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Reactivities of 9-Phenylxanthylium and 9-Phenylthioxanthylium Salts in Electrophilic and Nucleophilic Reactions. I.[1] Nitration

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On nitration of 9-phenylxanthylium salt (I) with a mixed acid, 9-mononitrophenylxanthylium salt was obtained in 99% yield. The treatment of 9-phenylthioxanthylium salt (II) in the same condition gave a dinitrated product. Various nitration conditions were examined to obtain a mononitrated product.

In order to determine the positions of the nitro group, various derivatives of I and II were synthesized.

On the other hand, acetamido compounds derived from mononitrated I was separated into two isomers. It was thus proved that they were 9-(*m*-acetamidophenyl)xanthene (IVa) and 9-(*p*-acetamidophenyl)xanthene (IVb) in the ratio of 4.5 to 1.0, while mononitrated II gave 9-(*m*-acetamidophenyl)thioxanthene (XVa) and 9-(*p*-acetamidophenyl)-thioxanthene (XVb) in the ratio of 1.0 to 1.25.

These results were particularly surprising in view of the fact that II was nitrated much easier than the oxygen analog I and also the *p*-nitro derivative was formed more than the *m*-nitro derivative.

Many papers have been published on electrophilic reactions of pyrylium salts and related compounds[3] and trityl salts.[4] However, quantitative comparison of chemical reactivities of the above compounds with that of corresponding sulfur derivatives has not been done.

Le Fèvre, *et al.*[5] conducted nitration of 9-phenylxanthylium perchlorate (I). They oxidized the reaction product with dilute nitric acid to get *p*-nitrobenzoic acid and reported that nitration occurred at a *para* position of a phenyl group at 9-position. In 1951 Shriner,

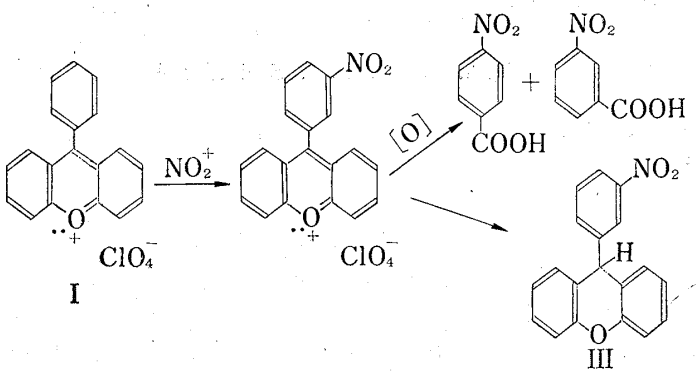

Chart 1

1) A part of this work was presented at Third Organic Sulfur Symposium, Caen (France), May, 1968. Abstracts of Papers, p. 91 and the International Symposium on the Chemistry of Nonbenzenoid Aromatic Compounds, Sendai, August, 1970. Abstracts of Papers, p. 35.

2) Location: *492-36, Mitahora, Gifu.*

3) *a*) C.G. Le Fèvre and R.J.W. Le Fèvre, *J. Chem. Soc.*, **1932**, 2894; *b*) R.J.W. Le Fèvre, *ibid.*, **1929**, 2771; *c*) C.G. Le Fèvre and R.J.W. Le Fèvre, *ibid.*, **1932**, 1988; *d*) C.G. Le Fèvre, R.J.W. Le Fèvre, and J. Pearson, *ibid.*, **1934**, 37; *e*) R.L. Shriner, H.W. Johnston, and C.E. Kaslow, *J. Org. Chem.*, **14** 204 (1949).

4) C.N. Wolf and R.L. Shriner, *J. Org. Chem.* **15**, 367 (1950).

5) R.J.W. Le Fèvre and J. Pearson, *J. Chem. Soc.*, **1933**, 482.

et al.[6] repeated the same reaction and obtained both *p*- and *m*-nitrobenzoic acids by oxidizing the reaction product. At the same time the reaction product was converted to 9-nitrophenylxanthene (III). III was identical with standard 9-(*m*-nitrophenyl)xanthene. From this result they reported that nitration occurred mainly at a *meta* position of a phenyl group at 9-position of I.

From the results by Le Fèvre, *et al.* and Shriner, *et al.*, the authors were led to assume that the nitration product of I is a mixture of isomers and were interested in studying the nitration of I and 9-phenylthioxanthylium perchlorate (II), a corresponding sulfur compound, in detail and in studying reactivities of both compounds against electrophiles.

Reinvestigation of Nitration of I

The authors conducted the nitration of I under the same condition as that by Shriner, *et al.*[6] converted the reaction product to acetamide (IV) or a methoxy derivative (V) by the routes shown in Chart 2 and determined the ratio of isomers by isolation or by the measurement of nuclear magnetic resonance (NMR) spectrum of the mixture.

9-Nitrophenylxanthene, prepared by nitration of I by Shriner's method, was reduced to an amino derivative with $SnCl_2$ and then acetylated with acetic anhydride. An acetamido derivative thus formed could be separated into two isomers (IVa) and (IVb) by the preparative thin-layer chromatography (preparative TLC) on silica gel using $CHCl_3$–ether (3: 10) as an eluent. The ratio of two isomers IVa/IVb was 4.5, and the main product was found to be 9-(*m*-acetamidophenyl)xanthene (IVa).

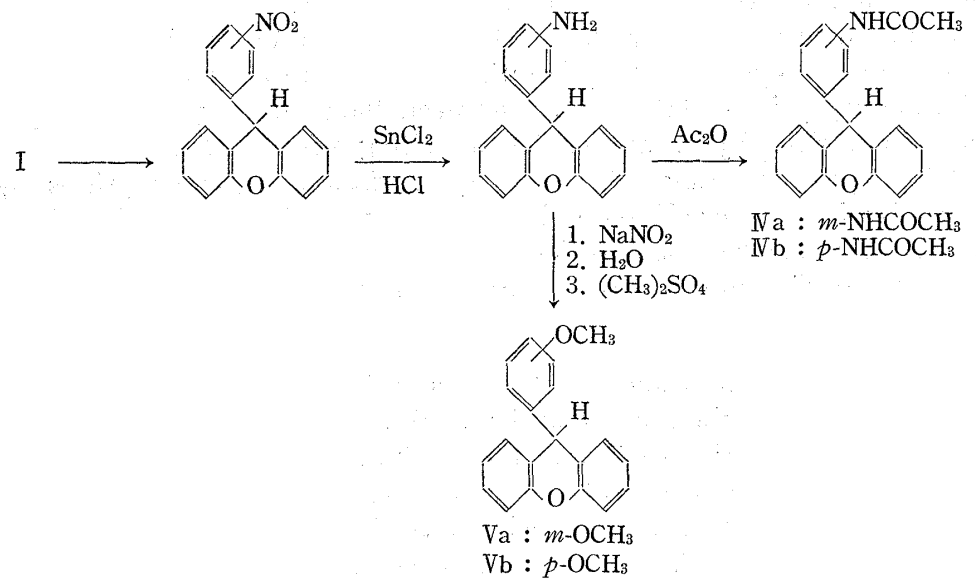

Chart 2

Structures of IVa and IVb were identified by the melting point test and from the comparison of instrumental data with those of authentic samples synthesized in different ways.

The ratio of isomers was obtained also from the ratio of proton strength of methoxy groups in the NMR spectrum of 9-methoxyphenylxanthene (V), which was synthesized by the method by Shriner, *et al.* Chemical shifts of methoxy groups were τ 6.16 for Va and τ 6.20 for Vb in NMR spectra of authentic samples. The ratio of isomers was obtained as Va/Vb$>$ 10 on this basis. Thus the ratios of isomers obtained by the two different ways, namely, the NMR measurement of methoxy derivatives and the separation of acetamido derivatives by preparative TLC, were somewhat different. The former method included the diazotiza-

6) R.L. Shriner and C.N. Wolf, *J. Am. Chem. Soc.*, 73, 891 (1951).

tion reaction of very low yield, while the latter method included acetylation of high yield. The acetamides obtained by acetylation could be well separated by preparative TLC. Therefore, the ratio obtained by the latter method was highly reliable. Thus, the ratio of IVa to IVb was determined as 4.5 to 1.0.

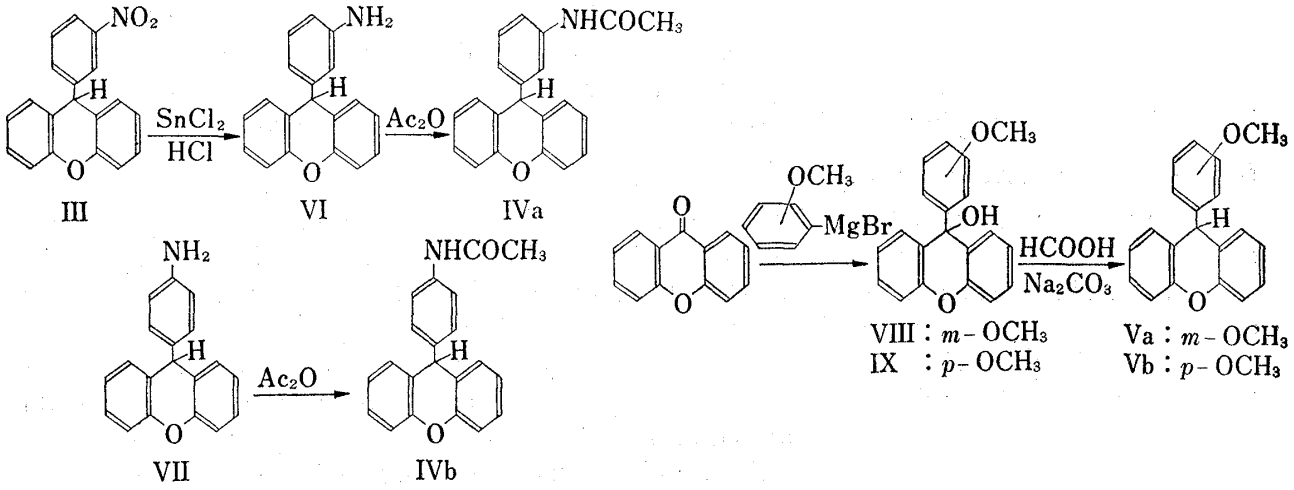

Chart 3

The route, by which authentic specimens were synthesized, was shown in Chart 3. 9-(*m*-Nitrophenyl)xanthene (III) was reduced to an amino derivative (VI) with $SnCl_2$ and then converted to IVa with acetic anhydride. The compound (IVb), which was synthesized by heating and refluxing 9-(*p*-aminophenyl)xanthene (VII) with glacial acetic acid by Shriner, *et al.*[6] had a melting point of 186—187°. However, the product synthesized by acetylating VII with acetic anhydride by the authors had a melting point of 203°.

9-(*m*-Methoxyphenyl)xanthene (Va) was synthesized as colorless prisms by reducing xanthenol (VIII) with formic acid and sodium carbonate, which was obtained from xanthone and *m*-methoxyphenylmagnesium bromide with the yield of 70%. The *para* isomer (Vb) was synthesized according to the method of Shriner, *et al.*[6]

Nitration of II

This reaction has not been known. It was surprising that a dinitro derivative was obtained by nitration of II in the same condition as that reported by Shriner, *et al.*[6] Various reaction conditions of nitration of II and the results are summarized in Table I.

The compound (II) was nitrated much easier than a corresponding oxygen compound (I). When I was nitrated with a mixed acid containing 15 equivalents of nitric acid, only one nitro group was introduced. On the other hand, two nitro groups were introduced in II when II was nitrated with a mixed acid containing only 5 equivalents of nitric acid.

To decide the structure of a nitrated compound obtained in Run 1 of Table I, the compound was converted to various derivatives shown in Chart 4.

Table I. Nitration Conditions of 9-Phenylthioxanthylium Perchlorate (II)

Run	1	2	3	4	5	6
HNO_3 (mole ratio)	1	5	15	1	1	1
Solvent	H_2SO_4	H_2SO_4	H_2SO_4	AcOH	AcOH	AcOH
(mole ratio)	23	35	27	19	19	19
Temperature (°C)	−3——4	0—5	5—10	0—5	40—50	100
Product	mononitrated compound	dinitrated compound	dinitrated compound	no reaction	no reaction	unknown
Yield (%)	90	88	91	0	0	—

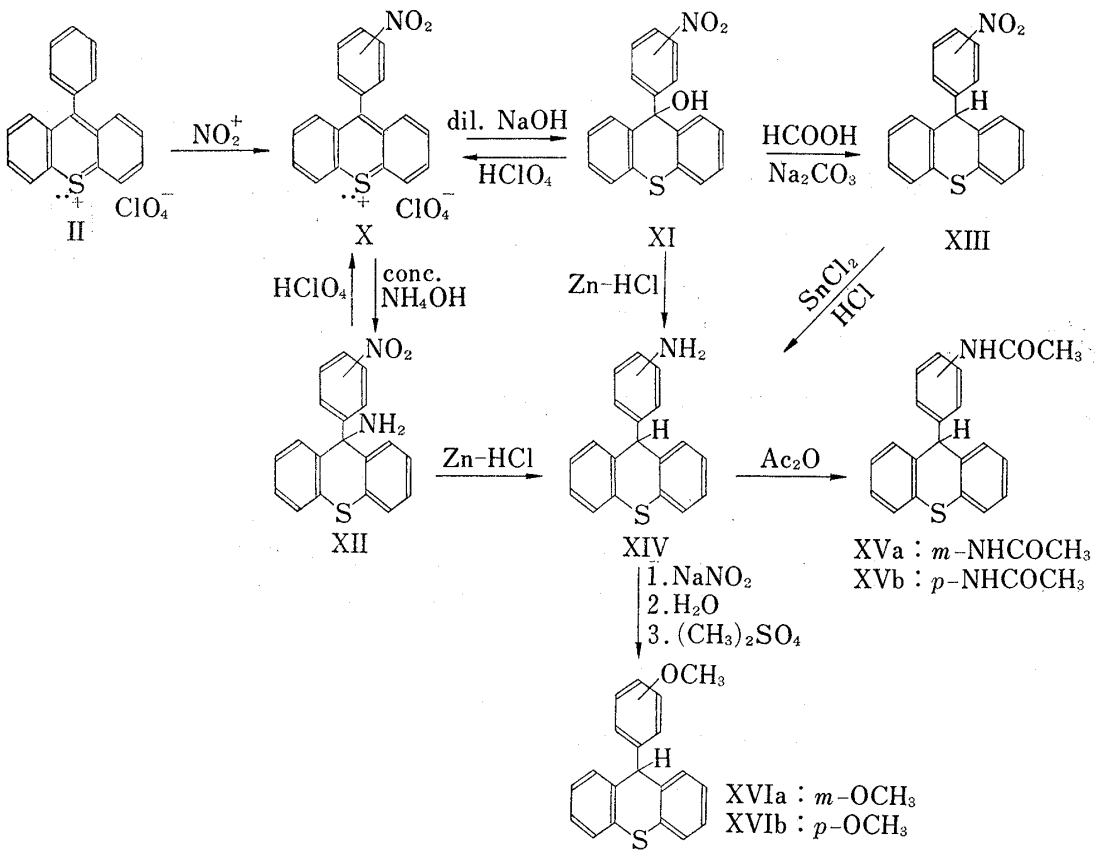

Chart 4

By an elemental analysis of compounds X to XV, the product obtained in this condition was found to be a mononitro derivative. By decomposing the reaction product (X) with concentrated ammonia, a compound (XII) with an amino group at 9-position was obtained. The structure of this compound was determined by the broad singlet absorption at τ 7.92 in the NMR spectrum, which disappeared by the addition of D_2O, and the absence of the absorption at τ 4.54, which was specific to a hydrogen atom at 9-position. Like thioxanthenol (XI) obtained by the decomposition of X with dilute sodium hydroxide, XII was converted to X with perchloric acid. Both XI and XII were converted to an amino derivative (XIV), by treating with zinc and hydrochloric acid. By reduction of XI with formic acid and sodium carbonate, XIII, in which only the hydroxyl group at 9-position was reduced, was obtained. By reducing the nitro group of XIII with $SnCl_2$, XIII was also converted to XIV. Acetamido derivatives obtained by acetylating XIV with acetic anhydride could be separated into two isomers (XVa) and (XVb) by preparative TLC on silica gel using $CHCl_3$–ether (3: 10) as an eluent. The ratio of the two isomers XVa/XVb was 1.0/1.25. Identification of these two compounds was carried out by the comparison of melting points and analytical data with those of authentic samples synthesized by different ways shown in Charts 5—7.

The NMR spectrum was measured to determine the ratio of two isomers (XVa) and (XVb) as a mixture. However, there was no difference between the chemical shifts of both compounds as in the case of IVa and IVb. Therefore, XIV was converted to a methoxy derivative (XVI). Chemical shifts of methoxy groups of authentic samples, XVIa and XVIb appeared at τ 6.32 and τ 6.28, respectively, in the NMR spectrum, on which the ratio of the reaction products was measured. The ratio obtained by this method was XVIa/XVIb=1.0/4.5. This value was somewhat different from that by the preparative TLC method. For the same reason as mentioned before on I, the ratio of two isomers was determined as XVIa/XVIb=1.0/1.25.

The syntheses of authentic samples adopted for the determination of the position of a nitro group will be described below.

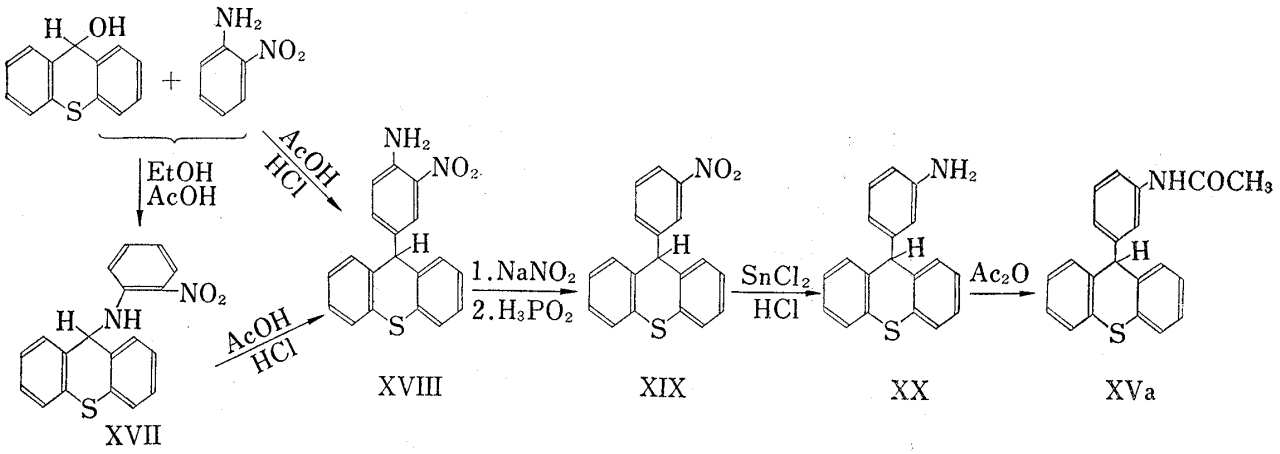

Chart 5

The methods of syntheses of 9-(*m*-nitrophenyl)thioxanthene (XIX) and its derivatives are shown in Chart 5. 9-(*p*-Amino-*m*-nitrophenyl)thioxanthene (XVIII) was synthesized directly, or through XVII, from *o*-nitroaniline and thioxanthenol. The compound (XIX) was obtained after diazotization and deamination of XVIII with hypophosphorous acid. The nitro compound (XIX) was reduced to an amino derivative (XX) with $SnCl_2$ and then converted to an acetamido derivative (XVa).

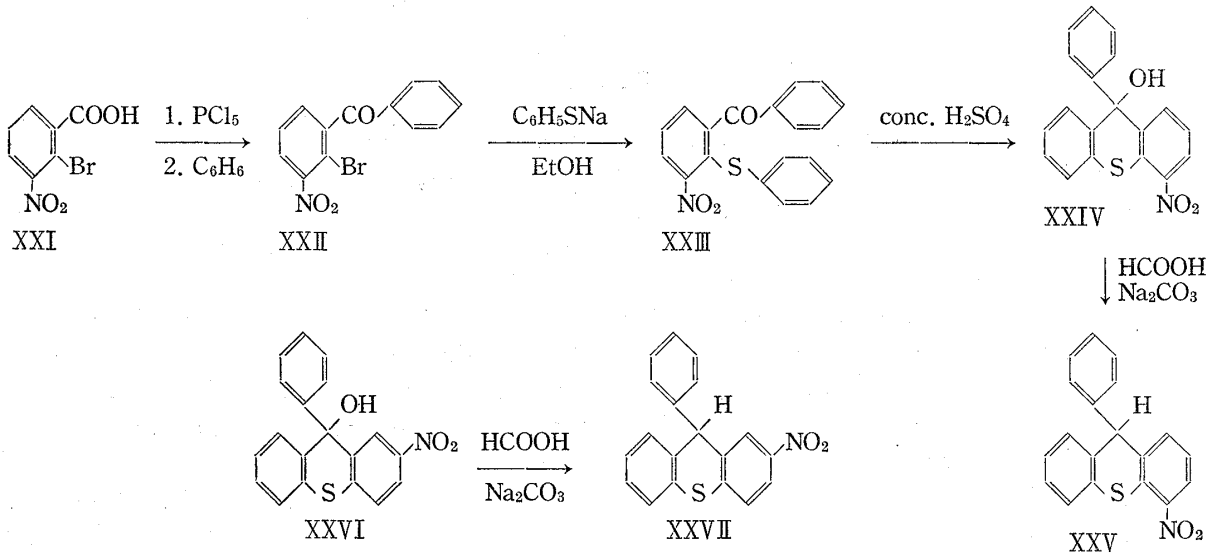

Chart 6

Syntheses of 4-nitro-and 2-nitro-9-phenylthioxanthene are shown in Chart 6. 2-Bromo-3-nitrobenzoic acid (XXI) was converted to an acid chloride with PCl_5 and then to XXII by the Friedel-Crafts reaction. 2-Phenylthio-3-nitrobenzophenone (XXIII) was synthesized from XXII with C_6H_5SNa in ethanol. By the treatment with concentrated sulfuric acid, a new ring was formed in a molecule of XXIII to give thioxanthenol (XXIV), which was reduced to 4-nitro-9-phenylthioxanthene (XXV) with formic acid and sodium carbonate. The 2-nitro-9-phenylthioxanthenol (XXVI) was synthesized according to the method by Galt, *et al.*[7] and was reduced to XXVII.

From the results on I, there was a possibility that nitration might occur at the *para* position of a phenyl group at 9-position. Therefore, 9-(*p*-acetamidophenyl)thioxanthene, which

7) R.H.B. Galt, J.D. Loudon, and A.D.B. Sloan, *J. Chem. Soc.*, **1958**, 1588.

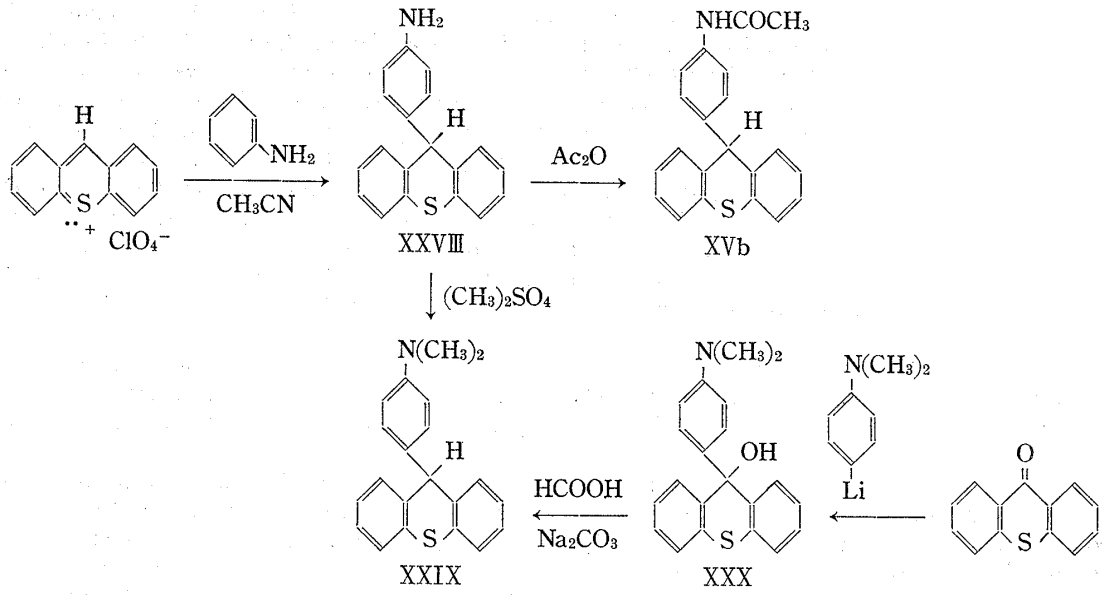

Chart 7

could be obtained from a corresponding *p*-nitro derivatives, was synthesized as shown in Chart 7. 9-(*p*-Aminophenyl)thioxanthene (XXVIII) was synthesized from thioxanthylium perchlorate and aniline in acetonitrile. An amino group of XXVIII was determined to be at the *para* position from the following two reasons. In the NMR spectrum, aromatic protons in a phenyl group at 9-position appeared at τ 3.17 and τ 3.49 as a pair of doublet (A_2B_2 type). The amino compound (XXVIII) was dimethylated to 9-(*p*-dimethylaminophenyl)thioxanthene (XXIX) with dimethyl sulfate. The structure of XXIX was compared with that of an authentic sample synthesized differently from thioxanthone and *p*-dimethylaminophenyl lithium. XXVIII was easily converted to an acetamido derivative (XVb) by the treatment with acetic anhydride.

Result

From the above results it was found that 9-phenylthioxanthylium perchlorate (II) was nitrated much easier than a corresponding I. It was interesting to find that the nitration occurred exclusively at the *meta* position of a phenyl group at 9-position of I, while in II a nitro group was introduced at the *para* position as well as in the *meta* position, and that the amount of the *para* nitro derivative formed was 1.25 times that of the *meta* nitro derivative.

The results on the nitration suggest that the reactivity of 9-phenylxanthylium perchlorate (I) in other electrophilic reactions will be much different from that of 9-phenylthioxanthylium perchlorate (II). The structure of the dinitro derivative of II and reasons for differences in reactivities of I and II will be reported in the following paper.

Experimental[8]

9-(*m*-Acetamidophenyl)xanthene (IVa) and 9-(*p*-Acetamidophenyl)xanthene (IVb)——To a solution of I (2 g) in conc. H_2SO_4 (8 ml), conc. HNO_3 (d=1.42) (6 ml) was added with stirring at 5—10°. After 30 min the reaction mixture was poured into dil. NaOH, and extracted with $CHCl_3$. The extract was dried and evaporated. A mixture of the residue in 85% formic acid (60 ml) containing Na_2CO_3 (1 g) was refluxed for

8) Melting points were measured on a Yanagimoto micromelting apparatus and uncorrected. The NMR spectra were recorded on a Hitachi R-20B spectrometer using tetramethylsilane as an internal standard. A Hitachi EPI-S2 spectrometer was used for the infrared (IR) absorption spectra.

3 hr and then evaporated under reduced pressure. The benzene solution of the residual yellow solid was washed with dil. Na_2CO_3 and water, dried, and evaporated. A solution of the resulting 9-nitrophenylxanthene (1.5 g) and $SnCl_2 \cdot 2H_2O$ (10 g) in AcOH (60 ml) saturated with HCl gas was allowed to stand overnight and decomposed with conc. NaOH. The precipitating amine was extracted with benzene. The extract was dried and evaporated. A solution of the residue (0.9 g) in Ac_2O (5 ml) was allowed to stand for 2 hr. The removal of Ac_2O afforded the crude acetamido derivative. Yield, 0.8 g. An analytical sample was obtained by recrystallization from $CHCl_3$-petr. ether as colorless needles, mp 185°. *Anal.* Calcd. for $C_{21}H_{17}O_2N$: C, 79.98; H, 5.43; N, 4.44. Found: C, 80.08; H, 5.65; N, 4.56. A treatment of the crude acetamido compound by TLC on silica gel using $CHCl_3$–ether (3: 10) as an eluent gave 9-(*m*-acetamidophenyl)xanthene (IVa) as colorless prisms, mp 211° and 9-(*p*-acetamidophenyl)xanthene (IVb) as colorless needles, mp 203°. These two samples were identified by the mixed melting point tests and the comparison of IR spectra with those of the authentic samples.

Nitration Product Ratio——a) Separation of IV by Preparative TLC: 9-Acetamidophenylxanthene (IV) was prepared from I by the method described above. Separation of the crude acetamido derivative (IV) by preparative TLC on silica gel using $CHCl_3$–ether (3: 10) as an eluent gave IVa and IVb in the ratio of 4.5: 1.0.

b) NMR Spectrum Measurement of V[9]: 9-Methoxyphenylxanthene (V) was derived from 9-nitrophenylxanthene according to Shriner's procedure.[6] The signals of methoxy groups of authentic samples appeared at τ 6.16 in Va and τ 6.20 in Vb. On the basis of these signals, nitration product ratio Va/Vb was determined to be more than 10 by means of NMR spectrum measurement of the nitration product V.

9-(*m*-Aminophenyl)xanthene (VI)——In a mixture of $SnCl_2 \cdot 2H_2O$ (4 g) and AcOH (30 ml) saturated with HCl gas, III[6] (0.9 g) was dissolved. The mixture was allowed to stand overnight. After evaporation of AcOH under reduced pressure, the residue was decomposed with conc. NaOH and extracted with benzene. The extract was dried and evaporated. After purification of the crude product by column chromatography, recrystallization from benzene–petr. ether gave colorless plates (0.7 g), mp 146°. *Anal.* Calcd. for $C_{19}H_{15}ON$: C, 83.49; H, 5.53; N, 5.13. Found: C, 83.53; H, 5.79; N, 4.89. IR ν_{max}^{KBr} cm^{-1}: 3400 (NH_2), 3300 (NH_2).

9-(*m*-Acetamidophenyl)xanthene (IVa)——A solution of VI (0.2 g) in Ac_2O (2 ml) was allowed to stand for 2 hr, and Ac_2O was evaporated *in vacuo*. The residue was washed with ether and recrystallized from $CHCl_3$–pet. ether to give colorless prisms (0.2 g), mp 211°. *Anal.* Calcd. for $C_{21}H_{17}O_2N$: C, 79.98; H, 5.43; N, 4.44. Found: C, 79.64; H, 5.50; N, 4.33. IR ν_{max}^{KBr} cm^{-1}: 3250 (NH), 1660 (CO). NMR ($CDCl_3$–DMSO-d_6) τ: 0.44 (1H, broad singlet, NH), 2.25—3.20 (12H, multiplet, aromatic H), 4.75 (1H, singlet, C_9-H), 7.93 (3H, singlet, CH_3).

9-(*p*-Acetamidophenyl)xanthene (IVb)——A solution of VII (0.4 g) in Ac_2O (3 ml) was allowed to stand for 2 hr, and Ac_2O was evaporated *in vacuo*. The residue was washed with EtOH and recrystallized from EtOH to give colorless plates (0.35 g), mp 203° (reported[6] 186—187°). *Anal.* Calcd. for $C_{21}H_{17}O_2N$: C, 79.98; H, 5.43; N, 4.44. Found: C, 79.86; H, 5.57; N, 4.31. IR ν_{max}^{KBr} cm^{-1}: 3275 (NH), 1670 (CO). NMR ($CDCl_3$–DMSO-d_6) τ: 1.10 (1H, broad singlet, NH), 2.30—3.10 (12H, multiplet, aromatic H), 4.78 (1H, singlet, C_9-H), 7.89 (3H, singlet, CH_3).

9-(*m*-Methoxyphenyl)xanthene (VIII)——To an ethereal solution of *m*-methoxyphenylmagnesium bromide prepared from *m*-bromoanisole (4.7 g) and Mg (0.7 g), a hot solution of xanthone (1.9 g) in benzene was added under an N_2 stream. After evaporation of ether the reaction mixture was refluxed for 10 hr and treated in the usual way. Recrystallization from ether–petr. ether gave colorless prisms (2.1 g), mp 112—113°. *Anal.* Calcd. for $C_{20}H_{16}O_3$: C, 78.93; H, 5.30. Found: C, 78.40; H, 5.28. IR ν_{max}^{KBr} cm^{-1}: 3550 (OH).

9-(*m*-Methoxyphenyl)xanthene (Va)——A reaction mixture of VIII (1 g) in 85% formic acid (50 ml) and a small amount of Na_2CO_3 was refluxed for 5 hr. After evaporation of formic acid under reduced pressure, the residue was neutralized with dil. Na_2CO_3 and extracted with benzene. The extract was dried and evaporated. Recrystallization of the residual solid from MeOH gave colorless prisms (0.8 g), mp 64°. *Anal.* Calcd. for $C_{20}H_{16}O_2$: C, 83.31; H, 5.59. Found: C, 83.13; H, 5.63.

Nitration of 9-Phenylthioxanthylium Perchlorate (II)——a) A solution of II[10] (3 g, 7 mmole) in conc. H_2SO_4 (3.6 ml) was nitrated at −3——4° with a mixture of HNO_3 (d=1.38) (0.6 ml, 7 mmole) and conc. H_2SO_4 (3.6 ml). The mixture was allowed to stand for 20 min at this temperature and then poured into cold 10% NaOH. The yellow precipitate was extracted with $CHCl_3$. The extract was dried and evaporated. The residue was purified by column chromatography on silica gel using $CHCl_3$ as an eluent. Recrystallization from ether–pet. ether gave 9-nitrophenylthioxanthenol (XI) as yellow prisms (2.4 g, 90%), mp 146—147°. *Anal.* Calcd. for $C_{19}H_{13}O_3NS$: C, 68.04; H, 3.91; N, 4.18. Found: C, 68.29; H, 4.09; N, 4.07. IR ν_{max}^{KBr} cm^{-1}: 3150 (OH), 1510 (NO_2), 1330 (NO_2).

b) A solution of II (5 g, 13 mmole) in conc. H_2SO_4 (6 ml) was nitrated at −3——4° with a mixture of HNO_3 (d=1.38) (1 ml, 13 mmole) and conc. H_2SO_4 (6 ml). The mixture was stirred for 20 min and poured into cold conc. NH_4OH. The yellow precipitate was filtered and washed with dil. NH_4OH. The crude

9) The NMR spectra were taken on a JEOL C-100 HL spectrometer (100 MHz).
10) C.C. Price, M. Hori, T. Parasaran, and M. Polk, *J. Am. Chem. Soc.*, **85**, 2278 (1963).

product (4 g) was purified by chromatography on alumina with $CHCl_3$. Recrystallization from ether–$CHCl_3$ gave 9-amino-9-nitrophenylthioxanthene (XII) as yellow needles (3.3 g, 77%), mp 158—159°. *Anal.* Calcd. for $C_{19}H_{14}O_2N_2S$: C, 68.24; H, 4.10; N, 8.38. Found: C, 68.27; H, 4.12; N, 8.76. IR ν_{max}^{KBr} cm^{-1}: 3400 (NH_2), 3300 (NH_2), 1525 (NO_2), 1350 (NO_2). NMR ($CDCl_3$–CCl_4) τ: 1.96—2.34 (12H, multiplet, aromatic H), 7.80—8.06 (2H, broad singlet, NH_2). In NMR spectrum the peak at τ 7.92 disappeared on addition of D_2O.

9-Nitrophenylthioxanthylium Perchlorate (X)——To a stirred solution of XI in dry ether (10 ml) and AcOH (0.5 ml), 70% $HClO_4$ (0.2 ml) was added. The resulting red precipitate was filtered and washed with dry ether. Recrystallization from AcOH gave red plates (0.2 g), mp 254—256° (decomp.). *Anal.* Calcd. for $C_{19}H_{12}O_6NSCl$: C, 54.62; H, 2.89; N, 3,35. Found: C, 54.93; H, 3.17; N, 3.38. IR ν_{max}^{KBr} cm^{-1}: 1530 (NO_2), 1350 (NO_2), 1090 (ClO_4^-). The same sample could also be obtained from XXII in the same way as mentioned above. It melted at 252—254° (decomp.). Both perchlorates indicated the same IR spectra.

9-Nitrophenylthioxanthene (XIII)——A solution of XI (0.2 g) in 80% formic acid (45 ml) containing a small amount of Na_2CO_3 was refluxed for 2 hr. The cooled mixture was diluted with water, and the resulting yellow solid was filtered and dried. Recrystallization from MeOH–$CHCl_3$ quantitatively gave yellow needles, mp 143°. *Anal.* Calcd. for $C_{19}H_{13}O_2NS$: C, 71.44; H, 4.11; N, 4.39. Found: C, 71.27; H, 4.06; N, 4.42. IR ν_{max}^{KBr} cm^{-1}: 1510 (NO_2), 1350 (NO_2).

9-Aminophenylthioxanthene (XIV) Hydrochloride——To a solution of XII (1 g) in a mixture of AcOH (30 ml), conc. HCl (10 ml), and water (10 ml), zinc powder (4 g) was gradually added with refluxing and stirring. The reaction was continued until the red solution became nearly colorless or light brown. The cold reaction mixture was made basic with dil. NaOH and extracted with ether. The ether extract was dried and evaporated. The oily residue was purified by column chromatography on alumina. To a solution of the amine (XIV) in dry ether, HCl gas was bubbled, and the resulting precipitate was filtered and washed with dry ether. Recrystallization from MeOH–AcOEt gave colorless fine needles (0.4 g), mp 160—161°. *Anal.* Calcd. for $C_{19}H_{16}NSCl$: C, 70.03; H, 4.95; N, 4.30. Found: C, 70.30; H, 5.23; N, 4.48. IR ν_{max}^{KBr} cm^{-1}: 2850 (NH_3^+), 2600 (NH_3^+). XIV was also obtained from XI in the same way as mentioned above and from XIII by reduction with $SnCl_2 \cdot 2H_2O$ in good yield.

9-(*m*-Acetamidophenyl)thioxanthene (XVa) and 9-(p-Acetamidophenyl)thioxanthene (XVb)——To a solution of XIV (0.5 g) obtained from XIII in AcOH (2 ml) was added a mixture of AcOH (3 ml) and water (10 ml). On standing for 2 hr the resulting white precipitate was filtered and washed with water. Recrystallization from MeOH gave colorless needles (0.4 g), mp 190°. *Anal.* Calcd. for $C_{21}H_{17}ONS$: C, 76.11; H, 5.17; N, 4.23. Found: C, 76.12; H, 5.40; N, 4.20. IR ν_{max}^{KBr} cm^{-1}: 3250—3050 (NH), 1670 (CO). The separation of this acetamide by preparative TLC on silica gel with ether–$CHCl_3$ (10: 3) gave 9-(*m*-acetamidophenyl)-thioxanthene (XVa), mp 206° and 9-(*p*-acetamidophenyl)thioxanthene (XVb), mp 208°. The two acetamides were identified with authentic samples by mixed melting point test and the comparison of IR and NMR spectra.

Nitration Product Ratio——a) Separation of XV by Preparative TLC: 9-Acetamidophenylthioxanthene (XV) was prepared from II without isolation of pure intermediates. Separation of the crude acetamido derivative (XV) by preparative TLC on silica gel with $CHCl_3$–ether (3: 10) as an eluent afforded XVa and XVb in the ratio of 1.0: 1.25.

b) NMR Spectrum Measurement of XVI[9]: 9-Methoxyphenylthioxanthene (XVI) was derived from XI in the same way as V. The signals of methoxy groups of authentic samples appeared at τ 6.32 in XVIa and τ 6.28 in XVIb[11]. On the basis of these signals, nitration product ratio XVIa/XVIb=1.0/4.5 was determined by the NMR spectrum measurement of the nitration product XVI.

9-(*o*-Nitrophenylamino)thioxanthene (XVII)——To a solution of thioxanthenol (1 g) and *o*-nitroaniline (0.8 g) in EtOH (20 ml), AcOH (0.5 ml) was added, and the mixture was stirred for 2 hr and allowed to stand in a refrigerator. The yellow precipitate was filtered and washed with dil. Na_2CO_3 till it became free from acid. Recrystallization of the dried solid from EtOH gave yellow needles (1.2 g), mp 146—147°. *Anal.* Calcd. for $C_{19}H_{14}O_2N_2S$: C, 68.24; H, 4.22; N, 8.38. Found: C, 68.31; H, 4.44; N, 8.58. IR ν_{max}^{KBr} cm^{-1}: 3300 (NH), 1500 (NO_2), 1340 (NO_2).

Rearrangement of 9-(*o*-Nitrophenylamino)thioxanthene (XVII) to 9-(*p*-Amino-*m*-nitrophenyl)thioxanthene (XVIII)——A solution of XVII (5 g) in AcOH (25 ml) and conc. HCl (4 ml) was refluxed gently for 4 hr on an oil-bath. The cooled mixture was poured into much water, neutralized with Na_2CO_3, and then warmed for 30 min on a water-bath. The yellow solid was isolated by filtration, washed, and dried. Recrystallization from EtOH gave yellow needles (0.4 g), mp 176—177°. *Anal.* Calcd. for $C_{19}H_{14}O_2N_2S$: C, 68.24; H, 4.22; N, 8.38. Found: C, 68.01; H, 4.24; N, 8.28. IR ν_{max}^{KBr} cm^{-1}: 3450 (NH_2), 3350 (NH_2), 1510 (NO_2), 1340 (NO_2).

9-(*p*-Amino-*m*-nitrophenyl)thioxanthene (XVIII)——A solution of thioxanthenol (5 g) and *o*-nitroaniline (4 g) in AcOH (24 ml) and conc. HCl (2 ml) was refluxed for 4 hr on an oil-bath. The cooled mixture was poured into water (200 ml) containing Na_2CO_3 (4 g) and warmed for 30 min on a water-bath. The dried yellow solid (7.2 g) was dissolved in a mixture of EtOH (80 ml) and conc. HCl (20 ml) and warmed for

11) M. Hori, M. Nozaki, and T. Kataoka, unpublished results.

8 hr on a water-bath. The cooled mixture was poured into water (200 ml) and neutralized with Na_2CO_3. The yellow precipitate was collected by filtration, washed with water, and dried. Recrystallization from EtOH gave yellow needles (6.5 g), mp 176°. IR ν_{max}^{KBr} cm^{-1}: 3550 (NH_2), 3425 (NH_2), 1520 (NO_2), 1350 (NO_2). The yellow needles showed no depression in mixed melting point measurement with an authentic sample prepared by rearrangement of XVII, and IR spectrum was identical with that of the authentic sample in every respect.

9-(*m*-Nitrophenyl)thioxanthene (XIX)——To a stirred solution of XVIII (2.7 g), in DMF (30 ml) and conc. HCl (2 ml), a solution of $NaNO_2$ (0.5 g) in water (2 ml) was added dropwise at 5° over 2 hr and allowed to react for an additional 1 hr. After the addition of 50% hypophosphorous acid (3 ml), the mixture was allowed to stand in a refrigerator overnight. The resulting yellow precipitate was collected, washed, dried, and purified by column chromatography. Recrystallization from MeOH–$CHCl_3$ gave yellow prisms (1.2 g), mp 126—127°. *Anal.* Calcd. for $C_{19}H_{13}O_2NS$: C, 71.44; H, 4.11; N, 4.39. Found: C, 71.39; H, 4.12; N, 4.22.

9-(*m*-Aminophenyl)thioxanthene (XX) Hydrochloride——In a mixture of $SnCl_2 \cdot 2H_2O$ (11.2 g) and AcOH (25 ml) saturated with HCl gas, XIX (1.5 g) was dissolved, and the mixture was allowed to stand overnight. Then it was warmed for 1 hr on a water–bath. On cooling a white amine-$SnCl_4$ double salt was precipitated. It was cooled and decomposed with conc. NaOH. The resulting amine was extracted with benzene and dried. The removal of the solvent afforded a crude amino compound. After purification by chromatography, bubbling of HCl gas into the etheral solution of the amine gave a white precipitate. Recrystallization from MeOH–AcOEt afforded colorless needles (0.7 g), mp 159—160°. *Anal.* Calcd. for $C_{19}H_{16}NSCl$: C, 70.03; H, 4.95; N, 4.30. Found: C, 70.07; H, 5.08; N, 4.43. IR ν_{max}^{KBr} cm^{-1}: 2850 (NH_3^+), 2600 (NH_3^+).

9-(*m*-Acetamidophenyl)thioxanthene (XVa)——A solution of XX (1.5 g) in Ac_2O (5 ml) was allowed to stand for 3 hr, and then Ac_2O was removed from the solution. The residue was washed with ether and recrystallized from MeOH–AcOEt to give colorless needles (1.5 g), mp 206°. *Anal.* Calcd. for $C_{21}H_{17}ONS$: C, 76.11; H, 5.17; N, 4.23. Found: C, 76.15; H, 5.46; N, 4.15. IR ν_{max}^{KBr} cm^{-1}: 3250 (NH), 1665 (CO). NMR ($CDCl_3$) τ: 2.40—3.25 (12H, multiplet, aromatic H), 4.65 (1H, singlet, C_9-H), 7.90 (3H, singlet, CH_3).

2-Bromo-3-nitrobenzophenone (XXII)——2-Bromo-3-nitrobenzoyl chloride was prepared from XXI[12] (16.8 g) and PCl_5 (16.8 g). To a cold solution of 2-bromo-3-nitrobenzoyl chloride in benzene (60 ml) and CS_2 (40 ml), powdered $AlCl_3$ (11 g) was added. After standing for 30 min in an ice-bath and then for 1 hr at room temperature, the reaction was refluxed for 30 min and decomposed with ice–water. The organic layer was separated and the benzene extract of the aquous phase was combined with the organic layer, dried, and evaporated. Recrystallization of the residue from EtOH gave colorless prisms (17.0 g), mp 72.5°. *Anal.* Calcd. for $C_{13}H_8O_3NBr$: C, 51.00; H, 2.63; N, 4.58. Found: C, 50.95; H, 2.75; N, 4.41. IR ν_{max}^{KBr} cm^{-1}: 1670 (CO), 1520 (NO_2), 1350 (NO_2).

3-Nitro-2-phenylthiobenzophenone (XXIII)——To a hot solution of XXII (6.1 g) in EtOH (40 ml), an EtOH solution of C_6H_5SNa prepared from thiophenol (2.2 g) and Na (0.5 g) was gradually added. After refluxing for 1 hr, EtOH was removed, and the residue was extracted with $CHCl_3$ under alkaline condition. The $CHCl_3$ extract was washed with water, dried, and evaporated. Recrystallization of the residue from ether gave yellow prisms (4 g), mp 88°. *Anal.* Calcd. for $C_{19}H_{13}O_3NS$: C, 68.04,; H 3.91; N, 4.18. Found: C, 67.99; H, 3.93; N, 4.06. IR ν_{max}^{KBr} cm^{-1}: 1665 (CO), 1510 (NO_2), 1335 (NO_2).

4-Nitro-9-phenylthioxanthenol (XXIV)——A solution of XXIII (0.5 g) in cold conc. H_2SO_4 (10 ml) was allowed to stand for 20 hr and then poured into a cold Na_2CO_3 solution. The precipitate was extracted with $CHCl_3$ and dried. Recrystallization of the refined product by chromatography from $CHCl_3$–MeOH gave yellow prisms (0.4 g), mp 178°. *Anal.* Calcd. for $C_{19}H_{13}O_3NS$: C, 68.04; H, 3.91; N, 4.18. Found: C, 68.26; H, 3.95; N, 4.04. IR ν_{max}^{KBr} cm^{-1}: 3500 (OH), 1510 (NO_2), 1330 (NO_2).

4-Nitro-9-phenylthioxanthene (XXV)——A reaction mixture of XXIV (0.2 g) in 85% formic acid (20 ml) containing a samll amount of Na_2CO_3 was refluxed for 2 hr. The yellow solid from the cooled reaction mixture was filtered and washed with dil. Na_2CO_3 and then water. Recrystallization from MeOH–$CHCl_3$ quantitatively gave yellow needles, mp 163°. *Anal.* Calcd. for $C_{19}H_{13}O_2NS$: C, 71.44; H, 4.11; N, 4.39. Found: C, 71.36; H, 4.34; N, 4.17. IR ν_{max}^{KBr} cm^{-1}: 1510 (NO_2), 1340 (NO_2).

2-Nitro-9-phenylthioxanthene (XXVII)——A reaction mixture of XXVI[7] (4.0 g) in 85% formic acid (100 ml) containing Na_2CO_3 (1.2 g) was refluxed for 2 hr and poured into water. The yellow precipitate was extracted with $CHCl_3$. The extract was washed with dil. $NaHCO_3$ and then water, dried, and evaporated. Recrystallization of the residue from MeOH gave yellow needles (3.5 g), mp 192°. *Anal.* Calcd. for $C_{19}H_{13}O_2NS$: C, 71.44; H, 4.11; N, 4.39. Found: C, 71.40; H, 4.29; N, 4.21. IR ν_{max}^{KBr} cm^{-1}: 1515 (NO_2), 1340 (NO_2).

9-(*p*-Aminophenyl)thioxanthene (XXVIII)——To a solution of thioxanthylium perchlorate[10] (2.5 g) in CH_3CN (30 ml), aniline (3 ml) was added dropwise. After stirring for 30 min the solvent was removed. The residue was treated with 10% NaOH and extracted with benzene. The benzene extract was dried, and

12) P.J. Culhane, "Organic Syntheses," Coll. Vol. I, ed. by A.H. Blatt, John Wiley and Sons, Inc., New York, N.Y., 1951, p. 125.

evaporated. Recrystallization of the residue from MeOH gave colorless plates (2 g), mp 133°. *Anal.* Calcd. for $C_{19}H_{15}NS$: C, 78.75; H, 5.22; N, 4.84. Found: C, 78.56; H, 5.30; N, 4.72. IR ν_{max}^{KBr} cm^{-1}: 3400 (NH_2), 3300 (NH_2). NMR ($CDCl_3$) τ: 2.30—2.90 (8H, multiplet, thioxanthene ring H), 3.17, 3.49 (4H, A_2B_2 pattern, J=8.4 Hz, aromatic H), 4.79 (1H, singlet, C_9-H), 6.84 (2H, broad singlet, NH_2).

9-(*p*-Acetamidophenyl)thioxanthene (XVb)——Ac_2O (2 ml) was added to a solution of XXVIII (1 g) in AcOH (5 ml). After standing for 2 hr, the reaction mixture was poured into water. The resulting precipitate was filtered and dried. Recrystallization from MeOH–ether gave colorless needles (0.8 g), mp 208°. *Anal.* Calcd. for $C_{21}H_{17}ONS$: C, 76.12; H, 5.17; N, 4.23. Found: C, 76.30; H, 5.33; N, 4.14. IR ν_{max}^{KBr} cm^{-1}: 3250 (NH), 1660 (CO). NMR ($CDCl_3$–DMSO-d_6) τ: 2.45—3.22 (12H, multiplet, aromatic H), 4.72 (1H, singlet, C_9-H), 7.94 (3H, singlet, CH_3).

Methylation of 9-(*p*-Aminophenyl)thioxanthene (XXVIII)——To a solution of XXVIII (1 g) in nitrobenzene (20 ml), dimethyl sulfate (1.1 g) was added, and the mixture was heated for 5 hr at 150°. After removal of the solvent the residue was extracted with benzene, washed with water, and dried. Crystals from the benzene layer were washed with petr. ether. Recrystallization from MeOH gave 9-(*p*-dimethylaminophenyl)thioxanthene (XXIX) as colorless plates (0.4 g), mp 140°. This sample was identified by the mixed melting point test and the IR spectrum comparison with that of a sample prepared from XXX.

9-(*p*-Dimethylaminophenyl)thioxanthenol (XXX)——An ethereal solution of *p*-dimethylaminophenyl lithium[13] prepared from Li (1 g) and *p*-bromodimethylaniline (11 g) was added to a hot solution of thioxanthone (5 g) in benzene (150 ml) under an N_2 stream. After evaporation of ether the reaction mixture was refluxed for 15 hr and treated in the usual way. Recrystallization from benzene–petr. ether gave colorless prisms (4.5 g), mp 135°. *Anal.* Calcd. for $C_{21}H_{19}ONS$: C, 75.40; H, 5.74; N, 4.20. Found: C, 75.56; H, 5.77; N, 4.20. IR ν_{max}^{KBr} cm^{-1}: 3250 (OH).

9-(*p*-Dimethylaminophenyl)thioxanthene (XXIX)——A solution of XXX (1 g) in 85% formic acid (60 ml) containing Na_2CO_3 (0.5 g) was refluxed for 3 hr and poured into water. The resulting precipitate was filtered, washed with dil. Na_2CO_3 and water, and dried. Recrystallization from MeOH gave colorless plates (0.8 g), mp 141°. *Anal.* Calcd. for $C_{21}H_{19}NS$: C, 79.45; H, 6.03; N, 4.41. Found: C, 79.30; H, 6.02; N, 4.48. NMR ($CDCl_3$) τ: 2.40—2.90 (8H, multiplet, aromatic H), 3.10, 3.40 (4H, A_2B_2 pattern, J=9.0 Hz, aromatic H), 4.80 (1H, singlet, C_9-H), 7.14 (6H, singlet, CH_3).

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13) *a*) H. Gilman, E.A. Zoellner, and W.M. Selby, *J. Am. Chem. Soc.*, **55**, 1252 (1933); *b*) H. Gilman and L. Summers, *ibid.*, **72**, 2767 (1950).