Sylanto

Cationic Photoinitiators for UV Curing

synthos SPECIALTIES

Sylanto Cationic Photoinitiators for UV Curing

Photoinitiators are chemical compounds which disintegrate upon exposure to UV light, acting as so-called active agents, contributing to the conditioning and speed of the polymerization process. Photoinitiators are included in the base of mixtures added, for instance, to paints, varnishes and polymeradhesives.

Photochemical characterization

Cationic polymerization initiators currently used in the industry are subject to a significant technological problem consisting in inefficient absorption of UV radiation. Due to the fact that the primary sources of high power UV light used to induce photochemical reactions are medium pressure mercury (MPM) lamps), and the majority of UV energy emitted by them is at approx. 365 nm, energy efficiency hovers around 10%. The result is that hitherto used cationic photoinitiators based on diaryloiodonium salts have poor absorption characteristics, which do not match the characteristics of UV light source emissions. All commercial diaryliodonium photoinitiators exhibit similar UV absorption characteristics in the wavelength range of λ_{max} = 220-280 nm, while there are no efficient light sources used for industrial applications in this range.

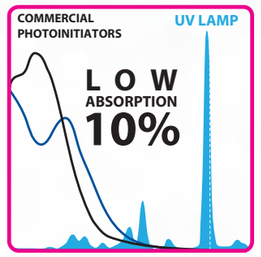


Fig.3. Comparison of the absorption characteristics of commercial iodonium photoinitiators with the emission characteristics of industrial light sources (MPM lamp – emission spectrum of medium pressure mercury lamp).

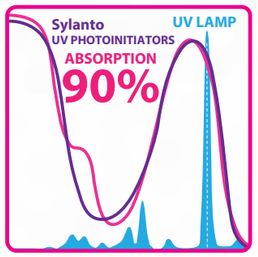


Fig.4. Comparison of the absorption characteristics of Sylanto UV-Photoinitiators with the emission characteristics of industrial light sources (MPM lamp – emission spectrum of medium pressure mercury lamp).

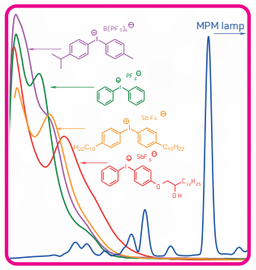


Fig.1. Comparison of the absorption characteristics of commercial iodonium photoinitiators with the emission characteristics of industrial light sources (MPM lamp – emission spectrum of medium pressure mercury lamp).

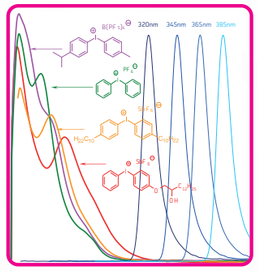


Fig.2. Comparison of the absorption characteristics of commercial iodonium photoinitiators with the emission characteristics of typical UV-LEDs.

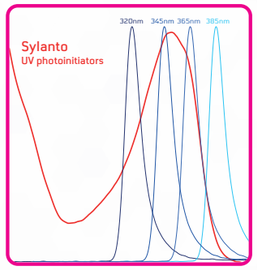


Fig.5. Comparison of the absorption characteristics of Sylanto UV-Photoinitiators with the emission characteristics of typical UV-LEDs.

Sylanto UV-Photoinitiators are devoid of this defect and offer around 90% efficiency allowing them to be used in much smaller concentrations, leading to an increase in the performance rate of production lines. At the wavelength of 365 nm, corresponding to the medium-strongest spectral line of MPM lamps, **Sylanto UV-Photoinitiators** exhibit absorption rates as high as 75% of the maximum absorption occurring at λ_{max} = 350 nm.

One modern solution in UV technology is the use of **UV-LED diodes**, which prevent processes from emitting ozone and heat release, a very important distinguishing feature of those systems in comparison to traditional MPM lamps. While standard cationic photoinitiators are incompatible with ultraviolet diode light sources, **Sylanto UV-Photoinitiators** retain their full functionality when UV-LED diodes are used.

Reactivity

The performance of **Sylanto UV-Photoinitiators** in comparison to the commercial iodonium photoinitiator (diphenyliodonium hexafluorophosphate, HIP) was evaluated in photopolymerization tests of 3,4-epoxycyclohexylmethyl 3,4-epoxycyclohexanecarboxylate under identical reaction conditions using fluorescence probe technology (FPT). The FPT method is based on molecular fluorescent probes, which change their fluorescence characteristics upon changes occurring in the cationic polymerizable composition.

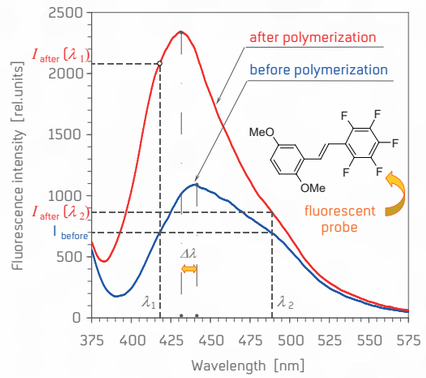


Fig.6. Fluorescence spectra of the trans-2-(2',5'-dimethoxyphenyl) ethenyl-2,3,4,5,6-pentafluorobenzene probe before and after polymerization of 3,4-epoxycyclohexylmethyl 3,4-epoxycyclohexanecarboxylate monomer.

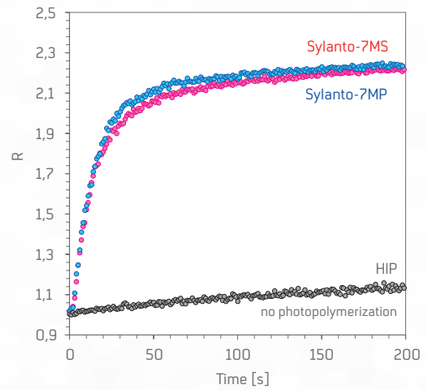


Fig.7. Kinetic profiles of cationic photopolymerization of 3,4-epoxycyclohexylmethyl 3,4-epoxycyclo-hexanecarboxylate monomer, obtained by FPT, using trans-2-(2',5'-dimethoxyphenyl)ethenyl-2,3,4,5,6-pentafluorobenzene as a fluorescent probe and different photoinitiators.

Under the irradiation conditions corresponding to the strongest emission lines of medium pressure mercury lamps (at λ_{max}=365nm), **Sylanto UV-Photoinitiators** exhibit very high activity, while a composition containing commercial HIP did not polymerize at all within the irradiation time applied, due to the lack of significant light absorption above 325 nm.

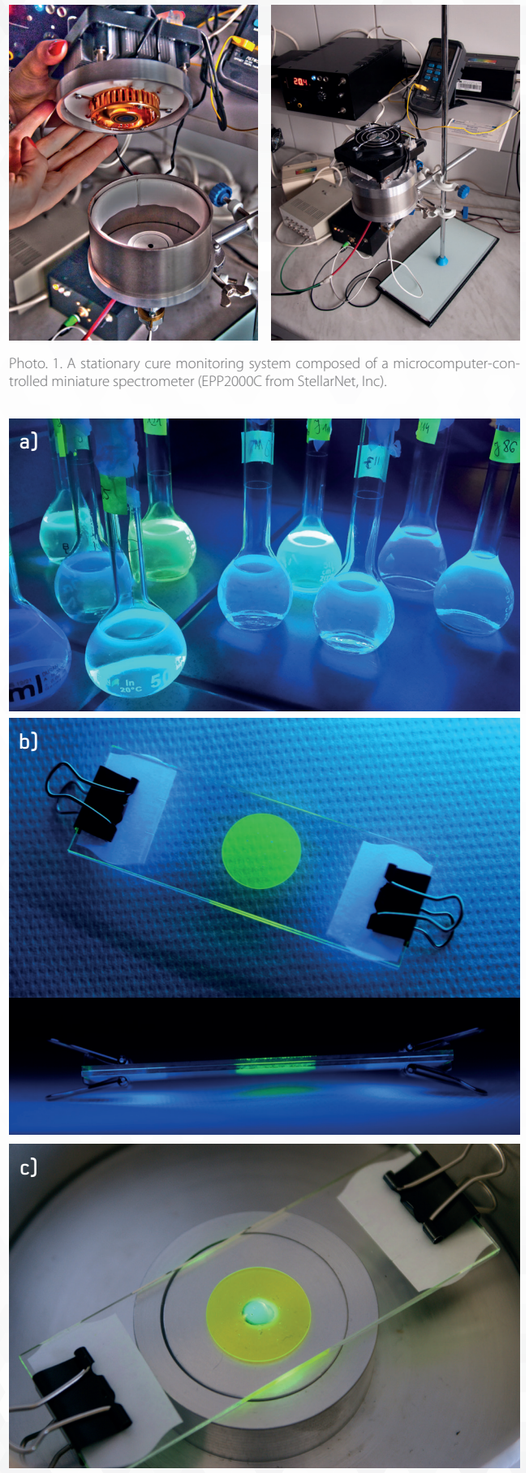


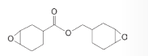
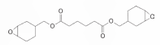
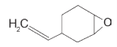
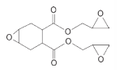
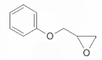
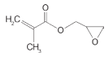
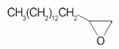
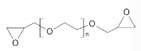
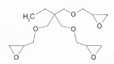
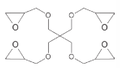
Photo. 1. A stationary cure monitoring system composed of a microcomputer-controlled miniature spectrometer (EPP2000C from StellarNet, Inc).

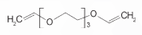
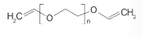
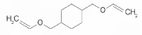
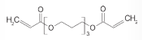
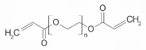
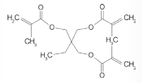
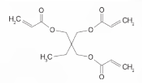
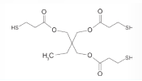
Photo.2. Fluorescence of molecular probes a) in solution, b) in thin coating sample, c) sample in the chamber of FPT equipment.

Solubility in the monomers

Standard photoinitiators generally have a low solubility in the commonly used monomers and mixtures of monomers. These difficulties become even more apparent when it is necessary to use higher concentrations of photoinitiators, often of up to 5 % by weight.
The answer to the above restrictions are **Sylanto UV-Photoinitiators** characterized by full reactivity in concentration ranges as low as 0.5 – 1 % by weight.

Table 1. Solubility of **Sylanto UV-Photoinitiators** (*)

Monomer			Solubility of photoinitiator	
Name	CAS	Structure	Sylanto 7MP	Sylanto 7MS
3,4-epoxycyclohexyl-methyl-3,4-epoxycyc-lo-hexanecarboxylate	2386-87-0		+	+
Bis((3,4-epoxycy-clohexyl)methyl) adipate	3130-19-6		+	+
4-Vinyl-1-cyclohexene 1,2-epoxide	106-86-5		+	+
Vinylcyclohexene dioxide	106-87-6		+	+
4,5-epoxytetrahy-drophthalic acid diglycidylester	25293-64-5		+	+
1,2-Epoxy-3-phenoxy-propane	122-60-1		+	+
Glycidyl methacrylate	106-91-2		+	+
1,2-epoxyhexade-cane	7320-37-8		+	+
Poly(ethylene glycol) diglycidyl ether	72207-80-8		+	+
Trimethylolpropane triglycidyl ether	3454-29-3		+	+
Pentaerythritol glycidyl ether	3126-63-4		+	+

Monomer			Solubility of photoinitiator	
Name	CAS	Structure	Sylanto 7MP	Sylanto 7MS
Diglycidyl 1,2-cy-clohexanedicarbo-xylate	5493-45-8		+	+
Tetrahydrophthalic acid diglycidyl ester	21544-03-6		+	+
3-ethyl-3-oxe-tanemethanol	3047-32-3		+	+
Tri(ethylene glycol) divinyl ether	765-12-8		+	+
Poly(ethylene gly-col) divinyl ether	50856-26-3		+	+
1,4-Cyclohexaned-imethanol divinyl ether	17351-75-6		+	+
Tri(propylene glycol) diacrylate (**)	42978-66-5		+	+
Poly(ethylene gly-col) diacrylate (**)	26570-48-9		+	+
Trimethylolpropane trimethacrylate (**)	3290-92-4		+ (clouding)	+
Trimethylolpropane triacrylate (**)	15625-89-5		+	+
Trimethylolpropane tris(3-mercaptopro-pionate) (**)	33007-83-9		+	+

Sylanto UV-Photoinitiators are also compatible with other monomers which are dedicated for cationic polymerization including both unsaturated monomers that undergo chain polymerization through carbon–carbon double bonds, and, cyclic monomers that undergo ring-opening photopolymerization (e.g. vinyl monomers, cycloaliphatic epoxide, glycidyl monomers, oxiranes, siloxanes, oxetanes, cyclic acetals and formals, cyclic sulfides, lactones and lactams etc.)
(*) photoinitiators in the form of solution in propylene carbonate, (**) monomers for free-radical or thiol-ene photopolymerization – S**ylanto UV-photoinitiators** with proper additive, such as co-initiator or photosensybilizator, can initiate free-radical photopolymerization and thiol-ene photopolymerization to produce IPN polymers.

Another advantage of **Sylanto UV-Photoinitiators** is their good solubility in a number of commonly used monomers at concentrations of up to 5 wt. % or more without the need for additional solvents. Our products are distributed in the form of granular solids or as solutions in propylene carbonate. **Sylanto UV-Photoinitiators** are highly stable during storage and processing of final compositions.

Yellowing effect

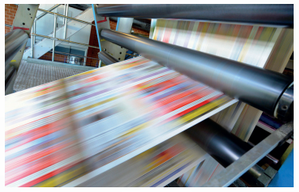
A common drawback of photoinitiators is the yellowing of final products resulting from the presence of colored products of initiators decomposition. **Sylanto UV-Photoinitiators** are colorless, just as the finished products, moreover all other physical properties are consistent with expectances.

Application

The main aim of our activities is to streamline the processes that are used in the automotive, printing, electronics, adhesive, packaging and broadly defined film forming industry.

Area of Sylanto UV-Photoinitiators application:

Printing industry: UV inks are used in screen printing, flexography, offset, letterset and digital printing . Photoinitiators constitute 1-10% of the inks by weight, allowing to initiate polymerization in order to achieve instant graphical content. **Sylanto UV-Photoinitiators** allow to improve printing technology by increasing its efficiency, while reducing production costs.



Furniture industry: Use of modern photocurable coatings can significantly reduce the emission of VOC (volatile organic compounds) by eliminating coating methods which use solvent paints. Radiation curable coatings for wood are characterized by excellent chemical and physical resistance. They also exhibit very good susceptibility to grinding, short curing time and very good overall mechanical properties.

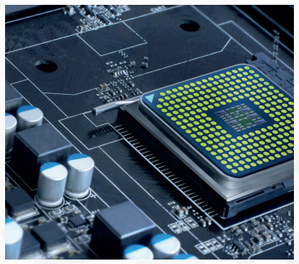
Paints and varnishes industry: UV technology allows for the reduction of environmentally harmful solvents, and also enables the production of coatings with improved mechanical properties.

Adhesives and sealants industry: Bonding materials incompatible with each other by definition, such as metal, glass, wood, paper and plastics is one of the major problems of manufacturers of various kinds of adhesives and sealants. At present, the available methods are characterized by low bonding efficiency. This can be solved by adhesives which polymerize under UV irradiation in the presence of highly efficient **Sylanto UV-Photoinitiators.**

Automotive industry: In automotive industry protective coatings are becoming a necessity, both due to the exposure of vehicle paint to harmful environmental conditions and to its contact with chemical agents. From technology and utility points of view, the latest trends are UV cured paint coats. In automotive industry, photocuring can also be used for joining all kinds of vehicle parts. Application examples of UV-curing include enclosure elements for head lamps, rear lamps, side decors, parts of mechanical and electronic systems, coats of internal plastic elements or external protective coats of aluminium rims.

Food packaging industry: Photopolymerisation processes are especially suitable for industrial graphics in food packaging, where UV-cured paints are commonly used. Modern paints intended for contact with food are mainly based on cycloaliphatic epoxy resins and have a number of advantages which include the fact that after polymerisation paint coat is odourless, organoleptically neutral and prevents the penetration of plastic composition elements to food.

Electronics industry: UV-curing technologies play an important role in electronic elements production processes and influence the quality and properties of products. UV-cured coats are used to make printed circuit boards in order to secure them against moisture, dust, chemicals and extreme temperatures. Photopolymerisation reactions are also used in the chips for mobile phones and other mobile devices.



Sylanto-7M Cationic UV-Photoinitiators

Sylanto-7MP is a diaryliodonium hexafluorophosphate.

Sylanto-7MS is a diaryliodonium hexafluoroantimonate.

General information

- **Sylanto-7M UV-Photoinitiators** are recommended for photopolymerization processes of epoxy monomers (especially cycloaliphatic epoxy monomers, glycidyl monomers, epoxy silicone resin) and vinyl ethers.
- **Sylanto-7M UV-Photoinitiators** have very good solubility in epoxy and vinyl monomers as well as in most organic solvents.
- **Sylanto-7M UV-Photoinitiators** exhibit very good absorption of light in the UV range between 200 nm and 400 nm, with maximum absorption located at λ_{max} = 350 nm, which guarantee high compatibility with emission characteristic of Medium Pressure Mercury Lamps.
- Recommended light sources for **Sylanto-7M UV-Photoinitiators** are: MPM (Medium Pressure Mercury) lamps, doped mercury arc lamps, UV-LEDs (especially recommended are UV-LEDs with emission characteristics of λ_{max} = 365 nm), as well as halogen and xenon lamps.
- Individual substrates used for the production of **Sylanto-7M UV-Photoinitiators** are non-toxic and free of VOC (Volatile Organic Compounds).

Benefits of Sylanto-7M Cationic UV-Photoinitiators

- Provide rapid cure at depth.
- Can be used in presence of pigment systems, including TiO_2.
- Typical concentration range: 0.5-2 wt.% per epoxide or vinyl containing material.
- No other co-initiators nor photosensitizers required.

Sylanto-7M UV-Photoinitiators usage recommendations

- The optimum concentration of **Sylanto-7M UV-Photoinitiators** should be established by the user.
- To ensure maximum solubility of **Sylanto-7M UV-Photoinitiators**, it is recommended to wait a few minutes prior to the use of the final formulation.
- "Dimmed" light conditions or another form of light shielding for mixing and formulating when using **Sylanto-7M UV-Photoinitiators** is recommended to prevent unwanted prepolymerization.
- **Sylanto-7M UV-Photoinitiators** and final formulations are light sensitive and should be kept in dark places or in light proof bottles when not in use.

Summary

Sylanto UV-Photoinitiators, thanks to their unique structure, offer unique properties in comparison with currently used cationic photopolymerization initiators. These features translate into more efficient use of power, increased performance rate of production lines, and transparent products without the yellowing effect.
All of our products are free of volatile organic compounds.

VOC FREE

synthos
chemical innovations

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