Toner Having Low Energy Fusibility for High Speed Non-magnetic Mono-component Process

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Abstract

A toner has been developed having low energy fusibility, high durability and high stability of charge characteristics for high speed non-magnetic mono-component process. This toner is applicable in printing speeds up to 45ppm in an electrophotographic printer, by improving the durability of the toner. The improvement was carried out by reducing the low molecular weight component without raising the thermal characteristics of toner resin, improving the dispersion of additives in toner resin and round-edging the toner shape. This toner is also suitable for application in printings with speeds down to 12ppm because of the improved stability of the charge characteristics and the reduced background fog.

Introduction

The technology of non-magnetic mono-component development process has progressed rapidly, and the high speed printer as excess of 30ppm is now on the market. Therefore, it is expected to develop further the high speed printer. The fundamental features of the toner required for the high speed printer are increased durability and lower temperature fixing characteristics, and the most significant technology will concern the ability of these two characteristics to coexist.

Various technologies for the improvement of durability on the toner have been proposed. However, raising the thermal properties of toner resin by increasing the molecular weight leads to a loss of the fixing characteristics. And also, increasing crosslinking density of toner resin leads to decline in the dispersion grade of additives, and thus, it may become difficult to maintain sufficient photographic properties. Furthermore, as the toner having the high thermal properties and high crosslinking density requires much energy for the toner fixing in high speed printing, it is not better in view of saving energy. Therefore, the lower energy fixing toner is strongly required, particularly, in high speed printer.

A toner was successively developed having low energy fixing characteristic and high durability for high speed non-magnetic mono-component process up to 45ppm, by adjusting the molecular weight distribution, improving the dispersivity of additives in the toner resin, and by round-edging the toner shape. The details of the result are described in this paper.

Experimental

Experiment of the Resistance of Adhesion

Fig. 1 shows the schematic diagram of experimental apparatus of non-magnetic mono-component development process employed in this study. In this apparatus, the development roller is made of conductive urethane rubber, and the supply roller is made of urethane sponge which is in contact with the development roller. The edge of L shaped stainless steel regulation blade presses against the development roller. The rotation speed of development roller is 428mm/sec.

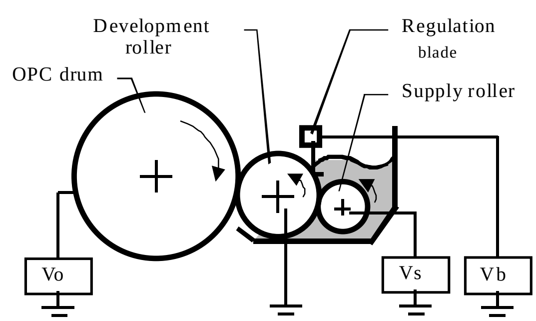

Figure 1. Schematic diagram of the experimental apparatus[T]

Toner Samples

The toner samples used in this study is polyester resin, and the thermal properties of glass transition temperature (Tg), the melt starting temperature(Ti), and the softening point temperature(Tm) are in range of 56.7-70.2°C, 93.3-130.7°C and 115.7-156.4°C, respectively.

Durability Evaluation

The experimental method for life assessment of toner was the following; a certain amount of toner was poured into the unit, and agitated by rotating the development roller at 428mm/sec. The time which it takes a vertical seam of toner to appear on the development roller caused by adhered toner on regulation blade was determined to be toner life.

Evaluation of Charge Distribution, Charge Stability and Background Fog

The characteristics of initial charge distribution, background fog and stability of the charge over a long term were evaluated with the following methods; the initial charge distribution was measured with a Hosokawa-Mikuron E-SPART analyzer with the toner from the layer formed on the development roller after two minutes from the start of agitation. The background fog is characterized by examining the dependence on the bias voltage between the OPC and the development roller. The experimental condition were as follows; the development roller speed was 143mm/sec., OPC rotation speed is 72mm/sec., which corresponds to a copy speed of 12ppm, and the bias voltage is changed from zero to -600V. It is well known that the speed is the most significant factor contributing to the background fog. Also, the surface voltage and the deposition amount of toner layer are measured to evaluate the charge properties of the toner.

Physical Characteristic

For the purpose of examining the flow characteristic as one of the physical characteristics, the effect of the particle shape of the toner was examined. Two different shaped toner particles were obtained by two different smash methods, and the time was measured for each toner to appear the seam on the development roller toner layer during the aging test.

Result and Discussion

Coexistence of the Resistance of Toner Adhesion and the Low Temperature Fixing Characteristic

A scale of 1 to 10 was established to rate the time it took for the seam to appear during the aging test, with 10 being the best. The relationship between the resistance of adhesion and various physical (the heat characteristic, molecular weight distribution etc) of a series of toner samples were then examined.

Fig. 2 shows the relationship between the flow softening point (Tm) and resistance of adhesion characteristic. It was found that there is a direct relationship between the heat characteristic of the toner and the resistance of adhesion.

Fig. 3 shows the relationship between the number average molecular weight (Mn) of the polyester resins used in this study and the resistance of adhesion characteristic. Fig. 4 shows the relationship between the weight average molecular weight (Mw) of the polyester resin used in this study and the resistance of adhesion characteristic. These results indicate that there is not any clear correlation between Mw and resistance of adhesion characteristic, particularly in the high molecular weight region. However, there is a clear correlation between Mn and the resistance of adhesion characteristic, in the low molecular weight region.

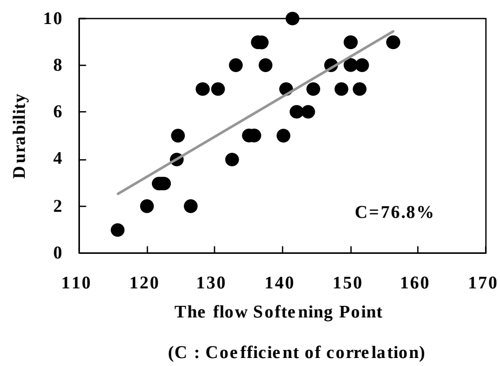

Figure 2. The dependence of durability on Tm of polyester toners

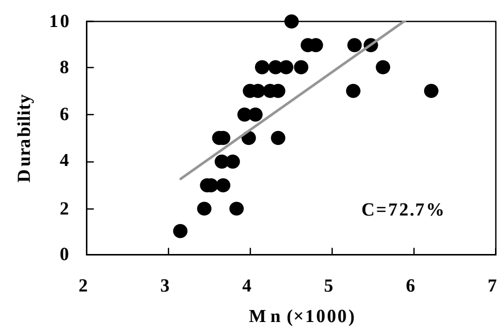

Figure 3. The dependence of durability on Mn of polyester toners

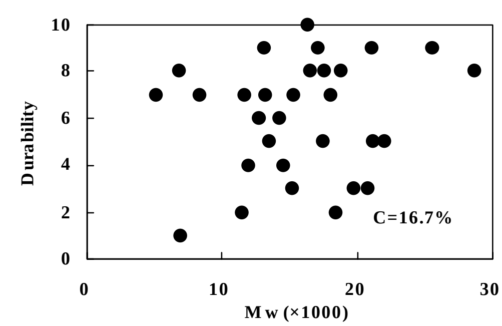

Figure 4. The dependence of durability on Mw of polyester toners

Fig. 5 shows the molecular weight distribution analysis about the adhesion toner on regulation blade. The adhered toner on regulation blade contains a significant portion of the low molecular weight resin (of about 500 or less) which is recognized as very low molecular weight (oligomer) in comparison with virgin toner.

It is suggested that the low molecular weight portion and especially oligomer content is one of the main causes of the occurrence of toner adhesion. It was proven that one of important points in designing the resin is to reduce the quantity of oligomer in order to achieve the high resistance of toner adhesion characteristic toner for high speed non-magnetic mono-component process.

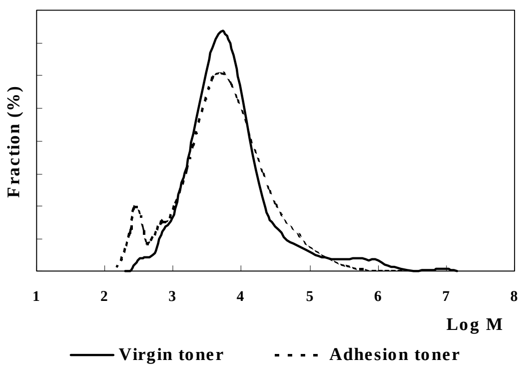

Figure 5. Comparison of molecular weight distribution between the adhesion toner resin on blade and the virgin toner resin

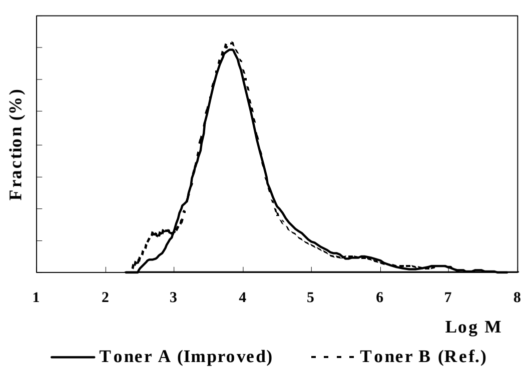

Figure 6. Comparison of the molecular weight distribution of toner resins A and B

To examine the effect on reduction of low molecular weight component, two samples A and B which have different molecular weight distribution as shown in Fig. 6, were prepared without changing Tm values which affect the toner fixing characteristics. The toner A, which has less lower molecular weight component, in comparing with the toner B, takes 7hrs to cause toner adhesion on regulation blade, against the toner B was 4.5hrs. Therefore, it was certainly proved that it is possible to improve the resistance of adhesion characteristic by reducing the oligomer content.

It was shown that coexistence of low temperature toner fixing ability and the resistance of adhesion is possible by designing the molecular weight distribution of the toner resin for the non-magnetic mono-component development process, even if we do not use the hard type polyester resin by raise softening temperature of resin.

Improvement of the Charge Characteristic

We improved that selecting the additives, adjusting the quantities and also producing condition. It was confirmed that the additives dispersion of the improved sample is better than non-improved (Ref. 1).

The charge distribution on the toners C and D are measured with the E-SPART analyzer, and the results show in Fig. 7. It was not observed any difference on the average charge quantity between the toners C and D. However, it can be seen from Fig. 7 that the low charged toner and oppositely charged toner was decreased in the toner C.

Fig. 8 shows the relationship between the background fog and the bias voltage of the OPC and development roller at a copy speed of corresponding 12ppm. The background fog is much less in the toner C than the toner D.

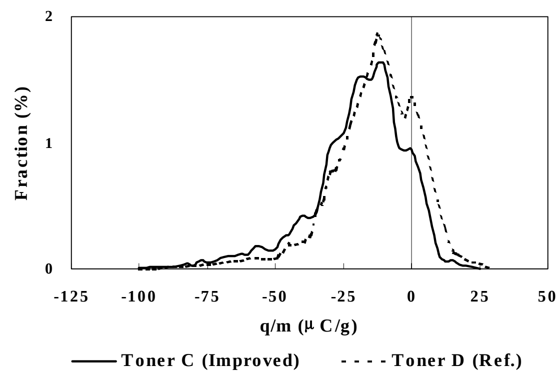

Figure 7. Comparison of charge distribution of toners C and D

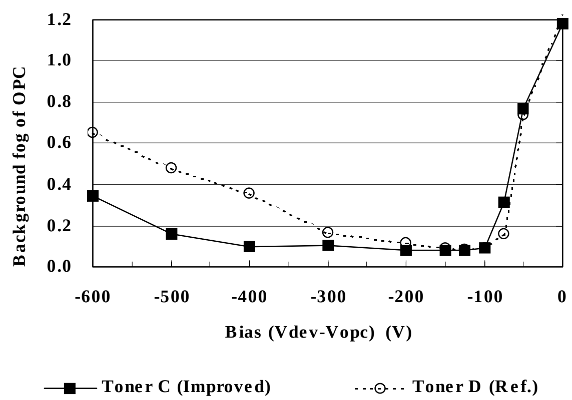

Figure 8. The dependence of background fog on the bias voltage between OPC and development roller for toners C and D

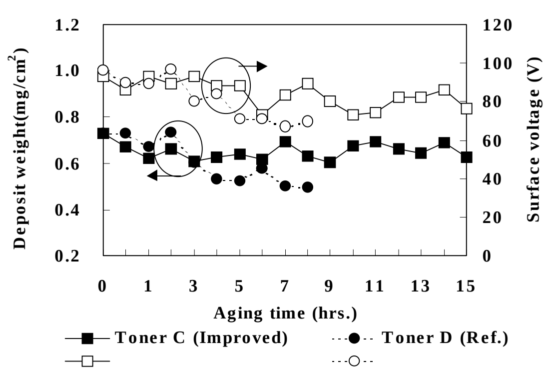

Figure 9. Relationship between surface voltage and aging time; the deposit weight of toner layer

Fig. 9 is the result that measured the surface voltage and the deposit weight of the toner layer during the aging test with regard to the toner C that improved the adjustment of quality, quantity of the additives and also product condition, and toner D that non-improved (Ref.).

The surface voltage and the deposit weight of toner C are keeping balance on the aging time, in comparing with these of toner D. It means that the formation of toner layer on the development roller is much better in the toner C than the toner D. This better toner layer formation strongly depends on the stability of charge characteristics. If the stability is not enough, the toner deposit weight on the development roller decrease, and it might lead toner adhesion on the regulation blade by increase of stress to the toner on the development roller.

According to these results, it is understood that high durability is obtained to be depends on the improvement of additives dispersion in addition to the adjustment of the types of the additives.

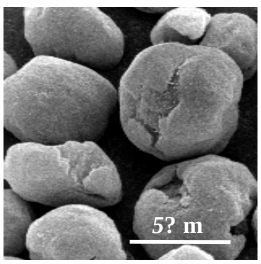

Figure 10. Round edging shape toner E

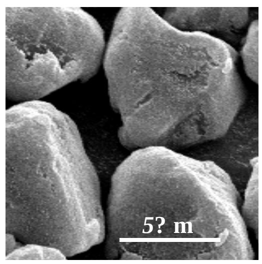

Figure 11. Irregular shape toner F

Rounding the Edges of the Toner Shape

Fig. 10 and Fig. 11 are photographs of the toner two different surfaces produced by two different kinds of smash methods.[4]

It measured the time until appearing the seam on the development roller toner layer at aging test in the same experimental apparatus[T] about these samples. The time was 20hrs for the toner E and 14hrs for the toner F. From this result, it can be confirmed that the round edging of toner shape improves the resistance of toner adhesion.

Conclusion

We developed the toner having high durability and excellent low temperature fixing characteristic for high speed non-magnetic mono-component process that is applicable up to 45ppm. This toner was prepared employing the following technologies;

(1) It is possible to achieve coexistence both having high durability characteristic and having low temperature fixing characteristics, by reducing the oligomer content that one of the cause of the toner durability.

(2) Because of improvements in the adjustment of the quality, optimized quantities of the additives and also optimized production conditions, the additives dispersion condition and charge characteristic was improved significantly.

(3) The resistance of adhesion is further improved by imparting a round shape to the toner.

References

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Biography

Tatsuru Matsumoto received his B.E. in Industrial Chemistry from the Science University of Tokyo in 1987. He joined Tomoegawa Paper Co., Ltd. in 1987 working on QC of toners in Chemicals Division (Toner Plant). He was transferred to Technical Research Laboratory in 1991 working on development of Organic Photo Conductor. He has worked on development of toners since 1996. His current interest is full color toner.