

Laser Microprobe Characterization of C Species in Interplanetary Dust
Particles (IDP)

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This communication presents preliminary results of a study whose aim is the characterization of C species in microvolumes of materials by means of the Laser Ionization Mass Spectrometry (LIMS).

LIMS, described in detail by Simons [1], employs a pulsed UV laser to produce nearly instantaneous ($\sim 2 \times 10^{-8}$ s) vaporization and ionization of materials, followed by acceleration and time-of-flight analysis of the ions produced. LIMS provides a survey technique, with nearly simultaneous acquisition of mass spectra covering the entire elemental range.

The main limitation of the LIMS technique at present is its limited ability to perform quantitative analysis, due in part to insufficient knowledge of the mechanism of laser-solid interaction. However, considerable effort is now being directed at making LIMS a more quantitative technique. Very interesting results bearing on the two issues of quantitative microanalysis [2] and identification of complex molecular species [3] have already been published.

In this study, we have analyzed a variety of different C samples, both natural and man made, to establish the ability of LIMS to differentiate among the various C phases. The results of preliminary analyses performed on meteoritical and IDP samples are also presented.

The C standards selected for the LIMS characterization range from essentially amorphous soot to diamond, which exhibits the highest degree of ordering.

The figures on page 3 show positive and negative ion spectra obtained from:

1. Soot,
2. Turbostratic carbon, (Lumpkin [4]),
3. Plasma reaction C,
4. A natural diamond from Arkansas,
5. Calcite.

The unknown specimens analyzed include:

6. Chondritic Porous Aggregates (CPA) from U2 collections,
7. Murchison matrix samples.

Positive ion spectra acquired from amorphous C (soot) (Fig.1), under our standard instrumental conditions, are characterized by a C cluster distribution skewed towards low masses, such as C (and CH), C₃ and C₅. The intensity of the higher mass clusters falls off rapidly. Negative ion spectra (Fig. 2) exhibit essentially the same pattern, except that the even number C clusters are favored over the odd-numbered ones, C₂ being the most intense peak.

Turbostratic C spectra are available only in the negative ion mode. These spectra (Fig. 3) exhibit a different pattern of C clusters, essentially centered around C₆.

Plasma-reaction C (Fig. 4) is characterized by peak distributions similar to those of turbostratic C, but with very significant C_xH_y peaks present in the even numbered clusters.

Diamond (Figs. 5 and 6) shows spectra with a dominance of C₁ in positive ion mode and C₂ in the negative ion mode.

Calcite (Fig. 7), presents the most extreme case, with C₁ (mass 12) being essentially the only C species identified in positive ion spectra.

The spectra acquired from U2 particles (Figs. 8 and 9) reveal substantial diversity in the constituent C species. One spectrum exhibits essentially a pure C pattern, centered at C₄, plus intense CN and CNO peaks and weaker Cl signals. Another spectrum reveals the presence of C species (C₂ to perhaps C₇), phosphates (PO₂ and PO₃ anions), Cl and F, and possibly Cl-bearing organic species.

The spectra acquired in the Murchison matrix (Fig. 10) reveal C cluster patterns up to C₁₀, with the most intense signal being that of C₄. In addition, intense peaks interpreted as SiO₂ and SiO₃ are detected, as well as PO₂ and PO₃ signals. Cl is also detected.

The LIMS technique thus shows the ability to acquire simultaneous elemental and molecular information on microvolumes of materials of interest to cosmochemists with essentially no sample preparation required. Limitations and possible improvements will also be discussed.

References

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2. Odom, R. W. and Niemeyer, I. C. (1986) *Proc. SIMS V Conf.*, A. Benninghoven et al., Eds., Springer Verlag, in press.
3. Mattern, D. E. and Hercules, D. M. (1985) *Anal. Chem.*, 57, p. 2041-2046.
4. Lumpkin, G. R. (1981), *Proc. Lunar Planet. Sci. Conf. 12th*, p. 630-632.

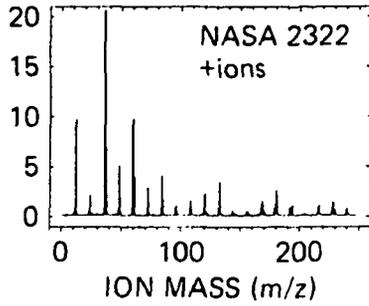


FIGURE 1

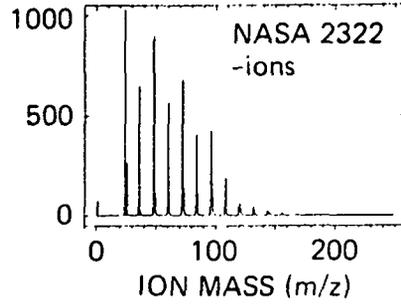


FIGURE 2

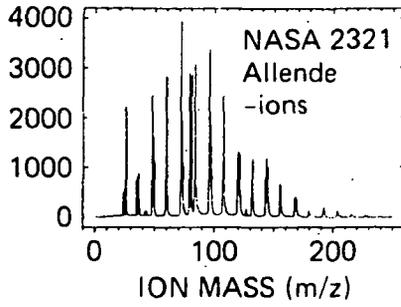


FIGURE 3

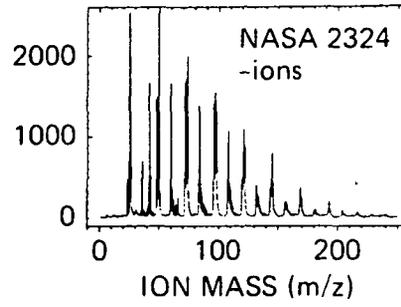


FIGURE 4

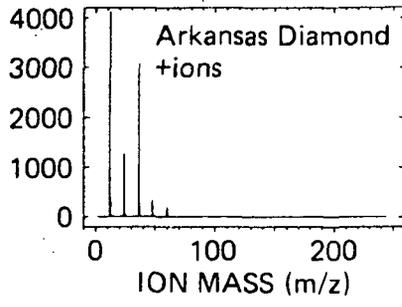


FIGURE 5

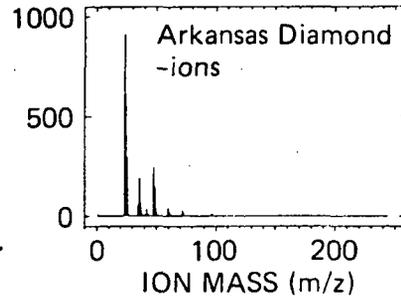


FIGURE 6

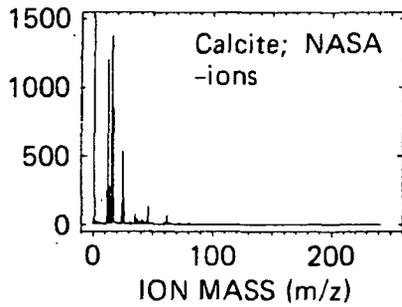


FIGURE 7

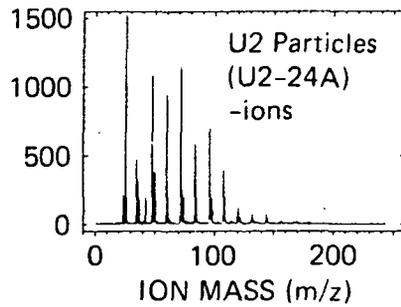


FIGURE 8

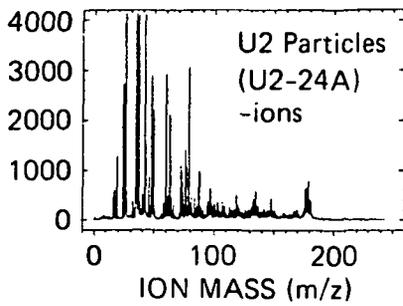


FIGURE 9

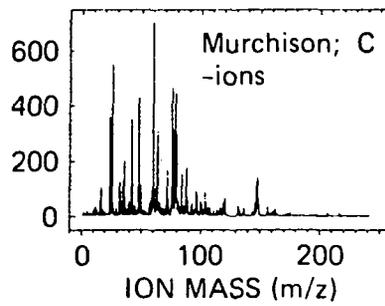


FIGURE 10