Health Effects of Vehicle Emissions

A SELECTIVE REPORT FROM THE FIRST INTERNATIONAL CONFERENCE

The first International Conference on Health Effects from Vehicle Emissions was held in London from 16th to 17th February at the Royal Society of Medicine. More than 200 delegates from over 18 countries, representing health bodies, the automobile and fuel industries, non-governmental organisations, universities and environmental groups, heard papers covering the major themes of legislation, to curb vehicle emissions, and the increasing concern over the effects of emissions and hence air quality on human health. Transport policies and vehicle and fuel technologies were also discussed.

This review covers these topics and also the role that catalysts based on platinum group metals play in the continued lowering of vehicle emissions globally.

Issues and Trends in Air Pollution

Both the keynote speaker, P. Perera (European Commission, DG XI), and Michael Walsh (International consultant, U.S.A.) gave overviews on legislative trends and processes pursued by various governments, aimed at further tightening emissions standards. Perera emphasised the importance of team involvement by the EU member states and by industrial partners, in effecting changes in air quality. He also stressed the impact of EC legislation on the rest of the world using, as an example, the Japanese air quality framework, which is based on EU guidelines. Future legislation should be harmonised, probably on a global basis with the U.S.A. and Japan, and will have to recognise market effects, such as cost effectiveness and the technology available. The EU guidelines will have to consider all sources of polluting emissions, and platinum metals are expected to play a crucial role in meeting new targets for vehicles and other emitters.

M. Walsh stressed the global progress made in the last 25 years: nearly 90 per cent of all petrol vehicles now have catalysts, Sweden has set up environmental zones and fuel is generally cleaner, with lower sulfur contents. The EU will phase out lead additions to petrol by 2000.

D. S. Greenbaum (Health Effects Institute, U.S.A.) described health effects in terms of public health. He examined the sources of toxic substances in the U.S.A. and the EU and presented evidence that increases in particulate matter (PM) in ambient air resulted in increased mortality when exposure levels were high. There are also some associations with increased illnesses at lower levels of pollution. The discussions centred on the long term effects of PM, and short term effects linked to particles alone; and these effects will continue to be debated. Data indicate that newer diesel cars are cleaner: from 1978 to 1998 many diesel car pollutants were significantly reduced (by 30 to 95 per cent) including PM, NOx (nitrogen oxides), hydrocarbons, benzene, benzopyrene and formaldehyde. When combined with cleaner fuels, platinum metals catalysts have clearly made and will continue to make a significant contribution to improved air quality.

R. Mills (National Society for Clean Air and Environmental Protection) emphasised the opportunities and constraints governing bodies will need to tackle in dealing with vehicle emissions. The main areas are: developments in vehicle technology, fuel quality improvements, driver behaviour and traffic management. The main hold-up in new technology for vehicles is its slow spread throughout a fleet, but oxidation catalysts and particulate filter trap devices, such as the Johnson Matthey CRT™ (Continuously Regenerating Trap) play an important role in reducing visible pollution. Changing to cleaner fuels (such as ultra low sulfur content 'City Diesel') has an immediate impact on emissions and allows all types of platinum-based catalysts to work more effectively. Only practical difficulties, such as refinery capacity and fuel mixture, will limit the supply of cleaner fuels. In the U.K., City Diesel will shortly be available and will replace standard diesel fuel, meeting EU fuel quality guidelines for year 2005.

Air quality, as related to life expectancy, was discussed by D. Maddison (University College London and University of East Anglia) using two large existing research studies which link poor air quality and illness. Using a statistical model, he derived the probability of survival as a function of exposure to ambient concentrations of PM. Although controversial, progress has been made in establishing a cost benefit analysis. Overall, current ambient concentrations of PM in England and Wales are predicted to reduce average life expectancy by 4.5 months, for a child born today. However, other studies show an aggregate increase in life expectancy of 3.5 years, possibly linked to recently improved air quality.

M. Morris (Nabarro Nathanson) outlined the EU and U.K. legal frameworks for dealing with air quality. As atmospheric pollution knows no boundaries, pollutant concentration controls must be adopted globally or at least regionally. Morris laid out the EU key principles of the Air Quality Framework Directive (96/62/EC) and its daughter directives. The CAFE (Clean Air for Europe) initiative is an EC feasibility study for integrating all the major EU policies. All individual sources of pollution would be treated in a similar manner. The programme should use the expertise gained in curbing transport emissions to combat stationary pollution sources.

Transport Policies and Measures

U.K. government initiatives, published in the White Paper on Integrated Transport (1998), were discussed by I. Todd (Department of Environment, Transport and the Regions, U.K.). He described 'confounding' factors, for instance, traffic calming schemes intended to lower traffic levels which have created pollution 'hot spots'. He described the Vehicle Excise Duty (VED) rebate scheme, which allows heavy goods vehicles and bus companies to claim back about £1000 per year for each vehicle meeting lowered emissions standards. The Johnson Matthey CRT™ can fulfil these requirements on a wide variety of engine.

Protecting and enhancing urban surroundings will depend on new transport and environmentally-friendly technologies, including new fuels and new control systems. P. Greening (European Commission, DG III) examined EU limits and their schedule of implementation. From year 2005, On Board Diagnostics (OBD) will be required for heavy duty diesel vehicles. The OBD device will monitor and log certain catalyst efficiencies and report these to the driver and to the engine control unit.

Vehicle and Fuel Technologies

Advances in vehicle technology resulting in improved tailpipe emissions were discussed by K. P. Schindler (Volkswagen). Particle size distributions, taken from modern turbo-charged and older, naturally-aspirated, diesel passenger cars showed that particle size had been reduced overall, both in particulate mass and in total particle numbers. This was unexpected as newer diesel cars have higher injection pressures and, although the engines produce lower soot mass, the total number of smaller particles is sometimes surmised to increase compared to older engines. Volkswagen have found that the soot formation process is the key to understanding the conflicting information. Newer injection systems do not produce as much PM10 (particulate mass of size < 10 μm) because there is very little liquid phase available in the combustion. Condensates cannot form if liquid phase precursors are not present at the molecular level, thus there are fewer 'small' particles produced. More research is in progress on particle formation during diesel fuel combustion.

The use of both electric vehicles and alternative fuels: LPG (liquid petroleum gas) and CNG (compressed natural gas) to run vehicles was discussed by D. Armstrong (Transtech Consultancy Services Ltd.). Issues covered were vehicle availability, vehicle related costs, payload space and weight, and refuelling logistics. Alternative vehicles were equivalent to petrol- or diesel-fuelled vehicles in terms of performance, reliability, durability and safety. In fact, alternative-fuelled vehicles are already a reality for some users.

Diesel fuel issues were discussed by H. Ross (A. D. Little, Sweden) using work from Finland and Sweden, where environmentally classified

diesel qualities were introduced between 1991 and 1993. Reasons for the change, the costs and environmental benefits ensuing, and the tax differentials which succeeded in encouraging use were described. Other critical factors are refinery investment costs, fuel tax revenues, crude supply and operating costs.

J. Lucas (Tesco Stores Ltd) discussed cleaner fuels. Tesco offers both City Diesel and City Petrol from the majority of their filling stations. City Petrol is a low benzene content unleaded petrol which meets the proposed European Specifications for year 2005. While the fuels are readily available, there are problems in supply and with customer awareness. Price parity is therefore needed to ensure the widespread use of these cleaner fuels. Tesco also run 100 of their goods delivery vehicles with CRT™ units.

Conclusions

This first conference on health effects caused by vehicle emissions indicated the depth of interest in air quality. Although high pollution levels increase hospital admissions, questions remain on pollution dosages and effects. With further demands on transport and lowering of permitted emissions, automotive manufacturers and suppliers will continue to reduce emissions from engines by cleaner combustion and by optimised catalyst systems.

JAMES P. WARREN

Self-Organisation of Nanostructures

A recurrent theme in contemporary research has been the understanding of processes of self-assembly or self-organisation. Perhaps the fascination that this topic exerts is its ubiquitous nature, from the co-ordinated movements of very large flocks of birds to the organisation of living organisms.

The chemist's (and physicist's) viewpoint has been to investigate the types of interaction that underpin co-operative phenomena, in attempts to highlight the common denominator responsible for structure recognition. Examples of this abound in the literature, as for instance, the seminal work of Langmuir at the beginning of the century on the ordering of molecules at interfaces resulting from a balance of polar/non-polar intermolecular interactions. In this case, the driving force for molecular recognition and self-organisation can be identified with particular aspects of molecular structure and functionality.

The forces responsible for organisation can be more subtle than those mentioned above, which rely on specific functionalities. One example of this is the ordering and crystallisation processes observed for non-interacting systems composed of particles of different sizes (1). In this case, entropic effects are entirely responsible for phase structure and composition. Importantly, there are now examples that these effects occur not only for systems having dimensions in the micrometre range, but also in the nanoscale dimension (2).

There is at present an intense interest in identifying the forces responsible for self-organisation of nanostructures formed at crystal surfaces. These issues have recently been further explored in a paper by Pohl and colleagues (3). The main question that they address is the nature of the forces responsible for order in a single monolayer of silver on a ruthenium (0001) surface, in particular in relation to the behaviour of vacancy islands formed by exposure to sulfur. The mobility of isolated vacancy islands has been measured by scanning tunnelling microscopy (STM), as previously observed for cobalt layers on copper (111) (4). The analysis of thermal fluctuations of the vacancies and their displacement is a beautiful example of the application of STM to the analysis of nanoscale structures. From the statistical analysis of these displacements, the forces responsible for the stabilisation of the island vacancy lattice can be investigated. These forces result from line tensions, related to the reduction of co-ordination by creating an island, and film strain due to elastic deformation resulting from strain in the film around the edges of islands. The possibility of predicting the structures formed from surface stresses can open up new avenues for designing self-organised surfaces.

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