Formation of Chiral Organic Molecules in Simulated Dense Cloud Environments

G.M. Muñoz Caro(1), U.J. Meierhenrich(2), W.A. Schutte(1),
B. Barbier(2), A. Arcones Segovia(1), H. Rosenbauer(3),
W.H.-P. Thiemann(4), A. Brack(2), J.M. Greenberg(1)

(1) Sackler Laboratory for Astrophysics, Leiden Observatory, The Netherlands
(2) Centre de Biophysique Moléculaire, Orléans, France
(3) Max-Planck-Institut für Aeronomie, Katlenburg-Lindau, Germany
(4)Bremen University, Dept. Phys. Chemistry, Bremen, Germany

Interstellar dust particles in dense clouds, the star formation regions, accrete ice mantles. As derived from infrared (IR) observations, this ice layer consists mainly of water ice, but also carbon and nitrogen containing molecules. This ice can undergo considerable processing by stellar UV photons and cosmic rays. UV irradiation is responsible for the dissociation of the ice molecules, creating reactive species which recombine to form new molecules. We simulated the ice photochemical processing using a vacuum apparatus at pressure P = 10^{-7}mbar, and temperature T = 12 K. During the deposition, a gas mixture freezes onto an Al-substrate, while being irradiated with a hydrogen flow discharge lamp (5 x 10^{+14} photons cm^{-2} s^{-1}), Eph = 7.3-10.5 eV). After warming the system to room temperature a small amount of material remained. This residue was analysed by gas chromatography-mass spectrometry (GC-MS). We were able to identify 16 chiral organic molecules of possible pre-biological significance in the residue.

Pyrroles and furanes were also found. The products were confirmed by ^{13}C-labelling of the ice. Comets form by the coagulation of dust particles. The here reported molecules could therefore be present in these objects. Given the large record of cometary collisions with the early Earth, it is likely that a fraction of these organic species were delivered to the earth's surface, providing our young planet with a soup of prebiotic molecules that could have triggered the origin of the first life forms.