Alk-1-ynyl(3-pyridyl)- and alk-1-ynyl(2-thienyl)carbenes as the first example of (alk-1-ynyl)carbenes with hetaryl substituents at carbenic centres

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Alk-1-ynyl(hetaryl)carbenes **3** have been generated from 1-(tosyloxy)-1-hetarylalk-2-ynes **2** *via* the elimination of *para*-toluenesulfonic acid on the treatment with Bu^{t}OK.

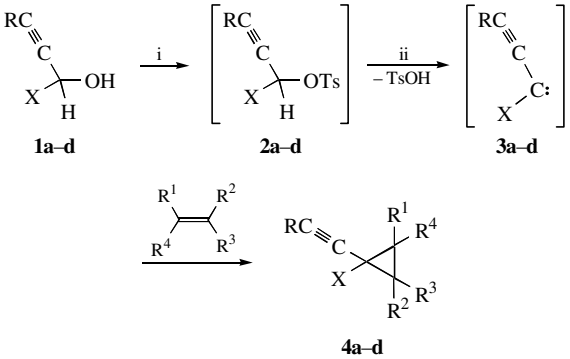
Previously, a number of (alk-1-ynyl)carbenes [R^{1}C≡C(R^2)C:; R^1 = H, Ph, Bu^t, Me$_3$Si, MeC≡C, PhC≡C, Bu^{t}C≡C; R^2 = H, Me$_3$SiC≡C, PhC≡C, Bu^{t}C≡C][1–3] and (alk-1-ynyl)halocarbenes [RC≡C(X)C:; R = Alk, cyclo-Alk, Ph, Me$_3$Si; X = F, Cl, Br][4–6] were described. These carbenes were generated by the photolysis of corresponding diazo compounds and by the elimination of HCl from appropriate halides. Hetarylcarbenes were described in the literature;[7] however, no data on alkynylcarbenes with hetaryl substituents at carbenic centres was published.

All our attempts to obtain 2-(1-chloroalk-1-ynyl)thiophenes, which are potential sources of (alk-1-ynyl)thienylcarbenes, from alcohols **1a**,**b** were unsuccessful. Under the action of chlorinating reagents ($SOCl_2$, PCl_5 and PCl_3), alcohols **1a**–**b** gave only polymeric products probably due to the extremely low stability of corresponding chlorides.

Nevertheless, we found, that tosylates **2** react with potassium *tert*-butoxide in hexane at –20 °C *via* the α-elimination of *para*-toluenesulfonic acid to yield previously unknown alk-1-ynyl-(3-pyridyl)- and alk-1-ynyl(2-thienyl)carbenes **3a**–**d** (Scheme 1). These carbenic species were trapped by a three- to fivefold molar excess of olefins with the formation of 1-(alk-1-ynyl)-1-hetaryl-cyclopropanes **4a**–**d**† in yields up to 40%. As expected, alkenes that are unsymmetrical relative to the plane of π-orbitals of the double bond (styrene and 2-phenylpropene) gave cyclopropanes **4c**,**d** as a mixture of two isomers with different substituent orientation relative to the three-membered ring.

Tosylates **2**, which are the precursors of carbenes **3**, are unstable compounds. They were synthesised from alcohols **1** by the conversion of the latter into lithium alkoxides using BuLi and the subsequent reaction with tosyl chloride in THF at –20 °C.

Alk-1-ynyl(3-pyridyl)carbenes **3c**,**d** can also be generated from corresponding 3-(1-chloroalk-2-ynyl)pyridinium chlorides **5a**,**b** by the treatment of the latter with a twofold molar excess of Bu^{t}OK in benzene under reflux. Using this method, cyclopropanes **4c** and **4d** were obtained in 30 and 25% yields, respectively (Scheme 2).



1–3: **a** R = Bu^t, X = 2-thienyl
b R = 1-adamantyl (Ad), X = 2-thienyl
c R = Bu^t, X = 3-pyridyl
d R = Ad, X = 3-pyridyl

4: **a** R = Bu^t, X = 2-thienyl, R^1 = R^4 = Me, R^2 = R^3 = H
b R = Ad, X = 2-thienyl, R^1 = R^2 = R^3 = R^4 = Me
c R = Bu^t, X = 3-pyridyl, R^1 = Ph, R^2 = R^3 = H, R^4 = Me
d R = Ad, X = 3-pyridyl, R^1 = Ph, R^2 = R^3 = R^4 = H

Scheme 1 *Reagents and conditions:* i, 1 equiv. BuLi, THF, –20 °C, then TsCl; ii, Bu^{t}OK, hexane, –20 °C.

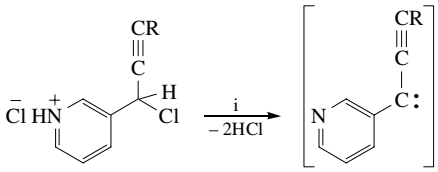
† All new compounds **4a**–**d** gave expected spectral and analytical data.

For **4a**: 40% yield from alcohol **1a** and 2-methylpropene. ^{1}H NMR, δ: 0.96 (s, 3H, Me), 1.12 (d, 1H from CH_2 in cyclo-C_3H_2, *J* 4.8 Hz), 1.27 (s, 9H, Bu^t), 1.36 (d, 1H from CH_2 in cyclo-C_3H_2, *J* 4.8 Hz), 1.44 (s, 3H, Me), 6.82 (dd, 1H, H-3 in cyclo-C_4H_3S, *J* 3.5 Hz, *J* 1.2 Hz), 6.93 (dd, 1H, H-4 in cyclo-C_4H_3S, *J* 5.2 Hz, *J* 3.5 Hz), 7.14 (dd, 1H, H-5 in cyclo-C_4H_3S, *J* 5.2 Hz, *J* 1.2 Hz). ^{13}C NMR, δ: 21.1 (Me), 22.8 (C≡C*C* in cyclo-C_3H_2), 23.7 (Me), 27.0 (*C*Me$_2$), 27.5 (*C*Me$_3$), 29.8 (CH_2), 31.7 (3Me in Bu^t), 81.5, 87.5 (C≡C), 123.6, 124.7, 126.1 (3CH in cyclo-C_4H_3S), 146.3 (C-1 in cyclo-C_4H_3S). MS, *m*/*z*: 232 [M]$^+$. Found (%): C, 77.42; H, 8.49. Calc. for $C_{15}H_{20}S$ (%): C, 77.58; H, 8.61.

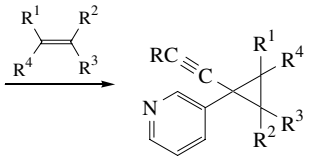
For **4b**: 26% yield from alcohol **1b** and 2,3-dimethylbut-2-ene. ^{1}H NMR, δ: 1.09 (s, 6H, 2Me), 1.32 (s, 6H, 2Me), 1.66 (t, 6H, 3CH_2 in Ad, *J* 3.1 Hz), 1.83 (d, 6H, 3CH_2 in Ad, *J* 3.1 Hz), 1.92 (m, 3H, 3CH in Ad), 6.85 (dd, 1H, H-3 in cyclo-C_4H_3S, *J* 3.5 Hz, *J* 1.2 Hz), 6.89 (dd, 1H, H-4 in cyclo-C_4H_3S, *J* 5.0 Hz, *J* 3.5 Hz), 7.17 (dd, 1H, H-5 in cyclo-C_4H_3S, *J* 5.0 Hz, *J* 1.2 Hz). ^{13}C NMR, δ: 20.2 (2Me), 20.4 (2Me), 27.6 (C≡C*C* in cyclo-C_3H_2), 28.2 (3CH in Ad), 29.8 (C≡C*C* in Ad), 30.6 (2*C*Me$_2$), 36.5 (3CH_2 in Ad), 47.5 (3CH_2 in Ad), 81.2, 89.1 (C≡C), 124.1, 125.9, 126.7 (3CH in cyclo-C_4H_3S), 144.0 (C-1 in cyclo-C_4H_3S). MS, *m*/*z*: 338 [M]+. Found (%): C, 81.43; H, 8.68. Calc. for $C_{23}H_{30}S$ (%): C, 81.65; H, 8.87.

For **4c**: a mixture of isomers (1:1), 28% yield from alcohol **1c** and 2-phenylpropene. For both isomers: ^{1}H NMR, δ: 0.80 (s, 9H, Bu^t), 1.05 (s, 3H, Me), 1.28 (s, 9H, Bu^t), 1.41 (d, 1H from CH_2 in cyclo-C_3H_2, *J* 5.4 Hz), 1.63 (d, 1H from CH_2 in cyclo-C_3H_2, *J* 5.5 Hz), 1.74 (s, 3H, Me), 1.76 (d, 1H from CH_2 in cyclo-C_3H_2, *J* 5.5 Hz), 2.13 (d, 1H from CH_2 in cyclo-C_3H_2, *J* 5.4 Hz), 6.81 (dd, 1H, H-5 in cyclo-C_5H_4N, *J* 4.7 Hz, *J* 8.1 Hz), 6.9–7.4 (m, 6H, Ph, H-5 in cyclo-C_5H_4N in one isomer), 7.10 (ddd, 1H, H-4 in cyclo-C_5H_4N, *J* 8.1 Hz, *J* 2.5 Hz, *J* 1.7 Hz), 7.71 (ddd, 1H, H-4 in cyclo-C_5H_4N, *J* 7.9 Hz, *J* 2.2 Hz, *J* 1.6 Hz), 8.15 (br. d, 1H, H-6 in cyclo-C_5H_4N, *J* 4.7 Hz), 8.42–8.51 (m, 2H, H-2, H-6 in cyclo-C_5H_4N), 8.73 (br. d, 1H, H-2 in cyclo-C_5H_4N, *J* 2.5 Hz). ^{13}C NMR, δ: 23.7, 26.2 (Me), 24.9, 26.3 (CH_2), 26.0, 26.1 (C≡C*C* in cyclo-C_3H_3), 26.9, 27.6 (*C*Me$_3$), 30.6, 31.3 (3Me), 35.3, 37.2 (*C*MePh), 80.0, 81.5, 89.7, 89.8 (C≡C), 121.9, 123.0, 134.1, 136.2, 146.5, 147.6, 149.5, 150.7 (pyridine ring), 126.2, 126.3, 127.9, 128.0, 128.9, 129.3 (Ph), 135.3, 135.8 (C-1 in Ph), 141.3, 143.7 (C-1 in cyclo-C_5H_4N). MS, *m*/*z*: 289 [M]$^+$. Found (%): C, 87.05; H, 8.03. Calc. for $C_{21}H_{23}N$ (%): C, 87.21; H, 7.95

For **4d**: a mixture of isomers (2:1), 25% yield from alcohol **1d** and styrene. For the major isomer: ^{1}H NMR, δ: 1.55–2.02 (m, 17H, Ad and CH_2 in cyclo-C_2H_3), 2.55 (dd, 1H, PhC*H*, *J* 8.3 Hz, *J* 8.3 Hz), 6.86–7.4 (m, 6H, Ph, H-5 in cyclo-C_5H_4N), 7.66 (br. d, 1H, H-4 in cyclo-C_5H_4N, *J* 8.2 Hz), 8.47 (br. s, 1H, H-6 in cyclo-C_5H_4N), 8.73 (br. s, 1H, H-2 in cyclo-C_5H_4N). ^{13}C NMR, δ: 23.4 (C≡C*C* in cyclo-C_3H_3), 24.1 (CH_2), 27.9 (3CH in Ad), 29.8 (C≡C*C* in Ad), 36.3 (3CH_2 in Ad), 36.9 (*C*HPh), 42.7 (3CH_2 in Ad), 77.3, 92.3 (C≡C), 122.9, 132.6, 135.9, 147.1 (4CH in cyclo-C_5H_4N), 126.5, 127.6, 128.5 (Ph), 137.2 (C-1 in cyclo-C_5H_4N), 138.5 (C-1 in Ph). For the minor isomer: ^{1}H NMR, δ: 1.55–2.02 (m, 17H, Ad and CH_2 in cyclo-C_2H_3), 2.90 (dd, 1H, PhCH, *J* 7.2 Hz, *J* 8.9 Hz), 6.86–7.4 (m, 7H, Ph, H-5, H-4 in cyclo-C_5H_4N), 8.27 (br. s, 1H, H-6 in cyclo-C_5H_4N), 8.45 (br. s, 1H, H-2 in cyclo-C_5H_4N). ^{13}C NMR, δ: 20.0 (CH_2), 22.0 (C≡C*C* in cyclo-C_3H_3), 28.0 (3CH in Ad), 30.6 (C≡C*C* in Ad), 24.1 (CH_2), 36.4 (3CH_2 in Ad), 43.1 (3CH_2 in Ad), 83.2, 86.4 (C≡C), 122.4, 136.1, 147.3, 150.2 (pyridine), 126.4, 127.9, 128.8 (Ph), 133.3 (C-1 in cyclo-C_5H_4N), 139.5 (C-1 in Ph). MS, *m*/*z*: 353 [M]$^+$. Found (%): C, 88.21; H, 7.58. Calc. for $C_{26}H_{27}N$ (%): C, 88.39; H, 7.64.



5a,**b** **3c**,**d**



4c,**d**

5a, **3c** R = Bu^t **4c** R = Bu^t, R^1 = Ph, R^2 = R^3 = H, R^4 = Me
5b, **3d** R = Ad **4d** R = Ad, R^1 = Ph, R^2 = R^3 = R^4 = H

Scheme 2 *Reagents and conditions*: i, Bu^{t}OK, benzene, reflux.

The structure of cyclopropanes **4a–d** was established according to ^{1}H and ^{13}C NMR spectroscopic data (200 MHz for ^{1}H NMR and 50 MHz for ^{13}C NMR spectra) for solutions of the compounds in deuterated chloroform and according to their mass spectra (EI, 70 eV).

Alk-1-ynyl(hetaryl)cyclopropanes, which were obtained by the addition of alk-1-ynyl(hetaryl)carbenes to olefins, are of interest as potentially physiologically active compounds and synthons.

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References

1 U. Mislitz and A. de Meijere, in *Methoden der Organische Chemie* (Houben-Weyl), 1989, Band E19b, Teil 1, S. 769.
2 A. de Meijere and R. R. Kostikov, *Synthesis*, 1991, 547.
3 Yu. V. Tomilov, G. P. Okonnishnikova, E. V. Shulishov, K. N. Shavrin and O. M. Nefedov, *Izv. Akad. Nauk, Ser. Khim*., 1998, 2278 (*Russ. Chem. Bull*., 1998, **47**, 2208).
4 K. N. Shavrin, I. V. Krylova, I. B. Shvedova, G. P. Okonnishnikova, I. E. Dolgy and O. M. Nefedov, *J. Chem. Soc., Perkin Trans. 2*, 1992, 1875.
5 K. N. Shavrin, V. D. Gvozdev and O. M. Nefedov, *Izv. Akad. Nauk, Ser. Khim*., 2002, 1143 (*Russ. Chem. Bull., Int. Ed.*, 2002, **51**, 1237).
6 K. N. Shavrin, V. D. Gvozdev and O. M. Nefedov, *Izv. Akad. Nauk, Ser. Khim*., 1998, 1185 (*Russ. Chem. Bull*., 1998, **47**, 1154).
7 C. Wentrup, in *Methoden der Organische Chemie* (Houben-Weyl), 1989, Band E19b, Teil 1, S. 999.

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