Gas Analysis
Application Note 259

HPR - 20
Analysis of Motor Vehicle Exhaust Emissions

Summary

A standard Hiden HPR-20 was used for the detection of various gaseous emissions from a motor vehicle. The mass spectrum was complex due to the mixture of air, hydrocarbons and other combustion products. Analysis of this type is important to detect levels of toxic or hazardous species. Such levels are often strictly controlled by local government legislation thereby forming an important target for motor manufacturers.

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Introduction

Hiden mass spectrometers provide a convenient and powerful monitoring method for emissions control.

The Hiden HPR-20 system is a flexible piece of equipment, able to utilise Hiden's range of quadrupole mass spectrometer (QMS) gauges and additional sampling and pumping options.

Procedure

For this experiment, the HPR-20 was fitted with a 200 amu mass range gauge with both Faraday Cup and Channeltron detectors and incorporated the foreline and bypass pumping option. The system utilised the heated quartz inlet capillary (QIC) for improved sensitivity and response speed. Control was achieved by computer remote control and Hiden's MASsoft software package. Additionally, to protect the pumps and gauge from particulates that may be present, a 2 micron filter was fitted on the end of the QIC.

The exhaust from a standard petrol fuelled engine was chosen for analysis. Although it is possible to monitor in situ, water vapour evolved will condense and rapidly block the filter, preventing accurate sampling. Therefore a sample was taken by filling a plastic bag with exhaust gases. This was then allowed to cool and the water vapour to condense out before the gas was sampled by the QMS.

The initial run was used to identify components of interest. The bulk carrier is air, but within this are the key sample substances of octane, C_8H_{18}, and combustion derivative gases CO_2, H_2O, CO, N_2O. A typical scan over the higher masses (looking at the octane traces) is shown in Figure 1. The clusters of peaks are common in hydrocarbons, and the peak positions and intensities match well with octane.

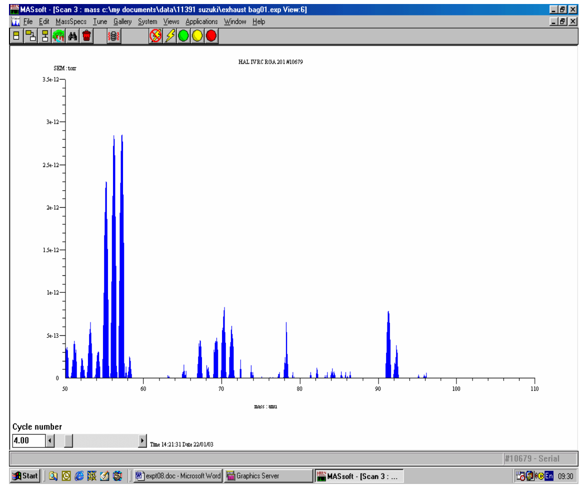

Figure 1: Profile Scan of Octane peaks

The most intense octane peak is 43 amu, but is overshadowed out by the 44 amu peak of CO_2.

Figure 2 shows the MID scan monitoring the levels of gas over the course of 45 minutes. After 30 minutes sampling was stopped, but scanning continued. This highlights the rapid response of the QIC.

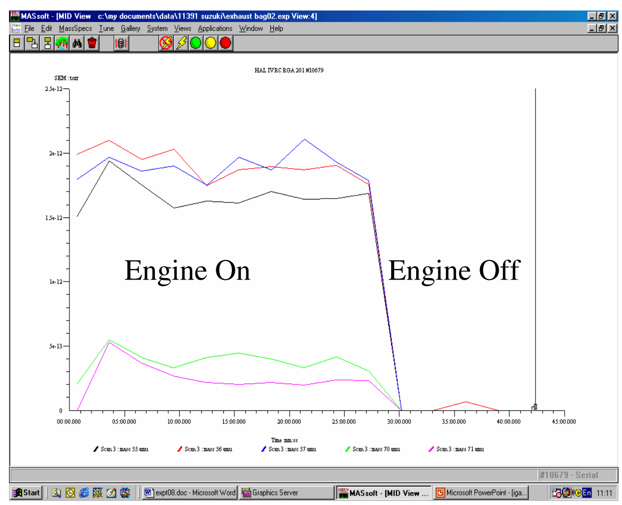

Figure 2: MID mode of Octane peaks

Figure 3 shows that the exhaust sample is enriched with CO2 and depleted of O2, as expected for combustion exhaust. Again, the change from exhaust gas to atmosphere sample is clearly seen.

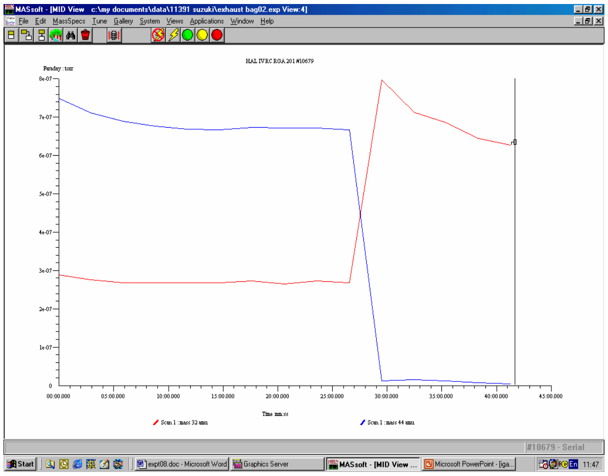

Figure 3: MID mode of Oxygen / Carbon Dioxide peaks.

When the QIC is exposed to atmosphere, the standard conditions are regained. The detection of the other components of interest is more complex. This is because several of the signals overlap. For example at 28 amu, both N_2 and CO are present, at 44 amu CO_2 and N_2O are present. The analysis therefore must take into account secondary peaks to confirm which samples are present. Using the amount of O_2, the other components can be detected and the amounts calculated.

This quantitative information can be obtained by using the software features of MASsoft. Once a run is set up, these values can be calculated automatically.

Conclusions

In conclusion, the combination of the rapid response QIC and the sensitive Channeltron detector allowed good data to be gathered. This gave knowledge about which species and the levels of these species in the sample.

The calculation of ppm is a useful feature of MASsoft and can be set up in a straightforward manner. MASsoft will then process the data automatically and give a real-time level for the selected species.