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C-Quaternary alkynyl glycinols *via* the Ritter reaction of cobalt complexed alkynyl glycols†

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A novel approach to *C*-quaternary alkynyl glycinols based on the Ritter reaction of acetonitrile with cobalt complexed alkynyl glycols is presented. The reaction is promoted by acids such as H_2SO_4 or $BF_3 \cdot Et_2O$ to give oxazolines as the reaction products. These are subjected to cobalt complex cleavage in oxidative conditions and subsequent acidic hydrolysis providing amino alcohols. The substrates for the Ritter reaction can be easily assembled to introduce structural diversity at both variable positions. The Ritter reaction conditions for oxazoline formation is compatible with a range of substituents at the alkyne terminal position providing oxazolines in moderate to good yields. Methyl, hydroxymethyl and silyloxymethyl substituents at the reaction center of glycols are well tolerated, while a phenyl group in this position is detrimental to the reaction.

Introduction

C-Quaternary alkynyl glycinols **1** and synthetically equivalent alkynyl glycine **2** derivatives (Fig. 1) are versatile building blocks for the construction of complex biologically active molecules.[1–7] While there is a good arsenal of methods for the synthesis of *C*-quaternary alkynyl glycines **2**,[1,2] the direct access to *C*-quaternary alkynyl glycinols **1** is limited to few alternatives avoiding the reduction of carboxyl groups in glycines **2**. The literature search revealed only the Seyferth–Gilbert homologation of a serinal derivative;[8] aminolysis of alkynyl epoxides[7,9–12] and the insertion of a nitrene into a propargylic C–H bond[13] as synthetically useful approaches. Thus, a short synthesis of glycinol derivatives **1** from readily available variable building blocks is very desirable.

We have recently reported the synthesis of alkynyl glycinols **1** (R^1 = H) *via* intramolecular propargylic amination of bis-trichloroacetimidates derived from alkynyl glycols.[14] Our attempts to extend this approach for the synthesis of *C*-quaternary derivatives were not successful. As an alternative, we turned our attention to the Ritter reaction of 1,2-diols which is a known method for the synthesis oxazolines and oxazines involving carbenium ion **A** and nitrilium ion **B** intermediates.[15–24] When alkynyl glycol **3** (R^1 = Me, R^2 = *n*Pent) was directly subjected to the Ritter reaction conditions (MeCN, AcOH, H_2SO_4) the expected oxazoline **6** was obtained in a very low yield (<10%) (Scheme 1). This prompted us to explore the Ritter reaction of cobalt complexed alkynyl glycols **4** (ref. 25 and 26) which has better ability to stabilize the intermediate carbenium ion **A**[27–29] providing oxazolines **5** as precursors of alkynyl glycinol derivatives **1**. Such approach gave the expected results which are summarized in this article.

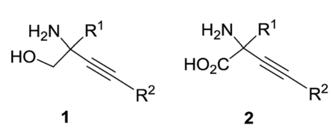
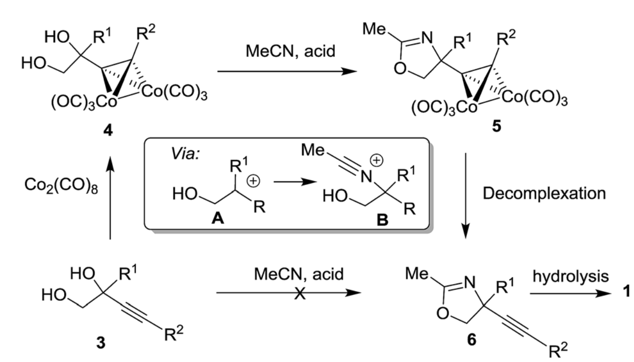


Fig. 1 *C*-Quaternary alkynyl glycinols **1** and glycines **2**.

Results and discussion

Cobalt complexed alkynyl glycols **4a–j** were prepared starting from hydroxy ketone derivatives **7a–j**. Addition of lithium



Scheme 1 The Ritter reaction for the synthesis of oxazolines **5** as precursors of amino alcohols **1**.

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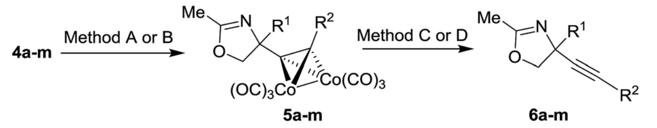
acetylenides provided alkynyl diols **3a–j** which were treated with $Co_2(CO_8)$ (Table 1).

If *O*-TBS protected starting materials **7l–n** were used, the corresponding addition products **8a–c** were deprotected before the complex **4l–m** formation. Several *O*-TBS protected alkynyl glycols **8b–d** were transformed to the corresponding cobalt complexes **9a–c**.

Cobalt complexed alkynyl glycols **4a–d** gave the expected oxazolines **5a–d** in the Ritter reaction with acetonitrile using both H_2SO_4 and $BF_3 \cdot EtO_2$ as acid promoters (Table 2, entries 1–4). Except for the substrate **4c**, better yields were obtained under conditions involving $BF_3 \cdot Et_2O$. Using $BF_3 \cdot Et_2O$ as acid, glycols **4e–h** were transformed to oxazolines **5e–h** (Table 2, entries 5–8). These results indicate that the Ritter reaction tolerates wide range of substituents at the terminal alkyne position in substrates **4**. Diols **4i,j** bearing Ph group at the reaction center were unsuitable substrates giving no yield of the expected oxazolines **5i,j** (Table 2, entries 9 and 10). Secondary alcohol **4k** could be successfully subjected to the Ritter reaction providing acetamide **5k** (Table 2, entry 11). Hydroxymethyl substituent at the reaction center of the substrates **4l,m** was tolerated to give the Ritter reaction products **5l,m** in moderate and good yields (Table 2, entries 12 and 13).

Several reaction conditions for the cleavage of cobalt complex **5a** were investigated to obtain the uncomplexed oxazoline **6a** (ethylenediamine, THF, 65 °C, yield of **6a**, 28%; NMO, CH_2Cl_2, r.t. yield of **6a**, 42%; DDQ, CH_2Cl_2, r.t. yield of **6a**, 84%).[30,31]

Table 2 The Ritter reaction of cobalt complexed alkynyl glycols **4** and the cleavage of cobalt complex[a]

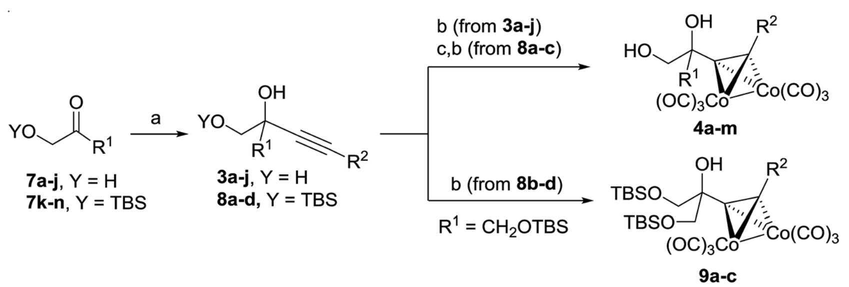


Entry	R¹	R²	**5**, yield% (method)	**6**, yield% (method)
1	Me	*n*Pent	**5a**, 58 (A); 78 (B)	**6a**, 84 (C), 42 (D)
2	Me	*t*Bu	**5b**, 75 (A); 82 (B)	**6b**, 64 (C)
3	Me	TMS	**5c**, 89 (A); 84 (B)	**6c**, 88 (C)
4	Me	Ph	**5d**, 57 (A); 86 (B)	**6d**, 83 (C)
5	Me	2-ClPh	**5e**, 61 (B)	**6e**, 92 (C)
6	Me	4-MeOPh	**5f**, 63 (B)	**6f**, 85 (C)
7	Me	CH_2OBn	**5g**, 78 (B)	**6g**, 82 (C)
8	Me	Me	**5h**, 74 (B)	**6h**, 46 (C)
9	Ph	*n*Pent	**5i**, dec. (B)	—
10	Ph	Ph	**5j**, dec. (B)	—
11	H	*n*Pent	**5k**, 77 (B)	**6k**, 78 (C)
12	CH_2OH	*n*Pent	**5l**, 46 (B)	**6l**, 61 (C); 65 (D)
13	CH_2OH	Ph	**5m**, 81 (B)	**6m**, 26 (C); 65 (D)

[a] Reagents and conditions: method A: MeCN, H_2SO_4, AcOH, 0 °C; method B: $BF_3 \cdot Et_2O$, MeCN, 0 °C; method C: DDQ, CH_2Cl_2, 0 °C. Method D: NMO CH_2Cl_2, 0 °C.

The best yield of **6a** was obtained in oxidative conditions with DDQ which to our knowledge has not yet been reported as

Table 1 Synthesis of cobalt complexed alkynyl diols **4** and **9**[b]



Entry	R¹	R²	Y	**3** or **8**, yield%	**4**, yield %[a]	**9**, yield%
1	Me	*n*Pent	H	**3a**, 98	**4a**, 98	—
2	Me	*t*Bu	H	**3b**, 47	**4b**, 75	—
3	Me	TMS	H	**3c**, 86	**4c**, >99	—
4	Me	Ph	H	**3d**, >99	**4d**, 94	—
5	Me	2-ClPh	H	**3e**, 90	**4e**, 90	—
6	Me	4-MeOPh	H	**3f**, 60	**4f**, 83	—
7	Me	CH_2OBn	H	**3g**, 39	**4g**, 70	—
8	Me	Me	H	**3h**, 47	**4h**, 70	—
9	Ph	*n*Pent	H	**3i**, 96	**4i**, 56	—
10	Ph	Ph	H	**3j**, 97	**4j**, 82	—
11	H	*n*Pent	TBS	**8a**, 82	**4k**, 40	
12	CH_2OTBS (CH_2OH)[a]	*n*Pent	TBS	**8b**, 94	**4l**, 78	**9a**, 73
13	CH_2OTBS (CH_2OH)[a]	Ph	TBS	**8c**, 95	**4m**, 73	**9b**, 79
14	CH_2OTBS	Me	TBS	**8d**, 75	—	**9c**, 86

[a] $R^1 = CH_2OTBS$ in compounds **8** was transformed to $R^1 = CH_2OH$ in compounds **4**. [b] Reagents and conditions: (a) alkyne, *n*BuLi, LiBr, THF, −40 °C-r.t.; (b) $Co_2(CO)_8$, CH_2Cl_2, r.t.; (c) TBAF, THF, 0 °C-r.t.

the reagent for the decomplexation of alkyne cobalt complexes. Other cobalt complexes **5a–h,l–m** were also cleaved with DDQ to give uncomplexed oxazolines **6a–h,l–m** typically in good yields. The only exception was substrate **5m** which gave product **6m** in poor yield. For the cleavage of the complex **5m**, NMO was better suited as oxidant to provide product **6m** more efficiently.

O-TBS protected alkynyl glycols **9a–c** could also be used as substrates for the Ritter reaction (Table 3). The reaction proceeded with concomitant deprotection of *O*-TBS group to give oxazolines **5l–n**. The cleavage of cobalt complex **5n** was performed with DDQ to give uncomplexed oxazoline **6n** (Table 3, entry 3).

Selected oxazolines **6d,g,h,l,m** were transformed to amino alcohols **1** by using acidic hydrolysis in mild conditions (Table 4). The hydrolysis proceed with good yields of product **1d,g,h,l,m** formation which were purified by the trituration with EtOAc.

Experimental

General information

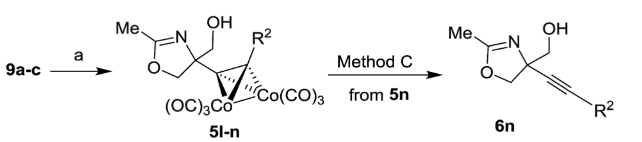
Commercially available reagents were used without further purification. All air or moisture-sensitive reactions were carried out under an argon atmosphere using oven-dried glassware. Flash chromatography was carried out using Merck Kieselgel 60 (230–400 mesh). Thin layer chromatography was performed on silica gel and was visualized by staining with $KMnO_4$. NMR spectra were recorded on a Varian Mercury spectrometer (400 MHz) and a Bruker Fourier spectrometer (300 MHz) with chemical shift values (δ) in ppm relative to TMS using the residual chloroform signal as an internal standard. Elemental analyses were performed using a Carlo-Erba EA1108 Elemental Analyser. HRMS were obtained using a Q-TOF micro high resolution mass spectrometer with ESI (ESI+/ESI−).

Preparation of diols/triols 3 and 8

Alcohols **3** and **8** were prepared according to the procedure described in the literature starting from the corresponding ketones **7**.[14]

Alcohols **3a**,[32] **3b**,[33] **3c**,[34] **3d**,[34] **3g**,[34] **3k**,[14] **3i,j**[35] **8a**[14] are known in literature.

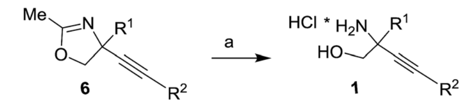
Table 3 The Ritter reaction of cobalt complexed alkynyl diols **9a–c** and the cleavage of cobalt complex in intermediate **5n**[a]



Entry	**9**, R^2	**5**, yield%	**6**, yield%
1	**9a**, *n*Pent,	**5l**, 37	See Table 2
2	**9b**, Ph	**5m**, 78	See Table 2
3	**9c**, Me	**5n**, 63	**6n**, 73 (C)

[a] Reagents and conditions: (a) $BF_3 \cdot Et_2O$, MeCN, 0 °C; method C: DDQ, CH_2Cl_2, 0 °C.

Table 4 Preparation of amino alcohols **1** *via* hydrolysis of oxazolines[a]



Entry	R^1	R^2	**1**, yield%
1	Me	Ph	**1d**, 96
2	Me	CH_2OBn	**1g**, 64
3	Me	Me	**1h**, 62
4	CH_2OH	*n*Pent	**1l**, 82
5	CH_2OH	Ph	**1m**, 77

[a] Reagents and conditions: (a) aq. 20% HCl, MeOH, r.t.

4-(2-Chlorophenyl)-2-methylbut-3-yne-1,2-diol (3e). White powder. M.p. 63–65 °C. ^{1}H NMR (400 MHz, CD_3OD) δ 7.50 (dd, J = 7.3, 2.1 Hz, 1H, $-C_6H_4Cl$), 7.43 (dd, J = 7.7, 1.6 Hz, 1H, $-C_6H_4Cl$), 7.30 (td, J = 7.7, 2.0 Hz, 1H, $-C_6H_4Cl$), 7.26 (td, J = 7.5, 1.5 Hz, 1H, $-C_6H_4Cl$), 3.63 (d, J = 11.0 Hz, 1H, $-CH_2O-$), 3.60 (d, J = 11.0 Hz, 1H, $-CH_2O-$), 1.54 (s, 3H, $-CH_3$). ^{13}C NMR (100 MHz, CD_3OD) δ 138.2, 135.9, 132.1, 131.7, 129.2, 125.4, 99.7, 82.5, 72.4, 71.1, 27.5. Anal. calcd for $C_{12}H_{14}O_3$: C, 62.72%; H, 5.26%; found: C, 62.71%; H, 5.23%.

4-(4-Methoxyphenyl)-2-methylbut-3-yne-1,2-diol (3f). Off white powder. M.p. 74–77 °C. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.36 (d, J = 8.9 Hz, 2H, $-C_6H_5$), 6.83 (d, J = 8.9 Hz, 2H, $-C_6H_5$), 3.81 (s, 3H, $-OCH_3$), 3.74 (dd, J = 11.0, 5.0 Hz, 1H, $-CH_2O-$), 3.56 (dd, J = 11.0, 8.8 Hz, 1H, $-CH_2O-$), 2.66 (s, 1H, –OH), 2.13 (dd, J = 8.8, 5.0 Hz, 1H, –OH), 1.55 (s, 3H, $-CH_3$). ^{13}C NMR (100 MHz, $CDCl_3$) δ 159.9, 133.4, 114.3, 114.1, 89.0, 84.7, 71.0, 69.2, 55.4, 20.2. Anal. calcd for $C_{12}H_{14}O_3$: C, 69.89%; H, 6.84%; found: C, 69.56%; H, 6.86%.

2-Methyl-pent-3-yne-1,2-diol (3h). Colourless oil. ^{1}H NMR (300 MHz, $CDCl_3$) δ 2.76 (d, J = 10.9 Hz, 1H, $-CH_2OH$), 2.61 (d, J = 10.9 Hz, 1H, $-CH_2OH$), 1.72 (s, 1H, –OH), 1.28 (s, 1H, –OH), 1.00 (s, 3H, $-CH_3$), 0.58 (s, 3H, $-CH_3$). ^{13}C NMR (100 MHz, $CDCl_3$) δ 109.9, 80.8, 70.9, 68.6, 25.5, 3.5. In HRMS conditions no signal observed. GC-MS (EI): *m/z*: 83 $[M - CH_2OH]^+$.

6-(Hept-1-yn-1-yl)-2,2,3,3,9,9,10,10-octamethyl-4,8-dioxa-3,9-disilaundecan-6-ol (8b). Colourless oil. ^{1}H NMR (300 MHz, $CDCl_3$) δ 3.61 (d, J = 9.5 Hz, 2H, $-CH_2O-$), 3.51 (d, J = 9.5 Hz, 2H, $-CH_2O-$), 2.80 (s, 1H, –OH), 2.11 (t, J = 7.1 Hz, 2H, $-CH_2(CH_2)_3CH_3$), 1.52–1.37 (m, 2H, $-CH_2CH_2(CH_2)_2CH_3$), 1.29–1.14 (m, 4H, $-CH_2CH_2(CH_2)_2CH_3$), 0.82 (s, 18H, $-SiC(CH_3)_3$), 0.81–0.77 (m, 3H, $-CH_2(CH_2)_3CH_3$), 0.00 (d, J = 1.1 Hz, 12H, $-Si(CH_3)_2$). ^{13}C NMR (100 MHz, $CDCl_3$) δ 85.6, 79.8, 71.1, 65.9, 31.0, 28.2, 25.8, 22.2, 18.7, 18.3, 13.9, −5.4. In HRMS conditions no signal observed. GC-MS (EI): *m/z*: 357 $[M - tBu]^+$.

Deprotection of silyl groups gave 2-(hept-1-yn-1-yl)propane-1,2,3-triol (3k). Colourless oil. ^{1}H NMR (400 MHz, $CDCl_3$) δ 3.70 (s, 4H, $-CH_2OH$), 2.18 (ddt, J = 9.2, 7.1, 3.7 Hz, 2H, $-CH_2(CH_2)_3CH_3$), 1.59–1.44 (m, 2H, $-CH_2CH_2(CH_2)_2CH_3$), 1.30 (qd, J = 3.6, 3.1, 1.5 Hz, 4H, $-CH_2CH_2(CH_2)_2CH_3$), 0.96–0.81 (m, 3H, $-CH_2(CH_2)_3CH_3$). ^{13}C NMR (100 MHz, $CDCl_3$) δ 87.9, 78.3, 71.5, 67.4, 31.0, 28.2, 22.1, 18.6, 13.9. In HRMS conditions no signal observed. GC-MS (EI): *m/z*: 155 $[M - CH_2OH]^+$.

2,2,3,3,9,9,10,10-Octamethyl-6-(phenylethynyl)-4,8-dioxa-3,9-disilaundecan-6-ol (8c). Colourless oil. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.44–7.39 (m, 2H, $-C_6H_5$), 7.30–7.26 (m, 3H, m, $-C_6H_5$), 3.80 (d, $J = 9.5$ Hz, 2H, $-CH_2O-$), 3.72 (d, $J = 9.5$ Hz, 2H, $-CH_2O-$), 3.04 (s, 1H, –OH), 0.90 (s, 18H, $-SiC(CH_3)_3$), 0.09 (d, $J = 0.9$ Hz, 12H, $-Si(CH_3)_2$). ^{13}C NMR (100 MHz, $CDCl_3$) δ 131.7, 128.1, 122.7, 89.3, 84.8, 71.6, 65.9, 25.8, 18.3, −5.4. HR-MS (ESI-TOF) *m/z*: calcd for $C_{23}H_{40}O_3Si_2Na$ 443.2399; found $[M + Na]^+$ 443.2414.

Deprotection of silyl groups gave 2-(phenylethynyl)propane-1,2,3-triol (3l). Colourless oil. ^{1}H NMR (300 MHz, $CDCl_3$) δ 7.52–7.41 (m, 2H, *o*-C_6H_5–), 7.39–7.31 (m, 3H, *m*,*p*-C_6H_5–), 3.92–3.82 (m, 4H, $-CH_2OH$), 3.08 (s, 1H, –OH), 2.18 (dd, $J = 8.6$, 4.8 Hz, 2H, $-CH_2OH$). ^{13}C NMR (100 MHz, $CDCl_3$) δ 131.3, 127.9, 127.9, 122.6, 88.9, 84.5, 71.5, 65.3. In HRMS conditions no signal observed. GC-MS (EI): *m/z*: 161 $[M - -CH_2OH]^+$.

2,2,3,3,9,9,10,10-Octamethyl-6-(prop-1-yn-1-yl)-4,8-dioxa-3,9-disilaundecan-6-ol (8d). Colourless oil. ^{1}H NMR (400 MHz, $CDCl_3$) δ 3.67 (d, $J = 9.5$ Hz, 2H, $-CH_2O-$), 3.58 (d, $J = 9.5$ Hz, 2H, $-CH_2O-$), 2.85 (s, 1H, –OH), 1.81 (s, 3H, $-CH_3$), 0.89 (s, 18H, $-SiC(CH_3)_3$), 0.06 (d, $J = 1.7$ Hz, 12H, $Si(CH_3)_2$). ^{13}C NMR (100 MHz, $CDCl_3$) δ 81.1, 79.2, 71.1, 65.8, 25.8, 18.3, 3.5, −5.3, −5.4. HR-MS (ESI-TOF) *m/z*: calcd for $C_{18}H_{48}O_3Si_2Na$ 381.2247; found $[M + Na]^+$ 381.2257.

General procedure for the preparation of cobalt-complexed propargyl alcohols 4 and 9

To a solution of alkyne (1 mmol) in CH_2Cl_2 (5 mL), $Co_2(CO)_8$ (1.1 mmol) was added under argon atmosphere. The solution was stirred at room temperature until no evolution of CO_2 was observed (TLC showed the formation of the complex to be completed). The solvent was removed *in vacuo* and the residue was purified by column chromatography on silica gel eluting with a mixture of ethyl acetate and petroleum ether (1 : 30–1 : 4) to yield the $Co_2(CO)_6$-alkyne complex.

^{13}C-NMR for compounds **4** and **9** was not possible to record due to Co induced line broadening. Typically compounds **4** and **9** were not stable under conditions used for HRMS.

Hexacarbonyl[μ-η^4-(2-methylnon-3-yne-1,2-diol)]dicobalt (4a). Red powder. ^{1}H NMR (300 MHz, $CDCl_3$) δ 3.70 (d, $J = 4.7$ Hz, 2H, $-CH_2O-$), 2.90–2.73 (m, 2H, $-CH_2(CH_2)_3CH_3$), 2.26 (s, 1H, –OH), 2.06–1.95 (m, 1H, –OH), 1.73–1.31 (m, 9H, $-CH_3$, $-CH_2CH_2(CH_2)_2CH_3$, $-(CH_2)_2(CH_2)_2CH_3$), 0.93 (t, $J = 6.2$ Hz, 3H, $-(CH_2)_4CH_3$). Not stable under HR-MS conditions.

Hexacarbonyl[μ-η^4-(2,5,5-trimethylhex-3-yne-1,2-diol)]dicobalt (4b). Red powder. ^{1}H NMR (300 MHz, $CDCl_3$) δ 3.72 (d, $J = 5.3$ Hz, 2H, $-CH_2O-$), 2.25 (s, 1H, –OH), 2.15–2.02 (m, 1H, –OH), 1.62 (s, 3H, $-CH_3$), 1.35 (s, 9H, $-C(CH_3)_3$). Not stable under HR-MS conditions.

Hexacarbonyl[μ-η^4-(2-methyl-4-(trimethylsilyl)but-3-yne-1,2-diol)]dicobalt (4c). Red powder. ^{1}H NMR (300 MHz, $CDCl_3$) δ 3.66 (d, $J = 5.9$ Hz, 2H, $-CH_2O-$), 2.04 (s, 1H, –OH), 2.04 (t, $J = 5.9$ Hz, 1H, –OH), 1.57 (s, 3H, $-CH_3$), 0.33 (s, 9H, $-Si(CH_3)_3$). Not stable under HR-MS conditions.

Hexacarbonyl[μ-η^4-(2-methyl-4-phenylbut-3-yne-1,2-diol)]dicobalt (4d). Red powder. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.69–7.56 (m, $J = 6.8$ Hz, 2H, *o*-C_6H_5–), 7.40–7.29 (m, 3H, *p*,*m*-C_6H_5–), 3.89–3.74 (br, 2H, $-CH_2O-$), 2.58 (s, 1H, –OH), 2.08–1.99 (br, 1H, –OH), 1.67 (s, 3H,$-CH_3$). Not stable under HR-MS conditions.

Hexacarbonyl[μ-η^4-(4-(2-chlorophenyl)-2-methylbut-3-yne-1,2-diol)]dicobalt (4e). Red powder. ^{1}H NMR (300 MHz, $CDCl_3$) δ 8.01–7.94 (m, 1H, C_6H_4Cl–), 7.45–7.37 (m, 1H), 7.32–7.26 (m, 2H, C_6H_4Cl–, overlapping with $CHCl_3$ signal), 3.82 (d, $J = 5.8$ Hz, 2H, $-CH_2O-$), 2.87 (s, 1H, –OH), 2.05 (t, $J = 5.8$ Hz, 1H, –OH), 1.67 (s, 3H, $-CH_3$). Not stable under HR-MS conditions.

Hexacarbonyl[μ-η^4-(4-(4-methoxyphenyl)-2-methylbut-3-yne-1,2-diol)]dicobalt (4f). Red powder. ^{1}H NMR (300 MHz, $CDCl_3$) δ 7.61 (s, 2H, *m*-MeO–C_6H_4–), 6.90 (s, 2H, *o*-MeO–C_6H_4–), 4.14 (s, 1H, $-CH_2OH$), 3.85 (s, 4H, $CH_3O-C_6H_4-$ (3H), and overlapping $-CH_2OH$ (1H)), 2.59 (s, 1H, –OH), 2.18 (s, 1H, –OH), 1.69 (s, 3H, $-CH_3$). Not stable under HR-MS conditions.

Hexacarbonyl[μ-η^4-(5-(benzyloxy)-2-methylpent-3-yne-1,2-diol)]dicobalt (4g). Red powder. ^{1}H NMR (300 MHz, $CDCl_3$) δ 7.37 (m, 5H, C_6H_5–), 4.76 (d, $J = 8.4$ Hz, 4H, $-CH_2O-CH_2-$), 3.65 (d, $J = 5.2$ Hz, 1H, $-CH_2OH$), 3.53 (s, 1H, $-CH_2OH$), 3.10 (s, 1H, –OH), 2.19 (s, 1H, –OH), 1.53 (s, 3H, $-CH_3$). HR-MS (ESI-TOF) *m/z*: calcd for $C_{19}H_{16}O_9Co_2$504.9382; found 504.9380.

Hexacarbonyl[μ-η^4-(2-methyl-pent-3-yne-1,2-diol)]dicobalt (4h). Red powder. ^{1}H NMR (300 MHz, $CDCl_3$) δ 3.72 (s, 2H, $-CH_2OH$), 2.72 (s, 3H, $-CH_3$), 2.31 (s, 1H, –OH), 2.06 (s, 3H, $-CH_3$). Not stable under HR-MS conditions.

Hexacarbonyl[μ-η^4-(2,4-diphenylbut-3-yne-1,2-diol)]dicobalt (4i). ^{1}H NMR (300 MHz, $CDCl_3$) δ 7.59 (d, $J = 7.5$ Hz, 2H, *o*-C_6H_4–), 7.41 (t, $J = 7.5$ Hz, 2H, *m*-C_6H_4–), 7.33 (d, $J = 7.5$ Hz, 1H, *p*-C_6H_4–), 4.36 (dd, $J = 10.0$, 4.5 Hz, 1H, $-CH_2OH$), 3.95 (t, $J = 10.0$ Hz, 1H, $-CH_2OH$), 3.10 (s, 1H, –OH), 2.75 (m, 2H, $-CH_2(CH_2)_3CH_3$), 2.19 (s, 1H, –OH), 1.69–1.58 (m, 2H, $-CH_2CH_2(CH_2)_2CH_3$), 1.52–1.30 (m, 4H, $-CH_2CH_2(CH_2)_2CH_3$), 0.95 (t, $J = 6.9$ Hz, 3H, $-CH_2(CH_2)_3CH_3$). Not stable under HR-MS conditions.

Hexacarbonyl[μ-η^4-(6-(hept-1-yn-1-yl)-2,2,3,3,9,9,10,10-octamethyl-4,8-dioxa-3,9-disilaundecan-6-ol)]dicobalt (4j). ^{1}H NMR (300 MHz, $CDCl_3$) δ 7.56 (d, $J = 7.2$ Hz, 4H, *o*-C_6H_4–), 7.42–7.29 (m, 6H, *m*,*p*-C_6H_4–), 4.60–4.43 (m, 1H, $-CH_2OH$), 4.25–4.03 (m, 1H, $-CH_2OH$), 3.39 (s, 1H, –OH), 1.84 (s, 1H, –OH). Not stable under HR-MS conditions.

Hexacarbonyl[μ-η^4-(non-3-yne-1,2-diol)]dicobalt (4k). Red powder. ^{1}H NMR (300 MHz, $CDCl_3$) δ 4.39 (s, 1H, –CH(OH)-), 3.62 (s, 2H, $-CH_2OH$), 2.21–2.09 (m, 2H, $-CH_2(CH_2)_3CH_3$), 1.44 (t, $J = 7.2$ Hz, 2H, $-CH_2CH_2(CH_2)_2CH_3$), 1.35–1.13 (m, 4H, $-CH_2CH_2(CH_2)_2CH_3$), 0.89–0.77 (m, 3H, $-CH_2(CH_2)_3CH_3$). Not stable under HR-MS conditions.

Hexacarbonyl[μ-η^4-(2-(hept-1-yn-1-yl)propane-1,2,3-triol)]dicobalt (4l). ^{1}H NMR (300 MHz, $CDCl_3$) δ 3.62 (s, 4H, $-CH_2OH$), 2.11 (t, $J = 7.2$ Hz, 2H, $-CH_2(CH_2)_3CH_3$), 1.99 (s, 1H, –OH), 1.51–1.35 (m, 2H, $-CH_2CH_2(CH_2)_2CH_3$), 1.29–1.19 (m, 4H, $-CH_2$-$CH_2(CH_2)_2CH_3$), 0.88–0.72 (m, 3H, $-CH_2(CH_2)_3CH_3$). Not stable under HR-MS conditions.

Hexacarbonyl[μ-η^4-(2-(phenylethynyl)propane-1,2,3-triol)]dicobalt (4m). ^{1}H NMR (300 MHz, $CDCl_3$) δ 7.46 (dd, $J = 7.4$, 2.2 Hz, 2H, *o*-C_6H_4–), 7.37–7.32 (m, 3H, *m*,*p*-C_6H_4–), 3.87 (dd, $J =$

6.3, 3.5 Hz, 4H, $-CH_2OH$), 3.08 (s, 1H, –OH), 1.57 (s, 1H, –OH). Not stable under HR-MS conditions.

Hexacarbonyl[μ-η^4-(6-(hept-1-yn-1-yl)-2,2,3,3,9,9,10,10-octamethyl-4,8-dioxa-3,9-disilaundecan-6-ol)]dicobalt (9a). Red powder. ^{1}H NMR (300 MHz, $CDCl_3$) δ 3.63 (dd, J = 24.5, 9.5 Hz, 4H, $-CH_2OTBS$), 2.80 (s, 1H, –OH), 2.75–2.65 (m, 2H, $-CH_2-$), 1.66–1.37 (m, 6H, $(-CH_2-)_3$), 1.31 (d, J = 3.0 Hz, 3H, $-CH_3$), 0.83 (s, 18H, $-SiC(CH_3)_3$), 0.00 (d, J = 3.1 Hz, 12H, $-Si(CH_3)_2$). Not stable under HR-MS conditions.

Hexacarbonyl[μ-η^4-(2,2,3,3,9,9,10,10-octamethyl-6-(phenyl ethynyl)-4,8-dioxa-3,9-disilaundecan-6-ol)]dicobalt (9b). Red powder. ^{1}H NMR (300 MHz, $CDCl_3$) δ 7.62 (dd, J = 7.7, 1.7 Hz, 2H, o-C_6H_5-), 7.30–7.23 (m, 3H, p,m-C_6H_5-), 3.89 (d, J = 9.6 Hz, 2H, $-CH_2OTBS$), 3.76 (d, J = 9.6 Hz, 2H, $-CH_2OTBS$), 3.20 (s, 1H, –OH), 0.85 (s, 18H, $-SiC(CH_3)_3$), 0.02 (d, J = 9.8 Hz, 12H, $-Si(CH_3)_2$). Not stable under HR-MS conditions.

Hexacarbonyl[μ-η^4-(2,2,3,3,9,9,10,10-octamethyl-6-(prop-1-yn-1-yl)-4,8-dioxa-3,9-disilaundecan-6-ol)]dicobalt (9c). Red powder. ^{1}H NMR (300 MHz, $CDCl_3$) δ 3.70 (dd, J = 21.3, 9.5 Hz, 4H, $-CH_2OTBS$), 2.85 (s, 1H, –OH), 2.65 (s, 3H, $-CH_3$), 0.91 (s, 18H, $-SiC(CH_3)_3$), 0.08 (d, J = 2.8 Hz, 12H, $-Si(CH_3)_2$). Not stable under HR-MS conditions.

Method A for the Ritter reaction

A solution of the cobalt complex of diol **4** (2.2 mmol) in CH_3CN (54 eq., 118.8 mmol, 6.2 mL) was cooled to 0–3 °C (ice/water bath) and AcOH (8 eq., 17.6 mmol, 1.0 mL) was added followed by dropwise addition of H_2SO_4 (9 eq., 19.9 mmol, 1.0 mL). The reaction mixture was allowed to stir at this temperature until complete conversion of the starting material was observed (TLC control, usually 8 min). The reaction mixture was diluted with Et_2O (30 mL) and poured into water (15 mL). The organic phase was separated and the aqueous phase was extracted with Et_2O (30 mL). The combined organic phase was washed with aq. $NaHCO_3$, dried over Na_2SO_4, filtered and evaporated. The crude residue was purified by chromatography on silica gel eluting with a mixture of ethyl acetate and petroleum ether (1 : 20–1 : 10) to afford oxazoline cobalt complex.

Method B for the Ritter reaction

A solution of the cobalt complex **4** or **9** (0.3 mmol) in MeCN (3 mL) was cooled to 0–3 °C (ice/water bath) and BF_3 Et_2O (0.38 mL, 10 eq., 2.96 mmol) was added dropwise. The reaction mixture was allowed to stir at this temperature until complete conversion of the starting material (TLC control, usually 5–10 min). The reaction mixture was diluted with DCM (15 mL) and aq. $NaHCO_3$ (7 mL) was added. The organic phase was separated and washed with brine (1 × 7 mL), dried over Na_2SO_4, filtered and evaporated. The crude residue was purified by chromatography on silica gel eluting with a mixture of ethyl acetate and petroleum ether (1 : 20–1 : 3) to afford oxazoline cobalt complex.

^{13}C-NMR for compounds **5** was not possible to record due to Co induced line broadening. Typically compounds **5** were not stable under conditions used for HRMS.

Hexacarbonyl[μ-η^4-(4-(hept-1-yn-1-yl)-2,4-dimethyloxazoline)] dicobalt (5a). Viscous colorless oil. ^{1}H NMR (400 MHz, $CDCl_3$) δ 4.28 (d, J = 8.4 Hz, 1H, $-CH_2O-$), 4.12 (d, J = 8.4 Hz, 2H, $CDCl_3$), 2.89–2.76 (m, 2H, $-CH_2(CH_2)_3CH_3$), 1.97 (s, 3H, $-CH_3$), 1.74–1.58 (m, 5H, $-CH_3$, $-CH_2CH_2(CH_2)_2CH_3$), 1.43 (qd, J = 15.2, 7.4 Hz, 4H, $-(CH_2)_2(CH_2)_2CH_3$), 0.93 (t, J = 7.1 Hz, 3H, $-(CH_2)_4CH_3$). Not stable under HR-MS conditions.

Hexacarbonyl[μ-η^4-(4-(3,3-dimethylbut-1-yn-1-yl)-2,4-dimethyl oxazoline)]dicobalt (5b). Viscous colorless oil with tendency to crystalize. ^{1}H NMR (300 MHz, $CDCl_3$) δ 4.28 (d, J = 8.4 Hz, 1H, $-CH_2O-$), 4.14 (d, J = 8.4 Hz, 1H, $-CH_2O-$), 1.97 (s, 3H, $-CH_3$), 1.68 (s, 3H, $-CH_3$), 1.35 (s, 9H, $-C(CH_3)_3$). Not stable under HR-MS conditions.

Hexacarbonyl[μ-η^4-(2,4-dimethyl-4-((trimethylsilyl)ethynyl) oxazoline)]dicobalt (5c). Viscous colorless oil. ^{1}H NMR (300 MHz, $CDCl_3$) δ 4.21 (d, J = 8.4 Hz, 1H, $-CH_2O-$), 4.15 (d, J = 8.4 Hz, 1H, $-CH_2O-$), 1.98 (s, 3H, $-CH_3$), 1.65 (s, 3H, $-CH_3$), 0.32 (s, 9H, $-Si(CH_3)_3$). Not stable under HR-MS conditions.

Hexacarbonyl[μ-η^4-(2,4-dimethyl-4-(phenylethynyl)oxazoline)] dicobalt (5d). Viscous colorless oil. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.74–7.68 (m, Hz, 2H, $-C_6H_5$), 7.41–7.27 (m, 3H, $-C_6H_5$), 4.40 (d, J = 8.4 Hz, 1H, $-CH_2O-$), 4.21 (d, J = 8.4 Hz, 1H, $-CH_2O-$), 2.02 (s, 3H, $-CH_3$), 1.70 (s, 3H, $-CH_3$). Not stable under HR-MS conditions.

Hexacarbonyl[μ-η^4-(4-((2-chlorophenyl)ethynyl)-2,4-dimethyl oxazoline)]dicobalt (5e). Viscous colorless oil. ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.31–8.09 (br, 1H, $-C_6H_4Cl$), 7.53–7.28 (br, 3H, $-C_6H_4Cl$ overlapping with $CDCl_3$), 4.50 (d, J = 8.2 Hz, 1H, $-CH_2O-$), 4.28 (d, J = 8.2 Hz, 1H, $-CH_2O-$), 2.02 (s, 3H, $-CH_3$), 1.68 (s, 3H, $-CH_3$). Not stable under HR-MS conditions.

Hexacarbonyl[μ-η^4-(4-((4-methoxyphenyl)ethynyl)-2,4-dimethyl-oxazoline)]dicobalt (5f). Red oil. ^{1}H NMR (300 MHz, $CDCl_3$) δ 7.69 (2H, $-C_6H_4-$), 6.92 (2H, C_6H_4-), 4.42 (1H, $-CH_2O-$), 4.24 (1H, $-CH_2O-$), 3.85 (3H, $-OCH_3$), 2.03 (3H, $-CH_3$), 1.71 (3H, $-CH_3$). Not stable under HR-MS conditions.

Hexacarbonyl[μ-η^4-(4-(3-(benzyloxy)prop-1-yn-1-yl)-2,4-dimethyl-oxazoline)]dicobalt (5g). Red oil. ^{1}H NMR (300 MHz, $CDCl_3$) δ 7.45–7.29 (m, 5H, C_6H_5-), 4.70 (t, J = 14.3 Hz, 4H, $-CH_2O-CH_2-$), 4.31 (d, J = 8.5 Hz, 1H, $-CH_2O-$), 4.13 (d, J = 8.5 Hz, 1H, $-CH_2O-$), 1.96 (s, 3H, $-CH_3$), 1.63 (s, 3H, $-CH_3$). Not stable under HR-MS conditions.

Hexacarbonyl[μ-η^4-(2,4-dimethyl-4-(prop-1-yn-1-yl)-oxazoline)] dicobalt 5h. Red oil. ^{1}H NMR (300 MHz, $CDCl_3$) δ 4.28 (1H, $-CH_2O-$), 4.15 (1H, $-CH_2O-$), 2.72 (s, 3H, $-CH_3$), 1.99 (s, 3H, $-CH_3$), 1.65 (s, 3H, $-CH_3$). Not stable under HR-MS conditions.

Hexacarbonyl[μ-η^4-(4-(hept-1-yn-1-yl)-2-methyl-oxazoline)] dicobalt (5k). Red oil. ^{1}H NMR (300 MHz, $CDCl_3$) δ 5.32 (dd, J = 8.7, 6.4 Hz, 1H, –CHN–), 4.58–4.45 (m, 1H, $-CH_2O-$), 4.18 (dd, J = 8.5, 5.6 Hz, 1H, $-CH_2O-$), 2.92–2.83 (m, 2H, $-CH_2-$), 2.01 (d, J = 1.0 Hz, 3H, $-CH_3$), 1.68 (dd, J = 15.6, 8.0 Hz, 2H, $-CH_2-$), 1.55–1.33 (m, 4H, $-CH_2-CH_2-$), 0.93 (dd, J = 13.7, 6.5 Hz, 3H, $-CH_3$). Not stable under HR-MS conditions.

Hexacarbonyl[μ-η^4-((4-(hept-1-yn-1-yl)-2-methyl-4,5-dihydro oxazol-4-yl)methanol)]dicobalt (5l). Red oil. ^{1}H NMR (300 MHz, $CDCl_3$) δ 4.46 (d, J = 8.4 Hz, 1H, $-CH_2O-$), 4.15 (d, J = 8.4 Hz, 1H, $-CH_2O-$), 3.84 (dd, J = 10.8, 4.4 Hz, 1H, $-CH_2OH$), 3.54 (dd, J =

20.4, 10.8 Hz, 1H, –CH_2OH), 3.09 (dd, J = 8.9, 4.4 Hz, 1H, –OH), 2.81–2.68 (m, 2H, –$CH_2(CH_2)_3CH_3$), 1.93 (s, 3H, –CH_3), 1.66–1.49 (m, 2H, –$CH_2CH_2(CH_2)_2CH_3$), 1.43–1.25 (m, 4H, –$(CH_2)_2(CH_2)_2CH_3$), 0.85 (t, J = 7.1 Hz, 3H, –CH_3). Not stable under HR-MS conditions.

Hexacarbonyl[μ-η^4-((2-methyl-4-(phenylethynyl)-4,5-dihydro oxazol-4-yl)methanol)]dicobalt (5m). Red oil. ^{1}H NMR (300 MHz, $CDCl_3$) δ 7.45 (d, J = 6.5 Hz, 2H, o-C_6H_5–), 7.13 (d, J = 7.4 Hz, 3H, m,p-C_6H_5), 4.42 (d, J = 8.4 Hz, 1H, –CH_2O–), 4.12 (d, J = 8.4 Hz, 1H, –CH_2O–), 3.82–3.69 (m, 1H, –CH_2OH), 3.42 (t, J = 10.4 Hz, 1H, –CH_2OH), 2.36 (d, J = 6.1 Hz, 1H, –OH), 1.84 (s, 3H, –CH_3). Not stable under HR-MS conditions.

Hexacarbonyl[μ-η^4-((2-methyl-4-(prop-1-yn-1-yl)-4,5-dihydro oxazol-4-yl)methanol)]dicobalt (5n). Red oil. ^{1}H NMR (300 MHz, $CDCl_3$) δ 4.50 (d, J = 8.2 Hz, 1H, –CH_2O–), 4.24 (d, J = 8.2 Hz, 1H, –CH_2O–), 4.00–3.84 (m, 2H, –CH_2OH), 3.76–3.60 (m, 1H, –OH), 2.72 (s, 3H, –CH_3), 2.06 (s, 3H, –CH_3). Not stable under HR-MS conditions.

General procedure for the cleavage of cobalt complexes 5, method C

DDQ (3 eq., 1.23 mmol) was added in portions to a solution of cobalt complexed oxazoline **5** (1 eq., 0.41 mmol) in CH_2Cl_2 (4 mL) at 0 °C (ice/water bath). The reaction mixture was stirred until complete conversion of the starting material (TLC control, 30 min – 2 h). The reaction mixture was diluted with CH_2Cl_2 (30 mL) and aq. $NaHCO_3$ (10 mL) was added. The organic phase was separated and washed with H_2O (1 × 10 mL). Organic phase was dried over Na_2SO_4, filtered and evaporated. The crude residue was purified by chromatography on silica gel eluting with a mixture of ethyl acetate and petroleum ether 1 : 4–1 : 1 to afford oxazoline **6**.

General procedure for the cleavage of cobalt complexes 5, method D

N-Methylmorpholine N-oxide (NMO) (10 eq., 4.1 mmol) was added in portions to a solution of cobalt complexed oxazoline **5** (1 eq., 0.41 mmol) in CH_2Cl_2 (4 mL) at 0 °C (ice/water bath). The reaction mixture was stirred until complete conversion of the starting material (TLC control, usually 30 min). The reaction was quenched with aq. $NaHCO_3$ (10 mL) and extracted with ethyl acetate (2 × 8 mL). The organic phase was washed with brine (1 × 10 mL), dried over Na_2SO_4, filtered and evaporated. The crude residue was purified by chromatography on silica gel eluting with a mixture of ethyl acetate and petroleum ether (1 : 4–1 : 1) to afford oxazoline **6**.

4-(Hept-1-yn-1-yl)-2,4-dimethyloxazoline (6a). Colorless oil. ^{1}H NMR (400 MHz, $CDCl_3$) δ 4.28 (d, J = 8.1 Hz, 1H, –CH_2O–), 4.02 (d, J = 8.1 Hz, 1H, –CH_2O–), 2.17 (t, J = 7.1 Hz, 2H, –$CH_2(CH_2)_3CH_3$), 1.98 (s, 3H, –CH_3), 1.54–1.44 (m, 5H, –CH_3, –$CH_2CH_2(CH_2)_2CH_3$), 1.37–1.24 (m, 4H, –$(CH_2)_2(CH_2)_2CH_3$), 0.89 (t, J = 7.1 Hz, 3H, –$(CH_2)_4CH_3$). ^{13}C NMR (100 MHz, $CDCl_3$) δ 165.0, 84.2, 82.8, 79.6, 64.4, 31.2, 29.3, 28.5, 22.3, 18.8, 14.2, 14.1. HR-MS (ESI-TOF) m/z: calcd for $C_{12}H_{20}NO$ 194.1545; found $[M + H]^+$ 194.1548.

4-(3,3-Dimethylbut-1-yn-1-yl)-2,4-dimethyloxazoline (6b). Colorless oil. ^{1}H NMR (400 MHz, $CDCl_3$) δ 4.23 (d, J = 8.0 Hz, 1H, –CH_2O–), 4.02 (d, J = 8.0 Hz, 1H, –CH_2O–), 1.97 (s, 3H, –CH_3), 1.45 (s, 3H, –CH_3), 1.18 (s, 9H, –$C(CH_3)_3$). ^{13}C NMR (100 MHz, $CDCl_3$) δ 164.7, 92.1, 81.2, 79.8, 64.3, 31.2, 29.6, 27.4, 14.2. HR-MS (ESI-TOF) m/z: calcd for $C_{11}H_{18}NO$ 180.1388; found 180.1389 $[M + H]^+$.

2,4-Dimethyl-4-((trimethylsilyl)ethynyl)oxazoline (6c). Colorless oil. ^{1}H NMR (400 MHz, $CDCl_3$) δ 4.32 (d, J = 8.2 Hz, 1H, –CH_2O–), 4.03 (d, J = 8.2 Hz, 1H, –CH_2O–), 1.98 (s, 3H, –CH_3), 1.49 (s, 3H, –CH_3), 0.14 (s, 9H, –$Si(CH_3)_3$). ^{13}C NMR (100 MHz, $CDCl_3$) δ 164.4, 107.1, 86.6, 78.4, 63.8, 28.1, 13.2, −0.9. HR-MS (ESI-TOF) m/z: calcd for $C_{10}H_{18}NOSi$ 196.1158; found 196.1156 $[M + H]^+$.

2,4-Dimethyl-4-(phenylethynyl)oxazoline (6d). Colorless oil. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.42–7.36 (m, 2H, –C_6H_5), 7.28–7.22 (m, 3H, –C_6H_5), 4.41 (d, J = 8.2 Hz, 1H, –CH_2O–), 4.09 (d, J = 8.2 Hz, 1H, –CH_2O–), 1.99 (s, 3H, –CH_3), 1.58 (s, 3H, –CH_3). ^{13}C NMR (100 MHz, $CDCl_3$) δ 165.5, 131.8, 128.4, 128.3, 122.9, 91.7, 83.5, 79.5, 64.9, 29.1, 14.2. HR-MS (ESI-TOF) m/z: calcd for $C_{13}H_{14}NO$ 200.1075; found 200.1075 $[M + H]^+$.

4-((2-Chlorophenyl)ethynyl)-2,4-dimethyloxazoline (6e). Colorless oil. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.45 (dd, J = 7.4, 1.9 Hz, 1H, –C_6H_4Cl), 7.37 (dd, J = 7.9, 1.3 Hz, 1H, –C_6H_4Cl), 7.22 (td, J = 7.7, 1.9 Hz, 1H, –C_6H_4Cl), 7.17 (td, J = 7.5, 1.4 Hz, 1H, –C_6H_4Cl), 4.49 (d, J = 8.2 Hz, 1H, –CH_2O–), 4.14 (d, J = 8.2 Hz, 1H, –CH_2O–), 2.02 (s, 3H, –CH_3), 1.63 (s, 3H, –CH_3). ^{13}C NMR (100 MHz, $CDCl_3$) δ 165.7, 136.2, 133.4, 129.4, 129.3, 126.4, 122.8, 96.9, 80.4, 79.4, 65.0, 28.9, 14.2. HR-MS (ESI-TOF) m/z: calcd for $C_{13}H_{13}NOCl$ 234.0686; found 234.0684 $[M + H]^+$.

4-((4-Methoxyphenyl)ethynyl)-2,4-dimethyl-oxazoline (6f). Colorless oil. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.33 (d, J = 8.9 Hz, 2H, –C_6H_4OMe), 6.79 (d, J = 8.9 Hz, 2H, –C_6H_4OMe), 4.41 (d, J = 8.1 Hz, 1H, –CH_2O–), 4.09 (d, J = 8.1 Hz, 1H, –CH_2O–), 3.78 (s, 3H, –OCH_3), 2.00 (s, 3H, –CH_3), 1.58 (s, 3H, –CH_3). ^{13}C NMR (100 MHz, $CDCl_3$) δ 165.2, 159.5, 133.1, 133.1, 114.8, 113.7, 90.1, 83.2, 79.4, 64.7, 55.2, 28.9, 14.1. HR-MS (ESI-TOF) m/z: calcd for $C_{14}H_{15}NO_2$ 229.1181; found 230.1178 $[M + H]^+$.

4-(3-(Benzyloxy)prop-1-yn-1-yl)-2,4-dimethyloxazoline (6g). Brownish oil. ^{1}H NMR (300 MHz, $CDCl_3$) δ 7.30–7.21 (m, 5H, C_6H_5–), 4.51 (s, 2H, –OCH_2Ph), 4.28 (d, J = 8.2 Hz, 1H, –CH_2O–), 4.13 (s, 2H, –CH_2OBn), 3.98 (d, J = 8.2 Hz, 1H, –CH_2O–), 1.93 (s, 3H, –CH_3), 1.46 (s, 3H, –CH_3). ^{13}C NMR (100 MHz, $CDCl_3$) δ 165.5, 137.4, 128.4, 128, 127.8, 88.9, 79.3, 79.1, 71.6, 64.2, 57.5, 28.8, 13.9. HR-MS (ESI-TOF) m/z: calcd for $C_{15}H_{17}NO_2$ 243.1338; found 244.1335 $[M + H]^+$.

2,4-Dimethyl-4-(prop-1-yn-1-yl)-oxazoline (6h). Colorless oil. ^{1}H NMR (400 MHz, $CDCl_3$) δ 4.26 (d, J = 8.1 Hz, 1H, –CH_2O–), 3.98 (d, J = 8.1 Hz, 1H, –CH_2O–), 1.95 (s, 3H, –CH_3), 1.79 (s, 3H, –CH_3), 1.44 (s, 3H, –CH_3). ^{13}C NMR (100 MHz, $CDCl_3$) δ 164.9, 81.8, 79.4, 79.3, 64.2, 29.0, 13.9, 3.6. HR-MS (ESI-TOF) m/z: calcd for $C_8H_{11}NO$ 137.0918; found 138.0919 $[M + H]^+$.

4-(Hept-1-yn-1-yl)-2-methyl-oxazoline (6k). Colorless oil. ^{1}H NMR (300 MHz, $CDCl_3$) δ 4.68 (d, J = 8.0 Hz, 1H, =NCH–), 4.33 (dd, J = 10.0, 8.0 Hz, 1H, –CH_2O–), 4.11–3.99 (m, 1H, –CH_2O–), 2.12 (td, J = 7.1, 2.0 Hz, 2H, –CH_2–), 1.93 (s, 3H, –CH_3), 1.49–

1.37 (m, 2H, $-CH_2-$), 1.30–1.22 (m, 4H, $-CH_2CH_2-$), 0.82 (t, J = 7.1 Hz, 3H, $-CH_3$). ^{13}C NMR (100 MHz, $CDCl_3$) δ 171.1, 84.9, 67.9, 60.4, 53.4, 31.0, 28.2, 22.1, 18.7, 14.2, 13.9. HR-MS (ESI-TOF) m/z: calcd for $C_{11}H_{17}NO$ 179.1388; found 180.1384 $[M + H]^+$.

(4-(Hept-1-yn-1-yl)-2-methyl-4,5-dihydrooxazol-4-yl)methanol (6l). Colorless oil. ^1H NMR (300 MHz, $CDCl_3$) δ 4.30 (d, J = 8.2 Hz, 1H, $-CH_2OH$), 4.19 (d, J = 8.2 Hz, 1H, $-CH_2OH$), 3.66 (d, J = 11.3 Hz, 1H, $-CH_2O-$), 3.46 (d, J = 11.3 Hz, 1H, $-CH_2O-$), 2.13 (t, J = 7.2 Hz, 2H, $-CH_2-$), 1.95 (s, 3H, $-CH_3$), 1.43 (t, J = 7.2 Hz, 2H, $-CH_2-$), 1.33–1.16 (m, 4H, $-CH_2CH_2-$), 0.82 (t, J = 6.9 Hz, 3H, $-CH_3$). ^{13}C NMR (100 MHz, $CDCl_3$) δ 167.4, 86.5, 79.2, 75.2, 69.4, 67.4, 31.0, 28.2, 22.1, 18.7, 14.0, 13.9. HR-MS (ESI-TOF) m/z: calcd for $C_{12}H_{19}NO_2$ 209.1494; found $[M + H]^+$ 210.1492.

(2-Methyl-4-(phenylethynyl)-4,5-dihydrooxazol-4-yl)methanol (6m). Colorless oil. ^1H NMR (400 MHz, $CDCl_3$) δ 7.45–7.37 (m, 2H, $-C_6H_5$), 7.32–7.24 (m, 3H, $-C_6H_5$), 4.46 (d, J = 8.3 Hz, 1H, $-CH_2OH$), 4.40 (d, J = 8.3 Hz, 1H, $-CH_2OH$), 3.87 (d, J = 11.3 Hz, 1H, $-CH_2O-$), 3.64 (d, J = 11.3 Hz, 1H, $-CH_2O-$), 2.04 (s, 3H, $-CH_3$). ^{13}C NMR (100 MHz, $CDCl_3$) δ 167.9, 131.8, 128.5, 128.2, 122.2, 88.1, 85.5, 75.0, 69.8, 67.1, 14.0. HR-MS (ESI-TOF) m/z: calcd for $C_{13}H_{13}NO_2$ 215.1022; found $[M + H]^+$ 216.1025.

(2-Methyl-4-(prop-1-yn-1-yl)-4,5-dihydrooxazol-4-yl)methanol (6n). Colorless oil. ^1H NMR (300 MHz, $CDCl_3$) δ 4.28 (d, J = 8.2 Hz, 1H, $-CH_2OH$), 4.20 (d, J = 8.2 Hz, 1H, $-CH_2OH$), 3.66 (d, J = 11.3 Hz, 1H, $-CH_2O-$), 3.47 (d, J = 11.3 Hz, 1H, $-CH_2O-$), 1.95 (s, 3H, $-CH_3$), 1.78 (s, 3H, $-CH_3$). ^{13}C NMR (100 MHz, $CDCl_3$) δ 170.2, 81.2, 76.3, 67.3, 66.8, 56.9, 14.2, 3.7. HR-MS (ESI-TOF) m/z: calcd for $C_8H_{11}NO_2$ 153.0864; found $[M + H]^+$ 154.0868.

General procedure for the synthesis of alkynyl glycinols 1

Aqueous 6 M HCl (1 mL) was added dropwise to a solution of oxazoline **6** (0.15 mmol) in MeOH (1.5 mL) at room temperature. The reaction mixture was stirred at room temperature for 2 h and the solvent was evaporated. Toluene (1 mL) was added to the mixture and evaporated. This procedure was repeated one more time. The residue was suspended in EtOAc and filtered to give amino alcohol hydrochloride salt **1**.

1-Hydroxy-2-methyl-4-phenylbut-3-yn-2-aminium chloride (1c). Amorphous compound. ^1H NMR (400 MHz, methanol-d4) δ 7.50–7.43 (m, 2H, C_6H_5-), 7.43–7.26 (m, 3H, C_6H_5-), 3.83 (d, J = 11.5 Hz, 1H, $-CH_2OH$), 3.70 (d, J = 11.5 Hz, 1H, $-CH_2OH$), 1.64 (s, 3H, $-CH_3$). ^{13}C NMR (100 MHz, CD_3OD) δ 131.4, 129.1, 128.2, 121.1, 86.4, 84.7, 66.3, 52.7, 21.5. HR-MS (ESI-TOF) m/z: calcd for $C_{11}H_{13}NO$ 175.23; found 159.0810 $[M - OH]^+$.

5-(Benzyloxy)-1-hydroxy-2-methylpent-3-yn-2-aminium chloride (1g). Amorphous compound. ^1H NMR (300 MHz, CD_3OD) δ 7.35–7.15 (m, 5H, C_6H_5-), 4.49 (s, 2H, $-OCH_2Ph$), 4.16 (s, 2H, $-CH_2OBn$), 3.66 (d, J = 11.4 Hz, 1H, $-CH_2OH$), 3.54 (d, J = 11.4 Hz, 1H, $-CH_2OH$), 1.48 (s, 3H, $-CH_3$). ^{13}C NMR (100 MHz, CD_3OD) δ 137.3, 128.0, 127.7, 127.6, 83.0, 82.5, 71.5, 66.2, 56.5, 54.4, 21.4. HR-MS (ESI-TOF) m/z: calcd for $C_{13}H_{18}NO_2$ 220.1336; found 220.1338 $[M + H]^+$.

1-Hydroxy-2-methylpent-3-yn-2-aminium chloride (1h). Amorphous compound. ^1H NMR (400 MHz, methanol-d_4) δ 3.67 (d, J = 11.5 Hz, 1H, $-CH_2OH$), 3.55 (d, J = 11.5 Hz, 1H, $-CH_2OH$), 1.85 (s, 3H, $-CH_3$), 1.49 (s, 3H, $-CH_3$), 1.36 (dt, J = 7.4, 3.9 Hz, 1H, $-OH$). ^{13}C NMR (101 MHz, CD_3OD) δ 83.4, 75.3, 66.4, 52.2, 21.6, 1.6. HR-MS (ESI-TOF) m/z: calcd for $C_{12}H_{12}NO$ 114.0919; found 114.0922 $[M + H]^+$.

1-Hydroxy-2-(hydroxymethyl)non-3-yn-2-aminium chloride (1l). Amorphous compound. ^1H NMR (400 MHz, CD_3OD) δ 3.74 (d, J = 11.3 Hz, 2H, $-CH_2OH$), 3.67 (d, J = 11.3 Hz, 2H, $-CH_2OH$), 2.24 (t, J = 7.1 Hz, 2H, $-CH_2(CH_2)_3CH_3$), 1.61–1.46 (m, 2H, $-CH_2CH_2(CH_2)_2CH_3$), 1.44–1.27 (m, 4H, $-CH_2CH_2(CH_2)_2CH_3$), 0.89 (t, J = 7.1 Hz, 3H, $-CH_2(CH_2)_3CH_3$). ^{13}C NMR (101 MHz, CD_3OD) δ 88.9, 74.1, 62.9, 56.9, 30.6, 27.6, 21.8, 17.8, 12.8. HR-MS (ESI-TOF) m/z: calcd for $C_{10}H_{20}NO_2$ 186.1494; found. 186.1494 $[M + H]^+$.

1-Hydroxy-2-(hydroxymethyl)-4-phenylbut-3-yn-2-aminium chloride (1m). Amorphous compound. ^1H NMR (400 MHz, CD_3OD) δ 7.53–7.43 (m, 2H, o-C_6H_5-), 7.43–7.33 (m, 3H, p,m-C_6H_5-), 3.87 (d, J = 11.4 Hz, 2H, $-CH_2OH$), 3.83 (d, J = 11.4 Hz, 2H, $-CH_2OH$). ^{13}C NMR (101 MHz, CD_3OD) δ 131.5, 129.1, 128.2, 121.1, 87.5, 82.8, 62.7, 57.4. HR-MS (ESI-TOF) m/z: calcd for $C_{11}H_{14}NO_2$ 192.10; found 175.0759 $[M - OH]^+$.

Conclusions

In summary, we have developed a novel approach to C-quaternary alkynyl glycinols. This is based on the Ritter reaction of acetonitrile with cobalt complexed alkynyl glycols to give oxazolines. The substrates can be easy assembled to introduce the structural diversity at both variable positions. The Ritter reaction is compatible with a range of substituents at the alkyne terminal position providing oxazolines in moderate to good yields. Hydroxymethyl substituent at the reaction center in both unprotected or O-TBS protected form was well tolerated. The Ritter reaction proceeds also with bis-O-TBS protected alkynyl glycerols with concomitant cleavage of the TBS groups. However, the phenyl group at the reaction center of glycols was detrimental inducing low or no yield of the product formation. Cobalt alkyne complexes in the oxazolines produced by the Ritter reaction can be cleaved in oxidative conditions using DDQ, or NMO as reagents. Hydrolysis of oxazoline ring in mild acidic conditions efficiently provides amino alcohols. We believe that method presented in this paper will find an application for the synthesis of complex amino alcohol derivatives. A version based on catalytic amount of cobalt additive or a protocol for efficient cobalt recovery needs to be developed in the future. This would enable the use of the method for economic and eco-friendly manufacturing processes.

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