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Ionization chemistry in the H2O-dominant atmospheres of the icy moons

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The main pathways of the ionization chemistry for pure H2O- and mixed H2O+O2+CO2+NH3+CH4 atmospheres which are representative for neutral and ionized atmospheres of the icy bodies in the Jovian and Saturnian systems are discussed. The gaseous envelopes of the icy moons of the giant planets are formed usually due to the surface radiolysis by the solar UV radiation and energetic magnetospheric plasma (Johnson, 1990).

The standard astrochemical UMIST2005 (UDFA05) network is used to infer the main chemical pathways of ionization chemistry in the pure or with admixtures of other volatile molecules water vapor atmospheres. In case of the H2O- dominant atmosphere the parent H2O molecules are easily dissociated and ionized by the solar UV-radiation and the energetic magnetospheric electrons. These impact processes result in the formation of the secondary neutral and ionized products - chemically active radicals O and OH, and H+, H2+, O+, OH+, and H2O+ ions. Secondary ions have admixture abundances in the H2O-dominant atmospheres, because they are efficiently transformed to H3O+ hydroxonium ions in the fast ion-molecular reactions. The major H3O+ hydroxonium ion does not chemically interact with other neutrals, and is destroyed in the dissociative recombination with thermal electrons mainly reproducing the chemically simple H, H2, O, and OH species.

In case of the mixed H2O+O2-dominant atmosphere corresponding to the near-surface atmospheres of icy moons (Shematovich et al., 2005), the ionization chemistry results in the formation of the second major ion O2+ - because ion of molecular oxygen has the lower ionization potential comparing with other parent species -H2, H2O, CO2.

The H+, O+, OH+, and H2O+ ions can be easily converted to O2+ ions through the ion-molecular reactions. In case of significant admixture of molecular hydrogen it is possible to transfer the O2+ ions to the O2H+ ions through the fast reaction with H2 and further to the H3O+ ions through the ion-molecular reaction with H2O. Therefore, the minor O2H+ ion is an important indicator of what is going on in the mixed O2-H2O atmosphere, i.e., at what partition between O2 and H2O in the atmosphere the ionization chemistry results in the major O2+ or H3O+ ion (Johnson et al., 2006 ; Luhmann et al., 2006). The ionization chemistry strongly depends on the sources of parent atmospheric species and, therefore, provides information on the chemical composition of the satellite's icy surface.

The inferred networks are used to describe the ionization chemistry in the rarefied atmospheres of the icy satellites in the inner Saturnian magnetosphere.

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