



EXECUTIVE SUMMARY

SOLA's proprietary Teflon® EasyCare Lens Coating is an advanced, integrated coating system specifically engineered to deliver premium performance, convenience, and protection on a range of lens products. This multilayer treatment offers protective scratch resistance, unique anti-static features, low reflectance, enhanced clarity, and easy-to-clean performance. The tough scratch-resistant coating layer provides an excellent base for the anti-static anti-reflection layers and, in conjunction with a superior top coating, makes the lenses extremely resistant to scratches and abrasion. The state-of-the-art, multilayer anti-reflection stack delivers the lowest reflectance in the industry and a pleasing arctic blue reflex color. The advanced hydrophobic and oleophobic properties of the top layer, combined with the anti-static properties of the AR stack, make the coating system resistant to smudges, smears, and particulates. The result is a proprietary new coating system that is exceptionally clear, clean, and tough. SOLA partnered with DuPont to develop this new technology and assure that this product would deliver the Teflon® promise, one of the most trusted and recognized brands in the world. Both companies aim to grow the premium coating category and simplify the purchasing decision for consumers by using a brand that conveys all the benefits of the new coating technology to the wearer in a single word: Teflon®.

THE PROBLEM

While modern lens coatings have progressed a great deal over the years, most still fail to satisfy all of the needs of the wearer. For example, while the scratch resistance of hard coatings and the optical advantages of anti-reflection (AR) coatings are indisputable, the wearer benefits are often overshadowed by the sensitivity of the coatings to “wear and tear.” Anti-reflection coatings, in particular, generally fall victim to three categories of “wear and tear” (Figure 1): scratches that penetrate the coating surface by either fine abrasions or deep splintering; particulates that adhere to the lens surface because of static electricity; and water, grease, and oil smudges that stick to the lens surface, leaving it soiled.

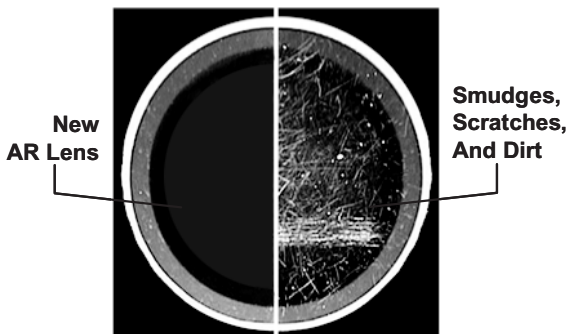


Photo courtesy of COLTS Laboratories, Clearwater, FL

Figure 1. “Dark Field Illuminator” photo of AR blemishes

A significant drawback of many lens coatings is their tendency to “attract” particles and smudges. The relatively porous nature of most anti-reflection coatings leaves an affinity for various liquids that often soil the surface and make the coating more

difficult to clean. The attraction of dust and dirt particles to the coating by static electricity also contributes to the problem. Moreover, the poor scratch and abrasion resistance of AR coatings makes them vulnerable and limits their longevity. Even the application of traditional top coatings results in only marginal improvements. Consequently, eye care professionals are often forced to choose between either the durability of hard coatings or the clarity of anti-reflection coatings.

These issues are magnified by the fact that blemishes are particularly noticeable on anti-reflection coatings, since there are no veiling surface reflections to conceal them, leaving the debris and relatively bright scratches to contrast noticeably with the clear lens surface. Furthermore, dirt, oil, grease, and other foreign matter obscure the surface and create a veil of haze that reduces visual performance. As a result, patients often complain that their lenses are “impossible to keep clean,” or that their lenses were rendered unusable by a haze of fine scratches resulting from overzealous cleaning.

BACKGROUND

The benefits of anti-reflection coatings to improve both lens cosmetics and vision are readily understood by most eyecare professionals. AR coatings eliminate the veil of reflected light that masks the wearer’s eyes, as well as the internal reflections that cause ghost images and exacerbate the apparent thickness of the lenses. Studies have also proven that AR coatings enhance contrast, improve night vision, and make everything appear “brighter and crisper.”

Even though AR coatings have been promoted for many years now, less than 25% of the lenses sold in the United States are dispensed with an anti-reflection coating. Indeed, if it were not for the durability and “cleanability” issues of traditional anti-reflection coatings, it would be reasonable to expect that AR coatings would be dispensed on the majority of lenses sold in the US. Wearers need a single coating solution that delivers the optical clarity of AR coatings with the scratch protection of hard coatings, while providing cleaning convenience that surpasses both.

TEFLON® EASYCARE

DuPont’s Teflon® brand has earned a global reputation for delivering enhanced performance to a range of products. The Teflon® name is now recognized and respected by consumers all over the world. Select consumer products have earned the Teflon® name by living up to the brand’s reputation for performance, convenience, and protection.

SOLA International now brings this level of performance to lens coatings with Teflon® EasyCare, which promises to make traditional lens coatings obsolete. Teflon® EasyCare is an integrated coating system that delivers three very important, consumer-driven benefits: *clear, tough and clean*.

SOLA's Teflon® EasyCare coating is an advanced, proprietary system comprising multiple unique component layers, which have been specifically engineered to deliver maximum performance, convenience, and protection. This integrated system includes an extremely tough hard coating that delivers exceptional scratch and abrasion resistance; a unique anti-static system that prevents the electrostatic attraction of particulates, embedded in a multilayer anti-reflection stack that achieves the lowest reflectance available; and an extremely slick top coating that is both hydrophobic and oleophobic. These components are demonstrated in Figure 2.

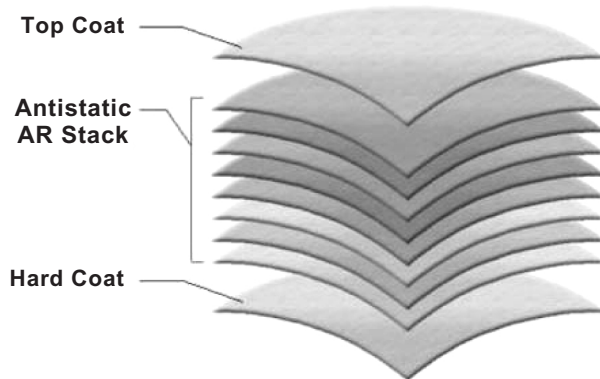


Figure 2. Teflon® EasyCare’s proprietary system

Teflon® EasyCare’s anti-static anti-reflection layers are applied using an advanced high-energy vacuum deposition process. In this ion-assisted process, the oxide materials are evaporated under high vacuum to condense on the lens surface while the surface is bombarded by high-energy ions of an inert gas, such as argon, using an ion gun. The momentum transfer from the ions to the surface atoms results in dense, tightly packed layers that, in combination with the other component layers, deliver an exceptionally durable, non-porous coating system.

CLEARER

Anti-reflection coatings reduce surface reflections and increase light transmittance by utilizing transparent thin films of *ceramic* or *metal oxides* that cause *destructive optical interference*. Modern, high-tech AR coatings use *multilayer* stacks, which often employ five alternating layers of low- and high-index films. While these quality multilayer AR coatings *nearly* eliminate the ghost images and veiling glare, some degree of light is still reflected. The final intensity and color of the remaining light reflected from the coating, called its *reflex color*, is the product of the interaction of the incident light with the various films that have been selected for the AR stack.

Most anti-reflection coatings have a reflex color that reaches peak intensity around 550 nanometers (nm), in the yellow-green region of the visible spectrum, which happens to be at the peak sensitivity of the human eye. For Teflon® EasyCare, the AR stack was designed to shift the peak to 470 nm, in the blue wavelengths of the spectrum. This reduces the reflex color intensity in the wavelength range at which the human eye is the most sensitive (i.e., 550 nm) by nearly half. Therefore, the *luminous* reflex color intensity (as seen by the human eye) of Teflon® EasyCare is roughly 50% lower than with conventional AR coatings, as shown in Figure 3.

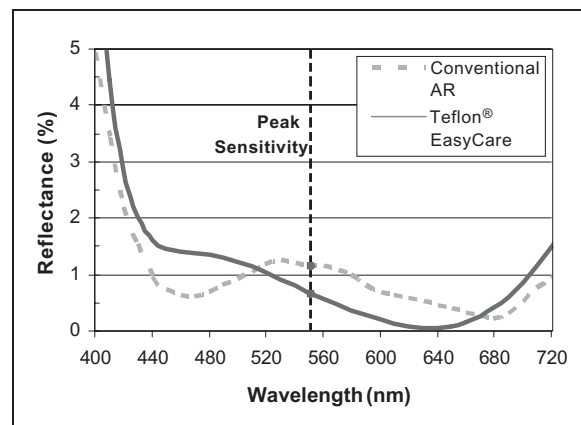


Figure 3. Actual spectral reflectance comparison

In terms of wearer comfort, this reduced reflex color intensity means that ghost images and internal reflections are two times *less* visible than with conventional AR-coated lenses, and ten times less visible than with non-coated lenses. As a result, Teflon® EasyCare’s sophisticated, multilayer anti-reflection stack offers unsurpassed optical clarity. Furthermore, in a developmental wearer trial, 74% of wearers preferred the low reflectance, arctic blue reflex color of Teflon® EasyCare to the green reflex color of the conventional AR coating.

CLEANER

Hydrophobic top coatings are intended to improve the “cleanability” of AR coatings. Essentially, the chemistry of the top coating reduces its affinity for certain liquids, which in turn increases the *contact angle* of droplets on the surface of the coating, as demonstrated in Figure 4. This allows the liquid to be more easily removed. However, not all top coatings are created equal. For instance, some top coatings do not repel grease and oil, which means that they will be prone to smudges.

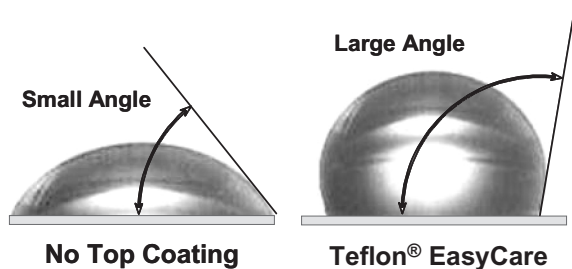


Figure 4. Contact angle comparison for a water droplet

The top coating of Teflon® EasyCare is both *hydrophobic* (water repelling) and *oleophobic* (oil repelling). Not only does the chemical composition of the top coating provide excellent adherence to the other layers of the Teflon® coating, the top coating also repels water, grease, and oil extremely well. For instance, consider the grease removal comparison in Figure 5. After twenty rubs with a tissue, 90% of the haze due to grease is removed from the Teflon® EasyCare coating, while only 50% is removed from the AR coating without a top coating—and only 30% is removed from the uncoated hard resin lens. This means that the uncoated hard resin lens has seven times more haze from leftover grease than the lens with Teflon® EasyCare.

Coating surfaces can become electrically charged, particularly by rubbing the lenses while cleaning them (a phenomenon referred to as the *triboelectric effect*). This static electricity attracts dust, dirt, and other particulates. Most coatings actually retain a

significant static charge long after cleaning. Consequently, these lenses can attract dust and dirt that degrade optical clarity, which also prompts additional cleaning and increases the likelihood of scratching, as well as the buildup of even more static.

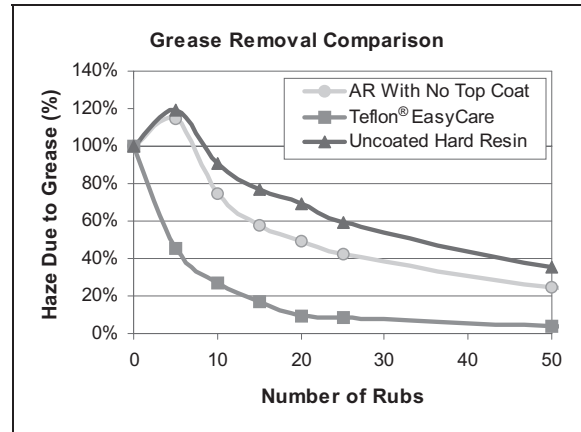


Figure 5. Grease removal comparison

However, Teflon® EasyCare’s proprietary formula includes a special component chosen for its electrical conductivity. This component allows the Teflon® coating to dissipate static electricity, preventing the build-up of electrostatic charge and the attraction of particulates. A comparison of the anti-static properties of Teflon® EasyCare to a conventional AR coating, after both have been rubbed with a tissue, is shown in Figure 6.

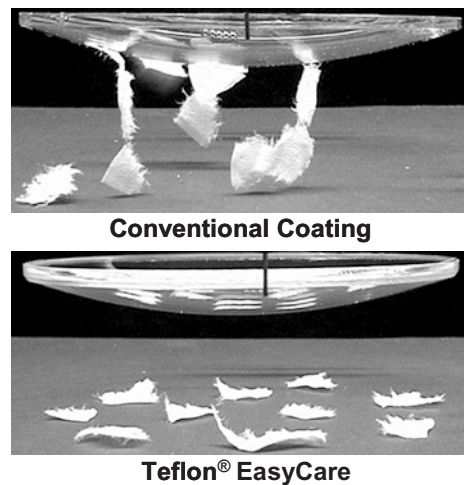


Figure 6. Electrostatic attraction comparison

The combination of hydrophobic (water-repellant), oleophobic (oil-repellant), and anti-static properties gives Teflon® EasyCare superior cleanability. Not only will lenses be easier to clean, but they will also stay cleaner longer. During preference trials, wearers found Teflon® EasyCare easier to clean than conventional anti-reflection coatings.

TOUGHER

Durability has long been a concern with ophthalmic lens coatings. Early AR coatings were often applied to bare lens surfaces or poorly engineered hard coatings, both of which make inadequate substrates for an anti-reflection stack. Applying an AR coating directly to a plastic lens material is the least robust approach. Mechanical differences between the coating and the lens substrate—including differences in elasticity, hardness, and in the rates of expansion and contraction under pressure or as the result of changes in temperature—can easily lead to delaminating, crazing, and scratching. Applying the AR coating to a poorly engineered hard coating can lead to similar compatibility issues and failure.

The first component in Teflon[®] EasyCare's integrated system of coatings is an *ultra-tough* hard coating base, which provides superior scratch protection and also serves as an excellent substrate for the anti-reflection stack. This coating was specifically chosen from a range of resins qualified for their excellent abrasion resistance, transparency, and surface quality. This remarkable hard coating is virtually impervious to wear and tear. Moreover, a well-engineered hard coating is essential to promote scratch resistance and adhesion of the AR coating, while reducing the possibility of coating crazing and delaminating (Figure 7).

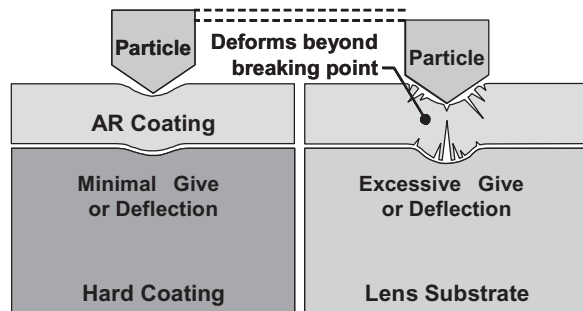


Figure 7. AR failure on an uncoated lens

The hard coating technology incorporated in the Teflon[®] EasyCare system is a thermally cured *organosiloxane* based system with *colloidal silica* (the chief ingredient in glass) dispersed throughout its matrix. The addition of *inorganic* (mineral) colloidal silica to an *organic* (plastic) siloxane resin produces a coating that marries the physical and mechanical properties of the organic lens substrate to the inorganic AR stack, bridging the chemistry gap between the relatively flexible lens substrate and the brittle anti-reflection stack. This reduces the likelihood of crazing and delaminating while maximizing scratch resistance. Not only does the colloidal silica provide increased scratch resistance and a stable substrate for the layers of the AR stack,

while allowing the coating to remain somewhat pliable, it also provides a more compatible surface on which to bind the primarily ceramic layers of the anti-reflection stack, resulting in superior adhesion through *covalent* bonding.

Scratch and abrasion resistance is further improved by the use of a high-energy deposition for the AR stack and a low-friction top coating. The ion-assisted deposition of the AR stack produces a very durable coating, while the exceptionally slick top coating reduces the potential for abrasive objects to catch or grip the surface and scratch it. The likelihood of scratching is further reduced by Teflon[®] EasyCare's proprietary anti-static formula, which eliminates the electrostatic attraction of particles like dust and dirt. These particles are generally the cause of abrasion during cleaning and handling.

These coating innovations imbue Teflon[®] EasyCare with remarkable durability. Teflon[®] EasyCare is two to three times more scratch- and abrasion-resistant than many conventional hard and anti-reflection coating configurations, and five to six times more abrasion-resistant than uncoated hard resin lenses.

CONCLUSION

SOLA International and DuPont have revolutionized the coatings market, by delivering a world first in lens coatings. The advanced technology and brand recognition of this exciting new product promises to grow the entire category, by establishing a new standard of performance: clarity, scratch protection, and cleaning convenience, all available in a single integrated coating solution that truly lives up to its name: Teflon[®] EasyCare.

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I Ross, J. and A. Bradley. "Visual performance and patient preference: a comparison of anti-reflection coated and uncoated spectacle lenses." *Journal of Amer. Optom. Assoc.* Vol. 68 (1997), pp.: 361-366.