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Enzymatic membrane concept

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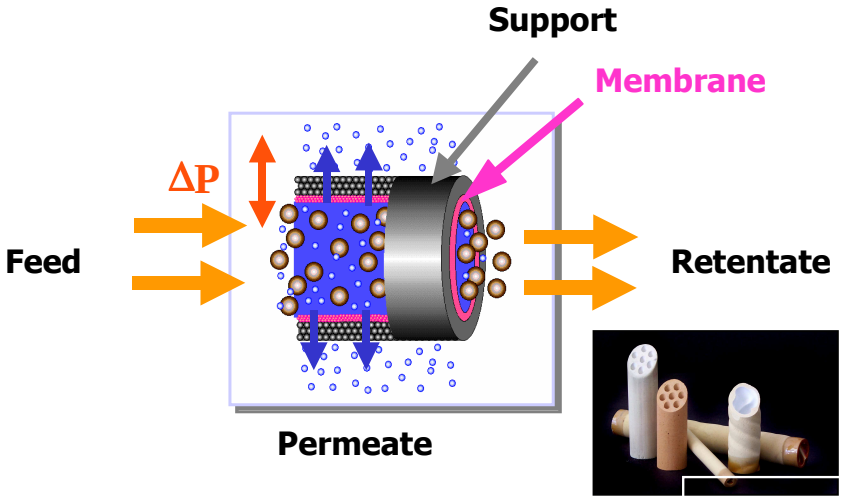
Membrane functions

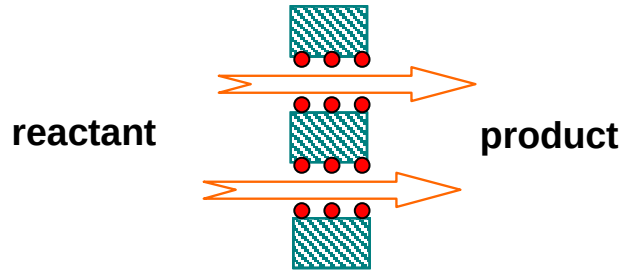
➢ *Classical function : separation*



➢ *Functionalized membranes*

Specific functions are given to the membrane by grafting or adsorption of active compounds on or inside the membrane
(ex : chemical catalyst, biocatalyst, chromatographic ligand)

Ex : reaction during the crossing of a catalytic membrane



Membrane functionalization

Organic membrane

Easy grafting due to the presence of functional groups

Inorganic membrane

High resistance
Membrane surface less reactive

Membrane functionalization by deposition of a polymer (gelatine, chitosan, polyvinyl alcohol…) on or inside the membrane in order to provide amine or hydroxyl groups able to fix active compounds (biological or chemical catalysts, ligands…).

⇒Hybrid membrane

Advantages :

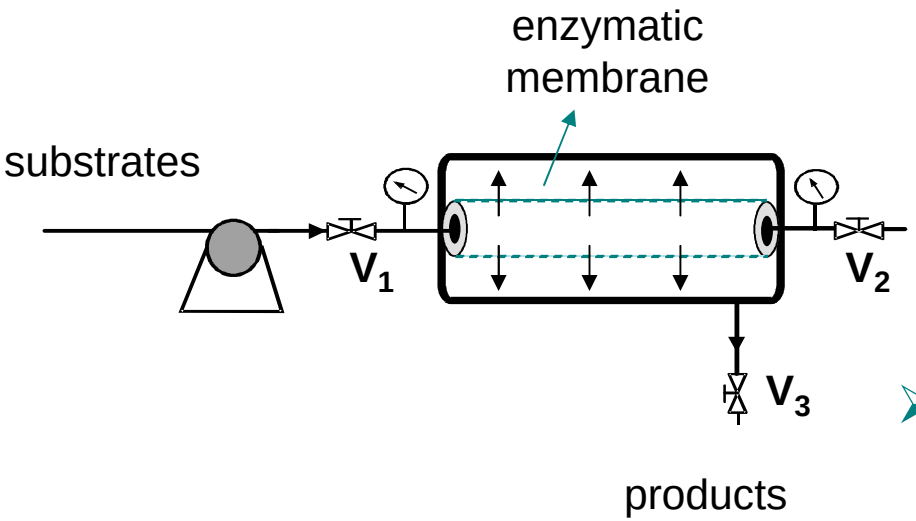
- Good chemical and physical resistance
- Limitation of membrane fouling
- Easy regeneration
- Biocompatibility (depending on the polymer)

Enzymatic membrane

For enzymatic membrane reactors

Application : ester synthesis

Enzymatic membrane reactor



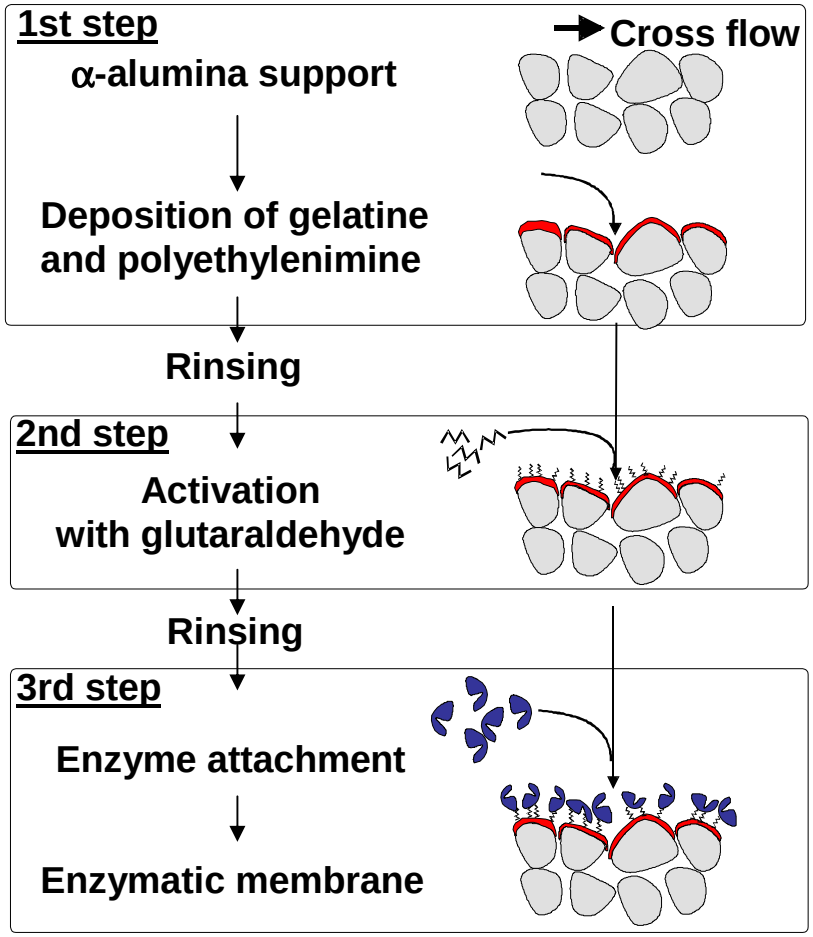
Advantages

- ✓ continuous operation
- ✓ enzyme reuse
- ✓ low pressure drop
- ✓ continuous extraction of the products

Limitations

- ✓ risk of concentration polarisation and membrane fouling

Enzymatic membrane



➢ Main advantages

✓Strongly resistant membrane

✓ Hydrophilic surface
⇒ water molecules in the enzymes microenvironment

✓Easy regeneration

✓Good reproducibility

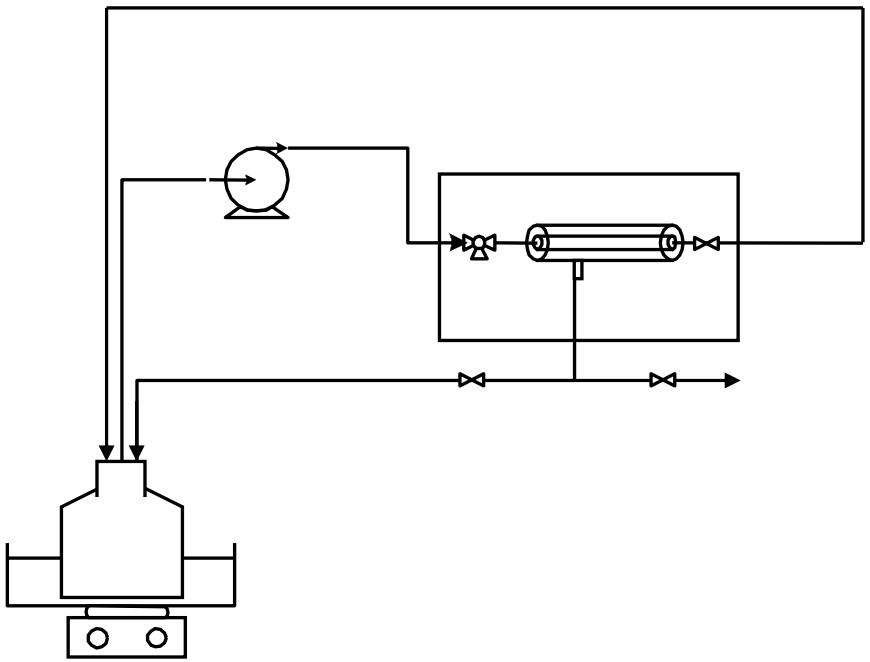
✓Stable during storage

Example of application : butyl laurate synthesis in hexane

Réaction :
butyl acetate + lauric acid → butyl laurate + acetic acid

Membrane : Al_2O_3/ZrO_2 (ϕ_p = 20 nm)

Method : permeate and retentate are recycled in the feed

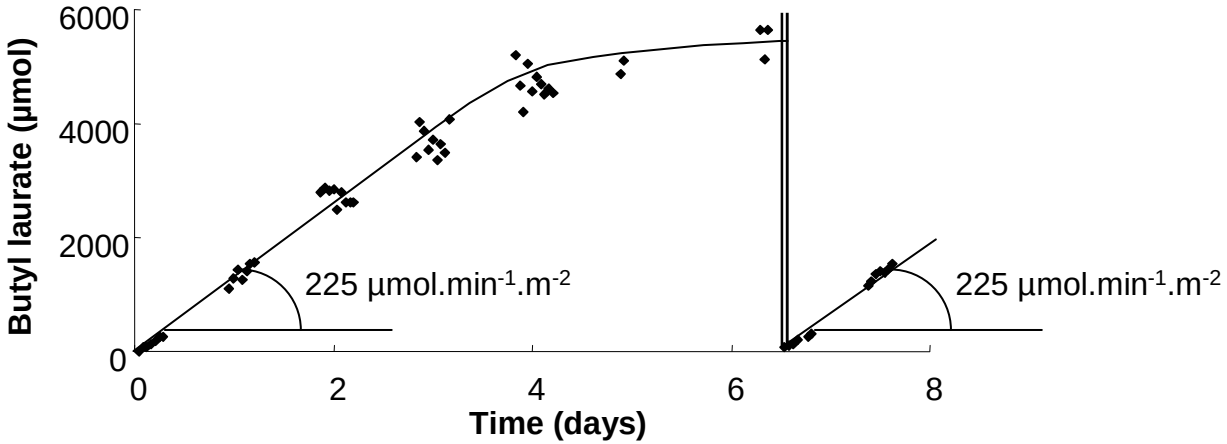


Operating conditions

- Temperature = 37°C
- ΔP = 2 bar
- Flux = 0,5 $ml.min^{-1}$
- Substrate concentrations = 50mM

Example of application : butyl laurate synthesis in hexane

Activity and stability of the enzymatic membrane



The amount of BL produced increases linearly during the first 3 days (productivity = 225 µmol.min^{-1}.m^{-2} - to be compared to 9 µmol.min^{-1}.m^{-2} with a non-enzymatic membrane)
Then the amount of BL produced levels off (when reaction equilibrium is reached)

Similar productivity after change of the reaction mixture

⇒ **The enzymatic membrane is active and stable in hexane during at least 8 days**

Applications of enzymatic membrane reactors

Enzyme = lipase

- Hydrolysis of butyl acetate
- Synthesis of butyl laurate in hexane
- Synthesis of butyl laurate in supercritical CO_2
- Interesterification of castor oil and methyl oleate fluidified by SC CO2

Enzyme = laccase

- Degradation of phenolic compounds

Conclusion

Functionalised membranes were successfully employed for two specific applications :

Enzymatic reaction

This application need further investigation to allow a transfer to industry

Acknoledgements

Enzyme membrane reactors

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