Do brands and prices of sunglasses ensure adequate UV radiation protection?

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Abstract

The function of the human eye is to receive electromagnetic waves and transform them into electrochemical signals, which interpreted by the brain create the sense of sight. However, its capacity for withstanding radiation, especially the ultraviolet part of the spectrum, is limited and exposure that exceeds these limits can cause serious ocular damage. Sunglasses are so far irreplaceable when it comes to the photoprotection of the eye. According to popular opinion, the brands and high prices of the sunglasses are satisfactory evidence of adequate performance. The purpose of this study is to determine whether these criteria offer a correct evaluation of the sunglasses’ protective abilities and to emphasize on the importance of complying with the current sunglass standards (AS/NZS 1067:2003, EN 1836:2005, ANSI Z80.3-2008).

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1) Introduction

Ultraviolet radiation is the part of the electromagnetic spectrum consisting of wavelengths shorter than 400nm. Its absorbance by nucleic acids results in the formation of DNA photoproducts, mostly pyrimidine dimmers, which – if not repaired – can cause mutations or cell-death. [1, 2]

Macroscopically, unprotected exposure to UV radiation can cause many ophthalmological health issues, such as photokeratitis (also called ultraviolet keratitis), conjunctivitis, pterygium, cataract and solar retinitis. [1, 2, 3, 4]

Therefore, protecting the eyes as much as possible from exposure to ultraviolet radiation is essential. A pair of sunglasses is an obvious and potentially
adequate solution. However, there seems to be some confusion among people as to what should be one’s criteria in choosing one’s sunglasses.

It is generally accepted by the scientific community that a pair of sunglasses with merely dark-tinted lenses and no proper UV filters, decreases the amount of visible light reaching the eyes, causing dilation of the pupils, which, in turn, can increase the exposure of the crystalline lens and retina to UV radiation. [2]

Overall, there has been a strong tendency of relating the brands and prices of the sunglasses with the level of protection they offer, which is definitely in the market’s interest, even if it isn’t propelled by it, as some might claim.

The purpose of the following experiment is to investigate the existence of such relation.

2) Problem formulation

- Do the brand and the price of a pair of sunglasses guarantee satisfactory ultraviolet radiation protection?
- What are the basic steps in the proper use of a UV spectrophotometer?

3) Theory

i) Electromagnetic Radiation

The electromagnetic spectrum is consisted of ultraviolet radiation (UV or UVR), visible light and infrared radiation (IR or IRR), in order of descending frequency and ascending wavelength. It has been further divided into the following seven photobiological spectral bands by the CIE (International Commission on Illumination). [4]

![Fig.1 The electromagnetic spectrum](image)

Exposure to infrared radiation, once considered as very dangerous for the human eye, has proved to be less important for acute ocular conditions in comparison to the exposure to ultraviolet and short-wavelength visible radiation. Nevertheless, its filtration can be beneficial, if only by increasing comfort. [4]

Concerning ultraviolet radiation, UVC is the one carrying the highest energy and it would pose the greatest biological threat, had it not been almost entirely filtered by the ozone layer in the stratosphere. Almost 90% of UVB is, also, blocked by the ozone layer, while practically all UVA radiation reaches the surface of the earth. [2, 3]

ii) Current Standards

The ideal sunglasses, of course, should be able to filter all ultraviolet radiation, while allow the unimpeded transmission of visible light. [2]

The world’s first national standard for sunglasses for general use was issued by Australia in 1971. The standard was revised and reissued several times, finally leading to the AS/NZS 1067:2003 Sunglasses and fashion spectacles standard, which is quite similar to the respective European standard, EN 1836:2005. The first sunglass standard in the United States was published by the American National Standards Institute (ANSI) in 1972, the most recent version of which is ANSI Z80.3-2008. [3]
According to the latter, the lens of the sunglasses should have no more than 1% transmittance of wavelengths below 315nm (UVB) and no more than 50% of the visual light transmittance of UVA transmittance. [2]

This standard, however, is voluntary and manufacturers are not obligated to follow it or label their products in accordance to it. [2, 3]

**iii) Beer-Lambert law**

As the main purpose of this report is to compare the absorbance of branded and unbranded sunglasses, therefore it has also been considered relevant to introduce the Beer-Lambert law, in order to better understand how the parameters that determine the absorbance of a given set of sunglasses influence its absorption.

The Beer-Lambert law comes from the field of spectroscopy and it actually is a relation that describes the absorption of radiant energy by an absorbing medium. Formulated by German mathematician and chemist August Beer in 1852, it states that the absorptive capacity of a dissolved substance is directly proportional to its concentration in a solution (in this case, a solid solution, the sunglass lens). Furthermore, the absorbance of a substance is the ratio of the initial intensity divided by the final intensity that is registered. [5]

A general overview of the absorptive capacity can be mathematically described by a given experimental absorbance as follows:

\[
\ln \frac{I}{I_0} = \int_{l_0}^{l_1} \frac{dl}{l} \quad \text{Eq. 1}
\]

Where \( I \) being the initial intensity of the light from the UV light source, \( I_0 \) the final intensity of the UV light after it has passed through a cuvette, \( c \) the concentration of the solution and \( L \) the length of a cuvette.

According to Beer’s law, this capacity depends on the intensity of a given UV light source as:

\[
dl = -\varepsilon \cdot n \cdot I = -\varepsilon \cdot c \cdot I \cdot dx \quad \text{Eq. 2}
\]

\( \varepsilon \) being the coefficient of extinction of UV light

Then the absorption capacity can be extrapolated from both equations 1 and 2, where the general expression is known as:

\[
A = \log \frac{I_0}{I} = \varepsilon \cdot c \cdot I
\]

\( A \) being the ratio of the initial and the final measured intensities \( (I_0/I) \) directly proportional to the concentration \( c \) of the solution of the sample.
4) Materials and Methods

In order to meet the goal of this report, it has been considered sufficient to simply take a pair of sunglasses and a pair of conventional glasses as experimental samples.

The measurement of the baseline UV irradiance with the UV photometer, which is normally an important part of the process, had to be skipped due to lack of time. The number of samples taken for this experiment was also limited for the same reason.

The basic setup of the photometer machine that was used follows this basic sketch.

![Basic Sketch of Photometer Setup](image)

**Fig. 3** Note that the sunglasses of the sample in question must be located in the UV chamber and always covered in order to optimize the results of the measurement.

The experiment began with the measurement of an empty cuvette in the UV chamber in order to set a standard.

Then it proceeded to the measurement of the absorbance of the sunglasses. The same procedure was taken for the measurement of the conventional glasses.

Lastly, the data was downloaded to a USB stick, from where it was sent through e-mail to the group members for analysis.

5) Results and Discussion

The experimental results, limited to the study of one pair of sunglasses vs. one pair of conventional glasses, are summarized in two absorbance graphs, as follows:

![UV Absorbance Graph](image)

**Fig. 4** The graph shows the relationship between the different wavelengths from the UV-light source and their absorbance by the sunglasses. In the visible area of the spectrum (760 nm – 400 nm) there is very little absorbance, whereas in the ultraviolet region (>400 nm) there is an exponential increase of absorbance.

![Comparison of UV Absorbances](image)

**Fig. 5** The graph shows the different absorbance of the different specimens.

These measurements are just intended to be a qualitative understanding of the absorptive capacity of sunglasses.
The expertise that has been gained from this experiment can be used for the successful fulfillment of the future/updated experiment.

Furthermore, similar studies that have been made point towards the expected results of such an experiment.

Leow, Y. H. and Tham, S. N. published an article in 1995, regarding patients who undergo PUVA treatment and the eye protection they need. The adequacy of protection of 34 pairs of sunglasses was investigated and 21 of them were found effective. They, also, concluded that “Expensive brands [...] do not guarantee optimal uva protection”. [6]

Additionally, a study by Atul M. Dongre, Gitanjali G. Pai and Uday S. Khopkar on the protective properties of branded and unbranded sunglasses in UV phototherapy chambers, showed that all branded and 9 out of the 12 unbranded sunglasses that were tested provided over 80% reduction of UVA, while both branded and unbranded sunglasses were not effective enough in providing UVB protection. One branded pair of sunglasses offered low protection against UVB, and, finally, some unbranded sunglasses had low protective efficiency against both UVA and UVB. [7]

The above studies indicate a lack of specific correlation between the brands and prices of the sunglasses and their effectiveness in UV protection. Thus, it can be expected that this lack would be reflected by the results of a future/updated experiment.

6) Conclusion

Discussion about the danger of exposure to sunlight is most often concentrating on the possible skin damage, but the potential ocular hazard should not be neglected. Photoprotection can be achieved in many ways, including simple choices such as avoiding, or at least limiting, exposure to sunlight during the sun’s UVR peak (10 am – 4 pm).

Sunglasses do seem to combine protection, convenience and practicality, so long as they are selected with the appropriate criteria, which of course cannot emphasize on style and design. However, as it was shown in this report, these criteria can neither be limited to brands and high prices.

The optimal ocular protection can only be guaranteed by sunglasses that are manufactured according to the existing standards and that bring the corresponding markings.

7) References


