Entropic Repercussion of Water-Dielectric Breakdown

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Upon achieving the voltage magnitude threshold associated with water-dielectric breakdown, a path of molecules is ionized between the negative and positive capacitor plates. After molecular ionization, an alternating positive negative ionic arrangement emerges where the negatively charged capacitor plate is followed by a positive ion then a negative ion in continuing repetition until the path is concluded by the positively charged capacitor plate; the arrangement of the ions is governed by an attempt to achieve charge neutrality. The newly established path of conductivity allows the voltage stored in the capacitor to discharge via the creation of a current flow through said path. In addition to the energy (E_{in}) delivered by the discharging of the capacitor, this publication suggested that a net kinetic energy (E_k) results from the alignment of the ions associated with water-dielectric breakdown conditions.

I. Introduction

The empirical parameters of water-dielectric breakdown have been thoroughly investigated throughout recently scientific history. Most recent it has been investigated by Sandia National Laboratories [1]. Their investigations have produced an empirical equation (1) specific devised for capacitors with ∞ area.

$$E_p \tau_{eff}^{0.330 \pm 0.026} = 0.135 \pm 0.009 \qquad (1)$$

In equation (1), $E_p = V_p / d$, where E_p is has units of MV/cm, V_p is the peak voltage across the capacitor with units of megavolts (MV), and d is the distance between the capacitor plates with units of centimeters (cm). τ_{eff} is a temporal parameter involving the pulse width of the applied voltage signal; this variable is measured in units of microseconds (μ_s).

In the research by Sandia National Laboratories [1] there was a total of 25 point-plane measurements taken and tabulated for the primary purpose of generating equation (1). Additional analysis of the 25 point-plane measurements has produced equation (2), and unlike equation (1), equation (2) has an additional parameter d, which is a variable representing the distance between capacitor plates. The variable d is measured in centimeters (cm).

$$E_p \tau_{eff}^{0.360 \pm 0.053} d^{0.030 \pm 0.077} = 0.230 \qquad (2)$$

The research of Sandia National Laboratories [1], that produced equation (1) and (2), was designed to supersede equation (3) produced by Eilbert and Lupton [2] for systems assuming ∞ area capacitors. Equation (3) is an empirical relationship specifically involving a finite area capacitor.

$$E_p \tau_{eff}^{1/3} A^{0.058} = 0.230 \qquad (3)$$

Another empirical equation (4) specific to a finite area capacitor has been created by (AWRE) at Aldermaston, England [3, 4, 5, 6], and published in References [5, 6].

$$E_p \tau_{eff}^{1/3} A^{1/10} = 0.3 \qquad (4)$$

Equations (1), (2), (3), and (4) are the result of a century of research and investigation into the magnitude of parameters necessary to induce water-dielectric breakdown. Equation (1) and (2) were specifically created for the design and construction of water based electrical insulation

systems. Equation (3), and (4) are more general and have been created for other purposes, although have been included in this publication to especially highlight the due diligence of past researchers to document the empirical parameters necessary to induce water-dielectric breakdown.

As a result of the latter due diligence, established in equations (1), (2), (3), and (4), it is now possible to investigate the subsequent reaction ensuing after the occurrence of water-dielectric breakdown. This publication deals with a potential entropic repercussion of water-dielectric breakdown, and the theorized kinetic energy (E_k) that emerges from ionic alignment.

II. Theory

Dielectric breakdown results in the formation of positively charged and negatively charged ions. These positive and negative charges arrange in an alternating fashion connecting the negative capacitor plate to the positive capacitor plate in an attempt to maintain net charge neutrality. The alternating charges form a conductive path, capable of propagating electric current, effectively allowing the discharge of the voltage stored in the capacitor beginning at the instant of dielectric breakdown. This newly established conductive path is well organized, in a relatively linear fashion, such that a low state of entropy occurs. Associated with a low state of entropy is a high molecular kinetic energy (E_k) magnitude, whereas the typical the random motions of particles, in a high state of entropy, tend to cancel each other.

III. Ionic Alignment and the Resulting Magnitude of Kinetic Energy (E_k)

Upon the alignment of the positive and negative charged ions, a state of low entropy is established resulting in a quantity of kinetic energy (E_k). This quantity of energy is in addition to the magnitude delivered by the current flow (E_{in}) associated with the discharging of the voltage stored in the capacitor.

IV. Energy Availability

The latter suggested kinetic energy (E_k) is summated with the input energy (E_{in}) illustrated in equation (5). Equation (5) also leads into the method of testing suggested in section **V**.

$$(2H_2O + E_{in} + E_k \rightarrow 2H_2 + O_2) \qquad (5)$$
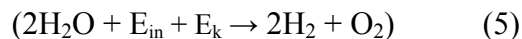
V. Method of Testing

A method of testing exists by using standard thermodynamic equipment. The system must be controlled; therefore a bomb calorimeter is to be used to quantity potential exothermic heat energy. The exact quantity of electrical energy input into the system can be measured by standard available electronic testing equipment. The energy resulting from the system (E_{out}) can be measured by quantifying the atomic byproducts of the chemical reaction in equation (5); such quantification can be achieved by standard chemical analysis of the resulting gases. As a result of having these two parameters (E_{in}), and (E_{out}), a simple arithmetic subtraction calculation can be made to determine the value of (E_k) that would be required to balance the stoichiometry.

VI. Appendix

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