Tribo-Charging Characteristics on Pulverized Toner Particles in Two-Component Developer

Youichi Nakamura and Yutaka Terao; Nippon Institute of Technology; Miyashiro, Minami-Saitama, Saitama 345-8501/JAPAN: nakamura@nit.ac.jp

Abstract

Tribo-charging characteristics on toner in a two-component developer are affected by various factors such as material component, shape, and methods of tribo-charging or measuring. A negative yellow type of pulverized toner is used as a sample, and the material is based on bisphenol A and polyester resin. Tribo-charging treatment is performed by using a developed mixing shaker with arm length of 200 mm. Charge to mass ratio q/m is measured by the E-SPART method. From the experimental results, it is shown that the q/m varies unstably and fluctuates with shaking time within 5 min, but the q/m changes gradually to a constant value of -13.5 μC/g at 20 min after 4 min for the 5 wt% of toner concentration. In order to investigate the change of the q/m, the observation via SEM on toner particles after the shaking treatment is performed. The q/m dependence on toner concentration from 1 wt% to 10 wt% in the developer is also reported.

Introduction

In the electrophotographic industry, a remarkable development has been made especially in color copying machine. In the development process, electro-static force due to tribo-charged toner via contact with carrier beads has a main role to produce an image. Toner used in two-component developer is a key factor for reproducing original images in a copy machine. For the high quality on toner image, smaller toner particles have been usually adopted in a conventional two-component developer. This trend towards the smaller size of toner brings about a strong demand in control of the size and charge distribution for toner. The electric charge quantity and the polarity on toner particles are affected by material components of toner and carrier, because the polarity becomes to be opposite in principle for each other and the charge on toner depends on the total amount of the charge on carrier. Charging characteristics are also affected by various factors such as shape of toner and methods of tribo-charging or measuring.

It is, therefore, important to evaluate tribo-charging behavior on toner. Measurements of charge on toner have been done by various methods, such as the blow-off Faraday cage [1], the charge spectrograph [2] and the E-SPART (Electrical Single Particle Aerodynamic Relaxation Time) method [3]. The E-SPART has an advantage of simultaneous measurement on charge and size, because drift velocity due to DC electric field and vibrating velocity under acoustic field for each dropping toner particle in air are detected by a laser-Doppler velocity meter. We have analyzed tribo-charging characteristics on toner by using an electrophotographic developer system of color toner particles and black carrier beads, in stead of a usual system of black toners and black carriers, where the mixed state of toner and carrier has also analyzed visibly [4].

In this paper, tribo-charging characteristics on toner are examined in terms of *q/m* under the various mixed conditions in two-component developer by using a developed mixing shaker and variation of toner shape through shaking process is also examined by SEM observation.

Experimental

As a toner, a negative yellow type of pulverized toner, based on bisphenol A and polyester resin, was used. As a carrier in the developer, a coated type of ferrite core was used. Toner concentration in two-component developer was varied from 1 *wt%* to 10 *wt%*. For sample preparation, certain amount of toner particles was poured over carrier beads in a glass bottle. After a preliminary treatment with manual shaking of 15 times, mixing process is added according to the mixing condition by using the shaker with arm length of 200 mm, corresponding approximately to human arm length. Shaking angle is 30 degrees. Photograph of the shaker with arm length of 200 mm is shown in *Figure 1*. Shaking frequency corresponded with rotation speed was maintained at 180 rpm and shaking time was varied from 1 min to 20 min. Measurement of charge to mass ratio *q/m* was performed under the RH of less than 70% by using a modified type of E-SPART analyzer, EST-2(Hosokawa-micron co.,) [5]. Observation on the surface of the treated toner particles was made by SEM, JSM-5310(JEOL co.,).

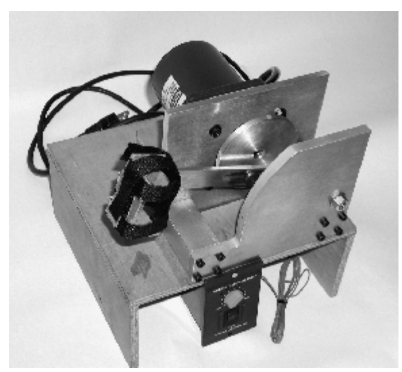

***Figure 1**. Photograph of toner mixing shaker*

Results and Discussions

The experimental results of tribo-charging characteristics on *q/m* in terms of shaking time are shown in *Figures 2-4*. As the sample is a negative type, *q/m* has negatively polarized values. In order to examine easily the experimental values, only the absolute values of *q/m* without a minus sign may be referred to in the following discussions except special cases. From *Figure 2* for 2 *wt%* of toner concentration in the two-component developer, a peak absolute value of *q/m*, 28.6 µC/g at 1 min was observed, the *q/m* decreased gradually with some variation and it finally reached at about 20 µC/g at 20 min of shaking time. From this result it was shown that *q/m* fluctuated with shaking time with a decrease tendency.

In *Figure 3* for 5 *wt%* of toner concentration, *q/m* showed 16.8 µC/g at 1 min, it had temporarily a slight increase and showed to be a saturation value of 13.5 µC/g at 20 min, although the degree of fluctuation was smaller than that for 2 wt%. In *Figure 4* for 10 *wt%* of toner concentration, the *q/m* showed to be 12.1 µC/g at 1 min, it had a peak value of 17.2 µC/g at 10 min and it decreased to 10 µC/g at 20 min. From these results, *q/m* showed to fluctuate to some extent with shaking time and the *q/m* at 20 min had a decrease tendency with toner concentration.

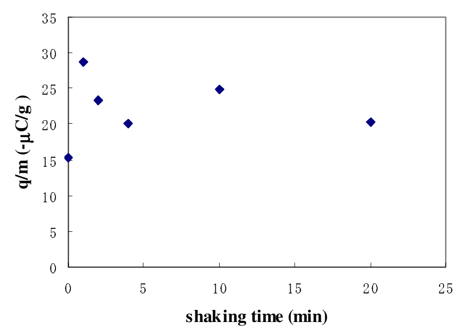

Figure 2. *q/m dependence on shaking time at 180 rpm for 2 wt% of toner concentration*

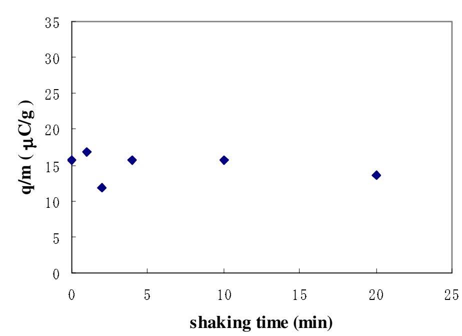

Figure 3. *q/m dependence on shaking time at 180 rpm for 5 wt% of toner concentration*

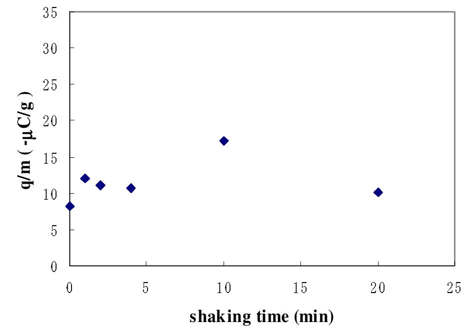

Figure 4. *q/m dependence on shaking time at 180 rpm for 10 wt% of toner concentration*

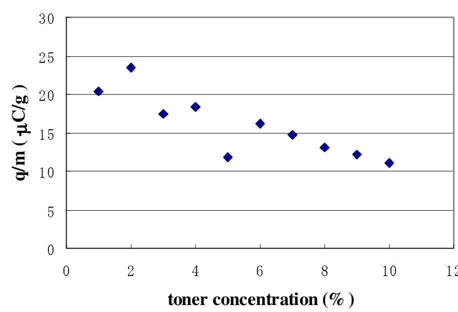

Figure 5. *q/m dependence on toner concentration at 180 rpm for 2 min of shaking time*

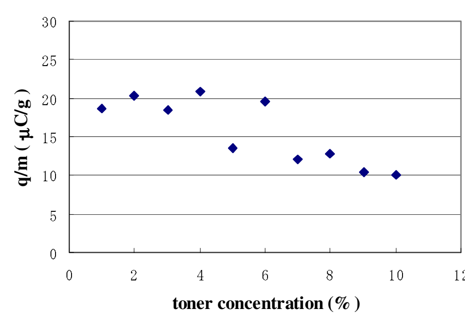

Figure 6. *q/m dependence on toner concentration at 180 rpm for 20 min of shaking time*

It is suggested that some additives such as CCA were removed from the toner surface, transferred to the carrier surface, and brought about the fluctuation of *q/m* due to the transfer between the toner and the carrier. Otherwise, it might be suggested that the shape and the surface area of toner particles changed through collisions among particles of toner or carrier during shaking time.

In order to investigate the change of *q/m* at 20 min of shaking time with toner concentration, the *q/m* dependences on toner concentration from 1 *wt%* to 10 *wt%* after the shaking treatment of 2 min and 20 min were examined. The *q/m* dependence on toner concentration at 2 min of shaking time is shown in *Figure 5* and that at 20 min is also shown in *Figure 6*. From these results, it is shown that *q/m* both for the 2 min and the 20 min decreased from about 20 µC/g to 10 µC/g gradually with the increase of toner concentration and a similar tendency of decrease was observed. This means that coverage ratio of toner onto carrier surface does not completely saturated at 10 *wt%*. It is, therefore, explained that the decrease of *q/m* occurred from sharing the total amount of tribo-charge with the increment of toner particles due to change of toner concentration. It is not so clear that the tendency is consistent with the expected dependence of *m/q* on toner concentration from the surface state theory [6].

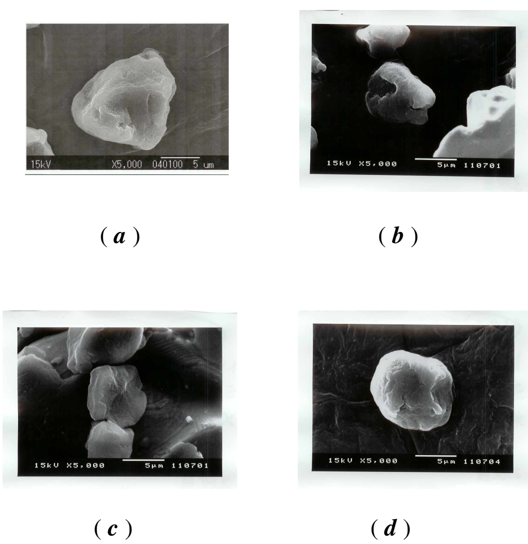

Figure 7*. SEM photograph of the toner shape variation on period of shaking time at 180 rpm for 5 wt% of toner concentration (a: no treatment of shaking, b: 1 min, c: 4 min, d: 20 min)*

For further information to examine the change of *q/m* on shaking time, the observation via SEM on toner particles after shaking treatment was carried out for the sample at 5 wt% of toner concentration. The SEM photograph is shown in *Figure 7*. In comparison with the toner shape before the treatment, the outer appearance of the toner surface after 1 min in *Figure 7-(a)* had transformed into a cracked one like a broken piece of coal. The toner shape after 4 min had also similar one in shape with that after 1 min and changed to a sharp-shaped particle. The shape after 20 min, however, had changed to a round one and it seemed to be a settled one in shape after sequence of collision during mixing procedure. From these results it is also suggested that the change of *q/m* might be certainly occurred according to the variation of surface area or shape.

Conclusion

1. Tribo-charging characteristics on the pulverized toner based on bisphenol A and polyester resin in two-component developer were examined via shaking treatment by the E-SPART method.
2. The absolute value of *q/m* fluctuated with shaking time and the *q/m* after 20 min of shaking time showed to have a decrease tendency with increase of toner concentration from 1 *wt%* to 10 *wt%*.
3. As the causes of fluctuation on the *q/m*, it was suggested that removed additives such as CCA from the toner transferred to the carrier and/or the toner particles changed in shape due to collisions under the shaking treatment.

References

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Author Biography

Youichi Nakamura received his BS in applied physics from Waseda University (1966), his M.S and Doctor of Sci. in physics from Tokyo Metropolitan University (1968 and 1973). He joined in R&D Div. of Semiconductor LSI Works of Hitachi Co., Ltd. in 1971. Since 1987 he has carried out on electrical and physical evaluation for electrophotographic materials at Nippon Institute of Technology. He is a member of IS&T, ISJ, the Physical Soc. Japan, and the Japanese Soc. Applied Physics.