Guest Editorial

Gold: The Catalytic Metal for the 21st Century?

The reasons for the catalytic excellence of the elements of Group 8 - 10 of the Periodic Classification include their ability to chemisorb or coordinate reactants in the fashion appropriate for the desired reaction in as *weakly* an absorbed state as is consistent with obtaining full coverage of the catalytic surface. This happens to greatest effect with nickel, palladium and platinum. Outside this compact group of metals, copper and silver also have catalytic properties, and there have been astonishing and totally unpredictable developments in the last decade in the uses of gold as a catalyst. Although gold had been demonstrated to be a catalytic metal as early as 1906, and the ability of gold to act as an hydrogenation catalyst was explored in the 1970s, there was a general feeling from this early work that it was surprising gold was a catalyst at all.

All this began to change towards the end of the 1980s when Dr Masatake Haruta of the Osaka National Research Institute in Japan started to publish a series of papers in which it was demonstrated that *suitably prepared* gold catalysts showed exceptional activity, exceeding even that of the Group 10 metals, in the oxidation of carbon monoxide. Because of their immense potential technical importance, his observations were quickly verified and extended in a number of other laboratories, with NASA scientists in the USA showing great interest in this development. In a comprehensive review which David Thompson and I have recently had accepted for publication in *Catal. Rev.-Sci. Eng.*, we have concluded that the most important factors in securing good activity are: (1) choice of support (transition metal oxides such as Mn_2O_3 and Fe_2O_3 are very effective, but Al_2O_3 and SiO_2 are not); (2) method of preparation (co-precipitation and deposition precipitation work well, but the classic methods impregnation and ion-exchange do not; and (3) calcination (best avoided). These considerations, backed by extensive physical characterization, lead to the view that a successful catalyst should

have gold particles of *ca* 2-4 nm in size, interacting with an oxide support that can itself in some way participate in the reaction. These requirements explain why gold's ability as a catalyst escaped detection for so long.

Gold catalysts have also been shown to have promise in both the selective and non-selective oxidation of hydrocarbons, in the reduction of nitrogen oxides by carbon monoxide, propene or hydrogen, and in the hydrogenation of carbon oxides (*eg* water-gas shift). It appears

that the same catalyst structure as that sketched above is needed in these other reactions.

It is not only elemental gold that has provided catalytic surprises. Cationic gold species have been shown by Professor Graham Hutchings to be more active than mercury catalysts for the hydrochlorination of ethyne (acetylene), while recent German work (at BASF) has shown that gold(I) phosphine complexes catalyse the addition of alcohols to alkynes (see Literature Highlights Section in this issue of *Gold Bulletin* - page 144).

Part I of Dr Thompson's IPMI presentation (see opposite page) will provide the interested reader with further information and insights into the abilities and potential of gold as a catalyst. We may confidently expect further developments, and early in the new millennium gold should take its place alongside its neighbours as a vital member of the armoury of transition metal catalysts.

A handwritten signature in black ink, appearing to read 'GCBond'.

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Geoff Bond held academic posts at Leeds and Hull Universities before joining Johnson Matthey plc as Head of Catalysis Research in 1962. In 1970 he was appointed Professor in Brunel University's Chemistry Department, and is currently an Emeritus Professor at that University.