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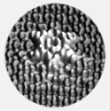

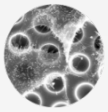

Protein adsorption in pores of ultrafiltration membranes

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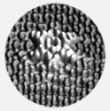
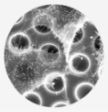
afaq ISO 9001 Qualité AFNOR CERTIFICATION

Heraklion – 28/06/19

Introduction

Membrane filtration



Pharmaceutical, food, petroleum, paper, … industries

Separation process widely used for :

- desalting, purifying, decontaminating, concentrating, …
- sea water, wastewaters, liquid food, …

Advantages :

- easy control, energy efficient process, environmental respect

Introduction

Aim of this work

Studying adsorption phenomena in UF membrane (commercial TiO_2) and consequences on the process performances

- ✓ hydraulic performances
  (filtrated flow rate)
- ✓ membrane selectivity
  (separation effectiveness)

Introduction

Context

Solutions filtrated (sea water, wastewater, liquid food, …)
Contain adhesive or viscous products as proteins

→ Gradual decline of membrane performances

→ Up to complete stop of the installation

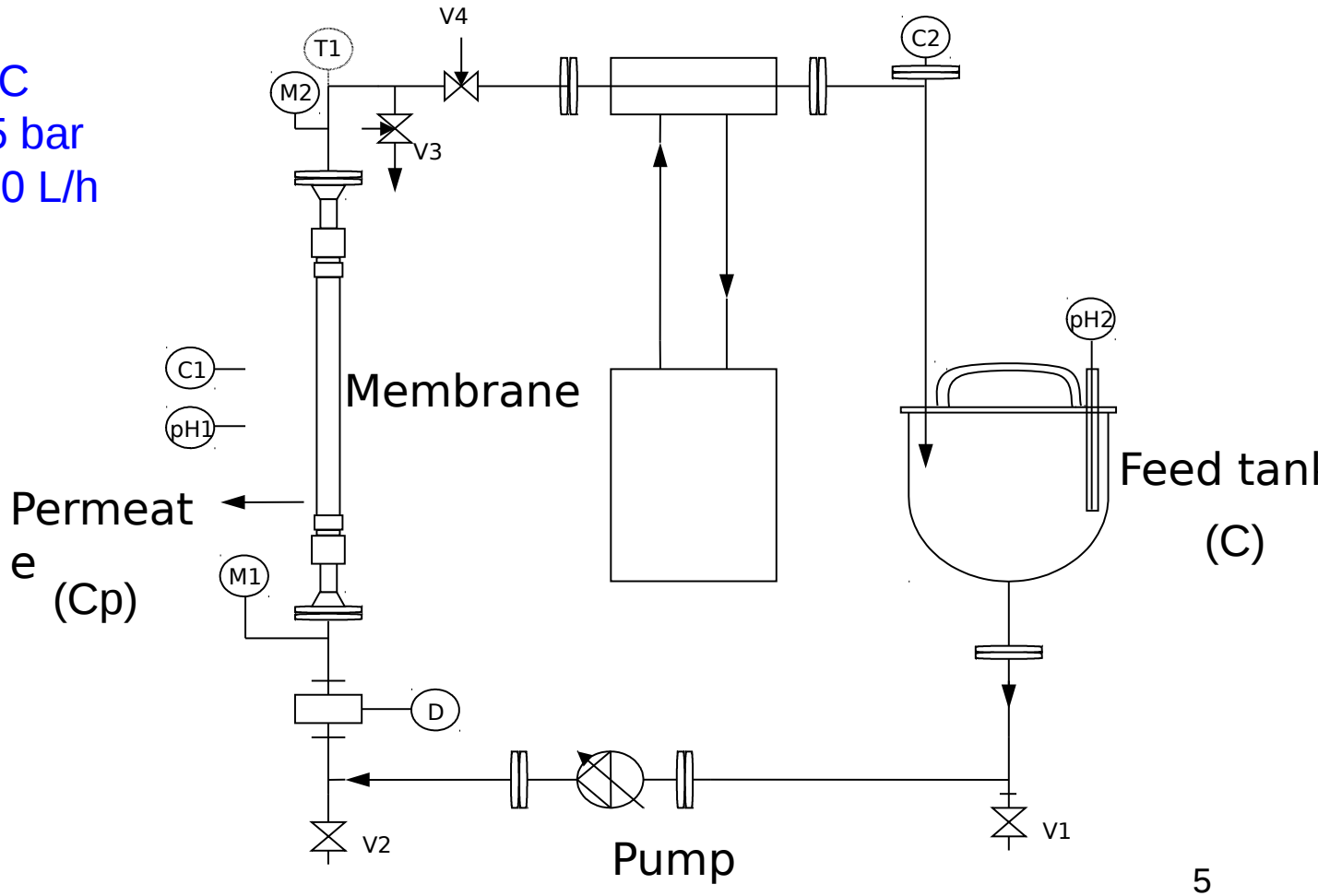
→ Requires a cleaning process waste of time and money, use of chemicals and energy

→ Generation of new wastes (solid and liquid)

Experimental section

Experimental setup

T = 25°C
ΔP ≤ 15 bar
Q = 700 L/h



Experimental section

Experimental tests:

Filtration of protein-water solutions

 rejection rate vs. applied pressure

$$R = \frac{C - Cp}{C}$$

After each test

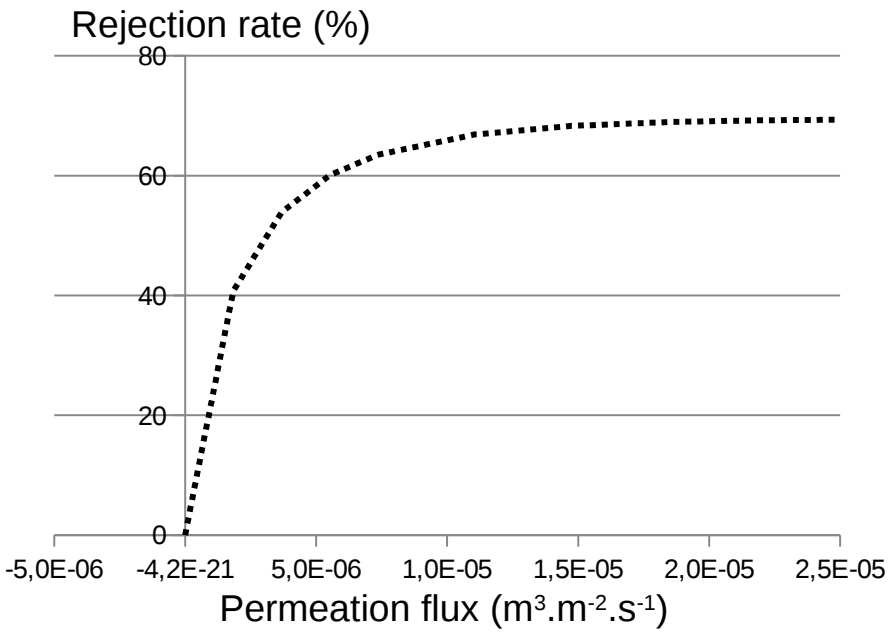
1 - Filtration of pure water estimation of hydraulic performances permeation flux (J_w) vs. applied pressure (ΔP)

2- Filtration of a neutral solute (Vitamin B12) rejection rate vs. applied pressure

 Nernst-Planck model for neutral molecule r_p

Experimental results

Filtration tests of a neutral solute (Vitamin B12)



Nernst-Planck approach for neutral solute

J(i) = f(convection, diffusion, steric effect)

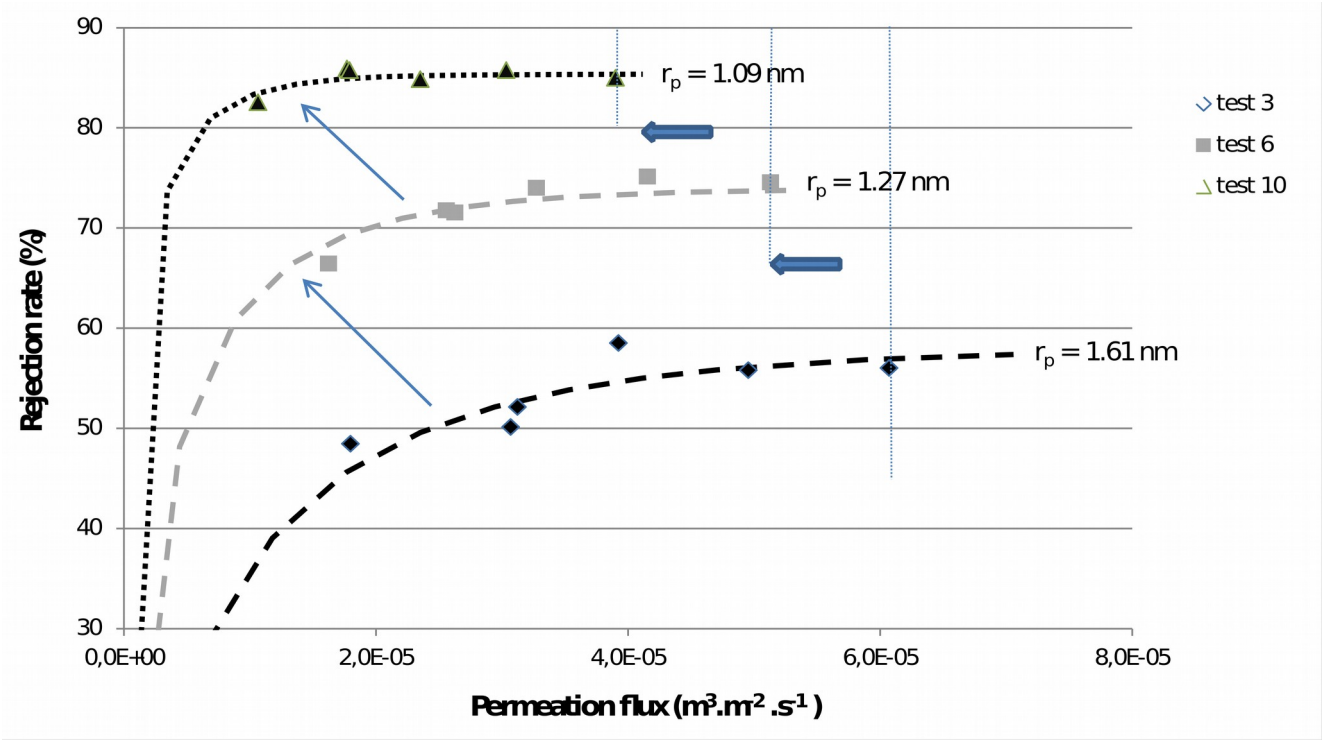
solute mass balance + equality chemical potentials

$\Rightarrow R = f(r_s, \Delta P, \mu, r_p)$

Approximating Rexp = f(ΔP) by the equation $\Rightarrow r_p$

Experimental section

3 filtration tests of lysozyme



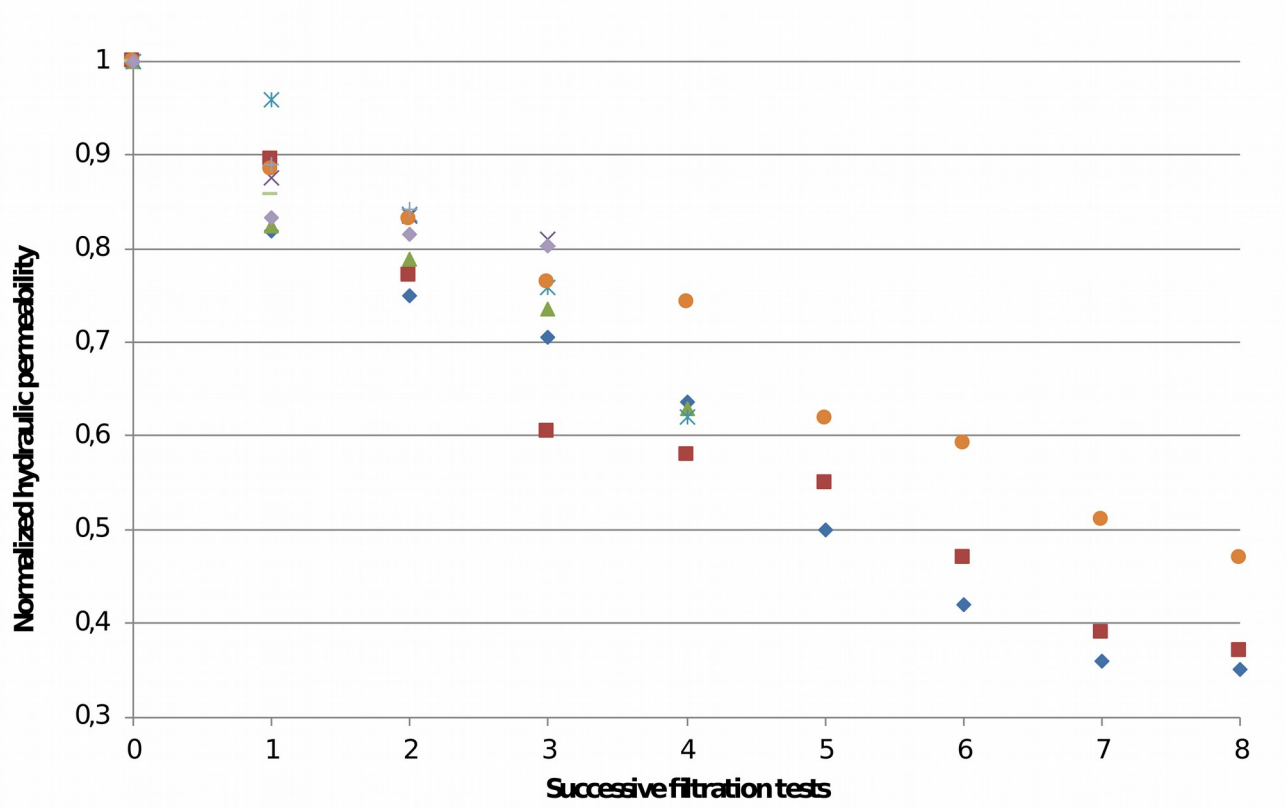
Increase of selectivity

R(VB12) = 54 to 85 % and R (lysozyme) = 65 to 100%

Hydraulic performances decline (> 30%)

Experimental results

Tests with 7 fresh membranes; filtration of Lysozyme and L-tyrosine (green - orange)



After 7-8 successive tests hydraulic performances (60-70 % decline)

Experimental results

Adsorption reversible / irreversible

Regeneration tests

hydrothermal treatment (100°C - 5 days)

Use of surfactant

Acid / base cleaning at room T

Acid / base cleaning at high temperature (> 80 °C)

Experimental results

Adsorption of proteins or amino-acids in membrane pores

- adsorption almost irreversible
- rapid performance downgrading
- ideal breeding ground for waterborne bacteria

Main issues / challenges

- understand adsorption phenomena in the pore
- limit pore clogging / or reversibility
- surface modification to reduce protein / surface afinity

Experimental results

Selectivity increases & hydraulic permeability decreases:

Average pore radius decreases

 little or no adsorption at the membrane surface

 size pore distribution

  adsorption in the largest pore

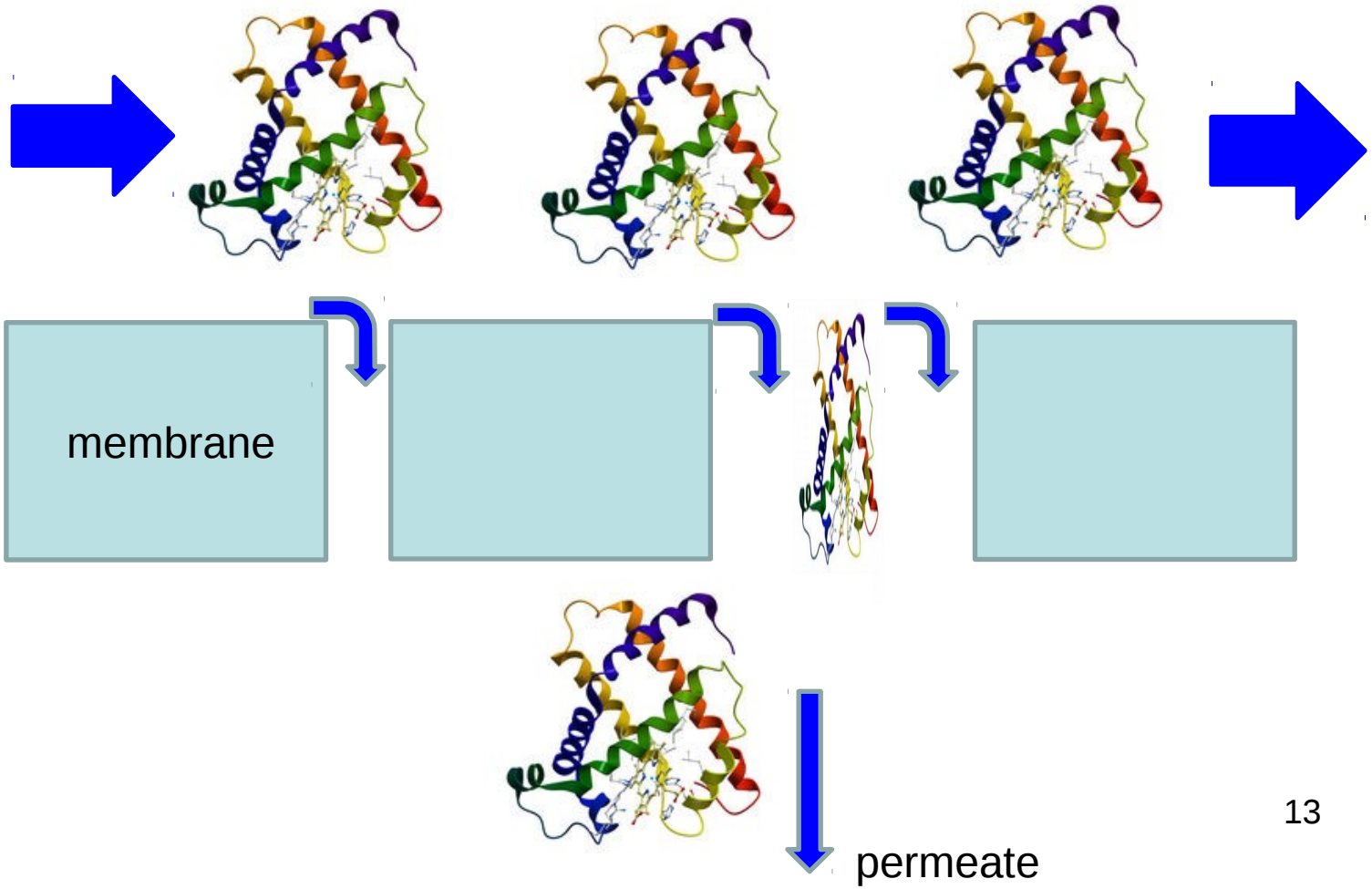
  no adsorption in the smallest size pores

Continuous vs. Discontinuous operation

→ filtration during 24 hours or 2 hours = same results

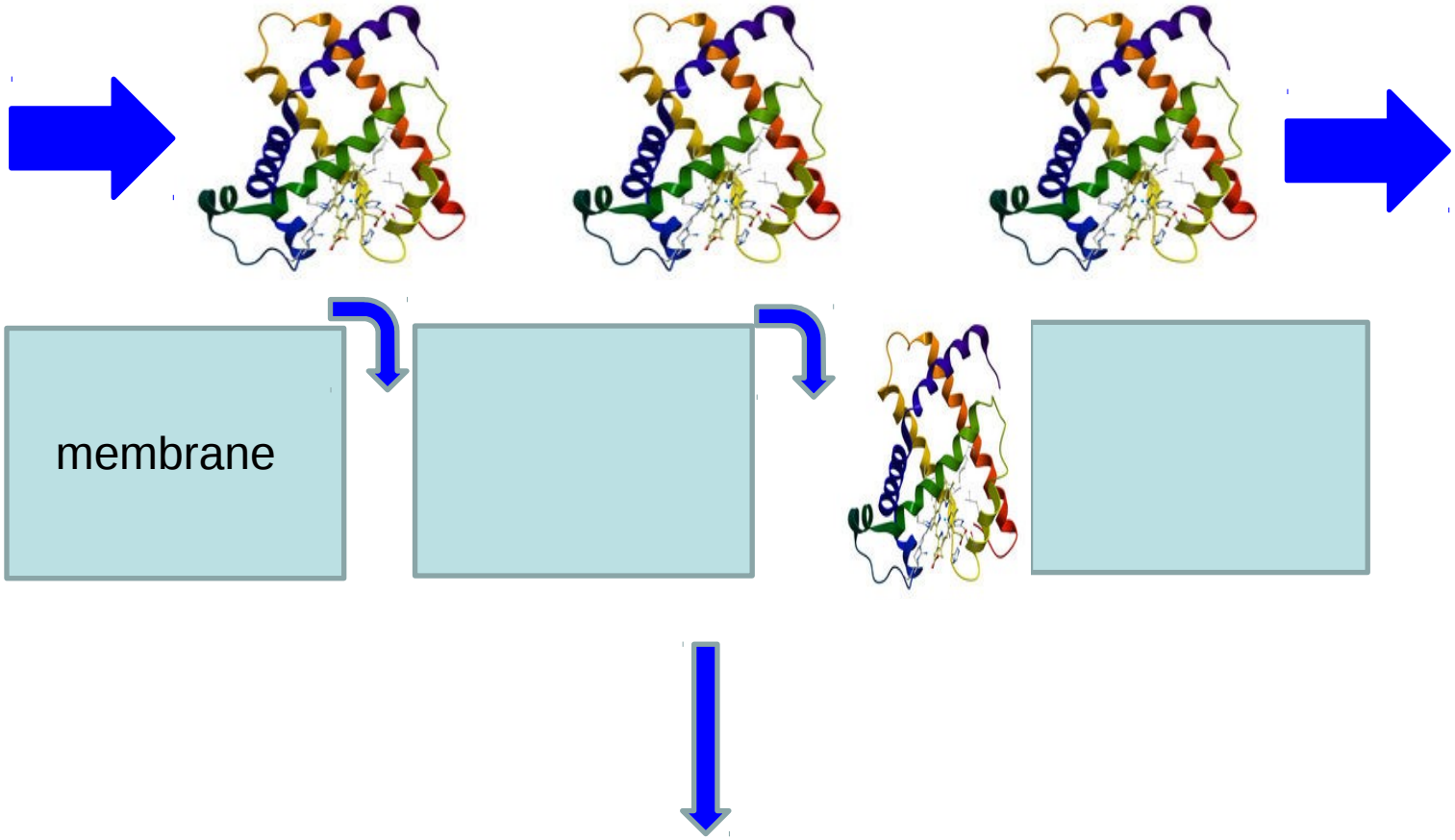
Experimental results

Adsorption phenomena (unsteady) 1st filtration test



Experimental results

After relaxation



Conclusion

Filtration tests of proteinic solutions

- membrane selectivity
- hydraulic performances

Due to

- adsorption in the largest pores
- no adsorption in the smallest and at the surface

- modification of protein conformation

And consequently

- requires treatment for membrane regeneration

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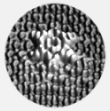

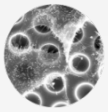

Thank you for your attention