

# Recovery of phenols by membrane contactors

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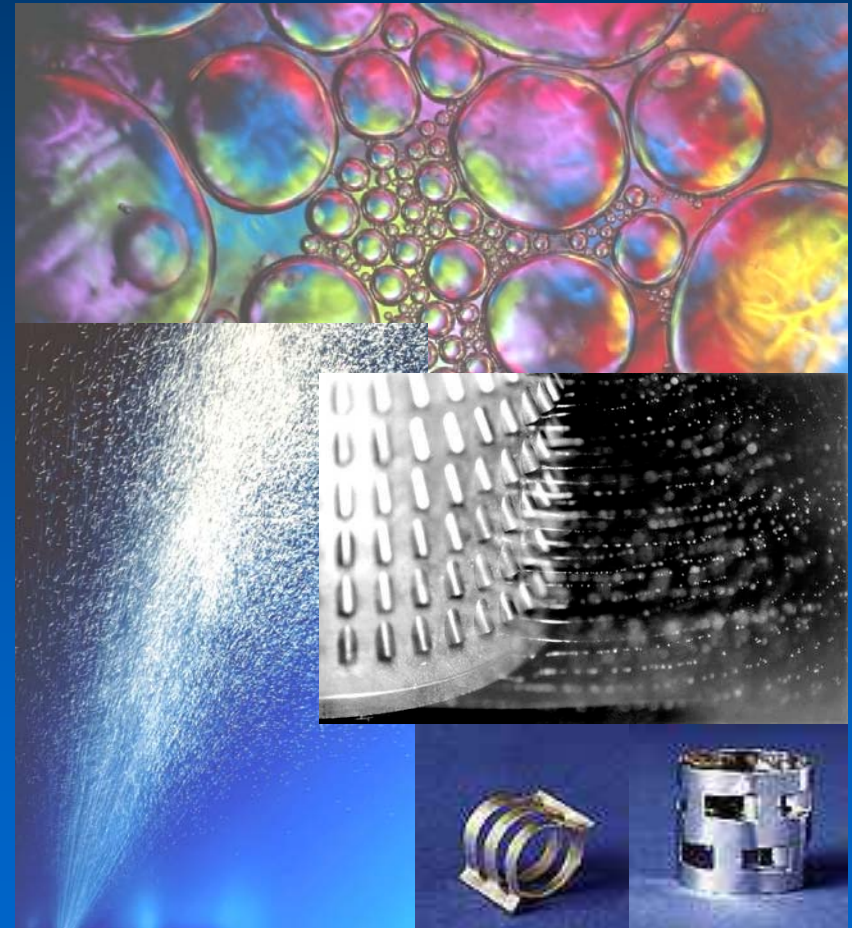
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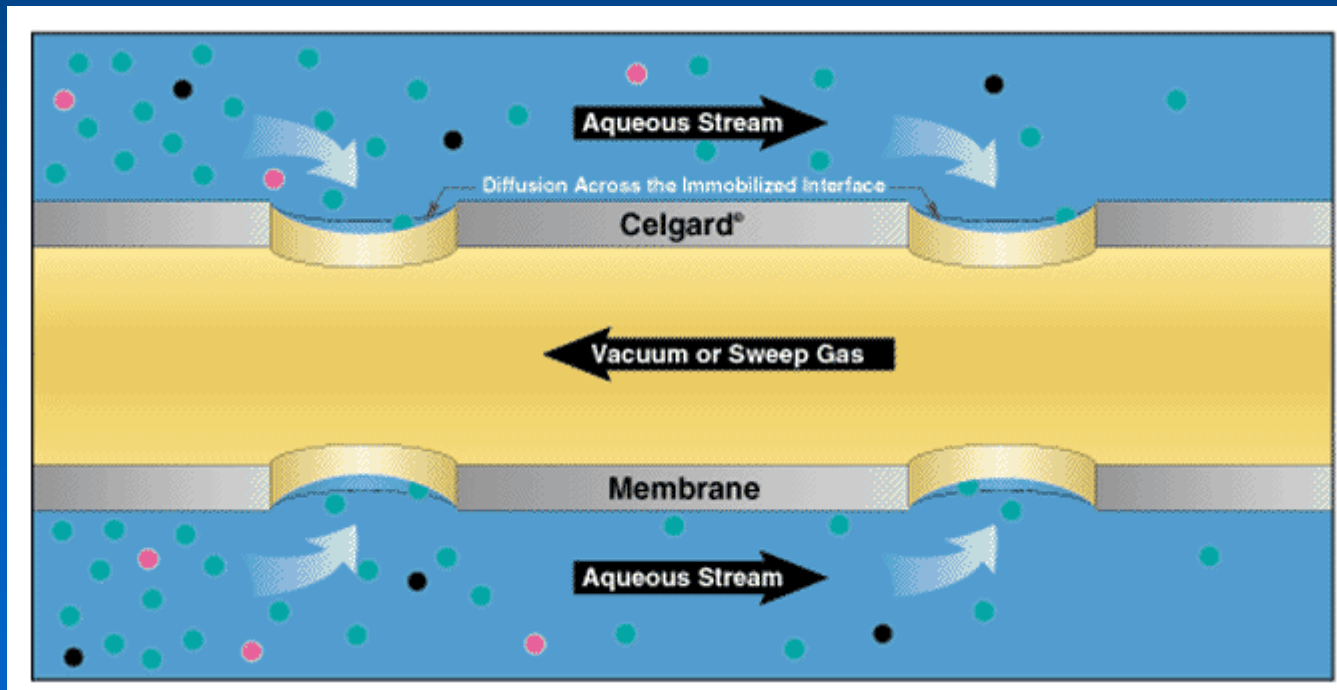
## What is a contactor?

- Multiphase mass transfer processes require interfacial area
- Technical generation of interface: Contacting equipment, e.g. columns, mixer-settlers, spray towers, etc.
- Common principle: Dispersion of one phase in the other



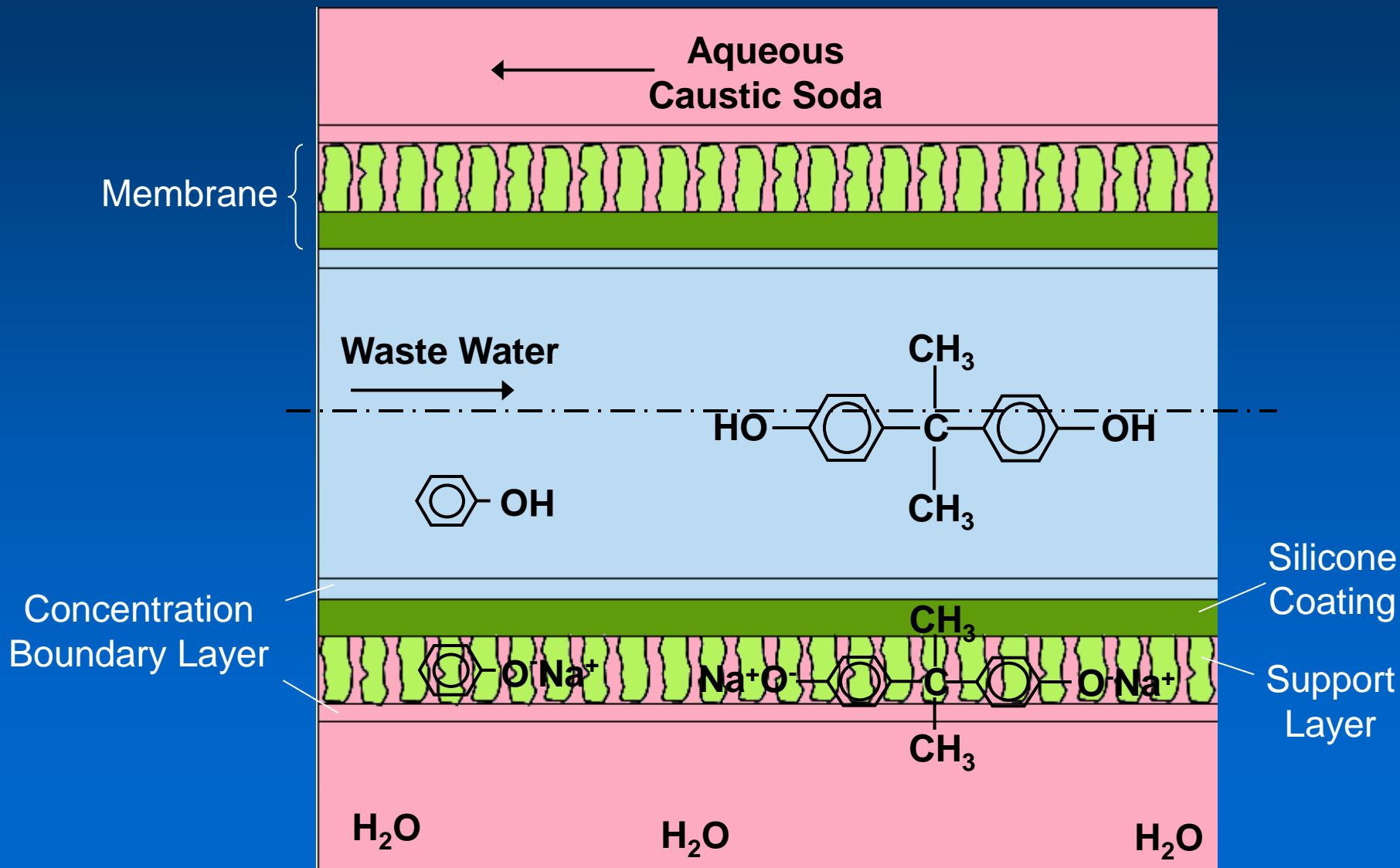
## What is a membrane contactor?

- Alternative to traditional contacting apparatuses
- Non-dispersive interface generation with a membrane

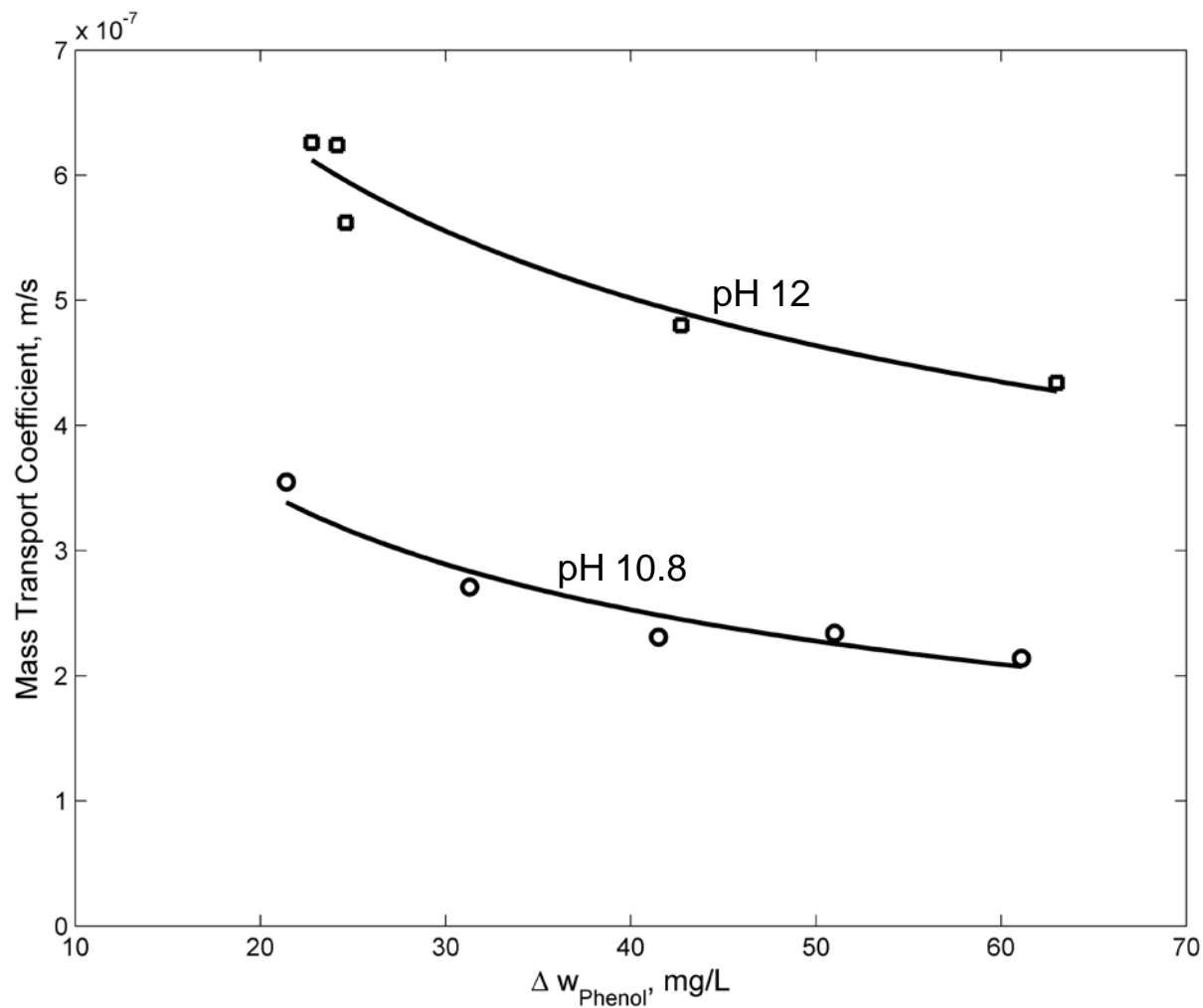


Source: Membrana GmbH, formerly Celgard GmbH

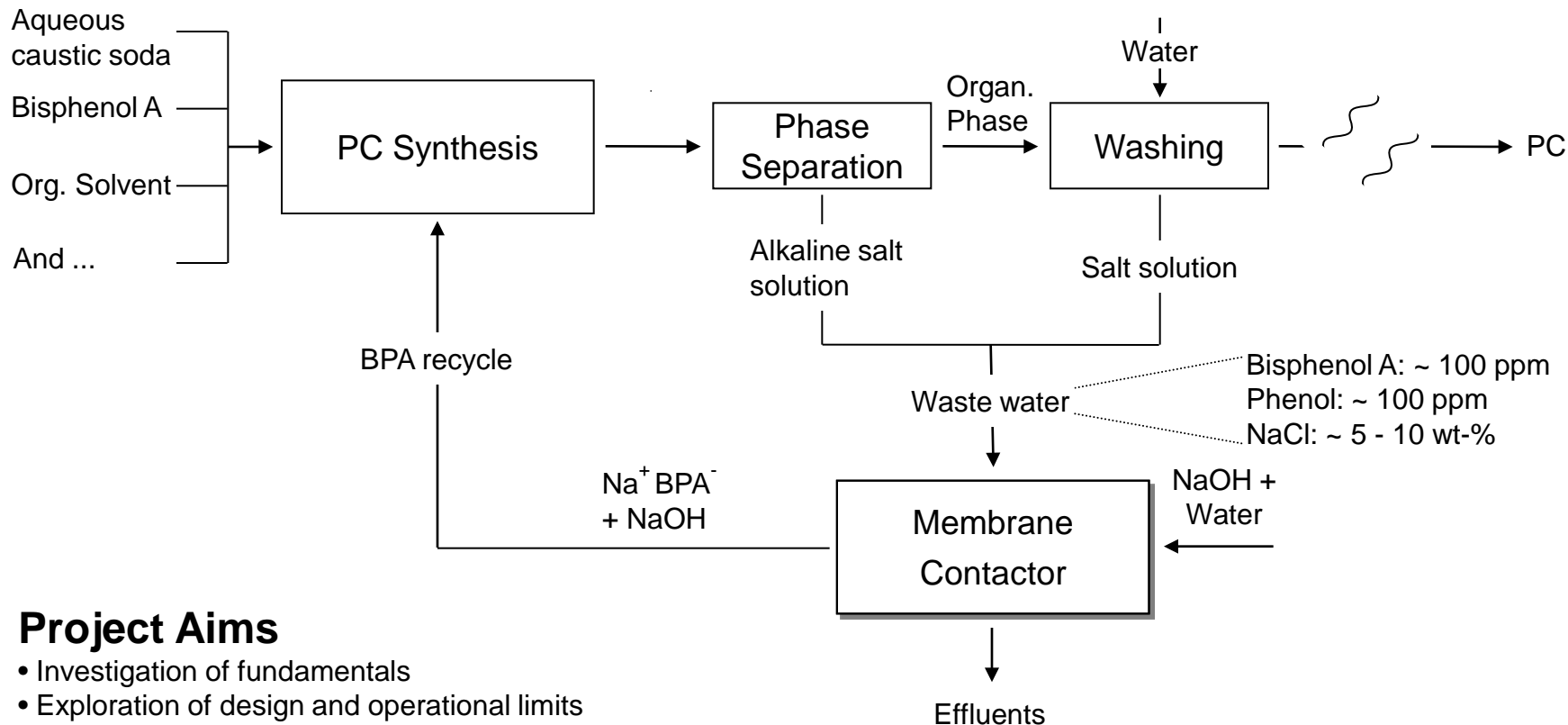
# Functional Principle



## Performance



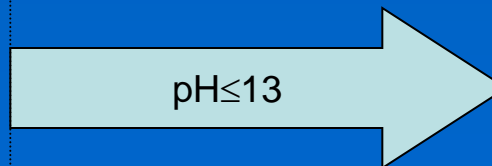
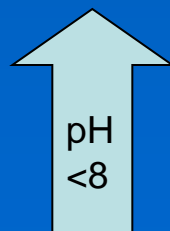
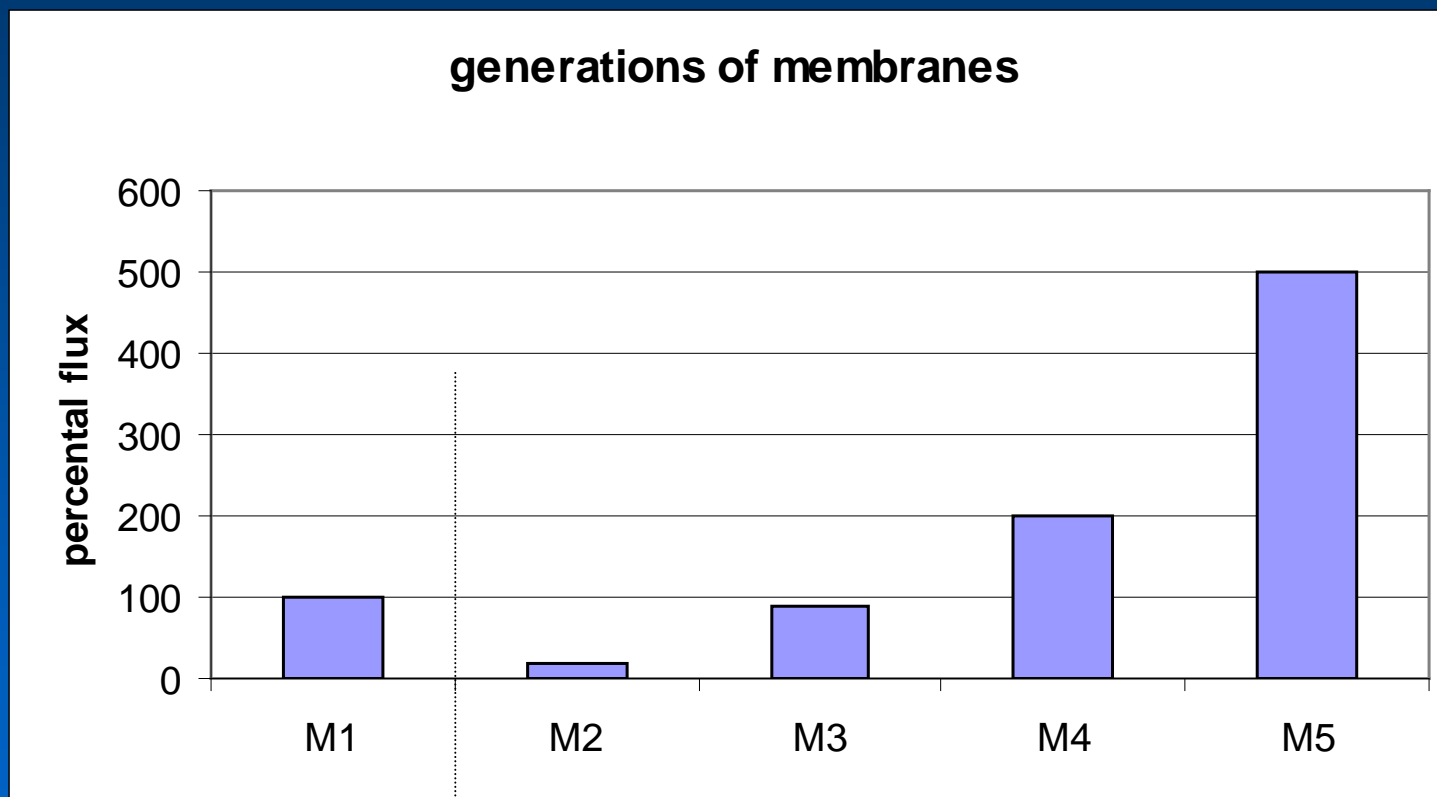
## Case Study



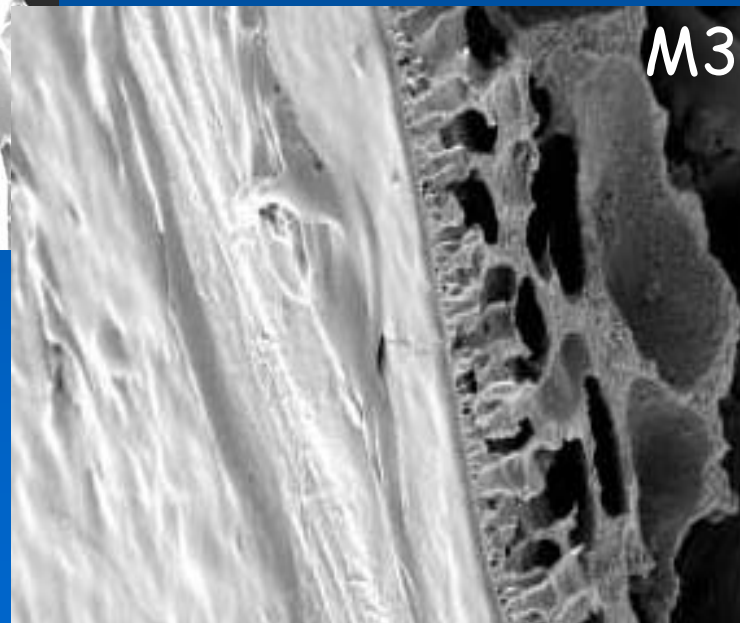
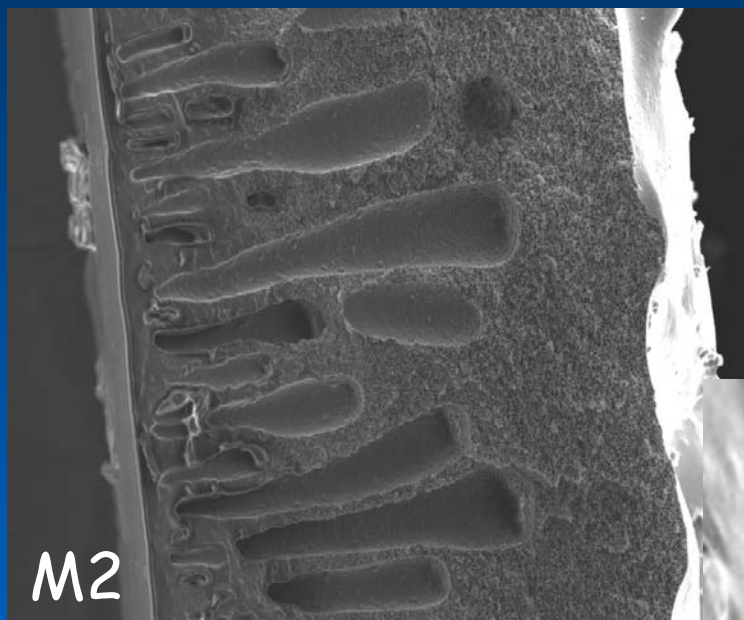
### Project Aims

- Investigation of fundamentals
- Exploration of design and operational limits (development of module designs)
- System integration
- Environmental assessment

## Membrane Development

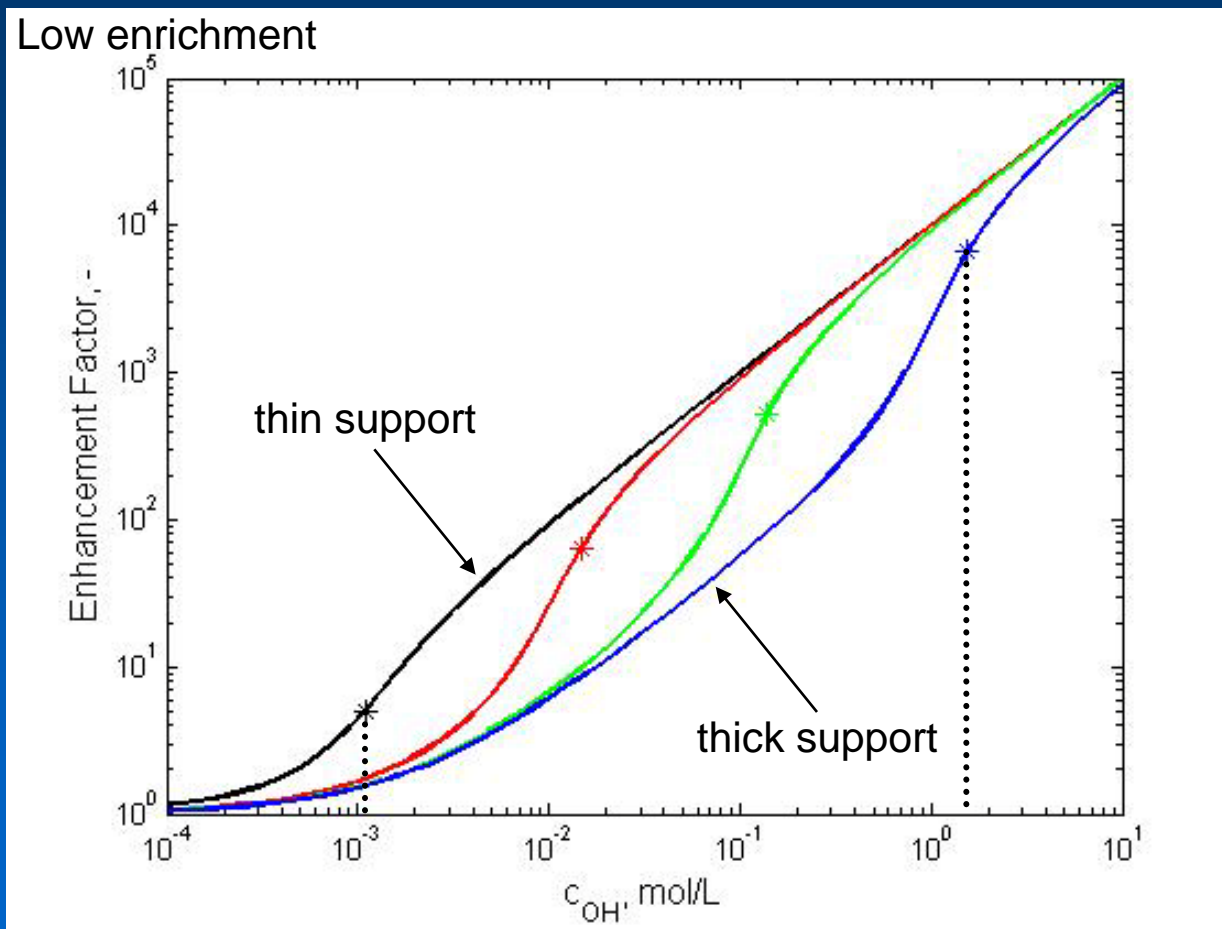


## Membrane Development II



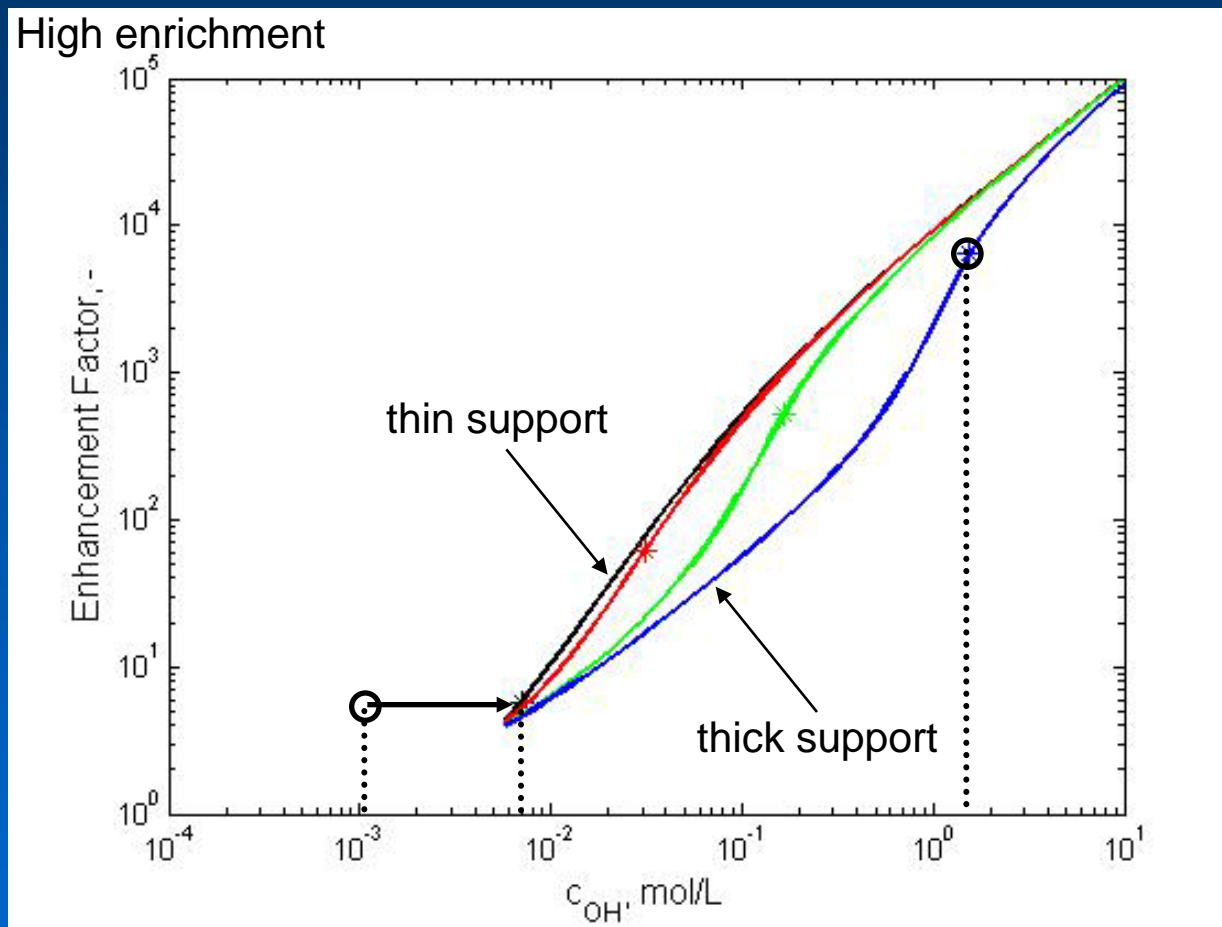


# Membrane Development III



→ Thicker supports require stronger stripping solutions

# Membrane Development IV

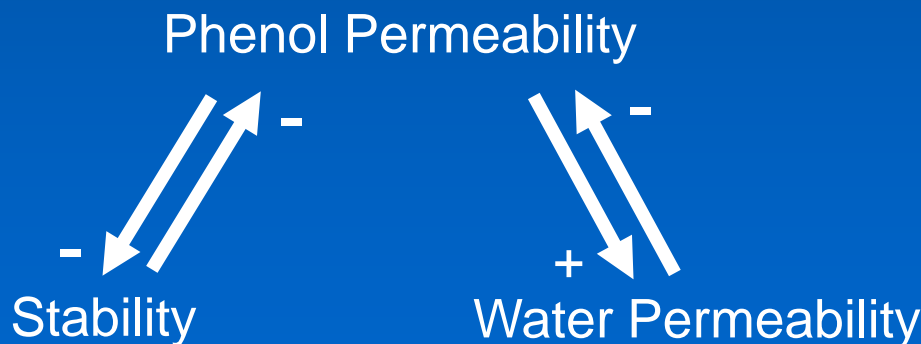


→ Development targeted at thin / highly porous supports  
 & high pH stability (~pH 13)

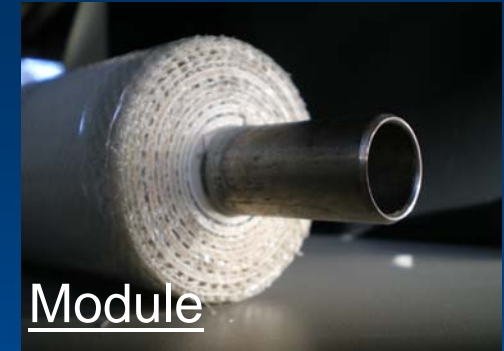
## Besides ...

- Aqueous / aqueous extraction:
  - $\Delta P_{\text{osmotic}}$  induces solvent flux
    - affects phenol mass transfer
    - magnitude depends on thickness & structure of dense layer
    - no contamination of other phase

## In short ...



## Scale-up



Mass Transfer

Limiting Current  
Technique

Cu-Dissolution  
Technique

Dispersion

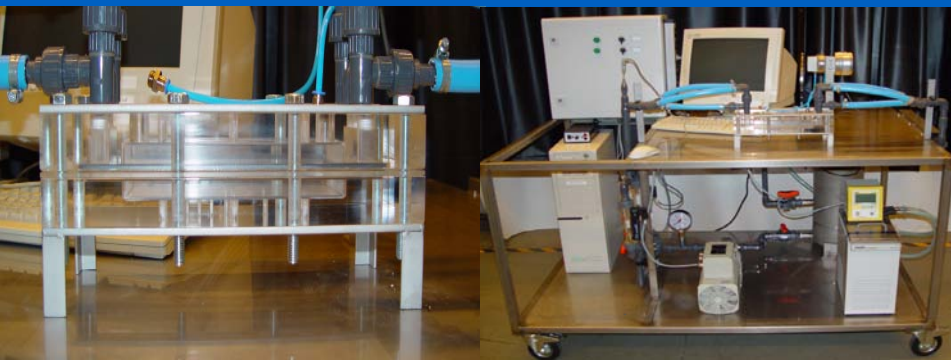
Color shift of pH  
indicator

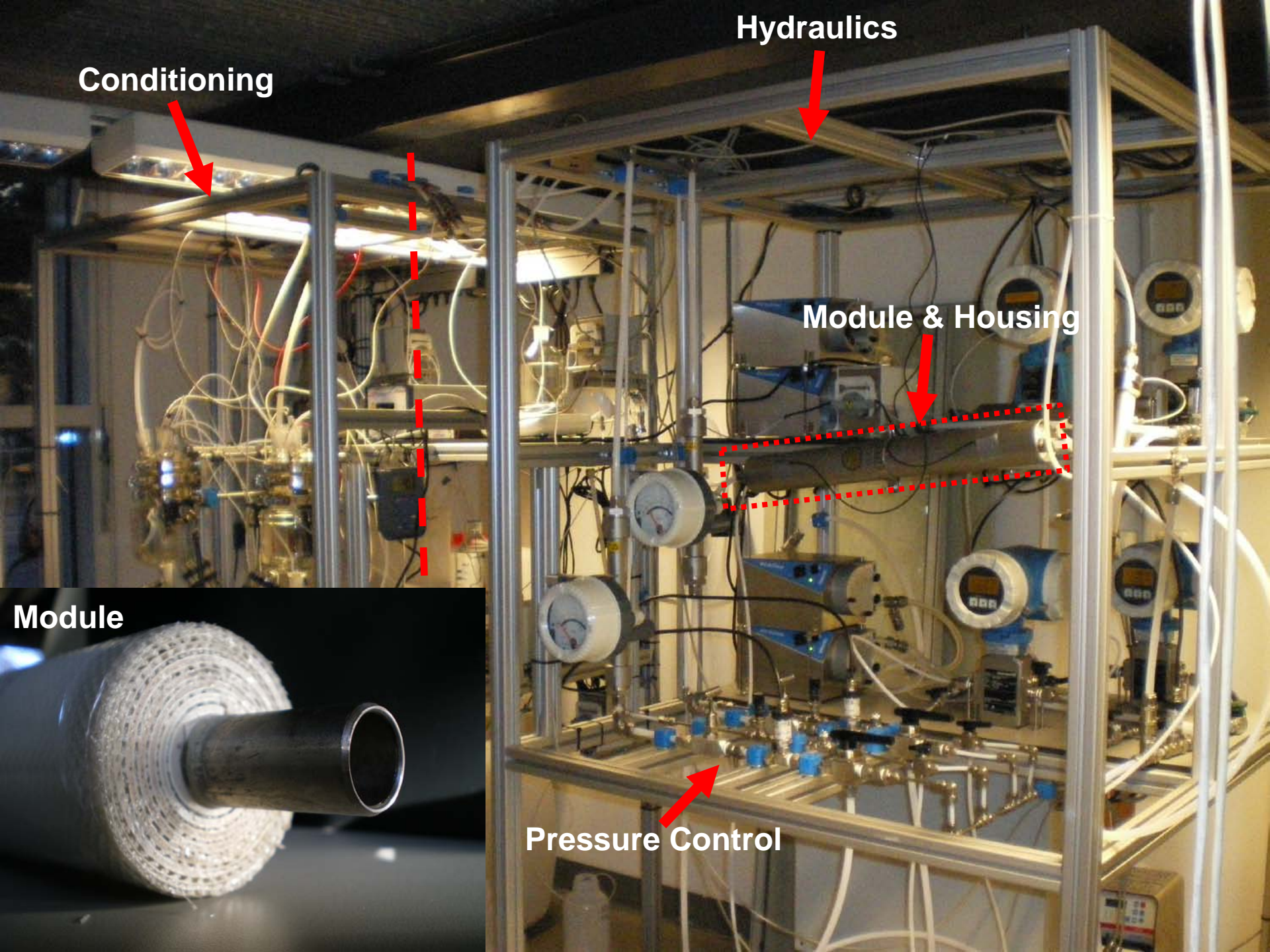
Residence Time  
Measurements

Energy Dissipation

Pressure Drop

Pressure Drop





Conditioning

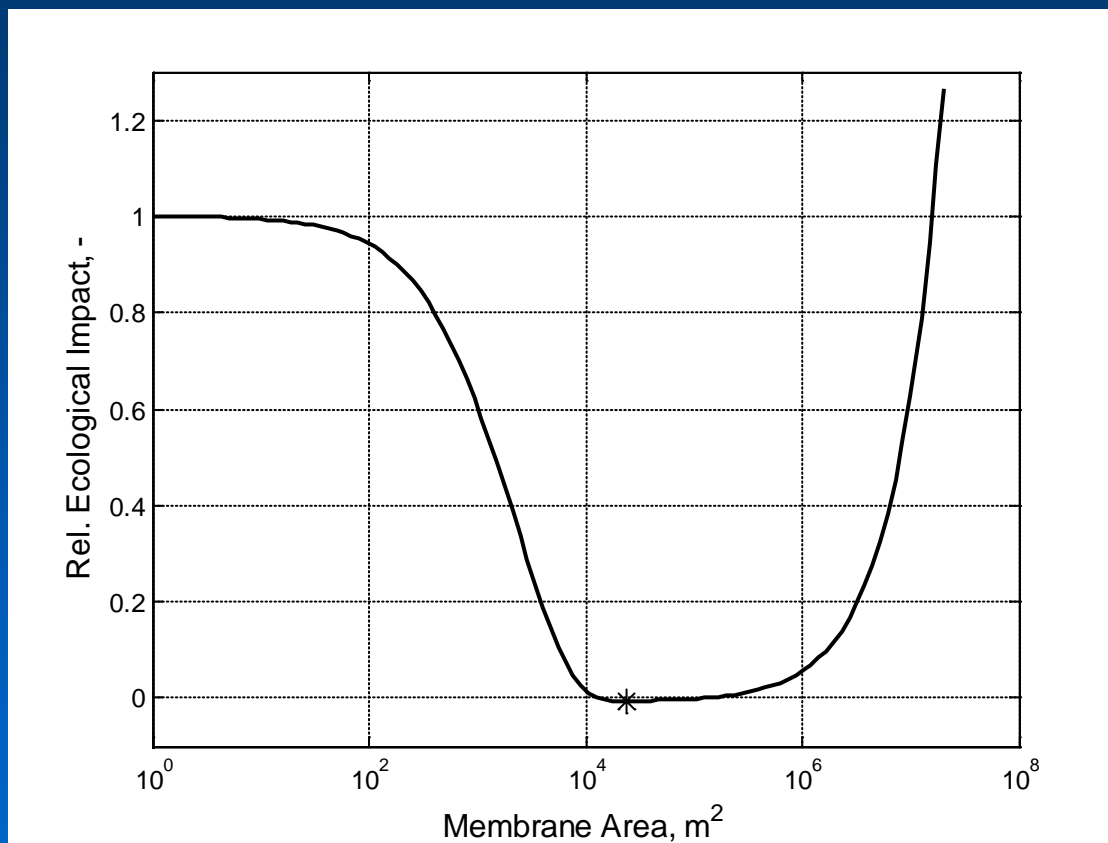
Hydraulics

Module & Housing

Pressure Control

Module

## Environmental Impact



→ Environmentally very beneficial!

## Economics

**... depends mainly on membrane area!**

- Requirements for a viable implementation:
  - well defined target components
  - process water inlet concentrations preferably at intermediate level
  - process water outlet concentrations not overly strict
  - small to intermediate processes
  
- ➔ For a process stream as large as in the case study with a low value product, the contactor is probably too expensive.

## Outlook

Extraction of metal ions with ion-exchange membranes  
with organic stripping solvent (i.e. D2EPHA)

- Decreased contamination of process water compared to conventional (membrane) extraction (here: no direct contact)
- Often small scale applications
- Discharge of heavy metal contaminated process water expensive



## **Acknowledgment**

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