Tiny Bubbles

➤ Continual energy loss makes bubble alumina an excellent insulating material that can withstand exceptionally high temperatures.

Hollow insulating spheres made from high-purity alumina are often referred to as *bubble alumina*. These spheres have been available commercially for more than 40 years, but it is only within the past 10 to 15 years that they have gained acceptance as a versatile and lightweight refractory mineral.

Alumina does not exhibit high thermal conductivity, and when in the form of hollow spheres, its thermal conductivity is additionally reduced. As the outside of the outermost bubble heats up, the heat is transferred through the solid portion of the bubble by conduction. When the heat energy reaches the air inside the bubble, it changes transport mechanisms and the result is a loss in energy. The heat then proceeds across the airspace and reaches the wall of the sphere, changes its transport mechanism again (losing additional energy), and continues through the bubble wall.

As the heat transfers either into another bubble, through the matrix, or through the airspace between bubbles, it loses additional energy. This process repeats itself all the way through the thickness of the insulating lining. This continual energy loss makes bubble alumina an excellent insulating material that can withstand exceptionally high temperatures.

Production and Properties

Alumina bubbles can be produced by various methods depending on the chemistry of the bubble and the final desired properties. For fused alumina bubbles, the fusion process involves melting the raw materials in an electric arc furnace at temperatures in excess of 2000°C and pouring the material out of the furnace through a high-pressure air stream. The molten stream is transformed into a barrage of particles that rapidly cools as the particles fly across the contained area in front of the furnace. Surface tension causes these molten particles to form perfect spheres as they are blown across the room.

As the bubbles get farther from the furnace, the exterior of the spheres cools more rapidly than the interior. This results in the walls shrinking away from the center of each particle, leaving an open core inside. The open core provides the lightweight insulating properties of the bubbles, which exhibit extremely fine crystals resulting from the rapid cooling. By the time the particles have moved 10-20 ft from the pouring spout, they have solidified and are firm hollow spheres. The size distributions of the bubbles are controlled by the velocity of the air stream and typically range from 5 mm to 100 microns.

Table 1. Typical properties of high-alumina and low-silica, low-soda bubbles.

Typical Chemistry	High-Alumina	Low-Silica, Low-Soda
% Al_2O_3	99.0	99.9
SiO_2	0.8	0.02
Na_2O	0.1	0.01
Fe_2O_3	0.03	0.03
CaO	0.03	0.02
Typical Bulk Density		
- 8 mesh split	35 lb/ft^3	55 lb/ft^3
Melting Temperature	**~ 2000°C**	**~ 2050°C**

Alumina bubbles are used in several applications in the refractories market.

The bubbles are then moved from the furnace floor to the screening operation for sizing/grading. The screening system allows for the sizing and separation of the bubbles from magnetics with minimal handling and rework. The bubbles can be placed in several types of packaging, ranging from small bags and drums to large totes and boxes.

High-alumina bubbles* find application in the refractory, abrasive and high-tech ceramic industries, while low-silica, low-soda bubbles** are useful for specialty applications. Table 1 illustrates the typical chemistries and properties of both product types.

High-alumina bubbles are used most often in the production of high-temperature, lightweight insulating refractories due to their low thermal conductivity and high melting temperature. These bubbles are also used as loose-fill insulation and in grinding wheels to add porosity, resulting in cooler cutting wheels.

The low-silica, low-sodium bubbles are used mainly in applications requiring extreme purity, in addition to low thermal conductivity and high operating temperature. These bubbles are often used in applications where a reducing atmosphere is present. Their very low silica and alkali content reduces/eliminates the tramp oxides that can be reduced in high-temperature zones and reoxidized in cooler, more humid zones. This reduces the chance of contamination to the parts being fired that may be sensitive to these oxides.

Applications

Alumina bubbles are used in three different types of refractory products—monolithics, pressed shapes and loose-fill insulation. Monolithics and pressed shapes are the two major applications in the refractories market.

High-purity alumina hollow insulating spheres are designed to withstand high temperatures and demanding environments.

Mixes containing bubble alumina are used to cast monolithic shapes such as burner blocks for kilns and covers for coreless induction furnaces. They are also used to cast backup linings for many types of reactors, especially those with hydrogen atmospheres. High-alumina bubbles are used to cast backup linings for secondary ammonia reformers, carbon black reactors, waste heat boiler tube sheets, controlled atmosphere furnaces, and other high-temperature backup linings.

The insulating firebrick (IFB) that contain high-alumina bubbles are often used as the working lining in ceramic kilns, but are used mainly as backup linings in gasifiers for coal and petroleum coke, gas/oil (with heavy residue feed stock), and industrial waste. These brick are also used in hazardous waste and fluorine processing incinerators, hydrogen generators, auto thermal reactors for methanol production, and ammonia reformers.

Low-silica, low-soda bubbles are currently used in higher-end applications. They are used to press ceramic tiles for lining the combustion chambers within gas turbines, resulting in higher engine efficiency and lower emissions (NO_x) than metal-shielded combustion chambers, and in backup linings in sintering furnaces for nuclear fuels. They are also used in both working linings and backup linings in sintering furnaces for powder metallurgy and metal injection molded parts, and can also be used in the gasifier applications listed previously.

Full Circle

High-purity alumina hollow insulating spheres are designed to withstand high temperatures and demanding, sometimes aggressive, environments. These bubbles are an important component in refractories used for many different applications, from insulating kiln brick and ceramic tile linings in gas turbines to backup linings in reactors and working linings in manufacturing high-purity quartz for the electronics industry.

For additional information regarding high-purity alumina bubbles, contact Washington Mills Electro Minerals Corp. at P.O. Box 423, 1801 Buffalo Ave., Niagara Falls, NY 14302; (716) 278-6600; e-mail bhauer@washington-mills.com; or visit www.washingtonmills.com.

Further Reading

1. W. W. Wellborn, "Synthetic Mineral Production Via Electric Furnace Process," *Industrial Heating*, December 1994.
2. A. J. Osekowski, "Selecting Refractories for PM and MIM Sintering Furnaces: Part 2," *Industrial Heating*, May 2001.

*DURALUM® AB, manufactured by Washington Mills, Niagara Falls, N.Y.
**DURALUM® AB LS, manufactured by Washington Mills, Niagara Falls, N.Y.