S^+ Implantation into Condensed CO_2: Relevance for Europa

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The implantation of reactive sulphur ions from the Jovian magnetosphere into the icy surface of Europa has been invoked as a possible source for the SO_2 observed on the water-dominated surface.[1] However, previous laboratory studies have shown that implantation of such ions into H_2O ices does not yield SO_2, instead forming H_2SO_4 hydrates. Moreover, implantations into CO_2 ices (a minor constituent of the Europan surface) have provided conflicting results. The possibility of an exogenic sulphur source for the SO_2 at the surface of Europa thus remains an open question.

We have therefore performed the implantation of 290 keV S^+ ions into CO_2 ice at 20 and 70 K to assess whether such a mechanism may account for the presence of SO_2 at the surface of Europa. This work was performed using the Ice Chamber for Astrophysics-Astrochemistry (ICA) located at the Institute for Nuclear Research (Atomki) in Debrecen, Hungary which is directly connected to a 2 MV Tandetron particle accelerator.[2] Physical and chemical changes occurring in the ice associated with the implantation process were monitored *in situ* using Fourier transform mid-infrared transmission absorption spectroscopy.

Our results show that the implantation of S^+ ions into CO_2 ice at 20 K does indeed yield SO_2 as a product, with a reasonable formation rate of 0.58 ± 0.02 molecules per ion. However, at 70 K (a temperature more relevant to Europa), no such SO_2 ice could be detected. We have attributed this to the higher recombination rate of oxygen atoms to form O_2 which, at 70 K, then efficiently sublimates from the ice phase thus reducing the oxygen content of the ice.[3] This is evidenced by the significantly reduced quantity of O_3 produced upon progressing from 20 to 70 K. Our results therefore suggest that the primary sulphur source for SO_2 on the surface of Europa is not exogenic, and that other surface processes (including geochemical ones) should instead be considered.

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