degrees. There is also clear evidence that deactivated catalysts can be regenerated for CO oxidation and Water Gas Shift activity.

Harold and Mayfair Kung's group (Northwestern University, USA) has done some very interesting mechanistic work with gold on alumina catalysts for CO oxidation. Water and hydrogen treatment have been used to revive deactivated catalysts. The role of water is particularly intriguing. The fact that very small amounts of chloride deactivate the catalyst implies that the intrinsic activity of gold is probably higher than has yet been recorded: more experiments with non-halide preparative routes are called for! The relative importance of and inter-relationships between metallic and oxidized gold in the mechanism was discussed by several speakers.

The activity of supported gold at ambient temperatures and below remains a unique feature of catalysis by gold. The fact that gold is much more plentiful than the platinum

group metals and its price is more stable and lower than that of platinum also augurs well for the future of applications for gold catalysts (1).

The present author was invited by Professor Gabor Somorjai (UC Berkeley) to act as editor for a special edition of 'Topics in Catalysis' on 'Catalysis by Gold' to be published in 2004.

For the first time in a major multi-faceted international catalysis conference, it was apparent that catalysis by gold has become respectable amongst catalysis practitioners and many of them are optimistic about the likely number of new applications.

David Thompson

Reference

- 1 C.W. Corti, R.J. Holliday and D.T. Thompson, *Gold Bull.*, 2002, **35**, 111

Nanoparticle Assemblies: RSC Faraday Discussion 125, Liverpool, UK, 14 – 16 July 2003

This was a stimulating meeting attended by 120 delegates, from 16 different countries overseas. Of the 65 presentations and posters, about half included work on gold. The chairman of the organising committee, Professor David Schiffrin's innovative pioneering paper (1), led to gold being firmly established as a key element in the field of nanotechnology. This was the first to demonstrate the formation of monolayer-protected clusters when thiols react with small gold particles (2). Since these nanoparticles protected by thiol-containing ligands are easy to prepare and stable, gold is now key to this new fast-developing research area.

Professor Uzi Landman (Georgia Institute of Technology, USA) presented an introductory lecture entitled 'Small is Different: Self-Selection, Assembly and Organisation at the Nanoscale'. The nanoscale regime produces novel phenomena: these are not merely a scaling down from the

macroscale regime – above the nanoscale, properties are predictable, but with nanotechnology a non-scaleable, non-predictable regime occurs, resulting in novel phenomena. In this regime interactions caused by hydrogen bonding, dipolar and Van der Waals forces, hydrobobic/hydrophilic interactions, surface tension, capillarity, physisorption and chemisorption, and gravity etc become important. Considerations include self assembly, self selection, abundance, size (magic numbers), shape, structure fluxionality, and spontaneous symmetry bonding and breaking, and there is a hierarchy of effective forces. Research in the area of metal nanoparticles is driven by the unusual optical, electronic and chemical (eg catalytic) properties of the materials which can be constructed from them.

As for all Faraday Discussions, the rest of the speakers were given five minutes to introduce their paper, which was then open for substantial discussion. Some of the gold papers presented included:

'*Gold Nanoparticle/Organic Linker Films: Self Assembly, Electronic and Structural Characterization, Composition and Vapour Sensitivity*' by Tobias Vossmeier et al, Sony International (Europe) GmbH, Stuttgart, Germany

'*Electrochemical and Optical Properties of Two Dimensional Electrostatic Assembly of Gold Nanocrystals*' by David Fermin et al, Ecole Polytechnique Fédérale de Lausanne, Switzerland

'*Hyper-Rayleigh Scattering of Gold Nanorods and Their Relationship with Linear Assemblies of Gold Nanospheres*' by P.-F. Brevet et al, Université Claude Bernard Lyon 1, France

'*Au/Ag Bimetallic Nanoparticles: Formation, Silica-Coating and Selective Etching*' by Luis M. Liz-Marzan, Universidade de Vigo, Spain

'Wiring Redox Molecules with Nanoparticles' by Richard Nichols, David Schiffrin et al, University of Liverpool, UK

'Adaptive Chemistry of Bifunctional Gold Nanoparticles at the Air/Water Interface. A Synchrotron X-Ray Study of Giant Amphiphiles' by Thomas Bjornholm, University of Copenhagen, Denmark.

'Growth, Conductivity, and Vapour Response Properties of Metal Ion-Carboxylate Linked Nanoparticle Films' by Royce W. Murray et al, University of North Carolina, Chapel Hill, USA.

In this last paper the change of electronic conductivity could be exploited for the sensing of organic vapours.

A very effective poster session was held and lively discussions continued for at least three hours. Amongst the presentations were two from Sony International (Europe) entitled 'Molecular Tuning of Conductivity in Molecule Nanoparticle Composites from Insulating to Metallic Behaviour', by H.-G. Nothofer et al and 'Self-Assembled Gold Nanoparticle/Alkanedithiol Films: Preparation, Electron Microscopy, XPS-Analysis, Charge Transport, and Vapour Sensitivity' by Y Joseph et al, and another entitled 'Gold Nanoparticles as Templates for the Realization of Functional Molecular Assemblies' by Lucia Pasquato et al from the University of Trieste, Italy. An interesting presentation was given by Wembo Song of Hokkaido University, Sapporo, Japan entitled 'Preparation and Electrochemical Properties of Nanoarchitectures of Gold Nanoclusters Protected by Mixed SAMs and Ionic Polymers'. A poster relevant to the interface between gold nanotechnology and biology was entitled 'Enzymic Manipulation of DNA/Gold Nanostructures' by A.G. Kanaras, Matthias Brust et al of the University of Liverpool, UK. The importance of gold nanotechnology in the field of

catalysis was represented by a paper entitled 'AuPd Bimetallic Nanoparticles: Synthesis, Electronic and Structural Characterization, Reactivity', by Maria Casaletto et al of the University of Palermo, Italy.

Most of the technology is still in the early stages, but applications can be foreseen in sensors for a variety of substrates in both gases and liquids. Monitoring body fluids for selected substances by developing colour changes has already been demonstrated, and many of these effects operate at room temperature. New ways of depositing electronic circuitry can also be foreseen, and new applications in materials and decorative technology are emerging (2). Catalysis by nanoparticulate gold is already an important part of the gold nanotechnology scenario, with applications being developed in chemical processing, pollution control and sensing. Use of nanoshells, nanorods, clusters and layers of gold will lead to the identification of further exploitable properties.

Those responsible for organizing this meeting will be encouraged by the free flow of ideas and stimulating discussions that resulted. It was evident that a wide range of applications for gold nanotechnology could emerge as the innovative research in this area continues.

David Thompson

References

- 1 M. Brust, M. Walker, D. Bethell, D.J. Schiffrin and R. Whyman, *J. Chem. Soc., Chem. Commun.*, 1994, 801
- 2 C.W. Corti, R.J. Holliday and D.T. Thompson, *Gold Bull.*, 2002, **35**, 111

ATTENDING A TECHNICAL CONFERENCE INVOLVING GOLD?

In keeping with its objective of publishing the latest progress, an aim of *Gold Bulletin* is to publish reports of relevant conferences that involve the science, technology and applications of gold.

The Technical Editor would like to hear from readers planning to attend such conferences and who are willing to write a conference report for publication. A small honorarium is payable for reports published.

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