

hydrocarbons but, under stoichiometric and lean conditions, hydrocarbons with a carbon number less than 3 show increased activity.

Natural gas is being considered as an alternative fuel for automotive applications in many parts of the world. However, methane is a powerful greenhouse gas, so emissions of unburnt methane are of particular concern. The paper by S. H. Oh, P. J. Mitchell and R. M. Siewert, from General Motors, examines the relative performance of platinum, palladium and rhodium on alumina for methane oxidation in a simulated exhaust gas. The results show the order of activity to be palladium > rhodium > platinum, and that optimum performance is obtained slightly rich of stoichiometry. The authors consider some of the mechanistic implications of these results, and conclude that high surface concentrations of oxygen inhibit methane adsorption and reaction, and that water gas shift reactions are unimportant in the system, except possibly for rhodium catalysts.

The second section of this volume deals with pollution control of stationary sources and also begins with a review by J. C. Summers, J. E. Sawyer and A. C. Frost of Allied Signal, who

examine the implications of the U.S. 1990 Clean Air Act. Two other papers in this section deal with laboratory investigations of the catalytic oxidation of trichloroethylene (TCE) over platinum and PdO on alumina. TCE is typical of a range of widely used industrial solvents. The principal products over both catalysts are carbon dioxide, chlorine and hydrogen chloride; the production of chlorine arises from each TCE molecule having a hydrogen:chlorine ratio of 1:3. However, if water or methane is introduced into the reaction system, sufficient hydrogen is provided to increase the proportion of hydrogen chloride, with a corresponding reduction in chlorine. In addition, these reductants lower the proportion of the intermediate tetrachloroethylene appearing in the gas stream.

Thus the emphasis on catalysis, particularly using the platinum group metals, to control gaseous emissions continues to be very great. The full understanding of how these metals can be promoted to achieve extra performance remains elusive. By sponsoring and publishing symposia of this kind a gradual understanding is being built up.

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## Nitrate and Nitrite Removal from Drinking Water

Nitrate contamination of ground water in intensively farmed arable areas may result from the over application of natural or artificial fertilisers. As nitrate can constitute a health risk to humans such contamination must be minimised and the European Community has stipulated that the nitrate concentration in drinking water should not exceed 50 mg/l, and in fact it recommends significantly lower levels. Although a number of different processes are available for the removal of nitrate from water they have disadvantages; now researchers in Germany are working to develop a catalytic process to reduce both nitrate and nitrite with hydrogen (S. Hörold, K.-D. Vorlop, T. Tacke and M. Sell, "Development of Catalysts for a Selective Nitrate and Nitrite Removal from Drinking Water", *Catal. Today*, 1993, 17, (1-2), 21-30).

Nitrite, which is more toxic than nitrate, can be reduced to nitrogen by the use of a number of supported platinum metals hydrogenation catalysts. The removal of nitrate can be achieved by first reducing it to nitrite, which is then

reduced to gaseous nitrogen and/or dissolved ammonia, the latter being undesirable in drinking water. The type of hydrogenation catalyst, activated by the addition of a second metal, determines the reduction products. Of the hydrogenation catalysts tested for the reduction of nitrite, 5 per cent platinum on carbon displayed the highest activity but resulted in substantial ammonia formation; with 5 per cent palladium on alumina the ammonia was significantly less. Palladium-copper bimetallic catalysts were studied for nitrate reduction, and optimum activity and selectivity were achieved with a palladium:copper ratio of 4:1.

A combination of suitable platinum metals nitrate and nitrite reducing catalysts, and strict hydrogen limitation, has enabled the complete removal of 100 mg/l nitrate to be achieved while the formation of ammonia is kept below 0.5 mg/l, which is the level permitted in drinking water. Thus it is suggested that, when optimised, bimetallic catalysts could possibly be applied to the purification of drinking water.