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Trinkwasserreinigung mit keramischen Filtrationsmembranen

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in Clean Water Technology

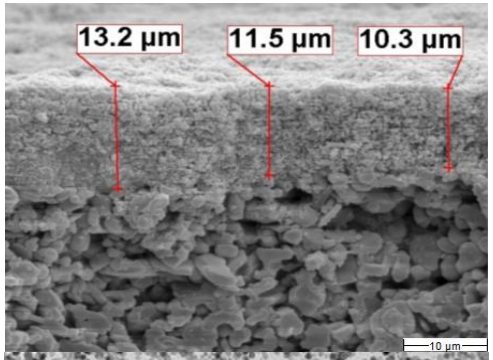
Initial situation

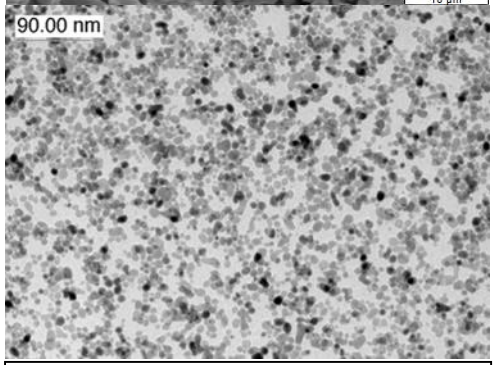
- Water scarcity, resource management, and the fear of epidemics lead to the call for stricter legal regulations worldwide.
- Globally increasing demand for economically efficient techniques for waste water and drinking water treatment.
- Established water technology undergoes paradigm shift: ecology and water footprint and sustainability become major drivers.
- Significant technical advantages of ceramic membranes through nanotechnology combined with an very efficient way of production: high cost efficiency combined with an innovative product!

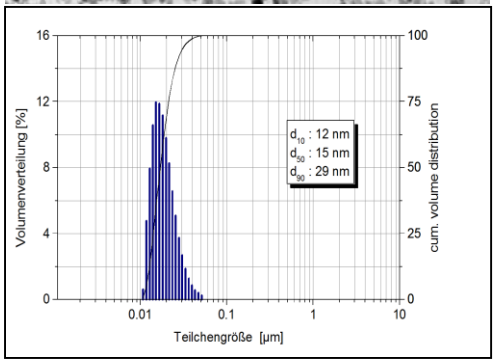
Source: http://www.waterfootprint.org

Ceramic Nanofiltration Membran

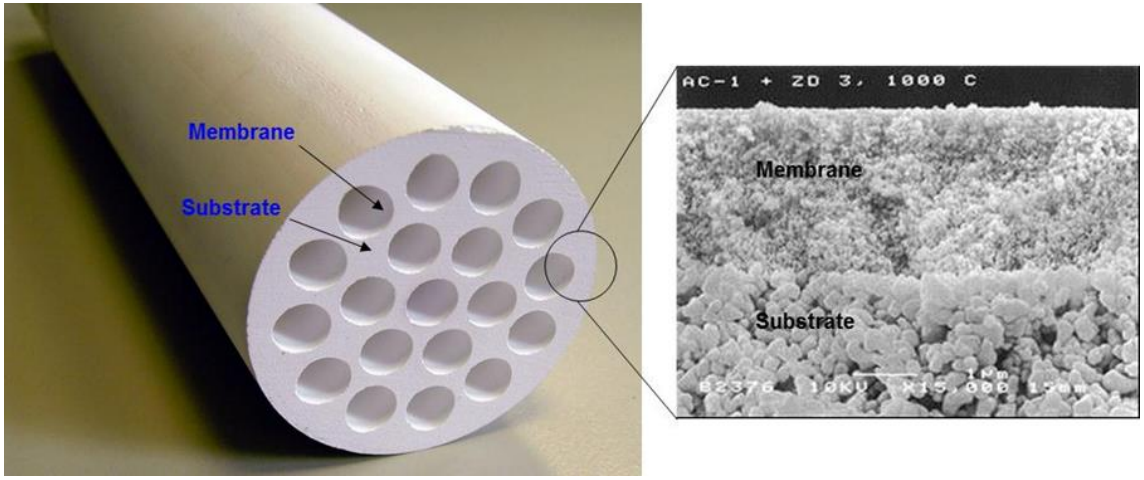
- Membranes for water filtration must have pore sizes smaller than 100 nm.
- The particle size of the nanoparticles defines the pore size of the separation layer.
- Defect-free membranes desire a narrow particle size distribution.
- Nanoparticles (e.g. Al_2O_3, TiO_2, & ZrO_2) used for the production of the separation layers are specially synthesized and modified to meet the mentioned requirements.







tubular ceramic substrat



Production nano particles

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1 Precursor synthesis & precipitation	Hydration of an organic metallic compound in a high energy stirrer and precipitation of a metal hydroxide. Surface modification prevents strong particle agglomeration or aggregation.
2 Controlled growth & crystallisation	Metal hydroxide is treated in a hydrothermal process for crystallisation and particle growth. Surface modification prevents strong particle agglomeration or aggregation.
3 Cleaning process	Removal of the chemical residues from the hydrothermal process and washing of the obtained filter cake.
4 Milling & surface modification	High energy milling for de-agglomeration of the loose agglomerates. Surface modification added to keep particles separated. →45 wt.% aqueous solution with a viscosity similar to water.

Competitive advantages of technology

1 Advantage 1

- Agglomerate-free product with narrow particle size distribution and a high solid content

2 Advantage 2

- Approved and easy scalable production up to several tons per year

3 Advantage 3

- High unique and stand-alone technology

Production membranes

1 Mixing & Extrusion	Alumina's with different particles sizes, organic binders and solvents are homogeneously mixed and extruded in the desired Geometry (specially designed dye head).
2 Drying & Firing	Removal of the excess water in a drying chamber, controlling humidity and temperature. After drying firing of the dried material in a furnace at T > 1.400°C
3 Coating & Firing	The fired ceramic is coated with the separating layer(s) (nanocoating) and fired in a furnace at 800 to 1.300°C
4 Module construction & Testing	Coated and fired membranes are potted in different materials e.g. FPR (fibre-reinforced plastics). The complete module is tested : e.g. bubble point, pressure test & permeability (performance)

Competitive advantages of technology

1 Advantage 1

- Combination of known ceramic technology with nanotechnology → better properties & performance

2 Advantage 2

- Automatable and scalable production → price competitive production
- Unique and stand-alone technology

3 Advantage 3

- Holistic and flexible concept adapted to the market and customers needs →competitive advantage

Competitive positioning

Polymer membranes

Pro

- Lightweight construction
- Large filtration areas per module
- Low price for purchasing

Contra

- Low stability against pressure & during backwashing (MF/UF)
- Cleaning of bio-fouling depreciates life expectancy
- Low temperature resistance and low resistance against chemicals
- 3-6 years product warranty

- *Limited application areas and markets*
- *High amount of maintenance*
- *Frequent replacement necessary*

Ceramic membranes

Pro

- High temperature resistance and und high resistance against chemicals
- High pressure resistance
- High abrasion stability
- High & stable filtration performance
- High operational stability
- 10-20 years product warranty

Contra

- High weight
- High price so far
- Smaller filtration area per module in comparison to polymer membranes

- *Application in all areas (MF/UF)*
- *Previous disadvantage of high price is compensated with 3C products due to optimized production process, high life time and larger filtration area per running meter*

Competitive positioning

Comparison of technologies on key parameters	Existing technology		3C technology
	Polymer	*Conventional ceramic*	*Nanoceramic*
Pore size for water filtration	Available	Available	Available
Pore size distribution	Inhomogeneous	Inhomogeneous	Homogenous
Availability, production capacity	Large capacities available	Limited	Large capacity available
Performance (permeability)	80 – 100 l/hm^2	250 – 500 l/hm^2	250 – 500 l/hm^2
Chemical, thermal & mechanical resistance	Low resistance	High resistance	High resistance

Competitive advantage of using technology

- High level of automation
- Large volumes for mass markets available
- Superior value proposition because of attractive price advantage compared to competitors
- High innovation potential due to the use of nanotechnology

Competitive positioning

	Surface water treatment (own research)		Drinking water processing (own research)	
	Ceramics	Polymer	Ceramics	Polymer
Estimated permeate flow per m² membrane area (flux)	200 L/hm²	80 L/hm²	200 L/hm²	80 L/hm²
Costs per m² membrane area in the module	175,00 €	95,00 €	125,00 €	31,50 €
Life time of the membrane	12 years	6 years	15 years	5 years
Recovery	99 %	95 %	99 %	95 %
Comparison of investment costs and operational costs				
Costs per module	3.500,00 €	4.500,00 €	3.875,00 €	1.890,00 €
Installed membrane area	320 m²	800 m²	25.017 m²	62.520 m²
Total investment costs	257.477,71 €	298.579,43 €	9.626.333,84 €	11.243.041,71 €
Share of the membranes in total investment costs	21,7 %	24,1 %	32,5 %	17,5 %
Total operational costs per year	10.702,27 €	62.470,95 €	500.526,11 €	834.268,24 €
Total annual costs including depreciation (10 years)	36.450,04 €	92.328,89 €	981.842,80 €	1.396.420,32 €
Price m³ (total costs : m³ x 24 x 365)	**0,069 €**	**0,176 €**	**0,022 €**	**0,032 €**

Application Areas for this kind of Ceramic Modules

Water @ Source

Applications

Ground and surface water filtration

Pre-Filtration
- Salt water filtration before desalination
- Clean intake water

Water @ Release

Applications

Waste Water Treatment

Water Reuse

Advanced Processing

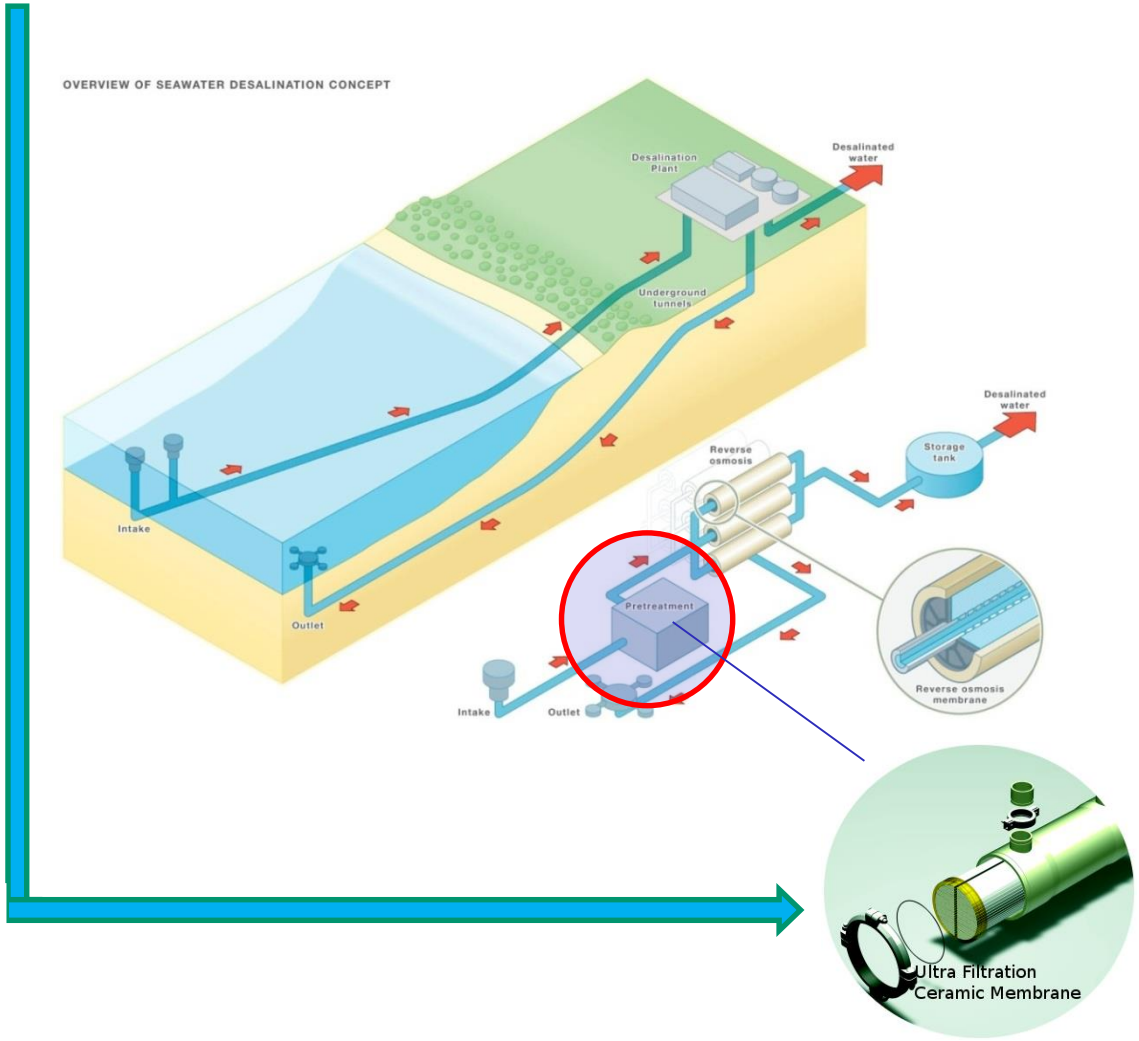
Water @ Process

Applications

Oil/water separation for oil production processes

Filtration of Produced Water

Pre- Treatment before Desalination



Osmosis is Nature's great way of separating matters in liquid environment.

Engineering has rebuild that principle and applies it to purify water. For example from sea water.

Ceramic membranes can support and improve this process, by taking out other substances that disturb the actual reverse osmosis and the membranes engaged to a great extent.

Life in water is a given. Ceramic, nanotechnology modified, membranes keep microorganisms out of the osmosis system, thus preventing fouling processes.

Waste water treatment

Target markets – Water @ Release

Released water cycle

Water contaminated Discharged from sanitary systems, communal and industrial

Black Water

Pre-Treatment

Water contaminated with sediment and bacteria

Dischargeable Water

Filtration

Clean water with minor virus and possible metals contamination

Use Water

Advanced treatment

Clean and germfree water with drinking quality

Drinking/ Production Water

Pre-Treatment
•sedimentation
•screening
•flocculaltion
•flotation
Water is processed through screens and clarifiers

Filtration
•Micro Filtration
•Ultra Filtration
•Nano Filtration
Water is processed through ceramic membranes.

Disinfection:
•Ozonisation
•UV treatment
•Chemical treatment
Water is sterilized and all viral and bacterial contamination is neutralized.
Reverse Osmosis:
Separating matter on molecular level from waster

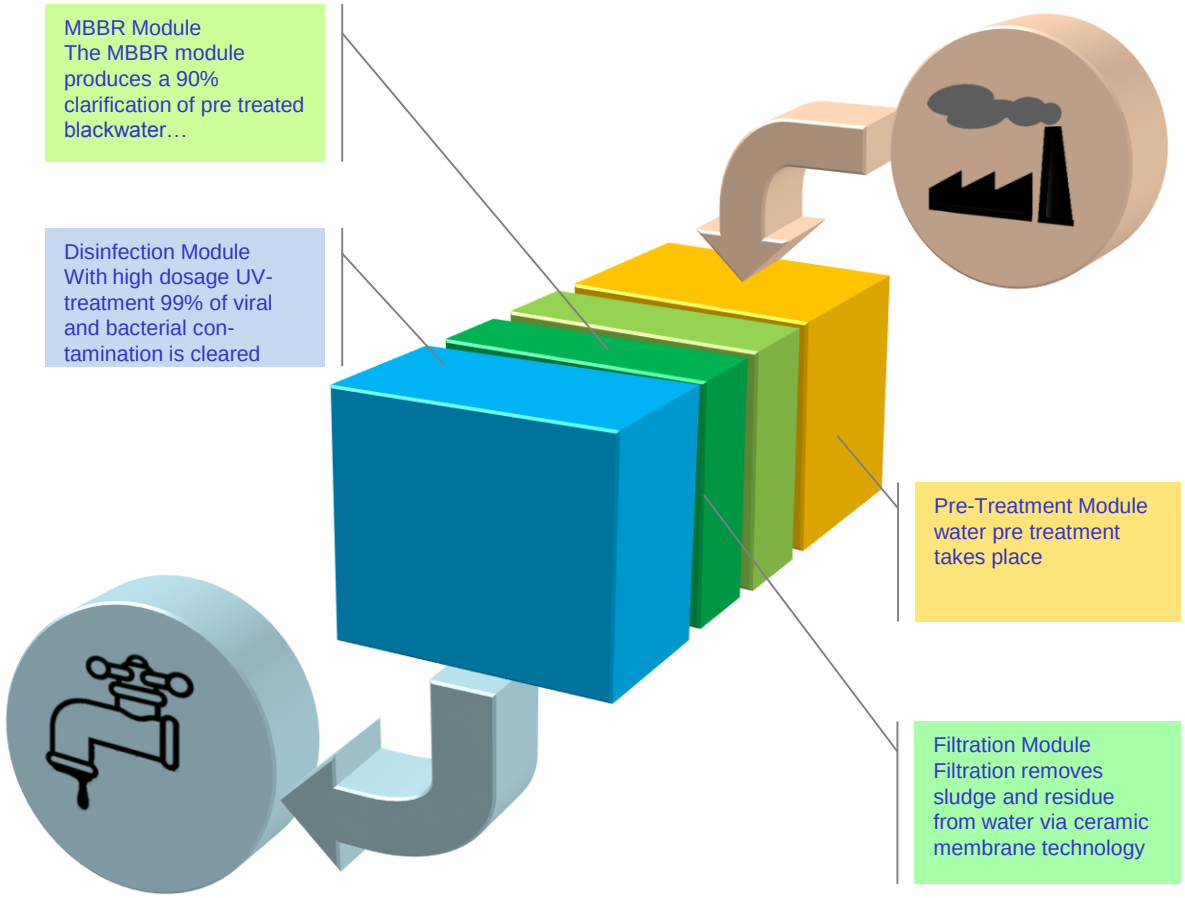
Filtration of released water is the core of measures to establish a sustainable water circulation

Ceramic membranes are capable of controlling a wide array of substances and microorganisms, enduring a great span of temperatures, separate many aggressive process reagents.

Thus they are ideally suited to conserve valuable water for the circulation of private, public or industrial reuse, instead of producing literally waste(ed) water

Whichever systems in use or deployed in the water cycle, ceramic membranes are a crucial part of the processing and value chain.

De-centralized water treatment systems



Decentralized Water Treatment Systems' (DWTS) focus lies with newly emerging market environments, where remote locations, settlements and natural environment conditions call for distributed systems and distributed access to clean water.

Various application scenarios can be supported by ceramic membrane products.

Container includes ceramic membranes

Zusammenfassung

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- An Membrantechnologien zur Reinigung von Prozeßabwässern, kommunalen Abwässer und zur Herstellung von Trinkwasser führt kein Weg vorbei
- Keramische Membrane sind Polymermembranen in vielen Belangen überlegen, aber:
  - limitierte Menge, Herstellungsverfahren
  - hoher Preis als Folge der limitierten Menge und des Herstellungsverfahren
  - hohes Gewicht
- Nanotechnologie führt zu kontinuierlichen Prozessen und verbesserter Qualität:
  - niedriger Preis, aber immer noch höher als bei Polymeren
  - beliebige Menge herstellbar
  - hohes Gewicht
  - erstmals konkurrenzfähig

Zusammenfassung

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- Keramikmembrane sind bezogen auf Lebenszeiten klar im Vorteil, das interessiert aber kaum jemanden

- Es gibt Anwendungen da führt kein Weg vorbei

  z. B. Grundwasser Saudi Arabien; hohe Temperaturen, Belastung mit radioaktiven Substanzen, Biofouling etc. führen dazu, dass Polymer-membrane versagen

- Keine Belastung des Wassers mit Nanopartikeln, da diese beim Brand sich zugunsten einer Keramik aufgelöst haben

Vielen Dank für Ihre Aufmerksamkeit