Synthesis and Reactions of Cyclic Isoimidium Salts

By **Gerhard V. Boyd** * and **René L. Monteil**, Department of Chemistry, Chelsea College, London SW3 6LX

Treatment of seven secondary and tertiary succinamic acids with acetic anhydride and perchloric acid gave succinisoimidium perchlorates (5), which reacted with primary and secondary amines to yield *NN'*-substituted succinamides. The deprotonation of tertiary and secondary succinisoimidium salts was investigated and evidence for the formation of unstable *N*-phenyl- and *N*-t-butyl-succinisoimides was obtained. Six phthalisoimidium perchlorates (11) were prepared: their reactions with nucleophiles are described. Stable phthalisoimides, obtained from secondary phthalisoimidium perchlorates, were studied. In the homophthalic acid series, five 3-ammonio-3,4-dihydro-1*H*-2-benzopyran-1-one perchlorates (27) were prepared, which yielded *N*-substituted 3-amino-1*H*-2-benzopyran-1-ones (28) on deprotonation. An isomeric homophthalisoimidium salt, 3,4-dihydro-1-morpholinio-1*H*-2-benzopyran-3-one perchlorate (32), was synthesised. Isoimidium salts derived from αα'-diphenylsuccinic, maleic, cyclopropane-1,2-dicarboxylic, and diphenic acid were obtained. 1,2-Dihydro-2-dimethylammonio-3,1-benzoxazin-4-one perchlorate (47) was converted into 2-dimethylamino-3,1-benzoxazin-4-one (48).

CYCLIC isoimides (1) have been known for over 80 years since Hoogewerff and van Dorp's discovery of the isoimides derived from phthalic [1] and camphoric acids [2] and there have been sporadic reports on this class of compounds to the present day,[3] culminating in an article on the use of phthalisoimides as protecting groups in penicillin chemistry.[4] It appears that stable isoimides have only been obtained by the dehydration of mono-

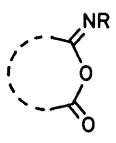
[1] S. Hoogewerff and W. A. van Dorp, *Rec. Trav. chim.*, 1892, **11**, 84.

[2] S. Hoogewerff and W. A. van Dorp, *Rec. Trav. chim.*, 1893, **12**, 12.

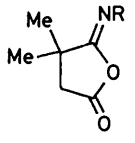
[3] For a useful summary and leading references, see W. R. Roderick and P. L. Bhatia, *J. Org. Chem.*, 1963, **28**, 2018.

[4] S. Sukolja and S. Lammert, *J. Amer. Chem. Soc.*, 1975, **97**, 5582.

amides of camphoric, phthalic, and maleic acid; recent work [5] on the saturated isoimides (2) and (3) suggests that these compounds are easily hydrolysed to amic acids and readily rearrange to the corresponding imides. Although the basic properties of isoimides were early recognised,[2] isoimidium salts, with the exception of tetrachloroaurates of camphorisoimides,[6] remained unknown. Some years ago, we briefly reported [7] the formation of such salts by the action of acetic anhydride and perchloric acid on *N*-substituted monoamides of phthalic, maleic, and succinic acid and we now give



(1)



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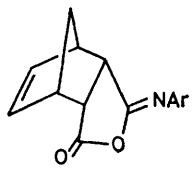
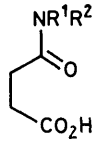


(3)

R = alkyl or aryl



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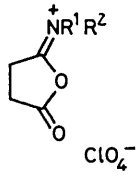
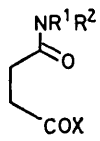


(5)



(6)

a; R^1 = Ph, R^2 = H
b; R^1 = 2,6-$Me_2C_6H_3$, R^2 = H
c; R^1 = *p*-NO_2·C_6H_4, R^2 = H
d; R^1 = Bu^t, R^2 = H
e; R^1 = Ph, R^2 = Me
f; NR^1R^2 = morpholino
g; NR^1R^2 = pyrrolidino

a; R^1 = Ph, R^2 = H, X = OMe
b; R^1 = Ph, R^2 = H, X = $NHBu^t$
c; R^1 = Ph, R^2 = H, X = piperidino
d; R^1 = Ph, R^2 = H, X = NHPh
e; R^1 = Ph, R^2 = H, X = $NHC_6H_3Me_2$-2,6
f; R^1 = Ph, R^2 = H, X = NMePh
g; R^1 = Ph, R^2 = H, X = $NHCH_2CO_2H$
h; R^1 = Ph, R^2 = Me, X = NMePh
i; R^1 = 2,6-$Me_2C_6H_3$, R^2 = H, X = OEt

details of the synthesis and properties of these compounds and of isoimidium salts derived from other dibasic acids.

Succinisoimidium Perchlorates.—Secondary and tertiary succinamic acids (4a—g), obtained by the action of succinic anhydride on the appropriate amines, were converted in nearly quantitative yields into the corresponding isoimidium perchlorates (5a—g) by the action of acetic anhydride and perchloric acid. Most salts were stable crystalline solids, which could be kept for years in the absence of moisture. The *p*-nitrophenyl derivative (5c) was very susceptible to hydrolysis and the pyrrolidino compound (5g) was obtained as an oil, which could not be induced to crystallise. The structure of these salts follows from analysis, their reaction with water, which yields the original amic acids, and their n.m.r. and i.r. spectra. The latter exhibit two characteristic bands near 1 700 and 1 900 cm^{-1}, which are assigned respectively to the $C{=}N^+$ and cyclic carbonyl groups. Comparably high-frequency carbonyl absorptions were observed in the spectra of 5-oxo-Δ^2-oxazolinium perchlorates.[8]

The succinisoimidium salts are highly susceptible to attack by nucleophilic reagents, which invariably occurred at the carbonyl group to yield derivatives of succinamic acids. Thus *N*-phenylsuccinisoimidium perchlorate (5a) reacted with methanol to give methyl succinanilate (6a) and with t-butylamine, piperidine, aniline, 2,6-dimethylaniline, *N*-methylaniline, and aqueous sodium glycinate to form the diamides (6b—g), respectively. The unsymmetrical diamide (6b) was also obtained from the alternative combination of *N*-t-butylsuccinisoimidium perchlorate (5d) and aniline; likewise, *N*-2,6-dimethylphenyl-*N'*-phenylsuccinamide (6e) was formed from the salt (5b) and aniline, and *N*-methylsuccinanilide from aniline and the ternary iminium salt (5e). The latter yielded *NN'*-dimethylsuccinanilide (6h) on treatment with *N*-methylaniline; the action of ethanol on the perchlorate (5b) resulted in the ester (6i).

When chloroform solutions of *N*-phenyl- and *N*-t-butyl-succinisoimidium perchlorate were treated with triethylamine there was evidence for the formation of the elusive succinisoimides (7a and b). The i.r. spectrum of

[5] C. K. Sauers, C. A. Marikakis, and M. A. Lupton, *J. Amer. Chem. Soc.*, 1973, **95**, 6792.

[6] S. Hoogewerff and W. A. van Dorp, *Rec. Trav. chim.*, 1895, **14**, 252.

[7] G. V. Boyd, *Chem. Comm.*, 1969, 1147.

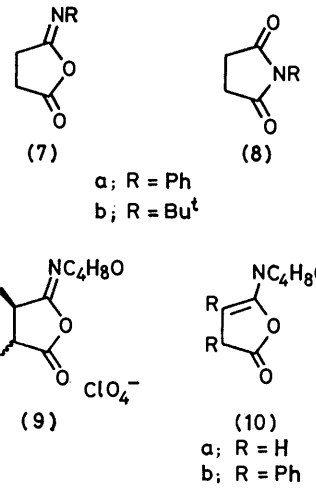
[8] G. V. Boyd and P. H. Wright, *J.C.S. Perkin I*, 1972, 909.

the solution obtained from the *N*-phenyl derivative contained a band at 1 825 cm^{-1}, attributable [5] to the carbonyl group of the isoimide structure, which gradually decayed and was replaced by intense absorption at 1 700 cm^{-1} due to the normal imide (8a), the process being complete after 5 h at room temperature. In contrast, the t-butyl analogue appeared to be stable in solution, as there was no change in the i.r. spectrum ($\nu_{max.}$ 1 820 cm^{-1}) over 5 days. However, all attempts to isolate the isoimide (7b) were unsuccessful. Evaporation of the chloroform solution at 0° left a yellow oil, which contained at least three components (t.l.c.), the main constituent being *N*-t-butylsuccinamic acid (4d). A similar experiment, in which ether instead of chloroform was used, gave a pale yellow solid, m.p. 92—102°, which did not give a satisfactory analysis. Its i.r. spectrum, which showed intense absorption at 1 820 cm^{-1}, and its reaction with aniline, which resulted in a 75% yield of *N*-t-butyl-*N*'-phenylsuccinamide (6b), indicated that it must have contained substantial amounts of *N*-t-butylsuccinisoimide. Attempts to purify the compound by recrystallisation or chromatography resulted in the formation of *N*-t-butylsuccinamic acid.

Chemical evidence for the formation of *N*-phenylsuccinisoimide and its rearrangement to *N*-phenylsuccinimide was obtained by carrying out the deprotonation of the perchlorate (5a) with a slight deficiency of triethylamine in dichloromethane, and immediately treating the solution with aniline, when succinanilide was obtained in 56.5% yield. When the solution was left for 2.5 h before the addition of aniline, the yield of succinanilide decreased to 24% and after 24 h to zero. Evaporation of such a solution left the normal imide. Two reactions of the *N*-phenylsuccinisoimidium perchlorate probably involve abstraction of the phenylimino group from the free isoimide (7a): *p*-dimethylaminobenzaldehyde gave the hydroperchlorate of *p*-dimethylaminobenzylideaniline (87%) and treatment with *p*-nitrobenzoyl chloride in the presence of triethylamine afforded a 14% yield of *N*-(*p*-nitrobenzoyl)aniline.

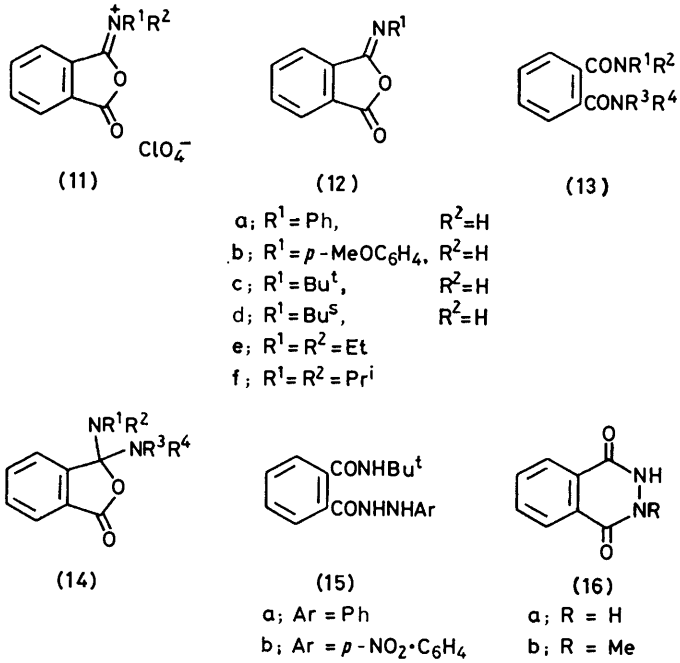
It appears that *N*-phenylsuccinisoimide rearranges so readily to the normal imide as to preclude isolation. The t-butyl analogue, on the other hand, shows no tendency to rearrange, presumably for steric reasons, but is extremely sensitive to hydrolysis.

A consideration of the structure of the isoimidium cations (5f and g) reveals that they are the conjugate acids of enamines, but an attempt to deprotonate the morpholine derivative (5f) to the base (10a) resulted in the formation of an intractable tar. However, it is shown in the following paper that this enamine is indeed formed and can be intercepted by suitable reagents. We attempted to prepare the diphenyl derivative (10b) in the hope that the presence of the phenyl substituents might stabilise the system. The amic acid, formed by the action of morpholine on αα'-diphenylsuccinic anhydride, was readily converted into the salt (9). Since the anhydride was prepared [9] from a mixture of DL- and



meso-diphenylsuccinic acids, the derived morpholide and the isoimidium salt contained both diastereoisomers. Indeed, both compounds, while giving correct analyses, melted over a wide range. Treatment of the perchlorate (9) with triethylamine resulted in a complex mixture, from which the enamine (10b) could not be isolated.

Phthalisoimidium Salts.—*N*-Substituted phthalamic acids, obtained from phthalic anhydride and primary and

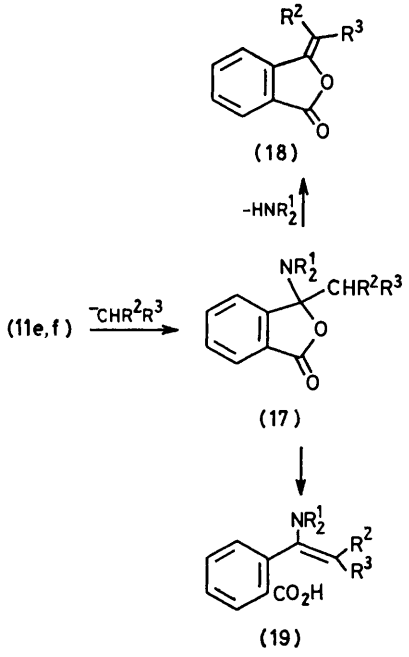


secondary amines, were converted into the corresponding isoimidium perchlorates (11a—f) in yields of 85—95%; the fluoroborate corresponding to (11c) was prepared by the action of acetic anhydride and aqueous fluoroboric acid on *N*-t-butylphthalamic acid. The phthalisoimidium salts, like the succinisoimidium per-

[9] H. Tillmans, *Annalen*, 1890, **258**, 90; W. Anschütz, *ibid.*, 1890, **259**, 73.

chlorates, show C=N$^+$ absorption near 1 700 cm^{-1}, but the carbonyl band is displaced to slightly lower frequencies, appearing at 1 850—1 870 cm^{-1}.

The action of numerous amines, NHR^{3}R^4, on a variety of phthalisoimidium salts gave phthalamides (13) in nearly quantitative yields; these products are described in the Experimental section. In no case was there



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any evidence for the formation of phthalides (14), resulting from attack of the amine at the alternative site of the isoimidium ring. Derivatives of phthalamide were also formed in the reaction of t-butylphthalisoimidium perchlorate with phenylhydrazine and with *p*-nitrophenylhydrazine to yield compounds (15a and b), respectively. The i.r. spectra of the products obtained from hydrazine and methylhydrazine indicated that they were similarly constituted; however, attempted recrystallisation resulted in the extrusion of t-butylamine to form the phthalazinediones (16a and b). These compounds were also obtained from the reactions of the *N*-phenyl derivative (11a) with hydrazine and methylhydrazine, respectively. Another example of nucleophilic attack at the carbonyl group was the formation of ethyl *N*-t-butylphthalamate from the salt (11c) and ethanol. In contrast, carbanions derived from ethyl cyanoacetate, dibenzoylmethane, and malononitrile reacted at the iminium carbon atom (see Scheme). The action of the first two compounds on the ternary iminium salt (11e) in the presence of triethylamine gave the known methylenephthalides (18; $R^2 = CN$, $R^3 = CO_2Et$)[10] and (18; $R^2 = R^3 = COPh$),[11] respectively.

[10] N. Maxim, *Ann. Chim.* (*France*), 1910, **9**, 62.

[11] J. Rotbergs, J. Lukina, V. Oskaja, and G. Vanags, *Latvijas P.S.R. Zinatnu Akad. Vestis, Khim. Ser.*, 1966, 358 (*Chem. Abs.*, 1966, **65**, 15,265).

Malononitrile, on the other hand, reacted with the salts (11e and f) to afford the styrene derivatives (19; $R^1 =$ Et, $R^2 = R^3 = CN$) and (19; $R^1 = Pr^i$, $R^2 = R^3 =$ CN), respectively, whose structures were established by ^{1}H n.m.r. and i.r. spectroscopy and, in the case of the second compound, which gave an unsatisfactory analysis for carbon, by the preparation of methyl and *p*-nitrobenzyl esters. We suggest that the formation of these products involves the common intermediates (17), which subsequently either eliminate an amine to yield a phthalide or undergo ring-opening to an *o*-carboxystyrene (see Scheme).

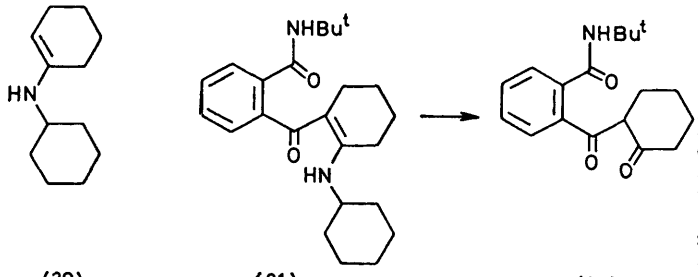
Deprotonation of the secondary phthalisoimidium perchlorates (11a—d) with triethylamine afforded the corresponding phthalisoimides (12a—d), of which only the first had been prepared previously.[12] The i.r. spectra of the isoimides show strong carbonyl bands near 1 800 cm^{-1} (which may be split into two) and C=N stretching vibrations at *ca.* 1 700 cm^{-1}. They are thus easily distinguished from the normal imides, in whose spectra the most intense carbonyl absorption is found at 1 700—1 720 cm^{-1}. All the isoimides rearranged to the normal imides on heating, the *N*-phenyl derivative most readily.[12] It completely isomerised in 1 h in boiling benzene. Attempted reactions of the *N*-phenylisoimidium salt (11a) with ethyl cyanoacetate and malononitrile in the presence of triethylamine yielded *N*-phenylphthalimide, presumably by deprotonation to the isoimide, followed by rearrangement. The *p*-methoxyphenyl analogue (12b) was more stable with a half-life of 5.5 h in boiling benzene. In contrast, *N*-t-butylphthalisoimide was unchanged after 7 days in boiling xylene and only isomerised to the extent of 10% after 4 h in boiling chlorobenzene; the change to *N*-t-butylphthalimide was complete after 1 h at 240°.

The isoimide ring is readily opened by nucleophilic reagents.[3] Accordingly, *N*-t-butylphthalisoimide yielded *N*-t-butylphthalamic acid with water and *N*-t-butyl-*N'*-phenylphthalamide with aniline. The phthalamide was also formed when the isoimide was treated with phenyl isocyanate or benzylideneaniline. From the former reaction *NN'*-diphenylurea was also isolated and from the latter benzaldehyde, which suggests that in both cases there was hydrolysis of the reagent to produce aniline. A similar result was obtained when *N*-cyclohexylidenecyclohexylamine was used, which gave *N*-t-butyl-*N'*-cyclohexylphthalamide. However, in this reaction a second product was formed in low yield, which is assigned structure (22) on the basis of its analysis, i.r. spectrum (3 280 cm^{-1}, NH; β-dicarbonyl CO absorptions at 1 710 and 1 690 cm^{-1}; and amide carbonyl at 1 630 cm^{-1}), and a positive enol test with iron(III) chloride. This diketone is thought to be formed by equilibration[13] of the imine with the enamine tautomer (20), followed by acylation by the isoimide to give (21), and, finally,

[12] P. H. van der Meulen, *Rec. Trav. chim.*, 1896, **15**, 282, 323.

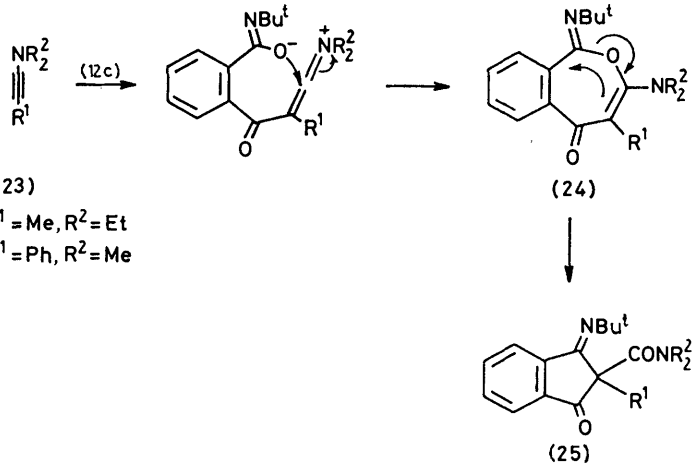
[13] H. Ahlbrecht, *Tetrahedron*, 1973, **29**, 659, and previous papers.

hydrolysis. The action of *N*-t-butylphthalisoimide on the ynamines (23a and b) resulted in the formation of



(20) (21) (22)

adducts, together with small amounts of *NN'*-di-t-butylphthalamide and *N*-t-butylphthalimide. The adducts showed ketone and amide carbonyl absorptions near 1 720 and 1 650 cm^{-1}, respectively, and are accordingly formulated as (25a and b). They are presumably



(23)
a; R^1 = Me, R^2 = Et
b; R^1 = Ph, R^2 = Me

(24)

(25)

produced from the primary products (24) as shown. Analogous seven-membered ring compounds (24; O in place of NBu^t), obtained from ynamines and phthalic anhydride, are known[14] to rearrange to the corresponding indane-1,3-diones.

Homophthalisoimidium Salts.—The formation of *N*-substituted amic acids from homophthalic anhydride and amides has not been described previously. t-Butylamine, morpholine, aniline, pyrrolidine, and piperidine each afforded a single product, which is regarded as a 2-amide (26)* by analogy with the structures of the amide[15] and esters,[15] obtained from the anhydride and ammonia and alcohols, and those of the ketones formed in the Friedel–Crafts reaction with aromatic compounds.[16] These products result from attack at the 2-carbonyl group of the anhydride, which is more electrophilic, because the electron deficiency of the other is decreased by conjugation with the benzene ring. The orientation of the amide group was rigorously proved for the case of the morpholide (26e) by an unambiguous alternative synthesis from *o*-bromobenzoic acid and *N*-acetoacetylmorpholine in the presence of sodium ethoxide and copper acetate (the Hurtley reaction[17]), the acetyl group being eliminated as sodium acetate in the process. The 2-homophthalamic acids (26a—e) were converted into the corresponding homophthalisoimidium perchlorates (27a—e) on treatment with acetic anhydride and perchloric acid. These salts are stable, colourless solids; their i.r. spectra show carbonyl absorption at the characteristically high frequency of *ca.* 1 800 cm^{-1}, somewhat lower than those of succinisoimidium and phthalisoimidium salts, and C=N^+ vibrations at 1 700 cm^{-1}; their ^1H n.m.r. spectra exhibit methylene resonances between δ 4.15 and 4.70. Treatment of the isoimidium perchlorates (27a and b) with morpholine gave the homophthalamides (30a and b), respectively.

The ternary homophthalisoimidium salts (27b, d, and e), unlike ternary succinisoimidium salts, readily afforded stable conjugate bases by the action of triethylamine. These 3-dialkylaminosocoumarins (1*H*-2-benzopyran-1-ones) (28b, d, e) are yellow crystalline solids, which revert to the parent salts on treatment with perchloric acid. The morpholino derivative was also obtained when the amic acid (26b) was heated with acetic anhydride. The isocoumarins show ν_{CO} at *ca.* 1 730 cm^{-1} and typical[18] enamine C=C absorption at 1 620—1 640 cm^{-1}; the olefinic proton signal appears between δ 5.85 and 5.05. Deprotonation of the *N*-phenyl derivative (27c) gave a base, which was evidently the anilinoisocoumarin (28c) rather than the tautomeric isoimide (29; R = Ph), since its i.r. spectrum showed the presence of a NH group and isocoumarin absorptions at 1 730 and 1 640 cm^{-1} and the n.m.r. spectrum exhibited singlets due to NH and olefinic protons. The imine ⇌ enamine equilibrium in this compound is shifted in

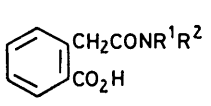
* The carboxy groups of homophthalic acid attached to the benzene ring and the methylene group are distinguished by the prefices 1 and 2, respectively (Beilstein, Handbuch der Organischen Chemie, 4th edn., vol. IX, 1926, p. 857).

[14] G. Höfle and W. Steglich, *Chem. Ber.*, 1972, **105**, 1368.
[15] R. Wegscheider and A. Glogau, *Monatsh.*, 1903, **24**, 915.
[16] G. Graebe and F. Trumpy, *Ber.*, 1898, **31**, 375.
[17] W. R. H. Hurtley, *J. Chem. Soc.*, 1929, 1870.
[18] N. J. Leonard and V. W. Gash, *J. Amer. Chem. Soc.*, 1954, **76**, 2781.

favour of the latter due to conjugative effects. The product obtained by deprotonation of the *N*-t-butylhomophthalisoimidium salt (27a) could not be obtained pure and its spectroscopic properties were ambiguous: the n.m.r. spectrum of its solution in deuteriochloroform showed an olefinic singlet at δ 5.35 in accord with structure (28a), but the i.r. spectrum of the solid, while indicating the presence of a NH group, exhibited abnormally high carbonyl absorptions at 1 770 and 1 670 cm^{-1}, and the product may well have been a mixture of the enamine (28a) and the isoimide (29; R = Bu^t).

The chemistry of the aminoisocoumarins (28) is discussed in the following paper.

A 1-homophthalisoimidium salt (32) was prepared as



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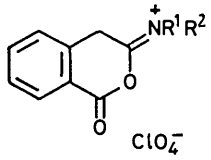

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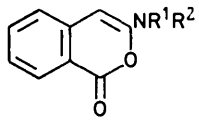
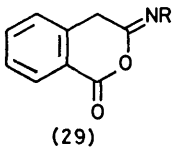
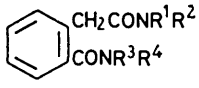


(28)

a; $R^1 = Bu^t$, $R^2 = H$
b; NR^1R^2 = morpholino
c; R^1 = Ph, R = H
d; NR^1R^2 = pyrrolidino
e; NR^1R^2 = piperidino



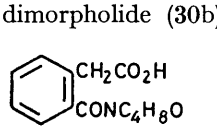
(29)



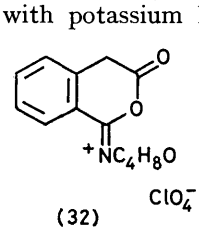
(30)

a; $R^1 = Bu^t$, R^2 = H, NR^3R^4 = morpholino
b; $NR^1R^2 = NR^3R^4$ = morpholino

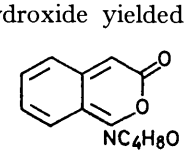
follows. Partial alkaline hydrolysis of a homophthalamide was expected to cause removal of the amine attached to the 2-carboxy group by analogy with the formation [15] of 1-methyl hydrogen homophthalate from the dimethyl ester. Accordingly, hydrolysis of the dimorpholide (30b) with potassium hydroxide yielded



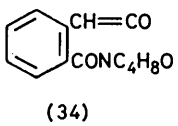
(31)



(32)



(33)



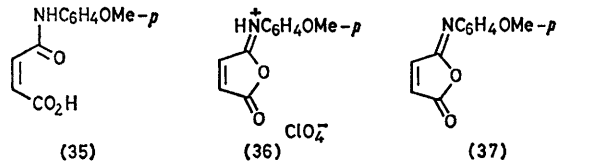
(34)

the potassium salt of the 1-homophthalamic acid (31). The free acid was obtained as an oil; it readily cyclised to the crystalline isoimidium perchlorate (32), which was characterised by analysis and n.m.r. and i.r. spectroscopy; its carbonyl stretching frequency at 1 830 cm^{-1} was higher than that (1 810 cm^{-1}) of the isomer (27b). The salt regenerated the dimorpholide when treated with morpholine. Attempts to isolate or obtain evidence for the formation of the non-benzenoid conjugate base (33) of this salt failed. Treatment of the perchlorate with triethylamine produced an intense purple colour, which rapidly faded; work-up gave an intractable gum. Experiments to trap compound (33) as a cycloadduct by carrying out the deprotonation in the presence of *N*-phenylmaleimide, dimethyl acetylenedicarboxylate, diphenylketen, and 4-phenyl-1,2,4-triazoline-3,5-dione were unsuccessful. The possibility that the 2-benzopyran-3-one (33) might undergo valence isomerisation to the ketene (34) was tested by treating the perchlorate with benzylideneaniline in the presence of triethylamine; however, no azetidinone was formed and the imine was recovered.

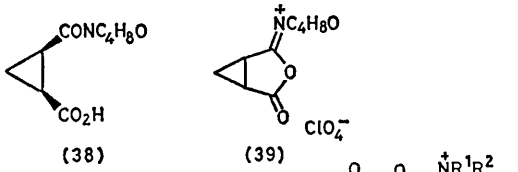
Isoimidium Salts derived from Miscellaneous Dibasic Acids.—The action of acetic anhydride and perchloric acid on the maleamic acid (35) led to the corresponding maleisoimidium perchlorate (36), which showed typical isoimidium carbonyl absorption at 1 860 cm^{-1}. Treatment of the salt with triethylamine gave the stable isoimide (37), which, like other maleisoimides, had been prepared previously [3] by the action of trifluoroacetic anhydride on the appropriate amic acid. *cis*-Cyclopropane-1,2-dicarboxylic anhydride furnished the morpholide (38), which was readily transformed into the bicyclic isoimidium salt (39), which showed ν_{CO} at 1 870 cm^{-1}.

Efforts directed towards the synthesis of 1,8-naphthalisoimidium salts (41) were unsuccessful due to our failure to prepare the required naphthalamic acids (40). 1,8-Naphthalic acid, because of the proximity of the carboxy groups, has a pronounced tendency to cyclise

and to yield cyclised products; a survey of the literature revealed only one claim of the formation of an amic acid from naphthalic anhydride and an amine, namely that

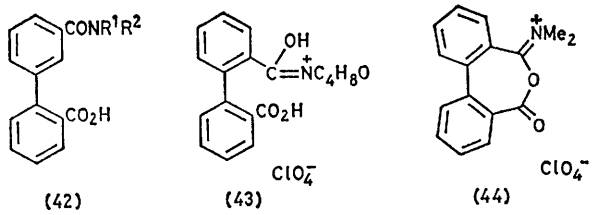


(35) (36) (37)



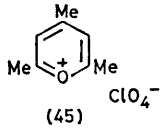
(38) (39)

(40) (41)



(42) (43) (44)

a; R^1 = Me, R^2 = H
b; R^1 = Et, R^2 = H
c; R^1 = Bu^t, R^2 = H
d; R^1 = R^2 = Me
e; R^1 = R^2 = Et
f; R^1 = R^2 = Pr^i
g; NR^1R^2 = morpholino

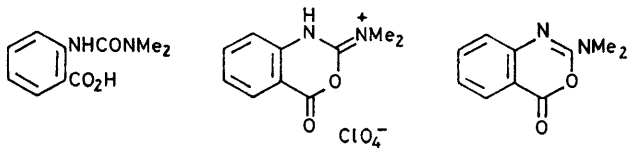


(45)

with 1,2-diaminoethane.[19] Treatment of the anhydride with aniline, t-butylamine, dimethylamine, and diethylamine in hot benzene or chloroform did not lead to the desired products, the anhydride being recovered. When benzylamine was used as reactant and solvent there were visible signs of a reaction occurring at room temperature and the i.r. spectrum of the resulting solid exhibited NH absorption at 3 400 cm^{-1}, attributed to the desired *N*-benzylnaphthalamic acid. However, the solid gradually reverted to naphthalic anhydride on standing and when the reaction was repeated with boiling benzylamine, *N*-benzylnaphthalimide was obtained.

Experiments in the 2,2′-diphenic acid series were almost equally discouraging. Although the reaction of diphenic anhydride with several amines afforded the amic acids (42a—g) without difficulty, subsequent treatment with perchloric acid and acetic anhydride gave hydroscopic gums in most cases. The morpholide (42g) gave a crystalline perchlorate whose analysis and i.r. spectrum indicated that it was most probably the *O*-protonated [20] amide (43). Only in the case of *NN*-dimethyldiphenamic acid (42d) did we obtain a diphenisoimidium salt, *i.e.* (44). This compound, which showed ν_{CO} 1 800 and $\nu_{C=N^+}$ 1 690 cm^{-1}, was formed in low yield on one occasion and the experiment could not be repeated. The failure to obtain isoimidium salts in this series may be due to unfavourable conformational effects. Attempted cyclisation of the t-butyldiphenamic acid (42c) produced an unexpected result: a crystalline salt was formed, which did not contain nitrogen. It was readily identified as 2,4,6-trimethylpyrylium perchlorate; the mother liquors yielded the mononitrile [21] of diphenic acid. It appears that the amide (42c) had suffered conversion into the nitrile by elimination of water and isobutene; the latter is known [22] to yield the pyrylium salt by the action of acetic anhydride and perchloric acid.

In conclusion, we describe an isoimidium salt containing a nitrogen atom in the lactone ring. The urea derivative (46), prepared [23] from isatoic anhydride and dimethylamine, was readily converted into the perchlorate (47) ($\nu_{max.}$ 1 810 and 1 690 cm^{-1}), which, in turn,



(46) (47) (48)

gave the base (48) on treatment with triethylamine or aqueous sodium hydrogen carbonate. The n.m.r. spectrum of the salt indicated the non-equivalence of the *N*-methyl groups, but this was not observed with the base, in which the dimethylamino substituent can rotate freely. Compound (48) appears to be the first 3,1-benzoxazin-4-one possessing an amino substituent at position 2.

EXPERIMENTAL

Perchloric acid was of 70% strength; light petroleum refers to the fraction of b.p. 40—60°. ^1H N.m.r. spectra were recorded with a Perkin-Elmer R 32 spectrometer at 90 MHz for trifluoroacetic acid solutions in the case of perchlorates and fluoroborates and deuteriochloroform solutions for other compounds, unless stated otherwise. I.r. spectra were determined with a Perkin-Elmer 257 instrument and refer to Nujol mulls, unless otherwise stated, and electronic spectra were recorded for ethanolic solutions with a Perkin-Elmer 402 u.v.–visible spectrometer. Column chromatography was done on silica (KG-60).

N-Substituted Succinamic Acids (4).—Succinic anhydride (10 g, 0.1M) was suspended in chloroform (70—100 ml) or

[19] A. Bistrzycki and J. Risi, *Helv. Chim. Acta*, 1925, **8**, 810.
[20] *Cf.* M. Lilier, *J.C.S. Chem. Comm.*, 1972, 527, and references therein.
[21] H. Underwood and L. A. Clough, *J. Amer. Chem. Soc.*, 1929, **51**, 583.
[22] A. T. Balaban and C. D. Nenitzescu, *Annalen*, 1959, **625**, 74.
[23] R. P. Staiger and E. B. Miller, *J. Org. Chem.*, 1959, **24**, 1214.

ethyl acetate (20 ml) and a primary or secondary amine (1 mol. equiv.) was added. The mixture was heated under reflux for 10 min, cooled, and the product was collected. The following succinamic acids were prepared: *N*-phenyl- (4a) (18.35 g, 95%), m.p. 144—145° (lit.,[24] 144.5—145.5°), $\nu_{max.}$ 3 350, 1 700, and 1 660 cm^{-1}; N-2,6-*xylyl*- (4b) (20.9 g, 94%), m.p. 188—189° (from aqueous ethanol), $\nu_{max.}$ 3 220, 1 712, and 1 650 cm^{-1} (Found: C, 65.0; H, 6.95; N, 6,3. $C_{12}H_{15}NO_3$ requires C, 65.15; H, 6.85; N, 6.35%); *N*-*p*-nitrophenyl- (4c) (20.65 g, 97%), m.p. 194—197° (lit.,[25] 197°), $\nu_{max.}$ 3 340, 1 705, and 1 650 cm^{-1}; *N*-t-butyl- (4d) (15.6 g, 90%), m.p. 131—132° (lit.,[26] 135°), $\nu_{max.}$ 3 400, 1 700, and 1 670 cm^{-1}; *N*-methyl-*N*-phenyl- (4e) (14.7 g, 70%), m.p. 92—94° (lit.,[27] 91—92.5°), $\nu_{max.}$ 1 715 and 1 630 cm^{-1}; 3-*morpholinocarbonylpropanoic acid* (4f) (11.6 g, 62%), m.p. 84—85° (from ethyl acetate), $\nu_{max.}$ 1 710 and 1 645 cm^{-1}, δ 9.6 (s, OH), 3.65 (8 H, s, morpholino), and 2.65 (s, $2CH_2$) (Found: C, 51.1; H, 7.3; N, 7.4. $C_8H_{13}NO_4$ requires C, 51.3; H, 7.0; N, 7.5%); 3-*pyrrolidinylcarbonylpropanoic acid* (4g) (13.8 g, 80%), m.p. 109—110° (from ethyl acetate), $\nu_{max.}$ 1 725 and 1 625 cm^{-1}, δ 3.6—3.3 (m, $2CH_2$), 2.65 (s, $2CH_2$), and 2.0—1.7 (m, $2CH_2$) (Found: C, 55.8; H, 8.0; N, 8.0. $C_8H_{13}NO_3$ requires C, 56.1; H, 7.7; N, 8.0%).

Succinisoimidium Perchlorates (5).—A suspension of the requisite succinamic acid (4) (0.05M) in acetic anhydride (50 ml) was treated slowly with perchloric acid (6 ml); the precipitated solid was collected and washed with ether. If the salt did not separate, the solution was treated with ether; if a gum appeared it was caused to solidify by trituration with ether. The following *succinisoimidium perchlorates* were obtained: N-*phenyl*- (5a) (13.1 g, 91%), m.p. 141° (decomp.), $\nu_{max.}$ 1 900, 1 700, and 1 100br cm^{-1}, δ 7.48 (m, Ph) and 3.3 (m, $2CH_2$) (Found: C, 43.25; H, 3.8; N, 5.25. $C_{10}H_{10}ClNO_6$ requires C, 43.55; H, 3.65; N, 5.1%); N-2,6-*dimethylphenyl*- (5b) (13.73 g, 90.5%), m.p. 125° (decomp.), $\nu_{max.}$ 1 892, 1 680, and 1 100br cm^{-1}, δ 7.24 (m, Ar), 3.55—3.05 (m, $2CH_2$), and 2.29 (s, 2Me) (Found: C, 47.75; H, 4.8; N, 5.0. $C_{12}H_{14}ClNO_6$ requires C, 47.45; H, 4.65; N, 4.6%); N-p-*nitrophenyl*- (5c) (9.78 g, 61%), m.p. 115° (decomp.), $\nu_{max.}$ 1 891, 1 680, and 1 100br cm^{-1} (Found: ClO_4, 30.8. $C_{10}H_9ClN_2O_8$ requires ClO_4, 31.0%); N-*t-butyl*- (5d) (9.5 g, 86%), m.p. 142—143°, $\nu_{max.}$ 1 900, 1 700, and 1 100br cm^{-1} (Found: C, 37.5; H, 5.5; N, 5.6. $C_8H_{14}ClNO_6$ requires C, 37.6; H, 5.55; N, 5.5%); N-*methyl*-N-*phenyl*- (5e) (14.5 g, 100%), m.p. 160° (decomp.), $\nu_{max.}$ 1 890, 1 690, and 1 100br cm^{-1}, δ 7.53 (m, Ph), 4.0—3.2 (m, $2CH_2$), and 3.84 (s, Me) (Found: C, 45.9; H, 4.3; N, 4.8. $C_{11}H_{12}ClNO_6$ requires C, 45.6; H, 4.2; N, 4.85%); *tetrahydro-5-morpholiniofuran-2-one perchlorate* (5f) (13.5 g, 100%), m.p. 130° (decomp.), $\nu_{max.}$ 1 885, 1 710, and 1 100br cm^{-1}, δ 4.5—3.0 (m) (Found: C, 35.5; H, 4.5; Cl, 13.1; N, 5.1. $C_8H_{12}ClNO_7$ requires C, 35.6; H, 4.5; Cl, 13.2; N, 5.2%).

Reaction of Succinisoimidium Perchlorates with Nucleophilic Reagents.—(*a*) The *N*-phenyl derivative (5a) (1.0 g) was added to water (50 ml), whereupon *N*-phenylsuccinamic acid (4a) (0.6 g, 80%), identified by mixed m.p. and i.r. spectrum, precipitated. Similar results were obtained when the salts (5c, e, and g) were hydrolysed.

[24] F. L. Dunlap, *Amer. Chem. J.*, 1899, **21**, 528.
[25] J. B. Tingle and F. C. Blanck, *J. Amer. Chem. Soc.*, 1908, **30**, 1589.
[26] K. C. Schreiber and V. P. Fernandes, *J. Org. Chem.*, 1961, **26**, 1744.
[27] K. Auwers, *Annalen*, 1896, **292**, 192.

(*b*) *Methyl succinanilate* (6a). The salt (5a) (2.75 g) was added to methanol (20 ml); the resulting solution was evaporated after 5 min and the residue triturated with N-hydrochloric acid (10 ml), giving the ester (1.9 g, 63%), m.p. 97° (lit.,[28] 97—99°), $\nu_{max.}$ 3 475, 1 730, and 1 690 cm^{-1}.

(*c*) Ethyl 2′,6′-dimethylsuccinanilate (6i) (0.55 g, 44%), m.p. 126—127.5° (lit.,[29] 127—128°), $\nu_{max.}$ 3 242, 1 738, and 1 652 cm^{-1}, was similarly obtained from the perchlorate (5b) (1.52 g) and ethanol (10 ml).

(*d*) N-*t-Butyl*-N′-*phenylsuccinamide* (6b). *N*-Phenylsuccinisoimidium perchlorate (5a) (1.0 g) was added to a stirred solution of t-butylamine (0.29 g, 1.1 mol. equiv.) and triethylamine (0.4 g, 1.1 mol. equiv.) in acetonitrile (1 ml). The *product* (0.75 g, 70%) was precipitated by adding N-hydrochloric acid, m.p. 165—166° (from ethanol), $\nu_{max.}$ 3 400, 3 300, and 1 650 cm^{-1} (Found: C, 67.4; H, 8.2; N, 11.1. $C_{14}H_{20}N_2O_2$ requires C, 67.7; H, 8.15; N, 11.3%). The diamide was also obtained (1.6 g, 78%) from *N*-t-butylsuccinisoimidium perchlorate (5d) (2.0 g) and aniline (2.0 g).

(*e*) The following *NN*′-substituted succinamides were similarly prepared: 3-*piperidinocarbonylpropionanilide* (6c) (0.82 g, 62%), m.p. 122.5—123.5° (from ethanol), $\nu_{max.}$ 3 282, 1 696, and 1 626 cm^{-1} (Found: C, 69.5; H, 7.75; N, 10.65. $C_{15}H_{20}N_2O_2$ requires C, 69.2; H, 7.75; N, 10.75%), from the salt (5a) (1.4 g) and piperidine (0.8 g); succinanilide (6d) (1.59 g, 75%), m.p. 226—227° (lit.,[30] 227°), from (5a) (2.18 g) and aniline (1.8 g); N-2,6-*dimethylphenyl*-N′-*phenylsuccinamide* (6e), m.p. 252—253° (from acetone) (Found: C, 73.0; H, 6.7; N, 9.35. $C_{18}H_{20}N_2O_2$ requires C, 72.95; H, 6.8; N, 9.45%) (i) (0.7 g, 47%) from (5a) (1.4 g) and 2,6-dimethylaniline (0.9 g), and (ii) (1.71 g, 58%) from the salt (5b) (3.03 g) and aniline (2.0 g); N-*methylsuccinanilide* (6f), m.p. 152.5—153° (from ethanol) (Found: C, 72.1; H, 6.45; N, 10.05. $C_{17}H_{18}N_2O_2$ requires C, 72.3; H, 6.45; N, 9.9%), (i) (1.6 g, 57%) from (5a) (2.75 g) and *N*-methylaniline (2.0 g) and (ii) (2.5 g, 88%) from (5e) (2.9 g) and aniline (1.5 g); N-*carboxymethyl*-N′-*phenylsuccinamide* (6g) (0.7 g, 56%), m.p. 191.5—192° (from water), $\nu_{max.}$ 3 320, 1 710, 1 665sh, and 1 645 cm^{-1} (Found: C, 57.8; H, 5.85; N, 11.5. $C_{12}H_{14}N_2O_4$ requires C, 57.6; H, 5.65; N, 11.2%), from (5a) (1.4 g) and glycine (1.5 g) in M-sodium hydroxide (10 ml), followed by acidification with hydrochloric acid; and *NN*′-dimethylsuccinanilide (6h) (2.5 g, 80%), m.p. 156—157° (lit.,[31] 155°) from (5e) (2.9 g) and *N*-methylaniline (1.5 g).

Experiments on Succinisoimides (7).—(*a*) A suspension of the perchlorate (5a) (0.17 g) in chloroform (10 ml) was treated with triethylamine (0.14 g, 1.39 mol. equiv.) and the i.r. spectrum of the resulting solution was determined at once and thereafter at hourly intervals. There was a progressive decrease of the intensity of the band at 1 825 cm^{-1}, while a band at 1 700 cm^{-1} increased. After 5 h the former band had disappeared; work-up afforded *N*-phenylsuccinimide (0.07 g), identified by direct comparison with an authentic specimen.

(*b*) The perchlorate (5a) (3.06 g) was added to an ice-cold solution of triethylamine (1.01 g, 0.9 mol. equiv.) in dichloromethane (24 ml). The resulting solution was divided into three equal portions. The first was immediately treated

[28] S. Hoogewerff and W. A. van Dorp, *Rec. Trav. chim.*, 1898, **17**, 200.
[29] E. Honkanen, *Ann. Acad. Sci. Fennicae, Ser. A* II, 1960, **99**, 1 (*Chem. Abs.*, 1961, **55**, 15,404).
[30] C. R. Barnicoat, *J. Chem. Soc.*, 1927, 2926.
[31] K. Auwers, *Annalen*, 1896, **292**, 132.

with aniline (0.465 g, 1.5 mol. equiv.), when succinanilide (0.32 g) separated. The filtrate was evaporated and the residue triturated with M-hydrochloric acid (10 ml), when a further 0.184 g of succinanilide was obtained; total yield 56.5%. The second portion was similarly treated with aniline after 2.5 h; 0.214 g (24%) of succinanilide was isolated. The third portion was left for 24 h before the addition of aniline; only *N*-phenylsuccinimide (0.496 g, 85%) was obtained.

(*c*) A mixture of the perchlorate (5a) (1.38 g), *p*-dimethylaminobenzaldehyde (0.75 g, 1 mol. equiv.), and acetonitrile (10 ml) was refluxed for 3 h, cooled, and treated with ether, whereupon the *hydroperchlorate* of p-*dimethylaminobenzylideneaniline* (0.97 g, 87%) separated, orange plates, m.p. 224—226°, $\nu_{max.}$ 1 640, 1 610, and 1 110br cm^{-1} (Found: ClO_4, 30.8. $C_{15}H_{17}ClN_2O_4$ requires ClO_4, 30.6%). Treatment of the salt with M-sodium hydroxide gave *p*-dimethylaminobenzylideneaniline, m.p. 98—99° (lit.,[32] 100°).

(*d*) The filtered solution, obtained from a mixture of the salt (5a) (0.918 g), triethylamine (0.3 g), and dichloromethane (8 ml), was treated with *p*-nitrobenzoyl chloride (0.62 g), whereupon *N*-(*p*-nitrobenzoyl)aniline (0.1 g, 14%), m.p. 211—213°, identified by direct comparison with an authentic specimen, separated.

(*e*) Addition of triethylamine (0.141 g, 1.39 mol. equiv.) to a suspension of *N*-t-butylsuccinisoimidium perchlorate (5d) (0.256 g) in chloroform (10 ml) gave a clear solution whose i.r. spectrum ($\nu_{max.}$ 1 820 and 1 720 cm^{-1}) did not change over 5 days.

(*f*) A mixture of the salt (5d) (13.36 g), ice-cold ether (100 ml), and triethylamine (4.7 g, 0.9 mol. equiv.) was shaken for 2 min and then filtered. Evaporation of the filtrate *in vacuo* at 0° left a pale yellow solid (6.0 g, 65%), m.p. 92—102°, $\nu_{max.}$ ($CHCl_3$) 1 820 and 1 720 cm^{-1}, which could not be purified. Attempts to recrystallise it from light petroleum resulted in the formation of *N*-t-butylsuccinamic acid (4d). A solution of the yellow solid (2.0 g) in ether (25 ml) was treated with aniline (2.0 g), whereupon *N*-t-butyl-*N'*-phenylsuccinamide (6b) (1.5 g, 75%) separated.

Tetrahydro-5-morpholinio-3,4-diphenylfuran-2-one Perchlorate (9).—A mixture of *cis*- and *trans*-αα'-diphenylsuccinic anhydride [33] (27.2 g) was added to a solution of morpholine (9.0 g, 1.2 mol. equiv.) in benzene (90 ml) and the mixture was refluxed for 10 min and then cooled, whereupon 3-*morpholinocarbonyl*-2,3-*diphenylpropanoic acid* (13.1 g, 38%) separated as a mixture of *cis*- and *trans*-isomers; it had m.p. *ca.* 150°, $\nu_{max.}$ 3 700—3 300, 1 730, and 1 623 cm^{-1}, δ 7.3—6.8 (m, 2 Ph), 4.35br (s, 2 CH), and 4.0—3.0 (9 H, m, morpholino and OH) (Found: C, 70.6; H, 6.1; N, 4.0. $C_{20}H_{21}NO_4$ requires C, 70.8; H, 6.3; N, 4.1%). Treatment of a suspension of the amic acid (3.39 g) in acetic anhydride (10 ml) with perchloric acid (1.5 ml) gave the *isoimidium salt* (9) (2.9 g, 65%) as a *cis–trans*-mixture, m.p. 148—156° (decomp.), $\nu_{max.}$ 1 885, 1 695, and 1 100br cm^{-1}, δ 8.5—6.5 (m, 2 Ph), 5.80 (d, CH), 4.65 (d, CH), and 4.5—2.0 (8 H, m, morpholino) (Found: C, 56.9; H, 4.9; Cl, 8.4; N, 3.2. $C_{20}H_{20}ClNO_7$ requires C, 56.9; H, 4.8; Cl, 8.4; N, 3.3%). A suspension of the perchlorate (0.9 g) in chloroform (10 ml) was treated with triethylamine (0.2 g, 1 mol. equiv.) and the resulting solution was decanted from a heavy oil (triethylammonium perchlorate); evaporation left a solid (0.3 g), $\nu_{max.}$ 1 780, 1 750, and 1 630 cm^{-1}, presumably impure (10b), which could not be purified.

N-*Substituted Phthalamic Acids*.—A mixture of phthalic anhydride (14.8 g), the appropriate amine (1 mol. equiv.), and chloroform (80 ml) or benzene (40 ml) was heated under reflux for 10 min, cooled, and the product was collected. The following phthalamic acids were obtained: *N*-phenyl- [34] (92%), *N*-*p*-methoxyphenyl- [35] (95%), *N*-t-butyl- [36] (80%), *N*-s-butyl- [37] (81%), *NN*-diethyl- [10] (91%), and *NN*-diisopropyl- [36] (72%).

Phthalisoimidium Salts (11).—Perchloric acid (12.5 ml) was slowly added to a suspension of the appropriate phthalamic acid (0.1M) in acetic anhydride (120 mol); the product usually crystallised. If it did not, it was precipitated by the careful addition of ether. The salt was washed repeatedly with ether and stored in a vacuum desiccator. The following *phthalisoimidium perchlorates* were obtained: N-*phenyl*- (11a) (30.4 g, 94%), m.p. 157° (decomp.), $\nu_{max.}$ 3 200, 1 870, 1 700, and 1 100br cm^{-1} (Found: C, 52.2; H, 3.15; N, 4.7. $C_{14}H_{10}ClNO_6$ requires C, 51.95; H, 3.1; N, 4.35%); N-p-*methoxyphenyl*- (11b) (31.0 g, 89%), m.p. 150° (decomp.), $\nu_{max.}$ 3 230, 1 870, 1 690, and 1 110br cm^{-1}, δ 8.1—7.0 (m, 8 H, Ar), 8.4br (s, NH), and 4.0 (s, Me) (Found: C, 50.5; H, 3.3; Cl, 9.8; N, 3.9. $C_{15}H_{12}ClNO_7$ requires C, 50.9; H, 3.4; Cl, 10.0; N, 4.0%); N-*t-butyl*- (11c) (26.5 g, 87%), m.p. 138° (decomp.), $\nu_{max.}$ 3 220, 1 870, 1 700, and 1 110br cm^{-1}, δ 8.8 (s, NH), 8.6—7.6 (4 H, m, Ar), and 1.75 (9 H, s, Bu^t) (Found: C, 47.3; H, 4.8; N, 4.8. $C_{12}H_{14}ClNO_6$ requires C, 47.45; H, 4.7; N, 4.6%); N-*s-butyl*- (11d) (28.1 g, 93%), m.p. 140° (decomp.), $\nu_{max.}$ 3 220, 1 860, 1 710, and 1 110br cm^{-1} (Found: C, 47.0; H, 4.75; Cl, 11.6; N, 4.5. $C_{12}H_{14}ClNO_6$ requires C, 47.45, H, 4.7; Cl, 11.7; N, 4.6%); NN-*diethyl*- (11e) (24.38 g, 91%), m.p. 202—203°, $\nu_{max.}$ 1 845, 1 695, and 1 100br cm^{-1} (Found: C, 47.4; H, 4.65; N, 4.2. $C_{12}H_{14}ClNO_6$ requires C, 47.45; H, 4.7; N, 4.6%); NN-*di-isopropyl*- (11f) (25.0 g, 76%), m.p. 187° (decomp.), $\nu_{max.}$ 1 850, 1 675, and 1 090br cm^{-1}, δ 7.9—7.4 (4 H, m, Ar), 4.2—3.7 (m, 2 CH), 1.7 (d, Me), 1.51 (s, 2 Me), and 1.35 (d, Me) (Found: C, 50.4; H, 5.6; Cl, 10.9; N, 4.1. $C_{14}H_{18}ClNO_6$ requires C, 50.7; H, 5.5; Cl, 10.7; N, 4.2%).

Treatment of a mixture of *N*-t-butylphthalamic acid (2.2 g) and acetic anhydride (20 ml) with 40% fluoroboric acid (5 ml) (Caution! Very violent.) gave N-*t-butylphthalisoimidium fluoroborate* (2.3 g, 89%), m.p. 142° (decomp.), $\nu_{max.}$ 3 230, 1 870, 1 700, and 1 095—1 055 cm^{-1}, δ 8.5—7.55 (5 H, m, Ar and NH) and 1.65 (9 H, s, Bu^t) (Found: C, 49.4; H, 4.8; N, 4.7. $C_{12}H_{14}BF_4NO_2$ requires C, 49.5; H, 4.9; N, 4.8%).

NN'-*Substituted Phthalamides* (14).—A phthalisoimidium perchlorate was added to a stirred solution of an amine (1.1 mol. equiv.) and triethylamine (1.5 mol. equiv.) in tetrahydrofuran, the mixture was stirred for 10 min, and water was then added to precipitate the product. *NN'*-Diphenylphthalamide (69%), m.p. 237—238° (lit.,[36] 230—231°), $\nu_{max.}$ 3 230, 3 190, and 1 640br cm^{-1}, was obtained from the salt (11a) and aniline, *N*-t-butyl-*N'*-phenylphthalamide (83%), m.p. 244° (lit.,[36] 245°), $\nu_{max.}$ 3 255, 1 665, and 1 630 cm^{-1}, from (11a) and t-butylamine, *N*-benzyl-*N'*-phenylphthalamide (96%), m.p. 201—202° (lit.,[36] 203°), $\nu_{max.}$ 3 240, 1 660, and 1 640 cm^{-1}, from (11a) and benzylamine, *o*-piperidinocarbonylbenzanilide (48%), m.p. 168° (lit.,[36]

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169°), $\nu_{max.}$ 3 260, 1 670, and 1 622 cm^{-1}, from (11a) and piperidine, *NN*-diethyl-*N'*-phenylphthalamide (87%), m.p. 122—123° (lit.,[38] 124°), $\nu_{max.}$ 3 260, 1 670, and 1 620 cm^{-1}, from (11a) and diethylamine, N-*n*-*butyl*-N'-*t*-*butylphthalamide* (75%), m.p. 175—176° (from ethanol), $\nu_{max.}$ 3 290, 3 220, 1 640, and 1 630 cm^{-1}, δ 7.6—7.25 (4 H, m, Ar), 7.1br (s, NH), 6.5br (s, NH), 3.36 (q, CH_2), 1.4 (9 H, s, Bu^t), and 1.39—0.6 (7 H, m, 2 CH_2 and Me) (Found: C, 69.5; H, 8.7; N, 10.2. $C_{16}H_{24}N_2O_2$ requires C, 69.5; H, 8.8; N, 10.1%), from (11c) and n-butylamine, N-*isobutyl*-N'-*t*-*butylphthalamide* (78%), m.p. 200.5—201.5° (from ethanol), $\nu_{max.}$ 3 290, 3 240, 1 640, and 1 630 cm^{-1}, δ 7.65—7.25 (4 H, m, Ar), 7.05br (s, NH), 6.45 br (s, NH), 3.23br (t, CH_2), 1.9 (m, CH), 1.4 (9 H, s, Bu^t), 1.0 (s, Me), and 0.92 (s, Me) (Found: C, 70.0; H, 8.9; N, 10.0%) from (11c) and isobutylamine, N-*s*-*butyl*-N'-*t*-*butylphthalamide* (65%), m.p. 197.5—199.5° (from ethanol), $\nu_{max.}$ 3 280, 3 230, 1 640, and 1 630 cm^{-1}, δ 7.65—7.3 (4 H, m, Ar), 6.8br (s, NH), 6.55br (s, NH), 5.95 (m, CH_2), 1.41 (9 H, s, Bu^t), and 1.25—1.02 (7 H, m, CH and 2 Me) (Found: C, 70.0; H, 9.0; N, 10.1%), from (11c) and s-butylamine, NN'-*di*-*t*-*butylphthalamide* (47%), m.p. 221° (from ethanol), $\nu_{max.}$ 3 290, 1 645, and 1 635 cm^{-1}, δ 7.63—7.2 (4 H, m, Ar), 6.55br (s, 2 NH), and 1.45 (18 H, s, 2 Bu^t) (Found: C, 69.6; H, 8.8; N, 10.0%), from (11c) and t-butylamine, N-*t*-*butyl*-N'-*cyclohexylphthalamide* (83%), m.p. 222—224° (from ethanol), $\nu_{max.}$ 3 300, 3 220, and 1 630 cm^{-1}, δ 7.65—7.25 (4 H, m, Ar), 6.85br (s, NH), 6.45br (s, NH), 2.3—1.0 (11 H, m, cyclohexyl), and 1.42 (9 H, s, Bu^t) (Found: C, 71.9; H, 8.9; N, 9.4. $C_{18}H_{26}N_2O_2$ requires C, 71.5; H, 8.7; N, 9.3%), from (11c) and cyclohexylamine, N-*benzyl*-N'-*t*-*butylphthalamide* (78%), m.p. 149—151°, $\nu_{max.}$ 3 290 and 1 640br cm^{-1}, δ 7.6—7.2 (10 H, m, Ar and NH), 6.5br (s, NH), 4.5 (d, CH_2), and 1.35 (9 H, s, Bu^t) (Found: C, 73.7; H, 7.3; N, 8.9. $C_{19}H_{22}N_2O_2$ requires C, 73.5; H, 7.2; N, 9.0%), from (11c) and benzylamine, N-*t*-*butyl*-N'-(2,6-*dimethylphenyl*)*phthalamide* (62%), m.p. 186—188° (from ethanol), $\nu_{max.}$ 3 310, 3 200, 1 660, and 1 645 cm^{-1}, δ 9.62 (s, NH), 7.85—7.09 (7 H, m, Ar), 6.6br (s, NH), 2.25 (s, 2 Me), and 1.4 (9 H, s, Bu^t) (Found: C, 74.2; H, 7.7; N, 8.4. $C_{20}H_{24}N_2O_2$ requires C, 74.0; H, 7.5; N, 8.6%), from (11c) and 2,6-dimethylaniline, N-*t*-*butyl*-N'-m-*methoxyphenylphthalamide* (94%), m.p. 167—168° (from ethanol), $\nu_{max.}$ 3 310, 3 230, 1 660, and 1 635 cm^{-1}, δ 9.65br (s, NH), 7.7—6.58 (8 H, m, Ar), 6.39br (s, NH), 3.78 (s, Me), and 1.35 (9 H, s, Bu^t) (Found: C, 70.2; H, 6.9; N, 8.5. $C_{19}H_{22}N_2O_3$ requires C, 69.9; H, 6.8; N, 8.6%), from (11c) and *m*-anisidine, N-*t*-*butyl*-N'-*p*-*methoxyphthalamide* (98%), m.p. 202.5—203.5° (from ethanol), $\nu_{max.}$ 3 250, 1 655, and 1 630 cm^{-1} (Found: C, 69.7; H, 6.9; N, 8.4%), from (11c) and *p*-anisidine, N-*t*-*butyl*-N'-p-*chlorophenylphthalamide* (25%), m.p. 227.5—228.5° (from acetone), $\nu_{max.}$ 3 295, 3 220, 1 660, and 1 630 cm^{-1}, δ 9.4br (s, NH), 7.7—7.25 (8 H, m, Ar), 5.95br (s, NH), and 1.35 (9 H, s, Bu^t) (Found: C, 65.4; H, 6.0; Cl, 10.6; N, 8.3. $C_{18}H_{19}ClN_2O_2$ requires C, 65.4; H, 5.8; Cl, 10.8; N, 8.5%), from (11c) and *p*-chloroaniline, N-*t*-*butyl*-N'-o-*nitrophenylphthalamide* (47%), m.p. 174—175° (from ethanol), $\nu_{max.}$ 3 330, 3 290, 1 680, and 1 660 cm^{-1}, δ 10.73 (s, NH), 8.92—7.1 (8 H, m, Ar), 6.0 (s, NH), and 1.4 (9 H, s, Bu^t) (Found: C, 63.0; H, 5.8; N, 12.2. $C_{18}H_{19}N_3O_4$ requires C, 63.3; H, 5.6; N, 12.3%), from (11c) and *o*-nitroaniline, N-*t*-*butyl*-N'-p-*nitrophenylphthalamide* (94%), m.p. 249—250° (from acetic acid), $\nu_{max.}$ 3 310, 3 230, 1 675, and 1 635 cm^{-1}, δ 10.8 (s, NH), 8.25—7.9 (4 H, AB, Ar), 7.51 (5 H, m, Ar and NH), and 1.3 (9 H, s, Bu^t) (Found: C, 63.4; H, 5.5; N, 12.2%), from (11c) and *p*-nitroaniline, and N-*t*-*butyl*-N'N'-*di*-*isopropylphthalamide* (98%), m.p. 123.5—124.5 (from ethanol), $\nu_{max.}$ 3320, 1665, and 1630 cm^{-1}, δ 7.86—7.02 (4 H, m, Ar), 3.72—3.4 (m, 2 CH), 1.57 (m, 2 Me), 1.41 (9 H, s, Bu^t), 1.1 (s, Me), and 1.01 (s, Me) (Found: C, 69.4; H, 9.4; N, 9.0. $C_{18}H_{28}N_2O_2$ requires C, 69.6; H, 9.5; N, 9.0%), from (11f) and t-butylamine.

Reactions of Phthalisoimidium Salts with Hydrazines.—(*a*) Addition of the t-butylphthalisoimidium perchlorate (11c) (3.04 g) to a solution of phenylhydrazine (1.24 g, 1.2 mol. equiv.) and triethylamine (3.03 g, 3 mol. equiv.) in tetrahydrofuran (10 ml) gave N'-(o-*t*-*butylcarbamoylbenzoyl*)-N-*phenylhydrazine* (15a) (3.03 g, 98%), m.p. 183.5—184° (from ethanol), $\nu_{max.}$ 3 300 and 1 645 cm^{-1}, δ 9.05br (s, NH), 7.8—6.9 (9 H, m, Ar), 6.35br (s, NH), 1.8br (s, NH), and 1.42 (9 H, s, Bu^t) (Found: C, 69.1; H, 6.8; N, 13.1. $C_{18}H_{21}N_3O_2$ requires C, 69.4; H, 6.8; N, 13.5%).

(*b*) A similar reaction with *p*-nitrophenylhydrazine (1.7 g, 1.1 mol. equiv.) yielded N'-(o-*t*-*butylcarbamoylbenzoyl*)-N-p-*nitrophenylhydrazine* (15b) (2.7 g, 75%), m.p. 251—251.5° (from aqueous ethanol), $\nu_{max.}$ 3 280 and 1 640 cm^{-1}, δ 8.2—6.91 (10 H, m, Ar and 2 NH), 2.2br (s, NH), and 1.45 (9 H, s, Bu^t) (Found: C, 60.1; H, 5.8; N, 15.4. $C_{18}H_{20}N_4O_4$ requires C, 60.6; H, 5.6; N, 15.7%).

(*c*) A similar reaction with hydrazine hydrate (0.55 g, 1.1 mol. equiv.) gave a crude solid, showing $\nu_{max.}$ 3 300, 3 250, 3 200, 1 660, and 1 640 cm^{-1}, which on repeated recrystallisation from ethanol formed 1,2,3,4-tetrahydrophthalazine-1,4-dione (16a) (1.7 g, 66%), m.p. 334° (lit.,[39] 333—336°), $\nu_{max.}$ 3 360—2 300 and 1 665 cm^{-1}. This compound was also obtained in 62% yield from *N*-phenylphthalisoimidium perchlorate (11a) and hydrazine.

(*d*) Reaction of the salts (11a and c) with methylhydrazine gave crude products, which on recrystallisation from ethanol afforded 1,2,3,4-tetrahydro-2-methylphthalazine-1,4-dione (16b), m.p. 236—237° (lit.,[40] 239—240°), $\nu_{max.}$ 3 380—3 000 and 1 645 cm^{-1}, in 55 and 94% yield, respectively.

Ethyl N-*t*-*Butylphthalamate.*—The perchlorate (11c) (3.04 g) was added to a solution of triethylamine (3.03 g, 3 mol. equiv.) in ethanol (50 ml); after 2 h chloroform (40 ml) was added and the solution was washed with M-hydrochloric acid and then with water; evaporation of the dried ($MgSO_4$) solution left the *ester* (2.3 g, 92%), m.p. 85—85.5° (from benzene–light petroleum), $\nu_{max.}$ 3 280, 1 725, and 1 645 cm^{-1}, δ 7.9—7.25 (4 H, m, Ar), 5.61br (s, NH), 4.35 (2 H, q), and 1.35 (3 H, t) (Et), and 1.46 (9 H, s, Bu^t) (Found: C, 67.4; H, 8.0; N, 5.6. $C_{14}H_{19}NO_3$ requires C, 67.5; H, 7.7; N 5.6%).

Reactions of Ternary Phthalisoimidium Salts with Active Methylene Compounds.—(*a*) *NN*-Diethylphthalisoimidium perchlorate (11e) (6.0 g) was added to a solution of ethyl cyanoacetate (2.5 g, 1.1 mol. equiv.) and triethylamine (6.0 g, 3 mol. equiv.) in acetonitrile (30 ml); addition of water to the resulting solution precipitated 3-(ethoxycarbonylcyanomethylene)phthalide (18; R^2 = CN, R^3 = CO_2Et) (3.44 g, 70%), m.p. 202° (lit.,[10] 200°), $\nu_{max.}$ 2 220, 1 830, 1 810, and 1 730 cm^{-1}.

(*b*) A similar reaction of the salt (11e) (3.04 g) with

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dibenzoylmethane (2.2 g, 1.0 mol. equiv.) afforded 3-(dibenzoylmethylene)phthalide (18; $R^2 = R^3 = COPh$) (0.6 g, 17%), m.p. 156—158° (lit.,[11] 158—160°), $\nu_{max.}$ 1 790, 1 670, 1 640, and 1 620 cm^{-1}.

(*c*) Addition of the salt (11e) (6.08 g) to a solution of malononitrile (1.32 g, 1.0 mol. equiv.) and triethylamine (3.03 g, 1.5 mol. equiv.) in acetonitrile (20 ml) gave 1-o-*carboxyphenyl*-2,2-*dicyano*-1-*diethylaminoethylene* (19; $R^1 = Et$, $R^2 = R^3 = CN$) (3.4 g, 58%), m.p. 151.5° (from benzene–ethanol), $\nu_{max.}$ 3 660—3 220, 2 210, 2 190, and 1 705 cm^{-1}, δ 8.2—7.22 (4 H, m, Ar), 5.5—4.25 (3 H, m, CH_2 and OH), 3.08 (q, CH_2), 1.43 (t, Me), and 1.0 (t, Me) (Found: C, 66.8; H, 5.7; N, 15.7. $C_{15}H_{15}N_3O_2$ requires C, 66.9; H, 5.6; N, 15.6%).

(*d*) A similar reaction of the di-isopropyl analogue (11f) (3.31 g) with malononitrile gave 1-o-*carboxyphenyl*-2,2-*dicyano*-1-*di-isopropylaminoethylene* (19; $R^1 = Pr^i$, $R^2 = R^3 = CN$) (0.5 g, 17%), m.p. 166° (from benzene–ethanol), $\nu_{max.}$ 3 640—3 200, 2 210, 2 185, and 1 710 cm^{-1}, δ 8.3—7.0 (4 H, m, Ar), 4.75—4.2 (m, CH), 3.9—3.4 (m, CH), and 1.7—0.9 (m, 4 Me) (Found: C, 68.0; H, 6.6; N, 13.9. $C_{17}H_{19}N_3O_2$ requires C, 68.7; H, 6.4; N, 14.1%). The *methyl ester* (0.3 g, 25%), m.p. 181.5—182.5° (from methanol), $\nu_{max.}$ 2 200, 2 180, and 1 730 cm^{-1}, δ 8.2—7.25 (4 H, m, Ar), 4.8—4.3 (m, CH), 3.91 (s, Me), 3.9—3.4 (m, CH), and 1.8—0.7 (m, 4 Me) (Found: C, 69.7; H, 7.0; N, 13.6. $C_{18}H_{21}N_3O_2$ requires C, 69.4; H, 6.8; N, 13.5%), was prepared by refluxing a mixture of the acid (1.16 g), dimethyl sulphate (0.55 g), 55% aqueous potassium hydroxide (1 ml), and dioxan (10 ml) for 30 min, then adding chloroform to the cooled solution, washing the mixture with aqueous sodium hydrogencarbonate and then water, and finally evaporating the dried ($MgSO_4$) solution. The p-*nitrobenzyl ester* was prepared in 48% yield in the usual way; it had m.p. 160.5—162° (from ethanol), $\nu_{max.}$ 2 200, 2 190, and 1 735 cm^{-1}, δ 8.4—7.25 (8 H, m, Ar), 5.48 (s, CH_2), 4.75—4.2 (m, CH), 3.9—3.2 (m, CH), and 1.7—0.8 (m, 4 Me) (Found: C, 67.0; H, 5.6; N, 13.0. $C_{24}H_{24}N_4O_4$ requires C, 66.7; H, 5.6; N, 13.0%).

Phthalisoimides (12).—Triethylamine (0.95 g, 0.9 mol. equiv.) was added to a suspension of a pthalisoimidium perchlorate (0.01M) in ether (50 ml); the mixture was stirred for 20 min, the ethereal layer was decanted, and the ether was removed, leaving the corresponding phthalisoimide. *N*-Phenylphthalisoimide (12a) (1.9 g, 85%) had m.p. 114—115° (lit.,[12] 115—117°), $\nu_{max.}$ 1 790 and 1 710 cm^{-1}, N-p-*methoxyphenylphthalisoimide* (12b), yellow (2.0 g, 80%), m.p. 122°, $\nu_{max.}$ 1 800, 1 775, 1 710, and 1 690 cm^{-1}, δ 7.8—6.65 (8 H, m, Ar) and 3.5 (s, Me) (Found: C, 70.6; H, 4.4; N, 5.7. $C_{15}H_{11}NO_3$ requires C, 71.0; H, 4.4; N, 5.5%), N-*t-butylphthalisoimide* (12c) (1.85 g, 91%), m.p. 75.5—76.5° (from light petroleum), $\nu_{max.}$ 1 820 and 1 720 cm^{-1}, δ 7.95—7.6 (4 H, m, Ar) and 1.46 (9 H, s, Bu^t) (Found: C, 70.6; H, 6.7; N, 6.8. $C_{12}H_{13}NO_2$ requires C, 70.9; H, 6.5; N, 6.9%), N-*s-butylphthalisoimide* (12d) (1.8 g, 90%), m.p. 44—45°, $\nu_{max.}$ 1 820, 1 790, and 1 705 cm^{-1}, δ 7.95—7.1 (4 H, m, Ar), 3.95 (m, CH), 1.55 (q, CH_2), and 1.2 (d, Me) (Found: C, 70.9; H, 6.4; N, 6.9%).

Rearrangement of Phthalisoimides to Phthalimides.—10% Solutions of the isoimides (12) were heated under reflux and the spectra of the solutions were determined at intervals. Compound (12a) was completely isomerised (according to i.r. spectroscopy) after 1 h in boiling benzene; (12b) had a half-life of 5.5 h in boiling benzene (by n.m.r. spectroscopy); (12c) had 10% isomerisation after 4 h in boiling chlorobenzene (by n.m.r.); when it was kept at 240° for 1 h the rearrangement was complete. The resulting *N*-substituted phthalimides were isolated and identified by direct comparison with authentic specimens: *N*-phenylphthalimide, m.p. 202—204° (lit.,[34] 208°); *N*-*p*-methoxyphthalimide, m.p. 158—159° (lit.,[35] 156°), $\nu_{max.}$ 1 780, 1 760, 1 745, and 1 720 cm^{-1}; *N*-t-butylphthalimide, m.p. 54° (lit.,[41] 59—60°), $\nu_{max.}$ 1 780 and 1 720 cm^{-1}; *N*-s-butylphthalimide, m.p. 21—23° (lit.,[37] 24—25°), $\nu_{max.}$ 1 780 and 1 720 cm^{-1}.

Reactions of N-*t-Butylphthalisoimide* (12c).—(*a*) A mixture of the isoimide (0.1 g) and water (10 ml) was heated on a steam-bath for 10 min; *N*-t-butylphthalamic acid (0.1 g), m.p. 144—148° (lit.,[36] 147—148°), $\nu_{max.}$ 3 380, 1 725, and 1 620 cm^{-1}, identified by direct comparison with an authentic specimen, separated on cooling.

(*b*) Aniline (0.1 g) was added to a solution of the isoimide (0.1 g) in ether (20 ml). The ether was removed at once and the solid residue was washed with M-hydrochloric acid and then with water, giving *N*-t-butyl-*N'*-phenylphthalamide (0.13 g, 87%), identical with the sample prepared previously.

(*c*) A solution of the isoimide (2.03 g) and cyclohexylidenecyclohexylamine [42] (1.79 g, 1 mol. equiv.) in benzene (100 ml) was refluxed for 7 days. The solvent was removed and light petroleum (50 ml) was added to the oily residue, whereupon *N*-t-butyl-*N'*-cyclohexylphthalamide (1.3 g), identical with the previous specimen, separated. Chromatography of the filtrate and elution with ethyl acetate–light petroleum (1 : 9) gave 2-(o-*t-butylcarbamoylbenzoyl*)-*cyclohexanone* (22) (25 mg, 0.8%), m.p. 138—140°, $\nu_{max.}$ 3 280, 1 710, 1 690, and 1 630 cm^{-1}, δ 8.0—7.0 (4 H, m, Ar), 6.0br (s, NH), 2.5—1.0 (9 H, m, cyclohexane), and 1.3 (9 H, s, Bu^t) (Found: C, 72.0; H, 7.8; N, 4.6. $C_{18}H_{23}NO_3$ requires C, 71.7; H, 7.7; N, 4.7%).

(*d*) A solution of the isoimide (2.03 g) and 1-diethylaminoprop-1-yne (1.2 g, 1.1 mol. equiv.) in benzene (50 ml) was refluxed for 6 h. The benzene was removed *in vacuo* and the oily residue was chromatographed, using ethyl acetate–light petroleum (0.5 : 9.5 and then 1 : 9), as eluants. The following fractions were obtained: (i) *N*-t-butylphthalimide (0.8 g), (ii) *NN'*-di-t-butylphthalamide (0.1 g), and (iii) 3-*t-butylimino*-2-*diethylcarbamoyl*-2-*methylindan*-1-*one* (25a) (0.7 g, 22%), m.p. 121—122°, $\nu_{max.}$ 1 730, 1 640br, and 1 590 cm^{-1}, δ (at 100°) 8.1—7.5 (4 H, m, Ar), 3.1 (q, 2 CH_2), 1.6 (s, Me), 1.4 (9 H, s, Bu^t), and 0.96 (t, 2 Me) (Found: C, 72.2; H, 8.3; N, 8.7. $C_{19}H_{26}N_2O_2$ requires C, 72.55; H, 8.35; N, 8.9%).

(*e*) A similar experiment with the isoimide (4.06 g), 1-dimethylamino-2-phenylacetylene (2.9 g), and benzene (100 ml) gave 3-*t-butylimino*-2-*dimethylcarbamoyl*-2-*phenylindan*-1-*one* (25b) (50 mg, 0.7%), m.p. 169—170° (from chloroform–light petroleum), $\nu_{max.}$ 1 720, 1 650, and 1 590 cm^{-1}, δ (at 100°) 8.2—7.2 (9 H, m, Ar), 2.8 (s, 2 Me), and 1.45 (9 H, s, Bu^t) (Found: C, 76.0; H, 6.9; N, 8.1. $C_{22}H_{24}N_2O_2$ requires C, 75.8; H, 6.9; N, 8.0%).

N-*Substituted* 2-*Homophthalamic Acids* (26).—A mixture of homophthalic anhydride [43] (3.24 g, 0.02M), the appropriate amine (1 mol. equiv.), and benzene (10 ml) was refluxed for 10 min, then cooled, and the product was collected. The following were prepared: N-*t-butyl*-2-(o-*carboxyphenyl*)-

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[43] O. Grummitt, R. Egan, and A. Buck, *Org. Synth.*, 1955, Coll. Vol. 3, p. 449.

acetamide (26a) (4.0 g, 87%), m.p. 176.5—177° (from ethanol–benzene), $\nu_{max.}$ 3 200, 1 680, and 1 650 cm^{-1}, δ 8.21—7.25 (4 H, m, Ar), 4.08 (s, CH_2), and 1.36 (9 H, s, Bu^t) (Found: C, 66.4; H, 7.2; N, 5.8. $C_{13}H_{17}NO_3$ requires C, 66.4; H, 7.3; N, 6.0%); N-2-(o-*carboxyphenyl*)*acetylmorpholine* (26b) (4.82 g, 96%), m.p. 171—171.5° (from ethanol–benzene), $\nu_{max.}$ 1 720 and 1 610 cm^{-1}, δ 8.05—7.15 (4 H, m, Ar), 4.06 (s, CH_2), and 3.59br (8 H, s, morpholino) (Found: C, 62.4; H, 6.0; N, 5.6. $C_{13}H_{15}NO_4$ requires C, 62.6; H, 6.0; N, 5.6%); N-*phenyl*-2-(o-*carboxyphenyl*)-*acetamide* (26c) (4.9 g, 96%), m.p. 174—176° (from ethanol–benzene), $\nu_{max.}$ 3 310, 1 700, and 1 665 cm^{-1} (Found: C, 72.7; H, 5.4; N, 5.3. $C_{15}H_{13}NO_3$ requires C, 72.6; H, 5.3; N, 5.0%); N-2-(o-*carboxyphenyl*)*acetylpyrrolidine* (26d) (4.0 g, 87%), m.p. 128—130°, $\nu_{max.}$ 3 600—3 080, 1 685, and 1 605 cm^{-1} (Found: C, 66.9; H, 6.5; N, 6.0. $C_{13}H_{15}NO_3$ requires C, 66.9; H, 6.5; N, 6.0%), N-2-(o-*carboxyphenyl*)*acetylpiperidine* (26e) (3.84 g, 78%), m.p. 125—126° (from ethanol), $\nu_{max.}$ 1 720 and 1 615 cm^{-1} (Found: C, 68.3; H, 7.0; N, 5.6. $C_{14}H_{17}NO_3$ requires C, 68.7; H, 7.1; N, 5.7%).

The morpholide (26b) was also obtained as follows: an ethanolic solution of sodium ethoxide, prepared from sodium (0.69 g) and ethanol (40 ml), was treated successively with *N*-acetoacetylmorpholine [44] (1.71 g, 0.01M), *o*-bromobenzoic acid (2.01 g, 1 mol. equiv.), and copper(II) acetate (0.2 g); the mixture was heated under reflux for 18 h and then cooled and filtered; acidification of the filtrate with 2M-hydrochloric acid precipitated the morpholide (0.62 g, 25%), identified by m.p., mixed m.p., and i.r. spectrum.

Homophthalisoimidium Perchlorates (27).—A suspension of *N*-t-butyl-2-(*o*-carboxyphenyl)acetamide (26a) (2.4 g, 0.01M) in acetic anhydride (10 ml) was treated dropwise with perchloric acid (1.5 ml) <40°, whereupon 3-*t-butylammonio*-3,4-*dihydro*-1H-2-*benzopyran*-1-*one perchlorate* (27a) (2.1 g, 66%) crystallised; it had m.p. 145° (decomp.), $\nu_{max.}$ 1 810, 1 675, and 1 125br cm^{-1}, δ 8.28—7.4 (4 H, m, Ar), 4.7 (s, CH_2), and 1.7 (9 H, s, Bu^t) (Found: C, 49.2; H, 5.2; N, 4.6. $C_{13}H_{16}ClNO_6$ requires C, 49.1; H, 5.1; N, 4.4%).

The following were prepared similarly on the same scale: 3,4-*dihydro*-3-*morpholinio*-1H-2-*benzopyran*-1-*one perchlorate* (27b) (3.1 g, 93%), m.p. 150° (decomp.), $\nu_{max.}$ 1 810, 1 670, and 1 100br cm^{-1}, δ 8.35—7.3 (4 H, m, Ar), 4.75 (s, CH_2), and 4.4—3.9 (8 H, m, morpholino) (Found: C, 47.3; H, 4.3; N, 4.3. $C_{13}H_{14}ClNO_7$ requires C, 47.1; H, 4.3; N, 4.2%); 3,4-*dihydro*-3-*phenylammonio*-1H-2-*benzopyran*-1-*one perchlorate* (27c) (0.41 g, 21%), m.p. 151° (decomp.), $\nu_{max.}$ 1 825, 1 665, and 1 100br cm^{-1}, δ 8.45—7.0 (9 H, m, Ar) and 4.25 (s, CH_2) (Found: C, 53.4; H, 3.7; N, 4.1. $C_{15}H_{12}ClNO_6$ requires C, 53.3; H, 3.6; N, 4.2%); 3,4-*dihydro*-3-*pyrrolidinio*-1H-2-*benzopyran*-1-*one perchlorate* (27d) (2.68 g, 85%), m.p. 190° (decomp.), $\nu_{max.}$ 1 810, 1 695, and 1 090br cm^{-1}, δ 8.26—7.4 (4 H, m, Ar), 4.6 (s, CH_2), and 4.05 (4 H, s,) and 2.25 (4 H, m) (pyrrolidino) (Found: C, 49.9; H, 4.5; N, 4.7. $C_{13}H_{14}ClNO_6$ requires C, 49.5; H, 4.5; N, 4.4%); and 3,4-*dihydro*-3-*piperidinio*-1H-2-*benzopyran*-1-*one perchlorate* (27e) (3.14 g, 95%), m.p. 181° (decomp.), $\nu_{max.}$ 1 780, 1 670, and 1 100br cm^{-1}, δ 8.32—7.3 (4 H, m, Ar) and 4.75—4.0 (6 H, m,) and 1.95br (6 H, s) (CH_2 and piperidino) (Found: C, 50.9; H, 4.8; N, 4.1. $C_{14}H_{16}ClNO_6$ requires C, 51.0; H, 4.9; N, 4.3%).

Reactions of Homophthalisoimidium Salts with Amines.—(*a*) The perchlorate (27a) (3.2 g, 0.01M) was added to a solution of morpholine (0.87 g, 1 mol. equiv.) and triethylamine (4.04 g, 4 mol. equiv.) in ether (20 ml); after 10 min the ether was distilled off and the residue was stirred with M-hydrochloric acid (20 ml), giving N-*t-butyl*-2-(o-4-*morpholinecarbonylphenyl*)*acetamide* (30a) (2.9 g, 95%), m.p. 137° (from chloroform–light petroleum), $\nu_{max.}$ 3 300, 1 680, and 1 620 cm^{-1}, δ 7.6—7.06 (4 H, m, Ar), 6.9 (s, NH), 4.15—2.9 (m, CH_2 and morpholino), and 1.26 (9 H, s, Bu^t) (Found: C, 67.2; H, 8.0; N, 9.1. $C_{17}H_{24}N_2O_3$ requires C, 67.1; H, 8.0; N, 9.2%).

(*b*) A similar reaction of the morpholinio perchlorate (27b) (0.16 g) with a mixture of morpholine (0.044 g) and triethylamine (0.4 g) in acetonitrile (3.5 ml) gave *homophthalic acid dimorpholide* (30b) (0.12 g, 75%), m.p. 131—132° (from chloroform–light petroleum), $\nu_{max.}$ 1 640 cm^{-1}, δ 7.41—7.1 (4 H, m, Ar) and 4.2—3.0 (18 H, m, CH_2 and 2 morpholino) (Found: C, 64.1; H, 7.0; N, 8.8. $C_{17}H_{22}N_2O_4$ requires C, 64.1; H, 7.0; N, 8.8%).

Deprotonation of Homophthalisoimidium Salts (27).—(*a*) Triethylamine (22.8 g, 0.94 mol. equiv.) was slowly added to a suspension of the morpholinio perchlorate (27b) (75.83 g) in ether (250 ml). The mixture was stirred for 20 min, the ethereal layer was decanted from the oil that separated, and the ether was removed, giving 3-*morpholino*-1H-2-*benzopyran*-1-*one* (28b) (49.2 g, 94%), yellow needles, m.p. 122—122.5° (from benzene–light petroleum), $\nu_{max.}$ 1 740 and 1 635 cm^{-1}, $\lambda_{max.}$ 245, 295, and 363 nm, δ 8.15—7.05 (4 H, m, Ar), 5.35 (s, CH), and 3.78 (4 H, t) and 3.27 (4 H t), (morpholino) (Found: C, 67.6; H, 5.8; N, 6.1. $C_{13}H_{13}NO_3$ requires C, 67.5; H, 5.7; N, 6.1%). This compound (0.4 g, 87%) was also obtained when a mixture of the amic acid (26b) (0.49 g) and acetic anhydride (5 ml) was heated on a steam-bath for 5 min and, after cooling, treated with water (30 ml). When a solution of the benzopyranone (0.5 g) in acetic acid (5 ml) was treated with perchloric acid (0.25 g), the isoimidium salt (27b) (0.6 g, 84%) crystallised.

(*b*) Deprotonation of the pyrrolidinio perchlorate (27d) (4.51 g) with triethylamine (1.4 g) in ether (30 ml) gave yellow 3-*pyrrolidino*-1H-2-*benzopyran*-1-*one* (28d) (3.3 g, 100%), yellow needles, m.p. 143—145° (from chloroform–ether), $\nu_{max.}$ 1 730 and 1 620 cm^{-1}, δ 8.1—6.9 (4 H, m, Ar), 5.05 (s, CH), 3.38 (4 H, m,) and 1.97 (4 H, m), (pyrrolidino) (Found: C, 72.8; H, 6.3; N, 6.6. $C_{13}H_{13}NO_2$ requires C, 72.5; H, 6.1; N, 6.5%).

(*c*) Addition of the piperidinio salt (27e) (3.2 g) to a solution of triethylamine (0.98 g) in ether (20 ml) gave 3-*piperidino*-1H-2-*benzopyran*-1-*one* (28e) (1.74 g, 76%), yellow needles, m.p. 92.5—94° (from ether), $\nu_{max.}$ 1 725 and 1 625 cm^{-1}, δ 8.15—6.98 (4 H, m, Ar), 5.3 (s, CH), and 3.29 (4 H, m), and 1.61 (6 H, m) (piperidino) (Found: C, 73.2; H, 6.8; N, 6.1. $C_{14}H_{15}NO_2$ requires C, 73.3; H, 6.6; N, 6.1%).

(*d*) Reaction of the phenylammonio perchlorate (27c) (0.66 g) with triethylamine (0.19 g) in ether (10 ml) similarly gave yellow 3-*phenylamino*-1H-2-*benzopyran*-1-*one* (28c) (0.5 g, 21%), m.p. 135—136° (from ether), $\nu_{max.}$ 3 250, 1 730, and 1 640 cm^{-1}, δ 0.99 (s, NH), 8.05—6.9 (9 H, m, Ar), and 5.85 (s, CH) (Found: C, 75.5; H, 4.7; N, 5.9. $C_{15}H_{11}NO_2$ requires C, 75.9; H, 4.7; N, 5.9%).

(*e*) A similar reaction of the t-butyl analogue (27a) (1.2 g) with triethylamine (0.37 g) in ether (10 ml) yielded a cream-coloured solid (0.75 g), m.p. 133° (decomp.), which resisted purification. It had $\nu_{max.}$ 3 380, 1 770, and 1 670 cm^{-1},

[44] K. Schank, *Chem. Ber.*, 1967, **100**, 2292.

δ 8.1—6.64 (4 H, m, Ar), 5.35 (s, CH), and 1.389 (9 H, s, Bu^t) (Found: C, 68.3; H, 6.3; N, 6.1%).

3,4-Dihydro-1-morpholinio-1H-2-benzopyran-3-one Perchlorate (32).—A mixture of homophthalic acid dimorpholide (30b) (9.54 g), potassium hydroxide (16.8 g), and ethanol (120 ml) was heated under reflux for 5 h. The solvent was removed *in vacuo*, water (150 ml) was added to the residue, and the mixture was filtered. The filtrate was acidified to pH 6 with 2M-hydrochloric acid; the resulting mixture was evaporated under reduced pressure and the residue was extracted with boiling ethyl acetate (100 ml). Removal of the solvent left impure homophthalic acid 1-morpholide (31) as a gum. A solution of the gum in acetic anhydride (20 ml) was treated slowly with perchloric acid (7.5 ml), whereupon the *salt* (7.7 g, 73%) crystallised. It had m.p. 103° (decomp.), $\nu_{max.}$ 1 830, 1 640, and 1 100br cm^{-1}, δ 8.65—7.2 (4 H, m, Ar) and 5.6—3.2 (10 H, m, CH_2 and morpholino) (Found: C, 46.9; H, 4.4; N, 4.1. $C_{13}H_{14}ClNO_7$ requires C, 47.1; H, 4.3; N, 4.2%).

The perchlorate (0.16 g) was added to a solution of morpholine (0.4 g) and triethylamine (0.4 g) in acetonitrile (3.5 ml). The mixture was warmed on a steam-bath for 1 min, cooled, and treated with water (20 ml). The resulting mixture was extracted with chloroform (3 × 5 ml), the combined extracts were washed with 2M-hydrochloric acid (10 ml) and then water (10 ml) and dried ($MgSO_4$). Evaporation of the chloroform left the dimorpholide (30b) (0.13 g, 85%), identified by m.p., mixed m.p., and its i.r. spectrum.

2,5-Dihydro-5-p-methoxyphenylammoniofuran-2-one Perchlorate (36).—Perchloric acid (3 ml) was slowly added to a suspension of *p*-methoxymaleanilic acid (35) [45] (4.42 g, 0.02M) in acetic anhydride (25 ml). The solution deposited the orange *salt* (5.2 g, 86%), m.p. 125° (decomp.), $\nu_{max.}$ 1 860, 1 680, and 1 100br cm^{-1}, δ 8.2 (1 H, d) and 7.21 (1 H, d) (*J* 6 Hz, CH=CH), 7.86 (2 H, d) and 7.18 (2 H, d) (*J* 10 Hz, Ar), and 4.0 (s, Me) (Found: C, 43.85; H, 3.3; N, 5.0. $C_{11}H_{10}ClNO_7$ requires C, 43.5; H, 3.35; N, 4.6%).

The perchlorate (1.0 g) was stirred with aqueous 0.2M-sodium hydrogencarbonate, whereupon the isoimide (37) (0.6 g, 90%), m.p. 70—72° (lit.,[3] 71°), separated.

cis-2-Morpholinocarbonylcyclopropane-1-carboxylic Acid (38).—A mixture of *cis*-cyclopropane-1,2-dicarboxylic anhydride [46] (2.24 g), morpholine (1.5 g, 1 mol. equiv.), and benzene (25 ml) was heated under reflux for 10 min; the *morpholide* (4.0 g, 100%) crystallised on cooling. It had m.p. 60° (from chloroform–ether), $\nu_{max.}$ 1 700 and 1 600 cm^{-1}, δ 3.7 (8 H, s, morpholino), 2.15 (q, CH_2), and 1.8—1.3 (m, 2 CH) (Found: C, 54.5; H, 6.4; N, 6.9. $C_9H_{13}NO_4$ requires C, 54.3; H, 6.6; N, 7.0%).

Tetrahydro-cis-3,4-methano-5-morpholiniofuran-2-one Perchlorate (39).—The foregoing morpholide (1.99 g) was added to an ice-cold mixture of acetic anhydride (5 ml) and perchloric acid (1.1 ml); the resulting solution deposited the *salt* (2.56 g, 91%), m.p. 101° (decomp.), $\nu_{max.}$ 1 870, 1 720, and 1 100br cm^{-1}, δ 4.5—4.0 (8 H, m, morpholino), 3.9—2.6 (m, 2 CH), and 2.5—1.8 (m, CH_2) (Found: C, 38.0; H, 4.40 Cl, 12.7; N, 4.7. $C_9H_{12}ClNO_7$ requires C, 38.4; H, 4.3; Cl, 12.6; N, 5.0%).

N-Substituted 2,2′-Diphenamic Acids (42).—The usual reaction of 2,2′-diphenic anhydride (0.01M) with the appropriate amine (1.2 mol. equiv.) in benzene (10 ml) gave the following *2,2′-diphenamic acids*: *N*-methyl- (42a) (2.3 g, 89%), m.p. 209° (lit.,[47] 209—211°), $\nu_{max.}$ 3 460—3 200, 1 720, and 1 612 cm^{-1}; *N*-ethyl- (42b) (2.52 g, 92%), m.p. 148—149° (lit.,[47] 150°), $\nu_{max.}$ 3 600—3 100, 3 300, 1 690, and 1 620 cm^{-1}; N-*t*-*butyl*- (42c) (2.9 g, 100%), m.p. 200—201°, $\nu_{max.}$ 3 390, 3 300, 1 700, and 1 625 cm^{-1} (Found: C, 72.5; H, 6.4; N, 4.3. $C_{18}H_{19}NO_3$ requires C, 72.7; H, 6.4; N, 4.7%), *NN*-dimethyl- (42d) (2.6 g, 100%), m.p. 159—160° (lit.,[47] 160—163°), $\nu_{max.}$ 1 720 and 1 590 cm^{-1}, *NN*-diethyl- (42e) (2.97 g, 100%), m.p. 174—177° (lit.,[47] 179—181°), $\nu_{max.}$ 3 300—3 000, 1 720, and 1 600 cm^{-1}, NN-*di-isopropyl*- (42f) (3.07 g, 94%), m.p. 213—215° (from ethanol), $\nu_{max.}$ 1 715 and 1 585 cm^{-1} (Found: C, 74.1; H, 7.25; N, 4.15. $C_{20}H_{23}NO_3$ requires C, 73.8; H, 7.1; N, 4.3%), *2′-morpholinocarbonylbiphenyl-2-carboxylic acid* (42g) (3.0 g, 97%), m.p. 248—249° (from ethanol), $\nu_{max.}$ 1 700 and 1 585 cm^{-1}, δ 8.7—6.8 (8 H, m, Ar) and 5.0—2.5 (9 H, m, OH and morpholino) (Found: C, 69.5; H, 5.6; N, 4.5. $C_{18}H_{17}NO_4$ requires C, 69.5; H, 5.5; N, 4.5%).

Reaction of Diphenamic Acids with Acetic Anhydride–Perchloric Acid.—Treatment of the acids (42a, b, e, and f) with acetic anhydride and perchloric acid in the usual way gave hygroscopic gums. The morpholide (42g) (1.0 g) yielded a solid, possibly (43) (1.3 g, 100%), m.p. 198—200° (decomp.), $\nu_{max.}$ 3 580—2 200, 1 700, 1 660, and 1 120br cm^{-1} (Found: C, 53.1; H, 4.5; Cl, 17.8; N, 3.4. $C_{18}H_{17}NO_4,HClO_4$ requires C, 52.5; H, 4.4; Cl, 18.6; N, 3.4%).

The *NN*-dimethyl derivative (42d) (0.2 g) gave *NN-dimethylammonio-2,2′-diphenisoimidium perchlorate* (0.02 g, 8%), m.p. 155° (decomp.), $\nu_{max.}$ 1 800, 1 690, and 1 090br cm^{-1} (Found: C, 54.2; H, 3.9; Cl, 9.9; N, 3.9. $C_{16}H_{14}ClNO_6$ requires C, 54.6; H, 4.0; Cl, 10.1; N, 4.0%). This experiment could not be repeated.

Treatment of the *N*-t-butyl derivative (42c) (5.94 g) with acetic anhydride (6.5 ml) and perchloric acid (2.5 ml) deposited 2,4,6-trimethylpyrylium perchlorate (0.8 g, 36%), m.p. 238° (lit.,[22] 248°), identified by direct comparison with an authentic specimen. Chromatography of the mother liquor yielded 2′-cyanobiphenyl-2-carboxylic acid (2.5 g, 57%), m.p. 172—174° (lit.,[21] 170—172°), $\nu_{max.}$ 2 220 and 1 695 cm^{-1}.

2,4-Dihydro-2-dimethylammonio-1H-3,1-benzoxazin-4-one Perchlorate (47).—Addition of perchloric acid (3.0 ml) to a suspension of *N*-dimethylcarbamoylanthranilic acid (46) [23] (4.16 g) in acetic anhydride (10 ml) caused the separation of the *perchlorate* (5.4 g, 93%), m.p. 195° (decomp.), $\nu_{max.}$ 3 224, 3 170, 1 810, 1 690, and 1 120br cm^{-1}, δ 8.25—7.1 (4 H, m, Ar), 3.49 (s, Me), and 3.45 (s, Me) (Found: C, 41.3; H, 3.6; Cl, 12.3; N, 9.5. $C_{10}H_{11}ClN_2O_6$ requires C, 41.3; H, 3.8; Cl, 12.2; N, 9.6%).

2-Dimethylamino-4H-3,1-benzoxazin-4-one (48).—The foregoing salt (2.9 g) was added to a solution of triethylamine (0.96 g) in ether (20 ml); the ethereal solution was decanted from a heavy oil and evaporated, leaving the *benzoxazinone* (1.67 g, 88%), m.p. 128—128.5° (from benzene–light petroleum), $\nu_{max.}$ 1 760 and 1 625 cm^{-1}, δ 8.02—6.96 (4 H, m, Ar) and 3.11 (s, 2 Me) (Found: C, 63.1; H, 5.4; N, 14.7. $C_{10}H_{10}N_2O_2$ requires C, 63.1; H, 5.3; N, 14.7%). The benzoxazinone was obtained in 92% yield when the perchlorate was added to aqueous 0.5M-sodium hydrogencarbonate.

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