SHORT PAPER

J. Chem. Research (S), 2000, 218–219

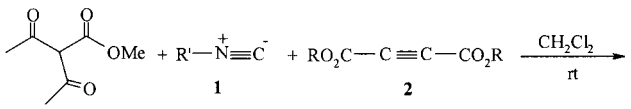
A simple synthesis of highly functionalized ketenimines†

Issa Yavari* and Farahnaz Nourmohammadian

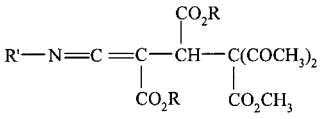
Department of Chemistry, University of Tarbiat Modarres, PO Box 14155-4838, Tehran, Iran

A one-pot synthesis of highly functionalized ketenimines by reaction of alkyl isocyanides with dialkyl acetylenedicarboxylates in the presence of methyl 2-acetyl-3-oxobutanoate is reported.

Compounds containing a heterocumulene entity are expected to have synthetic potential as a result of their ability to take part in dimerization, cycloaddition, and polymerization, among other reactions.[1] In general, hydrogen substituted ketenimines and those with small unbranched alkyl substituents are elusive substances. Ketenimines play a role as discrete but transient intermediates in many interconversions, especially in elimination-addition processes and in the formation of heterocyclic systems.[1–5] The spectroscopic properties of ketenimines have been intensively investigated.[6,7] We wish to report a simple one-pot preparation of stable ketenimines using alkyl isocyanides **1**, dialkyl acetylenedicarboxylates **2**, and a strong CH-acid, such as methyl 2-acetyl-3-oxobutanoate. This condensation reaction produces highly functionalized ketenimines **3** in fairly good yields. These ketenimines are recovered unchanged after refluxing a chloroform solution for several hours.



1 **2**



3

3	R	R'	% Yield of **3**
a	Me	^{t}Bu	85
b	Et	^{t}Bu	90
c	Me	Cyclohexyl	88

Scheme 1

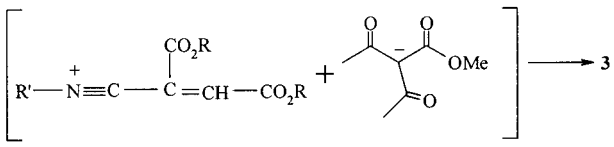
The structures of compounds **3a–c** were deduced from their elemental analyses, mass spectrometric data and their ^{1}H and ^{13}C NMR and IR spectra. The nature of these compounds as 1:1:1 adducts was apparent from the mass spectra which displayed molecular ion peaks at *m/z* = 383, 411, and 409.

The ^{1}H NMR spectra of **3a** exhibited seven single sharp lines arising from *tert*-butyl (δ = 1.40 ppm), acetyl (δ = 2.31 and 2.36 ppm), methoxy (δ = 3.60, 3.62 and 3.80 ppm), and the methine (δ = 4.62 ppm) protons. The ^{13}C NMR spectrum of **3a** showed sixteen distinct resonances consistent with the dimethyl 2-(*N-tert*-butyliminomethylidene)-3(1-acetyl-1-methoxycarbonyl-2-oxopropyl)succinate **3a**. Partial assignments of these resonances are given in the experimental section.

The ^{1}H and ^{13}C NMR spectra of **3b** and **3c** are similar to those of **3a**, except for the isocyanide and ester residues.

The structural assignments of compounds **3a–c** made on the basis of their NMR spectra were supported by their IR spectra. Of special interest are the strong ketenimine absorption bands at about 2060 cm^{-1} in all compounds.

We have not established a mechanism for the formation of dialkyl 2-(*N-tert*-butyliminomethylidene)-3(1-acetyl-1-methoxycarbonyl-2-oxopropyl)succinates **3**, but a reasonable possibility is indicated in Scheme 2. The functionalized ketenimine **3** apparently results from initial addition of the isocyanide[8-11] to the acetylenic ester and subsequent protonation of the 1:1 adduct, by methyl 2-acetyl-3-oxobutanoate followed by attack of the anion of the CH-acid on the positively charged ion to form the ketenimine **3**.



Scheme 2

In summary, the reaction of alkyl isocyanides with electron-deficient acetylenic esters in the presence of methyl 2-acetyl-3-oxobutanoate provides a simple one-pot entry into the synthesis of polyfunctionalized ketenimines of potential synthetic interest.

Experimental

Elemental analyses were performed using a Heraeus CHN-O-Rapid analyser. IR spectra were recorded on a Shimadzu IR-460 spectrometer. ^{1}H and ^{13}C NMR spectra were measured with a Bruker DRX-500 AVANCE instrument with $CDCl_3$ as solvent at 500 and 125.7 MHz, respectively. The mass spectra were recorded on a FINIGAN-MAT 8430 mass spectrometer operating at an ionization potential of 70 eV. Dialkyl acetylenedicarboxylates, alkyl isocyanides and methyl 2-acetyl-3-oxobutanoate were obtained from Fluka (Buchs, Switzerland) and were used without further purification.

General procedure for preparation of dimethyl 2-(N-tert-*butyliminomethylidene)-3(1-acetyl-1-methoxycarbonyl-2-oxopropyl) succinate* **3a:** To a magnetically stirred solution of methyl 2-acetyl-3-oxobutanoate (0.10 g, 1 mmol), and dimethyl acetylenedicarboxylate (0.12 ml, 1 mmol) in CH_2Cl_2 (2 ml) was added, dropwise, *tert*-butyl isocyanide (0.10 ml) over 5 min. The reaction mixture was then allowed to warm up to and stay at room temperature for one week. The solvent was removed under reduced pressure and the viscous residue was purified by silica gel (Merck silica gel 60, 230–400 mesh) column chromatography using ethyl acetate-hexane (1:3) as eluent. The solvent was removed under reduced pressure and the product (colourless oil, 0.34 g, yield 90%) was obtained. ν_{max}/cm^{-1} (KBr) 2060 (C=C=N), 1735, 1714, 1708 and 1684 (C=O) . *m/z* (%): 384 (M^++1, 10), 383 (M^+, 4), 226 (77), 194 (30), 59 (29), 57 (100). δ_H 1.40 (9 H, s, CMe_3); 2.31 and 2.36 (6 H, 2 s, 2 $COCH_3$); 3.60, 3.62 and 3.80 (9 H, 3 s, 3 OCH_3); 4.62 (1 H, s, CH). δ_C 29.08 and 29.69 (2 *C*H_3CO); 30.13 [(*C*H_3)$_3$C]; 45.12 (CH); 51.76, 52.65 and 53.02 (3 OCH_3); 58.72 (*C*=C=N); 62.10 (*C*Me_3); 79.41 (*C*COMe); 164.19 (C=*C*=N); 167.81, 171.30 and 171.41 (3C=O, ester); 200.22 and 200.79 (2C=O, ketone). (Found: C, 56.0; H, 6.5; N, 3.55. $C_{18}H_{25}O_8N$ requires C, 56.39; H, 6.57; N, 3.65).

3b: colourless oil, 0.35 g, yield 85%. ν_{max}/cm^{-1} (KBr) 2060(C=C=N), 1734, 1715, 1708 and 1688 (C=O) . *m/z* (%): 412

* To receive any correspondence.

† This is a Short Paper, there is therefore no corresponding material in *J Chem. Research (M).*

(M^++1, 9), 411 (M^+, 5), 388 (38), 283 (60), 240 (92), 195 (100), 57 (83). δ_H 1.22 and 1.25 (6 H, 2 t, $^3J_{HH}$ 7.2 Hz, 2 CH_3); 1.42 (9 H, s, 3 CMe_3); 2.32 and 2.38 (6 H, 2 s, 2 $COCH_3$); 3.82 (3 H, s, OCH_3); 4.14 and 4.17 (4 H, 2 q, $^3J_{HH}$ 7.2 Hz, 2 OCH_2); 4.62 (1 H, s, CH); δ_C 13.97 and 14.33 (2 CH_3–CH_2); 29.16 and 29.73 (2 CH_3CO); 30.13 [$(CH_3)_3C$]; 45.12 (CH); 52.94 (OCH_3); 59.29 (*C*=C=N); 60.39 and 61.69 (2 OCH_2); 61.98 (CMe_3); 79.37 (*C*-COMe); 165.20 (C=*C*=N); 167.85, 170.70 and 171.03 (3 C=O, ester); 200.31 and 200.88 (2 C=O, ketone). (Found: C, 58.2; H, 7.0; N, 3.7. $C_{20}H_{29}O_8N$ requires C, 58.38; H, 7.10; N, 3.40).

3c: colourless oil, 0.36 g, yield 88%. ν_{max}/cm^{-1} (KBr) 2070 (C=C=N), 1735, 1715, 1707 and 1603 (C=O). *m*/*z* (%): 410 (M^++1, 12), 409 (M^+, %), 254 (50), 226 (70), 170 (57), 55 (100). δ_H 1.25–1.99 (10 H, m, 5 CH_2); 2.34 and 2.35 (6 H, 2 s, 2 $COCH_3$); 3.68, 3.69 and 3.85 (9 H, 3 s, 3 OCH_3); 3.68 (1H, m, CHN); 4.64 (1 H, s, CH). δ_C 24.28, 25.63, 33.39 and 33.44 (CH_2); 29.42, 30.07 (2 CH_3CO); 45.49 (CH); 52.05, 53.05 and 53.39 (3 OCH_3); 57.41 (*C*=C=N); 60.31 (*C*HN); 79.65 (*C*-COMe); 164.33 (C=*C*=N); 168.19, 171.56 and 171.70 (3 C=O, ester); 200.59 and 201.26 (2 C=O, ketone). (Found: C, 58.5; H, 6.7; N, 3.5. $C_{20}H_{27}O_8N$ requires C, 58.67; H, 6.65; N, 3.42).

Research supported by the National Research Council of I. R. Iran (NRCI) as a National Research Project under the grant number 989.

Received 15 February 2000; accepted 28 April 2000
Paper 99/156

References

1 A. Arrieta, F.P. Cossio, and B. Lecea, J. Org. Chem., 1999, **6**, 1831; M.P. Dwyer, D.A. Price, J.E. Lamar, and A.I. Mayers, *Tetrahedron Lett*., 1999, **26**, 4765; M.S. Morales-Rios, O.R. Suarez-Castillo, C. Garcia-Martinez, and P. Joseph-Nathan, *Synthesis*, 1998, **12**, 1755.
2 R. Aumann, B. Jasper, M. Lage, and B. Kerbs, *Organometallics*, 1994, **13**, 3502.
3 R. Gertzmann, M.H. Moller, U. Rodewald, R. Frohlich, M. Grehl, and E-U. Wurthwein, *Tetrahedron*, 1995, **51**, 3767.
4 J.D. Coyle, and P.A. Raply, *J. Chem. Soc., Perkin Trans 1*, **1985**, 1957.
5 N.P. Gambarian, *Russ. Chem. Rev*., 1976, **45**, 1251.
6 J.C. Jochims, S. Herzberger, B. Gambke, and F.A.L. Anet, *Tetrahedron Lett*, 1977, 2255.
7 W. Kosbahn, and W. Runge, *J. Chem. Soc*., *Perkin Trans 2*, **1981**, 270.
8 I.Ugi, *Angew. Chem. Int. Ed. Engl*., 1982, **21**, 810.
9 H.M. Walborsky and M.P. Persiasamy, in *The Chemistry of Functional Groups, Supplement C*, ed. S. Patai and Z. Rappoport, Wiley, New York, 1983, ch. 20, pp 835–887.
10 S. Marcaccini and T. Torroba, *Org. Prep. Proced. Int*., 1993, **25**, 141.
11 I. Yavari, and M.T. Maghsoodlou, *J. Chem. Research(S)*, **1998**, 386.