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# Ion irradiation experiments relevant to the astrophysics ices

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Methane ($CH_4$) and methanol ($CH_3OH$) ices are present in various astrophysical environments, from dense molecular clouds to several small objects in the outer solar system, in particular on Saturn satellite Triton and to be a constituent of the icy mantle on interstellar grain [1]. There is a clear lack of information about the phenomena induced by the heavy-ion component of cosmic-rays in the electronic-energy-loss regime.

In this work, the chemical and physical effects induced by fast heavy ions irradiation on frozen pure methane and methanol at 15 K are studied. Measurements were performed at the medium energy beam-line of the heavy ion accelerator GANIL (Grand Acc\'el\'erateur National d'Ions Lourds), Caen-France [2]. The analysis was done by infrared spectroscopy (FTIR) during irradiation by 220 MeV $^{16}O^{7+}$ ion beam. For the case of methane, the principal molecular species identified as a product after irradiation are: $CH_3$, $C_2H_2$, $C_2H_4$, $C_2H_6$ and $C_3H_8$. For methanol ices are: $H_2CO$, $CH_2OH$, $CH_4$, CO, $CO_2$, HCO and $HCOOCH_3$ other products are identified with ambiguity. Their formation and dissociation cross sections are determined. The cross section of $CH_4$ and $CH_3OH$ and its daughters species follows a power law as a function of the electronic stopping power. It is found that, some daughters species cross sections increase with the electronic stopping power roughly as $\sigma \propto S_e^{3/2}$. As astrophysical implication, the $S_e^n$ power law, where $n \approx 3/2$ should be very helpful for predicting the $CH_4$ and $CH_3OH$ formation and the dissociation cross sections for other ion beam projectiles and energies in the ISM rich in hydrocarbons that are continuously bombarded by cosmic rays.

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