Delayed fragmentation of biomolecules induced by MeV ion collisions

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Delayed molecular fragmentation is one of the characteristic dissociation processes of polyatomic molecules, including biomolecules, induced by ion collisions or photoionization. Delayed fragmentation pathways provide rich information about the stability of intermediated ions and the thermal dissociation mechanisms. In addition, coincidence measurements reveal sequential dissociation pathways even involving neutral fragments. However, there are limited experimental studies on the delayed fragmentation of biomolecules by fast ion collisions [1–4]. In this study, we investigate the delayed fragmentation of the nucleobase molecules induced by MeV-energy ion collisions.

The experiment was performed using a 1.7-MV Cockcroft–Walton-type tandem accelerator facility. Pulsed beams of 0.5-MeV H^+ and 0.6–4.0-MeV C^{q+} (q = 1–3) were incident on gas-phase nucleobase molecules of adenine, guanine, cytosine, thymine, and uracil. The produced fragments were analyzed by time-of-flight (TOF) mass spectrometry and recorded in list mode. We focused mainly on delayed fragmentation events that generated positive ions and neutral fragments from singly charged intermediated ions. In delayed fragmentation processes, neutral fragments can be detected because they are generated after acceleration to some extent.

Figure 1 shows a TOF correlation map of the two fragments from adenine. Delayed fragmentation channels correspond to long diagonal tails. Delayed processes were observed for all the nucleobase molecules. We revealed specific dissociation pathways depending on the molecular species. In addition, the lifetimes of some dissociation pathways were evaluated. The neutral fragments have a low impact energy on the MCP detector, and the impact energy varies depending on the decay time. Therefore, the absolute detection efficiency of the MCP for neutral fragments was carefully determined from the results obtained with different extraction fields. As a result, the lifetimes were estimated to be on the order of hundreds of ns to μs.

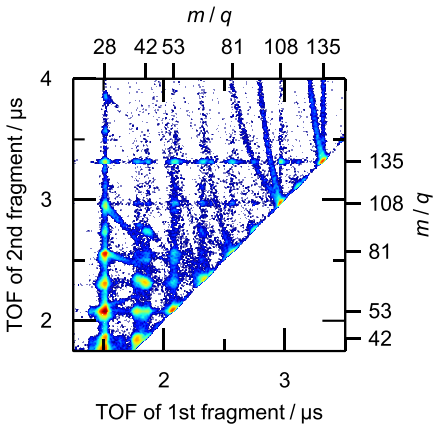

Figure 1: TOF correlation map of the two fragments from adenine.

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