



CatGold NEWS

A newsletter for information exchange on developments and progress in gold catalysis and its applications

Welcome to the first of what is intended to become a regular newsletter, CatGold News.

Following the success of the first International Conference on Gold Catalysis in Cape Town this year, we at the World Gold Council felt that a newsletter would be the best way to build on the sense of 'community' developed amongst the researchers in this rapidly developing field. Our aim is to provide readers with a relevant forum for exchanging views, news and comments on gold catalysis. The usefulness of the newsletter really will be dependent on you providing contributions, correspondence etc, so we urge you to do so.

In CatGold News we intend to publish short reports on new scientific developments, dates of relevant conferences and meetings, news of commercial developments and new appointments within the relevant academic/industrial communities. In each issue we will bring the latest news on developments from different countries around the world, beginning here with The Netherlands (Professor Nieuwenhuys).

If you have any news of interest, contact us at the address on the back page. We also intend to publish your opinions and letters, so please drop us a line!

The editorial team comprises Drs Christopher Corti, David Thompson and Richard Holliday. Richard, our new Industrial Applications manager, is Editor and so will be your contact point [richard.holliday@wgclon.gold.org]. Our address is on the back page.

We hope you find the first issue useful. Our next issue is planned for Spring 2002.

South African AuTEK Project Gathers Pace

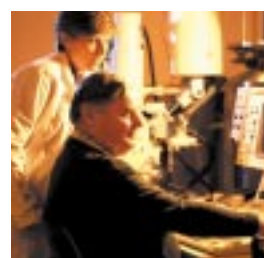


Project AuTEK is a collaborative research activity between AngloGold, Gold Fields Ltd and Mintek, all based in South Africa. The purpose of Project AuTEK is to exploit the unique properties of gold for industrial applications. The programme was officially launched in June 2000 at a glittering ceremony held at Mintek.

The initial phase of the project was focused almost exclusively on the use of gold in catalysts, and, in particular, on the metal's role in facilitating the catalysis of chemical reactions in industrial areas of economic and social significance. The research programme addresses specific applications, such as indoor air quality and air quality in underground mining environments. The catalyst research is considered as the first step in the big picture to demonstrate gold's useful technological properties as an industrial material.

Significant technical progress has been made at Mintek and two fully functional catalyst testing rigs have been commissioned this year. Mintek researchers were able to demonstrate an ability to match the performance of the gold-bearing catalysts prepared at leading research labs overseas, and have advanced the field further by developing several novel and unusual new catalytic materials containing gold. The gold-containing catalysts show significant activity for the oxidation of carbon monoxide at low temperature, and do not deactivate in the presence of moisture. The chemical activity and commercial prospects of these new materials are very good, and patent protection will be sought.

The capabilities of the project AuTEK team were considerably enhanced in early 2001 with the entry of Anglo American Research Laboratories to the project, which brought with it a wealth of expertise, intellectual property and equipment.



The entry of Gold Fields Ltd at the end of March 2001 has allowed Project AuTEK to diversify its portfolio, and the new research modules include, for example, the use of gold as a dopant in certain high performance alloys, and in advanced materials. Other gold mining houses have also indicated an interest in joining Project AuTEK and discussions are in progress. ■

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New World Gold Council Website

World Gold Council has a new upgraded website. Launched on the 15th August, it contains up to date information on all aspects of gold in today's society, including industrial applications, properties and an area specifically focused on gold catalysis. The website contains the latest and archived issues of *Gold Bulletin* and *CatGold News*, to be found within the Science and Industry section at www.gold.org. If you have any suggestions/queries regarding the Gold Catalysis section please contact Dr Richard Holliday at richard.holliday@wgclon.gold.org ■

POINTS OF VIEW

The Catalytic Gold Conference, Cape Town, April 2001: Analysis, Perspectives and Suggestions from the Point of View of an Organic Chemist

From 2 – 4 April 2001, the inaugural international conference on the use of gold in catalysis took place in Cape Town, South Africa. This letter is written with the intention of commenting on the conference and of offering some suggestions for the future so that even more can be achieved from the high enthusiasm and energy of the people working on gold catalysis.

In twenty six scientific lectures and numerous posters, a résumé of the current status of this young and emerging field was given. As might be expected for the first major conference on a new topic, the different sections of chemistry were far from being equally represented. Twenty of the lectures were devoted to physical chemistry, four to organic and two to inorganic and organometallic chemistry. But there is also another criterion by which one could classify the lectures, *ie* the aim of the catalysis: most talks covered the destruction of molecules which cause pollution (CO, nitrogen oxides, dioxin), only a limited number focused on the synthesis of desirable molecules (ranging from propene oxide to highly substituted arenes) and only one talk dealt with the production of (electrical) energy in fuel cells.

We all enjoyed the first contacts with people we knew only from the literature and learned a lot from questions and discussions both within the lecture room and in the breaks. There was a wide spectrum of interests and motivation amongst the participants and it was useful to see how one's own interests fitted into the various aspects of gold catalysis which have been investigated to date.

Gold producers would naturally like to sell as much of their product as possible and the ideal case for them would be an application that excludes recycling, as for example in a space craft that later vanishes into deep space. Where catalytic processes are concerned, chemists would like to find catalysts with almost unlimited activity, whereas gold producers would prefer a catalyst that beats existing catalysts and has novelty but is still not too active, so that a profitable amount of gold will be needed. Apart from recycling gold, the challenges for chemists will include synthesis of new complexes for homogeneous catalysis, and new alloys and heterogeneous catalysts, which are currently still difficult to prepare in a well defined manner and in large quantities.

In addition to industrialists with direct interests in gold, more representatives from industries who could with advantage develop processes based on gold and its derivatives should be invited to future conferences on gold catalysis. As far as organic synthesis is concerned, gold has received very little attention, but the limited studies to date have already yielded totally new and synthetically interesting transformations. In this area, high added value

products such as pharmaceuticals could be made using gold catalysts. Physical and technological chemists formed the majority of the participants. Dr Haruta, Director of the Research Institute for Green Technology, Tsukuba, Japan seems to be the current visionary in this area, following earlier work by Professors Bond and Hutchings (UK). Carbon monoxide oxidation is the greatest area of current interest, especially as far as gaining a mechanistic understanding is concerned, but this reaction is far removed from many of those that produce useful products from chemical reactions. It is, however, a good sign that in heterogeneous catalysis more effort is being devoted to the use of *in situ* methods under reaction conditions of the kind likely to be used in the potential catalytic processes. A broader exploratory screening of the substrates for catalysis would be preferable to the current preoccupation with CO oxidation, since one could visualize the discovery of new reactions if a wider perspective were taken. Such new reactions might even help to develop more general models and to understand the reaction mechanisms: I doubt whether even a full understanding of the CO oxidation mechanism would be of real help for reactions of more complicated molecules.

The synthetically orientated people working on homogeneous (organic) reactions also need to do their homework. Here the generation of a defined catalyst, either an inorganic or an organometallic compound, is much easier as we can rely upon the large volume of work already undertaken by inorganic and organometallic chemists. Emphasis should be on finding new organic transformations that simplify synthesis, or increase selectivity (chemo-, regio-, positional and stereoselectivity) and reactions that proceed under conditions that help to save energy. There are already well established methods for arriving at a mechanistic understanding of homogeneously catalysed reactions. Inorganic and organometallic chemists have already devoted some of their work to the synthesis of catalytically active complexes and the preparation of precursors for heterogeneous catalysts.

The objectives for this first conference were adequately fulfilled, and many new contacts and cooperations were established in the friendly atmosphere. Looking into the future in my positive and optimistic way, I am confident that this almost "white spot for catalysis" on the map of all the stable, *i.e.* non-radioactive, elements will be explored by many more chemists in the future. Especially in the field of organic chemistry, a large potential for gold has been seeded. ■

Yours sincerely

A Stephen K Hashmi

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REPORT

A Report on the Cape Town Catalytic Gold Conference appears in 'Gold Bulletin' Volume 34 Issue No. 2 2001. Full papers will appear in a Special Issue of 'Catalysis Today' (date to be confirmed). Catalytic Gold II Conference is planned for Autumn 2003, probably in Toronto or Vancouver, details to be published in the next issue of 'CatGold News' and 'Gold Bulletin'. ■



Research on Gold Catalysis in The Netherlands



Three university research groups in The Netherlands have a major activity in this field. At the Delft University of Technology (A.Zwijenburg, G.Mul, M.Makkee and J.A.Moulijn) the emphasis is on the development of a gold based catalyst that can directly convert propene into propene oxide (PO). Both the group in Delft and Haruta's group in Japan have found that Au/TiO₂ can produce PO from propene, oxygen and hydrogen with high selectivity. The PO yield, however, is too low for commercial applications. In combination with mechanistic studies, multi-component gold-based catalysts are being investigated with the aim of developing catalysts capable of producing PO with both high selectivity and high yield.

The group at the Leiden University (R.J.H.Grisel, A.Gluhoi and B.E.Nieuwenhuys) is investigating the behaviour of gold-based catalysts in reactions relevant to automotive pollution control: CO and hydrocarbon oxidation and NO_x reduction; and the selective oxidation of CO in the presence of hydrogen, a reaction important for the development of the polymer electrolyte fuel cell. Research is focused on gaining a fundamental

“the aim of developing catalysts capable of producing PO with both high selectivity and high yield”

understanding of gold catalysis the nature of the active site, the role of the gold particle size and the effect of an added transition metal oxide. In addition to catalysis studies using 'real' catalysts, a surface science orientated project starting later this year will use well-defined gold based 'model' catalysts. It is anticipated that these combined activities will help in understanding the essential features of catalysis by gold.

A third group, also at Delft and Leiden (A.Goossens, M.J.Craje and A.M.van der Kraan, Interfacultair Reactor Instituut, Delft and L.J.de Jongh, Kamerlingh Onnes Laboratory, Leiden) is involved in the characterisation of Au-based catalysts using ¹⁹⁷Au Mössbauer Effect Spectroscopy (MES). In collaboration with the groups mentioned above MES is used to study the nature of active Au species in gold-based catalysts. ■

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Reference Gold Catalysts

Following a suggestion first made at the Catalytic Gold Conference in Cape Town (see *Gold Bulletin*, 2001, 34, 56 – 66) that there should be 'standard' or reference gold catalysts available for comparison purposes, Professor Geoffrey Bond has been leading a discussion on this topic with the objective of defining which would be the best. Current thoughts are focused on making a limited number of supported gold catalysts in at least 2Kg quantities, using appropriate combinations of metal oxides, carbon and gold particles.

We would welcome inputs from readers on this topic so that choices can be made which are most relevant to the work of researchers in this field. The method of preparation (e.g. coprecipitation, deposition precipitation), choice

of support(s), gold particle size, and calcination and storage conditions all need to be carefully defined. Meanwhile it may be useful for investigators to exchange catalysts to compare results on the same catalyst in a number of laboratories, and we at WGC would like to encourage and facilitate these activities.

I look forward to receiving your comments on this topic. ■

David Thompson

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PS Another topic which would benefit from exchange of views is the types of soluble gold complexes most likely to be suitable for homogeneously catalysed reactions (see Stephen Hashmi's letter).

Catalysis and Gold Bulletin

Information on catalysis by gold has been published in recent issues of *Gold Bulletin*, both as full papers and abstracts: these include the following:

1. Catalysis: A Golden Future, G.J. Hutchings, *Gold Bull.*, 1996, **29**, 123-130
2. Condensation Reactions of Benzaldehyde Catalysed by Gold Alkoxides, S. Komiyama, T. Sone, Y. Usui, M. Hirano and A. Fukuoka, *Gold Bull.*, 1996, **29**, 131-136
3. The Electrocatalytic Behaviour of Gold in Aqueous Media, L.D. Burke and P.F. Nugent, *Gold Bull.* 1998, **31**, 39-50
4. Gold: The Catalytic Metal for the 21st Century?, G.C. Bond, *Gold Bull.*, 1998, **31**, 110
5. New Advances in Gold Catalysis, Parts I and II, D.T. Thompson, *Gold Bull.*, 1998, **31**, 111-118; 1999, **32**, 12-19
6. Nitric Oxide Reduction with Hydrogen, Carbon Monoxide and Hydrocarbons over Gold Catalysts, A. Ueda and M. Haruta, *Gold Bull.*, 1999, **32**, 3-11
7. New Gold Catalysts for Liquid Phase Oxidation, L. Prati and G. Martra, *Gold Bull.*, 1999, **32**, 96-101
8. Gold-Catalysed Oxidation of Carbon Monoxide, G.C. Bond and D.T. Thompson, *Gold Bull.*, 2000, **33**, 41-51
9. Highlights of the International Conference on Catalytic Gold, Cape Town, South Africa, 2-5 April 2001, D.T. Thompson, *Gold Bull.*, 2001, **34**, 56-66

Abstracts of recently published papers and patents on gold catalysis are included in the Literature Highlights section published in every issue.

Manuscripts for new papers and reviews to be published in *Gold Bulletin* should be sent to:

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Au/Ag Symposium at



This Symposium is taking place in Limerick from 2 – 7 September 2001. The objectives are the following:

Why are gold catalysts breaking the mould of precious metal catalyst conventions? Papers will describe recent activity and selectivity measurements on heterogeneous gold catalysts in oxidation, hydrogenation, hydrochlorination and other reactions. New developments in homogeneous catalysis by soluble gold systems will be described and homogeneous and heterogeneous systems compared. The similarities and differences between gold and silver systems will be explored. The importance of gold particle size and other physical and preparative variables will be considered, including choice of catalyst support; and the relevance of *in-situ* modification of the electronic properties of silver by oxygen incorporated in defects and into the lattice will be emphasized. Discussion will be initiated by two keynote lectures entitled "The Current Status of Catalysis by Gold" by Graham Hutchings (University of Cardiff) and "The Current Status of Catalysis by Silver" by Robert Schloegl (FHI-Berlin); and the implications of all the recent developments for applications in chemical processing and pollution control will be assessed.

The Symposium will have four half-day sessions and poster presentations. Topics include Catalytic Performance, Catalyst Characterisation and Mechanisms, as exemplified by studies of carbon monoxide oxidation. A review will also be given of the recent Cape Town Conference on Catalytic Gold ■

Patents in Gold Catalysis

Patents are an indication of industrial interest in developing applications from new scientific advances. The following patents on gold catalysis have been filed in recent years (see *Gold Bulletin*, 1998 – 2001):

1. RELATED TO PROCESSING

Manufacture of Vinyl Acetate (Pd/Au)

T. Wang and J.A. Brossard, Celanese International Corporation, USA, WO Patent 9962632 A1 (1999): Pd/Au on porous support

Production of Benzyl Esters (Pd/Au)

Y.Sato, J. Tatsumi, T.Iida and T. Hayashi, Nippon Shokubai KK Co Ltd, Japanese Patent 2000288392 A2 (17 October 2000)

Epoxidation of Olefins

S.R. Bare, R.G. Bowman, H.J. Clark, G.E. Hartwell and J.J. Maj, Dow Chemical Company, WO Patent 9800415 A

Carbonylation Catalysts (Ir/Au)

J.R. Zoeller, A.H. Singleton, G.C. Tustin and D.L. Carver, Eastman Chemical Company, USA, US Patent 6177380 B1 (23 January 2001): Au/Ir on carbon for vapour phase oxidation of methanol

2. RELATED TO POLLUTION CONTROL

Low Temperature Oxidation of CO, etc

P. Marecot and R. Emmanuel, Rhone Poulenc Chimie, French Patent 27771310 A1 (28 May 1999): 3nm Au (and PGMs) on ZrO₂/CeO₂

Exhaust Gas Purification and Environmental Control

Degradation of CO, HCs, NO_x, O₃, using Au/TiO₂/CeO₂
L.A. Petrov, Laman Consultancy, Bulgaria, WO Patent 9851401 A1 (19 November 1998) (See also *Stud. Surf. Sci. Catal.*, 2000, **130C**, 2345 - 2350)

3. RELATED TO FUEL CELLS

B. Grigorova, J. Mellor and J.A.J. Tumilty, Anglo American Research Labs, WO Patent 2000013791 (16 March 2000) (Au on ZrO₂/CeO₂)

Fuel: methanol or methane

V.M. Tatchev, Laman Consultancy, Bulgaria, WO Patent 9916546 A1 (8 April 1999): 0.1 – 2.5% Au on ZrO₂/TiO₂/CeO₂ for reforming and electrochemical oxidation of hydrocarbons and methanol

4. RELATED TO CATALYST PREPARATION

Gold Compound Solution and its Manufacture

H. Sasaki and M. Kida, Tanaka Noble Metal Industrial Co., Ltd., Japan, Japanese Patent 2001048537 A2 (20 February 2001): KAu(OH)₄ for catalyst preparation ■

Industrial Applications for Gold: Funding of R & D Projects

World Gold Council has recognised the importance of actively promoting industrial applications for gold and has a strategy in place to support this goal. One key element is the encouragement of commercial exploitation of applied gold based research by dissemination of the latest research in its leading scientific journal, *Gold Bulletin*.

Another key element is the encouragement of new research studies into the basic science of gold and in applying this to new potential applications. Limited funds are now available to support short term

R & D projects on basic science and technology and its applications, especially those feasibility studies focused on defining new or expanded uses for gold in industrial applications in areas such as catalysis, nanotechnology, electronics, dentistry and biomedicine/pharmaceuticals. Proposals for funding support are invited under the GROW programme (**Gold Research Opportunities World-wide**). Researchers in academia or industry should submit applications to Richard Holliday at the WGC address given below. Richard can provide further details and a project proposal form ■

CatGold News is published by World Gold Council. Please send submissions/correspondence to Dr Richard Holliday, Industrial Applications Manager, World Gold Council, 45 Pall Mall, London, SW1Y 5JG, United Kingdom. Tel: +44 (0)20 7930 5171; Fax: +44 (0) 20 7839 6561. E-mail: richard.holliday@wgclon.gold.org