Effects of Triboelectrical Charge of Toners on Display Characteristics of Toner Display

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Abstract

Toner Display is based on an electrical movement of charged toner particles. Two types of black and white particle charged in the different electric polarity are enclosed in the air space between two transparent electrodes. The black toners are collected to the electrode by an electrostatic force across the insulting layer to display a black image. Those toners can be put to the counter electrode by applying a reverse electric field, and white solid image is displayed.
The display contrast and driving voltage depend on the electrical charge of toner particle in the display cell. In this study, the triboelectric charges of particles in the display cell were measured using Q/M meter. Those charges depend on the mixture ratio of two toners. The triboelectric charging mechanism between small toner particles was discussed.

Introduction

As a consequence of series of researches on electronic paper, an electronic paper that can display and erase digital information has been investigated recently. As far as the toner display is concerned, it is one of the display type of electronic paper which is based on electrical movement of charged particles. The black and white particles which were charged positive and negative respectively are enclosed in between the electrodes using an insulating spacer. The particle movement is controlled by the external electric filed applied between the electrodes. The toners can be put back to the counter electrode by applying a reverse electric field, and white solid image is displayed. The threshold and driving voltage to move the particle depend on the electric charge and flow ability of particles [2,3]. When the features are concerned, it has a wide viewing angle, image memory and high responses. And also, the display contrast and driving voltage depend on the electrical charge of toner particles in the display cell.

Toner Display

The display device [4] is sandwiched type cell structure which is enclosed in two transparent ITO (Indium-Tin Oxide) electrodes using an insulating spacer. The model structure of toner display device using black and white particles is as shown in Figure 1. The toner particles are enclosed in the space between the two electrodes and the particular black and white particles were charged triboelectrically [1] in positive and negative respectively. The device displays black pattern due to movement of black particles to negative electrodes due to the Coulomb force between the particle charge and negative charge on the electrode. When the polarity of an applied voltage is reversed, the negative charged white particles move to the top electrode and covered on the top electrode and then the white pattern is seen through the top electrode. This mechanism is illustrates in Figure 2. Black and white patterns can be changed by the polarity of applied voltage caused by the movement of toner and white particle between two transparent electrodes.

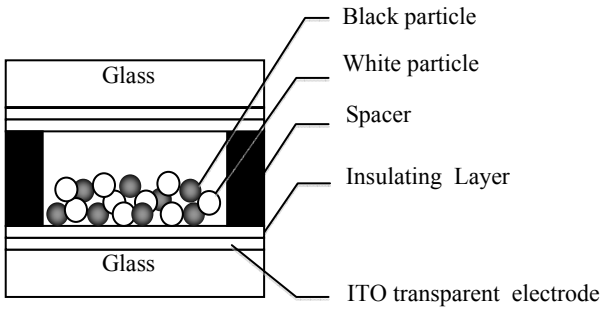

Figure 1. *Structure of the toner display.*

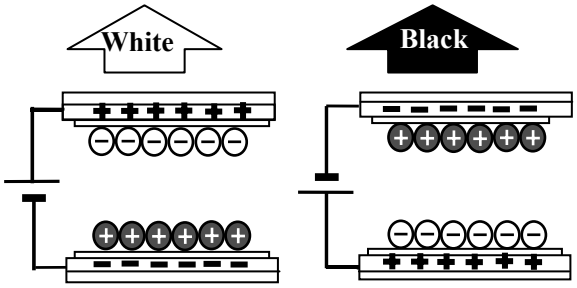

Figure 2. *Black and white toner movements by applied voltage and the device displays black or white patterns.*

Experimental Materials

As far as the experimental samples are concerned; positively charged black toner, negatively charged white toner (W Ⅱ), YellowTonerY-1 (Oki, microline) and an additive TiO_2 particle (NKT-90, Evonik) was used in this experiment. This specific additive has a negative electrostatic charge and provides a high charge stability to toners and efficient free flow aid for toners, were varied 1:1 to 2.5:1.
When the experimental set up is considered, the insulating polymer layer is coated on the each transparent electrode. The thickness of spacer is 100 μ m and the size of one pixel is 10mm x 10mm. The black toner and white particle were

used in this display cell. The toner particle is almost spherical in shape and its size is 10 μ m. The white particle is elliptical shaped particle with a size of 10 μ m and has a high electric resistance. The polycarbonate polymer (Teijin chemicals Ltd., Panlite k-1300) was coated on transparent electrode. The layer thickness is 3 μ m.

Measuring Method

In this study, the triboelectric charge of toner particles in the display cell were measured with the help of Q/M meter (Charge-To-Mass Ratio System H210S (TREK Japan). The particles were triboelectrically charged by shaking for 150 times. As the display contrast and the driving voltage depend on the electrical charge of toner particle, the optical reflection density was measured with Reflection Densitometer (Ihara Electron Ind. Co. Ltd., Ihac-11). Consequently, the data were analyzed for reflection density dependence on applied voltage.

Process of measuring electrical charging

As for the first step, the particles were inserted in to a screw type bottle and were triboelectrically charged. Then the charged particles placed in the toner display cell and voltage was applied so as to separate the black and white toners to the polarity of electrodes as shown in Figure 3.

Observation of particles

Put particles on substrate glass, superimpose another substrate glass, and spread it softly. Both particles of black and yellow toners are spread on the glass to observe the linkage of the particles using the optical microscope (VEX-200, KEYENCE).

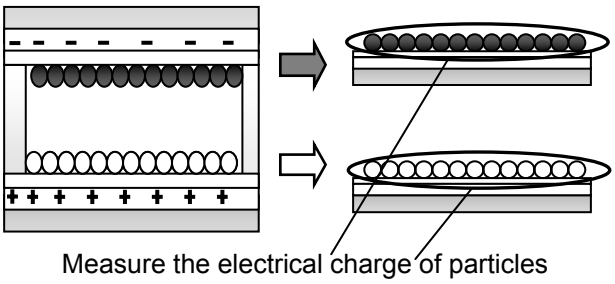

Figure 3. *Process of measuring.*

Results and Discussion

The weigh mixture ratio and electrical charge

Figure 5 shows relation between the weight mixture ratio and electrical charge when the Toner-K-1 and Toner-Y-1 are mixed. When increase the mass of black toner for mass of all, electrical charge decreases. On the contrary, when decrease mass of black toner for mass of all, electrical charge of yellow toner increases. The yellow toner show that reverse behaviour. But when mass of black toner become it than a certain value, electrical charge at that time show the constant value.

As far as the graph of dependence of reflection on applied voltage is concerned for the case of without additive (Figure 4), it is observed that the threshold voltage is 100v. The particle mixing ratio between white and black in this case is 2:1. By considering the respective reflection densities, the maximum contrast could be observed at the voltage of 500v. And also, the contrast is increased with the increment of voltage beyond 300v.

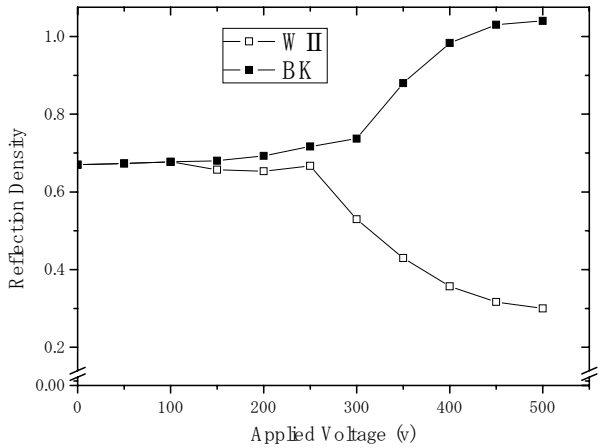

Figure 4. *Display characteristics for Black and White toner*

Figure 6 shows the specific toner charge dependence on toner weight percent. By observing the graph, it can be understood that the electrical charge does not exceed certain value. It is assumed that the difference of the number of positive and negative particles increased, the total electrical Charge is decreased when some particles are mixed with the opposite charging particles at attaching to the substrate glass. And also it can be noticed that the electrical charge does not decrease beyond a certain value.

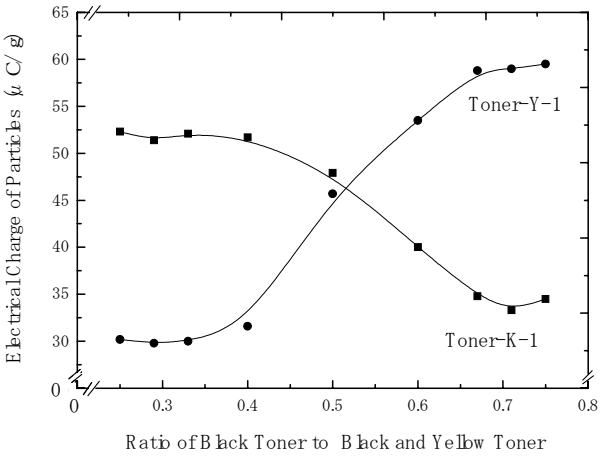

Figure 5. *Relation between an electrical charge to mass ration of toner and weigh mixture ratio of black toner.*

It is assumed that there is a possibility of having triboelectrically not charged particles and consequence of that, the electrical charge does not decrease due to the unability to measure such particles in this method.

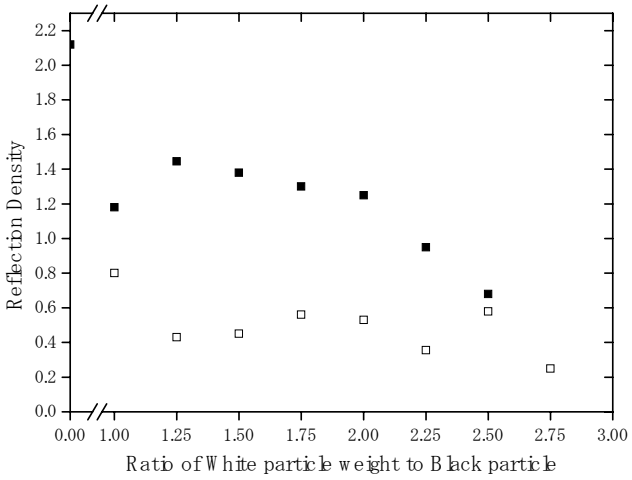

Figure 6. *Display characteristics for Ratio of White particle weight to Black particle.*

When the Figure 6 is concerned, it illustrates the dependence of reflection density on ratio of white particle weight to black particle, it is understood that reflection density decreases abruptly when the ratio increases. As a result of this the black contrast is decreased. When the white particles are concerned; it is decreased gradually and results an increment of appearance in white. It is understood that the charging mechanism according to the Figure 6 is affected on this type of result.

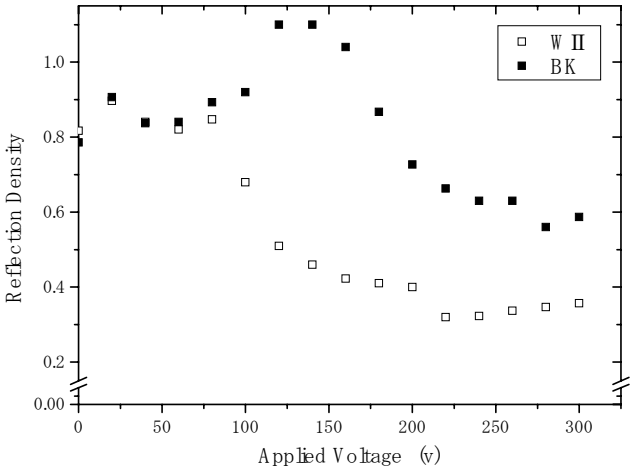

Figure 7. *Display characteristics for 0.5wt% additives NKT-90*

The Figure 7 shows the dependence on reflectance density on applied voltage for the case where additive is inserted. By comparing the Figures 4 and 7, it can be observed that, the threshold voltage which is 40v in the case where additive has used is less than the case where additive has not used. The reason for this is assumed as the bonds between charged particles are released due to the application of additives when shaking with the particles. And also it is noticed that the contrast is maximum at the voltage of 140 Volts.

Conclusion

The triboelectric charges of particles in the display cell were measured using Q/M meter. Those charges depend on the mixture ratio of two toners. The triboelectric charging mechanism between small toner particles was discussed.

It is understood that the reflectance density is directly affected by the ration of white particle weight to black particle. By applying the additives, the threshold voltage is reduced due to the destruction of bonds between triboelectrically charged particles.

References

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Author Biography

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