Standard Carrier for Blow-off Toner Charge Measurement

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Abstract

The Imaging Society of Japan (ISJ) Technical Committee part III (The technical committee of toner-based material) issues two types of standard carriers for blow-off toner charge measurements. When the standard measurement procedure, the calibrated blow-off apparatus with the standard developer and the standard carriers were employed, the dispersion of the toner q/m values obtained by different operators was very small. The obtained q/m values can thus be used not only for a common measure in commercial transactions, but also for carrying out the selection of materials and quality control in the manufacture of toner and carriers. In this paper, the concepts and applications for aligning the developer materials on the coordinates of tribo-electric series by using the standard carriers are discussed.

Introduction

The Imaging Society of Japan (ISJ) Technical Committee part III (The technical committee of toner-based material) standardized the measurement procedure for a blow-off toner charge q/m in the two component developer,[1] and issued standard developer,[2-4] to calibrate a measurement apparatus including a Faraday cage and to check a blow-off charge measurement procedure carried out by different operators. The standard developers are now extensively used not only by toner manufacturers but also by the original manufacturers of printers, copiers, and blow-off charge measuring apparatuses.

In addition to the standard developers, there is a strong need for a standard carrier, because the q/m value which is obtained with the standard carrier by the standard measurement procedure with a calibrated blow-off apparatus can be used as a common value; every operator will be able to obtain nearly the same q/m value on the same toner, and the value can be used as a comparable q/m in technical papers or in commercial transactions in the toner market.

Taking the above situation into account, the Technical Committee started at the beginning of 2003 to examine what are the essential conditions for the standard carrier. The examination finished in the end of 2004, and two types of standard carriers, which are to be mixed with toner that has a negatively or positively charging tendency will be issued in August 2005.

The concept of the standard carriers, the advantages by introducing the standard carriers for the blow-off q/m measurements and the results of the q/m measurements on the various types of toner-carrier mixtures will be mentioned below.

Concept of Standard Carrier

When two different kinds of materials are brought into contact or rubbing with each other, the charge transfer between the two material surfaces occurs, and one material acquires a positive charge and the other material a negative charge. If we repeat the examination of the charge polarity in randomly selected two different materials, and write down the positively charged material on the upper side and negatively charged material on the lower side, we obtain the sequence of materials which show a positively or negatively charging tendencies. Usually, we call it a tribo-electric series. The tribo-electric series published by many examiners are resembling each other. The fact suggests that certain intrinsic physico-chemical properties of the materials are dominating the charging tendency.

Here, we will not discuss the influences of the physico-chemical properties of the toner or carrier onto the tribo-electric series, but consider about the selection of the standard carriers. For this purpose, the following two factors are prerequisite.

a. The standard carriers can yields tribo-electric series with various kind of toners.
b. The tribo-electric series with toners can be aligned on by using, as a parameter, the amounts of q/m that are obtained by the standard blow-off measurement procedure with the standard carrier.

These conditions are tacitly admitted and already used in the toner development processes; selection of charge control materials and selection of a manufacturing processes are determined by the amount of tribo-charge generated between standard contact materials such as a developing roll or charge controlling blade in a mono- component developer and/or carrier particles in a two component developer.

In this report, it is confirmed that the tribo-electric series are obtained respectively with the two types of carriers that occupy the upper and lower positions in a tribo-electric series of toner. The carriers show stable tribo-charging characteristics and exhibit an excellent reproducibility.

Selection of Standard Carriers

Preferable characteristics to be a standard carrier are that the carrier,

a. occupies the highest (strongly positive) or lowest (strongly negative) position in tribo-electric series of toner,

b. suffers low surface contamination by a toner-carrier mixing operation and shows high q/m reproducibility obtained with the same toner-carrier combination,
c. exhibits rapid charge up with a mixing operation, reaches a saturated q/m value and maintains the value after saturation,
d. show the stable q/m value even in a storage or measurement atmosphere (temperature and/or humidity) change, and
e. has a spherical shape and narrow particle size distribution.

Two types of spherical ferrite carriers having a particle size of 45 to 125 µm, respectively, and coated resin layer on their surfaces are selected as ideal carriers that satisfy the above conditions. One of the carriers is called a P-type carrier and has a fluoro-resin coated layer on its surface which imparts a large and stable positive q/m to the toner having a positively charging tendency, and the other is called an N-type carrier and has a amino-resin coated layer on its surface which imparts a large and stable negative q/m to the toner having a negatively charging tendency. The SEM photographs of these two carriers are shown in Fig. 1 and Fig. 2, respectively.

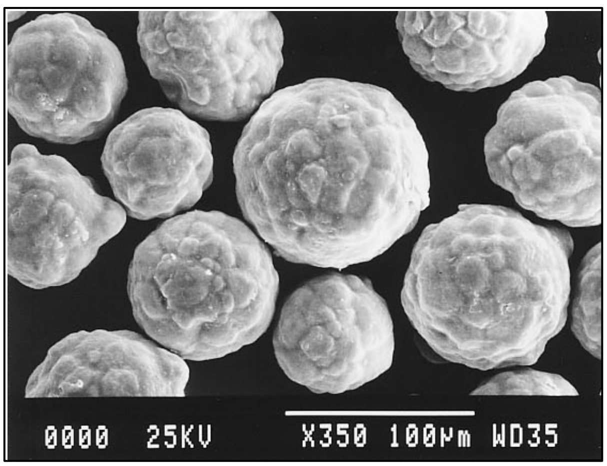

Figure 1. SEM photograph of carrier for P-type carrier

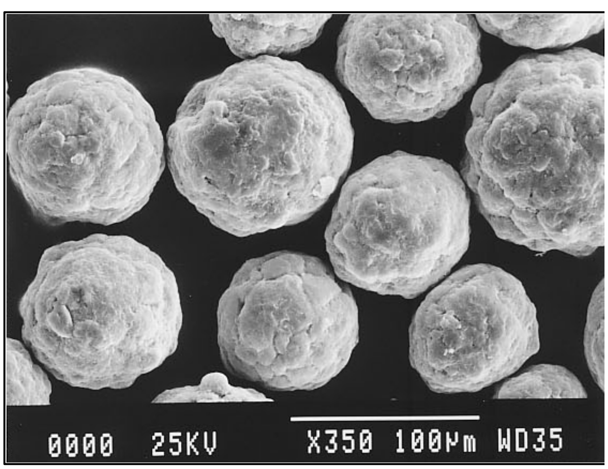

Figure 2. SEM photograph of carrier for N-type carrier

Blow-off q/m Measurements

The blow-off q/m of a toner was measured according to the standard procedure stipulated by the ISJ for the mixtures of two types of standard carriers and various types of toners.

A sample comprising 20 g of toner/carrier mixture (mixing ratio: 1 /19, toner concentration C_t: 5 wt%) was put into a 100 ml wide-mouth polyethylene bottle and maintained for 24 h under a 20 to 25°C, 50 to 60%RH atmosphere to adjust the moisture content. The bottle was shook 200 times by hand with 1 cycle/sec, 90° stroke. The obtained mixture was used as a sample for the blow-off measurement.

In addition to the toner/carrier mixture that has a toner concentration (C_t) of 5 wt%, samples of C_t of 3 wt% and 7 wt% were also prepared and investigated for the change of q/m by changing the toner concentration.

In addition to hand shaking, three types of mixing apparatuses, which are a T-mixer (turbulent shake mixing type), a B-mixer (roll mixing type) and a Y-mixer (shake mixing type), were also used, and the change of q/m was investigated by changing the mixing procedure.

Results and Discussion

Blow-off q/m Obtained by Standard-Carrier/Toner Mixtures

Figure 3 shows the blow-off q/m value obtained with the mixtures of two types of standard carriers (P-type and N-type) and four types of toners that are used in a one-component developer in the market. Figure 4 shows the blow-off q/m obtained with the mixture of two types of standard carriers and four types of toners that are used in a two-component developer in the market.

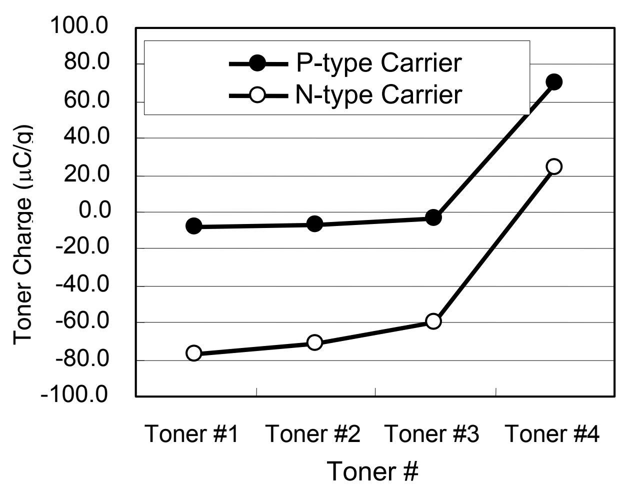

Figure 3. Blow-off q/m of four types of mono-component toners

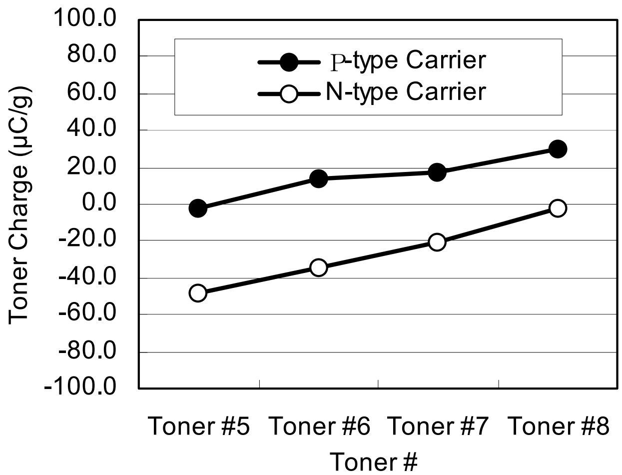

Figure 4. Blow-off q/m of four types of mono-component toners

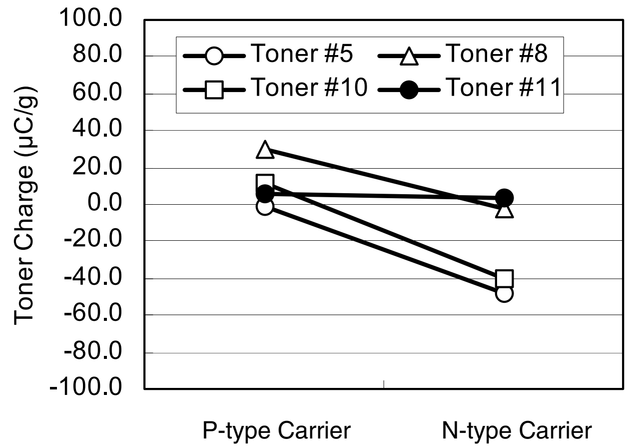

Figure 5. Comparison of blow-off q/m of toner #11 with those of toners #5, #8 and #10

In all combinations of each toner and two types of standard carriers shown in Figs. 3 and 4, the q/m obtained with the P-type-carrier/toner combinations $(q/m)_P$ are always larger, and occupying the upper or positive positions than those of obtained q/m with the N-type-carrier/toner combinations $(q/m)_N$. It is interesting that the difference between $(q/m)_P$ and $(q/m)_N$ for same toner is maintained nearly constant.

The result suggests that the two tribo-electric series which are obtained for eight toners in Figs. 3 and 4, and aligned on a coordinate by using $(q/m)_P$ or $(q/m)_N$ values as a parameters will be comparable with each other; it will be possible to acquire a quantitative tribo-electric series of toner that is aligned by using the $(q/m)_P$ or $(q/m)_N$ values as parameters.

However, the two tribo-electric series shown in Fig. 5 which are plotted by using the $(q/m)_P$ and $(q/m)_N$ values of four toners (#5, #8, #10 and #11) do not follow the same rule. It seems that the $(q/m)_N$ value that was obtained with the mixture of N-type-carrier and toner #11 disturbs the general order. The toner #11 is a model toner made of a polyester resin with carboxyl group in its molecular structure, and its acid value is 11.0. In the case of N-type-carrier/toner #11 mixture, it is suggested that the carrier surface contamination caused by the strong acid base interaction between the amino-group on the N type carrier surface and carboxyl group on the #11 toner surface results in the abnormal value of $(q/m)_N$.

The fluorocarbon resin that is coated onto the P-type carrier surface can be regarded as an ideal material; it does not possess a chemically reactive functional group, but shows the strongest electron attractive characteristics. In the case of the N-type carrier, on the other hand, the ideal resin to form the carrier surface that does not posses a chemically reactive functional group but shows the strongest electron donative characteristics has not been found yet.

Comparison of q/m Values Obtained by Different Mixing Processes

The q/m values that were obtained by the four different mixing processes are compared in Figs. 6 and 7. The measurement samples in Fig. 6 are the mixtures of toner #5 and the two types of standard carriers, and the measurement samples in Fig. 7 are the mixtures of toner #8 and the two types of standard carriers.

Both figure show that in the same standard-carrier/toner mixture, the difference of q/m values which are obtained by the different mixing modes or different mixing apparatuses are maintained nearly the identical; the Standard carriers impart comparable q/m values even in different mixing processes.

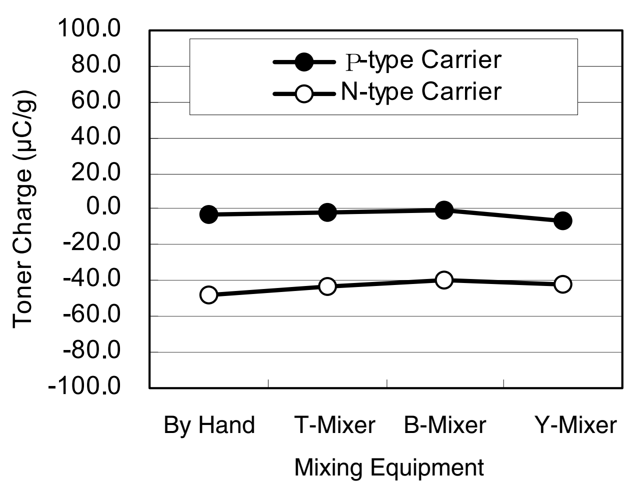

Figure 6. Blow-off q/m of toner #5-carrier mixtures prepared by four different processes.

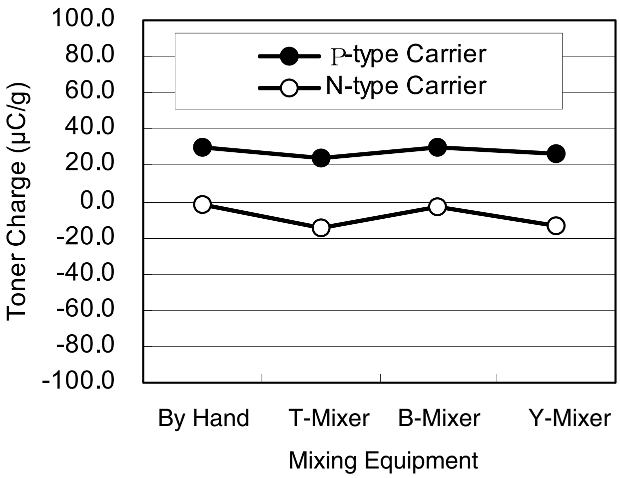

Figure 7. Blow-off q/m of toner #8-carrier mixtures prepared by four different processes

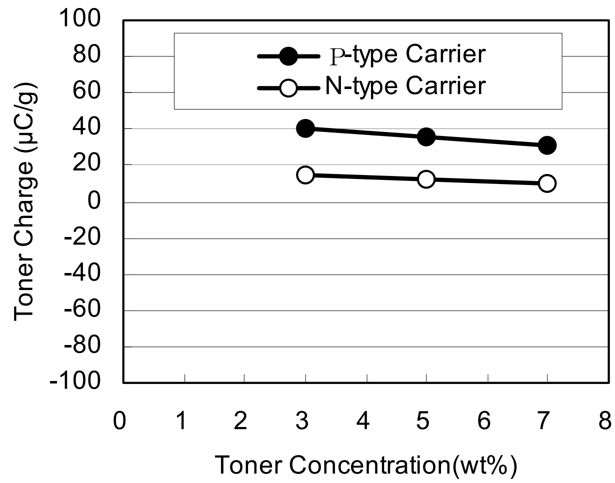

Figure 9. Blow-off q/m of toner #8 for different toner concentrations

Effect of Toner Concentration C_t on q/m Values

The change of q/m values by changing the toner concentration C_t was investigated with a standard-carrier/toner mixture. The measurement samples in Fig. 8 are the mixtures of toner #5 and two types of standard carriers, and the measurement samples in Fig. 9 are the mixtures of toner #8 and two types of standard carriers.

Both figure show that, within the C_t range from 3 wt% to 7 wt% which includes the recommended C_t range of 3 wt % to 5 wt% in standard measurement procedures determined by ISJ, the difference of q/m values obtained with the same toner-carrier combination is very small; the standard carriers are useful to obtain comparable q/m value which are obtained in the C_t range from 3 wt% to 7 wt%.

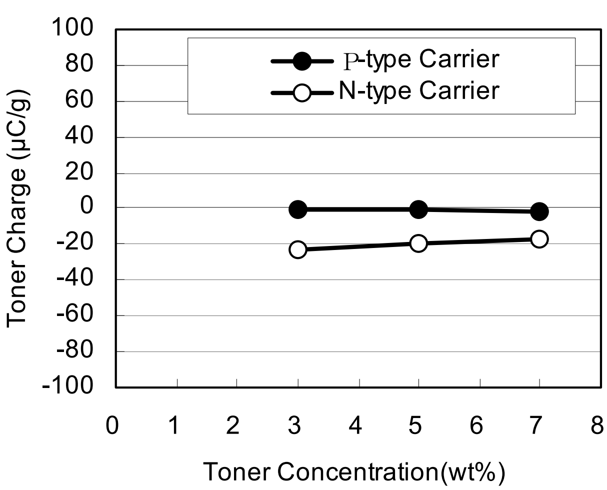

Figure 8. Blow-off q/m of toner #5 for different toner concentrations

Recommend q/m Measurement Conditions with Standard Carrier

According to the results mentioned above, ISJ recommended the following standard blow-off q/m measurement conditions with the standard carrier.

a) Toner concentration; from 3 wt % to 5 wt% (Carrier toner weight ratio: from 97/3 to 95/5)
b) Moisture adjustment; maintain the standard-carrier/toner mixture in 20 to 25ºC, 50 to 60 %RH atmosphere for 24h
c) Mixing bottle: 100 ml high-density-polyethylene bottle
d) Mixing method: 200 times shake by hand (1 cycle/sec, 90º stroke),
e) Measurement: the blow-off method (using a Faraday cage that satisfies the conditions regulated by the ISJ standard)
f) Measurement atmosphere: the same as moisture adjustment atmosphere
g) Storage atmosphere for standard carrier: a cool and dark place or the same as measurement atmosphere

Distribution of Standard Carriers

The following two types of standard carriers: are distributed by ISJ since August 2005,

a) a P-type carrier that is suitable for measuring the q/m for a toner with positively charging tendency, and
b) an N-type carrier that is suitable for measuring the q/m for a toner with negatively charging tendency,

Conclusion

Two types of standard carriers (P-type and N-type) are selected for the blow-off toner charge measurement. The carriers show an excellent stability and reproducibility in the blow-off toner q/m measurement, and satisfy the various conditions to be a standard carrier. It was confirmed that, by using the standard carrier, the dispersion of the q/m value of toner obtained by different operators is very small even if a mixing condition or toner concentration for a toner/carrier mixture are changed.

The obtained q/m values can thus be used not only as a common measure in commercial transactions but also for carrying out the selection of materials and quality control in the manufacture of toner and carriers. Using the standard carriers, the concepts and applications for aligning the developer materials on the coordinates of tribo-electric series were discussed.

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Author Biography

Hiromichi Kobayashi has been with Powdertech Co., Ltd. since 1993 and he is currently Manager, Research and Development. Ever since he joined the company he has been involved in development of the carrier for both high quality black/white and colour reprographic systems and on-demand printing systems. He is a graduate of Tokyo University of Science. He is also a member of ISJ's Technical Committee part III meeting (The technical committee of toner-based material).