Ion mobility study of negative corona discharge in mixtures $\text{O}_2/\text{N}_2$

M. Stano, E. Safonov, F. Janky, M. Kučera, M. Sabo, V. Y. Chernyak, J. D. Skalný and Š. Matejčík

Department of Experimental Physics, Comenius University, Mlynska dolina F2, 842 48 Bratislava, Slovakia.
Radiophysical Faculty, National Taras Shevchenko University, Glushkova 2, Kyiv, Ukraina.

INTRODUCTION

Ion mobility spectrometry (IMS) is an ion separation method based on individual velocities of ions as they drift in a weak electric field through an inert gas at ambient pressure. This analytical technique has a variety of applications especially for detection of trace amount of organic compounds in the air [1].

The velocity $v$ of a drifting ion is proportional to the electric field intensity $E$

$$v = KE$$

where $K [\text{cm}^2\text{V}^{-1}\text{s}^{-1}]$ is the ion mobility. As the mobility of ions depends on temperature and pressure of the drift gas, it is usually expressed in terms of reduced mobility $K_0$ which is the mobility of ion at standard conditions $T_0 = 273 \text{ K}$ and $p_0 = 101 \text{ kPa}$.

$$K_0 = K \frac{T_0 p}{T p_0}$$

Reduced mobility is characteristic for every combination of ion and a drift gas. In present work we use IMS to study ions formed in negative corona discharge in $\text{O}_2$. We investigate mobility of produced ions after introducing $\text{CO}_2$, $\text{N}_2$ and $\text{H}_2\text{O}$ into discharge.

EXPERIMENTAL SETUP

The work was carried out on a home built ion mobility spectrometer shown on figure 1. It consists of the corona discharge ion source, reaction part and a drift tube. The corona discharge is realised in a point to plane geometry between a tungsten wire tip (wire diam. 100 μm) and a stainless steel grid. The distance between electrodes is 9 mm and voltage 3 to 5 kV. The gas flows into discharge through a port which is in proximity of the corona electrode.

Fig. 1.Schematic view of ion mobility spectrometer.
The ions produced in the ion source drift through reaction region of the spectrometer. The sample gas can be introduced and can react with primary ions in this region. The reaction region of the spectrometer is separated from ion source and from drift tube by appertures with 10 mm diameter. Reaction region contains also gas outlet from the whole spectrometer. Entrance of the ions into the drift tube is controlled by a shutter grid (SG) which is periodically opened for a short time 100 μs. Shutter is a Bradbury-Nielsen type, it is formed by two sets of wires placed in one plane so that every second wire is from the same group. If there is a voltage applied between the wire sets, a transversal electrical field is formed, prohibiting ions to pass into the drift tube. SG is open when both wire sets are on the same potential. Ions are separated according to their drift velocities in homogenic electric field along the drift tube. The drift tube length is 94 mm and the intensity of electric field is 324 V/cm. The ion current is measured on a collector placed in the end of drift tube. The collector is shielded by an aperture grid.

RESULTS
In the present work we have studied ions formed in negative corona discharge in oxygen and in mixtures of oxygen with N₂. The gasses were added either to corona discharger or into reaction part of the spectrometer. The separation of ions was performed in oxygen. The purity of oxygen used in this work was 5.0.

In the pure oxygen discharge we have observed production of three ions of which the ion with mobility 2.46 cm²V⁻¹s⁻¹ was strongly dominant. The ions with mobilities 2.28 and 2.02 cm²V⁻¹s⁻¹ were observed with much lower intensities. The mobility of the dominant ion is close to 2.55 which was reported for O₃⁻ in O₂ by Snuggs et al. [2]. These authors reported similar values of mobility in O₂ also for CO₃⁻ 2.50 and for CO₄⁻ 2.45 cm²V⁻¹s⁻¹.

![Graph of ion mobility spectrum](image)

**Fig. 2.** Ion mobility spectrum of the negative corona discharge in pure O₂ (99.999%).

The mixture of oxygen with nitrogen was added to ion source or into reaction part with concentration of N₂ ranging from 2.5% to 50%. Presence of N₂ in the reaction part did not result in any observable effect except of slight decrease of the dominant ion intensity. The N₂ in ion source results in formation of new anionic products with mobilities 2.38 and 2.09 cm²V⁻¹s⁻¹. The intensity of new products is increasing with concentration of N₂ and the 2.38 cm²V⁻¹s⁻¹ ion becomes dominant at 50% content of N₂ in the gas mixture, see Fig. 3.
CONCLUSIONS

We have observed that formation of ions in negative corona discharge is strongly influenced when nitrogen is added into negative corona discharge in O₂. The formation of several new anionic products has been observed in addition to that observed in pure oxygen. Formation of these new products was not observed if N₂ was added to the reaction part of spectrometer where these compounds may react with ions formed in the ion source. We assume that formation of all new products is initiated by electron induced reaction in proximity of coronating electrode inside the ion source.

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REFERENCES