LENS TREATMENTS

PART 4: ULTRA-VIOLET PROTECTION

Peter Wilkinson PhD BSc(eng) CEng MIMechE is recognised as the UK's leading authority on spectacle lens surface treatments. He has extensive practical experience in lens manufacture particularly in the field of tinting, anti-reflection and anti-abrasion coating and holds senior positions in both the BSI and international standards organisations. After obtaining a PhD in engineering, and working initially at Rolls Royce, Dr Wilkinson was R&D manager at UK Optical, developed hard coating at American Optical and was then technical director at Cambridge Optical. He helped to develop Applied Vision's small AR coating process and has patented ideas for progressive lens design and for rapid acting photochromics. He now works as a consultant in ophthalmic optics particularly related to the manufacturing and quality of lens coatings. This series of articles was developed from a training course that he still teaches regularly for the Worshipful Company of Spectacle Makers.

This paper provides information about ultra-violet light, what it is, where it comes from, what are its dangers, and its relevance to the dispensing of spectacle lenses. Topics such as the importance of providing adequate protection from UV when tinted lenses are discussed.

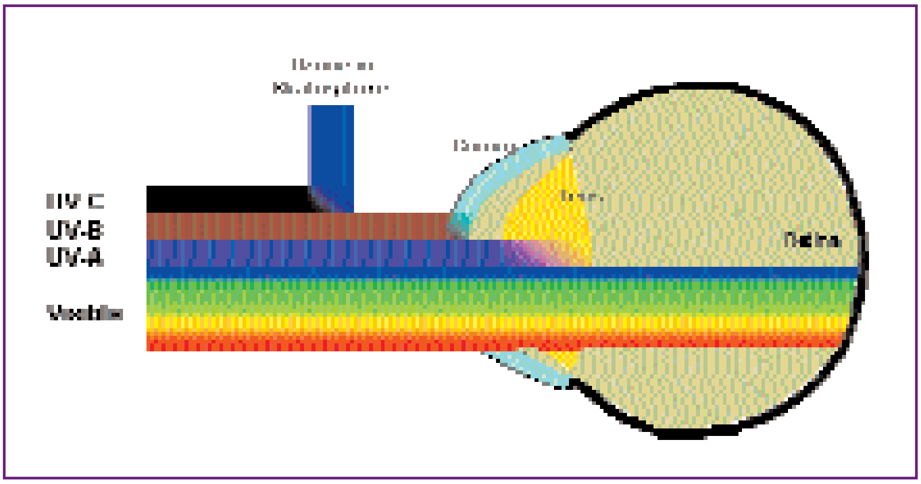
What is ultra-violet light?

The electromagnetic spectrum includes many types of waves, but the human eye can only see those where the length of the waves are between about 400nm and about 700nm (although the eye can observe light to a very limited extent below 400nm and above 700nm, the spectral luminous efficiency factor of the human eye in daylight, (below 400 and above 700) is less than 0.1% of that factor at the wavelength of peak sensitivity and can therefore be effectively ignored.[1]). Beyond this visible region, the waves are potentially hazardous, and include infra-red (above 700nm), and ultra-violet (below 400nm). At even shorter wavelengths there are X-rays and gamma-rays, and at much longer wavelengths are the radio and television waves.

UV waves can be divided into three categories. UVA is closest to the visible region and covers the range 400 down to 315nm. UVB covers 315 down to 280nm, and UVC covers 280 down to 200nm [2]. Just above the top of the UVA range, (at 400nm,) is the beginning of the visible region, where there is some concern about what is called the blue light hazard.

Where does UV light come from?

Outdoors, UV light comes from the sun, and this is partially blocked by the atmosphere. As we rarely look directly at the sun, (which is well known to be harmful) the exposure of the eye to UV comes from light dispersed by the atmosphere and also from reflected light. The amount of this reflection varies greatly from 80% for snow to 10% from



▲ **Figure 1:** Absorption of three types of ultra-violet light

water. Although we usually consider ultra-violet to be an outdoor problem, it is used industrially, for such applications as curing adhesives and has been used for curing dental fillings. Other sources include suntan lamps and even fluorescent lighting.

What are the non-ocular hazards of UV?

Virtually all UV may be harmful to animal and plant life, and although some insects see in the UVA region, it might be considered as being of limited beneficial value to human life. The best known result of excessive exposure to UV is of course sun burn, but this can lead to skin cancer, something that is now known to affect professional sports persons, such as tennis players. The fact that clouds do not block UV is a problem. Because of the lack of warmth under cloudy conditions, people assume that no protection is required.

Some ultra-violet light is absorbed by ozone in the stratosphere. Worries about the depletion of this ozone layer mean that UV may become more of a problem in the future. It has been estimated that only a 1% reduction in the amount of ozone could result in a 2-3% increase in skin cancers due to UV light.

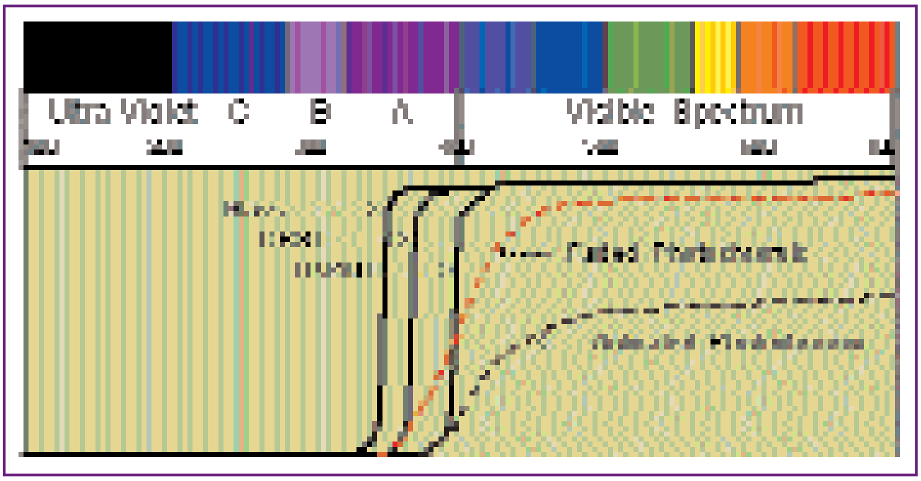
Ocular absorption and hazards of UV

UVC is not usually considered to be a problem to the human eye, because it is absorbed by the ozone layer. In the normal eye, UVB is absorbed by the cornea, and UVA by the crystalline lens, so that the retina is normally protected. (see **Figure 1**) In aphakia, the eye obviously loses some of its natural protection and the provision of UV absorbing lenses is important. Some drugs can cause photosensitivity and optometrists and dispensing opticians need to be aware of a patient's medical condition in order to provide appropriate advice.

Why is UV more dangerous for a spectacle or sunglass wearer?

The human eye automatically compensates for the brightness of light by adjusting the size of the pupil. The brighter the light, the smaller the pupil becomes. As long as the amount of UV light and visible light stay in proportion, this protective mechanism works well. However, if a tinted lens is worn, and the light appears less bright, the eye pupil may increase in size to permit more light to enter the eye. If the amount of UV has not been reduced by the same proportion as the visible light, then more UV will enter the eye than if no tinted lens was worn. It is therefore vital that any tinted lens includes a UV absorber, which absorbs at least the same percentage of UV as visible light. Apart from a professional responsibility, there are also strict European Standards[2,3] that cover this topic (see references at end of the article). Although these standards are written in rather complex mathematical terms, the basic criterion is that of reducing UV transmission, in proportion to visible transmission.

▼ **Figure 2:** Ultra-violet cut-off of ophthalmic materials



Why might tinted lenses be inadequate?

It was not intended that this article would discuss mass-produced plano sun lenses, however a brief word is necessary to explain why there should be no excuse for even cheap plastic sun-lenses providing adequate protection from ultra-violet rays (optical quality is of course another matter.) Plastic sun-lenses are normally produced in two stages. Firstly, 'white' lenses are cast with a UV absorber incorporated and as a second process the colour is added. This two-stage process should ensure good UV protection, even for gradutints where the tint at the bottom of the lens is pale. With mass-produced glass sun lenses a guarantee of adequate UV protection is not so easy, because glass is not a natural absorber of UV as many plastics are.

Prescription tinted lenses are made from conventional 'white' lenses which may have no, or only a small amount of, UV absorber. Prescription tinting is not so closely controlled as for mass produced sunglasses and it is therefore vital that the dispensing optician ensures that adequate UV protection has been provided (ie: up to 390nm or 400nm). Adding a UV absorber to a plastic lens is a similar process to colour tinting, with the exception that it is invisible and should be checked with an instrument. For glass lenses, the regulations are the same, but of course the UV absorber cannot be added in the same way as for plastic.

More details on standards for sunglasses may be obtained from The Personal Eye Protection Standard EN 1836.

Which lens materials provide UV protection?

Some lens materials provide UV protection by their basic nature. Photochromics work by absorbing UV energy; hence, as they become activated, they automatically block ultra violet light. Polycarbonate is also a natural absorber of UV so no further addition is required.

CR39 (as with all plastic and resin materials) have a tendency to yellow with age, and the manufacturers always include a small amount of UV absorber to prevent this. Various glasses are available

Cut off	Lens colour	Potential benefits
380nm	Very white	Prevents yellowing of CR39 material
400nm	Just white	For long term exposure eg: farmers, professional sportspersons, and so on
450nm	Yellow	As above but providing enhanced protection in the blue light hazard visible region
500nm	Orange	Medical conditions including photophobia and for outdoor sports

Note: Lenses that show definite colour should not be used for driving unless they conform to the traffic signal recognition test as defined in ISO standards. (See references at end of the article)

with different amounts of UV blocking incorporated.

Suppliers of plastic tinting dyes also provide UV absorbing dyes, and different versions are available depending how far up the spectral range the blocking is required. It is obviously important that lenses are left in the tint bath long enough at the correct temperature to absorb sufficient dye, and this should be checked with a suitable UV transmission instrument. Typical cut-off wavelengths for common materials are shown in **Figure 2**.

Should UV blocking be provided in 'white' lenses?

There is no harm, and potentially some benefit from including a UV absorber into 'white' (non-tinted) lenses. This is common practice in Australia because of the strong sunlight. There is no precise borderline between the top of the UV range and the blue end of the visible spectrum. The division is assumed to be at 400nm, but obviously one range merges gradually into the other. The choice of the 400 value is probably because the blue absorption above 400nm is sufficient for the eye to begin to perceive the complementary colour yellow. As the absorption point moves further up the spectrum, the yellow appearance increases, so that a strong yellow is seen at a cut-off point of 450nm and an orange at 500nm, well above what is normally considered to be the UV range. The application of such lenses is summarised in **Table 1**. *(Opinions are those of the author)*

Should a UV400 lens have a yellow tint?

The borderline between blocking UV and blocking part of the blue region of the spectrum is so narrow that it is easy for UV400 lenses to appear slightly yellow. How yellow will depend upon the sharpness of cut-off at the 400nm point, which will depend on the type (and age) of the UV dye. It should not be assumed therefore that a UV400 lens must look yellow.

Should non-spectacle wearers have UV protection?

This is a debatable point, but for those people who spend most of their time out of doors, particularly in regions of bright sunlight, there is a strong case that the eye should be protected from ultra-violet rays. It is now generally accepted that there is a link between UV exposure and the formation of some types of cataract. Studies of fishermen have shown that cataracts are much more common in equatorial latitudes, and those who regularly wear caps with brims are less affected.

How can a dispensing optician be sure that adequate UV protection has been provided?

Although it is usual to rely on the lens manufacturer to produce the necessary level of UV protection, some dispensing opticians like to have the ability to demonstrate this to the spectacle wearer. A number of simple light transmission meters (normally used for measuring tint transmission) are available to measure UV blocking. Some caution is needed in their use because they can only provide a guide to the amount of UV absorption. A precise value can only be obtained by using a spectrophotometer that measures the transmission at a range of wavelengths. It is then necessary to integrate these results to obtain an exact value of the UV absorption in the critical wavelength ranges. Also remember that non-plano lenses will distort the light beam of measuring instruments and this could affect the measured result. However, as a simple guide they are a useful addition to the dispensing optician's instrumentation.

Final point

UV protection is an important aspect of dispensing and with the diminishing ozone layer, and frequent travel to sunnier climates, dispensing opticians should perhaps consider whether UV protection, as with AR coating, should become a standard item rather than an extra.

References

1. International Standard ISO/CIE 10527.
2. EN ISO 1836:11077 Sunglasses and sunglare filters for general use.
3. BS EN ISO 8980-3:1999 Transmittance specifications for finished lenses.
● BS EN ISO 14889:1997 Fundamental requirements for finished lenses.

A list of other references and further reading will be published at the end of the final article in the series. ■