6,6-Disubstituted Furo[3,4-*c*]isoxazoles and 7,7-Disubstituted Pyrano-[3,4-*c*]isoxazoles from Intramolecular Cycloaddition Reactions

Raphaël Schneider, Philippe Gérardin and Bernard Loubinoux*

Laboratoire de Chimie Organique 4,
Université de Nancy I, Faculté des Sciences,
BP 239, 54506 Vandoeuvre-les-Nancy, France

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The reaction of β-nitroenones with unsaturated alkoxides anions, followed by intramolecular 1,3-dipolar cycloaddition, afforded in good yields 6,6-disubstituted furo[3,4-*c*]isoxazoles and 7,7-disubstituted pyrano[3,4-*c*]isoxazoles.

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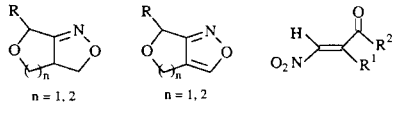
Introduction.

1,3-Dipolar cycloaddition of nitrile oxides or silyl nitronates to alkenes or alkynes allowed the construction of a variety of functionalized carbon skeletons. The cycloadducts, 2-isoxazolines or isoxazoles, may serve as precursors for various classes of compounds [1-5].

Recently, furo[3,4-*c*]isoxazoles and pyrano[3,4-*c*]isoxazoles **I** and related compounds **II** have been prepared by addition of unsaturated alkoxide anions to simple nitroolefines followed by intramolecular nitrile oxide (INOC) or silyl nitronate (ISOC) cycloadditions [6-11].

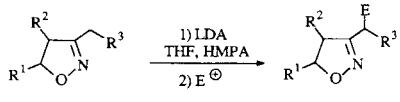


I II III

We have recently reported the synthesis of cyclic and acyclic β-nitroenones **III** [12,13]. It was of interest to study the behaviour of this class of compounds under the conditions mentioned here above since functionalisation of monosubstituted bicyclic derivatives **I** or **II** in position 6 (n = 1) or 7 (n = 2) may be difficult.

The deprotonation of compound **I** has never been studied but the alkylation of the lithium azaenolate of 3,4-disubstituted isoxazolines was reported to take place regioselectively in position 3α (Scheme 1) [14,15].

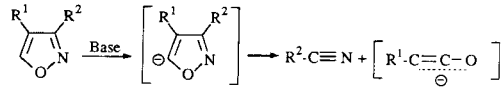
Scheme 1



Deprotonation of 3,4-disubstituted and 5-unsubstituted isoxazoles in position 3α is impossible. When these compounds were made to react with bases, a cleavage of both N-O and C_3-C_4 bonds was generally observed (Scheme 2) [5].

In this paper, we present some new bicyclic 2-isoxazolines **V** and isoxazoles **VI** obtained *via* 1,3-dipolar cycloaddition. These compounds are not only disubstituted on position 6 or 7, but one of the two substituents is an acyl group. Its presence should allow further functionalisations on the lateral chain.

Scheme 2



Results and Discussion.

The addition of unsaturated alkoxides to β-nitroenones **III** was performed accordingly to the procedure described recently by Kurth *et al.* [16]. A tetrahydrofuran solution of **III** was added dropwise at a rate of 0.1 ml/minute to two equivalents of the sodium or potassium alkoxide at −40°. When potassium hydride was used to deprotonate the alcohol, the reaction mixture must be quenched immediately after the end of the addition at −40° to avoid the formation of several by-products.

β-Nitroethers **IVa-n** were obtained in good to excellent yields after purification by chromatography on silica gel (Table 1).

We compared yields and stereochemistry of products **V** obtained by INOC and ISOC processes starting from unsaturated β-nitroethers **IV**.

A. 2-Isoxazolines **V** from Nitrile Oxides.

The procedure, first described by Mukaiyama and Hoshino [17], consisting in the dehydration of the primary

Scheme 3

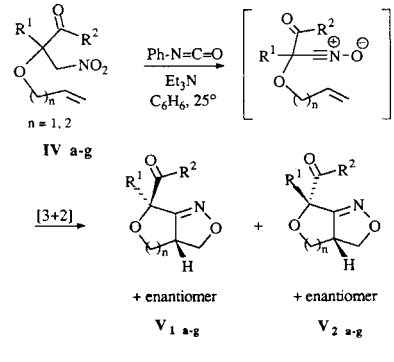
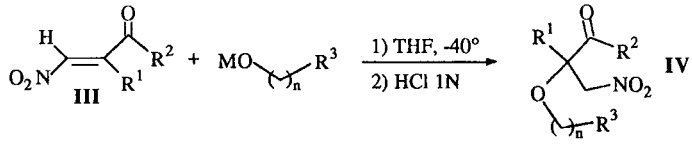


Table 1



Compound	R^1	R^2	R^3	n	M	Yield	Formula	Analysis. % Calcd./Found C	H	N
IVa	CH_3	CH_2CH_3	$CH=CH_2$	1	Na	57	$C_9H_{15}NO_4$	53.72 53.80	7.51 7.40	6.96 7.00
IVb	CH_3	$(CH_2)_4CH_3$	$CH=CH_2$	1	Na	65	$C_{12}H_{21}NO_4$	59.24 59.10	8.70 8.80	5.76 5.80
IVc	CH_3	$CH(CH_3)_2$	$CH=CH_2$	1	Na	62	$C_{10}H_{17}NO_4$	55.80 55.70	7.96 8.10	6.51 6.50
IVd	CH_2CH_3	CH_3	$CH=CH_2$	1	Na	55	$C_9H_{15}NO_4$	53.72 53.60	7.51 7.50	6.96 7.00
IVe	CH_3	CH_3	$CH=CH_2$	2	K	61	$C_9H_{15}NO_4$	53.72 53.70	7.51 7.50	6.96 6.80
IVf	CH_3	$CH(CH_3)_2$	$CH=CH_2$	2	K	53	$C_{11}H_{19}NO_4$	57.63 57.60	8.35 8.50	6.11 6.10
IVg	CH_2CH_3	CH_3	$CH=CH_2$	2	K	55	$C_{10}H_{17}NO_4$	55.80 55.70	7.96 7.90	6.51 6.60
IVh	CH_3	CH_3	$C\equiv CH$	1	Na	82	$C_8H_{11}NO_4$	51.89 51.70	5.99 6.10	7.56 7.50
IVi	CH_3	CH_2CH_3	$C\equiv CH$	1	Na	97	$C_9H_{13}NO_4$	54.26 54.10	6.58 6.60	7.03 7.10
IVj	CH_3	$(CH_2)_4CH_3$	$C\equiv CH$	1	Na	96	$C_{12}H_{19}NO_4$	59.73 59.70	7.94 8.00	5.80 5.90
IVk	CH_3	$CH(CH_3)_2$	$C\equiv CH$	1	Na	98	$C_{10}H_{15}NO_4$	56.33 56.20	7.09 7.10	6.57 6.50
IVl	CH_2CH_3	CH_3	$C\equiv CH$	1	Na	86	$C_9H_{13}NO_4$	54.26 54.30	6.58 6.60	7.03 6.90
IVm	CH_3	CH_2CH_3	$C\equiv CH$	2	K	55	$C_{10}H_{15}NO_4$	56.33 56.30	7.09 7.20	6.57 6.50
IVn	CH_2CH_3	CH_3	$C\equiv CH$	2	K	66	$C_{10}H_{15}NO_4$	56.33 56.20	7.09 7.20	6.57 6.50

nitromethyl group into nitrile oxide in the presence of phenyl isocyanate and triethylamine, was applied to the synthesis of furo[3,4-*c*]isoxazoles (n = 1) and pyrano[3,4-*c*]-isoxazoles (n = 2) **V** (Scheme 3).

The diastereomeric furo[3,4-*c*]isoxazoles and pyrano[3,4-*c*]isoxazoles $\mathbf{V_1}$ and $\mathbf{V_2}$ were obtained in good yields but the diastereoselectivity was poor (Table 2). The same results were obtained by others when chiral nitrile oxides bearing no bulky groups in the β position of the nitrile oxide cycloadded to alkenes [6-9].

B. 2-Isoxazolines **V** from Silyl Nitronates.

Silyl nitronates were used more rarely in 1,3-dipolar intramolecular cycloadditions than nitrile oxides. When furo[3,4-*c*]isoxazoles were formed, the ISOC process was much more stereoselective starting from α-monosubstituted β-nitroethers than the INOC process [8]. The diastereomer of compound **I** with the ring junction proton and the proton adjacent to the R group in a *trans* relationship was obtained almost exclusively.

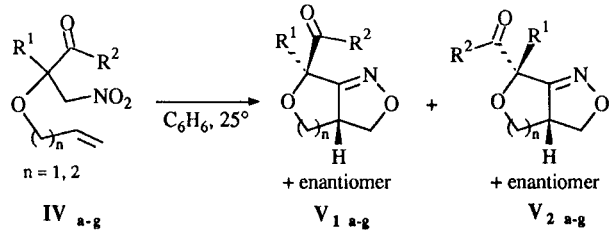
When compounds **IVa-d** were allowed to react with triethylamine and trimethylchlorosilane in benzene at room temperature, the corresponding diastereomeric furo[3,4-*c*]-isoxazoles $\mathbf{V_1}$ and $\mathbf{V_2}$ were obtained in good yields, after hydrolysis of the intermediate *N*-trimethylsilyloxyisoxazolidine with aqueous 1*N* hydrochloric acid (Scheme 4).

The cycloaddition into 6-membered heterocycles was more difficult. Pyrano[3,4-*c*]isoxazole **Ve** was obtained in 86% yield after 48 hours reaction time. Starting unsaturated β-nitroethers **IVf-g** were only isolated when hydrolysis was performed after 56 hours.

The results reported in Table 2 demonstrate that the chiral carbon α to the nitrile oxide or the silyl nitronate could affect olefin face selectivity. We found that, when $R^1 = CH_3$, the main diastereomer of the substituted tetrahydrofurans **Va-c** obtained by the INOC process became minor by the ISOC process.

The stereochemistry determination of products **V** was

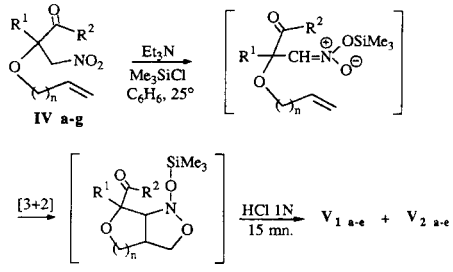
Table 2



IV a-g V1 a-g V2 a-g

Compound	R1	R2	n	INOC PROCESS Reaction time (h)	INOC PROCESS Diastereomeric ratio V1/V2	INOC PROCESS Yield %	ISOC PROCESS Reaction time (h)	ISOC PROCESS Diastereomeric ratio V1/V2	ISOC PROCESS Yield %	Formula	Analysis. % Calcd./Found C	H	N
Va	CH_3	CH_2CH_3	1	12	53/47	94	12	40/60	85	$C_9H_{13}NO_3$	59.00 58.90	7.15 7.10	7.65 7.70
Vb	CH_3	$(CH_2)_4CH_3$	1	12	65/35	84	12	21/79	78	$C_{12}H_{19}NO_3$	63.98 63.90	8.50 8.40	6.22 6.20
Vc	CH_3	$CH(CH_3)_2$	1	12	53/47	90	12	32/68	79	$C_{10}H_{15}NO_3$	60.90 60.80	7.67 7.70	7.10 7.20
Vd	CH_2CH_3	CH_3	1	12	67/33	76	12	51/49	75	$C_9H_{13}NO_3$	59.00 58.90	7.15 7.10	7.65 7.70
Ve	CH_3	CH_3	2	24	30/70	88	48	36/64	86	$C_9H_{13}NO_3$	59.00 59.00	7.15 7.00	7.65 7.70
Vf	CH_3	$CH(CH_3)_2$	2	24	45/55	86	56	-	0	$C_{11}H_{17}NO_3$	62.54 62.70	8.11 8.10	6.63 6.70
Vg	CH_2CH_3	CH_3	2	24	37/63	93	56	-	0	$C_{10}H_{15}NO_3$	60.90 60.80	7.67 7.50	7.10 7.10

Scheme 4



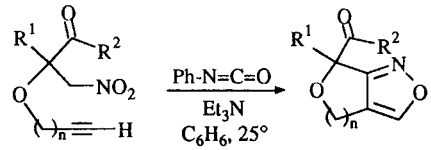
accomplished by ^{1}H-nmr on the two diastereomers of compounds **Vf** which were easily separated by silica gel chromatography. NOE experiments did not permit us to assign the stereochemistry (irradiation of the methyl group (C_7) caused no variation of the signal of the ring junction proton in both diastereomers). The ^{1}H-nmr spectra, recorded in deuteriochloroform, showed on the other hand a variation of the shifting of the C_{3a} proton in both diastereomers. The signal of this proton appeared at lower field (δ (H_{C3a}) = 3.53 ppm) in the minor isomer that in the major isomer (δ (H_{C3a}) = 3.32 ppm). The difference may be attributed to the anisotropic effect exerted by the carbonyl function. A *cis* relationship between the carbonyl group and the C_{3a} proton would be present in the minor isomer. To confirm this assignment, we have recorded the ^{1}H-nmr spectra of both diastereomers in methanol-D_4. This solvent complexes strongly the carbonyl group through hydrogen bond and should modify more significantly the signal of the C_{3a} proton in the minor isomer than in the major isomer. This hypothesis was confirmed. The chemical shift of the C_{3a} proton didn't change in the major isomer but was displaced at 3.64 ppm in the minor isomer.

The stereochemistry attribution of compounds **V** obtained by the INOC process is in agreement with those made previously by Hassner *et al.* and Kurth *et al.* on compounds **I** [6-9]. When 7-monosubstituted 3,3a,4,5-tetrahydro-7*H*-pyrano[3,4-*c*]isoxazoles were formed, the diastereomer containing the C_{3a} proton and the less bulkiness group H in a *cis* relationship was preferred. In contrast, when 6-monosubstituted furo[3,4-*c*]isoxazoles were formed, a *trans* relationship between this two groups was preferred.

C. Isoxazoles **VI**.

Furo and pyrano[3,4-*c*]isoxazoles **VI**, obtained in high

Table 3



Compound	R1	R2	n	Reaction time (h)	Yield %	Formula	Analysis. % Calcd./Found C	H	N
VI a	CH_3	CH_3	1	12	86	$C_8H_9NO_3$	57.48 57.60	5.43 5.40	8.38 8.40
VI b	CH_3	CH_2CH_3	1	12	99	$C_9H_{11}NO_3$	59.66 59.60	6.12 6.60	7.73 7.80
VI c	CH_3	$(CH_2)_4CH_3$	1	12	85	$C_{12}H_{17}NO_3$	64.55 64.60	7.67 7.80	6.27 6.20
VI d	CH_3	$CH(CH_3)_2$	1	12	92	$C_{10}H_{13}NO_3$	61.53 61.50	6.71 6.70	7.17 7.20
VI e	CH_2CH_3	CH_3	1	12	89	$C_9H_{11}NO_3$	59.66 59.60	6.12 6.10	7.73 7.70
VI f	CH_3	CH_2CH_3	2	24	91	$C_{10}H_{13}NO_3$	61.53 61.40	6.71 6.80	7.17 7.10
VI g	CH_2CH_3	CH_3	2	24	91	$C_{10}H_{13}NO_3$	61.53 61.50	6.71 6.60	7.17 7.10

yields from unsaturated β-nitroethers **IVh-n** by the INOC process, are described in Table 3.

EXPERIMENTAL

Melting points were determined in open capillaries and are uncorrected. The ir spectra of solids were recorded in potassium bromide pellets and liquids as thin film between sodium chloride plates on a Perkin-Elmer 1750 spectrophotometer. The ^{1}H-nmr spectra were recorded on Bruker AM 400 or AC 250 instruments with tetramethylsilane as internal reference. Coupling constants are in Hertz. Elemental analyses were performed by the CIBA Micro-Analysis Laboratory, Bâle, Switzerland. Column chromatographic separations were performed on Kieselgel 60 (70-230 Mesh) purchased from E. Merck and Co. Thin layer chromatography was performed using precoated Merck plates, silica gel 60 F_{254}, 0.2 mm thickness. All organic solvents were appropriately dried and purified prior to use.

a) General Procedure for the Preparation of β-Nitroethers **IV**.

Oil-covered sodium (or potassium, *cf* Table 1) hydride (6 mmoles) was washed with dry tetrahydrofuran (10 ml). Dry tetrahydrofuran (38 ml) is then added, followed by the appropriate alcohol (6 mmoles). The mixture is stirred at room temperature for one hour and cooled to −40°. A solution of the β-nitroenone **III** (3 mmoles) in 16 ml of tetrahydrofuran is added dropwise at the rate of 0.1 ml/minute. When potassium hydride was used to deprotonate the alcohol, the reaction mixture was quenched with 1*N* hydrochloric acid (15 ml) at −40° immediately after the end of the addition. When sodium hydride was used, the temperature of the reaction mixture is on the contrary allowed to warm up gradually to 0° before hydrolysis. The layers were then separated. The aqueous layer was further extracted with diethyl ether (3 x 40 ml). The combined organic layers were successively washed with a 5% aqueous hydrogenocarbonate solution (30 ml), water (30 ml) and brine (30 ml), dried over sodium sulfate and filtered. The solvent is removed under reduce pressure. The crude β-nitroether **IV** obtained was purified by chromatography on silica gel, eluting with 10-20% ethyl acetate/hexane (v/v).

All β-nitroethers **IV** are new. Except product **IVl** which is a solid, these compounds were obtained as pale yellow oils after silica gel chromatography.

4-Methyl-4-(nitromethyl)-5-oxaoct-7-en-3-one (**IVa**).

This compound was obtained in 57% yield; tlc (ethyl acetate-hexane, 30:70) R_f 0.55; ir (neat): ν 1723, 1645, 1553, 1421, 1379 cm^{-1}; ^{1}H-nmr (deuteriochloroform): (400 MHz) δ 5.96-5.85 (m, 1H), 5.33 (ddd, ^3J = 17.1 Hz, ^4J = $^4J'$ = 1.2 Hz, 1H), 5.21 (brd, ^3J = 10.7 Hz, 1H), 4.96 (d, ^2J = 12.8 Hz, 1H), 4.68 (d, ^2J = 12.8 Hz, 1H), 4.16 (dd, ^2J = 12.2 Hz, ^3J = 4.9 Hz, 1H), 3.98 (dd, ^2J = 12.2 Hz, ^3J = 7.0 Hz, 1H), 2.84 (qd, ^2J = 18.9 Hz, ^3J = 7.0 Hz, 1H), 2.66 (qd, ^2J = 18.9 Hz, ^3J = 7.0 Hz, 1H), 1.41 (s, 3H), 1.11 (t, J = 7.0 Hz, 3H).

5-Methyl-5-(nitromethyl)-4-oxaundec-1-en-6-one (**IVb**).

This compound was obtained in 65% yield; tlc (ethyl acetate-hexane, 30:70) R_f 0.62; ir (neat): ν 1720, 1645, 1560, 1425, 1379

cm^{-1}; ^1H-nmr (deuteriochloroform): (400 MHz) δ 5.98-5.81 (m, 1H), 5.32 (ddd, ^3J = 17.2 Hz, ^4J = $^4J'$ = 1.4 Hz, 1H), 5.20 (ddd, ^3J = 10.3 Hz, ^4J = $^4J'$ = 1.4 Hz, 1H), 4.94 (d, ^2J = 12.6 Hz, 1H), 4.66 (d, ^2J = 12.6 Hz, 1H), 4.15 (ddt, ^2J = 12.1 Hz, ^3J = 5.1 Hz, ^4J = 1.4 Hz, 1H); 3.96 (ddt, ^2J = 12.1 Hz, ^3J = 5.1 Hz, ^4J = 1.4 Hz, 1H), 2.76 (td, ^2J = 18.5 Hz, ^3J = 7.4 Hz, 1H), 2.64 (td, ^2J = 18.5 Hz, ^3J = 7.4 Hz, 1H), 1.67-1.54 (m, 2H), 1.40-1.23 (m, 4H), 1.38 (s, 3H), 0.92 (t, J = 6.8 Hz, 3H).

2,4-Dimethyl-4-(nitromethyl)-5-oxaoct-7-en-3-one (**IVc**).

This compound was obtained in 62% yield; tlc (ethyl acetate-hexane, 30:70) R_f 0.70; ir (neat): ν 1716, 1645, 1560, 1425, 1382 cm^{-1}; ^1H-nmr (deuteriochloroform): (400 MHz) δ 5.96-5.84 (m, 1H), 5.32 (ddd, ^3J = 17.1 Hz, ^4J = $^4J'$ = 1.5 Hz, 1H), 5.20 (ddd, ^3J = 10.4 Hz, ^4J = $^4J'$ = 1.5 Hz, 1H), 4.97 (d, ^2J = 12.8 Hz, 1H), 4.66 (d, ^2J = 12.8 Hz, 1H), 4.17 (ddt, ^2J = 12.2 Hz, ^3J = 5.2 Hz, ^4J = 1.5 Hz, 1H), 4.02 (ddt, ^2J = 12.2 Hz, ^3J = 5.2 Hz, ^4J = 1.5 Hz, 1H), 3.45-3.26 (m, 1H), 1.41 (s, 3H), 1.13 (d, J = 6.7 Hz, 3H), 1.12 (d, J = 6.7 Hz, 3H).

3-Ethyl-3-(nitromethyl)-4-oxahept-6-en-2-one (**IVd**).

This compound was obtained in 55% yield; tlc (ethyl acetate-hexane, 30:70) R_f 0.55; ir (neat): ν 1723, 1645, 1555, 1425, 1375 cm^{-1}; ^1H-nmr (deuteriochloroform): (400 MHz) δ 5.96-5.85 (m, 1H), 5.34 (ddd, ^3J = 17.4 Hz, ^4J = $^4J'$ = 1.5 Hz, 1H), 5.21 (ddd, ^3J = 10.4 Hz, ^4J = $^4J'$ = 1.5 Hz, 1H), 4.90 (d, ^2J = 12.8 Hz, 1H), 4.69 (d, ^2J = 12.8 Hz, 1H), 4.13 (ddt, ^2J = 11.9 Hz, ^3J = 5.2 Hz, ^4J = 1.5 Hz, 1H), 3.96 (ddt, ^2J = 11.9 Hz, ^3J = 5.2 Hz, ^4J = 1.5 Hz, 1H), 2.33 (s, 3H), 1.77 (q, J = 7.6 Hz, 2H), 0.88 (t, J = 7.6 Hz, 3H).

3-Methyl-3-(nitromethyl)-4-oxaoct-7-en-2-one (**IVe**).

This compound was obtained in 61% yield; tlc (ethyl acetate-hexane, 30:70) R_f 0.50; ir (neat): ν 1720, 1645, 1555, 1425, 1380 cm^{-1}; ^1H-nmr (deuteriochloroform): (400 MHz) δ 5.90-5.71 (m, 1H), 5.10 (ddd, ^3J = 17.1 Hz, ^4J = $^4J'$ = 1.3 Hz, 1H), 5.06 (ddd, ^3J = 10.2 Hz, ^4J = $^4J'$ = 1.3 Hz, 1H), 4.92 (d, ^2J = 12.6 Hz, 1H), 4.64 (d, ^2J = 12.6 Hz, 1H), 3.63 (td, ^2J = 8.0 Hz, ^3J = 6.7 Hz, 1H), 3.43 (td, ^2J = 8.0 Hz, ^3J = 6.7 Hz, 1H), 2.35 (brtd, ^3J = $^3J'$ = 6.7 Hz, 2H), 2.30 (s, 3H), 1.36 (s, 3H).

2,4-Dimethyl-4-(nitromethyl)-5-oxanon-8-en-3-one (**IVf**).

This compound was obtained in 53% yield; tlc (ethyl acetate-hexane, 30:70) R_f 0.55; ir (neat): ν 1716, 1638, 1560, 1425, 1379 cm^{-1}; ^1H-nmr (deuteriochloroform): (400 MHz) δ 5.89-5.71 (m, 1H), 5.09 (dd, ^3J = 17.1 Hz, ^4J = 1.3 Hz, 1H), 5.06 (brd, ^3J = 8.6 Hz, 1H), 4.96 (d, ^2J = 12.7 Hz, 1H), 4.64 (d, ^2J = 12.7 Hz, 1H), 3.64 (td, ^2J = 7.9 Hz, ^3J = 6.8 Hz, 1H), 3.51 (td, ^2J = 7.9 Hz, ^3J = 6.8 Hz, 1H), 3.43-3.30 (m, 1H), 2.36 (brtd, ^3J = $^3J'$ = 6.8 Hz, 2H), 1.37 (s, 3H), 1.11 (d, J = 6.9 Hz, 6H).

3-Ethyl-3-(nitromethyl)-4-oxaoct-7-en-2-one (**IVg**).

This compound was obtained in 55% yield; tlc (ethyl acetate-hexane, 30:70) R_f 0.65; ir (neat): ν 1723, 1645, 1555, 1423, 1379 cm^{-1}; ^1H-nmr (deuteriochloroform): (400 MHz) δ 5.87-5.76 (m, 1H), 5.12 (dd, ^3J = 17.1 Hz, ^4J = 1.3 Hz, 1H), 5.07 (brd, ^3J = 10.4 Hz, 1H), 4.89 (d, ^2J = 12.8 Hz, 1H), 4.67 (d, ^2J = 12.8 Hz, 1H), 3.59 (td, ^2J = 8.0 Hz, ^3J = 6.6 Hz, 1H), 3.45 (td, ^2J = 8.0 Hz, ^3J = 6.6 Hz, 2H), 2.36 (brtd, ^3J = $^3J'$ = 6.6 Hz, 2H), 2.29 (s, 3H), 1.72 (q, J = 7.5 Hz, 2H), 0.85 (t, J = 7.5 Hz, 3H).

3-Methyl-3-(nitromethyl)-4-oxahept-6-yn-2-one (**IVh**).

This compound was obtained in 82% yield; tlc (ethyl acetate-hexane, 30:70) R_f 0.30; ir (neat): ν 3283, 2120, 1723, 1560, 1379 cm^{-1}; ^1H-nmr (deuteriochloroform): (400 MHz) δ 4.92 (d, ^2J = 13.2 Hz, 1H), 4.77 (d, ^2J = 13.2 Hz, 1H), 4.36 (dd, ^2J = 15.9 Hz, ^4J = 2.3 Hz, 1H), 4.26 (dd, ^2J = 15.9 Hz, ^4J = 2.3 Hz, 1H), 2.51 (t, ^4J = 2.3 Hz, 1H), 2.37 (s, 3H), 1.46 (s, 3H).

5-Methyl-5-(nitromethyl)-4-oxaoct-1-yn-6-one (**IVi**).

This compound was obtained in 97% yield; tlc (ethyl acetate-hexane, 30:70) R_f 0.50; ir (neat): ν 3297, 2113, 1723, 1556, 1382 cm^{-1}; ^1H-nmr (deuteriochloroform): (400 MHz) δ 4.94 (d, ^2J = 13.1 Hz, 1H), 4.76 (d, ^2J = 13.1 Hz, 1H), 4.34 (dd, ^2J = 16.1 Hz, ^4J = 2.4 Hz, 1H), 4.25 (dd, ^2J = 16.1 Hz, ^4J = 2.4 Hz, 1H), 2.87 (qd, ^2J = 19.2 Hz, ^3J = 7.3 Hz, 1H), 2.67 (qd, ^2J = 19.2 Hz, ^3J = 7.3 Hz, 1H), 2.49 (t, ^4J = 2.4 Hz, 1H), 1.45 (s, 3H), 1.10 (t, J = 7.3 Hz, 3H).

5-Methyl-5-(nitromethyl)-4-oxaundec-1-yn-6-one (**IVj**).

This compound was obtained in 96% yield; tlc (ethyl acetate-hexane, 30:70) R_f 0.70; ir (neat): ν 3290, 2127, 1723, 1556, 1375 cm^{-1}; ^1H-nmr (deuteriochloroform): (400 MHz) δ 4.94 (d, ^2J = 13.1 Hz, 1H), 4.76 (d, ^2J = 13.1 Hz, 1H), 4.34 (dd, ^2J = 15.8 Hz, ^4J = 2.4 Hz, 1H), 4.24 (dd, ^2J = 15.8 Hz, ^4J = 2.4 Hz, 1H), 2.81 (td, ^2J = 18.9 Hz, ^3J = 7.3 Hz, 1H), 2.66 (td, ^2J = 18.9 Hz, ^3J = 7.3 Hz, 1H), 2.50 (t, ^4J = 2.4 Hz, 1H), 1.64-1.54 (m, 2H), 1.44 (s, 3H); 1.40-1.24 (m, 4H), 0.91 (t, J = 7.0 Hz, 3H).

2,4-Dimethyl-4-(nitromethyl)-5-oxaoct-7-yn-3-one (**IVk**).

This compound was obtained in 98% yield; tlc (ethyl acetate-hexane, 30:70) R_f 0.50; ir (neat): ν 3290, 2127, 1723, 1556, 1370 cm^{-1}; ^1H-nmr (deuteriochloroform): (400 MHz) δ 4.96 (d, ^2J = 13.3 Hz, 1H), 4.76 (d, ^2J = 13.3 Hz, 1H), 4.36 (dd, ^2J = 15.9 Hz, ^4J = 2.4 Hz, 1H), 4.25 (dd, ^2J = 15.9 Hz, ^4J = 2.4 Hz, 1H), 3.49-3.32 (m, 1H), 2.50 (t, ^4J = 2.4 Hz, 1H), 1.47 (s, 3H), 1.14 (d, J = 6.8 Hz, 3H), 1.13 (d, J = 6.8 Hz, 3H).

3-Ethyl-3-(nitromethyl)-4-oxahept-6-yn-2-one (**IVl**).

This compound was obtained in 86% yield, mp 59-60°; tlc (ethyl acetate-hexane, 30:70) R_f 0.60; ir (potassium bromide): ν 3290, 2120, 1716, 1560, 1375 cm^{-1}; ^1H-nmr (deuteriochloroform): (400 MHz) δ 4.91 (d, ^2J = 13.4 Hz, 1H), 4.78 (d, ^2J = 13.4 Hz, 1H), 4.35 (dd, ^2J = 15.5 Hz, ^4J = 2.4 Hz, 1H), 4.22 (dd, ^2J = 15.5 Hz, ^4J = 2.4 Hz, 1H), 2.49 (t, ^4J = 2.4 Hz, 1H), 2.36 (s, 3H); 1.82 (qd, ^2J = 14.8 Hz, ^3J = 7.6 Hz, 1H), 1.77 (qd, ^2J = 14.8 Hz, ^3J = 7.6 Hz, 1H), 0.90 (t, J = 7.6 Hz, 3H).

4-Methyl-4-(nitromethyl)-5-oxanon-8-yn-3-one (**IVm**).

This compound was obtained in 55% yield; tlc (ethyl acetate-hexane, 30:70) R_f 0.50; ir (neat): ν 3297, 2120, 1723, 1560, 1379 cm^{-1}; ^1H-nmr (deuteriochloroform): (400 MHz) δ 4.95 (d, ^2J = 12.7 Hz, 1H), 4.65 (d, ^2J = 12.7 Hz, 1H), 3.71 (td, ^2J = 7.9 Hz, ^3J = 6.7 Hz, 1H), 3.54 (td, ^2J = 7.9 Hz, ^3J = 6.7 Hz, 1H), 2.84 (qd, ^2J = 19.2 Hz, ^3J = 7.2 Hz, 1H), 2.65 (qd, ^2J = 19.2 Hz, ^3J = 7.2 Hz, 1H), 2.49 (td, ^3J = 6.7 Hz, ^4J = 2.6 Hz, 2H), 2.00 (t, ^4J = 2.6 Hz, 1H), 1.38 (s, 3H), 1.09 (t, J = 7.2 Hz, 3H).

3-Ethyl-3-(nitromethyl)-4-oxaoct-7-yn-2-one (**IVn**).

This compound was obtained in 66% yield; tlc (ethyl acetate-hexane, 30:70) R_f 0.60; ir (neat): ν 3290, 2120, 1723, 1556, 1375 cm^{-1}; ^1H-nmr (deuteriochloroform): (400 MHz) δ 4.91 (d, ^2J = 12.8 Hz, 1H), 4.67 (d, ^2J = 12.8 Hz, 1H), 3.70 (td, ^2J = 14.7 Hz, ^3J = 6.7 Hz, 1H), 3.54 (td, ^2J = 14.7 Hz, ^3J = 6.7 Hz, 1H), 2.51 (td,

^3J = 6.7 Hz, ^4J = 2.5 Hz, 2H), 2.33 (s, 3H), 2.00 (t, ^4J = 2.5 Hz, 1H), 1.76 (q, J = 7.4 Hz, 2H), 0.89 (t, J = 7.4 Hz, 3H).

b) Preparation of the 3,3a-Dihydro-4*H*,6*H*-furo[3,4-*c*]isoxazoles and the 3,3a,4,5-Tetrahydro-7*H*-pyrano[3,4-*c*]isoxazoles.

General Procedure for the INOC Reaction.

Under a nitrogen atmosphere, β-nitroether **IV** (1 mmole) was dissolved in dry benzene (5 ml). Two drops of triethylamine were added, followed by phenyl isocyanate (2 mmoles, 0.238 g). The solution was allowed to stand at room temperature for the time indicated in Table 2. Diphenylurea was filtered and benzene was removed under vacuum. The crude product was purified by chromatography on silica gel, eluting with 25-30% ethyl acetate/hexane, to give product **V**.

General Procedure for the ISOC Reaction.

Under a nitrogen atmosphere, 1 mmole of β-nitroether **IV** was dissolved in dry benzene (5 ml). Triethylamine (1.2 mmoles, 0.121 g) was added followed by trimethylchlorosilane (1.1 mmoles, 0.119 g). A precipitate formed and the mixture was allowed to stand at room temperature for the time indicated in Table 2. The *N*-trimethylsilyloxyisoxazolidine obtained was treated with a 5% aqueous solution of hydrochloric acid (3 ml) for 15 minutes. The benzene layer was separated and successively washed with water (5 ml), brine (5 ml), dried over magnesium sulfate and concentrated under vacuum. The crude product was purified by chromatography on silica gel, eluting with 25-30% ethyl acetate/hexane, to give product **V**.

6-Methyl-6-propanoyl-3,3a-dihydro-4*H*,6*H*-furo[3,4-*c*]isoxazole (**Va**).

This compound was obtained as a yellow oil from **IVa**. The yield was 94% with the INOC reaction and 85% with the ISOC reaction; tlc (ethyl acetate-hexane, 30:70) R_f 0.20; ir (neat): ν 1723, 1600 cm^{-1}; ^{1}H-nmr (deuteriochloroform): (400 MHz) δ $\mathbf{V_{1a}}$, 4.59 (dd, ^2J = 8.5 Hz, ^3J = 7.9 Hz, 1H), 4.41-3.96 (m, 3H), 3.77 (dd, ^2J = 8.7 Hz, ^3J = 8.5 Hz, 1H), 2.86 (qd, ^2J = 18.6 Hz, ^3J = 7.0 Hz, 1H), 2.58 (qd, ^2J = 18.6 Hz, ^3J = 7.0 Hz, 1H), 1.60 (s, 3H), 1.09 (t, J = 7.0 Hz, 3H); $\mathbf{V_{2a}}$, 4.62 (dd, ^2J = 8.5 Hz, ^3J = 7.9 Hz, 1H), 4.41-3.96 (m, 3H), 3.79 (dd, ^2J = 8.7 Hz, ^3J = 8.5 Hz, 1H), 2.73 (qd, ^2J = 18.6 Hz, ^3J = 7.0 Hz, 1H), 2.64 (qd, ^2J = 18.6 Hz, ^3J = 7.0 Hz, 1H), 1.61 (s, 3H), 1.08 (t, J = 7.0 Hz, 3H).

6-Hexanoyl-6-methyl-3,3a-dihydro-4*H*,6*H*-furo[3,4-*c*]isoxazole (**Vb**).

This compound was obtained as a yellow oil from **IVb**. The yield was 84% with the INOC reaction and 78% with the ISOC reaction; tlc (ethyl acetate-hexane, 30:70) R_f 0.27; ir (neat): ν 1723, 1570 cm^{-1}; ^{1}H-nmr (deuteriochloroform): (250 MHz) δ $\mathbf{V_{1b}}$, 4.63 (dd, ^2J = 8.0 Hz, ^3J = 7.3 Hz, 1H), 4.42-3.93 (m, 3H), 3.77 (dd, ^2J = 8.5 Hz, ^3J = 8.5 Hz, 1H), 2.81 (td, ^2J = 18.3 Hz, ^3J = 7.3 Hz, 1H), 2.50 (td, ^2J = 18.3 Hz, ^3J = 7.3 Hz, 1H), 1.68-1.53 (m, 2H), 1.59 (s, 3H), 1.38-1.20 (m, 4H), 0.89 (t, J = 6.8 Hz, 3H); $\mathbf{V_{2b}}$, 4.60 (dd, ^2J = 8.0 Hz, ^3J = 7.3 Hz, 1H), 4.42-3.93 (m, 3H), 3.78 (dd, ^2J = 9.1 Hz, ^3J = 7.6 Hz, 1H), 2.67 (td, ^2J = 18.3 Hz, ^3J = 7.3 Hz, 1H), 2.58 (td, ^2J = 18.3 Hz, ^3J = 7.3 Hz, 1H), 1.68-1.53 (m, 2H), 1.62 (s, 3H), 1.38-1.20 (m, 4H), 0.89 (t, J = 6.8 Hz, 3H).

6-Isobutanoyl-6-methyl-3,3a-dihydro-4*H*,6*H*-furo[3,4-*c*]isoxazole (**Vc**).

This compound was obtained as a yellow oil from **IVc**. The yield was 90% with the INOC reaction and 79% with the ISOC reaction; tlc (ethyl acetate-hexane, 30:70) R_f 0.25; ir (neat): ν 1723, 1610 cm^{-1}; ^{1}H-nmr (deuteriochloroform): (400 MHz) δ $\mathbf{V_{1c}}$, 4.60 (dd, ^2J = 8.0 Hz, ^3J = 7.3 Hz, 1H), 4.32 (dd, ^2J = 8.2 Hz, ^3J = 7.9 Hz, 1H), 4.37-3.97 (m, 2H), 3.78 (dd, ^2J = 11.6 Hz, ^3J = 7.9 Hz, 1H), 3.16-3.08 (m, 1H), 1.61 (s, 3H), 1.12 (d, J = 6.7 Hz, 6H); $\mathbf{V_{2c}}$, 4.62 (dd, ^2J = 8.0 Hz, ^3J = 7.3 Hz, 1H), 4.39 (dd, ^2J = 8.2 Hz, ^3J = 7.9 Hz, 1H), 4.37-3.97 (m, 2H), 3.79 (dd, ^2J = 11.6 Hz, ^3J = 8.5 Hz, 1H), 3.24-3.15 (m, 1H), 1.64 (s, 3H), 1.16 (d, J = 6.7 Hz, 3H), 1.11 (d, J = 6.7 Hz, 3H).

6-Acetyl-6-methyl-3,3a-dihydro-4*H*,6*H*-furo[3,4-*c*]isoxazole (**Vd**).

This compound was obtained as a yellow oil from **IVd**. The yield was 76% with the INOC reaction and 75% with the ISOC reaction; tlc (ethyl acetate-hexane, 30:70) R_f 0.25; ir (neat): ν 1723, 1610 cm^{-1}; ^{1}H-nmr (deuteriochloroform): (400 MHz) δ $\mathbf{V_{1d}}$, 4.57 (dd, ^2J = 8.8 Hz, ^3J = 8.5 Hz, 1H), 4.37 (dd, ^2J = ^3J = 7.9 Hz, 1H), 4.28-3.94 (m, 2H), 3.76 (dd, ^2J = 10.4 Hz, ^3J = 8.5 Hz, 1H), 2.33 (s, 3H), 2.00 (q, J = 7.3 Hz, 2H), 0.99 (t, J = 7.3 Hz, 3H); $\mathbf{V_{2d}}$, 4.60 (dd, ^2J = 8.2 Hz, ^3J = 8.5 Hz, 1H), 4.35 (dd, ^2J = 7.6 Hz, ^3J = 7.3 Hz, 1H), 4.28-3.94 (m, 2H), 3.74 (dd, ^2J = 10.4 Hz, ^3J = 9.1 Hz, 1H), 2.29 (s, 3H), 2.09 (q, J = 7.3 Hz, 2H), 1.00 (t, J = 7.3 Hz, 3H).

7-Acetyl-7-methyl-3,3a,4,5-tetrahydro-7*H*-pyrano[3,4-*c*]isoxazole (**Ve**).

This compound was obtained as a yellow oil from **IVe**. The yield was 88% with the INOC reaction and 86% with the ISOC reaction; tlc (ethyl acetate-hexane, 30:70) R_f 0.17; ir (neat): ν 1716, 1633 cm^{-1}; ^{1}H-nmr (deuteriochloroform): (250 MHz) δ $\mathbf{V_{1e}}$, 4.63 (dd, ^2J = 10.3 Hz, ^3J = 7.9 Hz, 1H), 3.91-3.76 (m, 1H), 3.62-3.47 (m, 1H), 3.34 (ddd, ^2J = 10.9 Hz, ^3J = 11.3 Hz, $^3J'$ = 6.3 Hz, 1H), 2.29 (s, 3H), 2.21 (ddt, ^2J = 13.0 Hz, ^3J = 6.3 Hz, $^3J'$ = 1.9 Hz, 1H), 1.94-1.71 (m, 1H), 1.57 (s, 3H); $\mathbf{V_{2e}}$, 4.66 (dd, ^2J = 10.3 Hz, ^3J = 7.9 Hz, 1H), 4.01 (ddd, ^2J = 12.3 Hz, ^3J = 4.5 Hz, $^3J'$ = 1.7 Hz, 1H), 3.91-3.76 (m, 1H), 3.50 (td, ^2J = 2.0 Hz, ^3J = 12.3 Hz, 1H), 2.27 (s, 3H), 2.08 (ddt, ^2J = 13.0 Hz, ^3J = 6.3 Hz, $^3J'$ = 1.9 Hz, 1H), 1.94-1.71 (m, 1H), 1.64 (s, 3H).

7-Isobutanoyl-7-methyl-3,3a,4,5-tetrahydro-7*H*-pyrano[3,4-*c*]isoxazole (**Vf**).

This compound was obtained as colorless crystals from **IVf** in a yield of 86% with the INOC reaction, mp $\mathbf{V_{1f}}$, 52°, mp $\mathbf{V_{2f}}$, 66°; tlc (ethyl acetate-hexane, 30:70) R_f 0.35; ir (potassium bromide): ν 1723, 1645 cm^{-1}; ^{1}H-nmr (deuteriochloroform): (400 MHz) δ $\mathbf{V_{1f}}$ 4.61 (dd, ^2J = 10.2 Hz, ^3J = 8.1 Hz, 1H), 4.01 (ddd, ^2J = 12.3 Hz, ^3J = 4.7 Hz, $^3J'$ = 1.8 Hz, 1H), 3.81 (td, ^2J = 2.2 Hz, ^3J = 12.4 Hz, 1H), 3.79 (dd, ^2J = 11.4 Hz, ^3J = 8.1 Hz, 1H), 3.59-3.47 (m, 1H), 3.26-3.14 (m, 1H), 2.20 (ddt, ^2J = 13.1 Hz, ^3J = 4.2 Hz, $^3J'$ = 2.0 Hz, 1H), 1.91-1.75 (m, 1H), 1.57 (s, 3H), 1.13 (d, J = 6.8 Hz, 3H), 1.08 (d, J = 6.8 Hz, 3H); $\mathbf{V_{2f}}$, 4.65 (dd, ^2J = 10.4 Hz, ^3J = 8.1 Hz, 1H), 3.98 (ddd, ^2J = 12.3 Hz, ^3J = 4.4 Hz, $^3J'$ = 1.8 Hz, 1H), 3.83 (dd, ^2J = 11.4 Hz, ^3J = 8.1 Hz, 1H), 3.54 (td, ^3J = 12.4 Hz, ^2J = 2.0 Hz, 1H), 3.39-3.20 (m, 2H), 2.07 (ddt, ^2J = 8.6 Hz, ^3J = 6.3 Hz, $^3J'$ = 1.9 Hz, 1H), 1.82-1.70 (m, 1H), 1.66 (s, 3H), 1.12 (d, J = 6.7 Hz, 3H), 1.06 (d, J = 6.7 Hz, 3H).

7-Acetyl-7-ethyl-3,3a,4,5-tetrahydro-7*H*-pyrano[3,4-*c*]isoxazole (**Vg**).

This compound was obtained as a yellow oil from **IVg** in a yield of 93% with the INOC reaction; tlc (ethyl acetate-hexane, 30:70) R_f 0.25; ir (neat): ν 1723, 1639 cm^{-1}; ^{1}H-nmr (deuteriochloroform): (250 MHz) δ $\mathbf{V_{1g}}$, 4.63 (dd, ^2J = 10.0 Hz, ^3J = 8.2 Hz,

1H), 4.01 (ddd, ^2J = 12.0 Hz, ^3J = 4.5 Hz, $^3J'$ = 1.8 Hz, 1H), 3.82 (dd, ^2J = 11.2 Hz, ^3J = 8.1 Hz, 1H), 3.74 (td, ^2J = 2.1 Hz, ^3J = 12.0 Hz, 1H), 3.61-3.43 (m, 1H), 2.29 (s, 3H), 2.26-1.72 (m, 4H), 0.87 (t, J = 7.5 Hz, 3H); V_{2g}, 4.62 (dd, ^2J = 10.5 Hz, ^3J = 8.0 Hz, 1H), 4.02 (ddd, ^2J = 12.5 Hz, ^3J = 4.0 Hz, $^3J'$ = 1.5 Hz, 1H), 3.79 (dd, ^2J = 11.5 Hz, ^3J = 8.1 Hz, 1H), 3.56 (td, ^2J = 2.2 Hz, ^3J = 12.5 Hz, 1H), 3.37-3.20 (m, 1H), 2.23 (s, 3H), 2.16-1.93 (m, 3H), 1.85-1.66 (m, 1H), 0.98 (t, J = 7.5 Hz, 3H).

c) Preparation of Furo and Pyrano[3,4-*c*]isoxazoles.

The compounds **VI** were prepared according to the INOC procedure described here above. Reaction times are given in Table 3.

6-Acetyl-6-methyl-4*H*,6*H*-furo[3,4-*c*]isoxazole (**VIa**).

This compound was obtained with 86% yield from **IVh** as a yellow oil; tlc (ethyl acetate-hexane, 30:70) R_f 0.40; ir (neat): ν 3130, 1723, 1631 cm^{-1}; ^{1}H-nmr (deuteriochloroform): (400 MHz), δ 8.06 (brs, 1H), 4.99 (dd, ^2J = 12.2 Hz, ^4J = 1.2 Hz, 1H), 4.96 (dd, ^2J = 12.2 Hz, ^4J = 1.2 Hz, 1H), 2.29 (s, 3H), 1.71 (s, 3H).

6-Methyl-6-propanoyl-4*H*,6*H*-furo[3,4-*c*]isoxazole (**VIb**).

This compound was obtained with 99% yield from **IVi** as a yellow oil; tlc (ethyl acetate-hexane, 30:70) R_f 0.42; ir (neat): ν 3134, 1723, 1631 cm^{-1}; ^{1}H-nmr (deuteriochloroform): (400 MHz) δ 8.05 (brs, 1H), 5.00 (dd, ^2J = 12.2 Hz, ^4J = 1.2 Hz, 1H), 4.96 (dd, ^2J = 12.2 Hz, ^4J = 1.2 Hz, 1H), 2.82 (qd, ^2J = 18.9 Hz, ^3J = 7.3 Hz, 1H), 2.53 (qd, ^2J = 18.9 Hz, ^3J = 7.3 Hz, 1H), 1.71 (s, 3H), 1.06 (t, J = 7.3 Hz, 3H).

6-Hexanoyl-6-methyl-4*H*,6*H*-furo[3,4-*c*]isoxazole (**VIc**).

This compound was obtained with 85% yield from **IVj** as a yellow oil; tlc (ethyl acetate-hexane, 30:70) R_f 0.60; ir (neat): ν 3130, 1725, 1631 cm^{-1}; ^{1}H-nmr (deuteriochloroform): (400 MHz) δ 8.05 (brs, 1H), 4.99 (dd, ^2J = 12.2 Hz, ^4J = 1.2 Hz, 1H), 4.95 (dd, ^2J = 12.2 Hz, ^4J = 1.2 Hz, 1H), 2.75 (td, ^2J = 18.3 Hz, ^3J = 7.3 Hz, 1H), 2.50 (td, ^2J = 18.3 Hz, ^3J = 7.3 Hz, 1H), 1.71 (s, 3H), 1.62-1.53 (m, 2H), 1.33-1.21 (m, 4H), 0.87 (t, J = 7.3 Hz, 3H).

6-Isobutanoyl-6-methyl-4*H*,6*H*-furo[3,4-*c*]isoxazole (**VId**).

This compound was obtained with 92% yield from **IVk** as a yellow oil; tlc (ethyl acetate-hexane, 30:70) R_f 0.45; ir (neat): ν 3134, 1716, 1631 cm^{-1}; ^{1}H-nmr (deuteriochloroform): (250 MHz) δ 8.05 (brs, 1H), 5.01 (dd, ^2J = 12.1 Hz, ^4J = 1.3 Hz, 1H), 4.95 (dd, ^2J = 12.1 Hz, ^4J = 1.3 Hz, 1H), 3.25-3.07 (m, 1H), 1.71 (s, 3H), 1.11 (d, J = 6.8 Hz, 3H), 1.04 (d, J = 6.8 Hz, 3H).

6-Acetyl-6-ethyl-2,3,4,5-tetrahydrofurano[3,4-*c*]isoxazole (**VIe**).

This compound was obtained with 89% yield from **IVl** as a yellow oil; tlc (ethyl acetate-hexane, 30:70) R_f 0.20; ir (neat): ν 3120, 1723, 1631 cm^{-1}; ^{1}H-nmr (deuteriochloroform): (250 MHz) δ 8.08 (brs, 1H), 5.00 (d, ^2J = 1.2 Hz, 2H); 2.32 (s, 3H), 2.13 (q, J = 7.6 Hz, 2H), 0.96 (t, J = 7.6 Hz, 3H).

7-Methyl-7-propanoyl-4,5-dihydro-7*H*-pyrano[3,4-*c*]isoxazole (**VIf**).

This compound was obtained in 91% yield from **IVm** as a yellow oil; tlc (ethyl acetate-hexane, 30:70) R_f 0.30; ir (neat): ν 3125, 1723, 1535 cm^{-1}; ^{1}H-nmr (deuteriochloroform): (250 MHz) δ 8.22 (brs, 1H), 4.05 (ddd, ^2J = 11.8 Hz, ^3J = 5.2 Hz, $^3J'$ = 4.4 Hz, 1H), 3.72 (ddd, ^2J = 11.8 Hz, ^3J = 8.8 Hz, $^3J'$ = 4.4 Hz, 1H), 2.88-2.54 (m, 4H), 1.72 (s, 3H), 1.05 (t, J = 7.3 Hz, 3H).

7-Acetyl-7-ethyl-4,5-dihydro-7*H*-pyrano[3,4-*c*]isoxazole (**VIg**).

This compound was obtained in with 91% yield from **IVn** as a yellow oil; tlc (ethyl acetate-hexane, 30:70) R_f 0.55; ir (neat): ν 3120, 1723, 855 cm^{-1}; ^{1}H-nmr (deuteriochloroform): (400 MHz) δ 8.22 (s, 1H), 4.11 (ddd, ^2J = 12.0 Hz, ^3J = 5.5 Hz, $^3J'$ = 2.9 Hz, 1H), 3.69 (ddd, ^2J = 12.0 Hz, ^3J = 10.6 Hz, $^3J'$ = 3.8 Hz, 1H), 2.80-2.71 (m, 1H); 2.35 (s, 3H), 2.20-2.05 (m, 1H), 2.13 (qd, ^2J = 8.0 Hz, ^3J = 7.2 Hz, 2H), 0.91 (t, J = 7.3 Hz, 3H).

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