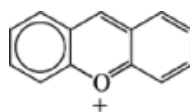
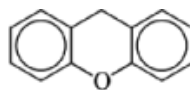


## XANTHENE DYES

Xanthene dyes are those containing the xanthylium [261-23-4] (**1a**) or dibenzo- $\gamma$ -pyran nucleus [92-83-1] (xanthene) (**1b**) as the chromophore with amino or hydroxy groups meta to the oxygen as the usual auxochromes. They are



(1a)



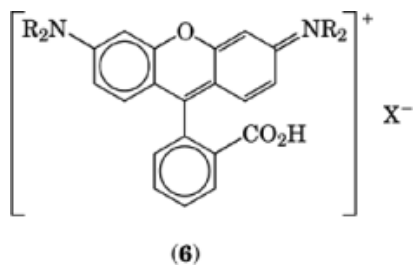
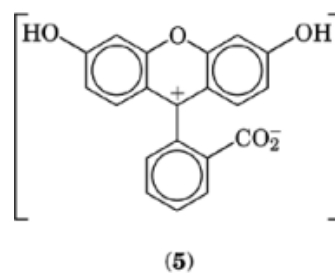
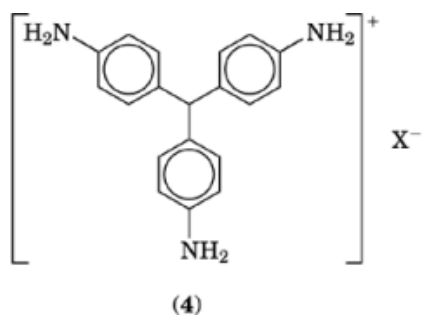
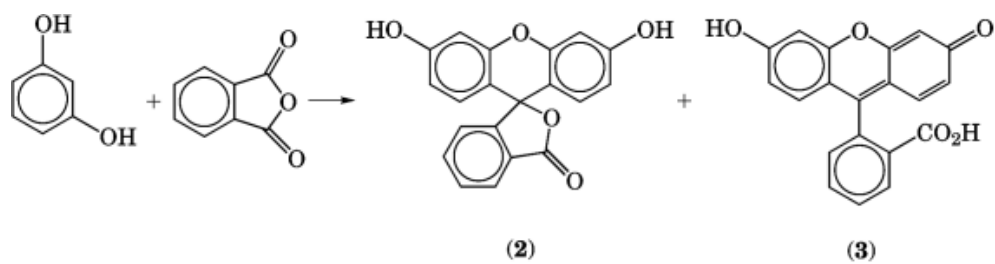
(1b)

important because of their brilliant hues, and shades between greenish yellows to dark violets and blues are obtainable, the most important being reds and pinks. They are generally very strong, with much higher oscillator strengths (and hence higher absorbances) than, for example, an anthraquinone dye of the same shade (see Dyes, anthraquinone). As a consequence of their rigid chromophoric nucleus, xanthenes are often fluorescent, which also adds to their strength and brightness, but, as is often the case with fluorescent dyes, they have lower lightfastness compared to other chromophores. Their use then is concentrated on those areas in which lightfastness is relatively unimportant compared to economy (eg, paper dyes) or where lightfastness can be achieved by modification by metallization. They are used for the direct dyeing of wool and silk and mordant dyeing of cotton. Paper, leather, woods, food, drugs, and cosmetics are dyed with xanthene dyes (see Dyes, application and evaluation). Brilliant insoluble lakes are used in paints and varnishes. In addition, several new applications for xanthene dyes have emerged, for example in ink-jet printers, as markers in biological and medical research, and even as insecticides.

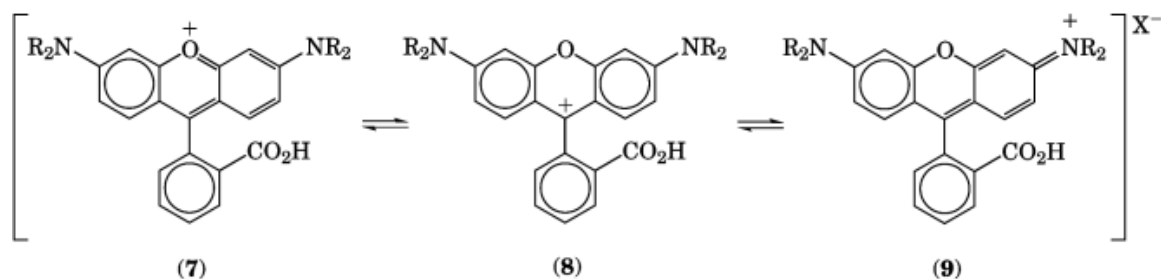
Xanthenes date from 1871 when von Bayer synthesized fluorescein (**5**) by the condensation of two moles of resorcinol with one mole of phthalic anhydride in the presence of concentrated sulfuric acid (1).

Depending on the reaction conditions, the product can be isolated in either the lactoid form A [2321-07-5] (**2**) or the quinonoid form B [56503-30-1] (**3**). These 9-phenylxanthenes are closely related structurally to the triphenyl methane dyes (**4**) and, like them, are cationic resonance hybrids.

## 2 XANTHENE DYES



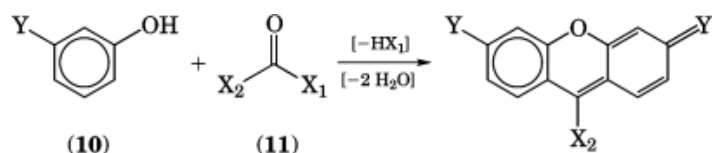
The main contributing resonance forms include the oxonium (7), carbonium (8), and ammonium structures (9):



For uniformity with the structures given in the *Colour Index* the ammonium radical (9) is used for the amino-substituted xanthenes and the keto form for the hydroxy derivatives. The xanthene dyes may be classified into two main groups: diphenylmethane derivatives, called pyronines, and triphenylmethane derivatives (eg, (4)), which are mainly phthaleins made from phthalic anhydride condensations. A third much smaller group of rosamines (9-phenylxanthenes) is prepared from substituted benzaldehydes. The phthaleins may be further subdivided into the following: fluoresceins (hydroxy-substituted); rhodamines (amino-substituted), eg, (6); and mixed hydroxy/amino-substituted.

Most xanthene dyes are classified as basic dyes by their method of application; acid dyes can be produced by introduction of sulfonic acid groups. The fluoresceins, which contain carboxy and hydroxy substituents, are also acid dyes for coloration of silk. Some of the fluoresceins in which the carboxy group has been esterified, are soluble in alcohol or other organic solvents and can be classified as solvent dyes. Mordant dyes can be produced by introducing *o*-dihydroxy or salicylic acid groups (2), which when metallized can have very good lightfastness.

In general, the xanthenes are synthesized by the reaction of two moles of a nucleophilic *m*-substituted phenol (10) with an electrophilic carbonyl compound (11), the reaction occurring most readily with an acid catalyst at temperatures of 100–200°C.



The physical properties of the xanthene type dye structure in general have been considered. For example, the aggregation phenomena of xanthene dyes has been reviewed (3), as has their photochemistry (4), electron transfer (5), triplet absorption spectra (6), and photodegradation (7). For the fluoresceins in particular, spectral properties and photochemistry have been reviewed (8), and the photochemistry of rhodamines has been investigated (9).

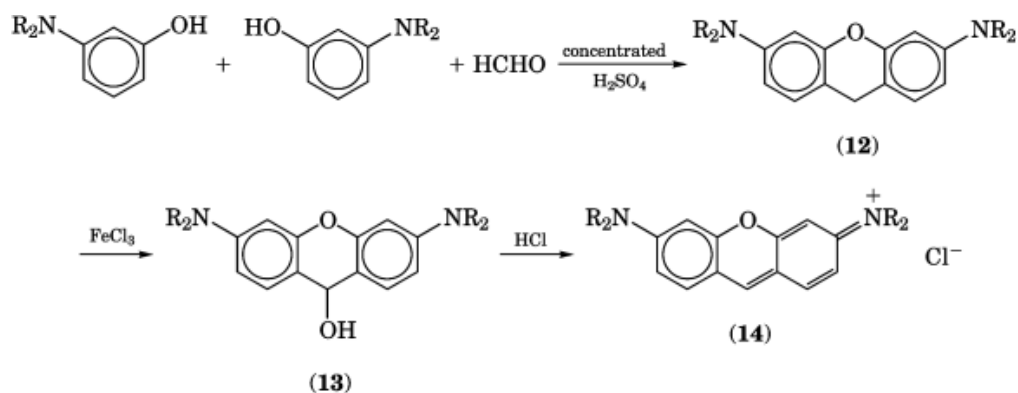
Recently, there have been many new uses for xanthene dyes reported. These include photo-activated insecticidal activity and pest-control (10, 11), as anticancer agents (12), in hydrogen generation during the photolysis of water (13), as nonlinear optical (NLO) materials (14), or charge control agents in electrophotographic toners (laser printers and photocopiers) (15), and many reports as markers or biological stains (16–19). Rhodamines and rosamines in particular have been used in inks for ink-jet printers. There has also been a significant amount of new activity on the use of xanthenes, and in particular rhodamines, as laser dyes (20–22).

## 4 XANTHENE DYES

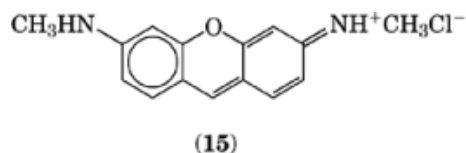
### 1. Diphenylmethane Derivatives

#### 1.1. Pyronines

Pyronines are diphenylmethane derivatives synthesized by the condensation of *m*-dialkylaminophenols with formaldehyde, followed by oxidation of the xanthene derivative (**12**) to the corresponding xanthanol (**13**) which in the presence of acid forms the dye (**14**). If R is methyl, the dye produced is



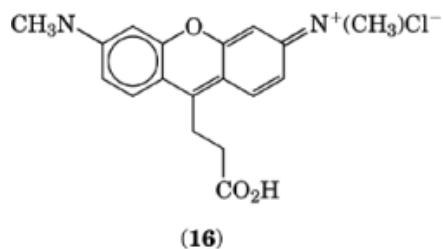
pyronine G (CI 45005); if R is ethyl, pyronine B (CI 45010) is obtained. If pyronine G is oxidized with potassium permanganate, two methyl groups are eliminated to give Acridine Red 3B (CI 45000) (**15**). Pyronine B and Acridine Red 3B



are used as biological stains and particularly in wet staining for the direct microscopic observations of living cells (23).

#### 1.2. Succineins

Succineins are carboxyethyl-substituted pyronines made by substituting succinic anhydride for formaldehyde in the basic synthesis, as, for example, in Basic Red 11 [72968-14-0] (CI 45050) (Rhodamine S) (**16**).

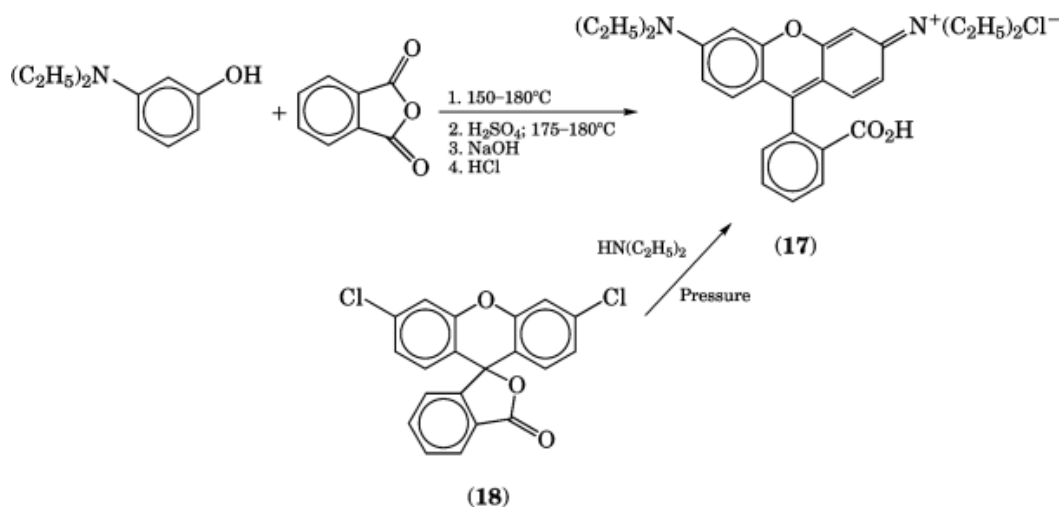


## 2. Triphenylmethane Derivatives

### 2.1. Amino-Derivatives

#### 2.1.1. Rhodamines

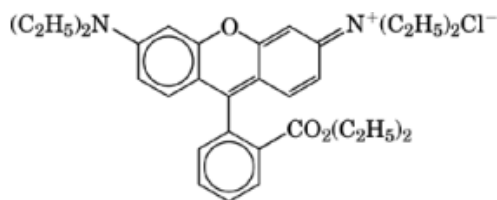
Rhodamines are commercially the most important aminoxanthenes. If phthalic anhydride is used in place of formaldehyde in the above condensation reaction with *m*-dialkylaminophenol, a triphenylmethane analogue, 9-phenylxanthene, is produced. Historically, these have been called rhodamines. Rhodamine B (Basic Violet 10, CI 45170) (**17**) is usually manufactured by the condensation of two moles of *m*-diethylaminophenol with phthalic anhydride (24). An alternative route is the reaction of diethylamine with fluorescein dichloride [630-88-6] (3,6-dichlorofluoran) (**18**) under pressure.



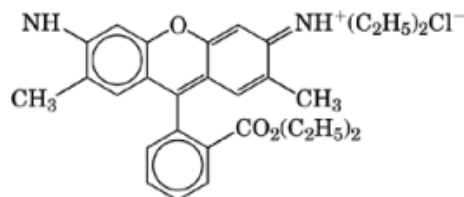
The free base of compound (**17**) is Rhodamine B base [509-34-2] (Solvent Red 49; CI 45170:1). The phosphotungstomolybdic acid salt of (**17**) is Pigment Violet 1 [1326-03-0] (CI 45170:2). Pigment Red 173 [12227-77-9] (CI 45170:3) is the corresponding aluminum salt.

Esterification of the carboxyl group also yields commercially useful dyes. If Rhodamine B is esterified with ethyl chloride or ethanol at  $160-170^\circ C$  under pressure, Basic Violet 11 [2390-63-8] (**19**) (CI 45175) forms. Another commercially important esterified aminoxanthene is Rhodamine 6G (Basic Red 1; CI 45160) [989-38-8] (**20**). This is manufactured by condensing 3-ethylamino-*p*-cresol with phthalic anhydride, then esterifying the product with ethanol and a mineral acid. The phosphotungstomolybdic acid salt of Rhodamine 6G is Pigment Red 81 [12224-98-5] (CI 45160:1). The copper ferrocyanide complex of structure (**20**) is Pigment Red 169 [122237-63-7] (CI 45160:2). Highly concentrated stable liquid forms of rhodamines can be prepared on a commercial scale by the reaction of the rhodamine base with dialkyl sulfate and a saturated aliphatic glycol at  $100-160^\circ C$  (25, 26). These solutions are particularly suited for dyeing paper.

## 6 XANTHENE DYES



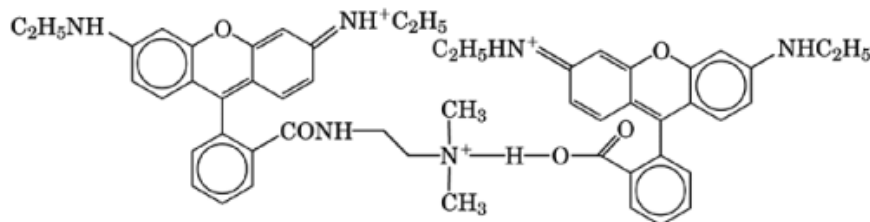
(19)



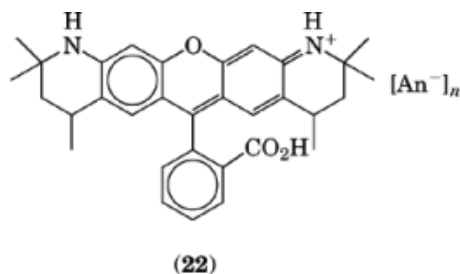
(20)

The rhodamines described thus far are basic rhodamines. They are used primarily for the dyeing of paper and the preparation of lakes for use as pigments. They are also used in the dyeing of silk and wool where brilliant shades with fluorescent effects are required, but where lightfastness is unimportant. Many new uses for rhodamine dyes have been reported. For example, when vacuum-sublimed onto a video disk, Rhodamine B loses its color to form a clear stable film which becomes permanently colored on exposure to uv light (27). This can be used in optical recording for computer storage or video recording (28). Fluorescent coloration of rigid or nonplasticized poly(vinyl chloride) (PVC) by the addition of selected rhodamines to the PVC resin before sheet or film formation has been reported (29). The addition of rhodamines to liquefied bis(hydroxyalkyl)aromatic dicarboxylic acid esters prior to their condensation to form polyesters to produce tinted polymer sheets is also used (30). Rhodamine 6G can be used in ink-jet printing where fluorescence under uv conditions is a desired property (31). Selected xanthenes, including fluorescein, Rhodamine B, and Rhodamine 6G, have been used as laser dyes (32).

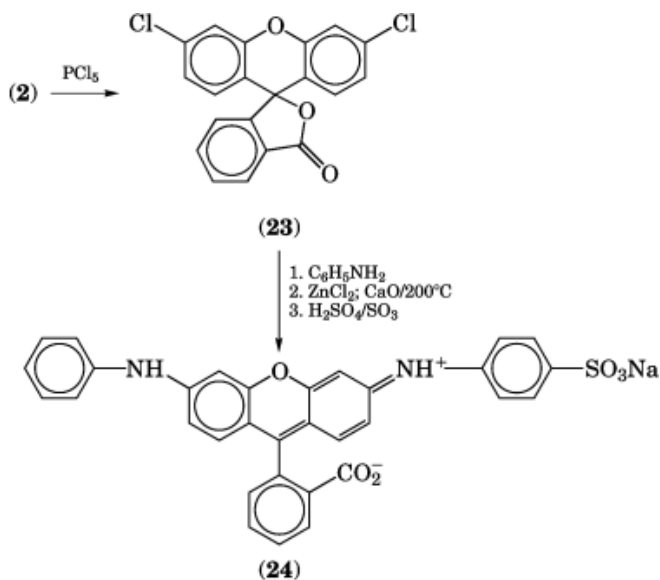
Recently, several rhodamines have been used as magentas in ink-jet printing. These have been chosen primarily for their brilliant magenta shades, but with the disadvantage of very poor light- and waterfastness on ordinary copy papers. On specially coated color ink-jet papers the waterfastness improves, but the lightfastness is still much lower than comparable azo dyes, and, on this media, the difference in brightness between azo and xanthene chromophores is also much smaller. Attempts to improve the waterfastness of xanthene dyes for ink-jet have been made as in (21) (33, 34). Improvements in lightfastness have been claimed by introducing branching and rings in the alkyl chains on the nitrogens and by using a polymeric counterion,  $(A_n^-)_n$ , eg, (22) (35).



(21)



Acid rhodamines are made by the introduction of the sulfonic acid group to the aminoxanthene base. The preferred route is the reaction fluorescein (**2**) with phosphorous pentachloride to give 3,6-dichlorofluoran (fluorescein dichloride) (**23**), which is then condensed with a primary aromatic amine in the presence of zinc chloride and quicklime. This product is then sulfonated. For example, if compound (**23**) (fluorescein dichloride) is condensed with aniline and the product is sulfonated, Acid Violet 30 (CI 45186) (**24**) is produced.

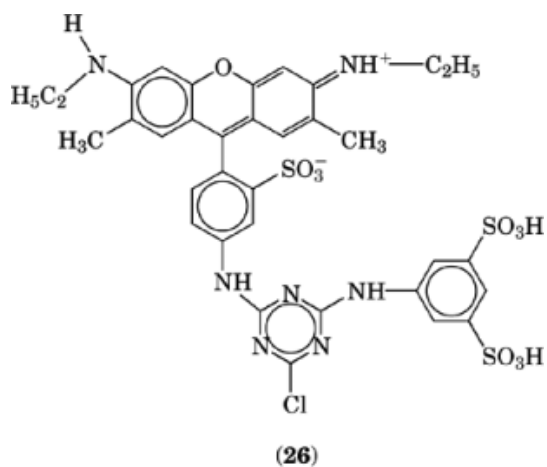
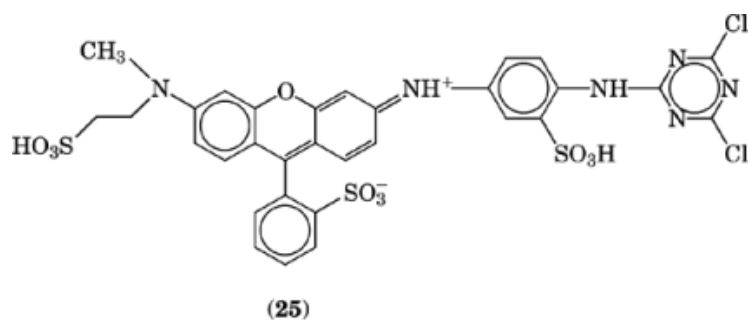


These acid rhodamines are usually used for silk and wool because they have level dyeing properties and show good fastness to alkali; however, they have poor lightfastness. An improved process for manufacturing 3,6-diaminosubstituted xanthenes is reaction of the inner salts of 3,6-dihalo-9(2-sulfophenyl)xanthene-9-ols with a primary or secondary amine in stoichiometric amounts in the presence of an inorganic acid-binding agent or acid-binding tertiary aliphatic or tertiary nitrogen-containing heterocyclic amine (**36**).

Highly substituted acid rhodamines have been reported for fiber-reactive dye applications. For example, if 3,6-dichloro-9-(2-sulfophenyl)xanthene is first condensed with 1,4-phenylenediamine-3-sulfonic acid and then *N*-methyltaurine and then acylated with cyanuric chloride, compound (**25**) is produced. This sulfurein derivative dyes cellulosic fibers blue; shades have good washfastness and improved lightfastness (**37**). Another route to fiber-reactive xanthenes is exemplified by the condensation of 4-nitro-2-sulfobenzaldehyde and 3-*N*-ethylamino-4-methylphenol. The product is reduced and then reacts with an acylating agent formed by the reaction of 1-amino-3,5-disulfonic acid and cyanuric chloride to produce compound (**26**), which gives brilliant red shades with good washfastness and moderate fastness to light (**38**). In general then, it appears that the

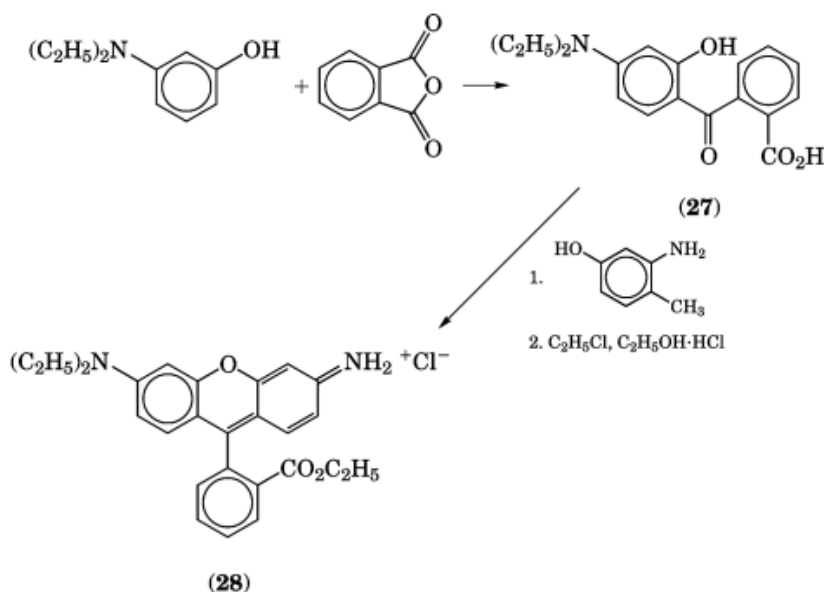
## 8 XANTHENE DYES

primary fading mechanisms for rhodamines is *N*-dealkylation, and substitution of the *N*-alkyl groups with *N*-aryl groups, ring fusions, or sterically hindered alkyls, which are less easily removed causes an increase in lightfastness.

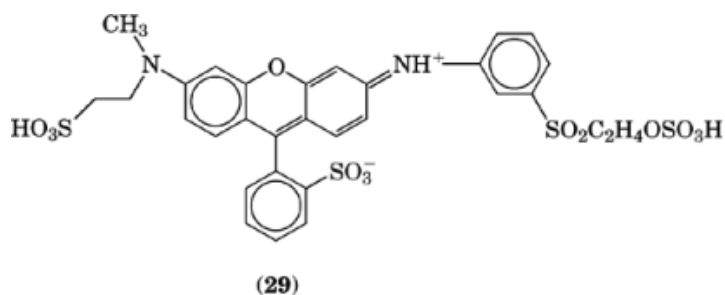


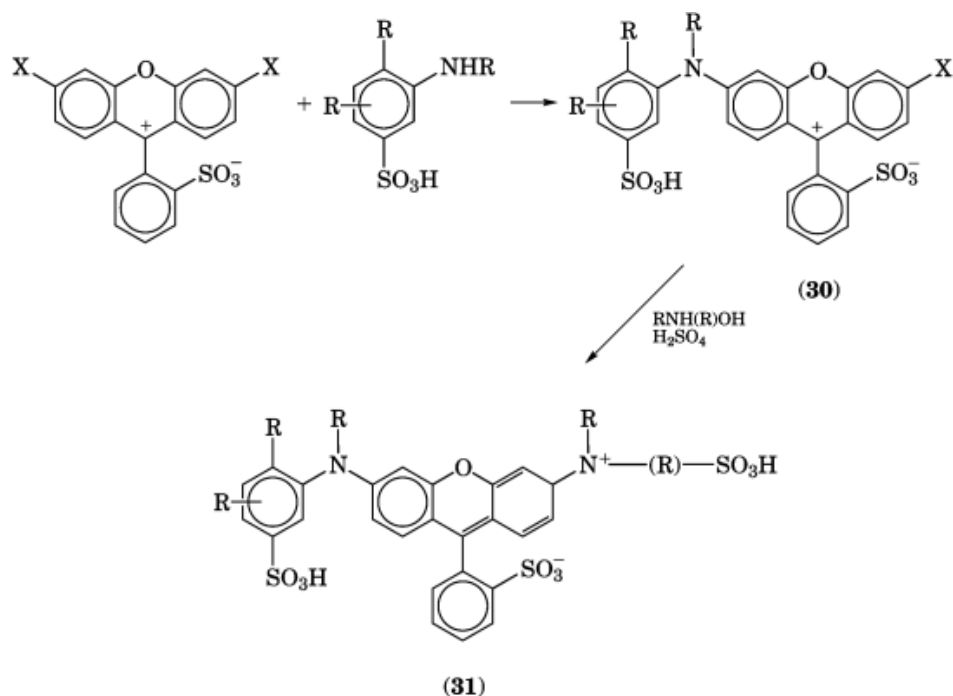
Unsymmetrical rhodamines can be prepared by the condensations of one mole of a *m*-aminophenol with phthalic anhydride to give an *o*-benzoyl benzoic acid (**27**) which is then further condensed with a different *m*-aminophenol to give the required product, Rhodamine 3GO (**28**) (2). A general route to asymmetrical acid xanthenes has been patented (39).





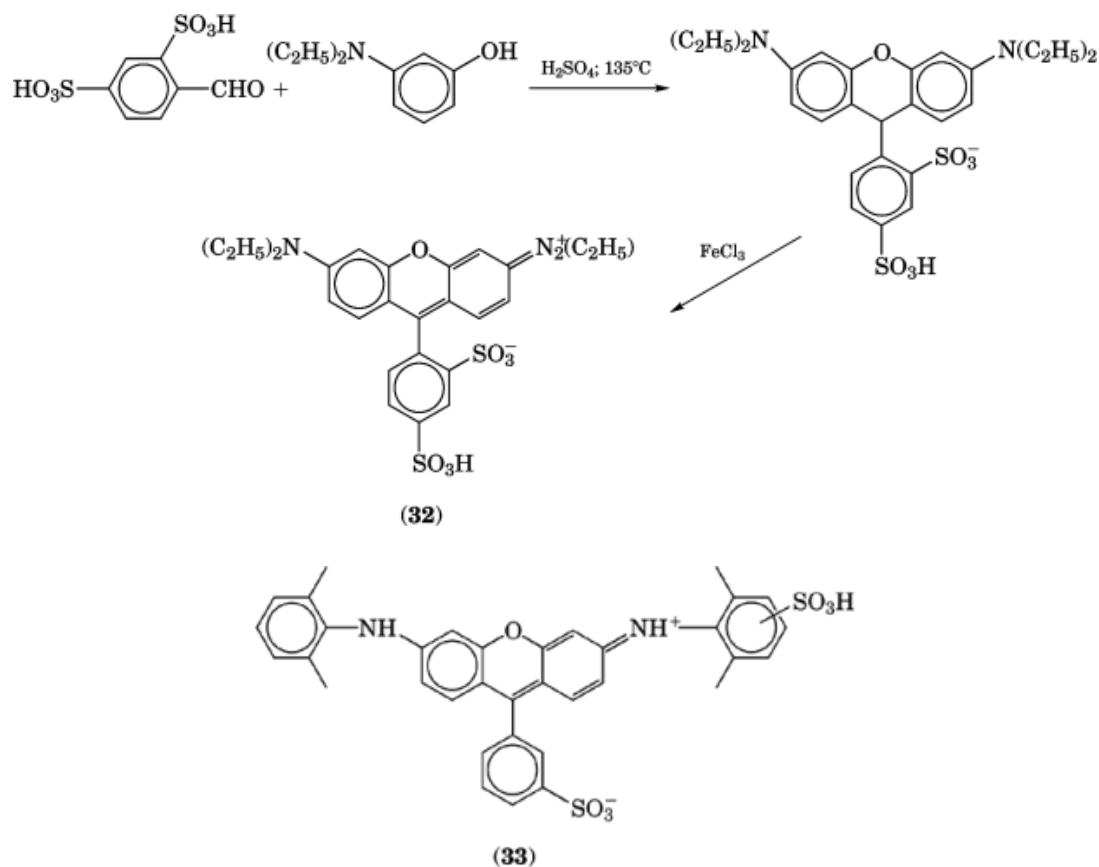
Reactive xanthene dyes with  $\beta$ -hydroxyethylsulfonyl groups, as exemplified by structure (29), provide brilliant shades and excellent washfastness on cotton (40). The sulfurein derivative (29) is synthesized by condensing 3-aminophenol- $\beta$ -hydroxyethylsulfone with 3,6-dichloroxanthene-9-phenyl-2'-sulfonate at  $90^\circ\text{C}$  in *N*-methylpyrrolidone or dimethylformamide, then condensing with *N*-methyltaurine, and finally esterifying with chlorosulfonic acid (41). Condensation of 3,6-dihaloxanthene-9-phenyl-2'-sulfonic acid with an aromatic amine yields compound (30), a second condensation with an appropriately substituted aliphatic amine, usually with subsequent sulfonation, yields the acid rhodamine (31).



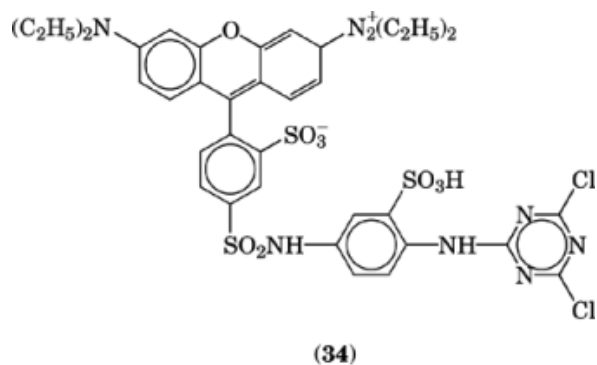


### 2.1.2. Rosamines

Rosamines are 9-phenylxanthene derivatives prepared from substituted benzaldehydes instead of phthalic anhydride. Condensing benzaldehyde-2,4-disulfonic acid with *m*-diethylaminophenol, dehydrating the product with sulfuric acid, and oxidizing with ferric chloride yields Sulforhodamine B [3520-42-1] (Acid Red 52; CI 45100) (**32**) which is the most important rosamine. Recently Acid Red 52 has been used in ink-jet printing as a magenta dye, sometimes in combination with other azo-magenta dyes to improve the lightfastness. The related compound Acid Red 289 (CI 45110) [12220-28-9] (**33**) can also be used and has slightly higher lightfastness. Both compounds have low waterfastness however, and cannot compete with the lightfastness achievable with an azo chromophore.



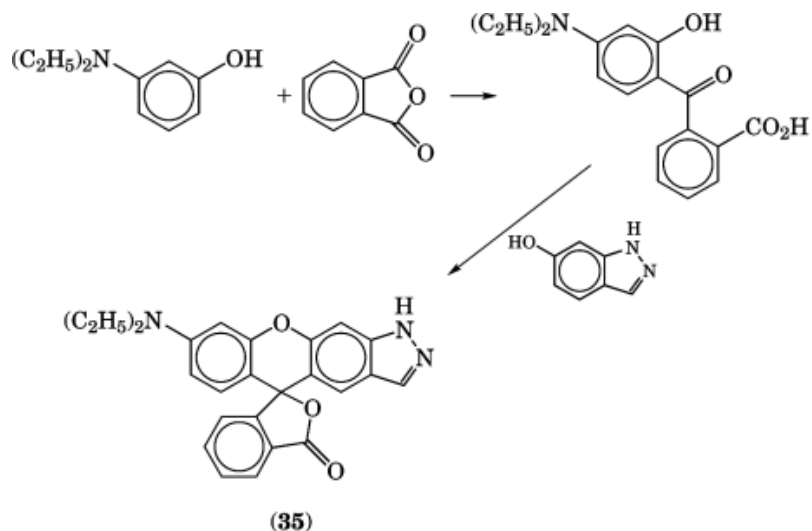
A series of fiber-reactive dyes have been made by the reaction of Sulforhodamine B with chlorosulfonic acid, an appropriately substituted diamine, and cyanuric chloride to yield dyes, eg, a Sulforhodamine B derivative (34), with good lightfastness (42).



A group of aminoxanthenes, ie, pyrazoloxanthenes, is used as color formers in pressure or heat-sensitive imaging papers (43). These compounds are colorless, but, upon contact with acidic electron-accepting material, are converted to resonance forms that are lightly colored. An example is structure [58294-05-6] (35), which

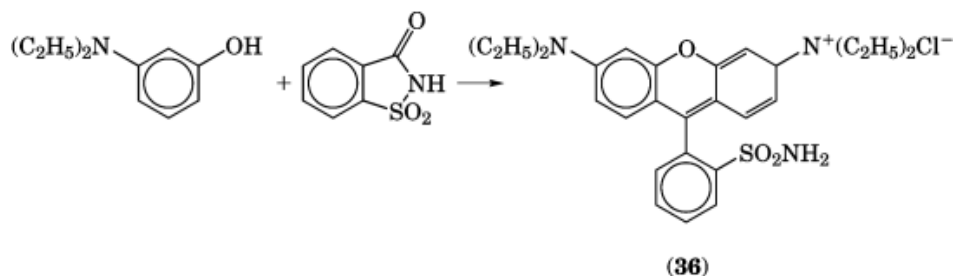
## 12 XANTHENE DYES

forms upon the condensation of *N,N*-diethyl-*m*-aminophenol with phthalic anhydride, followed by addition of 6-hydroxyindazole in 80% sulfuric acid (44).



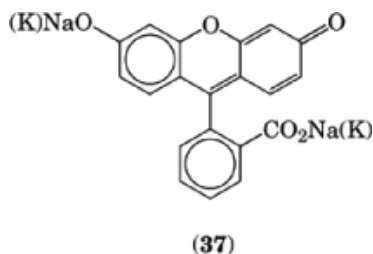
### 2.1.3. Saccharein

Saccharein [6837-69-0] (36) is a basic dye prepared by the condensation of *m*-diethylaminophenol with saccharin at 165°C.



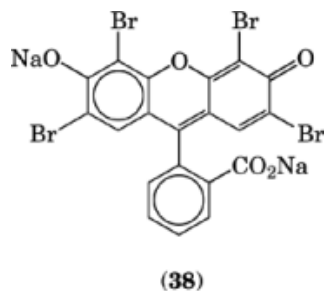
## 2.2. Hydroxyl Derivatives

The building block of most hydroxyl-substituted xanthenes, or fluorones, is fluorescein (2), (3). Fluoresceins can be made by the condensation of resorcinol with phthalic anhydride. Although fluorescein itself is no longer in general use as a textile dye, its intense green fluorescence, even at extremely high dilutions, makes it ideal for tracing water flows to detect leakage and as sea markers for downed aircraft and missing ships. However, Acid Red 388 is replacing fluorescein in such applications. The sodium or potassium salt of fluorescein, commonly called uranine [518-47-8] (CI 45350) (37), is still used for dyeing wool and silk brilliant yellow shades.



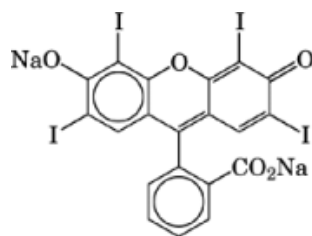
A modern use of uranine is in the manufacture of fluorescent laminates, eg, sheets, glass, and plastic films, that are transparent to electromagnetic waves and visible light rays (45). Such material might be used in windows, viewing partitions, and optical lenses.

The principal use of fluorescein is as an intermediate for more highly substituted hydroxyxanthenes. When fluorescein is brominated in ethanolic solution and converted to the sodium salt with sodium chlorate, eosine [17372-87-1] (Acid Red 87; CI 45380) (**38**) forms. This has been shown to be the 2',4',5',7'-tetrabromo analogue. It is used for dyeing silk red with a brilliant yellow fluorescence, and for coloring inks, dyeing paper, and coloring cosmetics. Another use is as an indicator in the analytical determination of polymeric biguanide concentrations in aqueous solutions (see Analytical methods), which is important in controlling the growth of bacteria and algae in swimming pools (46) (see Water, treatment of swimming pools, spas and hot tubs). The lead salt of eosine is Pigment Red 90 [1326-05-2] (CI 45380:1), the free acid is Solvent Red 43 [15086-94-9] (CI 45380:2), and the aluminum salt is Pigment Red 90:1 [17372-87-1] (CI 45380:3).

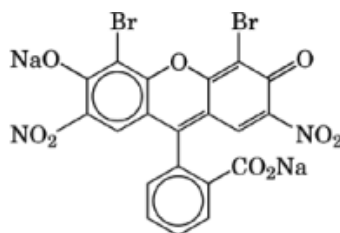


When fluorescein is reacted with iodine and potassium iodate in an ethanolic solution and converted to the sodium salt, the tetraiodo analogue erythrosine [16423-68-0] (Acid Red 51, CI 45430) (**39**) forms. This is used as a food coloring, a sensitizer in photographic plates, and in microscopical stains (see Colorants for food, drugs, and cosmetics; Photography). Nitrated fluoresceins are used in dye applications. For example, dibrominations of fluorescein in aqueous sodium hydroxide followed by treatment with mixed sulfuric–nitric acid yields the dibromo–dinitro analogue saffrosine [548-24-3] (Acid Red 91; CI 45400) (**40**). Saffrosine is used to make fade-resistant electrophotographic sheet material by incorporating such nitro-substituted xanthenes in the photoconductive layer (47).

## 14 XANTHENE DYES

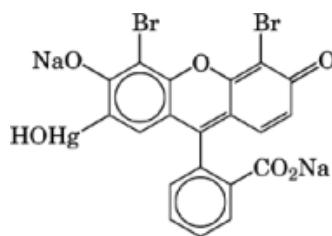


(39)



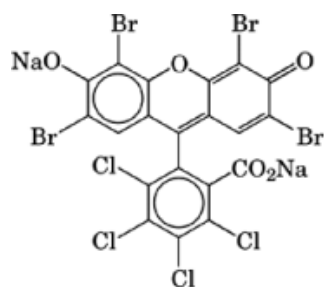
(40)

Treatment of this same 4',5'-dibromofluorescein intermediate with mercuric acetate and conversion to the disodium salt yields the hydroxymercuric analogue merbromin or mercurochrome [129-16-8] (41). It was once a widely used antiseptic, especially for skin disinfection, and was even administered internally. However, it has been replaced by more effective antibacterial agents.

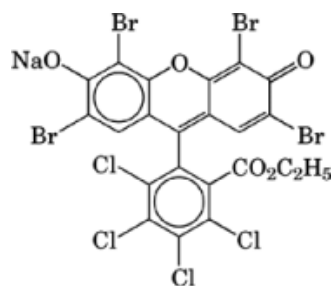


(41)

Another group of halogenated fluorescein dyes is prepared by condensing chloro derivatives of phthalic anhydride with resorcinol, followed by bromination or iodination. Thus Phloxine B [18472-87-2] (Acid Red 92, CI 45410) (42) is prepared by condensing tetrachlorophthalic anhydride with resorcinol followed by tetrabromination. Phloxine B undergoes ethylation to yield the yellowish red acid dye Cyanosine B [6441-80-1] (43).

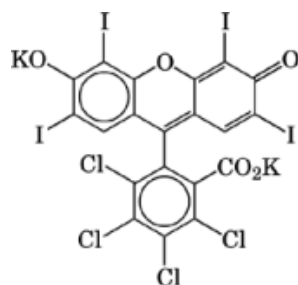


(42)



(43)

Another important polyhalogenated fluorescein dye is Rose Bengal [632-68-8] (Acid Red 94, CI 45440) (44). This is synthesized by condensation of resorcinol with tetrachlorophthalic anhydride, tetraiodination, and conversion to the potassium salt. A new use for Rose Bengal and other tetrabromo- or tetraiodofluoresceins involves their chemiluminescent reaction with ozone. Measuring the intensity of emitted light makes possible a quantitative determination of ozone concentration in the atmosphere (48) (see Luminescent materials, chemiluminescence). Another recent use is as a nonsilver halide photographic system, particularly for use in making direct prints for microfilm enlargements (49).



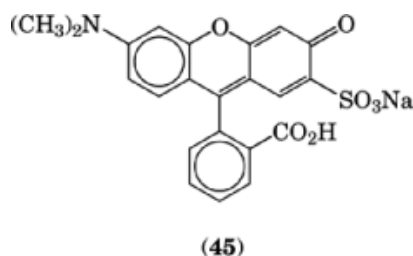
(44)

### 3. Aminohydroxy Derivatives

Aminohydroxy-substituted xanthenes are of little commercial importance. They are synthesized by condensing one mole of *m*-dialkylaminophenol with phthalic anhydride, and then condensing that product with an

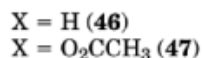
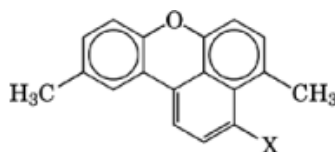
## 16 XANTHENE DYES

appropriately substituted phenol. For example, Mordant Red 77 [6528-43-4] (CI 45300) (**45**) is prepared by condensing *m*-dimethylaminophenol with phthalic anhydride, and then condensing the product with 2,4-dihydroxybenzenesulfonic acid.

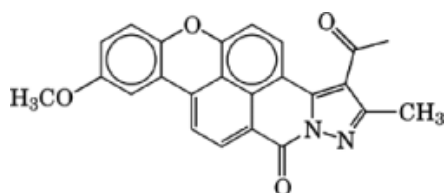


### 4. Miscellaneous Derivatives

Two additional xanthene analogues are termed *fluorescent brighteners*. Condensation of two moles of *p*-cresol with one mole of phthalic anhydride yields 2',7'-dimethyl fluoran which is cyclized with 24% oleum and then reduced with zinc dust and ammonia under pressure to form Fluorescent Brightener 74 (CI 45550) (**46**). If the reduction is carried out with zinc dust and caustic soda in the presence of pyridine, followed by acetylation with acetic anhydride, Fluorescent Brightener 155 (CI 45555) (**47**) is obtained. These are used in the formulation of solid dielectric compositions for application in high voltage cables to prevent conductive treeing (50). The naphthalene analogue of fluorescein can be made by melting 1,6-dihydroxynaphthalene and phthalic anhydride (51) and has been sold as Scheckfarbe AS, for security applications.

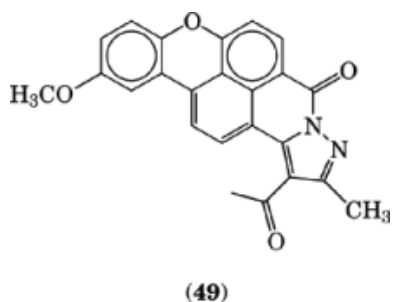


Another series of ring-closed xanthenes starting with benzoxanthene- and benzothioxanthenedicarboxylic acid hydrazides provides shades of bright yellow to red on cellulose acetate, polyamide and polyesters with excellent sublimation fastness and unusually good lightfastness. Because of their high fluorescence, they can be used for preparing daylight fluorescent pigments. For example, condensation of 8-methoxybenzo[*d,e*]xanthene-3,4-dicarboxylic acid hydrazide with acetylacetone in the presence of toluene sulfonic acid followed by cyclization of the hydrazone in *N*-methylimidizolidinone yields a mixture of isomers (**48**) and (**49**) (52).



(48)





A series of water-soluble fiber-reactive xanthene dyes has been prepared from the reaction of benzoxanthenedicarboxylic acid anhydride disulfonic acid with, for example, 3-aminophenyl- $\beta$ -hydroxyethyl sulfone to yield dyes, with high brilliance and good fastness properties for dyeing of or printing on leather, wool, silk, or cellulosic fibers (53).

## 5. Economic Aspects

Since 1973, the U.S. International Trade Commission has reported the manufacture and sales of dyes by application class only. During the latter half of the 1970s and all through the 1980s, annual dye production in the United States, including xanthene dyes, changed very little. Statistics for the production of basic dyes include those products listed as cationic dyes, eg, cyanines, for dyeing polyacrylonitrile fibers and the classical triarylmethane dyes, eg, malachite green, for coloring paper and other applications. Furthermore, statistics for xanthene dyes are also hidden in the production figures for acid, solvent, mordant, and food dyes and organic pigments. Between 1975 and 1984, the production of basic dyes in the United States varied from (11–17 million lbs). However, from 1985–1990, production of basic dyes varied from (11–12.5 million lbs) with an increase in sales value from \$56 to \$73 million per annum. The production figures for xanthenes in 1980 are reproduced in Table 1.

The rhodamines are economically the most important amino-substituted xanthene dyes. The total sales of Rhodamine B in the United States in 1980 were over \$10<sup>7</sup>. The total domestic market for fluorescein and uranine was estimated to be over  $0.5 \times 10^6$ /yr.

## 6. Health and Safety Factors, Toxicology

Xanthene dyes have not exhibited health or safety properties warranting special precautions; however, standard chemical labeling instructions are required. Toxicological properties of important dyes are listed in Table 2 (12).

## 18 XANTHENE DYES

Table 1. Economic Aspects of Xanthene Dyes

CI name	CAS Registry Number	CI Number	Common name	U.S. Imports (U.S. Production), t					U.S. suppliers
				1976	1977	1978	1979	1980	
Acid Yellow 73	[2321-07-5]	45350	fluorescein	0.45	0.7	1.6	1.7	2.0	American Cyanimid Co.; Leeбен Color, Div. of Tricon Colors, Inc.; International Dyestuffs Corp.; Hilton-Davis Chemical Group of Sterling Drug, Inc.
Solvent Yellow 94	[518-47-8]	45350:1	uranine						
Acid Red 52	[3520-42-1]	45100	Sulforhodamine B	2.7	5.4	3.6	9.1	7.3	Atlantic Chemical Corp.; Carolina Color and Chemical Corp.; American Hoechst Corp.; Organic Chemical Corp.; San-doz Colours and Chemicals, Inc.
Acid Red 87	[17372-87-1]	45380	eosine	0.45		0.7	3.2	2.7	
Pigment Red 90	[1326-05-2]	45380:1							Hilton-Davis Chemical Group of Sterling Drug, Inc. H. Kohnstann & Co. Hilton-Davis Chemical Group of Sterling Drug, Inc.; Sun Chemical Corp.
Solvent Red 43	[15086-94-9]	45380:2							
Acid Red 92	[18472-87-2]	45410	Phloxine B	3.4	1.1	0.2	0.2	0.2	Hilton-Davis Chemical Group of Sterling Drug, Inc.
Solvent Red 48	[13473-26-2]	45410:1							
Pigment Red 174	[15876-58-1]	45410:2							
Acid Red 94	[632-68-8]	45440	Rose Bengal		0.9	1.4	1.4	0.1	
Acid Red 289	[12220-28-9]			6.8			2.7	4.5	American Hoechst Corp.
Acid Violet 9	[6252-76-2]	45190		1.4	0.2	2.7	2.3	0.9	
Solvent Violet 10	[66225-66-9]								International Dyestuffs Corp.
Basic Red 1	[989-38-8]	45160	Rhodamine 6G	34	41	113	141	140	
Pigment Red 81	[12224-98-5]	45160:1		(263)	(233)	(254)	(227)	(186)	Atlantic Chemical Corp.; C. Lever Co.; International Dyestuffs Corp.; BASF Wyandotte Corp.; Dye Specialties, Inc.; C. Lever Co.; Sun Chemical Corp.; Mobay Chemical Corp.; CIBA-GEIGY Corp.; BASF Wyandotte Corp.
Basic Violet 10	[81-88-9]	45170	Rhodamine B	91	82	102	154	75	
Solvent Red 49	[509-34-2]	45170:1	Rhodamine B Base	6.8	11	21	2.7	14	Atlantic Chemical Corp.; American Cyanimid Co.; Buffalo Color Corp.; Sun Chemical Corp.; Leeбен Color, Div. of Tricon Colors, Inc.; International Dyestuffs Corp.; BASF Wyandotte Corp.; Dye Specialties, Inc.; Mobay Chemical Corp.; American Cyanimid Co.; C. Lever Co.; Buffalo Color Corp.; International Dyestuffs Corp.; Dye Specialties, Inc.; CIBA-GEIGY Corp.; Sun Chemical Corp.
Pigment Violet 1	[1326-03-0]	45170:2			(64)	(62)	(120)	(104)	
Basic Violet 11	[2390-63-8]	45175	Fanal Red 6BM (IG)	29	14	22	27	16	American Hoechst Corp.
Solvent Green 4	[81-37-8]	45550	Fluorescent Brightener 74	0.05	0.2	0.1			
Mordant Red 27	[6539-22-4]	45180	Chromoxane Brilliant Red				4.5	4.5	Warner Jenkinson Co.; Hilton-Davis Chemical Group of Sterling Drug, Inc.; Crompton and Knowles Corp.; Leeбен Color, Division of Tricon Colors, Inc.
Food Red 14	[16423-68-0]	45430	erythrosine						

Table 2. Toxicological Properties of Selected Xanthene Dyes<sup>a</sup>

Compound	Structure	Property	Value, mg/kg
xanthene	(1b)	LD <sub>50</sub> (mouse), subcutaneous	690
fluorescein	(5)	LD <sub>L0</sub> (rat), intraperitoneal	600
		LD <sub>L0</sub> (mouse) <sup>b</sup>	600
		LD <sub>L0</sub> (rabbit), intravenous	300
		LD <sub>L0</sub> (guinea, pig) <sup>b</sup>	400
eosine	(30)	LD <sub>L0</sub> (rat), intraperitoneal	500
		LD <sub>L0</sub> (rat), subcutaneous	1,500
		TD <sub>L0</sub> (rat), subcutaneous	1,300
		LD <sub>50</sub> (mouse), intravenous	550
		LD <sub>L0</sub> (rabbit), intravenous	300
erythrosine	(31)	LD <sub>50</sub> (rat), intraperitoneal	300
		LD <sub>L0</sub> (rat), intravenous	200
		LD <sub>L0</sub> (rabbit), intravenous	200
		LD <sub>L0</sub> (mouse), oral	2,500
		LD <sub>50</sub> (mouse), intravenous	370
Phloxine B	(34)	LD <sub>50</sub> (mouse), intravenous	310
		TD <sub>L0</sub> (mouse), oral	39,600
		TD <sub>L0</sub> (mouse) <sup>b</sup>	66,000
		TD <sub>L0</sub> (rat) <sup>b</sup>	63,000
merbromin	(33)	LD <sub>L0</sub> (mouse), subcutaneous	20
		LD <sub>L0</sub> (rabbit), intravenous	15
		LD <sub>L0</sub> (mouse), intravenous	50
uranine	(29)	LD <sub>50</sub> (rat), intraperitoneal	1,700
		TD <sub>L0</sub> (rat), subcutaneous	19
		LD <sub>50</sub> (mouse), intraperitoneal	1,800
		LD <sub>50</sub> (mouse), oral	4,700
		LD <sub>50</sub> (rat), oral	6,700
		LD <sub>L0</sub> (guinea pig), intraperitoneal	1,000
Rhodamine B	(15)	LD <sub>L0</sub> (rat), oral	500
		TD <sub>L0</sub> (rat), subcutaneous	360
		LD <sub>50</sub> (rat), intravenous	89,500
		LD <sub>L0</sub> (mouse), intraperitoneal	128
Rhodamine 6G	(18)	TD <sub>L0</sub> (rat), subcutaneous	100
		LD <sub>L0</sub> (mouse), intraperitoneal	2

<sup>a</sup>Ref. 12.<sup>b</sup>Administration method unknown.

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