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MEASUREMENTS OF DISSOCIATIVE IONIZATION CROSS SECTION OF SF_6 BY USING DOUBLE COLLECTOR CYCLOIDAL MASS SPECTROMETER

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ABSTRACT

Electron impact dissociative ionization of SF_6 has been studied as a function of electron energy up to 600 eV with a specially constructed double collector cycloidal mass spectrometer. High transmission of ions was obtained by using ion source without slit and the collectors with a large area.

INTRODUCTION

Measurements of the absolute total ionization cross sections of SF_6 molecules for electrons were performed by Rapp and Englander-Golden (ref. 1) up to 300 eV. Partial ionization efficiency of SF_6 at 70 eV electron energy was measured by Dibeler and Mohler (ref. 2) and by Marriot (ref. 3) as well.

In this work the measurements of partial ionization cross sections were performed by means of a mass spectrometer with a very high and constant ion transmission between place of ion production in the source and the collectors (ref. 4). It prevents the mass discrimination so characteristic of conventional mass spectrometers. High transmission is obtained by using an ion source without slit and the collectors with a large area.

METHODS

The principle of the experiment is shown in Fig. 1 and ion current as a function of the electric field strength is shown in Fig. 2.

In order to maintain constant ion current (i.e. constant ion transmission) it is advisable to apply a relatively high value of the analysing electric field. At collector C1 sensitivity for SF^+, S^+ and F^+ ions is not constant for electric field up to 1,5 kV/m. At moving collector C2 it is easy to obtain "plateau" for relatively smaller value of the electric field.

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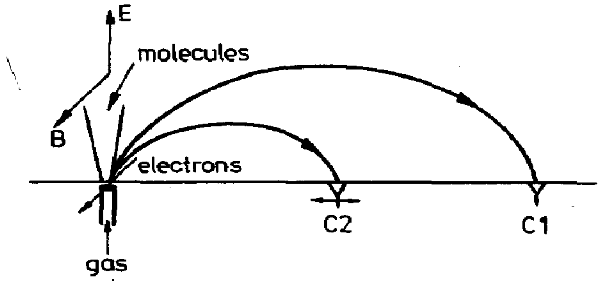

Fig. 1. Principle of the experiment: C1 - fixed collector, C2 - moving collector, E - electric field, B - magnetic field.

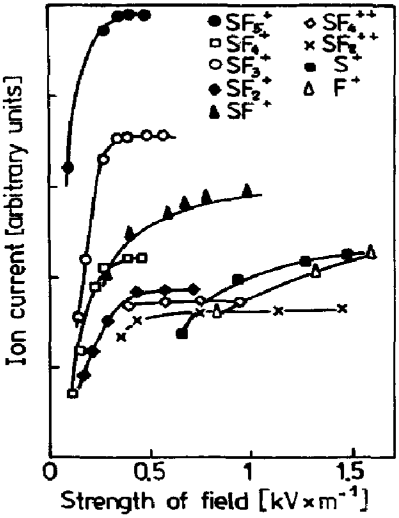

Fig. 2. Variation in sensitivity of the systems as a function of electric field strength.

RESULTS

The relative values of partial ionization cross section for the production of SF_5^+, SF_4^+, SF_3^+, SF_2^+, SF^+, S^+, F^+, SF_4^{++} and SF_2^{++} from SF_6 were measured. The values obtained were normalized according to absolute total ionization cross section of SF_6 obtained by Rapp and Englander-Golden. Total ionization cross section reported by Rapp and Englander-Golden and the sum of the ion currents as a function of electron energy is shown in Fig. 3. The equation

$$\frac{Q_T}{\Sigma I_i} = \mathrm{const} \tag{1}$$

where Q_T is the absolute total cross section and ΣI_i is the sum of ion currents is valid within error of 4% for the whole range of electron energies.

Variation of absolute partial ionization cross section with electron energy is shown in Fig. 4, 5, 6.

In this paper the SF_6^+ ion was not considered. For 100 eV electron energy the cross section for producing SF_6^+ is about 5×10^{-23} m^2 which is less than 0.1% of the total cross section.

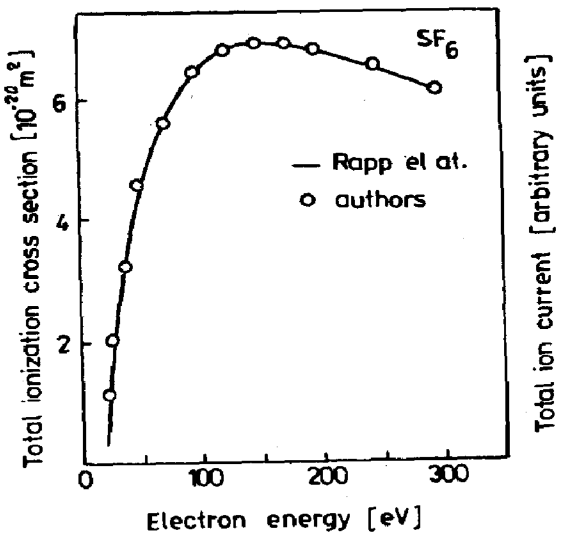

Fig. 3. Normalization of the sum of ion currents on the total cross section of Rapp and Englander-Golden.

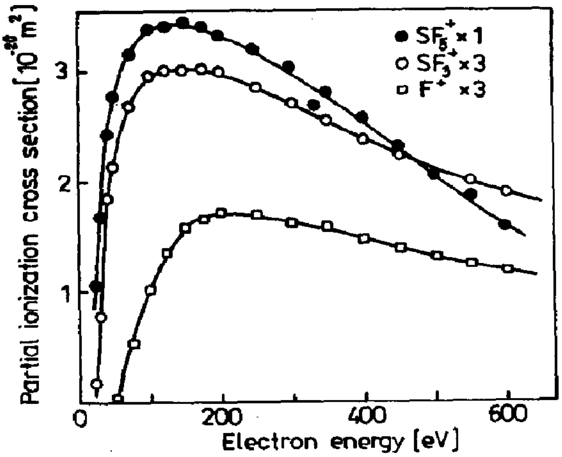

Fig. 4. Cross sections for the production of SF_5^+, SF_3^+ and F^+ from SF_6 by electron impact.

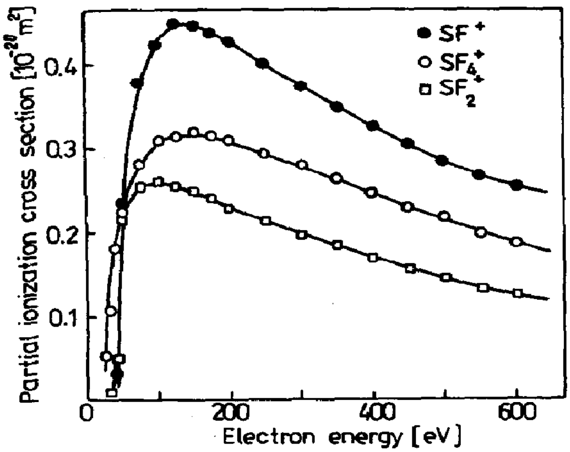

Fig. 5. Cross sections for the production of SF^+, SF_4^+ and SF_2^+ from SF_6 by electron impact.

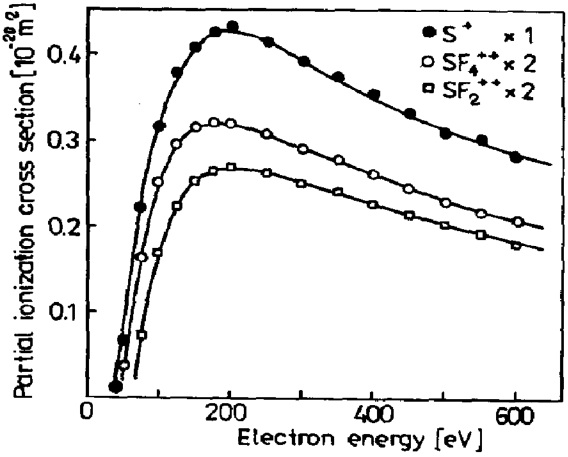

Fig. 6. Cross section for the production of S^+, SF_4^{++} and SF_2^{++} from SF_6 by electron impact.

The maximum of the curves appears to be at 145 eV with values of 3.43×10^{-20} m^2 for SF_5^+ and respectively:
145 eV - 0.32×10^{-20} m^2 for SF_4^+; 155 eV - 1.01×10^{-20} m^2 for SF_3^+;
100 eV - 0.26×10^{-20} m^2 for SF_2^+; 145 eV - 0.45×10^{-20} m^2 for SF^+;

200 eV - 0.43×10^{-20} m^2 for S^+; 215 eV - 0.56×10^{-20} m^2 for F^+; 190 eV - 0.16×10^{-20} m^2 for SF_4^{++}; 200 eV - 0.13×10^{-20} m^2 for SF_2^{++}.

To the authors' knowledge this is the first measurement of partial cross sections of the SF_6 molecule for such a wide range of electron energy.

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