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Abstract

Ionization: A Key Chemical Pathway in Ices Under Radiation Environment?

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Water-rich ices are ubiquitous throughout our solar system and interstellar medium. On Earth and Mars polar regions are covered with water-rich ices as well. In the absence of impurities, chemistry of ice is determined by the well-known radical reactions, radicals being generated through photon, electron or ion bombardment and sputtering [Johnson, 1990]. Our recent findings have shown that ionization of impurities, in the present case polycyclic aromatic hydrocarbons (PAHs), is the most prominent process in ices under radiation. Among many unique radiation-processing mechanisms listed below, lowering the ionization energy of impurities in ices by up to 2 eV has important consequences for both Earth's and Martian polar ice chemistry.

- PAHs embedded in cryogenic ice are easily and efficiently ionized (>80%, i.e., near quantitative ion yields) to the cation form by VUV photons.
- PAH ionization energy is lowered by up to 2 eV compared to the gas-phase, in agreement with recent theoretical predictions.
- Some of the PAH cations are stabilized in these ices to temperatures as high as 120 K.
- Even multiple ionization of aromatic molecules to generate closed-shell PAH dications occurs in water-ice, generating and stabilizing PAH²⁺.

On Earth more anthropogenic PAHs drift to the polar regions [Grannas *et al.*, 2007], facilitating PAH – ice chemistry. Due to lowering ionization energy of organic impurities in ices by up to 2 eV, solar radiation reaching the ice surface should be enough to ionize some of the large PAH molecules with gas-phase ionization energy below 6 eV. Similarly, much shorter wavelength radiation (<250 nm) penetrates Martian ice surface, enabling majority of PAH-type organics to be ionized in ices on Mars. Ionization changes dramatically the reactivity of ionized molecules compared to the neutral ones. Electrons that are generated in the ices facilitate further chemical processing of the organics.

References

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