Toner Charge Distribution Change on Toner Mixing Time

Effect of carrier charging ability

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Abstract

Toner tribocharging characteristics are affected by various factors : charging method, materials, environment and others. The toner charge stability is important for keeping a good image quality. Toner charge distribution is one of important factors in electrophotographic printing process. The toner charge distribution is changed by toner mixing conditions of toner weight % and toner mixing time. In this study, aerodynamic size and electrostatic charge distribution of the toner particles are measured individually by E-SPART (Electrical Single Particle Aerodynamic Relaxation Time) analyzer. It is found that two peaks in toner charge histogram arise in some conditions.

Introduction

As far as the toner charge is concerned , it gives a great influence to image quality in electrophotographic printing process[1,2]. Although lot of studies have been carried out for understanding the toner charging mechanism, it is considered that the charging process has not yet been understood well enough due to the complexity of the mechanism and influences by many factors as well such as; toner materials, charging conditions[3,5], humidity and so on. In the electrophotographic process, two-component developers have been widely used. The image quality is influenced by tribo-charging characteristics on toner which are affected by various factors such as material component, shape, charging mechanism, environmental conditions and so on. Since it is important to evaluate tribo-charging behavior on toner; in this report, toner charging mechanism is studied from the view point of toner mixing conditions such as toner wt% and toner mixing time.

The developers comprise a dry mixture of toner and carrier particles. The particles in such two component developers are formulated such that the toner particles and carrier particles occupy different positions in the tribo-electric continuum, so that when they become tribo-electrically charged, with the toner particles acquiring a charge of one polarity and the carrier particles acquiring a charge of the opposite polarity. These opposite charges attract each other such that the toner particles cling to the surfaces of the carrier particles. The specific tribo-electric charge on toner is measured by E-SPART (Electrical Single Particle Aerodynamic Relaxation Time), which has characteristics of simultaneous measurements of toner charge and size[8], detecting by a Laser Doppler Velocity meter. The schematic diagram is shown in Figure1.

Experimental

The toner used in this experiment was made by pulverization method and has been converted to rounded toner by rounding treatment. The SEM micrograph of toner is shown in the Figure 2 and it seems approximately spherical. The size of rounded toner is around 4.7 - 7.5 um as shown in Figure 7. Two types of carriers were used for developer samples, where as; high charging ability carrier (N-01 standard carrier of Imaging Society of Japan) and moderate charging ability carrier. The SEM micrographs of particular carriers are shown in Figure 3. The samples were prepared as the conditions mentioned in the Table 1 and the outline of the experimental procedure is shown in Figure 4. Further, the developer samples of mixture of toner and carrier were prepared at the conditions of 3,5,7 wt% of the toner and the mixing time was varied as 1,3,5,7,10,20,30,60 min. The toner was charged for the particular time durations by contacting with carrier with the help of rotation cylinder at a rotation speed of 120 rpm as shown in Figure 6.

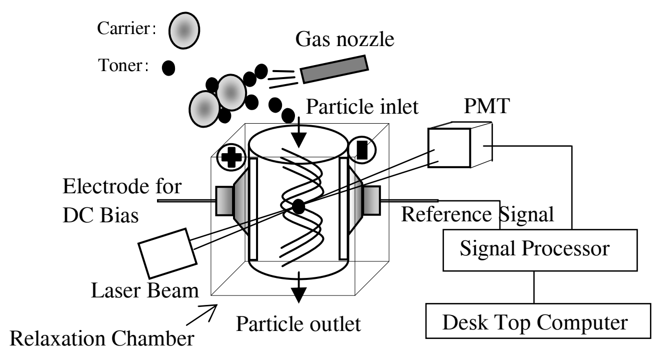


Figure 1. *The schematic diagram of E-SPART analyzer.*

Diameter, toner charge and size were measured using E-SPART analyzer (Hosokawa-Micron E-SPART type1 improved model). The charge and the size of individual toner were measured simultaneously. The toner particles were measured till 3000 counts in every mixing condition.

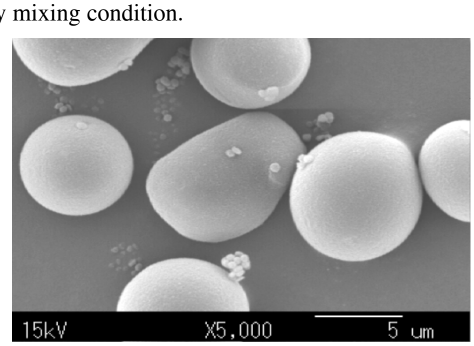
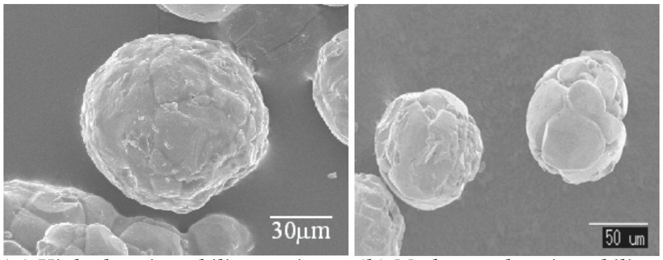


Figure 2. *The SEM micrograph of toner used in the experiment.*



(a) High charging ability carrier. *(b) Moderate charging ability carrier.*

Figure 3. *The SEM micrographs of carriers used in the experiment.*

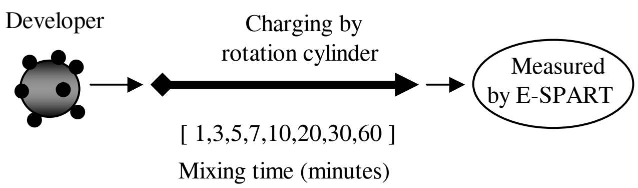


Figure 4. *The outline of the experiment.*

Figure 5 shows the SEM micrograph of toner attached to carrier used in the experiment.

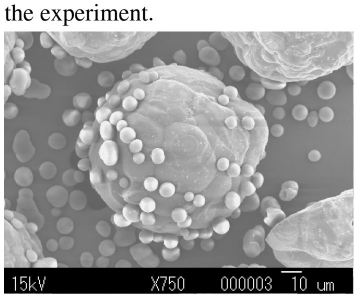


Figure 5. *The SEM micrograph of toner attached to carrier used in the experiment for 10 minutes mixing time at 3wt%.*

Table 1 Two-component toner charging conditions.

Samples	Toner wt% (with two types of carriers)		
	3,5,7		
Keeping	Temp. [° C]	Humidity [%]	Time [h]
conditions	20	60	24
Mixing	Rotate [rpm]	Time [min]	
conditions	120	1,3,5,7,10,20,30,60	

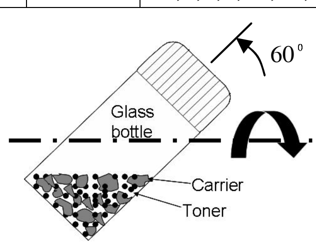


Figure 6. *The mixing method used in the experiment.*

Results and Discussions

The size distribution of toner was measured and it was distributed around 4.7 - 7.5 *u*m as shown in the Figure 7. At the toner wt% of 5 and 7, toner size distribution is nearly same, however at the 3wt% of toner, it is found that, small size toner increases. This may be considered that toner is broken at the 3wt% after 60 minutes mixing. It is found from Figure 8 that, at the initial rise of the toner charge, the toner specific charges decrease as the toner wt% increases. Another remarkable point is that, at 3 wt% of toner, the time dependence of the toner specific charge q/m decreases abruptly after the peak q/m value. On the other hand, at the toner 5, 7 wt%, the time dependences of q/m show slight decrease after the peak q/m value. The above mentioned data are shown in Figure 8.

Concerning the toner wt% dependence, the toner charge at the peak decreases as toner wt% increases, its behavior is qualitatively as predicted by surface state theory. The decrease of toner charge after the peak is considered due to the possibility of destruction of toner and contamination of carrier. When the toner wt% decreases, carrier is not covered by toner. Toner is sandwiched by carriers frequently, and it is considered that the abrupt toner charge decrease has arisen.

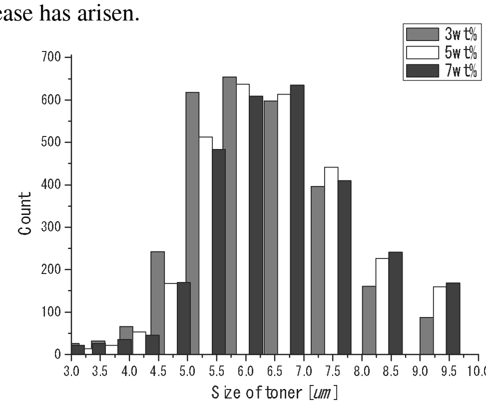


Figure 7. *Histogram of size of toners.*

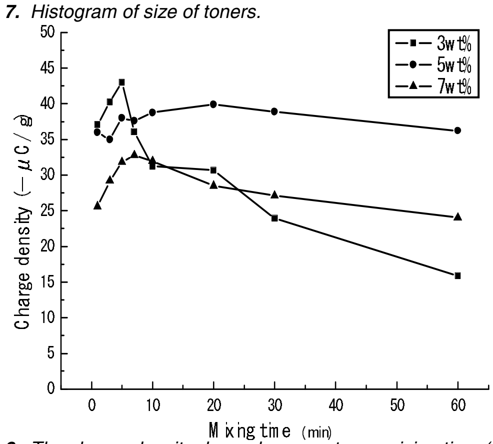


Figure 8. *The charge density dependence on toner mixing time (with High charging ability carrier).*

When the Figure 9 is considered, it can be noticed that, at 3wt% of toner, the time dependence of the toner specific charge q/m increases when the mixing time increases and then decreases after the peak. But in the cases of 5,7 wt%, the time dependences of q/m show gradual increments.

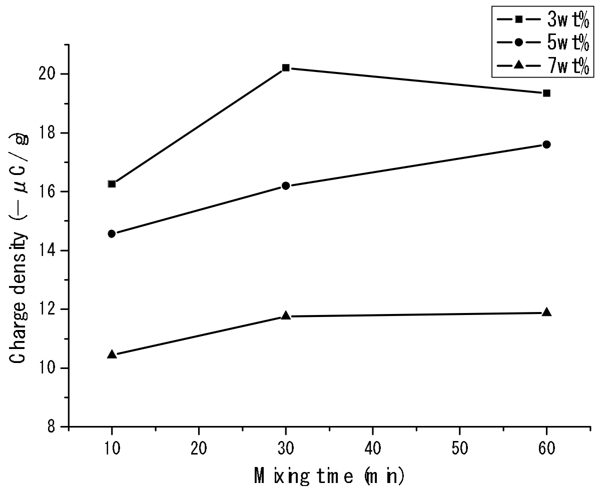


Figure 9. *The charge density dependence on toner mixing time (with Moderate charging ability carrier).*

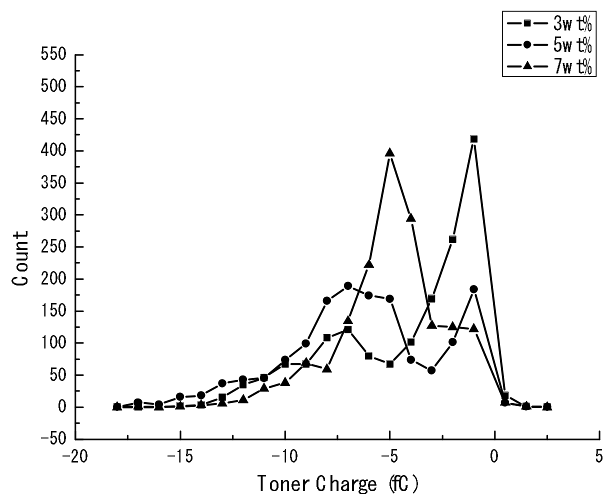


Figure 10. *Count dependence on toner charge in the cases of 10 minutes mixing time (with High charging ability carrier).*

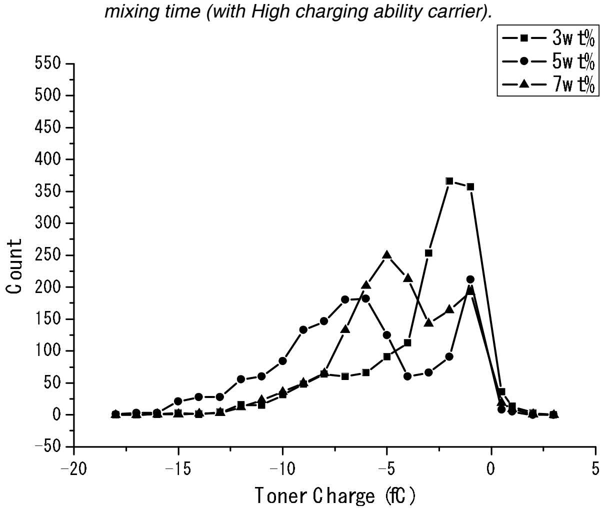


Figure 11. *Count dependence on toner charge in the cases of 30 minutes mixing time (with High charging ability carrier).*

Concerning the Figures 10,11 and 12 which depicts the count dependence on toner charge for experiment with using N-01 standard carrier, it is found that there are two peaks in every figure.

In general, toner charge histogram shifts to less charge side where the shift corresponds to the results of Figure 12. In the same figure ,at 5 and 7 wt%, two peaks are kept at 60 minute mixing, however at 3 wt%, high charged peak disappear. Concerning the origin of two peaks, it is considered the possibility of two types of charged toner: one (low charged toner) is toner charged partially and strongly sticks to carrier, other (high charged toner) is toner which contact carrier well and more area of toner surface is charged.

The following Figures 13,14 and 15 show the results of count dependence on toner charge in case of using the moderate charging ability carrier; where we can find only one unique peak. Compared with the peak above 5~10fC when toner is charged by high charge ability carrier, there is no peak in 5~10fC and high charged toner is few. It is proposed that high charge ability carrier has possibility of two peaks generation in toner charge distribution.

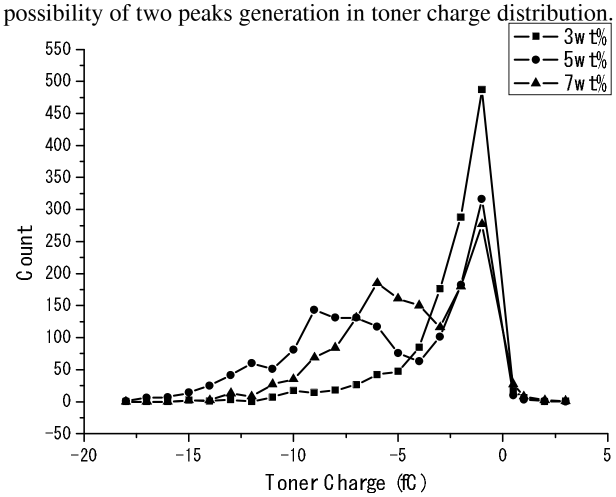


Figure 12. *Count dependence on toner charge in the cases of 60 minutes mixing time (with High charging ability carrier).*

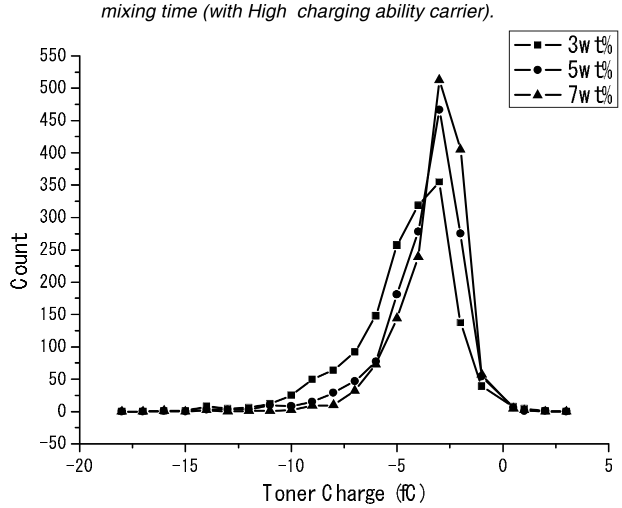


Figure 13. *Count dependence on toner charge in the cases of 10 minutes mixing time (with Moderate charging ability carrier).*

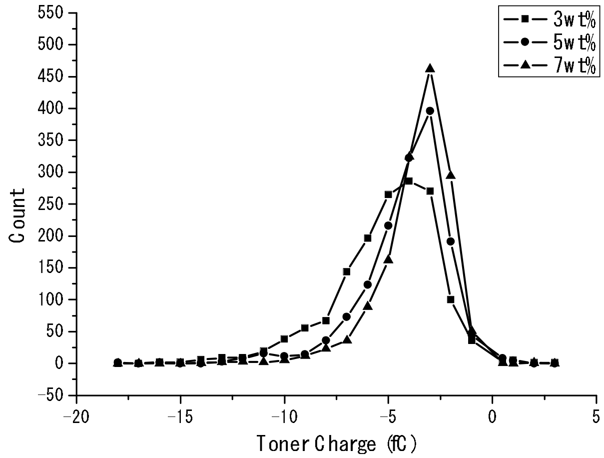


Figure 14. *Count dependence on toner charge in the cases of 30 minutes mixing time (with Moderate charging ability carrier).*

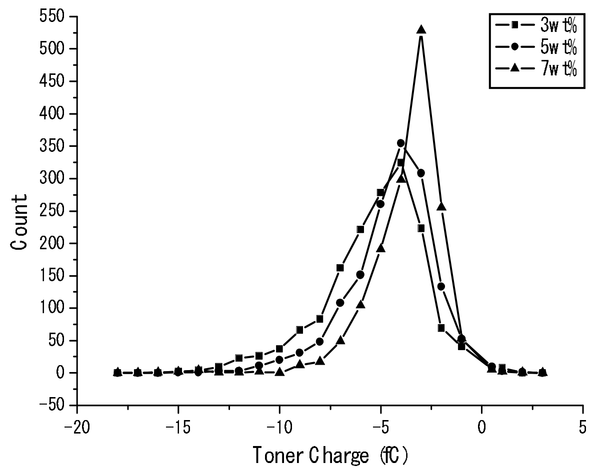


Figure 15. *Count dependence on toner charge in the cases of 60 minutes mixing time (with Moderate charging ability carrier).*

Summary

Toner is charged by mixing with high charge ability carrier (N-01 standard carrier of Imaging Society of Japan) and moderately charge ability carrier. Its charge is measured by E-SPART analyzer. Two peaks are found in the histogram of toner charge when using the high charge ability carrier. On the other hand only one unique peak was observed when using the moderate charge ability carrier. When mixing time is concerned it can be noticed that, toner charge will gradually decrease when mixing time of high charge ability carrier increases. It is proposed that, in high charge ability carrier case, there are two types toner: one is less charged by sticking to carrier and other is more charged toner by contact with carrier well.

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References

[1] R. M. Schaffert, “Electrophotography”, The focal press, London, (1975) pp.557-562.
[2] L.B. Schein, “Electrophotography and Development Physics”, Springer Verlag (1988) pp.63-87.
[3] C. Poomtien, S. Kiatkamjornwong, and Y. Hoshino, ”Effect of CCA and Charging Behavior on print Quality”, Particulate Science and Technology,16(1999) pp.295-310.
[4] W. Saelow, S. Kiatkamjonwong, T. Watanabe and Y. Hoshino, ” Dependence of Toner Charging Characteristics on Mixing Force”, J. Imaging Society of Japan, 38(1999) pp.310-313.
[5] The technical committee report, “Standardization of the amount measurement of toner electrifications”, J. Imaging Society of Japan, 37(1998) pp.461-468.
[6] T. Nakanishi, K. Sheu, J. S. Huang, Y. Hoshino, Toner Charging Characteristics Dependence on Toner Shape,
[7] Proceedings IS&T NIP21: International Conference on Digital Printing Technologies, (2005) pp.525-528.
[8] H. Ishihara and Y. Hoshino, "Charging characteristics of polymerized and pulverized toner in the roller rotation mixing system of toner and carrier", IS&T's NIP19 International Conference on Digital Printing Technologies, (2003) pp.161-164.
[9] Y. Nakamura et. al. “Simultaneous Measurement of Particle Size and Electric Charge of Toner for Two-Component Developer”, J. Imaging Soc. of Japan 130(1999) pp.302-309 (in Japanese).

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