Ion irradiation of N_2O 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_2O 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_2O) astrophysical ice analog. N_2O 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_2O ice.

Resultados e Discussão

The new compounds formed after N_2O 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.

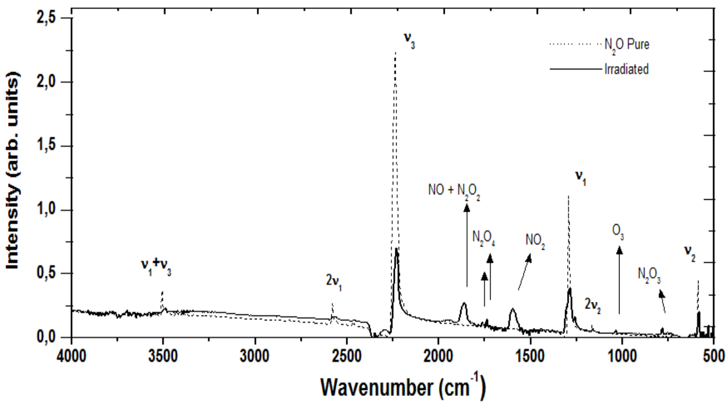

Figure 1. Evolution of the radiolysis of a 10K N_2O ice by the N^+ ion beam.

Table 1. Vibrational modes of the new compounds produced during N_2O irradiation with N^+ beam.

Wavenumber (cm^{-1})	Mode	Molecule
1873	***NO Monomer Stretch***	**NO**
1861	***NO Dimer Stretch***	**N_2O_2**
1765	***B_{2u} NO Sretch (Crystal)***	**N_2O_4**
1738	***B_{2u} NO Stretch/Antisymetric NO Stretch***	**N_2O_2/N_2O_5**
1613	***Antisymetric stretch***	**NO_2**
1038	**Antisymetric stretch**	**O_3**
1593	**NO_2 Antisymetric stretch**	**N_2O_3**

Conclusões

By monitoring the radiolysis of a N_2O 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 derivate the rate constants of formation and destruction for all those species. These data will be helpful for future space missions.

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