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## **Novel ceramic membranes for water purification and food industry**

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*Published in:*  
PPM 2013 abstracts

*Publication date:*  
2013

*Document Version*  
Early version, also known as pre-print

[Link to publication from Aalborg University](#)

*Citation for published version (APA):*  
Boffa, V. (2013). Novel ceramic membranes for water purification and food industry. In *PPM 2013 abstracts* (pp. 10)

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# Novel ceramic membranes for water purification and food industry

Vittorio Boffa

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# Aalborg University

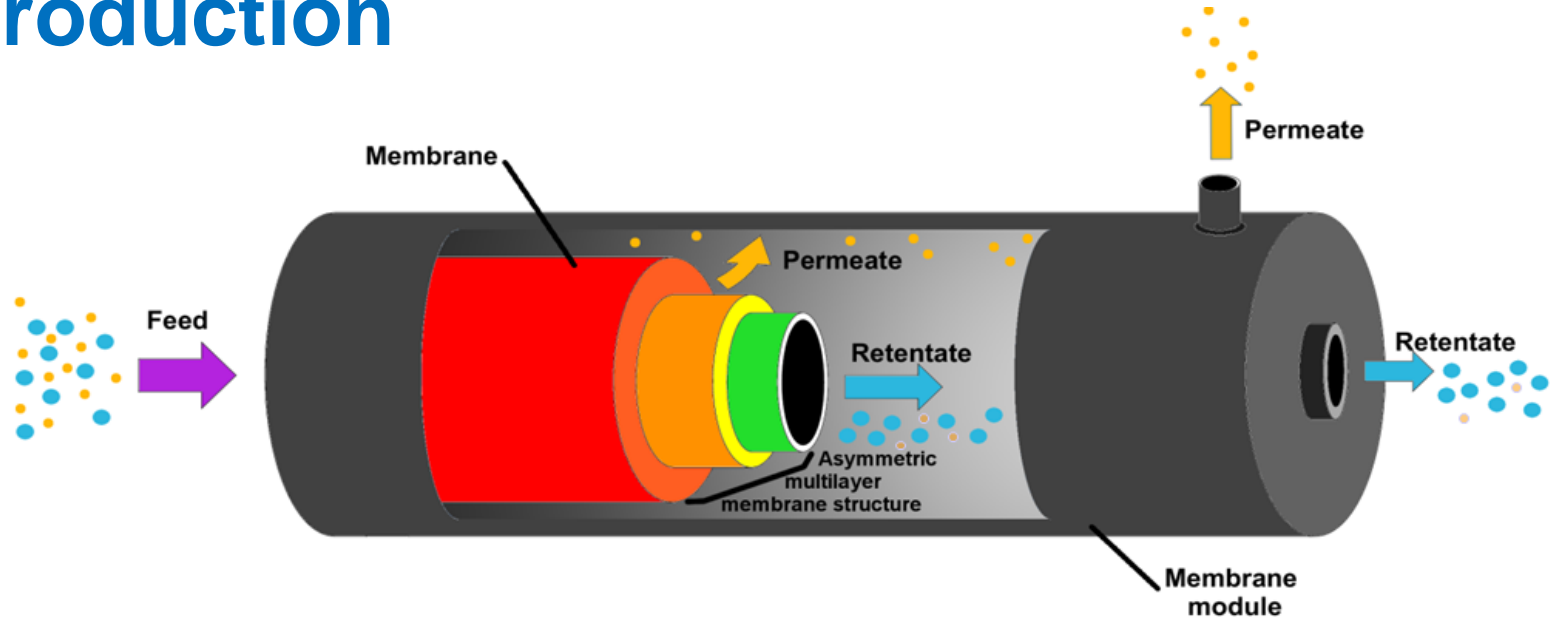
## Chemistry section



# Outline

- **Introduction**
- **Macroporous membrane (microfiltration membranes);**
- **Mesoporous membranes (ultrafiltration membranes) for water purification**
  - $\gamma$ -Al<sub>2</sub>O<sub>3</sub> membranes
  - SiC membranes
- **Conclusions**

# Introduction

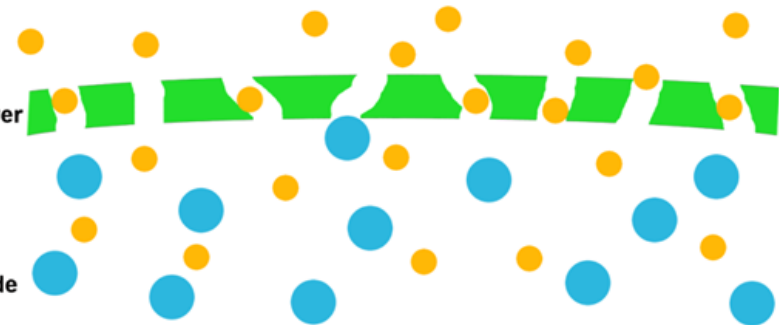


$$R\% = \left( 1 - \frac{C_p}{C_f} \right) \times 100$$

permeate side

selective layer

retentate side



# Introduction

## Porous ceramic membranes

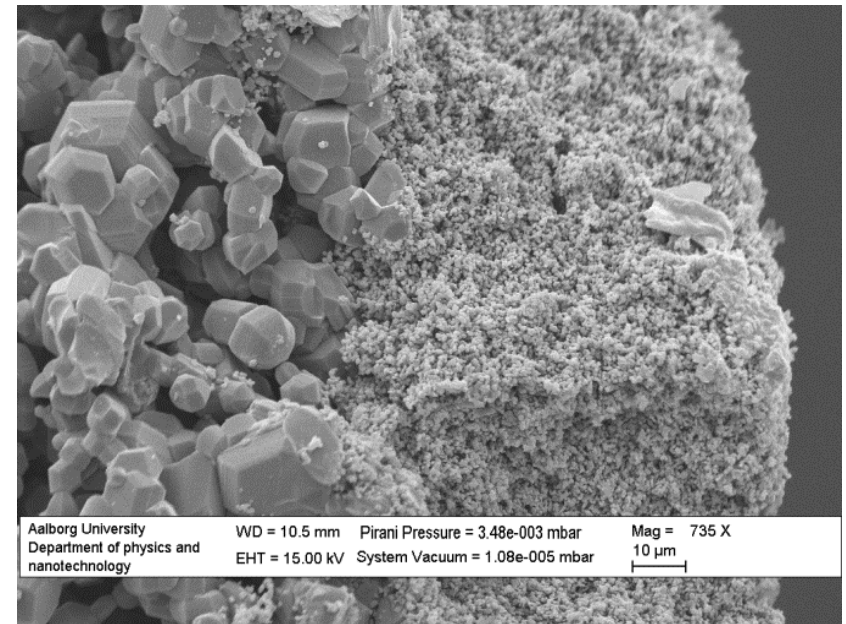
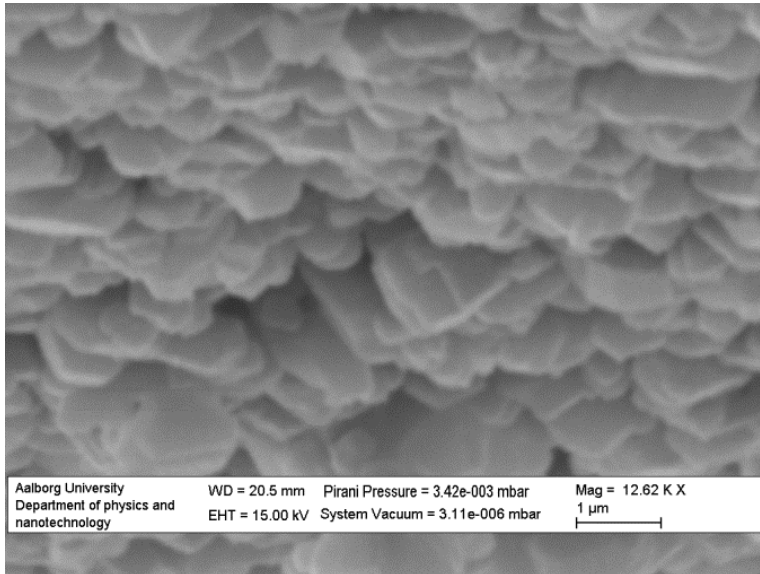
- High mechanical stability, allowing high pressures;
- High chemical and thermal stability, resulting in longer membranes lifetimes;
- High hydrophilicity, resulting in high water fluxes at low pressures, and low tendency to fouling.
- **High fabrication costs**

# Commercial SiC microfiltration membranes

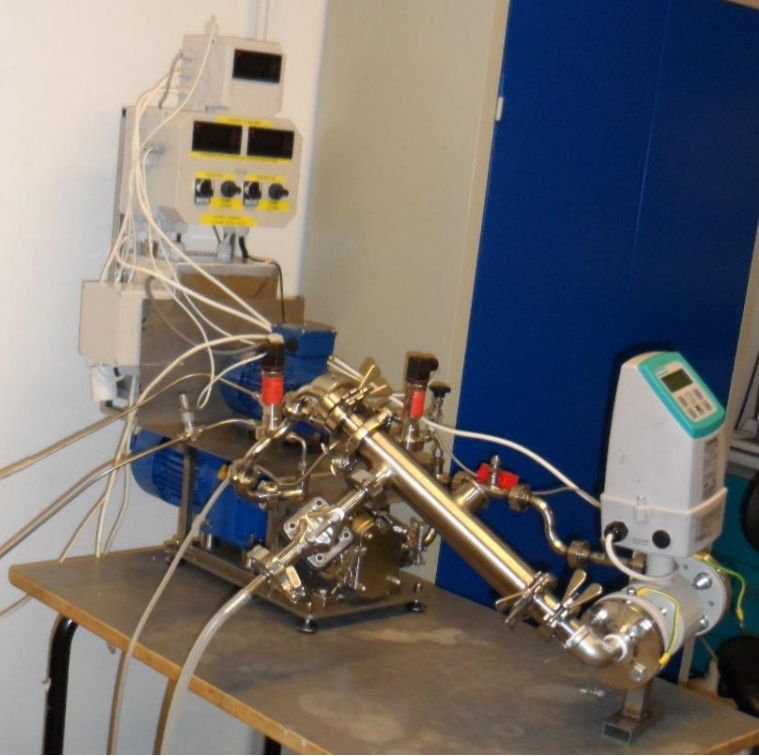
## Clarification and sterilization



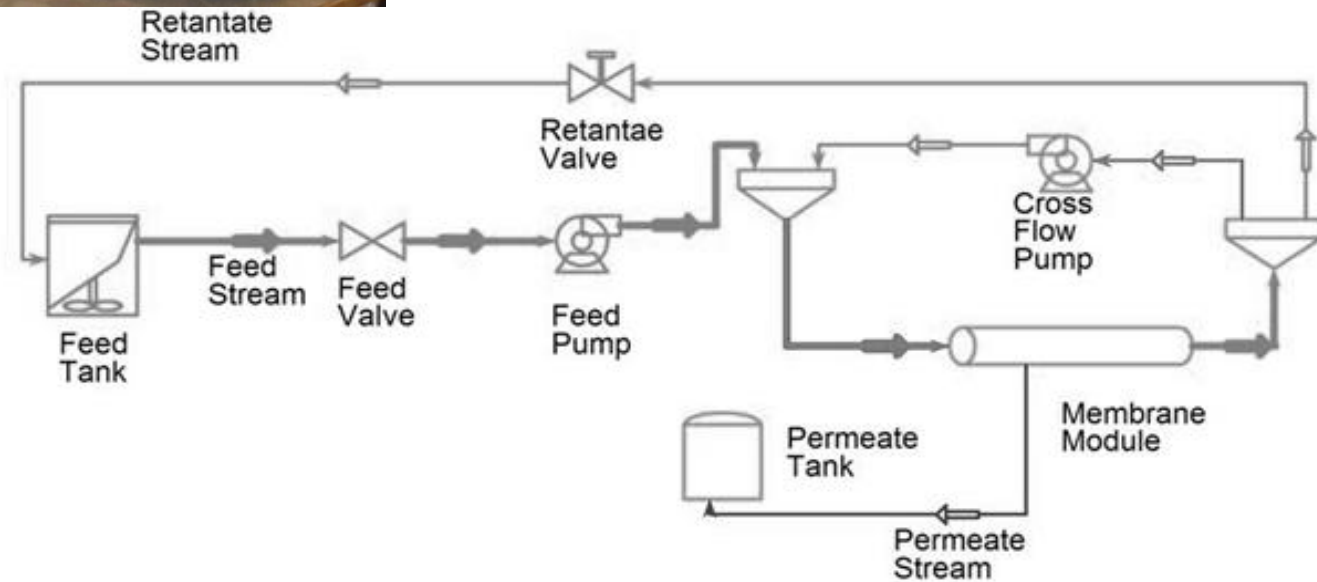
Inner membrane surface



Membrane cross-section

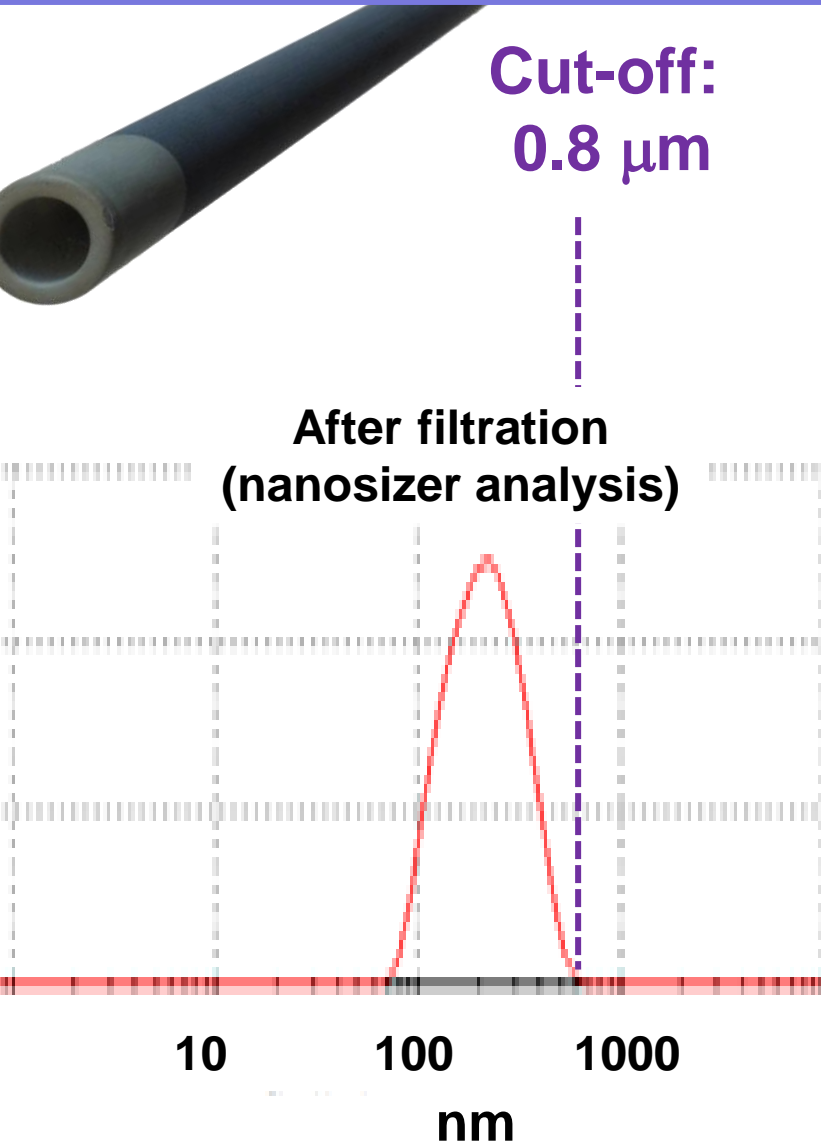


- Trans Membrane Pressure up to 20 bar;
- High cross flow rate up to 2 L/sec;
- Low pressure drop in system;
- Different tubular membranes could be used. (we have different kinds of membranes' houses).

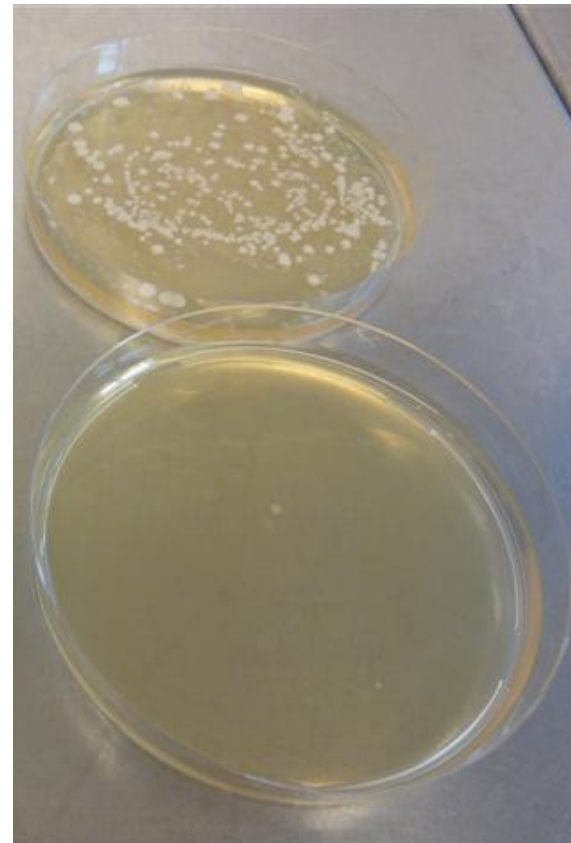




# Commercial SiC microfiltration membranes



## Clarification and sterilization

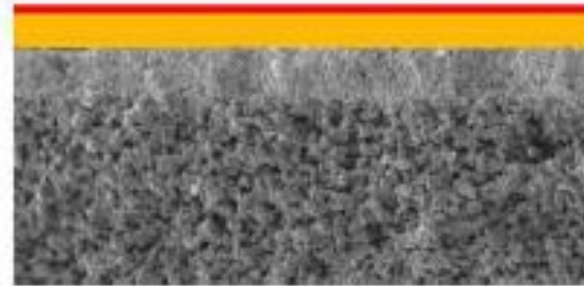


Feed

Permeate

In collaboration with CMR-onsite

- Commercial microfiltration SiC membranes can be applied to sterilization process in the food industry;
- Can be these membranes used as carrier for nanofiltration membranes?



The Danish National  
Advanced Technology Foundation

**Danish National Advanced Technology Foundation**  
project; “Low-Energy, High-Stability, Ceramic Reverse Osmosis  
Nano Membrane”



**Danish National Advanced Technology Foundation**  
project; “Low-Energy, High-Stability, Ceramic Reverse Osmosis  
Nano Membrane” Started in 2011



**Aalborg University**

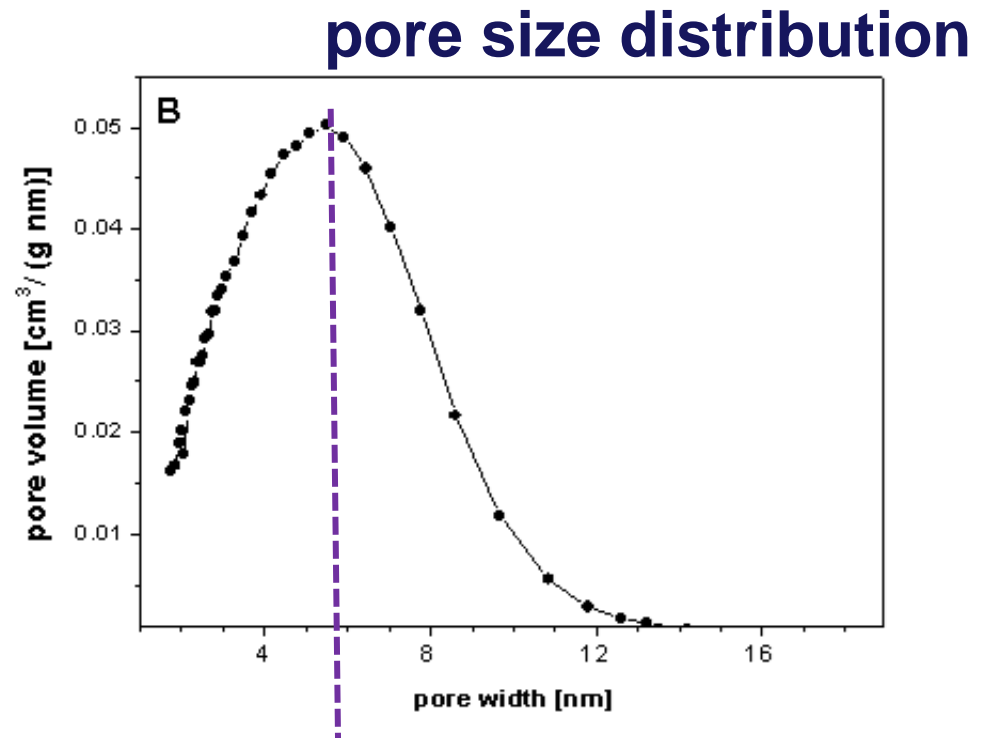
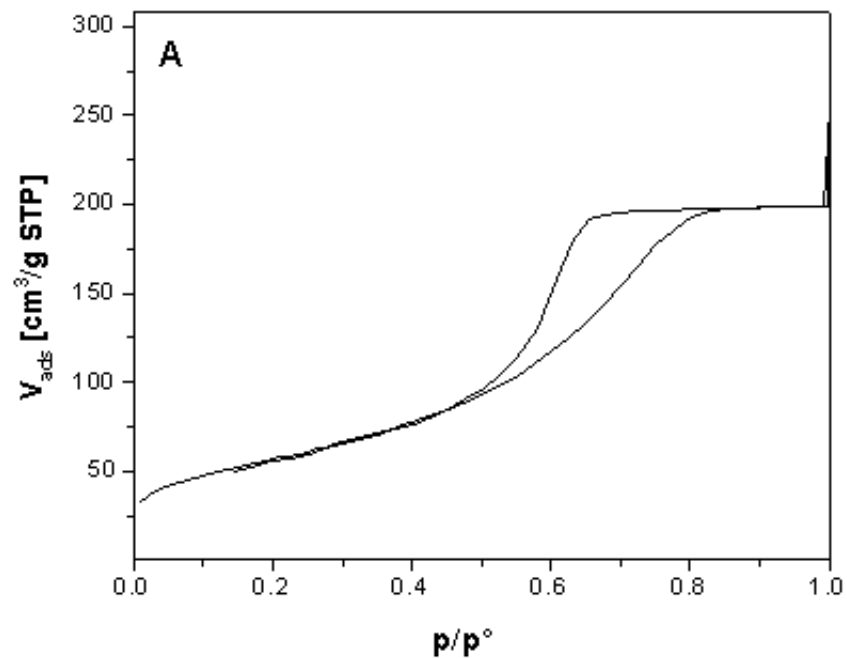
- **Katja König,** 
- **Ali Farsi,**
- **Morten L. Christensen,** 



**Liqtech international SAS**

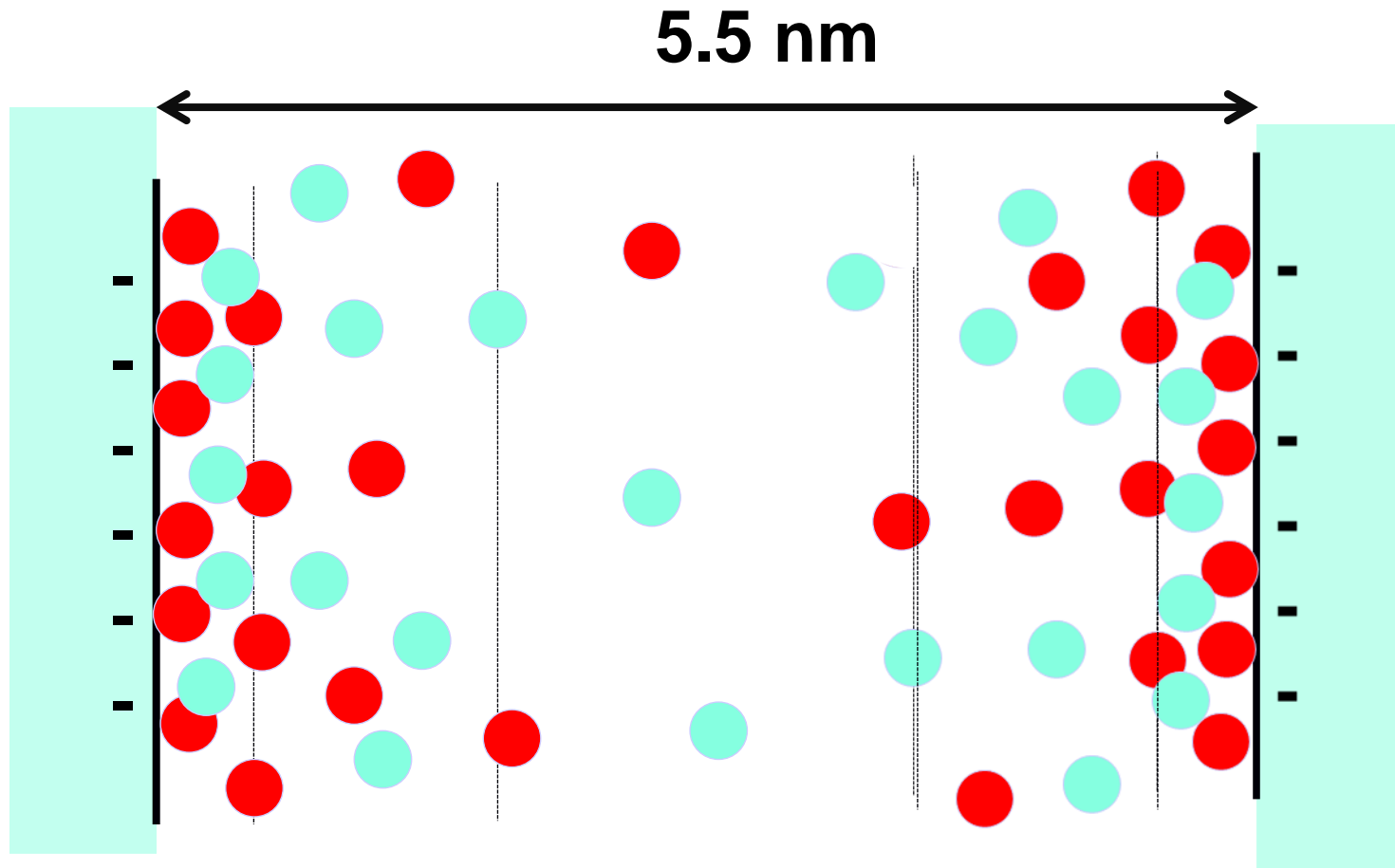
- **Jesper Ditlev Freisleben** 

# $\gamma$ -alumina ultrafiltration membranes



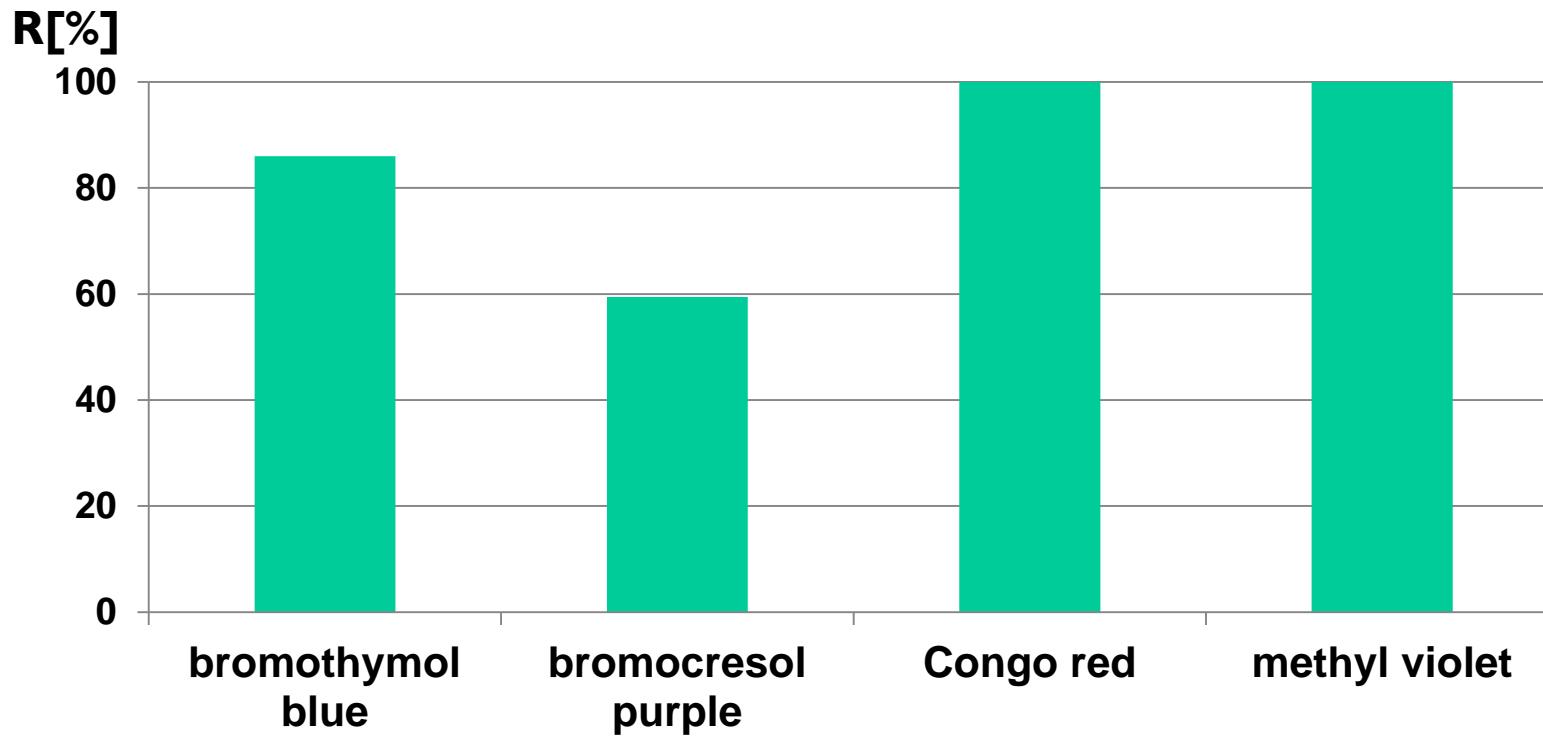
**Pore size:  
5.5 nm**

# $\gamma$ -alumina ultrafiltration membranes

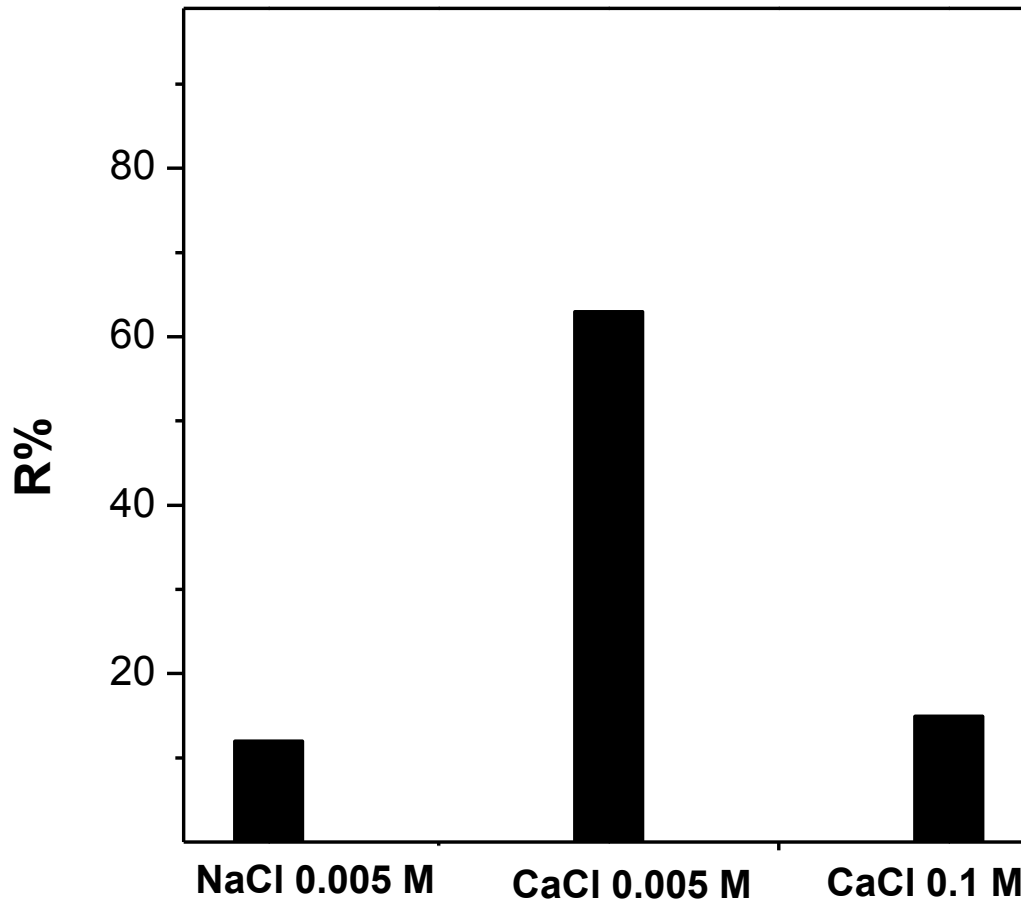


# $\gamma$ -alumina ultrafiltration membranes

pH9



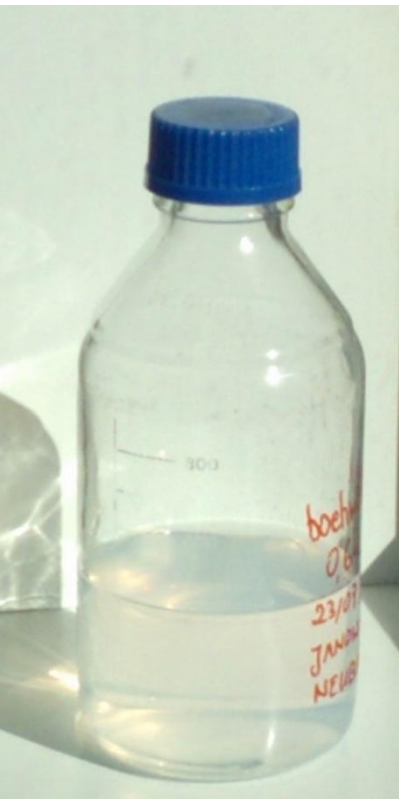
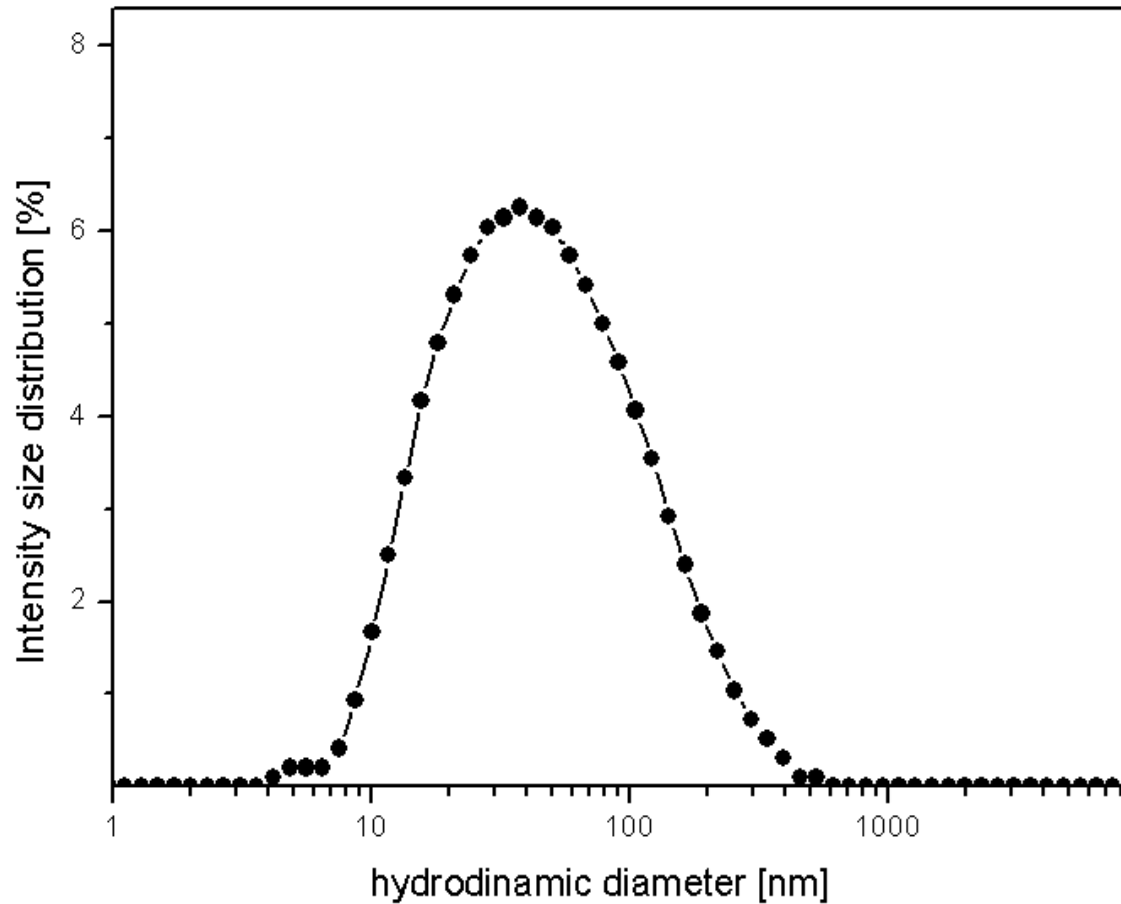
# $\gamma$ -alumina ultrafiltration membranes



- pH;
- ionic strength;
- surface charge.

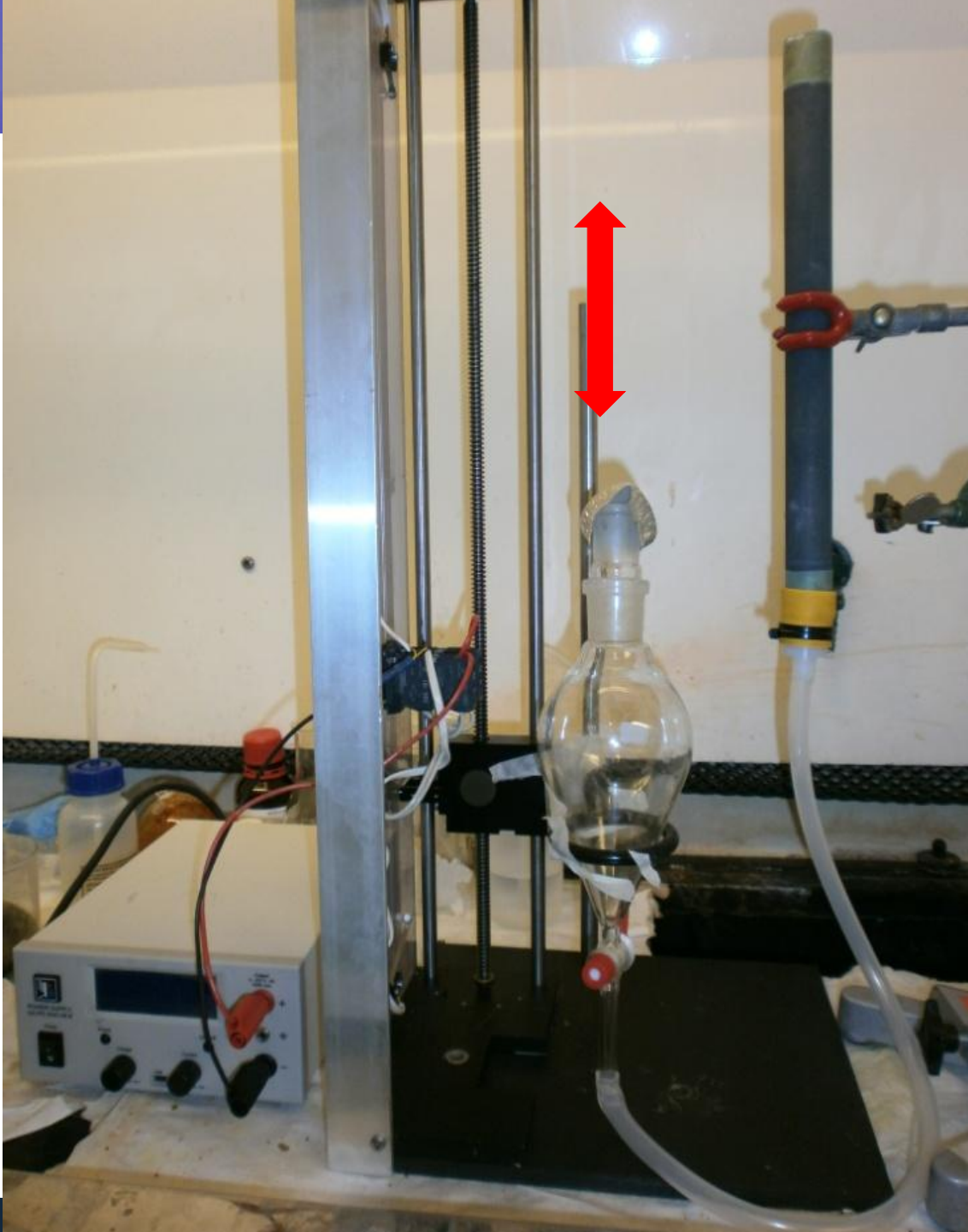
# $\gamma$ -ultrafiltration membranes

## particle size distribution



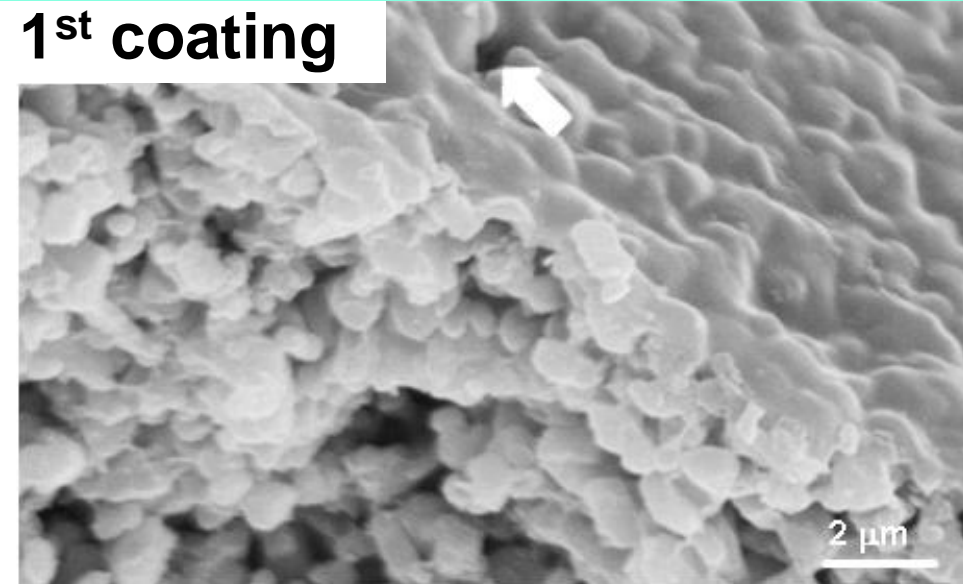


05 September 2013

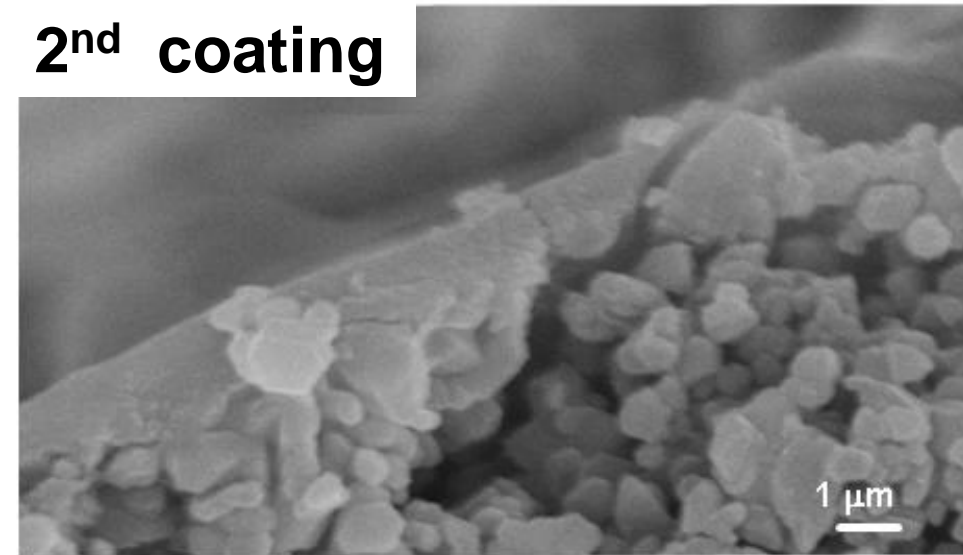


# $\gamma$ -ultrafiltration membranes

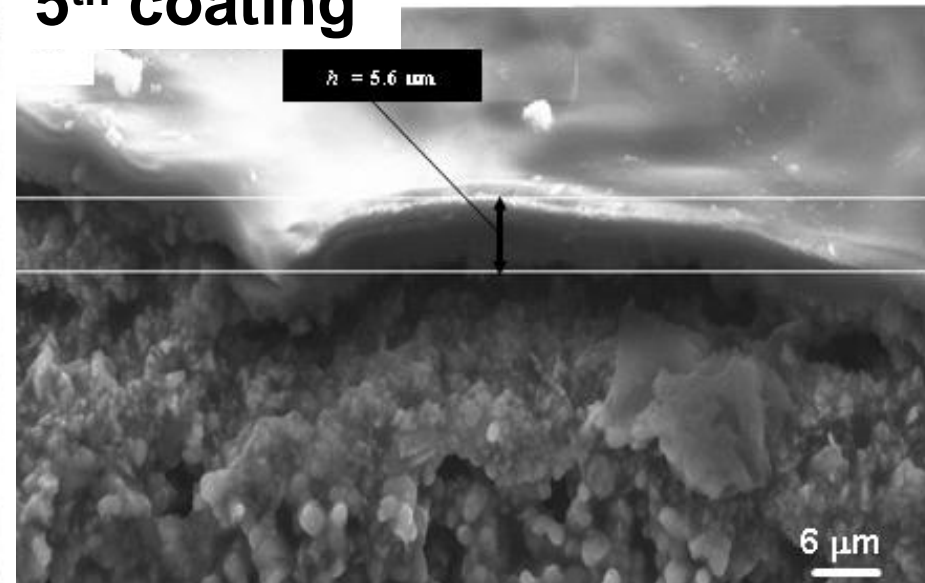
## 1<sup>st</sup> coating



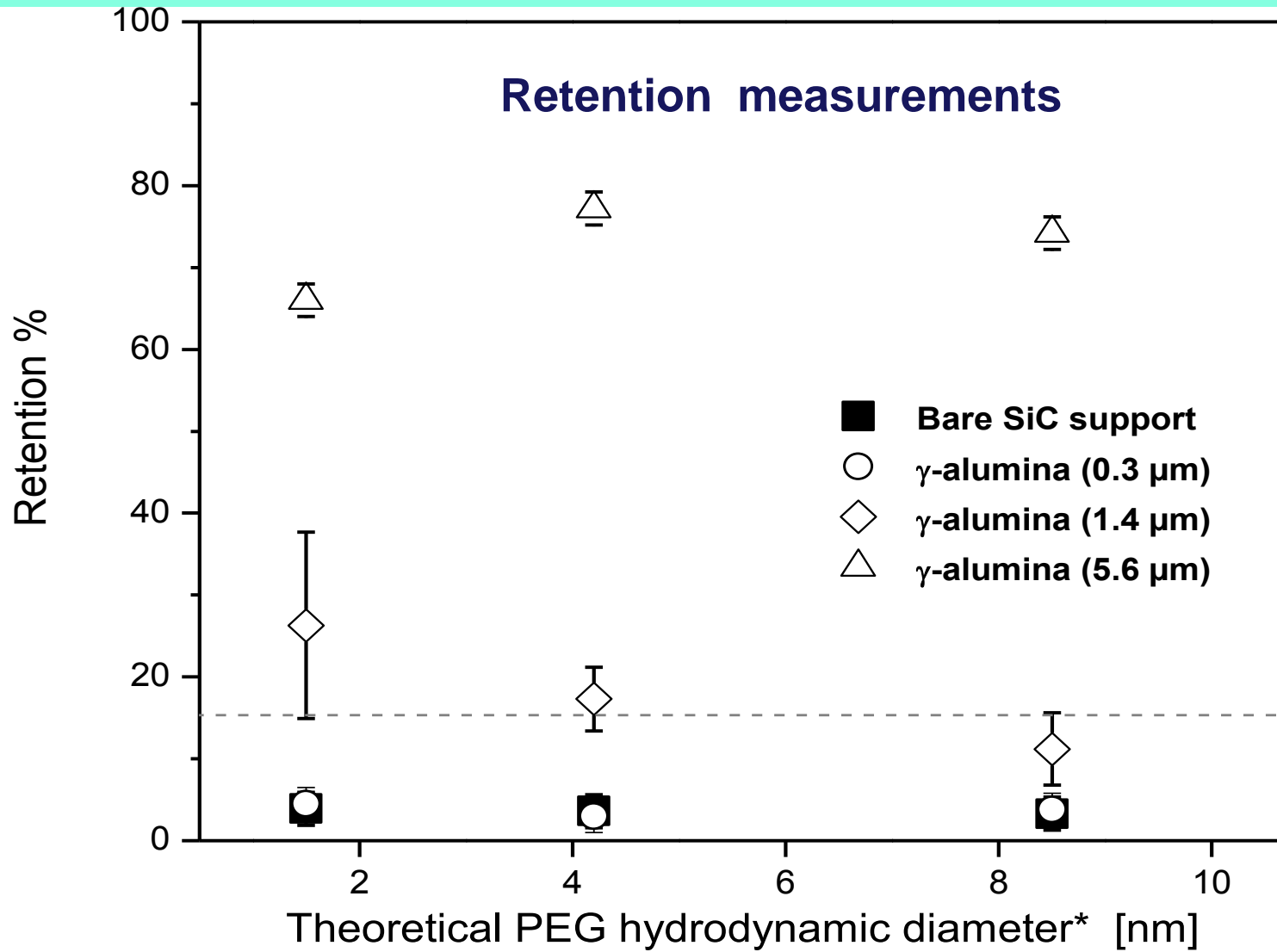
## 2<sup>nd</sup> coating



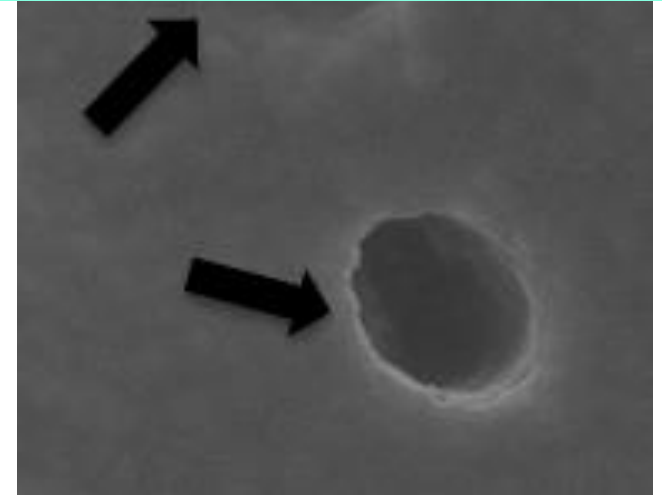
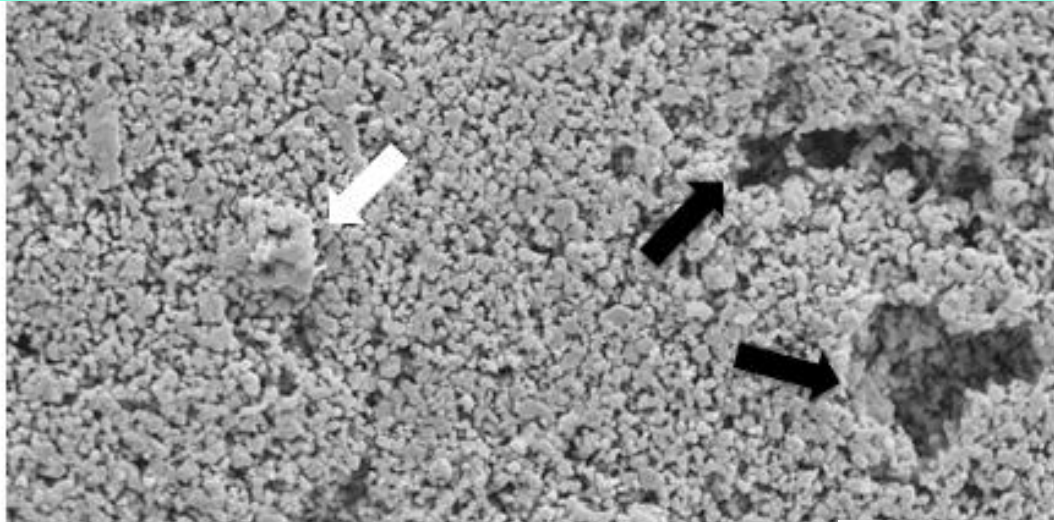
## 5<sup>th</sup> coating



# $\gamma$ -ultrafiltration membranes



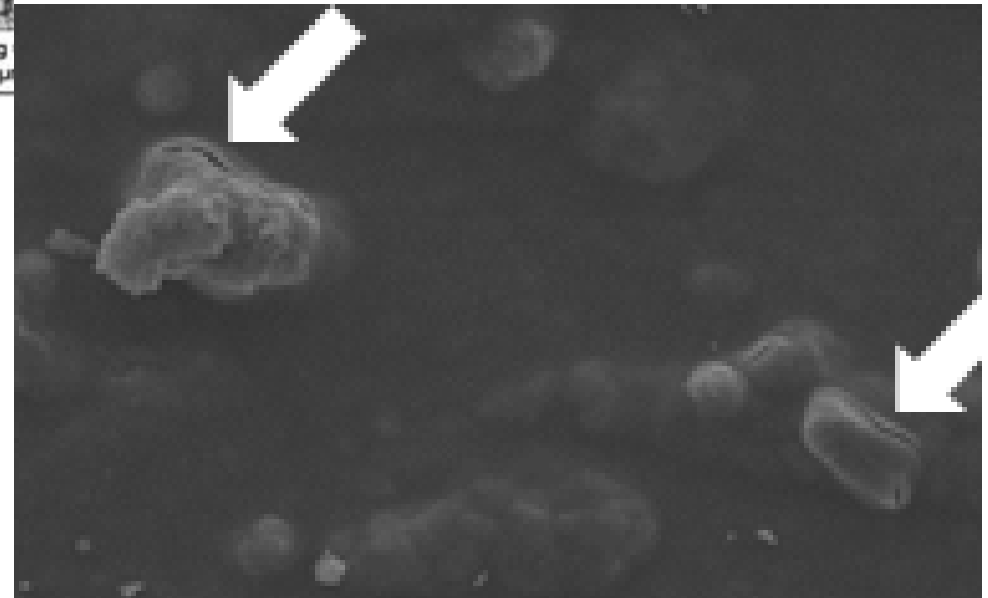
# $\gamma$ -ultrafiltration membranes



Aalborg University  
Department of physics and  
nanotechnology

WD = 5.0 mm Pirani Pressure = 3.42e-003 mbar  
EHT = 15.00 kV System Vacuum = 2.50e-005 mbar

Mag 10  $\mu$

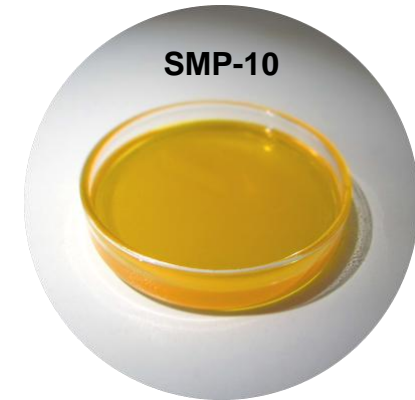
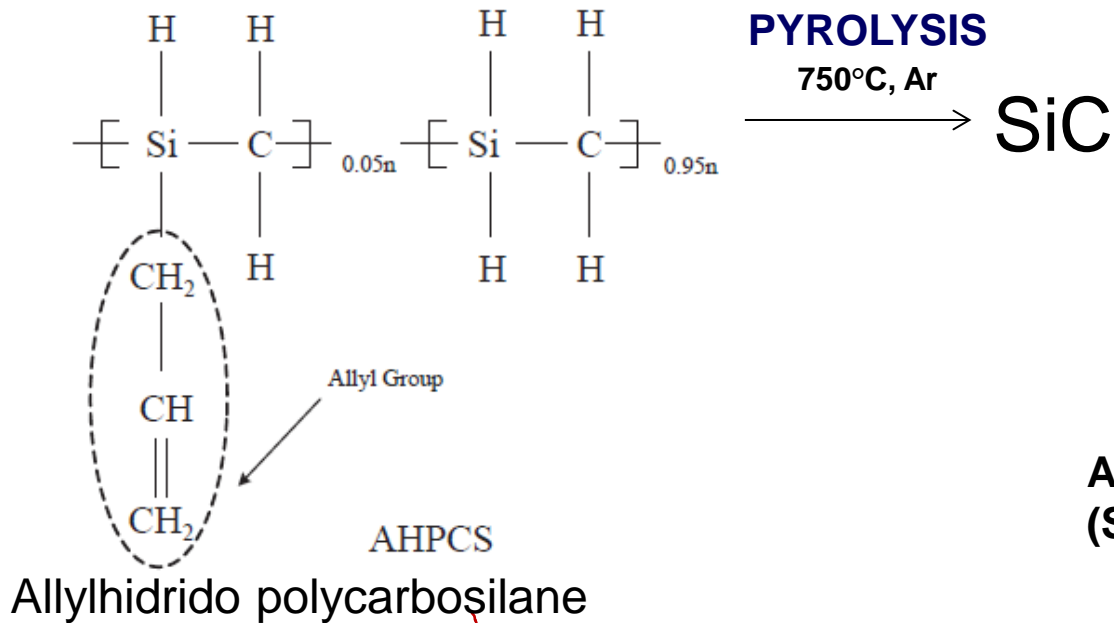


# SiC ultrafiltration membranes

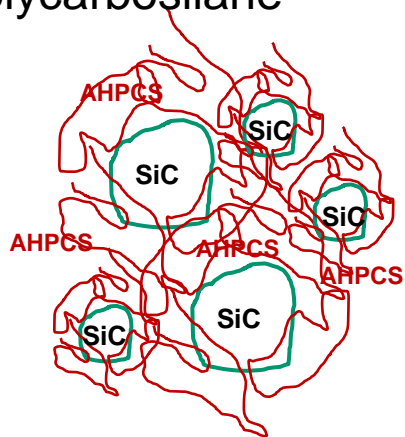


- **New material: novel properties, new product**
- **High mechanical, thermal and chemical stability: attractive for niche applications**
- **Complex fabrication procedure: reproducibility?**
- **Costs?**
- **New material: optimization is required**

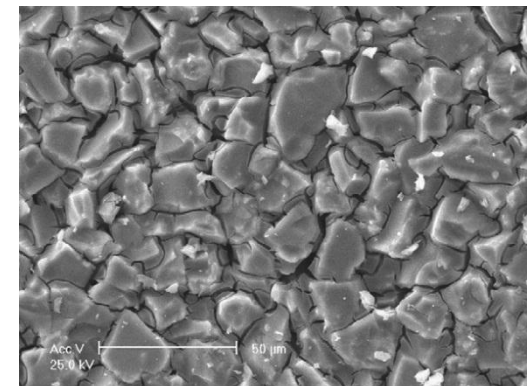
# SiC ultrafiltration membranes



**Allylhidrido polycarbosilane  
(SMP-10, Starfire Systems, Inc., USA)**

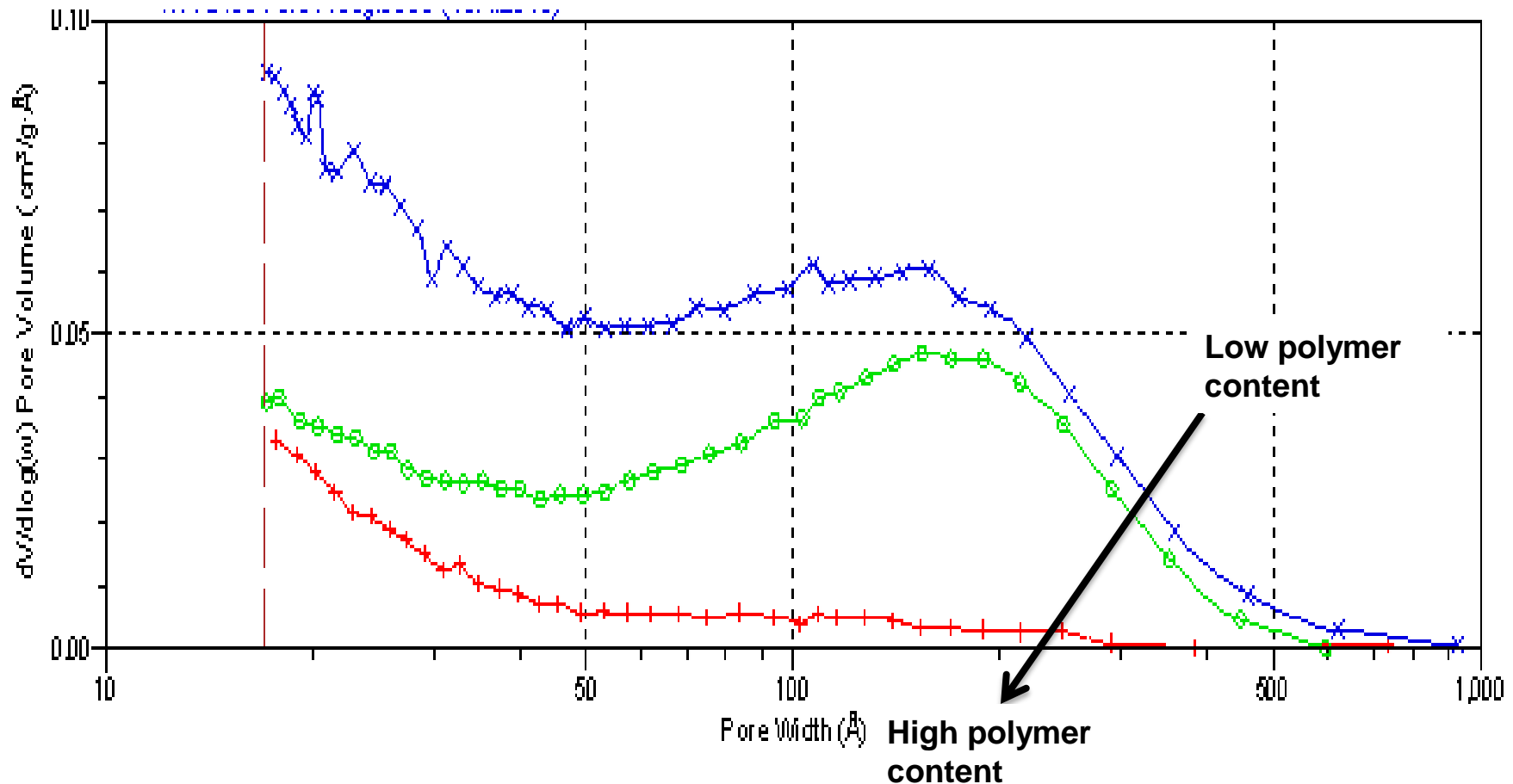


**PYROLYSIS**  
750°C, Ar

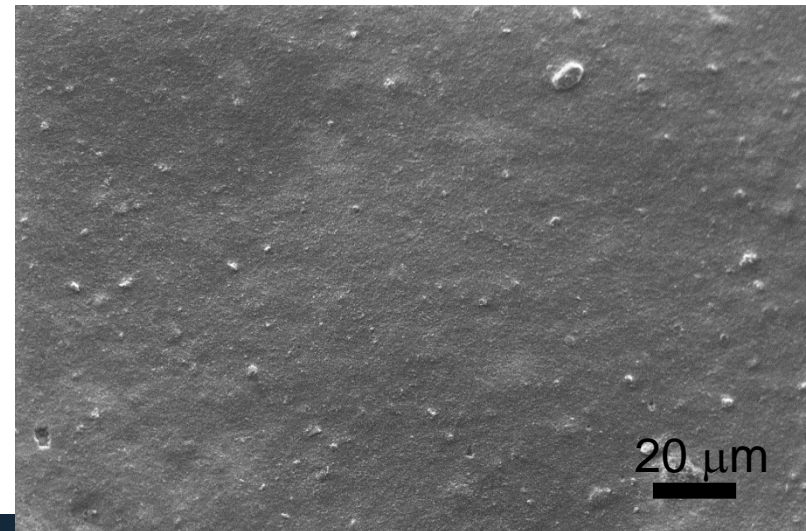
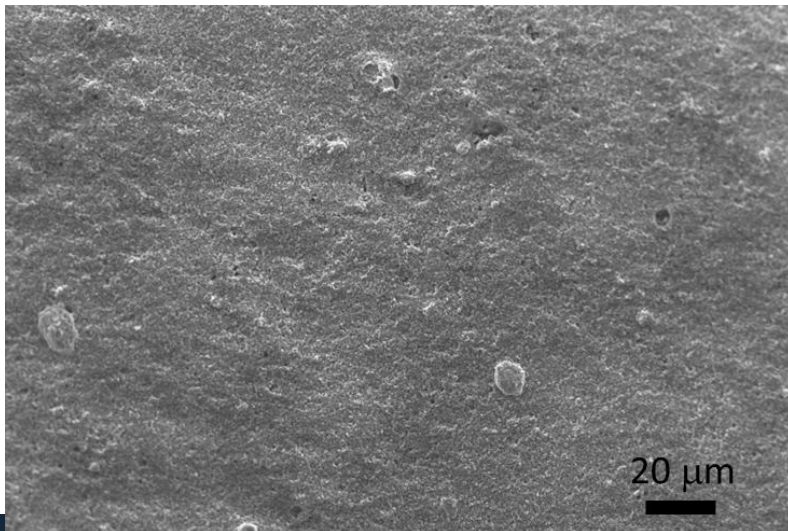
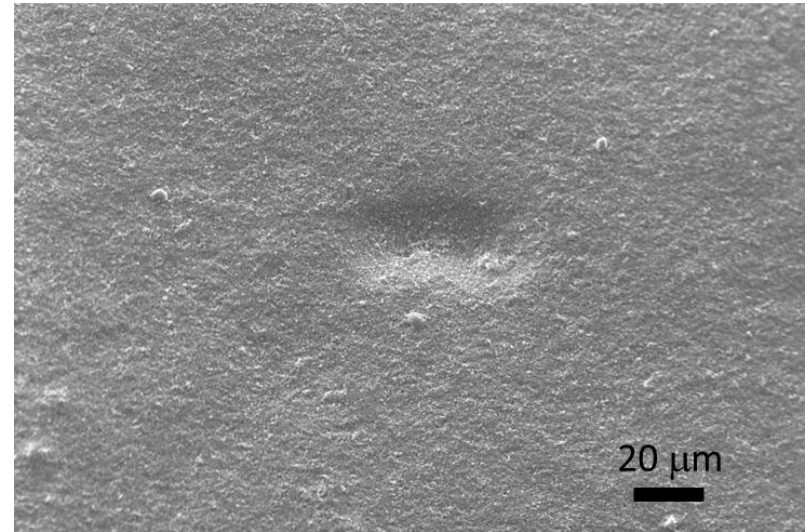
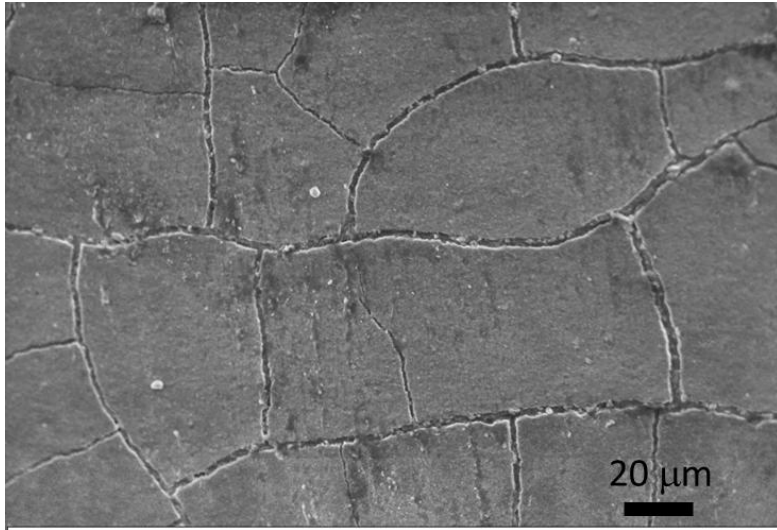


# SiC ultrafiltration membranes

## Powder analysis: pore size distribution



# SiC ultrafiltration membranes



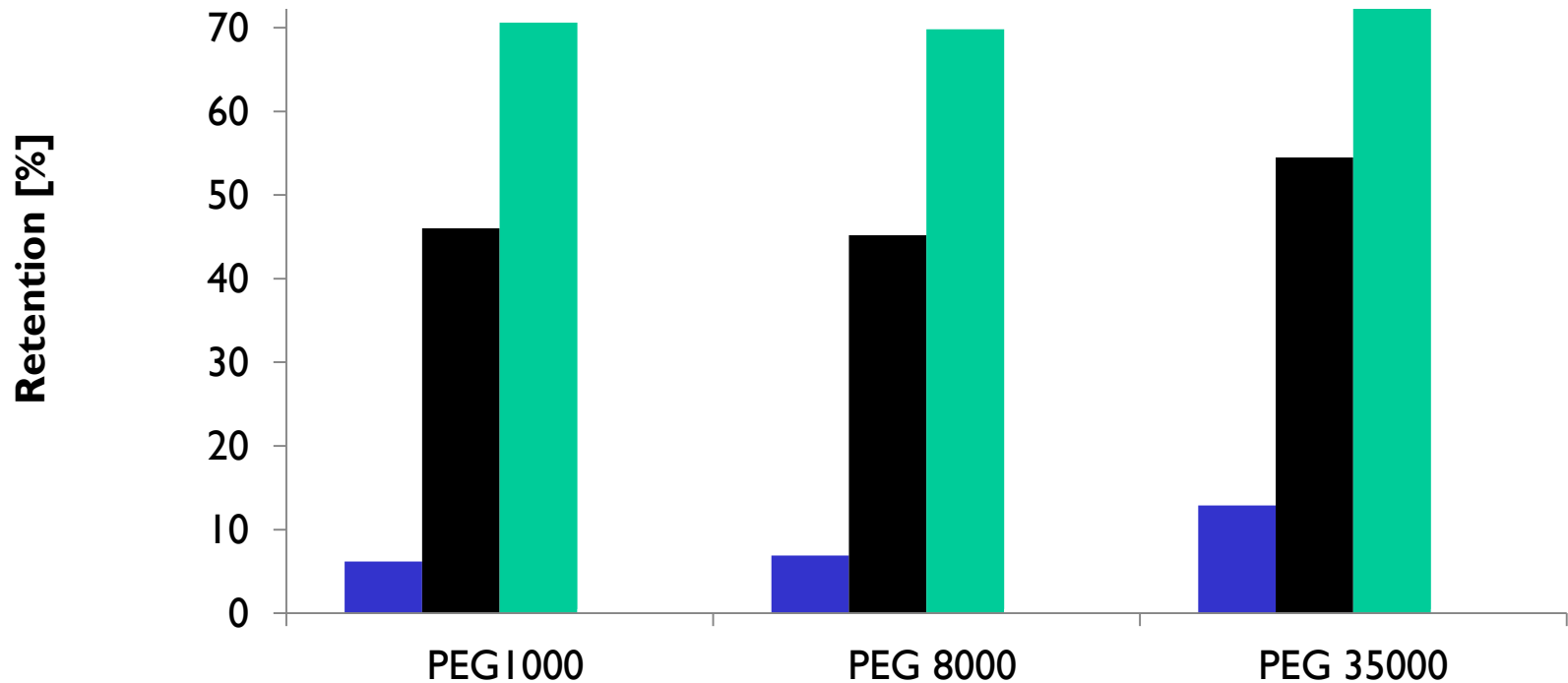


# SiC ultrafiltration membranes

■ macroporous SiC support

■ Procedure I

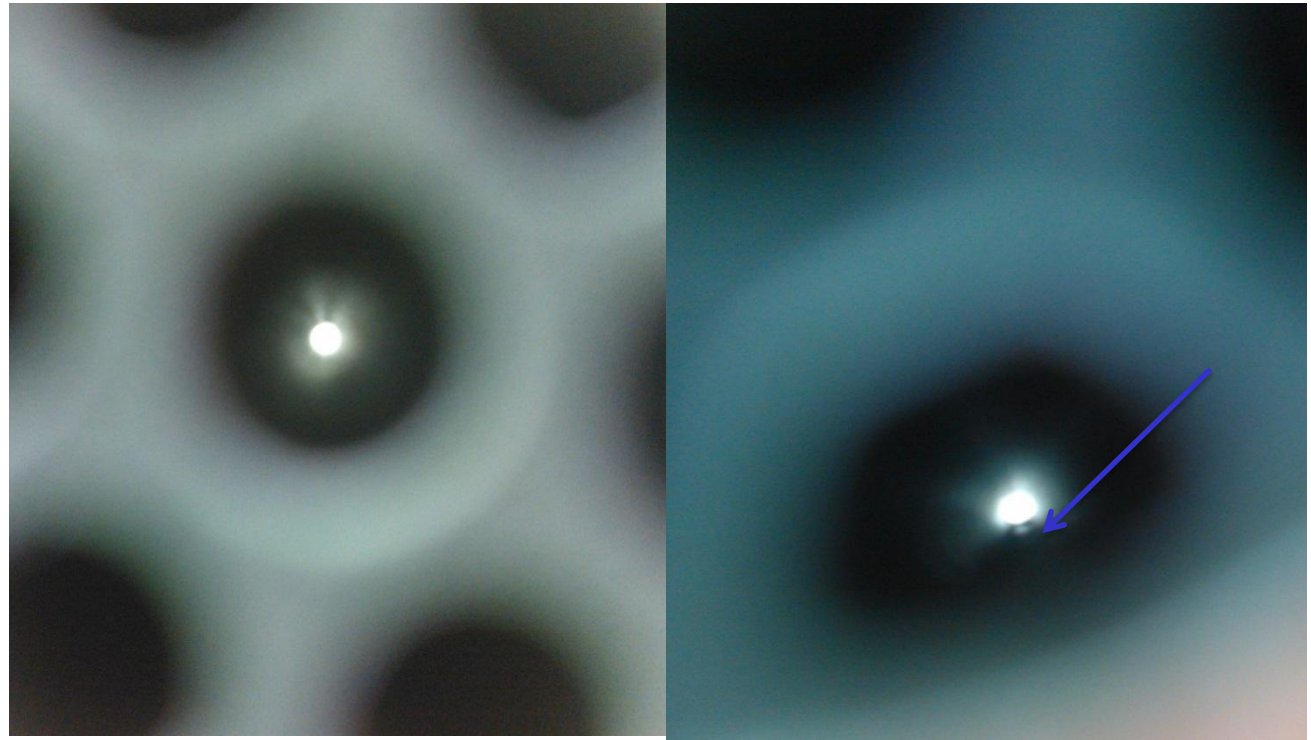
■ Procedure II



## Reproducibility issues



## Multi-channel tubes



## Conclusions:

- **Continuous mesoporous  $\gamma$ -alumina and SiC films were deposited on SiC supports supplied by LiqTech Int. A/S**
- **High retention towards PEG was observed: promising membranes for water decontamination processes.**
- **Reproducibility issues.**