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Reaction of 3,5-Disubstituted 4,5-Dihydroisoxazoles with Hexacarbonylmolybdenum

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Abstract—Depending on the reaction conditions and structure of the 5-substituent, reactions of substituted 4,5-dihydroisoxazoles with hexacarbonylmolybdenum involve cleavage of the heteroring at the N–O bond, its aromatization, or/and 1,3-decyclization.

The use of isoxazole derivatives as synthetic precursors of various acyclic compounds [1] has stimulated extensive studies on the development of preparative methods for implementation of latent functionality of the isoxazole ring. In the last decades, a number of effective procedures have been proposed for the transformation of isoxazole derivatives into difunctional acyclic compounds in the presence of organometallic reagents [2].

While studying the synthesis of prostaglandin analogs via isoxazole methodology [3], we have encountered with the problem of choosing a reagent for selective cleavage of the heteroring in polyfunctional isoxazole derivatives. The most effective was hexacarbonylmolybdenum $Mo(CO)_6$. It ensured opening of the isoxazole ring in compounds containing such groups as HC=CH, C=O, and COOR (i.e., sensitive to reducing agents) to the corresponding 1,3-aminoeneketones in up to 80% yield [4]. The efficiency of $Mo(CO)_6$ as a reagent for cleavage of dihydroisoxazole ring was demonstrated using a series of 5-substituted 4,5-dihydroisoxazoles having alkyl and aryl substituents on C^5. Here, no other products than 1,3-hydroxy ketones (products of heteroring opening at the N–O bond) was observed. However, in the reaction of 5-pyridyl-4,5-dihydroisoxazole (**Ia**) with $Mo(CO)_6$, aprat from the target hydroxy ketone **IIa**, compounds **III**–**VI** were isolated. Their formation indicates more profound decomposition of the isoxazole ring involving additional cleavage of the C^3–C^4 (1,3-decyclization) or C^4–C^5 bond (1,4-decyclization).

The ability of 5-(4-pyridyl)-4,5-dihydroisoxazoles to undergo 1,3-decyclization by the action of some organometallic compounds (such as butyllithium, dimsilsodium, and K-Selectride) was described by us previously [5]. 1,3-Decyclization in the presence of bases was also reported for 5-acyl- and 5-nitrodihydroisoxazoles [6]. However, in the reactions of 4,5-dihydroisoxazoles with polycarbonyl metal complexes, only the corresponding 1,4-decyclization products were isolated [7]. The above decomposition of 5-pyridyl-4,5-dihydroisoxazoles may be caused by the effect of the pyridyl substituent which gives rise to specific interaction with the reagent. With the goal of studying in detail the observed transformations we have synthesized a series of 3,5-disubstituted 4,5-dihydroisoxazoles **Ia**–**Ie** having heterocyclic, aromatic, heteroaromatic, and functional groups and examined their reactions with $Mo(CO)_6$.

Isoxazoles **Ia**–**Ie** were prepared by 1,3-dipolar cycloaddition to 4-vinylpyridine, 1-vinylpyrrolidin-2-one, and 1-vinylimidazole of nitrile oxides generated *in situ* from the corresponding nitro compounds or oxime chlorides [8]. The reactions of compounds **Ia**–**Ie** with $Mo(CO)_6$ were carried out in methanol or acetonitrile under the conditions typical for ring opening in 4,5-dihydroisoxazole derivatives. After primary treatment of the reaction mixture, the products were identified and their ratio was determined by IR and ^{1}H NMR spectroscopy. All products were isolated and characterized by the mass, IR, and ^{1}H NMR spectra.

Depending on the conditions (solvent, temperature, reaction time, presence of water), dihydroisoxazoles **Ia**–**Ie** reacted with $Mo(CO)_6$ to afford compounds **II**–**VII** which correspond to three possible modes of opening of the heteroring, and isoxazole **VIII** can be

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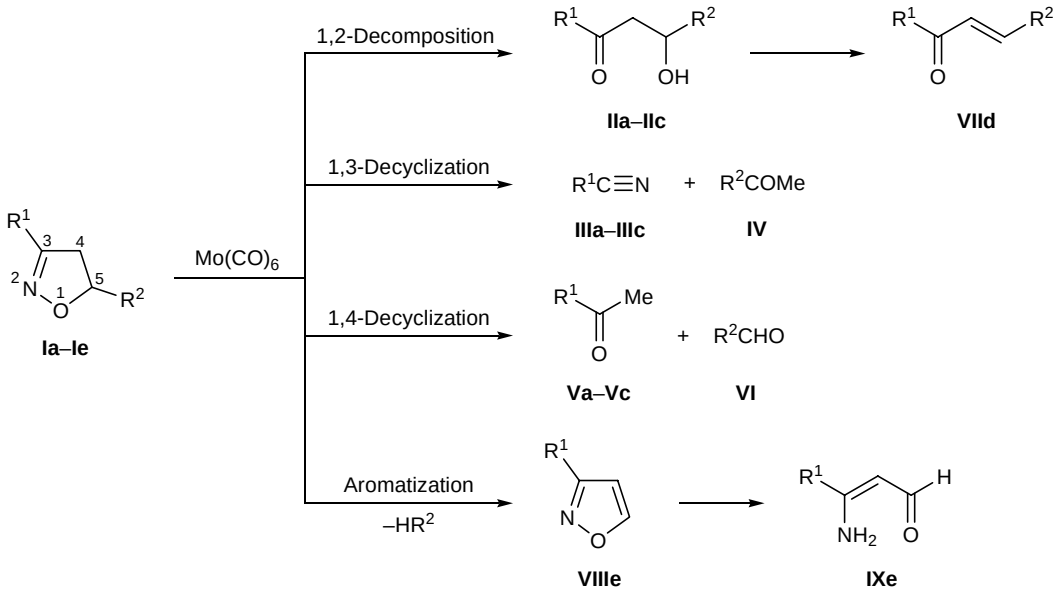
Scheme 1.



R^1 = 2-(6-methoxycarbonylhexyl)-3-oxocyclopentyl, R^2 = 4-pyridyl (**a**); R^1 = 4-methoxycarbonylbutyl, R^2 = 4-pyridyl (**b**); R^1 = 3,4-dimethoxyphenyl, R^2 = 4-pyridyl (**c**); R^1 = 2-(6-methoxycarbonylhexyl)-3-oxocyclopentyl, R^2 = 1-(2-oxopyrrolidinyl) (**d**); R^1 = 2-(6-methoxycarbonylhexyl)-3-oxocyclopentyl, R^2 = 1-imidazolyl (**e**).

regarded as an aromatization product (Scheme 1). According to the ^{1}H NMR data, the reaction mixtures contained 1,3-hydroxy ketones **IIa**–**IIc**, nitriles **IIIa**–**IIIc**, 4-acetylpyridine (**IV**), as well as methyl ketones **Va**–**Vc** and 4-pyridinecarbaldehyde (**VI**). Nitriles **IIIa**–**IIIc** were also identified by the presence in the IR spectrum of a characteristic absorption band at 2225–2260 cm^{-1}, belonging to stretching vibrations of the C≡N bond. 4-Acetylpyridine showed in the ^{1}H NMR spectrum a singlet at δ 2.65 ppm from the acetyl methyl protons and two doublets at δ 7.78 and 8.82 ppm (J = 5.0 Hz) from the aromatic protons, and a band at 1690 cm^{-1} was present in the IR spectrum due to the conjugated carbonyl group. The ^{1}H NMR spectrum of 4-pyridinecarbaldehyde (**VI**) contained a signal at δ 10.28 ppm due to the aldehyde proton, and methyl ketones **Va**–**Vc** gave rise to a three-proton singlet from the methyl protons at δ 2.15–2.18 ppm (**Va**, **Vb**) or 2.78 ppm (**Vc**).

The reaction with $Mo(CO)_6$ in anhydrous acetonitrile was characterized by low conversion of the initial dihydroisoxazole. In 3 h, the overall yield of the corresponding 1,3-hydroxy ketone, nitrile, and 4-acetylpyridine (ratio 8:1:1) from compounds **Ia**–**Ic** was no less than 25%. When the reaction was prolonged to more than 2 days, the products were 4-pyridinecarbaldehyde, ketones **Va**–**Vc**, and traces of hydroxy ketones **IIa**–**IIc**. The presence of traces of water accelerates the process, and dihydroisoxazoles **Ia**–**Ic** in 6 h are completely converted into mixtures of ketones **IIa**–**IIc** (up to 45%) together with 4-acetylpyridine and the corresponding nitrile (10–15%).

The absence of aldehyde **VI** in the reaction mixture in 3 h after the reaction started suggests that pyridinecarbaldehyde and methyl ketone **V** are products of retro-aldol decomposition of initially formed hydroxy ketone **II** rather than of synchronous 1,4-decyclization of dihydroisoxazole. In fact, considering dihydroisoxazoles to be a latent form of β-hydroxy ketones, and the formation of dihydroisoxazoles and their decomposition to hydroxy ketones, an equivalent of aldol condensation, the 1,4-decyclization may be regarded as retro-aldol decomposition. Obviously, the decomposition of hydroxy ketone occurs with participation of $Mo(CO)_6$. As a rule, the complete conversion of dihydroisoxazole is attained in 2 days with formation of compounds **III**–**VI**. When the reaction was carried out in anhydrous methanol, only the unchanged initial compounds were isolated, while the main reaction pathway in aqueous methanol was 1,3-decyclization.

The structure of the 5-substituent is an important factor determining the mode of ring opening in dihydroisoxazoles by the action of $Mo(CO)_6$. Presumably, the presence of a pyridyl group in position *5* favors 1,3-decyclization; however, this substituent

does not affect the ability of hydroxy ketone thus formed to undergo retro-aldol reaction. For example, hydroxy ketones **IIa** and **IIb** are more stable than **IIc**, and the amount of 1,3-decyclization products in the reaction mixture attains 15%. If both substituents in 4,5-dihydroisoxazole are aromatic (as in compound **Ic**), 1,3-decyclization competes with 1,2-decomposition. After 3 h, the reaction mixture contains compounds **II**, **III**, and **IV** at a ratio of 1:2:2; after 2 days, no hydroxy ketone **II** was present, but pyridinecarbaldehyde (δ, ppm: 10.28, 7.50, 8.75 ppm) and methyl 3,4-dimethoxyphenyl ketone (**Vc**; δ 2.75 ppm, MeCO) were identified instead.

5-(2-Oxo-1-pyrrolidinyl)-4,5-dihydroisoxazole (**Id**) did not react with $Mo(CO)_6$ in anhydrous acetonitrile. In the presence of water, the major product was enone **VIId** which was formed as a result of dehydration of hydroxy ketone **IId**. Enone **VIId** was isolated in a preparative yield. Obviously, the formation of **VIId** is favored by conjugation between the heteroatom and carbonyl group in the pyrrolidine ring.

The reaction of 5-imidazolylisoxazole (**Ie**) with $Mo(CO)_6$ leads to formation of enaminoaldehyde **IXe** in 40% yield. Obviously, compound **IXe** is the product of reductive cleavage of intermediate isoxazole **VIIIe** which is formed in turn by aromatization of the dihydroisoxazole ring via elimination of imidazole molecule. The aromatization is likely to be favored by the presence of a readily departing group at C^5. This is also confirmed by the formation of a considerable amount of isoxazole **VIIIe** as by-product in the synthesis of 5-imidazolyl-4,5-dihydroisoxazole and by the failure to obtain 3-veratryl-5-(1-imidazolyl)-4,5-dihydroisoxazole. In the latter case, cycloaddition of 3,4-dimethoxybenzonitrile oxide to 1-vinylimidazole afforded 3-veratrylisoxazole [9].

It should be noted that 1,3-decyclization of 5-(4-pyridyl)-4,5-dihydroisoxazoles by the action of $Mo(CO)_6$ has never been observed for analogous 5-phenyl-4,5-dihydroisoxazoles. However, Nitta and Kobayashi [10] described 1,4-decyclization products formed by the action of $Mo(CO)_6$ on 5-phenyl-substituted 4,5-dihydroisoxazoles in anhydrous acetonitrile [10].

EXPERIMENTAL

The ^{1}H NMR spectra were recorded on a Bruker AC-200 spectrometer (200 MHz) from solutions in $CDCl_3$ containing TMS as internal reference. The IR spectra were measured on a UR-20 instrument from samples prepared as thin films. The mass spectra (70 eV) were run on a Varian MAT-311 mass spectrometer. The progress of reactions and the purity of products were monitored by TLC on Silufol UV-254 (Serva) and Kieselgel 60 F_{254} plates (Merck) using hexane–ether (65:35) or chloroform–methanol (85:15) as eluent; spots were visualized by UV irradiation or by treatment with iodine or a mixture of EtOH (90%), H_2SO_4 (5%), and 4-methoxybenzaldehyde (5%). Silica gel 40/100 μm (Czechia) was used for column chromatography. Preparative thin-layer chromatography was performed on Kieselgel L 5/40 μm applied to glass plates using a solution of 5% of methanol in chloroform as eluent.

Initial 4,5-dihydroisoxazoles **Ia**–**Ie** were synthesized by the procedures described in [8, 11] and were isolated as oily substances.

3-[2-(6-Methoxycarbonylhexyl)-3-oxocyclopentyl]-5-(4-pyridyl)-4,5-dihydroisoxazole (Ia). Yield 85%. IR spectrum, ν, cm^{-1}: 1600, 1610, 1740. ^{1}H NMR spectrum, δ, ppm: 1.20–2.00 m (13H, CH_2), 2.26 m (4H, C**H**$_2$CO$_2$Me, C**H**$_2$CO), 2.92 d.d (1H, 4-H, isoxazole, J = 18.0, 7.0 Hz), 2.98 m (1H, C**H**C=N–O), 3.50 d.d (1H, 4-H, isoxazole, J = 18.0, 10.0 Hz), 3.68 s (3H, OCH_3), 5.63 d.d (1H, J = 10.0, 7.0 Hz, 5-H, isoxazole), 7.24 m and 8.60 m (4H, pyridine). Mass spectrum, m/z: 372 $[M]^+$. Found, %: C 67.84; H 7.49; N 7.56. $C_{21}H_{28}N_2O_4$. Calculated, %: C 67.72; H 7.58; N 7.52.

3-(4-Methoxycarbonylbutyl)-5-(4-pyridyl)-4,5-dihydroisoxazole (Ib). Yield 80%. IR spectrum, ν, cm^{-1}: 1520, 1580, 1600, 1730. ^{1}H NMR spectrum, δ, ppm: 1.68 m (4H, CH_2C**H**$_2$C**H**$_2$CH$_2$CO$_2$Me), 2.38 m (4H, C**H**$_2$(CH$_2$)$_2$CH$_2$CO$_2$Me), 2.84 d.d (1H, 4-H, isoxazole, J = 17.0, 7.0 Hz), 3.46 d.d (1H, 4-H, isoxazole, J = 17.0, 11.0 Hz), 3.66 s (3H, OCH_3), 5.66 d.d (1H, 5-H, isoxazole, J = 11.0, 7.0 Hz), 7.26 d and 8.62 d (4H, J = 4.5 Hz, pyridine). Mass spectrum, m/z: 274 $[M]^+$. Found, %: C 65.58; H 6.67; N 10.23. $C_{15}H_{18}N_2O_3$. Calculated, %: C 65.68; H 6.61; N 10.21.

3-(3,4-Dimethoxyphenyl)-5-(4-pyridyl)-4,5-dihydroisoxazole (Ic). Yield 80%. IR spectrum, ν, cm^{-1}: 1025, 1520, 1605, 1650, 1720. ^{1}H NMR spectrum, δ, ppm: 3.38 d.d (1H, 5-H, isoxazole, J = 7.5, 17.0 Hz), 3.86 d.d (1H, 4-H, isoxazole, J = 11.0, 17.0 Hz), 3.96 s and 3.87 s (6H, OCH_3), 5.74 d.d (1H, 5-H, isoxazole, J = 7.5, 11.0 Hz), 6.30 d.d and 7.72 d (3H, C_6H_3, J = 8.5, 2.0, 8.5 Hz), 7.34 d and 8.60 d (4H, pyridine, J = 5.0 Hz). Mass spectrum, m/z: 284 $[M]^+$. Found, %:

C 67.68; H 5.62; N 9.91. $C_{16}H_{16}N_2O_3$. Calculated, %: C 67.59; H 5.67; N 9.85.

3-[2-(6-Methoxycarbonylhexyl)-3-oxo-3-cyclopentyl]-5-(2-oxo-1-pyrrolidinyl)-4,5-dihydroisoxazole (Id). Yield 80%. IR spectrum, ν, cm^{-1}: 1610, 1640, 1710, 1750. ^1H NMR spectrum, δ, ppm: 1.40–2.00 m (14H, CH_2), 2.12 m (1H, C**H**C=O, cyclopentyl), 2.38 t (4H, C**H**$_2$CO$_2$Me, CH_2CO, J = 8.0 Hz), 2.5 t (2H, CH_2CO, pyrrolidine, J = 8.0 Hz), 2.82 d.d (1H, 4-H, isoxazole, J = 3.0, 17.5 Hz), 2.98 m (1H, CHC=N–O, cyclopentyl, J = 11.0 Hz), 3.18 m and 3.36 m (1H, 4-H, isoxazole), 3.66 s (3H, OCH_3), 6.56 d.d (1H, 5-H, isoxazole, J = 3.0, 10.0 Hz), 3.34 m (2H, CH_2N, pyrrolidine). Mass spectrum, *m*/*z*: 378 $[M]^+$. Found, %: C 63.56; H 7.92; N 7.33. $C_{20}H_{30}N_2O_5$. Calculated, %: C 63.47; H 7.99; N 7.40.

5-(1-Imidazolyl)-3-[2-(6-methoxycarbonylhexyl)-3-oxocyclopentyl]-4,5-dihydroisoxazole (Ie). Yield 55%. IR spectrum, ν, cm^{-1}: 1605, 1740. ^1H NMR spectrum, δ, ppm: 1.20–2.00 m (13H, CH_2,); 2.26 m (4H, C**H**$_2$CO$_2$Me, CH_2CO); 3.05 q (1H, CHC=N–O, cyclopentyl); 3.15 and 3.24 d.t (1H, 4-H, isoxazole, J = 18.0, 3.5 Hz,); 3.54 q (1H, 4-H, isoxazole, J = 18.0, 9.0 Hz): 3.66 s (3H, OCH_3), 6.44 d.d (1H, 5-H, J = 9.0, 3.5 Hz; 6.90 s, 7.12 s, 7.68 s (3H, imidazole). Mass spectrum, *m*/*z*: 361 $[M]^+$. Found, %: C 62.99; H 7.59; N 11.70. $C_{19}H_{27}N_3O_4$. Calculated, %: C 63.14; H 7.53; N 11.63.

Reaction of 4,5-dihydroisoxazoles with hexacarbonylmolybdenum (*general procedure***).** Water, 1 mmol, and hexacarbonylmolybdenum, 0.5–1 mmol, were added to a solution of 1 mmol of isoxazole **I** in 20 ml of acetonitrile or methanol, and the mixture was heated for 8–24 h under reflux, the progress of the reaction being monitored by TLC. The mixture was diluted with hexane or hexane–benzene (1:1) and filtered through celite 545, the filtrate was evaporated, and the residue was subjected to column chromatography on silica gel using diethyl ether as eluent. The products were isolated by column chromatography or preparative thin-layer chromatography with an overall yield of 55–70%. The isolated compounds were colorless oily substances.

3-Hydroxy-1-[2-(6-methoxycarbonylhexyl)-3-oxocyclopentyl]-3-(4-pyridyl)-1-propanone (IIa). Yield 56%. IR spectrum, ν, cm^{-1}: 600, 1710, 1735, 3380. ^1H NMR spectrum, δ, ppm: 1.20–2.00 m (12H, CH_2, CH), 2.30 t (4H, C**H**$_2$CO$_2$Me, CH_2CO, J = 8.0 Hz), 2.58 m (1H, CHC=O, cyclopentyl), 2.83 d.d (1H, COC**H**CHOH, J = 18.0, 3.0 Hz,], 2.92 m (1H, CHC=O, cyclopentyl), 3.03 d.d (1H, C**H**CHOH, J = 18.0, 8.0 Hz), 3.68 s (3H, OCH_3), 5.28 d.d (1H, C**H**OH, J = 8.0, 3.0 Hz), 7.23 m and 8.60 m (4H, pyridyl). Mass spectrum, *m*/*z*: 375 $[M]^+$. Found, %: C 67.04; H 7.80; N 3.78. $C_{21}H_{29}NO_5$. Calculated, %: C 67.18; H 7.78; N 3.73.

3-Hydroxy-1-(4-methoxycarbonylbutyl)-3-(4-pyridyl)-1-propanone (IIb). Yield 50%. IR spectrum, ν, cm^{-1}: 1600, 1710, 1740, 3400. ^1H NMR spectrum, δ, ppm: 1.58 m (4H, CH_2C**H**$_2C$**H**$_2CH_2CO_2$Me); 2.28–2.60 m (4H, C**H**$_2(CH_2)_2C$**H**$_2CO_2$Me); 2.80 d.d (2H, COC**H**$_2$CHOH, J = 5.0 Hz); 5.70 m (1H, C**H**OH); 7.39 d, 7.68 d, 8.56 d, and 8.65 d (4H, pyridyl, J = 5.0 Hz). Mass spectrum, *m*/*z*: 265 $[M]^+$. Found, %: C 63.30; H 7.28; N 5.38. $C_{14}H_{19}NO_4$. Calculated, %: C 63.38; H 7.22; N 5.28.

1-(3,4-Dimethoxyphenyl)-3-hydroxy-3-(4-pyridyl)-1-propanone (IIc). Yield 54%. IR spectrum, ν, cm^{-1}: 1025, 1610, 1670, 3450. ^1H NMR spectrum, δ, ppm: 3.26 d.d (1H, CHC**H**OH, J = 9.0, 16.0 Hz), 3.44 d.d (1H, C**H**CHOH) 3.89 s and 3.91 s (6H, OCH_3), 5.28 d.d (1H, C**H**OH, J = 9.0, 3.0 Hz), 6.44 d (1H, 3-H in C_6H_3, J = 1.5 Hz), 6.56 d.d (1H, 5-H in C_6H_3, J = 1.5 Hz), 7.36 d (2H, pyridine, J = 5.0 Hz), 7.88 d (1H, 6-H in C_6H_3, J = 8.5 Hz), 8.56 br.s (2H, pyridine). Mass spectrum, *m*/*z*: 287 $[M]^+$. Found, %: C 67.00; H 5.95; N 4.90. $C_{16}H_{17}NO_4$. Calculated, %: C 66.89; H 5.96; N 4.88.

7-(2-Cyano-5-oxocyclopentyl)heptanoic acid (IIIa). Yield 60%. IR spectrum, ν, cm^{-1}: 1740, 2245, 3500. ^1H NMR spectrum, δ, ppm: 1.2–2.00 m (13H, CH_2, CH), 2.35 t (4H, C**H**$_2$COOH, CH_2CO, J = 8.0 Hz), 2.65 d.d.d (1H, CHCN, J = 11.7, 10.0, 6.5 Hz), 5.0 br.s (COOH). Mass spectrum, *m*/*z*: 237 $[M]^+$. Found, %: C 65.94; H 7.95; N 5.85. $C_{13}H_{19}NO_3$. Calculated, %: C 65.80; H 8.07; N 5.90.

5-Cyanopentanoic acid (IIIb). Yield 60%. IR spectrum, ν, cm^{-1}: 1260, 1690, 1710, 2260, 3400. ^1H NMR spectrum, δ, ppm: 1.20–1.70 m (4H, CH_2), 2.40 m (4H, C**H**$_2$CH, C**H**$_2$COOH). Mass spectrum, *m*/*z*: 127 $[M]^+$. Found, %: C 56.31; H 7.24; N 11.06. $C_6H_9NO_2$. Calculated, %: C 56.68; H 7.13; N 11.02.

3,4-Dimethoxybenzonitrile (IIIc). Yield 60%. IR spectrum, ν, cm^{-1}: 810, 1030, 1580, 1610, 2220. ^1H NMR spectrum, δ, ppm: 3.85 s and 3.90 s (6H, OMe), 6.46 d (1H, 2-H, J = 1.7 Hz), 6.50 d.d (1H, 6-H,

J = 10.0, 1.7 Hz), 7.46 d (1H, 5-H, *J* = 10.0 Hz). Mass spectrum, *m*/*z*: 163 $[M]^+$. Found, %: C 66.33; H 5.58; N 8.61. $C_9H_9NO_2$. Calculated, %: C 66.25; H 5.56; N 8.58.

4-Acetylpyridine (IV). IR spectrum, ν, cm^{-1}: 1600, 1690, 1740. ^1H NMR spectrum, δ, ppm: 2.65 s (3H, CH_3CO), 7.78 d and 8.82 d (4H, pyridine, *J* = 5.0 Hz). Mass spectrum, *m*/*z*: 121 $[M]^+$. Found, %: C 69.37; H 5.89; N 11.58. C_7H_7NO. Calculated, %: C 69.41; H 5.82; N 11.56.

Methyl 7-(2-acetyl-5-oxocyclopentyl)heptanoate (Va). Yield 20%. IR spectrum, ν, cm^{-1}: 1500, 1715, 1740. ^1H NMR spectrum, δ, ppm: 1.64–1.80 m (13H, CH_2, CH), 2.18 s (3H, CH_3CO), 2.35 t (4H, C**H**$_2$COOMe, CH_2CO, *J* = 8.0 Hz), 2.9 m (1H, C**H**CO, cyclopentyl), 3.68 s (3H, OCH_3). Mass spectrum, *m*/*z*: 268 $[M]^+$. Found, %: C 67.09; H 8.91. $C_{15}H_{24}O_4$. Calculated, %: C 67.16; H 8.95.

Methyl 5-oxohexanoate (Vb). IR spectrum, ν, cm^{-1}: 1735–1750. ^1H NMR spectrum, δ, ppm: 1.68–1.72 m (4H, CH_2), 2.15 s (3H, CH_3CO), 2.35 m (4H, CH_2CO), 3.68 s (3H, OCH_3). Mass spectrum, *m*/*z*: 158 $[M]^+$. Found, %: C 60.78; H 9.01. $C_8H_{14}O_3$. Calculated, %: C 60.74; H 8.92.

1-(3,4-Dimethoxyphenyl)ethanone (Vc). IR spectrum, ν, cm^{-1}: 830, 1035, 1570, 1605. ^1H NMR spectrum, δ, ppm: 2.78 s (3H, CH_3CO) 6.42–6.55 m and 7.82 m (3H, H_{arom}), 3.86 s and 3.87 s (6H, OCH_3). Mass spectrum, *m*/*z*: 180 $[M]^+$. Found, %: C 66.60; H 6.82. $C_{10}H_{12}O_3$. Calculated, %: C 66.65; H 6.71.

4-Pyridinecarbaldehyde (VI). IR spectrum, ν, cm^{-1}: 1600, 1710. ^1H NMR spectrum, δ, ppm: 7.50 m and 8.75 m (4H, pyridine), 10.28 s (1H, CHO). Mass spectrum, *m*/*z*: 107 $[M]^+$. Found, %: C 67.39; H 4.61; N 13.15. C_6H_5NO. Calculated, %: C 67.28; H 4.70; N 13.08.

1-[2-(6-Methoxycarbonylhexyl)-3-oxocyclopentyl]-3-(2-oxo-1-pyrrolidinyl)-2-propen-1-one (VIId). Yield 50%. IR spectrum, ν, cm^{-1}: 1630, 1690, 1750. ^1H NMR spectrum, δ, ppm: 1.4–2.00 m (15H, CH_2, CH), 2.38 t (4H, C**H**$_2$CO$_2$Me, CH_2CO, *J* = 8.0 Hz), 2.5 t (2H, CH_2CO, pyrrolidine, *J* = 8.0 Hz), 3.24 m (1H, CHCO, cyclopentyl), 3.6 t (2H, CH_2N, *J* = 7.5 Hz), 3.68 s (3H, OCH_3), 5.64 d (1H, OCC**H**=CHN, *J* = 14.5 Hz), 8.14 d (1H, OCCH=C**H**N). Mass spectrum, *m*/*z*: 363 $[M]^+$. Found, %: C 66.15; H 8.08; N 3.83. $C_{20}H_{29}NO_5$. Calculated, %: C 66.09; H 8.04; N 3.85.

3-[2-(6-Methoxycarbonylhexyl)-3-oxocyclopentyl]isoxazole (VIII). Yield 63%. IR spectrum, ν, cm^{-1}: 1560, 1595, 1730, 3440. ^1H NMR spectrum, δ, ppm: 1.30–2.10 m (13H, CH_2, CH), 2.28 t (4H, C**H**$_2$CO$_2$Me, CH_2CO, *J* = 8.0 Hz), 3.18 m (1H, 3-CH), 3.65 s (3H, OCH_3), 6.10 d (1H, 4-H, *J* = 1.0 Hz), 8.35 d (1H, 5-H, *J* = 1.0 Hz). Mass spectrum, *m*/*z*: 293 $[M]^+$. Found, %: C 65.38; H 7.79; N 4.80. $C_{16}H_{23}NO_4$. Calculated, %: C 65.51; H 7.90; N 4.77.

3-Amino-3-[2-(6-methoxycarbonylhexyl)-3-oxocyclopentyl]-2-propenal (IX). Yield 40%. IR spectrum, ν, cm^{-1}: 1540, 1625, 1740, 3200, 3440. ^1H NMR spectrum, δ, ppm: 1.30–2.00 m (13H, CH_2, CH), 2.30 t (4H, C**H**$_2$CO$_2$CH$_3$, C**H**$_2$CO, *J* = 8.0 Hz), 2.98 m (1H, C**H**CNH_2), 3.65 s (3H, OCH_3), 5.12 br.s (1H, NH_2C=C**H**, *J* = 2.5 Hz), 9.18 d (1H, CHO, *J* = 2.5 Hz), 5.4, 10.0 br.s (2H, NH_2). Mass spectrum, *m*/*z*: 295 $[M]^+$. Found, %: C 65.21; H 8.63; N 4.65. $C_{16}H_{25}NO_4$. Calculated, %: C 65.06; H 8.53; N 4.74.

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