PRO TO PRO
CONTINUING EDUCATION

PRODUCT SPOTLIGHT – KODAK CLEAN&CLEAR™ UV

HELPING PATIENTS SEE AND FEEL BETTER IN GLASSES

By Deborah Kotob, ABOM

[1 CE CREDIT]

THIS COURSE IS SUPPORTED BY AN EDUCATIONAL GRANT FROM SIGNET ARMORLITE/KODAK LENS

LEARNING OBJECTIVES:

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

1. Describe how light is focused by an ametropic or presbyopic eye.
2. Describe the basics of lens optics.
3. List how lens performance is improved with lens enhancements such as premium AR.
4. Explain how AR will make the patient see, look and feel better.

TO EARN CONTINUING EDUCATION CREDIT:

This course has been approved for one (1) hour of Ophthalmic Level II continuing education credit by the ABO. To earn ABO credit, please review the questions and take the test at 2020mag.com/ce. Note: As of January 2020, no tests will be graded manually. Please call (800) 825-4696 for more information.

In this course, we will review corrective lens basics: who needs them, how they work and the options by type, material and lens enhancements. And since AR is the number one choice for improving lens optics and visual comfort, we will delve into premium AR; how it enhances the vision experienced by the wearer while increasing lens longevity. Once we better understand how premium AR works and other lens enhancements, we will be more inclined to offer the best options to every patient because we want to deliver the best product. After all, who doesn't want more UV protection for their eyes in their everyday pair of lenses? Who doesn't want to see better when driving at night? Who doesn't appreciate higher contrast and detail and reduced eyestrain? The list goes on, so let's jump in and learn why patients deserve the best lenses and lens enhancements for the optimum visual experience.

Emmetropes, ametropes and presbyopes: A normal (emmetropic) eye allows light to reach the retina. The light must focus on the fovea in the retina's central macula for sharp, clear vision in photopic daylight conditions.

Why do we need glasses? When a person has an abnormally-shaped eye, they have ametropia. Ametropia means the eye shape or axial length is abnormal (too long or too short), producing an incorrect focal length. With ametropia, light inside the eye focuses too soon, too late or at more than one focal distance, resulting in an out-of-focus image. Contacts and eyeglass lenses bring light to focus on the fovea of the retina by correcting the focal length of light entering the ametropic eye. Ophthalmic lenses correct refractive errors.

When an eye suffers from ametropia, it has a refractive error, meaning light inside the eye doesn't focus an image on the fovea. Only light focused on the fovea produces an in-focus image. Adding an ophthalmic lens in front of the eye makes the focal power weaker or stronger, thereby correcting the focal length so that the image focuses on the fovea (Fig. 1). (More than one focal length is needed in a lens that corrects astigmatism.)

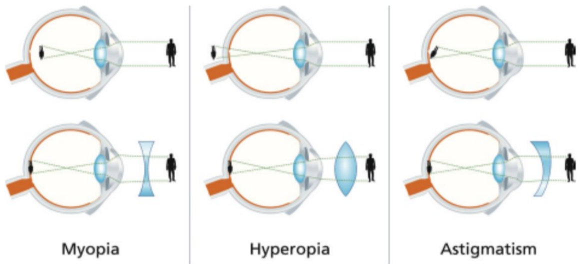

FIG. 1

The focal length of a myopic eye is too short. Therefore, a minus lens is used to lengthen the focal point. The focal length of a hyperopic eye is too long. A plus lens shortens the focal length back to the retina. The astigmatic eye has more than one focal length. A spherocylindrical lens corrects astigmatism.

The image formed on the retina is blurred when light does not focus correctly on the retinal fovea. Corrective lenses change the vergence of light entering the eye to lengthen or shorten the focal length. In the case of astigmatism, a lens has cylinder power 90 degrees away from the axis, creating more than one focal length.

FIG. 2

MYOPIA: Myopes (nearsighted) see excellent up close but they cannot see clearly in the distance. Therefore, myopes wear minus lenses to increase the focal length of light entering the eye, bringing distance views into focus. While they can see up close in the minus-powered glasses, a myope will often take off their glasses to read up close, especially in higher prescriptions (Fig. 2).

HYPEROPIA: Hyperopes (farsighted) can see clearly in the distance, but their near vision is poor. They wear plus power lenses to shorten the focal length of light entering the eye so that light lands on the retina and is focused (Fig. 3).

ASTIGMATISM: For the normal eye, the cornea and the crystalline lens are spherical like a basketball, with the power evenly distributed radially. However, for the astigmatic eye, both close and far views are out of focus because the cornea or crystalline lens is shaped

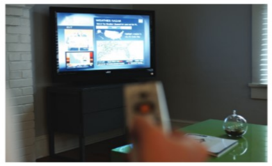
FIG. 3

FIG. 4

more like a football resulting in two curves, one flatter in the horizontal meridian and one steeper in the vertical meridian. Two focal lengths are needed in a lens to correct astigmatism (Fig. 4).

Presbyopia and Defocus: It is not an ametropia (abnormally shaped eye) caused by the aging of the crystalline lens. With presbyopia, the crystalline lens can no longer change shape sufficiently to produce the correct focal length and focus light adequately when viewing close-up objects (less than 20 feet away). Without the proper vision correction, eyeglass wearers fiddle with their eyeglasses, trying to find the right spot that allows them to view up close (Fig. 5).

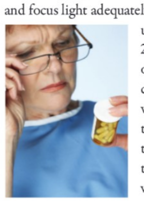
FIG. 5

Distance Focus: Optical infinity (20 feet and beyond). When an object is located at optical infinity, the focal length (distance from the cornea to the retina) of a normal relaxed eye is about 1.7 cm (17 mm). The crystalline lens is in its most relaxed (flattest) state to focus light from distant objects onto the retina. When focusing on near objects, the crystalline lens assumes a more convex curvature (adding more plus power). Snellen

FIG. 6

charts are used to measure how well we see 20 feet and beyond (Fig. 6).

Corrective Lenses: We use contacts or ophthalmic lenses to add or subtract from the cornea's and crystalline lens' combined refractive power. When viewing at a distance where the crystalline lens is in its flattest form, its refractive power is roughly 17 diopters, and the normal eye's cornea is approximately 43 diopters. The total refractive power of the non-accommodated eye averages 60 diopters of plus power.

The cornea and crystalline lens are plus power convex lenses that converge light. The light inside the eye converges to a focal point determined by the focal length. The focal length is the inverse of the dioptic (D) power. (1/D equals the focal length in meters, so the normal eyes' focal length is 0.01666 m or 1/60). A minus-power lens weakens the plus power of the converging light inside the eye to correct the focal length, while a plus-powered

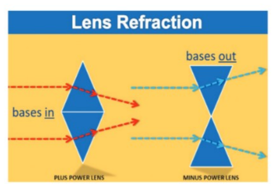

FIG. 7

lens amplifies the convergence of light rays inside the eye.

Ophthalmic lenses function as joined prisms that change the vergence of light entering the eye—base-in for plus lenses and base-out for minus (Fig. 7).

Plus, power lenses are convex and increase the convergence of light inside the eye, thereby shortening the focal length.

Minus power lenses are concave and contribute diverging (negative) power to the light entering the eye, thereby making the focal length of light inside the eye longer.

Spherical or aspherical single-vision lenses correct myopia and hyperopia (Fig. 8).

Single vision lenses have cylinder power to correct astigmatism. When the cornea is shaped more like a football than a spherical basketball, the eye has two focal lengths produced by a flatter curve in one meridian and a steeper curvature

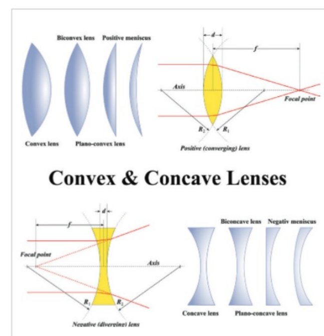

FIG. 8

in the meridian located 90 degrees away. A spherocylindrical lens (spherical and cylinder power) has two focal lengths needed to correct an astigmatic eye. The full cylinder power is located 90 degrees from the axis, and there is no cylinder power at the axis (Fig. 8).

Multifocal lenses correct presbyopia. Presbyopia occurs with age due to the crystalline lens

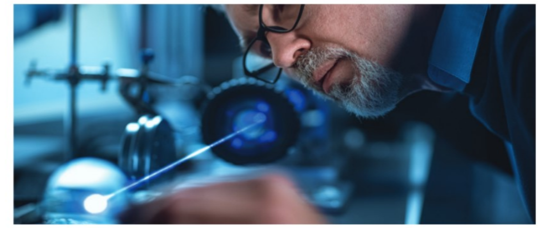
FIG. 9

losing flexibility and accommodative amplitude (the ability to steepen its curvature to bring close objects into focus). Multifocal lenses such as progressives or lined bifocals and trifocals are used to correct vision for the presbyope.

Multifocals can be plano for distance with an add power equaling the required reading power. This provides the convenience of wearing glasses all day without taking reading eyewear off and on.

The best correction for presbyopia is progressive lenses (PALs); no-line multifocal lenses provide the most natural vision with clear distance vision on top, intermediate vision in the middle and near vision at the bottom of the lens. Trifocal lenses provide far, intermediate and near vision, but they are lined or segmented multifocal with image jump as the eye moves between viewing fields. Bifocal lenses are lined/segmented multifocal, providing only distance and near vision. Reading glasses are magnifying lenses (plus power) only for focusing on near objects. Often an emmetrope (normal vision) who develops presbyopia will opt for reading glasses since they see fine in the distance. The problem becomes an inconvenience; since they don't always wear their glasses, they often misplace them.

There are two ways to improve the optics of a clear lens, one is through careful selection of material index and base curve combined with a premium AR coating, and the second is with freeform digital design for both single vision and PAL. Freeform digital designs have revolutionized the manufacture of lenses. (Note: The only way to ensure the best lens optics is by taking precise biometric (PD) and frame fit metrics (fitting height, wrap, panto and back vertex distance, BVD). Suppose the lens' optical axis isn't positioned correctly in front of the patient's visual axis. In that case, the patient will not experience the lens optics as intended, and distortions, aberrations and an inability for the eye to track through a progressive channel will occur.

Digital freeform is a manufacturing process that produces complex surfaces and designs. Processing is achieved via a single-point diamond tool, precisely guided by computer software allowing three-dimensional surfacing along x, y and z coordinates. As the lens spins, the diamond cutting tool tracks across the lens, providing an ultra-smooth finish to the lens design, which can be polished using a conformable pad (Fig. 9). (https://youtu.be/erBiT3CLCoQ)

Advantages of Digital Lenses: Expanded lens design and material availability, precision alignment of prescription and lens design, prescription customization based on frame fit parameters, lens optimization to reduce off-axis gaze lens aberrations in single vision and PALs, and a wider choice of frames.

Lens material is one of the pillars of vision

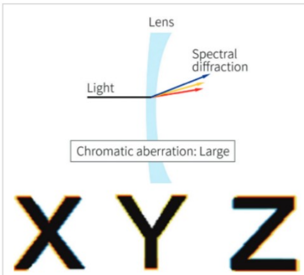

FIG. 10

correction. A lens is the sum of its material properties and performance features. Optical quality (Abbe value), thickness, weight, impact resistance, UV protection, reflectivity and durability must be considered when determining the best lens material for your patient. A lens material cannot be evaluated based on one exceptional feature. The best lens material for the patient has the best combination of properties and performance features.

Ophthalmic Lens Properties: The Abbe number indicates the degree of light dispersion. A higher Abbe number means lower dispersion, reduced chromatic aberration and peripheral distortion for higher visual quality (Fig. 10).

The Refractive Index (RI) of a lens material is the ratio of the speed of light in a vacuum divided by the speed of light in the lens material. Light refracts or bends more in a high-index material resulting in the power of the lens being achieved with a thinner lens. Higher refractive index lenses are flatter and reduce thickness compared to CR39 plastic or glass. The higher the index, the thinner the lens. But note: the higher the index, the greater the reflectivity. They need a premium AR coating to reduce reflectivity and improve contrast and acuity, as well as lens cosmetics.

The Abbe number tends to be lower for high-index plastic materials and polycarbonate. The optician faces a dilemma: choose lenses with a higher refractive index to reduce thickness but risk the patient experiencing poor peripheral optics due to chromatic aberration. More advanced high-index materials (Trivex and MR series) have higher Abbe values than standard mid to high-index lens monomers. Also, high-index lenses with an aspheric front surface can reduce peripheral lens aberrations and distortions.

Specific gravity (density/weight) is expressed in grams per cubic centimeter (g/cm3). It is the ratio between the weight of the lens material and the reference substance, water. When measuring specific gravity in ophthalmic lens materials, the density of the lens material is divided by the density of water. (Fig. 11)

FIG. 11

Impact resistance/strength: Ophthalmic dress lenses must be able to withstand the impact of a 5/8-inch steel ball dropped from 50 inches without breaking to meet ANSI Z87-1 impact resistance standards. Lens materials with good strength can resist deformation, breakage and abrasions, and tolerate stress without cracking.

Lens toughness or superior tensile strength is the ability to withstand pulling force. Durability means the lens is chemical, heat and scratch resistant, standing up to tough conditions.

Lenses should provide UV protection for the eyes and eyelids! There are acute and chronic eye and eyelid conditions linked to UV radiation exposure, such as photokeratitis, cataracts, pterygium and eyelid cancer. Eliminating UV transmission through the lens and reducing reflections from the back of the lens is paramount.

FIG. 12

According to the Skin Cancer Society, over 90 percent of skin changes associated with premature skin aging, including our eyelids' delicate skin tissue, are thought to result from UV exposure (Fig. 12).

We can protect our eyes and eyelids from serious harm from UV with the simple step of wearing lenses that block 100 percent UV from the front and reduce the UV reflected off the back of the lens into the eye.

Kids are at a higher risk of UV exposure due to their large pupils and crystal-clear crystalline lens that allows more UV to transmit to the posterior eye. Shouldn't all eyeglasses have maximum UV protection?

Reflectance: Lenses are reflective—front, back and internally. The basic principle behind AR is to minimize reflections from the front, back and internal lens surfaces. But why? Wearing a lens without anti-reflective treatment distracts the wearer as lens reflections degrade lens optical quality, impeding acuity and causing halos and ghost images that are particularly visible when driving at night. Uncoated lenses lose visible light transmission (VLT) due to these reflections, and we need light to see. The higher the VLT, the better the contrast sensitivity and vision through a lens. Reflections from the front surface of the lens obscure the visibility of the eyes behind the lens, which is unattractive and distracting.

The higher the lens material's refraction index, the greater the reflectance. For example, an uncoated polycarbonate lens material has a reflectance of around 10 percent. With premium AR, this reflectance is attenuated.

We see better through lenses with premium AR. Dr. Janice McMahon compared contrast sensitivity with AR-coated versus non-coated lenses. On average, subjects read one additional line of text under moderate glare conditions when using AR lenses. Lens enhancements, such as premium AR, improve optics, durability, cleanability and more. Every patient deserves to see, look and feel better in their eyeglasses, making AR essential to a great visual experience.

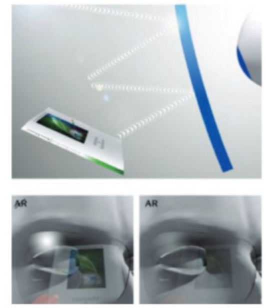

FIG. 13

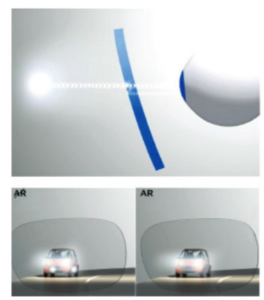

FIG. 14

Uncoated lenses negatively affect lens optics and performance. We don't see well through uncoated lenses, and we don't look good in uncoated lenses. ANSI Z80.1 – 2015, Section 6.1.6.1 states that AR must have a luminous reflectance of less than 2.5 percent to be called anti-reflective. Premium AR reduces reflections to as little as 1.0 percent or more.

There are three different types of reflection.

Front-surface reflections: Reflections from the front surface of the lens can cause a mirror effect. This results in the person looking at the front side of the lens to see a mirror image (Fig. 13).

Internal reflections: An internal reflection produces a double image. A second less intense and slightly displaced image can appear through a series of refractions and reflections of light as it encounters the internal surfaces of the lens. This is sometimes referred to as ghost images and at night can appear as halos around lights (Fig. 14).

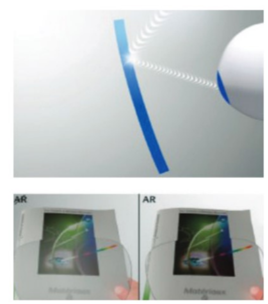

FIG. 15

Back-surface reflections: Reflection from the rear surface is when the light comes from behind the lens wearer. These usually involve low-light conditions such as night driving. Reflected light can be superimposed over the light from the scene being observed and cause a reduction in contrast and the quality of vision. Rear reflections may also cause glare (Fig. 15).

Premium anti-reflective coating comprises multiple layers, each with a specific thickness and index of refraction to cancel reflections of a particular wavelength.

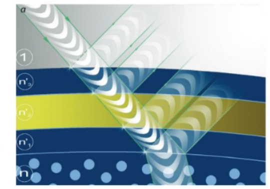

FIG. 16

The principle of "multi-layer" anti-reflective coating is to create multiple interferences (Fig. 16). Because the lens material is a three-dimensional item, light reflects off the front surface, passes through the lens and reflects again from the back of the lens. This results in reducing the intensity of the light that is transmitted through the lens.

The higher the refractive index of the material, the greater the reflected light. The loss of light transmission can be up to 15 to 20 percent on high-index lens materials.

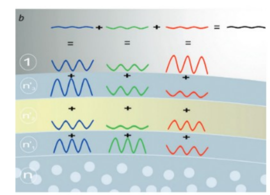

FIG. 17

Canceling reflections: Destructive interference is the light management principle behind anti-reflective lens treatment. It is used when we want to cancel reflected light waves to eliminate lens surface reflections (Fig. 17).

Two conditions must be met for destructive interference to cancel the reflected light waves:

1. The waves reflected from the coated surface

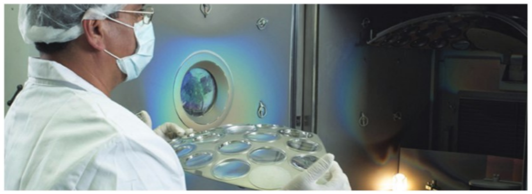

FIG. 18

will be out of phase with the light reflected from the lens surface. This destructive interference will cancel the reflection of those wavelengths allowing the energy from both waves to combine and travel through the lens to the eye. Light is composed of many wavelengths, each with its index of refraction, so multiple layers (the stack) with varying indices are applied.

2. The second condition that must be met is that the out-of-phase light waves must have the same amplitude (height) to cancel each other. The coating index must be equal to the square root of the index of the material. Each layer's index of refraction and thickness is chosen to create destructive interference of specific wavelengths that match the lens substrates.

Note: Sometimes we want to increase reflectance, such as in mirror coatings. To accomplish this, we use constructive interference to increase the amplitude of the reflected wave.

To cancel reflections, the multilayer AR coating uses phase changes in wavelengths.

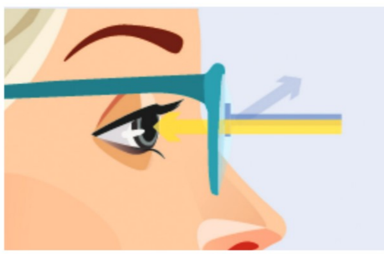

FIG. 19 FRONTSIDE: With KODAK Clean&CleAR™ UV, visible light transmits, but 100% of UV is bounced off the front lens surface

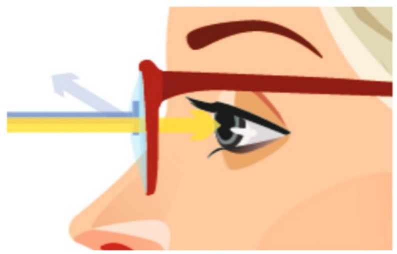

FIG. 20 FRONTSIDE: With a STANDARD AR, visible light passes through the lens as intended while the material absorbs most of the UV rays. Some UV is reflected from the AR-coated lens surface.

FIG. 21 BACKSIDE: With KODAK Clean&CleAR™ UV, visible light passes through the surface of the lens. Backside UV reflections are reduced by more than 5x.

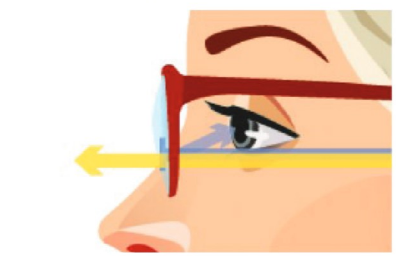

FIG. 22 BACKSIDE: With STANDARD AR, visible light passes through the lens as intended, while the AR lens coating reflects some UV rays into the eye

The higher the index of refraction of lens material, the higher the lens reflectivity. Each coating layer creates a double interface or two out-of-phase reflective waves that cancel or partially cancel the reflected wave. The energy of the canceled reflected waves transmits through the lens, increasing the lens' visible light transmission.

Premium AR manufacturers create a multi-layered AR stack, aka MAR, that consists of microscopically thin layers of varying indices of refraction to cancel a range of reflected light waves. Alternate layers of the MAR ¼ wave thick and ½ wave thick are applied to the lens. The first layer's refractive index must be the lens material's square root. Example: CR39 = 1.498 square root = 1.22 closest index of refraction used. High-index to low-index layers are built up to cause progressive reflection canceling across multiple wavelengths. This AR stack is applied to the hard coat, which has been index-matched to the lens substrate surface for maximum adhesion and durability (Fig. 18).

Improving the durability of the hard coat has two main effects. First, lens scratch and abrasion resistance are improved. Second, a more rigid substrate improves any subsequent AR coating. That means the anti-reflective layer's ultimate scratch and abrasion resistance becomes as hard or harder than the underlayer. Hard coating is applied in two layers. The first layer is a primer that is very sticky to the high-index surface and very sticky to the next hard coating layer. Thus, the hard coating layer can be cured to a harder, more scratch and abrasion-resistant surface. Next, the primer layer is an impact-enhancing coating layer. That means that upon impact, the primer layer will help manage a crack propagating through the lens by diverting through the coating horizontally rather than vertically and slowing it to a stop. Most hard coats' index of refraction closely matches standard plastic (hard resin, 1.50); however, a mismatch between the hard coat's refractive index and the lens refractive index results in interference fringe.

The interference fringe appears as a rainbow pattern on the lens surface. If the coating and lens have the same refractive index, the light passing through "sees" the two as one continuous substrate, and the reflections at the interface are minimized. For this reason, premium high-refractive index lenses are matched with higher index coatings. The result is lenses without a reflective color pattern. Many think this interference fringe is a problem with the Abbe value of the material. Not so—it's a lens refractive index mismatch with the coating refractive index.

What is the impact of ultraviolet (UV) rays on the eye? UV rays assault the cornea and crystalline lens daily (even when not in direct sunlight), causing eye aging and irreversible eye damage, including climatic droplet keratopathy, pterygium, cortical cataract and pinguecula. There are three reasons to prevent UV transmission through the front of the lens, along with reducing UV reflections from the back surface. 1. Ten percent of skin cancers occur in the eyelids and delicate skin surrounding the eyes. 2. UV exposure is the number one contributing factor to cataract formation in the crystalline lens, and 3. Ninety percent of premature skin aging is linked to UV exposure.

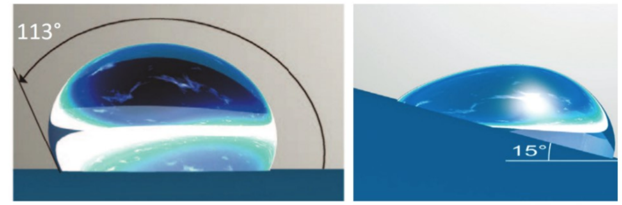

FIG. 23 KODAK Clean&CleAR™ Lenses with Silk® have an average contact angle of 115 to 119 degrees for a slicker surface (https://youtu.be/KPVzNYUqXzM)

KODAK Clean&CleAR™ UV Lenses have 100 percent protection from direct UVR and five times more protection from UV rays bouncing off the back surface of the lens into the patient's eye than standard plastic. (Fig. 19 to Fig. 22 compares front and backside reflections and UV transmission between standard AR and KODAK Clean&CleAR™ UV)

KODAK Clean&CleAR™ UV Lenses improve contrast by virtually eliminating reflections and to add high visible light transmission of 98 percent. They feature improved cleanability due to a special super hydrophobic layer with a contact angle of 115 to 199 degrees. The lenses reduce eye strain and fatigue, often related to glare from artificial lighting, tablets and computer screens. Decreased nighttime reflections make night driving better.

Silk®, an ultra-slick enhancement to KODAK Clean&CleAR®, KODAK Clean&CleAR® UV and KODAK Total Blue® protects lenses from scratches and gives patients what they want: less cleaning, more living (Fig. 23). Silk® adds a fluorocarbon topcoat to the anti-reflective layers making the lens surface ultra-slick. As a result, oil and water are repelled, making lenses the easiest to clean. New Silk® ultra-slick AR enhancement protects the lens and anti-reflective coating. Lifetime property tests were performed on Silk® that exceeded 20,000 tape pulls. Silk® has a 50 percent higher Bayer test score than KODAK ARs without it.

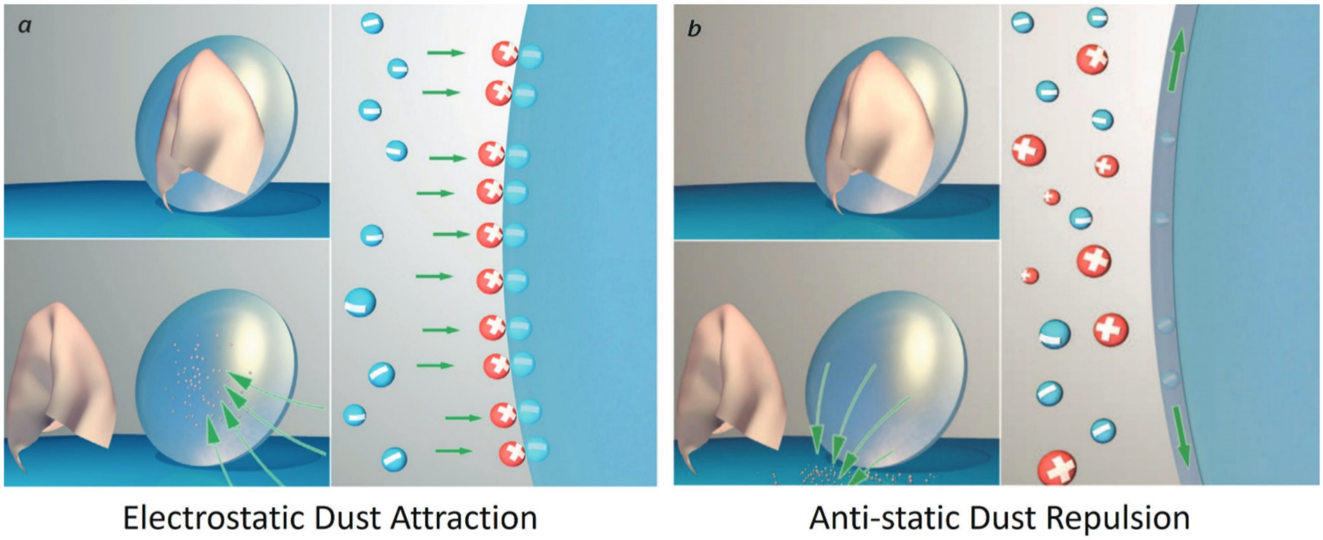

FIG. 24

KODAK Clean&CleAR™ UV features a scratch-resistant property that benefits the lens wearer's vision while also increasing the durability and longevity of the lens. There are two types of scratches: fine scratches, where small particles rub against the lens surfaces, and large scratches, where large particles rub against the lens surfaces, or the lens contacts a damaging surface. The application of scratch-resistant properties works to prevent damage from both fine and large scratches.

Smudge resistance—fingerprints and oil that transfer onto the lens are a nuisance to the lens wearer. KODAK Clean&CleAR™ UV includes a smudge-resistant topcoat; it repels oil and reduces its ability to adhere because of the slippery surface, making the lens easier to clean.

Dust accumulation on lenses is another nuisance that a lens wearer may encounter. KODAK Clean&CleAR™ UV features an anti-static property to repel dirt and dust particles, making them less likely to cling to the lens (Fig. 24). When the lens surface is rubbed, it causes an electrostatic charge, causing an accumulation of dust and lint on the lens surface. The anti-static coating helps minimize the collection of dust and lint on the lens surface and makes removing dust quick and efficient.

On a final note: Kids benefit from AR too. AR makes the lens more cosmetically attractive because reflections do not obscure the wearer's eyes. Aesthetics are important to children in this critical time in their social development; they need to look good in their glasses and maintain the clear vision essential for young developing eyes (Fig. 25). A special note on kids and AR: In a classroom setting, overhead lighting creates back surface reflections on their lenses that impede vision and contribute to eye strain. Emphasize to patients that without the protective coating on the lens, lens reflections will diminish the child's vision, and uncoated lenses are easily scratched. The scratches in uncoated lenses make it impossible for their child to see well through them. Also, explain that a child is more likely to wear their glasses if they feel good about them, which will directly impact their performance in school. AR makes the lenses clear and attractive, not dull, reflective and distracting like uncoated lenses. Parents are more willing to invest in their child's lenses when they equate good vision to their child's development and performance in school.

FIG. 25 It is easy to explain the different lens enhancements and their benefits with a visual display

Everyone deserves the protection, comfort, acuity and improved cosmetics that lens enhancements provide. But they cannot opt in if uninformed. Give them the chance to say yes. ■

The ABO does not endorse this or any product.

To earn ABO credit, please review the questions and take the test at 2020mag.com/ce.