Ultra-violet degradation of machined and three-dimensional printed nylon

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Motivation

Nylon is a synthetic polymer often used in outdoor applications. Exposure to solar radiation and particularly, ultra-violet (UV) radiation causes deterioration of nylon material properties such as strength and ductility through a process called photodegradation (see Figure 1). The purpose of this study is to compare the differences in the UV degradation of injection moulded and 3D printed nylon. Due to limited research on the effect of UV radiation on 3D printed nylon, little is known about the rate of degradation of material properties. 3D printing is rapidly becoming a popular choice for manufacture of polymer parts and as use becomes widespread an understanding of the material degradation is important.

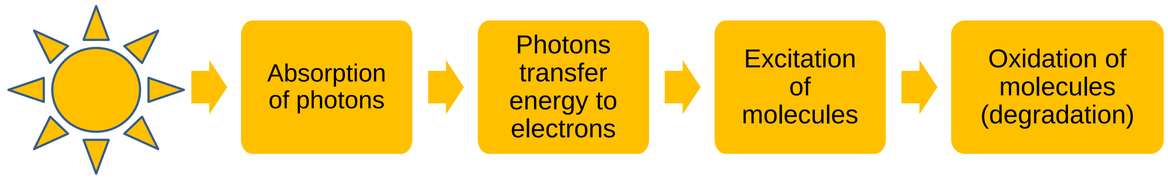


Figure 1: Polymer photodegradation as a result of exposure to solar radiation and oxygen.

Objectives

The objectives of the study are:

1. To determine the effect of UV radiation on the tensile strength of injection moulded and machined nylon and 3D printed nylon
2. To determine the relative effect of exposure to natural UV radiation and exposure in a xenon-arc accelerated weathering unit

Methodology

Figure 2 outlines the general process used to meet the study objectives. The accelerated exposure was conducted in the ATLAS Suntest CPS+, a xenon-arc weathering unit with a maximum irradiance output of 765W/m^2.

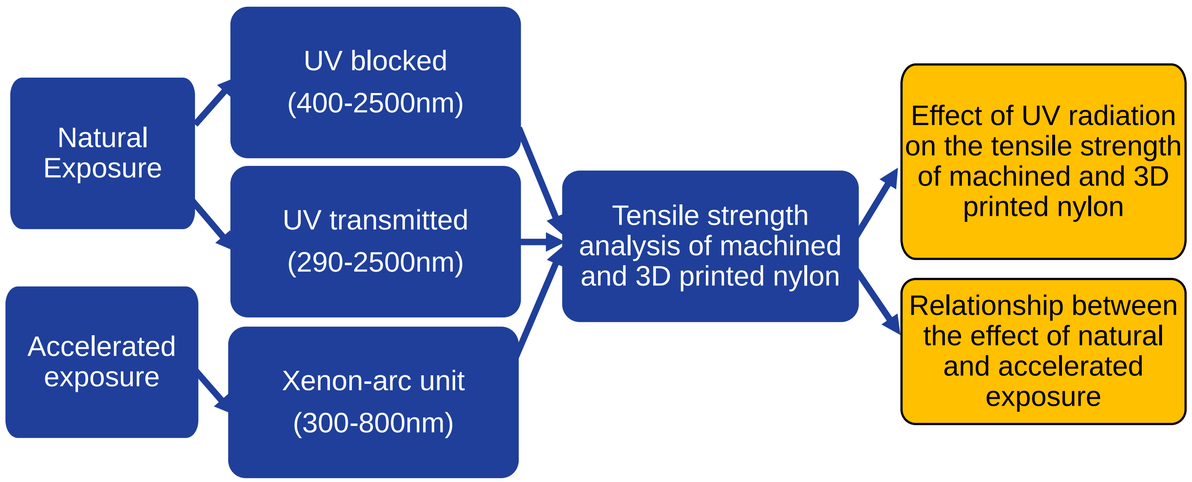
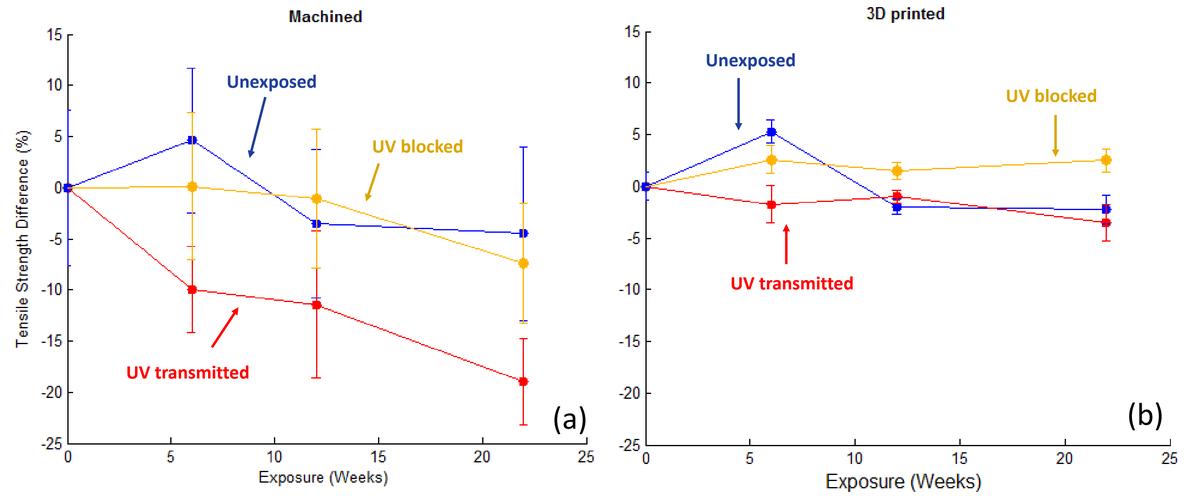


Figure 2: Overview of natural and accelerated exposure components of the study method.

Results and Conclusions

Significant findings from the natural exposure study (see Figures 3 a & b) :

- **Injection moulded and machined nylon exposed to the entire solar spectrum (UV transmitted) demonstrates a greater reduction in strength than nylon exposed to just infra-red and visible wavelengths (UV blocked).**
- **Overall, the 3D printed nylon does not demonstrate a significant reduction in tensile strength as a result of UV exposure.**



Figures 3 a & b: Tensile strength loss of the machined and printed nylon with UV transmitted, blocked and unexposed. Error bars represent standard deviation of measurements.

Machined and 3D printed nylon exposed in the xenon-arc unit also demonstrate a reduction in tensile strength. Comparing the natural (UV transmitted) and accelerated strength loss of nylon with respect to the total energy received from UV radiation (see Figure 4), the relative effect of the natural and accelerated exposure can be determined. It is apparent that the effects of both **accelerated and natural exposure on tensile strength are greater for injection moulded nylon than that produced by 3D printing.** The relatively insignificant reduction in tensile strength of the 3D printed nylon is likely due to the addition of UV stabilisers during the material manufacture.

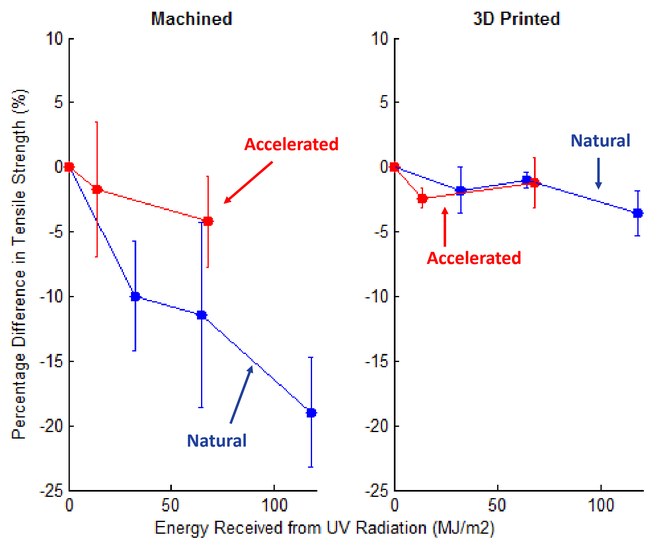


Figure 4: Percentage strength loss of natural (UV transmitted) and accelerated exposure nylon with respect to energy received. Error bars represent standard deviation of measurements