Stereoselective construction of vicinal diamines. Part 3.[1] Routes to the benz[*f*]indeno[1,7-*bc*]azepine and benz[*e*]indeno[2,1-*b*][1,4]-diazepine ring systems

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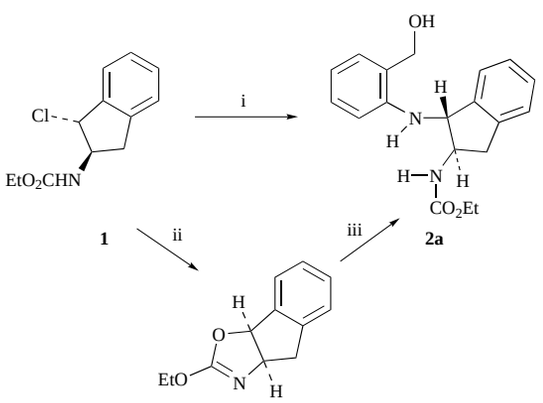
The *trans*-1-anilino-2-aminoindane derivative 2a derived from the adduct 1 of indene and *N*,*N*-dichlorourethane is suitably functionalised for further elaboration to give novel fused ring systems. This report describes the use of 2a to provide access to the benz[*f*]indeno[1,7-*bc*]azepines 4a,b and the benz[*e*]indeno[2,1-*b*][1,4]diazepines 5a,b. Further elaboration of 4a affords a route to the diazabenzo[5,6]cyclohepta[*def*]fluorene 9.

Vicinal diamine functionality is present in a variety of biologically active molecules.[2] In previous reports[3,4] we described a stereoselective synthesis of *trans*-1-anilino-2-aminoindane derivatives which relied on the reaction of an appropriate aniline with the *trans* adduct **1**[5] derived from indene and *N*,*N*-dichlorourethane (Scheme 1).† For example, the 2-

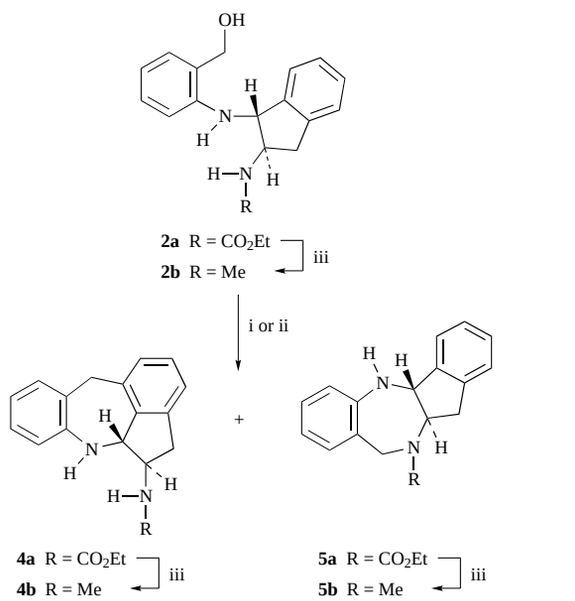


Scheme 1 *Reagents and conditions:* i, 2-aminobenzyl alcohol, $BaCO_3$, DMF, 85 °C; ii, K_2CO_3, EtOH–H_2O; iii, 2-aminobenzyl alcohol, toluene, toluene-*p*-sulfonic acid, 45–50 °C

hydroxymethylanilino derivative **2a** was obtained in moderate yield (51%) from the reaction of **1** with 2-aminobenzyl alcohol in the presence of barium carbonate. In addition, it was shown that the reaction proceeds *via* an oxazolinium species. This observation provides the basis for an alternative procedure, since the dihydrooxazole **3** can be generated from **1** in near quantitative yield under mild basic conditions, and then alkylated with a suitably substituted aniline employing acid catalysis. Using this protocol **2a** can be prepared from **3** in 60% yield. The carbamate **2a** is suitably functionalised for further elaboration to give fused ring systems. This report describes the use of this key intermediate to provide access to the novel benz[*f*]indeno-[1,7-*bc*]azepine and benz[*e*]indeno[2,1-*b*][1,4]diazepine ring systems.

Cyclisation of **2a** with methanesulfonic acid and phosphorus pentoxide[6] afforded two products (Scheme 2) which were readily separable by chromatography on silica gel. The lower R_f component was identified as the benz[*f*]indeno[1,7-*bc*]azepine

† For convenience only one enantiomer is shown in diagrams.



Scheme 2 *Reagents and conditions:* i, $MeSO_3H$–P_2O_5; ii, PPh_3, CBr_4, room temperature; iii, $LiAlH_4$, Et_2O

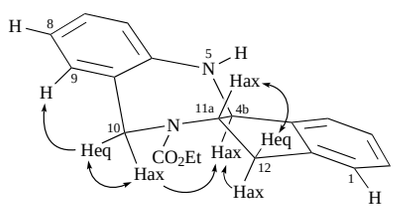
4a which arises from the anticipated intramolecular Friedel–Crafts alkylation reaction. The higher R_f component was found to be the benz[*e*]indeno[2,1-*b*][1,4]diazepine **5a** which presumably results from a competing pathway involving capture of the benzylic carbocation intermediate by the carbamate nitrogen. The ratio of the two products was found to be dependent on the reaction temperature. At room temperature the reaction proceeded slowly, requiring up to 7 days to reach completion, and the benz[*f*]indeno[1,7-*bc*]azepine **4a** was the predominant product. Isolated yields of **4a** and **5a** were 24 and 17% respectively. Increasing the reaction temperature to 65 °C resulted in complete reaction after 1 h. However, under these conditions the product ratio was reversed. The benz[*e*]indeno[2,1-*b*][1,4]-diazepine **5a** was isolated as the major product (31% yield) together with a lower yield (17%) of the benz[*f*]indeno[1,7-*bc*]-azepine **4a**.

The structure of **5a** was confirmed by ^{1}H NMR and ^{13}C NMR spectroscopy in [^{2}H]$_6$DMSO solution. The ^{1}H NMR spectrum (Table 1) was fully assigned on the basis of COSY 45 and heteronuclear multiple quantum coherence (HMQC) experiments. All experiments were acquired on a Bruker AMX 400 spectrometer. A series of one-dimensional NOE difference

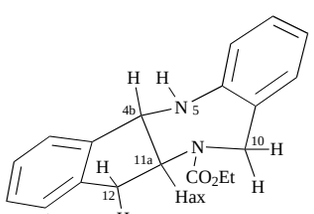
Table 1 ^{1}H NMR spectroscopic data for diazepine **5a**[a] relative to TMS at 0.00 ppm

Assignments	δ (ppm)	Multiplicity (J ± 0.4 Hz)
CH_3	1.19	t (^3J = 7.1)
12ax-H	2.81	dd ($^2J_{12ax–12eq}$ = 14.6, $^3J_{12ax–11a}$ = 10.5)
12eq-H	3.31	dd ($^2J_{12eq–12ax}$ = 14.6, $^3J_{12eq–11a}$ = 6.7)
OCH_2	4.06	m
11a-H	4.15	ddd ($^3J_{11a–12ax}$ = 10.5, $^3J_{11a–12eq}$ = 6.7, $^3J_{11a–4b}$ = 10.5)
10eq-H	4.55	d ($^2J_{10eq–10ax}$ = 15.5)
10ax-H	5.28	d ($^2J_{10ax–10eq}$ = 15.5)
4b-H	5.69	d ($^3J_{4b–11a}$ = 10.5)
N5-H	6.16	d ($^3J_{N5–4b}$ = 4.2)
C8-H	6.53	ddd ($^3J_{8–9}$ = 7.5, $^3J_{8–7}$ = 7.5, $^4J_{8–6}$ = 1.3)
C6-H	6.82	dd ($^3J_{6–7}$ = 7.9, $^4J_{6–8}$ = 1.3)
C9-H	6.90	dd ($^3J_{9–8}$ = 7.5, $^4J_{9–7}$ = 1.3)
C7-H	7.00	ddd ($^3J_{7–6}$ = 7.9, $^3J_{7–8}$ = 7.5, $^4J_{7–9}$ = 1.3)
C1-H, C2-H, C3-H	7.24–7.32	m
C4-H	7.53	d ($^3J_{4–3}$ = 6.7)

[a] 400 MHz spectrum in $[^2H]_6$DMSO.



major conformer



minor conformer

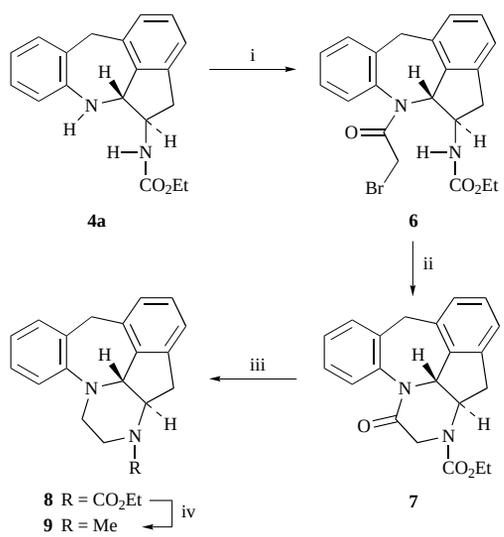
Fig. 1 Conformers of **5a** showing nuclear Overhauser enhancements

experiments produced several large positive enhancements which revealed the conformation of **5a**. A number of small negative enhancements were also observed due to indirect NOEs arising from three-spin systems,[7] and these provided valuable additional information. Irradiation of 4b-H produced a large NOE at the 10-H proton at δ 5.28 (10ax-H), with a three-spin effect at the 10-H proton at δ 4.55 (10eq-H). This suggests that 4b-H and the 10-H proton at δ 5.28 (10ax-H) adopt a pseudo-axial orientation which brings them into close proximity. Irradiation of 10ax-H at δ 5.28 produced a large NOE at 4b-H as well as at 10-H at δ 4.55 (10eq-H). The NOE at 10-H at δ 4.55 (10eq-H) gave rise to a three-spin effect at the aromatic doublet corresponding to 9-H. Irradiation of 10-H at δ 4.55 (10eq-H) gave large enhancements at 9-H (with a negative enhancement at 8-H) and at 10ax-H (with a negative enhancement at 4b-H). These data are consistent with the 10-H at δ 4.55 lying in the same plane as 9-H, that is pseudo-equatorially. When 9-H was irradiated, large NOEs at 8-H and 10eq-H were observed with a three-spin effect negative enhancement at 10ax-H. These results all indicate that the diazepine ring favours a distorted boat-like conformation (Fig. 1), where 4b-H and 10ax-H adopt a *syn*-orientation. Some of the NOE data pointed to contributions from a minor conformer (Fig. 1). Irradiation of the 10-H signal at δ 4.55 produced a small NOE at 12ax-H which is consistent with flipping of the diazepine ring into a chair-like conformation. The reverse NOE was also observed.

Further experiments provided confirmation of the relative orientation of 12ax-H and 4b-H. Irradiation of the 12-H signal at δ 2.81 (12ax-H) gave a large NOE at 4b-H, showing that these two protons are *cis* and pseudo-axial. Proton 4b-H also gave an NOE at the 12-H proton at δ 2.81 (12ax-H). When 12-H at δ 3.31 (12eq-H) was irradiated, an NOE was observed at 12ax-H, but not at 4b-H, showing that the irradiated proton is pseudo-equatorial and *cis* to 12a-H. Proton 12ax-H also gave an NOE at 12eq-H. These results are consistent with a *trans* relationship between 12ax-H and 4b-H.

Reduction of **4a** and **5a** with lithium aluminium hydride afforded the *N*-methylamines **4b** and **5b** respectively. Cyclisation of the diamine **2b**, obtained by reduction of **2a** with lithium aluminium hydride,[4] was examined under two different sets of conditions in order to explore the scope for achieving more selective routes to **4b** and **5b**. Treatment of **1b** with methanesulfonic acid and phosphorus pentoxide afforded the benz[*f*]indeno[1,7-*bc*]azepine **4b** in low yield (11%). Use of triphenyl phosphine–carbon tetrabromide[8] to activate the benzylic hydroxy group to attack from the methylamino group afforded the benz[*e*]indeno[2,1-*b*][1,4]diazepine **5b**, but the yield was disappointingly low.

Elaboration of **4a** by incorporation of the vicinal diamine functionality into a piperazine ring provided access to the diazabenzo[5,6]cyclohepta[*def*]fluorene ring system (Scheme 3). The piperazine ring was constructed by acylation of the



Scheme 3 *Reagents and conditions:* i, $BrCH_2COCl$, K_2CO_3, CH_2Cl_2, ii, NaH, DMF; iii, diborane, THF; iv, $LiAlH_4$, THF

anilinic nitrogen of **4a** with α-bromoacetyl bromide to give **6** which cyclised readily using sodium hydride in *N*,*N*-dimethylformamide to afford the lactam **7**. Reduction of the lactam carbonyl with diborane followed by treatment with lithium aluminium hydride afforded **9**. This approach complements the route described in an earlier report[4] where formation of the piperazine ring was effected prior to intramolecular cyclisation to form the azepine ring. Spectral data recorded for **9** were identical to those reported previously.

In summary, this study demonstrates the versatility of the *N*,*N*-dichlorourethane based methodology for the construction of complex fused ring systems incorporating vicinal diamine functionality. Use of this approach provides rapid access to the benz[*f*]indeno[1,7-*bc*]azepine **4a** and the benz[*e*]indeno[2,1-*b*]-[1,4]diazepine **5a** while further elaboration leads to the diazabenzo[5,6]cyclohepta[*def*]fluorene ring system. The structure of **5a** was confirmed by NMR studies which suggest that the diazepine ring favours a distorted boat-like conformation.

Experimental

Melting points were obtained on a Kofler hot stage apparatus

and are uncorrected. NMR spectra were recorded on a Varian CFT-20, a JEOL GX-270, a Bruker WM-250 or a Bruker AMX-400 spectrometer using tetramethylsilane as internal standard. *J* Values are given in Hz. Mass spectra were obtained on an AEI MS9 (70 eV) or a JEOL DX303 (70 eV) spectrometer and infra-red spectra on a Perkin-Elmer 197 spectrometer. All evaporations of solvent were carried out under reduced pressure, and organic solutions were dried over sodium sulfate. Silica gel used for column chromatography was Merck Kieselgel 60. Standard work-up for lithium aluminium hydride reductions involved quenching with wet diethyl ether followed by water and then filtration to remove precipitated aluminium salts. Light petroleum refers to the fraction with bp 60–80 °C. Ether refers to diethyl ether.

(1*R,2*R**)-2-Ethoxycarbonylamino-1-(2-hydroxymethylanilino)-indane 2a**

A mixture of *cis*-2-ethoxy-4,8b-dihydro-3a*H*-indeno[2,1-*d*]-oxazole **3**[4] (1.0 g, 5.0 mmol) and 2-aminobenzyl alcohol (0.615 g, 5.0 mmol) in dry toluene (20 cm^3) containing toluene-*p*-sulfonic acid (5 cm^3 of an anhydrous 0.1 M solution in benzene prepared by azeotropic distillation) was heated under argon at 45–50 °C for 1.5 h. The reaction was diluted with ethyl acetate and washed with water followed by brine. The dried organic layer was concentrated to give a foam. Purification by column chromatography on silica gel using light petroleum–ethyl acetate (3:1) as eluent afforded **2a** (0.98 g, 60%). Spectral characteristics were identical to those reported previously.[4]

(5*R,5a*R**)-5-Ethoxycarbonylamino-5,5a,6,11-tetrahydro-4*H*-benz[*f*]indeno[1,7-*bc*]azepine 4a and (4b*R**,11a*R**)-11-ethoxycarbonyl-4b,5,10,11,11a,12-hexahydrobenz[*e*]indeno[2,1-*b*]-[1,4]diazepine 5a**

Cyclisation of 2a at room temperature. A solution of alcohol **2a** (5.4 g, 0.0166 mol) in methanesulfonic acid (37 cm^3) was treated with phosphorous pentoxide (10.8 g) and stirred at room temperature for 7 days. The reaction mixture was poured onto ice, basified with dilute aqueous sodium hydroxide and extracted into ether. The dried extracts were concentrated to give a brown foam (5.8 g). TLC on silica using light petroleum–ethyl acetate (3:1) as eluent indicated two mobile products (R_f = 0.77 and 0.6). Purification by chromatography on silica gel using light petroleum–ethyl acetate (4:1) afforded the minor faster running component **5a** as a crystalline solid (0.88 g, 17%); mp 138–140 °C (from light petroleum–ethyl acetate) (Found: C, 74.0; H, 6.7; N, 9.1%. $C_{19}H_{20}N_2O_2$ requires C, 74.0; H, 6.5; N, 9.1%); ν_{max}(KBr)/cm^{-1} 3350 (NH), 1680 (C=O); δ_C(100 MHz; [^{2}H]$_6$DMSO) 14.4 (CH_3), 35.7 (12-C), 48.1 (10-C), 60.0 (4b-C), 60.7 (OCH_2), 69.4 (11a-C), 116.7, 116.9, 122.0, 122.3 (4-C), 124.7, 126.4, 127.4, 128.1, 131.0 (9-C), 138.7, 140.3, 146.8, 155.6; *m*/*z* 308 (M^+, 16%), 220 (18), 219 (86), 218 (100), 206 (11), 130 (13), 106 (18). The major slower running component **4a** was obtained as a pale brown crystalline solid (1.2 g, 24%); mp 94–98 °C (from pentane–ether) (Found: C, 74.2; H, 6.5; N, 9.1%. $C_{19}H_{20}N_2O_2$ requires C, 74.0; H, 6.5; N, 9.1%); ν_{max}(Nujol)/cm^{-1} 3280 and 3250 (NH), 1690 (C=O); δ_H(400 MHz; $CDCl_3$) 1.31 (3H, t, *J* 7, CH_3), 2.66 (1H, dd, *J* 15.2 and 10, 4-H), 3.19 (1H, dd, *J* 15.2 and 8, 4-H), 3.68 (1H, d, *J* 14.4, 11-H), 4.15 (4H, m, overlapping signals), 4.72 (1H, d, *J* 8, 5a-H), 5.09 (1H, d, *J* 7.6, exchanges with D_2O, NH), 6.70–7.30 (7H, m, aromatic); δ_C(20 MHz; $CDCl_3$) 14.61, 36.14, 38.69, 60.16, 61.32, 68.25, 120.29, 120.53, 122.40, 125.64, 127.46, 127.98, 128.12, 129.49, 137.70, 138.22, 138.47, 145.93, 157.36; *m*/*z* 308 (M^+, 8%), 220 (15), 219 (100), 218 (68), 217 (14).

Cyclisation of 2a at 65 °C. A solution of alcohol **2a** (3.31 g, 0.01 mol) in methanesulfonic acid (45 cm^3) was treated with phosphorous pentoxide (6.6 g) and heated at 65 °C for 1 h. The reaction mixture was poured onto ice, basified with dilute aqueous sodium hydroxide and extracted into ether. The dried extracts were concentrated to give a foam (1.2 g). Purification by chromatography on silica gel using light petroleum–ethyl acetate (6:1) afforded **5a** (0.95 g, 31%) and **4a** (0.51 g, 17%).

(5*R,5a*R**)-5-Methylamino-5,5a,6,11-tetrahydro-4*H*-benz[*f*]-indeno[1,7-*bc*]azepine 4b**

Method A: reduction of 4a. A solution of **4a** (1.17 g, 3.76 mmol) in dry tetrahydrofuran (20 cm^3) was added to a stirred suspension of lithium aluminium hydride (0.42 g, 11.0 mmol) in dry tetrahydrofuran (20 cm^3) under nitrogen. The mixture was refluxed for 1 h. Standard work-up afforded a dark oil (0.80 g, 85%); ν_{max}(film)/cm^{-1} 3320 (NH); δ_H(80 MHz; $CDCl_3$) 2.20–2.75 (5H, m, overlapping signals), 3.00–3.45 (2H, m, overlapping signals), 3.75 (1H, d, *J* 15, 11-H), 4.30 (1H, d, *J* 15, 11-H), 4.45 (1H, d, *J* 8, 5a-H), 6.65–7.30 (7H, m, aromatic); δ_C(20 MHz; $CDCl_3$) 34.16, 35.78, 38.60, 65.76, 69.38, 119.73, 120.29, 122.50, 125.00, 127.14, 127.42, 129.57, 130.99, 136.41, 138.85, 139.20, 146.32. Maleate salt mp 182–184 °C (from acetone–ether) (Found: C, 68.5, H, 6.1; N, 7.5%. $C_{21}H_{22}N_2O_4$ requires C, 68.8, H, 6.05, N, 7.6%).

Method B: cyclisation of 2b. A solution of alcohol **2b** (0.1 g, 0.37 mmol) in methanesulfonic acid (1 cm^3) was treated with phosphorous pentoxide (0.2 g) and the mixture was heated at 40 °C for 2 h and then at 60 °C for 5 h. The reaction mixture was poured onto ice, neutralised with dilute aqueous sodium hydroxide and then extracted into dichloromethane. Concentration of the dried extracts afforded an oil (80 mg) which was purified by preparative thin layer chromatography using toluene–ethyl acetate–methanol 3:1:1 as eluent to give **4b** (10 mg, 11%) identical by ^{1}H NMR to the product obtained in Method A; *m*/*z* 250 (M^+, 100%), 249 (30), 235 (15), 220 (28), 219 (59), 218 (70), 194 (80), 193 (20), 191 (12) (Found: M^+, 250.1473. $C_{17}H_{18}N_2$ requires *M*, 250.1470).

(4b*R,11a*R**)-11-Methyl-4b,5,10,11,11a,12-hexahydrobenz[*e*]-indeno[2,1-*b*][1,4]diazepine 5b**

Method A: reduction of 5a. A solution of carbamate **5a** (0.81 g, 2.63 mmol) in dry tetrahydrofuran (15 cm^3) was added to a suspension of lithium aluminium hydride (0.3 g, 7.89 mmol) in tetrahydrofuran (5 cm^3) stirred under nitrogen. The mixture was heated under reflux for 75 min. After standard work-up the crude oil (0.71 g) was purified by chromatography on silica gel using a graded eluent of 40–50% ethyl acetate in light petroleum to give diamine **5b** (0.44 g, 67%); mp 83–85 °C (from pentane–ether) (Found: C, 81.2, H, 7.3, N, 11.3%. $C_{17}H_{18}N_2$ requires C, 81.6, H, 7.25, N, 11.2%); *m*/*z* 250 (M^+, 22%), 249 (10), 218 (22), 206 (21), 144 (17), 134 (100), 133 (17) (Found: M^+, 250.1455. $C_{17}H_{18}N_2$ requires *M*, 250.1470). NMR data were identical to those recorded in Method B.

Method B: cyclisation of 2b. To a solution of amino alcohol **2b** (0.54 g, 2.0 mmol) and triphenylphosphine (1.05 g, 4.0 mmol) in dry acetonitrile (125 cm^3) under argon was added carbon tetrabromide (1.33 g, 4.0 mmol) and the mixture was stirred at room temperature for 20 h. The reaction was evaporated to dryness and the residue was partitioned between aqueous sodium hydroxide (100 cm^3 of a 2.5 M solution) and chloroform (100 cm^3). The organic layer was washed with brine then dried and concentrated. The residue was extracted into ether and insolubles were removed by filtration. The filtrate was treated with ethereal hydrogen chloride. The hydrochloride salt was isolated following centrifugation and then partitioned between ether and saturated aqueous sodium hydrogen carbonate. The aqueous layer was further extracted with ether and the combined ethereal extracts were dried and concentrated. Chromatography on silica gel using a gradient eluent of 10–50% ethyl acetate in light petroleum afforded **5b** (40 mg, 8%); δ_H(400 MHz; $CDCl_3$) 2.48 (3H, s, CH_3), 2.88 (1H, dd, *J* 14 and 10.5, 12-H), 3.05 (1H, m, 11a-H), 3.15 (1H, dd, *J* 14 and 7, 12-H), 3.61 (1H, d, *J* 14, 10-H), 4.12 (1H, d, *J* 14, 10-H), 4.42 (1H, d, *J* 8.6, 4b-H), 6.85 (2H, m, aromatic), 7.15 (2H, m, aromatic), 7.26 (4H, m, aromatic); δ_C(60 MHz; $CDCl_3$) 35.61, 41.52, 62.80,

63.94, 76.96, 117.97, 120.35, 121.23, 125.03, 125.97, 126.72, 127.63, 128.29, 132.02, 139.30, 141.90, 148.69.

(5*R,5a*R**)-5-Ethoxycarbonylamino-6-bromoacetyl-5,5a,6,11-tetrahydro-4*H*-benz[*f*]indeno[1,7-*bc*]azepine 6**

A solution of **4a** (3.08 g, 0.01 mol) in dry dichloromethane (25 cm^3) containing potassium carbonate (2.76 g, 0.02 mol) was cooled in ice and treated with bromoacetyl bromide (0.88 cm^3, 0.01 mol). The reaction was stirred at room temperature for 27 h, and during this period a further portion (0.2 cm^3) of bromoacetyl bromide was added. The mixture was diluted with water and the aqueous phase was further extracted with dichloromethane. The combined organic layers were washed with water, dried and concentrated. Trituration with pentane–ether afforded **6** (4.1 g, 95%); mp 207.5–210 °C (from ether); ν_{max}(Nujol)/cm^{-1} 3310 (NH), 1710 (C=O), 1665 (C=O)); δ_H(80 MHz; $CDCl_3$) 1.33 (3H, t, *J* 7, CH_3), 2.75 (1H, dd, *J* 15 and 10, 4-H), 3.32 (1H, dd, *J* 15 and 8, 4-H), 3.44 (1H, d, *J* 13, 11-H), 3.80 (2H, s, CH_2Br), 3.9–4.7 (4H, m, overlapping signals, 5-H, 11-H and OCH_2), 6.1 (2H, overlapping doublets, 5a-H and NH), 6.8–7.5 (7H, m, aromatic); δ_C(20 MHz; $CDCl_3$) 14.60, 27.25, 36.56, 37.08, 58.65, 60.84, 63.58, 123.39, 125.44, 127.84, 128.23, 128.67, 129.31, 130.09, 135.21, 135.37, 137.26, 139.82, 142.42, 156.95, 168.41; *m*/*z* 428, 430 (M^+, <5%), 341 (34), 339 (36), 307 (16), 261 (50), 260 (100), 233 (15), 219 (22), 218 (62), 217 (24), 132 (20) (Found: M^+, 428.0760. $C_{21}H_{21}N_2O_3Br$ requires *M*, 428.0734).

(4a*R,12c*R**)-5-Ethoxycarbonyl-7-oxo-4a,5,6,7,12,12c-hexahydro-4*H*-5,7a-diazabenzo[5,6]cyclohepta[*def*]fluorene 7**

A solution of **6** (3.35 g, 7.8 mmol) in dry *N*,*N*-dimethylformamide (200 cm^3) was added over 30 min to an ice cooled suspension of sodium hydride (0.26 g of an 80% dispersion in oil, 8.6 mmol) in *N*,*N*-dimethylformamide (20 cm^3) stirred under nitrogen. After a further 3 h at room temperature the reaction was diluted with water and extracted into ether. The extract was washed with water, dried and concentrated to give **7** (2.35 g, 90%); ν_{max}(Nujol)/cm^{-1} 1700 (C=O), 1680 (C=O); δ_H(80 MHz; $CDCl_3$) 1.35 (3H, t, *J* 7, CH_3), 2.75 (1H, dd, *J* 16 and 10, 4-H), 3.35–4.5 (7H, m, overlapping signals), 4.86 (1H, d, *J* 16, 12-H), 5.35 (1H, d, *J* 11, 12c), 6.80–7.40 (6H, m, aromatic), 7.6 (1H, m, aromatic); *m*/*z* 349 (16), 348 (M^+, 55%), 319 (16), 247 (16), 220 (40), 219 (100), 218 (85), 132 (18) (Found: M^+, 348.1448. $C_{21}H_{20}N_2O_3$ requires *M*, 348.1474).

(4a*R,12c*R**)-5-Ethoxycarbonyl-4a,5,6,7,12,12c-hexahydro-4*H*-5,7a-diazabenzo[5,6]cyclohepta[*def*]fluorene 8**

A solution of **7** (2.2 g, 6.3 mmol) in dry tetrahydrofuran (15 cm^3) was added dropwise to diborane (10.5 cm^3 of a 1 M solution in tetrahydrofuran) cooled to ice temperature under nitrogen, and the mixture was heated under reflux for 2 h. The reaction was cooled to −10 °C and acidified with 5 M aq. HCl. After stirring for 30 min the solvent was evaporated and the residue was basified with 2 M aq. NaOH before extraction into ether. The dried extract was concentrated and purified on silica gel using light petroleum–ethyl acetate (85:15) as eluent to give **8** as a foam (1.45 g, 70%); ν_{max}(film)/cm^{-1} 1690 (C=O); δ_H(250 MHz; $CDCl_3$) 1.31 (3H, t, *J* 7.5, OCH_2CH_3), 2.90–3.68 (6H, m, overlapping signals), 3.80–4.26 (4H, m, overlapping signals), 4.33 (1H, d, *J* 14, 12-H), 4.58 (1H, d, *J* 10, 12c-H), 6.75–7.20 (7H, m, aromatic); *m*/*z* 334 (M^+, 34%), 333 (26), 259 (32), 233 (22), 232 (70), 220 (67), 219 (100), 218 (32), 204 (15) (Found: M^+, 334.1683. $C_{21}H_{22}N_2O_2$ requires *M*, 334.1679).

(4a*R,12c*R**)-5-Methyl-4a,5,6,7,12,12c-hexahydro-4*H*-5,7a-diazabenzo[5,6]cyclohepta[*def*]fluorene 9**

A solution of **8** (1.4 g, 4.0 mmol) in dry tetrahydrofuran (10 cm^3) was added dropwise to a stirred suspension of lithium aluminium hydride (0.45 g, 12.0 mmol) in tetrahydrofuran (4 cm^3) under nitrogen and the mixture was heated at reflux for 50 min. Standard work-up afforded **9** (0.98 g, 89%); mp 151–152 °C (from pentane–ethyl acetate). Maleate salt mp 183–185 °C (from acetone–ether) (Found: C, 70.3; H, 6.25; N, 7.0%. $C_{23}H_{24}N_2O_4$ requires C, 70.4; H, 6.2; N, 7.1%). Spectral data were identical to those reported previously.[4]

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