DESCRIPTION

Overview:
The aims of this project are the synthesis of columnar side-chain liquid-crystalline polymers and the use of them to build up biomimetic membranes able to transport proton ions through the channel mechanism. These proton exchange membranes are of great interest for the construction of methanol fuel cells.

Background and State of the Art:
Fuel cells are a kind of electrochemical device that converts chemical energy directly into electrical energy. Among the several types of fuel cells, proton exchange membrane fuel cells (PEMFC) have acquired a growing importance; these fuel cells use membranes, which are able to conduct protons, as the electrolyte. PEMFCs mainly include hydrogen fuel cells and direct methanol fuel cells (DMFC). In DMFCs, methanol is fed directly as the fuel, and these systems have several advantages over fuel cells based on hydrogen and compressed natural gas.
The membranes currently used in DMFCs are far away to be considered optima with regard to their features and performance; therefore, the development of new proton exchange membranes is a topic of great interest. In this project we intend to approach this problem by preparing membranes containing selective ionic nanochannels.

The group of Prof. Percec has been working for almost the last twenty years in, among other topics, the design, synthesis and characterization of polymers containing tapered side groups. These materials self-assemble intramolecularly in cylindrical macromolecules, which subsequently self-organize in columnar lattices. They have elucidated the structure of these assemblies which lead to ion-active systems and have reported enhanced conductivity along the channels for selected ions.

Dr. J. A. Reina and Dr. M. Giamberini have recently reported, together with other authors, the synthesis and characterization of some sets of side-chain liquid-crystalline polyethers which self-assemble into supramolecular columnar structures. They prepared these polymers either by reacting poly(epichlorohydrin) with tapered mesogenic carboxylates or by ring opening polymerization of oxiranes bearing a tapered group. Different types of columnar mesophases and different stability ranges were obtained depending on the tapered group shape, the modification degree achieved and the polymer molecular weight. Although, in some cases, preliminary experiments glimpsed a good affinity of the polymer for lithium ions, no membranes were prepared and tested.
Project Contribution and Methodology:
This project will contribute to the improvement of alternative technologies for energy generation and exploitation represents one of the major challenges for sustainable development.

In this project we intend to prepare proton exchange membranes in a way that, to our knowledge, has not been applied before, i.e. by preparing membranes based on self-assembling columnar side-chain liquid-crystalline polymers which lead to the formation of biomimetic ionic channels. Moreover, to our knowledge, nobody has still reported the preparation of polyamines with tapered side groups, which, in our opinion, should show improved proton conductivity through the biomimetic channels. Therefore, if we achieve the expected results, the project will significantly contribute to the increase of scientific knowledge.

If a project leads to a good research training of the Ph.D. students which participate in its development, the society will certainly benefit from this fact in a medium to long term. This project is multidisciplinary and, therefore, the involved Ph.D. students will receive a multidisciplinary training which will give them a global and cooperative view of the scientific research. The work of these students will deal with a wide variety of techniques and methodologies: organic chemistry synthetic methodologies, purification of organic compounds, polymer synthesis and characterization methods, structural determination techniques, mesomorphic characterization methods and preparation, characterization and assessment of membranes.

We plan to publish the results of this project in international journals with good impact factor in the fields of polymer science, membrane technology and liquid-crystalline materials. Obviously, we plan also to present poster and oral contributions to national and international conferences on related topics.

The ideal candidate:
The ideal candidate should have a B.Sc. or B. Eng. Degree and should be able to express him/herself in correct English.

Some previous knowledge on membrane technology, would be took into account, but it is not compulsory.

In order to work in our research group motivation, team working and initiative are essential skills.

Finishing the project:
When finishing the project, the candidate will have acquired the fundamentals on membrane technology (preparation and characterization), an emergent methodology in most industrial fields, as well as, on organic chemistry synthetic methodologies, purification of organic compounds, polymer synthesis and characterization methods, structural determination techniques, mesomorphic characterization.

Besides the candidate will have experienced working in a dynamic multidisciplinary international research group.

References: