EGU23-7540, updated on 26 Mar 2024
https://doi.org/10.5194/egusphere-egu23-7540
EGU General Assembly 2023

Electron-induced radiolysis of water ice and the buildup of O_2

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Irradiation by energetic ions, electrons, and UV photons induces sputtering and chemical processes (radiolysis) on the surfaces of icy moons and comets. Radiolysis of water ice has important implications for the chemistry and evolution of these celestial bodies. In this work, we carried out a series of laboratory experiments to investigate the products of radiolysis and the retention of O_2 in porous water ice samples when irradiated with high-energy electrons.

To conduct our experiments, we irradiated two types of water ice samples with high energy electrons (0.5 keV to 5 keV) and measured the resulting chemical species using time of flight mass spectrometry. The experiments were performed under conditions replicating the icy moons' surface conditions (K and $^{-7}$ mbar). Our results showed production of H_2 and O_2 radicals, but other predicted radiolysis species, such as H_2O_2 and O_3, were not detected so far; their abundances remain below 0.005 by number compared to the release of O_2. This is in contrast to previous studies, which have reported the production of OH and H_2O_2 through the radiolysis of water ice.

We also studied the retention of oxygen in the ice. By computing the timescales of rise for the O_2 signal upon irradiation, we observed that it rises faster for non-pristine (follow-up) ice irradiations. This suggests that O_2 (or an O_2 precursor) produced during the first irradiation can be retained in the ice.

For some irradiations, the electron energy and current were chosen higher to provoke the water ice's sublimation. The water release showed different properties depending on the porosity and grain size of the irradiated ice.

Overall, our results contribute to our understanding of the radiolysis of water ice and its role in the chemistry and evolution of ice-covered bodies in the solar system. Further studies will be needed to fully understand the factors that influence the production and retention of different chemical species during the radiolysis of water ice.