

### 69. *Heterocyclic Compounds of Nitrogen. Part III.*<sup>1</sup> *The Synthesis of Some 2'-Indolylbenzoquinones.*

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2-(2,5-Dihydroxyphenyl)indole and three 2-(3,4-dihydroxyphenyl)indoles have been prepared and oxidised to the corresponding quinones. The absorption spectra of these compounds are discussed.

SYNTHESES of several 3-arylindoles and of 3'-indolyl-1,4- and 4-3'-indolyl-1,2-benzoquinone were reported in Part II.<sup>1</sup> The present paper describes the preparation of some isomers of these in which the aryl or quinonoid group is attached to the 2-position of the indole nucleus.

The 2-arylindoles listed in Table 1 were synthesised by Fischer's method from appropriate phenylhydrazones. 2,3-Dimethoxyacetophenone was prepared by treatment of 2,3-dimethoxybenzoic acid with methyl-lithium, and 4,5-dihydroxy-2-methylacetophenone from 3,4-diacetoxytoluene by the Fries rearrangement. The other ketones were prepared by previously described methods. Phenylhydrazones of dimethoxyphenyl ketones were cyclised with polyphosphoric acid,<sup>2</sup> but, with the exception of 4,5-dihydroxy-2-methylacetophenone phenylhydrazone, this reagent gave very poor yields when applied to the dihydroxy-compounds, and in these cases superior results were obtained with 88—90% phosphoric acid.

The main features of the ultraviolet absorption spectra of the 2-arylindoles are shown in Table 1. Compared with those of 3-arylindoles,<sup>1</sup> an extra maximum appears at 241—249 m $\mu$ , and, because the 2-aryl group is conjugated with the benzenoid nucleus of the indole moiety, the longer-wavelength absorption is shifted from 262—272 to 302—320 m $\mu$ .

Oxidation of 2-(2,5-dihydroxyphenyl)indole and the three 2-(3,4-dihydroxyphenyl)indoles with silver oxide in dry acetone afforded stable, intensely coloured quinones,

<sup>1</sup> Part II, Bruce, *J.*, 1959, 2366.

<sup>2</sup> Kissman, Farnsworth, and Witkop, *J. Amer. Chem. Soc.*, 1952, **74**, 3948.

TABLE 1. Absorption spectra of substituted 2-phenylindoles, in dioxan, in the region 215—350 m $\mu$ .

Subst. in 2-phenyl group	$\lambda_{\text{min.}}$		$\lambda_{\text{max.}}$		$\lambda_{\text{min.}}$		$\lambda_{\text{max.}}$	
	m $\mu$	log $\epsilon$	m $\mu$ *	log $\epsilon$	m $\mu$	log $\epsilon$	m $\mu$	log $\epsilon$
None	223	4.29	224.5	4.30	241	4.25	268	3.54
2,5-(OMe) <sub>2</sub>	—	—	222	4.56	241	4.22	{ 268.5 309 }	{ 3.58 4.14 }
2,3-(OMe) <sub>2</sub>	—	—	224.5	4.54	(240)	4.32	268.5	3.48
3,4-(OMe) <sub>2</sub>	219	4.52	223	4.53	—	—	271	3.65
2,5-(OH) <sub>2</sub>	—	—	222	4.55	240	4.21	{ 266 310 }	{ 3.60 4.09 }
2,3-(OH) <sub>2</sub>	—	—	224.5	4.53	(240)	4.30	268	3.66
3,4-(OH) <sub>2</sub>	—	—	215	4.52	241	4.13	269	3.66
2-Me-4,5-(OH) <sub>2</sub>	—	—	—	—	239	4.18	263.5	3.77
[2-(3,4-Dihydroxyphenyl)-3-methylindole]	—	—	—	—	240.5	4.22	270	3.75

\* Figures in parentheses indicate a pronounced inflexion.

TABLE 2. Absorption spectra of indolylbenzoquinones, in dioxan, in the region 215—600 m $\mu$ .

Benzoquinone	$\lambda_{\text{min.}}$		$\lambda_{\text{max.}}$		$\lambda_{\text{min.}}$		$\lambda_{\text{max.}}$	
	m $\mu$ *	log $\epsilon$	m $\mu$	log $\epsilon$	m $\mu$	log $\epsilon$	m $\mu$	log $\epsilon$
2'-Indolyl-1,4	237.5	4.42	263	4.03	294	4.17	302	4.18
4-2'-Indolyl-1,2	(235)	4.26	255	3.86	287	4.13	(294)	4.10
4-2'-Indolyl-5-methyl-1,2	—	—	253.5	3.83	278	4.07	—	—
4-2'-Indolyl-3'-methyl-1,2	—	—	260	3.81	289	4.04	—	—
3'-Indolyl-1,4	221	4.52	241	4.19	258	4.32	348	2.94
4-3'-Indolyl-1,2	(247)	4.16	270	3.99	286	4.06	323	3.57

\* Figures in parentheses indicate a pronounced inflexion.

TABLE 3. Infrared spectra of indolylbenzoquinones, in Nujol, in the regions 3400—3150 and 1700—1590 cm.<sup>-1</sup>.

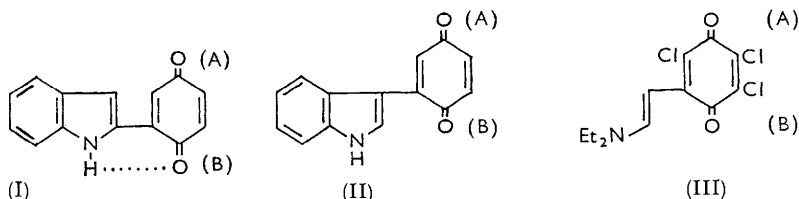
Benzoquinone	$\nu_{\text{max.}}$ (cm. <sup>-1</sup> ) *	
	$\nu_{\text{max.}}$ (cm. <sup>-1</sup> )	$\nu_{\text{max.}}$ (cm. <sup>-1</sup> )
2'-Indolyl-1,4	3354	1688 (w)
4-2'-Indolyl-1,2	3297	—
4-2'-Indolyl-5-methyl-1,2	3314	1678 (m)
4-2'-Indolyl-3'-methyl-1,2	3346	1672 (m)
3'-Indolyl-1,4	3196	1650
4-3'-Indolyl-1,2	3171	(1673) (m)

Benzoquinone	$\nu_{\text{max.}}$ (cm. <sup>-1</sup> ) *	
	$\nu_{\text{max.}}$ (cm. <sup>-1</sup> )	$\nu_{\text{max.}}$ (cm. <sup>-1</sup> )
2'-Indolyl-1,4	1646 (vs)	1614 (m)
4-2'-Indolyl-1,2	1644	1614
4-2'-Indolyl-5-methyl-1,2	1638 (vs)	1613
4-2'-Indolyl-3'-methyl-1,2	1622 (vs)	—
3'-Indolyl-1,4	1644	1604
4-3'-Indolyl-1,2	1632 (m)	1594

\* Absorption is strong unless stated otherwise. Figures in parentheses indicate shoulders.

*e.g.*, (I), but that derived from 2-(2,3-dihydroxyphenyl)indole decomposed before it could be isolated. The ultraviolet and visible absorption spectra of these compounds are given in Table 2, with the corresponding data for two 3'-indolylbenzoquinones.<sup>1</sup> Below 320  $m\mu$ , especially in the *p*-quinone series, the spectra resemble those of the related phenylindole, and in the 300–400  $m\mu$  region are characteristic of the quinonoid moiety, the *p*-quinones showing a pronounced minimum at 348–350  $m\mu$  [*p*-benzoquinone<sup>3,4</sup> absorbs only weakly ( $\log \epsilon < 1.3$ ) above 320  $m\mu$ ] whereas the *o*-quinones have a maximum ( $\log \epsilon$  3.8–3.9) at 353–362  $m\mu$  which resembles that shown by *o*-benzoquinone<sup>4</sup> at 366  $m\mu$  ( $\log \epsilon$  3.37). All the quinones have a pronounced maximum at 487–510  $m\mu$ . A methyl group in the 5- or 3'-position of 4-2'-indolyl-1,2-benzoquinone causes a bathochromic shift, since it is insufficiently bulky to affect appreciably the coplanarity of the rings.



Infrared maxima of the 2'- and 3'-indolylbenzoquinones in the N–H and C=O stretching regions are given in Table 3. The 2'-indolylbenzoquinones have a strong, sharp band between 3297 and 3354  $\text{cm}^{-1}$  due to N–H stretching, and at least one very strong peak between 1613 and 1650  $\text{cm}^{-1}$  which may be assigned to the carbonyl group, *e.g.*, "A" in (I), which is conjugated with the indole nucleus. Comparable figures have been reported<sup>5</sup> for 2-acetyl-3-methylindole and 1,2,3,4-tetrahydro-1-oxocarbazole (N–H, 3311, 3247  $\text{cm}^{-1}$ , and C=O, 1631, 1629  $\text{cm}^{-1}$  respectively). The *o*-quinones also have a strong or medium band between 1672 and 1679  $\text{cm}^{-1}$  which, since simple *o*-benzoquinones absorb<sup>6</sup> at 1657–1669  $\text{cm}^{-1}$ , is attributable to the less conjugated carbonyl group "B" [as in (I)]. The absence of a similar band in the spectrum of 2'-indolyl-1,4-benzoquinone is probably due to intramolecular hydrogen bonding, which lowers the carbonyl frequency sufficiently for the absorption to merge with that at 1646  $\text{cm}^{-1}$ , but a corresponding decrease in the N–H stretching frequency does not occur. Analogously, intramolecular hydrogen bonding in methyl *N*-methylantranilate<sup>7</sup> lowers the carbonyl frequency from the normal ester value of *ca.* 1730 to 1685  $\text{cm}^{-1}$ , but the N–H absorption (3361  $\text{cm}^{-1}$ ) is not appreciably different from that observed in intermolecular hydrogen bonding.

The N–H absorptions of 3'-indolyl-1,4- and 4-3'-indolyl-1,2-benzoquinone appear as broad (30–40  $\text{cm}^{-1}$ ) bands at 3196 and 3171  $\text{cm}^{-1}$  respectively. Peaks at 1604 and 1594  $\text{cm}^{-1}$  are probably due to the carbonyl groups, *e.g.*, "A" in (II), which are conjugated with the indole nitrogen atom, since simple 3-acylindoles show<sup>5,8</sup> a carbonyl band between 1592 and 1631  $\text{cm}^{-1}$  (the N–H absorption occurs between 3134 and 3220  $\text{cm}^{-1}$ ). The less intense peaks at 1670 and 1674  $\text{cm}^{-1}$  correspond to those shown in this region by the 4-2'-indolyl-1,2-benzoquinones, and at 1670  $\text{cm}^{-1}$  by the aminovinylquinone (III),<sup>9</sup> and may be attributed to the less conjugated carbonyl groups, *e.g.*, "B" in (II). However, these assignments are uncertain since 3'-indolyl-1,4-benzoquinone absorbs strongly at 1644  $\text{cm}^{-1}$ , and a similar, but weaker, peak at *ca.* 1640  $\text{cm}^{-1}$  in the spectrum of the quinone (III) has been attributed<sup>9</sup> to the carbonyl group "A" which is conjugated with the nitrogen atom.

<sup>3</sup> Bakenköhler and Rosenberg, *Ber.*, 1926, **59**, 2617.

<sup>4</sup> Goldschmidt and Graef, *Ber.*, 1928, **61**, 1858.

<sup>5</sup> Ballantine, Barrett, Beer, Boggiano, Eardley, Jennings, and Robertson, *J.*, 1957, 2227.

<sup>6</sup> Josien, Fuson, Lebas, and Gregory, *J. Chem. Phys.*, 1953, **21**, 331; Otting and Staiger, *Chem. Ber.*, 1955, **88**, 828.

<sup>7</sup> Rasmussen and Brattain, *J. Amer. Chem. Soc.*, 1949, **71**, 1073.

<sup>8</sup> Millich and Becker, *J. Org. Chem.*, 1958, **23**, 1096; O'Sullivan and Sadler, *J.*, 1959, 876.

<sup>9</sup> Buckley, Dunstan, and Henbest, *J.*, 1957, 4880; Buckley, Henbest, and Slade, *ibid.*, p. 4891.

## EXPERIMENTAL

Freshly distilled phenylhydrazine was used, and phosphoric acid contained 88—90% of  $\text{H}_3\text{PO}_4$ . Solutions in organic solvents were dried with sodium sulphate. Solvents were removed on the water-bath, where necessary under reduced pressure (water-pump). Light petroleum had b. p. 60—80°. Solids were dried ( $\text{P}_2\text{O}_5$ ) *in vacuo*. "Florisol" was obtained from the Floridin Co. Inc., Warren, Pennsylvania. Sublimation and bulb-to-bulb distillation temperatures are those of the heating-bath. Ultraviolet absorption spectra were measured in purified <sup>10</sup> dioxan in a Perkin-Elmer model 4000 recording spectrophotometer, and infrared spectra, in Nujol, in a Perkin-Elmer model 21 double-beam spectrometer. M. p.s are corrected.

2-Phenylindoles with a methoxyl or hydroxyl substituent in the 2-position of the phenyl group gave a violet-red colour with Ehrlich's reagent. The others gave a red-violet colour. Except for 2-(2,3-dihydroxyphenyl)indole which formed an initially violet solution, all the dihydroxyphenylindoles dissolved in aqueous 5% sodium hydroxide with a yellow colour which became brown in air. The quinones were sparingly soluble in the usual organic solvents.

2-(2,5-Dimethoxyphenyl)indole.—2,5-Dimethoxyacetophenone <sup>11</sup> (0.9 g.), phenylhydrazine (0.54 g.), and polyphosphoric acid, from phosphoric acid (1.3 g.) and phosphoric oxide (1.25 g.), were stirred together and heated to 140°; a vigorous reaction commenced. The internal temperature was held at 180—190° by water-cooling until the reaction subsided, and the mixture was then heated at 180° for 2 min., cooled, and diluted with water (10 c.c.). The suspension was extracted with ether, and the extract was washed successively with water, aqueous 10% sodium hydroxide, and water, and dried. Removal of the solvent, crystallisation of the residue from aqueous ethanol, and distillation (bulb-to-bulb, 195°/5 × 10<sup>-3</sup> mm.) of the product gave an oil which, on being crystallised from aqueous ethanol, afforded the *indole* (0.77 g., 61%) as needles, m. p. 101.5° (Found: C, 75.8; H, 5.9; N, 5.3.  $\text{C}_{16}\text{H}_{15}\text{O}_2\text{N}$  requires C, 75.9; H, 5.9; N, 5.5%).

2-(2,5-Dihydroxyphenyl)indole.—2,5-Dihydroxyacetophenone <sup>12</sup> (0.76 g.) and phenylhydrazine (0.54 g.) were heated together at 100° for 4 hr., phosphoric acid (3.5 c.c.) was added, and the mixture was heated at 100° for 15 min., and then at 175—180° for 7 min. The product was cooled, triturated with water (30 c.c.) until the gum solidified, and the solid was collected, washed with water, and dried. Sublimation at 190°/5 × 10<sup>-3</sup> mm. gave an upper band of 2,5-dihydroxyacetophenone, which was discarded, and a lower band of orange needles from which, by crystallisation from water containing a little sodium hydrogen sulphite, resublimation, and then recrystallisation, the *indole* (0.10 g., 9%) was obtained as plates, m. p. 172.5—173° (Found: C, 74.9; H, 5.2; N, 6.3.  $\text{C}_{14}\text{H}_{11}\text{O}_2\text{N}$  requires C, 74.7; H, 4.9; N, 6.2%).

2'-Indolyl-1,4-benzoquinone.—A solution of the foregoing indole (20 mg.) in dry ( $\text{Na}_2\text{SO}_4$ ) redistilled acetone (20 c.c.) was shaken with a mixture of anhydrous sodium sulphate (0.4 g.) and freshly prepared silver oxide <sup>13</sup> (0.2 g.) for 20 min., the suspension was filtered, and the wine-red filtrate was evaporated at *ca.* 25°/50 mm. to give the *quinone* (18.5 mg., 93%) as a dark red-brown powder, m. p. 180—200° (decomp.) after becoming light brown at 140° and darkening at 170° (Found: C, 75.0; H, 4.0.  $\text{C}_{14}\text{H}_9\text{O}_2\text{N}$  requires C, 75.4; H, 4.1%). The solution in ethanol was violet-red.

2,3-Dimethoxyacetophenone.—A suspension of powdered 2,3-dimethoxybenzoic acid <sup>14</sup> (9.1 g.) in ether (50 c.c.) was added during 15 min. to a vigorously stirred, ice-cooled solution of methyl-lithium [from methyl iodide (36 g.) and lithium wire (4 g.)] in ether (75 c.c.) under oxygen-free nitrogen, and the mixture was then stirred at room temperature for 1 hr., cooled to 0°, and decomposed with water (75 c.c.). The ethereal phase was separated, washed successively with 10% sodium hydroxide, water, 2% hydrochloric acid, and water, and dried. Removal of the solvent, and distillation of the residue afforded the impure ketone (7.92 g., 88%), b. p. 65—66°/0.015 mm. (Found: C, 67.5, 67.6; H, 7.2, 7.3. Calc. for  $\text{C}_{10}\text{H}_{12}\text{O}_3$ : C, 66.7; H, 6.7%).

2-(2,3-Dimethoxyphenyl)indole.—A mixture of 2,3-dimethoxyacetophenone (0.76 g.) and

<sup>10</sup> Vogel, "A Text Book of Practical Organic Chemistry," Longmans, Green and Co., London, 1951, p. 175.

<sup>11</sup> Kuroda and Matsukuma, *Sci. Papers Inst. Phys. Chem. Res., Tokyo*, 1932, **18**, 51 (*Chem. Zentr.*, 1932, I, 2169).

<sup>12</sup> Amin and Shah, *Org. Synth.*, 1948, **28**, 42.

<sup>13</sup> Willstätter and Müller, *Ber.*, 1908, **41**, 2580.

<sup>14</sup> Gilman, Swiss, and Cheney, *J. Amer. Chem. Soc.*, 1940, **62**, 1963.

phenylhydrazine (0.45 g.) was treated with phosphoric oxide (1 g.) in phosphoric acid (1 g.) as described for 2-(2,5-dimethoxyphenyl)indole, and the crude product, isolated by extraction with 2 : 1 ether-ethyl acetate, was distilled (bulb-to-bulb,  $190^{\circ}/5 \times 10^{-3}$  mm.) to give a viscous oil which, on being twice crystallised from light petroleum, afforded two crops of pale pink needles, (a) (0.17 g.), m. p. 101.5—102.5°, and (b) (0.02 g.), m. p. 126.5—127.5°. A mixture of (a) and (b) had m. p. 126.5—127.5°, indicating that the compound is dimorphic. The crops were combined and sublimed at  $125^{\circ}/5 \times 10^{-3}$  mm., and the colourless prismatic sublimate was crystallised from light petroleum, giving the *indole* (0.14 g., 13%) as prismatic needles, m. p. 130.5° (Found: C, 76.0; H, 5.9; N, 5.6.  $C_{16}H_{15}O_2N$  requires C, 75.9; H, 5.9; N, 5.5%).

2,3-Dihydroxyacetophenone.—A solution of 2,3-dimethoxyacetophenone (6.5 g.) in dry chlorobenzene (25 c.c.) was added to powdered anhydrous aluminium chloride (16 g.) in chlorobenzene (100 c.c.), and, when the initial reaction had subsided, the mixture was stirred and refluxed for 5 hr., cooled, and added to 10% hydrochloric acid (250 c.c.). The suspension was stirred for 1 hr. and extracted with ether, and the extract was washed with water, and dried. Removal of the solvent, distillation of the residue, and crystallisation of the fraction with b. p. 139—140°/20 mm. from light petroleum afforded the ketone (3.8 g., 69%) as needles, m. p. 77.5—78° raised to 97.5—98° by crystallisation from water (lit.,<sup>15,16</sup> 97—98°, 97°) (Found: C, 63.0; H, 5.5. Calc. for  $C_8H_8O_3$ : C, 63.2; H, 5.3%). Both forms yielded the same diacetate, m. p. 108.5—109° (lit.,<sup>15</sup> 109°) (Found: C, 59.8; H, 5.2. Calc. for  $C_{12}H_{12}O_5$ : C, 61.0; H, 5.1%).

2-(2,3-Dihydroxyphenyl)indole.—A mixture of 2,3-dihydroxyacetophenone (0.97 g.) and phenylhydrazine (0.69 g.) was heated on the boiling-water bath for 30 min., benzene (13 c.c.) was added, and the solution was refluxed for 1 hr., and then allowed to cool. The phenylhydrazone (1.12 g., 73%), which separated as platelets, m. p. 154°, was stirred with phosphoric acid (5 c.c.) at 100° for 15 min., then at 175—180° for 8 min., and the mixture was cooled, diluted with water (50 c.c.), and extracted with ethyl acetate. The extract was washed with water, then dried, and the solvent was removed. Distillation (bulb-to-bulb,  $200^{\circ}/5 \times 10^{-3}$  mm.) of the residue gave an oil from which, by crystallisation from benzene, sublimation at  $150^{\circ}/5 \times 10^{-3}$  mm., and then recrystallisation, the *indole* (0.50 g., 48%) was obtained as orange needles, m. p. 154.5—155° (Found: C, 75.0; H, 5.0; N, 6.2.  $C_{14}H_{11}O_2N$  requires C, 74.7; H, 4.9; N, 6.2%). The dimethyl ether, identical with that prepared from 2,3-dimethoxyacetophenone, was obtained in 57% yield when an air-free solution of the indole in aqueous 10% sodium hydroxide was treated with dimethyl sulphate. Reaction with silver oxide as described for 2'-indolyl-1,4-benzoquinone gave an intensely blue solution which rapidly became purple and then dull red-brown; filtration and removal of the solvent from the filtrate afforded a black "coke," m. p.  $\leq 360^{\circ}$ .

2-(3,4-Dimethoxyphenyl)indole.—3,4-Dimethoxyacetophenone<sup>17</sup> (0.9 g.) and phenylhydrazine (0.54 g.) were treated with polyphosphoric acid as described for 2-(2,5-dimethoxyphenyl)indole, and the crude product, isolated by extraction with ethyl acetate, was triturated with light petroleum (4 c.c.), and then sublimed at  $180^{\circ}/4 \times 10^{-3}$  mm. Crystallisation of the main band from benzene, resublimation, and crystallisation of the sublimate from aqueous ethanol afforded the *indole* (0.6 g., 47%) as blades, m. p. 189—189.5°, raised to 190° by a further sublimation and crystallisation (lit.,<sup>18</sup> 190—192°) (Found: C, 75.9; H, 6.1; N, 5.4. Calc. for  $C_{16}H_{15}O_2N$ : C, 75.9; H, 5.9; N, 5.5%).

2-(3,4-Dihydroxyphenyl)indole.—A mixture of 3,4-dihydroxyacetophenone<sup>19</sup> (0.91 g.) and phenylhydrazine (0.64 g.) was heated at 100° for 1 hr., and then crystallised from benzene-light petroleum to give the phenylhydrazone (1.38 g., 95%) as needles, m. p. 143—143.5°. This material was stirred with phosphoric acid (6 c.c.) at 100° for 15 min., then at 170° for 6 min., and the mixture was cooled and triturated with water (50 c.c.), and the solid was collected, washed with water, and sublimed at  $175^{\circ}/5 \times 10^{-3}$  mm. Crystallisation of the sublimate from ethyl acetate-light petroleum, resublimation, and then recrystallisation, under nitrogen, from aqueous ethanol afforded the *indole* (0.21 g., 16%) as hexagonal plates, m. p. 228.5—229.5° (slight decomp.) after darkening at 220° (Found: C, 75.0; H, 5.1; N, 6.2.  $C_{14}H_{11}O_2N$  requires C, 74.7; H, 4.9; N, 6.2%).

<sup>15</sup> von Krannichfeldt, *Ber.*, 1913, **46**, 4016.

<sup>16</sup> Baker and Smith, *J.*, 1936, 346.

<sup>17</sup> Pictet and Gams, *Ber.*, 1909, **42**, 2943.

<sup>18</sup> Woodward, Cava, Ollis, Hunger, Daeniker, and Schenker, *J. Amer. Chem. Soc.*, 1954, **76**, 4749.

<sup>19</sup> Rosenmund and Lohfert, *Ber.*, 1928, **61**, 2601.

4-2'-Indolyl-1,2-benzoquinone.—The foregoing indole (20 mg.) was oxidised as described for 2'-indolyl-1,4-benzoquinone, giving the *quinone* (18 mg., 91%) as a violet-black powder with an intensely green reflex, m. p.  $\leq 360^\circ$  after losing the green reflex at *ca.*  $180^\circ$  (Found: C, 74.9; H, 4.2.  $C_{14}H_9O_2N$  requires C, 75.4; H, 4.1%). The solution in acetone was wine-red, and that in ethanol was red-violet. When hydrogenated in ethyl acetate over Adams catalyst the quinone absorbed 1.015 mol. of hydrogen, and yielded 2-(3,4-dihydroxyphenyl)indole.

4,5-Dihydroxy-2-methylacetophenone.—Powdered anhydrous aluminium chloride (13.3 g.) was added during 10 min. to an ice-cooled solution of 3,4-diacetoxytoluene, from 4-methylcatechol (6.2 g.) and acetyl chloride (7.9 g.), in dry nitrobenzene (30 c.c.), and the mixture was then heated at  $75^\circ$  (internal) for 2 hr., cooled in ice, and decomposed with 5% hydrochloric acid (30 c.c.). The nitrobenzene was removed in steam, the residual aqueous suspension was filtered, and the solid crystallised from toluene to give the ketone (2.8 g., 34%) as needles, m. p.  $168-170^\circ$  (lit.,<sup>15,20</sup>  $168-169^\circ$ ,  $164^\circ$ ).

2-(4,5-Dihydroxy-2-methylphenyl)indole.—A mixture of the foregoing ketone (1.66 g.) and phenylhydrazine (1.08 g.) was heated at  $100^\circ$  for  $4\frac{1}{2}$  hr., and then crystallised from benzene to give the phenylhydrazine (1.6 g., 63%) as platelets, m. p.  $157-158^\circ$ . This material (1.46 g.) was stirred and heated with phosphoric oxide (0.75 g.) in phosphoric acid (1.5 c.c.). At  $150^\circ$  a vigorous reaction commenced, and the temperature was held at  $170-180^\circ$  by external cooling. When the reaction had subsided the mixture was heated at  $180^\circ$  for 1 min., and then cooled, diluted with water (40 c.c.), and extracted with ethyl acetate. The extract was washed with water and dried, and the solvent was removed. The residue was distilled (bulb-to-bulb,  $240^\circ/7 \times 10^{-3}$  mm.), and the oily distillate (0.22 g.), which did not crystallise, was treated in boiling benzene (10 c.c.) with 1,3,5-trinitrobenzene (0.196 g.). The solution was diluted with boiling cyclohexane (5 c.c.), and allowed to cool, affording the *adduct* (0.265 g., 10%) as deep brown rhombic platelets, m. p.  $162.5-163.5^\circ$  after sintering at  $159^\circ$  (Found: C, 56.1; H, 3.5; N, 12.4.  $C_{21}H_{16}O_8N_4$  requires C, 55.8; H, 3.6; N, 12.4%). This product (0.215 g.) in benzene (10 c.c.) at  $50^\circ$  was chromatographed on "Florisol" ( $180 \times 12$  mm.) which had been swept with nitrogen, and the column was eluted, first, with benzene (80 c.c.) at  $45-50^\circ$  to remove 1,3,5-trinitrobenzene, and then with ethyl acetate (35 c.c.) at  $20^\circ$ . Removal of the ethyl acetate, and distillation (bulb-to-bulb,  $220^\circ/7 \times 10^{-3}$  mm.) of the residue, afforded the *indole* (0.10 g., 88% based on adduct) as a yellow glass, softening point *ca.*  $30^\circ$  (Found: C, 75.3; H, 5.4; N, 5.7.  $C_{15}H_{13}O_2N$  requires C, 75.3; H, 5.5; N, 5.9%).

4-2'-Indolyl-5-methyl-1,2-benzoquinone.—The foregoing indole (20 mg.) was oxidised as described for 2'-indolyl-1,4-benzoquinone, giving the *quinone* (18 mg., 91%) as a dark brown powder, m. p. *ca.*  $190-210^\circ$  (decomp.) after darkening at  $50^\circ$ , becoming light brown at  $150-155^\circ$ , and again darkening at  $185^\circ$  (Found: C, 75.7; H, 4.7.  $C_{15}H_{11}O_2N$  requires C, 76.0; H, 4.7%). Solutions in acetone and ethanol were blood-red and violet-red respectively.

2-(3,4-Dihydroxyphenyl)-3-methylindole.—3,4-Dihydroxypropiophenone<sup>19</sup> (0.83 g.) and phenylhydrazine (0.54 g.) were heated together at  $100^\circ$  for 4 hr., phosphoric acid (3.5 c.c.) was added, and the mixture was stirred at  $100^\circ$  for 15 min., at  $175-180^\circ$  for 7 min., and then cooled. The *product* was triturated with water until it solidified, then distilled (bulb-to-bulb,  $240^\circ/5 \times 10^{-3}$  mm.), and the distillate was crystallised from benzene. Redistillation and recrystallisation afforded felted needles (0.70 g., 50%), m. p.  $122-122.5^\circ$ , containing benzene of crystallisation (Found: C, 77.4; H, 5.7; N, 5.1.  $C_{15}H_{13}O_2N \cdot \frac{1}{2}C_6H_6$  requires C, 77.7; H, 5.8; N, 5.0%). Distillation (bulb-to-bulb,  $230^\circ/5 \times 10^{-3}$  mm.) of this material gave a quantitative recovery of the free *indole* as an orange-yellow glass, softening point *ca.*  $25^\circ$  (Found: C, 75.6; H, 5.6; N, 6.0.  $C_{15}H_{13}O_2N$  requires C, 75.3; H, 5.5; N, 5.9%).

4-2'-Indolyl-3'-methyl-1,2-benzoquinone.—The foregoing indole (20 mg.) was oxidised as described for 2'-indolyl-1,4-benzoquinone, giving the *quinone* (16.6 mg., 84%) as a black powder, m. p.  $195-205^\circ$  (decomp.) after becoming brown at  $125-145^\circ$ , and darkening at  $180^\circ$  (Found: C, 75.6; H, 4.9.  $C_{15}H_{11}O_2N$  requires C, 76.0; H, 4.7%). The solution in acetone was red-violet, and that in ethanol was blue-violet.

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