INSTITUT EUROPÉEN DES MEMBRANES

Unité Mixte de Recherche N°5635
CNRS - ENSCM - UM II

Comportement d'une membrane d'U.F. lors de la filtration de solutions salines ou polluées en fonction de différents facteurs

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ULTRAFILTRATION MEMBRANES

FILTRATION

purification,
clarification,
concentration,
depollution,
separation, …

chemistry industries, food industries, water, engineering industries..

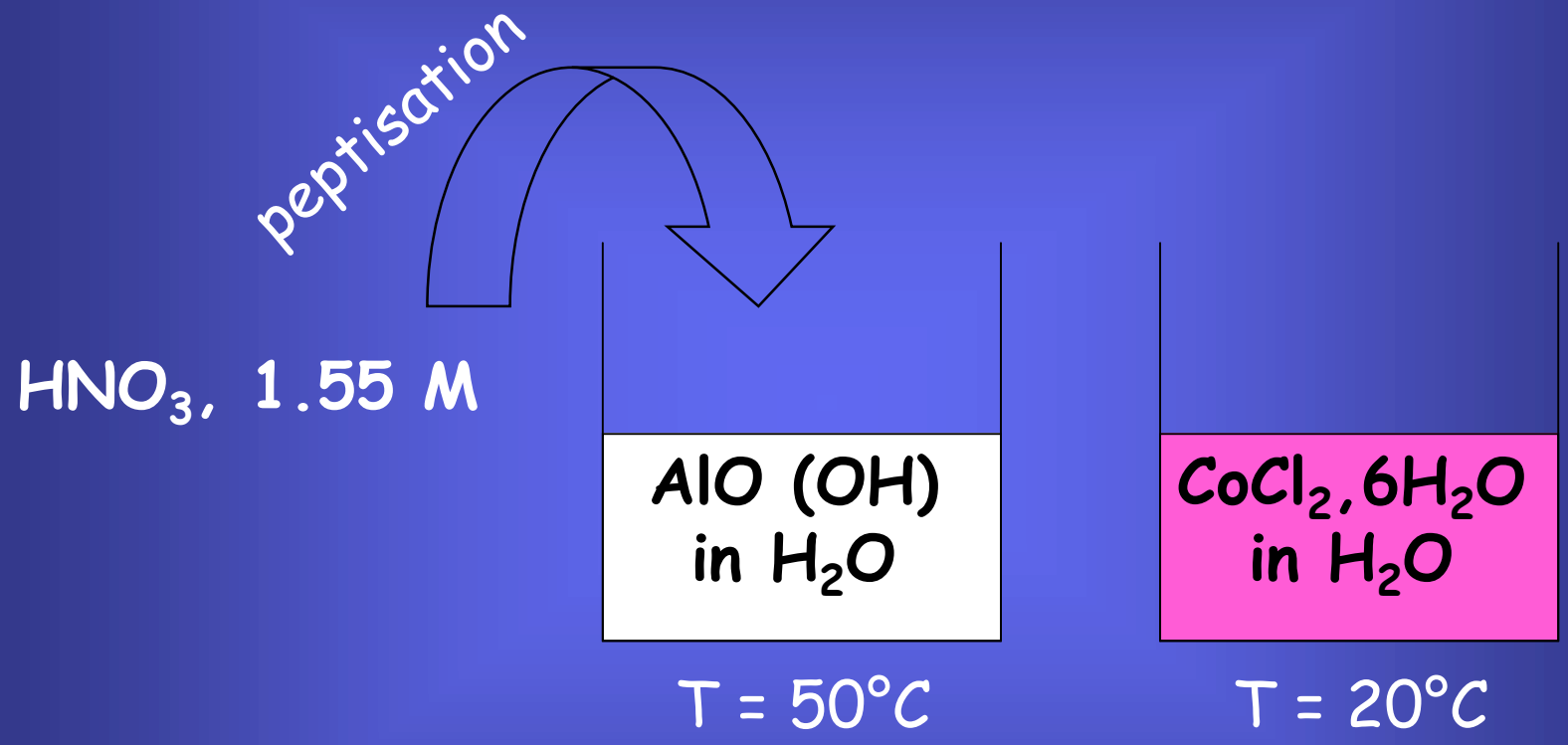
textile, paper, leather, rubber, chemistry, …

milk, fish meals, fruit juices, sugar, wine, …

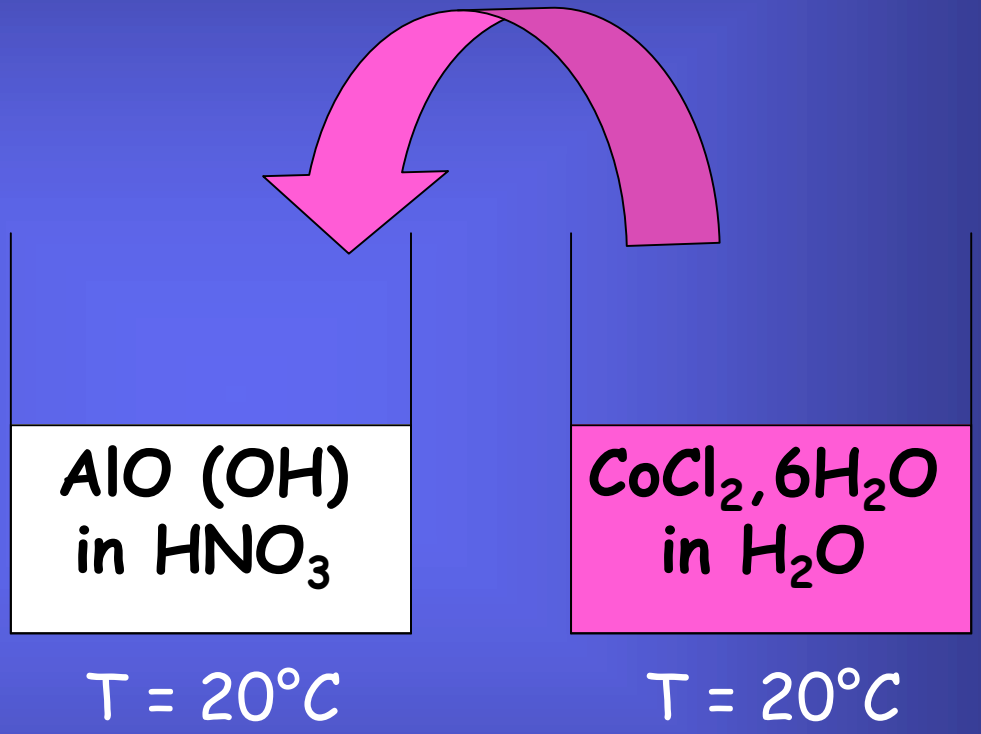
pure water by desalination, by purification of waste waters, …

recovery of oils, painting,…

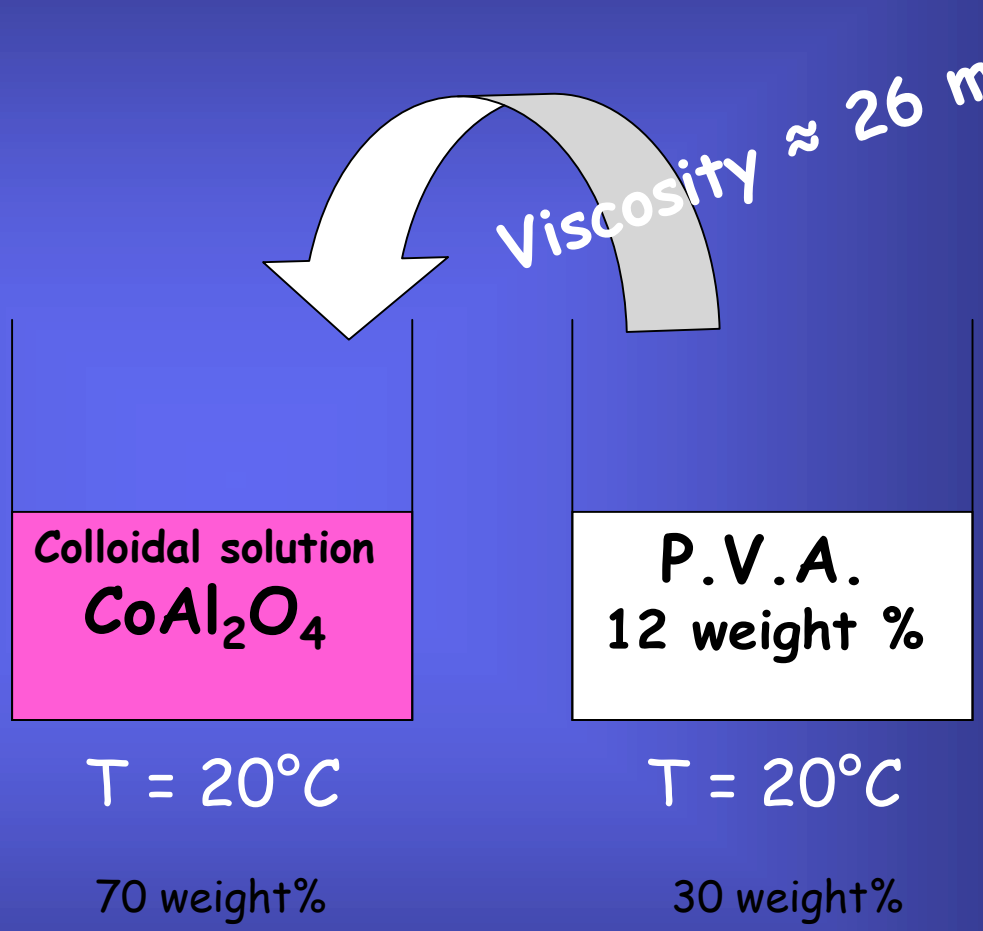
PREPARATION OF THE MEMBRANE $CoAl_2O_4$



PREPARATION OF THE MEMBRANE $CoAl_2O_4$



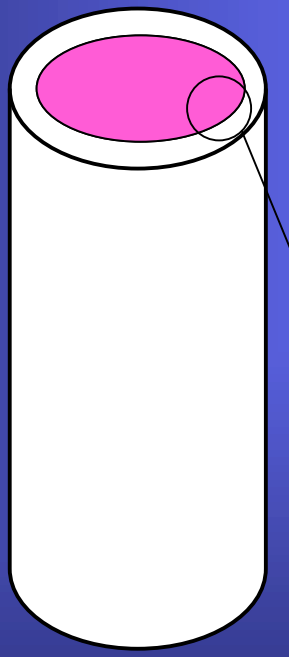
PREPARATION OF THE MEMBRANE $CoAl_2O_4$



PREPARATION OF THE MEMBRANE $CoAl_2O_4$

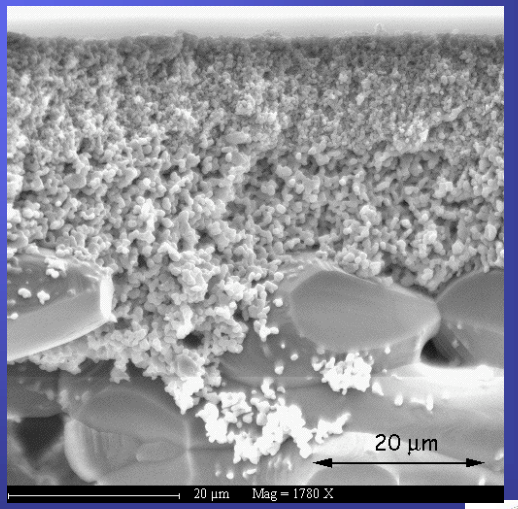
t = 30 s

T = 600°C



$CoAl_2O_4$ + P.V.A.

T = 20°C



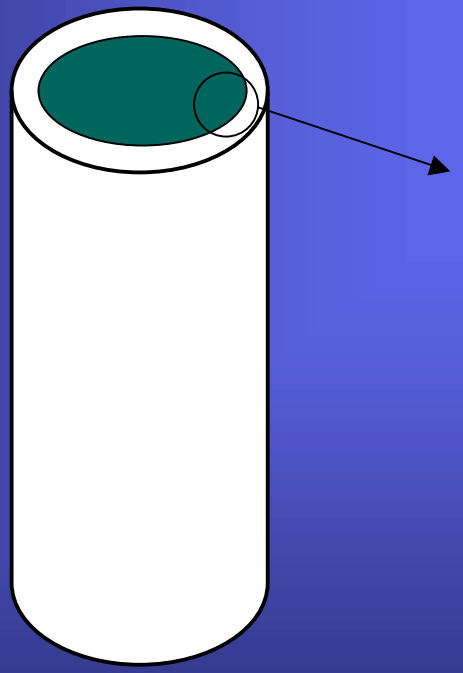
200 nm

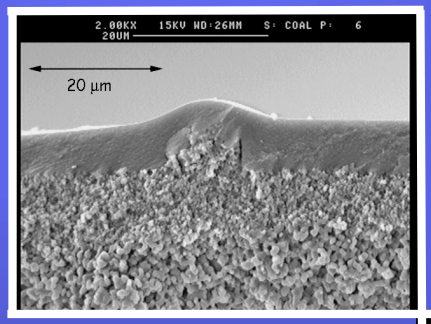
400 nm

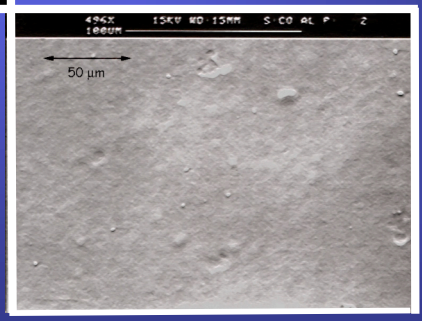
100 nm

PREPARATION OF THE MEMBRANE $CoAl_2O_4$

Active layer = 26 cm^2
Pore size = 2.4 nm
Thickness = 3.2 µm
Water permeability = 6.7 $Lm^{-2}h^{-1}bar^{-1}$
Cut off = 2300 D







SELECTIVITY OF THE MEMBRANE

PURE SALT SOLUTION

- 1:1 NaCl
- 1:2 Na_2SO_4
- 2:1 $CaCl_2$
- 2:2 $CaSO_4$

Donnan exclusion
Adsorption of ions
} *

Selectivity in function of the pH, ionic strength

FILTRATION

$I_0 = 10^{-3}$ M

OTHER SALTS OR MIXED-SALT SOLUTION

?

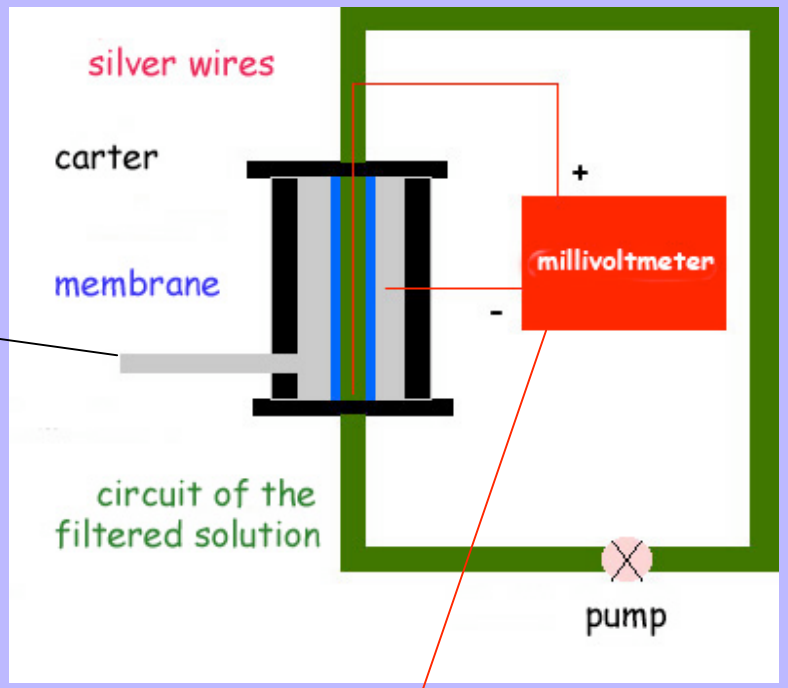
* S. Condom et al., Desalination 168 (2004) 207-213.

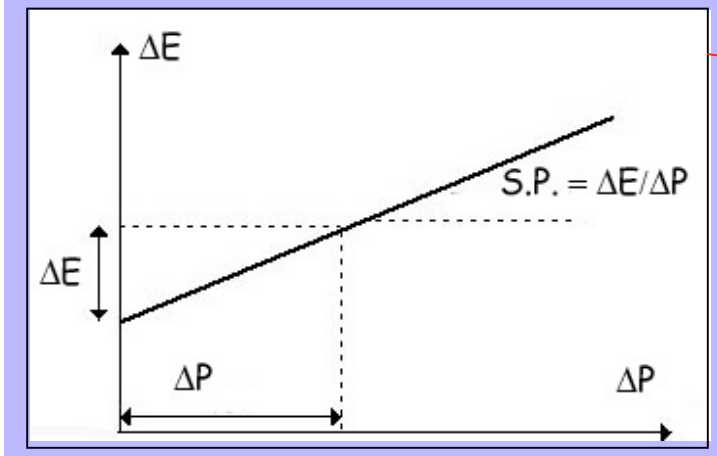
FILTRATION

chromatography

Permeate

$R.R. = (1 - C_p/C_0)\ 100\ \%$





Streaming potential

Smoluchowsky relation

$S.P. = \varepsilon\zeta / \eta\lambda$

surface charge*

* S. Condom et al., Sep. Pur. Technol. 25 (2001) 545-548.
* S. Condom et al., Desalination 149 (2002) 447-451

Global surface charge and Donnan effect explain the rejection rate in case of pure salt solutions.

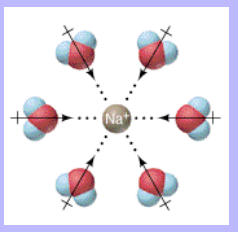
Sign of the surface charge	pH	Salt solution	Retention rate
+	low I.E.P. high	$nC^{+}\ A^{n-}$ (Na_2SO_4)	low minimum high
-			
+	low I.E.P. high	$C^{n+}\ nA^{-}$ ($CaCl_2$)	high minimum low
-			
+	low I.E.P. high	$nC^{+}\ nA^{-}$ (NaCl, $CaSO_4$)	? minimum ?
-			

$2(M\text{-}O^{-}) + C^{2+} \longleftrightarrow [C\text{-}MO]^{+}$

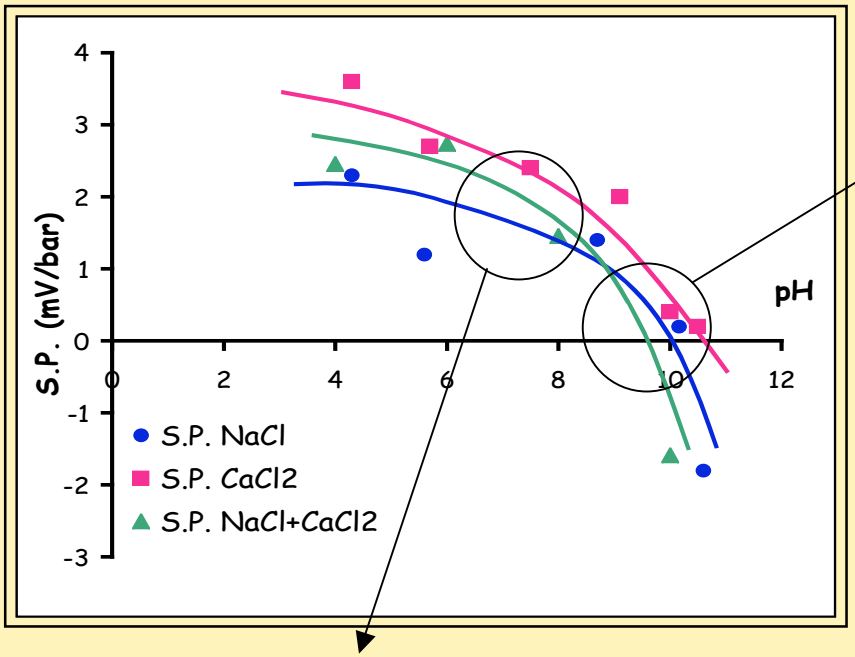
$2\ (M\text{-}OH_2^{+}) + A^{2-} \longleftrightarrow [(M\text{-}OH_2^{+})_2A^{2-}]$

Adsorption

Hydratation



FILTRATION OF A MIXTURE NaCl (10^{-3}M) + $CaCl_2$ (10^{-3}M) *



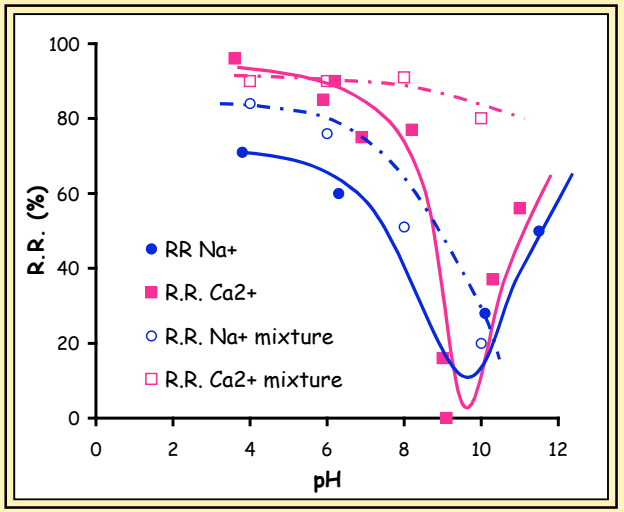
Identical values for the I.E.P..

$Ca^{2+} + MO^- \Leftrightarrow [CaMO]^+$

$Ca^{2+} + MOH \Leftrightarrow [CaMO]^+ + H^+$

$Ca^{2+} + MOH_2^+ \Leftrightarrow [CaMO]^+ + 2H^+$

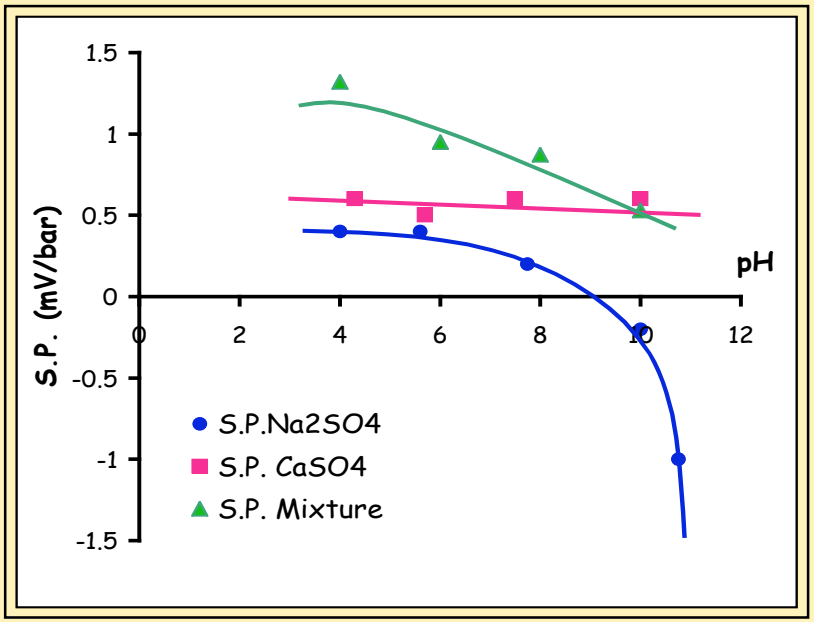
The mixture has an influence on the surface charge value.



∀ pH, in the case of common anion Cl^-, the cation R.R. is more higher in the mixture than in a pure salt solution.

* S. Condom et al., J. Membr. Sci. 300 (2007) 117-121.

FILTRATION OF A MIXTURE $Na_2SO_4(10^{-3}M)$ + $CaSO_4(10^{-3}M)$ *

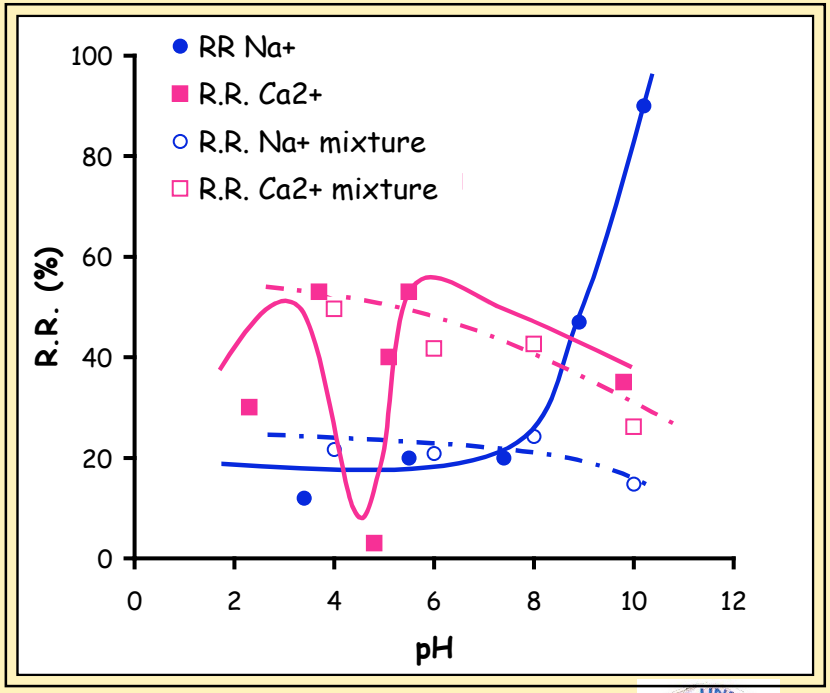


$2\ M\text{-}OH_2^+ + A^{2-} \Leftrightarrow [(M\text{-}OH_2^+)_2\ A^{2-}]$

$2\ M\text{-}OH + A^{2-} + 2\ H_2O \Leftrightarrow [(M\text{-}OH_2^+)_2\ A^{2-}] + 2\ OH^-$

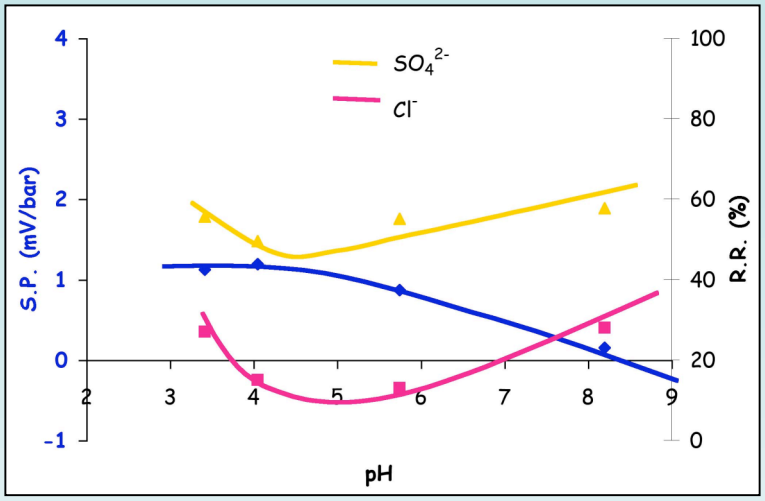
$2\ MO^- + A^{2-} + 4\ H_2O \Leftrightarrow [(M\text{-}OH_2^+)_2\ A^{2-}] + 4\ OH^-$

The R.R. variations are in agreement with the streaming potential. At high pH, le cation R.R. decrease in the mixture in comparison with pure solutions.



* S. Condom et al., J. Membr. Sci. 300 (2007) 117-121.

FILTRATION OF A MIXTURE NaCl (10^{-3} M) + Na_2SO_4 (10^{-3} M) *

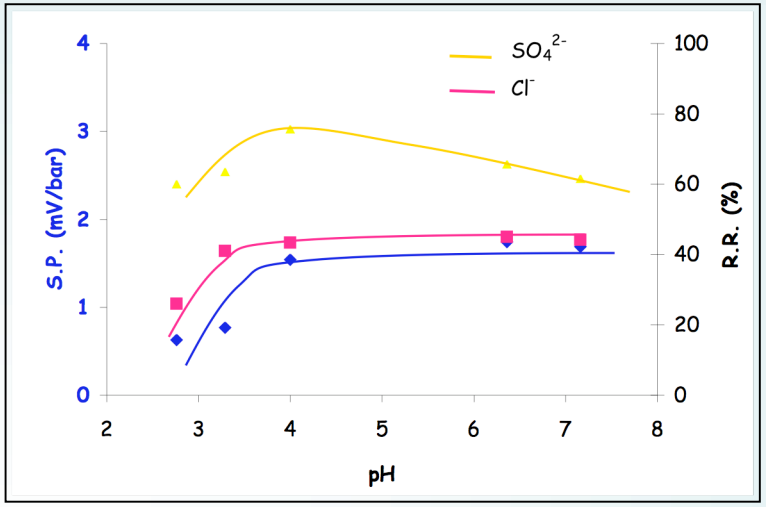


Sulfate anion adsorption.

Low value for the surface charge.

Take in account hydratation.

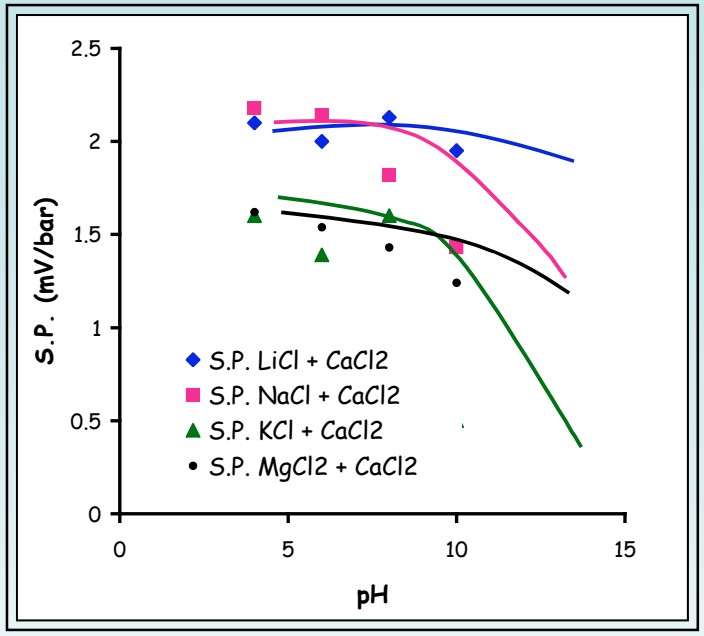
and $CaCl_2$ (10^{-3} M) + $CaSO_4$ (10^{-3} M) *

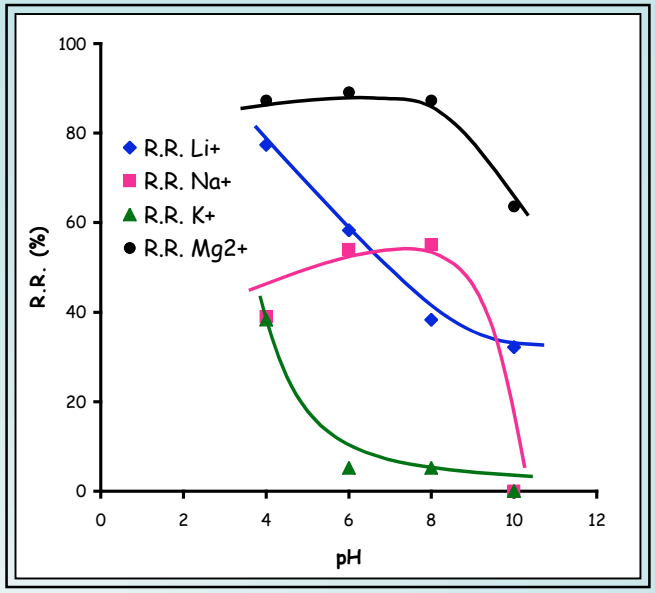


Competition between adorption of Ca^{2+} cations and SO_4^{2-} anions; stabilisation of streaming potential.

* A. Abouzaïd et al., C.R. Chimie, (2003), 431-436
* S. Condom et al., 10th I.C.I.M. (2008) Tokyo - Japan.

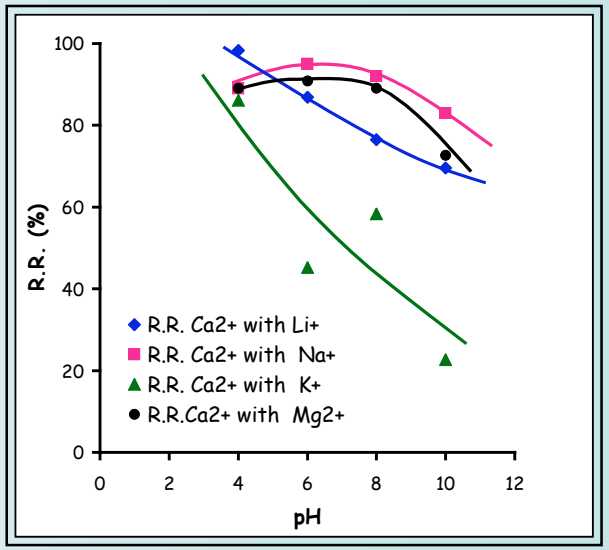
INFLUENCE OF THE CATIONS FOR MIXTURE MCl_n (10^{-3}M) +$CaCl_2$ (10^{-2}M):



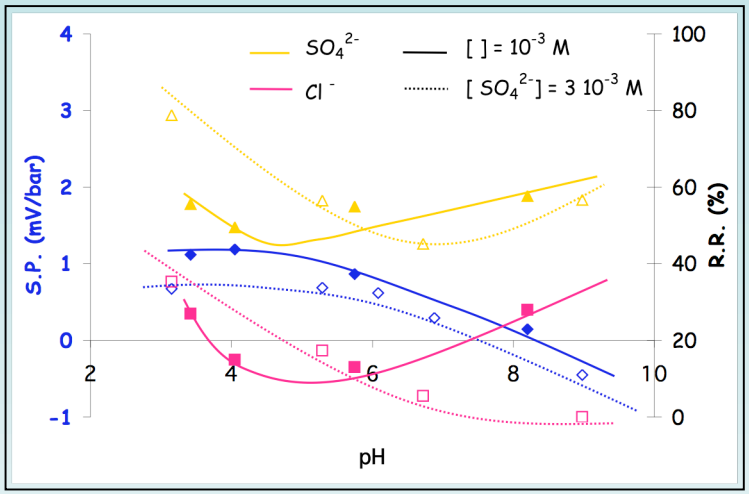


Positive surface charge due to the adsorption of Ca^{2+}.

This membrane presents a good selectivity to divalent ions.

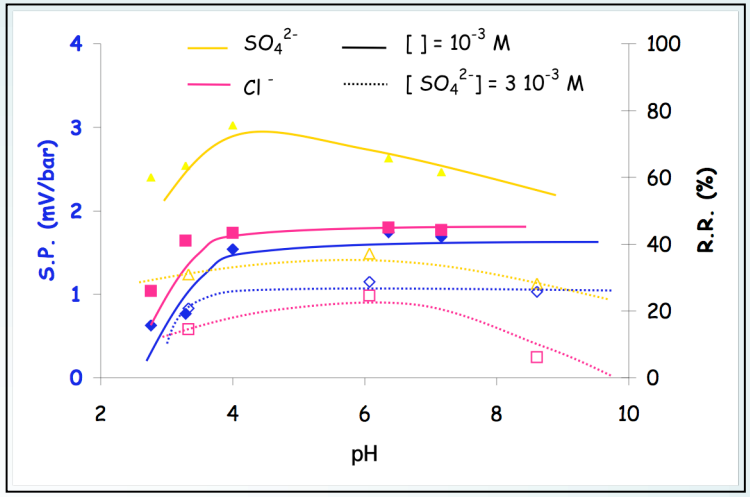


INFLUENCE OF THE ION CONCENTRATION *



Filtration of NaCl (10^{-3}M) + Na_2SO_4 (10^{-3} et 3 10^{-3}M)

Decrease of the surface charge when SO_4^{2-} anions increase.



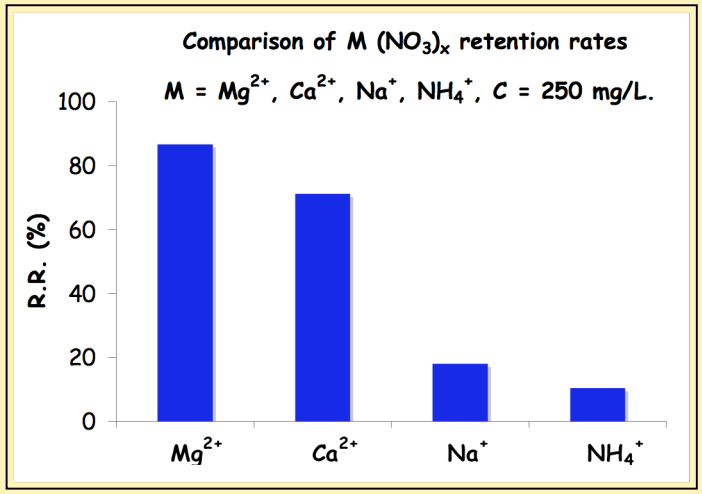
Filtration of

$CaCl_2$ (10^{-3}M) +$CaSO_4$ (10^{-3} et 3 10^{-3}M)

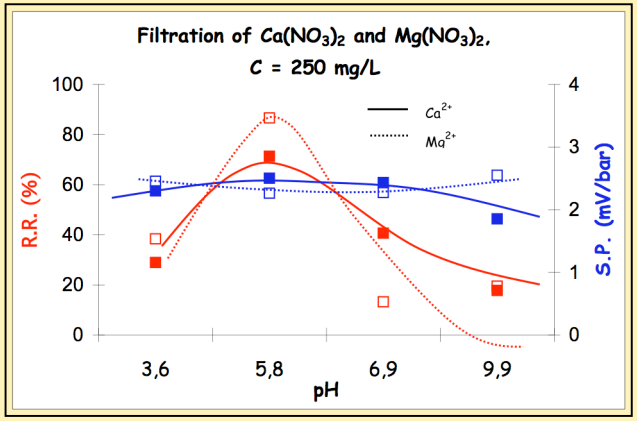
Decrease of streaming potential versus [SO_4^{2-}], adsorption of these ions is more important than adsorption of Ca^{2+}.

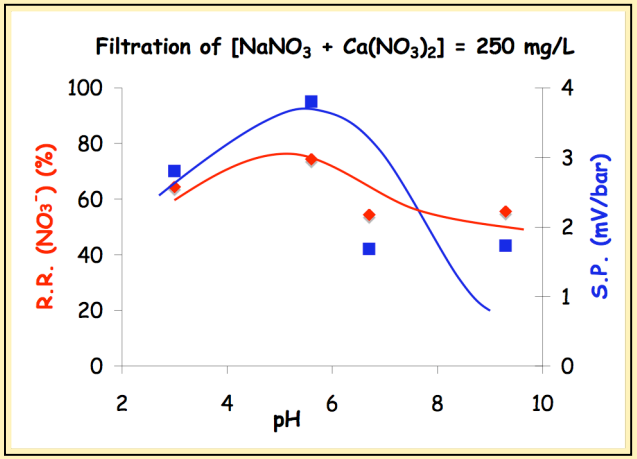
* A. Abouzaïd et al., C.R. Chimie, (2003), 431-436
* S. Condom et al., 10th I.C.I.M. (2008) Tokyo - Japan.

NITRATE POLLUTED WATER FILTRATION *



High R.R. if nitrate anions are associated to divalent cations.

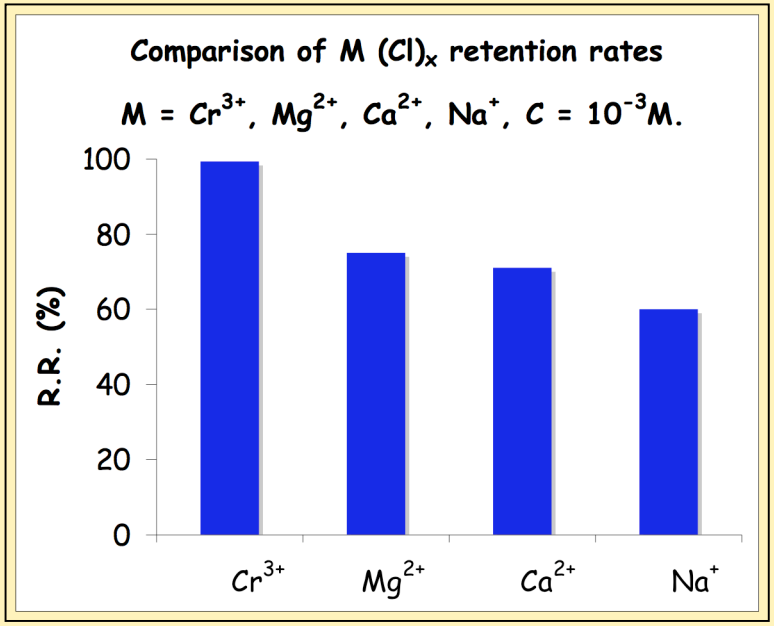




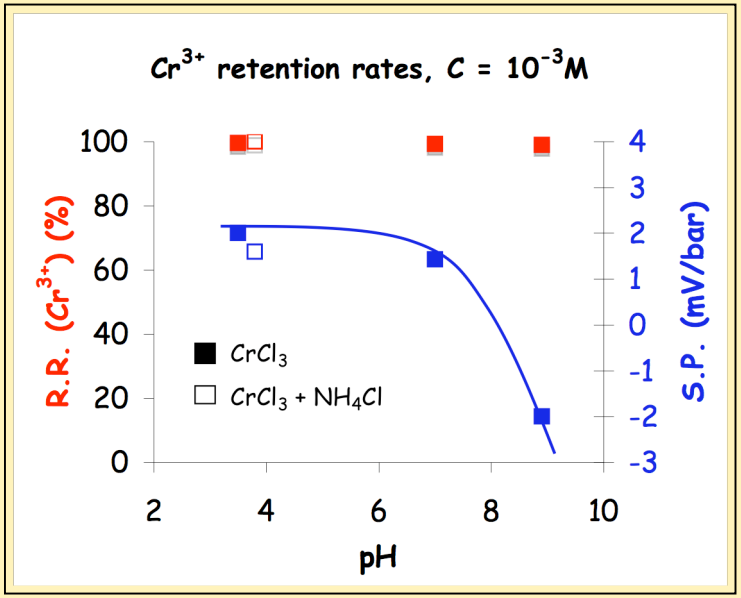
Nitrate retention rates can reach 65 %.

* A. Abouzaïd et al., C.R. Chimie, (2003), 431-436
* S. Condom et al., 10th I.C.I.M. (2008) Tokyo - Japan.

CHROMIUM POLLUTED WATER FILTRATION *



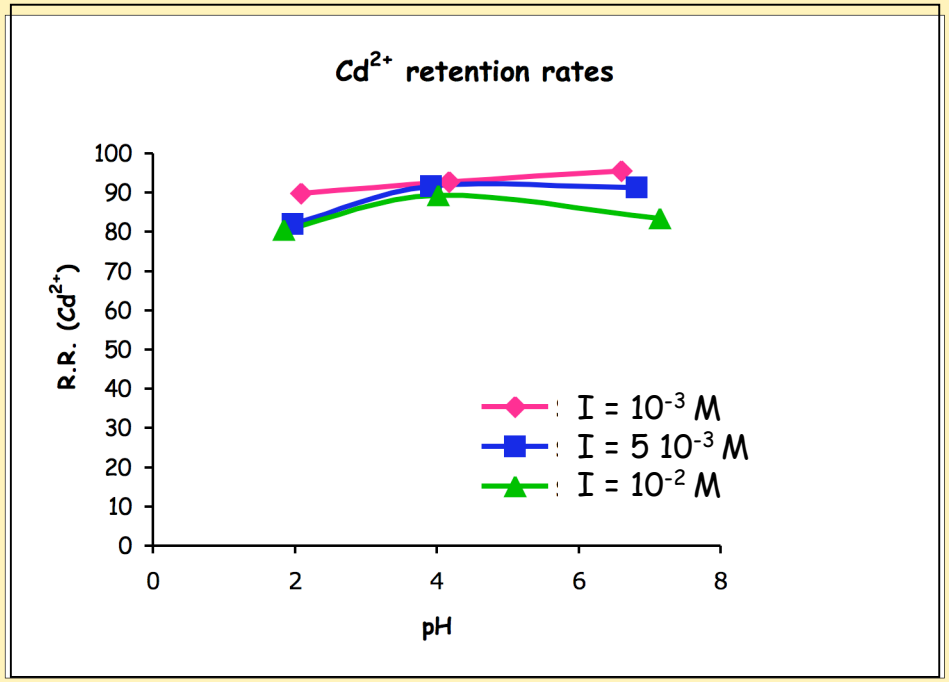
This membrane presents a good selectivity to multi charged cations.



The presence of other cations does not change the selectivity membrane for Cr^{3+}.

* S. Condom et al., 10th I.C.I.M. (2008) Tokyo - Japan.

CADMIUM POLLUTED WATER FILTRATION

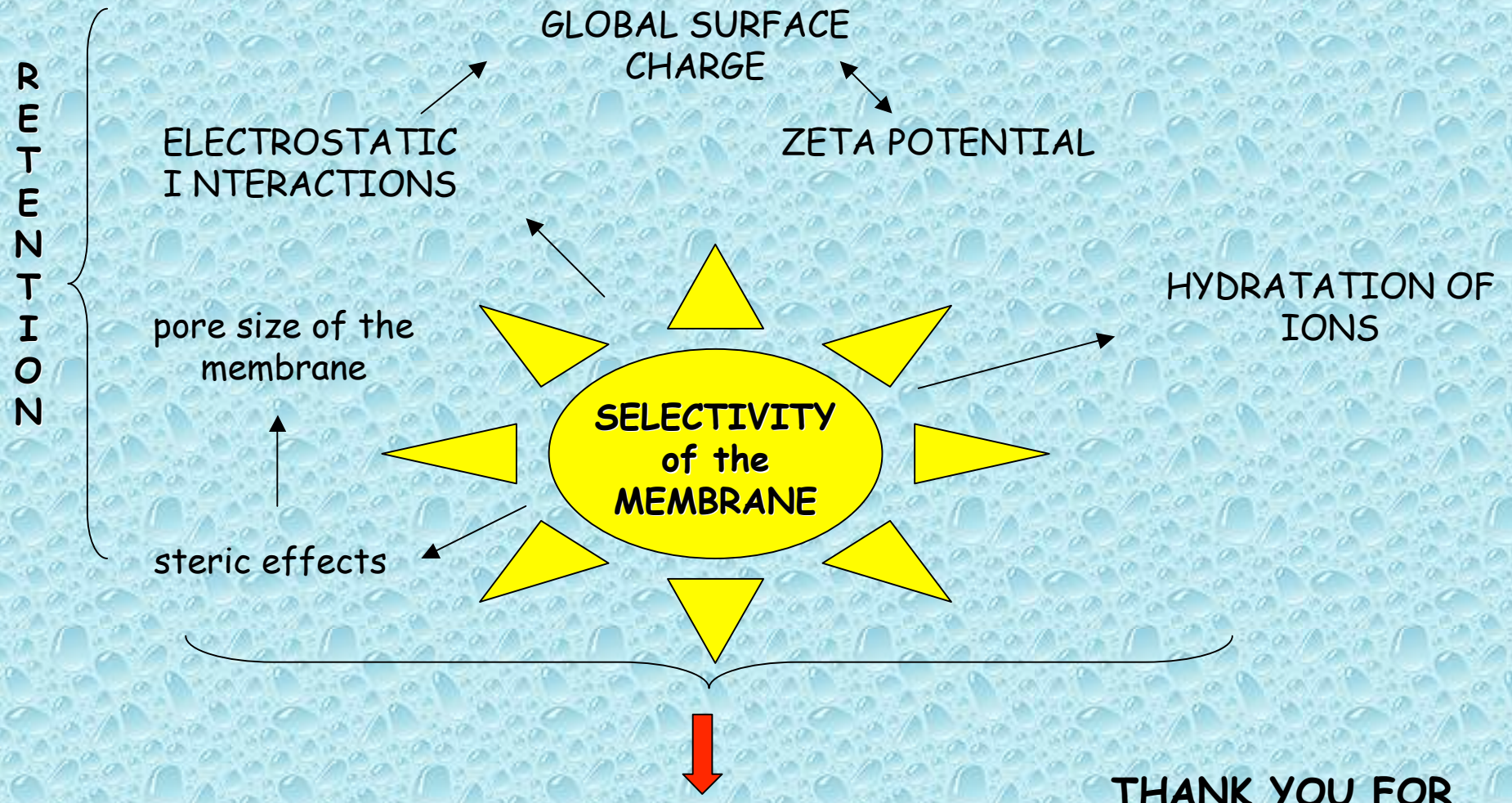


High Cd^{2+} retention rate.

Investigations have to be made to confirm and explain the evolution versus ionic strength.

Filtration of Pb solutions and mixtures of different salts are in progress.

CONCLUSION AND OUTLOOK



APPLICATIONS: DEPOLLUTION, CONCENTRATION, …

THANK YOU FOR YOUR ATTENTION