The Charging Characteristics of CCA

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Abstract

In recent years, printing speed and resolution in digital printing have been increasing according to various market requirements. As a result, it is required that the toner behaviors in developing system is controlled more precisely and uniformly. In the electrophotographic system, toner charge is one of the important factors to identify toner behaviors.

In general, Charging Control Agent (CCA) is necessary for toner to obtain stable and superior image quality. CCA provides quick charge and suitable triboelectric charging level. Therefore, toner triboelectric charge can be affected by a variety of CCA, CCA content, and so on. In addition, maintenance of a stable and uniform charge requires a balancing of many complex interactions.

In this review, the charging characteristics of CCA are discussed and illustrated using actual experimental data in non-magnetic one component developing system. It is found that the performance of toner charge depends on the type and amount of CCA. We have designed optimum condition to obtain the better performance of toner charging.

Introduction

In conventional xerography, triboelectrically charged toner particles containing a colorant, wax, and other substances are used to visualize a latent electrostatic image formed on the photoreceptor. Such toners are required to have satisfactory performance in terms of fixing ability, anti-offset characteristics, chargeability, and so on. From a toner viewpoint, toner chargeability such as its polarity, magnitude and stability is a critical property in electrophotography system. However, the optimum performance in toner is controlled by many intrinsic and extrinsic factors such as external and/or internal additives. Unfortunately these additives may also affect toner charge level and stability.

Usually, a charge controlling agent (CCA) providing positive or negative charge is added to the toner to obtain and control the desired charging characteristics of a toner. The charging mechanism of a toner is difficult to study because toner composition is complicated. Each constituent has many functional groups, and toner particles contact with many kinds of material in the developing unit, such as the developing roller, the metering blade, and the photoreceptor. All of these materials are associated with tribocharging. In order to obtain better performance, the study of the tribocharging mechanism and the intrinsic role of CCA is very valuable and necessary.

The addition of charge controlling agents allows to control the polarity of the toner and to adapt it to the preferred position in the triboelectric series. Many charge controlling agents such as nigrosine, aniline black, quaternary ammonium salts and metal complex salt dyes are conventionally used. Positive CCAs like Nigrosine or Triphenylmethane dyes consist of bulky organic cations and small inorganic counterions of high charge density. Negative charge controlling agents are most bulky anionic metal complexes with protons or metal ions as counterparts.[1] However, some charge controlling agents have various drawbacks. For instance, the usage of azo-chromium complex compounds as negative CCA has been limited in that chromium compound is detrimental to environmental problems.

In electrophotographic system, the CCA is indispensable component to obtain suitable charging characteristics. The charging rate, level and stability of the toner affects the quality of the print image. It has already been found that total charge is one of the dominant factors affecting the quality of the print image.[2,3] Therefore, it is important to understand the function of CCA. In this study, we investigated the effects of CCA on toner chargeability. The charging characteristics of CCA are discussed and illustrated using actual experimental data in non-magnetic one component developing system.

Experimental

In this study, test toners were based on polyester resins containing colorant, wax and charging controlling agent. Six types of CCAs were selected for preparing negative charge toners. The chemical characters of the investigated CCAs are tabulated in Table 1. CCA concentration was adjusted to 1.0, 1.5, 2.0 and 3.0 wt.%. They were prepared in the sequence of melt kneading, pulverizing and classification. The mean particle size of toner was about 8μm(d50). The measurement condition was at 25ºC and 50% RH.

Table 1. Investigated CCA Types

No.	Chemical Character	Charge	Remark
1	Zirconium Complex	Negative	CCA1
2	Zinc Salicylate	Negative	CCA2
3	Inorganic polymeric compound	Negative	CCA3
4	Calcium Salicylate	Negative	CCA4
5	Boron Acetyl type	Negative	CCA5
6	Azo-iron Complex	Negative	CCA6

To investigate the characteristics of developing performance according to the charge of toner (Q/M) and mass of toner (M/A) on the photoreceptor, we set up experimental developing apparatus for non-contact type single component development system.

Measurement of the Charge and Mass of Toner

It is very important to measure the charge of toner (Q/M) on the photoreceptor in the developing zone. We can measure toner charge (Q) and mass (M) of toner layer on the photoreceptor in each case, then we can calculate the charge of toner (Q/M) based on the mass of toner on the surface of the photoreceptor.

We use suction-type Faraday Cage through 0.8µm filter with 0.5MPa pressure to collect toner from the photoreceptor and to measure toner charge by electrometer.

The toner layer can be described as the mass of toner (M/A) based on the surface area of the toner layer on the photoreceptor. We can measure mass (M) of the toner which is collected from the toner layer on the photoreceptor in fixed area, then we can calculate the mass of toner (M/A) based on the area of the toner layer on the photoreceptor.

Measurement of Background

We evaluate the background level by measurement of optical density at the non-image area of photoconductive drum.

Results and Discussion

Chemical Character

The charge (Q/M) and mass (M/A) of toner as a function of the CCA type are shown in Fig. 1 and 2. We can find that the charge of toner depends on the chemical character of CCA in the range from -11 to -22µC/g. The charge of toner containing CCA1, CCA2 and CCA3 are measured to have rather higher level in absolute value than that of CCA4 and CCA5. According to the previous paper,[4,5] it was reported that the tribocharge mechanism of complex type CCA is governed by transference of light weight counter ion. In addition, it is well known that tribocharge level is significantly affected by the kind of metal ion introduced into the azo-metal complex.

All of the mass of toner are approximately in range from 0.8 to 1.0 mg/cm^2. From the results of Fig. 1 and 2, it is found that the level of charging value is inversely proportional to that of the mass of toner. The mass of toner become lower as the charging level of toner increases. Toners containing 3 wt.% CCAs show high level of charging value and low toner mass as compared with the toners containing 1.5 and 2 wt.% CCAs.

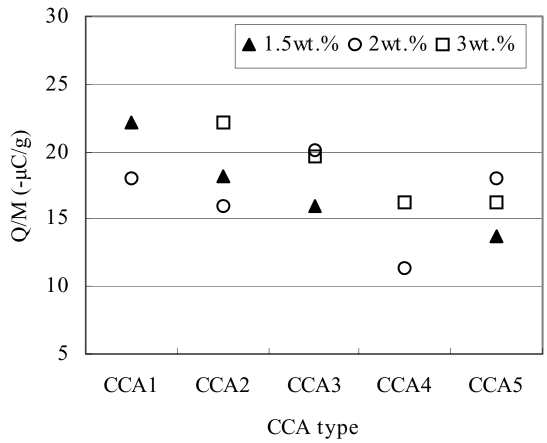

Figure 1. The charge of toner (-µC/g) according to CCA type.

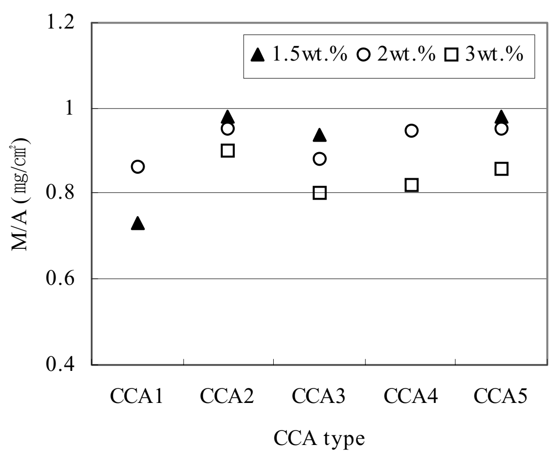

Figure 2. The mass of toner (mg/cm^2) according to CCA type.

In order to identify the generation of wrong signed toner from triboelectric mechanism during printing operation, background level was investigated. The trend of background is shown in Fig. 3 according to the CCA type added in toner. At the same condition, CCA4 shows worst background level. This result is due to the low charging character of CCA4 as shown in Fig. 1. It is considered that background also depends on the charging level of toner.

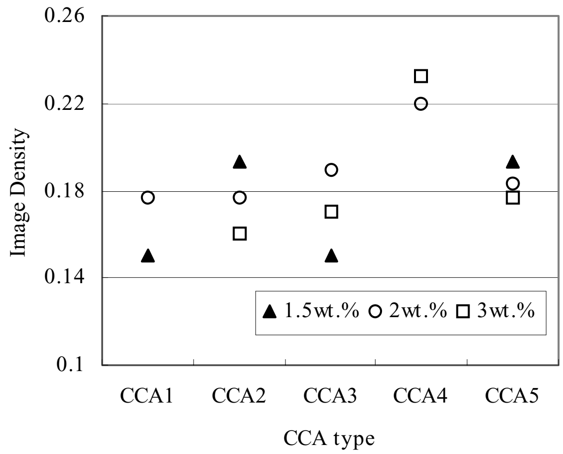

Figure 3. Background according to CCA type.

Effect of CCA Content

The variations of charging level with CCA content are illustrated in Fig. 4 and 5. Experimental results show that as the content of CCA increases, the charging level of toner doesn't increase continuously. Each CCA has maximum or optimum charging level, even though those values are somewhat different with CCA type. Maximum charging value of CCA1 is obtained at 1.5 wt.%. On the other hand, as the CCA content increases, the charging values of CCA2, CCA3 and CCA5 increase gradually and then saturate at 1.5 ~ 2 wt.%. As for the saturating point, CCA2, CCA3 and CCA5 are about 1.5, 2 and 2 wt.%, respectively. From these results, we can find that in the CCA3 and CCA5, to obtain same charging level and stability, higher amount of CCA is required to be added. This observation of charging characteristics according to CCA content can help toner design having desired triboelectric charge.

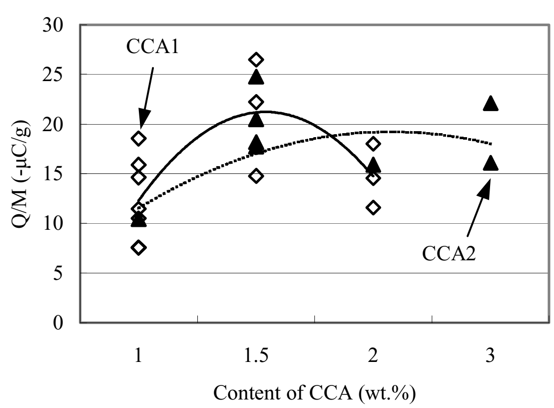

Figure 4. The charge of toner (-μC/g) according to CCA content.

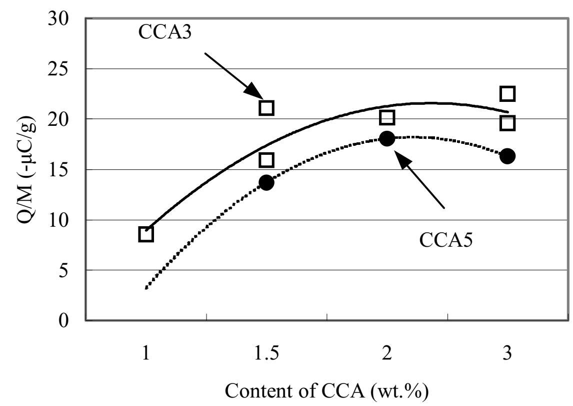

Figure 5. The charge of toner (-μC/g) according to CCA content.

Result of the Life Test

One of the important problems related to toner performance is deterioration in printing quality by toner stress throughout the cartridge life. Therefore, CCA is required to maintain good charging level and stability during long term printing operation as well as initial stage. To investigate the charge stability, we performed running test with CCA1 and CCA6. The test file is consisted of arbitrary character sets with 5% coverage of print duty to evaluate cartridge life.

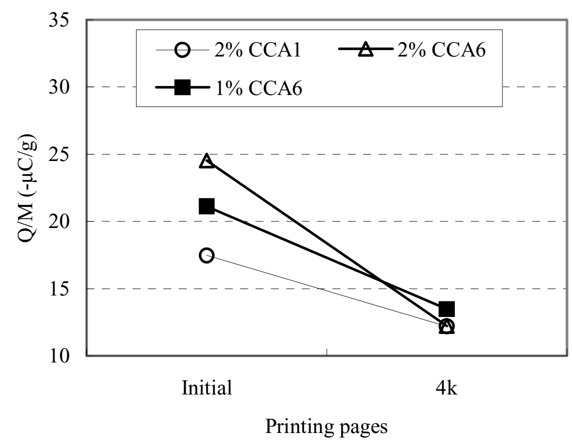

Figure 6. The variation of toner charge (-μC/g) according to the printing volume.

The results of running test are shown in Fig. 6, 7 and 8. It is observed that in all of the test samples, the charge of toner decreases with increasing of printing page. Toner containing 2 wt.% CCA6, however, shows dramatic decrease in charging level with a reduction ratio of about 50% after 4000 pages. We can see that this decrease of charging character affect the printing quality during printing operation, as shown in Fig. 8. With increasing printing pages, the background level of toner containing 2 wt.%

CCA6 is found to increase significantly, even though the other toner samples illustrate stable background level. This trend supports that charging stability is function of chemical character and amount of CCA.

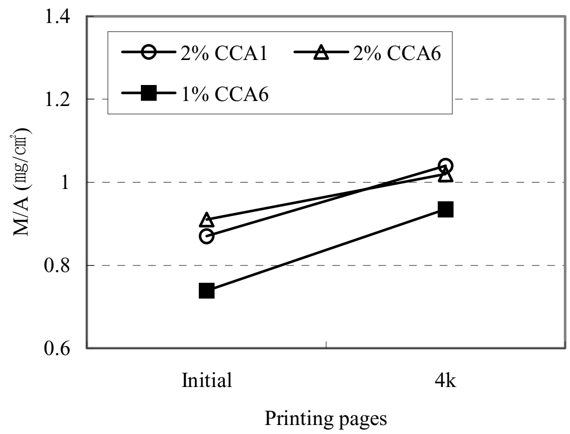

Figure 7. The variation of toner mass (mg/cm^2) according to the printing volume.

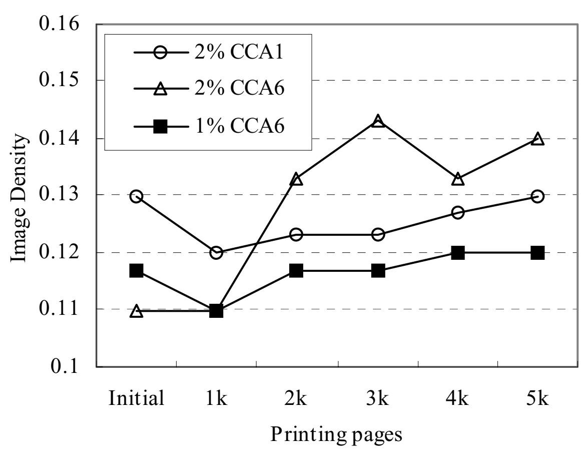

Figure 8. The variation of background level according to the printing volume.

Conclusion

The charging characteristics of CCA were investigated in terms of chemical character and CCA content. The tribocharge level of CCA is greatly subjected to the kind of chemical character. In addition, the trend of background depends on the charging level of toner.

Since the content of CCA to obtain the maximum charging level depends on CCA type, the suitable combination in chemical type and content are required to design toner having desired performance.

Long term printing quality is also related with CCA type and amount. The better printing quality results from the minimization of a degree of charge variability during printing process. As a result, optimum performance can be achieved by via incorporation of these factors.

References

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Biography

Duck Hee Lee received his Ph. D. degree in Material Science & Engineering from the Korea Advanced Institute of Science and Technology, Korea, in 2000 majoring in mechanical properties analysis. He has been involved in system development of laser beam printing system at Samsung Electronics since 2000, and his work is focused on the development of imaging materials.