Development of the 2nd Generation Full-Color PxP Toner

Osamu Uchinokura, Masahide Yamada, Junichi Awamura, Akinori Saitoh, Naohito Shimota, Toshiki Nanya; Ricoh Company, Ltd.; Numazu-city, Japan

Abstract

The 2nd generation full-color PxP toner was developed by ester elongation polymerization method.

Owing to its smaller particle size and narrow particle size distribution, the newly developed 2nd generation full-color PxP toner brought about better image granularity than the 1st generation full color PxP toner.

Despite its small particle size, the 2nd generation full color PxP toner enabled the use of blade-cleaning system for high-speed copier by new particle shape control technology.

Furthermore, the small-sized 2nd generation full-color PxP toner provides excellent fixing performance at low temperature and heat resistance, because of using newly designed polyester resin with optimized molecular weight.

Introduction

Electrophotographic copiers and printers are making remarkable progress in recent years. Accordingly, digital, multifunctional, and full-color copiers and printers have been put into practical use in various fields in accordance with widespread use of network systems. Specifically, a demand for full-color high-quality images, as the same level as offset printing images, is increasing. To obtain high-definition and non-grainy images, it is effective to reduce the size of toner in electrophotography, so that a latent image is reliably reproduced with the toner. Figure 1 is a graph showing recent trend of toner size.

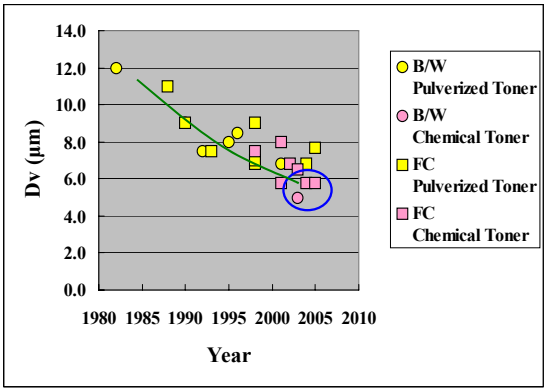

Figure 1. *Trend of Toner Size*

Toner having a particle diameter of 6 μm or less is in the market now. Toners are required to have various properties as described in Table 1.

Table 1. Requirement For Toner

High image quality	1.Small size and narrow particle size distribution 2.Uniform and stable chargeability 3.High transfer efficiency 4.Environmental stability
Reduction of environmental impact	1.Low temperature fixation 2.Reduction in CO_2 emission in production process 3.Reduction in toner consumption
Blade- cleaning performance	1.Prevention of toner passing through cleaning blade 2.Prevention of OPC surface contamination with toner

Toner manufacturing methods are broadly classified into dry pulverization methods and wet chemical methods. Most conventional toners are manufactured by the pulverization methods. However, it is difficult to manufacture smaller-sized toners by the pulverization methods because a greater amount of energy is required in pulverization process. On the other hand, the chemical methods, such as polymerization methods, are capable of manufacturing smaller-sized toner with a narrower particle size distribution easily. Accordingly, novel chemical methods have developed by various manufacturers in recent years.

In contrast to conventional chemical toners using styrene-acrylic resins as binder resin, Ricoh's PxP toner uses polyester resins, which express excellent fixing performance. The 2nd generation full-color PxP toner has developed to provide higher image quality and much excellent fixing performance. This report is a summary of the development of the 2nd generation full-color PxP toner.

Technology

Manufacturing Method of PxP Toner

In a conventional pulverization method, at first, toner components such as a binder resin, a colorant, a wax, etc., are melt-kneaded. The melt-kneaded mixture is rolled and cooled, and then subjected to pulverization and classification.

The PxP toner is manufactured using a method called "ester elongation polymerization method", including the following 6 processes illustrated in Figure 2. [1,2]

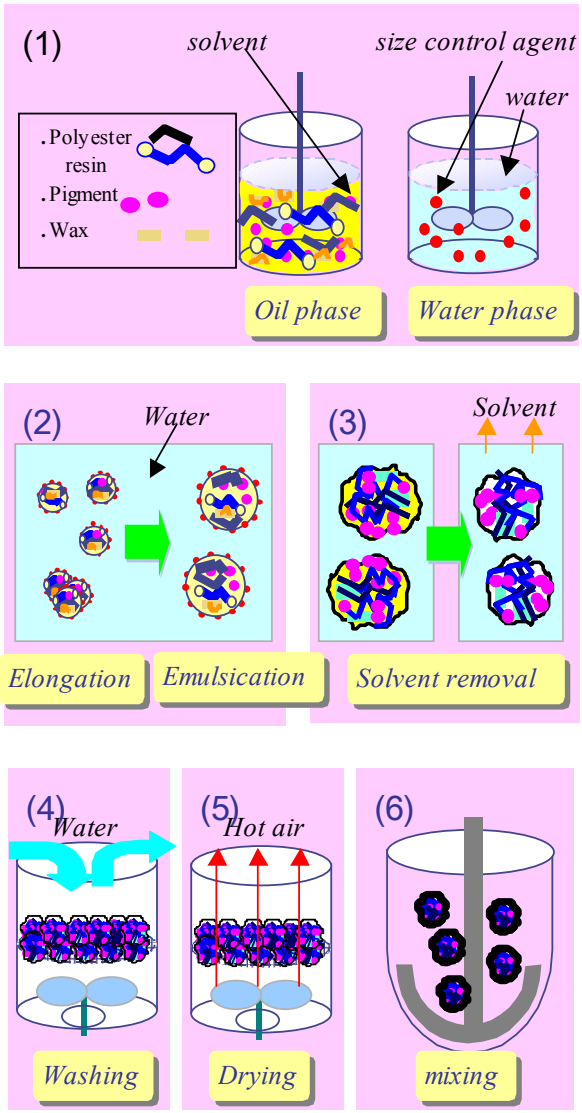

Figure 2. *Production Scheme of PxP Toner*

(1) Preparation of Oil Phase and Water Phase

To prepare an oil phase, toner components such as a polyester resin, a prepolymer, a wax, and a colorant are dispersed in an organic solvent. To prepare a water phase, a toner size control agent, a surfactant, and the like, are dispersed in pure water.

(2) Emulsification and Elongation

The oil phase is emulsified in the water phase so that oil droplets containing the toner components such as a polyester resin, a prepolymer, a wax, and a colorant are formed. The oil droplets are appropriately converged (united) so as to have a narrow particle diameter distribution, while a prepolymer is subjected to the ester elongation polymerization reaction to form high-molecular-weight components, simultaneously.

(3) Solvent Removal

The organic solvent remaining in the oil droplets is removed, so that toner particles are obtained.

(4) Washing

Impurities on the surfaces of the toner particles are washed away with water.

(5) Drying

Water is completely evaporated from the toner particles.

(6) External Addition (Mixing)

External additives are mixed with the dried toner particles. Thus, product toner particles are obtained.

Properties of the 2nd generation full-color PxP toner

Particle Size and Color Reproduction

As shown in Figure 3, the 2nd generation full-color PxP toner has a smaller particle size and a narrower particle size distribution compared to the 1st generation full-color PxP toner, thereby providing higher image quality.

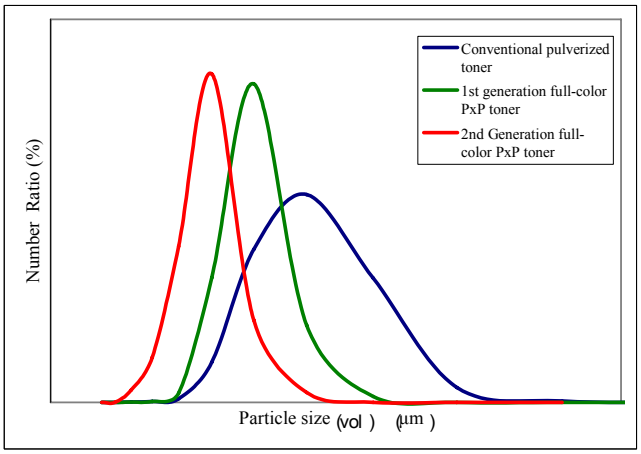

Figure 3. *Particle Size Distribution*

As shown in Figure 4, the 2nd generation full-color PxP toner much reliably reproduces a character (i.e., thin line image) and dots compared to a conventional toner. The 2nd generation full-color PxP toner particles hardly scatter over non-image portions because of having a smaller particle size and a narrower particle size distribution than the conventional toner.

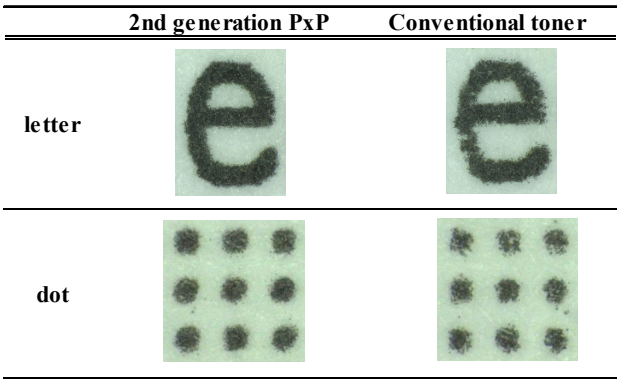

Figure 4. *Reproducibility of 2nd generation full-color PxP toner and Conventional Toner*

To enhance coloring power, dispersibility of colorants is improved in the 2nd generation full-color PxP toner. Accordingly, the 2nd generation full-color PxP toner provides a wider color reproduction area compared to the 1st generation full-color PxP toner, especially in magenta and green regions.

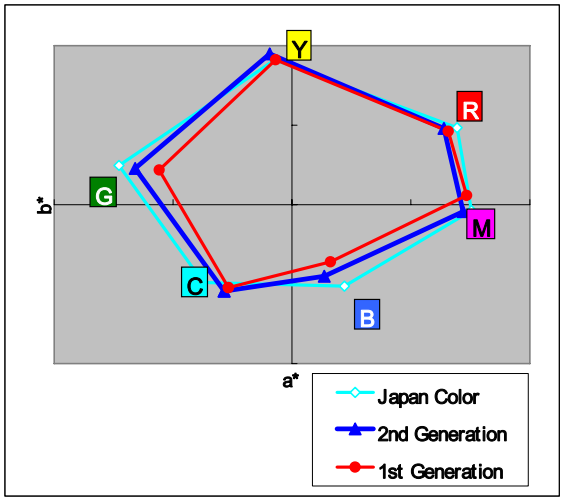

Figure 5. *Color Gamut of PxP Toner*

Shape Control of PxP toner

The shape of PxP toner is easily controllable. Therefore, PxP toners are applicable to various cleaning systems.

To correspond to a cleaning system using a blade (i.e., blade-cleaning system), the 1st generation full-color PxP toner has a shape, as shown in Figure 6-1, which is formed by rapidly removing organic solvents from oil droplets in the solvent removal process described above. There is a difference in contraction speed between the surface and inside of the oil droplets when the organic solvents are rapidly removed therefrom, thereby forming this shapes on the surfaces of the resultant toner particles. [3]

However, we found that smaller-sized particles with this shape are not reliably removed (cleaned) from a photo-conductor surface in a blade-cleaning system, particularly in high-speed copiers. Accordingly, the 2nd generation full-color PxP toner having a smaller particle size employs a new shape, as shown in Figure 6-2, which is reliably removed (cleaned) in a blade-cleaning system.

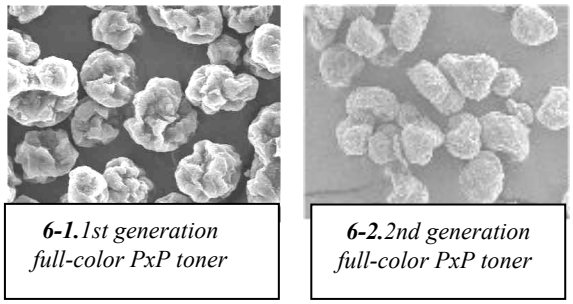

Figure 6-1. and 6-2. *SEM Images of 1st and 2nd generation full-color PxP toners*

In manufacture of the 2nd generation full-color PxP toner, a rheology control agent for controlling viscosity of oil phase is further added to the oil phase. Therefore, the oil phase expresses a thixotropic property, in which viscosity is kept at a certain high level even when shearing speed is small, as shown in Figure 7. [4]

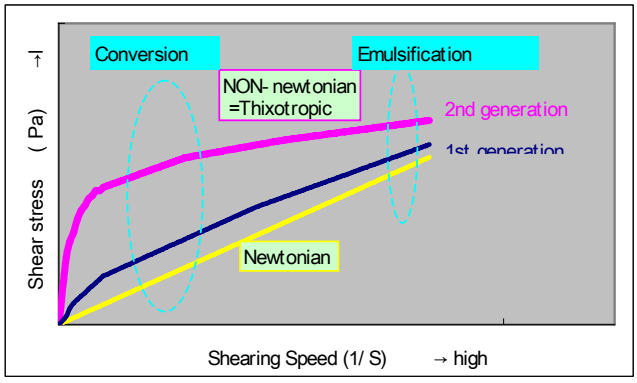

Figure 7. *Relation between Shear Stress and Shearing Speed*

Once the oil droplets with such a thixotropic property are deformed in the emulsification process, the deformed oil droplets hardly change their shapes in the succeeding processes. Accordingly, the 2nd generation full-color PxP toner with a new shape, which has a similar shape to conventional pulverization toners, is obtained.

The shape of PxP toner is further controllable by controlling thixotropic properties and solvent-removing time, as shown in

Figure 8. Therefore, as mentioned above, the 2nd generation full-color PxP toners are applicable to various cleaning systems.

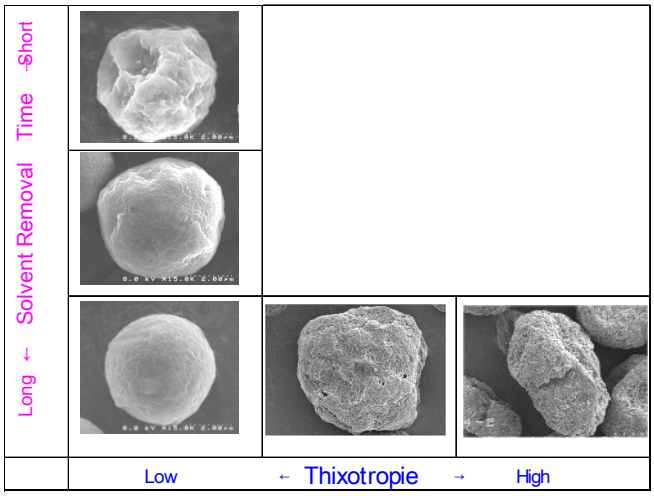

Figure 8. *Shape Control of Full-Color PxP Toner*

Fixing Performance at Low Temperatures

The PxP toner includes both a low-molecular-weight polyester resin and a high-molecular-weight polyester resin, which is formed by the ester elongation polymerization reaction of prepolymer, thereby providing a wide fixable temperature range. Polyester binder of the 2nd generation full-color PxP toner is further optimized so that the minimum fixable temperature is about 20°C lower than the 1st generation full-color PxP toner. Accordingly, warm-up time of a copier machine using the 2nd generation full-color PxP toner can be reduced to one-fifth of that of a conventional machine, resulting in energy saving.

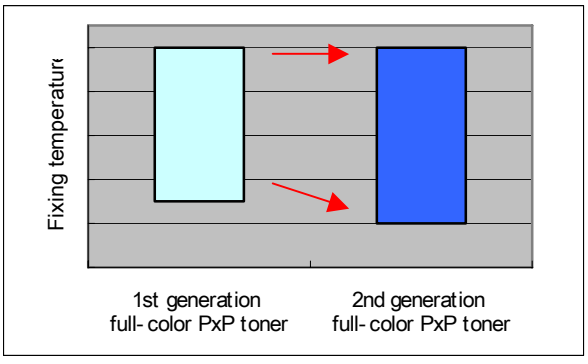

Figure 9. *Fixable Temperature Range of 1st and 2nd generation full-color PxP toners*

Conclusions and Futures

The 2nd generation full-color PxP toner provided high quality images and excellent fixing performance especially at low temperatures. We will need to advance technology in more toner requirement. Especially more reduction of the environmental impact will be important point in future.

Reference

[1] Toshiki Nanya et al, IS&T's NIP20 International Conference on Digital Printing Technologies, p143 (2004)

[2] Junichi Awamura, Powder Science & Engineering, Vol.39, No.12, (2007)

[3] Fumihiro Sasaki et al, IS&T's NIP21 International Conference on Digital Printing Technologies, p647 (2005)

[4] JP2006-293311

Biography

Osamu Uchinokura received his MS in chemistry from Tokyo University of Science in 1996. Since 1996, he joined Ricoh Company, Ltd. He is responsible for designing toners and developers for new imaging system. He holds more than 17 US, 12 Japanese and 3 European patents