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Photo-dissociation dynamics of halogenated aromatic molecules

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Introduction

The studies of the dynamics of formation and subsequent dissociation of the multiply charged molecules produced by inner-core excitation with soft x-ray have been an active field of research over the last decade. However, such studies on the polyatomic molecules have been rare, probably due to the complex nature of different dissociation pathway of the multiply charged molecular ions formed. Recent developments of the multi-hit coincidence method combined with momentum imaging of ions give us the opportunity to study the correlation of three dimensional momentum between the fragment ions that would enable us to discuss the dissociation dynamics of molecules in detail. In the present study, we have applied the momentum imaging measurements for four halogenated benzene molecules (FC_6H_5, ClC_6H_5, BrC_6H_5, IC_6H_5) in C 1s ionization threshold region.

Experiment

The experiment has been performed at the undulator beamline BL-2C of the Photon Factory using the multi-coincidence velocity-map imaging spectrometer. The photon beam crossed perpendicularly with the molecular beam of halogenated benzene at the ionization region. Electrons and ions were extracted by a uniform electrostatic field on opposite sides towards two position and time sensitive detectors with delay-line readout and detected in coincidence. The ion momenta were determined from the time-of-flight and the impact positions on the detector. The projection of the electron momenta on the coplanar plane, which is defined by the electric vector and propagation direction of incident light, was determined from the positions.

Results and discussions

Figure 1 shows the time of flight (TOF) mass spectrum of FC_6H_5 following C 1s ionization. The sharp peak at m/z = 48 correspond to the doubly charged ion of parent molecules (FC_6H_5). The sharp peak corresponding to the singly charged ion of FC_6H_5 (m/z=96) is not observed in this spectrum. Broad peaks correspond to the series of fragment ions of $C_nH_m^+$ and $FC_nH_m^+$. Broadness of fragment peaks suggests the large kinetic release for these fragment ions.

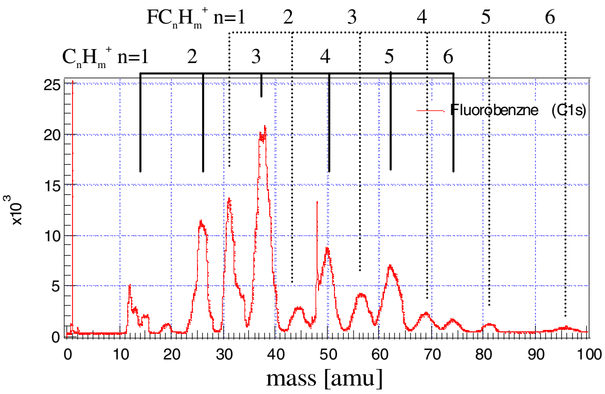

Fig. 1 TOF mass spectrum of FC_6H_5 following C 1s ionization. Thre sharp peak at m/z = 48 amu corresponds to the $FC_6H_5^{2+}$ ions.

Figure 2 shows the angular correlation of momenum vectors between two fragment ions. Here, we have selected the signals from C 1s ionization event by choosing the energy of photoelectrons which are detected in coincidence with ions. As shown in fig. 2(a), the correlation between F^+ and H^+ shows clear peaks at $\cos\theta =$ 0.5, -0.5 and -1.0. These peaks correspond to the hexagonal shape of benzene molecule. However, C^+-H^+ correlation shown in fig 2(b) have no clear peaks. The difference of the angular correlation would give us the information on the dissociation pathway

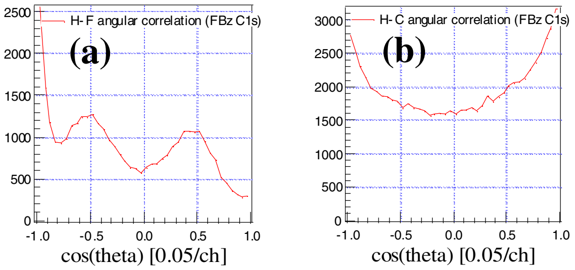

Fig. 2 Angular correlation of momenum vectors between two fragment ions, (a) F^+ and H^+, (b) C^+ and H^+.

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