Proposition de sujet de thèse – rentrée 2022

ANALYSE DES PHENOMENES ELECTRIQUES-MECANIQUES COUPLES DANS LA DEFAILLANCE DES ISOLANTS PAR TECHNIQUE DE LUMINESCENCE

Proposition of thesis topics 2022-2023

CORRELATION BETWEEN MECHANO-LUMINESCENCE AND ELECTROLUMINESCENCE FOR THE INVESTIGATION OF THE RELIABILITY OF DIELECTRIC POLYMERS

CONTEXT AND OBJECTIVES

Along the energy transition and decarbonization, electrification is a critical step, at the crossover between renewable energy harvesting and switch to cleaner transport modes, industry and domestic appliance. This transition demands more powerful, more compact, more efficient electrical systems with new forms of electrical stresses. A consequence of that is the design of more complex electrical insulation with coupled stresses that may alter insulating materials endurance and power systems reliability.

Coupled electrical-mechanical effects are considered as one of the failure modes of electrical insulating materials, at different scales of the 'electrical ageing' scheme, ranging from polymer chain scission to electrical tree propagation. A better understanding of these phenomena would provide a better insight into the endurance of materials to electrical stresses. New insights into these effects could be obtained with analyzing the luminescence under mechanical, electrical or coupled stresses as it can provide a fingerprint of degradation processes being at play.

In this context, the DSF (*Diélectriques Solides et Fiabilité*) group at Laplace has developed a new experimental set-up for the diagnosis of dielectric polymers under mechanical stress. This new bench is dedicated to analyze luminescence from conventional as well as doped polymers submitted to mechanical stress, i.e. **mechano-luminescence (ML)**. It may provide needed new inputs for improving the understanding of the degradation of polymers under electric field, based on an ensemble of signatures already obtained by the group by electroluminescence (EL) measurements on a panel of polymeric materials ranging from polyolefins to polyesters and epoxy materials. Luminescence measurements allow probing polymers down to a molecular scale in investigating the emission spectra resolved in wavelength. The combined analysis of the mechanical and electrical responses is useful for detecting weak points in the backbone of the polymer chain at the origin of degradation. Effects of continuous and dynamical (sinusoidal) stresses should be studied both with electrical and mechanical stresses. Preliminary results show that ML can be detected in polyesters and epoxy materials provided complementary excitations are used, either with electron irradiation or by thermal stressing.

Besides challenges in detecting small light emission intensity when studying commercial polymers, we could exploit the approach to probe self-healing polymeric materials as well as materials provided with mechanophore groups as thermoplastic polyurethanes (TPU). Along this project, a collaboration with Prof. Sijbesma's research group of the Eindhoven University, The Netherlands, will be run. This group has a know-how to add special functions in polymers and has skills on mechano-chemistry and mechano-luminescence phenomena.

THESIS TASKS

The main tasks of the research undertaken during the thesis are:

- To define the conditions for mechano-luminescence detection, particularly the necessity of combined stresses (temperature, electron irradiation, other). The bench is based on a traction/compression mechanical module recently installed in a light-tight chamber equipped with photomultiplier and CCD detector. Digital Image Correlation (DIC) method will be implemented as a way to control in-plane deformation of samples.
- To develop a methodology to combine electroluminescence and mechano-luminescence measurements.

- To investigate the EL and ML in various materials in order to improve our understanding of degradation processes at a molecular level. Doped materials, with dyes acting as energy acceptors introduced in PMMA or mechanophore containing-polymers will be characterized. Commercial polymers such as polypropylene and polyethylene naphthalate used in power capacitors as well as self-healing polymers will follow.
- To identify EL and ML thresholds (before breakdown) for irreversible behaviors on the materials.
- To identify through spectra analyses the similarities/differences in spectra depending on kind of stress, and therefore to compare degradation processes.

THESIS SUPERVISION

The PhD work will be performed in the DSF group at LAPLACE (http://www.laplace.univ-tlse.fr/Presentation-1431), under supervision of Dr G Teyssedre (DR CNRS) and with participation of Dr JL Augé and Dr V Griseri (MCF), who will bring their expertise in luminescence detection and electron irradiation, respectively. Prof. Rint Sijbesma, from Laboratory of Supramolecular Polymer Chemistry, University of Technology, Eindhoven will be foreign supervisor of the thesis. Periodic stays are scheduled at Eindhoven University for materials processing. The profile of Sijbesma's group is available at: https://sijbesmalab.nl/lab-tour/.

CANDIDATE PROFILE AND APPLICATION

We expect a PhD candidate having a Master degree in Materials Science or Mechanical or Electrical Engineering with preference for experimental research. Good English is required. Objectivity, autonomy and team oriented skills are highly demanded.

Beginning of thesis: Sept/Oct 2022. PhD grant allocated for 3 years

For Application: Please send email with:

-CV

-Motivation Letter

-Reference Letter

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Deadline: May, 20th, 2022.