Reactions of Bromine and Lead Tetra-acetate with 2-(Substituted hydrazino)-5-phenyl-1,3,4-oxadiazoles: Routes to 3-Aryl-6-phenyl-1,2,4-triazolo[3,4-*b*][1,3,4]oxadiazoles

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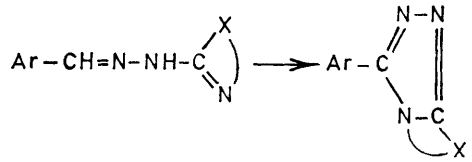
2-(Substituted hydrazino)-5-phenyl-1,3,4-oxadiazoles react with bromine in acetic acid to yield hydrazone perbromides, or hydrazonyl bromides in the presence of sodium acetate. Treatment of the hydrazonyl bromides with triethylamine in benzene or solvolysis in aqueous solvents results in cyclisation to the new 1,2,4-triazolo[3,4-*b*]-[1,3,4]oxadiazole ring system. The cyclisation involves the oxadiazole ring as a nucleophile which attacks the labile carbon–bromine site in the hydrazonyl bromide. In the solvolysis, this internal nucleophilic attack is in competition with external nucleophilic attack by solvent molecules, and direct solvolysis products are also obtained. A second route to the new ring system with tribromodiazabutadienes has also been developed. The oxadiazole ring of the new 1,2,4-triazolo[3,4-*b*][1,3,4]oxadiazoles is labile to acid and base and a preferential ring interconversion pattern of oxadiazole to triazole has been noted. In the reaction of the 2-(substituted hydrazino)-5-phenyl-1,3,4-oxadiazoles with lead tetra-acetate, the presence of the oxygen atom at the potential cyclisation site inhibits the cyclisation. The reaction instead involves acetoxylation of the hydrazone and only gives, at most, traces of 1,2,4-triazolo[3,4-*b*][1,3,4]oxadiazoles.

THE oxidative cyclisation of heterocyclic aldehyde hydrazones with bromine and lead tetra-acetate has provided routes to a range of new fused heterocyclic systems.[1] The efficiency of the method varies with the reagent and the structure of the hydrazone system. For example, with bromine the cyclisation may involve hydrazonyl bromide intermediates [2] or it may occur as a single-step process, and various degrees of efficiency are encountered in each pathway.[2] With lead tetra-acetate, cyclisation occurs directly but it may be dominated by a competing acetoxylation (acetoxylation being taken to mean here the overall replacement of a hydrogen atom by the elements of an acetoxy-group).[3] The overall course of the cyclisation is also influenced by the nature of the heteroatom of the hydrazone. We have investigated the influence of a second heteroatom X on the course of the reaction for X = N [4] and X = S.[5]

This present work concerns the course of the reactions with bromine and lead tetra-acetate when X = O.



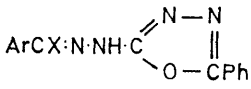
The system we studied was the hydrazino-oxadiazole (I).

RESULTS AND DISCUSSION

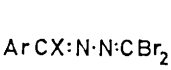
(a) *Oxidation with Bromine.*—The hydrazones (I) were prepared as described elsewhere [6] and also by treating the dibromodiazabutadienes (II) with benzohydrazide and triethylamine in benzene under reflux. When the hydrazones (I) were treated with bromine (2 mol. equiv.) in glacial acetic acid, the products were unexpectedly the perbromides (III) (85—90%). These

[1] For a review see R. N. Butler, *Chem. and Ind.*, 1968, 437.
[2] For a review see R. N. Butler and F. L. Scott, *Chem. and Ind.*, 1970, 1216.
[3] F. L. Scott and R. N. Butler, *J. Chem. Soc.* (*C*), 1966, 1202.
[4] R. N. Butler and F. L. Scott, *J. Chem. Soc.* (*C*), 1968, 1711; F. L. Scott and T. A. F. O'Mahony, *Tetrahedron Letters*, 1970, 1841.
[5] R. N. Butler, P. O'Sullivan, and F. L. Scott, *J. Chem. Soc.* (*C*), 1971, 2265.
[6] R. N. Butler, T. Lambe, and F. L. Scott, *Chem. and Ind.*, 1970, 628.

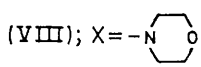
materials displayed properties similar to the open-chain azinium perbromides.[7] They liberated iodine from acidified potassium iodide solution and brominated



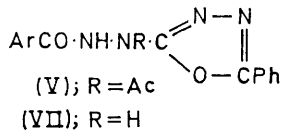
(I); X = H
(III); X = H,HBr$_3$
(IV); X = Br



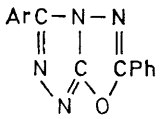
(II); X = H
(IX); X = Br



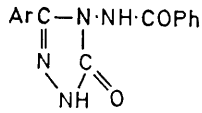
(VIII); X = –N(CH$_2$)$_2$O



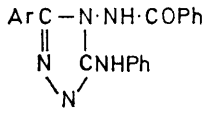
(V); R = Ac
(VII); R = H



(VI)



(X)



(XI)

a; Ar = Ph
b; Ar = *p*-ClC$_6$H$_4$
c; Ar = *p*-BrC$_6$H$_4$
d; Ar = *p*-NO$_2$·C$_6$H$_4$
e; Ar = *m*-BrC$_6$H$_4$
f; Ar = *p*-MeC$_6$H$_4$

acetanilide in acetic acid. When the materials were distributed between sodium thiosulphate solution and ether, the starting hydrazones (I) were regenerated quantitatively.

Bromination in the presence of sodium acetate led to different products. Thus when the hydrazones (I) were stirred with 1·1 mol. equiv. of bromine and 2 equiv. of sodium acetate suspended in glacial acetic acid at room temperature, the hydrazonyl bromides (IV) were formed in 80—90% yields together with small quantities (2—3%) of the *N*-acetyl-*N'*-aroylhydrazines (V). The latter probably arose from the reaction of the acetate ion present with the bromides (IV); a reaction typical of hydrazonyl halides.[2]

When the hydrazonyl bromides (IV) were heated under reflux in benzene with 2·5 equiv. of triethylamine, the new 1,2,4-triazolo[3,4-*b*][1,3,4]oxadiazoles (VI) were obtained in yields greater than 95%. The reaction, in which the oxadiazole ring behaves as a nucleophile, probably involves a dehydrobromination to a nitrilimine intermediate [8] which readily cyclises, and it is an excellent route to the new fused ring system (VI).[9] Solvolysis of the hydrazonyl bromides (IV) by heating under reflux in 50% aqueous acetone also yielded the triazolo-[1,3,4]oxadiazoles (VI) but in lower yields (*ca.* 60%). Here, the oxadiazole ring also participates in a nucleophilic attack at the labile carbon–bromine site. The cyclisation may involve a carbonium ion intermediate, resulting from cleavage of the carbon–bromine bond, a nitrilimine intermediate, or an internal nucleophilic displacement, depending on the relative timing of C–Br and N–H bond cleavages. The internal nucleophilic attack of the oxadiazole ring at the electrophilic centre was in competition with external attack by solvent molecules, and the products of this latter reaction, the aroylhydrazines (VII), were also isolated in yields of 20—40% from the solvolyses. When the solvent was sufficiently nucleophilic, this external attack was predominant: for example, when the bromide (IVd) was heated in morpholine, the only product isolated was the material (VIIId) (84%).

A second route to the triazolo-oxadiazoles (VI) involved the tribromodiazabutadienes (IX). These compounds were prepared by treating 5-[aryl(bromo)-methylenehydrazino]tetrazoles with bromine (2 mol. equiv.) in 60% aqueous acetic acid (*cf.* ref. 10). When the tribromides (IX) were heated under reflux with benzohydrazide (1 equiv.) and triethylamine (3 equiv.), the triazolo[1,3,4]oxadiazoles (VI) were obtained (75—80%). Clearly this reaction proceeds *via* the hydrazonyl bromides (IV) and represents a merging of the reactions discussed before into one step. [In a trial run, with compound (IXd) (1 equiv.) and benzohydrazide (3 equiv.) in benzene at room temperature for 1 h, the hydrazonyl bromide (IVd) (32%) was isolated.]

(b) *Oxidation with Lead Tetra-acetate.*—In seeking a further route to the triazolo[1,3,4]oxadiazoles (VI) we investigated the reactions of the hydrazones (I) with lead tetra-acetate. Two types of behaviour have been reported in the reactions of heterocyclic aldehyde hydrazones with this reagent, namely cyclisation [11] and acetoxylation [3] to yield materials such as (V). When the hydrazones (I) were treated with lead tetra-acetate in glacial acetic acid at room temperature, the cyclised products (VI) could not be isolated, although traces of these compounds were formed as shown by t.l.c. The oxidation was accompanied by a considerable amount of decomposition and the main products were the hydrazides (V) (40—50%). The products were identical with those obtained in low yields from the bromination of hydrazones (I) in the presence of sodium acetate described before. The i.r. spectra of the materials displayed

[7] F. L. Scott and P. A. Cashell, *J. Chem. Soc.* (*C*), 1970, 2674; *Chem. and Ind.*, 1969, 1343.
[8] R. Huisgen, *Angew. Chem. Internat. Edn.*, 1963, **2**, 565, 633.
[9] The existence of a fused triazolo[3,4-*b*][1,3,4]oxadiazole system has been suggested previously but never authenticated (*cf.* K. T. Potts, *Chem. Rev.*, 1961, **61**, 87; *J. Org. Chem.*, 1963, **28**, 543).
[10] F. L. Scott, J. Donovan, and J. K. O'Halloran, *Tetrahedron Letters*, 1970, 4079.
[11] J. D. Bower and F. P. Doyle, *J. Chem. Soc.*, 1957, 727; L. A. Williams, *ibid.*, 1960, 1829; R. G. W. Spickett and S. H. B. Wright, *J. Chem. Soc.* (*C*), 1967, 498; A. Pollak and M. Tisler, *Tetrahedron*, 1966, **22**, 2073.

the strong N–H (3320—3340 cm^{-1}) and carbonyl doublet (1670—1690 cm^{-1} conjugated; 1715—1730 cm^{-1} unconjugated) absorptions associated with the *N*-acetylhydrazine structure.[3,4] These results indicate that the presence of the oxygen atom adjacent to the potential site of cyclisation of the heterocyclic hydrazones (I) strongly favours acetoxylation, and hence the lead tetraacetate method does not provide an efficient cyclisation route to such compounds. The effect of the oxygen atom parallels that of a sulphur atom in the same location; then cyclisation is also inhibited.[5]

(c) *Stability of* 1,2,4-*Triazolo*[3,4-b][1,3,4]*oxadiazoles*.—The triazolo[1,3,4]oxadiazole ring system (VI) was readily cleaved by acid or base. For example, when the materials (VI) were heated briefly under reflux in acetic acid, the benzamidotriazolones (X) were obtained in yields greater than 80%. The same products were obtained by hydrolysing the materials (VI) with 0·1N-hydrochloric acid or 0·05N-sodium hydroxide, both in 50% aqueous dioxan under reflux. In the basic cleavage it was necessary to acidify the solution in order to isolate the triazolones (X) since these were, as expected, very soluble in base. The structure of the triazolones (X) was further confirmed by their i.r. spectra, which showed all the expected absorptions (see Experimental section). This cleavage of the ring system (VI) is analogous to the well known cleavage observed when substituted imidazo[2,1-*b*][1,3,4]oxadiazoles are treated with acid or base.[12] It exemplifies a general trend in heterocyclic ring systems in that the triazole system is more stable than the oxadiazole system. This is exemplified by the sequence (IV) ⟶ (VI) ⟶ (X). The lability of the oxadiazole ring may account for the difficulties encountered previously in preparing the triazolo[1,3,4]oxadiazole system. A further example of this lability in the triazolo[1,3,4]oxadiazole system (VI) was encountered when (VId) was heated in aniline under reflux. The product (58%) was the amidoaminotriazole (XId). Similar cleavages of fused oxadiazole systems have been observed;[13] for example, the oxadiazole ring of substituted 1,3,4-oxadiazolo[3,2-*a*]-pyrimidines cleaves in an analogous manner when these materials are treated with primary amines.[13]

EXPERIMENTAL

M.p.s were measured with an Electrothermal apparatus. Molecular weights were determined by vapour-pressure techniques. I.r. spectra were measured with Perkin-Elmer spectrophotometers (models 137E and 257) with sodium chloride optics. Solids were examined as KBr discs. Microanalyses were carried out by Mrs. K. M. Duggan and Miss D. Healy of this Department.

The hydrazino-oxadiazoles (I) were prepared by the procedure described in ref. 6. The compounds were recrystallised from glacial acetic acid and had the following characteristics: 2-(p-*chlorobenzylidenehydrazino*)-5-*phenyl*-1,3,4-*oxadiazole* (Ib), m.p. 248—249° (Found: C, 60·0; H, 3·65; N, 18·9. $C_{15}H_{11}ClN_4O$ requires C, 60·3; H, 3·7; N, 18·8%); the p-*bromo-analogue* (Ic), m.p. 255—258° (Found: C, 52·2; H, 2·9; N, 16·2. $C_{15}H_{11}BrN_4O$ requires C, 52·5; H, 3·2; N, 16·2%); the p-*nitro-analogue* (Id), m.p. 273—274° (Found: C, 58·7; H, 3·6; N, 22·4. $C_{15}H_{11}N_5O_3$ requires C, 58·25; H, 3·55; N, 22·65%); and the m-*bromo-analogue* (Ie), m.p. 218—220° (Found: C, 52·35; H, 3·0; N, 16·1%). These compounds were also prepared by treating the dibromodiazabutadienes (II) [14] with benzohydrazide and triethylamine in benzene under reflux. Typically, to a solution of 1,1-dibromo-4-(*p*-chlorophenyl)-2,3-diazabuta-1,3-diene (IIb) (2 g) in benzene (100 ml) were added benzohydrazide (838 mg) in warm benzene (50 ml) and triethylamine (1·55 g) also in benzene (10 ml). The mixture was heated under reflux for 12 h and the resultant yellowish solid was filtered off and washed with water to remove triethylamine hydrobromide. The remaining solid (600 mg), m.p. 248—249° (from glacial acetic acid), was the hydrazone (Ib). More hydrazone (800 mg) was obtained when the benzene mother liquor was evaporated and the residue was shaken in cold chloroform to remove a small quantity of a yellow gum. The total yield of hydrazone (Ib) was 1·4 g (76·5%). The compounds (Ic) and (Id) were prepared similarly in yields greater than 70% and were identical (mixed m.p. and i.r. spectra) with those prepared as described in ref. 6.

Reaction of the 2-(*Arylmethylenehydrazine*)-5-*phenyl*-1,3,4-*oxadiazoles* (I) *with Bromine*.—(a) *Synthesis of hydrazone perbromides* (III). Typically, bromine (0·3 ml) was added dropwise during 5 min to a suspension of the hydrazone (Ic) (1 g) in glacial acetic acid (35 ml) and the mixture was stirred for 24 h at room temperature. The bright yellow 2-(p-*bromobenzylidenehydrazino*)-5-*phenyl*-1,3,4-*oxadiazole hydroperbromide* (IIIc) (1·44 g, 85%) which separated was removed and washed with dry ether, m.p. 180—183° (Found: C, 30·7; H, 2·0; Br, 54·6; N, 9·6. $C_{15}H_{12}Br_4N_4O$ requires C, 30·8; H, 2·05; Br, 54·8; N, 9·6%). The following compounds were prepared in a similar manner: 2-*benzylidenehydrazino*-5-*phenyl*-1,3,4-*oxadiazole hydroperbromide* (IIIa), m.p. 152—155° (89%) (Found: C, 35·3; H, 2·5; Br, 48·0; N, 11·1. $C_{15}H_{13}Br_3N_4O$ requires C, 35·6; H, 2·5; Br, 47·5; N, 11·1%); the p-*nitrobenzylidene derivative* (IIId), m.p. 216—219° (87%) (Found: C, 35·1; H, 2·4; Br, 46·1; N, 14·0. $C_{15}H_{12}Br_3N_5O_3$ requires C, 34·75; H, 2·3; Br, 46·3; N, 13·5%); and the p-*methylbenzylidene derivative* (IIIf), m.p. 170—175° (87%) (Found: C, 37·4; H, 3·0; Br, 46·1; N, 11·3. $C_{16}H_{15}Br_3N_4O$ requires C, 37·0; H, 2·9; Br, 46·2; N, 10·8%).

(b) *Synthesis of the hydrazonyl bromides* (IV). Typically, a solution of bromine (0·36 ml) in glacial acetic acid (5 ml) was added dropwise with stirring during 10 min to a suspension of compound (Id) (2 g) and anhydrous sodium acetate (1 g) in the same solvent (50 ml). The mixture was stirred for 2 h and the pale yellow solid (2·1 g, 82·5%), m.p. 192—194° [filtrate (A)], which separated was washed with dry ether and recrystallised to give the *hydrazonyl bromide* (IVd), m.p. 193—194° (from glacial acetic acid) (Found: C, 46·4; H, 2·5; Br, 20·5; N, 18·15. $C_{15}H_{10}Br_3N_5O_3$ requires C, 46·4; H, 2·55; Br, 20·5; N, 18·05%). Filtrate (A) was evaporated under a current of air and the

[12] A. Hetzheim and H. Beyer, *Chem. Ber.*, 1970, **103**, 272 and previous papers in the series.

[13] H. Gehlen and B. Simon, *Arch. Pharm.*, 1970, **303**, 511.

[14] F. L. Scott and D. A. Cronin, *Chem. and Ind.*, 1964, 1757.

residue was stirred in cold water (*ca.* 50 ml). The insoluble blackish material was separated and treated with concentrated sodium carbonate solution. Traces of an insoluble gum were removed from the basic solution and after acidification with dilute hydrochloric acid white crystals of compound (Vd) separated (30 mg, 2%), m.p. 208—210° (from 95% ethanol). This material was identical (mixed m.p. and i.r. spectra) with that obtained from the reaction of compound (Id) with lead tetra-acetate described later.

The following 2-(*substituted hydrazino*)-5-*phenyl*-1,3,4-*oxadiazoles* were prepared similarly, in yields greater than 80%: α-*bromobenzylidene* (IVa), m.p. 133—134° (from benzene) (Found: C, 52·2; H, 3·3; Br, 22·9; N, 16·3. $C_{15}H_{11}BrN_4O$ requires C, 52·5; H, 3·2; Br, 23·3; N, 16·3%); α-*bromo*-p-*chlorobenzylidene* (IVb), m.p. 161—163° (from chloroform) (Found: C, 47·3; H, 2·8; Br, 21·0; N, 14·25. $C_{15}H_{10}BrClN_4O$ requires C, 47·7; H, 2·65; Br, 21·2; N, 14·85%); α,p-*dibromobenzylidene* (IVc), m.p. 166—168° (from glacial acetic acid) (Found: C, 43·05; H, 2·6; Br, 37·6; N, 12·9. $C_{15}H_{10}Br_2N_4O$ requires C, 42·65; H, 2·35; Br, 37·9; N, 13·3%); α,m-*dibromobenzylidene* (IVe), m.p. 163—164° (from chloroform) (Found: C, 43·0; H, 2·5; Br, 38·2; N, 13·4%); and α-*bromo*-p-*methylbenzylidene* (IVf), m.p. 146° (from benzene) (Found: C, 53·9; H, 3·65; Br, 22·1; N, 15·5. $C_{16}H_{13}BrN_4O$ requires C, 53·8; H, 3·65; Br, 22·4; N, 15·7%). From the reactions with compounds (Ib) and (Ic) the corresponding compounds (Vb) and (Vc) were also isolated in yields of 2·5 and 2·3%, respectively. These materials were identical with the samples obtained from the lead tetra-acetate reactions described later.

Synthesis of 1,2,4-*Triazolo*[3,4-b][1,3,4]*oxadiazoles* (VI).—(a) *Reaction of the hydrazonyl bromides* (IV) *with triethylamines*. Typically, a suspension of hydrazonyl bromide (IVd) (1 g) and triethylamine (650 mg) in benzene (260 ml) was heated under reflux for 8 h. The insoluble triethylamine hydrobromide was removed and the benzene solution was evaporated. The residue (760 mg, 96%), m.p. 268—270° (from ethanol), was pure *triazolo-oxadiazole* (VId), (Found: C, 58·4; H, 2·8; N, 22·8%; *M*, 320. $C_{15}H_9N_5O_3$ requires C, 58·6; H, 2·9; N, 22·8%; *M*, 307). The following 1,2,4-*triazolo*[3,4-b][1,3,4]*oxadiazoles* were prepared similarly: 3,6-*diphenyl* (VIa) m.p. 179—180° (Found: C, 68·2; H, 3·8; N, 21·1. $C_{15}H_{10}N_4O$ requires C, 68·7; H, 3·81; N, 21·35%); 3-p-*chlorophenyl*-6-*phenyl* (VIb), m.p. 213—214° (Found: C, 60·6; H, 2·95; Cl, 11·5; N, 19·21. $C_{15}H_9ClN_4O$ requires C, 60·7; H, 3·05; Cl, 11·95; N, 18·9%); 3-p-*bromophenyl*-6-*phenyl* (VIc), m.p. 218—219° (Found: C, 53·1; H, 2·7; Br, 23·02; N, 16·4. $C_{15}H_9BrN_4O$ requires C, 52·8; H, 2·65; Br, 23·45; N, 16·4%); 3-m-*bromophenyl*-6-*phenyl* (VIe), m.p. 185—187° (Found: C, 52·75; H, 2·8; Br, 23·2; N, 16·2. $C_{15}H_9BrN_4O$ requires C, 52·8; H, 2·65; Br, 23·45; N, 16·4%); and 6-*phenyl*-3-p-*tolyl* (VIf), m.p. 223—225° (Found: C, 69·1; H, 4·4; N, 19·9. $C_{16}H_{12}N_4O$ requires C, 69·55; H, 4·35; N, 20·3%). Each of the compounds was recrystallised from ethanol and in each case the yield was greater than 95%.

(b) *Solvolysis of the hydrazonyl bromides* (IV). (i) *Aqueous solvents*. A solution of bromide (IVc) (480 mg) in acetone (300 ml) was treated with water (300 ml) and heated under reflux for 35 min. The solution was cooled and treated with crushed ice (*ca.* 400 g) whereupon compound (VIc) (240 mg, 62%), m.p. 218°, separated out [filtrate (A)]. This material was identical (mixed m.p. and i.r. spectra) with that prepared by treating compound (IVc) with triethylamine as described before.

The filtrate (A) was evaporated to *ca.* 50% of its original volume at 40° under vacuum and on cooling white crystals of the oxadiazole (VIIc) separated (100 mg, 24·5%), m.p. 173—175° (from 95% ethanol) (Found: C, 49·9; H, 3·25; N, 15·15. $C_{15}H_{11}BrN_4O_2$ requires C, 50·13; H, 3·05; N, 15·6%), $\nu_{max.}$ 3205 (N–H) and 1678 (C=O) cm^{-1}.

A similar reaction with bromide (IVd) yielded the triazolo-oxadiazole (VId) (57%) and the *oxadiazole* (VIId), m.p. 224—226° (from 95% ethanol) (Found: C, 55·8; H, 3·55; N, 21·25. $C_{15}H_{11}N_5O_4$ requires C, 55·4; H, 3·4; N, 21·5%) (42%), $\nu_{max.}$ 1680 (C=O) and 3205 (N–H) cm^{-1}.

(ii) In *morpholine*. A solution of bromide (IVd) (300 mg) in morpholine (3 ml) was heated at 50° for 5 min, cooled, and added to water (20 ml) whereupon a yellowish *solid* (VIId) separated (270 mg; 84·5%), m.p. 240° (from 95% ethanol) (Found: C, 57·4; H, 4·65; N, 21·35. $C_{19}H_{18}N_6O_4$ requires C, 57·85; H, 4·55; N, 21·3%).

(c) *From tribromodiazabutadienes* (IX). The materials (IX) were prepared as previously described.[10] In the typical preparation of 3-*p*-nitrophenyl-6-phenyl-1,2,4-triazolo[3,4-*b*][1,3,4]oxadiazole, compound (IXd) (1·5 g) in benzene (150 ml), benzohydrazide (450 mg) in benzene (50 ml), and triethylamine (1·1 g) in benzene (20 ml) were mixed and heated under reflux for 8 h. Insoluble triethylamine hydrobromide was removed and the solution was evaporated. The residue, a yellowish solid (840 mg, 75%); m.p. 265—270°) and a small quantity of gum, was shaken with cold chloroform to remove the gum. The material, m.p. 268—270° (from ethanol), was identical (mixed m.p. and i.r. spectra) with compound (VId) obtained from the reactions described before. Compounds (VIb) and (VIc) were also prepared from the corresponding bromides (IX) in this manner in yields of 70 and 72%, respectively.

Reactions of the Hydrazones (I) *with Lead Tetra-acetate*.—Typically, lead tetra-acetate (1·3 g) in glacial acetic acid (10 ml) was added during 5 min to a well stirred suspension of hydrazone (Ic) (1 g) in glacial acetic acid (30 ml) at 20°. The mixture was heated at 50° for 5 min, stirred at room temperature for 2 h, and slowly added to ice-cold water (200 ml). A pinkish solid (800 mg), m.p. 150—170°, [filtrate (A)] separated. This solid was shaken with small quantities of cold ether. The ether dissolved a pinkish gum (150 mg), and the solid remaining after recrystallisation from aqueous alcohol was *compound* (Vc) (630 mg; 54%), m.p. 179—181° (Found: C, 50·6; H, 3·35; Br, 20·1; N, 14·35. $C_{17}H_{13}BrN_4O_3$ requires C, 50·85; H, 3·25; Br, 19·95; N, 13·95%). Further work-up of filtrate (A) (as in ref. 3) yielded only intractable gums.

Similar reactions of the hydrazones (I) yielded the following acetylhydrazides (V) together with considerable quantities of gums: 2-(N-*acetyl*-N′-*benzoylhydrazino*)-5-*phenyl*-1,3,4-*oxadiazole* (Va), m.p. 151—152° (42%) (Found: C, 63·3; H, 4·4; N, 17·2. $C_{17}H_{14}N_4O_3$ requires C, 63·35; H, 4·35; N, 17·4%); 2-(N-*acetyl*-N′-p-*chlorobenzoylhydrazine*)-5-*phenyl*-1,3,4-*oxadiazole* (Vb), m.p. 173—175° (57%) (Found: C, 56·9; H, 3·75; Cl, 10·05; N, 15·9. $C_{17}H_{13}N_4O_3$ requires C, 57·2; H, 3·6; Cl, 9·95; N, 15·7%); 2-(N-*acetyl*-N′-p-*nitrobenzoylhydrazino*)-5-*phenyl*-1,3,4-*oxadiazole* (Vd), m.p. 208—210° (49%) (Found: C, 55·85; H, 3·6; N, 19·1. $C_{17}H_{13}N_5O_5$ requires C, 55·6; H, 3·55; N, 19·05%); and 2-(N-*acetyl*-N′-p-*toluoylhydrazino*)-5-*phenyl*-1,3,4-*oxadiazole* (Vf), m.p. 148—149° (41%) (Found: C, 64·05;

H, 4·7; N, 16·7. $C_{18}H_{16}N_4O_3$ requires C, 64·3; H, 4·75; N, 16·65%).

Reactions of 1,2,4-*Triazolo*[3,4-b][1,3,4]*oxadiazoles* (VI).—(a) *With acid.* When the materials (VIb—d) were heated under reflux for a few min in acetic acid and the resulting solutions were treated with water and cooled, the products (Xb—d) were isolated pure in yields up to 80%. These materials had the following characteristics: 4-*benzamido*-3-(p-*chlorophenyl*)-1,2,4-*triazol*-5(4H)-*one* (Xb), m.p. 260—261° (Found: C, 56·8; H, 3·2; N, 17·35. $C_{15}H_{11}ClN_4O_2$ requires C, 57·2; H,3 ·5; N, 17·8%); 4-*benzamido*-3-(p-*bromophenyl*)-1,2,4-*triazol*-5(4H)-*one* (Xc), m.p. 263—264° (Found: C, 49·8; H, 3·2; N, 15·4. $C_{15}H_{11}BrN_4O_2$ requires C, 50·15; H, 3·05; N, 15·55%); and 4-*benzamido*-3-(p-*nitrophenyl*)-1,2,4-*triazol*-5(4H)-*one* (Xd), m.p. 320° (Found: C, 55·15; H, 3·5; N, 21·4. $C_{15}H_{11}N_5O_4$ requires C, 55·4; H, 3·4; N, 21·55%). The products (X) were also obtained in yields greater than 75% when compounds (VI) were heated under reflux for 1 h in 0·1N-hydrochloric acid in dioxan–water (1 : 1 v/v).

(b) *With base.* A solution of compound (VId) (400 mg) in dioxan–water (600 ml; 1 : 1 v/v) containing sodium hydroxide (1 g) was heated under reflux for 45 min and then evaporated to 20 ml under reduced pressure at 40°. After cooling it was made slightly acidic with dilute hydrochloric acid, whereupon compound (Xd) (75%) separated immediately.

The materials (X) were extremely soluble in base (*e.g.*, dilute sodium carbonate or dilute sodium hydroxide) and could be recovered quantitatively from basic solutions by acidification with dilute hydrochloric acid. The i.r. spectra of these materials were consistent with structure (X), $\nu_{max.}$ 3150 (N–H), 1725 (triazolone C=O), 1680 (amide C=O) cm^{-1}, and 1610 (C=N) cm^{-1}.

(c) *With aniline.* When a solution of compound (VId) (1 g) in aniline (5 ml) was heated under reflux for 2 h, cooled, and treated with ether (15 ml) a yellowish gummy solid separated. This material was washed with small quantities of cold ethanol to remove the gum and the remaining yellow crystalline solid (800 mg), was purified by recrystallisation from ethanol, m.p. 163—165°, (740 mg, 58%). This material was 3-*anilino*-4-*benzamido*-5-p-*nitrophenyl*-4H-1,2,4-*triazole* (XId) (Found: C, 62·9; H, 3·8; N, 20·6. $C_{21}H_{16}N_6O_3$ requires C, 63·0; H, 4·0; N, 21·0%), $\nu_{max.}$ 3290 (N–H) and 1690 (C=O) cm^{-1}.

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