Transmittance analysis in sunglasses lenses following sun exposure

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Abstract: The hypothesis that sunglass ultraviolet (UV) protection can degrade with Sun exposure has never been proven experimentally. No sunglasses standards take into account UV transmittance changes after long Sun exposure. We selected 12 sunglass lenses and measured transmittance values from 280 nm to 780 nm. After 50 hours of exposure, new transmittance measurements were taken and transmittance variations inferior to 0.2% were observed. The exposition continues longer and more lenses will be tested to obtain conclusive results. We hope to obtain experimental data to confirm UV protection loss hypothesis and obtain a relation between Sun and solar simulator exposition.

Keywords: Sunglasses solar exposure; Sunglasses; UV protection; Sunglasses standards

1. INTRODUCTION

Sunglasses are widely used fundamentally for visual comfort, fashion and protective issues. There is a strong association between UV light exposure and at least 6 different diseases involving 3 different ocular structures (eyelid, cornea and crystalline lens) [1]. Eye's natural response to intense visible light is to reduce its exposure by closing the eyelid and constricting the pupil. When using dark lenses, visible light is attenuated and the natural response is not activated, with less visible light reaching the eye, the pupil does not constrict increasing eye's exposure, thus sunglasses with improper UV protection are dangerous [2]. There is a hypothesis that after long exposition to Sun sunglass lenses may lose their UV protection.

The brazilian standard NBR 15111:2013 specifies physical characteristics (mechanical, optical etc) for sunglasses and sunglare filters for general use [3].

The luminous transmittance or visible transmittance, τ_V, is defined as the mean of the spectral transmittance, $\tau_F(\lambda)$, between 380 nm and 780 nm weighted with the spectral distribution of radiation of day light (CIE Standard illuminant D65), $S_{D65\lambda}(\lambda)$, and relative spectral visibility function of daylight vision, V(λ), and it is calculated using Equation (1) [3].

$$\tau_V = \frac{\int_{380}^{780} \tau_F(\lambda) V(\lambda) S_{D65\lambda}(\lambda) d\lambda}{\int_{380}^{780} V(\lambda) S_{D65\lambda}(\lambda) d\lambda} \qquad (1)$$

The solar UV transmittance, τ_{SUV}, is the mean of the spectral transmittance, $\tau_F(\lambda)$, between 280 nm and 400 nm weighted with the solar radiation, $E_{s\lambda}(\lambda)$, at sea level for air mass 2 and the relative spectral effectiveness function for UV radiation, S(λ), and it is calculated using Equation (2) [3].

$$\tau_{SUV} = \frac{\int_{280}^{400} \tau_F(\lambda) E_{s\lambda}(\lambda) S(\lambda) d\lambda}{\int_{280}^{400} E_{s\lambda}(\lambda) S(\lambda) d\lambda} \qquad (2)$$

The solar UVA transmittance, τ_{SUVA}, is calculated using Equation 2 but integration interval between 315 nm and 400 nm.

Depending on visible spectral transmittance, lenses are classified into different categories and for each category there is a minimum required UV protection (Table 1) [3]. For being improper for general use, lenses with visible transmittance less than 3% are not classified into any category.

Table 1. Transmittance requirements for sunglass lenses for general use [3].

Lens category	Visible spectral range		UV spectral range		
	Range of luminous transmittance		Maximum value of spectral transmittance		Maximum value of solar UVA transmittance
	From over (%)	To (%)	280 nm to 315 nm	Over 315 nm to 350 nm	315 nm to 400 nm
0	80	100			
1	43	80		τ_V	τ_V
2	18	43	$0{,}1\tau_V$		
3	8	18		$0{,}5\tau_V$	$0{,}5\tau_V$
4	3	8			

Brazilian standard proposes a resistance-to-irradiation test in which category lenses could not change after 50 uninterrupted hours of irradiation by 450 W solar simulator. There are not any sunglasses standards that take into account UV transmittance changes after long Sun exposure or any previous experimental studies about transmittance variation by solar exposition.

The researchers of the LIO have developed an online survey to evaluate the sunglasses use conditions by the Brazilian population. Over 2000 people have been surveyed. Some questions were asked, for example where the person lives, person's degree of education and the time one takes to change or buy new sunglasses. Another important asked question was about how long was the daily wearing time of sunglasses. The results have shown that people used to wear the sunglasses for 22 days and 8 hours in summer, and 52.6% buy new sunglasses every 2-4 year. Based on the answers and estimations, it is reasonable to assume that the UV protection of sunglasses should last at least 2 years [4].

Our team is developing a device capable of automatically expose sunglasses lenses to the Sun [5]. The project consists of a panel with cover, housing 100 lenses fixed on a rotating axis, which will be irradiated by the Sun from sunrise until sunset. The lid opens and turns the panel towards the Sun automatically, so that the lens will always be facing the Sun. Humidity, dust, time and UV index sensors, as well as a video camera are part of the system. The exposure time and UV index will be recorded and automatic opening or closing the lid may also be controlled by a PC using online software.

In this study, we analyze UV and visible spectral range transmittance variation in sunglass lenses after long Sun exposition. We aim to obtain experimental data to confirm the hypothesis that sunglass lenses lose their UV protection after solar exposition. As secondary goal, we aim to compare Sun exposition and solar simulator exposition from transmittance variations.

2. METHODOLOGY

Twelve dark sunglasses (categories 3, 4 and without category) were selected for this study. Once our goal is to analyze variation in UV (280 nm - 400 nm) and visible transmittance (380 nm - 780 nm), initial transmittance values from 280 nm to 780 nm of the left lenses were measured using VARIAN Cary 5000 spectrometer. The right lenses were saved for future exposition on solar simulator. An acrylic frame and metal base panel as shown in Figure 1 were mounted to fix left lenses for exposition.

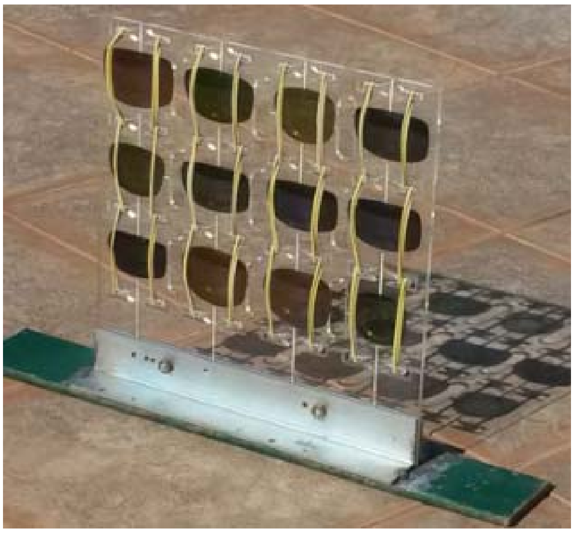

Figure 1. Lenses during Sun exposure.

Every 50 hours of solar exposition new transmittance measures are performed. The transmittance measures were performed in 5 different points of each lens. Lenses transmittance variation analyses are calculated using the free software GNU Octave v.3.8.2 [6].

3. RESULTS

After 50 hours of exposition small transmittance variations were observed. These variations were inferior to 0.2% of initial value for all wavelengths from 280 nm to 780 nm. Figure 2 illustrates percentual transmittance variation for measured wavelengths. This figure shows one lens' percentual transmittance variation for every wavelength from 280 nm to 780 nm. A negative value means transmittance increase in some wavelength and a positive one means transmittance decrease.

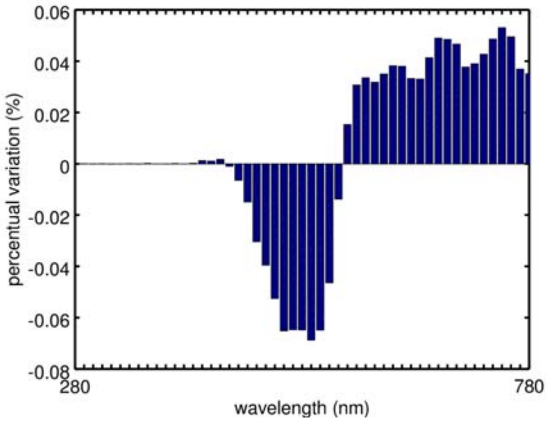

Figure 2. Percentual transmittance variation from 280 nm to 780 nm.

In 7 lenses, transmittance values increased for all wavelengths. In 4 lenses, transmittance values increased for some wavelengths and decreased for others. In only 1 lens, transmittance values decreased for all wavelengths.

This short solar exposition (50 hours) produced small transmittance variations.

4. CONCLUSION

In almost all lenses, transmittance values increased slightly for every wavelength. However, we could not trace a variation behavior tendency because not only the variations measured were little and number of lenses small but also we encountered different responses.

With more exposition time and more lenses tested, we hope acquire enough data to confirm the hypothesis that lenses lose their UV protection after long solar exposition. Furthermore, with these data and spectroscopy measures after solar simulator expositions of right lenses, we will be able to compare experimentally solar exposition and solar simulator exposition. Therefore we will obtain experimental data to analyze whether UV protection is lost after 2 years (1460 hours of use).

We are also developing an automated panel [5] to facilitate the exposure of the lens and the control over exposure.

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