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3-Acyl-1,2,3,4-tetrahydropyridine-2,4-diones: Synthesis and Chemical Properties

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Abstract—N-Substituted 6-methyl-1,2,3,4-tetrahydropyridine-2,4-diones reacted with aliphatic carboxylic acid chlorides in the presence of pyridine or triethylamine to give the corresponding 4-*O*-acyl derivatives which underwent O,C-migration of the acyl group by the action of 2 equiv of triethylamine and a catalytic amount of 2-hydroxy-2-methylpropanenitrile. Reactions of 3-acyl-6-methyl-1,2,3,4-tetrahydropyridine-2,4-diones thus formed with aliphatic and aromatic amines gave the corresponding enamino derivatives at the side acyl group. Enamino derivatives at the C^4=O group were obtained by transformation of 3-acyl-1,2,3,4-tetrahydropyridine-2,4-diones into 3-acyl-4-methoxy-6-methyl-1,2-dihydropyridin-2-ones via alkylation with dimethyl sulfate and subsequent treatment with amines.

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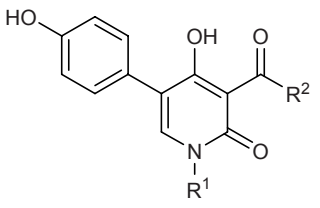
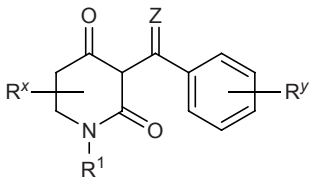
Pyridinone and pyridinedione derivatives are widely used in the synthesis of natural [1] and biologically active compounds [2]. 3-Acyl-2,4-dioxopyridine fragment constitutes a structural base of Tenellin (**Ia**), Bassianin (**Ib**) [3], Militarinone (**Ic**) [4], Pyridovericin (**Id**) [5], and other natural alkaloid pigments isolated from entomopathogenic fungi. It is known that synthetic 3-aroyl-substituted pyridine-2,4-diones and oximes derived therefrom (**II**, Z = NOR′) exhibit herbicidal activity [6–9]; like carbocyclic β-triketones, they are prepared from the corresponding pyridinediones via reaction with aroyl chlorides, followed by O–C migration of the aroyl group in enol esters in the presence of potassium cyanide [10, 11]. Syntheses of β-triketones of the pyrimidine series having an aliphatic side chain include a number of steps, and the yields of the target products are often poor [4, 12–14]. Acylation of pyridine-2,4-diones with aliphatic carboxylic acid chlorides was not reported.

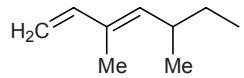
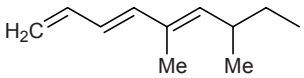
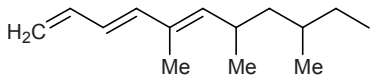
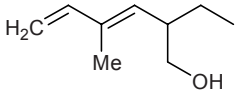
We previously proposed a simple and efficient procedure for the synthesis of 1,6-disubstituted pyridine-2,4-diones **III** from 5-(1,3-dioxobutyl)-2,2-dimethyl-1,3-dioxane-4,6-dione [15]. While continuing studies on the chemical properties of pyridine-2,4-dione derivatives, we have found that the procedure used by us previously for the preparation of 2-aroylcyclohexane-1,3-diones [16] ensures synthesis of 3-acylpyridine-2,4-diones **V** in good yields. Our results contradict the



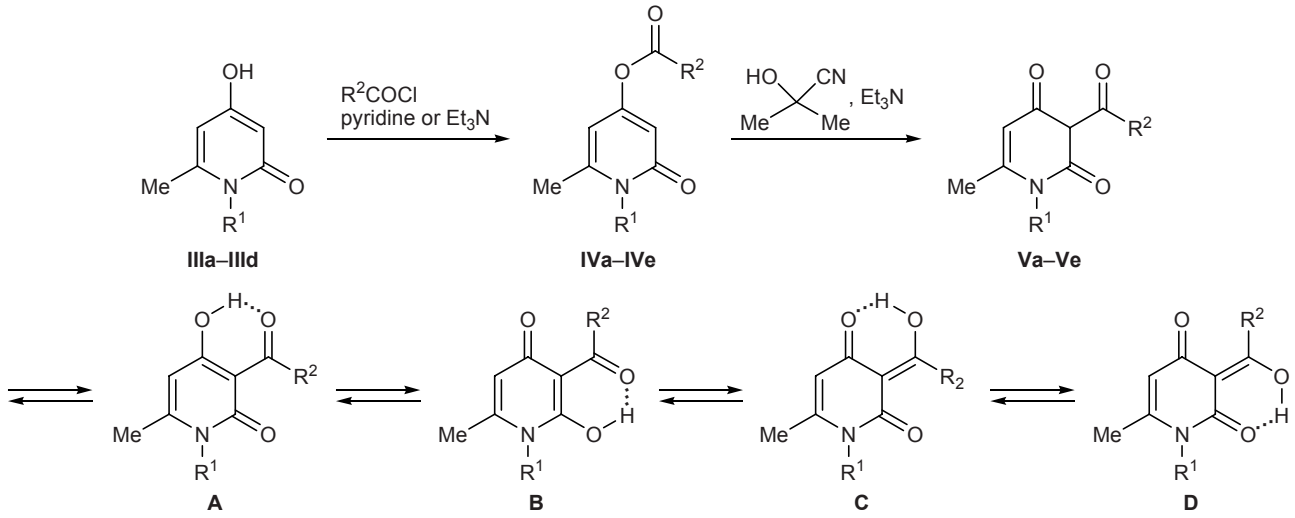
Ia–Id



II

I, R^1 = OH, R^2 =  (**a**),  (**b**); R^1 = H, R^2 =  (**c**),  (**d**); **II**, R^2 = H, Alk, Ar, NH_2; Z = O, NOR′ (R′ = Alk, alkenyl, ...); R^x, R^y = Alk, alkenyl, PhO, ...

Scheme 1.



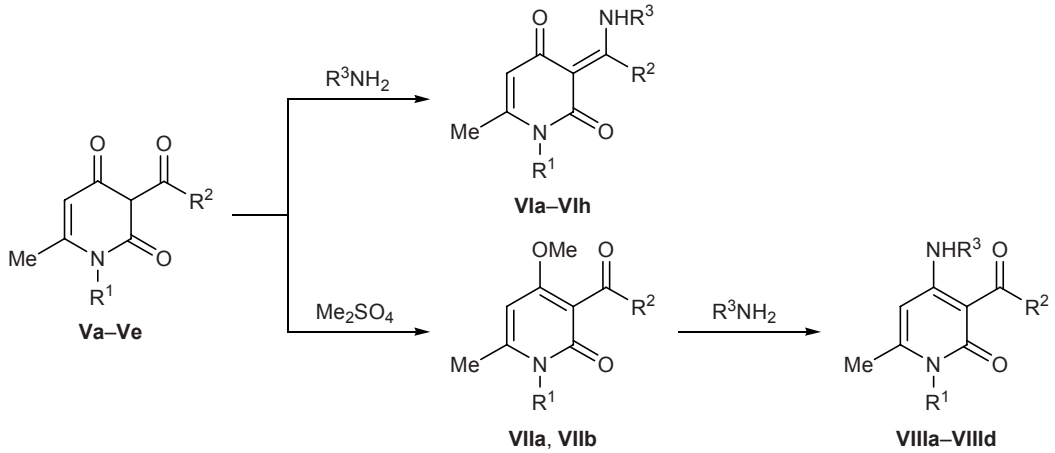
III, R^1 = Me (**a**), Pr (**b**), $PhCH_2$ (**c**), 4-$MeOC_6H_4$ (**d**); **IV**, **V**, $R^1 = R^2$ = Me (**a**); R^1 = Pr, R^2 = Et (**b**); $R^1 = PhCH_2$, R^2 = Et (**c**), Me (**f**); R^1 = 4-$MeOC_6H_4$, R^2 = Pr (**d**); R^1 = Me, R^2 = Bu (**e**).

data of Schnell and Kappe [11] who failed to obtain 3-aroylpyridine-2,4-diones following an analogous approach. It should be noted that we did not succeed in synthesizing β-triketones **V** using Lewis acids and 4-dimethylaminopyridine as catalysts.

Treatment of diketones **IIIa**–**IIId** with acetyl, propionyl, and butyryl chlorides in methylene chloride in the presence of pyridine gave enol esters **IVa**–**IVf** with high regioselectivity. Compounds **IVa**–**IVf** can be isolated as individual substances in 90–95% yield or subjected (without isolation) to O–C-migration of the acyl group with formation of 3-acyl-1,2,3,4-tetrahydropyridine-2,4-diones **Va**–**Vf** in the presence of excess triethylamine and 2-hydroxy-2-methylpropanenitrile as catalyst (Scheme 1).

The assumed structure of enol esters **IV** follows from the ^{1}H NMR spectra of compounds **IVa**–**IVc** and **IVf**, where the 3-H and 5-H olefinic protons (δ 5.50–6.50 ppm) displayed an allylic coupling constant ^4J of 2.0–2.5 Hz. Like other cyclic β-triketones [17], 3-acylpyridine-2,4-diones **Va**–**Vf** are completely enolized: their ^{1}H NMR spectra contain a one-proton signal from the chelated hydroxy group in the region δ 15–16 ppm. Theoretically, unsymmetrical heterocyclic β-triketones

Scheme 2.



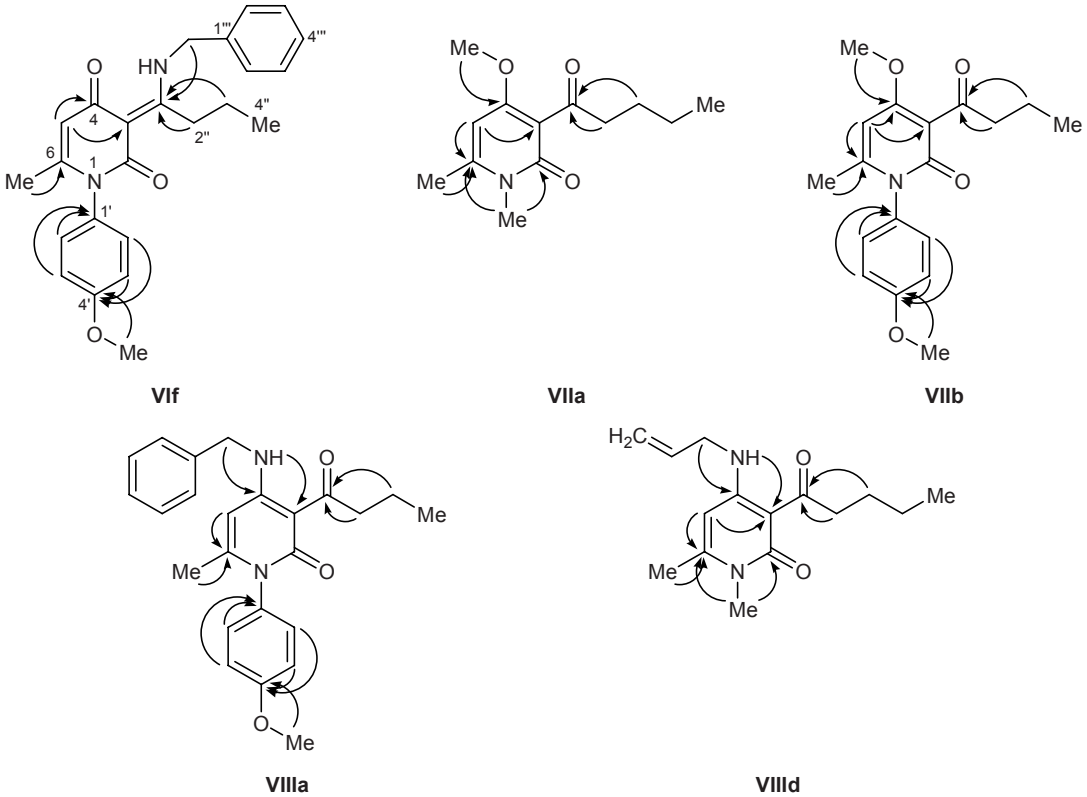
VI, $R^1 = R^2$ = Me, R^3 = Ph (**a**), CH_2=$CHCH_2$ (**b**); R^1 = Me, R^2 = Bu, R^3 = CH_2=$CHCH_2$ (**c**), 4-$MeOC_6H_4$ (**d**, **h**); R^1 = Pr, R^2 = Et, $R^3 = PhCH_2$ (**e**); R^1 = 4-$MeOC_6H_4$, R^2 = Pr, $R^3 = PhCH_2$ (**f**), 4-$MeOC_6H_4$ (**g**); R^1 = Me, R^2 = Bu, R^3 = 4-$MeOC_6H_4$ (**h**); **VII**, R^1 = Me, R^2 = Bu (**a**); R^1 = 4-$MeOC_6H_4$, R^2 = Pr (**b**); **VIII**, R^1 = 4-$MeOC_6H_4$, R^2 = Pr, $R^3 = PhCH_2$ (**a**), 4-MeC_6H_4 (**b**); R^1 = Me, R^2 = Bu, R^3 = 4-$MeOC_6H_4$ (**c**), CH_2=$CHCH_2$ (**d**).

Va–**Vf** can give rise to four tautomeric forms **A**–**D**. The presence of only one enol proton signal suggests that compounds **Va**–**Vf** have structure **A** or **C**; the contribution of tautomers **B** and **D** is quite insignificant, or they are absent at all.

3-Acylpyridinediones **Va**–**Vf**, as well as other cyclic β-triketones, reacted with amines at the acyl carbonyl group, yielding enamines **VIa**–**VIh** (Scheme 2). The reactions with aliphatic amines (allylamine and benzylamine) in boiling toluene required several hours, whereas the conversion of triketones **V** in the reactions with aromatic amines (aniline and *p*-methoxyaniline) was not complete even after heating for a weak, and the yields of the corresponding enamines **VI** did not exceed 50%.

With a view to extend the synthetic potential of 3-acylpyridine-2,4-diones we tried to obtain their enamino derivatives at one of the endocyclic carbonyl groups. Analogous transformations of carbocyclic β-triketones are usually accomplished via intermediate preparation of the corresponding enol methyl ethers, and these reactions involve no difficulties [17]. We previously synthesized regioisomeric enol methyl ethers at both endocyclic carbonyl groups of sulfur-containing heterocyclic β-triketones of the 3-acylthiotetronic acid series [18] and 3-acetyltetrahydrothiopyran-2,4-dione [19]. 4-Acyl-2*H*-thiopyran-3,5-diones reacted with methylating agents to give complex mixtures of products, from which we failed to isolate the desired enol ethers [20]. By heating triketones **Vc** and **Vf** with 1.2 equiv of dimethyl sulfate and 4 equiv of anhydrous potassium carbonate in toluene we obtained the corresponding 4-methoxy derivatives **VIIa** and **VIIb** in almost quantitative yield. Compounds **VIIa** and **VIIb** reacted with allylamine, benzylamine, aniline, and *p*-methoxyaniline to produce enamino derivatives **VIIIa**–**VIIId** at the C^4=O carbonyl group. Unlike enol ethers derived from β-triketones of the cyclohexane [17] and heterocyclic series [18, 19], 4-methoxypyridinones **VIIa** and **VIIb** turned out to be low reactive; as in the synthesis of enamino derivatives **VIa**–**VIh** at the side-chain carbonyl group, the yields in the reactions of **VIIa** and **VIIb** with aromatic amines were considerably lower.

The product structure was determined using two-dimensional NMR techniques (COSY, HSQC, HMBC), and complete assignment of carbon signals in the ^{13}C NMR spectra was made. The assignment of signals from carbon atoms attached to protons involved no difficulties, for the COSY and HSQC data were fully



Principal ^{13}C–^{1}H interactions in the HMBC spectra of compounds **VIf**, **VIIa**, **VIIb**, **VIIIa**, and **VIIId**.

consistent with each other. Some problems appeared while assigning signals from protons in the 4′-methoxyphenyl substituent in compounds **Vd**, **VIf**, **VIIb**, and **VIIIa**. The COSY spectra of these compounds displayed only a weak cross-peak between the methyl protons and 3′-H. Nevertheless, taking into account more upfield positions of the ^{13}C (δ_C 114–115 ppm) and ^1H signals (δ 6.98–7.03 ppm), they were assigned to $C^{3'}$ and 3′-H, respectively, while the signals located at δ_C 129–130 ppm and δ 7.07–7.09 ppm were assigned to $C^{2'}$ and 2′-H.

Signals from quaternary carbon atoms were assigned by analysis of long-range ^1H–^{13}C couplings in the HMBC spectra. The principal interactions are shown in figure. All compounds having an exocyclic carbonyl group displayed cross-peaks between the carbonyl carbon atoms (δ_C 203–208 ppm) and protons in the α- and β-positions with respect to the carbonyl group. The corresponding protons in molecule **VIf** interact with the carbon nucleus resonating at δ_C 179.37 ppm, and that carbon nucleus also gives a cross-peak with methylene protons in the benzyl group. These data unambiguously indicate that the enamino fragment originates from the exocyclic carbonyl group. The lactam carbonyl carbon atom (δ_C 162–165 ppm) showed no strong cross-peaks because of the absence of protons in the vicinity of C^2=O. Only the HMBC spectra of *N*-methyl derivatives **VIIa** and **VIIId** contained cross peaks resulting from coupling between the methyl protons and the carbonyl carbon atom. The quaternary carbon atom in the 3-position of the pyridine ring is readily identified taking into account upfield position of the corresponding signal (δ_C 101–112 ppm) and the presence of a cross-peak due to coupling with 5-H. Enamines **VIIIa** and **VIIId** also displayed a cross-peak between C^3 and NH proton. It should be noted that the C^3 signal in the spectra of methyl ethers **VIIa** and **VIIb** is observed in a weaker field as compared to the other examined compounds ($\Delta\delta_C \approx 10$ ppm).

The C^4 signal was identified by the presence of a weak cross peak with 5-H and (for 4-substituted compounds) by the coupling with protons of the methoxy group (**VIIa**, **VIIb**) and methylene protons in the secondary amine moiety (**VIIIa**, **VIIId**). Here, variations of ^{13}C chemical shifts reflect the character of substitution and degree of conjugation in the system. The C^4 signal in the spectra of enamino derivatives appears at δ_C 159 ppm, methoxy compounds display the C^4 signal in a weaker field (by 5–6 ppm), while the C^4 nucleus in diketone **VIf** resonates at δ_C 183.73 ppm.

Interactions with protons in the methyl group and 5-H allowed us to distinguish signal from the quaternary C^6 atom in the pyridine ring. *N*-Methyl derivatives **VIIa** and **VIIId** additionally showed a cross-peak between C^6 and NCH_3 protons. Signals from the quaternary carbon atom in the methoxyphenyl substituent in compounds **VIf**, **VIIb**, and **VIIIa** were assigned on the basis of coupling between the OCH_3 protons and carbon nucleus resonating at δ_C 159 ppm; the chemical shift of the latter was also taken into account.

Unlike carbo- [21] and heterocyclic β-triketones [22, 23] studied previously, we failed to obtain condensation products of triketones **IIIa** and **IIIb** with isoquinoline derivatives (diaza analogs of steroids) regardless of the reaction conditions (acid or base catalysis).

EXPERIMENTAL

The IR spectra of solid products were recorded in KBr on a UR-20 spectrometer; liquid products were examined as films (neat). The ^1H and ^{13}C NMR spectra were measured on a Bruker Avance 500 instrument at 500 and 125 MHz, respectively; chloroform-*d* was used as solvent, and tetramethylsilane, as reference. The mass spectra were run on an MKh-1320 spectrometer. The melting points were determined on a Boetius hot stage. The progress of reactions and the purity of products were monitored by thin-layer chromatography on Silufol UV-254 or Alufol UV-254 plates (Merck); spots were detected under UV light, followed by spraying with a solution of iron(III) chloride. Preparative thin-layer chromatography was performed using silica gel Kieselgel 60 HF_{254} (Merck).

Enol esters IVa–IVd (*general procedure*). Pyridine, 10.5 ml (0.13 mol), and the corresponding carboxylic acid chloride, 0.11 mol, were added under stirring to a mixture of 0.1 mol of diketone **IIIa**–**IIId** and 100 ml of methylene chloride. The mixture was stirred for 24 h at room temperature (TLC), 50 ml of cold water was added, the mixture was acidified to pH 5 by adding 2 N hydrochloric acid, the organic phase was separated, washed with water and a 5% solution of sodium carbonate, and dried over magnesium sulfate, and the solvent was removed on a rotary evaporator.

1,6-Dimethyl-2-oxo-1,2-dihydropyridin-4-yl acetate (IVa). Yield 95%, mp 136–137°C (from diethyl ether). IR spectrum, ν, cm^{-1}: 1775, 1670, 1600, 1570. ^1H NMR spectrum, δ, ppm: 2.27 s (3H, 6-CH_3), 2.36 s (3H, CH_3CO), 3.50 s (3H, NCH_3), 5.96 d (1H, 5-H, J = 2.5 Hz), 6.23 d (1H, 3-H, J = 2.5 Hz). Found,

%: C 59.80; H 6.21; N 7.87. $[M]^+$ 181. $C_9H_{11}NO_3$. Calculated, %: C 59.66; H 6.12; N 7.73. *M* 181.19.

6-Methyl-2-oxo-1-propyl-1,2-dihydropyridin-4-yl propanoate (IVb). Yield 90%. Oily substance. IR spectrum, ν, cm^{-1}: 1780, 1670, 1600, 1570. ^1H NMR spectrum, δ, ppm: 0.98 t (3H, C**H**$_3$CH$_2$CH$_2$, *J* = 7.0 Hz), 1.23 t (3H, C**H**$_3$CH$_2$CO, *J* = 7.5 Hz), 1.72 m (2H, CH$_3$C**H**$_2$CH$_2$), 2.38 s (3H, 6-CH$_3$), 2.54 q (2H, CH$_3$C**H**$_2$CO, *J* = 7.5 Hz), 3.96 m (2H, NC**H**$_2$), 5.94 d (1H, 5-H, *J* = 2.5 Hz), 6.20 d (1H, 3-H, *J* = 2.5 Hz). Found, %: C 64.60; H 7.83; N 6.43. $[M]^+$ 223. $C_{12}H_{17}NO_3$. Calculated, %: C 64.55; H 7.67; N 6.27. *M* 223.27.

1-Benzyl-6-methyl-2-oxo-1,2-dihydropyridin-4-yl propanoate (IVc). Yield 93%, mp 86–87°C. IR spectrum, ν, cm^{-1}: 1765, 1660, 1600, 1580. ^1H NMR spectrum, δ, ppm: 1.25 t (3H, C**H**$_3$CH$_2$, *J* = 7.5 Hz), 2.28 s (1H, 6-CH$_3$), 2.58 q (2H, CH$_3$C**H**$_2$, *J* = 7.5 Hz), 5.34 s (2H, C**H**$_2$C$_6$H$_5$), 5.95 d (1H, 5-H, *J* = 2.5 Hz), 6.33 d (1H, 3-H, *J* = 2.5 Hz), 7.13–7.37 m (5H, C$_6$H$_5$). Found, %: C 70.96; H 6.51; N 5.20. $[M]^+$ 271. $C_{16}H_{17}NO_3$. Calculated, %: C 70.83; H 6.32; N 5.16. *M* 271.32.

1-(4-Methoxyphenyl)-6-methyl-2-oxo-1,2-dihydropyridin-4-yl butanoate (IVd). Yield 97%, mp 109–110°C. IR spectrum, ν, cm^{-1}: 1780, 1670, 1610, 1570. ^1H NMR spectrum, δ, ppm: 1.04 t (3H, C**H**$_3$CH$_2$, *J* = 7.7 Hz), 1.77 m (2H, CH$_3$C**H**$_2$), 1.97 s (3H, 6-CH$_3$), 2.53 t (2H, CH$_2$CH$_2$, *J* = 7.3 Hz), 3.85 s (3H, OCH$_3$), 6.00 d (1H, 5-H, *J* = 2.2 Hz), 6.28 d (1H, 3-H, *J* = 2.2 Hz), 7.03 d (2H, C$_6$H$_4$, *J* = 8.8 Hz), 7.10 d (2H, C$_6$H$_4$, *J* = 8.8 Hz). Found, %: C 67.69; H 6.47; N 4.48. $[M]^+$ 301. $C_{17}H_{19}NO_4$. Calculated, %: C 67.76; H 6.36; N 4.65. *M* 301.34.

3-Acyl-6-methyl-1,2,3,4-tetrahydropyridine-2,4-diones Va–Vd (*general procedure*). Compound **IVa–IVd**, 0.05 mol, was dissolved in 50 ml of methylene chloride, 14 ml (0.1 mol) of triethylamine and 0.5 ml (0.005 mol) of 2-hydroxy-2-methypropanenitrile were adde, and the mixture was stirred for 48 h at 25–30°C, following the disappearance of initial compound **IVa–IVd** (TLC). The mixture was acidified to pH 5 with 10% hydrochloric acid, and the organic phase was separated, washed with water, dried over magnesium sulfate, and passed through a thin layer of silica gel. The solvent was removed under reduced pressure on a rotary evaporator, and the oily residue was recrystallized from ethyl acetate–petroleum ether.

3-Acetyl-1,6-dimethyl-1,2,3,4-tetrahydropyridine-2,4-dione (Va). Yield 83%, mp 130–131°C. IR spectrum, cm^{-1}: 1655 (C=O, lactam), 1615 (CH$_3$C=O), 1580 (C=C, enol). ^1H NMR spectrum, δ, ppm: 2.36 s (3H, 6-CH$_3$), 2.74 s (3H, COCH$_3$), 3.45 s (3H, CH$_3$N), 5.86 s (1H, 5-H), 15.52 s (1H, OH). Found, %: C 59.59; H 6.07; N 7.84. $[M]^+$ 181. $C_9H_{11}NO_3$. Calculated, %: C 59.66; H 6.12; N 7.73. *M* 181.19.

6-Methyl-1-propyl-3-propionyl-1,2,3,4-pyridine-2,4-dione (Vb). Yield 85%, mp 58–59°C. IR spectrum, ν, cm^{-1}: 1665 (C=O, lactam), 1620 (EtC=O), 1570 (C=C, enol). ^1H NMR spectrum, δ, ppm: 0.99 t (3H, C**H**$_3$CH$_2$CH$_2$, *J* = 7.4 Hz), 1.16 t (3H, C**H**$_3$CH$_2$CO, *J* = 7.4 Hz), 1.69 m (2H, CH$_3$C**H**$_2$CH$_2$), 2.37 s (3H, 6-CH$_3$), 3.18 q (2H, CH$_3$C**H**$_2$CO, *J* = 7.0 Hz), 3.87 m (2H, NCH$_2$), 5.81 s (1H, 5-H), 15.60 s (1H, OH). Found, %: C 64.47; H 7.50; N 6.37. $[M]^+$ 223. $C_{12}H_{17}NO_3$. Calculated, %: C 64.55; H 7.67; N 6.27. *M* 223.27.

1-Benzyl-6-methyl-3-propionyl-1,2,3,4-tetrahydropyridine-2,4-dione (Vc). Yield 80%, mp 75–76°C. IR spectrum, ν, cm^{-1}: 1670 (C=O, lactam), 1625 (EtC=O), 1570 (C=C, enol). ^1H NMR spectrum, δ, ppm: 1.60 t (3H, C**H**$_3$CH$_2$, *J* = 7.0 Hz), 2.28 s (3H, 6-CH$_3$), 3.21 q (2H, CH$_3$C**H**$_2$), 5.27 s (2H, C**H**$_2$C$_6$H$_5$), 5.86 s (1H, 5-H), 7.13 d (2H, H$_{arom}$), 7.26 m (1H, H$_{arom}$), 7.33 m (2H, H$_{arom}$), 15.74 s (1H, OH). Found, %: C 70.89; H 6.33; N 5.22. $[M]^+$ 271. $C_{16}H_{17}NO_3$. Calculated, %: C 70.83; H 6.32; N 5.16. *M* 271.32.

3-Butyryl-1-(4-methoxyphenyl)-6-methyl-1,2,3,4-tetrahydropyridine-2,4-dione (Vd). Yield 82%, mp 105–106°C. IR spectrum, ν, cm^{-1}: 1670 (C=O, lactam); 1620 (PrC=O); 1610, 1570 (C=C, enol). ^1H NMR spectrum, δ, ppm: 0.94 t (3H, C**H**$_3$CH$_2$, *J* = 7.4 Hz), 1.66 m (2H, CH$_3$C**H**$_2$), 1.99 s (3H, C**H**$_3$CH$_2$), 2.28 s (3H, C**H**$_3$C=CH), 3.11 t (2H, CH$_2$CH$_2$, *J* = 7.4 Hz), 3.85 s (3H, OCH$_3$), 5.93 s (1H, 5-H), 7.03 m (2H, H$_{arom}$), 7.08 m (2H, H$_{arom}$), 15.97 s (1H, OH). ^{13}C NMR spectrum, δ_C, ppm: 13.82 (C$^{4''}$), 17.36 (C$^{3''}$), 22.33 (6-Me), 44.71 (C$^{2''}$), 55.54 (MeO), 100.90 (C^5), 105.43 (C^3), 115.12 (C$^{3'}$), 129.08 (C$^{2'}$), 130.60 (C$^{1'}$), 154.08 (C^6), 159.72 (C$^{4'}$), 163.50 (C^2), 176.30 (C^4), 208.30 (C$^{1''}$). Found, %: C 67.89; H 6.32; N 4.72. $[M]^+$ 301. $C_{17}H_{19}NO_4$. Calculated, %: C 67.76; H 6.36; N 4.65. *M* 301.34.

3-Acyl-6-methyl-1,2,3,4-tetrahydropyridine-2,4-diones Ve and Vf (*general procedure*). Triethylamine, 18.2 ml (0.13 mol), was added under stirring to a mixture of 0.1 mol of diketone **IIIa** or **IIIc** in 100 ml of methylene chloride, and a solution of 0.11 mol of pentanoyl or acetyl chloride in methylene chloride (1:1 by volume) was added dropwise over a period of 4 h under stirring. The mixture was then stirred for 0.5 h at

room temperature, and 28 ml (0.20 mol) of triethylamine and 0.5 ml (0.005 mol) of 2-hydroxy-2-methylpropanenitrile were added. As in the reactions with enol esters **IV**, the C–O isomerization was complete in 48 h (TLC). The mixture was treated as described above.

1,6-Dimethyl-3-pentanoyl-1,2,3,4-tetrahydropyridine-2,4-dione (Ve). Yield 73%. Oily substance. IR spectrum, ν, cm^{-1}: 1660 (C=O, lactam), 1620 (BuC=O), 1565 (C=C, enol). ^1H NMR spectrum, δ, ppm: 0.95 t (3H, C**H**$_3$CH$_2$CH$_2$, J = 7.3 Hz), 1.41 m (2H, CH$_3$C**H**$_2$CH$_2$), 1.65 m (2H, CH$_2$C**H**$_2$CH$_2$), 2.35 s (3H, 6-CH$_3$), 3.17 t (2H, CH$_2$C**H**$_2$CO, J = 7.7 Hz), 3.45 s (3H, NCH$_3$), 5.84 s (1H, 5-H), 15.67 s (1H, OH). Found, %: C 64.69; H 7.65; N 6.40. $[M]^+$ 223. $C_{12}H_{17}NO_3$. Calculated, %: C 64.55; H 7.67; N 6.27. M 223.27.

3-Acetyl-1-benzyl-6-methyl-1,2,3,4-tetrahydropyridine-2,4-dione (Vf). Yield 75%. Oily substance. IR spectrum, ν, cm^{-1}: 1660 (C=O, lactam), 1620 (MeC=O), 1575 (C=C, enol). ^1H NMR spectrum, δ, ppm: 2.28 s (3H, 6-CH$_3$), 2.74 s (3H, CH$_3$CO), 5.27 s (2H, C**H**$_2$C$_6$H$_5$), 5.86 s (1H, 5-H), 7.13 d (2H, H$_{arom}$), 7.27 m (1H, H$_{arom}$), 7.33 m (2H, H$_{arom}$), 15.65 s (1H, OH). Found, %: C 70.13; H 5.78; N 5.42. $[M]^+$ 257. $C_{15}H_{15}NO_3$. Calculated, %: C 70.02; H 5.88; N 5.44. M 257.19.

Enamines VIa–VIh (*general procedure***).** Triketone **Va**, **Vb**, **Vd**, or **Ve**, 5 mmol, was dissolved in 50 ml of toluene, 6.5 mmol of the corresponding amine was added, and the mixture was heated under reflux for 4–6 (aliphatic amines) or 60 h (aromatic amines), the progress of the reaction being monitored by TLC. The mixture was washed with 5% hydrochloric acid and water, the aqueous phases were combined and extracted with chloroform (3×10 ml), the chloroform extracts were combined with the toluene layer, dried over anhydrous magnesium sulfate, and passed through a thin layer of silica gel, and the solvent was evaporated under reduced pressure.

1,6-Dimethyl-3-[1-(phenylamino)ethylidene]-1,2,3,4-tetrahydropyridine-2,4-dione (VIa). Yield 52%, mp 116–118°C (from diethyl ether). IR spectrum, ν, cm^{-1}: 3060, 1660, 1620, 1560. ^1H NMR spectrum, δ, ppm: 2.25 s (3H, 6-CH$_3$), 2.71 s (3H, CH$_3$CN), 3.42 s (3H, CH$_3$N), 5.79 s (1H, 5-H), 7.10–7.40 m (5H, C$_6$H$_5$), 17.1 s (1H, NH). Found, %: C 70.39; H 6.21; N 11.02. $[M]^+$ 256. $C_{15}H_{16}N_2O_2$. Calculated, %: C 70.29; H 6.29; N 10.93. M 256.30.

3-[1-(2-Allylamino)ethylidene]-1,6-dimethyl-1,2,3,4-tetrahydropyridine-2,4-dione (VIb). Yield 85%, mp 69–69.5°C (from diethyl ether). IR spectrum, ν, cm^{-1}: 3070, 1660, 1620, 1600, 1560. ^1H NMR spectrum, δ, ppm: 2.22 s (3H, 6-CH$_3$), 2.70 s (2H, CH$_3$CN), 3.35 s (3H, CH$_3$N), 4.13 t (2H, NHC**H**$_2$, J = 5.5 Hz), 5.29 m (2H, C**H**$_2$=CH), 5.70 s (1H, 5-H), 5.90 m (1H, CH$_2$=C**H**), 15.3 s (1H, NH). Found, %: C 65.61; H 7.42; N 12.66. $[M]^+$ 220. $C_{12}H_{16}N_2O_2$. Calculated, %: C 65.43; H 7.32; N 12.72. M 220.27.

3-[1-(2-Allylamino)pentylidene]-1,6-dimethyl-1,2,3,4-tetrahydropyridine-2,4-dione (VIc). Yield 87%, mp 38–40°C (from diethyl ether). IR spectrum, ν, cm^{-1}: 3070, 1655, 1620, 1590, 1560. ^1H NMR spectrum, δ, ppm: 0.97 t (3H, C**H**$_3$CH$_2$, J = 7.4 Hz), 1.51 m (2H, C**H**$_2$CH$_3$), 2.22 s (3H, 6-CH$_3$), 3.13 m (2H, C**H**$_2$CH$_2$CH$_2$), 3.35 s (3H, CH$_3$N), 4.13 t (2H, NHC**H**$_2$, J = 5.5 Hz), 5.30 m (2H, C**H**$_2$=CH), 5.67 s (1H, 5- H), 5.90 m (1H, CH$_2$=C**H**), 15.3 s (1H, NH). Found, %: C 68.77; H 8.55; N 10.46. $[M]^+$ 262. $C_{15}H_{22}N_2O_2$. Calculated, %: C 68.67; H 8.45; N 10.68. M 262.35.

3-{1-[(4-Methoxyphenyl)amino]propylidene}-6-methyl-1-propyl-1,2,3,4-tetrahydropyridine-2,4-dione (VId). Yield 44%, mp 89–90°C (from diethyl ether). IR spectrum, ν, cm^{-1}: 3080, 1670, 1620, 1590, 1560. ^1H NMR spectrum, δ, ppm: 1.00 t (3H, C**H**$_3$CH$_2$CH$_2$, J = 7.5 Hz), 1.22 t (3H, NHCCH$_2$C**H**$_3$, J = 7.5 Hz), 1.68 m (2H, CH$_3$C**H**$_2$CH$_2$), 2.30 s (3H, 6-CH$_3$), 3.10 q (2H, NHCC**H**$_2$CH$_3$, J = 7.5 Hz), 3.80 m (2H, NC**H**$_2$), 3.84 s (3H, OCH$_3$), 5.73 s (1H, 5-H), 6.94 d (2H, C$_6$H$_4$, J = 9.0 Hz), 7.12 d (2H, C$_6$H$_4$, J = 9.0 Hz), 16.85 s (1H, NH). Found, %: C 69.77; H 7.61; N 8.37. $[M]^+$ 328. $C_{19}H_{24}N_2O_3$. Calculated, %: C 69.49; H 7.37; N 8.53. M 328.41.

3-[1-(Benzylamino)propylidene]-6-methyl-1-propyl-1,2,3,4-tetrahydropyridine-2,4-dione (VIe). Yield 82%. Oily substance. IR spectrum, ν, cm^{-1}: 3080, 1670, 1620, 1590, 1560. ^1H, δ, ppm: 0.95 t (3H, C**H**$_3$CH$_2$CH$_2$, J = 7.5 Hz), 1.23 t (3H, NHCCH$_2$C**H**$_3$, J = 7.5 Hz), 1.68 m (2H, CH$_3$C**H**$_2$CH$_2$), 2.23 s (3H, 6-CH$_3$), 3.24 q (2H, NHCC**H**$_2$CH$_3$, J = 7.5 Hz), 3.82 m (2H, NC**H**$_2$), 4.78 d (2H, NHC**H**$_2$Ph, J = 5.5 Hz), 5.68 s (1H, 5-H), 7.20–7.42 m (5H, C$_6$H$_5$), 15.65 s (1H, NH). Found, %: C 73.10; H 7.65; N 9.01. $[M]^+$ 312. $C_{19}H_{24}N_2O_2$. Calculated, %: C 73.05; H 7.74; N 8.97. M 312.41.

3-[1-(Benzylamino)butylidene]-6-methyl-1-(4-methoxyphenyl)-1,2,3,4-tetrahydropyridine-2,4-dione (VIf). Yield 85%, mp 154–155°C (from ethyl acetate). IR spectrum, ν, cm^{-1}: 3080, 1670, 1630, 1590, 1560. ^1H NMR spectrum, δ, ppm: 1.00 t (3H, C**H**$_3$CH$_2$CH$_2$, J = 7.4 Hz), 1.64 m (4H, CH$_3$C**H**$_2$C**H**$_2$),

1.82 s (3H, 6-CH_3), 3.13 t (1.6H, J = 8.0 Hz) and 3.31 br.s (0.4H, NHCC**H**$_2$CH$_2$), 3.83 s (3H, OCH_3), 4.64 br.s (0.4H) and 4.71 d (1.6H, J = 5.5 Hz) (NHC**H**$_2$Ph), 5.74 s (1H, 5-H), 6.97 m (2H, H_{arom}), 7.08 m (2H, H_{arom}), 7.33–7.38 m (5H, H_{arom}), 15.59 s (1H, NH). Found, %: C 73.98; H 6.65; N 7.03. $[M]^+$ 390. $C_{24}H_{26}N_2O_3$. Calculated, %: C 73.82; H 6.71; N 7.17. M 390.48.

1-(4-Methoxyphenyl)-6-methyl-3-[1-(4-tolylamino)butylidene]-1,2,3,4-tetrahydropyridine-2,4-dione (VIg). Yield 44%, mp 150–152°C (from diethyl ether). IR spectrum, ν, cm^{-1}: 3060, 1660, 1625, 1560, 1520. ^{1}H NMR spectrum, δ, ppm: 0.80 t (2.4H, J = 7.4 Hz) and 0.89–0.98 m (0.6H) (C**H**$_3$CH$_2$CH$_2$), 1.60 m (2H, CH$_3$C**H**$_2$CH$_2$), 1.86 s (3H, 6-CH_3), 2.39 s (C**H**$_3$C$_6$H$_4$), 2.98 t (1.6H, J = 7.7 Hz) and 3.14 m (0.4H) (C**H**$_2$CH$_2$CH$_3$), 3.84 s (3H, CH_3O), 5.81 s (1H, 5-H), 6.97–7.25 m (8H, H_{arom}), 14.7 s (0.2H) and 16.85 s (0.8H) (NH). ^{13}C NMR spectrum, δ_C, ppm: 14.60 ($C^{4''}$), 20.86 ($C^{3''}$), 21.81 (6-Me), 31.95 ($C^{2''}$), 47.20 (**C**H$_2$Ph), 55.44 (MeO), 101.92 (C^3), 107.50 (C^5), 114.76 ($C^{3'}$), 127.16 ($C^{2'''}$), 127.96 ($C^{4'''}$), 129.03 ($C^{3'''}$), 129.76 ($C^{2'}$), 131.87 ($C^{1'}$), 136.04 ($C^{1'''}$), 149.12 (C^6), 159.17 ($C^{4'}$), 165.03 (C^2), 183.73 (C^4), 179.37 ($C^{1''}$). Found, %: C 74.01; H 6.61; N 7.30. $[M]^+$ 390. $C_{24}H_{26}N_2O_3$. Calculated, %: C 73.82; H 6.71; N 7.17. M 390.48.

1,6-Dimethyl-3-[1-(4-methoxyphenylamino)-pentylidene]-1,2,3,4-tetrahydropyridine-2,4-dione (VIh). Yield 48%, mp 120–121°C (from methanol). IR spectrum, ν, cm^{-1}: 3050, 1650, 1625, 1570, 1555. ^{1}H NMR spectrum, δ, ppm: 0.79 t (3H, C**H**$_3$CH$_2$CH$_2$, J = 7.1 Hz), 1.29 m (2H, CH$_3$C**H**$_2$CH$_2$), 1.56 m (2H, CH$_3$CH$_2$C**H**$_2$), 2.26 s (3H, 6-CH_3), 3.05 m (2H, NHCC**H**$_2$CH$_2$), 3.80 s (3H, NCH_3), 3.84 s (3H, CH_3O), 5.74 s (1H, 5-H), 6.93 m (2H, H_{arom}), 7.08 m (2H, H_{arom}), 16.85 s (1H, NH). Found, %: C 69.33; H 7.17; N 8.47. $[M]^+$ 328. $C_{19}H_{24}N_2O_3$. Calculated, %: C 69.49; H 7.37; N 8.53. M 328.41.

Enol ethers VIIa and VIIb (*general procedure*). Triketone **Vd** or **Ve**, 0.05 mol, was dissolved in 50 ml of toluene, 2.8 g (0.02 mol) of finely powdered anhydrous potassium carbonate and 0.57 ml (0.06 mol) of dimethyl sulfate were added, and the mixture was heated for 6–8 h under reflux with stirring. The mixture was cooled and filtered from potassium carbonate, the precipitate was washed on a filter with toluene, the filtrate was passed through a thin layer of silica gel, the solvent was removed under reduced pressure, and the residue was recrystallized from a mixture of diethyl ether and petroleum ether.

4-Methoxy-1,6-dimethyl-3-pentanoyl-1,2-dihydropyridin-2-one (VIIa). Yield 98%, mp 52–53°C. IR spectrum, ν, cm^{-1}: 1700, 1655, 1590, 1560. ^{1}H NMR spectrum, δ, ppm: 0.90 t (3H, C**H**$_3$CH$_2$CH$_2$, J = 7.4 Hz), 1.35 m (2H, CH$_3$C**H**$_2$CH$_2$), 1.64 m (2H, CH$_2$-C**H**$_2$CH$_2$), 2.39 s (3H, 6-CH_3), 2.83 t (2H, CH$_2$C**H**$_2$CO, J = 7.7 Hz), 3.48 s (3H, NCH_3), 3.82 s (3H, OCH_3), 5.95 s (1H, 5-H). ^{13}C NMR spectrum, δ_C, ppm: 13.97 ($C^{5''}$), 21.74 (6-Me), 22.41 ($C^{4''}$), 26.11 ($C^{3''}$), 30.82 ($C^{1'}$), 43.54 ($C^{2''}$), 56.02 (MeO), 94.84 (C^5), 112.64 (C^3), 127.16 ($C^{2'''}$), 149.25 (C^6), 162.03 (C^2), 164.08 (C^4), 203.18 ($C^{1''}$). Found, %: C 65.64; H 7.95; N 6.02. $[M]^+$ 237. $C_{13}H_{19}NO_3$. Calculated, %: C 65.80; H 8.07; N 5.90. M 237.30.

3-Butanoyl-4-methoxy-1-(4-methoxyphenyl)-6-methyl-1,2-dihydropyridin-2-one (VIIb). Yield 97%, mp 142–143°C. IR spectrum, ν, cm^{-1}: 1710, 1650, 1610, 1585. ^{1}H NMR spectrum, δ, ppm: 0.92 t (3H, C**H**$_3$CH$_2$CH$_2$, J = 7.4 Hz), 1.67 m (2H, CH$_3$C**H**$_2$CH$_2$), 2.03 s (3H, 6-CH_3), 2.85 t (2H, CH$_2$C**H**$_2$CO, J = 7.4 Hz), 3.84 s (3H, NCH_3), 3.88 s (3H, OCH_3), 6.02 s (1H, 5-H), 7.08 m (2H, H_{arom}), 7.14 m (2H, H_{arom}). ^{13}C NMR spectrum, δ_C, ppm: 13.93 ($C^{4''}$), 17.58 ($C^{3''}$), 22.50 (6-Me), 45.75 ($C^{2''}$), 55.67 (4′-MeO), 56.36 (4-MeO), 94.95 (C^5), 113.05 (C^3), 115.18 ($C^{3'}$), 129.06 ($C^{2'}$), 130.70 ($C^{1'}$), 150.09 (C^6), 159.81 ($C^{4'}$), 162.84 (C^2), 165.30 (C^4), 202.96 ($C^{1''}$). Found, %: C 65.64; H 7.95; N 6.02. $[M]^+$ 315. $C_{18}H_{21}NO_4$. Calculated, %: C 68.55; H 6.71; N 4.44. M 315.37.

Enamines VIIIa–VIIId (*general procedure*). A mixture of 0.01 mol of 4-methoxypyridine **VIIa** or **VIIb** and 0.013 mmol of the corresponding amine in 50 ml of toluene was heated for 18–24 h under reflux (TLC). The mixture was then treated as described above for enamino derivatives **VI**.

4-Benzylamino-3-butanoyl-1-(4-methoxyphenyl)-6-methyl-1,2-dihydropyridin-2-one (VIIIa). Yield 85%, mp 145–146°C (from methanol). IR spectrum, ν, cm^{-1}: 3070, 1660, 1630, 1560, 1520. ^{1}H NMR spectrum, δ, ppm: 0.92 t (3H, C**H**$_3$CH$_2$CH$_2$, J = 7.4 Hz), 1.63 m (2H, CH$_3$C**H**$_2$CH$_2$), 1.87 s (3H, 6-CH_3), 3.10 t (2H, CH$_2$C**H**$_2$CO, J = 7.4 Hz), 3.83 s (3H, OCH_3), 4.52 d (2H, NHC**H**$_2$, J = 5.8 Hz), 5.73 s (1H, 5-H), 6.99 m (2H, H_{arom}), 7.07 m (2H, H_{arom}), 7.26–7.40 m (5H, H_{arom}), 11.53 t (1H, NH, J = 5.45 Hz). ^{13}C NMR spectrum, δ_C, ppm: 14.12 ($C^{4''}$), 18.15 ($C^{3''}$), 22.58 (6-Me), 46.31 ($C^{2''}$), 46.64 (**C**H$_2$Ph), 55.56 (4′-MeO), 94.48 (C^5), 101.73 (C^3), 114.95 ($C^{3'}$), 127.05 ($C^{2'''}$, $C^{6'''}$), 127.66 ($C^{4'''}$), 128.98 ($C^{3'''}$, $C^{5'''}$), 129.46 ($C^{2'}$), 131.48 ($C^{1'}$), 150.80 (C^6), 137.41 ($C^{1'''}$), 159.45 ($C^{4'}$), 164.52 (C^2), 159.82 (C^4), 204.82 ($C^{1''}$).

Found, %: C 73.78; H 6.60; N 7.25. $[M]^+$ 390. $C_{24}H_{26}N_2O_3$. Calculated, %: C 73.82; H 6.71; N 7.17. *M* 390.48.

3-Butanoyl-1-(4-methoxyphenyl)-6-methyl-4-(4-tolylamino)-1,2-dihydropyridin-2-one (VIIIb). Yield 43%, mp 153–154°C (from diethyl ether). IR spectrum, ν, cm^{-1}: 3070, 1665, 1630, 1560, 1520. ^1H NMR spectrum, δ, ppm: 0.95 t (3H, C**H**$_3$CH$_2$CH$_2$, *J* = 7.4 Hz), 1.67 m (2H, CH$_3$C**H**$_2$), 1.83 s (3H, C**H**$_3$C$_6$H$_4$), 2.38 s (3H, 6-CH$_3$), 3.15 t (2H, CH$_2$C**H**$_2$CO, *J* = 7.7 Hz), 3.84 s (3H, NCH$_3$), 5.87 s (1H, 5-H), 7.01 m (2H, H$_{arom}$), 7.09 m (2H, H$_{arom}$), 7.14 m (2H, H$_{arom}$), 7.21 m (2H, H$_{arom}$), 12.63 s (1H, NH). Found, %: C 73.98; H 6.65; N 7.03. $[M]^+$ 390. $C_{24}H_{26}N_2O_3$. Calculated, %: C 73.82; H 6.71; N 7.17. *M* 390.48.

4-(4-Methoxyphenylamino)-1,6-dimethyl-3-pentanoyl-1,2-dihydropyridin-2-one (VIIIc). Yield 45%, mp 98–99°C (from hexane). IR spectrum, ν, cm^{-1}: 3050, 1650, 1620, 1565, 1520. ^1H NMR spectrum, δ, ppm: 0.96 t (3H, C**H**$_3$CH$_2$CH$_2$, *J* = 7.4 Hz), 1.42 m (2H, CH$_3$C**H**$_2$CH$_2$), 1.67 m (2H, CH$_3$CH$_2$C**H**$_2$), 2.19 s (3H, 6-CH$_3$), 3.20 t (2H, CH$_2$C**H**$_2$CO, *J* = 7.4 Hz), 3.41 s (3H, NCH$_3$), 3.83 s (3H, OCH$_3$), 5.69 s (1H, 5-H), 6.91 m (2H, H$_{arom}$), 7.10 m (2H, H$_{arom}$), 12.26 s (1H, NH). Found, %: C 69.48; H 7.27; N 8.35. $[M]^+$ 328. $C_{19}H_{24}N_2O_3$. Calculated, %: C 69.49; H 7.37; N 8.53. *M* 328.41.

4-Allylamino-1,6-dimethyl-3-pentanoyl-1,2-dihydropyridin-2-one (VIIId). Yield 65%, mp 59–60°C (from diethyl ether). IR spectrum, ν, cm^{-1}: 3090, 1660, 1620, 1570, 1520. ^1H NMR spectrum, δ, ppm: 0.94 t (3H, C**H**$_3$CH$_2$CH$_2$, *J* = 7.4 Hz), 1.39 m (2H, CH$_3$C**H**$_2$-CH$_2$), 1.63 m (2H, CH$_3$CH$_2$C**H**$_2$), 2.29 s (3H, 6-CH$_3$), 3.14 t (2H, CH$_2$C**H**$_2$CO, *J* = 7.69 Hz), 3.41 s (3H, NCH$_3$), 3.88 m (2H, NHC**H**$_2$), 5.23 m (2H, C**H**$_2$=CH), 5.62 s (1H, 5-H), 5.88 m (1H, CH$_2$=C**H**), 10.90 s (1H, NH). ^{13}C NMR spectrum, δ_C, ppm: 14.30 ($C^{5''}$), 22.03 (6-Me), 22.83 ($C^{4''}$), 27.33 ($C^{3''}$), 30.52 ($C^{1'}$), 44.10 ($C^{2''}$), 44.85 ($C^{1'''}$), 94.56 (C^5), 101.74 (C^3), 133.33 ($C^{2'''}$), 116.89 ($C^{3'''}$), 150.15 (C^6), 164.06 (C^2), 159.01 (C^4), 205.01 ($C^{1''}$). Found, %: C 68.77; H 8.55; N 10.46. $[M]^+$ 262. $C_{15}H_{22}N_2O_2$. Calculated, %: C 68.67; H 8.45; N 10.68. *M* 262.35.

REFERENCES

1. O'Hagan, D., *Nat. Prod. Rep*., 2000, vol. 17, p. 435.
2. Malle, E., Stadlbauer, W., Ostermann, G., Hofmann, B., Leis, H.J., and Kostner, G.M., *Eur. J. Med. Chem*., 1990, vol. 25, p. 137.
3. Wat, C.-K., McInnes, A.G., Smith, D.G., Wright, J.L.C., and Vining, L.C., *Can. J. Chem*., 1977, vol. 55, p. 4090.
4. Schmidt, K., Riese, U., Li, Z., and Hamburger, M., *J. Nat. Prod*., 2003, vol. 66, p. 378.
5. Irlapati, N.G., Adlington, R.M., Conte, A., Pritchard, G.J., Marquez, R., and Baldwin, J.E., *Tetrahedron*, 2004, vol. 60, p. 9307.
6. Hirono, Y., Ishikawa, H., Iwataki, I., and Sawaki, M., JPN Patent Appl. no. 75-154272, 1975; *Chem. Abstr*., 1976, vol. 85, no. 78010s.
7. Grina, J., FRG Patent Appl. no. 3820538, 1989; *Chem. Abstr*., 1989, vol. 110, no. 212625x.
8. Curtis, J.K., EPV Patent Appl. no. 249149, 1987; *Chem. Abstr*., 1988, vol. 109, no. 73334r.
9. Geach, N.J., Gilmour, J., Hatton, L.R., and Smith, P.H.G., EPV Patent Appl. no. 278742, 1988; *Chem. Abstr*., 1989, vol. 110, no. 38898b.
10. Kappe, T. and Schnell, B., *J. Heterocycl. Chem*., 1996, vol. 33, p. 663.
11. Schnell, B. and Kappe, T., *Monatsh. Chem*., 1998, vol. 129, p. 871.
12. Alonso, P., Martin-Leon, N., Quinteiro, M., and Soto, J.L., *Justus Liebigs Ann. Chem*., 1990, p. 841.
13. Takahashi, S., Kakinuma, N., Uchida, K., Hashimoto, R., Yanagishima, T., and Nakagawa, A., *J. Antibiot*., 1998, vol. 51, p. 596.
14. Kappe, T. and Kappe, C.O., *J. Heterocycl. Chem*., 1989, vol. 26, p. 1555.
15. Rubinov, D.B., Zheldakova, T.A., and Rubinova, I.L., *Russ. J. Org. Chem*., 2004, vol. 40, p. 1329.
16. Rubinov, D.B., Rubinova, I.L., and Akhrem, A.A., *Russ. J. Org. Chem*., 1995, vol. 31, p. 386.
17. Rubinov, D.B., Rubinova, I.L., and Akhrem, A.A., *Chem. Rev*., 1999, vol. 99, p. 1047.
18. Budnikova, M.V. and Rubinov, D.B., *Russ. J. Org. Chem*., 2001, vol. 37, p. 1478.
19. Budnikova, M.V., Gulyakevich, O.V., Zheldakova, T.A., Mikhal'chuk, A.L., and Rubinov, D.B., *Russ. J. Org. Chem*., 2002, vol. 38, p. 1696.
20. Zheldakova, T.A., Budnikova, M.V., Rubinova, I.L., and Rubinov, D.B., *Russ. J. Org. Chem*., 2003, vol. 39, p. 1772.
21. Gulyakevich, O.V., Mikhal'chuk, A.L., Verenich, A.I., Rubinov, D.B., Zenyuk, A.A., and Akhrem, A.A., *Enaminy v organicheskom sinteze* (Enamines in Organic Synthesis), Yekaterinburg: Ural. Otd. Ross. Akad. Nauk, 1996, p. 111.
22. Budnikova, M.V., Zheldakova, T.A., Rubinov, D.B., and Mikhal'chuk, A.L., *Russ. J. Org. Chem*., 2001, vol. 37, p. 293.
23. Budnikova, M.V., Rubinov, D.B., and Mikhal'chuk, A.L., *Khim. Geterotsikl. Soedin*., 2002, p. 1067.