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Some Phenomena of Electrical Ereakdown of Vinyl Chloride Film and its Application to a Simple Method of Electric-spark-machnning for Vinyl Chloride Film

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Abstract

Results are presented of a brief experimental study of the characteristics of the electrical break-down for vinyl chloride resin film. By making use of these results, a simple method of electric-spark-machinning for vinyl chloride film was originated.

The followings are the main conclusions:

(I) The break-down voltage of vinyl chloride film in air for direct current and alternating current at the commercial frequency (50 C. P. S) has been measured over the temperature range from 30°C to 90°C using needle-plane electrodes.

(II) The pin-hole through the film of vinyl chloride punctured by the break-down at about 100°C has a clean structure, while that at about 30°C is unclean.

(III) When the liquid drop is placed on the surface of the film, the break-down voltage for alternating current decreases and a finer pin-hole results.

I Introduction

The electrical strength of solid dielectrics depends on the temperature of dielectrics. Higher temperature gives lower break-down voltage. Generally, when the break-down occurs through the film of vinyl resin, there remain one or more pin-holes with dark stains around them. The bore of the pin-hole increases with the augmentations in supplied electric power and the duration of the current after the break-down has been initiated. The main object of this experiment is to investigate the appearance of this pin-hole.

II Experimental

An apparatus was constructed to measure the break-down voltage of the specimens and to produce the pin-holes through the specimens. Fig. 1 is the schematic diagram of this apparatus. The size of specimens was 5cm×5cm, 0.12mm in thickness and each of them was cut out from four sorts of the vinyl chloride

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film. The specimens were placed between the needle electrode and the surface of the drum heated by water steam.

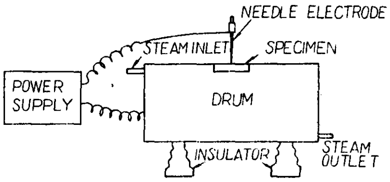


Fig. 1 Experimental Aparatus.

Break-down voltage of the vinyl chloride film

The alternating current (50 C. P. S.) and the direct current break-down voltages of the vinyl resin films contaning the plasticizer were measured. Fig. 2 shows these results. The abscissa represents reciprocal of the temperature of the specimens and the ordinate the logarithm of alternating current break-down voltage.

Each point represents the average of three readings. As seen in the figures each curve consists of one or two fragments of the straight-line. The gradient of these straight lines alter between the temperature range from 50°C to 60°C except for the line #2. From the results of tensile test of these specimens it was recognized that the softening of these films had begun at about 60°C, while at the same temperature the electrical strength had begun to decrease.

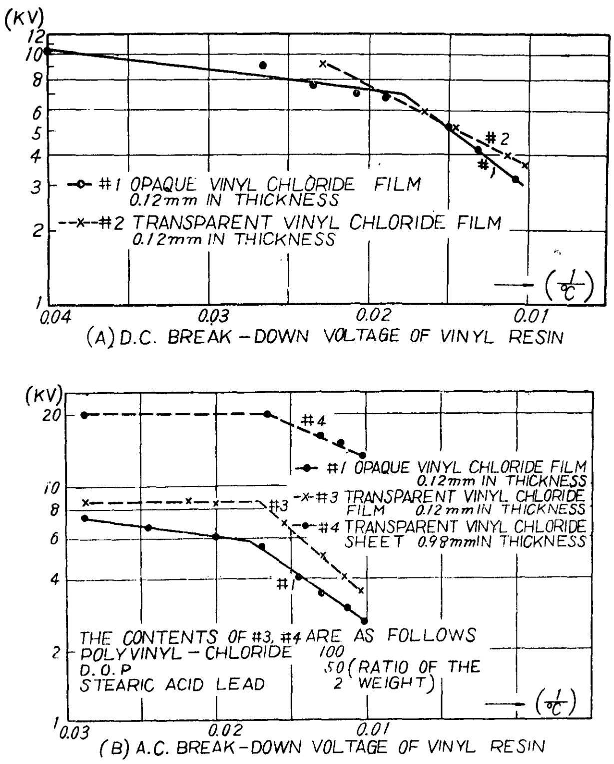
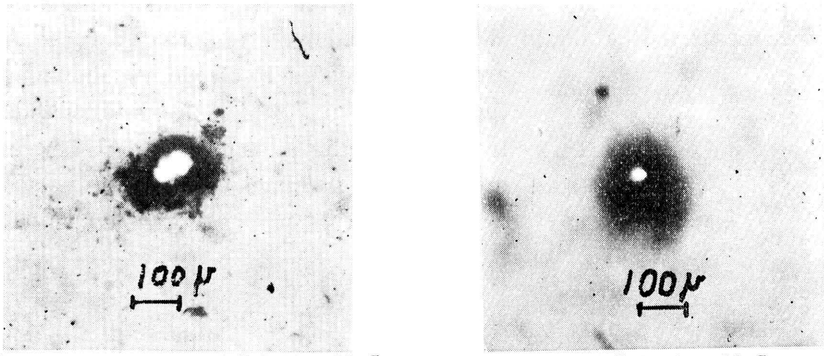


Fig. 2 Break-down Voltage of Vinyl Resin.

Pin-hole bored by the Electrical Break-down

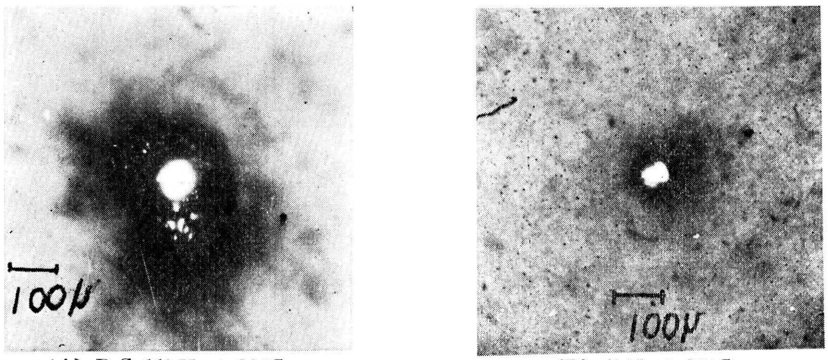
Figs. 3 is the microscopic photographs of the pin-holes made through the film after the break-down. A white pattern seen at the center of each photograph is the pin-hole and around it there is a black stain of carbon. The pin-hole in Fig. 3(A) was produced by the alternating current of 8kV at 32°C and 3(B) by alternating current of 3kV at 96°C. In both cases the current duration after the start of the break-down was of the same order, so the supplied power of the former was larger than that of the latter. The diameter of a pin-hole in Fig. 3(B) is smaller than that of Fig. 3(A) and the circumference of the former is clear while



(A) Pin-hole bored by A.C 8kV at 32 °C (B) A.C 3kV at 96 °C

Fig. 3 Photographs of Pin-holes.

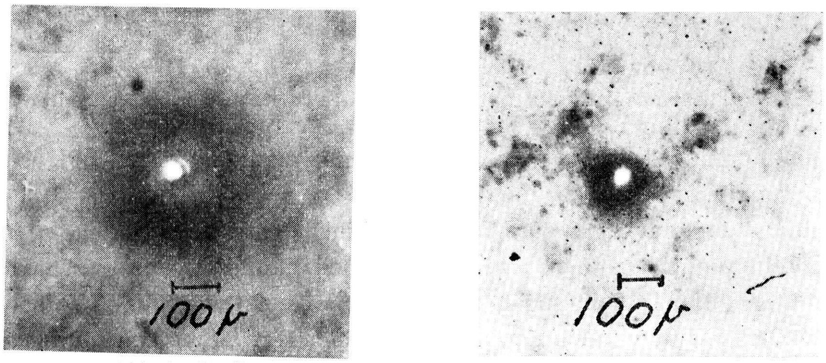
the latter is uncrean. Next, the power supply of direct current and alternating



(A) D.C 11kV at 30 °C (B) 4kV at 96 °C

Fig. 4 Pin-holes bored by D. C.

current of 1Mc were used respectively. Fig. 4 and 5 show the appearance of



(A) At 30 °C (B) At 96 °C

Fig. 5 Pin-holes bored by 1Mc.

the pin-holes in these cases. As seen in Figs. 3-5 higher temperature produces clearer circumference of the pin-hole. The circuit impedance for the alternating break-down and that for the direct current break-down were adjusted equally in these experiments. If a liquid drop is placed on the surface of the specimen around the needle electrode as shown in Fig. 6, the break-down voltage of specimens decreases. In Table 1, this effect of a number of liquid drops on the specimens from the observations of ten pin-holes for each kind is shown. Fig. 7 shows the pin-holes produced by the use of various kinds of liquid drops and using 1Mc as power supply.

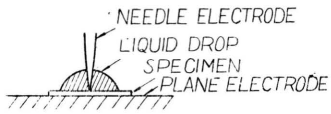
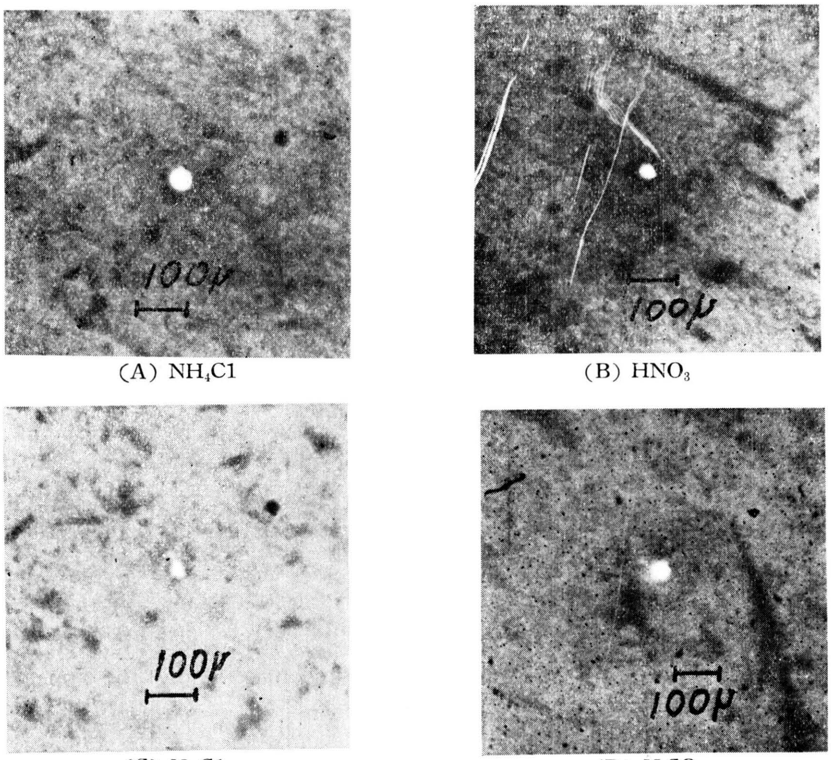


Fig. 6



(A) NH_4Cl (B) HNO_3

(C) NaCl (D) H_2SO_4

Fig. 7 The photographs of the pin-holes bored by the use of liquid drops.

Distilled water and liquid paraffine give higher bıeak-down voltage of the film than the other liquids in this Table, because these liquids themselves have higher electrical strength. Table I shows the appearance of the pin-holes punctured by 1Mc at 96°C and with various liquid drops. The effect of the liquid upon the pin-hole may be classified into two groups; first, that for the liquid having lower electrical conductance, second, larger direct current conductance than the former. The pin-holes bored by means of the former group have tiny bore and clear surounding, while those by the latter group have large bore and extensive stain.

Table I

Liquid	B. D. V (32°C, 50C.P.S)	Black stain around pin-hole bored by IMc at 96°C	Bore of pin-hole
NH_4Cl	6200V	almost none-6 little- 4	about 20μ
NaOH		almost none-6 little- 4	
NaCl		none- 10	about 20μ
HCl	6000V	almost none-3 little- 4	about 40μ
HNO_3		almost none-5 little- 2	
H_2SO_4	5000V	almost none-10	
None	7300V		
Distilled water			none-10
Liquid paraffine	7000V	almost none-5 little- 5	none-5
Xyrene		little- 2	none-8

III Conclusions

From the results of this experiment, it has been made clear that the film of vinyl chloride resin produces thermal break-down in the temperature range from 30°C to 90°C as the curves of Fig. 2 represent straight lines. Above 60°C the break-down voltage decreases steeply. The break-down voltage for A. C. is smaller that for direct current at the same temperature. The appearance of the pin-hole varies little with the conditions of the power supply at the puncture, but changes considerably with temperature and the surounding medium. The placing of liquid layer produces the decrease of the break-down voltage of the specimen. If the liquid giving high dielectric strength is used, either tiny bore pin-hole is made or none at all, and the liquid of lower direct current conductance produces pin-hole with clearer surounding area.

When clean pin-hole is desired as in the case of the electric-spark-machining of vinyl chloride resin film, the condition which produces lower break-down voltage is suitable: for example, to heat up the film of vinyl, to place suitable liquid layer on the surface of the film, and to use alternating current as a power supply at the machinning.

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