Processing of Cometary surface by swift ions (Poster Flash Talk)

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1. Introduction

In the last years, a great variety of experimental work have been performed to analyze the chemical transformations of astrophysical ices exposed to cosmic ray analogs and other agents (Moore et al 2003, Palumbo et al. 2006, Pilling et al. 2010, Pilling et al. 2011). These experiments have helped the comprehension of observational data from space telescopes (for example ISO and Spitzer) and spacecrafts like ROSETTA, that provided detailed data about the composition of 67P/Churyumov-Gerasimenko comet (Carpaccioni et al. 2015).

In this work we conducted an experimental study on the effects of medium-mass highly charged and energetic ions with astrophysical ice analogs with composition H_2O,CO_2,CH_4 (10:1:1) and H_2O,CO_2,CH_4:NH_3 (10:1:1:1). The experiment were conducted in physicochemical condition similar to the ones found in comets and other cold surfaces of solar system such as Enceladus and other solar system objects. We investigate the stability and chemical changes of the ices, determine the effective dissociation (destruction) cross section of parent species molecules and the effective formation cross sections of formed species (e.g. CO, CO_3, H_3COH) in the sample from the radiolysis.

2. Methodology

We used the facilities at the heavy ion accelerator GANIL (Grand Accelerateur National d'Ions Lourds) in Caen, France. The analysis of data sets were performed in-situ by employing Fourier transform infrared spectroscopy (FTIR) in a transmission mode. The frozen sample at 72 K was bombarded by 15.7 MeV O^{+5} ions up to the fluence of 3.10^{14} ion cm^{-2} simulating the incoming cosmic rays and/or solar energetic particles in the interplanetary ices. Figure 1 shows a schematic picture of the apparatus.

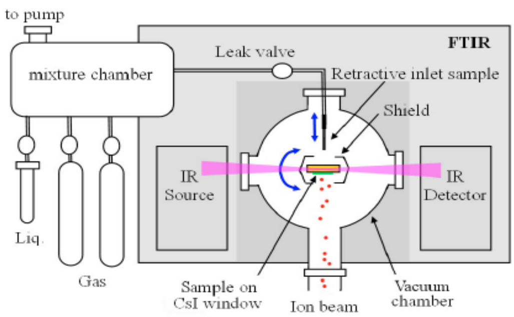

Figure 1: Schematic diagram of the experimental set-up.

3. Results

We measure the area of IR bands of parents and daughter species varying with the fluence. With this measurement we could calculate the effective cross section for destruction/formation of species and consequently other physicochemical parameter, as half-live and EBR. Figure 2 shows the graph of the difference areas of some selected bands of parent and daughter species for H_2O,CO_2,CH_4 (10:1:1) ice , that is related to the effective destruction/formation cross section by:

$$A - A_0 = A_{\infty}(1 - \exp(-\sigma_{d,f}F)) \quad [\,cm^{-1}\,], \qquad (1)$$

where F is the fluence (in ions cm^{-2}), A, A_0 , and A_∞ are the areas of the infrared band area at a given fluence (A), for the unirradiated sample (A_0), and at the highest fluence (A_∞). In this equation, $\sigma_{d,f}$ represents the effective formation cross section (σ_f) of new formed species or the effective destruction cross section (σ_d) of parent species, in cm^2 (see also Pilling & Bergantini, 2015).

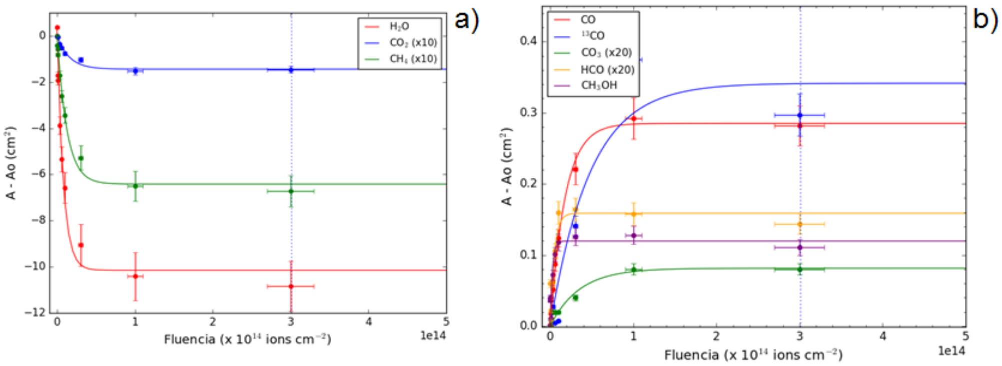

Figure 2: a) Difference area of parent specie bands for H_2O,CO_2,CH_4 (10:1:1) ice; b) Difference area for daughter species bands

Another parameter of interest is the EBR (Equilibrium branching ration). The EBR is the relative abundance of detected new molecules after the system reach chemical equilibrium. Using the column density of daughter species at infinite fluence we calculate the EBR for daughter species, given by:

, (2)

where n_i is the column density of each identified species after the icy sample reaches chemistry equilibrium (higher fluences). The calculated EBR for the detected and assigned species are show in are 75% for CO, 23,1% for CH_3OH, 1% for HCO and 0,12% for CO_3. The CO was the main product of the radiolysis.

4. Summary and perspectives

We studied the chemical transformation of astrophysical ices with composition H_2O,CO_2,CH_4 (10:1:1) and H_2O,CO_2,CH_4:NH_3 (10:1:1:1) under cosmic ray analogs bombardment. We calculated physicochemical parameters of astrochemical interest and studied the composition of such ices in equilibrium. Currently, we are studying the chemical transformation of ices with similar composition when exposed to low energy ions (solar wind and low energy magnetospheric particles). This will give us a more complete scenario of the interaction of cosmic rays with astrophysical ices and chemical changes that are going on in ice bodies of interplanetary medium.

5. Acknowledgement

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6. References

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Short Summary

We conducted an experimental study on the effects of medium-mass highly charged and energetic ions with astrophysical ice analogs with composition H2O,CO2,CH4 (10:1:1) and H2O,CO2,CH4:NH3 (10:1:1:1). The frozen sample at 72 K was bombarded by 15.7 MeV O+5 ions to simulate the effect of cosmic ray bombardment in astrophysical ices in the solar system.