Toner Characteristics and Xero Interactive Performance of EA Particles with Specific External Additives

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Abstract

Small particle size of silica and titanium oxide as external additives for toner have been used to control toner flow and charging characteristics.

Recently, in order to meet high priority requirements, such as better image quality and the highest possible reliability, color toner size is getting smaller, and is being covered with highly loaded additives. As the process speed increases, the developer including the toner and carrier, is required to exhibit corresponding developability, transfer, cleaning and fusing characteristics.

It is very difficult to maintain high transfer and cleaning performance of spherical toner with small external additives.

We developed EA (emulsion aggregation) color toner containing at least substantially spherical silica fine particles having a size of 100nm to 150nm and a narrow size distribution. This EA toner exhibits satisfactory fluidity, high transfer efficiency and cleanability while retaining environmental stability and durability. The developer does not cause any toner filming on the surface of a photoreceptor and or on the surface of a carrier.

Introduction

The purpose of this study is to understand how chemical toner can be applied to a conventional system such as development, blade cleaning and transferring.

Generally dry developer is required to satisfy various conditions in electrophotography, particularly in the development step, transferring step and cleaning step. To meet this requirement, the toner should have sufficient fluidity and the flow characteristics, electrical characteristics and transfer performance of the toner should not be changed with time or with change in environmental conditions such as temperature and humidity. Furthermore, a toner should take the form of an independent particle without agglomeration and the toner surface morphology should not be changed by aging stress throughout its life in the xerographic system.

The toner on the photoreceptor should be completely transferred to a transfer material, or if it remains, the residual toner should be completely removed from the photoreceptor by a cleaning step.

It is proposed to make the shape of the toner approaching a sphere shape to improve the flowability, the charging characteristics and the transferring property. However, the following problems occur when the toner shape is spherical.

(1) The flowability of the developer is increased, and at the same time, the tapped bulk density thereof is increased.

As a result transporting the amount of toner through the development zone becomes unstable - typically control the transport by controlling the distance between the mag roll and the mag brush layer controlling plate.

(2) The packing phenomenon due to tightness of developer including spherical toner causes a remarkable increase the stress applied to the toner.

As a result, the change of the micro structure of the surface of the toner, particularly burying and peeling of an external additive, readily occurs, and thus the developing property and the transferring property are greatly changed from those in the initial stage.

(3) The cleaning technology of spherical toner remains a major problem. The cause of this poor cleanability is believed to be that the spherical toner tends to roll between the cleaning blade and the photoreceptor and has some trouble in making the dam form before blade. As a result, a part of the toner passes through the cleaning blade and this causes poor cleaning.

The study has been undertaken to solve the problems associated with conventional techniques to use a spherical toner for developing, transferring and blade cleaning.

Experimental

(Samples)

Three kinds of toners with which shape differed were prepared as follows.

Toner A: Shape indicator ML.sup.2/A is about 145.
Resin, pigment and wax were kneaded in extruder, pulverized and classified to obtain toner A having an average particle size of 6.5.mu.m.

Toner B: Shape indicator ML.sup.2/A is about 131.
Sub-micron sized resin, pigment and wax were emulsified in ~~a~~ water, aggregated, grown and coalesced to obtain toner B having an average particle size of 5.8.mu.m.

Toner C: Shape indicator ML.sup.2/A is about 118.
Toner C was prepared in the same manner as for toner B.

The graph in Figure illustrates the shape distribution of the each toner (Figs. 1 and 2).

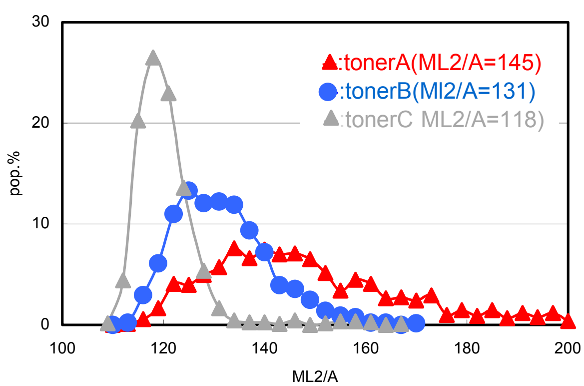

Figure 1. Shape (ML2/A) Distribution of toner

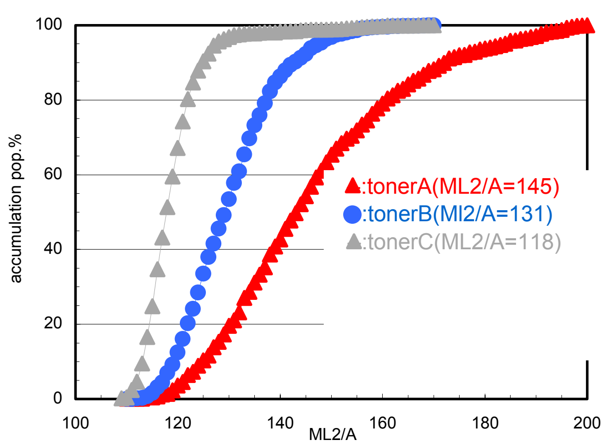

Figure 2. Shape (ML2/A) accumulation

Table 1. Constitutes a Profile for the Sample.

Size	Polymer Particle		Inorganic Particle (Silica)
	PMMA	Crosslinkaged	
Small	PM-1(50nm)	-	Si-1(40nm)
Middle	PM-2(150nm)	PL-2(150nm)	Si-2(80nm)
Large	PM-3(300nm)	PL-3(300nm)	Si-3(150nm)

External additives having a volume average particle diameter of from 50 to 300 nm were studied. The addition amount of external additive is about 20% as coverage to toner.

Observation of Surface Morphology of Toner

The adhesion morphology of the toner with external additive was observed by means of FE-SEM before and after agitating toner and carrier.

Measurement of Transfer Characteristics Initially and After Aging without Printing for 30min.

After completing the transferring step by using DC1250, a hard stop is conducted, and remained toner on the photoreceptor is transferred to an adhesive tape and transfer efficiency is obtained by measuring the weight of the tape and calculating it.

Confirmation of Cleanability

Cleanability of toner using conventional process was confirmed as follows.

A 5cm wide black band was formed on the photo-receptor as a toner image, and without being transferred, the toner image was wiped off with a cleaning blade.

Results and Discussion

Observation of Surface Morphology of Toner

The observation of an SEM confirms that the polymer particles as external additive are crushed by the stress regardless of the size of a particle (Fig. 3).

Cross-linked polymer particles cannot be crushed easily. On the other hand, they are liable to come off from the toner particles, whereby they shift to a carrier from toner particles and cause charging trouble.

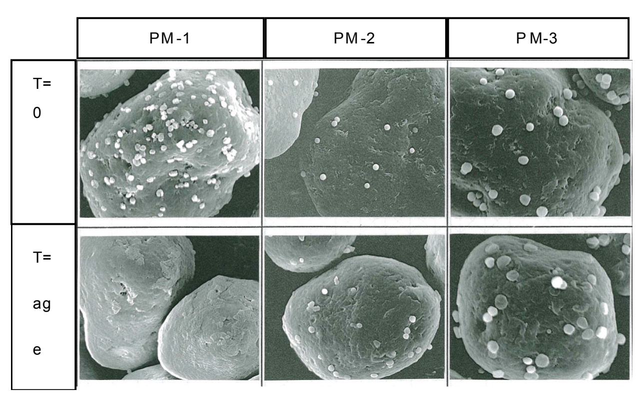

Figure 3. The FE-SEM picture of toner with polymer particles before and after agitating

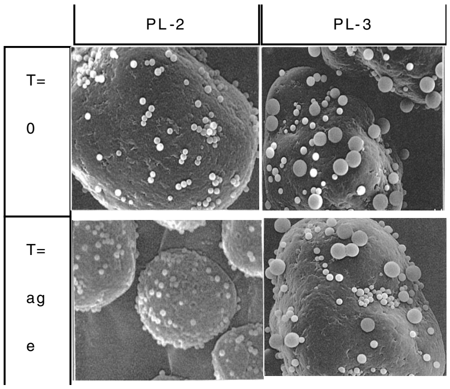

Figure 4. The FE-SEM picture of toner with cross-linked polymer particles before and after agitating

When the volume average particle diameter of the mono-disperse spherical silica is less than 80nm, it is liable to be buried in the toner particles due to the stress of agitation.

On the other hand, the mono-disperse spherical silica having a volume average particle diameter of 150nm is hard to bury in the toner particles after agitating stress and it is uniformly dispersed on the surface of the toner particles to obtain a stable spacer effect (Fig. 5).

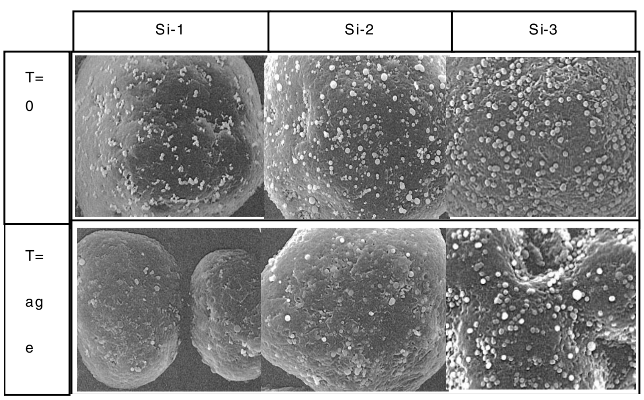

Figure 5. The FE-SEM picture of toner with inorganic particles before and after agitating

Measurement of Transfer Characteristics in Initial Stage and After Agitating without Printing for 30min.

The transfer occurs when the electrostatic attracting force is larger than the adhesion force. Therefore, in order to improve the transfer efficiency, the electrostatic attracting force is increased, or the adhesion force is decreased. In the case of increasing the transferring force, when the transferring electric field is increased, a secondary fault, such as formation of an inversely polarized toner, is liable to occur. Therefore, it is more effective to decrease the adhesive force.

In the initial stage, transfer efficiency of spherical toner is superior to the performance of potato shape and the conventional toner (Fig. 6).

There are cases where changes with the lapse of time, such as burying and peeling, occur due to stress by the carrier, and the good transfer performance in the initial stage is difficult to maintain. Particularly in the case of toner particles having a shape indicator approaching 100, the external additive is difficult to escape from toner to suffer uniform stress and thus such changes with the lapse of time are liable to occur.

When the volume average particle diameter of the mono-disperse spherical silica is about 150nm such as Si-3, it is hard for it to be buried in the toner particles due to stress in the developing HSG, which enables almost maintenance of the good transfer performance (Fig. 6).

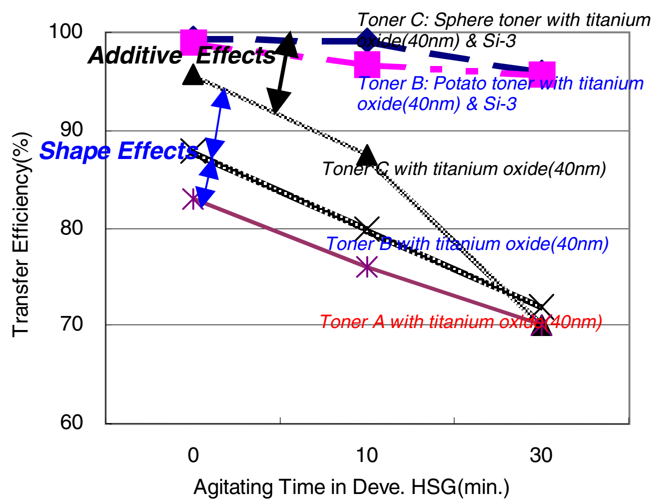

Figure 6. The influence of transfer efficiency on toner shape and external additive

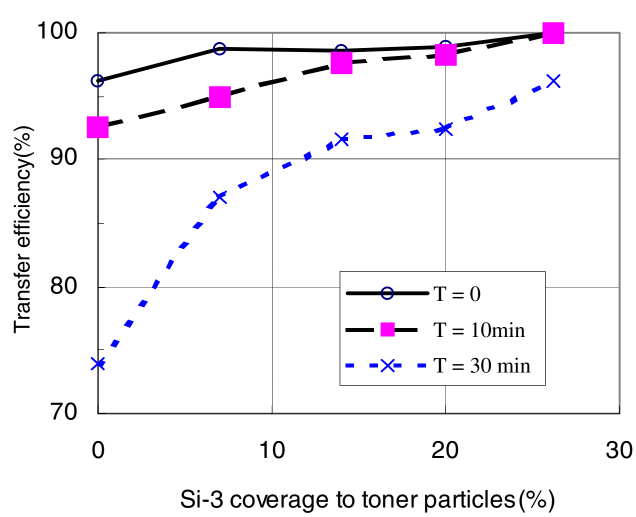

Figure 7. The influence of transfer efficiency on the coverage of Si-3 as external additive to Toner B

High transfer efficiency and its maintenance are obtained when the amount of addition of the mono-disperse spherical large silica is controlled to 20% or more as coverage.

Table 2. Cleaning Performance of Each Toner with Titanium Oxide

	Toner A	Toner B	Toner C
T=0	Complete-cleaning	Complete-cleaning	Poor-cleaning
T=30min.	Complete-cleaning	Poor-cleaning	Poor-cleaning

Confirmation of Cleanability

Since the potato shape toner (Toner B) also contains some spherical toner particles, it cannot maintain good blade cleaning performance over a long time.

It is difficult to obtain good blade cleaning in the case of using spherical toner (Toner C).

Table 3. Cleaning Performance of Each Toner with Titanium Oxide and Si-3

	Toner A	Toner B	Toner C
T=0	Complete-cleaning	Complete-cleaning	Complete-cleaning
T=30min.	Complete-cleaning	Complete-cleaning	Poor-cleaning

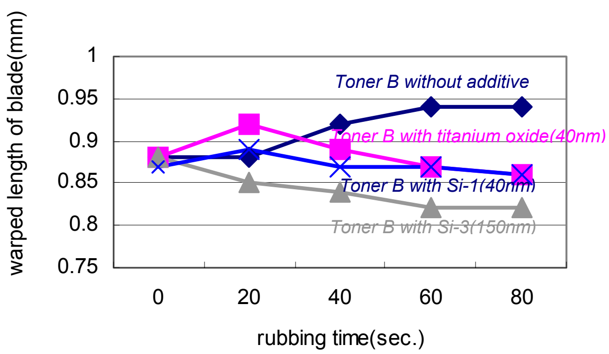

Figure 8. The relationship between rubbing time and warped length of blade (influence of additive kind)

It was confirmed that the addition of Si-3 to the toner improves cleanability. This reason is considered as follows.

The large silica particles uniformly contact toner particles and the photoreceptor with a very small contact area because of their high sphericity and therefore have a significant effect on reducing adhesive forces.

Toner B with Si-3 exhibited low warped length of a blade in comparison with another toner. (Fig. 8) The reason is considered as follows.

The large spherical silica particles serving as a roller reduce the frictional force between a cleaning blade and a photoreceptor to improve cleaning properties.

Conclusion

With respect to the problems associated with conventional techniques to provide a spherical toner for developing, transferring and cleaning, mono-disperse spherical inorganic particles having a volume average particle diameter of from 100 to 150nm is a key material.

The problems described in the foregoing can be solved by changing the toner shape into potato form from sphere form and using EA toner with the above-mentioned specific external additives.

References

1. USP6403271
2. Y. Matsumura et al. Fuji Xerox Technical report 2002 (No.14)

Biography

Chiaki Suzuki is Manager of Toner and Developer Chemicals Creation Center in Fuji Xerox. He received M.Eng. degree from Science University of Tokyo Japan in 1984. He has been working for the R&D division to develop toner and developer for 19 years.