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About Cordierite

Cordierite ceramics are well known for their low thermal expansion and refractory character. Although cordierite is available as a powder, when we use the term we are generally talking about ceramic that went into the kiln as ordinary composite of ceramic powders but emerges as a cordierite crystalline matrix (grown by the firing process tuned to its needs).

Cordierite makes the ceramic manufacture of products like catalytic converters possible. They constantly heat up and cool down quickly and must not crack because of the shock. These converters get their thermal shock resistance properties from a bonded matrix of low-expansion cordierite crystals. These crystals form during firing between 1300 to 1400C (interestingly, cordierite crystals have a lesser thermal expansion along one axis than another). Thus, the better the density of the precursor mix and controlled the firing the better the properties of the cordierite material are.

The ideal chemistry to produce the crystals is 13.8% MgO, 34.8% Al2O3 and 51.4% SiO2 (2MgO, 2Al2O3, 5SiO2). Talc, kaolin and raw alumina powder can be blended to produce this chemistry (other materials are also used e.g. aluminum hydroxide, steatite and other MgO minerals). Compound materials (like kaolin and talc) react better than pure oxide materials (like MgO, Al2O3, SiO2). Materials of finer particle size react better.

A simple firing to 1300C (about cone 11 and within the reach of many ordinary kilns) and soaked may produce some crystal development. However firing (actually sintering) at 1400C+ with significant soaking time is needed for the best results. Thermal expansion measuring equipment is needed to determine if your firing is actually developing the crystal matrix or not.

As noted, a continuous crystal matrix is the object of cordierite creation (not just the presence of the crystals in an otherwise typical ceramic). Notwithstanding this, cordierite powder is available, it is prefired and finely ground. It can be plasticized for forming and bonded during firing (at much lower than normal cordierite creation temperatures) to produce a ceramic that certainly has lower expansion.

The practicality of cordierite, as a refractory, can be better appreciated when comparing it to alumina. Although alumina by itself, is more refractory than cordierite, it is also much more prone to cracking when subjected to thermal shock. By comparison, cordierite has low expansion and much less expensive. No wonder that cordierite kiln shelves are common.

While cordierite ceramic vessels could be made (e.g. ovenware), the material has such a low thermal expansion it is very difficult (or impossible) to match a glaze (without crazing). Notwithstanding this, many recipes can be found for cordierite ovenware or flameware. However these are seldom fired above cone 10 so any thermal shock resisting behavior they have is attributable to grog content or open fired matrix rather than to any cordierite development (which is of course not happening).

Material Details

Cordierite ceramic is a magnesium aluminum silicate material that has been widely used in applications where thermal shock resistance is important. Cordierite ceramic is also useful because it has a low thermal expansion and good electrical insulation compared to other ceramic materials. It can be formed into a variety of complex geometries by employing several types of manufacturing process such as axial pressing, isotactic pressing, injection molding and extrusion.

Overview of Physical Properties

- Good thermal shock resistance
- Low thermal expansion
- Low thermal conductivity
- High dielectric strength
- Overview of Applications
- Household Appliances (Insulators)
- Heating element supports
- Refractory supports in ovens or kilns
- Thermocouples
- Electrical Insulators

Item	Test Condition	Unit	Cordierite
Main Chemical composition			2MgO·2Al2O3·5SiO2
Density		g/cm³	2.5
Porosity		%	0
Firing Temp		°C	1350
Hardness		HV	800
Flexural Strength	20℃	Kgf/cm²	900
Compressive Strength	20℃	Kgf/cm²	3500
Max Operating Temperature		°C	1000
Coefficient of Thermal Expansion		$1x10^{-6}$/°C	≤2
Coefficient of Thermal Conductivity	25℃~30℃	W/m°K	1.3
Thermal Shock Resistance	△Tc	°C	50
Dielectric Constant	1MHz.25℃		6
Volume Resistivity	20°C	ohm-cm	10^{12}
	100°C		10^{7}-10^{8}
	300°C		$3*10^{5}$
Dielectric Strength		ac-kV/mm（ac V/mil）	10