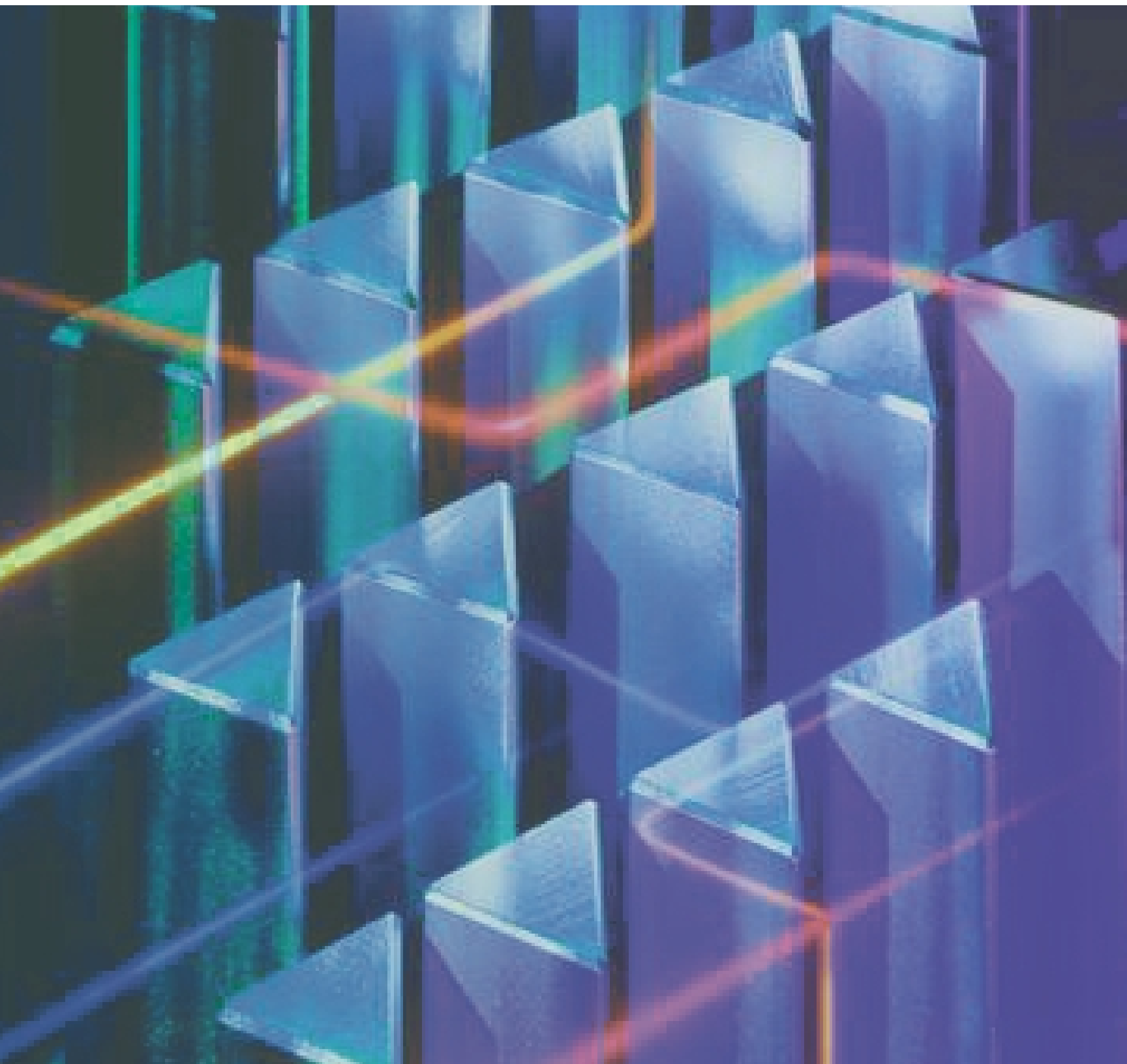


# Optical Brighteners



Fluorescent Whitening Agents for  
Plastics, Paints, Imaging and Fibers



# Uvitek Tinopal NFW SFP

Ciba Specialty Chemicals is the global leader in an ever-expanding technology for high-value additives. For more than 30 years, we have developed light stabilizers, antioxidants, corrosion inhibitors, optical brighteners and algicides that enhance and improve the performance of our customers' products. Our technology is driven by evolving customer needs, increasingly stringent environmental demands and the recognition that insofar as our customers succeed, so do we. We are committed to the success of our customers' businesses.

# Light, Bright and Brilliant Colors

Ciba Specialty Chemicals' Additives Division produces a family of fluorescent whitening agents (FWA), also called optical brighteners (OB), designed to brighten colors or mask yellowing in plastics, lacquers, paints, inks, photo-processing solutions and fibers. These optical brighteners work via a fluorescent mechanism which absorbs light in the UV spectrum and emits light in the blue region of the visible spectrum to yield a brighter, fresher appearance.

**Ciba® UVITEX®** and **Ciba® TINOPAL®** optical brighteners are designed for use in a variety of applications.

## Suggested Applications:

- Molded thermoplastics
- Films and sheets
- Clear and pigmented lacquers
- Paints
- Printing inks
- Synthetic leather
- Ultraviolet tracer
- Photo processing solutions
- Adhesives
- Fibers

## Features and Benefits:

- Brilliant, bluish whitening effects
- Good light fastness
- Excellent resistance to heat
- High chemical stability
- Low volatility
- Readily soluble in organic solvents
- Good compatibility with most substrates



# Whiter than White– Principles of Whiteness Improvement

Optical brighteners or fluorescent whitening agents (FWA) are colorless to weakly colored organic compounds that, in solution or applied to a substrate, absorb ultraviolet light and re-emit most of the absorbed energy as blue fluorescent light between 400 and 500 nm (Figure 1).

**Figure 1** Uvitex OB Absorption and Fluorescence Emission Curves

Solvent	DMF
Concentration	4.4 mg/l
Layer Thickness	1 cm
Absorption Maximum	375 nm
Fluorescence Maximum	437 nm
Quantum yield $\Phi$	0.81

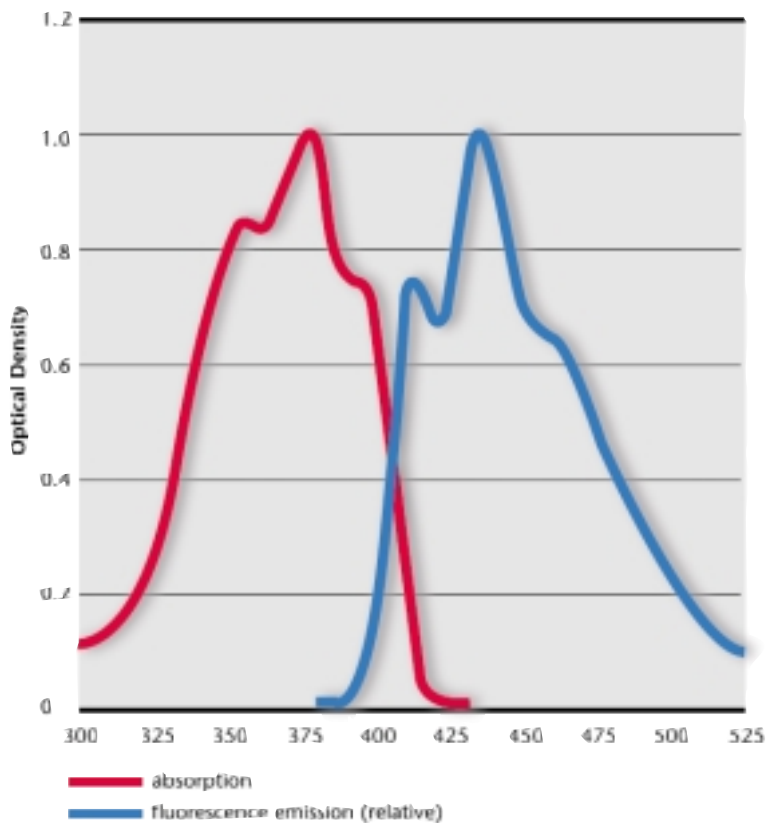


Figure 2 illustrates the processes involved in light absorption and fluorescence by optical brighteners.

Absorption (A) of light quanta by the brightener molecules induces transitions from the singlet ground state  $S_0$  to vibrational levels of the electronically excited singlet states ( $S_1$ ).

Brighteners in the  $S_1$  state are deactivated by several routes. Fluorescence results from radiative transitions to vibrational levels of the ground state (F).

Deactivation processes competing with fluorescence are mainly non-radiative deactivation to the  $S_0$  state (IC) and non-radiative transition to the triplet state (intersystem crossing, ISC).

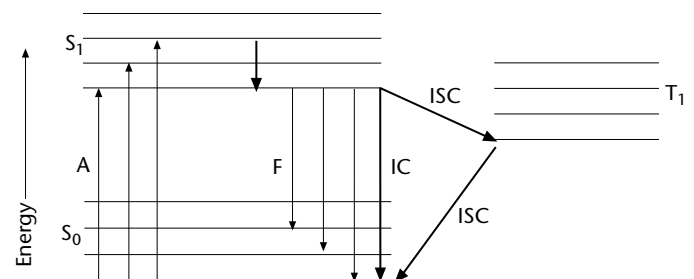
The efficiency of fluorescence is measured by the quantum yield  $\Phi$ :

$$\Phi = \frac{\text{Number of quanta emitted}}{\text{Number of quanta absorbed}}$$

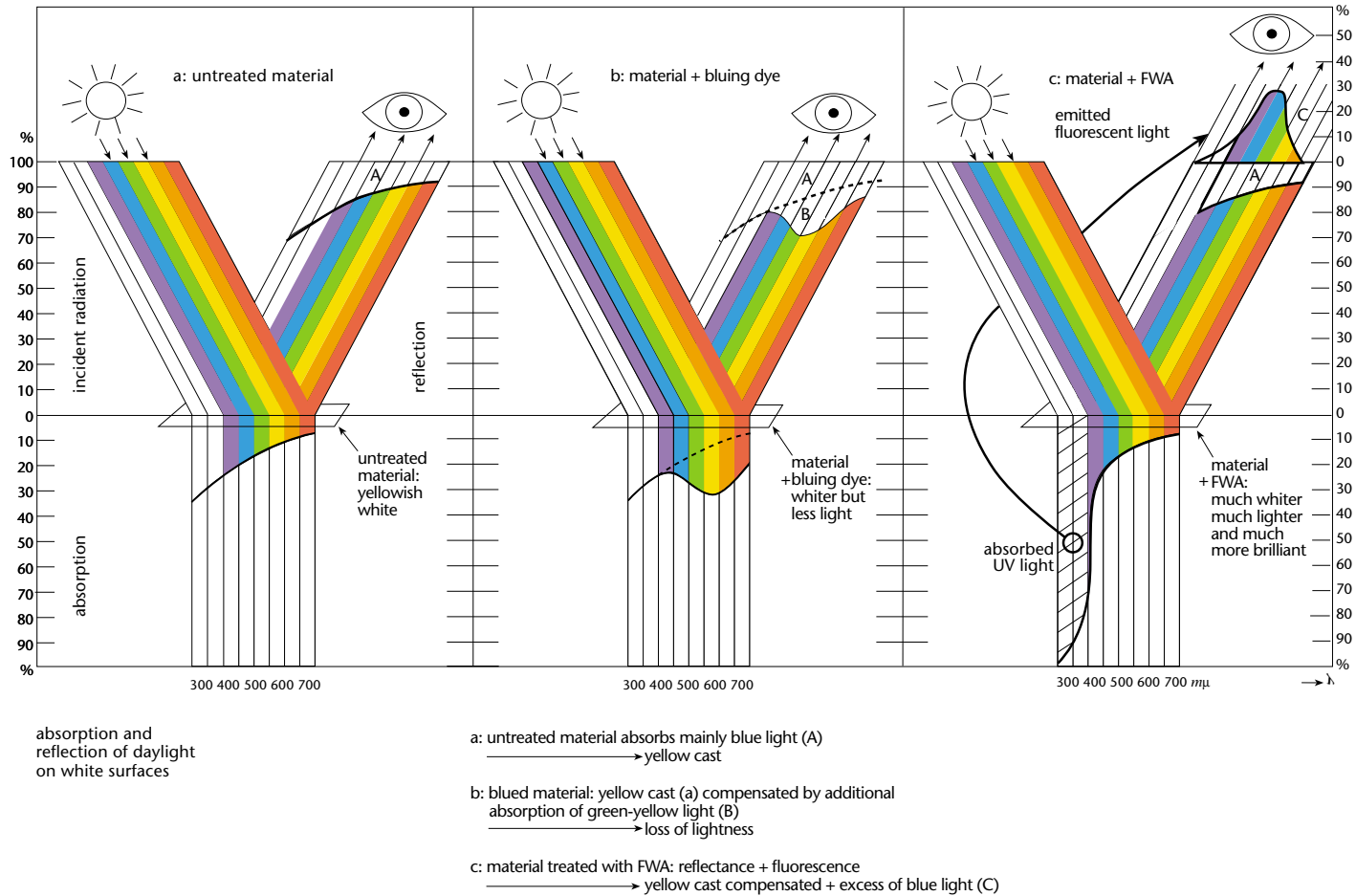
It is determined by the relative rates of fluorescence emission and the competing processes. When fixed in solid substrates, brighteners fluoresce with high quantum yields ( $\Phi$  ca. 0.9).

**Figure 2** Energy Diagram of Optical Brighteners and Transitions

A = absorption  
F = fluorescence  
IC = internal conversion  
ISC = intersystem crossing  
S = singlet state  
T = triplet state



**Figure 3 Physical Principles of Whiteness Improvement**



Materials that evenly reflect most of the light at all wavelengths striking their surface appear white to the human eye. Natural fibers, for example, generally absorb more light in the blue region of the visible spectrum ('blue defect') than in others because of impurities (natural pigments) they contain. As a result, natural fibers take on an unwanted, yellowish cast. Synthetic fibers also have this yellowish cast, although not as pronounced.

Whiteness in substrates can be improved by (1) increasing reflection (reflectance) or (2) compensating the blue defect. Bleaching has both of these effects to some extent, but invariably leaves behind part of the yellowish cast. Even the most thorough bleach cannot remove all traces of a yellowish cast.

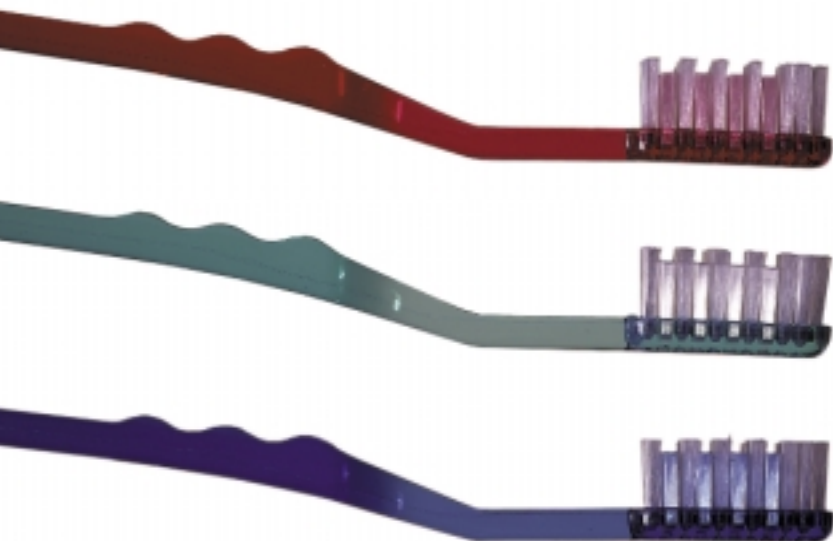
Before the advent of fluorescent whitening agents (FWA), common practice was to apply small amounts of blue or violet dyes (called 'bluing') to boost the visual impression of whiteness. These dyes absorb light in the green-yellow

region of the spectrum, thereby reducing lightness. But, since at the same time they shift the shade of the yellowish material towards blue, the human eye perceives an increase of whiteness.

Unlike dyes, FWAs offset the yellowish cast and at the same time improve lightness because their bluing effect is not based on subtracting yellow-green light, but rather on adding blue light. FWAs are virtually colorless compounds which, when present on a substrate, absorb primarily invisible ultraviolet light in the 300-400 nanometer (nm) range and re-emit in the visible violet-to-blue fluorescent light.

This ability of FWAs to absorb invisible short wavelength radiation and re-emit in the visible blue light which imparts a brilliant whiteness to the light reflected by a substrate, is the key to FWAs effectiveness.

# Plastics and Fibers Applications



Brightening agents impart a healthy, clean-looking appearance to the white bristles and colored plastic handles of these toothbrushes.



These polyurethane flexible foam sneakers are "tennis-white" thanks to FWAs.



Man-made fibers have an inherent yellowish color (left). Add Uvitex® OB and PET fibers appear cleaner and whiter (right).



White sails in the sunset must provide good light fastness characteristics.



FWAs help capture the natural blue tones of mother-of-pearl buttons.



Uvitex® optical brighteners make her inflatable PVC beach tube both bright-white and colorful.

# Fluorescent Whitening Agents for Plastics and Fibers

Fluorescent whitening agents in plastics can provide

- Improved initial color
- Brilliant white end-use articles
- Increased brilliancy of colored and black pigmented articles

FWAs are effective in a variety of polymer substrates such as engineering plastics (e.g. polyesters, polycarbonate, polyamides and acrylics) thermoplastic polyurethane, polyvinylchloride, styrene homo- and copolymers, polyolefins, adhesives, and other organic substrates. Main applications include fibers, molded articles, films and sheets.

The effectiveness of a fluorescent whitener is dependent upon the type of substrate, processing conditions and possible interactions with other components in the formulation such as white pigments or UV absorbers. In general, fluorescent whiteners are effective at very low concentrations.

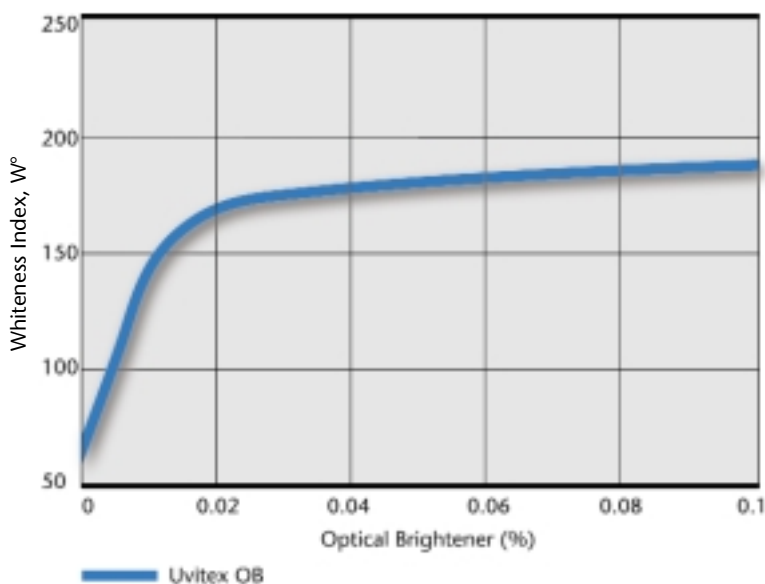
Ciba Specialty Chemicals has developed a measurement to evaluate the whitening effect of FWAs,  $W^\circ$ .

Titanium dioxide pigments ( $TiO_2$ ) absorb light in the same UV wavelength range as fluorescent whiteners and thus generate lower whiteness degrees. The whitening effectiveness of Uvitex OB in a PET fiber sample test containing titanium dioxide shows the degree of whiteness is dependent on the concentration levels of the fluorescent whitener (Figure 4).

Anatase type titanium dioxide pigments absorb approximately 40% of the incident radiation at 380 nm, while rutile type titanium dioxide pigments absorb about 90%. In the flexible PVC sample in Figure 5, a brilliant white is obtained using only small concentrations of Uvitex FP with anatase titanium dioxide. When rutile types are used, a slightly reduced whiteness is noted at equal concentrations.

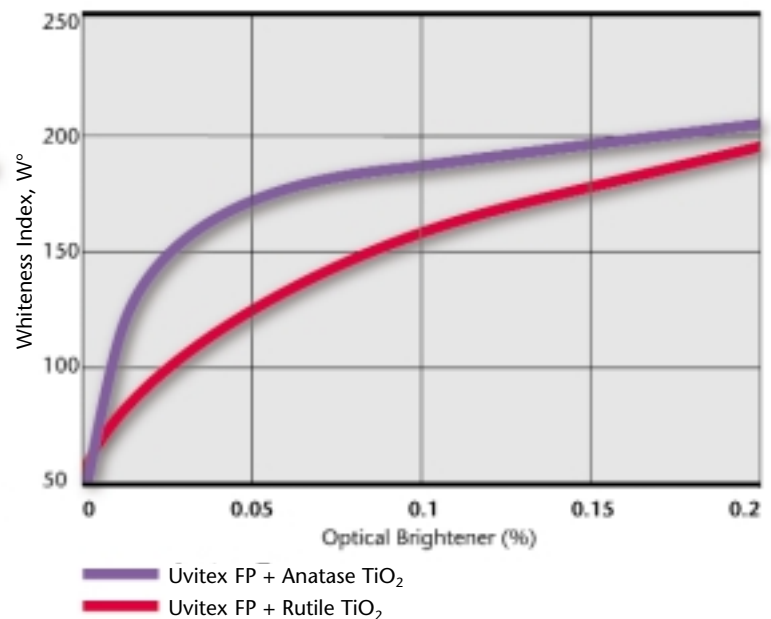
**Figure 4** Concentration Dependency of Whitening Effect in PET Fibers

Uvitex OB in PET Fibers (4.6 dtex), 0.5%  $TiO_2$



**Figure 5** Concentration Dependency of Whitening Effect in Flexible PVC

Uvitex FP in Flexible PVC (1 mm film). Different  $TiO_2$  Types Composition (parts): 100 PVC, 35 DOP, 2 Heat Stabilizer, 5  $TiO_2$



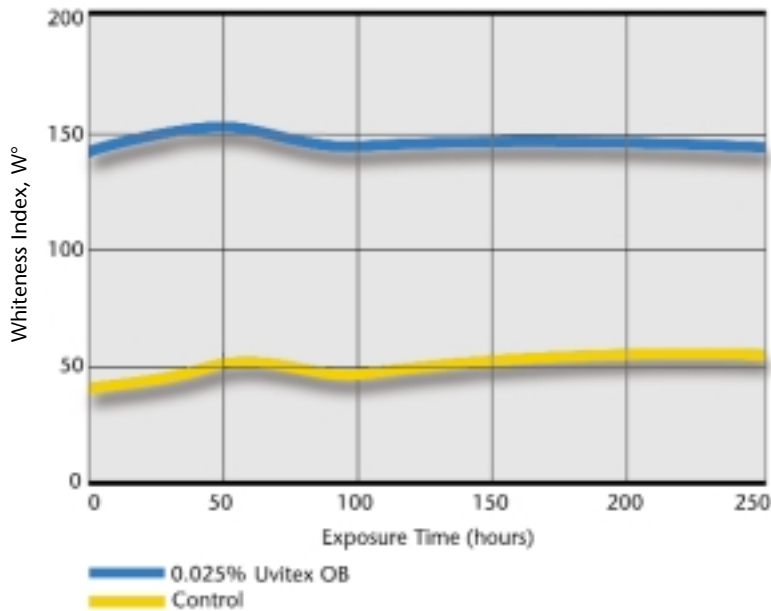


## Light Fastness in Plastics and Fibers

An essential criterion for the technical suitability of a FWA is its light fastness in the substrate. Figures 6, 7 and 8 demonstrate the stability of Ciba Uvitex brightening agents in a variety of polymers.

**Figure 6** Light Fastness of Whitening Effect in PET Fibers

Uvitex OB in PET Fibers (4.6 dtex), 0.5% TiO<sub>2</sub>  
Xenon Arc Weathering: Xenotest 150

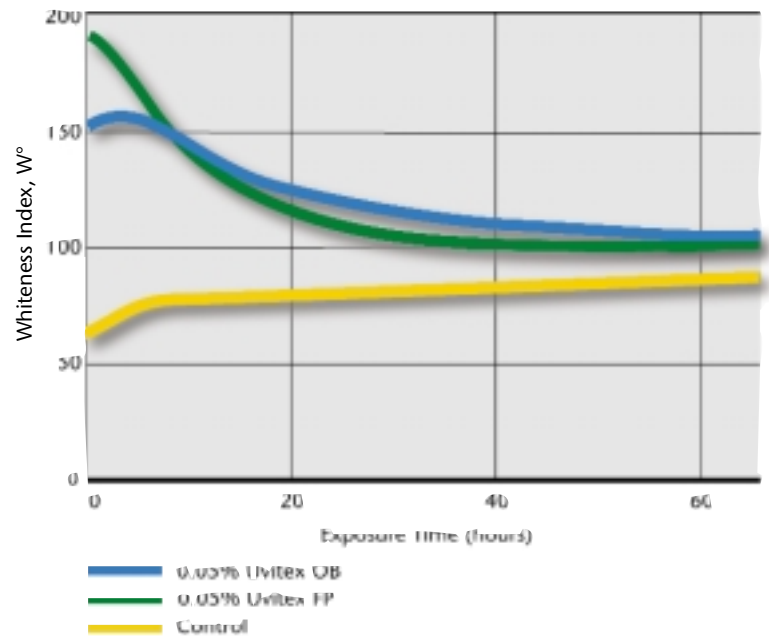


## Ciba's Family of Optical Brighteners

Ciba offers the widest product line and expertise in the industry, providing recommendations and technical support to help solve customer problems.

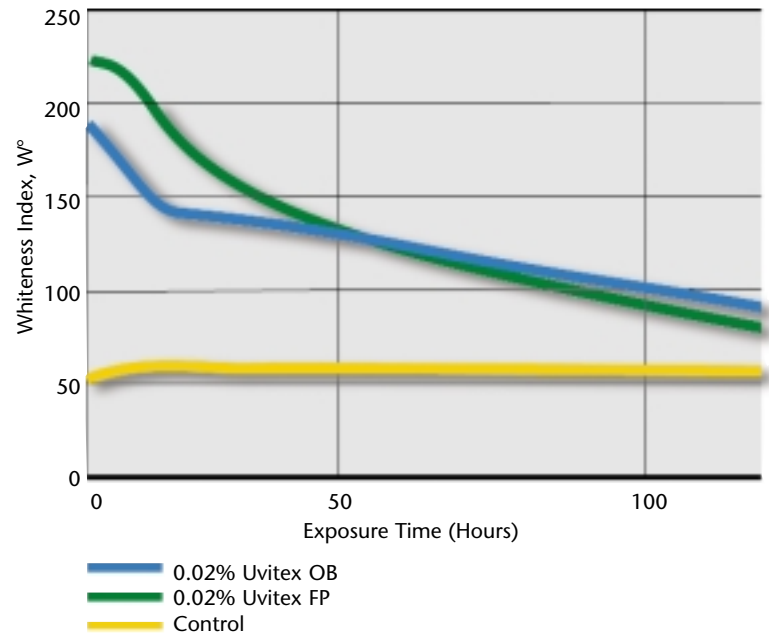
**Figure 7** Light Fastness of Whitening Effect in Flexible PVC

Uvitex FP and Uvitex OB in Flexible PVC (1mm sheet)  
Composition (parts): 100 PVC, 35 DOP, 2 Heat Stabilizer, 5 TiO<sub>2</sub>  
Xenon Arc Weathering: Xenotest 150, Diffuse Daylight Filter System



**Figure 8** Light Fastness of Whitening Effect in Styrenics

Uvitex FP and Uvitex OB in IPS, 2mm Plaques;  
Xenon Arc Weathering: Xenotest 150, Diffuse Daylight Filter System



# Imaging and Coatings Applications



Uvitex® OB fluoresces blue when exposed to ultraviolet light, thus providing quick identification of security printing of bank notes and other legal and financial instruments.

Washer/dryers, refrigerators and other appliances appear whiter when FWAs are added to the paint.



Uvitex® OB and Uvitex NFW liquid are used to brighten and increase the deep tones of colors in overprint varnishes for a variety of packaging applications.

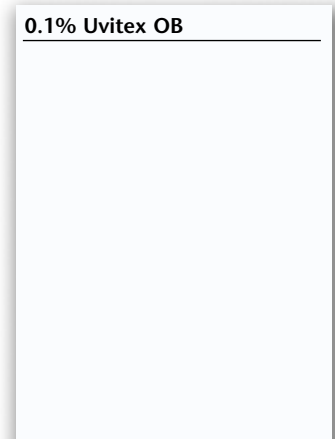
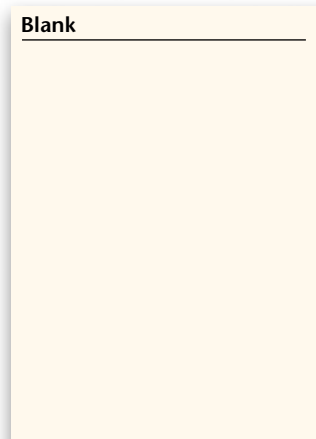


Brilliant, white golf balls coated with a Uvitex® OB containing clearcoat are easily spotted and retrieved from fairway, rough, sand trap, green or cup.



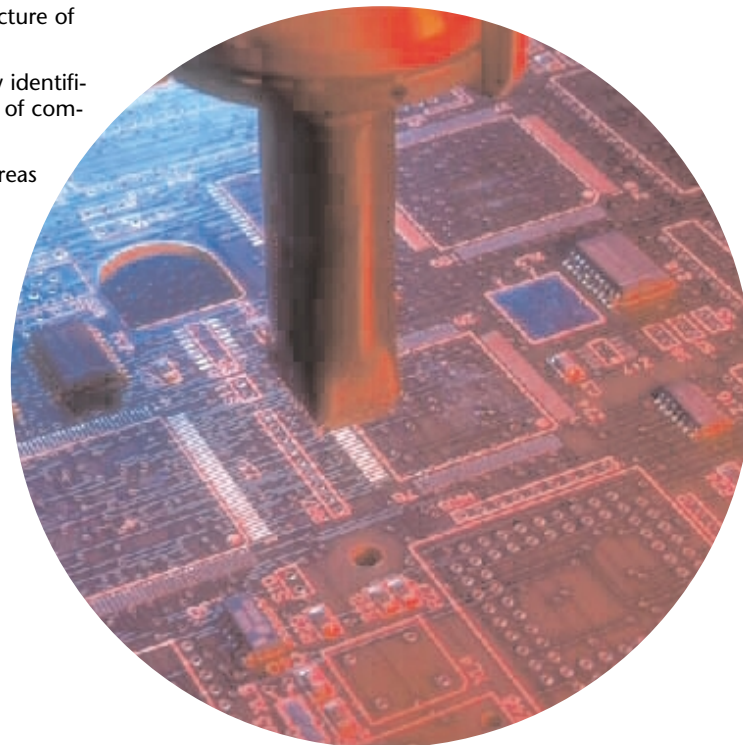
Tinopal® optical brighteners are used in photographic developing solutions to brighten whites and increase the deep tones of black, as well as reduce stains in processed color prints.

Panels of a 2-part PU clearcoat over a white coil coat show Uvitex® OB helps brighten and mask yellowing of clearcoats. Uvitex OB is particularly recommended for high bake systems such as coil and powder coatings.



FWAs can be used in the manufacture of printed circuit boards:

- 1) as tracers in adhesives to allow identification of locations for placement of components.
- 2) as UV filters to protect some areas from the UV curing process.



# Fluorescent Whitening Agents for Imaging and Coatings

FWAs help to brighten coatings and mask yellowing. Applications include clear lacquers, pigmented lacquers, paints and printing inks. FWAs can also be used where fluorescence can provide a means of detecting film thickness, registration, identification and to detect voids. We recommend Uvitex OB for solvent-borne applications and Uvitex NFW liquid for water-borne applications.

Many clear lacquers have an intrinsic yellow color. When a FWA is dissolved in a thinner and stirred into the clear lacquer, it intensifies the whiteness or color of the basecoat underneath the lacquer (Figure 9).

In white pigmented lacquers, the FWA works to intensify the whiteness of the pigmented lacquer. The amount of FWA to use in the systems is determined by the pigment content of the lacquer. If a system contains greater quantities of titanium dioxide, for example, greater quantities of FWAs are required to achieve optimum brightness (Figure 10).

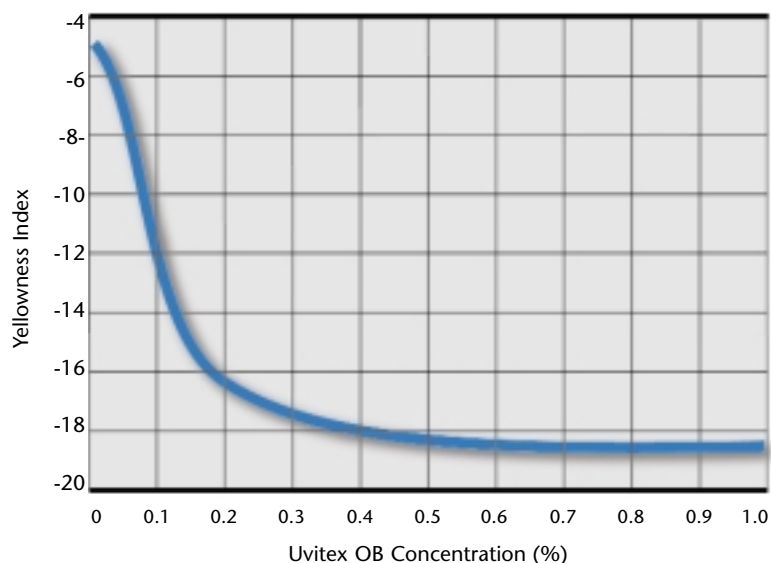
Due to the intrinsic light instability of FWAs in coating systems, we recommend the use of these products for indoor applications only.

FWAs can brighten whites as well as increase the deep tone of black and blue in printing inks. They are also used for quick identification of security printing, such as for bank notes.

Water-soluble FWAs can also be used in photoprocessing baths where they reduce the stain by removing sensitizing dyes and improve the quality of the blacks and whites of photographs.

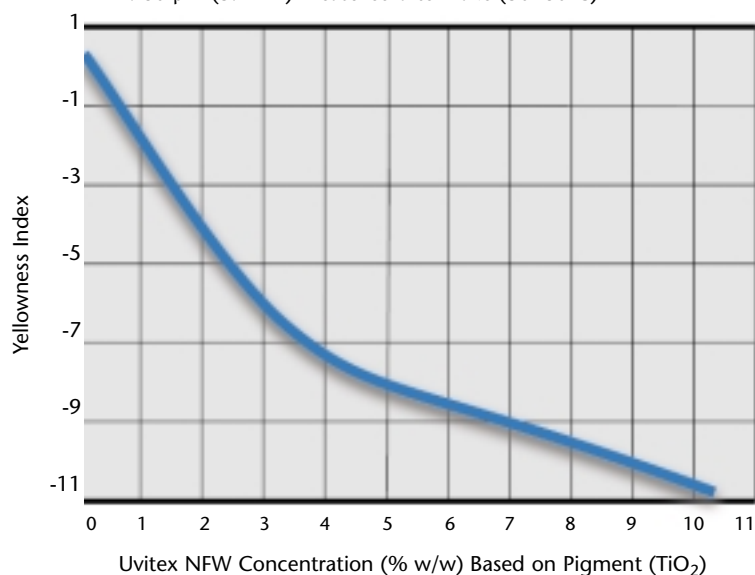
**Figure 9** Whitening Effect in Polyurethane Clearcoat

Uvitex OB in 2-Part Polyurethane Clearcoat over White Coil Coat; DFT: 35  $\mu\text{m}$  (1.4 mil)



**Figure 10** Whitening Effect in Pigmented Coating

Uvitex NFW in White Pigmented Coating over White Coil Coat; DFT: 80  $\mu\text{m}$  (3.2 mil) Measured after Bake (30' 80°C)



# Applications

Products		Water-borne Coatings	Solvent-borne Coatings	Water-borne Inks	Solvent-borne Inks	Photoprocessing	Polyolefins	Styrenics	PVC	Adhesives	UP	PET	PC	PMMA*	PA
Uvitex OB		●		●		●	●	●	●	●	●	●	●	●	●
Uvitex OB-C								●							
Uvitex OB-P								●							
Uvitex NFW Liquid	●	●	●	●					●						
Uvitex FP		●					●	●	●	●				●	
Uvitex FP-C								●							
Tinopal SFP	●		●		●				●						
Tinopal MSP/MSP Liquid	●		●		●										

● Recommended

● Alternative

\* If optical brighteners are used in PMMA, take care that PMMA polymerization is conducted to full completion: Minimal traces of not reacted monomer can lead to discoloration when exposed to light.

# Ciba Expertise and Customer Support

Ciba's scientists, engineers and technicians concentrate on customer-oriented and cost-effective technological solutions. From three major Research and Development Centers and numerous Technical Service Centers around the globe, Ciba's focus is on substrate protection, polymer properties and polymer design that help make our customers' products better and more successful in the marketplace.

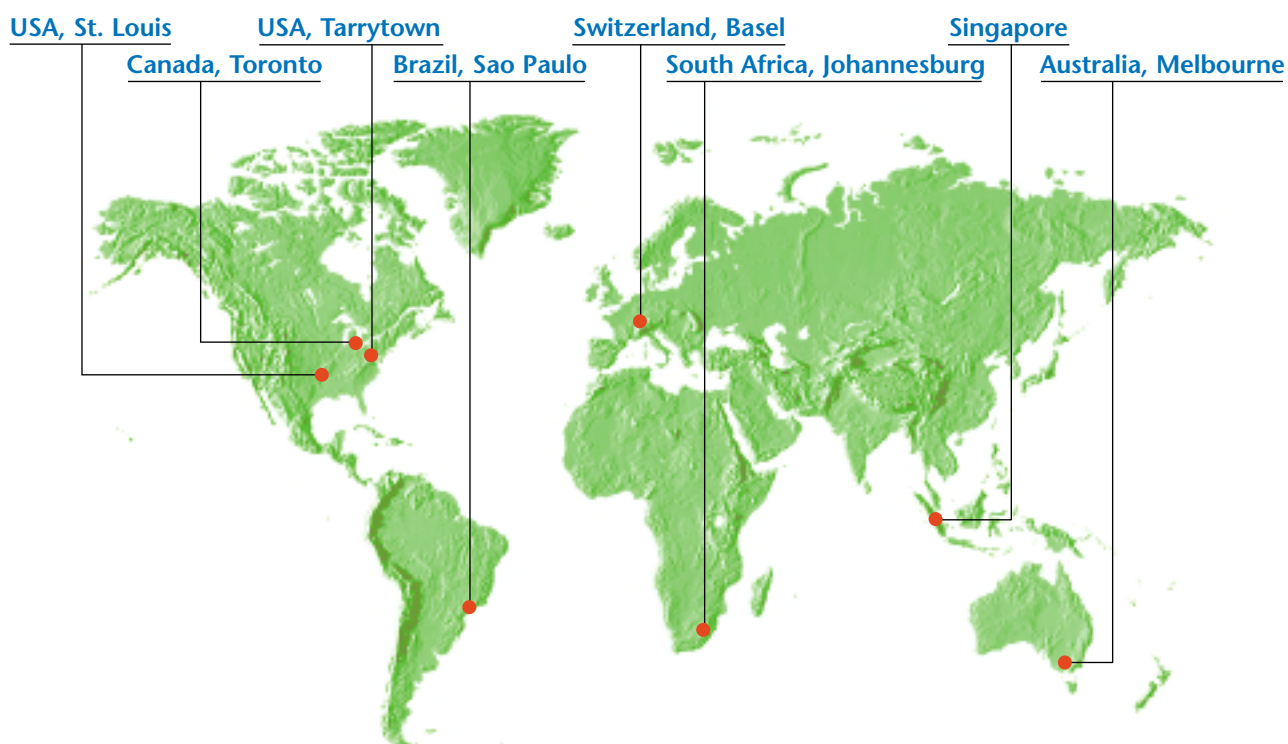
Ciba's extensive technical support laboratories develop customer-specific solutions and are designed to provide advanced analytical and process capabilities for solving customer problems.

For specific application requirements, please contact your local Ciba representative.

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## Head Office

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