Electron and positron collisions with molecules

C. Makochekanwa[1,2], O. Sueoka[3], M. Kimura[1] and H. Tanaka[2]

[1] *Graduate School of Sciences, Kyushu University, Fukuoka 812-8581, Japan*

[2] *Department of Physics, Sophia University, Chiyoda-ku, Tokyo 102-8554, Japan*

[3] *Faculty of Engineering, Yamaguchi University, Ube 755-8611, Japan*

Commendable studies of the fundamental interactions in electron- and positron-atom have been carried out based on discussions around the differences observed in the electrostatic, exchange (electron only) and polarization interactions [1]. However, even in positron-atom collisions, it has since been observed that the contribution of the virtual positronium formation mechanism, at energies below the positronium formation threshold, contributes significantly to the interaction – even leading to the production of either low-lying positron–atom virtual states or weakly bound states [2]. Formation of these states is expected to be even enhanced for molecules with dipole moments exceeding the critical value of 1.625 Debye [3].

In this report comparative studies of electron and positron total cross sections (TCSs) are carried out (as examples from the more than 70 molecular targets studied) for (I) CH_4, CH_3F, CH_2F_2, CHF_3 and CF_4 molecules for the *fluorination effect*, and (II) CH_3H, CH_3F, CH_3Cl, CH_3Br and CH_3I molecules for the *halogenation effect*. These TCSs have been measured using a retarding potential time of flight apparatus [4]. These effects are also jointly studied, for two molecular groups, in our electron impact differential cross sections (DCSs) are measured using a crossed-beam method [5]. In group (I), only the electron TCSs show the dipole moment characteristic enhanced long-range scattering at energies below 2 eV (also observed in DCSs at 1.5 eV at angles below 50º), as evidenced by the significantly rising TCSs for the polar molecules CH_3F, CH_2F_2 and CHF_3. Positron TCSs show a clear *fluorination effect* above 100 eV, where they are seen increasing in magnitude with increase in the number of F atoms substituted for the H atoms. This is not observed in electron TCSs, although it's clearly observed in electron DCSs as a conspicuous shoulder at 30 eV and angles 60º – 65º. In group (II), though the positron TCSs do not show, in the limit of the current lowest energy range of 0.2 eV, the low energy rise of TCSs expected for the polar CH_3F, CH_3Cl, CH_3Br and CH_3I molecules, the *halogenation effect* is observed over all the energy range 0.2 – 1000 eV. Though both electron TCSs and DCSs, on the other hand, show the typical dipole characteristic long-range scattering below about 1.5 eV, both the TCS and DCS magnitudes show a complicated ordering, i.e. deviating from the expected *halogenation effect*. These and other observations will be systematically discussed at the conference with reference to the dipole moments, molecular polarizabilities and molecular sizes.

The work was supported in part by the Ministry of Education, Sport, Culture and Technology, and the Japan Society for Promotion of Science (JSPS). Author C. M. is also grateful to the JSPS for financial support under the grant number P04064, and also to Yamaguchi University as he did part of this work whilst he was a Ph.D. student there.

[1] M. A. Morrison, *Positron (Electron)-Gas Scattering* (W. E. Kauppila, T. S. Stein and J. M. Wadehra eds.), World Scientific, Singapore, 1986.

[2] J. Mitroy, M. W. J. Bromley and G. G. Ryzhikh, J. Phys. B **35**, R81 (2002).

[3] O. H. Crawford, *Proc. Phys. Soc.* **91**, 279 (1967).

[4] O. Sueoka and S. Mori, J. Phys. B **19**, (1986) 4035.

[5] H. Tanaka, L. Boesten, D. Matsunaga and T. Kudo, J. Phys. B **21**, 1255 (1988).