INTERSTELLAR AND METEORITIC ORGANIC MATTER AT 3.4 μm

P. EHRENFREUND [1,2], F. ROBERT [3], L.d'HENDECOURT[2], F. BEHAR[4]
[1] *Huygens Laboratory Astrophysics, Leiden, The Netherlands*
[2] *Groupe de Physique des Solides, Univ. Paris 7, Paris,France*
[3] *Lab. Geochimie des Isotopes Stables, Paris, France*
[4] *Institute Francais du Petrole, Rueil-Malmaison, France*

ABSTRACT. The 3 micron spectrum of the galactic center source IRS 7 is compared to a spectrum obtained on the deuterium-rich organic polymer extracted from the Orgueil carbonaceous meteorite. The almost perfect match between the two spectra in the 3.4 μm region suggests that the chemical composition of the interstellar organic matter resembles that of the meteoritic macromolecule.

1. Introduction

The IR spectrum of the galactic center source IRS 7 indicates, that aliphatic hydrocarbons are coating the surface of interstellar grains in the line of sight (Butchart, 1986).

There has been considerable discussion on the 3.4 μm interstellar absorption. Several attempts have been made to identify this matter by fitting the IRS 7 spectrum with known carbonaceous polymers (Sagan & Khare, 1979, Ogmen & Duley, 1988, Hoyle et al., 1982, Greenberg, 1982, Sandford et al.,1991). We have analyzed recently a series of organic samples extracted from terrestrial and extra-terrestrial rocks to study the relation between various organic samples at 3.4 μm. Such a comparison was considered important because any type of organic macromolecule would exhibit a signature at this wavelength, that characterizes aliphatic chains branched to aromatic cycles.

2. Results

We have compared the 3.4 micron spectrum of Orgueil to the spectrum of the galactic center source IRS 7 in Fig. 1., obtained by Butchart et al. (1986). This spectrum represents actually the best available fit of IRS 7 and suggests that the chemical composition of the interstellar organic matter and that of the meteoritic polymer are similar.

Because thermal events at the surface of the parent body meteorite or in the solar nebula can yield such an organic structure, the meteoritic polymer was compared to various terrestrial samples (kerogens) of known thermal history. Kerogens can be considered as a mixture of complex macromolecules deriving from organic remains. Similar macromolecules, with a highly aromatic cross linked 3-dimensional network have been described in meteorites by Hayatsu & Anders (1981).

In Fig. 2 we show the signature at 3.4 μm of Type II kerogens with increasing C/H ratio. The C/H ratio acts as a parameter of maturation of the sample. However, the details of the interstellar organic structure cannot be found in the vast majority of natural or synthetic kerogens.

P. D. Singh (ed.), Astrochemistry of Cosmic Phenomena, 423–424.

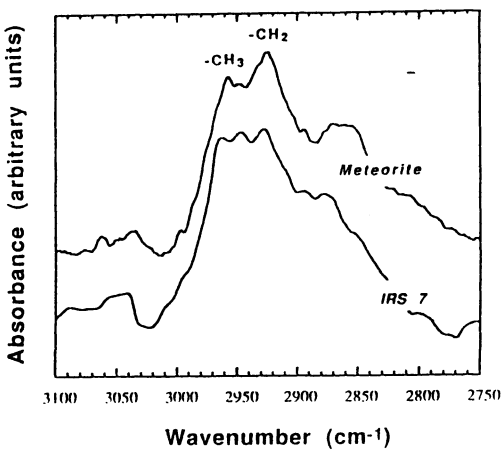

Figure 1. Comparison of the spectrum observed towards IRS 7 (Butchart et al., 1986) with a meteoritic macromolecule of Orgueil in the range 3100-2750 cm^{-1}. Ordinate is given in absorbance units ($\ln I_o/I$).

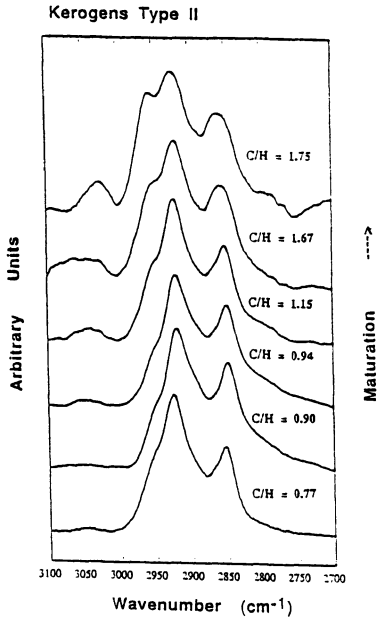

Figure 2. Kerogen Type II (marine) at 3.4 μm as a function of their C/H ratio.

3. Discussion

Several processes may lead to this organic structure and thus severe transformations of the original interstellar organic carbon may have taken place during or after the formation of the solar system. However, a thermal degradation of the meteoritic macro-molecule remains unlikely, since labile organic structures are still bounded with the aromatic cycles. Furthermore the meteoritic sample is enriched in deuterium D/H ($3.5\ 10^{-4}$) and no other possibility than ion-molecule reactions in molecular clouds can account for this enrichment. The present comparison studies of the near infrared feature in organic matter indicate the existence of large molecules in the interstellar medium, at least on grain mantles.

An interesting implication of the match between the 3.4 μm spectra of Orgueil and IRS 7 is the possibility to estimate with some accuracy the fraction of the cosmic carbon locked up in complex interstellar organic molecules. Compared to the carbon density towards IRS 7 ($6.8\ 10^{19}$), one finds that about 12 % of carbon is locked up in aliphatic CH bonds whereas 30 % participates to other carbon bonds.

References

Butchart, I., et al. (1986), *Astron. Astrophys.* **154**, L 5
Greenberg, J.M. (1982), *Comets* , eds. Wilkening L.L., Univ. of Arizona Press, Tucson, 131
Hayatsu, R., Anders E. (1981), *Topics of Current Chemistry* **99**, ed. Springer Verlag, 1
Hoyle, F., Wickramasighe, N.C., Al Mufti, S., Olavesen, A.H. (1982), *Astrophys. Space Sci.* **83**, 405
Ogmen, M., Duley, W.W. (1988), *Astrophys. J. Lett.* **334**, L 117
Sagan, C., Khare, B.N. (1979), *Nature* **277**, 102
Sandford, S.A., et al. (1991), *Astrophys J.* **371**, 607

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