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Syntheses of Quinolines, Dihydro- and Tetrahydroquinolines via *ortho*-Quinone Methide Imine intermediate

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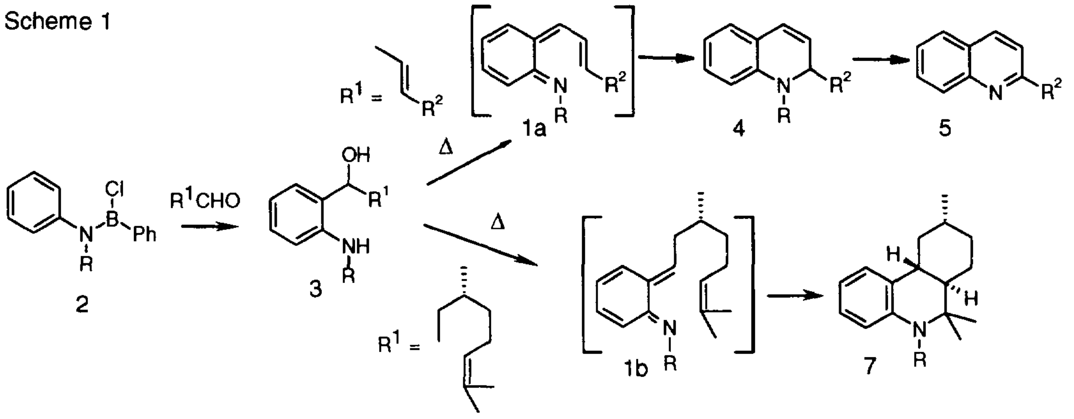
Abstract: A general process for *ortho*-specific hydroxyalkylation of secondary anilines via N-alkylanilinochlorophenylboranes has been developed. Pyrolysis of the resulting *ortho*-aminobenzyl alcohols generated the corresponding *ortho*-quinone methide imines, which can participate in an electrocyclic reaction to yield 2-substituted-1,2-dihydroquinolines. The resulting dihydroquinolines can be converted readily to a variety of 2-substituted quinolines. Intramolecular trapping of the *ortho*-quinone methide imines with an olefin via a [2+4] cycloaddition reaction leads to the syntheses of various polycyclic tetrahydroquinolines. Copyright © 1996 Elsevier Science Ltd

INTRODUCTION

ortho-Quinone methide imines **1** are highly reactive and unstable species which however, exhibit great potential in the synthesis of nitrogen-containing heterocycles.[1] *ortho*-Quinone methide imine intermediates may be trapped with an olefin and proceed through cycloaddition or electrocyclization reactions to produce a wide variety of heterocycles.[1-11] These highly unstable and reactive intermediates are generally formed *in situ* by pyrolysis or photolysis of various precursors such as *ortho*-aminobenzyl alcohols or their tert-butoxycarbonylamino derivatives,[2,3] dihydro-1,3-benzoxazine-2-one,[4] 2,1-benzisothiazoline 2,2-dioxide,[5,6] oxindol,[7] 2-azidoindole[8] and N-phenylbenzoazetine.[9] Fluoride-induced 1,4-elimination of [*ortho*-[(trimethylsilyl)alkylamino]-benzyl]trimethylammonium iodide provides a mild alternative to the pyrolytic reactions.[10]

Recently, we reported a facile method to prepare various substituted *ortho*-N-methylaminobenzyl alcohols as *ortho*-quinone methide imine precursors (Scheme 1).[11] Thermolysis of these *ortho*-N-methylaminobenzyl alcohols, followed by trapping of the corresponding *ortho*-quinone methide imine intermediates with an olefin via electrocyclic or intramolecular [4+2] cycloaddition reactions has led to the synthesis of dihydro- and tetrahydroquinoline derivatives, respectively. Herein the extension of this methodology to prepare a variety of other *ortho*-aminobenzyl alcohols with a removable group such as allyl or *p*-methoxybenzyl on the nitrogn, and their pyrolysis to generate *ortho*-quinone methide imine intermediates **1** under fairly mild conditions is reported. Trapping of the N-substituted quinone methide imines with an olefin via electrocyclization, followed by removal of the N-substituent and subsequent aromatization leads to the synthesis of 2-substituted quinolines and other related heterocycles (Scheme 1). Intramolecular [2+4] cycloaddition reaction of the N-substituted *ortho*-quinone methide imine intermediates **1** provides the syntheis of some unusual analogs of aza-cannabinoids **7**.

Scheme 1



RESULTS AND DISCUSSION

ortho-Hydroxyalkylation of N-Substituted Anilines

ortho-Specific hydroxyalkylation of aniline is readily achieved by *ortho*-lithiation of *tert*-butoxycarbonylaniline, followed by trapping of the resulting anion with an appropriate aldehyde.[3] Reaction of an aldehyde with N-methylanilinodichloroborane, prepared from N-methylaniline and boron trichloride *in situ*, provided a non-basic alternative. The latter reaction, however, works well with benzaldehyde but rather poorly with aliphatic aldehydes.[12] Recent successes in the *ortho*-hydroxyalkylation of phenol[13] and N-methylaniline[11] using dichlorophenylborane as the complexing agent prompted us to further pursue the use of dichlorophenylborane in the preparation of other N-alkyl *ortho*-aminobenzyl alcohols.

Preliminary investigation into the choice of easily removable N-substituents revealed that reaction of benzaldehyde with either the N-trifluoroacetyl- or N-phenylsulphonyl-anilinochlorophenylborane failed to yield the corresponding diphenylmethanol. In the case of N-acetylanilinochlorophenylborane, *ortho*-hydroxyalkylation with benzaldehyde gave the corrresponding ortho-aminobenzyl alcohols only in very low yield. However, *ortho*-hydroxyalkylation using N-*para*-methoxybenzylaniline and N-allylaniline as starting materials proved to be quite successful.

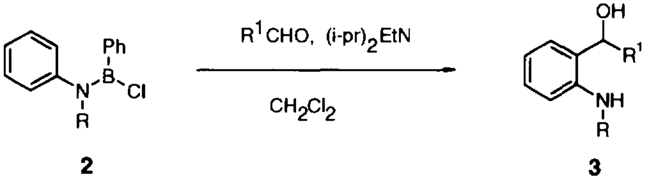
Following the procedure utilized for the *ortho*-hydroxyalkylation of N-methylaniline,[11] preformed N-*para*-methoxybenzylanilinochlorophenylborane **2a** was reacted with cinnamaldehyde in the presence of diisopropylethylamine at -20 °C and warming to 0 °C, to give the desired alcohol **3a** in a 63% yield. Reaction with crotonaldehyde resulted in a 42% yield of the corresponding alcohol **3b** (Table 1). Reactions of preformed N-allylanilinochlorophenylborane **2b** with cinnamaldehyde and crotonaldehyde under the above-noted conditions gave the N-allyl alcohols, **3c** and **3d**, in 94% and 46% yield, respectively. Crotonaldehyde gave lower yield in both cases. This is probably due to the instability of the product which is more prone to polymerization under these conditions. Comparing the two N-alkyl groups, the N-allyl protecting group appears to give higher yields. This led to the decision to study further the reaction of **2b** with other aldehydes. The results are summarized in Table 1. Reaction of **2b** with 2-hexenal gave a 81% yield of the corresponding allylic alcohol **3e**. Similarly, **2b** reacts with 3-(2-thienyl)acrolein and 3-(2-furyl)acrolein at -20 °C gave **3f** (73%) and **3g** (69%), respectively.

Good yields of heteroaryl alcohols were also obtained with unconjugated heteroaryl aldehydes. Reaction of **2b** with 3-thiophenecarboxaldehyde and 2-furaldehyde gave the corresponding *ortho*-aminobenzyl alcohols **3h** and **3i** in 80% yield in both cases.

The utility of the *ortho*-hydroxyalkylation reaction was extended further to bicyclic aniline derivatives such as indoline and tetrahydroquinoline. The results are summarized in Table 2. Reaction of **2c**, the aminochlorophenylborane derived from indoline, with benzaldehyde gave the corresponding *ortho*-aminobenzyl alcohol **3j** in 82% yield. Reaction of **2c** with α,β-unsaturated aldehydes such as cinnamaldehyde and crotonaldehyde gave the corresponding **3k** and **3l** in 68% and 84% yield respectively. Compound **3l** was unstable. It decomposed readily even when stored under nitrogen at -20 °C. Attempt to recrystalize the compound resulted in extensive decomposition. As a result, this compound was subjected to electrocyclization immediately without further manipulation.

An enolizable aliphatic aldehyde such as (*R*)-(+)-citronellal also reacts readily with **2c** to give **3m** in 79% yield. This procedure provides a convienient route to 7-substituted indoline and hence indoles. Similar results were obtained with the tetrahydroquinoline derived aminochlorophenyl borane (**2d**). The yields of the reaction of **2d** with cinnamaldehyde, crotonaldehyde, and citronellal were 86%, 73% and 72% respectively. In general, the products derived from tetrahydroquinoline (**3n**-**3p**) were more stable than the corresponding analogs derived from indoline.

Table 1. Preparation of *ortho*-aminobenzyl alcohols



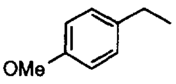
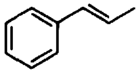
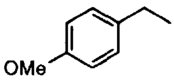
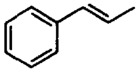
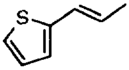
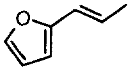
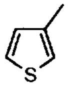
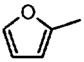
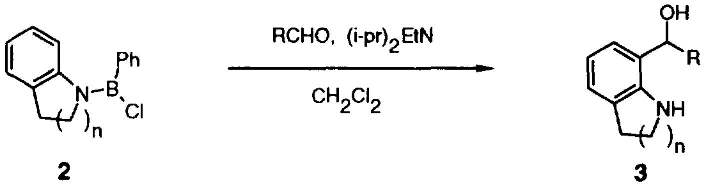
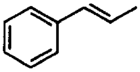
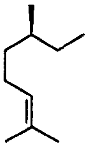
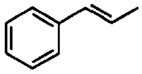
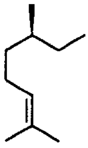
	R	R^1	Temp (°C)	Time (h)	Product (yield %)
2a			-20 to 0	3	**3a** (63)
			-20 to 0	3.5	**3b** (42)
2b			-20 to 0	3	**3c** (94)
			-20	3	**3d** (46)
			-20 to 0	3	**3e** (81)
			-20 to 0	3	**3f** (73)
			-20 to 0	3	**3g** (69)
			-20 to 0	3	**3h** (80)
			-20 to 0	3	**3i** (80)

Table 2. Preparation of *ortho*-aminobenzyl alcohols

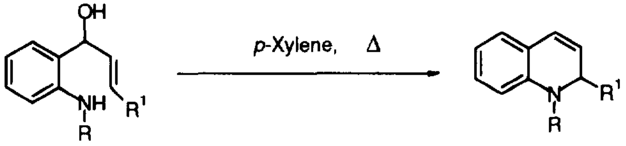


	n	R	Temp (°C)	Time (h)	Product (yield %)
2c	1		0	1.5	**3j** (82)
			-20 to 0	1.5	**3k** (68)
			-20 to 0	2	**3l** (84)
			-20 to 0	4	**3m** (79)
2d	2		0	3	**3n** (86)
			-20	25	**3o** (73)
			-20 to 0	3.5	**3p** (72)

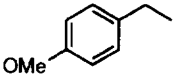
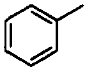
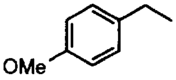
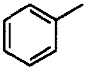
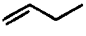
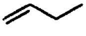
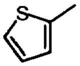
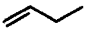
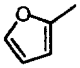
Electrocyclization of ortho-Quinone Methide Imines

The allylic alcohols of N-substituted anilines prepared are all well predisposed for electrocyclization. Pyrolysis of the N-*para*-methoxybenzyl alcohol **3a** in refluxing *para*-xylene yielded 59% of the desired dihydroquinoline **4a** after 7.5 h. Pyrolysis of the crotyl alcohol derivative **3b** gave 31% yield of the corresponding product **4b**. The results are summarized in Table 3. Electrocyclization of the analogous N-allyl derivatives **3c** and **3d** was more successful. After 3.5 h in refluxing *para*-xylene, the corresponding N-allyl-2-substituted-1,2-dihydroquinolines, **4c** and **4d**, were isolated in 68% and 51% yields, respectively. Again, the N-allyl substituent shows a slight advantage over the *para*-methoxybenzyl substituent. Pyrolysis of the hexenol analog **3e** gave only 37% yield of the corresponding **4e**. Compound **4e** was very unstable and decomposed readily on standing at room temperature.

Table 3. Electrocyclization of *ortho*-quinone methide imines



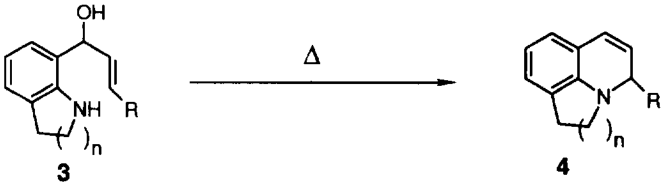
3 **4**

	R	R^1	Time (h)	Product (yield %)
3a			7.5	**4a** (59)
3b		CH_3	3	**4b** (31)
3c			3.5	**4c** (68)
3d		CH_3	3.5	**4d** (51)
3e			3	**4e** (37)
3f			2.5	**4f** (59)
3g			5	**4g** (4)

Pyrolysis of **3f** gave a 59% yield of N-allyl-2-(2-thienyl)-1,2-dihydroquinoline (**4f**) after only 2.5 h of refluxing in *para*-xylene. However, the yield of the 2-(2-furyl)-1,2-dihydroquinoline (**4g**) was very low (4%). The low yield of **4g** was likely due to the instability of the highly electron rich starting material, **3g**, which decomposes readily at room temperature. In general, the N-allyl substituted dihydroquinolines were much less stable than the N-*para*-methoxybenzyl or N-methyl analogs.

Application of the electrocyclization reaction to the indoline and tetrahydroquinoline derivatives (**3k**, **3l** and **3n**, **3o**) led to the syntheses of some interesting tricyclic compounds (Table 4). Pyrolysis of the cinnamyl alcohol derivative of indoline, **3k**, gave 63% yield of the corresponding tricyclic compound **4h**. The yield of pyrolysis of the crotyl alcohol analog **3l** gave only 23% of **4i**. Compound **4i** was extremely air sensitive. The instability of the starting material and the product might account for the low yield of the reaction. In contrast, pyrolysis of the crotyl alcohol derivative of tetrahydroquinoline, **3o**, gave better yield of the 5-methyl-1,2,3,5-tetrahydro-pyrido[3,2,1-ij]quinoline, (**4k**) (51%). Compound **4k** was much more stable than **4i**. However, the yield of the phenyl analog **4j** (40%) was lower than that of the indoline derivative (**4h**) and the reaction required higher temperature and longer reaction time.

Table 4. Electrocyclization of *ortho*-quinone methide imines

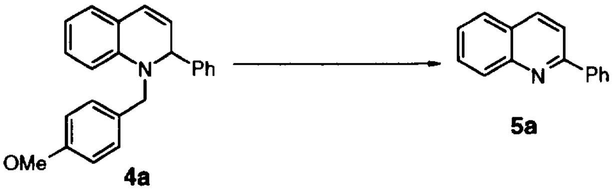


	n	R	Temp (°C)	Time (h)	Product (yield %)
3k	1	Ph	139	5	**4h** (63)
3l	1	Me	139	26	**4i** (23)
3n	2	Ph	180	20	**4j** (40)
3o	2	Me	139	2	**4k** (51)

Synthesis of Quinolines

The N-allyl and N-*para*-methoxybenzyl substituent on the dihydroquinolines **4** were designed for easy removal. By deprotection and subsequent aromatization, the 1,2-disubstituted-1,2-dihydroquinolines may be converted into 2-substituted quinolines. Removal of the *para*-methoxybenzyl substituent proved to be more difficult than expected. Only 32% of the 2-phenylquinoline **5a** was isolated when **4a** was treated with $ALCl_3$ in anisole[14]. Refluxing **4a** in DDQ for a 24 h period failed to produce any of the desired product. Treatment of **4a** with trifluoroacetic acid and sulfuric acid in anisole[15] also met with minimal success, as less than 26% of the targetted compound was actually obtained (Table 5).

Table 5. Deprotection of *p*-methoxybenzyl substituent



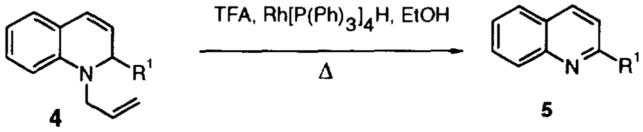
4a

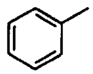
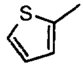
5a

Conditions	Time (h)	Yield (%)
$AlCl_3$, anisole, 0°C	18	32
DDQ, Δ	24	(no reaction)
TFA, H_2SO_4 (conc.), anisole, Δ	4	26

Removal of the allyl substituent (Table 6) was achieved much more readily. 2-phenylquinoline (**5a**) was isolated in 66% yield, after only 1.5 h of refluxing **4c** in ethanol in the presence of trifluoroacetic acid and hydridotetrakis(triphenylphosphine)rhodium.[16] The deprotection results indicate that the allyl substituent is preferred to the *para*-methoxybenzyl substituent. Deprotection of the remaining 1,2-disubstituted-1,2-dihydroquinolines was also successfully achieved. 2-Methylquinoline (**5b**), was isolated in 45% yield. Similarly, 2-propylquinoline (**5c**) and 2-(2-thienyl)quinoline (**5d**) were obtained in 67% and 59% yields, respectively. Insufficient material was recovered from the pyrolysis reaction of **3g** to attempt deprotection of **4g**. Based on the results reported above, the allyl substituent provides consistently higher yields than the *para*-methoxybenzyl substituent in the *ortho*-hydroxyalkylation, pyrolysis, and deprotection reactions leading to the formation of 2-substituted quinolines.

Table 6. Synthesis of quinolines

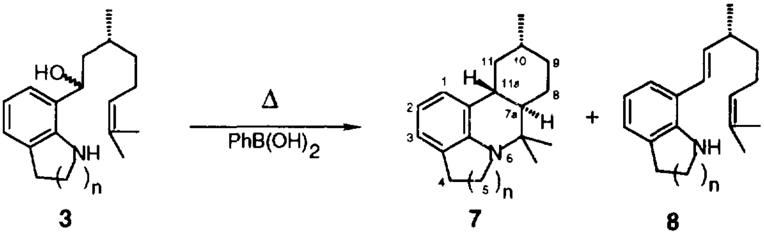


	R^1	Time (h)	Product (yield %)
4c		3.5	**5a** (68)
4d	CH_3	3.5	**5b** (45)
4e		3	**5c** (67)
4f		2.5	**5d** (59)

Synthesis of aza-cannabinoids

The *ortho*-aminobenzyl alcohols derived from citronellal, **3m** and **3p**, were set up for intramolecular Diels-Alder reaction. Pyrolysis of **3m** in the presence of phenyl boronic acid[11] gave 50% yield of the tetracyclic aza-cannabinoid derivative **7a** ($[\alpha]_D^{25}$ -34 (c 2, $CHCl_3$)) as a single enantiomer. The only other product isolated was the diene **8a** resulted from the dehydration of **3m**. The stereochemistry of **7a** was determined by 2D-COSY and NOESY experiments. The vicinal coupling constant of the protons across the ring junction, *J*(7a, 11a), was measured to be 12.3 Hz. This is consistent with a *trans* ring junction. The equatorial orientation of the 10-methyl group was deduced from the analysis of the highest field proton H-11_{ax} (δ 0.85). This proton appeared as an apparent quartet, due to approximate equal geminal and two *trans* diaxial vincinal coupling (12 Hz). H-10 and H-11a is therefore axial and the methyl substituent is equatorial. This was further supported by the strong nOe observed between H-8_{ax}, H-10 and H-11a. The stereochemistry at the ring junction and the methyl substituent of compound **7a** is the same as that of natural cannabinoids. It is of interest to note that compound **7a** is also stucturally related to the amaryllidaceae alkaloids.[17] Similar results were obtained with the tetrahydroquinoline derivative **3p**. The yield of the corresponding aza-cannabinoid derivative **7b** ($[\alpha]_D^{25}$ +44 (c 2, $CHCl_3$)) was higher (66%). Only 14% of the diene **8b** was isolated. Compound **7b** exhibits similar spectral characteristics as **7a** with the same stereochemistry.

Table 7. Synthesis of aza-cannabinoids



	n	Temp (°C)	Time (h)	Product (yield %)	
3m	1	180	1	**7a** (50)	**8a** (33)
3p	2	139	60	**7b** (66)	**8b** (14)

The numbering of compound **7** shown above is for **7a** only

In summary, it has been shown that *ortho*-hydroxyalkylation of N-alkylaniline via N-alkyl anilinochlorophenylborane is a general and efficient process that works well with aryl, heteroaryl, α,β-unsaturated and enolizable aliphatic aldehydes. The *ortho*-hydroxyalkylation of N-allylaniline has been shown to be particularly efficient. The *ortho*-N-allylaminobenzyl alcohols thus obtained are useful precursors of *ortho*-quinone methide imines, the latter of which can be generated pyrolytically. With the alkyl chain properly substituted with an olefin, the resulting *ortho*-quinone methide imine may undergo facile electrocyclization to give various dihydroquinolines. Deprotection of the N-allyl substituent of the dihydroquinolines followed by aromatization, provides a facile synthesis of 2-substituted quinolines. Intramolecular [2+4] cycloaddition of the *ortho*-quinone methide imine intermediates with an olefin has lead to the syntheses of some interesting tetracyclic aza-cannabinoid derivatives.

EXPERIMENTAL

General Information

^{1}H NMR and ^{13}C NMR spectra were measured with a Varian 200 spectrometer, Brucker ARX400 spectrometer or on a Brucker ARX 500 spectrometers. Melting points were measured on a Büchi 510 melting point apparatus and are uncorrected. Low-resolution mass spectral analyses were performed by the Oneida Research Services, Inc. of Whitesboro, New York. Exact masses were obtained by high resolution mass spectroscopy performed by Dr. O. Maimer of McGill University, Montreal, Quebec. Elemental analyses were performed by Galbraith Laboratories, Inc. of Knoxville, Tennessee. Infrared spectra were obtained on a Perkin-

Elmer infrared spectrophotometer, model 681. Flash chromatography was performed using Merck silica gel 60, 230-400 mesh and tlc using Merck silica gel 60F 254 sheets.

General Procedure A

Preparation of N-alkyl-ortho-aminobenzyl alcohols (3)

A stock solution of N-*para*-methoxybenzylanilinochlorophenylborane **2a** was prepared by adding dichlorophenylborane (100 mmol) to a solution of N-*para*-methoxybenzylaniline **2a** (100 mmol) in 1,2-dichloroethane (100 mL) at 0 °C. The resulting mixture was refluxed for 2 h under a rapid stream of nitrogen to remove any HCl formed. The mixture was cooled to give a cloudy solution (≈0.8M), which could be stored at 0 °C for more than six weeks without deteriorating. Similarly, **2b**, **2c** and **2d** were prepared from their corresponding amino compound. In a typical procedure, a solution of **2a** (10.7 mmol) in dichloroethane was added dropwise at -20 °C to a mixture of the aldehyde (10 mmol) and diisopropylethylamine (20 mmol) in dichloromethane. The mixture was stirred at -20°C to 0°C for the appropriate time, quenched with ammonium hydroxide, and filtered through a short, wide pad of silica gel. The filtrate was concentrated and the residue was chromatographed on silica gel, eluted with an ethyl acetate/hexane (0-20%).

1-[2-(4-Methoxy-benzylamino)-phenyl]-3-phenyl-prop-2-en-1-ol (3a)

Following the general procedure A, cinnamaldehyde (1.32g, 10 mmol) was reacted with **2a** to afford, after chromatography, 2.17 g (63%) of the title compound; IR (neat): 3390 (NH, OH), 1605, 1510 cm^{-1}; ^{1}H nmr (200 MHz, CD_3COCD_3) δ 3.75 (s, 3H, OCH_3), 4.30 (d, 2H, J = 5.68 Hz, NCH_2), 4.79 (d, 1H, J = 3.9 Hz, OH), 5.44 (t, 1H, J = 4.3 Hz, CHO), 5.76 (m, 1H, NH), 6.61 (m, 4H), 6.81 (m, 2H), 7.24 (m, 9H); ^{13}C nmr (100.6 MHz, CD_3COCD_3) δ 47.4, 55.4, 75.0, 111.8, 114.6, 116.8, 127.3, 127.6, 128.2, 128.4, 129.2, 129.3, 129.4, 130.4, 131.9, 132.8, 138.0, 147.6, 159.6; Exact Mass calcd. for $C_{23}H_{24}NO_2$ (M+1): 346.1807; found: 346.1807.

1-[2-(4-Methoxy-benzylamino)-phenyl]-but-2-en-1-ol (3b)

According to the general procedure A, crotonaldehyde (260 mg, 3.7 mmol) was reacted with **2a** (4 mmol) for 3.5 h to yield, after chromatography, 439 mg (42%) of the title compound as an oil; IR (neat): 3390 (NH, OH) cm^{-1}; ^{1}H nmr (200 MHz, CD_3COCD_3) δ 1.69 (d, 3H, J = 6.0 Hz, CH_3), 3.77 (s, 3H, OCH_3), 4.29 (d, 2H, J = 5.5 Hz, NCH_2), 4.48 (d, 1H, J = 3.9 Hz, OH), 5.17 (m, 1H, CHO), 5.76 (m, 3H), 6.55 (m, 2H), 6.96 (m, 4H), 7.31 (m, 2H); ^{13}C nmr (100.6 MHz, CD_3COCD_3) δ 17.8, 47.6, 55.5, 75.1, 111.7, 114.6, 116.8, 126.4, 128.1, 128.1, 128.9, 129.3, 132.9, 133.5, 147.5, 159.8; Exact Mass calcd. for $C_{18}H_{22}NO_2$ (M+1): 284.1651; found: 284.1651.

1-(2-Allylamino-phenyl)-3-phenyl-prop-2-en-1-ol (3c)

Following the general procedure A, cinnamaldehyde (1.32 g, 10 mmol) was reacted with **2b** (10.7 mmol) to give, after chromatography, 2.49 g (94%) of the title compound as an oil; IR (neat): 3390 (NH, OH), 1605, 1515 cm^{-1}; ^{1}H nmr (200 MHz, CD_3COCD_3) δ 3.81 (m, 2H, NCH_2), 4.78 (d, 1H, J = 4 Hz, OH), 5.09 (dd, 1H, J = 10.3, 1.8 Hz, CH=C$\underline{H}_2$), 5.28 (dd, 1H, J = 17.2, 1.8 Hz, CH=C$\underline{H}_2$), 5.42 (t, 1H, J = 4.4 Hz, CHO), 5.53 (m, 1H, NH), 5.98 (m, 1H, C$\underline{H}$=CH_2), 6.65 (m, 4H), 7.28 (m, 7H); ^{13}C nmr (100.6 MHz, CD_3COCD_3) δ 46.5, 75.1, 111.9, 115.7, 117.0, 127.3, 127.7, 128.3, 128.5, 129.3, 129.5, 130.6, 131.9, 136.9, 138.1, 147.7; Exact Mass calcd. for $C_{18}H_{18}N$ (M+1 - H_2O): 248.1439; found: 248.1438.

1-(2-Allylamino-phenyl)-but-2-en-1-ol (3d)

According to the general procedure A, crotonaldehyde (701 mg, 10 mmol) was reacted with **2b** at -20°C for 3 h to yield, after chromatography, 930 mg (46%) of the title compound; IR (neat): 3400 (NH, OH) cm^{-1}; H nmr (200 MHz, CD_3COCD_3) δ 1.68 (d, 3H, J = 5.9 Hz, CH_3), 3.78 (m, 2H, NCH_2), 4.46 (d, 1H, J = 3.9 Hz, OH), 5.12 (m, 2H), 5.27 (dd, 1H, J = 17.2, 1.8 Hz, CH=C$\underline{H}_2$), 5.45 (br s, 1H, NH), 5.85 (m, 3H), 6.56 (m, 2H), 7.06 (m, 2H); ^{13}C nmr (100.6 MHz, CD_3COCD_3) δ 17.8, 46.4, 75.0, 111.6, 115.5, 116.8, 126.4, 128.1, 128.9, 133.5, 137.0, 147.5; Exact Mass calcd. for $C_{13}H_{18}NO$ (M+1): 204.1388; found: 204.1388.

1-(2-Allylamino-phenyl)-hex-2-en-1-ol (3e)

Following the general procedure A, 2-hexenal (982 mg, 10 mmol) was reacted with **2b** (10.7 mmol) to yield, after chromatography, 1.88 g (81%) of the title compound as an oil; IR (neat): 3400 (NH, OH) cm^{-1}; ^{1}H nmr (200 MHz, CD_3COCD_3) δ 0.89 (t, 3H, J = 7.3 Hz, CH_3), 1.39 (m, 2H, C$\underline{H}_2$$CH_3$), 2.02 (m, 2H, C$\underline{H}_2$$CH_2CH_3$), 3.78 (m, 2H, NCH_2), 4.48 (d, 1H, J = 3.9 Hz, OH), 5.13 (m, 2H), 5.27 (m, 1H, CH=C$\underline{H}_2$), 5.42 (br s, 1H, NH), 5.74 (m, 2H), 5.97 (m, 1H, C$\underline{H}$=CH_2), 6.56 (m, 2H), 7.06 (m, 2H); Exact Mass calcd. for $C_{15}H_{22}NO$ (M+1): 232.1701; found: 232.1701; Anal. calcd. for $C_{15}H_{21}NO$: C 77.88, H 9.15, N 6.05; found: C 77.75, H 9.20, N 5.86.

1-(2-Allylamino-phenyl)-3-(2-thienyl)-prop-2-en-1-ol (3f)

According to the general procedure A, 3-(2-thienyl)acrolein (415 mg, 3 mmol) was reacted with **2b** (3.2 mmol) to afford, after chromatography, 593 mg (73%) of the title compound as an oil; IR (neat): 3400 (NH, OH) cm^{-1}; ^{1}H nmr (200 MHz, CD_3COCD_3) δ 3.81 (m, 2H, NCH_2), 4.81 (d, 1H, J = 3.84 Hz, OH), 5.09 (m, 1H, CH=C$\underline{H}_2$), 5.28 (m, 1H, CH=C$\underline{H}_2$), 5.39 (m, 1H, CHO), 5.52 (br s, 1H, NH), 5.97 (m, 1H, C$\underline{H}$=CH_2), 6.49 (m, 3H), 7.06 (m, 6H); ^{13}C nmr (100.6 MHz, CD_3COCD_3) δ 46.3, 74.7, 111.8, 115.5, 116.9, 123.7, 125.0, 126.6, 127.4, 128.3, 128.4, 129.2, 131.5, 136.9, 143.0, 147.6; Exact Mass calcd. for $C_{16}H_{18}NOS$ (M+1): 272.1109; found: 272.1109.

1-(2-Allylamino-phenyl)-3-(2-furyl)-prop-2-en-1-ol (3g)

According to the general procedure A, 3-(2-furyl)acrolein (1.22 g, 10 mmol) was reacted with **2b** (10.7 mmol) to give, after chromatography, 1.77 g (69%) of the title compound as an oil; IR (neat): 3400 (NH, OH) cm^{-1}; ^{1}H nmr (200 MHz, CD_3COCD_3) δ 3.80 (m, 2H, NCH_2), 4.80 (d, 1H, J = 4.0 Hz, OH), 5.09 (m, 1H, CH=C$\underline{H}_2$), 5.27 (m, 1H, CH=C$\underline{H}_2$), 5.40 (m, 1H, CHO), 5.52 (br s, 1H, NH), 5.98 (m, 1H, C$\underline{H}$=CH$_2$), 6.48 (m, 6H), 7.08 (m, 2H), 7.47 (s, 1H); Exact Mass calcd. for $C_{16}H_{16}NO$ (M+1 - H_2O): 238.1232; found: 238.1231. The compound was very unstable and was pyrolysed without further charaterization.

(2-Allylamino-phenyl)-thiophen-3-yl-methanol (3h)

Following the general procedure A, 3-thiophenecarboxaldehyde (1.12 g, 10 mmol) was reacted with **2b** (10.7 mmol) to yield, after chromatography, 1.96 g (80%) of the title compound as an oil; IR (neat): 3400 (NH, OH) cm^{-1}; ^{1}H nmr (200 MHz, CD_3COCD_3) δ 3.74 (m, 2H, NCH$_2$), 5.04 (m, 2H), 5.15 (dd, 1H, J = 17.3, 1.8 Hz, CH=C$\underline{H}_2$), 5.38 (br s, 1H, NH), 5.88 (m, 2H), 6.57 (m, 2H), 7.05 (m, 3H), 7.29 (m, 2H); Exact Mass calcd. for $C_{14}H_{16}NOS$ (M+1): 246.0953; found: 246.0953; Anal. calcd. for $C_{14}H_{15}NOS$: C 68.54, H 6.16, N 5.71; found: C 68.12, H 6.16, N 5.40.

(2-Allylamino-phenyl)-furan-2-yl-methanol (3i)

According to the general procedure A, 2-furanaldehyde (961 mg, 10 mmol) was reacted with **2b** (10.7 mmol) to afford, after chromatography, 1.84 g (80%) of the title compound as an oil; IR (neat): 3410 (NH, OH) cm^{-1}; ^{1}H nmr (200 MHz, CD_3COCD_3) δ 3.78 (m, 2H, NCH$_2$), 5.08 (m, 2H), 5.22 (m, 1H), 5.30 (br s, 1H, NH), 5.92 (m, 2H), 6.25 (dd, 1H, J = 3.2, 0.8 Hz), 6.37 (dd, 1H, J = 3.3, 1.8 Hz), 6.59 (m, 2H), 7.08 (m, 2H), 7.47 (dd, 1H, J = 1.7, 0.8 Hz); Exact Mass calcd. for $C_{14}H_{16}NO_2$ (M+1): 230.1181; found: 230.1181; Anal. calcd. for $C_{14}H_{15}NO_2$: C 73.34, H 6.59, N 6.11; found: C 73.24, H 6.36, N 5.94.

(2,3-Dihydroindolin-7-yl)-phenyl-methanol (3j)

Following the general procedure A, benzaldehyde (318 mg, 3 mmol) was reacted with **2c** (3.2 mmol) to afford, after chromatography, 555 mg (82%) of the title compound; ^{1}H nmr (400 MHz, CD_3COCD_3) δ 2.82-2.96 (m, 2H), 3.46 (t, 2H, J = 8.6 Hz, NCH$_2$), 4.68 (d, 1H, J = 4 Hz, OH), 4.80 (br s, 1H, NH), 5.76 (d, 1H, J = 3.9 Hz, C$\underline{H}$O), 6.53, (t, 1H, J = 7.5 Hz), 6.88 (dd, 1H, J = 7.7, 0.5 Hz), 6.93 (dd, 1H, J = 7.2, 1 Hz), 7.15-7.22 (m, 1H), 7.25-7.32 (m, 2H), 7.40-7.46 (m, 2H); Anal. calcd. for $C_{15}H_{15}NO$: C 79.97, H 6.71, N 6.22; found: C 79.97, H 6.80, N 6.08.

1-(2,3-Dihydroindolin-7-yl)-3-phenyl-prop-2-en-1-ol (3k)

Following the general procedure A, cinnamaldehyde (660 mg, 5 mmol) was reacted with **2c** (5 mmol) to afford, after chromatography, 857 mg (68%) of the title compound; ^{1}H nmr (400 MHz, CD_3COCD_3) δ 2.78-2.98 (m, 2H), 3.45-3.55 (m, 2H), 4.41 (d, 1H, J = 3.8 Hz, OH), 4.85 (br s, 1H, NH), 5.28-5.33 (m, 1H, C$\underline{H}$O), 6.49 (dd, 1H, J = 15.9, 6.4 Hz), 6.59 (t, 1H, J = 7.5 Hz), 6.68 (d, 1H, J = 15.9 Hz), 6.96 (t, 2H, J = 7.7 Hz), 7.18-7.23 (m, 1H), 7.27-7.35 (m, 2H), 7.38-7.45 (m, 2H); Anal. calcd. for $C_{17}H_{17}NO$: C 81.24, H 6.82, N 5.57; found: C 81.13, H 6.70, N 5.31.

1-(2,3-Dihydroindolin-7-yl)-but-2-en-1-ol (3l)

Following the general procedure A, 2-butenal (350 mg, 5 mmol) was reacted with **2c** (5 mmol) to afford, after chromatography, 792 mg (84%) of the title compound; ^{1}H nmr (400 MHz, CD_3COCD_3) δ 1.65 (d, 3H, J = 4.9 Hz), 2.85-2.98 (m, 2H), 3.42-3.55 (m, 2H), 4.09 (d, 1H J = 3.7 Hz), 4.74 (br s, 1H, NH), 5.01-5.08 (m, 1H, $\text{C}\underline{\text{H}}\text{O}$), 5.62-5.78 (m, 2H, CH=CH), 6.52 (t, 1H, J = 7.4 Hz), 6.88 (d, 1H, J = 7.6 Hz), 6.91 (d, 1H, J = 7.2 Hz). The compound was very unstable and was pyrolysed without further charaterization.

1-(2,3-Dihydroindolin-7-yl)-3,7-dimethyl-oct-6-en-1-ol (3m)

Following general procedure A, *(R)*-(+)-citronellal was was reacted with **2c** to afford, after chromatography, (79%) of the title compound as an oil; ^{1}H nmr (400 MHz, CD_3COCD_3) δ 0.92-0.97 (d, 3H, J = 7Hz, $\text{C}\underline{\text{H}}_3$-CH), 1.07-1.23 (m, 1H), 1.32-1.48 (m, 1H), 1.50-2.02 (m, 11H), 2.85-2.96 (m, 2H), 3.42-3.54 (m, 2H), 4.02-4.07 (d, 1H, J = 4Hz, OH), 4.68-4.75 (m, 1H, $\text{C}\underline{\text{H}}$-OH), 4.77-4.87 (bs, 1H, NH), 5.03-5.15 (m, 1H, $\text{C}\underline{\text{H}}$=C), 6.50-6.57 (m, 1H), 6.83-6.96 (m, 2H); ^{13}C nmr (100.6 MHz, CD_3COCD_3) δ 5.7, 21.8, 21.8, 23.6, 24.8, 29.96, 30.0, 30.2, 30.3, 41.6, 42.7, 48.3, 48.5, 52.0, 74.9, 75.5, 122.15, 122.22, 127.6, 127.7, 129.3, 129.6, 129.9, 131.1, 131.6, 134.3, 134.4, 135.3, 135.4, 154.6, 154.7; Exact Mass calcd. for $C_{18}H_{28}NO$ (M+1): 274.2171; found: 274.2171.

3-Phenyl-1-(1,2,3,4-tetrahydro-quinolin-8-yl)-prop-2-en-1-ol (3n)

Following the general procedure A, cinnamaldehyde (400 mg, 3 mmol) was reacted with **2d** (3.2 mmol) to afford, after chromatography, 690 mg (87%) of the title compound as a solid; mp: 87-89°C; IR (neat): 3360 (NH), 3270 (OH), 1600, 1495 cm^{-1}; ^{1}H nmr (200 MHz, CD_3COCD_3) δ 1.84 (m, 2H), 2.74 (m, 2H), 3.32 (m, 2H), 4.60 (d, 1H, J = 4.1 Hz, OH), 5.31 (m, 2H), 6.47 (m, 1H), 6.64 (m, 2H), 6.78 (m, 1H), 6.94 (d, 1H, J = 7.5 Hz), 7.34 (m, 5H); Exact Mass calcd. for $C_{18}H_{20}NO$ (M+1): 266.1545; found: 266.1545; Anal. calcd. for $C_{18}H_{19}NO$: C 81.48, H 7.22, N 5.28; found: C 81.38, H 7.21, N 5.03.

1-(1,2,3,4-Tetrahydro-quinolin-8-yl)-but-2-en-1-ol (3o)

Following the general procedure A, 2-butenal (350mg, 5 mmol) was reacted with **2c** (5 mmol) to afford, after chromatography, 744 mg (73%) of the title compound; ^{1}H nmr (400 MHz, CD_3COCD_3) δ 1.66 (d, 3H, J = 6 Hz), 1.77-1.87 (m, 2H), 2.65-2.75 (m, 2H), 3.25-3.35 (m, 2H), 4.20 (d, 1H, J = 4 Hz), 4.98-5.07 (m, 1H, $\text{C}\underline{\text{H}}\text{O}$), 5.18 (br s, 1H, NH), 5.60-5.87 (m, 2H, CH=CH), 6.41 (t, 1H, J = 7.5 Hz), 6.75 (d, 1H, J = 8 Hz), 6.84 (d, 1H, J = 7.6 Hz); ^{13}C nmr (100.6 MHz, CD_3COCD_3) δ 21.9, 26.8, 32.4, 46.5, 78.5, 120.2, 126.0, 130.1, 130.3, 131.4, 133.3, 137.8, 148.2; Exact Mass calcd. for $C_{13}H_{18}NO$ (M+1): 204.1388; found: 204.1388.

1-(1,2,3,4-Tetrahydroquinlolin-8-yl)-3,7-dimethyl-oct-6-en-1-ol (3p)

Following general procedure A, *(R)*-(+)-citronellal was was reacted with **2c** to afford, after chromatography, (72%) of the title compound as an oil; ^{1}H nmr (400 MHz, CD_3COCD_3) δ 0.92-0.96 (d, 3H, J = 7Hz, $\text{C}\underline{\text{H}}_3$-CH), 1.08-1.25 (m, 1H), 1.32-2.01 (m, 14H), 2.64-2.78 (m, 2H), 3.23-3.35 (m, 2H), 4.16-4.22 (m, 1H, OH), 4.68-4.75 (m, 1H, CH-OH), 5.02-5.15 (m, 1H, CH=C), 5.33-5.43 (m, 1H, NH), 6.38-6.45 (m, 1H), 6.72-6.82 (m, 2H); ^{13}C nmr (100.6 MHz, CD_3COCD_3) δ 21.8, 21.9, 23.7, 24.8, 26.8, 30.0, 30.1, 30.2, 30.3, 32.5, 41.6, 42.7, 46.46, 46.5, 47.2, 47.5, 76.2, 77.1, 120.0, 120.2, 126.06, 126.1, 129.7, 129.9, 130.1, 132.3, 132.9, 133.0, 133.1, 135.3, 135.4, 148.4; Exact mass calcd. for $C_{19}H_{30}NO$ (M+1): 288.2327; found: 288.2328.

General Procedure B

*Preparation of 1-(4-methoxy-benzyl)-2-phenyl-1,2-dihydroquinoline (**4a**)*

A solution of **3a** (500 mg, 1.45 mmol) in *para*-xylene (10 mL) was heated to reflux for 7.5 h. The solvent was evaporated under vacuum and the residue was chromatographed on silica gel using 5% ethyl acetate/hexane, to yield 278 mg (59%) of the title compound; ^{1}H nmr (200 MHz, CD_3COCD_3), δ 3.76 (s, 3H, OCH_3), 4.06 (d, 1H, J = 16.2 Hz, NCH_2), 4.51 (d, 1H, J = 16.2 Hz, NCH_2), 5.32 (dd, 1H, J = 5.1, 0.9 Hz, NCHPh), 5.73 (dd, 1H, J = 9.8, 5.1 Hz, C=CH), 6.47 (m, 3H), 6.89 (m, 4H), 7.25 (m, 7H); Anal. calcd. for $C_{23}H_{21}NO$: C 84.37, H 6.46, N 4.28; found: C 84.03, H 6.60, N 4.24; ms, *m/z*: 328 (M+1), 222, 206.

*1-(4-Methoxy-benzyl)-2-methyl-1,2-dihydroquinoline (**4b**)*

According to the general procedure B, a solution of **3b** (200 mg, 0.71 mmol) in *para*-xylene (5 mL) was heated to reflux for 3 h to give, after chromatography, 58 mg (31%) of the title compound; ^{1}H nmr (200 MHz, CD_3COCD_3), δ 1.11 (d, 3H, J = 6.3 Hz, CH_3), 3.77 (s, 3H, OCH_3), 4.20 (m, 1H, $CHCH_3$), 4.33 (d, 1H, J = 15.9 Hz, NCH_2), 4.52 (d, 1H, J = 15.9 Hz, NCH_2), 5.71 (dd, 1H, J = 9.7, 5.3 Hz, C=CH), 6.35 (d, 1H, J = 9.7 Hz, C=CH), 6.45 (d, 1H, J = 8.2 Hz), 6.50 (t, 1H, J = 7.4 Hz), 6.88 (m, 4H), 7.28 (d, 2H, J = 8.4 Hz); ^{13}C nmr (100.6 MHz, CD_3COCD_3), δ 19.8, 33.9, 52.1, 55.2, 55.4, 112.4, 114.6, 117.1, 125.5, 127.5, 127.8, 129.0, 129.4, 131.3; Exact Mass calcd. for $C_{18}H_{19}NO$: 265.1467; found: 265.1466.

*1-Allyl-2-phenyl-1,2-dihydroquinoline (**4c**)*

Following the general procedure B, a solution of **3c** (1.49 g, 5.60 mmol) in *para*-xylene (30 mL) was heated to reflux for 3.5 h to afford, after chromatography, 939 mg (68%) of the title compound; ^{1}H nmr (200 MHz, CD_3COCD_3), δ 3.60 (dd, 1H, J = 16.9, 5.9 Hz, NCH_2), 3.94 (dd, 1H, J = 16.9, 4.6 Hz, NCH_2), 5.09 (dd, 1H, J = 10.3, 1.7 Hz, $CH{=}CH_2$), 5.18 (dd, 1H, J = 17.3, 1.7 Hz, $CH{=}CH_2$), 5.33 (dd, 1H, J = 4.8, 1.3 Hz, NCH), 5.66 (dd, 1H, J = 9.8, 4.8 Hz, C=CH), 5.72 (m, 1H, $CH{=}CH_2$), 6.36 (d, 1H, J = 9.7 Hz, C=CH), 6.52 (m, 2H), 6.89 (dd, 1H, J = 7.5, 1.5 Hz), 7.00 (dt, 1H, J = 7.8, 1.6 Hz), 7.30 (m, 5H); ^{13}C nmr (100.6 MHz, CD_3COCD_3), δ 33.9, 51.4, 64.5, 110.9, 116.7, 117.0, 121.6, 124.9, 126.2, 127.4, 127.9, 128.1, 129.4, 130.0, 134.8, 144.9; Exact Mass calcd. for $C_{18}H_{18}N$ (M+1): 248.1439; found: 248.1438.

1-Allyl-2-methyl-1,2-dihydroquinoline ***(4d)***

According to the general procedure B, a solution of **3d** (873 mg, 4.29 mmol) in *para*-xylene (25 mL) was heated to reflux for 3.5 h to give, after chromatography, 404 mg (51%) of the title compound; ^{1}H nmr (200 MHz, CD_3COCD_3), δ 1.11 (d, 3H, J = 6.3 Hz, CH_3), 3.89 (m, 2H, NCH_2), 4.21 (m, 1H, $C\underline{H}CH_3$), 5.15 (m, 1H, $CH{=}C\underline{H}_2$), 5.30 (m, 1H, $CH{=}C\underline{H}_2$), 5.65 (dd, 1H, J = 9.7, 5.1 Hz, C=CH), 5.90 (m, 1H, $C\underline{H}{=}CH_2$), 6.30 (d, 1H, J = 9.7 Hz, C=CH), 6.50 (m, 2H), 6.84 (d, 1H, J = 7.5 Hz), 6.97 (m, 1H); ms, *m/z*: 186 (M+1), 170, 144; Exact Mass calcd. for $C_{13}H_{14}N$ (M-1): 184.1124; found: 184.1125.

1-Allyl-2-propyl-1,2-dihydroquinoline ***(4e)***

According to the general procedure B, a solution of **3e** (1.70 g, 7.35 mmol) in *para*-xylene (40 mL) was heated to reflux for 3 h to yield, after chromatography, 579 mg (37%) of the title compound; ^{1}H nmr (200 MHz, CD_3COCD_3), δ 0.86 (t, 3H, J = 7 Hz, CH_3), 1.47 (m, 4H), 3.82 (dd, 1H, J = 16.7, 5.4 Hz, NCH_2), 3.99 (dd, 1H, J = 16.7, 5.0 Hz, NCH_2), 4.15 (m, 1H, NCH), 5.14 (m, 1H, $CH{=}C\underline{H}_2$), 5.28 (m, 1H, $CH{=}C\underline{H}_2$), 5.67 (dd, 1H, J = 9.8, 5.2 Hz, C=CH), 5.88 (m, 1H, $C\underline{H}{=}CH_2$), 6.35 (d, 1H, J = 9.8 Hz, C=CH), 6.47 (m, 2H), 6.83 (dd, 1H, J = 7.0, 1.8 Hz), 6.95 (m, 1H). Compound very unstable. Decomposes on standing.

1-Allyl-2-(thien-2-yl)-1,2-dihydroquinoline ***(4f)***

Following the general procedure B, a solution of **3f** (584 mg, 2.15 mmol) in *para*-xylene (12 mL) was heated to reflux for 2.5 h to afford, after chromatography, 323 mg (59%) of the title compound; ^{1}H nmr (200 MHz, CD_3COCD_3), δ: 3.75 (dd, 1H, J = 16.6, 6 Hz, NCH_2), 4.01 (dd, 1H, J = 16.6, 5 Hz, NCH_2), 5.14 (dd, 1H, J = 10.2, 1.6 Hz, $CH{=}C\underline{H}_2$), 5.25 (dd, 1H, J = 17.3, 1.6 Hz, $CH{=}C\underline{H}_2$), 5.56 (d, 1H, J = 5.31 Hz, NCH), 5.72 (m, 1H, $C\underline{H}{=}CH_2$), 5.80 (dd, 1H, J = 9.7, 5.3 Hz, C=CH), 6.46 (d, 1H, J = 9.5 Hz, C=CH), 6.57 (m, 2H), 6.98 (m, 4H), 7.29 (d, 1H, J = 4.5 Hz); ^{13}C nmr (100.6 MHz, CD_3COCD_3), δ: 51.4, 58.5, 112.1, 117.1, 117.6, 122.3, 125.0, 125.6, 125.8, 126.0, 127.1, 127.9, 129.8, 135.1, 144.1, 147.3.

1-Allyl-2-(furan-2-yl)-1,2-dihydroquinoline ***(4g)***

According to the general procedure B, a solution of **3g** (1.57 g, 6.15 mmol) in *para*-xylene (35 mL) was heated to reflux for 5 h to give, after multiple chromatography, 55 mg (4%) of the title compound; ^{1}H nmr (200 MHz, CD_3COCD_3), δ 3.82 (dd, 1H, J = 16.7, 5.8 Hz, NCH_2), 4.00 (dd, 1H, J = 16.7, 4.6 Hz, NCH_2), 5.11 (dd, 1H, J = 10.3, 1.5 Hz, $CH{=}C\underline{H}_2$), 5.21 (dd, 1H, J = 17.3, 1.6 Hz, $CH{=}C\underline{H}_2$), 5.31 (d, 1H, J = 5.3 Hz, NCH), 5.70 (m, 2H), 6.18 (d, 1H, J = 3.2 Hz), 6.32 (m, 1H), 6.54 (m, 3H), 6.98 (m, 2H), 7.43 (s, 1H); ^{13}C nmr (100.6 MHz, CD_3COCD_3), δ 51.9, 56.8, 107.7, 111.0, 111.8, 116.8, 117.4, 122.2, 122.6, 127.0, 127.9, 129.7, 135.0, 143.0, 144.4, 156.1.

2H, 4H-4-Phenyl-pyrrolo[3,2,1-ij]quinoline ***(4h)***

Following the general procedure B, a solution of **3k** (380 mg, 1.51 mmol) in *p*-xylene (10 mL) was heated to reflux for 5 h to give, after chromatography, 221 mg (63%) of the title compound as a solid; mp: 99-101°C; ^{1}H nmr (400 MHz, CD_3COCD_3), δ 2.75-3.04 (m, 3H), 3.11-3.18 (m, 1H), 5.09 (t, 1H, J = 2.5 Hz), 5.47 (dd, 1H, J = 9.7, 2.9 Hz), 6.39 (dd, 1H, J = 9.7, 2.3 Hz), 6.50 (t, 1H, J = 7.4 Hz), 6.74 (d, 1H, J = 7.5 Hz), 6.88 (d, 1H, J = 7.4 Hz), 7.25-7.48 (m, 5H); Anal. calcd. for $C_{17}H_{15}N$: C 87.52, H 6.48, N 6.00; found: C 87.02, H 6.59, N 5.90.

2H, 4H-4-Methyl-pyrrolo[3,2,1-ij]quinoline (4i)

Following the general procedure B, a solution of **3l** (357 mg, 189 mmol) in *para*-xylene (13 mL) was heated to reflux for 26 h to give, after chromatography, 75 mg (23%) of the title compound; ^{1}H nmr (400 MHz, CD_3COCD_3), δ 1.31 (d, 3H, J = 6.8 Hz), 2.75-2.95 (m, 4H), 3.98 (m, 1H, NCH), 5.44 (dd, 1H, J = 9.7, 2.4 Hz), 6.28 (dd, 1H, J = 9.7, 2.4 Hz), 6.46 (t, 1H, J = 7.4 Hz), 6.65 (d, 1H, J = 7.5 Hz), 6.84 (d, 1H, J = 7.3 Hz). Compound **4i** is very unstable, no satisfactory analysis was obtained.

5-Phenyl-1,2,3,5-tetrahydro-pyrido[3,2,1-ij]quinoline (4j)

Following the general procedure B, a solution of **3n** (694 mg, 2.62 mmol) in *ortho*-dichlorobenzene (20 mL) was heated to reflux for 20 h to give, after chromatography, 260 mg (40%) of the title compound as a solid; mp: 97-104°C;^{1}H nmr (200 MHz, CD_3COCD_3), δ 1.85 (m, 2H), 2.62 (m, 2H), 2.98 (m, 2H), 5.13 (dd, 1H, J = 4.6, 1.1 Hz, NCH), 5.58 (dd, 1H, J = 9.8, 4.8 Hz, C=CH), 6.32 (dd, 1H, J = 9.8, 1.3 Hz, C=CH), 6.41 (d, 1H, J = 7.3 Hz), 6.72 (m, 2H), 7.36 (m, 5H); ^{13}C nmr (100.6 MHz, CD_3COCD_3), δ 22.0, 28.1, 47.9, 65.5, 116.4, 120.3, 121.0, 125.1, 125.5, 126.0, 127.4, 128.4, 129.4, 129.9, 141.9, 144.2; Exact Mass calcd. for $C_{18}H_{18}N$ (M+1): 248.1439; found: 248.1440.

5-Methyl-1,2,3,5-tetrahydro-pyrido[3,2,1-ij]quinoline (4k)

Following the general procedure B, a solution of **3o** (634 mg, 3.12 mmol) in *para*-xylene (15 mL) was heated to reflux for 2 h to give, after chromatography, 297 mg (51%) of the title compound; ^{1}H nmr (400 MHz, CD_3COCD_3), δ 1.12 (d, 3H, J = 6.3 Hz), 1.80-2.0 (m, 2H), 2.54-2.72 (m, 2H), 2.98-3.08 (m, 1H), 3.35-3.43 (m, 1H), 4.0-4.10 (m, 1H), 5.58 (dd, 1H, J = 9.7, 5.1 Hz), 6.22 (d, 1H, J = 9.7 Hz), 6.35 (t, 1H, J = 7.4 Hz), 6.63 (d, 1H, J = 7.3 Hz), 6.68 (d, 1H, J = 7.5 Hz); ^{13}C nmr (100.6 MHz, CD_3COCD_3), δ 23.0, 26.4, 32.4, 51.5, 59.8, 120.3, 125.3, 125.9, 129.6, 129.8, 130.8, 133.5, 145.7; Exact Mass calcd. for $C_{13}H_{15}N$: 185.1204; found: 185.1204.

General Procedure C

Preparation of 2-phenylquinoline (5a)

A solution of **4c** (1.14 g, 4.61 mmol) in ethanol (65 mL) was combined with a solution of TFA (683 mg, 5.99 mmol) in ethanol (33 mL). To this was added $Rh[P(C_6H_5)_3]_4H$ (1.06 g, 0.92 mmol) and the resulting solution was heated to reflux for 1.5 h. Following basic work up, the residue was chromatographed to give 622 mg (66%) of 2-phenylquinoline (**5a**) as a pale yellow solid; mp: 83-84°C (lit. 84-85°C);[18] ^{1}H nmr (200 MHz,

CD_3COCD_3), δ 7.56 (m, 4H), 7.78 (m, 1H), 7.97 (d, 1H, J = 8.16 Hz, C=CH), 8.11 (d, 2H, J = 8.6 Hz), 8.32 (m, 2H), 8.41 (d, 1H, J = 8.7 Hz, C=CH); Anal. calcd. for $C_{15}H_{11}N$: C 87.77, H 5.40, N 6.82; found: C 87.58, H 5.40, N 6.69; ms, *m/z*: 206 (M+1).

2-Methylquinoline (5b)

According to the general procedure C, a solution of **4d** (395 mg, 2.13 mmol), TFA (316 mg, 2.77 mmol), and $Rh[P(C_6H_5)_3]_4H$ (496 mg, 0.43 mmol) in ethanol (45 mL) was heated to reflux for 2.5 h to afford, after chromatography, 138 mg (45%) of **5b** as an oil; ^1H nmr (200 MHz, CD_3COCD_3), δ: 2.67 (s, 3H, CH_3), 7.38 (d, 1H, J = 8.4 Hz, C=CH), 7.51 (dt, 1H, J = 7.0, 1.1 Hz), 7.69 (dt, 1H, J = 7.0, 1.6 Hz), 7.91 (m, 2H), 8.18 (d, 1H, J = 8.4 Hz, C=CH). ^1H nmr spectrum identical to that of commercially available product.

2-Propylquinoline (5c)

Following the general procedure C, a solution of **4e** (535 mg, 2.52 mmol), TFA (374 mg, 3.28 mmol), and $Rh[P(C_6H_5)_3]_4H$ (580 mg, 0.50 mmol) in ethanol (53 mL) was heated to reflux for 1.5 h to yield, after chromatography, 288 mg (67%) of **5c** as a yellowish oil; ^1H nmr (200 MHz, CD_3COCD_3), δ 0.99 (t, 3H, J = 7.3 Hz, CH_3), 1.85 (m, 2H, $C\underline{H}_2CH_3$), 2.91 (m, 2H, $C\underline{H}_2CH_2CH_3$), 7.40 (d, 1H, J = 8.6 Hz, C=CH), 7.51 (t, 1H, J = 7.0 Hz), 7.70 (m, 1H), 7.92 (m, 2H), 8.20 (d, 1H, J = 8.6 Hz, C=CH). ^1H nmr spectrum consistent with that reported.[19]

2-(2-Thienyl)quinoline (5d)

According to the general procedure C, a solution of **4f** (273 mg, 1.08 mmol), TFA (160 mg, 1.40 mmol), and $Rh[P(C_6H_5)_3]_4H$ (254 mg, 0.22 mmol) in ethanol (23 mL) was heated to reflux for 1.5 h to yield, after chromatography, 130 mg (57%) of **5d** as an oil; ^1H nmr (200 MHz, CD_3COCD_3), δ 7.21 (dd, 1H, J = 5.1, 3.7 Hz), 7.55 (m, 1H), 7.64 (dd, 1H, J = 5.1, 1.1 Hz), 7.75 (m, 1H), 7.94 (m, 3H), 8.04 (d, 1H, J = 8.7 Hz, C=CH), 8.34 (d, 1H, J = 8.7 Hz, C=CH); Anal. calcd. for $C_{13}H_9NS$: C 73.90, H 4.29, N 6.63; found: C 73.76, H 4.40, N 6.39.

Preparation of 2-phenylquinoline (5a) from 1-(4-methoxy-benzyl)-2-phenyl-1,2-dihydroquinoline

Method A. To a solution of $AlCl_3$ (325 mg, 2.44 mmol) in anisole (2 mL) cooled to 0°C was added **4a** (200 mg, 0.61 mmol) in anisole (6 mL). The mixture was stirred for 2.5 h at 0°C and then warmed to room temperature for 16 h. Following work up, the residue was chromatographed to yield 40 mg (32%) of **5a**.

Method B. A solution of **4a** (200 mg, 0.61 mmol), TFA (1.95 mL), and concentrated H_2SO_4 (0.10 mL) in anisole (0.19 mL) was stirred at room temperature for 1.5 h and then heated to reflux for 2.5 h. Following basic work up, the residue was chromatographed to yield 33 mg (26%) of **5a**.

*Preparation of (7aR, 10R, 11aR)-7,7,10-trimethyl-5-7-7a-8-9-10-11-11a-octahydro-4H-pyrrolo[3,2,1-de]-phenanthridine (**7a**) and (7R)-3,7-dimethyl-1,6-octadienyl)indoline (**8a**)*

To a solution of **3m** (10 mmol) in 100 ml benzene, at room temperature, was added phenylboronic acid (30 mmol), under nitrogen. The reaction mixture was stirred at reflux for 2 hours and benzene was evaporated on the rotovap. The residue was then dissolved in 100 ml *ortho*-dichlorobenzene and stirred at reflux for an hour. The mixture was chromatographed on silica gel, eluted with 5% EtOAc/Hexane. The partially purified mixture was then separated on preparative tlc plates, eluted with 15% EtOAc/hexane, yielding 1.28g (50%) of **7a** as a solid and 0.84g (33%) of **8a** as an oil. Compound **7a**: mp 71° - 73° C; $[\alpha]_D^{25}$ = -29 (c 2, $CHCl_3$); ^1H nmr (500 MHz, CD_3COCD_3) δ 0.83 (q, 1H, J = 12 Hz. H-11_{ax}), 0.84 (s, 3H), 0.93-1.07 (m, 4H), 1.13 (dq, 1H, J = 11, 3 Hz, H-8_{ax}), 1.22 (s, 3H), 1.34 (dt, 1H, J = 12.3, 2 Hz, H-7a), 1.50-1.66 (m, 1H), 1.80-1.95 (m, 2H), 2.36-2.47 (m, 2H), 2.78-2.87 (m, 2H), 3.15-3.25 (m, 1H, NCH_2), 3.47 (dt, 1H, J = 7, 3 Hz, NCH_2), 6.50 (t, 1H, J = 6 Hz), 6.81 (d, 1H, J = 6 Hz), 6.89 (d, 1H, J = 6 Hz); ^{13}C nmr (100.6 MHz, CD_3COCD_3) δ 19.0, 27.0, 30.1, 31.9, 33.7, 37.5, 40.2, 41.7, 44.8, 51.5, 54.8, 59.1, 122.0, 126.5, 126.6, 126.7, 127.9, 133.2; Exact Mass calcd. for $C_{18}H_{26}N$ (M+1): 256.2065; found: 256.2065; **8a**: $[\alpha]_D^{25}$ = -33.8° (c 2, CHCl3); ^1H nmr (400 MHz, CD_3COCD_3) δ 1.03-1.09 (d, 3H, J = 8 Hz, $C\underline{H}_3$-CH), 1.35-1.43 (q, 2H, J = 8 Hz, $C\underline{H}_2$-CH-CH_3), 1.58 (s, 3H, $C\underline{H}_3$-C=C), 1.65 (s, 3H, $C\underline{H}_3$-C=C), 1.95-2.05 (m, 2H, $C\underline{H}_2$-CH=C), 2.22-2.31 (m, 1H, $C\underline{H}$-CH_3), 2.9-2.98 (t, 1H, J = 9 Hz), 3.46-3.54 (t, 2H, J = 9 Hz), 4.85-4.95 (br s, 1H, NH), 5.08-5.17 (t, 1H, J = 6 Hz, $(CH_3)_2$-C=C$\underline{H}$), 5.94-6.02 (dd, 1H, J = 14, 7 Hz, Ph-CH=C$\underline{H}$), 6.33-6.40 (d, 1H, J = 15 Hz, Ph-C$\underline{H}$=CH), 6.52-6.58 (t, 1H, J = 7 Hz), 6.88-6.93 (d, 1H, J = 7 Hz), 7.02-7.05 (d, 1H, J = 7 Hz); ^{13}C nmr (100.6 MHz, CD_3COCD_3) δ 21.9, 25.3, 30.0, 30.7, 34.5, 42.2, 42.3, 51.7, 122.8, 124.3, 127.7, 129.3, 129.6, 130.1, 134.5, 135.7, 140.3, 154.9; Exact Mass calcd. for $C_{18}H_{26}N$ (M+1): 256.2065; found: 256.2065;

*Preparation of (8aR, 11R, 12aR)-8,8,11-trimethyl-4,5,6,8,8a,9,10,11,12,12a-decahydro-pyrido[3,2,1-de]-phenanthridine (**7b**) and 8-((3R)-3,7-dimethyl-1,6-octadienyl)tetrahydroquinoline (**8b**)*

To a solution of **3p** (10 mmol) in 100 ml benzene, at room temperature, was added phenylboronic acid (30 mmol), under nitrogen. The reaction mixture was stirred at reflux for 2 hours and benzene was evaporated on the rotovap. The residue was then dissolved in 100 ml *para*-xylene and stirred at reflux for 60 hours. Xylene was evaporated and the residue was chromatographed on silica gel, eluted with 5% EtOAc/hexane. The partially purified mixture was then chromatographed on preparative tlc plates, eluted with 15% EtOAc/hexane, yielding 1.78g (66%) of **7b** as a solid and 0.38g (14%) of **8b** as an oil; **7b**: $[\alpha]_D^{25}$ = +44 (c 2, CHCl3); mp 67° - 69°C; ^1H nmr (500 MHz, CD_3COCD_3) δ 0.79 (q, 1H, J = 12 Hz, H-12_{ax}), 0.90-1.02 (m, 7H), 1.14 (dq, 1H, J = 3.3, 12.3 Hz, H-9_{ax}), 1.26 (dt, 1H, J = 11.6, 2.8 Hz, H-8a), 1.28 (s, 3H), 1.50-1.61 (m, 1H), 1.78-1.95 (m, 4H), 2.38-2.48 (m, 2H), 2.61 (dt, 1H, J = 15.7, 4.9 Hz), 2.68-2.78 (m, 1H), 2.94-3.01 (m, 1H, NCH_2), 3.46-3.52 (m, 1H, NCH_2), 6.43 (t, 1H, J = 7.5 Hz), 6.70 (d, 1H, J = 7.5 Hz), 6.95 (d, 1H, J = 7.7 Hz); ^{13}C nmr (100.6 MHz, CD3COCD3) δ 21.9, 27.2, 27.9, 29.9, 32.7, 33.3, 37.4, 40.0, 41.4, 45.9, 47.0, 52.7, 60.9, 120.3, 127.0, 128.2, 130.2, 132.1, 147.3; Exact Mass calcd. for $C_{19}H_{28}N$ (M+1): 270.2222; found: 270.2222; **8b**:

$[\alpha]_D^{25}$ = +44 (c 2, $CHCl_3$); ^1H nmr (200 MHz, CD_3COCD_3) δ 1.02-1.15 (d, 3H, J = 6 Hz, $C\underline{H}_3$-CH), 1.35-1.48 (q, 2H, J = 8 Hz, $C\underline{H}_2$-CH-CH_3), 1.6 (s, 3H, $C\underline{H}_3$-C=C), 1.68 (s, 3H, $C\underline{H}_3$-C=C), 1.95-2.12 (m, 2H), 1.78-1.92 (m, 2H), 2.21-2.40 (m, 1H, C$\underline{H}$-CH3), 2.68-2.79 (t, 2H, J = 6 Hz), 3.26-3.40 (t, 2H, J = 6 Hz), 4.68-4.8 (br s, 1H, NH), 5.08-5.22 (t, 1H, J = 8 Hz, C$\underline{H}$=C$(CH_3)_2$), 5.80-5.98 (dd, 1H, J = 8, 16 Hz, C$\underline{H}$=CH-Ph), 6.37-6.52 (m, 2H), 6.70-6.82 (d, 1H, J = 8 Hz), 6.98-7.08 (d, 1H, J = 8 Hz); ^{13}C nmr (100.6 MHz, CD3COCD3) δ 21.9, 25.2, 26.8, 30.0, 30.8, 32.4, 42.09, 42.1, 46.8, 120.7, 125.8, 127.7, 129.2, 129.4, 129.6, 133.1, 135.7, 141.9, 147.0; Exact Mass calcd. for $C_{19}H_{28}N$ (M+1): 270.2222; found: 270.2222.

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