Comparison Between Resin Sphere and Film Charging by Various Charging Characteristic Carrier

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Abstract

Tribo-charging phenomena have been known since Greek age and various studies have been carried out. In electrophotography, toner tribo-charging by carriers is very important. Standard carriers have been developed for estimating toner charging property by ISJ (Imaging Society of Japan). There are four types of carriers from positive to negative charging characteristics. The carriers are expected to be applied to estimate characteristics of other materials. Film charging characteristics by the carriers have been studied. Film charging abilities are estimated by plotting surface voltage against four types of carrier charging abilities. The estimated film charging abilities show good correlation with film-film rubbing charging experiments. In this report, resin sphere balls which are bigger than carrier and made from PMMA (Polymethylmethacrylate), PP (Polypropylene) and PTFE (polytetrafluoroethylene) are charged by the ISJ standard carriers and the charging abilities is estimated. It is suggested that the carriers are also applicable to estimate the charging characters of bigger size resin ball.

Introduction

Tribo-charging phenomena happen when insulator material contacts with other materials. It is very familiar phenomena. One of important its application is electrophotography [1,2]. Toner charge amount is very important in the electrophotograpic printing process [1-3]. Many studies on triboelctricity phenomena of powders has been carried out [4,5], and even recently possibilities of new charging mechanism [6] and studies for deeper understanding [7] have been reported. Although toner charging mechanism is not understood enough, toner charging is controlled to the level of realizing practical use in electrophotography.

Standard carriers have been developed for estimating toner charging property by ISJ (Imaging Society of Japan) [8,9]. There are four types of carriers from positive to negative charging characteristics. The carriers are expected to be applied to estimate charging characteristic of other materials.

Charging phenomena by contact have been studied on various type of contact system. Typical contact system is mixing system of toner and carrier. Carrier and film contact is other contact system [10-12]. The contact condition is controlled to approach uniform contact and charge amount is estimated by surface voltage measurement. Larger size sphere balls than toner are also used in triboelectricity study [13,14]. The method of using large size sphere ball has characteristics that the ball contact uniformly with object although its contact is macroscopic and every charge amount of ball can be measured by Faraday cage.

In this report, resin balls which are bigger size than carrier are used as material for charging. Three types of resin ball made from different material are charged by contact with film, steel and 4 different charging characteristics ISJ carriers. The applicability of ISJ carriers to resin ball is studied.

Brief Review of ISJ (Imaging Society of Japan) Standard Carriers

Four types of carriers are developed as standard carriers which have different charging abilities, where as; highly positive, medium positive, medium negative and highly negative by The Technical Committee of Toner Technology of ISJ. They are developed for estimating toner charging properties and it is expected that they can position the charging ability of various substance in addition to toner. Photos of carriers are shown in Fig. 1.

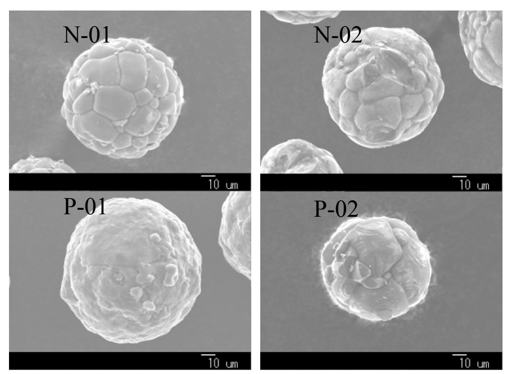

Fig. 1 SEM photo of carriers: N-01, N-02, P-01, P-02 [10].

It is found that the surface of carrier seems same. Base material of these carriers is same and surface treatment is different. The Technical Committee of Toner Technology in ISJ has delivered positively charged carriers (P01, P02) with positive toners and negatively charged carriers (N01, N02) with negative toners.

The measured positive and negative toner charge by standard charging method of ISJ are shown in Fig. 2. The measured results of typical pulverized toner also shown in Fig. 2 and the toner shows also same tendency with carrier charging ability [15].

Also it apply to estimate insulator particle styrene sphere particle diameter 5μm which components are simpler than toner [16]. The styrene particle is charged by four types of carriers and the particle charge is also estimated as same tendency of toner.

These carriers are also applied to estimate film charging property. The results of film charging by standard carriers are shown in Fig. 3. It is found that the film shows the tendency predicted by carrier charging ability.

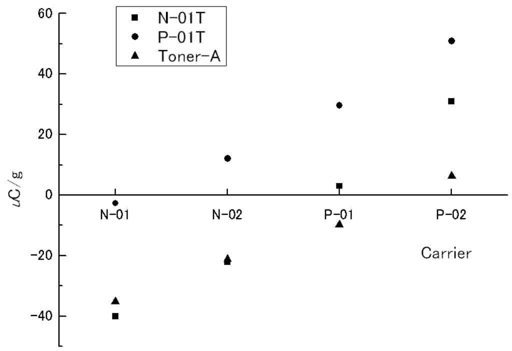

Fig. 2 Specific charge of positive, negative and typical toners dependence on ISJ carriers[10].

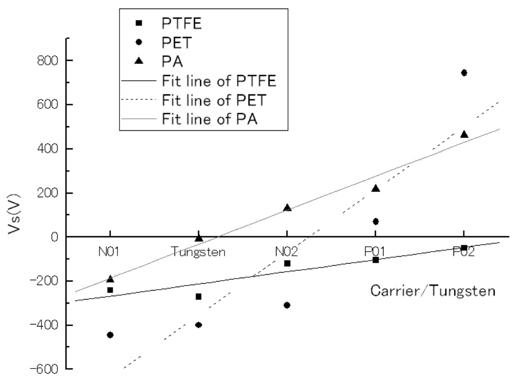

Fig. 3 Surface voltage dependence on ISJ standard carrier and tungsten[10].

Experimental

Ball charging by film

Concerning materials in this experiment, films of Aluminium evaporated 75um thick PET (polyethyleneterephthalate), PTFE (polytetrafluoroethylene, 90um) and PA (polyamide, 50um) were used and three kinds of resin spheres were used for the charge comparison. The three types of resin spheres are made of polytetrafluoroethylene (PTFE), Polypropylene (PP) and Polymethylmethacrylate (PMMA) resin with the size of 3.17mm dia.

Concerning the procedure, firstly, the three types of films were triboelectrically charged by resin ball with the help of a handmade rotating instrument. For an example, a PET film cut to square shape of 100 mm x 100 mm was rolled and placed in a cardboard barrel (30 mm dia. and 100 mm long) where the dielectric side was exposed for the contact with balls. Then, end-cap one side and 100 balls were inserted. Closed the other end and placed on the rotating instrument. The film was triboelectrically charged for 5 minutes at the rotating speed of 120 rpm. Then the charge amount of spheres ball was measured with a Faraday cage. Spheres were neutralized by ethanol after each measurement.

Ball charging by steel and ISJ carrier

Photo of sphere balls is shown in Fig. 4. A ball is charged by contact with steel. The charge amount of the ball is measured by Faraday cage.

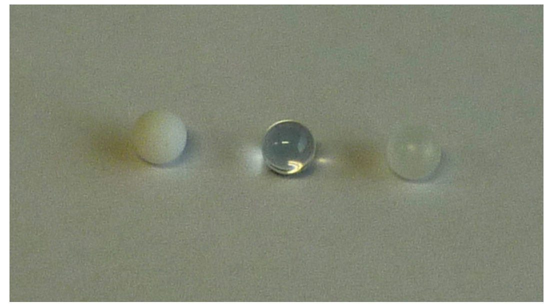

Fig. 4 Photo of balls; from left, PTFE, PMMA, PP ball.

Next a new ball is mixed with carrier by shaking 50 times by hand. Photo of balls after mixed with N-01 is shown in Fig. 5. It is found that PTEF ball is covered with carriers. Photo of balls after mixed with P-01 is shown in Fig. 6.

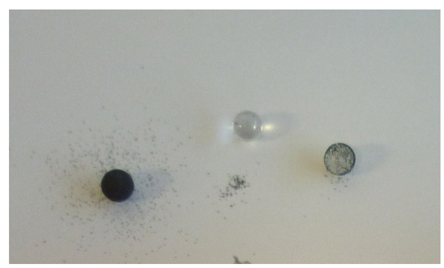

Fig. 5 Photo of balls after mixed with carrier N01; from left, PTFE, PMMA, PP ball.

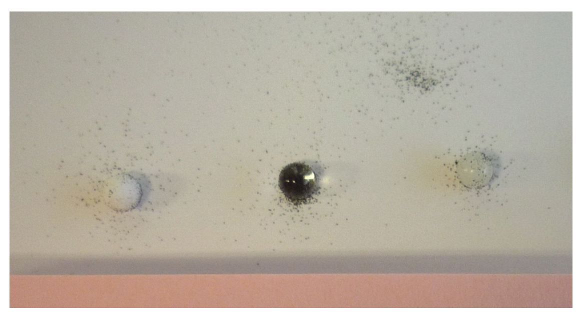

Fig. 6 Photo of balls after mixed with carrier P01; from left, PTFE, PMMA, PP ball.

It is found that PMMA ball is covered with carriers. These covering phenomena are considered to be occurred by electrostatic force between the ball and carriers, when the ball is charged strongly. After ball is mixed with the ISJ standard carrier by shaking 50 times, the ball is picked up by tweezers and carriers on the ball is blown off by air flow. The charge of the ball is measured by Faraday cage. Measurements are carried out at the temperature 21-23 ℃ and relative humidity 56-60%.

Results and Discussions

Ball charging by film

The results of ball charging by contact with film are shown in Fig.7. From Fig. 7, it is found that PMMA and PP balls are positively charged and PTFE ball is negatively charged against PA, PET and PTFE film. The charge amount of PMMA and PP ball decreases as the order: PTFE, PET and PA film. It is reported that the charging tendency of theses film is from negative PTFE, PET, and to positive PA[10]. The materials contacted with these films are predicted to be charged inverse order the film charging tendency. The experimental results of the order of charge amount ball show predicted order. Concerning the PTFE ball does not show such a tendency.

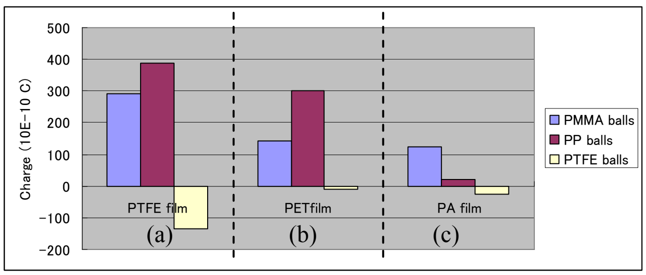

Fig.7 Charge of PMMA, PP and PTFE ball charged by film: (a) PTFE, (b) PET and (c) PA.

Ball charging by steel and ISJ carrier

The charges of ball contacted with steel are shown in Fig. 8. This experiment is carried out for checking the charging characteristics of the ball against steel. PMMA ball is positively charged, on the other hand PP and PTFE ball are negatively charged. From the positive side, the order is obtained as from positive to negative PMMA, PP and PTEF.

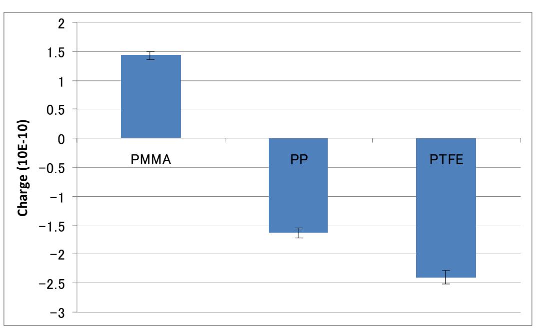

Fig. 8 Charge of PMMA, PP and PTFE ball charged by contact with steel.

Results of ball charging by standard carriers are shown in Fig. 9 a, b, c, d. It is found that the order of charge amount is roughly kept against ball materials and that the charge is shift to positive side as the order of N01, N02, P01, P02 as report of committee of toner technical group of ISJ.

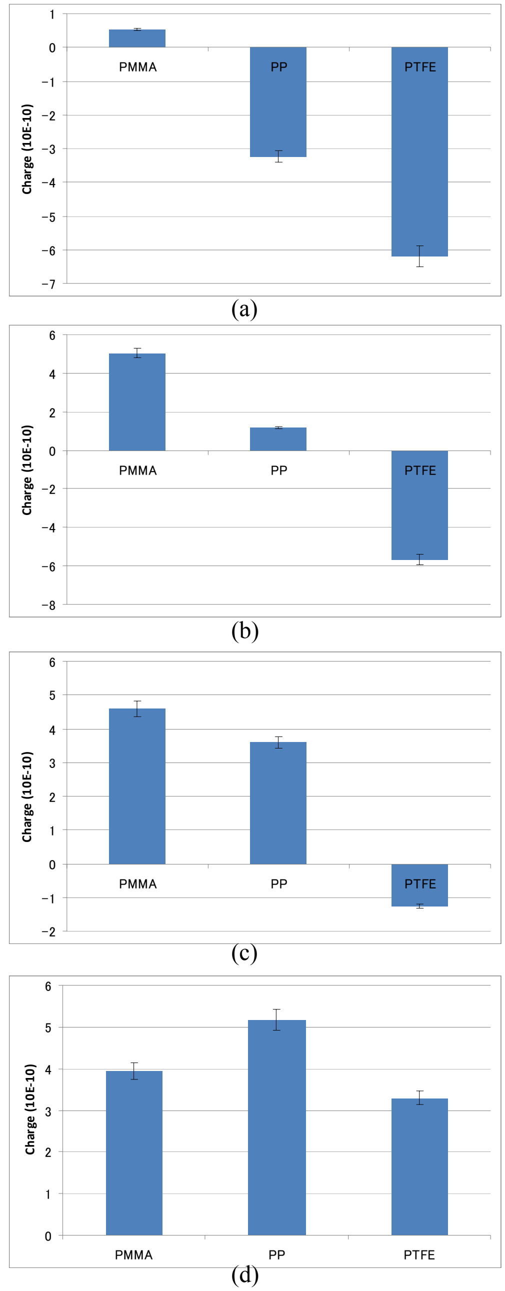

Fig. 9 Charge of PMMA, PP and PTFE ball charged by following carrier: (a) N-01, (b) N-02, (c) P-01, and (d) P-02.

Surface charge density of the ball is compared with the charge density of the typical toner. The highly charged PTFE ball is charged to 6×10^{-10} C. The surface charge density σ is obtained by the following equation,

$$\sigma = Q/(4\pi r^2),$$

Where Q is total charge of the ball and r is radius of the ball.

The surface density is obtained as $\sigma = 3\times10^{-5}$ C/m^2. In the typical toner case of radius 5 μm, toner charge is 2.5×10^{-12} C[17]. In the case, the surface charge is calculated to 0.8×10^{-5} C/m^2. This result shows bigger surface charge density. This difference is proposed due to that contact is macroscopically uniform.

In the highly charged case of $6x10^{-10}$ C, the electric field E on the ball is calculated as, $E=10^6$V/m.

Carries are observed attached around the ball, when the carrier is blown off, the electric field maybe bigger and air breakdown arises.

Conclusions

Ball charging experiences by film, steel and standard carriers are carried out and the following results are obtained. Concerning the ball versus film contact charging, the ball is charged by the contact of film. The ball charge amount is inverse order of film charging characteristics. This agrees with triboseries.

It is found that the order of ball charge amount measured by steel contact is kept in four types of ISJ developed carriers. The charge amount of ball increases as the carriers charging ability reported by ISJ. The steel used in this experiment charging ability is estimated between N-01 and N-02. Quantitative evaluation of ball charging by standard carriers is future subject.

The standard carriers of ISJ are proposed to be also effective to estimate charging characteristics of far bigger size ball than toner.

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