

Editorial

New Frontiers in Gold Catalyzed Reactions

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1. Background

For many years, gold has been regarded as a poor catalyst due to its chemical inertness towards reactive molecules such as oxygen and hydrogen. The interest in using gold in catalysis has increased during the last 20 years, since Haruta reported the surprisingly high activity in CO oxidation at low temperature for small (3–5 nm) gold particles supported on various oxides.

Since then, gold nanostructured catalysts have attracted, rapidly growing attention, due to their potential applicability in various reactions of industrial and environment interest. The catalytic applications of gold have been, indeed, explored in several processes, such as NO removal, catalytic combustion of Volatile Organic Compound (VOC), hydrotreatment and chemical processing, and purification of hydrogen for fuel cell applications. Moreover, gold catalysts are, nowadays, employed as air-cleaning devices, for respiratory protection (gas masks), as sensors to detect individual poisonous or flammable gases, as well as deodorizers. Gold catalysts with low-temperature activity towards CO and hydrocarbons oxidation are suitable also for vehicles exhaust gas treatment, especially during the cold start period. Accordingly, at the end of 2007 the company Nanostellar announced the development of a diesel exhaust catalyst using a first catalytic component based on gold alloyed with palladium as the active component for CO oxidation. Nevertheless, despite the extensive recent efforts addressing the extraordinary catalytic behavior of gold nanoparticles, the attainment of the best performing supported gold catalyst is still a challenge and the origin of the structure sensitivity of Au catalytic activity is yet to be completely unravelled. The main reason for this is ascribed to the multiplicity of factors influencing the catalytic activity, including the size of the Au clusters, the oxidation state of gold, the nature of the support material, the Au-support interface, and the preparation method. The catalytic performances of gold nanoparticles have been correlated, in turn, with electronic (quantum size effect, oxidation state), structural and support (defects, perimeter interface) effects, but a

consensus has not been reached. Despite the lack of consensus, in my opinion, the research in this field has reached by now a satisfactory level of knowledge and I believe that the papers published in this “Gold Catalysts” special issue give an overview of the most important developments in the field.

2. The Present Issue

I am honored to be the Guest Editor for this thematic issue including 14 papers (see contents list). Gratifyingly, several of the leaders within this area have contributed articles and I would like to take this opportunity to thank them for their excellent contributions. I would like to thank also the many reviewers who helped me in the evaluation of the manuscripts.

Particular appreciation is due to Prof. Keith Hohn, the Editor-in-Chief, who invited me to guest edit this special issue, Ms. Mary Fan, Managing Editor, Dr. Brietta Pike, MDPI Production Editor, as well as the entire staff of the *Catalysts* Editorial Office who productively collaborated.

The present issue offers a wide array of articles dealing with Gold Catalysts. It comprises 5 reviews and 9 research articles. The first review article by Sun *et al.* [1] covers aspects of atomically monodisperse gold nanoclusters, with precise core-shell structure, which are fundamental to design new types of highly active and selective gold catalysts for a variety of catalytic processes. The role of surface steps and surface doping in the catalytic reactions on model gold surface was addressed through Density Functional Theory (DFT) based calculations by Gomes and coworkers [2] in a second review. Recent developments on synthesis of gold catalysts supported on mesoporous silica were exhaustively reviewed by Belkacemi *et al.* [3] who highlighted the importance of gold nanoparticles incorporation into the channels in order to prevent Au agglomeration and leaching. A comprehensive survey of the different methods available for preparing active gold catalysts on oxide supports has been reported by Prati [4]. The activity of gold catalysts in organic transformations was, finally, addressed by Pálinkó and coworkers [5] in the fifth review of the issue. Besides the most frequently studied CO oxidation, this work describes recent application of supported gold catalysts in the epoxidation of different olefinic compounds, such as ethylene, propylene, styrene, stilbene and cyclooctene. Moreover, examples of ring-opening reactions, like epoxide ring, are reported.

The role of support effects on the catalytic activity of gold clusters for H₂ dissociation was addressed by Lyalin *et al.* [6] who carried out a density functional theory study on boron nitride, as an example of inert support and rutile TiO₂ (110), taken as an example of active support. The length of the perimeter interface between gold nanoparticles and the rutile support has proven once again to be the major requisite to promote H₂ dissociation.

Two contributions focus on the effect of the support on the activity of gold for CO oxidation. In the first paper, Centeno and coworkers [7] investigated gold nanoparticles dispersed on an ionic liquid layer deposited over alumina. The size of gold particles strongly depends on the solvent employed. The use of water seems to produce gold active sites well stabilized by the ionic liquid dispersed on the support. In the second paper, by Grabowski and coworkers [8], the influence of dopant metals, Cu, Fe and Ni, on the catalytic properties of promoted gold/titania catalysts was addressed.

Two papers, by Koga *et al.* [9] and by Koga, Kitaoka *et al.* [10] investigated the catalytic features of bimetallic hybrid metal nanoparticles, AuAg on ZnO whiskers and AuPd over cellulose nanofibers, for aqueous reduction of 4-nitrophenol to 4-aminophenol.

The water-gas shift reaction at low-temperature was studied by two groups, Romero and coworkers [11] and Mae and coworkers [12], by using gold catalysts supported on different carriers, carbon materials and iron oxide, respectively.

A novel preparation method based on bimetallic carbonyl cluster salts was successfully applied by Albonetti *et al.* [13] for synthesis of tailored Au/FeO_x supported catalysts tested in the complete oxidation of toluene, methanol and in the PROX reaction.

The activity of Au over Ce-Zr-Co mixed oxides for CO oxidation and ethanol steam reforming was described by Pitchon *et al.* [14] in the last paper appearing in this thematic issue. They demonstrated that in the presence of gold, the reaction proceeds mainly on CeZrCo active sites preferentially through an acetaldehyde intermediate, thus increasing the catalytic activity and selectivity into hydrogen.

In conclusion, the Gold Catalysts special issue underscores the ongoing importance of gold based catalysts focusing on the influence of different parameters on the properties as well as on the catalytic applications of such systems.

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Biographical Sketch



Leonarda Liotta is first-class researcher in Palermo (Italy) at the Institute for the Study of Nanostructured Materials (ISMN) of CNR (National Council of Researches) since 2001. She received her education at the University of Palermo, where obtained the degree in chemistry (1992). Then, promptly in the 1992, she was hooked on heterogeneous catalysis via research projects financed by CNR. In the 1993–1994 she worked as fellow at “Institut de Recherches sur la Catalyse”, in Villeurbanne (France) with Dr. Guy Martin and Dr. Claude Mirodatos and successively she spent a period in Daresbury at Laboratory and Manchester University. In the 1995, she took position as associate researcher in Palermo at the CNR. After 2000, she is permanent researcher at the Study of Nanostructured Materials (ISMN) of CNR and since 2001 she is first-class researcher. Her research deals with various aspect of heterogeneous catalysis, particularly, supported gold catalysts for CO and VOCs oxidation at vehicles cold start emission. She is referee of many ISI Journal published by Elsevier, Springer, ACS and evaluator of projects for French National Research Agency (ANR). She now has about 100 papers and she was winner of a special CNR Award for high quality scientific researches carried out during 2005.

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