Toner Charging Characteristics Dependence on Toner Shape

Tsunenori Nakanishi and Yasushi Hoshino, Nippon Institute of Technology Miyashiro, Minami-Saitama, Saitama, Japan; Kueiying Sheu and Jain-Sheng Huang, Trend Tone Imaging, Inc., Taiwan R. O. C.

Abstract

Toner charge is very important in electrophographic printing process. Toner charge depends on various factors: charging method, materials including additives, and environment. Many studies have been carried out from the various points, but the charging characteristics of toner are not yet understood well. In this study, toner charging characteristics are investigated form the viewpoint of toner shape. A series of toner are prepared from pulverized to several degrees of rounded. Toner charge is measured by E-SPART analyzer. Toner charging carried out as: toner and carrier are kept in standard humidity and temperature more than 24 hours, and they are bottled and the bottle is rotated. The toner charge dependence on toner weight % is obtained. It is found that the toner charge dependence on toner weight % shows different tendency between no-rounded and rounded toner.

Introduction

Toner plays a very important role in the electrophotographic printing process.[1,2] Toner is required to have various functions. Among them, toner charge is essential one, because development and transfer are carried out by utilizing its charge. Toner charge gives great influence to image quality in the electrophotographic printing. A lot of studies have been done for understanding toner charging mechanism. But the mechanism is complex and is influenced by many factors such as toner materials, charging conditions,[3-5] humidity and so on. It is considered that the understanding of toner charging mechanism is not yet sufficient. In this report, toner charging mechanism is studied from the viewpoint of toner shape. The specific toner charge of various shape toner is measured by E-SPART (Electrical Single Particle Aerodynamic Relaxation Time), which has characteristics of simultaneous measurement of toner charge and size.[6] The dependence of the toner charge on toner weight % are obtained. Its dependence is important in practical developing process and also is used as a probe for understanding toner charging mechanism. For example, the applicability of the surface state theory is discussed often from the relation of inverse of toner charge and toner weight%.[7] The difference of the toner charge dependence on toner weight % is found among the different shape toners and is discussed.

Experimental

The toners used in this experiment are made by pulverization method. The toner shape is controlled by rounding process and several rounded level toners are prepared. The shape factor and diameter are summarized in Table 1. Toner M1 is just pulverized and toners M2-M4 are rounded. Photos of the toners are shown in Fig. 1. The toners are adjusted to a negative charging type by CCA (Charge Control Agent) and the flow property is controlled by surface additive treatment. The carrier used in this experiment is shown in Fig. 2. It is found that the surface of the carrier is wrinkled. The carrier is made of steel and the diameter is around 60-120μm. The developer samples of mixture of toner and carrier are prepared at the conditions of 1-7weight% of the toner. The developers are mixed in a rotation cylinder with a rotating speed of 120 rpm and the toner is charged by the contact with carrier. The mixing time is 10 min.

Table 1: Toner Size and Shape Factor

Toner Sample	Shape factor	Number mean diameter (μm)	Volume mean diameter (μm)
M1	0.911	7.45	10.38
M2	0.957	7.07	9.52
M3	0.964	7.02	11.04
M4	0.971	6.80	9.05

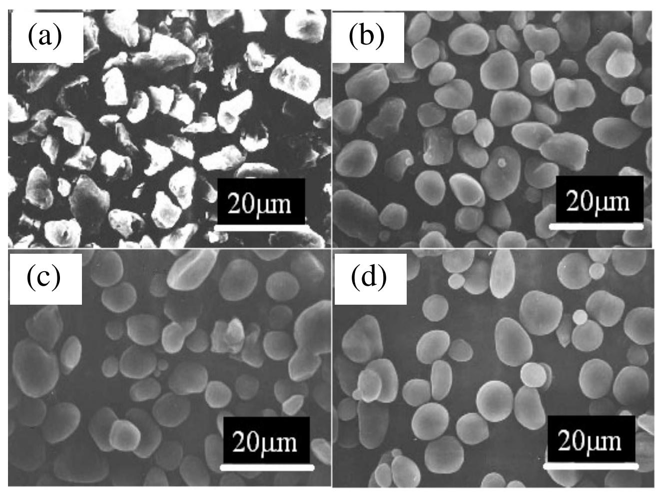

Figure 1. SEM images of toners: (a) M1, (b) M2, (c) M3, (d) M4.

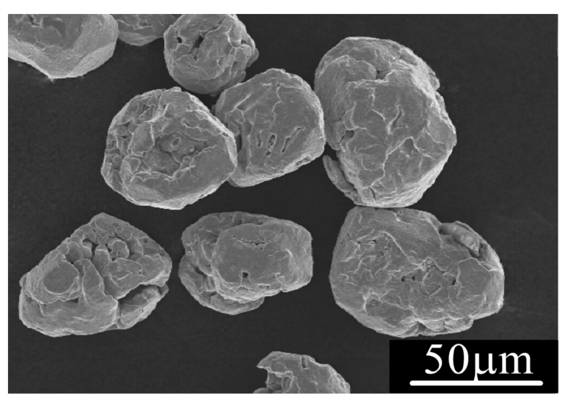

Figure 2. SEM image of carrier.

Toner charge and size are measured using E-SPART analyzer (Hosokawa-Micron E-SPART type1 Improved model). The charge and the size of individual toner are measured simultaneously. The toner particles are measured till 3000 counts on every mixing condition.

Results and Discussions

The histograms of toner diameter are shown in Fig. 3-6. The diameter measured by E-SPART is aerodynamic diameter. It is found that the diameters of each toner are distributed from 4 to 8 μm. The histogram of toner diameter seems to be independent of the toner weight%. This suggests that the sampling of the toner from the carrier is carried out in a good condition in this measurement.

Mean diameter of toner measured by number mean diameter and volume mean diameter, which are shown in Table 1, is a little bit bigger than the value by E-SPART. The difference maybe due that the toner shape is not spherical. Next, the relations of a specific toner charge and the toner weight % are shown in Fig. 7. For the just pulverized toner, it is found that the specific toner charge decreases as the toner weight% increases. However, it is found that the specific toner charge of the rounded toner is nearly constant between 1wt% and 4wt%, and then shows decrease. The same different characteristics of the toner specific charge dependence on the toner weight % between polymerized and pulverized toner was also reported.[8] The two causes of the difference are considered: from the difference of the shape or of manufacturing method. Even in the same manufacturing method, same tendencies of the toner specific charge dependence on the toner weight % is obtained in this experiment. So, it is considered that the difference of the toner specific charge dependence is due to toner shape. This is because of the difference of flowability. It is considered that the difference of the tendencies results from the toner shape. It is inferred that the rounded toner has good flowability and easy to roll because the rounded toner is more round than the just pulverized toner. Therefore the almost all surface of the rounded toner contacts with carrier and is charged till the carrier fully covered by toner. The decrease at 5wt% and above is due to the excess toner for single layer coverage on the carrier surface. The relations between toner charge and toner size are shown in Figs. 8-11. It is inferred that the rounded toner has good flowability and can easily roll on carrier surface because the rounded toner is more round than the just pulverized toner. The square relation is considered to be reasonable because the surface of toner increases as the square of toner size. In the case of irregular shape toner, toner charge showed decrease at the big size area in 3, 5wt%. This may result from the difference of the toner flowability.

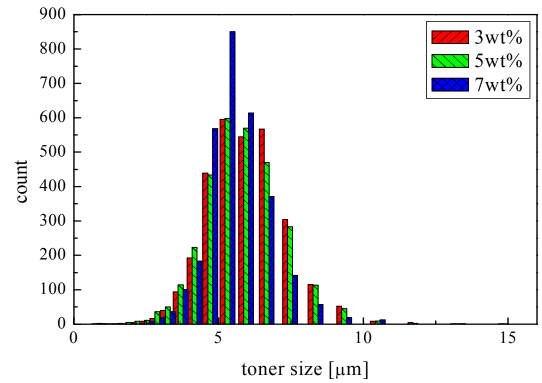

Figure 3. Histogram of toner size of M1 toner.

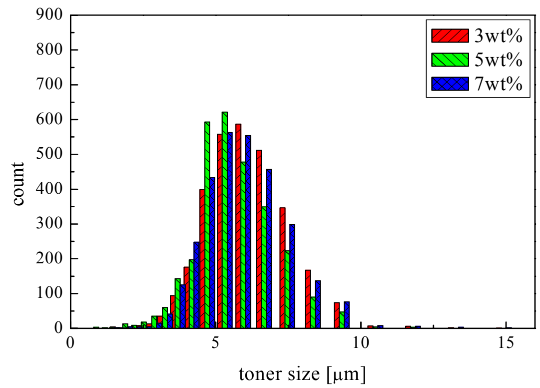

Figure 4. Histogram of toner size of M2 toner.

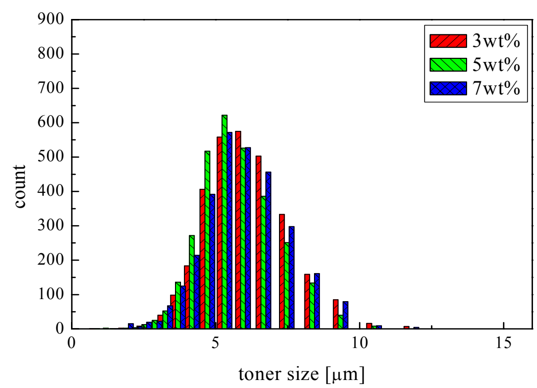

Figure 5. Histogram of toner size of M3 toner.

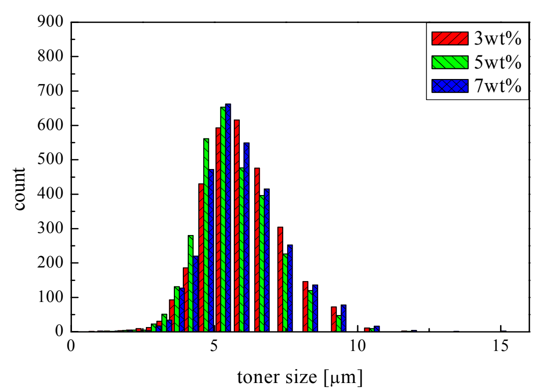

Figure 6. Histogram of toner size of M4 toner.

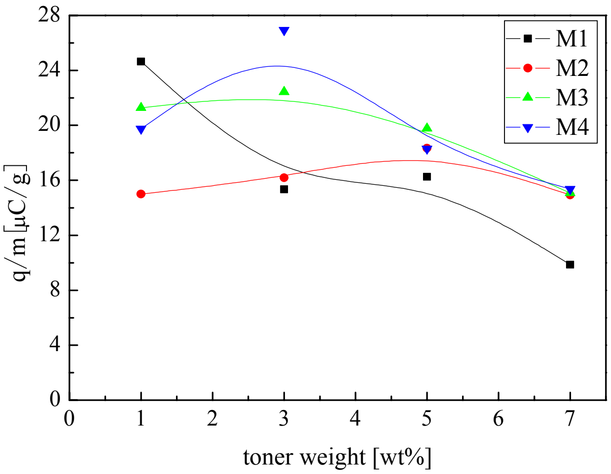

Figure 7. Specific toner charge dependence on toner weight%.

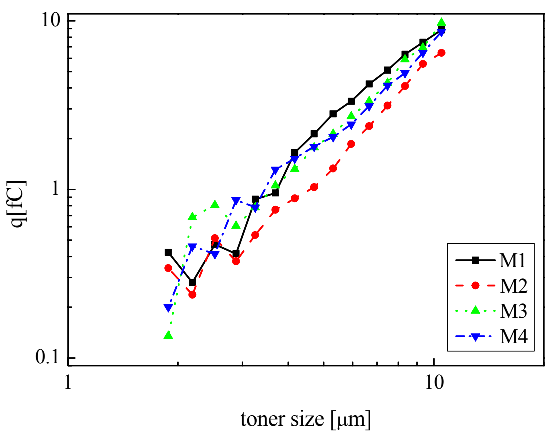

Figure 8. Toner charge dependence on toner diameter of 1wt%.

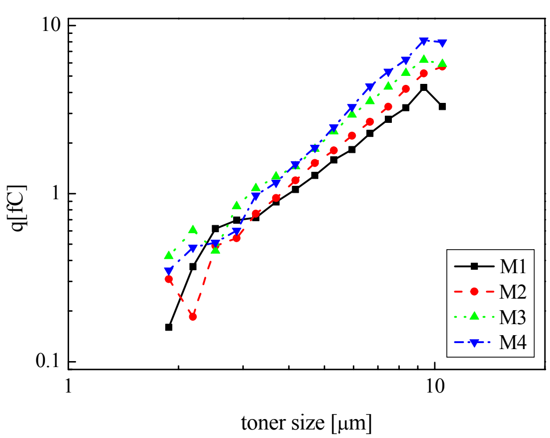

Figure 9. Toner charge dependence on toner diameter of 3wt%.

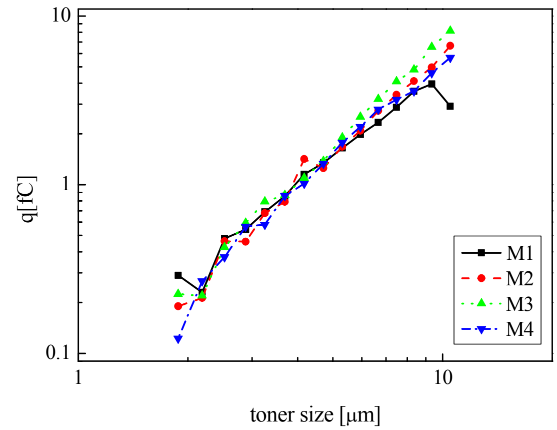

Figure 10. Toner charge dependence on toner diameter of 5wt%.

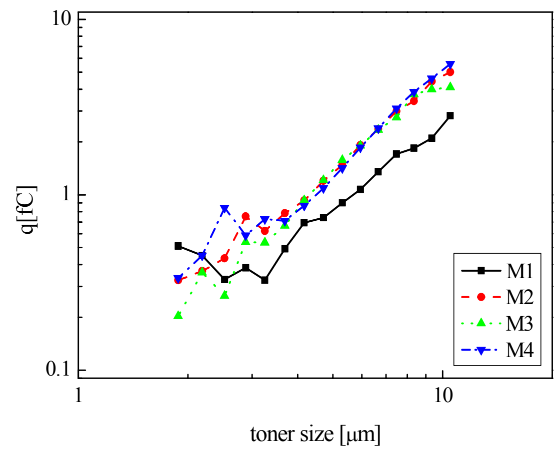

Figure 11. Toner charge dependence on toner diameter of 7wt%.

Conclusions

The obtained results are summarized as follows:

1. The specific toner charge dependence on toner weight % is measured on the different shape toner of same material. The specific toner charge of irregular shape toner shows decrease according to the toner weight % increase, however the specific toner charge of spherical shape toner does not show distinct decrease till a certain toner weight %, then shows decrease.
2. Same tendencies of specific toner charge dependence on toner weight % are obtained for an irregular shape pulverized toner and a spherical shape polymerized toner.
3. So, it is considered that the difference is mainly due to the shape of toner.

Acknowledgements

The authors would like to express their sincere thanks to Prof. Nakamura of Nippon Institute of Technology for his advices on E-SPART measurement.

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. 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).
7. L. B, Schein, "Electrophotography and Development Physics", Springer-Verlag (1988) pp.87-93.
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.

Author Biographies

Tsunenori Nakanishi is graduate course student of Nippon Institute of Technology. He gained Bs. Degree from Nippon Institute of Technology and is now studying toner technology in Hoshino laboratory of Nippon Institute of Technology. E-mail: naplusa2000@hotmail.com

Kueiying Sheu is currently the Vice President of Trend Tone Imaging, Inc (TTI). TTI is an independent toner manufacturer in Taiwan with yearly capacity of 4000 tons. She is in charge of R&D, QA and Production Departments. Dr. Sheu received her Ph.D. Degree in Materials Science from the University of Connecticut in 1989. She previously worked for Nashua Corporation as a Senior Scientist and Lab Supervisor. Combine the experiences in both companies, she engaged herself in the field of Toner Technology for 17 years. She is also members of IS&T, ISJ and SPSTJ.

Jian-Sheng Huang is R&D manager in Trend Tone Imaging, Inc. He received his Bachelor in Chemical Engineering from FunChia University in 1993 and received his Master degree in Chemical Engineering form TungHai University in 1995. He has cumulated eight-year experience in the field of toner technology.

Yasushi Hoshino is Professor of Nippon Institute of Technology. He gained Bs., Ms. And Dr. degree from the University of Tokyo, 1970, 1972, and 1984 respectively. After he gained Ms. Degree, he joined Electrical Communication Laboratories of NTT and joined the developing of first LED printer, high speed laser printer, color-laser printer by using ultra elliptical laser beam scanning, photo-induced toning technology and ion flow printing. He moved to Nippon Institute of Technology on 1994. His recent interests are toner technology, corona discharge and image processing. E-mail: hoshino@nit.ac.jp