[Contribution from the Chemistry Department, Faculty of Science, Cairo University]

2-Styrylchromones in the Diene Synthesis

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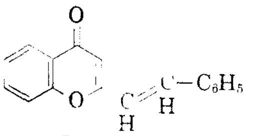
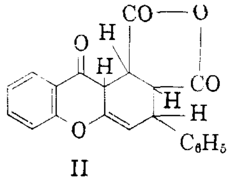
2-Styrylchromones, having conjugated double bonds, one of which is part of the heterocyclic ring, take part in the Diels-Alder reaction. Thus, an easy formation of xanthone derivatives, namely, 1, 2,3,9a-tetrahydro-9-oxo-3-aryl-1,2-xanthonedicarboximides, is available. Similarly, 2-styryl-7,8-benzochromones lead to the corresponding 7,8-benzoxanthonedicarboximide derivatives.

Recently, it has been shown[1] that, in the heterocyclic series, the oxygen-containing 2-styrylchromones having conjugated double bonds, one of which is part of the heterocyclic ring, take part in the Diels-Alder reaction. Thus, an easy formation of xanthone derivatives is available, *e.g.*, 1,2,3,9a-tetrahydro - 9 - oxo - 3 - phenyl - 1,2 - xanthonedicarboxylic anhydride (II) is obtained when 2-styrylchromone (I) is allowed to react with maleic anhydride in boiling xylene.



I



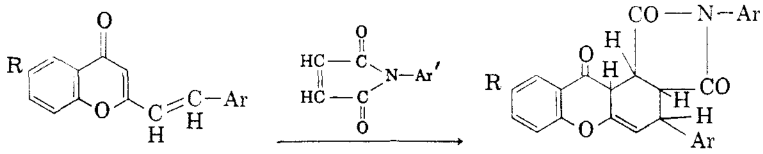
II

We now have investigated the dienophilic reactivity of N-arylmaleimides[2] toward 2-styrylchromones. Thus, when I was allowed to react with N-phenylmaleimide in boiling xylene, 1,2,3,9a-tetrahydro - 9 - oxo - 3 - phenyl - (N - phenyl) - 1,2-xanthonedicarboximide (IVa) was obtained. Similar results were also obtained by the reaction of N-arylmaleimides on 2-styrylchromones (IIIa-e), leading to the adducts IVa-o.

We have also found that 2-styryl-7,8-benzochromones (Va,b) react with N-phenylmaleimides. Thus, 1,2,3,9a - tetrahydro - 9 - oxo - 3 - phenyl-(N - phenyl) - 1,2 - (7,8 - benzo)xanthonedicarboximide (VIa) is obtained when 2-styryl-7,8-benzochromone (Va) is allowed to react with N-phenylmaleimide in boiling phenetole.

The reactions were primarily carried out in dry xylene, but in some cases, higher boiling solvents, *e.g.*, phenetole or nitrobenzene had to be used.

The adducts obtained by these Diels-Alder syntheses are practically colorless and are insoluble in alkali. Treatment of the adduct IVn with alcoholic sodium hydroxide and subsequent acidification, yielded the corresponding alkali-soluble acid VII, which was proved to be identical with the product obtained by the action of maleic acid on IIIe in boiling phenetole.



IIIa, R = H; Ar = $C_6H_4OCH_3$—*p*
b, R = H; Ar = $C_6H_3{:}O_2CH_2$—*3′,4′*
c, R = CH_3; Ar = $C_6H_4OCH_3$—*p*
d, R = CH_3; Ar = $C_6H_4OC_2H_5$—*o*
e, R = CH_3; Ar = $C_6H_3{:}O_2CH_2$—*3′,4′*

IVa, R = H; Ar = Ar′ = C_6H_5
b, R = H; Ar = C_6H_5; Ar′ = $C_6H_4OCH_3$—*p*
c, R = H; Ar = C_6H_5; Ar′ = $C_6H_4OC_2H_5$—*p*
d, R = H; Ar = C_6H_5; Ar′ = $C_6H_3(CH_3)_2$—*2″, 4″*
e, R = H; Ar = $C_6H_4OCH_3$—*p*; Ar′ = C_6H_5
f, R = H; Ar = $C_6H_4OCH_3$—*p*; Ar′ = $C_6H_4OC_2H_5$—*p*
g, R = H; Ar = $C_6H_3{:}O_2CH_2$—*3′,4′*; Ar′ = C_6H_5
h, R = H; Ar = $C_6H_3{:}O_2CH_2$—*3′, 4′*; Ar′ = $C_6H_4OCH_3$—*p*
i, R = CH_3; Ar = $C_6H_4OCH_3$—*p*; Ar′ = C_6H_5
j, R = CH_3; Ar = Ar′ = $C_6H_4OCH_3$—*p*
k, R = CH_3; Ar = $C_6H_4OCH_3$—*p*; Ar′ = $C_6H_4OC_2H_5$—*p*
l, R = CH_3; Ar = $C_6H_4OC_2H_5$—*o*; Ar′ = C_6H_5
m, R = CH_3; Ar = $C_6H_4OC_2H_5$—*o*; Ar′ = $C_6H_4OC_2H_5$—*p*
n, R = CH_3; Ar = $C_6H_3{:}O_2CH_2$—*3′,4′*; Ar′ = C_6H_5
o, R = CH_3; Ar = $C_6H_3{:}O_2CH_2$—3′,4′; Ar′ = $C_6H_4OCH_3$—*p*

2-(*p*-Nitrostyryl)chromone (III, R = H; Ar = $C_6H_4NO_2$ — *p*) failed to function as diene component when allowed to react with N-*p*-methoxyphenylmaleimide in boiling phenetole or nitrobenzene.

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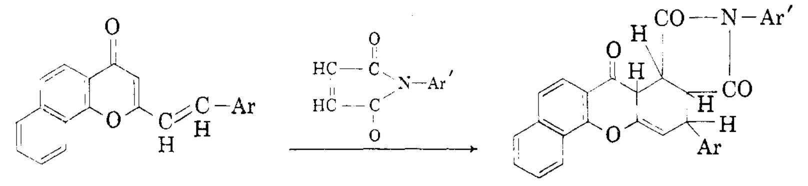
(1) Schönberg, Mustafa, and Aziz, *J. Am. Chem. Soc.*, 76, 4576 (1954).

(2) For the dienophilic reactivity of N-phenylmaleimide and its *para*-substituted derivatives toward 6,6-diphenylfulvene, compare Barnstoff and Meek, ***Abstracts of papers presented at the American Chemical Society Meeting, Kansas City, Mo., March 23 to April 1, 1954,*** p. 29N.



Va, Ar = C_6H_5
b, Ar = $C_6H_3:O_2CH_2$—*3′,4′*

VIa, Ar = Ar′ = C_6H_5
b, Ar = C_6H_5; Ar′ = $C_6H_4OCH_3$—*p*
c, Ar = $C_6H_3:O_2CH_2$—*3′,4′*; Ar′ = C_6H_5
d, Ar = $C_6H_3:O_2CH_2$—*3′,4′*; Ar′ = $C_6H_4OCH_3$—*p*

TABLE I

NEW 2-STYRYLCHROMONES

2-Styryl-chromone	M.p.,[a] °C.	Solvent for Cryst.[b]	Yield, %	Color with H_2SO_4	Formula	Analysis Calc'd C	Calc'd H	Found C	Found H
IIIb	209–210	A	80	Deep red	$C_{18}H_{12}O_4$	73.97	4.11	74.06	4.08
IIIc	162–163	A	84	Red	$C_{19}H_{16}O_3$	78.07	5.48	78.05	5.48
IIId	125–126	A	76	Orange	$C_{20}H_{18}O_3$	78.43	5.88	78.23	5.76
IIIe	194–195	B	85	Deep red	$C_{19}H_{14}O_4$	74.50	4.58	74.64	4.72
Vb	230–231	B	72	Deep red	$C_{22}H_{14}O_4$	77.20	4.09	77.00	4.06

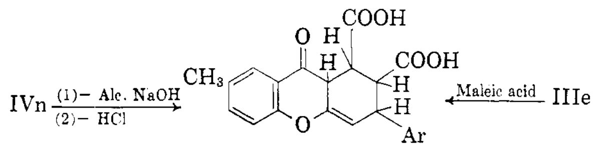
[a] Melting points are uncorrected. [b] A, ethyl alcohol; B, xylene.

TABLE II

ADDUCTS WITH 2-STYRYLCHROMONES

2-Styryl-chromone	Ad-duct	Medium of Reac-tion[a]	Solvent for Cryst.[a]	M.p.,[b] °C.	Yield, %	Color with H_2SO_4	Formula	Analysis Calc'd C	Calc'd H	Calc'd N	Found C	Found H	Found N
I	IVa	A	A	252–254	75	Orange	$C_{27}H_{19}NO_4$	76.95	4.51	3.33	76.48	4.77	3.60
I	IVb	A	A	264–266	68	Orange	$C_{28}H_{21}NO_5$	74.49	4.66	3.10	74.69	5.16	2.98
I	IVc	A	A	271–273	72	Orange	$C_{29}H_{23}NO_5$	74.84	4.95	3.01	74.47	5.14	3.10
I	IVd	A	C	241–242	60	Yellow	$C_{29}H_{23}NO_4$	77.52	5.12	3.12	77.31	5.03	3.11
IIIa	IVe	A	D	240–241	74	Orange-yellow	$C_{28}H_{21}NO_5$	74.49	4.66	3.10	73.85	4.49	3.16
IIIa	IVf	A	A	214–215	65	Orange	$C_{30}H_{25}NO_6$	72.73	5.05	2.83	72.76	5.17	2.78
IIIb	IVg	B	B	above 300	68	Red	$C_{27}H_{19}NO_6$	72.26	4.09	3.01	71.92	4.29	3.05
IIIb	IVh	B	B	296–298	65	Brown-red	$C_{29}H_{21}NO_7$	70.31	4.24	2.83	70.26	3.69	3.04

[a] A, xylene; B, nitrobenzene; C, ethyl alcohol; D, dioxane-petroleum ether (b.p. 60–80°) mixture. [b] Melting points are uncorrected.



VII (Ar = $C_6H_3:O_2CH_2-3′,4′$)

EXPERIMENTAL*

Preparation of new 2-styrylchromones. General procedure. To a solution of the 2-methylchromone[3] (0.02 mole) and the aromatic aldehyde (0.02 mole) in 40 ml. of absolute ethyl alcohol was added an aldoholic sodium ethoxide solution from 0.02 g.-atom of sodium in 20 ml. of absolute ethyl alcohol, and the mixture was left for 24 hours at 25°. The solid that separated was filtered, washed with small amounts of cold ethyl alcohol, and crystallized from a suitable solvent (*cf.* Table I).

For the preparation of the known 2-styrylchromones, used in this investigation, see Cheema, *et al.*[4]

For the preparation of N-(*p*-methoxyphenyl)maleimide, see Searle,[5] and for N-(*p*-ethoxyphenyl)-, and N-(2,4-dimethylphenyl)maleimide, see Piutti[6] and Mustafa, *et al.*[7]

Action of N-arylmaleimides on 2-styrylchromones. General procedure. The 2-styrylchromone (0.7 g.) and the appropriate N-arylmaleimide (1 g.) were dissolved in 25 ml. of the freshly distilled solvent (*cf.* Tables II, III, and IV). The reaction mixture was refluxed for a period ranging from 10 to 15 hours. The crystalline solid so obtained was filtered

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* Analyses were done by Drs. Weiler and Strauss Microanalytical Laboratories, Oxford, England.

[3] For the preparation of 2-methylchromone and 2-methyl-7,8-benzochromone, see Wittig, Bangert and Richter, *Ann.*, **446**, 155 (1926); and for the preparation of 2,6-dimethylchromone, see Baker, *J. Chem. Soc.*, 1381 (1933).

[4] Cheema, Gulati and Venkataraman, *J. Chem. Soc.*, 925 (1932).

[5] Searle, U. S. Patent 2,444,536; *Chem. Abstr.*, **42**, 7340 (1948).

[6] Piutti, *Ber.*, **39**, 2767 (1906).

[7] Mustafa, Zayed, and Khattab, *J. Am. Chem. Soc.*, **78**, 145 (1956).

TABLE III

ADDUCTS WITH 6-METHYL-2-STYRYLCHROMONES

2-Styryl-chromone	Adduct	Medium of Reaction[a]	Solvent for Cryst.[a]	M.p.,[b] °C.	Yield, %	Color with H_2SO_4	Formula	Analysis Calc'd			Analysis Found		
								C	H	N	C	H	N
IIIc	IVi	A	A	242–243	78	Yellow	$C_{29}H_{23}NO_5$	74.84	4.95	3.01	75.02	5.05	2.88
IIIc	IVj	A	A	266–268	75	Orange	$C_{30}H_{25}NO_6$	72.73	5.05	2.83	72.91	4.96	2.63
IIIc	IVk	A	A	257–259	84	Orange	$C_{31}H_{25}NO_6$	73.08	5.31	2.75	72.95	5.41	2.68
IIId	IVl	A	A	233–235	74	Yellow	$C_{30}H_{25}NO_5$	75.16	5.22	2.92	74.87	5.32	2.58
IIId	IVm	A	A	225-226	63	Orange	$C_{32}H_{29}NO_6$	73.41	5.55	2.68	73.16	5.85	2.18
IIIe	IVn	B	C	215	54	Brown-red	$C_{29}H_{21}NO_6$	72.66	4.38	2.92	72.88	4.65	2.94
IIIe	IVo	B	B	315	57	Brown-red	$C_{30}H_{23}NO_7$	70.73	4.52	2.75	70.89	3.98	2.52

[a] A, phenetole; B, nitrobenzene; C, acetic anhydride. [b] Melting points are uncorrected.

TABLE IV

ADDUCTS WITH 2-STYRYL-7,8-BENZOCHROMONE

2-Styryl-chromone	Adduct	Medium of reaction[a]	Solvent for cryst.[a]	M.p.,[b] ° C.	Yield, %	Color with H_2SO_4	Formula	Analysis Calc'd			Analysis Found		
								C	H	N	C	H	N
Va	VIa	A	C	306–308	64	Orange	$C_{31}H_{21}NO_4$	78.98	4.46	2.97	78.00	4.83	2.67
Va	VIb	B	D	267–269	58	Orange	$C_{32}H_{23}NO_5$	76.65	4.59	2.80	75.87	4.24	2.83
Vb	VIc	B	A	288–289	72	Brown-red	$C_{32}H_{21}NO_6$	74.57	4.08	2.72	74.78	4.33	2.53
Vb	VId	B	B	218–219	75	Brown-red	$C_{33}H_{23}NO_7$	72.66	4.22	2.57	71.78	3.85	2.82

[a] A, phenetole; B, nitrobenzene; C, acetic anhydride; D, anisole.
[b] Melting points are uncorrected.

off, washed with benzene (*ca.* 20 ml.), and recrystallized form a suitable solvent.

Action of maleic acid on IIIe. A mixture of 0.5 g. of IIIe, 1 g. of maleic acid, and 25 ml. of freshly distilled phenetole was refluxed for 15 hours. The almost colorless crystals that separated on cooling were filtered, washed with ether, and recrystallized from glacial acetic acid, m.p. 255° decomp. Yield is *ca.* 75%.

Anal. Calc'd for $C_{23}H_{18}O_8$: C, 65.40; H, 4.27. Found: C, 64.95; H, 4.08.

The acid VII dissolves in aqueous sodium hydroxide solution and is regenerated on acidification.

Opening of the imide ring (IVn). Compound IVn (0.8 g.) was dissolved in 50 ml. of methyl alcohol containing 1 g. of sodium hydroxide and the reaction mixture was refluxed for 2 hours, then filtered while hot. The filtrate was acidified with ice-cold dilute hydrochloric acid and the precipitate which formed was collected and washed thoroughly with cold water. The acid VII was crystallized from glacial acetic acid, m.p. 250° decomp.; it is soluble in aqueous sodium hydroxide solution, and is identical with the product obtained by the action of maleic acid on IIIe. Yield is *ca.* 0.35 g.

Anal. Calc'd for $C_{23}H_{18}O_8$: C, 65.40; H, 4.27. Found: C, 65.36; H, 4.49.

CAIRO, EGYPT