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TOTAL ELECTRON IMPACT IONIZATION CROSS SECTIONS OF METHANOL, ETHANOL AND n-PROPANOL MOLECULES

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In this paper we report results of first measurements of total electron impact ionization cross section on methanol (CH_3OH), ethanol (C_2H_5OH) and n-propanol (C_3H_7OH) molecules in the incident electron energy range from threshold to 300 eV. Cross section values were determined to within $\pm 10\%$.

1. Introduction

Measurements of total charge production cross sections for the three simplest alcochols: methanol, etanol and n-propanol, represent a continuation of our efforts in absolute determination of these collision parameters for simple molecules of interest in various fields of physics and other related sciences. The discovery of these molecules in the interstelar space[1)] caused lately an increased interest for all properties related to collisions with electrons and photons.

The investigation of these three simplest alcochols was limited so far in electron and photon collisions to determination of electron binding energies[2,3)], ionization potentials[4)], abundances of various ions at a given incident electron energy[5,6,7,8)] and angular distributions of ions[9)]. Preliminary results of total ionization cross section measurements were reported recently[10)].

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2. *Experimental*

The measurements were performed using an interaction chamber with parallel plate collection electrodes and a trochoidal electron monochromator as a source of the incident electron beam, described in details elsewhere[11].

For the present set of measurements some experimental details were changed. In the interaction chamber two sets of parallel plate electrodes were used. Apart of the standard three-element parallel plate open-sided ion collector system, a five-element closed-sided collector system was used, too. The reason for its application were some doubts that in the three-element open-sided system two sources of errors could cause uncertainties in measured cross section values: the electric fringe field effect in the primary electron beam direction and the escape of some ions sideways due to the drift in the combined electric and magnetic fields.

The influence of the fringe field was investigated with the five-element system by collecting ions either only on the middle electrode or on the three inside electrodes. It was shown that this effect does not influence the measured cross section values and that the three-element collector system suffices for the purpose.

The other possible effect, the escape of ions sideways could not be proved with the five-element system. Instead, some additional effects close to ionization thresholds, due to collection of electrons with small excess energies drifting in the crossed electric and magnetic fields were observed. This made us to return to the earlier thoroughly investigated three-element open-sided collector system.

Gaseous targets were prepared by introducing the alcohol vapour through a needle valve from a bottle containing liquid alcohol into the interaction chamber. All alcohols of PA purity were further purified and dewaterized by metallic magnesium to 99.99%.

The target gas pressure, of the order of 10^{-3} Pa, was monitored by an ionization gauge, while the pressure value for callibration purposes was determined by a baratron-type capacitance manometer to within 3% as its accuracy is stated by the manufacturer (MKS).

Temperature of the interaction chamber was measured and monitored by a calibrated thermocouple. Mostly the measurements were done at room temperature. For final cross section determinations we have adopted the procedure as in the case of Ar ionization cross section measurements[11].

Primary electron beam and ion collection efficiencies have been determined for a number of incident electron energies following the procedure for quantitative determination of absolute ionization cross sections[12]. Linear dependences of the total ion currents vs. target gas pressure for constant electron energies and collection electric fields, as well as vs. electron beam intensities for constant target pressure and collection electric fields have been proved in tedious calibration procedures.

The total uncertainty in the cross section is mainly due to the determination of the target alcohol gas pressure and it is estimated to be about 10%.

3. *Results*

Total ionization cross section values at incident electron energies E were calculated using the well known equation

$$\sigma_{i,tot}(E) = (I_i/I_e) \cdot [(k \cdot T)/p] \cdot (1/L)$$

where: I_i is the intensity of the total ion current, I_e is the incident electron beam current, p is the target gas pressure and L is the length of the collection electrode along the primary electron beam. T is the gas temperature and k the Boltzmann constant.

Numerical values of total ionization cross section for methanol (CH_3OH) are tabulated in Table 1 and shown in Fig. 1. To the authors knowledge there are no other measurements of the total ionization cross section with which our data could be compared.

TABLE 1.

Electron energy (eV)	Cross section	Electron energy (eV)	Cross section
11	0.006	60	4.00
12	0.13	70	4.15
13	0.25	80	4.24
14	0.40	90	4.33
15	0.55	100	4.32
16	0.72	120	4.24
17	0.92	140	4.15
18	1.04	160	4.04
19	1.19	180	3.87
20	1.35	200	3.71
22	1.62	220	3.58
24	1.88	240	3.42
26	2.15	260	3.32
28	2.35	280	3.22
30	2.50	300	3.10
35	2.88		
40	2.31		
45	3.48		
50	3.66		

Total ionization cross sections of the methanol molecule by electron impact; in unit of 10^{-20} m^2, with an error of $\pm 10\%$.

Careful measurements of total ionization cross section for ethanol (C_2H_5OH) and n-propanol (C_3H_7OH) showed that their relative cross section curves are, apart in a narrow energy range above threshold, identical in shape with the corresponding curve for methanol. In order to prove this statement in Fig. 2 ratios of cross sections for these two molecules to those od methanol are presented. The variations of these ratios around mean values of 1.55 for ethanol and 1.78 for n-

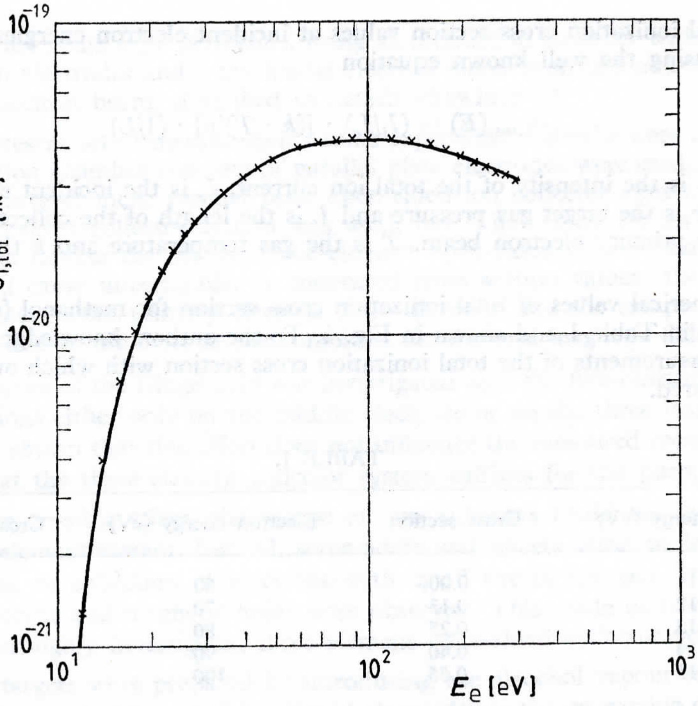

Fig. 1. Total ionization cross section of the methanol molecule by electron impact.

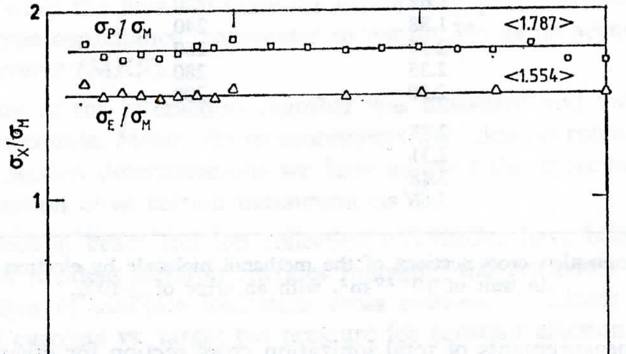

Fig. 2. Ratios of total ionization cross sections for the ethanol (E) and n-propanol (P) molecules to those of methanol (M) proving identical shapes of cross section curves.

propanol, respectively, are within the experimental errors in individual cross section measurements. For these two alcochols there are also no other measurements available in the literature to which present data could be compared.

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TOTALNI PRESECI ZA JONIZACIJU MOLEKULA METANOLA, ETANOLA I n-PROPANOLA UDAROM ELEKTRONA

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Originalni naučni rad

U ovom radu saopštavamo rezultate prvih merenja totalnih preseka za jonizaciju molekula metanola (CH_3OH), etanola (C_2H_5OH) i n-propanola (C_3H_7OH) udarom elektrona upadne energije od praga do 300 eV. Vrednosti preseka određene su sa greškom od $\pm 10\%$.

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