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Catalysis Club of Philadelphia

Thursday, April 24, 2008
Holiday Inn Select Hotel
Naamans Road and I-95, Claymont, DE

In situ Structural and Mechanistic Investigation of the Catalytic Properties of Silver and Gold Nanoclusters

Prof. Robbie Burch
The School of Chemistry and Chemical Engineering
Queen's University, Belfast

&

Election of New CCP Officers for 2008-2009

Social Hour: 5:30 PM
Dinner: 6:30 PM
Meeting: 7:30 PM

Members: $30.00
Walk Ins & Non-members: $35.00
Student & Retired Members: $15.00

Menu

Chicken Hawaiian *- Served with Grilled Pineapple & Sweet and Sour Sauce*
Broiled Filet of Salmon *- Served with a Pomerey Mustard Sauce*
Penne Pommodoro

Meal reservations - Please notify your company representative or Carl Menning (menning@udel.edu, phone: 302-893-9398, fax: 302-831-1048) by ***Thursday, April 17***.

Company Representatives – We would like to encourage you to make meal/meeting reservations to your company representative.

Membership - Dues for the 2007-08 season will be $10.00 ($5.00 for the local chapter and $5.00 for the national club). Dues for students and post-docs will be $6.00 ($5.00 for local club and $1.00 for national club). Please send your payment to Steve Harris, Lyondell Chemical Co., 3801 West Chester Pike, Newtown Square, PA 19073-2387.

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In situ Structural and Mechanistic Investigation of the Catalytic Properties of Silver and Gold Nanoclusters

Prof. Robbie Burch
The School of Chemistry and Chemical Engineering
Queen's University, Belfast

Abstract

It is "well known" that gold is one of the most inert elements in the Periodic Table. However, in recent years it has been demonstrated that the chemical properties of gold are strongly dependent on the size of the gold crystals. In addition, when very small gold particles are supported on inorganic oxides they can display even more unusual and interesting properties. Similarly, it has now been found that nanoclusters of silver have unique size-related properties.

This lecture will describe the catalytic properties and the structural characterisation of gold and silver nanoclusters supported on inorganic oxides. It will be seen that the formation of these clusters and their stability is dependent on the exact reaction conditions. Rapid transformation from nanocluster to isolated atoms to dispersed ionic states can be seen using *in situ* methods such as Extended X-ray Absorption Fine Structure (EXAFS) to determine the local structure, and X-ray Absorption Near Edge Spectroscopy (XANES) to determine the oxidation state.

The unusual chemical properties of these nanoclusters is best seen in their catalytic performance. The activity of gold nanoclusters in the water gas shift reaction that is used to purify hydrogen for use in hydrogen fuel cells will be described. Changes in structure under reaction conditions will be used to show the delicate nature of these materials and their sensitivity to their environment. The importance or otherwise of possible reaction intermediates and the reaction mechanisms will be discussed on the basis of experiments using fast transient kinetics with isotopically-labelled molecules and DFT calculations.

Silver nanoclusters are good catalysts for the selective reduction of nitrogen oxides for automotive lean-burn emission control. It will be shown that the formation of the nanoclusters occurs readily under mild reducing conditions and that the specific catalytic performance is dependent upon the formation of these metallic clusters. In the presence of hydrogen these nanoclusters appear to have exceptional activity for NOx reduction and possible mechanisms for the hydrogen effect will be discussed. It will be shown that it is probably the unique combination of silver nanoclusters and hydrogen that is responsible for the remarkable catalytic properties of these systems. Some other opportunities to use gold and silver nanoclusters for catalytic purposes will be considered but the relatively low cost of silver, and the higher thermal and hydrothermal stability compared to gold nanoclusters, make these of particular interest for future applications.

Speaker's Bio

Professor Robbie Burch received his Ph.D. in inorganic chemistry from Queen's University, Belfast in 1968. He was a research fellow at the University of Oxford 1968-1970 and joined the faculty at University of Reading in 1970, where he was director of the Catalysis Research Centre and Professor of Catalytic Chemistry 1990-1999. He is currently Head of the School of Chemistry and Chemical Engineering and a Professor of Physical Chemistry at Queen's University, Belfast. Among many notable awards are the Royal Society of Chemistry Medal for Research on Hydrocarbon Oxidation Chemistry 1991, the Institute of Chemical Engineers Innovation Award for Applied Catalysis 2003 and the Royal Society of Chemistry Medal for Heterogeneous Catalysis in 2003. He was also elected to membership of the Royal Irish Academy in 2006.

Professor Burch has worked on the understanding of heterogeneous catalysis as applied to environmental issues for more than 30 years. Over his career he has published around 250 peer-reviewed papers and is the inventor on a number of patents. His publications are among the most cited in his field, giving an overall "H-index" of 46, with 11 papers being cited more than 100 times and a further 34 with more than 50 citations each. Throughout his career Professor Burch has undertaken research with a strong emphasis on understanding the fundamental principles of environmental issues. From his PhD, which was on aspects of the Hydrogen Economy, through research on clean fuel production, clean power generation, environmental protection, conversion of biomaterials into fuels, and the synthesis of clean hydrogen for fuel cell applications he has made major contributions to a sustainable world. The thrust of his research has been to develop methodologies for uncovering fundamental principles that contribute to our knowledge of catalytic systems and processes. At an early stage in his career, he developed the concept of using chemical molecules to probe solid surfaces using the simple principle that the most sensitive and smallest probe for investigating the chemical properties of a surface would be a small molecule. The natural extension of this concept was to use isotopically-labelled molecules and Professor Burch has developed leading-edge equipment for making fast transient kinetic studies under steady state reaction conditions. These techniques have been used to elucidate the mechanisms of the pivotal reactions such as occur in automotive emission control and hydrogen production.