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Pyridazines. III.[1] Intramolecular Cycloaddition of 3-Substituted-6-(2-allylphenoxy)pyridazines[2]

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Intramolecular cycloaddition of 3-phenyl-6-(2-allylphenoxy)pyridazines afforded 2-phenyl-1,9a-dihydroxanthenes, while 3-methyl-6-(2-allylphenoxy)-, and 3-(2-allylphenoxy)pyridazines gave mixtures of dihydroxanthenes. Depending upon condition, 3-chloro-6-(2-allyl-4-alkoxycarbonylphenoxy)pyridazines gave rise to the corresponding 1,9a-, and 1,4-dihydroxanthenes along with 2-alkoxycarbonylxanthenes.

Thermal intramolecular cycloaddition of 3-chloro-6-(2-allylphenoxy)pyridazines (I) and 3-substituted-6-[2-(2-methylallyl)phenoxy)]pyridazines (III) produced xanthenes[4] (II) and 2-substituted-9a-methyl-1,9a-dihydroxanthenes[1] (IV), respectively. Formation of these products indicates that interaction between the allylic double bonds and pyridazine rings has occurred to form $\pi^4+\pi^2$ cycloadducts (A and B). Elimination of both nitrogen and hydrogen chloride from the above adduct (A) produced II, while elimination of only nitrogen from (B) gave IV (Chart 1).

This paper describes further studies on the reaction of 3-substituted-6-(2-allylphenoxy)-pyridazines with certain kinds of substituents on the pyridazine and (or) benzene rings.

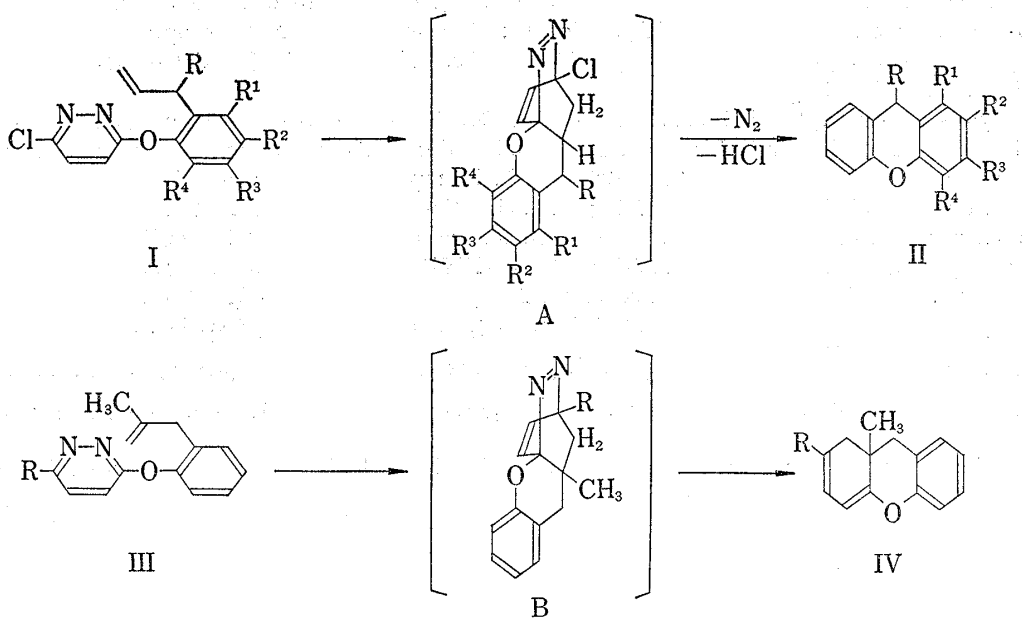


Chart 1

The reaction of 3-phenyl-6-chloropyridazine (V) with sodium salt of 2-allylphenol (VI) gave 3-phenyl-6-(2-allylphenoxy)pyridazine (VII). Refluxing VII in diethylaniline (DEA) for 2.5 hr afforded a product (VIII) of molecular formula, $C_{19}H_{16}O$ in 83% yield. Its ultra-

1) Part II: T. Jojima, H. Takeshiba, and T. Kinoto, *Chem. Pharm. Bull.* (Tokyo), **24**, 1581 (1976).
2) Presented mainly at the 7th Congress of Heterocyclic Chemistry, Chiba, October 1974.
3) Location: *Hiromachi, Shinagawa-ku, Tokyo.*
4) T. Jojima, H. Takeshiba, and T. Konotsune, *Chem. Pharm. Bull.* (Tokyo), **20**, 2191 (1972).

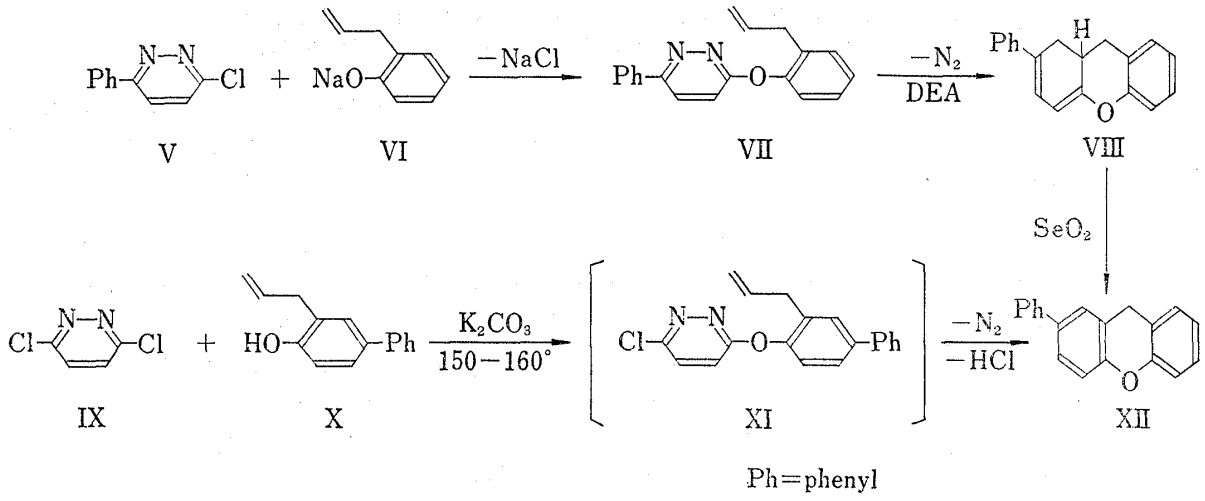


Chart 2

violet (UV) spectrum which resembles closely to that of 2-phenyl-1,9a-methyl-1,9a-dihydroxanthene (IV, R=phenyl)[1] showed maximum absorptions at 235, 287 and 338 mμ. The nuclear magnetic resonance (NMR) spectrum of this compound exhibited double-doublet at δ 6.28 and 5.57 (J=6.5 and 2.0 Hz) due to two olefinic protons of >CH–C(Ar)=CH–CH=Ċ–CH– and a multiplet at δ 2.50—3.65 due to five protons of >C=C(Ar)–CH_2–ĊH–CH_2–Ar in addition to aromatic proton peaks (9H).

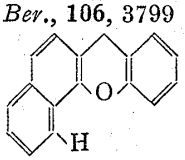
When the signal at δ 6.28 was irradiated the double-doublet at δ 5.57 became a doublet. When the signals at δ 3.30 and 2.70 were irradiated the double-doublets at δ 5.57 and 6.28 became doublets, respectively, suggesting the presence of a 1,4,5-tri-substituted-1,3-cyclohexadiene ring system.[5] On the basis of these spectroscopic data, the structure of VIII was assigned to be 2-phenyl-1,9a-dihydroxanthene. The structure of VIII was further confirmed by the following chemical conversion. Dehydrogenation of VIII with selenium dioxide in aqueous dioxane at room temperature afforded 2-phenylxanthene (XII) whih was identical in all respects with the compound obtained by heating 3,6-dichloropyridazine (IX) with 2-allyl-4-phenylphenol (X) in the presence of potassium carbonate at 150—160° (Chart 2). Formation of trace XII was also confirmed by examination of the NMR spectrumof crude VIII. Refluxing pure VIII in DEA for 3 hr produced a small amount of 2-phenylxanthene (XII), most of VIII being recovered unchanged (VIII/XII: *ca.* 80/20). This stability of VIII is probably ascribable to the extended conjugation in the 1-phenyl-1,3-cyclohexadiene system.

Next, various 3-phenyl-6-(2-allylphenoxy)pyridazines (XIV) were converted into 2-phenyl-1,9a-dihydroxanthenes (XV) which were, in turn, dehydrogenated with selenium dioxide into 2-phenylxanthenes (XVI). The structure of these compounds were confirmed by NMR spectra and elementary analyses. The starting materials (XIV) were obtained from 3-phenyl-6-chloropyridazine (V) and 2-allylphenols (XIII) (Table I).

Refluxing 1-phenyl-4-(2-allylphenoxy)phthalazine (XVIII) in DEA for 1.5 hr gave a product (XIX) of molecular formula $C_{23}H_{18}O$ in 97% yield (Chart 3). Its NMR spectrum exhibited a double-doublet at δ 7.92 due to one proton at the 1-position of a 7*H*-benzo[*c*]-xanthene ring system,[6] a triplet at δ 4.00 (J=9 Hz) due to one proton of $(Ar)_2C\underline{H}$–CH_2–, a broad singlet at δ 3.03 due to two protons of $ArCH_2$–Ċ= a doublet at δ 2.30 (J=9 Hz) due to

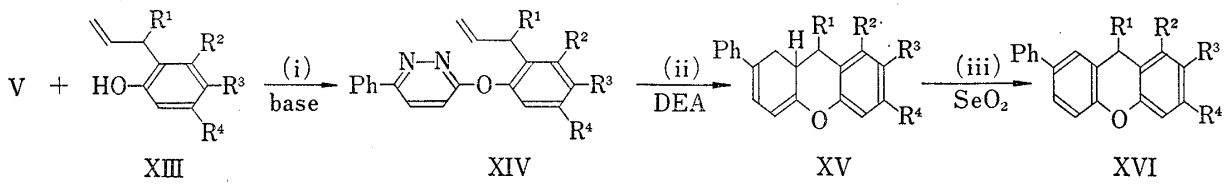
5) An analogous pattern of olefinic proton signals is recently reported with the NMR spectra of 1,3-cyclohexadiene system: F. Bohlmann and C. Zdero, *Chem. Ber.*, **106**, 3799 (1973).

6) Similar low-field proton signal was also observed in the NMR spectrum of 7*H*-benzo[*c*]xanthene



(see ref. 4)

Table I. Synthesis of 2-Phenylxanthenes (XVI) Starting from 3-Phenyl-6-chloropyridazine (V) and 2-Allylphenols (XIII)



XIII XIV XV XVI

No.	R^1	R^2	R^3	R^4	Step i Condition[a]	Step i Yield (%)	Step ii Condition[b]	Step ii Yield (%)	Step iii Yield (%)
a)	H	H	CH_3	H	A	76	C	100	38
b)	H	CH_3	H	CH_3	A	100	C	78	90
c)	H	H	Cl	H	A	71	C	68	100
d)	H	H	CH_3S	H	A	100	C	73	47
e)	H	H	NO_2	H	B	42[c]	D	46	20
f)	H	H	COOEt	H	B	22[d]	C	100	80
g)	CH_3	H	H	H	A	73	C	73	93

a) A: V and XIII were refluxed in toluene in the presence of sodium.
B: V, XIII and K_2CO_3 were heated at 150—160°.
b) C: XIV was refluxed in DEA.
D: XIVe was heated without a solvent.
c) 2-Phenyl-7-nitro-1,9a-dihydroxanthene (XVe) was also obtained in 23% yield.
d) 2-Phenyl-7-ethoxycarbonyl-1,9a-dihydroxanthene (XVf) was also obtained in 24% yield.

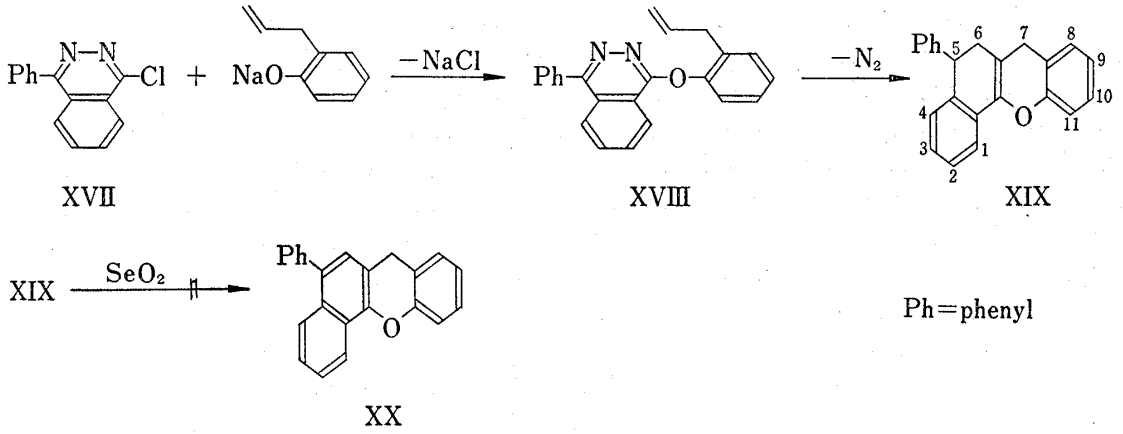


Chart 3

two protons of $(Ar)_2CH-\underline{CH_2}-\dot{C}=$, and showed no olefinic proton signals. On the basis of these results, the structure of XIX was assigned to be 5-phenyl-5,6-dihydro-7*H*-benzo[*c*]xanthene. An attempt to dehydrogenate XIX with selenium dioxide in hot aqueous dioxane failed. This resistance of XIX toward dehydrogenation may be ascribable to a steric hindrance.

Next, 3-(2-allyl-4-methylphenoxy)pyridazine (XXIIIa), obtained from 3-chloropyridazine (XXIa) and 2-allyl-4-methylphenol (XXIIa), was heated in DEA for 2 hr. The dihydroxanthene thus obtained was rather unstable in comparison with those derived from the phenyl analogues (VIII and XV), and were shown to be a mixture of several components. Therefore, the mixture was dehydrogenated with selenium dioxide without further purification to give 2-methylxanthene (XXIV), which was identical in all respects with the compound obtained by cycloaddition of 3-chloro-6-(2-allyl-4-methylphenoxy)pyridazine (XXV). Similarly, the same product (XXIV) was also obtained from 3-methyl-6-(2-allylphenoxy)pyridazine (XXIIIb) under the same conditions (Chart 4).

Thus, the substituents such as methyl or phenyl at the 3-position of the pyridazine ring were not eliminated during the cycloaddition reaction. In contrast, as reported earlier,[4] the chlorine

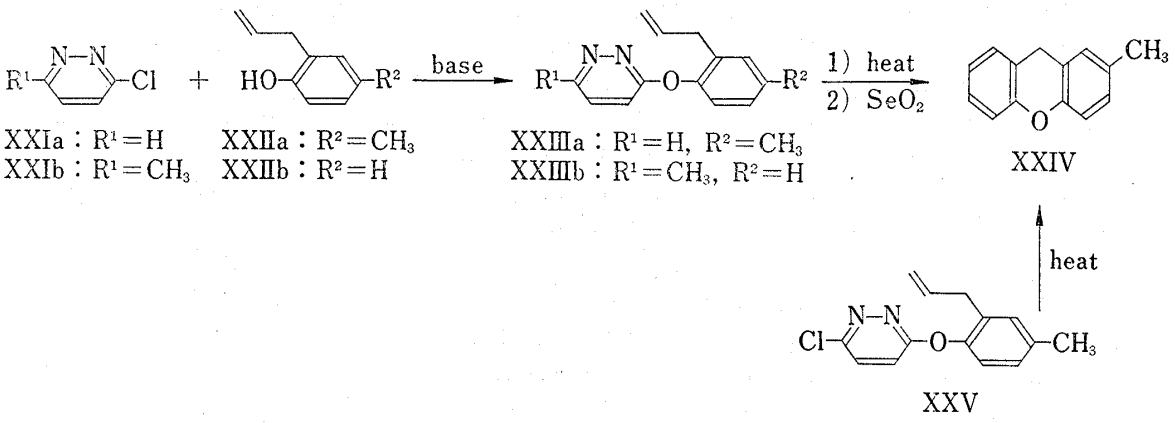


Chart 4

substituent at that position is very labile and elimination of both nitrogen and hydrogen chloride occurred during cycloaddition of 3-chloro-6-(2-allylphenoxy)pyridazines. However, small amounts of dihydroxanthenes were sometimes detected in the crude reaction mixture.

In order to obtain the chlorine-substituted dihydroxanthenes, 3-chloro-6-(2-allyl-4-ethoxycarbonylphenoxy)pyridazine (XXVIIa) and 3-chloro-6-(2-allyl-6-methoxycarbonylphenoxy)pyridazine (XXVIIb) with polar substituents on the benzene rings were subjected to cycloaddition (Chart 5). Refluxing XXVIIa in DEA for 2 hr and fractional crystallization of the crude xanthene mixture afforded 2-ethoxycarbonylxanthene (XXVIIIa) and 2-chloro-7-ethoxycarbonyl-1,4-dihydroxanthene (XXIX) in 49 and 14% yields, respectively.

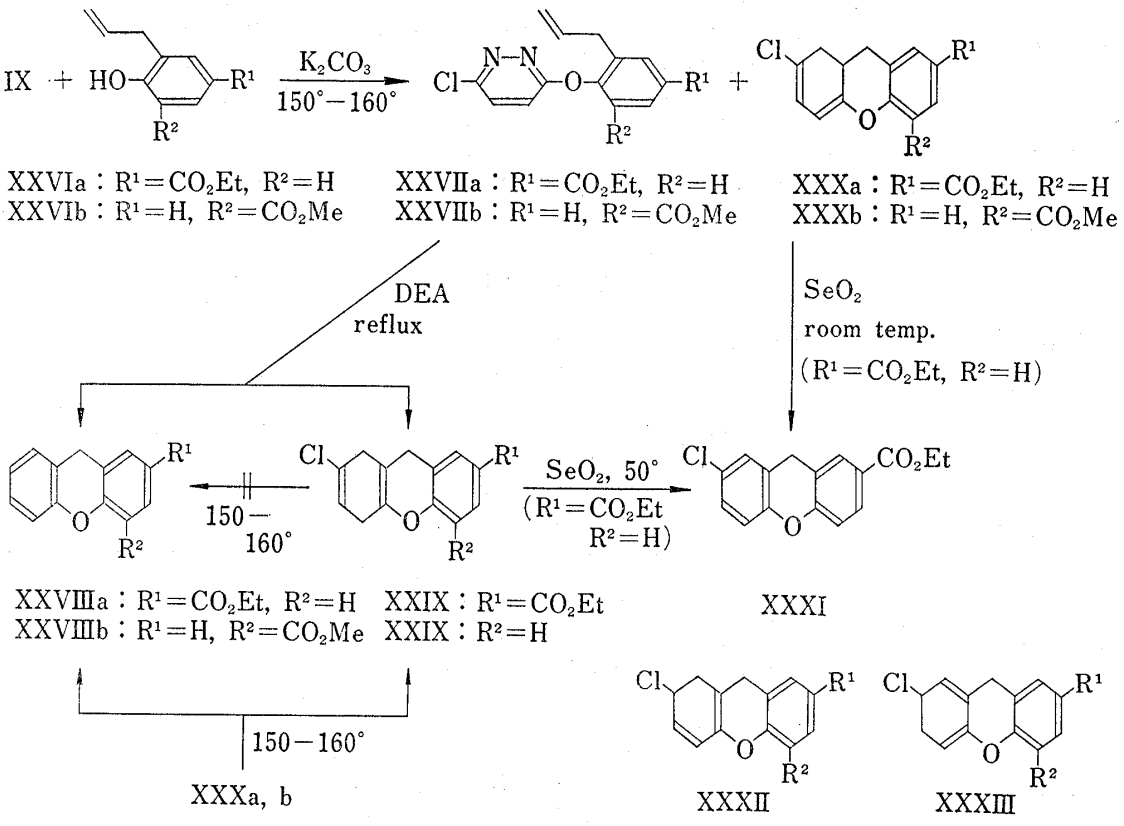


Chart 5

On the other hand, reaction of 3,6-dichloropyridazine (IX) and 2-allyl-4-ethoxycarbonylphenol (XXVIa) in the presence of anhydrous potassium carbonate at 150—160° for 1 hr gave 3-chloro-6-(2-allyl-4-ethoxycarbonylphenoxy)pyridazine (XXVIIa) and 2-chloro-7-ethoxy-

carbonyl-1,9a-dihydroxanthene (XXXa) in 84 and 13% yields, respectively. Clearly, the phenoxypyridazine (XXVIIa) was formed at first, and then, it was converted into XXXa through intramolecular cycloaddition. Heating XXXa at the same temperature for 0.5 hr gave a mixture of the xanthene (XXVIIIa) and 1,4-dihydroxanthene (XXIX) (ratio from NMR spectrum: 71: 29). As expected, this ratio was nearly equal to the corresponding ratio obtained by refluxing XXVIIa in DEA. In contrast, treatment of XXIX under the same condition recovered unchanged starting material.

Similarly, refluxing 3-chloro-6-(2-allyl-6-methoxycarbonylphenoxy)pyridazine (XXVIIb) in DEA gave 4-methoxycarbonylxanthene (XXVIIIb) in 86% yield. In this case, the 1,4-dihydroxanthene corresponding to XXIX was not obtained. The reaction of IX and 2-allyl-6-methoxycarbonylphenol (XXVIb) in the presence of anhydrous potassium carbonate at 150—160° for 0.5 hr gave 3-chloro-6-(2-allyl-6-methoxycarbonylphenoxy)pyridazine (XXVIIb) and 2-chloro-5-methoxycarbonyl-1,9a-dihydroxanthene (XXXb) in 26 and 13% yields, respectively. Heating XXXb at the same temperature for 1 hr afforded XXVIIIb as the single product. The structure of these compounds were confirmed on the basis of elementary analyses and spectroscopic data (see Experimental).

The structure of these dihydroxanthenes were further supported by chemical conversions. Dehydration of XXXa with selenium dioxide at room temperature yielded 2-chloro-7-ethoxycarbonylxanthene (XXXI), while treatment of the 1,4-dihydroxanthene (XXIX) recovered unchanged starting material under the same condition and produced a mixture of XXXI and XXIX at a more elevated temperature.

From the above results, likely pathways of formation of XXVIII, XXIX and XXX will be proposed as follows. Upon intramolecular cycloaddition of the phenoxypyridazines (XXVIIa and XXVIIb), the 1,9a-dihydroxanthene (XXXa and XXXb) were formed at first. Then, they were converted into heat-stable 1,4-dihydroxanthenes such as XXIX, or transformed into dihydroxanthenes such as XXXII and XXXIII by hydrogen transfer. Elimination of hydrogen chloride from these intermediates will produce the xanthenes (XXVIIIa and XXVIIIb).

These 1,9a-dihydro- and 1,4-dihydroxanthenes in the present report are previously unknown type of compounds.

Experimental

All melting points were uncorrected. NMR spectra were taken using A-60 and HA-100 spectrometers with tetramethylsilane as an internal standard. Substituted 2-allylphenols were prepared as reported in the literature.[7]

3-Phenyl-6-(2-allylphenoxy)pyridazine (VII)——Sodium (0.23 g) was added to a mixture of 2-allylphenol (VI, 2 g) and dry toluene (30 ml), and the mixture was refluxed for 2 hr. After cooling, 3-phenyl-6-chloropyridazine (V, 1.9 g) was added, and the toluene solution was refluxed for further 3 hr. The reaction mixture was poured into dil. NaOH, and the aqueous layer was extracted with toluene. The combined toluene extracts were washed with water, dried over anhyd. Na_2SO_4, and the solvent was evaporated *in vacuo*. The crude solids were recrystallized from hexane–benzene (3: 1) to give 1.3 g (60%) of VII as colorless needles, mp 101—102°. *Anal.* Calcd. for $C_{19}H_{16}ON_2$: C, 79.14; H, 5.59; N, 9.72. Found: C, 78.81; H, 5.47; N, 10.03.

2-Phenyl-1,9a-dihydroxanthene (VIII)——A mixture of VII (1.2 g) and DEA (5 ml) was refluxed for 2.5 hr. Ether (20 ml) was added to the cooled reaction mixture, and the solution was extracted three times with 10 ml-portions of cold 6 N HCl. The ether layer was once washed with water and dried over anhyd. Na_2SO_4, and the ether was evaporated *in vacuo*. The crude solids were recrystallized from hexane–benzene (2: 1) to give 0.9 g (83%) of colorless leaflets, mp 113—115°. UV and NMR spectral data were described in the text. *Anal.* Calcd. for $C_{19}H_{16}O$: C, 87.66; H, 6.20. Found: C, 87.59; H, 6.22.

2-Phenylxanthene (XII)——A) Dehydrogenation of VIII: Selenium dioxide (0.9 g) dissolved in 10 ml of H_2O was added dropwise to a mixture of VIII (1.04 g) and acetone (20 ml). The resulted suspension was stirred at 40—45° for 1 hr. The filtered solution was extracted with benzene (20 ml), and the benzene was

7) D.S. Tarbell, "Organic Reactions," Vol. II, ed. by R. Adams, John Wiley, and Sons, Inc., New York, N. Y., 1960, p. 1.

evaporated *in vacuo*. The crude product was chromatographed over silica gel. Elution with benzene gave 0.81 g (80%) of XII, mp 130° (colorless leaflets from hexane). NMR δ ppm ($CDCl_3$): 6.9—7.8 (12H, m, Ar), 4.05 (2H, s, Ar–CH_2–Ar). *Anal.* Calcd. for $C_{19}H_{14}O$: C, 88.34; H, 5.46. Found: C, 88.26; H, 5.42.

B) Reaction between 3,6-Dichloropyridazine (IX) and 2-Allyl-4-phenylphenol (X): An equimolar mixture of IX (1.49 g), X (2.1 g) and anhyd. K_2CO_3 (1.38 g) was heated at 150—160° for 2 hr. After cooling, benzene (20 ml) was added to the reaction mixture, and the benzene solution was washed twice with 20 ml-portions of 2 N NaOH and once with 20 ml of water. Evaporation of the benzene afforded an oily solid, which was chromatographed over silica gel. Elution with benzene gave 1.15 g (45%) of XII, mp 128°. Mixed mp with the product by method A above did not depress. Spectral data were also found identical with those of the product by method A.

3-Phenyl-6-(2-allylphenoxy)pyridazines (XIVa—g)——Method A: 3-Phenyl-6-chloropyridazine (V) and 2-allylphenols (XIII) were reacted in the presence of sodium in the same way as described for the synthesis of VII.

Method B: An equimolar mixture of V, XIII and anhyd. K_2CO_3 was heated at 150—160° for 2 hr. After cooling, benzene was added to the reaction mixture and the benzene solution was washed with 2 N NaOH and water. Evaporation of the benzene gave crude products, which were chromatographed over silica gel using benzene as an eluant. Physical constants of these phenoxypyridazines were listed in Table II.

Table II. Physical Constants of 3-Phenyl-6-(2-allylphenoxy)pyridazines (XIV)

Compounds	mp (°C)	Formula	Analyses (%) Calcd. (Found)		
			C	H	N
XIVa	116[a]	$C_{20}H_{18}ON_2$	79.44 (79.74)	6.00 (6.00)	9.27 (9.33)
XIVb	106[a]	$C_{21}H_{20}ON_2$	79.71 (79.46)	6.37 (6.37)	8.85 (9.14)
XIVc	137—138[a]	$C_{19}H_{15}ON_2Cl$	70.70 (70.99)	4.68 (4.62)	8.68 (8.75)
XIVd	93.5[a]	$C_{20}H_{18}ON_2S$	71.83 (71.84)	5.43 (5.42)	8.38 (8.48)
XIVe	141—142[b]	$C_{19}H_{15}O_3N_3$	68.46 (68.95)	4.54 (4.56)	12.61 (12.46)
XIVf	126[c]	$C_{22}H_{20}O_3N_2$	73.31 (73.41)	5.59 (5.59)	7.77 (7.91)
XIVg	130—131[c]	$C_{20}H_{18}ON_2$	79.44 (79.26)	6.00 (5.98)	9.27 (9.10)

a) recrystallized from hexane
b) recrystallized from pet. ether–hexane (1: 1)
c) recrystallized from benzene–hexane (1: 1)

2-Phenyl-1,9a-dihydroxanthenes (XVa—g)——Method C: The corresponding 3-phenyl-6-(2-allylphenoxy)pyridazines (XIVa—g) were heated in DEA and worked up in the same way as described for the synthesis of 2-phenyl-1,9a-dihydroxanthene (VIII).

Method D: 2-Phenyl-7-nitro-1,9a-dihydroxanthene (XVe) was prepared without a solvent as follows. 3-Phenyl-6-(2-allyl-4-nitrophenoxy)pyridazine (XIVe, 0.32 g) was heated at 180° for 3.5 hr. After cooling, benzene (20 ml) was added to the reaction mixture, and the solution was refluxed for 0.5 hr. The filtered solution was evaporated *in vacuo*, and the residue was chromatographed over silica gel. Elution with benzene–ethyl acetate (40: 1) gave 0.14 g (46%) of XVe, mp 196—201° (orange rods from pet. ether–hexane). The physical constants of these dihydroxanthenes were shown in Table III.

2-Phenylxanthenes (XVIa—g)——These compounds were prepared by the dehydrogenation of the corresponding dihydroxanthenes (XVa—g) in the same way as described for 2-phenylxanthene (XIII). The physical constants were also listed in Table III.

1-Phenyl-4-(2-allylphenoxy)phthalazine (XVIII)——Sodium (0.23 g), VI (1.4 g) and 1-phenyl-4-chlorophthalazine[8] (XVII, 2.4 g) were treated in the same way as described for the synthesis of VII to give 2.44 g (62%) of XVIII, mp 136—137° (colorless prisms from benzene–hexane). *Anal.* Calcd. for $C_{23}H_{18}ON_2$: C, 81.63; H, 5.36; N, 8.28. Found: C, 81.10; H, 5.53; N, 8.40.

Cyclization of XVIII——The phthalazine (XVIII, 1.45 g) was refluxed in DEA (10 ml) for 1.5 hr. Work-

8) O. Bromberg, *Chem. Ber.*, **29**, 1434 (1896).

Table III. Physical Constants of 2-Phenyl-1,9a-dihydroxanthenes (XV) and 2-Phenylxanthenes (XVI)

No.	XV			XVI		
	mp (°C)	Formula	Analyses (%) Calcd. (Found) C H	mp (°C)	Formula	Analyses (%) Calcd. (Found) C H
a)	180—183[a]	$C_{20}H_{18}O$	87.56 6.61 (87.34) (6.71)	172—174[b]	$C_{20}H_{16}O$	88.20 5.92 (88.17) (5.88)
b)	120—123[a]	$C_{21}H_{20}O$	87.46 6.99 (87.35) (6.92)	144—145[c]	$C_{21}H_{18}O$	88.08 6.34 (88.01) (6.27)
c)	154—156[a]	$C_{19}H_{15}OCl$	77.42 5.13 (77.80) (5.31)	167[c]	$C_{19}H_{13}OCl$	77.95 4.48 (77.82) (4.48)
d)	158[a]	$C_{20}H_{18}OS$	78.39 5.92 (78.62) (5.92)	143—145[c]	$C_{20}H_{16}OS$	78.98 5.30 (78.34) (5.41)
e)	221—223[a]	$C_{19}H_{15}O_3N$	74.74 4.95 (75.21) (4.96)	188—189[d]	$C_{19}H_{13}O_3N$	75.24 4.32 (74.59) (4.42)
f)	153—155[b]	$C_{22}H_{20}O_3$	79.49 6.06 (80.32) (5.96)	131—132[a]	$C_{22}H_{18}O_3$	79.98 5.49 (89.63) (5.54)
g)	96—98[c]	$C_{20}H_{18}O$	87.56 6.61 (87.42) (6.50)	79—80[b]	$C_{20}H_{18}O$	87.56 6.61 (87.72) (6.56)

a) recrystallized from benzene–hexane (1: 1)
b) recrystallized from pet. ether
c) recrystallized from pet. ether–hexane (1: 1)
d) recrystallized from benzene

ing up as described for the synthesis of VIII, and chromatography of the crude product over silica gel by elution with benzene–hexane (1: 1) yielded 1.2 g (97%) of 5-phenyl-5,6-dihydro-7*H*-benzo[*c*]xanthene as an light-orange solid, mp 48—52°. Attempts to recrystallize this product from several kinds of solvent resulted in decomposition. UV λ_{max}^{EtOH} mμ (log ε): 270 (3.68) and 295 (sh) (3.60). The NMR spectral data are given in the text. *Anal.* Calcd. for $C_{28}H_{18}O$: C, 89.00; H, 5.85. Found: C, 88.18; H, 6.01.

3-(2-Allyl-4-methylphenoxy)pyridazine (XXIIIa)——The procedure for the syntheses of XIV (Method B) was applied to 3-chloropyridazine (XXIa), giving 1.35 g (33%) of XXIIIa as a light-yellow oil, bp 159—166°/0.3 mmHg. *Anal.* Calcd. for $C_{14}H_{14}ON_2$: C, 74.31; H, 6.23; N, 12.38. Found: C, 74.60; H, 6.34; N, 12.08.

3-Methyl-6-(2-allylphenoxy)pyridazine (XXIIIb)——The procedure for the synthesis of VII was applied to 3-methylpyridazine (XXIb), giving XXIIIb as a colorless oil (89%), n_D^{25} 1.5656. *Anal.* Calcd. for $C_{14}H_{14}ON_2$: C, 74.31; H, 6.24; N, 12.38. Found: C, 74.71; H, 6.26; N, 12.52.

2-Methylxanthene (XXIV)——a) From XXIIIa: The pyridazine (XXIIIa, 1.7 g) was refluxed in DEA (5 ml) for 2 hr. Working up as usual and chromatography of the crude products over silica gel by elution with benzene gave 0.7 g of a mixture of dihydroxanthenes as an light-yellow oil. This mixture (0.66 g) was dehydrogenated with selenium dioxide (0.6 g) in aq. acetone in the same way as the dehydrogenation of VIII to give 0.18 g (28%) of XXIV, mp 99—100° (from hexane). Mixed mp with an authentic sample[4] prepared by the cyclization of 3-chloro-6-(2-allyl-4-methylphenoxy)pyridazine (XXV) did not depress. The spectral data were also found identical with those of the authentic sample. b) From XXIIIb: The procedure as above was applied to XXIIIb, giving XXIV in 35% yield, mp 100—101° (from hexane). Mixed mp with an authentic sample[4] did not depress.

Reaction of IX with 2-Allyl-4-ethoxycarbonylphenol (XXVIa——A mixture of IX (2.98 g), XXVIa (4.13 g) and anhyd. K_2CO_3 (2.76 g) was heated at 150—160° for 1 hr. Working up as described for the synthesis of XII (Method B) and chromatography of the crude products over silica gel by elution with benzene gave 0.75 g (13%) of 2-chloro-7-ethoxycarbonyl-1,9a-dihydroxanthene (XXXa) in the earlier eluate, mp 94—96° (colorless needles from hexane). Further elution with benzene–ethyl acetate (40: 1) gave 5.1 g (84%) of 3-chloro-6-(2-allyl-4-ethoxycarbonylphenoxy)pyridazine (XXVIIa), mp 55—57° (colorless needles from hexane). XXXa: IR ν_{max}^{Nujol} cm^{-1}: 1720 (COOEt). UV λ_{max}^{EtOH} mμ (log ε): 230 (3.97), 311 (4.24). NMR δ ppm (CCl_4): 7.70—7.97 (2H, m, 6-H+8-H), 6.87 (1H, d, 5-H), 5.88 (1H, dd, 3-H), 5.33 (1H, dd, 4-H, J=7+2 Hz), 4.34 (2H, q, $-\underline{CH_2}-CH_3$), 2.47—3.80 (4H, m, 1-H+9-H), 1.37 (3H, t, $-CH_3$). *Anal.* Calcd. for $C_{16}H_{15}O_3Cl$: C, 66.10; H, 5.20; Cl, 12.19. Found: C, 66.30; H, 5.31; Cl, 12.15. XXVIIa: IR ν_{max}^{Nujol} cm^{-1}: 1715 (COOEt). *Anal.* Calcd. for $C_{16}H_{15}O_2N_2Cl$: C, 60.29; H, 4.74; N, 8.79; Cl, 11.12. Found: C, 60.29; H, 4.80; N, 9.03; Cl, 11.09.

Reaction of IX with 2-Allyl-6-methoxycarbonylphenol (XXVIb)——A mixture of IX (8.94 g), XXVIb (11.54 g), and anhyd. K_2CO_3 was heated at 150—160° for 0.5 hr. Working up as above gave 2.3 g (13%)

of 2-chloro-5-methoxycarbonyl-1,9a-dihydroxanthene (XXXb), mp 72—74° (colorless needles from hexane–ether) and 4.8 g (26%) of 3-chloro-6-(2-allyl-6-methoxycarbonylphenoxy)pyridazine (XXVIIb), mp 88° (colorless needles from hexane). XXXb: IR ν_{max}^{Nujol} cm^{-1}: 1730 ($COOCH_3$). UV λ_{max}^{EtOH} mμ (log ε): 318 (3.79). NMR δ ppm (CCl_4): 7.58 (1H, dd, 6-H), 6.7—7.3 (2H, m, Ar), 5.89 (1H, dd, 3-H), 5.39 (1H, dd, 4-H, $J_{3,4}$=6 Hz, $J_{4,9a-H}$=2 Hz), 3.82 (3H, s, CH_3O), 2.3—3.7 (5H, m, $-CH_2-\underset{|}{C}H-CH_2-$). *Anal.* Calcd. for $C_{15}H_{13}O_3Cl$: C, 65.11; H, 4.74; Cl, 12.81. Found: C, 65.00; H, 4.70; Cl, 12.51. XXVIIb: IR ν_{max}^{Nujol} cm^{-1}: 1730 ($COOCH_3$). *Anal.* Calcd. for $C_{15}H_{13}O_3N_2Cl$: C, 59.12; H, 4.30; N, 9.19; Cl, 11.63. Found: C, 59.28; H, 4.34; N, 9.43; Cl, 11.74.

Cyclization of XXVIIa——The pyridazine (XXVIIa, 3.5 g) was refluxed in DEA (18 ml). Working up as described for the synthesis of VIII and chromatography of the crude products over silica gel by elution with benzene gave 2.65 g of the dihydroxanthene mixture. The mixture was then recrystallized with methanol to give 0.45 g (14%) of 2-chloro-7-ethoxycarbonyl-1,4-dihydroxanthene (XXIX), mp 150—152° (colorless needles). The mother liquor which separated XXIX was evaporated *in vacuo* and the crude crystalline solid was recrystallized from hexane to give 1.35 g (49%) of 2-ethoxycarbonylxanthene (XXVIIIa), mp 79—81° (colorless needles). XXIX: IR ν_{max}^{Nujol} cm^{-1}: 1700 (COOEt). UV λ_{max}^{EtOH} mμ (log ε): 225 (4.03), 277 (3.93) and 297 (3.82). NMR δ ppm (CCl_4): 7.68—7.90 (2H, m, 6-H+8-H), 6.67—7.03 (2H, m, 5-H), 5.77 (1H, m, 3-H), 4.35 (2H, q, $-\underline{CH_2}-CH_3$), 3.25 (2H, broad s, 9-H), 2.90 (4H, broad s, 1-H+4-H), 1.37 (3H, t, $-CH_2-\underline{CH_3}$). *Anal.* Calcd. for $C_{16}H_{15}O_3Cl$: C, 66.10; H, 5.20; Cl, 12.19. Found: C, 66.67; H, 4.89; Cl, 12.41. XXVIIIa: IR ν_{max}^{Nujol} cm^{-1}: 1705 (COOEt). UV λ_{max}^{EtOH} mμ (log ε): 275 (4.20). NMR δ ppm (CCl_4): 7.72—7.93 (2H, m, 1-H+3-H), 6.9—7.2 (5H, m, Ar), 4.30 (2H, q, $-\underline{CH_2}-CH_3$), 4.02 (2H, s, 9-H), 1.38 (3H, t, CH_3). *Anal.* Calcd. for $C_{16}H_{14}O_3$: C, 75.58; H, 5.55; Found: C, 75.48; H, 5.47.

Cyclization of XXVIIb——The pyridazine (XXVIIb, 2.8 g) was refluxed in DEA (15 ml) for 2 hr. Working up as above gave 1.85 g (86%) of 4-methoxycarbonylxanthene (XXVIIIb) as a light-brown oil, bp 160—170°/0.09 mmHg. IR $\nu_{max}^{liq.}$ cm^{-1}: 1730 ($COOCH_3$). NMR δ ppm (CCl_4): 6.83—7.83 (7H, m, Ar), 3.95 (2H, s, $-CH_2-$), 3.85 (3H, s, CH_3O). *Anal.* Calcd. for $C_{15}H_{12}O_3$: C. 74.99; H, 5.03. Found: C, 74.90; H, 5.00.

Thermal Treatment of XXXa——A mixture of XXXa (0.13 g) and anhyd. K_2CO_3 (0.031 g) was heated at 150—160° for 0.5 hr. When cool, the reaction mixture was extracted with benzene (30 ml), and the extracts were once washed with water. Evaporation of the solvent *in vacuo* gave 0.1 g crystalline solid, mp 72—77°. This material was indicated to be a mixture of XXVIIIa and XXIX (ratio: 71: 29) from the NMR spectrum.

Thermal Treatment of XXXb——A mixture of XXXb (1 g) and anhyd. K_2CO_3 (0.25 g) was heated at 150—160° for 1 hr. Working up as above gave 0.5 g (58%) of XXVIIIb, as a light-brown oil.

Dehydrogenation of XXXa——This reaction was conducted in the same way as described for the synthesis of XII (Method A) except that dioxane was used instead of acetone as the organic solvent. The yield of 2-chloro-7-ethoxycarbonylxanthene (XXXI) was 31%, mp 132—135° (colorless needles from hexane). IR ν_{max}^{Nujol} cm^{-1}: 1700 (COOEt). UV λ_{max}^{EtOH} mμ (log ε): 2.73 (4.40). NMR δ ppm ($CDCl_3$): 6.9—8.0 (6H, m, Ar), 4.37 (2H, q, $-\underline{CH_2}-CH_3$), 4.02 (2H, s, $-CH_2$), 1.37 (3H, t, $-CH_2-\underline{CH_3}$). *Anal.* Calcd. for $C_{16}H_{13}O_3Cl$: C, 66.56; H, 4.54; Cl, 12.28. Found: C, 67.23; H, 4.62; Cl, 11.99.

Dehydrogenation of XXIX——A mixture of XXIX (0.23 g) and selenium dioxide (0.24 g) in a mixed solvent (dioxane 8 ml+water 2 ml) was stirred at room temperature for 7 hr and at 50° for 9 hr. Working up as above gave 0.15 g of a mixture of XXXI and starting material (XXIX) (ratio: 44: 56, calcd. from the NMR spectrum).

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