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LABORATORY AND OBSERVATIONAL STUDY OF THE INTERRELATION OF THE CARBONACEOUS COMPONENT OF INTERSTELLAR DUST AND SOLAR SYSTEM MATERIALS

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Interstellar dust and gas is the primordial material of the Solar System. Since the Sun and planets formed only some 4.6 billion years ago in a universe thought to be perhaps 15 billion years old, most of the biogenic elements may have already been tied up in complex organic molecules by the time they became incorporated into the planets, asteroids, satellites, and comets. Most interstellar material is concentrated in large molecular clouds where simple molecules are formed by gas phase and dust grain surface reactions. Gaseous species (except H_2) striking the cold (10 K) dust will stick, forming an icy grain mantle. This accretion, coupled with energetic particle bombardment and UV photolysis will produce a complex chemical mixture containing volatile, non-volatile, and isotopically fractionated species. These primordial ices and complex organics may well be preserved without major modification in comets, carbonaceous meteorites, and interplanetary dust particles. By studying the chemical and isotopic composition of interstellar ice and dust, one gains insight into the composition and chemical evolution of the solid bodies in the solar nebula and the nature of the material subsequently brought into the inner part of the solar system by comets and meteorites.

It is now possible to spectroscopically probe the composition of interstellar ice and dust in the mid-infrared, the spectral range which is most diagnostic of fundamental molecular vibrations. We can compare these spectra of various astronomical objects (including the diffuse and dense interstellar medium, comets, and the icy outer planets and their satellites) with the spectra of analogs we produce in the laboratory under conditions which mimic those in these different objects. In this way one can determine the composition and abundances of the major constituents of the various ices and place general constraints on the types of organics coating the grains in the diffuse interstellar medium. In particular we have shown the ices in dense clouds contain H_2O, CH_3OH, CO, perhaps some NH_3 and H_2CO, as well as nitriles and ketones or esters. Furthermore, by studying the photochemistry of these ice analogs in the laboratory, one gains insight into the chemistry which takes place in interstellar/pre-cometary ices. Chemical and spectroscopic studies of photolyzed analogs (including deuterated species) are now underway. The results of some of these studies will be presented and implications for the evolution of the biogenic elements in interstellar dust and comets will be discussed.