Polyester Chemical Toner with Low Fusing Temperature

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Abstract

Polyester-based chemical toner with a low fusing temperature is demonstrated. The toner composition is based on spherical toner particles produced using the proprietary Chemical Milling process of DPI Solutions with a diameter centered about 6 µm. It exhibits the fusing latitude in the range of 100-150 ℃, of which the low fusing temperature is significantly lower than commercial 'low temperature' toner used in a printer with a ribbon fuser architecture. The low fusing temperature with excellent blocking resistance is achieved through a new amorphous resin with a linear polyester chemical architecture in which the alkyl group length of alkylene diol monomers was optimized for the glass transition temperature about 60℃. We present the molecular design principle and the thermo-physical performance of the resin as well as toner processing characteristics of the resin in this paper.

Introduction

Since year 2000, we in DPI Solutions, Inc. (DPI, henceforth) 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® to high-speed on-demand printing market, we have tried to achieve a wide fusing latitude in the toner by controlling the resin molecular structure.

A common method of expanding the fusing latitude of toner is to incorporate branching structure in the binder resin. The branching method is generally used to improve the high fusing temperature. In contrast, to lower the low fusing temperature, one could include a long alkyl monomer to form an amorphous linear polyester resin with a low glass transition temperature. However, it is accompanied by a lowering of the high fusing temperature.

Recently there have been many studies related to lowering of toner fusing temperature, which enables reduction in energy consumption during the printer operation.[7-9]

Here, we report a study in which we explored polyester chemical structure that would give us a wide fusing latitude of CM toner® essentially by lowering the low fusing temperature while maintaining the high fusing temperature at about 150℃, an identical value for widely-used CM toner® ver. 1.0. fusing temperature.

Experimental

Here experimental polyester resins with different molecular structures were prepared from various structure monomers, especially by varying the diol component in type and in qualtity. We then measured basic material properties of the experimental resins such as molecular weight and its distribution, thermal properties, solubility in organic solvents, and the solution viscosity.

Spherical toner particles of the resins were prepared using Chemical Milling process. Then the properties of polyester toners were investigated by size analyzer and in-house fusing tester.

Results

Molecular weight and the glass transition temperature (Tg) of the polyester resins are summarized in Table 1 and 2. The molecular weight of the resins is similar among themselves as well as to that of the standard polyester resin for CM toner®. Some of the resins that contained diols comprising of an even number of alkylene groups and without a side chain developed a crystallinity and could not be dissolved in solvents that can be used in our CM toner process. These results are also summarized in Table 1.

Table 1. Molecular weight of the Experimental Polyester Resins

Molecular weight				
Code (eq %)	Mn	Mw	PDI	Solubility
1,2-PG **	2634	7273	2.7	O
1,3-PG 8.6% *	2626	7040	2.6	O
1,3-PG 17.2% *	2653	6906	2.6	O
1,2-BD 8.6% **	2586	6545	2.5	O
1,2-BD 17.2% **	2673	7022	2.6	O
1,3-BD 8.6% **	2605	6996	2.6	O
1,3-BD 17.2% **	2725	7268	2.6	O
1,4-BD 8.6% *	2616	7024	2.6	O
1,4-BD 17.2% *	-	-	-	X
EG 8.6% *	-	-	-	X
EG 17.2% *	-	-	-	X

- * Non-side group linear polyester , ** Side group content polyester
- - : Non-soluble polyester resin in solvent
- Solubility O : good, X :bad

Table 2 and Fig. 1 show that inclusion of diols with a larger alkylene number in the chain portion (in contrast to the side chain portion) of the polyester lowers the glass transition temperature. Relatively long aliphatic chain, 1,4-butanediol content resin, showed a lower Tg than that of short chain, that is ethylene glycol content resin (about 55℃ vs about 67℃) because of improved flexibility of polyester main chain. In contrast, the effects of different side group was less than that in the main chain length effect because chain flexibility is mainly affected by chain length.(Fig 2)

Table 2. Tg of the Polyester Resins

*Resin(eq%)	Tg(℃)	**Resin (eq%)	Tg(℃)
EG 8.6%	67	EG 8.6%	67
1,3-PG 8.6%	62	1,2-PG (STD)	68
1,4-BD 8.6%	55	1,2-BD 8.6%	63

** Non-side group linear polyester, ** Side group content polyester, *** STD : standard resin*

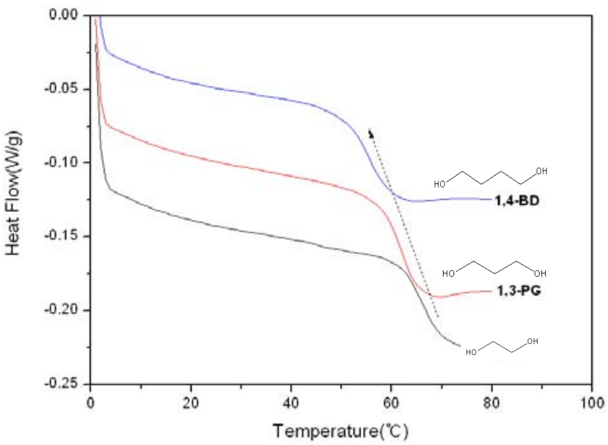

Figure 1. Main chain length effect of the Experimental Polyester Resins at 8.6eq%

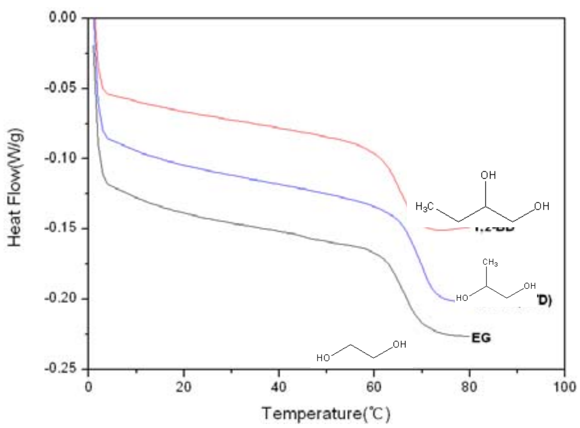

Figure 2. Side chain effect of the Experimental Polyester Resins at 8.6eq%

We prepared base toner samples from the experimental polyester resins using DPI's proprietary Chemical Milling process and determined the fixing behavior of the toner samples.

All resins except on linear polyester resins containing even numbered methylene groups such as 1,4-butanediol 17.2eq% and ethylene glycol(all content eq%), which did not dissolve in organic solvents used in chemical milling, showed excellent chemical milling properties.

As listed in Table 3, the toner samples showed similar particle size and size distribution(span value) in the range 6~ 9 ㎛ and 0.6~0.7 respectively.

Table 3. Properties of toner samples produced using Chemical Milling process

Base toner size & size distribution		
Code (eq%)	Size (㎛)	Size distribution (Span)
1,2-PG	9.5	0.60
1,3-PG 8.6%	6.2	0.63
1,3-PG 17.2%	5.7	0.57
1,2-BD 8.6%	8.0	0.60
1,2-BD 17.2%	8.6	0.58
1,3-BD 8.6%	6.0	0.62
1,3-BD 17.2%	6.7	0.61
1,4-BD 8.6%	6.2	0.63
1,4-BD 17.2%	-	-
EG 8.6%	-	-
EG 17.2%	-	-

**Particle size distribution defined by (d90-d10)/d50.*

In terms of fusing property, we observed that the fusing range of 8.6eq% content toner samples is wider than that of 17.2eq% content toner samples in fusing test. Especially, the base toner prepared from co-polyester resin of linear structure and appropriate side group content was showed significantly broader fusing latitude when compared to others because improving of fixing property at low temperature around 100℃ according to increase in the chain flexibility and appropriate side group content(1,2-propanediol co-polymer) for keeping up with high temperature fixing property.

As a result, at the 8.6eq% content, especially 1,3-PG base toner sample was shown that the fusibility at low temperature was extended about 40% without loss of high temperature fusibility compare to 1,2-PG standard toner sample. (Compare the fusing property with that of Dell 1320 OEM toner.).

Table 5. Fusing latitude of different chemical structure toner samples measured in- house fuser (24ppm)

C ode (eq %)	,2- PG TD	,3- PG .6%	1 ,3-PG 1 7.2%	,2- BD .6%	1 ,2-BD 1 7.2%	,3- BD .6%	1 ,3-BD 1 7.2%	,4- BD .6%	ell 1320
F uing Temp.(℃)	20 50	00 50	9 0 ~ 1 20	10 50	1 00 ~ 1 30	10 40	1 00 ~ 1 30	00 40	10 55

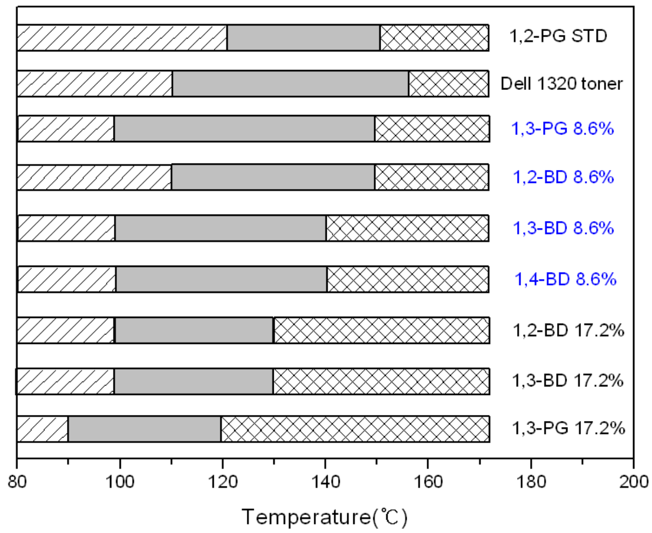

Figure 4. Fusing latitude of different molecular structure toner samples measured in- house fuser (24ppm)

Printing test in a Dell 1320 printer is in progress.

Conclusion

Polyester resins with a different molecular structure were designed and influence of molecular structure over the properties of base toner produced by Chemical Milling process were investigated. Thermal property of different polyester resins was dependent on the main chain length and it was proved by DSC from 67 ℃ (Ethylene glycol) to 55 ℃ (1,4-Butanediol) respectively. Whereas, the solubility was shown that could be affected by the kind of side group such as ethylene glycol, 1,2-butanediol and 1,3-propanediol. Also, the low temperature fixing property of base toner sample prepared from different molecular structure polyester resins was mainly affected by main chain length.

As a result, we demonstrated that the fusing latitude of toners from 1,3-PG 8.6eq% content polyester resin was significantly broadened by about 20℃ in the low temperature range without a loss in the high temperature fusibility, ascribing to the use of more extended, flexible monomer and reduction in the amount of side chain methyl group.

The resulting toner showed outstanding printing performance in a printer with a low fusing temperature, Dell 1320 printer. Complete analysis of the printing performance will be forthcoming as well as the toner's performance in a high speed color printer with the printing speed exceeding 35 pages per minute.

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Biography

Dr. Eui-Jun Choi is the Technical Director of DPI Solutions, Inc. He is responsible for developing chemical toner technologies, and also contributes to designing and developing novel toner products reflecting the various market needs of color EP industry. 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).