Low-temperature condensation of polyaromatic carbon grains from PAHs

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Carbon is ubiquitous in space and plays a key role in the evolution of the ISM and the formation of stars and planets. Yet the journey of carbon from large organic molecules to dust grains (or vice versa) still raises many open questions. ISO and Spitzer observations of infrared emission features between 3 to 20 μm (collectively known as aromatic infrared bands, AIBs [1]) towards diverse targets (HII regions, reflection nebulae, post-AGB stars) have informed laboratory research with astronomical constraints. Although the structure of the carriers is still not precisely determined, they are generally characterized as aromatic, leading to two competing hypotheses: PAHs (polycyclic aromatic hydrocarbon) [2-4] or condensed aromatic-aliphatic nanograins [5-8]. Our goal is to reproduce analogs to interstellar dust and to shed light on the origin and molecular structure of these carriers.

Generally, laboratory analogs are condensed with different techniques (combustion, plasma, ablation) leading to samples spanning a wide variety of structure and aromatic/aliphatic ratios. Here we present the results of a study using the COsmic SImulation Chamber (COSmIC) experimental facility at NASA Ames [9]. The COSmIC setup includes as Pulsed Discharge Nozzle (PDN) used in grain condensation. The PDN is fed by a supersonic jet of Argon seeded with organic molecules of increasing size (i.e., increasing ring number), that include benzene, naphthalene, anthracene and pyrene. High voltage pulses generate a plasma discharge in the stream of the jet-cooled supersonic expansion (50-150 K). Grains are condensed within the cold plasma and are collected *in-situ* onto substrates placed a few centimeters away from the electrodes. The grains are extracted from the COSmIC chamber and characterized *ex-situ* via infrared microscopy and mass spectrometry. Infrared absorption spectra in the 3 - 16 μm range exhibit stretching and bending modes associated to CC bonds within the rings and CH groups attached to the rings and are also accompanied by aliphatic group vibrations, broad bands and plateaus, suggesting the presence of a mixed aromatic-aliphatic backbone. The solid grain samples are further characterized via the laser desorption mass spectrometry technique [10] in collaboration with the de Vries group at UCSB. In this technique, laser desorption volatilizes low vapor pressure molecules from a surface into the gas phase without fragmentation or thermal degradation. Jet cooled molecules are excited and photo-ionized and the ions are detected in a time-of-flight mass spectrometer. Mass spectra reveal the rich molecular complexity within the grains and show the presence of molecules larger in mass than the seed for all PAH precursors.

These results allow us to propose a new picture of stable molecular pathways in PAH-grain condensation. The correlative study of both infrared and mass spectra will further help benchmark laboratory to astronomical spectra. We discuss how this study provides new links between the molecular PAHs and the condensed phase of cosmic carbon.

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