Modification of the physico-chemical properties of interstellar organic analogues by UV-irradiation.

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In the interstellar medium (ISM), photochemical reactions in ice lead to the formation of relatively complex organic molecules [1]. These molecules are among the potential building blocks of our solar system and could be the precursors of a part of the organic matter found in comets and meteorites. However, it is not clear how the organic ice formed in the ISM may have evolved through temperature increase and irradiations by UV-photons and cosmic rays until their incorporation into the Solar System objects.

The experimental apparatus PICACHU developed at Hokkaido University was used to produce molecular cloud organic analogues and study their evolution through UV-irradiation. Typical ISM gases (H_2O, CH_3OH, NH_3, or CH_4,) are deposited onto the faces of a refrigerated substrate (~12 K) and simultaneously irradiated by UV under high vacuum. The organic residues that remain after the sublimation of volatiles are thus analogues of the organic matter formed in the dense and cold molecular clouds. In this study, we are characterizing these residues before and after UV photoprocessing at room temperature in order to simulate their alteration in diffuse clouds or protoplanetary disks, in which, the UV photon flux and temperature are higher than those in the dense molecular cloud [2].

By irradiating the residues with UV doses corresponding to short residence durations in diffuse cloud ($\leq 10^4$ yrs), significant changes occurred in the morphological and physical properties of the organic residues [3]. They became highly porous and more rigid, and contain amorphous nanoparticles similar to organic nanoglobules found in chondrites, IDPs and cometary samples. UV-photoprocessing of molecular cloud organics derived from D-rich ices seems thus to be a possible pathway to form D-rich amorphous nanoparticles.

According to the empirical formula of [4], the viscoelastic properties of the UV-irradiated organic residues would favor the merging of grains coated by organics after collision in protoplanetary disks. However, the organic coating might also reduce the growth efficiency of aggregates because the viscoelastic nature of organic coating could strengthen the grain-grain connections and make the dust aggregates brittle.

UV-irradiation in the diffuse clouds or in the outermost part of the protoplanetary disks thus has a strong influence on the evolution of the precursor organic compounds of protoplanetary disks.

References

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