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Effective ionization coefficients and limiting field strength of SF_6-N_2O and CF_3I-SF_6-N_2 mixtures

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We have measured the effective ionization coefficient of the SF_6-N_2O mixtures (1-70% SF_6) and of the ternary mixture CF_3I-SF_6-N_2 with a fixed share of 40% N_2 and CF_3I concentrations of 10% and 50%. We have found that the limiting electric field strength E/N_{lim} of the SF_6-N_2O mixture is superior to that of SF_6-N_2. The E/N_{lim} values for the CF_3I-SF_6-N_2 are very close to300 Td.

The high global warming potential (GWP) of SF_6, nearly 24,000 times that of CO_2, has raised concern and prompted research activity in the direction of finding substitutes in high voltage applications. On the other hand, CF_3I has a GWP similar to that of CO_2 and a residence time in the atmosphere of just a few days, in contrast with about 2,400 years of SF_6.

We report on the measurement of the density-normalized effective ionization coefficient $(\alpha-\eta)/N$ (α and η are the ionization and attachment coefficients, respectively) of the SF_6-N_2O mixtures and of the ternary mixture CF_3I-SF_6-N_2. The overall, density-reduced electric field strength E/N has been varied widely from 100 to 460 Td (1 Townsend)=10^{-17} V cm^2). Once $(\alpha-\eta)/N$ is known then the limiting field strength E/N_{lim} can be assessed for the case where $\alpha=\eta$. This parameter is a measure of the goodness of a gas or gas mixture as a dielectric. A pulsed Townsend apparatus was used for the measurement of $(\alpha-\eta)/N$ [1]. All measurements presented here were performed at room temperatures in the range 293-298 K.

Figure 1 shows the values of $(\alpha-\eta)/N$ for the SF_6-N_2O mixtures, covering a wide range of E/N and mixture ratios. It is interesting to see that for an even a relatively small share of 20% SF6 in the mixture, the E/N_{lim} value increases by 43% from 200 Td (N_2O) to 285 Td (20% SF_6-N_2O). Moreover, the 50% SF_6-N_2O mixture renders an E/N_{lim} value of 333 Td, that is, only 8% smaller than that for SF_6 (360 Td).

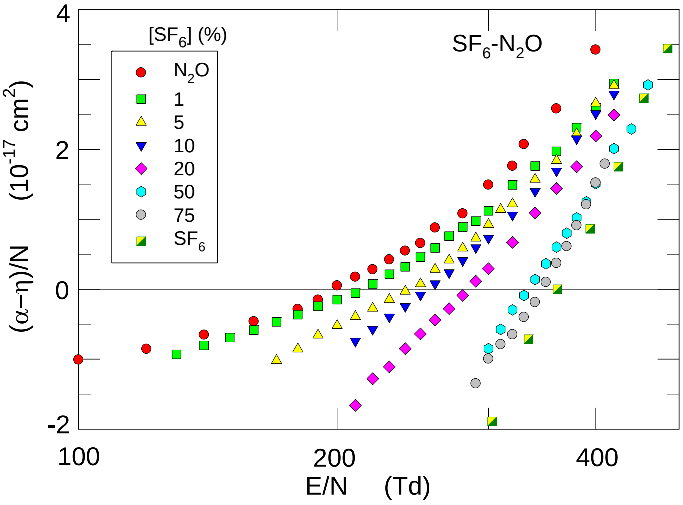

Figure 1. The present effective ionization coefficient $(\alpha-\eta)/N$ in the SF_6-N_2O mixtures. Measurements for pure N_2O and SF_6 were taken from Refs. [2] and [3], respectively.

The values of (α–η)/N for the two CF_3I-SF_6-N_2 mixtures are shown in Fig. 2, where the E/N_{lim} values are 308 Td and 298 Td for 10% and 50% CF_3I, respectively, retaining the strongly electronegative character of both SF_6 and CF_3I, marked by a linear dependence of (α–η)/N with E/N. The interested reader is advised to compare these curves and E/N_{lim} values with those for the CF_3I-N_2 mixture [4].

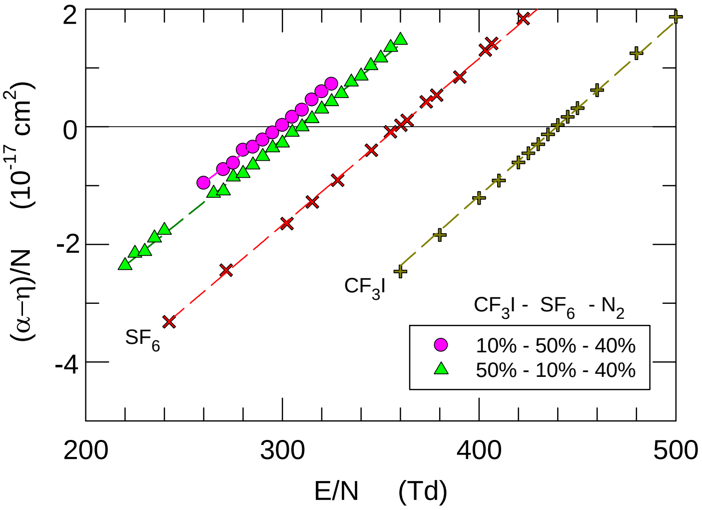

Figure 2. The present effective ionization coefficient (α–η)/N in the CF_3I-SF_6-N2 mixtures. Values for pure SF_6 and CF_3I are from Refs. [3] and [4], respectively.

From Fig. 3 one notes that the SF_6-N_2O mixture is slightly superior in dielectric performance to that of SF_6-N_2. It may be argued that electron detachment in N_2O may degrade the dielectric behaviour of the mixture; however, the low-energy detached electrons would be immediately attached to the SF_6 molecules, thereby stabilizing the detachment effect at least to some extent.

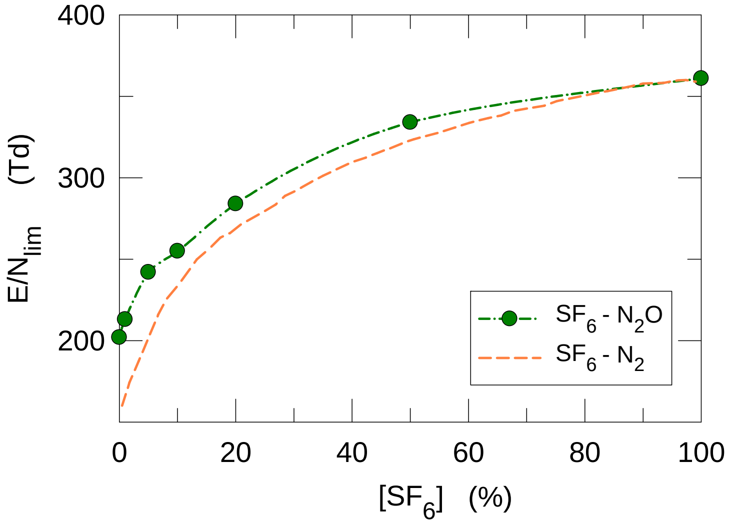

Figure 3. The present E/N_{lim} values of SF_6-N_2O and those of SF_6-N_2 [3] as a function of the SF_6 amount in the mixtures.

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References

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