The use of selective contrast colour filters for eye disease

Ian Pyzer describes the research about the use of colour filters in the management of visually impairing eye disease

FOR SOME TIME the use of contrast enhancing colour filters has been identified as a way of attempting to improve visual performance to a broad selection of patients with anterior segment eye disease.

As high contrast filters absorb short wave blue light, often below 520nm, this results in a relative increase in the ratio of yellow to red visible light being transmitted. With the eye's photoreceptors' peak sensitivity being at 555nm, the resulting retinal illumination is accentuated, providing, in effect, an increase in image contrast.

With their selective filtering of blue light, these high contrast filters are often alternatively referred to as 'blue blockers'.

Aside from taking a look at a selection of the filters available and reviewing what methods can be used to evaluate them, this article will also deal with the question of whether they might be used to help slow the decline in visual function for individuals with degenerative retinal conditions, or delay the onset.

IS BLUE LIGHT A HAZARD?

It has long been understood that light can damage the eye. With the cornea and crystalline lens between them absorbing 99 per cent UVB and 98 per cent UVA,[1] overexposure can lead to long-term damage of these structures. With only 1 per cent UVB and 2 per cent UVA transmitted to the retina in the phakic eye, however, the likelihood of ultraviolet light causing significant damage to the retina is questionable.

The cornea and crystalline lens do not afford the eye any natural protection from the visible spectrum – but do they need to? The question of whether the high energy short wavelength blue light emerging from the invisible ultraviolet end is capable of causing damage to the human retina, was investigated by Marshall who published his findings in the 1980s.[2] Marshall was the first to use the term 'blue light hazard' when he found that 100 times less energy is required to cause damage to the retina at 440nm than at 590nm.

Retinal pigment is found in the pre-receptor fibre layer. Being particularly dense in the foveal region, and evenly distributed around the peripheral retina, it is capable of filtering short wave blue light due to the presence of two isomers of zanthophyll; carotenoids called lutein and zeaxanthin. The retinal pigment in fact filters 50 per cent of the high energy blue light at its peak transmission of 440nm (Figure 1) and aside from protecting the receptors from its potentially damaging effects, it is also suggested that these carotenoids also act as antioxidants, preventing the breakdown of the membrane lipids,[3] caused by free radicals and produced when photo energy is metabolised. A lower density of retinal pigment has been shown to closely correlate to a reduction in visual sensitivity. This can be a precursor to many retinal diseases[3] and is supported by the fact that 25 per cent of macular pigment is lost by the age of 60 in that the incidence of age-related macular degeneration (AMD) is greatest among those over 50 years of age.

Further evidence that visible light is a risk factor comes from animal model studies mirroring human retinal dystrophies and retinitis pigmentosa (RP), which showed an increased sensitivity to bright light exposure, accelerating the death of receptor cells.[4-8] Likewise, there is also increasing experimental evidence that it can be responsible for initiating or enhancing AMD[9-11] where conclusive experimental evidence reveals that high energy short wavelength blue light has a distinct potential to damage and destroy visual cells in these models.[12-17]

This, along with recent evidence from a longitudinal, population-based study which indicated that extended exposure to sunlight in teenagers and young adults is associated with the development of early AMD in later years of life,[18] adds to a growing consensus of concern that visible light has the potential to cause damage to the retina.

For AMD patients, the metabolic activity in processing high energy short wavelength blue light, coupled to the aforementioned age-related reduction in the density of retinal pigment, is damaging and can lead to photoreceptor death and further loss of visual function. It is also known that AMD is frequently seen to progress following cataract extraction.[19] Preoperatively, the retina would have been well protected from high energy short wave blue light by the yellow-brown discolouration of the crystalline lens. This is no longer the case once the cataract is removed, suggesting that some prophylactic should be recommended to the postoperative cataract patient and those at risk from developing retinal diseases, particularly where an IOL fails to absorb shorter wavelenths.

Indeed, in response to these associated risks, Retina International, a charity that funds research into degenerative retinal conditions, issued this statement endorsing the use of high contrast blue block filters: 'It is strongly recommended that UV blocking and blue-reducing sunglasses are prescribed to patients affected with retinal degenerations and dystrophies. Apart from possible contrast enhancement and reduction of visual discomfort by minimising glare, there are now medical indications for the use of protective sunglasses. The overall level of transmission of visible light in such glasses may vary according to the needs of the respective patients, however, UV blocking (400nm) and a reduction of blue light transmission (up to 470nm) is mandatory in view of several scientific publications.'

BLUE LIGHT, VISUAL FUNCTION AND COMFORT

High frequency blue light exhibits chaotic characteristics. This is evident in nature, where blue light from the sun scatters as it enters the earth's upper atmosphere, resulting in it being the dominant colour in the sky. Likewise, blue light is dispersed and reflected by water and off of reflective or polished surfaces and is also emitted from artificial light sources, as well as from computer and TV screens.

When it enters the eye, blue light continues to disperse and scatter and therefore dominates over other longer wavelengths. For those with degenerative retinal diseases, the poor function of the retinal pigment in absorbing the blue light causes reduced contrast sensitivity, dark adaptation problems, symptoms of glare and photosensitivity.[20]

The eye-care professional's duty of care dictates that they should readily inform ▶

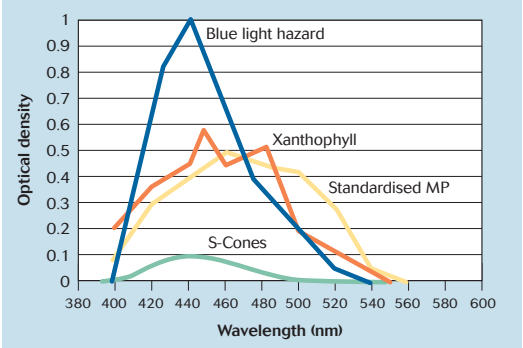


FIGURE 1

low vision patients of the availability of these filters. The protection and possible enhancement of visual function they afford means that assessing patients subjectively and, wherever possible, using selective high contrast blue blocking filters should be an essential part of the low vision assessment.

ASSESSING THE EFFECTIVENESS OF CONTRAST COLOUR FILTERS

When possible, some of the tests that might be carried out in the consulting room to measure or evaluate the improvements provided by the filters include:

- VA with and without glare source
- Contrast acuity
- Colour vision test
- Light to dark adaptation time
- Timed reading tests
- Visual fields.

However, such subjective assessments are sometimes not possible to quantify, as these tests, especially high contrast Snellen charts, are insufficiently sensitive or may not be possible where visual impairment simply prohibits such evaluation. Instead, it is often subjective feedback based on a real world trial that should be employed as the best guide as to whether the filters will be of help.

Such testimony as to their effectiveness may include:

- An improved ability to define shapes and outlines better, therefore helping to avoid obstacles more easily
- Easier identification of steps, yellow kerb lines and undulations ahead of them therefore increasing their mobility confidence rating
- Reduced levels of photosensitivity
- Faster adaptation when moving between areas of high and low illumination
- Easier viewing of their computer screen, television, or ability to read text.

Filter suppliers offer various methods for patients to evaluate them, such as; clip-ons, plano fit overs, glazed lorgnettes, satisfaction guarantee, exchange service.

Mostly, the choice of filter will be dependent on eye condition and consideration of the environment where they are most needed, ie artificial vs sunlight. Table 1 is a guide for some of the more common ones.

EVIDENCE OF EFFECTIVENESS

Various papers pointing to evidence of improvement for patients with a variety of eye conditions have been published.

In a recent trial[21] of 22 AMD and 40 RP subjects, they were asked to subjectively evaluate the overall effectiveness of either a 527nm or 540nm contrast colour filter for effectiveness against glare; how they compared to previously worn tinted spectacles; and whether they experienced any improvements to their vision. The results for the top two box responses are shown here (Figure 2).

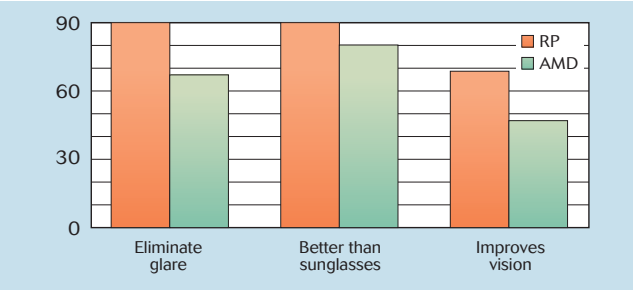


FIGURE 2. Subjective responses regarding the wearing of contrast filters (n = 40RP, 22AMD)

In a study of 32 eyes with RP, 24 had significant (P=0.01) visual acuity improvements using a 550nm blue block filter vs neutral density filter.[22]

Frith used a 520nm orange filter, where, out of 13 patients trialled, nine reported subjective reductions in photophobia, most felt there was an increase in visual acuity, only measurable in three, and five reported improved field of vision and mobility.[23]

Visual performance improved according to 26 out of a total of 34 patients using a 550nm filter, rating it as the best lens they had ever tried.[24]

Cone dystrophy causes patients to experience extreme photophobia. A group were tested using electro-diagnostic evaluation while wearing colour contrast blue block filters. It was concluded that because the rods were protected from saturation, this allowed them to operate more fully in photopic conditions, supported by the subjective improvements in visual acuity and reduced photosensitivity that were found.[25] Lynch also recorded significant improvements to visual-motor function and visual acuity when using a 527nm filter, by three of the five patients evaluated with cone dystrophy.[22]

Thirty nine eyes with cataracts were tested using a 550nm filter. In non-glare situations, an average increase in visual acuity of 15 per cent was noted, whereas with a glare source, an average increase of 70 per cent was recorded.[26] Using a red lens, it was found that contrast sensitivity (CS) was improved most significantly in the higher range.[27]

In a separate study, 32 per cent of cataract patients had CS improvements and it was postulated that this was due to a reduction in chromatic aberration, photophobia and intraocular light scatter.[19] Another suggested possible reason for improvement was that with a low transmission, the pupil dilates, enabling patients with central opacities to view around the periphery of the obstruction.[26]

With central vision loss due to AMD, patients no longer see high spatial frequencies, being unable to resolve fine edge detail. Filters are used to boost amplitude and hence improve CS to intermediate and high spatial frequencies. With AMD, these filters have been found not only to reduce the magnification needed for reading by up to 70 per cent, but also to increase the observer's reading speed by 2-4 times.[28] In a separate study, yellow and orange lenses have also been found to increase contrast sensitivity, and these objective changes were supported by subjective ratings in subjects with AMD and concluded that the subjective benefit of coloured lenses appears to be due to an enhancement of contrast sensitivity.[29]

Diabetics, post laser treatment, are often prone to loss of contrast, increased haze and photosensitivity as well as poor colour perception. The use of contrast colour filters will often be found to significantly reduce these symptoms.

TABLE 1

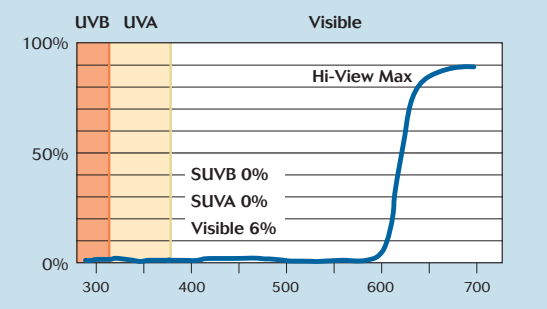
Eye condition	Higher per cent LTF filter (lighter)	Lower per cent LTF (darker)
AMD	460nm	527nm
RP	527nm	540nm
Cataract	527nm	540nm
Diabetic retinopathy	527nm	540nm
Albinism	540nm	600nm
Cone dystrophy	540nm	600nm

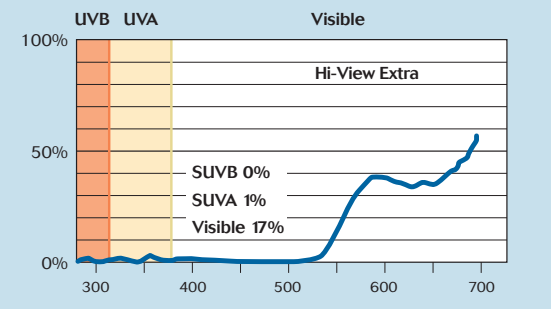
PRODUCTS

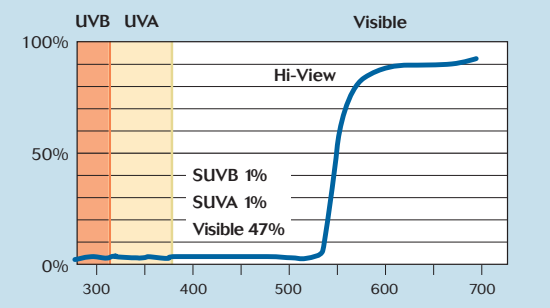
Table 2 is not intended as an exhaustive list; more information can be requested from the suppliers. Corning offers a range of glass photochromic lenses with blue cut-off properties and Noir Medical manufactures a range of polycarbonate filters glazed into fit-over styles. MediView's Hi-View low vision filters are made from 1.5 index plastic and are available as uncuts or glazed into a range of protective eyewear styles with sideshields. Transmission curves for the HiView filter range from MediView are shown in Figures 3,4,5,6.

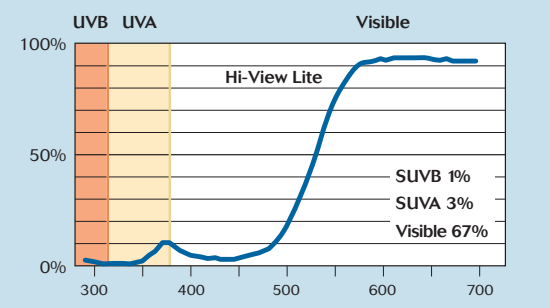
CONCLUSION

The use of selective contrast colour filters for eye diseases is easy both to incorporate into the eye examination routine and dispensing consultation, giving these patients an informed choice of whether to protect their eyes from potential damage









FIGURES 3-6. Transmission curves for four filters available from MediView

caused by high energy short wave blue light, and at the same time experience the benefits that these filters can often provide them by enhancing contrast and reducing photosensitivity.

Acknowledgements

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References

1 Voke. Radiation effect on the eye. *Optometry Today*, July 1999; 37-40.

2 Marshall J. Thermal, mechanical mechanisms and laser damage to the retina. *Invest Ophth* 1970; 9:97-115.

3 Pratt. *Journal of American Optom Assoc*, 1999; 70: 39-47.

4 Cideciyan AV, Hood DC, Huang Y, Banin E, Li ZY, Stone EM, Milam AH and Jacobson SG. Disease sequence from mutant rhodopsin allele to rod and cone photoreceptor degeneration in man, *Proc Natl Acad Sci* USA, 1998; 95 7103-7108.

5 Chen CK, Burns ME, Spencer M, Niemi GA, Chen J, Hurley JB, Baylor DA and Simon MI. Abnormal photoresponses and light-induced apoptosis in rods lacking rhodopsin kinase. *Proc Natl Acad Sci USA*, 1999; 96 3718-3722.

6 Chen J, Simon MI, Matthes MT, Yasumura D and LaVail MM. Increased susceptibility to light damage in an arrestin knockout mouse model of Oguchi disease (stationary night blindness), *Invest Ophthalmol Vis Sci*, 1999; 40 2978-2982.

7 Naash ML, Peachey NS, Li ZY, Gryczan CC, Goto Y, Blanks J, Milam AH and Ripps H. Light-induced acceleration of photoreceptor degeneration in transgenic mice expressing mutant rhodopsin. *Invest Ophthalmol Vis Sci*, 1996; 37 775-782.

8 Wang M, Lam TT, Tso MO and Naash MI. Expression of a mutant opsin gene increases the susceptibility of the retina to light damage. *Vis Neurosci*, 1997; 14 55-62.

9 Rozanowska M, Jarvis-Evans J, Korytowski W, Boulton ME, Burke JM and Sarna T. Blue light-induced reactivity of retinal age pigment. *In vitro* generation of oxygen-reactive species. *J Biol Chem*, 270 (1995) 18825-18830.

10 Sparrow JR, Nakanishi K and Parish CA. The lipofuscin fluorophore A2E mediates blue light-induced damage to retinal pigmented epithelial cells. *Invest Ophthalmol Vis Sci*, 2000; 41 1981-1989.

11 Suter M, Remé C, Grimm C, Wenzel A, Jaattela M, Esser P, Kociok N, Leist M and Richter C. Age-related macular degeneration. The Lipofuscin component N-Retinyl-N-Retinylidene Ethanolamine detaches proapoptotic proteins from mitochondria and induces apoptosis in mammalian retinal pigment epithelial cells. *J Biol Chem*, 2000; 275 39625-39630.

12 Chen E. Inhibition of cytochrome oxidase and blue-light damage in rat retina. *Graefes Arch Clin Exp Ophthalmol*, 1993; 231 416-423.

13 Grimm C, Wenzel A, Williams TP, Rol PO, Hafezi F and Reme CE. Rhodopsin-Mediated Blue-Light Damage to the Rat Retina: Effect of Photoreversal of Bleaching. *Invest Ophthalmol Vis Sci*, 2001; 42 497-505.

14 Grimm C, Reme CE, Rol PO and Williams TP. Blue light's effects on rhodopsin: photoreversal of bleaching in living rat eyes. *Invest Ophthalmol Vis Sci*, 2000; 41 3984-3990.

15 Grimm C, Reme CE, Rol PO and Williams TP. Blue light's effects on rhodopsin: photoreversal of bleaching in living rat eyes. *Invest Ophthalmol Vis Sci*, 2000; 41 3984-3990.

16 Delmelle M. Possible implication of photooxidation reactions in retinal photo-damage. *Photochem Photobiol*, 1979; 29 713-716.

17 Van Norren D and Schellekens P. Blue light hazard in rat. *Vision Res*, 1990; 30 1517-1520.

18 Cruickshanks KJ, Klein R, Klein BE and Nondahl DM. Sunlight and the five-year incidence of early age-related maculopathy: the Beaver Dam Eye Study. *Arch Ophthalmol*, 2001; 119 246-250.

19 Klein *et al*. *Arch Ophthalmology*, 1998; 116: p506-513.

20 Rosenblum *et al*. Spectral filters in low vision correction. *Ophthal Physiol Opt*, 20, 335-341.

21 Medi-View Ltd data on file 2000.

22 Lynch D and Brilliant R. An evaluation of the Corning CPF550 lens. *Optometric Monthly*, 1984; 75, 36-42.

23 Frith MJ. The use of low transmission lenses for patients with pigmentory degeneration of the retina. *Aust J Optom*, 1980; 63, 80-82.

24 Morrisette *et al*. Users and non-users evaluation of the CPF550 lenses. *Am J Optom Phy Opt*, 1984; 61, 704-710.

25 Bremer *et al*. Photochromic filter lenses for cone dystrophy. *Contemporary Ophthalmic Forum*, 1987; 5, 157-162.

26 Topper *et al*. The effect of a 550nm cut off filter on the vision of cataract patients. *Ann Ophthal*, 1985; 17, 67-72.

27 Zigman S. Light filters to improve vision. *Optom Vision Sci*, 1992; 69, 325-328.

28 Lawton TB. Image enhancement filters significantly improve reading performance for low vision observers. *Ophthalmic Physiol Opt*, 1993; Apr, 12(2): 193-200.

29 Wolffsohn JS, Dinardo C and Vingrys AJ. Benefit of coloured lenses for age-related macular degeneration *Ophthalmic and Physiological Optics*, 2002; Volume 22 Issue 4 Page 300.

TABLE 2

Company	Material	Range	Filters/nm
Corning	Glass photochromic	Plano single vision	450 511 527 550
Noir Medical	Polycarbonate	Plano	440 450 520 550
MediView	CR39	Plano single vision bifocal	460 527 540 600

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