

In addition to the single-crystal studies, researchers working with zeolites (porous materials with large surface areas) have been able to identify catalytically active sites⁴. Because the zeolites are crystalline, these sites can constitute nearly uniform arrays, and thus the average structure and performance data reflect the performance of each individual catalytic site.

Arrays of catalytic sites on supports have also been made by anchoring analogues of homogeneous catalysts to oxide surfaces⁵, but these supported 'molecular catalysts' are not uniform because the support surfaces are intrinsically non-uniform, and can also influence the chemistry. However, anchoring molecular analogues to zeolite surfaces seems to be a step towards the desired uniformity and fundamental understanding⁶, and this work complements that with individual catalytic species by Mulvaney and co-workers.

The choice by the Melbourne team of a gold nanoparticle catalyst is also timely, as nanostructures of gold on supports have recently been found to offer new, unexpected catalytic properties for an amazing range of reactions, including

oxidations, hydrogenations and coupling reactions^{7,8}. The literature confirms the importance of the (average) gold nanoparticle size, but it fails to identify the active catalytic sites. The experiments of Mulvaney and colleagues point towards ways to develop such understanding, and surface science data foretell that the different sites on the nanoparticle surface will act differently. However, much finer-grained information about the structure and composition of the surface and the charges on the surface gold atoms is needed before we will understand how this catalyst really works.

As the authors note, a considerable limitation of their method is that today's instruments restrict it to relatively large nanoparticles. The gold particle they used was about 50 nm in diameter, but most active gold (and other) nanoparticles are much smaller — and new catalytic properties are expected to emerge from even smaller nanoparticles, especially in the blurry zone between molecular and nanoscale structures.

In the future, and with improved instrumentation, surface plasmon

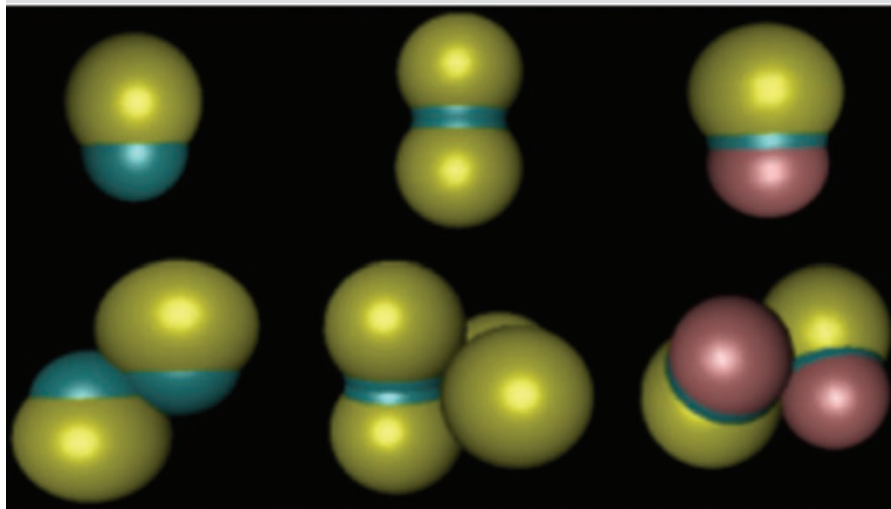
spectroscopy could be applied to individual nanoparticles of various sizes, shapes and compositions to provide insight into how their structures and compositions determine their properties. What is more, researchers will continue to find new techniques for the investigation of individual nanoparticles in working catalysts. The day will come when new methods will allow imaging and spectroscopy of nanoparticles with dimensions of less than 1 nm, and we will see the extension of single-molecule spectroscopy to molecules reacting on surfaces of individual catalyst nanoparticles.

References

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CLUSTERS

A colloidal twist



Colloids — a dispersion of small particles in a medium — can be used to mimic atoms, allowing phenomena in condensed-matter physics, such as glass transitions and crystal nucleation, to be visualized and studied. They also offer intriguing possibilities for building large-scale intricate and functional

structures. However, colloids typically form crystals or aggregates, and the synthesis of precise 'molecules' has so far proved difficult. Now, Jérôme Bibette and colleagues from the ESPCI in Paris and New York University have developed colloidal 'atoms' that can self-assemble into a variety of controlled structures,

including chiral clusters (*Nature* **455**, 380–382; 2008).

The researchers began by synthesizing magnetic colloids (illustrated in the figure) that included an oil-based ferrofluid (blue) and micrometre-sized silica particles (yellow or red). By precisely controlling the conditions, they were able to create doublets of silica particles that had a solid magnetic ring located around the point of contact between the two particles. In the presence of a magnetic field, these magnetic 'belts' assembled into a chain (bottom middle). The researchers found that when the dimers had different-sized silica particles, the chain was forced to coil (bottom right), and if the size ratio between the particles was high enough, a single helicity developed.

Bibette and team expect that this colloidal chemistry could prove useful in creating optical and light-activated structures, and in modelling enantiomeric separation.

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