CLINICAL RESEARCH

Spectral Characteristics of Sports and Occupational Tinted Lenses

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Introduction

Tinted spectacle lenses are used for a variety of reasons including comfort, reduction of glare, enhanced vision under certain conditions, cosmesis, status for the wearer, and protection from radiation and/or impact. The selection of tints for protection from hazardous levels of optical radiation in industry and other work environments is well documented[1,2] and governed by various standards [3-7]. However, the selection of tinted lenses for other uses is usually arbitrary and made without professional advice. The purchaser often chooses tinted lenses on the basis of advertising material provided by the manufacturer. Few manufacturers provide accurate lens transmittance data, and some make claims which cannot be substantiated.

We have previously reported on tinted prescription spectacle lenses[8] and contact lens materials[9]. However, the majority of tinted lenses worn for sports and occupational purposes do not fall into these categories. Thus, the object of this study was to evaluate the absorptive characteristics of a variety of special-purpose non-prescription tinted lenses.

Materials and Methods

The lenses used in this study were randomly selected samples either supplied by the manufacturer or distributors, or taken from sample lenses used in the Clinic of the School of Optometry, University of Waterloo. The type of lenses used are listed in Table 1.

Spectral transmittance measurements were made with a Zeiss (Oberkochen) DMR-21 dual-beam recording spectrophotometer, following the procedure reported elsewhere[8], and transmittance curves traced from the chart record.

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Table I

Lenses Tested In Study

Lens Tint	Substrate	Intended Use	Figure
Norton 180 Clear	Polycarbonate	Industrial protector	1
Norton 180 Grey	Polycarbonate	Industrial protector	1
Norton 180 Yellow	Polycarbonate	Industrial protector	1
Norton 180 Green	Polycarbonate	Industrial protector	1
Eyeguard 2000 Grey	Polycarbonate	Industrial protector	2
AO CNTS Poly 17	Polycarbonate	Industrial protector	2
Wilson Green	Polycarbonate	Industrial protector	2
Uvex 810 016	Polycarbonate	Industrial protector	2
BPI Tennis	CR-39	Sport tint	3
BPI Skeet	CR-39	Sport tint	3
BPI Ski	CR-39	Sport tint	3
BPI Golf	CR-39	Sport tint	3
BPI Sport	CR-39	Sport tint	3
Ski Optics All-Weather	Polycarbonate Gradient mirror	Ski Sunglass	4
Ski Optics High altitude	Polycarbonate	Ski Sunglass	4
Ski Optics Nautilux	Glass	Ski Sunglass	4
Vuarnet	Glass	Ski Sunglass	5
Vuarnet Orlux	Glass	Ski Sunglass	5
Vuarnet Nautilux	Glass	Ski Sunglass	5
Vuarnet PX5000	Glass	Ski Sunglass	5
Suncloud	Glass	Ski Sunglass	5,6
Haida	Glass	Ski Sunglass	6
Central Optical Vuarnet Type	Glass	Ski Sunglass	6
Nite Site	Glass	Contrast enhancer	6
CPF 511	Glass	Glare reduction vision enhancer	7
CPF 527	Glass	Glare reduction vision enhancer	8
CPF 550	Glass	Glare reduction vision enhancer	9
Guardian	CR-39	Dental protective lens	10
DDL	CR-39	Dental protective lens	10
Liteshield 520	CR-39	Dental protective lens	10
Noir 650E	CR-39	Experimental cut-off filter	10

Results

Spectral transmittance curves over the waveband 200 to 2500 nm are presented in Figures 1 to 10. In each figure the ultraviolet (UV) region (wavelength less than 400 nm) is marked off from the rest of the spectrum by a vertical line at 400 nm. The scale of the figures is changed at 700 nm.

Fig. 1

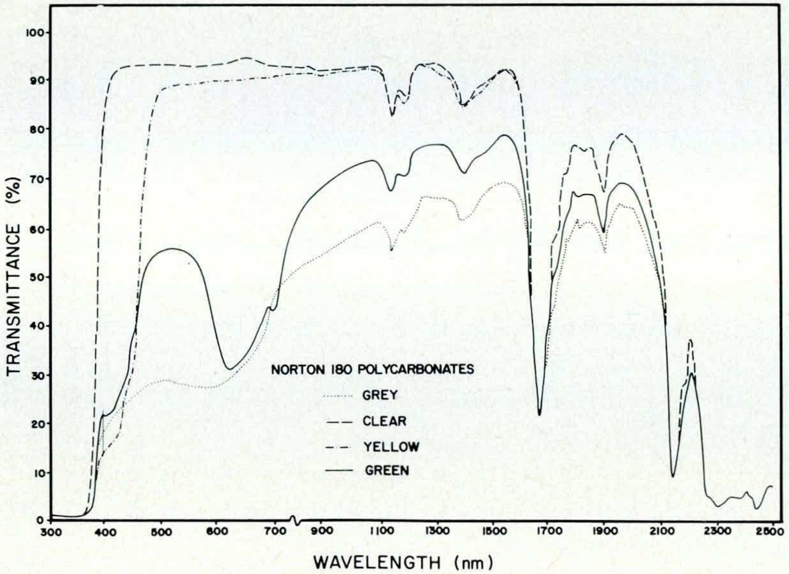


Fig. 3

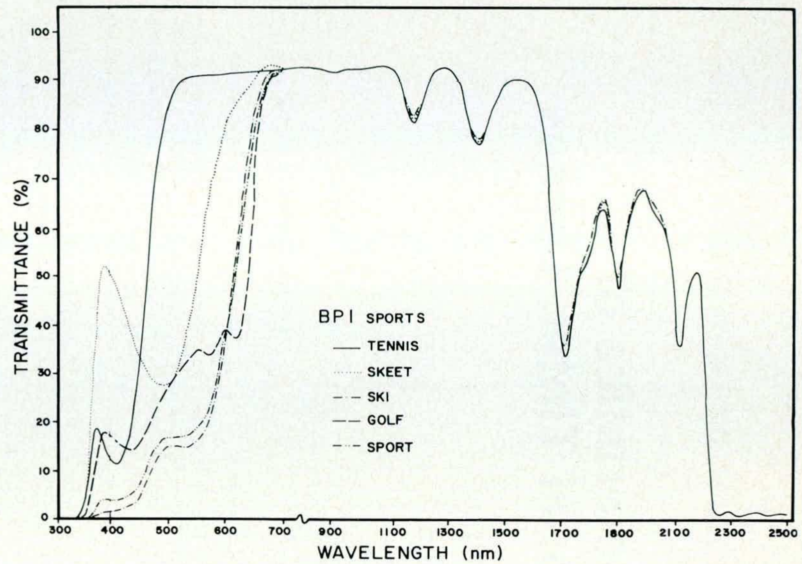


Fig. 2

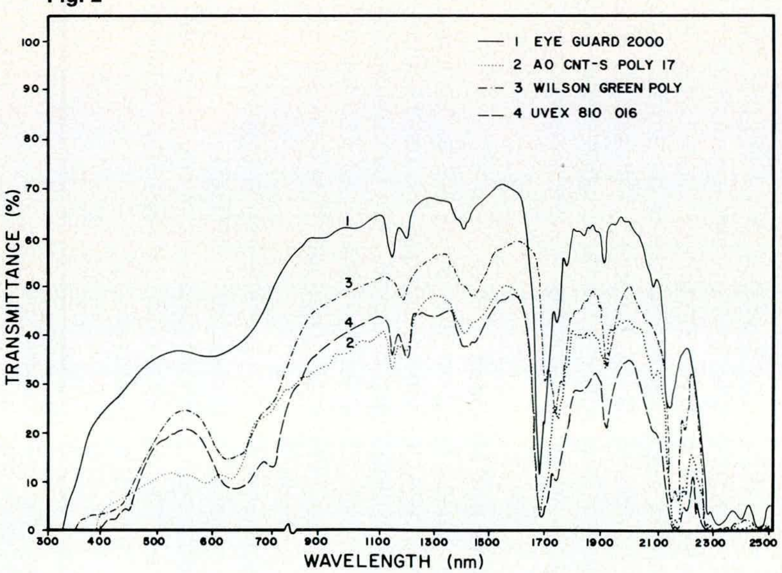


Fig. 4

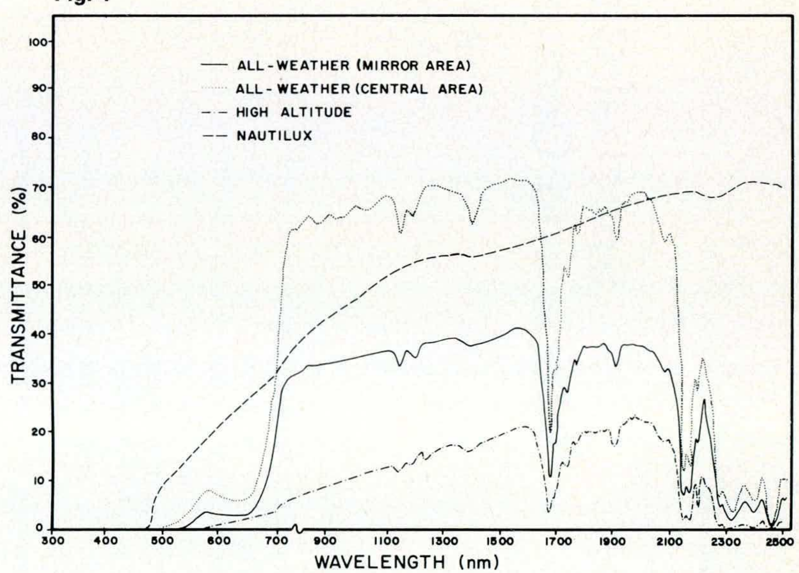


Fig. 5

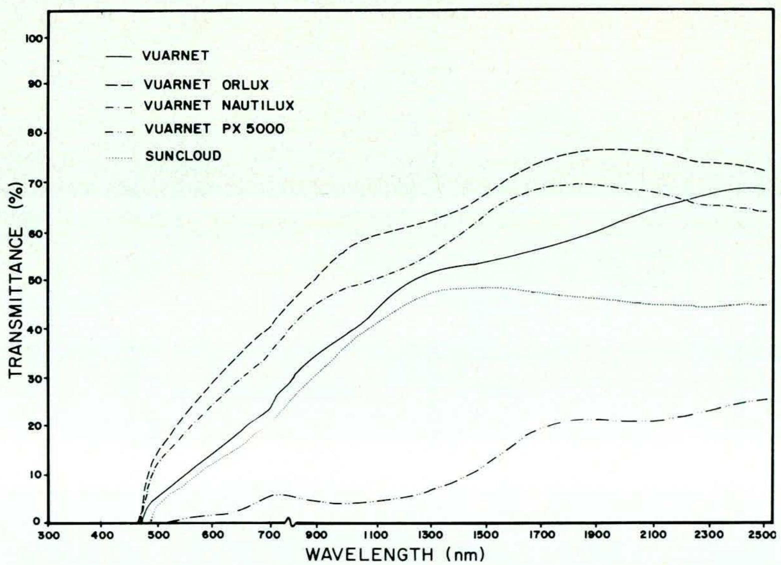


Fig. 6

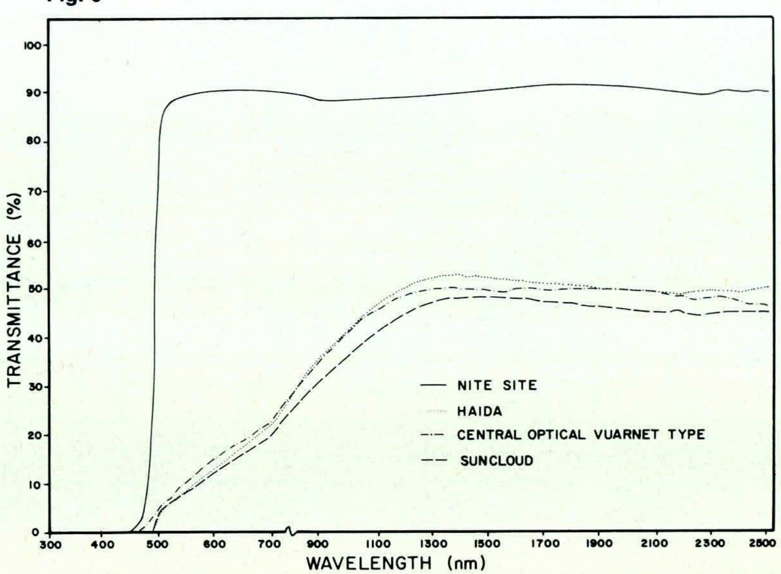


Fig. 7

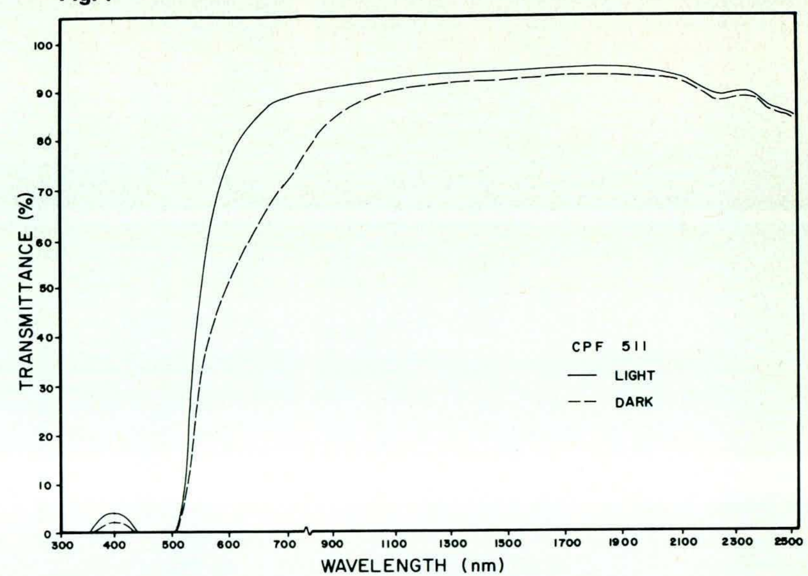
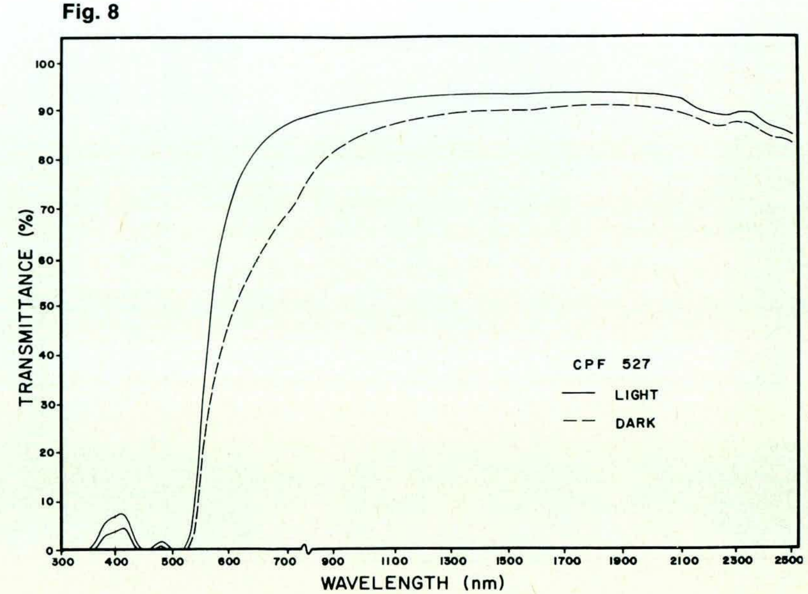


Fig. 8



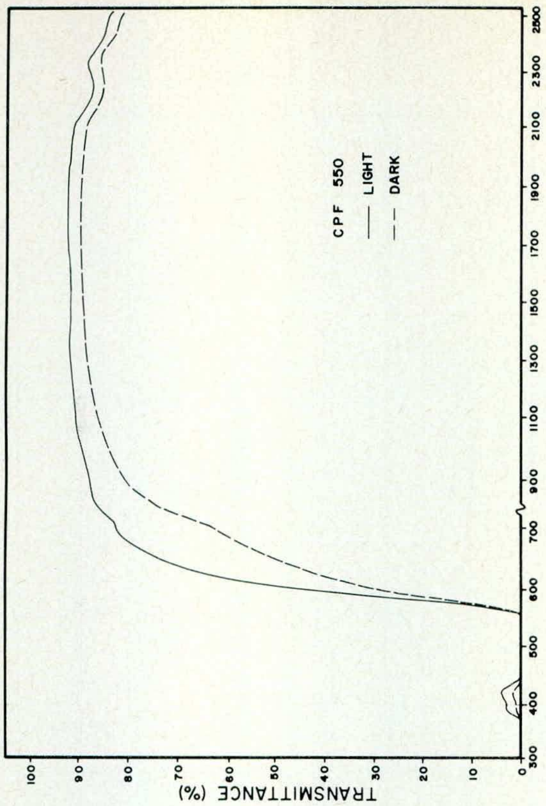


Fig. 9

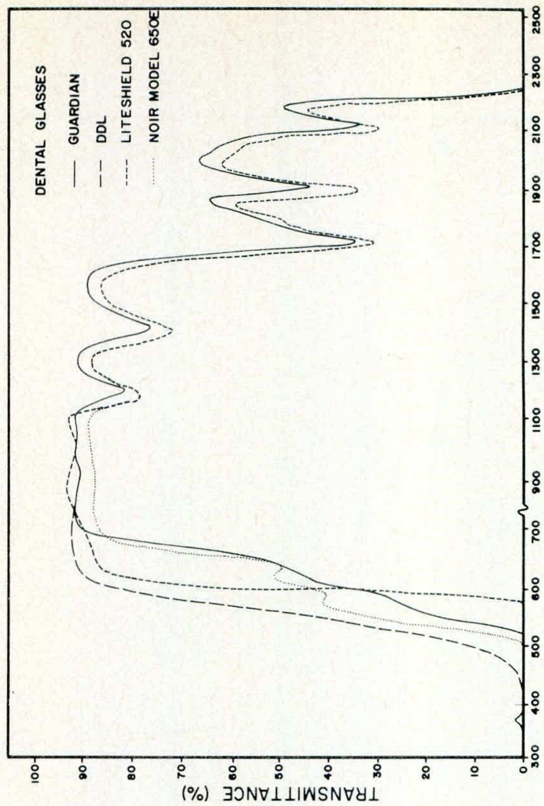


Fig. 10

Calendar concluded from P. 92

1986

January

11-12 Pan Pacific Contact Lens Conference
Sheraton Royal Waikaloa Hotel, Hawaii
12 hours CE
Information: Dr. Stanley J. Yamane, Chairman
Pan Pacific Contact Lens Conference
94-748 Hikimoe Street, Suite C
Waipahu, Hawaii
96797
USA

March

23-26 OptiFair International '86
Hilton and Sheraton Center Hotels
New York
Information: Program Director, OptiFair
17 Washington Street
Norwalk, CT
06854, USA
Telephone (203) 852-0500

April

26-29 Optica '86
International Trade Fair for Ophthalmic Optics
and 38th Annual Congress of the WVAO
Cologne, Germany
Information: KolnMesse
Messe- und Ausstellungs-Ges.m.b.H.
Koln
D-5000, Koln 21 Messeplatz
Germany
Telephone:
Willi Julich
221/821-2912
Telex: 8 873 426 mua d

It can readily be seen that almost all of the industrial protectors transmit some UV-A (320-400 nm) but none transmits UV-B (290-320 nm).

Among the sports tints, it was surprising to note the relatively high blue transmittance of the "skeet tint", which is used in activity which requires enhanced contrast of a target against a blue background (the sky). All of the BPI Sports Tints are aqueous dye mixtures for use on CR-39 lenses. All transmit some UV-A, but only the "Skeet" tint transmits a significant level of this waveband.

The special purpose sunglasses by Ski Optics (Fig. 4), Vuarnet (Fig. 5), Suncloud (Fig. 5 and 6), Central Optical and Haida Optical (Fig. 5) do not transmit measurable amounts of energy below 470 nm. Thus they protect very well against both UV and blue-light. However, like the bright yellow lenses (e.g. Nite Site, Fig. 5) these lenses suffer from the lack of blue transmittance. Colour perception is greatly distorted; indeed, it is almost impossible to discriminate blue from green.

The CPF photochromic glass series (Fig. 7 to 9) show some insignificant leaks of blue light and UV. The short wave cut-offs in the visible region are very sharp for all of these lenses. They are excellent contrast enhancers, but induce a loss of blue sensitivity.

Recently, several tinted lenses have been developed for use by dentists, dental hygienists and assistants when working with units for light-curing resin filling materials. The resin is cured by an exposure of up to 15 seconds to blue-rich visible light conducted through a fibre optic from a tungsten-halogen source. All three varieties of tint (Guardian, DDL and Liteshield 520) provide adequate protection, as does the Noir 650E, however there is a significant loss of colour discrimination due to the relatively sharp spectral cut-offs of these tints.

Manufacturers of some of the lenses evaluated claim that their lenses absorb all infrared radiation. It is clear from the figures that while some lenses have significant infrared absorption, no lens prevents *all* infrared energy from reaching the eye.

Discussion

Chronic exposure to shortwavelength non-ionising radiation has been implicated in the development of changes in both the anterior eye[10] and the retina[2,11,12]. High levels of environmental UV and blue light (less than 500 nm) are found in industry[1,13,15], reflected from the surface of snow or water, and at high altitudes. Thus protective filters against direct and combined direct and reflected UV and blue wavelengths should be used when mountaineering, skiing, gliding, or participating in outdoor water sports. The goal should be to bring the exposure level of blue light and UV to levels at or below the threshold limit values[17] which have been adopted for industry.

Reduction of glare and scatter to enhance vision is often cited as the reason to use a tinted lens. In daylight discomfort glare is produced when the luminance of the field of view exceeds 10 $cd.cm^{-2}$ with shorter wavelengths producing slightly more discomfort than the longer wavelengths.

A common misconception is that much veiling glare arises from Rayleigh scattering in the ocular media and that the sensation of glare is due to the combination of greater scattering of short i.e. blue wavelengths and the relatively higher sensitivity of the photoreceptors at these wavelengths. In fact, Mie scattering predominates in ocular media, and is not as strongly wavelength-dependent. Thus glare is not necessarily a consequence of preferential scattering of short wave light in the eye, and the subjective reports of reduced glare with selective filters may have other explanations.

Elimination of UV-A (320-400 nm) by an absorptive lens would eliminate biofluorescence of the ocular tissues and media which degrades the retinal image. Tints which absorb strongly in the shortwave visible waveband reduce chromatic aberration of the eye: approximately 0.75 D of chromatic aberration in the eye is due to the waveband between 400 and 480 nm[18,19].

The sport tints are designed to enhance visual perception through the selective reduction of certain regions of the visible spectrum. The wavebands to be reduced should vary with the visual task of the sporting activity. The BPI sport tints appear to be appropriate with the exception of, "Skeet" tint for the reason described above.

Yellow lenses (e.g. Nite Lite) have long been advocated for "sharpening" vision for such activities as target shooting, and driving in fog or haze. This is primarily due to reduction of chromatic aberration in the retinal image. However, the loss of colour discrimination in the blue/green due to the sharp cut-off at about 460 nm reduces the visibility of green traffic signals. The fashion sports sunglasses (e.g. Vuarnet, Suncloud, Haida etc.) which are based on yellow glass suffer from the same disadvantage. Furthermore, these tints use gradient mirror coatings to reduce retinal illuminance still further. Such lenses should never be worn at dusk or at night, and are less than ideal for use as regular sunglasses for non-sports wear.

All industrial protectors tested had adequate absorption characteristics. It is important that any fit-over type sideshields used with these lenses have the same or greater absorption in the shortwave band below 480 nm as the lenses themselves.

"Red" lenses such as the CPF series were developed primarily for the retardation of retinal pigmentary degenerative disease such as retinitis pigmentosa (RP). There is some confusion in the literature over this point; Adrian and Schmidt reported on the successful treatment of a patient with a specific red filter[20], whereas Lederer[21] advocated the use of a blue lens for the same type of condition. Berson[22], in order to test the hypothesis that light deprivation helps to retain visual function in RP, fitted one eye of each patient with an opaque scleral contact lens and compared the progression of the disease in the occluded eyes with that in their fellow eyes. After five years there was no difference in the rates of progression supporting the findings in light deprivation studies of pigmented rodents with retinal degenerations[23]. However, while emphasizing that there is no evidence that any type of sunglass retards the progression of RP, Berson advocated the use of "dark" sunglasses by RP patients when outdoors since sudden increases in illumination may aggravate the course of the disease. Well controlled clinical trials have yet to be completed.

The introduction of dental restorative resins cured by high intensity visible light and near-UV has led to concerns regarding eye safety for the patient, dentist and dental assistants exposed to the light source. While the patient hazard is minimal, the dentist and assistant *may* be at risk of retinal damage. Ham et al[24] have demonstrated that frequently repeated subthreshold or near-threshold exposures are additive. The lenses tested (Fig. 10) provide adequate protection for users of light-curing units. The shortwave leak of the DDL lens is insignificant when the radiant output of typical light-curing units is considered.[25].

We have addressed the spectral characteristics of special-purpose tinted lenses in this report. However other factors must also be considered in determining the suitability of a given filter.

The type of lens material will determine how the lens is tinted. The quality of lens fabrication (surface quality, uniformity of tint, edge quality) should be comparable to that of a prescription optically worked lens. The quality of the frame and security of the lens when mounted in the frame should be inspected also.

In general, minor optical imperfections do not present a problem. As in the case of non-prescription sunglasses[26], we have found that cost is NOT a good indicator of performance of a given protective filter.

Conclusions

1. Lenses which are claimed to block all or most UV perform as advertised.
2. No lens tested in this study was a complete infrared blocker.
3. Sharp shortwave cut-off filters provide effective UV and blue light protection at the expense of blue-green colour detection and discrimination.

Acknowledgements

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We also thank S. Jany and M.G. Hall for making the spectrophotometric measurements, A. Weber for the drawings and G. Smith for typing the manuscript. This study was supported in part by grants from the Natural Sciences and Engineering Research Council of Canada (to APC) and the Canadian Optometric Education Trust Fund (to BRC).

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opinion has contributed the most to the profession's progress?

CP: Well, I think of Austin Forsyth in Saskatoon; Harold Arnold; Ivan McNabb in Calgary has devoted a lot of time to the profession as a whole, despite operating a one-man practice. He was provincial Secretary for years and then went on to CAO Council and a term as national President.

I also think of Irving Baker, of course, who is still very active, and Emerson Woodruff in his multiple roles of administrator and teacher.

Ed Higgins, I think we have to think of in a different light. He wasn't an optometrist, of course, but from my experiences with him, I think he did a superlative job in helping the profession to organize itself on a national level.

CJO: I understanding that you have a serious interest in music as well.

CP: Yes, and that actually started at six years of age. My brother was a pianist and I took up the violin. In those days, it seemed like whenever a church group was having a banquet, I was invited to come and play a violin solo — gratis, of course.

I actually kept up my training with the violin right up to the year I went to College. I can't tell you now how much my mother, in those hard times, must have sacrificed to pay for my lessons. I was active in all the trios and quartets that I could join.

When I went to College, I took my violin with me and became a member of the University symphony. I played with them for the two years that I was in Toronto. When I returned to Lethbridge, there wasn't too much happening musically, and I did not want to start back to solo playing. Then a gentleman from Winnipeg, Albert Radmunsky, arrived and he elected to try and organize a symphony orchestra in Lethbridge. He was also qualified to teach and I was the first person to whom he was referred as a consultant for help in organizing it. It became very successful and very popular in the city. We had large crowds and a lot of season ticket holders, and I was made concert master.

I still don't know how he managed to control everything, but he also organized a symphony choir and a musical theatre. As a result, I also found myself playing in the theatre orchestra which, once a year, was for fourteen nights in a row and, occasionally, we'd do an oratorio with the choir.

I kept this up until my retirement from active optometric practice. I am still involved in a trio with another former member of the Symphony, and we perform at functions for senior citizens and others.

When I retired from active concert participation, the orchestra's executive paid me a great honour by making me "Concert Master Emeritus".

The Alberta Optometric Association has also honoured me with a life membership "in recognition of valued and devoted service to the profession of Optometry".

I consider both these honours as the highlights in my respective careers as optometrist and musician.

CJO: Have you any comment to make by way of concluding this interview?

CP: Only that I congratulate the optometrists presently holding executive positions in the provincial and national Associations. The progress being made in the profession of Optometry today is due directly to their devotion.

References Concluded from P. 83

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Letters Concluded from P. 60

Dear Dr. Backman:

The sale of contact lenses is regulated by the Food and Drugs Act and the Medical Devices Regulations and the Health Protection Branch is responsible for their implementation. However it is the *sale* of these devices which is regulated, not the practitioner who uses them. The practitioner is subject to regulation by the provincial licensing authorities and the professional associations; I believe this is where you must go to influence the practice you mention.

If I can be of any further help please let me know.

M.T. Cooper, M.D.
Chief
Division of Clinical Assessment
Bureau of Medical Devices
Health Protection Branch
Health and Welfare Canada