On the Radiolysis of Ethylene Ices by Energetic Electrons and Implications

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The investigation of the chemical evolution of the largest satellite of Saturn Titan offers a unique opportunity to understand the origin and chemical evolution of the Solar System especially of proto-Earth. In Titan's atmosphere, nitrogen (N_2, 98.4%) and methane (CH_4) are the dominating constituents with hydrocarbons such as acetylene (C_2H_2), ethylene (C_2H_4), diacetylene (C_4H_2), etc., several cyanides (HCN, HCCCN, C_2N_2), carbon dioxide (CO_2), carbon monoxide (CO), and water (H_2O) being present in trace amounts. The gaseous molecules might also agglomerate to aerosol particles and sequester to Titan's surface. In a pioneering study, Sagan and Thomas outlined that energetic cosmic ray particles can penetrate deep into the lower atmospheric layers. These energetic particles could incorporate part of their kinetic energy into chemical reaction and thus process simple organics in Titan's lower atmosphere. In a more recent study, Molina-Cubero et al. derived an energy deposition on Titan's surface of 4.5×10^{9} eVcm^{-2}s^{-1}. However, the radiation processing of these simple organics by energetic electrons is not well understood. To shed light on this matter and to gain a comprehensive picture on the hydrocarbon chemistry, we present data on the interaction of ionizing radiation, in form of energetic electrons, with solid ices of acetylene, ethylene, and ethane (C2-ices) at temperatures between 10 and 70 K. We will also investigate to what extent the radiation processing can lead to the formation of polymer-like macromolecules, which could present building blocks of Titan's organic aerosol layers, via heterogeneous chemistry.

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L. Zhou, S. Marry, M. Abplanalp, A.Turner, R.I. Kaiser, On the radiolysis of Ethylene ices by energetic electrons and Implications to the Extraterrestrial Hydrocarbon Chemistry. ApJ 790, 38, 1-10 (2014).