Hydrazinolysis of 2-Phenyl-2-(phthalimidoalkyl)indan-1,3-diones

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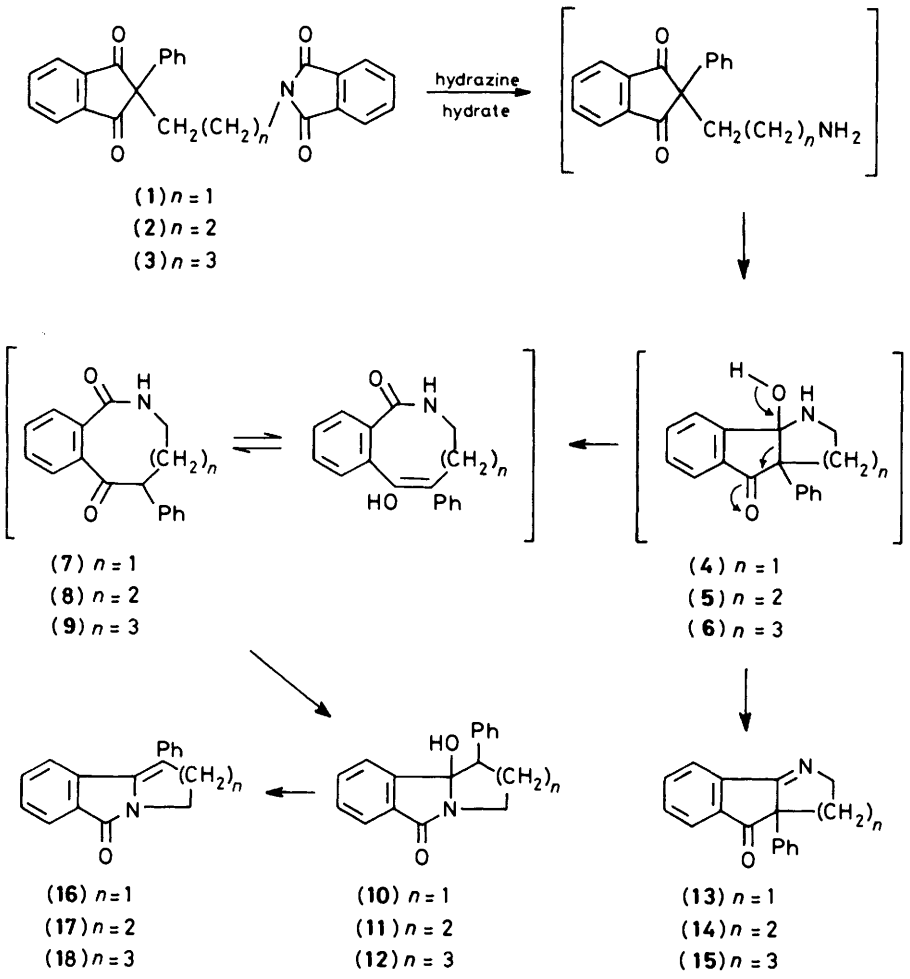
Hydrazinolysis of 2-phenyl-2-(3-phthalimidopropyl)indan-1,3-dione gave 1,2,3,10b-tetrahydro-10b-hydroxy-1-phenylpyrido[2,1-*a*]isoindol-6(4*H*)-one (**11**) (major product), and 2,3,4,4a-tetrahydro-4a-phenylindeno[1,2-*b*]pyridin-5-one (**14**) (minor product). Hydrazinolysis of the butyl analogue gave 2,3,4,5-tetrahydro-5a-phenylindeno[1,2-*b*]azepin-6(5a*H*)-one (**15**) (major product) and 2,3,4,5-tetrahydro-1-phenylazepino[2,1-*a*]isoindol-7-one (**18**) (minor product).

The pyrido[2,1-*a*]isoindol-6(4*H*)-one (**11**) and the azepino[2,1-*a*]isoindol-7-one (**18**) arise *via* ring expansion of the carbinolamines from the 2-(2-aminoalkyl)-2-phenylindan-1,3-diones to give 2,3,4,5-tetrahydro-7-hydroxy-6-phenylbenz[3,4]azonin-1-one and 3,4,5,6-tetrahydro-8-hydroxy-7-phenylbenz[3,4]azecin-1(2*H*)-one respectively which undergo transannular cyclisation.

The hydrazinolysis of 2-phenyl-2-(2-phthalimidoethyl)indan-1,3-dione (**1**) gives 1,2,3,9b-tetrahydro-9b-hydroxy-1-phenylpyrrolo[2,1-*a*]isoindol-5-one (**10**) *via* the conversion of 2-(2-aminoethyl)-2-phenylindan-1,3-dione into the carbinolamine (**4**) which undergoes ring expansion to 3,4-dihydro-6-hydroxy-5-phenylbenz[3,4]azocin-1(2*H*)-one (**7**) followed by transannular cyclisation to (**10**)[1] (see Scheme).

In order to test the generality of the ring expansion reaction, as occurs in (**4**)—(**7**), a study of the hydrazinolysis of 2-phenyl-2-(3-phthalimidopropyl)indan-1,3-dione (**2**) and of 2-phenyl-2-(4-phthalimidobutyl)indan-1,3-dione (**3**) was undertaken. The required 2-phenyl-2-(ξ-phthalimidoalkyl)indan-1,3-diones (**2**) and (**3**) were prepared by the reaction between *N*-(ξ-bromoalkyl)phthalimides (from 1,ξ-dibromoalkanes and phthalimide in acetone) and 2-phenylindan-1,3-dione in the presence of sodium propoxide in propanol.



Scheme. The hydrazinolysis of 2-phenyl-2-(2-phthalimidoalkyl)indan-1,3-diones

Hydrazinolysis of 2-Phenyl-2-(3-phthalimidopropyl)indan-1,3-dione.—Treatment of 2-phenyl-2-(3-phthalimidopropyl)indan-1,3-dione (**2**) with hydrazine hydrate in boiling ethanol gave a mixture of three products which were separated by column chromatography over silica. The first fraction, eluted with ether, gave 1,2,3,10b-tetrahydro-10b-hydroxy-1-phenylpyrido[2,1-*a*]isoindol-6(4*H*)-one (**11**) as a white crystalline solid, m.p. 225 °C. The i.r. spectrum of this exhibited bands at 3 560 and 3 320 (OH) and at 1 688 cm^{-1} (γ-lactam). The n.m.r. spectrum of (**11**) showed absorption for 4_{eq}-H as a doublet of doublets ($J_{4_{ax},4_{eq}} = -12.5$, $J_{4_{eq},3_{ax}} = 3.75$ Hz) at low field (δ 4.07) as a consequence of deshielding by the amide group. Decoupling of the signals at δ 3.15 removed a large coupling from the 4_{eq}-H signals at δ 4.07, and a small coupling from the highest field signal at δ 1.35—1.55. This allowed the signals at δ 3.15 to be assigned to 4_{ax}-H, which gave a triplet of doublets ($J_{4_{ax},4_{eq}} = -12.5$, $J_{4_{ax},3_{ax}} = 12.5$, $J_{4_{ax},3_{eq}} = 3.75$ Hz). Decoupling of the highest field signals (δ 1.35—1.55) removed a large coupling from both the 4-methylene proton signals, which permitted their assignment to 3_{ax}-H. The quartet of doublets δ 2.35 ($J_{2_{ax},2_{eq}} = -12.5$, $J_{2_{ax},1_{ax}} = J_{2_{ax},3_{ax}} = 12.5$, $J_{2_{ax},3_{eq}} = 3.75$ Hz) was assigned to 2_{ax}-H and the magnitude of the $J_{2_{ax},1_{ax}}$ coupling showed the equatorial orientation of the phenyl substituent.

1,2,3,10b-Tetrahydro-10b-hydroxy-1-phenylpyrido[2,1-*a*]-isoindol-6(4*H*)-one (**11**) was also prepared by the catalytic reduction of 2-(2-cyanoethyl)-2-phenylindan-1,3-dione (**19**) (from the Michael reaction between 2-phenylindan-1,3-dione and acrylonitrile) over Raney nickel catalyst at atmospheric pressure.

A second fraction eluted with ether afforded a pale yellow crystalline solid, m.p. 96 °C with molecular formula $C_{18}H_{15}NO$. This was assigned the structure 2,3,4,4a-tetrahydro-4a-phenylindeno[1,2-*b*]pyridin-5-one (**14**) on the basis of the i.r. spectrum [$\nu_{max.}$ 1 720 (CO) and 1 660 cm^{-1} (C=N)] and the n.m.r. spectrum (see Experimental section).

The third fraction eluted with an ether–dichloromethane mixture afforded a small amount of 2,3-dihydro-1-phenylpyrido[2,1-*a*]isoindol-6(4*H*)-one (**17**), also obtained by the treatment of 1,2,3,10b-tetrahydro-10b-hydroxy-1-phenylpyrido-[2,1-*a*]isoindol-6(4*H*)-one (**11**) with concentrated hydrochloric acid. The i.r. spectrum of the product showed a band at 1 680 cm^{-1}, attributed to the γ-lactam function.

Catalytic reduction of (**17**) over Raney nickel catalyst gave 1,2,3,10b-tetrahydro-1-phenylpyrido[2,1-*a*]isoindol-6(4*H*)-one (**20**). The n.m.r. spectrum of this showed a doublet at δ 4.75 ($J_{10b_{ax},1_{ax}} \simeq 5.3$ Hz) assigned to 10b-H. A partially obscured multiplet at δ 4.62—4.7 was assigned to 4_{eq}-H and a triplet of doublets at δ 3.17 ($J_{4_{ax},3_{ax}} = -12$, $J_{4_{ax},3_{eq}} \simeq 6.0$ Hz) to 4_{ax}-H.

Catalytic hydrogenation of the lactam (**17**) in methanol over Adams platinum oxide catalyst gave 1-cyclohexylperhydropyrido[2,1-*a*]isoindol-6-one (**21**) as a white crystalline solid, $C_{18}H_{29}NO$, m.p. 77—79 °C ($\nu_{max.}$ 1 680 cm^{-1}).

The mechanism proposed for the formation of 1,2,3,10b-tetrahydro-10b-hydroxy-1-phenylpyrido[2,1-*a*]isoindol-6(4*H*)-one (**11**) and 2,3,4,4a-tetrahydro-4a-phenylindeno-[1,2-*b*]pyridin-5-one (**14**) is outlined in the Scheme.

Hydrazinolysis of 2-Phenyl-2-(4-phthalimidobutyl)indan-1,3-dione.—The reaction between 2-phenyl-2-(4-phthalimidobutyl)-indan-1,3-dione (**3**) and hydrazine hydrate in boiling ethanol afforded a mixture of products which was separated by column chromatography over Woelm neutral alumina (grade III). The first fraction, eluted with ether, afforded 2,3,4,5-tetrahydro-5a-phenylindeno[1,2-*b*]azepin-6(5a*H*)-one (**15**) as a white crystalline solid, m.p. 107—110 °C. The i.r. spectrum exhibited bands at 1 720 and 1 659 cm^{-1} indicative of the CO and CN functions respectively.

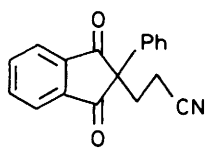
Reduction of 2,3,4,5-tetrahydro-5a-phenylindeno[1,2-*b*]-azepin-6(5a*H*)-one (**15**) with sodium borohydride in ethanol afforded an orange oil, purification of which by column chromatography over Woelm neutral alumina (grade IV), afforded the expected 1,2,3,4,5,6-hexahydro-6-hydroxy-5a-phenylindeno[1,2-*b*]azepine (**22**).

The second fraction in the chromatographic separation of the products of hydrazinolysis of (**3**), eluted with ether–chloroform, afforded in moderate yield 2,3,4,5-tetrahydro-1-phenylazepino[2,1-*a*]isoindol-7-one (**18**) as a yellow crystalline solid, $C_{19}H_{17}NO$, m.p. 125—127 °C ($\nu_{max.}$ 1 680 cm^{-1}, amide function). The n.m.r. spectrum of (**18**) showed an eight proton multiplet at δ 7.0—7.8 attributed to the aromatic ring protons, and a 1 H doublet at δ 6.22 due to 11-H. This latter signal is at much higher field than those absorptions from the other aromatic protons, presumably as a result of the shielding effect of the phenyl substituent. The 5-H and 2-H signals appeared as multiplets at δ 4.18 and 2.85 respectively and the C-3 and C-4 methylene protons at δ 1.9—2.3.

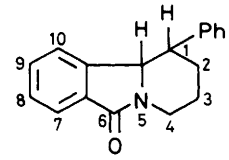
The formation of 2,3,4,5-tetrahydro-1-phenylazepino[2,1-*a*]-isoindol-7-one (**18**) suggests that the hydrazinolysis proceeds *via* the ring-expanded 3,4,5,6-tetrahydro-8-hydroxy-7-phenylbenz[3,4]azecin-1(2*H*)-one intermediate (**9**), which undergoes a transannular cyclisation reaction to afford (**12**), the dehydration of which affords (**18**) (Scheme).

Discussion of Hydrazinolysis Reactions.—No medium-sized ring heterocycles (**7**), (**8**), and (**9**) have been obtained by the hydrazinolysis of the 2-phenyl-2-(phthalimidoalkyl)indan-1,3-diones (**1**)—(**3**). The isolation of products (**10**), (**11**), and (**18**) from (**1**), (**2**), and (**3**) respectively, however, demonstrates the occurrence of these as intermediates.

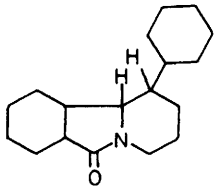
The carbinolamines (**4**), (**5**), and (**6**) may either undergo dehydration to (**13**), (**14**), and (**15**) or a ring expansion to (**7**), (**8**), and (**9**) followed by transannular cyclisation to (**10**), (**11**), and (**12**). The results described in this paper show that the relative amounts of the products (**13**), (**14**), and (**15**):(**10**), (**11**), and (**12**) depend on *n* in the general structure (**4**), (**5**), and (**6**) (Table). Whereas hydrazinolysis of 2-phenyl-2-(2-phthalimidoethyl)-indan-1,3-dione (**1**) gave only (**10**) arising from ring expansion of (**4**) followed by transannular cyclisation reaction, the hydrazinolysis of 2-phenyl-2-(3-phthalimidopropyl)indan-1,3-dione (**2**) gave the analogous product (**11**) together with 2,3,4,4a-tetrahydro-4a-phenylindeno[1,2-*b*]pyridin-5-one (**14**) as a minor product, obtained by loss of water from the carbinolamine intermediate (**5**). Ring expansion of the carbinolamine (**4**) containing two fused 5-membered rings to the



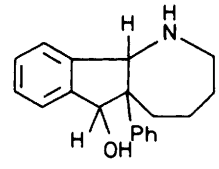
(**19**)



(**20**)



(**21**)



(**22**)

Table. Reaction pathway of the carbinolamine intermediates (**4**), (**5**), and (**6**) in the hydrazinolysis of 2-phenyl-2-(phthalimidoalkyl)indan-1,3-diones (**1**)—(**3**)

		Reaction products from the carbinolamine intermediates	
n In general structures (**4**)—(**6**)	Carbinolamine	Product arising from ring expansion followed by transannular cyclisation reaction	Product arising from dehydration of carbinolamine
1	(**4**)	Sole product (**10**)	No product (**13**)
2	(**5**)	Major product (**11**)	Minor product (**14**)
3	(**6**)	Minor product (**18**)	Major product (**15**)

8-membered ring intermediate (**7**) is favoured possibly because of ring fusion strain or steric interactions in such a system. In the case of the carbinolamine (**5**), however, ring expansion gives a 9-membered ring intermediate (**8**), whereas dehydration gives a 5/6 ring fused system (**14**), which is presumably not as strained or sterically unfavourable as the 5/5 ring fused system (**13**).

In contrast to (**1**) and (**2**), the hydrazinolysis of 2-phenyl-2-(4-phthalimidobutyl)indan-1,3-dione (**3**) produces moderate yields of 2,3,4,5-tetrahydro-1-phenylazepino[2,1-*a*]isoindol-7-one (**18**), but 2,3,4,5-tetrahydro-5a-phenylindeno[1,2-*b*]azepin-6(5a*H*)-one (**15**) as the major product.

Compound (**6**) contains a 5/7 fused system and the presence of the larger ring will reduce any ring fusion strain present in (**4**) and (**5**). Accordingly, the drive to ring expansion is reduced and dehydration to (**15**) is preferred.

Experimental

Elemental analyses were carried out at the Butterworth Microanalytical Laboratory, Teddington, Middlesex, Glaxo Group Research Ltd., Analytical Research Department, and Portsmouth Polytechnic Analytical Service. I.r. spectra were recorded on a Perkin-Elmer (SP 197) spectrometer in either deuteriochloroform or chloroform, unless otherwise stated. ^{1}H N.m.r. spectra were determined at 60 MHz with a Varian T60 spectrometer and/or at 90 MHz with an EM 390 spectrometer, and/or at 270 MHz with a Bruker Spectrospin WH-270 spectrometer. The solutions employed for recording the spectra at 60 MHz and/or 90 MHz and/or 270 MHz were in deuteriochloroform, deuteriobenzene, deuteriodimethyl sulphoxide unless otherwise stated, with tetramethylsilane as internal standard; assignments of hydroxy protons were checked by deuterium exchange. U.v. spectra were recorded on a Pye-Unicam spectrometer (SP 800A) in solutions of absolute alcohol or methanol.

Column chromatography was carried out with Woelm neutral alumina. Woelm neutral alumina of Brockmann activity 1 was deactivated as required by addition of the appropriate amount of distilled water, the alumina being allowed to stand for 2 h.

Melting points were determined in sealed tubes and are uncorrected.

N-(3-*Bromopropyl*)*phthalimide*.—Potassium phthalimide (206.5 g) was added portionwise over a 4 h period to 1,3-dibromopropane (300 g) in acetone (700 ml), and the resulting reaction mixture heated under reflux for 30 h. The potassium bromide deposited on cooling was filtered off, and the filtrate evaporated. Repeated recrystallisation of the residue from light petroleum (b.p. 40—60 °C) gave *N*-(3-bromopropyl)-phthalimide as a crystalline solid (175 g, 59%), m.p. 72 °C (lit.,[2] 72 °C).

2-*Phenyl*-2-(3-*phthalimidopropyl*)*indan*-1,3-*dione* (**2**).—2-Phenylindan-1,3-dione (44.4 g) and sodium iodide (30 g) were added to a solution of sodium (4.6 g) in n-propanol (200 ml). The mixture was stirred and boiled under reflux for 1.5 h, after which time *N*-(2-bromopropyl)phthalimide (53.6 g) was added portionwise to the reaction mixture and the whole stirred and boiled under reflux for 18 h. The cooled reaction mixture was then poured into water, and the precipitate formed was filtered off, dried, and washed with ether. Repeated recrystallisation from dichloromethane gave 2-*phenyl*-2-(3-*phthalimidopropyl*)-*indan*-1,3-*dione* as an off-white crystalline solid (42 g, 51%), m.p. 124—124.5 °C, $\nu_{max.}$($CHBr_3$) 1 772, 1 745, and 1 710 cm^{-1}; $\lambda_{max.}$(MeOH) 225, 240infl. and 250infl. nm; δ($CDCl_3$) 7.6—8.1 (8 H, m, ArH), 7.2—7.5 (5 H, m, ArH), 3.6 (2 H, t, CH_2N), 2.2—2.6 (2 H, m, $CH_2CH_2CH_2N$), and 1.4—2.0 (2 H, m, $CH_2CH_2CH_2N$) (Found: C, 76.1; H, 4.7; N, 3.6. $C_{26}H_{19}NO_4$ requires C, 76.3; H, 4.7; N, 3.4%).

N-(4-*Bromobutyl*)*phthalimide*.—A mixture of 1,4-dibromobutane (100 g) and potassium phthalimide (64.4 g) was heated under reflux for 24 h in acetone (500 ml). The potassium bromide formed was filtered off and the solvent evaporated to leave a white solid. Repeated recrystallisation of this from light petroleum (b.p. 40—60 °C) gave *N*-(4-bromobutyl)phthalimide as a crystalline solid (31 g, 32%), m.p. 77—78 °C (lit.,[3] 76—78 °C), $\nu_{max.}$($CHBr_3$) 1 772, 1 740, 1 710, 765, and 720 cm^{-1}; δ($CDCl_3$) 7.6—8.1 (8 H, m, ArH), 7.2—7.6 (5 H, m, ArH), 3.58 (2 H, t, CH_2CH_2N), 2.32 (2 H, m, $BrCH_2CH_2$) and 1.1—1.9, (4 H, m, $CH_2CH_2CH_2CH_2N$).

2-*Phenyl*-2-(4-*phthalimidobutyl*)*indan*-1,3-*dione* (**3**).—2-Phenylindan-1,3-dione (26 g), *N*-(4-bromobutyl)phthalimide (33 g), and sodium iodide (17.6 g) were added to a solution of sodium (2.7 g) in n-propanol (150 ml), and the resulting mixture was stirred and boiled under reflux for 8 h. The cooled solution was poured into water, and the precipitate formed was filtered off, washed with ether, dried, and recrystallised from dichloromethane to give 2-*phenyl*-2-(4-*phthalimidobutyl*)*indan*-1,3-*dione* as a pale orange crystalline solid (39 g, 78.7%), m.p. 167—168 °C, $\nu_{max.}$($CHBr_3$) 1 772, 1 740, and 1 710 cm^{-1}; δ($CDCl_3$) 7.6—8.1 (8 H, m, ArH), 7.2—7.6 (5 H, m, ArH), 3.5 (2 H, t, $-CH_2N$), 2.1—2.5 [2 H, m, $CH_2(CH_2)_2CH_2N$], and 1.1—1.9 (4 H, m, $CH_2CH_2CH_2CH_2N$) (Found: C, 76.2; H, 4.9; N, 3.3. $C_{27}H_{21}NO_4$ requires C, 76.6; H, 4.9; N, 3.3%).

Hydrazinolysis of 2-*Phenyl*-2-(3-*phthalimidopropyl*)*indan*-1,3-*dione*.—2-Phenyl-2-(3-phthalimidopropyl)indan-1,3-dione (20 g) was stirred and heated under reflux with hydrazine hydrate (6 ml) in ethanol (500 ml) for 1 h. The phthalhydrazide formed on cooling was filtered off and the filtrate evaporated to dryness. Chromatographic separation of the residue (10 g) over a silica column using ether as eluant gave 1,2,3,10b-*tetrahydro*-10b-*hydroxy*-1-*phenylpyrido*[2,1-a]*isoindol*-6(4H)-*one* (**11**) as a white crystalline solid (3 g), m.p. 224—225 °C, $\nu_{max.}$($CHBr_3$) 3 560, 3 320, 1 680, and 1 600 cm^{-1}; δ[$(CD_3)_2SO$] 7.1—7.7 (8 H, m, ArH), 6.5 (1 H, s, OH), 6.3 (1 H, d, ArH), 4.1 (1 H, $J_{4_{ax}.4_{eq}}$ −12.5, $J_{4_{eq}.3_{ax}}$ 3.75 Hz, 4_{eq}-H, 3.15 (1 H, $J_{4_{ax}.4_{eq}} = J_{4_{ax}.3_{ax}} = 12.5$

Hz, 4_{ax}-H, 2.5 (1 H, m, 1_{ax}-H), 2.35 (1 H, $J_{2_{ax},2_{eq}} = J_{2_{ax},1_{ax}} = J_{2_{ax},3_{ax}} = 12.5$ Hz, $J_{2_{ax},3_{eq}} = 3.75$ Hz, 2_{ax}-H), 1.6—2.0 (2 H, m, 2_{eq}-H, 3_{eq}-H), and 1.45 (1 H, m, 3_{ax}-H) (Found: C, 77.5; H, 6.2; N, 5.2. $C_{18}H_{17}NO_2$ requires C, 77.4; H, 6.1; N, 5.0%).

A second fraction eluted with ether gave 2,3,4,4a-*tetrahydro*-4a-*phenylindeno*[1,2-b]*pyridin*-5-*one* (**14**) as a yellow crystalline solid (1.5 g), m.p. 95—96 °C, $\nu_{max.}$(CDCl$_3$) 1 720, 1 660, and 1 600 cm^{-1}; $\lambda_{max.}$(EtOH) 205infl., 228 and 250infl. nm; δ(CDCl$_3$) 7.2—8.2 (9 H, m, ArH), 3.95 (2 H, t, CH_2N), 2.4—2.8 [2 H, m, C(Ph)CH_2], and 1.45—2.2 (2 H, m, $CH_2CH_2CH_2$) (Found: C, 82.9; H, 5.9; N, 5.4. $C_{18}H_{15}NO$ requires C, 82.7; H, 5.8; N, 5.4%).

A third fraction eluted with ether gave 2,3-*dihydro*-1-*phenylpyrido*[2,1-a]*isoindol*-6(4H)-*one* (**17**) as a pale yellow crystalline solid (0.5 g), m.p. 142 °C (Found: C, 82.6; H, 5.9; N, 5.3. $C_{18}H_{15}NO$ requires C, 82.7; H, 5.8; N, 5.4%).

2,3-*Dihydro*-1-*phenylpyrido*[2,1-a]*isoindol*-6(4H)-*one* (**17**).—1,2,3,10b-Tetrahydro-10b-hydroxy-1-phenylpyrido[2,1-*a*]isoindol-6(4*H*)-one (2 g) was suspended in concentrated hydrochloric acid (120 ml) and warmed on a water-bath for 25 min. The yellow solid formed was filtered off, washed with water, dried and recrystallised from ethyl acetate to give 2,3-dihydro-1-phenylpyrido[2,1-*a*]isoindol-6(4*H*)-one as a pale yellow crystalline solid (1 g), m.p. 142 °C, $\nu_{max.}$(Nujol) 1 690 and 1 660 cm^{-1}; δ(CDCl$_3$) 7.87 (1 H, m, ArH), 7.1—7.6 (2 H, m, ArH), 7.47 (5 H, s, ArH), 6.8 (1 H, m, ArH), 3.9 (2 H, t, CH_2N), 2.75 [2 H, t, C(Ph)CH_2], and 2.2 (2 H, m, $CH_2CH_2CH_2N$) (Found: C, 82.5; H, 5.9; N, 5.2. $C_{18}H_{15}NO$ requires C, 82.7; H, 5.8; N, 5.4%).

1,2,3,10b-*Tetrahydro*-1-*phenylpyrido*[2,1-a]*isoindol*-6(4H)-*one* (**20**).—2,3-Dihydro-1-phenylpyrido[2,1-*a*]isoindol-6(4*H*)-one (1.5 g) was dissolved in ethanol (70 ml) and hydrogenated at 1 atm over Raney nickel catalyst (0.3 g, W2), until absorption ceased after 20 h. The catalyst was filtered off and the filtrate evaporated to give a white solid. Recrystallisation from methanol gave 1,2,3,10b-*tetrahydro*-1-*phenylpyrido*[2,1-a]*isoindol*-6(4H)-*one* (**20**) as a white solid (1.2 g, 80%), m.p. 212—214 °C; $\nu_{max.}$(CHBr$_3$) 1 675 and 750 cm^{-1}; $\lambda_{max.}$(MeOH) 232 (ε 9 300), 250 (5 900), and 281 nm (1 800); δ(CDCl$_3$) 6.8—7.8 (9 H, m, ArH), 4.75 (1 H, d, $J_{10b_{ax},1_{ax}} = 5.3$, 10b-H), 4.65 (1 H, m, $J_{4_{ax},4_{eq}} = 12$ Hz, 4_{eq}-H), 3.7 (1 H, $J_{1_{ax},2_{ax}} = 5.3$, $J_{1_{ax},2_{eq}} = 3.4$ Hz, 1_{ax}-H), 3.17 (1 H, $J_{4_{ax},4_{eq}} = J_{4_{ax},3_{ax}} = 12$, $J_{4_{ax},3_{eq}} = 6$ Hz, 4_{ax}-H), and 1.5—2.5 [4 H, m, C(2)H$_2$, C(3)H$_2$] (Found: C, 82.4; H, 6.4; N, 5.3. $C_{18}H_{17}NO$ requires C, 82.1; H, 6.5; N, 5.3%).

1-*Cyclohexylperhydropyrido*[2,1-a]*isoindol*-6-*one* (**21**).—2,3-Dihydro-1-phenylpyrido[2,1-*a*]isoindol-6(4*H*)-one (0.9 g) was dissolved in methanol (400 ml). Concentrated hydrochloric acid (2 ml) was added to the solution, and the reaction mixture hydrogenated at atmospheric pressure using an excess of Adams platinum oxide catalyst for 48 h. The catalyst was then filtered off, and the filtrate evaporated to dryness to afford a white solid. Repeated recrystallisation from ether gave 1-*cyclohexylperhydropyrido*[2,1-a]*isoindol*-6-*one* as a white crystalline solid (0.6 g), m.p. 79—79.5 °C, $\nu_{max.}$(CDCl$_3$) 1 680 cm^{-1}; $\lambda_{max.}$(EtOH) 215 nm; δ(CDCl$_3$) 3.6—4.2 (2 H, m, CH_2N) (Found: C, 78.3; H, 10.4; N, 5.1. $C_{18}H_{29}NO$ requires C, 78.5; H, 10.6; N, 5.1%).

2-(2-*Cyanoethyl*)-2-*phenylindan*-1,3-*dione* (**19**).—2-Phenylindan-1,3-dione (10 g) dissolved in benzene (50 ml) was treated with triethylamine (6.3 ml) and acrylonitrile (3.6 ml), and the solution heated under reflux for 24 h. After the mixture had cooled to room temperature, the organic layer was washed with 2M-NaOH (3 × 10 ml), 2M-hydrochloric acid (10 ml), and water (10 ml). The dried ($MgSO_4$) benzene layer was evaporated to yield a gum which was recrystallised from ethanol to give 2-(2-*cyanoethyl*)-2-*phenylindan*-1,3-*dione* as a pale yellow crystalline solid (20 g, 54%), m.p. 74 °C, $\lambda_{max.}$(EtOH) 228 nm; $\nu_{max.}$(CHCl$_3$) 1 710, 1 740, 1 600, and 2 250; δ(CDCl$_3$) 7.8—8.2 (4 H, m, ArH), 7.3—7.6 (5 H, m, ArH), and 2.5 (4 H, s, CH_2CH_2) (Found: C, 78.7; H, 4.7; N, 5.0. $C_{18}H_{13}NO_2$ requires C, 78.5; H, 4.8; N, 5.1%).

1,2,3,10b-*Tetrahydro*-10b-*hydroxy*-1-*phenylpyrido*[2,1-a]*isoindol*-6(4H)-*one* (**11**).—2-(2-Cyanoethyl)-2-phenylindan-1,3-dione (2 g) was dissolved in ethanol (100 ml) and Raney nickel catalyst was added. The mixture was shaken under hydrogen at 1 atm for 11 h. The catalyst was filtered off and the filtrate evaporated to yield a red gum. The gum was dissolved in ethyl acetate and the solution washed with 2M-hydrochloric acid and 2M-sodium hydroxide, dried ($MgSO_4$), and evaporated to yield a gum. Repeated recrystallisation from ethanol afforded 1,2,3,10b-*tetrahydro*-10b-*hydroxy*-1-*phenylpyrido*[2,1-a]*isoindol*-6(4H)-*one* as a white crystalline solid (0.25 g), m.p. 224 °C (Found: C, 77.5; H, 6.2; N, 5.1. $C_{18}H_{17}NO_2$ requires C, 77.4; H, 6.1; N, 5.0%).

Hydrazinolysis of 2-*Phenyl*-2-(4-*phthalimidobutyl*)*indan*-1,3-*dione*.—2-Phenyl-2-(4-phthalimidobutyl)indan-1,3-dione (27 g) was stirred and heated under reflux with hydrazine hydrate (6 ml) in ethanol (400 ml) for 1.5 h. The phthalhydrazide formed on cooling was filtered off and the solvent evaporated to dryness. Column chromatography of the residue (10 g) over Woelm neutral alumina (grade III) afforded 2,3,4,5-*tetrahydro*-5a-*phenylindeno*[1,2-b]*azepin*-6(5aH)-*one* (**15**) as a white crystalline solid (4.1 g), m.p. 108—110 °C; $\nu_{max.}$(CHBr$_3$) 1 720, 1 659, 770, and 748 cm^{-1}; $\lambda_{max.}$(EtOH) 232 (ε 42 600) and 253 nm (15 000); δ(CDCl$_3$) 8.21 (1 H, d, ArH), 7.5—8.0 (3 H, m, ArH), 7.3 (5 H, s, ArH), 4.12 (1 H, $J_{2_{eq},2_{ax}}$ 12, $J_{2_{eq},3_{ax}}$ 5 Hz, 2_{eq}-H), 3.35 (1 H, $J_{2_{ax},3_{ax}}$ 12 Hz, 2_{ax}-H), 2.75 (1 H, $J_{5_{ax},5_{eq}}$ −12, $J_{5_{eq},4_{ax}}$ 5 Hz, 5_{eq}-H), and 1.4—2.1 [5 H, m, 5_{ax}-H, C(3)-H$_2$, C(4)-H$_2$] (Found: C, 82.6; H, 6.2; N, 5.0. $C_{19}H_{17}NO$ requires C, 82.8; H, 6.2; N, 5.0%).

A second fraction eluted with ether–chloroform afforded 2,3,4,5-*tetrahydro*-1-*phenylazepino*[2,1-a]*isoindol*-7-*one* (**18**) as an orange solid (0.3 g), m.p. 137—138 °C, $\nu_{max.}$(CDCl$_3$) 1 680 cm^{-1}; δ(CDCl$_3$) 6.22—7.8 (9 H, m, ArH), 4.18 (2 H, m, NCH_2CH_2), 2.85 (2 H, m, $PhCCH_2CH_2$), and 1.9—2.3 (4 H, m, $CH_2CH_2CH_2CH_2$); *m/z* 275 (M^+), 247 ($M^+ - CH_2{=}CH_2$), 219 ($M^+ - CH_2{=}CH_2CH_2{=}CH_2$), and 191 ($M^+ - CH_2{=}CH_2CH_2{=}CH_2CO$) (Found: C, 82.7; H, 6.3; N, 5.0. $C_{19}H_{17}NO$ requires C, 82.8; H, 6.2; N, 5.0%).

1,2,3,4,5,6-*Hexahydro*-6-*hydroxy*-5a-*phenylindeno*[1,2-b]*azepine* (**22**).—Sodium borohydride (0.05 g) was added to a solution of 2,3,4,5-tetrahydro-5a-phenylindeno[1,2-*b*]azepin-6(5a*H*)-one (0.1 g) in ethanol (20 ml), and the mixture was stirred at room temperature for 4 h. After the gradual addition of water, the ethanol was distilled off and the mixture extracted with ethyl acetate. Solvent evaporation gave a brown oil. Chromatographic separation over a silica column using ether as eluant gave 1,2,3,4,5,6-*hexahydro*-6-*hydroxy*-5a-*phenylindeno*[1,2-b]*azepine* as an orange oil (0.05 g), $\nu_{max.}$(CHBr$_3$) 3 550 and 1 060 cm^{-1}; δ(CDCl$_3$) 6.9—7.7 (9 H, m, ArH), 4.9 (1 H, s, 10a-H), 4.72 (1 H, s, 6-H), 3.3—3.6 (1 H, m, 2-H), 2.9—3.1 (1 H, m, 5-H), and 1.5—2.2 (7 H, m) (Found: C, 81.4; H, 7.6; N, 5.0. $C_{19}H_{21}NO$ requires C, 81.7; H, 7.5; N, 5.0%).

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