

Carrier Characterization and Related Toner Charging Property in Two Component Developers

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Abstract

Our proposed model[1)] for toner tribo-charging can well explain the dependence of toner charge to mass ratio q/m of two-component developer on toner concentration. According to the model, there are three types in dependence of toner charge to mass ratio on toner concentration. Type I is constant toner charge to mass ratio and Type II is decreasing toner charge to mass ratio with increasing toner concentration. Type III shows the Type I and Type II mixed characteristics. These dependence of toner charge to mass ratio on toner concentration are affected by toner and carrier properties. However, we have scarce information of carrier side to toner tribo-charging. We try the characterization of commercial carriers. Carrier charge to mass ratio, Q_c/M_c to metal plate having different work function is measured. It is found that there are well defined the relationship between carrier charge to mass ratio and type of toner concentration dependence of toner charge to mass ratio.

Introduction

Two component developer for electrophotography is charged by tribo-charging between toner and carrier. To control tribo-charge is important in forming the images. It is generally said that the tribo-charge behavior of developer is largely influenced by carrier and toner surface property. But we have scarce information of carrier side. In this study, we have measured tribo-charge between carriers and metal plates with various work functions, and between carrier and glass bottle. And we have measured tribo-charge between carriers and toners. We report the relationship between carrier tribo-charge and toner concentration dependence of toner charge to mass ratio.

Experimental

Table 1 shows the list of the carriers and the toners used in this experiments. Carrier and toner samples are commercially available ones. All carrier samples are spherical type and approximately 100μm diameter. Two toner samples are minus and plus type with 10μm diameter respectively. Toner charge to mass ratio in the combination with each carrier and toner is measured by modified blow-off method.[2)] In this experiment, toner concentration is determined by toner weight adhering on carrier particles.

Table 1. Used carrier and toner

Carrier A	Uncoated Iron Carrier
Carrier B	Uncoated Ferrite Carrier
Carrier C	Uncoated Ferrite Carrier
Carrier D	Silicone Coated Ferrite Carrier
Carrier E	Uncoated Magnetite Carrier
Carrier F	Silicone Coated Magnetite Carrier
Carrier G	Fluorine Coated Magnetite Carrier
Toner M	Minus Toner
Toner P	Plus Toner

Carrier A,B : Powder Tech
Carrier G, D, E, F, G : Kanto Denka

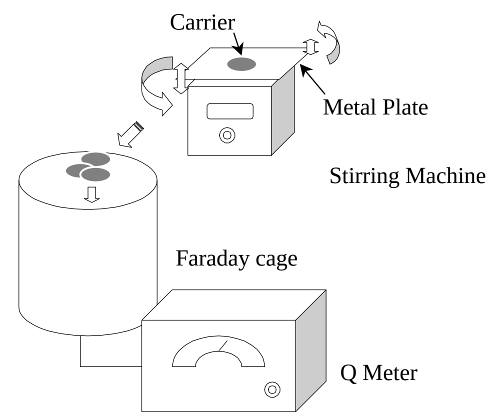

Figure 1. Schematic illustration of equipment

Carrier tribo-charge to metal plates having different work function is measured to obtain carrier property. Metals are Al, Sn, Brass, German silver, Cu (each metal plate having 15x13cm^2 size, and 0.3mm thickness). Metal is set on the stirring machine. Carrier is putted on metal plate and stirring machine is turning. Carrier tribo-charge measured by Faraday cage method. Figure 1 shows schematic illustration of equipment. Carrier amount per a measurement is 0.03g. Time dependence of carrier charge to mass ratio by metal plates is measured. Metal work function are measured by Kelvin method. Additionally, carrier charge with several glass bottle are measured. Glass bottles are 5,50 and 100ml, and carrier weight for three glass bottles per a measurement are commonly. Carrier charge is measured by Faraday cage method. Carrier tribo-charging time by hand shaking is 5minutes.

Results and Discussions

Tribo-charge between Carrier and Metal

Table 2. Work Function of Metals

Al	4.30eV
Sn	4.56eV
German Silver	4.70eV
Brass	4.73eV
Cu	4.80eV

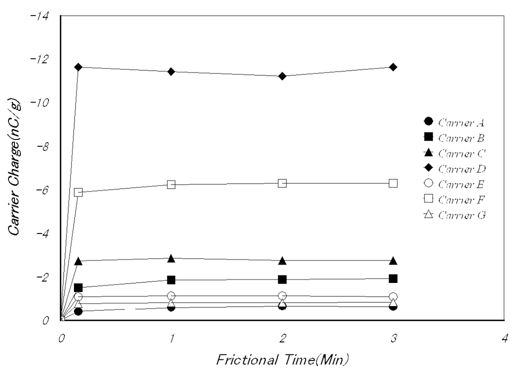

Figure 2. Relationship between carrier charge to mass ratio and frictional time on Al plate

The work function of each metal used in this experiment are shown in Table 2. Figure 2 shows the relationship between carrier charge to mass ratio and frictional time at Al plate. Carrier charge to mass ratio dose not depend on frictional time at every carrier. These carrier charge to mass ratio are saturated in a short time. And every carrier shows different value for Al metal plate. The same tendency as Figure 2 for seven kinds of carrier was found at other metal plates with different work function. Figure 3 shows the relationship between work function of metals and carrier charge to mass ratio at 3minutes of frictional time. We could not find any relationship between work function of metals and carrier charge to mass ratio as shown in Figure 3. In other words, the characteristics of tribo-charge can not be determined by using work function or ionized potential of metals. But we must take it into consideration a oxidized layer and micro shape on metal surface as well as work function and ionized potential. Three groups shown in Figure 3 will be explained in next section.

Measurement of Toner Charge by Tested Carriers

Toner concentration dependence of toner charge to mass ratio for tested carriers are classified into three types[1,2]. The value of toner charge to mass ratio is constant with increasing toner concentration. This is so called Type I and the surface condition is Nc>Nt, where Nc and Nt is the number of charging sites on carrier and toner, respectively. The value of toner charge to mass ratio is decreasing with increasing toner concentration. This is Type II and the surface condition is Nc<Nt. Type III shows the Type I and Type II mixed characteristics. Additionally, groups of carrier in Figure 3 can be classified by the type of toner concentration dependence.

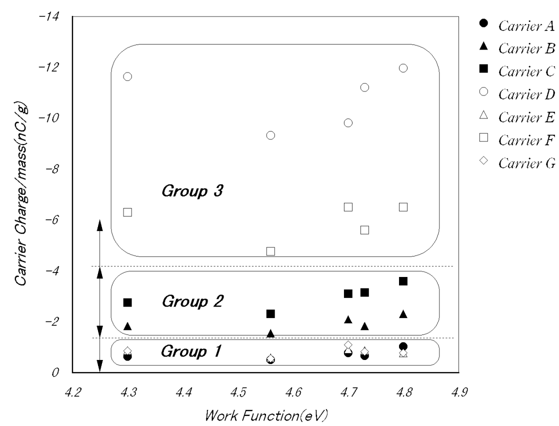

Figure 3. Relationship between carrier charge to mass ratio and work function of metals

- **Toner Characterization by Group 1 Carriers**

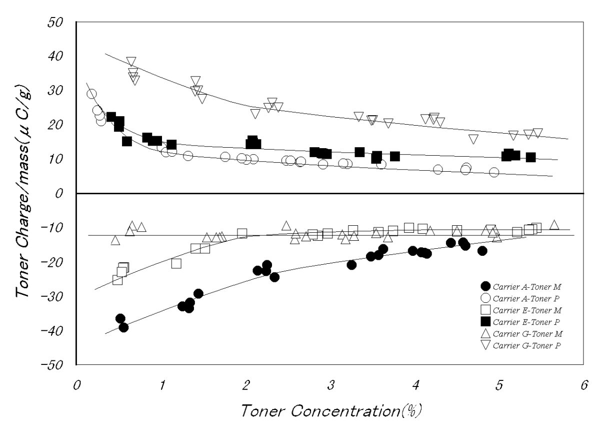

Figure 4. Relationship between toner charge to mass ratio and toner concentration with group 1 carriers

Figure 4 shows the relationship between toner charge to mass ratio and toner concentration with group 1 carriers. These carriers are classified in group 1 of Figure 3 and show small carrier charge to mass ratio less than –1 nC/g for metals. For toner M and toner P, these carriers show Type II characteristics: toner charge of a toner particle is decreasing with increasing toner concentration. These carriers are considered to have not enough effective charging sites on carrier surface. Group 1 carriers consist of Iron (A), Magnetite (E), Fluorine coated magnetite (G).

- **Toner Characterization by Group 2 Carriers**

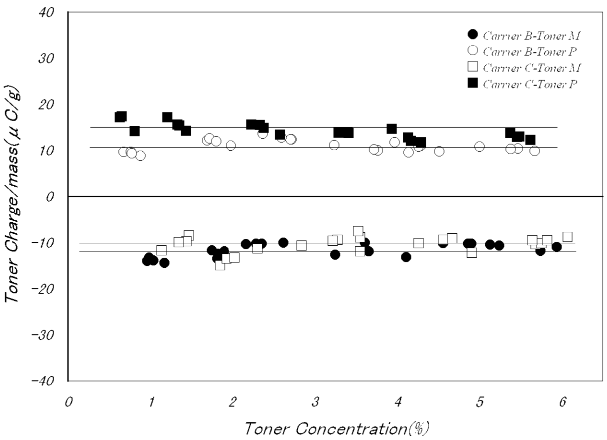

Figure 5. Relationship between toner charge to mass ratio and toner concentration with group 2 carriers

These carriers are classified in group 2 of Figure 3. For toner M and P, these carriers show Type I characteristics: toner charge of toner particle is constant with increasing toner concentration. These carriers are considered to have enough effective charging sites on carrier surface. Group 2 carriers consist of Ferrite B (Powdertech) and Ferrite C (Kantodenka), and these uncoated ferrite carriers show Type II characteristics with no relation to manufacture company.

- **Toner Characterization by Group 3 Carriers**

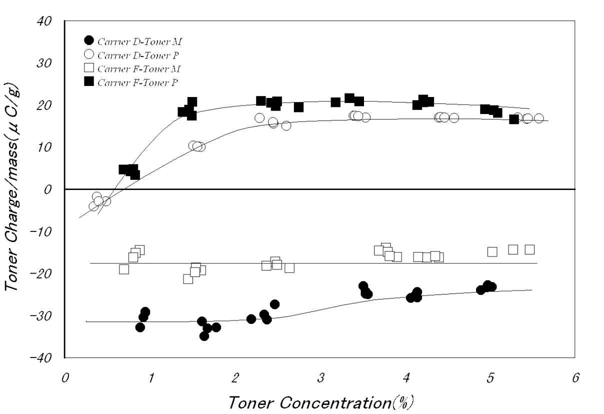

Figure 6. Relationship between toner charge to mass ratio and toner concentration with group 3 carriers

Figure 6 shows the relationship between toner charge to mass ratio and toner concentration with group 3 carriers. These carriers are classified in group 3 of Figure 3 and show carrier charge to mass ratio over – 4 nC/g. In the combination of these carriers and toner P, plus toner charge to mass ratio is increasing monotonously at less toner concentration than 1.5wt%, and it shows constant value at over 2wt% toner concentration. This is new tendency that has not been observed. This tendency was observed only in the case for plus toner. The other factors additionally to charging site number between toner and carrier must be taken into consideration for this phenomenon. The cause of phenomenon is now under examination. We regard basically these toner concentration dependence as Type I characteristics. In the combination of carrier D and toner M, minus toner charge to mass ratio shows Type III characteristics. In the combination of carrier F and toner M, minus toner charge to mass ratio shows Type I characteristics. Group 3 carriers consist of silicone coated carrier D (ferrite carrier) and F (magnetite carrier).

Tribo-Charge Between Carrier and Glass Bottle

We considered tribo-charging behavior between toner and carrier is governed by relative difference of charging site number on their surface. We measured carrier charge with three glass bottles which having different surface area to obtain carrier property from viewpoint of charging site number.

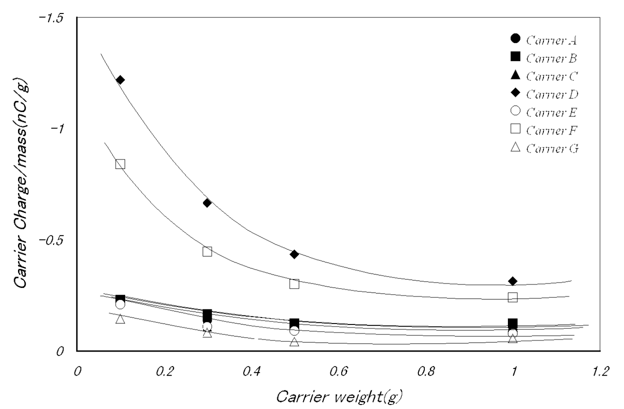

Figure 7. Relationship between carrier charge to mass ratio and carrier weight in 5ml glass bottle

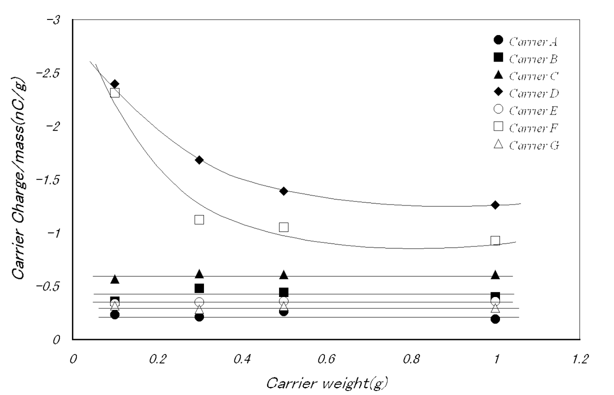

Figure 8. Relationship between carrier charge to mass ratio and carrier weight in 50ml glass bottle

Figure 7, 8 and 9 show the relationship between carrier charge to mass ratio for three glass bottles and carrier weight per a measurement. In Figure 7, every carrier charge to mass ratio depend on carrier weight, and show small values than other two bottles. But in Figure 8 and 9, carrier charge to mass ratio of carrier A, B, C, E and G show constant values for every carrier weight, these carrier charge to mass ratio is saturated. In other words, the relation of carrier and glass bottle surface condition changes from Nc>Ng to Nc<Ng as glass bottle turn 5ml into 50ml and 100ml, where Ng is the numbers of charging site on glass bottle.

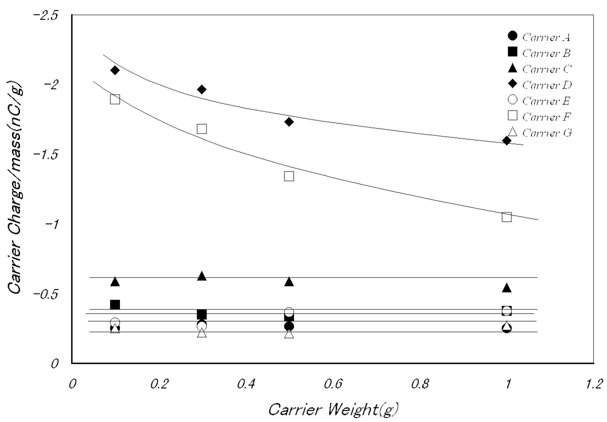

Figure 9. Relationship between carrier charge to mass ratio and carrier weigh in 100ml glass bottle

Then, the charging site number of glass bottle is enough to tribo-charging of carrier with increasing size of glass bottle. However, carrier charge to mass ratio of carrier D and F decrease with increasing carrier mass, that is, these carrier charge to mass ratio is not saturated. The relation of carrier and glass bottle surface condition is still kept to Nc>Ng even though glass bottle turn 5ml into 50ml and 100ml. In this case, the charging site number of glass bottle is not enough to tribo-charging of carrier. Therefore, we considered tribo-charging behavior is governed by charging site number on material.

Summary

In this report, seven kinds of test carrier exhibit different carrier charge to mass ratio for metal plates. Carrier charge to mass ratio does not depend on frictional time with metal at every carrier and shows practically similar value for metals of different work functions. The carriers used in this experiment can be classified in three groups by the relationship between carrier charge to mass ratio Q/M for metal plates and toner charge to mass ratio q/m for seven kind of carrier. In the tribo-charge between carrier and glass bottle, carrier charge to mass ratio with increasing carrier mass is related to glass bottle size which include charging site number. It is found that the tribo-charge does not related to work function in this study. Therefore, we considered that tribo-charging behavior is governed by charging site number on material surface.

Reference

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Biography

He entered Tokai University, Japan 1993 (Department of Electro-Photo-Optics). He graduated from Tokai University, Japan 1997 (Department of Electro-Photo-Optics). He entered Graduate School of Tokai University 1997, Master course (Study of Electrostatic Marking Materials at Dept. of Electro-Photo-Optics). He is interested in Electrophotographic materials.