Formation of cosmic carbon dust analogues in plasma reactors

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SUMMARY: Cosmic carbon dust analogs are produced, processed and analyzed in the laboratory using NASA's COSmIC Facility. These experiments can be used to derive information on the most efficient molecular precursors in the chemical pathways that eventually lead to the formation of carbonaceous grains in the stellar envelopes of carbon stars.

The study of the formation and destruction processes of cosmic dust is essential to understand and to quantify the budget of extraterrestrial organic molecules. 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 carbonaceous dust. We report the progress that was recently achieved in this domain using the NASA Ames' COSmIC facility.

Polycyclic Aromatic Hydrocarbons (PAHs) are important chemical building blocks of interstellar dust. They are detected in interplanetary dust particles and in meteoritic samples. Additionally, observational, laboratory, and theoretical studies have shown that PAHs, in their neutral and ionized forms, are an important, ubiquitous component of the interstellar medium [1]. The formation of PAHs, nanoparticles and micrograins from smaller molecules has not been extensively studied. Therefore, we've performed laboratory experiments to study the dynamic processes of carbon grain formation, starting from the smallest hydrocarbon molecules into the formation of larger PAH and further into nanograins.

Studies of interstellar dust analogs formed from a variety of PAH and hydrocarbon precursors as well as species that include the atoms O, N, and S, have recently been performed in our laboratory using the COSmIC facility to provide conditions that simulate interstellar and circumstellar environments [2]. The species formed in the COSmiC chamber through a pulsed discharge nozzle (PDN) plasma source are detected and characterized with a high-sensitivity cavity ringdown spectrometer (CRDS) coupled to a Reflectron time-of-flight mass spectrometer (ReTOF-MS), thus providing both spectroscopic and ion mass information in-situ [3]. Analysis of soot material was also conducted using scanning electron microscopy (SEM) at the NASA Ames' MACS facility. Studies of Ar-based gas mixtures containing hydrocarbon precursors show the feasibility to form PAHs from specific precursor molecules, while gas mixtures containing carbon ring systems (benzene and derivatives, PAHs) precursors provide information on pathways toward larger carbonaceous molecules. The SEM analysis of the deposition of soot from methane and acetylene seeded argon plasmas provide examples on the types of nanoparticles and micrograins that are produced in these gas mixtures under the COSmIC experimental conditions. From these measurements, we can derive information on the size and the structure of interstellar dust grain particles, the growth and the destruction processes of interstellar dust and the resulting budget of extraterrestrial organic molecules.

References

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