ZEISS UVProtect: Protection against Harmful UV Radiation, Even with Clear Eyeglass Lenses

As scientific and medical evidence have demonstrated, there are many ways that ultraviolet radiation (UVR) can cause damage on and in the eye as well as on the eyelids. In the daylight, we are exposed to varying high doses of UVR throughout the year without being aware of it. UV exposure is omnipresent regardless of whether we face the sun or not, or whether the sky is clear or cloudy. Premium sunglasses are not the only source of significant protection against UV rays: clear eyeglass lenses offer this, too. However, unlike high-quality sunglasses or self-tinting lenses, the materials used for the standard clear lenses do not fully absorb the most intense portion of solar UVR on Earth – the solar spectrum between 380 nanometers (nm) and 400 nm. This has led a major protection gap. ZEISS has successfully modified the lens materials currently used for clear eyeglass lenses so that these absorb and filter harmful UVR effectively up to 400 nm without limiting the clarity of the lens. ZEISS UVProtect ensures that all clear plastic lenses from ZEISS provide full protection against hazardous UVR.

Solar UVR and UV exposure

Short-wave, high-energy ultraviolet radiation is found on the electromagnetic spectrum between X-rays and visible light. Along with the risks, UVR also positively impacts human health, such as by triggering vitamin D production in the skin. However, UVR exposure does not benefit the eyes or the surrounding tissue. It can lead to premature aging of the skin (photoaging) and degenerative processes in the crystalline lens (cataract). Moreover, it can cause cancer of the eye (e.g. malignant uveal melanoma) or of the periorbital tissue, such as on the eyelid. For most people, the problem is daily exposure to natural UVR outdoors, i.e. sunlight constitutes the major source of UVR and visible light.

Several atmospheric, geographical and geometric factors affect how UVR reaches the eye and the surrounding tissue. Even on hazy or partially cloudy days, people can still be exposed to a significant amount of UVR. Even though UVR is typically at its most intense around noon, the risk of UV exposure for the eyes and periorbital tissue is actually greatest in the mornings and afternoons. The reason: during these periods, the sun is not as high up in the sky and can reach a person's face or eyes directly or as a reflection. The less direct, scattered radiation caused by atmospheric molecules and aerosols are an additional source of ocular UVR exposure.

All the recognized international health organizations, especially the WHO (World Health Organization) and national standards committees like the ISO (International Organization for Standardization) or the IEC (International Electrotechnical Commission) reference the upper exposure limit of 400 nm for UVA radiation defined by the CIE (International Commission on Illumination) in the 1930s. The EN-ISO standard for eyeglass lenses [1] constitutes an exception both in practice and in industry, setting the upper limit for UVA radiation at 380 nm. This definition, however, leaves out 40 percent of the solar UV spectrum that reaches the Earth (Figure 1) in the band between 380 and 400 nm. By way of contrast, the rigid Australian / New Zealand Standard [2] for sunglasses sets the regular upper limit values for UVR at 400 nm.

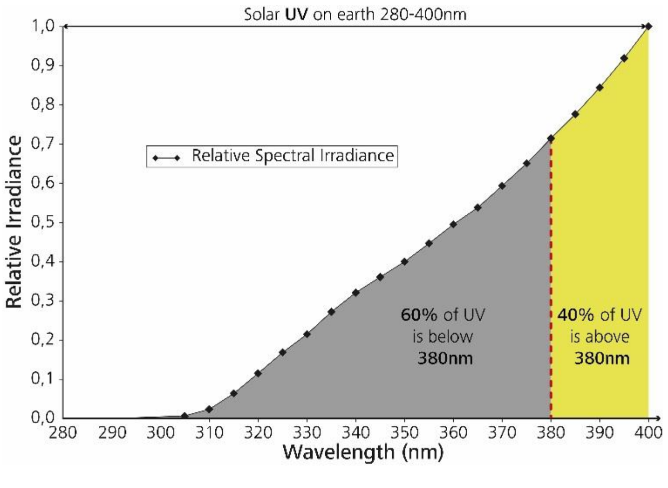

Figure 1: Solar UV spectrum as per DIN EN ISO 8980-3 normalized to the radiation value at 400 nm wavelength.

[1] DIN EN ISO 13666:2012 - Ophthalmic optics - Spectacle lenses - Vocabulary

[2] AS / NZS 1067:2003. Australian / New Zealand Standard ™ Sunglasses and fashion spectacles

ZEISS eyeglass lenses reduce UV exposure to a minimum

A pair of eyeglasses can block a substantial amount of UVR depending on different factors like the size of the lenses, their distance from the wearer's face and the UV absorption of the lens material, thereby reducing the eye and surrounding tissue's exposure. It is important to ensure maximum absorption for the UVR hitting the lens from the front.

The reason for this become apparent if you consider that the eye's level of exposure depends on the direction in which UVR moves. There are three ways UVR reaches the eye: by traveling through the lens, through potential reflections on the reverse side of the lens, and by passing between the frames and the skin (Figure 2). Leaving aside the fact that typically five to eight percent of the eye's exposure is the result of UVR that passes between the frames, lenses and skin, then the ratio of the remaining UVR hitting the lens from front and reverse sides is 20:1.[3]

Thus it is obvious that the absorption of UVR in the eyeglass lenses themselves has the greatest impact on just how well the wearer's eyes are protected. A UV anti-reflective coating on the reverse side of the lens can also reduce reflections: it guides the portion of UV radiation inside the lens, where it is absorbed. Yet the absolute portion UVR hitting the back of the lens is minimal. A lens material that absorbs nearly all UVR contributes significantly to UV protection.

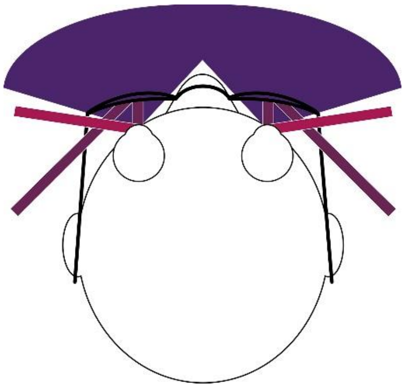

Figure 2: Diagram of the angles (2D projection of head from top) showing the direction of radiation as it travels toward the eye

Lenses with UV absorption resemble self-tinting lenses, except that the invisible UV-absorbent molecules in the organic eyeglass lens material are stimulated by UV energy, causing them to oscillate. This energy is ultimately transformed into heat without impacting the lens transparency whereas, with self-tinting lenses, the UV-absorbent molecules temporarily alter their shape and reduce the transmission of light, i.e. tint the lens.

The lens material and a dedicated UV anti-reflective coating for optimum protection are the hallmarks of ZEISS UVProtect lenses. Thanks to the highly effective absorption of UV radiation in the lens substrate, the ultimate goal is to guide all UVR into the lens – either from the front or the back. This protective combination on the front and reverse side of the lens keeps UV exposure to a minimum.

Damage and diseases caused by UVR

The penetration depth of UVR in the tissue and hence in the interior structures affected by UV radiation depends largely on the wavelength (Figure 3). The types of damage caused by UVR are typically divided into two categories: acute and chronic. Chronic damage and the diseases that follow as a result are generally caused by UV exposure over a long period of time. However, sometimes a single or just a few occurrences are sufficient for this damage to manifest itself after a longer period of time, as is frequently the case with cancer. Chronic damage is often considered particularly insidious because it progresses very slowly, and the person affected typically does not notice the changes.

[3] Rifai, Katharina, et al. "Efficiency of ocular UV protection by clear lenses." Biomedical optics express 9.4 (2018): 1948-1963.

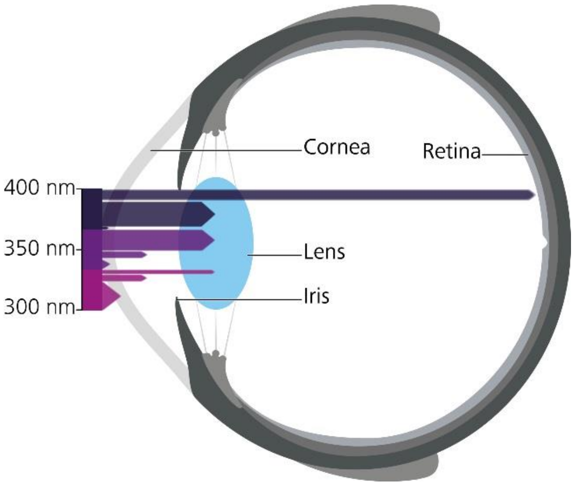

Figure 3: Diagram of the penetration depth in the eye based on different UVR wavelengths

Chronic illnesses include:

- Photoaging, i.e. the premature aging of the skin (wrinkles), and early-onset degenerative effects caused by repeated exposure to the sun
- Cancer in the eye and on the eyelids: according to the German Cancer Society (DKG), UVR is one of the most frequent causes of changes to the skin on the eyelids. Five to ten percent of all skin cancer cases are located on the eyelids.
- UVR can cause a clouding of the lens (cataract) and, in many cases, accelerate this process by several years. If it goes untreated, the patient runs the risk of going blind. Yet even before a cataract is diagnosed, UV radiation can alter a person's vision by reducing contrast or color perception.
- UV-induced degeneration or damage to the retina have not been scientifically proven and remain the subject of clinical research. However, it cannot be ruled out that long-wave UVA, which penetrates deep into the eye, does not have a negative effect.

Why ZEISS is challenging the 380 nm limit

In particular plastic clear lens materials with a low to medium refractive index generally provide UV protection up to 360 nm and 385 nm. Lenses with a high refractive index as well as self-tinting, photochromic lenses generally feature a very high level of UV protection for wavelengths of between 395 nm and 400 nm.

The danger of UVR in the 380 nm to 400 nm range, which has the highest intensity within the UV spectrum on the Earth's surface, is real. Even if the risks in the long-wave UVA range are less likely to cause acute damage like erythema or DNA damage potentially resulting in skin cancer, patients and society have a vested interest in reducing the long-term risks of aging and the degeneration of the structures in the skin and the eye.

The ISO standard currently stipulates 380 nm as the upper limit value for UV protection in eyeglass lenses. This was a pragmatic choice from the standpoint of the ophthalmic industry, but it does not reflect biomedical realities. This is why, for example, for years the Australian / New Zealand Standard for sunglasses is respecting the upper UVA limit at 400 nm.

Materials research along with the requisite manufacturing technologies now make it possible to close this gap in UV protection in clear organic eyeglass lenses. Thus, ZEISS Vision Care has made the conscious decision to modify its clear plastic lenses so that these offer full protection against harmful UVR in line with the stringent Australian/New Zealand Sunglass Standard – without significantly compromising the transmittance of visible light or altering the look of the lens from the wearer's perspective.

Conclusion

No modification has been made to the ISO standard for clear eyeglass lenses yet, and every day lenses continue to come to market, many of which have a low refractive index that allows potentially dangerous UVR to pass through. However, recent documents and reports indicate that standardization committees have begun to discuss the issue of 380 nm versus 400 nm.[4]

The research community focusing on UV damage welcomes a potential improvement to the protective standard for patients and consumers. Harmonizing the standard for clear lenses with the UV protection standard for sunglass lenses with an upper UVA limit of 400 nm would be seen as a positive step forward by the entire eye care industry.

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[4] ISO/TR 20772:2018 Ophthalmic optics — Spectacle lenses — Short wavelength visible solar radiation and the eye