Processing of astrophysical ices by UV and ion radiation: origin and radio-resistance of organic matter

This project has 2 goals. On one hand, the first one is to study how we can produce complex organic molecules if we irradiate a mixture of simple molecules at low temperature (around 10K). This goal is clearly oriented on astrophysics. Indeed ices are ubiquitous in space. We can find ices on comets, on Jovian moons like Europa and on the grains of dense cloud in the interstellar medium. These ices are mainly composed of simple molecules like H_2O, CO, CO_2, NH_3, CH_4 etc. In outer space, theses mixtures are constantly exposed to a complex radiation field (UV photons, cosmic and solar wind ions). Following the radiolysis of mother molecules synthesis of complex organic molecules occurs [1,2]. At the CIMAP laboratory, we simulate the energetic processes leading to synthesis of organic matter in icy space environments: samples are irradiated at low temperatures (10-150K) by ion beams from GANIL, or UV radiation from a UV lamp. The induced modifications are followed by infrared spectroscopy which allows us to know which molecules are produced during the irradiation process. As an example, for a H_2O-CO_2-NH_3 mixture, we have shown that, after annealing of the sample, the residue contains vibrational bands associated to glycine, the simplest amino acid [2]. It is pertinent to compare if UV and ion irradiation lead to synthesis of the same (or different?) organic molecules [1,2].
On the other hand, since complex organic molecules have been observed in space, we need to study their radio resistance in order to know if they are sufficiently resistant to survive in a cold environment under irradiation [2-4]. If so, they may be at the origin of life on earth or elsewhere. This is the second goal of the project. We have already started this program with nucleobases [2-4] and pyridine [2]. We have shown that nucleobases are sufficiently resistant to survive in dense clouds under cosmic ray irradiation. We plan now to include UV photons and, eventually, synergy effects in the studies, and also to increase the complexity of the molecules. These studies are also pertinent for radiobiology (exposure to ionizing radiation, cancer treatment).

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Ion radiation in icy space environments:
Synthesis and Radioresistance of Complex Organic Molecules
Low Temperature Physics/Fizika Nizkikh Temperatur 45 No. 6 (2019) 692–700 (Topical review)
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