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Short Communication

Spectacle Lens Materials and their Special Coatings at a Glance

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As technology advances so, too, do eyeglass lenses. Eyeglass lenses were mainly made up of glass in the past. Today, most eyeglasses are made of various types of advanced plastics. These new lenses are lighter, more scratch resistant, do not break as easily as glass lenses or the older common plastic lenses and can be treated with a filter to shield eyes from damaging ultraviolet light. The material used in glasses or sunglass lenses will affect their clarity, durability weight and cost. Below are the main advantages and disadvantages of the various lens materials.

Crown glass lenses

Previously eyeglass lenses were mainly made of glass, which ware very resistant to scratching, but they were very heavy and prone to breakage [1]. These lenses are now becoming obsolete with the exception of industrial safety glasses:

- Refractive index- 1.5228.
- Abbe value- 58.5 (it denotes the chromatic aberration caused by a lens. It depends upon refractive index of material, size of the lens. Higher the refractive index, larger the size of lens, lesser is the abbe value and more of chromatic aberration. It is independent of the lens being of spheric, aspheric or atoric design).
- Density- 2.55 g/cm^3.
- UV cutoff- 320 nm.

Advantages:

- Scratch resistance (don't need scratch resistant coating).
- Excellent optical clarity.
- Anti-reflective (AR) coating sticks to glass lens easily.

Disadvantages:

- Heavy weight, almost twice the weight of plastic or polycarbonate lenses.
- Thicker, about 25 - 40% thicker than lenses made of other materials.
- Can shatter or chip easier.
- Need a UV blocking coating for UV protection.

Plastic lenses - CR39

CR 39 is the most common optical polymer used to make eyeglass lenses. It gives very little light distortion (more than glass lens but less than polycarbonate lens), it is more light in weight and thinner than glass making it comfortable to wear and it is more impact resistant though it may still break and shatter upon impact [2]. So, it is not recommended for active sports.

- Refractive index- 1.498.
- Abbe value- 59.3.
- Density- 1.31 g/cm^3.
- UV cut-off- 355 nm.

Advantages:

- Good optical quality.
- Light weight - nearly half the weight of glass lenses.
- More resistant to breakage than glass lenses.

Disadvantages:

- Thicker than polycarbonate or high index plastic lenses (25 - 30% more thickness)
- Require scratch-resistant coating for more durability.
- Need a UV blocking coating for UV protection.

Polycarbonate lenses

Polycarbonate is one of the strongest and safest materials used for spectacles. They have exceptional strength and resilience [2]:

- Refractive index-1.586.
- Abbe value- 30.
- Density- 1.2 g/cm^3
- UV cut-off- 385 nm.

Advantages:

- Extraordinarily impact-resistant - About 10 times more impact resistant than other lenses.
- Thin - About 20 to 25 percent thinner than CR39 lenses.
- Lightweight - About 20 percent lighter than CR39 lenses.
- Doesn't need a UV blocking coating for UV protection.

Disadvantages:

- Requires scratch-resistant coating for durability.
- In strong prescription powers, there occurs distortion of the peripheral vision.
- More surface reflections than glass or plastic lenses (AR coating required).

NXT lenses

NXT was invented in USA for military personnel use. It is a urethane based pre-polymer. It is also called TRIVEX because of its three performance properties- superior optics, ultralight weight, extreme strength. This material has combined the properties of CR39, Mid-Index lenses and polycarbonate, leaving behind all their inherent disadvantages [3]. It may be called as a lens without weakness. It is the best material for mild to moderate prescriptions:

- Refractive index- 1.53
- Density- 1.11 g/cm^3
- Abbe value- 45
- UV cut-off- 380 nm.

Advantages:

- Excellent impact-resistance. Passes all standards of impact resistance (Impact Resistance Standard, ANSI Z-87.1 and High Speed Impact Test, EN 166) and its impact resistance is higher than polycarbonate.
- Excellent optical clarity even with higher powers.
- Flexible and ultra-lightweight, lighter than polycarbonate and plastic lenses.
- Solvent resistant.
- Excellent UV rays protection without any special coating.
- Thin - Ideal for those with lens powers of between -4 to +5.00.

Disadvantage:

- More expensive.

Mid to high index plastic lenses - Thin and light and super thin and light

Mid and high index lenses are recommended for high eyeglass powers. They allow spectacle lenses to be made thinner, lighter and flatter than other lens materials. They are compressed lenses that offer better optical clarity. For higher prescriptions, they reduce the weight and also reduce the thickness. So, they are better accepted cosmetically. High index lenses are made of thiourethanes [4]:

- Refractive index: 1.60 - 1.75.
- Density: 1.3 - 1.5 g/cm^3.
- Abbe value: 42 - 32.
- UV cut-off: 380 nm - 400 nm.

Advantages:

- Lightweight - Than plastic and polycarbonate lenses
- Thin - About 15 - 30% thinner than CR39 lenses.
- Better optics than polycarbonate lenses.

Disadvantages:

- Requires scratch-resistant coating for durability.
- More surface reflections than glass or plastic lenses (AR coating required).

Classification of lens materials based on their refractive index

- Normal index: 1.48 - 1.53.
- Mid index: 1.54 - 1.59.
- High index: 1.60 - 1.75.
- Very high index: 1.76 or more.

Spectacle lens coatings

Anti-reflective coatings

Anti-reflective coating is applied to eyeglass lenses to reduce the amount of reflection on a lens to avoid glare.

Principle

To reduce the reflection from lens surfaces, the phenomenon of destructive interference is utilized. Anti-reflective coatings produce a wave that is out of phase from that reflected from anterior lens surface [5].

Anti-reflective material

- It should have a refractive index square root of the refractive index of lens material.
- Thickness of coating should be one fourth the wavelength of light.
- For high power lenses, magnesium fluoride (1.38) is used.
- Single coating works for single wavelength only. This limitation is overcome by multilayer coatings, which work for a wide range of visible spectrum.

Advantages:

- This increases the amount of light transmitted through the lens, which improves quality of vision.
- Anti-reflective coating reduces the disturbing night glare and halos.
- It also makes the lens almost invisible and very thin. So, it is beneficial for people with high eyeglass power, people who have a decrease in vision in dim light conditions due to glare, and people who are very much aware cosmetically.

Disadvantages:

- These have poor scratch resistance.
- They can be damaged by hot weather also.

Scratch-resistant coatings

During the process of manufacturing of the eyeglass lens, SR coatings made from silicone dioxide are applied to the front and back of lens [4]. As no lens is scratch-proof, this special coating makes the lens scratch-proof to the rubbing and when it is dropped on a hard surface.

Ultraviolet treatments

As the UV sunrays are very harmful for our eyes, they can accelerate the various degenerative processes in the eye like cataracts and ARMD. So, it is important to protect eyes from the damaging effects of the UV rays [6]. UV treatment of the lenses is done by following methods.

Tinted eyeglasses

Tinting of lenses decreases transmittance. Tinting is done by following methods:

- Mixing dye to molten glass material (integral tints).
- Blowing a film of coloured material on white glass(flashing).
- Deposition of fine layer of tint on the surface by vacuum or electron beam process (most preferred).
- Deposition of mirror like coatings.
- Dipping plastic lenses into molten dye.
- Lighter tints with transmittance levels of 75 - 80% are meant for indoor use.
- Darker tints (grey and brown) with transmittance as low as 20% are used as sunglasses.
- Light pink tints reduce drastically the transmittance of UV-B rays, though UV-A rays can pass.
- Strong colour tints should not be given for long term use because they will result in altered color perception even after removal of spectacles.

Polarized (blue light blocking) lenses

- They are available mostly in greyish or brownish hues: Polarized lenses have a pigment applied to them which creates vertical openings for light to enter the eye and block the short wavelength high energy horizontal rays, so the object seen is somewhat darker but clearer. These lenses also protect the retina from blue light hazards [7].

- Polarized lenses have been used by fishermen for years to better deal with bright light being reflected off water and to see deeper into the water.

Photochromatic lenses

Photochromatic lenses have a special chemical coating of silver halide in them that disintegrates on exposure to UV rays in the region of 300 - 400 nm that makes them change to a darker colour in the bright sunlight and again fades indoors. So, the photochromic lenses significantly improved subjects' ability to cope with intense lighting conditions [8]:

- Transmittance range: It indicates the maximum (fully faded) and minimum (fully darkened) transmission of UV rays.
- Fading rate: It indicates the time taken to fade back to 70% of original transmittance value.
- Reaction time: It is the time taken to darken completely.
- First generation photochromics (photogray) have narrow transmittance range, slow fading rate and longer reaction time. This condition has improved with second generation photochromatic lenses (photogray extra).

The material from which a lens is made can have a major impact on lifestyle. From the different lens material options available make the best choice for eyeglasses as per the personal and professional requirements.

Bibliography

1. Bhargava A and Singh P. "Ophthalmic lens dispensing". *DOS Times* 19.4 (2013): 55-61.
2. Diallo ML., *et al.* "Resistance of plastic Ophthalmic lenses: the effect of base curve on different materials during static load testing". *Optometry and Vision Science* 78.7 (2001): 518-524.
3. Rychwalski PJ., *et al.* "Impact resistance of common spectacle and safety lenses to airgun and rimfire projectiles". *Journal of AAPOS* 7.4 (2003): 268-273.
4. Pillay R., *et al.* "Historical development, applications and advances in materials used in spectacle lenses and contact lenses". *Clinical Optometry* 12 (2020): 157-167.
5. Raut HK., *et al.* "Anti-reflective coatings: A critical, in-depth review". *Energy and Environmental Science* 4 (2011): 3779-3804.
6. Liou JC., *et al.* "UV-blocking spectacle lens protects against UV-induced decline of visual performance". *Molecular Vision* 21 (2015): 846-856.
7. Leung TW., *et al.* "Blue light filtering spectacle lens: optical and clinical performances". *PLoS One* 12.1 (2017): e0169114.
8. Hammond LMR and Hammond Jr BR. "The effects of photochromic lenses on visual performance". *Clinical and Experimental Optometry* 99.6 (2016): 568-574.