TRIVEX® LENS MATERIAL: THE TECHNOLOGY BEHIND THE TRIPLE BENEFIT

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Advancements in lens materials in the last half of the 20th century allowed eyecare professionals to offer their patients higher performing lenses than ever before. The introduction of plastic lenses in the 1960s kicked off the revolution by presenting a lighter weight and thinner option over glass lenses. Polycarbonate, introduced in the '80s, offered eyecare professionals an impact-resistant option for their patients, although without the optical performance of CR-39 or glass. Advancements continued, and within the past decade, dozens of plastic lens materials in higher indices have enabled thinner and lighter lenses than ever before, though none exhibited the impact resistance of polycarbonate.

Recently, PPG Industries introduced Trivex® tri-performance lens material, a breakthrough optical polymer that offers the impact resistance of polycarbonate with excellent optics on par with CR-39 and glass. Additionally, lenses made from the material can be thin, because the material is so durable, and are ultra-light weight, because Trivex is the world's lightest lens material. The combination of properties is truly revolutionary, enabling the material's "tri-performance:"

- Excellent optics
- Impact resistance to the highest standard
- Ultra-light weight and thinness

The reason Trivex material can offer what previous materials cannot is its unique chemical structure. The differences at the molecular level help explain the material's benefits.

A Revolutionary Chemical Structure

Trivex material is not simply a variation of an existing material. It is a completely new optical monomer. The monomer was first developed by the defense industry as "visual armor" for use in helicopter canopies, and was adopted for use in ophthalmic eyewear by PPG scientists.

The Trivex lens polymer is extremely light weight on a molecular level, giving the material a specific gravity of 1.10. This enables Trivex material to be the lightest commercially available lens material, significantly lighter than other materials traditionally valued for their light weight, such as polycarbonate (specific gravity 1.22) and high-index (specific gravity 1.30 to 1.40).

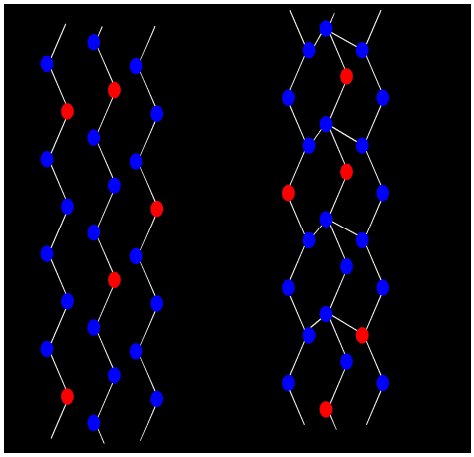
As with all plastic lens materials, Trivex material comprises polymer chains. Before Trivex material, plastic lens materials were primarily categorized as either thermoplastics or thermosets, based on whether the polymer chains were connected.

Thermosets, like CR-39, are *cross-linked*, which holds the chains together and results in a hard and scratch- and chemical-resistant material. Thermoplastics, like polycarbonate, are *unconnected* (see Figure 1). The unconnected structure of thermoplastics results in a trade-

off in benefits with thermosets. The unconnected chains easily move over one another to absorb energy, making the material very impact resistant. Without the cross-linkage to stabilize the material, however, thermoplastics can exhibit cold flow – a phenomenon in which the material changes shape under pressure. This can create a disadvantage for thermoplastics for drill-mountings.

Figure 1

Thermoplastic **Thermoset**

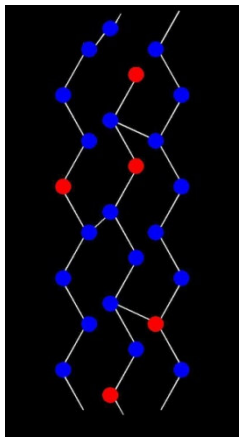


Unconnected ***Cross-linked***

Trivex material is a hybrid design between thermoplastics and thermosets, enabling it to offer the best properties of each. The polymer chains in Trivex material are *lightly cross-linked*. In addition, there are strong, polar interactions between the polymer chains. The polar interactions allow the cross-linked chains to move around and absorb energy when pressure is applied to the material, so that the cross-links in Trivex material aren't broken easily. This interaction helps provide Trivex material with its impact-resistant qualities. Additionally, because the lightly cross-linked chains don't move as easily, they hold their shape better for drilling purposes, allowing the material to easily accommodate popular three-piece frames. Because of its unique structure, Trivex material has enabled a new category of optical monomer, called a quasi-thermoset.

Figure 2

"Quasi-thermoset" (Trivex™)

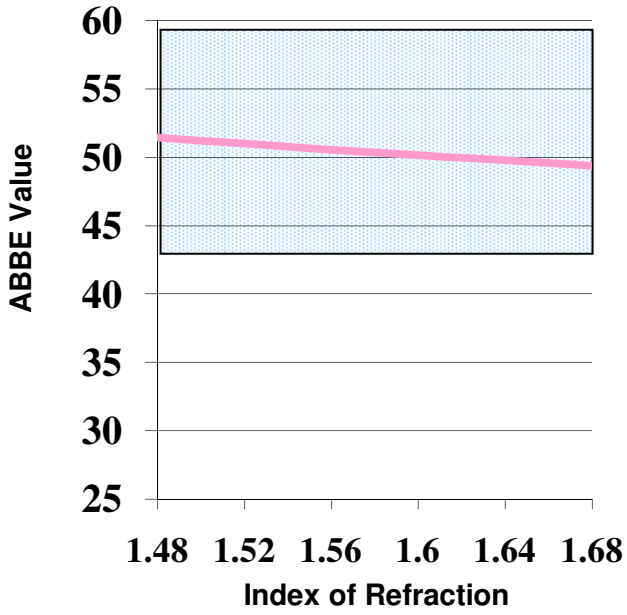


Lightly Cross-linked

As a result of Trivex material's incredible impact resistance, lenses made from Trivex material pass the ANSI Z87.1 standard for occupational safety and can also be reliably ground to 1.00 mm center thickness and pass the U.S. FDA drop ball test for impact resistance. This allows lenses made from Trivex material to be very thin – comparably thin even to high-index lenses for most prescriptions (-6 to +4). This thinness also contributes further to the light weight of lenses made from Trivex material.

In addition to a unique molecular structure that enables Trivex material to be impact resistant, ultra-light weight and thin, the material was designed to exhibit extremely low birefringence (the stress distortion inherent in lens manufacturing) and a high ABBE number (which minimizes chromatic aberration and maximizes visual acuity) for outstanding optical performance. In fact, the ABBE value of Trivex material (43-46) is on par with materials that have even higher ABBE numbers, because the human eye cannot distinguish a difference in ABBE value above 43-45[1] (see Figure 3).

Figure 3



When comparing the attributes of Trivex material to other lens materials, it's evident that this recent introduction may be the most revolutionary (see Figure 4). With Trivex material, excellent optics, impact resistance and light and thin qualities are all provided, so eyecare professionals can rely on this material for the majority of their patients.

[1] *As reported by Gullstrand.

As recent PPG research has shown[2], eyecare professionals that have dispensed the material are highly satisfied with its unique properties. Patients are even commenting on the light weight and clarity of their lenses. And eyecare professionals are enthusiastic about the material's impact resistance and its suitability for three-piece frames. After only a short time in the lens material market, Trivex is finding multiple niches and is demonstrating its versatility and potential for continued growth. With a breakthrough chemical structure delivering the attributes eyecare professionals desire for their patients, Trivex material is quickly becoming a "go-to" material to meet multiple patient needs.

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[2] "Real-world Experience by Laboratories and Eyecare Professionals Reveals Trivex™ Offers More Than Triple Benefit" by Gerard Dooley, PPG Industries, and Sam Odom, Benedict Optical, Inc. Sept. 12, 2002, www.ppgtrivex.com.