Get a grip on light with Uvinul®!

Light stabilizers from BASF: Expect more!

BASF
The Chemical Company
Every sunset is a sunrise.
Anywhere in the world
BASF – The synergy of global disciplines.

As the worldwide leading chemical company, BASF is not only one of the most important suppliers of plastics on the international market, but also in the development and manufacturing of colorants, stabilizers and other additives for the plastics processing industry.

We conduct intensive research in our laboratories to stabilize plastics against UV radiation. Our chemists and physicists investigate the degradation mechanisms of plastic aging. The knowledge gained in this process flows directly into the development for radical scavengers and UV absorbers. Application testing takes place in specially equipped laboratories and application centers. In-house accredited analysis laboratories support our Department of Safety and Regulations and, at the same time, serve our customers with expertise in this field.

But we are not only concerned with protecting plastics. The safety of our staff and environmentally compatible production are also our top priorities. Our commitment to Responsible Care® and sustainable development forms the basis of our actions and hence also guarantees sustainable success for our customers.

Please contact us if you have problems to solve in the field of polymer stabilization. Your technical inquiries will be answered reliably, competently and quickly via the regional application technology centers in USA, China and Germany. With sales offices in over 120 countries and a worldwide logistics network, we guarantee that the entire BASF range of colorants and stabilizers is available to you at all times – on time and in the highest quality!
Nature serves as our model for UV protection. In the course of evolution, it has developed the most sophisticated techniques for protecting the cells in plants and animals from ultraviolet rays.

Today, protection from UV radiation not only plays an important role in nature, but also in the world of plastics. Polymer degradation is omnipresent - especially in outdoor applications. UV radiation can stimulate molecules to such an extent that their chemical bonds break. Bond breakage of this nature releases highly reactive radicals, which are able to destroy other molecules. As further radicals are formed by this reaction, the degradation of the polymer proceeds indefinitely in a chain reaction. If this chain reaction is not interrupted, the plastic component soon loses its mechanical, optical and coloristical properties.

In order that your plastics remain in form for as long as possible, they need protection against UV radiation. Just as skin can be protected with sunlotion, so can a plastic be protected by a UV absorber. These compounds absorb the UV radiation and transform the incident energy into harmless heat. The great advantage of organic UV absorbers over substances such as commercially available carbon black or TiO₂ is that they neither compromise color nor transparency and are easy to disperse in the polymer. This also allows transparent or colored polymer applications to be protected against UV radiation without problems.

To fulfill these tasks, UV absorbers must exhibit a number of essential properties. They must not be damaged by UV radiation themselves and they must be sufficiently thermostable for the extrusion process. Their tendency to migrate must be low, since otherwise the molecules easily drift to the surface where they may, for example, be washed away by rain. Protection against UV radiation is lost as a result and the durability of the polymer is not sufficiently extended.
Besides the UV absorbers, the hindered amine light stabilizers (HALS) help extend the durability of plastics exposed to UV radiation. This product group has made many long-term applications possible for the first time, especially for thin-walled applications such as fibers and films.

In contrast to the physically active UV absorbers, the various HALS react chemically. They interrupt the propagation of polymer degradation by scavenging the radicals created at chain breaks, thus rendering them harmless. Their high level of protection is due to the fact that each stabilizer molecule is not only able to react once but may react many times. This sustainably decelerates the chain reaction of degradation.

As the HALS work chemically, they are suitable for applications in any layer thickness. However, HALS molecules are also subject to migration, especially if they have a low molecular weight (under 1,000 g/mol). Oligomeric HALS with a molecular weight of 2,000-5,000 g/mol demonstrate clear advantages in this respect. If their structure is matched to the application polymer, they show very good compatibility with these polymers and do not migrate. BASF works closely with its customers to jointly find the best solution for the stabilization problem at hand.
Accelerated weathering

As a means of reducing the time to test samples, these are subjected to simulated environmental conditions (sunshine, rain etc.) in accelerated weathering devices. The reduction in testing time essentially results from the continuous radiation or weathering of the samples. We operate one of the largest European stations for accelerated weathering to allow comparative tests to be carried out for our customers or for our own test series related to R&D. The capacity of this station is 17 m² of irradiated or weathered surface and is therefore sufficient for about 1,700 samples. These tests are especially important if products from research and development are to be tested in our customers’ applications. On the basis of the data obtained from accelerated weathering, the durability to be expected for polymers in the different applications may be estimated.

The most important standards, according to which the tests are performed, are:

- DIN EN ISO 4892-2
- DIN EN ISO 105-B 06
- DIN 53387 (1982) for PVC (SST: 50C)
- SAE J 1885
- GMI 00002
- DIN EN ISO 105-B 02
- DIN EN ISO 513
- SAE J 1960
- AATCC 169 (1995)
- PV 1323

In principle, other light exposure and weathering tests, based on other standards and regulations, may also be adopted. Additional in-house accelerated weathering stations are available to BASF and our customers in the USA, Japan and in China.
Since environmental conditions differ significantly between different regions of the world, the test should be carried out in the region in which the final product will be employed. Therefore, BASF also carries out outdoor tests in many countries around the globe: Spain, Kenya, Brazil, Ecuador, Mexico, USA as well as Thailand, Australia, Japan and China.

Outdoor weathering

Although accelerated weathering yields meaningful and reproducible data, it cannot simulate all environmental conditions. For example, the influence of air pollution, the shape and setup of the final work piece and mechanical stress through wind, hail or snow will not be covered by the standardized weathering of samples. Thus, in addition to accelerated weathering, we perform outdoor application together with our customers. Here BASF has set up a weathering station close to Ludwigshafen offering a light exposure area of over 100 m², thus allowing larger items, such as garden chairs, to be weathered over extended periods.
Effective and efficient research is of ultimate importance when it comes to being in a position to offer innovative solutions for the market requirements of today and tomorrow. This is where the BASF synergy concept once again proves itself. It not only leads to excellent results in production optimization, but also gives rise to extraordinary solutions, particularly in the field of research. BASF is the worldwide largest chemical company and includes plastics as well as colorants and light stabilizers in its portfolio. Experience from these areas may not only be mutually combined, but also used synergistically.

As a chemical company with a history stretching back almost 150 years, BASF draws upon extensive know-how founded upon a broad knowledge base. State-of-the-art technology is available in our laboratories to reveal degradation mechanisms and to develop innovative solutions for stabilization problems.

The entire development process — from research to realization in large-scale production through to product marketing — is subject to the demands of Responsible Care®.

With yearly more than 15,000 patents for the synthesis, production, technology and analysis, BASF is one of the outstanding innovation pools in the worldwide chemical industry. Not least for this reason, we have succeeded in developing unique products in the field of UV stabilization and, at the same time, in being able to offer cost-effective solutions for standard applications.

We will maintain this successful course along with our customers in the future and will continue offering innovations in UV stabilization.
With its excellent physical and chemical properties, Uvinul® 5050 H is your first choice when it comes to light stabilization of polyolefins. It belongs to the group of hindered amine light stabilizers (HALS). Polyolefins stabilized with Uvinul® 5050 H offer extreme long-term stability and are excellent to process — irrespective of whether you want to use them for films or thick-walled plastic products. As a result of its spectrum of properties, Uvinul® 5050 H offers you a whole range of astonishing advantages:

- **Uvinul® 5050 H** has significantly little effect on alkali-sensitive pigments and minimal interaction with acids. The latter plays an important role especially in agricultural films. This property also makes Uvinul® 5050 H a suitable stabilizer for PVC.

- **In tape production**, Uvinul® 5050 H is outstanding in respect of its extremely low water carry-over. Using Uvinul® 5050 H as an additive only minimally alters the surface, such that affinity to water is not significantly increased. You can run your plants significantly faster than with every competing product — an enormous advantage for your production!

- **The use of Uvinul® 5050 H** to stabilize polyolefin films permits lower welding temperatures than with other oligomeric HALS compounds. This makes polyolefin films easier and quicker to weld. Especially in packaging lines, in which stretch or shrink film covers are welded, you are not only able to save time but also the associated costs.
• Uvinul® 5050 H exerts no negative influence on the surface quality of white (TiO₂) m-LLDPE films. Conversely, films stabilized with competing products show melt fracture – a disadvantage you can simply avoid with Uvinul® 5050 H.

**Manufacturing guidelines:**
The following settings should be used when batching Uvinul® 5050 H (10-50 %):
- The feeding zone should be cooled to 40-60°C.
- The first heating zone should be set to 80-100°C, whereas the subsequent heating zones are set as they are normally.

This modification has no negative impact on the throughput of the plant whatsoever.
Uvinul® 4050 H

Uvinul® 4050 H is a highly effective light stabilizer for polyolefins, ABS and polyamide, which also exhibits very good compatibility with pigments.

The melting range of Uvinul® 4050 H (155-160°C) is ideally suited for extrusion for these polymers. For example, in polyamides a low melting point (e.g., HALS 3: 81-85°C) means that the product may not be homogenously distributed into the polymer during extrusion. The thermostability of Uvinul® 4050 H is also extraordinarily high. A TGA at 300°C reveals a loss of < 1 % for Uvinul® 4050 H and of more than 7 % for HALS 3 (see graph page 13). Polyolefins such as polypropylenes and higher density polyethylenes achieve very high light and weather fastness with Uvinul® 4050 H.

The yellowing occurring with exposure of ABS to light sources is significantly reduced with Uvinul® 4050 H; even tertiary HALS often used for ABS cannot keep up with the excellent performance of Uvinul® 4050 H.

The stability of polyamides can also be considerably increased using Uvinul® 4050 H. The surface degradation arising through weathering with the formation of cracks and chalking is significantly retarded with Uvinul® 4050 H in combination with Uvinul® 3035. Polyamide fibers can be effectively light protected with a combination of Uvinul® 4050 H and Uvinul® 5050 H.

Effectiveness without a downside.

Uvinul® 4050 H / Uvinul® 3030, 3035, 3039 / standard products
Uvinul® 3030 / 3035 / 3039 / standard products

Cyanacrylates are excellent UV absorbers, which, through their stabilizing effect, serve to prevent yellowing on exposure to light. The cyanacrylates distinguish themselves in that the color of the polymer is not affected even at higher concentrations.

Uvinul® 3030 as a UV absorber with high molecular mass (> 1,000 g/mol) has very little volatility. Furthermore, it is highly thermostable making it especially suitable for the use in polymers at high processing temperatures (e.g., PC, PET). Uvinul® 3030 also offers you the processing advantage that it does not lead to the commonly experienced deposition on the cooling roller in the manufacture of PC sheets. Hence it contributes to a continuous process with minimized setting-up times and supports your smooth and economical production. Moreover, Uvinul® 3030 confers excellent protection against yellowing for highly transparent polycarbonate parts without impairing clarity or base color.

Uvinul® 3039 is a liquid UV absorber, which, as a consequence of its good compatibility with plasticizers, is extremely well-suited for use with PVC-P (plasticized PVC) and plastisols.

Uvinul® 3035 offers excellent performance in the protection of PVC-U (unplasticized PVC).

Standard products. Besides its stabilization stars, BASF also offers a whole range of standard products, with which you are equipped for every application. The range of light stabilizers is rounded off with standard UV absorber products, including Uvinul® 3008, 3026, 3027, 3028, 3029 and 3033 P, as well as a simple monomeric HALS, Uvinul® 4077 H.

Apart from its diverse individual products, BASF offers you the blend Uvinul® 3434 C, specially tailored to the demands of polyurethane stabilization. As a fluid formulation, Uvinul® 3434 C can be optimally metered into the RIM process.
With a worldwide market share of about 60%, the polyolefins represent the largest group of polymers used today. Besides the large number of different copolymers, polypropylene and polyethylene are most important. By altering processing parameters, it is possible today to manufacture polyolefins covering a broad application spectrum.

**Polypropylene** (PP) is partially crystalline and, at a lower density, has higher stiffness and strength than polyethylene. Polymerization takes place in the low-pressure process on different catalysts. Dependent upon the polymer chain structure, isotactic, syndiotactic and atactic types are distinguished. Of these, the isotactic PPs are of the greatest importance in terms of quantities.

The injection molding types are generally manufactured into vehicle parts, transport boxes, or garden chairs at melt temperatures of 250-270°C. Isotactic PP is manufactured into fibers for carpet yarns in the melt spinning process. Films are used as BOPP (biaxial oriented PP), for example for cigarette and silage films. Split tapes, fiber fleece and insulation sheets are other important applications.

The majority of polypropylenes are manufactured as copolymers. This leads to low glass transition temperatures and the application options for the PP at low temperatures are improved accordingly as a result of a lower tendency towards embrittlement. Polypropylenes are primarily damaged by light at the wavelengths of 290-300 nm and 310-360 nm.
The polyethylenes (PE) are sub-divided into the classes LDPE, LLDPE, and HDPE dependent on their density and degree of branching. Polyethylenes are resistant against most chemicals, such as acids and alkalis, and are used, for example, as pipes, bottle crates, and films. Their tendency to macerate in aliphatic and aromatic solvents drops with increasing density; some HDPE types are even licensed as vehicle fuel tanks. PE mainly degrades through UV radiation at the wavelengths of 290-300 nm and 310-340 nm.

**LDPE** is manufactured in the high-pressure process without catalysts. This process leads to a highly branched product of low density. LDPE usually requires no process stabilization and is easy to process across a wide temperature range. It requires extrusion temperatures of around 200°C for the manufacture of films and up to 260°C in injection molding extrusion.

**LLDPE** is produced catalytically in the low-pressure process, whereby molecule chains with short chain branches mainly arise. These polymers are mostly used as mixing components in films, as well as for fibers and rotation molding parts. Metallocene-catalyzed types (m-LLDPE) are a special type of LLDPE. They are characterized by a particularly narrow molecular weight distribution and this is also associated with high strength. However, as a result of their poor processibility, m-LLDPE types usually have to be combined with fluoroelastomers.

**HDPE** is also manufactured catalytically in the low-pressure process. A significantly higher density arises from the largely un-branched polymer chains and greater strength compared with the aforementioned types. Melt temperatures around 250°C are required for film extrusion. In injection molding, temperatures of over 300°C are achieved.
PVC

For PVC, the distinction is made between unplasticized PVC (PVC-U), plasticized PVC (PVC-P) and plastisoles. Emulsion, suspension and solid polymerization are suitable manufacturing methods. PVC has a tendency to photochemically degrade and is therefore provided with light stabilization (its sensitivity is particularly high for radiation at wavelengths of 310-325 nm). Dependent on the manufacturing process, processing temperatures of 120C to 220C are common.

- Unplasticized PVC is used for floor coverings, films, pipes, credit cards, window profiles and house building materials.
- Plasticized PVC is formed by injection molding into shoe soles, motorbike and cycle grips. Hoses, shower curtains, conveyor belts and self-adhesive films may be manufactured by extrusion.
- Plastisoles are applied to different substrates in diverse ways. Rainwear and canvas materials are examples of products obtained.

UV protection for PVC / PA

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<th>Product</th>
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- UV absorbers Uvinul® 3008
- UV absorbers Uvinul® 3030
- UV absorbers Uvinul® 3033 P
- UV absorbers Uvinul® 3035
- UV absorbers Uvinul® 3039

Recommended
Suitable
PA

The crystallinity of polyamide varies between 10 and 60 percent. The relationship between the amide groups and the aliphatic groups is crucial for a high modulus of elasticity. The higher the amide group content, the more the intermolecular hydrogen bonding between the amide becomes apparent. This raises the strength, and polyamide is therefore mainly used for high quality fibers, machine parts, such as gear wheels, and for pipes or ski shoes. Polyamide must be light stabilized for outdoor use. It is particularly damaged by radiation between 290 and 315 nm.
Polystyrene (PS) includes various amorphous and transparent polymers. Standard PS is chiefly processed by injection molding, for example into packaging in the food and pharmaceutical industries or into disposable cutlery, drinking cups and CD sleeves. Due to their low thermal stability, all polystyrenes are thermostabilized and also UV-stabilized for outdoor applications. PS degrades predominantly with radiation of wavelengths of 310-325 nm.

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<th>Product</th>
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<td>HALS (Hindered Amines Light Stabilizers)</td>
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<td>Uvinul® 4077 H</td>
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<td>UV absorbers</td>
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ABS

ABS is a copolymer of acrylonitrile, butadiene and styrene with a high impact strength and better chemical resistance than pure polystyrene. ABS is often used in casing of domestic appliances such as refrigerators, vacuum cleaners and drilling machines, but it is also used in vehicle interiors or toys (e.g., LEGO® blocks). Since the UV stability of ABS is low, it has to be light-stabilized for very many applications. ABS is especially sensitive to UV light in the wavelength range of 300-370 nm.
Polycarbonate is an amorphous plastic, manufactured at high temperatures; 320°C is not uncommon. Blends with styrene polymers and also polyesters improve the property profile and make the material available for a broader range of applications. PC undergoes various degradation reactions on exposure to light (e.g., photo-Fries rearrangement) and must therefore be light-stabilized.

The greatest damage is caused by UV radiation of wavelengths of 280-340 nm. Sheet for greenhouses and winter gardens, electronics casings, automobile parts such as headlights as well as CDs and DVDs are the most important applications.
PET

The condensation polymer PET is a partly crystalline plastic, which is also available as an amorphous material for certain applications. Its very good transparency, its high strength and food compatibility make drink bottles one of the main applications for amorphous PET. PET is also used for functional fibers, labeling shrink film, substrate films for electronic applications, as well as for food and pharmaceuticals packaging. As PET only absorbs UV up to a wavelength of approximately 320 nm, additional UV absorbers must be used in packaging for protection contents e.g., vitamins or dyes. PET itself is mainly damaged by radiation of wavelengths of 290-320 nm.
PMMA

As a very UV-stable polymer, PMMA is found in many outdoor applications and is additionally stabilized for long-term applications. Its extreme surface hardness ensures good scratch resistance. PMMA is therefore favored for transparent applications, for example sheeting, spectacle glasses, electronics casings and optical storage devices. PMMA suffers the greatest photochemical damage through short wave UV radiation (280-315 nm).

UV protection for PMMA / Polyurethane

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<th>UV absorbers</th>
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Polyurethanes

Polyurethanes can be produced in such a variety that the applications range from soft foams through attractive surface films (spray skin for the automotive industry) to hard-molded parts such as gear-wheels for electric motors. Articles colored with carbon black are additionally provided with light stabilizers for diverse applications in automobile interiors as well as all outdoor applications. Polyurethanes are particularly susceptible to UV radiation damage in the 330-400 nm wavelength range.

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<th>Product</th>
<th>TPU</th>
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HALS = Hindered Amine Light Stabilizers
The data contained in this publication are based on our current knowledge and experience. In view of the many factors that may affect processing and application of our product, these data do not relieve processors from carrying out their own investigations and tests; neither do these data imply any guarantee of certain properties, nor the suitability of the product for a specific purpose. Any descriptions, drawings, photographs, data, proportions, weights etc. given herein may change without prior information and do not constitute the agreed contractual quality of the product. It is the responsibility of the recipient of our products to ensure that any proprietary rights and existing laws and legislation are observed.

www.basf.com/lightstabilizers