



Membrane engineering inspired by nature

10 October 2018 in Morocco



From 14:00 to 18:00 in Le Meridien N'fis Hotel
Avenue Mohamed VI, Marrakech

Proceedings of the workshop

Organized in relationship with
the 1st International Symposium on Nanomaterials and Membrane Science
(ISNMS 2018)



UNESCO Chair
"Membrane Science applied for Environment",
University of Montpellier
(Chemistry School of Engineering)



Proceedings of the workshop



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• Acknowledgments

The UNESCO SIMEV Chair, in conjunction with its supervisory authorities, would like to warmly thank all the speakers and participants for their involvement in conducting the workshop "Membrane Engineering Inspired by Nature" held on October 10 in Marrakech.

Thanks in particular to Professor Saad Alami Younssi for his warm welcome and support, to K2i organization (Saad Lahbabi and Kawtar Ouhmid) for the quality of their logistic support, as well as to the two students Dounia Beqqour and Omar Samhari for their efficient help.

Thanks also to the speakers for the quality of their presentations, which introduced rich exchanges, ahead of the [ISNMS2018](#). A Congress which has been very successful!



Symbol of a reciprocal and advantageous collaboration

Professor Gilbert Rios - SIMEV Chairman - was very pleased to receive the award presented to him by Professor Saad Alami Younssi - President of the SMMD, Hassan II University of Casablanca - for his valuable contribution to the Congress, through the organization of the workshop (photo opposite).

• Reminder of the background and programme

With the support of the Moroccan Society of Membrane and Desalination (SMMD) and the Laboratory of Materials, Membranes and Environment of University Hassan II of Casablanca, the UNESCO SIMEV Chair and its supervisory authorities organized on 10 October 2018 a workshop dedicated to the new membrane technologies inspired by nature.

Why this workshop?

Professor Gilbert Rios, SIMEV Chairman, introduced the workshop as follows:

"Having reached the end of my career, I observe that, once the enthusiasm of the youth and the desire to rediscover the world have passed, the researchers realize each day a little more with wonder that everything already existed before their own lifetime, and that there is a lot to be learned from observing nature and a lot of things to do for the benefit of human societies by taking inspiration from it.

When I started my career in the field of membrane technologies almost 30 years ago, I remember that Louis Cot had organized in Montpellier a seminar under the authority of Professor Pierre Joliot focused on biological membranes: their structures and their functions. During this day, Pierre Joliot, member of the 3rd generation of the famous Joliot-Curie family, Director of the Chair of Cellular Bioenergetics at the Collège de France, Associate Member of the National Academy of Sciences USA, Member of the Institute, Medal CNRS gold ... had delighted us by opening up to this wonderful world, rich in so many extraordinary performances that seemed light years away from the human achievements of the time.

Since then, the study of membranes and associated processes has been the subject of considerable investment in many countries - all the prospective studies carried out in the most advanced countries make them "dominant technologies" - and of considerable advances that all bring us back to the ultimate model of natural phenomena.

You will see through the various presentations that will be made during this workshop and through the topics discussed, that its place in preliminary ISNMS Congress seemed quite "logical".

You will also easily understand that, in so far as in terms of sustainable development no one can claim to offer more efficient systems, the UNESCO framework for conducting it has appeared to me to be "natural".

Agenda of the half-day workshop:

- 14:00**
- Welcome and presentation of the Moroccan Society of Membrane and Desalination (SMMD), by *Prof. Saad Alami Younssi, President of the SMMD, FST Mohammedia - University Hassan II of Casablanca, Morocco*
 - "Why a UNESCO Chair (Membrane Science Applied to the Environment) hosted by IEM?" by *Prof. Ph. Miele, IEM Director, Montpellier, France. Slideshow shared with the proceedings*

Thematic presentations

- 14:15
- "Bio- and nano- : keys for new intensified membrane processes inspired by nature" by *Prof. G.M. Rios - SIMEV Chairman, France*
- 14:45
- "Valorization of natural material in development of new ceramic membranes" by *Prof. Saad Alami Younssi, Director of L2ME - University Hassan II of Casablanca, Morocco*
- 15:15
- "Membranes from biopolymers: challenges ahead" by *Prof. J.G.Crespo - UNL Lisbon, Portugal*
- 15:45
- "Sustainable bio-catalytic processes in membrane systems: Towards a clean chemical industry" by *Prof. P.Lozano Rodriguez - Univ. Murcia, Spain*
- 16:15
- "Bio-inspired engineered surface for membrane filtration" by *Dr Sana Gassara - IEM, France*
- 16:45
- Coffee break

Rountables

- 17:00
- Biomimetic materials.
Moderators: Ph. Miele & J. Crespo. Rapporteur: M. Boucher
- 17:30
- Nature inspired processes.
Moderators: G.M.Rios & P. Lozano Rodriguez. Rapporteur: M. Boucher
- 18:00**
- End of the workshop & cocktail

• Thematic presentations



Bio- and nano- : keys for new intensified membrane processes inspired by nature
by Prof. G.M. Rios - SIMEV Chairman, France
Dedicated slideshow shared with the proceedings



Valorization of natural material in development of new ceramic membranes by Prof. Saad Alami Younssi, Director of L2ME - University Hassan II of Casablanca, Morocco
Dedicated slideshow shared with the proceedings



Membranes from biopolymers: challenges ahead by Prof. J.G. Crespo - UNL Lisbon, Portugal
Dedicated slideshow shared with the proceedings



Sustainable bio-catalytic processes in membrane systems: Towards a clean chemical industry by Prof. P. Lozano Rodriguez - Univ. Murcia, Spain
Dedicated slideshow shared with the proceedings



Bio-inspired engineered surface for membrane filtration
by Dr Sana Gassara - IEM, France
Dedicated slideshow shared with the proceedings

• Round tables summary

Biomimetic materials

Moderators: Philippe MIELE and Joao CRESPO

What are the challenges of developing biomaterials, in terms of applications? Taking the example of aquaporin quoted by G. Rios, the question about the development of materials inspired by or integrating this protein is: could it meet concrete needs? Or is it more a matter of concepts (the Nobel Prize for their discovery was awarded in 2003 to Peter Agre) still far from applied solutions?

G. Rios reminds that aquaporins are proteins found in all natural systems, which provide water transport and a barrier effect (with respect to salts in particular) with maximum efficiency. **Understanding and mimicking their operation could / should (?) enable the development of systems with a high level of performance** (production, quality, energy because transport is passive), especially for the production of drinking water.

There are today a few companies trying to develop around these ideas such as Aquaporin (created about ten years ago in Denmark and today also implanted in Singapore). In practice, it would involve implanting aquaporins into polymeric supports. One of the main difficulties encountered is to do so under conditions close to that observed in the natural state: the protein creates a real channel of transfer through the cell membrane. Other issues concern: the duration in time of the structures thus created which are subjected to pressure cycles (process conditions) and cleaning (management of fouling already mentioned) "tiring", the resistance of the protein to the possible action of microorganisms (the activity depends on the structure that will be strongly influenced by the environment)... How to rethink the modules to adapt them to new membranes (which has been little investigated until then ...)?

In general, we note that **when it comes to the transfer of bio-inspired technologies, we often think materials but little process conditions (operating conditions, modules ...) and knowledge of the products to be treated**. It would be necessary to combine all this to develop a holistic approach to the problems encountered.

The example of the strategy of large groups such as VEOLIA is mentioned: to be able to go from the idea to its industrialization in 4 to 5 years maximum, it is essential to have an applied objective. The development of biomaterials becomes then part of the proposal for a concrete solution to commercialize. The recent partnership between IEM and VEOLIA is a good illustration of the desire to make the link between research and the implementation of concrete solutions. Research is needed to enable industrial partners to innovate, and the industry shares the field constraints with researchers who can take them into account in their work.

Nature inspired processes

Moderators: G.M. RIOS and Pedro LOZANO R.

Following the first round table, the importance of the membrane fouling management is again mentioned as a key point for the engineering of bio-inspired membrane process systems. A comparison between a clean boat hull and another full of inlaid shells is advanced to illustrate the impact of fouling on process performance: the shelled boat full of shells will have a higher displacement cost.

The types of fouling may vary from one system to another - appearance of biofilms in water treatment, fouling by protein/membrane interactions in agribusiness - and their treatment must be studied on a case-by-case basis - for manufacturing fruit juice for example, use of pectinases to limit the clogging deposit that tends to form ... -. **The transition from frontal filtration to tangential filtration is a good example of a process innovation that reduces fouling, without focusing on material aspects.** Choice of the type of flow, speed, viscosity of the solution ... are all characteristics that will make it possible to modulate the fouling and the additional resistances induced.

The process engineering approach will also have its place for bio-inspired materials, as the optimization of the membrane material may have only a limited impact on the final product. It is important to restore the material to its rightful place, considering process further. There will be no single solution, but multiple specific answers, related to the environments on which we work. The importance of a multidisciplinary approach needs to be remembered.

Most man-made membrane systems operate in the convection mode. Nature does not hesitate to use diffusive systems when necessary with very high specific surfaces, or even to couple them with convection ... **Perhaps it would be interesting for our own achievements to change the paradigm and to be inspired by these networking of several modes of operation? This should be facilitated by the new possibilities offered by nanotechnologies to increase the specific surfaces within the equipment?** (see presentation of G. Rios)

Today, research results on nanomaterials serving membranes can be the subject of good publications; but their real impact in terms of applications is very limited! **The lack of recognition of concrete results obtained for applied research** (as opposed to the importance given to publications, necessary for career development) **is a general problem that greatly hampers the development of real technological solutions in these fields.** By constantly looking for "sensational" and often very specific applications, we do not focus enough on global solutions applicable in the short term.

• Final list of participants

Anyone interested in learning more about nature-inspired membrane technologies (materials and processes) was invited to register for free online, within the limit of the number of places available (50).

The workshop brought together 29 participants (excluding [speakers](#)) from Morocco (62%), France (24%), Kuwait, Lebanon and Spain.

Name	Surname	Structure
ACHARGUI	Nezha	Univ. Hassan II Casablanca, Maroc
ACHIOU	Brahim	Univ. Hassan II Casablanca, Maroc
ALAMI YOUNSSI	Saad	Univ. Hassan II Casablanca, Maroc
BEN YUCEF	Hicham	Univ. Polytechnique Mohammed VI, Maroc
BEQQOUR	Dounia	Univ. Hassan II Casablanca, Maroc
BOUCHER	Mathilde	Chaire Unesco SIMEV, Montpellier, France
BOUHRIA	Mohamed	SMMD- Univ. Hassan II Casablanca, Maroc
BOUSSOUGA	Youssef-Amine	Univ. Sidi M. Ben Abdellah, Fez, Maroc
BREIDA	Majda	Univ. Hassan II Casablanca, Maroc
CRESPO	Joao	FCT-NOVA University of Lisbon, Portugal
DEROUICH	Ghizlane	Univ. Hassan II Casablanca, Maroc
EL ATTAR	Anas	Univ. Hassan II Casablanca, Maroc
GARUDACHARI	Bhadrachari	Kuwait institute for scientific research
GASSARA	Sana	IEM, Montpellier, France
GHAFFOUR	Noreddine	King Abdullah University of Science and Technology, Saudi Arabia
HAFSI	Mahmoud	ONEE - Office National de l'Electricité et de l'Eau Potable, Maroc
HALIM	Elmahdi	Univ. Hassan II Casablanca, Maroc
HERRO	Ziad	Univ. Libanaise, Beyrouth
KARIM	Abdelaali	Univ. Hassan II Casablanca, Maroc
KHAYET	Mohamed	University Complutense of Madrid, Spain
LESAGE	Geoffroy	IEM, Montpellier, France
LHASSANI	Abdelhadi	Univ. Fez , Maroc
LOULERGUE	Patrick	Institut des Sciences Chimiques de Rennes, France
LOZANO	Pedro	Univ. Murcia, Spain
MAGNES	Pierre	FIRMUS France
MAMA	El Rhazi	Univ. Hassan II Casablanca, Maroc
MIELE	Philippe	IEM, Montpellier, France
OUAMMOU	Mohamed	Univ. Hassan II Casablanca, Maroc
RABILLER-BAUDRY	Murielle	Institut des Sciences Chimiques de Rennes, France
RIOS	Gilbert M.	Chaire Unesco SIMEV, Montpellier, France
SAMHARI	Omar	Univ. Hassan II Casablanca, Maroc
SZYMCZYK	Anthony	Institut des Sciences Chimiques de Rennes, France
TAHRI	Khalid	ONEE - Office National de l'Electricité et de l'Eau Potable, Maroc
TAKY	Mohamed	Univ. Ibn Tofaïl, Kenitra, Maroc
ZAVISKA	François	IEM, Montpellier, France