Synthesis and Thermal Reactions of 1,2-Dihydro-1,2,4-benzotriazines

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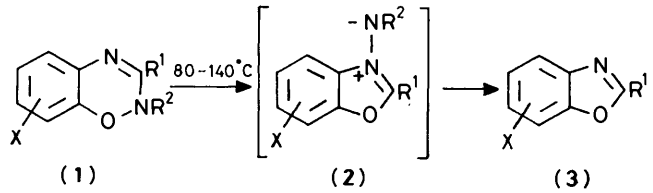
The 1,2-dimethyl-1,2,4-benzotriazines (**7**), (**8**), and (**9**) were prepared by acid-catalysed cyclisation of the 2-aminophenylhydrazine derivatives derived from (**12**), (**13**), and (**14**) respectively. Compounds (**7**) and (**9**) undergo a thermal elimination to fully aromatic benzotriazines. However, the 2-acyl derivative (**18**) rearranges to the thermodynamically more stable 4-acyl compound (**21**). In the presence of traces of water, a ring contraction to benzimidazoles is a competing reaction. For (**18**) the nitrogen fragment is retained in the benzamide (**22**). A mechanism for the ring contraction has been suggested in which initial hydration of the imine bond gives 1,2,3,4-tetrahydrobenzotriazines which ring-open, then re-cyclise to benzimidazoles. The benzimidazo[2,1-*a*]phthalazine (**23**) was shown not to be an intermediate in the water-mediated ring contraction of (**18**).

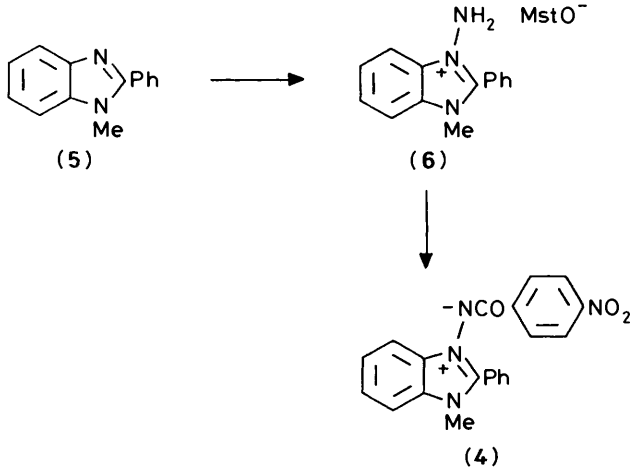
It has previously been shown that 1,2,4-benzoxadiazines (**1**) undergo a thermal ring contraction to benzoxazoles (**3**) (Scheme 1).[1] The fate of the extruded nitrogen was found to be



Scheme 1.

dependent upon the nature of R^2. When R^2 = H, N_2, and NH_3 were formed by disproportionation of 'NH'. When R^2 = 4-nitrobenzoyl, however, 4-nitrobenzamide was formed.[2] A mechanism for the ring contraction was suggested in which the first step was N–O bond cleavage with subsequent rearrangement to the benzoxazolium *N*-imide (**2**). These ylides are unknown and our attempts to prepare them failed. However, benzimidazolium-*N*-amines are known[3] and therefore the *N*-4-nitrobenzoyl derivative (**4**) was prepared as a model system and its thermal stability investigated.

1-Methyl-2-phenylbenzimidazole (**5**) was *N*-aminated with *O*-mesitylsulphonylhydroxylamine (MSH), prepared by methanolysis of the *N*,*N*-bistrimethylsilyl derivative,[4] and the *N*-amino compound (**6**) benzoylated with 4-nitrobenzoyl chloride (Scheme 2). The ylide (**4**) proved to be very thermally

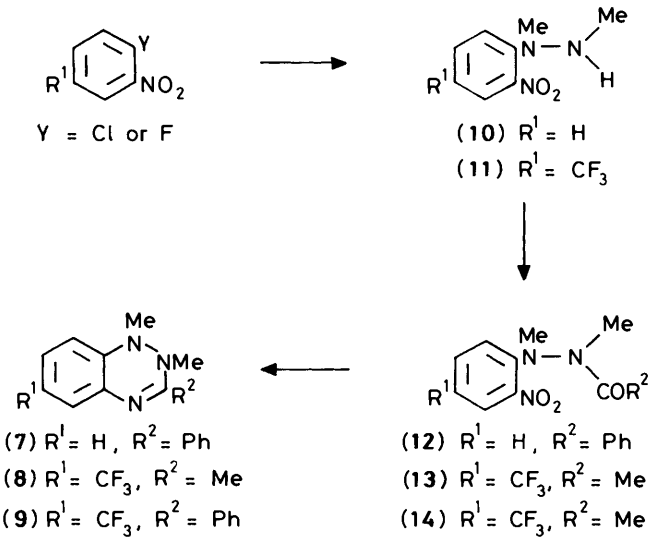


Scheme 2. Mst = mesitylsulphonyl

stable and was recovered unchanged both after 17 h in refluxing chlorobenzene and after heating to 140 °C in a triphenylarsine–copper bronze melt. The thermal stability of (**4**) prompted us to investigate the 1,2-dihydro-1,2,4-benzotriazine system as one which could potentially undergo a thermal ring contraction, but which might allow the isolation of the thermally stable, putative ylide.

Very few stable 1,2-dihydro-1,2,4-benzotriazines with simple 3-alkyl or aryl substituents have been reported in the literature.[5,6] The 1,2-unsubstituted compounds are intermediates in the synthesis of benzotriazines and are so susceptible to oxidation that they are frequently not isolated.[7] 1,2-Dihydro-1,3-diphenyl-1,2,4-benzotriazine has also been reported to be readily oxidised, to a highly coloured, stable radical.[8] No synthesis of 1,2-disubstituted derivatives has been reported.

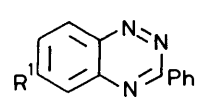
The 1,2-dimethyl-1,2,4-benzotriazines (**7**), (**8**), and (**9**) were readily prepared by acid-catalysed cyclisation of the 2-aminophenylhydrazine derivatives derived from (**12**), (**13**), and (**14**) respectively (Scheme 3). These 1,2-dihydrobenzotriazines were



Scheme 3.

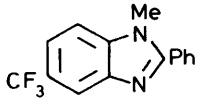
readily isolable compounds with no tendency to aerobic oxidation and were much more thermally stable than the benzoxadiazines. Prolonged heating of (**7**) in chlorobenzene resulted in total recovery, even in the presence of triethyl phosphite which was previously found to catalyse the ring contraction of the related 1,2,4-benzothiadiazines.[9] Flash

vacuum pyrolysis (FVP) of (**7**) at 400 °C also resulted in total recovery, however, FVP at 500 °C gave the bright yellow, fully aromatic benzotriazine (**15**) in 85% yield. This was presumably formed by elimination of ethane. This type of reaction is not readily available to either of the related benzoxadiazines or benzothiadiazines. In contrast, pyrolysis in *N*-methylpyrrolidone (NMP) at reflux gave two products identified as the benzotriazine (**15**) (26%) and 1-methyl-2-phenylbenzimidazole (**5**) (43%). Similar pyrolysis of (**9**) gave the 6-trifluoromethylbenzotriazine (**16**) (5%) and the 5-trifluoromethylbenzimidazole (**17**) (55%). The benzimidazoles (**5**) and (**16**) are the products expected from a ring contraction similar to that found with the



(**15**) R^1 = H

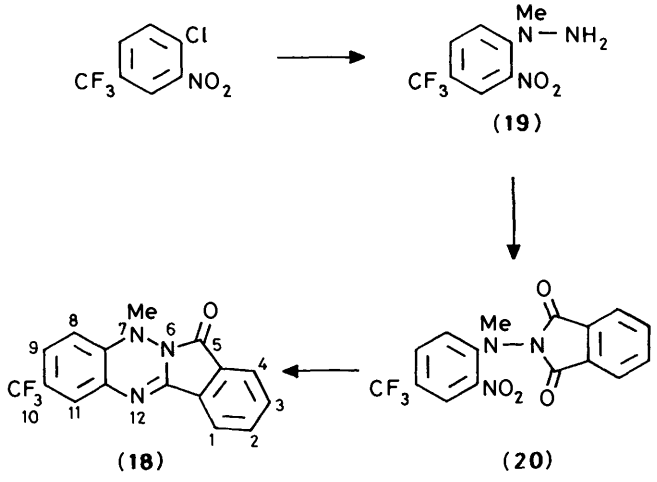
(**16**) R^1 = CF_3



(**17**)

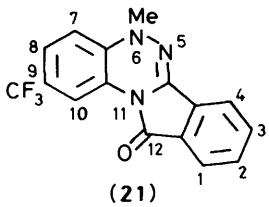
benzoxadiazines. The product derived from the nitrogen fragment was believed to be methylamine, which was detected both by its smell and by its action on moist indicator paper.

In order to determine more accurately the fate of the nitrogen fragment, the isoindolo[2,1-*b*]-1,2,4-benzotriazone (**18**) was prepared in which the nitrogen fragment would be retained. It was expected that the 3-aroylbenzotriazines would also undergo the thermal ring contraction, as was the case in the benzoxadiazine series.[2] Reaction of 2-nitro-4-(trifluoromethyl)-chlorobenzene with methylhydrazine gave the *N*-methyl-*N*-arylhydrazine (**19**). Reaction of 2-chloronitrobenzene and methyl hydrazine has previously been shown to give exclusively the *N*,*N*-disubstituted product.[10] Reaction with phthalic anhydride gave the phthalimide derivative (**20**) which, on reduction with zinc in acetone–acetic acid–water, gave the desired product (**18**) (Scheme 4). A number of other reduction methods were tried, none of which gave the desired product.

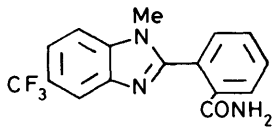


Scheme 4.

Melt pyrolysis of (**18**) under nitrogen at 300 °C for 10 min gave, not an elimination product as seen with the 1,2-dimethyl compounds, but an isomer of (**18**) assigned on the basis of its n.m.r. and i.r. spectra as the 1,4-disubstituted product (**21**). In the n.m.r. spectrum of (**21**), the methyl group appears at δ 3.46 consistent with an *N*-methyl. The 7-*H* doublet appears at δ 6.58 which is again consistent with an electron rich *o*-substituent, such as an *N*-methyl and not an electron deficient N=N, for example in the benzotriazine (**16**) where the equivalent proton appears at δ 8.71. In addition the 11-H proton of (**18**), which appears at δ 7.61 has shifted downfield to δ 8.79 in (**21**). This could be due to the deshielding effect of the nearby carbonyl in (**21**). It would therefore appear that the 1,4-disubstituted (**21**) is thermodynamically more stable than (**18**). Both systems are formally 18π-electron aromatic systems. A comparison of the carbonyl stretching frequencies of compounds (**18**) and (**21**) at 1 735 and 1 695 cm^{-1}, respectively, indicates that there is much more single bond character to the carbonyl group of (**21**), and hence more double bond character to the C=N in the ring system. This is probably due to the differing stabilisation of the charge-separated forms of (**18**) and (**21**). Whereas for (**21**), the charge-separated forms exist independently of the trifluoromethyl substituted benzo ring; for (**18**), one of the forms constrains this ring to an *ortho*-quinoid form. In addition, for (**18**) the positive charge is delocalised on adjacent N atoms, which is not the case for (**21**).

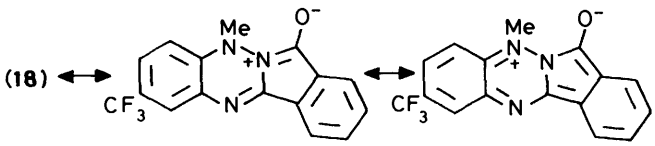


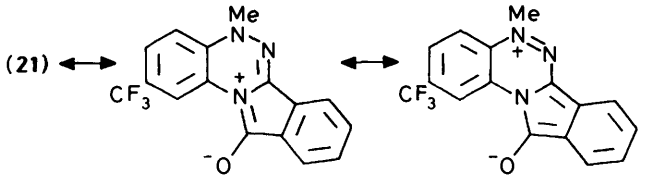
(**21**)



(**22**)

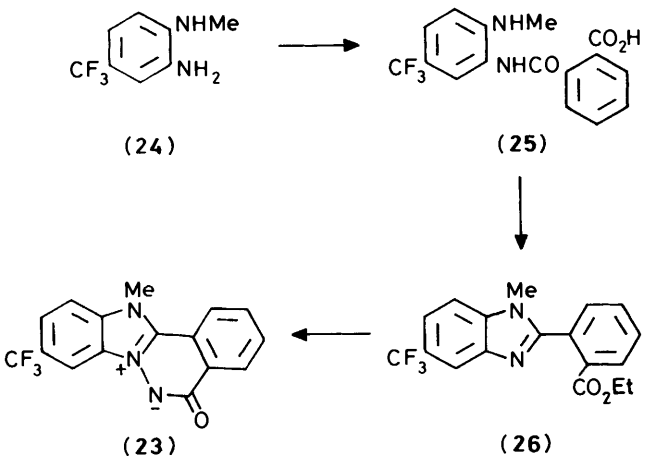
Pyrolysis of compound (**18**) in *N*-methylpyrrolidone (NMP) at reflux gave a mixture of (**21**) (30%) and the benzimidazole (**22**) (45%). Therefore both the 2-aroyl-1,2-dihydro-1,2,4-benzotriazines and the 2-aroyl-1,2,4-benzoxadiazines appear to undergo a thermal ring contraction and in both cases the nitrogen fragment was isolated as the benzamide. In the ring





contraction of (**18**) there was no evidence for an ylide-type intermediate (**23**) related to (**4**). The synthesis of this novel ylide (**23**) was, therefore, undertaken to investigate its properties.

Reaction of the *o*-phenylenediamine (**24**) with phthalic anhydride gave the amido acid (**25**). It would appear that the deactivating effect of the trifluoromethyl group eliminates the problems of lack of selectivity found with other *o*-phenylenediamines.[11] A portion of this acid was converted into the amide (**22**) for comparison purposes. The remainder was cyclised and esterified. *N*-Amination with MSH gave, on basification, a compound whose structure was assigned as (**23**) (Scheme 5). This compound proved to be of very low solubility in most organic solvents, though sufficiently soluble in hot NMP to effect crystallisation. It was not sufficiently soluble to record an n.m.r. spectrum nor sufficiently volatile for mass spectral measurement. However an elemental analysis was

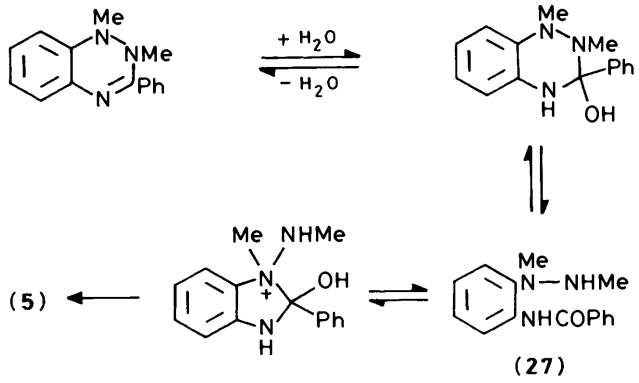


Scheme 5.

consistent with the proposed structure and the i.r. spectrum showed the expected shift of the carbonyl stretch from 1 710 cm^{-1} in the ester (**26**) to 1 590 and 1 555 cm^{-1} for (**23**), indicative of considerable single bond character. When heated alone up to 320 °C under nitrogen compound (**23**) was recovered unchanged. This high thermal stability is consistent with its formal 18π-electron aromaticity. When heated for a prolonged period in refluxing NMP, however, the amide (**22**) (35%) was obtained together with unchanged (**23**) (60%). Periods of heating for both 10 and 36 h gave the same result. Thus the N–N cleavage appears to proceed only so far and then stop. It was considered that there could be an impurity, such as water, in the NMP, the reaction stopping once this was consumed. An additional 2 mol equiv. of water was therefore added to the NMP and, after 10 h under reflux, the proportion of (**22**) had increased to 60%, with only 25% recovery of (**23**). This result strongly implies the need for water for the N–N cleavage reaction. In the light of these results, the decomposition of the isoindolo-benzotriazine (**18**) was re-investigated.

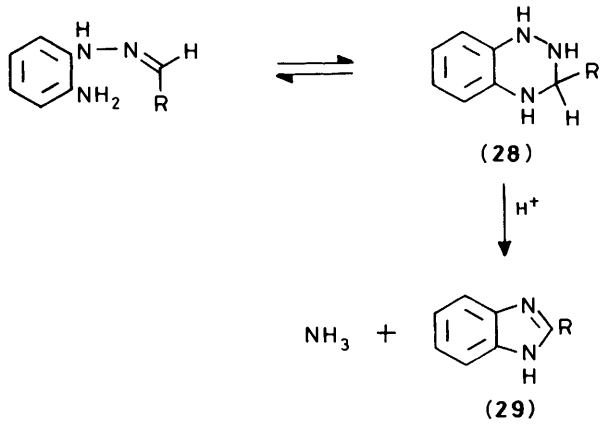
A sample of compound (**18**) was placed in a previously dried flask and NMP was distilled from CaH_2 into the flask *via* a high vacuum line. The reaction mixture was heated to 200 °C in a sealed tube *in vacuo* for 24 h to give, on work-up, only the rearranged product (**21**) (86%). This result was identical with that obtained by melt pyrolysis and strongly suggests that the ring contraction of (**18**) is also mediated by water. This was not the case for the ring contraction of the thermally more labile benzoxadiazines which was found to be solvent independent.

In conclusion, although the 1,2-dihydro-1,2,4-benzotrazines do undergo a ring contraction under suitable conditions, the solvent effect noted leads to the conclusion that the mechanism is not the same as for the benzoxadiazines. Even though the putative ylide intermediate (**23**) undergoes N–N bond cleavage in the presence of water, it is unlikely that water is determining the course of the reaction at this point. Firstly, the ylide (**23**) is very stable and, therefore, if this were an intermediate prior to the mediation of water, it should have been detectable. Secondly in the absence of water, the 1,2-dihydrobenzotriazines can undergo the alternative aromatisation reaction, or for (**18**), rearrangement to a more stable isomer. For (**18**), if the ylide (**23**) were an intermediate prior to the mediation of water, the formation of (**23**) would have to be reversible for thermolytic conversion to (**21**). In effect this would be reversing the formation of a very stable, aromatic ylide. In addition, (**21**) was never detected in any of the pyrolysis experiments with (**23**). Water must, therefore, determine the course of the thermal reaction of the benzotriazines at the first stage. Nucleophilic addition to the imine bond of electron deficient *N*-heterocycles is well known, for example the Chichibabin reaction and, therefore, a possible mechanism could involve an initial addition of water to the imine bond, ring opening to the amide (**27**) with a subsequent alternative cyclisation to the benzimidazoles (Scheme 6). Corroborative evidence for this



Scheme 6.

mechanism is the reported acid-mediated conversion of 1,2,3,4-tetrahydrobenzotriazines (**28**) to the benzimidazoles (**29**) with elimination of ammonia (Scheme 7)[12] and phenylhydrazines related to (**27**) have been reported to cyclise to benzotriazines under dehydrating conditions, but to benzimidazoles thermally.[13]



Scheme 7.

In summary, therefore, 1,2-dihydro-1,2,4-benzotriazines represent another class of compound which undergo thermal ring contraction with a formal N extrusion first observed with benzoxadiazines, but in this case the reaction appears to be mediated by water.

Experimental

1-Methyl-2-phenylbenzimidazolium 3-(4-Nitrobenzoyl)imide (**4**).—A solution of 1-methyl-2-phenylbenzimidazole (**5**) (0.6 g, 2.9 mmol) and *O*-mesitylsulphonylhydroxylamine (0.7 g, 3.2 mmol) in dichloromethane (20 ml) was stirred at 0 °C for 30 min. Diethyl ether (60 ml) was added and the solid collected, washed with ether (20 ml), and dried. This was 3-amino-1-methyl-2-phenylbenzimidazolium mesitylsulphonate (**6**)(0.92 g, 75%), m.p. 217 °C (decomp.) (ether–dichloromethane). A solution of the salt (**6**) (0.42 g, 1 mmol) in pyridine (10 ml) at 0 °C was treated was treated with 4-nitrobenzoyl chloride (0.24 g, 1.3 mmol) and stirred at room temperature for 1.5 h. The

reaction mixture was poured into an excess of aqueous sodium carbonate and the product extracted into dichloromethane. The dried (K_2CO_3), filtered extracts were evaporated to dryness and the residue triturated with ether to give the ylide (**4**) (0.25 g, 67%) as a pale yellow solid, m.p. 242—243 °C (ethanol) (Found: C, 67.5; H, 4.3; N, 15.3. $C_{21}H_{16}N_4O_3$ requires C, 67.7; H, 4.3; N, 15.1%); $\nu_{max.}$(Nujol) 1 580 cm^{-1}; $\delta(CDCl_3)$ 3.95 (3 H, s), 7.50—7.67 (6 H, m), 7.71—7.81 (3 H, m), 8.17 (2 H, d), and 8.24 (2 H, d).

N-(2-*Nitro*-4-*trifluoromethylphenyl*)-N,N'-*dimethylhydrazine* (**11**).—A solution of 1,2-dimethylhydrazine dihydrochloride (4.0 g, 30 mmol), potassium carbonate (10 g), and 2-nitro-4-(trifluoromethyl)chlorobenzene (6.5 g, 29 mmol) in water (5 ml) and ethanol (30 ml) was heated under reflux for 4 h. The cooled reaction mixture was poured into ice–water and the product extracted into dichloromethane. Purification of the organic extracts by column chromatography (silica–$CHCl_3$) gave the title compound (**11**) as orange crystals (5.4 g, 75%), m.p. 70 °C (ethanol) (Found: C, 43.6; H, 4.0; N, 16.8. $C_9H_{10}F_3N_3O_2$ requires C, 43.4; H, 4.0; N, 16.9%); $\delta(CDCl_3)$ 2.58 (3 H, s), 3.10 (3 H, s), 6.98 (1 H, d), 7.61 (1 H, d), and 7.73 (1 H, s).

1,2-*Dimethyl*-3-*phenyl*-6-*trifluoromethyl*-1,2-*dihydro*-1,2,4-*benzotriazine* (**9**).—A suspension of compound (**11**) (2.4 g, 9.6 mmol) was treated with benzoyl chloride (4 ml) in pyridine (20 ml) to give, after column chromatography (silica–$CHCl_3$), the benzoylhydrazide (**14**) as a yellow oil (3.6 g, 90%) which was used without further purification. A solution of compound (**14**) (1.77 g, 5 mmol) in ethanol (200 ml) was reduced with hydrogen over 5% Pd–C (0.15 g) at atmospheric pressure and room temperature to give a colourless oil which darkened rapidly on exposure to air. This oil was dissolved in 6M hydrochloric acid and heated under reflux for 30 min. Neutralisation of the mixture with potassium carbonate and extraction with dichloromethane gave, followed by flash vacuum distillation (100 °C/0.2 mmHg) of the extract, the benzotriazine (**9**) as an orange oil (0.77 g, 50%) (Found: C, 63.0; H, 4.7; N, 13.8. $C_{16}H_{14}F_3N_3$ requires C, 62.9; H, 4.6; N, 13.8%); picrate, m.p. 167 °C (ethanol); $\delta(CDCl_3)$ 2.81 (3 H, s), 2.85 (3 H, s), 6.90 (1 H, d), and 7.20—8.00 (7 H, m).

The following were prepared similarly: 1,2-*dimethyl*-3-*phenyl*-1,2-*dihydro*-1,2,4-*benzotriazine* (**7**) as an orange oil; picrate, m.p. 252 °C (decomp.) (ethanol) (Found: C, 53.8; H, 4.0; N, 18.3. $C_{21}H_{18}N_6O_7$ requires C, 54.1; H, 3.9; N, 18.0%); $\delta(CDCl_3)$ 2.76 (3 H, s), 2.89 (3 H, 2), 6.82—6.90 (1 H, m), 7.00—7.10 (2 H, m), 7.20—7.26 (1 H, m), 7.30—7.40 (3 H, m), and 7.72—7.80 (2 H, m); *m/z* 237 (M^+), 222 ($M^+ - CH_3$).

1,2,3-*Trimethyl*-6-*trifluoromethyl*-1,2-*dihydro*-1,2,4-*benzotriazine* (**8**), picrate, m.p. 167 °C (ethanol) [Found: C, 43.2; H, 3.1; N, 17.6. $C_{17}H_{15}F_3N_6O_7$ (picrate) requires C, 43.3; H, 3.2; N, 17.8%]; $\delta(CDCl_3)$ 2.08 (3 H, s), 2.67 (3 H, s), 3.13 (3 H, s), 6.77 (1 H, d), 7.15 (1 H, br d), and 7.20 (1 H, br s); *m/z* (c.i.; NH_3), 262 (MNH_4^+) and 244 (MH^+).

N-*Methyl*-N-[2-*nitro*-4-(*trifluoromethyl*)*phenyl*]*hydrazine* (**19**). A solution of methylhydrazine (0.92 g, 20 mmol), K_2CO_3 (1.4 g, 10 mmol), and 2-nitro-4-(trifluoromethyl)chlorobenzene (2.25 g, 10 mmol) in water (50 ml) was stirred vigorously overnight. The orange solid was collected and recrystallised to give the title compound (**19**) (1.8 g, 75%), m.p. 156 °C (ethanol) (Found: C, 41.0 H, 3.4; N, 17.8. $C_8H_5F_3N_3O_2$ requires C, 40.9; H, 3.4; N, 17.9; $\delta(CDCl_3)$ 3.23 (3 H, s), 4.00 (2 H, br s), 7.02 (1 H, d), 7.62 (1 H, br d), and 7.85 (1 H, br s).

N-*Methyl*-N-(2-*nitro*-4-[*trifluoromethyl*]*phenyl*)-N',N'-*phthaloylhydrazine* (**20**).—An intimate mixture of compound (**19**) (2.35 g, 10 mmol) and phthalic anhydride (1.5 g, 10 mmol) was heated until the mixture melted. On cooling, the solid mass was crystallised from ethanol to give the title compound (**20**) (3.2 g, 90%), m.p. 170 °C (Found: C, 52.8; H, 2.8; N, 11.7. $C_{16}H_{18}F_3N_3O_4$ requires C, 52.6; H, 2.8; N, 11.5%); $\nu_{max.}$(Nujol) 1 785 and 1 730 cm^{-1} (C=O); $\delta(CDCl_3)$ 3.40 (3 H, s), 7.29 (1 H, d), 7.73 (1 H, br d), and 7.79—7.94 (5 H, m); *m/z* 365 (M^+).

7-*Methyl*-10-(*trifluoromethyl*)-7H-*isoindolo*[2,1-b]-1,2,4-*benzotriazin*-5-*one* (**18**).—A solution of compound (**20**) (0.36 g, 1 mmol) in acetone (5 ml), water (0.8 ml), and glacial acetic acid (0.8 ml) was stirred with finely divided iron (0.7 g) under reflux for 6 h. On cooling, the mixture was filtered and the solvent removed. The yellow oily residue crystallised on trituration with ether. Purification by column chromatography (silica, $CHCl_3$) gave the title compound (**18**) (0.25 g, 80%), m.p. 160 °C (ethanol) (Found: C, 60.4; H, 3.2; N, 13.4. $C_{16}H_{10}F_3N_3O$ requires C, 60.6; H, 3.2; N, 13.3%); *m/z* 317 (M^+); $\nu_{max.}$(Nujol) 1 735 (C=O) and 1 655 cm^{-1} (C=N); $\delta(CDCl_3)$ 3.25 (3 H, s), 7.08 (1 H, d), 7.44 (1 H, br d), 7.61 (1 H, br s), 7.70—7.80 (2 H, m), 7.87—7.94 (1 H, m), 7.97—8.04 (1 H, m); $\lambda_{max.}$(ethanol) 247 (log ε 4.53), 278 (3.94), and 440 nm (3.85).

Ethyl 2-[1-*Methyl*-5-(*trifluoromethyl*)*benzimidazol*-2-*yl*]-*benzoate* (**26**).—A solution of 2-methylamino-5-trifluoromethylaniline (1.9 g, 10 mmol) and phthalic anhydride (1.5 g, 10 mmol) in ethanol (100 ml) was heated under reflux for 2 h. On cooling, the mixture was extracted with 2M aqueous sodium hydroxide. The basic solution was washed with EtOAc, acidified, and the precipitated acid (**25**) collected and dried (2.4 g, 75%), m.p. 280—290 °C; $\nu_{max.}$(Nujol) 3 450 and 3 250 (NH) and 1 695 and 1 650 cm^{-1} (C=O) (Found: C, 56.8; H, 3.7; N, 8.2. $C_{16}H_{13}F_3N_2O_3$ requires C, 56.8; H, 3.9; N, 8.3%); $\delta([^2H_6]$-DMSO) 2.83 (3 H, s), 5.86 (1 H, br s), 6.69 (1 H, d), 7.39 (1 H, d), 7.55—7.73 (4 H, m), 7.92 (1 H, d), 9.73 (1 H, d), and 13.28 (1 H, br s); *m/z* 338 (M^+), 320 ($M^+ - H_2O$), 303 ($M^+ - H_2O$, OH), and 275 ($M^+ - CO_2H$). A sample of the acid (**25**) (1.6 g, 5 mmol) in ethanol (20 ml) was heated under reflux with concentrated H_2SO_4 (1 ml) for 3 h. The reaction mixture was cooled, poured into water, and the product extracted into dichloromethane. Removal of solvent from the extract gave the title compound (**26**) (1.0 g, 60%), m.p. 79 °C (heptane) (Found: C, 61.8; H, 4.3; N, 8.3. $C_{18}H_{15}F_3N_2O_2$ requires C, 62.1; H, 4.3; N, 8.0%); $\nu_{max.}$(Nujol) 1 710 cm^{-1} (C=O); $\delta([^2H_6]$DMSO) 0.80 (1 H, t), 3.61 (3 H, s), 4.00 (2 H, q), 7.60—7.90 (5 H, m), 8.01 (1 H, s), and 8.08 (1 H, dm); *m/z* (f.a.b.) 349 (MH^+), 303 ($MH^+ - HOEt$).

2-[1-*Methyl*-5-(*trifluoromethyl*)*benzimidazol*-2-*yl*]*benzamide* (**22**).—A sample of the above acid (**25**) (1.6 g, 5 mmol) was heated under reflux in thionyl chloride (10 ml) for 4 h. The excess of thionyl chloride was removed and the yellow solid residue was suspended in THF (10 ml) and added to concentrated aqueous ammonia (20 ml). After the mixture had been stirred for 2 h, the solid was collected and recrystallised from aqueous ethanol to give the title compound (**22**) (1.0 g, 65%), m.p. 164 °C (Found: C, 60.2; H, 3.8; N, 13.3. $C_{16}H_{12}F_3N_3O$ requires C, 60.2; H, 3.8; N, 13.2%); $\nu_{max.}$(Nujol) 3 325 and 3 075 (NH) and 1 665 and 1 615 cm^{-1} (C=O); $\delta(CDCl_3)$ 3.65 (3 H, s), 7.16 (1 H, br s), 7.50—7.70 (5 H, m), 7.78—7.88 (2 H, m), and 7.91 (1 H, s).

12-*Methyl*-9-(*trifluoromethyl*)-12H-*benzimidazo*[2,1-a]-*phthalazine*-5-*one* (**23**).—A stirred solution of the ester (**26**) (350 mg, 1 mmol) in dichloromethane (10 ml) at 0 °C was treated with a solution of *O*-mesitylsulphonylhydroxylamine (215 mg, 1 mmol) in dichloromethane (10 ml). After 30 min, ether was added to give separation of an oily layer of the ester and *N*-aminated product. The oil was separated, dissolved in ethanol, and treated with an excess of aqueous K_2CO_3 solution. After 5 min, the white precipitate of the title compound (**23**) was

collected and dried (200 mg, 60%); it was insoluble in most common solvents, m.p. > 320 °C (crystallised by heating under reflux in NMP for 2 h) (Found: C, 60.7; H, 3.0; N, 13.2. $C_{16}H_{10}F_3N_3O$ requires C, 60.6; H, 3.2; N, 13.3%); $\nu_{max.}$(Nujol) 1 590 and 1 555 cm^{-1}; $\lambda_{max.}$(methanol) 257sh (log ε 4.35), 280 (4.04), 290sh (4.08), 301 (4.28), 316 (4.22), and 352 nm (3.55).

Pyrolyses of the Benzotriazines.—Flash vacuum pyrolysis of compound (**7**). The benzotriazine (**7**) (110 mg, 0.46 mmol) was sublimed at 0.02 mmHg, the vapour being passed through a hot tube at 500 °C and the products collected on a cold finger. Isolation afforded 3-phenyl-1,2,4-benzotriazine (82 mg, 85%) as the sole product, m.p. 123—124 °C (lit.,[14] 123 °C). Pyrolysis at 400 °C gave recovery of starting material (**7**).

Pyrolyses in N-*methylpyrrolidone* (*NMP*). A solution of compound (**7**) (200 mg, 0.85 mmol) in NMP (5 ml) was heated under reflux under dry nitrogen for 4 h. An amine-like gas evolved was detected by smell and damp indicator paper. On cooling, the reaction mixture was poured into water and the products extracted into dichloromethane. Purification by preparative thin layer chromatography on silica, eluting with chloroform containing 2% acetone gave, as the less polar product, 3-phenyl-1,2,4-benzotriazine (45 mg, 25%) and 1-methyl-2-phenylbenzimidazole (75 mg, 45%), m.p. 170—172 °C (lit.,[15] 170—171 °C).

Similar pyrolysis of compound (**9**) (200 mg) gave 3-phenyl-6-trifluoromethyl-1,2,4-benzotriazine (**16**) (9 mg, 5%), m.p. 122 °C (hexane) (Found: C, 61.0; H, 3.0; N, 15.1. $C_{14}H_8F_3N_3$ requires C, 61.6; H, 2.9; N, 15.3%); δ($CDCl_3$) 7.59—7.66 (3 H, m), 8.00 (1 H, dd), 8.45 (1 H, br s), 8.71 (1 H, br d), and 8.76—8.83 (2 H, m); *m/z* 275 (M^+), 247 ($M^+ - 28$) and 1-methyl-2-phenyl-5-trifluoromethylbenzimidazole (**17**) (110 mg, 55%), m.p. 156 °C (ethanol) (Found: C, 65.2; H, 3.9; N, 10.3. $C_{15}H_{11}F_3N_2$ requires C, 65.2; H, 4.0 N, 10.1%); δ($CDCl_3$) 3.91 (3 H, s), 7.48 (1 H, d), 7.51—7.60 (4 H, m), 7.73—7.80 (2 H, m), and 8.10 (1 H, s).

Pyrolyses of (**18**). (*a*) Melt pyrolysis. A sample of compound (**18**) (0.1 g, 3.2 mmol) was heated under nitrogen at 300 °C for 10 min. After cooling and recrystallisation the residue gave 6-methyl-9-(trifluoromethyl)-6*H*-isoindolo[2,1-*c*]-1,2,4-benzotriazin-12-one (**21**) (95 mg, 95%), m.p. 258 °C (ethanol) (Found: C, 60.3; H, 3.1; N, 13.2. $C_{16}H_{10}F_3N_3O$ requires C, 60.6; H, 3.2; N, 13.3%); δ($CDCl_3$) 3.46 (3 H, s), 6.58 (1 H, d), 7.30 (1 H, br d), 7.65—7.76 (2 H, m), 7.94—7.99 (1 H, m), 8.00—8.05 (1 H, m,), and 8.79 (1 H, br s); *m/z* 317 (M^+); $\nu_{max.}$(Nujol) 1 695 and 1 685 cm^{-1} (C=O); $\lambda_{max.}$(ethanol) 247 (log ε 4.21), 271 (4.19), and 408 nm (3.56).

(*b*) In 'wet' NMP. A solution of compound (**18**) (320 mg, 1 mmol) in NMP (10 ml, not dried) was heated under reflux for 36 h. The solvent was removed and the residue purified by preparative t.l.c. (silica, $CHCl_3$–5% acetone) gave (**21**) (95 g, 30%) and 2-[1-methyl-5-(trifluoromethyl)benzimidazol-2-yl]benzamide (**22**) (150 mg, 45%) identical to that prepared earlier.

(*c*) In 'dry' NMP. NMP (20 ml) Previously dried over CaH_2 was distilled on a vacuum line from CaH_2 directly into a dried reaction vessel containing (**18**) (100 mg). The vessel was sealed *in vacuo* and heated to 200 °C for 24 h. The vessel was opened, the solvent removed, and the residue purified by preparative t.l.c. to give (**21**) (86 mg, 86%).

Pyrolyses of Compound (**23**). (*a*) Compound (**23**) (20 mg, 0.06 mmol) heated at 320 °C for 30 min was recovered unchanged.

(*b*) In NMP. A suspension of (**23**) (150 mg, 0.5 mmol) in NMP (5 ml, previously distilled and stored for 2 months) was heated under nitrogen under reflux for 10 h. On cooling, dichloromethane was added and the precipitated compound (**23**) collected (90 mg, 60%). Concentration of the filtrate afforded, on ether trituration, compound (**22**) (55 mg, 35%) identical with that previously prepared.

(*c*) In 'wet' NMP. A suspension of compound (**23**) (100 mg, 0.32 mmol) in NMP (5 ml) and water (0.01 ml) was heated under reflux under nitrogen for 10 h. Work-up as before gave recovery of compound (**23**) (25 mg, 25%) together with compound (**22**) (60 mg, 60%).

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