General Optical Council Approved CET For Optometrists
General Optical Council Approved CET For Dispensing Opticians

Complete course in dispensing

Part 5 – Ophthalmic lens materials

In the latest in our complete course in dispensing, **Andrew Keirl** and **Richard Payne** look at lens material properties and how they may be best selected for the final appliance. Module C10130, two general CET points, suitable for optometrists and dispensing opticians

In recent years, the optical profession has seen a revolution in spectacle lens technology and in the vast variety of lenses that are commercially available. Some of us will remember when there was no need to question the V-value of an ophthalmic lens material since we really had little or no choice in what we were dispensing. Today, the practitioner has a wide selection of lens designs and lens materials to choose from and the choice of lens material is often one of the first factors to be considered when dispensing a new prescription. To do this effectively the practitioner must have a clear understanding of the properties of ophthalmic lens materials and be able to communicate these facts to the client.

TABLE 1
Lens materials offered by Hoya

Product	Refractive index (n_e)	V-value (V_e)	Density (g/cm^3)
Plastics materials			
CR39	1.50	58	1.32
PNX (Trivex)	1.53	43	1.11
Eyas	1.60	41	1.32
Eynoa	1.67	31	1.37
Eyry	1.70	36	1.41
Glass materials			
1.5	1.52	56	2.54
LHI-2 1.6	1.6	41	2.63
LHI 1.7	1.7	40	2.99
THI-2 1.8	1.81	33	3.47
THI-1 1.9	1.89	31	3.99

The 'ideal' spectacle lens

In order to provide our clients with the optimum correction for their refractive error, spectacle lenses should be:

- Optically and mechanically stable
- Free from aberrations
- Free from reflections
- As thin as possible
- As light as possible
- Abrasion resistant
- Impact resistant
- Easily tinted
- Available with a range of surface processes with the ability to retain hard and reflection-free coatings without complex chemistry
- Easily manufactured at a reasonable cost.

Most of the major lens manufacturers and suppliers offer a wide (and similar) range of lens materials with various surface processes and options. It is of course impossible to mention every product on the market, so as an example, Table 1 gives an overview of the materials offered by Hoya.

Plastics materials can be classified as thermosetting or thermoplastics. CR39 is an example of a thermosetting material. Such materials are cast in moulds as a liquid monomer and then polymerised using heat. Thermoplastic materials such as polycarbonate are injection moulded as a hot liquid and then cooled to form long chain molecules, resulting in materials that offer increased impact resistance. Trivex is a urethane based pre-polymer that does not fall into either the thermosetting or thermoplastics categories.

So what do the numbers in Table 1 actually mean? When choosing a lens material for a given prescription, the practitioner must consider three well-known physical properties that are usually provided by a manufacturer or supplier. These are refractive index, V-value (constringence or Abbe number) and density. These properties enable us to achieve or at least control some of the objectives listed above.

- Lens thickness is controlled by the refractive index of the material
- Off-axis vision is affected by the V-value of the material
- The weight of the lens is affected by the density of the material.

SERIES MODULES

- Practice development, marketing and communication
- Prescription interpretation
- Frame design
- Spectacle lenses
- Tints and coatings
- Dispensing
- Specialist lenses
- Ordering, checking and collection
- Non-tolerance
- Glossary

Refractive index

Refractive index is the term given to the ratio of the velocity of light of a given frequency in air to the velocity of the same frequency in the refracting medium. It is important to note that the refractive index of a material varies with wavelength. Two wavelengths are commonly used to measure refractive index. The helium d-line is used in the UK and the US. This has a wavelength of 587.56nm and gives a refractive index (n_d) of 1.523 for crown glass. In continental Europe however, refractive index is measured on the mercury e-line,

TABLE 2
Classification of refractive Indices

Normal index	1.48 but < 1.54
Mid index	1.54 but < 1.64
High index	1.64 but < 1.74
Very high index	1.74 and above

TABLE 3
Illustration of curvature, sag and edge thickness reduction for a -12.00 D plano-concave lens made using materials of normal, high and very high refractive indices. r_2 is the radius of curvature of the back (concave) surface, s_2 is the sag of the back (concave) surface and t_e is the edge thickness. The centre thickness of the lens is 1.0mm

Refractive index	r_2	s_2	t_e
1.523	43.58 mm	7.88 mm	8.88 mm
1.701	58.42 mm	5.62 mm	6.62 mm
1.890	74.17 mm	4.34 mm	5.34 mm

wavelength 546.07nm. This wavelength gives a refractive index (n_e) of 1.525 for crown glass. This can be misleading, as the material appears to have a higher refractive index.

With the wide range of materials available today, it is important to use a consistent system when describing a lens material as 'mid' or 'high' index, as vague generalisations can be ambiguous. Table 2 is taken from the British Standards publication, Specification for Complete Spectacles (BS 7394-2 1994).

Generally speaking, higher refractive index materials are used to produce thinner lenses. This is particularly common with myopic prescriptions. A reduction in thickness is achieved by the fact that a lens made using a higher refractive index material requires flatter curves to produce the stated power in comparison to a material with a lower refractive index, for example, crown glass or CR 39. The flatter curves result in a decrease in the sag of the surface and therefore a reduction in lens thickness. This can be illustrated by considering a plano-concave lens of power -12.00D, diameter 50 mm and centre thickness 1.0 mm. The lens is to be made in three refractive indices, 1.523, 1.701 and 1.890. Table 3 has the results. Inspection of Table 3 shows that as the refractive index increases, the concave surface of the lens becomes flatter. This flattening results in a reduction in the sag of the curve with a consequent reduction in edge thickness.

A very useful 'spin-off' from refractive index is a value known as Relative Curvature or Curve Variation Factor. The relative curvature of a material is given by $(1.523 - 1)/(n_{mat} - 1)$ where n_{mat} is the refractive index of an alternative (usually a higher) refractive index, and 1.523 is 4the refractive index of crown glass. However, if a higher refractive index material is being compared with CR39 then $(1.498-1)/(n_{mat}-1)$ should be used. Relative curvature is used to indicate the degree of flattening achieved by the use of a higher refractive index material. As it is also a reasonably accurate indicator of relative lens thickness; it can be used to predict the reduction in edge thickness obtained. Table 4 gives typical relative curvature values for materials compared to spectacle crown glass of refractive index n = 1.523.

From Table 4, a lens material with a refractive index in the region of 1.7 will have a relative curvature of 0.75. This means that a lens made using this material will require only 75 per cent of the curvature compared to the same lens made using crown glass. In other words, the higher refractive index material will result in a lens that is 25 per cent flatter than the crown glass equivalent lens. This should be evident if the values for r_2 given in Table 4 are now compared.

Relative curvature can also be used to predict the dioptric appearance of a lens made using a material of a higher refractive index if the power of the lens in dioptres is multiplied by the relative curvature of the material to be used. Using a -10.00D lens as an example, the finished lens would 'look like' a -7.50D lens (0.75 x -10.00) if it were made from a material with a refractive index in the region of 1.7. If the same lens were manufactured using a material with a refractive index of 1.8 its appearance would be similar to a -6.50D lens and so on.

The third practical use of relative curvature is in the estimation of the refractive index of a lens. This is obviously an important consideration if a client visits your practice for the first time and you suspect that the client is wearing a lens made from a higher refractive index material. It is impossible to give the client the correct advice as to material selection unless you know what the client is already wearing. If thin lens theory is assumed to be sufficiently accurate then the following procedure can be used to estimate the refractive index of a lens. The procedure requires the use of a lens measure and a focimeter.

- Record the surface powers F_1 and F_2 of the lens using a lens measure
- Calculate the power of the lens as determined using the lens measure, F_L, using $F_L = F_1 + F_2$
- Record the power of the lens using a focimeter, F_F
- Calculate the relative curvature using $RC = F_L/F_F$
- When the relative curvature is known the refractive index of the lens can be estimated. For example, if RC = 0.75, the refractive index of the lens must be in the region of 1.7. Alternatively, the RC expression given above can be used to calculate the refractive index of the lens.

This method is accurate enough to distinguish between materials of refractive indices of 1.5, 1.6, 1.7, 1.8 and 1.9 if the lens measure is used carefully and accurately. The lens measure must be held perpendicular to lens surface and if the lens under test is astigmatic, parallel to a principal meridian. It must be stressed that this method is an estimation of refractive index and has a predisposition to inaccuracies!

Chromatic aberration

High refractive index materials are, of course, used with the aim of improving the cosmetic appeal of spectacle lenses, particularly in the correction of myopia and in general terms, the higher the refractive index the thinner the finished lens. However, there is a disadvantage that can occur when higher refractive index materials are used.

The term chromatic aberration or dispersion refers to the inability of different wavelengths of light within a pencil of rays to focus at the same point and arises due to the fact that the refractive index of a material varies with the wavelength of light under consideration. This is because light of different wavelength travels at different velocities through a

TABLE 4
Relative curvature values. Four higher refractive indices are compared to crown glass

Refractive index	Relative curvature	% Thickness reduction
1.6	0.87	13%
1.7	0.75	25%
1.8	0.65	35%
1.9	0.58	42%

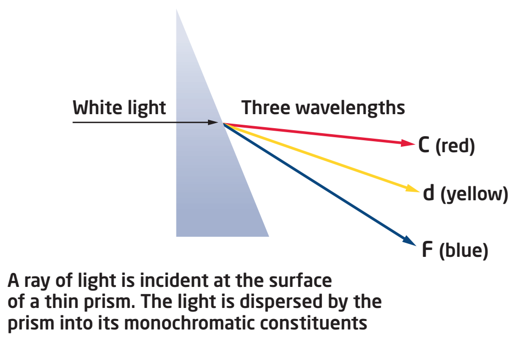

Figure 1 Dispersion produced by a thin plano-prism

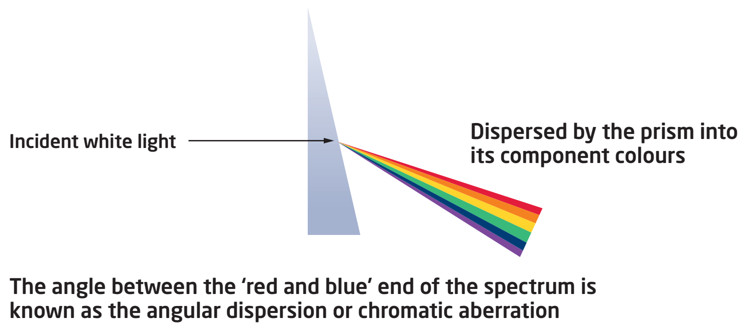

Figure 2 Dispersion produced by a thin plano-prism

particular medium. As a result, red light is refracted less and blue light is refracted more than yellow light. Consequently, the shortest wavelengths of the visible spectrum are deviated to a greater extent than the longer wavelengths. Figure 1 shows the refraction by a prism for three wavelengths, while Figure 2 attempts to illustrate the refraction (dispersion) of all wavelengths within the visible spectrum. Chromatic aberration can be either axial or transverse. However, the transverse variety is of most interest when dispensing spectacle lenses.

Transverse chromatic aberration

Transverse chromatic aberration (TCA) is an aberration which creates multiple images of objects. These images are perceived by the spectacle wearer as coloured fringes around the outline of an object and can be observed when a subject views through off-axis points away from the optical centre of the lens. For example, if a myopic subject observed a dark window bar against a bright background through a point above the optical centre of the lenses (effectively a base up prism), the subject would perceive a blue line above the bar and a red/yellow line below. These effects would be reversed for a hypermetrope corrected with positive lenses as the subject is now effectively looking through a base down prism (Figure 3).

The effect of TCA is to 'spread out' the image formed of an object. Consider an object in the form of a line emitting white light. When a prism with its base-apex line perpendicular to the line object is placed before an eye, the retinal image formed will comprise the component wavelengths of the spectrum, therefore 'spreading out' the image over an area of the retina. This dispersive effect always occurs along the base-apex line of the prism. If the base-apex line of a prism is placed parallel to the lines of a target in the form of a bar grating, the dispersive effect of the prism will fractionally lengthen the image of the bars due to blur at its ends. This effect will not interfere with resolution. However, when the base-apex line is perpendicular to the bars, the image formed will suffer from dispersion across the whole of the image, causing maximum image degradation.

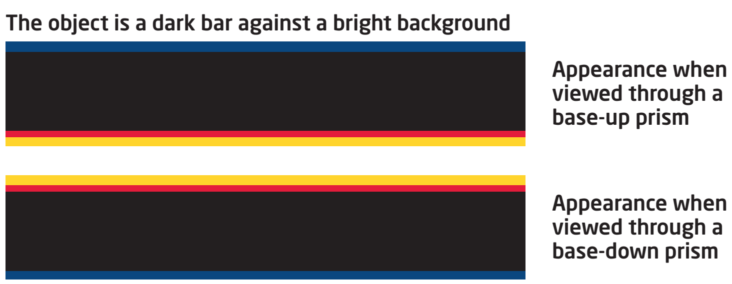

Figure 3 Illustration of colour fringing as a result of transverse chromatic aberration. The object is a dark bar against a bright background

V-value and chromatic aberration

The visual performance provided by a spectacle lens material is related to the V-value or constringence of the material used. The V-value gives the practitioner information regarding the amount of angular dispersion produced by the lens material and is used to calculate the amount of TCA or angular dispersion produced when the client wears a particular spectacle lens. The V-value is the reciprocal of the dispersive power of a material and along with the prismatic effect at a given point on a lens, gives an indication of the visual consequence of TCA to the client. Dispersion is the splitting of white light into its component colours and V-value is a function of refractive index, which of course is a function of the wavelength of the light used to measure it.

V-value is given by

$$V_d = \frac{n_d - 1}{n_f - n_c}$$

where n_d is the refractive index for a wavelength of 587.56 nm (yellow light), n_F is the refractive index for a wavelength of 486.13 nm (blue light) and n_C is the refractive index for a wavelength of 656.27 nm (red light). The term $(n_d - 1)$ is referred to as the refractivity of the material and the term $(n_F - n_C)$ is known as the mean dispersion. The dispersion or spread of light will be greater when a low V-value material is used compared to the dispersion produced by a high V-value material. The spread will always be along the base-apex line of the prismatic effect. Relating this to a spectacle lens, a greater amount of dispersion causes the image formed to be 'less sharp' than it would be with a lower amount of dispersion. Vision may therefore be better with high V-value materials. The visual acuity obtained by a client can therefore be influenced to a certain extent by the lens material chosen. The classification of V-value based on dispersion is given below (BS 7394-2 1994).

- Low dispersion $V = 45$ and above
- Medium dispersion $V > 39$ but < 45
- High dispersion $V < 39$.

Table 1 provides V-values for Hoya's glass and plastics ophthalmic lens materials.

When considering glass materials we can state that as the refractive index increases the V-value reduces as this is always the case when considering glass materials. However, it is not so easy to make this simple statement for modern plastics materials. Referring to Table 1, the material with the lowest refractive index and highest V-value is, as expected, CR39. PNX (Trivex) and Eyas have different refractive indices but similar V-values whereas Eynoa and Eyry have similar refractive indices but different V-values. The visual performance of Eyry is therefore theoretically better than that of Eynoa. It is interesting to note that the V-Values of plastics materials are generally lower than that of glass equivalents. For example, the V-value of a 1.7 glass material is around 40 whereas the V-value of a 1.7 plastics material can be in the low 30s. Also, the V-value of Eynoa (n = 1.67) has the same V-value (V = 31) as 1.9 glass!

Pilkington used to produce a glass material known as Slimline 50. It had a refractive index of 1.7 with a very respectable V-value of 50.8. It was taken out of production due to poor commercial support. It is also interesting to note that because of its superior impact resistance, polycarbonate has become the default material for paediatric dispensing in the US. The major drawback of polycarbonate is its low V-value of 30. However, since the arrival on the market of Trivex a plastics material manufactured by PPG and used by Hoya as PNX and Younger as Trilogy, practitioners now have an alternative to polycarbonate as Trivex has the following properties:

- It passes FDA testing at 1mm centre thickness
- It meets BS EN 166-F and ANSI Z87.1 standards for eye protection
- It withstands a pulling force of 80kg
- It withstands pressure of 10kg
- It has a higher V-value (43) when compared to polycarbonate (30)
- It displays a good resistance to scratching
- It absorbs UV to 395nm
- It displays resistance to high temperatures
- It displays resistance against solvents

TABLE 5

Density values for five glass lens types

Lens type	Density (g/cm^3)
1.5 Glass	2.55
1.6 Glass	2.67
1.7 Glass	3.19
1.8 Glass	3.62
1.9 Glass	4.02

TABLE 6

A comparison of weights for four glass materials. The lens compared is a round 50mm diameter lens

Lens Power	1.5 Glass Weight (g)	1.7 Glass Weight (g)	1.8 Glass Weight (g)	1.9 Glass Weight (g)
-4.00	11.11	12.0	12.8	13.6
-6.00	13.3	13.6	14.3	15.6
-8.00	16.6	16.6	17.2	18.5
-10.00	20.1	19.6	20.2	21.4
-12.00	23.5	22.5	23.2	24.4
-14.00	26.4	24.8	25.5	27.4
-16.00	30.6	28.1	28.2	30.6
-18.00	35.0	31.6	32.3	33.7
-20.00	42.0	35.4	36.0	37.1

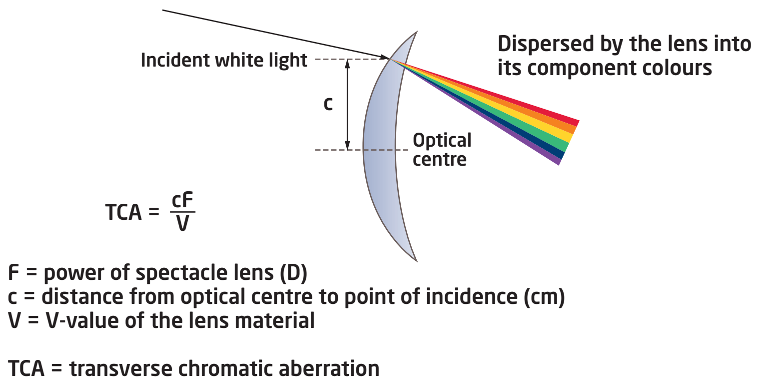

Figure 4 Transverse chromatic aberration

- It requires no special edging equipment required
- It can be manufactured with a centre thickness of 1.3mm for minus lenses.

The calculation of TCA in spectacle lenses

In the case of a spectacle lens, angular dispersion is referred to as transverse chromatic aberration (TCA) in the UK or lateral colour in the US, to distinguish it from axial chromatic aberration, which is not considered in spectacle lens design. TCA is measured in prism dioptres (Δ) or in minutes of arc and is given by the prismatic effect at the point of incidence upon the lens divided by the V-value of the lens material.

TCA in spectacle lenses (when measured in prism dioptres) is given by:

$$TCA = \frac{P}{V}$$

where P is the prismatic effect at the oblique visual point on the lens (Δ) and V is the V-value of the material used. From Prentice's rule, the prismatic effect can be expressed as the product of the decentration in cm and the power of the lens in dioptres. It is therefore more useful to express TCA in the form of expression 1 below:

$$TCA = \frac{cF}{V} \qquad (1)$$

This is illustrated in Figure 4.

The amount of TCA produced by a spectacle lens therefore depends on three factors:

- The power of the lens (F in dioptres)
- The distance from the optical centre to the oblique visual point (c in cm)
- The V-value of the material used.

TCA can manifest itself in two ways. The increased dispersion with low V-value materials causes a spread of light within the image formed. This spread is along the base apex line of the prismatic effect at the oblique visual point. This is the tangential meridian and results in off-axis blur known as tangential blur. High contrast objects are seen with coloured

TABLE 7
Surface reflectance values for various indices

n	P %
1.523	4.3
1.600	5.3
1.700	6.7
1.800	8.2
1.900	9.4

TABLE 8
Reflectance and transmittance of various optical materials

Material	Reflectance %	Transmission %
Crown 1.523	4.5	91.6
Mid index 1.6	4.8	89.6
High index 1.701	5.3	86.9
High index 1.74	5.2	85.9
Very high index	6.2	84.2
Very high index	6.7	82.1

fringes when a client looks through a point on the lens away from the optical centre. Clients have been known to complain about this effect but it is often treated as novelty rather than a nuisance. Under conditions of low contrast, the effect of TCA has more serious consequences as it causes a reduction in visual performance. This complaint often presents in the form, 'these lenses are fine when I view through the centres but are blurred when I view through the edge.' Any complaint is usually directed towards distance vision as opposed to near vision although the visual effects of TCA can result in non-tolerance to progressive power lenses. It is generally accepted that the average threshold value for TCA is 0.1Δ.

It is useful to be able to estimate the point of a spectacle lens where a client will notice the TCA threshold. This can easily be calculated using expression 1.

It is generally agreed that if prescriptions of 5.00D and above are dispensed using materials with a V-value less than 58, then the client should be warned about the effects of off-axis blur and colour fringing in oblique gaze. When considering the off-axis performance of a spectacle lens, the maximum ocular rotation is usually taken to be 30Δ. At a fitting distance of 27mm, this angle equated to a distance of only 15mm from the optical centre of a spectacle lens. The TCA produced by a -5.00D lens is illustrated in Figure 5.

The major ophthalmic lens manufacturers are now producing higher refractive index plastics materials with reasonably respectable V-values. However, there is a trend among manufacturers to supply newer lens designs only in plastics materials, which have a refractive index of 1.6 or greater. These materials invariable have V-values in the region of 32.

To keep effects of TCA to a minimum, the following points should be considered by practitioners:

- Use materials with a high V-value
- Apply correct horizontal and vertical centration and pantoscopic tilt. Placing the optical centres of high-powered, low V-value lenses at the zero pupil position with a zero pantoscopic tilt will reduce the effects of TCA and hence avoid reduced visual acuity in primary gaze
- Use best form designs
- Be sensible with frame selection – consider shape and size carefully
- Fit the spectacle frame with as small a vertex distance as possible. The larger the vertex distance, the greater the distance from the optical centre to the visual point for a particular ocular rotation. So fitting the lenses as close as possible to the eyes keeps the visual points as close to the optical centres as possible and minimises the effects of TCA.

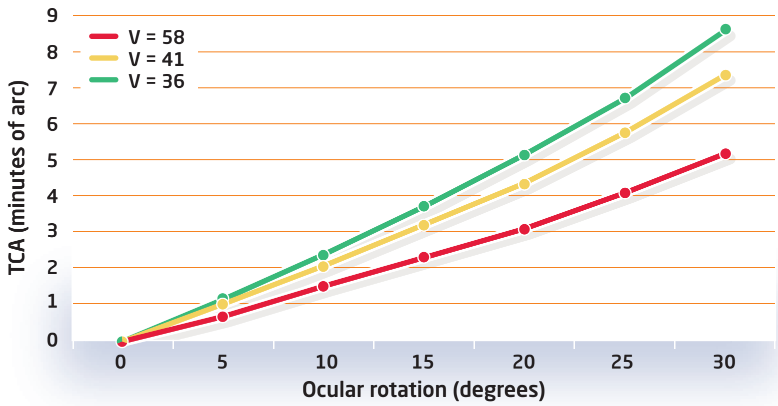

Figure 5 Chromatism produced by a -5.00D lens made in three plastics materials. Data provided by Hoya Lens (UK)

Other advantages are to be gained by keeping the vertex distance as small as possible. The field of view is larger, with a smaller vertex distance. Both TCA and distortion increase with the distance of the chief ray from the optical axis. So, with a smaller vertex distance, both distortion and TCA are marginally less because the chief ray meets the lens closer to the optical axis for a given eye rotation. These effects are small but not insignificant and can be demonstrated by the application of accurate trigonometrical ray tracing.

It should also remembered that myopes do not need to use as much ocular rotation as emmetropes or hypermetropes to observe at oblique angles in the object space because of the increased field of view with high minus lenses. Hence, less ocular rotation is needed which may mitigate the effects of TCA.

Density and weight

The weight of a spectacle lens depends on its shape and size, volume and the density of the lens material. Density is given by mass/volume (g/cm^3) and gives an indication as to the weight of the finished spectacle lens. In general terms, and for glass materials in particular, the density of a material increases with refractive index. This does not mean, however, that the finished lens will be heavier. Naturally, we want spectacle lenses to be as light as possible. This means that the density of the material must be as low as possible. The density of plastics materials are about half that of glass so that plastics lenses are about half the weight of glass lenses. However, in reality we cannot just compare the densities of the materials since higher refractive index materials will have less volume, owing to the fact that the same curve will produce a higher surface power on a higher refractive index material. Unfortunately, some low-density materials have very low V-values. This means that a potential reduction in off-axis vision must be considered when dispensing low-density materials with low V-values. Polycarbonate is a good example here because it has a low-density (1.2) and a low V-value (30). An example of a low-density material with a much more respectable V-value is PNX which has a density of 1.1 and a V-value of 43.

The weight of a spectacle lens can be predicted by considering the density of the material used. Manufacturers quote the density of a material in g/cm^3. It is convenient for the practitioner to assume that the density of the material is the same as the weight in grammes as one cubic centimetre of the material. Table 5 gives density values for five glass lens types.

Table 5 shows that, as the refractive index of the lens increases, so does the density. A density of 2.55 means that a one centimetre cube of the 1.5 material will weigh 2.55 grammes. A one centimetre cube of the 1.6 material will weigh 2.67 grammes and so on.

It is therefore true to say that high refractive index glass materials are heavier if we compare like with like, for example, a one-centimetre cube. This does not always translate to the finished spectacle lens. It is therefore incorrect to say that high refractive index glass lenses are heavier than normal refractive glass lenses.

Because a high refractive index glass lens is thinner than a normal refractive glass lens its volume will be reduced – there is less of it! This means that even though the lens is made from a denser material its finished weight may be less than the same lens made using a normal refractive glass material. In lower powers however, it is probably true to say that high refractive index glass lenses will be heavier. This is illustrated in Table 6.

It is interesting to note that the 1.5 and 1.9 glass lenses weigh the same when the power reaches -16.00D, and the 1.9 lens is actually lighter for -18.00D and -20.00D. This is due to the reduction in lens volume brought about by the use of a higher refractive index material. If the weight of the finished lens is the main priority for the client a plastics material should be considered. If the refractive indices and V-values of two materials are similar then it is sensible to opt for the lower density material. However, one should not forget other factors such as impact resistance and durability.

Reflectance

A further consequence of increasing the refractive index of a material is an increase in surface reflectance. Surface reflectance (P) is calculated using the expression

$$P = \frac{(n-1)^2}{(n+1)^2} \times 100\%$$

For a lens made from a material of refractive index 1.5 the surface reflectance would be 4.00 per cent at the first surface and 3.84 per cent at the second surface. The total light transmitted by the lens is therefore 92.16 per cent. The total light transmitted by the lens made from a material of refractive index 1.8 would be 84.3 per cent. It goes without saying that lenses made using higher refractive index materials should be supplied with multi-layer, reflection free coatings. Indeed, some lenses are only available with reflection free coatings. It is worth mentioning at this point the fact that surface reflections are increased if a low-powered aspheric lens is used. Again, the solution is to use a multi-layer, reflection free coating. The reflectance and transmittance of various optical materials is shown in Tables 7 and 8.

Conclusion

An ideal spectacle lens material should have:

- A high refractive index. The higher the index, the thinner the lens
- A high V-value. Higher V-value materials exhibit less chromatism
- A low density. The lower the density the lighter the lens
- Low surface reflectance. Surface reflectance can be eliminated by applying a multi-layer reflection-free coating to the lens.

Strategies for obtaining thinner and lighter lenses include the careful selection of frame size and shape to ensure minimum decentration and the use of aspheric lenses. Other factors which need to be considered when selecting a lens material are:

- Abrasion resistance
- Impact resistance
- Ease of tinting and availability of tints and filters
- Availability of surface processes and the ability to retain hard and reflection-free coatings without complex chemistry
- Mechanical stability
- Ease of processing.

The ideal lens material does not unfortunately exist. Perhaps it never will if we keep moving the goal posts. However, with the aid of the polymer chemist, fantastic advances in ophthalmic lens technology have been made in the last 10 years. Lens materials chosen are generally a compromise between vision and thickness or weight. It is also apparent that mid-index materials will soon become the 'standard' material. It is, however, important to ensure that the material best suited to the client's requirements is always dispensed.

In some cases, this material may be glass. While the use of glass as an ophthalmic lens material is in decline, there are some areas where glass can outperform plastics. The demise of glass spectacle lenses over recent years has left many entrants into the optical profession with little knowledge or understanding of the attributes of glass as an ophthalmic lens material. This has probably contributed the current lack of recommendation for glass lenses. As with any product, there are advantages and disadvantages.

Advantages of glass lenses

- Refractive indices from 1.5 to 1.9
- Less constringence than with plastics materials of equivalent refractive index
- Resistant to surface abrasion
- Increased durability
- Very high refractive indices means that very high powers can be surfaced.

Advantages of plastics lenses

- Refractive indices currently from 1.5 to 1.74
- Lightweight and comfortable to wear
- Most products can be tinted
- Ideal for rimless mounts
- Resistant to solvents
- Stable up to about 100°C
- Ideal for use in protective eyewear.

Further reading

Cripps A J. Ophthalmic lens materials and properties *Dispensing Optics,* 2008; 23 5 pp 4-10.

Fowler C and Latham Petre K. *Spectacle Lenses: Theory and Practice*. Butterworth Heinemann Oxford UK, 2001.

Jalie M. *Principles of Ophthalmic Lenses* 4th edition The Association of British Dispensing Opticians London UK, 1984.

Jalie M. *Ophthalmic Lenses & Dispensing* 3rd Edition Butterworth Heinemann Oxford UK pp 34-36, 2008.

Keirl AW. The properties of ophthalmic lens materials *Optometry in Practice,* 2007; 8 4 123-138.

● Optometrist and dispensing optician **Andrew Keirl** runs his own independent practice in Cornwall. **Richard Payne** is a dispensing optician working in private practice in Cornwall

MULTIPLE-CHOICE QUESTIONS – take part at opticianonline.net

1 Which of the following statements is incorrect?

A Lens thickness is affected by the refractive index of an ophthalmic lens material
B Off-axis vision is affected by the V-value of an ophthalmic lens material
C The weight of the lens is affected by the density of an ophthalmic lens material
D Lenses manufactured using high refractive index materials are always heavier than lenses manufactured using low refractive index materials

2 When measuring the refractive index of an ophthalmic lens material, which wavelength is used in continental Europe?

A 479.99nm
B 486.13nm
C 546.07nm
D 587.56nm

3 Which if the following terms best describes Hoya's Eynoa material (n_e= 1.67)?

A Normal refractive index
B Mid refractive index
C High refractive index
D Very high refractive index

4 The relative curvature for polycarbonate (n_e = 1.591) when compared to a normal index material (n_e = 1.502) is:

A 1.13
B 1.18
C 0.85
D 0.88

5 A plano-concave lens is made using a material of refractive index 1.7. A lens measure, placed on the concave surface of the lens gives a reading of -6.00D. The true power of the lens is:

A -6.00D
B -7.00D
C -8.00D
D -9.00D

6 A thin prism has the following refractive indices: n_C = 1.527, n_d = 1.530 and n_F= 1.536. Which of the statements regarding values for the mean dispersion, refractivity, dispersive power and V-value (V_d) of the prism are correct?

A Mean dispersion = 0.530, refractivity = 0.009, dispersive power = 58.88, V_d = 0.01698
B Mean dispersion = 0.530, refractivity = 0.009, dispersive power = 0.01698, V_d = 58.88
C Mean dispersion = 0.009, refractivity = 0.530, dispersive power = 58.88, V_d = 0.01698
D Mean dispersion = 0.009, refractivity = 0.530, dispersive power = 0.01698, V_d = 58.88

7 A -8.00D lens is made using a plastics material with a V-value of 32. The transverse chromatic aberration produced when an eye looks through a point 10mm below the optical centre of the lens is:

A 0.25Δ
B 0.20Δ
C 0.15Δ
D 0.10Δ

8 A subject looks through a point 14mm below the optical centre on a lens of power -5.00D. If the transverse chromatic aberration at that point is 0.175Δ the V-value of the lens material will be:

A 58
B 40
C 36
D 30

9 Which of the following statements is most correct?

A For all mineral and resin spectacle lens materials, as the refractive index increases, so does the density
B The term density simply relates to the weight of a finished spectacle lens
C The density of a material is given by mass/volume
D A lens manufactured using a low refractive index material will always weigh less than the same lens manufactured using a very high refractive index material

10 The surface reflectance for a material with a refractive index of 1.85 is:

A 5.7%
B 6.8%
C 8.9%
D 9.4%

11 With reference to PNX (Trivex), which of the following statements is true?

A It requires special processing equipment
B It does not meet the requirements of BS EN 166-F
C Its V-value is lower that that of polycarbonate
D It is neither a thermosetting nor a thermoplastics material

12 A subject is dispensed with a pair of -5.00D lenses made using a material with a V-value of 50. Through what angle (to the nearest degree) would the subject need to rotate his eyes away from the principal axis of the lens to experience the 0.1Δ threshold for transverse chromatic aberration? The fitting distance is 27 mm and the pantoscopic angle is zero. (Hint: This question requires the use of trigonometry).

A 17°
B 18°
C 19°
D 20°

To take part in this module go to **opticianonline.net** Successful participation in each module of this series counts as two credits towards the GOC CET scheme administered by Vantage and one towards the Association of Optometrists Ireland's scheme.
The deadline for responses is December 11 2008