Possibility of Long Life Developer by Using Cyclo Olefin Copolymer Resin

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Abstract

A long life developer is expected for printers and multi-function machines. Key factors of a long life developer are low contamination to carrier and durability of toner particles. Therefore the contamination ratio and durability of typical toner binder such as styrene/acrylic resin, polyester resin and COC resin were examined. Among three binders tested, COC resin showed least contamination ratio against carrier and excellent durability. This result suggests that COC resin toner has good potential for long life performance in dual component systems.

Introduction

Different types of developing systems are adopted for printers, copiers and multi-function machines depending on the applications. Recent trend in higher speed applications are placing more value on the printed product thus requiring greater output quality. In these segments, a dual component system is mainly used due to the broad ability in electrostatic charging. The important quality requirements for those applications are stability of print quality and long life developer. The stability of print quality means that the developer should have less variation through the developer life. From the viewpoint of toner design, the durability of toner particles is one important factor that greatly influences the life of the developer.

Presently, styrene acrylic and polyester resins are mainly utilized as toner binders, however Cyclo Olefin Copolymer (COC) resin is being introduced as a potential binder for toner because of its eco-friendly properties. In this paper, we will compare the three resins for electrostatic charge ability and toner particle durability.

What is COC Resin?

Cyclo Olefin Copolymer is polymerized from ethylene and norbornene by metallocene catalyst. Strong consideration is being given to COC resin as a potential toner binder following styrene acrylic and polyester resins because of its excellent optical, thermal, mechanical, electrical, and eco-friendly properties. These properties are derived from the olefinic nature of COC resins and the freedom of endocrine disrupters.

Experimental

Toner Sample

Preparation of toner sample:

Following materials were premixed, extruded, crushed and classified (average particle size 10 μm toner was obtained).

Binder resin: 100 parts
Polypropylene: 2 parts
Carbon black: 7 parts
Metal complex CCA: 1.5 parts

Non-treated additives sample were used for evaluation to avoid any influence from secondary treatment additives. The thermal properties of the toner samples are shown in Table 1.

Table 1. Thermal Properties

	St/Ac Toner	Pes. Toner	COC Toner
Ti ℃	114.8	110.9	113.6
Tm ℃	135.0	132.6	133.6
Tg ℃	65.4	64.9	63.5

Ti : Melt starting temperature
Tm: Softening point temperature
Tg: Glass transition temperature
The thermal property of each sample showed similar results.

Electrostatic Charge

Fig. 1 shows the electrostatic charge stability and Fig. 2 shows the charging ability of each sample. Silicone coated carrier with average particle size of 90μm was employed. The sample toner was prepared with carrier at a 5% toner concentration. The sample developer was placed into a polyethylene bottle and agitated by rotation. Then the electrostatic charge was measured incrementally. To measure the charging properties, the sample developer was placed into a 50cc beaker and magnetically stirred. Both of the measurements were done using a Toshiba blow off charge apparatus at 10 second intervals. COC sample toner showed the highest value followed by Pes toner and St/Ac toner. Transition of electrostatic charge of those samples was stable.

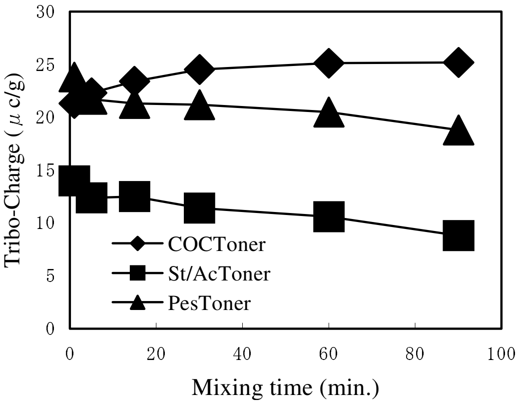

Figure 1. Electrostatic Charge by time

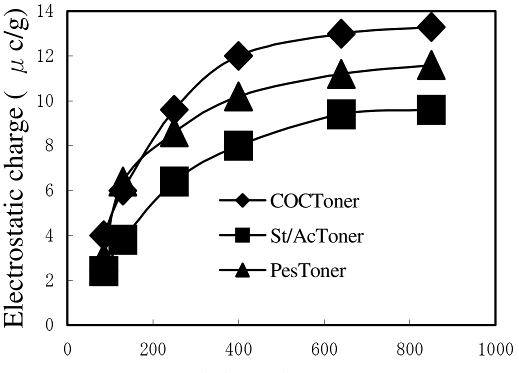

Figure 2. Charging-up speed

Environmental Test

Figure 3 shows the environmental test results. The 60 min. samples from the above experiments were taken and left in 35ºC/80%RH, 25ºC/60%RH and 15ºC/20%RH conditions for 24 hours. The electrostatic charge was measured. A similar tendency was observed as with the above experiment, COC toner showed higher electrostatic charge. The electrostatic charge drop of COC toner in 35ºC/80%RH was similar to the other resins.

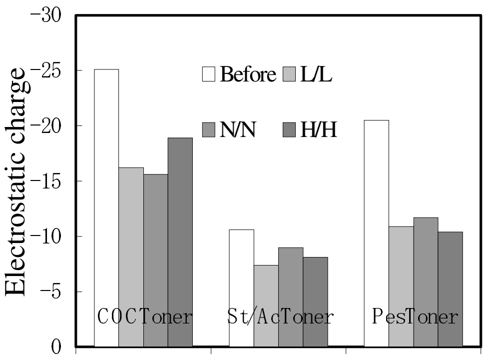

Figure 3. Environmental test

Carrier Contamination – Spent Toner

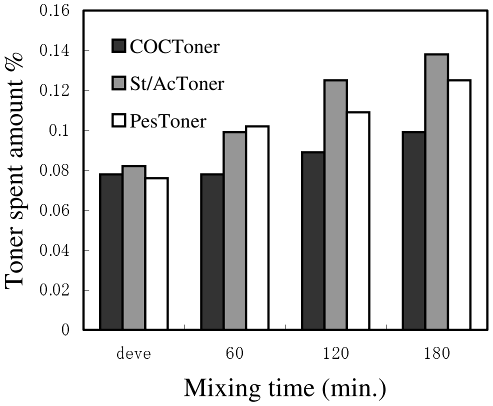

Figure 4. Carrier Contamination

Figure 4 shows the spent toner test results that was measured as following:

Silicone coated iron carrier with average particle size of 60 μm and the sample toners were mixed at a 5% toner concentration. The developer sample was installed into a dual component developer unit system. The toner sample was agitated in the system for 180 minutes without toner being consumed and replenished. The spent toner amount of each sample was increased with agitation time. COC resin toner showed the lowest rate.

Toner Particle Size Change In Developer

Toner Particle size changes in developer was examined to predict the toughness of each binder resin. Silicon coated magnetite carrier with average particle size of 80 μm and the sample toners were mixed at a 3.5% toner concentration. The 200g of developer were mixed for 15 hours using a paint shaker. The particle size was measured incrementally. The change in population 50% and population under 5 μm were evaluated (Fig. 5 and Fig. 6, respectively). The data shows that COC resin toner has less change in both population 50% and population under 5 μm.

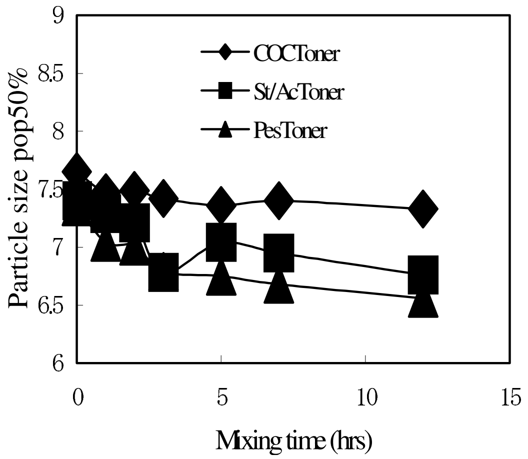

Figure 5. Particle size change pop 50%

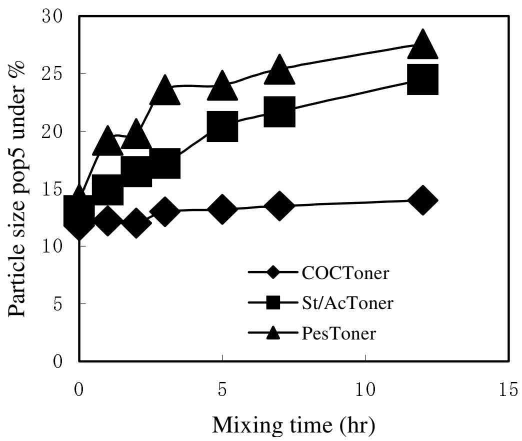

Figure 6. Particle size change pop under 5μm

Result and Discussion

Table 1 shows the thermal properties of each sample was very similar. The storage stability of each toner sample is expected to be normal from Tg data. The relative differences in Ti and Tm of each sample is also similar which predicts similar fusing abilities. As shown in Fig. 1 and Fig. 2, the electrostatic charge result of the COC resin toner showed the highest value followed by Pes toner and St/Ac toner. Transition of electrostatic charge of those samples was stable. Since COC has an olefin structure and has no oligomers in the low molecular range, it is thought that the ability to hold the electrical charge is high. From the environmental test shown in Fig. 3, it is interesting that the remaining charge in H/H was higher than in N/N. We can consider that the COC resin has less moisture pick up due to no carbonyl groups or double bonds. In this paper, no post-treatment was applied to the samples to avoid any influence from the additives. In general, fumed silica and/or titanium dioxide are used as the additives to improve flowability, however it also effects charge ability in different environments. In case the core toner has good environmental characteristics, post treatment can have some tolerance for the formulation.

From the test result of carrier contamination showed in Fig. 4, COC resin toner showed the lowest increase among those samples. One consideration is that COC resin has less oligomers due too the sharp molecular weight distribution caused by use of the metallocene catalyst. Other factors of COC resin include low resin density and higher surface energy compared to other resins. This is due to the cyclo olefin structure. As shown Fig. 5 and 6, particle size change over time is reduced with COC resin toner. This also supports the hypothesis above. In the actual developing process, toner consumption and replenishment is repeated continuously and if the carrier contamination is increased, it strongly inhibits new replenished toner from adequately charging. The fine particles generated in the developer unit have a tendency not to contribute to development and stay in the unit. As a result of this issue, toner dusting and print quality deteriorate. Also, the developer life is considerable shortened.

Conclusion

The possibility of COC resin toner for long life developer can be summarized as follows:

1. Thermal properties of COC resin toner is similar to the St/Ac or Pes resin toner.
2. COC resin toner can obtain similar electrostatic charging ability and stability compared with St/Ac or Pes resin toner.
3. The durability of COC resin toner is comparable or even better than St/Ac toner and Pes toner in our tests.

Based on these investigations, it is apparent that Cyclo Olefin Copolymer resin toner is a potential long life candidate for future dual component system.

References

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Biography

Nobuyuki Aoki received his bachelor in Chemical Engineering from the University of Shizuoka, Japan, in 1986 and then joined the Research and Development section of the Chemical Products Division of Tomoegawa Paper Co Ltd.. He is currently working on toner development for copiers and printers.