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

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Since low-*Z* plasma facing components such as carbon materials are usually used in recent large tokamak devices, there are carbon ions and many kinds of carbon containing molecules as well as another impurities in their edge plasmas. Among many collision processes relevant to low temperature fusion edge plasmas, charge transfer of these ions with molecules play a key role in determining properties of high temperature plasmas at the core region. We therefore systematically measured the charge transfer cross sections of H^+, He^+, C^+ and O^+ ions in collisions with various molecules.1)

The C_3H_4 molecule is know to possess two stable isometric-molecular structures, i.e., allene ($H_2C{=}C{=}CH_2$) and propyne ($HC \equiv C\text{-}CH_3$). The apparent isomer effect on charge transfer processes in collisions of the ground-state C^+ (^2P) 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 provide the rational.

In this work, as a continuing study, we have measured the charge transfer cross sections of the C^{q+} (q = 2, 3) ions in collisions with two isometric C_3H_4 molecules in the energy range between 0.35 and 3.0 keV/q. The C^{q+} (q = 2, 3) ions were extracted from the compact electron beam ion source called micro-EBIS 3) using a strong ring permanent magnet of Fe-Nd-B. The multiply charged carbon ions were produced in a 3 cm long drift tube from high purity CO or CH_4 gas by impacting about 1 mA and 2 keV electron beam emitted from a barium oxide (BaO) cathode of 2 mm in diameter. Because $^{12}C^{3+}$ ions cannot be distinguished from $^{16}O^{4+}$ ions, enriched ^{13}CO or $^{13}CH_4$ gas was used for generating $^{13}C^{3+}$ 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 the cross sections for single- and double-charge transfer in C^{2+} + C_3H_4 collision. Both the present double-charge transfer cross sections σ_{20} gradually decrease as the incident energy increases. Energy dependence of both cross sections is resemble, but the cross section values for allene are slightly larger than these for propyne. The present single-charge transfer cross sections σ_{21} are almost constant for allene, while these for propyne have a minimum at about 2 keV. The σ_{21} values for allene are also slightly larger than these for propyne.

In C^{3+} + C_3H_4 collision, the cross sections for single-, double- and triple-charge transfer could be measured. The present single- and double-charge transfer cross sections (σ_{32} and σ_{31}) are almost constant, while the present triple-charge transfer cross sections σ_{30} gradually decrease with increasing collision energy. All of the cross sections for allene are found to be slightly larger than these for propyne.

The experimental and theoretical studies are now in progress for C^{q+} (q =1, 2, 3) + C_3H_6 and $(CH_2)_3$ collisions and for H^+, He^+, He^{2+} + C_3H_4 (allene and propyne), C_3H_6 and $(CH_2)_3$ collisions.

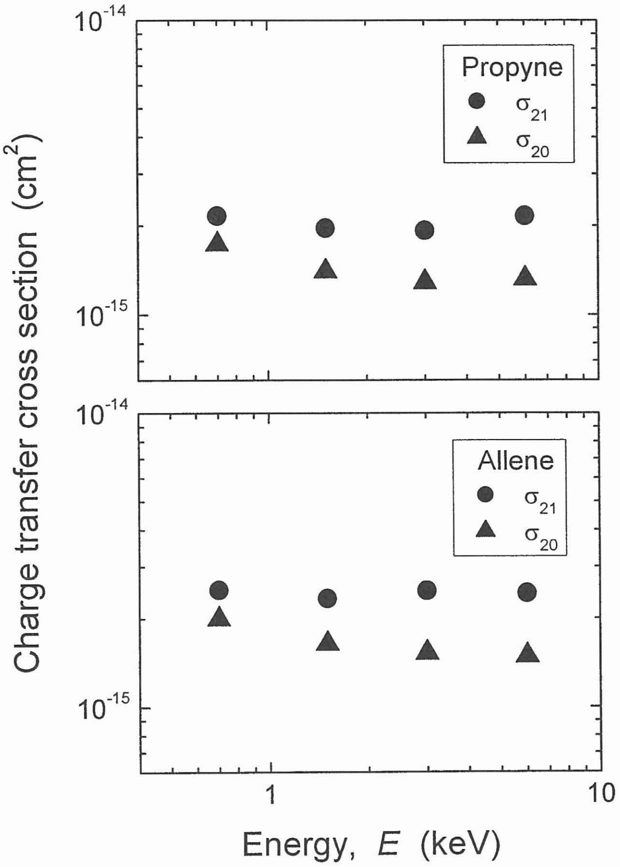

Fig. 1. Single- and double-charge transfer cross sections for C^{2+} ions colliding with C_3H_4 molecules.

Reference
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2) Kusakabe, T. *et al.*: Phys. Rev. Lett. **87** (2001) 243201.
3) Kusakabe, T. *et al.*: Physica Scripta **T73** (1997) 378.