ZIRCONIUM OXIDE (Zirconia, ZrO2)

Zirconium oxide is a common metal oxide ceramic with a wide range of uses due to its thermal stability, strength, chemical resistance, and optical properties. In most applications, particle size is an important parameter in the final product performance.

Manufacturing Zirconium

Zirconium occurs in more than 30 mineral species. Zirconium metal is produced commercially by reduction of chloride with magnesium (the Kroll Process), and by other methods. Zircon, ZrSiO4, the principal ore, is pure ZrO2 in crystalline form.

Applications of Zirconium Oxide

Zirconia has the common characteristics of ceramics that are not found in metallic or organic materials, including high hardness (next to diamond), high mechanical strength, low coefficient of friction, high temperature stability, chemical resistance, erosion resistance, low electrical conductivity.

Zirconium oxide (zircon) also has a high index of refraction and is used as a gem material. The impure oxide, zirconia, is used for laboratory crucibles that will withstand heat shock, for linings of metallurgical furnaces, and by the glass and ceramic industries as a refractory material. Its use as a refractory material accounts for a large share of all zirconium consumed.

Zirconium dioxide, ZrO_2, is used for optical coatings. Dense layers with exceptional hardness can be deposited by electron-beam evaporation or sputtering. Because of its hardness, it also finds common use as an abrasive material.

Solid Oxide Fuel Cells (SOFC) use yttria-stabilised zirconia as its electrolyte, sandwiched between the anode and the cathode. It runs at a temperature of around 1,000°C. The heat and chemical resistance of the ceramic material are critical in this application.

Importance of Particle Size

As with all ceramic materials, performance of the final product directly depends on the particle size of the ceramic material. Mechanical strength of the final part depends on the ability of the particles to pack to the appropriate density in the casting process. An excess of large particles can form discontinuities in the body, which are a weak point. In products where gas or liquid flow through the material is important, the packing density of the individual particles defines the porosity of the final product.

Horiba LA-930 Particle Size Analyzer

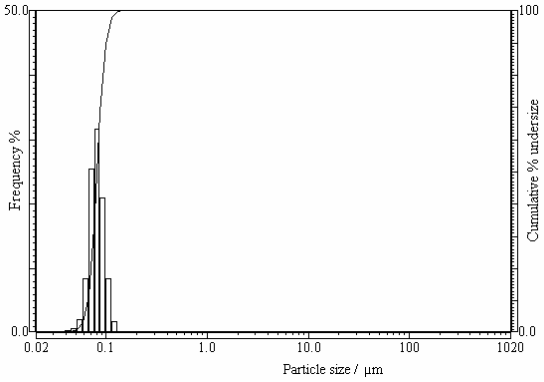
Zirconia is a fairly easy material to analyze using Horiba's LA-series particle size analyzers. Samples are usually dispersed in water, with 0.1% sodium pyrophosphate added as a surfactant. A short period of

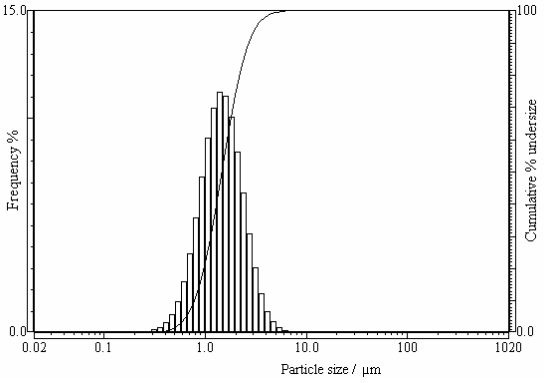
ultrasonics is usually required to disperse agglomerates, particularly in the finer grades. Because of its high density, pump speeds must be kept high enough to ensure suspension of larger particles.

Example Data

The example below shows zirconia used as an abrasive in the electronics industry for Chemical Mechanical Polishing (CMP) of silicon wafer surfaces. The abrasive particles are dispersed in water with a variety of chemical additives and an acid or base to modify pH. The pH, which makes the surface softer, allows a higher polishing rate. Zirconia CMP slurries are usually dispersed in water with no additional surfactant. Dilution of the additives has not been shown to affect the dispersion of the sample.

The example below shows a mixture of silica and zirconia used as abrasives in a tooth polishing product. The abrasive particles are dispersed in a paste with several chemical additives. A larger particle size will polish faster, but too large will scratch the tooth surface. The abrasive mixture is measured before addition to the paste. Silica and zirconia are usually dispersed in water with some added surfactant to prevent agglomeration. Ultrasonic treatment may be necessary to disperse agglomerates.





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