An In-depth Study of the Azidobenzophenone–Anthranil–Acridone Transformation

David G. Hawkins and Otto Meth-Cohn *·†

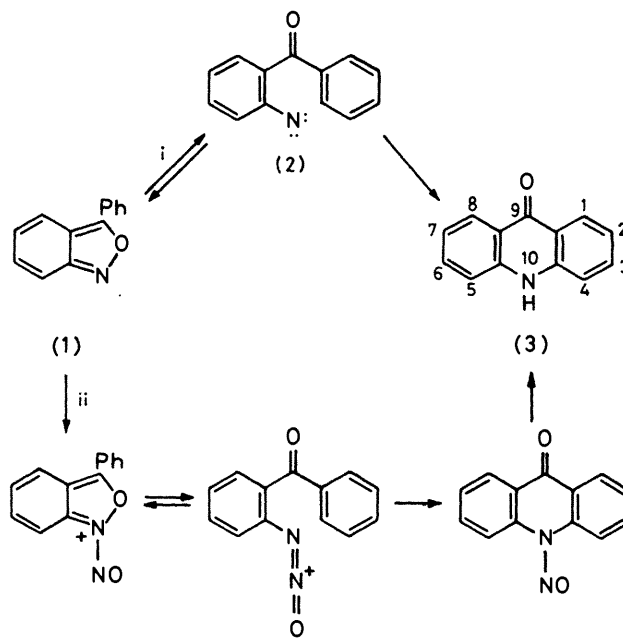*Ramage Laboratories, Chemistry Department, Salford University, Salford M5 4WT*

The title transformation, particularly the conversion of anthranils into acridones, is shown to be critically sensitive to temperature, solvent, substituent, and metal catalysts. Thus the conversion of 3-(p-tolyl)-anthranil into an acridone gives a ratio of 2- and 3-methyl derivatives varying from 0.6 : 1 to 4.7 : 1 with changing temperature and solvent. In other similar thermolyses, solvents (e.g. 1,2,4-trichlorobenzene) were incorporated into the product and traces of metals and their derivatives had a dramatic effect on the rate and course of the reaction. The most effective catalysts were iron powder and aluminium acetyl-acetonate. 3-(2,6-Disubstituted phenyl)anthranils gave acridones in which the substituents were either lost or rearranged onto N or C, the last cases involving sequential [1,5]-sigmatropic shifts.

3-Thienylanthranils gave related thienoquinolones on thermolysis; again the reactions were very sensitive to catalysis. Blocked thienylanthranils also gave rearrangement products, but the non-aromatic intermediates could be isolated.

In 1909 two transformations of 3-phenylbenz[3,4]isoxazole (3-phenylanthranil) (1) into acidone (3) were reported using heat [1] or nitrous acid.[2] These reactions are typically rationalised in Scheme 1. The thermal reaction was also shown [3] to produce 3-methylacridone from 3-p-tolylanthranil which is indicative of the direct attack of the nitrene (2) on the position *ortho* to the carbonyl group. The various analogues of the second pathway were thoroughly studied, particularly by Tanasescu and his co-workers.[4]

The anthranils [e.g. (1)] are conveniently prepared by gentle heating of 2-azidobenzophenones,[5] a non-nitrene process involving concerted cyclisation and nitrogen loss.[6] However the subsequent conversion of anthranils into acridones is one of the family of reactions [7] depicted in Scheme 2 whereby a singlet nitrene (4) (or some closely related species) is generated and yields a *rearranged* product (6), generally explained by involvement of a spiro-intermediate (5), or a product of *direct* substitution (8), via (7).‡ In general, rearranged products (6) derive from systems with X = S,[7,9,10] and probably NAc [8,11] and O.[11–13] However, with the sulphone analogue (4; X = SO₂) mixtures of both types of products (6) and (8) were isolated, the ratio depending on the nature and position of R. Electron-releasing *para*-substituents favoured spiro-attack while *para*-electron-withdrawing substituents favoured direct substitution.[11] Related effects were noted with *ortho*- and *meta*-substituted analogues.[14]

In applying the acridone-forming reaction, Kwok and Pranc [15] noted that 3-(2,4-dimethoxyphenyl)anthranil yielded solely the rearranged 2,4-dimethoxyacridone on thermolysis. However, 3-(4-methoxyphenyl)-5-chloroanthranil gave primarily the direct substitution product, 3-methoxy-7-chloro-acridone, admixed with 2-methoxy-7-chloro-9-acridone, the rearranged product, in a 3 : 1 ratio. Similarly the imidazole-

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† *Present address:* National Chemical Research Laboratory, C.S.I.R. P.O. Box 395, Pretoria 0001, South Africa.

‡ The product of ' direct ' attack has also been explained as being derived from the spiro-intermediate (5) by nitrogen migration,[7,8] or by ring-expansion of the alternative intermediate aziridine (5a).[9]

(5a)

Scheme 1. *Reagents:* i, heat; ii, HNO₂

and pyrazole-substituted anthranils (9) gave mixtures of both types of products.[16]
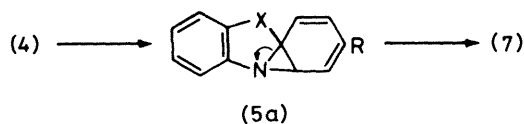
We herein describe an in-depth study of the formation of acridones and their hetero-analogues from anthranils in which we consider the reaction course as a function of structure, temperature, catalytic action, and solvent, revealing some most unexpected results.
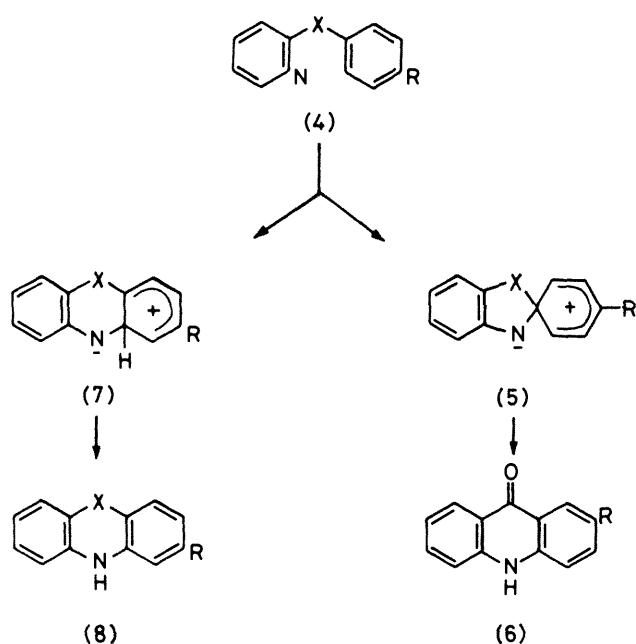
In order to analyse mixtures of acridones (generally rather insoluble, high melting solids) we found it easy and efficient to first N-methylate them (methyl iodide and sodium hydride in dry dimethylformamide at room temperature) whereby column chromatography then allowed ready separation.

On repeating Bamberger's original thermolysis of 3-(p-tolyl)anthranil we found that the reaction was remarkably sensitive to temperature, solvent, and to catalysis by traces of metals (Scheme 4 and Table 1) and that in all cases mixtures
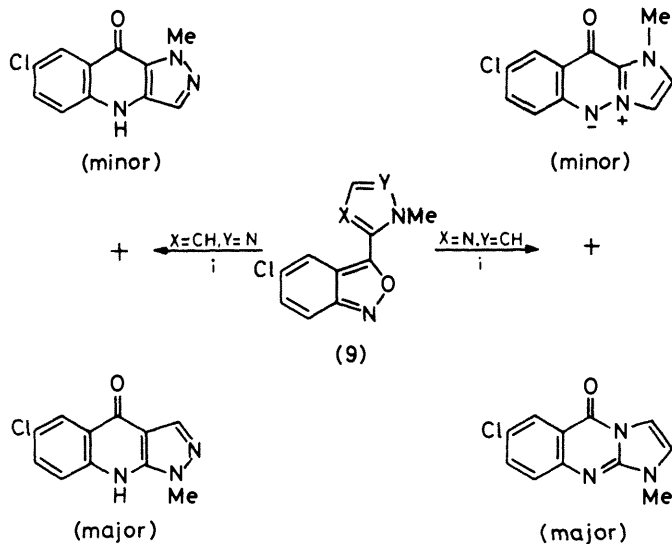
Scheme 2.

Scheme 4. *Reagents:* i, heat. The effects of varying the reaction conditions are shown in Table 1

Table 1. Thermolysis of 3-(p-tolyl)anthranil (10) under different conditions (see Scheme 4)

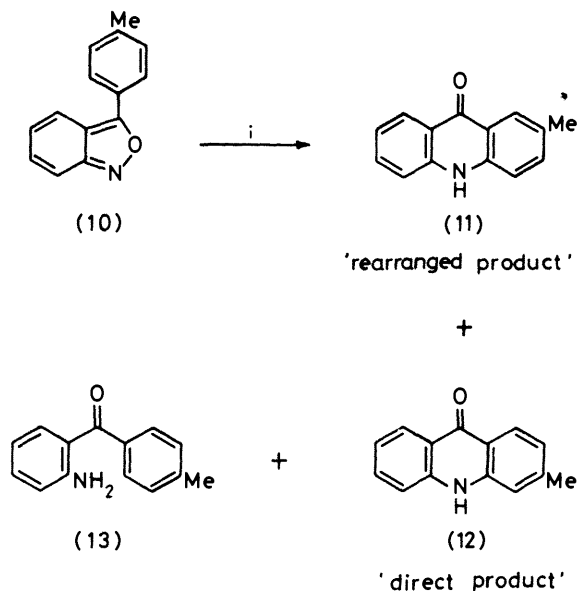| Conditions *			Acridones (11) + (12)	
Temp. (°C)	Solvent	Time (h)	Total (%)	Ratio (11)/(12)
214	Neat	24	55	2.14
280	Neat	0.5	48	2.06
350	Neat	0.08	53	4.72
214	TCB	24	71	0.57
214	TCB–Fe	4	84	0.70

* TCB = 1,2,4-trichlorobenzene.

Scheme 3. *Reagents:* i, heat

of the two acridones (11) and (12) resulted.* On the contrary, Bamberger's alternative method, employing nitrous acid, gave only the product (12) of direct attack, though other workers [15] noted rearranged product occurred via spiro-attack with the 4-methoxyphenylanthranil.

In all the above thermolyses, the anthranil was heated until absent or present in minimal amounts (t.l.c.). A by-product, 2-amino-4'-methylbenzophenone (13), was also formed in 9—30% yield. We thus tentatively conclude that raising the temperature favours the rearranged product (11), solution thermolysis favours the unrearranged product (12), while iron catalysis is primarily effective in reducing the reaction time

* The difference in m.p. between 2- and 3-methylacridone is only 5 °C and mixed m.p.s are only slightly depressed thus accounting for Bamberger's erroneous interpretation.

six-fold and increasing the product yields (total product yield is 98%).

(1) *The Effect of Metal Catalysts.*—The dramatic role of a trace of iron powder encouraged us to look closer at this catalytic effect. A variety of transition metals, metal salts, metal complexes, co-ordinatively unsaturated metal complexes, zero-valent metal carbonyls, and Lewis acids, were investigated in the conversion of anthranil (10) into the acridones (11) and (12), no attempt being made to analyse the acridone ratio (see Table 2). Several very interesting points emerge: (a) all the catalysts had some beneficial effect on the conversion of the anthranil into products. In terms of the extent of reaction of anthranil, the most effective catalysts are iron or copper powder (expts. 2—4), cobalt (expts. 8, 9) and aluminium (expts. 14, 15) acetylacetonate, and, most effective of all, bis(triphenylphosphine)copper nitrate (expt. 18). However in so far as preferred acridone formation is concerned, the weak Lewis acid, aluminium acetylacetonate, is outstanding, while iron powder is probably the most convenient and cheapest catalyst.

(b) In almost all cases the acridone formation was accompanied by reductive ring-cleavage of the anthranil (10) to the 2-aminobenzophenone (13). While, in general, the amine was the minor product, in certain cases it was the major [copper (expt. 4), or its low-valent derivative (expt. 18)] or co-product

Table 2. The effect of various catalysts on the conversion of 3-(p-tolyl)anthranil (10) (1.0 g, 4.8 mmol M) into acridones (11) and (12) in refluxing 1,2,4-trichlorobenzene (100 ml) for 4 h

Expt. no.	Catalyst [a] (g, mmol)	Reacted anthra- nil (%)	Products (%) [b]		
			(11) + (12)	(13)	Total
1	None	13	47	0	47
2	Fe powder (0.01, 0.18)	66	64	6	70
3	Fe powder (0.05, 0.90)	100	77	21	98
4	Cu powder (0.05, 0.79)	100	18	18 + 14 [c]	60
5	$FeCl_3$ (0.05, 0.30)	61	28	20	48
6	$Fe(C_5H_5)_2$ (0.05, 0.27)	84	55	45	100
7	$Fe(acac)_3$ (0.05, 0.14)	92	48	33	81
8	$Co(acac)_3$ (0.05, 0.14)	100	65	35	100
9	$Co(acac)_3$ [d] (0.05, 0.14)	100	48	40 + 6 [c]	94
10	$Ni(acac)_2$ (0.05, 0.20)	64	56	41	97
11	$Cu(acac)_2$ (0.05, 0.19)	82	66	32	98
12	$Cr(acac)_3$ (0.05, 0.14)	28	86	0	86
13	$Mn(acac)_3$ (0.05, 0.14)	50	56	28	84
14	$Al(acac)_3$ (0.05, 0.16)	100	86	14	100
15	$Al(acac)_3$ [d] (0.05, 0.16)	100	54	42 + 2 [c]	98
16	$BF_3 \cdot Et_2O$ (0.05, 0.35)	78	77	18	95
17	$Cu(PPh_3)_2NO_3$ (0.05, 0.08) [e]	66	57	42	99
18	$Cu(PPh_3)_2NO_3$ (0.05, 0.08)	100	44	44 + 7 [c]	95
19	$Cu(PPh_3)_2NO_3$ (1.00, 1.66)	100	42	34 + 5 [c]	81
20	$Rh(PPh_3)_3Cl$ (0.10, 0.11)	80	37	31	68
21	$Rh_2(OAc)_4$ (0.05, 0.23)	90	49	31	80
22	$Th(OAc)_4$ (0.05, 0.11)	26	31	8	39
23	$UO_2(OAc)_2 \cdot 2H_2O$ (0.05, 0.12)	38	16	5	21
24	$Eu(fod)_3$ (0.05, 0.11)	42	57	29	85
25	$Cr(CO)_6$ (0.025, 0.17)	44	68	23	91
26	$Mo(CO)_6$ (0.025, 0.10)	88	50	45	95

[a] acac = Acetylacetonate; fod = 6,6,7,7,8,8,8-heptafluoro-2,2-dimethyloctane-3,5-dionato. [b] Yield based on reacted anthranil. [c] Included with the yield of amine is a product (14) derived by solvent attack on the amine (see text). [d] Acetylacetone was added to the reaction mixture. [e] Only 1 h reaction time.

[Mo(CO)$_6$, Co(acac)$_3$ + acetylacetone]. It is tempting to suggest that the amine is a triplet nitrene-derived product, though the total absence of the formation of azobenzenes is not wholly consistent with this view. It is also a puzzle where the hydrogen is taken from. In several cases the product accounting is almost quantitative and the amine yields considerable suggesting that the solvent is the source of hydrogen. However, no biphenyls or other by-products were observed.

(c) Copper-based catalysts (expts. 4, 18, 19) [and to a much lesser extent those experiments conducted with acetyl-acetonates containing added acetylacetone (expts. 9, 15)] caused the formation of the diphenylamine derivative (14), an Ullmann reaction product (Scheme 5). That this was indeed the source of the compound was shown by a separate control experiment, whereby the amine (13) in 1,2,4-trichlorobenzene was heated with copper powder for 4 h under reflux, giving the same product (6%). The structure was confirmed by conducting a classical Ullmann reaction using 2,4-dichloroiodobenzene and the amine with added potassium carbonate and copper, when the same product (14) ensued in 52% yield.

(d) The catalytic trend using the first series of transition metal acetylacetonates is most instructive (Figure) and indicates that cobalt is probably the best in the series. It is
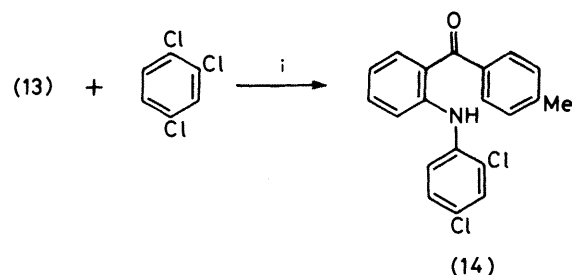
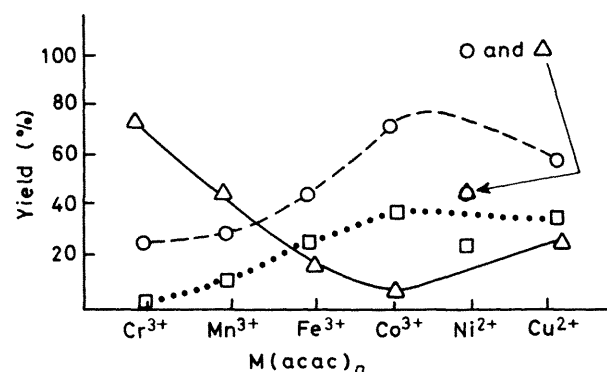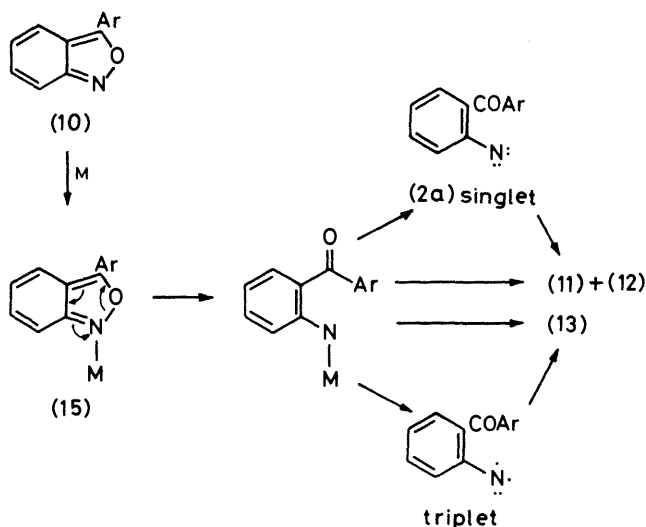**Scheme 5.** *Reagents:* i, catalyst, heat

Figure. The products (%) from heating 3-(p-tolyl)anthranil (10) under reflux in trichlorobenzene for 4 h with metal acetylacetonates O = acridone, $\square$ = amine, $\triangle$ = anthranil
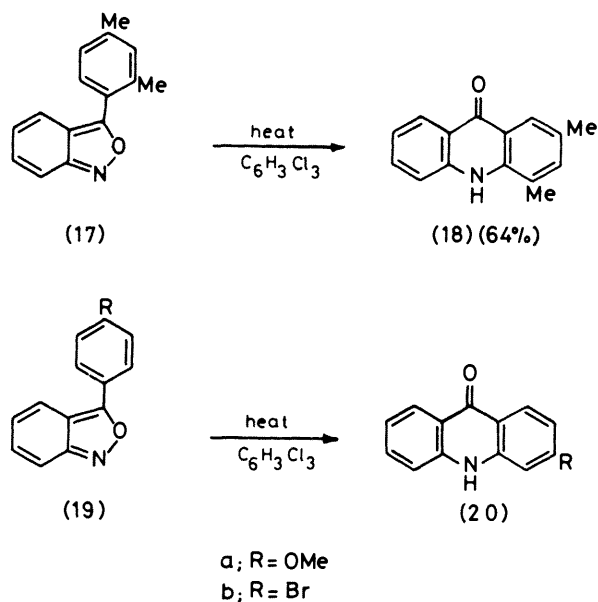

Scheme 6.

significant that the thermal stability of metal acetylacetonates is variable, the chromium derivative being stable [17] above 250 °C while the iron [18] and cobalt compounds [19] decompose below 200 °C, suggesting the formation of a co-ordinatively unsaturated derivative under our reaction conditions.

(e) Lewis acids (expts. 5, 14, 16) are also effective in promoting the reaction generally tending to give low yields of amine. Indeed aluminium acetylacetonate is the best catalyst examined.

(f) From a mechanistic viewpoint, two metal–substrate reactions at least are significant to account for the above results (Scheme 6). The first is the co-ordination of the catalyst with the anthranil, group (15), whereby the N–O bond is

(17) $\xrightarrow[C_6H_3Cl_3]{heat}$ (18) (64%)

(19) $\xrightarrow[C_6H_3Cl_3]{heat}$ (20)

a; R = OMe
b; R = Br

(21) $\xrightarrow{i}$ (22)

(26) (27%) + (25) (12·5%) + (24) (5%)

(23)

Scheme 7. *Reagents:* i, heat, $C_6H_3Cl_3$

(23) [1.5] (27) [1.5] $\rightleftharpoons$ (25)

Scheme 8.

weakened and thus the anthranil consumed. The most effective agents for catalysing the reaction of the anthranil will thus clearly reflect the azaphilicity of the catalyst. Thus Lewis acids should be effective, or perhaps any electrophile (hence the nitrous acid catalysis). Catalysts that are (or can readily become) co-ordinatively unsaturated should be decidedly more effective. Thus the copper–phosphine complexes (expts. 17—19), Wilkinsons catalyst (expt. 20), and the thermally unstable acetylacetonates (expts. 7, 8) should be and are effective.

The second metal–substrate interaction important in this catalysis is determined by the stability of the nitrene–metal (or catalyst) bond (16) following ring-opening of the anthranil. Where this is very weak the singlet nitrene (2a) is rapidly released to give the acridones. However, given a stronger metal–nitrene bond the singlet nitrene reactivity is reduced and it may thus undergo intersystem crossing to give the triplet species. When this triplet is surrounded by readily abstractable hydrogens (as in acetylacetonate ligands) amine formation is rendered easy. This feature is underlined by the considerable increase in amine yields when extra acetylacetone is added (expts. 9, 15).

It would thus appear that the ideal catalyst for acridone formation should have a strong affinity for the weakly basic anthranil nitrogen, but should be only a poor ligand for a nitrene.

(2) *The Effect of Structure.*—We next studied a number of further substituted-aryl anthranils, looking in particular at which route to acridone was favoured. Surprisingly only one isomer, the rearranged acridone (18), was formed by thermolysis of the 2,4-dimethylphenylanthranil (17), indicating that the *ipso* site in the intervening nitrene was sufficiently electron-rich to form the spiro-type intermediate exclusively. The structure of the acridone (18) was confirmed by an Ullmann synthesis and cyclisation (see Experimental section).

Furthermore, 4-methoxy- and 4-bromophenyl-anthranils (19) gave solely the unrearranged acridones (20) in 62 and 57% yield, respectively, together with some amine, in contradistinction to the result of Kwok and Pranc [15] who noted isomer mixtures with 5-chloro-4-methoxyphenylanthranil. Clearly, a simple argument based on the relative electron densities of the *ipso* and *ortho* positions is not the only factor to be considered.

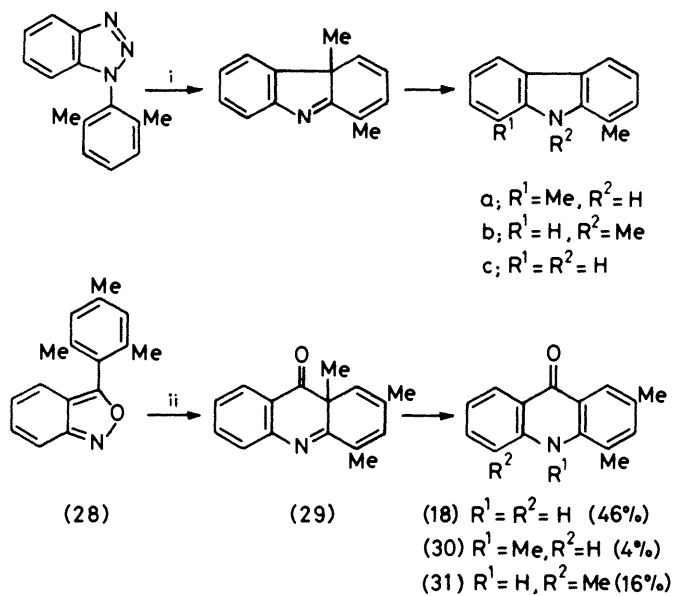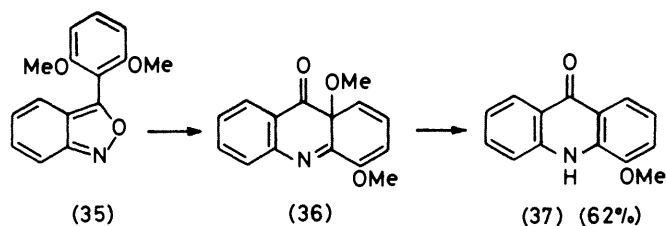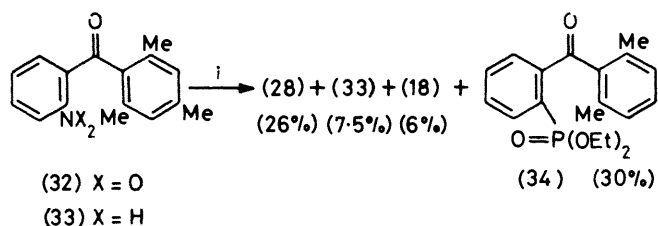2,6-Dimethylphenylanthranil (21) presented an interesting
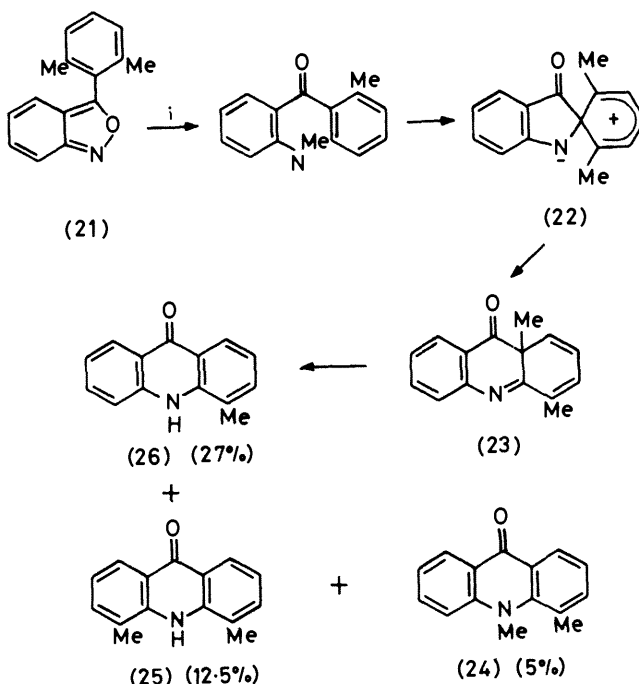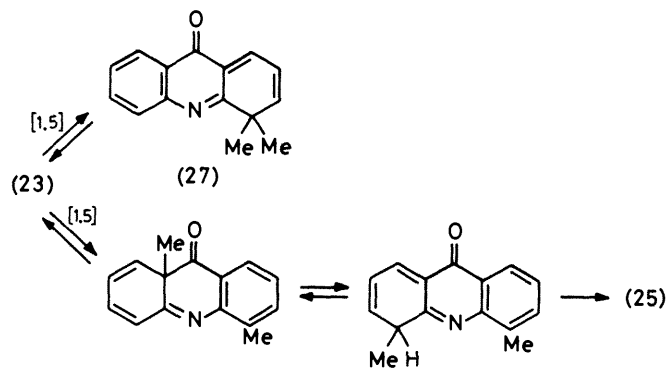
new dimension in this study since related 'blocked' 2-nitrenophenyl aryl sulphides underwent a variety of fascinating rearrangements.[7] Thermolysis of (21) proceeded readily to give three products (24)—(26) all explainable by invoking the spiro-intermediate (22), which on ring expansion should give the non-aromatic acridone (23) (Scheme 7). The major product, 4-methylacridone (26), arose by demethylation of the key intermediate (23) and was confirmed by comparison with an authentic specimen. On *N*-methylation, 4,10-dimethyl-acridone was produced, identical with the second product from this reaction, presumably formed by *N*-methylation rather than concerted rearrangement.

The minor product (25) is the most interesting mechanistically, being readily identified by its very simple ABC pattern in the [1]H n.m.r. spectrum, indicative of symmetry. Each aromatic proton was distinct (7.10, 7.40, and 8.25 p.p.m.) and the coupling pattern readily analysed and simplified by double irradiation (see Experimental section). Consecutive [1,5]-methyl shifts followed by prototropy can be seen to explain the structure (Scheme 8); the alternative [1,5]-shift, giving (27), is clearly unproductive. A closely related mechanism to explain

a; R^1 = Me, R^2 = H
b; R^1 = H, R^2 = Me
c; R^1 = R^2 = H

(28)   (29)   (18) R^1 = R^2 = H (46%)
                            (30) R^1 = Me, R^2 = H (4%)
                            (31) R^1 = H, R^2 = Me (16%)

Scheme 9. *Reagents:* i, heat; ii, heat, C$_6$H$_3$Cl$_3$

(32) X = O
(33) X = H

(34) (30%)

(35)   (36)   (37) (62%)

Scheme 10. *Reagents:* i, P(OEt)$_3$, PhBr, 154 °C

the formation of the products in a carbazole-forming reaction has very recently been postulated by Rees and his co-workers [20] (Scheme 9). The corresponding mesitylanthranil (28) reacted in a similar manner giving the analogous three products (18), (30), and (31), clearly formed by way of the same type of unstable non-aromatic acridone (29). The 2,4-dimethyl-acridone (18) was identical with that produced from 3-(2,4-dimethylphenyl)anthranil (17), and was readily N-methylated to give (30).

We also conducted a parallel deoxygenation of the nitro-benzoylmesitylene (32) (Scheme 10) which gave the expected anthranil (28) and amine (33) and the 2,4-dimethylacridone (18), but the major product (34) arose by nucleophilic substitution of the nitro group (activated by the carbonyl group) by the phosphite reagent. Such substitution is not without precedent,[21] but is exceptional in all our work, suggesting that the bulky mesityl group is out of plane with the nitrophenyl group, discouraging intramolecular reaction.
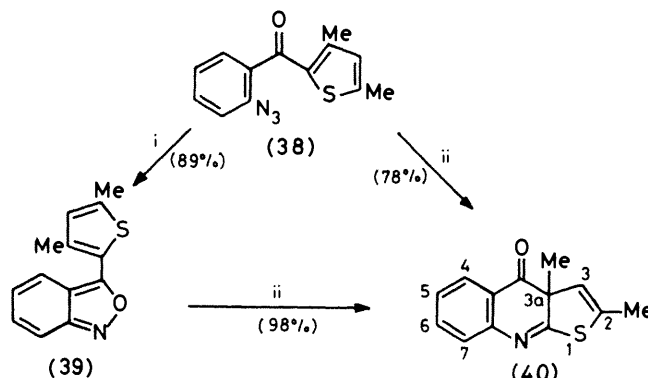
Scheme 11. *Reagents:* i, PhBr, heat, 3 h; ii, PhBr, Fe, heat, 3 h

(41)
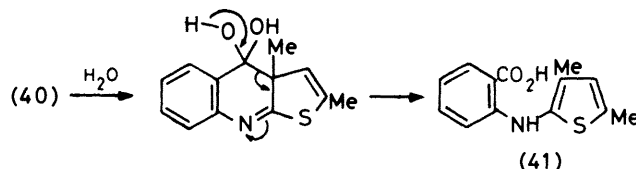
Scheme 12.

2,6-Dimethoxyphenylanthranil (35) behaved similarly to the above systems, giving 4-methoxyacridone (37), but with no evidence of products with rearranged dimethoxy substituents.

(3) *Thermolysis of 3-Thienylanthranils.*—The non-aromatic 9aH acridones [e.g. (23), (29), or (36)] are clearly compounds of considerable chemical versatility. In order to isolate and study such systems we next investigated the thermolysis of some thienylanthranils, hoping that such systems may be isolable since the lesser aromaticity of the thiophene ring should favour this end. The results were fascinating.

Thermolysis of 2-(2-azidobenzoyl)-3,5-dimethylthiophene (38) in refluxing commercial bromobenzene (conditions which we normally employ for anthranil formation), proved erratic, on some occasions giving solely the anthranil (39) and on others giving solely the desired thienoquinolone (40). Traces of iron, as noted earlier, proved to be the key to this dilemma, as shown in Scheme 11. Deoxygenation of the nitrobenzoyl-thiophene (38; NO$_2$ in place of N$_3$) with triethyl phosphite in bromobenzene gave the same quinolone (40) in 36% yield.

The structure of the thienoquinolone (40) was clearly supported by its spectral data. In particular, the ^{1}H n.m.r. spectrum showed a methyl resonance shifted upfield by 0.9 p.p.m. compared to the starting azide (1.45 p.p.m.) indicative of an sp^3 bonded methyl group, and a methyl doublet (J 2.0 Hz) coupled to a vinylic proton quartet (6.05 p.p.m.). Addition of europium shift reagent [Eu(fod)$_3$] shifted downfield the 3a-methyl group (0.45 p p.m.), the vinylic proton (0.50 p.p.m.) and 4-H (0.95 p.p.m.) indicative of complexation to the carbonyl oxygen. The ^{13}C n.m.r. spectrum showed thirteen carbons with two methyl resonances (16.84 and 27.24 p.p.m.) and an sp^3 quaternary carbon (66.55 p.p.m.) appropriate for C-3a.

The liquid thienoquinolone (40) proved an interesting intermediate; on standing for several days it slowly crystallised, a process that occurred rapidly in aqueous alkali, giving the anthranilic acid (41). No doubt the rearomatisation of the thiophene ring was the driving force for this reaction (Scheme 12).

The attempted sigmatropic rearrangement of the thieno-
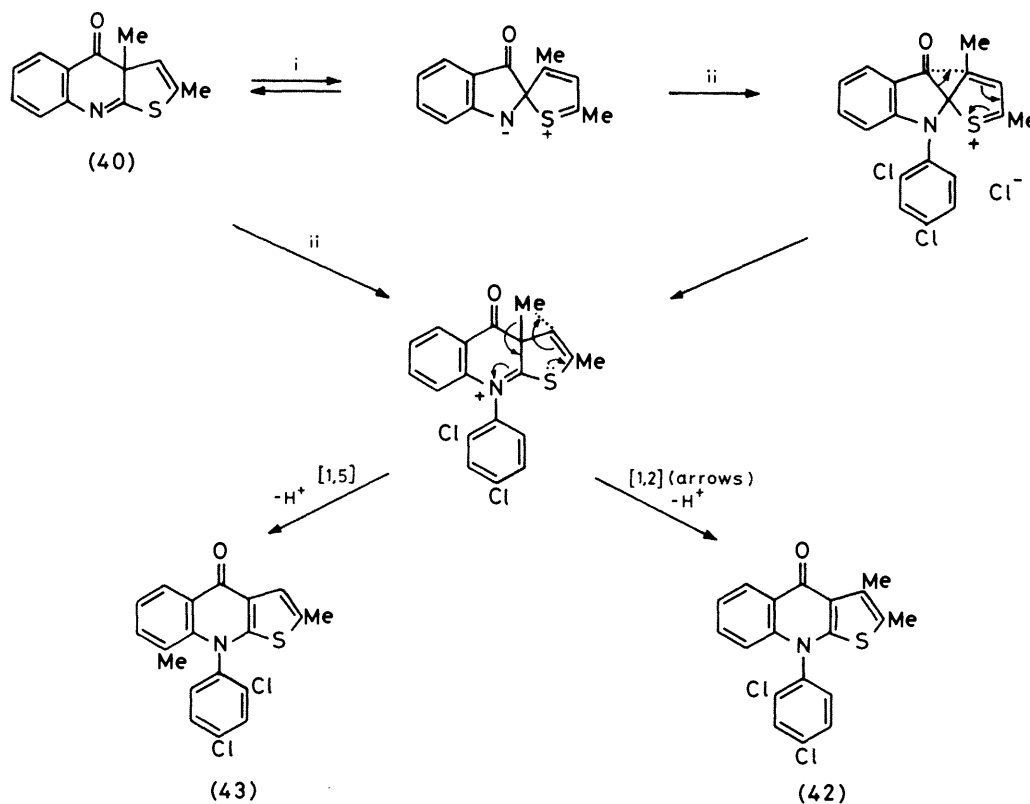
Scheme 13. *Reagents:* i, heat; ii, $C_6H_3Cl_3$

quinolone (40) gave unexpected results. When heated in trichlorobenzene both the thienoquinolone (40) and the anthranil (39) gave a product incorporating the solvent to which we assign either structure (42) or (43) in 18 and 33% yield respectively; both of these did indeed involve a methyl migration. That the nitrene was not responsible for the insertion into the solvent was revealed by the non-incorporation of solvent when N-dimethylaniline or p-dimethoxybenzene replaced the trichlorobenzene in the pyrolysis of the anthranil (39) or quinolone (40); only amine (38; NH_2 in place of N_3) and a trace of the quinolone (46) were formed. Also nucleophilic substitution by the quinolone (40) seemed questionable since, when heated with the much better electrophile, p-fluoronitrobenzene, at 216 °C it gave much tar and some amine, while at 100 °C the mixture was unchanged.

The product, a yellow crystalline solid, gave an appropriate elemental analysis and accurate mass measurement for $C_{19}H_{13}Cl_2NOS$, a strong carbonyl (1 680 cm^{-1}) but no NH absorption in its i.r. spectrum, and ^1H n.m.r. features including two methyl absorptions, one of them showing a small vinylic coupling as well as a multiplet due to seven aromatic protons. Attempted Raney nickel desulphurisation was unproductive. The above data would seem to favour compound (43) for which a mechanistic rationale is postulated in Scheme 13, involving either the quinolone or spiro-isomer in a nucleophilic substitution.

As a further endeavour to establish both the structure and mechanism of formation of this product, we also thermolysed 3-(4,5-dimethyl-2-thienyl)anthranil (44) which gave the expected quinolone (45) together with a little amine (46) (20%) (Scheme 14). This amine was the major product (61%) when the anthranil was refluxed in chlorobenzene in the presence of iron, the quinolone yield being reduced to 34%. This quinolone was heated under Ullmann conditions with
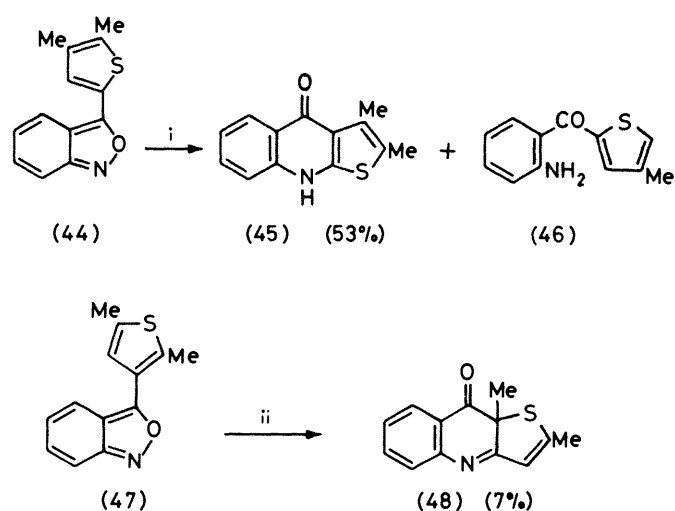
Scheme 14. *Reagents:* i, $C_6H_3Cl_3$, heat, Fe, 3 h; ii, $C_6H_3Cl_3$, heat, 3 h

2,4-dichloroiodobenzene, using the highly reactive Rieke copper.[22] Unfortunately, only starting materials were isolated, with no trace of product (42).

When 3-(2,5-dimethyl-3-thienyl)anthranil (47) was heated in trichlorobenzene, a low yield of the thienoquinolone (48) was found together with the amine, 3-(2-aminobenzoyl)-2,5-dimethylthiophene, in 36% yield. No trace of the ' direct ' insertion product by attack at the unsubstituted thiophenic position was observed. The spectral data for (48) is fully in accord with the structure (see Experimental section).

Experimental

General conditions are as follows: m.p.s were taken in capillary tubes and are uncorrected. B.p.s refer to oven temperatures in a Kugelrohr apparatus. I.r. spectra were recorded on a Perkin-Elmer 257 spectrometer and ¹H n.m.r. spectra in a Varian EM 360 A or Perkin-Elmer R 32 instrument at 60 and 90 MHz respectively, using deuteriochloroform as solvent unless otherwise indicated and tetramethylsilane as internal standard. ¹³C N.m.r. spectra were recorded on a Varian CFT 20 instrument. Mass spectra were taken on an AEI MS 12, MS 902 or a Kratos MS 30 spectrometer. Column chromatography utilised alumina type H from B.D.H. Ltd., and silica, type MFC from Hopkin and Williams Ltd. Light petroleum refers to the fraction with b.p. 40—60 °C and petroleum refers to that with b.p. 60—80 °C unless stated otherwise. Ether refers to diethyl ether; this was dried over sodium, and tetrahydrofuran was dried using sodium and benzophenone. Butyl-lithium in hexane was obtained from Pfizer Ltd., Sandwich, Kent. Thermolyses were conducted under nitrogen.

Thiophene, 2,5-dimethylthiophene, 2,4-dimethylthiophene, and 3-methylthiophene were kindly supplied by Croda Synthetic Chehmicals Ltd.

Preparation of 3-Arylanthranils. (1) *The Synthesis of 2-Aminobenzophenones and their Thiophene Analogues.*—Method A. This method was a modification of the method of Lothrop and Goodwin,[23] whereby an aryl-lithium or -magnesium halide is treated with 2-methylbenz[3,1]oxazin-4-one (prepared by the action of acetic anhydride on anthranilic acid in 91% yield,[24] m.p. 79—80 °C). A typical example is as follows. The Grignard reagent prepared from 4-iodotoluene (98.11 g, 0.45 mol) and magnesium (11.88 g, 0.495 mol) in ether (250 ml) was added dropwise under nitrogen into a suspension of the above benzoxazinone (72.45 g, 0.45 mol) in ether (250 ml) with vigorous stirring and cooling with an ice-bath. After the addition the mixture was stirred for a further 4 h; water was then added and the mixture stirred overnight. The solution was acidified with conc. hydrochloric acid and the yellow precipitate was filtered. The aqueous phase was extracted with chloroform and the organic phases and the filtered material were combined, the solution dried (MgSO₄) and evaporated to give 2-amino-4'-methylbenzophenone as a brown solid which recrystallised from ethanol as yellow crystals, m.p. 82—83 °C (49.9 g, 52.5%) (lit.,[25] m.p. 94—95 °C).

Similarly, from 4-bromoiodobenzene[26] (14.15 g, 0.05 mol) was obtained 2-amino-4'-bromobenzophenone (6.14 g, 45%) as yellow crystals from ethanol, m.p. 110—111 °C (lit.,[27] m.p. 108 °C). From 2-iodoanisole (11.70 g, 0.05 mol) was obtained 2-amino-4'-methoxybenzophenone (4.59 g, 40%), m.p. 63—65 °C (lit.,[25] m.p. 76 °C). From 2,6-dimethyliodobenzene[28] (9.88 g, 0.0425 mol) was obtained 2-amino-2',6'-dimethylbenzophenone (2.62 g, 27.5%), as an oil, used directly in the next stage. From 2,4-dimethyliodobenzene[28] (11.60 g, 0.05 mol) was obtained 2-amino-2',4'-dimethylbenzophenone (3.25 g, 29%), m.p. 71—72 °C (lit.,[29] m.p. 89 °C). From 3-bromo-2,5-dimethylthiophene (9.55 g, 0.05 mol) was obtained 3-(2-*aminobenzoyl*)-2,5-dimethylthiophene as a yellow oil, b.p. 180—184 °C/0.15 mmHg (Found: C, 67.6; H, 5.6; N, 6.1. C₁₃H₁₃NOS requires C, 67.5; H, 5.7; N, 6.05%). ν_{max.} (liquid film) 3 450, 3 350 (NH₂), and 1 610 cm⁻¹ (CO); δ 2.35s and 2.45s (2 Me), 6.10br (NH₂), 6.40—6.75m (3 H, aromatic 3-, 5-, 4'-H), 7.10—7.35dd (4-H, J 8 and 2 Hz), 7.40—7.55dd (6-H, J 8 and 2 Hz). From 1,3-dimethoxybenzene (6.90 g, 0.05 mol) by conversion into 2,6-dimethoxyphenyl-lithium with butyl-lithium in ether (30 min at ambient temperature) under nitrogen, was obtained 2-*amino-2',6'-dimethoxybenzophenone* as yellow crystals from ethanol (3.00 g, 23.5%), m.p. 150—

151 °C (Found: C, 70.1; H, 6.1; N, 5.5. C₁₅H₁₅NO₃ requires C, 70.0; H, 5.9; N, 5.4%). In a similar way from 2,3-dimethyl-thiophene (5.60 g, 0.05 mol) by way of 2-lithio-4,5-dimethyl-thiophene was obtained 2-(2-*aminobenzoyl*)-4,5-*dimethyl-thiophene* as yellow crystals from ethanol, m.p. 104—105 °C (5.84 g, 50.5%) (Found: C, 67.6; H, 5.7; N, 6.1. C₁₃H₁₃NOS requires C, 67.5; H, 5.7; N, 6.05%); ν_{max.} (Nujol) 3 475, 3 375 (NH₂), and 1 630 cm⁻¹ (CO). δ 2.10s and 2.35s (2 Me), 5.50br (NH₂), 6.50—6.75m (3- and 5-H), 7.10—7.35m (3'- and 4-H), and 7.65—7.80dd (6-H, J 8 and 2 Hz).

Method B. 2-Nitrobenzoic acid (8.00 g, 0.48 mol) and trifluoroacetic anhydride (16.00 g, 0.076 mol) were stirred together until homogeneous and to the solution was added boron trifluoride–ether (6.80 g, 0.048 mol) dropwise with cooling. This deep red solution was added dropwise with stirring and cooling in an ice-bath to mesitylene (9.00 g, 0.075 mol), and after a further 2 h was poured onto ice and the mixture extracted with chloroform. The extract was washed with aqueous sodium hydroxide (40%), dried (MgSO₄), and evaporated to give 2-nitro-2',4',6'-trimethylbenzophenone, which recrystallised from ethanol as cream needles, m.p. 145—146 °C (4.60 g, 36.5%) (lit.,[30] m.p. 145—146 °C). This nitro compound (7.00 g, 0.027 mol) in ethanol (100 ml) was added slowly to a well stirred refluxing mixture of reduced iron powder (3.50 g, 0.063 mol) and ammonium chloride (3.50 g, 0.065 mol) in water (100 ml). After a further 3 h the hot mixture was filtered through Celite and the Celite washed with chloroform. This extract and the chloroform extract of the filtrate were combined, dried (MgSO₄), and evaporated to give 2-amino-2',4',6'-trimethylbenzophenone as a brown solid which recrystallised from ethanol as yellow prisms, m.p. 146 °C (4.75 g, 76%) (lit.,[9a] m.p. 130—131 °C).

In a similar manner 2,4-dimethylthiophene (11.20 g, 0.1 mol) was converted into 3,5-*dimethyl-2-(2-nitrobenzoyl)thiophene* as cream crystals from ethanol, m.p. 81—82 °C (18.38 g, 71%) (Found: C, 59.7; H, 4.2; N, 5.2. C₁₃H₁₁NO₃S requires C, 59.8; H, 4.25; N, 5.4%). ν_{max.} (Nujol) 1 660 (CO), 1 540, and 1 360 cm⁻¹ (NO₂). δ 2.35s and 2.40s (2 Me), 6.70s (4-H), 7.45—7.85m (4'-, 5'-, and 6'-H), and 8.10—8.20dd (3'-H, J 9 and 2-Hz). This nitro compound (18.0 g, 0.069 mol) was reduced as above to give 2-(2-*aminobenzoyl*)-3,5-*dimethyl-thiophene* as yellow needles from ethanol, m.p. 93—94 °C (13.60 g, 85%) (Found: C, 67.3; H, 5.6; N, 5.9. C₁₃H₁₃NOS requires C, 67.6; H, 5.7; N, 6.1%). ν_{max.} (Nujol) 3 450, 3 350 (NH₂), and 1 630 cm⁻¹ (CO); δ 2.30s (Me), 2.45s (Me), 5.80br (NH₂), 6.6—6.9m (3-, 4'-, 5-H), 7.25—7.60dd (4-H, J 8 and 2 Hz), and 7.70—7.80dd (6-H, J 8 and 2 Hz).

(2) *The Synthesis of 2-Azidobenzophenones and Their Thiophene Analogues.*—The following method, exemplified for 2-azido-4'-methylbenzophenone, was used to convert all the above amines into the corresponding azides. 2-Amino-4'-methylbenzophenone (49.90 g, 0.235 mol) in acetic acid (250 ml) and concentrated hydrochloric acid (250 ml) was cooled below 5 °C and treated dropwise with stirring with sodium nitrite (17.00 g, 0.245 mol) in water (40 ml), and the temperature maintained below 5 °C. After being stirred for a further 15 min this solution was added gradually to a cold, stirred solution of sodium azide (17.00 g, 0.26 mol) and sodium acetate (150 g) in water (500 ml). After 1 h, the solution was filtered, the precipitate washed with water, and air dried. Recrystallisations from ethanol gave 2-azido-4-methylbenzo-phenone as pale yellow crystals (50.25 g, 94%), m.p. 75 °C (lit.,[31] m.p. 75—76 °C).

In a similar way the azides in Table 3 were synthesised.

(3) *The Conversion of the Azidophenyl Ketones into Anthranils.*—The azide, dissolved in a small amount of the

Table 3. Properties of the 2-azidophenyl ketones [2-N$_3$C$_6$H$_4$C(O)Ar]

Ar	Yield (%)	M.p. (°C)	Colour	I.r. (cm^{-1}) N$_3$	CO	^{1}H N.m.r. (δ)	Found (%) (Required) C	H	N	Formula
C$_6$H$_4$Me-4	94	75 [a]	Yellow	2 150	1 660	2.40s (Me), 7.15—7.75m (ArH)				
C$_6$H$_4$Br-4	92	63—64 [b]	Yellow	2 150	1 670	7.15m (ArH)				
C$_6$H$_4$OMe-4	78	73—74 [c]	Orange	2 150	1 660	3.75s (Me), 6.88d (3'-, 5'-H, J 9 and 2 Hz), 7.1—7.6m (4 H), 7.77d (2'-, 6'-H, J 9 and 2 Hz)				
C$_6$H$_3$Me$_2$-2,6	86	Oil	Straw	2 150	1 680	2.25s (Me), 7.1—8.1m (ArH)				
C$_6$H$_3$Me$_2$-2,4	77	Oil	Straw	2 150	1 670	2.30s and 2.50s (Me), 6.85—7.55m (ArH)				
C$_6$H$_3$(OMe)$_2$-2,6	87	119—120	Pale yellow	2 150 2 100	1 680	3.70s (Me), 6.55m (2 H), 7.00—7.70m (ArH)	63.5 (63.6)	4.2 4.6	14.5 14.8)	C$_{15}$H$_{13}$N$_3$O$_3$
C$_6$H$_2$Me$_3$-2,4,6	78	95—96	Pale yellow	2 125 2 100	1 660		72.5 (72.4)	5.7 5.7	15.4 15.8)	C$_{16}$H$_{15}$N$_3$O
2-C$_4$HSMe$_2$-3,5	81	66—67	Pale yellow	2 150 2 100	1 640	2.35s and 2.40s (Me), 6.65s (4-H), 7.05—7.55m (ArH)	60.7 (60.7	4.5 4.3	16.2 16.3)	C$_{13}$H$_{11}$N$_3$SO
3-C$_4$HSMe$_2$-2,5	93	Oil	Pale yellow	2 150 2 100	1 650	2.45s and 2.65s (Me), 6.65s (4-H), 7.05—7.65m (ArH)	60.5 (60.7	4.3 4.3	16.3 16.3)	C$_{13}$H$_{11}$N$_3$SO
2-C$_4$HSMe$_2$-4,5	72	Oil	Straw	2 175 2 125	1 650	2.15s and 2.45s (Me), 7.20—7.85m (ArH)	60.8 (60.7	4.2 4.3	16.2 16.3)	C$_{13}$H$_{11}$N$_3$SO

[a] Lit.,[31] m.p. 75—76 °C. [b] Lit.,[31] m.p. 62—63 °C. [c] Lit.,[31] m.p. 73—74 °C.

Table 4. Properties of the 3-arylanthranils obtained from the 2-azidophenyl ketones (Table 3)

3-Ar	Reaction solvent [a]	Yield (%)	M.p. (°C) [b.p. (°C/ mmHg)]	^{1}H N.m.r. (δ)	Found (%) (Required) C	H	N	Formula
C$_6$H$_4$Me-4	A	99	92—93 [b]	2.35s (Me), 6.90—8.05m (ArH)				
C$_6$H$_4$Br-4	A	86	134—135 [c]	6.90—7.90m (ArH)				
C$_6$H$_4$OMe-4	A	94	99—100 [d]	3.80s (Me), 6.95—8.05m (ArH)				
C$_6$H$_3$Me$_2$-2,6	A	49	Oil	2.10s (Me), 6.65—7.75m (ArH)	81.0 (80.7	5.8 5.9	6.1 6.3)	C$_{15}$H$_{13}$NO
C$_6$H$_3$Me$_2$-2,4	A	83	[140—144/ 0.1]	2.35s (Me), 2.45s (Me), 6.80—7.65m (ArH)	80.9 (80.7	5.9 5.9	6.2 6.3)	C$_{15}$H$_{13}$NO
C$_6$H$_3$(OMe)$_2$-2,6	A	87	122—123	3.70s (Me), 6.55—7.70m (ArH)	70.8 (70.6	5.3 5.1	5.1 5.5)	C$_{15}$H$_{13}$NO$_3$
C$_6$H$_2$Me$_3$-2,4,6	A	99	97—99	2.05s (2 Me), 2.35s (Me), 6.85—7.00m (3'-, 5'-, 4-H), 7.20—7.40t (5-, 6-H), 7.57—7.87d (7-H)	80.8 (81.0	6.5 6.4	5.9 5.9)	C$_{16}$H$_{15}$NO
2-C$_4$HSMe$_2$-3,5	A	89	78	2.40s (Me), 2.50s (Me), 6.58s (4'-H), 6.80—7.00dd (5-H), 7.12—7.30dd (6-H), 7.45—7.55d (4-H), 7.62—7.72d (7-H)	68.0 (68.1	4.9 4.8	6.0 6.1)	C$_{13}$H$_{11}$NOS
3-C$_4$HSMe$_2$-2,5	A	83	Oil	2.40s (Me), 2.65s (Me), 6.75—7.05q and s (4'- and 5-H), 7.15—7.40dd (6-H), 7.45—7.60dd (4-, 7-H)	68.1 (68.1	4.9 4.8	5.9 6.1)	C$_{13}$H$_{11}$NOS
2-C$_4$HSMe$_2$-4,5	B	94	130—131	2.10s (Me), 2.35s (Me), 6.80—7.75m (ArH)	68.0 (68.1	4.9 4.8	6.1 6.1)	C$_{13}$H$_{11}$NOS

[a] A = Bromobenzene, B = chlorobenzene. [b] Lit.,[31] m.p. 92—92.5 °C. [c] Lit.,[31] m.p. 149—150 °C. [d] Lit.,[31] m.p. 99—99.5 °C.

thermolysis solvent, was added to the remaining solvent at reflux under nitrogen, giving a 2% (w/v) solution. After being heated for a further 3 h the solvent was removed and the product purified by column chromatography on alumina using light petroleum–ether as eluant to give the 3-aryl-anthranils recorded in Table 4.

Thermolysis of the 3-Arylanthranils. (1) *General Methods.*—
(a) The anthranil in a small amount of the thermolysis solvent was added to the bulk of the refluxing solvent (containing the appropriate catalyst) to give a 1—2% (w/v) solution. The reflux under nitrogen was followed by t.l.c. until the anthranil was consumed or present in minimal amounts (from 2—24 h). The reaction conditions and products are recorded in Table 2, Scheme 4, and below. After removal of the solvent the crude material was chromatographed on alumina.

(b) The neat anthranil under nitrogen was heated as recorded in Scheme 4. The crude material was extracted with hot n-butyl alcohol, the solvent evaporated, and the extract chromatographed on alumina.

A typical chromatography method is illustrated for the thermolysis of 3-(p-tolyl)anthranil in refluxing 1,2,4-trichlorobenzene. Elution with light petroleum–ether (4 : 1) gave unchanged anthranil. With the same solvents (1 : 1) 2-amino-4'-methylbenzophenone was eluted, while with ether–methanol (9 : 1) a mixture of 2- and 3-methylacridone was obtained.

(2) *Separation of 2- and 3-Methylacridones.*—The mixture of the acridones in dry dimethylformamide (25 ml) was treated with sodium hydride (1.01 equiv.) under nitrogen and after 30 min the mixture was further treated with methyl iodide (1.01 equiv.) and stirred overnight. The green fluorescent solution was poured into water (100 ml). The precipitate was filtered, washed with water, and dried. Chromatography on alumina eluting with light petroleum–ether (4 : 6) gave 2,10-dimethylacridan-9-one which crystallised as pale yellow crystals from ethanol, m.p. 146—148 °C (lit.,[32] m.p. 150—151 °C). Further elution with ether gave 3,10-dimethylacridan-9-one as pale yellow crystals from ethanol, m.p. 180—182 °C (lit., [33] m.p. 183—184 °C).

(3) *Products from the Thermolysis of the 3-Arylanthranils.*— (a) *From 3-(p-tolyl)anthranil.* The products in Table 2 and Scheme 4 were obtained. The acridones were separated and had the properties indicated above. 2-Amino-4'-methylbenzophenone was identified by comparison with the known material described above. 2-(2,4-*Dichlorophenylamino*)-4'-*methylbenzophenone* (14) was obtained as an orange glassy material, b.p. 162—175 °C/0.05 mmHg (Found: C, 67.3; H, 4.3; N, 3.9. $C_{20}H_{15}Cl_2NO$ requires C, 67.4; H, 4.2; N, 3.9%). $\nu_{max.}$ 3 300 cm^{-1} (NH). δ 2.43s (Me), 6.73—7.83m (arom. H), and 9.97s (NH). This compound was also prepared by heating a mixture of 2-amino-4'-methylbenzophenone (1.10 g, 0.0053 mol), 2,4-dichloroiodobenzene (2.90 g, 0.0106 mol), potassium carbonate (1.00 g, 0.007 mol), and copper bronze (0.1 g) at 200—220 °C for 5 h, and then purifying the mixture by elution through alumina. Light petroleum gave 2,4-dichloroiodobenzene (0.64 g) while light petroleum admixed with ether (4 : 1) gave the required compound (14) (0.97 g, 52%) as an orange oil. By heating 2-amino-4'-methylbenzophenone in refluxing 1,2,4-trichlorobenzene for 4 h with copper bronze and work-up as above, the same product (14) was isolated (6%).

(b) *From 3-(4-bromophenyl)anthranil.* After being refluxed for 6 h in 1,2,4-trichlorobenzene, the solution was cooled to give crystallisation of the 3-bromoacridones. After chromatography of the residue on evaporation, unchanged anthranil (32%) was first eluted (light petroleum–ether, 4 : 1) followed by more 3-bromoacridone (ether–chloroform, 1 : 1) (combined yield 40%), m.p. 355—360 °C (lit.,[34] m.p. 350 °C; lit.,[35] m.p. of 2-bromoacridone 389 °C).

(c) *From 3-(4-methoxyphenyl)anthranil.* After being refluxed for 6 h in 1,2,4-trichlorobenzene crystallisation of 3-methoxy-acridone ensued. Chromatography again gave unchanged anthranil (light petroleum–ether, 4 : 1) (62%) followed by 2-amino-4'-methoxybenzophenone (light petroleum–ether, 1 : 1) (8%) and 3-methoxyacridone (chloroform) (29%), m.p. 291 °C (lit.,[36] m.p. 290 °C). $\nu_{max.}$ (Nujol) 3 250 (NH) and 1 640 cm^{-1} (C=O); δ[(CD$_3$)$_2$SO] 3.95s (Me), 6.85—7.00m (2 H), 7.15—7.80 (3 H), 8.10—8.35m (2 H), and 11.60br (NH).

(d) *From 3-(2,4,6-trimethylphenyl)anthranil.* The same treatment as in (b) gave the following products: 2,4,10-*tri-methylacridone* (30) (light petroleum–ether, 1 : 1) as yellow crystals from ethanol, m.p. 83—85 °C (4%) (Found: C, 80.7; H, 6.4; N, 5.8. $C_{16}H_{15}NO$ requires C, 81.0; H, 6.4; N, 5.9%). δ 2.39s (2-Me), 2.60s (4-Me), 3.83s (10-Me), 7.10—7.35m (3- and 7-H), 7.47dd (5-H), 7.57—7.75dt (6-H, J 8 and 2 Hz), 8.12s (1-H), and 8.37—8.45dd (8-H, J 8 and 2 Hz).

2,4,5-*Trimethylacridone* (31) (ether) as yellow crystals from ethanol, m.p. 208—209 °C (16%) (Found: C, 80.9; H, 6.2; N, 6.1. $C_{16}H_{15}NO$ requires C, 81.0; H, 6.4; N, 5.9%). $\nu_{max.}$ (Nujol) 3 450 cm^{-1} (NH); δ 2.40s (2-Me), 2.45s (4- and 5-Me), 7.02—7.25dd (7-H), 7.27d (3-H), 7.40—7.47dd (6-H), 7.57br (NH), 8.10d (1-H), and 8.27—8.37dd (8-H).

2,4-Dimethylacridone (18) (chloroform) as yellow crystals from ethanol, m.p. 314—315 °C (46%) (lit.,[37] m.p. 314—315 °C). $\nu_{max.}$ (Nujol) 3 300 (NH) and 1 630 cm^{-1} (C=O). δ[(CD$_3$)$_2$-SO] 2.37s (2-Me), 2.55s (4-Me), 7.15—7.30dd (7-H), 7.37s (3-H), 3.60—7.77dd (6-H), 7.85—7.95d (5-, 1-H), 8.20—8.30dd (8-H), and 10.50br (NH).

(e) *From 3-(2,6-dimethylphenyl)anthranil.* After 4 h of reflux in 1,2,4-trichlorobenzene, chromatography of the crude product gave unchanged anthranil (light petroleum–ether, 4 : 1) (52%) followed by 4,10-*dimethylacridone* (light petroleum–ether, 3 : 2) (5%) as a yellow oil. δ 2.65s (4-Me), 3.85s (10-Me), 7.00—8.50m (arom. H).

4,5-Dimethylacridone (ether) as pale brown crystals (12%) from light petroleum (b.p. 100—120 °C), m.p. 235 °C (lit.,[38] m.p. 234—235 °C); δ 2.45s (4- and 5-Me), 6.92—7.27dd (2- and 7-H), 7.30—7.45d (3- and 6-H), 7.50br (NH), and 8.15—8.30dd (1- and 8-H).

4-Methylacridone (ether–chloroform, 1 : 1) as pale brown crystals from ethanol, m.p. 348 °C (lit.,[39] m.p. 347 °C). $\nu_{max.}$ (Nujol) 3 250 (NH) and 1 620 cm^{-1} (C=O). δ[CDCl$_3$ and (CD$_3$)$_2$SO] 2.55s (Me), 7.00—7.90m (5 arom. H), and 8.15—8.40t (1- and 8-H).

(f) *From 3-(2,4-dimethylphenyl)anthranil.* After being refluxed for 3 h in 1,2,4-trichlorobenzene the following products were obtained on chromatography: unchanged anthranil (2%) (light petroleum–ether 9 : 1) followed by 2-amino-2',4'-dimethylbenzophenone (light petroleum–ether, 4 : 1) (17%) as a brown oil and 2,4-dimethylacridone (chloroform), m.p. 314—315 °C (pale brown crystals from ethanol) (lit.,[37] m.p. 314—315 °C).

Pyrolysis of the anthranil at 280 °C for 30 min which involved considerable sublimation gave after extraction with hot n-butyl alcohol and chromatography of the extract the following products: unchanged anthranil (3%) followed by 2-amino-2',4'-dimethylbenzophenone (11%) as a brown oil and 2,4-dimethylacridone (55%) as pale brown crystals.

(g) *From 3-(2,6-dimethoxyphenyl)anthranil.* After 6 h of reflux in 1,2,4-trichlorobenzene followed by the usual work-up the following products were isolated: the unchanged anthranil (light petroleum–ether, 1 : 1) (15%) followed by 4-methoxy-acridone (chloroform) as yellow crystals from ethanol, m.p. 294—296 °C (lit.,[40] m.p. 295—296 °C) (62%). δ[(CD$_3$)$_2$SO] 3.95s (Me), 6.90—7.25m (2 H), 7.35—7.95m (3 H), and 8.05—8.20dd (1- and 8-H).

(h) *From 3-(3,5-dimethyl-2-thienyl)anthranil* (39). (i) After being refluxed for 3 h in pure bromobenzene (distilled from sodium hydride) the anthranil was unchanged.

(ii) After being refluxed for 48 h as in the first experiment the usual work-up gave, in order of mobility on elution from an alumina column, firstly 2,3a-*dimethylthieno*[2,3-b]*quinolin-4-one* (40) (4% as a yellow oil, b.p. 118—128 °C/0.05 mmHg. m/z 229.0558 (M^+) ($C_{13}H_{11}NOS$ requires 229.0561). $\nu_{max.}$ 1 690 (C=O), 1 590, and 1 560 cm^{-1}. δ 1.45s (3a-Me), 2.12d (2-Me, J 2 Hz), 6.05q (3-H, J 2 Hz), 7.20—7.70m (3 H), and 7.85dd (8-H, J 8 and 2 Hz); δ(^{13}C) 16.84q (3a-Me), 27.24q (2-Me), 66.55s (C-3a), 187.49s (C-8a), and 197.13s p.p.m. (C-9). This product was followed by unchanged anthranil (2%).

(iii) The anthranil was heated under reflux for 3 h in pure bromobenzene in the presence of a trace of reduced iron powder and worked up as above to give the thienoquinolone (40) (98%).

(iv) The anthranil was heated under reflux in pure 1,2,4-

trichlorobenzene for 6 h and worked up as above to give the following products in order of chromatographic mobility on alumina: the thienoquinolone (40) (70%); N-(2,4-*dichlorophenyl*)-2,3(*or* 8)-*dimethylthieno*[2,3-b]*quinolin*-4-*one* (42) or (43) (33%) as yellow crystals from ethanol, m.p. 192—193 °C (Found: C, 60.5; H, 3.8; N, 3.6. $C_{19}H_{13}Cl_2NOS$ requires C, 60.7; H, 4.0; N, 3.7%). m/z 373.0092 (M^+, 100%) ($C_{19}H_{13}$-$^{35}Cl_2NOS$ requires 373.0094), 375 (74), 377(16), 338 (M — Cl, 39), and 228 (M — C_6H_3Cl, 32). $\nu_{max.}$ (Nujol) 1 680 cm^{-1} (C=O), δ 2.20d (Me), 2.50s (Me), and 6.60—7.65m (aromatic H); and finally 2-(2-aminobenzoyl)-3,5-dimethylthiophene (12%), m.p. 93—94 °C.

(v) After 6 h reflux in N,N-dimethylaniline, work-up gave the quinolone (40) (4%) and 2-(2-aminobenzoyl)-3,5-dimethyl-thiophene (39%).

(vi) After 6 h reflux in p-dimethoxybenzene, 2-(2-amino-benzoyl)-3,5-dimethylthiophene (21%) was isolated.

(*i*) *From* 3-(4,5-*dimethyl-2-thienyl*)*anthranil* (44). (i) When the title anthranil in 1,2,4-trichlorobenzene in the presence of a trace of reduced iron was refluxed for 3 h the usual work-up gave firstly 2-(2-aminobenzoyl)-4,5-dimethylthiophene (20%), m.p. 104—105 °C, followed by 2,3-*dimethylthieno*[3,2-b]-*quinolin*-4-*one* (45) (53%) as pale orange crystals, m.p. 305—310 °C (Found: C, 68.4; H, 4.8; N, 5.9. $C_{13}H_{11}NOS$ requires C, 68.1; H, 4.8; N, 6.1%). $\nu_{max.}$ (Nujol) 1 620 cm^{-1} (C=O). δ(CF$_3$CO$_2$D) 2.15s (Me), 2.30s (Me), and 7.35—8.45m (aromatic H) m/z 229 (M^+, 100%), 214 (M — Me, 18), and 196 (M — SH, 15).

(ii) When the thermolysis was conducted in bromobenzene as in the above case the anthranil was recovered (50%) together with the thienoquinolone (45) (44%) and 2-(2-aminobenzoyl)-4,5-dimethylthiophene (12%).

(iii) A similar thermolysis in chlorobenzene gave the anthranil (38%), quinolone (45) (34%), and 2-(2-amino-benzoyl)-4,5-dimethylthiophene (46) (61%).

(*j*) *From* 3-(2,5-*dimethyl-3-thienyl*)*anthranil* (47). (i) Thermolysis of the anthranil in 1,2,4-trichlorobenzene under reflux for 3 h gave on the usual work-up unchanged anthranil (1%), 3-(2-aminobenzoyl)-2,5-dimethylthiophene (36%), and 2,9a-*dimethylthieno*[3,2-b]*quinolin*-9-*one* (48) (7%) as an orange gum. $\nu_{max.}$ 1 650 cm^{-1}. δ 1.95s (8a-Me), 2.35s (2-Me), 6.50s (3-H), and 6.90—7.55m (aromatic H). m/z 197 (M^+ — S, 100%), 196 (M — SH, 96), and 182 (197 — Me, 25).

(ii) When the thermolysis was conducted in bromobenzene in the presence of reduced iron powder under reflux for 4 h, 3-(2-aminobenzoyl)-2,5-dimethylthiophene (45%) was formed.

Other Decompositions of Azidobenzoylthiophenes.—2-(2-Azidobenzoyl)-3,5-dimethylthiophene as a 1% solution in pure bromobenzene was refluxed for 3 h in the presence of various catalysts with the following results: (i) with a trace of reduced iron, 2,3a-dimethylthieno[2,3-*b*]quinolin-4-one (40) (68%) was produced.

(ii) With a trace of copper powder the same quinolone (40) (14%) and 2-(2-aminobenzoyl)-3,5-dimethylthiophene (31%) were produced.

(iii) With a trace of toluene-*p*-sulphonic acid, the anthranil (68%) was recovered together with a trace of 2-(2-amino-benzoyl)-3,5-dimethylthiophene.

Deoxygenation of Nitrobenzoyl Aromatic Compounds with Triethyl Phosphite.—(*a*) 2-*Nitrobenzoylmesitylene* (32). To the nitro compound (1.50 g, 0.0059 mol) in refluxing bromo-benzene (90 ml) under nitrogen was added triethyl phosphite (2.31 g, 0.014 mol) in bromobenzene (10 ml) in one portion. After 72 h the solvent was removed and the residue chromato-graphed on alumina giving the following products in order of

mobility: 3-mesitylanthranil (28) (0.34 g, 26%); unchanged nitro compound (0.27 g, 18%), m.p. 145—146 °C; 2-amino-benzoylmesitylene (33) (0.10 g, 7.5%); diethyl 2-(2,4,6-tri-methylbenzoyl)phenylphosphonate (34) (0.40 g, 30%), as pale yellow crystals from light petroleum, m.p. 78—80 °C (Found: C, 66.5; H, 7.1. $C_{20}H_{25}O_4P$ requires C, 66.7; H, 7.0%). δ 1.37t (Me), 2.12s (2 Me), 2.20s (Me), 4.13—4.47q (CH$_2$), 6.86s (mesityl 3-, 5-H), 7.25—7.65m (3 H), and 8.02—8.27dd (1 H). m/z 360 (M^+, 38%), 331 (M — Et, 18), 314 (M — EtO, 12), 303 (331 — Et, 15), 285 (314 — Et, 12), 275 (303 — C_2H_4, 12), and 223 [M — PO(OEt)$_2$, 100%].

(*b*) 2-(2-*Nitrobenzoyl*)-3,5-*dimethylthiophene.* When the nitro compound (5.22 g, 0.02 mol) was deoxygenated as in the above case in commercial bromobenzene the following products were isolated by chromatography. Light petroleum elution through an alumina column gave a mixture of three compounds (3.55 g). Further elution through a silica column gave, in order of mobility: the thienoquinolone (40) (1.65 g, 36%) and unchanged nitro compound (0.50 g, 9.5%). Using purified bromobenzene the products were the anthranil (39) (23%), unchanged nitro compound (28%), and an oil presumed to be diethyl N-[2-(3,5-dimethyl-2-thenoyl)phenyl]phosphonate, which decomposed during distillation, b.p. 170 °C/0.3 mmHg. $\nu_{max.}$ 3 450 (NH) and 1 630 cm^{-1} (C=O); δ 1.30t (Me), 2.35s (Me), 2.50d (Me), 4.10q (CH$_2$), 6.65s (4'-H), 6.90—8.25m (aromatic H), and 9.05br (NH).

Thermolysis of 2,3a-*Dimethylthieno*[3,2-b]*quinolin*-4-*one* (40).—(*a*) When the title quinolone (1.00 g, 0.0045 mol) in 1,2,4-trichlorobenzene (50 ml) was refluxed for 6 h in the usual way, unchanged quinolone (11%) and N-(2,4-dichloro-phenyl)thienoquinolone (42) or (43) (18%) was isolated.

(*b*) When the thermolysis was conducted in p-fluoronitro-benzene at 100 °C (24 h) or o-dichlorobenzene under reflux (6 h), unchanged quinolone in 80 and 100% yield respectively was isolated.

(*c*) Thermolysis in refluxing p-fluoronitrobenzene (6 h) gave some tar and 2-(2-aminobenzoyl)-3,5-dimethylthiophene (14%).

Hydrolysis of 2,3a-*Dimethylthieno*[2,3-b]*quinolin*-4-*one* (40). —(*a*) When the liquid thienoquinolone was allowed to stand exposed to the atmosphere for several days, crystals appeared in the oil. Trituration with light petroleum gave N-(3,5-*dimethyl-2-thienyl*)*anthranilic acid* (41) as cream crystals which recrystallised from ethanol, m.p. 193—195 °C (Found: C, 63.2; H, 5.25; N, 5.6. $C_{13}H_{13}NO_2S$ requires C, 63.1; H, 5.3; N, 5.6%). $\nu_{max.}$ (Nujol) 3 350 (NH) and 1 670 cm^{-1} (C=O). δ 1.95s (Me), 2.40s (Me), 2.40s (Me), 6.50s (4'-H), 6.60—6.75m (3- and 5-H), 7.30dt (4-H, J 9 and 2 Hz), 7.95dd (6-H, J 9 and 2 Hz), 9.15br (NH), and 10.00br (OH).

(*b*) When the thienoquinolone (0.50 g) in aqueous sodium hydroxide (10 ml, 40%, w/v) was allowed to stand for 48 h, neutralisation gave a precipitate (0.48 g, 89%) of the above anthranilic acid (41).

Attempted Syntheses of the N-(2,4-*Dichlorophenyl*)*thieno-quinolone* (42) *or* (43).—A 100-ml flask was charged with potassium (0.50 g, 0.128 mol), cuprous iodide (2.50 g, 0.013 mol), naphthalene (0.12 g, 0.000 94 mol), and dry tetra-hydrofuran and the mixture stirred vigorously under nitrogen for 8 h. To this suspension was added the thienoquinolone (40) (0.30 g, 0.0013 mol) and 2,4-dichloroiodobenzene (4.00 g, 0.0145 mol) in dry tetrahydrofuran (25 ml). After 16 h reflux under nitrogen the solvent was removed and the residue chromatographed on alumina. The two starting materials were quantitatively recovered.

2,4,10-*Tetramethylacridone* (30).—Potassium 2-chloro-benzoate (5.00 g, 0.026 mol), potassium carbonate (2.00 g, 0.0145 mol), cuprous chloride (0.02 g, 0.0002 mol), and 2,4-xylidine (20.00 g, 0.165 mol) were mixed and heated for 10 min at 190—200 °C. This mixture was eluted through a short silica column. Elution with ether gave 2-(2,4-dimethyl-phenylamino)benzoic acid (3.37 g, 54%) which recrystallised from toluene, m.p. 186 °C (lit.,[37] m.p. 187 °C).

This acid (1.00 g, 0.004 mol) and polyphosphoric acid (*ca.* 10 g) were stirred for 1 h at 250 °C. The cooled mixture was diluted with water and basified. The yellow precipitate was recrystallised from ethanol to give 2,4-dimethylacridone (0.70 g, 75%), m.p. 314—315 °C (lit.,[37] m.p. 314—315 °C).

2,4-Dimethylacridone (0.50 g) in dry dimethylformamide (15 ml) was treated with sodium hydride (0.125 g; 50% suspension in oil). Methyl iodide (0.35 g, 0.0024 mol) was added, and the mixture was stirred overnight. Addition of water gave a precipitate which recrystallised from ethanol as yellow crystals of the title compound, m.p. 83—85 °C (0.48 g, 90%), identical with the material prepared by thermolysis of 3-mesitylanthranil.

2-(2,4-*Dichlorophenylamino*)-4'-*methylbenzophenone* (14).—2-Amino-4'-methylbenzophenone (1.10 g, 0.0053 mol), 2,4-dichloroiodobenzene (2.90 g, 0.016 mol), potassium carbonate (1.00 g, 0.007 mol), and copper bronze (0.10 g) were heated together at 200—220 °C for 5 h. Elution of the mixture through an alumina column gave firstly 2,4-dichloroiodo-benzene (0.64 g) followed by a mixture of dichloroiodobenzene and the title product (2.99 g). This mixture was dissolved in ether and extracted with aqueous hydrochloric acid (4M). Basification of the extract gave a thick orange oil (0.97 g, 52%), b.p. 162—175 °C/0.05 mmHg. This product was identical with that referred to above. When the reaction was repeated using 1,2,4-trichlorobenzene, 2-amino-4'-methylbenzophenone, and copper powder under reflux for 4 h, the same product was isolated in 6% yield.

4,10-*Dimethylacridone* (24).—4-Methylacridan-9-one (0.10 g, 0.000 48 mol), sodium hydride (0.10 g; 50% suspension in oil; 0.002 mol), and dimethylformamide (10 ml) were stirred together for 30 min and then methyl iodide (0.284 g, 0.002 mol) was added. After 3 h the mixture was poured into water (100 ml) then extracted with ether and the extract dried (MgSO₄) and evaporated. The orange gum (0.06 g, 60%) was identical with that described above from the thermolysis of 3-(2,6-dimethylphenyl)anthranil.

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