Some Reactions of 6-Chloro-2-Methyl 4H-1-Benzopyran-4-one (Part I)

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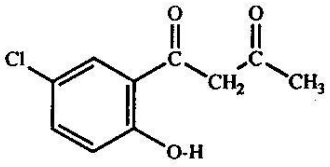
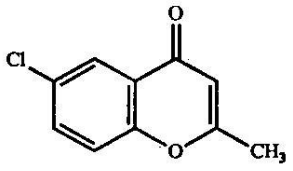
Summary: 4H-1-Benzopyran-4-ones (Chromones are proved to be of special importance in medicine as stimulants of the central nervous system, spasmolytics, coronary dilators, inhibitors for the growth of human cancer cells, reductants for blood pressure, diuretics, antiallergic, antibiotics and cardiovascular agents. In the course of the present work several new derivatives containing the chromone moiety were prepared. Some of their reactions were investigated in the hope of obtaining new compounds having biological activities. The reactivities of chromone nucleus towards cycloaddition reactions under Diels- Alder conditions, nucleophilic and electrophilic reagents, photocyclodehydrogenation and thiation have been investigated.

Introduction

6-Chloro-2-methy-l4H-1-benzopyran-4-one (II) was prepared *via* acid-catalyzed cyclodehydration of the β–diketone [1,2], 2-aceto-acetyl-4-chlorophenol (I).



I



II

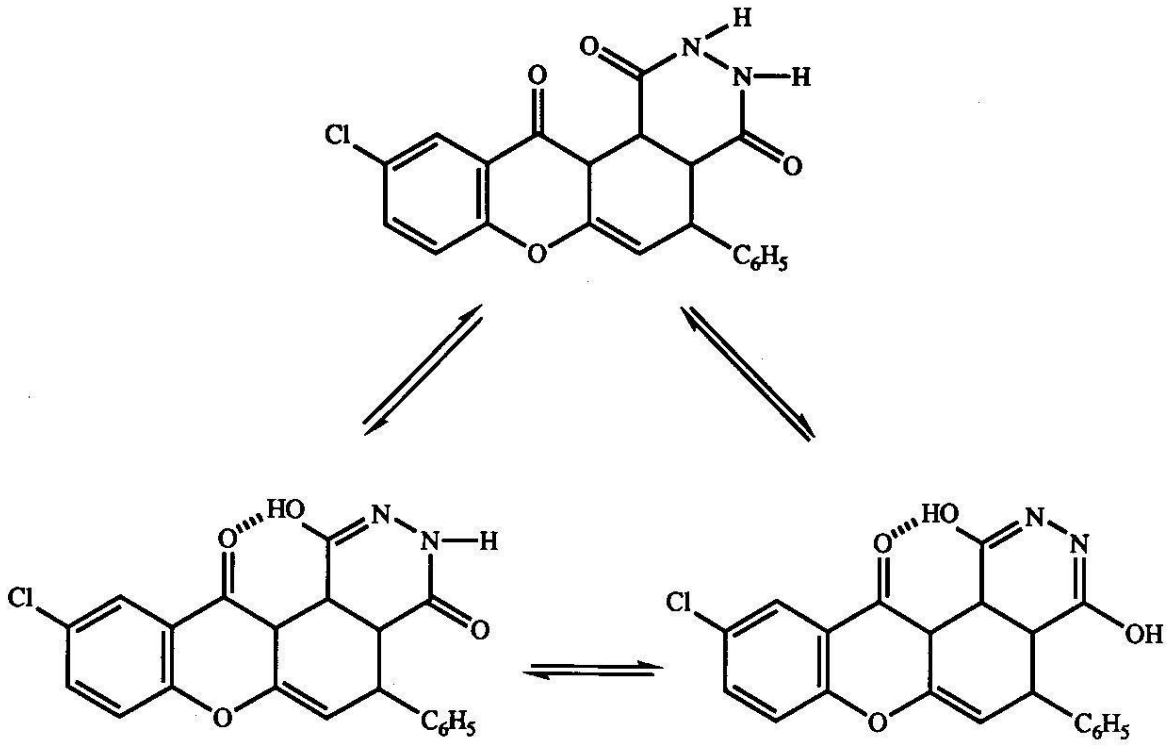
The 2-styryl derivatives IIIa-f were synthesised by the treatment of II with aromatic aldehydes namely, benzaldehyde, anisaldehyde, p-chlorobenzaldehyde, p-nitrobenzaldehyde, piperonal and furan-2- aldehyde in the presence of sodium ethoxide in asbolute ethanol at room temperature [3].

IIIa-f as dienes undergo Diels-Alder reaction with maleic anhydride and N-aryl maleimides to give the xanthone derivatives IVa-d and Va-t respectively.

Hydrolysis of IVa and Va with ethanolic potassium hydroxide gave the same dicarboxylic acid VI. Treatment of VI with absolute ethanol in presence of hydrogen chloride gas gave the corresponding ester VII, which was also obtained from the ethanolysis of both IVa and Va respectively. Aromatisation of the xanthone derivative IVa to VIII was readily accomplished by bromination and dehydrobromination without isolation of the brominated intermediate [4].

It was previously reported that phthalazinones which are useful [5] were synthesised *via* treatment of o-aroylbenzoic acid with hydrazine hydrate. This prompted us to investigate the action of hydrazine hydrate on the xanthone derivative IVa in acetic acid aiming to yield the desired 1,4-phthalazindione derivative IX which really exists in the lactam-lactim dynamic equilibrium.

On the other hand, when IVa,b were allowed to react with primary aromatic amines namely; p-toluidine, p-anisidine and p-chloroaniline, the products obtained were found to be identical with the Diels-Alder adducts Vb-d,g-i by means of m.p., mixed m.p. determination and IR spectra comparison.



IX

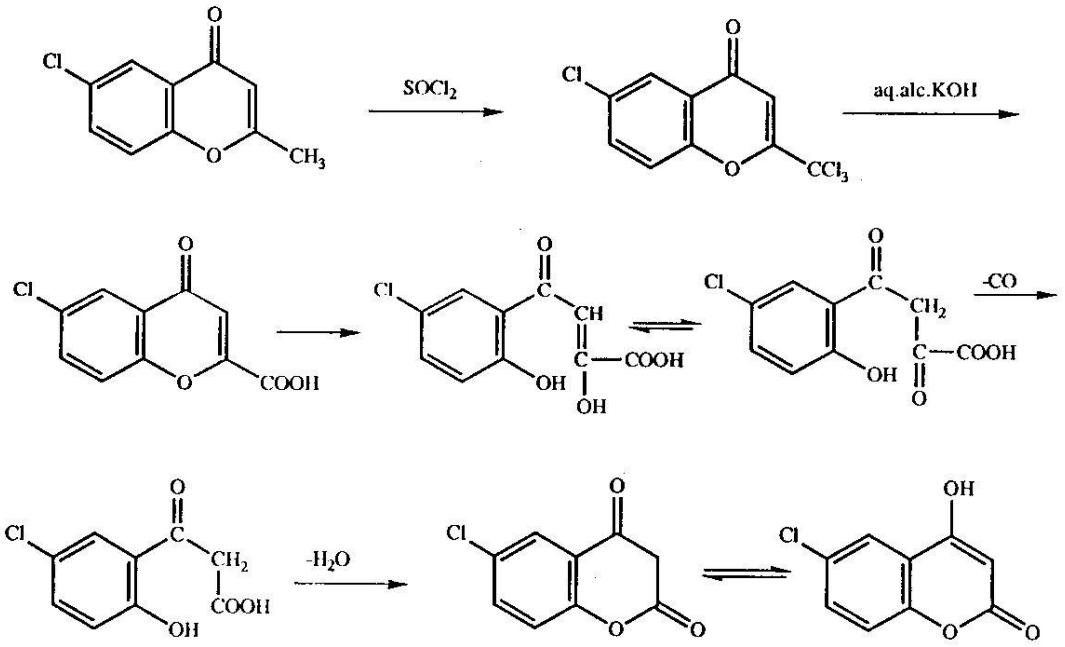
Results and Discussion

Photocyclodehydrogenation of stilbenes and their analogues is a potential synthetic method for polycyclic aromatic compounds, and has been studied extensively [6]. As part of our work we studied the photocyclization of 6-chloro-2-styryl-4H-chromen-4- ones (IIIa-d) in order to obtain 12-H-benzo [a] xanthen-12-ones (Xa,b). We have found that photocyclization occurred when the 4-position of the styryl ring was occupied by an electron donating group whereas the process did not succeed absolutely in case of an electron withdrawing group set in *para* position. Thus we concluded that the polar effect of substituents in the styryl moiety plays a significant role in the process.

Bromination of 2-styryl chromones IIIa-d in glacial acetic acid gave the corresponding vicinal dibromides XIa-d. XIa-d reacted with thiourea yielding thioimidazolone derivatives as intermediates which were directly hydrolysed with aqueous alcoholic KOH and gave the corresponding imidazolone derivative XIIa-d which can exist in keto-enol dynamic equilibrium. Also, treatment of the vicinal dibromides XIa,b with urea in boiling ethanol in the presence of aq.alc. KOH gave products which were found to be identical with XIIa,b respectively by means of m.p., mixed m.p. determination and IR spectra comparison.

Chlorination of chromone II was achieved by thionyl chloride in boiling benzene to give XIII which was hydrolysed with alcoholic alkali to yield the desired 6-chloro-chroman-2,4-dione (XIV) in poor yield [8]. On the basis of the IR spectra of XIII and XIV, the hydrolysis product has the proposed structure XIV.

Compound XIV is soluble in sodium bicarbonate solution and gives a brown colouration with neutral $FeCl_3$, which disappeared quickly.



XIV

Thiation of the chromone II was carried out by the use of either 2,4-bis-(4-methoxyphenyl)-1,2,3, 4-dithiadiphosphetane-2,4-disulphide (Lawesson's reagent) [9] or phosphorous pentasulphide to give 6-chloro-2-methylchromen-4-thione (XV). The former reagent has the advantage of high yield of the product and time- saving.

6-Chloro-2-methyl-4-thiochromone (XV) con -densed with aromatic aldehydes namely, anisaldehyde, p-chlorobenzaldehyde, p-nitrobenzaldehyde and piperonal in presence of piperidine to yield the desired 2-styryl derivatives XVIa-d respectively.

Aiming to synthesise the epoxide of the chromone II, we have found that epoxidation of the double bond at C_2-C_3 position in the γ-pyrone ring is highly difficult probably due to the presence of C=O group at α,β-position with respect to the double bond and the chlorine atom at the aryl ring. We could isolate only 5-chloro-2-hydroxyphenylglyoxal (XVII) and 5- chlorosalicylic acid in case of using alkaline hydrogen peroxide. The substrate chromone II was always separated whatever the reaction conditions. The product XVII gave positive Fehling's solution test, it reduced ammonical silver nitrate and restored the color of Schiff's reagent.

The structures of the products obtained were confirmed by elemental analysis, infrared spectra and ^1H and ^{13}C-nuclear magnetic resonance spectral data (c.f. Tables 1-8).

Experimental

Melting points reported are uncorrected. IR spectra in KBr were recorded on a Beckmann IR-20 spectrophotometer and Pye Unicam SP 3300 spectrophotometer. The ^1H-NMR spectra were determined on a Varian T-60 or Jeol FX 90 spectrometer. In all NMR experiments the internal standard was TMS and the solvent was $CDCl_3$. All chemical shifts are in ppm downfield from TMS. The ^{13}C-NMR spectra were determined on Jeol FX 90 Q Fourier Transform instrument operating at 22.50 MHz, 8192 data points were collected and a sweep width of 5000 Hz, i.e., digital resolution of 0.6 Hz (0.03 ppm). Pulse intervals of 5 seconds or more were used to achieve resonable signal-to-noise ratios especially for the singals of carbons of long relaxation times, e.g., C=O and C=N.

5-Chloro-2-hydroxyacetophenone was prepared from p-chlorophenylacetate ester *via* Fries rearrangement by the method of Auwers and Wittig.

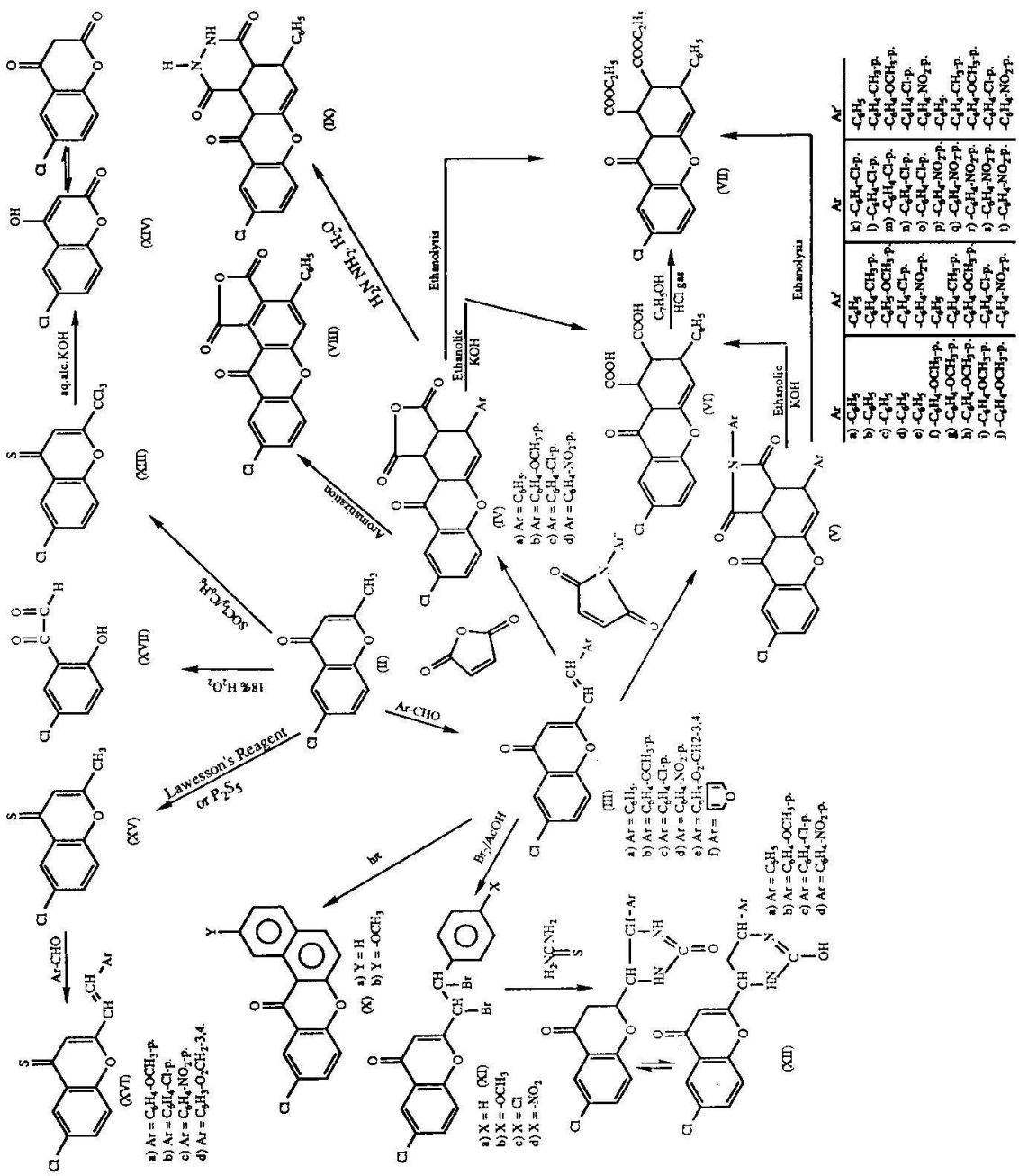

Ar-CHO
Lawesson's Reagent or P_2S_5
18% H_2O_2
$SOCl_2/C_6H_6$
aq.alc.KOH
Ethanolic KOH
Ethanolysis
C_2H_5OH / HCl gas
Aromatization
$H_2N.NH_2.H_2O$
Br
Br_2/AcOH
H_2NCSNH_2
a) Ar = C_6H_5
b) Ar = C_6H_4-OCH_3-p.
c) Ar = C_6H_4-Cl-p.
d) Ar = C_6H_4-NO_2-p.
e) Ar = C_6H_3-O_2CH_2-3,4.
f) Ar = furyl
a) X = H (XI)
b) X = $-OCH_3$
c) X = Cl
d) X = $-NO_2$
a) Y = H
b) Y = $-OCH_3$
(X)
(XII)
(XIII)
(XIV)
(XV)
(XVI)
(XVII)
(II)
(III)
(IV)
(V)
(VI)
(VII)
(VIII)
(IX)
Ar | Ar'
a) $-C_6H_5$ | $-C_6H_5$
b) $-C_6H_5$ | $-C_6H_4$-CH_3-p.
c) $-C_6H_5$ | $-C_6H_4$-OCH_3-p.
d) $-C_6H_5$ | $-C_6H_4$-Cl-p.
e) $-C_6H_5$ | $-C_6H_4$-NO_2-p.
f) $-C_6H_4$-OCH_3-p. | $-C_6H_5$
g) $-C_6H_4$-OCH_3-p. | $-C_6H_4$-CH_3-p.
h) $-C_6H_4$-OCH_3-p. | $-C_6H_4$-OCH_3-p.
i) $-C_6H_4$-Cl-p. | $-C_6H_4$-Cl-p.
j) $-C_6H_4$-OCH_3-p. | $-C_6H_4$-NO_2-p.
k) $-C_6H_4$-Cl-p. | $-C_6H_5$
l) $-C_6H_4$-Cl-p. | $-C_6H_4$-CH_3-p.
m) $-C_6H_4$-Cl-p. | $-C_6H_4$-OCH_3-p.
n) $-C_6H_4$-Cl-p. | $-C_6H_4$-Cl-p.
o) $-C_6H_4$-Cl-p. | $-C_6H_4$-NO_2-p.
p) $-C_6H_4$-NO_2-p. | $-C_6H_5$
q) $-C_6H_4$-NO_2-p. | $-C_6H_4$-CH_3-p.
r) $-C_6H_4$-NO_2-p. | $-C_6H_4$-OCH_3-p.
s) $-C_6H_4$-NO_2-p. | $-C_6H_4$-Cl-p.
t) $-C_6H_4$-NO_2-p. | $-C_6H_4$-NO_2-p.

Table-1: Physical data of compounds I, II & III_{a-f}

No	M.P.°C (colour)	Solvent of crystal-lisation/ (yield %)	M.F./(M.W)	Analysis Calcd./Found C%	H%	IR spectra (KBr) ν (cm^{-1})
I	113-114 (yellow)	Light pertrol (60-80°C) (82)	$C_{10}H_9ClO_3$ (212.5)	56.46 56.62	4.23 4.20	1700 and 1630 (keto & enol forms of β-diketo system) 3420 intensive (intramolecular hydrogen bonded -OH)
II	119-120 (yellow)	Light petrol (80-100°C) (94)	$C_{10}H_7ClO_2$ (194.5)	61.69 61.24	3.59 3.55	1680 (-CO-pyrone 1610 (C=C) 1150 (-O-) 2870 ($-CH_3$) no ν -OH
III_a	159-160 (yellow)	Benzene (82)	$C_{17}H_{11}ClO_2$ (282.5)	72.21 71.89	3.89 3.87	1645-1630 (-CO-pyrone)
III_b	186-187 (yellow)	Benzene (78)	$C_{18}H_{13}ClO_3$ (312.5)	69.12 69.42	4.16 4.12	1610-1600 (C=C) 1130-1090 (-O-) 3090-3060 (-CH trans).
III_c	244-245 (pale yellow)	Benzene (91)	$C_{17}H_{10}Cl_2O_2$ (317)	64.35 64.51	3.15 3.12	
III_d	315-316 (bright yellow)	Anisole (94)	$C_{17}H_{10}ClNO_4$ (327.5)	62.29 61.97	3.05 2.92	
III_e	240-241 (yellow)	Toluene (74)	$C_{18}H_{11}ClO_4$ (326.5)	66.16 66.30	3.37 3.24	
III_f	213-214 (yellow)	Toluene (69)	$C_{15}H_9ClO_3$ (272.5)	66.06 66.09	3.30 3.42	

Condensation of 6-chloro-2-methyl-4H-1-benzopyran-4-one (II) and/or 6-chloro-2-methyl-4H-1-benzopyran-4-thione (XV) with aromatic aldehydes; Formation of 2-styryl-6- chloro-4H-1-benzopyran-4-one (III_{a-f}) and 2-styryl-6-chloro-4H-1- benzopyran-4-thione (XVI_{a-d})

A solution of II and/or XV (0.01 mol., 1.9 g) in the least amount of absolute ethanol was treated at room temperature with alcoholic sodium ethoxide (0.23) g. of sodium metal in 40 ml. of absolute ethanol) or 5-7 drops of piperidine. The appropriate aldehyde was added and the reaction mixture was stirred for 2 hrs. [the mixture was refluxed for 6 hrs. in case of XV]. The product obtained after pouring into ice-water was filtered off and crystallized from suitable solvent to give the styryl derivatives III or XVI respectively (c.f. Table 1 & 7).

Diels-Alder reaction of the 2-styryl derivatives III_{a-d} with meleic anhydride and/or N-arylmaleimides; Formation of xanthone derivatives IV_{a-d} & V_{a-t}

0.004 mole of the 2-styryl derivative III_{a-d} was mixed with meleic anhydride (0.04 mol, 4 g.) or the appropriate N- arylmaleimide (0.008 mol) in molar ratio 1:10 (while the molar ratio was 1:2 in case of N-arylmaleimides), in 30 ml. of dry phenetole. The reaction mixture was heated under reflux for 48 hrs. (15 hrs. in case of N-arylmaleimide) left to cool and the product was filtered off and recrystallized from the proper solvent to give xanthone IV_{a-d} or V_{a-t} respectively (c.f. Tables 2 & 3).

Hydrolysis of IV_a and/or V_a; Formation of VI

The Diels-Alder adduct IV_a and/or V_a (0.5 g) was refulxed with 10% aqueous alcoholic potassium hydroxide (10-20 ml.) for 1-4 hrs. respectively.

The product that separated out after cooling was acidified with diluted hydrochloric acid, washed with water several times, dried and then crystallized from the suitable solvent to give the same dicarboxylic acid VI (c.f. Table 4).

Ethanolysis of xanthone derivative (IV_a); Formation of VII

Xanthone derivative (IV_a) (0.003 mol; 1.1 g.) was suspended in 30 ml. of absolute ethanol and

Table-2: Physical data of adducts IV_{a-d}

No.	M.P.°C (Colour)	Solvent of crystal-lisation/ (yield %)	M.F./(W.M)	Analysis Calcd./Found C%	H%	N%	IR spectra (KBr) $\nu(cm^{-1})$
IV_a	258-260 (colourless)	Anisole (46)	$C_{21}H_{13}ClO_5$ (380.5)	66.22 66.15	3.41 3.38		1860-1820 doublet 1790-1770 (-CO-anhydride)
IV_b	243-244 (colourless)	Toluene (62)	$C_{22}H_{15}ClO_6$ (410.5)	64.31 64.55	3.65 3.69		
IV_c	289.-290 (colourless)	Anisole (43)	$C_{21}H_{12}Cl_2O_5$ (415)	60.72 61.02	2.89 2.93		1650-1640 (-CO-pyrone) 1610-1600 (C=C)
IV_d	274-276 (colourless)	Xylene (38)	$C_{21}H_{12}ClNO_7$ (425.5)	59.22 59.56	2.82 3.00	3.29 3.18	

hydrogen chloride gas was passed into the suspension for 1 hr. Most of the solvent was removed and then the cold yellow solution was diluted with water. The solid that precipitated was filtered off, washed with water, dried and then crystallized from the proper solvent yielding the desired diester (VII) (cf. Table 4).

Esterification of the dicarboxylic acid (VI); Formation of VII

A mixture of the dicarboxylic acid (VI) (2g.; 0.005 mol), absolute ethanol (1 ml., 0.017 mol), 10 ml. of sodium - dried benzene and few drops of concentrated sulphuric acid was refluxed for 8 hrs. The reaction mixture was poured into excess of water. The benzene layer and the aqueous layer was extracted with ether. The combined extracts were washed with saturated sodium hydrogen carbonate solution until effervescence ceased, then with water, and dried with anhydrous sodium sulphate. The solvent was removed and the product that separated out was collected and crystallized from aqueous ethanol to give VII.

Aromatization of the xanthone derivative (IV_a); Formation of VIII

To a suspension of 1 g. xanthone derivative (IV_a) in 10 ml. of chloroform was added 10 ml. of 1 M solution of bromine in chloroform (1.6 g of bromine in 10 ml. of chloroform) dropwise and during the addition the reaction mixture was chilled in an ice - bath and stirred for 3 hrs. After the bromine solution had been added, the reaction mixture was warmed on a steam bath until the evolution of hydrogen bromide had ceased and the volume was reduced to 50%. Then absolute ethanol was added and the solution was chilled in ice. The solid that precipitated was collected, washed with water, dried and crystallized from the suitable solvent to give the aromatized adduct (VIII) (cf. Table 4).

Action of hydrazine hydrate on the xanthone (IV_a); Formation of 1,4-phthalazindione (IX)

A mixture of IV_a (0.003 mol, 1.1 g) and hydrazine hydrate (0.006 mol 0.4 ml; assay 99-100%) was heated under reflux in glacial acetic acid (20 ml) for 6 hrs. After cooling, the reaction mixture was diluted with water and the solid that separated out was filtered off and crystallized from the suitable solvent to give IX (cf. Table 4).

Reaction of primary aromatic amines with the xanthone ($IV_{a,b}$); Formation of $V_{a-d\ \&\ g-i}$

To IV_a and/or IV_b (0.003 mol) was added the appropriate primary aromatic amine namely p-toluidine, p-anisidine and p-chloroaniline (0.004 mol) in glacial acetic acid (30 ml.). The reaction mixture was refluxed for 6 hrs. The reaction mixture

Table-3: Physical data of adducts IV_{a-t}

No.	M.P.°C (Colour)	Solvent of crystal-lisation/ (yield %)	M.F./(W.M)	Analysis Calcd./Found C%	H%	N%	IR spectra (KBr) $\nu(cm^{-1})$
V_a	321-322	Anisole	$C_{27}H_{18}ClNO_4$	71.12	3.95	3.07	
	(colourless)	(72)	(455.5)	71.12	3.92	2.98	1720-1710 -CO-imide 1680-1650
V_b	317-318	Xylene	$C_{28}H_{20}ClNO_4$	71.56	4.25	2.98	1660-1630 (-CO- pyrone)
	(colourless)	(68)	(469.5)	71.82	4.19	3.00	
V_c	302-303	Xylene	$C_{28}H_{20}ClNO_5$	69.20	4.11	2.88	1620-1610 (C=C)
	(colourless)	(66)	(485.5)	68.92	4.18	2.74	
V_d	331-332	Xylene	$C_{27}H_{17}Cl_2NO_4$	66.12	3.46	2.85	
	(colourless)	(71)	(490)	66.43	3.29	2.77	
V_e	>340	Anisole	$C_{27}H_{17}ClN_2O_6$	64.73	3.39	5.59	
	(pale buff)	(72)	(500.5)	64.68	3.44	5.80	
V_f	235-236	Toluene	$C_{28}H_{20}ClNO_5$	69.20	4.11	2.88	
	(pale yellow)	(63)	(485.5)	68.97	4.15	2.72	
V_g	262-263	Toluene	$C_{29}H_{22}ClNO_5$	69.66	4.40	2.80	
	(pale yellow)	(68)	(499.5)	69.32	4.29	2.54	1720-1710 -CO-imide 1680-1650
V_h	241-242	Toluene	$C_{29}H_{22}ClNO_6$	67.50	4.26	2.71	
	(pale yellow)	(72)	(515.5)	67.29	4.16	2.63	1660-1630 (-CO-pyrone)
V_i	294-295	Anisole	$C_{28}H_{19}Cl_2NO_5$	64.61	3.65	2.64	1620-1610 (C=C)
	(pale yellow)	(63)	(520)	64.44	3.75	2.67	
V_j	279.280	Anisole	$C_{28}H_{19}ClN_2O_7$	63.33	3.58	5.27	
	(pale yellow)	(68)	(530.5)	63.60	3.47	5.40	
V_k	176.178	Toluene	$C_{27}H_{17}Cl_2NO_4$	66.12	3.46	2.85	
	(decomp.) (pale yellow)	(70)	(490)	65.48	3.32	2.79	
V_l	263-265	Benzene	$C_{28}H_{19}Cl_2NO_4$	66.66	3.76	2.77	
	(decomp.) (pale yellow)	(65)	(504)	66.50	3.82	2.70	
V_m	188-189	Anisole	$C_{28}H_{19}Cl_2NO_5$	64.61	3.65	2.69	
	(decomp.) (colourless)	(66)	(520)	64.92	3.47	2.50	
V_n	305-307	Anisole	$C_{27}H_{16}Cl_3NO_4$	61.77	3.05	2.66	
	(colourless)	(72)	(524.5)	62.11	3.22	2.62	1720-1710 -CO-imide
V_o	303-304	Anisole	$C_{27}H_{16}Cl_2N_2O_6$	60.56	2.99	5.23	
	(decomp.)	(58)	(535)	60.82	3.05	5.18	1660-1630 (-CO-pyrone)
V_p	250-252	Xylene	$C_{27}H_{17}ClN_2O_6$	64.73	3.39	5.59	1620-1610 (C=C)
	(pale yellow	(55)	(500.5)	64.64	3.18	5.48	
V_q	271-273	Xylene	$C_{28}H_{19}ClN_2O_6$	65.30	3.69	5.44	
	(pale orange)	(68)	(514.5)	65.24	3.74	5.28	
V_r	255-256	Anisole	$C_{28}H_{19}ClN_2O_7$	63.33	3.58	5.27	
	(pale buff)	(72)	(530.5)	63.20	3.64	5.19	
V_s	280-285	Xylene	$C_{27}H_{16}Cl_2N_2O_6$	60.56	2.99	5.23	
	(Shr.) (pale orange)	(62)	(535)	60.32	2.83	5.40	
	V_t	289-290	Anisole	$C_{27}H_{16}ClN_3O_8$	59.39	2.92 7.69	
	(pale buff)		(55)	(545.5)	59.64	3.00 7.53	

Table-4: Phyical data of compounds VI, VII, VIII & IX..

No.	M.P.°C (Colour)	Solvent of crystal-lisation/ (yield %)	M.F./(W.M)	Analysis Calcd./Found C%	H%	N%	IR spectra (KBr) $\nu(cm^{-1})$
VI	139-140 (decomp.) (colourless)	Benzene (62)	$C_{21}H_{15}ClO_6$ (398.5)	63.23 63.48	3.76 3.62		1690 (-CO-acid) 1650 (-CO pyrone) 1610 (C=C) 3460 (-OH acid)
VII	218-219 (colourless)	Aqueous Ethanol (1:2) (67)	$C_{25}H_{23}ClO_6$ (454.5)	66.00 65.97	5.06 4.88		1730-1700 (-CO-ester) 1640 (-CO-pyrone) 1610 (C=C) 1280 (-O-)
VIII	232-233 (decomp.) (yellow)	Benzene (84)	$C_{21}H_8ClO_5$ (375.5)	67.11 67.00	2.11 2.20		1830 1750 -CO-anhydride 1645 (-CO-pyrone) 1610 (C=C)
IX	246-247 (pale yellow)	Benzene (63)	$C_{21}H_{15}ClN_2O_4$ (394.5)	64.00 63.92	3.80 3.93	7.10 7.05	1690 1645 (CO-1,4-phthalazindione, -CO-pyrone) 1620 (C=N) 1605 (C=N) 3240 3320 (NH) 3430 (-OH)

Table-5: Physical data of compounds $X_{a,b}$ & XI_{a-d}

No.	M.P.°C (Colour)	Solvent of crystal-lisation/ (yield %)	M.F./(W.M)	Analysis Calcd./Found C%	H%	N%	IR spectra (KBr) $\nu(cm^{-1})$
X_a	148-149 (pale orange) (17)	Benzene + L.P (80-100°C)	$C_{17}H_9ClO_2$ (280.5)	72.72 72.53	3.20 3.42		1640-1635 (-CO-chromone) 1610 (C=C)
X_b	173-174 (pale orange)	Light petrol (100-120°C) (22)	$C_{18}H_{11}ClO_3$ (310.5)	69.56 69.37	3.54 3.66		1140 (-O-)
XI_a	175-178 (decomp.) (colourless)	Benzene (72)	$C_{17}H_{11}Br_2ClO_2$ (442.5)	46.10 46.46	2.49 2.33		1660-1640 (-CO-chromone)
XI_b	179-181 (decomp.) (pale yellow)	Toluene (68)	$C_{18}H_{13}Br_2ClO_3$ (472.5)	45.71 45.83	2.75 2.80		1615-1600 (C=C) 1170-1130 (-O-) 585-550 (C-Br)
XI_c	187-188 (decomp.) (pale yellow)	Toluene (71)	$C_{17}H_{10}Br_2Cl_2O_2$ (477.0)	42.76 43.00	2.09 2.10		1370 for XI_d only ($-NO_2$)
XI_d	247-248 (pale yellow)	Xylene (72)	$C_{17}H_{10}Br_2ClNO_4$ (487.5)	41.84 42.10	2.05 2.13	2.87 2.94	

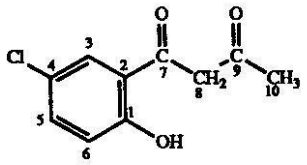
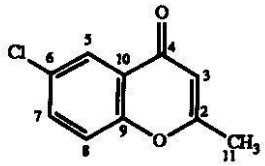
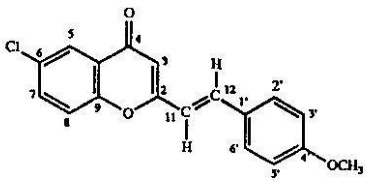
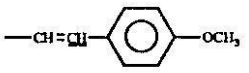
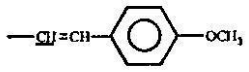
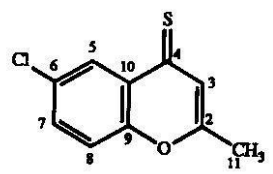
Table-6: Physical data of compounds XII_{a-d}

No.	M.P.°C (Colour)	Solvent of crystal-lisation/ (yield %)	M.F./(W.M)	Analysis Calcd./Found C%	H%	N%	IR spectra (KBr) $\nu(cm^{-1})$
XII_a	146-147 (yellow)	LP (100-120°C) (34)	$C_{18}H_{13}ClN_2O_3$ (340.5)	63.44 63.65	3.82 3.76	8.22 8.17	1710-1690 (-CO-pyrazolone)
XII_b	158-159 (orange)	LP (100-120°C) (28)	$C_{19}H_{15}ClN_2O_4$ (370.5)	61.45 61.97	4.05 3.94	7.56 7.68	1660-1640 (-CO-chromone)
XII_c	195-196 (intense yellow)	Benzene + L.P. (80-100°C) (31)	$C_{18}H_{12}Cl_2N_2O_3$ (375.0)	57.60 57.74	3.20 3.29	7.47 7.60	1620 (C=N) 1610-1600 (C=C) 3230-3190 (NH) 3450 (-OH)
XII_d	>360 (deep orange)	Ethyl acetate (27)	$C_{18}H_{12}ClN_3O_5$ (385.5)	56.03 56.21	3.11 3.17	10.89 10.96	

Table-7: Physcal data of compounds XIII, XIV, XV, XVL_{a-d} & XVII

No.	M.P.°C (Colour)	Solvent of crystal-lisation/ (yield %)	M.F./(W.M)	Analysis Calcd./Found C%	H%	N%	IR spectra (KBr) $\nu(cm^{-1})$
XII	338-340 (green)	Ethyl-acetate (38)	$C_{10}H_4Cl_4O_2$ (298)	40.30 40.55	1.30 1.40	1	1640 (-CO- chromone) 605 (C=C) 1180 (-O-)
XIV	298-299 (brown)	Xylene (29)	$C_9H_5ClO_3$ (196.5)	54.98 55.05	2.49 2.53		3380 strong (-OH) 1720 (β-diketone) 1645 (-CO-chromone) 1610 (C=C) 1120 (-O)
XV	139.140 (deep purple) (92)	Benzene + L.P. (80-100°C)	$C_{10}H_7ClOS$ (210.5)	57.00 56.98			3.32 1610 (C=C) 3.41 1350 (C=S) 1170 (-O-)
XVI_a	195-196 (wine-red)	Benzene (74)	$C_{18}H_{13}ClO_2S$ (328.5)	65.75 65.60	3.95 3.97		no ν-CO-chromone 1360 (C=S) 1610-1600 (C=C) 1090-1140 (-O-)
XVI_a	249-250 (orange)	Benzene (78)	$C_{17}H_{10}Cl_2OS$ (333.0)	61.26 61.16	3.00 3.03		3040-3120 (CH-trans)
XVI_c	308-309 (brown)	Anisole (81)	$C_{17}H_{10}ClNO_3S$ (343.5)	59.38 59.25	2.91 2.90	4.07 4.05	
XVI_d	235-236 (deep purple)	Xylene (79)	$C_{18}H_{11}ClO_3S$ (342.5)	63.06 63.43	3.21 3.20		
XVII	121-122 (colourless	L.P. (80-100°C) + Benzene (38)	$C_8H_5ClO_3$ (184.5) 5	52.03 2.10	2.71 2.94		1720 (α- dicarbonyl) 1690 (C=O) 1660 (C HO) 1590 (C = C) 3450 (-OH)

Table-8: ^{1}H-NMR and ^{13}C-NMR data of some synthesised new compounds

Compound Structural formula	^{1}H-NMR δ-value	No. of H (splitting)	Group	^{13}C-NMR δ-value (ppm)	Carbon atom
I. 	2.62	3H(S)	-CO-CH$_3$	16.9	C_1
	3.77	2H(S)	-C-CH$_2$	123.6	C_2
			probably exists	127.7	C_3
			about 5% in enol	124.9	C_4
			form -C = CH-	135.7	C_5
	6.11	1H (S)	phenolic -OH	119.8	C_6
				194.1	C_7
	7.3-7.6	3H (m)	aromatic protons	95.3	C_8
				183.9	C_9
II 	2.38	3H(S)	-CH$_3$	19.8	C_{11}
	6.1	1H(S)	-CO-CH=C	165.6	C_2
				134.8	C_3
	7.3-7.6	3H(m)	aromatic protons	176.4	C_4
				127.8	C_5
				125.1	C_6
				133.6	C_7
				119.7	C_8
				153.0	C_9
				123.4	C_{10}
IIIb 	3.85	3H(S)	O-CH$_3$	55.3	Ar-OCH$_3$
	6.20	1H(S)	olefinic proton of pyrone ring	162.6	C_2
	6.6-6.68	1H(d)	—CH=CH— 	177.8	C_4
	6.88-6.90	1H(d)	—CH=CH— 	129.3	C_5
				124.9	C_6
	The ethylenic bond has a trans configuration (J = 15.86 Hz.)			133.6	C_7
	7.5-8.1 7H (m) aromatic protons			119.4	C_8
				153.2	C_9
				123.1	C_{10}
				137.0	C_{11}
				137.1	C_{12}
				134.8	C_1'
				129.3	C_2'
XV 				157.6	C_2
				133.7	C_3
				200.9	C_4
				131.9	C_5
				127.6	C_6
				133.7	C_7
				199.9	C_8
				150.1	C_9
				123.4	C_{10}
				19.8	C_{11}

was left to cool and then poured into ice-water. The products that separated out were collected and crystallized from the proper solvents to give products which arefound to be identical with (V_{b-d} & g-i).

Photocyclization of 2-styryl-4H-chromen-4-ones ($III_{a,b}$); Formation of 12-H-benzo [a] xanthen-12-ones ($X_{a,b}$).

Method (A)

A solution of 1 g of each of 2-styryl-4H-chromen-4-ones ($III_{a,b}$) in 500 ml. benzene was irradiated in a quartz immersion apparatus equipped with high pressure mercury - lamp (Toshiba 400 p) which was cooled internally with running water. Irradiation was conducted through a pyrex filter under air with stirring. The irradiation was continued till the starting material has disappeared (15-20 hrs.) The solvent was evaporated under reduced pressure and the residue was purified by crystallization from the proper solvent to give $X_{a,b}$ respectively (cf. Table 5).

Method B

A solution of 1 g. of chromone derivatives ($III_{a,b}$) in 500 ml. benzene was irradiated by direct sunlight for 7 days at room temperature, the solvent was evaporated under reduced pressure and the solid separated out was filtered and crystallized from the proper solvent to yield $X_{a,b}$ respectively but the yield % of the product was less than that in method (A).

Bromination of 2-styryl-4H-ones (III_{a-d}); Formation of (Xi_{a-d}).

To a warm solution or suspension of 2-styryl-4H-chromen-4-ones (III_{a-d}) (0.004 mol; 1.2 g) in glacial acetic acid (15 ml), bromine (0.008 mol, 0.5 ml) dissolved in 3 ml of glacial AcOH was added dropwise with continuous stirring. The reaction mixture was left overnight at room temperature, poured into ice/water. The solid deposited was filtered and crystallized from the suitable solvent to give the dibromides (IX_{a-d}) (cf. Table 5).

Action of thiourea on dibromo-derivatives (XI_{a-d}); Formation of (XII_{a-d}).

In a 250 ml round-bottomed flask fitted with reflux condenser were placed 20 ml. of 95% ethanol and thiourea (0.004 mol, 0.3 g). The mixture was heated under reflux on a steam bath. About 0.002 mol, 1g, of dibromide was added, then the reaction mixture was refluxed for 5 hrs., then 20 ml of 95% ethanol was added. After the reaction mixture had been cooled, potassium hydroxide solution (0.02 mol, 1.5 g in 10 ml of distilled water) was added to the reaction mixture and the latter was refluxed again for another 5 hrs., coold and acidified with cold conc. sulphuric acid. The product that separated out was filtered off, washd with water, dried and then crystallized from the proper solvent, to give XII_{a-d} (cf. Table 6). In the same wasy the products $XII_{a,b}$ were obtained in the high yield by the action of urea on the dibromides ($XI_{a,b}$)..

Action of thionyl chloride on 6-chloro-2-methyl-chromone (II); Formation of XIII

The chromon (II) (0.02 mol, 3.9 g) was dissolved freely in benzene (50 ml), the thionyl chloride (0.80 mol, 7 ml.) was addedand the reaction mixture was refluxed for 3 hrs. on a water bath at 70°C. A solid began to deposit after one hr. The solid obtained after concerntration under fuming cupboard was collected and purified by crystallization to give XIII (cf. Table 7).

Action of aqueous alcoholic potassium hydroxide on (XIII); Formation of XIV

A mixture of 1 g of compound XIII and aqueous ethanolic 10% KOH (20 ml.) was heated under reflux for 3 hrs. The solid that separated out after cooling and acidification by 10% cold sulphuric acid was filtered off and crystallized from the proper solvent to give XIV as brown solid (cf. Table 7).

Thiation of 6-chloro-2-methylchromone (II); Formation of 6- chloro-2-methyl-4H-chromen-4-thione CXV

Method (A) by Lawesson's Reagent

To chromone (II) (0.01 mol; 1.9 g) in dry toluene (20 ml) was added (0.005 mol; 2.02 g.) of 2,4-bis (4-methoxyphenyl) 1,3,2,4-dithiadiphosphetane 2,4-disulphide (Lawesson's Reagent).

The reaction mixture was refluxed for 30 minutes and the red crystalline solid that deposited after cooling was collected and crystallized from the proper solvent to give XV.

Method (B): By Phosphorus Pentasulphide

A mixture of chromone (II) (0.01 mol; 1.9 g.) and phosphorus pentasulphide (0.02 mol. 4.6 g.) was refluxed in dry xylene (50 ml.) for 4 hrs.

The reaction mixture was filtered off while hot, left to cool at room temperature and the solid that separated out was crystallized from the proper solvent to give a solid which was found to be identical with the product of method (A). (cf. Table 7).

Effect of alkaline hydrogen peroxide on chromone (II); Formation of XVII and 5-chlorosalicyclic acid

To 2 g. of the chromone (II) dissolved in 30 ml. of methanol and one ml. of 4N aqueous sodium hydroxide, hydrogen peroxide (4 ml, 18%) was added dropwise with continuous stirring for 2 hrs. while the reaction mixture was cooled to 5-8°C using ice- NaCl mixture. The reaction mixture was left at room temperature overnight and then neutralized with cold dilute (10%) sulphuric acid. The solid precipitated was washed with water, dried and crystallized from the proper solvent to give 5-chloro-2- hydroxyphenyl glyoxal (XVII) (cf. Table 7).

When the above reaction was conduced by 30% hydrogen peroxide; 5- chlorosalicylic acid was isolated and identified.

References

1. S.M. Sami, A.A. Sayed and S.S.Ibrahim, *Egypt.J.Chem., 23(5), 337 (1980).*
2. Auwers and Wittig, *Ber.*, **57**, 1270 (1924).
3. I.Yokoe, K. Higuchi, Y. Shirataki and M. Komatsu, *Chem.Pharm.Bull.*, **29**(9), 2670 (1981).
4. A.A. Sammour, M.I.B. Selim and Y.A El-Rehim, *J.Chem.U.A.R.*, **12**, 493 (1969).
5. M.A.I. Salem, A.M. El-Gendy and S.L. El-Nagdy, *Ain Shams.Sci.Bull.*, **27** ('1985) (in press).
6. M. Sainsbury, *Tetrahedron* **36**, 3327 (1980).
7. A.A. Sammour, M.A. El-Kassaby, M.A. Hassan and M.A.I. Salem, *Egypt. J.Chem.*, **19**(6), 989 (1977).
8. J.R. Merchant, A.R. Bhat, and D.V. Rege, *Tetrahedron Letters*, **20**, 2061 (1972).
9. I.Thomsen, K. Clausen, S. Scheibye and S.Lawesson, *Organic Synthesis*, **62** 158.