

Positively Chargeable Full Color Toners Using Polyester Resin

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Abstract

Polyester resin is the most popular binder for full color toners, because of the excellent dispersibility of colorants, the higher fixing ability, durability and transparency on OHP film. However, it is not easy to use polyester resin as positively chargeable color toners, because polyester resin has carboxylic groups, which show itself negative charge polarity.

Polyester resin, which has lower acid value and styrene-acrylic resin would be useful for positive charged toners, but the dispersibility of colorants is not sufficient. That causes poor chroma in the print images.

In this paper, the positive charged full color toners, which have the excellent dispersibility of colorants and the good charge stabilization, are investigated. Binder formulation consisted of polyester resin and styrene-acrylic resin. Polyester resin had high acid value for the better dispersibility of colorants and styrene-acrylic resin had alkyl-amino groups for highly positive charge. It was found that the dispersibility and the charged level are controlled by changing the ratio of two kinds of resins.

Introduction

A positively charged organic photoconductor (OPC) has several advantages in comparison with a negative charging one. For example, a positively charged OPC generates less ozone than that of a negatively charged one in electrophotography system. A positive charged toner is necessary for using a positively charged OPC in laser beam printers (LBP). Recently many color LBP are announced. But all of them are using a negatively charged OPC and negative charged toners. One of the reasons is that the polyester's negative polarity has made it difficult to apply to positive charged toner. And positively colorless Charge Control Agents (CCAs) are not so effective to improve charge level.

In this paper, the positively chargeable full color toners, which binder formulation consisted of polyester resin and styrene-acrylic resin with alkyl-amino groups, are investigated.

Experimental

Toner Samples

(a) Preparation of Polyester Resin

Bisphenol A propylene oxide adduct and fumaric acid were allowed to react for condensation polymerization at 230ºC with 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. The height of acid value was adjusted by changing ratio between acid and alcohol.

(b) Preparation of Styrene-acrylic Resin

Styrene, 2-ethylhexylacrylate and dimethylaminoethyl-methacrylate were copolymerized in xylene with dicumyl peroxide as a initiator at 130ºC, then up to 200ºC followed by removal of xylene. The structural formula of dimethylaminoethylmethacrylate in shown in Fig. 1.

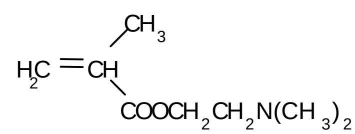


Figure 1. The structural formula of dimethylaminoethylmeth-acrylate.

The properties of experimental resins are listed in Table 1 and Table 2.

Table 1. Properties of Experimental Polyester Resin

Sample	Acid Value[1)] (KOHmg/g)	T1/2[2)] (ºC)	Tg[3)] (ºC)
PEs-1	5	101	63
PEs-2	20	100	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 10ºC/min.

Table 2. Properties of Experimental Styrene-Acrylic Resin

Sample	N value[4] (mol%)	T1/2[2] (ºC)	Tg[3] (ºC)
SA-1	0	104	57
SA-2	2	103	59
SA-3	4	102	58

4) [N value] = the mol number of an acrylic monomer with alkyl-amino group / total mol number of monomers x 100

The toner used in this experiment is; base material: resin, pigment: β type copper phthalocyanine, sub CCA: quarternary ammonium CCA, particle size : around 10 µm (Volume diameter: 50%), surface additives: silica size (diameter: 10-15nm), manufacturing method: crushing.

The toner names and its resin compositions are listed in Table 3.

Table 3. Formulation of Toner Samples

Toner Name	PEs-1 (parts)	PEs-2 (parts)	SA-1 (parts)	SA-2 (parts)	SA-3 (parts)	feed rate (kg/hr)
Toner 1			100			10
Toner 2				100		10
Toner 3	100					10
Toner 4		100				10
Toner 5		90	10			10
Toner 6		90		10		10
Toner 7		90			10	10
Toner 8	90			10		10
Toner 9		80		20		7
Toner10		70		30		10
Toner11		60		40		10
Toner12		70		30		7

Measurement of Tribo-Charging Characteristics

The toner charging properties were investigated by using ball mill. The rotation speed is 250 rpm. Mixing ratio is: carrier 19g and toner 1g. Charge amount of toner is measured by blow off method.

Measurement of Transparency of Images

A developer was prepared by blending 5parts of the toner and 95 parts of Iron powder coated with fluorine resin. Each of the developers prepared as described above was loaded on a commercially available, two component, full color copier to get unfused images on transparency sheet. An independent fusing device; process speed: 100mm/sec, heat roller temperature: 180ºC. The diameter of heat roller covered with silicone rubber was 40mm. Nip width and nip pressure was 5mm and 2.0kg/cm. Transparency of the images on transparency was measured with Color Measuring •80 manufactured by NIPPON DENSHOKU KOGYO CO., LTD.

Results and Discussions

Effect of Resin

The dependencies of q/m (toner charge amount /toner mass [coulomb/g]) on mixing time are shown in Fig. 2. The charge amount of toner using polyester resin is lower than that of toner using styrene-acrylic resin. This is due to carboxyl group, which shows itself negative charge.

Toner 2 using styrene-acrylic resin with alkyl-amino group shows a very high charge level. Alkyl-amino group is very effective for improvement of positive charge level.

The results of transparency are listed in Table 4. Toner 3 and Toner 4 showed higher transparency than Toner 1 and Toner 2. This is caused by good dispersion of pigment.

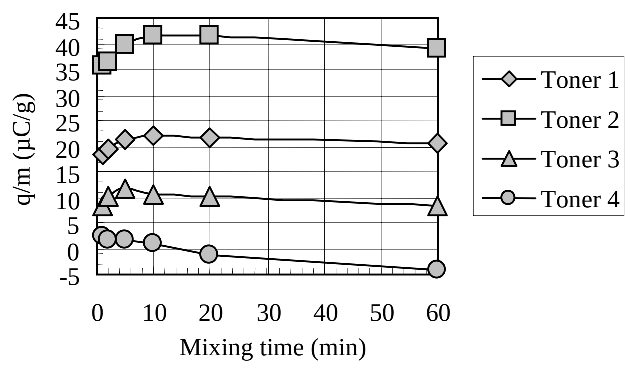


Figure 2. Dependencies of q/m on mixing time.

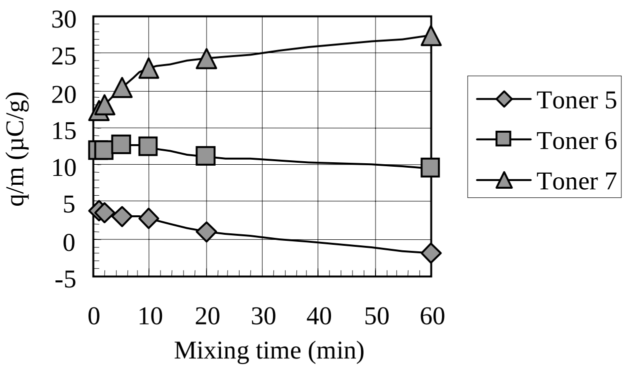
Table 4. Transparency of toner

Toner Name	Transparency (%)
Toner 1	53
Toner 2	57
Toner 3	77
Toner 4	85

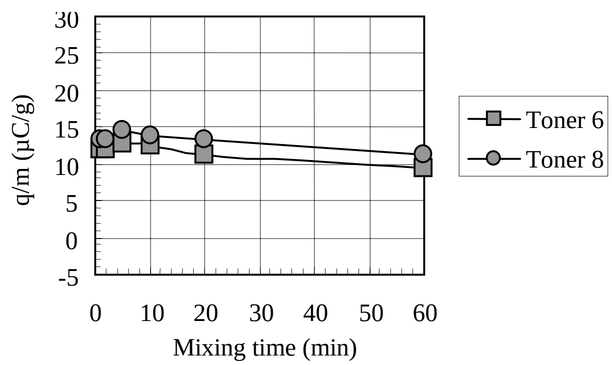
Effect of Blending Styrene-Acrylic Resin with Polyester Resin

The dependencies of q/m on mixing time are shown in Fig. 3(a) and Fig. 3(b). Fig 3(a) shows that this styrene-acrylic resin is useful for CCA.

The charge amount of Toner 8 using low acid value polyester is heigher than that of Toner 6 using high acid value polyester. But the influence of acid value on chargeablity becomes smaller. The low influence of acid value is thought to be due to the appearance of styrene-acrylic domain on the surface of toner at pulverizing process.



(a) Toner 5, Toner 7 and Toner 8



(b) Toner 6 and Toner 8

Figure 3. Dependencies of q/m on mixing time.

Effect of Blending Ratio Styrene-Acrylic Resin and Polyester Resin

The dependencies of q/m on mixing time are shown in Fig. 4. The q/m level increases with the amount styrene-acrylic resin SA-2. On the other hand, the transparency of these toners decrease with the blend ratio of SA-2, as shown in Table 6. That is caused that styrene-acrylic resin is insoluble with polyester resin and the light reflections occur at the interface between polyester domain and styrene-acrylic domain.

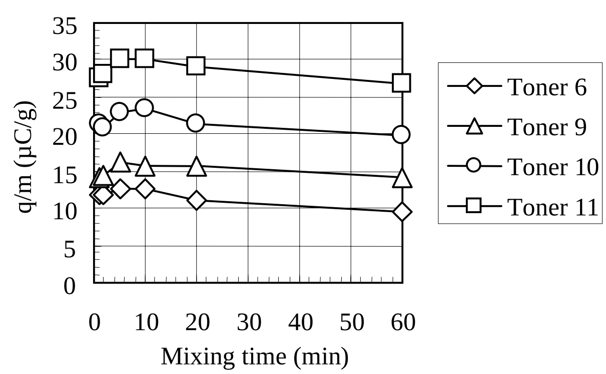


Figure 4. Dependencies of q/m on mixing time.

Effect of Kneading Condition

The dependencies of q/m on mixing time are shown in Fig. 5. The charge amount of Toner 12 is more stable than Toner 10. The results of transparency are listed in Table 7. The transparency of toner increases with decreasing feed rate. That is caused that styrene-acrylic domain .became smaller by decreasing feed rate.

Table 6. Transparency of Toner

Toner Name	Transparency (%)
Toner 6	82
Toner 9	78
Toner 10	70
Toner 11	65

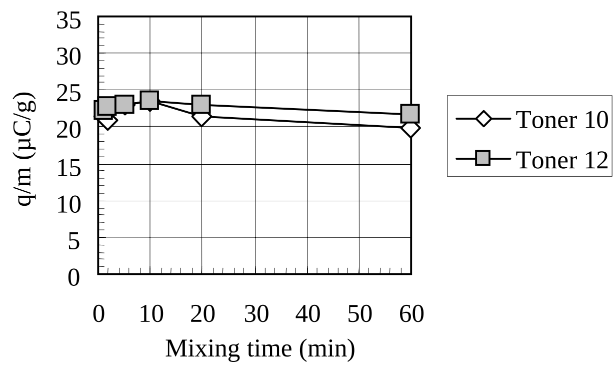


Figure 5. Dependencies of q/m on mixing time.

Table 7. Transparency of Toner

Toner Name	Transparency (%)
Toner 10	70
Toner 12	78

Conclusion

The conclusion of this study on positively chargeable full color toner can be summarized as follows.

1. Polyester resin having high acid value shows good dispersion quality and high transparency.
2. By blending styrene-acrylic resin with alkyl-amino groups, the charge level of polyester toner is improved.
3. The dispersion quality of styrene-acrylic resin is improved by kneading condition and it causes toner transparency to increase.

Biography

Yutaka Kanamaru studied organic chemistry at Osaka City University for 6 years from 1979 to 1985. Since 1985, he has been working at Kao Corporation in the Wakayama Research Laboratories. He has been involved in Research and Development of Toner and Toner Binder with Polyester resin, including full color toners.