

# Toner Materials

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## Abstract

The toner properties affect the almost xerographic processes. Therefore the toner must yield to many requirements. These requirements sometimes conflict each other. However the designers of the toner have been achieved such difficult demands. And the theory of the toner has not been clear. Then someone says "The toner technology is look like alchemy." This paper reviews the trends of the toner and the toner materials with concerning the historical background.

## Introduction

The basic toner consists of a binder resin and a colorant. To improve the flowability and the chargingability, the fumed silica were added to the toner surface.<sup>1</sup> To optimize the charging level and the charging speed, many charge control agents were developed. To remove the oil tank from the fuser roll, an olefin wax was included to the toner.<sup>2</sup> To move the function of the carrier to the toner, the magnetite powder was also included. The morphology of the toner has been complex day by day.

Because the first toner was melt-mixed and pulverized, the size distribution was very wide. But the recent toner is classified after pulverizing, therefore the flow-ability and durability of the toner have been improved extremely. The efficiency and the yield of each manufacturing process have been also improved. And NOW electrophotography is on the stage of the COLOR.

## The history and the trend of the raw materials of the toner

### Binder resins

Styrene/acrylic resins are generally used as the binders of the toner. At the former days their molecular weight was 50,000 - 100,000 having the single peak in the molecular weight distribution. But the recent styrene/acrylic toners consist of the blend of the low molecular weight resin,  $M_w = 5,000-20,000$ , and the high molecular weight resin,  $M_w > 100,000$ , or crosslinked resin. The high molecular weight and crosslinked resins can be obtained by the emulsion polymerization or the suspension polymerization. This design of the molecular weight distribution became to be able to achieve the oilless fusing.

The first polyester was used to the toners for the radiant fusing system. This type polyester is similar to that of the color toner. The development of the crosslinked polyester

have been able to make the low temperature fixable toner with enough durability. It is because that the carrier impaction of the polyester toner is less than that of the styrene/acrylic toner. Epoxy resin are used to the toner for the flush fusing system.

### Colorants

The colorant of the black toner is carbon black. It is important to select of the kind of the carbon black because some kinds of the carbon black are carcinogens.<sup>3</sup> Carbon black is the best charge control agent. Because carbon black is conductive, it improves the charging speed of the toner. And carbon black has the role of the filler to spread the non offset temperature for heat roll fusing.<sup>4</sup>

Copper phthalocyanine is usually used as the cyan pigment, which has the charge stabilization effect because it has the long electric conjugation and it is not conductive. Therefore, Q/M control of cyan toner is generally the easiest among three different color toners, cyan, magenta and yellow.

Formerly Rhodamine dye was used in the magenta toners. It gave the good transparent but has the tendency to charge positive strongly. Therefore it has not been used no longer. Recently as magenta pigments, 2,9-dimethyl-quinacridone and Carmine 6B are popular. Quinacridone tends to charge to be positive because the amino groups are included in the molecule. Carmine 6B tends to charge to be negative, but it is humidity sensitive because of its ionic structure and the existence of the water soluble by-products.

Disazo-type yellow pigment is the most popular among yellow pigments. They are strongly charged to negative. Therefore the charge of the yellow toners has the tendency to be charged up by mixing with the carrier. Recently Blue Angel required that the pigments made from benzidine must not be used in the printer toners. Then new yellow pigments have been developed. Pigment Yellow 93, 95, 180, and 185 are the candidates of the new yellow pigment.<sup>5</sup>

### Charge Control Agents

Many compounds had been tested to control the toner charging properties. In these trials, some kinds of surfactants and dyes were found to be effective.<sup>6</sup> Cationic surfactants and Nigrosine dye are effective to make the toner charge to be positive. And acid dyes, Cr-azo complexes, are effective to make the toner charge to be negative. Recently Fe-azo complex<sup>7</sup> is often used and CCA without metal are developing now.

For the color toners, ditertiarybutyl salicylic acid complexes are the most popular as the Charge Control Agent.<sup>8</sup> Further the new charge control agents, for example

Boron compounds<sup>9,10</sup> and the polymer type charge control agents<sup>11</sup> are proposed. However there are no CCA which gives enough charging-ability to color toners.

### Wax

Polypropylene and/or polyethylene wax is used. The melting point of wax is selected to be suit to the fusing condition and the melt properties of the binder resin. Recently as the fusing temperature of the toner has become to be low, the wax with the lower melting point is often used.

Because the compatibility of wax to binder resins is not good, wax tends to fall off and cause a filming problem of photoconductor. By dissolving wax to styrene/acrylic monomer and polymerizing, the size of wax can be decreased and the filming problem can be solved.<sup>12</sup>

### Surface Additives

Surface additives are effective to control the flowability and chargingability of toners. The flowability of toners depends on the amount of the surface additive and the diameter of the surface additive. Typical additives are SiO<sub>2</sub>, Al<sub>2</sub>O<sub>3</sub>, TiO<sub>2</sub>, and polymer beads.<sup>13</sup> To decrease the water adsorption, the surface of the inorganic powder is treated by silane-cuppling agents or silicone oil. The surface additives are often put into the toner and then the flowability and chargingability of toners changes by the printed volume.

## Topics on Toners

### Color Toners

Recently many electrophotographic color printers have been putted on the market. Such as Chromapress, DocuColor 4040, the application of the color xerography has been popular. The linear polyester with the low molecular weight are used as the binder resin in the most of color toners. It is because both the brilliant color reproduction and enough durability must be satisfied. On the other hand, the crosslinked polyester is used in HP Color Laser Jet and Casio Pagepresto N-4. It gives the low gloss pictures suitable to the office documents and is able to simplify the fusing system. However enough transparency of pictures is hardly obtained. About the detail design of color toners, please see my previous papers.<sup>14</sup>

### Mono Component Toners for the Desk Top Printers

Recently the electrophotographic printers have been spread to the office. Their print speed are 4-10 ppm. And mono component, magnetic or non-magnetic, development system is used in such printers. For the non-magnetic mono component toner the crosslinked polyester is useful to achieve both the low power fusing and the enough durability. Recently Brother HL-720 printer was putted on the market. In HL-720, the positive non-magnetic mono component toner with polyester binder is used. By the

advances of the charge control method, the positive toner made from polyester resin can be easily obtained.

### Toners for High Speed Printers

At the former days, the toners for the high speed printers were very simple. For example, the toner consist of only the simple binder resin and carbon black. Most of the requirements were satisfied by controlling mechanically. But now even in this region, there are many requirements to the toner. Then charge control agents are used and the usage of the polyester resin has been increased. A certain printer manufacture succeeded to achieve to increase the print speed dramatically by changing to the polyester toner.

### Synthetic Toners

Oki OL-400e is the first printer to success to use the synthetic toner. Generally the merit of the synthetic toner is that the transfer efficiency is high. By this merit, there are no cleaning system in OL-400e. The reason of the good transfer efficiency of the synthetic toner is that there is only the resin component on the surface of the toner.

However because of the absence of the carbon black on the toner surface, the charge stability of the synthetic toner is not good.

## Summary

The toner is the key material of electrophotography. The toner has been developed to yield the requirements of the sub-systems of the electrophotography.

Now the high efficient color toner must be completed. Then in the next step, the novel material, which allows the completely new marking system, must be developed.

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