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From Organic Molecules to Carbon Particles: Implications for the Formation of Interstellar Dust

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Abstract.
The study of the formation and destruction processes of cosmic dust is essential to understand and to quantify the budget of extraterrestrial organic molecules. Interstellar dust presents a continuous size distribution from large molecules, radicals and ions to nanometer-sized particles to micron-sized grains. The lower end of the dust size distribution is thought to be responsible for the ubiquitous spectral features that are seen in emission in the IR (UIBs) and in absorption in the visible (DIBs). The higher end of the dust-size distribution is thought to be responsible for the continuum emission plateau that is seen in the IR and for the strong absorption seen in the interstellar UV extinction curve. All these spectral signatures are characteristic of cosmic organic materials that are ubiquitous and present in various forms from gas-phase molecules to solid-state grains. Although dust with all its components plays an important role in the evolution of interstellar chemistry and in the formation of organic molecules, little is known on the formation and destruction processes of dust. Recent space observations in the UV (HST) and in the IR (ISO) help place size constraints on the molecular component of carbonaceous IS dust and indicate that small (i.e., subnanometer) PAHs cannot contribute significantly to the IS features in the UV and in the IR. Studies of large molecular and nano-sized IS dust analogs formed from PAH precursors have been performed under conditions that simulate diffuse ISM environments (the particles are cold -100 K vibrational energy, isolated in the gas phase and exposed to a high-energy discharge environment in a cold plasma). The species (molecules, molecular fragments, ions, nanoparticles, etc) formed in the pulsed discharge nozzle (PDN) plasma source are detected in situ with a high-sensitivity cavity ringdown spectrometer (CRDS) and spectroscopically analyzed (see parallel contribution of Tan et al.). The higher end of the size distribution of the particles formed in the discharge is collected (soot) and further analyzed and characterized with microprobe laser desorption/ionization mass spectrometry (μL^2MS). The flow dynamics and the plasma generated in the PDN have also been simulated for a quantitative understanding of the mechanisms involved in these dust simulation experiments. We will present new experimental results that indicate that nanoparticles are generated in the plasma that when combined with the modeling of the extinction in the simulation chamber allow us to derive information on the nature, the size and the structure of interstellar dust particles, as well as the growth process of interstellar dust.

Keywords. Astrochemistry, carbon, dust, PAH, ISM: molecules

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