Polytech network form for PhD Research Grants from the China Scholarship Council

This document describes the PhD subject and supervisor proposed by the French Polytech network of 14 university engineering schools. Please contact the PhD supervisor by email or Skype for further information regarding your application.

Supervisor information	
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Country	France

PhD information	
Title	Understanding the aging mechanisms of polymeric materials for energy
Main topics regards to CSC list (3 topics at maximum)	Biomaterials and polymer materials Energy of hydrogen and technology of hydrogen storage

	Combustible battery
Required skills in science and engineering	This basic research subject with a strong experimental focus is directed toward a physicochemist of polymers wishing to acquire a solid experience in microscopy (optical, near field, electronic) and spectroscopy (FTIR, Raman). By his skills in material physics and macromolecular chemistry he will have to understand the impact of the aging of the material on its chemistry, morphology and functional properties. To do this, the doctoral student will evolve within a multidisciplinary team composed of physicists, physicochemists of polymers and specialists of large scale facilities

Subject description (two pages maximum)

Proton exchange membrane fuel cells (PEMFC) and water electrolysers (PEMWE) are promising and environmentally friendly technologies. One of their key components is the **polymer electrolyte membrane** acting as a gas separator and proton conductor. Membrane **degradation under harsh and/or long-term operating conditions** is highly detrimental and ultimately causes the system failure[1-6]. Improving both the performances and durability of the membrane is critical before any large scale diffusion of these technologies.

The **"energy" theme is central for the SyMMES activities**, and **the fuel cell, which is one of the important components** of this theme, is carried by the **Synthesis, Structure & Properties of Functional Materials (STEP) team**. This team aims, among other things, to understand **the structure / proton transport / durability relationships** of the polymer electrolytes of the membrane/electrode assembly (MEA) located at the heart of the cell. This proposal for thesis funding is presented by a full professor and an associate professor from the SYMMES/Polytech Grenoble, for a project that is positioned both in the **"aging" research axis** initiated in 2002 (with the aim of a better understanding of the mechanisms limiting the lifetime of the device[7-9], but also in a more recent research axis concerning **the improvement of the properties of existing membranes** by insertion of a stabilizing chemically active sol-gel network[10-11]. Finally, this work offers the opportunity to use the **global strategy coupling chemical / morphological / mechanical information** developed during JP Cosas Fernandes' thesis[12-14] (2014-2017) to understand the ionomer membrane's aging after ex-situ aging (H_2O_2) and fuel cell aging. This strategy allows after cross-sectioning the membrane or the MEA by cryo-ultramicrotomy[13] (if possible without epoxy embedding) to proceed successively and in a **co-localized manner** (uniqueness of the analyzed area) to **chemical analysis by µATR-FTIR, confocal µRaman, µEDX (TEM), EDX (SEM), morphological analysis by AFM, SEM and TEM and nanomechanical and thermomechanical analysis by AFM**. These analyzes will allow the **development of alternative membranes for fuel cells** in a general way. Indeed, in addition to the hybrid membranes developed by our team, this thesis will allow the study of **alternative membranes** through **national and international collaborations** for Fuel cell applications.

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7 C. Perrot et al., Polymer, **50**(7): p. 1671-1681 (2009).
8 C. Perrot et al., Journal of Power Sources, **195**(2): p. 493-502 (2010).
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10. " Use of a functionalized polysiloxane network for chemically stabilizing a polymer membrane used as proton exchange membrane for fuel cell and electrolyser applications", L. Gonon et al., European patented n°EP 2774946 A1 2014.
11. I. Zamanillo Lopez, "Hybrid membranes for fuel cell", Grenoble University PhD, 2015
12. J. P. C. Fernandes et al., Polymer, 137, 231 (2018)
13. J. P. C. Fernandes et al., Int. J. Polym. Anal. Charact. 23, 113 (2018)
14. J. P. C. Fernandes, "Co-localized AFM/Raman characterization of multiphase polymer systems", Grenoble University PhD, 2017