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Fragmentation of H_2O molecules induced by singly charged projectiles

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Fragmentation of H_2O molecules induced by singly charged projectiles

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Synopsis Ion impact induced fragmentation of H_2O molecules was experimentally studied. Energy and angular distribution of the charged fragments were measured by an energy dispersive electrostatic spectrometer. The measured spectra were converted into absolute double differential cross section (DDCS). The fragment ion spectra are different for H^+ and N^+ projectiles. From the fragmentation spectra we deduced the cross sections for the different ionization degrees of the target molecules.

By studying the ion impact induced fragmentation of small molecules different levels of information can be achieved. The fragmentation pattern is mainly determined by the perturbation strength of the projectile. According to the Bohr-Sommerfeld parameter ($k=q/v$), the interaction is governed by the charge over velocity ratio of the projectile: at small k values ($k<<1$) the target is only slightly perturbed, while at high k values ($k\geq1$) the projectile strongly interact with the target [1].

In this work we compare the fragmentation spectra of H_2O molecules induced by 1 MeV H^+ and 650 keV N^+ projectiles [2]. A jet of H_2O vapor was crossed by the ion beam supplied by the 5 MV VdG accelerator at Atomki, Debrecen. The energy and angular distribution of the charged fragments were measured by an energy dispersive electrostatic spectrometer in the angular range of 20°-160° relative to the incident ion beam. The measured spectra were converted to absolute DDCSs.

In figure 1 two different regions of the fragment ions can be identified: The peak below 2 eV contains dominantly heavy fragments (OH^+; O^{q+}). The more structured region above 2 eV is due to H^+ fragments. The energy of the H^+ ions is increasing towards higher ionization degrees of the H_2O^{q+} transient molecular ion (Coulomb explosion) [3]. Therefore H^+ fragments from the double, triple or four-fold ionized H_2O^{q+} molecules appear in the energy ranges of 4-15 eV, 16-28 eV and 30-38 eV respectively [4].

According to the energies of the H^+ fragments the maximal ionization degree was $q=2$ for H^+ projectiles, and $q=5$ for N^+ projectiles. The difference in the average degree of target ionization for the two, singly charged projectiles is originating from the difference in their impact velocities, and their effective charges in close collision events. While for N^+ the Bohr-Sommerfeld parameter is $k_{min}=0.74$ for the ionic, and $k_{max}=5.1$ for the nuclear charge, for H^+ it is as small as $k=0.16$.

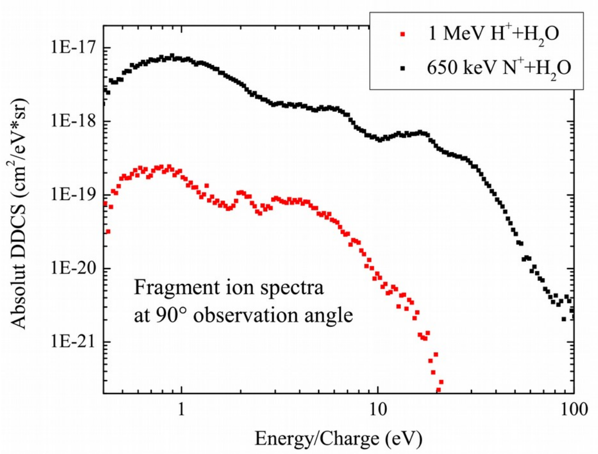

Figure 1. Fragment ion energy spectra for the two types of projectiles at 90° observation angle. The high energy protons for N^+ reveals to three, four- and five-fold ionization.

The theoretical work is under progress. Comparison of calculated partial multiple ionization cross sections (CTMC and CDW-EIS) to the extracted experimental values will be presented at the conference for a larger set of collision systems.

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