263. *A New Synthesis of* para-*Substituted Benzils, and Preparation of Some of the Corresponding Benzoins.*

By T. van Es and O. G. Backeberg.

para-Substituted diphenyloxazoles are readily oxidised in good yield to the corresponding benzils by bromine in aqueous acetic acid; when electron-releasing substituents are present in the phenyl groups, the oxidising solution must be buffered with sodium acetate to prevent bromination of the benzil.

Some of the benzils have been reduced to benzoins by sodium dithionite. With unsymmetrical benzils the alcohol group in the resulting benzoin was adjacent to the phenyl group which contained the substituent with the greater electron-attracting power.

R. Kuhn was reported [1] to have prepared benzil derivatives having high antibacterial activity, and there have been other similar claims [2] (but compare Finkelstein and Linder [3]). 4,4'-Diaminobenzil is particularly active.[2,4]

The synthesis of compounds such as 4-amino-4'-sulphamoyl- and 4-dichloroacetamido-4'-nitro-benzil, which contain functional groups present in sulphanilamide and chloramphenicol, was therefore undertaken. The normal method of preparation from the corresponding benzoin did not appear promising for these compounds and it has now been shown that substituted 2-methyl-4,5-diphenyloxazoles (see preceding paper) may be readily oxidised, in almost quantitative yield, to the corresponding benzils by means of bromine in aqueous acetic acid.

If the oxazole derivative contained activating groups such as an acylamino- or an acyloxy-group, it was necessary to buffer the oxidising solution (and sometimes to control the temperature), otherwise the hydrogen bromide which was liberated hydrolysed the protected group and led to brominated substituted benzils. Oxidation was therefore carried out, as appropriate, by bromine in (a) refluxing aqueous acetic acid or (b) aqueous acetic acid buffered with sodium acetate at the b. p. or (c) room temperature. 5-*p*-Acetamidophenyl-2-methyl-4-phenyloxazole formed different benzils under each of the above three conditions. Table 1 shows the benzils prepared without simultaneous nuclear bromination, and indicates the procedure. Table 2 gives the results where bromination also occurred.

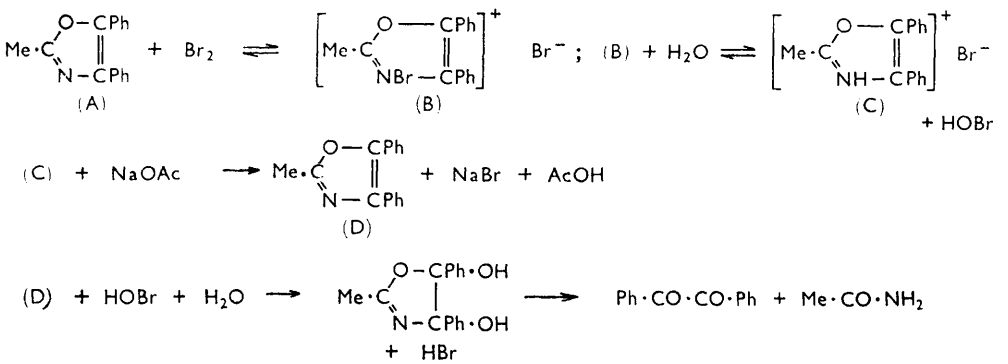
In most cases the constitution of the benzils was confirmed by oxidation to the corresponding benzoic acids by chromic oxide or hydrogen peroxide in acetic acid. However, the benzil obtained from 5-*p*-acetamidophenyl-2-methyl-4-phenyloxazole by procedure (a) yielded only a tar, so the procedure of Jourdan [5] or Dilthey and Scheidt [6] was used.

As regards the mechanism of the oxidation, the following observations are of interest. (i) If equimolar quantities of bromine and 2-methyl-4,5-diphenyloxazole were dissolved in glacial acetic acid at room temperature, heat was evolved and the solution became colourless almost immediately; removal of the acetic acid by distillation led to the evolution of hydrogen bromide and recovery of most of the oxazole, together with a small quantity of benzil. (ii) If 20 mol. of bromine were used at the b. p., hydrogen bromide was evolved and the colour of the bromine was rapidly discharged; practically all the oxazole was again recovered, as well as bromoacetic acid, together with other brominated products which were not examined; clearly the oxazole was acting as a bromine carrier. (iii) The amount of benzil formed increased on addition of water to the solution, and for

[1] B.I.O.S. Final Report, No. 219.
[2] Kuhn, Möller, and Wendt, *Ber.*, 1943, **76**, 405; Kuhn and Hensel, *ibid.*, p. 900; Kuhn, Birkofer, and Möller, *Chem. Ber.*, 1951, **84**, 557; Gee and Harley-Mason, *J.*, 1947, 251; U.S.P. 2,359,280; Youmans, Feldman, and Doub, *Amer. Rev. Tuberculosis*, 1946, **54**, 296; Schales and Suthon, *Arch. Biochem.*, 1946, **11**, 397.
[3] Finkelstein and Linder, *J. Amer. Chem. Soc.*, 1949, **71**, 1010.
[4] Chattaway and Coulson, *J.*, 1928, 1080, 1361.
[5] Jourdan, *Ber.*, 1883, **16**, 658.
[6] Dilthey and Scheidt, *J. prakt. Chem.*, 1935, **142**, 125.

quantitative conversion into benzil ~20 mol. of water were required. (iv) 2 Mol. of water sufficed if an excess of sodium acetate was present and the solution was kept at room temperature. (v) The oxazole rapidly and exothermally absorbed one mol. of bromine in chloroform. (vi) Reaction in carbon tetrachloride gave almost immediately an orange-red oil that liberated iodine from acidified potassium iodide and was decomposed by acetone to the oxazole and bromoacetone. (vii) If this oil was refluxed in glacial acetic acid, the oxazole was regenerated, hydrogen bromide was evolved, and bromoacetic acid, together with a small quantity of benzil, was formed. (viii) The oxidation of the oxazoles was retarded by the presence of electron-attracting groups and accelerated by electron-releasing groups.

Gompper and Rühle [7] studied the nuclear and side-chain halogenation of oxazoles and suggested that a perbromide was first formed. In our experiments we were not able to isolate an intermediate product from the oxazole but we suggest the annexed mechanism for the oxidation:



A similar 1,2-glycol was postulated by Biltz [8] as an intermediate in the oxidation of 4,5-diphenyl-2-imidazolone. In terms of the above mechanism, the function of the water would be to hydrolyse the bromide (C) of the weak base, and the buffering action of the sodium acetate would be to hinder the formation of the salt, so that less water would be necessary for the oxidation.

In addition to the oxidation products listed in Table 1, some of the acylamino- and acyloxy-oxazoles were also oxidised by procedures (a) and (b), giving rise to brominated benzils. The oxidation of other 4,5-diphenyloxazoles, imidazoles, and similar compounds was also briefly investigated; and, although bromine was the oxidising agent of choice, a number of other reagents also converted 2-methyl-4,5-diphenyloxazole into benzil. It is noteworthy that 4,5-diphenylimidazole and its 2-methyl homologue were not oxidised by bromine, but yielded oils containing bromine which were not further investigated; yet, if electron-attracting substituents were present in the phenyl groups, the expected oxidation occurred. This difference must be related to the greater basic strength of the imidazoles than of the oxazoles, a weakening in basic strength being necessary for the formation of an intermediate (B).

Benzoins are conveniently obtained from benzils by the action of sodium dithionite,[9] and Table 3 lists unsymmetrical benzoins prepared in this way; in one case only, namely, 4,4′-disulphamoylbenzil, was a different product formed: in this case reduction gave the hydrobenzoin, which is to be ascribed to the powerful electron-attracting effect of the two sulphamoyl groups.

The formation of unsymmetrical benzoins was studied by Merz and Plauth,[10] who

[7] Gompper and Rühle, *Annalen*, 1959, **626**, 83, 92.
[8] Biltz, *Ber.*, 1908, **41**, 1754; *Annalen*, 1909, **368**, 156.
[9] Grandmougin, *J. prakt. Chem.*, 1907, **76**, 124; Pearl, *J. Amer. Chem. Soc.*, 1952, **74**, 4593.
[10] Merz and Plauth, *Chem. Ber.*, 1957, **90**, 1744.

found that the aldehyde with the lower electron-density at the carbonyl group takes over the alcohol function in the benzoin condensation; we have found (see Table 3) that in the reduction of unsymmetrical benzils, reaction takes place at the carbonyl group adjacent to the phenyl group which contains the substituent having the greater electron-attracting power. The constitution of these benzoins was established by periodate oxidation [10] which yielded an aromatic acid from the carbonyl group and the corresponding aromatic aldehyde (isolated as its semicarbazone) from the alcoholic portion.

Experimental

M. p.s were determined in an electrically heated copper block. Known compounds were identified by mixed melting points. Unless otherwise stated, the quantity of starting material used in each experiment was 5·0 g.

The benzils were mostly yellow or pale yellow compounds which crystallised from alcohol or acetic acid or from these solvents diluted with water. 4,4′-Dinitrobenzil crystallised from acetic acid in yellow blades 6 cm. in length; benzil behaves similarly from methanol.

The oxazoles were oxidised by one of the following procedures, additional acetic acid being

Table 1.

(A) Benzils.

					Found (%)				Required (%)		
No.	Method	4,4′-Subst.		M. p.	C	H	N	Formula	C	H	N
	a	H	H	94—95°							
1	a	NO_2	NO_2	213—214							
2	a	H	NO_2	140—141							
3	c	H	NHAc *	139—140							
4	c	H	NHBz	178—179			4·3	$C_{21}H_{15}NO_3$			4·4
	a	H	Cl [a]	73—74							
	a	H	Br [a]	84—85							
5	b	H	CN	108—109			6·0	$C_{15}H_9NO_2$			6·0
6	a	H	CO_2H	227—228	70·7	4·1	—	$C_{15}H_{10}O_4$	70·9	3·9	—
	b	H	CO_2Me	65—66	71·45	4·7	—	$C_{16}H_{12}O_4$	71·6	4·5	—
7	a	H	$SO_2{\cdot}NH_2$	151—152	58·0	4·0	4·95	$C_{14}H_{11}NO_4S$	58·1	3·8	4·8
8	a	$SO_2{\cdot}NH_2$	NO_2	224—225	50·2	3·1	8·4	$C_{14}H_{10}N_2O_6S$	50·3	3·0	8·4
9	c	$SO_2{\cdot}NH_2$	NHAc	228—229			8·2	$C_{16}H_{14}N_2O_5S$			8·2
10	a	$SO_2{\cdot}NH_2$	Cl	225—226			4·5	$C_{14}H_{10}ClNO_4S$			4·3
11	a	$SO_2{\cdot}NH_2$	Br	244—245			3·8	$C_{14}H_{10}BrNO_4S$			3·8
	b	$SO_2{\cdot}NH_2$	CN	194—195			8·9	$C_{15}H_{10}N_2O_4S$			8·9
12	a	SO_2NH_2	CO_2H	281—282			4·25	$C_{15}H_{11}NO_6S$			4·2
13	b	$SO_2{\cdot}NH_2$	CO_2Me	211—212			4·2	$C_{16}H_{13}NO_6S$			4·0
14	c	NHAc	NHAc [b]	251—252							
15	c	NHBz	NHBz	281—282			6·1	$C_{28}H_{20}N_2O_4$			6·25
16	a	$SO_2{\cdot}NH_2$	$SO_2{\cdot}NH_2$	257—258 [f]			7·6	$C_{14}H_{12}N_2O_6S_2$			7·6
	a	Cl	Cl [c]	194—195							
	a	Br	Br [d]	223—224							
	a	I	I	245—246 [g]							
17	b	CN	CN †	221—222			10·85	$C_{16}H_8N_2O_2$			10·8
18	a	CO_2H	CO_2H †	324—325	64·6	3·4	—	$C_{16}H_{10}O_6$	64·6	3·4	—
19	b	CO_2Me	CO_2Me	196—197	66·4	4·4	—	$C_{18}H_{14}O_6$	66·3	4·3	—
20	b	$CO{\cdot}NH_2$	$CO{\cdot}NH_2$ †	311—312			9·8	$C_{16}H_{12}N_2O_4$			9·5
21	c	NO_2	NHAc	192—193			9·05	$C_{16}H_{12}N_2O_5$			9·0
22	a	NO_2	Cl	199—200			4·9	$C_{14}H_8ClNO_4$			4·8
23	a	NO_2	Br	228—229			4·15	$C_{14}H_8BrNO_4$			4·2
	b	NO_2	CN	187—188			9·8	$C_{15}H_8N_2O_4$			10·0
24	a	NO_2	CO_2H	330—331			4·6	$C_{15}H_9NO_6$			4·7
25	b	NO_2	CO_2Me	185—186			4·5	$C_{16}H_{11}NO_6$			4·5
26	c	NHAc	Cl [e]	172—173							
27	c	NHAc	Br	151—152			3·9	$C_{16}H_{12}BrNO_3$			4·05
28	a	Br	Cl	203—204	52·2	2·6	—	$C_{14}H_8BrClO_2$	51·9	2·5	—

* This compound softened at 60°, but if the temperature was raised gradually, resolidification occurred followed by melting at 139—140°. † These benzils were also prepared in good yield by the selenium dioxide oxidation of the corresponding 4,4′-disubstituted deoxybenzoins.

[a] Arnold and Fuson, *J. Amer. Chem. Soc.*, 1936, **58**, 1295. [b] Ref. 2. [c] Kenner and Witham, *J.*, 1910, **97**, 1967. [d] Ref. 8. [e] Ref. 10. [f] U.S.P. 2,860,165 gives m. p. 238° (decomp.). [g] Willgerodt and Ucke, *J. prakt. Chem.*, 1912, **86**, 283 (m. p. 255°).

TABLE 1. (*Continued.*)

(B) Quinoxalines.

No.	M. p.	Formula	Found: N (%)	Reqd.: N (%)
1	201—202°			
2	160—161			
3	228—229			
4	216—217	$C_{27}H_{19}N_3O$	10·5	10·5
5	167—168	$C_{21}H_{13}N_3$	14·0	13·7
6	260—261	$C_{21}H_{14}N_2O_2$	8·8	8·6
7	250—251	$C_{20}H_{15}N_3O_2S$	11·5	11·6
8	279—280	$C_{20}H_{14}N_4O_4S$	13·7	13·8
9	313—314	$C_{22}H_{18}N_4O_2S$	13·4	13·45
10	194—195	$C_{20}H_{14}ClN_3O_2S$	10·5	10·6
11	246—247	$C_{20}H_{14}BrN_3O_2S$	9·6	9·55
12	304—305	$C_{21}H_{15}N_3O_4S$	10·1	10·4
13	231—232	$C_{22}H_{17}N_3O_4S$	9·9	10·0
14	>370	$C_{24}H_{20}N_4O_2$	14·3	14·1
15	272—273	$C_{34}H_{24}N_4O_2$	10·8	10·8
16	296—297	$C_{20}H_{16}N_4O_4S_2$	12·5	12·7
17	218—219	$C_{22}H_{12}N_4$	16·7	16·9
18	332—333	$C_{22}H_{14}N_2O_4$	7·75	7·6
19	229—230	$C_{24}H_{18}N_2O_4$	7·0	7·0
20	329—330	$C_{22}H_{16}N_4O_2$	15·1	15·2
21	131—132	$C_{22}H_{16}N_4O_2$	14·5	14·7
22	161—162	$C_{20}H_{12}ClN_3O_2$	11·65	11·6
23	184—185	$C_{20}H_{12}BrN_3O_2$	10·35	10·35
24	290—291	$C_{21}H_{13}N_3O_4$	11·4	11·3
25	172—173	$C_{22}H_{15}N_3O_4$	11·0	10·9
26	253—254			
27	254—255	$C_{22}H_{16}BrN_3O$	10·0	10·05
28	182—183	$C_{20}H_{12}BrClN_3$	7·2	7·1

added for sparingly soluble compounds: (a) The oxazole was refluxed with a M-solution of bromine in acetic acid (50 c.c.) and water (5 c.c.) for 1 hr. (b) The procedure as in (a) was used but with the addition of crystalline sodium acetate (10 g.). (c) The procedure as in (b) was used (>1 mol. of bromine), but the mixture was left at room temperature for 24 hr. (not heated) and then poured into water, any unchanged bromine being destroyed by addition of sodium sulphite. After completion of the reaction, most of the solvent was removed under diminished pressure. In nearly all cases the yield of benzil was almost quantitative.

The *products* are listed in Tables 1 and 2.

For characterisation, the benzils were converted into a quinoxaline by refluxing them (0·001 mole) with *o*-phenylenediamine (120 mg.) in acetic acid (15 c.c.) for 2 hr. The solution was then filtered hot, water added to the boiling solution till it was just cloudy, and the solution allowed to cool; the pure, crystalline quinoxaline separated.

4-*Acetamido*-, m. p. 360° (Found: N, 4·3. $C_9H_7Br_2NO_3$ requires N, 4·2%), and 4-*benzamido*-3,5-*dibromobenzoic acid*, m. p. 264—265° (Found: C, 42·3; H, 2·3; N, 3·5. $C_{14}H_9Br_2NO_3$ requires C, 42·1; H, 2·3; N, 3·5%), were obtained by oxidation of the corresponding benzil by hydrogen peroxide in acetic acid.

4-*Amino*-4′-*sulphamoylbenzil*, m. p. 193—194° (Found: N, 9·0. $C_{14}H_{12}N_2O_4S$ requires N, 9·2%) [*hydrochloride*, m. p. 201—202° (decomp.) (Found: N, 8·4. $C_{14}H_{12}N_2O_4S$,HCl requires N, 8·2%)], 4-*amino*-4′-*nitrobenzil* (4·0 g., 92%), m. p. 92—93° (Found: N, 10·5. $C_{14}H_{10}N_2O_4$ requires N, 10·4%) [*dichloroacetyl derivative*, m. p. 164—165° (Found: N, 7·65. $C_{16}H_{10}Cl_2N_2O_5$ requires N, 7·35%)], and 4-*amino*-4′-*bromobenzil* (4·0 g., 90%), m. p. 129—130° (Found: N, 4·5. $C_{14}H_{10}BrNO_2$ requires N, 4·6%), were obtained by hydrolysis of the corresponding acetamidobenzils with aqueous-alcoholic hydrogen chloride.

Of the oxazoles examined, the 5-*p*-hydroxyphenyl-4-*p*-nitrophenyl compound alone did not form a benzil on oxidation with bromine. By procedure (a) a product was obtained which appears from its analysis to be 5-(3,5-*dibromo*-4-*hydroxyphenyl*)-2-*methyl*-4-p-*nitrophenyloxazole* (6 g., 73%), m. p. 234—235° (Found: C, 42·0; H, 2·4; N, 6·2. $C_{16}H_{10}Br_2N_2O_4$ requires C, 42·3; H, 2·3; N, 6·2%).

4,4′-Dicyano-, -dicarboxy-, and -dicarbamoyl-benzil were also prepared in good yield from the corresponding deoxybenzoins by oxidation with selenium dioxide; the compound (1 g.),

TABLE 2.

Bromobenzils and derived quinoxalines.

			Substituents							Benzils					Quinoxalines			
										Found (%)				Required (%)				
No.	Method	Yield (%)	3	4	5	3′	4′	5′	M. p.	C	H	N	Formula	C	H	N	M. p.	Found N (%)	Formula	Reqd. N (%)
1	a	88	Br	NH_2	Br	H	H	H	165—166°	43·7	2·4	3·7	$C_{14}H_9Br_2NO_2$	43·9	2·35	3·7	130—131°	9·3	$C_{20}H_{13}Br_2N_3$	9·2
2	b	81	Br	NHAc	Br	H	H	H	230—231	45·5	2·65	3·4	$C_{16}H_{11}Br_2NO_3$	45·2	2·6	3·3	217—218	8·6	$C_{22}H_{15}Br_2N_3O$	8·45
3	b	95	Br	NHBz	Br	H	H	H	180—181			3·1	$C_{21}H_{13}Br_2NO_3$			2·9	207—208	7·5	$C_{27}H_{17}Br_2N_3O$	7·5
4	a	92	Br	OH	Br	H	H	H	167—168	44·0	2·2		$C_{14}H_8Br_2O_3$	43·75	2·1		208—209	6·4	$C_{20}H_{12}Br_2N_2O$	6·1
5	b	94	H	OBz	H	H	H	H	109—110	76·5	4·4		$C_{21}H_{14}O_4$	76·4	4·2		166—167	7·0	$C_{27}H_{18}N_2O_2$	7·0
6	a	92	Br	NH_2	Br	H	$SO_2{\cdot}NH_2$	H	240—241			6·2	$C_{14}H_{10}Br_2N_2O_4S$			6·1	279—280	10·4	$C_{20}H_{14}Br_2N_4O_2S$	10·5
7	b	80	Br	NHAc	Br	H	$SO_2{\cdot}NH_2$	H	223—224			5·7	$C_{16}H_{12}Br_2N_2O_5S$			5·6	245—246	9·6	$C_{22}H_{16}Br_2N_4O_3S$	9·7
8	a	86	Br	OH	Br	H	$SO_2{\cdot}NH_2$	H	241—242			3·1	$C_{14}H_9Br_2NO_5S$			3·0	225—226	7·8	$C_{20}H_{13}Br_2N_3O_3S$	7·85
9	a	94	Br	NH_2	Br	Br	NH_2	Br	355—356			4·8	$C_{14}H_8Br_4N_2O_2$			5·0	202—203	8·8	$C_{20}H_{12}Br_4N_4$	8·9
10	b	56	Br	NHAc	Br	Br	NHAc	H	293—294	38·7	2·4	5·0	$C_{18}H_{13}Br_3N_2O_4$	38·5	2·3	5·0	260—261	9·0	$C_{24}H_{17}Br_3N_4O_2$	8·8
11	b	97	Br	NHBz	Br	Br	NHBz	H	250—251			4·2	$C_{28}H_{17}Br_3N_2O_4$			4·1	261—262	7·3	$C_{34}H_{21}Br_3N_4O_2$	7·4
12	a	90	Br	OH	Br	Br	OH	Br	301—302 *								227—228	4·4	$C_{20}H_{10}Br_4N_2O_2$	4·4
13	b	95	H	OBz	H	H	OBz	H	164—165	74·5	4·1		$C_{28}H_{18}O_6$	74·7	4·0		186—187	5·4	$C_{34}H_{22}N_2O_4$	5·5
—	b		H	OAc	H	H	OAc	H	85—86 †			6·5	$C_{14}H_6Br_2N_2O_4$			6·5				
—	a	81	Br	OMe	H	Br	OMe	H	219—220 ‡	40·9	2·3	6·1	$C_{16}H_{10}Br_2N_2O_5$	40·85	2·1	6·0	217—218	10·6	$C_{22}H_{14}Br_2N_4O_3$	10·5
14	a	86	Br	NH_2	Br	H	NO_2	H	230—231			3·4	$C_{14}H_8Br_2ClNO_2$			3·35	176—177	8·4	$C_{20}H_{12}Br_2ClN_3$	8·6
15	b	93	Br	NHAc	Br	H	NO_2	H	241—242			3·05	$C_{14}H_8Br_3NO_2$			3·05	184—185	7·9	$C_{20}H_{12}Br_3N_3$	7·9
16	a	82	Br	NH_2	Br	H	Cl	H	221—222											
17	a	97	Br	NH_2	Br	H	Br	H	233—234											

* Knobloch and Schraufstätter, *Chem. Ber.*, 1948, **81**, 224. † Vanderlinde, Vasington, and Westfeld, *J. Amer. Chem. Soc.*, 1955, **77**, 4178. ‡ van Alphen, *Rec. Trav. chim.*, 1929, **48**, 1113.

acetic acid (15 c.c.), and selenium dioxide (0·3 g.) were refluxed together for 3 hr., the solvent was removed from the filtered solution, and the residue crystallised.

4,4′-*Dicarbamoyldeoxybenzoin*.—4,4′-Dicyanodeoxybenzoin and polyphosphoric acid (75 g.) were heated at 110—120° for 1·5 hr.; water (100 c.c.) was added; the precipitated *diamide* (5·5 g., 96%), crystallised from acetic acid, had m. p. 290—291° (Found: N, 9·8. $C_{16}H_{14}N_2O_3$ requires N, 9·9%).

Reaction of 2-*Methyl*-4,5-*diphenyloxazole with Other Oxidising Agents*.—Benzil was obtained from this oxazole (3 g.) in the yield stated by use of the following reagents: (i) Chlorine, bubbled through the cooled solution in concentrated hydrochloric acid (25 c.c.) for 20 min., and storage for 1 hr.; 97%. (ii) Potassium bromate (4 g.) in refluxing acetic acid (25 c.c.) and water (10 c.c.) for 1 r.; 63%. (iii) Potassium iodate (3 g.) in boiling acetic acid (25 c.c.), water (10 c.c.), and concentrated sulphuric acid (1 c.c.) for 1 hr.; 93%. (iv) *N*-Bromosuccinimide (2·5 g.) in boiling acetic acid (25 c.c.) and water (10 c.c.) for 1 hr. (or storage overnight at room temperature); 97%. (v) t-Butyl hypochlorite (1·5 c.c.) in methanol (25 c.c.) and water (25 c.c.) at room temperature for 2 days; 43%. (vi) Chloramine-T (3·3 g.) in boiling acetic acid (25

c.c.) and water (10 c.c.) for 1 hr. or overnight at room temperature; 97%. (vii) Nitric acid (*d* 1·5; 5 c.c.) in acetic acid (15 c.c.) on the water-bath for 1 hr; 91%. (viii) Ferric or cupric nitrate (4 g.) in boiling acetic acid (25 c.c.) and water (10 c.c.) for 3 hr.; 75%.

Oxidation of 4,5-Diphenyloxazoles and Similar Compounds.—The following compounds were oxidised to the corresponding benzil in high yield by bromine (2 c.c.) in acetic acid (40 c.c.) and water (5 c.c.) under reflux for 1 hr. (unless otherwise stated): 4,5-Diphenyl-, 5-*p*-nitrophenyl-4-phenyl-, 4,5-di-*p*-nitrophenyl-, 4,5-di-*p*-sulphamoylphenyl-, 4,5-di-*p*-nitrophenyl-2-phenyl-, 2,4,5-tri-*p*-nitrophenyl-, and 2-*p*-nitrophenyl-4,5-diphenyl-oxazole [procedure (b) was used in the last three cases; compounds containing a 2-phenyl substituent gave also the corresponding benzoic acid, which was removed at the end of the reaction by adding aqueous ammonia after removal of the solvent]; 4,5-diphenyl- (2 hr.), 4,5-di-*p*-sulphamoylphenyl- (2 hr.), and 4,5-*di*-p-*bromophenyl-oxazolone* (m. p. 216—218°) (Found: N, 3·7. $C_{15}H_9Br_2NO_2$ requires N, 3·5%); 2-methyl-4-*p*-nitrophenyl-5-phenyl-, 2-methyl-4,5-di-*p*-nitrophenyl-, 4,5-di-*p*-nitrophenyl-, and 4,5-di-*p*-sulphamoylphenyl-imidazole.

Reaction between 2-Methyl-4,5-diphenyloxazole and Bromine in Glacial Acetic Acid.—(i) The oxazole (2·35 g., 0·01 mole) was refluxed with "AnalaR" acetic acid (10 c.c.) and a M-solution of bromine in "AnalaR" acetic acid (10 c.c.) for 1 hr.; hydrogen bromide was evolved copiously. The solvent was removed under diminished pressure and on addition of water the oxazole was recovered with a trace of benzil (detected as the osazone). (ii) The above experiment was repeated with acetic acid (20 c.c.) and bromine (10 c.c., added portionwise) and refluxing until all the bromine had been consumed; this required ~3 hr., during which hydrogen bromide was freely evolved. Pouring the mixture into water regenerated almost all the oxazole. (iii) Experiment (ii) was repeated but, after refluxing, the mixture was fractionally distilled, the fraction boiling at 195—205°/620 mm. being collected; this solidified and proved to be bromoacetic acid (*p*-nitrobenzyl ester, m. p. 88°). Practically all the oxazole was recovered from the residue.

(iv) Experiment (i) was repeated with the addition of various amounts of water, the benzil formed being isolated as described previously; the following results were obtained:

Water added (10^{-2} mole) ...	2·8	4·2	5·6	7·0	8·3	9·7	11·1	12·5
Yield (%) of benzil	29	43	52	60	64	71	76	81
Water added (10^{-2} mole) ...	13·9	15·3	16·7	19·4	22·2	27·8	33·4	
Yield (%) of benzil	86	90	93	95	95	95	95	

(v) Experiment (iv) was repeated with the addition of anhydrous sodium acetate (4 g.); the mixture was set aside overnight at room temperature, then poured into water, the following results being obtained:

Water added (10^{-2} mole)	0	0·56	0·83	1·11	1·39	1·67	1·94	2·22	2·78	5·56
Yield (%) of benzil	—	24	38	50	67	81	88	100	100	100

Reduction of Some Benzils to Benzoins.—The benzil, alcohol (150 c.c.), water (50 c.c.), and sodium dithionite (15 g.) were refluxed for 30 min.; most of the solvent was removed under diminished pressure and the benzoin which separated was washed with water and recrystallised; yield quantitative. *Products* are listed in Table 3. The constitution was established by periodate oxidation,[10] as follows: The benzoin (0·04 mole), sodium periodate (0·04 mole), alcohol (500 c.c.), and 2N-sulphuric acid (50 c.c.) were set aside at room temperature for 24 hr. The solution was neutralised with aqueous ammonia, and semicarbazide hydrochloride (0·3 g.) and sodium acetate (1 g.) in water (25 c.c.) were added. The mixture was set aside for 2 hr., the solvent then distilled off, and the residue made faintly alkaline by sodium carbonate. The semicarbazone was filtered off and the filtrate acidified, the corresponding benzoic acid then separating. The acids and aldehydes obtained are included in Table 3.

When the above reduction was applied to 4-nitrobenzil [with the addition of a second amount (15 g.) of sodium dithionite after 15 minutes' refluxing, with further refluxing for 30 min.], 4-*aminobenzoin* was formed (0·8 g., 18%); this amine was obtained in almost quantitative yield by reduction of 4-acetamidobenzil, followed by acid hydrolysis.

4,4′-*Di*-p-*sulphamoylhydrobenzoin.*—Reduction of 4,4′-di-*p*-sulphamoylbenzil by the above procedure yielded the corresponding *hydrobenzoin* (4·5 g., 90%), m. p. 273—274° (Found: N, 7·5. $C_{14}H_{16}N_2O_6S_2$ requires N, 7·5%). The same product was obtained when the benzil (1 g.), propan-2-ol (50 c.c.), and sodium borohydride (0·3 g.) were stirred for 5 hr., the solvent removed

TABLE 3.

Benzions.

Substituents					Found		Reqd.	Degradn. products	
3	4	5	4′	M. p.	N (%)	Formula	N (%)	A	B
H	NHAc	H	H	157—158° §				NHAc	H
H	NH_2	H	H	203—204	6·1	$C_{14}H_{13}NO_2$	6·2		
Br	NH_2	Br	H	161—162	3·7	$C_{14}H_{11}Br_2NO_2$	3·6	X	H
H	NHAc	H	Cl	149—150 §				NHAc	Cl
Br	NH_2	Br	Cl	136—137	3·4	$C_{14}H_{10}Br_2ClNO_2$	3·3	X	Cl
H	NHAc	H	Br	144—145	4·0	$C_{16}H_{14}BrNO_3$	4·0	NHAc	Br
Br	NH_2	Br	Br	133—144	3·1	$C_{14}H_{10}Br_3NO_2$	3·0	X	Br
H	NHAc	H	$SO_2{\cdot}NH_2$	191—192	8·2	$C_{16}H_{16}N_2O_5S$	8·0	NHAc	$SO_2{\cdot}NH_2$
Br	NH_2	Br	$SO_2{\cdot}NH_2$	215—216	6·2	$C_{14}H_{12}Br_2N_2O_4S$	6·0	X	$SO_2{\cdot}NH_2$
H	H	H	$SO_2{\cdot}NH_2$	164—165	4·9	$C_{14}H_{13}NO_4S$	4·8	H	$SO_2{\cdot}NH_2$
H	Cl	H	$SO_2{\cdot}NH_2$	178—179	4·4	$C_{14}H_{12}ClNO_4S$	4·3	Cl	$SO_2{\cdot}NH_2$
H	Br	H	$SO_2{\cdot}NH_2$	165—166	3·75	$C_{14}H_{12}BrNO_4S$	3·8	Br	$SO_2{\cdot}NH_2$
Br	OH	Br	$SO_2{\cdot}NH_2$	253—254	3·0	$C_{14}H_{11}Br_2NO_5S$	3·0	Y	$SO_2{\cdot}NH_2$
Br	OH	Br	H	125—126		$C_{14}H_{10}Br_2O_3$ *		Y	H
H	Br	H	Cl	77—78		$C_{14}H_{10}BrClO_2$ †		Br	Cl
H	H	H	Br	123—124 ¶				H	Br
H	H	H	Cl	114—115 ¶				H	Cl
H	Br	H	Br	99—100		$C_{14}H_{10}Br_2O_2$ ‡			

A = *p*-Substituent in benzoic acid. B = *p*-Substituent in benzaldehyde. X = 3,5-Br_2-4-NH_2; Y = 3,5-Br_2-4-OH.

* Found: C, 43·7; H, 2·7. Required: C, 43·5; H, 2·6%. † Found: C, 51·7; H, 3·3. Required: C, 51·6; H, 3·1%. ‡ Found: C, 45·5; H, 2·8. Required: C, 45·4; H, 2·7%. § Ref. 10. ¶ Ref. *a* of Table 1.

and the residue crystallised from alcohol (yield, 0·35 g., 34%). Infrared examination of the product showed strong hydroxyl absorption at 3300—3400 cm.$^{-1}$, the carbonyl peak being absent.

UNIVERSITY OF THE WITWATERSRAND,
JOHANNESBURG, SOUTH AFRICA.

[*Received, May 31st*, 1962.]