Toner Charging Behavior in Mono-Component Developing Process

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Abstract

Charging behavior of toner in the nonmagnetic mono-component developing process was examined experimentally. A developing unit, which consisted of a developing roller, a supply roller and a doctor blade, was fabricated, and charging characteristics of the toner layer on the developing roller surface was investigated. The influence of CCA contained in the toner on its charging was also studied. It was found that the toner particles were charged mainly when they passed the gap between the doctor blade and developing roller. Although a negative toner was used, some toner particles were charged positively. The fraction of wrong sign toner decreased from 22% to 8% by passing the doctor blade. SEM observation suggested that toner particles of small particle size passed the doctor blade more easily.

Introduction

Improvement of the quality of output images is a permanent problem in the electrophotography. One of the keys for the improvement is control of charging of toner in the developing process. For that purpose, a lot of research on the elucidation of the charging mechanism are widely carried out.

The nonmagnetic mono-component developing method can make the electrophotographic system compact, and it is also available for a color system, since no magnetic component is used for the toners. Toner particles are carried to the developing zone on a developing roller and developed onto a photoreceptor by tribocharge generated between the developing roller and doctor blade in the nonmagnetic mono-component developing process.

Generally, most toner particles may be charged in a uniform polarity. However, some toner particles are charged in the opposite polarity. The non-uniformity of charge polarity causes the toner charging unstable and may decrease image quality.

The charging behavior of toner in the mono-component developing process was examined experimentally from the viewpoint of the wrong sign toner in this study.[1]

Experimental

Structure of Developing Unit

The mono-component developing unit used in this study is shown in Figure 1. It was consisted of a developing roller, a supply roller, and a doctor blade [2]. A practical developing unit was remodeled for the experiment. The developing roller and supply roller contacted to each other, and both were grounded. The developing roller and supply roller were made of silicon rubber and urethane foam, respectively. The doctor blade was made of stainless steel.

The roller rotation rate was controlled between 10 rpm and 50 rpm by using a speed controllable motor. The rotation rate was 48 rpm except for the case examining roller-rotation-rate dependence of toner charge in this study. The toner charge was measured by E-SPART analyzer.

Mono-Component Developer

Toners used in this study are shown in Table 1. The main resin of the toners was styrene-acrylic, and some CCA was contained. Since the toners were prepared by the pulverizing method, their shape was irregular. Toner of 1g was charged into the developing unit for each measurement. The toner of 1% of CCA (T3) was mainly used in this study except for the case examining the influence of CCA concentration on toner charge Q/M.

Table 1. The Toners Used In This Study.

Specimen	Mean particle size (μm)	Apparent resistivity (TΩ•cm)	CCA concentration (wt%)
T1	8.5	2.98	Free
T2	8.9	4.54	0.5
T3	9.2	7.72	1
T4	9.1	7.31	3
T5	9.2	6.91	10

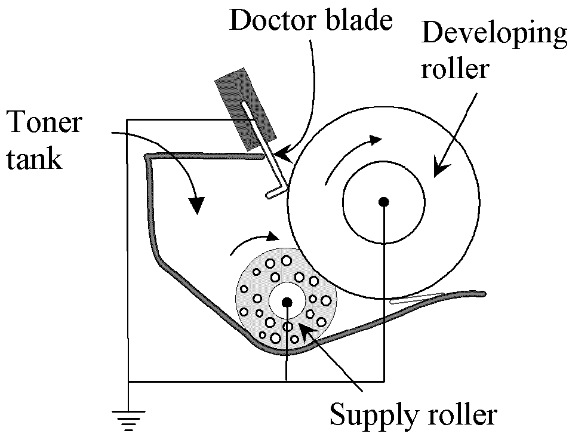

Figure 1. Schematic drawing of mono-component developing unit.

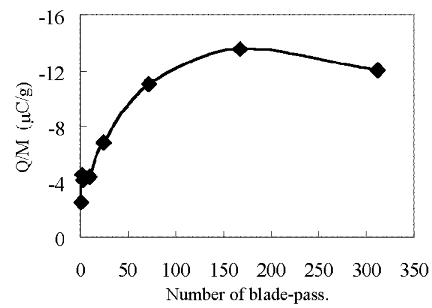

Figure 2. Toner charge Q/M as a function of number of blade-pass of toner.

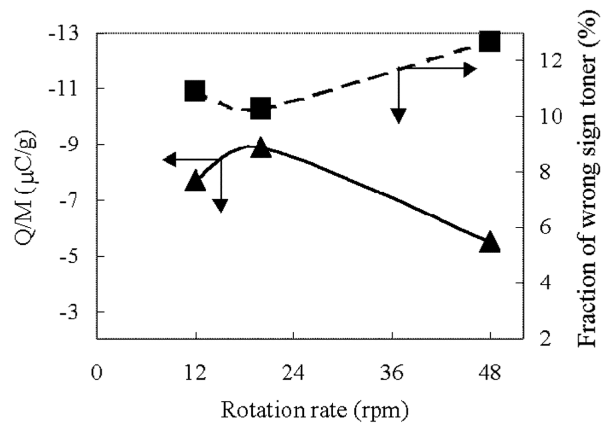

Figure 3. Inference of rotation rate of developing roller on toner charge Q/M and fraction of wrong sign toner.

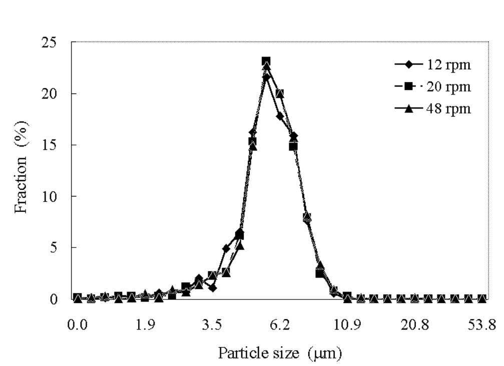

Figure 4. Particle size distribution of the toner on the developing roller as a function of roller rotation rate. Agitation time was 30s.

Results and Discussion

Influence of Agitation Time on the Toner Charge Q/M

Mono-component toners are considered to be tribocharged by the friction with the supply roller, doctor blade and developing roller in the developing unit. Toner charge usually increases and then saturated with agitation time.

The influence of agitation time on the toner charge Q/M on the developing roller is shown in Figure 2. The abscissa indicates the number of blade-pass of the toner. The toner chare Q/M increases with an increase in number of blade-pass. After the maximum value of Q/M of –13μC/g at 190s, however, the toner charge Q/M begins to decrease with further agitation. This phenomenon concerns with wrong sign (positively charged) toner particles.

Influence of Rotation Rate of Developing Roller on Toner Charge Q/M

Next, the influence of rotation rate of developing roller on toner charge Q/M on the developing roller is shown in Figure 3. The toner charge Q/M increased with an increase in roller rotational rate in the low rotation rate region, which may be explained by an increase in momentum of toner particles at a higher rotation rate. After passing the maximum value at about 20rpm, however, the toner charge Q/M decreased with further increase in rotation rate.

Particle size distribution of the toner on the developing roller at various rotation rates are shown in Figure 4. The particle size distribution was found to be independent of rotation rate of developing roller, which should not be the reason for the decrease in Q/M at higher rotation rates.

The toner supply rate from the supply roller also increases with an increase in rotation rate of developing roller. This may be a reason for the decrease in Q/M at higher rotation rates. The fraction of wrong sign toner was also given in Figure 3, which can be the main reason for the decrease in Q/M at higher rotation rates.

Then, Q/M was measured for the toners just before passing the doctor blade (point B) and on the supply roller (point S), in addition to the toner on the developing roller (point A) as shown in Figure 5.

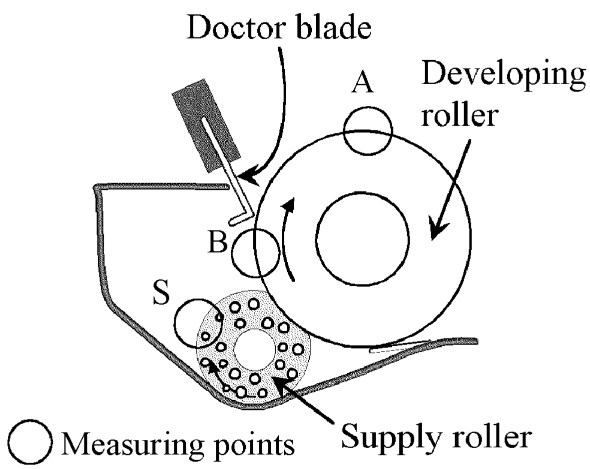

Figure 5. Measuring points of toner Q/M in the developing unit..

Figure 6 shows the toner charge Q/M at various points as a function of agitation time. Toner Q/M at points B and S are smaller than that at point A. The Q/M for the original toner before charging into the developing unit (point O) is also given in Figure 6. These results indicate that the toner is charged mainly when it passes the doctor blade.

The fractions of wrong sign toner at various points as a function of agitation time are shown in Figure 7. The fraction of wrong sign toner was almost constant for the toners on the developing roller and on the supply roller. While, the fraction of wrong sign toner fluctuated considerably for the toner before passing the doctor blade. Wrong sign toner may be generated when the toner transfers from the supply roller to the developing roller. However, the doctor blade reduced the fraction of wrong sign toner from 22% to 8%. This result suggests an important role of the doctor blade in the mono-component developing process.

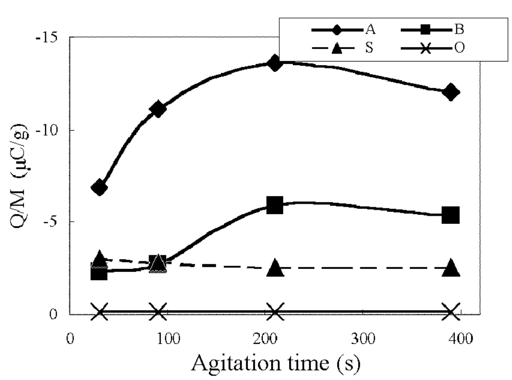

Figure 6. Toner charge Q/M at various points as a function of agitation time.

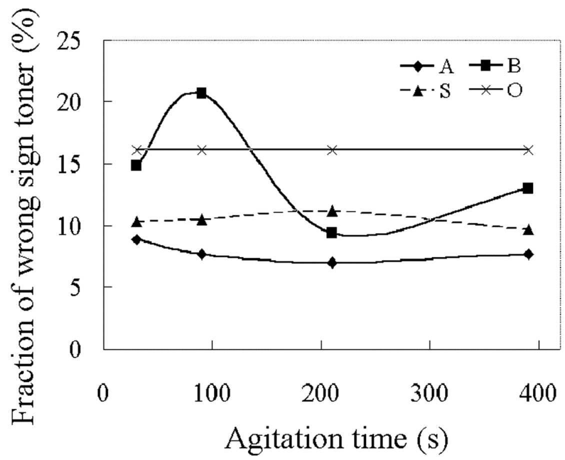

Figure 7. Fraction of wrong sign toner at various points as a function of agitation time.

Next, effect of the doctor blade on particle size distribution of the toner was examined before and after passing the doctor blade. The results are given in Figure 8. The particle size distribution of the toner was shifted in smaller direction by passing the doctor blade. In other words, toner particles of smaller sizes pass the doctor blade selectively. However, change in particle shape, before and after passing the doctor blade, could hardly be confirmed by SEM observation.

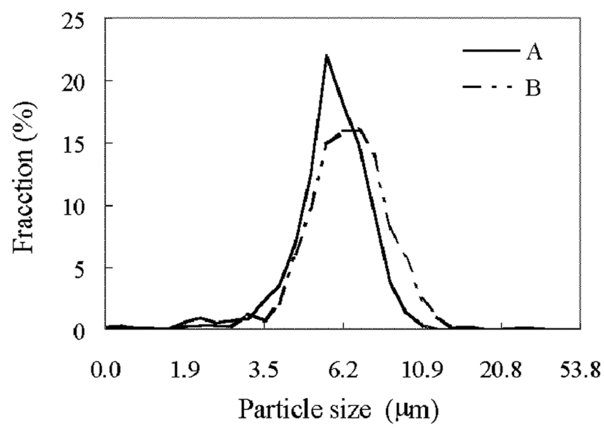

Figure 8. Change in particle size distribution of toner by passing the doctor blade.

Influence of CCA concentration on Q/M

Figure 9 shows the relationship between Q/M of toner on the developing roller and CCA concentration for two choices of agitation time. The CCA-free toner charged considerably, and the toner charge increased with an increase in CCA concentration. However, effect of CCA on toner charging is not so evident in the mono-component developer used in this study as usual dual-component developers.

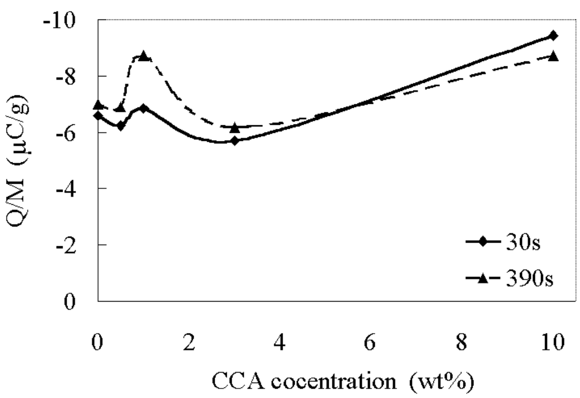

Figure 9. Toner charge Q/M as a function of CCA concentration.

Conclusions

The charging behavior of toner in the nonmagnetic mono-component developing process was examined and the following results were obtained.

1. The toner tribocharges mainly when passing through the doctor blade.
2. The toner charge Q/M tends to increase with an increase in CCA concentration. However, the effect of CCA is not so significant as dual-component developers.
3. Wrong sign toner may be generated when the toner transfers from the supply roller to the developing roller.
4. The toner of small particle size passes the blade selectively.

References

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2. Chiseki Yamaguchi, *Proc. IS&T's NIP15: 1999 Int. Conf. Digital Printing Technol.*, pp.490-494 (1999).

Biography

Manabu Takeuchi received the B. Sc., M. Sc. and D. Sc. degrees from the Tokyo Institute of Technology, Tokyo, Japan, in 1966, 1968, and 1971, respectively.

In 1972, he joined the Department of Electrical Engineering at Ibaraki University as an Assistant Professor. He was promoted to Associate Professor and Professor in 1976 and 1987, respectively. His research interests include static electrification and adhesion forces of electrophotographic developers and photoelectronic properties of semiconductor layers.