CLUSTER ION EMISSION FROM C_2H_2 AND C_2H_6 ICES INDUCED BY ^{252}CF FISSION FRAGMENTS

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Surfaces covered with astrophysical ices are the predominant materials of many solar system bodies, such as comets and trans-Neptunian objects. They are constantly subjected to ion bombardment by solar wind ions and cosmic rays, which induces: i) chemical reactions in the ice and ii) sputtering, supplying the exosphere with neutral and ionic radicals or clusters. Energetic processing of these materials at low temperature have been investigated through laboratory studies, aiming to analyze the processes of astrophysical ion desorption and new molecular species synthesis [1][2]. C_2H_2 and C_2H_6 were observed in molecular clouds, comae of comets, the hydrocarbon-rich atmosphere of planets and their moons (like Jupiter and Saturn), and on the surfaces of Titan, Triton and Pluto [1][3].

In the current work, pure C_2H_2 and C_2H_6 ices at 10 K were irradiated by energetic (MeV/u) multicharged heavy ions (e.g., ^{105}Rh and ^{140}Ba). The positive and negative secondary ions were analyzed by the ^{252}Cf – PDMS – TOF technique (Time-of-Flight Plasma Desorption Mass Spectrometry). This system is also connected to a Van de Graaff accelerator, that can be used for the same purpose (e.g., expose the astrophysical ices to ionizing radiation in the MeV range), but for the aim of this work, only the fission fragments from a ^{252}Californium ionization source was used.

A large number of ionic species were identified during the bombardment, indicating strong molecular synthesis. They are classified into several ion series: C_nH_{2n+2}, C_nH_{2n}, C_nH_{2n-2}, C_nH_{2n-4}, C_nH_{2n-6}, C_nH_{2n-8} and C_nH_{2n-10}. As illustrated in Fig 1, their yield distributions are described by the sum of two decreasing exponentials, one fast (*-F*) and another slow (*-S*) decaying, suggesting a two-regime formation, see Eq. (1) below:

$$Y = Y_0^F e^{(-k_F m/z)} + Y_0^S e^{(-k_S m/z)} \tag{1}$$

where *m/z* is the mass-to-charge ratio, k_F and k_S are the exponential decay constants representing the two-regime formation. Zigzag yields are due to their chemical molecular structures. The new ionic species and their relative yields are provided, contributing to the understanding of the processes by which, in space, neutral and ionized molecular species are delivered to the gas phase.

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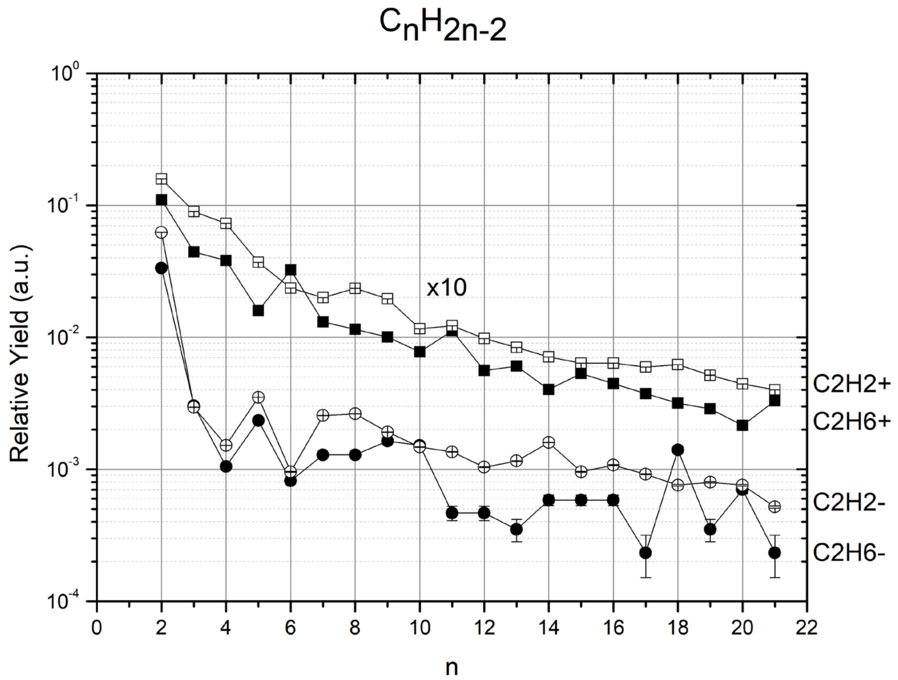

FIG. 1. Positive and negative ion yields of molecular species with C_nH2_{n-2} stoichiometry, emitted from C_2H_2 and C_2H_6 ices bombarded by MeV projectiles. Data were obtained by Time-of-Flight Mass Spectrometry.

REFERENCES

[1] PEREIRA, R.C., DE BARROS, A.L.F., DA COSTA, C.A.P., OLIVEIRA, P.R.B., FULVIO, D., DA SILVEIRA, E.F., Ion irradiation of acetylene ice in the ISM and the outer Solar system: laboratory simulations, MNRAS 495 (2020) 40–57.

[2] OLIVEIRA, P.R.B., R., FULVIO, D., DA SILVEIRA, E.F., Energetic ion irradiation of N2O ices relevant for Solar system surfaces, MNRAS 502 (2021) 1423–1432.

[3] ABPLANALP, M.J., KAISER, R., Complex hydrocarbon chemistry in interstellar and solar system ices revealed: A combined infrared spectroscopy and reflectron time-of-flight mass spectrometry analysis of ethane (C_2H_6) and D6-ethane (C_2H_6) ices exposed to ionizing radiation, ApJ 827 (2016) 132.