A Simple Electron Source for Impact Experiments

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A narrow energy width is necessary in the bombarding electron beam to derive useful information on the energy levels of a molecule from the ionization efficiency curve, and several techniques were proposed for the purpose. Amongst them the RPD method by Fox[1] and the electrostatic filter utilized first by Clarke[2] have been used widely in many laboratories. But the methods require some expensive and delicate devices, and they are sometimes not practical.

A hair-pin type filament is proposed for the purpose in the present note. A tungsten filament of 0.125 mm in dia. had a V shape with an angle about 60° and a tiny slice of the same metal was tipped at its point. The ion source was simply composed of the tungsten filament and a gold-plated cylindrical cage (8.5 mm dia. and 15 mm length) with an electron entrance aperture (1 mm dia.) and a trap at each side. No other electrode was used to narrow the energy spread it the electron beam. Ions produced by the beam were extracted through the system of electrodes of extractor and field adjuster around the cage, and then introduced to an analyzer after collimation by an intermediate electrode. Mass analysis of the ions was made by a quadrupole mass filter, which corresponds to no usage of auxiliary magnet for the bombarding electron collimation.

Samples used for the test were rare gases, Ne, Ar, Kr and Xe, and two hydrocarbons, CH_4 and C_2H_4. The sample was introduced at a pressure of $(3—6)\times10^{-5}$ Torr into the system, and intensity of the bombarding electron beam was set at about $(1—2)\times10^{-8}$ A. Ion current of the order of $10^{-12}—10^{-14}$ A was obtained at about 1V above the ionization potential with a multiplier in the mass filter system.

The results obtained in the efficiency curves are all in good agreement with those of the RPD or other methods. In the case of Kr, distinct changes in the slope of the curve are observed, which probably correspond to the states $^2P^\circ_{3/2}$ and $^2P^\circ_{1/2}$[3] (see Fig. 1). At least three breaks were also observed for CH_4^+ in the case of methane, at

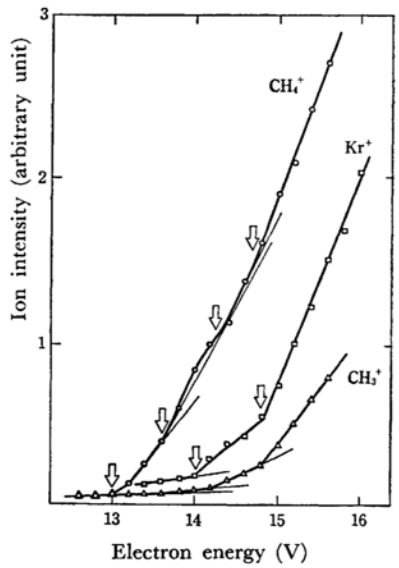

Fig. 1. Ionization efficiency curves for Kr^+ and for CH_4^+ and CH_3^+ from methane.
Sample pressure: $5—6\times10^{-5}$ Torr
Bombarding current: $1.5—2\times10^{-8}$ A.

0.6 V, 1.2 V, and 1.7 V above the ionization threshold. The result is also shown in Fig. 1, together with the results of CH_3^+. These features in the curves are almost the same with the results by the RPD method.[4] Ethylene also gave the same results with the RPD method, *i.e.*, breaks were found at 0.6 V, 1.2 V and 2.0 V above the ionization potential[4], and the difference of the appearance potentials of $C_2H_2^+$ and $C_2H_3^+$ was observed with a value about 0.4 V.

The obtained results show the present simple method is sufficiently good for obtaining the ionization efficiency curve with some structure. It might not be applicable for precise experiments, but practical enough compared with the RPD method because it requires no complicated electronic circuit and no delicate operation, nevertheless gives the adequate resolution. The width of the electron energy is now under measurement and details of the experiments will be presented in subsequent publications.

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2) E. M. Clarke, *Can. J. Phys.*, **32**, 764 (1954).
3) C. E. Brion, D. C. Frost and C. A. McDowell, *J. Chem. Phys.*, **44**, 1034 (1966).
4) C. E. Melton and W. H. Hamil, *J. Chem. Phys.*, **41**, 546, 1469 (1964).