1

Chemical Process Industries

Lecture (8)

Ceramic Industries

The word ‘ceramic’ is originated from greek word keromikos, which means ‘burnt stuff". Ceramics are compounds of metallic and non-metallic elements.

**Characteristics of ceramics are:**

-high temperature stability

-high hardness

-brittleness

-high mechanical strength

-low elongation under application of stress

-low thermal and electrical conductivities

**Classification – Ceramics**

Ceramics are classified in many ways. It is due to divergence in composition, properties and applications.

**Based on their composition, ceramics are:**

**-** Oxides

- Carbides

- Nitrides

- Sulfides

- Fluorides

etc.

**Based on their specific applications, ceramics are classified as:**

**-** Glasses

- Clay products

- Refractories

- Abrasives

- Cements

- Advanced ceramics for special applications

In general, ceramic materials used for engineering applications can be divided into two groups: traditional ceramics, and the engineering ceramics. Typically, traditional ceramics are made from three basic components: clay, silica (flint) and feldspar. For example bricks, tiles and porcelain articles. However, engineering ceramics consist of highly pure compounds of aluminium oxide (Al2O3), silicon carbide (SiC) and silicon nitride (Si3N4).

**Glasses:** glasses are a familiar group of ceramics – containers, windows, mirrors, lenses, etc. They are non-crystalline silicates containing other oxides, usually CaO, Na2O, K2O and Al2O3 which influence the glass properties and its color.

**Clay products:** clay is the one of most widely used ceramic raw material. It is found in great abundance and popular because of ease with which products are made. Clay products are mainly two kinds – **structural products** (bricks, tiles, sewer pipes) and **white-wares** (porcelain, chinaware, pottery, etc.)

**Refractories:** these are described by their capacity to withstand high temperatures without melting or decomposing; and their inertness in severe environments. Thermal insulation is also an important functionality of refractories.

**Abrasive ceramics:** these are used to grind, wear, or cut away other material. Thus the prime requisite for this group of materials is hardness or wear resistance in addition to high toughness.

**Cements:** cement, plaster of paris and lime come under this group of ceramics. The characteristic property of these materials is that when they are mixed with water, they form slurry which sets subsequently and hardens finally. Thus it is possible to form virtually any shape. They are also used as bonding phase, for example between construction bricks.

**Advanced ceramics:** these are newly developed and manufactured in limited range for specific applications. Usually their electrical, magnetic and optical properties and combination of properties are exploited. Typical applications: heat engines, ceramic armors, electronic packaging, etc.

**Some typical ceramics and respective applications are as follows:**

**Aluminium oxide / Alumina (Al2O3):** it is one of most commonly used ceramic material. It is used in many applications such as to contain molten metal, where material is operated at very high temperatures under heavy loads, as insulators in spark plugs, and in some unique applications such as dental and medical use. Chromium doped alumina is used for making lasers.

**Aluminium nitride (AlN):** because of its typical properties such as good electrical insulation but high thermal conductivity, it is used in many electronic applications such as in electrical circuits operating at a high frequency. It is also suitable for integrated circuits.

**Diamond (C):** it is the hardest material known to available in nature. It has many applications such as industrial abrasives, cutting tools, abrasion resistant coatings, etc. it is, of course, also used in jewelry.

**Silica (SiO2):** is an essential ingredient in many engineering ceramics, thus is the most widely used ceramic material. Silica-based materials are used in thermal insulation, abrasives, laboratory glassware, etc. it also found application in communications media as integral part of optical fibers. Fine particles of silica are used in tires, paints, etc.



**Silicon carbide (SiC):** it is known as one of best ceramic material for very high temperature applications. It is used as coatings on other material for protection from extreme temperatures. It is also used as abrasive material. It is used as reinforcement in many metallic and ceramic based composites. It is a semiconductor and often used in high temperature electronics.

**Titanium oxide (TiO2):** it is mostly found as pigment in paints. It also forms part of certain glass ceramics. It is used to making other ceramics like BaTiO3.

**Titanium boride (TiB2):** it exhibits great toughness properties and hence found applications in armor production. It is also a good conductor of both electricity and heat.

**Uranium oxide (UO2):** it is mainly used as nuclear reactor fuel. It has exceptional dimensional stability because its crystal structure can accommodate the products of fission process.

**white-wares ceramic:**

Traditional ceramics refers to ceramic products that are produced from unrefined clay and combinations of refined clay and powdered or granulated nonplastic minerals. Often, traditional ceramics is used to refer to ceramics in which the clay content exceeds 20 percent. The general classifications of traditional ceramics are described below.

**Pottery** is sometimes used as a generic term for ceramics that contain clay and are not used for structural, technical, or refractory purposes.

**White ware** refers to ceramic ware that is white, ivory, or light gray in color after firing.

White ware is further classified as earthenware, stoneware, chinaware, porcelain, and technical ceramics.

**Earthenware** is defined as glazed or unglazed nonvitreous (porous) clay-based ceramic ware. Applications for earthenware include artware, kitchenware, ovenware, tableware, and tile.

**Stoneware** is vitreous or semivitreous ceramic ware of fine texture, made primarily from nonrefractory fire clay or some combination of clays, fluxes, and silica that, when fired, has properties similar to stoneware made from fire clay. Applications for stoneware include artware, chemicalware, cookware, drainpipe, kitchenware, tableware, and tile.

**Chinaware** is vitreous ceramic ware of zero or low absorption after firing that are used for nontechnical applications. Applications for chinaware include artware, ovenware, sanitaryware, and tableware.

**Porcelain** is defined as glazed or unglazed vitreous ceramic ware used primarily for technical purposes. Applications for porcelain include artware, ball mill balls, ball mill liners, chemicalware, insulators, and tableware.

****