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Correlation between multiple ionization and fragmentation of small hydrocarbon molecules induced by fast heavy ions

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Synopsis We investigate correlations between multiple ionization and fragmentation processes of the acetylene, ethylene and ethane molecules in collisions with 0.58-1.2 MeV $C^{+, 2+}$ ions under specific charge changing conditions. The number of ionized electrons are observed directly by an electron counting technique. Fragmentation processes are discussed in terms of the charge state of parent ions prior to fragmentation. The correlation results reveal evidently roles of the charge state and the internal excitation in the molecular fragmentation processes.

Although a large number of studies of collision-induced dissociation of molecules have been performed so far, understanding of the mechanism is still challenging especially for large molecular targets. Most studies have tended to focus on specific fragmentation pathways which can be analyzed by coincidence measurements among the product ions. Understanding of the overall picture is still limited. One of the key parameters is the charge state of intermediate parent ions prior to fragmentation. To obtain the charge state, an electron counting method with a semiconductor detector is employed [1-3]. In this work, we apply this technique to collisions of 0.58–1.2 MeV $C^{+, 2+}$ ions with the acetylene, ethylene, and ethane molecules (C_2H_{2n}, n = 1-3).

Experimental procedures are described elsewhere in detail [1]. In brief, product ions were analyzed by time-of-flight measurements with a position sensitive detector. Electrons emitted in collisions were detected with a semiconductor detector on a potential at +25 kV. Number distributions of the electrons are derived from pulse-height distributions of the signals. Charge states of outgoing projectile ions were analyzed to selectively study collision events in specific charge-changing conditions.

Figure 1 shows intensity fractions of product ions among the whole product ions from $C_2H_6^{r+}$* parent ions generated in single (1e)-capture and 1e-loss conditions of 0.56 MeV C^+ ions. We see how distributions of product ions shift to smaller fragments with increasing the charge state r. Even at the same parent charge state, 1e-loss collisions exhibit higher degrees of H or H_2 loss than 1e-capture collisions, indicating higher internal energies accompanying in electron loss collisions. One can also see that H_3^+ ions are generated only from doubly charged parent ions (r = 2). This is a good example of charge-specific reaction processes of multiply charged polyatomic molecular ions.

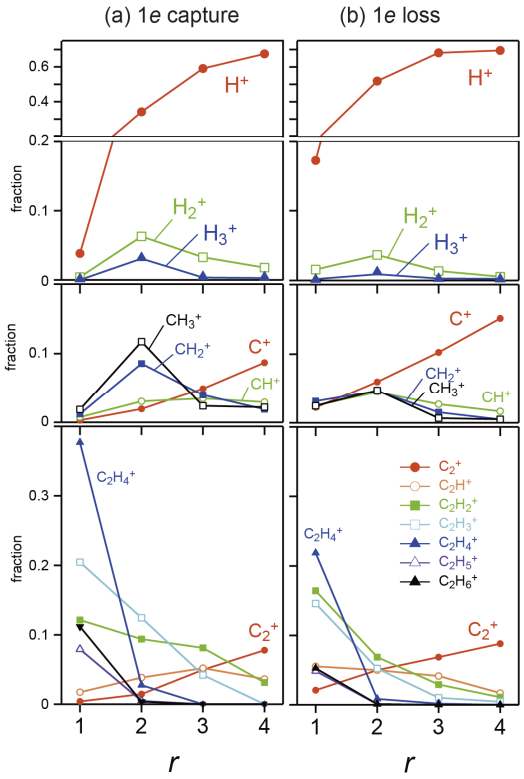

Figure 1. Fractions of product ions from $C_2H_6^{r+}$* parent ions generated in (a) 1e-capture and (b) 1e-loss conditions of 0.56 MeV C^+ ions.

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