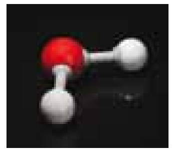
FROM TINY BEGINNINGS

Manipulating the basic building blocks of matter, one atom at a time, nanotechnology produces unique materials and novel processes



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IN the remote regions of the arid North West Province, drinking water is a scarce commodity. Brack borehole water, unpleasant-tasting and invariably polluted, is often all that's available. But now there's sweet, pure water on tap – thanks to nanotechnology.

A pioneering project at Madibogo, a village about 100 km from Mafikeng, has shown that nanofiltration technology can vastly improve water quality and at the same time make a significant impact on quality of life.

Pollution of local groundwater, particularly by nitrates, is a serious concern. Nitrates have the potential for interfering with the body's oxygen-carrying capacity in children, skin and hair irritations, increasing the risk for organ damage and even cancer.

Conventional reverse osmosis helps purify the water, but it also removes essential nutrients. By contrast, nanofiltration membranes reject substances selectively, removing pollutants but leaving essential nutrients intact, the CSIR has found. Even better: the nanotech also helps scrub out microbial nasties.

Not only does the technology do its job, it's proved to be a positive influence on community involvement. There's a new, heightened awareness of water's pivotal role in life, and locals have been trained to maintain the system.

The elemental difference

At the scale of atoms and molecules, materials stop behaving the way we'd expect.

Nanomaterials have a large surface area when compared with the same mass of material produced in a larger form, potentially making them more chemically reactive and affecting their strength or electrical properties. Quantum effects can begin to dominate the behaviour of matter at the nanoscale, changing its optical, electrical and magnetic behaviour.

But this is nothing new: nanoparticles have been used in glass and ceramics for centuries. Materials scientists have been using nanoscale features of many chemicals for decades, and the natural world also contains many examples of nanoscale structures.

However, in recent years there's been a boom in nanotechnology. The discovery of C60 in 1985 and carbon nanotubes in 1991 boosted the development of nanomaterials. Advances in computing power, materials modelling and microscopy gave scientists the tools to observe and handle individual atoms and to synthesise nanomaterials for specific purposes

Current applications of nanotechnology include:

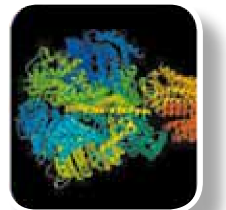
- nanosized particles in sunscreens, lipsticks and paints
- antibacterial nanosilver in wound dressings, plasters, catheters, and even socks
- breathable, waterproof, wear-resistant, wrinkle-resistant and stain-resistant textiles
- nanofilters for water purification
- nanomembranes in fuel cells and batteries
- nanoparticles in new-generation solar cells
- nanoclays in plastics, tennis balls and many more
- stain-resistant fabrics
- self-cleaning, water-repellent and antibacterial glass
- wear-resistant cutting tools
- self-repairing, corrosion-resistant coatings.

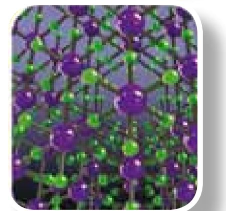
Potential future uses under development cover a vast range from medicine to the environment.

- Medicine: nanorobots as vehicles for drug delivery; durable implants, prosthetics and heart valves; artificial retinas and cochleas, organ replacements
- Food and nutrition: atomically engineered food and crops that can be produced on less land and using less labour; nutritionally enhanced "smart" foods
- Energy: more efficient fuel cells; lightweight, high-energy density batteries; lighting that uses very little energy
- Environment: self-cleaning filters to produce clean drinking water from waste water; techniques to clean up hazardous chemicals; sensors able to detect single molecules to monitor pollution; nanoscale traps to remove pollutants from the environment and remediation of toxic waste
- Security: new imaging, detection and personal identification systems; decontamination equipment; nanoforensics
- Information technology: smaller, lighter, more powerful and cheaper computers; miniature data storage systems that can store vast amounts of information; high resolution displays that can be rolled up like a poster
- Manufacturing: ultra-strong, durable materials that are very light and can be used, for example, to build aircraft; nanoceramics for more durable automotive components or high-temperature furnaces; wear-resistant tyres; paints that can change colour by the flick of a switch.

One scenario has tiny nanorobots programmed to manufacture objects atom by atom – from large and complex products to more nanofactories.

NANOTECHNOLOGY
PUBLIC ENGAGEMENT





Nanoterminology

- The prefix "nano" is derived from the Greek word for dwarf.
- The nanoscale refers to sizes at the level of atoms and molecules.
- A nanometre (nm) is one billionth of a metre (10^{-9} m).
- Six bonded carbon atoms is about 1 nm wide.
- A red blood cell is about 7 000 nm in diameter, and 2 000 nm in height.
- A virus is about 100 nm long.
- A human hair is between 50 000 and 80 000 nm thick.
- A sheet of normal office paper is about 100 000 nanometres thick.
- Materials can be produced that are nanoscale in one dimension (very thin surface coatings), in two dimensions (nanowires and nanotubes) or in three dimensions (nanoparticles).
- A nanoparticle is any chunk of material smaller than 100 nanometres.

Hopes and hazards

Some believe nanotechnology will transform the world for the better, providing clean and abundant energy, fantastically strong materials, environmentally friendly production processes, and smart drugs able to detect and treat diseases super-effectively. However, sceptics worry about unpredictable health and environmental risks, as well as uncertainties around its socio-political consequences into the future.

Along with optimism about the promise of nanotechnology, there are uncertainties about its potential impact on health, the environment and societies in general.

There's the threat of a nanodivide as the technology widens the gap between rich and poor countries. Nano-equivalents might wipe out producers in developing countries of natural products such as rubber, cotton, coffee and tea. And there's uneasiness about nanotechnology (much like genetic modification) "messing" with the building blocks of nature. And what are the chances nanorobots could escape and reproduce uncontrollably?

Nanoparticles may be toxic simply because of their unique properties: incredibly small size, with a relatively large surface area. It is also likely that nanoparticles will penetrate cells more readily than larger particles. Carbon nanotubes, already commercially available to reinforce plastic materials, are thought to be capable of affecting the lungs in ways similar to asbestos.

A key question is how society can control the development and deployment of nanotechnologies and craft responsible policy to maximise benefits and reduce risks.

At the launch of the South African National Nanotechnology Strategy in 2006, the then Deputy Minister of Science and Technology, Derek Hanekom, said that nanotechnology held tremendous potential. Its possible applications ranged from increasing soil fertility and crop production to providing solutions for improved drug delivery through the development of biodegradable polymers that ensure sustained and gradual release treatments. Furthermore, nanotech microbiocides could substantially reduce the risk of HIV infection in women.

To ensure a balanced outlook, in an Emerging Issues Paper on nanotechnology, published March 2008, South Africa's Department of Environmental Affairs and Tourism calls for a South African research strategy to address the safety, health and environmental aspects of nanotechnology, and increase public awareness related to the issue.

Key nanotechnology players

The Department of Science and Technology outlined the country's vision for nanotechnology in the National Nanotechnology Strategy. It positions nanotechnology as a tool to address development challenges and provide solutions to local development needs, such as safe drinking water and innovative delivery of health services.

The DST supports a range of Nanotech projects such as the South African Nanotechnology Initiative (SANI), a network of researchers, policy makers and other stake-holders interested in promoting South Africa's competitiveness in nanotechnology.

Two centres in South Africa provide a dedicated platform for nanotechnology research, innovation and capacity building:

- The National Centre for Nano-structured Materials at the CSIR focuses on the design and modelling of novel nano-structured materials, with an emphasis on developing materials relevant to South Africa's needs.
- The DST/Mintek Nanotechnology Innovation Centre at Mintek focuses on water, health, mining and minerals.

The South African National Nanotechnology Strategy aims to ensure that South Africa is ready to optimally use nanotechnology to enhance the country's global competitiveness, and to achieve its social development and economic growth targets.

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NRF National Research Foundation | SAASTA South African Agency for Science and Technology Advancement

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