



Protect Your Product, Profits and Brand with ClearShield™ UV Absorber for PET

Foods and beverages, personal care products and household cleaners packaged in clear polyethylene terephthalate (PET) bottles face a threat to their formulations and ingredients from ultraviolet (UV) light.

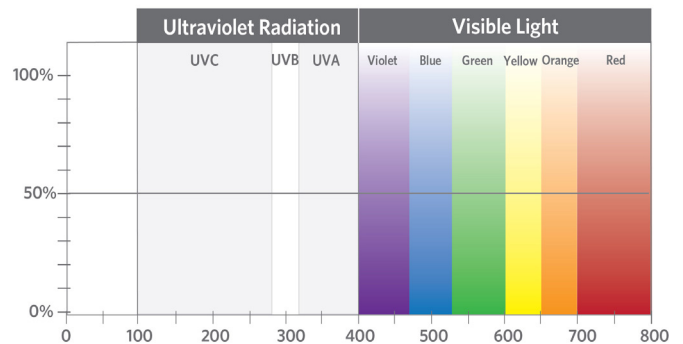
Exposure to sunlight and artificial light sources during warehousing, distribution, retail display and post-purchase storage can degrade the color, flavor, fragrance and nutritional value of consumer products. Ultraviolet light can cause color fading and shifting, create off-flavors and aromas, and reduce vitamin potency. Lower product quality and shorter shelf life resulting from UV damage can impact profitability and brand reputation.

The traditional solutions to UV light protection for PET bottles may not appeal to consumers. Many people prefer clear packaging, which offers visibility and connotes purity and safety. Using opaque or dark-colored plastics or covering the bottle with graphics to block UV radiation prevent consumers from seeing what they are buying.

The other approach – incorporating UV stabilizers, preservatives and other additives in the product itself – has drawbacks as well. It runs counter to the “clean label” trend, which emphasizes natural, simple ingredients, and

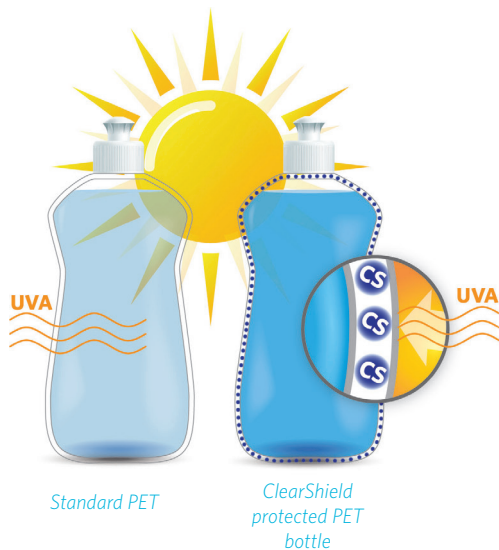
speaks to a desire for quality, trust and transparency. These additives also can raise the cost of the product.

The most effective strategy is incorporating UV absorbers in clear PET packaging to protect against wavelengths above 320 nm (the limit of inherent PET resistance). However, most of these additives only absorb UV wavelengths up to 370 nm. Therefore, if an ingredient degrades under exposure to light at a higher wavelength, a UV 370 absorber will not help.



Milliken’s ClearShield™ 390B is one of the few UV absorbers that protect ingredients from damaging UV light at a wavelength of up to 400 nm. Certain colors, fragrances and vitamins are highly susceptible to high wavelengths, and will degrade very quickly. These include Blue #1 colorant, various lavender fragrances and a variety of vitamins such as Vitamin A, B2 (Riboflavin), B6, B12 and Folic Acid. In some cases, such as with Vitamin B2 and B12, protection may even require the addition of a colorant since the ingredient is susceptible to wavelengths in the visible portion of the light spectrum. As a result, products such as milk, beer, and wine will commonly incorporate colors Keyplast™ Blue KR, Keyplast™ Yellow 4GL and Keyplast™ Red 60 for PET, as these colorants contain unique UV properties.

ClearShield 390B stands out from competitors such as bumetrizole because it is food contact compliant and offers a polymer-bound formulation, which means it does not migrate out of the plastic and potentially contaminate the product. In an age where customers are increasingly concerned not only about the ingredients within their food, but also the additives within the plastic packaging, ClearShield offers a one-of-a-kind solution. Testing completed by Milliken revealed that there is no migration of ClearShield 390B from the packaging to its contents. Furthermore, ClearShield does not affect the desirable crystal clarity of PET packaging which is important to brand owners and retailers who want to give consumers a clear view of the contents of their products.



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By choosing clear PET enhanced with ClearShield 390B UV Absorber, converters, packaging manufacturers and brand owners can protect UV-sensitive content, support the clean label trend and deliver a satisfying customer experience. All these factors help boost profits and strengthen brand integrity.

Extending Shelf Life

Without proper UV protection, foods and beverages can degrade on store shelves or in consumers' homes. In turn, shorter shelf life can increase costly waste and cause consumer dissatisfaction. Degradation also can cause a product to become non-compliant with food labeling regulations such as the U.S. Food and Drug Administration's 21 CFR Part 101, which requires that nutrient levels in the food or beverage must remain close to the value declared on the label or are otherwise considered misbranded. Brand owners and retailers should familiarize themselves with the 80/120 rule, which states that a product should have between 80 to 120 percent of the stated nutrient content. While overdosing on ingredients may seem like a simple fix to anticipate future degradation, additional amounts of particular ingredients can lead to changes in taste, aroma, or color, and are sometimes much costlier and more complex than incorporating the necessary protection into the packaging in the first place.



Bottles exposed to 45 accelerated UV hours

Beyond the tangible observations of vitamin degradation, it is important to note the deeper chemical effects. A slight change in the molecular structure of a nutrient can render it biologically ineffective. Many vitamins are known to be specifically vulnerable to degradation by UV light, including vitamin A, B2 (riboflavin), B6, B12 and folic acid. Light also accelerates the destructive interaction between vitamins. For example, the degradation of both folic acid and ascorbic acid (vitamin C) is accelerated by the combined presence of riboflavin and light. This causes vitamin C degradation in milk exposed to light.

ClearShield 390B helps to extend shelf life by maintaining nutritional value. Studies conducted by Milliken have shown that vitamin A's shelf life, for example, is 30 times better when protected in a ClearShield-modified bottle than when packaged in standard PET. Vitamin B6 shows a 70X improvement in shelf life, with a 7X improvement for riboflavin, 3.5X for folic acid and 2X for vitamin B12.

Ingredient Shelf Life* improvement compared to Standard PET

INGREDIENTS	PET BOTTLE WITH CLEARSHIELD 390B
Vitamin A	30X
Vitamin B6	>70X
Vitamin B12	2X
Riboflavin (B2)	7X
Folic Acid	3.5X

*Ingredient Shelf Life defined as 80% of initial concentration

Reinforcing Brand Identity

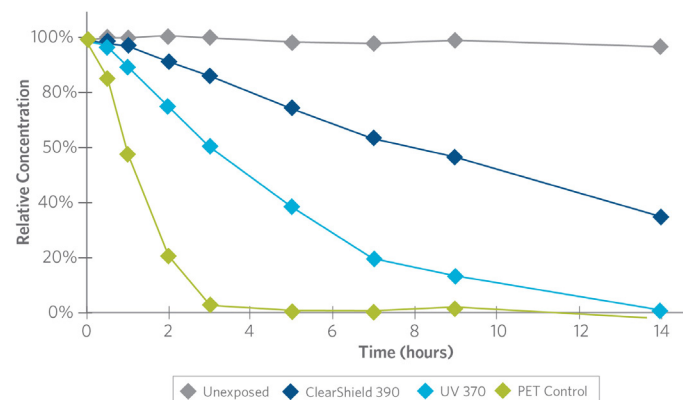
Brand identity is often associated with a "signature" color and flavor, such as the yellow-green color and lemon-lime flavor of a well-known sports beverage. When the distinctive color of a beverage, shampoo, dish soap or other product has faded or shifted due to UV exposure, consumers can spot the change immediately. Inconsistent color can imply uneven quality and reflect poorly on the brand's image, which in turn negatively affects repeat purchase and total lifetime customer value. We all know someone that consumes several bottles a day of their favorite energy drink or carbonated soft drink. In 2016, carbonated soft drink consumption was 38.5 gallons per capita, according to industry tracker Beverage Marketing Corp. Imagine if these customers suddenly stopped purchasing their favorite beverage because of an off-taste, color or aroma versus continuing to purchase the item for a decade or more as many loyal beverage customers routinely do. The effects on profitability far outweigh the costs of protection.

In the United States, seven synthetic dyes are approved for general food use and more than 30 others for general use in cosmetics. Although many of these dyes independently exhibit favorable stability to UV light, they have been shown to be unstable to light when formulated with certain ingredients. For example, ascorbic acid is frequently added to beverages for nutritional value and to scavenge dissolved oxygen that can attack certain flavor components.

When ascorbic acid in beverages containing certain synthetic colorants is exposed to UV light, rapid fading of the colorant can result. Milliken has conducted UV exposure testing on several Food, Drug, & Cosmetic Act colorants, including Blue #1, Red #40 and Yellow #5. Over an exposure period of 14 hours, each of the colors showed substantially increased stability in clear PET bottles enhanced with ClearShield 390B protection.

Effect of UV Light on FD&C Blue #1

in presence of citric acid and 1ppm Iron (Fe3+)



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Returning to the sports drink example, one of the significant contributors to lemon flavor, and one of the most photosensitive, is citral. When exposed to UV light, citral ingredients degrade into several byproducts, including photocitral-A, photocitral-B and another compound that exhibits a strong off-flavor at levels that are hard to detect through analytical methods. Milliken testing using sensory panels has shown that PET with ClearShield 390B protection retains the integrity of a citrus-flavored beverage to a much greater extent than 370 protection, green PET or standard PET.

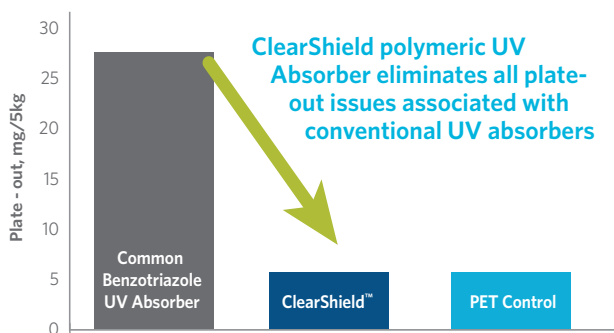
Supporting the "Clean Label" Movement

Although the definition of clean label can vary, in general, it refers to consumer desires for products containing mostly recognizable ingredients. This can mean all-natural or organic ingredients, no artificial preservatives and colors, and the elimination of hormones and antibiotics.

To protect against UV light damage and extend shelf life, preservatives such as sodium benzoate and ascorbic acid are often added. Removing preservatives and other synthetic ingredients from product formulations to support a clean label requires an alternative method to block UV radiation. ClearShield 390B ensures that the PET bottle itself will protect sensitive ingredients without the need to add preservatives to the food, beverage or other product.

Perhaps even more important, ClearShield 390B will not leach from the packaging into the contents, addressing a growing consumer concern about the purity and safety of plastics. The ClearShield technology is the only polymer-bound UV absorber on the market. In comparison, non-polymer-bound additives can migrate to the surface of the PET bottle, leaving residue on the inside of the packaging or even contaminating the product itself.

Another benefit of the unique ClearShield 390B formulation is its resistance to plate-out during manufacturing. Due to the high heat of processing, conventional UV absorbers extract out of the PET and create residue on the molds. This residue could contaminate other bottles. It also requires frequent cleaning of the machinery, which adds cost and causes production downtime and delays.



Enhancing Sustainability

Opaque and intensely colored PET materials that are produced to block UV light can darken the recycle stream, causing processing difficulties and lessening the value of the reclaimed plastic. By supporting the use of clear, uncolored PET, ClearShield 390B helps to facilitate effective recycling.

Further, adding ClearShield 390B to PET packaging eliminates concerns about toxicity or waste water contamination that can be caused by some of the chemicals traditionally used in other UV stabilizers.



Colored PET
recycle stream



Uncolored PET
recycle stream

High Performance, High Value

Natural or artificial UV light can damage products, profitability and brand reputation. The ideal way to protect against UV degradation, while meeting consumer demands for clean labels and recyclability, is to use clear PET bottles containing Milliken ClearShield 390B additive. This advanced technology provides an effective shield against high-wavelength UV light. It can help avoid impacts to color, flavor, aroma and nutrients. ClearShield 390B is also cost-effective: it avoids processing issues such as plate-out, and delivers high performance at very low loadings. Customers can obtain the same protection using one-tenth the amount of ClearShield 390B versus the amount required of traditional UV absorbers.

14 Hours Accelerated UV Exposure



Unexposed

ClearShield
390B

370

Unprotected

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