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Electrode surface-gas interface as seat of light-effect under silent electric discharge

Pimple Sushama Sitaram

Department of Physics, S S & L S Patkar College of Arts and Science, S.V. Road, Goregaon(west), Mumbai - 400 062.
Email: sushamapimpale04@gmail.com

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ABSTRACT

A negative and positive hysteresis effects have been observed in the variation of electrical conductivity with applied V during silent discharges through air and H_2 in ozonizers. The ratio (i_5/i_{50}) of the discharge pulses at a counting time for the biases of 5V and 50V have been measured in dark and under light. These measurements are then used for determination of its associated light-effects, like net and relative light- effects, net average current in increasing and decreasing fields. The present series of experiments are to study the relative effect % Δ (i_5/i_{50}) in the ratio of discharge currents measured with different detectors in pure gases and to understand the mechanism responsible for its occurrence.

Keywords: Anti-hysteresis, Light-effect, Ozonizer discharge, etc.

INTRODUCTION

The phenomenon of hysteresis has recently been reported by several researchers [1-3]. The effect has been caused by injection of thermo-electrons [4] in an annular space of tube excited by corona discharge [5-7]. Salvi and Pimpale [8] have shown that the positive hysteresis was caused due to the photo-enhancement of the discharge current with the decrease in voltage being larger than the discharge current with increase in voltage. These studies have further revealed the dependence of discharge current on the applied potential in rising and falling fields, the discriminator bias, the capacitor formed by gas and salt solution, the nature of gas, the nature of current detector, the size of the tube the electrical and optical factors etc.

The present work reports the ratio (i_x/i_y) i.e. the pulse height distribution as a function of the applied potential in both dark and under light by using different detectors.

METHODOLOGY

A Siemen's type ozonizer formed by sealing together two cylindrical glass tube coaxially. The experimental procedure used in the present work is to compare the discharge current in dark and under light produced in hydrogen and air. In each system the measurements are taken for a biases of x = 5 and y = 50 volts at temperature 27^0 C with a sensitive reflection galvanometer actuated by crystal rectifier. Also, a side by side measured discharge current in terms of counts with a scaler connected across a series resistance included in the low-tension circuit. The experimental arrangement was exactly the same as that described earlier [8].

RESULT

Two ozonizers one filled with air and the other with H_2 at 4 torr, were used in this work. Using these tubes, the potential-variation (50Hz) of the discharge current (i.e. scaler counts) with and without irradiation is taken for different values of d.c. bias, viz, 5V and 50 V. For different voltages, the ratio of discharge currents at the two biases is then determined in dark $(i_5/i_{50})_D$ and under light $(i_5/i_{50})_L$. The difference between the two ratios i.e. % $\Delta (i_5/i_{50}) = (i_5/i_{50})_L - (i_5/i_{50})_D$, and the percentage value of light – effect i.e. 100 x $\Delta (i_5/i_{50}) / (i_5/i_{50})_D$, represents the net and relative effects of light at a given potential. The measurements are repeated at different potentials and its associated net effects are also determined in their increasing and decreasing fields. The non-identity of the discharge current ratios and of the corresponding effects in the two fields refers to the hysteresis or anti-hysteresis. In the case of hydrogen, the values of (i_5/i_{50}) with decrease in kV are found to be greater than those observed during its progressive increase. This incongruity of the discharge current ratio in the two fields clearly indicates the phenomenon of anti-hysteresis, and the hysteresis is observed in air. In air, the magnitude of both the net and relative effects of the current ratio is comparatively more pronounced than those observed in hydrogen.

It is seen from Table 1 that for suitable operational conditions +% $\Delta (i_5/i_{50})$ inverts to - % $\Delta (i_5/i_{50})$ as the voltage is increased progressively above the threshold value. This potential –reversal of a positive into negative or / and a negative in to positive light- effect is observed. Such an inversion as well as enhancement in + % $\Delta (i_5/i_{50})$ with kV is non-linear, the threshold voltage decreases with electro-conditioning. The inversion with the different detectors occurs in the different potential ranges.

DISCUSSION

Since the discharge current contains high frequency (h.f.) component, it is evident that the intensity of detected current would depend on the type of the detector used. The detecting instrument for recording the voltage is generally placed across a high resistance R put in series with discharge circuit. The counter scaler in series with the discharge circuit has been used to measure the discharge pulses directly. Now,

Table 1: Inversion of net effect of light in the discharge current ratio in pre-aged hydrogen (at 4 torr) with potential of 50 Hz.

Applied kV (r.m.s.)	Ratio of count rate $(i_5/i_{50})_D$ in dark	$(i_5/i_{50})_L$ in light	$\Delta (i_5/i_{50})$	% $\Delta (i_5/i_{50})$
0.28	00.00	00.00	0.00	00.00
0.70	48.29	00	- 48.29	- 100.00
1.05	09.120	11.160	+ 2. 08	+ 22.81
1.40	03.520	03.434	- 0.086	- 02.44
2.10	03.595	03.454	-0.141	-03.91
2.45	03.398	02.813	-0.58	-176.07

since the discharge current has a h.f. component, it is obvious that the current value as obtained from the instrument is less if the detecting instrument has appreciable self-capacity through which the h.f. is by-passed. The authors in their experiments noticed the difference between the readings of a scaler, a galvanometer actuated by crystal rectifier coupled resistively through a bell type transformer and hence concluded that there was a h.f. component of the discharge current. In recent years, unfortunately this simple fact has not been recognized and there has been much confusion in the interpretation of the experimental results. The result obtained by the authors can all be explained if the capacities, inherent or stray, of the indicating instrument and the associated apparatus are taken into account. For example, the scaler indicates a higher discharge current as also higher relative light-effect while the galvanometer actuated by a crystal rectifier not coupled or coupled resistivity though a step-down transformer shows a smaller effect. The result is as expected. The galvanometer actuated by a crystal rectifier coupled resistively has much larger associated capacity than the other two detectors which by-pass a large proportion of the h.f. current. Again, it has been found that the other conditions remaining the same, the +% Δ (i_5/i_{50}) obtained by using galvanometer actuated by a crystal rectifier coupled resistively, galvanometer actuated by a crystal diode and scaler as detectors, were 40%, 80% and 97% respectively. Here also the input capacities of three detectors for both the ozonizers decrease in the order mentioned.

On the basis of Joshi's theory reported by Ramaiah [9] it may be seen that the effect +% Δ (i_5/i_{50}) contemplates three stages, viz (1) at and above the characteristic threshold, an ionic + molecular adsorption like boundary layer is formed on the surfaces of electrode under field, (2) photo-electric emission occurs from this layer due to visible radiation and (3) these photo-electrons are captured by the excited atoms and molecules to form slow moving negative ions and produce the observed photo-diminution in the current ratio, i.e. – Δ (i_5/i_{50}) , as a space charge effect. Conditions disfavoring (3) give rise to the + Δ (i_5/i_{50}). Since stages (2) and (3) are instantaneous and fully reversible, the development with time in magnitude of the current ratio is attributable to that of adsorption in stage (1) of this theory.

CONCLUSION

All the above observations confirm that the localization of % Δ (i_5/i_{50}) is the dielectric, specially in the charged layer at the glass-gas interface. Further studies are in progress to study the mechanism of the formation and light modulation of this interface layer.

Conflicts of interest: The authors stated that no conflicts of interest.

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