

SunSpots®

Spring 2009

The Photofading of Colored Materials

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ABSTRACT

Under the influence of natural or artificial light, as well as other factors of stress, the properties of organic colorants are altered, resulting either in their fading or in a color shift. This article discusses the main photochemical reactions of organic colorants in a polymeric matrix environment. Since the chemical evolution of the colorants and the matrix influence each other, they cannot be studied independently. From these generalities, guidelines for performing reliable accelerated testing of colored materials are provided.

INTRODUCTION

A colored polymeric object is a complex chemical system consisting of a macromolecular matrix (including processing agents), fillers, stabilizers, and colorants (pigments or dyes¹).

Environmental or artificially applied stresses (UV light, heat, oxygen, and moisture), induce chemical processes that cannot be accounted for by visual or colorimetric assessments only. The chemical evolution of the matrix with all its additives and the evolution of the colored products that are formed or transformed must be analyzed at the molecular level, as two or more of the four following processes can occur simultaneously²:

- a) The photooxidation of the matrix produces chain scissions and reticulation reactions, which can alter the mechanical properties and cause appearance changes, such as gloss loss and whitening,

¹ Pigments are colorants of inorganic or organic nature that do not dissolve in the host medium, whereas dyes are organic colorants that are soluble in the host medium. See for instance: Harris, R.M., *Coloring Technology for Plastics*, New York: Plastics Design Library, 1999.

² Haillant, O., *Sun Spots*, 76, 2006, 1.

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Florida Test Site
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2009

Plast 2009

March 24–28
Milano, Italy
Booth D06

Asia Solar 2009

March 30–April 1
Shanghai, China
Booth #3C29

European Coatings Show

March 31–April 2
Nuremberg, Germany
Booth #9-256

Romcontrola

April 1–4
Bucuresti, Romania

Control

May 5–8
Stuttgart, Germany
Booth #1726

Elmia Polymer

May 5–8
Jönköping, Sweden

Focus 2009

May 7
Troy, MI, USA

Measurement & Testing of Coatings

May 12–13
Birmingham, England

Lab Africa

June 2–4
Johannesburg,
South Africa

Q-Tech India

June 5–7
New Delhi, India
Booth #17

ITM

June 6–10
Istanbul, Turkey

Automotive Testing Expo

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NPE 2009

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June 24–26
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Plasto Isopack

September 7–9
Tel Aviv, Israel

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Automotive Testing Expo China

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Shanghai, China
Booth #4018

PV SEC

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Hamburg, Germany

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September 28–October 2
Moscow, Russia

Eurofinish

October 7–9
Gent, Belgium

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Solar Power International

October 19–22
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RichMac

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Milano, Italy

AtlasSpeaks

2009

European Coatings Congress

March 30–April 1 • Nuremberg, Germany

“Accelerated Weathering Tests of Plastics and Coatings: New Technologies and Standardization”

» Dr. Artur Schönlein

DFO Conference

March 17–18 • Bamberg, Germany

“Summary of the ATCAE Conference in Oxford in September 2008”

» Mr. Andreas Riedl

Polyolifin Additives 2009

March 30–April 1 • Cologne, Germany

“Assessing the Chemical Evolution of a Weathered HALS-Stabilized Propylene-Ethylene Copolymer: Guidelines for Optimizing Accelerated Weathering Testing Procedures”

» Dr. Olivier Haillant

ISOS 2009 - International Summit on OPV Stability

April 21–22 • Amsterdam, The Netherlands

“Correlation and Acceleration—How Does Laboratory Accelerated Testing Correlate to Real-Life Ageing?”

» Mr. Andreas Riedl

10th International Conference on Wood & Biofiber Plastic Composites

May 11–13 • Madison, WI, USA

“Why Durability Testing Is Needed and Methods to Accomplish It”

» Mr. Allen Zielnik

Measurement & Testing of Coatings

May 12–13 • Birmingham, England

“The Best Accelerated Weathering Test for Coatings—Does It Exist?”

» Mr. Cees van Teylingen

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Atlas® Client Education helps clients learn to design durability test programs to understand how weathering affects materials. Our education and training solutions will help you and your staff effectively master the skills and knowledge needed to develop long-lived products in shortened development cycles. Our programs are designed for all levels to ensure that everyone develops the skills required to understand the fundamentals of weathering and how to operate our instruments. For the latest schedules and locations, check the Atlas website, www.atlas-mts.com, or e-mail info@atlas-mts.com.

2009

Fundamentals of Weathering I

March 31 »
Lochem, The Netherlands
April 15 » Paris, France
June 11 » Chicago, IL, USA
September 30 » Chicago, IL, USA
November 3 » Bochum, Germany
November 4 » Paris, France

Fundamentals of Weathering II

April 1 »
Lochem, The Netherlands
April 16 » Paris, France
June 12 » Chicago, IL, USA
October 1 » Chicago, IL, USA
November 4 » Bochum, Germany
November 5 » Paris, France

Ci35/Ci65

April 21–22 » Chicago, IL, USA

Xenotest® Workshop

March 17–18 »
Linsengericht, Germany
September 29–30 »
Linsengericht, Germany

Weather-Ometer® Workshop

September 15–16 »
Linsengericht, Germany

Ci4000/Ci5000

April 23 » Chicago, IL, USA
June 10 » Chicago, IL, USA
September 29 » Chicago, IL, USA

SUNTEST® Workshop

March 20 »
Linsengericht, Germany
October 2 »
Linsengericht, Germany

Thought Leaders Gather for Atlas Conference

More than 70 industry experts convened in Oxford, England, in September 2008 for the third Atlas Technical Conference for Accelerated Ageing and Evaluation (ATCAE).

Speakers from European and U.S. car manufacturers, automotive suppliers, and the chemical industry presented papers examining degradation phenomena using chemical and analytical methods, as well as on the simulation of specific influence factors and how these are replicated in weathering instrument technology. Significant attention was dedicated to the simulation of harsh environmental conditions, such as the Arizona desert, using the latest state-of-the-art technology in solar simulation and corresponding software tools.

In all, 11 presenters and 60 participants spent two exciting days discussing the latest advances in weathering—all against the backdrop of Christ Church College, a site well known to Harry Potter fans.

For conference proceedings/papers, please contact clienteducation@atlasmtt.de.



Attendees of the third ATCAE in Oxford, England

Future Is Bright for Solar Energy

The solar energy market has grown considerably in the past few years—and with it, a growing need for testing. Materials like glass, plastics, polymers, sealants, and metals are used to build Photovoltaic (PV) modules, concentrating dishes, troughs, and other systems to convert solar into thermal or electrical energy. The expected lifetime of these systems is 20, 30, or even 40 years. Accelerated testing of the long-term durability of single components as well as the complete systems is crucial in product development, quality control, and certification testing.

Atlas has been active in the solar energy industry for more than 20 years, offering solar simulation systems, outdoor and laboratory exposure testing, and consulting services to help clients design the most appropriate test procedures. Atlas experts are members of national and international standards committees like IEC, and cooperate with leading research institutes and test laboratories to advance the industry as a whole.

To help weathering and testing professionals respond to new demand in this area, the next Atlas Technical Conference on Accelerated Weathering and Evaluation (ATCAE) will focus on the durability of materials, components, and systems for the solar energy industry. The conference will take place in Phoenix, Arizona, USA, in December 2009. Look for details soon at www.solardurability.com.

ATCAE  **Solar 2009**
ATLAS TECHNICAL CONFERENCE ON AGEING & EVALUATION

- as surface micro-cracks develop.³ Meanwhile, inert degradation photoproducts accumulate linearly, measurable by spectroscopic techniques.
- b) The formation of chemical groups able to absorb visible light leads to the discoloration of the polymeric system—from yellowing or browning to darkening, depending on the wavelength range of absorption.⁴ These colored products, generally unsaturated molecules, are not photostable and do not accumulate linearly. Relatively early in the lifetime of a polymeric product, photobleaching reactions (decomposition of colored products into colorless products) compete with photodiscoloration processes. Colored photoproducts are therefore not a relevant criterion to represent the long-term evolution of a polymeric system and cannot be correlated with the evolution of the mechanical properties.
 - c) The formation of fluorescent products absorbed in the UV range and emitting visible light (frequent in aromatic matrices) changes the appearance in the presence of UV light. However, fluorescent photoproducts do not accumulate in the system, as they are easily photooxidized in non-fluorescent species and cannot account for the long-term degradation in a polymeric system.
 - d) The photofading of organic pigments and dyes (discussed in the next section) influences the appearance of the system. Inorganic pigments are generally photostable, rarely exhibiting a photocatalytic activity able to induce the photooxidation of the matrix with the consequences described in a). In very stable matrices—i.e., matrices undergoing no chemical evolution during the evolution of the colorants—the change in colorant concentration (different from the change of a colorimetric value) can be used as a criterion of degradation to convert accelerated lifetime into service lifetime.

While the evolution described in process a) mostly affects the mechanical properties, all four processes affect the overall appearance of a polymeric system and obey distinct kinetic laws represented in Figure 1. Moreover, unless coincidentally, the relative rates of these processes are different in service use and in laboratory testing.

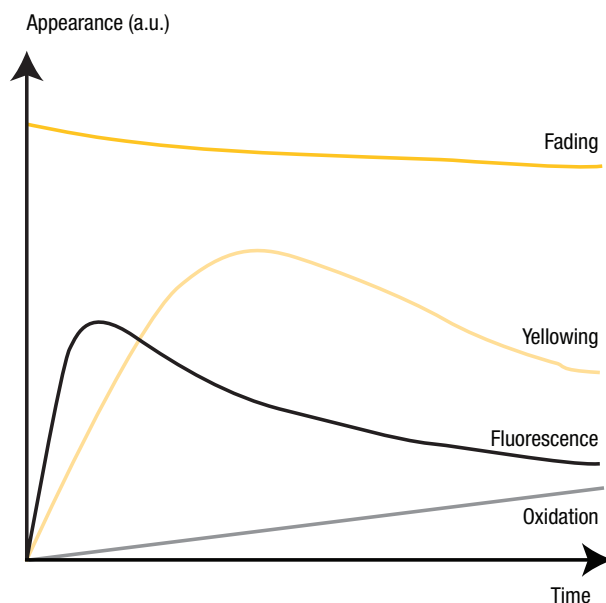


Figure 1: Characteristic allure of the rates of chemical evolutions responsible for the appearance of a colored polymeric matrix

³ When micro-cracks develop on the surface, the ratio of diffused light to specular light reflected by the surface increases, resulting in a less glossy and whiter appearance.

⁴ For instance, substances absorbing light between 400 nm and 440 nm will appear yellowish.

ASSESSING THE CONTRIBUTION OF COLORANTS TO THE APPEARANCE CHANGE OF POLYMERIC MATERIALS

The perceived color of an object is determined by the spectral distribution of either the reflected or the emitted visible light.⁵ The addition of a pigment or dye will change that distribution by producing additional absorption of visible radiation and, in the case of fluorescent dyes, by emitting in the visible range. However, colorants, especially organic ones, exhibit a broad range of long-term lightfastness and it is not clearly established which wavelength ranges are mostly responsible for the degradation of organic colorants, as shown in several examples from the literature.^{6,7,8,9,10,11} There is no universal degradation mechanism for all organic colorants. Any formulation consisting of a polymer matrix and colorants behaves specifically and such behavior should only be assessed through a scientific approach.

To determine how the fading of pigments or dyes contributes to the appearance change of a polymeric object aged in real or artificial conditions, it is essential that the matrix be sufficiently stabilized in order to:

- Preserve the normal environment of dyes and pigments in usage conditions, particularly to maintain the permeability to oxygen of the system to its normal value;
- Avoid any whitening, yellowing, or formation of fluorescent products due to the matrix oxidation;
- Prevent the attack of organic dyes and pigments by free radicals originating from the matrix (the unsaturated structure of organic colorants may be very reactive to free radicals);
- Avoid a reaction with photoactive inorganic pigments;
- Avoid any change in the protonation state of organic colorants through the acidic groups formed during the matrix oxidation that would fade the colorants.

BEHAVIOR OF MINERAL PIGMENTS

Before focusing on organics colorants, as they are more easily degraded, here are some generalities on the different types of inorganic/mineral pigments. They can be classified relative to their crystalline structure:

- Pigments with highly organized crystalline structures and electronic bands: The probability of transitions between electronic bands is high, and such pigments are highly absorbing. Very often, those transitions occur in the UV range (e.g., TiO₂, ZnO), while some occur in the visible range (e.g., CdS, CdSe, Ce₂S₃).
- Pigments whose color property is associated to cations and anions in disorganized solids: Optical transitions are less likely in the visible and UV ranges, and the pigments are weakly absorbing, requiring their use in high concentration to obtain sufficient coloring properties.
- Carbon black absorbs any wavelength in the whole UV range, making it a universal UV absorber as well as the pigment of choice to obtain dark colors and black shades.

⁵ Visible light is the portion of the electromagnetic spectrum ranging from ca. 400 nm to 720 nm.

⁶ Searle, N., *Sun Spots*, 38, 1987, 1.

⁷ Rosenberg, A. et al., *Fogra Research Report* No. 52.024, München, December 2002, p. 9.

⁸ Suhadolnik, J.C. et al., Proc. International Conference on Digital Printing Technologies, San Diego, California, September 29, 2002, 348.

⁹ Batchelor, S.N. et al., *Dyes and Pigments*, 59, 2003, 169.

¹⁰ Wilhelm, H., *The Permanence and Care of Color Photographs: Traditional and Digital Color Prints, Color Negatives, Slides, and Motion Pictures*, Preservation Publishing Company, Grinnell, Iowa, USA, 1993, p. 145.

¹¹ Duxbury, D.F., *Chem. Rev.*, 93, 1993, 381.

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The long-term behavior of a polymeric matrix will be influenced by the type of pigment used in the formulation.

Weakly Absorbing Pigments

These pigments (e.g., iron oxide Fe_2O_3) are mostly neutral or even stabilizing. Other iron oxides have a pro-oxidant effect on thermooxidation, and since photooxidation is actually a photothermal oxidation process, UV radiation can activate this pro-degrading effect. Colored salts or oxides with a basic character—for instance, a basic iron oxide—may be transformed into photo-active carboxylates through reaction with the acidic species formed during the matrix oxidation.¹² These carboxylates will be a new source of radicals able to further oxidize the matrix (Figure 2). Thus, an iron oxide will exhibit a wide range of stabilizing properties depending on its origin and purity.

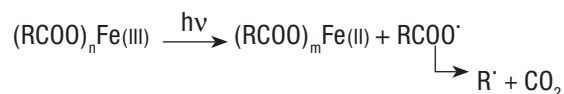


Figure 2: Photoreactivity of iron (III) carboxylates

Highly Absorbing Pigments

Pigments with organized crystalline structure are relatively rare (TiO_2 anatase and rutile, ZnO, CdS, CdSe, Ce_2S_3). They are qualified as photo-active since they will profoundly affect the behavior of polymeric matrices they are added to.¹³ Their influence can be evaluated by considering all their properties:

- Dispersibility;
- Internal filter property toward the matrix and oxidation products at $\lambda < 400$ nm;
- Photocatalytic activity toward the matrix and oxidation products;
- Photocatalytic activity toward non-absorbing stabilizers;
- Photoprotection of absorbing stabilizers;
- Photoprotection of yellowing products.

Among these properties, the photocatalytic activity toward the matrix and the stabilizers or other colorants are particularly important. These photocatalytic properties can be drastically reduced through surface treatments. CdS and CdSe are exceptions since their photoactivity is so weak that they seem to act as photostabilizers.

Carbon Blacks

These pigments are a specific case. They degrade UV and visible energy into harmless heat through vibrational relaxation (a non-radiative photophysical process). However, when the concentration is too low or the dispersion not sufficient in a matrix with low heat conductivity, hotspots may occur and lead to localized thermal oxidation, affecting appearance (white spots). Therefore, carbon black must always be used in sufficient concentration to produce the thermal coalescence of particles that will dissipate the produced heat in a larger zone and out of the matrix and “thermostat” the system. Since carbon black does not provide sufficient photostabilization, the addition of an antioxidant is recommended (redox and conventional). Conventional antioxidants, which absorb in the UV range, are photochemically protected by the pigment.

¹² Zuo, Y., and Hoigné, J., *Environ. Sci. Technol.*, 26, 1992, 1014.

¹³ Lemaire, J., *Pure Appl. Chem.*, 54, 1982, 1667.

PHOTOCHEMICAL BEHAVIOR OF ORGANIC PIGMENTS AND DYES

Due to the vast range of reactions that organic colorants can undergo, very few general statements can be made regarding the photochemical behavior of these compounds and their influence on the aging of polymeric matrices. The only long-term stabilizing property that can be anticipated for an organic colorant is that of a UV absorber that improves the matrix photoprotection.

The color of organic dyes and pigments is the result of an electronic transition from the ground state quoted as S_0 to the first excited state S_1 through the absorption of radiation in the visible range. Although the relaxation of the S_1 excited state of organic molecules may occur through several possible photophysical and photochemical processes, in the case of colorants it often evolves to the ground state S_0 through harmless heat release.¹⁴

Exposure to more energetic radiation, typically in the UV range, may activate the second electronic excited state S_2 . In the condensed phase, a molecule excited in the S_2 state generally undergoes a quantitative internal conversion to the S_1 state via a radiationless process.¹⁵ Thus, when a colorant absorbs strongly between 300 and 360 nm and when the probability of the internal conversion $S_2 \rightarrow S_1$ is higher than 0.999, it will protect the host matrix by competitive absorption of the UV radiation.

When the probability of the internal conversion $S_2 \rightarrow S_1$ is lower than 0.999, the colorant may undergo primary photochemical processes from S_2 that can either be independent of the chemical evolution of the host matrix or interact with it.¹⁶ Both scenarios are reviewed below. Figure 3 summarizes the processes originating from the primary excitation of the colorant.

Note 1: Colorants that degrade under visible light exposure (typically poorly weatherable colorants) may undergo some of the processes described hereafter for S_2 from the S_1 state or from the lower energy state T_1 .

First Case: The Evolution of the Matrix Does Not Interfere

The colorant may then evolve according to two pathways:

a) Non-oxidative (independent of surrounding oxygen concentration)

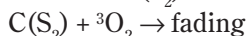
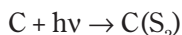
The result is the photodissociation or the photoisomerization of the colorant, yielding colorless products or a product with a different color



where $C(S_0)$ and $C(S_2)$ refer respectively to the ground state and the second singlet excited state of the colorant C.

b) Oxidative

» Direct reaction



where 3O_2 denotes molecular oxygen in the ground state.

Note 2: Fluorescent colorants typically undergo photooxidation from their first singlet excited state.¹⁷

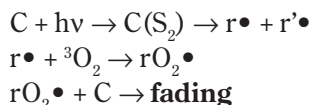
¹⁴ Photophysical processes are the photoexcitation and subsequent events that leave the initial molecule unchanged, such as fluorescence, phosphorescence, or internal conversion. Photochemical processes yield new chemical species through isomerization, addition, ionization, or dissociation.

¹⁵ Turro et al., *J. Am. Chem. Soc.*, 1978, 125.

¹⁶ Lemaire et al., *Caoutch. Plast.*, 793, 2001, 32.

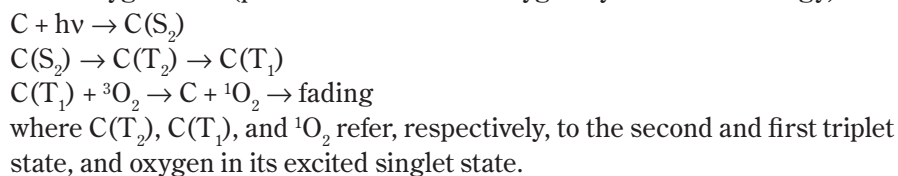
¹⁷ The relatively long lifetime of the S_1 state of fluorescent molecules (10^{-9} – 10^{-6} s, compared with the lifetime of S_1 states of non-fluorescent organic molecules 10^{-12} – 10^{-9} s) enables a reaction with atmospheric oxygen and further degradation. This accounts for the generally poor lightfastness associated with fluorescent dyes.

- » Indirect reaction (e.g., radicalar dissociation of the excited colorant and oxidation of the colorant in the ground state)



Note 3: The addition of such a colorant to a photostable matrix may induce the photooxidation of the matrix through the attack by $rO_2\bullet$ radicals. This process can be prevented by adding antioxidants to the formulation.

- » Photooxygenation (production of excited oxygen by transfer of energy)¹⁸



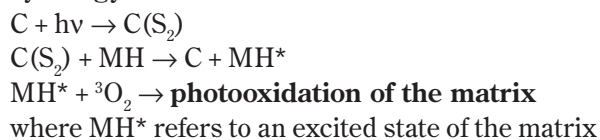
Note 4: To check whether 1O_2 is produced, DABCO is usually added.

Second Case: The Evolution of the Matrix Interferes

When the long-term behavior of the system is controlled by the evolution of the matrix, both the colorant and the matrix may present a reactivity that influences each other through

c) Photosensitization of the matrix

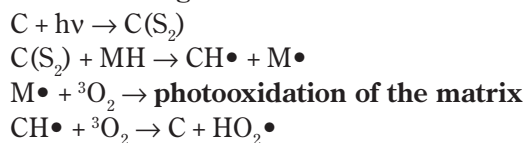
- » by energy transfer from the excited state of the colorant to the matrix MH (very rare)



- » indirectly, by energy transfer to atmospheric oxygen and production of singlet oxygen



- » through photoreduction of the excited state by the matrix or any additive bearing labile hydrogen atoms.¹⁹ Atmospheric oxygen can regenerate the colorant in its ground state while the matrix undergoes photooxidation

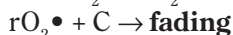
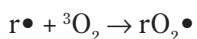


Although all three processes have a stabilizing effect on the colorant, they occur relatively infrequently.

¹⁸ Rabek, J.F., *Polymer Photodegradation*. Mechanisms and Experimental Methods, London: Chapman and Hall, 1995, p. 405.

¹⁹ Allen, N.S., and McKellar, J.F., *Photochemistry of Dyed and Pigmented Polymers*, London: Applied Science Publ., 1980, p. 247.

d) Co-photooxidation of the matrix M and the colorant



Co-photooxidation occurs frequently, where both the matrix and the colorant are simultaneously degraded. However, the photostabilization of the matrix automatically brings about the photostabilization of the colorant.

The study of the phototransformation of colorants in a polymeric medium is therefore greatly affected by the permeability of the matrix to oxygen. This should be kept in mind particularly when performing accelerated weathering tests where oxygen diffusion is not always representative of environmental conditions. Obviously, any such study is only possible if the radicals formed through the photooxidation of the matrix are neutralized beforehand to prevent any reaction with the non-excited pigments or dyes.

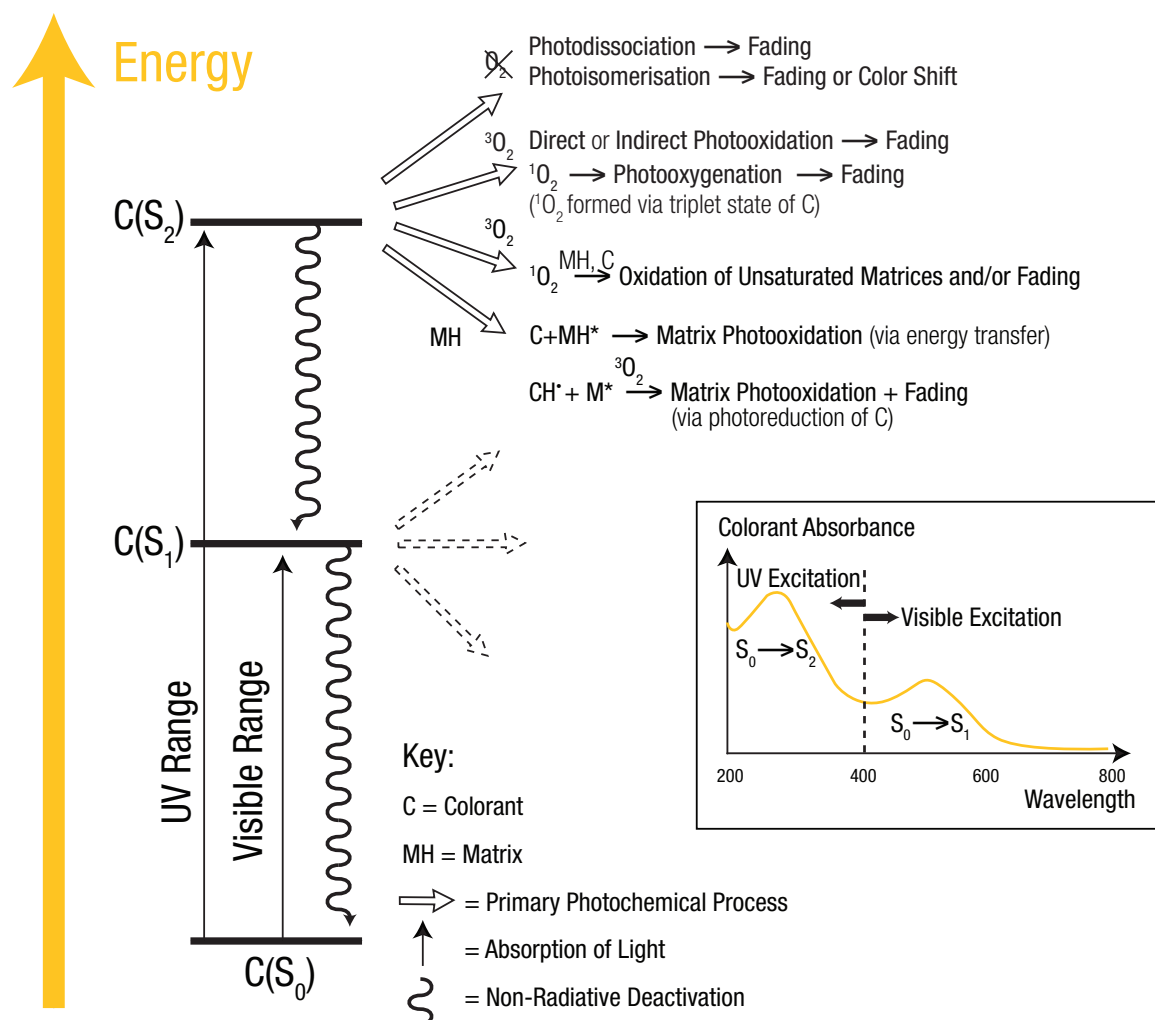


Figure 3: Representation of the primary photochemical processes in organic colorants that do not interfere (in gold) and interfere (in black) with the evolution of the host matrix

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RECOMMENDATIONS FOR ACCELERATED TESTING

Besides the generalities reported above on the photochemical evolution of colorants, each formulation of colored polymeric material presents a specific behavior. The data provided by colorant producers on the long-term durability of their products is only fragmentary since it is not possible to consider all possible end-use conditions. Nevertheless, this knowledge may help to improve the reliability of the accelerated testing of colored materials, with the following recommendations:

- **Spectral distribution of the light source:** It was shown that the long-term behavior of organic colorants is generally more influenced by the spectral distribution of the light source in the UV range than by that of the visible range. It is therefore important to monitor the spectral characteristics of the UV range of the light source used in laboratory tests. In particular, only wavelengths longer than 300 nm should be used to reproduce outdoor conditions and longer than 340 nm to reproduce indoor conditions. This broadly accepted principle was used in the development of Atlas[®] MTT's new Rightlight[™] lamp, which incorporates a filtered xenon light that very closely matches the average SPD of solar radiation in the UV range (Figure 4).
- **The intensity of the source** should be limited to 3 to 4 times the average irradiance level in end-use conditions to avoid the unnatural case of oxygen starvation in the inner layers of a material. This effect may become significant in coated materials.²⁰
- **Uniformity of stresses:** The rate of photooxidative processes is affected by the value of the temperature and the light intensity. Thus, control of the uniformity of the light intensity and the temperature at the surface of the exposed samples during an accelerated test is essential to ensure good repeatability and reproducibility.

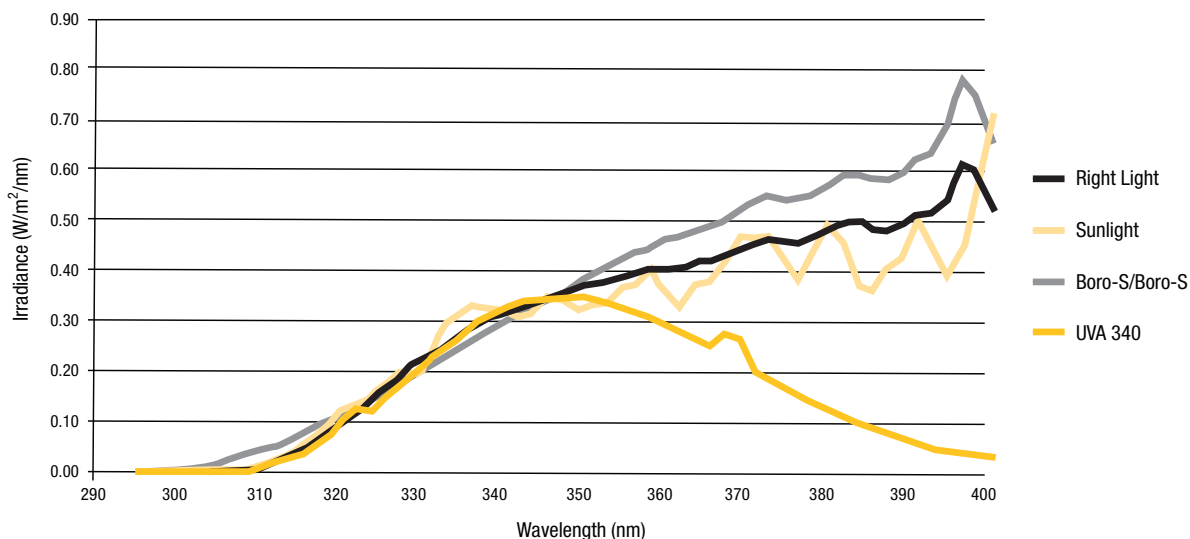


Figure 4: Spectral power distribution of xenon arc with daylight filters vs. fluorescent UVA 340 light vs. sunlight. The black plot (Rightlight) shows the closest match to sunlight in the whole UV range.

²⁰ The use of a coating is recommended when the matrix undergoes discoloring rearrangement reactions that cannot be prevented by chemical stabilizers, such as in aromatic polymers. However the use of a physical barrier may produce an unrealistic oxygen depletion at the matrix-coating interface in accelerated aging that would not occur during service life.

- **The impact of moisture** on the degradation of the material needs to be examined and understood to determine the most relevant water cycle for a test.
- **The change of chemical composition and color/appearance** shall be assessed on parts of the finished product so the effect of the processing operations can be accounted for.

CONCLUSION

The behavior of a colored material can only be correctly understood through the simultaneous study of the chemical evolution of the matrix and the evolution of the coloring species, so it is possible to detect any premature failure of the colored system.

When the failure is triggered by the photoreactivity of the matrix, it is possible to develop a stabilization strategy (either by adding stabilizers to the formulation or using an external photoprotective layer such as a stabilized coating).

When the failure is initiated by the photoreactivity of the colorant, a more photostable colorant is recommended. ■

Atlas® Supports Automotive Weathering Testing in China

Some 150 professionals from China's automotive industry traveled to Shanghai in October for a two-day technical symposium, organized in part by Atlas. The 5th **Sino-American Academic Symposium on Environmental Corrosion and Degradation Tests of Material** helped advance their knowledge in the application of testing technology in material and product development.

The October 30–31 event was sponsored by the State Key Lab of Environmental Adaptability for Industrial Products and organized by China Electric Apparatus Research Institute (CEI), Guangzhou Vkan Certification and Testing Institute, SDL Atlas Ltd., and Atlas.

Keynote speaker Dr. Jeffrey Helms, of Ford Motor Company, presented a paper entitled "Global Harmonization of Materials Weathering Requirements at Ford Motor Company." Other papers were presented by Richard Fischer, 3M Weathering Resource Center; Kanji Mori, Toyota Central R&D Labs., Inc.; Qian Huiming, Shanghai GM; Kevin Smith, Auto Technology Company; Zhu Chunjin Nanjing, AUTO Group Technology Research Institute; Peng Jian, State Key Lab of Environmental Adaptability for Industrial Products; Gao Jin, University of Science and Technology Beijing; Chen Guangqiang, KINGFA Science and Technology Co. Ltd.; Kurt Scott, Atlas Material Testing Technology LLC; and Laurence Bond, Atlas Material Testing Technology LLC.

Attendees engaged in in-depth academic exchanges on testing techniques and standards for weathering and corrosion in order to improve the level of research and technology of materials in China. ■



Conference speakers and organizers in Shanghai.

Atlas Commitment to Growth



Weathering Experimenter's Toolbox: Single Variable: On-Off

By Henry K. Hardcastle, Atlas® R & D

Single variable or “on-off” trials probably represent the earliest levels of experiment. Representing “experiment” in its simplest application, this type of test forms the foundation for all other levels of experimentation, enjoys wide use in the weathering industry today, and is a good starting point for developing a lexicon describing weathering experimentation evolution. At this level, the experimenter wants to understand the effect of a single variable on a system. The system is tested with and without the variable applied. Other conditions are kept constant or “blocked.”

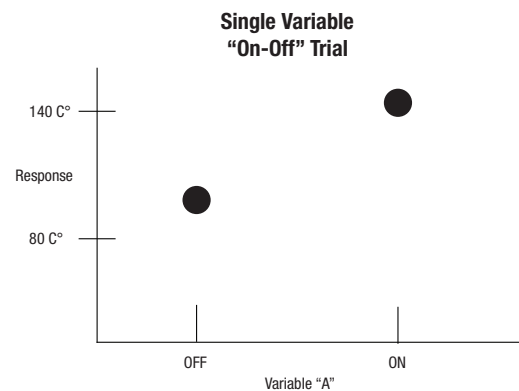
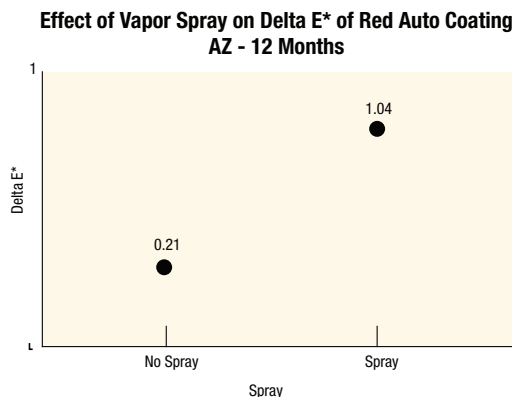
This type of experiment answers questions such as:

- Will doubling line speed sacrifice critical weathering properties?
- Will adding photo stabilizer improve impact strength retention after three years of Florida exposure?
- Will adding new lubricant “X” affect gloss retention on Arizona exposure?
- Will increasing filler content by 10% affect loss of color retention on Florida exposure?
- Will increasing the process temperature by 30° C affect weathering color stability?
- Will adding regrind decrease tensile strength after exposure?

Application of this experimental design is simple. The experimenter prepares two sets of samples for trial: sample set “A” without the variable applied and sample set “B” with the variable applied (often referred to as “The Input Variable” or the “Independent Variable”), and exposes the two sets side by side to the weather. After a period of exposure, the experimenter measures the two sets and analyzes the measured values (often referred to as the “Output Variables” or “Dependent Variables”). The analysis looks for differences between the two sets.

The graphic below shows a representation of this simple variable design.

For example, a red automotive coating was subject to a 45° south exposure for 12 months in Arizona. Specimens were placed on plywood backing. One specimen was exposed to a 30 second water spray every hour during the day. The other sample did not have water spray. ■



Atlas Test Instruments Group

Atlas® Chooses Agent for UK and Ireland



Atlas Material Testing Technology is pleased to announce that it has selected Weiss Gallenkamp as an exclusive sales agent for selected Atlas products in the UK and Ireland.

Weiss Gallenkamp is a leader in environmental simulation, with over 40 years of experience in supplying environmental test chambers and rooms to many of the world's most prestigious companies across a range of industries. There is a high degree of synergy between the two companies as both are involved in environmental test and simulation, and the relationship will prove extremely beneficial to our mutual customers.

"We are extremely excited by this opportunity," said Jürgen Parr, Atlas Export Sales Manager. "It will give us the extra presence we have been looking for in the UK, and working with a renowned company like Weiss Gallenkamp will strengthen our leadership position."

"We are delighted to have this partnership with Atlas, said Mike Reilly, Weiss Gallenkamp Managing Director. "The quality of Atlas products is excellent, complementing our existing range, and we look forward to a successful relationship."

For further information, please contact James Walton of Weiss Gallenkamp at +44(0)1509-631590 or james.walton@weiss-gallenkamp.com, or Jürgen Parr and Chris Hazelby of Atlas at +44(0)1869-365440 or sales@atlasmtt.co.uk. ■

'Spring into EMMAQUA®'

*Don't Let Tough Economic Times
Delay Your EMMAQUA Testing!*

The sooner you begin your testing, the quicker you will have the data you need. To help you get started, Atlas is offering discounted EMMAQUA pricing before the peak summer season begins.

Start your testing before April 1, 2009, and receive a 25% discount on all EMMAQUA exposures. This includes EMMAQUA, EMMA®, EMMAQUA Night Time Wetting, EMMAQUA Soak Freeze Thaw, and all Temperature-Controlled EMMAQUA options.

Atlas is also offering an attractive corporate lease program for EMMAQUA. Reserve your machine today and save 25% on full machine leasing through December 2009!

For more information, contact your client services representative at 1-800-255-3738. Request your quote today! Mention "Spring into EMMAQUA" to receive the discounted price. www.atlas-mts.com.



Atlas Commitment to Growth

Clients Master Weather-Ometer® at New Training Center

Atlas' Weather-Ometer workshops have a new home. After conducting trainings for years in Duisburg, Germany, we have relocated these workshops to the Client Education Training Center in Linsengericht-Altenhaßlau.

A two-day Ci Series® Workshop in November was the first event held in Linsengericht, the German production site, attracting clients from Germany and Switzerland. The morning sessions covered a range of topics, including weathering theory, test methods, calibration procedures, and trouble shooting. The afternoons were devoted to practical hands-on training, with a review of all the essentials for effectively operating and running a Ci Weather-Ometer.

The workshop included a comprehensive presentation by the German company Millipore about the importance and quality of the spray water used in the Weather-Ometer instruments.

The Client Education Training Centre is fully equipped with xenon arc instruments like the Xenotest®, SUNTEST® and Weather-Ometer line, as well as fluorescent devices like the UV 2000®. All are fully operational and ready for workshops, seminars, and technical and service trainings for you and your team.

For more information on our instrument workshops, visit www.atlas-mts.com or write clienteducation@atlasmtt.de. ■



Participants and instructors paused for a photo during the Weather-Ometer Workshop in Linsengericht-Altenhaßlau.

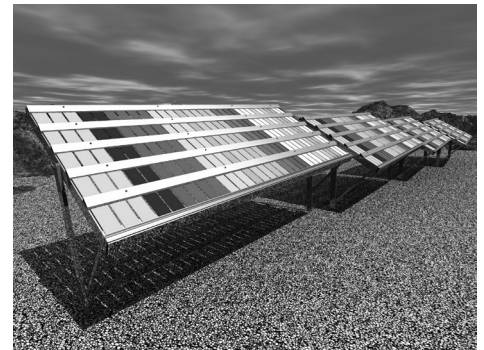
Atlas Partners with Pausch Messtechnik

Atlas Material Testing Technology GmbH has assigned exclusive sales rights for its fluorescent product line in Germany to Pausch Messtechnik GmbH (www.pausch.com). Effective immediately, all sales and service responsibilities will be carried out by Pausch.

Pausch Messtechnik brings more than 25 years of experience in the field of weathering testing to Atlas. The cooperation between Atlas and Pausch expands Atlas' capabilities in environmental simulation, online colorimeters and surface measurement. Pausch will also strengthen Atlas' commercial laboratory services by offering UV fluorescent weathering services at our laboratory in Haan. ■

A Good Thing Gets Even Better with New Exposure Rack

Atlas® is proud to present the newest product in our ever-growing weathering testing product line—the **Atlas Outdoor Exposure Rack**. Our new design takes into account the best features of our exposure racks used at weathering sites around the world and incorporates innovative ideas from our in-house weathering technicians and experts. We asked the question, “How can we make the exposure rack better?” and we are sure the new Atlas Outdoor Exposure Rack has answered that question with improved ease of use!



How is the Atlas Outdoor Exposure Rack an improvement over the historically available exposure rack and other similar products in the marketplace?

1. We have improved on the old flap-assembly’s traditional wingnut fasteners with an ergonomically friendly cam-lock design.
2. We have designed new “quick-release” hardware to panel and sample mounting hardware such as the flap assembly that will allow in-place removal as opposed to the slide functionality of traditional model racks.

The enhanced test rack continues to meet all applicable outdoor weathering standards, but with better construction, it will be easier and more efficient to use.

Contact an Atlas customer service representative for a quotation today at info@atlas-mts.com. Upgrade your entire test field now to take advantage of low metal prices and increased volume purchase savings! ■

Florida Test Site Consolidation Complete!

The consolidation of our South Florida test sites in Miami has been completed. We have closed our Okeechobee Road facility and our new headquarters is the current Everglades Test Laboratory, now known as South Florida Test Service. Interior building renovations have been completed with exterior renovations soon to follow. In addition to our new headquarters, we have also purchased an ancillary piece of property to ensure all of our clients’ specimens can be exposed in the most pristine exposure site in South Florida.

Our new headquarters includes static (outdoor) weathering, a complete evaluations laboratory, and a special projects area. The accelerated laboratory is now located at our new weathering “Center of Excellence” at our global Atlas® headquarters in Chicago, IL.

Please send all tests for outdoor exposure testing to the following address:

South Florida Test Service

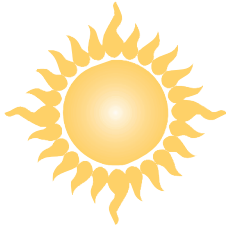
16100 SW 216th Street

Miami, FL 33170

Phone: (305) 245-3659

Fax: (305) 245-9122

Please contact our client service representative or your local representative if you have any questions or would like to learn more. ■



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