Mixed State of Color Toner Particles in Two-Component Developer via Shaker

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Abstract

We have analyzed tribo-charging characteristics on black toner particles in two-component developer. The electrophotographic characteristics on toner in the developer are affected by various factors such as material component, shape and methods of tribo-charging or measurement. It is, therefore, important to evaluate not only tribo-charging behavior but also the mixed state of toner particles and carrier beads in the two-component developer. For this purpose, yellow color toner particles instead of black toner are adopted in the developer for evaluation of tribo-charging characteristics. Tribo-charging on toner is performed by using the two types of shaker with different arm length, 130mm and 200mm, where the shaker with 130mm arm length is based on the recommended design by the ISJ. From the results of photographs on the outside appearance of mixed toner samples in a glass bottle, the completely mixed state for toner is obtained after 20min of mixing time at 150rpm with arm length of 130mm and also after 1 min of mixing time at 150rpm with arm length of 200mm. For the tribo-charging behavior, it is showed that the charge to mass ratio *q/m* is –12.5μC/g for 20min of shaking time at 150rpm with the 130rpm arm length shaker and –19.0μC/g for 1min at 150rpm with the 200mm. In the case of 120rpm with the 130mm, the *q/m* shows to be slightly charged values corresponding to the insufficiently mixed states.

Introduction

In the electrophotographic industry, a remarkable development has been made especially in color copying machine. For the high quality on color image, the smaller toner particles have been adopted in two-component developer. The charge quantity and 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. Charging behavior is also affected by tribo-charging methods. Although we have analyzed tribo-charging characteristics on toner particles in the developer, they are only the results for the black toner without evaluation on the mixed state due to the difficulty in the developer system of black toner and black carrier. For the development of color technologies, scientific approaches on toner in all its aspects are requested. On the other hand, evaluation on the mixed states in a color electrophotographic developer is not difficult. In order to examine various mixed states of the color developer system, yellow toner particles in this study are tribo-charged by mixing with black carrier beads via one of the mixing shakers.

We investigated the effect on tribo-charging behavior for toner particles with or without preliminary manual shaking. We also investigated the tribo-charging characteristics on toner via a shaker by preparing the two types with different arm length and analyzed the experimental results.

Experimental

The two kinds of developed mixing shaker with different arm length were used for tribo-charging on toner. One has a shorter arm of 130mm and it is based on the recommended design[1] by the Image Society of Japan. The other has a longer arm of 200mm, corresponding approximately to a human arm length. The shaking angle is 30 degrees. The sample in a glass bottle was located on the top of the arm. Rotation speed corresponding with shaking frequency was varied from 120 rpm to 180 rpm. When a preliminary manual shaking over 15 cycles was carried out, mechanical mixing procedure via a shaker followed after the interval of 24 hours for tribo-charging on toner particles in the developer.

Measurement of charge to mass ratio *q/m* was carried out by the Electrical Single Aerodynamic Relaxation Time (E-SPART) method.[2] As a carrier in the developer, a type of coated ferrite core was used. As a toner a negative yellow type of toner based on bisphenol A and polyester resin was used. In order to prepare the experimental samples to examine the mixed state of toner and carrier, a certain amount of toner particles was poured on a layer of carrier beads so carefully as to perform another separate layer of toner in a glass bottle. Nominal quantity ratio of toner particles added to the carrier beads for a developer was 5*wt*%. This ratio does not necessarily mean the toner concentration.

Results and Discussions

1 Mixed State for Yellow Toner

In case of condition without preliminary manual shaking, it was found that the mixed states of yellow toner particles with black carrier beads varied drastically with rotation speed from 120rpm to 150rpm and 180rpm and also the arm length in the shaker. At 120rpm with the arm length of 130mm, toner particles could be scarcely mixed with carrier beads from 1min to 4min of mixing time and the degree of mixture increased gradually to about 50% with mixing time from 6min to 20min. For the 200mm arm length at 120rpm, more than half amount of toner could be mixed but a small amount of toner remained as non-mixing state. In *Figure 1* and *Figure 2*, the mixed states of yellow toner particles and black carrier beads at 150rpm for the 130mm and the 200mm are shown respectively.

(o) preliminary manual shaking only

(a) 0min

(b) 1min

(c) 4min

(d) 6min

(e) 10min

(f) 20min

Figure 1. Mixed states for yellow toner particles on shaking time dependence via the shaker with the 130mm arm length without preliminary manual shaking except (o).

From the result in *Figure 1*, it is shown that toner particles could be barely mixed with the carrier beads at 20min with the arm length of 130mm. On the other hand it is also shown in *Figure 2* that all amount of toner could be already seen as a mixed state at 1min and the outer look on the mixed state in a bottle from 2min to 20min was almost same as that at 1min. For the cases at 180 rpm with the 130mm and the 200mm arm length, the state showed to be a complete mixture.

(o) preliminary manual shaking only

(a) 0min

(b) 1min

(c) 4min

(d) 6min

(e) 10min

(f) 20min

Figure 2. Mixed states for yellow toner particles on mixing time dependence via the shaker with the 200mm arm length without preliminary manual shaking except (o).

From the results in *Figure 1*-(o) and *Figure 2*-(o), only a preliminary manual shaking of 15 cycles appeared to make a fully mixed state of toner and carrier. The mixed states of toner after the treatment of mechanical shaking via a shaker with the 130mm or the 200mm appeared to be almost same as the starting state.

2 Charge to Mass Ratio *q/m*

Dependence of negative electric charge to mass ratio, *q/m*, on mixing time for yellow toner particles is shown in *Figure 3* - *Figure 6*. For the case at 120rpm with the 130mm arm length, the absolute value of *q/m* without manual shaking showed to gain only small values in the range of mixing time below 5min and the *q/m* increased slightly to round 5 μC/g at 20min in *Figure 3*. For the case with manual shaking, the *q/m* did not varied particularly and it was nearly constant from 7μC/g to 10 μC/g.

In *Figure 4*, the experimental result of saturation curve on tribo-changing characteristics at 150rpm with the 130mm arm length is shown. The absolute value of *q/m* increased to about 15μC/g at 2min of shaking time and gradually decreased to a constant value 10μC/g for each case with or without preliminary manual shaking.

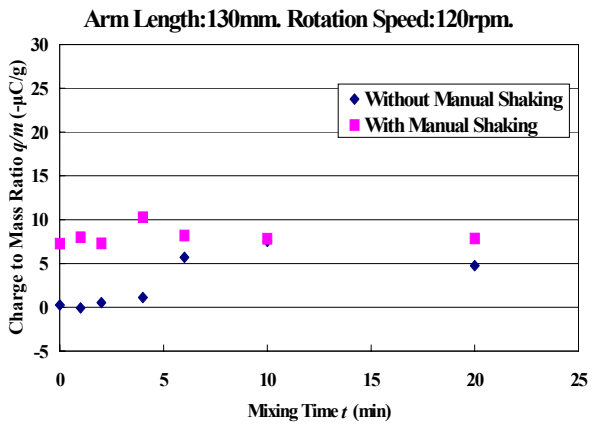

Figure 3. Mixing time dependence of negative electric charge to mass ratio q/m for yellow toner particles at 120rpm with the 130mm arm length.

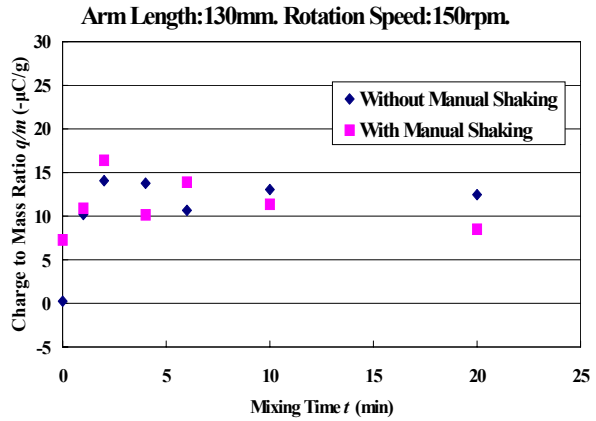

Figure 4. Mixing time dependence of negative electric charge to mass ratio q/m for yellow toner particles at 150rpm with the 130mm arm length.

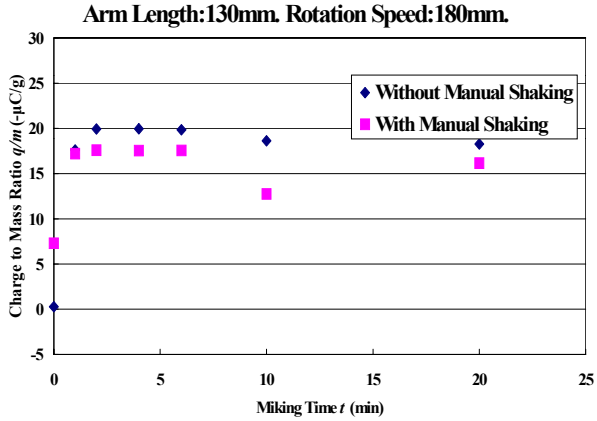

Figure 5. Mixing time dependence of negative electric charge to mass ratio q/m for yellow toner particles at 180rpm with the 130mm arm length.

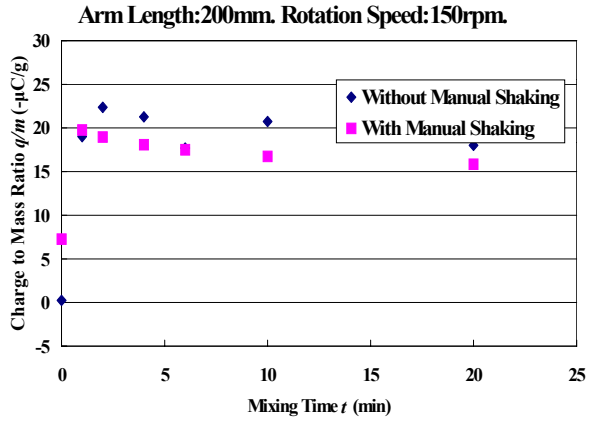

Figure 6. Mixing time dependence of negative electric charge to mass ratio q/m for yellow toner particles at 150rpm with the 200mm arm length

In *Figure 5*, the *q/m* at 180rpm with the 130mm increased rapidly near to 20μC/g for the case without preliminary manual shaking. After 2min, the *q/m* was maintained at 20μC/g and it decreased slightly to 18μC/g at 20min. For the case with preliminary manual shaking, the *q/m* was a slightly lower level from 17μC/g to 15μC/g.

From the results for the both cases with or without manual shaking in *Figure 3-5*, the peak value of the *q/m* gained a higher saturation value with the higher rotation speed from 120rpm to 180rpm and it had also a higher constant level at 10min-20min of shaking time. This result suggests that mixing degree of yellow toner particles and black carrier beads gained a higher level due to the higher rotation speed from 120rpm to 180rpm. This is consistent with the result from the mixed state examined from the outer look.

In *Figure 6*, the *q/m* at 150rpm with the 200mm arm length increased rapidly near to 23μC/g at 2min and gradually decreased to 18μC/g for the case without manual shaking. On the other hand, the *q/m* for the case with manual shaking reached to 20μC/g at 1min and gradually decreased to a lower level of 16μC/g at 20min.

The above tendency with or without manual shaking at 150rpm showed to be similar to the case at 180rpm with the 130mm. This suggests that the arm lengthened from 130mm to 200mm produced a strongly tribo-charging effect due to the torque force. This is also consistent with the result from the experiment on mixed state of toner and carrier, where the state was changed drastically from the 130mm to the 200mm. It was, however, suggested that shaking by a strong torque reduced slightly the *q/m* value due to removal of some additives, such as CCA's, from the toner surface.

In order to obtain a sufficient mixed state and tribo-charging quantity on toner particle in the two-component developer, it is suggested that the satisfied condition is 180rpm of rotation speed and 5min or more of shaking time for the 130mm arm length and also 150rpm and 5min for the 200mm in the shaker.

Conclusion

1. Combining yellow color toner particles with black carrier beads, the mixed state of toner and carrier in a bottle could be examined on various mixing conditions via a shaker.
2. It was found that the mixed state depended strongly on mixing time, rotation speed and the arm length in a shaker. In order to obtain a sufficient mixed state, the rotation speed over 150rpm was needed for the 130 mm arm length.
3. The saturation curves for negative yellow particles showed that the *q/m* by tribo-charging with the longer arm length of 200mm in the shaker was obtained as a higher absolute value of about 20μC/g than that with the arm length of 130mm.
4. The satisfied condition was 180rpm of rotation speed and 5min or more of shaking time for the 130mm arm length shaker, which was based on the recommended design of the ISJ.

References

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Biography

Youichi Nakamura received his B.S degree 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. He is a member of the IS&T, the Image Society of Japan and the Japanese Society of Applied Physics. nakamura@nit.ac.jp