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ANALYSIS OF ORGANIC COMPOUNDS IN RETURNED COMET NUCLEUS SAMPLES;

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Comets are widely held to be the most primitive solar system bodies, that is, they are believed to contain solar system matter in, or nearly in, its primordial state. In the limit, comets may contain a low-temperature condensate representative of the precursive dust and gas cloud. However, there are reasons to believe that cometary matter has been processed while in the Oort cloud and during excursions into the inner solar system. Again in the limit, this processing may have converted the original constituents at least partially to chondrite-like material. Various intermediate stages between these extremes can also be envisioned. The organic analyst must be prepared for analytes characteristic of each of these possibilities, i.e., interstellar, chondritic, and transitional organic species.

The interstellar component may have contributions from both the gas phase (1) and grain mantles (2). Analysis of the condensed gas phase components is complicated by the fact that many are unstable radicals or ions, or stable molecules that will rapidly react with each other or their matrix components upon warming. This fact dictates sampling, sample return, and storage at low temperature and analysis in the solid state, e.g., by electron spin resonance and ion-beam techniques.

Chondritic organic matter has been the subject of extensive analyses over the past 20 years (3). CM and CI chondrites have been found to contain most of their carbon as an insoluble macromolecular material with both aromatic and aliphatic components as well as various organic functional groups. The CM and perhaps CI chondrites contain, in addition, a complex mixture of discrete, molecular species, e.g., hydrocarbons, carboxylic acids including amino acids, and nitrogen heterocycles including purines and pyrimidines. Recent stable isotope analyses have shown that these organic molecules (4), along with a fraction of the macromolecular carbon (5), are enriched in deuterium. This finding has been interpreted as indicating a genetic relationship with interstellar molecules (6). Furthermore, several observations are consistent with the formation of chondritic organics from interstellar precursors by hydrothermal processes: (a) abundant organic molecules occur only in chondrites with hydrated silicate matrices; (b) amino acid abundance follows the content of the so-called "poorly characterized phases" (PCP) which is thought to be an early product in the aqueous alteration process (7); (c) amino acid/hydroxy acid ratios suggest their formation by aqueous phase Strecker synthesis (8); (d) facile aqueous phase reactions exist which could account for the conversion of interstellar molecules to many other chondritic organics. Any evidence for the occurrence of aqueous phases in cometary nuclei, e.g., the identification of hydrous silicate minerals, will suggest the occurrence of the more complex, stable organic molecules characteristic of carbonaceous chondrites and dictate that appropriate liquid chromatographic, gas chromatographic, and combined gas chromatographic-mass spectrometric methods be developed.

Appropriate sampling procedures will be essential to the success of these analyses. It will be necessary to return samples that represent all the various regimes found in the nucleus, e.g., a complete core, volatile components (deep interior), and crustal components (surface minerals, rocks, processed organics such as macromolecular carbon and polymers). Furthermore, sampling, storage, return, and distribution of samples must be done under conditions that preclude contamination of the samples by terrestrial matter.

References:

1. Irvine, W.M. and Hjalmarson, A. (1984) Origins of Life 14, 15-23.

2. Greenberg, J.M. (1982) in Comets, Wilkening, L., ed., pp. 131-163, Univ. Ariz. Press.

3. Cronin, J.R., Pizzarello, S. and Cruikshank, D. (1988) in Meteorites and the Early Solar System, Kerridge, J. and Mathews, M., eds., in press, Univ. Ariz. Press.

4. Epstein, S. Krishnamurthy, R.V., Cronin, J.R., Pizzarello, S. and Yuen, G.U. (1987) Nature 326, 477-479.

5. Robert, F. and Epstein, S. (1982) Geochim. Cosmochim. Acta 46, 81-95.

6. Kolodny, Y., Kerridge, J.F. and Kaplan, I.R. (1980) Earth Planet Sci. Lett. 46, 149-158.

7. Cronin, J.R. (1988) Adv. Space Res., in press.

8. Peltzer, E.T., Bada, J.L., Schlesinger, G. and Miller, S.L. (1984) Adv. Space Res. 4 (#12), 69-74.