Research paper

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Proton Impact Charge Transfer on Hydantoin - Prebiotic Implications.

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Abstract. Formation and destruction of prebiotic compounds in astrophysical environments is a major issue in reactions concerning the origin of life. Detection of hydantoin in laboratory irradiation of interstellar ice analogues has confirmed evidence of this prebiotic compound and its stability to UV radiation or collisions may be crucial. Considering the different astrophysical environments, we have investigated theoretically proton-induced collisions with hydantoin in a wide energy range, from eV in the interstellar medium, up to keV for processes involving solar wind or supernovae shock-waves protons. Results are compared to previous investigations and qualitative trends on damage under spatial radiation are suggested.

Keywords. Hydantoin. Prebiotic compounds. Charge transfer processes. Ion-biomolecule collisions. Ab-initio molecular calculations.

1. Introduction

The possibility of extra-terrestrial organic compounds deposited on the primitive earth has been widely discussed as a possible origin of prebiotic molecules at the origin of life. This exogen apparition of life was first suggested by the discovery of aminoacids in the Murchison meteorite [1] which, apart from the formation of these species, raises fundamental questions about their transport and their survival in space under intense UV radiations or ion bombardment [2,3]. More generally UV irradiation appears to be a key factor in a number of reactions in the interstellar medium, on ice grains or comets. Recently, the formation of 2-aminooxazole, pointed out as a possible intermediate in the synthesis of RNA nucleotides under prebiotic conditions [4,5], has been widely investigated theoretically through photochemical processes in the gas phase [6,7], as well as in water clusters [8]. In laboratory, the importance of the photochemistry of 'dirty' ices has been also observed in the experiments of de Marcellus *et al.* [9] showing the formation of molecules of prebiotic interest by UV irradiation of interstellar ice analogues. In particular, small amounts of hydantoin (2,4-imidazolidinedione) could be evidenced. Such species detected in primitive carbonaceous meteorites may be formed also from urea/water ices [10]. As a purin-related heterocycle, it is assumed to be determinant in the formation of polypeptides [11] and has been evidenced for a long time to be an intermediate in the chemistry of HCN [12] shown to be crucial in the reaction schemes at the origin of life [13].

Apart from the photochemical formation reactions, spatial radiation may induce also destruction of organic compounds. Radiation damage to prebiotic species could be thought to be caused by high-energy photon irradiation [14], but it can also be driven by ion bombardment, in particular collisions with protons which are by far the most abundant ions in space. Such