

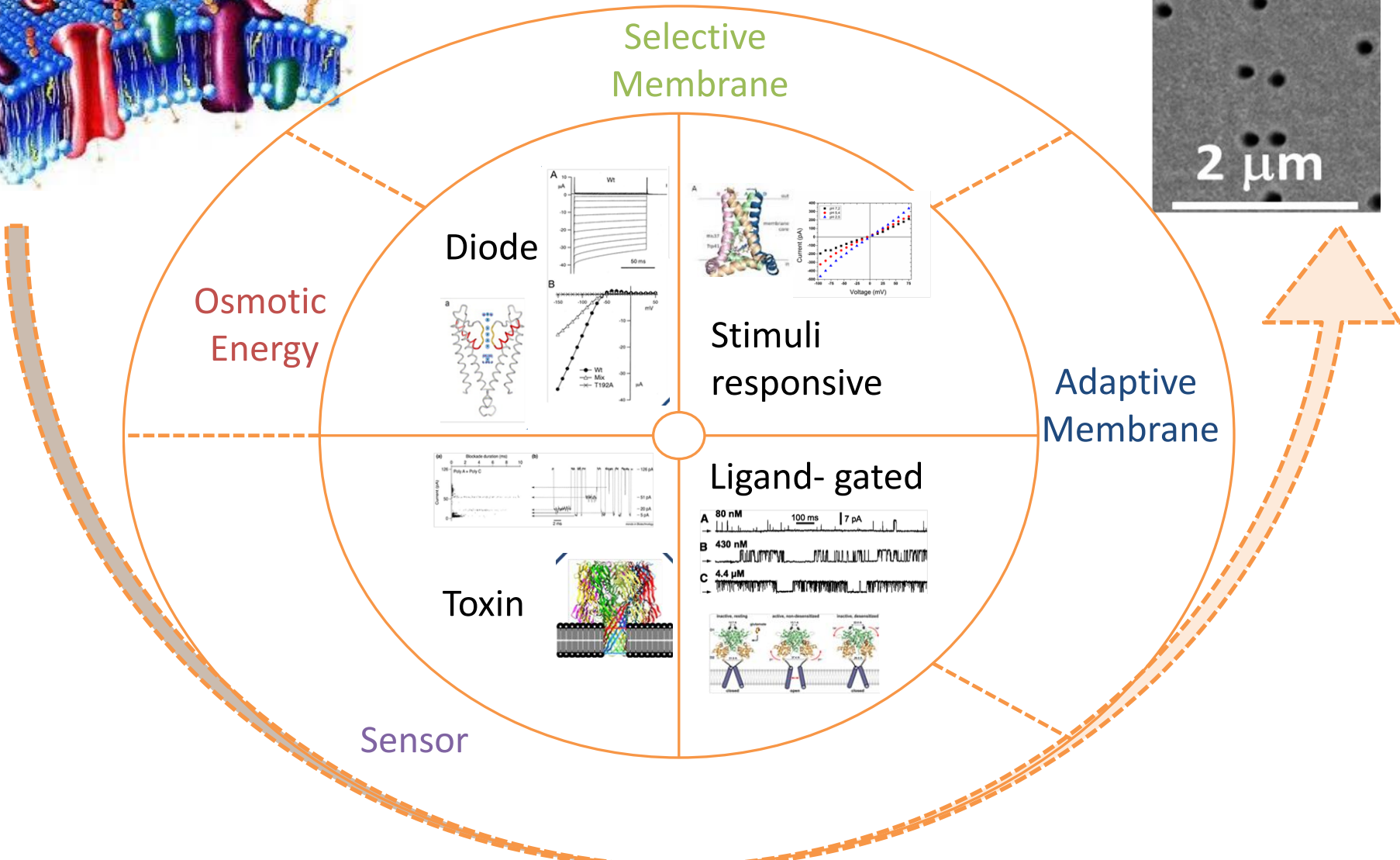
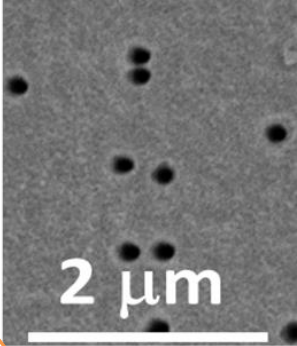
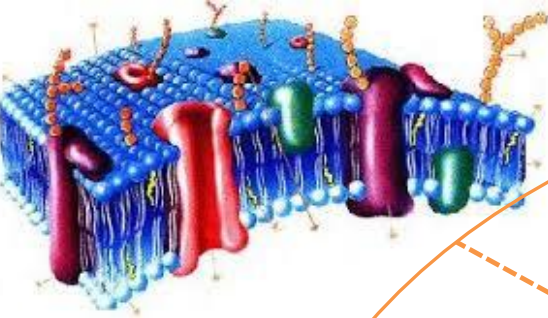
Biomimetic nanopore to design “smart” membranes

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sebastien.balme@umontpellier.fr*

Bio-inspired nanopores

Inspired by the nature to design synthetic
membrane



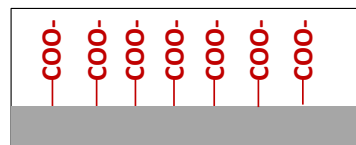
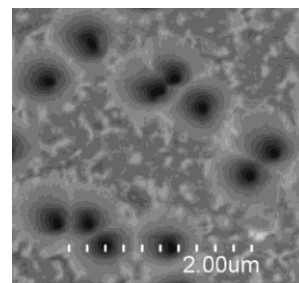
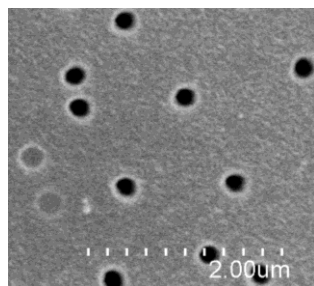
Polymer nanopore How obtain a single nanopore ?

Advances in colloid and interface science DOI 10.1016/j.cis.2017.09.001



Track

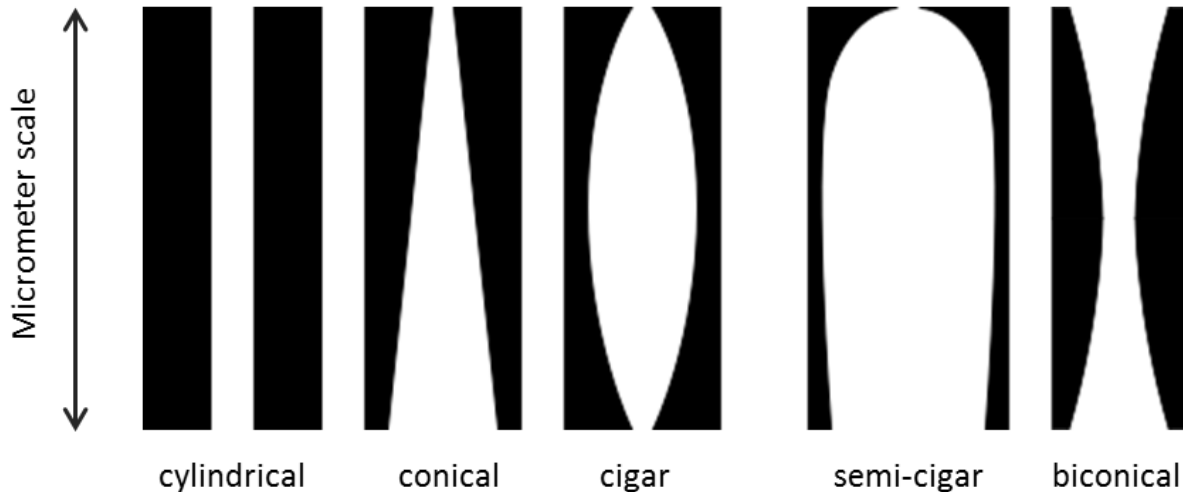
Etching



Kr, Xe (Mev)

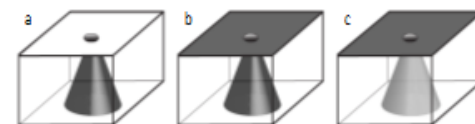
1 ion = 1 pore

Polymeric nanopore drilled by track-etched technique



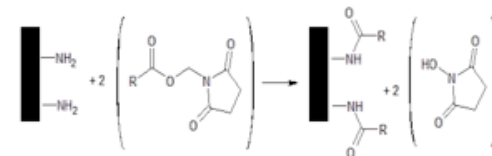
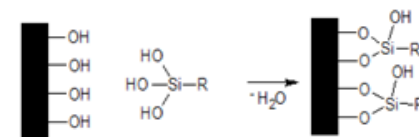
Functionalisation

Deposition

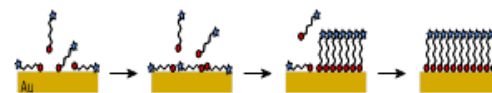


Plasma modification

Chemical modification



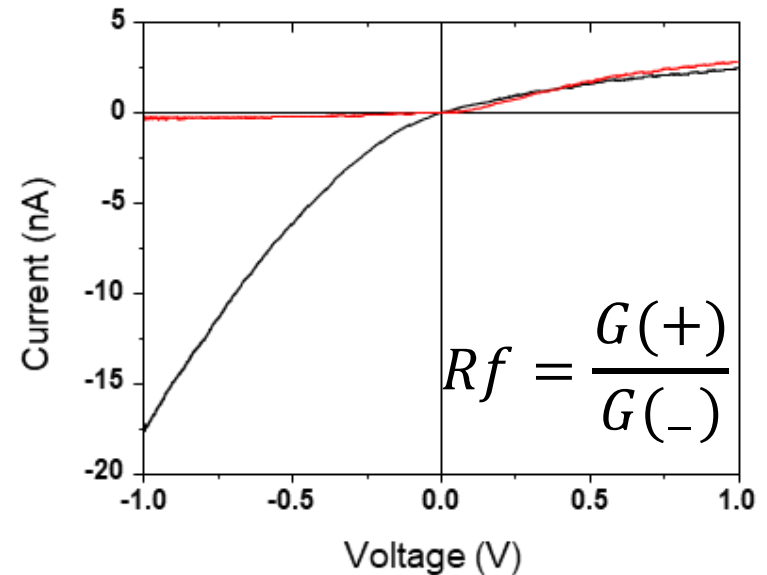
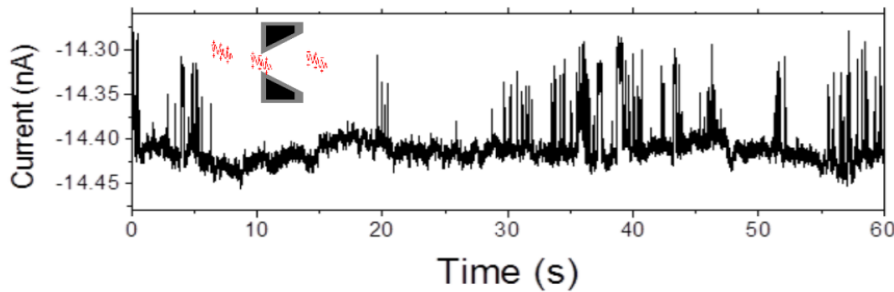
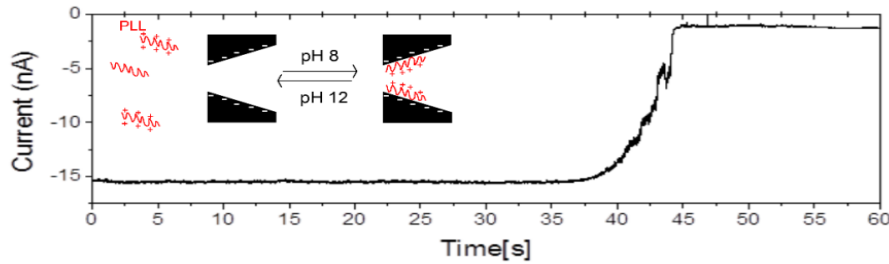
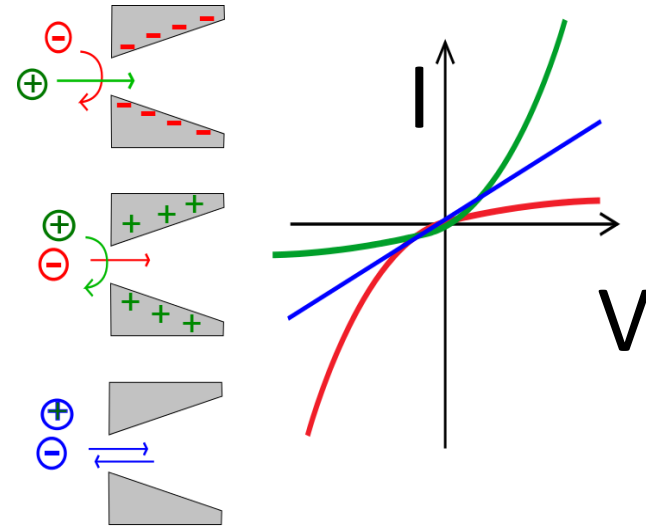
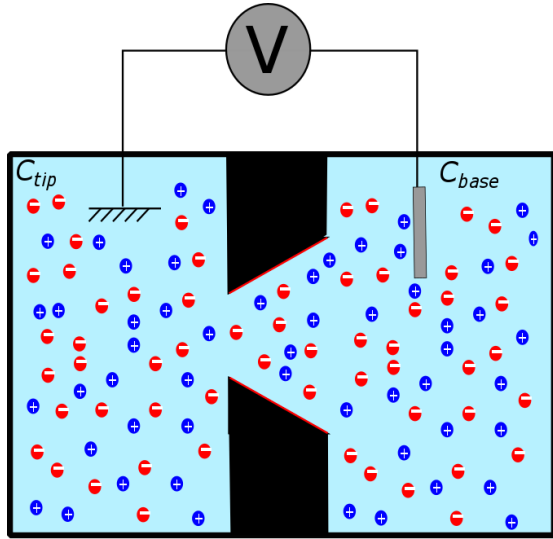
Self-assembled layer(s)



Ionic diode

Using Polyelectrolyte adsorption to modify the ionic transport

RSC Advances, **6**, 32228, (2016)

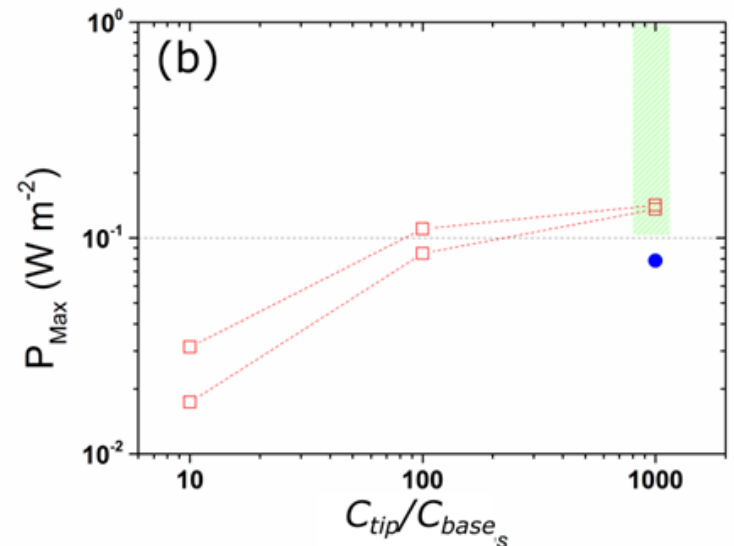
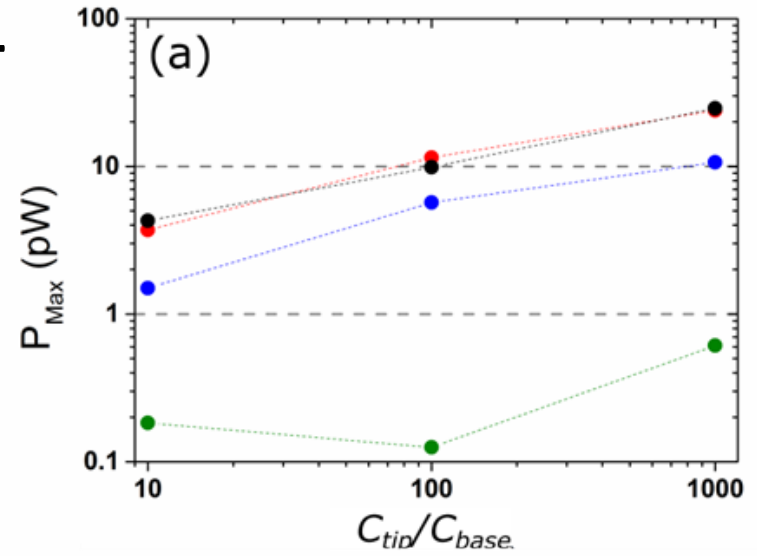
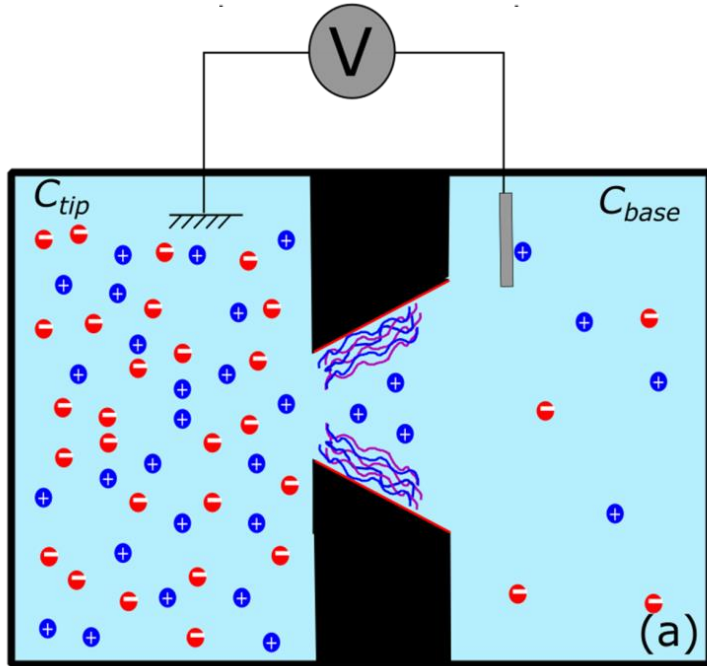
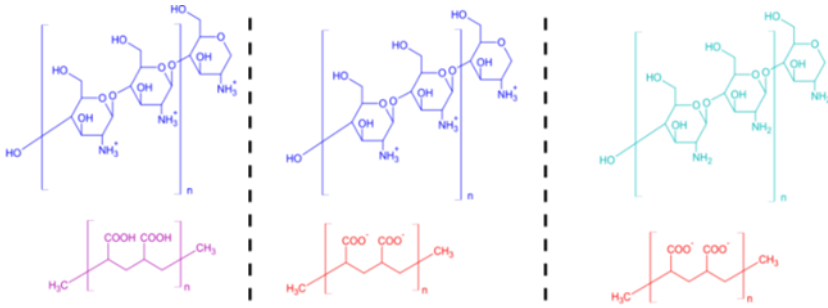


Ionic diode

Mimic ionic channel for osmotic energy

J Membrane science, **544**, 18-24 (2017)

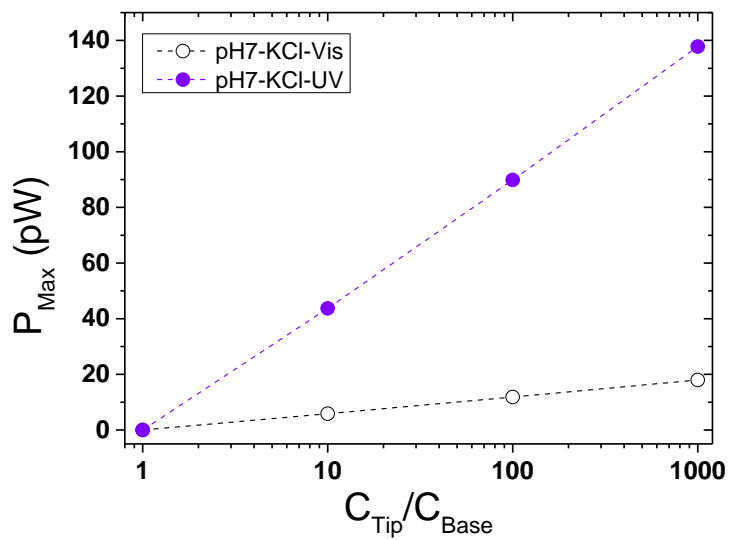
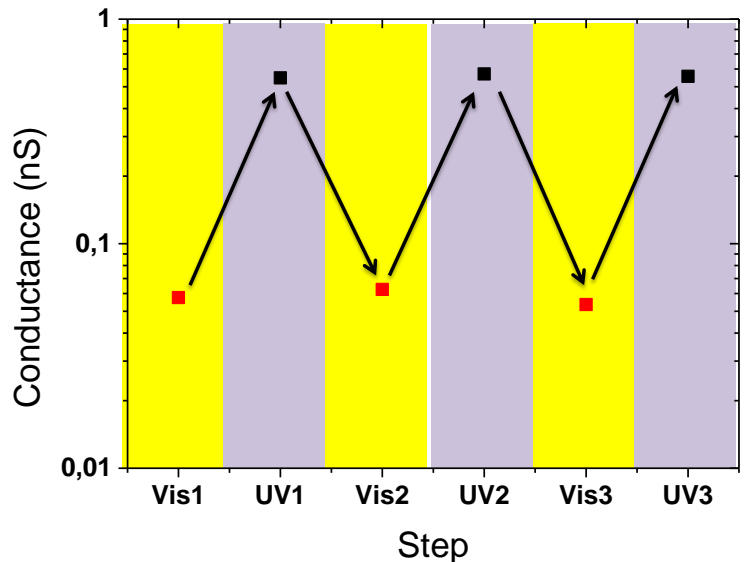
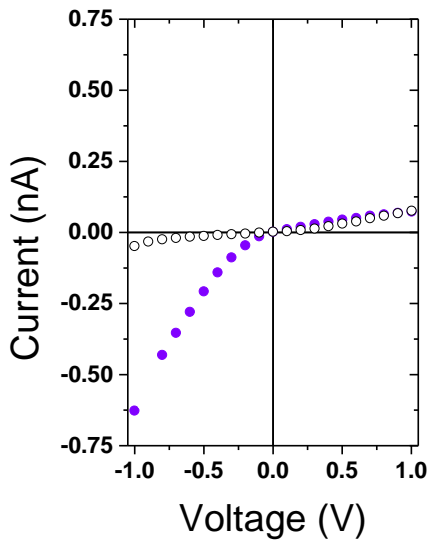
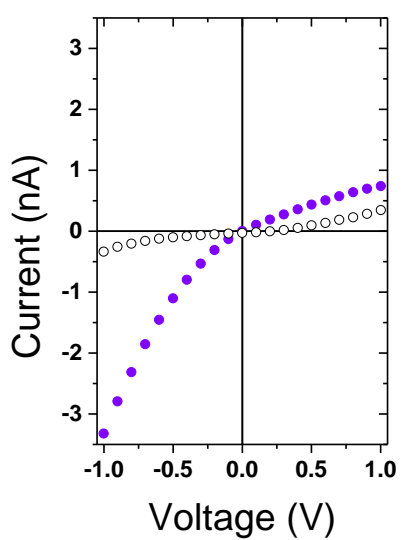
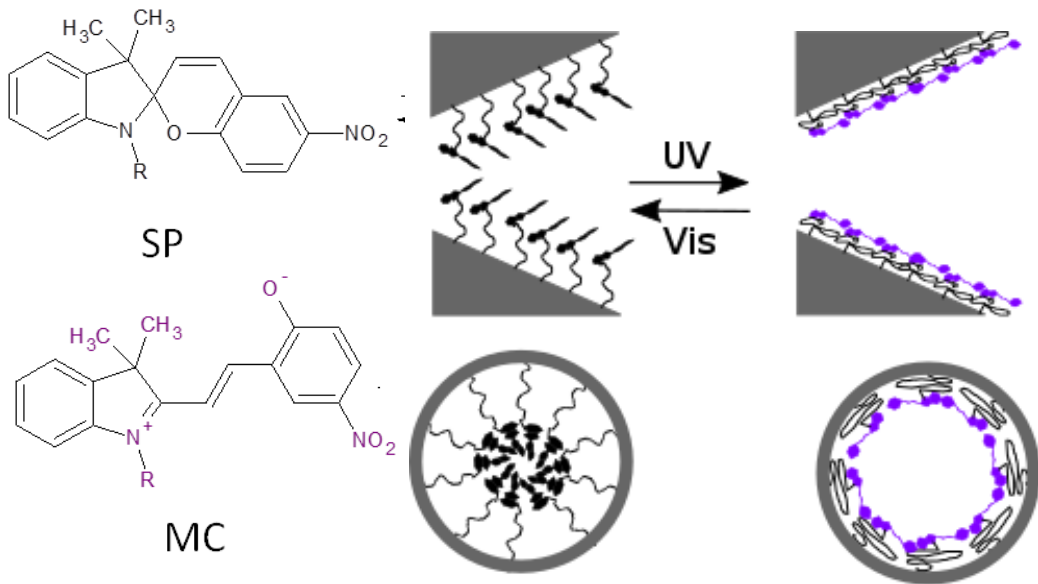
$$I_{osm} \approx \frac{2\pi R\sigma k_B T}{L \eta \lambda_B} \log(C_s) \quad \text{Chitosan/PAA LbL}$$



Stimuli-response nanopore

Light-gated using Spiropyrane-PEG self-assembly

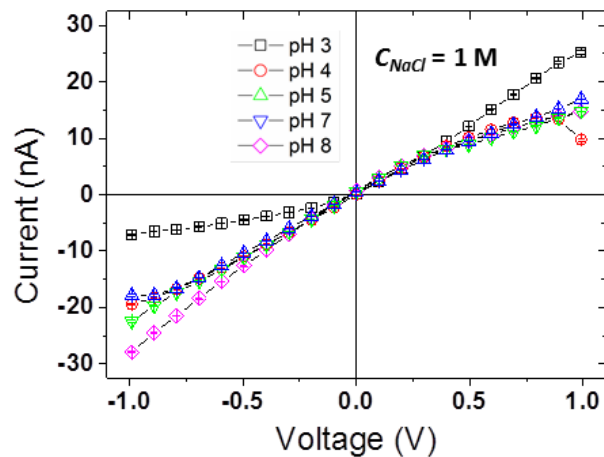
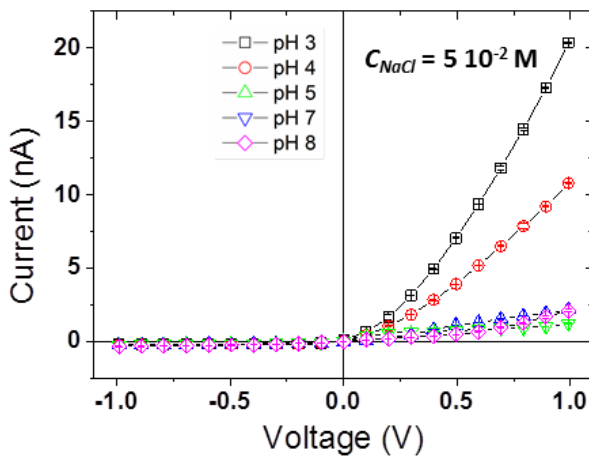
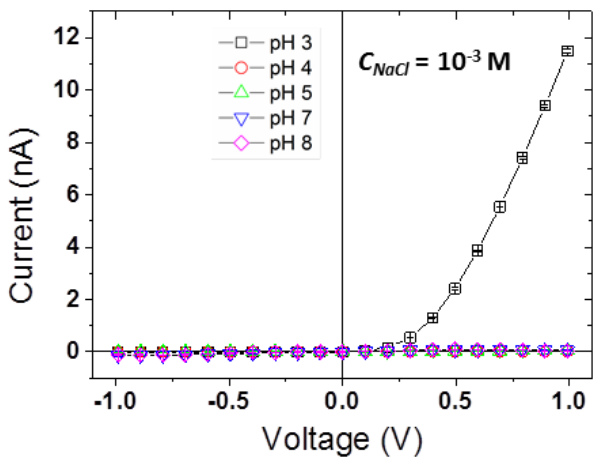
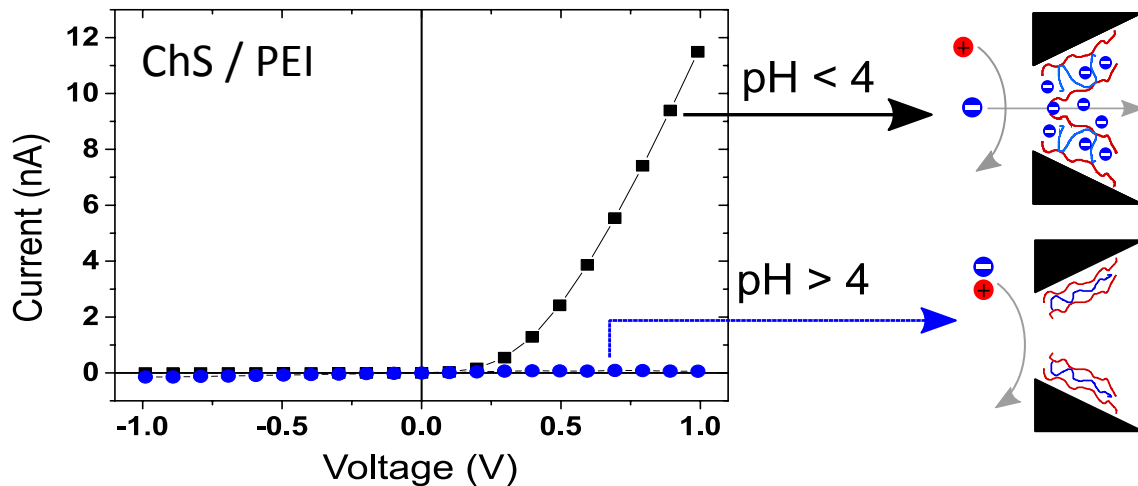
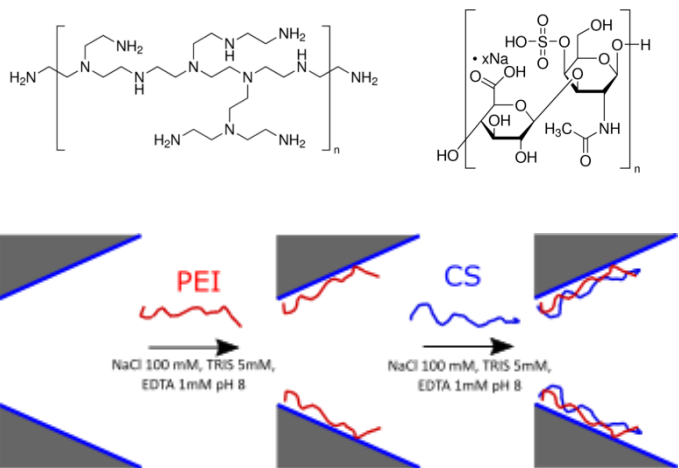
Advanced material interfaces in press(2017)



Stimuli-response nanopore

pH gated regulated by ionic strength

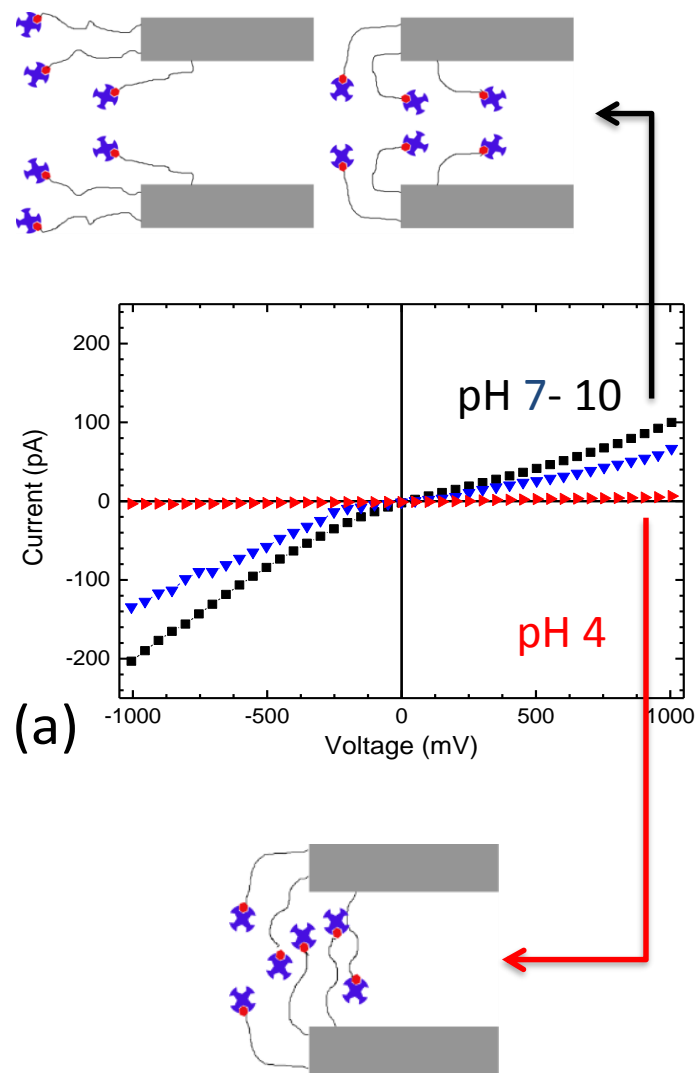
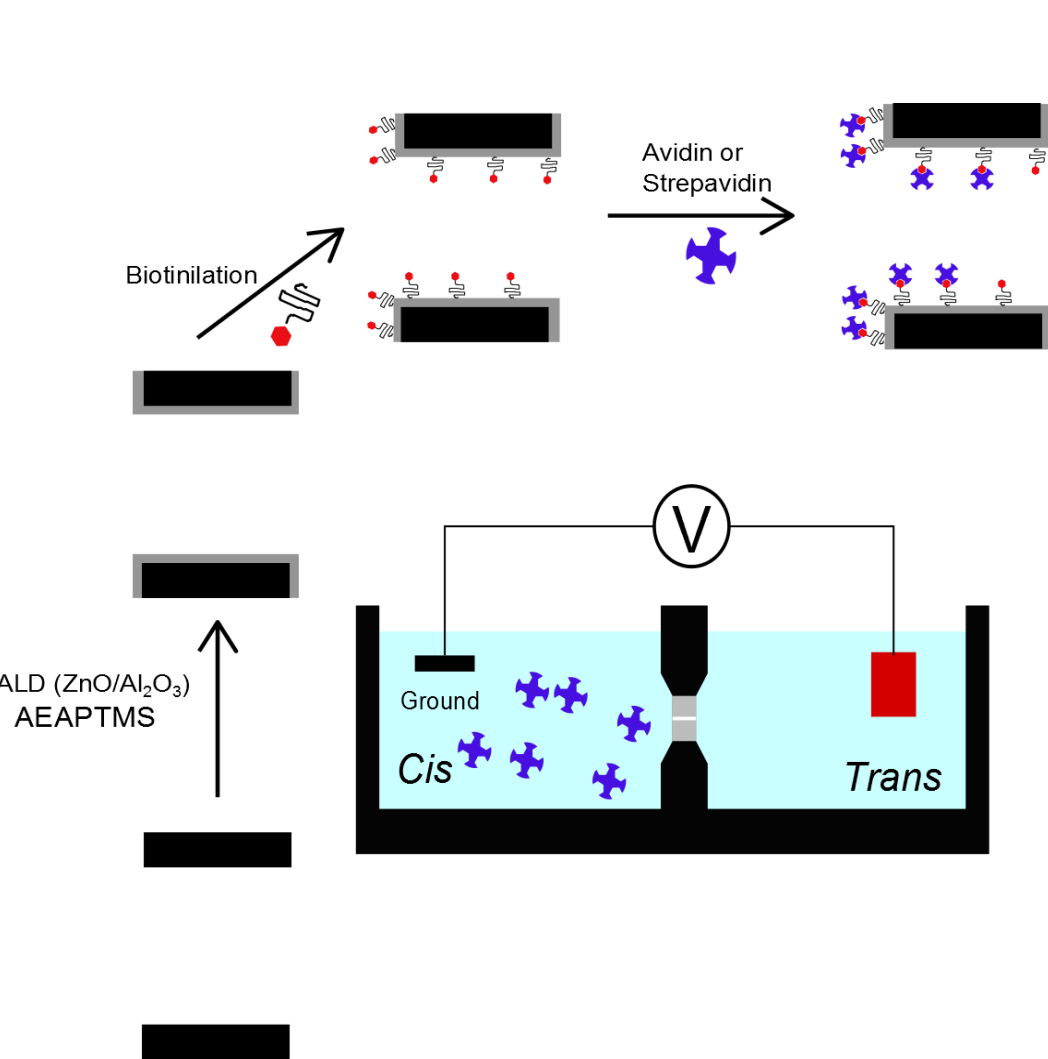
Langmuir, 2017, 33 (14), pp 3484–3490



Stimuli-response nanopore

pH gate by PEG/protein precipitation

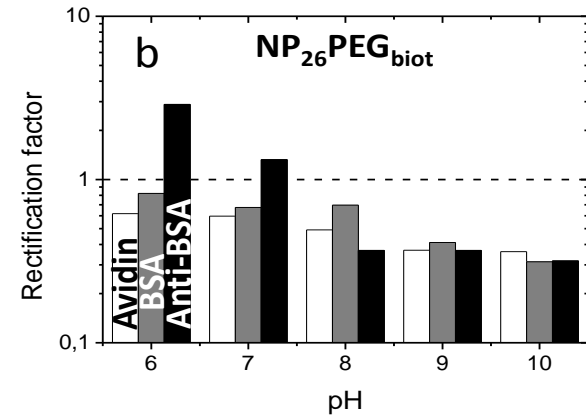
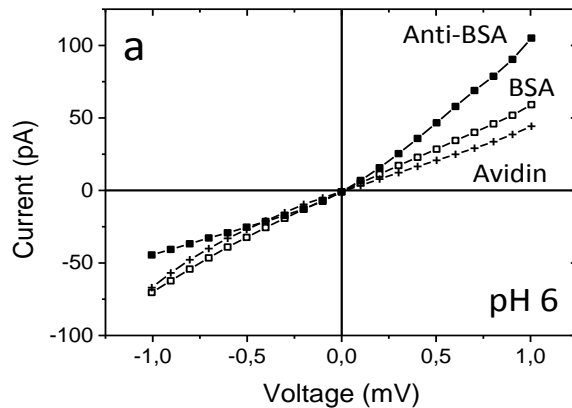
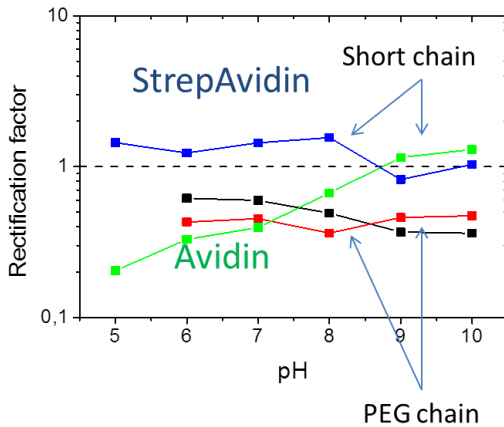
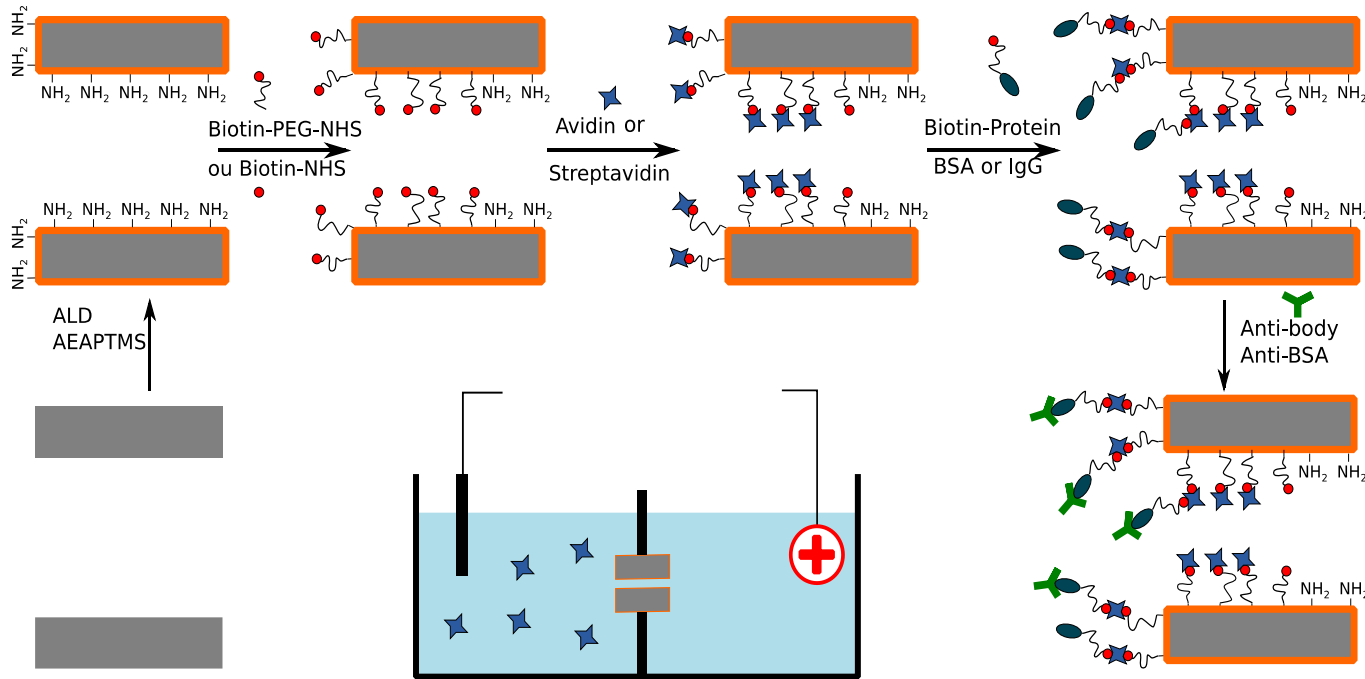
Chemical Communications **51**, 5994-5997 (2015)



Ligand-responsive nanopore

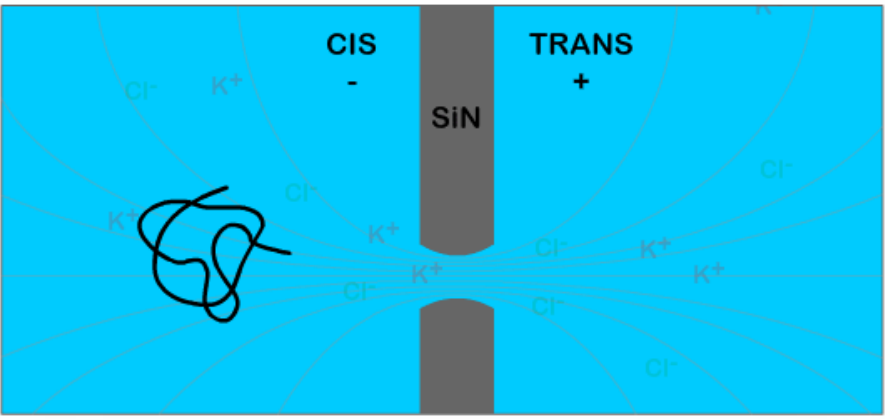
Biomacromolecules sensing

Electrochimica Acta, **211**, 611–618, (2016).

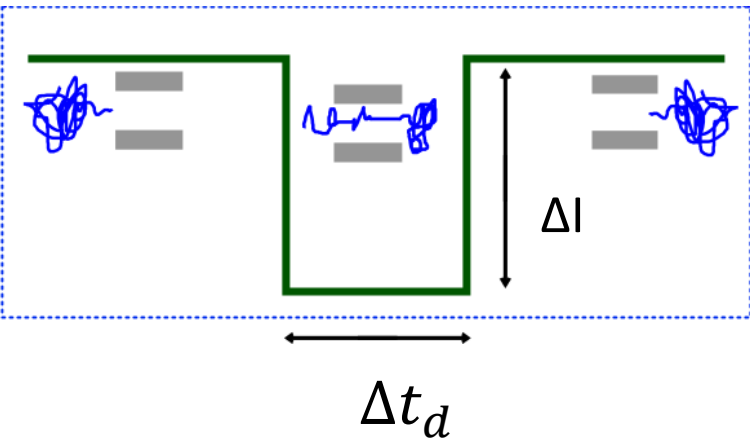
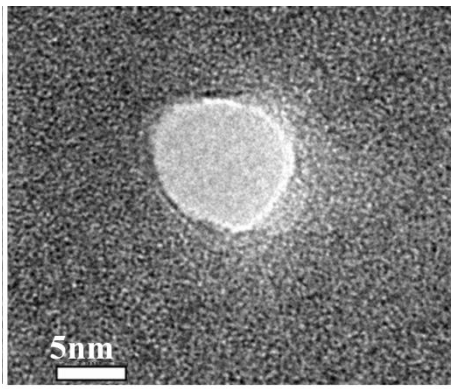
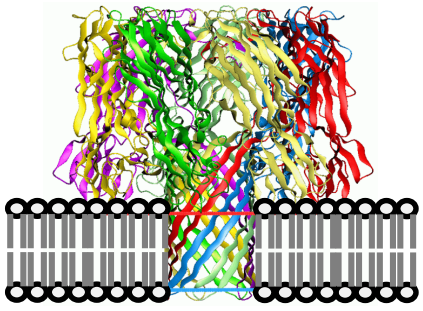


Toxin

Resistive pulse technique for single molecule analysis



- Single molecule sensing



	Biological	SiN	2D	Polymer
Sensitivity	High,	Low	High	Very low
Life time	Hour	Min to hours	Min to hours	weeks
Electric field	high	high	Very high	low
Dwell time	short	short	Very short	long
Noise	Low	High	High	low

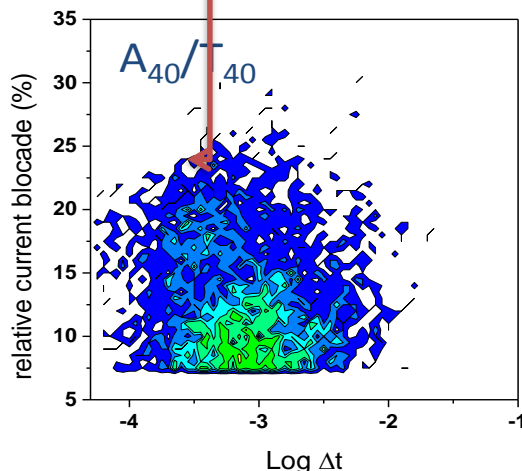
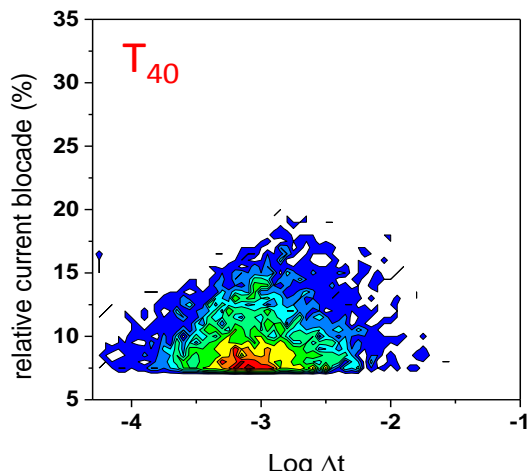
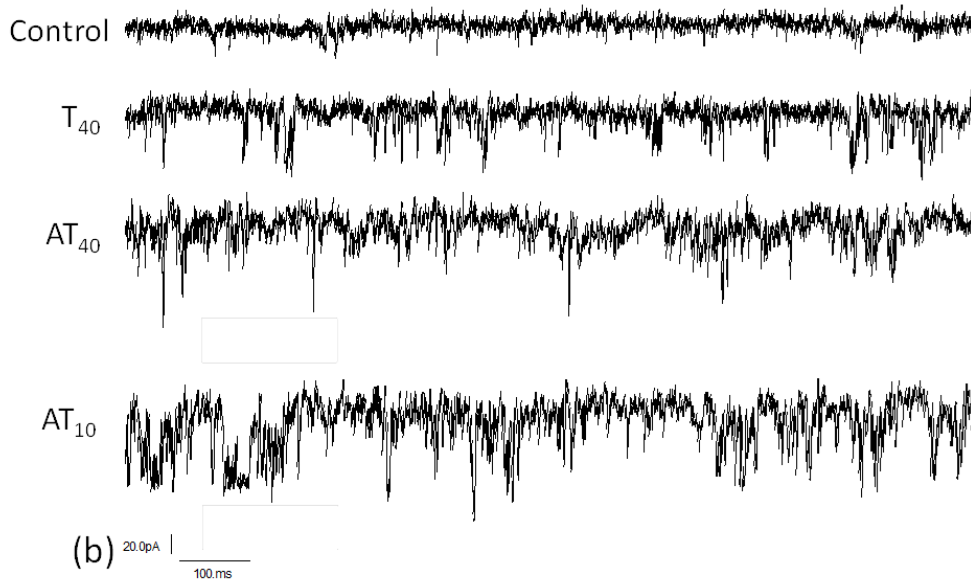
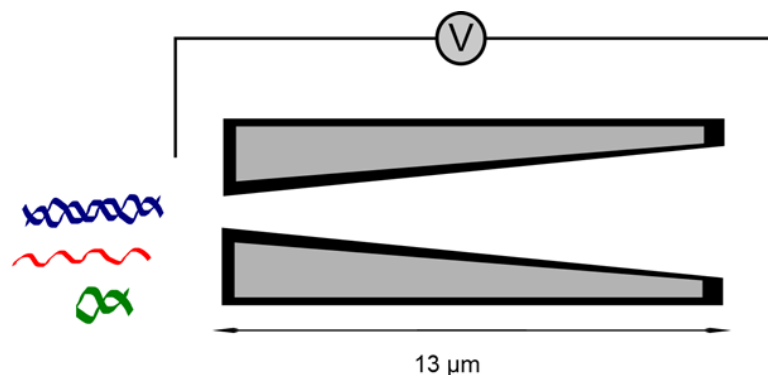
Toxin

Slow DNA translocation

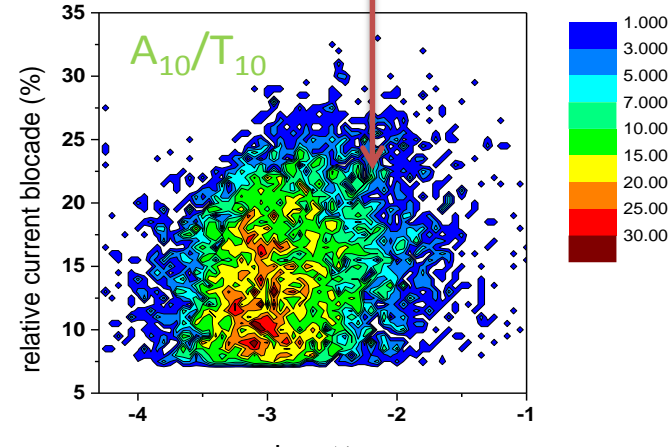
Microchimica Acta, 183, 1011-1017 (2016)

a **long pore length** to decrease the electrostatic field : high aspect ratio tip
diameter $\sim 2\text{nm}$

Al_2O_3 coating to reduce the noise



dsDNA

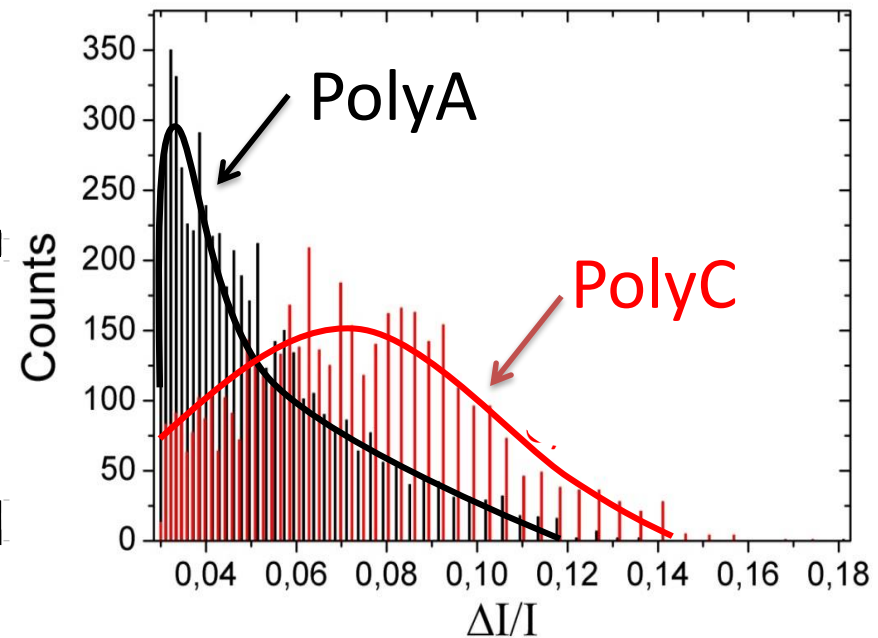
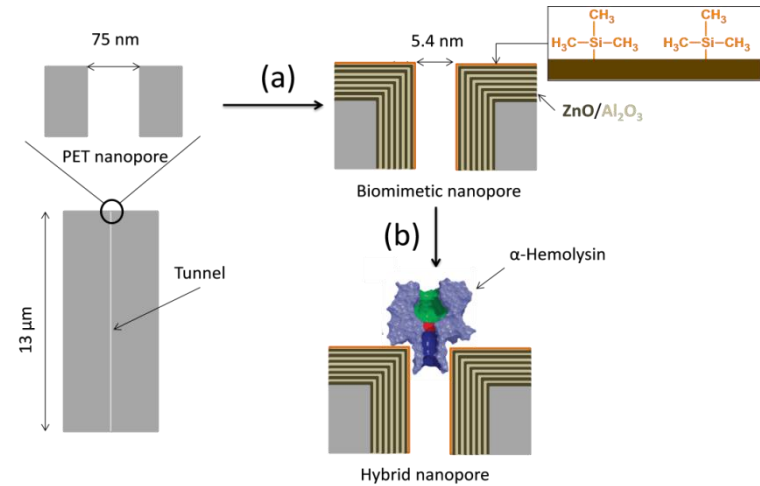


Toxin

Hybrid biological/polymer nanopore

Nanoscale 5, 9582-9586 (2013),

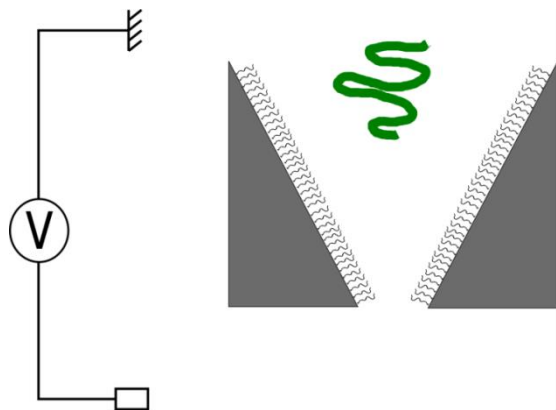
- a **diameter** close to the hydrophobic part of the protein (4 nm),
- **surface functions** which permit to mimic phospholipid chain / α -hemolysin barrel interactions



Toxin

Amyloid fibril detection

Work in progress

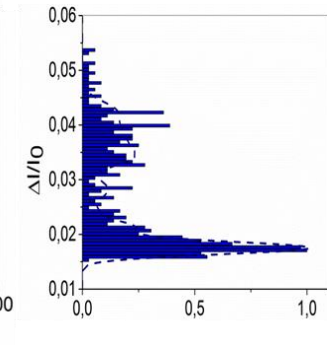
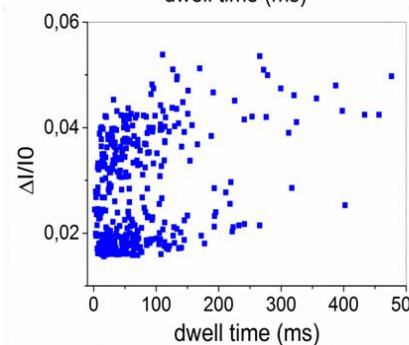
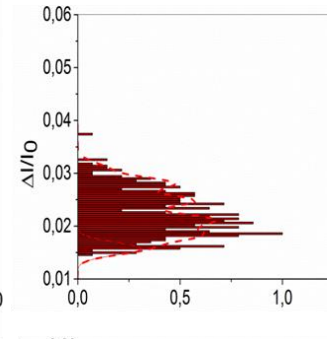
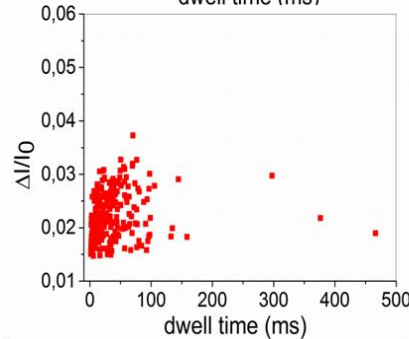
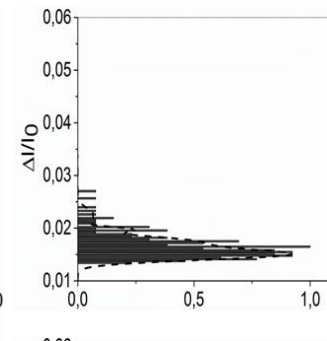
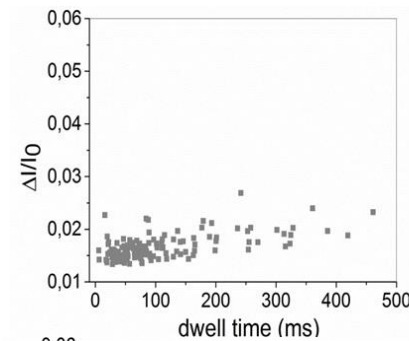
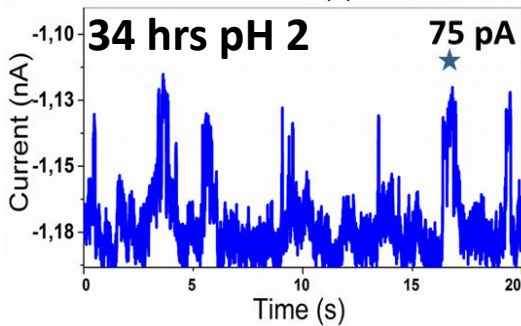
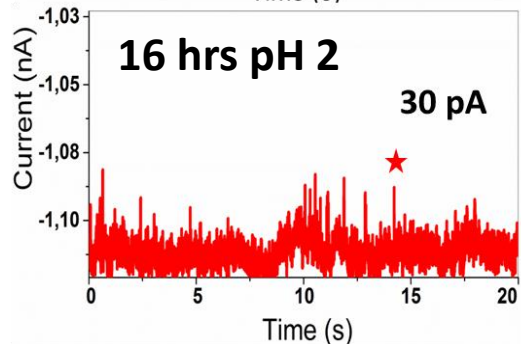
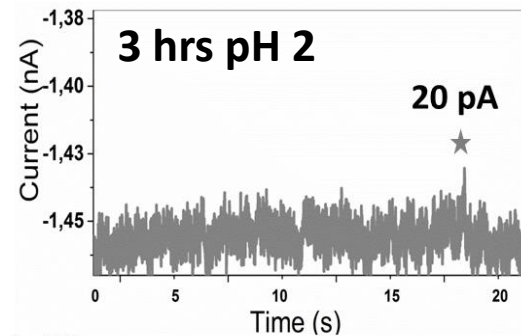


Fibril detection

- Correlation size/signal
- Stability 2 month
- Acidic solution

In situ detection

- Degradation
- Maturation
- inhibitor/promotor effect



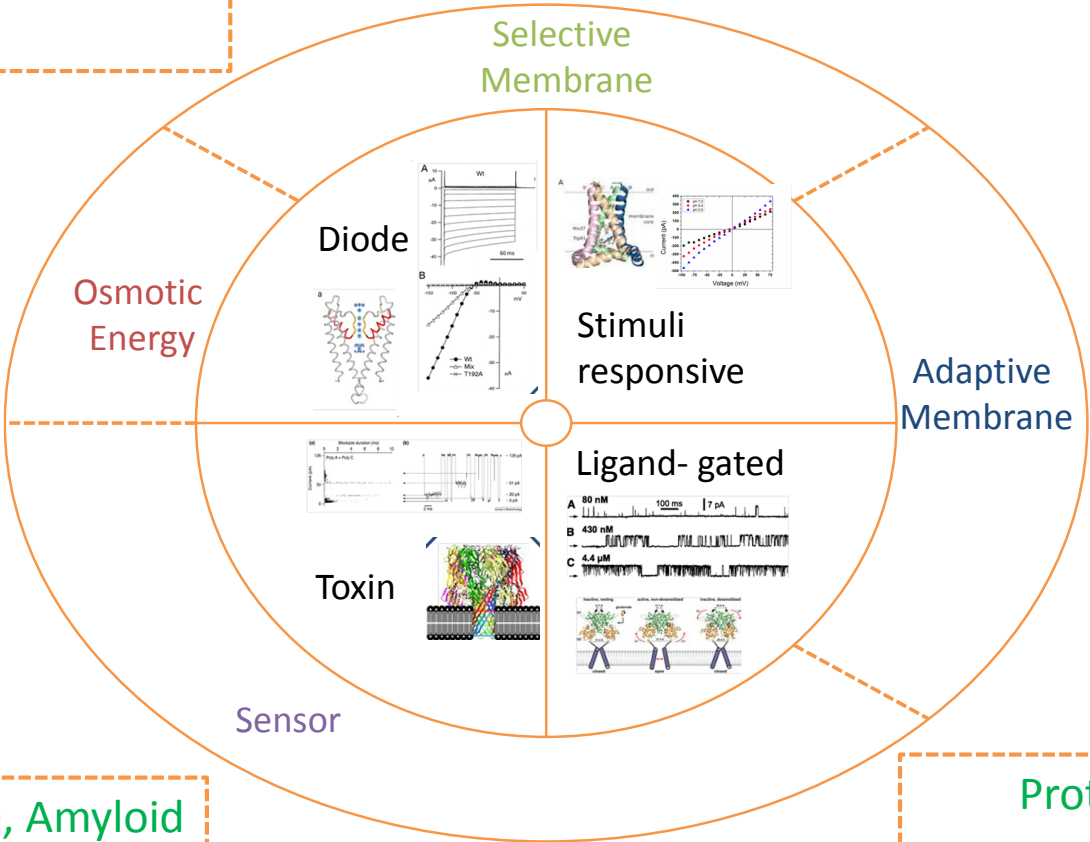
Conclusion

Inspired by the nature to design synthetic membrane

Membrane for osmotic process
Energy production
Logic gate

Cation/Anion
Biomolecule

Ph-gated
Light
Voltage
Temperature
Solvent



Protein, aggregate, Amyloid
DNA
Nanoparticle

Protein, antibody
Heavy ion
DNA mismatch/quadplex
Specific sequence etc..

Acknowledgments

The bio-inspired interface team

JM. Janot , T. Thami, S. Balme (team leader)

Current members

D. Coglitore, N. Giambianco, T. Ma,,

Previous members

Postdoc : G. Nguyen, V. Tangaraj

PhD Students : M. Lepoitevin, S.Cabello-Aguilar,

Students: P. Gailalas, Y. Zhao, B. Jamilloux,

Collaborations

Montpellier

M. Bechelany, P Miele, (IEM) M. Smietana, JC Vasseur (IBMM)

France

E. Balanzat (Caen GANIL), Fabien Picaud, (Besançon Nanomedecine lab)

International

A. Kocer (university of Groningen), V. Smietina (Mechnikov University Odessa), S. Subramanian (Chennai Anna University)



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Européen des
Membranes

