Moving molecules within molecules

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Experts in the field of nanoscience have discovered a way of controlling the motion and detecting the forces that move molecules within molecules.

Their ground-breaking discovery could play a major role in the development of nanomechanical devices. For instance — looking far into the future it could transform the way computer microchips are assembled reducing the size of computers and at the same time making them much more powerful.

This research at the nano scale — 10 nanometers is 10,000 times smaller than the diameter of a human hair — is so fundamental that the applications are, for the time being, purely hypothetical. However, it helps in understanding of how molecules can be manipulated and positioned at the single-molecule level. It could lead to the use of molecules as components for electronic devices and could also lead to significant applications for biomedical sciences and sensors technology.

Researchers at The University of Nottingham are among a team of experts from across the globe, led by Dr Makoto Ashino at the University of Hamburg, who have measured the mechanical responses of molecules to the atom at the tip of an atomic force microscope.

The research has been published in *Nature Nanotechnology.*

In collaboration with experts at the University of Hamburg, the Max Planck Institute for Solid State Research in Germany, the Technical

University of Eindhoven in the Netherlands and The Hong Kong University of Science and Technology, researchers at The University of Nottingham have played a key role in this ground-breaking discovery.

Dr Andrei Khlobystov, Associate Professor and Reader in Chemical Nanosciences in the School of Chemistry, specialises in the chemistry of carbon nanostructures — with a particular emphasis on the chemistry inside carbon nanotubes — using the nanotube with a typical diameter of 1-2 nm as a miniature test tube.

Dr Khlobystov designed a structure of carbon nanotubes in which the movement and response of the molecules could be measured. He said: “It was a long and iterative process, but eventually I developed a technique which allowed us to fill nanotubes with molecules and at the same time to keep nanotubes well-dispersed.”

The crucial experiments were carried out by Dr Makoto Ashino from the Institute of Applied Physics and Microstructure Research Centre, University of Hamburg. Using the materials prepared by Dr Kholbystov he probed the structures with dynamic non-contact atomic force microscopy (AFM) — a high resolution type of atomic force microscope capable of producing a three dimensional profile of surface structures measuring attractive forces within just fractions of a nanometer.

In addition to studying the surface topography of these structures the team simultaneously measured the energy lost by the vibrating tip of the AFM as it moved over the surface of the structures.

Nanotechnology is so small powerful microscopes are needed just to see it but it has already had a huge impact on our everyday lives. Nanotechnology is used in sports, clothing, motoring, engineering, medicines and forensics.

Scientists have been able to confine small molecules inside larger molecules for a number of years. They have even been able to watch the movement of the smaller molecules inside molecules. However, until now, it has not been possible to control this motion or measure the forces that move the smaller molecules.

Dr Ashino said: "Our achievements are directly related to the development of nanomechanical devices. We have shown that the manipulation of individual molecular oscillations can be activated by the energy transfer from a truly mechanical oscillator via the nanotube to the molecule. The site-specific control of individual dynamic motions in a chain of molecules can be important for the future development and precise control of nano-molecular machines and nano-transporters (i.e. long-distance transporting of individual molecules), as well as for ultra-sensitive molecular sensors."

The online version of the paper is available at www.nature.com/nnano/journal/v … /nnano.2008.126.html .

Source: University of Nottingham