

Application of Laser Particle Size Analyzer in Pigments

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Introduction

Color is the most sensitive element that can cause our aesthetic pleasure. Color is closely related to the development of the pigment industry. The color of pigments arises because they absorb only certain wavelengths of visible light, and the light of other wavelengths is reflected or scattered. The reflected light spectra define the color.

Pigments are finely divided organic or inorganic solids. They are insoluble materials that often used in dyeing process, mainly coming from natural pigment extraction and chemical synthesis. Minerals have been used as colorants since prehistoric times. Early humans used colorants for aesthetic purposes such as body decoration. Synthetic pigments were introduced as early as the second millennium BCE. For thousands of years, the types of pigments have not increased obviously, until the arrival of the industrial revolution in the 18th century. Along with research and development of pigments made continuous breakthroughs, large-scale industrial productions were achieved.



Bettersizer 2600

Different pigments emerged one after another, and have been widely used in ceramics, coatings, printings, etc. With the rapid development of the downstream industries, the demand for pigments is expanding, and the requirement for the quality of pigments is improving. Particle size and its distribution play a significant role in the quality control of pigments, which is in direct relation with the light scattering power of pigments ^[1]. The light scattering power increases when particle size decreases, which in turn affects the tinting strength and the opacity of pigments. Moreover, both gloss and weather resistance improve as the particle sizes of pigments decrease. In addition, uneven distribution of pigment particle sizes reduces gloss and opacity ^[2]. Depending on the particle size, it can be distinguished as 'fine grain' pigments with particle dimensions smaller than 1 μm , 'medium grain' pigments with the particle dimensions between 1 and 10 μm , and 'coarse grain' pigments with the particle dimensions greater than 10 μm . Pigments consisting of coarse grain particles induce very saturated color but have poor hiding power unlike those with fine grain ^[3].

Laser diffraction is the most popular method of particle size analysis for the production and storage process of pigments, owing to the advantages of simple operation, fast measurement, wide range of testing, and high accuracy, allowing close control and optimization of pigment performance. In this note, the Bettersizer 2600 laser particle size analyzer (Manufactured by Bettersize Instruments Ltd.) with a wet dispersion system was used to measure the particle size distributions of pigments.

Particle size distributions of pigment particles

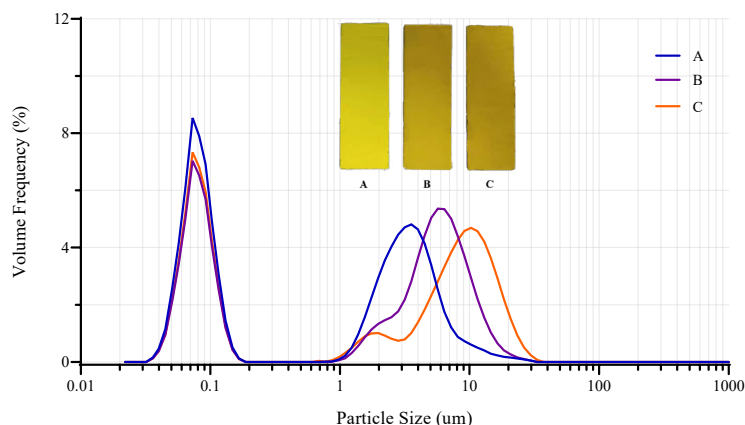


Figure 1. Particle size distribution of pigments

Table 1. Typical particle size values of three pigments

Sample	Dv10 (µm)	Dv50 (µm)	Dv90 (µm)
A	0.058	1.417	4.995
B	0.061	3.023	8.945
C	0.060	3.491	13.820

Three pigments were synthesized by hydrothermal method under different reaction conditions in the laboratory. As shown in Figure 1, the particle size distributions of three pigments are wide with two peaks detected. Three samples consist of nanoparticles and micron particles. Pigment A, B, and C have similar particle size distributions in 0.036 to 0.166 microns, but differ greatly in 0.6 to 33.3 microns. The uneven distributions have limited their application in industries.

The pigment A with smaller particle size exhibits excellent greenish-yellow colour, which is similar to corresponding commercial pigments, while the pigment B and C are golden-orange coloured. The gloss of pigment B and C become darker, owing to the red hue of pigment B and C increases as the particle sizes increase. And pigment C with large scale of coarse grain particles has a relatively more saturated color.

As can be seen from Table 1, three samples have similar Dv10 (about 0.06 µm), but differ greatly at Dv50 (1.417 µm to 3.491 µm) and Dv90 (4.995 µm to 13.820 µm). The pigment A, B, and C have incremental median particle sizes and coarse end particle sizes.

Image analysis of pigment particles

In order to cross-verify the measurement results of laser particle size analyzer, the BeVision S1 particle size analyzer (Manufactured by Bettersize Instruments Ltd.) was used to observe pigment A. Figure 2 shows the images of pigment A that are captured during particle size evaluation. Some large particles have been observed in pigment A, indicating the presence of microparticles detected by a laser particle size analyzer.

In short, the particle size measurement can effectively monitor the particle size distribution of pigments, and thereby guaranteeing the performance of products.



BeVision S1 particle size analyzer

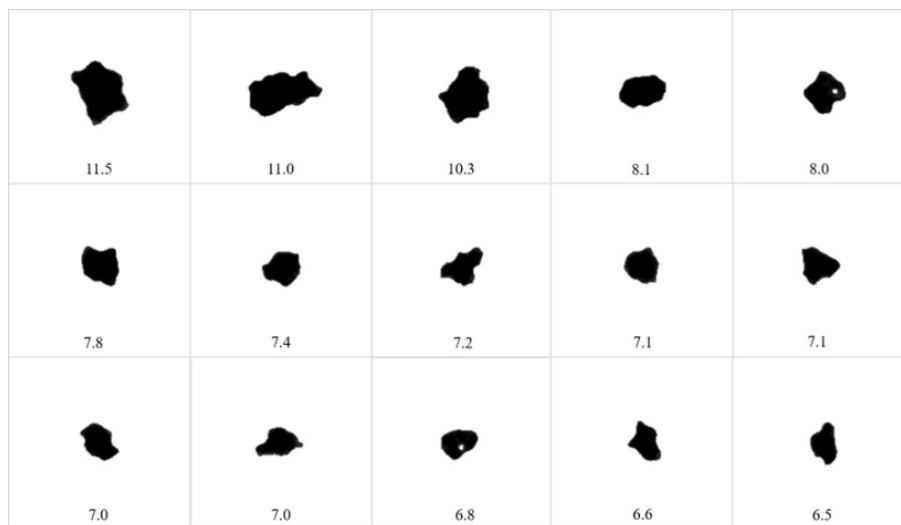


Figure 2. Microscopic images of pigment A

Repeatability analysis

It can be seen from Figure 3 that the multiple measurements of the particle size distribution of pigment B by the Bettersizer 2600 show a good repeatability. The repeatability for Dv10, Dv50, and Dv90 are 0.00%, 1.77%, and 0.79%, respectively, which meet the ISO 13320 standard^[4]. Therefore, high repeatability can be achieved by using the Bettersizer 2600 to measure the particle size distribution of pigments.

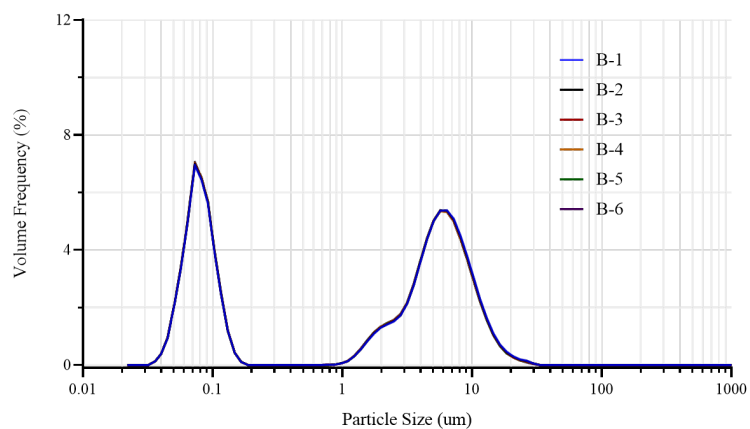


Figure 3. Repeatability test of pigment B

Storage stability analysis

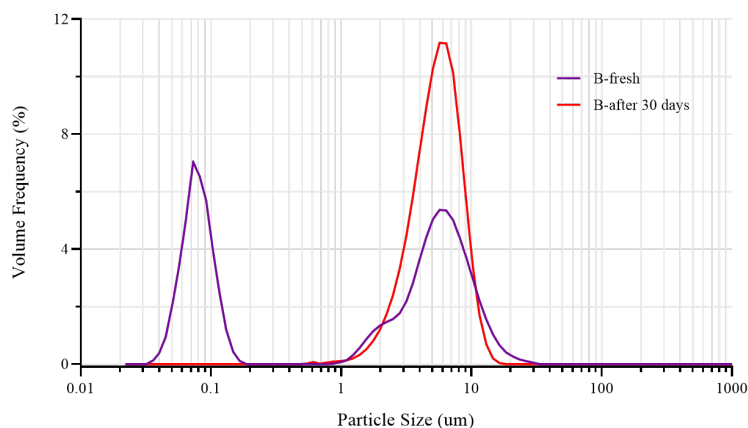


Figure 4. Particle size distribution of pigment B after storing for 30 days

As Figure 4 shows, the particle size distributions of pigment B, which is stored for 30 days, are detected with a single peak in 0.54 to 16.44 microns. It is quite different from the particle size distributions of the fresh pigment B, mainly due to particle aggregation that occurred during storage. Therefore, the particle size measurement can effectively monitor the particle size change of pigments during the storage process, ensuring the stability of product performance.

Conclusion

The presence of coarse particles influences the color of pigments, and particle aggregation that occurred during storage reduces the stability of product performance. The particle size distribution can be adjusted to optimize the properties of pigments, to meet the application requirements in different industries. The Bettersizer 2600 laser particle size analyzer enables the manufacturers to monitor the particle size and its distribution of pigments in the production and storage process. The instrument's wide detection range and high resolution allow all pigments to be measured accurately, and ensure excellent batch-to-batch reproducibility.

References

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- [3] Gueli A M, Bonfiglio G, Pasquale S, et al. Effect of particle size on pigments colour [J]. Color Research & Application, 2017. DOI: 10.1002/col.22062.
- [4] ISO 13320 (2009) Particle size analysis – Laser diffraction methods.

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