LENS TREATMENTS

PART 5: TINTS AND COLOURS

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This paper provides information about light and tints which are both important aspects of dispensing.

What is colour?

The spectrum of electromagnetic waves includes the visible part of the spectrum as well as many other waves such as microwave, radio, x-rays, ultra-violet (UV) and infra-red (IR) **(Figure 1)**.

Just either side of the visible region are the ultra-violet and infra-red, both of which are potentially harmful. Some special tints are available which can prevent UV and IR from reaching the eye. On the borders between UV and visible light is a special region about which much has been discussed recently which is referred to as the blue light hazard. Although nothing has been medically proven, it is suspected that prolonged excessive exposure could cause effects similar to the neighbouring UV region.

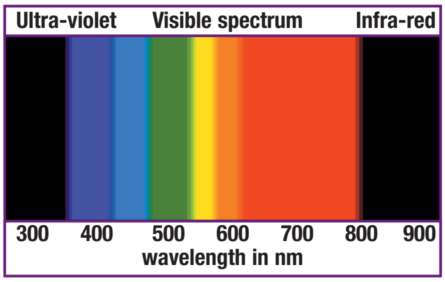

Figure 1: The spectrum (*spectrum representation is diagramatic*)

The eye itself is a remarkable device, with features way in advance of current camera technology! Not only does the eye have variable aperture and variable focussing, but when it transmits messages to the brain, it processes complex images in ways that are still only vaguely understood; and it does so without apparently any effort on our part. It can even translate a series of still film images into an apparently smooth movement, providing these are fast enough to exceed the critical fusion frequency. We should really ask the questions 'Do we see with our eyes, or with our brains?' and 'Is the retina more an extension of the brain rather than part of the eye?'.

Is the eye equally sensitive to all wavelengths of light?

The eye does not 'measure' the brightness (or energy) of all wavelengths of light in a way that gives them equal importance. It gives greater significance to the central green/yellow region and less significance to the blue and red light at either end of the visible region. This relative sensitivity of the human eye to different wavelengths of light is different for bright daylight and for duller evening light. These relative sensitivity curves are known as the photopic eye sensitivity **(Figure 2)** and the scotopic eye sensitivity. There are differences of opinion about these curves but it is generally accepted that the photopic peak is at 555nm and the scotopic peak is at 500nm. Obviously the sensitivity curve will vary slightly from person to person, (or dramatically in the case of a person with colour vision anomolies).

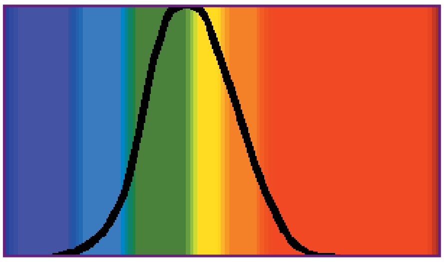

Figure 2: Photopic response of the eye

Does lighting affect colour perception?

Lighting can be significant in recognising colour, and tinted lenses can appear to be different when viewed under different lighting conditions. While the energy of sunlight is spread fairly evenly through the spectrum, this may not be the case with artificial lighting. Fluorescent* lights in particular are known to emit light that is concentrated into specific regions of the visible spectrum. (In fact it is only by use of a special coating on the inside of fluorescent lighting tubes that a moderately white colour is produced.) This fact has considerable practical significance to any company producing tinted lenses. It is particularly important that tinting is carried out under suitable lighting conditions. For instance, viewing a tint under fluorescent* lighting without the addition of daylight-simulation-lighting or preferably natural daylight, may considerably distort colour perception. Dispensing opticians should be aware of this, so that they can respond when spectacle wearers comment that the colour of the tint in their lenses seems quite different at home, or out of doors, compared to when they viewed it on the opticians premises. (* Note that there now exist some high-pressure Daylight fluorescent lights that provide better colour rendering than the original low frequency fluorescent lights.)

How is colour produced by a tinted lens?

A simplified way of understanding why a lens appears coloured is that it absorbs the complementary colour **(Figure 3)**. The solid yellow line shows the effect of the eyes sensitivity curve. Hence a yellow colour is perceived. As an alternative to absorption, it is also possible to reflect light, a method adopted in mirror coatings. Again the complementary colour theory works so that a 'blue' mirror allows yellow light to be transmitted and vice versa.

Is it logical to combine an AR with a tint?

It is a commonly held belief that there is no logic in combining a tint with AR. While a tint reduces transmission, anti-reflection does the opposite. However, it is not the transmission value that is important. (The eye can easily adapt to brightness by changing pupil size.) Vision is effected in a much greater way by contrast; so when the image we see through a tinted lens is reduced in brightness, it no longer dominates our vision and we become much more aware of surface reflections.

As an illustration of this phenomenon consider a sunglass lens with an 80% internal absorption. (Note that values given in the calculation

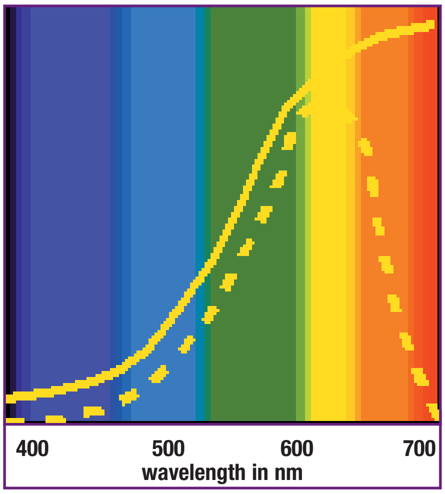

Figure 3: An illustration of how a tint that reduces blue transmission, can, in combination with the relative sensitivity curve for the eye, result in a yellow tint

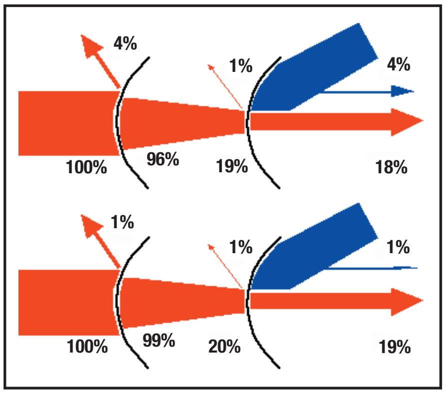

Figure 4: An illustration of how tinted lens, with and without AR, affects visual contrast

below are approximated for simplicity.) On a non-AR coated lens light experiences a loss of 4% due to reflection at the front surface (see earlier article in this series which gave a formula for calculating the loss due to reflection at a surface). This is followed by an absorption of 80% (of the 96%) due to the tint, leaving about 19% remaining. At the back surface there is a reflection loss of about 1% (calculated as 4% of the remaining 19%) which means that about 18% actually exits the back surface of the lens. Any back surface reflections (from light coming from behind the lens) have a reflected strength of 4%. This means that there is a difference in contrast seen by the sunglass wearer between 19% and 4% (a contrast ratio of almost 5:1) which can be quite disturbing. A back surface AR coating allowing only a 1% reflection will improve the contrast ratio to about 20:1. The result of the above calculation makes it obvious that an AR coating on the back surface of a dark tinted lens is important for good vision so that reflections of light coming from behind do not detract from vision **(Figure 4)**.

Why is it better to use ABS than LTF?

Luminous transmission factor (LTF) is frequently used to specify a tint. It is often wrongly assumed that the absorption (ABS) and the LTF together add up to 100% so that each is 100 less the other. This is not true because it ignores reflection. This may be understood by following this logic:

- If a lens is dipped in a dye for a minute it may acquire 10% absorption, but because it already has 8% surface reflection the LTF will actually be 82% (ie: 100% – 10% – 8%). It is therefore clear that 82%LTF plus 10%ABS do not add up to 100%.
- If the same lens then has an MAR coating applied, with only 1% reflection the lens LTF will now increase to 89% (ie: 100% - 10%abs -1%refl). The tint will still look almost the same because the absorption (of 10%) remains unchanged. This illustrates why (with the increase in

transmission due to AR coating) the author believes that it is better to specify ABS instead of LTF.

Does LTF/ABS differ for different colours?

It is easy to understand the luminous transmission factor or absorption for a grey (neutral density) tint since the transmission will be relatively constant across the whole of the visible spectrum. The meaning of LTF/ABS for a strongly coloured tint (with varying transmission across the spectrum) is more difficult to appreciate. It depends whether you are measuring the linear average, the spectrally weighted average, or just a single value at a single wavelength. To obtain a truly accurate value the spectral curve must be measured with a spectrophotometer. However, this is not what the eye perceives because it essentially multiplies the measured values by the photopic response to create an observed colour. (The lighting under which it is viewed will also have an effect.)

How do you specify the darkness of a tint?

In practice it is too complicated to specify a tint by using a spectral transmission curve, and the use of colour samples is a common solution. Spectral transmission curves are however available from tint suppliers on request and are useful where dispensing for particular requirements. Remember also that AR coatings can affect the appearance of tints and this must be allowed for when ordering.

Close contact and communication between tint supplier and dispensing optician is strongly recommended to ensure that the desired tints are supplied.

Do tints fade with time?

Tints normally fade with time, but this problem can be significantly minimised by using the following techniques.

- One method is to use dyes that have a longer life, however they do require a very much longer tinting time (hours instead of minutes) than the normal ophthalmic dyes. These slow dyes are normally used by the sunglass manufacturers, where speed of tinting is less significant and the slowness makes the tinting process easier to control accurately and consistently.
- Another method is to heat the lenses in an oven after tinting. This reduces the depth of colour slightly, but thereafter the colour is more stable. The slight loss of colour can be compensated for by initially tinting the lens slightly too dark.
- A third method (which is in fairly common use) is to tint the lenses a little too dark, and then to place them in bleach for a few seconds. This has the advantage of washing the dye out of the surface of the lens. The tint which is deeper into the lens is then much less likely to be reduced by cleaning.

What colour choices are possible?

Coloured lenses is a huge, varied, and fascinating subject. With uses ranging from pure fashion to medical and safety applications, and with the infinite variety of gradu-tints and the variable darkness colours of photochromics, it is difficult to know how practitioners can best advise wearers about the available choice. Later articles in this series will cover sports and driving lenses, photochromics and quasi-medical lenses, and the previous article covered ultra-violet protection.

Years ago, the choice of colour was restricted to a limited range of coloured glasses, some of which are still available. This range was extended when vacuum coating was developed, but with the advent of plastic lenses and dye tinting, it is now possible to produce an almost infinite variety of colours. The practicalities of applying colour to different hardcoats and high index lenses adds some complexity, but in theory at least, almost any colour, shade, hue, and graduation is now possible.

While cosmetic choice is a primary factor in choosing colour, there are also many other reasons for opticians to recommend tinted lenses. These range from the simple glare reduction of conventional sunglasses, through contrast enhancing tints for sporting use, to medical applications such as relieving photosensitivity and cataract protection. Tints for driving are also available where special care has been given to ensuring conformity with the European standards traffic signal recognition criteria. It is important that dispensing opticians are aware of the safety and legal implications of sunglare and UV protection as well as colour recognition and refer to the relevant International and European Standards (see list in the final article in this series).

Conclusion

Tints should be viewed as an important aspect of dispensing. Even if they are purely for cosmetic purposes, the psychological benefits should not be ignored, and for sport and other outdoor pursuits they can provide real benefits.

Note: This article has attempted to explain light and tints in a simplified way, however the reader is referred to BS3521 and EN ISO 13666 for the full definitions of terms such as luminous transmittance. ■