# Highly Safe, Environmentally Friendly Toners for Dual Component Systems

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## Abstract

A highly safe, environmentally friendly toner for printers and copiers is studied. To reduce potential carcinogens, endocrine disrupter risks, and Volatile Organic Compounds (VOC), alternate materials of carbon black and Cyclic Olefin Copolymer (COC) type resins are examined in dual component systems. The examined toner provided adequate image density and good durability with comparable fixability. There was also less risk in human toxicity. Due to these results, COC resin toner is expected to be the third generation toner, (next to Styrene/Acrylic and Polyester toners) for high-speed printers and copiers.

## Introduction

The recent focus on the global environment and human safety, in addition to product consumption in the printer and copier industry, has greatly influenced the development of toners. When individual materials are deemed “safe,” the toner is considered “safe,” assuming there are no adverse chemical reactions in the conventional manufacturing process. Material safety is a very important factor in the toner design process.

Due to its fundamental characteristics and the possibility of practical use, COC with low magnetic magnetite (LMM) as an alternate material of carbon black was examined. COC is known as the “safety binder resin” because of its olefinic nature and no endocrine disrupter issues.

## Samples

The tested samples are described in Table 1 and Table 2 in regard to the LMM% and carbon black%.

**Table 1. Toner Sample Name**

| | LMM content % | | | |
|---|---|---|---|---|
| Resin | 10% | 15% | 20% | 25% |
| COC | C1 | C2 | C3 | C4 |
| Pes. | - | - | P1 | - |
| St/Ac | - | - | S1 | - |

**Table 2. Toner Sample Name**

| Resin | Carbon Black content 4.5% |
|---|---|
| COC | CB1 |
| Pes. | PB1 |
| St/Ac | SB1 |

## Experimental

The following properties were tested on the sample.

**1. Fixing ability**
**2. Blackness**
**3. Magnetic properties**
**4. Durability**
**5. Estimation of toner consumption from specific gravity**
**6. Volatile Organic Components**

**1. Fixing Ability**

The fixing ability of the COC with LMM sample was comparable to others based on the test results of Non-Offset Windows and Fixing Strength of the sample C3, P1, and S1 described in Table 3. The melting point of each sample was almost in the same range; around 125 degrees C.

**Table 3. Fixing Ability**

| | Non Off-set window °C | Fixing Strength 180°C |
|---|---|---|
| C3 | 130 - 230 | 96 % |
| P1 | 140 - 230 | 97 % |
| S1 | 135 - 230 | 98 % |

Process speed: 200 mm/sec

**2. Blackness**

**Table 4. Blackness of Each Sample**

| Sample | I.D. | L* a* b* |
|---|---|---|
| C1 | 1.26 | 29.09 / 2.01 / -0.03 |
| C2 | 1.32 | 27.19 / 1.62 / 0.28 |
| C3 | 1.34 | 26.56 / 1.51 / 0.43 |
| C4 | 1.35 | 25.55 / 1.41 / 0.51 |
| P1 | 1.23* | 30.06 / 1.10 / -0.11 * |
| S1 | 1.25* | 29.19 / 1.01 / 0.03 * |
| CB1 | 1.37 | 23.17 / -0.09 / -0.04 |
| PB1 | 1.36 | 24.60 / -0.13 / 0.24 |
| SB1 | 1.36 | 24.34 / -0.01 / 0.53 |

*Samples P1 and S1 were not black enough with this formulation.
*The print sample was produced on 70 ppm printer.
*The ID was measured by a Macbeth density meter.
*The L* a* b* were measured by a Color Meter ZE2000.

By increasing the LMM content, the image density became higher and the L* became lower; close to the carbon black toner as in CB1, PB1 and SB1. The a* of sample C1 to C4 was higher than the carbon black toner and was slightly redder than the carbon black toner. However, the difference was not noticeable to the human eye. The LMM has potential as a black colorant for carbon black.

**3. Magnetic Properties**

**Table 5. Magnetic Properties**

| Sample | Ms/g emu/g | Mr/g emu/g | Hc kOe |
|---|---|---|---|
| C1 | 3.0 | 0.6 | 0.2 |
| C2 | 4.0 | 0.7 | 0.2 |
| C3 | 5.2 | 1.0 | 0.2 |
| C4 | 6.0 | 1.2 | 0.2 |
| LMM | 24.0 | 5.5 | 0.2 |

Ms: Saturated Magnetization, Mr: Remanence
Hc: Coercivity, Magnetic filed: 5kOe

The Ms of the C4 sample in which the LMM content was 25% was approximately 10 to 15% of the Ms of regular magnetic toner and was considered usable for dual component systems.

**4. Durability**

The toner particle size distribution changes in the developer was examined to predict the toughness of each binder resin. The silicon coated 80µm magnetite carrier and the toner sample were mixed using a paint can mixer for 4 hours. Changing ratio in population 5 micron under particles is calculated.

The COC toner showed a higher toughness than the others.

**5. Estimation of Toner Consumption from Specific Gravity**

The specific gravity of the sample was calculated from the materials and content.

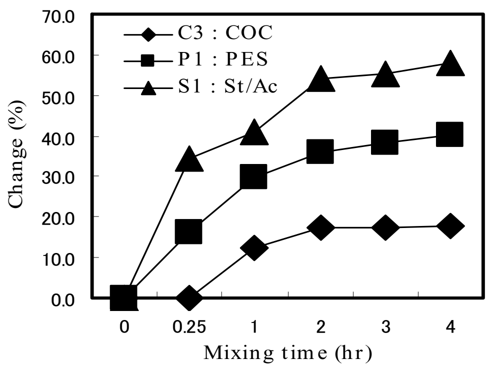


*Figure 1. Particle size change ratio in pop 5 mm under*

Since the COC has a low specific gravity, it was expected to lower the toner consumption. The data suggested that the toner consumption of the COC+LMM toner would be equivalent to the regular polyester toner, even though LMM is heavy.

**Table 6. Specific Gravity**

| Sample | Specific gravity g/cm$^3$ |
|---|---|
| C3: COC+LMM20% | 1.21 |
| P1: Pes+LMM20% | 1.42 |
| S1: St/Ac+LMM20% | 1.27 |
| CB1: COC+C.B 4.5% | 1.04 |
| PB1: Pes+C.B 4.5% | 1.26 |
| SB1: St/Ac+C.B 4.5% | 1.10 |

**6. Volatile Organic Components**

The total amount of the volatile organic components was analyzed at three different temperatures. There was no big difference at 90 and 140 degrees C however, sample C3 showed less generation at 180 degrees C.

**Table 7. Total Gus Analysis**

| | 90 °C | 140 °C | 180 °C |
|---|---|---|---|
| C3 | 224 | 2092 | 3777 |
| P1 | 162 | 2012 | 8919 |
| S1 | 731 | 2151 | 12182 |

Analysis: GC/MS, purge and trap: 5min unit: ppm

## Conclusion

The possibility of a COC resin with a low magnetic force magnetite toner for a dual component system can be summarized as follows.

1. The said toner had better durability, with a comparable fixing ability, to the St/Ac or Pes resin toner.
2. Adequate image density can be expected without sacrificing the toner consumption levels, even though the low magnetic magnetite is heavy material,
3. The total VOC would be less than the St/Ac or Pes resin toners.

Based on these investigations, it is clear that a COC with a low magnetic force magnetite toner has the potential to be an environmentally friendly toner for a dual component system.

## References

1. Klaus Berger, Toru Nakamura *Japan Hardcopy* (1999)

## Biography

**Nobuyuki Aoki** received his Bachelor's Degree in Chemical Engineering from the University of Shizuoka, Japan, in 1986. He then joined the Research and Development Department in Chemical Products Unit, Imaging Material Division of Tomoegawa Paper Co., Ltd. He is currently working on toner development for copiers and printers.