The Influence of the Toner Reverse-Charge Element in the Mono-Component Development System

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Abstract

A magnetic mono-component development system for printers and copiers is comprised with silica particles on the surface of each toner. The silica particles are used as external additives to improve flow ability, to reduce toner aggregation and to modify the tribo-charge characteristics. In most cases, increasing the amount of positive additives to the positive toner result in the increasing of the positive tribo-charge, while sometimes the charge perform too high or too low and it makes toner tribo-charge unstable. Thus, the reverse charge additives are applied to stabilize the tribo-charge and image density in the printing. This study is about how the reverse-charge elements stabilize the image density in the printing.

Introduction

The toner charge and mass transport are important factors for producing fine and high quality images in the electrophotographic development system. A model of contact charging between insulators and showed that most of published experimental result were fitted to the model presented by Castle and Schein[1]. As we known the tribo-charge of toner is major factor in electrophotographic process, the external additives and CCA (charge control agent) are usually used for toner to improve the tribo-charge characteristics.

For the purpose of stabilizing the charge amount of the toner where copying is repeatedly performed for a long period of time, chemically treated surface of fumed silica is widely used as toner's external additives. The functions of these treatments enhance the tribo-charge of toner including positive or negative charge. This affects the toner developing and transfer efficiency in the machine and, ultimately, image quality.

Experimental

Material and Instrument

The styrene acrylate copolymer is selected as the binder resin for the toner of the present invention. The glass transition temperature (Tg) is about 57~63 ℃, the acid value is 8 mgKOH/g, and the melt flow index is about 5~10 g/10min.

The magnetite with 50~100 Oe Hc value is used in the present invention.

The triphenylmethane type charge control agent for making the toner with the positive characteristic is selected and the pH value is 2~5, conductivity is less than 10 ms/cm.

The wax used in present invention is polypropylene type, the melting point is about 130~150 □, and the molecular weight is about 6000~6500.

There are two different charge characteristics of external surface additives were used in the present invention. RA200HS is selected as the positive charge characteristic silica and R972 is negative charge characteristic silica both supplied by EVONIK. The hydrophobic treatments of RA200HS and R972 are HMDS/AS and DDS respectively. The BET of RA200HS is 120~160 and R972 is 90~130.

The Charge-to-Mass Ratio (Q/m) of the toner of the present invention was measured by two different kinds of instruments. One is the Field-Projection method tribo-charge measurement system manufactured by DIT Japan; another one is the homemade Q/m analyzer which utilizes the draw-off toner transfer method.

The Q/m analyzer which utilizes the draw-off method is configured as a separate main indicator unit, a plug-in sample cell unit, and a plug-in absorption nozzle unit.

The image density of the print-out is measured by the Gretag Macbeth D19C.

Preparation of Toner

The conventional process for toner manufacture includes the steps of premixing, kneading, pulverizing and classifying, post-blending, and sieving.

The toner consisted of resin around 60wt%, the magnetite around 40wt%, positive type CCA of 0~2wt% and the wax of 0~5wt%. The individual components were premixed in mixer and then kneaded by twin screw extruder for the purpose to disperse the materials consistently into binder resin. After kneading, the extrusion chips were ground to be the particles with the size around 150~250μm by the pre-grinding equipment. The jet-mill was used for the pulverizing and classifying step. After pulverizing and classifying, the D50 of the toner of the present invention is about 8μm and the population percentage of particle size smaller than 5μm is <35%. To 100 mass parts of these toner particles, 0 to 1 mass parts of silica (included positive and negative charge) was added externally and then mixed with toner particles by Henschel mixer. The amount and type of silica of different toner sample are listed in Table 1.

Table 1

Toner No.	Positive Silica (wt%)	Negative Silica (wt%)
1	0.2	
2	0.4	
3	0.6	
4	0.8	
5	1	
6	0.2	0.2
7	0.4	0.2
8	1	0.2

Evaluation

The evaluation indices of the present invention are image density, Q/m value of toner with carrier and Q/m value of toner on developer sleeve. The copier machine used in this invention is mono component system, output is 16 ppm in A4, the

photoconductor is made of α-Si, and the developer roller is made of stainless steel. The test chart used in this invention is 6% coverage in letter size.
Image Density: Measured by densitometer/per 1000 pages.
Q/m value (toner with carrier): Measured by Field-Projection method tribo-charge measurement system before printing test. (Sample pretreatment: 2% toner concentration, 10 minutes mixing time).
Q/m value (toner on developer sleeve): Measured by draw-off Q/m analyzer/before the printing test and after 6000 pages.

The results of evaluation are presented in Table 2, in which the symbol * indicate that the printing test was stopped. Waving is remarkable uneven of a thin layer over the entire surface of the developer sleeve.

Result and Discussion

From figure 1, increasing silica content could decrease the Q/m value, this result is the same with Japanese publication patent [2]. The printing test results show that increasing the amount of positive silica could increase the image density (Figure 2). But after adding the reverse charge silica, the trend of the image density dropped obviously. From this phenomenon, the reverse charge silica affect the initial image density was apparently.

Table 2

Toner No.	Q/m Value (Toner with carrier)	Initial stage Image Density	After 6000 pages Image Density	Defect
1	15.9	1.24	1.07	None
2	12.1	1.39	0.83	None
3	9.8	1.34	*	None
4	9.5	1.41	*	None
5	7.1	1.43	*	Waving
6	17.0	1.13	0.99	None
7	9.1	0.97	0.69	None
8	5.9	1.24	*	Waving

Test pattern: 6% coverage

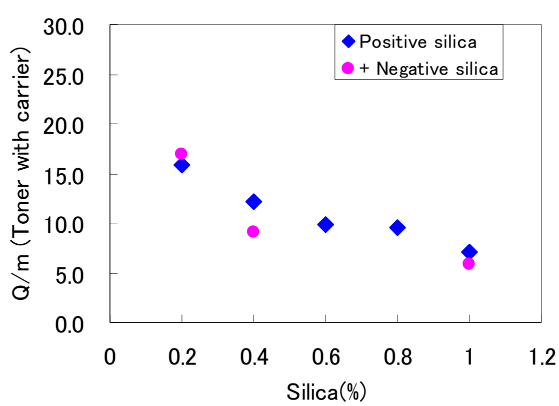

***Figure 1**. The relationship between the amount of silica and Q/m value.*

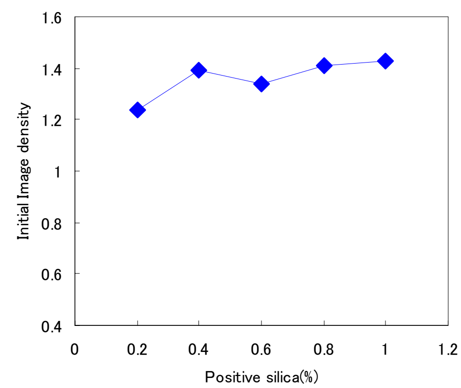

***Figure 2**. Increasing the positive silica made the initial image density increase slowly.*

From the comparison of toner No.1 and 6 (Figure 3), toner No.2 and 7 (Figure 4), the image density is more stable when added the reverse charge silica, but without reverse charge silica the image density decay faster.

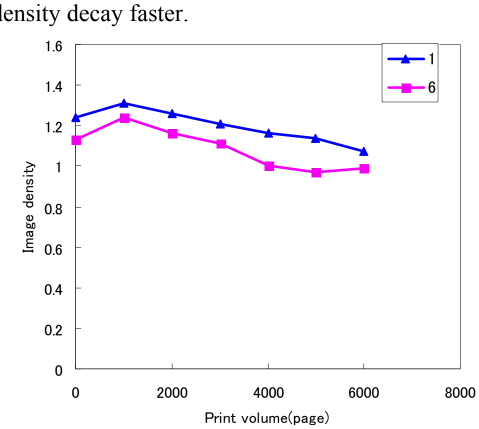

Figure 3. Adding reverse charge silica made the image density decrease slowly.

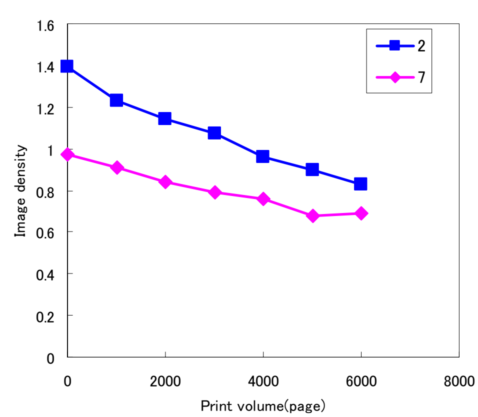

***Figure 4**. Adding reverse charge silica made the image density decrease slowly.*

From the data in Table 3, the Q/m values on developer sleeve in the initial and after 6000 pages printing are both higher when the reverse charge silica is added. That caused the image density lower than the toner which without reverse charge silica even the image density is more stable when the reverse charge silica was added.

Table 3

Toner	Positive	Negative	Initial stage	After 6000 pages
No.	Silica (wt%)	Silica (wt%)	Q/m on sleeve (μc/g)	Q/m on sleeve (μc/g)
1	0.2		6.9	7.6
6	0.2	0.2	13.4	9.1

Conclusions

By adding the reverse charge silica could stabilize the image density in the real machine printing. The results of the present invention show that the image density decay tend to slow when the reverse charge silica is added even the image density is lower than the toner without reverse charge silica. Also, the Q/m value of toner with carrier is getting lower by increasing the amount of positive silica and the Q/m value of the toner on developer sleeve is higher when the reverse charge silica is added.

References

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Wei-Ting Chen serves in Trend Tone Imaging, Inc. as R&D supervisor. He graduated in Chemical Engineering from National Kaohsiung University of Applied Sciences in 2004 and received his master degree in Organic and Polymeric Materials from National Taipei University of Technology in 2006. His research interest includes toner technology.

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