



## Evolution and Benefits of Materials containing Blue Light Absorbers

*By Dr Richard Young - Research & Development Manager*

*An increasing number of surgical procedures are employing intraocular lenses that contain a blue light absorber. Such lenses are characterised by their yellow appearance and are designed to reduce the transmission of light, which potentially can be hazardous. However the use of such colour additives is not a new concept and this article will highlight the evolution of this type of lens, and the potential benefits that these lenses may offer.*

Cataract surgery is amongst the most commonly performed surgical procedures with over 300,000 operations carried out last year in the UK alone. The removal of the crystalline lens followed by the implantation of an intraocular lens is now a relatively short procedure that has evolved considerably in recent years. PMMA was long regarded as the material of choice for the fabrication of intraocular lenses however the development of phacoemulsification was a catalyst for the development of foldable materials. Such materials enable the finished IOL to be inserted or injected through a small incision and examples include hydrophilic, silicone and foldable acrylic, also known as hydrophobic.

PMMA was initially implanted as a clear material without any light absorbing components. For many years however, it has been common for this material to contain an Ultraviolet (UV) light absorber and this trend continued in the materials that evolved for small incision surgery procedures. The inclusion of a yellow colour additive to absorb blue light is a much more recent proposition.

As well as the visible spectrum, the light that emits from the sun also contains UV and Infrared (IR) radiation. A proportion of this light is absorbed by the earth's atmosphere but light of various wavelengths also passes through this layer and can penetrate the eye. This includes UV-B radiation (230-300nm), UV-A radiation (300-400nm) visible light (400-700nm) and near IR radiation (700-1400).

The different parts of the eye absorb light of specific wavelengths, although this also depends greatly on age and previous exposure to sunlight. The cornea will absorb light of wavelengths below 300nm (UV-B), however light of greater wavelength will pass through freely. At infancy the crystalline lens will transmit all light of wavelength greater than 300nm, however increased exposure to light results in the production of yellow pigments. The crystalline lens turns yellow and absorbs light below 400nm with the transmission of blue light between 400-500nm also being greatly affected. Many IOLs contain a UV absorber that will absorb some light between 300-400nm like the crystalline lens, however these compounds do not absorb blue light. The light transmission properties of a typical clear IOL are shown in Figure 1, together with the transmission profile of the crystalline lens.



The first suggestions to use a yellow colour additive in an IOL can be found in various patents filed in the 1980's. One such example is US patent 5,374,663 assigned to Hoya, which describes the use of yellow colour additives for use in intraocular lenses to correct for Cyanopsia. This condition relates to the increase in blue light reaching the retina when a cataract is replaced with a standard clear intraocular lens. This condition can result in objects looking more blue than when seen through normal eyes and also makes distinguishing between blues and violets difficult. This patent suggested the incorporation of a yellow colour additive in the IOL, so that its light transmission properties would mimic that of the crystalline lens of a person around the age when a cataract operation would likely be required. Figure 2 shows the change in light transmittance properties achieved by the addition of a yellow colour additive. The patent discusses a wide variety of yellow/orange compounds suitable for this application. Unfortunately, the overall success of yellow IOLs produced from PMMA was relatively limited at this time. A possible reason may be that colour perception was not a serious clinical issue that required a resolution.

In recent years there has been increased interest for inclusion of a yellow colour additive in an Intraocular lens and Figure 3 shows examples of commercially available products. A wide range of potential benefits have been described, although clinical evidence for some of these has not been conclusive. The potential benefit that stimulates the most discussion, is that blue light absorbing IOLs reduce the risk of age related macular degeneration. A detailed overview of the various theories on this subject is not appropriate here, however some background information is important to consider. The inclusion of the blue light absorber may have negative effects and these can include reduction of scotopic vision, interference with circadian rhythm and problems with perception of colours and contrast sensitivity.

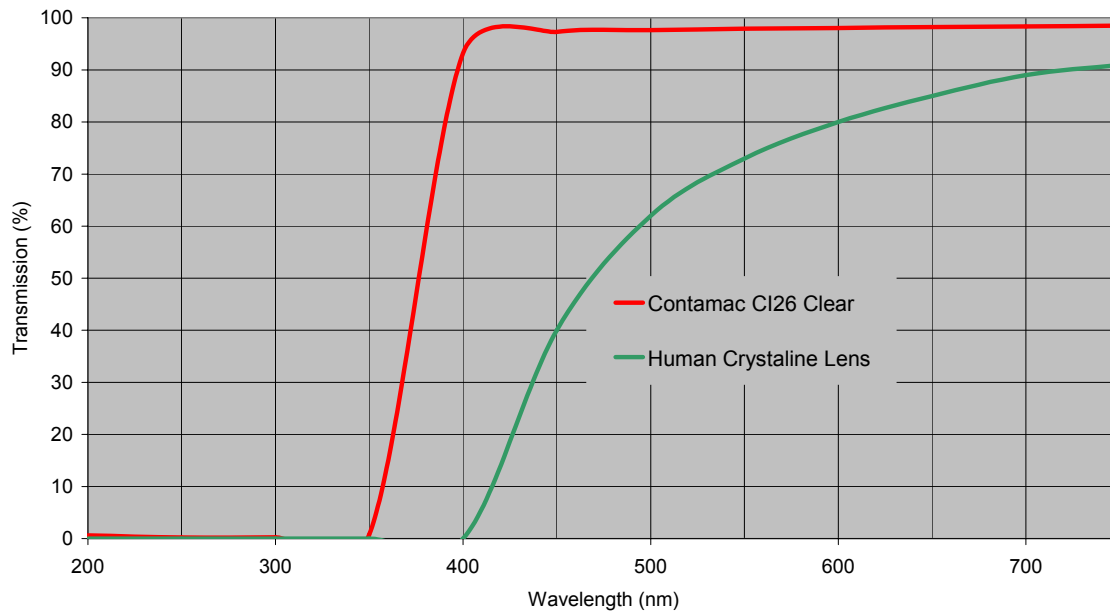
A number of large population studies have been conducted, but only a small number have suggested a link between light exposure and macular degeneration. Although it has been proven that acute exposure to blue light causes retinal damage, a link between longer-term chronic exposure and age related macular degeneration, has not been determined.

The most recent topic of discussion on this subject is the actual wavelengths of light that should be absorbed. It has been suggested that a lens should absorb only violet light and the majority of blue light should be transmitted by the IOL. Blue light blocking lenses will absorb blue and violet light and some researchers argue this is not ideal. They consider violet light to be more harmful than blue light and transmission of blue light improves scotopic vision and is important for circadian photoreception. One study has found that Lipofuscin may be responsible for the majority of damage to the retinal pigment epithelium. This substance is sensitive to blue light that results in the formation of reactive oxygen species or radicals that damage the epithelium cells. Light of wavelength of 440nm activates this process; so blocking only violet light may not prevent this process.

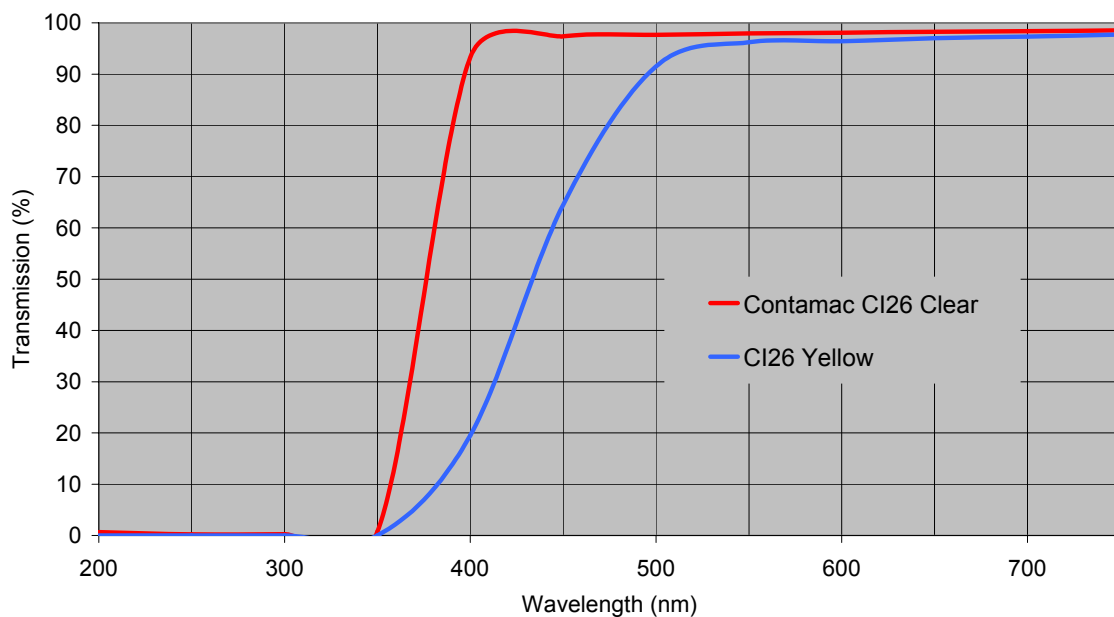


Most researchers would agree that blocking certain wavelengths of visible light is beneficial, however there is continued debate on the precise wavelengths that would provide the optimum balance between protection and visual performance. Until definitive clinical results are obtained and published, it seems likely that the use of both blue and violet blocking IOLs will increase. If the yellow IOLs that block blue light have no perceived drawback, then they surely provide the greatest level of protection.

**Figure 1 - Transmission of Clear IOL and Crystalline Lens**



**Figure 2 - Transmission Properties of Clear and Yellow IOL**





*Figure 3 - Examples of Blue Blocking IOLs*

