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Momentum imaging of dissociative electron attachment in biologically relevant molecules

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Synopsis We measured dissociative electron attachment in biologically relevant molecules using momentum imaging for negative ions in an apparatus that combines high resolutions of impact energy, fragment mass and fragment momentum. First investigations of the production of NH_2^--ions around the A_1 resonance at 5.7 eV impact energy show a clear dependence of the distribution of fragment dissociation angles on the projectile energy.

Since Pan et. al. [1] showed that dissociative electron attachment (DEA) an important process which can lead to the creation of strand breaks in DNA, much effort has been put into investigations of this process. Most experimental work however only identifies fragmentation channels while studies of the dissociation angles or kinetic energy transfer to the fragments are scarce. Our experimental setup is designed to perform those tasks. Based on the design of Adaniya et. al. [2], a pulsed electron beam from a photo-emission source with an energy spread of 200 meV (FWHM) is crossed with a supersonic gas jet. The created anion is pushed into the spectrometer by a pulsed extraction voltage applied after 1 μs. The potentials of spectrometer and extraction electrode as well as the extraction delay can be set to compress the time of flight of different momenta. This operation mode allows to significantly improve the mass resolution while still recording the momentum projection in the detector plane. Due to the axial symmetry of the problem, the complete information about the momentum distribution can be reconstructed.

An analysis of the distribution of dissociation angles in DEA to ammonia leading to production of NH_2^- ions shows a broad peak around 110° up to 5.7 eV electron impact energy, in agreement with measurements by Ram et. al. [3] who investigated H^--production at the same resonance. At higher energies, we observe a shift of the peak towards higher angles and a second peak in the forward direction that has not been described before.

The kinetic energy release of the reaction has its maximum at 0.95 eV and a FWHM of 0.5 eV. This distribution is constant over the investigated energy range from 4.3 eV to 7.3 eV, showing that excess energy has to be stored in internal degrees of freedom, i.e. a vibrationally excited state of the fragment.

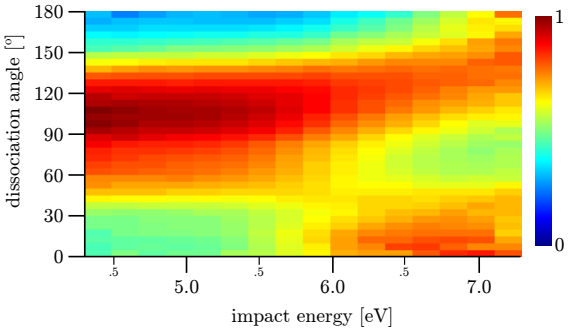

Figure 1. Distributions of fragment dissociation angles for the production of NH_2^- ions. Results have been normalized for every energy to compensate the varying total cross section.

The mass resolution of the setup has been demonstrated using the dissociation of furan around 6 eV. Here, production of $C_4H_3O^-$ (67 amu), C_4H^- (49 amu), C_2HO^-, (41 amu) and $C_3H_3^-$ (39 amu) can be observed [4]. Although the fragment with a mass of 39 amu is created with a significant amount of momentum, corresponding to a kinetic energy release up to 0.5 eV, it can be separated in time of flight from the fragment at 41 amu.

References

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