Laboratory Formation and Properties of Carbonaceous Particles for Astrophysical and Cometary Comparisons

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Spacecraft and ground instruments have observed infrared absorption features in interstellar and circumstellar phenomena for many years. The sources of a number of these features has been attributed to grains of various organic compositions. Thus far, no one molecule or class of compounds has provided a definitive fit to the observational spectra. Interstellar grains were incorporated into the solar nebula and may have survived to now in comets. Particles in the coma of Comet Halley were analyzed by the Giotto spacecraft to be composed of carbon, hydrogen, oxygen, and nitrogen and have been labeled as the "CHON" particles. A recently developed laboratory technique can generate small carbonaceous particles from gas mixtures of varying organic compositions either in the presence or the absence of water. FTIR spectra of these particles can provide comparison with observational spectra.

Small carbonaceous particles are formed in the laboratory by photolysis of a gas mixture of parts per million of small organic molecules in a carrier gas at atmospheric pressure. The photolysis source is an excimer laser at 193 nm. Since the flow area of the gas is larger than that of the laser beam, a mixture of irradiated and unirradiated gases are producing the particles. A visible laser (He-Ne at 633 nm) is used to monitor the particles by scattering. Nitrogen, Argon, or Helium are the carrier gases in slowly flowing gas streams. Initially, the laser beam penetrates 10 - 40 cm of the 150 cm long flow tube where the gas is flowing counter to the laser beam propagation direction; therefore, a particle formation front is established. The particles are collected on ZnS substrates, and their IR spectra from 2.5-14 microns is measured with an FTIR instrument.

The most extensive set of experiments has consisted of photolyzing a gas mixture of several parts per million of small aromatic molecules (benzene, toluene, ethylbenzene, xylenes) and water with each of the carrier gases. Small spectral differences were noted depending upon the carrier gas. Low temperature heating (40°C) of the samples produced some spectral changes. Aromatic gas mixtures without water were photolyzed to be more representative of interstellar and circumstellar conditions. Gas mixtures containing either alkynes or alkenes were photolyzed to determine the effect of the type of carbon bond upon the particle generation process. Aromatic molecules have what is loosely called a "bond and a half" C-C bond. The alkynes, of which acetylene is a member, have a triple bond structure, which is a strong molecular bond. A mixture of C_2 - C_4 alkynes were photolyzed. The alkene or olefin family of organic molecules have a weaker double C=C bond. A mixture of C_2 - C_6 organics were photolyzed. In previous experiments the alkanes which contain a single C-C bond or simple alcohols did not produce particles.

Acknowledgments:
This research is being supported by the Laboratory Astrophysics Program of NASA Headquarters.