ZEISS Platinum Blue Light Protector.

Protecting our eyes from potentially harmful blue-violet light.

Light is necessary for vision and physical health. High-energy visible light in the blue and violet end of the spectrum may contribute to the development of certain retinal diseases or even directly damage the retina. But there is compelling evidence that blue light plays an important role in the regulation of circadian rhythms and therefore may affect sleep patterns. ZEISS Platinum Blue Light Protector is designed to reduce the harmful effects of blue-violet light while preserving the healthy effects of longer wavelength blue light.

The Benefits of Light

Our vision evolved in a world illuminated solely by the sun, enabling the human eye to develop a sensitivity to available daylight. Direct light from the sun and sunlight reflected from clouds and the atmosphere provide a spectrum that is relatively uniform throughout the range of wavelengths that we can see, between 390 to 700 nm. The longest wavelengths are perceived as red, and shorter wavelengths follow the familiar colors of the rainbow through orange, yellow, green, blue and violet.

In daylight our vision is most sensitive to green wavelengths of about 550 nm while at night our vision shifts its sensitivity to blue-green wavelengths of about 510 nm. This so-called Purkinje Shift is due to the different sensitivities of the light-receiving “photoreceptor” cones of the retina responsible for daytime vision and the photoreceptor rods responsible for night vision[1,2].

Although the retina has three kinds of cones, it has only one type of rod. The three cones give us the ability to see finely detailed patterns and to perceive many different colors. Working together the three cone types comprise “trichromatic vision” in the same way that a color video camera works. Like a color camera, the cones require a lot of light to work properly, so they work best in daylight. In contrast, night vision is color-free and therefore “monochromatic” because of the single type of rod. Rods act like a black-and-white video camera, and are much more sensitive in low levels of light. Both classes of photoreceptors can be active at the same time; for example, we can see color at night if an object is illuminated with sufficient light, even if overall illumination levels are quite low.

The varying sensitivities between the photoreceptor types to different wavelengths of light are shown in the following graph (Figure 1)[3]. The rod receptor curve is plotted as a dotted black line, while the Short (S), Medium (M) and Long (L) cone photoreceptor curves are shown in blue, green and red.

The wide separation of the three cone responses shows that the entire visible light range of wavelengths contributes significantly to color vision. In contrast, rods respond best to a much narrower range.

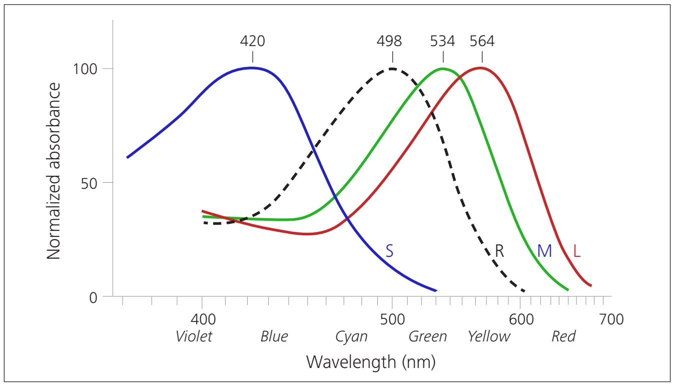

Figure 1. Spectral response of rods and cones

For many generations scientists thought the retina had only these four photoreceptors. A fifth type of light receptor was discovered in the retina in the last decade. These intrinsically photosensitive retinal ganglion cells (ipRGC) are sensitive to light falling on the retina, but do not contribute directly to the sensation of vision. The maximum sensitivity of the ipRGC is at approximately 470 to 480 nm, lying between the S-cone peak at 420 nm and the rod peak at 500 nm. This range of wavelengths is located in the part of the spectrum that we see as blue (Figure 2)[4].

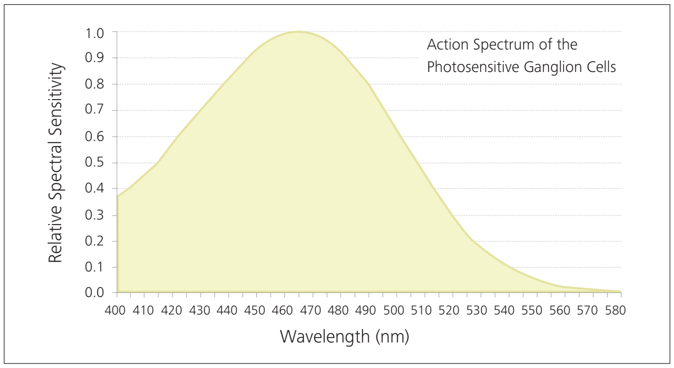

Figure 2. Relative spectral dependence of the ipRGC action spectrum

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We make it visible.

One function of the ipRGC appears to be the control of pupil size. Working together with the S cones, they act like a dimmer control to regulate the amount of light reaching the retina. The ipRGC also provide a control for our biological clock. Known as the "circadian rhythm," this clock regulates the secretion of the hormone melatonin into the bloodstream. When very active, the photosensitive ganglion cells contribute to higher levels of alertness and may contribute significantly to more effective visual learning.

There is compelling scientific research showing that inadequate exposure of the photoreceptive retinal ganglion cells to blue light may aggravate many common age-associated problems, including sleep disorders, depression, and impaired cognitive function.

Because of these findings, it has become apparent that blue light plays an important role in several important elements of health and well-being[5, 6].

Blue Light Also Can Damage the Retina

Doctors have known for a long time that eyesight can suffer permanent damage from very bright light. For example, "solar retinopathy" can occur by staring too long at the sun. This kind of damage is caused when the retina is overheated by intense light focused on the retina through the optics of the eye, just as a magnifying glass can be used to concentrate the sun's light to set a piece of paper on fire. Known as a "thermal hazard," the effect can be caused by any wavelength of light that is transmitted by the eye.

Several decades ago, scientists discovered that blue light is potentially more damaging to the retina than other colors[7]. The hazardous blue light (approx. 390 to 500 nm) is also known as high energy visible light (HEV) (Figure 3).

The energy of an individual photon of light is in inverse proportion to its wavelength. But energetic blue photons do more damage than one would expect simply from thermal energy effects alone.

It is now understood that this effect is a "photochemical hazard," caused by changes to molecules in the retina that result in toxic reactions. Standards have been developed to ensure that people are not exposed to excessive levels of blue light. Such standards refer to the necessary safety analysis as an assessment of the Blue Light Hazard (Figure 4)[8].

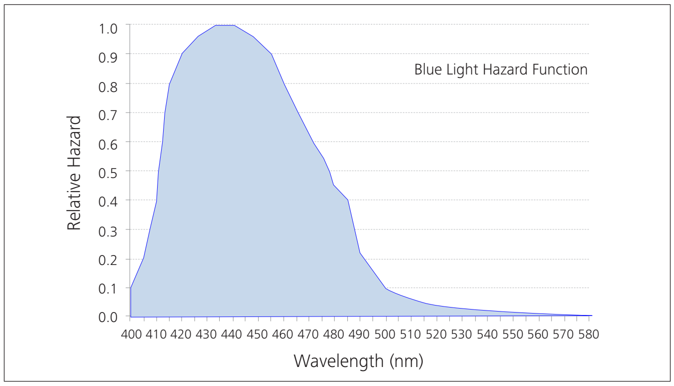

Figure 4. Relative spectral dependence of the Blue Light Hazard

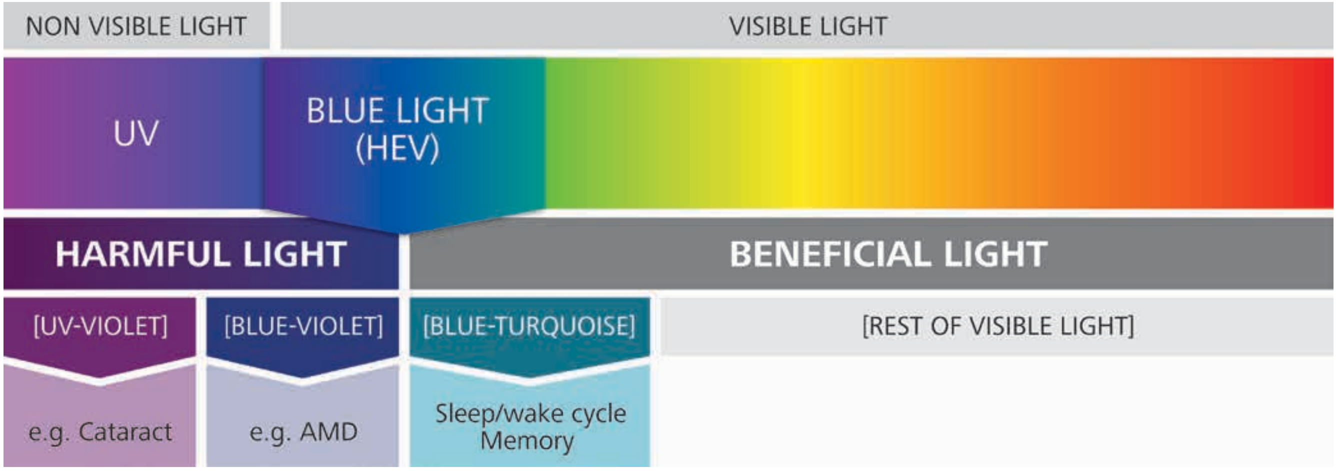

Figure 3. Light spectrum and wavelength–related effect on the human eye and metabolism

The Blue Light Hazard function spreads roughly from 390 to 510 nm. The full width at half maximum (FWHM) is about 70 nm with a peak value around 440 nm.

Some scientists think that the Blue Light Hazard may be a significant contributor to the development of age-related macular degeneration (AMD), although this is controversial. It appears that the aging retina is less able to repair and protect itself against the toxic oxidative products caused by short-wavelength blue light exposure[9-12].

Dualism of Blue Light

Because it is involved in both beneficial and harmful ocular effects, the blue light spectrum cannot be labeled simply good or bad. ZEISS refers to this as the "dualism of blue light." If we are to mitigate the risk of eye damage, we must do this very carefully so that we do not cause a different kind of problem.

For example, in the past some lenses contained light absorbers to reduce most or all blue light. If this approach is taken without careful thought, two problems may occur. The first is that blue-blocking lenses can make the world look intensely yellow or orange. Generally, such lenses are not tolerated very well. The second problem is that removing all blue light with lenses might reduce the ipRGC response so much that melatonin is secreted by the pineal gland during daytime, making the lens wearer drowsy and inattentive.

Thus, we are faced with a balancing act. On one hand we want to protect the retina from unnecessarily high levels of blue light. On the other hand we do not want to interfere with the natural diurnal cycle of alert activity and restful sleep.

The band between 440 and 460 nm exhibits the greatest overlap between the beneficial and harmful effects of blue light and therefore is called the transition zone (Figure 5).

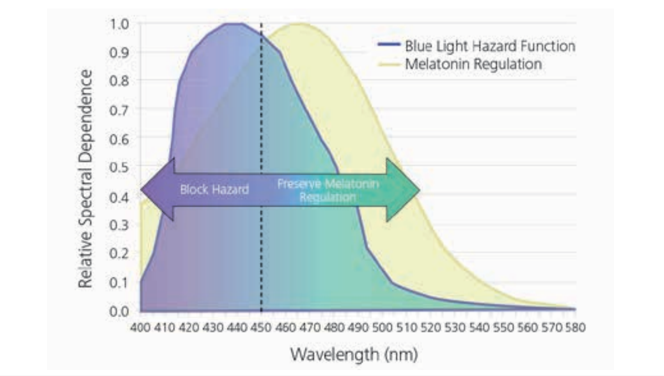

Figure 5. Managing the dualism of blue light

Problems Caused by Artifical Lighting

As the role of ipRGC in circadian rhythm has become clearer, new concerns have been expressed about artificial lighting. The latest artificial light sources such as white light-emitting diode (LED) lamps, color visual displays and even fluorescent lights emit much more blue light than traditional lighting, and may suppress melatonin secretion at night[13]. This is the other side of the problem of too little blue light during daytime; at night we do not want very much blue light or we may not be able to sleep. This is an unintended consequence of the movement toward more efficient light sources and high quality color visual displays.

When humans mastered fire, it provided light to see inside of their homes. A fire has a temperature of about 1,200 K. When an object is heated its color progresses from red to yellow and then white. The lower temperature of fire (much lower than the sun's surface temperature of about 6500 K) means that it emits more energy toward the longer wavelength red light and relatively little blue light.

As technology advanced and artificial light sources were created, the lamps that were used to light our homes operated at a temperature that is hotter than fire, about 2650 K. The light produced was pleasing and natural looking, whiter than fire but not nearly as white as the sun. Incandescent lamps therefore also did not produce very much blue light.

Further advances in technology created fluorescent lamps. These lights produce a plasma, emitting intense energy in the ultraviolet, violet and blue wavelengths. This stimulates a coating on the inside of the glass tube to fluoresce, converting energy into visible light. Fluorescent lights can be as white as daylight, producing much more blue light than incandescent lamps. They also directly emit some of the ultraviolet and violet-blue light generated by the plasma.

Both incandescent and fluorescent lights are being gradually eliminated because they create problems for our environment by being inefficient or containing toxic substances. The most advanced type of lamps today contain tri-color LED sources which produce a broad spectrum of light that appears as white as sunlight, and they emit a lot of energy as blue wavelengths. In addition to illumination devices, our technology has developed white light displays for visual information. The latest screens in smartphones, tablets, television and computer monitors are not only in higher-resolution than their predecessors, they are also much brighter and emit more blue light (Figure 6).

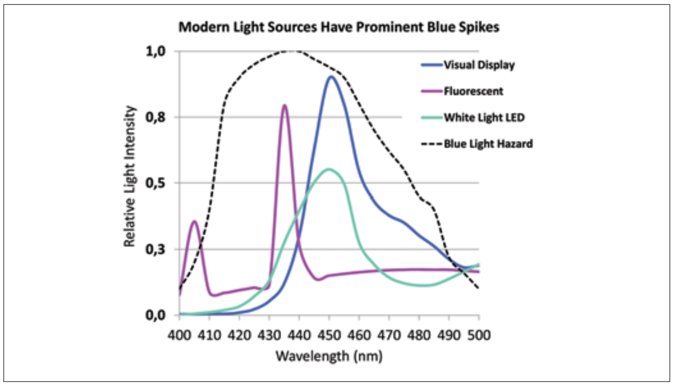

Figure 6. Relative power spectrum for various light sources

The shift toward brighter and bluer artificial light sources has combined with changes in social behavior causing many people to spend more time during the evening using such devices. Many experts are sure that this trend is responsible for an increasing prevalence of sleep disorders[14].

Eye Protection Concept of ZEISS Platinum Blue Light Protector

When designed and used properly, modern light sources for indoor illumination and visual displays are safe and do not directly damage the retina.

At the same time, eye care professionals may be concerned that excess blue light can combine with other risk factors for retinal disease, and that frequent use of modern artificial light sources at night can disrupt sleep. It therefore may be desirable to attenuate blue light.

But the dualism of blue light tells us not to eliminate its beneficial effects. Fortunately, it is known that the melatonin-activating ipRGC are more sensitive to bluish-green light, while the more toxic wavelengths are shorter. The most damaging light may be described as blue-violet. Furthermore, modern light sources also have peaks at wavelengths shorter than the maximum ipRGC response, so it is possible to selectively reduce those shorter blue-violet wavelengths to alleviate the worst effects on sleep.

ZEISS has carefully considered this balance and has tuned the filtering characteristics of its new ZEISS Platinum Blue Light Protector to deflect the most harmful wavelengths without interfering with circadian rhythm.

Its excellent light transmission throughout the rest of the visible light range means that ZEISS Platinum Blue Light Protector is an exceptional anti-reflective coating, affording very high luminous transmittance. All lenses that selectively filter blue light must pass more yellow light, but the low yellow index of ZEISS Platinum Blue Light Protector confirms that this color shift has been carefully managed and will not affect color vision.

ZEISS Platinum Blue Light Protector passes almost all light in the visible light range of wavelengths longer than 460 nm, while significantly reducing the amount of hazardous blue-violet light below 440 nm. Figure 7 illustrates the reflection of some specific portion of the light spectrum on the front surface of the lens.

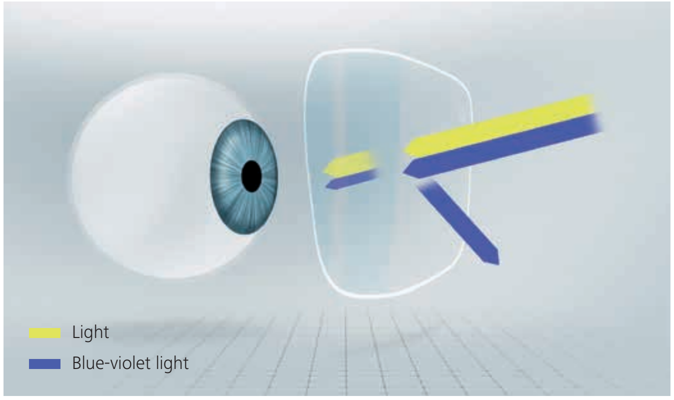

Figure 7. Blue light reduction by selective reflection

ZEISS believes that its approach represents a scientific and rational management of blue light, providing natural, true color vision while reducing potentially damaging light that is not necessary for good vision or health.

ZEISS Platinum Blue Light Protector

Eyecare professionals emphasize the need for anti-reflective coatings to deliver more than just optimum light transmission. They also have an expectation for excellent scratch-resistance and cleanability. The thin-film scientists at ZEISS have continued to explore new developments in vacuum deposition and materials science.

Anti-reflective coatings incorporate thin, brittle layers of ceramic metal and semi-metal oxides to achieve the required variation of refractive index. Significant differences exist between the physical properties of these coatings and the relatively soft, plastic lens substrate, including differences in elasticity, hardness, and the rates of expansion under pressure or during temperature changes.

ZEISS Platinum Blue Light Protector delivers exceptional, long-lasting durability by utilizing a system of integrated coating layers that have been engineered for maximum compatibility and robustness (Figure 8).

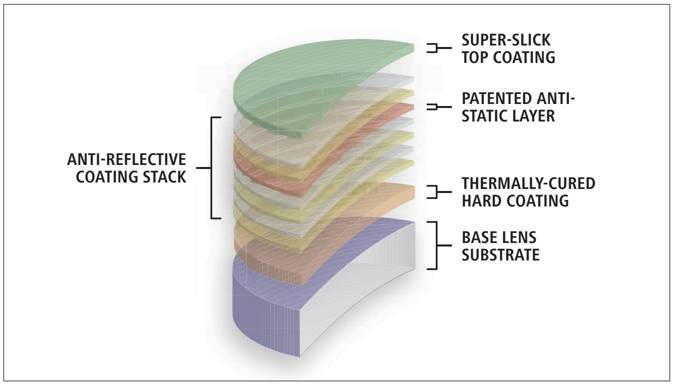

Figure 8. ZEISS Platinum Blue Light Protector is an integrated system of precisely applied coating layers

The foundation layer of the ZEISS Platinum Blue Light Protector is a thermally-cured hard coating that has been engineered from an organosiloxane resin with microscopic particles of colloidal silica — the chief ingredient in glass — dispersed throughout its matrix. The addition of mineral-like silica to the synthetic coating resin increases abrasion resistance while promoting adhesion and mechanical compatibility between the relatively brittle anti-reflective layers and the more pliable plastic lens substrate.

The durability of the ZEISS Platinum Blue Light Protector has been maximized through the use of ion-assisted deposition. During the application of the AR layers, the lens is bombarded with high-energy ions from an inert gas as the AR materials condense on the surface, transferring the momentum of the ions to the coating molecules. This results in more densely packed coating layers with stronger adhesion (Figure 9).

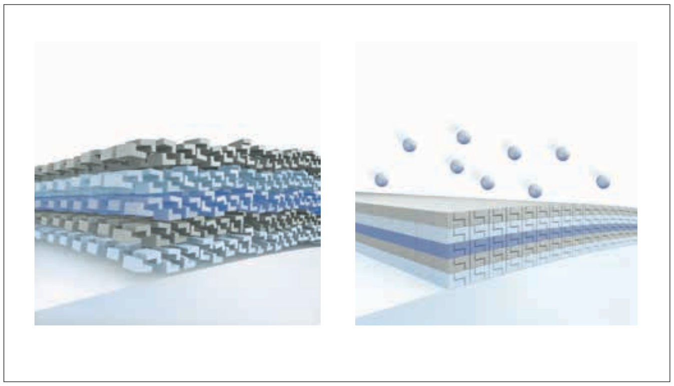

Figure 9. ZEISS Platinum Blue Light Protector (right) is more densely packed using ion assisted deposition

The integrated layers of the ZEISS Platinum Blue Light Protector are sealed with a final top coating layer that provides a protective barrier against the environment, while also producing a super-slick surface that is easy to clean — and keep clean. Fluids therefore bead up on the surface, instead of clinging to it. This beading action is described by the contact angle of the lens or coating surface, which is the angle that the edge of a droplet of water makes with the surface. Because the ZEISS Platinum Blue Light Protector has a higher contact angle, the coating repels smudges, water, and oil better than standard AR coatings (Figure 10)[15].

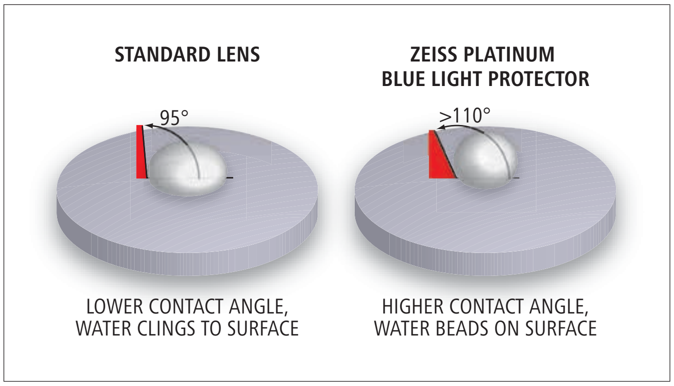

Figure 10. ZEISS Platinum Blue Light Protector (right) has a higher contact angle than standard lenses (left)

The ZEISS Platinum Blue Light Protector incorporates patented "anti-static" technology[16]. Permanently encapsulated within the coating system is a thin layer of an electrically conductive metal oxide material with high transparency. This unique anti-static layer dissipates static electricity, preventing the build-up of electrostatic charge and the attraction of particulates (Figure 11).

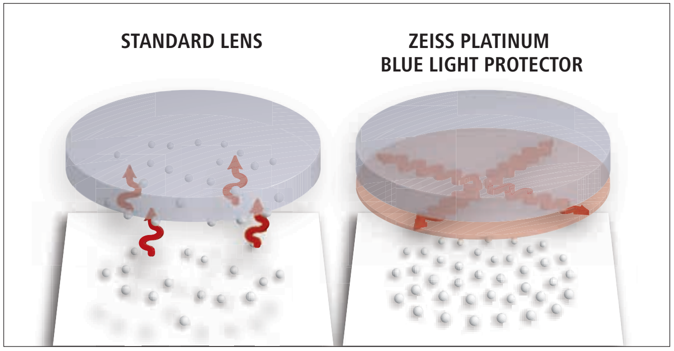

Figure 11. ZEISS Platinum Blue Light Protector (right) antistatic layer dissipates the static charge that would otherwise attract dust and dirt particles like standard AR coatings (left)

ZEISS Platinum Blue Light Protector offers the best-in-class properties of ZEISS AR coatings for superior hardness, anti-static properties and ease of cleaning.

Durability[17]	Bayer scratch resistance always >10 (scratch resistance similar to glass)
Easy to clean	Surface adhesion reduced, contact angle >110°
Dirt resistant	Antistatic properties enable easier cleaning and do not attract particles

Selected References

1. Curcio, C. A., K. R. Sloan, et al. Human photoreceptor topography. The Journal of Comparative Neurology 1990; 292(4): 497-523.
2. Frisby J.P. Seeing: Illusion, Brain and Mind. Oxford University Press : Oxford. 1980
3. Schacter, Daniel L. Psychology Second Edition. 41 Madison Avenue, New York, NY 10010: Worth Publishers. 2011; pp. 136–137.
4. Enezi J., Revell V., Brown T., Wynne J., Schlangen, L., Lucas, R. A. Melanopic Spectral Efficiency Function Predicts the Sensitivity of Melanopsin Photoreceptors to Polychromatic Lights. J Biol Rhythms 2011; 26:314.
5. Taylor HR, West S, Munoz B, et al. The long-term effects of visible light on the eye. Arch Opthalmol. 1992; 110:99-104.
6. Holzman, D. What's in a Color? The Unique Human Helath Effects of Blue Light. Environmental Health Perspectives. 2010; 118:A23-27
7. Ham, W., Mueller, H., Ruffolo, J., Clarke, A. Sensitivity of the Retina to Radiation Damage as a Function of Wavelength. Photochemistry and Photobiology 1979; 29:735-743.
8. American Conference of Industrial Hygienists (ACGIH). Threshold Limit Values for Chemical Substances and Physical Agents 2014; 148-155.
9. Fletcher, A.E., Bentham, G.C., Agnew, M., Young, I.S., Augood, C., Chakravarthy, U., de Jong, P.T., Rahu, M., Seland, J., Soubrane, G., Tomazzoli, L., Topouzis, F. Vingerling, J.R., Vioque, J. Sunlight exposure, antioxidants, and age-related macular degeneration. Arch. Ophthalmol. 2008; 126: 1396e-1403.
10. Wang J.J., Jakobsen K., Smith W., Mitchell P. Five-year incidence of age-related maculopathy in relation to iris, skin or hair colour, and skin sun sensitivity: the Blue Mountains Eye Study. Clin Experiment Ophthalmol 2003; 31(4): 317–321
11. Mitchell P., Smith W., Wang J.J. Iris color, skin sun sensitivity, and age-related maculopathy. The Blue Mountains Eye Study. Ophthalmology 1998; 105(8): 1359–1363
12. Hirvela H., Luukinen H., Laara E., et al. Risk factors of age-related maculopathy in a population 70 years of age or older. Ophthalmology 1996; 103:871-7
13. Herljevic, M., Middleton, B., Thapan, K., Skene, D., Light-induced melatonin suppression: age-related reduction in response to short wavelength light. Experimental Gerontology 2005; 40(3):237-242
14. Turner P., Van Someren E., Mainster M.. The role of environmental light in sleep and health: Effects of ocular aging and cataract surgery. Sleep Med Rev. 2010; 14(4)
15. Based on water contact angle measurements conducted on coated hard resin lenses.
16. Marechal N. and Blacker R. "Anti-Static, Anti-Reflection Coating." US Patent 6,852,406; 2005.
17. Based on Bayer test conducted in accordance with the COLTS standard operating procedure and COLTS-certified abrasive on coated hard resin lenses.

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