# Radiolysis of carbon-dioxide ice by swift Ti and Xe ions*

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## Introduction and Experiment

Ices ($H_2O$, CO, $CO_2$, $NH_3$, ..) are omnipresent in space on comets, the moons of giant planets, dust grains in dense clouds (the birthplaces of stars and planetary systems). They are exposed to cosmic rays, which in turn induce radiolysis, i.e. fragmentation of initial molecules, formation of radicals, and subsequent synthesis of molecules. Even complex pre-biotic molecules such as amino acids can be formed. Due to their high electronic energy loss the heavy ion fraction in cosmic rays yields non-negligible contributions to sputtering and radiolysis, even if protons and alpha particles are more abundant [1].

Heavy-ion beams from large accelerator facilities are useful to simulate the specific effects induced by the heavy ion fraction of cosmic radiation in the laboratory. We complemented the experiments (550 MeV Ti beams) reported in [2] at the UNILAC M-branch, by irradiation with 630 MeV Xe beams. On-line Fourier transform infrared absorption spectroscopy (FTIR) allowed us to follow molecule destruction and synthesis in $CO_2$ ice deposited at approx. 20 K on a CsI substrate.

## Radiolysis and Sputtering of $CO_2$

As shown in [1,2], cross sections for $CO_2$ destruction $\sigma_d$ can be determined from the fluence dependence of molecular column densities (“thickness”). After fragmentation of the initial $CO_2$ molecules, radicals can combine and form daughter molecules such as CO, $CO_3$ and $O_3$. The formation can also be quantified by cross sections $\sigma_f$ [1]. An important information, needed e.g. for estimating life times of molecules exposed to cosmic rays in space, is the dependence of the cross sections on the amount of deposited energy.

The destruction cross sections and the cross sections for synthesis of CO, $CO_3$ and $O_3$ are shown in figure 1 as a function of the electronic energy loss. Data obtained with Ni beams of about 50 MeV [1] and with 0.1 MeV protons [3] are also included. The measurements at GSI were performed with two different charge states both for the Ti and Xe beams, but within experimental uncertainties no related effect was observed. All cross sections are found to be proportional to the electronic stopping power. In contrast, sputtering yields are found to follow a quadratic dependence, in agreement with previous studies [1,3].

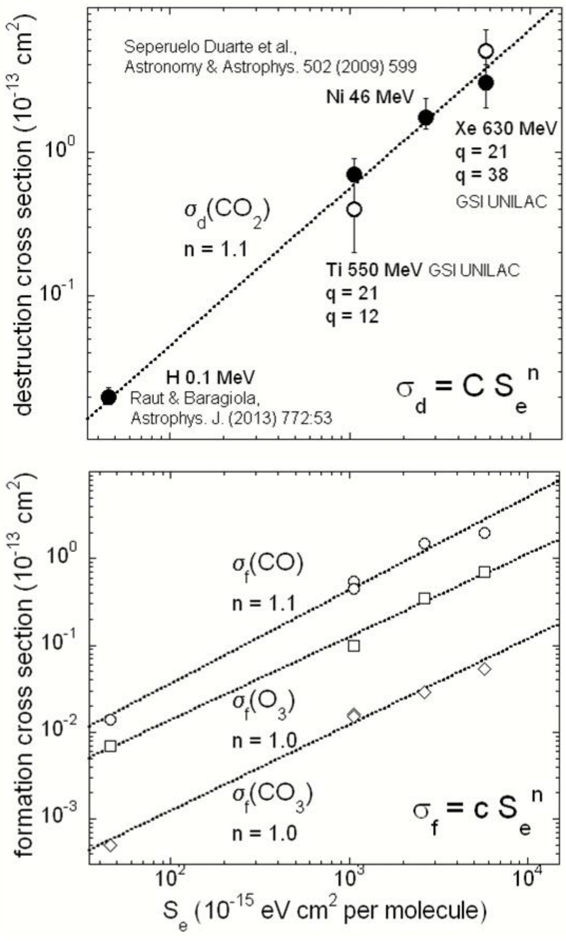


Figure 1: Cross section for destruction of $CO_2$ (top) and synthesis of CO, $CO_3$ and $O_3$ (bottom) as a function of electronic energy loss.

## References

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