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Ion bombardment of cometary ices analogues: production of organic samples for the EXPOSE-R2 mission on the International Space Station

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Abstract

We describe the preparation and characterization (by UV-Vis-IR spectroscopy) of a set of organic samples, stable at room temperature and above, that are part of the experiment "Photochemistry on the Space Station (PSS)" planned to be enclosed in the EXPOSE-R2 mission, which will be conducted on the EXPOSE-R facility, outside the International Space Station (ISS).

1. Introduction

The used facility is the ESA (European Space Agency) EXPOSE-R, placed outside the ISS on the Universal Platform D (URM-D platform) of the Russian module Zvezda and useful to perform long term exposures. The EXPOSE-R2 mission (2014) uses the core facility of previous missions (EXPOSE, EXPOSE-R [1] and references therein). It will accommodate several chemical and biological Russian and European experiments. The exposure of the organic materials here discussed is part of the PSS experiment that has an astrobiological relevance being aimed at evaluating the evolution of organic molecules and at measuring to what extent some chemical, biological or biochemical samples are resistant to long term exposure to the space environment.

2. Experimental apparatus

The organic materials are prepared in the Catania laboratory after 200 keV He^+ irradiation of icy mixtures, namely N_2:CH_4:CO deposited at 16 K on MgF_2 windows furnished by European Space Agency (see Fig. 1). The deposited mixtures have three different thicknesses (about 1.2, 0.8, and 0.4 μm) and have been subjected to an irradiation dose of about 110 eV/16u. The produced refractory organic residues have, as a consequence, three different thicknesses (about 0.19, 0.13, and 0.065 μm) that, after the long exposure to space environment, will allow estimation of the depth profile of destruction [2].

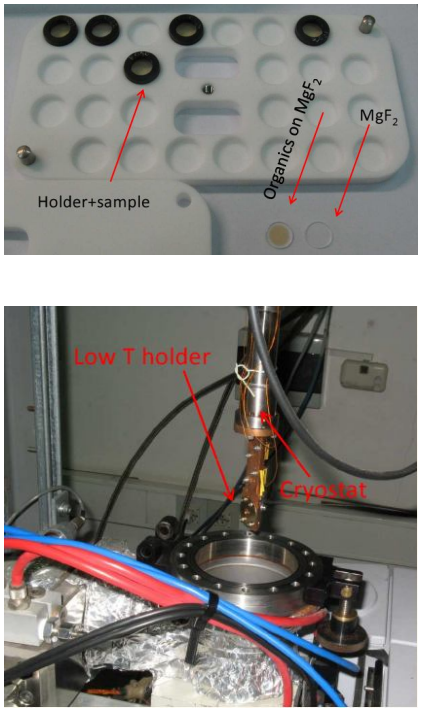

Figure 1: (upper panel) sample holder; Two MgF_2 windows with and without the organic sample deposited on it, are also shown. (lower panel) low T-holder and the cryostat used for the experiments.

3. Results

We have prepared thirty samples (ten for each thickness) and characterized them by UV-Vis-IR spectroscopy. An example of the obtained spectra is

given in Fig. 2, from which we can see that our residues contain different chemical groups, including triple C≡N bonds that are considered relevant to pre-biotic chemistry [3].

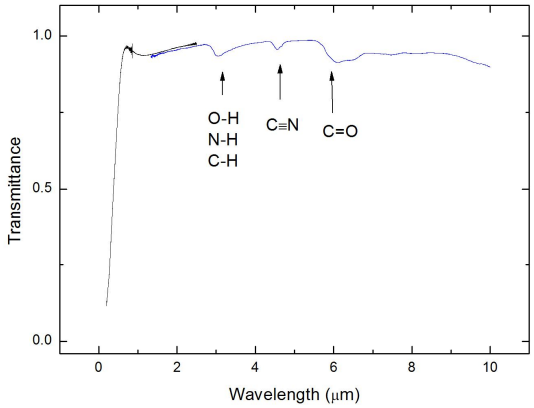

Figure 2: Transmittance spectrum (0.2-10 μm) of an organic residue (0.19 μm; 300 K) obtained after ion bombardment (200 keV He^+) of an ice mixture N_2:CH_4:CO=1:1:1 (1.2 μm; 16 K; 110 eV/16u).

4. Discussion

The ice mixtures (N_2:CH_4:CO) we used to prepare the residues is well representative of ices present on the surfaces of Trans Neptunian Objects (TNO) and of comets in the Oort cloud. In fact TNOs (e.g. Pluto) exhibit surface spectral features attributed to several species, among which solid nitrogen, methane and carbon monoxide [4]. Water ice is also observed on the surface of some objects and it is thought to be present in the underneath layers of all of them. Its observation is restrained or inhibited by the presence of dark materials that could be the result of cosmic ion bombardment of surface ices as suggested since a long time on the base of simulation experiments similar to those here described [5]. Also comets in the Oort cloud are rich in C, N, and O bearing icy molecules and could have developed a thick organic crust [6] under which water ice remain the dominant species. When comets that originates both from the Kuiper (TNOs region) and from the Oort clouds arrive in the proximity of the Sun the water dominated sublimation, expels gas and dust. As a component of the dust there are solid refractory carbon-rich materialss thought to be similar to those synthesized in laboratory experiments similar to those here discussed. These materials travel the interplanetary medium where they are exposed to the radiation (cosmic rays, solar ion populations, solar photons), before to be eventually delivered on the surfaces of the Earth and of all the other objects in the solar system. The exposure of these materials to interplanetary space environments in the EXPOSE-R2 facility on board ISS, will allow the analysis of their destruction and the evaluation of their lifetime in the interplanetary medium.

Acknowledgements

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