ICN in partnership with DENOSA. At that time Professor Nzimande, no longer President of DENOSA, was the 2nd Vice President of ICN and served on the Board of the Commonwealth Nurses Federation. DENOSA's President is currently Mr Ephraim Mafolo – a well respected psychiatric nurse specialist. An international student network met at the ICC as part of the Congress and this was well attended by South African student nurses. DENOSA has been strengthening its professional ties with the SA Medical Association and is a leading member of the Southern African Network of Nurses and Midwives (SANNAM) – similar in membership to the 15 countries of the SADC region. Through SANNAM strategies for fighting diseases such as HIV are co-ordinated. A directorate of nursing services for the region is ultimately envisaged.

It is also an auspicious year for occupational health nurses. In April this year the South African Society of Occupational Health Nurses celebrated its 30th anniversary. In KZN, in 1978, the first OHN certificate course was run at the then University of Natal's Department of Nursing under Miss Noelle Hunt and stimulated by OHNs such as Dr Linda Grainger, and the course was open to all race groups as evidenced by Ms Hani Allee being one of the students. I believe certified OHNs should have their courses and experience accredited in order to make the acquisition of a Diploma easy.

The 2009 ICN Congress has stimulated DENOSA to try to get a database of members of all professional nurses in order to respond to the challenge of "united we stand." "This can only be achieved if we can work together".[1]

My challenge to the South African OHN in 2010 and beyond is to:

- ensure certified OHNs are accredited appropriately towards being awarded a diploma in OHN;
- play their part in helping SA achieve the Millennium Development Goals including
  - o early antenatal screening and treatment of pregnant HIV positive women and compliance with PMTCT programmes,
  - o encouraging male medical circumcision;
- support the prevention, early diagnosis and treatment of cancer, cervical screening and the administration of the HPV vaccine;
- support the prevention, early diagnosis and treatment of TB; and
- share their knowledge and skills with other professional nurses
  - o working in occupational health and safety for hospital and clinic nurses
  - o through publication in general nursing journals.

I leave you with these and your own challenges to help transform OHN and ensure that you assist in achieving South Africa's health goals as well those of your employer and your own goals.

With grateful thanks to the following informants:

Mr C Lekhoahti	KZN Provincial Secretary, DENOSA
Ms H Allee	Retired OHNP and DENOSA Central Board Member
Mrs R Du Toit	Health Facility Planner

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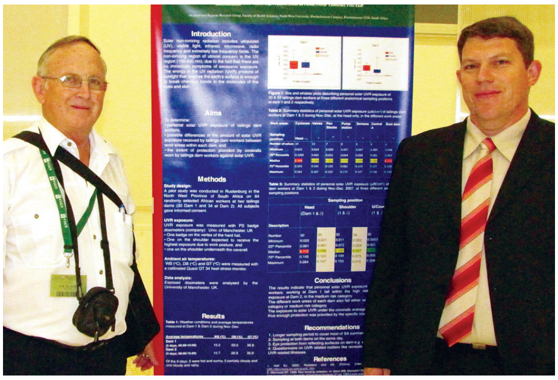
8th International Scientific Conference of the International Occupational Hygiene Association

The 8th International Scientific Conference of the International Occupational Hygiene Association (IOHA) took place from the 28th of September to the 2nd of October in Rome, Italy. The event was organised by AIDII, the Italian Industrial Hygiene Association, on behalf of IOHA and by INAIL and ISPESL, the two Italian institutions responsible for the prevention and insurance of professional risks.

The conference theme was "Health, work and social responsibility – the occupational hygienist and the integration of environment, health and safety". A total of 634 abstracts were accepted and presented at the conference. This large amount of contributions emphasises the dedication and efforts of the occupational hygiene community to promote environmental and occupational health and safety, to minimise workplace and environmental pollution involving chemical, physical and biological hazards, and to face the present challenges related to new emerging technologies and social scenarios. The organising committee managed to attract high profile scientists to deliver well received plenary session presentations, amongst them Professor Brian Davies from the School of Health Sciences, University of Wollongong, Australia, who was the joint winner of the IOHA Lifetime Achievement Award in 2009 together with Professor Trevor Ogden, Chief Editor, Annals of Occupational Hygiene, BOHS, UK. The conference was well attended by occupational hygienists from all over the world. South Africa was well presented at the conference by occupational hygienists from national institutions, universities and business.

A number of well received oral and poster presentations were made by the South African delegation. A total of seven oral presentations from them included:

- o Dermal exposure and skin condition of workers exposed to nickel at two South African base metal refineries, by Johan Du Plessis, North West University.
- o Exposure of vehicle operators to vibration and noise at a Tanzanian opencast goldmine, by F Eloff, North West University.
- o The need for proficiency testing in asbestos fibre counting in South Africa, by G Mizan, National Institute for Occupational Health.



Nico van Aarde from the North West University and Cas Badenhorst from Anglo Platinum with their poster presentation on the exposure of tailing dam workers to ultraviolet radiation

- o Quartz exposure on farms in South Africa representing various soil types, by A Swanepoel, University of the Witwatersrand, School of Public Health.
- o Ergonomics of underground mining equipment: a baseline assessment of conditions in a South African mine, by C Badenhorst, Anglo Platinum.
- o Formaldehyde exposure during decontamination of microbiological safety cabinets, by D Jones, National Health Laboratory Services.
- o Occupational hygiene monitoring – the importance of observations, by K Renton, National Institute for Occupational Health.

Both of the papers presented by Andrew and Johan were recently published in the Annuals of Occupational Hygiene, one of the most recognised international occupational hygiene journals with the highest impact factor in occupational hygiene – well done guys!

South Africa was also well presented at the poster presentations where five posters from South Africa were presented. These poster presentations were:

- o Digital occupational hygiene exposure monitoring system – DOHEMS®: A project update, by C Badenhorst, Anglo Platinum.

Andrew Swanepoel, presenting his paper on Quartz exposure amongst South African farm workers

Johan du Plessis presenting his paper on dermal exposure to nickel

The entrance to the Università Urbaniana, venue of the IOHA 2010 conference

- o Personal exposure and oxidative status of African welders exposed to welding fumes in an engineering workshop. A pilot study, by P Laubscher, North West University.
- o Protection offered by microbiological safety cabinets in pathological laboratories, by D Jones, National Health Laboratory Services.
- o Eliminating noise induced hearing loss through equipment silencing, by C Badenhorst, Anglo Platinum.
- o Exposure of mine workers to solar ultraviolet radiation at a platinum mine, by N van Aarde, North West University.

Suppliers and manufacturers of occupational hygiene equipment were also present during the conference and a lot of technical knowledge and expertise were shared amongst them and the scientists.

One of the highlights of the conference was the social dinner that took place at the beautiful Villa Miani overlooking the very old city of ancient Rome. A lot of new friendships were made and collaborations established during the dinner.

Besides the sharing of knowledge from across the globe, the conference also provided an ideal opportunity for networking and meeting occupational hygienists from all over the world. The next IOHA conference will be the 25th anniversary of IOHA and this momentous occasion will take place during 2012 in the beautiful city of Kuala Lumpur, Malaysia. The theme for this conference is "Growing the seeds of Occupational Hygiene" and judged by the past IOHA conference in Rome it promises to be a conference surely not to be missed. SAIOH encourages scientists as well as occupational hygiene practitioners to diarise this and start preparing abstracts so that South Africa will once again be strongly represented at this wonderful occasion.

Dr Cas Badenhorst, Andrew Swanepoel

ICOH/Scientific Committee on Occupational Health Nursing news 2010

SASOHN promoted ICOH membership in South Africa by encouraging its regional chairpersons to become ICOH and Scientific Committee on Occupational Health Nursing (SCOHN) members, thus broadening their interest in occupational health and safety at an international level. ICOH members may affiliate to any of the 35 scientific committees (SCs), but no more than three, by notifying the respective chairperson and secretary. Susan Randolph from the USA is the Secretary for SCOHN, with Linda Grainger from SA serving the same for the SC on Education and Training in Occupational Health.

The ICOH website has been renewed to facilitate the activities of members and various stakeholders, role players like national secretaries, chairpersons and secretaries of scientific committees and ICOH officers. To find out more go to www.icohweb.org. There is a link to the various SCs where you can register your interest in affiliation. The ICOH newsletter was made available on the web as from August 2009 and can be accessed through www.icohweb.org/newsletter or e-mail address: icohnews@kosha.net. The membership fee is still 60 Swiss francs for a period of 3 years (developing countries 2009-2012).

ICOHN/ACOHN (SCOHN special session) 5–8 August 2010, Yokohama, Japan

The Joint 3rd International Conference on Occupational Health Nursing (OHN) and The 2nd Asia Conference on OHN was opened by Prof. Keiko Kono, Chairperson of the conference and President of Yokkaichi Nursing and Medical University, Japan. The theme was "Global challenges in occupational health nursing – how can we contribute to workers' health, safety and quality of life?" Prof. Kogi, ICOH President, delivered the first keynote address on how teamwork can support the functions of OH in future. He reminded us of the significance of the opening day which coincided with the bombing of Hiroshima in 1945, signalling the end of the 2nd World War. Other keynote speakers included Susan Randolph, highlighting competencies in OHN with specific reference to nursing education and training in USA; past SCOHN Exco member Annette Jorgenson, who spoke on SCOHN activities, the past and the importance of current activities for the future; Janine Cantineau who addressed the occupational health nursing practitioners' (OHNP) contribution to productivity; and Mieke Nakajima who outlined new challenges for OHNPs from a perspective of internationalisation and developments in Japan.

A SCOHN special session (three hours) on Education and Training of OHNs took place as part of the joint conference. It included speakers from the USA, Finland, Thailand, Phillipines, South Africa and Japan. All SCOHN Exco members participated in the conference through paper or poster presentations. Conference highlights included the current status of OH in developing countries in the East, the need for education and training (OH qualifications vary from 1 week to 3 months training), the lack of adequate legislation and enforcement, taking into account the current capacity available from the inspectorate in comparison with millions of small, medium and large business (it is the 3rd largest economy after the USA, China).

The conference consisted of two parallel sessions of oral presentations and poster presentations held daily. The good organisation, technological sophistication, disciplined behaviour (no ringing of cellphones during conference), time consciousness, and punctuality, along with the safe and secure environment and clinical cleanliness of the city and facilities, are aspects that will remain as first and lasting impressions of the Japanese culture and lifestyle. Delegates came from the Philippines, Korea, Vietnam, Malaysia, and Thailand, Australia, New Zealand, France, Denmark, Sweden, Finland and Norway.

I was privileged to meet Prof. Yukiko Okui, past SCOHN Exco member and founder of the Yukiko fund – a lady with great tenacity, drive and enthusiasm for establishing OH in the developing Asian countries. She remains very active in her quest, even at the age of 78. We were fortunate to attend a traditional Japanese evening meal, with the President of the conference, Prof. Keiko Kono and Prof. Yukiko Okui present. The conference gala dinner included a boat cruise in the Yokohama Habour, with classical music and traditional dancing.

Pictured after enjoying a traditional Japanese meal are: Back row: Susan Randolph, Caroline Randolph, Maria Ratio, Marjatta Peurala. Front row: Mieke Nakajima, Kazuka Nishidi, Louwna Pretorius, Prof. Keiko Kono

SCOHN Business Meeting

The first of two business meetings of the SCOHN Executive took place during the conference.

- Work plan (2009–2010) – the draft criteria and scoring method for the Yukiko Fund Award for the best research article/ paper/ abstract presented at an international conference have been completed and accepted with minor changes. It will be implemented for the 2012 ICOH conference in Mexico.
- The existing history of SCOHN project (40+ years) will be compiled by Finland and presented as SCOHN Report No. 10. The previous SCOHN reports were handed to Finland by Annette Jorgenson, who joined us for the second meeting.
- The SCOHN Reports (No.s 1–9) will be converted to electronic format, so that they are available to both developing and developed counties, and SCOHN members.
- The research project results from Dr Bonnie Rogers (The role of the OHNP in a multidisciplinary team) first presented during ICOH 2009 in Cape Town, will be presented as the SCOHN No. 11 Research Report in 2012.
- SCOHN put forward nominations for keynote and plenary session speakers for ICOH 2012 and the planning of a SCOHN special session is in progress.
- The ICOH midterm meeting is taking place in Milan during 3–5 February 2011. SCOHN will be represented by the secretary, Susan Randolph.

Pictured at a business meeting of the SCOHN Executive are: Susan Randolph (secretary), Mieke Nakajima (past Exco Treasurer), Kazuka Nishidi (Treasurer), Maria Ratio (Vice Chair), Louwna Pretorius (Chairperson SCOHN), Marjatta Peurala (ex Officio SCOHN – Past Chairperson/Treasurer)

ICOH 2012

The first announcement for the ICOH 2012 (18–23 March 2012) to be held in Monterrey Mexico was sent out in April 2010. The registration fee for developing countries is $500 USD (ICOH member) prior to 30/06/11 and $600 USD after 30/06/2011. The theme of the conference is "Occupational health for all: from research to practice".

The Organizing Committee intends to provide pre- and post congress tours and the accommodation is priced between $46 126 USD, with on-line reservations available. The website www.icohcongress2012.org can be viewed for more information.

Louwna Pretorius, SCOHN Chairperson
SASOHN Exco Portfolio: ICOH/SCOHN

Annual SASOHN National Conference 2010: Western Cape

SASOHN Western Cape hosted the 30th Annual SASOHN Conference and AGM on the West Coast. Over 200 delegates, speakers, exhibitors and guests were welcomed to the Greek themed conference – "Occupational Health Nursing: from Alpha to Omega". Delegates were welcomed to the shores of the magical Langebaan lagoon by two Greek gladiators.

Early Greek history

The "Alpha" of occupational health in Greece was first described between 23 and 79 AD by Pliny the Elder, who classified occupational diseases as "diseases of slaves". He was referring to those workers in manufacturing and mining, who used linen pieces or sheep bladders as protection for their respiratory system. The slaves in the silver mines were aware that working in those conditions affected their health, because nobody lived more than two or three years before dying of lead poisoning. Today, most countries have enacted legislation that assists in recognising workplace risks to health, and in doing so, have adopted programmes and methods for identifying and preventing workplace injuries and diseases.

The conference

The informal welcome took place at the beach and poolside where delegates networked and friendships were renewed. On the conference day, following the hustle and bustle of meeting old friends and visiting the many exhibition stands, delegates moved into the Conference Centre. Sonja Kruger, the SASOHN President, opened the conference with a keynote address paying tribute to nurses. As 2010 is "The Year of the Nurse" she reflected on the "Alpha" of nursing, delegates were challenged to follow the example left by Florence Nightingale.

Other morning speakers included Daniel de Kock who gave an inimitable presentation on nine tips to building self confidence and becoming a positive person. One of his quotes was "All glory comes from daring to begin" (Eugene F. Ware), which was also included in the next presentation by Dr Lize Hellstroom who shared her research and experiences in establishing HIV programmes in "Walk-in Clinics for Workers" in the Stellenbosch and Mbekweni areas of the Western Cape. Although many workplaces in South Africa are mechanised, many workers are still exposed to heavy manual labour causing chronic health problems, such as sprains and strains. Dale Kennedy presented "What you need to know about Ergonomic Legislation in South Africa". He emphasised Government Circular Instruction 180 regarding the compensation of work-related upper limb disorders (WRULDs). Dr Sharon Vasuthevan enlightened delegates on the changes taking place in nursing education and the "Future of the Specialist Nurse". Brenda Ferrar and her team encouraged delegates to integrate ecological practices into workplaces by implementing a standardised environmental management system.

The afternoon session began with a humorous look at many mishaps that occur world-wide due to human error and lack of direction and signs. The Ludicks encouraged delegates to ensure appropriate signage is used in situations where warnings or instructions are required. The final session brought the delegates full circle from a personal point of view. The day began with learning how to build self confidence and being positive, and ended with a personal challenge to engage the six pillars of character transformation. Being fully aware of changes that are required in South Africa, Anne-Marie Joubert spoke of the necessity for personal transformation to effect that change.

Presentation of SASOHN awards

At the Gala Evening, some guests were clothed in togas, adding to the ambience of the Greek theme. Recognition was given to the Honorary Life Members both absent and present. Other deserving awards were made as follows: Eastern Cape was named the Region of the Year for 2010 for the contribution the members had made to the growth of OHN in the area, and in tough economic times. The Journal Article of the Year award was made to Karen Michell for her article on the calibration of audiometers in the occupational setting. Regional Certificates of Merit were made to Ronwynn Fourie (Eastern Cape) and Marinda Lazenby (Pretoria) in recognition of their personal contributions to OHN in their regions. The OHNP of the Year for 2010 in the corporate category was made to Kareen Willers from Vaal. Kareen manages a team of OHNs and manages to maintain high standards despite the geographical location of her clinics. Following the presentations, the outgoing President, Sonja Kruger announced that the newly elected Education Representative for 2011 was herself, and the newly elected President was Karen Michell, who was welcomed to take office for the next 2 years.

As the sun set over the western sky, delegates expressed how they were not only enriched by the conference, but many new friendships had been formed and new business links made. Thanks and appreciation is extended to the SASOHN Western Cape Committee for all their hard work in organising yet another successful SASOHN conference.

Conclusion

Even with the new cyber-techno age upon us, the needs of people in workplaces remain the same, and there will never be an "Omega" to occupational health nursing. We trust that the delegates will have been inspired to continue in the good work they are doing, and to always remember to keep abreast in changing times.

Christine Van Wyk
Conference Organising Committee Member

Corporate OHNP of the year 2010 Kareen Willers (centre) with Deon Oberholzer (OCSA) on the left and Sonja Kruger, SASOHN President (right)

Recent SASOM activities

SASOM Inland Chapter

The SASOM Inland Chapter Annual General Meeting took place on 29 October 2010. During the past year members of the Chapter attended a CME meeting at a pathology laboratory and were actively involved in different projects, such as the Accreditation of Occupational Health Services, the SA Business Coalition on HIV/AIDS (SABCOHA) and the signing of a certificate of fitness to work.

A group of senior SASOM members arranged meetings with legal representatives at the Health Professions Council of SA, the SA Medical Association and the Department of Labour to discuss the signing of certificates of fitness by occupational medical practitioners and occupational health nursing practitioners, in terms of applicable legislation.

Certificate of fitness

Dr Greg Kew, an occupational medicine specialist, and Dr Jan Lapere, who is an occupational medical practitioner and lawyer, presented an overview of certification and SA law and revealed the existing dilemma in terms of the requirements of the Constitution of the Republic of South Africa (Act 108 of 1996), the Health Professions Act (Act 56 of 1974), the Nursing Act (Act 33 of 2005), the Occupational Health and Safety Act (Act 85 of 1993) and its regulations, and the Mine Health and Safety Act (Act 29 of 1996).

A certificate of fitness is a legal document that may influence job placement, work capacity and tenure of employment, illness and disability notification. It is a defined certificate in format, in content and in outcome and may be disputed under the Employment Equity Act (Act 55 of 1998), the Labour Relations Act (Act 66 of 1995), the Basic Conditions of Employment Act (Act 75 of 1997), the SA Maritime Safety Authority Act (Act 5 of 1998), the National Road Traffic Act (Act 93 of 1996) or the Civil Aviation Act (Act 13 of 2009).

The importance of signing certificates in occupational health is unique because of the doctor and nurse team relationship and operational and legal co-dependency. From the mentioned acts of legislation one realises the many different departments in government and the immense and lengthy task of amending legislation to address the current dilemma.

The presenters concluded that occupational health practitioners must find a balance between the need and the law, expediency and liability, and working within the law and changing the law. There is a need to deal with commercial or vested interests – and to deal with the inertia of statutory bodies.

The new SASOM Inland Chapter Executive Committee members will no doubt continue the good work and the search for solutions under the able leadership of the Chairman, Dr Elton Dorkin.

Forthcoming events

The SASOM National Annual General meeting took place on 26 November 2010 and a report will appear in the next journal issue.

In March 2011 two similar SASOM conferences will take place in Kimberley and in East London, in an effort to reach 'off the beaten track' occupational health practitioners.

ARAOH International Congress – call for papers

The main event in 2011 will be the international African Regional Association of Occupational Health Congress, to be held under the auspices of SASOM, on 25 to 27 August 2011 at the Birchwood Hotel.

This is a call for papers – please e-mail the SASOM National office at info@sasom.org giving your name, affiliation, topic and a brief summary thereof. Suggestions are welcome.

Jenny Acutt, SASOM National Office
info@sasom.org

Mine Medical Professionals' Association
Thirteenth Annual Congress

The 13th Annual MMPA Congress was successfully held at the Valley Lodge in Magaliesberg, with many eminent speakers from a variety of disciplines sharing their wealth of expertise and experience with an audience of more than sixty, thirsty for this knowledge. History and the evidence clearly illustrate that knowledge alone does not necessarily mean that the right action and correct behaviours are adopted. There was some robust debate around how we as medical professionals should be innovative within our teams to continuously raise consciousness in an environment that is fraught with poor behavioural decisions. We have a major role to play as role models in society. After all, how can we as medical professionals, ask or advise a patient to stop smoking if we ourselves are smokers? Hence a common theme throughout the conference was that of "Prevention is better than cure".

"The rocky road to zero harm" outlined the significant challenges that we face as we continuously strive towards achieving the Health and Safety Milestones; perhaps as important are the lessons to be learnt as we embark on this journey of continuous improvement towards zero harm. This theme applies just as much to the workplace as it does to the home and our general environment and it was emphasised repeatedly that carnage on the roads are preventable, as are occupational injuries and illnesses.

So the question that was raised amongst the medical professionals was "Are we flapping hard enough?" Are we putting health on the agenda at each and every opportunity? In an environment where the blood and guts of occupational injuries jolt us into action, do we flap hard enough to create the awareness that health and wellness are the core enablers of safety at the workplace? Are we striving hard enough to make that difference? Are we acting on those results of the medical examinations or merely conducting the examinations so we are legally compliant? Are we using the economic decline as an excuse that we have limited funding, when we know that immunisations and tobacco smoking prevention programmes are the most cost-effective preventative interventions in medicine?

Conference delegates were called on to be true health ambassadors at our workplaces to realise the MMPA vision "raise the profile of mining medicine". Members were called on to go beyond the line of duty, because if we don't nobody else will.

While the conference provided the platform to raise the issues, so too did it provide the platform to network with colleagues, discuss ethical and professional dilemmas and to share best practices. If attendees went away with just one action or new idea then this conference achieved its objective.

The MMPA EXCO expressed its gratitude for delegates' attendance and also for participating in the snapshot survey at the 2009 Congress, whereby ideas were invited on how to elevate the visibility of the MMPA. Regional meetings in association with RMA are being held, focussing on the clinical aspects of mining medicine as well as aiming to attract and retain new members into the organisation.

Whilst the conference opened with hopeful news that the 33 Chilean miners will be rescued before Christmas; it closed with the update that rescue was imminent, reminding us of the tough and dangerous environment we work in and the importance of having health and of course, safety conversations followed up with action, at every opportunity.

Vanessa Govender (Immediate Past President)

Delegates had the opportunity to discuss ethical issues and challenges in smaller groups. From left to right: Drs Peggy Sekele, Martjie Joubert, Ann Strätling

Representatives from all sectors in the mining industry attended and shared experiences. From left to right: Drs Mabusane Khumalo (Goldfields), Busi Mashaba (RMA), Anita Edwards (CSIR), Prof. Mary Ross (De Beers), Khanyile Baloyi (Chamber of Mines), Dipaleso Mokobota (Department of Minerals and Energy Resources), Elton Dorkin (Global Occnet)

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