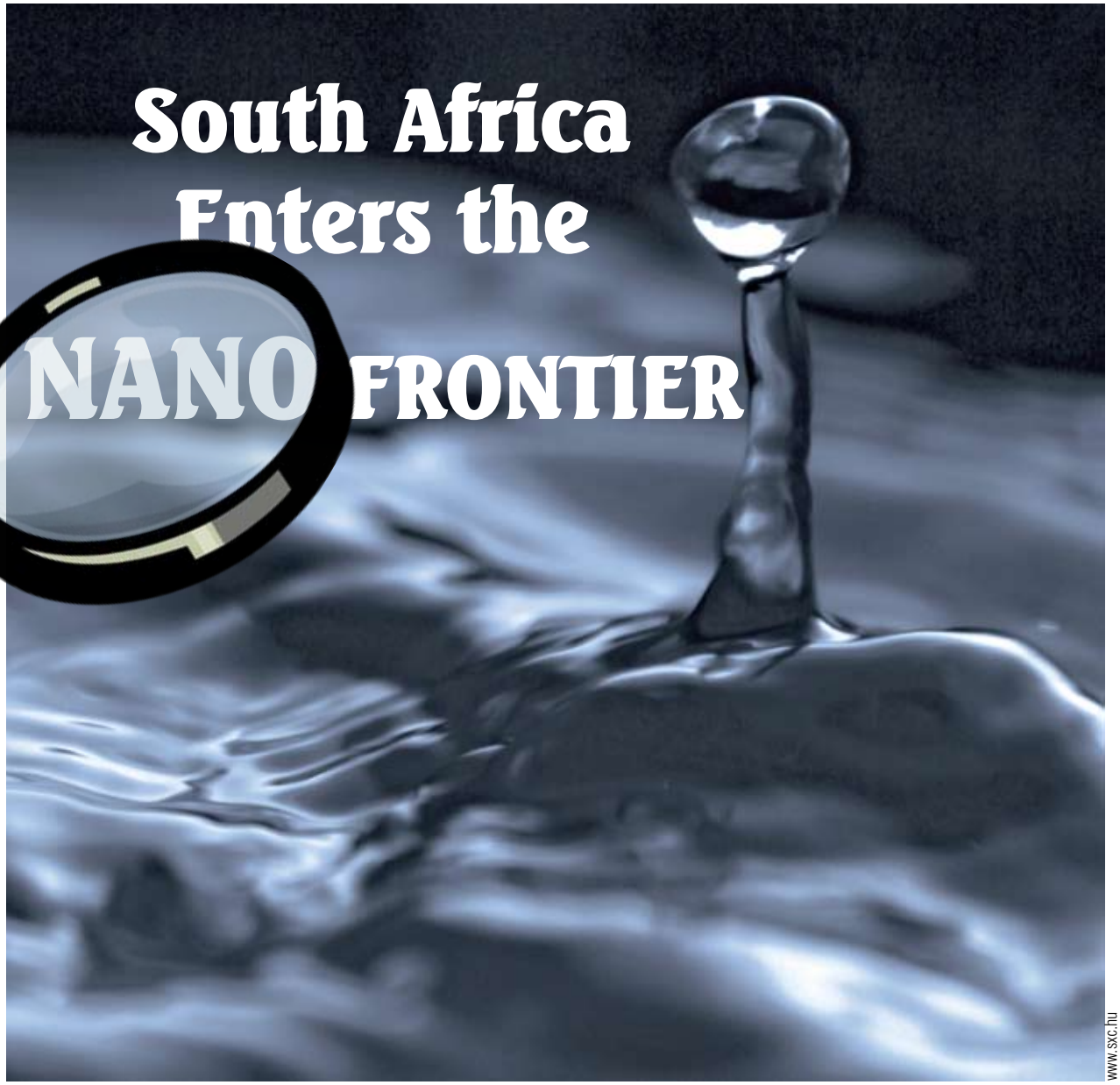


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***Some deem it as big as the industrial revolution or the dawn of the information era. Now South Africa has officially joined the nanotechnology race following the launch of two Nanotechnology Innovation Centres. Lani van Vuuren reports.***

Nanotechnology has captured the attention of governments, researchers and industries worldwide. A new generation of technology it holds the potential to revolutionalise the world we live in. Its possibilities seem endless, bound only by the limits of the imagination.

Independent research firm Lux Research predicts that by 2014, the market for manufactured goods incorporating nanotechnology would be worth US$2,6-trillion. There are already more than 500 products being sold that claim they are made with nanoscale or engineered nanomaterials, from nanotube-infused graphite tennis rackets to antimicrobial bandages.

Nanotechnology is the act, science and engineering for manipulating objects at the nanoscale. We are talking minute scales here – one nanometre is about one million times smaller than a millimetre. Or to put it another way, one nanometre is about 10 000 times narrower than a human hair or ten times the diameter of a hydrogen atom.

At this size materials often take on unique and sometimes unexpected

properties. Nano-sized gold, for example, can appear red rather than metallic yellow. Nano-sized carbon tubes are many times stronger than the same weight of steel, while bulk carbon (i.e. graphite or coal) can be very brittle.

This means that at the nanoscale, materials can be 'tuned' to build faster, lighter, stronger and more efficient devices and systems, as well as new classes of materials. In the water sector, nanotechnology can be applied to develop more cost-effective and high-performance water treatment systems as well as instant and continuous ways to monitor water quality, among others. Nano-technology is a multi-disciplinary research and development activity, bringing together chemists, physicists, biotechnologists, and engineers.

## NATIONAL NANOTECHNOLOGY STRATEGY

To date, nanoscale research and development has been rather on a small-scale in South Africa, driven mostly by individual researchers' interests. A recent investigation by the University of Pretoria on behalf of the Water Research Commission (WRC) into local nanotechnology found that the country's nanoscale research is below what one would expect in light of its overall publication output. At present, the country's nanoresearch is distributed at a number of universities with a sub-critical concentration of researchers.

This is set to change, however. Government's interest in the potential of nanotechnology has led to the National Nanotechnology Strategy, which will see the coordination of nanoscale research and development at a national level. Joseph Molapisi, Manager: Emerging Research Areas at the Department of Science & Technology (DST) explains that the explosive interest in nanotechnology internationally meant that the South African government could no longer ignore its potential. "Our interest lies in its socio-economic potential."

**"One nanometre is about 10 000 times narrower than a human hair or ten times the diameter of a hydrogen atom."**

South Africa is one of the first countries to have an official nano-technology strategy. It is an ambitious long-term plan which seeks to position the country as a player in this emerging area of science and technology. The focus areas are very clear, namely water, energy, chemical and bioprocessing, mining and minerals, and advanced materials and manufacturing.

Molapisi is quick to point out that government's investment in nanoscale research is not "for the fun of it". "The activities we support are aimed towards identified, tangible measures to address some of the countries social challenges while enhancing our industries' competitiveness. For example, we would like to see the development of marketable products such as low-cost filters to provide clean drinking water, medical devices to detect and treat diseases more effectively, and enhanced nano-materials. "

An initial sum of R170-million over the 2006/07 period has been secured from Treasury to support the development of this field of science. "This is a drop in the ocean compared to the investments being made by other countries and much less than we initially anticipated, however, we realise that we are competing with other, more pressing needs in the country," says Molapisi.

Due to its multidisciplinary nature nanoscale research is an expensive business, and it is hoped to get more buy-in from the private sector who will eventually be the beneficiaries of the research outcomes. "Many industries still see nanotechnology as pie-in-the-sky research, thus it is difficult to

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*Prof Bheki Mamba of the Department of Chemical Technology at the University of Johannesburg with equipment used in the generation of nanomaterials.*

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## INTERNATIONAL NANO WATER INNOVATIONS

- In India, a nanotechnology product which removes dissolved pesticide residues has been developed. Dispersed in a cartridge that is 120 mm long, particles of silver measuring 60 to 80 nanometres are used to destroy pesticides found at elevated levels in Indian water supplies.
- The wax-like exterior of the Stenocara beetle, which lives in the Namib Desert was reportedly the inspiration behind the Massachusetts Institute of Technology's development of a nano-sponge material that snatches water droplets from the air. Compared to the polypropylene nets used to harvest fog in some regions, the new material can reportedly increase water capture by tenfold. The material features enhancements, including a decontaminating agent which eliminates harmful bacteria that might otherwise develop in rainwater as it collects.
- Rice University researchers have devised the nanotechnology equivalent of arsenic magnets – nano-sized rust particles that bind to the contaminant. In this process a magnet can remove the combinations of arsenic and rust, leaving behind clean water.

### SO HOW BIG IS NANO?

**One nanometre** = one billionth of a metre
**One DNA molecule** = 2 nanometres
**Virus** = 50 nanometres
**Visible colour** = 400-700 nm
***E. coli*** = 2 000 nm
**Red blood cells** = 5 000 nm
**Hair diameter** = 75 000 nm

attract them, especially in the early stages," notes Molapisi.

South Africa is also set to play a leading role in nanoscale research and development in the Southern African Development Community. A workshop is being planned later this year to discuss how the southern African countries can pool their resources to enhance their nanotechnology knowledge. South Africa already has cooperation agreements with countries such as France and Argentina to enable its researchers to gather crucial experience.

## NANOTECHNOLOGY INNOVATION CENTRES

South Africa's first two Nanotechnology Innovation Centres (NICs) were launched at CSIR and Mintek last year. The activities at these centres are strongly aligned with DST's nanotechnology strategy. At the CSIR, the focus is on the design and modelling of novel nano-structured materials. The centre at Mintek, which is collaborating with the WRC, the Medical Research Council, as well as the universities of Johannesburg, the Western Cape and Rhodes, is focusing on research in the fields of sensors, biolabelling and water nanotechnology.

The Water & Health Research Group at the University of Johannesburg (UJ), which acts as the water platform of the Mintek NIC, has been investigating nanotechnology for water treatment since 2002. The group's research focuses on the use of nanoporous polymers to remove organic pollutants in drinking water, explains Bheki Mamba, associate professor at the Department of Chemical Technology, This involves the synthesis of water insoluble cyclodextrin- and calixarene-based polymers and their derivatives to remove organic pollutants, which include trihaloethylene, endocrine disrupting compounds (EDCs) and medications, which can be potentially toxic.

"At present, efficiently and affordably detecting and removing these compounds from water supplies remains a significant challenge," Prof Mamba tells *the Water Wheel*. "While conventional treatment technology such as activated carbon is being used with some success, it is not always effective in the removal of minute quantities (parts per billion). The so-called 'nanosponges' developed by UJ have been shown to remove pollutants at nanograms/litre

with high efficiency (>80%). In addition, they are reusable, which reduces treatment cost." The research is attracting students from various disciplines, and the UJ group now boasts 27 post-graduate researchers, including postgraduate students from Swaziland and Zimbabwe and post-doctoral fellows from India.

**"The activities we support are aimed towards identified, tangible measures to address some of the countries social challenges while enhancing our industries' competitiveness."**

Prof Mamba is excited about the potential pooling of resources and exchange of information being offered through the NICs. "Rhodes University, for example, is focusing on nanosensors for the early detection of diseases, such as cancer. The possibility exists that we might be able to apply these nanosensors for the real-time monitoring of pollutants at water treatment plants." In the long term, smart membranes with specifically tailored nanopores might be designed to both detect and remove pollutants from drinking water.

With South Africa's drinking water quality coming under increased scrutiny, the time has come to look increasingly towards alternative treatment technologies which could offer a more efficient solution, maintains Prof Mamba. "In the end we do not just want to offer South Africa's citizens drinking water, but good-quality drinking water. Nanotechnology offers us the opportunity to tailor-make solutions to meet our country's unique challenges."

Lani van Vuuren

## NANOTECHNOLOGY & WATER

Nanotechnology shows much potential for the water sector, and research efforts in this field could serve to ameliorate many of South Africa's water problems. It seems that a window of opportunity has opened and that a number of exciting developments in this field holds great promise for improved treatment technologies, water quality assessment and for other environmental applications.

**Water treatment**: Nanomaterials can already be harnessed to enhance existing water treatment processes. Replacing existing materials and equipment such as activated carbon and reverse osmosis and nanofiltration membranes by nanotechnology modified or produced materials can lead the way for more advanced nanotechnology processes. Nanosize iron, for example, can detoxify organic solvents. Other nanoparticles that are bioactive, such as silver and magnesium oxide, can kill bacteria and might be used in place of chloride to disinfect water.

**Water pollution**: There are several new techniques being investigated for the remediation of water pollution. One of the most promising examples is zero-valent, nano-iron which is being tested for use in removing solvents from pumped groundwater.

**Diagnostic tools**: Great potential exists for the development of nanotechnology-based diagnostic tools can be used for real-time drinking water quality assessment. Detection of viruses, bacteria and parasites in real-time is needed rather than culture-based techniques that could provide information in days.

*** Source**: *Evaluation of Nanotechnology for Application in Water and Wastewater Treatment and Related Aspects in South Africa* (WRC Report No **KV 195/07**). To order the report contact Publications at Tel: (012) 330-0340; Fax: (012) 331-2565; E-mail: orders@wrc.org.za