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Carbonaceous Interstellar Dust Analog Candidate: Formation By Reactive Plasma Polymerization

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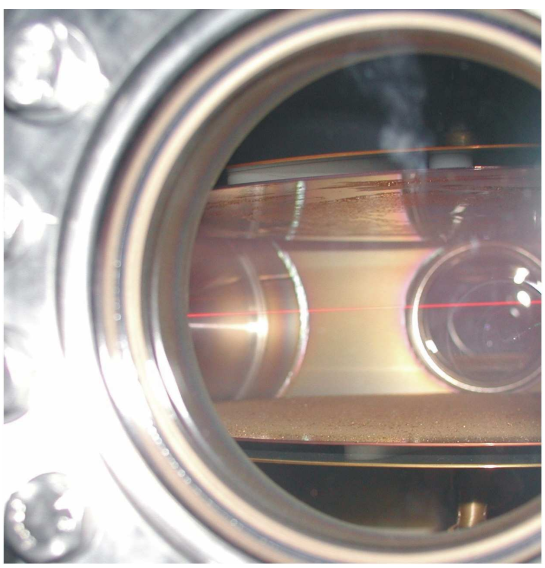
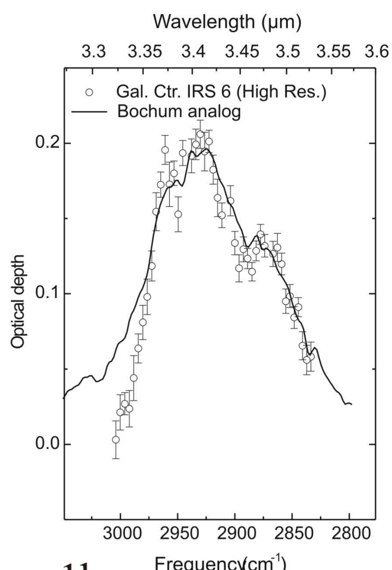
Carbonaceous compounds are a significant component of interstellar dust and the composition and structure of such materials is therefore of key importance (see for review Pendleton 2004). We present a plasma polymerized carbonaceous material produced in RF discharge under low pressure, using C_2H_2 as a precursor component. The infrared spectra (1.5 μm-15 μm) of the resulting spheroidal carbonaceous nanoparticles reveal a strong aliphatic band (3.4 μm feature), weak OH and carbonyl bands, and traces of aromatic compounds, all characteristics identified with dust in the diffuse interstellar medium of our galaxy (data in Kovačević et al. 2005, analog review in Pendleton & Allamandola 2002). Particles produced this way have an H/C ratio from 0.5 to 1 (depending on discharge conditions) and do not show luminescence in the blue part of visible spectra (Furton et al. 1999).


1a



1b

Figure 1. a) Particles trapped in a gaseous argon matrix (red line- He-Ne laser beam scattered on the cluster); b) IR spectral comparisons: lab data (line), observational data (points)

The plasma polymerization process described here has similarities to stellar outflow conditions (Kovačević et. al. 2003, Chiar et. al. 1998) and provides a convenient way to make carbonaceous interstellar dust analogs under controlled conditions and to compare their characteristics to astronomical observations. Low temperature plasmas with low ionized buffer gases, such as argon or helium (Figure 1a), and controllable power input provide an excellent trap for the nanoparticles (through matrix isolation), enabling investigations of the UV extinction feature at 217.5 nm and scattering measurements as well as further manipulation of the particles, e.g. with atomic hydrogen source. The chemistry of polymerization (presence and behaviour of neutrals/ions) can be followed in-situ by means of mass spectroscopy, optical spectroscopy, and IR spectroscopy (from near to far infrared region).

Here, we focus on a comparison to the MIR spectra of interstellar dust. The infrared spectrum of carbonaceous dust in the diffuse interstellar medium is characterized by a strong 3.4 μm C-H stretching band and weak 6.8 and 7.2 μm C-H bending bands, with little evidence for the presence of oxygen in the form of carbonyl (C=O) or hydroxide (OH) groups. The plasma polymerization products produced under oxygen-poor conditions provide a good comparison to the peak position and profiles of the observed diffuse dust IR spectrum (Figure 1b).

Also, we find that the addition of nitrogen to the plasma results in strong bands at 6.15 μm (C=N band) and at 3 μm (NH band), with a weaker band at 4.62 μm (OCN- band). We note that, with the addition of nitrogen, the 3.4 μm hydrocarbon band diminishes greatly in strength as the NH band grows. This may have implications for the puzzling absence of the 3.4 μm hydrocarbon bands in the IR spectra of dust in dense molecular clouds, given that the presence of nitrogen-related bands have been established in dense cloud dust.

Keywords. Infrared: spectra ISM: dust, extinction astrochemistry dust, ISM: lines and bands lines: identification methods: laboratory plasma

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