Analysis of Tribo-charging Characteristics on Toner Particles in Two-component Developer via Shaker with Different Arm Length

Youichi Nakamura, Zhou Ye, Hironori Hayashi, Pranchalee Rattanasakornchai, Yasushi Hoshino, Yutaka Terao, and Yasuyuki Suzuki
Nippon Institute of Technology
Saitama, Japan

Abstract

We have analyzed tribo-charging characteristics on several kinds of toner particles in two-component developer. These characteristics are affected by various factors, such as materials and methods of tribo-charging. We have made two types of shaker with different arm length for tribo-charging, one of which is based on the recommended design by the Imaging Society of Japan. We evaluated tribo-charging characteristics on toner particles of styrene-acrylic copolymer in contact with binder carrier beads through the shaker by the E-SPART analyzer. The two types of negative toner samples are prepared by adding negative CCA or none of CCA. One sample of positive toner is also prepared by adding positive CCA. The saturation curves for the negative toner added CCA with different arm length show that the absolute value of *q/m* increases rapidly within about 5 minutes and tends to the different two levels: one is about 15μC/g by tribo-charging in the shaker with the longer arm length of 200mm, the other is about 10μC/g with the arm length of 130mm. For the positive toner, the value of *q/m* increases similarly and also tends to the different levels. These results suggest that tribo-charging on toner particles is affected strongly by the difference of arm length in the shaker.

Introduction

Two-component magnetic brush development has been conventionally used in the electrophotographic process. Tribo-electrical charging on toner particle occurs by mixing and contacting with carrier beads in the two-component developer. The quantity and polarity are affected by material components of toner and carrier, where the polarity becomes to be opposite in principle for each other. In the development process, the latent electrostatic images on the photoreceptor are properly transformed into toner images by electrostatic force. The charged toner particles, therefore, have a main role for reproducing original images on paper through the developing process in the electrophotographic technology.

It is important to evaluate not only electric charge on toner particles but also the tribo-charging behavior. This behavior is affected by tribo-charging methods. In order to pursue this purpose, we have developed the mixing shakers with different arm length for tribo-charging on toner instead of the actual reservoir in the copying machine.

Concerning material components of toner, Charge Control Agent (CCA) as additives to a base resin has a key function for tribo-charging. We investigate the effects on tribo-charging behavior for toner particles with or without CCA additives. We also investigate the tribo-electrical charging characteristics on toner by preparing the two kinds of arm length in the mixing shakers and analyzing the experimental results.

Experimental

Measurement of charge to mass ratio *q/m* was carried out by the Electrical Single Particle Aerodynamic Relaxation Time (E-SPART[1]) analyzing method with a dual-beam frequency biased Laser Doppler velocimeter. The two kinds of shaker were used for tribo-charging on toner with different arm length of 130 mm and 200 mm, one of which was based on the recommended design [2] by the Image Society of Japan. The shaking angle is 30 degrees. The samples were fixed on the top of the arm. Rotation speed corresponded with shaking frequency was varied from 120 rpm to 180 rpm. Mechanical mixing via shaker followed the preliminary hand shaking over 15 cycles for tribo-charging on toner particles in the two-component developer after the interval of 24 hours.

As carrier in the two-component developer, a type of binder carrier was used. As black toner, the two kinds of negative toner as based on styrene-acrylic copolymer were used with or without CCA additives of azo-chromium compound, whereas the positive toners on the same based resin ware used with CCA of triphenyl methane. All the toner samples were treated on the surface with silica coating. Toner concentration in the developer was maintained at 5 *wt%*.

Results and Discussions

In Figure 1, the experimental result of saturation curve on tribo-charging characteristics for the negative toner with CCA additives is shown. In this case, the mixing shaker with arm length of 130mm is used. The absolute value of charge to mass ratio *q/m* becomes larger gradually with increase of mixing time and tends to a lower constant value of 10 μC/g. The value does not particularly vary with rotation speed from 120 rpm to 180 rpm.

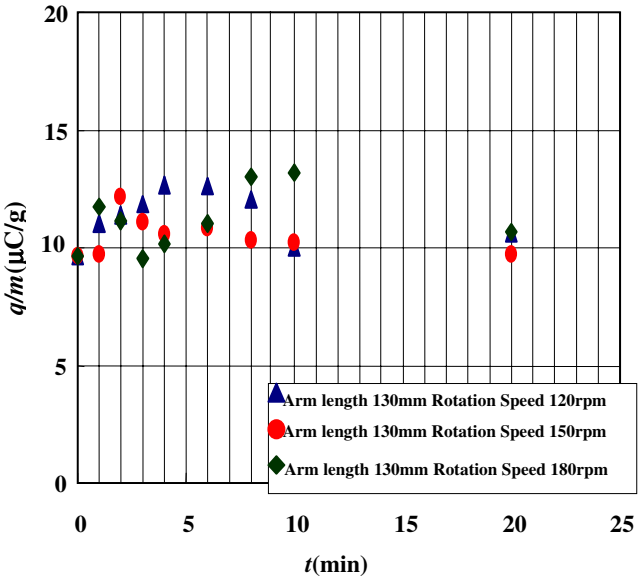

Figure 1. Negative Electric Charge to Mass Ratio q/m Dependence on Mixing Time (Toner with CCA additives)

The result in the case of arm length 200 mm is shown in Figure 2. The absolute of *q/m* increases rapidly with in about 5 minutes and tends to a higher value of 15 μC/g. From the results in Figure 1 and 2, it is suggested that the difference of *q/m* between 10 μC/g and 15 μC/g after 20 minutes of mixing time appeared not because the rotation speed was increased but because the arm was lengthened from 130 mm to 200 mm and the toque was increased.

In Figure 3, the result for the negative toner without CCA additives in the case of arm length 130 mm is shown. The absolute *q/m* values are scattered over the region within 10 ± 5 μC/g for the mixing time from 0 to 20 minutes. A tendency to lift up the level of *q/m* can be seen by increase of the rotation speed.

In Figure 4, the result in the case of arm length 200 mm is shown. The absolute values are also scattered within 15±5 μC/g and they have a higher level of *q/m*. This tendency of shifting the level due to the difference of arm length is similar with the results obtained in Figure 1 and 2 for the negative toner with CCA additives. The appearances in excess of scattering in Figure 3 and 4 are the cause of non-CCA additives.

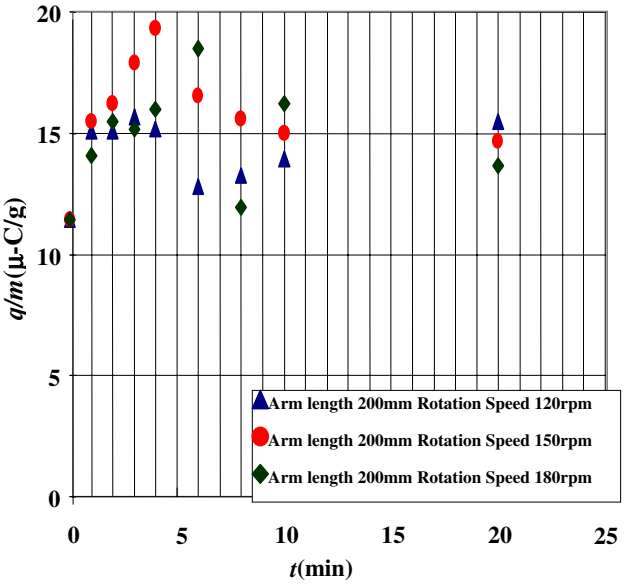

Figure 2. Negative Electric Charge to Mass Ratio q/m Dependence on Mixing Time (Toner with CCA additives)

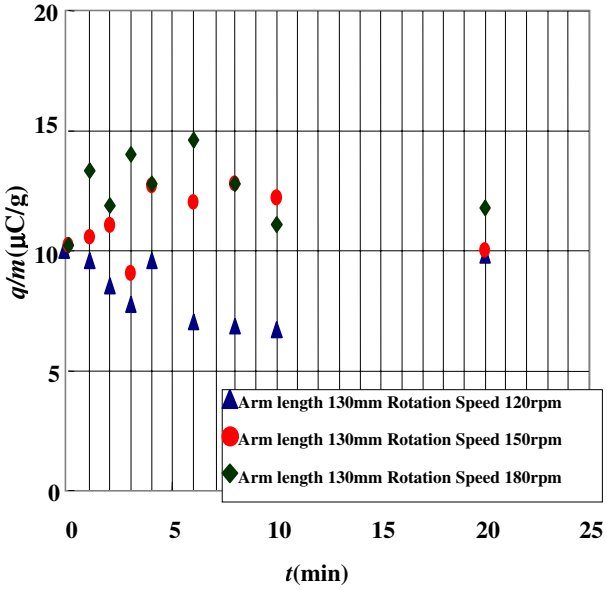

Figure 3. Negative Electric Charge to Mass Ratio q/m Dependence on Mixing Time (Toner without CCA additives)

In Figure 5, the result for the positive toner with CCA additives in the case of arm length 130 mm is shown. The value of *q/m* increases gradually near to 10 μC/g and slightly decreases to less than 10 μC/g after 10 minutes of mixing time. The value of *q/m* is in the region from 5 μC/g to 10 μC/g.

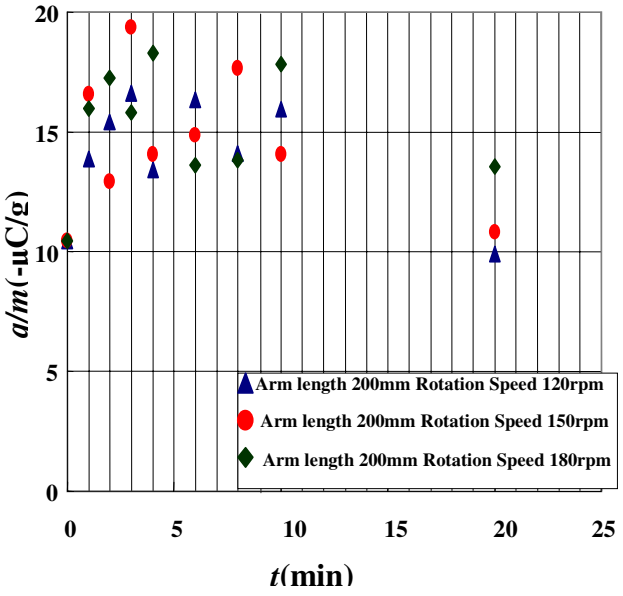

Figure 4. Negative Electric Charge to Mass Ratio q/m Dependence on Mixing Time (Toner without CCA additives)

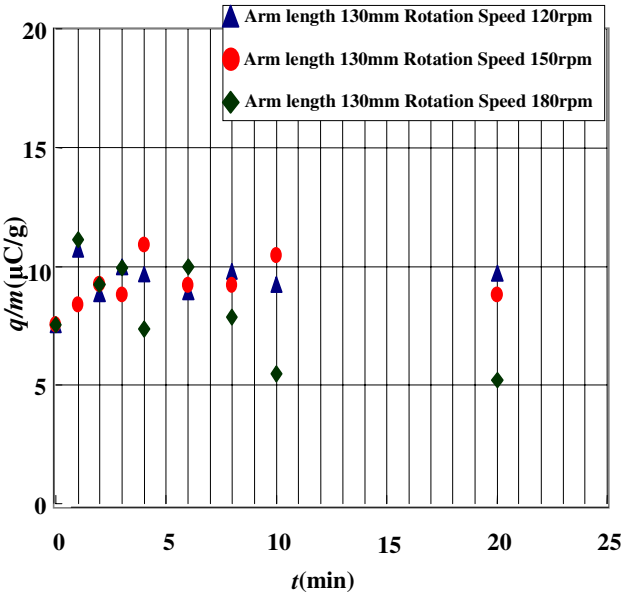

Figure 5. Positive Electric Charge to Mass Ratio q/m Dependence on Mixing Time (Toner with CCA additives)

In Figure 6, the result in the case of 200 mm is shown. The values of *q/m* increases sharply round to 15 μC/g within 1-2 minutes and they decreases also gradually to 10-13 μC/g after 5minutes of mixing time.

The tendency of shifting the level also appears in the case of the positive toner in the two-component developer. This tendency is consistent with all the samples with the negative or positive toners. From our previous report, it was visually showed that the mixing state in the two-component developer depended strongly on the shaking conditions by using color magenta toner.[3] From the above results in Figure 1-6, it was suggested that the more mixed state in the developer might have been induced by the stronger torque due to the longer length of arm in the shaker. The insufficiently mixed state of toner causes to be effectively a higher concentration of toner level of the *q/m*. It leads to a lower level of the *q/m*.

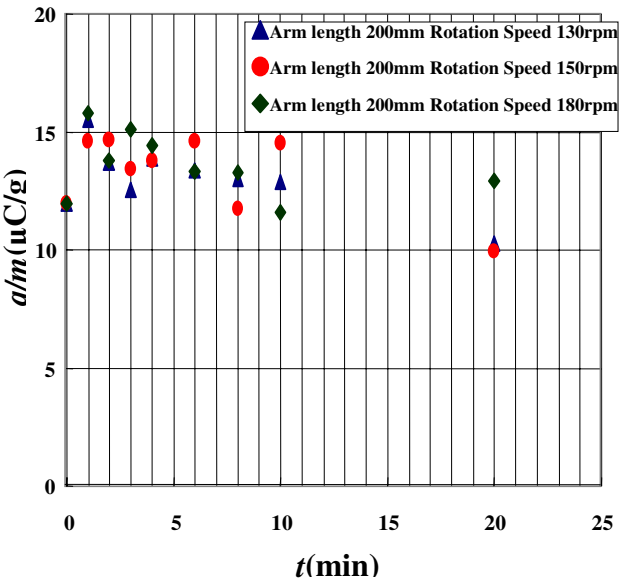

Figure 6. Positive Electric Charge to Mass Ratio q/m Dependence on Mixing Time (Toner with CCA additives)

Summary

1. The tribo-charging characteristics have been measured on the negative toner particles with or without CCA additives and the positive with CCAs in the toner system of styrene-acrylic copolymer in the two-component developer.
2. The saturation curves for the negative toner added CCAs shows that the *q/m* by tribo-charging with the longer arm length of 200 mm in the shaker is obtained as a higher absolute value of 15 μC/g than that with the arm length of 130 mm.
3. The variation of the *q/m* for all the samples according to change of the arm length is suggested that the stronger torque might have induced a well mixed state of toner particles in the developer.

References

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2. Imaging Soc. Japan, Standards of ISJ-Method for measurement of electric charge on toner, Imaging Soc. Japan, **37** (1998) 461-470.
3. Y. Nakamura, Zhou Ye, H. Yoshida, M. Kurosaki, K. Shinoyama, Y. Suziki, Y. Terao, *Proc. of Int'l Conf. of Imaging Science 2002.*, May 13-17, 2002, Tokyo, pp.676.

Biography

Youichi Nakamura received his B. S in Applied Physics from Waseda University in Tokyo in 1966, and his M. S and Doctor of Science from Tokyo Metropolitan University in 1968 and 1973, respectively. 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.