# §19. Cross Section Measurement of Charge Transfer by Slow Tungsten Ions in Collisions with Hydrocarbon Molecules

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Construction of the next-day large nuclear fusion device ITER (International Thermo-nuclear Experimental Reactor) is progressing by international cooperation. Tungsten (W) materials are planned to use together with carbon based materials at the divertor of the ITER, and the engineering performance testing is progressing. For the modeling of ITER plasma, the cross section data of charge-transfer processes of W ions colliding with some kinds of hydrocarbon molecules are required as well as other simple molecules such as $H_2$, CO, and so forth. However, these cross section data are still scarce in the low collision energy.[1-3] In this research, the producing method of W ions is established first, and we measure the charge-transfer cross sections of W ions in collisions with hydrocarbon molecules in the energy region below 4 keV/$q$ ($q$ : the number of ionic charge).

The extraction of tungsten ions was successful last year from the electron impact ion source (EIIS) with the experimental apparatus for testing the ion source. In these experiment, tungsten hex carbonyl $W(CO)_6$ was used to produce the W ions. It is noted that the tungsten hex carbonyl is widely used in electron beam-induced deposition technique. Because its vapor pressure is relatively high, it is easily vaporized under a high vacuum. In these experiment, the tungsten hex carbonyl powder in a reservoir evaporates under a high vacuum, and is introduced into the EIIS. $W(CO)_6$ molecules were ionized and decomposed by 100eV electron impact. Extracted ions were mass-separated with homogeneous magnetic field in a 60° sector magnet, and were detected with a channel electron multiplier (CEM) or a micro-channel plate detector (MCP). Singly and doubly charged tungsten ions were detected and separated from many fragment $W(CO)_n^{+}$ and $W(CO)_n^{2+}$ ions ($n = 1 \sim 6$).

However, in our current experimental apparatus for cross section measurement, a Wien filter has been used to analyze the mass and charge of extracted ions from the ion source. At present, the mass resolution of this Wien filter is low, and these fragment ions are not separable from the W ions. In order to perform cross section measurement, some improvements are required about the mass resolution of this Wien filter.

(1) The first step of improvement proposal is as follows:

A cylindrical type electrostatic energy analyzer has been constructed and installed between the Wien filter and the ion source in the experimental apparatus for cross section measurement as shown in Fig. 1. The 90-degree cylindrical type energy analyzer whose orbital radius $r$ for the energy analysis of an ion beam is 60 mm was manufactured. Two cylindrical electrodes were made from stainless steel, the outer radius of an internal electrode is 57 mm, and the internal radius of the external electrode is 63 mm.

(2) Another improvement proposal is as follows:

As mentioned above, in the ion source test equipment, we have already succeeded in separating from other fragment ions and extracting the $W^{+}$ and $W^{2+}$ ions. However, in this equipment, an ultimate vacuum is low and this has no collision chamber. Then, first, we will newly install a 350 l/s turbo-molecular pump (TMP) with higher exhausting speed instead of the 50 l/s TMP present in use, and enhance the performance of the vacuum pumping system. The collision cell and a position sensitive micro-channel detector system will be newly installed in order to perform the cross section measurement of charge transfer.

Those preparations and performance testing are progressing now based on the improvement proposal of two directions mentioned above.

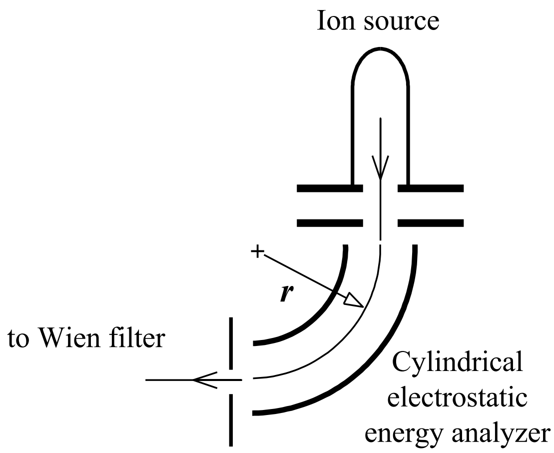


Fig. 1. Schematic diagram of the electrostatic energy analyzer installed between the ion source and the Wien filter.

1) Janev, R. K., Belić, D. S., Bransden, B. H.: Phys. Rev. A **28** (1983) 1293.
2) Meyer, F. W. *et al*.: Phys. Rev. A **19** (1979) 515.
3) Kheyrandish, H., Armour, D. G., and Jones, E. J.: Vacuum **34** (1984) 269.