Unité Mécanique Lille UML J. Boussinesq

Université de Lille

Ph-D proposal in Mechanics of materials @ Lille University (FRANCE)

Photomechanical response and modeling of smart textile fibers

Context

An organic photochrom is a molecule that reversibly changes its absorption spectra under illumination. Beyond the change of color (photochromic sunglasses is a well-known example from general public), photochromic materials can be used for their photomechanical effects, especially on textile fibers: a photochromic fiber changing its shape during the change of color [1] under visible irradiation is illustrated in figure 1; reversibility is achieved through visible irradiation.

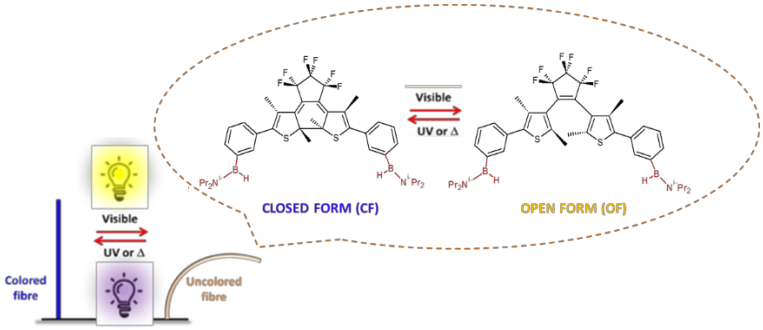

Figure 1 (left) Photochromic fiber actuated by UV/Visible light. (right) Photochromism of diarylethene based on reversion / electrocylization between the closed Form (CF) and the open form (OF).

Project description

The aim of the PhD thesis is to study the photomechanical response of smart textile fibers coated with a blend of an elastomer and the photosensitive diarylethene.

An experimental part will consist in measuring the deflection of the smart fiber submitted to light irradiation (UV or visible) and to extract the effect of the fiber contents (volume fractions of each component) and of the irradiation intensity and time exposure.

In parallel a constitutive mechanical model must be build to describe the light-induced deformation mechanism. The mechanical model must be able to describe the effects of irradiation time for a given intensity on the global mechanical response of the material. This could be done by introducing an additional phase which appears and vanishes depending on the irradiation (UV or visible). Indeed, the chain mobility associated to the relaxation processes and the modifications induced by irradiation will be also involved in the modeling. The network parameters of this supplementary phase as well as its volume fraction must be linked to the photochemical process parameters (time of irradiation, intensity…). Accounting for the gradient of these quantities in the thickness is also scheduled. The macroscopic network stress-strain behaviour could be expressed by using the Boyce[1] (1998) eight-chain model of rubber elasticity. The photomechanical coupling will be integrated by re-examining and adapting the work of Long et al[2] (2009). The scale transition from micromechanism (photo-switch) to macroscopic light induced deformation can be envisioned based upon the work of Yun et al[3]. The parameters of the model will be identified using the experimental measurements. Finally, the constitutive model will be implemented in a Finite element software and some primary simulations are expected.

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[1] Arruda, E.M. and Boyce, M. C., Journal of the Mechanics and Physics of Solids, 41, 2, 389-412 (1993). doi: https://doi.org/10.1016/S0022-5096(97)00075-6

[2] Long, K. N., Scott, T. F., Jerry Qi, H., Bowman, C. N. and Dunn, M. L., Journal of the Mechanics and Physics of Solids 57, 1103-1121 (2009). doi: https://doi.org/10.1016/0022-5096(93)90013-6

[3] Yun, J.-H., Li, C., Chung, H., Choi, J. and Cho, M., International Journal of Solids and Structures 128, 36-49 (2017). doi: https://doi.org/10.1016/j.ijsolstr.2017.08.011

Keywords. Photomechanics, Finite strain, constitutive model, Finite element

Applicant: Master degree with a good expertise in mechanics of materials. The applicant will have to develop both experimental and modeling aspects. Therfore, the applicant must be motivated showing a deep interest on these 2 aspects. Basic knowledge of polymer physics (or organic chemistery) would be a bonus.

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