Comparison between anion and cation emission from CH_4 molecules colliding with 10.5-keV C^+ ions: fragment-energy aspects

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Synopsis It is shown that both positive and negative ions can be ejected from gas-phase methane molecules when bombarded with positive ions at keV energies. The kinetic energy distribution of the negatively charged fragments shows strong similarities with that of the ejected cations. However, in a hard binary collision between the C^+ projectile and an H atom, the formation of H^- ions is more endothermic than the formation of H^+ ions.

We show that both cations (H^+, C^+, CH_x^+) and anions (H^-, C^-) are emitted from methane molecules when bombarded by positive ions at an impact energy of a few keV. The experiment was performed at GANIL in Caen, France. A 10.5-keV C^+ ion beam crossed an effusive gas jet of CH_4. The collision-induced ionic fragments were selected according to their kinetic energy by means of an electrostatic analyzer. To avoid electron contamination of the anion spectra, the electrons and anions were magnetically separated so that only anions could reach the detector [1].

Figure 1 shows the energy distribution of the anions and cations ejected at the forward angle of 70° (with respect to the beam direction) in 10.5-keV C^+ + CH_4 collisions. The anion yield is relatively large, more than 3% of the cation yield, and the total cross section for anion formation is estimated to be higher than 10^{-18} cm^2. The main component of each spectrum is a broad structure, slowly decreasing with energy. This component results from soft many-body processes involving large impact parameters. On the other hand, at angles below 90°, pronounced peaks are observed at higher emission energies (Fig. 1). As recently observed for other collision systems [1-3], these peaks are due to recoil ions formed in hard binary collisions occurring at small impact parameters.

The kinetic energy distribution of the ejected anions shows strong similarities with that of the cations. This finding suggests a statistical picture in which the final charge state distribution of the emitted H centers barely depends on how closely the atomic centers approach each other during the collision. However, the binary peak due to H^- ions is centered at a lower energy than the peak due to H^+ ions with an energy difference of 20–30 eV in the 40°–70° angular range. This result shows that the formation of H^- ions in hard binary collisions is more endothermic than that of H^+ fragments.

This work was supported by the Hungarian National Science Foundation OTKA (Grant No. K109440) and the French-Hungarian CNRS-MTA Cooperation (ANION project).

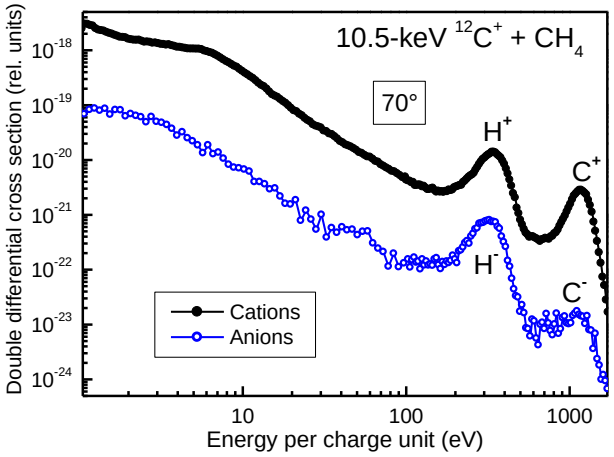

Figure 1. Energy distributions of anions and cations emitted at 70° in 10.5-keV C^+ + CH_4 collisions.

References

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