

Application of Time-of-Flight SIMS in Charging Studies of Xerographic Toners

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Abstract

This paper reports an investigation on the use of the time-of-flight secondary ion mass spectrometry technique to study the mechanisms of charging and charge transfer in model xerographic toners. By analyzing the surfaces of toner and carrier particles at different stages of the charging process, insight on the mechanisms is obtained. The merit and the limitation of the technique will be discussed.

Introduction

The essence of the xerographic process is the generation of latent electrostatic images and the development of these images electrostatically by a xerographic toner to make copies. In two-component xerographic developer, the electrostatic charge in toner is generated by a contact (frictional) charging process involving tumbling toner particles with carrier beads inside a developer housing.¹ In addition to charging, the rate of charge-sharing between charged toner and fresh uncharged toner in the developer is another important parameter, since a slow charge-sharing rate may limit the operating speed of the machine. In this paper, an investigation on the charging and charge-sharing mechanisms in xerographic toner is reported. Model Cesium 3,5-di-*t*-butyl-salicylate (CstBSA)/styrene-butadiene and Rubidium 3,5-di-*t*-butylsalicylate (RbtBSA)/styrene-butadiene toners, which were prepared by solution coating CstBSA or RbtBSA on the surface of the styrene-butadiene toner, were chosen for the study because they exhibit similar charging and charge-sharing properties.² The whereabouts of the mobile cations in these toners is monitored by the time-of-flight secondary ion mass spectrometry (TOF SIMS) technique. Our results suggest that the toner is charged by an ion-transfer mechanism, by transfer of the mobile cation from the toner surface to the surface of the carrier beads. Charge-sharing is shown to proceed via a dual mechanism involving ion-transfer from the toner surface to the carrier beads and ion-exchange among charged and uncharged toner particles.

Results and Discussion

Charging of the Model Toners

Both model toners were charged by first mixing the respective toner with the carrier beads inside a 2oz bottle, followed by conditioning the contents at 20% RH for 16

hours. Toner particles were then tumbled with the carrier beads inside the developer bottle on a roll mill at a speed of 90 ft/min to generate the toner charge. The toner charge was determined by the blow-off technique.³ The results show that the toner acquires a negative charge rapidly upon contact with the carrier beads. The charging process becomes saturated when the toner is rolled for 230 minutes. The charging behavior for both toners is identical. The equalibrated negative charges acquired by the CstBSA and RbtBSA toners are about 32 and 50 IIC/g, respectively.

Surface Analysis and Mechanism of Toner Charging

After each blow-off experiments the carrier beads were recovered for surface analysis. For carriers that were contacted with the CstBSA model toner, we detected a strong signal at m/z 133, attributable to the Cs⁺ ion. In addition, we have been able to image the carrier surface using the 133 peak, which suggests that Cs⁺ is distributed uniformly on the carrier surface. Since controlled experiments indicate that the anion is not mobile under the same contact charging condition, we conclude that the CstBSA toner is charged by an ion-transfer mechanism. Identical TOF SIMS results were obtained for the RbtBSA toner.

Admix Times and Charge Sharing Mechanism for the Model Toners

The rate of charge-sharing between toner particles is studied by the so-called "admixture" measurement, which is defined as the time required for the fresh uncharged toner becomes equilibrated charge-wise with the charged toner when mixing. The admix times for the two model toners are 15 minutes according to charge spectrograph results.³

In the admix mechanism study, we add 1% of the uncharged RbtBSA/styrene-butadiene toner into a (charged) developer containing 2% of the CstBSA/styrene-butadiene toner. Charge spectrograph data indicate that the mixed toner system also gives an admix time of 15 minutes. Insight regarding the charge-sharing mechanism is obtained by studying the whereabouts of the Cs⁺ and Rb⁺ ions using TOF SIMS in the admixed toner before and after toner admixing. Results show that Cs⁺ and Rb⁺ are observable on the surfaces of the admix toners and carriers after admixing. This, along with results from controlled experiments, leads to the conclusion that there is a dual charge-sharing mechanism in toner, specifically both iontransfer and ion-exchange are shown to contribute to the charge-sharing process.

Summary

Using model toners, this work demonstrates that toners containing metal salicylates as charge control agents on the toner surface are charged by an ion-transfer mechanism. Charge-sharing is found to proceed via a dual mechanism, involving both ion-transfer and ion-exchange. While the TOF SIMS technique is useful in detecting minute quantity of ions on the surfaces of toner and carrier particles, we found that quantification of the ions is difficult. We have been reasonably successful in addressing the ion-to-charge

accountability issue using correlations between the ion counts and the tribocharges.²

References

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