Performance analysis of pulvized "rounding" surface treated toner (RST-toner) vs. chemically prepared toner (CP-toner)

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Abstract

Chemically prepared toner (CP-toner) has been a popular research subject recently, especially in color printing application. Spherical shape is one of the most noticeable traits of CP-toner, and is attributed to as one of the advantages for superior print quality and toner transfer efficiency. Nevertheless, it is also well-known that certain modification of the spherical shape is essential to achieve an optimized toner performance to include other characters, such as OPC cleanness.

This paper is to explore the feasibility of using traditional pulverized produced non-spherical toner (TP-toner) and applying a "rounding" surface treatment process to create spherical toner (RST-toner). The performance of RST-toner, CP-toner, and non-spherical TP-toner will then be compared. The parameters for comparison are: transfer efficiency, image density, and other print quality in general.

This paper shows when TP-toner treated with "rounding" surface treatment process in addition to proper post blending material and process, the performance of the RST-toner can be significantly improved.

Introduction

Printer consumables have become more popular in the market place due to its remarkable improvement in quality. Trend Tone Imaging, Inc. (TTI) as a toner producer has been constantly striking for excellence.

This paper compares the performance of three different toners (OEM CP-toner, TTI's RST-toner, and TTI's TP-toner) which have different circularity and various surface treatments. All three toners were evaluated with same printer, and test protocol. Toner performances characteristics evaluated are: image density – small solid, image density – full page, toner consumption (T.C.), transfer efficiency (T.E.), and print quality in general.

Measuring circularity

This project uses Systmex FPIA 3000[1] to measure the particle images, the size distribution and the information on shapes of the particle in real time. Besides the shape and circularity, the size distribution and circularity distribution are also produced for all three toners: OEM black CP-toner (circularity 0.987, see Fig 1.), TTI TP-toner (circularity 0.942, see Fig 2.), and TTI RST-toner (circularity 0.974, see Fig 3.).

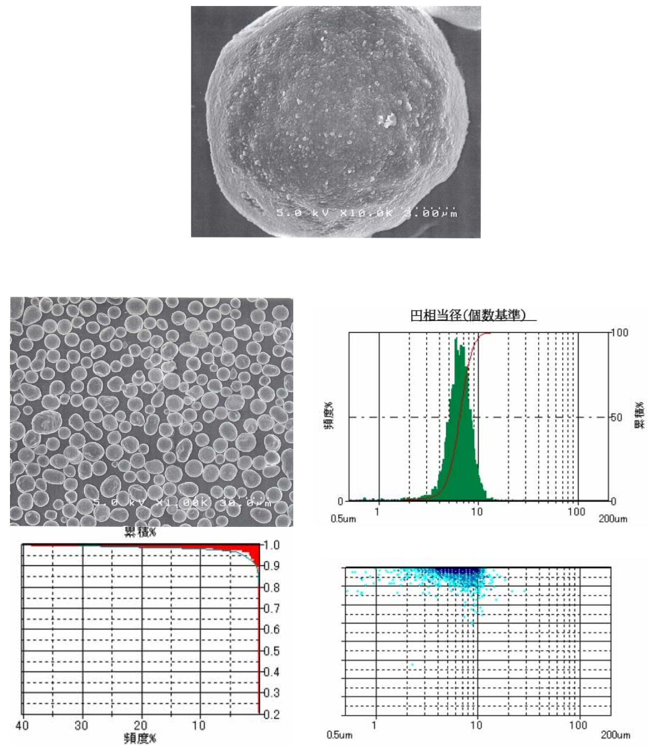
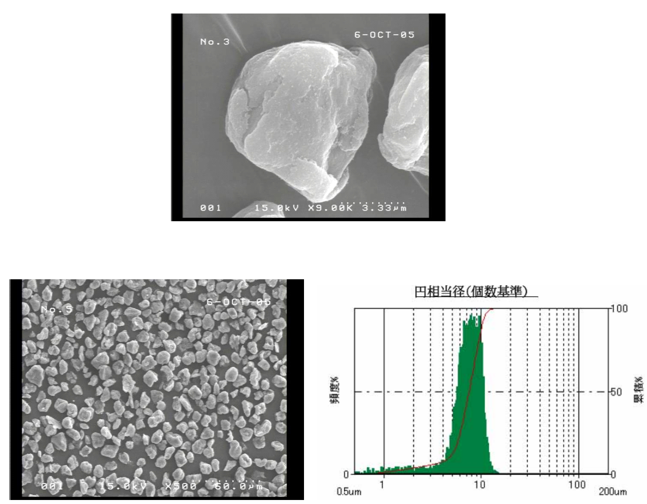


Figure 1. *Images of OEM black tone (CP-toner) with circularity of 0.987, different shape of toner particles; size distribution and circularity distribution*



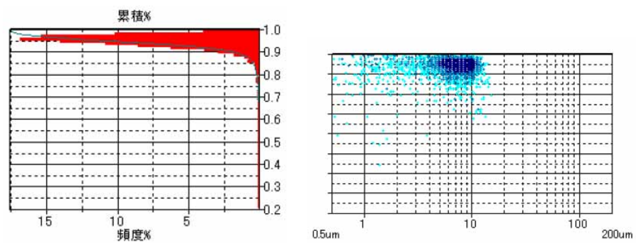


Figure 2. Images of TTI's TP-toner with circularity of 0.942, different shape of toner particles; size distribution and circularity distribution

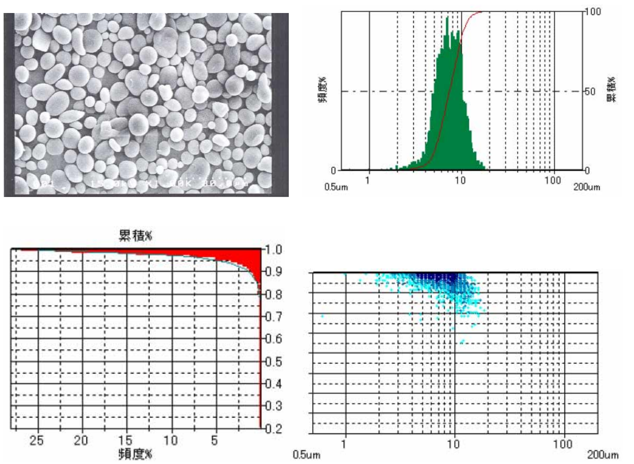


Figure 3. Images of TTI's RST-toner with circularity of 0.974, different shape of toner particles; size distribution and circularity distribution

Experimental

Toners tested:

OEM black toner
Test toner A: TTI RST-toner w/ x% Silica A + y% Resin Bead
Test toner B: TTI RST-toner w/ x% Silica B + y% Resin Bead
Test toner C: TTI TP-toner w/ x% Silica A + y% Resin Bead
Test toner D: TTI RST-toner w/ x% Silica A + x% Silica C
Test toner E: TTI RST-toner w/ x% Silica A + x% Resin Bead
Test toner F: TTI RST-toner w/ x% Silica A + x% Silica D
Test toner G: TTI RST-toner w/ x% Silica A + x% TiO_2
Test toner H: TTI TP-toner w/ x% Silica A + x% TiO_2
Test toner I: TTI RST-toner w/ x% Silica A + z% TiO_2

Post blending material used:

Post blending material: Silica A (BET 300 m^2/g), Silica B (BET 130 m^2/g), Silica C (BET 50 m^2/g), All Silica A , Silica B and Silica C have same surface treatment (coating) , Silica D (0.1 – 0.2um) Resin Bead, and TiO_2 post blended with predetermined rpm and processing time.

Silica: know in the toner industry for improving dry toner's flowability and stabilizing electrostatic charge.

Resin Bead: large particle than most silica and used as "spacer' to prevent other additives from embedding to toner. It is also used to enhance cleaning capability for doctor blade and wiper blade.

TiO_2: used to stabilize electrostatic charge and prevent OPC filming

Print test protocol:

Printer: Single component system, tandem process, 600 dpi color laser printer with speed of 17ppm

Test cartridge: new OEM black

Components: aftermarket OPC, aftermarket doctor blade, other components are OEM virgin

Test pages: 10% area coverage

Test Chart: full solid page, full 30%HTpage, "Lombardi's" page, "Ghost" page, 5% text page, blank page

Results

(1) Compare the performance of silica A and silica B with RST-toner

Table 1-1: Quantitative comparison of the performance of silica A and silica B with RST-toner

	T.C. (g/kp)	Waste (g/kp)	Waste (%)	ID-small ini / avg
Test toner A	19.53	1.18	6.05	1.68/1.62
Test toner B	19.85	1.92	9.60	1.66/1.63

Table 1-2: Qualitative comparison of the performance of silica A and silica B with RST-toner

	Print quality	Remark
Test toner A	O.K.	N.A.
Test toner B	O.K.	N.A.

Base on above test data especially the % waste of toner generated during 1000 pages print test and actual performance comparison of test toner A (contains silica A) and test toner B (contains silica B), toner A is the preferred choice to use as the main ingredient with other post blending materials.

(2) Compare the performance of RST-toner, TP-toner post blended with silica A and Resin Bead

Table 2-1: Quantitative comparison of the performance of RST-toner, TP-toner post blended with silica A and Resin Bead

	ID-small ini / avg	ID-Full ini / avg	T.C. (mg/200pgs)	T.E. (%)
OEM toner	1.47 / 1.45	1.47 /1.45	8.54	96.31
Test toner A	1.68 / 1.62	1.62 / 1.64	19.53	93.95
Test toner C	1.58 / 1.53	1.56 / 1.40	13.80	94.92

Table 2-2: Qualitative comparison of the performance of RST-toner, TP-toner post blended with silica A and Resin Bead

	Print quality	Remark
OEM toner	O.K.	N.A
Test toner A	O.K.	N.A.
Test toner C	Uniformity / White streak issue on full solid black page	N.A.

With Resin Bead present, toner A (RST-toner) performs better than test toner C (TP-toner). Although test toner C has a lower toner consumption than test toner A, the full black page unevenness is a major issue compare to OEM toner and test toner A's full black page uniformity. This is because test toner C is "stuck' behind doctor blade and having problem passing through doctor blade to be fully and uniformly developed on to paper.

Although quantitatively TP-toner seems to match OEM CP-toner better, print quality issue (see table 2-2) is a major concern and the overall performance is not acceptable. The higher image density resulted by TP-toner is not desired because of possible fusing concern and other print quality issue (HALO…) associate with C, M, Y, K process color printing.

(3) Performance of RST-toner, TP-toner post blended with silica A and TiO_2

Table 3-1: Quantitative comparison of the performance of RST-toner, TP-toner post blended with silica A and TiO_2 present

	ID-small ini / avg	ID-Full ini / avg	T.C. (mg/200pgs)	T.E. (%)
OEM toner	1.47 / 1.45	1.47 /1.45	8.54	96.31
Test toner G	1.46 / 1.37	1.41 / 1.41	8.72	94.06
Test toner H	1.46 / 1.47	1.42 / 1.42	10.33	90.80

Table 3-2: Qualitative comparison of the performance of RST-toner, TP-toner post blended with silica A and TiO_2

	Print quality	Remark
OEM toner	O.K.	N.A.
Test toner G	Slight background	PCR contamination
Test toner H	Slight background	PCR contamination

With TiO_2 present, toner G (RST-toner) performs better than test toner H (TP-toner). Test toner G and test toner H have compatible ID. However, test toner G has lower toner consumption than test toner H, and it is almost the same as OEM toner's. Some minor background issue and PCR contamination still need to be improved. The % wt part of TiO_2 will be adjusted and compared in test set (4).

(4) Performance of RST-toner, TP-toner post blended with silica A and various silica, optimized TiO_2%wt and Resin Bead %wt.

Base on the results from (1), (2), and (3) both RST-toner, silica A were final candidates along with a serious of choices for post blending and comparison. They are test toner D, test toner E, test toner F, test toner G, and test toner I.
Both test toner E and test toner F were not included in the summary, because poor performance in the early stage of the test. Test toner E had severe blade filming and streaking on the print, and test toner F had sever background and doctor blade filming full black page uniformity issue.

The following is the comparison of test toner D, G, I with OEM toner:

Table 4-1: Quantitative Comparison of the performance of RST-toner post blended with silica A along with silica C, and two different TiO_2%wt

	ID-small ini / avg	ID-Full ini / avg	T.C. (mg/200pgs)	T.E. (%)
OEM toner	1.47 / 1.45	1.47 /1.45	8.54	96.31
Test toner D	1.67 / 1.59	1.67 / 1.60	12.67	96.83
Test toner G	1.46 / 1.37	1.41 / 1.41	8.72	94.06
Test toner I	1.45 / 1.52	1.44 / 1.53	10.29	97.38

Table 4-2: Qualitative Comparison of the performance of RST-toner post blended with silica A along with silica C, and two different TiO_2%wt

	Print quality	Remark
OEM toner	O.K.	N.A.
Test		

toner D	Slight uniformity issue	N.A.
Test toner G	Slight background	PCR contamination
Test toner I	O.K.	N.A.

Judging from both of the table above, test toner I stand out to be the best of all test toners, and is very compatible to OEM toner without major print defect and other concerns.

Variations on transfer efficiency appear insignificant, however, toner consumptions can vary noticeably with different toners. A decrease in toner consumption will create thinner toner layer and make more efficiently use of the pigment dispersed in the toner particles. Other than the more efficient use of toner, the OPC drum cleaning frequency will also decreased because less toner and additive material irreversibly deposited onto the OPC drum surface[2]. This is of importance for the industry's approach for a good OEM matching system

Also, PCR contamination issue frequently observed during the tests is proven to be caused by freed additives from toner surface including silica, TiO_2, and polycarbonate from paper.

Conclusions

Thermal and / or mechanical shape modification has been commercially adapted as a way to achieve some of the advantages of chemical toner and avoid some of the disadvantage[3]. This paper demonstrates that the key performances of RST-toner are compatible to CP-toner. It is the intention of the authors to investigate whether the performance of RST-toner can be further improved with the following approaches:

(1) Quantitatively decide the effect of external additives on transfer efficiency and tribo charge. Especially the effect of various BET silica has on % waste generated during a long run life test[4].

(2) Further investigate the effect of silica (SiO_2) size[4] on toner cohesion (flow) and tribo charge[6].

(3) Further investigate different size[5], shape and % weight of TiO_2 to achieve even superior performance of TTI RST-toner.

(4) Match TTI RST-toner particle size distribution with OEM toner.

(5) Apply most appropriate parameters to Cyan, magenta and yellow colors to TTI's RST-toner.

References

[1] www.malvern.com

[2] L. Deprez,,Sabine Vanhee, Dirk Gijsbrechts IS&T's NIP22 (2006).

[3] A. SHIMADA, M. SAITO, T. MIYASAKI, Journal of the Imaging Society of Japan, Vol. 45, No. 6 p.514~519

[4] C. Suzuki, M. Takagi, Satoshi, T. Ishiyama, H. Ishida, T. Aoki IS&T's NIP19 (2005) p.134~142

[5] M. McDougall, R. Veregin, IS&T's NIP 20, p.111~114.

[6] T. Nakanishi, Y. Hoshino, K. Sheu, J. S. Huang IS&T's NIP19 (2005) p.525~528

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