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Light transmission and ultraviolet protection of contact lenses under artificial illumination

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ABSTRACT

Purpose: To determine the spectral transmission of contact lenses (CLs), with and without an ultraviolet (UV) filter to evaluate their capacity for protection under UV radiation from artificial illumination (incandescent, fluorescent, xenon (Xe) lamps, or white LEDs (light-emitting diode)).
Methods: The transmission curves of nine soft CLs were obtained by using a PerkinElmer Lambda 35 UV–vis spectrophotometer. A CIE standard was used for the emission spectra of incandescent and fluorescent lamps, and Xe lamps and white LEDs were measured by using an International Light Technologies ILT-950 spectroradiometer.
Results: Five of the nine soft CLs analysed state that they incorporate UV filters, but the other four do not specify anything in this regard. The spectral transmission of all the CLs studied is excellent in the visible region. The CLs with UV filters filter out this radiation more or less effectively. Xe lamps emit a part in the UV region. Incandescent, fluorescent and white LEDs do not emit at all in the UV.
Conclusions: Incorporating UV filters is important when the illumination is from a Xe lamp since this light source emits in the UV region. This, however, does not occur with incandescent and fluorescent lamps or white LEDs. The CLs that do incorporate UV filters meet all the standard requirements that the U.S. FDA (Food and Drug Administration) has for UV-blocking CLs Class II (OcularScience, CooperVision and Neolens), and AcuvueMoist and HydronActifresh400 even comply with the stricter Class I. The CLs without UV filters let UVA, UVB and even some UVC through.

1. Introduction

The spectral transmission characteristics of contact, spectacle, and intraocular lenses have been studied widely with a view to analysing the protection they provide against ultraviolet (UV) radiation [1–7]. In the case of intraocular lenses, UV protection is imperative, as it substitutes the crystalline lens which is the basic filter that stops UV radiation from reaching the retina. This is not the case with contact and spectacle lenses, however, as these are external elements that are added to the visual system to compensate for vision defects; protecting the eye from all types of radiation is not their main function, although we believe it should be in all cases as a preventive measure.

The UV rays (300–380 nm) from solar light that affect the eye are mainly absorbed by the lens of the eye. Different studies reveal that this UV radiation is one of the main factors that induces the formation of cataracts [8,9] and that chronic exposure to UV can cause damage to the anterior structure of the eye, which can range from minor (pterygium) to serious (photokeratitis) [10]. Moreover, although in only a very small proportion, UVA radiation [11] can reach the retina. Age-related macular degeneration (AMD) has been associated with prolonged exposure to sunlight [12] which is why it is important, from a clinical viewpoint, to advise that both spectacles and CLs incorporate ultraviolet filters that can help prevent, or slow down, the appearance of cataracts and other eye diseases. The American Optometric Association (AOA) recommends the U.S. Food and Drugs Administration (FDA) standard for UV-blocking CLs based on the American National Standard Institute (ANSI) Z80.20 standards [13]. The CLs that incorporate UV filters not only significantly reduce the amount of such radiation that reaches the surface of the eye, but they also have the

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Table 1
Characteristics of the nine soft contact lenses measured in this study. All the lenses were made of silicone hydrogel with different water contents. The PureVision lens is multifocal (−1.50 sph, −0.75 cyl).

Contact Lens	Manufacturer	Material	Water (%)	Power	UV Filter
AcuvueMoist	Jonhson&Jonhson	EtafilconA	58	−4.00	Yes
55YV	OcularScience	OcufilconD	55	−1.00	Yes
Dailies	Alcon	NelfilconA	69	−3.00	No
CooperVision	CooperVision	OcufilconB	52	−3.00	Yes
Extreme	Hydrogelvision	Hioxifilcon	54	−3.25	No
HydronActifresh400	Hydron	LidofilconA	73	−0.50	Yes
Neolens	Eurolent	OcufilconD	55	−1.50	Yes
PureVision	Bausch&Lomb	BalafilconA	36	−1.50	No
AirOptix	Ciba Vision	Lotrafilcon	33	−3.25	No

advantage of protecting the areas of the eye from radiation that comes from above or around the sides of sunglasses, as they cover the whole pupil.

Nevertheless, most of the studies that analyse the action of UV radiation on the visual system assume that the light that affects the eye is solar light. Obviously this is often the case, but we are not always under solar light since in the workplace and at home we spend much time under artificial lighting (incandescent, fluorescent, white LEDs (light-emitting diode) and xenon (Xe) lamps). The emission of artificial sources is not the same as that of the sun, therefore the protective filters different ophthalmological elements should incorporate should also be adapted to such sources [14]. Moreover, it is also important to take photoprotection and photoreception into account, since in addition to protecting the retina from harmful radiation, the filters must let the radiation through that allows the phenomenon of vision to take place under favourable conditions [15].

The most commonly used artificial sources, until now, have been fluorescent lighting (in the workplace) and incandescent bulbs (at home). However, at present, the use of Xe lamps, and particularly the use of white LEDs, is increasing throughout the world because of their efficiency and low consumption of energy.

In this study we determine the spectral transmission of different CLs experimentally, starting at 200 nm with a view to covering the UVA and UVB spectrum. Then, taking into consideration the emission spectra of artificial light (incandescent, fluorescent, Xe lamps, and white LEDs) and solar light for comparison purposes, we determined the area of the spectrum of these light sources that each of the CLs filters. Finally, we analysed the results to determine the photoprotection and photoreception each CL provides.

2. Methods

The spectral transmission curve of nine soft CLs was measured. All the soft lenses were made of silicone hydrogel with different water contents. Table 1 shows the characteristics of the nine CLs used in this study.

The transmission curves were obtained by using a PerkinElmer Lambda 35 UV–vis spectrophotometer and following the ISO (International Standards Organization) norms for measuring transmission in ophthalmic lenses [16]. This apparatus can measure the spectrum from 200 to 800 nm, which means that spectral transmissions in UVA, UVB, and part of ultraviolet C (UVC) are accurately determined (precision is up to 1 nm). The air was taken as a reference to measure transmittance. As in the case of Walsh et al. [17], we measured the transmission of the CLs in air. For this we exchanged the quartz cuvette that is generally used in the spectrophotometer for a lens holder specially designed for this purpose that fits perfectly in the spectrophotometer. This lens holder is made of aluminium and has a 6 mm diameter hole into which the CL is placed. The CL had previously been cut with a trephine (punch) so that it would fit exactly into the hole of the lens holder. Three lenses of each type were used to carry out the measurements and calculate the mean values.

Contact lenses are exposed to solar light and artificial lighting, usually incandescent lamps and fluorescent bulbs, however nowadays they are also exposed to Xe lamps and white LEDs. For solar light we used the relative spectral power distribution curve of daylight (NASA standard data of spectral irradiance ($W\,m^{-2}\,\mu m^{-1}$) for the solar disk at the Earth's surface at air mass 2) which is the D65 [18] of the Commision Internationale d'Eclaraige (CIE) standard. For incandescent lamps we used a CIE standard A

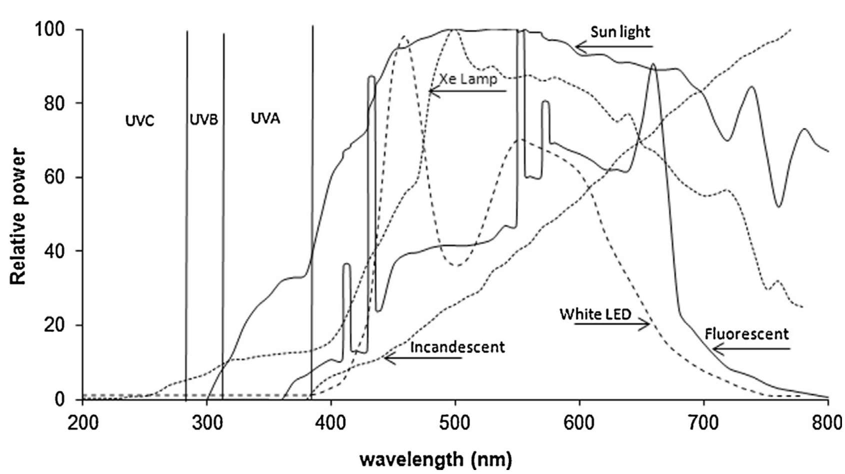

Fig. 1. Relative spectral power distribution curves of the illuminants used in this study.