Pyrolysis-GCGC-TOFMS to characterize carbonaceous chondrites

Conference or Workshop Item

PYROLYSIS-GC×GC-TOFMS TO CHARACTERIZE CARBONACEOUS CHONDRITES. J. S. Watson[1], V. K. Pearson[1], I. Gilmour[1], C. T. Pillinger[1], D. Turner[2], R. Perkins[2], G. H. Morgan[1], [1]Planetary and Space Sciences Research Institute, Open University, Walton Hall, Milton Keynes, MK7 6AA, UK (j.watson@open.ac.uk or g.h.morgan@open.ac.uk), [2]Anatune Ltd, Broadway House, 149-151 St Neots Road, Hardwick, Cambridge, CB3 7Q, UK.

Introduction: The carbonaceous chondrite meteorites contain up to 5 % indigenous extraterrestrial organic material, including many organic species that are important biological precursors. However, due to its high molecular weight nature, the majority of this organic phase can only be analyzed following thermal decomposition in order to elucidate small molecular weight fragments that are amenable to gas chromatography.

Pyrolysis-gas chromatography-mass spectrometry (Py-GC-MS) has been used in the analysis of materials such as carbonaceous chondrites [1,2], however traditional systems can be easily overwhelmed by the complexity of the sample and a great deal of information can be lost by the inability to resolve these unresolved complex mixtures (UCM). Recent advances in instrument design have resulted in a major increase in sensitivity and analytical resolution of pyrolysis-based instruments.

We have used the Pegasus 4D GC×GC-Time of Flight Mass Spectrometry system from Leco to analyze the organic material in five carbonaceous chondrites: Murchison, Orgueil, Renazzo, Cold Bokkeveld and Tagish Lake.

Results: Figure 2 displays the total ion chromatograms (TIC) from Murchison obtained by analyzing 1% of the amount of whole rock sample normally required for traditional Py-GC-MS (Figure 1). When compared to traditional techniques this new method of analyzing extraterrestrial organic material can significantly increase the resolution of the components present and elucidate significantly more compounds than have previously been observed.

Figure 3 shows a partial mass chromatogram (m/z 91) from Murchison demonstrating the ability of the Py-GC×GC-TOFMS system to separate a number of different isomers. Isomers of alkylbenzenes up to C5 were identified, which are rarely identified by traditional techniques. This system therefore significantly improves the structural information obtainable about the organic carbon present in carbonaceous chondrites.

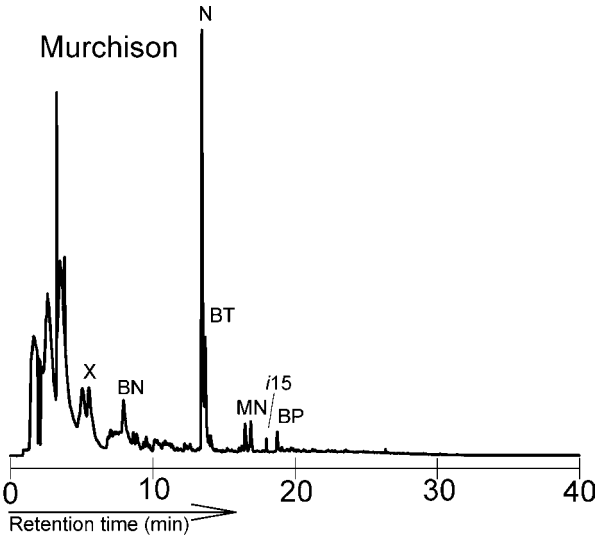

Fig 1: Total ion chromatogram of Murchison carbonaceous chondrite using traditional Py-GC-MS. X = xylenes, BN = benzonitrile, N= naphthalene, BT = benzothiophene, MN = methylnaphthalenes, BP = biphenyl.

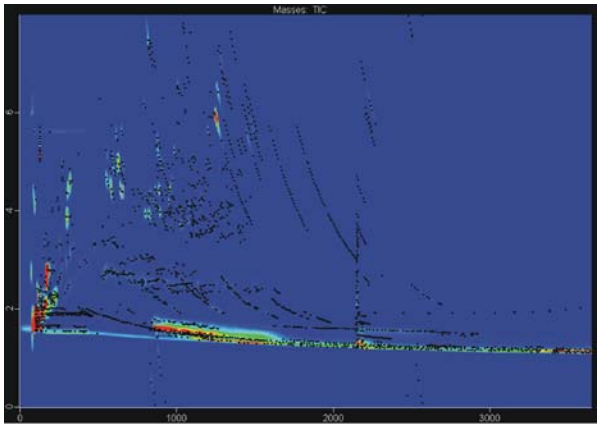

Fig 2: Total ion chromatogram of Murchison carbonaceous chondrite using Py-GC×GC-TOFMS.

Discussion: The main advantages of Py-GC×GC-TOFMS include:

i) The increased sensitivity of the mass spectrometer, over the whole mass range, when compared to the more conventional quadrupole mass spectrometer.

ii) The 2D gas chromatograph is able to separate compounds that co-elute on a standard gas chromatograph system. Separation of analytes by volatility and

polarity enables traditionally unresolved complex mixtures (UCM) to be examined in detail, and vastly increases the number of compounds identified.

iii) Greatly increased signal to noise ratio, due to compounds being separated from the column bleed of the first column on the second GC column and a Spectral Generation Rate of up to 500 spectra/sec.

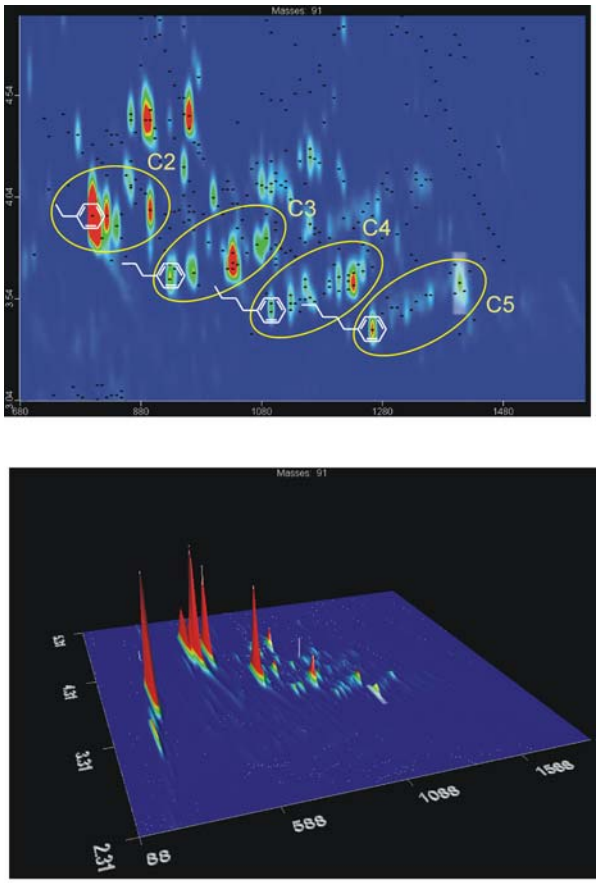

Figure 3: Partially reconstructed mass chromatogram (m/z 91) displaying the alkylbenzenes released upon pyrolysis of the Murchison meteorite displayed in 2D and 3D.

Conclusion: The discussed advantages of the GC×GC-TOFMS system over a standard quadrupole GC-MS system mean that a fraction (approximately two orders of magnitude less) of sample can be used, but also with a massive increase in the information gained from the sample. This increase in resolving power and sensitivity provides us with the opportunity to analyze samples that have in the past been unattainable, such as interplanetary dust particles (IDPs), micrometeorites and the ability to gain information on the organic constituents from sample return missions. Other areas of astrobiology that could benefit from this technique include the detection of biomarkers and metabolites in extremophiles.

References: [1] Gilmour, I. (2004) in *Meteorites, Comets and Planets* (ed. Davies, A. M.), Elsevier, 269-289. [2] Watson J. S., et al. (2004) *International Journal of Astrobiology*, 3, 107-116.