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HSE HORIZON SCANNING INTELLIGENCE GROUP SHORT REPORT NANOTECHNOLOGY

1. Issue

Status: HSE Action

This report is presented as a brief update to the earlier, more comprehensive Commission Paper,[1] in which the workplace health & safety issues raised by the development of Nanosciences and Nanotechnologies were discussed.

Nanotechnology involves the study and manipulation of matter on an incredibly small scale (1 nanometre being 1 billionth (10^{-9}) of a metre) and has been defined by the Royal Society and Royal Academy of Engineering,[2] as:

> "*The design, characterisation, production and application of structures, devices and systems by controlling shape and size at nanometre scale*".

A variety of products, which incorporate nanomaterials are already on the market, including e.g. sunscreens, additives for diesel engines, anti-microbial materials, polymer composites and stain-repellent textiles. The potential future applications of nanotechnology are believed to be extremely wide ranging and massive growth is predicted in the field but at present:

> "*It's awfully difficult to find where the hype ends and the hope begins*"[3]

Numerous attempts have been made to predict the extent and timing of future developments in the field[4] and the general view seems to be that these will occur in several phases. Over the medium term (perhaps the next 10 years) the focus is expected to be on applications of nanotechnology in areas such as catalysis, energy production and storage, medical diagnosis and drug delivery and materials for the food, construction and electronics industries. For the longer term, the development of "molecular manufacturing" and personal desktop "nanofactories" through the convergence of nanotechnology with biotechnology, IT and the cognitive sciences is foreseen.

2. Relevance to Occupational Health & Safety

It is anticipated that some applications of nanotechnology will introduce novel health & safety risks as a result of the fact that the properties of materials tend to change, often dramatically, once they are produced at very small sizes.[5] Particles in the nanosize range may be able to cross more readily into the bloodstream after inhalation, ingestion or possibly dermal exposure and the toxicological effects may differ from those resulting from exposure to the same material in a more conventional size or form. Similarly, there is a concern that the fire and explosion hazards associated with a given material may well increase as the particle size decreases to within the nanometre range.

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[1] Managing the Risks from Nanotechnology, HSC/04/42 and accompanying Annexes.
[2] Nanoscience and Nanotechnologies: Opportunities and Uncertainties, R.S. & R.A.E., July 2004
[3] Nanohype, The Truth Behind the Nanotechnology Buzz, D.M.Berube, Prometheus Books, 2006
[4] see e.g "RoadMaps" at: http://www.nanoroadmap.it/; http://www.nanoroad.net/
[5] Nanotechnology: A Research Strategy for Addressing Risk, A.D.Maynard, Woodrow Wilson International Center for Scholars, July 2006

Nanotechnology also offers the opportunity to develop new forms and structures of existing materials, the most notable example at present being carbon nanotubes (CNT's). The apparent similarity in the size and shape of CNT's to asbestos fibres has raised concerns that they may pose similar health risks, although this is by no means proven.[6]

Owing to the very small size of nanoparticulate materials, the accurate and reproducible measurement of their properties presents problems and this in turn makes it difficult to monitor occupational exposure to these materials and to ensure the effectiveness of any control measures.

3. Implications

The key implications for HSC/HSE, around the extent to which a precautionary approach should be adopted to nanotechnology were highlighted in the earlier Commission Paper.[1]

The application of nanotechnology is growing very rapidly and there are predictions that the worldwide production rate of engineered nanomaterials will rise to over 50,000 tonnes per year over the period 2011-2020.[2] This total is likely to be made up of a wide variety of materials including metals, alloys and metal salts (oxides, nitrides, carbides etc.), together with clays, carbon nanotubes and a range of polymeric and organic compounds. Similarly a large array of different manufacturing processes, including e.g. Chemical or Physical Vapour Deposition, Sol-Gel or Arc Discharge processes are likely to be involved in the production of the nanomaterials and their subsequent use.

The sheer diversity of the materials and processes involved here may well pose a challenge in terms of the assessment and control of any potential risks and the future operation of the general regulatory framework.

In the longer term, molecular manufacturing could have a profound impact on industry and the workforce, if as is envisaged, the fabrication of products can be carried out essentially in the home, using nanoscale technologies. While this may seem fanciful at this stage, there are some early indicators of the possible development of such systems in the growing use of 3D printing techniques for Rapid Prototyping and Rapid Manufacturing.[7]

4. Recommendations

The main issues of concern in relation to managing the potential risks associated with nanotechnology are around a lack of data, measurement difficulties and the fact that hazard assessment frameworks are still at an early stage of development. Through its involvement with Defra and other government departments, HSE is actively involved in addressing all these issues as well as contributing to the debate on the societal and ethical implications of nanotechnology. The key recommendations are that this work should continue to be supported and that a detailed Horizon Scanning brief should be maintained across the broad nanotechnology field.

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[6] nanoRISK, Issue 1, Vol.1, June 2006, published by Nanowerk, LLC
[7] see e.g. C.Phoenix, tct Magazine, Vol.14, Issue 4, p. 37-9.