Improved Fusing Properties and Characteristics of Polyester Toners Prepared by Chemical Milling

Eui-Jun Choi, Hak-Soo Kim, Kyung-Rak Lee, and Hyun-Nam Yoon, R&D Center of DPI Solutions, Inc., Daejon, Korea

Abstract

We developed a polyester color toner with a broad fusing latitude of from 150℃ to over 220℃, using our proprietary 'Chemical Milling Process'. In this study, we explored the relationship between the fusing latitude and the chemical milling property, on the one hand, and the chemical structure of toner resin, especially molecular weight, molecular weight distribution and the amount of long chain branching, on the other. The fusing latitude, in a hot roll fusing system(both soft and hard roll), expanded with the degree of branching while the chemical milling property was little affected by the branching. The hot offset temperature increased with the degree of branching whereas the cold offset temperature was not affected. An attempt to understand the results in terms of effects of the branching on resin physicochemical properties such as the acid value, the polymer chain dimension and thermo-rheological property is to be presented.

Introduction

Since year 2000, we have developed a novel polyester chemical toner (CM toner®) using our proprietary Chemical Milling process and have demonstrated its excellent performance in office printing application.[1-6] To expand the application area of CM toner® high-speed on-demand-printing market, we have tried to achieve a wide fusing latitude in the toner by controlling resin molecular structure and melt rheological property.

A usual method of improving high temperature fixing property of toner is enhancing elasticity of the molten toner by adding gel moiety to resin system. However, this method is generally unworkable in Chemical Milling, as the gels in the resin may cause partial separation problem and in-homogeneous particle formation during the CM process.

Therefore, we have investigated the different way to improve fusing property of CM toner® controlling branch structure of polyester resin. Here we present the effect of branching degree on fusing property and other physical properties of polyester chemical toner.

Experimentals

The experimental polyester resins with different molecular structures were synthesized by adjusting the amount of multi-functional moiety in monomer mixture. We measured several basic material properties of the experimental resins using GPC, DSC, etc.

We, then, prepared spherical toner particles of the resins using Chemical Milling process. The properties of polyester toners were investigated by size analyzer, powder tester, and in-house fusing tester.

Results

The molecular weight and branching degree (number of branch per each polyester molecule) of the polyester resins are summarized in Table 1. We found that the average molecular weights of the resins were similar irrespective of the branching degree. We therefore could investigate the effect of branching degree on toner fusing property on the same basis without the influence of molecular weight difference.

Table 1 Molecular Structure of the Experimental Polyester Resins

Resin	Molecular Weight		Branching Degree (number of branch per molecule)
	Mn	Mw	
Resin A*	4400	9600	-
Resin B**	3800	9300	0.88
Resin C**	3900	9300	2.25

* Linear polyester
** Branched polyester

Table 2 shows that the branching degree in the polyester molecule little affected the acid value and the glass transition temperature of the resin. However, the melt flow temperature (T1/2) of the resins was strongly affected by the branching degree. The polyester (Resin C) with the highest branching degree showed the higher melt flow temperature and this may be ascribed due to increase in chain entanglement between side branches as well as backbone and side branch.

Table 2 Properties of the Experimental Polyester Resins

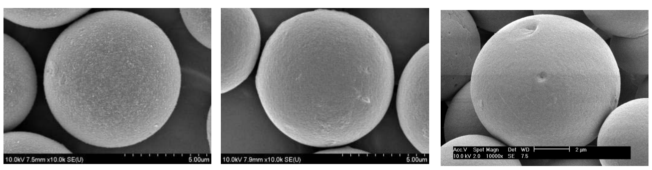
Resin	Acid Value (mg KOH/g)	Tg(℃)	T1/2(℃)
Resin A*	7	67	160
Resin B**	12	71	170
Resin C**	3	68	190

* Linear polyester
** Branched polyester

We produced three toner samples (A,B,C) based on the experimental polyesters above using the Chemical Milling process, and measured physical properties of the toner samples (Figure 1 and Table 3).

The three toner samples showed similar particle shape in spherical form (Figure 1), which is common shape of CM toner®, and we could confirm all three kinds of polyester resin have appropriate particle formation characteristics for Chemical Milling process.

The average particle size of the toner samples was in the range of 8 ~ 8.5 ㎛, and the size distribution (span80) and the particle density were also similar between the samples in common range. Particularly, during the particle formation process we have not experienced any problems such as gel separation, which is observed when we use a gel-containing polyester. Therefore, we could conclude that the branched polyester is more stable in CM process than the gel-containing polyester, and this can be a good alternative to control fusing property of CM toner®.



(a) (b) (c)

Figure 1 *SEM micrographs of toner samples (X 10,000) (a) Toner A (b) Toner B (c) Toner C*

Table 3 Properties of toner samples produced using Chemical Milling process

	Size (㎛)	Span80*	Density (g/㎤)	Fusing Range(℃)**
Toner A***	8.5	0.72	0.67	135-145
Toner B***	8.1	0.67	0.61	145-165
Toner C***	8.4	0.63	0.61	145-205

* Particle size distribution defined by (d90-d10)/d50.
** Fusing latitude measured with hard roller type fusing tester. (22ppm)
*** Toner samples produced with Resin A, B, C respectively.

In terms of fusing property, Toner C based on the polyester resin C with high branching degree showed significantly broader fusing latitude when compared to the Toner samples A and B. As shown in Table 3 and Figure 2, we observed the fusing range of Toner C is very wide in both hard roller and soft roller fusers. On the contrary Toner A and B showed relatively narrower fusing range, particularly more in hard roller fuser.

The difference in fusing range according to the fuser type could be attributed to several factors such as nip time, nip pressure, interfacial energy and so on. However, it was obvious that the high branching degree extends the fusing latitude in any fuser system.

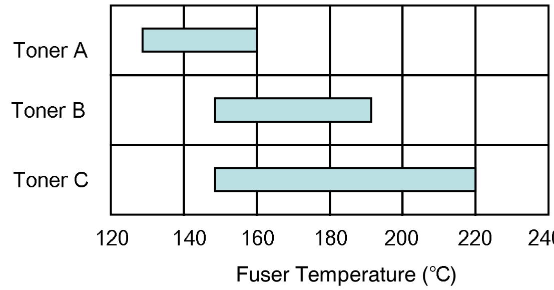


Figure 2 *Fusing latitude of toner samples measured in soft roller fuser (24ppm)*

Also, as the branching degree increased, the high temperature fusibility was improved without loss of low temperature fusibility.

The excellent fusing performance of Toner C based on highly branched polyester is related with its melt flow characteristics. Figure 3 compares melt viscosities of Resin B and C with different branching degree. The melt viscosity of the polyester resins increases with the branching degree and it is believed the reason is due to the increase of chain entanglement in highly branched resin as already explained.

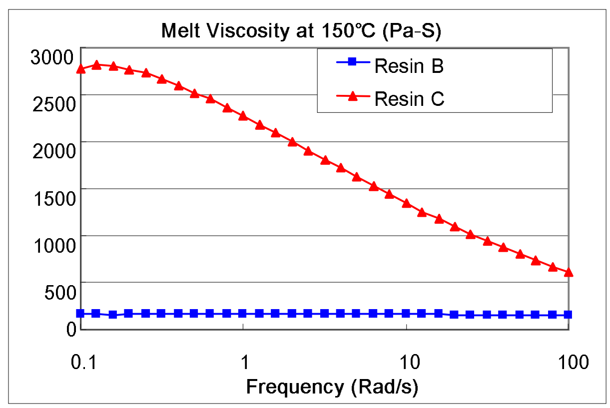


Figure 3 *Melt viscosities of the experimental polyester resins*

Conclusion

We designed polyester resins with a different branching degree and investigated influence of the branching degree on the properties of chemical toner produced by Chemical Milling process. Most physical properties of CM toner were not dependent on the resin branching degree. However, the fusing property of CM toner® varied widely with the branching degree. As the branching degree increased, the high temperature fusibility improved significantly without loss of low temperature fusibility. We concluded the chain branching is a good alternative instead of gel incorporation in controlling the fusing property of a chemical toner. .

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Author Biography

Dr. Eui-Jun Choi is the Technical Director of DPI Solutions, Inc. He is responsible for developing chemical toner technology and products for high resolution color electro-photography. Prior to joining DPI Solutions in 2000, he had worked in LG Chemical Tech. Center. He received Ph.D (1998) in polymer science and engineering from Korea Advanced Institute of Science and Technology (KAIST).