FIRST RESULTS FROM THE STUDY OF EXTRACTED INSOLUBLE ORGANIC MATTER WITH C60-TOF-SIMS. D. Rost, H. Busemann, T. Henkel, A. King, N. Spring, C.M.O’D. Alexander and I. Lyon, 1School of Earth, Atmospheric and Environmental Sciences, The University of Manchester, Williamson Bldg. Oxford Rd., Manchester, M13 9PL, UK, detlef.rost@manchester.ac.uk, 2Department of Terrestrial Magnetism, Carnegie Institution of Washington, 5241 Broad Branch Rd. NW, Washington, DC 20015, USA.

Introduction: Insoluble organic matter (IOM) is the macromolecular component that dominates organic compounds in meteorites, interplanetary dust particles and comets [1-3]. IOM extracted from the original samples has been characterized by a wide range of different analytical techniques, including nuclear magnetic resonance [4], (pyrolysis) gas chromatography mass spectrometry [5], Raman spectrometry [6], and two-step laser mass spectrometry (L²MS) [7]. The latter method can be also used for in situ identification of organic compounds spatially resolved to the ten micrometer scale. However, during L²MS analysis certain molecules, e.g. polycyclic hydrocarbons (PAHs), might be synthesized by the laser pulses itself [8].

Time-of-flight secondary ion mass spectrometry (ToF-SIMS) utilizing cluster ions (Au³⁺, Bi³⁺, C₆₀⁺) offers an alternative approach for organic analysis with spatial resolutions down to one micrometer or less. The impact of cluster primary ions onto a surface results in a very gentle and efficient desorption of large molecules [9,10], which is highly beneficial for the detection of organic compounds. In 2007, we equipped one of our ToF-SIMS instruments [11] with a 40kV C₆₀ primary ion gun from Ionoptika Ltd [12] and a 20kV post-acceleration detector from Kore Technology Ltd. Measurements can be routinely performed with a lateral resolution of ~2µm. Sub-micrometer resolution is possible although at the expense of intensity. Additionally, C₆₀-ToF-SIMS can accurately detect many major and some minor and trace elements at the same time [13].

A range of organic standards was first measured to test the efficiency of detection of organic molecules and characterize the degree of fragmentation of large molecules. We are now commencing a program of systemically studying IOM.

Samples: PAH standards anthracene, phenanthrene, tetracene, pentacene, and pyrene were either deposited on an Al surface by using hexane as a solvent, or pressed in Au. Analyses of the blank Au and Al surfaces were obtained to quantify surface contamination.

Murchison (CM2) and GRO 95577 (CR1) IOM residues were produced by demineralising the bulk meteorites using CsF/HCl [4] and pressed in Au.

Results and discussion: Spectra of anthracene, phenanthrene, tetracene (Figure 1), and pentacene feature the respective molecule as the most prominent peak in the relevant mass range, at least 5 times more intense than any fragment or combination compound. It is worth noting that the isomers phenanthrene and anthracene produce different fragmentation signatures. For pyrene pressed in Au (Figure 1), hydrogenated pyrène (C₁₀H₁₂⁺) is the most intense organic peak >100u. Sample preparation for pyrene on Al proved to be difficult but it seems that here the pyrene ion itself prevails. In general, these measurements demonstrate the capability of C₆₀-ToF-SIMS to detect and identify PAHs.

In our first measurements of IOM residues (Figure 2), pure C clusters and C₆₀H₁₂ comprise the most intense peaks that can be attributed to the samples. However, at this point it cannot be excluded that this is an instrumental artifact. Further measurements and a new mechanical press for sample preparation will hopefully improve the quality of the results.

It is clear, however, that the residues are not purely organic but contain noticeable amounts of Cr as well as some Cs, the latter resulting from the acid treatment.


Acknowledgement: This work was supported by the Science and Technology Facilities Council, through its UKCAN program and through a rolling grant. The University of Manchester is thanked for major SRIF and other funding for equipment. The authors express their gratitude to D. Blagburn, B. Clementson and B. Gale for essential construction and maintenance work.
Figure 1. Spectra of PAHs on Al (tetracene, phenanthrene, and anthracene) and pressed in Au (pyrene).

GRO 95577 IOM pressed in Au, field of view: 50×50µm²

Murchison IOM pressed in Au, field of view: 80×80µm²,

Figure 2. Secondary ion images of IOM pressed in Au.