Bio-inspired nanopore: from fundamental transport properties to applications

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In the life science, it is well known that biological membranes insure exchange and communication of living cells. Their properties in terms of ionic permeability, selectivity and response regarding the environment are exceptional. On the other hand, the artificial membrane has huge applications in industry. Even if effort was made to improve their properties like self-healing, responsiveness, we are far than biological one. The next generation of membranes will overcome its basic separation role. As the cell membrane, they will play numerous role as selective barrier, sensor and will interact with its environment as element of communication. For the latter point, this membrane could be seen as element of an electronic circuit. Imagine such breakthrough membranes require an absolute control of the pore membrane in term of chemistry and a deep fundamental knowledge of each physical process that govern the transport. This is particularly truth at nanoscale, when the non-linear effect becomes preponderant[1].

Working on a single and well define nanopore is a key point to understand the fundamental mechanisms of transport. It also allows building each brick of future membranes aiming to exhibit each property of the cell membrane (ionic selectivity, energy harvesting, gate, sensor and counter)[2]. Among all strategy to work in single nanopore, the ones obtained by track-etched methods are the most interesting since they allow designing single and multipore membrane until m^2 scale. In addition, this method allows drilling dissymmetrical nanopores that have like "ionic-diode" properties. They are also easy to functionalize with more and less complex system to improve their properties in term of response against a stimulus, selectivity, or antifouling.

In this talk, we will outline our work about such biomimetic membranes. We will give an overview about the method to obtain such nanopore, their functionalization and their ionic transport properties. We will define physical properties of transport that occur at nanoscale and how we can gain from them to give desired properties to artificial membrane. As for the biological membrane, the properties presented will be ionic separation[3,4], sensing[1,5–7], counter[8–12], energy harvesting[13,14] and stimuli-responsive membrane[15–17]. They will be illustrated by several examples of applications in the area of blue energy, health, quality control, diagnosis, separation.

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