As the rotational speed is decreased, attrition plays a greater role in particle size reduction relative to impaction and compression, yielding a finer grind at the expense of longer processing times.

Some characteristics of the grinding media that affect processing in a ball mill are shape, density, size, and hardness. Increasing the density and hardness of the grinding media increases the rate and extent of size reduction. Decreasing the media size tends to increase the rate and extent of size reduction. The grinding media for generating ultrafine product is typically spherical in shape and composed of ceramic, flint pebbles, or steel. The size of the final product is certainly dependent on the size of the grinding media used (smaller ball size resulting in smaller final product diameter). There are sophisticated versions of the ball mill—pearl mill, bead mill, and sand mill—that use finer grinding media, as the name suggests (Stehr and Schewdes, 1983; Stehr, 1988; Czekai and Seaman, 1999; Muller et al., 1999; Blanton et al., 2002). Ball milling could be conducted as a batch operation or in the contiguous feed mode, making it an attractive technique for specialized applications. Fine grindings with a particle size of 100 ~ 5 mm can be obtained.

Ball milling in water with the presence of surfactants or water-soluble polymers extends the applicability of ball milling poorly water-soluble compounds into the submicron range (Ikekawa, 1971). Particle size distributions with the median particle diameter below 200 nm can be achieved. Figure 17.4 shows the particle size distribution of an aqueous dispersion of a steroid processed in a ball mill. The steroid was milled with polyvinyl alcohol as a stabilizer using 1 mm zirconium silicate beads at 50% of the critical speed. Figure 17.5 shows a scanning electron micrograph of steroid crystals comminuted in a wet ball mill to submicron dimensions.

Media Milling

Media milling, also called stirred ball milling, is a classical wet milling technique wherein a sufficiently concentrated dispersion of solids within a suitable liquid medium (aqueous/nonaqueous) is subjected to traditional ball milling operation (Merisko-Liversidge et al., 2003; Patravale et al., 2004). Media mills are designed in the horizontal or vertical orientation. The cylindrical grinding chamber contains a shaft coincident with its principal axis. Several disks are mounted along the shaft.

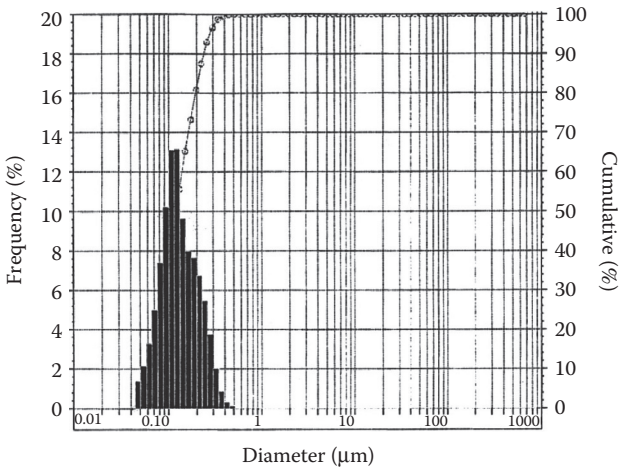

FIGURE 17.4 Particle size distribution of a steroid processed in a wet ball mill as measured by light scattering. (Data generated by NanoSystems, Elan Drug Technologies, a member of the Elan Corporation, plc.)