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The Stereochemistry of Organometallic Compounds. XLII* The Preparation of [2,1-*b*]Quinazolines Involving Rhodium-Catalysed Hydroformylation of 2-Amino-*N*-alkenylbenzylamines

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Abstract

Rhodium-catalysed reactions of 2-amino-*N*-alkenylbenzylamines with H_2/CO give hexahydropyrrolo- and hexahydropyrido-[2,1-*b*]quinazolines. Reactions of *N*-allyl derivatives give a single regioisomer, and reactions of but-3-enyl analogues give mixtures of pyrrolo and pyrido derivatives. Some reactions give significant amounts (10–30%) of tetrahydro derivatives. The origin of these compounds remains unclear.

Introduction

In a previous paper[1] we described rhodium-catalysed routes to [1,2-*a*]quinazolines and quinazolones. Many of the isomeric [2,1-*b*] derivatives are pharmacologically active including some well established commercial drugs having a wide variety of activity.[2,3] In addition, some of these compounds have been isolated from plants of *Mackinlaya* genus.[4–6] An alternative route to this important class of compounds opens up the opportunity for variation in substitution patterns, and in this paper we describe their preparation through the rhodium-catalysed reactions of 2-amino-*N*-alkenylbenzylamines with H_2/CO.

Results and Discussion

*Preparation of 2-Amino-*N*-alkenylbenzylamines (2)*

Condensation of 2-nitrobenzaldehyde with the appropriate alkenylamine followed by *in situ* reduction of the initially formed imine[7,8] gave the 2-nitro-*N*-alkenyl-

* Part XLI, *Aust. J. Chem.*, 1994, **47**, 1061.

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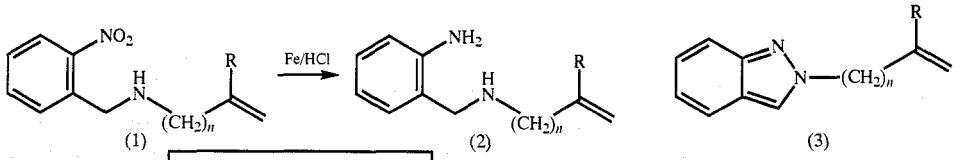
benzylamines (1) in 84–96% yield. Fe/HCl reduction of the nitro compounds (1) gave the desired amino compounds (2) together with *c.* 10% of 2-alkenylindazoles (3) which were readily removed by radial chromatography (Scheme 1). Pure amino compounds (2) were obtained in 45–75% yield. Use of Sn/HCl and Zn/HCl gave variable product mixtures in which the desired amine predominated, but a Zn/NaOH reduction gave predominantly an indazole. Reductions of nitro compounds using Zn/NaOH give hydroxylamines[9] which in our system could lead to indazole formation. Sn/HCl reduction of *N*-aryl-2-nitrobenzylamines has been reported to give indazoles as by-products.[10] Authentic samples of the indazoles (3a,c) were prepared by the alkylation of indazole with the appropriate alkenyl bromide.[10]

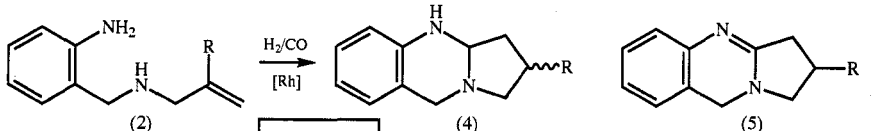


	n	R		*n*	R
(a)	1	H	(c)	2	H
(b)	1	Me	(d)	2	Me

Scheme 1

*Rhodium-Catalysed Reactions of 2-Amino-*N*-alkenylbenzylamines (2) with H_2/CO*

Rhodium-catalysed reactions of 2-amino-*N*-alkenylbenzylamines (2a,b) with H_2/CO gave the hexahydropyrrolo[2,1-*b*]quinazolines (4a,b) (Scheme 2). In a typical reaction the alkene (2a) (1·85 mmol), $[Rh(OAc)_2]_2$ and PPh_3 in the molar ratio 200:1:4 were reacted with H_2/CO (1:1, 400 p.s.i.) in ethyl acetate for 20 h at 80°C. Several reactions of the allyl compound (2a) gave a crude mixture which contained the quinazoline (4a) as the sole product according to ^1H and ^{13}C n.m.r. spectroscopy. Removal of the catalyst gave the quinazoline (4a) as light-brown crystals (96%) and chromatography gave analytically pure material (78%). The exclusive formation of the pyrroloquinazoline (4a) presumably arises from an initial regiospecific hydroformylation of (2a) leading to the terminal aldehyde as was observed previously for a similar reaction of the isomeric 2-aminomethyl-*N*-allylbenzenamine.[1]

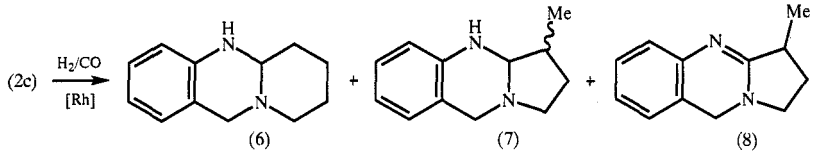


Scheme 2

[9] March, J., 'Advanced Organic Chemistry' 4th Edn, p. 1216 (Wiley–Interscience: New York 1992).

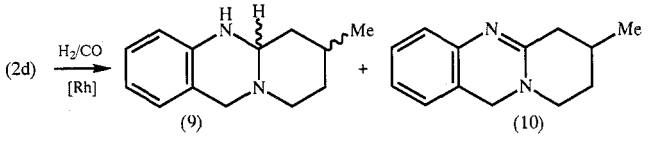
[10] Behr, L. C., Fusco, R., and Jarboe, C. H., in 'The Chemistry of Heterocyclic Compounds', Part on Pyrazoles, Pyrazolines, Pyrazolidines, Indazoles and Condensed Rings, p. 289 (John Wiley: New York 1967).

Reaction of the methallyl homologue (2b) was slower and some starting alkene was recovered from reactions at both 80 and 90°C. A diastereoisomeric mixture (*c.* 60 : 40) of the hexahydropyrroloquinazoline (4b) was formed together with 20–30% of the tetrahydro compound (5b). The tetrahydro compound was readily separated by chromatography but separation of the diasteroisomers could not be achieved. The route by which the tetrahydro compound (5b) is formed will be discussed below.

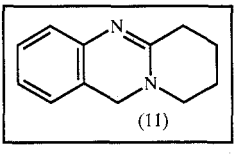


Scheme 3

Reaction of the butenyl homologue (2c) gave a mixture of the pyrido (6) and pyrrolo (7) isomers in 60 : 40 ratio together with *c.* 20% of the tetrahydro pyrrolo compound (8) (Scheme 3). The methyl pyrrolo compound (7) was formed as a mixture (80 : 20) of diastereoisomers. Recovery of these materials after removal of catalyst was 93%. No evidence for the formation of any tetrahydro pyrido compound could be found in the product of this high-yielding reaction. The reaction was also carried out with the bulky tricyclohexylphosphine in place of triphenylphosphine in an attempt to improve the regioselectivity. Surprisingly the proportion of pyrrolo isomers (7), arising from the branched-chain aldehyde, increased and the ratio of (6) to (7) was now 30 : 70. No tetrahydro compound (8) was observed in this reaction.



Scheme 4



Reaction of the methylbutenyl analogue (2d) gave a stereoisomeric mixture of the hexahydropyridoquinazolines (9) together with *c.* 15% of the tetrahydro compound (10) (Scheme 4). Reaction in the presence of tricyclohexylphosphine again gave no tetrahydro compound (10). The parent tetrahydropyrido[2,1-*b*]-quinazoline (11) has been shown to oxidize slowly over a period of several years to form the analogous quinazolinone.[5,6] One of the crude product mixtures of (9) and (10) was shown to have partially oxidized to the related quinazolinone after standing for 6 months.

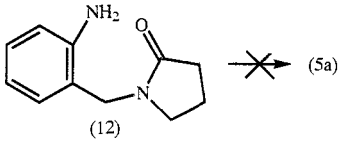
^{1}H n.m.r. experiments* showed that the *cis*-compound (with equatorial methyl group) was the major diastereoisomer of (9). The ratio of *cis*- to *trans*-isomers was *c.* 3 : 1 and this value did not vary with reaction time or on standing. In contrast we have previously observed that the isomeric [1,2-*a*]quinazolines resulting from reaction of 2-aminomethyl-*N*-(methylbutenyl)benzenamine again

* Irradiation of the methyl doublet of the major diastereoisomer allowed observation of H 7 as a broad multiplet, *J* *c.* 10 Hz, this result suggesting that H 7 was axial (and the methyl substituent equatorial), i.e. the major product was the *cis*-isomer of (9).

gave predominantly the *cis*-isomer but the amount of this isomer increased with increasing reaction time or on allowing an isolated mixture of the diastereoisomers to stand at room temperature.[1] Unfortunately, it was not possible to achieve significant separation of the diastereoisomers of (9) and thus to check whether or not equilibration was occurring.

Formation of Tetrahydro Compounds (5b), (8) and (10)

The formation of significant amounts of tetrahydro compounds (5b), (8) and (10) in some of the above hydroformylation reactions was investigated. One route could involve oxidation of the hexahydro compounds (4), (7) and (9) during product isolation. A reaction mixture of (2c) was worked up with rigorous exclusion of air but the product still contained *c.* 20% the tetrahydro compound (8). Attempts to oxidize the product mixture from a reaction of (2d) by bubbling air through a solution of the product in ethyl acetate for 7 h failed. Similarly no oxidation occurred when a sample of the product was adsorbed on silica gel containing an ultraviolet sensitizer in ethyl acetate and stirred overnight with exposure to air and ultraviolet light. A second route could involve an initial carbonylation rather than hydroformylation of the alkenylbenzylamines. The resulting lactams, e.g. (12) could possibly cyclize to form the tetrahydro compound, e.g. (5a). Indeed, the possibility that the hexahydroquinazolines arose wholly or in part by reduction of initially formed tetrahydro compounds could not be discounted.



(12)

Scheme 5

However, a sample of the lactam (12), prepared by reduction of the product from pyrrolidin-2-one and 2-nitrobenzyl bromide, did not cyclize (Scheme 5) under the reaction conditions or at more elevated temperatures (100°C). Furthermore, no hydrogenation of a sample of the tetrahydro compound (10) was observed when it was placed back under the reaction conditions at 90°C.

The formation of these tetrahydro compounds is thus not readily explicable especially as their formation does not occur for any of the hexahydro pyrrolo- or pyrido-[1,2-*a*]quinazolines.[1] In addition, only the methyl-substituted compounds (5b), (8) and (10) are formed in the hexahydro [2,1-*b*] series. However, it appears that their formation can be suppressed by use of tricyclohexylphosphine as a ligand. Alternatively, reduction of the initial product mixture with $NaBH_4$ or $LiAlH_4$ results in conversion of any tetrahydro compound into the hexahydro derivatives.[4,11]

Experimental

General

General conditions were as described previously.[12,13]

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[12] Anastasiou, D., and Jackson, W. R., *Aust. J. Chem.*, 1992, **45**, 21.
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Alkenylamines

The amines were purchased from Aldrich (prop-2-enylamine) or prepared from the corresponding alcohols.[13]

Preparation of 2-Nitro-*N*-alkenylbenzylamines (1)

2-Nitro-*N*-alkenylbenzylamines were prepared following the procedure of Verardo[7] and Schellenberg.[8]

*2-Nitro-*N*-(prop-2′-enyl)benzylamine (1a)*

A mixture of 2-nitrobenzaldehyde (5·00 g, 33·1 mmol) and prop-2-enylamine (3·78 g, 66·2 mmol) in methanol (30 ml) was stirred for 2 h at ambient temperature. Sodium borohydride (2·00 g, 53·0 mmol) was added portionwise, this procedure resulting in a vigorous reaction. The mixture was stirred for a further 1 h. The solution was acidified with concentrated HCl (to pH 2–3) to destroy the excess sodium borohydride. The mixture was made basic with sodium hydroxide (to pH 12–13), and extracted with ether (3×30 ml). The ether layer was separated, dried ($MgSO_4$) and the solvent removed under reduced pressure to yield a brown liquid (5·64 g, 84%). Kugelrohr distillation gave *2-nitro-*N*-(prop-2′-enyl)benzylamine* (1a) as a light brown liquid, b.p. (oven) 64–67°/0·08 mm (Found: C, 62·3; H, 6·0; N, 14·4. $C_{10}H_{12}N_2O_2$ requires C, 62·5; H, 6·3; N, 14·6%). ν_{max} (Nujol): 3354w, 3076m, 1643m, 1610m, 1577m, 1523s, 1347s, 1111m, 995m, 921s, 858s, 729s cm^{-1}. ^1H n.m.r. δ (200 MHz) 1·69, br s, 1H, NH; 3·28, dt, *J* 5·9, 1·4 Hz, 2H, H1′; 4·09, s, 2H, PhC**H**$_2$; 5·08–5·26, m, 2H, H3′; 5·92, ddt, *J* 17·25, 10·20, 5·95 Hz, 1H, H2′; 7·41, m, 1H, and 7·61, m, 2H, H4,5,6; 7·95, dd, *J* 8·3, 1·2 Hz, 1H, H3. ^{13}C n.m.r. δ (50 MHz) 50·01, 50·65 (C1′, Ph**C**H$_2$); 116·29 (C3′); 124·75, 127·94 (C3,4); 131·32, 133·35 (C5,6); 136·24 (C1); 136·52 (C2′); 149·13 (C2). Mass spectrum: *m/z* 191 (M − 1, <1%), 175 (19), 144 (80), 133 (50), 120 (19), 117 (43), 104 (40), 91 (48), 78 (100), 65 (50), 56 (61), 51 (56).

The Benzylamines (1b–d)

N-(2′-Methylprop-2′-enyl)-2-nitrobenzylamine (1b) was prepared as an oil (95%), b.p. (oven) 85–90°/0·08 mm. ν_{max} (Nujol): 3355w, 3073w, 1654w, 1610m, 1578w, 1525s, 1448m, 1347s, 1116m, 897m, 858m, 787m, 729s cm^{-1}. ^1H n.m.r. δ (200 MHz) 1·76, s, 3H, CH_3; 1·89, br s, 1H, NH; 3·19, s, 2H, H1′; 4·00, s, 2H, PhC**H**$_2$; 4·86, s, 1H, and 4·9, s, 1H, H3′; 7·41, m, 1H, and 7·65, m, 2H, H4,5,6; 7·94, dd, *J* 8·0, 1·2 Hz, 1H, H3. ^{13}C n.m.r. δ (50 MHz) 20·61 (CH_3); 49·82, 55·20 (C1′, Ph**C**H$_2$); 111·19 (C3′); 124·63, 127·81 (C3,4); 131·21, 133·02 (C5,6); 135·73 (C1); 143·58 (C2); 146·92 (C2′). Mass spectrum: *m/z* 205 (M − 1, 1%), 189 (10), 171 (62), 158 (37), 144 (20), 136 (92), 119 (23), 118 (50), 105 (23), 104 (34), 91 (35), 78 (90), 55 (100).

N-(But-3′-enyl)-2-nitrobenzylamine (1c) was prepared as an oil (96%), b.p. (oven) 80–85°/0·1 mm. ν_{max} (Nujol): 3328w, 3075m, 1640m, 1610m, 1578m, 1526s, 1348s, 1120m, 996m, 916m, 858m, 788s, 729s cm^{-1}. ^1H n.m.r. δ (200 MHz) 1·89, br s, 1H, NH; 2·30, q, *J* 6·7 Hz, 2H, H2′; 2·73, t, *J* 6·7 Hz, 2H, H1′; 4·06, s, 2H, PhC**H**$_2$; 5·01–5·15, m, 2H, H4′; 5·79, ddt, *J* 17·1, 10·2, 6·8 Hz, 1H, H3′; 7·41, m, 1H, and 7·61, m, 2H, H4,5,6; 7·95, dd, *J* 8·3, 1·2 Hz, 1H, H3. ^{13}C n.m.r. δ (50 MHz) 34·26 (C2′); 48·46, 50·71 (C1′, Ph**C**H$_2$); 116·48 (C4′); 124·74, 127·89 (C3,4); 131·19, 133·18 (C5,6); 135·70 (C1); 136·22 (C3′); 143·58 (C2). Mass spectrum: *m/z* 206 (M, <1%), 165 (91), 136 (100), 118 (23), 91 (30), 89 (20), 78 (80), 77 (28).

N-(3′-Methylbut-3′-enyl)-2-nitrobenzylamine (1d) was obtained as an oil (95%). ν_{max} (Nujol): 3346w, 3073w, 1648m, 1610m, 1578w, 1525s, 1458m, 1347s, 1121m, 890m, 858m, 788m, 729s cm^{-1}. ^1H n.m.r. δ (200 MHz) 1·74, s, 3H, CH_3; 1·85, br s, 1H, NH; 2·24, t, *J* 6·8 Hz, 2H, H2′; 2·74, t, *J* 6·8 Hz, 2H, H1′; 4·04, s, 2H, PhC**H**$_2$; 4·72, s, 1H, and 4·78, s, 1H, H4′; 7·41, m, 1H, and 7·62, m, 2H, H4,5,6; 7·95 dd, *J* 8·8, 1·2 Hz, 1H, H3. ^{13}C n.m.r. δ (50 MHz) 22·14 (CH_3); 37·96 (C2′); 46·98, 50·72 (C1′, Ph**C**H$_2$); 111·67 (C4′); 124·67, 127·82 (C3,4); 131·15, 133·11 (C5,6); 135·68 (C1); 143·30 (C2); 149·02 (C3′). Mass spectrum: *m/z* 220 (M, 3%), 219 (M − 1, 5), 165 (69), 136 (100), 118 (15), 91 (19), 78 (85), 51 (17).

Preparation of 2-Amino-*N*-alkenylbenzylamines (2)

2-Amino-N-*(prop-2′-enyl)benzylamine (2a)*

Reduction with Fe/HCl was carried out according to the method of Mahood.[14] A mixture of 2-nitro-*N*-(prop-2′-enyl)benzylamine (1a) (3·00 g, 15·6 mmol), iron powder (5·64 g, 100 mmol) and aqueous ethanol (10 ml, 50% by volume) was heated to reflux. The mechanical stirrer was started and hydrochloric acid (0·5 ml, 32% in aqueous ethanol 2·5 ml, 50% by volume) was slowly added, this procedure resulting in a vigorous reaction. The mixture was stirred for a further 3 h, heating stopped and the reaction mixture was made alkaline with alcoholic (ethanol) potassium hydroxide (5·0 ml, 15% by weight) while still hot. The warm mixture was filtered through a Celite pad and washed with aqueous ethanol. The filtrate was concentrated to 25 ml, water added (30 ml) and the mixture extracted with ether (3×30 ml). The combined ether extracts were dried ($MgSO_4$) and the solvent was removed under vacuum to give a brown oil (2·36 g, 94%). Kugelrohr distillation, b.p. (oven) 75–80°/0·08 mm, 53–55°/0·05 mm, gave the product (2a) and a by-product (*c.* 10%, ^{1}H n.m.r. spectrum) which was identified as 2-(prop-2′-enyl)indazole (3a). The amine was purified by radial chromatography (silica: 20% ethyl acetate/light petroleum) to give the title amine (2a) (1·91 g, 75%) (Found: C, 73·6; H, 8·9; N, 17·3. Calc. for $C_{10}H_{14}N_2$: C, 74·0; H, 8·7; N, 17·3%). ν_{max} (Nujol): 3428s, 3312s, 1618s, 1495s, 1281m, 1156m, 1098s, 750s cm^{-1}. ^{1}H n.m.r. δ (200 MHz) 1·45, br s, 1H, NH; 3·26, dt, *J* 5·9 Hz, 1·5 Hz, 2H, H1′; 3·79, s, 2H, PhC**H**$_2$; 4·67, br s, 2H, NH$_2$; 5·06–5·23, m, 2H, H3′; 5·91, ddt, *J* 17·2, 10·2, 5·9 Hz, 1H, H2′; 6·63–6·71, m, 2H, H3,5; 7·00–7·13, m, 2H, H4,6. ^{13}C n.m.r. δ (50 MHz) 51·66, 52·28 (C1′, Ph**C**H$_2$); 115·65 (C3′); 115·84, 117·47 (C3,5), 123·99 (C1); 128·30, 129·85 (C4,6); 136·71 (C2′); 146·88 (C2). Mass spectrum: *m/z* 162 (M, 6%), 131 (13), 121 (60), 106 (73), 77 (29), 56 (100), 51 (21). Spectroscopic data were in agreement with literature values.[3]

2-(Prop-2′-enyl)indazole (3a) was also obtained whose ^{1}H and ^{13}C n.m.r. spectra were shown to be identical with those of an authentic sample prepared by reaction of indazole with 3-bromopropene.[15,16] ^{1}H n.m.r. δ (200 MHz) 5·00, dt, *J* 6·1, 1·4 Hz, 2H, H1′; 5·28, dq, *J* 16·7, 1·5 Hz, 1H, and 5·31, dq, *J* 10·3, 1·2 Hz, 1H, H3′; 6·10, ddt, *J* 16·7, 10·4, 6·1 Hz, 1H, H2′; 7·07, ddd, *J* 8·4, 6·7, 1·0 Hz, 1H, 7·27, ddd, *J* 8·7, 6·6, 1·2 Hz, 1H, 7·63, dt, *J* 8·4, 1·1 Hz, 1H, and 7·72, dq, *J* 8·7, 1·0 Hz, 1H, H4,5,6,7; 7·89, d, *J* 0·8 Hz, 1H, H3. ^{13}C n.m.r. δ (50 MHz) 55·92 (C1′); 117·30 (Ar **C**H); 119·22 (C3′); 119·97, 121·54 (Ar **C**H); 121·81 (Ar **C**); 122·40 (C3); 125·77 (Ar **C**H); 132·12 (C2′); 148·77 (Ar **C**).

A reduction with Sn/HCl according to the method of Vogel[17] gave amine (2a) (75%) with no indazole. Reduction with Zn/HCl as described by Kuhn[18] gave the crude amine (2a) (85%) together with some indazole (5%).

2-Amino-N-*(2′-methylprop-2-enyl)benzylamine (2b)*

Reduction of the nitro compound (1b) with Fe/HCl gave the *amine* (2b) after purification (59%), b.p. (oven) 95–100°/0·15 mm (Found: *m/z* 176·131±0·002. $C_{11}H_{16}N_2$ requires *m/z* 176·131). ν_{max} (Nujol): 3425s, 3309s, 1649m, 1617s, 1586m, 1496s, 1280m, 1166w, 1098m, 896s, 751s cm^{-1}. ^{1}H n.m.r. δ (200 MHz) 1·45, br s, 1H, NH; 1·75, s, 3H, CH$_3$; 3·17, s, 2H, H1′; 3·77, s, 2H, PhC**H**$_2$; 4·70, br s, 2H, NH$_2$; 4·84, s, 1H, and 4·88, s, 1H, H3′; 6·67–6·71, m, 2H, H3,5; 7·00–7·13, m, 2H, H4,6. ^{13}C n.m.r. δ (50 MHz) 20·79 (CH$_3$); 52·42, 55·18 (C1′, Ph**C**H$_2$); 110·87 (C3′); 115·65, 117·62 (C3,5); 124·04 (C2′); 128·27, 129·86 (C4,6); 143·76 (C1); 146·92 (C2). Mass spectrum (c.i.): *m/z* 177 (M+1, 100%), 106 (85). The ^{1}H n.m.r. spectrum of the total product showed *c.* 10% of 2-(2′-methylprop-2′-enyl)indazole. ^{1}H n.m.r. δ (200 MHz) 1·65, s, 3H, CH$_3$; 4·89, s, 2H, H1′, 4·87, d, *J* 0·9 Hz, 1H, and 4·99, d, *J* 0·9 Hz, 1H, H3′; 7·05, m, 1H, 7·25, m, 1H, 7·62, dd, *J* 8·4, 1·0 Hz, 1H, and 7·72, dd,

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J 8·4, 0·8 Hz, 1H, H4,5,6,7; 7·85, d, *J* 0·5 Hz, 1H, H3. Reduction of (1b) with Zn/NaOH[19] gave a mixture of amine (2b) (29%) with the indazole (3b) (50%).

*2-Amino-*N*-(but-3′-enyl)benzylamine (2c)*

Reduction of the nitro compound (1c) with Fe/HCl gave after distillation and chromatography the *amine* (2c) (59%), b.p. (oven) 90–95°/0·1 mm (Found: *m/z* 176·131±0·002. $C_{11}H_{16}N_2$ requires *m/z* 176·131). ν_{max} (Nujol): 3356s, 3073w, 1618s, 1495s, 1280m, 1156w, 998m, 915m, 750s cm^{-1}. ^1H n.m.r. δ (200 MHz) 1·45, br s, 1H, NH; 2·25, q, *J* 6·7 Hz, 2H, H2′; 2·71, t, *J* 6·7 Hz, 2H, H1′; 3·79, s, 2H, PhC**H**$_2$; 4·67, br s, 2H, NH_2; 4·99–5·12, m, 2H, H4′; 5·80, ddt, *J* 17·1, 10·2, 6·8 Hz, 1H, H3′; 6·63–6·73, m, 2H, H3,5; 7·00–7·13, m, 2H, H4,6. ^{13}C n.m.r. δ (50 MHz) 34·20 (C2′); 48·24, 52·88 (C1′, Ph**C**H_2); 115·68 (C3 or 5); 116·32 (C4′); 117·66 (C3 or 5); 124·19 (C1); 128·29, 129·77 (C4,6); 136·55 (C3′), 146·94 (C2). Mass spectrum: *m/z* 176 (M, 20%), 161 (10), 147 (15), 135 (15), 123 (20), 106 (100), 77 (20). The ^1H n.m.r. spectrum of the total product showed the presence of the indazole (3c) identical to an authentic sample prepared as above for (3a).

2-(But-3′-enyl)indazole (3c) (Found: *m/z* 172·099±0·002. $C_{11}H_{12}N_2$ requires *m/z* 172·100). ν_{max} (Nujol): 3061m, 2946m, 1628s, 1515s, 1470s, 1389m, 1309w, 1157s, 1141s, 995m, 920s, 837w, 782m, 756s cm^{-1}. ^1H n.m.r. δ (200 MHz) 2·75, qt, *J* 7·0, 1·2 Hz, 2H, H2′; 4·46, t, *J* 7·1 Hz, 2H, H1′; 5·05, m, 2H, H4′; 5·75, ddt, *J* 17·1, 10·3, 6·8 Hz 1H, H3′; 7·05, ddd, *J* 8·4, 6·7, 1·0 Hz, 1H, 7·27, ddd, *J* 8·7, 6·7, 1·1 Hz, 1H, 7·64, dt, *J* 8·4, 1·0 Hz, 2H, and 7·71, dq, *J* 8·7, 0·9 Hz, 1H, H4,5,6,7; 7·88, d, *J* 0·8 Hz, 1H, H3. ^{13}C n.m.r. δ (50 MHz) 34·70 (C2′); 53·09 (C1′); 117·28 (Ar **C**H); 117·86 (C4′); 120·01, 121·48 (Ar **C**H); 121·50 (Ar **C**); 122·63 (C3); 125·73 (Ar **C**H); 133·67 (C3′); 148·79 (Ar **C**). Mass spectrum: *m/z* 172 (M, 28%), 144 (26), 131 (21), 118 (100), 104 (12), 91 (20), 77 (38), 63 (15), 51 (16).

*2-Amino-*N*-(3′-methylbut-3′-enyl)benzylamine (2d)*

Fe/HCl reduction of the nitro compound (1d) gave after chromatography the *amine* (2d) (44%) (Found: *m/z* 190·147±0·002. $C_{12}H_{18}N_2$ requires *m/z* 190·147). ν_{max} (Nujol): 3432s, 3305s(br), 3072w, 1618s, 1495s, 1459s, 1281m, 1156w, 1110m, 889m, 750s cm^{-1}. ^1H n.m.r. δ (200 MHz) 1·45, br s, 1H, NH; 1·71, s, 3H, CH_3; 2·21, t, *J* 6·7 Hz, 2H, H2′; 2·73, t, *J* 6·7 Hz, 2H, H1′; 3·75, s, 2H, PhC**H**$_2$; 4·65, br s, 2H, NH_2; 4·72, s, 1H, and 4·76, s, 1H, H4′; 6·66, m, 2H, H3,5; 7·06, m, 2H, H4,6. ^{13}C n.m.r. δ (50 MHz) 22·14 (CH_3); 37·87 (C2′); 46·70, 52·85 (C1′, Ph**C**H_2); 111·44 (C4′); 115·56, 117·53 (C3,5); 124·16 (C3′); 128·17, 129·66 (C4,6); 143·55, 146·88 (C1,2). Mass spectrum: *m/z* 190 (M, 8%), 144 (10), 135 (16), 106 (100), 77 (10). The ^1H n.m.r. spectrum of the total product showed *c.* 10% of the indazole (3d). A sample was obtained by chromatography. ^1H n.m.r. δ (200 MHz) 1·77, s, 3H, CH_3; 2·72, t, *J* 7·5 Hz, 2H, H2′; 4·52, t, *J* 7·5 Hz, 2H, H1′; 4·71, br s, 1H, and 4·81, br s, 1H, H4′; 7·07, ddd, *J* 8·3, 6·6, 0·9 Hz, 1H, 7·27, ddd, *J* 8·7, 6·7, 1·0 Hz, 1H, 7·64, dt, *J* 8·4, 1·0 Hz, 1H, and 7·71, dq, *J* 8·7, 0·9 Hz, 1H, H4,5,6,7; 7·89, s, 1H, H3. ^{13}C n.m.r. δ (50 MHz) 22·37 (CH_3); 38·58 (C2′); 52·19 (C1′); 112·75 (C4′); 117·30, 120·02, 121·49 (Ar **C**H); 121·64 (Ar **C**); 122·58 (C3); 125·75 (Ar **C**H); 141·43 (C3′); 148·76 (Ar **C**).

Hydroformylation Reactions

General conditions were as described previously.[12,13]

*Reaction of 2-Amino-*N*-(prop-2′-enyl)benzylamine (2a)*

2-Amino-*N*-(prop-2′-enyl)benzylamine (2a) (0·30 g, 1·85 mmol), triphenylphosphine (9·70 mg, 0·037 mmol) and rhodium(II) acetate dimer (4·10 mg, 0·0092 mmol) in deoxygenated ethyl acetate (10 ml) were reacted with H_2/CO (1:1 molar ratio, 400 p.s.i.) at 80° for 20 h. The ^1H n.m.r. spectrum of the crude reaction mixture showed that the quinazoline (4a) was present as the sole product. The catalyst was separated from the product by passing the mixture down a short silica column (elution with ethyl acetate) to yield a brown oil (0·31 g, 96%). Radial chromatography (silica: 20% ethyl acetate/light petroleum) gave 1,2,3,3a,4,9-hexahydropyrrolo[2,1-*b*]quinazoline (4a) as a white crystalline solid (0·25 g, 78%),

[19] Martin, E. L., *Org. Synth.*, 1943, Collect. Vol. 2, 501.

m.p. 66–68° (lit.[20] 69–70°). ν_{max} (Nujol): 3422s(br), 1663m, 1608m, 1495m, 1436w, 1303m, 1258w, 1029s, 952m cm^{-1}. ^1H n.m.r. δ (200 MHz) 1·62, m, 1H, H2; 1·96, m, 3H, H2,3; 2·65, td, *J* 8·5, 5·5 Hz, 1H, and 3·00, td, *J* 8·5, 5·6 Hz, 1H, H1; 3·87, d, *J* 15·4 Hz, 1H, and 4·0, d, *J* 15·4 Hz, 1H, H9; 4·15, m, 1H, H3a; 6·50, d, *J* 7·9 Hz, 1H, H5; 6·67, t, *J* 7·3 Hz, 1H, H7; 6·89–7·02, m, 2H, H6,8. ^{13}C n.m.r. δ (50 MHz) 21·00 (C2); 31·65 (C3); 50·13, 50·38 (C1,9); 71·08 (C3a); 114·80, 117·86 (C5,7); 119·17 (C8a); 126·89, 127·07 (C6,8); 142·84 (C4a). Mass spectrum: *m/z* 174 (M, 62%), 171 (22), 131 (84), 118 (50), 106 (100), 78 (50), 63 (42).

*Reaction of 2-Amino-*N*-(2′-methylprop-2′-enyl)benzylamine (2b)*

The benzylamine (2b) (0·30 g, 1·73 mmol) was reacted as above at 80° for 20 h. The ^1H n.m.r. spectrum of the crude product indicated the presence of starting material (2b) (*c.* 20%) and the hexahydropyrroloquinazoline (4b) as a diastereoisomeric mixture (60:40) (0·24 g, 80%). The ^{13}C n.m.r. spectrum of the crude product indicated the presence of the tetrahydropyrroloquinazoline (5b) (*c.* 30% of the product). The catalyst was separated from the products by passing the mixture down a short silica column (elution with ethyl acetate). The products were separated from starting material and purified by radial chromatography (silica: 20% ethyl acetate/light petroleum) to yield the title quinazoline (4b) as a diastereoisomeric mixture as well as (5b) (0·18 g, 60%). Preparative chromatography (silica: 50% ethyl acetate/light petroleum) was used to separate (5b) but the two diastereoisomers (4b) could not be separated.

The reaction was repeated on the same scale as above at 90° for 20 h. The ^1H n.m.r. spectrum showed some starting material (2b) was still present (*c.* 15%). Radial chromatography (silica: 20% ethyl acetate/light petroleum) gave the mixture of diastereoisomers (60:40) of the quinazoline (4b) as well as *c.* 20% of (5b).

*2-Methyl-1,2,3,3a,4,9-hexahydropyrrolo[2,1-*b*]quinazoline* (4b) (Found: *m/z* 188·129±0·002. $C_{12}H_{16}N_2$ requires *m/z* 188·131. Found: C, 75·8; H, 8·4; N, 14·8. $C_{12}H_{16}N_2.0{\cdot}1H_2O$ requires C, 75·8; H, 8·6; N, 14·7%).* ν_{max} (Nujol): 3352m(br), 2925s, 1668s, 1608m, 1300w, 1260m, 1153m, 1037w, 750s cm^{-1}. ^1H n.m.r. δ (200 MHz)† 1·12, d, *J* 6·9 Hz, 3H (1·14, d, *J* 6·5 Hz), CH_3; 1·73, m, 1H, and 1·90, m, 1H (1·30, m, and 2·4, m), H3; 2·31, dd, *J* 8·9, 6·0 Hz, 1H (2·73, dd, *J* 8·8, 5·8 Hz and 2·88, dd, *J* 8·8, 8·2 Hz), H1; 2·47, m, 1H (2·4, m), H2; 3·24, t, *J* 8·6 Hz, 1H, H1; 3·87, d, *J* 15·6 Hz, 1H, and 3·98, d, *J* 15·6 Hz, 1H (3·87, d, *J* 15·6 Hz and 4·01, d, *J* 15·6 Hz), H9; 4·19, m, 1H, H3a; 6·56, d, *J* 7·9 Hz, 1H, H5; 6·71, td, *J* 7·4, 1·1 Hz, 1H, H7; 6·95, d, *J* 7·5 Hz, 1H, H8; 7·03, m, 1H, H6. ^{13}C n.m.r. δ (50 MHz) 21·19 (21·75) (CH_3); 29·65 (30·09) (C2); 40·63 (40·94) (C3); 50·82 (50·57) (C9); 58·70 (58·42) (C1); 71·98 (71·78) (C3a); 115·41 (115·22) and 118·45 (118·42) (C5,7); 119·45 (119·52) (C8a); 127·25, 127·41 (127·31) (C6,8); 142·97 (142·65) (C4a). Mass spectrum: *m/z* 188 (M, 52%), 146 (29), 131 (100), 118 (58), 106 (71), 91 (15), 77 (38), 55 (15), 51 (23).

*2-Methyl-1,2,3,9-tetrahydropyrrolo[2,1-*b*]quinazoline* (5b) had m.p. 75–77° (Found: *m/z* 186·115±0·002. $C_{12}H_{14}N_2$ requires *m/z* 186·115). ν_{max} (Nujol): 3357w(br), 2925w, 2360s, 1668s, 1495m, 1438m, 1263m, 1119w, 750m cm^{-1}. ^1H n.m.r. δ (200 MHz) 1·06, d, *J* 6·6 Hz, 3H, CH_3; 2·05, dd, *J* 15·9, 6·6 Hz, 1H, H3; 2·38, m, 1H, H2; 2·58, dd, *J* 16·0, 8·4 Hz, 1H, H3; 2·85, dd, *J* 9·7, 6·0 Hz, 1H, and 3·41, dd, *J* 9·7, 7·6 Hz, 1H, H1; 4·34, s, 2H, H9; 6·65, m, 2H, H5,7; 7·02, dd, *J* 7·7, 1·5 Hz, 1H, H8; 7·11, td, *J* 7·7, 1·7, 1H, H6. ^{13}C n.m.r. δ (50 MHz) 19·76 (CH_3); 26·32 (C2); 39·28 (C3); 44·30, 54·02 (C1,9); 115·48, 117·09 (C5,7); 119·32 (C8a); 129·38, 131·25 (C6,8); 145·88 (C4a); 174·79 (C3a). Mass spectrum: *m/z* 185 (M, 24%), 152 (18), 134 (38), 119 (29), 106 (74), 104 (18), 98 (15), 93 (11), 77 (72), 69 (13), 51 (34).

* Previous workers have found that these compounds retain water of crystallization even after prolonged drying and satisfactory analytical data are difficult to obtain.[4]

† In the case of compounds (4b), (7) and (9), the ^1H and ^{13}C n.m.r. data for the minor isomer are given in parentheses where appropriate.

[20] Koretskaja, N. I., and Utkin, L. M., *Zh. Obshch. Khim.*, 1958, **28**, 1087.

*Reaction of 2-Amino-*N*-(but-3′-enyl)benzylamine (2c)*

The benzylamine (2c) (0·30 g, 1·70 mmol) was reacted at 80° for 20 h to give a crude product (0·31 g) as a dark brown oil. The ^{1}H and ^{13}C n.m.r. spectra of the crude product showed that the pyrido (6) and pyrrolo (7) quinazolines in the ratio 60:40 (the ratio of pyrrolo diastereoisomers was 80:20), as well as the tetrahydropyrrolo isomer (8) were present. The ratio of (8) to the major pyrrolo isomer (7) was 1:1. The mixture was passed down a short silica column (elution with ethyl acetate) to remove the spent catalyst (93%). Preparative chromatography (silica: ethyl acetate) allowed separation of pyrido (6) and pyrrolo (7) quinazolines but the pyrrolo diastereoisomers could not be separated.

5,5a,6,7,8,9-Hexahydro-11*H*-pyrido[2,1-*b*]quinazoline (6) had m.p. 72–74° (lit.[21] 71–72°) (Found: *m/z* 188·130±0·002. Calc. for $C_{12}H_{16}N_2$: *m/z* 188·131). ν_{max} (Nujol): 3349w, 1268w, 1130w, 1066w, 850w, 744w cm^{-1}. ^{1}H n.m.r. δ (200 MHz) 1·41–1·95, m, 6H, H6,7,8; 2·19, m, 1H, and 3·04, m, 1H, H9; 3·62–3·79, m, 3H, H5a,11; 6·53, dd, *J* 7·9, 1·0 Hz, 1H, H4; 6·66, td, *J* 7·4, 1·0 Hz, 1H, H2; 6·91, dd, *J* 7·5, 1·0 Hz, 1H, H1; 7·01, td, *J* 7·6, 1·0 Hz, 1H, H3. ^{13}C n.m.r. δ (50 MHz) 21·59 (C7); 25·29 (C8); 31·95 (C6); 52·12 (C9); 56·07 (C11); 70·14 (C5a); 114·09 (C4); 117·62 (C2); 119·54 (C11a); 126·59, 127·05 (C1,3); 142·00 (C4a). Mass spectrum: *m/z* 188 (M, 41%), 187 (22), 185 (17), 132 (20), 131 (100), 106 (32), 104 (15), 77 (18). The ^{1}H n.m.r. and mass spectral data were in agreement with the literature.[4]

*3-Methyl-1,2,3,3a,4,9-hexahydropyrrolo[2,1-*b*]quinazoline* (7) (Found: *m/z* 188·131±0·002. $C_{12}H_{16}N_2$ requires *m/z* 188·131). ν_{max} (Nujol): 3258w, 1609w, 863w cm^{-1}. ^{1}H n.m.r. δ (200 MHz) 1·14, d, *J* 6·7 Hz, 3H (1·09, d, *J* 7·0 Hz), CH_3; 1·50, m, 1H, 2·05, m, 1H, and 2·25, m, 1H, H2,3; 2·60, m, 1H, and 3·15, m, 1H, H1; 3·56, d, *J* 5·4 Hz, 1H, and 3·89, d, *J* 5·4 Hz, 1H, H9; 3·84, m, 1H (4·20, m), H3a; 6·60, d, *J* 8·0 Hz, 1H, H5; 6·70, m, 1H, H7; 6·95, d, *J* 7·7 Hz, 1H, H8; 7·03, m, 1H, H6. ^{13}C n.m.r. δ (50 MHz) 18·58 (14·65) (CH_3); 30·17 (C2); 39·44 (36·84) (C3); 50·52, 51·99 (49·78, 49·87) (C1,9); 78·63 (72·56) (C3a); 115·59 (114·83) (C5); 118·50 (117·89) (C7); 120·36 (C8a); 127·15, 127·28 (127·15, 127·41) (C6,8); 142·93 (C4a). Mass spectrum: *m/z* 188 (M, 55%), 185 (43), 171 (13), 146 (47), 132 (15), 131 (84), 118 (100), 106 (44), 104 (25), 91 (18), 78 (25), 77 (32), 51 (14).

*3-Methyl-1,2,3,9-tetrahydropyrrolo[2,1-*b*]quinazoline* (8) had m.p. 74–76° (Found: *m/z* 186·114±0·002. $C_{12}H_{14}N_2$ requires *m/z* 186·115). ν_{max} (Nujol): 3349m, 1664w, 1592m, 1268m, 1099m, 894m, 850m, 789w, 744s cm^{-1}. ^{1}H n.m.r. δ (200 MHz) 1·21, d, *J* 7·2 Hz, 3H, CH_3; 1·62, m, 1H, 2·18, m, 1H, and 2·50, m, 1H, H2,3; 3·21, m, 2H, H1; 4·35, br s, 2H, H9; 6·65, m, 2H, H5,7; 7·02, m, 1H, H8; 7·10, m, 1H, H6. ^{13}C n.m.r. δ (50 MHz) 16·28 (CH_3); 26·71 (C2); 36·57 (C3); 44·44, 44·65 (C1,9); 115·28 (C5); 116·85 (C7); 119·23 (C8a); 129·18, 131·12 (C6,8); 145·80 (C4a); 177·45 (C3a). Mass spectrum: *m/z* 186 (M, 22%), 185 (M − 1, 22%), 132 (23), 131 (100), 118 (18), 106 (54), 104 (18), 77 (23).

Hydroformylation the benzylamine (2c) (0·30 g, 1·70 mmol) with tricyclohexylphosphine as the ligand gave the crude product (0·31 g) as a mixture of the pyrido (6) and pyrrolo (7) quinazolines in the ratio 30:70. The ratio of the pyrrolo diastereoisomers was 80:20.

*Reaction of 2-Amino-*N*-(3′-methylbut-3′-enyl)benzylamine (2d)*

Reaction of the benzylamine (2d) (0·30 g, 1·60 mmol) at 90° for 20 h gave a dark brown oil (0·31 g). The ^{1}H and ^{13}C n.m.r. spectra showed that starting material (2d) (*c.* 10%) and a mixture of two diastereoisomers of the quinazoline (9) in the ratio 75:25 as well as the tetrahydro compound (10) (*c.* 15%) were present. The two diastereoisomers were separated from the starting material and (10) by radial chromatography (silica: 20% ethyl acetate/light petroleum). No further attempts were carried out to separate the diastereoisomers.

*7-Methyl-5,5a,6,7,8,9-hexahydro-11*H*-pyrido[2,1-*b*]quinazoline* (9) (Found: *m/z* 202·147±0·002. $C_{13}H_{18}N_2$ requires *m/z* 202·147). ν_{max} (Nujol): 3354w(br), 1992w, 1611m, 1592m, 1032w, 834m, 743m cm^{-1}. ^{1}H n.m.r. δ (200 MHz) 0·99, d, *J* 6·4 Hz, 3H (0·95, d, *J* 6·6 Hz), CH_3; 1·20, td, *J* 12·1, 10·2 Hz, 1H, H6; 1·40, m, 1H, H8; 1·61, m, 1H (1·90, m), H7; 1·68, m, 1H (1·70, m), H8; 1·87, dq, *J* 12·4, 3·1 Hz, 1H, H6; 2·11, td, *J* 12·0, 2·6 Hz, 1H, and 3·10, m, 1H (2·51, dt, *J* 11·3, 3·9 Hz, and 2·81, td, *J* 11·3, 2·9 Hz),

[21] Späth, E., and Platzer, N., *Ber. Dtsch. Chem. Ges.*, 1935, **68**, 2221.

H 9; 3·41, dd, *J* 10·1, 3·1 Hz, 1H (4·49, m), H 5a; 3·44, d, *J* 14·5 Hz, 1H, and 3·79, d, *J* 14·5 Hz, 1H (3·60, d, *J* 16·3 Hz, and 4·31, d, *J* 16·3 Hz), H 11; 6·54, d, *J* 8·0 Hz, 1H (6·47, d, *J* 7·9 Hz), H 4; 6·66, td, *J* 7·4, 1·1 Hz, 1H, H 2; 6·91, d, *J* 7·3 Hz, 1H, H 1; 7·00, m, 1H, H 3. Irradiation of the CH_3 signal of the major diastereoisomer (*cis*) at 3667 Hz (δ 0·99) led to the H 7 signal collapsing to a broad multiplet (δ 1·6), *J c.* 10 Hz. ^{13}C n.m.r. δ (50 MHz) 21·82 (21·40) (CH_3); 29·66 (24·17) (C 7); 33·77 (33·91) (C 8); 41·11 (38·72) (C 6); 53·78 (46·32) (C 9); 56·16 (55·25) (C 11); 71·27 (65·86) (C 5a); 114·47 (113·80) and 117·95 (117·56) (C 2,4); 120·26 (118·40) (C 11a); 126·62, 127·23 (127·10, 127·14) (C 1,3); 141·84 (142·85) (C 4a). Mass spectrum: *m/z* 202 (M, 100%), 201 (M − 1, 65%), 199 (23), 159 (20), 146 (40), 132 (20), 131 (95), 106 (28).

*7-Methyl-6,7,8,9-tetrahydro-11*H*-pyrido[2,1-*b*]quinazoline* (10) (Found: *m/z* 200·131±0·002. $C_{13}H_{16}N_2$ requires *m/z* 200·131). ν_{max} (Nujol): 3347w, 1617m cm^{-1}. ^1H n.m.r. δ (200 MHz) 0·98, d, *J* 6·2 Hz, 3H, CH_3; 1·38, m, 1H, 1·80, m, 1H, and 1·90, m, 1H, H 7,8; 1·99, m, 1H, and 2·52, m, 1H, H 6; 3·17, m, 1H, and 3·28, m, 1H, H 9; 4·36, d, *J* 14·3 Hz, 1H, and 4·64, d, *J* 14·3 Hz, 1H, H 11; 6·62, m, 2H, H 2,4; 7·01, dd, *J* 7·7, 1·6 Hz, 1H, H 1; 7·09, td, *J* 7·6, 1·6 Hz, 1H, H 3. ^{13}C n.m.r. δ (50 MHz) 20·42 (CH_3); 27·08 (C 7); 30·36, 39·73 (C 6,8); 45·29, 47·54 (C 9,11); 114·82, 116·05 (C 2,4); 118·89 (C 11a); 128·78, 131·32 (C 1,3); 145·79 (C 4a); 169·31 (C 5a). Mass spectrum: *m/z* 200 (M, 32%), 199 (80), 147 (30), 120 (20), 112 (49), 107 (39), 106 (100), 84 (20), 77 (38).

The hydroformylation was repeated on the same scale at 90° for 20 h and air was allowed to bubble through the crude reaction mixture for 7 h. The crude reaction mixture was stirred over silica (Merck, 7749) overnight in air under ultraviolet light (254 nm). The ^1H and ^{13}C n.m.r. spectra of the crude reaction mixture showed no significant changes in product ratios, and spectroscopic data were identical to those given above.

The hydroformylation was repeated on the same scale at 90° for 66 h giving an identical product mixture.

Hydroformylation by using tricyclohexylphosphine as a ligand gave a crude product (87%) whose ^1H and ^{13}C n.m.r. spectra showed the presence of (2d) (*c.* 25%) and two diastereoisomers of the quinazoline (9) in the ratio 75 : 25.

Reaction of the tetrahydroquinazoline (10) (0·10 g, 0·50 mmol) with rhodium(II) acetate dimer, triphenylphosphine and H_2/CO (400 p.s.i.) in ethyl acetate at 90° for 20 h gave recovered starting material by ^1H and ^{13}C n.m.r. spectroscopy. No evidence of the hexahydroquinazoline (9) was obtained.

A crude hydroformylation product mixture of (9) and (10) was shown to have partially oxidized on standing for 6 months* (^1H and ^{13}C n.m.r.). Purification by chromatograpy on silica (ethyl acetate) gave a sample of *7-methyl-6,7,8,9-tetrahydro-11*H*-pyrido[2,1-*b*]quinazolin-11-one* (Found: *m/z* 214·111±0·001. $C_{13}H_{14}N_2O$ requires *m/z* 214·111). ν_{max} ($CDCl_3$) 1665s, 1612m, 1590m, 1568m, 1480m cm^{-1}. ^1H n.m.r. δ (300 MHz) 1·15, d, *J* 6·5 Hz, 3H, CH_3; 1·61, m, 1H, H 8; 2·04–2·24, m, 2H, H 7,8; 2·60, dd, *J* 17·2, 10·3 Hz, 1H, and 3·09, ddd, *J* 17·2, 4·9, 2·0 Hz, 1H, H 6; 3·81, ddd, *J* 14·4, 10·6, 5·0 Hz, 1H, and 4·35, ddd, *J* 14·4, 5·6, 4·0 Hz, 1H, H 9; 7·42, m, 1H, 7·60, d, *J* 7·9 Hz, 1H, 7·71, m, 1H, and 8·25, dd, *J* 8·0, 1·5 Hz, 1H, ArH. ^{13}C n.m.r. δ (50 MHz) 21·13 (CH_3); 26·14 (C 7); 30·12 (C 8); 40·13, 42·18 (C 6,9); 120·32 (Ar **C**); 126·04, 126·32, 126·52, 134·12 (Ar **C**H); 147·36 (Ar **C**); 154·48 (C 5a). Mass spectrum: *m/z* 214 (M, 75%), 199 (100), 185 (23), 160 (31), 131 (24), 118 (25), 106 (23), 104 (21), 77 (29).

Preparation and Attempted Reactions of *N*-(2′-Aminophenylmethyl)pyrrolidin-2-one (12)

N-(2′-Aminophenylmethyl)pyrrolidin-2-one (12) was prepared by the Fe/HCl reduction of *N*-(2′-nitrophenylmethyl)pyrrolidin-2-one obtained from the reaction of pyrrolidin-2-one with 2-nitrobenzyl bromide. The crude oil (93%) was purified by flash chromatography (silica; ethyl acetate) to give a pale yellow *solid*, m.p. 70·5–72·5° (Found: C, 69·2; H, 7·5; N, 14·4. $C_{11}H_{14}N_2O$ requires C, 69·5; H, 7·4; N, 14·7%). ν_{max} 3432m, 3355m, 3238m, 1660s(br), 1496s, 1460s, 1306s, 1260s cm^{-1}. ^1H n.m.r. δ (300 MHz) 1·98, m, 2H, H 4; 2·42, t, *J* 8·1 Hz,

* The sample had been standing in a small glass sample vial with a plastic cap—at ambient temperature in the laboratory—i.e. no exclusion of light or rigorous exclusion of air.

2H, H3; 3·31, t, *J* 7·1 Hz, 2H, H5; 4·34, s, 2H, CH_2Ar; 4·48, br s, 2H, NH_2; 6·66, m, 2H, H4′,6′; 7·03, d, *J* 7·2 Hz, 1H, H3′; 7·10, td, *J* 7·6, 1·4 Hz, 1H, H5′. ^{13}C n.m.r. δ (50 MHz) 17·40 (C4); 30·74 (C3); 44·27, 46·68 (C5, CH_2Ar); 115·41, 117·00 (Ar **C**H); 119·26 (Ar **C**); 129·30, 131·19 (Ar **C**H); 145·83 (Ar **C**); 175·14 (C2). Mass spectrum: *m/z* 191 (M+1, 22%), 190 (M, 97), 171 (20), 161 (29), 144 (19), 134 (82), 133 (78), 120 (22), 119 (69), 118 (36), 107 (47), 106 (100), 104 (50), 93 (27), 84 (31), 79 (29), 78 (48), 77 (75).

Reaction of *N*-(2′-aminophenylmethyl)pyrrolidin-2-one (12) (0·20 g, 1·05 mmol) with H_2/CO (400 p.s.i.) under the standard hydroformylation conditions at 80 or 100°C gave recovered starting material. No evidence of the tetrahydroquinazoline (5a) or any quinazoline products was observed in the ^1H and ^{13}C n.m.r. spectra of the crude products.

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