Journal of Physics: Conference Series **488** (2014) 052033 doi:10.1088/1742-6596/488/5/052033

An (e, 2e + ion) investigation of fragmentation of methane induced by low energy electrons

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Synopsis An (e, 2e+ion) investigation of the ionization and dissociation of methane by 54 eV electron impact is performed using the advanced reaction microscope. By measuring two electrons and the ion in the final state in triple coincidence, the species of the ions are identified, and the energies deposited into the target are determined. The species and the kinetic energies of the fragmented ion show strong dependence on the intermediate states of the parent ion.

Methane is the simplest hydrocarbon with a highly symmetric tetrahedral structure. Electron induced dissociation of methane is an ideal model for our understanding of some basic physical and chemical processes, for example, the breakup of the C-H chemical bond. Besides, it also plays very important roles in many application fields such as plasma physics and the chemistry of planetary atmospheres.[1] In an (e, 2e+ion) measurement, both the fragmented ion and the electrons are detected in triple coincidence, thus much detailed information can be deduced to investigate the dissociative ionization mechanisms. [2]

An (e, 2e+ion) triple coincidence experiment was performed using (e,2e) reaction microscope at MPI-K, Heidelberg.[2] The species of the fragments are identified according to the time of flight of the ion. The kinetic energy of the fragmented ion as well as the energy deposition in the target are determined by reconstructing the momentum vectors of the charged particles. The energy deposition distributions for the different ion species are presented in Fig. 1, and the corresponding electronic states are assigned.

It can be concluded from Fig. 1 that the energy deposition distributions are quite different for different fragments, which indicates that the species of the fragment ion strongly depends on the electronic state of the precursor ion. The $(1t_2)^{-1}$ ground state mainly results in CH_4^+ and CH_3^+ ions, while the ionization-excitation states such as$(1t_2)^{-2}(3a_1)^1$ can fragment to CH_n^+, H_2^+ and H^+ ions. The $(2a_1)^{-1}$ inner valence shell single ionization state contributes to CH_n^+ and H^+. It was also found that not only the species of the fragments but also their kinetic energies are strongly determined by the intermediate electronic state of the parent ions. Details of the fragmentation mechanisms will be presented in the conference.

This study demonstrates that reaction microscope is a powerful tool for the investigation of the electron induced dissociative ionization of molecules.

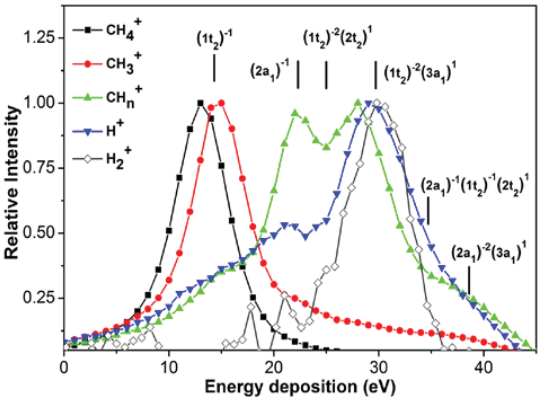

Figure 1. The energy deposition distributions of CH_4^+, CH_3^+, CH_n^+ (n=0,1,2), H_2^+ and H^+. The data have been normalized to unity at the maxima independently.

This work is partly supported by the National Natural Science Foundation of China under Grants No. 11204322 and No. 10979007. S. Xu is grateful for support from the CAS-MPS doctor training program.

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