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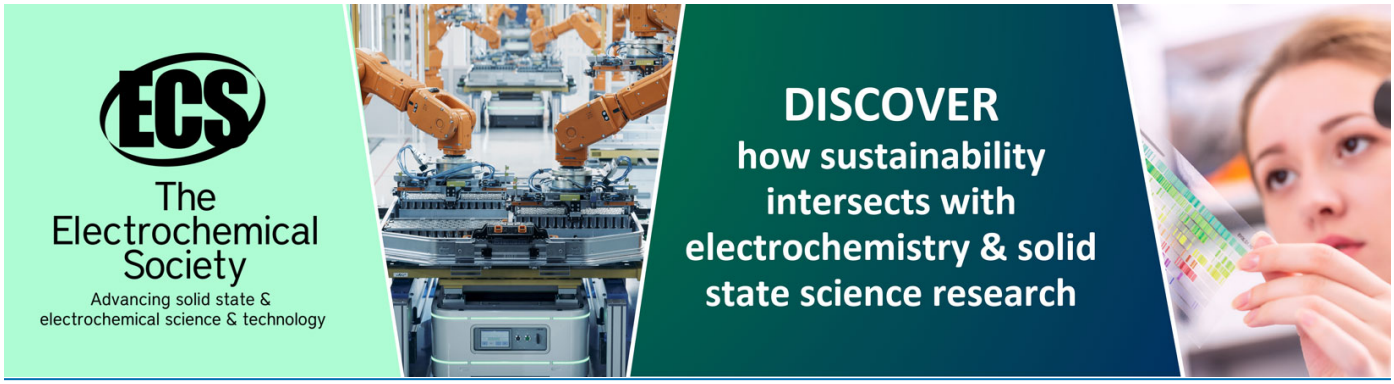

Ionization cross sections of gaseous amino acids of isoleucine by 2MeV He^+ ions

Y. Iriki[1], A. Nishimura, H. Tsuchida, M. Imai, H. Shibata, and A. Itoh[2]

[*] Department of Nuclear Engineering, Kyoto University, Kyoto 606-8501, Japan

Synopsis Double differential cross sections for ionization by 2 MeV He^+ ions have been measured for gaseous amino acids of isoleucine using a crossed beam method. Ejected electrons with energies below 600 eV were analyzed by a 45-degree electrostatic analyzer which was movable inside a collision chamber from 15 to 165 degrees with respect to the incident beam direction. K-LL Auger peaks of carbon, nitrogen, and oxygen were observed strongly with expected intensities from the number of consitituent atoms in an isoleucine molecule. Binary encounter peaks were also observed at angles smaller than 90 degrees.

Ionization of biomolecules by MeV ion impacts has been the subject of a great deal of attention for understanding of biological effects of ionizing radiations on living cells. A primary particle interacting with individual molecules in matter leads to excitation, ionization and fragmentation. Through the process the primary particle loses its kinetic energy with producing secondary particles such as low energy electrons, radicals and secondary ions. In particular, secondary electrons are the most abundant secondaries in ionization and are liberated with a wide range of kinetic energies. In a relatively low-energy region, secondary electrons are known to cause single or double strand breaks of a plasmid DNA via dissociative electron attachment[1], while high energy electrons like Auger electrons and δ-rays can cause molecular fragmentation directly via excitation and ionization. Hence, secondary electrons play a decisive role in biological effects induced by a fast charged particle irradiation. It is important, therefore, to measure ionization cross sections $\sigma(\theta, E)$ as functions of the emission angle θ and the kinetic energy E of secondary electrons.

A beam of He^+ ions produced at the Van de Graaff accelerator facility of Kyoto University was carefully collimated and collected in a Faraday cup. Secondary electrons ejected in collisions were energy analyzed by a 45-degrees electrostatic analyzer and detected by a channel electron multiplier. The electrostatic analyzer has an energy resolution of 8% at FWHM. A gaseous target of isoleucine ($C_6H_{13}NO_2$) was produced by heating pure powder (99%) at 340 K in a quartz oven. A base pressure was kept below 1×10^{-7} Torr whole through the measurements. A contribution from residual gases to cross section data was found to be negligibly small. The inside of the collision chamber was covered by a double μ-metal wall to reduce residual and earth's magnetic fields. We achieved the magnetic field less than a few mG in the area of the electron analyzer.

Fig. 1 shows double differential cross sections for electron emission in collisions of 2MeV He^+ ions with gaseous isoleucine. In order to deduce absolute cross sections, we also measured ionization cross sections of Ar and compared with those reported by Toburen et. al.[2]. Besides binary-encounter peaks observed clearly at forward angles, one can see broad peaks attributable to K-LL Auger electrons from carbon, nitrogen, and oxygen. At present, experimental results are examined with a semiempirical formula[3] using the additivity rule. Comparison will also be made with standard nCTMC calculations[4].

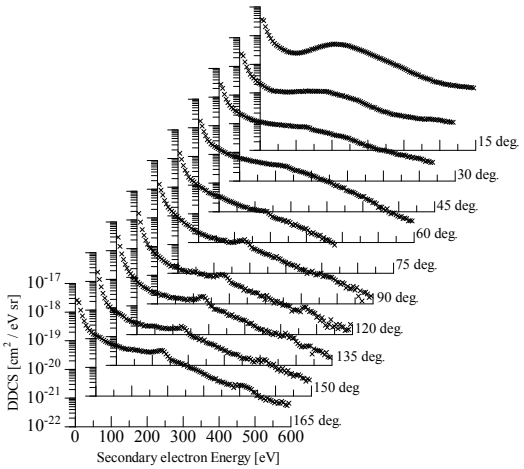

Fig. 1. Differential cross sections for electrons ejected from gaseous isoleucine by 2MeV He^+ ions measured at 15-165 degrees.

References

[1] L.Sanche et al, *Science* 287, 1658(2000)
[2] L.H.Toburen *et al*. 1979 *Phys. Rev. A* **19** 2214
[3] M.E.Rudd, 1988 *Phys. Rev. A* **38** 6129
[4] R.E.Olson and A.Salop, 1977 *Phys. Rev. A* **16** 531

[1]E-mail: iriki@ nucleng.kyoto-u.ac.jp
[2]E-mail: itoh@nucleng.kyoto-u.ac.jp