Optical Radiation Protection by Non-Prescription Sunglasses

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Abstract

We present spectral transmittance curves over the waveband 200 to 2500 nm for 47 non-prescription sunglass lenses. All appear to provide adequate protection from ultraviolet radiation, especially those which have been advertised as such. Other criteria for choosing the "right" sunglass are discussed briefly.

Résumé

Le document présente des courbes de transmission spectrale sur la gamme d'ondes 200-2 500 nm pour 47 lunettes de soleil non correctrices. Toutes semblent assurer une protection adéquate contre les rayons ultraviolets, particulièrement celles dont les fabricants annoncent qu'elles offrent cette protection. Il est brièvement question d'autres critères de sélection d'un verre fumé.

Introduction

The most widely used non-industrial non-prescription tinted lenses sold in the world are sunglasses. Ideally sunglasses should be used to provide ocular protection from hazardous levels of ultraviolet (UV), visible and infrared (IR) radiation. They are often used to improve visual perception in certain activities in brightly illuminated environments (e.g. shooting glasses) and to reduce glare (e.g. polarising lenses for driving). Sunglasses are often used to increase comfort under bright illumination. However, cosmesis is probably the most important consideration of the average purchaser of sunglasses.

The variety of sunglasses available to the public has increased greatly in recent years. They have a wide range of price, quality and style. Some types are prominently identified with a logo or brand name to enhance the status of the wearer who follows the latest fad of fashion. The average purchaser decides arbitrarily what sunglasses to buy with the main source of information being manufacturers' advertising.

We have previously reported on tinted prescription lenses,[1] and special non-prescription tints for occupational and sports use.[2] Recent queries to our laboratory from practitioners, industry, labour, the media and the general public have indicated that there is also a need for independent evaluation of the spectral transmittance characteristics of non-prescription cosmetic shades and sunglasses.

General Considerations of Sunglass Quality

Lenses

Sunglass lenses are either glass or some form of plastic. Glass lenses are either optically surfaced in the same way as prescription lenses, or made by the faster inexpensive coquille process. In the latter, a bubble of glass is blown to approximately the radius of curvature of a 6D-base lens, and allowed to cool. Once hard, the glass can be broken into pieces which are of approximately plano power and can be shaped and edged to fit into a frame. As is the case of prescription lenses, such glass may be tinted either by mixing colorants into the molten glass, or by vacuum-coating the white lens with either a colorant or mirror coating. Photochromic lenses may be made either by generating optical-quality surfaces, or by the coquille process.

Plastic lenses may be cast, pressed from sheet, injection molded or optically worked. A wide variety of plastics is used, including CR-39, PVC, poly-

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carbonate and polystyrene. The lenses are tinted by mixing colorants with the plastic prior to polymerisation, or by dyeing. Vacuum coated tints are rare.

Polarising lenses can be obtained most often as plastic membranes (Polaroid[R] material) or (rarely) as laminated glass lenses or bonded plastic lenses.

In evaluating the lenses, it is necessary to consider colour, uniformity and density of the tint, as well as the optical quality of the lens.

The density of the tint chosen is a matter of arbitrary choice by the purchaser. In general, cosmetic shades and sunglasses are made in the following categories: light (transmittance up to 80%), medium (up to 40%) and dark (less than 20%). Tints of more than 40% transmittance should be regarded as "fun tints", i.e. cosmetic or fashion shades, rather than sunglasses, especially if violet or pink in colour. These may be placed on a UV-absorbing substrate such as polycarbonate or similar plastics. It is generally regarded, on psychophysical grounds, that in order to reduce glare effectively a tint which transmits less than 60% should be used.[3] We have discussed the choice of colour of the tinted lens in a previous paper.[1]

The impact resistance provisions of the U.S. Food and Drug Administrator's Statement on General Policy "Use of Impact-Resistant Lenses in Eyeglasses and Sunglasses"[4] are usually followed by the makers of non-prescription sunglasses in order to gain access to the huge American market. Lenses must withstand the impact of a 16mm (5/8-inch) steel ball weighing 15.9gm (0.56 ounce) dropped from a height of 1.27m (50 inches) onto the circular area 16mm (5/8-inch) in diameter located at the geometric centre of the lens. The lenses must also meet standards of the American National Standards Institute (ANSI)5[5]. No analogous standard exists in Canada at this time.

Frames

Frames used in non-prescription sunglasses are made in a wide variety of styles in both plastic and metal. Most are inferior in quality and robustness when compared to most frames intended for use with prescription lenses.

Lenses are often roughly shaped and edged, then wedged into the eyewire. It is not uncommon for the lens to be of incorrect size or shape, making dislodgement of the lens highly probable. If the lens is slightly oversize and forced into the eyewire, it will be warped, inducing some cylinder power, and may be stressed at certain points along the edge, making the lens more vulnerable to breakage. Some of these problems are reduced in plastic frames by cementing the lenses in place. Metal eyewires are generally closed by either rivets or solder, as the lenses are not expected to be removed. With few exceptions, lenses are edged with little or no bevel to enhance lens retention in the frame.

As a rule, sunglasses are made so that "one size fits all". This is especially true of the high fashion frames. The frame materials generally do not lend themselves well to easy adjustment by the consumer. The wearer of a poorly fitting frame will experience all the physical discomforts which result from such a situation. The fit and quality of the frame are as important as the quality of the lenses if the sunglasses are to be useful to the wearer.

Materials and Methods

Randomly selected samples of non prescription sunglasses were obtained from manufacturers or distributors of various brands. We also obtained samples of plano uncut finished sunglass lenses from two wholesale optical laboratories.

Lenses were removed from their mountings and thoroughly cleaned. The spectral transmittance curve of each lens was recorded with a Zeiss DMR21 dual-beam recording spectrophotometer following the procedure described elsewhere[1,2].

Gradient lenses were tested at the areas of most dense and least dense tint. Photochromic lenses were tested in the clear state, then exposed to bright sunlight for 5 minutes, and immediately re-tested. (For such lenses we did not control ambient temperature, previous light exposure history or hardening process).

Table 1 is an alphabetical list of the 47 lenses studied, with descriptions and corresponding figure number to locate the spectral transmittance curve.

Results

Spectral transmittance curves of tinted lenses are shown in Figures 1 to 24.

In general, lenses which were claimed to block ultraviolet radiation were found to do so, with shortwave cut offs in the range of approximately 370 to 400 nm; the Bollé Irex curve agrees well with the advertised claims, having a cut off for our sample lenses of approximately 475nm. The curves for other glass and plastic lenses are similar in their shortwave cut offs to other tinted lenses which we have examined previously[1,2].

Discussion

It is often stated that the price of a given item is directly related to its quality. In the optical industry, inexpensive sunglasses have often been condemned as inferior products which can give rise to patient complaints of headache and/or eyestrain. We are unaware of any epidemiological support for such claims; indeed the majority of users of inexpensive sunglasses do not appear to have these complaints. There is no evidence of damage to the eyes from the use of inferior quality sunglasses.

Table 1
Lenses Tested

Lens	Description	Figure
Children's sunglasses		
Foster Grant (FG)	Grey plastic sheet	1
FG Smurf	Grey plastic sheet	1
Riviera (R)	Blue-grey molded plastic	1
Shoppers Drug Mart (SDM)	Grey-green plastic sheet	1
Adults' sunglasses		
FG 1242-01 Magnum*	gradient grey on yellow polarized plastic	2
FG 1264-01 Chromic mirror*	semi-mirror coat on grey coquille glass	2
FG 1636-01 All Weather Spec 1000*	Gradient grey on yellow plastic	3
FG 1658-01 Spec 1000*	Grey polarized plastic	3
FG 1802-01 Photochromic*	Photochromic coquille glass	5
FG 1866-01 Ultralens*	Mirror coat on coquille glass	2
FG 6250-01 Clip-ons*	Green polarized plastic	4
FG 7358-01 Opti-clips*	Grey polarized plastic	4
FG Space Tech*	Gradient blue-grey plastic	4
Pirate	Grey-green plastic	6
Solaire	Gradient green plastic	7
Tropical	Grey glass	6
R All Weather	Semi-mirror coat on amber plastic	8
R Mirror	Mirror coat on coquille glass	9
R Slalom	Blue polarized plastic	9
R Titan	Green glass (ground)	8
R Violet	Gradient tinted plastic	10
R Amber Polarized	Plastic sheet	8
R Brown Polarized	Plastic sheet	9
Bolle Irex 100*	Mirror coat on brown plastic	11
Plano sunglass lenses (finished uncuts)		
C-15 with Televis	Yellow coat on grey glass	12
Nitesite	Yellow glass	12
Rayban 3	Green glass	13
Sun-sensor	Brown glass	13
Televis	Yellow coat on glass	12
Varigray	Photochromic grey glass	22
Varigray Extra	Denser photochromic grey glass	23
XDF	Light grey glass	14
CR39 Grey Solid	Dyed CR39	14
CR39 Grey gradient	Dyed CR39	15
CR39 Brown gradient	Dyed CR39	16
Photolite	Photochromic plastic	21
Plastic polarized (71)	Polaroid bonded to CR39	17
PLS polarized (65)	Polaroid bonded to green glass	17
Glass polarized	Polaroid bonded to grey glass	17
Clarlet brown gradient 85%	Dyed CR39	18
Clarlet gray gradient 65%	Dyed CR39	18
Clarlet nr 07	Dyed green-grey CR39	19
Clarlet brown 65%	Dyed CR39	19
Zeiss Umbral 65	Brown glass	20
Zeiss Umbral 75	Brown glass	20
Zeiss Umbral 85	Brown glass	20
Zeiss Umbramatic 35SR	Brown photochromic glass	24

*Labelled or advertised as a UV-blocking lens.

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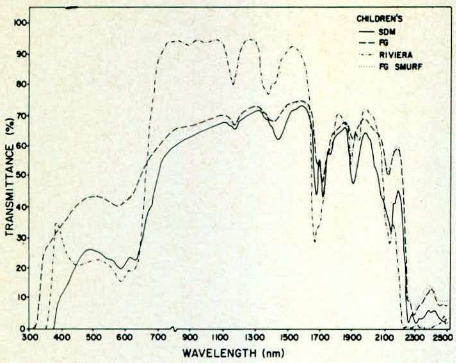

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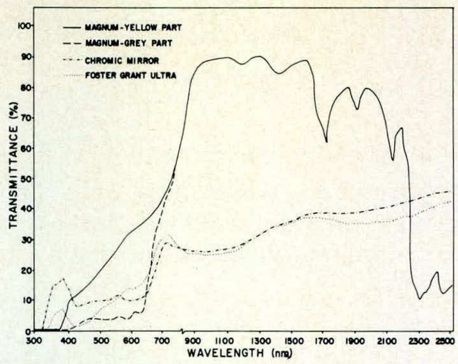

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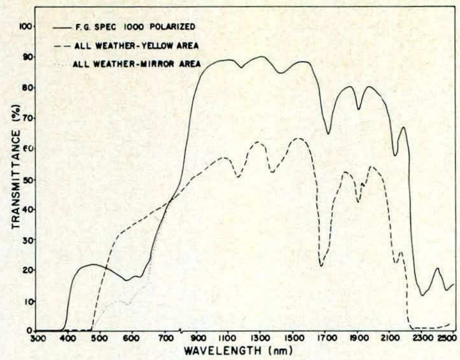

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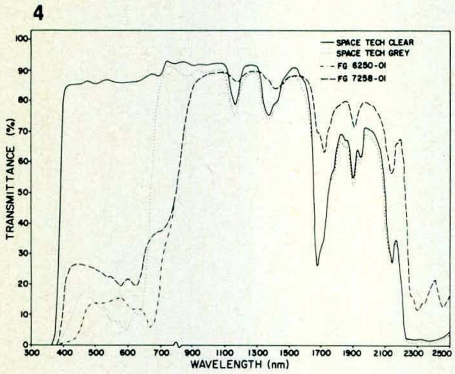

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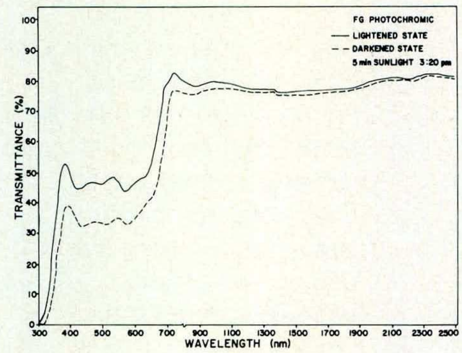

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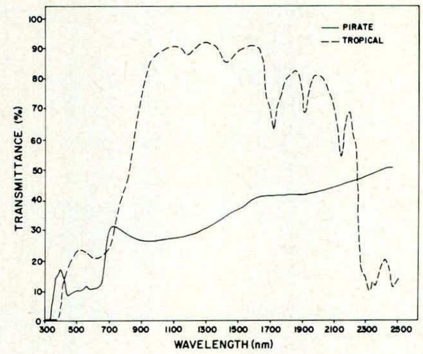

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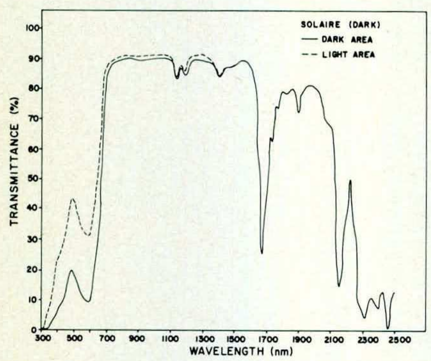

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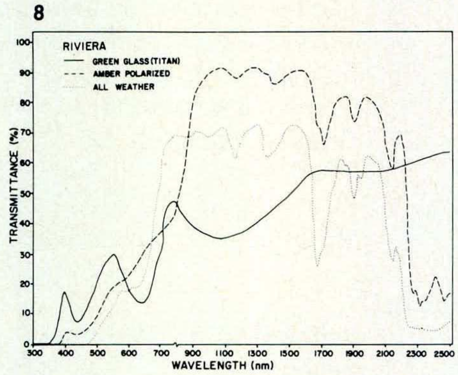

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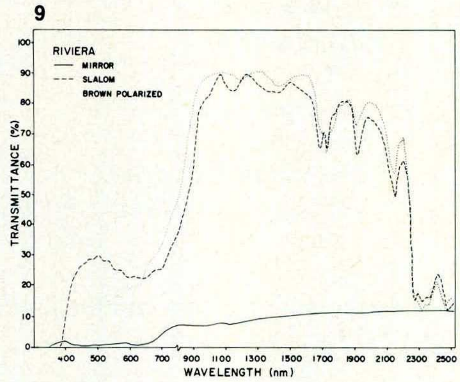

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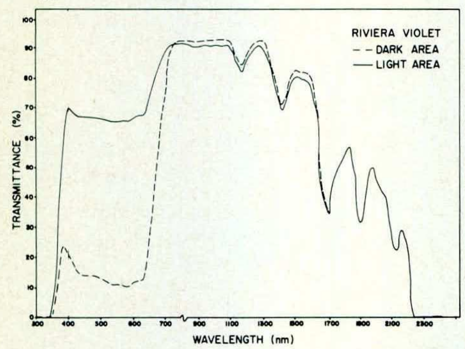

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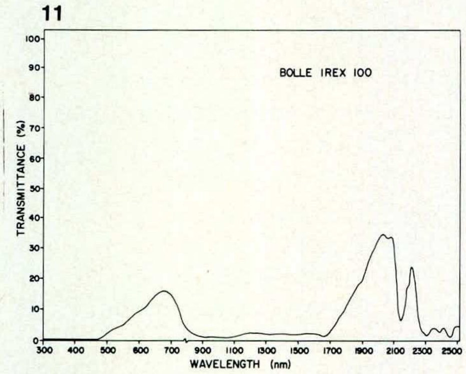

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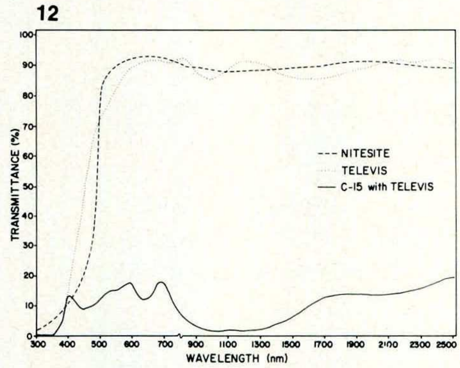

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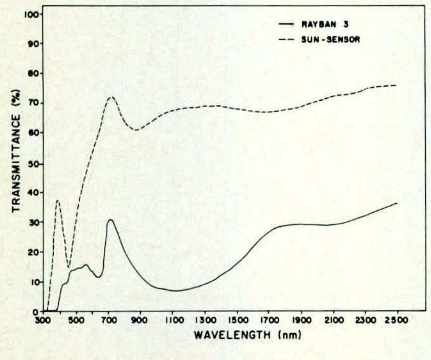

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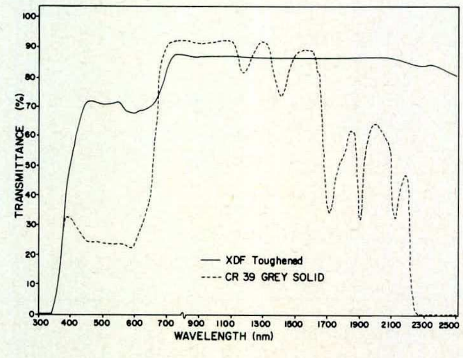

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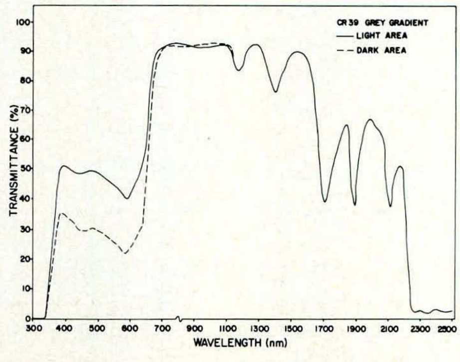

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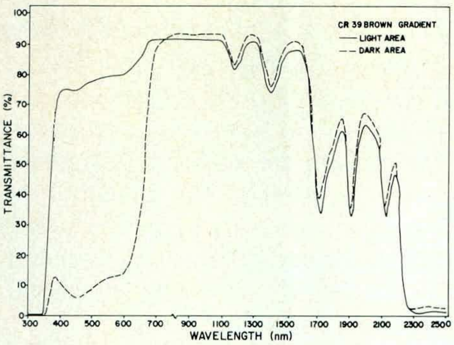

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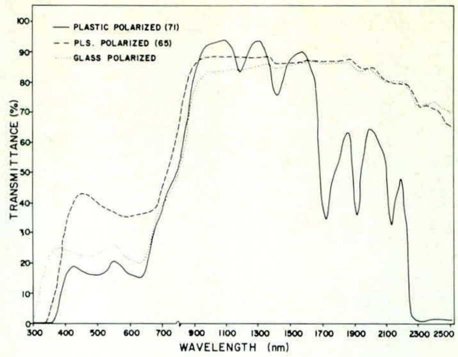

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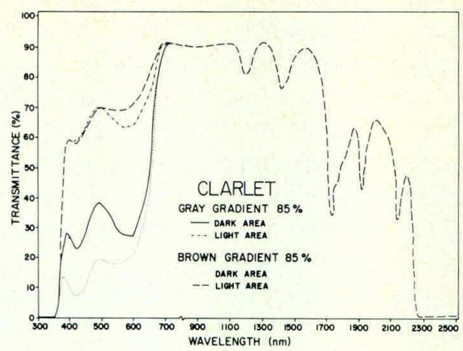

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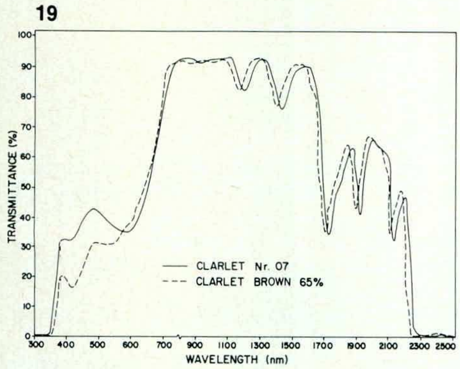

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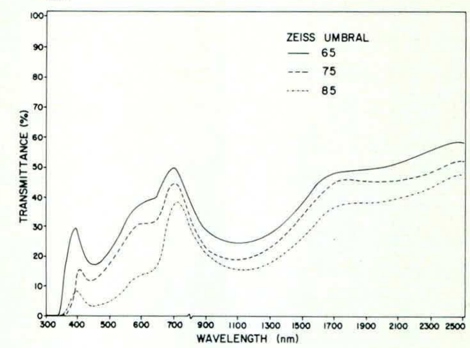

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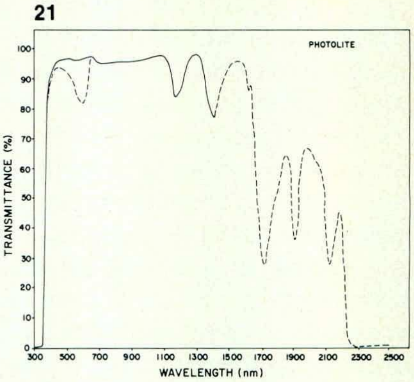

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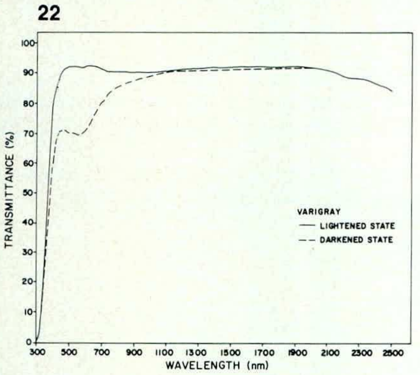

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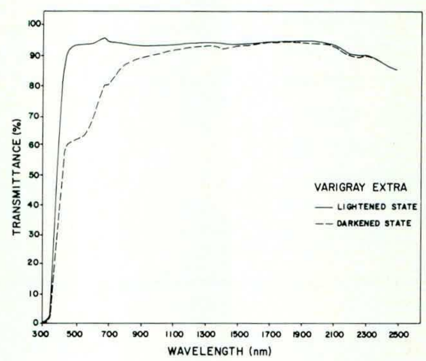

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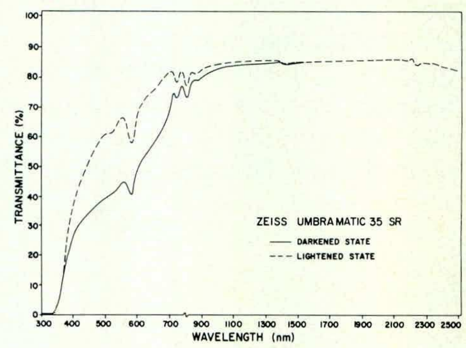

Fig. 1 — **Spectral transmittance curves of children's sunglasses. There are significant differences in ultraviolet transmittance.**

Figs. 2-5 — **Transmittance curves of Foster Grant sunglasses.**

Fig. 6 — **Transmittance curves of Pirate (glass) and Tropical (plastic) lenses show the different infrared transmittance properties which we have demonstrated with tinted prescription lenses.[1]**

Fig. 7 — **The transmittance data of the Solaire lens show how plastic gradient tints affect only the UV and visible regions of the spectrum.**

Figs. 8-10 — **Transmittance curves of Riviera sunglass lenses.**

Fig. 11 — **The Bollé Irex 100 lens has excellent protective qualities over the entire optical waveband.**

Figs. 12-20 — **Transmittance curves of sunglass lenses supplied by wholesale optical laboratories.**

Figs. 21-24 — **Transmittance curves of photochromic sunglass lens materials.**

The purpose of the present study was to determine whether the spectral transmittance characteristics of non prescription sunglass tints met advertised claims of protection from optical radiation. The figures show that in almost all cases these lenses provide a level of radiation protection which is comparable to or greater than that afforded by prescription lens tints.[1] This was irrespective of the suggested price of the sunglasses, which ranged from 65¢ to over $100.

This last point begs the question, how does one differentiate between a good and poor quality sunglass? Price is not a good indicator, as some "designer" sunglasses are priced according to fashion considerations, rather than quality of the frame and lenses. This is *not* to imply, however, that *all* expensive sunglasses are poor. Many such sunglasses are indeed of quality comparable to prescription spectacles. It is therefore necessary to educate the patient on how to inspect frames and lenses. While this is relatively simple for the trained professional, it may not be quite so apparent to the casual sunglass purchaser.

Lens surfaces should be well polished with no visible surface defects such as ripples, scratches or pits. As with ophthalmic lenses, the presence of inclusions or other foreign matter within the lens substance is reason to reject the lens. Lenses should be mounted snugly with no gaps or tight spots around the eyewire.

Frames should be carefully inspected for cracks at solder points. Hinges should turn smoothly and be securely joined with screws (not rivets) and the moving parts should be metal. Nosepads should fit flush on the sides of the nose, without pinching or digging into the flesh. There should be no weight-bearing edges. Unless they are cable-type, temples should be long enough for the bend to begin just above the ear, but short enough that the ends are not below the earlobe. Temples, hinges and nosepad guardarms (if any) should be adjustable. These criteria are no different from those for acceptable prescription spectacle frames.[6] Comfort and safety are as important considerations as fashion. Mechanical soundness of the frame and ease of adjustment are just as important in choosing the "right" sunglasses.

In conclusion, most non-prescription sunglasses offer an acceptable level of protection from optical radiation from the ultraviolet through visible light to the near infrared, especially those advertised as blocking specific parts of the optical spectrum.

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Supplemental Note

New Instrument
"UV-Protec" Meter

Introduction

Although the evaluation of the spectral transmittance of prescription and nonprescription lenses may be made in the laboratory using sophisticated and expensive spectrophotometers, such instruments are neither readily available nor practical as in-office instrumentation. However practitioners often wish or are frequently asked to evaluate the protection afforded by sunglasses presented by patients. These are commonly of unknown origin and as we have mentioned earlier (1-4) it is usually not possible to deduce the degree of UV protection from the transmittance characteristics in the visible spectrum. In addition it is difficult to confirm the protective efficacy of UV-absorbing prescription lenses.

Evaluation

The OMS UV-Protec meter[1] (Figure 1) is designed for in-office use with the intent of measuring UV transmittance of a lens at 400 nm. The basic design of the UV-Protec meter (Figure 2) is a UV-A source and a photocell isolated by a long wavelength UV transmitting filter. The lens to be tested is placed over an aperture above the UV source and the movable photocell is placed in line as indicated. The top of the instrument is closed to prevent stray light effects and the reading is provided directly on a digital readout. The instrument is adjusted to a 100% without the test lens in position prior to taking the

[1] **Manufactured by: Optical Moulding Systems, 5120 de Courtrai, Montréal, Québec, H3W 1A7. Cost with only the UV photocell $475.00.**

reading. The digital readout suggests a precision of 0.1% although the manufacturer admits an error of ± 1.9% at 400 nm.

We compared the transmittance reading given by the UV-Protec meter with the transmittance recorded on the Zeiss DM 21 spectrophotometer at 390 nm and 400 nm, and the integrated UV-A (320-400 nm) transmittance of 20 different tinted lens samples used in our earlier studies published in the Canadian Journal of Optometry and elsewhere (1-4). The results indicated considerable variability, with the UV-Protec meter measurements more closely corresponding to the spectrophotometric readings at 390 nm in many cases and the total UV-A transmittance in others.

Fig. 1 Prototype UV-PROTEC meter. The current production model does not use the separate sensing unit illustrated to the right of the meter.

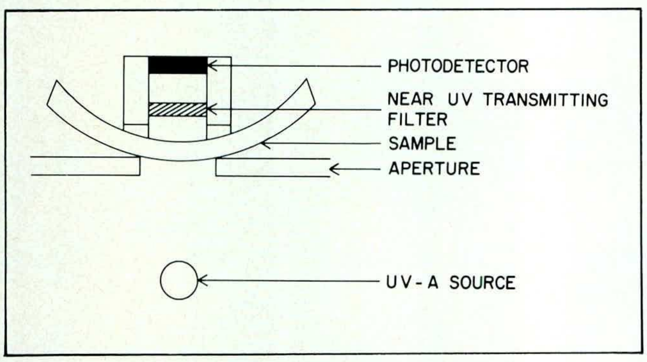

Fig. 2 Schematic design of the radiometric system.

Using UV interference filters as lens samples we found that the instrument is "blind" to UV-B (290-320 nm) but is still sensitive to the mid UV-A (365 nm).

Positive Features

The meter is easy to use without removing lenses from the frame. We found it to be most accurate for assessing UV protection afforded by lenses such as the UV-400, or CR-39 lenses treated with UV-Protec Dye. In addition, the UV reading is clearly demonstrable to the patient.

Negative Features

The reading is not accurate to 0.1% as suggested by the digital readout. The reading varies with the spectral transmittance characteristics of the sample lens in the UV-A. "Windows" in a lens in the UV-B band would not be detected, however we have detected no such windows in lenses specifically designed for UV and blue light protection.

Additional Features

Because of its modular design visible light and infrared radiation attachments will be available in the near future.

Conclusion

This instrument provides a simple method of evaluating near ultraviolet transmittance of spectacle lenses and sunglass lenses without the necessity of removing them from the frame. It functions within the limits of a simple radiometric system with a tendency to over estimate UV-A transmittance. From the practical viewpoint of whether a filter absorbs UV, the answer is readily provided by the UV-Protec meter.

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