

A Study of Background Development and Toner Charge Distribution on Photoconductors

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Abstract

We have measured the charge distributions of background developed toner to get a picture of the underlying mechanism of background development in two-component development process.

Polycarbonate films containing molecularly dispersed charge transporting material were used as a model of photoreceptor. Positive charged toner was developed onto the model photoreceptor using a practical analogue copier machine without charging process, which was corresponding to the background development in the practical photography process.

It was found that a charge distribution curve of background toner had two peaks assignable to low-charged wrong sign toner and high-charged right sign toner, respectively. The peak of high-charged right sign toner was observed to coincide with the peak of toner in a developer. Another peak was found to appear around 0fC/μm.

The pattern of charge distribution curves for background developed toner was able to be classified into two types according to the type of toner. One was such that the amounts of high-charged right sign toner was dominant. And the other was that the amounts of low charged toner was a major component.

Moreover, the peak of high-charged right sign toner particles was selectively reduced by the addition of lubricant to photoreceptors. This result suggests that the background deposition of high-charged right sign toner was primarily caused by the adhesion force of toner particle to the photoreceptor.

Introduction

The two-component development technique is popular in the electrophotographic processes. Many inventions with regard to two-component development were provided to improve the irregular images. Several papers have already explained the mechanisms of background development to some existent.[1)-4)] However, the background development still remains a significant issue to achieve high-resolution images in electro-photography.

Recently, we have reported the technique for measuring the charge distribution of toner particles developed on photoreceptor films and the existence of tribocharging between toner and photoreceptor in the development process.[5)] This technique is efficient to evaluate the charge distribution of background developed toner to clarify the mechanism of background development which still remain to be unsolved.

In this paper, we report electrostatic charge distributions of toner particles developed in the background of image and identify the contribution of the surface free energy of photoreceptor and the chargeability of developer to the background development.

Experimental

All of experiments were carried out at room temperature, 40-50% of humidity and in the atmospheric pressure.

Sample Preparation

PET (Polyethylene telephthalate) films of 75μm thickness with an aluminum evaporated electrode were employed as substrates of photoreceptor. Polymer films consisting of polycarbonate (Teijin Chemicals TS2050) and charge transport material were coated on the substrate by blade-coating method from its solution in tetrahydrofuran.

0.02 parts of silicone oil (Shinetsu Silicone KF50) per hundred weight resin was added in a certain polycarbonate solution to control the surface free energy of photoreceptor. The contact angle by a distilled water was 90.8 degree for the photoreceptor with silicone oil and 85.5 degree without silicone oil.

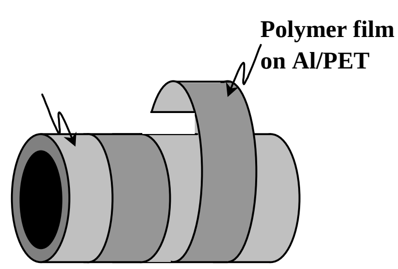

Figure 1. The method of utilizing polymer films as a model photoreceptor

Polymer films were attached on the surface of an aluminum tube and an Al electrode on PET was connected electrically to the tube by copper sealing tapes, as shown in Figure 1. The aluminum tube was set in an analogue copier, Ricoh FT6500 model, as substitutes for the photoreceptor drum. The machine was used with a slight change that charging and cleaning sub-units were removed.

The commercial toner and carrier (Ricoh toner TYPE650 & Ricoh carrier TYPE1) were used as a “standard developer” in this study. The other commercial toner and carrier (Ricoh toner TYPE3300 & Ricoh carrier TYPE3300) were also used. The development condition of “standard developer” was such that Q/M was 23±3μC/g and the concentration of toner (Tc) was 2.4±0.4%. The volume mean diameter of toner particles was 9.0±0.5μm for TYPE650, 11.5±0.5μm for TYPE3300, respectively.

The two types of specially blended toner were used in order to investigate the contribution of the developer (toner & carrier beads) to the background development.

Toner No.1: Not containing CCA,
Qsat=16μC/g at Tc=2.5%.
Toner No. 2: Containing CCA twice as much as standard toner,
Qsat=31μC/g at Tc=2.5%.
Standard : TYPE650 toner, Qsat=25μC/g at Tc=2.5%

Only CCA contents varied in both type from a standard toner. “Qsat” means the Q/M value of the toner measured after adequate mixing with the standard carrier beads.

The following two types of carrier were also used in the experiment.

Carrier No.1: Qsat=-33μC/g for Tc=2.5% of TYPE650 toner.
Carrier No.2: Qsat=-20.7μC/g for Tc=2.5% of TYPE650 toner.
Standard : TYPE1 carrier, Qsat=25μC/g at Tc=2.5%

Toner chargeability and carrier chargeability will be abbreviated to “TA” and “CA” hereafter, respectively.

Then, the two types of combinations, such as Low-TA/High-CA type [Toner No.1/Carrier No.1] and High-TA/Low-CA type [Toner No.2/Carrier No.2] were employed as developers in the experiment.

Under –150V of externally controlled DC bias, the toner were deposited on the polymer films on the model photoreceptor without charging it.

After development, the polymer films were pealed off from an aluminum tube. And then, the number of toner particles per unit area [N/A, counts/mm^2] on polymer films were counted from the image data magnificated by a CCD microscope (×200) by using the automatically image analysis system.

Measurements of Toner Charge Distributions on Films

The E-SPART analyzing system[6)-7)] (Hosokawa Micron corp.) was applied to measuring the charge distribution of toner particles developed on a polymer film.

Figure 2 shows a schematic diagram of the measurement for toner particles deposited on a film.

The developed sample films were cut off lean and long strips in the width of 10-12mm. The strips of the film were attached to a disk-like rotational sample holder of the E-SPART analyzing system shown in Figure 2. The toner particles were separated from the polymer film by nitrogen (N_2) gas blowing and leaded into a measurement chamber of E-SPART analyzing system. Then, the charge distributions were measured up to 3000 counts of toner particles.

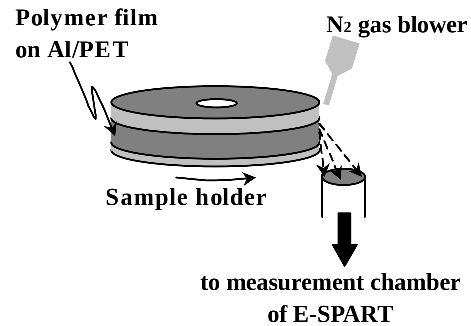

Figure 2. Charge distribution measurement for toner developed on polymer film

The particle counts were normalized by multiplying the number of developed toner particles per unit area (N/A) in order to compare each other.

Results and Discussion

1. Charge Distribution of Background Developed Toner

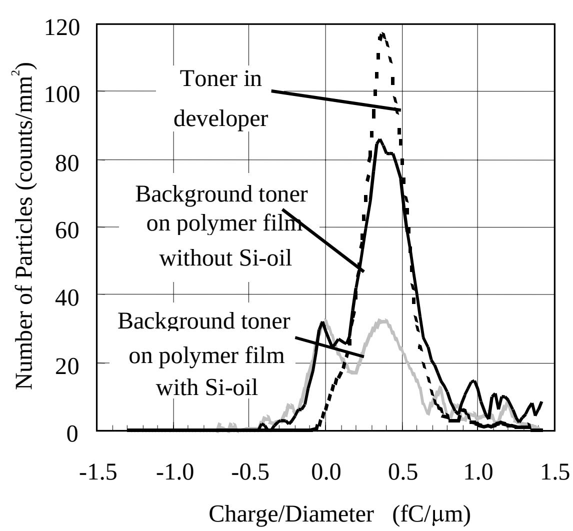

Figure 3. Charge distribution for the standard toner developed on background of photoreceptor

Figure 3 shows the charge distribution curves for the standard toner (Ricoh toner TYPE650) developed on the film without silicone oil (Black Solid line) and with silicone oil (Gray Solid line), respectively. The charge distribution curve for the toner in the development sub-unit is also shown (Dashed line). In these measurements, the standard carrier

(Ricoh carrier TYPE1) was used and –150V was applied as the development bias. The vertical axis for the toner in the developer was arbitrary varied to fit a figure scale.

It is pointed out that the charge distribution of background developed toner exhibited two peaks that was assignable to low-charged wrong sign toner and high-charged right sign toner, respectively. The peak of high-charged right sign toner was observed to coincide with the peak of toner in the development sub-unit. Another peak was found to appear around 0fC/μm.

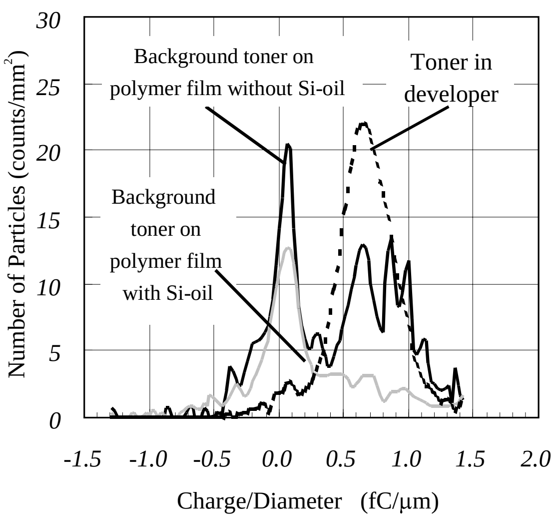

Figure 4. Charge distribution for TYPE 3300 toner developed on background of photoreceptor

Figure 4 shows the charge distribution curves for the other type positive-charged toner (Ricoh toner TYPE3300) developed on the film without silicone oil (Black Solid line) and with silicone oil (Gray Solid line), respectively. The charge distribution curve for the toner in the developer is also shown (Dashed line). In these experiments, the Ricoh carrier TYPE 3300 was used.

For TYPE 3300 toner, the charge distribution curve of background toner was also found having two peaks. But, in this case, the peak around 0fC/μm was more emphasized than that for the high-charged right sign toner, in contrast to the result in Figure 3.

These results indicate that the pattern of charge distribution curves for background developed toner can be classified into two types. One is such that the amounts of high-charged right sign toner was dominant. And the other is that the amounts of low-charged toner is a major component.

The presence of silicon oil in photoreceptors can influence the charge distribution of background developed toner, which were observed for both TYPE 650 toner and TYPE 3300 toner, as shown in Figure 3 & 4. These figures show that the amount of right sign toner deposited in the background was selectively reduced by the addition of silicone oil to the photoreceptor film. It is well known that silicon oil act as a material to reduce the surface free energy. This means that the film with silicon oil will decrease the adhesion force of toner particles attached to it and bring about the relationship that the adhesion force between a toner particle and a carrier bead exceed that between a toner particle and a surface of photoreceptor. Thus, it is so that toner particles are pushed away to the carrier beads in the development process.

2. Effect of Chargeability Between Toner and Carrier

In order to get the dependence of developer on the charge distribution of background toner, the specially blended two developers with similar toner charge distribution (see Experimental edition) were employed for the background development on the film without silicone oil.

In Figure 5, the black solid line, gray solid line and the dashed line shows the charge distribution of background developed toner obtained from High-TA/Low-CA developer, Low-TA/High-CA developer and the standard developer, respectively.

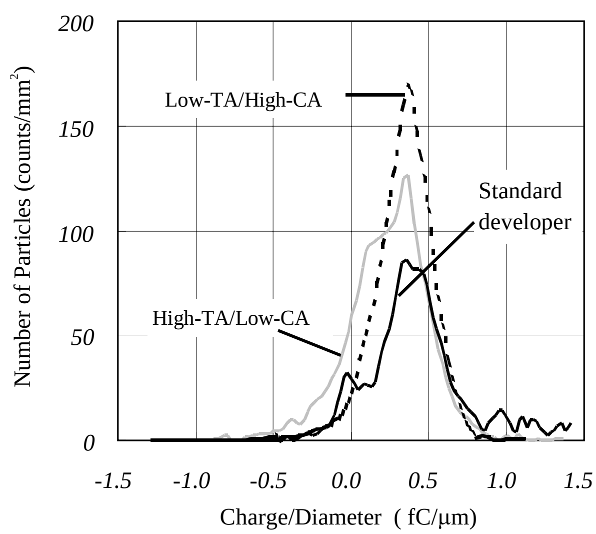

Figure 5. Charge distribution for background developed toner particles with combination of TA&CA

The curve shows a shoulder in the vicinity of 0fC/μm in the case of High-TA/Low-CA developer, whereas only one peak is shown in the case of Low-TA/High-CA developer. The peak of the curve in the latter case was the same position as in development sub-unit.

This results indicates that the pattern of the charge distributions curve for background developed toner are determined by the balance of chargeabilities for toner and carrier.

Conclusions

1. It was found that a charge distribution curve of background toner has the two peaks that assignable to low-charged wrong sign toner and high-charged right sign toner, respectively. The peak of high-charged right

sign toner was observed to coincide with the peak of toner in a developer.
2. The pattern of charge distribution curves for background developed toner was able to be classified into two types. One was such that the amounts of high-charged right sign toner was dominant. And the other was that the amounts of low charged toner was a major component.
3. It was investigated that the amounts of high-charged right sign toner attached to the photoreceptor film was selectively reduced by the addition of silicone oil to the photoreceptor. This result suggests that the background deposition of high-charged right sign toner was primarily caused by the adhesion force of toner particle to the photoreceptor.

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Biography

Takeo Yamaguchi received his M.S. degrees in Surface Chemistry from Science University of Tokyo and joined Ricoh in 1985. Hisao Kurosu received his M.S. degrees in Faculty of Engineering Department of Image science and technology from Chiba University and also joined Ricoh in 1992. Recently they belong to Electrophotography Development Center in Ricoh as Research Scientists. Their present research interest includes measurements of the dominant force of toner movement in development process.