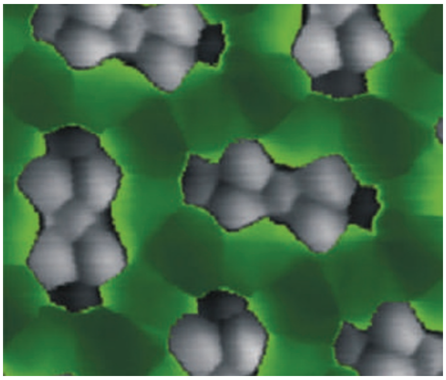
research highlights

SCANNING TUNNELLING MICROSCOPY

Image of the weak

J. Am. Chem. Soc. doi:10.1021/ja104332t (2010)



Scanning probe techniques such as the scanning tunnelling microscope (STM) and the atomic force microscope are regularly used to image molecules on surfaces but typically reveal only the vague overall shape of the adsorbed species. By attaching a small molecule to the end of the probe's tip, the microscopes have, however, recently been used to resolve atomic positions and bonds in organic molecules. Stefan Tautz and colleagues at the Jülich Research Centre in Germany have now shown that weak intermolecular bonds between adsorbed molecules can also be directly imaged with a STM.

The German team examined an ordered layer of PTCDA — a platelet-like molecule with a perylene core and acid anhydride side groups — adsorbed on a gold surface. STM imaging of the surface with a bare tip yielded only unstructured protrusions corresponding to the individual molecules. However, when imaged with a modified version of the STM in which molecular hydrogen is condensed in the tunnelling junction, some of the internal structure of the PTCDA was discernable (the seven connected lobes shown in grey and black in the image). Moreover, a tile pattern between the PTCDA molecules was observed that did not belong to the surface below (contrasting areas of green and black). By comparing this pattern with the arrangement of the molecules on the surface, Tautz and colleagues were able to assign these features to the non-covalent interactions that connect oxygen atoms on one molecule to hydrogen atoms on neighbouring molecules.

METAMATERIALS

A world in a grain of sand

Phys. Rev. Lett. **105,** 067402 (2010)

The advent of metamaterials has allowed scientists to learn about the very big — such as black holes and wormholes — by studying the very small. By permitting almost any spatial configuration of dielectric permittivity and magnetic permeability (which control how light interacts with a material), metamaterials can create benchtop analogues of cosmological problems that are otherwise hard to test. Now, Igor Smolyaninov of the University of Maryland and Evgenii Narimanov of Purdue University, both in the United States, have shown theoretically that metamaterials can be used to test a cosmological theory called the 'big flash'.

This theory holds that a reduction in the number of dimensions in the early universe led to a large flash of radiation. The American team showed that an appropriately constructed metamaterial could undergo a similar transition, leading to a flash of light and a test of the theory. They focus on a composite metamaterial made of thin semimetallic gallium wires inside a silica matrix. Femtosecond laser pulses can be used to melt these wires into liquid metallic phases, effecting a 'metric signature change' in the material that should lead to a release of a large number of infrared photons.

ASTROCHEMISTRY

C_{60} in space

Science doi:10.1126/science.1192035 (2010)

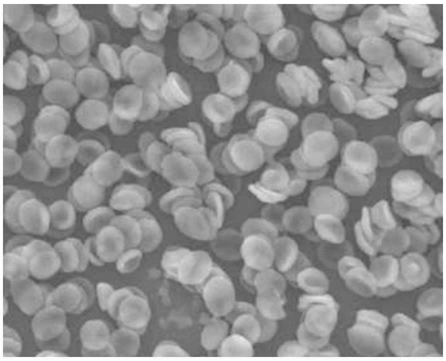
The discovery of C_{60} molecules in 1985 is one of the best known events in the history of nanotechnology, and was recognized with the Nobel Prize in Chemistry in 1996. Less well known is the fact that the motivation for this work came from astrophysics. Indeed, the first sentence of the paper reporting evidence for C_{60} reads as follows: "During experiments aimed at understanding the mechanisms by which long-chain carbon molecules are formed in interstellar space and circumstellar shells, graphite has been vaporized by laser irradiation, producing a remarkably stable cluster consisting of 60 carbon atoms." Now, 25 years later, the story has turned full circle with astronomers finding evidence for C_{60}, and also C_{70}, in space for the first time.

Jan Cami of the University of Western Ontario and co-workers in Canada, the United States and France used the Spitzer Space Telescope to study infrared emission from a young planetary nebula called Tc 1. Their results show that the C_{60} and C_{70} molecules are cold and neutral, and suggest that they are attached to solid grains of carbonaceous material rather than being free molecules in the gas phase. In laboratory experiments the formation of C_{60} and C_{70} is inhibited by the presence of hydrogen, so it seems that Tc 1, unlike most planetary nebulae, contains very little hydrogen.

BLOOD PURIFICATION

Nanomagnets pick up toxins

Small **6,** 1388–1392 (2010)



Removing toxins or other disease-causing substances from the blood is an attractive alternative to using drugs. One example is haemodialysis, which is the removal of waste products such as urea and creatinine from the blood of patients with kidney failure using semipermeable membranes. Dialysis is useful for filtering out compounds with low molecular weight but not other large and harmful biomolecules. Now, Wendelin Stark and co-workers at various institutes in Switzerland show that magnetic nanoparticles injected into blood can remove compounds with both low and high molecular weight.

Stark and colleagues synthesized carbon-coated iron carbide magnets (mean diameter ~30 nm) and functionalized them with either chelators that can remove metals, or antibodies that recognize specific proteins and inflammatory substances in the blood. Fresh human blood was spiked with different substances to model different intoxication or disease scenarios before adding the nanomagnets for about five minutes. After removing the magnets, blood was analysed for remaining toxins or substances. The method effectively removed lead ions, digoxin (a cardiac drug) and an anti-inflammatory substance (interleukin-6) that plays a role in the development of arthritis. Blood integrity remained intact; no clotting occurred and clinically relevant levels of ions and other substances remained in the normal range.

Although the method is promising for treating intoxications, several parameters, including the quantity of magnets required, need to be optimized in an *in vivo* model.