National Academy of Opticianry

Continuing Education Course

Absorption, Transmission, Tints, and Coatings

National Academy of Opticianry
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National Academy of Opticianry

PREFACE:

This continuing education course was prepared under the auspices of the National Academy of Opticianry and is designed to be convenient, cost effective and practical for the Optician.

The skills and knowledge required to practice the profession of Opticianry will continue to change in the future as advances in technology are applied to the eye care specialty. Higher rates of obsolescence will result in an increased tempo of change as well as knowledge to meet these changes. The National Academy of Opticianry recognizes the need to provide a Continuing Education Program for all Opticians. This course has been developed as a part of the overall program to enable Opticians to develop and improve their technical knowledge and skills in their chosen profession.

The National Academy of Opticianry

INSTRUCTIONS:

Read and study the material. After you feel that you understand the material thoroughly take the test following the instructions given at the beginning of the test. Upon completion of the test, mail the answer sheet to the National Academy of Opticianry, 8401 Corporate Drive, Suite 605, Landover, Maryland 20785 or fax it to 301-577-3880. Be sure you complete the evaluation form on the answer sheet. Please allow two weeks for the grading and a reply.

CREDITS:

The American Board of Opticianry has approved this course for One (1) Continuing Education Credit toward certification renewal. To earn this credit, you must achieve a grade of 80% or higher on the test. The Academy will notify all test takers of their score and mail the credit certificate to those who pass. You must mail the appropriate section of the credit certificate to the ABO and/or your state licensing board to renew your certification/licensure. One portion is to be retained for your records.

AUTHOR:

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INTENDED AUDIENCE:

This course is intended for opticians of all levels

COURSE DESCRIPTION:

This course presents absorption and transmission of lenses as well as the different types of tints and coatings used on lenses. Included in the discussion will be different types of lens materials and the properties of them with regard to absorption, transmission, tints, and coatings. A brief description of anti-reflective coatings, polarized lenses, photochromic lenses, UV coatings, scratch-resistant coatings, and tints will be included.

LEARNING OBJECTIVES / OUTCOME

At the completion of this course, the participant should be able to:

- Describe the differences between absorption and transmission of lenses
- Explain how absorption and transmission is affected by tints and coatings
- Discuss various types of tints and what they would be best used for
- Identify the principles of polarization and how polarized lenses work
- Explain the principles of a photochromic lens
- Discuss UV coatings and identify some of the lenses that have UV protection inherent in the material
- Discuss the basic properties of anti-reflective coatings
- Describe scratch-resistant coatings

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Absorption, Transmission, Tints, and Coatings

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Introduction

A basic understanding of absorption and transmission of lenses is important in being able to present options to your patients in order to maximize their vision. “Basic” concepts will be presented during this course. Because technologies vary from the various manufacturers with regard to tints, anti-reflective coatings, and polarization, this module will only touch on the basics rather than give a full description of proprietary methods used by each manufacturer. For that reason, this will be considered an overview of these lens options and their applications.

Absorption – The Definition

According to the “Dictionary of Ophthalmic Optics”, the definition is stated thusly:

In spectacle optics, the reduction of transmission of radiant energy through a medium.

Transmission – The Definition

According to the “Dictionary of Ophthalmic Optics”, the definition is stated thusly:

In spectacle optics, the transit or passing of radiant energy through a medium.

Absorptive Lenses

In a clear ophthalmic lens, less than 1% of visible light is absorbed. Depending on the index of refraction of the lens, some light is reflected. Beginning with CR-39 and crown glass lenses approximately 4 percent of light is reflected from each surface of the lens (4% on the front surface and 4% on the back surface). We’ll discuss some of the other percentages of reflection during the presentation of anti-reflective coatings. The absorption of light in lenses is classified by two variables. First of all, is the amount of tint, and lens transmission. The amount of light transmitted through a lens is directly related to the amount of light absorbed by the lens (tinted lens).

Transmission of Light

As stated, the transmission of light through a lens is dependent on lens tint. That means that the denser the tint in the lens, the less transmission of light through the lens.

The amount of absorption in a lens may be identified as #1, #2 or #3, which would correspond with a, b, or c respectively. A #1 tint (a) would be lighter, while #2 (b) would be medium and #3 (c) would be darkest and have the least amount of transmission. In addition, some manufacturers identify the lenses based on transmission alone. That means that in the name of the lens color, they would identify the percentage of transmission. For example, Rayban’s G-15 lens, allows only 15% transmission of light, while absorbing 85% of light. The numbers 1,2,3 or the letters a,b,c are not always uniform from manufacturer to manufacturer, or even from one dispenser to another. However, for those manufacturers who use the percentage of transmission, the identified percentage would be the same, regardless. However, remember that the colors could still vary between manufacturers.

Tints used for standard sun lenses should have a transmission of between 15% - 30% of light. Darker tints with less than 15% transmission could present problems with back surface reflections that could be helped with a back-surface AR coating. Only specialty sun lenses such as those used for mountain climbing or skiing should have lenses darker than 8% transmission.

In addition, if a person has exposure to sunlight at least 2 hours or more during the day, their ability to adapt to night vision is compromised if they don't protect their eyes from sun exposure.

Tinted lenses may have a uniform density throughout the lens or, because of the nature of the lens material such as glass, the lens may have density variations within the lens itself. For example, pigmented glass lenses are those lenses that have had the color mixed into the lens material in the molten state. So, while the raw material would be uniform in the tint, the more of the material that is used in the lens, the darker the final lens would be. That means that a patient ordering Gray 3 sunglass lenses having a +3.00 on the right and +2.00 on the left would not be happy with the color because the center of the +3.00 would be much denser in color that the +2.00 in the center. In addition, the lenses would appear to have a darker center than in the periphery. Minus lenses would be lighter in the center than on the edge, due to thickness variations. Ways to overcome this would be to order clear glass lenses with color coatings or to use a different material, that would not be dependent on the pigmentation within the molten state.

CR-39, polycarbonate, and a number of high-index lens materials can be tinted to the desired color and density. The reason for this is that the tint is absorbed from the outside in and the longer it is left in the tint, the darker the color. When ordering polycarbonate, it's important to order tintable polycarbonate material as the hard scratch coating on some polycarbonate is so hard that it cannot be tinted. In addition, tinting must be done after UV coating and before any AR coatings. Many manufacturers also don't recommend additional UV or tinting since it affects the substrate of the lens material, and the AR coating doesn't get a good "bond".

Tints

While we won't be discussing every possible color combination, this course will discuss the most commonly used tints. We will present some of the color recommendations of tints for various visual tasks. Manufacturers have identified certain colors as being useful for certain specific visual tasks. In addition, certain manufacturers have "trade" names for their specific variations of a certain color. Furthermore, when we get to lenses that change color, certain trade names have been given to the different lenses, however, there are different manufacturing processes for the variable tinted lenses.

So, let's discuss some of the tints, the densities and what they would be recommended for.

Gray is the most widely used tint, particularly for sunwear. That's because it transmits colors evenly with less color change. However, it is not as recommended for patients with emerging cataracts. If tinting in office, it is possible to add yellow to improve contrast for these patients.

Brown has more yellow in the color, so it increases contrast better than the gray. For that reason, it is a better choice for patients with emerging cataracts. It is also good for hazy days, or if the patient is participating in visual tasks that require good contrast and depth perception, such as golfers and drivers.

Yellow can be added to any color to improve contrast and depth perception. Hunters have used yellow for years as a shooting lens, and they are finding that mixing yellow with other colors increases visual performance due to contrast improvement. In addition, yellow filters out blue light and makes an excellent sun lens for overcast days.

Green is a better choice over gray for improving contrast and will give a fairly good color balance. It is considered ideal for tennis players, golfers and for driving. It also produces a transmission curve of light closest to that of the human eye. For that reason, it is steadily gaining popularity in the U.S. sunglass market.

Green tinted glass lenses also have fairly good absorption of the Infra-Red wavelength, whereas other tinted lens materials are not as effective. In addition, green vacuum-coated glass lenses are not as effective as well.

Pink tints have been used in the past to reduce some glare, and soften bright light situations, such as fluorescent lighting. It can be referred to as pink, rose, or by adding a little yellow, peach. Only light shades are considered useful for reducing some glare, and in practicality, these patients would have better results with an AR coating.

Blue tints cause more glare by adding to the blue wavelength.

Darker pinks and blues are considered "Café`" tints or "Disco" tints and are trendy. While they are fun, the patient should be advised that colors of objects will be changed and perception is compromised. They are often used with a "flash" mirror coating which adds reflections and actually helps with glare but are light enough to be used indoors.

Due to the increase of computer usage, using appropriate tints combined with UV protection, and AR coatings can improve contrast, and reduce VDT glare and reflection.
Tints used for CRT use include:

- Gray
    - Multi-color screens
    - Black & white screens
- Violet
    - Green screens
- Blue
    - Amber screens

While this course will not be addressing the newest concern of "blue light", there are several filters, coatings and lens monomers that address these concerns.

Vacuum Coatings

Vacuum color coatings are generally inorganic materials (metals or minerals) that are vacuum deposited to add color on glass lenses to give a uniform density of color on the lenses. As mentioned earlier, a disadvantage of pigmented glass lenses is the variations in density of color. This process allows the same color density across the entire surface of the lens.

This process is also used to deposit mirror coatings on lenses.

Lens Materials

Availability of materials includes glass, CR-39, polycarbonate, mid-index, high index, and *Trivex.*

Each material has certain characteristics that are inherent in each. While glass has been around the longest for use in ophthalmic lenses and offers superb optics, it is heavier and is the least impact resistance.

With the introduction of CR-39® (1.498 index, abbe value of 58) resin lenses by PPG Industries in the late 1960s, glass lenses started being replaced by this very popular lighter weight material, which was half the weight of glass and much more impact resistant. It was extremely easy to drill and is/was extremely easy to use with the nylon type mountings or cord mountings. Although new lens materials have been introduced, CR-39 still continues to enjoy popularity among many Ophthalmic professionals. However, due to the construction of newer rimless mountings, CR-39 is not as favorable in holding up to the stress and strain required. *Trivex*, polycarbonate and some high index materials such as 1.67 are more widely used, now.

The introduction of polycarbonate (1.59 index, abbe value of 30) by Gentex Corporation in early 1980 was met with mixed feelings due to imperfections in the material. The early generation lenses had a somewhat gray appearance and many contained black specks. However, its superior impact resistance made it the lens material of choice for eyewear used for children and safety eyewear. It would appear that the visual demand for a superior ophthalmic lens would have been the driving force behind improving the quality of polycarbonate, however, the quality of polycarbonate was much refined and improved because of the compact disk usage in the entertainment and computer industries in the 1990s. Today's polycarbonate is superior to previous poly and many manufacturers now utilize a water white polycarbonate in their lenses.

Polycarbonate is available in single vision, multifocals, progressive addition lenses, light-changing lenses, and polarized lenses. UV protection is inherent in the material itself. Due to the softness of the material, scratch-resistant coatings are applied to both the front and back surfaces. The back-surface coating can be applied as either a tintable coating which is softer allowing it to accept tints up to 80% or a non-tintable coating.

Because of the manufacturing process, a concern of polycarbonate is the birefringence (double refraction) that is caused because of the injection molding process. This process which heats the material to a high temperature and pressing it into molds causes internal stress which is visible with the use of a polarizing filter. Birefringence or double refraction can result in distortion reducing the visual performance to the wearer.

Various manufacturers utilize both mid and high index materials. It's important to remember that the highest index is not necessarily the best for every patient.

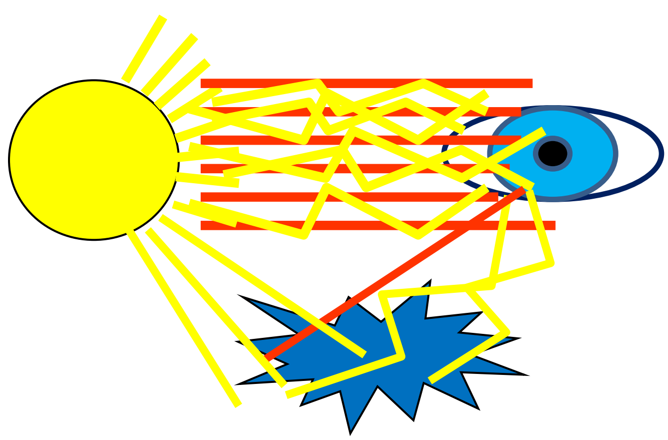
Introduced by PPG in 2001, *Trivex* (1.53 index, abbe value of 43 - 45) is manufactured by a host of manufacturers today in the USA and worldwide. *Trivex* is available in single vision, multifocals, and progressives, is tintable and is available in light changing lenses as well. It also accepts AR coatings well. Newest offerings include aspherics and digital. Features and benefits of the material are superior optics, impact resistance, and ultra-lightweight. *Trivex* passes the FDA drop ball test, in which the metal ball is dropped onto the material, in 1.0mm center thickness. Considered a mid-index, it is lightweight, UV protective and is an exceptionally impact-resistant lens material with excellent optics, *Trivex* combines the crisp optics of a CR-39® lens with the durability, light weight, and impact resistance of polycarbonate lenses, making it an excellent choice for drilled rimless.

Effects of Light on The Eye

In addition to UV damage and blue light damage, some of the negative effects of light on the eye include glare, reflections, discomfort.

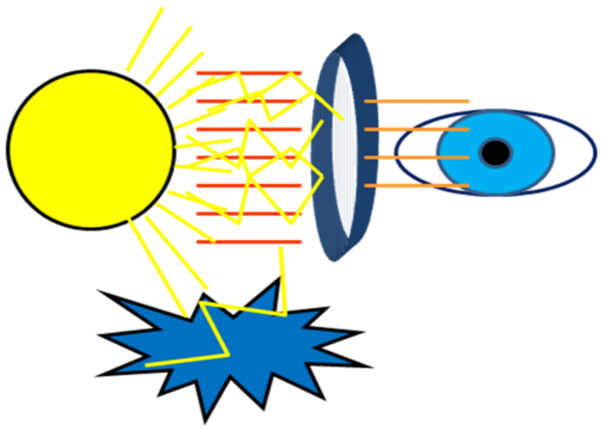
Glare and Reflections

Visible glare is caused by sunlight that is reflected off of surfaces such as water, roads, car windshields, snow, and sand. Visible glare can be dangerous because it can not only wash out colors but, in some instances can cause photokeratitis or temporary blindness sometimes referred to as snow blindness.



Polarizing Filters

Polarizing filters virtually eliminate reflective glare, with the worse being blinding glare that can cause dangerous accidents because of not being able to see.



Principles of Polarization

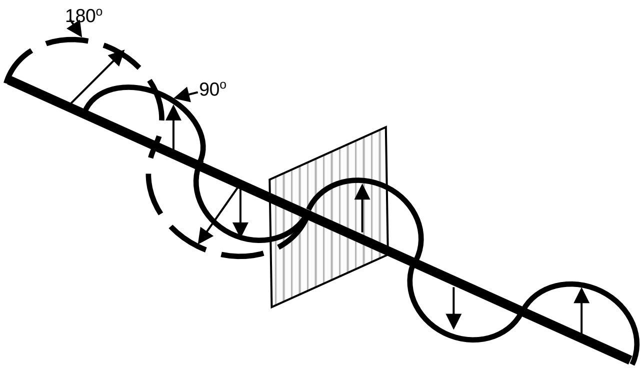
To understand the principles of polarization, think of a venetian blind. Polarized filters are made by stretching thin sheets of polyvinyl alcohol in one meridian. The film is oriented to block reflections from horizontal surfaces such as water, roads, snow, car hoods, or in other words, any horizontal surface. This is the reason why polarized sunglasses are so effective at blocking reflected glare. No other sun lens has the ability to selectively block reflected glare in this way. With ordinary sunglasses, the excessive light from reflected surfaces is transmitted through the lens into the eye.

Formerly, there was only one way or orienting the film in a lens, which was by way of lamination. The film would be laminated (sandwiched) between two lenses. Sometimes, this lamination would de-laminate and the lens would not be usable. For lenses using lamination, it is advised that grooved or rimless frames not be used. Molded technology has been added as a way of incorporating the polarizing filter in the mold at the point the liquid monomer is released into the mold. Although some manufacturers make lighter colors in polarized lenses, most have a higher density of colors such as Gray 3, Brown 3, and G-15. Lighter colors offer less benefit to the polarization.

As previously mentioned, it is now possible to combine polarization with photochromic technology in lenses. In addition, adding an AR coating on the back surface of the lenses makes a superior sun lens.

Since light can travel in different directions, it may vibrate in a vertical, horizontal or even oblique plane at the same time. As it reaches a polarizing filter, light in only one plane will pass through, having the other absorbed by the filter, thereby reducing glare.

Because the filter must be oriented to eliminate horizontal vibrations, prescription lenses must be custom ground for each specific patient.



Polarized lenses are not recommended for visual tasks that involve the use of LCD (Liquid Crystal Diodes) instrumentation because the polarizing filter blocks them out. Examples include gas pumps, some automobile panels, some airplane panels, as well as some watches. Some new polarized lenses are manufactured that are not blocked by these devices.

Photochromic Lenses

The first photochromic lenses were introduced by Corning in 1964. They were glass and the first ones released were called Photo Gray. The next addition was Photo Brown. The color change occurs as a result of silver halide crystals which are a silver chloride/silver bromide combination, that is added to the molten glass. These crystals are activated by UV light, in addition to some visible light. Now identified as in-mass technology, the photochromics are throughout the lens. The early lenses would have a fairly dark change, but not as good as the second generations, which were PhotoGray Extra and PhotoBrown Extra. They would get darker and return to a lighter state. The next addition was PhotoSun, which was identified as a sun density lens when exposed to full UV out-of-doors. It is too dark to be considered an indoor lens. The addition of the PhotoGray Thin & Dark, and PhotoBrown Thin & Dark meant that people can have a thinner and lighter lens ground to a 1.5mm center in the USA. Because these are all available in glass, they have natural scratch resistance.

Plastic Photochromic Lenses

It must be stated that this course will introduce only some of the photochromic lenses available on the market today. There has been a plethora of new technology introduced in just recent years. In addition, some lens technology has been replaced. The purpose of introducing some trade names is to illustrate that there are different technologies and materials available and more all the time.

While certainly not the only photochromic resin lens on the market, *Transitions Optical* introduced the first successful plastic photochromic lens in 1991. They have had a number of technology changes through the years that make them get darker and lighten more quickly. The technology used is imbibed technology, which means that the photochromic technology is on the surface of the lenses, ensuring that the color density is uniform throughout the lens. Current lenses include Transitions Next Generation (NG), Transitions VII (Signature), Vantage and DriveWear Lenses that combine photochromic technology with polarization technology.

Corning introduced its plastic photochromic lens in a 1.56 mid-index. Named SunSensors, the technology is in-mass technology, which means that the photochromic crystals are in the matrix of the material which distributes photochromic molecules throughout the lens, allowing a consistent and effective light response for the life of the lens. SunSensors are available in Gray or Brown.

Rodenstock ColorMatic Extra uses in-mass technology, which again means the photochromic crystals are in the matrix of the lens material allowing even distribution of color throughout the lens for the life of the lens.

LifeRx by Vision-Ease Lens lenses (called Light Responsive Lenses) are made of polycarbonate and are available in gray and brown photochromic tints in a variety of lens designs. The technology used to create Lifer lenses is a dye film that is applied to the lenses that is similar to a polarized film.

ChangeRx by Vision-Ease Lens lenses uses In-Mass Technology in order to change color.

Sensity by Hoya Vision Care lenses uses In-Mass Technology in order to change color.

Photo Fusion lenses by Carl Zeiss Vision are available in gray and brown. They use a combination technology with a special polymer layer of photochromic naphthopyrone molecules being permanently bonded to the front surface of the lens blank. This photochromic layer is then sealed by an extremely durable hard coating that has been engineered to provide exceptional scratch resistance and AR coating compatibility.

PhotoViews™ Photochromic Lenses by Signet Armorlite

Photochromic Lenses

Factors influencing darkening/lightening include light intensity, the temperature, how much prior exposure has been given to the lenses, as well as the thickness, of the lens, and what type of tempering has been done to a glass lens. In addition, the age of the lens will make it change to a different degree as well as have an impact on how quickly the lens will react to light. What has changed with this formula, is that Transitions VII has been developed such that it is not dependent on temperature to perform maximally.

UV Coatings

Features and benefits of UV coatings include that they reduce damage caused by ultraviolet radiation. UV filtering properties are inherent in certain lenses, such as polycarbonate, many of the high index materials, *Trivex*, polarized lenses, and Transitions lenses as well as other photo-sensitive lenses.

A clear crown glass lens only absorbs 9% of UV, but a Gray #3 glass lens includes metal oxides that increase the UV absorption to approximately 82%. However, a standard CR-39 lens, while offering approximately 55% absorption of UV, will offer not much better absorption if it is tinted dark unless it has had additional UV treatment to the lens. Therefore, if a lens is tinted for a sun lens in CR-39 and doesn't have additional UV protection included, since the darkness of the lens would cause the pupil to be larger (more dilated), more UV would actually enter the eye, causing more UV exposure and therefore more damage to the interior of the eye. So, you should include UV coatings on ALL CR-39 sun lenses.

Ultraviolet radiation reaches the eye not only from the sky above but also by reflection from the ground, especially water, snow, sand, and other bright surfaces. Protection from sunlight can be obtained by using both a brimmed hat or cap and UV absorbing eyewear. A wide-brimmed hat or cap will block roughly 50% of the UV radiation and reduces UV radiation that may enter above or around glasses. Ultraviolet absorbing eyewear provides the greatest measure of UV protection, particularly if it has a wraparound design to limit the entry of peripheral rays.

AR Coatings

While AR usage in the USA has increased significantly over the years, primarily to the use of higher index materials, Americans still have not yet discovered the need for AR coating or want it bad enough to ask for it. The Europeans surely have "discovered" it and the Japanese can't do without it! However, as eyecare professionals make better recommendations, this concept should change.

Who Benefits from ARC?

Everyone

Night driving
At night, reflections caused by oncoming headlights, streetlights or lights striking water standing on the road can make driving uncomfortable and dangerous. Internal reflections also cause ghost images (dull duplicate images) making it more difficult to focus on the image quickly making driving more dangerous. AR coating eliminates these problems and provides enhanced night vision.

Reflections at work
Many people use computers at work which produce reflections on their lenses leading to eyestrain. Other artificial light in the office such as fluorescent lighting also produces reflective glare leading to eye fatigue. Offering AR coatings to your patients will enhance their ability to work for longer periods of time without eyestrain.

Personal appearance
Eye contact is important and many people spend a good deal of time making their eyes look beautiful. This means that for a lot of people, simply discussing that their eyes can be seen better with the use of an anti-reflective coating is reason enough to purchase it. AR coating allows

others to see your patient's eyes rather than the reflections and it makes the lenses appear almost invisible which aids eye contact for better communication.

Sunwear and sports eyewear

Sunwear should have AR coating on it because without it, the back surface of the dark tinted sun lens accentuates the mirror effect and your patient will see their eye reflected there – and it can be REALLY annoying. A good AR coating is invaluable for avoiding this problem.

What is an AR Coating?

An anti-reflective coating is a thin film (coating) that is applied to the front and back surfaces of a lens, or in the case of some sun lenses, to the back surface only. Depending on the manufacturer, the film is actually composed of a stack of various layers, each one eliminating more reflections. Some of the premium AR coatings today, have additional hydrophobic and/or oleophobic topcoats that repel water, oils, dirt, debris, and makes the lens easier to clean. In addition, most of the newer AR coatings are also super tough and won't scratch as easily as early generation AR coatings. Because of the bonding processes used by newer manufacturers, the process can actually make the coating bond to substrate (underlying lens material) actually making it a part of the lens material, so it will be less likely to craze. Now, we won't go much further in the actual processes used by manufacturers, because many of them are proprietary, and essentially will change frequently as new technology evolves.

So how does an AR coating work? To understand this, you have to understand the principles of optical interference. First, there are destructive waves that are essentially lightwaves that are out of phase. For example, they move along at the same rate, but the crest of one is at the trough of the other and will cancel each other out. Each layer in an AR coating will have waves that would be out of phase to one of the wavelengths of the visible spectrum, canceling it out.

On the other hand, constructive lightwaves are in phase. That means they are at the same rate and build on each other. This would add reflections, like in a mirror coated lens.

Combination Tinted With AR

Sunlens should have back surface AR to prevent corneal reflections or "mirror" effect of an eye on the back surface of the dark lens.

Combining AR Coating with Photochromic Lenses

Combining an anti-reflective coating with a photochromic lens used to be considered a bad idea, however, because of the chemistry changes in photochromics, it is now advocated to improve vision.

Mirror Coatings

Mirror coatings are applied in a vacuum process to the front surface of a lens only. It acts to reflect light and is beneficial in reducing light transmission through the lens offering protection from intense sunlight. Mirror coatings are also beneficial in reflecting both UV and IR. A mirror lens would enable the observer to see themselves, in much the same way they would through a standard mirror.

The type of mirror that has been used for many years is a reflex mirror. It can be used on all types of lenses. It is best applied to a tinted lens with a transmission of at least 50%. Reflex mirror coatings can currently be produced in standard colors of silver, gold, blue and rainbow colors in addition to rainbow colors. They can be done in solid mirrors, single or double gradients. This type of mirror coating would allow the wearer to see out, but the observer could not see in. The coating itself adds density to the lens reducing transmission of light.

Flash mirrors are also reflex mirrors but are produced with less intensity and would not obscure vision from the observer looking at the wearer.

The dielectric mirror uses layers of virtually colorless materials that as they become the stack results in brilliant color mirror effects. They can be applied to all lens materials. They do NOT add density to the lens. They come in a variety of colors and are good for increasing high contrast to visual tasks out-of-doors.

Scratch-Resistant Coatings

Before CR-39 lenses had any hard coating, they were fairly easily scratched. Dispensers would sometimes recommend a light (dip) coat of tint that would somewhat help to harden the surface. Whether it really helped or not, remains to be seen. Another thing that would be recommended would be to polish a product called “Glaze Coat” on the surface of each lens about once a week or so. It was similar to polishing the surface of a car or furniture. It put a protective coating on the surface and created a smoother surface by filling in hairline scratches. Some dispensers even recommended a liquid creamy furniture polish to do the same thing.

In the 1970s when CR-39 lenses became more popular, the drawback was scratching. Scratch Resistant Coatings (Hard Coatings) were introduced by the 3M company. The first generation of SRC were so hard, that they couldn’t be tinted. Because tints had become so popular about that time, another type of hard coating was developed that allowed the lens to be tinted. While factory-applied coatings seemed to be of a higher quality because they were done during the manufacturing process in the mold, laboratory hard coatings were primarily applied to the back surface of the lenses. A number of methods have evolved over the years including factory applied resin in the mold, spin coatings that harden and then cured, and dipping in a bath, similar to tinting a lens.

Manufacturing processes vary today on the application of scratch-resistant coatings.

Because of the soft nature of polycarbonate lenses, a hard coating is applied to the surfaces of all polycarbonate lenses. Some can be tinted, and some cannot, so if you need to be able to tint a polycarbonate lens, you must specify tintable poly.

In addition, most high-index material lenses today have hard coats applied to the front and back surfaces.

Further, scratch-resistant coatings (hard coatings) are applied to most premium anti-reflective coatings.

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