

Gold Catalysis Highlights at 13 ICC, Paris, 11–16 July 2004

This 13th International Congress on Catalysis proved to be a lively and stimulating meeting with around 2,000 participants from more than 60 countries. There were 186 oral presentations, including ten keynotes and six plenaries and over 1,300 posters, exhibited in three very lively afternoon sessions. Altogether there were close to fifty presentations where the principal theme was catalysis by gold or gold alloys. The fast developing interest in gold catalysis was also indicated by other speakers. A greater understanding of the mechanistic pathways operating during the reactions catalysed by gold and better definition of the optimal catalyst preparation methods and reaction conditions will lead to yet more new discoveries and new applications for gold catalysis.

The World Gold Council exhibition stand headed Exploiting Advances in Technology demonstrated descriptions of five application areas, together with a working model of a borohydride fuel cell producing useful electricity (QinetiQ), catalyst units from AIST (Japan) used for removing odours from toilets, and descriptions of applications for gold catalysts in gas masks for CO removal (Union Chemical Company, Taiwan), oxidizing mercury in the effluent from coal-fired power plants (Tennessee Valley Authority, USA), and air quality-control equipment from Givaudan (UK).

Two of the gold presentations attracted prizes for best abstracts: these were awarded to Andreea Gluhoi from Leiden, The Netherlands for 'The prominent part of base metal oxides in the performance of Au/Al₂O₃ catalysts in reactions of N-containing molecules', and to Sophie Hermans from Louvain, Belgium for 'Nano-sized gold as a promoter for Pd-catalysed glyoxal oxidation'. There were large, enthusiastic audiences at all the gold presentations, even on the last (Friday) afternoon, when a significant number of them had been scheduled!

The gold presentations included twenty four on carbon monoxide oxidation; three each on the selective epoxidation of propene, and other aspects of hydrocarbon oxidation; two each on hydrogen peroxide formation from

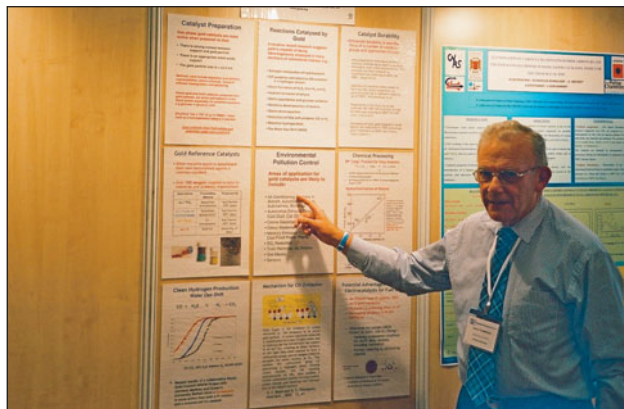
hydrogen and oxygen, NO_x reduction, sugar processing, and selective hydrogenation; and one each on water gas shift, benzaldehyde hydrogenation, hydrocarbon isomerization and oxidation, methanol reforming, glyoxal oxidation, methanol electrooxidation, glucose oxidation, catalytic wet air oxidation (CWAO) of succinic acid, ethanol conversion to ethene and acetaldehyde, carbonylation of methanol and the reduction of cyanoaurate, and a general review of reaction mechanisms and potential applications.

The selective oxidation of lactose and maltose using molecular oxygen with Au/TiO₂ catalyst (Mirescu et al, Federal Agricultural Research Centre, Germany) gave 100% selectivity to lactobionic acid and maltobionic acid respectively, products which have potential uses in the food, pharmaceutical, and detergent industries: these results highlighted the potential for gold in these industries, especially as it is environmentally benign. A paper by Sabine Schimpf, B. Kusserow, Y. Önal, and Peter Claus (Darmstadt, Germany) described the catalytic conversion of glucose under hydrogenation and oxidation conditions to sorbitol and gluconic acid respectively, both of which are produced in at least 60,000 t/a quantities.

Gold catalysis was also included in some of the plenary lectures, including that entitled 'Attempts to fill the gap between enzymic, homogeneous and heterogeneous catalysis, given by Avelino Corma, from Valencia, Spain. The potential for discovering new catalytic phenomena and applications based on gold is clearly very significant once there is increasing expansion of investigations from CO oxidation into other reactions catalysed by gold.

Now that catalysis by gold has been established as an interesting and important topic, investigations have begun on mixed metal / alloy catalysts containing both gold and platinum group metals (PGMs). There were five presentations describing work with Au/Pd systems and one with Au/Pt, and there is already evidence that the presence of the PGMs can increase the catalyst activity still further





compared with gold alone. There was an interesting paper describing the beneficial effect of the presence of Au/TiO₂ on the electrooxidation of methanol using a Pt/Ru catalyst: the presence of the gold catalyst increases overall catalyst activity and reduces the tendency to CO poisoning and this could find application in fuel cells. There was also a paper on the decomposition of ethanol using an Au/Ag catalyst.

The talks principally focused on gold had the following titles:

Direct Synthesis of Hydrogen Peroxide from H₂ and O₂ using Gold Catalysts, by Graham Hutchings, *University of Cardiff, UK*

Propylene Epoxidation with O₂ and H₂ over Gold Nanoparticles Supported on Mesostructural Titania, by Masatake Haruta, *Research Institute for Green Technology, Tsukuba, Japan*

Nano-Sized Gold as a Promoter for Pd-Catalysed Glyoxal Oxidation, by Sophie Hermans, *Catholic University of Louvain, Belgium*

Water Gas Shift and PROX Reaction Activity of Low Content Gold-Ceria Catalysts, by Maria Flytzani-Stephanopoulos, *Tufts University, Medford, MA, USA*

Microstructural Structural Investigation of Pd-Au Alloying and Sulfur Poisoning in Highly Dispersed Bimetallic Pd-Au/C Catalyst Systems, by Patrizia Canton, *University of Venice, Italy*

Catalysis by Gold: Imaging and Local Chemical Probing of CO Oxidation under in-situ Conditions, Norbert Kruse, *Université Libre de Bruxelles, Belgium*

Au/MgO(100) Model Catalyst for Low temperature CO Oxidation, by Claude Henry, *CNRS, Marseilles, France*

Modelling Interfacial Structure of Gold Nanoparticles: Electron Density and Activity, by László Gucci, *Institute of Isotope and Surface Chemistry, Budapest, Hungary*

Role of Cations in Supported Molecular Gold Catalysts for CO Oxidation, by Juan C. Fierro-Gonzalez, *University of California, Davis, USA*

Size Effect of Zirconia Nanoparticles in Au/ZrO₂ Catalyst for CO Oxidation, by Xin Zhang, *Tsinghua University, Beijing, China*

Au/MnO_x Catalyst for Low-Temperature CO Oxidation: Effect of Preparation Method on Activity, by Diandree Padayachee, *Mintek, Randburg, South Africa*

The Prominent Part played by Base Metal Oxides in the Performance of Au/Al₂O₃ Catalysts in Reactions of Nitrogen-Containing Molecules, by Andreea Gluhoi, *Leiden University, The Netherlands*

Surface Structure Modification of Au(110) and Au(111) Induced by CO Adsorption; in situ STM Study under CO Pressure, by FJ Cadette Santos Aires, *CNRS, Villeurbanne, France*

Atomic Insight into Reactions on TiO₂, by Flemming Besenbacher, *University of Aarhus, Denmark*

In a poster entitled 'The Mechanism of Catalysis by Gold and its Implications for Industrial Applications' by D.T. Thompson, C.W. Corti and R.J. Holliday, World Gold Council, London, UK, the recent results which indicated unexpected stability for supported gold catalysts at high temperatures and their selectivity and activity at low temperatures were highlighted. Attempts were made to fit recent results showing that naked gold is active in the liquid phase and polycarbonate-supported gold nanotubes in the gas phase into a general mechanistic picture which could be 'tuned' to each individual reaction. Recent homogeneous catalysis by gold was also illustrated. The experimental potential of the recent advances in gold catalysis for applications in pollution control, fuel cells and chemical processing applications were highlighted and the commercial benefits of using gold in these areas rationalized. The importance of selecting the right method for preparation of the catalyst is a key to success, and preferably the catalysts contain as little chloride and sodium as possible since these promote sintering at high temperatures. Interest in the work described was expressed by many academic and industrial delegates, and it is clear that the profile of gold catalysis has increased considerably during the last few years and will continue to increase in the near future.

All the presentations can be viewed as two page abstracts on the conference website <http://www.13icc.jussieu.fr>

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