Application note 2017.02

Number and volume distributions in particle size analysis

Particle size data are often expressed as volume or number distributions. These distributions express the percentage that each size class occupies of the overall distribution, either when calculated as a percentage of the total volume of particles or number of particles. In both cases they are relative distributions, but they are fundamentally different ways of expressing size data and can be used to extract different information about a particle population.

Some particle size measurement techniques determine number distributions and some determine volume distributions by first intent. Laser diffraction, for example, is typically considered to yield particles sizes which approximate to a sphere of equivalent volume. Other techniques which measure size distributions on a particle by particle basis, such as laser obscuration time (LOT) or image analysis, measure number distributions by first intent.

Example distributions

Consider a sample which contains 10 spherical particles, with incrementally spaced particles of diameter 1µm, 2 µm, 3 µm and so on, up to 10µm. We can represent the particle size of this sample using the distributions shown in Figure 1. The number distribution histogram shows equal number of particles in each size class. But this same particle population can be expressed as an area and a volume distribution and these look very different; the larger particles proportionately influence the area and volume distributions to a much greater extent than the smaller particles. In this respect, volume distributions will always give more information about the larger particles in a distribution. Indeed, sometimes the smaller particles, even though great in number, may be invisible in a volume distribution.

Since the presence of fine particles is more readily observed from the number distribution it can be used with advantage in circumstances where fine particles influence material behaviour, for example where moisture sorption and stability are an issue.

Volume distributions are particularly useful where we need to control the presence of large particles, perhaps where we need to control content uniformity for example, or in

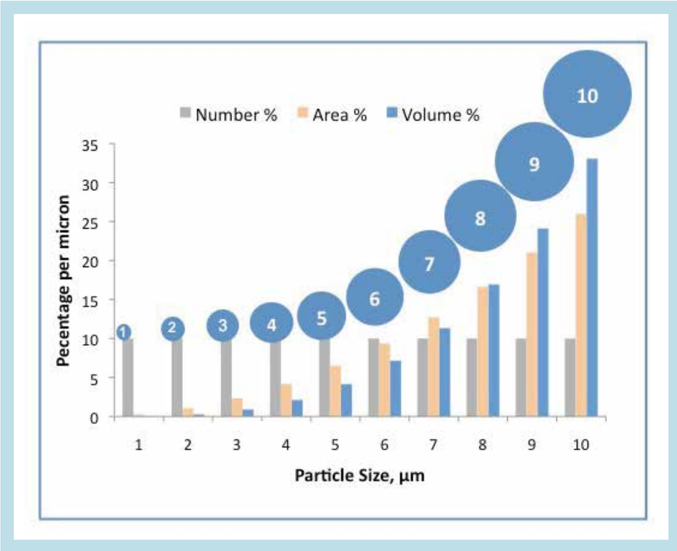

Figure 1 Number, area and volume distributions for a sample containing equal numbers of spherical particles 1-10 microns in diameter.

the development of a topical dosage form where any perceived product “grittiness” might be an issue. Ultimately the type of distribution will be chosen by the user depending upon the information that is sought.

The equivalent sphere

The use of volume distributions introduces the concept of the equivalent sphere (Figure 2). An equivalent sphere is a sphere which is equal to our real particle in the property which we are measuring. Thus for light scattering methods, it is a sphere which would produce the same scattering intensities as our real particle. This approximates to a sphere of equal volume, although the more non-spherical a particle is, the greater the error in this approximation.

LOT directly measures the chord length of a particle without assuming particle shape to derive a number distribution by first intent. This number distribution can also be used to calculate a volume distribution when the particle diameters are taken to represent the diameter of a spherical object. Laser diffraction generates a pseudo volume distribution by first intent and it does this by using an optical model which assumes that the particles being measured are spherical in the first instance. It maintains this assumption to generate a number distribution from the volume distribution.

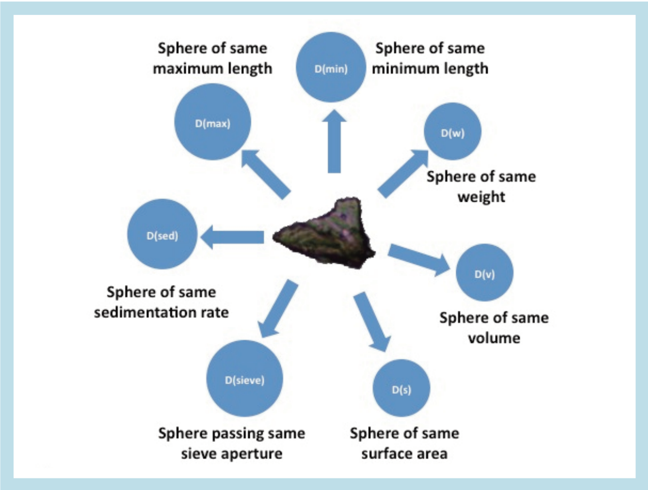

Figure 2. Particle sizes expressed as the diameter of an equivalent sphere. These diameters often appear very different to the particle dimensions observed under a microscope.

Applications

Since obscuration time technology measures a chord length across a particle directly without assuming sphericity, accurate size measurements may be obtained and expressed as number distributions. The same is true of size and shape parameters derived from image analysis. In many cases, differences between samples can only be observed through number distributions; Figures 3 (a) and (b) show that differentiation of batches of HPMC was only possible with number distributions. These types of size differences can lead to performance differences during granulation for example.

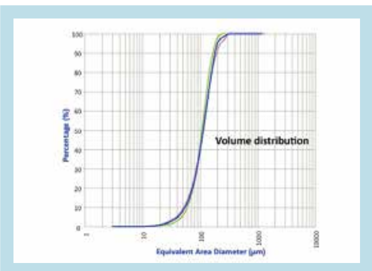

Figure 3(a). Cumulative undersize distributions of batches of HPMC presented as volume distributions. Each line represents a different batch of HPMC.

Figure 3(b). Cumulative undersize distributions of three batches of HPMC presented as number distributions. The size of the batch represented in green can now be differentiated.

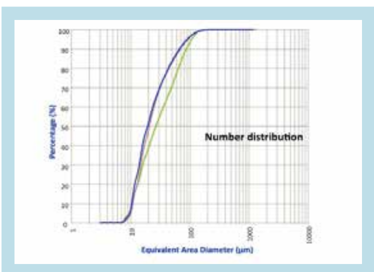

Figure 4 shows how volume and number distributions give complementary information about a sample of ground aspirin. The small number of relatively large agglomerates is only seen in the volume distribution but the predominance of the much smaller ground particles can only be appreciated from the number distribution. Volume distributions are therefore useful in looking for the presence of unmilled material in the presence of milled materials.

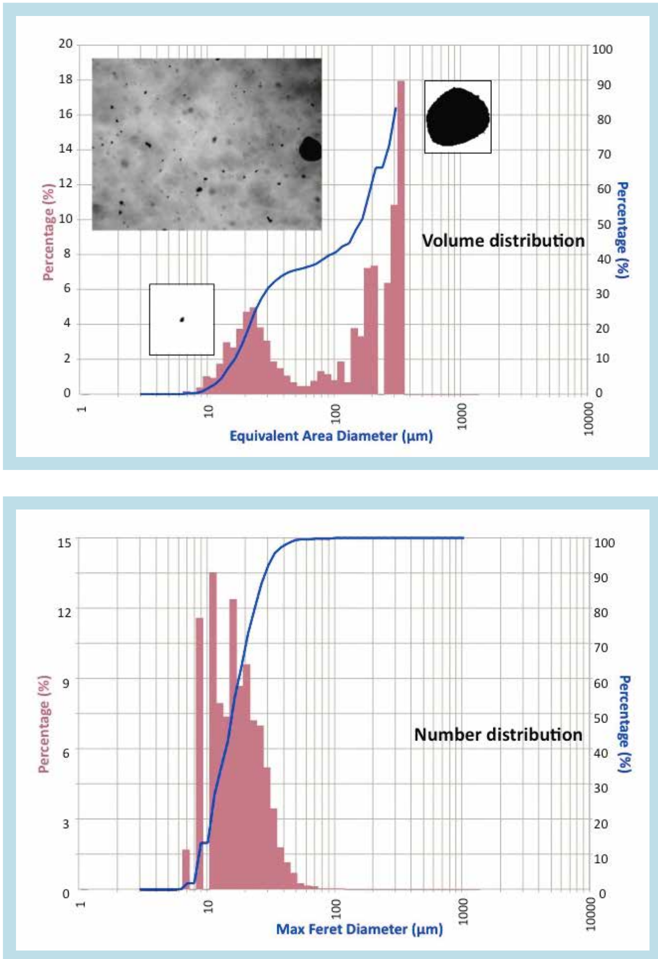

Figure 4. Volume and number distributions for a ground sample of aspirin. Visual evidence (see insert) suggests that the sample dispersion mainly consists of a large number of small primary particles with a small number of larger agglomerates. The volume distribution shows that the small numbers of agglomerates have the highest intensity in the frequency distribution.

The number distribution gives a different perspective and confirms that the number of agglomerates are small in number. These data were acquired using the EyeTech particle size and shape analyser and present two size parameters derived from image analysis, the equivalent area diameter and maximum Feret diameter.