Acid-Catalyzed [4+2] Cycloaddition Reaction of 2-(Alk-2-enyl)amino-3-(*N*-arylimino)methyl-4-oxo-4*H*-pyrido[1,2-*a*]pyrimidines

Michihiko Noguchi,* Takashi Mizukoshi, and Shigeki Nishimura

Department of Applied Chemistry, Faculty of Engineering, Yamaguchi University, Tokiwadai, Ube 755

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The *N*-arylimines of 2-(alk-2-enyl)amino-4-oxo-4*H*-pyrido[1,2-*a*]pyrimidine-3-carbaldehyde undergo the intramolecular [4+2] cycloaddition reaction under Lewis acid-catalyzed conditions to afford diastereomeric tetraazapentaphene derivatives. The diastereoselectivity as well as the scope and limitations of the cycloaddition reactions is discussed.

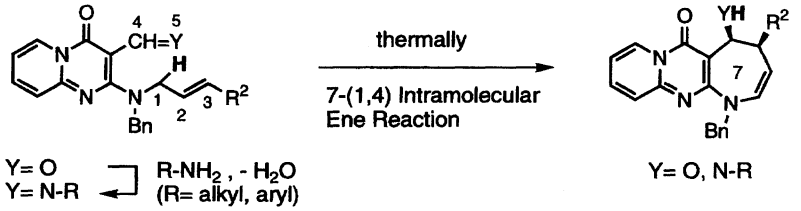
In recent papers we have reported on a facile and stereoselective azepine-ring formation at the periphery of heterocyclic systems through thermal imine- and carbonyl-ene reactions,[1] classified as a 7-(1,4) intramolecular ene reaction[2] (Scheme 1). Further investigations on the reaction mechanism have revealed that the ene reactions proceeded in an almost concerted manner.[3] Therefore, our next concern was focused on their reactions under acid-catalyzed conditions. Although many precedent studies concerning acid-catalyzed carbonyl-ene reaction have been found in the literature,[4] examples of the imine-ene reaction have been relatively rare.[5] We thus attempted to examine the reaction of 3-(alk-2-enyl)amino-4-oxo-4*H*-pyrido[1,2-*a*]pyrimidine-3-carbaldehydes and their imines under acidic conditions. Both Brönsted and Lewis acids did not provide any good fortune for the carbonyl-ene reaction, giving a recovered aldehyde together with unidentified products. On the other hand, the *N*-arylimines of the aldehydes, obtained from the aldehydes and arylamines in situ, underwent an acid-catalyzed imino Diels–Alder reaction to form tetraazapentaphene derivatives in moderate to good yields. Since the substituents on the alkenyl amino moiety strongly influenced both the reactivity and the diastereoselectivity, we have proposed a stepwise process for the [4+2] cycloaddition reaction.

Results and Discussion

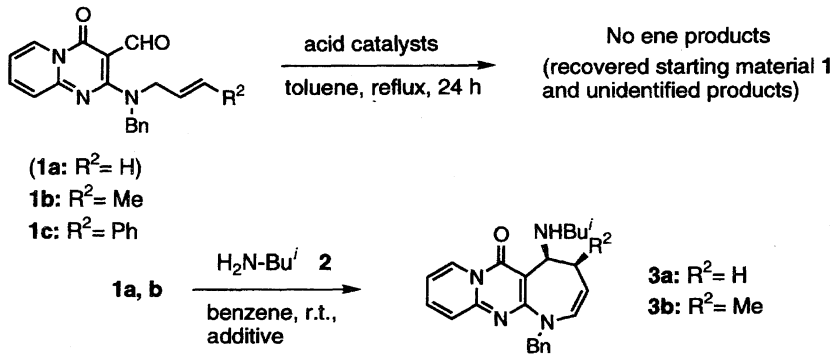
A toluene solution of 2-{*N*-benzyl[(*E*)-but-2-enyl]amino}-4-oxo-4*H*-pyrido[1,2-*a*]pyrimidine-3-carbaldehyde (**1b**) and boron trifluoride etherate ($BF_3 \cdot OEt_2$, 1.0 molar amount) heated under reflux gave recovered **1b** in 61% yield. Similarly, the utilization of toluene-*p*-sulfonic acid (PTSA, 1 crop), magnesium bromide etherate ($MgBr_2 \cdot OEt_2$, 0.5 molar amount), ethylaluminium dichloride ($EtAlCl_2$, 0.1 molar amount), and diethylaluminium chloride (Et_2AlCl, 0.1 molar amount) as catalysts afforded only disappointing results (recovered **1b** in 30—81% yields); especially, in the last two cases intractable mixtures of products, probably due to the decomposition of **1b**, were formed. Almost the same results were obtained in the reaction of 2-{*N*-benzyl[(*E*)-cinnamyl]-amino} substrate **1c** (Scheme 2).

The effects of acid catalysts on the reaction of the imines of aldehydes **1** were also examined; the reactions of 2-[*N*-allyl-(benzyl)amino]-4-oxo-4*H*-pyrido[1,2-*a*]pyrimidine-3-carbaldehyde (**1a**) and 2-[*N*-benzyl(but-2-enyl)amino] homolog **1b** with isobutylamine (**2**) in the presence of several acid catalysts were performed to afford ene products **3a** and **3b** in good to to excellent yields, even at room temperature (Scheme 2 and Table 1). However, similar good results were obtained in reactions utilizing molecular sieves (MS; 3 Å) instead of acid catalysts (Entries 1 and 4). This means that the acid catalysts could be effective to the dehydrating step in the imine formation and suggests that the imine-ene reaction process in azepine-ring formation might not be accelerated by acid catalysts.

A similar reaction of aldehyde **1b** with aniline (**4**) in the presence of $BF_3 \cdot OEt_2$ (0.5 molar amount) at room temperature gave two products, **5b** and **6b**, in 56 and 34% yields, respectively. While the isolated **6b** was stable under the reaction conditions, product **5b** was partially decomposed under similar conditions. Both products **5b** and **6b** showed the



Scheme 1.



Scheme 2.

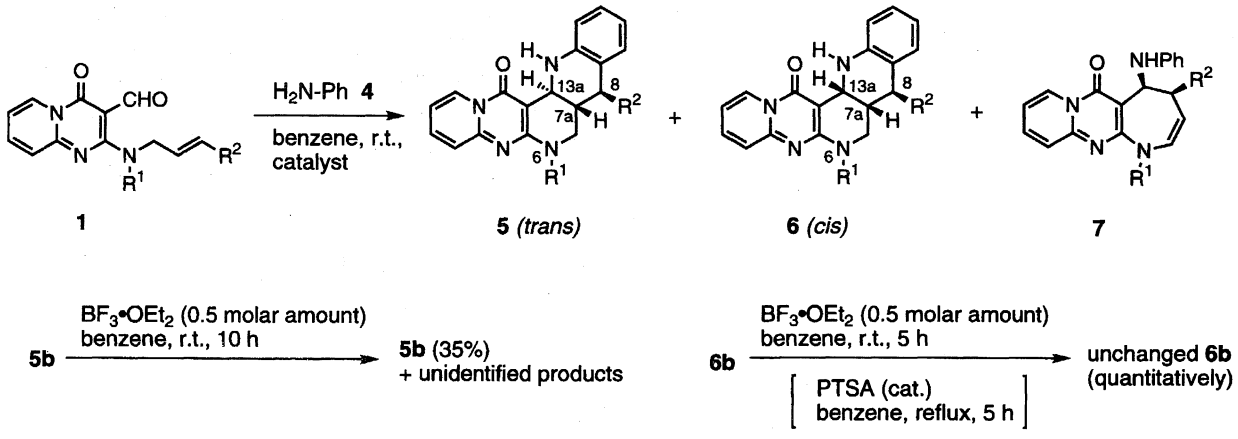
Table 1. Reaction of Aldehydes **1a,b** with Isobutylamine (**2**) in the Presence of Additives

Entry	Substrate	Additive (Molar amount)	Time h	Product/Yield(%)[a] 3	1
1	**1a**	MS (3 Å)	5	**3a**/75	—
2	**1a**	PTSA (1 crop)	20	**3a**/79	—
3	**1a**	$EtAlCl_2$ (0.5)	72	**3a**/82	—
4	**1b**	MS (3 Å)	24	**3b**/91	—
5	**1b**	PTSA (1 crop)	48	**3b**/98	**1b**/trace
6[b]	**1b**	$EtAlCl_2$ (1.5)	24	**3b**/trace	**1b**/28
7	**1b**	BF_3·OEt_2 (0.5)	24	**3b**/57	**1b**/41

a) Based on isolated products. b) Many unidentified products were also formed.

same molecular formula, corresponding to the imine initially formed; also an NH stretching absorption band was observed in their IR spectra. Their ^{13}C NMR spectral signals were almost consistent with each other over the whole region. Their ^1H–^1H and ^1H–^{13}C COSY spectra suggested that products **5b** and **6b** had a tetraazapentaphene structure, obtained by an intramolecular [4+2] cycloaddition reaction between the *N*-phenylimine and ene moieties.[6] The configurations among the three adjacent protons, 8-H, 7a-H, and 13a-H, of the two pentaphenes were deduced to be *trans* and *trans* for **5b** (J_{7a-8} = 11.2 Hz and J_{7a-13a} = 10.2 Hz) and *trans* and *cis* for **6b** (J_{7a-8} =< 1.0 Hz and J_{7a-13a} = 3.3 Hz) on the basis of their coupling constants, compared with the experimental and calculated ones of the related systems.[7] These results mean that the [4+2] cycloaddition reaction is carried out while retaining the stereochemistry on the ene moiety. Recently, Laschat et al.[8] reported on the intramolecular [4+2] cycloaddition reaction of *N*-arylimines as 2-azabuta-1,3-dienes with a non-activated ene moiety under acidic conditions. Although the diastereoselectivity of the cycloaddition reaction, therein, depended mainly on the kind of acid-catalysts utilized and the reaction temperature, control of the stereoselectivity has not been accomplished.[9]

In order to elucidate the effects of acid catalysts on the reactivity and diastereoselectivity, similar reactions in the presence of several acid catalysts were examined (Scheme 3 and Table 2). Utilizing both Brönsted and Lewis acid catalysts caused the [4+2] cycloaddition reaction of the corresponding *N*-phenylimine. *Cis*-annulated pentaphene **6b** was formed predominantly in reactions which utilized PTSA and



Scheme 3.

Table 2. Reaction of Aldehydes **1** with Aniline (**4**) in the Presence of Acid Catalysts

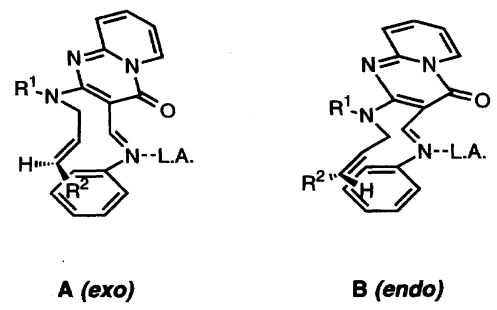
Entry	Substrate	R^1	R^2	Acid catalyst (Molar amount)	Time h	Product/Yield (%)[a] **5**(*trans*)	**6**(*cis*)	**7**[b]
1	**1a**	Bn	H	BF_3·OEt_2 (0.5)	36	—	**6a**/20	**7a**/59
2	**1b**	Bn	Me	PTSA (1 crop)	48	**5b**/29	**6b**/52	**7b**/3
3	**1b**			$EtAlCl_2$ (0.3)	24	**5b**/28	**6b**/56	—
4	**1b**			Et_2AlCl (0.5)	24	**5b**/28	**6b**/56	—
5	**1b**			BF_3·OEt_2 (0.5)	5	**5b**/56	**6b**/34	—
6	**1b**			MS (3 Å)	7d	—	—	**7b**/80
7	**1c**	Bn	Ph	BF_3·OEt_2 (0.5)	5	**5c**/64	**6c**/18	—
8[c]	**1d**	Bn	CH=CHMe	BF_3·OEt_2 (0.5)	5	**5d**/78	—	—
9	**1e**	Me	2-Furyl	BF_3·OEt_2 (0.5)	5	**5e**/86	—	—

a) Based on isolated products. b) Azepines **7** were partially isomerized to the 2,4-ethanopyrido[1,2-*a*]pyrimidine derivatives during the isolation procedures.[1d] c) A mixture of unidentified products was also obtained.

Lewis acids, except for BF_3·OEt_2, though the *cis*-selectivity seemed to be moderate. The effect of the substituent (R^2) on the ene moiety on the *cis*- and *trans*-selectivity was also examined in the presence of BF_3·OEt_2; the reaction of the allyl(benzyl)amino substrate **1a** with **4** gave the ene product **7a** as a major product along with a small amount of *cis*-annulated tetraazapentaphene **6a**. The similar reaction of 2-{*N*-benzyl[(2*E*,4*E*)-hexa-2,4-dienyl]amino} substrate (**1d**) and 2-{*N*-[3-(2-furyl)prop-2-enyl]methylamino} one (**1e**) gave *trans*-annulated pentaphenes, **5d** and **5e**.

The formation of the *cis*- and *trans*-annulated pentaphenes was attributed to the conformation of the transition states in the [4+2] cycloaddition reaction of the 2-azabutadiene part of the *N*-phenylimine with the ene part. Two possible transition states, **A** and **B**, leading to the *trans*- and *cis*-isomer, respectively, are demonstrated in Fig. 1. In the *exo*-approaching transition state **A** the substituent R^2 on the ene moiety is located close to the benzene ring of the imine (Fig. 1). The benzene ring is expected to bear an electron-deficient nature due to iminium ion formation by the Brönsted or Lewis acids. In the case of substituents with an electron-donating nature, such as phenyl **1c**, prop-1-enyl **1d**, and 2-furyl group **1e**, an electrostatic interaction between these substituents and the electron-deficient benzene ring (the π–π stacking) should make the *exo*- approaching transition state more favorable than the *endo* one.

To obtain a better understanding of the interaction, the reaction of aldehyde **1b** with 4-substituted anilines (**13**, **16**, and **19**) was performed; in every case, although the *trans*-isomer was formed predominantly, the apparent effect of the substituents on the 4-position of aniline could not be observed (Scheme 6, see Experimental section). Finally, the effect of the substituent R^2 on the ene part on the reaction patterns and the diastereoselectivity in the [4+2] cycloaddition reaction was examined in two other heterocyclic systems; while the reaction of 4-{*N*-benzyl[(*E*)-but-2-enyl]amino}-1,6-dimethyl-2-oxo-1,2-dihydropyridine-3-carbaldehyde (**8b**) with aniline (**4**) in the presence of BF_3·OEt_2 gave an ene product **9b**, a similar reaction of 4-{*N*-benzyl[3-(2-furyl)-prop-2-enyl]amino} substrate **8f** gave the [4+2] cycloadduct **10f**. The reaction of 6-{*N*-benzyl[(*E*)-but-2-enyl]amino}-1,3-dimethyl-2,4-dioxo-1,2,3,4-tetrahydropyrimidine-5-carbaldehyde (**11b**) in benzene at room temperature catalyzed by BF_3·OEt_2 gave the unreacted aldehyde **11b**. The reaction of 6-[*N*-benzyl[3-(2-furyl)prop-2-enyl]amino substrate **11f** with aniline (**4**) under similar conditions also gave the [4+2] cycloadduct **12f** (Scheme 4).

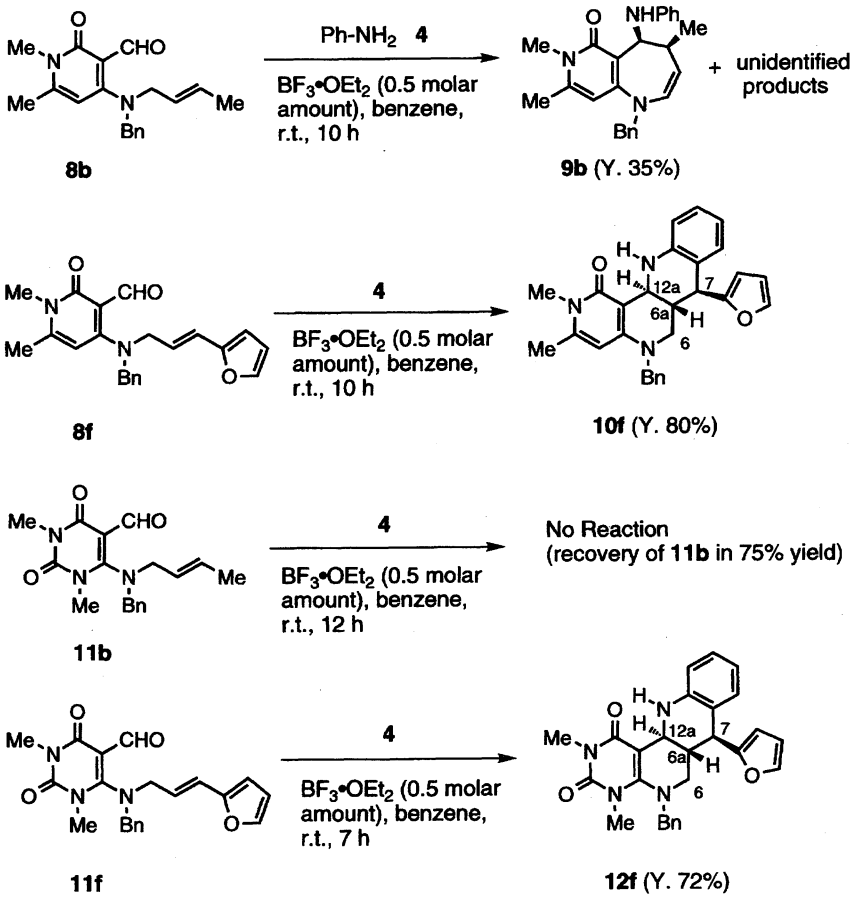


A (*exo*) **B (*endo*)**

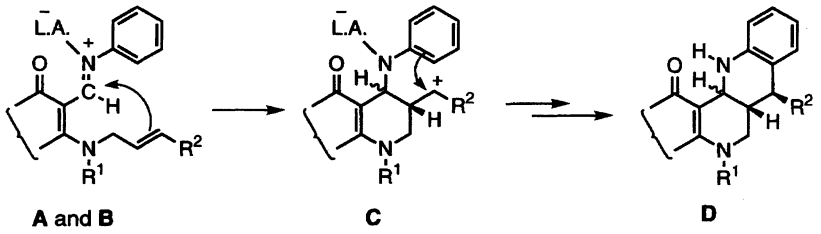
Fig. 1. Possible transition states geometries **A** and **B** leading to *trans*- and *cis*-annulated pentaphenes.

The exact mechanism for the intramolecular [4+2] cycloaddition reaction of the *N*-arylimines is still obscure. However, a stepwise process, involving the cyclization of iminium ions followed by Friedel–Crafts-type alkylation (Scheme 5), seems to be plausible from the following reasons: These imines underwent a thermal ene reaction without acid catalysts to afford the azepine derivatives. The azepines were expected to convert into 2,4-ethanopyrido[1,2-*a*]pyrimidine derivatives under acidic conditions. The kind of substituent R^2 effected the reaction patterns and diastereoselectivity of the cycloaddition reaction. The presence of a cation-stabilizing substituent R^2 on the ene moiety facilitated cycloaddition. The imines having the 2-furyl group as the substituent R^2, one with a powerful electron-donating nature, gave the *trans*-annulated pentaphene derivatives exclusively. Recently, a similar stepwise mechanism in the hetero-Diels–Alder reaction of *N*-arylimines under Lewis acid-catalyzed conditions was proposed.[10]

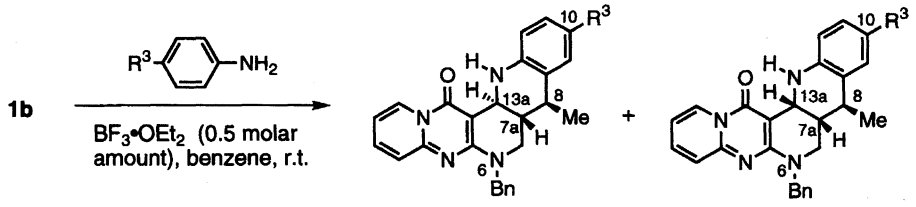
In this paper we have described how the Lewis acid-catalyzed reaction of the heterocyclic phenyl-substituted aldimines bearing the alk-2-enylamino groups at the adjacent position undergoes the [4+2] cycloaddition reaction between the *N*-phenylimine and ene part. Further investigations on the scope and limitations of the cycloaddition reactions are



Scheme 4.



Scheme 5.



Scheme 6.

now under progress.

Experimental

General. Descriptions of the usual instruments, general procedures, and chromatographic procedures have been reported previously.[1d] The NMR spectra were measured on a JEOL EX-270 spectrometer (270 MHz for ^{1}H and 67.9 MHz for ^{13}C) as deuteriochloroform solutions unless otherwise stated. The splitting patterns are indicated as s, singlet; d, doublet; t, triplet; q, quartet; m, multiplet; br, broad signal; and ov, overlapping with each other. The

starting aldehydes **1a**—**e**, **8b**, **8f**, **11b**, and **11f** were known.[1d,11,12]

Acid-Catalyzed Reaction of Aldehyde 1 with Isobutylamine (2). Typical Procedure: A dry benzene solution (5 ml) of aldehyde **1b** (50 mg, 0.15 mmol), isobutylamine (**2**; 11 mg, 0.15 mmol), and PTSA (1 crop) was stirred at room temperature for 20 h. The mixture was evaporated to dryness, which was treated with 5% aqueous sodium hydrogencarbonate and extracted with ethyl acetate (2×15 ml). The ethyl acetate was removed under reduced pressure and the residue was subjected to silica-gel column chromatography to afford azepine **3b** (57 mg, 98%) and a trace amount of aldehyde **1b** with hexane–ethyl acetate (4/1) as an eluent. The structures of the azepines (**3a**, **3b**, **7a**, **7b**, and **9b**) in this study were identified on the basis of the accordance with the spectral data of authentic samples.[1d]

Acid-Catalyzed Reaction of Aldehyde 1 with Aniline (4). Typical Procedures: A dry benzene solution (5 ml) of aldehyde **1a** (75 mg, 0.24 mmol), aniline (**4**; 30 μl, 0.33 mol), and BF_3·OEt_2 (15 μl, 0.12 mmol) was stirred at room temperature for 5 h. The reaction mixture was neutralized with sodium hydrogencarbonate and extracted with benzene. The benzene layer was dried over magnesium sulfate and evaporated to dryness, and the residue was subjected to silica-gel chromatography to afford *cis*-annulated tetraazapentaphene **6a** (18 mg, 20%) and azepine **7a** (53 mg, 59%) with hexane–ethyl acetate (4/1 to 2/1).

(7a*R,13a*R**)-(±)-6-Benzyl-6,7,7a,8,13,13a,-hexahydro-14*H*-quinolino[2′,3′ : 4,5]pyrido[2,3-*d*]pyrido[1,2-*a*]pyrimidin-14-one (6a):** Yellow needles (hexane–benzene); mp 215—216 °C; IR (KBr) 3400 (NH), 1660 cm^{-1} (CO); ^{1}H NMR δ = 2.36 (1H, m, 7a-H), 2.53 (1H, dd, $J_{7a\text{-}8}$ = 2.0, J_{gem} = 16.8 Hz, 8-H), 3.11 (1H, dd, $J_{7\text{-}7a}$ = 4.3, J_{gem} = 12.2 Hz, 7-H), 3.18 (1H, dd, $J_{7a\text{-}8}$ = 6.3, J_{gem} = 16.8 Hz, 8-H), 3.46 (1H, dd, $J_{7\text{-}7a}$ = 11.8, J_{gem} = 12.2 Hz, 7-H), 4.40 (1H, br s, NH), 4.66, 5.27 (each 1H, each d, J_{gem} = 15.2 Hz, C*H*$_2$Ph), 4.84 (1H, d, $J_{7a\text{-}13a}$ = 3.3 Hz, 13a-H), 6.46 (1H, d, $J_{11\text{-}12}$ = 7.9 Hz, 12-H), 6.59 (1H, t, $J_{9\text{-}10}$ = $J_{10\text{-}11}$ = 7.3 Hz, 10-H), 6.84—7.36 (9H, ov, 2-, 4-, 9-, and 11-H and Ph), 7.55 (1H, ddd, $J_{1\text{-}3}$ = 1.7, $J_{2\text{-}3}$ = 6.6, $J_{2\text{-}4}$ = 8.9 Hz, 3-H), 8.90 (1H, dd, $J_{1\text{-}3}$ = 1.7, $J_{1\text{-}2}$ = 7.3 Hz, 1-H); ^{13}C NMR δ = 29.0 (8-C), 29.1 (7a-C), 45.7 (13a-C), 47.3 (7-C), 51.1(*C*H$_2$Ph), 92.3 (13b-C), 112.3 (2-C), 114.3 (12-C), 117.1 (10-C), 118.0 (8a-C), 124.3 (4-C), 127.1, 127.6, 128.6, 138.1 (Ph-C), 127.2 (1-C), 128.3 (9-C), 129.2 (11-C), 136.0 (3-C), 142.2 (12a-C), 150.0 (4a-C), 156.8 (5a-C), 157.0 (14-C). Found: C, 75.79; H, 5.80; N, 14.04%. Calcd for $C_{25}H_{22}N_4O$: C, 76.12; H, 5.62; N, 14.20%.

(7a*R,8*S**,13a*S**)-(±)-6-Benzyl-8-methyl-6,7,7a,8,13,13a-hexahydro-14*H*-quinolino[2′,3′ : 4,5]pyrido[2,3-*d*]pyrido[1,2-*a*]-pyrimidin-14-one (5b):** Yellow needles (hexane–benzene); mp 165—167 °C; IR (KBr) 3340 (NH), 1655 cm^{-1} (CO); ^{1}H NMR δ = 1.28 (3H, d, $J_{8\text{-Me}}$ = 6.6 Hz, 8-Me), 2.00 (1H, m, 7a-H), 2.75 (1H, qd, $J_{8\text{-Me}}$ = 6.6, $J_{7a\text{-}8}$ = 11.2 Hz, 8-H), 3.10 (1H, dd, $J_{7\text{-}7a}$ = 11.9, J_{gem} = 12.2 Hz, 7-H), 3.52 (1H, dd, $J_{7\text{-}7a}$ = 3.9, J_{gem} = 12.2 Hz, 7-H) 4.36 (1H, d, $J_{7a\text{-}13a}$ = 10.2 Hz, 13a-H), 4.98, 5.07 (each 1H, each d, J_{gem} = 15.2 Hz, C*H*$_2$Ph), 6.68—6.74 (2H, ov, 10- and 12-H), 6.87 (1H, t, $J_{10\text{-}11}$ = $J_{11\text{-}12}$ = 7.9 Hz, 11-H), 7.15 (1H, d, $J_{9\text{-}10}$ = 7.3 Hz, 9-H), 7.24—7.36 (6H, ov, 4-H and Ph), 7.54 (1H, ddd, $J_{1\text{-}3}$ = 1.7, $J_{2\text{-}3}$ = 6.6, $J_{3\text{-}4}$ = 8.9 Hz, 3-H), 8.88 (1H, dd, $J_{1\text{-}3}$ = 1.7, $J_{1\text{-}2}$ = 7.3 Hz, 1-H); ^{13}C NMR δ = 18.7 (8-Me), 34.4 (8-C), 41.2 (7a-C), 49.0 (7-C), 51.6 (*C*H$_2$Ph), 51.8 (13a-C), 91.0 (13b-C), 112.5 (2-C), 116.0 (12-C), 118.0 (10-C), 124.2 (4-C), 125.6 (8a-C), 126.9 (11-C), 127.0, 127.5, 128.6, 137.8 (Ph-C), 127.3 (1-C), 127.5 (9-C), 136.0 (3-C), 145.5 (12a-C), 156.5 (5a-C), 157.4 (14-C), MS *m/z* 408 (M^+), 288. Found: C, 76.53; H, 5.88; N, 13.60%. Calcd for $C_{26}H_{24}N_4O$: C, 76.44; H, 5.92; N, 13.72%.

(7a*R,8*S**,13a*R**)-(±)-6-Benzyl-8-methyl-6,7,7a,8,13,13a-hexahydro-14*H*-quinolino[2′,3′ : 4,5]pyrido[2,3-*d*]pyrido[1,2-*a*]-pyrimidin-14-one (6b):** Colorless needles (hexane–benzene); mp 200—201 °C; IR (KBr) 3320 (NH), 1660 cm^{-1} (CO); ^{1}H NMR δ = 1.35 (3H, d, $J_{8\text{-Me}}$ = 6.9 Hz, 8-Me, 1.99 (1H, m, 7a-H), 2.64 (1H, br q, $J_{8\text{-Me}}$ = 6.9 Hz, 8-H), 3.04 (1H, dd, $J_{7\text{-}7a}$ = 4.3, J_{gem} = 12.2 Hz, 7-H), 3.31 (1H, t, $J_{7\text{-}7a}$ = J_{gem} = 12.2 Hz, 7-H), 4.37 (1H, br s, NH), 4.60, 5.28 (each 1H, each d, J_{gem} = 15.2 Hz, C*H*$_2$Ph), 4.92 (1H, d, $J_{7a\text{-}13a}$ = 3.3 Hz, 13a-H), 6.45 (1H, d, $J_{11\text{-}12}$ = 8.3 Hz, 12-H), 6.60 (1H, t, $J_{9\text{-}10}$ = $J_{10\text{-}11}$ = 7.3 Hz, 10-H), 6.87 (1H, ddd, $J_{2\text{-}4}$ = 1.3, $J_{2\text{-}3}$ = 6.6, $J_{1\text{-}2}$ = 7.3 Hz, 2-H), 6.94—6.99 (2H, ov, 9- and 11-H), 7.24—7.36 (6H, ov, 4- and 6-H and Ph), 7.55 (1H, ddd, $J_{1\text{-}3}$ = 1.7, $J_{2\text{-}3}$ = 6.6 $J_{3\text{-}4}$ = 8.9 Hz, 3-H), 8.92 (1H, dd, $J_{1\text{-}3}$ = 1.7, $J_{1\text{-}2}$ = 7.3 Hz, 1-H); ^{13}C NMR δ = 25.5 (8-Me), 33.7 (8-C), 35.5 (7a-C), 41.7 (13a-C), 47.4 (7-C), 51.1 (*C*H$_2$Ph), 92.2 (13b-C), 112.3 (2-C), 114.3 (12-C), 116.9 (10-C), 123.5 (8a-C), 124.3 (4-C), 127.2, 129.3 (9- and 11-C), 127.2 (1-C), 127.6, 127.7, 128.6, 138.1 (Ph-C), 136.0 (3-C), 141.0 (12a-C), 150.0 (4a-C), 157.0 (5a-C), 157.1 (14-C); MS *m/z* 408 (M^+), 288, 91. Found: C, 76.37; H, 5.89; N, 13.71%. Calcd for $C_{26}H_{24}N_4O$: C, 76.44; H, 5.92; N, 13.73%.

(7a*R,8*R**,13a*S**)-(±)-6-Benzyl-8-phenyl-6,7,7a,8,13,13a-hexahydro-14*H*-quinolino[2′,3′ : 4,5]pyrido[2,3-*d*]pyrido[1,2-*a*]-pyrimidin-14-one (5c):** Orange needles (hexane–benzene); mp 194—195 °C; IR (KBr) 3330 (NH), 1650 cm^{-1} (CO); ^{1}H NMR δ = 2.52 (1H, dddd, $J_{7\text{-}7a}$ = 4.0, $J_{7a\text{-}13}$ = 10.2, $J_{7\text{-}7a}$ = 11.5, $J_{7a\text{-}8}$ = 11.6 Hz, 7a-H), 3.00 (1H, dd, $J_{7\text{-}7a}$ = 4.0, J_{gem} = 12.5 Hz, 7-H), 3.12 (1H, dd, $J_{7\text{-}7a}$ = 11.5, J_{gem} = 12.5 Hz, 7-H), 3.86 (1H, d, $J_{7a\text{-}8}$ = 11.6 Hz, 8-H), 4.61, 5.03 (each 1H, each d, J_{gem} = 15.2 Hz, C*H*$_2$Ph), 4.61 (1H, d, $J_{7a\text{-}13a}$ = 10.2 Hz 13a-H), 6.57—7.30 (17H, ov, 2-, 4-, 9-, 10-, 11-, and 12-H and NH and Ph), 7.54 (1H, ddd, $J_{1\text{-}3}$ = 1.7, $J_{2\text{-}3}$ = 6.6, $J_{3\text{-}4}$ = 8.9 Hz, 3-H), 8.85 (1H, dd, $J_{1\text{-}7}$ = 1.7, $J_{1\text{-}2}$ = 7.3 Hz, 1-H); ^{13}C NMR δ = 41.2 (7a-C), 48.4 (8-C), 48.8 (13a-C), 51.5 (7-C), 52.4 (*C*H$_2$Ph), 91.0 (13b-C), 112.6 (2-C), 115.7 (12-C), 117.8 (10-C), 124.2 (4-C), 124.7 (8a-C), 126.8, 127.0, 127.5, 128.5, 128.6, 129.0, 137.6, 143.3 (Ph-C), 127.1 (11-C), 127.2 (1-C), 130.0 (9-C), 136.0 (3-C), 145.5 (12a-C), 149.7 (4a-C), 156.6 (5a-C), 157.4 (14-C). Found: C, 78.85; H, 5.61; N, 11.68%. Calcd for $C_{31}H_{26}N_4O$: C, 79.12; H, 5.57; N, 11.91%.

(7a*R,8*R**,13a*R**)-(±)-6-Benzyl-8-phenyl-6,7,7a,8,13,13a-hexahydro-14*H*-quinolino[2′,3′ : 4,5]pyrido[2,3-*d*]pyrido[1,2-*a*]-pyrimidin-14-one (6c):** Yellow needles (hexane–benzene); mp 211—212 °C; IR (KBr) 3360 (NH), 1665 cm^{-1} (CO); ^{1}H NMR δ = 2.28 (1H, m, 7a-H), 3.27 (1H, dd, $J_{7\text{-}7a}$ = 4.3, J_{gem} = 12.2 Hz, 7-H), 3.41 (1H, dd, $J_{7\text{-}7a}$ = 11.2, J_{gem} = 12.2 Hz, 7-H), 3.88 (1H, d, $J_{7a\text{-}8}$ = 2.3 Hz, 8-H), 4.64 (1H, br s, NH), 4.73, 5.21 (each 1H, each d, J_{gem} = 15.5 Hz, C*H*$_2$Ph), 4.74 (1H, d, $J_{7a\text{-}13a}$ = 2.6 Hz, 13a-H), 6.54—7.37 (16H, ov, 2-, 4-, 8-, 9-, 11-, and 12-H and Ph), 7.53 (1H, ddd, $J_{1\text{-}3}$ = 1.7, $J_{2\text{-}3}$ = 6.6, $J_{3\text{-}4}$ = 8.9 Hz, 3-H), 8.85 (1H, dd, $J_{1\text{-}3}$ = 1.7, $J_{1\text{-}2}$ = 7.3 Hz, 1-H); ^{13}C NMR δ = 37.4 (7a-C), 42.1 (13a-C), 44.8 (8-C), 47.9 (7-C), 51.2 (*C*H$_2$Ph), 92.0 (13b-C), 112.3 (2-C), 114.3 (12-C), 117.1 (10-C), 119.5 (8a-C), 124.2 (4-C), 126.2 (11-C), 127.3 (1-C), 127.4, 127.6, 127.7, 128.4, 128.5, 128.6, 138.0, 142.3 (Ph-C), 130.7 (9-C), 136.0 (3-C), 146.4 (12a-C), 150.0 (4a-C), 156.8 (5a-C), 156.9 (14-C). Found: C, 79.01; H, 5.60; N, 11.78%. Calcd for $C_{31}H_{26}N_4O$: C, 79.12; H, 5.57; N, 11.91%.

(7a*R,8*S**,13a*S**)-(±)-6-Benzyl-8-[(*E*)-prop-1-enyl]-6,7,7a,8,13,13a-hexahydro-14*H*-quinolino[2′,3′ : 4,5]pyrido[2,3-*d*]-pyrido[1,2-*a*]pyrimidin-14-one (5d):** Yellow needles (hexane–benzene); mp 220–221 °C; IR (KBr) 3250 (NH), 1650 cm^{-1} (CO); ^{1}H NMR δ = 1.73 (3H, dd, $J_{allylic}$ = 1.7, $J_{=CH\text{–}Me}$ = 6.6 Hz,, =CH–*Me*), 2.09 (1H, m, 7a-H), 3.06 (1H, dd, $J_{7\text{-}7a}$ = 11.9, J_{gem} = 12.5 Hz, 7-H), 3.20 (1H, dd, $J_{>CH\text{–}CH}$ = 9.9, $J_{7a\text{-}8}$ = 10.6 Hz, 8-H), 3.43 (1H, dd, $J_{7\text{-}7a}$ = 4.0, J_{gem} = 12.5 Hz, 7-H), 4.43 (1H, d, $J_{7a\text{-}13a}$ = 10.2

Hz, 13a-H), 4.85, 5.13 (each 1H, each d, J_{gem} = 15.2 Hz, CH_2Ph), 5.22 (1H, m, –C*H*=CHMe), 5.56 (1H, m, –CH=C*H*Me), 6.63—7.35 (12H, ov, 2-, 4-, 9-, 10-, 11-, and 12-H and NH and Ph), 7.53 (1H, ddd, $J_{1\text{-}3}$ = 1.7, $J_{2\text{-}3}$ = 6.6, $J_{3\text{-}4}$ = 8.9 Hz, 3-H), 8.88 (1H, dd, $J_{1\text{-}3}$ = 1.7, $J_{1\text{-}2}$ = 7.3 Hz, 1-H); ^{13}C NMR δ = 17.8 (=CH*Me*), 38.6 (8-C), 45.6 (7a-C), 49.0 (7-C), 51.6 (*C*H_2Ph), 51.7 (13a-C), 91.1 (13b-C), 112.5 (2-C), 115.7 (12-C), 117.6 (10-C), 123.0 (8a-C), 124.2 (4-C), 127.0 (11-C), 127.2, 127.6, 128.6, 137.9 (Ph-C), 127.3, (1-C), 129.0 (–*C*H=CHMe), 129.2 (9-C), 132.4 (–CH=*C*HMe), 136.0 (3-C), 145.2 (12a-C), 149.7 (4a-C), 156.6 (5a-C), 157.6 (14-C). Found: C, 77.62; H, 6.02; N, 12.78%. Calcd for $C_{28}H_{26}N_4O$: C, 77.39; H, 6.02; N, 12.90%.

(7a*R,8*S**,13a*S**)-(±)-8-(2-Furyl)-6-methyl-6,7,7a,8,13,13a-hexahydro-14*H*-quinolino[2′,3′ : 4,5]pyrido[2,3-*d*]pyrido[1,2-*a*]-pyrimidin-14-one (5e):** Yellow needles (hexane–benzene); mp 232—233 °C; IR (KBr) 3350(NH), 1690 cm^{-1} (CO); ^{1}H NMR δ = 2.70 (1H, m, 7a-H), 3.16 (3H, s, 6-Me), 3.15—3.26 (2H, ov, 7-H), 4.10 (1H, d, $J_{7a\text{-}8}$ = 10.6 Hz, 8-H), 4.56 (1H, d, $J_{7a\text{-}13a}$ = 10.2 Hz, 13a-H), 6.26 (1H, d, $J_{3'\text{-}4'}$ = 3.0 Hz, furyl-3), 6.38 (1H, dd, $J_{4'\text{-}5'}$ = 2.0, $J_{3'\text{-}4'}$ = 3.0 Hz, furyl-4), 6.57—6.89 (5H, ov, 9-, 10-, 11-, and 12-H and NH), 7.03 (1H, br dd, $J_{2\text{-}3}$ = 6.6, $J_{1\text{-}2}$ = 7.3 Hz, 2-H), 7.26 (1H, d, $J_{4'\text{-}5'}$ = 2.0 Hz, furyl-5), 7.37 (1H, d, $J_{3\text{-}4}$ = 8.9 Hz, 4-H), 7.54 (1H, ddd, $J_{1\text{-}3}$ = 1.7, $J_{2\text{-}3}$ = 6.6, $J_{3\text{-}4}$ = 8.9 Hz, 3-H), 8.87 (1H, dd, $J_{1\text{-}3}$ = 1.7, $J_{1\text{-}2}$ = 7.3 Hz, 1-H); ^{13}C NMR δ = 36.4 (8-C), 38.3 (6-Me), 41.7 (7a-C), 51.4, 52.1 (7- and 13a-C), 90.7 (13b-C), 108.1, 110.1, 142.0, 155.1 (furyl-C), 112.5 (2-C), 115.8 (12-C), 117.7 (10-C), 121.1 (8a-C), 124.1 (4-C), 127.0 (11-C), 127.7 (1-C), 128.7 (9-C), 136.0 (3-C), 145.3 (12a-C), 149.8 (4a-C), 156.2 (5a-C), 157.7 (14-C). Found: C, 71.62; H, 5.30; N, 14.40%. Calcd for $C_{23}H_{20}N_4O_2$: C, 71.86; H, 5.24; N, 14.58%.

Acid-Catalyzed Reaction of Aldehyde 1b with 4-Substituted Anilines 13, 16, and 19. (Scheme 6.)

Typical Procedures: To a dry benzene solution (5 ml) of aldehyde **1b** (50 mg, 0.15 mmol) and *p*-anisidine (**13**, 24 mg, 0.020 mmol), 10 ml of BF_3·OEt_2 (0.075 mmol) was added and the resulting reaction mixture was stirred at room temperature for 5 h. The mixture was neutralized with 5% aqueous sodium hydrogencarbonate and extracted with benzene. The usual work-up with column chromatography gave **14b** (30.5 mg, 49%) and **15b** (19.3 mg, 26%) with hexane/ethylaetate = 3/1.

(7a*R,8*S**,13a*S**)-(±)-6-Benzyl-10-methoxy-8-methyl-6,7,7a,8,13,13a-hexahydro-14*H*-quinolino[2′,3′ : 4,5]pyrido[2,3-*d*]-pyrido[1,2-*a*]pyrimidin-14-one (14b):** Pale yellow needles (hexane–benzene); mp 183—184 °C; IR (KBr) 3330 (NH), 1660 cm^{-1} (CO); ^{1}H NMR δ = 1.27 (3H, d, $J_{8\text{-Me}}$ = 6.6 Hz, 5-Me), 1.99 (1H, m, 7a-H), 2.73 (1H, dq, $J_{8\text{-Me}}$ = 6.6, $J_{7a\text{-}8}$ = 10.9 Hz, 8-H), 3.10 (1H, dd, $J_{7\text{-}7a}$ = 11.5, J_{gem} = 12.5 Hz, 7-H), 3.51 (1H, dd, $J_{7\text{-}7a}$ = 4.0, J_{gem} = 12.5 Hz, 7-H), 3.75 (3H, s, 10-OMe), 4.28 (1H, d, $J_{7a\text{-}13a}$ = 10.2 Hz, 13a-H), 5.00, 5.06 (each 1H, each d, J_{gem} = 15.5 Hz, CH_2Ph), 6.48 (1H, br s, NH), 6.63—6.75 (3H, ov, 9-, 11-, and 12-H), 6.87 (1H, br dt, $J_{2\text{-}4}$ = 1.3, $J_{1\text{-}2}$ = $J_{2\text{-}3}$ = 6.8 Hz, 2-H), 7.24—7.33 (6H, ov, 4- and Ph), 7.55 (1H, m, 3-H), 8.89 (1H, dd, $J_{1\text{-}3}$ = 1.7, $J_{1\text{-}2}$ = 6.8 Hz, 1-H); ^{13}C NMR δ = 18.9 (8-Me), 34.6 (8-C), 41.6 (7a-C), 48.9 (7-C), 51.5 (*C*H_2Ph), 52.1 (13a-C), 55.7 (OMe), 91.2 (13b-C), 112.5 (2-C), 112.6, 113.6, 116.8 (9-, 11-, and 12-C), 124.2 (4-C), 126.9, 127.5, 128.6, 137.8 (Ph-C), 127.0 (8a-C), 127.3 (1-C), 135.9 (3-C), 139.6 (10-C), 149.7 (4a-C), 152.4 (12a-C), 156.5 (5a-C), 157.4 (14-C). Found: C, 73.97; H, 5.90; N, 12.55%. Calcd for $C_{27}H_{26}N_4O_2$: C, 73.95; H, 5.98; N, 12.78%.

(7a*R,8*S**,13a*S**)-(±)-6-Benzyl-10-methoxy-8-methyl-6,7,7a,8,13,13a-hexahydro-14*H*-quinolino[2′,3′ : 4,5]pyrido[2,3-*d*]-pyrido[1,2-*a*]pyrimidin-14-one (15b):** Yellow needles (hexane–benzene); mp 183—184 °C; IR (KBr) 3340 (NH), 1660 cm^{-1} (CO); ^{1}H NMR δ = 1.37 (3H, d, $J_{8\text{-Me}}$ = 7.3 Hz, 8-Me), 1.98 (1H, m, 7a-H), 2.61 (1H, br q, $J_{8\text{-Me}}$ = 7.3 Hz, 8-H), 3.04 (1H, dd, $J_{7\text{-}7a}$ = 4.6, J_{gem} = 12.2 Hz, 7-H), 3.36 (1H, dd, J_{gem} = 12.2, $J_{7\text{-}7a}$ = 12.5 Hz, 7-H), 3.72 (3H, s, 10-OMe), 4.16 (1H, br s, NH), 4.60, 5.29 (each 1H, each d, J_{gem} = 15.5 Hz, CH_2Ph), 4.88 (1H, d, $J_{7a\text{-}13a}$ = 2.3 Hz, 13a-H), 6.42 (1H, d, $J_{11\text{-}12}$ = 8.6 Hz, 12-H), 6.56—6.63 (2H, ov, 9- and 11-H), 6.87 (1H, br dt, $J_{2\text{-}4}$ = 1.3, $J_{1\text{-}2}$ = $J_{2\text{-}3}$ = 6.9 Hz, 2-H), 7.23—7.32 (6H, ov, 4-H and Ph), 7.54 (1H, ddd, $J_{1\text{-}3}$ = 1.7, $J_{2\text{-}3}$ = 6.6, $J_{3\text{-}4}$ = 8.9 Hz, 3-H), 8.92 (1H, dd, $J_{1\text{-}3}$ = 1.7, $J_{1\text{-}2}$ = 7.3 Hz, 1-H); ^{13}C NMR δ = 25.6 (8-Me), 33.9 (8-C), 35.7 (7a-C), 41.9 (13a-C), 47.4 (7-C), 51.1 (*C*H_2Ph), 92.4 (13b-C), 112.3 (2-C), 113.4, 114.7, 115.4 (9-, 11-, and 12-C), 124.3 (4-C), 124.8 (8a-C), 127.2 (1-C), 127.6×2, 128.6, 135.3 (Ph-C), 136.0 (3-C) 138.1 (10-C), 150.0 (4a-C), 151.7 (12a-C), 157.0 (5a-C), 157.1 (14-C). Found: C, 73.81; H, 6.01; N, 12.57%. Calcd for $C_{27}H_{26}N_4O_2$: C, 73.95; H, 5.98; N, 12.78%.

(7a*R,8*S**,13a*S**)-(±)-6-Benzyl-8,10-dimethyl-6,7,7a,8,13,13a-hexahydro-14*H*-quinolino[2′,3′ : 4,5]pyrido[2,3-*d*]pyrido-[1,2-*a*]pyrimidin-14-one (17b):** Pale-yellow needles (hexane–benzene); mp 182—183 °C; IR (KBr) 3330 (NH), 1660 cm^{-1} (CO); ^{1}H NMR δ = 1.27 (3H, d, $J_{8\text{-Me}}$ = 6.6 Hz, 8-Me), 2.00 (1H, m, 7a-H), 2.23 (3H, s, 10-Me), 2.71 (1H, qd, $J_{8\text{-Me}}$ = 6.6, $J_{7a\text{-}8}$ = 10.6 Hz, 8-H), 3.10 (1H, dd, $J_{7\text{-}7a}$ = 11.5, J_{gem} = 12.5 Hz, 7-H), 3.51 (1H, dd, $J_{7\text{-}7a}$ = 4.0, J_{gem} = 12.5 Hz, 7-H), 4.31 (1H, d, $J_{7a\text{-}13a}$ = 10.2 Hz, 13a-H), 4.98, 5.06 (each 1H, each d, J_{gem} = 15.5 Hz, CH_2Ph), 6.57 (1H, br s, NH), 6.66 (1H, d, $J_{11\text{-}12}$ = 8.3 Hz, 12-H), 6.82—6.89 (2H, ov, 2-, and 11-H), 7.00 (1H, br s, 9-H), 7.23—7.50 (6H, ov, 4-H and Ph), 7.54 (1H, ddd, $J_{1\text{-}3}$ = 1.3, $J_{2\text{-}3}$ = 6.6, $J_{3\text{-}4}$ = 8.9 Hz, 3-H), 8.88 (1H, dd, $J_{1\text{-}3}$ = 1.3, $J_{1\text{-}2}$ = 7.3 Hz, 1-H); ^{13}C NMR δ = 18.8 (8-Me), 20.7 (10-Me), 34.4 (8-C), 41.6 (7a-C), 49.0 (7-C), 51.6 (*C*H_2Ph), 52.0 (13a-C), 91.2 (13b-C), 112.5 (2-C), 116.1 (12-C), 124.2 (4-C), 125.7 (8a-C), 127.0, 127.5, 128.6, 137.8 (Ph-C), 127.1 (10-C), 127.3 (1-C), 128.1×2 (9- and 11-C), 135.9 (3-C), 143.2 (12a-C), 149.7 (4a-C), 156.5 (5a-C), 157.4 (14-C). Found: C, 77.18; H, 6.22; N, 13.01%. Calcd for $C_{27}H_{26}N_4O_2$: C, 76.75; H, 6.20; N, 13.26%.

(7a*R,8*S**,13a*R**)-(±)-6-Benzyl-8,10-dimethyl-6,7,7a,8,13,13a-hexahydro-14*H*-quinolino[2′,3′ : 4,5]pyrido[2,3-*d*]pyrido-[1,2-*a*]pyrimidin-14-one (18b):** Yellow needles (hexane–benzene); mp 190—191 °C; IR (KBr) 3260 (NH), 1660 cm^{-1} (CO); ^{1}H NMR δ = 1.35 (3H, d, $J_{8\text{-Me}}$ = 6.9 Hz, 8-Me), 2.00 (1H, m, 7a-H), 2.19 (3H, s, 10-Me), 2.59 (1H, br q, $J_{8\text{-Me}}$ = 6.9 Hz, 8-H), 3.02 (1H, dd, $J_{7\text{-}7a}$ = 3.6, J_{gem} = 12.2 Hz, 7-H), 3.33 (1H, dd, J_{gem} = 12.2, $J_{7\text{-}7a}$ = 12.3 Hz, 7-H), 4.27 (1H, br s, NH), 4.60 5.26 (each 1H, each d, J_{gem} = 15.2 Hz, CH_2Ph), 4.89 (1H, d, $J_{7a\text{-}13a}$ = 2.3 Hz, 13a-H), 6.38 (1H, d, $J_{11\text{-}12}$ = 8.9 Hz, 12-H), 6.77—6.88 (3H, ov, 2-, 9-, and 10-H), 7.20—7.36 (6H, ov, 4-H and Ph), 7.52 (1H, dd, $J_{2\text{-}3}$ = 6.9, $J_{2\text{-}4}$ = 8.9 Hz, 3-H), 8.91 (1H, dd, $J_{1\text{-}3}$ = 0.7, $J_{1\text{-}2}$ = 7.3 Hz, 1-H); ^{13}C NMR δ = 20.4 (10-Me), 25.6 (8-Me), 33.6 (8-C), 35.7 (7a-C), 41.7 (13a-C), 47.4 (7-C), 51.1 (*C*H_2Ph), 92.3 (13b-C), 112.2 (2-C), 114.4 (12-C), 123.5 (8a-C), 124.2 (4-C), 126.0 127.2 (9- and 11-C), 127.3 (10-C), 127.5, 127.6, 128.5, 138.1 (Ph-C), 127.9 (1-C), 129.7 (12a-C), 135.9 (3-C), 148.7 (4a-C), 120.0 (5a-C), 157.0 (14-C). Found: C, 76.83; H, 6.24; N, 12.96%. Calcd for $C_{27}H_{26}N_4O$: C, 76.75; H, 6.20; N, 13.26%.

(7a*R,8*S**,13a*S**)-(±)-6-Benzyl-10-bromo-8-methyl-6,7,7a,8,13,13a-hexahydro-14*H*-quinolino[2′,3′ : 4,5]pyrido[2,3-*d*]-pyrido[1,2-*a*]pyrimidin-14-one (20b):** Yellow needles (hexane–benzene); mp 234—235 °C; IR (KBr) 3340 (NH), 1650 cm^{-1} (CO); ^{1}H NMR δ = 1.26 (3H, $J_{8\text{-Me}}$ = 6.6 Hz, 8-Me), 1.97 (1H, m, 7a-H), 2.69 (1H, br q, $J_{8\text{-Me}}$ = 6.6 Hz, 8-H), 3.09 (1H, dd, $J_{7\text{-}7a}$ = 11.5, J_{gem} = 12.5 Hz, 7-H), 3.51 (1H, dd, $J_{7\text{-}7a}$ = 4.0, J_{gem} = 12.5 Hz, 7-H), 4.23 (1H, d, $J_{7a\text{-}13a}$ = 10.2 Hz, 13a-H), 4.96, 5.06 (each 1H, each d,

J_{gem} = 15.2 Hz, CH_2Ph), 6.58 (1H, d, $J_{11\text{-}12}$ = 8.6 Hz, 12-H), 6.79 (1H, br s, NH), 6.88 (1H, br dt, $J_{2\text{-}4}$ = 1.3, $J_{1\text{-}2}$ = $J_{2\text{-}3}$ = 7.3 Hz, 2-H), 7.07—7.36 (8H, ov, 4-, 9-, and 11-H and Ph), 7.55 (1H, m, 3-H), 8.87 (1H, br d, $J_{1\text{-}2}$ = 7.3 Hz, 1-H); ^{13}C NMR δ = 18.5 (8-Me), 34.4 (8-C), 40.7 (7a-C), 48.9 (7-C), 51.6 (*C*H_2Ph), 51.8 (13a-C), 90.7 (13b-C), 109.5 (10-C), 112.6 (2-C), 117.4 (12-C), 124.2 (4-C), 127.0 (8a-C), 127.4 (1-C), 127.6, 127.7, 128.7, 137.7 (Ph-C), 129.6, 130.3 (9- and 11-C), 136.1 (3-C), 144.5 (12a-C), 149.8 (4a-C), 156.5 (5a-C), 157.4 (14-C). Found: C, 64.16; H, 4.74; N, 11.29%. Calcd for $C_{26}H_{23}BrN_4O$: C, 64.07; H, 4.76; N, 11.50%.

(7a*R,8*S**,13a*S**)-(±)-6-Benzyl-10-bromo-8-methyl-6,7,7a,8,13,13a-hexahydro-14*H*-quinolino[2′,3′ : 4,5]pyrido[2,3-*d*]-pyrido[1,2-*a*]pyrimidin-14-one (21b):** Pale yellow plates (hexane–benzene); mp 153—154 °C; IR (KBr) 3300 (NH), 1655 cm^{-1} (CO); ^{1}H NMR δ = 1.33 (3H, d, $J_{8\text{-Me}}$ = 7.3 Hz, 8-Me), 1.98 (1H, m, 7a-H), 2.59 (1H, br q, $J_{8\text{-Me}}$ = 7.3 Hz, 8-H), 3.02 (1H, dd, $J_{7\text{-}7a}$ = 3.3, J_{gem} = 12.2 Hz, 7-H), 3.22 (1H, dd, J_{gem} = 12.2, $J_{7\text{-}7a}$ = 12.5 Hz, 7-H), 4.44 (1H, br s, NH), 4.61, 5.25 (each 1H, each d, J_{gem} = 15.2 Hz, CH_2Ph), 4.88 (1H, d, $J_{7a\text{-}13a}$ = 2.6 Hz, 13a-H), 6.32 (1H, d, $J_{11\text{-}12}$ = 8.9 Hz, 12-H), 6.87 (1H, br dt, $J_{2\text{-}4}$ = 1.7, $J_{1\text{-}2}$ = $J_{2\text{-}3}$ = 7.3 Hz, 2-H), 7.02 (2H, ov, 9- and 11-H), 7.10—7.36 (6H, ov, 4-H and Ph), 7.55 (1H, ddd, $J_{1\text{-}3}$ = 1.7, $J_{2\text{-}3}$ = 6.6, $J_{2\text{-}4}$ = 8.9 Hz, 3-H), 8.90 (1H, dd, $J_{1\text{-}3}$ = 1.7, $J_{1\text{-}2}$ = 7.3 Hz, 1-H); ^{13}C NMR δ = 25.1 (8-Me), 33.7 (8-C), 35.0 (7a-C), 41.7 (13a-C), 47.3 (7-C), 51.1 (*C*H_2Ph), 91.8 (13b-C), 108.1 (10-C), 112.4 (2-C), 115.7 (12-C), 124.3 (4-C), 125.4 (8a-C), 127.3 (1-C), 127.6, 128.3, 128.6, 137.9 (Ph-C), 129.9, 131.6 (9- and 11-C), 136.1 (3-C), 140.0 (12a-C), 150.0 (4a-C), 156.9 (5a-C), 157.1 (14-C). Found: C, 64.41; H, 5.07; N, 11.13%. Calcd for $C_{26}H_{23}BrN_4O$: C, 64.07; H, 4.76; N, 11.50%.

Similarly, the reaction of aldehydes **8** and **11** with aniline (**4**) in the presence of BF_3·OEt_2 was performed to give ene product **9b**[1b] and cycloadducts **10f** and **12f**.

(6a*R,7*S**,12a*R**)-(±)-5-Benzyl-7-(2-furyl)-2,3-dimethyl-5,6,6a,7,12,12a-hexahydropyrido[3′,4′ : 5,6]pyrido[4,3-*b*]quinolin-1(2*H*)-one (10f):** Yellow needles (hexane–benzene); mp 226—227 °C; IR (KBr) 3330 (NH), 1630 cm^{-1} (CO); ^{1}H NMR δ = 2.19 (3H, s, 3-Me), 2.71 (1H, m, 6a-H), 3.03 (1H, dd, $J_{6\text{-}6a}$=4.0 J_{gem}=12.2 Hz, 6-H), 3.20 (1H, dd, $J_{6\text{-}6a}$ = 11.6, J_{gem} = 12.2 Hz, 6-H), 3.44 (3H, s, 2-Me), 4.04 (1H, d, $J_{6a\text{-}7}$ = 11.5 Hz, 7-H), 4.36, 4.50 (each 1H, each d, J_{gem} = 17.2 Hz, CH_2Ph), 4.42 (1H, d, $J_{6a\text{-}12a}$ = 10.2 Hz, 12a-H), 5.64 (1H, s, 4-H), 6.14 (1H, d, $J_{3'\text{-}4'}$ = 3.0 Hz, furyl-3), 6.29 (1H, dd, $J_{4'\text{-}5'}$ = 1.7, $J_{3'\text{-}4'}$ = 3.0 Hz, furyl-4), 6.56 (1H, br t, $J_{8\text{-}9}$ = $J_{9\text{-}10}$ = 7.4 Hz, 9-H), 6.70—6.74 (2H, ov, 8- and 11-H), 7.00 (1H, br t, $J_{9\text{-}10}$ = $J_{10\text{-}11}$ = 7.5 Hz, 10-H), 7.10—7.35 (7H, ov, NH and furyl-5 and Ph); ^{13}C NMR δ = 21.3 (3-Me), 30.2 (2-C), 39.2 (6a-C), 41.7 (12a-C), 51.2 (6-C), 52.1 (7-C), 54.4 (*C*H_2Ph), 96.2 (4-C), 100.0 (12b-C), 107.8, 109.9, 144.7, 155.2 (furyl-C), 116.0 (11-C), 121.3 (7a-C), 126.2, 127.5, 128.8, 137.1 (Ph-C), 127.3 (10-C), 128.6 (8-C), 141.8 (11a-C), 145.8 (4a-C), 151.4 (3-C), 163.0 (1-C). Found: C, 76.55; H, 6.28; N, 9.58%. Calcd for $C_{28}H_{27}N_3O_2$: C, 76.86; H, 6.22; N, 9.61%.

(6a*R,7*S**,12a*S**)-(±)-6-Benzyl-7-(2-furyl)-2,4-dimethyl-5,6,6a,7,12,12a-hexahydropyrimido[5′,4′ : 5,6]pyrido[4,3-*b*]quinoline-1,3(2*H*,4*H*)-dione (12f):** Yellow needles (hexane–benzene); mp 233—235 °C; IR (KBr) 3350 (NH), 1650, 1630 cm^{-1} (CO); ^{1}H NMR δ = 2.51 (1H, m, 6a-H), 2.78 (1H, dd, $J_{6\text{-}6a}$ = 11.9, J_{gem} = 12.2 Hz, 6-H), 2.95 (1H, dd, $J_{6\text{-}6a}$ = 4.3, J_{gem} = 12.2 Hz, 6-H), 3.39 (1H, s, 4-Me), 3.47 (3H, s, 2-Me), 3.90 (1H, d, J_{gem} = 15.5 Hz, CH_2Ph), 4.00 (1H, d, $J_{6a\text{-}7}$ = 11.8 Hz, 7-H), 4.18—4.23 (2H, ov, 12a-H and CH_2Ph), 6.10—6.14 (2H, ov, NH and furyl-3), 6.27 (1H, dd, $J_{3'\text{-}4'}$ = 2.0, $J_{4'\text{-}5'}$ = 3.0 Hz, furyl-4), 6.65 (1H, m, 9-H), 6.75 (2H, ov, 10-H and furyl-5), 7.02—7.38 (7H, ov, 8- and 11-H and Ph); ^{13}C NMR δ = 27.8 (7-C), 33.5 (4-Me), 35.6 (2-Me), 40.8 (6a-C), 48.1 (12a-C), 52.3 (6-C), 56.1 (*C*H_2Ph), 97.3 (12b-C), 108.2 111.0, 145.3, 155.4 (furyl-C), 116.4 (11-C), 118.5 (9-C), 121.8 (7a-C), 127.5, 127.9, 128.8, 135.2 (Ph-C), 127.6 (10-C), 129.0 (8-C), 141.7 (11a-C), 152.4 (4a-C), 154.5 (4a-C), 163.0 (1-C). Found: C, 71.53; H, 5.82; N, 12.34%. Calcd for $C_{27}H_{26}N_4O_3$: C, 71.34; H, 5.77; N, 12.33%.

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