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Application Note

Particle Size Distribution of Black Toner

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Abstract

Toner is a primary component of the electrophotographic printing and copying processes. The synthesized toner particles must exhibit some special characteristics such as particle size and shape to obtain high quality and high-resolution printed images. Utilization of smaller particle size toners has been suggested to be effective in achieving high image quality. In this study, the analysis of the particle size distribution of black toner is optimized using HORIBA Partica LA-960V2 laser diffraction particle size distribution analyzer.

Introduction

Toners are very fine powders consisting of 5 to 30 µm particles that are mainly used in photocopiers and laser printers. Toner cartridges come in sets of cyan, magenta, yellow and black (CMYK), allowing a very wide range of colours to be generated by mixing (Figure 1). In addition to providing the best print quality, the toners must meet the technical requirements of the device, while maintaining their uniformity and consistency throughout use. One of the biggest limitations in the toner industry is the requirement of fine particles with narrow particle size distribution. A small particle size ensures good ink coverage and colour mixing, thin application, precise colour gradients as well as complete and streak-free coverage. Accurate particle size characterisation is therefore essential to ensure consistent material properties.

Figure 1: Typical toner cartridges: cyan, magenta, yellow and black (CMYK)

Several analytical tools , such as the Coulter counter method, have traditionally been used to analysis the particle size of toner materials. The technique measures the changes in electrical conductance as particles suspended in a conductive fluid passes through a small orifice. The method has been well recognized for its high sensitivity ability to detect very small particles, excellent reproducibility, and high-resolution size information. But at the same time, it has several disadvantages that including the need for calibration, the use of electrolyte as the medium (limited to hydrophilic particles), clogging of the orifice and the ability to measure low-particle concentration. In addition, errors may occur when measuring porous particles, particles below the minimum detectable size are not detected as they pass through the orifice, and it is difficult to characterize high-density materials. These limitations can be easily overcome by using the advances in laser diffraction particle distribution analyzer.

Laser diffraction is a widely used particle sizing technique for materials ranging from a few hundred nanometers up to several millimeters in size. The technique calculates particle size by measuring the angular variation in the intensity of light scattered as a laser beam passes through a dispersed particulate system. Partica LA-960V2 (Figure 2) from HORIBA presents the latest advances in laser diffraction technology with its innovative design and ultimate performance. The system offers many advantages, including a high level of precision, fast response, no requirement for calibration, and a wide measurable particle diameter range of 10 nm to 3,000 µm. Here we demonstrate the capability of the system in efficiently analyzing black toner sample with excellent repeatability and reproducibility.

Figure 2: Partica LA-960V2 Laser Diffraction Particle Size Distribution Analyzer

Instruments and Methods

Sample preparation is the most important and a very crucial step for any analysis and must be done very carefully to make accurate and precise measurements. Black toner powders particles produced from carbon black material are naturally hydrophobic, and hence known to repel water. The first challenge therefore is to form a stable aqueous dispersion of such material. Coulter counter method uses electrolyte solutions for dispersion of the toner powder. To derive an equivalent volume and number distribution with laser diffraction, it is important to find a suitable aqueous suspension. Surfactants are known to act as surface-active agents by reducing the interfacial energy barrier

between the particles and dissolution medium; and thereby increasing the wettability. Non-ionic surfactants, consisting of a hydrophilic head group and a hydrophobic tail, carry no charge and are relatively non-toxic. They can help to improve the solubility of some poorly soluble materials. After testing a few non-ionic surfactants in different proportions, the black toner powder was finally dispersed in water with 2% Triton X-100.

Laser diffraction uses the Mie theory of light scattering to calculate the particle size distribution, assuming a volume equivalent sphere model. Partica LA-960V2 system was used in wet mode for particle size distribution analysis of the black toner samples with following analytical conditions:

Real RI (particle): 1.746; Imaginary RI (particle): 0.5
Dispersant: water
Samples: Sample A and Sample B

The data acquired by laser diffraction analysis was then compared to the Coulter Counter method.

Result and Discussion

Both sample A and sample B were tested multiple times on Partica LA-960V2 system in wet mode. The obtained particle size distribution profile displayed excellent repeatability and reproducibility with narrow distribution as shown in Figure 3 with overlay for triplicate runs.

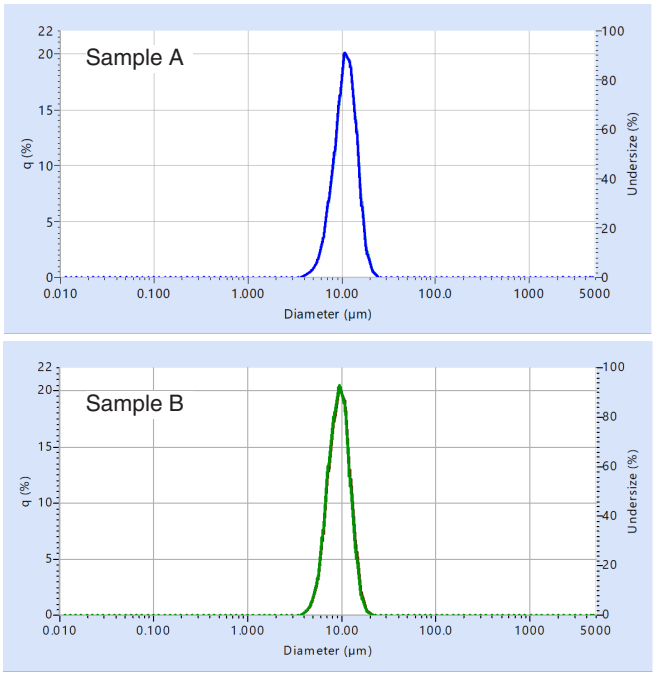

Figure 3: Overlay of particle size distribution profile for sample A and sample B in wet mode

The parameters interpreted from Figure 3 are further shown in Table 1. The reported values of D10, D50, D90 and cumulative percentage under 6 micron and 5 micron shows good match among the runs for each sample, and that further confirms high precision and accuracy of the obtained data.

Calculated Parameters	Sample A			Sample B		
	Run 1	Run 2	Run 3	Run 1	Run 2	Run 3
D10 (µm)	6.882	6.871	6.875	6.565	6.561	6.553
D50 (µm)	10.762	10.725	10.732	9.309	9.303	9.352
D90 (µm)	15.799	15.701	15.711	12.822	12.813	12.918
< 6 µm (%)	4.993	5.028	5.013	5.353	5.366	5.485
< 5 µm (%)	1.694	1.700	1.696	1.708	1.080	1.160

Table 1: Laser Diffraction analysis data of sample A and sample B for triplicate runs.

Originally, the laser diffraction system calculates volume-based distributions, which can then be converted to number-based distribution using an algorithm available in the software. Both volume and number distribution data obtained from laser diffraction was then compared to the one obtained using Coulter counter method. Table 2 represents good correlation between the two technologies which can be partially attributed to spherical or quasi-spherical shape of the toner particles. The laser diffraction analysis however does not require any calibrations prior to analysis hence reducing the analysis time. Moreover, use of electrolytes is not required which further reduces the cost of analysis. From this study, we confirm that laser diffraction technology has been proved to be applicable in efficient analysis of toner particles with high proficiency.

Distribution Type	Observed Value	Sample A		Sample B	
		Coulter Counter	Laser Diffraction	Coulter Counter	Laser Diffraction
Volume	< 50% (µm)	10.42	10.76	9.1	9.31
	< 6 µm (%)	5.56	4.99	4.61	5.35
	< 5 µm (%)	1.61	1.69	1.09	1.08
Number	< 50% (µm)	7.19	7.48	7.59	7.49
	< 6 µm (%)	29.30	28.17	19.50	20.37
	< 5 µm (%)	14.40	14.55	8.24	6.41

Table 2: Laser diffraction data comparison to coulter counter method

Conclusion

Partica LA-960V2 laser diffraction particle distribution analyzer has been demonstrated to characterize particle size distribution of black toner. Narrow size distribution with major population below 15 micron ensures optimal performance of the toner with reliable adhesion on the print medium.