British Journal of Dermatology 2004; **151:** 873–876. DOI: 10.1111/j.1365-2133.2004.06098.x

Photobiology

Implication for photosensitive patients of ultraviolet A exposure in vehicles

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Accepted for publication 16 February 2004

Summary

Background Photosensitive patients sometimes report disease flares during journeys by car. Window glass blocks all UVB but not all UVA. All car windscreens are made from laminated glass. Side and rear windows are usually made of nonlaminated glass.

Objectives To determine which types of glass provide most protection from UVA with particular reference to the implications for patients with polymorphic light eruption (PLE).

Methods The percentage transmission of UVA was determined for a selection of glass, both laminated and nonlaminated, and with differing colour tints.

Results Laminated glass transmits less UVA than nonlaminated glass. Tinted glass transmits less UVA than clear glass. Nonlaminated clear glass transmitted the highest percentage of UVA (62·8%) and grey laminated glass the lowest (0·9%). A dose of 5 J cm^{-2} UVA, enough to trigger PLE in some patients, could be transmitted through clear nonlaminated glass in 30 min but would take 50 h through grey laminated glass.

Conclusion Patients with severe UVA-induced PLE and other photosensitivity disorders may have disease flares from solar UVA transmission through side-window glass. Protective measures such as wearing long-sleeved clothing, keeping the arm beneath the bottom of the window aperture, or choosing tinted and laminated car windows may be helpful.

Key words: car windows, photosensitivity, polymorphic light eruption, ultraviolet A (UVA)

Patients with polymorphic light eruption (PLE) and other photosensitivity disorders who spend long periods in vehicles may ascribe provocation of their rash to UV transmission through the windows.[1] UVB (280–315 nm) is completely filtered by glass but some UVA (315–400 nm) may be transmitted. The degree of UV transmission will depend on the type of glass. For safety, windscreens are made from a laminate of glass and plastic. Side and rear windows are made from toughened glass. Both types of glass can be tinted to improve comfort by reducing the transmission of visible and infrared radiation. Prior to the 1970s tinting was rare, but now all new cars on the U.K. market have tinted windows. Around 90% of new cars have green tinted windows (personal communication, Pilkington PLC, St Helens, U.K.), although colours such as blue and grey are also available. In 2001, 99% of glass supplied by Pilkington PLC for coaches was tinted and for lorries 50% was green tinted and 50% was clear.

We wished to measure the UVA transmission of the different sorts of vehicle glass and to estimate solar UVA doses that might be received during journeys. We considered the relevance of these doses to patients with photosensitive disorders. Our aim was to be in a position to advise patients and to understand better the diagnostic relevance of a patient's history of rash provocation during car journeys.

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Materials and methods

Glass samples

Fourteen samples of vehicle glass were obtained with the assistance of a glass manufacturer and a car windscreen repair company. The samples, chosen to be representative of the range of glass currently used in U.K. vehicles, included both laminated windscreen glass, and toughened side glass, both with a variety of tints.

Measurement of UV transmission

A solarium was fitted with eight 2-ft fluorescent lamps (4 × TL20W/12; 3 × TL20W/09; and 1 × TL20W/10; Philips, the Netherlands). This combination was selected as together the lamps give high irradiance throughout the wavelength range from 280 to 400 nm. The spectral irradiance at 30 cm from the mid-point of the solarium was measured from 300 to 400 nm in steps of 1 nm using a double diffraction grating spectroradiometer (Model DMc150FC; Bentham Instruments Ltd, Reading, U.K.). The bandwidth of the monochromator was fixed at 1 nm and wavelength calibration was achieved using a low-pressure mercury discharge lamp (253·7 nm and 435·8 nm). The spectral sensitivity calibration of the instrument was determined before measurement by reference to a calibrated deuterium spectral irradiance standard obtained from the National Physical Laboratory in the U.K. After allowing the lamp output to stabilize for 10 min, spectral irradiance measurements were made with and without glass samples positioned perpendicularly immediately in front of the input optic. The filtered spectra were divided by the unfiltered spectrum to produce transmission spectra, and the mean fractional transmission in the UVA (315–400 nm), UVA1 (340–400 nm) and UVA2 (315–340 nm) wavebands was calculated.

Results

Figure 1 shows representative transmission spectra for the various glass samples tested, and the calculated values for percentage UVA transmission are shown in Table 1.

Discussion

We have shown that the most important factor in reducing penetration of UVA through car window glass

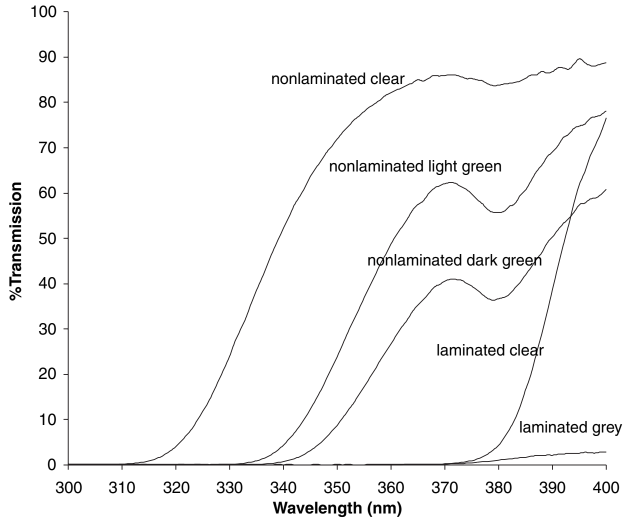

Figure 1. The spectral transmission of representative samples of car window glass.

is lamination, which provides better protection against UVA than nonlaminated glass regardless of the degree of tinting. All vehicle windscreens have been laminated for many years for safety reasons. Therefore, UVA-sensitive patients will be affected only by UVA transmission through side windows since the use of laminated glass at these sites is currently restricted to a few very expensive cars.

In accord with others,[2–4] we found that tinting increases the protection from UVA by glass. Our results show that clear glass protects least followed by light green, dark green, light grey and finally dark grey providing the best protection. The degree of tinting used is determined partly by the legal requirement for visible light transmission (VLT).[5] Windscreens must have at least 75% VLT and the front side windows must have at least 70% VLT. There are no such restrictions for rear side or rear screen windows. Therefore, any of these types of glass can be used in the rear of a car, but the dark-green or grey tinted glass cannot be used in front side windows. Day to day observation suggests that this requirement is not infrequently ignored.[6]

In addition to lamination and tinting, other factors influencing UVA exposure within a vehicle include the position of the individual, direction of travel with respect to the sun, time of day and cloud cover. Dosimetric studies[4,7] have shown appreciable differences in the exposure at various anatomical sites within a car. This is especially true of the forearms, a common site for developing PLE, with the forearm furthest away from the window receiving 1% or less of

Table 1. The percentage transmission of different types of glass

Type of glass	Average transmission (%) Total UVA (315–400 nm)	UVA1 (340–400 nm)	UVA2 (315–340 nm)	Approximate time for 5 J cm^{-2}
Nonlaminated: clear (1)	62·8	80·5	21·0	30 min
Nonlaminated: light green (2)	35·7	50·1	0·6	1 h
Nonlaminated: dark green* (1)	22·9	32·2	0·1	1·3 h
Nonlaminated: grey* (2)	11·4	16·1	0·0	2·5 h
Laminated: clear (2)	9·7	13·7	0·0	3 h
Laminated: green (3)	9·0	12·7	0·0	3 h
Laminated: grey (3)	0·6	0·8	0·0	50 h

The values in parentheses refer to the number of different glass samples that were examined. The two nonlaminated samples indicated by an asterisk had < 70% visible light transmission and so would not be allowed for use in front side windows. The final column gives the approximate time required to receive an unweighted ultraviolet dose of 5 J cm^{-2} when the arm nearest the window is in full sunlight throughout this period (worst case condition). With the window fully open this time is about 20 min.

ambient UV radiation outside the car.[4] If the arm closest to the (closed) window is resting at a level below the bottom of the side window and is in shadow from direct sunlight, the maximum exposure is typically around 5–10% of ambient with the side window facing towards the sun.[4] With the car randomly oriented with respect to the sun during a journey, Moehrle *et al.* estimated[4] that the overall exposure on the arm nearest to a closed window is 3–4% of ambient. The worst case occurs when the arm nearest the window is elevated to the extent that it is exposed to direct sunlight. Here, the exposure through a closed window of nonlaminated clear glass will be around two-thirds of ambient, whereas with the window open the exposure will be equal to, or even higher[4,8] than the ambient on a horizontal plane outside the car since the arm may be perpendicular to the sun's rays.

How relevant are these findings to patients with photosensitivity disorders? Induction of lesions on the skin of the forearm in a typical patient with PLE often requires, at least under laboratory test conditions, an exposure on two or more consecutive days to a UVA dose of 10 J cm^{-2}.[9,10] In the small proportion of patients with PLE who have severe photosensitivity, a single UVA exposure of around 5 J cm^{-2} may be sufficient to induce the rash.[10] Likewise, in patients with chronic actinic dermatitis, a UVA dose of 5 J cm^{-2} may exceed the minimal erythema dose in this waveband.[11,12] In a car journey involving random orientations with respect to the sun, with the windows closed, and with the arm resting below the level of the side window and in shade from direct sunlight, it is unlikely that either arm will receive sufficient UVA exposure to provoke lesions of PLE. With the arms raised to a level above the bottom of the window aperture for an appreciable part of the journey, sufficient UVA exposure through closed side windows could be received in an hour or two to cause a clinical problem in patients with severe photosensitivity—but only on the arm nearest the window. This can be seen from the final column of Table 1, which gives the approximate time required to receive an unweighted ultraviolet dose of 5 J cm^{-2} when the arm nearest the window is in full sunlight throughout this period (worst case condition). The time has been estimated by combining the spectral transmission of the relevant glass type with the spectral power of midday summer sunlight in the U.K.[13] With the window fully open this time is about 20 min. In the very small number of patients with more extreme photosensitivity these times would need to be adjusted accordingly. In these extreme cases patients may also be sensitive to visible light, which makes protection a problem. It is sometimes suggested that a UV protective film should be applied to the vehicle windows in cases of marked sensitivity. We would question the safety of this approach. If the film is imperfectly applied or adhesion deteriorates with time, air bubbles may appear between the film and the glass and result in impaired vision.

It is unlikely that the arm furthest from the window would ever receive sufficient UVA to provoke PLE. Consequently a pointer to whether PLE is provoked whilst driving in a car would be asymmetry in the severity of rash on the forearms. Provocation of lesions is unlikely to result from UVA coming through (laminated) windscreens, unless the journey time is of several hours with the sun shining directly onto the arms throughout that period (Table 1), although it is quite feasible for a pre-existing PLE rash to be aggravated by a hot sun shining directly onto affected sites.[1]

In conclusion, exposure to UVA in vehicles is only likely to be a problem for a small number of patients in certain circumstances. Simple protective measures such as wearing long-sleeved clothing, keeping the arm beneath the bottom of the window aperture, or choosing tinted and laminated car windows may be helpful in these cases.

Acknowledgments

We are grateful for technical advice and provision of glass samples from Pilkington, St Helens, U.K. and Autoglass, Bedford, U.K.

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