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Relationship between the Physicochemical Properties of Materials and the Fractal Dimension of Creeping Discharges Propagating at Solid/Fluid Interfaces

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The solid/fluid (gas or liquid) insulating systems are widely used in high voltage equipment (bushings, insulators, switchgears, gas insulating lines, gas circuit breakers, high voltage power transformers, power capacitors …) where they are exposed to different stresses and particularly to discharges phenomena that can develop within the body of insulator or at the solid/fluid interface leading respectively to breakdown or flashover (arc) of insulator and hence to the failure of the system. It is therefore imperative to understand the mechanisms and conditions of initiation and development of these discharges to avoid turning off equipment services. In this work we are interested by the propagation of discharges at the solid/fluid interface (i.e., the creeping discharges) especially their patterns and stopping length; these parameters are of great interest for the design of insulation systems used in high voltage components and systems.

The present paper is aimed at the main parameters that affect the fractal dimension D of creeping discharges propagating over different types of insulators immersed in gases at different pressures and in dielectric liquids, in a point-plane electrode arrangement. Especially, the dielectric constant, thickness of insulators, gas pressure, type of liquids (mineral and vegetable oils) and the type of voltage waveforms (lightning impulse voltage or DC) are analyzed. The considered insulators are circular samples of different thicknesses made of glass, epoxy resin and PTFE and pressboard; different types of liquid are also considered. The fractal dimension D of the observed discharge patterns is determined by the box counting method. It is shown that the fractal dimension D of these discharges depends on the thickness (e) and the dielectric constant of insulator (εr), gas and its pressure, type of liquid. D decreases when e increases and it increases with εr; this dependency of D upon e and er indicates the important role of the electric field and capacitive effect in the propagation mechanism. Also, D decreases when the gas pressure is increased; and D is higher with lightning impulse voltage than with DC voltage. These results evidence the existence of a relation between the fractal dimension and the physicochemical characteristics of materials constituting the interface.

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