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INTRAMOLECULAR HYDRIDE TRANSFER TO A DIAZONIUM INTERMEDIATE AND TO A BENZYNE

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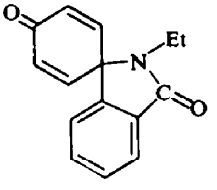
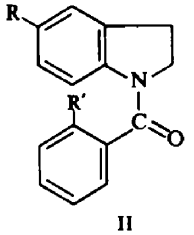
Abstract—Diazotization of N-*o*-aminobenzoylindolines and subsequent decomposition of the diazonium ions yields, among other products, substantial amounts of N-benzoylindoles. Deuteration studies have shown that their formation involves an intramolecular hydrogen transfer which can be viewed as a hydride shift. A similar transfer of hydride is probably involved in the formation of N-benzoylindole from the benzyne generated from N-*o*-bromobenzoylindoline.

THE formation of the spirodienone (I) as the major product of the decomposition the diazonium ion derived from N-ethyl-N-(4′-methoxyphenyl)-2-aminobenzamide[1] suggested that if the reaction could be extended to more complex molecules (e.g. II; R = OMe, R′ = NH_2) then a new route would become available for the synthesis of alkaloids containing a quaternary C atom. When the amine (II; R = OMe, R′ = NH_2) was diazotized and the diazonium ion decomposed, none of the expected spirodienone (III) was obtained. One of the major products was N-benzoyl-5-methoxyindole (IV; R = OMe). As will be shown in the sequel, this arises by an intramolecular transfer of hydride from C-2 of the indoline to the *ortho*-position of the benzoyl moiety.



I



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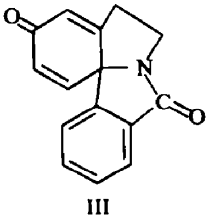
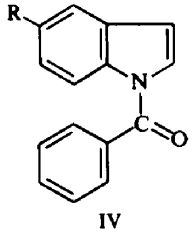


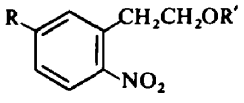
III



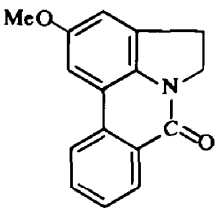
IV

The amide (II; R = OMe, R′ = NH_2) was prepared by catalytic reduction of the corresponding nitro compound which was prepared by treating 5-methoxyindoline with *o*-nitrobenzoyl chloride. Our starting point for the synthesis of the indoline was 5-methoxy-2-nitrobenzaldehyde.[2] Condensation with N-acetylglycine in acetic

anhydride afforded the azlactone which on hydrolysis with acid yielded 5-methoxy-2-nitrophenylpyruvic acid. Oxidation with hydrogen peroxide gave the corresponding phenylacetic acid, whose methyl ester was smoothly reduced to the alcohol (V; R = OMe, R′ = H) with potassium borohydride in the presence of lithium chloride. Catalytic hydrogenation, in the presence of potassium acetate, of the tosylate (V; R = OMe, R′ = Ts) afforded directly a high yield of 5-methoxyindoline, presumably by an intramolecular displacement of the tosyloxy group by the amino group initially formed. This route to indolines, incorporating the prior reduction of the ester group, avoids the difficulties which have previously been encountered when *o*-nitrophenylacetic acids have been used as precursors.[3,4]



V



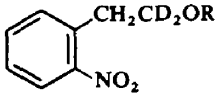
VI

The amine (II; R = OMe, R′ = NH_2) was diazotized with sodium nitrite in aqueous acid. Decomposition of the diazonium salt, effected by heating the reaction mixture at 70–80° for 2 hr, afforded the Pschorr-type cyclization product (VI), the indoline (II; R = OMe, R′ = OH) and N-benzoyl-5-methoxyindole (IV; R = OMe) in comparable amounts. The structures of the amide (VI) and of the indoline were deduced from their elemental analyses and from very characteristic spectral data; that of the indoline was confirmed by converting it into its methyl ether. Spectral data, supported by a positive Ehrlich test, indicated that compound (IV; R = OMe) was an indole. This was confirmed by its ready hydrolysis to 5-methoxyindole and benzoic acid.

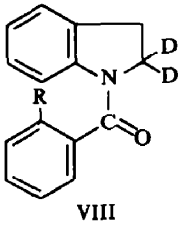
When N-2′-aminobenzoylindoline (II; R = H, R′ = NH_2) was diazotized and the diazonium salt decomposed, N-benzoylindole was obtained as a major product, accompanied by N-2′-hydroxybenzoylindoline (II; R = H, R′ = OH). No Pschorr cyclization product was obtained in this instance.

The production of N-benzoylindoles in this type of reaction has been noted previously.[5,6] These groups of workers obtained the indole as the major product from the N-methylenedioxybenzoyl analogue of II. This was accompanied by the Pschorr cyclization product, but not apparently by the N-2′-hydroxybenzoylindoline.

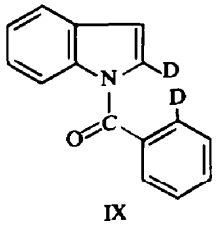
It seemed likely that the N-benzoylindoles were formed by an intramolecular hydrogen transfer from C-2 of the indoline to the carbon bearing the diazonium group. Accordingly, we synthesized[2.2-^2H]indoline by the method outlined above for



VII



VIII



IX

5-methoxyindoline—the key stage being the reduction of methyl 2-nitrophenylacetate with lithium borodeuteride in tetrahydrofuran. The resulting alcohol (VII; R = H) contained two deuterium atoms as shown by the NMR spectrum (see Table 1) of its toluene-*p*-sulphonyl derivative (VII; R = Ts). Catalytic reduction of this derivative gave [2,2-^2H]indoline directly—no loss of deuterium having occurred. We confirmed also that when indoline or N-benzoylindoline were shaken under deuterium in the presence of Adams catalyst no deuterium was incorporated into the substrates.[3] The NMR spectrum (see table) of N-*o*-nitrobenzoyl[2,2-^2H]indoline (VIII; R = NO_2) also confirmed that deuterium labelling at C-2 of the indoline was greater than about 95%. Diazotization of the N-*o*-aminobenzoyl derivative (VIII; R = NH_2) and decomposition of the diazonium ion gave the hydroxy compound (VIII; R = OH) and the N-benzoylindole (IX). The NMR spectrum (see Table 1) of the indoline (VIII; R = OH) clearly showed that the two deuterium atoms had been retained at C-2 of the indoline throughout the sequence of reactions.

TABLE 1. NMR SPECTRA IN DEUTEROCHLOROFORM. ALIPHATIC PROTONS

Chemical Shift (τ-*scale*)

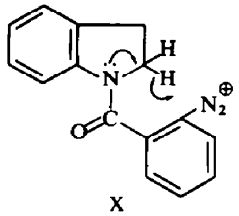
Compound	α-(or 2-)Position	β-(or 3-)Position	Other
VII; R = Ts	-(deuterated)	6·78(s)[2]	7·60(s)[3] (methyl)
II; R = H, R′ = NO_2	6·25(tr)[2]	6·90(tr)[2]	
VIII; R = NO_2	-(deuterated)	6·90(s)[2]	
II; R = H, R′ = OH	5·72(tr)[2]	6·88(tr)[2]	8·75(s)[1]
VIII; R = OH	-(deuterated)	6·92(s)[2]	8·75(s)[v]

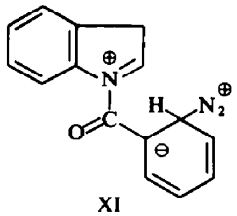
S = singlet, tr = triplet, figures in square brackets refer to integrated proton counts, v = variable.

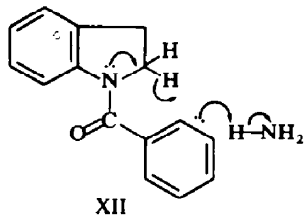
The disposition of the deuterium atoms in the indole (IX) was demonstrated as follows. Its IR spectrum lacked the band at 705 cm^{-1} characteristic of a monosubstituted benzene which was present in the non-deuterated compound (IV; R = H). Its mass spectrum showed a parent ion *m/e* 223 and prominent peaks at *m/e* 106 and 78 which can be assigned to ions $C_7\,{}^1H_4\,{}^2H_1\,O^{\oplus}$ and $C_6\,{}^1H_4\,{}^2H_1^{\oplus}$ as expected from the fragmentation of the [2-^2H]benzoyl group. Alkaline hydrolysis of the indole (IX) afforded [2-^2H]benzoic acid and [2-^2H]indole. The IR spectrum of the former corresponded exactly with that of an authentic specimen, and its mass spectrum gave a parent ion *m/e* 123 (incorporation of one deuterium atom). The IR spectrum of the latter differed markedly from that of indole itself in the 700–850 cm^{-1} region, and its mass spectrum gave a parent of ion *m/e* 118 showing that is contained one deuterium atom.

The lack of exchange of the protons on C-2 of the indoline was confirmed when the indoline (II; R = H, R′ = NH_2) was diazotized in a medium containing about 98% deuterium oxide. The N-benzoylindole produced contained no deuterium.

The mechanism of the production of the N-benzoylindoles allows of a number of possibilities. Humber *et al.*[6] suggested a radical mechanism but presented no evidence or argument in its favour. We prefer a heterolytic mechanism, which must necessarily involve an intramolecular hydride transfer (X), for the reasons outlined below. The conversion of the resulting indolenine to the indole is unexceptional.


X


XI


XII

The uncatalysed decomposition of aryl diazonium cations (the type of reaction we have on hand) has been shown to be a unimolecular, non-radical reaction involving the intermediacy of phenyl cations.[7] However, the presence of strongly electron—withdrawing groups which can serve as electron sinks (e.g. *o*- and *p*-nitro) can convert this reaction into a bimolecular nucleophilic substitution involving an intermediate with an sp^3 carbon.[8] Since an *ortho* or *para*-carbonyl group can serve effectively as an electron sink we can view the production of the phenols that we obtain as occurring by a bimolecular mechanism. The production of the indole can then be envisaged as occurring in competition with this reaction, the competing nucleophile being a hydride from C-2 of the indoline. This will lead to the intermediate (XI) which affords the stable indole by the loss of nitrogen and a proton. Since the rate-determining stage in aromatic nucleophilic substitutions is the production of the tetrahedral intermediate, it follows that the intramolecular transfer of hydride will be rate-determining, and should be subject to an isotope effect. Experiment bears this out, for the 2,2-dideutero-indoline (VIII; R = NH_2) gives a lower yield of the indole (IX) relative to that of the indoline (VIII; R = OH) as would be expected for the higher energy barrier required for deuteride transfer.

In another attempt to prepare the spirodienone (III), we treated N-*o*-bromobenzoyl-5-hydroxyindoline (II; R = OH, R′ = Br) with potassamide in liquid ammonia (cf. Ref. 1). Traces of a compound which gave a positive Ehrlich test for an indole encouraged us to try the reaction with the indoline (II; R = H, R′ = Br). Indole and benzoic acid were obtained. These must arise from a hydrolysis of N-benzoylindole, whose formation we envisage as involving an intramolecular transfer of hydride to the intermediate benzyne (XII). This, so far as we are aware, is the first recorded instance of a reaction which may be viewed as involving the transfer of hydride to a benzyne.

EXPERIMENTAL

UV spectra were recorded on a Cary 14 Recording Spectrophotometer. IR spectra were obtained on a Perkin–Elmer Model 21 spectrometer. NMR spectra were recorded at 60 Mc/s using tetramethylsilane as an internal standard.

2-Methyl-4-(2′-nitro-5′-methoxybenzal)-oxazoline-5-one. A mixture uf 2-nitro-5-methoxybenzaldehyde[2] (22·4 g), NaOAc (9·93 g), acetylglycine (21·7 g) and Ac_2O (60 ml) was heated on a water-bath for 2·5 hr. After standing at 4° for 3 days, the solid mass was collected, washed with H_2O and dried to give the *azlactone* (27·5 g) which crystallized from EtOH in yellow needles, m.p. 151–152°, λ_{max} (EtOH) 320 and 286 mμ, ε_{max} 1540 and 3600 (resp.). (Found: C, 54·5; H. 3·5; N, 11·0. $C_{12}H_{10}N_2O_5$ requires: C, 55·0; H, 3·8; N, 10·7%).

Methyl 2-nitro-5-methoxyphenylacetate was prepared from 2-nitro-5-methoxyphenylacetic acid[9] using MeOH and H_2SO_4, and recrystallized from MeOH as pale yellow needles, m.p. 65·5–66°; ν_{max} (CH_2Cl_2) 1740 and 1584 cm^{-1}. (Found: C, 53·3; H, 5·15; N, 6·0. $C_{10}H_{11}NO_5$ requires: C, 53·3; H, 4·9; N, 6·2%).

2-(2′ Nitro-5′-methoxyphenyl)ethanol (V; R = OMe, R′ = H). A mixture of methyl 2-nitro-5-methoxyphenylacetate (2·25 g), KBH_4 (0·59 g), LiCl (0·5 g) and THF (20 ml) was heated under reflux (3½ hr) with

exclusion of moisture, and then poured into H_2O. The mixture was extracted with ether and the ether extracts were dried and evaporated to give 2-(2'-*nitro*-5'-*methoxyphenyl*)*ethanol* as an oil (1·83 g); ν_{max} (liquid) 3350 and 1510 cm^{-1}, λ_{max} (EtOH 302·5 and 232 mμ. Its p-*toluenesulphonate* had m.p. 89–90°; (Found: C, 54·8; H, 5·2; N, 3·9. $C_{16}H_{17}NO_5S$ requires: C, 54·7; H, 4·8; N, 4·0%) The p-*nitrobenzoate* separated from MeOH as yellow needles, m.p. 150·5–151·5°; ν_{max} (CH_2Cl_2) 1727, 1531 and 1518 cm^{-1}. (Found: C, 55·05; H, 4·5. $C_{16}H_{14}N_2O_7$ requires: C, 54·5; H, 4·1%).

5-*Methoxyindoline*. 2-(2'Nitro-5-methoxyphenyl) ethyl *p*-toluenesulphonate (8·6 g) in EtOH (300 ml) containing KAc (2·84 g) was shaken under H_2 at 6 ats. press. with Raney nickel catalyst. The filtered soln was concentrated, treated with 10% NaOH aq (50 ml) and extracted with ether. The extract was washed, dried and evaporated to give 5-*methoxyindoline* (3·23 g) as an oil; ν_{max} (liquid) 3300 cm^{-1}, λ_{max} (EtOH) 304 and 263 mμ, ε_{max} 2900 and 15,500 (resp.).

The *picrate* separated from EtOH as yellow needles, m.p. 159–160·5°; (Found: C, 47·4; H, 4·0; N, 14·7. $C_{15}H_{14}N_4O_8$ requires: C, 47·6; H, 3·7; N, 14·8%). The N-*benzoyl derivative* crystallized from MeOH as colourless needles, m.p. 123–124°; ν_{max} 1670 cm^{-1}, λ_{max} (EtOH) 275 mμ, ε_{max} 11800. (Found: C, 76·05; H, 6·0; N, 5·7. $C_{16}H_{15}NO_2$ requires: C, 75·9; H, 6·0; N, 5·5%).

N-(2'-*Nitrobenzoyl*)-5-*methoxyindoline*. A solution of *o*-nitrobenzoyl chloride (3·74 g) in ether (15 ml) was added to a soln of 5-methoxyindoline (2·72 g) in ether (5 ml) and pyridine (15 ml). The mixture was shaken for 14 hr, poured into ice and conc HCl and extracted with $CHCl_3$. The extract was washed, dried and evaporated giving a dark oil (5·6 g) which was purified by chromatography on silica gel using benzene-$CHCl_3$ (5:1) as eluant. N-(2'-*Nitrobenzoyl*-5-*methoxyindoline* was obtained as a yellow oil (4·0 g) which solidified. Recrystallization from EtOH afforded yellow plates, m.p. 164·5–166°; ν_{max} (CH_2Cl_2) 1643 and 1531 cm^{-1}, λ_{max} (EtOH) 305 (shoulder), 294 (S), 261 and 255 mμ, ε_{max} 5000, 6600, 17,000 and 17,000 (resp). (Found: C, 64·45; H, 4·4; N, 9·6. $C_{16}H_{14}N_2O_4$ requires C, 64·4; H, 4·7; N, 9·4%).

N-(2'-*Aminobenzoyl*)-5-*methoxyindoline*. N-(2'-Nitrobenzoyl)-5-methoxyindoline in EtOH was shaken under H_2 at 7 ats. press. with Raney nickel catalyst for 12 hr. The filtered soln was evaporated and the product, N-(2'-*aminobenzoyl*)-5-*methoxyindoline* was recrstallized from hexane–benzene as needles, m.p. 117–118°; ν_{max} (CH_2Cl_2) 3470, 3375 and 1617 cm^{-1}, λ_{max} (EtOH) 238, 271 and 306 mμ, ε_{max} 17,000, 12,800 and 9700 (resp.). (Found: C, 71·5; H, 6·3; N, 10·6. $C_{16}H_{16}N_2O_2$ requires: C, 71·6; H, 6·0; N, 10·4%).

Diazotization and decomposition of N-(2'-*amino benzoyl*)-5-*methoxyindoline*. A soln of $NaNO_2$ (0·48 g) in H_2O (5 ml) was added slowly to a stirred soln of the amino (1·31 g) in dil. H_2SO_4 (5%; 90 ml) at 0°. The precipitated solid (318 mg) was collected, washed with water and dried. Recrystallization from hexane–benzne gave rhombs., m.p. 141–142°; (Found: C, 68·45; H, 5·0; N, 15·3. $C_{16}H_{13}N_3O_2$ requires: C, 68·8; H, 4·7; N, 15·05%). The filtrate was heated at 70° for 2 hr and extracted with $CHCl_3$. The extract was washed with dil. NaOH aq and with H_2O, dried and evaporated leaving a brown oil (450 mg) which was chromatographed on alumina (Brockmann activity III; 10 g) in hexane–benzene (1:4). Elution with hexane–benzene gave N-*benzoyl*-5-*methoxyindole* (180 mg) which crystallized from hexane–benzene as colourless needles, ν_{max} (CH_2Cl_2) 1680 cm^{-1}, λ_{max} (EtOH) 314 and 257 mμ, ε_{max} 7600 and 20,100 (resp,). (Found: C, 76·5; H, 5·15; N, 5·7. $C_{16}H_{13}NO_2$ requires: C, 76·5; H, 5·2; N, 5·6%). Elution with $CHCl_3$-benzene (1:9) gave 2-*methoxy*-4,5-*ethanophenanthridone*, (142 mg) which separated from hexane–benzene as yellow crystals, m.p. 183–184°; ν_{max} (CH_2Cl_2) 1646 cm^{-1}, λ_{max} (EtOH) 346, 265, 254, 238 and 234 mμ, ε_{max} 9900, 23,000, 19,800, 49,800 and 50,200 (resp.). (Found: C, 76·7; H, 5·2; N, 5·5%). The combined alkali washes were acidified and extracted with $CHCl_3$. The extract was washed and dried and evaporated giving a solid (280 mg) which was chromatographed on silica gel (5 g). Elution with benzene–ether (20:1) gave a pale yellow solid (240 mg) which, on recrystallization from benzene gave N-(2'-*hydroxybenzoyl*)-5-*methoxyindoline* as needles, m.p. 191–192°; ν_{max} (CH_2Cl_2) 1628 cm^{-1}, λ_{max} 307, 297·5, 274 and 267·5 mμ, ε_{max} 6800, 8700, 13,000 and 13,000 (resp.). (Found: C, 71·0; H, 5·35; N, 5·2. $C_{16}H_{15}NO_3$ requires: C, 71·4; H, 5·6; N, 5·2%). This compound gave a purple colour with $FeCl_3$ soln. The *methyl ether*, prepared in the usual way, separated from aq. MeOH as colourless plates, m.p. 95–96°; ν_{max} (CH_2Cl_2) 1638 cm^{-1}, λ_{max} (EtOH) 307·5, 297·5, 274 and 268 mμ, ε_{max} 6900, 9000, 15,600 and 15,100 (resp.). (Found: C, 72·0; H, 6·3; N, 4·8. $C_{17}H_{17}NO_3$ requires: C, 72·1; H, 6·05; N, 4·9%).

Hydrolysis of N-*benzoyl*-5-*methoxyindole*. The indole (55 mg) was boiled with 5% NaOH aq (2 ml) for 1 hr. Extraction of the cooled soln with ether gave a yellow oil (34 mg) whose IR spectrum (CS_2) was identical to that of an authentic specimen of 5-methoxyindole. The picrate, obtained as red needles from EtOH had m.p. and mixed m.p. 143–145°. The aqueous soln was acidified and extracted with ether. This extract gave a colourless solid (40 mg) whose IR spectrum (CH_2Cl_2) was identical to that of benzoic acid. It crystallized from hexane as needles, m.p. and mixed m.p. 123–124·5°.

N-2'-Nitrobenzoylindoline. Indoline (0·57 g) and *o*-nitrobenzoic acid (0·80 g) were dissolved in EtOAc (25 ml) dicyclohexylcarbodi-imide (0·97 g) was added and the mixture was stirred at 0° for 2 hr. The soln was filtered and the filtrate evaporated to dryness. Recrystallization of the residue from EtOH gave *N-2'-nitrobenzoylindoline* (0·70 g) as yellow rhombs, m.p. 143–145° ν_{max} (CH_2Cl_2) 1650 and 1530 cm^{-1}, λ_{max} (EtOH) 291, 280 and 253 mμ, ε_{max} 8500, 9700 and 18,500 (resp.). (Found: C, 67·0; H, 4·75; N, 10·4. $C_{15}H_{12}N_2O_3$ requires: C, 67·2; H, 4·5; N, 10·4%).

N-2'-Aminobenzoylindoline. The above nitro compound (2·08 g) was shaken in EtOAc (50 ml) under H_2, with Adam's catalyst. Evaporation of the filtrate gave N-2'-aminobenzoylindoline (1·76 g) which separated from hexane–benzene as rhombs, m.p. 140–146°; ν_{max} (CH_2Cl_2) 3472, 3382 and 1635 cm^{-1}, λ_{max} (EtOH) 293, 267 and 237 mμ, ε_{max} 9200, 12,000 and 12,000 (resp.). (Found: C, 75·55; H, 6·2; N, 11·6. $C_{15}H_{14}N_2O$ requires: C, 75·6; H, 5·9; N, 11·8%). Treatment of the amine with phenyl isocyanate gave the *N-phenyl urea* which separated from benzene–EtOH as needles m.p. 198–199·5°; ν_{max} (CH_2Cl_2) 3360. 1707 and 1625 cm^{-1}, λ_{max} (EtOH) 291 and 207 mμ, ε_{max} 2100 and 7200 (resp.). (Found: C, 74·2; H, 5·4; N, 11·6. $C_{22}H_{19}N_3O_2$ requires: C, 73·9; H, 5·4; N, 11·8%).

Diazotization and decomposition of N-2'-aminobenzoylindoline. The amine (686 mg), in a mixture of dioxan (16 ml) and 5% H_2SO_4 aq (50 ml) was treated at 0° with a soln of $NaNO_2$ (0·29 g) in H_2O (10 ml). The soln was heated at 80° for 1·5 hr, cooled and extracted with $CHCl_3$. This extract yielded a dark oil (925 mg) which was chromatographed on silica gel (20 g). Elution with hexane–benzene (1:1) gave N-benzoylindole (194 mg) which on recrystallization from hexane gave colourless needles, m.p. 73–73·5°; ν_{max} (CH_2Cl_2) 1685 cm^{-1}. (Found: C, 81·9; H, 5·1. Calc. for $C_{15}H_{11}NO$: C, 81·4; H, 5·0%) (Lit.[10] m.p. 67–68°). Elution with benzene–ether (99:1) gave a yellow solid (400 mg) which crystallized from hexane–benzene to give *N-2'-hydroxybenzoylindoline* as needles, m.p. 192–193°; ν_{max} (CH_2Cl_2) 1631 cm^{-1}. (Found: C, 75·3; H, 5·5; N, 6·05. $C_{15}H_{13}NO_2$ requires: C, 75·3; H, 5·5; N, 5·85%).

Hydrolysis of N-benzoylindole. The N-benzoylindole from the above reaction (52 mg) was boiled with dilute NaOH (5%; 2 ml) for 1 hr. Extraction of the resulting soln with ether gave a pale yellow oil (33 mg) which solidified. Its IR spectrum (CS_2) was identical to that of indole. The picrate separated from EtOH as orange-red needles, m.p. 135–150°. An authentic specimen also melted over this range (Lit.[11,12] cite m.p. 182° and 175° resp.) and the UV spectra of the two samples were identical. The aqueous portion was acidified and extracted with ether to give a solid (28 mg) whose IR spectrum was identical to that of benzoic acid. It crystallized from heptane as needles, m.p. 122–124°, mixed m.p. with an authentic sample, 123–125°.

[1,1-^{2}H]-2-(2'-Nitrophenyl)ethanol. Methyl 2-nitrophenylacetate (3·76 g), lithium borodeuteride (0·51 g) and THF (30 ml) were heated under reflux for 4 hr. Water was added and the mixture extracted with ether. The ether extract was washed with H_2O, dried and evaporated leaving a brown oil (2·6 g). Its solution in $CHCl_3$ was washed with dil H_2SO_4 and H_2O, dried and evaporated. The residual oil (1·67 g) which darkened rapidly, was chromatographed on silica gel, and elution with benzene–ether (9:1) gave *[1,1-^{2}H]-2-(2'-nitrophenyl)ethanol* as a yellow oil (1·28 g) which was homogeneous by TLC R_f (benzene–ether, 9:1) = 0·37 as detected by I_2 vapour; ν_{max} (liquid) 3360 and 1520 cm^{-1}.

The *p-toluenesulphonate*, prepared in the usual way, separated from heptane–ether as rhombs., m.p. 46·5–48°. (Found: C, 55·6; H, 5·1; N, 4·4. $C_{15}H^*_{15}NO_5S$ requires: C, 55·8; H, 4·7; N, 4·3%).

[2,2-^{2}H]-Indoline. A soln of [1,1-^{2}H]-2-(2'-nitrophenyl) ethyl *p*-toluenesulphonate (1·8 g) and AcOK (0·55 g) in EtOH (40 ml) was shaken under H_2 with Adam's catalyst. After the absorption of H_2 (ca. 3 moles) the product was worked up as described for 5-methoxyindoline. On TLC the oil obtained (0·73 g) showed R_f values identical to those shown by authentic indoline i.e. R_f (heptane–benzene, 1:1) = 0·12, R_f (benzene–EtOH, 98:2) = 0·43.

[2,2-^{2}H]-(2'-Nitrobenzoyl)indoline, prepared in the manner described for the non-deuterated compound gave m.p. 143–144·5°, mixed m.p. with non-deuterated compound 142–143·5°; (Found: C, 66·4; H, 4.8; N, 10·4. $C_{15}H^*_{14}N_2O_3$ requires: C, 66·7; H, 4·5; N, 10·4%).

[2,2-^{2}H]-(2'-Aminobenzoyl)indoline was obtained by catalytic hydrogenation of the nitro compound, as described for the non-deuterated compound. Its IR spectrum (CH_2Cl_2) was virtually identical to that of the non-deuterated compound, as was its behaviour on TLC R_f (benzene–EtOH, 97:3) = 0·33.

The diazotization and decomposition of the amine (VIII; R = NH_2; 280 mg) was carried out as described earlier and the crude product chromatographed on silica gel. Elution with hexane–benzene (1:1) gave *[2,2'-^2H]*-N-benzoylindole (49 mg) and elution with benzene-ether (9:1) gave *[2,2-^2H]*-N-(2'-hydroxybenzoyl)indoline (136 mg).

* Includes two atoms of deuterium.

Hydrolysis of [2,2'-^2H]-N-benzoylindole with (30 mg) with dil NaOH as described above gave [2-^2H-]benzoic acid (12·5 mg) and [2-^2H]indole (12 mg) which were identified as described in the text.

N-(2'-Bromobenzoyl)indoline. A soln uf *o*-bromobenzoyl chloride (2·6 g) in benzene (20 ml) was added slowly to a soln of indoline (1·42 g) in pyridine (20 ml). After 2 hr the mixture was poured into ice and conc, HCl and extracted with benzene. The extracts were washed, dried and evaporated leaving an oil (3·08 g) which solidified. Recrystallized from EtOAc afforded *N-(2'-bromobenzoyl)indoline* as rods, m.p. 97–98°; ν_{max} (CH_2Cl_2) 1645 cm^{-1}, λ_{max} (EtOH) 292, 283 and 257 mμ, ε_{max} 7700, 8300 and 14,400 (resp.). (Found: C, 59·5; H, 4·2. $C_{15}H_{12}BrNO$ requires: C, 59·6; H, 4·0%).

Treatment with potassium amide. N-(2'-Bromobenzoyl) indoline (1·21 g) was added to a stirred suspension of KNH_2 in liquid NH_3 (100 ml), prepared from K (0·62 g). After 0·5 hr, ether (100 ml) was added and stirring was continued for 12 hr with exclusion of moisture. Dilute HCl was added and the mixture was extracted with ether; the extract was washed dried and evaporated to give an oil (357 mg) which gave a purple colour with Ehrlich's reagent. This oil was chromatographed on silica gel (7 g). Elution with hexane–ether (99:1) gave indole (180 mg) which was identified by its IR spectrum. Its picrate, orange needles from EtOH, had m.p. 145–160°. The UV spectrum of the picrate was identical to that of an authentic specimen. Elution with hexane–ether (10:1) gave benzoic acid (48 mg) identified by its Ir spectrum. After recrystallization from hexane it gave m.p. and mixed m.p. 120–123°. The aqueous solution was made alkaline and extracted with ether. Evaporation of the extract gave an oil (184 mg) whose IR spectrum was identical to that of indoline. Its N-benzoyl derivative had m.p. and mixed m.p. 116–117.

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