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Investigation of electrical breakdown in high pressure (0.1 to 1 MPa) carbon dioxide and its mixtures under pulsed fields

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Sulphur Hexafluoride (SF_6) is an insulating gas which is used in high-voltage circuit breakers due to its unique insulating properties. However, it is an extremely potent greenhouse gas with a global warming potential (GWP) of 23900! Also, it produces toxic byproducts during electrical arcing. Hence, environment friendly and easier to handle alternative insulating gases are being investigated.

Carbon dioxide (CO_2) is a promising alternative insulating gas and is the focus of this research. The electrical breakdown strength of CO_2 and its mixtures under lightning impulses are investigated. The voltage pulses are generated using a 500 kV Marx generator and have a rise time of 700 ns. A rod-plane electrode geometry is used in the experiments to study the electrical breakdown phenomena under non-homogeneous electric fields. The rod has a hemispherical tip with a diameter of 20 mm and the gap distance between the electrodes is 30 mm.

The electrical breakdown strength of CO_2 is measured experimentally from 0.1 to 1 MPa under both positive and negative polarities. The results show that breakdown strength of CO_2 is greater under positive polarity and shows higher scatter in the breakdown voltage when compared to negative polarity. The polarity effect is inverse to that of air and currently, experiments are under way to understand this phenomena by using additional diagnostics such as high speed imaging and measurement of the pre-discharge currents.

It is reported in literature that addition of oxygen (O_2) can improve the dielectric strength of CO_2, due to its electronegative properties. Therefore, the effect of adding 10-30% O_2 to CO_2, on breakdown strength is being investigated at various pressures in order to find the optimum gas mixture ratio.

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