

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

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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 benzoin 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 reported¹ to have prepared benzil derivatives having high antibacterial activity, and there have been other similar claims² (but compare Finkelstein and Linder³). 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 Jourdan⁵ or Dilthey and Scheidt⁶ 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.

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 benzoin was established by periodate oxidation¹⁰ 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 I.
(A) Benzils.

No.	Method	4,4'-Subst.		M. p.	Found (%)			Formula	Required (%)		
					C	H	N		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 ₉ NO ₂		6.0	
6	a	H	CO ₂ H	227—228	70.7	4.1	—	C ₁₅ H ₁₀ O ₄	70.9	3.9	—
	b	H	CO ₂ Me	65—66	71.45	4.7	—	C ₁₆ H ₁₂ O ₄	71.6	4.5	—
7	a	H	SO ₂ ·NH ₂	151—152	58.0	4.0	4.95	C ₁₄ H ₁₁ NO ₄ S	58.1	3.8	4.8
8	a	SO ₂ ·NH ₂	NO ₂	224—225	50.2	3.1	8.4	C ₁₄ H ₁₀ N ₂ O ₆ S	50.3	3.0	8.4
9	c	SO ₂ ·NH ₂	NHAc	228—229			8.2	C ₁₆ H ₁₄ N ₂ O ₅ S			8.2
10	a	SO ₂ ·NH ₂	Cl	225—226			4.5	C ₁₄ H ₁₀ ClNO ₄ S			4.3
11	a	SO ₂ ·NH ₂	Br	244—245			3.8	C ₁₄ H ₁₀ BrNO ₄ S			3.8
	b	SO ₂ ·NH ₂	CN	194—195			8.9	C ₁₅ H ₁₀ N ₂ O ₄ S			8.9
12	a	SO ₂ ·NH ₂	CO ₂ H	281—282			4.25	C ₁₆ H ₁₁ NO ₆ S			4.2
13	b	SO ₂ ·NH ₂	CO ₂ Me	211—212			4.2	C ₁₆ H ₁₃ NO ₆ S			4.0
14	c	NHAc	NHAc ^b	251—252							
15	c	NHBz	NHBz	281—282			6.1	C ₂₈ H ₂₀ N ₂ O ₄			6.25
16	a	SO ₂ ·NH ₂	SO ₂ ·NH ₂	257—258 ^f			7.6	C ₁₄ H ₁₂ N ₂ O ₆ S 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 ₈ N ₂ O ₂			10.8
18	a	CO ₂ H	CO ₂ H †	324—325	64.6	3.4	—	C ₁₆ H ₁₀ O ₆	64.6	3.4	—
19	b	CO ₂ Me	CO ₂ Me	196—197	66.4	4.4	—	C ₁₆ H ₁₄ O ₆	66.3	4.3	—
20	b	CO·NH ₂	CO·NH ₂ †	311—312			9.8	C ₁₆ H ₁₂ N ₂ O ₄			9.5
21	c	NO ₂	NHAc	192—193			9.05	C ₁₆ H ₁₂ N ₂ O ₅			9.0
22	a	NO ₂	Cl	199—200			4.9	C ₁₄ H ₈ ClNO ₄			4.8
23	a	NO ₂	Br	228—229			4.15	C ₁₄ H ₈ BrNO ₄			4.2
	b	NO ₂	CN	187—188			9.8	C ₁₅ H ₉ N ₂ O ₄			10.0
24	a	NO ₂	CO ₂ H	330—331			4.6	C ₁₅ H ₉ NO ₆			4.7
25	b	NO ₂	CO ₂ Me	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 ₈ BrClO 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 deoxybenzoin.

^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 I. (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 ₁₆ N ₃ O	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 ₂ O ₂	8.8	8.6
7	250—251	C ₂₀ H ₁₅ N ₃ O ₂ S	11.5	11.6
8	279—280	C ₂₀ H ₁₄ N ₄ O ₄ S	13.7	13.8
9	313—314	C ₂₂ H ₁₈ N ₄ O ₃ S	13.4	13.45
10	194—195	C ₂₀ H ₁₄ ClN ₃ O ₂ S	10.5	10.6
11	246—247	C ₂₀ H ₁₄ BrN ₃ O ₂ S	9.6	9.55
12	304—305	C ₂₁ H ₁₅ N ₃ O ₄ S	10.1	10.4
13	231—232	C ₂₂ H ₁₇ N ₃ O ₄ S	9.9	10.0
14	>370	C ₂₄ H ₂₀ N ₄ O ₂	14.3	14.1
15	272—273	C ₃₄ H ₂₄ N ₄ O ₂	10.8	10.8
16	296—297	C ₂₀ H ₁₆ N ₄ O ₄ S 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 ₂ O ₄	7.75	7.6
19	229—230	C ₂₄ H ₁₈ N ₂ O ₄	7.0	7.0
20	329—330	C ₂₂ H ₁₆ N ₄ O ₂	15.1	15.2
21	131—132	C ₂₂ H ₁₆ N ₄ O ₃	14.5	14.7
22	161—162	C ₂₀ H ₁₉ ClN ₃ O ₂	11.65	11.6
23	184—185	C ₂₀ H ₁₂ BrN ₃ O ₂	10.35	10.35
24	290—291	C ₂₁ H ₁₃ N ₃ O ₄	11.4	11.3
25	172—173	C ₂₂ H ₁₅ N ₃ O ₄	11.0	10.9
26	253—254			
27	254—255	C ₂₂ H ₁₆ BrN ₃ O	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. C₉H₇Br₂NO₃ 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. C₁₄H₉Br₂NO₃ 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. C₁₄H₁₂N₂O₄S requires N, 9.2%) [hydrochloride, m. p. 201—202° (decomp.) (Found: N, 8.4. C₁₄H₁₂N₂O₄S.HCl requires N, 8.2%)], 4-amino-4'-nitrobenzil (4.0 g., 92%), m. p. 92—93° (Found: N, 10.5. C₁₄H₁₀N₂O₄ requires N, 10.4%), [dichloroacetyl derivative, m. p. 164—165° (Found: N, 7.65. C₁₆H₁₀Cl₂N₂O₅ requires N, 7.35%)], and 4-amino-4'-bromobenzil (4.0 g., 90%), m. p. 129—130° (Found: N, 4.5. C₁₄H₁₀BrNO₂ 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. C₁₈H₁₀Br₂N₂O₄ 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 deoxybenzoin by oxidation with selenium dioxide; the compound (1 g.),

TABLE 2.

Bromobenzils and derived quinoxalines.

No.	Method	Yield (%)	Substituents					M. p.	
			3	4	5	3'	4'		5'
1	a	88	Br	NH ₂	Br	H	H	H	165—166°
2	b	81	Br	NHAc	Br	H	H	H	230—231
3	b	95	Br	NHBz	Br	H	H	H	180—181
4	a	92	Br	OH	Br	H	H	H	167—168
5	b	94	H	OBz	H	H	H	H	109—110
6	a	92	Br	NH ₂	Br	H	SO ₂ ·NH ₂	H	240—241
7	b	80	Br	NHAc	Br	H	SO ₂ ·NH ₂	H	223—224
8	a	86	Br	OH	Br	H	SO ₂ ·NH ₂	H	241—242
9	a	94	Br	NH ₂	Br	Br	NH ₂	Br	355—356
10	b	56	Br	NHAc	Br	Br	NHAc	H	293—294
11	b	97	Br	NHBz	Br	Br	NHBz	H	250—251
12	a	90	Br	OH	Br	Br	OH	Br	301—302*
13	b	95	H	OBz	H	H	OBz	H	164—165
—	b	—	H	OAc	H	H	OAc	H	85—86 †
—	a	81	Br	OMe	H	Br	OMe	H	219—220 ‡
14	a	86	Br	NH ₂	Br	H	NO ₂	H	230—231
15	b	93	Br	NHAc	Br	H	NO ₂	H	241—242
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.

No.	Benzils							Quinoxalines			
	Found (%)			Formula	Required (%)			M. p.	Found N (%)	Formula	Reqd. N (%)
C	H	N	C		H	N					
1	43.7	2.4	3.7	C ₁₄ H ₉ Br ₂ NO ₂	43.9	2.35	3.7	130—131°	9.3	C ₂₀ H ₁₃ Br ₂ N ₃	9.2
2	45.5	2.65	3.4	C ₁₆ H ₁₁ Br ₂ NO ₃	45.2	2.6	3.3	217—218	8.6	C ₂₂ H ₁₅ Br ₂ N ₃ O	8.45
3			3.1	C ₂₁ H ₁₃ Br ₂ NO ₃			2.9	207—208	7.5	C ₂₇ H ₁₇ Br ₂ N ₃ O	7.5
4	44.0	2.2		C ₁₄ H ₈ Br ₂ O ₃	43.75	2.1		208—209	6.4	C ₂₀ H ₁₂ Br ₂ N ₂ O	6.1
5	76.5	4.4		C ₂₁ H ₁₄ O ₄	76.4	4.2		166—167	7.0	C ₂₇ H ₁₈ N ₂ O ₂	7.0
6			6.2	C ₁₄ H ₁₀ Br ₂ N ₂ O ₄ S			6.1	279—280	10.4	C ₂₀ H ₁₄ Br ₂ N ₄ O ₂ S	10.5
7			5.7	C ₁₆ H ₁₂ Br ₂ N ₂ O ₅ S			5.6	245—246	9.6	C ₂₂ H ₁₆ Br ₂ N ₄ O ₃ S	9.7
8			3.1	C ₁₄ H ₉ Br ₂ NO ₃ S			3.0	225—226	7.8	C ₂₀ H ₁₃ Br ₂ N ₃ O ₃ S	7.85
9			4.8	C ₁₄ H ₈ Br ₄ N ₂ O ₂			5.0	202—203	8.8	C ₂₀ H ₁₂ Br ₄ N ₄	8.9
10	38.7	2.4	5.0	C ₁₈ H ₁₃ Br ₃ N ₂ O ₄	38.5	2.3	5.0	260—261	9.0	C ₂₄ H ₁₇ Br ₃ N ₄ O ₂	8.8
11			4.2	C ₂₈ H ₁₇ Br ₃ N ₂ O ₄			4.1	261—262	7.3	C ₃₄ H ₂₁ Br ₃ N ₄ O ₂	7.4
12								227—228	4.4	C ₂₀ H ₁₀ Br ₄ N ₂ O ₂	4.4
13	74.5	4.1		C ₂₈ H ₁₈ O ₆	74.7	4.0		186—187	5.4	C ₃₄ H ₂₂ N ₂ O ₄	5.5
14			6.5	C ₁₄ H ₈ Br ₂ N ₂ O ₄			6.5				
15	40.9	2.3	6.1	C ₁₆ H ₁₀ Br ₂ N ₂ O ₅	40.85	2.1	6.0	217—218	10.6	C ₂₂ H ₁₄ Br ₂ N ₄ O ₃	10.5
16			3.4	C ₁₄ H ₈ Br ₂ ClNO ₂			3.35	176—177	8.4	C ₂₀ H ₁₂ Br ₂ ClN ₃	8.6
17			3.05	C ₁₄ H ₈ Br ₃ NO ₂			3.05	184—185	7.9	C ₂₀ H ₁₂ Br ₃ N ₃	7.9

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. C₁₆H₁₄N₂O₃ 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 hr.; 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. C₁₅H₉Br₂NO₂ 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 portion-wise) 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 Benzoin.—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 2*N*-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. C₁₄H₁₆N₂O₆S₂ 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.

Substituents					M. p.	Benzions.		Degradn. products	
3	4	5	4'	Found N (%)		Formula	Reqd. 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 ₂ NO 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 ₂ ClNO 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 ₂ NO ₂	3.0	X	Br
H	NHAc	H	SO ₂ ·NH ₂	191—192	8.2	C ₁₆ H ₁₆ N ₂ O ₅ S	8.0	NHAc	SO ₂ ·NH ₂
Br	NH ₂	Br	SO ₂ ·NH ₂	215—216	6.2	C ₁₄ H ₁₂ Br ₂ N ₂ O ₄ S	6.0	X	SO ₂ ·NH ₂
H	H	H	SO ₂ ·NH ₂	164—165	4.9	C ₁₄ H ₁₃ NO ₄ S	4.8	H	SO ₂ ·NH ₂
H	Cl	H	SO ₂ ·NH ₂	178—179	4.4	C ₁₄ H ₁₂ ClNO ₄ S	4.3	Cl	SO ₂ ·NH ₂
H	Br	H	SO ₂ ·NH ₂	165—166	3.75	C ₁₄ H ₁₂ BrNO ₄ S	3.8	Br	SO ₂ ·NH ₂
Br	OH	Br	SO ₂ ·NH ₂	253—254	3.0	C ₁₄ H ₁₁ Br ₂ NO ₅ S	3.0	Y	SO ₂ ·NH ₂
Br	OH	Br	H	125—126		C ₁₄ H ₁₀ Br ₂ O 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 ₂ O ₂ ‡			

A = *p*-Substituent in benzoic acid. B = *p*-Substituent in benzaldehyde. X = 3,5-Br₂-4-NH₂; Y = 3,5-Br₂-4-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.

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