POROUS CERAMICS

WITH EXPANDABLE MICROSPHERES

A technical insight of applications, properties, processing methods and benefits

OVERVIEW

Product Type
Expanded microspheres

Main Benefits
Controlled & uniform pore structure
Cracking & deformation avoided
Easy & rapid burnout

Applications
Absorbers
Dust collectors
Filters
Hot gas collectors
Thermal insulation

About Porous Ceramics

Porous ceramics products have a unique combination of **valuable properties**, which makes them useful in a variety of advanced engineering applications.

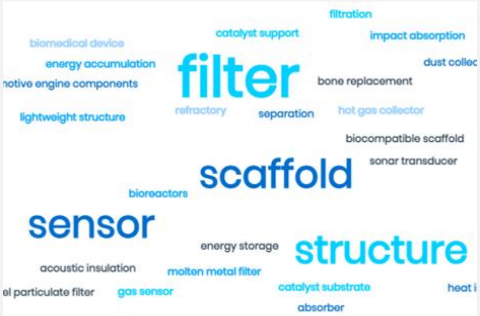
Filtration and **separation** are the main applications for porous ceramics.

These **low density** ceramics are **chemically inert** and **corrosion resistant**. They can be manufactured in a wide range of **pore sizes** and **pore size distributions**.

The **final properties** of the porous ceramic product is not only influenced by the **ceramic material**, such as alumina, zirconia or non-oxide based ceramics, used to make it, but also the **relative density**, **pore shape** and **topology** of the product itself.

Porous materials can be classified by their pore diameter:

- Microporous <2 nm
- Mesoporous >2 nm - <50 nm
- Macroporous >50 nm



Applications

Porous ceramics are favoured for their **superior** characteristics and **properties**. They are suitable for processes carried out **under pressure** and **high temperatures**, and offer several advantages over filters made of other materials, such as, metal and plastic:

- Excellent chemical resistance against acids and alkalis
- Good dimensional stability, structural strength and hardness
- Excellent thermal shock resistance
- High permeate flow rate
- May be coated with catalytic or functional materials

Applications of porous ceramics include:

- Absorption
- Chemical engineering
    - Catalyst supports
    - Porous burners
    - Sensors; gas, liquid
- Filtration
    - Chemical processing
    - Dedusting
    - Electroplating
    - Filtration of liquids
    - medical
    - Particulate filtration; air, gases
- Heat insulation
- Lightweight structural components
- Medical technology
    - Bone substitution material
- Separation techniques

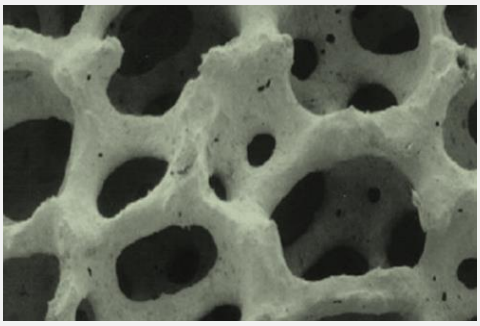
An Example

Using porous ceramics as a filter

Porous ceramic filters offer **reliability** and **sustainable cleanliness** levels in air, gas and liquid filtration by **continually** and **efficiently** removing contaminants, and having a **holding capacity** for a vast amount of contaminants.

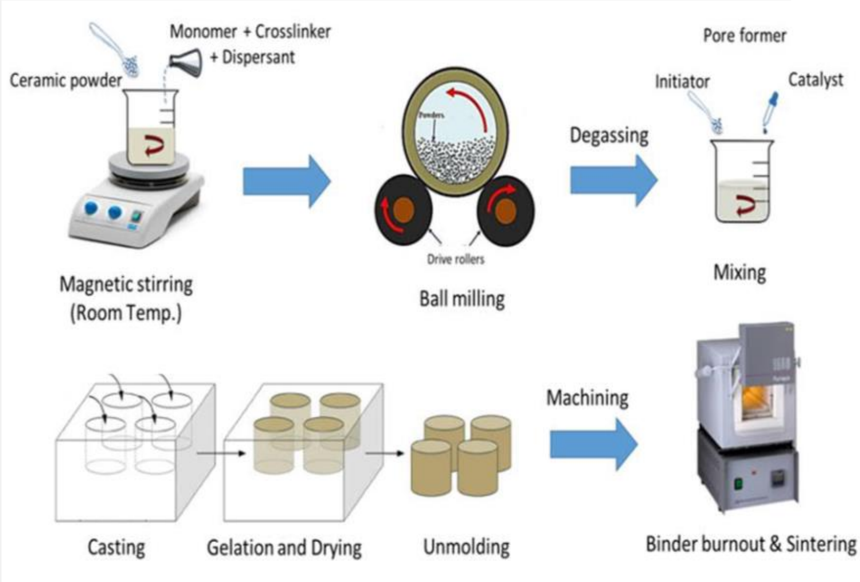
Filters are produced in various shapes with different **lengths**, **diameters** and number of **channels**, which play a crucial role in **performance efficiency**. A longer length filter or higher number of channels would give a greater surface area for filtration.

In **cross-flow filtration**, high solid suspensions can be filtered continuously, without blinding. A suspension pumped through a porous ceramic filter with multiple channels, flows laterally across the surface of the filter membrane. **Contaminants** smaller than the membrane pore size, pass through the membrane. The permeate is drawn off transversely to the direction of the flow. The lateral motion of the flow of the suspension causes contaminants trapped on the surface of the filter membrane to be rubbed off, therefore **no filter cake** is formed.



An Example

Sacrificial template method



Processing Methods

Dry expanded microspheres create a **uniform cell structure**. With a specific particle size and density it is possible to determine quantity of microspheres required to achieve a **specific weight reduction** or **pore volume density**.

The microspheres can be used in different **manufacturing techniques** to produce porous ceramics:

With **direct foaming**, porous ceramics are processed by foaming a ceramic suspension using mechanical agitation or incorporating gas, followed by drying and sintering.

The **replica technique** produces porous ceramics by impregnating a natural or synthetic template with a ceramic suspension, followed by drying, removal of the template and sintering.

In the **sacrifical template method**, a sacrificial phase added to a ceramic precursor in liquid or solid form, is removed by sintering.

The **sacrificial template method** by gel casting consists of the preparation of a two-phase homogeneous solution comprising a continuous matrix of ceramic powders, or pre-cursors, and a dispersed sacrificial phase which is distributed evenly throughout the matrix.

The sacrificial phase is removed by burning out before, or during sintering, to create pores within the microstructure.

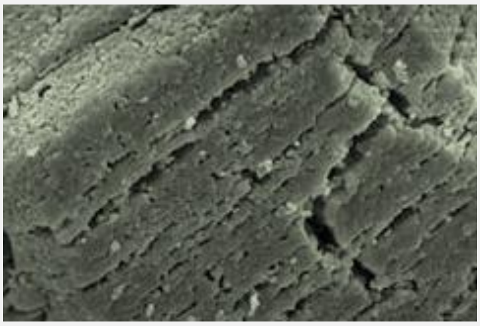
Dry expanded microspheres, with **densities** as **low** as **0.025 g/cm³**, used as the sacrificial phrase in the production of macro porous ceramics, offers simple, fast and scalable processing with **better control** over **properties** during debinding:

- Density reduction
- Pore size
- Pore size distribution
- Porosity
- Shape of the pores

As with any burnout process, it is important to ensure good ventilation.

Large Pore Volume

With low organic content



Cracking & Strength

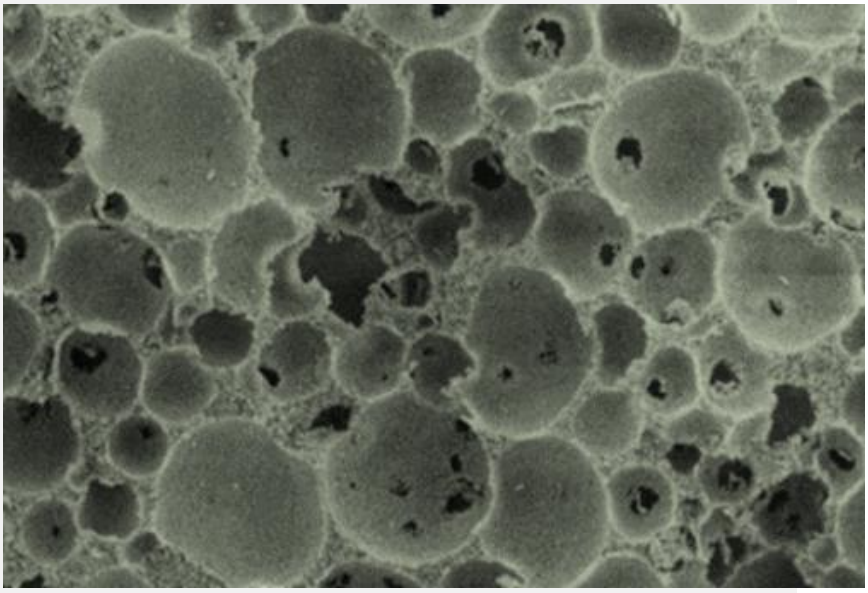
Cracking and **deformation** can be **avoided** when using dry expanded microspheres due to lower carbon dioxide release.

The **burnout process** can be drastically **shortened** without causing problems with stress, warping and crack formation. This has a **positive effect** on compressive strength of the final product.

The **compressive strength** of a foam prepared with dry expanded microspheres is higher than a foam containing glassy carbon.

In the presence of **glassy carbon**, the amount of **gases released** are up to **twenty times higher**, than in the presence of dry expanded microspheres. This high amount of released gases leads to an increase in internal stress, resulting in defects such as cracking and deformation, through bloating. Ultimately, this leads to failure at lower mechanical stress.

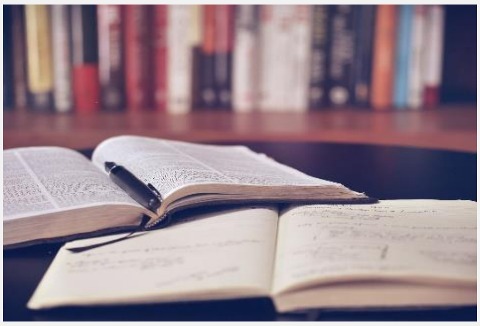
Compressive strength may be reduced, in the presence of expandable microspheres or glassy carbon, if the heating rate is increased, due to volatiles forming faster than they can escape.



A **low amount** of **organic material** allows **easy** and **rapid burn out**. When dry expanded microspheres are used to prepare a sacrificial template, the burnout of the sacrificial microspheres from the ceramic can be up to **ten times faster** than **alternative templates**, such as, glassy carbon.

With faster burnout of the microspheres, the burnout cycle is reduced with **less gases released**, and **mechanical strength** is **maintained**, This is particularly beneficial in the manufacture of large ceramic parts.

Furnace atmosphere can strongly affect the burnout process. A larger weight reduction can be achieved when burnout is carried out under oxygen than in an inert atmosphere, such as, argon. In the presence of oxygen, both thermal combustion and decomposition occur. In an inert atmosphere, only thermal decomposition takes place. Thermal decomposition and removal of volatiles can also be influenced by **sample size**. Volatile removal is decreased, when the sample size is increased. This is true for both expandable microspheres and glassy carbon.



What's Next?

Further Reading

Our **Application Guides** and **Case Studies** show the many other ways in which expandable microspheres can be used:

- Adhesives
- Automotive bodyfiller
- Concrete
- Crack filler
- Elastomeric coatings
- Fairing compounds
- Faux leather
- Faux marble
- Filling compounds
- Leather finishing
- Lightweight foam
- Modelling board
- Modelling clay
- Paints & coatings
- Plastisols
- Polyester putty
- Porous ceramics
- Printing ink
- Rubber
- Sealants
- Silicone rubber
- Technical textiles
- Thermoplastics

If your application is not listed, then please get in touch so we can help you.

Discover the unique properties of expandable microspheres and the benefits of using them in our **Technical Guide – Properties of Expandable Microspheres**.

Do you need help **choosing the right grade** for your application, **more information** or a **sample** to try?

We are always happy to help and answer any questions you may have. Please do not hesitate to contact us:

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