Effect of CCA Particle Configuration on the Charging Behavior of CCA/Binder Matrix Film Surface

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Abstract

The amount of tribo-charging generated between CCA/binder matrix films and ferrite carrier beads were measured by the cascade method. CCA particles were dispersed or dissolved in several binder solutions, and these solutions were applied to stainless steel plates to prepare the CCA/binder matrix films. The results show that the amount of charge is determined by the size or orientation of the CCA particles on the matrix film surfaces and by the chemical interactions between the binder-resin molecules and the CCA particles. It was confirmed that the charging characteristics of the CCA/binder matrix can be evaluated quantitatively by the cascade measurement.

Introduction

The amount of charge of the toner particles for an electrophotographic developer is the most important physical parameter that determines the quality of developed images. Usually, a Charge Control Agent (CCA) is used to adjust the amount of toner charge. The charge control function is attained by adding the CCA particles into a toner. The following factors affect the charge control function of the CCA in a toner.

1. The physical and chemical properties of the CCA; electron donating and electron accepting characteristics, electrical conductivity, etc.
2. The particle or molecule configuration of the CCA on the toner surface; particle agglomeration, the particle diameter, particle orientation, the ratio of the surface area occupied by the particle, etc.
3. The migration of a CCA component from the toner surface to the carrier surface.
4. The chemical and physical interaction of the CCA with a binder resin.

Little work has been done to clarify the effect of CCA particle configuration on the amount of charge on the toner surface. In general, CCA is considered to decisively control the toner charge. The amount of charging of toner which contains the same kind of CCA, however, differs remarkably by the chemical interaction with resins and pigments. From this point of view, this report aims at clarifying the effect of factor 2 and factor 4 mentioned above.

A thin CCA/binder-resin matrix film surface was used as the model surface that represents the toner surface. The amount of charge generated by cascading a ferrite carrier on the thin film surface was measured by the cascade method. From the amount of measurement charge, the effect of the CCA on the charging characteristics of the film has been evaluated quantitatively. The effects of the configuration of CCA particles on the matrix film and the chemical interaction between the CCA and binder resin were also considered. The results and considerations are described below.

Experimental Methods

Preparation of the CCA/Binder-Resin Matrix

Fig. 1 shows the structural formula of the CCA (tert-butyl-salicylate zinc complex SZC) used in this experiment.

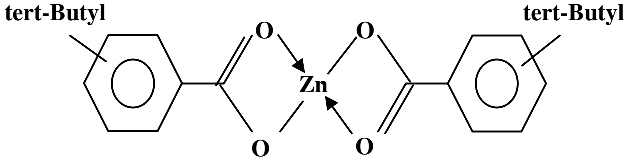

Figure 1 Charge Control Agent tert-Butyl-salicylate Zinc complex (SZC)

The formulations of the binder-resin solutions for the preparation of CCA/binder-resin matrix films are shown in Table 1. The binder-resin concentration in the solutions was kept constant at 5 wt%. All binder-resins are commonly used as the binders of commercial toners.

The procedures for preparing the CCA/binder-resin matrix films are shown in Fig. 2. For preparing a COC-1 matrix film with the solution No. 1, a prescribed amount of the SZC and zirconium oxide beads (Diameter: 0.4 mm ϕ) are added to the solution in a shaking glass vessel. The vessel was set to a paint conditioner and shaken to obtain the SZC dispersion. For preparing other matrix films of the solutions No. 2 - No. 6, a prescribed amount of SZC particles was added to one at the solution in a glass beaker. Ultrasonic waves were applied to the beaker for 5 minutes to obtain a SZC dispersion. The particle size distribution was measured for the SZC dispersions of different mixing time and different concentration by using a dynamic light scattering particle size analyzer.

Table 1 Formulation of the Matrix Film

Solution No.	Matrix film name	Binder resin	Solvent
1	COC-1	Cyclo-olefin-Copolymer (COC)	Toluene/Heptane (1/1)
2	COC-2	Cyclo-olefin-Copolymer (COC)	MEK/ Toluene/Heptane (1/10/10)
3	PE-1	Polyester-1 (A.V. : 1)	THF/Toluene
4	PE-2	Polyester-2 (A.V. : 10)	MEK
5	EP-1	Epoxy	MEK
6	SA-1	Styrene-acryl-copolymer	MEK

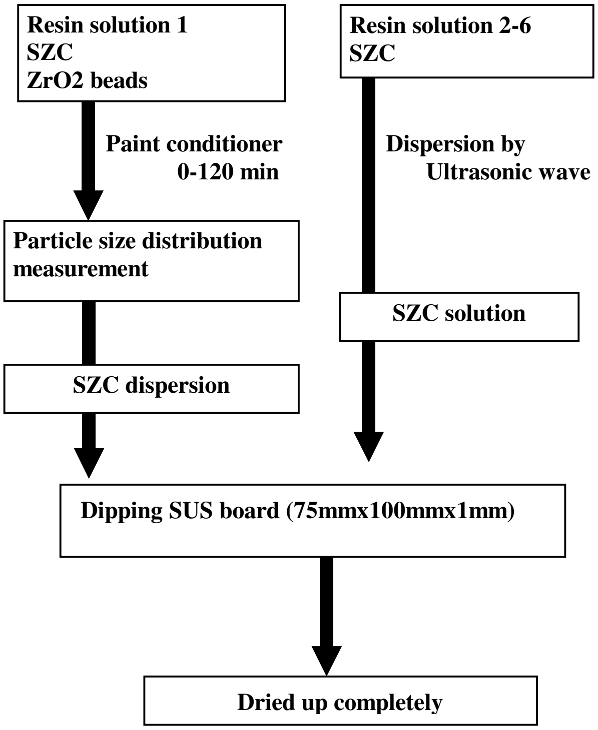

Figure 2 Preparation of the CCA/resin matrix film

A stainless steel (SUS) plate is dipped to the dispersion, pulled up, and dried in a 70 degree C oven for more than 1 hour to obtain a dry matrix film. The films were prepared by using the dispersions of different SZC concentrations and different mixing times.

Cascade Charge Measurement

The outline of the cascade charge measurement equipment is shown in Fig. 3.

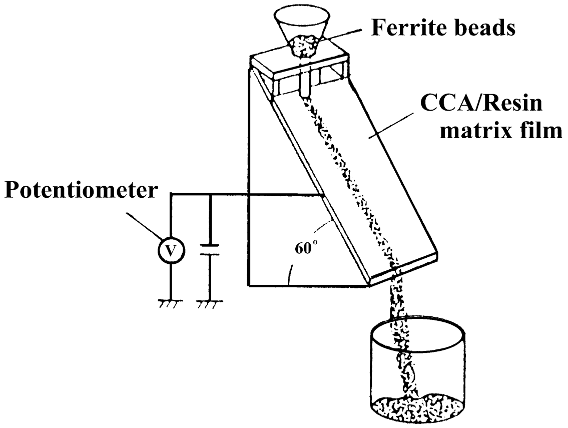

Figure 3 Schema of cascade method

Ferrite beads (Diameter: 55~74 μm) were cascaded onto the matrix film coated on the SUS plate set on the declined surface of a PTFE block. The charge generated on the film was measured with an electrometer connected to the SUS plate.

Results

Effects of SZC Particle Size on the Matrix Film Surface

The amount of charge of the COC-1 matrix film prepared from the solution No. 1 (Resin: cyclo-olefin-copolymer COC) was measured by the cascade method. The results are shown in Fig. 4. The amount of charge increases with the concentration of SZC in the matrix film. When mixing the dispersions with the paint conditioner, the particle size decreased from 5.2μm (mixing time: 0 min.) to 2.4 μm (mixing time: 120 min.) as the mixing time increased. By the initial mixing of the dispersion (mixing time: <30 min.), the amount of charge at the low SZC concentration region increases remarkably. When increasing the mixing time to more than 30 min., however, the charge increasing effect by increasing the mixing time becomes much smaller and nearly the same saturation charge is obtained.

In general, the surface occupation ratio of the SZC particles on the matrix film determines the amount of charge. This means that the decrease of particle size by mixing the dispersion increases the number of the SZC particles on the matrix film surface, and thus increases the ratio of the surface area occupation by SZC. The increase of charge by the initial mixing of the dispersion can be explained by this concept. The fact that the charge does not increase any more by continuing the mixing operation, however, is contradictory to the concept. The saturation of the amount of charge in this case is attributed to the surface degradation of the SZC particles by the mixing operation.

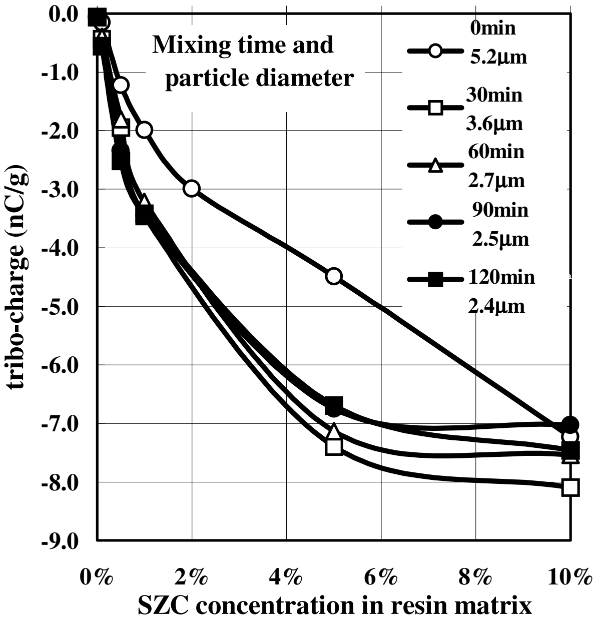

Figure 4 Effect of SZC particle size on the amount of charge

Effects of the SZC Particles Configuration on the Matrix Film Surface

The amounts of charge of the COC-1 and COC-2 matrix films prepared from the solutions No. 1 and No. 2 are compared in Fig. 5.

The solubility of the SZC particles to each solution, however, is quite different. The SZC particles were dissolved perfectly in the solution No. 2; SZC particles were not detected on the COC-2 matrix film surface by the microscope observation.

In the low toner concentration region (toner conc.: <2 Wt%) the amount of charge of the COC-2 matrix film prepared from the solution No. 2 was nearly five times as large as that of the COC-1 matrix film made from the solution No. 1. It is said that the charge control effect disappears if the particle size of CCA becomes too small. In the case of the COC-2 matrix film, however, the particle size of SZC is considered to be comparable to the molecular size but still possess a strong charge control function. This result suggests that, in the case of COC-2 matrix film, a small amount of SZC particle addition bring about a useful amount of charge to the matrix film.

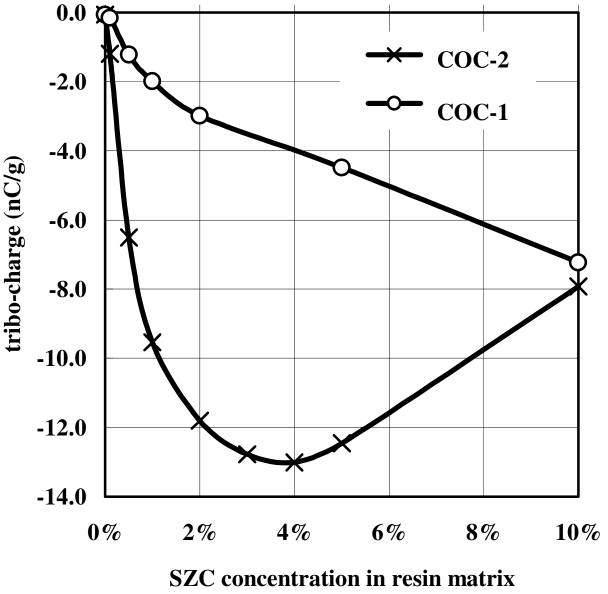

Figure 5 Effect of SZC particle configuration on the amount of charge

The amount of charge of the COC-2 matrix film reached a saturated value at a SZC concentration of 3wt%, then decreased as the concentration increased. At the concentration of 3wt%, it is considered that the orientation of molecular size SZC particles on the film surface reaches to the maximum order, and then the order decreases gradually as the concentration increases.

Effects of the Types of Binder Resin in the Matrix Film

The amount of cascade charge of the SZC matrix films prepared from the solution No. 2 solution ~ No. 7 are compared in Fig. 6. In this experiment, the SZC concentration was changed from 0 wt% to 50 wt%.

The charge increasing profiles with increasing SZC concentration are extremely different by the types of resin in the solution.

In the case of the COC-2 matrix film prepared from the solution No. 2 (resin: COC), the charge increasing profile is quite different from other matrix films. The large amount of charge obtained at a SZC concentration of 3wt% suggests that, in the film drying process of the coated dispersion, the molecular size SZC particles (crystals) are deposited and oriented on the matrix film surface because of the poor solubility of the SZC molecules in the COC resin.

The PE-2 matrix film made from the solution No. 4 (resin: polyester-2, acid value 10) also shows a large amount of charge. This matrix film, however, has already a large negative charge at the SZC concentration of 0wt%. This large negative charge is considered to come from the large acid value of the polyester-2 resin.

In the case of the PE-1 matrix film prepared from the solution No. 3 (resin: polyester-1, having a similar molecular structure to the polyester-2, acid value 1), the amount of charge is not so large. It is interesting that the charge increasing profiles in both matrix films prepared from the solution No. 3 and the solution No. 4 are nearly equivalent when the amount of SZC addition is increased. In the case of the charge increasing profile on the PE-2 matrix film, it seems that an additional fixed amount of negative charge was given by the acidic functional group in the polyester-2 resin.

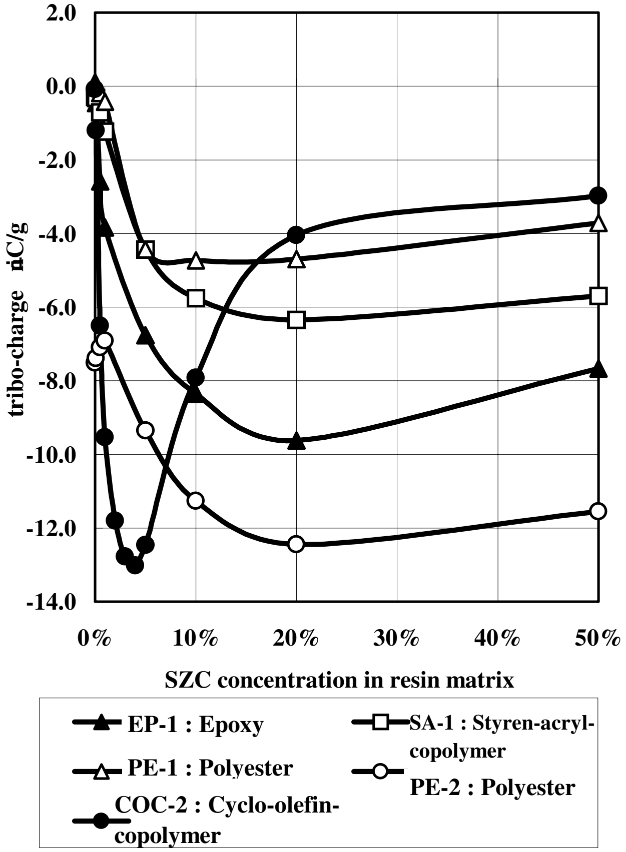

Figure 6. Effect of types of resin on the amount of charge

The cascade charge increasing profile obtained for the EP-1 matrix film (resin: epoxy) and SA-1 matrix film (resin : styrene-acryl- copolymer) shows similar tendencies, but the amount of saturated charge is different.

As a result, it is considered that the difference of the charge increasing profiles or saturation values obtained from the matrix films made from different types of resins are determined by the solubility of the SZC particles in a resin film or chemical interactions between the SZC particles and the resin molecules; the particle size and the degree of orientation of the SZC particle determine the configuration of the SZC particles on the matrix film surface.

Conclusion

It was confirmed that the cascade method is an excellent tool to evaluate the charging characteristics of the CCA/binder-resin matrix film. The amount of charge is determined by the size or orientation of the CCA particles on the matrix film surface. The effect of the CCA particle to the amount of charge is attributed to the area occupation ratio of the CCA particles on the matrix film surface.

The amount of charge is also determined by the interaction between the binder resin molecules and the CCA particles. Since the CCA/binder-resin interaction affects the solubility of the CCA molecules into the film, the interaction also determines the CCA particle size or particle orientation of the CCA at the matrix film surface.

The difference between the amount of charging measured by the cascade method and by the blow-off method will be discussed elsewhere.

References

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Biography

Keiki Suganami obtained his B.S. in chemistry from Sophia University in 1982. Since that year, he worked on research and development division at Morimura-Badische Co., Ltd. 1999, the company name was changed to Morimura-Chemicals Ltd. In this year, he entered a Ph D. course of Ibaraki University.