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ELECTROCHEMICAL OXIDATION OF 4-MONOALKYL-SUBSTITUTED 1,4-DIHYDROPYRIDINES

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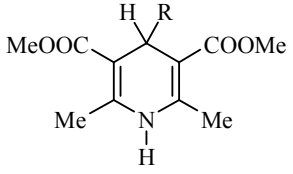
The electrochemical oxidation of 4-monoalkyl-substituted 1,4-dihydropyridines has been studied in an aprotic medium and in the presence of pyridine. In an aprotic medium the products of oxidation are both 4-alkyl-substituted and 4-unsubstituted pyridines or mixtures of them. On oxidation in acetonitrile of 4-Et-, 4-n-Pr-, and 4-i-Bu-substituted dihydropyridines, 2-methylene-1,2,3,4-tetrahydropyridines were obtained in addition to the oxidized forms. In the presence of base the products of preparative electrolysis of the studied compounds were 4-alkyl-substituted pyridines. The exception was the 4-i-Pr-substituted dihydropyridine which was dealkylated on oxidation even in the presence of base.

Keywords: 4-alkyl-substituted pyridines, 1,4-dihydropyridines, alkyl radicals, exocyclic double bond, electrochemical oxidation.

Dihydropyridines are one of the most investigated classes of organic compounds. The synthesis and reactions of 1,4-dihydropyridines have been examined in detail in reviews [1-4]. Many compounds of this series possess pharmacological activity. A series of pharmaceuticals [5] has been developed based mainly on 4-aryl-substituted 1,4-dihydropyridines. Antioxidant properties have also been confirmed for the heterocycle itself in reactions with various radicals [6, 7]. On the other hand study of the redox reaction of the dihydropyridine ring is also important for the reason that its oxidation is the main metabolism of dihydropyridines.

The attention of electrochemists is mainly attracted [8-13] by the oxidation of 4-methyl-, 4-aryl-1,4-dihydropyridines or those unsubstituted in position 4. In all the mentioned cases proton is split off from the position 4 of the ring on oxidation.



1–5

1 R = Me, **2** R = Et, **3** R = *n*-Pr, **4** R = *i*-Pr, **5** R = *i*-Bu

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The electrochemical oxidation of 4-monoalkyl-substituted 1,4-dihydropyridines **1-5** by cyclic voltamperometry and preparative electrolysis has been studied in this work. In addition the rotating disk electrode was used to determine oxidation potentials and limiting current values.

In aprotic medium the oxidation of all the compounds studied proceeds in one irreversible step (Fig. 1) at potentials ~1 V (Table 1). Preparative electrolysis at a controlled potential was carried out to clarify the products of electrochemical oxidation of dihydropyridines **1-5**. Analysis of ^{1}H NMR spectra of the reaction mixture directly after evaporation of the solvent showed that the main oxidation products of compounds **1-5** were the corresponding pyridinium perchlorates. The deprotonated reaction mixture was analyzed by GC-MS with subsequent isolation of products.

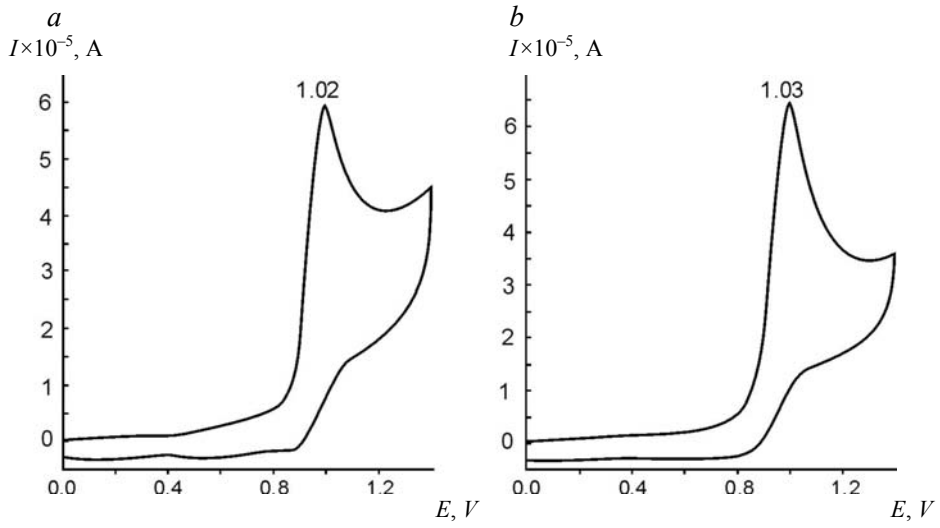


Fig. 1. Electrochemical oxidation of 1,4-dihydropyridines **2** (*a*) and **4** (*b*) (concn. = 5×10^{-4} M) at the stationary glass-graphite electrode. Base electrolyte 0.1 M $NaClO_4$/MeCN

According to literature data [14-18], the substituent in position 4 of the oxidized form of the heterocycle is retained on electrochemical and chemical oxidation of 4-methyl-substituted 1,4-dihydropyridines. Moreover on oxidation of 4,4-dimethyl-substituted dihydropyridines in an aprotic medium the sole product is a stable cation-radical [19].

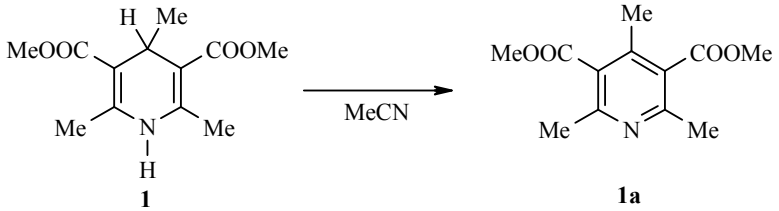
The methyl group is also retained on electrochemical oxidation of 4-methyl-substituted dihydropyridine **1** and 3,5-dimethoxycarbonyl-2,4,6-trimethylpyridine (**1a**) is the sole product (95.7%) of electrolysis.

TABLE 1. Oxidation Potentials (E^{ox}), Limiting Current Values (I) and the Coulometrically Determined Number of Electrons (n) on Oxidation of Dihydropyridines **1-5** in 0.1 M $NaClO_4$/MeCN

Compound	E^{ox}, V	E^{ox}, V	I, μA	I, μA (Py)	n, F/mol
	Stationary glassy carbon electrode	Rotating disk electrode			
1	1.03	1.10	110	126	1.15
2	1.02	1.00	78	137	0.69
3	1.01	1.00	78	108	0.84
4	1.03	0.97	124	117	1.50
5	1.03	0.97	94	145	1.04

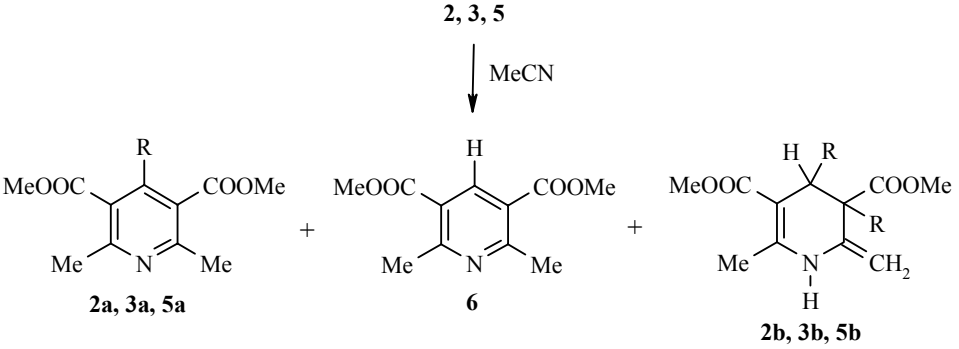
TABLE 2. Products and Yields on Electrochemical Oxidation of 4-Monosubstituted 1,4-Dihydropyridines in Acetonitrile

Compound	Yield, %						
	2a	**3a**	**5a**	**2b**	**3b**	**5b**	**6**
2	18.5	—	—	12.9	—	—	61.1
3	—	46.6	—	—	19.4	—	27.3
5	—	—	36.7	—	—	7.5	46.1



1 **1a**

However the products of electrochemical oxidation of dihydropyridines **2**, **3**, and **5** contain both 4-substituted pyridines (**2a, 3a, 5a**) and also 4-unsubstituted pyridine (**6**). In addition to both oxidized forms, tetrahydropyridines **2b, 3b, 5b** were isolated from the reaction mixture.

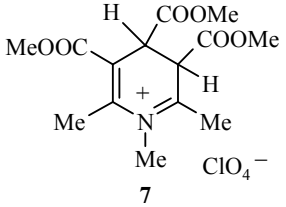


2a, 3a, 5a **6** **2b, 3b, 5b**

2 R = Et; **3** R = *n*-Pr; **5** R = *i*-Bu

The formation of a similar exocyclic C=C bond was noted only on trying to alkylate N-substituted 1,4-dihydropyridines in the presence of a strong base (lithium diisopropylamide) [20] capable of deprotonating a methyl group. In some cases the presence of 2-methylene-1,2,3,4-tetrahydropyridines was also demonstrated as an intermediate products in the Hantzsch synthesis of N-substituted, as well as N-unsubstituted, dihydropyridines according to [21-24].

The formation of similar tetrahydropyridines on electrochemical oxidation of 4-monoalkyl-substituted dihydropyridines **2**, **3**, and **5** may be explained in two ways. After removing the first electron the alkyl group is eliminated as a carbocation, and on its subsequent attack on a double bond in the dihydropyridine molecule, ejection of proton from the 2-methyl group of the heterocycle must follow. This is extremely improbable since the acidity of the N–H proton is significantly greater than the acidity of methyl group protons.



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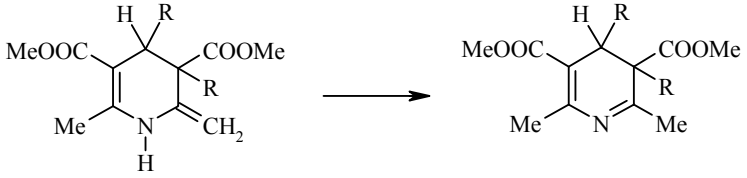
In addition no formation of an exocyclic bond was observed [25] in the protonated dihydroderivative **7**. 3,4,5-Trimethoxycarbonyl-1,2,6-trimethyl-3,4-dihydropyridinium perchlorate is a stable compound which is deprotonated in the presence of water regenerating the initial dihydropyridine.

If the primary product of anodic oxidation of dihydropyridine, the cation-radical, eliminates an alkyl radical from position 4 then, on attacking it at the double bond of the dihydropyridine molecule, fission of an H atom from the methyl group in position 2 of the heterocycle seems more realistic.

2-Methylene-substituted tetrahydropyridines **2b** (Fig. 2), **3b**, and **5b** are stable compounds, which in solution are slowly converted into 3,4-dihydropyridines **2c**, **3c**, and **5c**.



2b, 3b, 5b **2c, 3c, 5c**

On electrochemical oxidation of 4-*i*-Pr-substituted dihydropyridine **4** the substituent at position 4 of the heterocycle is lost and the sole product of electrolysis is the pyridine **6** (92.8%), corresponding to literature data [26-29] on the oxidation of dihydropyridines of such a type. In addition to the oxidized form the presence of nitrilium perchlorate **8**, was proved in the solution by a counter-synthesis [30].

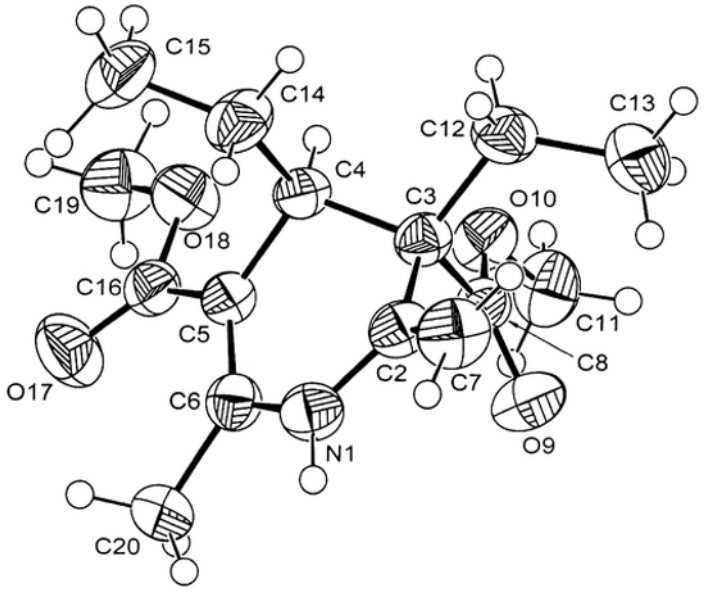


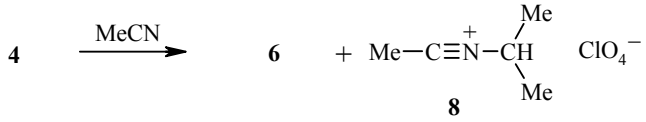
Fig. 2. Structure of the **2b** molecule with numbering and thermal vibration ellipsoids of atoms.

Compared to other alkyl radicals the isopropyl radical is more stable, its subsequent oxidation at the anode to carbocation is therefore possible. It then attacks an acetonitrile molecule.

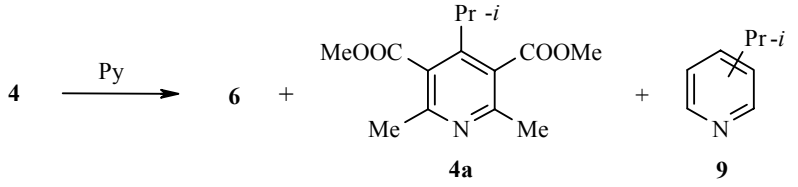
Preparative electrolysis in mixed solvent ($MeCN–C_5H_5N$, 1:1) was carried out to investigate the products obtained on electrochemical oxidation of 4-monoalkyl-substituted 1,4-dihydropyridines **1-5** in the presence of base. The oxidation products after workup of the anolyte were also analyzed by GC-MS. In the presence of base the 4-alkyl-substituted pyridine derivatives **1a-3a, 5a** were the sole products of the electrolysis of dihydropyridines **1-3, 5**, respectively.

TABLE 3. Crystallographic Data for Compound **2b**

Empirical formula	$C_{15}H_{23}NO_4$
Molecular mass, *M*	281.352
Crystal system	Triclinic
Space group	$P\bar{1}$
Parameters of unit cell:	
a, Å	8.6672(4)
b, Å	8.8310(4)
c, Å	10.2452(4)
α, deg	81.868(2)
β, deg	89.108(2)
γ, deg	80.558(2)
Volume of unit cell, *V*, Å^3	765.74(6)
Number of molecules in unit cell, *Z*	2
Density of crystals, *D*, g/cm^3	1.220
Absorption coefficient, μ, mm^{-1}	0.088
Number of reflections with $I > 3\sigma(I)$	2586
Number of parameters refined	273
Final divergence factor, *R*	0.047
Programs used	SIR97 [33], maXus [34]



Even in the presence of base the mechanism of oxidation of dihydropyridine **4** was unchanged, and in this case the sole electrolysis product was the dealkylated pyridine **6**. The 4-*i*-Pr-substituted pyridine **4a** (25%) was only obtained on carrying out the electrolysis in pyridine, but in this case too the main product was the dealkylated pyridine **6** (68%). In the products of electrolysis of 4-*i*-Pr-substituted dihydropyridine **4** in pyridine, or in the presence of pyridine, the formation of isopropylpyridine **9** was demonstrated by GC-MS.



The results obtained indicate that in aprotic medium 4-monoalkyl-substituted 1,4-dihydropyridines undergo a one-electron oxidation (Table 1) with subsequent fission of an alkyl radical, with the exception of the 4-methyl-substituted analog **1**. Depending on the substituent in position 4 of the dihydropyridine the place of attack of the eliminated alkyl radical may be sterically screened, as was observed in the case of the oxidation of the 4-*i*-Pr-substituted dihydropyridine **4**. In the presence of base the mechanism of oxidation is changed and the yield of 4-alkyl-substituted pyridines depends on the basicity of the medium.

EXPERIMENTAL

Cyclic voltamperograms were taken on a PARSTAT 2273 electrochemical system. Oxidation potentials were determined at the stationary glass-graphite electrode (*d* = 6 mm). All potentials were measured relative to a saturated calomel electrode fitted with a salt bridge. A Pt wire served as auxiliary electrode.

Preparative oxidation of dihydropyridines **1-5** was carried out using a PAR-170 electrochemical system. Oxidation of dihydropyridines **1-5** was carried out in an H-shaped cell at a potential of +1.20 V in acetonitrile, prepared according to the method of [31]. Anhydrous $NaClO_4$, dried in vacuum at 40°C, was used as base electrolyte. The cell was filled with 0.1 M solution of base electrolyte (100 ml), and into the anode space compounds **1-5**, 0.80 g, 3.3 mmol, 0.81 g, 3.2 mmol, 0.80 g, 3.0 mmol, 0.88 g, 3.3 mmol, and 0.58 g, 2.1 mmol, respectively, were introduced. Platinum gauze (3.5 x 2.5 cm) served as anode and cathode and argon was blown through the anode space throughout electrolysis. After the end of the electrolysis, the reaction mixture was evaporated, the residue treated with water, and extracted with chloroform. The chloroform was evaporated, and the residue subjected to column chromatography.

Preparative oxidation of dihydropyridine **4** (0.5 g, 1.8 mmol) was also carried out in pyridine, using anhydrous $LiClO_4$ dried in vacuum at 40°C as base electrolyte. Electrolysis and processing of anolyte was in accordance with that mentioned above.

Silica gel type Acros (0.060-0.200 mm) was used for preparative column chromatography (column 2×70 cm), eluent was chloroform–hexane–acetone, 9:7:1.

^{1}H NMR spectra were recorded on a Bruker WH 90 (90 MHz) in $CDCl_3$ (compounds **1, 1a, 2, 2a-c, 3, 3a-c, 4, 4a, 5, 5a-c**), internal standard was TMS.

Mass spectra were recorded on a HP 6890 GC-MS chromato-mass spectrometer with energy of ionizing electrons 70 eV.

For the X-ray crystallographic analysis the diffraction picture of a monocrystal of compound **2b** (obtained by crystallization from methylene chloride) of size 0.15×0.28×0.44 mm, was taken on a Nonius KappaCCD automatic diffractometer to $2\theta_{max} = 55^o$ ($\lambda_{Mo} = 0.71073$ Å). The main crystallographic characteristics of compound **2b**, and also the parameters of the refined structure are given in Table 3. The crystal structure has been deposited in the Cambridge structural data bank (CCDC 707926).

4-Monoalkyl-substituted 1,4-dihydropyridines **1-5** were obtained by the procedure of [32].

3,5-Dimethoxycarbonyl-2,4,6-trimethyl-1,4-dihydropyridine (1). ^{1}H NMR spectrum, δ, ppm (*J*, Hz): 0.94 (3H, d, ^3J = 6.4, 4-CH_3); 2.26 (6H, s, 2,6-CH_3); 3.70 (6H, s, 3,5-$COOCH_3$); 3.80 (1H, q, ^3J = 6.4, H-4); 5.87 (1H, s, NH).

3,5-Dimethoxycarbonyl-2,4,6-trimethylpyridine (1a). ^{1}H NMR spectrum, δ, ppm: 2.24 (3H, s, 4-CH_3); 2.50 (6H, s, 2,6-CH_3); 3.92 (6H, s, 3,5-$COOCH_3$). Mass spectrum, *m/z* (I_{rel}, %): 237 $[M]^+$ (46), 222 $[M\text{-}Me]^+$ (63), 206 (100), 190 (16), 178 $[M\text{-}CO_2Me]^+$ (31).

4-Ethyl-3,5-dimethoxycarbonyl-2,6-dimethyl-1,4-dihydropyridine (2). ^{1}H NMR spectrum, δ, ppm (*J*, Hz): 0.72 (3H, t, ^3J = 7.0, 4-$CH_2C\underline{H}_3$); 1.34 (2H, m, 4-$C\underline{H}_2CH_3$); 2.25 (6H, s, 2,6-CH_3); 3.65 (6H, s, 3,5-$COOCH_3$); 3.87 (1H, t, ^3J = 5.0, H-4); 5.43 (1H, s, NH).

4-Ethyl-3,5-dimethoxycarbonyl-2,6-dimethylpyridine (2a). ^{1}H NMR spectrum, δ, ppm (*J*, Hz): 1.14 (3H, t, ^3J = 7.0, 4-$CH_2C\underline{H}_3$); 2.49 (6H, s, 2,6-CH_3); 2.58 (2H, q, ^3J = 7.0, 4-$C\underline{H}_2CH_3$); 3.92 (6H, s, 3,5-$COOCH_3$). Mass spectrum, *m/z* (I_{rel}, %): 251 $[M]^+$ (13), 236 $[M\text{-}Me]^+$ (100), 220 (39), 204 (35), 160 (22), 91 (18).

3,4-Diethyl-3,5-dimethoxycarbonyl-6-methyl-2-methylene-1,2,3,4-tetrahydropyridine (2b). ^{1}H NMR spectrum, δ, ppm (*J*, Hz): 0.81 (6H, m, 3,4-$CH_2C\underline{H}_3$); 1.62 (4H, m, 3,4-$C\underline{H}_2CH_3$); 2.36 (3H, s, 6-CH_3); 3.10 (1H, t, ^3J = 5.0, H-4); 3.70 (3H, s, 3-$COOCH_3$); 3.76 (3H, s, 5-$COOCH_3$); 4.50, 4.98 (2H, two s, =CH_2); 5.78 (1H, s, NH). Mass spectrum, *m/z* (I_{rel}, %): 281 $[M]^+$ (44), 266 $[M\text{-}Me]^+$ (16), 252 $[M\text{-}Et]^+$ (77), 222 $[M\text{-}CO_2Me]^+$ (100), 208 (54), 192 (70), 59 (66).

3,4-Diethyl-3,5-dimethoxycarbonyl-2,6-dimethyl-3,4-dihydropyridine (2c). ^{1}H NMR spectrum, δ, ppm (*J*, Hz): 0.81 (6H, m, 3,4-$CH_2C\underline{H}_3$); 1.26 (4H, m, 3,4-$C\underline{H}_2CH_3$); 2.27 (3H, s, 2-CH_3); 2.53 (3H, s, 6-CH_3); 2.98 (1H, t, ^3J = 5.0, H-4); 3.70 (3H, s, 3-$COOCH_3$); 3.76 (3H, s, 5-$COOCH_3$).

3,5-Dimethoxycarbonyl-2,6-dimethyl-4-propyl-1,4-dihydropyridine (3). ^{1}H NMR spectrum, δ, ppm (*J*, Hz): 0.81 (3H, t, ^3J = 7.0, 4-$CH_2CH_2C\underline{H}_3$); 1.23 (4H, m, 4-$C\underline{H}_2C\underline{H}_2CH_3$); 2.25 (6H, s, 2,6-$CH_3$); 3.67 (6H, s, 3,5-$COOCH_3$); 3.91 (1H, t, ^3J = 5.0, H-4); 5.69 (1H, s, NH).

3,5-Dimethoxycarbonyl-2,6-dimethyl-4-propylpyridine (3a). ^{1}H NMR spectrum, δ, ppm (*J*, Hz): 0.87 (3H, t, ^3J = 7.0, 4-$CH_2CH_2C\underline{H}_3$); 1.54 (4H, m, 4-$C\underline{H}_2C\underline{H}_2CH_3$); 2.49 (6H, s, 2,6-$CH_3$); 3.93 (6H, s, 3,5-$COOCH_3$). Mass spectrum, *m/z* (I_{rel}, %): 265 $[M]^+$ (11), 250 $[M\text{-}Me]^+$ (59), 234 (100), 218 $[M\text{-}Pr]^+$ (43), 202 (25), 177 (22), 77 (24).

3,5-Dimethoxycarbonyl-6-methyl-2-methylene-3,4-dipropyl-1,2,3,4-tetrahydropyridine (3b). ^{1}H NMR spectrum, δ, ppm (*J*, Hz): 0.80 (6H, m, 3,4-$CH_2CH_2C\underline{H}_3$); 1.51 (8H, m, 3,4-$C\underline{H}_2C\underline{H}_2CH_3$); 2.27 (3H, s, 6-$CH_3$); 3.12 (1H, t, ^3J = 5.0, H-4); 3.67 (3H, s, 3-$COOCH_3$); 3.72 (3H, s, 5-$COOCH_3$); 4.49, 5.00 (2H, two s, $=CH_2$); 5.83 (1H, s, NH). Mass spectrum, *m/z* (I_{rel}, %): 309 $[M]^+$ (42), 280 $[M\text{-}Et]^+$ (71), 266 $[M\text{-}Pr]^+$ (38), 250 $[M\text{-}CO_2Me]^+$ (35), 224 (100), 192 (39), 59 (53).

3,5-Dimethoxycarbonyl-2,6-dimethyl-3,4-dipropyl-3,4-dihydropyridine (3c). ^{1}H NMR spectrum, δ, ppm (*J*, Hz): 0.80 (6H, m, 3,4-$CH_2CH_2C\underline{H}_3$); 1,14 (8H, m, 3,4-$C\underline{H}_2C\underline{H}_2CH_3$); 2.29 (3H, s, 2-$CH_3$); 2.51 (3H, s, 6-$CH_3$); 2.89 (1H, t, ^3J = 5.0, H-4); 3.75 (3H, s, 3-$COOCH_3$); 3.76 (3H, s, 5-$COOCH_3$).

4-Isopropyl-3,5-dimethoxycarbonyl-2,6-dimethyl-1,4-dihydropyridine (4). ^{1}H NMR spectrum, δ, ppm (*J*, Hz): 0.71 (6H, d, ^3J = 6.4, 4-$CH(C\underline{H}_3)_2$); 1.84 (1H, m, 4-$C\underline{H}(CH_3)_2$); 2.29 (6H, s, 2,6-CH_3); 3.70 (6H, s, 3,5-$COOCH_3$); 3.87 (1H, d, ^3J = 5.6, H-4); 5.60 (1H, s, NH).

4-Isopropyl-3,5-dimethoxycarbonyl-2,6-dimethylpyridine (4a). ^{1}H NMR spectrum, δ, ppm (*J*, Hz): 1.25 (6H, d, ^3J = 6.4, 4-$CH(C\underline{H}_3)_2$); 2.44 (6H, s, 2,6-CH_3); 2.90 (1H, m, 4-$C\underline{H}(CH_3)_2$); 3.91 (6H, s, 3,5-$COOCH_3$). Mass spectrum, *m/z* (I_{rel}, %): 265 $[M]^+$ (5), 250 $[M\text{ –}Me]^+$ (100), 234 (24), 200 (96), 91 (16), 77 (20).

4-Isobutyl-3,5-dimethoxycarbonyl-2,6-dimethyl-1,4-dihydropyridine (5). ^{1}H NMR spectrum, δ, ppm (*J*, Hz): 0.83 (6H, d, ^3J = 5.6, 4-$CH_2CH(C\underline{H}_3)_2$); 1.08 (2H, t, ^3J = 6.0, 4-$C\underline{H}_2CH(CH_3)_2$); 1.41 (1H, m, 4-$CH_2C\underline{H}(CH_3)_2$); 2.31 (6H, s, 2,6-$CH_3$); 3.67 (6H, s, 3,5-$COOCH_3$); 3.94 (1H, t, ^3J = 6.4, H-4); 5.71 (1H, s, NH).

4-Isobutyl-3,5-dimethoxycarbonyl-2,6-dimethylpyridine (5a). ^{1}H NMR spectrum, δ, ppm (*J*, Hz): 0.82 (6H, d, ^3J = 5.6, 4-$CH_2CH(C\underline{H}_3)_2$); 1.66 (3H, m, 4-$C\underline{H}_2CH(CH_3)_2$ + 4-$CH_2C\underline{H}(CH_3)_2$); 2.48 (6H, s, 2,6-$CH_3$); 3.89 (6H, s, 3,5-$COOCH_3$). Mass spectrum, *m/z* (I_{rel}, %): 279 $[M]^+$ (5), 264 $[M\text{-}Me]^+$ (26), 248 (100), 222 $[M\text{-}Bu]^+$ (94), 206 (52), 177 (26), 77 (30).

3,4-Diisobutyl-3,5-dimethoxycarbonyl-6-methyl-2-methylene-1,2,3,4-tetrahydropyridine (5b). ^{1}H NMR spectrum, δ, ppm (*J*, Hz): 0.85 (12H, m, 3,4-$CH_2CH(C\underline{H}_3)_2$); 1.53 (4H, m, 3,4-$C\underline{H}_2CH(CH_3)_2$); 1.68 (2H, m, 3,4-$CH_2C\underline{H}(CH_3)_2$); 2.25 (3H, s, 6-$CH_3$); 3.13 (1H, m, H-4); 3.66 (3H, s, 3-$COOCH_3$); 3.69 (3H, s, 5-$COOCH_3$); 4.53, 5.20 (2H, two s, $=CH_2$); 5.80 (1H, s, NH). Mass spectrum, *m/z* (I_{rel}, %): 337 $[M]^+$ (6), 294 $[M\text{-}Pr]^+$ (68), 262 (25), 224 (100), 41 (30).

3,4-Diisobutyl-3,5-dimethoxycarbonyl-2,6-dimethyl-3,4-dihydropyridine (5c). ^{1}H NMR spectrum, δ, ppm: 0.85 (12H, m, 3,4-$CH_2CH(C\underline{H}_3)_2$); 1.53 (4H, m, 3,4-$C\underline{H}_2CH(CH_3)_2$); 1.68 (2H, m, 3,4-$CH_2C\underline{H}(CH_3)_2$); 2.25 (3H, s, 2-$CH_3$); 2.46 (3H, s, 6-$CH_3$); 2.82 (1H, m, H-4); 3.71 (3H, s, 3-$COOCH_3$); 3.74 (3H, s, 5-$COOCH_3$).

3,5-Dimethoxycarbonyl-2,6-dimethylpyridine (6). ^{1}H NMR spectrum ($CDCl_3$), δ, ppm: 2.82 (6H, s, 2,6-CH_3); 3.91 (6H, s, 3,5-$COOCH_3$); 8.66 (1H, s, H-4). ^{1}H NMR spectrum (DMSO-d_6), δ, ppm: 2.71 (6H, s, 2,6-CH_3); 3.85 (6H, s, 3,5-$COOCH_3$); 8.50 (1H, s, H-4). Mass spectrum, *m/z* (I_{rel}, %): 223 $[M]^+$ (55), 192 (100), 164 $[M\text{-}CO_2Me]^+$ (40), 77 (28), 63 (33).

Isopropylnitrilium Perchlorate (8). ^{1}H NMR spectrum (DMSO-d_6), δ, ppm (*J*, Hz): 1.00 (6H, d, ^3J = 7.0, $CH(C\underline{H}_3)_2$); 1.76 (3H, s, CH_3); 3.74 (1H, m, $C\underline{H}(CH_3)_2$).

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