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The Organic Component of Interstellar Grains

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The 3.4 μm absorption feature observed in the spectrum of a number of Galactic Center sources indicates the presence of organic molecules in the interstellar medium. It is ascribed to the C-H stretch vibration of tetrahedrally bonded carbon (carbon which has only single bonds with other carbon atoms). These sources are thought to be principally obscured by the diffuse interstellar medium, as no molecular clouds have been observed in the direction of the G.C.. Fig. 1 shows the I.R. spectrum of the G.C. source IRS 7 (Butchart et al. 1986). Apart from the 3.4 μm feature two other absorptions are present: a broad feature centered at 2.98 μm and a rather shallow feature at 3.28 μm. The last feature can be ascribed to the C-H stretch vibration of trigonally bonded carbon. (carbon that has one double bond with another carbon atom). Laboratory experiments showed that the water band of a dirty ice mixture of composition $H_2O:CO:NH_3:O_2 = 20:14:8:20$ matches the 2.98 μm feature very well (fig. 1). This band possibly originates in intervening molecular clouds along the long line of sight towards the G.C.

From the observed features due to the interstellar organic material we can make an estimate of its composition and abundance. From $W_\lambda(3.28)/W_\lambda(3.4) = 0.11$ for IRS 7 we find a ratio of the number of C-H groups of tetrahedrally to those of trigonally bonded carbon $n(C_{te}\text{-}H)/n(C_{tr}\text{-}H) = 1.5$. The number of tetrahedral C-H bonds per carbon atom is given by:

$$\frac{n(C_{te}\text{-}H)}{n(C)} = \frac{W_\lambda(3.4)/A_\lambda(C_{te}\text{-}H)}{\alpha.\beta\ \tau(10).[C]}$$

where $W_\lambda(3.4)$ equals the equivalent width of the 3.4 μm feature, A_λ is the integrated intensity of the trigonal C-H stretch vibration = 0.45 x 10^{-20} cm^2 μm (Francis 1950, 1951), α is $A(V)/\tau(10)$ = 18.5 (Roche and Aitken 1984), β is $N(H)/A(V)$ = 1.9 x 10^{21} cm^{-2} mag^{-1} and [C], the cosmic abundance of carbon = 3.7 x 10^{-4}. τ (10), the depth of the silicate absorption towards the G.C. was taken equal to 3.6 (Becklin et al. 1978). We find $n(C_{te}\text{-}H)/n(C) = 0.26$. Taking into account the relative abundances of the different organic groups it follows that the organic material contains about 35 % of the cosmically available carbon.

The broadness of the 3.4 μm feature indicates a solid implying that the organic material indeed is a component of the grains. Gaseous species would exhibit a number of sharply peaked absorptions.

Duley and Williams (1986) proposed on the basis of observations of the depletion of argon and carbon in diffuse clouds (Duley 1985) that direct accretion of elemental carbon forming a hydrocarbon mantle around preexisting silicate cores is the production source of the organic material. However, the ratio of elemental hydrogen to elemental carbon in normal diffuse clouds is about equal to $n(H)/n(C) = 10^3$ (see e.g. Morton 1974), and therefore surface reactions between carbon and hydrogen would transform all accreting carbon into CH_4 (d'Hendecourt 1985), which would be desorbed in diffuse clouds circumstances (Draine and Salpeter 1979). Alternatively, it has been shown that photoprocessing of dirty ice mantles accreting on grains in molecular clouds form organic refractory grain mantles in sufficient abundance to explain the amount observed (Schutte and Greenberg 1986).

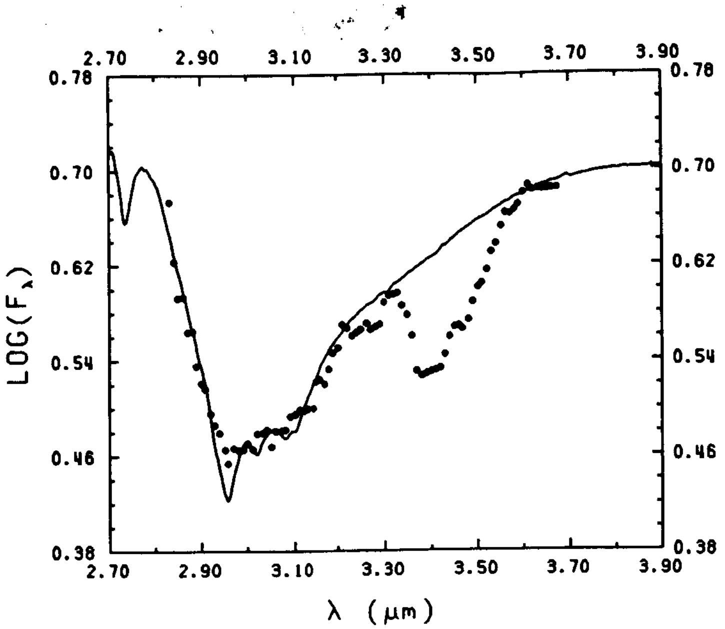

Fig 1. The I.R. spectrum of the G.C source IRS 7 compared with the H_2O absorption at 2.98 μm of an ice mixture of composition $H_2O:CO:NH_3:O_2$ = 20:14:8:20

In the diffuse medium, this organic mantle could be transformed into a hydrocarbon type material trough further photoprocessing by the interstellar radiation field eliminating the oxygen from the material and simultaneous hydrogenization by the interstellar atomic hydrogen.

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