A Method for Measuring Electrical Properties of OPC Drum Using "Liquid Electrode Contact Method"

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Abstract

Electrical properties of OPC (Organic Photoconductor) drum have been measured by using liquid electrode contact method. On conventional measurement for electrical characterization of OPC drum, some simulators made based on electrophotographic process have been used. Meanwhile, on the liquid electrode contact method, there are the features that the liquid electrode is put on OPC directly, which can maintain stable charge supply to surface of OPC drum, and measurement area is fixed,. And the time required for fatigue of OPC drum was significantly reduced compared to conventional method when water was used as a liquid electrode. Additionally, it is also an advantage that the surface of OPC drum is unsoiled before and after testing, unlike the methods using vapor-deposited films etc. In this report, we aimed to capture, assess and compare the characteristics of the OPC drum by using liquid electrode contact method.

Introduction

Generally, for measuring electrical properties of OPC drum, the simulators based on electrophotographic process with rotation have been using. In that system, charger, exposure, electrostatic voltmeter and eraser are arranged around a sample drum, and charging is contactless. As for TOF (Time of Flight) measurement etc., the methods which electrode such as ITO and Au are made on surface of a drum are well known. Though each mean is excellent, there are still a few improvements. For example, the former method has uneven charging, and it is not easier to remove electrode material in the latter case. Then we invented a method which clear liquid is used for an electrode, contacts with surface of a drum and voltage is applied directly. In this method, charging is uniform, determining area is fixed without rotation during a measurement, and removing an electrode is easy. Additionally, it is also one of the features to be able to measure any shapes of samples.

In this report, we show some results about characteristics of OPC drums measured using this liquid electrode contact method. And some comparison of the data between this way and a general and conventional method are included partially. For example, in fatigue test, time for a fatigue level was significantly shorter than general method.

This liquid electrode contact method is still inadequately-tested and the data is just one case which used H_2O as an electrode. Therefore we show results include merit and controversial point as a proposal for noble way for characterization of OPC.

Methods

1. Device Configuration

For measurement by liquid electrode contact method (liquid-method), we used a device, "C_LIQ" (GENTEC). Fig.1 shows a configuration of C_LIQ. Liquid electrode on surface of OPC drum is connected to network system through an electrode inside the pot. That network system is composed of the measurement plate connected an electrode inside the pot and several relay-circuits to regulate the plate. High-voltage supply is connected the pot and controlled by a PC connected the network system. For measurement of surface potential, two kinds of probes are adopted. For light exposing, LED (λ=650nm) was used and irradiated from above to detective area through clear liquid. In this report, H_2O is used as liquid electrode material and the detective area is 0.5cm^2.

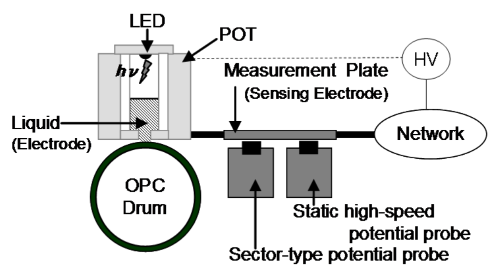

***Figure 1**. Schematic drawing of measurement system " C_LIQ"*

2. Materials and Measurements

Several kinds of OPC drums, which compositions are uncertain for us, were measured as the sample in this report. And H_2O is used as a liquid electrode. All of the data were measured at room temperature.

Fatigue test – In fatigue test using C_LIQ, a sample drum was charged through liquid electrode, meaning that surface potential of the drum comes to around 0V when charging is stopped. And charging and exposing were continued during measurement interval. The sequence of the measurement was shown Fig.2.

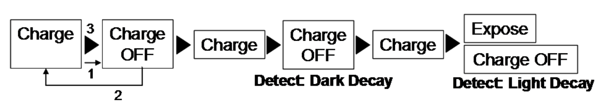

***Figure 2**. A sequence of LIFE test, per 1 cycle, in C_LIQ.*

In the test using CINDIE743 (GENTEC) and CYNTHIA94 (GENTEC), sample drums were fatigued by the repetition LIFE test sequence; sample drums were charged by scorotron, exposed by LED light at 780nm (250µW/cm^2) and then erased by LED light at 650nm.

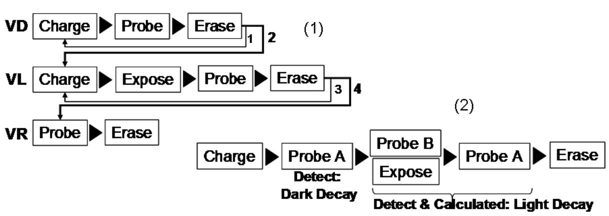

Figure 3. A sequence of LIFE test, per 1 cycle, in CINDIE743 (1), and LD2 test in CYNTHIA94 (2).

TOF measurement - On TOF test using C_LIQ, drum current was measured with 3μs of exposure. Transit time and drift mobility are calculated from obtained data. The charging voltage was set to -600V. In the test using CYNTHIA94, as a comparison experiment, mobility was calculated using transition value of surface potential of a drum. After corona charging, surface potential is decayed to the set level, -600V. Then measurement of light decay was immediately started after light exposing.

MEMORY test - The memory phenomenon was measured using C_LIQ. An OPC drum stayed dark was exposed by light at 650nm (760μW/cm^2) for 0.1s. Following that, it started to charge to set voltage by degree and detect as a pre-exposed drum data. After that, at intervals of 0.1s, charging was started again and detect as a without pre-exposed data. Fatigue test is used the same program as above-mentioned.

TRAP test – In the trap test using C_LIQ, constant current circuit was adopted for charging by pulse charging. A sample drum stayed in the dark was exposed by light at 650nm (760μW/cm^2) for 0.1s, promptly after that, pulse charging was started. Pulse width of charging was 1.5ms and 3.0ms.

Results

1. Fatigue test

Fig.4, Fig.5 and Fig.6 show the results of fatigue test using C_LIQ5D, CINDIE743 and CYNTHIA94, respectively. The result in Fig.6 was measured after fatigue test by CINDIE743, each for 12 or 24 hours.

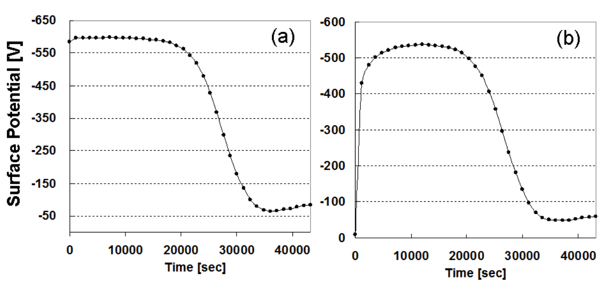

Figure 4. Transition curves of residual potential of an OPC drum measured using C_LIQ. All of the points were plotted each surface potential 1 second after start measuring dark decay (a) and light decay (b), respectively. Horizontal axis shows time for fatigue by light and charging.

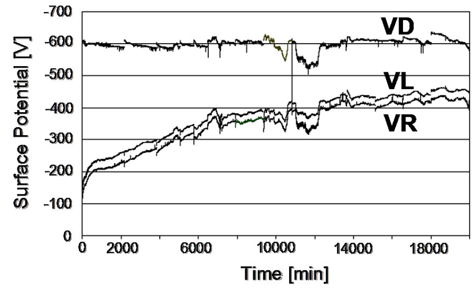

Figure 5. Transition curves of residual potential of an OPC drum measured using CINDIE743. The sample is the same as that of Fig.4.

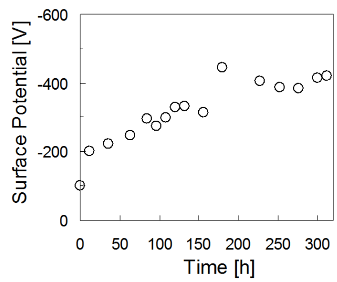

Figure 6. Residual potential transition of an OPC drum measured using LD2 program of CYNTHIA94. Each value was detected 1 second after start measuring light decay. Horizontal axis shows time for fatigue by CINDIE743. The sample is the same as that of Fig.4.

Comparing transition of residual potential on surface of a drum, the time for fatigue on liquid-method is significantly shorter than that on conventional method at a same residual potential. One of the major reasons of that is considered to charge voltage and expose light to the fixed area continuously. And since H_2O is contacted with surface of an OPC drum, the humidity condition for OPC is stringent. So it seems to be easier to fatigue. Additionally, in liquid method various kinds of OPC became colorless within 1 hour in fatigue test. (data not shown) The colorless means that absorbance of photoreceptor in CGL might be decreased or the absorption wavelength was varied.

2. TOF measurement

Table.1 shows the transit time and drift mobility calculated from the result of TOF test. Compared liquid-method with conventional method, these calculated values, transit time and mobility, were respectively about the same in the drums.

Table 1: Drift mobility and transit time of carriers in OPC drum. Comparison of liquid-method and a conventional method.

Drum	C_LIQ		CYNTHIA94	
	Transit time [ms]	Drift mobility [cm^2/V·s]	Transit time [ms]	Drift mobility [cm^2/V·s]
1	0.68	1.53E-05	0.65	1.59E-05
2	1.23	8.46E-06	1.54	6.76E-06
3	1.16	9.00E-06	1.17	8.94E-06
4	0.74	1.41E-05	0.81	1.28E-05
5	1.62	5.94E-06	1.71	6.08E-06

3. MEMORY test

Fig.7 shows the fatigue dependence on charging pre-exposure conditions. And each difference between with and without pre-exposure conditions is shown in Fig.8

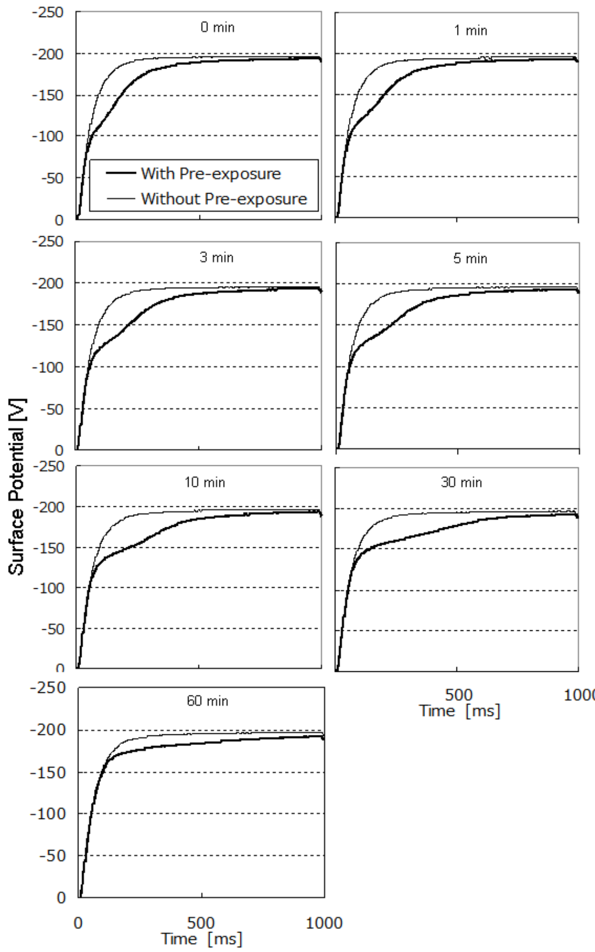

Figure 7. *Fatigue dependence on charging characteristics on with pre-exposure conditions. Time displayed inside each figure is time for fatigue.*

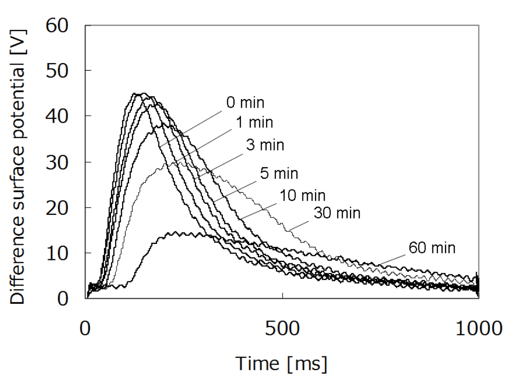

Figure 8. *Difference surface potential between with and without pre-exposure conditions. And fatigue dependence of them. Time displayed inside each figure is time for fatigue.*

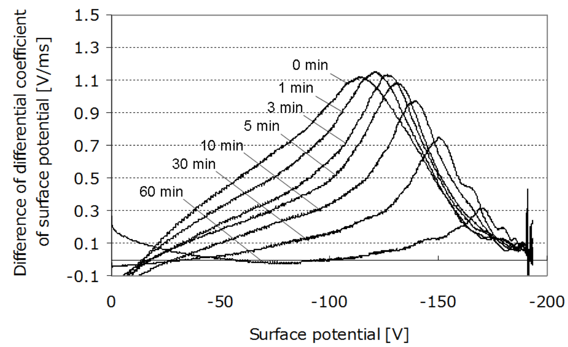

Figure 9. *Difference of differential coefficient of surface potential between with and without pre-exposure conditions. And fatigue dependence of them. Times for fatigue are displayed in the figure.*

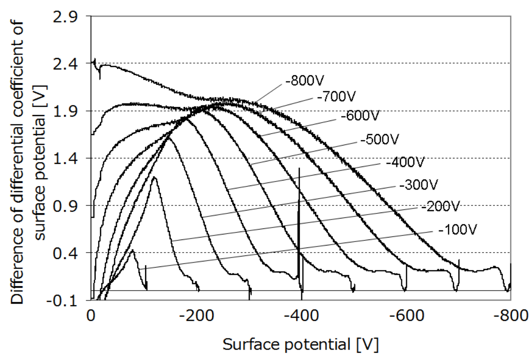

Figure 10. *Comparison of charging characteristics on each setup charging voltage. The voltage values displayed inside the graph are setup charging voltages, and voltage is charged by degrees from 0V to setup voltage.*

The results in Fig.7 indicate that charging in the case of pre-exposed drum is delayed relative to that in the case of without pre-exposed drum. And it was also showed that the peaks of difference charging curves in Fig. 8 are downshifted with increasing fatigue of the drum. In the Fig.9, all of the curves respectively have peaks which are thought to be attributable to the carrier emission from the trap by electric field. The time τ, which carriers are trapped, has been explained by the following equation. [1], [3], [4]

$$1/\tau = 1/\tau_0 \exp(-(\varepsilon_0 - \alpha\sqrt{E}) - kT) \quad (1)$$

$$E = V_s / d \quad (2)$$

The ε_0 (eV) is the depth of trap, E is electric field, k is Boltsmann constant, T (K) is the absolute temperature, d (m) is layer thickness of OPC, and each τ_0 and α is the constant. Then the current J_{abs} which is attributable to carrier emission by the electric field is expressed by the following equation. [1], [3], [4]

$$J_{abs} \sim n[1/\tau]\left[\exp(\ -\int_0^t 1/\tau\, dt\ )\right] \quad (3)$$

n is the density of trapped carriers.

Additionally, dependence of charging characteristics on charging voltage was able to be observed in Fig. 10.

4. TRAP test

The comparison of difference on charging properties is shown in Fig. 11. It is demonstrated that charging quantity of a pre-exposed drum was decreased compared to without pre-exposed drum at the same time after start charging. It is thought that surface potential is canceled by carriers liberated from the trap.

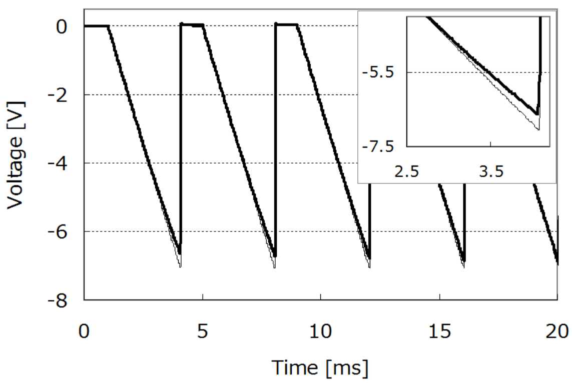

Figure 11. *Pulse charging waveform. Comparison of difference between with and without pre-exposure. A Heavy line and a narrow line shows with and without pre-exposure, respectively. Inset is their enlarged view.*

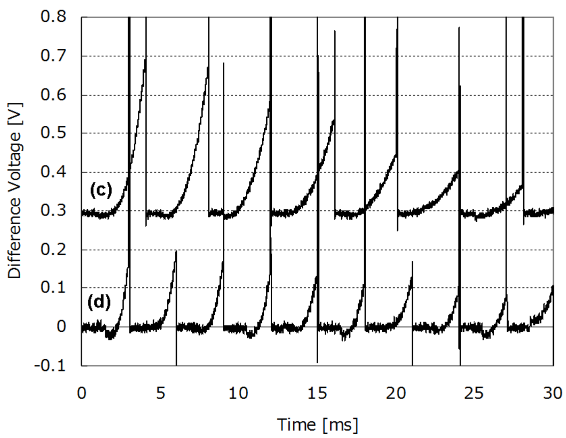

Figure 12. *Difference between with and without pre-exposure charging waves calculated using the data shown in Fig.11. And comparison of charging characteristics. Pulse charging time was 1.5ms/pulse at upper (c) and 3.0ms/pulse at lower (d).*

The difference voltage signals between with and without pre-exposure were shown in Fig.12. Compared to the maxima in each pulse, those in wave (c) were decreased with charging time. On the other hand, those in (d) had a peak in the transition and decrease gradually relative to wave (c).

Though it is still not able to be estimated the quantity of carriers by pre-exposure because signal is too small and noisy to estimate, it would be enough to do it when these problems are improved.

Summary

We tried to investigate the liquid electrode contact method by measuring electrical properties of several OPC drums. As a result, it showed that the values obtained by liquid-method were relatively the same as the results by using conventional method in TOF test, and it considered that this liquid-method is useful for fatigue test because the measurement time for fatigue is able to be dramatically short. However, it still has problems in this liquid-method, meaning that it is necessary to reveal the effects on an OPC drum from liquid materials and also improve signal detection to analyze in detail.

The method using liquid electrode is under investigation. Although the problems have still remained, it would be useful method for characterization of OPC, especially in trap and memory phenomenon.

References

[1] C.W. Lin, et al., Dependence of Photoreceptor Charging Characteristics on Pre-Exposure Conditions (IS&Ts NIP 14, International Conference on Digital Printing Technologies, 1998) pg. 548.

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[4] Y. Hoshino, et al., "Thermally Stimulated Current Measurements on the Trapping Levels in a Cu-Phthalocyanine Binder Photoreceptor", J. Appl. Phys., 52, 5655 (1981).

Author Biography

Toshinori Nozaki is the president of GENTEC Co. He graduated Shibaura institute of technology in 1969. Since then he established GENTEC in 1982, and has been involved in research and development in the field of imaging engineering and electrophotographic technology. He is a member of ISJ (the imaging society of Japan).