Standardization of The Blow-off Charge Measurement Procedure and Standard Developer

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Abstract

The Imaging Society of Japan (ISJ) Technical Committee part III meeting (The technical committee of toner-based material) standardized the blow-off toner charge measurement procedure,[1] and released the standard two-component developer for the procedure.[2] According to the standard procedure, the dispersion of the measured amount of toner charge (q/m) in the same two-component developer is minimized even when different operators measure the charge with different types of Faraday-cages. The obtained q/m according to the standardized procedure can be treated as a reproducible common value which can be obtained by everybody. The standard two-component developer can be used not only for calibrating Faraday-cages or blow-off measuring apparatuses, but also for carrying out quality control in the manufacturing of toner and carrier.

Introduction

The amount of charge in two-component developer is the most important value for determining the quality of the developed images in elecrophtography. The blow-off method is the most popular method for measuring the amount of charge. Thanks to the blow-off measurement, the tribo-charging phenomena can be analyzed quantitatively. Even today, many researchers are investigating the tribo-charging characteristics by using the q/m value obtained by the blow-off method. The q/m in the technical papers, however, cannot be compared with each other, because the q/m cannot be treated as an intrinsic value. In fact, the q/m in the same developer sometimes show deviations of 200~300% as the preparation condition or equipment for the measurement is changed.

From this point of view, the ISJ technical committee started the investigation to clarify the factors that affect the q/m value dispersion measured for the same two-component developer.[1] The purpose of this initiative is to minimize the dispersion when different operator measures the charge with different measuring devices. It was found that the dispersion can be reduced to less than• ±20% when all the factors were regulated within a fixed range.[2] In Accordance with the investigation result, the standardization of blow-off measurement procedure was issued in 1998.

In the practical application of the standard procedure, standard developer is essential to examine Faraday-cages and other implements. In 1999, a work for the selection of the standard developer according to the standardized procedure was started. First, the essential characteristics which the standard developers has to have were defined. The work was completed at the end of 2000, and released the two types of developers having an appropriate amount of charge (±20 μC/g) and satisfying the essential requirements were released.

The details of the works in standardization of the measurement procedure and the setting of the standard developer will be mentioned below.

The Factors That Determine the Amount of Toner Charge

The tribo-charge in a two-component developer is generated when toner and carrier particles are mixed. It is said that the product of physical, chemical and mechanical factors determines the amount of charge (q/m).[3~4] Determination of the intrinsic q/m in a two-component developer, however, is almost impossible. The reason is that in measuring the q/m of the same developer by different operators using different measurement devices, it is difficult to reproduce all the three factors. In particular, it is most difficult to reproduce the mechanical factors to obtain the toner having the same tribo-history. Even the tribo-charge generated by the agitation in the blow-off charge measuring operation cannot be neglected. The chemical composition-change of toner and carrier surfaces occurrs in the mixing operation, and affects the chemical factor. The change of the toner and carrier surfaces by adsorbing the moisture must also be considered.

Standardization of the Charge Amount Measuring Procedure

For the regulation of "Standardization for The Blow-off Toner Measurement Procedure" at the ISJ technical committee, the following items were investigated and regulated. The essential point of the regulation is to reproduce the same physical, chemical, and mechanical factors mentioned above.

Sample and Implements:

Developer sample (toner and carrier), mixing bottle, balance, mixer, Faraday-cage, mesh to separate the toner from carrier.

The developer samples were limited to the two-component developer for electrophotography. The implements were regulated to realize the same tribo-history; that is, to realize the same mixing strength and mixing amount.

Four types of Faraday-cages (blow type, magnet-blow type, blow and suction type, and suction type) were investigated. The schemes of these Faraday cages are shown in Fig. 1. At the first stage, the difference of the obtained amount of toner charge in the same two-component developer by using the different types of Faraday-cages was very large. It was confirmed that the difference was originates from the difference of the degree of additional mixing in the blowing operation due to the difference of the Faraday-cage structure. The ISJ regulation recommended the Faraday cages satisfying the following conditions that 1) the additional mixing by blowing operation is minimized, 2) the high separation and high blow-off ratio of the toner particles from the carrier surface is realized, 3) the friction of toner and carrier particles with the Faraday-cage wall or the mesh, etc. is minimized.

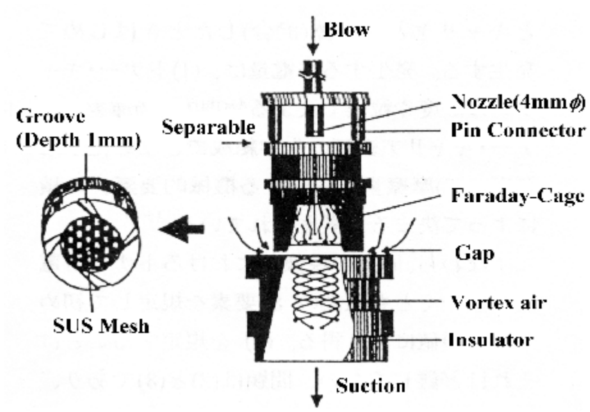

Figure 1a. Blow and suction type Faraday-cage

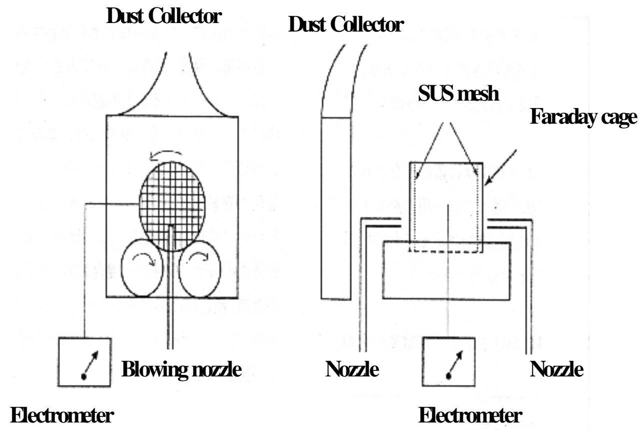

Figure 1-b. Blowtype Faraday-cage

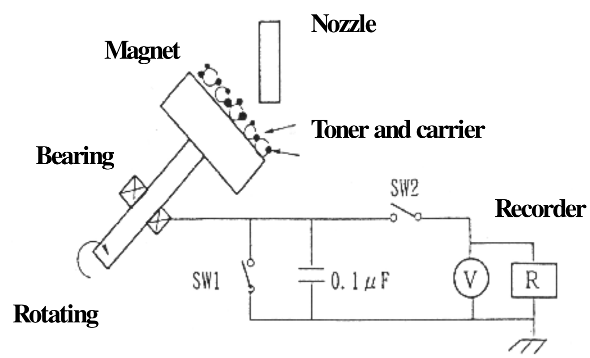

Figure 1c. Magnet-blow type Faraday-cage

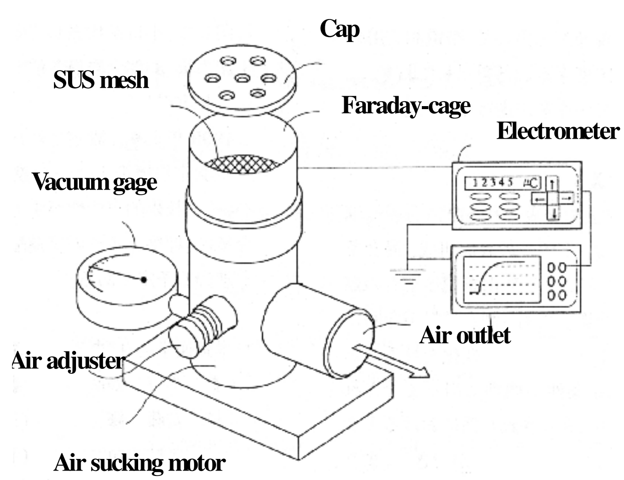

Figure 1d. Suction type Faraday cage.

2. Preparation of the Measuring Sample:

Mixing bottle, mixing amount, toner concentration, adjustment of moisture adsorption amount, mixing condition.

Many researchers studied the dispersion of the q/m with the toner concentration. In the regulation, the toner concentrations of 3~5wt% are selected as the most suitable concentration range to obtain good q/m reproducibility. The adjustment of the amount of moisture adsorption on the toner and carrier particle surfaces is the most important factor to obtain the reproducibility in the chemical factor. The samples to be measured must be exposed in the standard atmosphere (20~25ºC, 50~60%RH), or the moisture adjusting atmosphere, for more than 24 hrs before the measurement was performed to equilibrate the moisture content of the samples with the atmosphere.

3.Measurement:

Measuring atmosphere, blowing or sucking condition, measuring time, timing of the measurement, sample handling, calculation of q/m.

The atmosphere for the measurement is made equal to the moisture-adjusting atmosphere. The blowing or sucking condition is regulated so as to satisfy the following requirements; 1) to realize the toner removing ratio of more than 90wt%, 2) to prevent the additional tribo-charging caused by the separated toner and carrier particles due to the blowing and sucking operation, 3) to prevent the abrasion of the carrier particles surface and to prevent the distortion or abrasion of the mesh due to the blowing or sucking operation.

Selection of the Standard Developer

The standard developer was selected on the assumption that the amount of toner charge is an irreversible amount because of the irreversible change of the toner and carrier surface which inevitably occurs by the tribo-operation. Therefore, the tribo-history of the toner and carrier before or at the measurement must be maintained identical. In addition to the maintenance, the following characteristics are required for the standard developer.

1) The amount of saturation charge is reached rapidly by mixing operation and is maintained although the mixing operation is continued.
2) The amount of saturated charging does not show large dispersion in different atmospheres.
3) By blowing and/or sucking operation, toner particles are easily separated from the carrier particle surface, and generate an appropriate amount of saturation charge.
4) The carrier particles have an appropriate particle size for the blow-off measurement.

At the early stage, the ideal toner/carrier combinations composed of organic or inorganic particles mass produced in industry were selected as a model and evaluated. However, it was later found that appropriate developers selected from commercial two-component developer satisfy every needed characteristic mentioned above.

Selection of Standard Developer and Charge Measurement

Table 1 shows the amount of toner charge (q/m) in two-component developers No 1 ~ No 6 measured by operators A ~ G. All measurements were performed according to the standard procedure. The results are interesting considering the fact that it was the first trial to compare the q/m obtained by using the different types of Faraday-cages. The difference of the q/m in the same developer obtained by the different operators was minimized by the standard procedure. In the comparison of q/m, the operators can be classified to three types; those who always obtained the larger value (E), those who always obtained the lower value (D), and those obtained the larger and lower value (the remaining operators). The difference of the q/m seems to come from the difference of additional tribo-charge in the blowing or sucking operation due to the difference of the Faraday-cage structure, or due to the difference of the amount of moisture adsorbed from the atmosphere. In developers No 3 and No 5, the dispersion of the q/m are ±30~40 %. This large dispersion seems to come from the moisture susceptibility of these developers.

Table 2 shows the results of the third trial for the selection of standard developer. In this trial, operators B, G, and F performed the measurement using a developer which has been exposed for more than 24 hrs to three different atmospheres, namely low temperature and low relative humidity atmosphere (LL), the standard atmosphere (NN), and a high temperature and high relative humidity atmosphere (HH). The obtained q/m decreased remarkably as the atmosphere changed from LL to HH. The result shows that the adsorbed moisture on the toner and carrier particle surfaces causes the decrease of the q/m. The q/m dispersion was larger in developers No 7 and No 8. Developers No 5, No 7 and No 8 are made of the same toner, but of the different types of carriers. The large q/m dispersion of these developers is considered to come from the high sensitivity to the relative humidity, and consequently should be excluded from the list for the standard developer.

The developers No 10 and No 11 were selected as a standard developer for the following reasons. 1) The q/m in these developers, which were exposed to the standard atmosphere (20~25 ºC, 50~60%RH), shows a suitable q/m amount of about ±20 μC/g. 2) The dispersion of the amount of charge obtained by the different operators with different Faraday-cages is within the rang of ±20%. 3) The result suggests that these developers are satisfying the condition to be the standard developer mentioned above.

Table 1. Measured q/m by standard procedure (Second trial) Unit: mC/kg (µC/g)

Operator (Faraday-cage)*	A (S&B)	B (S&B)	C (S&B)	D (S&B)	E (MB)	F (B)	G (S)	Av
Developer No 1	12.7	12.4	16.2	12.3	15.7	13.6	10.2	13.3
Developer No2	12.3	11.6	10.6	9.8	12.7	10.9	8.3	10.9
Developer No3	39.1	34	30.1	25.1	45.7	38.3	38.8	35.8
Developer No4	13.4	12.8	10.7	10.5	12.3	11.5	12.2	11.9
Developer No5	18.1	11.9	9.1	8.1	15.6	13.5	14.2	14.6
Developer No6	21.8	24.4			33	34.9	25.5	27.9
Equilibrating atmosphere	-	-	25 ºC 60% 24H	23 ºC 65% 24H	24 ºC 15%	22 ºC 55%	23 ºC 60%	-
Measuring atmo.	-	26ºC34%	25 ºC60%	23 ºC65%	24 ºC 34%	-	23ºC 60%	-
Mixing**	Hand 200	Hand 200	Hand 200	Hand 200	Hand 200	Hand 200	Hand 200	

(light shading): Maximum value (dark shading): Minimum value

* S&B: Suction and Blow type MB : Magnet Blow type, B : Blow type, S : Suction type

** Toner/carrier mixtures are mixed by hand shaking (mixing speed: 2~3cycle/sec, stroke: 0.3m)

Table 2 Measured q/m by standard procedure (Third trial) Unit: mC/kg (µC/g)

Operator (Faraday-cage)*	B (S&B)			G (S)			F (B)		
Developer No 7	-12.2	-12.1	-7.2	-22.2	-17.5	-9.1	-19.2	-15.2	-12.4
Developer No 8	-16.3	-15.9	-8.8	-31.3	-20.9	-10.0	-26.4	-16.5	-11.6
Developer No 9	15.1	15.7	10.1	15.8	12.5	6.2	18.3	12.9	9.2
Developer No 10	19.3	18.6	16.4	22.2	18.6	14.8	23.9	21.6	20.6
Developer No 11		-17.6			-23.2			-20.4	
Equilibrating	LL	NN	HH	LL	NN	HH	LL	NN	HH
atmosphere	23ºC 30%	25ºC 40%	23ºC80%	23ºC 5%	23ºC 60%	30ºC80%	18ºC 20%	22ºC 55%	25ºC85%
Mixing**	Hand 200			Hand 200			Hand 200		

Operator (Faraday-cage)*	D (S&B)			E (MB)			A (S&B)		
Developer No 7		-10.9			-18.5				
Developer No 8		-11.7			-17.1				
Developer No 9		13.1			14.8				
Developer No 10		17.3			21.7				
Developer No 11		-15.8			-17.0			-18.0	
Equilibrating	LL	NN	HH	LL	NN	HH	LL	NN	HH
atmosphere		22ºC 55%			27ºC 43%				
Mixing**	Hand 200			Hand 200			Hand 200		

(light shading): Maximum value (dark shading): Minimum Value

* S&B : Suction and Blow type MB : Magnet Blow type, B : Blow type, S : Suction type

** Toner/carrier mixtures are mixed by hand shaking (mixing speed: 2~3cycle/sec, stroke: 0.3m)

Meaning of the Regulation

The significance of the regulation of the standardized measuring procedure and the standard two-component developer are as follows.

1) The obtained q/m can be treated as a common value which can be reproduced by anybody; the q/m obtained by the different operator is comparable, the q/m published in a brochure or in a technical paper can be reproduced, the q/m can be used in the commercial transaction as a common value.
2) The standard developer can be used to calibrate a Faraday-cage or to calibrate measuring equipment.
3) The standard developer can be used as a reference material in the manufacturing process of a toner and a carrier; the standard developer can be used as a reference material in quality control.
4) The q/m cited in a brochure or in a technical paper can be compared with q/m values of other literatures when it is indicated that the q/m was measured by using the standardized procedure.

Conclusion

The ISJ Technical Committee part III meeting (The technical committee of toner based material) worked to standardize the blow-off toner charge measurement procedure and to set the standard two-component developers for the procedure. It was found that, according to the standard procedure, the dispersion of the amount of toner charge (q/m) in the same two-component developer can be controlled within the range of ±20 μC/g even when different operators measure the charge with different types of Faraday-cages. The obtained q/m according to the standardized procedure can be treated as a reproducible common value, which can be obtained by any operator. The standard two-component developers would be useful for the reference material to calibrate measuring apparatuses and to maintain the charging characteristics in the manufacturing of toner and carrier.

References

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Biography

Toshihiko Oguchi joined Morimura chemicals Ltd. In April 2000. He is responsible for new product development and application research. Previously at R & D center in Toshiba Corporation his work has primary focused on the development of liquid and dry toners for electro-photography and perpendicularly recording media. He is a chief member of ISJ's Technical Committee part III meeting (The technical committee of toner-based material). He received his BS from Tokyo Metropolitan University in 1967 and Dr. of Engineering from Tokyo Institute of Technology in 1988.