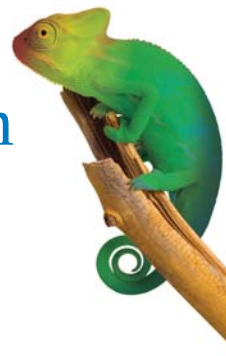


JamesRobinson



Reversacol™ Photochromic Dyes



Technical Summary for Reversacol™ Product Range

Spectrophotometer Conditions for Wavelength and Fade Rate Analysis:

Concentration: 0.05%;

Temperature: 23 °C;

Carrier System: Low Density Polyethylene

Lambda max is the wavelength of maximum absorbance in the activated, coloured state.

T^{1/4}, T^{1/2} and T^{3/4} are the times taken in seconds for the dyes to fade by 25%, 50% and 75% from their maximum intensity. Visual strength assessment carried out by a trained colourist with 5 being the strongest. Reversacol™ dyes are preferably activated with light from 350-410nm. Further information is available on request.

Solubility values listed are in grams per litre, performed at 25 °C and are approximate. Moving from best to worst, our recommendations for solvent choice are as follows: Toluene > THF~Xylene > Ethyl Acetate > Acetone > Ethanol (or any other alcohols) ~ hydrocarbons eg. Petroleum Ether.

Name	Lambda λ Max (nm) (in coloured form)	Fade rate T ^{1/4} (s)	Fade rate T ^{1/2} (s)	Fade rate T ^{3/4} (s)	Visual Strength Assessment	Solubility in Toluene (g/l)	Solubility in Methanol (g/l)
Solar Yellow	430	75	408	1865	4	43	<2
Rush Yellow	430	4	13	467	1	55	<3
Sunflower	445	18	43	119	4	143	<5
Corn Yellow	455	6	15	34	3	17	<2
Flame	475	11	27	63	2	88	<2
Ruby	490	10	24	58	2	96	<4
Berry Red	490	22	53	112	2	56	<2
Poppy	500	7	18	43	3	16	2
Cardinal	505	16	39	84	3	34	3
Cherry	520	11	27	60	4	29	<5
Lilac	540	20	52	122	4	175	2
Claret	545	15	37	74	2	47	<5
Plum Red	555	12	28	56	3	25	<2
Amethyst	560	8	20	40	2	76	2
Royal Purple	560	24	57	112	5	98	<1
Oxford Blue	570	4	10	20	1	108	<4
Velvet Blue	570	15	37	74	1	123	<5
Storm Purple	585	13	24	41	4	64	<5
Palatinate Purple	595	30	52	87	5	78	<2
Aqua Green	610	33	77	152	4	210	<2
Sea Green	635	199	376	675	5	245	2
Mulberry	450, 555	31	78	175	4	50	<1
Amber	450, 560	4	8	16	2	34	1
Volcanic Grey	460, 560	12	28	56	4	88	<1
Heather	476, 546	23	53	117	4	61	<1
Misty Grey	485, 570	2.5	5	12	2	17	<5
Midnight Grey	485, 570	7	17	38	3	67	<5
Graphite	485, 585	70	214	620	3	61	<5

Colour Guide

Colour Guide for dyes incorporated into low density polyethylene at 0.05% concentration, shown before and after activation with UV light. Please note that the shades of Reversacol™ dyes are highly system dependent and the colours shown are intended as an approximate guide.



Reversacol™ Dye Selection

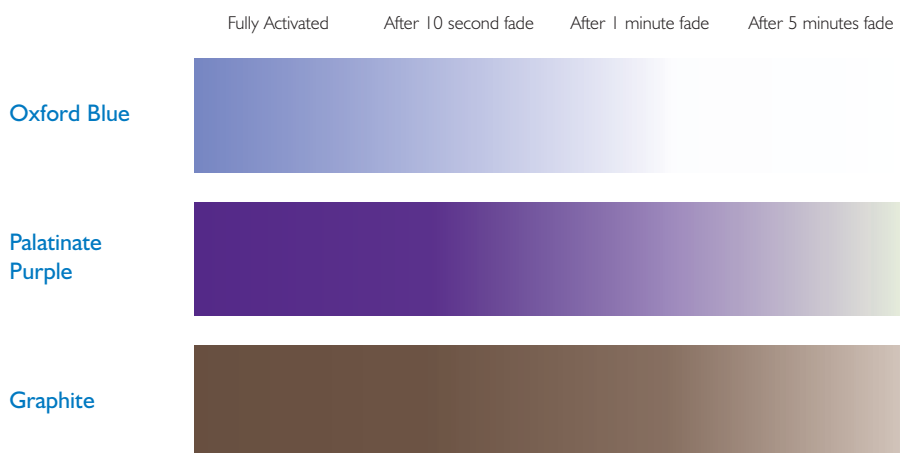
The factors below should be considered when choosing your Reversacol™ dye. The applications team at James Robinson can provide advice in making the most appropriate selection.

Dye Mixtures

It is possible to achieve additional shades by mixing Reversacol™ dyes. Products with similar fade rates should be selected to ensure the dye mixture fades uniformly.

Rate of Fade

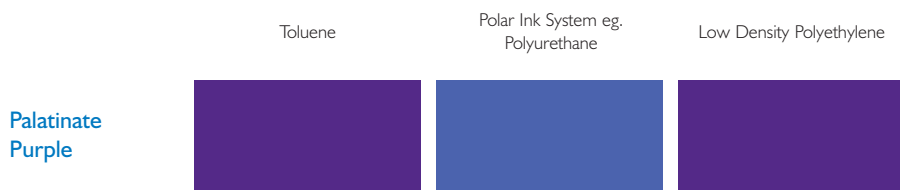
The rate at which Photochromic dyes fade back to their original state varies by product. The extent of this is illustrated below. The technical summary on the left gives values for the fade rate of each product in Low Density Polyethylene. Please note that these rates are system dependent and may vary.



Activated Colour

The page on the left shows the standard range of colours available from James Robinson, however the choice of carrier system can significantly affect the shade of the product. This colour change is normally due to changes in pH and polarity.

Such a variation is depicted below, an example of the effect using Reversacol™ Palatinate Purple.



General Application Advice

Important factors to consider when using Reversacol™ dyes



- Our range of Photochromic dyes are supplied in powder form and do not exhibit any photochromic properties until they are incorporated into a suitable carrier system.
- Acidic conditions degrade most Photochromic dyes.
- Singlet oxygen and free radicals also cause increased degradation.
- The products are not soluble in water and are unstable in water based media.
- The dye inclusion levels usually range between 0.01% and 2%. This is only a guide due to the significant effect of different media on the properties of the photochromic dye.
- No photochromic effect will be observed if too much of the Reversacol™ dye is used.
- The Reversacol™ products are temperature and shear heat sensitive above 250°C.
- Polymers with a flexural modulus higher than 2000 Mpa are not suitable when desiring a strong photochromic response. Softer systems work better as they provide the flexibility for the dyes to twist into their coloured form.
- The strength and shade of each product may vary according to the medium. A wavelength shift of up to 20nm may be observed.

- The rate of fatigue depends significantly on the medium used.
- Additives such as HALS, antioxidants, thermal stabilisers, UV absorbers and quenchers may be used to improve the fatigue of photochromics. The combination and selection of such additives is totally dependent on the medium and is usually exclusive to each. The wrong combination can increase the fatigue rate.
- The rate of fatigue is dependent on total UV exposure.

Application in Polymers

The characteristics of the photochromic molecule and the physical and chemical properties of the desired polymer matrix determine the effect of the photochromic response. The best properties to look for are higher polymer purities, a low flexural modulus and lower glass transition temperatures.

- **Polyolefins** - excellent photochromic response
- **Vinyls and Rubbers** - good photochromic response
- **Acrylic resins and Styrenics** - poor photochromic response due to high flexural modulus
- **Engineering Plastics** - many of these have a high flexural modulus and therefore give a poor photochromic response

Application in Inks

As mentioned previously, the key is the flexural modulus of the resin. The dyes are known to work in acrylics, polyurethanes, polyvinyl butyrals (PVB) and PVC, provided there is plasticiser present to bring down the flexural modulus.

- Avoid low pH acidic conditions which can degrade the properties of the molecule.
- Use sparingly - the dye inclusion levels usually range between 0.2% and 2%, depending on the system.
- Don't add too much! No photochromic effect will be observed in the event of adding too much dye.

Reversacol™ Photochromic Dyes

James Robinson is a world leader in the development of innovative Photochromic dyes. These are unique dyes that reversibly change colour upon exposure to ultraviolet sources, such as sunlight. James Robinson produces and markets a large range of Photochromic dyes under the Reversacol™ trade name.

When correctly formulated, the products are colourless until exposed to sufficient UV light or sunlight. On exposure, they become brightly coloured and then fade back to colourless once they are removed from the source of light.

The Reversacol™ Photochromic product range currently includes over 25 vibrant colours. There is even a range of unique single molecule Photochromic greys, which offer the advantage of achieving a neutral colour without the need to mix several dyes.

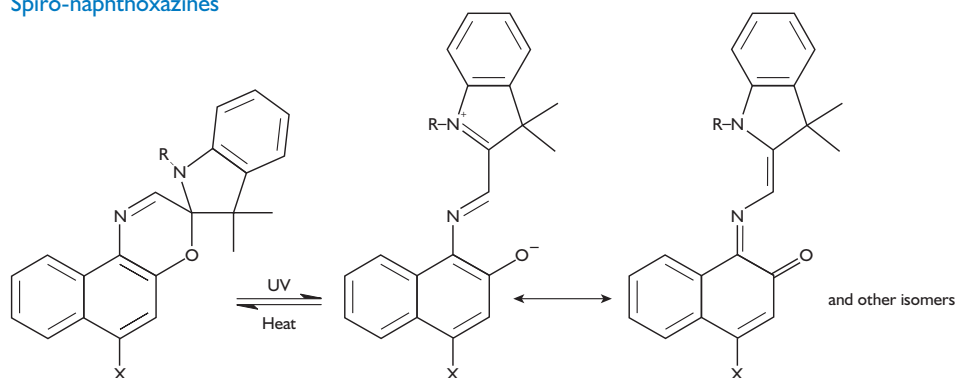
James Robinson offers the most comprehensive patented range of Photochromic dyes, with a wide range of colours and a choice of fade kinetics.

Photochromic dyes can be used in a variety of end products. Ophthalmic lenses are the largest application, but other major applications include: children's toys, films, novelties, packaging, security markers, clothes and cosmetics. Many other applications are currently being investigated.

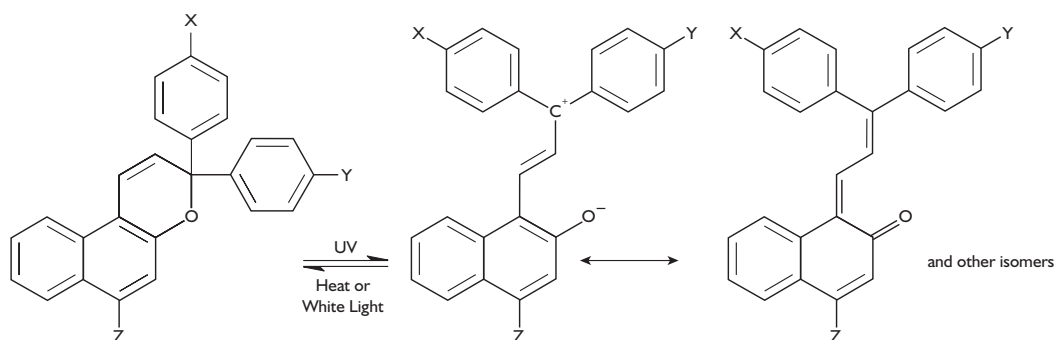
Photochromic Chemistry

The James Robinson Reversacol™ Photochromic range is made up of two types of dye families; spiro-naphthoxazines and naphthopyrans. General examples of each type are shown below. With our experience and knowledge of how to influence the kinetics and colourability of the Reversacols, an extensive range of dyes with different colours and properties has been developed.

Spiro-naphthoxazines



Naphthopyrans



Further information on the chemistry of photochromism is available on our web site: www.photochromics.co.uk/mechanism.htm

See your product in a different light

Reversacol™ colour change technology

The obvious application for the Reversacol dyes is in the eyewear market. However, in addition to this, the dyes may be used to authenticate and enhance products or brands either alone, or in combination with other special effect dyes, pigments and security features.



Company Information

James Robinson is a long established European based company involved in the development, manufacture and supply of speciality chemicals and intermediates.

Key application areas include:

- Hair dye intermediates
- Photographic chemicals
- Fluorescent dyes
- Pharmaceutical intermediates
- Photochromic dyes
- Speciality marker dyes for security applications

A global business with significant sales in all major countries in Europe, the Americas and Asia, James Robinson provides both major multi-nationals and smaller independent companies with the highest levels of service, reliability and quality.

James Robinson has three sites;

- Huddersfield, UK, which serves as the group headquarters
- Dieburg, Germany
- Vapi, India

Each site has dedicated Research & Development facilities, applications laboratories and pilot plant capabilities. The German plant is fully FDA approved and is operated to cGMP standards for manufacture of Active Pharmaceutical Intermediates.

R&D programmes make up a significant part of the groups' activities. Focused development of customer-led projects as well as specialist custom manufacture is seen as a key strength within the organisation. This, together with close liaison with world class academic institutions ensures James Robinson remains at the cutting edge of its field in speciality complex organic synthesis of dye-related chemistry. Following on from this strength in development, 2006 saw the award of one of UK Industry's highest accolades, the Queen's Award for Innovation.

James Robinson prides itself on its strong working relationship with all customers which allow close collaboration, leading to mutually beneficial, proactive partnerships.

Contact Us

For more details of the products and services James Robinson are able to offer, or for more specific technical information on any of the products listed overleaf, please contact our sales department:

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