

Dangers come in small particles



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NANOTECHNOLOGY: WHAT THEY DON'T KNOW COULD HURT YOU

Hundreds of nanotechnology applications are already in commercial production despite a huge health and safety question mark. Hazards editor Rory O'Neill looks at how an industry the safety authorities admit they know precious little about has been allowed to grow, unregulated, into the biggest thing since the microchip.

In the two decades since the birth of the nanotechnology revolution, it has been a strict case of small is beautiful. Dollar signs have blotted out the warning signs, and the technology has developed, as one observer put it, "at warp speed." This is a modern day gold rush – forget precaution, get to production.

President Clinton gushed about the potential when he launched the US National Nanotechnology Initiative in 2000. Tiny sensors would in the future speed through arteries detecting cancers at an early stage; exotic lightweight materials would have 10 times the strength of steel.

The whole world caught the nanotech bug, quietly ignoring early but serious indications that the new industry brought serious new hazards.

A US Senate hearing in 2003 heard that most Fortune 500 companies now have nanotechnology programmes. Household names and big employers in the UK – IBM, ExxonMobil, DuPont, Hewlett Packard – all have had major programmes operational for years.

Wealth and safety

In the US, the epicentre of the nanotech revolution, the breakneck race to commercial production pre-dated by years the first "nano-toxicity" conference in January 2004 and the creation in February of a US government nanotechnology health and safety research programme.

In the UK, attention to safety has been more sluggish still. On 29 July, the Royal Society and the Royal Academy of Engineering announced the findings of a UK study of the safety of nanoparticles and called for new rules to guard against dangers to health. In October 2004, the Health and Safety Executive's Buxton-based labs will host an international conference on workplace nanotech risks. For now, though, it's business as usual.

In the introduction to a March 2004 HSE paper prepared for the Health and Safety Commission (HSC), the HSE chief scientist, Paul Davies, notes: "In the absence of complete and robust evidence of the risks HSC/E must work with stakeholders to promote and assure risk management of this technology without unnecessarily stifling innovation and wealth creation."

Already hundreds of nanotechnology-based products are on the market, from new computer displays to self-cleaning windows, from wrinkle creams to wrinkle-resistant pants.

We might not know for certain whether or how the nanotech industry will make you sick, but the industry knows it can certainly make you rich.

Reasonably dangerous

The Davies paper argues that a "precautionary approach" – giving workers' health, rather than the industry, the benefit of the doubt – could hamper the development of nanotech-based safety technology and "would also earn the opprobrium of the government, which is strongly committed to the development of nanotechnology."

Instead, a "Provisional Information Note" says "control strategies should be based on the principle of reducing exposure to as low a level as is reasonably practicable."

But applying to nanotechnology the same control strategy you might apply to, say, grass cuttings or table salt would guarantee widespread ill-health in the nanotech workforce if exposures were found to be anything other than low risk. This is a point not lost on John Howard, head of the US government's research body NIOSH.

He told a May 2004 conference: "Research over the past few years has shown that nanometre-diameter particles are more toxic than larger particles on a mass basis. The combination of particle size, unique structures, and

unique physical and chemical properties, suggests that a great deal of care needs to be taken to ensure adequate worker protection when manufacturing and using nanomaterials."

Howard added that nano products in development "are so far from our current understanding that we cannot easily apply existing paradigms to protecting workers."

Nano regulation

Back in the UK, HSE's preferred "reasonably practicable" measures would treat nanoparticles as a routine hazard, not subject to the more stringent controls that have seen many highly dangerous substances banned outright and others, for example substances that can cause cancer, subject to special and more exacting regulations.

But while some workplace safety regulations may be an ill-fit, some don't fit at all. Getting a new substance onto the market is normally regulated by the Notification of New Substances Regulations 1993 (NONS). But nanotechnology uses structural, smaller, variants of common industrial substances. As far as NONS goes, they are no different from their non-nano namesakes, and do not require notification.

The HSE briefing acknowledges "there can be considerable uncertainty in any assessment of the health and safety risks because of lack of knowledge about the hazards. Similarly there may be also a lack of knowledge about the effectiveness of risk control measures."

Out of touch

The evidence we do have raises real concerns about human and environmental health effects, sufficient to justify serious controls on the nanotech production frenzy. TUC's Hugh Robertson told *Hazards* we have to learn the lesson of asbestos and adopt a "precautionary approach," with "a moratorium on any work with nanotechnology which involves contact between the materials and a human."

Reinsurance company Swiss Re has already warned that uncertainty about risks from nanotoxicity and nanopollution could make the industry uninsurable.

This isn't tomorrow's world. But it could be tomorrow's occupational health calamity.



Nanotechnology at work

You may already own or work with products using nanotechnology.

The website of global technology watchdog ETC includes an unofficial document from the US Environmental Protection Agency (EPA) that lists well over 100 commercial products based on nanotechnologies.

These are already on the market or soon will be and include: stain-resistant fabrics for clothing and bedding, cosmetics and sunscreens, tennis balls and racquets, odour-eating socks, time-release perfumed fabrics, paints, capsules carrying haemoglobin (under development), sensors to test water impurities, sprayable vitamins, nanoparticle water purifiers, ski wax, car parts, long-lasting paper, nanotubes for flat panel display screens, artificial silicon retinas, several drug delivery systems, flash memory devices, diagnostic agents for use in MRI scans.

What's it all about?

Nanotechnology is engineering on an atomic scale. One nanometre is a billionth of a metre, or about 1/80,000 the width of a human hair. A grain of sand is a million nanometres across. A red blood cell is 10,000 nanometres. Nanotechnology works on a scale of up to 100 nanometres. We are talking small.

Physical properties of a substance change at the nano level, which creates new possibilities for products and

applications. It also creates new and unknown hazards. Workers might be exposed to a range of nano scale hazards in a range of forms, from nano tubes, to dusts, to liquids.

It's the size not the substance that defines what is and isn't nanotech. Commonly used materials include carbon, silicon/germanium, titanium dioxide, calcium oxide, metals including gold, and proteins or DNA.

What makes it dangerous?

Two factors could make nanoparticles a particularly serious occupational risk. Firstly their size alone could present hazards; secondly their massive surface areas may adsorb other toxins that can then be transported into the body.

Before nanotechnology became an industry, there was nano scale workplace and environmental pollution. Pollution from power plants, incinerators, cement kilns and diesel engines all contain "ultrafine" airborne particles that fall in the right size range.

These particles are attributed with thousands of pollution-related deaths each year – perhaps 60,000 per year in the US alone. Other studies have linked nanoparticles to cardiovascular disease, asthma, lung fibrosis and Alzheimer's.

The new nanoparticles are very effective in finding routes into the body by ingestion, inhalation or absorption through the skin and have high mobility once inside the body.

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Red flags the regulators ignored

US and other regulatory agencies are "privately admitting they have made a mistake in letting nanoproducts onto the market without safety studies, and are looking for ways to tweak existing regulations," says Jim Thomas, an Oxford-based programme officer with the global technology watchdog ETC.

A July 2004 ETC report revealed that only in recent months have governments on both sides of the Atlantic "reluctantly conceded that current safety and health regulations may not be adequate" for nano materials.

According to Thomas: "Only a handful of toxicological studies exist on engineered nanoparticles, but not-so-tiny red flags are popping up everywhere."

In his May 2004 "Nanowatch" column in *The Ecologist*, Thomas lists "Ten toxic warnings" including NASA research in 2003 showing nanotubes produce a more toxic response in rats than quartz dust and claims by top UK toxicopathologist Vyvyan Howard that that nanoparticles can cross the blood-brain barrier in humans and gold nano-particles can move across the placenta from mother to fetus.

Studies suggest the toxicity is more related to their size than to the material from which they are made; while the reduction in size confers a variety of interesting and potentially profitable properties to substances, it can also confer unforeseen toxic properties.

The findings of a March 2004 European Commission workshop,

"Mapping out nano risks", were in sharp contrast to the clamour for nano production encouraged and financed elsewhere in the Commission.

It warned that "some engineered nanoparticles produced via nanotechnology may have the potential to pose serious concerns" and that "adverse effects of nanoparticles cannot be predicted (or derived) from the known toxicity of bulk material."

The experts recommended "striving for the elimination whenever possible and otherwise the minimisation of the production and unintentional release of nanosized particles."

Nanotech news in living colour: An update on white papers, red flags, green goo (and red herrings), ETC Communiqué no. 85, 8 July 2004. www.etcgroup.org