Charge Control of the Polyester Color Toners on Non-magnetic Single Component Development

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Abstract

Non-magnetic single component development system have widely been used in desk top color laser printers, however, the charge control of the toner is very difficult compared with that of the dual component developer because of no carrier. We have investigated the charge control of single component color toners. Charging behavior at mixing with a carrier and flowability of the toner are closely related to the image quality (background, image density). Especially, resistance of the toner, quick charge and saturated charge ability influence to the image quality.

In this paper the most suitable design of the charge control agent and the surface additive for single component color toners is also reported. The application of the charge control agent and the surface additive is very important for the charge stability on single component development. For instance, it is possible to decrease the background by decreasing the amounts of the surface additive.

Introduction

In recent years, the demands of the color printing have been increasing. And several kinds of the color printing technologies have been deveoped[1]. The electrophotographic system has attracted in this field because of the high print speed and the enough print quality. In this system, the non-magnetic single component development apparatus has been widely used, because this apparatus is compact, low cost and easy maintenance. In this development system the toner charge is controlled by the optimization of charging and mechanical design of the development system. And a mechanical condition of this system has been widely studied[2-6]. However, the study on the material design of the non-magnetic single component toner almost hasn't been reported. Especially, that of color toners hasn't been reported at all.

On the other hand, it is well known that polyester resin has been widely used for color toners because the dispersibility of pigments and the durability of the toner are excellent. Especially, since polyester resin has good negative charge ability, it is suitable for the single component toners. Therefore charge control of the polyester color toners is necessary to obtain the excellent print qualities.

In this paper, the charge control of polyester color toners by charge control agent and surface additive was investigated.

Experiment

Toner Samples

(a)Preparation of Polyester Resin

Bisphenol A propylene oxide adduct, fumaric acid were allowed to react for condensation polymerization at 200°C with the small amount of catalyst in a glass flask, which was equipped with a thermometer, a stainless steel stirring rod, a reflux condenser and nitrogen inlet tube.

Table.1 Properties of the Experimental Polyester Resin

Sample	Acid Value[1)] (KOH mg/g)	T1/2[2)] (°C)	Tg[3)] (°C)
Linear-type polyester	20	101	59

1. The acid value was measured according to ASTM D-1980-67
2. The softening point (T1/2) was measured according to ASTM E-28-67
3. The glass transition temperature (Tg) was measured by a differential scanning calorimeter "DSC Model 200" manufactured by Seiko Instruments Inc., at a heating rate of 10°C/min.

(b) Preparation of Toner Samples

Toner samples were comprised of this resin, charge control agent and colorant. The charge control agent is Boron compound. The colorant for cyan toner is a ß type copper phthalocyanine (Pigment Blue 15:3), and that for the black toner is a carbon black.

These toners were prepared through the same process. The materials were premixed in a batch mixer; then they were kneaded, pulverized and classified. Finally samples having average size of 9.0 µm were obtained.

Each toner was blended with fumed silica to get efficient flow ability for the test operation.

And the toner samples are listed in Table 2.

Table.2 Formulation of Toner Samples

Toner	The Amount of CCA	The amount of Silica	Color
Toner 1b	None	0.4%	Cyan
Toner 2a	1%	0.1%	Cyan
Toner 2b	1%	0.4%	Cyan
Toner 2c	1%	0.7%	Cyan
Toner 2d	1%	1.0%	Cyan
Toner 3b	2%	0.4%	Cyan
Toner 4b	3%	0.4%	Cyan
Toner 5b	1%	0.4%	Black

Measurement Procedures

(a) Resistivity

The toner was pressed to form thin circle pellet. The thickness of the pellet was about 2mm and diameter was about 50mm. The resistivity of each samples was measured by PRECISION LCR METER (manufactured by HEWLETT PACKARD Co.) at 1kHz.

(b) Flow Ability

Aerated bulk density of the toner samples was measured by Powder -Tester (manufactured by Hosokawa Micron Co.).

(c) Blow-off q/m

For the measurement of q/m with roll mill, all the toner powders were mixed to carrier (Cu-Zn ferrite carrier coated silicon resin) at 3.0% of T/D, and roll milled at 250rpm for appropriate time. 0.5g grams of the mixture was then transferred into a pre-weighted Farady cage and the toner particles were blown off from the carrier by air jet (2sec. At 1.5kgf/cm2) through a wire screen with 36µm opening. The carrier beans were recovered for further analysis. The q/m values of the powders were calculated from the charge measured with Kawaguchi Universal Electrometer (model MMA2-17A).

(d) Evaluation of Print Qualities

The samples were printed by the commercial printer with the non-magnetic single component system (Tektronix Phaser 550).

And the print qualities were evaluated by the method described below.

Image Density

The image density was measured by MACBETH reflectodensitometer.

Background

The background was determined by the difference of delta X (cyan) and Z (black) between before and after printing. (Delta X and Y were measured by COLOR/COLOR DIFFERENCE METER manufactured by Nippon Denshoku Kogyo Co., Ltd.).

Q/m of the Toner Layer

The average toner q/m of the toner layer was measured according to the charge and the quantity of the sucking toner formed on the developing roller.

Result and Discussion

The Dependency of the Resistivity and the Charge Ability on the Amount of CCA At Cyan Toner

The polyester resin has high negative q/m revel. And the charge of color toner tends to be unstable compared with the black toner, which has electric conjugation. Therefore, we used Boron compound[7,8].

The resistivity of the cyan toner with the various amount of CCA is shown Fig.1. These indicated that the resistivity was reduced with increasing the amount of CCA.

On the other hand, in Fig.2, the blow-off q/m of toners with varying content of CCA was measured with roll mill by using the two components developer. For the toner with no CCA (Toner 1b), the q/m grew gradually and came to a plateau. Namely the charging rate is very slow. Except Toner 1b, the q/m suddenly reached the maximum, and then decreased little by little. By including CCA to the toner, the charging rate became fast, because the saturated q/m level became lower with increasing CCA. It is thought that decreasing of the resistivity caused the lower q/m level.

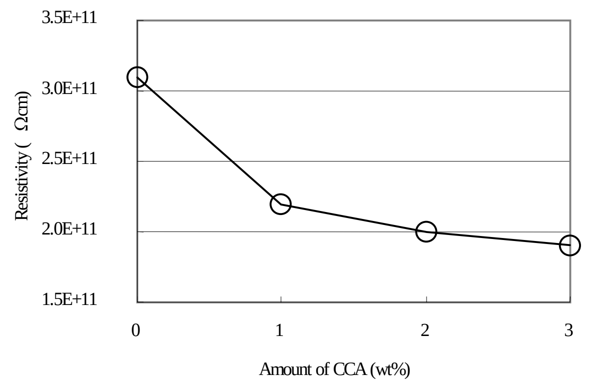

Figure 1. The dependency of the resistivity on the amount of CCA

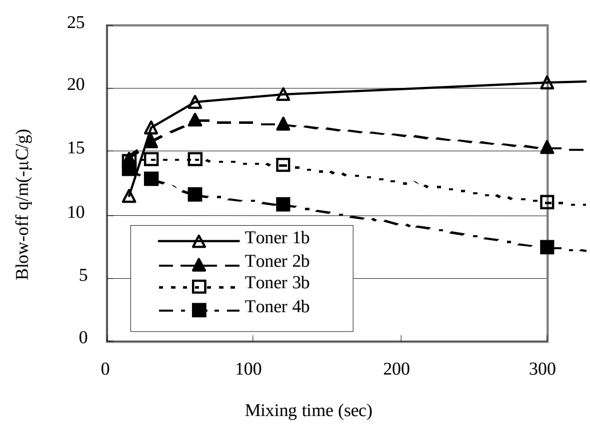

Figure 2. Q/m as a function of roll mill time of toners with different amount of CCA

Relation Between the Print Qualities and the Amount of CCA

The q/m of toner layer is shown in Fig. 3, and the image density and the background are shown in Fig. 4 with various amount of CCA. These indicated that the q/m of toner layer and the image density were reduced, and the background was raised with increasing the amount of CCA except the toner with no CCA. It is thought that these are due to lower saturated q/m level measured at the two components developer with increasing CCA.

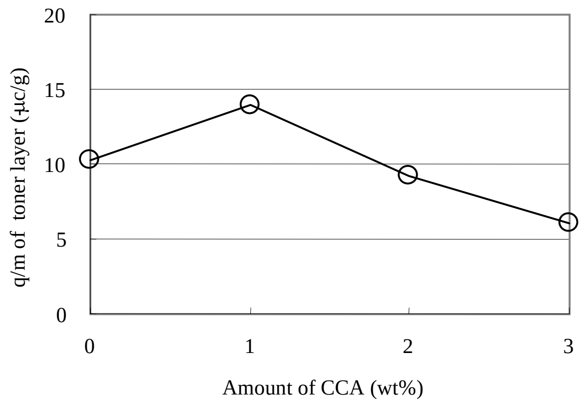

Figure 3. The dependency of the q/m of toner layer on the amount of CCA

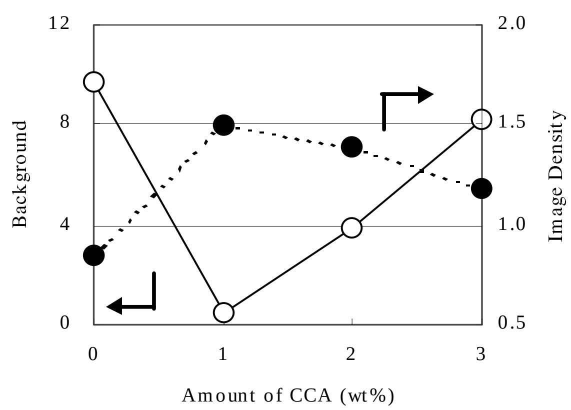

Figure 4. The dependency of the image density and the background on the amount of CCA

On the other hand, the toner with no CCA showed bad background level in spite of the high q/m of toner layer. It is thought that since the q/m of the toner with no CCA grows gradually, the charge distribution of toner layer is broad.

The Dependency of the Flow Ability and the Charge Ability on the Amount of Surface Treatment at Cyan Toner

In the single component development apparatus, it is very important to control the flow ability to obtain the excellent print qualities compared with the case of the two components development system.

The flow ability (aerated bulk density) of the cyan toner with the various amounts of surface additive (fumed silica) is shown Fig.5. These indicated that the flow ability of the toner was improved with increasing the amount of silica.

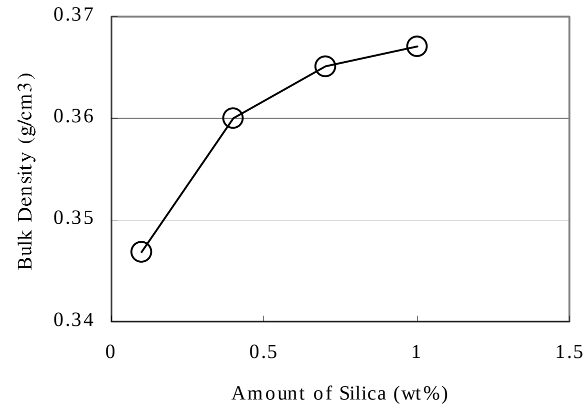

Figure 5. The dependency of the bulk density on the amount of silica

And Fig.6 shows the charging up behavior of toners with varying content of silica. The saturated q/m level was raised with increasing the amount of silica. But it is thought that the charging rate was the same.

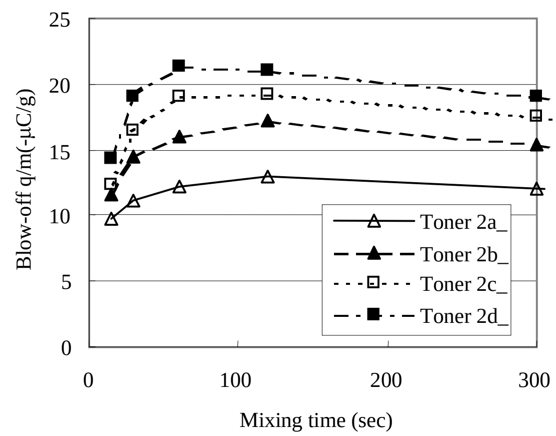

Figure 6. Q/m as a function of roll mill time of toners with different amount of silica

Relation Between the Print Qualities and the Amount of Silica

The q/m of toner layer is shown in Fig 7, and the image density and the background are shown in Fig.8 with various amount of silica. These indicated that the q/m of toner layer was reduced and the background was raised with increasing the amount of silica in spite of higher saturated q/m level at two components developer. It is thought that these are due to high flow ability with increasing the amount of silica. When the flow ability is usually excessive, the retention time within the nip between the blade and the developer roller becomes smaller and q/m of the toners becomes lower.

On the other hand, the image density was raised with increasing the amount of silica. It is thought that the toner layer becomes thick with same reason.

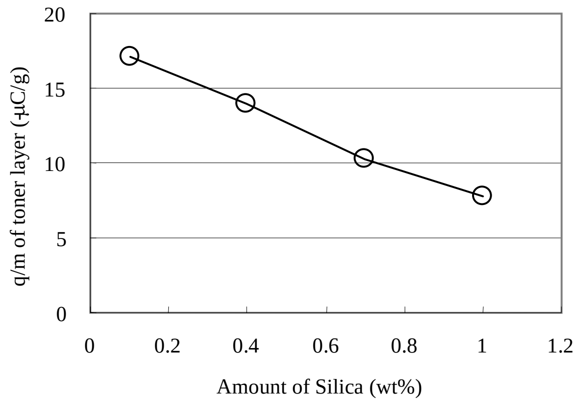

Figure 7. The dependency of the q/m of toner layer on the amount of silica

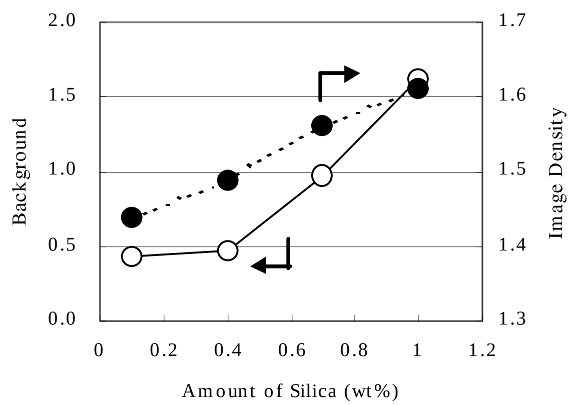

Figure 8. The dependency of the image density and the background on the amount of silica

Comparison Between Color and Black Toners

Since the pigment of black toner is carbon black, which has very low resistivity, the charge ability of black toner tends to become lower than that of color toner.

The Resistivity, the q/m of toner layer and the background of the black toner, which has same components with cyan toner, are shown in Table.3. Since black toner has low resistivity, the toner tends to become low charge and high background. Therefore it is necessary to use the CCA having ability of increasing charge to obtain the excellent print qualities.

Table 3. Evaluation of Black Toner Which Has Same Components with Cyan Toner

Toner	Color	Resistivity (ohm cm)	q/m of toner Layer (-μC/g)	background
Toner 2b	Cyan	2.2xE11	14.0	0.47
Toner 5b	Black	8.7xE10	8.3	7.96

Conclusion

Conclusion of the study on non-magnetic single component development can be summarized as follows:

1. Both the charging behavior and the flowability of the toner control the charge of polyester color toners on non-magnetic single component development.
2. Q/m of the black toner using conductive CCA isn't enough for non-magnetic component development.

References

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Biography

Jun Shimizue received his master degree in applied chemistry from Osaka University in 1986. He has been working for Wakayama Research Laboratories of Kao Corporation, Japan since 1986. And he has been involved in research and development of toner and toner binding with polyester resin.