THE RADIOLYSIS OF SOLID STATE GLYCERALDEHYDE IN THE CONTEXT OF CHEMICAL EVOLUTION

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Abstract: We investigated the radiolysis of racemic glyceraldehyde in the solid state, and adsorbed in a clay mineral. The irradiation was carried out in a Co-60 gamma source (Gammabeam 650PT), with doses up to 123 kGy, at different temperatures. For the analysis, we used different spectroscopic, chromatographic analytical methods. The results show that this compound is very labile under irradiation and form sugar-like compounds.

I. INTRODUCTION

An important step toward the origin of life on Earth is the transition from inorganic molecules to the compounds that are part of the living cell. An approach to answering this question has been to simulate the possible processes that may take place on the primitive Earth leading to the formation of complex molecules, and finally a living cell. These physical and chemical processes are called chemical evolution.

A simulation of the possible relevant environments to the primitive Earth may require the participation of a multi-faceted system, as a mineral surface and the aqueous solution of the biologically-related organic compound under the influence of an energy source. Glyceraldehyde is considered the simplest triose. It is readily formed in prebiotic experiments simulating extraterrestrial ices [1] or in primitive terrestrial conditions [2]. Glyceraldehyde is important in this type of studies because it may form more complex sugars of biological importance. To this end, we investigate the radiolysis at different temperatures of racemic glyceraldehyde in the solid state, simulating extraterrestrial conditions and absorbed in clay mineral to study the stability of this compound in both environments.

1.A. Experimental procedures

(D, L) Glyceraldehyde was purchased from the Sigma Chemical Company, USA, of the highest purity available. Aqueous solution 1 x10-2 M, oxygen-free of glyceraldehyde was prepared, and the samples were adsorbed in a clay mineral according to Ramos and Negron. [3]. The clay used (Na-montmorillonite) was obtained from Clay Minerals Repository of the Clay Minerals Society at the University of Missouri.
Samples in sealed vials containing the solid or the clay-glyceraldehyde system were irradiated at room temperature (298 K), dry ice (198 K) and liquid nitrogen temperature (77 K) in a ^{60}Co source (Gammabeam 650PT), at a dose rate of 257 Gy/minute with doses up to 123 kGy. The dose rate was measured by using a Fricke dosimeter.

The effect of □-irradiation on solid state (D, L) Glyceraldehyde has been investigated by using different spectroscopic, chromatographic analytical methods: electron paramagnetic resonance (EPR); UV spectroscopy, high-performance liquid chromatography (HPLC) and liquid chromatography-mass spectrometry. The irradiated samples were analyzed immediately after irradiation. A molecular simulation carried out by Gaussian09 was made to follow how the free radicals affect the Gibbs free energy and other thermodynamic parameters.

II. CONCLUSIONS

According to the results obtained, the degree of glyceraldehyde alteration was noticeable even for the lowest radiation dose used. The UV spectra change upon the irradiation procedure. Many compounds are formed as result of the irradiation, although in low yields. The preliminary results presented in this work remark the role of ionizing radiation as a source of driving force in prebiotic processes. In the early Earth, ionizing radiation might have been important for the reactions in the period of chemical evolution in which simple molecules led to more complex ones. Hence, regardless the nature of this energy, it is capable of inducing complex chemical changes in organic compounds such in this case in the (D, L)-glyceraldehyde.

ACKNOWLEDGMENTS

This work was supported by C001-CONACYT-ANR-188689 Grant and PAPIIT grant No. IN226817. J.C was supported by a CONACyT fellowship and the Posgrado en Ciencias Químicas. Thank Q.1Claudia Camargo, M. Sc. Benjamin Leal, and Phys. Francisco Flores for their technical assistance.

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