Charging Mechanism of Polymers with CCA (II)

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Abstract

To understand tribocharging characteristic of polymers containing CCA, thermally stimulated current measurements were carried out on polymers with several kinds of CCA. A new peak appeared in the TSC curves for the resin with CCA, which are expected to work as trapping sites for tribocharging. The TSC measurements on the CCA/resin stacked layers suggest that the interface between CCA and resin work as charging sites for tribocharging.

Introduction

Tribocharge of toners is a major factor in electrophotographic process, and CCA (charge control agent) is used for toners to improve their tribocharging characteristics. However the tribocharging mechanism of toners with CCA has not sufficiently been clarified yet.[1,2] We have been measuring thermally stimulated currents (TSC) on toner layers to study tribocharging characteristics of polymers containing CCA.[3] This paper describes results of TSC measurements on a resin, CCA and resins containing CCA, and discusses charge trapping sites in resins with CCA.

Experimental

Samples used in this study were styrene-acrylic resin (Himer TB-1000F; Sanyo Chemical Co. Ltd.) and azo-iron complex compound CCA (T-77, N-type, 2.2µm; Hodogaya Chemical Co. Ltd.), salicylic acid zinc complex (N-type, 3.2µm; laboratory made) or quaternary ammonium salt (TP-415, P-type, 6.8µm; Hodogaya Chemical Co. Ltd.). The chemical structures of CCA are shown in Table 1. Pseudo toners with or without CCA were prepared by the conventional sequence of kneading, pulverizing and classification. The mean particle size of all the pseudo toners was 10 µm. First tribocharging of the resin, CCA and toner powders were measured by blow-off method using a coating-free ferrite carrier, where the powder concentration was 4 wt%. All the measurements were carried out at 25 °C and 50%RH.

The TSC measurement was performed in the following procedure.[4] A sample powder was compressed by a pressure to make a 1 mm thick disk. The compressing pressures were 10 and 30 kgf/cm^2 for toner and CCA, respectively. The sample disk was sandwiched by a pair of metal electrodes and polarized with an electric field (100 – 800 V) at 60 °C for 15 min and subsequently cooled rapidly to –70 °C by liquid nitrogen before the field was removed. After short circuiting the electrodes for 15 min, the sample was heated upto 80 °C at the rate of 6.0 °C/min, and the current was measured using an electrometer (Keithley 617). Figure 1 shows the TSC measuring system.

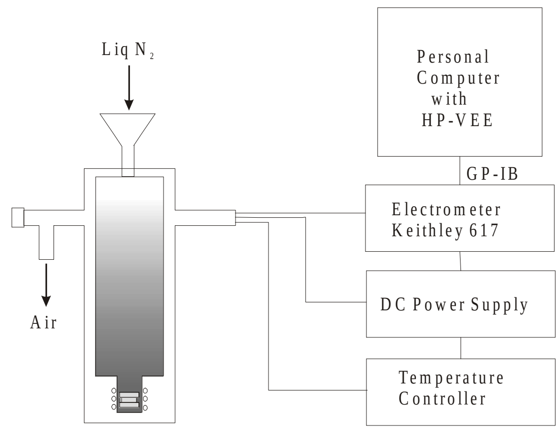
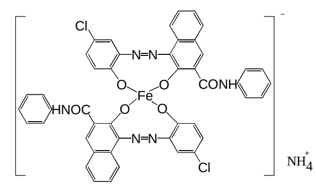
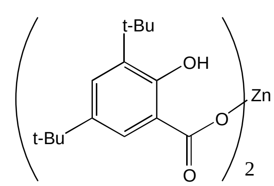


Figure 1. TSC measuring system.

Table 1. Chemical structures of CCA.

Azo-iron complex T-77	
Salicylic acid zinc complex	
Quaternary ammonium salt TP-415	$[(C_{14}H_{29})_2N(CH_3)_2]Mo_8O_{26}$

Results and Discussion

Azo-Iron Complex Compound CCA

The azo-iron complex compound is popular as an N-type CCA. Tribocharging characteristics of the resin, CCA and toner (resin + CCA(1%)) powders are shown in Fig 2.

This result indicates that the resin containing 1% of CCA charges more strongly than the resin or CCA only, which confirms that the CCA works normally in the toner.

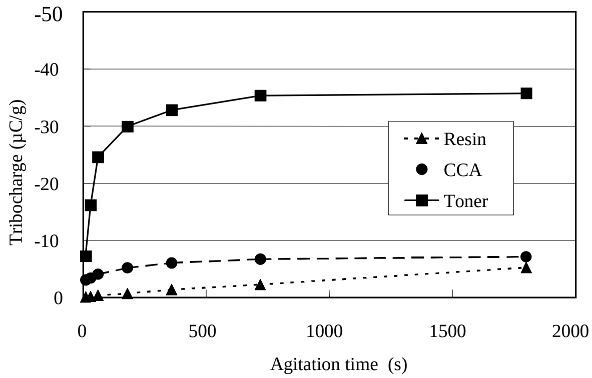


Figure 2. Tribocharging characteristics.

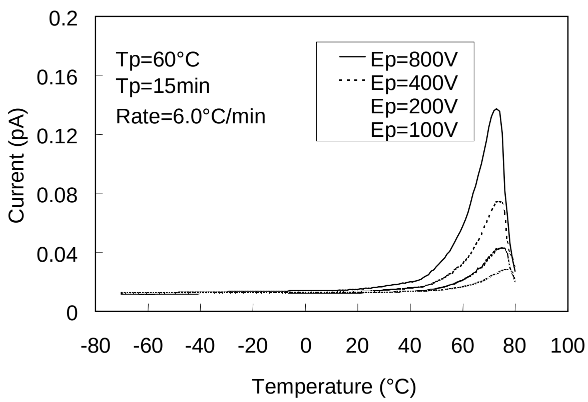


Figure 3. TSC curves for resin.

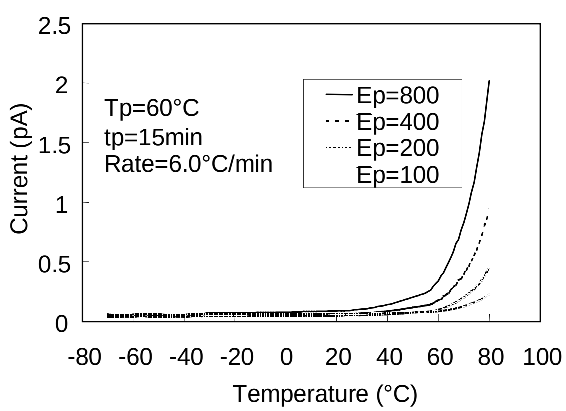


Figure 4. TSC curves for CCA.

Figures 3 and 4 show TSC curves for CCA-free resin and CCA, respectively. The former has a peak, which may be originated from Tg, while the later no peak and increases monotonously with an increase in temperature. Figure 5 shows TSC curves for resin with 1% of the CCA, in which a new peak is observed at around –20 °C. This new peak can be expected to work as trapping sites in the resin with CCA.

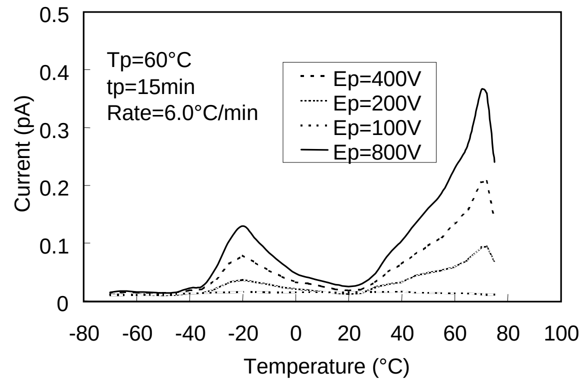


Figure 5. TSC curves for resin with CCA of 1.0%.

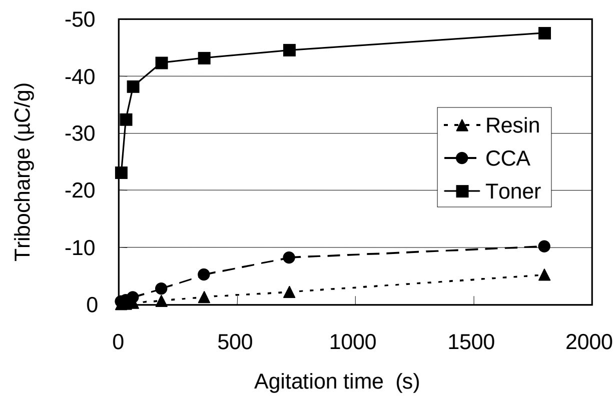


Figure 6. Tribocharging characteristics.

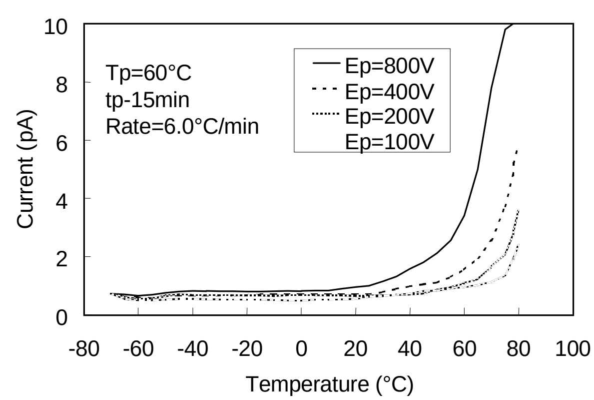


Figure 7. TSC curves for CCA.

Salicylic Acid Zinc Complex Compound CCA

The salicylic acid zinc complex compound is used as an N-type colorless CCA. Tribocharging characteristics of the powders are shown in Fig 6. This result also indicates that the resin containing 1% of the CCA charges more strongly than resin or CCA only.

Figure 7 shows TSC curves for the CCA only. The TSC curves for the CCA have no peak and increase monotonously with temperature, too. Figure 8 shows TSC curves for the resin containing 1% of CCA, in which no new peaks appear. However, heterogeneous currents are observed in the temperature range of –70 °C to –10 °C, which are independent of the polling fields.

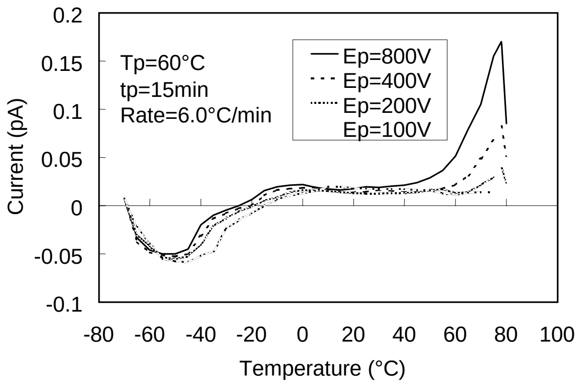


Figure 8. TSC curves for resin with CCA of 1.0%.

Quaternary Ammonium Salt CCA

Similar results for the case of quaternary ammonium salt, which works as a P-type CCA, are given in Figs. 9 to 11.

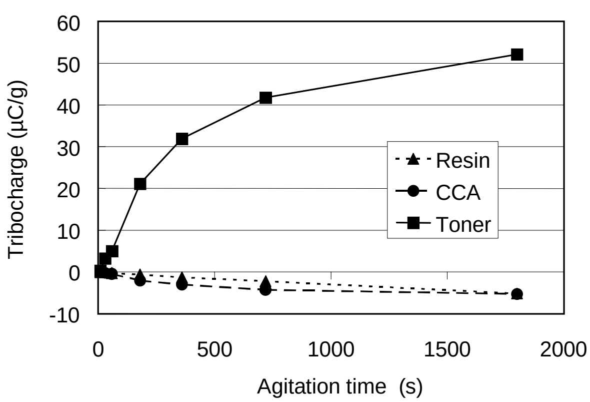


Figure 9. Tribocharging characteristics.

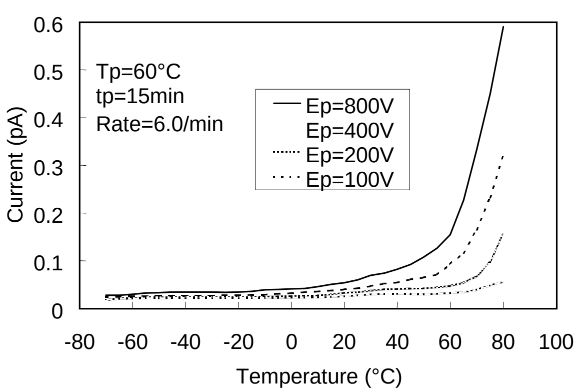


Figure 10. TSC curves for CCA.

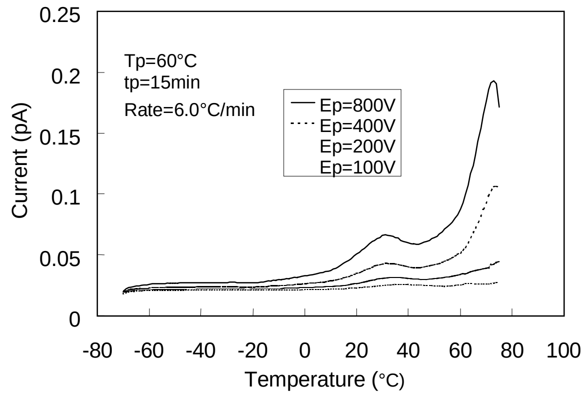


Figure 11. TSC curves for the resin with CCA of 1%.

It should be noted that both the resin and CCA charge negatively, while the resin containing 1% of CCA charges positively strongly. The CCA interacts with the resin and appears a strong positive charge.

A new peak appeared at around 32 °C may work as trapping sites for the resin with 1% of the CCA.

TSC Measurement on the CCA/Resin Stacked Layers

TSC measurements were also carried out on CCA/resin stacked layers. The results for the azo-iron complex compound CCA are shown in Fig. 12. A new peak also appeared at around –20 °C, which suggests that trapping sites are located at the interface between the resin and the CCA. Similar results were also obtained for the other two types of CCA.

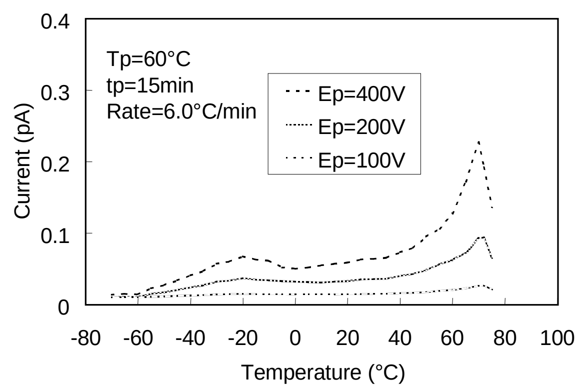


Figure 12. TSC curves for CCA/resin stacked layers.

Conclusion

Thermally stimulated current measurements were carried out on polymers with several kinds of CCA to investigate their charging mechanism. A new peak appeared in the TSC curves for the resin with CCA, which are expected to work as trapping sites for tribocharging. The TSC measurements on the CCA/resin stacked layers suggest that the interface between CCA and resin works as charging sites for tribocharging.

References

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Biography

Shinji Otani graduated from the Ehime University, Japan and joined Hodogaya Chemical Co., Ltd. in 1989. He has been working on R&D of CCA for toner materials. He is currently a Ph.D. course student at the Ibaraki University. He is a member of the Imaging Society of Japan and the Japan Society of Applied Physics.