Plasma generation and processing of interstellar carbonaceous dust analogs

V. J. Herrero[1], I. Tanarro[1], B. Maté[1], R. J. Peláez[1], G. Molpeceres[1], V. Timón[1], R. Escribano[1], and M. Jiménez-Redondo[2]

[1] *Instituto de Estructura de la Materia (IEM-CSIC), Serrano 121-123, 28006, Madrid, Spain*
[2]*Centro de Física da Universidade do Minho, Universidade do Minho, 4710-057, Braga, Portugal*

Different samples of plasma deposited amorphous hydrogenated carbon (HAC or a-C:H) are used as analogs of carbonaceous dust in the diffuse interstellar (IS) medium. Comparison of measured and theoretically calculated spectra suggests that IS dust grains are likely made of small aromatic islands linked by aliphatic chains. Irradiation of the HAC deposits with 5 keV electrons shows that the effects of cosmic rays on the aliphatic dust component, characterized by an absorption band at 3.4 μm, are small and cannot explain the disappearance of this band in dense interstellar clouds.

1. Introduction

IR absorption spectra indicate that carbonaceous dust in the diffuse IS medium is largely made of some sort of amorphous hydrogenated carbon (HAC). Two alternative models for the structure of this dust can be found in the literature. One of them favors small aromatic islands linked by aliphatic chains [1], whereas the other one proposes large polyaromatic structures with small aliphatic substituents at the edges [2].

The most prominent spectroscopic feature of the aliphatic component of IS carbonaceous dust (the 3.4 μm absorption band) disappears inside dense molecular clouds. In this environment, shielded from the UV galactic field, cosmic rays (CR) could provide a destruction mechanism, but again discrepant CR destruction efficiencies are found in the literature [3, 4].

In this work, we use IS carbonaceous dust analogs produced in cold hydrocarbon plasmas in combination with theoretical calculations and irradiation with high energy electrons to help clarify these questions.

2. Experimental

Dust grains and thin films of HAC were generated by plasma deposition in RF discharges. Mixtures of hydrocarbons and He were used as plasma precursors. The deposition conditions were selected to obtain HAC films with a variable proportion of aliphatic and aromatic structures.

Optical spectroscopy, mass spectrometry and Langmuir probes were used for plasma diagnosis. HAC deposits were analyzed mainly with IR spectroscopy, but other techniques (SEM, AFM, ...) were also used.

The effects of cosmic rays on the carriers of the 3.4 μm feature were investigated by irradiating the HAC samples with 5 keV electrons.

3. Theoretical calculations

Models of HAC solids of variable density, based on the mentioned competing structures [1,2], were constructed using Montecarlo/Molecular Mechanics and their electronic energies and IR spectra were computed at Density Functional Theory (DFT) level.

4. Results and conclusion

The comparison of measured and calculated IR spectra [5] suggests that the structure of carbonaceous dust in the diffuse IS medium is intermediate between those of the two literature models [1,2] but closer to that with small aromatic units [1].

The estimated effects of cosmic rays are found to be small and are not enough to explain the disappearance of the 3.4 μm band inside dense clouds [6].

At present, we intend to relate the gas-phase characteristics of the plasma with the properties of the carbonaceous solids produced in the discharges. We expect thus to shed light on gas phase polymerization mechanisms that might be of relevance for the interstellar medium.

5. References

[1] E. Dartois et al. A&A **432** (2005) 895
[2] M. Steglich et al. ApJSS **208** (2013) 26
[3] V. E. Mennella et al. ApJ. **587** (2003) 727
[2] M. Godard et al., A&A, **529** (2011) A146
[5] G. Molpeceres et al. PCCP **19** (2017) 1352
[6] B. Maté et al. ApJ **831** (2016) 51