Development of Polymerized Toner

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Abstract

We have investigated the application of polymerized toner to one-component non-magnetic development system, especially focused on the relationship between toner layer states and its particle shape and charge. The spherical shaped polymerized toner, produced by our single-stage-dispersion system[1)2)], is required less force and rotation time of development roller to build stable toner layer comparing with an irregular shaped conventional toner. Polymerized toner used the charge controlling agent having functional groups such as SO_2NH_2 or NO_2 on typical azo-iron complex dye, can be sufficiently charged for development. Print qualities with these toners are satisfactory, as the toner layer built on a development roller is uniform, thin and tight.

Introduction

It has been made much efforts in cost reduction of printing system which used Carlson process. In such situation, one-component non-magnetic development systems are expected to be advantageous because of their simplicities. On the other hand, particle size of toner has been reduced for the purpose of improving image resolution. With conventional melt-mixing method, the reduction of toner particle size has caused a sharp increase in production cost, because crushing energy of melt-mixed materials rises, and what is worse the collection efficiency declines. As mentioned above, raise of cost in producing small sized toner is very serious problem especially for this development system. Therefore, alternative production methods are greatly interested in. Our polymerization method called single-stage-dispersion (hereinafter S.S.D.)system is considered to be suitable in making small sized toner, as its dispersion process is designed rational to make inexpensive polymer particles ranged approximately from 2 to 8 micron meters in average [3)]. It seems that one of the most fundamental technologies in these development systems is on formation of an uniform and stable toner layer on a development roller. The toner made by S.S.D. system is expected to have good performance in forming a fine toner layer even in use of small sized toner, as it has excellent fluidity based on its highly spherical shape. At first, we have investigated the suitability of the S.S.D. toner to this development system by measuring of horizontal force against regulation blade and rapidness of toner layer formation in comparison with the conventional toner having the same formulation. Secondary, the adaptation of the charge controlling agents(hereinafter C.C.A.) to S.S.D. toner are described. In this study, typical azo-iron complex dye was applied as the base structure of C.C.A. We have investigated the relationship among their functional groups and tribo-electric charge and states of the toner layer.

Experimental

Experimantal 1

Toner layer formation model is shown on *Fig.1*. A sandblasted flat metal plate(A5052) assumed as a surface of a development sleeve were prepared for the measurement of horizontal force(F_h) against regulation blade. A blade made of urethane rubber, of which Young ratio is 87 kg/cm^2, is attached to the metal plate at 60 degrees of its contact angle. Feed direction of the metal plate is shown as an arrow. Process speed was set at 25 mm/sec. Blade pressure are variable form 10 to 80 g/cm. Toner was located in the backwards of the plate.

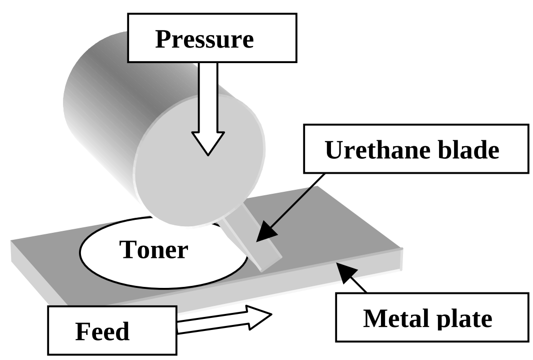

Figure 1. Toner layer formation model on metal plate

Rapidness of toner layer formation on a development roller of a commercialized L.B.P. was measured by a surface potential meter. On this L.B.P., an elastic development roller is utilized for contact development. Surface potential(V_t) of toner layer by each rotation cycle of the development roller was evaluated.

Experimental 2

Toner charge(Q/M) and deposited toner weight(w) on the development sleeve of the above-mentioned LBP were measured. Total charge(Q) was measured directly as the counter-charge from the development roller by removing the toner layer with air suction. At the same time, removed toner was caught by a filter, and measured of its weight(M). We define toner charge as the charge to mass ratio(Q/M). Deposited toner weight(w) is calculated as dividing M by the surface area after removal. Filling ratio(p) is given as the unknown in the equation(1). Thickness(d) of toner layer is given by the equation(2). Toner shape factor(S_f) is defined as equation(3).

$$V_t = \{w^2(Q/M)\} / [2\varepsilon_0\{1+p(\varepsilon_t-1)\}p\, D_t] \qquad (1)$$

where D_t is toner density
ε_t is relative permittivity of toner

$$d = w/(p\, D_t) \qquad (2)$$

$$S_f = (4\pi S)/l^2 \qquad (3)$$

Where S is the projected area of a toner particle
l is the projected boundary length of a toner particle

Image density of solid area and background fog on photoreceptor before transfer was measured by reflect meter.

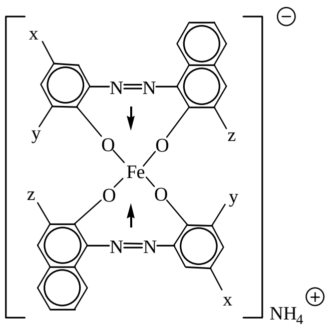

Figure 2. Structure of C. C. A.

Preparation of Toner

Base Structure of C.C.A. is shown on *Fig.2*. Applied functional groups are shown on *Tab.1*. Every toner has the same formulation, 85% Styrene / 15% n-Butyl-acrylate monomer is adopted. Contents of carbon black and C.C.A. were fixed in 5.0 and 2.0 weight pert to the total monomer weight. Every toner from “A” to “F” was produced by S. S. D. system, “REF” and “REF(R. E.)” were both conventional toners, which have the same formulation as “D”, especially “REF(R. E.)” was treated on its surface to be round-edged by mechanical force.

Table 1. Combination of Functional Groups on C.C.A.

Toner	Functional groups x	y	z	Toner production
A	H	H	H	*1
B	H	H	CONH-C_6H_5	*1
C	Cl	H	CONH-C_6H_5	*1
D	NO_2	H	CONH-C_6H_5	*1
E	NO_2	NO_2	CONH-C_6H_5	*1
F	SO_2NH_2	H	CONH-C_6H_5	*1
REF	NO_2	H	CONH-C_6H_5	*2
REF(R.E.)	NO_2	H	CONH-C_6H_5	*3

*1 polymerized, *2 conventional,
*3 conventional / round-edged

Results and Discussions

Dynamic Properties of Toner Layer Formation

Polymerized “D”(S_f=0.92) and conventional “REF” (S_f=0.59) were chosen for measuring horizontal force(F_h.) The relation between blade pressure and F_h is shown in *Fig.3*. The spherical toner “D” produced by S. S. D. system is suffered less stress from regulation blade on building toner layer in every pressure condition. This result indicates that spherical toner is highly advantageous in durability at continuous usage. We have already reported a test result on 2000 continuous printing which proved the stability of our polymerized toner.[4] At the blade pressure 50g/cm, large increase of F_h are observed, It shows the critical pressure from edge to surface attaching of the blade.

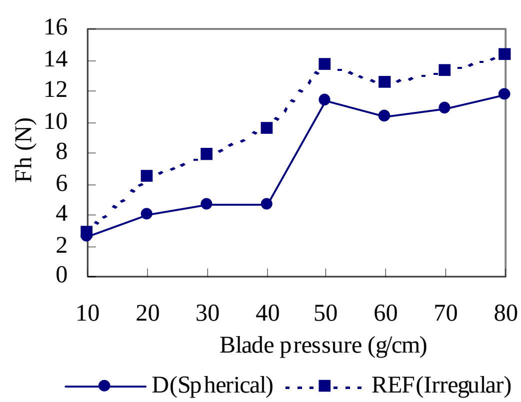

Figure 3. Relation between blade pressure and horizontal force

Fig.4 shows a result on rapidness of toner layer formation which is directly effected to image qualities. In this test, “D”, “REF”, “REF(R. E.)” (S_f=0.73) were evaluated. Polymerized toner “D” stands up quickly to steady state even in a few rotations. Rapidness of toner layer formation is highly correlated with the shape factor. This result shows that spherical shape assists smooth formation of toner layer by self-rotating of toner particles under a blade pressure field. As V_t is considered to be mainly depended on Q/M and w from equation(1), it also suggests the goodness of polymerized toner both on tribo-electrical and mechanical properties.

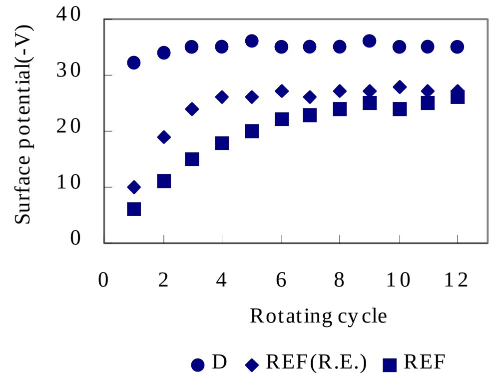

Figure 4. Rapidness of toner layer formation on a development roller

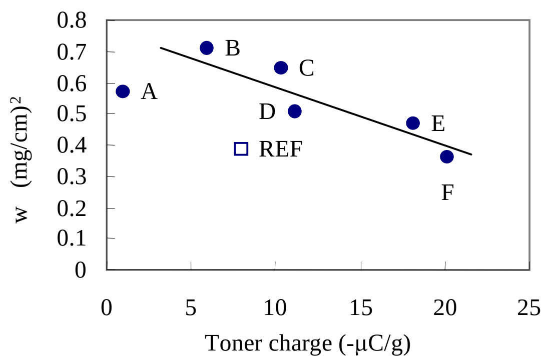

Figure 5. Relation between toner charge and deposited toner weight on a development roller

Static Properties of Toner Layer

Relation between toner charge(Q/M) and deposited toner weight(w) are shown in *Fig.5*. Polymerized toners named "E", "F", using C.C.A. that consists of NO_2, SO_2NH_2 as functional groups, respectively, have enough charge and obtained uniform layer. "A", on which adopted C.C.A. has only hydrogen, is given very low charge. It results in the reduction of toner image force to sleeve, therefore its layer became to have defects such as small soft-lumps of toner on the sleeve. Absolute value of w is very fundamental ,as it determines supplying mass of toner to the development zone and finally effects on image density and resolution. On "F", w might be seemed to be slightly low, but is judged enough to get high image density, because the development speed is set twice to process, (usually described as θ=2), so the supplying mass to electrostatic latent image on photoreceptor results in up to 0.7mg/cm^2 approximately. This amount is enough for 7μm polymerized toner to obtain image density up to 1.3 or more.

Calculation of Filling ratio(p) and Thickness(d) of toner layer by Equation(1) and (2) are given in Fig.6 and Fig.7, respectively. With the increase of toner charge, filling ratio increases and thickness decreases. These results show that well charged toner tends to build a thin and tightened, uniform layer. In the case of toners "D", "E", "F", any defect has never observed on toner layer. Conversely, low-charged toner such as "A", "B", have a tendency to be coarse and bulky layer, as the result of reduction of image force.

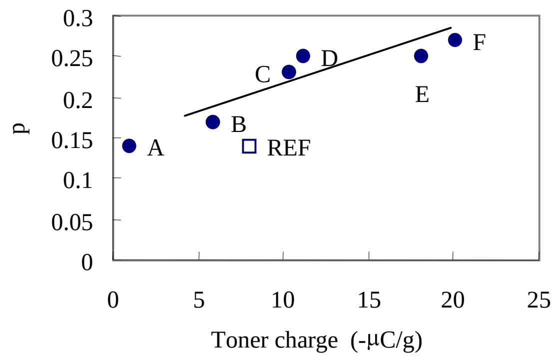

Figure 6. Filling ratio of toner layer

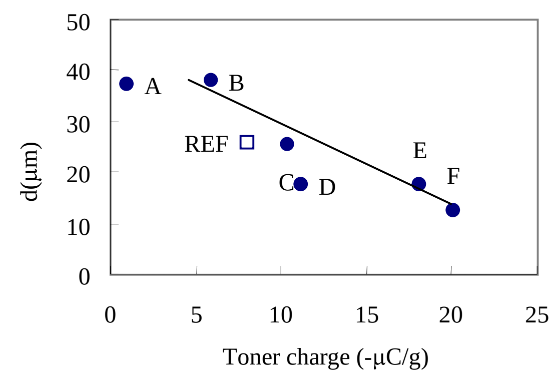

Figure 7. Thickness of toner layer

Fig. 8 shows image density. Although deposited toner on sleeve of "F" is just little as noted above, it proved that "F" can have relatively high image density.

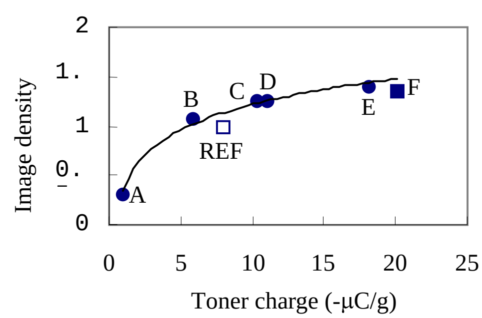

Figure 8. Image density

Fig. 9 shows that the threshold of background fog is approximately at -10μC/g in this LBP. "C", "D", "E", "F" were observed no fog. "A" resulted in high background fog which was still remained on photoreceptor after transfer process. Primary cause of the occurrence of residual toner is thought to be depended on counter charged toner originated from the lower charge ability of the applied C.C.A.[4]. Conventional "REF" shows slightly higher fog comparing with polymerization "D" of the same formulation. The difference may come mainly from the standing up properties of V_t as shown on *Fig.4*.

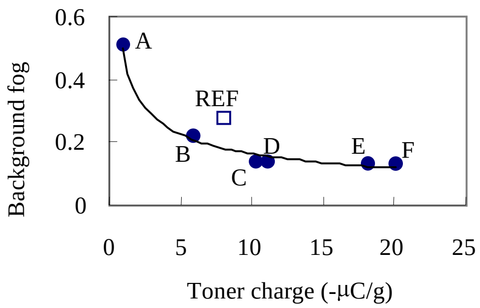

Figure 9. Background fog

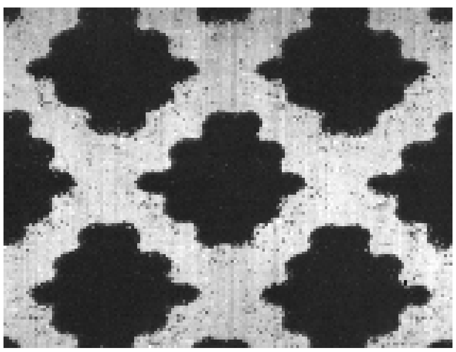

Figure10-a. Polymerized toner "F"

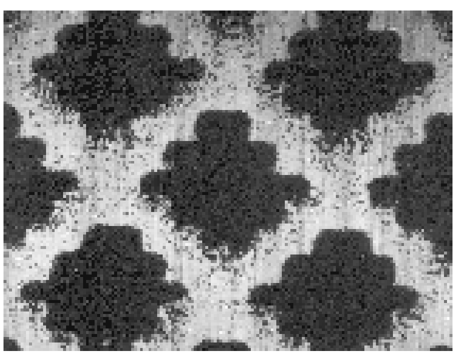

Figure10-b. Conventional toner "REF"

Magnified image on photoreceptor of "F" and "REF" are shown on Fig.10-a and Fig10-b, respectively. Comparison of these print samples shows that S. S. D. toner, under suitable usage of C.C.A., can produce superior qualities on raggedness. It is well-known that particle size is one of the most important factor to determine image quality. But in this case, even almost similar particle size do these toners have, difference of the both images is clear. The reason of this difference is thought to be come from the difference of the mechanical and tribo-electrical uniformity .

Summary and Conclusions

At a regulating part of toner layer on a development roller, high fluidity of toner particles should be strongly required to prevent toner aggregation and lack of supplying mass. Cited every polymerized toner "A" to "F", has a good fluidity comparing with the conventional toner, and what is more, spherical shaped polymerized toner is able to take a view to rotate easily at the regulating part, resulted in a reduction of blade stress(F_h), rising in rapidness of toner layer potential(V_t). But, on a formation of toner layer, fluidity of itself could be only one of the essential conditions, but can not be sufficient. It is thought that image force of toner to sleeve surface could be another key factor. Such as "E", "F", enough charge-able toner and consequent sufficient image force makes its toner layer uniform, thin, and tight. Image quality of these toners are satisfactory.

Polymerized toner was investigated on one-component non-magnetic development. Conclusions are as the follows:

- Spherical shape reduces mechanical stress against regulating blade and rises on rapidness of toner layer formation.
- C. C. A. based on azo-iron dye having SO_2NH_2 or NO_2 .as the functional groups can give toner sufficient charge for development.
- Increase of toner charge result in raise of filling ratio and reduction of thickness on toner layer.

References

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Biography

Hiroki Totsuka received his B.E. and M.E. in Mechanical Engineering from Shizuoka University in 1978 and 1980, respectively. He joined Tomoegawa Paper CO., LTD. in 1980 working on R&D of both conventional and polymerized toner in Technical Research Laboratory. His current interests are in full color polymerization toner and high speed process of one–component non-magnetic development.