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NO^+, N^+_3, O^+_3 Ion Generation as an Effect of Crossing an Effusion Air Molecular Beam with an Electron Beam

Dedicated to Professor
Mieczysław Subotowicz on occasion
of his 65th birthday and
45th years of scientific work

INTRODUCTION

The nitrogen and oxygen are the main compounds of air. A knowledge of ion/molecular reactions in these gases is helpful for interpretation of number processes connected with physics and chemistry of atmosphere in particulary with air pollution.

In previous papers [1-4] the authors presented structures of effusion molecular beams generated by channels of different cross-sections. These studies presented a method of an optical simulation of molecular beams ionized by a transverse electron beam. In the work [5] the authors disscused ion/molecular reactions as an effect of crossing a CH_4 and H_2O effusion molecular beams with an electron beam. Secondary CH_5^+ and $C_2H_5^+$ ions were recorded in the case of CH_4 beam and H_3O^+ ions in the case a H_2O beam. Since molecular beams generated directly by effusive channels feature very high non-homogeneity both in the longitudinal and transverse directions with respect to their axis. Therefore this displacement of the electron beam along and transversely to the molecular beam enabled the authors to distinguish zones of different intensities of effusion beams, where respective ion/molecular reactions took place .

In the papers [6-7] the authors reported about mass-spectrometric investigations of dynamics of ozone and the nitric oxides synthesis in the corona discharges.

In this paper the investigations were preformed for air since the authors expected secondary NO^+, N_3^+, O_3^+ ions to appear as a result of well-known most probable reactions, which have been described in the literature for several decades [8-14], viz.

for primary ions :

$$O_2 + e \longrightarrow O_2^+ + 2e$$
$$\longrightarrow O^+ + O + 2e$$
$$N_2 + e \longrightarrow N_2^+ + 2e$$
$$\longrightarrow N^+ + N + 2e$$

for secondary ions :

$$O_2^+ + O_2 \longrightarrow O_3^+ + O$$
$$N_2^+ + N_2 \longrightarrow N_3^+ + N$$
$$N_2^+ + O_2 \longrightarrow NO^+ + NO$$

The air effusion molecular beam was generated by means of cylindrical capillary of diameter 2R = 0.2 mm and length h = 15 mm (h = 150R). The molecular beam was ionized by an electron beam of circular cross-section of diameter of 0.2 mm. The energy of electrons was 100 eV, because in this area of energy the ionization cross-section for N_2, O_2 is maximal [15-18]. The electron beam was the constant central position to the molecular beam axis. This system was an ion source of a cycloidal

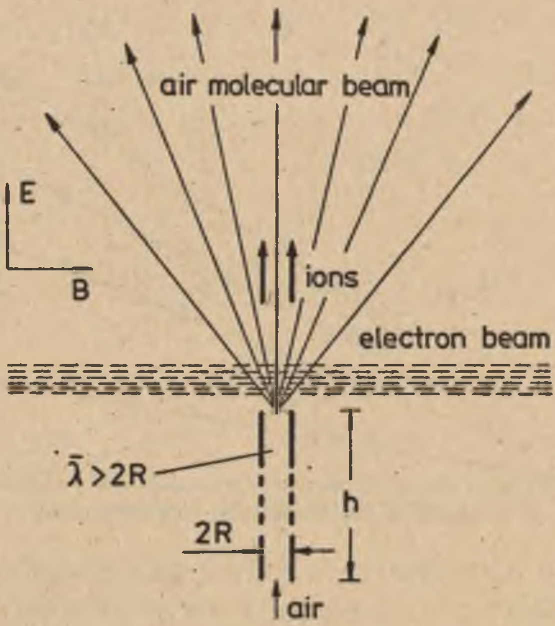

Fig. 1. An open ion source in a cycloidal mass spectrometer. A non-homogeneous effusion molecular beam generated directly by cylindrical capillary, crossed by an electron beam.

mass spectrometer, which was used to analyse and register the ions being generated (fig. 1).

RESULTS

In this paper, the account is limited to a qualitative presentation of the observed ion/molecular reactions in an air effusion beam crossed by an electron beam. For this reason, only relative values are specified for the gas pressures which were maintained during the experiment described. Figure 2 shows primary current intensity of N^+, O^+, N_2^+, O_2^+, ions as a function of air pressure in the molecular beam. Figure 3 shows an effect of the air molecular beam intensity on the intensity of the secondary NO^+, N_3^+ and O_3^+ ions generated as the result of crossing of molecular beam with the electron beam.

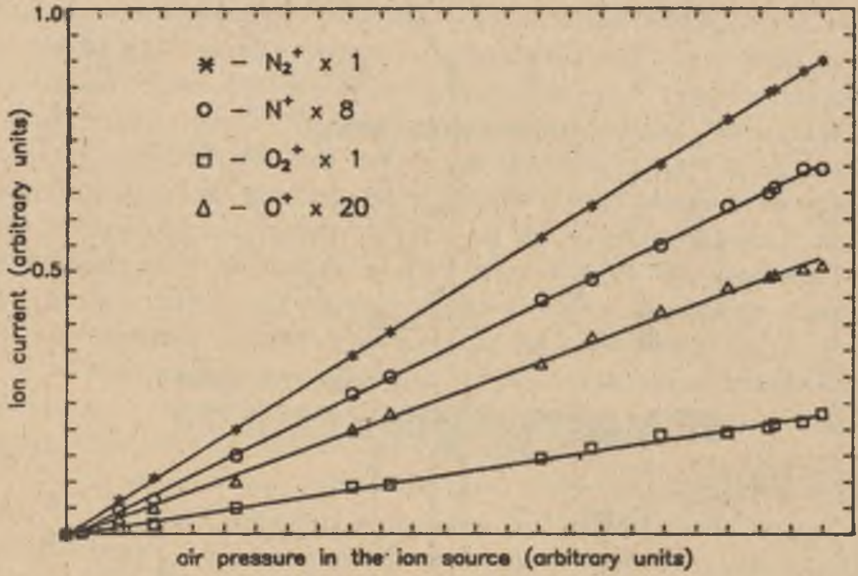

Fig. 2. Primary ionization of the air effusion molecular beam by electron impact. The ion currents are plotted as a function of pressure in the effusion beam.

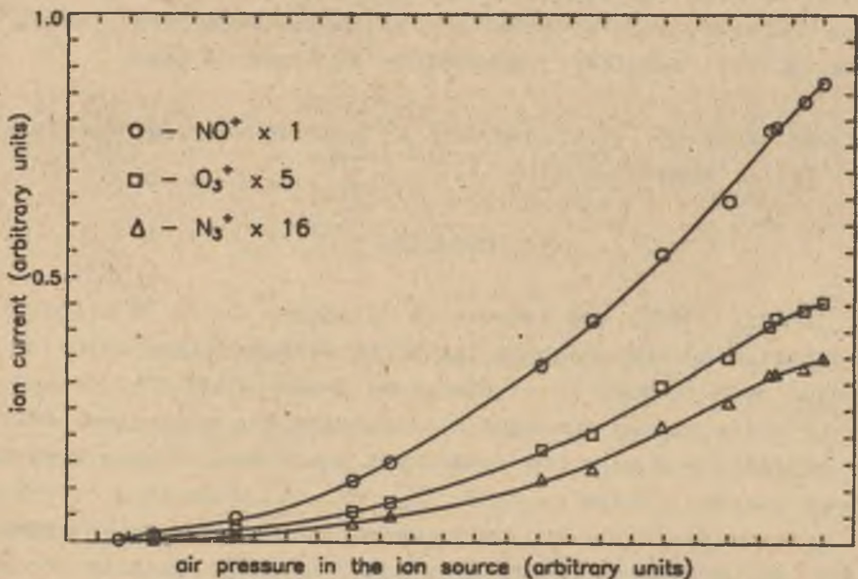

Fig. 3. Secondary ionization of the air effusion molecular beam.

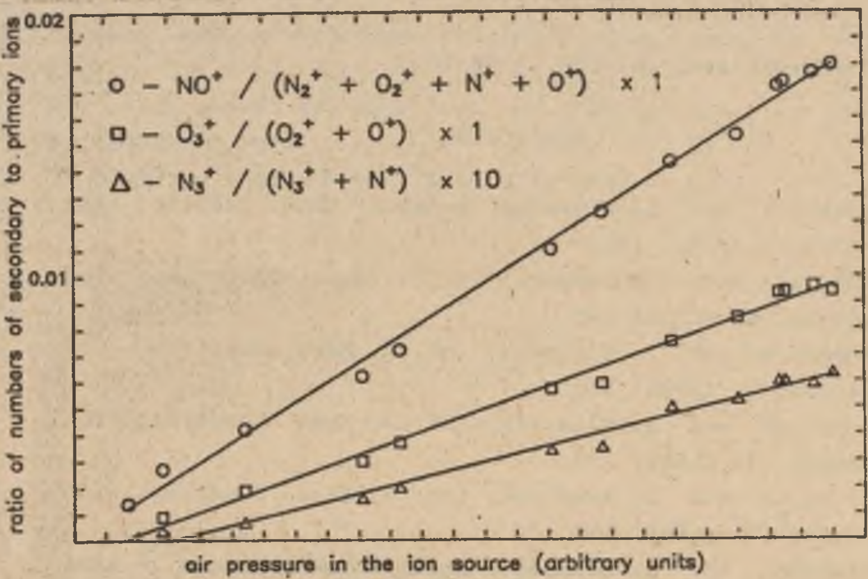

Fig. 4. The ratios of the number of secondary to primary ions are plotted as a function of air pressure in the air effusion beam.

In the case of primary ionization (fig.2) the ion currents are the linear function of pressure, while in the case of secondary ionization this is parabolic dependence.

Figure 4 presents the ratios of numbers of secondary to primary ions as a function of air pressure in the effusion beam.

CONCLUSION

In this work the system of crossing an air effusion molecular beam with an electron beam is an open ion source of a cycloidal mass spectrometer. Thus the ionization processes that take place are recorded directly, free of effect concerned with walls on slots, which are characteristic for conventional ion sources.

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