Effect of Surface Treatment of Carrier on Toner Charging Characteristics

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Abstract

Nowadays the two-component developers are widely used in electrophotography. In two-component developing system toner is tribo-electrically charged by contacting with carrier. In this study, two types of crushed toners categorized according to the constitution of external additives and four types of carriers which are also categorized according to the surface treatment were used for the experiment. The toner charge distribution is changed by the type of carrier coating and concentration of external additives as well. The Aerodynamic size and electrostatic charge distribution of the toner particles are measured individually by E-SPART (Electrical Single Particle Aerodynamic Relaxation Time) analyzer.

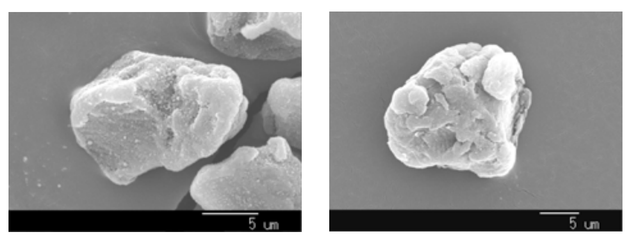
Introduction

In the electrophotographic printing process[1,2], the electrostatic force which is the dominant for moving toner particles in the electric field is induced due to the tribo-charging by contacting carrier with toner in the development unit. Therefore carrier plays an important role in the process. As far as the good quality of a print is concerned, it is generally considered that stabilizing the distribution of charged amount of developer leads to the improvement. Since two-component developers are widely used in electrophotography, dynamics of charged toner in electrostatic fields have been investigated. However, it is considered that the charging mechanism has not yet been understood well enough from the view point of toner charging. Therefore it has become the necessity of studying the toner charging mechanism in various aspects. Since the toner charge distribution depends on the surface treatment which it is subjected to; in this report, the study on effect of surface treatment on toner charge characteristics is discussed. With the adaptation of coated carriers in two-component dry-type developers, it is considered that they are partially useful in development of negatively charged photoreceptors as they have negative tribo-electrical charging properties. The coated carriers which impart excellent durability, moisture resistance, flow ability and so on, out put the developed images with high quality and bears a long life time. Carrier particles are coated with materials having appropriate tribo-electric properties as well as certain other physical characteristics such as smooth outer surfaces and intermediate hardness so as not to scratch the drum surface.

Also the effect of concentration of the constituents of toner particles on the charge distribution is studied as well. In order to make improvements, such as better image quality and higher reliability, toner size becomes smaller and smaller. Therefore, each of toner function should be separately controlled with various factors such as core materials, surface materials and external additives. Therefore in this study it is studied that, how the additives are affected on the toner charge distribution. The specific tribo-electric charge on toner particles is measured with the help of E-SPART (Electrical Single Particle Aerodynamic Relaxation Time) analyzer. Since the drift velocity due to DC electric field and vibrating velocity under acoustic field for each dropping toner particle in air is detected by a Laser Doppler Velocity meter, ability to take simultaneous measurement of toner size with its charge is an advantage[6].

Experimental

In two-component development system, the tribo-electrical charging is caused by rubbing the carriers and toners themselves well in the development unit so as to acquire a charge of one polarity for toner and the opposite polarity on the carrier. The developer samples for experiment were prepared so as to be similar with two-component developers where as mixing toner with carrier. Two types of crushed toners where as; Toner-A and Toner-B which were categorized according to the concentration of external additives have used for preparing the developer samples. Figure 1 shows the SEM micrographs. The Toner-B has been manufactured so as to be one third of constituent of external additives of Toner-A.

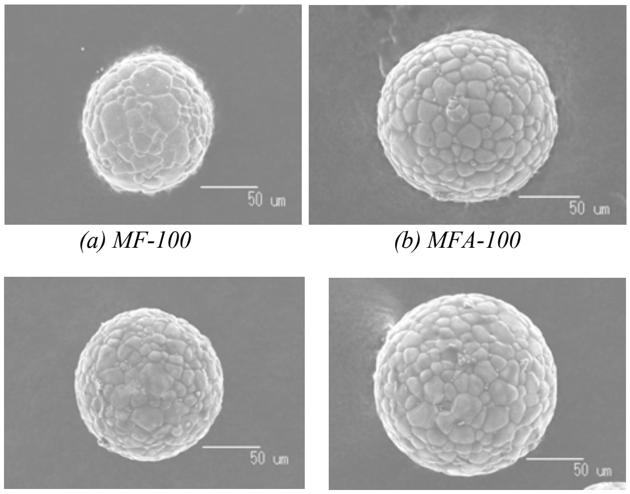


(a) Toner - A *(b) Toner - B*

Figure 1. SEM micrographs of toners used in the experiment.

Four types of magnetic ferrite carriers were used for the samples and they were categorized according to the surface treatment. They are named as MF-100, MFA-100, MFB-100 and MFC-100 where as; non-coating, silicon-coating, acrylic-coating and fluorine-based coating carriers respectively and the SEM micrographs are shown in Figure 2. Toner concentration of the developer samples were 3wt%, 5wt% and 7wt%. Soon after preparing the samples, they were kept under control conditions where as 20℃ of temperature and relative humidity of 60% for 24 hours duration for stabilization. Just before analyzing the samples, the toner was tribo-electrically charged by contacting with carrier well for 10 minutes for each sample with the help of a mixing instrument which the speed was fixed to 120 rpm. As the final step; each sample was analyzed till 3000 count by E-SPART analyzer. The schematic diagram of E-SPART is shown in Figure

3 and the outline of the experimental procedure is as illustrated in Figure 4.



(a) MF-100 *(b) MFA-100*

(c) MFB-100 *(d) MFC-100*

Figure 2. SEM micrographs of carriers used in the experiment.

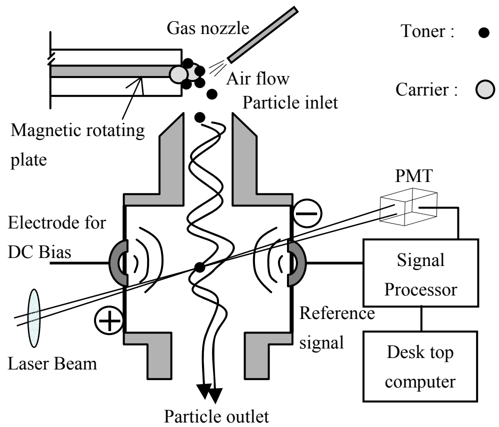


Figure 3. The schematic diagram of E-SPART analyzer.

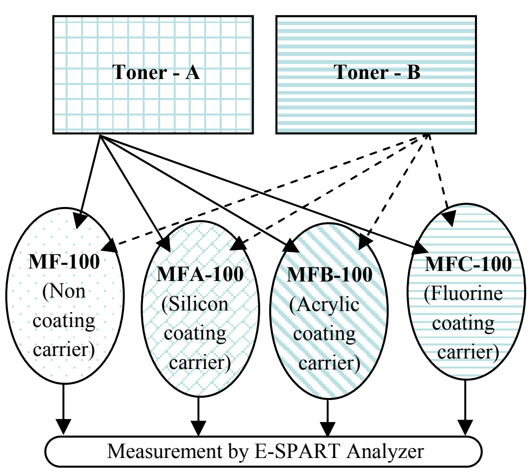


Figure 4. Experimental outline.

The following Figure 5 shows the schematic diagram of the tribo-charging method.

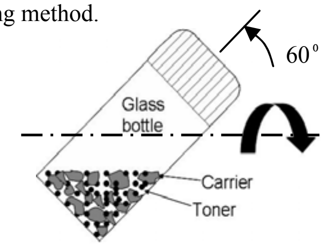
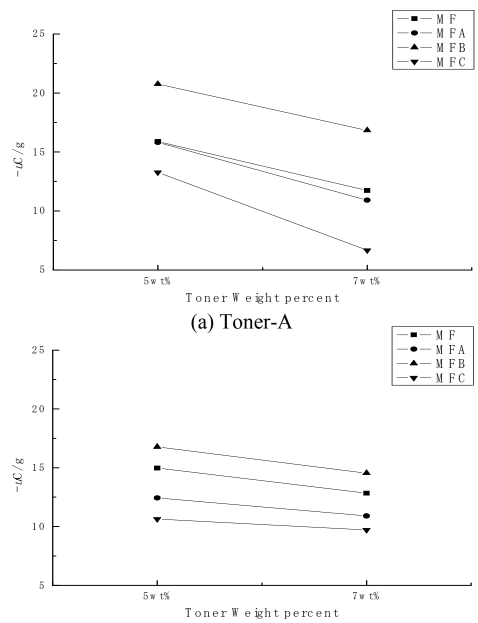


Figure 5. The schematic diagram of mixing method.

Results and Discussions

The Figure 6 depicts the specific toner charge dependence on toner concentration for the two cases; toner-A and toner-B. It can be noticed that the q/m decreases when the toner wt% increases in every case. The gradient at toner-A case shows a higher value than toner-B case. And also it can be understood that; always MFB-100 carrier case shows the highest values for both types of toners.



(a) Toner-A

(b) Toner-B

Figure 6. Specific toner charge dependence on toner weight percent.

On the other hand MFC-100 carrier case shows the lowest charge density values. The MF-100 and MFA-100 carrier cases lie in between MFB-100 and MFC-100 and at toner-A, they shows nearly same while in the other shows little a bit gap. When the q/m dependence on carrier type is plotted for 5wt% by considering as a standard condition, it can be noticed by concerning the Figure 7 that always toner-A case shows the highest values. This kind of charging difference could be observed as a consequent of manufacturing toner-B so as to be the amount of external additives one third as toner-A. By this it could be understood that the concentration of external additives can directly affect to the charge quantity. When the carriers are queued as shown in the Figure 7, it can be understood that charging tendency increases gradually.

Another point which can be noticed here is, the q/m difference between two toner cases looks similar except in MF-100 case.

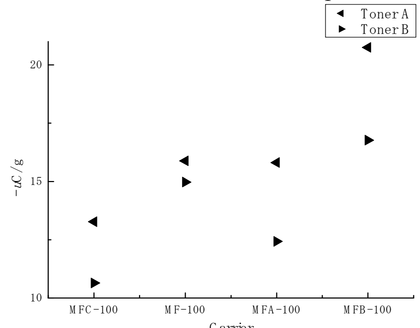


Figure 7. Specific charge dependence on carrier type for 5wt%.

Figure 8 shows the histogram of size of toners for both types at 5wt%. By observing the graph, it can be determined that the histogram for toner-B has shifted a little to right side. Also can be found that the size of toner-A varies from 4.71 to 7.47 *u*m while toner-B shows a distribution around 5.31 *u*m −8.35 *u*m.

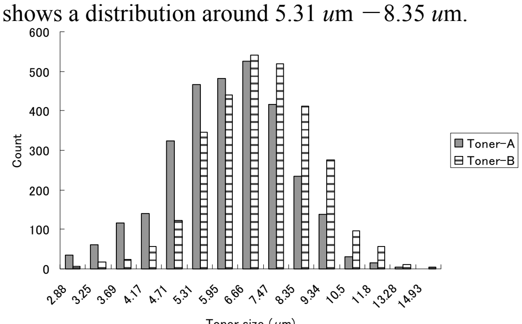


Figure 8. Histogram of size of toners.

Figures 9,10,11 and 12 shows the count dependence on toner charge for four types of carriers respectively by mixing with toner-A. It can be noticed that in general, the peak value has taken by 7wt% and respectively decreased as 5wt% and 3wt%. And also there is a shift of the toner charge histogram to less charge side. It can be clearly observed in Figure 10, that the 7wt% shows a narrow peak while the 3wt% shows the widest. The 5wt% lies in between them.

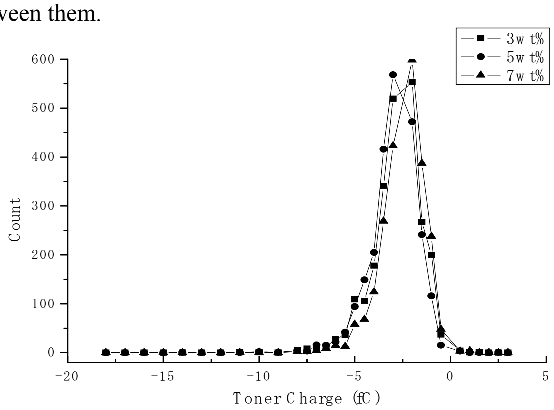


Figure 9. Count dependence on toner charge in the case of mixing toner-A with MF-100 carrier.

Since there are two peaks are observed in the Figure 11, it can be assumed that; there is a possibility of appearing this kind of result due to adhering the toner strongly to carrier which are partially charged, and due to contact carrier well with charging more surface area of toner.

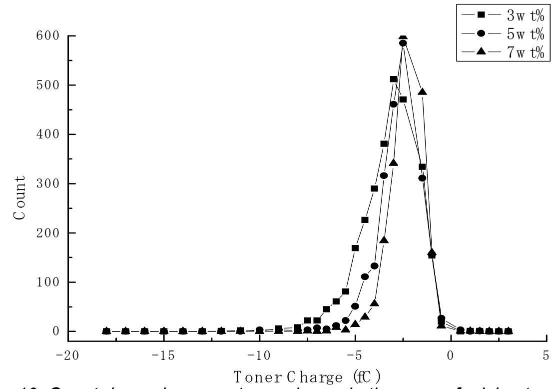


Figure 10. Count dependence on toner charge in the case of mixing toner-A with MFA-100 carrier.

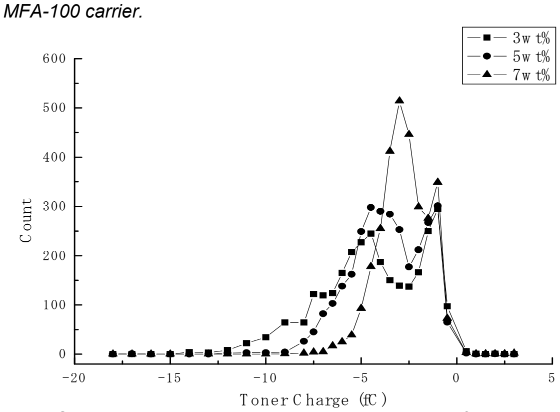


Figure 11. Count dependence on toner charge in the case of mixing toner-A with MFB-100 carrier.

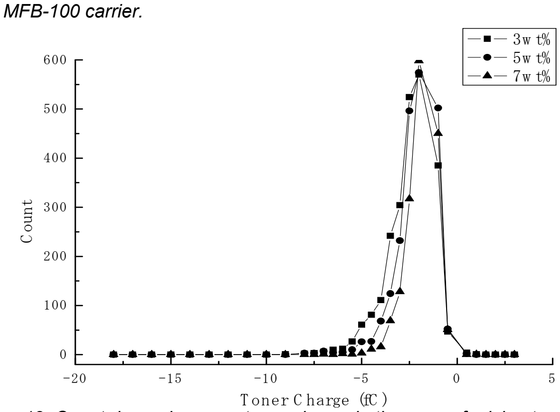


Figure 12. Count dependence on toner charge in the case of mixing toner-A with MFC-100 carrier.

Figures from 13 to 16 show the count dependences on toner charge for toner-B with the same carriers. In this case also, it can be clearly observed that the count decreases when the toner wt% increases. When using the toner-B also, two peaks has outcome when mixed with MFB-100 carrier. Therefore it can be determined that MFB-100 carrier has the ability of giving two peaks by charging toner partially or strongly. The peak of the count is comparatively lower than the case of toner-A. But, in toner-B case we could observe larger gaps between the peaks of three weight percents rather than the case of toner-A. This can be clarified by comparing the Figures 10 and 14.

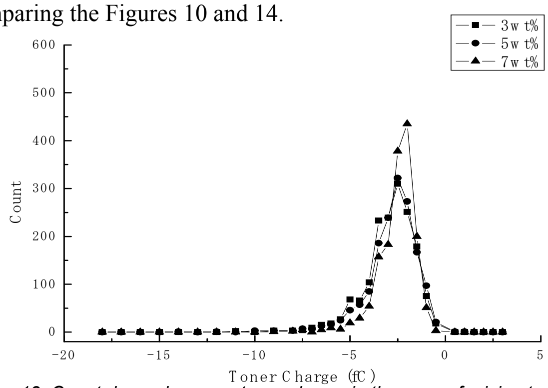


Figure 13. Count dependence on toner charge in the case of mixing toner-A with MF-100 carrier.

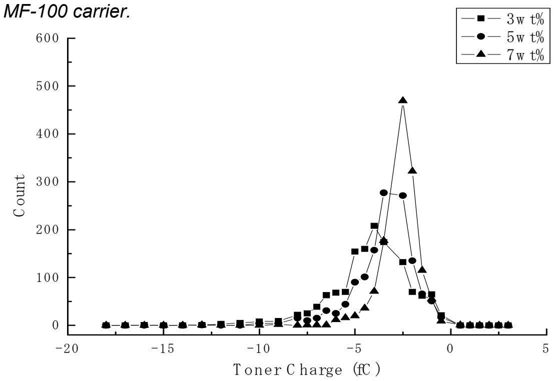


Figure 14. Count dependence on toner charge in the case of mixing toner-A with MFA-100 carrier.

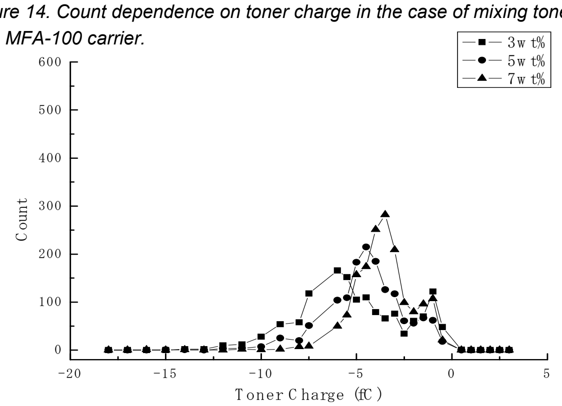


Figure 15. Count dependence on toner charge in the case of mixing toner-A with MFB-100 carrier.

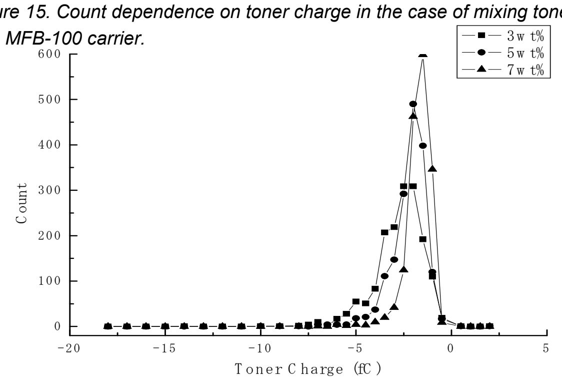


Figure 16. Count dependence on toner charge in the case of mixing toner-A with MFC-100 carrier.

Summary

Four types of carriers of different surface treatments and two types of toners with different constituents of external additives were used for the experiment and the toner charge was measured by E-SPART analyzer. It could be noticed that the peak of the count dependence on toner charge histogram decreases with the toner wt% decrement. The Acrylic-coating carrier (MFB-100) which has a high chargeability can make two peaks in the count versus charge graph. When the toner charge is concerned, it can be concluded that the charging tendency of carrier depends on the surface treatment and the external constituent of toner as well.

Acknowledgement

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