Benzopyrones. Part X.[1] Bromination of Chromones and Coumarins with Dibromoisocyanuric Acid. Nitrations of Chromones

By **Gwynn P. Ellis** * and **Idris L. Thomas**, Department of Chemistry, University of Wales Institute of Science and Technology, Cardiff CF1 3NU

The bromination of benzopyrones with dibromoisocyanuric acid (DBI) (12) has been investigated. Chromone, ethyl 4-oxochromen-2-carboxylate, and ethyl 2-oxochromen-3-carboxylate each gave the 6-bromo-derivative on monobromination. Treatment of chromone with 2 mol. equiv. of DBI gave 5,6,8-tribromochromone (9) and a little 3,5,6,8-tetrabromochromone (10); similar treatment of ethyl 4-oxochromen-2-carboxylate gave the 5,6,8-tribromo-product (9); ethyl 5,6,7,8-tetrabromo-2-oxochromen-3-carboxylate (17) was the product from ethyl 2-oxochromen-3-carboxylate under the same conditions. These products were identified by n.m.r. spectroscopy and by chemical means. Attempted monobromination of coumarin failed to give a single product, but with 3 mol. equiv. of DBI 3,5,6,7,8-pentabromocoumarin (15) was obtained. Some ambiguity concerning the identity of the products from the nitration of chromone and 3-methylchromone has been resolved. In both cases nitration occurred at C-6.

CHROMONE (1) is resistant to substitution by bromine, both by direct electrophilic attack and by addition–elimination at the 2,3-double bond.[2] The latter process has been accomplished, however, by addition of bromine to a concentrated solution of chromone in carbon disulphide and subsequent dehydrobromination to give 3-bromochromone (2),[3] although the conditions must be carefully controlled to avoid the formation of bischromone hydrotribromide, $(C_9H_6O_2)_2,HBr,Br_2$.[3,4] The only account of substitution in the unactivated benzene ring of

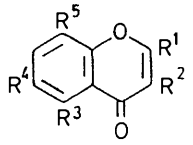
[1] Part IX, G. Barker, G. P. Ellis, and D. Shaw, *J. Medicin. Chem.*, 1973, **16**, 87.

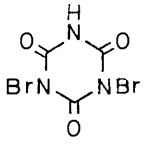
[2] A. Albert, 'Heterocyclic Chemistry,' 2nd edn., The Athlone Press, London, 1968, p. 351.

[3] (*a*) F. Arndt, W. Flemming, E. Scholz, V. Lowensohn, G. Källner, and B. Eistert, *Ber.*, 1925, **58**, 1612; (*b*) J. Colonge and A. Guyot, *Bull. Soc. chim. France*, 1958, 329.

[4] R. D. Desai, *Rasayanam*, 1938, **1**, 155.

a chromone is the reaction of 2,3-dimethylchromone with bromine and a trace of iodine in carbon disulphide at 140° under pressure.[5] The products were a tetrabromo-compound and two tribromo-derivatives which were not identified further; there was some evidence for the presence of dibromomethyl groups and of bromine in the benzene ring. Activation by hydroxy-groups results in ready bromination of the aromatic ring of substituted chromones.[6]





(1) $R^1=R^2=R^3=R^4=R^5=H$

(2) $R^1=R^3=R^4=R^5=H$, $R^2=Br$

(3) $R^1=R^2=R^3=R^5=H$, $R^4=Br$

(4) $R^1=CO_2H$, $R^2=R^3=R^5=H$, $R^4=Br$

(5) $R^1=CO_2Et$, $R^2=R^3=R^5=H$, $R^4=Br$

(6) $R^1=CO_2Et$, $R^2=R^5=H$, $R^3=R^4=Br$

(7) $R^1=CO_2Et$, $R^2=H$, $R^3=R^4=R^5=Br$

(8) $R^1=CO_2H$, $R^2=H$, $R^3=R^4=R^5=Br$

(9) $R^1=R^2=H$, $R^3=R^4=R^5=Br$

(10) $R^1=H$, $R^2=R^3=R^4=R^5=Br$

(11) $R^1=R^3=H$, $R^2=R^5=Br$, $R^4=NO_2$

(12)

Dibromoisocyanuric acid (DBI) (12), in which both bromine atoms are available for substitution reactions, was recently shown to be a powerful electrophilic brominating agent effective with many aromatic substrates rendered resistant to electrophilic attack by strongly deactivating substituents.[7] We have investigated the bromination of several benzopyrones with this reagent.

Monobromination of chromone with DBI proceeded readily to give 6-bromochromone (3), identified from its n.m.r. spectrum (Table 1) with use of a lanthanide shift reagent to resolve the δ 7·5—8 region, and by independent synthesis from 6-bromo-4-oxochromen-2-carboxylic acid (4). This was prepared from 5′-bromo-2′-hydroxyacetophenone and diethyl oxalate *via* the ester (5),[8] and gave the chromone (3) on decarboxylation.

When chromone was treated with more than 1·5 mol. equiv. of DBI, a tribromo-derivative was the usual product, but on certain occasions a small quantity of a tetrabromochromone was obtained. Attempts to modify the reaction conditions to standardise the preparation of this latter product and to improve the yield (by performing the reaction at elevated temperatures and in fuming sulphuric acid) were not successful. The structure of these products is discussed later.

Ethyl 4-oxochromen-2-carboxylate was monobrominated to give the known [8] 6-bromo-isomer (5); the presence of an excess of DBI led to formation of a tribrominated product in good yield. In the spectrum of the tribromo-ester a singlet, δ 7·13, arises from the C-3 proton [6a] and the sole aromatic proton gives a singlet at δ 8·23. In order to elucidate the structure of this product the bromination was carried out with 1·25 mol. equiv. of DBI (2·5 equiv. Br) to give a mixture of mono-, di-, and tri-substituted products. The disubstituted product was isolated by fractional recrystallisation and its n.m.r. spectrum was consistent with structure (6). Comparison of the spectra of the three bromination products of ethyl 4-oxochromen-2-carboxylate indicates that when compound (6) is brominated further, the additional bromine atom is at C-8, *i.e.* the tribrominated product is ethyl 5,6,8-tribromo-4-oxochromen-2-carboxylate (7). Acidic hydrolysis of this ester and decarboxylation of the resulting acid (8) gave 5,6,8-tribromochromone (9), identical with the tribromochromone obtained by direct bromination of chromone. The absence of a signal at about δ 6·4 in the spectrum of the tetrabromochromone indicates that it is 3,5,6,8-tetrabromochromone (10).

The presence of a nitro-group in the 6-position of chromone does not prevent the introduction of bromine into the molecule by DBI. Thus, a dibromo-6-nitrochromone was readily prepared by use of 1 mol. equiv. of

TABLE 1

N.m.r. spectra of the products of bromination with DBI

Compound	Ring proton shifts (δ values; *J* in Hz) 2	3	4	5	7	8	Solvent
(3)	7·83, *J* 6·5	6·35, *J* 6·5		8·32, *J* 2·0	*a*	7·35, *J* 8·7	$CDCl_3$
(3) [b]	8·20, *J* 6·5	7·35, *J* 6·5		9·25, *J* 2·0	7·92, *J* 2·0, 8·7	7·60, *J* 8·7	$CDCl_3$
(5)		7·10		8·31, *J* 2·0	7·82, *J* 2·0, 8·7	7·52, *J* 8·7	$CDCl_3$
(6)		7·08			7·92, *J* 8·5	7·48, *J* 8·5	$CDCl_3$
(7)		7·13			8·23		$CDCl_3$
(9)	7·86, *J* 6·5	6·43, *J* 6·5			8·18		$CDCl_3$
(10)	9·0				8·58		$(CD_3)_2SO$
(11)	9·08			8·89, *J* 2·8	8·70, *J* 2·8		$(CD_3)_2SO$
(14)	8·33, *J* 2·2	7·06, *J* 2·2					$(CD_3)_2SO$
(15)			8·42				$(CD_3)_2SO$
(18)		6·71, *J* 10·0	8·12, *J* 10·0				$(CD_3)_2SO$
(19)			8·84				$CDCl_3$

[a] Obscured by C-2 signal. [b] Compound (3) + $Eu(dpm)_3$ (0·13 mol. equiv.)

[5] H. Simonis and L. Herovici, *Ber.*, 1917, **50**, 646.

[6] G. Barker and G. P. Ellis, *J. Chem. Soc.* (*C*), (*a*) 1970, 2230; (*b*) 1970, 2609.

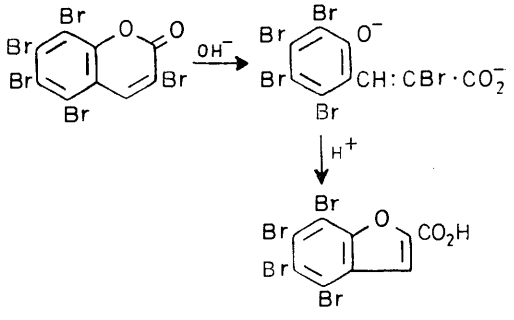
[7] W. Gottardi, *Monatsh.*, 1968, **99**, 815; 1969, **100**, 42.

[8] V. A. Zagorevskii, D. A. Zykov, and E. K. Orlova, *J. Gen. Chem.* (*U.S.S.R.*), 1961, **31**, 523.

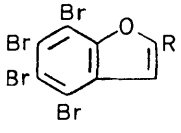
this reagent. Its n.m.r. spectrum showed a singlet (δ 9·08) and a pair of doublets (J 2·8 Hz). The magnitude of the coupling constant and the chemical shift of the singlet led to the conclusion that the product was 3,8-dibromo-6-nitrochromone (11).

Coumarin is known to be more readily brominated than chromone. It adds bromine to give 3,4-dibromo-3,4-dihydrocoumarin, which gives 3-bromocoumarin on dehydrobromination.[9] The introduction of bromine into the benzene ring of coumarin has been accomplished by use of the ' swamping catalyst ' technique in which the aluminium chloride complex of coumarin is treated with bromine in the absence of a solvent.[10] The product is 6-bromocoumarin, which has also been prepared in poor yield from the reaction of hypobromous acid with the heterocycle.[11]

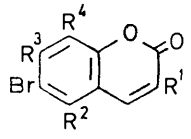
Attempted monobromination of coumarin with DBI gave a mixture of products; similarly, attempts to synthesise a single dibromocoumarin were unsuccessful. No attempt was made to isolate and identify the products of these reactions. However, on reaction with 3 mol. equiv. of DBI, coumarin gave a pentabrominated product. In order to identify this compound it was necessary to locate the sole remaining hydrogen atom. When a 3-halogenocoumarin is warmed with alkali the pyrone



SCHEME



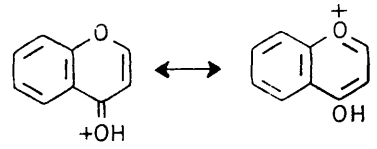
(13) R = CO_2H
(14) R = H



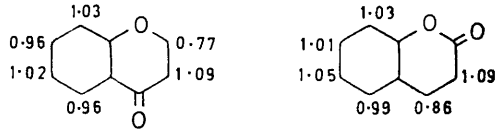
(15) $R^1 = R^2 = R^3 = R^4 = Br$
(16) $R^1 = CO_2Et$, $R^2 = R^3 = R^4 = H$
(17) $R^1 = CO_2H$, $R^2 = R^3 = R^4 = Br$
(18) $R^1 = H$, $R^2 = R^3 = R^4 = Br$
(19) $R^1 = CO_2Et$, $R^2 = R^3 = R^4 = Br$

ring is opened; recyclisation then occurs to give a benzofuran-2-carboxylic acid (coumarillic acid) (see Scheme).[9] When the pentabromocoumarin was treated in this way, the product was a tetrabromobenzofuran-2-carboxylic acid (13), which indicated the presence of a bromine atom at C-3 of the original coumarin. Decarboxylation of the acid (13) gave a tetrabromobenzofuran (14), the n.m.r. spectrum of which showed a pair of doublets (J 2·2 Hz,a value typical for $J_{2,3}$ in a benzofuran [12]) indicating that the product was 3,5,6,7,8-pentabromocoumarin (15).

Whereas attempted monobromination of coumarin gave a mixture of products, ethyl 2-oxochromen-3-carboxylate readily gave the known 6-bromo-isomer



(20) (21)



Electron density diagrams for chromone [17] and coumarin [18]

(16) [13] on similar treatment. When sufficient DBI was employed a tetrasubstituted product was obtained; in order to identify this unambiguously it was subjected to hydrolysis [to (17)] and decarboxylation. This procedure gave a tetrabromocoumarin (18) whose n.m.r. spectrum consisted of a pair of doublets (J 10·0 Hz), indicating that the original product was ethyl 5,6,7,8-tetrabromo-2-oxochromen-3-carboxylate (19).

Coumarin and chromone are weak bases and form salts in strongly acidic solutions and with Lewis acids.[14] In all cases the carbonyl oxygen atom is the electron donor [15] (20) and there is evidence that the 4-hydroxybenzopyrylium structure (21) contributes to the resulting cation for chromone.[16] The electron density distribution has been calculated for both molecules [17,18] (see Figure), but the results are not directly relevant to electrophilic bromination with DBI, as the reaction medium employed is concentrated sulphuric acid. Nevertheless the products obtained can be reconciled with the electron density maps to a certain degree. Thus, for chromone, the calculations suggest that C-3 is most prone to electrophilic attack, followed by C-8 and C-6. The protonation of the pyrone ring accounts for the lack of reactivity of C-3 under these conditions and thus the formation of

[9] R. C. Fuson, J. W. Kneisley, and E. W. Kaiser, *Org. Synth.*, 1960, Coll. Vol. III, p. 209.
[10] D. E. Pearson, W. E. Slomper, and B. R. Suthers, *J. Org. Chem.*, 1963, **28**, 3147.
[11] J. Read and W. G. Reid, *J. Chem. Soc.*, 1928, 745.
[12] P. J. Black and M. L. Heffernan, *Austral. J. Chem.*, 1965, **18**, 353.
[13] R. O. Clinton and S. C. Laskowski, *J. Amer. Chem. Soc.*, 1949, **71**, 3602.
[14] G. T. Morgan and F. M. G. Micklethwait, *J. Chem. Soc.*, 1960, 863; M. V. Vol'kenstein and Y. K. Syrkin, *Acta Physicochim. (U.S.S.R.)*, 1939, **10**, 677; M. Gomberg and L. H. Cone, *Annalen*, 1910, **376**, 183.
[15] R. C. Gibbs, J. R. Johnson, and E. C. Hughes, *J. Amer. Chem. Soc.*, 1930, **52**, 4895; J. T. Struckov, A. I. Kitaigorodski, and T. L. Chozionova, *Doklady Akad. Nauk S.S.S.R.*, 1953, **93**, 675.
[16] D. Cook, *Canad. J. Chem.*, 1963, **41**, 505; M. H. Palmer, ' Heterocyclic Compounds,' Arnold, London, 1967, p. 226.
[17] A. A. Efimov and V. M. Komarov, *Opt. Spectrosk.*, 1971, **30**, 19.
[18] D. K. Chatterjee and K. Sen, *J. Indian Chem. Soc.*, 1969, **46**, 639.

6-substituted products from both chromone and ethyl 4-oxochromen-2-carboxylate on monobromination is not unexpected. On further bromination it was found that C-5 and C-8 were most susceptible to electrophilic substitution and, in the case of chromone, it was also possible to introduce a bromine atom at C-3. The relative lack of reactivity of C-8 and enhanced reactivity of C-5 may be a consequence of the contribution of the 4-hydroxybenzopyrylium (21) form to the protonated chromone structure (*cf.* the *meta*-nitration of anilinium sulphate), and of the directing influence of the 6-bromo-substituent. The C-7 position of the chromone ring was found to be resistant to electrophilic attack under these circumstances. That this is not due to a steric effect is shown by the substitution of bromine into all four vacant positions of the benzene rings of coumarin and ethyl 2-oxochromen-3-carboxylate. The electron density map of coumarin indicates the lack of reactivity of C-4 towards electrophiles and this is borne out by the inability of DBI to brominate the ring at this position in both cases considered.

This work demonstrates the value of DBI as a rapid, low-temperature electrophilic brominating agent in a strongly acidic medium.

Two reports disagree on the structure of the nitration product of chromone: in 1956, the product was described as 8-nitrochromone [19] and a recent textbook [20] repeats this assertion. The structure of the product was demonstrated [19] by degradation to the nitro-2′-hydroxyacetophenone, m.p. 103—104°, which did not depress the melting point of ' 2-hydroxy-3-nitroacetophenone.' The structure of the latter was not proved, neither was its synthesis described. Similarly, it was concluded that 3-methylchromone gave the 8-nitro-derivative. In 1959 Indian workers [21] degraded their nitrochromone and obtained 2′-hydroxy-5′-nitroacetophenone, m.p. 99°, which was synthesized by way of a Fries reaction on 4-nitrophenyl acetate.

We have repeated the nitration of chromone following Da Re's procedure; [19] degradation and spectral analysis showed the only product to be the 6-nitro-compound. 3-Methylchromone has been similarly shown to be nitrated at C-6. These and earlier [6a] results show that chromone, 2- and 3-alkyl-, 2-alkoxycarbonyl-, and 2,3-dialkylchromones are nitrated at C-6.

EXPERIMENTAL

M.p.s were determined on a Reichert hot-stage apparatus. N.m.r. spectra were obtained with a Perkin-Elmer R10 (60 MHz) instrument (tetramethylsilane as internal reference).

The following compounds were prepared by published methods: chromone,[22] ethyl 4-oxochromen-2-carboxylate,[23] 6-bromo-4-oxochromen-2-carboxylic acid,[8] 6-nitrochromone,[21] ethyl 2-oxochromen-3-carboxylate,[24] and 3-methylchromone.[25]

TABLE 2

Bromination products

Compound	M.p. (°C)	Yield (%)	Solvent [a]	Found (%) C	Found (%) H	Formula	Required (%) C	Required (%) H
(3)	136—137	60	C	47·9	2·1	$C_9H_5BrO_2$	48·0	2·2
(6)	178—180		A, C	38·2	2·1	$C_{12}H_8Br_2O_4$	38·3	2·1
(7)	186—187	77	A	31·9	1·6	$C_{12}H_7Br_3O_4$	31·7	1·6
(8)	294—295	95	D	28·0	0·7	$C_{10}H_3Br_3O_4$	28·1	0·7
(9) [b]	245	57	C	28·5	1·0	$C_9H_3Br_3O_2$	28·2	0·8
(10)	222—223	18	A, C	23·0	0·4	$C_9H_2Br_4O_2$	23·4	0·4
(11) [c]	218	51	B	31·4	1·0	$C_9H_3Br_2NO_4$	31·0	0·9
(13)	>325	79	D	22·9	0·4	$C_9H_2Br_4O_3$	22·6	0·4
(14)	197 [d]	15	A, E	22·5	0·4	$C_8H_2Br_4O$	22·2	0·5
(15)	224—225	44	D	19·5	0·2	$C_9HBr_5O_2$	19·7	0·2
(16)	166—167 [e]	83	A					
(17)	257—258	70	D	23·7	0·5	$C_{10}H_2Br_4O_4$	23·8	0·4
(18)	221—222	10	C, D	23·4	0·4	$C_9H_2Br_4O_2$	23·4	0·4
(19)	199—200	57	C	26·7	1·2	$C_{12}H_6Br_4O_4$	27·0	1·1

[a] Solvents for recrystallisation: A, EtOH; B, benzene; C, benzene–petroleum (b.p. 60—80°); D, HOAc; E, AcOEt. [b] Prepared by decarboxylation of (9); yield 13%. [c] Found: N, 4·2. Required: N, 4·0%. [d] Sublimes. [e] Lit.,[13] 168—169°.

Brominations.—Compounds (3), (5), (7), (11), (15), (16), and (19) were prepared by adding the appropriate benzopyrone (0·007 mol) to a stirred solution of DBI [7] [0·0035 mol (for monobromination) or the required multiple thereof] in concentrated sulphuric acid (*d* 1·84; 20 cm³ per g of DBI) at room temperature. After 0·5 h [for (3), (5), and (16)] or 1 h [for (7), (11), (15), and (19)] the solution was poured into ice–water; the precipitate was filtered off and extracted with chloroform. The extract was filtered and dried (Na_2SO_4); removal of the solvent gave the crude bromo-product (Table 2).

Hydrolysis of the Esters (5), (7), *and* (19).—The ester (0·005 mol) in glacial acetic acid (30 cm³) and concentrated hydrochloric acid (10 cm³) was heated under reflux for 4—5 h and the cooled solution was poured into water (50 cm³). The product was filtered off and recrystallised to give the acids (4), (8), and (17) respectively.

Decarboxylation of Compounds (4), (8), (13), *and* (17).—The acid (0·002 mol) and an equal weight of charcoal were heated

[19] P. Da Re, *Farmaco, Sci. Ed.*, 1956, **11**, 662.
[20] J. A. Joule and G. F. Smith, ' Heterocyclic Chemistry,' Van Nostrand–Reinhold, London, 1972, p. 174.
[21] P. P. Joshi, T. R. Ingle, and B. V. Bhide, *J. Indian Chem. Soc.*, 1959, **36**, 59.
[22] R. Heywang and S. V. Kostanecki, *Ber.*, 1902, **35**, 2887.
[23] Z. J. Vejdelek, V. Trcka, O. Chyba, and H. Chybova, *Chem. listy*, 1953, **47**, 575.
[24] E. C. Horning, M. G. Horning, and D. A. Dimmig, *Org. Synth.*, Coll. Vol. III, 1960, p. 165.
[25] M. Clerk-Bory, H. Pacheco, and C. Mentzer, *Bull. Soc. chim. France*, 1955, 1083.

over a Bunsen burner at 10—30° above the m.p. of the acid for 5 min. The residue was cooled and was extracted with warm chloroform. The charcoal was filtered off and the chloroform solution was extracted with 10% sodium carbonate solution, washed with water, dried, and evaporated. Recrystallisation of the residue gave the products (3), (9), (14), and (18), respectively.

Ethyl 5,6-Dibromo-4-oxochromen-2-carboxylate (6).—Ethyl 4-oxochromen-2-carboxylate (3 g, 0·0133 mol) was added to a solution of DBI (4·8 g, 0·0166 mol) in concentrated sulphuric acid (90 cm³) and after 1 h the mixture was worked up as already described. The solid so obtained was recrystallised from ethanol and gave a product which was shown by n.m.r. spectroscopy to consist of the *dibromo-compound* (6) and *ethyl 5,6,8-tribromo-4-oxochromen-2-carboxylate* (7). It was recrystallised again from ethanol and an impure sample of (7) was deposited. The mother liquors were evaporated and the residue was recrystallised from ethanol and twice from benzene—petroleum (b.p. 60—80°) to give a pure sample of compound (6).

5,6,8-Tribromochromone (9) *and 3,5,6,8-Tetrabromochromone* (10).—When chromone (1 g, 0·0068 mol) was added to a solution of DBI (6 g, 0·021 mol) in concentrated sulphuric acid (100 cm³) and the mixture was worked up in the usual manner, the product obtained after recrystallisation from benzene–petroleum (b.p. 60—80°) was *5,6,8-tribromochromone* (1·5 g). In some experiments *3,5,6,8-tetrabromochromone* (0·6 g) was isolated.

4,5,6,7-Tetrabromobenzofuran-2-carboxylic Acid (13).—A suspension of 3,5,6,7,8-pentabromocoumarin (1 g, 0·0019 mol) in 10% potassium hydroxide solution (20 cm³) was refluxed for 1 h. The cooled solution was acidified with dilute hydrochloric acid and the precipitate was filtered off and recrystallised to give the *tetrabromide* (13) as fine white needles.

Nitration of Chromone.—To chromone (2 g) dissolved in concentrated sulphuric acid (5 cm³) at 0°, a mixture of fuming nitric acid (*d* 1·5; 0·6 cm³) in concentrated sulphuric acid (2 cm³) was added slowly with stirring. Stirring was continued for 2 h while the temperature was allowed to reach that of the surroundings. When the mixture was poured on crushed ice, a yellow solid precipitated. Recrystallization from benzene gave 6-nitrochromone (1·7 g, 65%), m.p. 173—175° (lit.,[21] 170—171°), δ 9·00 (1H, d, *J* 3·0 Hz, 5-H), 8·58 (1H, q, *J* 9 and 3·0 Hz, 7-H), 8·15 (1H, d, *J* 6·5 Hz, 2-H), 7·73 (1H, d, *J* 9 Hz, 8-H), and 6·45 (1H, d, *J* 6·5 Hz, 3-H).

Alkaline hydrolysis [6a] of the nitrochromone gave an 84% yield of 2′-hydroxy-5′-nitroacetophenone, m.p. 99° (from ethanol) (lit.,[21] 99°), δ 8·80 (1H, d, *J* 2·6 Hz, 6′-H), 8·44 (1H, q, *J* 8 and 2·6 Hz, 4′-H), 7·16 (1H, d, *J* 8 Hz, 3′-H), and 2·75 (3H, s, Me).

Nitration of 3-Methylchromone.—A similar procedure gave a 78% yield of *3-methyl-6-nitrochromone*, m.p. 147—148° (from benzene), δ 9·10 (1H, d, *J* 3 Hz, 5-H), 8·55 (1H, q, *J* 9·0 and 2·8 Hz, 7-H), 7·98 (1H, s, 2-H), 7·67 (1H, d, *J* 9·0 Hz, 8-H), and 2·10 (3H, s, Me) (Found: C, 58·2; H, 3·5; N, 6·8. $C_{10}H_9NO_4$ requires C, 58·5; H, 3·4; N, 6·8%).

Alkaline hydrolysis gave 2′-hydroxy-5′-nitropropiophenone (85%), m.p. 99° (from ethanol) (lit.,[26] 93—94°), δ 8·83 (1H, d, *J* 2·7 Hz, 6′-H), 8·41 (1H, q, *J* 9·2 and 2·7 Hz, 4′-H), 7·14 (1H, d, *J* 9·2 Hz, 3′-H), 3·23 (2H, q, *J* 7·0 Hz, CH_2), and 1·31 (3H, t, *J* 7·0 Hz, Me) (Found: C, 55·1; H, 4·7; N, 7·2. Calc. for $C_9H_9NO_4$: C, 55·4; H, 4·7; N, 7·2%).

2′-Hydroxy-5′-nitropropiophenone (m.p. and mixed m.p. with the foregoing sample, 99°) was prepared by treating a stirred solution of 2′-hydroxypropiophenone in glacial acetic acid with fuming nitric acid at 10°. The temperature was then allowed to rise to 60° and the mixture was quickly poured on crushed ice. The yellow solid was steam-distilled to give pale yellow needles of the ketone in the early distillate.

We thank the University of Wales for a Postdoctoral Fellowship (to I. L. T.), Mr. A. R. Hughes for experimental assistance, Mr. C. Taylor for the n.m.r. spectra, and Mr. D. Jervis for the elemental analyses.

[3/1541 *Received*, 23*rd July*, 1973]

[26] T. Széll, A. Furka, and I. Szilagyi, *J. Sci. Ind. Res.* (*India*), 1959, **18***B*, 325.