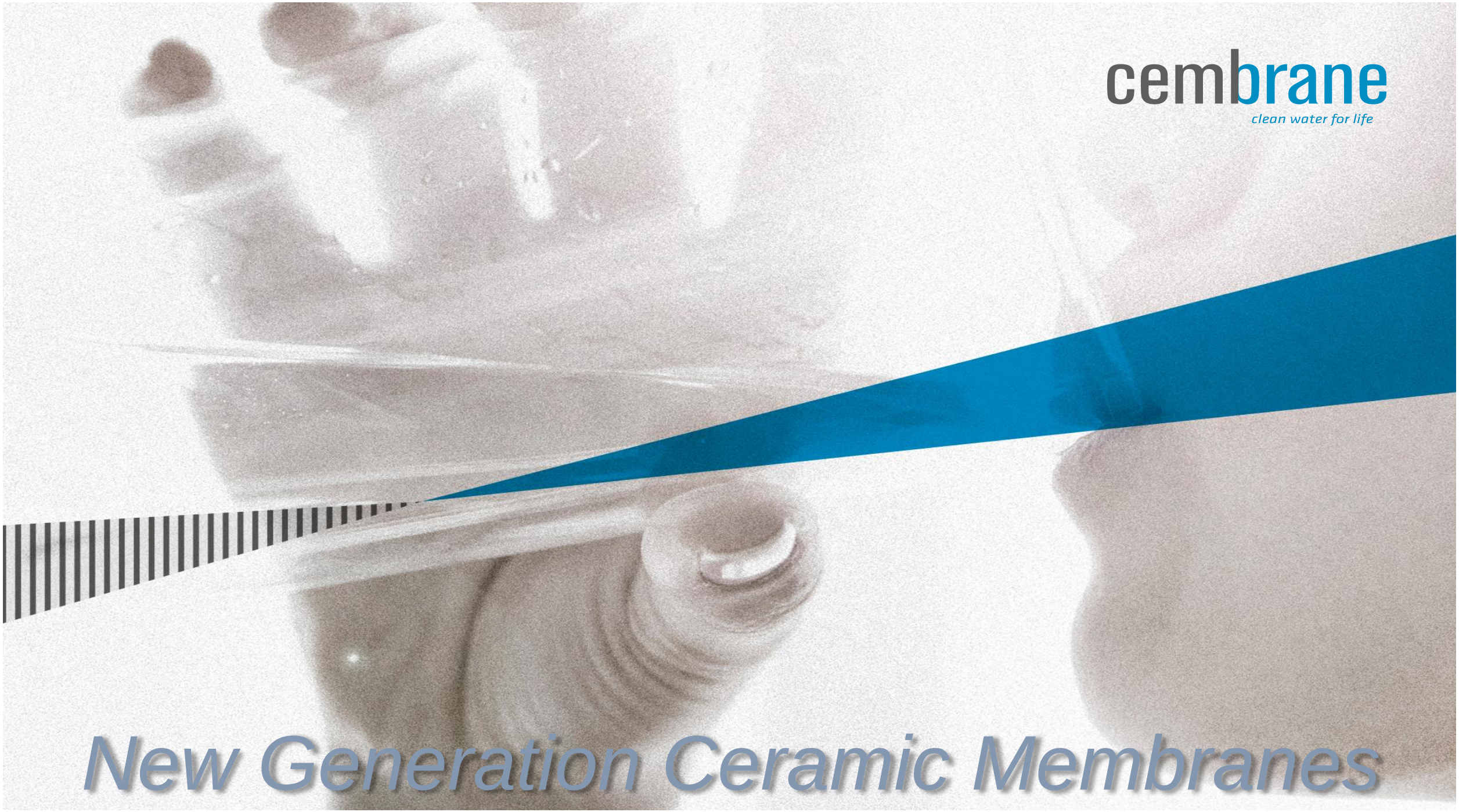
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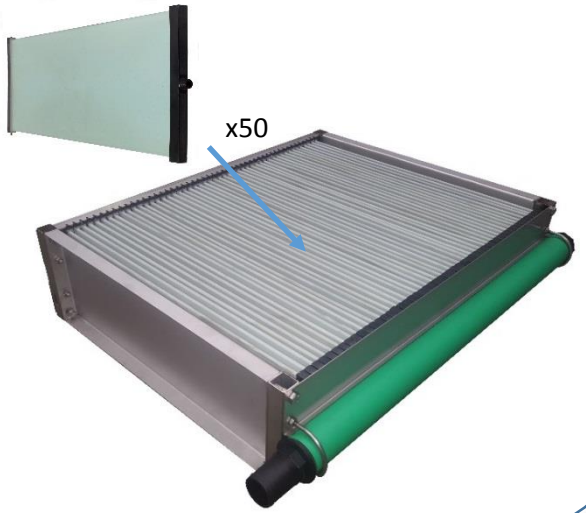
New Generation Ceramic Membranes

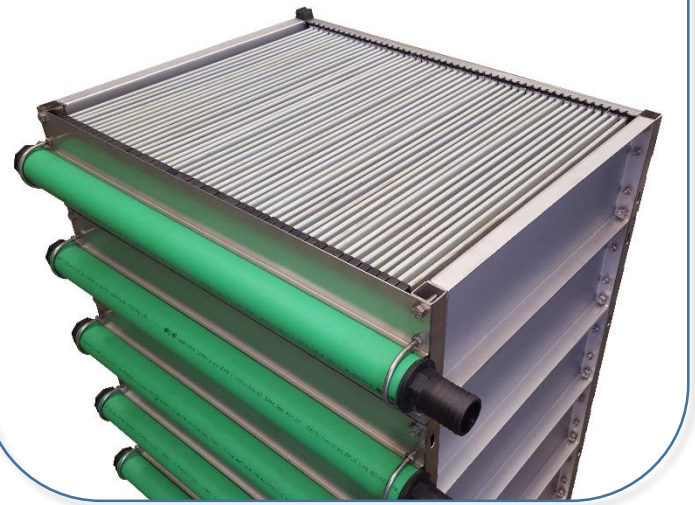
Product scope

- ✓ Silicon Carbide Flat sheet
- ✓ Outside-in filtration
- ✓ Individual mounting
- ✓ High flux rate
- ✓ Minimal bio-fouling due to strong negative charge

- ✓ 7,25 m^2 module
- ✓ Submersible
- ✓ Highly compact
- ✓ High chemical and ozone resistance
- ✓ Easy to handle and install



- ✓ Stackable system
- ✓ Framing of air-bubbles for optimal flux
- ✓ Good shock absorption between modules



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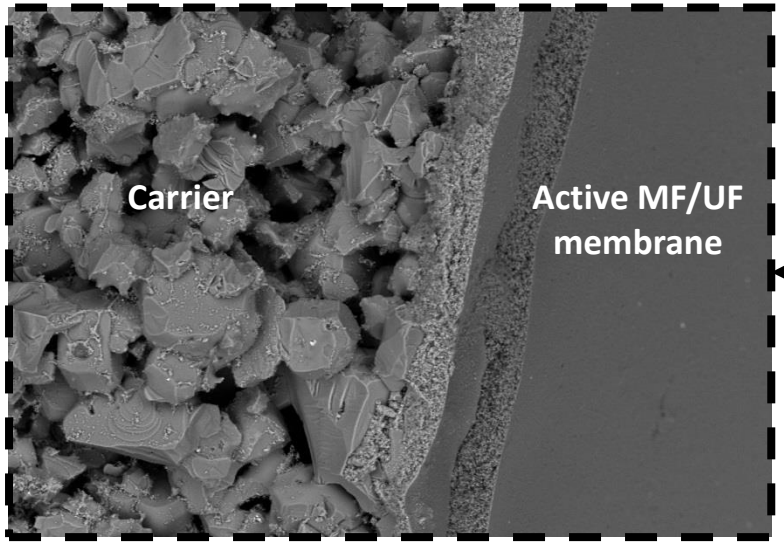
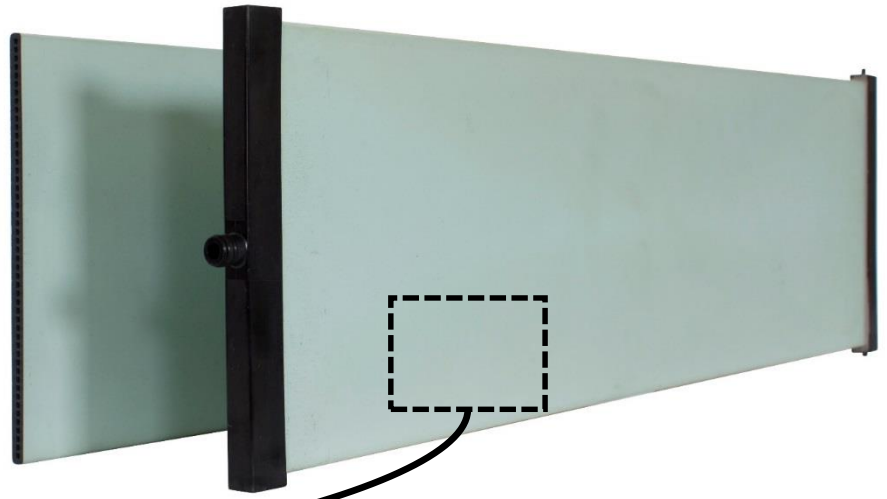
Flat sheet MF/UF membrane



Scanning Electron microscope



- ✓ Silicon Carbide membrane material
- ✓ Outside-in submerged filtration
- ✓ Asymmetric structure to provide minimal pressure loss

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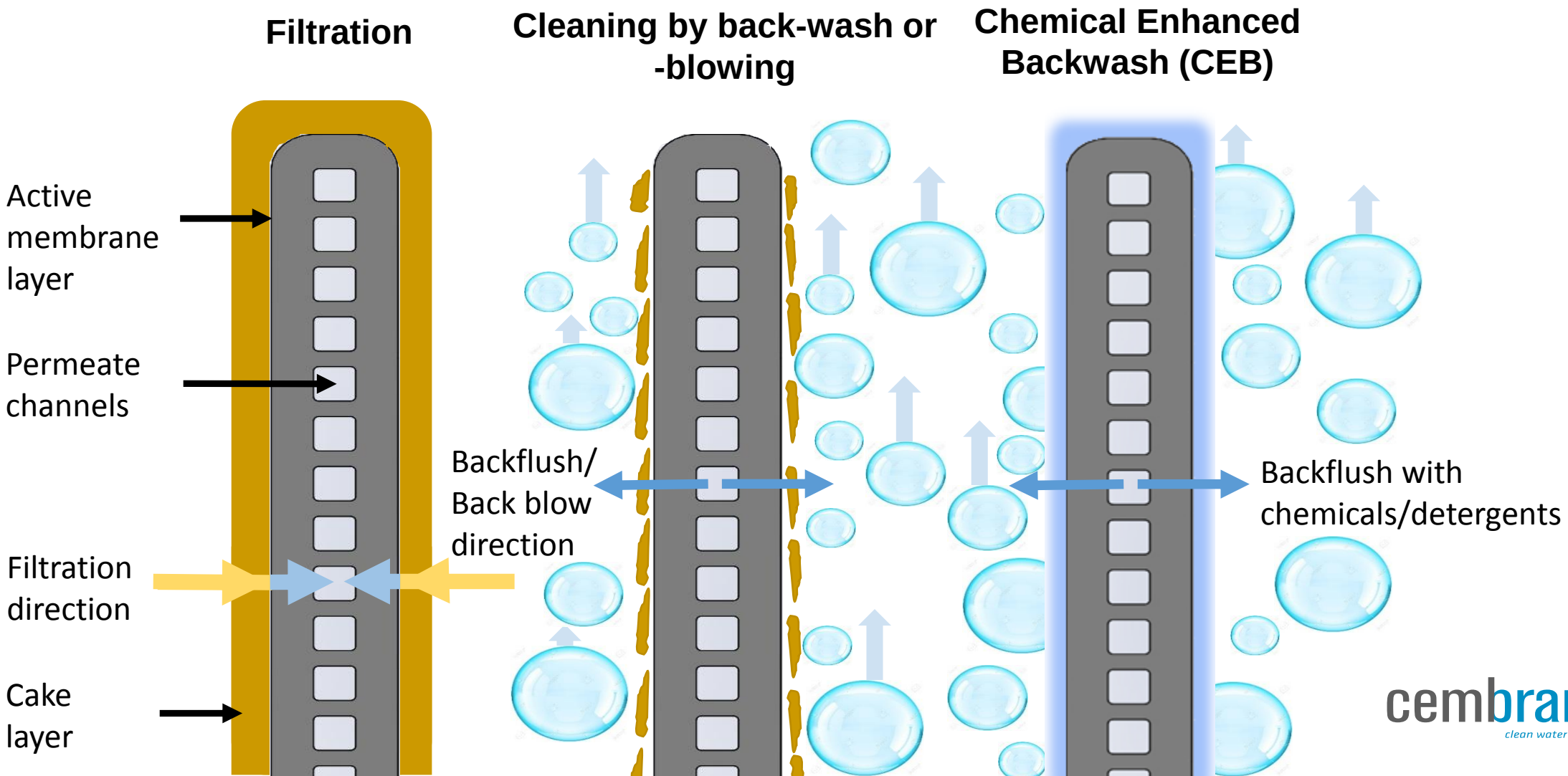
Cross section of Flat sheet membrane during different operation modes



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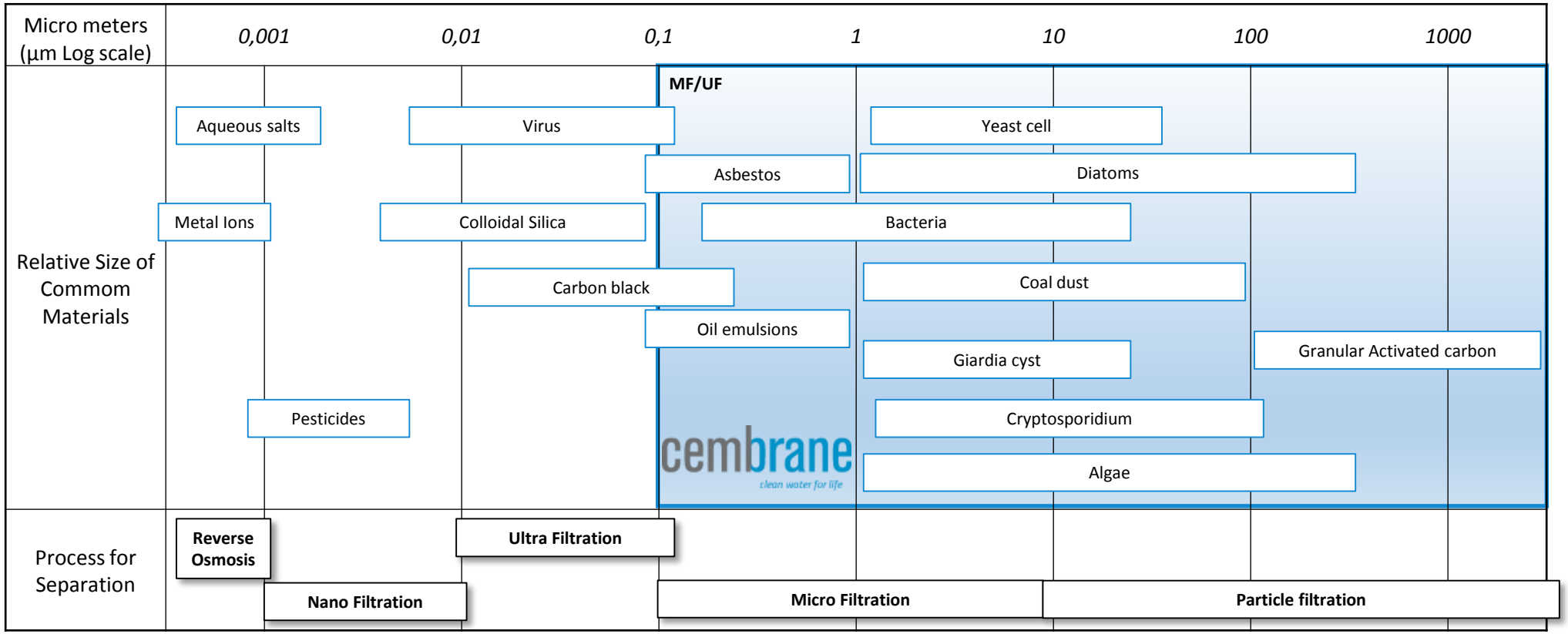
Pore size and filtration spectrum



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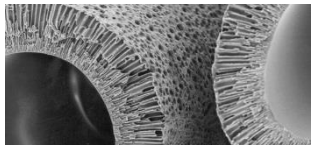
Evolution of filtration



Sand filter

- Traditional method
- Robust solution
- Very low recovery rate
- Poor permeate quality
- High chemical demand during pre & post treatment due to poor permeate quality

Polymer membranes

- Good permeate quality
- Low flux rate and robustness
- Low recovery rate
- Frequent cleanings
- Excessive use of chemicals
- Short lifetime (3-4 years)
- Not resistant to oil, temperature & harsh chemicals
- Maintenance is labour intensive

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NEW GENERATION CERAMIC MEMBRANE

- Good permeate quality
- Long lifetime (>10 years)
- Unprecedented high flux rates
- High resistance towards chemicals & High pressure operation
- Resistant towards ozone
- Highest recovery rate
- Low operating and maintenance cost due to robustness and limited use of chemicals

”Combining the robustness of a sandfilter, with the filtration quality of a polymeric membrane.”

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Technical features

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Unique Selling Points of SiC membranes

- **Low fouling potential** due to low Zeta potential (iso electric point at pH 2.7)
  - ✓ Longer operating cycles in waste water without backwashing/cleaning
  - ✓ Less cleaning efforts
  - ✓ Lower energy consumption
  - ✓ Less maintenance efforts
  - ✓ More stable operation
- **Extremely high flux rates** due to low contact angle to water
  - ✓ More compact plants
  - ✓ Less piping, instrumentation etc.
- **Full chemical resistance** (ph 1-14)
  - ✓ More flexibility in cleaning
  - ✓ Treatment of highly corrosive feed waters

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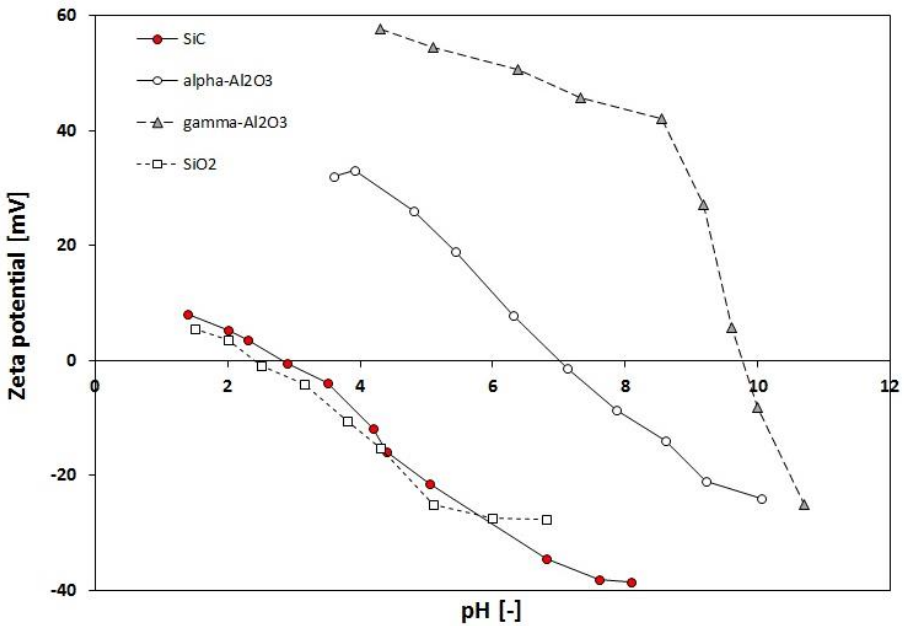
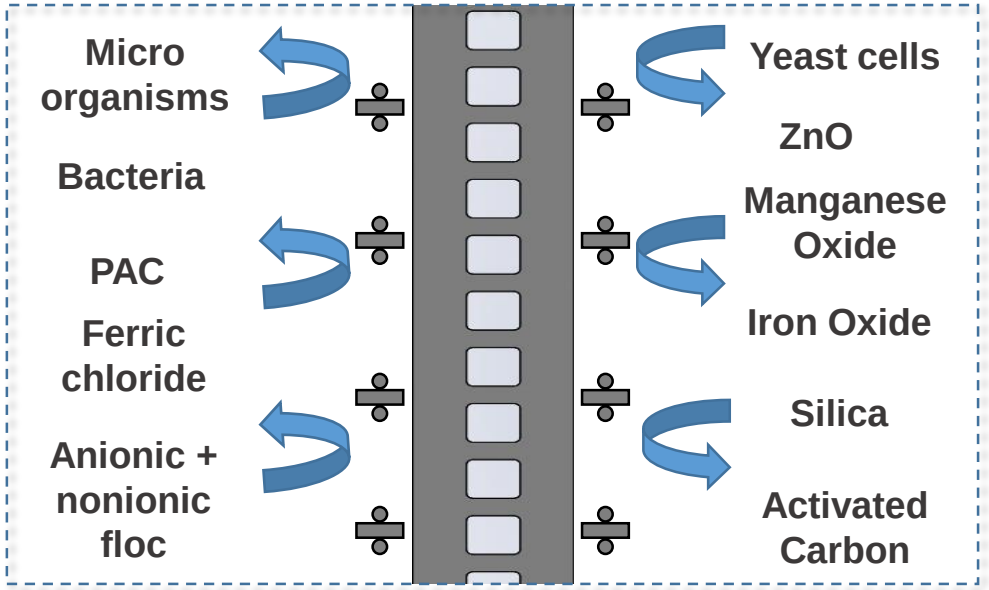
Zeta potential

Zeta potential of difference ceramics



**Farsi.Ali – Department of Chemistry and Bioscience, Aalborg University*

Illustration of anti-clogging & anti-fouling behaviour by the SiC membrane at neutral pH



Strong negative charge of SiC at pH 7-8

- ✓ Limited Bio-fouling
- ✓ Limited risk of clogging
- ✓ Extensive backwash frequency

Stable operation & limited maintenance

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Flux rate

- Low contact angle between water and SiC
- Super hydrophilic surface
- Ultrathin membrane layer
- Asymmetric membrane structure between membrane and substrate
- High porosity substrate (50%)

→

- ✓ Highest flux rate for any ceramic membrane
- ✓ Low membrane surface area required
- ✓ High flow on small foot-print
- ✓ High recovery rate close to 100%
- ✓ Low pressure operation → low energy

Average flux rate @ 25 °C	Removal	LMH
Ground water	Fe, Mn, Ra, As	600-800
Sea Water Pre-RO open intake	Algae, TSS, Oil	250-300
Surface water	Micro organisms, TSS, Silt	250
MBR	TSS, Bacteria, COD, BOD	45-60
MBBR	TSS, Bacteria, COD, BOD	150-200
Treated sewage effluent	TSS, Bacteria, COD, BOD	200
Sandfilter backwash water	Coagulalents, TSS, Microorganisms, Bacteria, etc.	350

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Chemical resistance of Silicon Carbide

Silicon Carbide is chemically inert & exhibit close to 0% weight loss in extreme conditions

- ✓ Membrane is stable in extreme feed conditions where no other membrane survives:
  - ✓ Solvents
  - ✓ Ozone
  - ✓ pH 1-12 constant exposure
  - ✓ Oxidizing agents
- ✓ Enables highly effective cleanings
- ✓ Long membrane life

Corrosion test results in liquids. Weight loss in [mg/cm² yr]

Test environment* Conc. reagent (Wt%)	° C	Temp. ° F	Si/SiC composites (12% Si)	Tungsten carbide (6% Co)	Aluminum oxide (99%)	Silicon carbide (No free Si)
98% H_2SO_4	100	212	55.0	>1000	65.0	1.8
50% NaOH	100	212	>1000	5.0	75.0	2.5
53% HF	25	77	7.9	8.0	20.0	<0.2
85% H_3PO_4	100	212	8.8	55.0	>1000	<0.2
70% HNO_3	100	212	0.5	>1000	7.0	<0.2
45% KOH	100	212	>1000	3.0	60.0	<0.2
25% HCl	70	158	0.9	85.0	72.0	<0.2
10% HF plus	25	77	>1000	>1000	16.0	<0.2
57% HNO_3						

**Test time: 125 to 300 hours of submersive testing, continuously stirred.*
*** >1000 mg/cm yr* - Completely destroyed within days.
**** 100 to 999 mg/cm2 yr* - Not recommended for service greater than a month.
***** 50 to 100 mg/cm2 yr* - Not recommended for service greater than one year.
****** 10 to 49 mg/cm2 yr* - Caution recommended, based on the specific application. 0.3 to 9.9 mg/cm2 yr Recommended for long term service.
******* <.2 mg/cm2 yr* - Recommended for long term service: no corrosion other than as a result of surface cleaning was evidenced.

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