CoMeTas
COPENHAGEN MEMBRANE TECHNOLOGY A/S
Future Filtration
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BACKGROUND

CoMeTas is proud to introduce a new series of ceramic membranes and elements made solely from Silicium Carbide (SiC) for use in industrial processing, water treatment and waste water purification.

Membrane filtration is normally divided into four areas with the following approximate pore size:

1. Microfiltration (MF) - 0.05 to 2.00 µm
2. Ultrafiltration (UF) - 0.003 to 0.100 µm
3. Nanofiltration (NF) - 0.001 to 0.003 µm
4. Reverse Osmosis (RO) - smaller than 0.002 µm

This translates into the following approximate molecular weight cutoff (MWCO) in Daltons (D):

1. Microfiltration (MF) - larger than 100,000 D
2. Ultrafiltration (UF) - 2,000 to 200,000 D
3. Nanofiltration (NF) - 150 to 2000 D
4. Reverse Osmosis (RO) - smaller than 250 D

The definitions and limits listed in the above should not be taken too literally. The limits between the various membrane filtration technologies are not well defined and there are overlaps between them. It may be more important to divide the membrane filtration technologies into two groups according to the transport phenomena applied.

The transport of material through MF and UF membranes relies largely on the pores in the membrane, i.e. the pore size, the pore size distribution and the total area of the pores. MF is normally considered to be an extension of particle filtration, where the filtrate from an MF membrane can be considered to be void of particles. Likewise, the filtrate from MF can be considered to be void of bacteria, but, in most cases, MF will only provide a reduction, not a total removal, of the content of viruses in a feed stream. Somewhat depending on the tightness of a UF membrane viruses will be rejected to a very high extent together with all bacteria due to the tightness of the pores in a UF membrane.

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The type of membrane normally used in connection with industrial process streams, water treatment and waste water purification, no matter if it is called MF or UF, generally has a pore size larger than 0.2 µm, approximately 150,000 MWCO. The membranes discussed in this paper will be characterized as MF membranes, although the tightest varieties technically fall into the grey area between MF and UF.

SILICIUM CARBIDE MEMBRANE TECHNOLOGY

CoMeTas is actively developing, producing and marketing advanced technical products made from SiC and represents a breakthrough in ceramic membrane technology. The new range of ceramic membranes made entirely from silicium carbide (SiC). This means that both the carrier and the thin membrane layer deposited on the carrier is made from the same material. This innovation presents a range of important performance benefits to the users:

- High Flux Rate
- Low Cost
- Compact Modules
- Wear Resistant Material
- High Durability
- Small Footprint

The ceramic membrane carrier is based on the so-called honeycomb or monolith structure as illustrated in Fig. 1. A number of parallel flow channels extend through the element in the porous support structure. The feed stream is introduced under pressure at one end of the element and flows through the channels during processing. The portion of the liquid passing through the membrane, the permeate, flows into the porous structure of the element. The combined volume of permeate from all flow channels flow toward the outer shell of the monolith support and is removed continuously.

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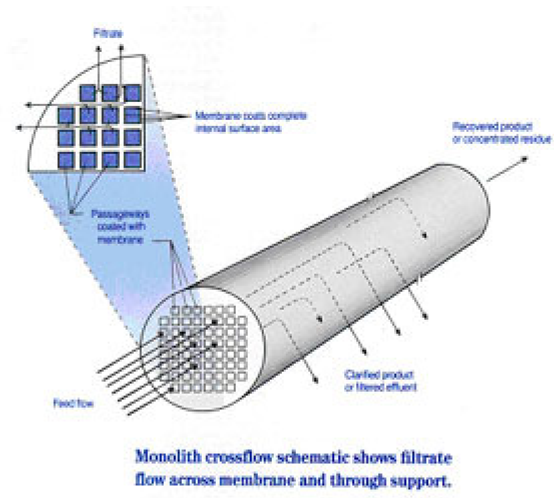
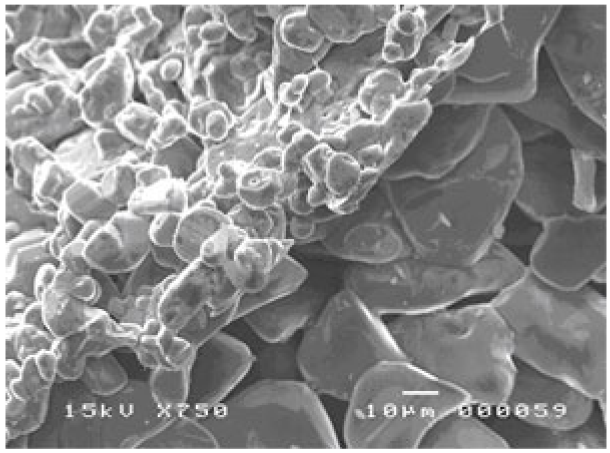
Fig. 1: The structure of the porous support material.



The actual ceramic membranes are formed on wall of the flow channels extending through porous ceramic structure of the element by slip casting a specific coating of ceramic particles according to the desired pore size and distribution. The coating material, containing the silicium carbide, is dried and sintered. This process ensures a strong bond with the carrier material and provides the membrane with its unique ruggedness and durability.

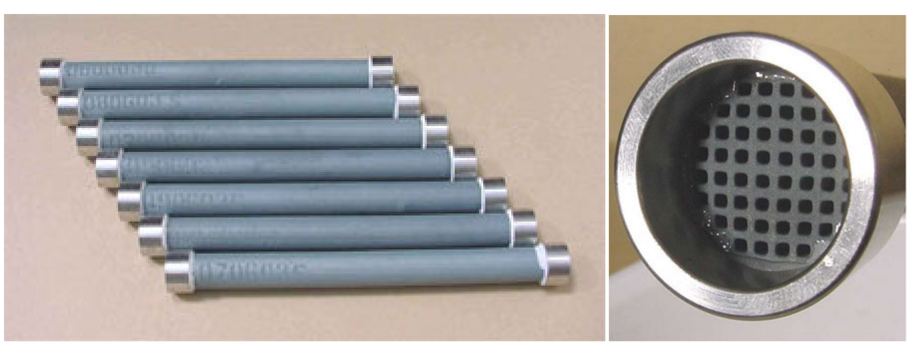
Several layers may be deposited on top of each other in order to reach the desired combination of membrane pore sizes and water flux. Fig. 2 shows a silicon carbide membrane layer on top of a silicium carbide carrier.

Fig. 2: Scanning Electron Micrograph of a CoMem® membrane.



The monolith or porous structure of the element is formed from Silicon Carbide by extrusion. The elements can be extruded in sizes up to 172 mm in diameter and in lengths up to 1500 mm, which results in membrane areas up to 37 m^2 per element. Different designs of the extrusion matrices makes it possible to change of the shape and the number of flow channels. The flow channels in, for instance, the CO25 element are 3 x 3 mm. Fig. 3 shows a number of 25 mm diameter CO25/305 modules with 32 3 x 3 mm flow channels. The length of the elements is 305 mm, which gives a membrane area of 0.10 m^2.

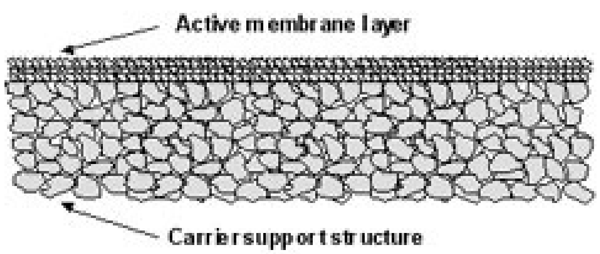
Fig. 3: The CO25/305 ceramic membrane elements.



CHARACTERISTICS OF THE SILICIUM CARBIDE MEMBRANE

As mentioned previously, the element consists of porous support material with a number of flow channels extruded from Silicium Carbide. The flow channels are coated with one or more layers of a proprietary SiC slip casting media. The slip casting media is a colloidal suspension of SiC in a dispersion media. The composition of the slip casting media, the structure of the carrier and the conditions during slip casting determines the characteristics of the final membrane. The structure of the membrane is illustrated in Fig. 4 showing the porous structure of the carrier covered with the denser surface membrane layer which determines the properties of the membrane.

Fig. 4: The structure of a Silicium Carbide membrane.



The series of Silium Carbide membranes and elements supplied by CoMeTas cover pore sizes ranging from 0.04 – 33µm. The water flux is very high compared to other ceramic membranes due to the high porosity of the support material.

The membranes are chemically stable over the full pH range of 0 – 14. In durability tests performed on SiC membranes exposed to 1N NaOH at 90°C over several hundred hours and to 60% sulfuric acid at 90°C only negligible degradation was observed and only a fraction of the degradation of ceramic membranes made from other materials.

The SiC membranes tolerate temperatures up to 1000°C. Cleaning and sanitation with harsh chemicals and even steam sterilization do not affect the membranes.

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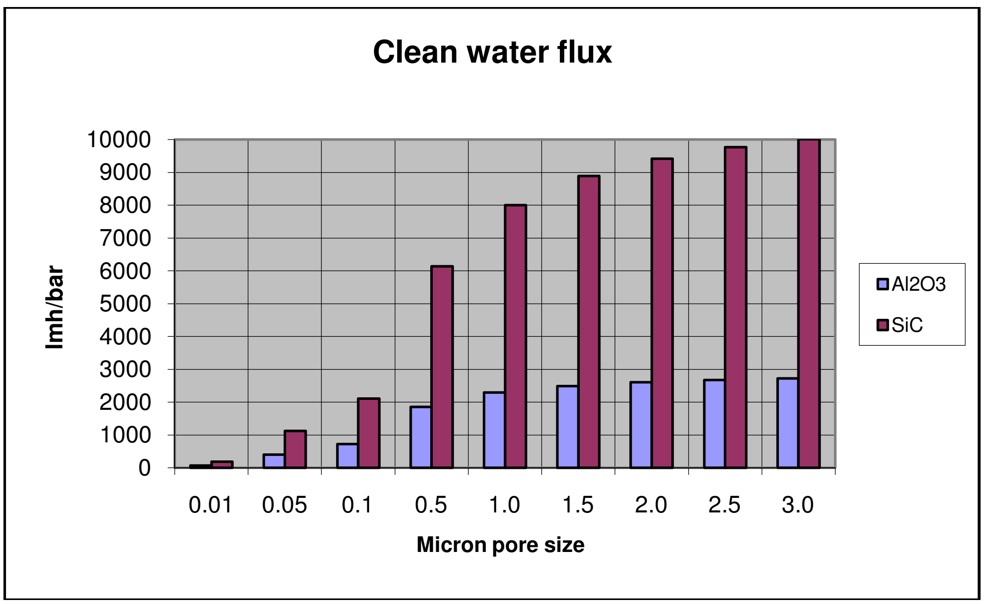
As stated above, SiC is one of the most resistant material materials as it pertains to temperature and chemicals. This allows for a wide range of new applications of ceramic membrane technology in various fields, e.g. industrial processes, water treatment and waste water purification.

The very high water fluxes of the Silicium Carbide membranes are illustrated in Fig. 6. The difference in flux performance compared to other ceramic membranes is due to the structure of the support material and the membrane layers in SiC membranes and elements. A benchmark clean water flux test was made comparing SiC membranes and other types of ceramic membranes with comparable pore-size and filtering effect. The test shown in Fig. 6 clearly indicates a higher flux for the SiC membrane.

Fig. 6: Water flux for SiC membranes versus conventional ceramic membranes.



Microfiltration is mainly used when there is a requirement for particle filtration, bacteria removal and/or virus reduction in industrial processes and municipal water and wastewater treatment. The nature of these applications often poses high demands to the membranes and equipment in terms or thermal and chemical resistance in connection with cleaning and sanitization. All of those demands are met by Silicium Carbide membranes.

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APPLICATIONS OF THE SILICIUM CARBIDE MEMBRANE

Silicium Carbide membranes are used or have potential uses in a large number of industries and applications, among them:

- Drinking water
- Industrial and municipal wastewater treatment
- Treatment of industrial process water
- Membrane bioreactors (MBRs)
- Pretreatment before other membrane filtration processes (RO, NF, UF)
- The chemical, pharmaceutical and biotech industries
- The food and dairy industries
- The brewing and beverage industries
- Oily waste water (e.g. produced water)