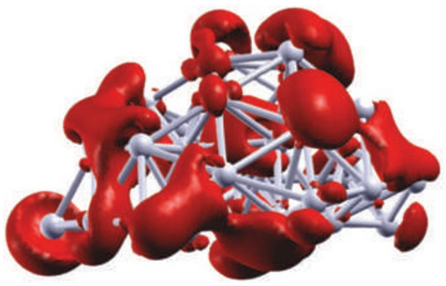
SILVER CATALYSTS

Three is the active number

Science **328,** 224–228 (2010)



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The epoxidation of ethene — which involves the conversion of a carbon–carbon double bond into a ring that contains two carbon atoms and an oxygen atom — is an important industrial reaction that, since the 1930s, has been efficiently carried out using a silver catalyst. However, when the same catalyst is used to epoxidize propene — an industrial reaction of even greater significance — the process is very unselective, despite the fact that the two reactants differ only by a single methyl group ($–CH_3$). As a result, the large-scale production of propene oxide currently involves an inefficient, two-stage process that can create undesirable by-products. Larry Curtiss, Stefan Vajda and colleagues at Argonne National Laboratory, the University of Illinois in Chicago, the Fritz Haber Institute in Berlin and Yale University, have now developed a catalyst containing three-atom clusters of silver that is active towards the epoxidation of propene.

The catalysts were prepared by depositing mass-selected clusters from a molecular beam onto an alumina support. The supported silver trimers are stable up to temperatures of about 110 °C, above which they start to agglomerate, and the researchers used this effect to prepare nanoparticles with sizes of around 3.5 nm. Both the clusters and the nanoparticles catalyse the direct epoxidation of propene by molecular oxygen, returning high selectivities towards propene oxide at low temperatures.

Density functional calculations suggest that the superior catalytic capabilities of these silver catalysts are due to the open-shell nature of their electronic structure.

FUNDAMENTAL PHYSICS

Ion trap sets force record

Phys. Rev. Lett. **104,** 143002 (2010)
http://arxiv.org/abs/1004.0780 (2010)

Atomic physicists have been trapping and cooling atoms and ions with various combinations of electric fields, magnetic fields and laser beams for over two decades to explore a variety of quantum phenomena. Other physicists have been using nanomechanical oscillators, often cooled to ultralow temperatures, to investigate fundamental aspects of quantum mechanics, and also to measure extremely small forces and masses. There has been relatively little overlap between these two areas of endeavour to date, but this situation has just been changed by two experiments.

Nanomechanical oscillators can be cooled by coupling them to a variety of systems, including optical cavities and superconducting quantum bits. Philipp Treutlein and co-workers in Munich and Paris coupled their micromechanical oscillator to an ultracold gas of rubidium atoms in which all the atoms had collapsed into a single quantum ground state — a state of matter known as a Bose–Einstein condensate. Because the coupling relies on surface forces, rather than components such as mirrors and magnets, Treutlein and co-workers predict that it should be possible to couple much smaller oscillators to gases of ultracold atoms.

In separate work, Michael Biercuk and colleagues at the US National Institute of Standards and Technology have used a gas of trapped beryllium ions to detect forces as small as 174 yoctonewtons ($1\ \mathrm{yN} = 10^{-24}\ \mathrm{N}$), which is three orders of magnitude more sensitive than previous measurements. The force, which is applied to one of the electrodes in the ion trap, is detected by shining a laser into the trap and measuring how the fluorescence from the ions is changed by the application of the force.

FRICTION

Thick and thin

Science **328,** 76–80 (2010)

Understanding friction at the atomic scale is important for the design of devices that involve the movement of nanoscale components across surfaces, and for the development of nanolubricants. Solid materials are often used for lubrication at the nanoscale because liquid lubricants can be forced out of the gaps between the moving parts. Robert Carpick of the University of Pennsylvania and co-workers in the US, the Netherlands and Switzerland have now explored the frictional properties of four solid lubricants — graphene, molybdenum disulphide (MoS_2), hexagonal boron nitride (h-BN) and niobium diselenide ($NbSe_2$) — at the nanoscale.

All four lubricants showed similar behaviour, even though $NbSe_2$ is metallic, MoS_2 is a semiconductor, h-BN is an insulator and graphene is a semimetal. Using friction force microscopy, Carpick and co-workers found that the friction between thin films of the lubricant and a silicon oxide surface increased as the film became thinner. They argue that this is because it is easier for the thinnest layer to deform. The results of measurements of graphene on a mica substrate — to which graphene binds strongly — are consistent with this interpretation.

PROTEIN-NANOPARTICLE INTERACTIONS

Long lived

J. Am. Chem. Soc. doi:10.1021/ja910675v (2009)

Until now, it has been thought that cellular responses to nanoparticles depend on particle size, shape and surface chemistry. However, it was shown recently that the bare surface of nanoparticles form a 'protein corona' when they come into contact with biological media. Kenneth Dawson, Francesca Baldelli Bombelli and co-workers at the University College Dublin (UCD) show that nanoparticles dispersed in blood plasma form long-lived multimeric protein–particle assemblies, suggesting that the cell 'sees' these protein structures rather than the surface of the particle itself.

The UCD team incubated three different types of nanoparticles in human blood plasma, and measured the time-dependent changes of the protein corona using differential centrifugal sedimentation, dynamic light scattering and transmission electron microscopy. Dawson and co-workers found that the protein coronas were formed in a relatively stable manner over a period of one hour, although much slower and more subtle changes continued for up twelve hours. Strikingly, particles that were isolated from the plasma, washed (to remove unbound proteins) and resuspended in saline solution showed protein–particle complexes that were similar to those seen on the particles that had remained in the plasma. This suggests that these protein complexes are highly stable and may play a primary role when they come into contact with cells.

Nanoparticles in dispersion are thought to involve a stable protein complex (termed 'hard corona') consisting of one or two packed protein layers that slowly exchange proteins with their environment, and particle multimer and their corona complexes that may reorganize over time.