Heterocyclic derivative syntheses by palladium-catalyzed oxidative cyclization-alkoxycarbonylation of substituted γ -oxoalkynes

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X-Ray Diffraction Analysis for Compounds **14b** and **15a**

Results and Discussion

Figures S1 and S2 show the molecular structures of compounds **14b** and **15a**, together with labeling schemes. Table S2 reports the main geometric features for both compounds. In the crystal structure of **14b** the heterocyclic 6-membered ring is slightly puckered and its conformation can be described as a half-boat, with C3 deviating by 0.35 Å from the average plane containing C1, C2, N, C4 and C5 (maximum deviation from planarity 0.06 Å). The methyl ester group is highly skewed relatively to the ring plane, as shown by the torsion angle C5-C1-C6-O4=62.0(2)°. The endocyclic double bond is localized between C1 and C5 (1.344(2) Å). The two ketonic groups are electronically different, as shown by the bond distances (C2=O1 = 1.209(2), C4=O4 = 1.231(2) Å), due to the influence of the -NH group on the latter, which induces an incipient tautomerization with consequent slight shortening of the C4-N bond =1.334(2) Å. The effects of the -NH-C=O/ -N=C-OH tautomerization on the ring geometry are shown by the molecular structure of **15a**, where the latter form is established by oxygen methylation. Compound **15a** crystallizes with four independent molecules in the unit cell, respectively paired by two distinct pseudo-2₁ axes parallel to *b*. No trace of twinning was revealed by accurate inspection of reflections data, nor was found any possibility of reconducing the cell to a higher symmetry. The two pairs are differentiated by the orientation of the phenyl groups relatively to the methyl ester substituents. Figure S2 shows one pair of different conformers with the labeling scheme, while the other pair is substantially identical. In both conformers the heterocyclic rings are planar, the methyl ester groups are perpendicular to the ring planes (C4-C3-C9-O3=84(2)°, C36-C35-C41-O11=77(1)°), while the phenyl groups are tilted in opposite directions referring to the C9-O3 and C41-O11 directions (C3-C4-C11-C16= -65°, C35-C36-C43-C44= -127(1)°). The endocyclic double bonds are localized on C3-C4=1.32(1) and C35-C36=1.33(1) Å, which are similar to **14b**, and on N1-C5=1.25(1) and N3-C37=1.27(1) Å, which are shorter than in **14b**.

Figure S1. Molecular structure of **14b**.

Figure S2. Perspective view of one pair of different conformers in **15a**. A similar pair completes the content of the asymmetric unit. Thermal ellipsoids are at the 30% level.

Experimental

Single crystals of **14b** and **15a** were mounted on glass fibers and X-ray diffraction data were collected on a Enraf-Nonius CAD4 diffractometer, using graphite monochromated CuK α radiation ($\lambda=1.54178\text{\AA}$) for **14b**, and on a Philips PW1100 diffractometer using MoK α radiation ($\lambda=0.71073\text{\AA}$) for **15a**. Relevant details concerning data collection and structure refinements are listed in Table S1. Crystals were stable during data collection. The intensity data were processed with a peak-profile analysis procedure and corrected for Lorentz and polarization effects. The phase problem was solved by direct methods¹ and refined by full matrix least squares on all F²,² implemented in the WinGX package.³ Anisotropic displacement parameters were refined for all non hydrogen atoms, while hydrogen atoms were introduced in calculated positions in **15a**, and located on difference maps in **14b**. The final Fourier difference maps were featureless. Use of PARST⁴ and of the Cambridge Crystallographic Database⁵ package was made for structure discussion.

Table S1. Crystal data and structure refinement for **14b** and **15a**.

	14b		15a	
Empirical formula	$C_{10}H_{13}NO_4$		$C_{16}H_{17}NO_4$	
Formula weight	211.21		287.31	
Temperature (K)	293(2)		293(2)	
Wavelength (Å)	1.54178		0.71073	
Crystal system	triclinic		triclinic	
Space group	$P \bar{1}$		$P \bar{1}$	
Unit cell dimensions (Å, °)	a = 13.914(3)	$\alpha = 100.19(2)$	a = 15.528(3)	$\alpha = 74.70(2)$
	b = 6.448(2)	$\beta = 97.74(2)$	b = 18.993(4)	$\beta = 86.06(2)$
	c = 6.075(2)	$\gamma = 87.12(2)$	c = 10.971(2)	$\gamma = 82.38(2)$
Volume(Å ³)	531.4(3)		3091(1)	
Z	2		8	
Density (calculated) (Mg/m ³)	1.320		1.235	
Absorption coefficient (mm ⁻¹)	0.864		0.089	
F(000)	224		1216	
Reflections collected	1982		9664	
Independent reflections	1982		9664	
Refinement method	Full-matrix least-squares on F ²		Full-matrix least-squares on	
	F ²			
Data / restraints / parameters	1982 / 0 / 188		9664 / 0 / 773	
Goodness-of-fit on F ²	1.173		1.013	
Final R indices [I>2σ(I)]	R1 = 0.0495, wR2 = 0.1450		R1 = 0.1153, wR2 = 0.1484	
R indices (all data)	R1 = 0.0542, wR2 = 0.1714		R1 = 0.3408, wR2 = 0.2084	
Largest ΔF maximum/minimum(e.Å ⁻³)	0.250 / -0.307		0.259 / -	
0.250				

Table 2S. Selected bond lengths [Å] and angles [°] for **14b** and **15a**.Compound **14b**

N-C(4)	1.334(2)	C(4)-N-C(3)	126.99(15)
N-C(3)	1.463(2)	C(5)-C(1)-C(2)	121.95(15)
O(1)-C(2)	1.208(2)	C(1)-C(2)-C(3)	117.37(15)
O(2)-C(4)	1.231(2)	N-C(3)-C(8)	108.89(16)
C(1)-C(5)	1.344(3)	N-C(3)-C(2)	110.23(14)
C(1)-C(2)	1.481(2)	N-C(4)-C(5)	117.61(15)
C(2)-C(3)	1.525(2)	C(1)-C(5)-C(4)	119.33(16)
C(4)-C(5)	1.505(2)		

Compound **15a**

N(1)-C(5)	1.25(1)	N(2)-C(21)	1.27(1)	N(3)-C(37)	1.27(1)	N(4)-C(53)	1.26(1)
N(1)-C(1)	1.46(1)	N(2)-C(17)	1.48(1)	N(3)-C(33)	1.47(1)	N(4)-C(49)	1.47(1)
O(1)-C(2)	1.21(1)	O(5)-C(18)	1.23(1)	O(9)-C(34)	1.247(9)	O(13)-C(50)	1.21(1)
O(2)-C(5)	1.35(1)	O(6)-C(21)	1.36(1)	O(10)-C(37)	1.372(9)	O(14)-C(53)	1.36(1)
C(1)-C(2)	1.52(1)	C(17)-C(18)	1.50(1)	C(33)-C(34)	1.53(1)	C(49)-C(50)	1.52(1)
C(2)-C(3)	1.49(1)	C(18)-C(19)	1.48(1)	C(34)-C(35)	1.47(1)	C(50)-C(51)	1.49(1)
C(3)-C(4)	1.32(1)	C(19)-C(20)	1.33(1)	C(35)-C(36)	1.33(1)	C(51)-C(52)	1.33(1)
C(3)-C(9)	1.52(1)	C(19)-C(25)	1.52(1)	C(35)-C(41)	1.49(1)	C(51)-C(57)	1.50(1)
C(4)-C(5)	1.48(1)	C(20)-C(21)	1.49(1)	C(36)-C(37)	1.48(1)	C(52)-C(53)	1.49(1)

C(5)-N(1)-C(1)	119.7(8)	C(21)-N(2)-C(17)	118.4(8)	C(37)-N(3)-C(33)	119.4(8)	C(53)-N(4)-C(49)	119.2(9)
N(1)-C(1)-C(2)	117.7(9)	N(2)-C(17)-C(18)	116.8(8)	N(3)-C(33)-C(34)	115.0(8)	N(4)-C(49)-C(50)	117.1(8)
C(3)-C(2)-C(1)	116.3(9)	C(19)-C(18)-C(17)	118.3(9)	C(35)-C(34)-C(33)	119.1(8)	C(51)-C(50)-C(49)	117.4(9)
C(4)-C(3)-C(2)	120.6(9)	C(20)-C(19)-C(18)	122.1(9)	C(36)-C(35)-C(34)	121.5(9)	C(52)-C(51)-C(50)	120.8(9)
C(3)-C(4)-C(5)	119.1(9)	C(19)-C(20)-C(21)	116.2(9)	C(35)-C(36)-C(37)	116.4(9)	C(51)-C(52)-C(53)	117.8(9)
N(1)-C(5)-C(4)	126.3(9)	N(2)-C(21)-C(20)	128.1(9)	N(3)-C(37)-C(36)	128.6(9)	N(4)-C(53)-C(52)	127(1)

General Experimental Methods. Solvents and chemicals were reagent grade and were used without further purification. Reactions were analytically monitored by GLC with an instrument equipped with a flame ionization detector and a electronic peak integrator. A 5% methylsilicone (30 m $\times$ 0.25 mm) capillary column was used with helium as the carrier gas. All yields were determined gas chromatographically using the internal standard method unless otherwise specified. Thin-layer chromatography (TLC) was performed on silica gel coated aluminum plates. Gravity-flow liquid chromatography was carried out on silica gel (0.063-0.200 mm), solvent mixtures were prepared by volume. Melting points are uncorrected. IR spectra were obtained with a FT-IR spectrometer. Mass spectra (m/z relative intensity) were taken at 70 eV ionizing voltage. ^1H NMR and ^{13}C NMR spectra were taken in CDCl_3 , unless otherwise specified, at room temperature and recorded at 300 and 75 MHz, respectively. Chemical shifts and coupling constants (J) are given in ppm (δ) and in Hz, respectively.

Preparation of Substrates

4-Yn-1-ones **6b-e**, **6g**, **6h** were prepared according to the following procedure: propargyl bromide (5.9 mL, 80% solution w/w in toluene 40 mmol) was added dropwise to a well stirred suspension of 25 mmol of the alkylated β -ketoesters, or β -diketone or β -ketoamide and 14.0 g (100.4 mmol) of K_2CO_3 in 150 mL of acetone. The mixture was refluxed for 15 h, then was cooled at room temperature and filtered to remove most of the potassium carbonate. Acetone was evaporated under reduced pressure, the residue diluted with water was extracted three times with ether and dried. The solvent was evaporated under vacuum and the resulting oil was purified by flash chromatography (SiO_2).

Substrates **10a,b**, **12a,b** and **16** were prepared following a standard procedure from pyruvic or benzoylformic acid chloride and the respective propargyl alcohol or amine.

Characterization of substrates

2-Acetyl-2-ethyl-pent-4-ynoic acid methyl ester 6b. Chromatography with *n*-hexane/EtOAc (5/1) gave (4.010 g, 88 %) as a colorless oil; IR (film) ν_{max} cm^{-1} 3285 (s), 2965 (s), 2883 (m), 2115 (w), 1743 (s), 1720 (s), 1429 (s), 1196 (s), 632 (s); ^1H NMR (300 MHz) δ_{H} 3.75 (s, 3 H, OMe), 2.75 (d, 2 H, $J = 2.7$, $\text{CH}_2\text{C}\equiv$), 2.16 (s, 3 H, COMe), 2.19-2.01 (m, 2 H, CH_2CH_3), 1.98 (t, 1 H, $J = 2.7$, $\text{HC}\equiv\text{C}$), 0.80 (t, 3 H, $J = 7.6$, CH_2CH_3); ^{13}C NMR (75 MHz) δ_{C} 203.1, 171.3, 79.1, 71.1, 63.2, 52.5, 26.4, 24.2, 20.9, 8.04; MS m/z 182 (M^+ , 1), 167 (20), 153 (5), 151 (10), 140 (100), 125 (60), 112 (5),

111 (100), 93 (20), 83 (10), 79 (35), 65 (10), 59 (22), 51 (5). Anal. Calcd for C₁₀H₁₄O₃: C, 65.92; H, 7.74. Found C, 65.84; H, 7.80.

2-Acetyl-2-benzylpent-4-ynoic acid ethyl ester 6c. Chromatography with *n*-hexane/EtOAc (5/1) gave (5.540 g, 86%) as colourless oil; IR (film) $\nu_{\max}$ cm⁻¹ 3289 (s), 2982 (m), 2116 (w), 1720 (s), 1716 (vs), 1598 (w), 1495 (m), 1358 (m), 1273 (s), 1195 (s), 1159 (s); ¹H NMR (300 MHz) δ_{H} 7.26-7.11 (m, 5 H, CH aromatic), 4.25-4.06 (m, 2 H, CH₂Me), 3.38 (d, 1H, *J* 14.1, CHHPh), 3.28 (d, 1H, *J* 14.1, CHHPh), 2.68 (dd, 1 H, *J* 17.5, 2.8, CHHC≡), 2.58 (dd, 1 H, *J* 17.5, 2.8, CHHC≡), 2.21 (s, 3 H, COMe), 2.12 (t, 1 H, *J* = 2.8, HC≡), 1.25 (t, 3 H, *J* = 7.1, Me); ¹³C NMR (75 MHz) δ_{C} 202.3, 170.1, 135.6, 129.7, 128.3, 127.0, 79.3, 72.3, 63.9, 61.7, 36.8, 26.6, 21.4, 13.9; MS *m/z* 258 (M⁺, 5), 240 (1), 229 (1), 215 (100), 197 (1), 195 (1), 187 (70), 173 (70), 152 (1), 141 (100), 128 (40), 115 (50), 91 (100), 78 (25), 65 (25), 51 (10). Anal. Calcd for C₁₆H₁₈O₃: C, 74.40; H, 7.02. Found C, 74.33; H, 7.10.

3-Ethyl-3-prop-2-ynylpentane-2,4-dione 6d. Chromatography with *n*-hexane/EtOAc (10/1) gave (3.650 g, 88 %) as a colorless oil; IR (film) $\nu_{\max}$ cm⁻¹ 3287 (s), 2975 (s), 2944 (s), 2882 (m), 2115 (w), 1719 (s), 1699 (s), 1581 (m), 1461 (m), 1422 (m), 1359 (m), 1198 (m), 1161 (m), 1110 (m); ¹H NMR (300 MHz) δ_{H} 2.75 (d, 2 H, *J* = 2.7, CH₂C≡), 2.14 (s, 6 H, 2 COMe), 2.13 (q, 2 H, *J* = 7.5, CH₂CH₃), 1.99 (t, 1 H, *J* = 2.7, HC≡), 0.76 (t, 3 H, *J* 7.6, CH₂CH₃); ¹³C NMR (75 MHz) δ_{C} 204.9, 79.3, 71.5, 70.3, 26.7, 23.3, 19.9, 7.9; MS *m/z* 166 (M⁺, 1), 151 (1), 137 (1), 124 (100), 121 (20), 109 (40), 96 (10), 95 (100), 85 (10), 77 (10), 67 (10), 53 (5). Anal. Calcd for C₁₀H₁₄O₂: C, 72.26; H, 8.49. Found C, 72.20; H, 8.53.

2-Oxo-1-prop-2-ynylcyclohexanecarboxylic acid methyl ester 6e. Chromatography with *n*-hexane/EtOAc (10/1) gave (4.122 g, 85 %) as a pale yellow oil; IR (film) $\nu_{\max}$ cm⁻¹ 3285 (m), 2950 (m), 2866 (w), 2120 (w), 1715 (s), 1655 (w), 1617 (w), 1437 (m), 1349 (w), 1315 (m), 1267 (m), 1232 (s), 1206 (s), 1140 (m), 1093 (m), 1000 (w), 957 (w), 815 (w), 645 (m); ¹H NMR (300 MHz) δ_{H} 3.71 (s, 3 H, CO₂Me), 2.70 (d, 2 H, *J* = 2.7, CH₂C≡), 2.85-2.14 (m, 4 H, 2 CH₂), 2.03 (t, 1 H, *J* = 2.7, HC≡), 1.91-1.45 (m, 4 H, 2 CH₂); MS *m/z* 194 (20), 179 (12), 163 (14), 151 (10), 149 (1), 135 (100), 127 (42), 107 (54), 106 (50), 91 (63), 79 (50), 65 (72), 55 (30), 51 (10). Anal. Calcd for C₁₁H₁₄O₃: C, 68.02; H, 7.27. Found C, 67.95; H, 7.33.

1-Phenylpent-4-yn-1-one 6f. Chromatography with *n*-hexane/EtOAc (10/1) gave (2.528 g, 64 %) as a pale yellow solid, mp 65-68 °C; IR (KBr) $\nu_{\max}$ cm^{-1} 3267 (s), 2975 (m), 2117 (w), 1680 (s), 1448 (m), 1429 (m), 1412 (m), 1364 (m), 1208 (m); ^1H NMR (300 MHz) δ_{H} 7.99-7.95 (m, 2 H, aromatic), 7.60-7.55 (m, 1 H aromatic), 7.50-7.44 (m, 2 H aromatic), 3.25 (t, 2 H, $J = 7.1$, $\text{CH}_2\text{CH}_2\text{C}\equiv\text{CH}$), 2.64 (td, 2 H, $J = 7.1, 2.7$, $\text{CH}_2\text{CH}_2\text{C}\equiv\text{CH}$), 1.98 (t, 1 H, $J = 2.7$, $\text{HC}\equiv$); ^{13}C NMR (75 MHz) δ_{C} 197.6, 136.4, 133.2, 128.6, 128.0, 83.3, 68.7, 37.5, 13.1; MS m/z 158 (M^+ , 19), 130 (5), 115 (2), 105 (100), 91 (1), 77 (59), 74 (2), 63 (1), 51 (19). Anal. Calcd for $\text{C}_{11}\text{H}_{10}\text{O}$: C, 83.52; H, 6.37. Found C, 83.44; H, 6.42.

2-Benzoyl-2-methylpent-4-ynoic acid ethyl ester 6g. Chromatography with *n*-hexane/EtOAc (10/1) gave (4.636 g, 76 %) as a pale yellow oil; IR (film) $\nu_{\max}$ cm^{-1} 3284 (s), 2981 (s), 2125 (w), 1738 (s), 1682 (s), 1597 (m), 1580 (m), 1446 (m), 1378 (m); ^1H NMR (300 MHz) δ_{H} 7.85-7.81 (m, 2H aromatic), 7.55-7.49 (m, 1H aromatic), 7.43-7.38 (m, 2H aromatic), 4.20-4.09 (m, 2H, OCH_2CH_3), 2.94 (dd, 1 H, $J = 17.1, 2.7$, $\text{CHHC}\equiv\text{C}$), 2.86 (dd, 1 H, $J = 17.1, 2.7$, $\text{CHHC}\equiv\text{C}$), 2.02 (t, 1 H, $J = 2.7$, $\text{HC}\equiv$), 1.66 (s, 3 H, CH_3CCO), 1.08 (t, 3 H, $J = 7.2$, CH_2CH_3); ^{13}C NMR (300 MHz) δ_{C} 195.9, 172.5, 135.0, 132.9, 128.5, 128.4, 79.1, 71.7, 61.7, 56.5, 26.9, 20.8, 14.1; MS m/z 244 (M^+ , 1), 215 (10), 105 (100), 77 (40). Anal. Calcd for $\text{C}_{15}\text{H}_{16}\text{O}_3$: C, 73.75; H, 6.60. Found C, 73.67; H, 6.62.

2-Acetyl-2-ethylpent-4-ynoic acid phenylamide 6h. Chromatography with *n*-hexane/EtOAc (4/1) gave (326 g, 67 %) as a pale yellow oil; IR (film) $\nu_{\max}$ cm^{-1} 3325 (s), 3290 (s), 2970 (m), 2118 (w), 1712 (s), 1682 (s), 1598 (m), 1537 (s), 1441 (m), 1358 (m); ^1H NMR (600 MHz) δ_{H} 8.58 (s, broad, 1 H, NH), 7.55 (dd, $J = 8.3, 0.8$, 2 H aromatic), 7.35 (dd, $J = 8.3, 7.6$, 2 H aromatic), 7.15 (td, $J = 7.6, 0.8$, 1 H aromatic), 3.03 (dd, 1 H, $J = 17.4, 2.4$, $\text{CHHC}\equiv\text{C}$), 2.81 (dd, 1 H, $J = 17.4, 2.4$, $\text{CHHC}\equiv\text{C}$), 2.40 (s, 3 H, COMe), 2.21-2.14 (m, 1 H, CH_2CH_3), 2.13-2.06 (m, 1 H, CH_2CH_3), 2.11 (t, 1 H, $J = 2.4$, $\text{HC}\equiv$), 0.93 (t, 3 H, $J = 7.5$, CH_2CH_3); ^{13}C NMR (75 MHz) δ_{C} 208.4, 167.6, 128.9, 127.1, 124.7, 120.2, 79.6, 71.9, 63.7, 27.0, 26.9, 22.4, 8.6; MS m/z 243 (M^+ , 52), 214 (8), 200 (100), 186 (63), 172 (33), 131 (12), 109 (12), 93 (62), 77 (32). Anal. Calcd for $\text{C}_{15}\text{H}_{17}\text{O}_2\text{N}$: C, 74.05; H, 7.04; N, 5.76. Found C, 73.96; H, 7.09; N, 5.70.

2-Oxopropionic acid 1,1-dimethylprop-2-ynyl ester 10a. Chromatography with *n*-hexane/EtOAc (10/1) gave (3.050 g, 66 %) as a colorless oil; IR (film) $\nu_{\max}$ cm^{-1} 3288 (s), 2990 (s), 2942 (m), 2121 (w), 1744 (s), 1737 (s), 1368 (m), 1302 (s), 1245 (s), 1116 (s), 844 (m); ^1H NMR (300 MHz) δ_{H} 2.60 (s, 1 H, $\equiv\text{CH}$), 2.44 (s, 3 H, COMe), 1.76 (s, 6 H, 2 Me); ^{13}C NMR (75 MHz) δ_{C}

191.6, 159.0, 83.0, 74.3, 73.7, 28.4, 26.1; MS m/z 111 (M^+ - (COMe), 2), 67 (100), 65 (20), 51 (8). Anal. Calcd for $C_8H_{10}O_3$: C, 62.33; H, 6.54. Found C, 62.26; H, 6.61.

Oxophenyacetic acid 1,1-dimethylprop-2-ynyl ester 10b. Chromatography with *n*-hexane/EtOAc (10/1) gave (3.510 g, 65 %) as a colorless oil; IR (film) $\nu_{\max}$ cm^{-1} 3285 (s), 2984 (s), 2948 (m), 2119 (w), 1722 (s), 1690 (s), 1373 (m), 1299 (s), 1239 (s), 1115 (s), 841 (m); 1H NMR (300 MHz) δ_H 7.99 (dd, $J = 7.5, 1.4$, 2 H aromatic), 7.64 (t, $J = 7.5, 1.4$, 1 H aromatic), 7.49 (td, $J = 7.5, 1.4$, 2 H aromatic), 2.71 (s, 1 H, $\equiv CH$), 1.82 (s, 6 H, 2 Me); ^{13}C NMR (75 MHz) δ_C 185.8, 162.4, 134.8, 132.4, 129.9, 128.8, 83.3, 74.8, 74.0, 28.8; MS m/z 105 (M^+ - ($C_6H_7O_2$), 100), 77 (50), 67 (50), 51 (23). Anal. Calcd for $C_{13}H_{12}O_3$: C, 72.21; H, 5.59. Found C, 72.11; H, 5.63.

N-(1,1-Dimethylprop-2-ynyl)-2-oxopropionamide 12a. Chromatography with *n*-hexane/EtOAc (10/1) gave (3.25 g, 85%) as a pale yellow solid, mp 37 °C; IR (KBr) $\nu_{\max}$ cm^{-1} 3312 (s), 3266 (m), 2989 (m), 2940 (m), 1723 (s), 1677 (s), 1223 (m); 1H NMR (300 MHz) δ_H 7.01 (s, 1 H, NH), 2.44 (s, 3 H, MeCO), 2.36 (s, 1 H, $\equiv CH$), 1.65 (s, 6 H, 2 Me); ^{13}C NMR (75 MHz) δ_C 197.2, 158.9, 85.7, 69.9, 47.4, 28.4, 23.8; MS m/z 153 (M^+ , 20), 138 (5), 110 (8), 95 (20), 82 (2), 67 (90), 43 (100). Anal. Calcd for $C_8H_{11}O_2N$: C, 62.73; H, 7.24; N, 9.14. Found C, 62.66; H, 7.27; N, 9.10.

N-(1,1-Dimethylprop-2-ynyl)-2-oxo-2-phenylacetamide 12b. Chromatography with *n*-hexane/EtOAc (10/1) gave (4.300 g, 80 %) as a pale yellow solid, mp 76-77 °C; IR (KBr) $\nu_{\max}$ cm^{-1} 3308 (m), 3270 (s), 3054 (m), 2986 (m), 2115 (w), 1654 (s), 1668 (s), 1539 (m), 1450 (m), 1384 (s), 1230 (m); 1H NMR (300 MHz) δ_H 8.32 (dd, $J = 8.7, 1.5$, 2 H aromatic), 7.56-7.61 (m, 1 H aromatic), 7.44 (dd, $J = 8.7, 8.7$, 2 H aromatic), 7.24 (s, broad, 1 H, NH), 2.40 (s, 1 H, $\equiv CH$), 1.71 (s, 6 H, 2 Me); ^{13}C NMR (75 MHz) δ_C 187.4, 160.5, 134.3, 133.1, 131.2, 128.3, 85.9, 69.9, 47.7, 28.5; MS m/z 215 (M^+ , 3), 105 (100), 77 (35), 67 (20), 51 (12). Anal. Calcd for $C_{13}H_{13}O_2N$: C, 72.54; H, 6.09; N, 6.51. Found C, 72.44; H, 6.15; N, 6.45.

2-Oxo-N-prop-2-ynylpropionamide 16. Chromatography with CH_2Cl_2 /EtOAc (9/1) gave (2.175 g, 87 %) as a pale yellow oil; IR (film) $\nu_{\max}$ cm^{-1} 3291 (s), 2125 (w), 1718 (s), 1685 (s), 1522 (s), 1361 (s), 1171 (m); 1H NMR (300 MHz) δ_H 7.15 (s, 1 H, NH), 4.06 (dd, 2 H, $J = 5.7, 2.7$, CH_2), 2.45 (s, 3 H, MeCO), 2.25 (t, 1 H, $J = 2.7$, $\equiv CH$); ^{13}C NMR (75 MHz) δ_C 196.1, 159.6, 78.2, 72.1, 29.0, 24.3; MS m/z 125 (M^+ , 25), 97 (2), 82 (100), 55 (25), 52 (5). Anal. Calcd for $C_6H_7O_2N$: C, 57.59; H, 5.64; N, 11.19. Found C, 57.50; H, 5.61; N, 11.11.

References

1. Sir97: *A new Program For Solving And Refining Crystal Structures* – Altomare A., Burla M.C., Camalli M., Cascarano G., Giacovazzo C., Guagliardi A., Moliterni A.G., Polidori G., Spagna R., 1997, Istituto di Ricerca per lo Sviluppo di Metodologie Cristallografiche C N R, Bari.
2. Shelxl97. *Program for structure refinement*. Sheldrick G., University of Goettingen, Germany, 1997.
3. Farrugia, L. J., J. Appl. Crystallogr., 1999, 32, 837-838
4. Nardelli, M. J. Appl. Crystallogr. 1995, 28, 659.
5. Allen, F. H.; Kennard, O.; Taylor, R. Acc. Chem. Res. 1983, 16, 146-153.