Organic Chemistry and Nanoparticles in Astrophysics

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Solar nebulae contain gas and dust under a wide range of conditions. A range of these conditions can lead to the formation of solids through cluster formation and nucleation. Complex molecules such as polyacetylenes and benzene were observed recently in extrasolar nebulae. [1]

Our work addresses three types of processes relevant to astrophysics and astrochemistry: 1) Gas phase ion chemistry, including condensation, polymerization and dissociative reactions under nebula conditions; 2) Nucleation leading to metal and oxide nanoparticles models of solid grains under nebula conditions; and 3) Adsorption of organics and catalytic reactions on these nanoparticle surfaces.

In ion chemistry, we study reactions that can form or destroy aromatics and heterocyclics such as the compounds preserved in carbonaceous chondrites. We recently identified a special type of intra-cluster reactions that may be important in the solar nebula. In (propene)n (benzene)m clusters, we found that the benzene core ion can induce a concerted reaction of charge transfer and polymerization of the alkene components, driven by exothermic covalent bond formation. [2]

Sub-micron and micron-size metal, metal oxide, and silicate nanoparticles form in the nebula and may be responsible for its opacity, and also catalyze reactions leading to condensation and polymerization. We will present results on the synthesis of nanoparticles containing Fe, Fe/Mg, Fe/Ni, Al, Si, and the respective oxides similar to interstellar grains, using the recently developed Laser Vaporization/Controlled Condensation (LVCC) technique. [3, 4].

Parts of the nebula are subject to strong electric and magnetic fields, which can affect the morphology, aggregation, and chemistry of nanoparticles. We have recently discovered that several metallic and intermetallic nanoparticles form filament-like and tree-like aggregates under electric fields that polarize the charges on the nanoparticles surface, resulting in enhancing the sticking of particles. Magnetic properties can also enhance coagulation, and control the movement of grains in magnetic fields [4].

References:

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