

New Composite-Carrier for Electrophotographic Developers

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Abstract

A new composite-carrier based on magnetic particles and phenol resin has been developed for long-life electrophotographic developers. The present carrier, composed of core particles and a resin shell, is quite spherical in shape and is characterized by a narrow particle-size distribution (controllable range: 10-200 µm in diameter). The carrier core can either be made up of magnetic fine particles such as ferrites and magnetites, or of non-magnetic particles such as hematites. The content of the core particles can be as high as 90 wt%. The core particles were prepared by dispersing magnetic or non-magnetic fine particles in an aqueous solution of phenol and formaldehyde using ammonium as an initiator. The surface of the core particles was then coated with silicone resin. The composite-carrier thus prepared exhibits an excellent performance in charging and charge-holding properties that greatly exceeds the characteristics of commercial ferrite-carriers.

Introduction

With the increase in wide range applications of electrophotography, the high-quality image as well as high printing speed are the stringent demand for the electrophotographic process in order to compete with alternative imaging processes such as inkjet printers, thermal printers etc. In this respect, the long-life carrier in combination with fine toner particles plays the key role.

Conventionally, carriers based on iron, ferrite or magnetite particles are widely used in a variety of developers. When the carrier is mixed and agitated with toners to generate electrostatic charge on the toner and carrier surface, the carrier suffers significantly from mechanical stress due to collisions with toners, leading ultimately to a deterioration of the carrier surface. This may reduce the charging efficiency of the toner. Furthermore, if the carrier surface is not even, the toner can easily deposit and adhere on the carrier surface. This again lowers the effective area of the carrier surface necessary for the charging.

In consideration of the above difficulties, an attempt was made in the present investigation to develop a new composite-carrier made of core particles and a resin shell as shown in Fig.1 to meet the requirements for the high resolution as well as high printing speed of the printers. The present carrier is quite spherical in shape and is characterized by a narrow particle-size distribution (controllable range: 10-200 µm in diameter). In addition, the carrier core can either be made up of magnetic fine particles such as ferrites and magnetites or of non-magnetic particles such as hematites. The content of the core par-ticles can be as high as 90 wt%. The appealing features of our composite-carrier are its charging and charge-holding ability for a long period as well as its mechanical stability during the charging process.

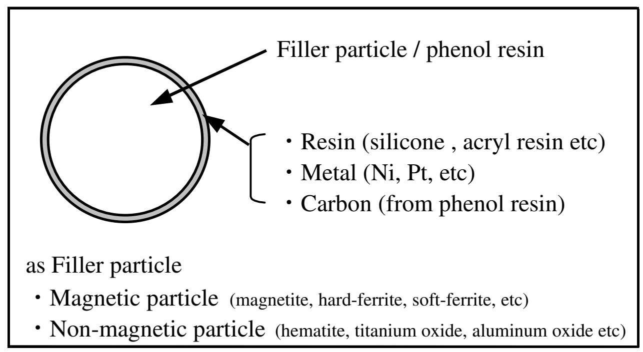


Figure 1. Structure of the composite-carrier.

Experimental

1. Preparation of Core Particles

400 g of magnetite particles (average particle size: 0.23 µm in diameter) were dispersed in 150 ml of an aque-ous solution containing 40g of phenol and 60 g of 37% formalin and 12 g of ammonia. The reaction vessel was gradually heated up to 85°C in 40 minutes while stirring and mixing the materials. During this process, the crude core particles made of magnetite and phenol resin were formed. The temperature was then maintained at 85°C for 180 minutes to complete the curing of the phenol resin. After that, the temperature was lowered to about 30°C and 300 ml of water was added to the reaction mixture. The precipitate was then filtered and washed with water. The product was finally dried at about 180°C under reduced pressure to give spherical composite-particles of magnetite and phenol resin.

2. Surface Coating with Silicone Resin

Surface coating was carried out in a reaction vessel (Universal stirrer: "5XDML" from K.K.Dalton). 1 Kg of the above composite particles were charged and stirred while the vessel was heated to 50°C. Then, 50 g of sili-cone resin dissolved in toluene was added to the vessel. The mixture was stirred at 50°C for 2 hours for the surface coating of the composite particles. After that, the temper-ature was raised to 150°C and maintained for 2 hours under nitrogen to complete the curing f the silicone resin.

3. Performance of the Composite-Carrier

The performance of the composite-carrier was evalu-ated by charging and charge-holding ability. SEM pictures were also taken in order to observe the surface deter-ioration of the carrier. The maximum charging amount was measured by means of a blow-off charge apparatus (MODEL TB-200 from Toshiba Chemical Co., Ltd.), using commercial ferrite-carriers (from A company) as the reference. The charge amount was expressed as the value per one gram of toner particles. The SEM pictures were taken by a scanning electron microscope (S-800 from Hitachi Ltd.)

The test sample was prepared in the following. A mixture of 50 g of test carriers and 4 g of a commercial magenta toner (from company A) were placed in a 100 ml bottle. Then, the bottle was closed with a cap and shaken with a paint shaker from Red Devil Co. Ltd. for a period of 3, 20 and 40 hours.

Table 1 shows the characteristics of the composite-carrier as well as commercial ferrite-carriers.

Table 1. Characteristics of the carriers used in the evaluation test

		New Composite-Carrier		Commercial Ferrite Carrier	
Nominal density	g/ml	1.93		2.67	
Flowing rate	sec/50g	32		22	
Density	g/ml	3.6		5.14	
Electric resistivity	Ωcm				
under the applied voltage:					
	100V	1.70E+10		4.00E+10	
	500V	7.00E+08		5.50E+08	
	1000V	breakdown		breakdown	
Coercive force Hc	KA/m	4.77	5.97	0.32	0.56
Maximum magnetization	Am2/Kg	58.3	72.7	54.7	59.5
Residual magnetization	Am2/Kg	4.6	5.7	0.4	0.7
Applied magnetic field	KA/m	$1/4\pi$	$10/4\pi$	$1/4\pi$	$10/4\pi$
Average diameter	µm				
based volume (Dv)		49.0		48.9	
based particle (Dp)		43.2		36.1	
Distribution (Dv/Dp ratio)		1.13		1.35	

Results and Discussion

Fig. 2 shows the toner charge amount as a function of shaking time. The composite-carrier exhibits no charge decay even after 40 hours time; whereas a significant charge degradation is clearly observed in the first 20 hours for the ferrite-carrier, followed by a less significant decay between 20 and 40 hours.

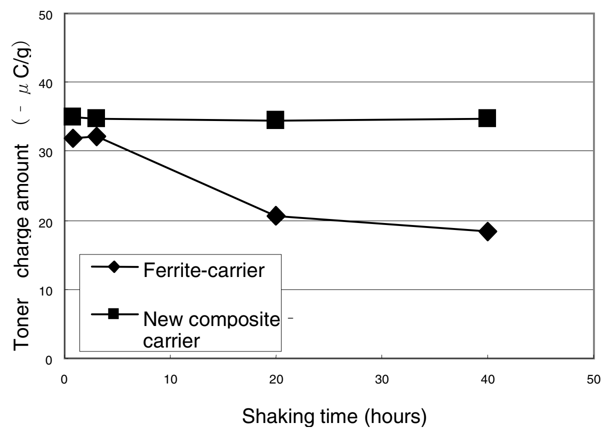
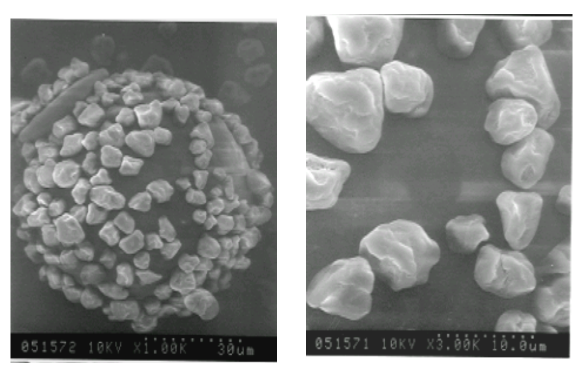


Figure 2. Change in toner charge as a function of shaking time.

Figs. 3 and 4 show the SEM pictures for the surface of the composite-carrier and the ferrite-carrier together with toners, respectively. No noticeable surface damage is recognized in both carriers and toners after 40 hours for the composite-carrier. On the other hand, a heavy damage of the toner as well as toner adhesion on the carrier surface are observed for the ferrite-carrier after 20 hours. Due to the toner adhesion on the carrier surface, the effective area of the carrier is greatly diminished. This explains why the ferrite-carrier showed an insufficient charging and charge-holding characteristics in Fig. 2.



×1000 ×3000

Figure 3. After 40 hours Composite-carrier.

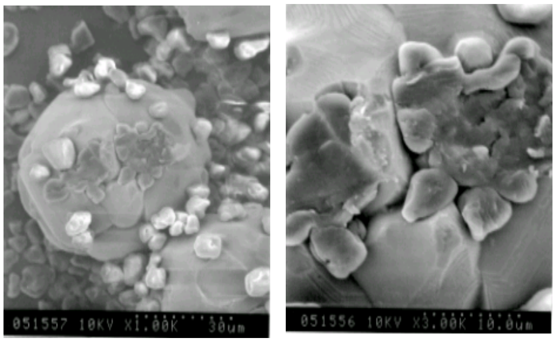


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Figure 4. After 20 hours Ferrite-carrier.

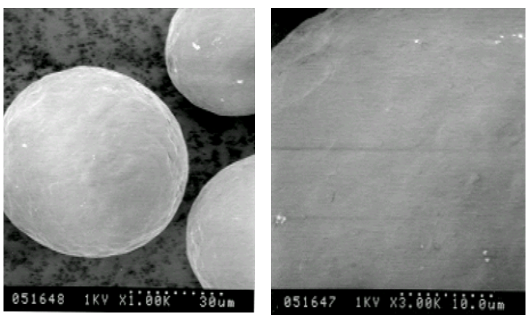

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Figure 5 The SEM pictures for the surface of the composite-carrier after 40 hours.

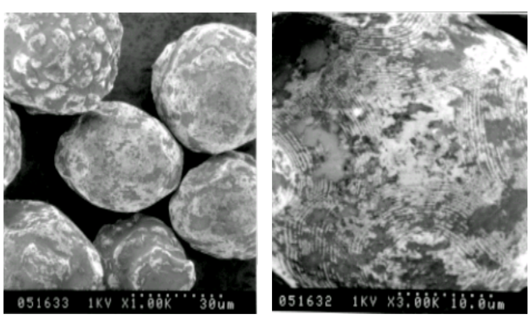

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Figure 6 The SEM pictures for the surface of the ferrite-carrier after 40 hours.

Figs. 5 and 6 show the SEM pictures for the carrier surface without toners after 40 hours for the composite-carrier and the ferrite-carrier, respectively. No surface damage of the coated layer is observed for the composite-carrier while the coating layer is heavily destroyed and the ferrite-cores were exposed on the surface: white areas.

As described above, the newly developed composite-carrier has been characterized to feature good charging and charge-holding characteristics as well as good mechanical stability. As a result the composite-carrier can well be mixed with toners, and this allows us to increase the electrification speed of the toner as well as to assure the stable operation of the carrier for a long period.

Conclusion

The long-life composite-carrier based on magnetic parti-cles and phenol resin has been developed. The carrier exhibits an excellent charging and charge-holding charac-teristics that greatly exceeds the characteristics of commercial ferrite-carriers. Furthermore, the surface of the carrier remains undamaged even after 40 hours' charging experiment. The present carrier enables us to achieve high quality images as well as high speed operation of the printers.

References

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Biography

Toshiyuki Hakata received BS in chemistry in 1980 and his MS in 1982 from Osaka University. During this time, he was involved in the research on alcohols/amine reactions under Ru or Pd catalysts. In 1982, he joined DIC-HERCULES CORPORATION and worked there in research and development of chemicals for paper-making process. Since 1988, he has been working at TODA KOGYO CORPORATION in the field of toners and composite-carriers.