§10. Isomer Effect on Charge Transfer by Slow Ions from Hydrocarbon Molecules

Kusakabe, T. (Dept. Phys. Kinki Univ.)
Kimura, M. (Yamaguchi Univ.)
Sakaue, H.A.

Since carbon based plasma-facing materials are usually used in recent large tokamak devices, there are carbon ions and many kinds of carbon containing molecules as well as other impurities in their edge plasmas. We therefore systematically measured the charge transfer cross sections of H\(^+\), He\(^+\), C\(^-\) and O\(^-\) ions in collisions with various molecules.\(^1\) The apparent isomer effect on charge transfer processes in collisions of the ground-state C\(^+\) (\(^2S\)) ions with allene and propyne has been observed in collision energy from 0.2 to 4.5 keV.\(^2\) The difference in the cross sections between the two isomers was found to be 32% at 0.2 keV, although it decreases to 10% at 4.5 keV. Theoretical analysis based on a molecular expansion method has also confirmed the experimental finding and provides the rational.

The C\(_3\)H\(_6\) molecule is also known to possess two stable isomeric-molecular structures, i.e., propene and cyclopropane [(CH\(_3\)_2)]. In this work, as a continuing study, we have measured the charge transfer cross sections of the C\(^+\) (q = 1, 2, 3) ions in collisions with two isomeric C\(_3\)H\(_6\) molecules. The investigated energy region is 0.2 to 4.5 keV for C\(^+\) ions and 0.35 to 3.0 keV/q for C\(^+\) (q = 2, 3) ions, respectively. The singly charged carbon ions were produced by 25.3 eV electron beam from CO molecules into an electron impact ion source, in order to generate the ground state C\(^+\) (\(^2S\)) ions. The multiply charged C\(^+\) (q = 2, 3) ions were extracted from a compact electron beam ion source called micro-EBIS 3) using a strong ring permanent magnet. The multiply charged carbon ions were produced from high purity CH\(_4\) gas by impacting about 1 mA and 2 keV electron beam emitted from a barium oxide (BaO) cathode. Because \(^{12}\)C\(^+\) ions cannot be distinguished from \(^{16}\)O\(^+\) ions, enriched \(^{12}\)CH\(_4\) gas was used for generating \(^{12}\)C\(^+\) ions. The cross sections of charge transfer were determined by the initial growth rate method with a position sensitive micro-channel plate detector.

Figure 1 shows a comparison of the observed cross sections for single-charge transfer in C\(^+\) + C\(_3\)H\(_6\) and (CH\(_3\)_3) collisions. The cross sections are practically the same for both C\(_3\)H\(_6\) and (CH\(_3\)_3) molecules. Both the present single-charge transfer cross sections \(\sigma_{10}\) gradually decrease as the incident energy increases up to about 1.2 keV and then above 1.2 keV they are almost constant.

![Figure 1. Single-charge transfer cross sections for C\(^+\) ions colliding with C\(_3\)H\(_6\) and (CH\(_3\))\(_3\) molecules.](image1)

Energy, \(E\) (keV)

![Figure 2. Single- and double-charge transfer cross sections for C\(^2+\) ions colliding with C\(_3\)H\(_6\) and (CH\(_3\))\(_3\) molecules.](image2)

Energy (keV)

![Cross section vs Energy](image3)

Reference