Fragmentation and desorption from condensed alcohols due to soft X-rays and electron interactions: Relevance to solid state astrochemistry

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Introduction

Methanol (CH_3OH), the simplest organic alcohol, is an important precursor of more complex prebiotic species and is found abundantly in icy mantles on interstellar and protostellar dust. This molecule has been detected through infrared spectroscopy in some low- and high-mass protostars such as W33A and RAFGL 7009, and also in comets, as Hale-Bopp and other Solar system bodies, such as the Centaur 5145 Pholus grains. Another important molecule is the ethanol, which was detected in region associated with stellar formation, such as Sg B2, Sg A, G34.3+0.2, G34.3+0.15, and also in comets such as the Hale-Bopp (C/1995 O1). All of these astronomical environments are subjected to some kind of ionizing agents, such as cosmic rays, electrons and photons (e.g. stellar radiation field).
The aim of this paper was to experimentally study the ionization, dissociation and ion desorption processes induced by photons and electrons on alcohols, CH_3OH and CH_3CH_2OH, as part of a systematic experimental study of condensed (ice phase) prebiotic molecules[1].

Results and Discussion

We have employed soft X-ray photons at the oxygen 1s-edge and variable energy electrons to simulate the effects of stellar radiation field on the astrophysics ices. These results were also compared with effects produced by charged particles from cosmic rays. Ion photodesorption experiments on the icy surface were carried out at the Brazilian Synchrotron Light Source (LNLS), using the Spherical Grating Monochromator (SGM) beam line, operated in the single-bunch mode of the storage ring, with a period of 311 ns and bunch width of 60 ps. The electron stimulated desorption (ESD) technique was performed at the Laboratório de Química de Superfícies do IQ-UFRJ on ice methanol and ethanol. Several fragments have been identified and their desorption rates per impact were determined, providing data to astrochemistry models. The results show that fragments released due to 290 eV photons and 70 eV electrons interacting with methanol are mainly caused by C-H bond rupture, since the COH_n^+ group ($1 \le n \le 4$) yields are higher at these energies. On contrary, 537 eV photons (O 1s-edge) on icy methanol tend to provide fragments due to C-O and O-H bonds rupture, since CH_2^+, O^+, H^+ and H_3^+ are the most intense fragments. Moreover, the negative spectra at 537 eV energy photons present only intense O^- and H^- ions. At 537 eV photon energy, the positive yield for CH_3OH^+ vanishes, suggesting higher degree of dissociation promoted by energetic photons at the O 1s-edge. Ethanol shows similar behavior and its desorption ion yield curves will be discussed in terms of the direct (Auger) and indirect processes. Condensed methanol and ethanol ESD data and desorption yields will be also presented and discussed.

Conclusions

Several ionic fragments have been identified and their desorption rate per impact were determined, providing data to astrochemistry models. This study helped to understand how some precursor species are formed qualitatively and quantitatively by determining their photodesorption ion yields, pointing out to the important role of ionic species in the evolution of molecular abundance and complexity of several astrophysics environments.

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[1]Andrade D. P. P., Rocco M. L. and Boechat-Roberty H. M., *Monthly Notices Royal Astronomical. Society*, Volume 409, Issue 3, pp. 1289-1296, (2010).