Behavior of Wrong Sign Toner Particles in Electrophotographic Developing Process

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Abstract

Toner scattering from a developing roller was examined under various conditions. An apparatus for evaluation of toner scattering was fabricated. Several kinds of toners differing in CCA concentration and a ferrite carrier were used in this study. The amount of scattering toner increased with increases in rotation rate of the sleeve of developing roller and toner concentration in the developer. Toner scattering was minimum for the toner with CCA of 3 %. Wrong sign toner was found to play an important role in toner scattering by forming toner pairing.

Introduction

The development process in electrophotography affects the quality of output images strongly. Recently both mono-component and dual-component developers are widely used in electrophotography systems [1]. Since tribocharging of powdered materials are influenced by many factors; the tribocharging mechanism has not been clarified in detail yet. Therefor it is not so easy to control tribocharging characteristics of electrophotographic developers.

One of the important problems is wrong sign toner both in mono-component and dual component developers. Wrong sign toners affect most steps of electrophotographic developing process, and finally lower image quality. It is well known that wrong sign toners cause fogging in output images. I addition to fogging, we found that wrong sign toners promoted toner scattering from the developing roller [2]. Scattered toner particles are deposited on anywhere including photoreceptor, paper and electrophotography system, etc. The scattered toner deposited on points except for latent image area causes fogging and decreases the quality of output images.

Recently, reduction of particle diameter of toner is proceeding in order to make output images fine and high quality. Fine particle toner is more easily scatted than conventional sized toners. High developing speed is also desirable from the standpoint of high-speed machines. However, high developing speed also promotes the toner scattering.

Toner scattering phenomenon was studied from the standpoint of wrong sign toner in this paper. First, an apparatus for evaluation of toner scattering developed in this study is described. Then experimental results on toner scattering carried out under various developing conditions are given. Finally the mechanism of toner scattering will be discussed in terms of wrong sign toners.

Experimental

Toner scattering evaluation system

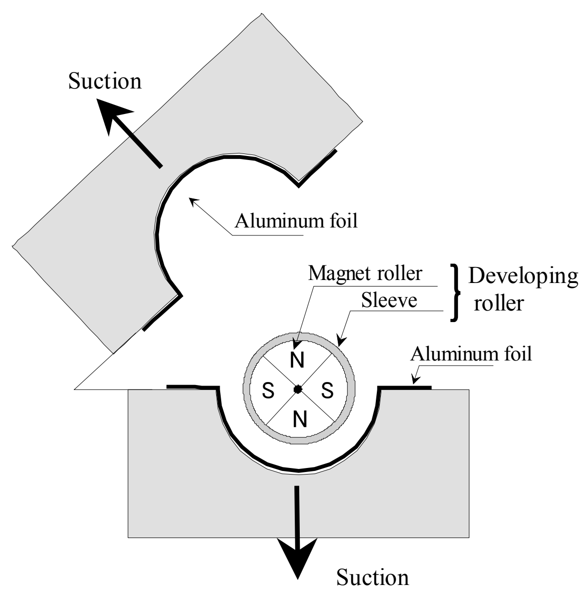

Figure 1. Schematic drawing of the apparatus for evaluation of toner scattering,

The schematic drawing of an apparatus for evaluation of toner scattering is shown in figure 1. This system was developed in this study [3, 4]. An electrophotographic developing roller, which consists of a magnetic roller and a sleeve (38 mm in diameter, 290 mm in length), was installed in the central part of the system. The sleeve of developing roller holds dual component developer on its surface. A cylinder made of polyvinyl chloride (PVC) was set around the developing roller for collecting scattered toner particles from the sleeve. Aluminum foil was mounted on the PVC cylinder to measure the mass of scattered and collected toner particles. The cylinder of the system can be split into two parts as shown in figure 1.

Evaluation of toner scattering

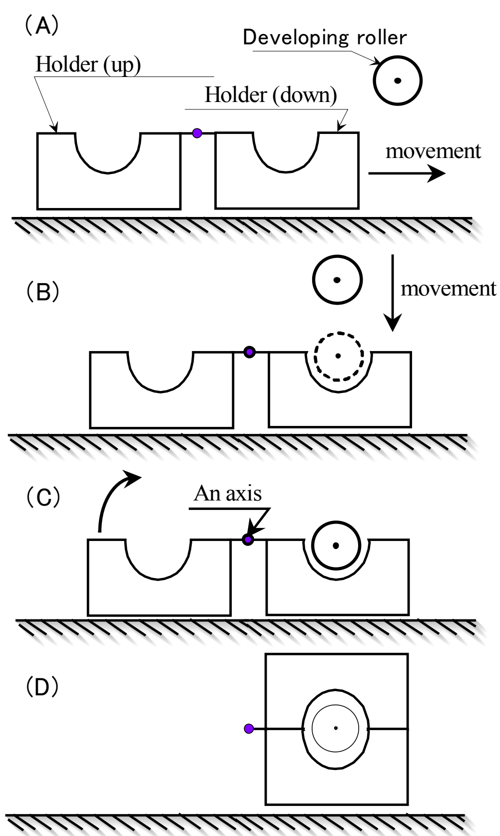

Figure 2. Sequence of evaluation of toner scattering.

The sequence of evaluation of toner scattering is shown schematically in figure 2. First, an appropriate amount of developer was put on the developing roller, and aluminum foil was mounted on the surface of both holders, and then the holders were moved under the developing roller (A). The developing roller holding developer was moved down to the holder (B). Then, the two holders were put up together (C). Finally the developing roller was rotated at a rotation rate for a definite time and toner scattering was evaluated (D).

Dual-component developers were prepared for evaluation of toner scattering in this study. Several kinds of toners differing in CCA concentration and a ferrite carrier (KBN100) were used as shown in Table 1. All the toners were prepared by conventional pulverization method and negatively charging type. The main resin is styrene-acrylic for all the toners. The mean particle sizes of the toners and carrier were about 9 µm and 98 µm, respectively. The toner concentration of the developers was 5 wt% except for examining toner concentration dependence of toner scattering.

A dual-component developer of 40 g was agitated by ball milling at 40rpm for 60 minutes and then held on the sleeve of developing roller for evaluation of toner scattering. The mass of scattered toner was measured as a function of rotation time of the developing roller. The rotation rate of the sleeve was changed to examine its influence on toner scattering.

Charge distributions of toners were measured to evaluate wrong sign toner by E-Spart analyzer.

Results and Discussion

Toner scattering was examined under various experimental conditions. The influence of sleeve rotation rate on the toner scattering is shown in figure 3. The ordinate and abscissa indicate fraction of integrated scattered toner and rotation time of the sleeve, respectively. The integrated scattered toner increased with an increase in sleeve rotation time. In addition, the toner scattering is promoted at higher sleeve rotation rates. Toner particles may be removed from carrier particles when the sum of centrifugal force and air resistance exceeds adhesion force.

Table 1. Samples used in this study.

Sample	Toner			Carrier
	CCA concentration (wt%)	Mean particle size (µm)	Q/M (µC/g)	
Developer 1	Free	8.5	- 2.62	KBN-100
Developer 2	0.5	8.9	- 10.3	
Developer 3	1.0	9.2	- 11.5	
Developer 4	3.0	9.1	- 11.4	
Developer 5	10	9.2	- 6.41	

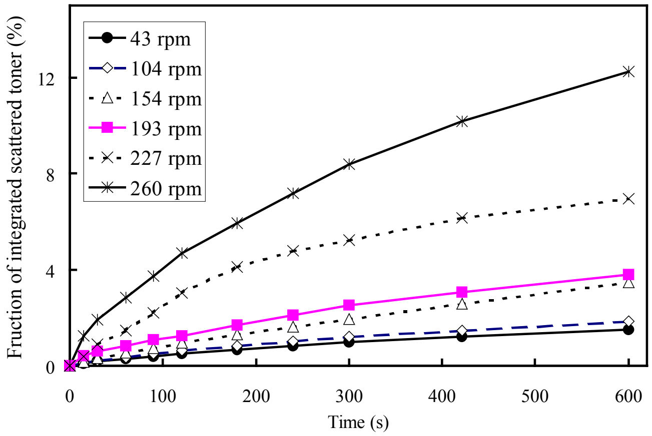

Figure 3. Fraction of integrated scattered toner as a function of sleeve rotation time for various choices of sleeve rotation rate for Developer 4.

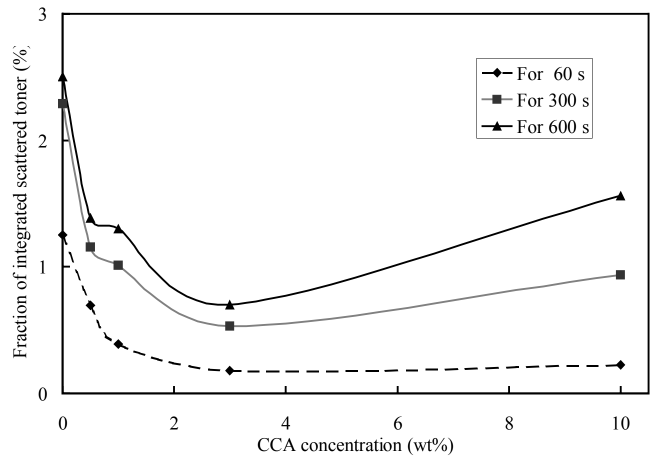

Figure 5. Fraction of integrated scattered toner as a function of CCA concentration in the toner. The sleeve rotation rate was 154 rpm.

The effect of toner concentration in the dual-component developer on the toner scattering is shown in figure 4. Toner particles in the developer of high toner concentration tend to be scatter at early stage of sleeve rotation. This result can be attributable to the low tribocharge of developer of high toner concentration.

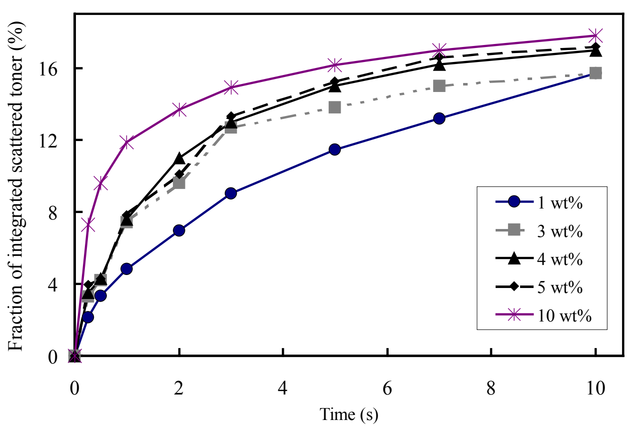

Figure 4. Fraction of integrated scattered toner as a function of sleeve rotation time for various choices of toner concentration for Developer 4. The sleeve rotation rate was 260 rpm.

Effects of CCA concentration in the toners on toner scattering are shown in figure 5. The CCA free toner scattered heavily, and toner scattering was minimum for the toner with CCA of 3 %. These results are considered that to be related with tribocharge of toners.

Tribocharge Q/M was measured for toners of various CCA concentrations to examine its influence on toner scattering. The results are given in figure 6. It was found that all the toners contained wrong sign toner of about 10 % regardless of CCA concentration except for CCA free toner, whose wrong sign toner was about 20 %. Net charge of the toner was maximum at around CCA concentration of 1 to 3 %, where the toner scattering was minimum.

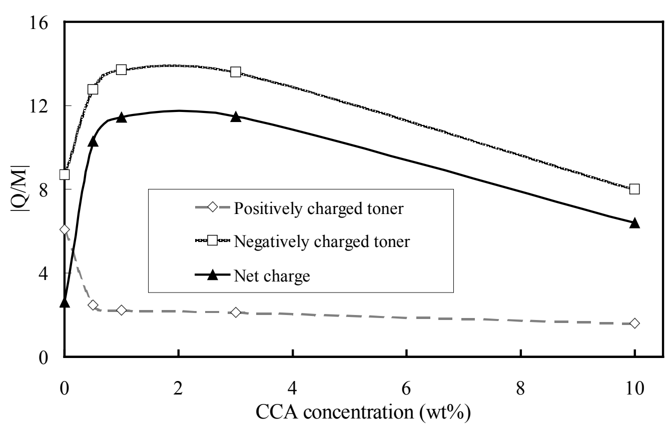

Figure 6. Q/M of positively and negatively charged toner particles as a function of CCA concentration in toners. The net charge is also plotted.

The charge distributions of the toners used in this study are shown in figure 7. It can be confirmed that the CCA free toner has small Q/M value for normally charged particles and contains considerable amount of wrong sign toner [5]. Although the wrong sign toner in the toner with CCA of 10 % is approximately the same level as other toners with CCA, its Q/M for normally charged particles is smaller than other toners. These results are consistent with large amount of scattering toner in these two toners.

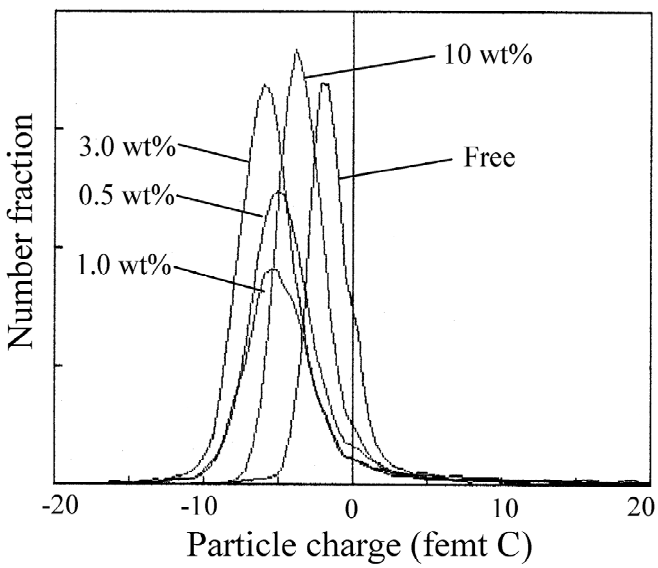

Figure 7. Charge distributions for toners used in this study.

Finally, in order to clarify the role of wrong sign toner in toner scattering more in detail, SEM observation was carried out on the scattered toner. The SEM image of the scattered toner is shown in figure 8. Some toner pairing can be observed in the image. The toner couples should consist of normally charged and wrong sign toner particles. Adhesion force of the coupled toners to a carrier bead is weak and causes the toner scattering easily.

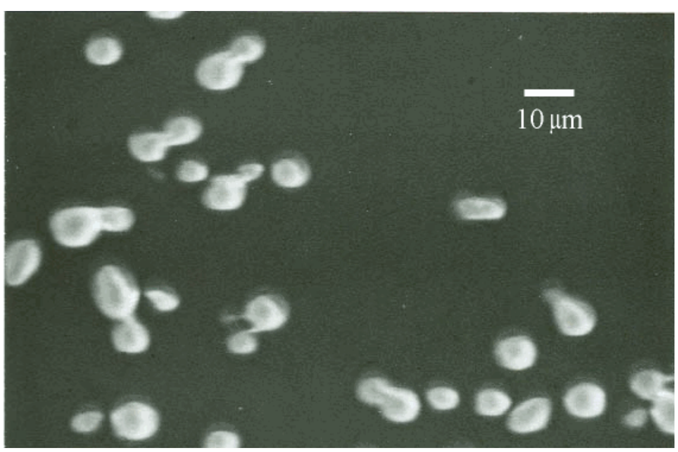

Figure 8. SEM image of scattered toner particles.

Conclusion

An apparatus for evaluation of toner scattering from the developing roller was fabricated, and factors affecting toner scattering was studied. The following results were obtained.

1. Scattering toner increased with an increase in rotation rate of the sleeve of developing roller.
2. Scattering toner increased with an increase in toner concentration in developer.
3. Scattering toner was minimum for the toner with CCA of 3 %.
4. Tribocharge of toner influenced strongly on the toner scattering.
5. Wrong sign toner plays an important role in toner scattering by forming toner pairing.

References

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Biography

Norimasa Iwai received his B. Eng. in Electrical and Electronic Engineering from Ibaraki University in 1999. He is now working for M. Eng. at the same university. He is studying charging characteristics of toners, application of electret to the developing process in electrophotography and electrochemical imaging.