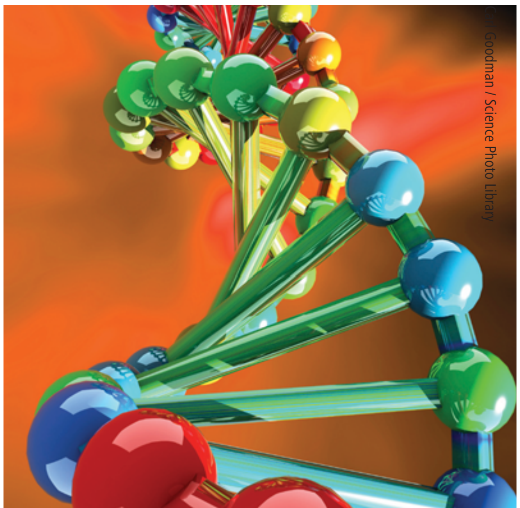
Nanotechnology

Tiny tweezers hold promise

Patrick Walter

The first nano-sized tweezers that can grab and release objects in a controlled manner have been constructed out of strands of DNA. These tweezers could form part of a nano-scale toolbox that could one day be used to manufacture tiny machines or as part of an intelligent drug delivery device.

Researchers from the University of Science and Technology of China created the tiny tweezers by using strands of DNA. Three of the strands act as the 'arms' of the tweezers and will only bind to a specific piece of target DNA. Once the target is bound, the arms can be closed by adding another strand of DNA, which locks the tweezers shut. The tweezers' environment is then made less acidic to ensure the target stays bound.



DNA: could grab nano-size objects

Yet another DNA strand, the unlocking strand, which displaces the locking strand, can be added to open up the tweezers, releasing the target DNA. The complementary locking and unlocking strands are left as waste (*J Am Chem Soc* 2008, **130**, 14414).

Author Zhaoxiang Deng says that these tweezers will not find any practical purposes in the short-term as a great deal more work is needed to develop the processes and tools for proposed ideas like nano-machine construction. Deng says, 'We are working hard toward obtaining an even sharper transition between the "hold" and "release" states, which will make the tweezers function more efficiently.'

According to Deng, other possible uses for the tweezers include controlled chemical and biological processes. This would involve using the tweezers to hold chemicals or biological molecules, releasing them into a reaction when needed.

Sylvain Martel, a nanotechnology researcher at the École Polytechnique de Montréal, Canada, says, 'Overall, it is certainly an interesting tool that could be embedded in some types of future nano-robots where pH change does not interfere with other actuation mechanisms.' Martel adds that the next big challenge is likely to be orientation of tools such as these tweezers so that they are in the right place to grab their target.

Organic chemistry

Self-assembling organic wires

Andrew Turley

Scientists have synthesised self-assembling 'organic wires' inspired by beta-amyloids, proteins that build up in the brains of patients with Alzheimer's disease.

At 10-50nm in diameter, the wires are thinner than human hair. But they should conduct electricity, bringing nanoscale electronic devices a step closer.

The researchers synthesised peptide chains based on bithiophenes (*J Am Chem Soc* 2008, **130**, 13840). These exhibit intermolecular hydrogen-bonding, leading to the formation of flat sheets or ribbons. But the pi electron systems associated with the bithiophene groups encourage further coordination. 'These ribbons can either stack amongst themselves or you can picture them twisting to some extent, not like a DNA helix but more like a telephone cord,' said John Tovar, who led the group from John Hopkins University in Baltimore, MD, US.

'The formation of amyloid plaques is usually associated with patients who have Alzheimer's disease,' said Tovar. 'We have utilised the same design principles.'

The researchers plan to investigate the electrical properties of the wires by adapting the molecules so they respond to current. 'We're looking at developing new chromophores, new electronic units, that we can embed within our peptides that will facilitate measuring the electronic conductivity,' said Tovar. They also plan to explore cell adhesion and recognition, so the system might be adapted for biomedical applications.

According to Holger Frauenrath, from the Swiss Federal Institute of Technology in Zurich, this forms part of a highly promising area of research, but significant conceptual obstacles have to be overcome. 'It may be nice to have an electron-carrier with nanoscopic dimensions, but how would one build it into something like a "circuit"?' he asked. 'How would one actually make a "processor" out of it, place it where it is needed, contact it, etc?'

Nanofibres synthesis more energy intensive

Researchers have calculated that on a weight-for-weight basis products manufactured with carbon nanofibres require far more energy to produce when compared with traditional materials.

A group from Ohio State University, US, performed cradle-to-market life cycle assessments for carbon nanofibres produced from three feedstocks: methane, ethylene and benzene. They found that carbon nanofibres require between 13-50 times more energy than materials with similar applications like aluminium. The group also looked at the carbon footprint of carbon nanofibres (*J Ind Ecol* 2008, 12, 394).

'The numbers for carbon nanofibres are huge compared to aluminium, polypropylene and steel,' said principal author Vikas Khanna. 'Carbon nanofibres are primarily synthesised by the catalytic cracking of hydrocarbons. It's a very high temperature process and the conversion efficiencies are really low.'

However, replacing traditional materials with materials based on carbon nanofibres will not necessarily result in higher overall energy consumption. So-called nano-products typically require less material so may be more efficient when used.

Khanna cautions that it is more useful to compare the life cycles of finished products with an equivalent made from different materials. The group is now comparing steel car body components with body parts made from carbon nanofibre-based materials.

Over time, production processes inevitably become more efficient, something the group considered. But, according to Khanna, energy requirements for nanofibres will not improve significantly until they are produced at lower temperatures.