Post-doctoral position (12 months)
CEA-INAC-SyMMES
Grenoble, France

Start Sept-Oct 2018

Nanostructure of ionomers developed for hydrogen fuel cells investigated by scattering techniques

A 12 months post-doctoral position is offered in the framework of the **international ANR project** NSPEM, between CEA, LEPMI and University of Simon Fraser Vancouver (Canada), dedicated to the development and characterization of **fuel cells based on block copolymer electrolytes**. This project aims at providing in-depth structural characterization of the electrolyte used both as proton-conducting membrane and ionomer in the catalytic layers by means of lab thermal/mechanical characterizations coupled to structural investigation by means of **X-rays and neutron scattering experiments.**

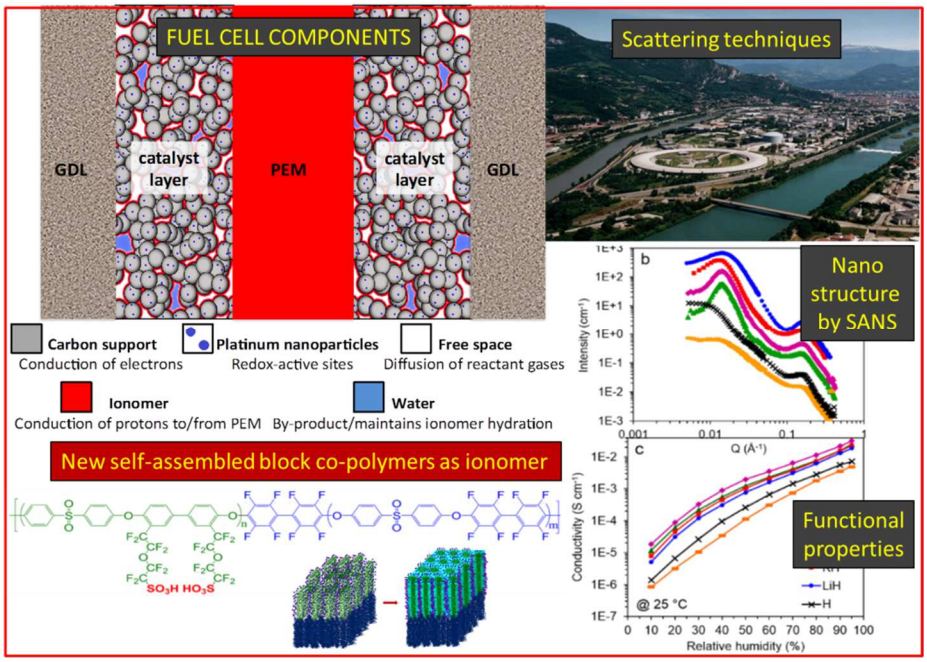
Context:

The proton exchange membrane fuel cell sector accounts for the largest share of world commercial demand for fuel cells, a sector that will increase considerably over the next 5 years. To remain competitive, fuel cell manufacturers must reduce materials costs. The challenges are a re-design of the materials that constitute the heart of the fuel cell, i.e., the membrane-electrode assembly. The current technical standard of choice for the proton exchange membrane (PEM) and for the solid electrolyte in the catalyst layer is the family of polymers known as perfluorosulfonic acid (PFSA) ionomers. Despite its ubiquitousness, it is costly and requires the use of controlled and potentially dangerous fluorous vinyl monomers, and it suffers from a loss of conductivity at low relative humidity and/or elevated temperatures. The project NSPEM addresses the challenge of developing proton-conducting media that do not require the use of perfluorinated polymer backbones and possess a much lower fluorine content, and which are sufficiently versatile to be viable candidates to replace existing perfluorinated materials in the membrane and catalyst layer. This project explores the design of durable, solid hydrocarbonated (HC) polymer electrolytes for PEMFC membranes and catalyst layers, with the ultimate goal of designing the first all-HC efficient fuel cell. The proposal focuses on researching the synthesis and development of a class of materials known as the polyarylene ethers bearing fluorosulfonic acid [1-2].

Objectives:

The present post-doctoral project aims at a **multi-scale multi-technique investigation of the properties of a family of promising aromatic ionomers** developed by LEPMI/CEA since few years. The materials, including second-generation high performance ionomers selected for use as both membrane and conducting phase in electrodes, are prepared by a post-doctoral fellow hired at LEPMI in the frame of the project. Our main goal at CEA is to **correlate functional properties, structure and transport** efficiency, in order to select best performing ionomers and improve their design. For this purpose, we apply a methodology based on the combination of lab characterization and advanced scattering techniques. Understanding the organization of the proton-conducting phase in fuel cell components is of paramount importance to improve the performances. To achieve this goal, a variety of scattering techniques, can be employed: small angle neutron/x-rays scattering (SANS/SAXS), grazing incidence techniques (GISAXS), Infra-red Synchrotron spectroscopy. Moreover, operando

studies of the real-time behavior are possible using home-made fuel cells (neutron imaging, SANS).
At the end of the project, we expect to have gained substantial understanding of the properties of the new materials at microscopic scales. This will help to realize the first all-aromatic fuel cell with performances competing with those of state of the art devices based on Nafion (or derivatives).



Hosting Team:

The CEA is a major player in the field of materials synthesis, characterization, design and testing in real devices in the field of energy conversion and storage. At INAC, advanced characterization tools are developed to probe the structure and functional properties of nanomaterials used as electrolytes and/or electrodes. Dr. Sandrine Lyonnard is soft matter physicist specialized in neutron and x-rays studies applied to nanomaterials for energy applications.

Candidate profile:

The post doctorate fellow will be in charge of characterizing the physical properties of the newly developed ionomers by means of lab techniques (Conductivity, DSC, Sorption, DMA…) and neutron/X-rays scattering techniques. He/she will design and perform the scattering experiments using X-rays lab-spectrometers or the world-class Large Scale facilities (ILL, ESRF, SOLEIL), and analyze/interpret the data. He will interact with the physicists/chemists of the French partners (CEA-INAC and LEPMI), and the Canadian experts in electrochemistry and fuel cell testing. The candidate should have a solid experience of scattering techniques (neutrons and/or X-rays, spectroscopy and/or small angle techniques) and data modeling (capabilities to develop/code specific data treatment programs and handle fitting of data batches would be highly appreciated). Scientific backgrounds in soft matter and/or nanomaterials would be an excellent basis. Good communication skills will be also important to allow the synergy between the various actors involved in the project.

Application: Please join a CV, a cover letter and two recommendation letters.

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1. Aromatic Copolymer/Nafion Blends Outperforming the Corresponding Pristine Ionomers, Huu-Dat Nguyen, Jacques Jestin, Lionel Porcar, Cristina Iojoiu, and Sandrine Lyonnard
ACS Appl. Energy Mater., 2018, 1 (2), pp 355–367
2. Controlling Microstructure -Transport Interplay in Highly Phase-Separated Perfluorosulfonated Aromatic Multiblock Ionomers via Molecular Architecture Design H-D. Nguyen, L. Assumma, P. Judeinstein, R. Mercier, L. Porcar, J. Jestin, C. Iojoiu, Cristina, S. Lyonnard, *ACS Appl. Mater. Interfaces* 9 (2), 1671–1683, 2017