

LABORATORY STUDIES OF GRAIN MANTLES IN INTER-STELLAR SPACE

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ABSTRACT. At Laboratory Astrophysics we are simulating the most relevant conditions in interstellar space in order to follow the chemical and physical evolution of, among others, interstellar organic grain mantles.

1. Introduction

In the atmospheres of evolved stars, small silicate condensates are formed. When they are injected into the interstellar space, they are cooled down to temperatures of about 10 K. It is on these sub-micron particles that atoms and molecules in the molecular clouds freeze down to form icy mantles (Greenberg and Yench, 1972, Greenberg, 1979). At the same time that these icy condensates form, they are being irradiated by ultraviolet light which comes from stars and is generated by cosmic ray particles. Some of the molecules in the mantles are broken down, free radicals are created and new molecules are formed. The ice mantles evolve thermally by impulsive heating triggered by grain-grain collisions (Greenberg 1979, Greenberg, 1982, Schutte, 1988 and Grim, 1988), by nearby protostellar objects (Lacy *et al*, 1984), by energetic particles (Léger *et al*, 1985), or by local heating in accretion disks (Cohen 1983 and van de Bult *et al*, 1985).

2. Laboratory Studies

In order to study the physical and chemical processes taking place in the interstellar medium in general, and in particular on these interstellar mantles, the most relevant conditions in interstellar space are reproduced at Laboratory Astrophysics (see e.g. Hagen *et al*, 1979 and Greenberg, 1986). We deposit gas mixtures (consisting mainly of H_2O , CO , NH_3 , CH_4 , etc in various ratios) on an aluminum block (representing the silicate core of interstellar grains) cooled down to interstellar temperatures (10 K) and we irradiate them with UV light (simulating the radiation field in interstellar space). These irradiated ice mixtures are warmed-up to room temperature and what is left over on the block (the so-called organic residue) is being analysed by several methods.

3. Results

The more soluble part is being analysed by the group of Prof. J. Ferris at the R.P.I. (Troy, N.Y.) by GCMS (Gas Chromatography - Mass Spectrometry) and HPLC (High Pressure Liquid Chromatography).

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The results of these analyses are reported elsewhere (see e.g. Agarwal *et al*, 1986 and Schutte, 1988). The less soluble part is analysed by pyrolysis chemical ionization mass spectrometry (PYCI- MS) at the FOM-Institute in Amsterdam (see e.g. Westmore and Alauddin, 1986 and Pouwels *et al*, 1989). All the samples consist of compounds of very high molecular weight - many (especially those with initial composition containing CH_4 and C_2H_2) with mass peaks of more than 500 AMU (see figures) well above the background noise level. In order to check whether these big molecules do not come from contamination (e.g. pump oil in the system), we labelled some of the samples and compared their spectra with the ones of unlabelled samples. It was found that the peaks shifted, and thus the peaks are real and do not come from contamination. We also checked whether the peaks were reproducible or not, and we found they were, i.e. two different samples with the same parent gas mixture and irradiation time, gave the same main peaks.

Although not yet completely characterized, we can say that the pyrolysate is a very complex mixture of hydrocarbon chains since a significant number of main peaks are separated by mass number 14 (CH_2 groups) and, following a main peak, decrease in intensity with increasing fragment weight. The complexity of the spectra would arise from there being many different isomers within homologous series from C_5 onto beyond C_{30} . One very interesting thing is that our spectra looks very much like the one found for the aliphatic hydrocarbons of the Murchison Meteorite (Cronin, 1990), since its most prominent fragment ions belong to a C_nH_{2n-1} series ($m/z = 69, 83, 97, 111, \dots$) that declines in intensity with increasing m/z .

In order to better characterize the composition of the laboratory photoproduct organic residues, they are also being analyzed by other methods. Residues examined for us by the group of Dr. Colin Pillinger using stepwise heating and oxidation, for isotopic analysis, indicated an evaporation sequence similar to that of meteoritic organics, i.e., the presence of aromatic kerogens (see Franchi *et al*, 1989). This is yet to be confirmed, although the preliminary mass spectra obtained by Dr. Krueger, similar to the one performed for Comet Halley (see Kissel and Krueger, 1987) also gave such indications.

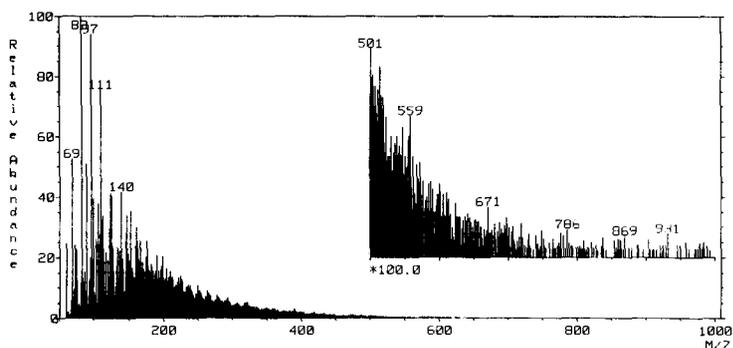


Figure 1. PYCI-mass spectra of irradiated $H_2O: CO: C_2H_2: NH_3 = 5:5:2:2$

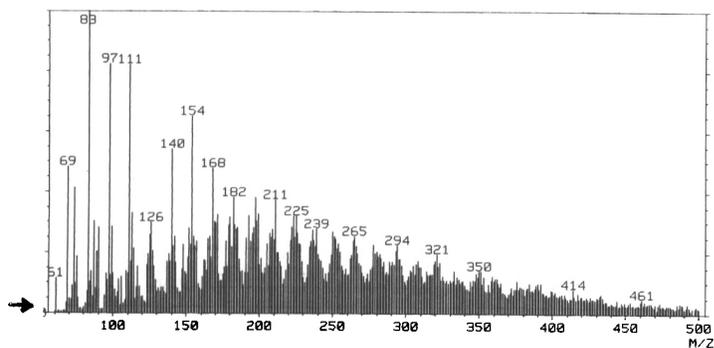


Figure 2. Amplification of the first region of figure 1.
The arrow indicates the background noise level.

4. Conclusions

What has been found up to now on the analysis of our residues would agree well with what has been found for the hydrocarbons of the Murchison Meteorite (Cronin, 1990) and for other meteoritic organics (Franchi *et al*, 1989). The confirmation of this will establish a direct connection between meteorites and interstellar dust via the organics, as well as the connection through mineral compositions. Both carbonates and hydrated silicates may be used to show connections with interstellar dust via aggregates in which the ice of the dust is melted.

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