FRAUNHOFER INSTITUTE
FOR APPLIED POLYMER RESEARCH

Process-Specific Membrane Adjustment for Tailored Filtration

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pioneers in polymers

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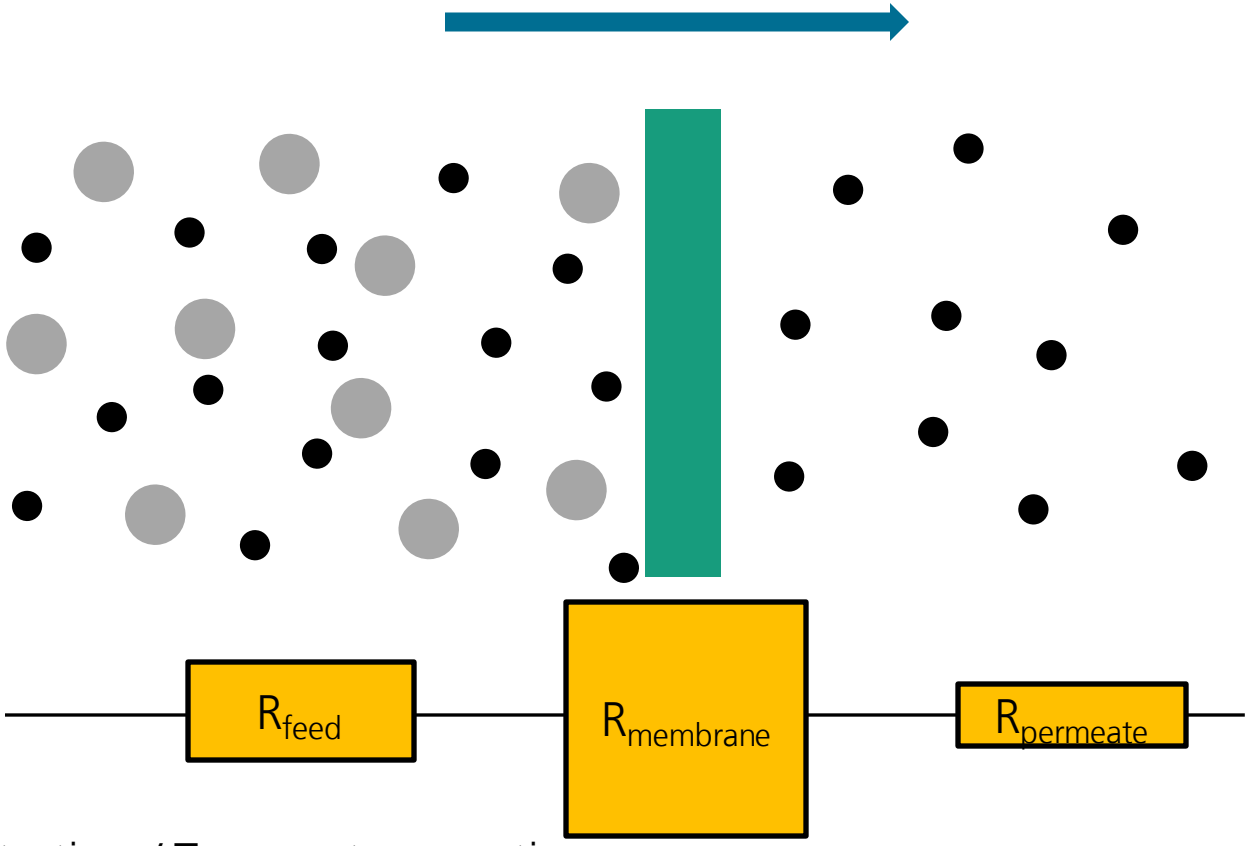
Separation Process:
Resistance of Permeation



Relevant applications:
- Water purification
- Technical filtration
- Medical filtration
- Battery separators
- Fuel cells
- Biogas, Hydrogen
- Oil and gas
- Dehydration
- Air ventilation systems

Advantage of filtration / Transport properties:
- Aggregation state stays constant -> reduced energy demand
- Membrane morphology is relevant for transport characteristics (energy demand)

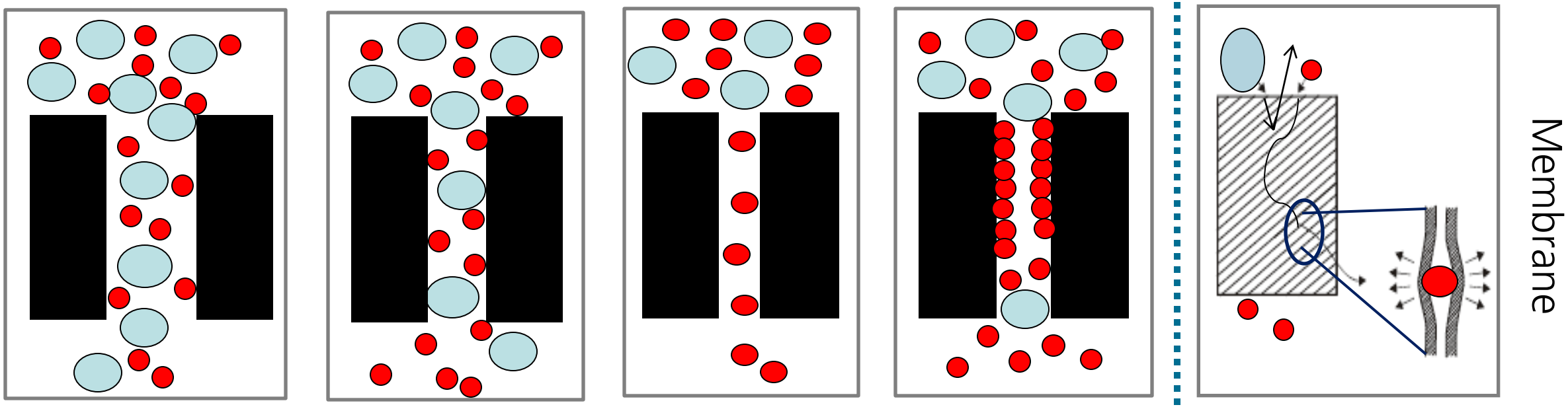
General Principles: Membrane Technology

Various transport mechanisms:

Porous Membrane
-> Pore Model

Dense Membrane
->Solution-Diffusion

Trabsport



Membrane

Viscous flux

Knudsen-diffusion

Configurational diffusion

Surface diffusion

Solution-diffusion

Size Regimes of Filtration Processes

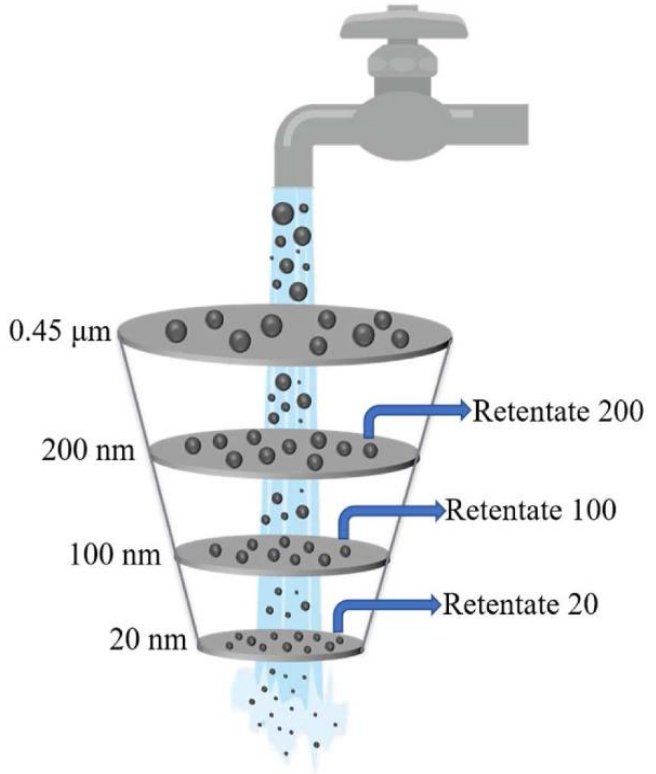
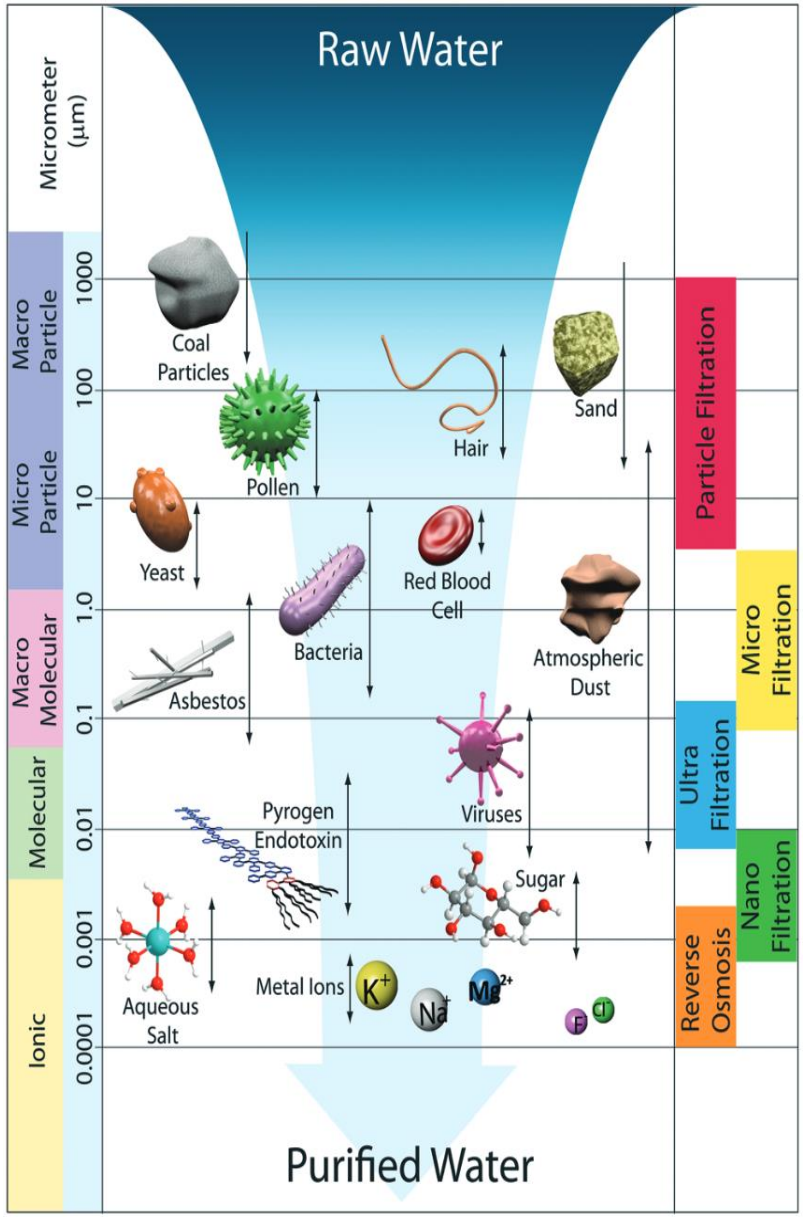


Fig. 1. Schematic diagram of nanoparticles separation from tap water with micro/nano-porous membrane.



Environ. Sci.: Water Res. Technol. ,2016, 2 ,17- 42

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Capital Requirements

New production facilities

Cost of Water Item	Cost of Water	
	US$/m^3	% of Total
Fixed Costs		
Capital cost recovery	0,430	47,8
Labor costs	0,029	3,2
Maintenance	0,048	5,3
Environmental and performance monitoring	0,008	0,1
Indirect O&M costs	0,048	5,3
Subtotal, fixed costs	0,563	61,7
Variable costs		
Energy	0,231	25,7
Chemicals	0,030	3,3
Replacement of RO membranes and cartridge filters	0,053	5,9
Waste stream disposal	0,023	2,4
Subtotal, variable costs	0,337	37,3
Total cost of water	0,90/m^3	*100*

Established production facilities

Cost of Water Item	Cost of Water	
	US$/m^3	% of Total
Fixed Costs		
Labor cost	0,029	6,1
Maintenance	0,048	10,2
Environmental and performance monitoring	0,008	1,8
Indirect O&M costs	0,048	10,2
Subtotal, fixed O&M costs	0,133	28,3
Variable costs		
Energy	0,231	49,1
Chemicals	0,030	6,4
Replacement of RO membranes and cartridge filters	0,053	11,4
Waste stream disposal	0,023	4,8
Subtotal, variable costs	0,337	71,7
Total cost of water	0,470/m^3	100

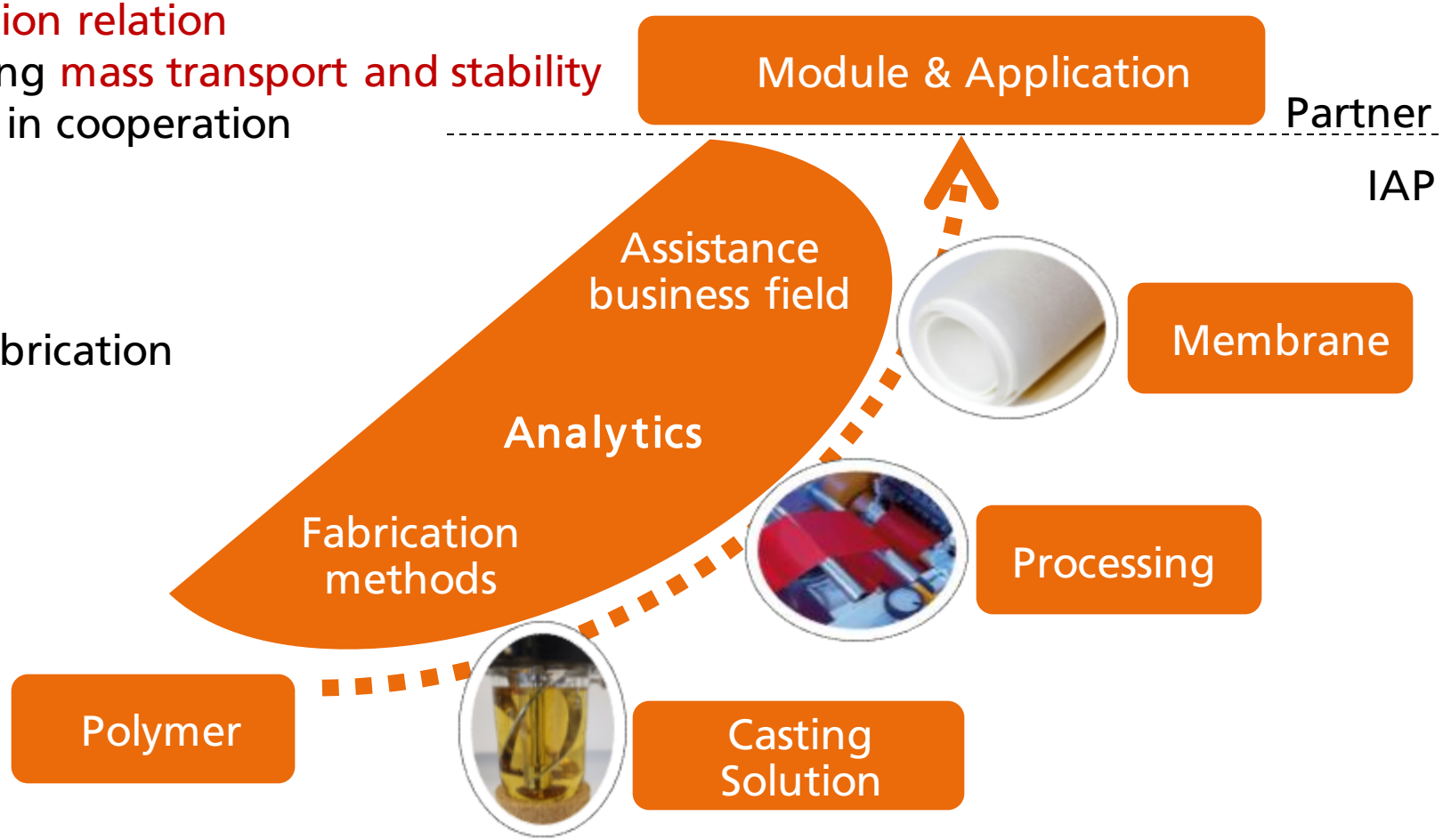
Situation in Germany corresponds to financially depreciated facilities!

Desalination Engineering, McGraw Hill, 2013

Fundamental Activities of the Membrane Group

- Membrane fabrication
  - Development of non-commercial membranes
    - Membrane structure and function relation
    - Structure optimization regarding mass transport and stability
  - Protected knowledge - patents in cooperation

- Project scope
  - **Polymer** selection:
    - Chemical stability, impact: fabrication
  - **Casting solution**:
    - Solvents, impact: safety
  - **Fabrication**:
    - Screening: discontinuous
    - Scale up: continuous, R2R
    - Adapted to plants
    - Impact: morphology
  - **Membrane**:
    - Target properties
    - Impact: mass transport



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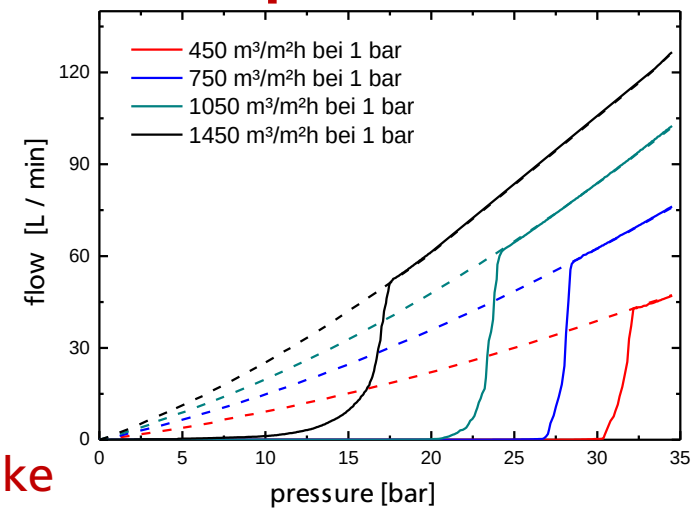
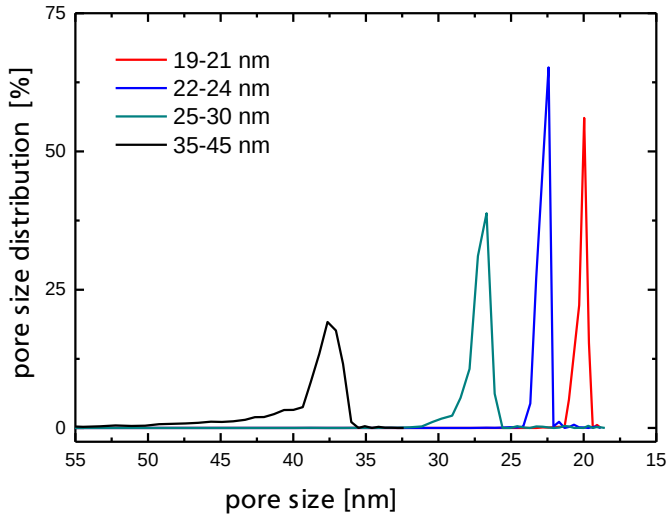
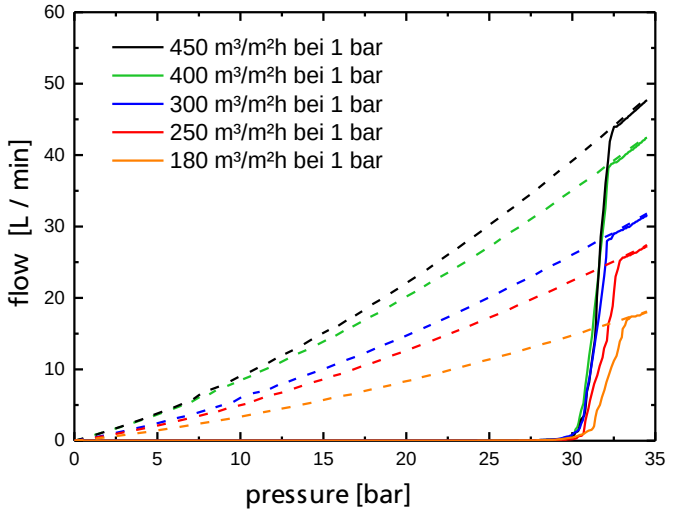
Pore Size and Porosity Adjustments

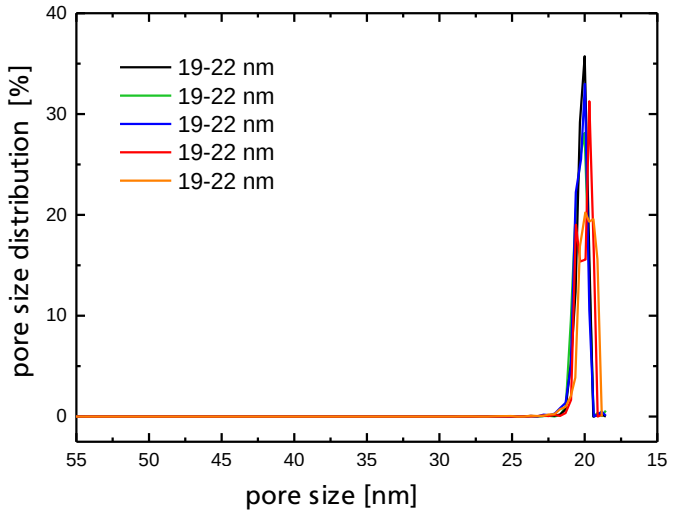
USP: Membrane Optimization

First step:
- Screening phase
- Basic structures like pore size









Second step:
- Membrane adjustment
- Porosity

Narrow pore size distribution: +/- 10%

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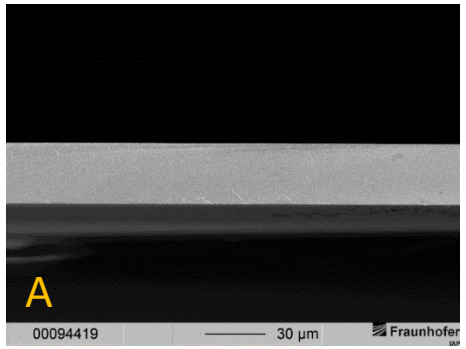
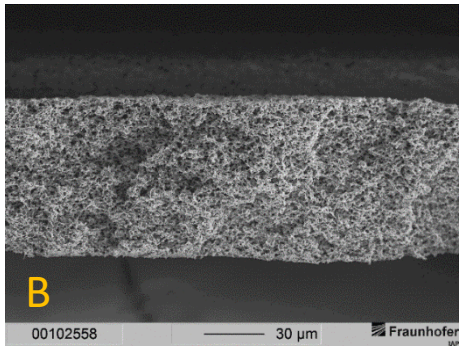
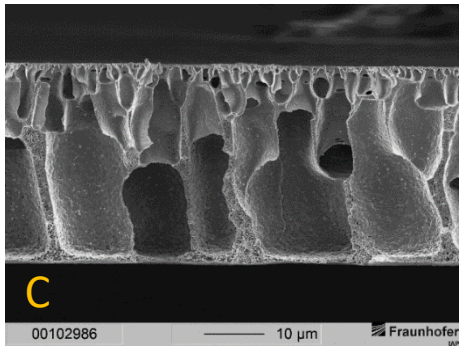
Expertise Membrane Group
USP: Variation of Membrane Morphologies and Adjustment of Pore Sizes

1-step formation and variation of membrane morphology with variety of polymers

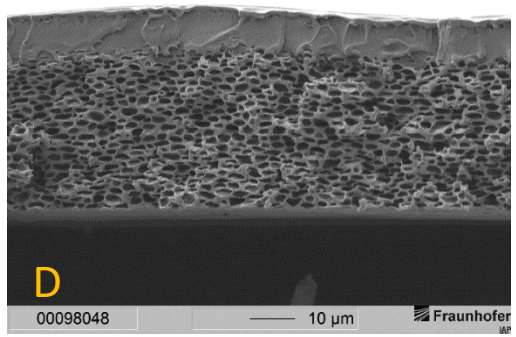
standard

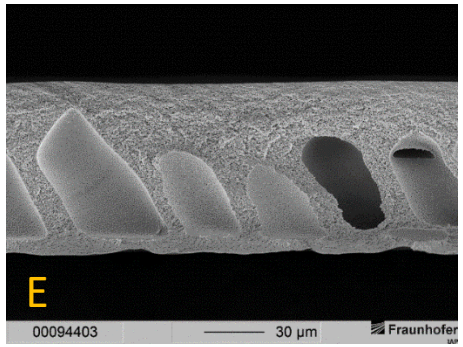






complex





A = dense
B = porous (symmetric)
C = porous (asymmetric)

D = combination A and B
E = Combination B and C

Take away

- variety of polymers with best chemical stability

-standard & complex morphologies

- customized morphologies

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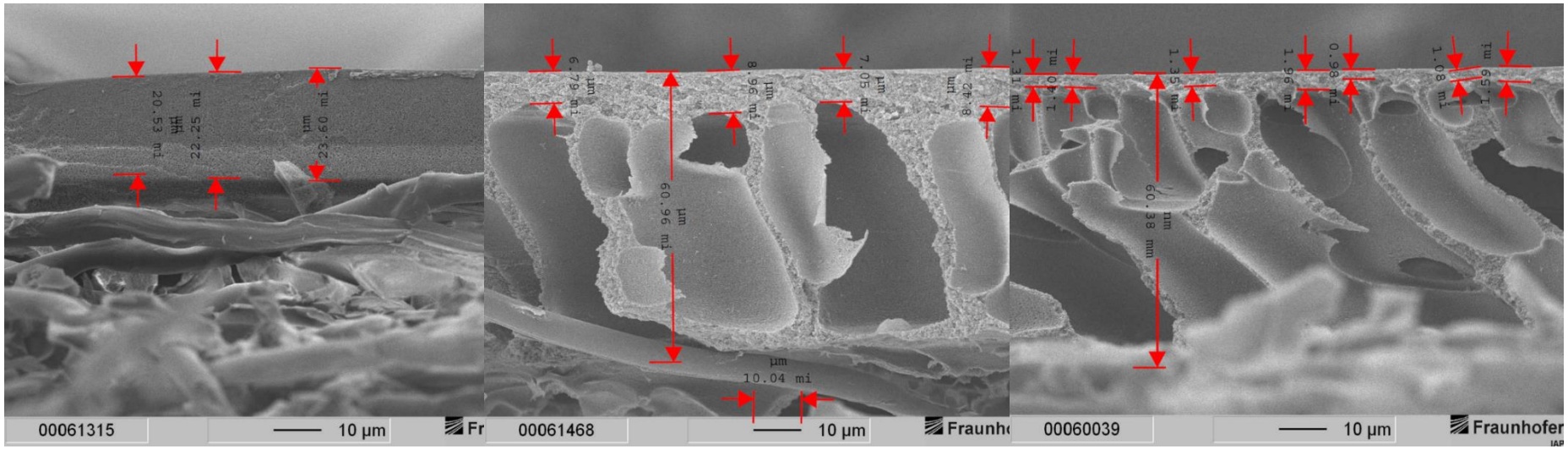
USP: **Porous** membrane adjustment according to costumer specification



mechanical stability

permeability

- Variation of the morphology via changing the precipitation parameters of constant casting solutions.
- Pore size adjustment between 5 - 100nm
- Porosity adjustment or stability adjustment

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Removing of Particles approx. 40nm from Process Liquids

Motivation:
- Particle removal (water, polymer fabrication, virus & pathogens, recycling)
- Here Separation of specific particles carbon black and regeneration of cleaning solution, agglomerates of approx. 150nm, high loading

Aim:
- Separation of identified particles by adjusted size differentiation
- High permeability, low energy demand

Improvement:
- Differentiation of specific particles, no change of liquid system
- Reduced wastewater

removal of approx. 99,8%
after first filtration
non-optimized filtration

Feed | Permeate

Membrane surface after filtration

Membrane Department @Fraunhofer IAP

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Materials, Analytics Filtration

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for Tailored Filtration

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