Ion irradiation of N$_2$O astrophysical ice analogs: Creating Cosmic Chemistry Inside Laboratory

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Abstract

The recent results of NASA’s New Horizons Probe showed that, understanding the N-O ice phase chemistry is fundamental for future breakthroughs regarding the limits of our solar system and the surface chemistry of the frozen trans-Neptunian objects such as Pluto. The aim of this work is to investigate the effects of cosmic ray impact on a N$_2$O astrophysical ice analog and to identify the new compounds produced.

Introdução

Cosmic rays are one of the main ionizing agents in the interstellar medium (ISM). They can penetrate inside cold dense clouds inducing chemical processing in the ice mantles deposited on the grains of spatial dust. The chemical reactions induced by the cosmic rays on the surface of these astrophysical ices can lead to complex molecules such as amino acids and cyanopolyynes$^1$. Among the wide range of cosmic rays, the less abundant heavy ions (Z>6) may play the dominant role on the chemical processing of these ices. The aim of this study is to simulate the impact of a typical heavy ion constituent of the cosmic rays on a nitrous oxide (N$_2$O) astrophysical ice analog. N$_2$O was chosen as a model molecule for this study, because it could be used as a tracer to indirectly estimate the abundances of N$_2$ in the surfaces of Triton (Neptune’s largest moon) and Pluto. Moreover, astronomical data obtained by NASA’s New Horizons Mission suggests that these molecule freeze on the spatial dust grains, being one of the main precursors of a complex nitrogen organic chemistry in the surface of the astrophysical ices$^2$. An 1.5 MeV N$^+$ ionic beam generated in the PUC’s Van de Graaff ion accelerator was employed to simulate the cosmic ray impact within the N$_2$O ice.

Resultados e Discussão

The new compounds formed after N$_2$O ice irradiation with the N$^+$ beam are shown in Table 1. They were characterized by Fourier Transform Infrared Spectrometry (FTIR) as shown in Figure 1.

Conclusões

By monitoring the radiolysis of a N$_2$O ice with FTIR we were able to identify all the compounds produced by the reactions induced by a cosmic ray analog in the ice and derive the rate constants of formation and destruction for all those species. These data will be helpful for future space missions.

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