The Pulverized Full-color Toner with High Performances

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Abstract

The full color printer has been widely used in the office and the demand on the full color printer has been also increasing. Especially the high-speed printing and the oilless fusing are strongly requested. However it is difficult for the full color printer to achieve the oil-less fusing because of the higher pile height of the developed toner and the lower viscosity of the melted toner.

In this report the design of the oil less color toner on nonmagnetic single component development was investigated. It is necessary to add a large amount of wax with low melting point and to control the dispersion of wax for oil-less fusing. Especially, it is very important to keep the dispersion of the wax extremely small on nonmagnetic single-component development. The durability of the toner with large dispersion of wax becomes worse, because the toner is crashed at the interface between the wax and the resin. And it is suitable to use open-roll type kneading machine to have good dispersibility of the wax.

Introduction

In recent years, as color printers have become to be widely used, the requirements of the improvement for the color printer have been also increasing, for instance, low cost, high image quality, high speed, and so on. To achieve these requirements, various functions are required for the toner.

To meet the demands, several chemical toners are developed and launched. It is said that the chemical toner is much better than the pulverized toner in various points of the performance.[1,2]

1. Small and Narrow Size Distribution

To obtain high image quality, the toner with small and narrow size distribution is necessary. It is not necessary to classify in case of producing and using chemical toner has an advantage over small and narrow size distribution, because the chemical toner is directly polymerized.

2. Capability of Shape Control

It is said that spherical toner is profitable to achieve high transfer efficiency because such toner comes in contact with photoconductor by a point area and it is easy to remove from that. The chemical toner is generally spherical, and it is possible to control the shape on the grounds of producing methods.

3. Oil-Less Fusing

Generally, the resin of color toner has low and narrow molecular weight distribution, and such resin cannot give the wide non-offset range in fusing. Therefore, many color toners contain much wax. The chemical toner can include a large quantity of wax, because the toner can include wax inside and the wax does not exist on the toner surface.

The chemical toner has some merit described above, but the pulverized toner is also improved and has become to have good performances.

It was reported that it is possible to generate small toner particles at high yields by investigating better rotor and new nozzle design.[3] We also improved the pulverizing process of the toner and could produce the pulverizing toner with small and narrow size distribution similar to the chemical toner (Fig. 1).

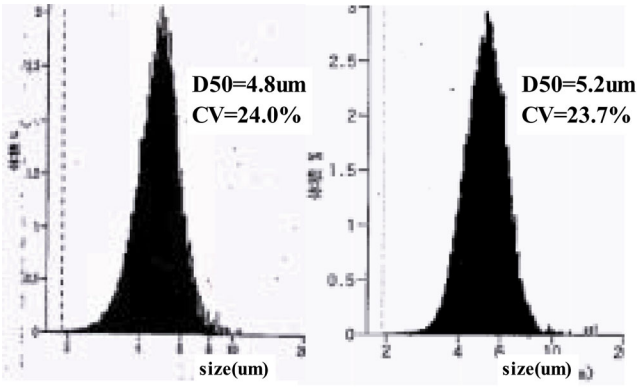

Figure 1. The size distribution of the improved pulverized toner compared to typical chemical toner.

Furthermore, it is possible to get high transfer efficiency by using the spherically shaped pulverizing toner. Recently many technologies of that were unveiled.

As above, oil-less fusing is possible by using the chemical toner. But the resin of the chemical toner mostly consists of styrene-acrylic. Accordingly, the chroma of the color image is not so good because of the worse

dispersibility of the pigments. And as the durability of the styrene-acrylic resin is bad, that of the toner becomes bad. Accordingly, the molecular weight tends to be high and broad, and as a result, the gloss of the image becomes low. Especially, it is not possible to use on single component developing system, because especially high durability is required on that system. Generally, the durability of the polyester resin and the pigment dispersibility are good compared to styrene-acrylic resin. Consequently, the technology of oil-less fusing by using pulverized polyester color toner is needed.

The fusing property of the polyester toner with several kinds of molecular weight distributions is shown in Fig. 2. This indicates that basically oil-less fusing can be achieved by using the resin with high and wide molecular weight distribution. But the gloss of the image becomes low, and the color tends to be bad.[4] Accordingly, the technology of oil-less fusing on the polyester resin with low molecular weight is necessary for high image quality.

We have already reported the relationship between fusing ability and durability, and a kind of wax and the dispersed size of that for polyester color toner on single component development system.[5]

In this report, the actual product design of oil-less color toner on single component development system is investigated.

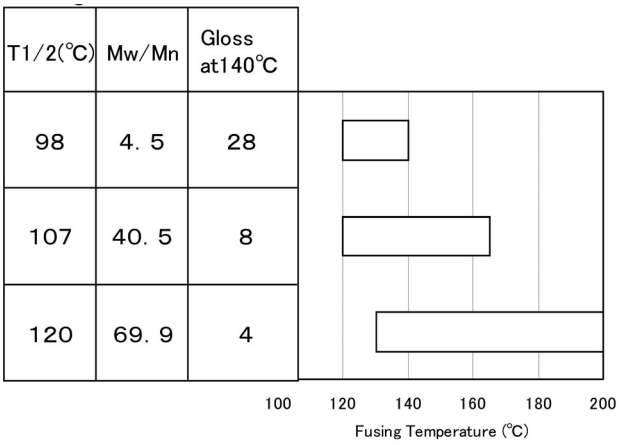

Figure 2. The dependency of the fusing latitude and the gloss of the image on the molecular weight distribution.

Experimental

Preparation of Polyester Resin

Bisphenol A propylene oxide adducts, ethylene oxide adducts, Terephthalic acid, C_{12}-Succinic anhydride, and Trimellitic anhydride were allowed to react for condensation polymerization at 230°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

Resin	Acid Value[1] (mg KOH/g)	T1/2[2] (°C)	Tg[3] (°C)
Polyester	20	115	63

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/min.

Preparation of Toner Samples

Toner samples were comprised of this resin, the wax, the charge control agent and the colorant. The colorant was Carmine 6B (Pigment Red 57:1) and the melting point of the wax was 80°C.

The materials were premixed in a batch mixer; then they were kneaded, pulverized and classified. And then, samples with average size of 8.5μm were obtained. We used two types of kneading machines, twin extruder and open-roll type kneader. Each toner was blended with fumed silica to get efficient flow ability and charging ability for the test operation.

The toner samples are listed in Table 2.

Table 2. Toner Samples

Amount of Wax / Kneader	3%	5%	7%
Twin Extruder	Toner A-1	Toner A-2	Toner A-3
Open-roll Type	Toner B-1	Toner B-2	Toner B-3

Measurement of the Fusing Ability

The fusing ability was tested by using a off-line fuser. (Heat roller: silicone / Pressure roller: silicone) The silicone oil was removed completely. The diameter of the heat roller was 35mm.

At first, each toner sample was developed and transferred on the paper (LX paper; Xerox Corporation) so that the mass per area was 1.8 mg/cm^2 (It is equivalent to 3 layers of toner.). Then the paper was passed through the fuser. The line speed was 100mm/sec.

The upper limit of the fusing temperature was defined as the upper limit temperature that the hot-offset was not observed.

And the lower limit of the fusing temperature was also defined as the lower limit temperature that the cold-offset was not observed.

The range from lower limit of the fusing temperature to upper limit was defined as the fusing latitude of the each toner sample.

Measurement of the Durability

The durability was tested by using a toner cartridge of color laser printer of which developing system was single

component. The toner was put into the cartridge and the developer roll was rotated at 60r/min without developing the toner to OPC. The durability was defined as the time when the filming of the toner to the doctor blade occurred and the streak appeared at the toner layer on the developer roller.

Measurement of the Wax Dispersibility

The dispersed size of the wax was observed by TEM photograph.

Results and Discussion

The Dependency of the Fusing Ability and the Durability of the Toner Produced by Twin Extruder on the Amount of Wax

The fusing latitude of the Toner A-1, A-2, and A-3, which were kneaded by conventional twin extruder, is shown in Fig. 3. This figure indicates that the fusing latitude expands with an increasing in the amount of wax. The toner of which wax content is 5% has enough wide offset range.

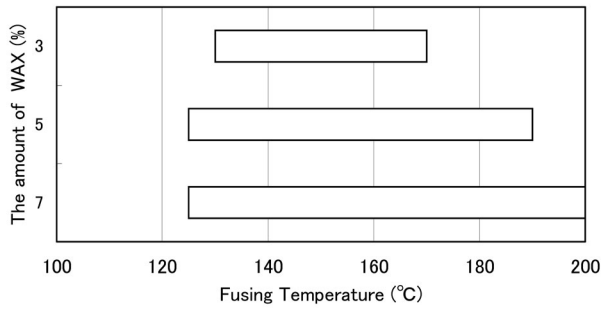

Figure 3. The dependency of the fusing latitude on the content of WAX (The investigation on the toner produced by twin extruder)

The dependency of the durability of these toners on the amount of wax is shown in Fig. 4. This figure indicates that the durability of the toner goes down with an increasing in the amount of wax. Especially, the durability of the toner with over 5% content of the wax becomes extremely worse and the toner can not be used on single component development system.

To investigate the decline of the durability, we measured the dispersed size of the wax. Figure 5 shows the TEM photographs of these toners. These photographs indicate that the dispersed size becomes larger with an increasing of the amount of wax. The toner is easy to be crushed at the interface between the resin and the wax on single component development system. Therefore, the increase of a large size wax causes the decline of the durability.

Then we investigated kneading conditions on twin extruder. But both the dispersibility of the wax and the durability of the toner did not change. It is conjectured that the temperature of the kneaded toner in twin extruder is high and the difference of viscosity between the resin and the wax is very large.

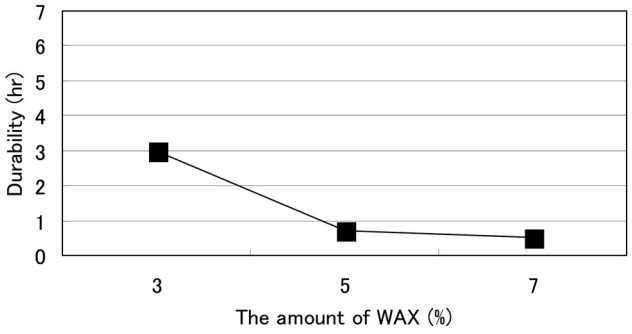

Figure 4. The dependency of the durability on the content of WAX (The investigation on the toner produced by twin extruder).

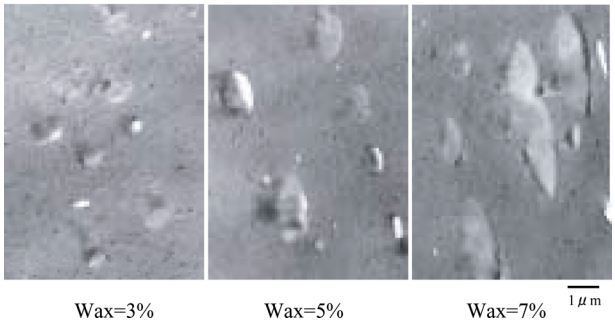

Figure 5. The TEM investigation of the toner containing different content of WAX (Twin Extruder)

The Dependency of the Fusing Ability and the Durability of the Toner Produced by Open-Roll Type Kneader on the Amount of Wax

As above, to produce the toner with good durability, high dispersibility of the wax is needed. To disperse wax highly, it is required to keep the temperature of the kneaded toner low. Then we investigated another kneading machine.

Figure 6 shows the kneading machine "Open-roll Type Kneader" we used. This type of kneader is suitable for kneading the resin and the low melt wax, because the toner can be kneaded with low temperature.

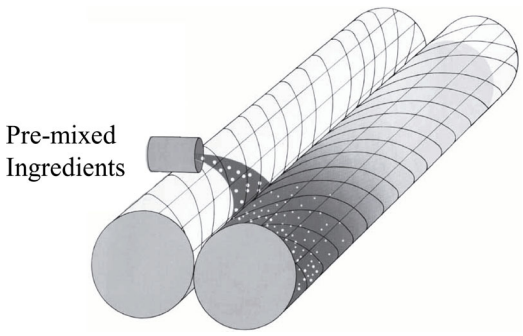

Figure 6. Open-roll Type Kneader

The TEM photographs of the Toner B-1, B-2, and B-3, which were kneaded by Open-roll Type kneader, are shown in Fig. 7. These photographs indicate that the dispersed size of the wax becomes still larger with an increasing of the amount of wax, but the dispersed size is much smaller than that of toner kneaded by twin extruder.

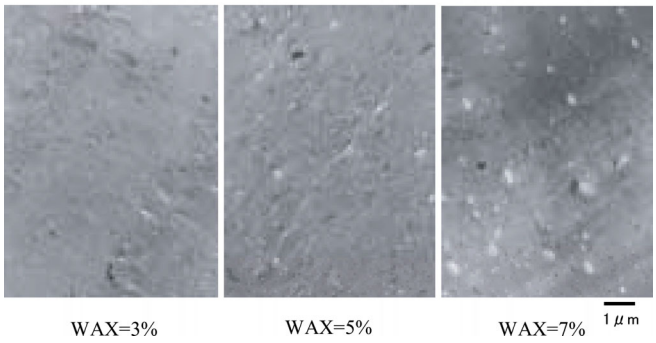

Figure 7. The TEM investigation of the toner containing different content of WAX (Open-roll Type Kneader)

The fusing latitude of these toners is shown in Fig. 8. This data indicates that the fusing latitude of the toner is narrower than that of toner with the same wax content kneaded by twin extruder, because the dispersed size is smaller. But the fusing latitude expands with an increasing in the amount of wax and the toner with more than 5% of the wax have good offset ability.

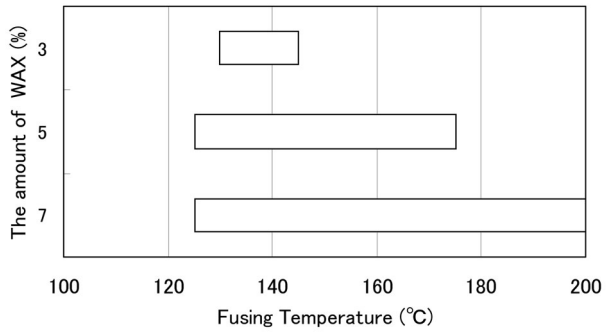

Figure 8. The dependency of the fusing latitude on the content of WAX (the investigation on the toner produced by Open-roll Type Kneader)

The dependency of the durability of these toners on the amount of wax is shown in Fig. 9. This figure indicates that the durability of the toner goes down with an increasing in the amount of wax, but the durability is much better compared with the toner kneaded by twin extruder. Even the toner with the wax content of 5% has enough durability for use.

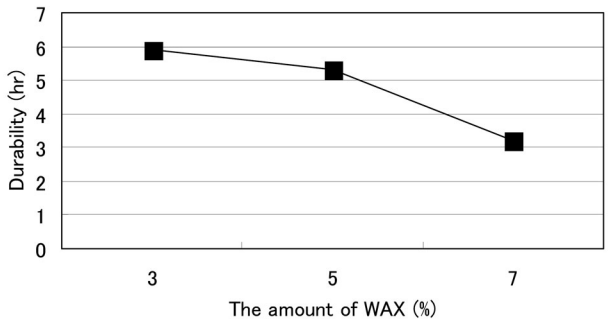

Figure 9. The dependency of the durability on the content of WAX (The investigation on the toner produced by Openroll Type Kneader)

Conclusion

The design of the pulverized oil-less toner on single component development can be summarized as follows.
(1) The dispersed size of the wax has relation to the offset ability and durability of the toner. The durability of the toner with large dispersed size of the wax becomes bad because the toner is crashed at the interface between the resin and the wax.
(2) The low melt wax is effective to expand the fusing latitude for oil-less fusing. But the dispersed size of the wax of the toner kneaded by twin extruder is very large, and it is very difficult to control the dispersed size.
(3) The open-roll type kneader is suitable for high dispersibility of the wax, because the temperature of kneading toner is very low. It is possible to achieve both the offset ability and durability of the toner.

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Biography

Jun Shimizu 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 binder with polyester Resin. His current research interest is full color toner for desktop printers. E-mail: shimizu.jun@kao.co.jp