



SIMEV CHAIRE UNESCO
Science des membranes appliquée à l'environnement



Sustainable nanotechnology for water : what about membrane developments ?

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United Nations
Educational, Scientific and
Cultural Organization

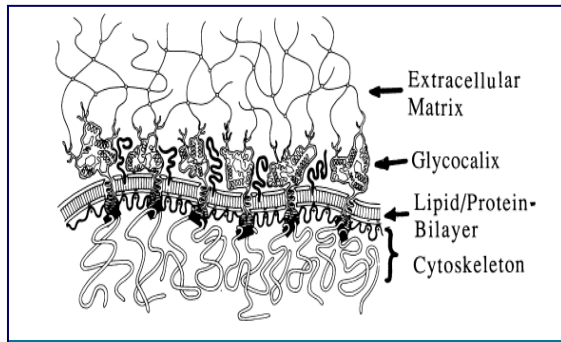
International
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<http://www.simev.org>



Membranes... a long standing model

- The model....



On the schema the two top layers are enlarged in thickness by a factor of about 300 compared to cytoskeleton

- **In nature , a strategy entirely based on the use of nano-scale devices** to take benefit from large specific surfaces , high powerful function and to compensate for slow kinetic rates at ambient temperatures...

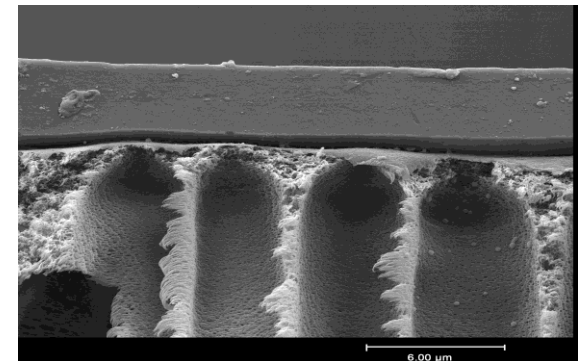
- **The same trend today with artificial systems ... by biomimicry...**

"..enabling the separation of living entities from the lifeless and hostile environment under preservation of selective material exchange between the two worlds ..."

*E. Sackmann in Handbook of biological physics
"Biological membranes . Architecture and function" -
Elsevier 1995*

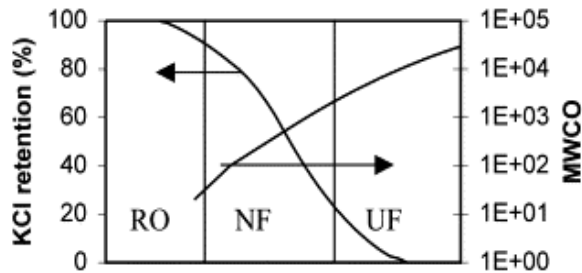
- The copy...

*PVDF support
& polymeric top layer*



In the field of water ... the emergence of different processes

- Nanofiltration / Removal from water of nanoscale uncharged molecules - size exclusion (UF), differences in diffusion rates (RO) - and ions (mainly multivalent) - electric charge effect - .



⇒ Applications to drinking water - softening (hardness), NOM separation, micro-pollutants, fluoride,... - and sanitation (MBR)...

- Mixed-matrix membranes / New materials

*Quantum flux membranes for desalination
Cross-linked matrix of polymers and nanoscale engineered particles*

⇒ flux improved without loss of selectivity

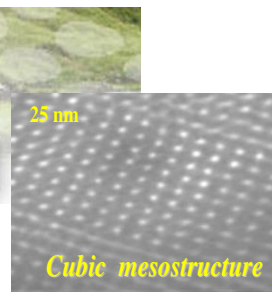
⇒ energy saved for desalination

NanoH₂O

Microporous Material



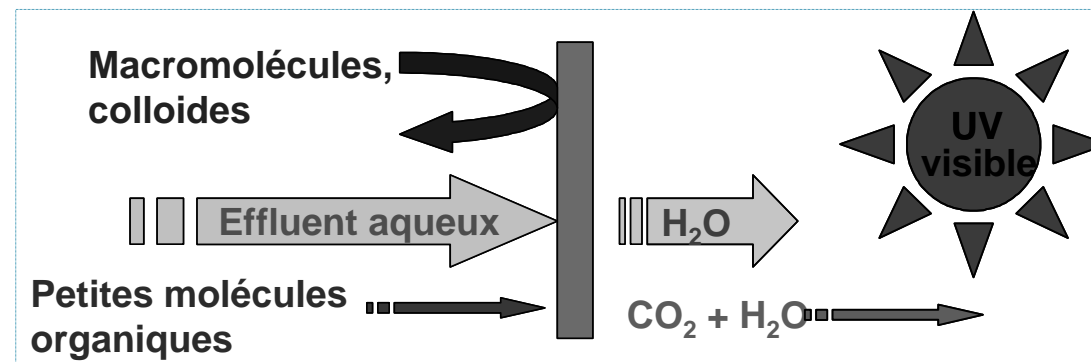
Polymeric Matrix



Ordered mesoporous TiO₂ membrane for coupled separation and photodegradation

- Photo-catalysis / New concepts

- ⇒ Great potential as a low-cost, environmental friendly and sustainable treatment technology to align with the “zero” waste scheme in the water/wastewater industry.
- ⇒ Ability of advanced oxidation technology : to remove persistent organic products (POPs) and microorganisms in water (even it sometimes it can generate other kind of pollutants...).
- ⇒ Different kind of materials and / reactors



*The need for a pragmatic and nuanced approach of issues ...
based on scientific grounds and not simply on dogma...*

About the risks of using nanomaterials

- For membranes an interesting study to avoid demonizing the concept of “nano”
(Journal of Hazardous Materials 211– 212 (2012) 275– 280 : ECJRC Ispra , Swiss lab St Gallen...)

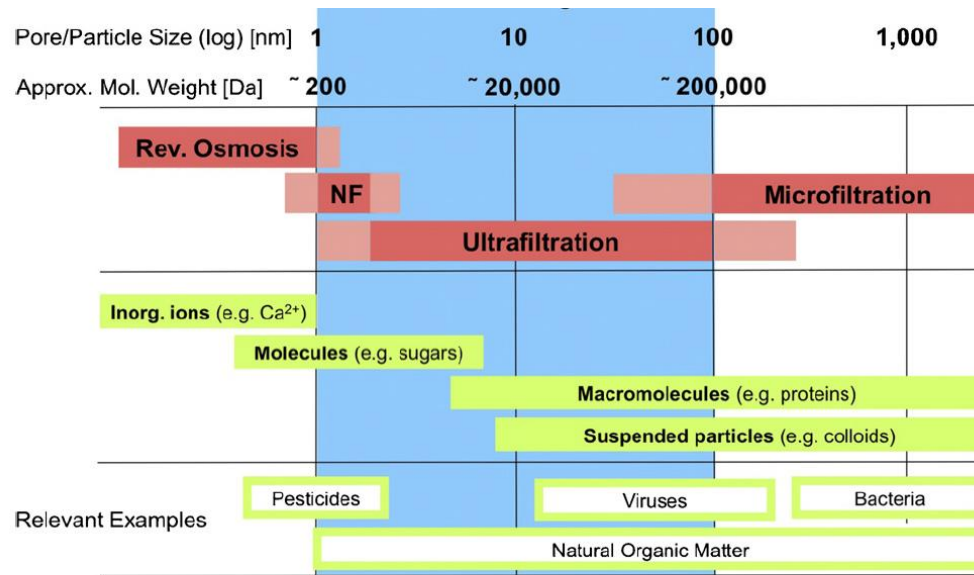


Fig. 3. Comparison of the filtration range of the four filtration methods: reverse osmosis (RO), nanofiltration (NF), ultrafiltration (UF) and microfiltration (MF) with respect to the “nanoscale” as defined by the ISO. Some relevant examples illustrate possible application areas.



Decision tree for authorities
Supporting tool for the risk estimation of membranes

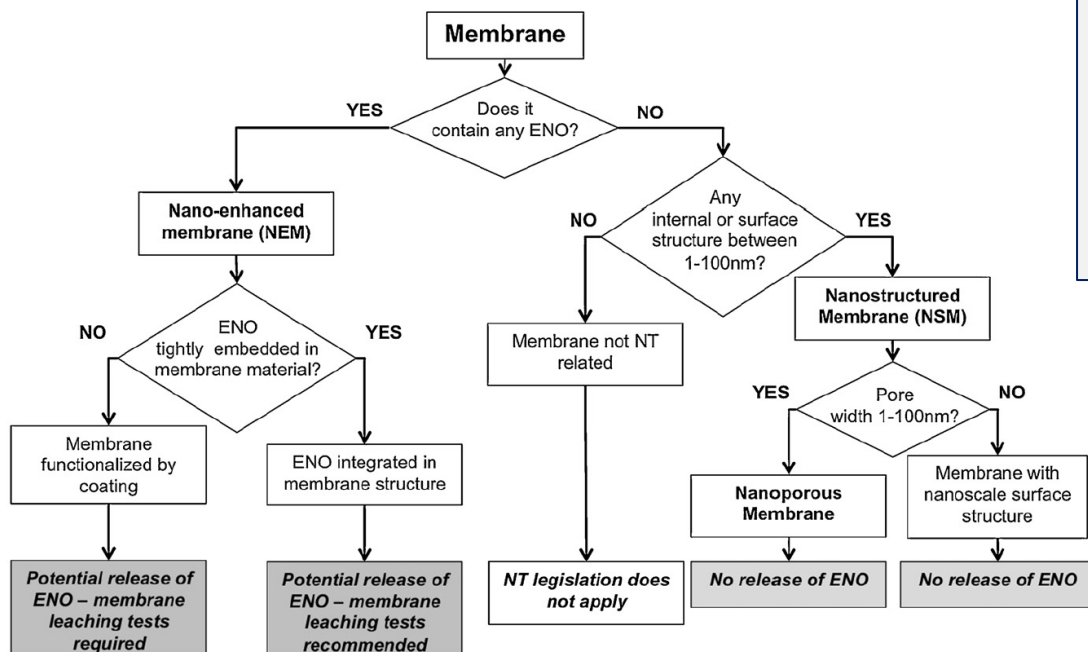


Fig. 4. Decision tree for the risk estimation of nanoparticle release by membranes. ENO, engineered nano-objects; NT, nanotechnology.

Materials where the nanoscale structure does not result from discrete particles and/or where there is no risk for the release of nano-objects should thus not be considered as nanomaterials from a regulatory point of view. Definitions of nanomaterials must reflect this basic difference to be pertinent for any new nanotechnology legislation.



Nano-enhanced membranes (NEM) vs Nano-structured membranes (NSM)



NEM : functionalized with discrete nanoparticles NSM : nano internal structure (pores)
The technology readiness level and the risk associated differ significantly => Industry



To conclude ...

- 1) Is it possible and interesting to use membranes designed at nano-scale to treat water ?

Undoubtedly YES

- 2) What risks with the use of nano-designed membranes as regards the potential leakage of nano toxic objects from reactor/treatment zone ?

From a regulatory point of view

risks are existing with NEM (functionalized with discrete nanoparticles)

but not with NSM (nano internal structure in pores)



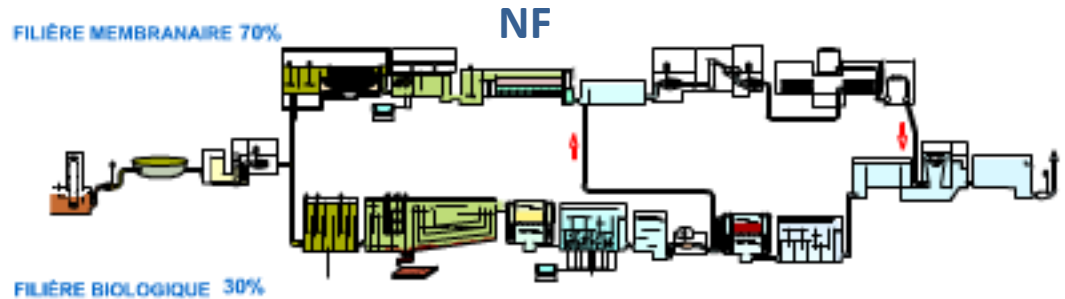


- 3) What achievements with the use of nano-materials for water purification ?

Problems with regulations ?

- ✓ Méry-sur-Oise (VEOLIA) : a plant to provide daily 158,000 m³ of water per 800 000 inhabitants in northern Paris suburbs. Production capacity increased to 340,000 m³ per day to meet the growing needs of a highly urbanized area. Quality objectives related to the new standards (Code of Public Health) entirely fulfilled.

No



- ✓ NanoH₂O Inc. purchased by Seoul-based Korean Chemical giant LG Chem Ltd. for \$200 million in March 2014 . The Southern California startup, established in 2005 from research that stemmed from the University of California at Los Angeles, makes water potable from fresh, brackish and saltwater sources in better working conditions (footprint, energy...).

No

- ✓ For the future : aquaporins (proteins / Aquaporin DK), CNTs (particles) , graphene (monolayer) ...

No

???

No ?





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Thank you for your attention



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