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Experimental Ion Mobility measurements in Ne-CO₂ and CO₂-N₂ mixtures

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ABSTRACT: In this paper we present the experimental results for the mobility, K_0 , of ions in neon-carbon dioxide (Ne-CO₂) and carbon dioxide-nitrogen (CO₂-N₂) gaseous mixtures for total pressures ranging from 8–12 Torr, reduced electric fields in the 10–25 Td range, at room temperature. Regarding the Ne-CO₂ mixture only one peak was observed for CO₂ concentrations above 25%, which has been identified as an ion originated in CO₂, while below 25% of CO₂ a second-small peak appears at the left side of the main peak, which has been attributed to impurities. The mobility values for the main peak range between 3.51 ± 0.05 and 1.07 ± 0.01 cm²V⁻¹s⁻¹ in the 10%–99% interval of CO₂, and from 4.61 ± 0.19 to 3.00 ± 0.09 cm²V⁻¹s⁻¹ for the second peak observed (10%–25% of CO₂). For the CO₂-N₂, the time-of-arrival spectra displayed only one peak for CO₂ concentrations above 10%, which was attributed to ions originated in CO₂, namely CO₂⁺(CO₂), with a second peak appearing for CO₂ concentrations below 10%. This second peak, with higher mobility, was attributed to CO₂⁺ ions. The mobility values of the main peak range between 2.11 ± 0.04 and 1.10 ± 0.03 cm²V⁻¹s⁻¹ in the 1%–99% interval of CO₂, while the second peak's from 2.26 ± 0.02 and 1.95 ± 0.04 cm²V⁻¹s⁻¹ (1%–10% of CO₂). The inverse of the mobility displays an approximately linear dependence on the CO₂ concentration in the mixture.

KEYWORDS: Charge transport and multiplication in gas; Ion sources (positive ions, negative ions, electron cyclotron resonance (ECR), electron beam (EBIS)); Gaseous detectors; Ionization and excitation processes

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1 Introduction

Measuring the mobility of ions in gases is highly relevant in several areas from physics to chemistry. For example, in gaseous radiation detectors, the drift of positive ions together with the drift of electrons have an important role in pulse shaping [1–3]. In order to fully understand and to model these detectors it is of great importance to have detailed information on the transport properties of ions.

The present work, investigates the ionization processes taking place in neon-carbon dioxide (Ne-CO₂) and carbon dioxide-nitrogen (CO₂-N₂) mixtures, extending previous studies developed in our group for other gases [4–11]. Using the experimental method described in detail in [5], the mobility of ions in Ne-CO₂ and in CO₂-N₂ is measured in the 6 to 10 Torr range and for reduced electric fields used in gaseous detectors. Very good results for other gases have already been reported with the technique and analysis used.

1.1 Ion Mobility

Consider a group of ions moving in a weakly ionized gas under a uniform electric field. Under these conditions, the ions collide with the neutral molecules of the gas, losing energy in the collisions and gaining/losing energy from the electric field. A steady state will eventually be reached when the resulting average speed of this group of ions, also called drift velocity, v_d , is directly proportional to the electric field intensity, as expressed by the following equation:

$$v_d = KE \quad (1.1)$$

where K is the mobility of the ions, expressed in units of $\text{cm}^2 \cdot \text{V}^{-1} \cdot \text{s}^{-1}$ and E the intensity of the drift electric field. In the literature, the ion mobility, K , is frequently expressed in terms of the reduced mobility K_0 , as follows

$$K_0 = KN/N_0 \quad (1.2)$$

where N is the gas number density and N_0 is the Loschmidt number ($N_0 = 2.6867 \times 10^{25} \text{ m}^{-3}$). The mobility measurements are usually presented as a function of the reduced electric field E/N in units of Td ($1 \text{ Td} = 10^{-21} \text{ Vm}^2$).

1.2 Langevin's Theory

According to Langevin's theory [12], one limiting value of the mobility is reached when the repulsion becomes negligible compared to the polarization effect. This limit is given by the following equation,

$$K_0 = 13.88 \left(\frac{1}{\alpha\mu} \right)^{\frac{1}{2}} \quad (1.3)$$

where α is the neutral polarisability in cubic angstroms ($\alpha = 0.394 \text{ \AA}^3$ for Ne [13], $\alpha = 2.613 \text{ \AA}^3$ for CO_2 [11] and $\alpha = 1.74 \text{ \AA}^3$ for N_2 [13]) and μ is the ion-neutral reduced mass in atomic mass units. The Langevin limit is the value of K_0 in the double limit of low E/N and low temperature, conditions which ensure the dominance of the polarization attraction over the hard sphere repulsion. The approximations involved in this model are consistent and describe well our experimental conditions: low pressure, low temperature and low reduced electric fields.

1.3 Blanc's Law

In gaseous detectors such as drift and wire chambers, gaseous electron multipliers (GEMs) and ionization and scintillation chambers, the use of gas mixtures is commonly adopted. Mixtures can be used to optimize radiation detection, in particular by adding molecular dopants to noble gases to improve the electron drift velocities and minimize diffusion, which include experiments like NEXT [14] and ALICE TPC. Blanc's empirical law, which resulted from Blanc's work in the mobility of ions in binary gaseous mixtures, has proven to be most useful when determining the ions' mobility using mixtures of gases. Blanc found that the mobility of ions in gaseous mixtures, K_0 , obeyed a simple relationship as long as the charge transfer interaction is negligible compared to the polarization attraction and short-range repulsion between ion and atoms/molecules.

This relationship can be expressed as follows:

$$\frac{1}{K_{0 \text{ mix}}} = \frac{f_1}{K_{0 \text{ g1}}} + \frac{f_2}{K_{0 \text{ g2}}} \quad (1.4)$$

where $K_{0 \text{ mix}}$ is the reduced mobility of the ion in the binary mixture; $K_{0 \text{ g1}}$ and $K_{0 \text{ g2}}$ the reduced mobility of that same ion in an atmosphere of 100% of gas #1 and #2 respectively; f_1 and f_2 are the molar fraction of each gas in the binary mixture [15].

2 Method and Experimental setup

The measurements were carried out using a technique conceived and developed by Neves et al., [5]. This technique makes use of a gaseous electron multiplier (GEM) covered with a 250 nm thick

CsI film, which acts as a photocathode emitter of electrons that will further ionize the atoms or molecules of the gas, a UV flash lamp (Hamamatsu L2439) with a frequency of 10 Hz with a pulse duration shorter than $0.5 \mu\text{s}$, and two grids (the collecting and Frisch grids) separated by 0.5 mm.

The flash of the UV lamp releases photoelectrons from the CsI film deposited on the top electrode of the GEM. These electrons are guided through the GEM holes by the electric field applied between the top and bottom electrodes of the GEM, leading to the ionization of the gas molecules encountered along their drift. Electrons are then collected at the bottom GEM electrode while the resulting cations drift in the opposite direction, towards the Frisch and collecting grids under an uniform electric field. The electronic pulse collected is then converted from current to voltage by a pre-amplifier before being recorded in a digital oscilloscope (Tektronix TDS 1012) and fed to a PC for further processing and storage. From the centroid of the gaussian fit the ions' drift time is determined which, together with the known distance from the GEM to the collecting grid, allows the calculation of both average ion drift velocity and mobility. For the gaussian fittings the least-squares method was used [16] with an estimated uncertainty in the peaks centroids lower than 0.5%. Additionally, estimated errors (systematic plus statistical) for the drift distance, drift time and reduced electric field are about 1%, and are included in the error figures of tables 1 and 2.

The conceived experimental technique described has already been used for the determination of ion mobility in their parent gases in earlier experiments, which is useful for gaseous detectors studies [3]. Even though this method does not allow direct identification of the ions it has some features which allow their indirect identification. One of the features of the method is the capability of controlling the voltage across the GEM (V_{GEM}) and thus, the energy gained by the photoelectrons as they move across the GEM holes. This characteristic proves to be a great advantage since it enables the identification of the primary ions based on their ionization energies. Identifying the primary ions will allow to pinpoint secondary reaction paths that lead to the identification and validation of the detected ions. The method described together with the knowledge of the dissociation channels, product distribution and rate constants represent a valid, although elaborate, solution to the ion identification problem.

3 Results and Discussion

The mobility of the ions originated in Ne-CO₂ and in CO₂-N₂ mixtures has been measured for different reduced electric fields E/N (from 10 Td up to 25 Td) and different pressures (in the 8-12 Torr range) at room temperature (298 K). For each spectrum the background noise was subtracted and since impurities play an important role in the ions' mobility, a strict gas filling procedure was carried out. No measurement was considered until the signal stabilised, and all measurements were done in a 2-3 minutes time interval to prevent the degradation of the ions induced signal due to outgassing. Before each experiment the vessel was vacuum pumped down to pressures of 10^{-6} to 10^{-7} Torr to guarantee minimal contamination of the system. The limited range of the reduced electric field values used to determine the ions' mobility has two distinct origins: one is the electric discharges that occur at high E/N values; the other is the observed deterioration of the time of arrival spectra for very low values of E/N (below 5 Td), which has been attributed to the collisions between the ions and impurity molecules.

We recall that a background work on the mobilities and ionization processes of Ne [4], CO₂ [11] and N₂ [6] in their parent gases has already been performed in our group. The results regarding these works will be summarized in the next sections.

3.1 Neon (Ne)

In previous work [4] for Neon (Ne) and for electron impact ionization with energies of about 30 eV, using reduced electric fields (E/N) between 6 and 26 Td and for a pressure range of 4-10 Torr at room temperature (298 K), two peaks have been reported. These peaks were identified as corresponding to the atomic (Ne⁺) and dimer ions (Ne₂⁺).

From the literature it is known that while the atomic ion (Ne⁺) is the result from direct electron impact ionization at our working pressures, the dimer rare gas ion (Ne₂⁺) is a result of a 2-step process described by the following reactions:



The atomic ion has a lower mobility than the dimer one, in agreement with the quantum-mechanical concept of weaker exchange forces, which consists of the resonant charge transfer process between Ne⁺ ions and Ne atoms, that results in the slowing down of these ions.



In this work the extrapolation to zero field yields values of 4.4 cm²V⁻¹s⁻¹ for Ne⁺ and 6.2 cm²V⁻¹s⁻¹ for Ne₂⁺ which are in good agreement with other published data [17, 18].

3.2 Carbon Dioxide (CO₂)

Regarding the pure carbon dioxide (CO₂) case, we recall that only one peak was observed for different reduced electric fields, E/N , (6–40 Td) and for pressures in the 8–12 Torr range at room temperature (298 K) in previous works, which was attributed to CO₂⁺ in [11] and to CO₂⁺(CO₂) cluster in [19].

The experimental measurements lead to a reduced mobility value, K_0 , of 1.17 cm²V⁻¹s⁻¹ which is in good agreement with the ones obtained by other authors [20, 21].

Despite this good experimental agreement with either [11] and [19], these values substantially differ from the theoretical ones for CO₂⁺ ($K_0 = 1.81$ cm²V⁻¹s⁻¹), obtained using the Langevin limit.

In [11], the authors suggest that the ion responsible for the peak in the time-of-arrival spectra is CO₂⁺ and that the difference observed in the mobility value (when compared to the Langevin limit) may be due to the charge transfer process between CO₂⁺ and its parent gas, expressed by:



which lowers the ion velocity. The reaction constant of this process is $k = 3.7 \pm 0.37 \times 10^{-10}$ cm⁶s⁻¹ [22]. On the other hand in [19] it is proposed that the ion responsible for the peak observed is a CO₂ ion cluster. The authors of this work assume that under these conditions (E/N of 6–40 Td and pressures of 8–12 Torr at room temperature) the most important reaction of

CO_2^+ with the gas molecules is a three-body reaction (3.5) instead of the well-known resonant charge transfer reaction (3.4), leading to the formation of a $\text{CO}_2^+(\text{CO}_2)_n$, with n equal to 1.



with a reaction constant equal to $k = 2.1 \times 10^{-28} \text{ cm}^6 \text{ s}^{-1}$ [23].

3.3 Nitrogen (N_2)

In previous work with nitrogen (N_2) [6], for different reduced electric fields (15 to 35 Td) and pressures (6 to 16 Torr) at room temperature (298 K), only one peak has been reported using a V_{GEM} of 22 V. The mobility value obtained in this case when extrapolating to zero reduced electric field was $2.37 \pm 0.02 \text{ cm}^2 \text{ V}^{-1} \text{ s}^{-1}$, with the ion being identified as N_4^+ , in good agreement with other published data [24, 25].

In the same work it is explained why, although both N_2^+ and N_4^+ are produced, only the N_4^+ is present. In fact N_2^+ quickly reacts with N_2 originating N_4^+ through reaction (3.6) ($k \approx 5 \times 10^{-29} \text{ cm}^6 \text{ s}^{-1}$).

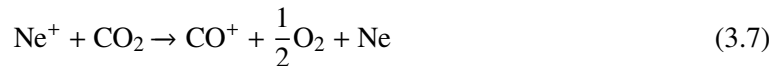


Also, since the dissociation energy of N_4^+ (0.87 eV) is much larger than the kinetic energy of the ion under low reduced electric field, once N_4^+ is formed it will have a low probability of dissociating back into N_2^+ and N_2 [6].

3.4 Ne- CO_2 Mixture

In neon-carbon dioxide (Ne- CO_2) mixtures with CO_2 concentrations higher than 25% only one peak is observed, as seen in figure 1. The ion responsible for this peak is the same ion as in pure CO_2 .

Since the total ionization cross section for electron impact (for an energy of 25 eV) in Ne is $0.036 \times 10^{-16} \text{ cm}^2$ [26] — much lower than the total cross section of CO_2 ($1.18 \times 10^{-16} \text{ cm}^2$ [27]), it is expected that even at low CO_2 concentrations, CO_2 ions are still the ones that are preferentially produced. Additionally, with the increasing availability of Ne in the mixture, Ne^+ ions will be produced more abundantly, and according to the rate constants available, they are more likely to react with CO_2 (3.7) ($k = 0.05 \pm 0.1 \times 10^{-9} \text{ cm}^3 \text{ s}^{-1}$), than with Ne via reaction (3.2) ($k = 0.6 \times 10^{-31} \text{ cm}^6 \text{ s}^{-1}$) since the reaction time of the latter is higher than any other reaction channel in the pressure conditions used in this experiment. So, in the present conditions the presence of Ne ions will lead to the formation of the same ions as seen in pure CO_2 but through a different reaction channel, first producing CO^+ (reaction (3.7)) which will further react with CO_2 via reaction (3.8) ($k = 1.02 \times 10^{-9} \text{ cm}^3 \text{ s}^{-1}$) leading to the formation of CO_2^+ :



In figure 1 the time-of-arrival spectra for several Ne- CO_2 mixtures (10%, 25%, 50% and 75% of CO_2) at a pressure of 8 torr, temperature of 298 K and for a reduced electric field of 25 Td with a voltage across GEM of 25 V are displayed.

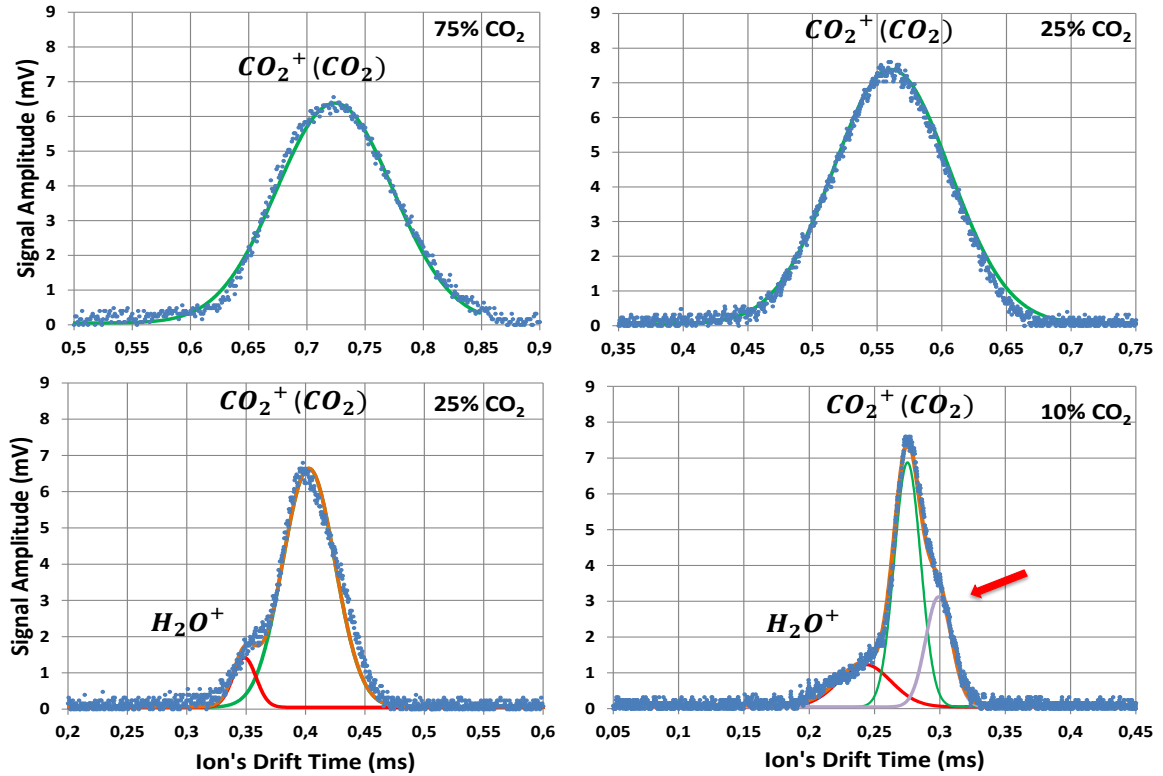


Figure 1. Time-of-arrival spectra averaged over 128 pulses for several Ne-CO₂ mixtures (10%, 25%, 50% and 75% of CO₂) at a pressure of 8 torr, temperature of 298 K and for a reduced electric field of 20 Td with a voltage across GEM of 25 V (background noise was already subtracted).

Apart from the peak area, that varies with CO₂ concentration in the mixture, which is clearly related to the availability of CO₂, a peak shift to lower drift times with decreasing concentration of CO₂ was also observed. This shift translates into an increase in the ion mobility. The peak shift can be due to two effects: the decreasing availability of CO₂ that will decrease the probability of collision between CO₂⁺ and CO₂ gas molecules resulting in less resonant charge transfer reactions; and the fact that Ne has a much smaller mass than CO₂ ion species implying much lower energy loss.

Besides the decrease in peak area with the decreasing concentration of CO₂ in the mixture, for CO₂ concentrations below 25% a small bump starts to show up on the left side of the main peak. The possibility of this peak corresponding to O⁺ was discarded by lowering the GEM voltage below the ionization energy for this ion formation (19 eV) and observing that the small bump remained visible, for CO₂ concentrations lower than 25%. We attributed this second peak to the presence of water, that result from outgassing processes inside the detector and also observed in other mixtures like in Ar-CO₂ [11].

For CO₂ concentrations below 10% yet another peak starts to appear. Since there are lack of reaction paths that originate new ions, we were not able to completely identify the origin of this bump. One possibility is that this bump corresponds to CO₂⁺, due to the lower availability of CO₂ to produce the clusters, making the cluster formation through reaction (3.4) less probable and allowing some CO₂⁺ ions to reach the collecting grid.

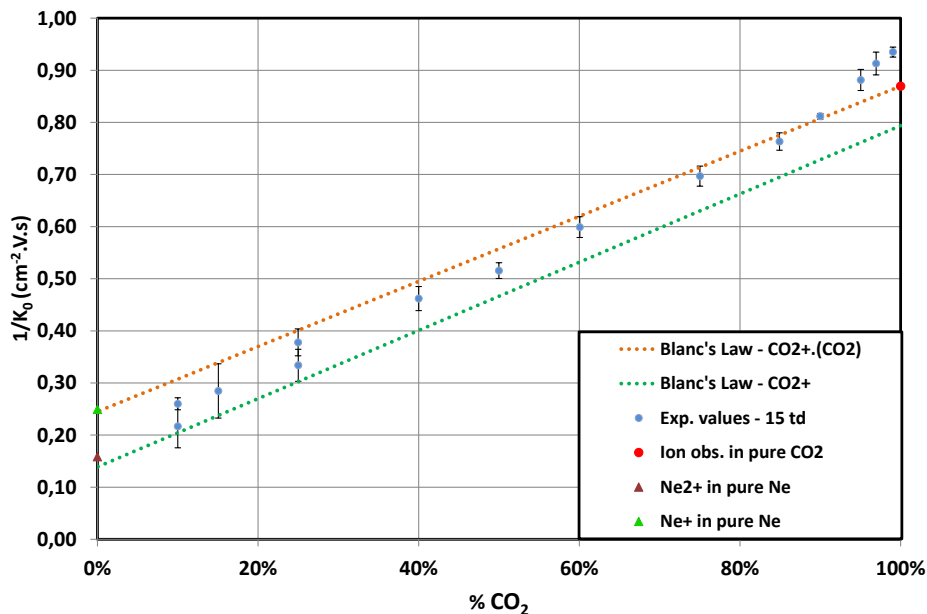


Figure 2. Inverse of the reduced mobility of the ions produced in the Ne-CO₂ mixture for a pressure of 8 Torr and for a E/N of 15 Td at room temperature. The dotted lines (orange — CO₂⁺(CO₂) and green CO₂⁺) represent the mobility values expected from Blanc's law.

As mentioned, Blanc's law is used to predict the mobility of the ions in gaseous mixtures. In figure 2 we plot the inverse of the reduced mobility of the ions produced in the Ne-CO₂ mixture as a function of the different mixture ratios studied for a pressure range of 8-12 Torr and for $E/N = 15$ Td, at room temperature (298 K).

Dotted lines representing the Blanc's law of the most probable candidate ions namely CO₂⁺ and CO₂⁺(CO₂) are also displayed. The K_{0g1} and K_{0g2} used for the representation Blanc's law (1.4) were taken from [29] for CO₂⁺ in Ne and for CO₂⁺ in CO₂, while for CO₂⁺(CO₂) in CO₂ the experimental value was used and for CO₂⁺(CO₂) in Ne it was calculated using Langevin's formula (see Equation 1.3).

Looking at figure 2 it is possible to observe that the ion mobility experimentally obtained roughly follows Blanc's law for the CO₂⁺(CO₂) ion throughout the entire mixture range, while for the concentrations below 25% of CO₂ slightly deviating from it towards the CO₂⁺ theoretical line. Due to the high uncertainty on the determination of the centroid of this small bump on the right side of the main one, it was discarded and its mobility value is not displayed in table 1.

From 0 to 100% CO₂, the peaks observed were seen to vary in position and area, demonstrating that the ion or ions formed and their mobilities depend on the ratio of the two gases used. The mobility values of the ions observed for the Ne-CO₂ mixture ratios of 5%, 10%, 15%, 25%, 40%, 50%, 60%, 75%, 85%, 90%, 95%, 97% and 99% of CO₂, at E/N of 15 Td, pressure of 8 Torr and at room temperature (298 K) are summarized in table 1.

In the range of pressures used (8–12 Torr) no significant dependence of the mobility was observed, with the behaviour of the mobility with E/N (from 10 to 25 Td) remaining approximately constant.

Table 1. Mobility of the ions observed for the Ne-CO₂ mixture ratios studied, obtained for E/N of 15 Td, a pressure of 8 Torr at room temperature (298 K).

Mixture	Mobility (cm ² V ⁻¹ s ⁻¹)	Mobility (cm ² V ⁻¹ s ⁻¹)
Ne-CO ₂	CO ₂ ⁺ .CO ₂	H ₂ O ⁺
10% CO ₂	3.85 ± 0.04	4.61 ± 0.19
15% CO ₂	3.51 ± 0.18	-
25% CO ₂	2.65 ± 0.07	3.00 ± 0.09
40% CO ₂	2.16 ± 0.02	-
50% CO ₂	1.94 ± 0.03	-
60% CO ₂	1.67 ± 0.03	-
75% CO ₂	1.43 ± 0.03	-
85% CO ₂	1.31 ± 0.02	-
90% CO ₂	1.23 ± 0.01	-
95% CO ₂	1.13 ± 0.02	-
97% CO ₂	1.10 ± 0.02	-
99% CO ₂	1.07 ± 0.01	-

3.5 CO₂-N₂ Mixture

In carbon dioxide-nitrogen (CO₂-N₂) mixtures, only one peak was observed for CO₂ concentrations ranging from 10% to 100%, while below 10% a second peak starts to emerge from the first one as can be seen in figure 3. In this case the ion responsible for the main peak observed is the ion produced in pure CO₂ as in the previous mixture — CO₂⁺.(CO₂) (see section 3.4), while the second peak is attributed to CO₂⁺.

In this case, the total electron impact ionization cross section of N₂ for 25 eV is 0.64×10^{-16} cm² [28], lower than the total CO₂ ionization cross section (1.18×10^{-16} cm² [27]). It is thus expected that even at higher N₂ concentrations, CO₂ ions are the ones preferentially produced. With increasing availability of N₂ in the mixture, N₂⁺ ions will be produced more abundantly, and according to the rate constants available, they are more likely to transfer the charge to CO₂ through reaction (3.9) ($k = 0.55 \times 10^{-9}$ cm³s⁻¹), rather than reacting with N₂ via the three-body reaction (3.6) ($k = 5 \times 10^{-29}$ cm⁶s⁻¹) for which the reaction time is higher than the other possible reaction channels, for the pressure conditions used in the present study. As a result in the CO₂-N₂ mixtures, N₂ ions will lead to the formation of the same CO₂ ion as in pure CO₂, originating CO₂⁺ through the following reaction:



This reaction is similar to the one observed before in Ne-CO₂ mixture (see reactions (3.7) and (3.8)). In figure 4 we plot the inverse of the reduced mobility of the ions produced in the CO₂-N₂ mixture as a function of the different mixture ratios studied for a pressure of 8 Torr and for E/N of 15 Td, at room temperature (298 K). Dotted lines representing Blanc's law for the most probable candidate ions (CO₂⁺, CO₂⁺(CO₂)) are also displayed. In this case, for the representation the Blanc's law (1.4) $K_{0\text{g}1}$ and $K_{0\text{g}2}$ were taken from [29] for CO₂⁺ in N₂ and for CO₂⁺ in CO₂ while for CO₂⁺(CO₂) in

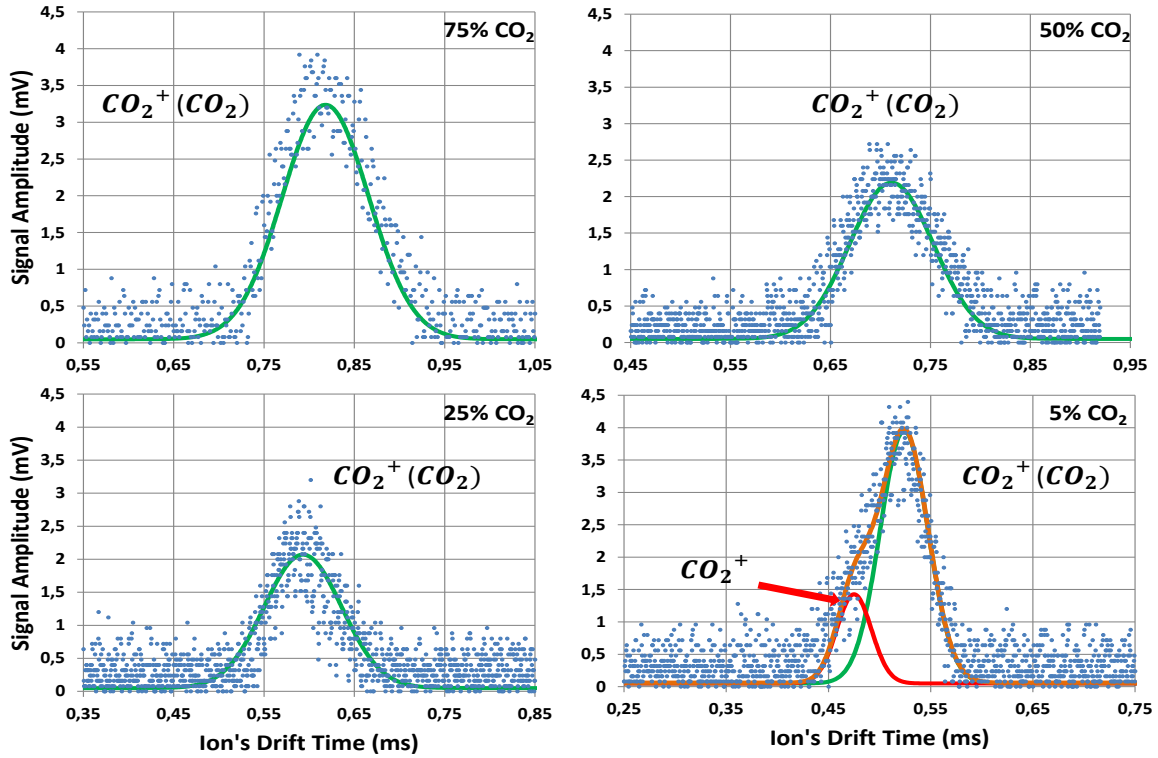


Figure 3. Time-of-arrival spectra averaged over 128 pulses for several Ne-CO₂ mixtures (5%, 25%, 50%, 75%, of CO₂) at a pressure of 8 torr, temperature of 298 K and for a reduced electric field of 20 Td with a voltage across GEM of 25 V (background noise was already subtracted).

CO₂ our experimental value was considered and the Langevin's formula (see Equation 1.3) was used to estimate the mobility of CO₂⁺(CO₂) in N₂.

Observing figure 4 it is possible to confirm that the ion mobility experimentally obtained follows Blanc's law for the CO₂⁺(CO₂) ion throughout the entire mixture range.

In addition it is possible to see that the experimental mobility values of the main ion observed display a behaviour coherent with the theoretical Blanc's law curves for the ion candidate (CO₂⁺(CO₂)) from 15% of CO₂, with the experimental values slightly deviating from those theoretical lines towards the CO₂⁺ line for lower CO₂ concentrations in the mixture. In fact, the lower availability of CO₂ in the mixture is responsible for the appearance of the second peak in this mixture as can be seen in figure 4. Since with lower availability of CO₂ the probability of producing CO₂⁺(CO₂) decreases, with the probability of observing the CO₂⁺ ion increasing, which is a direct result from the longer time of formation of the CO₂⁺(CO₂) (about 100 μs — only 4 times smaller than the drift time).

From 0 to 100% CO₂ the peaks observed were seen to vary, demonstrating that the ion mobility in the mixture depends on the ratio of the two gases. The mobility values of the peaks observed for the CO₂-N₂ mixture ratios of 1%, 3%, 5%, 10%, 15%, 25%, 40%, 50%, 60%, 75%, 85%, 90%, 95%, 97% and 99% of CO₂, obtained for E/N of 15 Td, with a pressure of 8 Torr at room temperature (298 K) are summarized in table 2.

No significant variation of the mobility was observed in the range of pressures (4-20 Torr) and of E/N (10-25 Td) studied, being approximately constant.

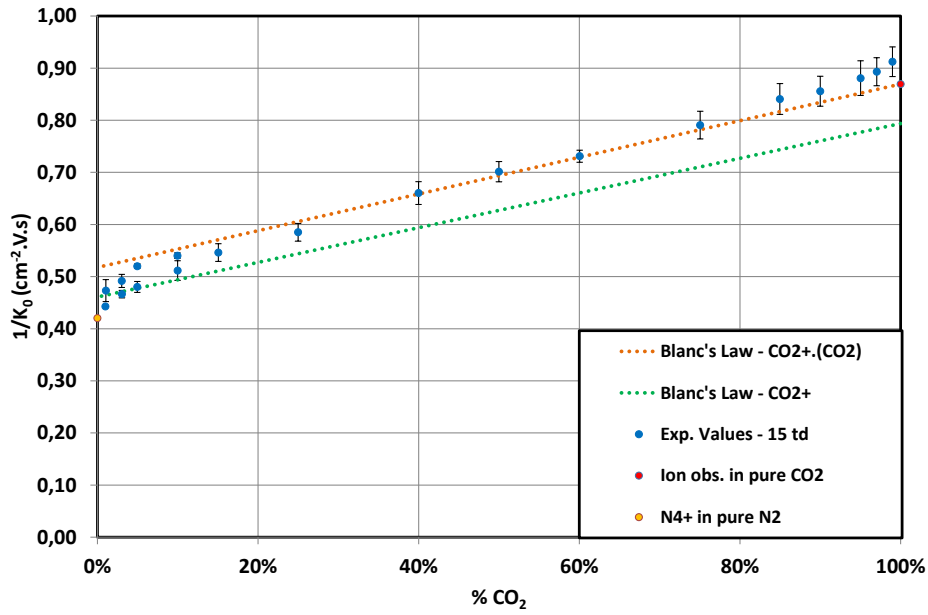


Figure 4. Inverse of the reduced mobility of the ions produced in the CO₂-N₂ mixture for a pressure range of 8-12 Torr and for a E/N of 20 Td at room temperature. The dotted lines (orange — CO₂⁺.(CO₂) and green CO₂⁺) represent the mobility values expected from Blanc's law.

Table 2. Mobility of the ions observed for the CO₂-N₂ mixture ratios studied, obtained for E/N of 15 Td, and a pressure of 8 Torr at room temperature (298 K).

Mixture	Mobility (cm ² V ⁻¹ s ⁻¹)	Mobility (cm ² V ⁻¹ s ⁻¹)
CO ₂ -N ₂	CO ₂ ⁺ .CO ₂	CO ₂ ⁺
1% CO ₂	2.11 ± 0.04	2.26 ± 0.02
3% CO ₂	2.03 ± 0.03	2.14 ± 0.02
5% CO ₂	1.92 ± 0.01	2.08 ± 0.02
10% CO ₂	1.85 ± 0.01	1.95 ± 0.04
15% CO ₂	1.83 ± 0.03	-
25% CO ₂	1.71 ± 0.03	-
40% CO ₂	1.51 ± 0.03	-
50% CO ₂	1.43 ± 0.03	-
60% CO ₂	1.37 ± 0.02	-
75% CO ₂	1.26 ± 0.03	-
85% CO ₂	1.19 ± 0.04	-
90% CO ₂	1.17 ± 0.03	-
95% CO ₂	1.11 ± 0.03	-
97% CO ₂	1.12 ± 0.03	-
99% CO ₂	1.10 ± 0.03	-

4 Conclusion

In the present work we measured the reduced mobility of ions originated by electron impact in Ne-CO₂ and CO₂-N₂ mixtures under different pressures (from 6 to 10 Torr), for low reduced electric fields (from 10 to 25 Td), at different mixture ratios.

Regarding the Ne-CO₂ mixture, our experimental results show that for mixtures with CO₂ concentrations higher than 25 % only one peak is observed, which was identified as the same ion present in pure CO₂, while a second peak appears for CO₂ concentrations below 25 %, which was attributed to impurities, mainly H₂O⁺. Our experimental results for the mobility of the CO₂ ions seem to be consistent with the ones predicted by the Blanc law for the studied mixtures of Ne-CO₂.

Concerning the CO₂-N₂ mixture, two peaks were observed for CO₂ concentrations below 10% in the CO₂-N₂ mixture. The experimental values of the ion mobility follows Blanc's law, displaying a behaviour coherent with Blanc's law lines depicted for the main candidate (CO₂⁺(CO₂)) throughout the entire mixture range studied. A second peak starts to appear for CO₂ concentrations below 10% which deviates from CO₂⁺(CO₂) theoretical line towards the CO₂⁺ line. This can be explained by the lower concentration of CO₂ in the mixture which increases the reaction time for the formation of the CO₂ cluster (about 100 μs for 5% of CO₂), lowering its availability and changing the species relative abundance.

Additionally we verified that the mobilities calculated did not display a significant dependence neither with pressure in the pressure range studied (8–12 Torr), nor with E/N in the range used in this work (10–25 Td).

Future work is expected with other gaseous mixtures. It is our intention to extend the work on ion mobility using different mixtures of known interest such as Ne-CO₂-N₂, Ar-CO₂-N₂, Ne-CF₄, Xe-CF₄ and Xe-CO₂.

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