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Comparison between Natural and Artificial Aging of Polyethylene Textiles for the Design of Mosquito-proof Shield Adapted to Tropical Environment

T. Pertin[1], A. L. Flory[1*], M. Adoue[1], J. Gustave[2], L. Romana[1]

[1]*Université des Antilles, Groupe de Technologie des Surfaces et Interfaces, Campus de Fouillole, 97159 Pointe à Pitre Cedex, French West Indies*
[2]*ARS Guadeloupe ARS, Bisdary, Guadeloupe, 97113 Gourbeyre*

*Corresponding author E-mail: anny.flory@univ-antilles.fr

This study is part of a project initiated by the French Agency, ARS (Agence Regional de la Santé) in Guadeloupe to fight against the spread of the mosquito Aedes aegypti in the past years. These mosquitoes are responsible for several major tropical diseases outbreaks such as the dengue fever, Chikungkunya and more recently Zika. The finality of this project is to design and manufacture a mosquito-proof shield product to prevent larvaes of mosquitos to develop in rain recuperation reservoir and thus to reduce the mosquito population and the infection risk. Such polymeric based screening needs to be mechanically resistant and durable under our tropical environment. Analysis of the durability of materials in natural conditions is very time-consuming therefore artificial aging is often used for material selection because of the shorter research time. However, in order to fully reflect the natural aging process, a good correlation between natural and artificial aging has to be established[1]. The use of aging chambers enables the control of UV radiation, temperature and humidity during artificial aging. Study of the effect of artificial aging requires careful design with regard to the environmental and operating conditions of the material. In Guadeloupe, materials are subjected to very severe tropical environmental conditions. In fact, these conditions are 80% more severe than Mediterranean climates and 40% more severe than subtropical climates (Florida). Therefore, reliable methods of accelerated aging to predict durability of polymeric materials in our specific severe environmental conditions needs to be developed. In this work, we compare the artificial and natural aging behaviors of a polymeric mosquito-proof shield candidate.

We investigate a commercial polyethylene net, i.e. PEG (Green color polyethylene). This material offers a high flexibility, is water permeable and has small enough meshes to prevent mosquitoes to reach the water contained in the reservoir. Artificial aging of this polymeric material was realized using an artificial UV aging chamber, the ARTACC[2] whereas natural aging was performed in Guadeloupe. The sample were aged up to 32 days in artificial chamber and up to 12 months in natural environment. Material aging is often characterized by changes in chemical and physical changes[3]. Here the chemical degradation of the polymer has been characterized by IRTF spectroscopy by following the evolution of the carbonyl index at the wavelength of 1750 cm^{-1}. The mechanical properties have been measured using of a universal traction testing machine. Specifically, the mechanical degradation of the polymer is measured by the evolution of the rupture force, F_{rupt}. An illustration of F_{rupt} is shown in Figure 1.

We found that as expected the kinetic of oxidation is faster in artificial aging than in natural aging. In fact, figure 2A shows an immediate and linear increase of the carbonyl index for the sample aged under artificial condition while no evolution was found for the sample aged in natural environment. The evolution of mechanical property is shown in Figure 2B. Under artificial aging, the rupture force remains constant up to 20 days and then decreases drastically down to 60N showing the mechanical degradation of the sample. Under natural aging, the rupture force remains constant up to at least 180 days. A slight decrease of F_{rupt} is observed at one year of natural aging. We define an accelerated factor as the ratio of the natural aging time to the artificial aging time required to reach a 20% decrease in the rupture force. This is indicated by the dotted line in Figure 2B. The value of the accelerated factor found here is high since it is close to 10. Also, it has to be noted that the slight mechanical degradation observed under natural aging does not seem to be related to the oxidation of the sample since the carbonyl index remains constant. This work shows that longer natural aging time than 1 year needs to be performed in order to compare aging under natural and artificial conditions.

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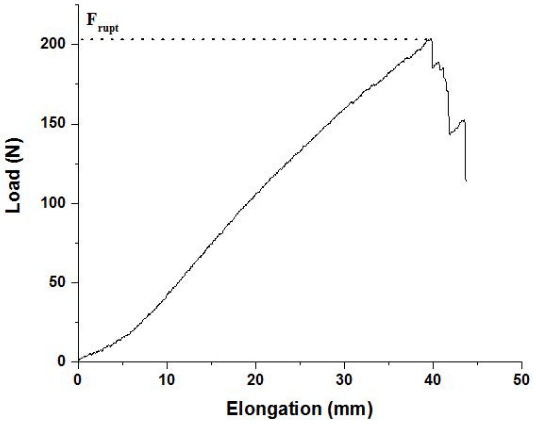
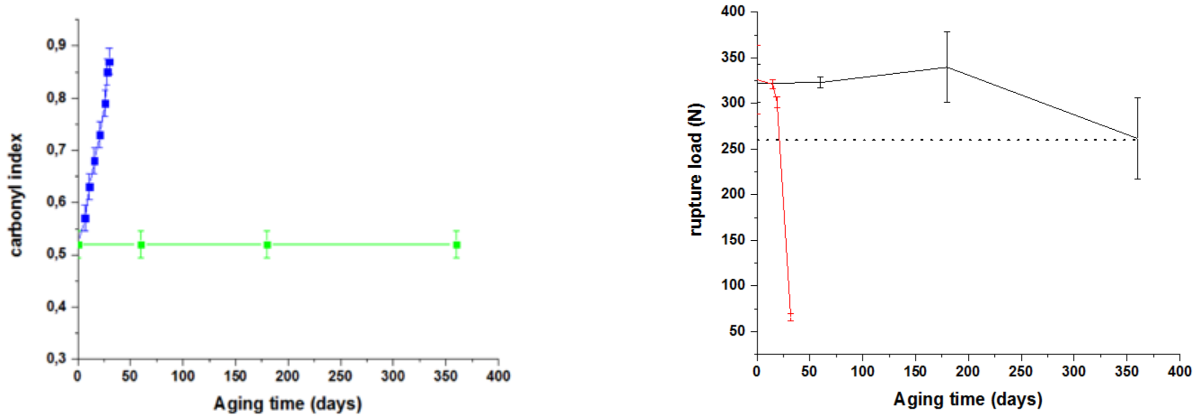


Figure 1. Typical Load –Elongation curve



A) B)

Figure 2. Evolution of: (A) carbonyl index as a function of aging time under artificial aging (blue) and natural aging (green), (B) rupture load as a function of aging time under artificial aging (red) and natural aging (black)