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Decomposition of high pressure SF_6 and SF_6-N_2 (10-90) mixtures submitted to negative polarity corona discharges. Effect of the percentage of water added

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Résumé:
L'utilisation dans les câbles à isolation gazeuse de SF_6-N_2 à forte proportion d'azote en remplacement du SF_6 est fortement recommandée. L'étude des taux de formation de différents produits de décomposition gazeux a été menée dans SF_6 pur et SF_6-N_2 (10-90), à 400 kPa, sans et avec ajout de 0.1 et 0.3% d'eau. Ces produits ont été obtenus par génération dans le gaz de décharges couronne sous tension continue de polarité négative.
Contrairement à ce qui a été observé à sec, la quantité totale de sous-produits avec l'ajout d'eau est moins importante dans le mélange que dans le gaz pur. Cela s'explique essentiellement par l'effet défavorable, observé seulement dans SF_6-N_2, d'un fort ajout d'eau sur la formation des composés directement issus de SF_5 et des composés azotés.
Le bilan souligne donc le bénéfice d'une utilisation du mélange en remplacemant du SF_6 pur en phase gazeuse humide.

Abstract:
SF_6-N_2 with a high proportion of nitrogen is recommended to replace pure SF_6 in transmission electrical lines. The study of the formation rates of several gaseous by-products was displayed in both pure SF_6 and SF_6-N_2 (10-90), at a pressure of 400 kPa, without and with additions of 0.1 and 0.3% water. These products were obtained by generating corona discharges under dc negative polarity in the gas.
Contrary to what was observed under dry conditions, the total quantity of products obtained with water added was lower in SF_6-N_2 than in pure SF_6. This can be essentially explained by the unfabourable effect, only observed in the mixture, of a large addition of water on the compounds directly stemming from SF_5 and those containing nitrogen. Finally, these experiments pointed out that under wet conditions, the use of SF_6-N_2 instead of pure SF_6 is entirely beneficial.

Sulphur hexafluoride (SF_6) is commonly employed as a dielectric in gas insulated equipments and should soon be used in transmission lines, thanks to its good insulating and heat transfer properties.
However, the use of this gas presents major drawbacks like its rather high cost and its liquefaction, which appears under –37.7°C at normal operating pressures (400-500 kPa). It also causes problems of ecology. Indeed, its chemical inertness and its efficient infrared absorption give SF_6 a potentially high contribution to the greenhouse effect. Moreover, the decomposition of SF_6 under electrical discharges leads to the formation of toxic and corrosive compounds (e.g. S_2F_{10}, SOF_2, ...).
A possible alternative to pure SF_6 lies in the use of SF_6-N_2 mixtures with a high proportion of nitrogen, which provides satisfactory dielectric characteristics, a lower cost and an improvement in terms of air quality.
The real using conditions of SF_6 are characterized, among other things, by a high pressure of the gas and the presence of impurities like water. The formation rates of several gaseous decomposition products were then measured both in an SF_6-N_2 (10-90) mixture and in pure SF_6, at a pressure of 400 kPa, with additions of 0, 0.1 and 0.3% of water. Each time, the decomposition was obtained by submitting the gas to negative dc corona discharges, up to 10 C of accumulated charge.

The following by-products were assayed by gas-chromatography: SOF_4, SO_2F_2, SF_4+SOF_2, SO_2, S_2F_{10}, S_2OF_{10}, $S_2O_2F_{10}$, $S_2O_3F_6$, SF_5NF_2, $(SF_5)_2NF$ and NF_3.

Experimental

Each experiment was carried out at room temperature (23°C) in a 340 cm^3 cell filled with the gas. Before the filling, the cell was evacuated down to about 1 Pa. Then, for the damp tests 1000 or 3000 ppm_v were introduced before to put 400 kPa of either SF_6, either SF_6-N_2, in the discharge cell. For the dry experiments, the residual water content was about 150 ppm_v.
The corona discharges were generated between a stainless steel point and an aluminium plane electrode. These two items were separated by 2.3mm in pure SF_6 and 3.4mm in SF_6-N_2. The high voltage was applied to the point and kept the same value during the test, whereas the plane was connected to the earth via a microammeter, which gave the value of the discharge current. The evolution of this current was free during the run and its mean value, I, was calculated, so that the determination of the transported charge