

Nano Machines

Molecular analogues of mechanical devices

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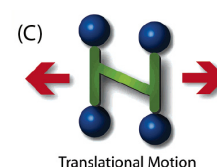
The continued quest to miniaturize machinery in our current scientific and technological disciplines has led to the preparation of a variety of molecular machines, such as the ones presented here. Miniaturization can be only be pushed further beyond the limit set by the current top-down approach if we construct functional nanoscopic entities using individual molecules, designed from the "bottom-up." As Richar Feynman said: "There's plenty of room at the bottom".



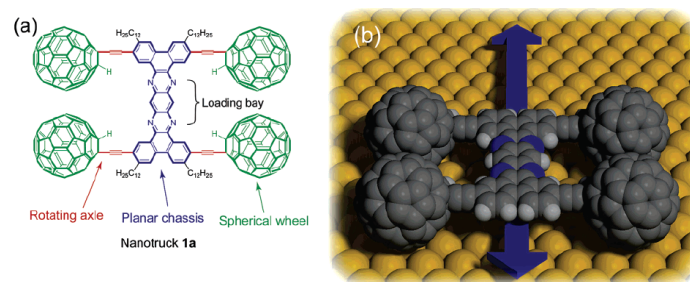
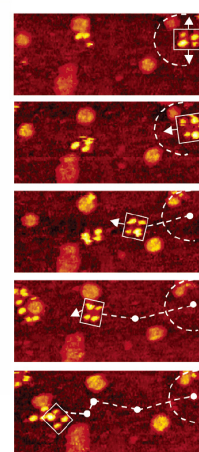
Nanocars

Surface-rolling molecules to study motion on surfaces

The positioning of molecule-sized machines on a surface is the first step toward being able to pump, push, or lift materials, generating useful work. The most intuitive machinery for controlled translations on such surfaces would be a nanovehicle with molecular wheels.



Translational Motion



(a) Molecular structures of the molecular machines.
(b) Space-filling model of the nanocar.

(c) Thermally induced motions of the four-wheeled nanocar and its STM-imaged motions.

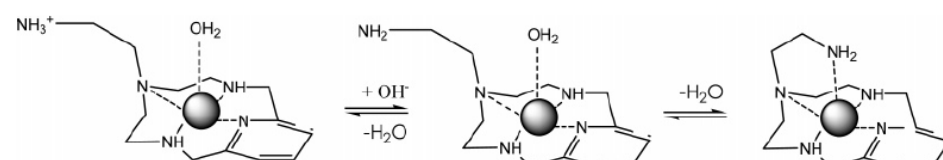
The surface-rolling nanovehicles give us opportunities to learn some basic rules for the design and operation of molecular scale transporter. Motion could be observed by STM, placing the tip in front of the nanocar would induce rolling motion toward the tip as the tip was moved across the surface

Tour, J. M.; et al. *J. Am. Chem. Soc.* 2006, 128, 4854-4864

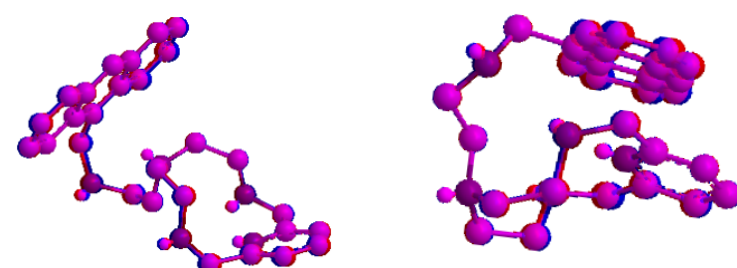


Scoriand Ligands

Controlled molecular movements play a major role in many biological processes, that's why is important to study synthetic molecular systems able to generate movement by the action of an external stimuli.



(a) Scheme of the molecular movement of a scoriand-like ligand.



(b) 3D image of the same ligand functionalized with an anthracene moiety.

Scoriand-like ligands display movement of the flexible pendant arm, mediated by the pH of the solution, on the basis of minimization of electrostatic repulsion. This leads to possible biological applications such as enzyme mimics. Another advantage of this compounds is that they can be easily functionalized in order to achieve improved applications.

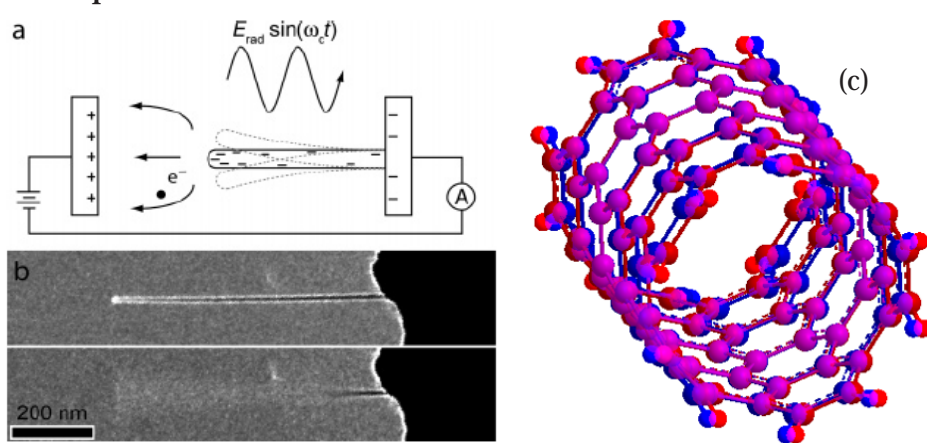
García-España, E. *Chem. Comm.* 2011. Submitted.

Nanotube Radio



Radio has had a profound effect on civilization since the day of it was invented. Today silicon-based technology is fast approaching hard physical limits, and it is expected that future progress will require new nanoscale materials, for example carbon nanotubes.

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(a) Schematic of the nanotube radio.
(b) TEM of a nanotube radio off and on resonance during a radio transmission.
(c) 3D image of a carbon-nanotube

A fully functional radio receiver from a single carbon nanotube has been constructed. It is orders-of-magnitude smaller than previous radios, and the nanotube serves simultaneously as all essential components of a radio: antenna, tunable band-pass filter, amplifier, and demodulator. Successful music and voice reception has been demonstrated.

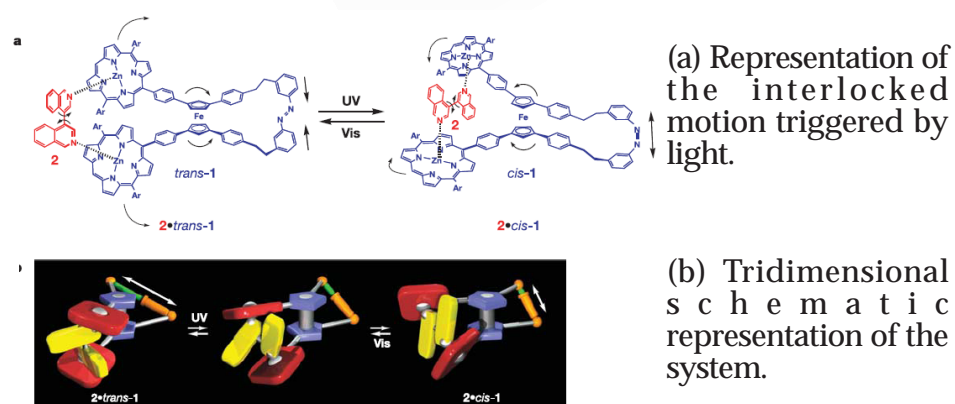
The nanotube radio may lead to radical new applications, such as radio controlled devices small enough to exist in a human's bloodstream.

Zettl, A.; et al. *Nano Lett.* 2007, 7, 3508-3511



Nanotweezers

The design of complex machines requires full understanding and control over the events of large interlocked systems.



The light-induced conformational changes of this molecular "tweezer" can give rise to mechanical twisting of a non-covalently bound guest molecule.

Aida, T.; et al. *Nature.* 2006, 440, 512-515