Topic number: 1

Electron interactions in the mixtures of H_2O with O_2, CO_2 and dry air mixtures

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There is an increasing need of reliable swarm coefficients and cross sections for the interactions of electrons with water. A fairly recent review on the subject strongly suggests the need for further measurements in this direction [1]. On the other hand, knowledge of electron transport data in mixtures of water with oxygen, carbon dioxide and dry air are essential for modeling atmospheric discharges. Moreover, the accurate measurement of swarm coefficients permits the testing and derivation of cross section sets, which are also essential to accomplish the above purposes.

We have measured the electron drift velocity v_e, and the density-normalized effective ionization coefficient $(\alpha-\eta)/N$, (α and η are the electron impact ionization and attachment coefficients, respectively) for the mixtures of 10% water with dry air, carbon dioxide and oxygen over a wide range of the density-reduced electric field from 2 to 200 Td (1 Td=10^{-17} V cm^2), and for water concentrations between 1-50%. The time-resolved pulsed Townsend technique was used [2]. The measurements were performed at room temperature (293-298 K). Care was taken not to saturate the mixtures. The uncertainty in the measurements on v_e, and $(\alpha-\eta)/N$ are 1% and 4-7%, respectively. We have found no previous data in the literature for comparison purposes.

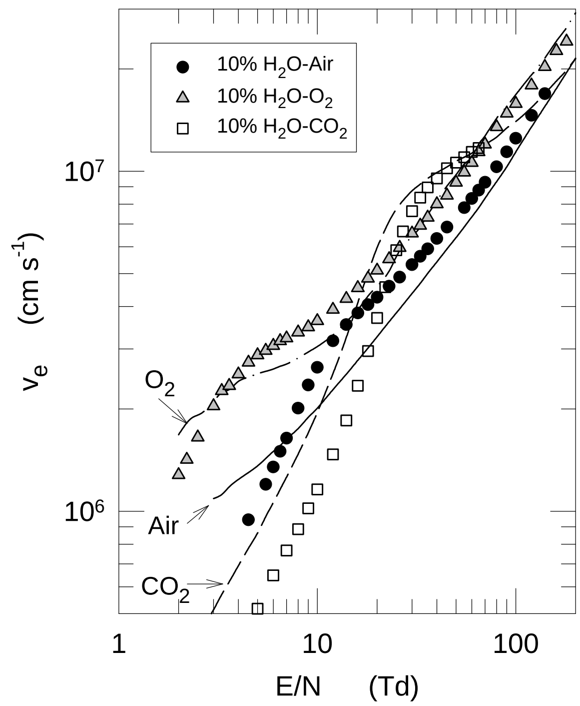

Figure 1. The electron drift velocities for the mixtures of 10% water with dry air, oxygen and carbon dioxide. Also shown are the measured drift velocities in O_2, CO_2 [3], and dry air.

Figure 1 shows an example of the measured electron drift velocities in the mixtures of 10% H_2O with dry air, oxygen and carbon dioxide, and for reference, those for O_2, CO_2 [3] and dry air [4]. Note that for the case of the 10% H_2O-O_2 and 10% H_2O-dry air, the electron drift velocity becomes higher than that on the pure gases over a wide region E/N, and it displays a structure resembling that of negative differential conductivity. On the other hand, for the case of 10% H_2O-CO_2, v_e becomes smaller than that for pure CO_2 up to E/N=40 Td.

The effective ionization coefficients, $(\alpha-\eta)/N$, for the H_2O-CO_2 mixtures with 1%, 2% and 50% water content are displayed in Fig. 2. One can note that the mixture becomes more electronegative as the water content in the mixture increases. Below E/N=30 Td we have observed a clear trend towards and increase in the attachment coefficient (there is no ionization at these low values of E/N) due to, probably, a three-body collision process between the electrons and the neutrals. A formal study of this process is outside the subject of this paper. We have already observed this phenomenon in the dry air-H_2O mixtures [4].

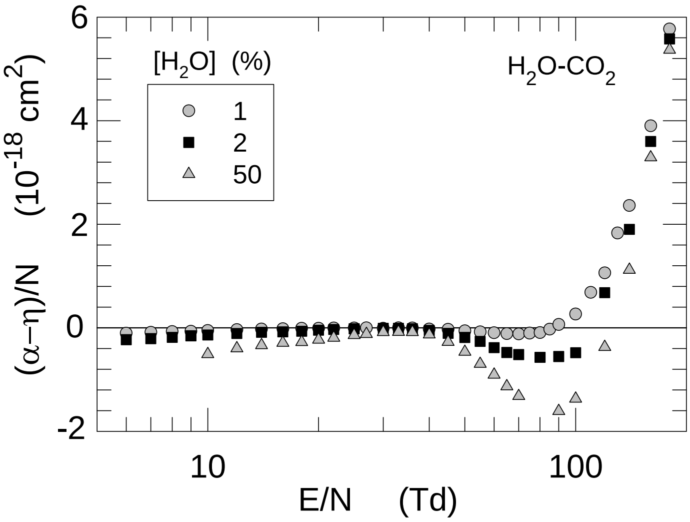

Figure 2. The density-normalized effective ionization coefficients $(\alpha-\eta)/N$ for the H_2O-CO_2 mixtures.

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