THE USE OF ^{13}C N.M.R. IN THE DETERMINATION OF STEREOCHEMISTRY OF 1,2,3-TRISUBSTITUTED TETRAHYDRO-β-CARBOLINES

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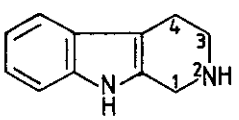
Abstract —— The chemical shift of the benzylic carbon of N(2)-benzyl-*cis*-1,3-disubstituted 1,2,3,4-tetrahydro-β-carbolines is downfield of the corresponding peak of the *trans*-isomer, and should be valuable, therefore, in the assignment of stereochemistry to these systems.

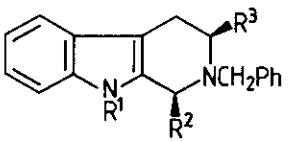
Many indole alkaloids possess a tetrahydro-β-carboline moiety (1) incorporated within their structure, and the assignment of stereochemistry to these systems is often of paramount importance. Simple 1,3-disubstituted analogues can be analysed using a ^{13}C n.m.r. method in which the C(1) and C(3) carbons of the *cis*-isomer are observed to resonate downfield of the corresponding peaks of the *trans*-isomer.[1,2] However, the extension of this analysis to 1,2,3-trisubstituted derivatives leads to ambiguities in the observed spectra.[3,4]

During recent synthetic work directed towards the synthesis of indole alkaloids, we wished to develop a method for determining directly the stereochemistry of N(2)-benzyl-1,2,3-trisubstituted tetrahydro-β-carbolines. Initially, we hoped that either the C(1) or the C(3) carbons might exhibit reliable changes in chemical shift between the *cis*- and *trans*-isomers.[4] In order to test this possibility, we prepared a range of suitable analogues, and studied the ^{13}C spectra in detail.

The simple 1-alkyl and 1-phenyl derivatives (2a-f)/(3a-f) were prepared by the sequence shown in Scheme 1. Thus, aprotic Pictet-Spengler reaction between L-tryptophan methyl ester and appropriate aldehydes[5,6] yielded 1,3-disubstituted tetrahydro-β-carbolines as mixtures of the cis- and trans-isomers,[7] which were separated by flash chromatography[8] or recrystallisation; treatment with benzyl bromide afforded the 2-benzyl derivatives (2a)/(3a), (2c)/(3c), (2e)/(3e), and subsequent treatment with MeI/NaH gave the corresponding N^{in}-methylated products (2b)/(3b), (2d)/(3d), and (2f)/(3f). Compounds (2g)/(3g) and (2h)/(3h) were prepared, as previously reported,[9] via a modified Pictet-Spengler reaction[10] (Scheme 2), and the N(2)-H analogues of (2i)/(3i) were generated similarly; after N(2)-benzylation with benzyl bromide, the diastereoisomers (2i)/(3i) were separated by flash chromatography[8], and N^{in} methylation with MeI/DMF yielded (2j)/(3j). Stereochemical assignment utilised Cook's method[1] with the N(2)-H analogues, or unambiguous correlation with compounds of known structure.[9]



(1)



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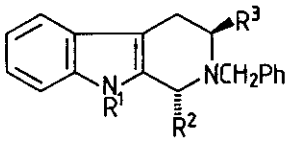
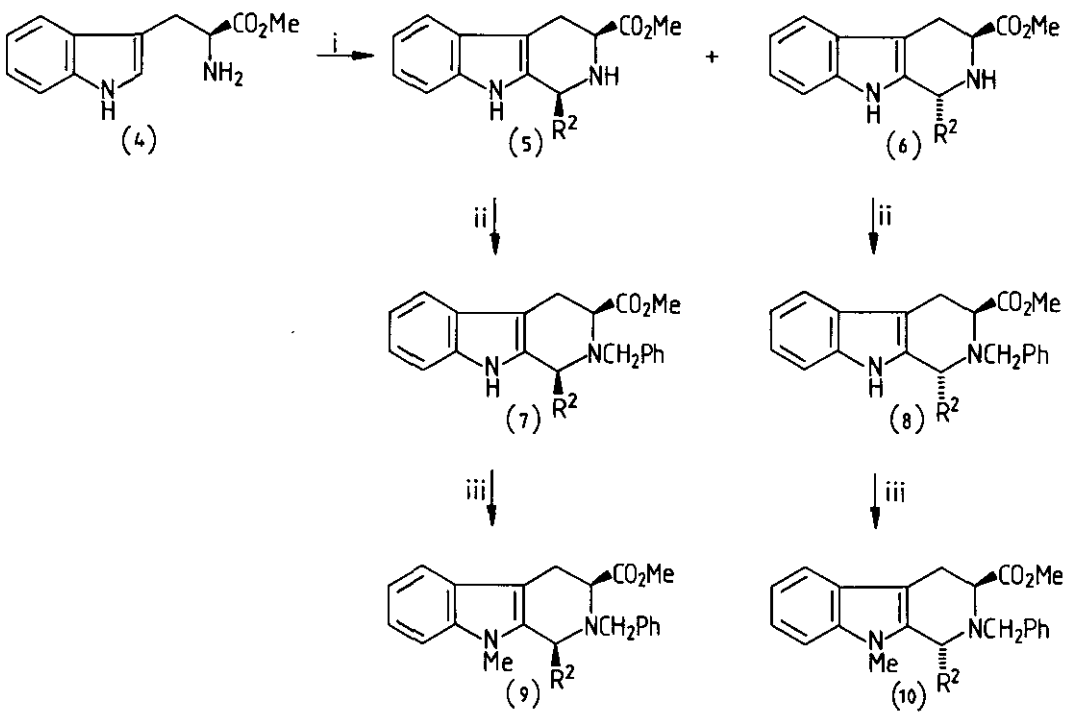


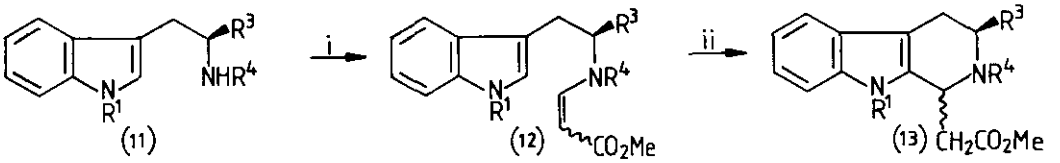
(3)

a; R^1 = H, R^2 = Ph, R^3 = CO_2Me
b; R^1 = Me, R^2 = Ph, R^3 = CO_2Me
c; R^1 = H, R^2 = C_6H_{11}, R^3 = CO_2Me
d; R^1 = Me, R^2 = C_6H_{11}, R^3 = CO_2Me
e; R^1 = H, R^2 = Et , R^3 = CO_2Me
f; R^1 = Me, R^2 = Et, R^3 = CO_2Me
g; R^1 = H, R^2 = CH_2CO_2Me, R^3 = CO_2Me
h; R^1 = Me, R^2 = CH_2CO_2Me, R^3 = CO_2Me
i; R^1 = H, R^2 = CH_2CO_2Me, R^3 = CH_2CN
j; R^1 = Me, R^2 = CH_2CO_2Me, R_3 = CH_2CN

When the ^{13}C n.m.r. spectra of (2a-j)/(3a-j) were studied and compared, it became apparent that C(1) and C(3) could not always be distinguished unambiguously. However, the H(1) or H(3) protons could always be identified, either directly (characteristic splitting pattern or chemical shift), or by virtue of an n.O.e. between H(1) and the indolic NH/NCH_3 group; thereafter, selective irradiation of the H(1) and H(3) protons in the fully proton coupled



Scheme 1 Reagents: i, R^2CHO/TsOH/PhH/Reflux; ii, $PhCH_2Br/NaHCO_3$; iii, MeI/NaH/DMF: R^2 = Ph, C_6H_{11}, Et

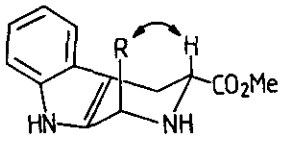


Scheme 2 Reagents: i, $HC{\equiv}CCO_2Me/CHCl_3$/r.t.; ii, TFA/$CHCl_3$/r.t.: R^1 = H or Me, R^3 = CO_2Me or CH_2CN, R^4 = H or CH_2Ph

^{13}C spectrum identified the C(1) and C(3) carbons. For three of the pairs of compounds, both C(1) and C(3) in the cis-isomers were downfield of both C(1) and C(3) in the trans-isomers, so detailed assignment was unncessary for the purposes of our investigation.

When the results were collated (Table 1), it became apparent that neither C(1) nor C(3) gave a reliable change in ^{13}C chemical shift between the cis- and trans-isomers. However, the N(2)-exocyclic carbon did give consistent results, with the benzylic signal from the cis-isomers resonating 3-11 p.p.m. downfield from the corresponding peak of the trans-isomers. In order to gain more insight into these observations, we studied the explanation given for the significance of the C(1) and C(3) chemical shifts in the stereochemical assignments of 1,3-disubstituted tetrahydro-β-carbolines.[1]

The method devised by Cook's group[1] for 1,3-disubstituted analogues presumes that the 3-substituent occupies a roughly equatorial position on the twist-chair conformer; increased 1,3-diaxial interactions for the trans-isomer (14) cause the C(1) and C(3) carbons to resonate upfield of their respective positions in the cis-isomer because of the compression effect.[11] The addition of an N(2)-substituent evidently invalidates this analysis, presumably by distorting the ring or by greatly increasing the 1,2-interactions. We can



(14)

now report that the benzylic carbons of N(2)-benzyl-cis-1,3-disubstituted tetrahydro-β-carbolines (2a-j) resonate typically about 7 p.p.m. downfield of the corresponding peaks in the trans-isomers(3a-j). From X-ray crystal structure data, the N(2)-benzyl substituent for the trans-isomer (3g) occupies an axial position;[12] if this conformation is representative of (3a-j), then the change in chemical shift may indicate that the (N)2-substituents occupy the expected equatorial position in the cis-isomers, and therefore experience a reduced

Compound	Substituents			Chemical Shift (ppm) of cis-isomer (2)			Chemical Shift (ppm) of trans-isomer (3)			C(1)/C(3) Assignment
	R^1	R^2	R^3	C-1	C-3	C-2'	C-1	C-3	C-2'	
a	H	Ph	CO_2Me	61.60	60.73	57.26	60.84	56.02	54.34	Irrad.
b	Me	Ph	CO_2Me	58.56	57.37	59.16	59.43	55.91	53.20	Irrad.
c	H	C_6H_{11}	CO_2Me	63.66	58.45	61.38	61.49	56.94	53.20	Irrad.
d	Me	C_6H_{11}	CO_2Me	(60.58)	(60.96)	63.01	(56.29)	(59.54)	52.98	Corr.
e	H	Et	CO_2Me	(59.01)	(59.49)	58.41	(56.84)	(56.84)	53.53	Corr.
f	Me	Et	CO_2Me	(57.37)	(58.02)	61.22	(56.08)	(56.24)	52.99	Corr.
g	H	CH_2CO_2Me	CO_2Me	52.80	57.10	57.91	52.42	57.73	53.52	n.O.e.
h	Me	CH_2CO_2Me	CO_2Me	53.88	55.29	60.50	52.99	56.24	53.01	n.O.e.
i	H	CH_2CO_2Me	CH_2CN	52.12	53.04	59.59	52.76	51.45	49.76	Irrad.
j	Me	CH_2CO_2Me	CH_2CN	53.26	51.26	61.07	52.67	49.36	49.62	Irrad.

Table 1: C(1)/C(3) Assignment; n.O.e. - nuclear Overhauser enhancement; Irrad. - irradiation of C(1) proton caused sharpening of C(1) carbon in the ^{13}C spectrum; Corr.- correlation with similar compounds, although incorrect assignment would not affect relative chemical shifts of C(1) or C(3).

compression effect. Because this exocyclic carbon atom is so readily identified in the ^{13}C n.m.r. spectrum [off-resonance triplet at about 50-60 p.p.m.; c.f. differentiation of C(1) from C(3)[4]], this should constitute a rapid and reliable method of determining the cis : trans ratio in reactions that yield mixtures of 1,2,3-trisubstituted tetrahydro-β-carbolines.

EXPERIMENTAL

Mps were determined on a Reichert microscope hot-stage apparatus, and are uncorrected. I.r. spectra were recorded on a Pye-Unicam SP3-200 spectrophotometer. N.m.r. spectra were recorded on a JEOL FX90Q spectrometer, at 90 MHz (^1H) or 22.5 MHz (^{13}C); chemical shifts are quoted in p.p.m. downfield from Me_4Si as internal standard. Mass spectra were obtained by electron impact at 70 eV on an A.E.I. MS3076 spectrometer. All solvents were purified and dried by standard methods, and flash chromatography[8] used silica as the stationary phase.

The N(2)-H analogues of (2c)/(3c) were prepared according to Ungemach et al.[5] and the N(2)-H analogues of (2a)/(3a) and (2e)/(3e) were prepared by the method of Soerens et al.[6] Compounds (2g,h)/(3g,h) were prepared as previously reported:[12] (2i)/(3i) were prepared analogously from (S)-3-amino--4-(indol-3-yl)-butanonitrile[13], followed by benzylation and separation of diastereoisomers; N^{in}-methylation using MeI/NaH yielded (2j) and (3j).[12]

cis-2-Benzyl-3-(methoxycarbonyl)-1-phenyl-1,2,3,4-tetrahydro-9H-pyrido[3,4-b]-indole (2a). This typical benzylation was carried out by refluxing the N(2)-H analogue of (2a) (554 mg, 1.81 mmol) with benzyl bromide (309 mg, 1.81 mmol) in CH_2Cl_2 for 90 h. Filtration and evaporation gave a crude white foam which crystallised from MeOH as fluffy crystals (510 mg, 71%), mp 164-166°C; $\delta_H(CDCl_3)$ 2.88-3.44[5H, m, including singlet (3H, CO_2CH_3) at 3.39 + $ArCH_2$], 3.55-4.01 (3H, m, CH_2Ph + $ArCH_2CH$), 4.89 (1H, s, CHPh), 7.05-7.45 (14H, m, aromatic), 7.55 (1H, br, s, indole NH); $\delta_C(CDCl_3)$ 23.62(t), 51.41(q), 57.26(t), 60.73(d), 61.60(d), 107.05(s), 110.84(d), 118.26(d),

119.24(d), 119.40(d), 121.51(s), 121.73(d), 127.09(d), 127.91(d), 128.07(d), 128.34(d), 133.05(s), 136.36(s), 138.20(s), 140.20(s), 173.63(s); m/z 396(M^+), 337, 319, 305, 91; $\nu_{max}(CH_2Cl_2)$ 1738 cm^{-1}.

(3a). Prepared as for (2a) (18 h reaction) on a 1.23 mmol scale; crystallisation from MeOH/Et_2O gave (3a) (275 mg, 60%) as white crystals: mp 221-223°C (lit.,[6] 224-225°C); $\delta_H(CDCl_3)$ 3.20 (2H, dd, J 4.7 and 1.6 Hz, $ArCH_2$), 3.61 (3H, s, CO_2CH_3), 3.87 (2H, s, CH_2Ph), 3.90 (1H, m, $ArCH_2CH$), 5.46 (1H, s, CHPh), 7.01-7.60 (15H, m, aromatic and indole NH); $\delta_C(CDCl_3)$ 24.43(t), 51.30(q), 54.34(t), 56.02(d), 60.84(d), 106.29(s), 110.79(d), 118.15(d), 119.29(d), 121.57(d), 127.04(d), 128.01(d), 128.29(d), 128.56(d), 128.72(d), 128.88(d), 134.89(s), 136.47(s), 139.39(s), 142.15(s), 173.52 (s); m/z 396(M^+), 337, 305, 91; ν_{max} (CH_2Cl_2) 1736 cm^{-1}.

(2c). Prepared as for (2a) (40 h reaction) on a 1.81 mmol scale; flash chromatography ($CHCl_3/CCl_4$, 1:1) and crystallisation from methanol gave colourless cubes of (2c) (450 mg, 62%), mp 172-173.5°C; $\delta_H(CDCl_3)$ 0.62-1.91 (10H, m, cyclohexyl), 2.27-2.45 (1H, m, cyclohexyl), 2.81-3.34 (2H, ABX, J_{AB} 16.0, J_{AX} 6.6, and J_{BX} 4.4 Hz, $ArCH_2CH$), 3.41 (1H, m, ch-CH), 3.62 (3H, s, CO_2CH_3), 3.67-3.80 (1H, m, $ArCH_2CH$), 3.81 (2H, s, CH_2Ph), 7.05-7.54 (9H, m, aromatic), 7.70 (1H, br s, indole NH); $\delta_C(CDCl_3)$19.77(t), 26.22(t), 26.49(t), 29.96(t), 31.31(t), 42.58(d), 51.84(q), 58.45(d), 61.38(t), 63.66(d), 106.34(s), 110.62(d), 118.05(d), 119.18(d), 121.46(d), 126.77(s), 127.20(d), 128.18(d), 128.99(d), 133.38(s), 135.82(s), 139.23(s), 174.60(s); m/z 402(M^+), 343, 319, 91; ν_{max} (CH_2Cl_2) 3468, 1736 cm^{-1}.

(3c). Prepared as for (2a) (40 h reaction) on a 1.38 mmol scale; crystallisation from MeOH/Et_2O gave (3c)(450 mg, 62%) as white crystals, mp 164.5-166°C; $\delta_H(CDCl_3)$ 0.62-1.80 (10H, m, cyclohexyl), 2.13-2.47 (1H, m, cyclohexyl), 3.01-3.34 (2H, ABX, J_{AB} 22.7, J_{AX} 6.3, and J_{BX} 8.1 Hz, $ArCH_2$), 3.30 (1H, m, ch-CH), 3.30-3.87 (2H, AB quartet, J 13.9 Hz, CH_2Ph), 3.75 (3H, s, CO_2CH_3), 4.15 (1H, dd, J 9.3 and 6.5 Hz, $ArCH_2CH$), 7.01-7.58 (9H, m, aromatic), 7.80 (1H, br s, indole NH); $\delta_C(CDCl_3$ 20.69(t), 26.27(t),

30.39(t), 30.61(t), 42.09(d), 51.90(q), 53.20(t), 56.94(d), 61.49(d), 107.27(s), 110,62(d), 118.05(d), 119.24(d), 121.46(d+s), 126.88(d), 127.91(d), 129.10(d), 134.24(s), 135.87(s), 139.66(s), 173.74(s); m/z 402(M^+), 343, 319, 91; ν_{max} (CH_2Cl_2) 3472, 1737 cm^{-1}.

(2e). Prepared as for (2a) (6h reaction) on a 1.30 mmol scale; flash chromatography ($CHCl_3$) gave (2e) (270 mg, 60%) as a white foam which failed to crystallise; $\delta_H(CDCl_3)$ 0.99 (3H, t, J 7.2 Hz, CH_2CH_3), 1.60 (2H, m, $CHCH_2CH_3$); 2.91-3.18 (2H, m, $ArCH_2$), 3.58 (3H, s, CO_2CH_3), 3.40-3.93 (4H, m, $ArCH_2CH$ + CHEt + CH_2Ph), 6.99-7.52 (9H, m, aromatic), 7.82 (1H, br s, indole NH); $\delta_C(CDCl_3)$ 11.01 (q), 20.33(t), 26.93(t), 51.64(q), 58.41(t), 59.01(d), 59.49(d), 106.30(s), 110.80(d), 118.11(d), 119.30(d), 121.47(d), 127.10(d), 128.19(d), 128.84(d), 134.58(s), 136.10(s), 139.51(s), 174.23(s); m/z 348(M^+), 319, 257, 91; $\nu_{max}(CH_2Cl_2)$ 3380, 1725 cm^{-1}.

(3e). Prepared as for (2a) (6h reaction) on a 1.55 mmol scale; flash chromatography ($CHCl_3$) gave (3e) as a white foam (330 mg, 61%), which crystallised from methanol, mp 146-149°C (lit.,[7] 149-150°C); $\delta_H(CDCl_3)$ 0.85 (3H, t, J 7.0 Hz, CH_2CH_3), 1.78 (2H, m, $CHCH_2CH_3$), 3.05 (2H, m, $ArCH_2$), 3.58-4.08 [7H, including singlet (3H, CO_2CH_3) at δ3.70 + $ArCH_2CH$ + CHEt + CH_2Ph], 7.01-7.53 (9H, m, aromatic), 7.91 (1H, br s, indole NH); $\delta_C(CDCl_3)$ 9.98(q), 21.73(t), 27.10(t), 51.75(q), 53.53(t), 56.84(d+d), 107.06(s), 110.90(d), 118.00(d), 119.30(d), 121.41(d), 126.99(d), 127.92(s), 128.19(d), 128.89(d), 135.23(s), 136.26(s), 139.78(s), 173.80(s); m/z 348(M^+), 319, 257, 91; $\nu_{max}(CH_2Cl_2)$ 3380, 1725 cm^{-1}.

cis-2-Benzyl-3-(methoxycarbonyl)-9-methyl-1-phenyl-1,2,3,4-tetrahydro-9H-pyrido-[3,4-b] indole (2b). This typical N^{in}-methylation was carried out by adding sodium hydride (11 mg of an 80% dispersion in oil, 0.394 mmol, 1.1 equiv.) to a stirred solution of (2a) (142mg, 0.358 mmol) and iodomethane (56mg, 0.394 mmol, 1.1 equiv.) in DMF at 0°C. After 30 min, the mixture was allowed to warm to room temperature, and stirring was maintained until t.l.c. indicated an absence of starting material (30 min). The solvent was removed in vacuo, the residue

was taken into CH_2Cl_2, and this solution was washed with H_2O, dried ($MgSO_4$), and evaporated to dryness. Purification by flash chromatography ($CHCl_3$) gave (2b) as a white foam (120 mg, 82%), which crystallised from MeOH/Et_2O as colourless needles, mp 131.5-133.5°C; δ_H($CDCl_3$) 2.97 (3H, s, $NC\underline{H}_3$), 3.18 (3H, s, $CO_2C\underline{H}_3$), 3.22-3.85 (3H, m, $ArC\underline{H}_2C\underline{H}$), 4.10 (2H, s, $C\underline{H}_2Ph$), 5.01 (1H, s, $C\underline{H}Ph$), 7.02-7.67 (14H, m, aromatic); δ_C($CDCl_3$) 20.42(t), 29.58(q), 50.92(q), 57.37(d), 58.56(d), 59.16(t), 107.10(s), 108.73(d), 118.53(d), 118.91(d), 121.35(d), 126.61(d), 127.31(d), 127.85(d), 128.45(d), 128.94(d), 129.37(d), 133.05(s), 137.33(s), 139.07(s), 173.47(s); m/z 410(M^+), 351, 333, 319, 91; ν_{max} (CH_2Cl_2) 1735 cm^{-1}.

(3b). Prepared as for (2b) on 0.308 mmol scale, and purified by crystallisation from MeOH giving (3b) (110 mg, 87%), mp 168-169°C; δ_H ($CDCl_3$) 3.16-3.23 (2H, m, $ArC\underline{H}_2$), 3.24 (3H, s, $NC\underline{H}_3$), 3.64 (3H, s, $CO_2C\underline{H}_3$), 3.80-3.90 (2H, m, $C\underline{H}_2Ph$), 3.92 (1H, m, $ArCH_2C\underline{H}$), 5.15 (1H, s, $C\underline{H}Ph$), 7.11-7.62 (14H, m, aromatic); δ_C($CDCl_3$) 22.70(t), 29.80(q), 51.52(q), 53.20(t), 55.91(d), 59.43(d), 107.10(s), 108.78(d), 118.21(d), 118.91(d), 121.24(d), 126.44(s), 127.09(d), 127.58(d), 128.23(d), 128.88(d), 129.37(d), 134.79(s), 137.39(s), 139.66(s), 141.40(s), 173.41(s); m/z 410(M^+), 351, 322, 319, 91; ν_{max} (CH_2Cl_2) 1735 cm^{-1}.

(2d). Prepared as for (2b) on 0.323 mmol scale, giving chromatographically pure (2d) (125 mg, 93%) as a white foam which recrystallised from MeOH, mp 116-118°C; δ_H($CDCl_3$) 0.60-1.81 (10H, m, cyclohexyl), 2.24-2.46 (1H, m, cyclohexyl), 3.13 (2H, dd, J 9.0 and 6.6 Hz, $ArC\underline{H}_2$), 3.48-3.90 [10H, m, including singlets at δ3.53 (3H) and δ3.70 (3H), $NC\underline{H}_3$+ $CO_2C\underline{H}_3$+ $ArCH_2C\underline{H}$+ $C\underline{H}_2Ph$ + ch-$C\underline{H}$], 7.07-7.58 (9H, m, aromatic); δ_C($CDCl_3$) 21.08(t), 26.18(t), 26.39(t), 29.97(t), 30.35(t), 30.78(q), 43.78(d), 51.69(q), 60.58(d), 60.96(d),63.01(t), 105.00(s), 109.01(d), 117.62(d), 118.92(d), 120.60(d), 126.13(s), 127.05(d), 128.02(d), 129.00(d), 137.02(s), 137.88(s), 139.08(s), 175.05(s); m/z 416(M^+), 357, 333, 91; ν_{max} (CH_2Cl_2) 1736 cm^{-1}.

(3d). Prepared as for (2b) on 0.373 mmol scale, giving (3d) (146 mg, 94%) as a white foam which was recrystallised from MeOH/Et_2O, mp 119-121°C

(lit[6] 118-120°C); $\delta_H(CDCl_3)$ 0.73-1.72 (10H, m, cyclohexyl), 2.15-2.31 (1H, m, cyclohexyl), 3.04-3.67 [8H, m, including singlet (3H, $NC\underline{H}_3$) at δ3.49 + $ArC\underline{H}_2$ + $C\underline{H}_2Ph$ + ch-C<u>H</u>], 3.80 (3H, s, $CO_2C\underline{H}_3$), 4.31 (1H, dd, J 9.7 and 7.5 Hz, $ArCH_2C\underline{H}$), 7.11-7.52 (9H, m, aromatic); $\delta_C(CDCl_3)$20.48(t), 26.44(t), 26.71(t), 30.61(t), 30.99(t), 31.15(q), 43.94(d), 52.01(q), 52.98(t), 56.29(d), 59.54(d), 106.62(s), 109.05(d), 118.05(d), 119.13(d), 121.19(d), 126.88(s+d), 128.01(d), 129.10(d), 136.47(s), 137.82(s), 139.66(s), 173.68(s); m/z 416(M^+), 357, 333, 91; ν_{max} (CH_2Cl_2) 1736 cm^{-1}.

<u>(2f)</u>. Prepared as for (2b) on a 0.430 mmol scale, and purified by flash chromatography ($CHCl_3$) giving (2f) as a white foam (125 mg, 80%) which failed to crystallise: $\delta_H(CDCl_3)$1.05 (3H, t, J 7.1 Hz, $CH_2C\underline{H}_3$), 1.50 (2H, m, $CHC\underline{H}_2CH_3$), 2.86-3.39 (2H, <u>ABX</u>, J_{AB} 16.9, J_{AX} 5.9, J_{BX} 2.6 Hz, $ArC\underline{H}_2$), 3.55 (3H, s, $NC\underline{H}_3$), 3.65 (3H, s, $CO_2C\underline{H}_3$), 3.67-3.95 (4H, m, $C\underline{H}_2Ph$ + C<u>H</u>Et + $ArCH_2C\underline{H}$), 7.07-7.59 (9H, m, aromatic); $\delta_C(CDCl_3)$ 11.05(q), 18.69(t), 27.85(t), 29.74(q), 51.63(q), 57.37(d), 58.02(d), 61.22(t), 104.88(s), 108.73(d), 118.21(d), 118.91(d), 121.13(d), 127.26(d+s), 128.23(d), 128.94(d), 135.71(s), 137.44(s), 139.34(s), 174.50(s); m/z 362(M^+), 333, 303, 91; ν_{max}(CH_2Cl_2) 1734 cm^{-1}.

<u>(3f)</u>. Prepared as for (2b) on a 0.706 mmol scale, and purified by flash chromatography ($CHCl_3$) giving (3f) as a white foam (215 mg, 84%) which failed to crystallise: $\delta_H(CDCl_3)$ 0.94 (3H, t, J 7.1 Hz, $CH_2C\underline{H}_3$), 1.65 (2H, m, $CHC\underline{H}_2CH_3$), 3.02-3.16 (2H, dd, J 9.4 and 6.6 Hz, $ArC\underline{H}_2CH$), 3.36-3.93 (2H, AB quartet, J 13.8 Hz, $C\underline{H}_2Ph$), 3.46 (3H, s, $NC\underline{H}_3$), 3.61-3.74 (1H, m, C<u>H</u>Et), 3.75 (3H, s, $CO_2C\underline{H}_3$), 4.06 (1H, dd, J 9.4 and 6.6 Hz, $ArCH_2C\underline{H}$), 7.06-7.57 (9H, m, aromatic); $\delta_C(CDCl_3)$ 10.96(q), 20.49(t), 26.88(t), 29.64(q), 51.85(q), 52.99(t), 56.08(d), 56.24 (d), 106.03(s), 108.74(d), 118.06(d), 119.03(d), 121.09(d), 126.62(s), 126.94(d), 128.04(d), 129.05(d), 136.64(s), 137.34(s), 139.67(s), 173.53(s); m/z 362(M^+), 333, 303, 91; ν_{max} (CH_2Cl_2) 1737cm^{-1}.

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