Development of a New Polyester-Based Polymerization Toner

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Abstract

Synthesized superior toner with intension of protection of environment is developed aiming energy saving and environment lord decreasing. The new polymerization toner is synthesized with new manufacturing method that utilized ester elongate reaction of a pre-polymer. The new polymerization toner is superior to usual polymerization toners in low temperature fixing. It consists of polyester resins, while usual toners consist of styrene-acrylic copolymers. The futures of new polymerization toner are as follows;

(1) Energy saving by low temperature fixing with polyester resins.
(2) High image quality and reduction of 40% in toner consumption (the antecedent machine ratio) by super fine toner.
(3) Superior characteristics in toner cleaning process.
(4) Reduction of 35% in environmental load (as CO_2 discharge).

1. Introduction

Copiers of electrophotographic system are digitized and made to change into multifunctional printers in recent years, and a demand to high image quality is increasing more than the past. Thus the toner of smaller particle size is required to make reproducibility of image pixel higher. In addtion, we are dealing with not only saving energy in operation, but also reduction of the environmental impact in production.

The conventional toner is manufactured by heat of the materials and melt blending, pulverizing it in the air. When the toner is controlled in small particle size by using of the conventional method, its direct cost and environment impact in production increase because the productivity lowers. Then, in the case of the conventional method, colorant and wax of toner materials are easily exposed on the surface of toner, so that it will cause such problems as toner filming, poor charging.

The polymerization toner is easily controlled in small particle size and sharp particle size distribution compared with the conventional pulverized toner. Moreover, it will be able to control the structure of toner particle with colorant and wax. Thus, the polymerization toner attracts attention.

We have developed a new polyester-based polymerization toner and acquired various performances not given in the conventional pulverizing methods. This talk is about the technology of our polyester-based polymerization toner, named ‘PxP toner’.

2. Technology

2.1 The Characteristics and the Manufacturing Method of PxP Toner

Ricoh PxP toner utilizes the ester elongation polymerization, so that is manufactured with wet process, similar to suspension polymerization method and dissolution suspension method.[1,2] It is possible to control in small particle size and sharp particle size distribution easily. Pulverizing process using a large quantity of electric power becomes unnecessary fundamentally.

As shown in Figure 1, structure control containing colorant and wax is possible. Thus, we intended to design the particle structure of PxP toner, that the high molecular weight polyester resin, contributing to hot-offset and heat-resistance, seems to cover the low molecular weight polyester resin to be influenced for low temperature fixing, by controlling materials and manufacturing process conditions. The structure of PxP toner brought about high heat-resistant and low temperature fixing simultaneously.

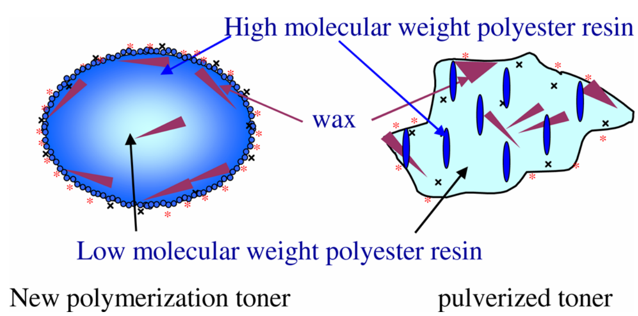


Figure 1. Illustration of PxP toner and the pulverized toner.

As other characteristic, there are small particle size and sharp particle size distribution, the toner shape which makes blade-cleaning possible in Ricoh PxP toner.

The production of PxP toner consists of six processes as follows.

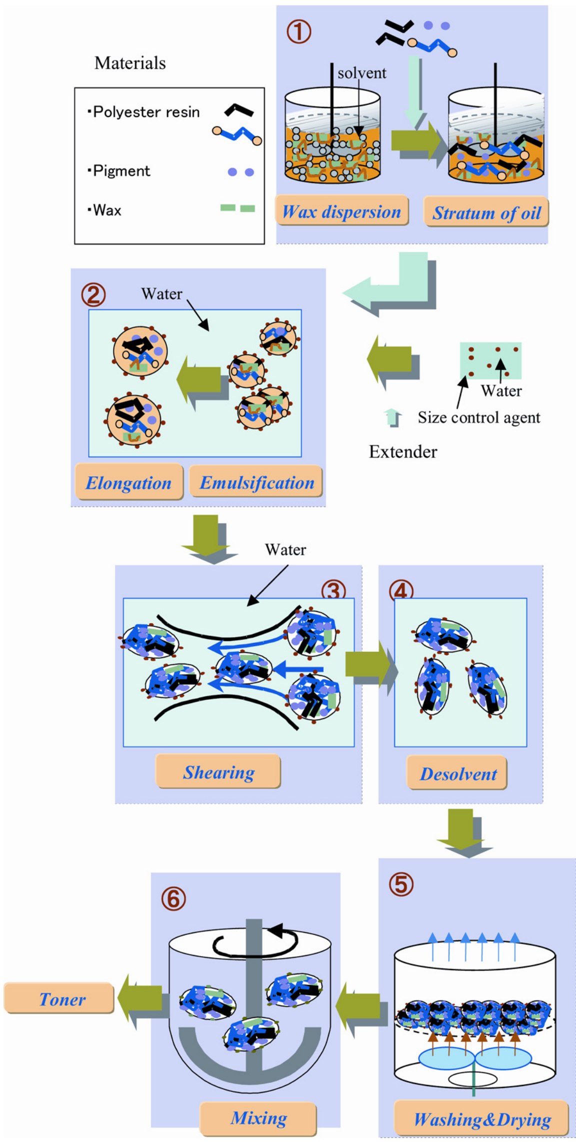


Figure 2. Production scheme of Ricoh PxP toner.

(1) Preparing Oil Phase and Water Phase

Wax dispersion in organic solvent is prepared and is mixed with the materials solution including polyester resin, pre-polymer and pigment, and becomes oil phase. While water phase is produced by mixing size control agent and surface active agent in water.

(2) Emulsification and Elongation

The oil phase and the water phase are stirred with homo mixers and are emulsified. After emulsified, oil droplets including wax, polyester resin, pre-polymer, pigment and so on in the water phase are formed. The oil droplets converge simultaneously while doing ester elongation polymerization reaction, and are coalesced to sharp particle size distribution. The high molecular weight layer is formed in the surface layer of the toner oil droplet by the ester elongation reaction in this process at the same time.

(3) Shearing and Transforming

The toner oil droplets are transformed from spherical shape to spindle shape that makes blade-cleaning possible by adding shear and adjusting the viscosity of the slurry solution, so as not to become fine.

(4) Removal Solvent (Desolvent)

Solvent in the oil droplets is removed from the slurry solution, and toner particles of solid condition are obtained from them.

(5) Washing and Drying

The impurity on the surface of toner particles is washed away with water. After that, the surface and internal moisture is evaporated, and it is turned into dry powder.

(6) Mixing

The toner particles are mixed with external additives, and product toner is provided.

2.2 Development of New Polymerization Toner

2.2.1 Low Temperature Fixing

We developed the Quick Start Up technology named QSU (Quick Start Up) technology in order to achieve the ZESM (Zero Energy Standby Mode) specification.[3,4] QSU technology is one of Ricoh's original energy saving technologies that achieves a shorter warm-up time and recovery time to make the device both energy saving and user friendly.

It is necessary to lower toner temperature fixing for this saving energy technology. Low temperature fixing of toner is achieved by using of the resin of low molecular weight, but it may make hot-offset, heat-resistance, and blocking in development unit of toner worse. In development of PxP toner, we set molecular weight of low molecular weight polyester resin in the range that meets the target of fixing lower limit temperature to lose were provided, as shown in Figure 3. Furthermore we controlled toner viscoelasticity by the ester elongation polymerization and improved hot offset, so that we got wider fixing latitude while the toner is used, as shown in Figure 4.

Furthermore we made wax disperse near the toner surface, so as to ooze out easily, and we got enough offset. Figure 5 shows what the wax dispersion of PxP toner actually looks like. The black division shown lamellar structure in this TEM section image is wax, shown in red arrows.

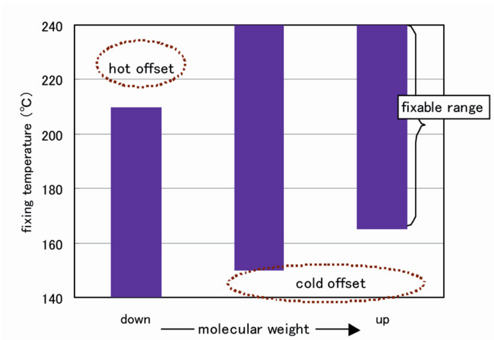


Figure 3. Relationship between fixing temperature and molecular weight of polyester resin.

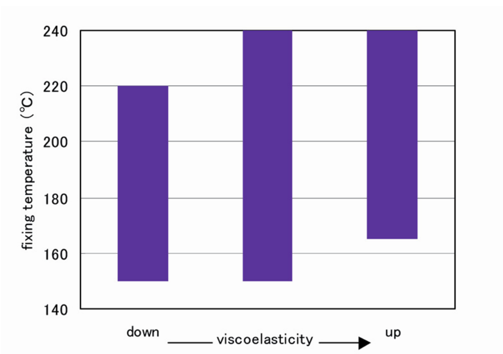


Figure 4. The relationship between fixing temperature and viscoelasticity.

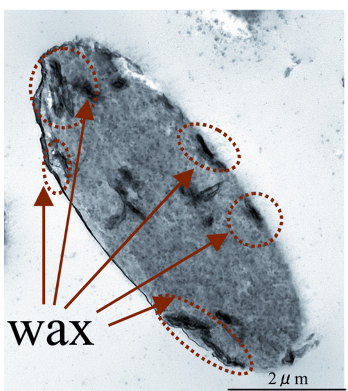
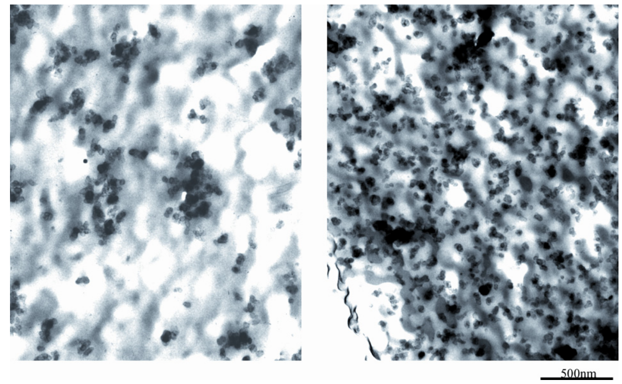


Figure 5. TEM image of new polymerization toner.

2.2.2 Carbon Black Dispersion

Figure 6 shows TEM images of the incomplete dispersion toner and the complete dispersion toner. Carbon black is used for colorant of monochromatic toner, but shown on your left in Figure 6, it is easy to aggregate and causes the incomplete dispersion because the primary particle size of that is very small. The incomplete dispersion of carbon black causes not only poor image density but also variant toner electric resistance, poor transfer, and poor charging. As a result, Pollution in a machine happens by toner scattering. We controlled the carbon black dispersion by using polarity control or dispersing agent of carbon black.



Incomplete dispersion *Complete dispersion*

Figure 6. TEM image of toners.

2.2.3 Particle Size Distribution

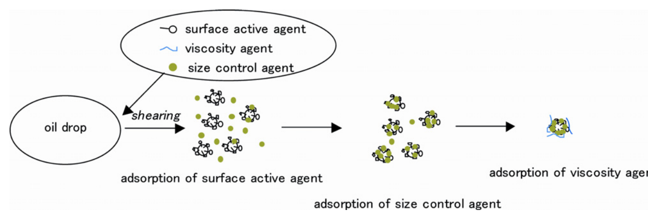


Figure 7. Process of emulsification

In the emulsification and converging process, absorption of size control agent to oil droplet happens with coalescense of oil droplets including polyester resin, pre-polymer and pigment simultaneously, as shown in Figure 7. The absorption of size control agent to oil droplets prevents oil droplets from excessive coalescense. We controlled the rate of absorption and coalescense, respectively, and the aiming toner size was obtained.

Figure 8 shows change of particle size distribution before and after converging. Particle size is small and particle size distribution is broad in emulsification, but that is sharp after converging.

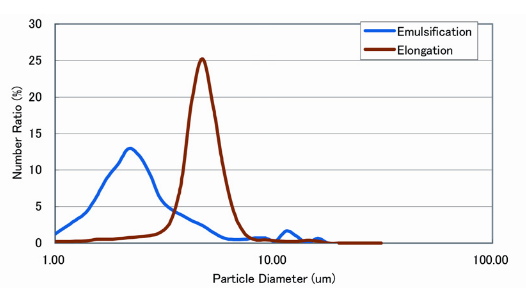


Figure 8. Change of particle size distribution.

2.2.4 Shape Control

Toner shape influences blade-cleaning performance and transfer efficiency. As shown in Figure 9, the rounder toner tends to increase transfer efficiency, but to decrease the blade-cleaning performance because of not being caught on a blade and going through the blade. Toner shape is related with system design in chemical toner closely. Non-spherical shape but spindle shape was demanded to be equivalent to the blade-cleaning system. So we built up transforming process afresh and adjusted the toner shape by controlling viscosity and shear stress to give. As a result, the spindle shape toner and high blade-cleaning performance are obtained.

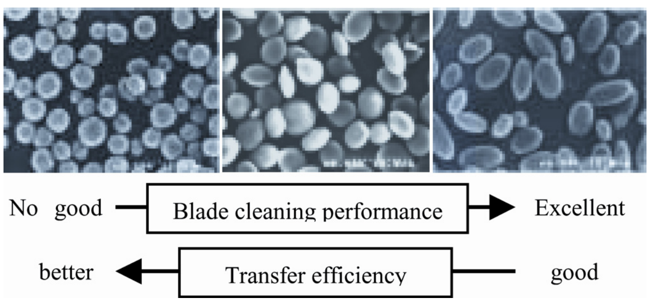


Figure 9. Shape control of new polymerization toner.

3. Results

3.1 Performance of Low Temperature Fixing

The fixing temperature of PxP toner is 10 degrees lower than other polymerization toners and PxP toner achieves hot offset-resistant as good as conventional toner. If fixing temperature falls 10 degrees, about 80W of saving energy effect is provided.

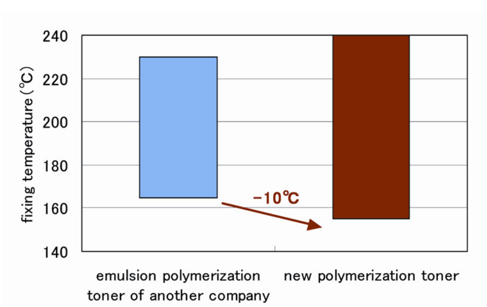


Figure 10. Fusibility of emulsion polymerization toner of another company and new polymerization toner.

3.2 Achievement of High Image Quality by Small Particle Size

Figure 11 is a reproducibility of letter and dot of the PxP toner compared with the conventional pulverization toner.

The PxP toner can be controlled in smaller than the conventional pulverization toner and sharp particle size distribution as shown Figure 12. Thus the PxP toner is less toner spattering of non-image area and reproduces the images very well. Furthermore PxP toner can reduce about 40% toner consumption to get enough image density, comparing with the conventional larger pulverization toner, because of the small and sharp particle size distribution as shown in Figure13.

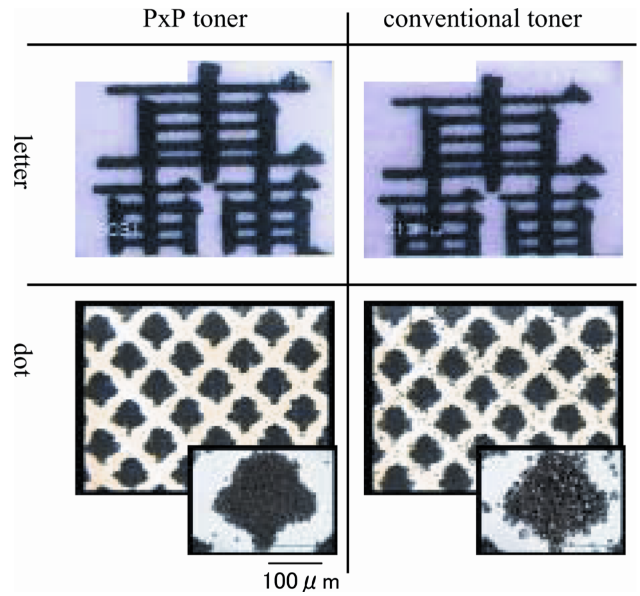


Figure 11.Reproducibility of PxP toner and the conventional toner.

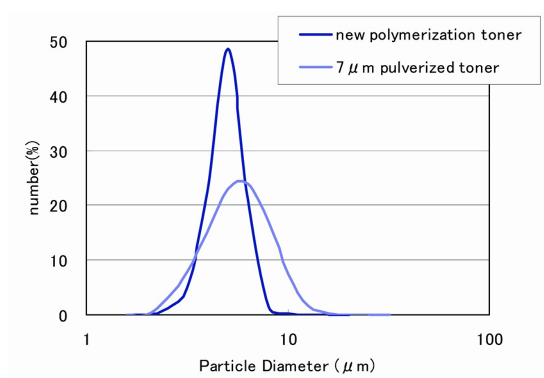


Figure 12. Particle size distribution of PxP toner.

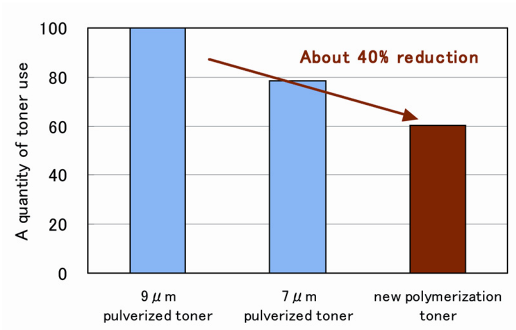


Figure 13. Comparison about toner consumption.

3.3 Realization of Blade-Cleaning System by Toner Shape Control

The new shape, spindle shape of PxP toner made blade cleaning possible. And the PxP toner collected by cleaning is recycled in a machine and cannot produce disposal toner at all.

3.4 Reduction of Environmental Impact

PxP toner was able to reduce about 35% CO2 output cutbacks comparing with the conventional pulverization toner when they produced equivalence particle size, 6 microns as shown in Figure 14.

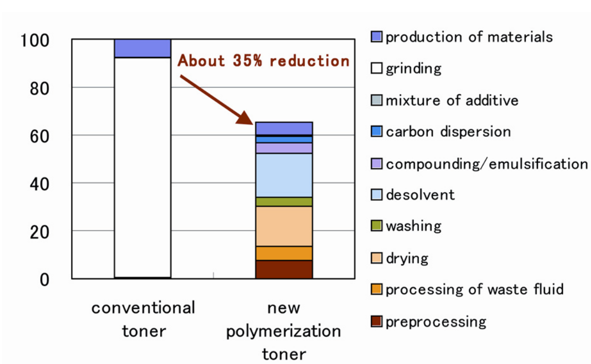


Figure 14. Comparison with conventional toner and new polymerization toner about environment load.

4. Conclusion

Ricoh PxP toner has many merits, for example, low temperature fixing, oil-less fixing, high blade-cleaning performance, recycling in a machine, high image quality, and reduction of environmental impact. We will need to advance technology in the development of color toner. And higher image quality, higher reliability, more reduction of the environmental impact will be important points in future.

Reference

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Biography

As Manager for Ricoh Company, Ltd., in Tokyo, Japan, **Toshiki Nanya** is responsible for designing toners and developers for new imaging system. Having graduated from Nagoya University with a bachelor of engineering degree in chemistry, he has been associated with toner design and evaluation over these last 24 years. He holds more than 80 Japanese, 10 US and 6 European patents and is a member of the Quality Engineering Society in Japan.