Headline Articles

Transformation of Oximes of Phenethyl Ketone Derivatives to Quinolines and Azaspirotrienones Catalyzed by Tetrabutylammonium Perrhenate and Trifluoromethanesulfonic Acid

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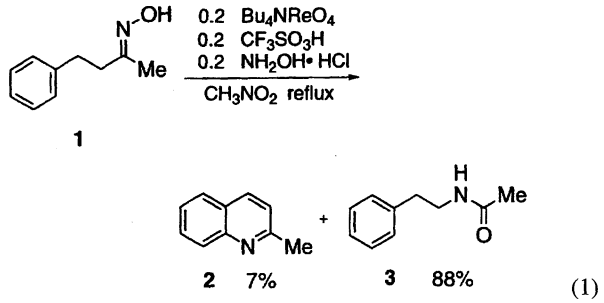
(Received December 10, 1996)

Phenethyl ketone oximes are converted to quinolines by the treatment with tetrabutylammonium perrhenate, trifluoromethanesulfonic acid, and chloranil in refluxing 1,2-dichloroethane. Azaspirotrienones can be synthesized from *p*-hydroxyphenethyl or 3-(*p*-hydroxyphenyl)propyl ketone oximes by applying the above method. Thus prepared azaspirotrienones are converted to quinolines by acid treatment.

Recently, we have reported that the combined use of tetrabutylammonium perrhenate (Bu_4NReO_4) and Brønsted acid such as *p*-toluenesulfonic acid and trifluoromethanesulfonic acid (CF_3SO_3H) catalyzes the 1,3-rearrangement of allylic alcohols[1] and the Beckmann rearrangement of oximes.[2] During the study of the generality of the catalytic Beckmann rearrangement, it was found that the cyclization reaction proceeded on the nitrogen atom of 4-phenylbutan-2-one oxime (**1**) by the treatment with 0.2 molar amounts of Bu_4NReO_4 and CF_3SO_3H to give 2-methylquinoline (**2**) in 7% yield along with the Beckmann rearrangement product, *N*-phenethylacetamide (**3**), in 88% yield (Eq. 1).



(1)

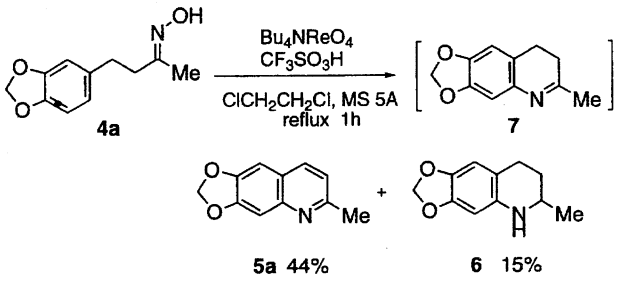
The formation of 2-methylquinoline (**2**) was an unexpected result, which suggested that intramolecular substitution of the oxime hydroxy group with the phenyl group occurred directly on the oxime nitrogen atom. It is well known that oximes undergo the Beckmann rearrangement to generate nitrilium ions, which have been utilized as synthetic intermediates in the syntheses of isoquinolines,[3] pyridines,[4] and azepines.[5] But there have been only a few examples that the substitution of the oxime hydroxy group proceeds on the nitrogen atom without the formation of nitrilium ion intermediates. For instance, 1-(cyclopent-2-en-1-yl)propan-2-one oxime is cyclized by treating with zinc in acetic acid to give a pyrrolidine derivative,[6] and the treatment of a cyclohexanone *O*-methylsulfonyloxime having an allylsilane moiety with diisobutylaluminum hydride affords a piperidine derivative.[5] An intermolecular substitution has been also reported; tetraphenylcyclopentadienone *O*-*p*-tolysulfonyloxime reacts with aryl Grignard reagents to afford the corresponding imine derivatives.[7]

Accordingly, the formation of 2-methylquinoline (**2**) in the rhenium reagent-catalyzed reaction of 4-phenylbutan-2-one oxime (**1**) prompted us to improve the conversion of phenethyl ketone oxime derivatives to quinolines. This report gives the full accounts of the rhenium-catalyzed transformation of oximes to heterocyclic compounds.[8]

Results and Discussion

Synthesis of Quinoline Derivatives. In order to increase the nucleophilicity of the phenyl group, a 3,4-methylenedioxyphenyl derivative **4a** was used for screening the reaction conditions. It was noted that the solvent was essential to improve the yield of the quinoline formation. That is, the treatment of 4-(3,4-methylenedioxyphenyl)butan-2-one oxime (**4a**) with equimolar amounts of Bu_4NReO_4 and CF_3SO_3H, and Molecular Sieves 5A[9] in refluxing nitromethane, acetonitrile, or toluene gave **5a** only in 20%, 31%, or 29% yield, respectively, while the reaction in refluxing 1,2-dichloroethane gave the desired product, 2-methyl-6,7-methylenedioxyquinoline (**5a**) in 44% yield along with 2-methyl-

6,7-methylenedioxy-1,2,3,4-tetrahydroquinoline (**6**) in 15% yield (Eq. 2). Under the reaction conditions, the Beckmann rearrangement product was not detected but 4-(3,4-methylenedioxyphenyl)butan-2-one, the hydrolyzed product of the oxime **4a**, was isolated. Isomerization of the (*Z*) and (*E*)-oximes **4a** took place under the above acidic reaction conditions, so that the geometry of the starting oxime did not influence the yield of the quinoline. In fact, the reactions of an (*E*)-oxime and an *E* and *Z* mixture of **4a** gave exactly the same results.



(2)

In the above reaction, a 3,4-dihydroquinoline **7** was supposed to be initially formed by the cyclization of **4a** and then disproportionated into **5a** and **6**. As the yield of the quinoline **5a** was 3 times as much as that of the tetrahydroquinoline **6** and the total yield of **5a** and **6** was not good enough, even by using an equimolar amount of the rhenium reagent, Bu_4NReO_4 was thought to be consumed for oxidation of the 3,4-dihydroquinoline **7** into the quinoline **5a**. Accordingly, the above reaction was tried in the presence of various oxidizing agents, as shown in Table 1. When the reaction was carried out with 2,3,5,6-tetrachloro-*p*-benzoquinone (chloranil), the quinoline **5a** was obtained in 75% yield without forming the tetrahydroquinoline **6**, even by the use of a 0.2 molar amount of Bu_4NReO_4 (Entry 6).[10] Although we were afraid that the cyclization reaction might occur via cation radical intermediate of **4a** by oxidation of the aryl group with chloranil, none of the cyclized product was detected in the absence of Bu_4NReO_4 (Entry 7).

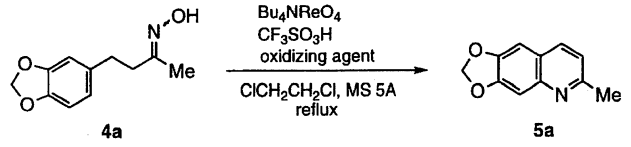
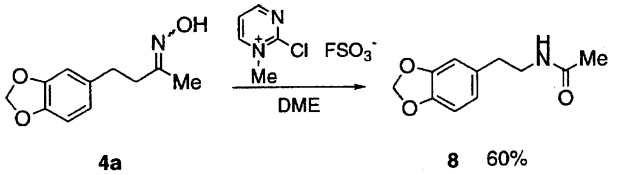


Table 1.

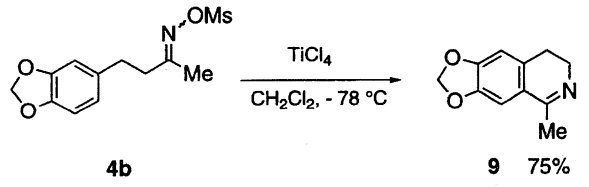
Entry	Bu_4NReO_4 (molar amount)	Oxidizing agent[a)]	Yield/%
1	0.5	DDQ	45
2	0.5	$PhNO_2$[b)]	51
3	0.5	$CuCl_2$	37
4	0.5	O_2[c)]	38
5	0.5	Chloranil	66
6	0.2	Chloranil	75
7	0	Chloranil	0

a) An equimolar amount of CF_3SO_3H and 0.5 molar amount of oxidizing agent were used. b) Ten molar amounts of nitrobenzene was used. c) The reaction was carried out under oxygen atmosphere.

Thus, by the catalytic use of the rhenium reagent, the cyclization reaction on the nitrogen atom of **4a** proceeded in 1,2-dichloroethane without the Beckmann rearrangement. To examine the effect of Bu_4NReO_4, the cyclization of **4a** was also attempted by using various reagents which are known to promote the Beckmann rearrangement. The treatment of the oxime **4a** with 2-chloropyrimidinium salt[11] only gave the amide **8** by the Beckmann rearrangement (Eq. 3). The reaction of an *O*-methylsulfonyloxime **4b** with $TiCl_4$ also afforded a Beckmann rearrangement product, a dihydroisoquinoline **9**, in 75% yield and the quinoline **5a** was not detected (Eq. 4). Among the various procedures of the Beckmann rearrangement, the quinoline **5a** was obtained in 47% yield by treatment of **4a** with trimethyloxonium tetrafluoroborate in dimethylformamide[12] (Eq. 5). The reactions of an *O*-acetyloxime **4c** with $BF_3 \cdot OEt_2$ or CF_3SO_3H also gave the quinoline **5a** but in low yields of 10 or 30%, respectively, along with the Beckmann rearrangement products **8** or **9** (Eqs. 6 and 7). Thus, it is noteworthy that the use of Bu_4NReO_4 and CF_3SO_3H promotes the present cyclization reaction effectively.



(3)



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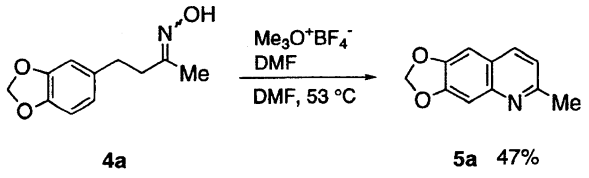
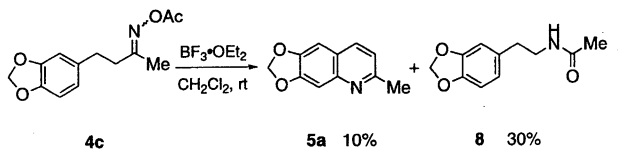
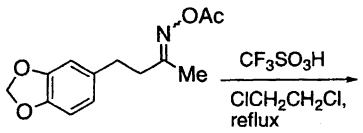


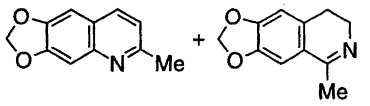
(5)



(6)



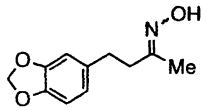
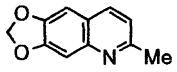
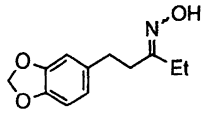
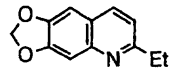
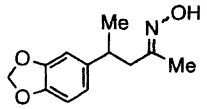
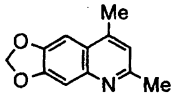
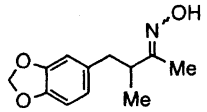
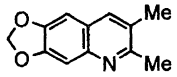
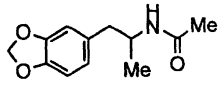
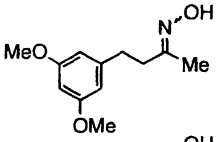
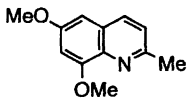
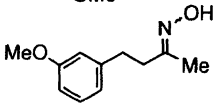
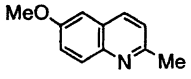
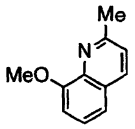
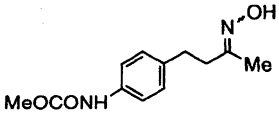
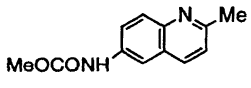
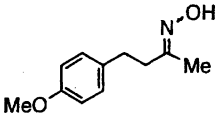
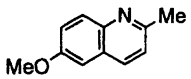
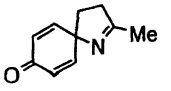
4c



5a 30% **9** 18% (7)

The cyclization of several oximes of phenethyl ketone derivatives[13] was attempted; the results are listed in Table 2.[14,15] As well as the methyl ketone oxime **4a**, an ethyl ketone oxime **4d** cyclized to a 2-ethylquinoline **5d** in 89% yield (Entries 1 and 2). The reaction of 2-methyl-2-(3,4-methylenedioxyphenyl)ethyl ketone oxime **4e** gave a 2,4-dimethylquinoline **5e** in 83% yield (Entry 3), while the cyclization and the Beckmann rearrangement proceeded competitively in the reaction of 1-methyl-2-(3,4-methylenedioxyphenyl)-ethyl ketone oxime **4f** to afford a quinoline **5f** and an amide **10** in 49 and 47% yield, respectively (Entry 4). Oximes

Table 2. Cyclization of Several Phenethyl Ketone Oximes

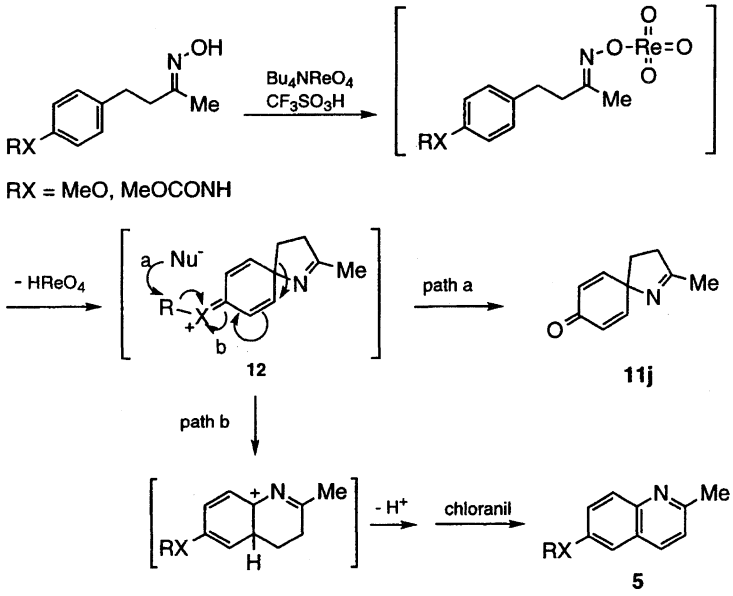
Entry	Oxime	Time/h	Product (Yield/%)		
1		**4a** 1		**5a**	(75)
2		**4d** 1.5		**5d**	(89)
3		**4e** 1		**5e**	(83)
4		**4f** 1.5		**5f**	(49)
				**10**	(47)
5		**4g** 2		**5g**	(74)
6		**4h** 2		**5h-1**	(51)
				**5h-2**	(15)
7		**4i** 2		**5i**	(76)
8[a]		**4j** 1		**5h-1**	(4)
				**11j**	(76)

a) The reaction was carried out in the absence of chloranil.

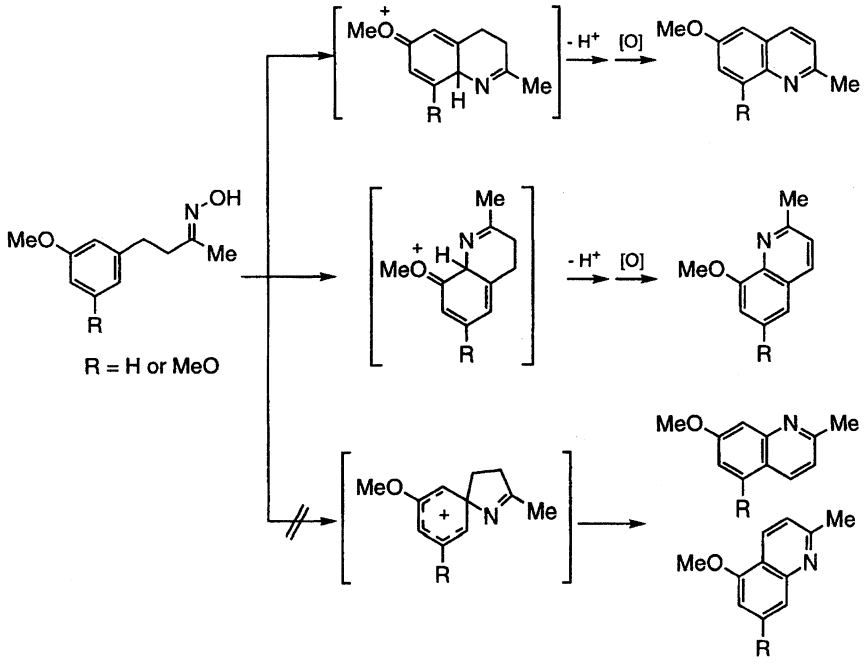
4g and **4h**, which have electron-donating methoxy group(s) on the meta position of the phenyl group, also cyclized to quinolines **5g** and **5h** in good yield (Entries 5 and 6). The reaction of a *p*-(methoxycarbonylamino)phenethyl ketoxime **4i** gave 6-(methoxycarbonylamino)-2-methylquinoline (**5i**) in 76% yield without the formation of the 7-substituted isomer (Entry 7). 4-(4-Methoxyphenyl)butan-2-one oxime **4j**, however, gave an azaspirotrienone **11j** in 76% yield with a small amount of the 6-methoxy quinoline **5h-1** (Entry 8). As shown in the above reactions, the quinolines prepared from the *p*-substituted phenethyl ketone oximes **4i** and **4j** have a characteristic feature: the alkyl moiety on the phenyl group rearranged from the para (to MeO or MeOCONH group) to the meta position.

The results of Entries 7 and 8 indicate that the cyclization reaction of a para substituted oxime initially occurs at the ipso position to give a cationic spiro intermediate **12**, as shown in Scheme 1. The azaspirotrienone **11j** is formed by the Me–O bond cleavage (path a) of the *O*-methyl trienonium ion **12** (RX=MeO) (Entry 8), while dienone–phenol rearrangement (path b)[16] proceeds from the iminium ion **12** (RX=MeOCONH) to afford a dihydroquinoline (Entry 7).

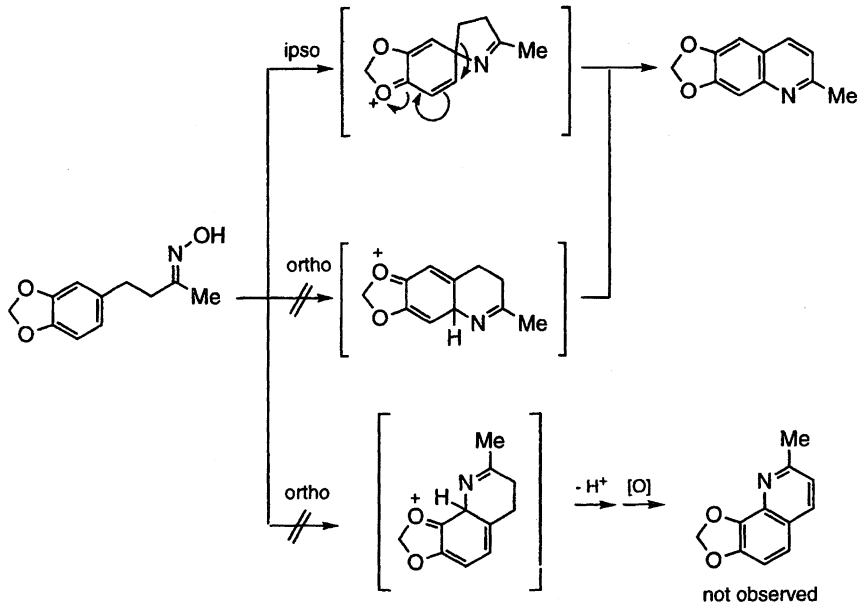
By the reactions of the *m*-methoxy derivatives **4g** and **4h**, the 6,8-dimethoxyquinoline **5g** and the 6- and 8-methoxyquinolines **5h** were formed, though the 5- and 7-methoxyquinolines which would be formed via the rearrangement of



Scheme 1.



Scheme 2.



Scheme 3.

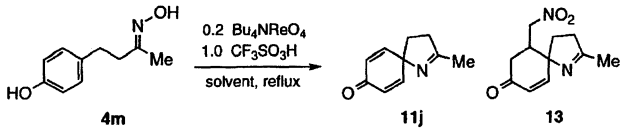


Table 3.

Entry	Solvent	Time/h	Yield/%	
			11j	**13**
1	$ClCH_2CH_2Cl$	1.5	91	
2	CH_3CN	3.0	30	
3	CH_3NO_2	0.5	86	9

an ipso-cyclized intermediate were not detected (Entries 5 and 6). This means that the cyclization of the oximes **4g** and **4h** which have an electron-donating substituent at the meta position proceeds directly at the ortho position without the formation of the spiro intermediates (Scheme 2).

In the reaction of 2-(3,4-methylenedioxyphenyl)ethyl ketone oximes **4a,d,e,f**, which have electron-donating groups on meta and para positions, ipso and/or ortho cyclization were supposed to proceed (Scheme 3). But, as shown in Table 1, only 6,7-methylenedioxyquinolines were obtained in good yields and the other isomers could not be detected. These results reveal that the cyclization of the oxime having electron-donating groups on meta and para positions proceeds on ipso position exclusively.

As previously mentioned (Eq. 1), under the conditions for the Beckmann rearrangement[2] (CH_3NO_2 was used as solvent), the reaction of 4-phenylbutan-2-one oxime (**1**) gave 2-methylquinoline (**2**) only in 7% yield and the Beckmann rearrangement product **3** was isolated as the main product. Though the oxime **1** has no electron-donating substituent, treatment of **1** under the present reaction conditions in 1,2-dichloroethane gave the quinoline **2** as a main product (55%) and the Beckmann rearrangement product **3** was not detected at all (Eq. 8).

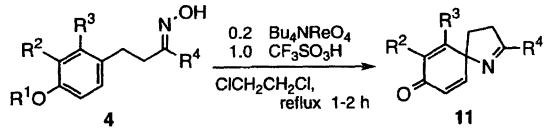
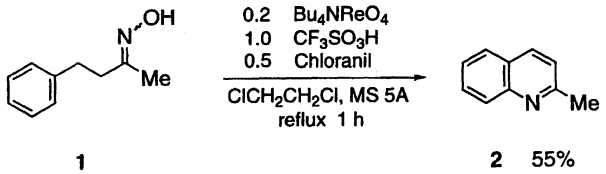


Table 4. Cyclization of Oximes **4**[13,15]

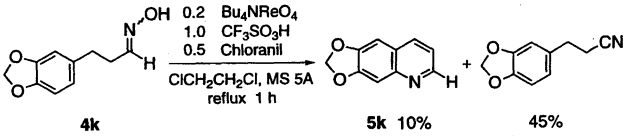
Entry	Oxime					Yield/%
		R^1	R^2	R^3	R^4	
1[a]	**4n**	Me	OMe	H	Me	**11n** 46
2	**4o**	H	OMe	H	Me	**11n** 75
3	**4p**	H	H	OMe	Me	**11p** 89
4	**4q**	H	$CONEt_2$	H	Me	**11q** 52
5[b]	**4r**	H	H	H	H	**11r** 0

a) 2-Methyl-5,6-dimethoxyquinoline was obtained in 10% yield.
b) 3-(4-Hydroxyphenyl)propiononitrile was produced in 36% yield by the Beckmann fragmentation.



(8)

In contrast to the above cyclization of phenethyl ketone oximes, the reaction of an aldoxime **4k** and an oxime of α-keto ester **4l** gave the corresponding quinolines **5k** and **5l** in poor yields of 10 and 28%, respectively (Eqs. 9 and 10).



(9)

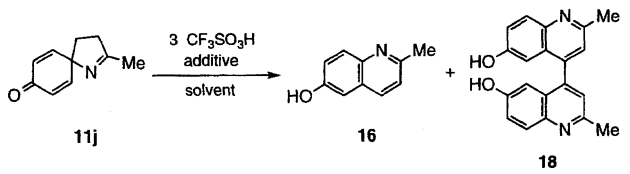
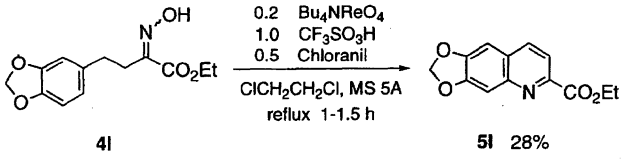


Table 5.

Entry	Solvent	Temperature/°C	Additive	Yield/%	
				16	18
1	CH_3NO_2	100	—	15	—
2	DMSO[a)]	150	—	47	—
3	$PhNO_2$	120	—	61	21
4	$PhNO_2$	120	Chloranil[b)]	75	—

a) Dimethyl sulfoxide. b) 0.5 molar amount.



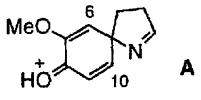
(10)

Synthesis of Azaspirotrienones. Azaspiro skeletons are one of the basic structures of some alkaloids, such as protoberberine alkaloids,[17] erythrina alkaloids,[18] and historionicotoxins.[19] The unique azaspiro structure has attracted much attention from synthetic chemists, and various studies for their syntheses have been reported.[17—19] In most cases, however, multi-step sequences were required for the construction of azaspirocyclic skeletones.

As shown in the above section, the reaction of the *p*-methoxyphenethyl ketone oxime **4j** afforded the azaspirotrienone, 2-methyl-1-azaspiro[4.5]deca-1,6,9-trien-8-one (**11j**), in good yield along with a small amount (4%) of the quinoline **5h-1** (Table 2, Entry 8).

The formation of an azaspirotrienone was supposed to be facilitated by employing *p*-hydroxyphenethyl ketone oxime **4m** instead of the *p*-methoxy derivative **4j**, because O–H bond cleavage would proceed more readily as compared with that of Me–O bond in the trienonium intermediate **12**. In fact, when the reaction of **4m** was attempted with a 0.2 molar amount of Bu_4NReO_4 and an equimolar amount of CF_3SO_3H in refluxing 1,2-dichloroethane, the azaspirotrienone **11j** was obtained in 91% yield and 2-methylquinolin-6-ol could not be detected (Table 3, Entry 1). Though the reaction in nitromethane also gave **11j** in good yield (86%), the Michael addition of nitromethane to the azaspirotrienone **11j** occurred to afford a dienone **13** as a by-product (Entry 3).

In the absence of Bu_4NReO_4, the desired ipso-cyclization and the Beckmann rearrangement occurred concurrently and, after 8 h, the mixture of the azaspirotrienone **11j** (50%) and an amide (22%) was obtained. Thus the combined use of Bu_4NReO_4 and CF_3SO_3H is indispensable to promote the smooth cyclization (Eq. 11).

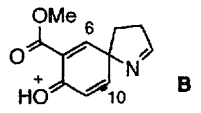


A

LUMO = - 6.6 eV

Atom No.	Coefficient	Mulliken Charge
6	0.4	-0.12
10	0.5	0.07

Fig. 1.

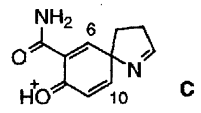


B

LUMO = - 6.5 eV

Atom No.	Coefficient	Mulliken Charge
6	0.5	0.10
10	0.4	0.02

Fig. 2.

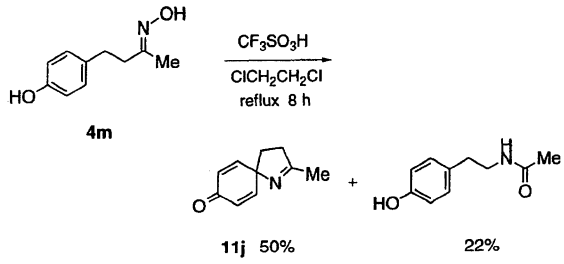


C

LUMO = - 5.8 eV

Atom No.	Coefficient	Mulliken Charge
6	0.6	0.05
10	0.1	-0.11

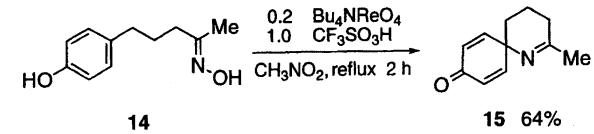
Fig. 3.



(11)

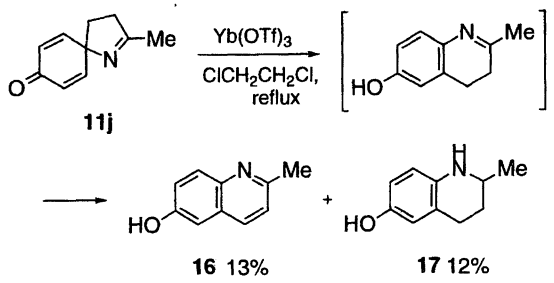
Azaspirotrienones were prepared from various oximes of *p*-hydroxyphenethyl ketone derivatives, as shown in Table 4. Though the reaction of *m,p*-dimethoxyphenethyl ketone oxime **4n** afforded a 7-methoxyazaspirotrienone **11n** in 46% yield along with 10% of 2-methyl-5,6-dimethoxyquinoline, that of the *p*-hydroxy-*m*-methoxy derivative **4o** gave an azaspiro compound **11n** exclusively in 75% yield (Entries 1 and 2). In addition, a *p*-hydroxy-*o*-methoxy derivative **4p** cyclized to give the corresponding 6-methoxy azaspirotrienone **11p** in 89% yield (Entry 3). Introduction of an electron-withdrawing *N,N*-diethylcarbamoyl group did not disturb the cyclization reaction; the treatment of an oxime **4q** with the rhenium catalyst gave a 7-*N,N*-diethylcarbamoyl azaspirotrienone **11q** in 52% yield (Entry 4). Thus, *p*-hydroxyphenethyl ketone oximes were converted to azaspirotrienones, while the cyclization of an aldoxime **4r** did not proceed, but the Beckmann fragmentation occurred to afford 3-(4-hydroxyphenyl)propiononitrile in 36% yield (Entry 5).

As was the case with *p*-hydroxyphenethyl ketone oximes, a one-carbon homologated oxime **14** cyclized to afford an azaspiro[5.5]undecatrienone **15** in 64% yield (Eq. 12).[20]



(12)

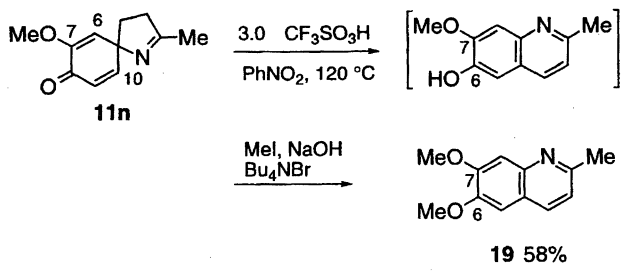
Transformation of Azaspirotrienones into Quinolines. Transformation of the 1-azaspiro[4.5]decatrienones into quinoline derivatives was also investigated by applying dienone-phenol rearrangement. It has been known that dienone–phenol rearrangement of carbocyclic spirodienones proceeds by the treatment with a Brønsted acid or a Lewis acid, such as hydrochloric acid, trifluoroacetic acid, and boron trifluoride etherate.[16,21] The reaction of **11j** with boron trifluoride etherate in refluxing toluene resulted in a complex mixture, and that with ytterbium trifluoromethanesulfonate gave a rearranged product, a quinoline **16** and a tetrahydroquinoline **17**, in 13 and 12% yields, respectively (Eq. 13).



(13)

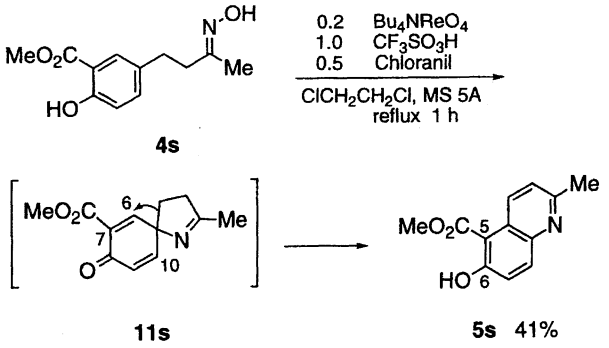
Since the treatment of **11j** with Lewis acid gave **16** in quite low yield, the reaction was investigated by using a Brønsted acid in various solvents. The rearrangement of the azaspirotrienone **11j** with 3 molar amounts of CF_3SO_3H in nitrobenzene at 120 °C afforded the quinoline **16** in 61% yield and a quinoline dimer **18** (Table 5, Entry 3). Since it was supposed that **18** was formed by dimerization of initially generated dihydroquinoline, the reaction was performed in the presence of chloranil to facilitate the oxidation of the dihydroquinoline into the quinoline **16** and the yield of **16** was improved to 75% (Entry 4).

In the rearrangement of the 7-methoxy spiro compound **11n**, chloranil was not necessary for the transformation to a quinoline. Presumably, nitrobenzene acts as an oxidizing agent of the 7-methoxydihydroquinoline intermediate which is readily susceptible to oxidation. After the rearrangement, the crude product was treated with methyl iodide, tetrabutylammonium bromide, and aqueous sodium hydroxide, giving a 6,7-dimethoxy derivatives **19** in 58% yield (Eq. 14). Thus, the rearrangement of azaspirotrienone **11n** having an electron-donating group on C-7, alkyl substituents migrates toward C-10 of the spiro compounds to afford a 6,7-disubstituted quinolines.



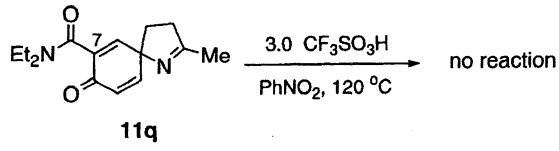
(14)

The spiro cyclization of an oxime **4s**, which have an electron-withdrawing methoxycarbonyl group on *m*-position, gave methyl 6-hydroxy-2-methylquinoline-5-carboxylate (**5s**) in 41% yield without the expected spiro compound (Eq. 15). That is, the rearrangement of an initially formed azaspirotrienone **11s** proceeded simultaneously, giving the quinoline **5s**. Thus, when an azaspirotrienone has an electron-withdrawing group at C-7, an alkyl moiety rearranges to C-6 to give a 5,6-disubstituted quinoline.



(15)

Rearrangement of the 7-*N*,*N*-diethylcarbamoyl azaspirotrienone **11q** which also has an electron-withdrawing group at C-7, however, did not occur under the above reaction conditions (Eq. 16).



(16)

To understand the reactivity and regioselectivity on the above dienone–phenol rearrangement clearly, semi-empirical MO calculation of protonated model compounds **A**, **B**, and **C**, which correspond to the cationic intermediate of the rearrangement of **11n**, **11s**, and **11q**, was performed using a PM3 Hamiltonian.[22] The direction of the rearrangement of the alkyl moiety is mainly controlled by charge population. As shown in Figs. 1 and 2, cationic charge is more populated at C-10 and C-6 in the model **A** and **B**, respectively. This accords well with the experimental results: The alkyl moiety is rearranged to C-10 in the rearrangement of **11n**, to C-6 in the case of **11s**. Low reactivity of **11q** is probably due to the higher LUMO level (Fig. 3) as well as the steric hindrance around the 6-position due to the *N*,*N*-diethylamino group.

Experimental

General. All melting points are uncorrected. ^{1}H NMR (500 MHz) and ^{13}C NMR (125 MHz) spectra were recorded on Bruker AM500 and JEOL α-500 spectrometers with $CHCl_3$ (δ=7.24 and 77.0) as an internal standard. IR spectra were measured with a Horiba FT-300S spectrometer. High resolution mass spectra were recorded on a JEOL JMS-SX102A mass spectrometer operating at 70 eV. Flash column chromatography was performed on silica gel (Merck Silica gel 60) and preparative thin-layer chromatography was carried out using Wakogel B-5F. 1,2-Dichloroethane was distilled from P_2O_5 then from CaH_2, and dried over Molecular Sieves 4A (MS4A). Tetrabutylammonium perrhenate (Bu_4NReO_4)

was purchased from Aldrich Chemical Co., Inc. and was purified by recrystallization from methanol–ether. Trifluoromethanesulfonic acid was used without purification. Chloranil was recrystallized from benzene and dried under reduced pressure. The reaction of oxime **4a** with trimethyloxonium tetrafluoroborate and dimethylformamide was carried out according to the literature procedure.[12] All reactions were carried out under an argon atmosphere unless otherwise noted.

Preparation of Oximes. Experimental procedures for the preparation of 4-(3-methoxyphenyl)butan-2-one were shown below as a typical example for the synthesis of phenethyl ketone derivatives.

To an ethanol solution (100 ml) of 3-methoxybenzaldehyde (25.4 g, 0.15 mol) and acetone (27.0 g) was added 10% aqueous sodium hydroxide (50 ml) at room temperature. After the mixture was stirred for 2 h, the solution was neutralized by adding 1 M hydrochloric acid (1 M=1 mol dm^{-3}). The organic materials were extracted with dichloromethane and the combined extracts were washed with brine and dried over Na_2SO_4. After the solvent was removed in vacuo, the crude materials were purified by flash column chromatography (hexane : ethyl acetate=2 : 1) to give 4-(3-methoxyphenyl)but-3-en-2-one (24.7 g, 75%). Under a hydrogen atmosphere, an ethanol (100 ml) solution of 4-(3-methoxyphenyl)but-3-en-2-one (14.2 g, 0.07 mmol) and glacial acetic acid (15 ml) were added to an ethanol suspension (50 ml) of 10% Pd/C. The mixture was heated to 70 °C for 24 h. After saturated aqueous sodium hydrogencarbonate was added, the mixture was filtered through a short pad of Celite to remove Pd/C. The organic materials were extracted with dichloromethane and the combined extracts were washed with brine and dried over Na_2SO_4. After the solvent was removed in vacuo, the crude materials were purified by flash column chromatography (hexane : ethyl acetate=3 : 1) to give 4-(3-methoxyphenyl)butan-2-one (7.7 g, 57%).

4-(3-Methoxyphenyl)butan-2-one was converted to the corresponding oxime under the literature procedures.[23]

Spectral Data for Oximes of Phenethyl Ketone Derivatives. **(*E*)-4-Phenylbutan-2-one Oxime (1) :** ^{1}H NMR δ=1.90 (3H, s), 2.49 (2H, t, J=8.0 Hz), 2.82 (2H, t, J=8.0 Hz), 7.17—7.20 (3H, m), 7.25—7.29 (2H, m), 8.14 (1H, bs).

(*E*)-4-(3,4-Methylenedioxyphenyl)butan-2-one Oxime (4a) : Mp 97 °C; IR (KBr) 1244, 1493, 3226 cm^{-1}; ^{1}H NMR δ=1.88 (3H, s), 2.42, 2.45 (2H, m), 2.72—2.75 (2H, m), 5.90 (2H, s), 6.61 (1H, dd, J=1.6, 7.9 Hz), 6.66 (1H, d, J=1.6 Hz), 6.70 (1H, d, J=7.9 Hz), 8.19 (1H, bs); ^{13}C NMR δ=13.8, 30.4, 37.9, 100.7, 108.2, 108.7, 121.0, 134.8, 145.8, 147.6, 157.7. Found: C, 63.50; H, 6.23; N, 7.00%. Calcd for $C_{11}H_{13}NO_3$: C, 63.79, H, 6.28; N, 6.76%.

1-(3,4-Methylenedioxyphenyl)pentan-3-one Oxime (4d) : Inseparable mixture of *E* and *Z* form (1 : 1)

^{1}H NMR δ=1.05 (1.5H, t, J=7.5 Hz), 1.09 (1.5H, t, J=7.7 Hz), 2.14 (1H, q, J=7.5 Hz), 2.38 (1H, q, J=7.7 Hz), 2.43—2.46 (1H, m), 2.56—2.59 (1H, m), 2.72—2.78 (2H, m), 5.89 (1H, s), 5.90 (1H, s), 6.62—6.72 (3H, m), 9.00 (1H, bs). HRMS Found : m/z 221.1089. Calcd for $C_{12}H_{15}NO_3$: M, 221.1052.

4-(3,4-Methylenedioxyphenyl)pentan-2-one Oxime (4e) : Inseparable mixture of *E* and *Z* form (3 : 1)

^{1}H NMR δ=1.20 (2.25H, d, J=6.9 Hz), 1.24 (0.75H, d, J=7.0 Hz), 1.67 (0.75H, s), 1.81 (2.25H, s), 2.36—2.47 (1.75H, m), 2.73 (0.25H, dd, J=7.3, 13.1 Hz), 2.96 (0.75H, m), 3.12 (0.25H, m), 5.89 (1.5H, s), 5.90 (0.5H, s), 6.63—6.75 (3H, m), 9.33 (1H, bs); ^{13}C NMR *E*-form: δ=13.7, 21.8, 37.2, 44.3, 100.7, 107.1, 108.1, 119.7, 140.2, 145.8, 147.6, 157.2; *Z*-form : δ=20.6, 22.3, 36.4, 37.5, 100.7, 107.1, 108.1, 119.7, 140.2, 145.8, 147.5, 157.6. HRMS Found : m/z 221.1055. Calcd for $C_{12}H_{15}NO_3$: M, 221.1052.

(*E*)-3-Methyl-4-(3,4-methylenedioxyphenyl)butan-2-one Oxime (4f) : ^{1}H NMR δ=1.03 (3H, d, J=6.9 Hz), 1.84 (3H, s), 2.48 (1H, dd, J=8.5, 13.5 Hz), 2.57 (1H, m), 2.78 (1H, dd, J=6.3, 13.5 Hz), 5.89 (2H, s), 6.57 (1H, dd, J=1.5, 7.9 Hz), 6.62 (1H, d, J=1.5 Hz), 6.69 (1H, d, J=7.9 Hz), 8.25 (1H, bs); ^{13}C NMR δ=11.3, 17.2, 40.1, 41.7, 100.8, 108.1, 109.3, 121.8, 133.7, 145.8, 147.5, 161.5. HRMS Found : m/z 221.1048. Calcd for $C_{12}H_{15}NO_3$: M, 221.1052.

(*E*)-4-(3,5-Dimethoxyphenyl)butan-2-one Oxime (4g) : Mp 89 °C; IR (KBr) 953, 1053, 1155, 1207, 1423, 1464, 1603, 3244 cm^{-1}; ^{1}H NMR δ=1.90 (3H, s), 2.48 (2H, t, J=8.2 Hz), 2.76 (2H, t, J=8.2 Hz), 3.76 (6H, s), 6.30 (1H, t, J=2.2 Hz), 6.34 (2H, d, J=2.2 Hz), 8.59 (1H, bs); ^{13}C NMR δ=13.7, 32.8, 37.5, 55.2, 98.1, 106.3, 143.5, 157.8, 160.8. Found: C, 64.61; H, 7.61; N, 6.41%. Calcd for $C_{12}H_{17}NO_3$: C, 64.55; H, 7.67; N, 6.27%.

(*E*)-4-(3-Methoxyphenyl)butan-2-one Oxime (4h) : Mp 59 °C; IR (KBr) 1261, 1602, 3235 cm^{-1}; ^{1}H NMR δ=1.89 (3H, s), 2.47—2.50 (2H, m), 2.78—2.81 (2H, m), 3.78 (3H, s), 6.72—6.78 (3H, m), 7.19 (1H, dd, J=8.9, 7.6 Hz), 7.78 (1H, bs); ^{13}C NMR δ=13.8, 32.6, 37.5, 55.0, 111.4, 114.0, 120.6, 129.3, 142.6, 157.7, 159.6. Found: C, 68.24; H, 7.61; N, 7.20%. Calcd for $C_{11}H_{15}NO_2$: C, 68.41; H, 7.77; N, 7.25%.

(*E*)-4-(4-*N*-Methoxycarbonylaminophenyl)butan-2-one Oxime (4i) : Mp 118 °C; IR (KBr) 960, 1074, 1238, 1533, 1707, 3350 cm^{-1}; ^{1}H NMR δ=1.88 (3H, s), 2.45 (2H, t, J=8.0 Hz), 2.76 (2H, t, J=8.0 Hz), 3.74 (3H, bs), 6.80 (1H, bs), 7.08 (2H, d, J=8.5 Hz), 7.25 (2H, bs); ^{13}C NMR δ=13.7, 31.9, 37.7, 52.3, 118.9, 128.8, 135.9, 136.2, 154.2, 157.8. HRMS Found : m/z 236.1161. Calcd for $C_{12}H_{16}N_2O_3$: M, 236.1161.

(*E*)-4-(4-Methoxyphenyl)butan-2-one Oxime (4j) : Mp 77 °C; IR (KBr) 1241, 1514, 3244 cm^{-1}; ^{1}H NMR δ=1.90 (3H, s), 2.45—2.49 (2H, m), 2.76—2.79 (2H, m), 3.77 (3H, s), 6.81—6.84 (2H, m), 7.07—7.11 (2H, m), 9.06 (1H, bs); ^{13}C NMR δ=13.7, 31.7, 37.8, 55.1, 113.7, 129.1, 133.0, 157.6, 157.8. Found: C, 68.45; H, 7.76; N, 7.27%. Calcd for $C_{11}H_{15}NO_2$: C, 68.41; H, 7.77; N, 7.25%.

3-(3,4-Methylenedioxyphenyl)propanal Oxime (4k) : Inseparable mixture of *E* and *Z* form (5 : 4)

^{1}H NMR δ=2.44—2.48 (1.1H, m), 2.62—2.67 (0.9H, m), 2.70—2.75 (2H, m), 5.92 (2H, s), 6.60—6.73 (3.45H, m), 7.42 (0.55H, t, J=5.9 Hz), ; ^{13}C NMR *E*-form : δ=31.4, 32.5, 100.8, 108.2, 108.8, 121.2, 134.3, 145.9, 147.7, 151.3; *Z*-form : δ=26.6, 31.7, 100.8, 108.2, 108.7, 121.1, 134.4, 145.9, 147.7, 151.7. Found: C, 62.13; H, 5.70; N, 7.32%. Calcd for $C_{10}H_{11}NO_3$: C, 62.17; H, 5.74; N, 7.25%.

Ethyl (*Z*)-2-Hydroxyimino-4-(3,4-methylenedioxyphenyl)-butyrate (4l) : Mp 100 °C; IR (KBr) 1018, 1043, 1113, 1186, 1246, 1429, 1491, 1726, 3276 cm^{-1}; ^{1}H NMR δ=1.31 (3H, t, J=7.5 Hz), 2.72—2.75 (2H, m), 2.83—2.86 (2H, m), 4.26 (2H, q, J=7.5 Hz), 5.89 (2H, s), 6.64 (1H, dd, J=1.5, 7.8 Hz), 6.69—6.71 (2H, m); ^{13}C NMR δ=14.7, 27.0, 31.5, 61.8, 100.8, 108.2, 108.9, 121.2, 134.7, 145.9, 147.5, 152.3, 163.4. Found: C, 58.95; H, 5.64; N, 5.37%. Calcd for $C_{13}H_{15}NO_5$: C, 58.86; H, 5.70; N, 5.28%.

(*E*)-4-(4-Hydroxyphenyl)butan-2-one Oxime (4m) :[24] Mp 104 °C; IR (KBr) 1228, 1516, 3303 cm^{-1}; ^{1}H NMR δ=1.88 (3H, s), 2.43—2.46 (2H, m), 2.73—2.76 (2H, m), 6.71—6.73 (2H, m), 7.02—7.03 (2H, m); ^{13}C NMR δ=13.5, 31.7, 37.6, 115.3, 129.4, 133.2, 153.9, 158.3.

(*E*)-4-(3,4-Dimethoxyphenyl)butan-2-one Oxime (4n) : Mp 93 °C; IR (KBr) 1236, 1512, 2925, 3228 cm^{-1}; ^{1}H NMR δ=1.89 (3H, s), 2.45—2.49 (2H, m), 2.75—2.78 (2H, m), 3.83 (3H, s), 3.85 (3H, s), 6.70—6.78 (3H, m), 8.38 (1H, bs); ^{13}C NMR δ=13.7, 30.1,

37.7, 55.7, 55.8, 111.2, 111.5, 120.0, 133.5, 147.3, 148.8, 157.7. Found: C, 64.71; H, 7.50; N, 6.51%. Calcd for $C_{12}H_{17}NO_3$: C, 64.59; H, 7.62; N, 6.27%.

(*E*)-4-(4-Hydroxy-3-methoxyphenyl)butan-2-one Oxime (4o): Mp 85 °C; IR (KBr) 1510, 2929, 3251, 3469 cm^{-1}; ^1H NMR δ=1.88 (3H, s), 2.45 (2H, t, J=8.1 Hz), 2.74 (2H, t, J=8.1 Hz), 3.85 (3H, s), 5.47 (1H, bs), 6.66 (1H, d, J=8.5 Hz), 6.67 (1H, s), 6.81 (1H, d, J=8.5 Hz); ^{13}C NMR δ=13.7, 32.3, 37.9, 55.9, 111.0, 114.4, 120.9, 132.9, 143.9, 146.4, 158.0. Found: C, 62.99; H, 7.06; N, 6.68%. Calcd for $C_{11}H_{15}NO_3$: C, 63.14; H, 7.23; N, 6.69%.

(*E*)-4-(4-Hydroxy-2-methoxyphenyl)butan-2-one Oxime (4p): Mp 94 °C; IR (KBr) 1468, 1512, 1614, 3305 cm^{-1}; ^1H NMR δ=1.88 (3H, s), 2.39 (2H, t, J=7.8 Hz), 2.72 (2H, t, J=7.8 Hz), 3.76 (3H, s), 6.29 (1H, dd, J=2.5, 8.1 Hz), 6.35 (1H, d, J=2.5 Hz), 6.91 (1H, d, J=8.1 Hz); ^{13}C NMR δ=13.6, 26.7, 36.1, 55.2, 98.9, 106.6, 121.0, 130.2, 155.5, 158.4, 159.3. HRMS Found: *m/z* 209.1050. Calcd for $C_{11}H_{15}NO_3$: M, 209.1052.

4-(3-Diethylcarbamoyl-4-hydroxyphenyl)butan-2-one Oxime (4q): Mp 150 °C; IR (KBr) 1431, 1612, 3184 cm^{-1}; ^1H NMR δ=1.25 (6H, t, J=7.1 Hz), 1.86 (3H, s), 2.43 (2H, t, J=7.9 Hz), 2.75 (2H, t, J=7.9 Hz), 3.50 (4H, q, J=7.1 Hz), 6.89 (1H, s), 6.91 (1H, d, J=8.4 Hz), 7.05 (1H, d, J=2.5 Hz), 7.12 (1H, dd, J=2.5, 8.4 Hz), 9.41 (1H, s). Found: C, 64.90; H, 8.03; N, 10.16%. Calcd for $C_{15}H_{22}N_2O_3$: C, 64.73; H, 7.97; N, 10.06%.

(*E*)-3-(4-Hydroxyphenyl)propanal Oxime (4r): Mp 107 °C; IR (KBr) 1234, 1514, 3377 cm^{-1}; ^1H NMR δ=2.63—2.67 (2H, m), 2.74 (2H, t, J=7.5 Hz), 4.61 (1H, bs), 6.72 (1H, t, J=5.3 Hz), 6.75 (2H, d, J=8.4 Hz), 7.06 (2H, d, J=8.4 Hz); ^{13}C NMR δ=26.6, 31.0, 115.2, 129.1, 131.8, 151.7, 154.9. Found: C, 65.66; H, 6.81; N, 8.20%. Calcd for $C_9H_{11}NO_2$: C, 65.44; H, 6.71; N, 8.48%.

(*E*)-5-(4-Hydroxyphenyl)pentan-2-one Oxime (14): Mp 136 °C; IR (KBr) 1240, 1514, 3357 cm^{-1}; ^1H NMR δ=1.78 (2H, q, J=7.7 Hz), 1.84 (3H, s), 2.18 (2H, t, J=7.7 Hz), 2.54 (2H, t, J=7.7 Hz), 4.55 (1H, bs), 6.73 (2H, d, J=8.5 Hz), 7.02 (2H, d, J=8.5 Hz); ^{13}C NMR δ=13.2, 28.4, 34.4, 35.2, 115.1, 129.2, 132.8, 154.6, 158.7. Found: C, 68.55; H, 7.83; N, 7.25%. Calcd for $C_{11}H_{15}NO_2$: C, 68.37; H, 7.82; N, 7.25%.

Methyl (*E*)-2-Hydroxy-5-(3-hydroxyiminobutyl)benzoate (4s): Mp 132 °C; IR (KBr) 1209, 1687, 3246 cm^{-1}; ^1H NMR δ=1.88 (3H, s), 2.44 (2H, t, J=8.0 Hz), 2.75 (2H, t, J=8.0 Hz), 3.92 (3H, s), 6.89 (1H, d, J=8.5 Hz), 7.27 (1H, dd, J=2.3, 8.5 Hz), 7.63 (1H, d, J=2.3 Hz), 10.58 (1H, s); ^{13}C NMR δ=13.7, 31.5, 37.7, 52.2, 112.1, 117.6, 129.1, 131.7, 135.9, 157.6, 160.0, 170.5. Found: C, 60.50; H, 6.26; N, 5.91%. Calcd for $C_{12}H_{15}NO_4$: C, 60.75; H, 6.37; N, 5.90%.

General Procedure for the Synthesis of Quinolines. (Table 1, Entry 6): To a 1,2-dichloroethane (6 ml) suspension of 4-(3,4-methylenedioxyphenyl)butan-2-one oxime (**4a**) (203 mg, 0.98 mmol), chloranil (126 mg, 0.51 mmol), Bu_4NReO_4 (98 mg, 0.20 mmol), and Molecular Sieves 5A (100 mg), was added a 1,2-dichloroethane solution of CF_3SO_3H (150 mg, 1.0 mmol) and the mixture was immediately heated to reflux. After 1 h, the reaction was quenched by saturated aqueous sodium hydrogen carbonate and the resulting inorganic materials were filtered off through Celite. Organic materials were extracted with dichloromethane. After evaporation of the solvent, the crude products were purified by thin layer chromatography (hexane : ethyl acetate=2 : 1) to afford 2-methyl-6,7-methylenedioxyquinoline **5a** (137 mg, 75% yield).

5a: Mp 143 °C; IR (KBr) 935, 1038, 1217, 1238, 1456, 1471, 1495 cm^{-1}; ^1H NMR δ=2.65 (3H, s), 6.05 (2H, s), 6.98 (1H, s), 7.10 (1H, d, J=8.3 Hz), 7.30 (1H, s), 7.82 (1H, d, J=8.3 Hz); ^{13}C NMR δ=24.9, 101.5, 102.6, 105.3, 120.1, 123.0, 135.0, 146.0, 147.1, 150.5, 156.5. Found: C, 70.35; H, 4.85; N, 7.68%. Calcd for $C_{11}H_9NO_2$: C, 70.58; H, 4.85; N, 7.48%.

The spectral data were in good agreement with those of the authentic sample which was prepared from 3,4-methylenedioxyaniline and crotonaldehyde according to the literature procedure.[14]

Spectral Data. 2-Methylquinoline (2):[25] ^1H NMR δ=2.69 (3H, s), 7.20 (1H, d, J=8.4 Hz), 7.41 (1H, ddd, J=1.0, 8.4, 8.4 Hz), 7.62 (1H, ddd, J=1.0, 8.4, 8.4 Hz), 7.69 (1H, dd, J=1.0, 8.4 Hz), 7.95 (1H, d, J=8.4 Hz), 7.99 (1H, d, J=8.4 Hz); ^{13}C NMR δ=25.1, 122.0, 125.7, 126.4, 127.4, 128.3, 129.5, 136.3, 147.5, 158.9.

2-Methyl-6,7-methylenedioxy-1,2,3,4-tetrahydroquinoline (6): ^1H NMR δ=1.17 (3H, d, J=6.3 Hz), 1.53 (1H, ddd, J=5.4, 5.9, 8.0 Hz), 1.87 (1H, ddd, J=3.3, 4.5, 11.5 Hz), 2.60 (1H, ddd, J=3.3, 5.4, 16.2 Hz), 2.74 (1H, ddd, J=5.9, 11.5, 16.2 Hz), 3.29 (1H, ddd, J=4.5, 6.3, 8.0 Hz), 5.77 (2H, s), 6.07 (1H, s), 6.45 (1H, s); ^{13}C NMR δ=22.4, 26.6, 30.3, 47.4, 96.5, 100.2, 109.0, 114.0, 139.0, 139.5, 146.1.

2-Ethyl-6,7-methylenedioxyquinoline (5d): IR (KBr) 930, 1039, 1232, 1255, 1460, 1495 cm^{-1}; ^1H NMR δ=1.34 (3H, t, J=7.6 Hz), 2.90 (2H, q, J=7.6 Hz), 6.04 (2H, s), 6.98 (1H, s), 7.13 (1H, d, J=8.3 Hz), 7.31 (1H, s), 7.85 (1H, d, J=8.3 Hz); ^{13}C NMR δ=14.1, 31.7, 101.5, 102.6, 105.5, 118.9, 123.3, 135.2, 146.0, 147.1, 150.5, 161.7. HRMS Found: *m/z* 201.0820. Calcd for $C_{12}H_{11}NO_2$: M, 201.0790.

2,4-Dimethyl-6,7-methylenedioxyquinoline (5e): IR (KBr) 1038, 1240, 1443, 1471 cm^{-1}; ^1H NMR δ=2.52 (3H, s), 2.59 (3H, s), 6.04 (2H, s), 6.96 (1H, s), 7.15 (1H, s), 7.29 (1H, s); ^{13}C NMR δ=18.97, 24.72, 99.31, 101.48, 105.75, 121.21, 122.90, 142.92, 145.85, 147.05, 150.06, 156.28. HRMS Found: *m/z* 201.0781. Calcd for $C_{12}H_{11}NO_2$: M, 201.0790.

The spectral data were in good agreement with those of the authentic sample which was prepared from 3,4-methylenedioxyaniline and acetylacetone according to the literature procedure.[14]

2,3-Dimethyl-6,7-methylenedioxyquinoline (5f): IR (KBr) 943, 1041, 1209, 1244, 1398, 1464, 1495 cm^{-1}; ^1H NMR δ=2.34 (3H, s), 2.57 (3H, s), 6.02 (2H, s), 6.91 (1H, s), 7.26 (1H, s), 7.61 (1H, s); ^{13}C NMR δ=19.3, 23.1, 101.3, 102.0, 105.1, 123.9, 128.0, 134.6, 144.3, 147.0, 149.7, 156.3. HRMS Found: *m/z* 201.0786. Calcd for $C_{12}H_{11}NO_2$: M, 201.0790.

The spectral data were in good agreement with those of the authentic sample which was prepared from 3,4-methylenedioxyaniline and 2-methylbut-2-enal according to the literature procedure.[14]

***N*-[1-Methyl-2-(3,4-methylendioxyphenyl)ethyl]acetamide (10):** IR (KBr) 1039, 1248, 1444, 1496, 1554, 1647 cm^{-1}; ^1H NMR δ=1.06 (3H, d, J=6.7 Hz), 1.89 (3H, s), 2.57 (1H, dd, J=7.2, 13.6 Hz), 2.71 (1H, dd, J=5.8, 13.6 Hz), 4.14 (1H, m), 5.50 (1H, bs), 5.88 (2H, s), 6.57 (1H, dd, J=1.5, 7.8 Hz), 6.63 (1H, d, J=1.5 Hz), 6.69 (1H, d, J=7.8 Hz). HRMS Found: *m/z* 221.1049. Calcd for $C_{12}H_{15}NO_3$: M, 221.1052.

6,8-Dimethoxy-2-methylquinoline (5g): Mp 72 °C; IR (KBr) 843, 1128, 1159, 1215, 1462, 1620 cm^{-1}; ^1H NMR δ=2.68 (3H, s), 3.84 (3H, s), 3.97 (3H, s), 6.56 (1H, d, J=2.4 Hz), 6.64 (1H, d, J=2.4 Hz), 7.19 (1H, d, J=8.4 Hz), 7.83 (1H, d, J=8.4 Hz); ^{13}C NMR δ=25.1, 55.2, 55.8, 96.7, 100.8, 122.7, 127.8, 134.9, 136.1, 155.2, 155.5, 157.3. HRMS Found: *m/z* 203.0950. Calcd for $C_{12}H_{13}NO_2$: M, 203.0946.

The spectral data were in good agreement with those of the authentic sample which was prepared from 2,4-dimethoxyaniline and crotonaldehyde according to the literature procedure.[14]

6-Methoxy-2-methylquinoline (5h-1):[26] ^1H NMR δ=2.68 (3H, s), 3.89 (3H, s), 7.02 (1H, d, J=2.8 Hz), 7.22 (1H, d, J=8.4

Hz), 7.31 (1H, dd, J=2.8, 9.2 Hz), 7.89 (1H, d, J=9.2 Hz), 7.92 (1H, d, J=8.4 Hz); ^{13}C NMR δ=24.9, 55.5, 105.0, 121.6, 122.0, 127.1, 130.0, 134.9, 143.9, 156.3, 157.1.

8-Methoxy-2-methylquinoline (5h-2) :[26] ^{1}H NMR δ=2.77 (3H, s), 4.09 (3H, s), 7.01 (1H, dd, J=1.2, 7.6 Hz), 7.29 (1H, d, J=8.4 Hz), 7.32 (1H, dd, J=1.2, 8.0 Hz), 7.37 (1H, dd, J=7.6, 8.0 Hz), 7.99 (1H, d, J=8.4 Hz); ^{13}C NMR δ=25.7, 56.0, 107.6, 119.8, 122.7, 125.7, 127.3, 136.1, 139.7, 154.8, 158.1.

6-Methoxycarbonylamino-2-methylquinoline (5i) : Mp 178 °C; IR (KBr) 1063, 1236, 1379, 1552, 1576, 1724 cm^{-1}; ^{1}H NMR δ=2.68 (3H, s), 3.78 (3H, s), 7.17 (1H, bs), 7.21 (1H, d, J=8.4 Hz), 7.46 (1H, dd, J=2.4, 9.0 Hz), 7.90 (1H, d, J=9.0 Hz), 7.93 (1H, d, J=8.4 Hz), 8.00 (1H, bs); ^{13}C NMR δ=25.0, 52.4, 114.3, 122.4, 122.5, 127.0, 129.2, 135.2, 135.8, 144.6, 154.1, 157.6. Found: C, 66.66; H, 5.66; N, 13.10%. Calcd for $C_{12}H_{12}N_2O_2$: C, 66.65; H, 5.59; N, 12.95%.

The spectral data were in good agreement with those of the authentic sample which was prepared by condensation of *p*-phenylenediamine and crotonaldehyde followed by *N*-methoxycarbonylation with methyl chloroformate.[14]

6,7-Methylenedioxyquinoline (5k) : ^{1}H NMR δ=6.08 (2H, s), 7.03 (1H, s), 7.22 (1H, dd, J=4.4, 8.2 Hz), 7.37 (1H, s), 7.94 (1H, dd, J=1.5, 8.2 Hz), 8.68 (1H, dd, J=1.5, 4.4 Hz); ^{13}C NMR δ=101.7, 102.7, 105.8, 119.5, 125.3, 134.9, 146.5, 147.8, 148.0, 150.7. HRMS Found : m/z 173.0516. Calcd for $C_{10}H_7NO_2$: M, 173.0477.

3-(3,4-Methylenedioxyphenyl)propiononitrile : IR (KBr) 1038, 1248, 1444, 1495, 2247 cm^{-1}; ^{1}H NMR δ=2.55 (2H, t, J=7.3 Hz), 2.85 (2H, t, J=7.3 Hz), 5.92 (2H, s), 6.66 (1H, dd, J=1.5, 7.9 Hz), 6.68 (1H, d, J=1.5 Hz), 6.75 (1H, d, J=7.9 Hz); ^{13}C NMR δ=19.6, 31.2, 101.0, 108.5, 108.6, 119.0, 121.3, 131.7, 146.7, 147.9. HRMS Found : m/z 175.0634. Calcd for $C_{10}H_9NO_2$: M, 175.0633.

Ethyl 6,7-Methylenedioxyquinoline-2-carboxylate (5l) : IR (KBr) 1024, 1248, 1477, 1736 cm^{-1}; ^{1}H NMR δ=1.45 (3H, t, J=7.1 Hz), 4.51 (2H, q, J=7.1 Hz), 6.12 (2H, s), 7.06 (1H, s), 7.55 (1H, s), 8.02 (1H, d, J=8.4 Hz), 8.05 (1H, d, J=8.4 Hz); ^{13}C NMR δ=14.4, 62.0, 102.1, 102.3, 106.7, 119.9, 127.2, 135.5, 146.0, 146.1, 149.6, 151.4, 165.5. HRMS Found : m/z 245.0709. Calcd for $C_{13}H_{11}NO_4$: M, 245.0688.

Reaction of Oxime 4a with 2-Chloro-1-methylpyrimidinium Salt. 2-Chloro-1-methylpyrimidinium fluorosulfate was prepared by the following procedure; To an ether solution (10 ml) of 2-chloropyrimidine (1.72 g, 15 mmol) was added methyl fluorosulfate (1.82 g, 16 mmol) in ether (10 ml) at 0 °C. After 1 h, the reaction mixture was warmed to room temperature and kept for 2 h. The resulting white solid was separated and washed with ether, then dried under vacuum to give the pyrimidinium salt (2.10 g, 31%). The reaction of oxime **4a** with 2-chloro-1-methylpyrimidinium salt was performed by the literature procedure.[11]

***N*-[2-(3,4-Methylenedioxyphenyl)ethyl]acetamide 8 :** IR (KBr) 1625 cm^{-1}; ^{1}H NMR δ=1.91 (3H, s), 2.68—2.71 (2H, m), 3.40—3.44 (2H, m), 5.54 (1H, bs), 5.90 (2H, s), 6.60 (1H, dd, J=1.4, 7.9 Hz), 6.64 (1H, d, J=1.4 Hz), 6.71 (1H, d, J=7.9 Hz). HRMS Found : m/z 207.0888. Calcd for $C_{11}H_{13}NO_3$: M, 207.0895.

Reaction of the Mesyloxyimino Derivative 4b with $TiCl_4$. To a dichloromethane solution (6 ml) of **4b** (172.3 mg, 0.60 mmol) was added a dichloromethane solution of $TiCl_4$ (1.5 mol dm^{-3}, 0.8 ml) at −78 °C. After 1 h, the reaction was quenched by saturated aqueous sodium hydrogen carbonate and organic materials were extracted with dichloromethane. The combined extracts were washed with brine and dried over Na_2SO_4. After evaporation of the solvent, the crude products were purified by thin layer chromatography (hexane : ethyl acetate=1 : 1) to afford 1-methyl-6,7-methylenedioxy-3,4-dihydroisoquinoline (**9**) (83.0 mg, 75% yield). IR (neat) 1032, 1240, 1279, 1489 cm^{-1}; ^{1}H NMR δ=2.29 (3H, t, J=1.4 Hz), 2.57 (2H, t, J=7.6 Hz), 3.56 (2H, tq, J=1.4, 7.6 Hz), 5.94 (2H, s), 6.63 (1H, s), 6.94 (1H, s); ^{13}C NMR δ=23.5, 26.1, 46.8, 101.2, 106.0, 107.8, 123.6, 132.8, 146.3, 146.7, 163.6. HRMS Found : m/z 189.0802. Calcd for $C_{11}H_{11}NO_2$: M, 189.0790.

General Procedures for the Synthesis of Azaspirotrienones. (Table 3, Entry 1) : To a 1,2-dichloroethane solution (8 ml) of 4-(4-hydroxyphenyl)butan-2-one oxime (**4m**) (209 mg, 1.17 mmol) and Bu_4NReO_4 (115 mg, 0.23 mmol) was added a 1,2-dichloroethane solution (2 ml) of CF_3SO_3H (177 mg, 1.18 mmol), and the mixture was immediately heated to reflux. After 1.5 h, the reaction was quenched by saturated aqueous sodium hydrogen carbonate and organic materials were extracted with dichloromethane and dried over Na_2SO_4. After evaporation of the solvent, the crude products were purified by thin layer chromatography (hexane : ethyl acetate=1 : 1) to give 2-methyl-1-azaspiro[4.5]deca-1,6,9-trien-8-one (**11j**) (171 mg, 91% yield).

IR (neat) 1270, 1626, 1666, 3568 cm^{-1}; ^{1}H NMR δ=2.05 (2H, t, J=8.0 Hz), 2.12 (3H, s), 2.80 (2H, t, J=8.0 Hz), 6.19—6.20 (1H, m), 6.21—6.22 (1H, m), 6.59—6.60 (1H, m), 6.61—6.62 (1H, m); ^{13}C NMR δ=19.7, 33.7, 40.0, 74.8, 127.8, 150.5, 179.4, 183.6. HRMS Found : m/z 161.0840. Calcd for $C_{10}H_{11}NO$: M, 161.0841.

Spectral Data. 10-Nitromethyl-2-methyl-1-azaspiro[4.5]-deca-1,6-dien-8-one (13) : IR (CH_2Cl_2) 1381, 1552, 1647, 1685 cm^{-1}; ^{1}H NMR δ=2.01—2.04 (1H, m), 2.07 (3H, s), 2.11—2.15 (1H, m), 2.67—2.73 (4H, m), 2.92—2.97 (1H, m), 4.26 (1H, dd, J=9.0, 13.2 Hz), 4.66 (1H, dd, J=4.7, 13.2 Hz), 5.99 (1H, d, J=10.2 Hz), 6.47 (1H, d, J=10.2 Hz). HRMS Found : m/z 222.1002. Calcd for $C_{11}H_{14}N_2O_3$: M, 222.1004.

7-Methoxy-2-methyl-1-azaspiro[4.5]deca-1,6,9-trien-8-one (11n) : IR (CH_2Cl_2) 1635, 1674 cm^{-1}; ^{1}H NMR δ=2.03—2.15 (5H, m), 2.78—2.83 (2H, s), 3.63 (3H, s), 5.45 (1H, d, J=2.6 Hz), 6.21 (1H, d, J=9.8 Hz), 6.58 (1H, dd, J=2.6, 9.8 Hz); ^{13}C NMR δ=20.0, 34.8, 40.1, 54.8, 76.0, 117.9, 127.1, 150.3, 150.6, 178.3, 180.9. HRMS Found : m/z 191.0935. Calcd for $C_{11}H_{13}NO_2$: M, 191.0947.

6-Methoxy-2-methyl-1-azaspiro[4.5]deca-1,6,9-trien-8-one (11p) : Mp 130 °C; IR (KBr) 1593, 1657, 3419 cm^{-1}; ^{1}H NMR δ=1.92—1.98 (1H, m), 2.12 (3H, s), 2.23—2.29 (1H, m), 2.72—2.78 (1H, m), 2.82—2.89 (1H, m), 3.69 (3H, s), 5.53 (1H, d, J=1.5 Hz), 6.12 (1H, dd, J=1.5, 9.8 Hz), 6.34 (1H, d, J=9.8 Hz); ^{13}C NMR δ=19.8, 33.0, 40.9, 55.8, 76.8, 101.5, 126.6, 146.7, 175.3, 180.1, 187.9. HRMS Found: m/z 191.0946. Calcd for $C_{11}H_{13}NO_2$: M, 191.0947.

7-Diethylcarbamonyl-2-methyl-1-azaspiro[4.5]deca-1,6,9-trien-8-one (11q) : IR (CH_2Cl_2) 1286, 1437, 1630, 1672 cm^{-1}; ^{1}H NMR δ=1.06 (3H, t, J=7.2 Hz), 1.16 (3H, t, J=7.2 Hz), 2.04—2.09 (1H, m), 2.11 (3H, s), 2.13—2.18 (1H, m), 2.80 (2H, t, J=8.0 Hz), 3.09—3.23 (2H, m), 3.38—3.52 (2H, m), 6.24 (1H, d, J=9.9 Hz), 6.58 (1H, d, J=2.9 Hz), 6.63 (1H, dd, J=2.9, 9.9 Hz); ^{13}C NMR δ=12.8, 13.9, 19.9, 33.7, 38.9, 40.2, 43.0, 74.8, 127.6, 136.7, 146.9, 150.5, 165.9, 180.1, 182.2. HRMS Found: m/z 260.1529. Calcd for $C_{15}H_{20}N_2O_2$: M, 260.1525.

2-Methyl-1-azaspiro[5.5]undeca-1,7,10-trien-9-one (15) : IR (CH_2Cl_2) 1626, 1673 cm^{-1}; ^{1}H NMR δ=1.64—1.66 (2H, m), 1.78—1.82 (2H, m), 2.00 (3H, s), 2.25 (2H, t, J=6.7 Hz), 6.22 (2H, d, J=10.0 Hz), 6.67 (2H, d, J=10.0 Hz); ^{13}C NMR δ=16.0, 28.0, 29.3, 30.7, 57.6, 127.9, 151.8, 171.7, 185.6. HRMS Found : m/z 175.1001. Calcd for $C_{11}H_{13}NO$: M, 175.0997.

3-(4-Hydroxyphenyl)propiononitrile : IR (CH_2Cl_2) 2252, 3383 cm^{-1}; ^1H NMR δ=2.57 (2H, t, J=7.3 Hz), 2.87 (2H, t, J=7.3 Hz), 4.95 (1H, bs), 6.78 (2H, d, J=8.4 Hz), 7.08 (2H, d, J=8.4 Hz). HRMS Found : m/z 147.0688. Calcd for C_9H_9NO : M, 147.0684.

Transformation of Azaspirotrienones into Quinolines. 2-Methylquinolin-6-ol (16) :[27] To a nitrobenzene solution (4 ml) of the azaspirotrienone **11j** (50.9 mg, 0.32 mmol) and chloranil (40.7 mg, 0.17 mmol) was added a nitrobenzene solution (2 ml) of CF_3SO_3H (161.3 mg, 1.07 mmol), and the mixture was immediately heated to 120 °C. After 6 h, the reaction was quenched by saturated aqueous sodium hydrogen carbonate and organic materials were extracted with dichloromethane. The combined extracts were washed with brine and dried over Na_2SO_4. After the solvent was removed in vacuo, the crude products were purified by thin layer chromatography (hexane, then hexane : ethyl acetate=1 : 1) to give **16** (38.3 mg) in 75% yield.

Mp 212 °C; ^1H NMR ($CDCl_3$: $(CD_3)_2CO$=1 : 1) δ=2.61 (3H, s), 4.35 (1H, bs), 7.04 (1H, d, J=2.6 Hz), 7.17 (1H, d, J=8.4 Hz), 7.26 (1H, dd, J=2.6, 9.1 Hz), 7.79 (1H, d, J=9.1 Hz), 7.78 (1H, d, J=8.4 Hz); ^{13}C NMR (CD_3OD : $(CD_3)_2CO$=1 : 1) δ=24.8, 109.3, 122.5, 123.0, 128.7, 130.2, 135.8, 143.6, 155.9, 156.3. HRMS Found : m/z 159.0690. Calcd for $C_{10}H_9NO$: M, 159.0684.

6,7-Dimethoxy-2-methylquinoline (19) : To a nitrobenzene solution (3 ml) of the azaspirotrienone **11n** (92.6 mg, 0.48 mmol) was added a nitrobenzene solution (3 ml) of CF_3SO_3H (218 mg, 1.45 mmol), and the mixture was immediately heated to 120 °C. After 5 h, an aqueous solution (10 ml) of sodium hydroxide (187 mg, 4.68 mmol), Bu_4NBr (310 mg, 0.96 mmol) in dichloromethane (2 ml), and iodomethane (136 mg, 0.96 mmol) were added to the mixture at room temperature, and the mixture was stirred overnight. Inorganic materials were filtered off through a short pad of Celite and organic materials were extracted with dichloromethane. The combined extracts were washed with brine and dried over Na_2SO_4. After the solvent was removed in vacuo, the crude products were purified by thin layer chromatography (ether) to give **19** (57.2 mg) in 58% yield.

Mp 100 °C; IR (neat) 1161, 1250, 1505, 1601 cm^{-1}; ^1H NMR δ=2.66 (3H, s), 3.96 (3H, s), 3.99 (3H, s), 6.98 (1H, s), 7.11 (1H, d, J=8.3 Hz), 7.34 (1H, s), 7.85 (1H, d, J=8.3 Hz); ^{13}C NMR δ=24.9, 55.9, 56.0, 105.0, 107.5, 120.0, 121.7, 134.4, 144.7, 149.0, 152.3, 156.5. HRMS Found: m/z 203.0951. Calcd for $C_{12}H_{13}NO_2$: M, 203.0947.

Methyl 6-Hydroxy-2-methylquinoline-5-carboxylate (5s) : IR (CH_2Cl_2) 839, 1192, 1346, 1655, 3033 cm^{-1}; ^1H NMR δ=2.68 (3H, s), 4.09 (3H, s), 7.31 (1H, d, J=8.9 Hz), 7.34 (1H, d, J=8.9 Hz), 8.07 (1H, d, J=8.9 Hz), 8.94 (1H, d, J=8.9 Hz), 12.11 (1H, s); ^{13}C NMR δ=24.4, 52.4, 103.9, 122.6, 123.4, 125.2, 133.6, 137.4, 143.3, 155.8, 163.5, 172.0. HRMS Found : m/z 217.0728. Calcd for $C_{12}H_{11}NO_3$: M, 217.0739.

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