Available online at www.sciencedirect.com
SCIENCE DIRECT®
Tetrahedron Letters 45 (2004) 8409–8413
Tetrahedron Letters

A novel pseudo four-component reaction: unexpected formation of densely functionalized pyrroles

Ahmad Shaabani,* Mohammad Bagher Teimouri and Sakineh Arab-Ameri

Department of Chemistry, Shahid Beheshti University, PO Box 19396-4716, Tehran, Iran

Received 13 April 2004; revised 17 August 2004; accepted 3 September 2004
Available online 25 September 2004

Abstract—A novel pseudo four-component reaction of isocyanides and dialkyl acetylenedicarboxylates in the presence of acidic N–H compounds is described. Unexpectedly, during the course of this reaction densely functionalized pyrroles are formed.

Synthetic approaches to highly substituted pyrroles are of special interest and of contemporary importance because of the growing variety of pyrrole derivatives isolated from natural products[1] and their remarkable biological activities.[2] They form part of many alkaloids and natural macrocycles (hemes, bile, pigments, chlorophylls, etc.).[3] Therefore, it is not surprising that many methods for the syntheses of substituted and functionalized pyrroles have been reported in the literature.[4] Recently, syntheses of polysubstituted pyrroles have been reported from conjugate addition reactions,[5] transition metal intermediates,[6] reductive coupling,[7] aza Wittig reactions,[8] isocyanide-based reactions,[9] utilizing the sila-Stetter/Paal-Knorr sequence strategy[10] and other useful pathways.[11]

Due to the atom economy, convergent character and simplicity of one-pot procedures, multicomponent condensation reactions (MCRs) occupy an advantageous position among other reactions. Therefore, the discovery and development of novel MCRs is receiving growing interest from industrial chemistry research groups and represents a new challenge for organic chemists and to the basic understanding of organic chemistry itself.[12]

Continuing our interest in isocyanide-based multicomponent reactions[13] and electron deficient acetylenic esters,[13e,f,14] we disclose herein hitherto unknown pseudo four-component reactions, which, starting from simple and readily available precursors afford products containing densely functionalized pyrroles (Scheme 1).

The reaction of unhindered isocyanides with dialkyl acetylenedicarboxylates in the presence of five-membered cyclic imides such as succinimide or maleimide afforded 1′-alkyl or aryl-5′-alkyl or arylamino-2,5-dioxo-2,3,4,5-tetrahydro- or 2,5-dihydro-1′*H*-[1,2′]bipyrrol-3′,4′-dicarboxylic acid dialkyl esters **5**, in relatively high yields. The structures of the products were deduced from their elemental analyses and IR, ^{1}H NMR and ^{13}C NMR spectra. The mass spectra of these compounds displayed molecular ion peaks at the appropriate *m*/*z* values.

The ^{1}H NMR spectrum of **5a** consisted of multiplet signals for the cyclohexyl rings (δ 1.14–1.90), the NH–C*H* resonance (δ 2.67), two methylene groups (δ 2.81–3.03, AA′BB′ pattern) and two sharp singlets for the methoxy groups (δ 3.71 and 3.77). A multiplet was observed for the second N–C*H* group (δ 4.13) and a fairly broad singlet (δ 4.92) was observed for the NH group.

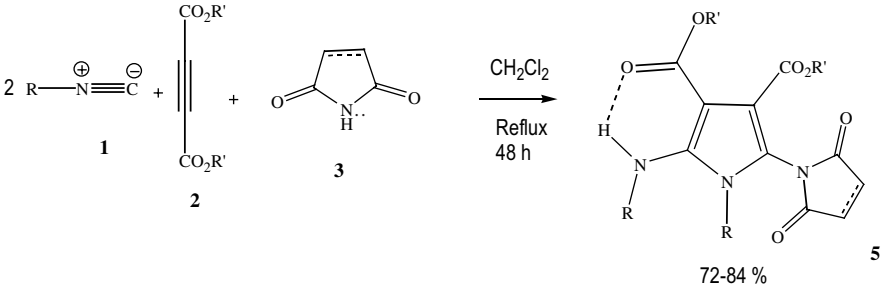
The ^{1}H decoupled ^{13}C NMR spectrum of **5a** showed 17 distinct resonances. Partial assignment of these resonances is given in Section 1.

Finally, the assigned structures were confirmed unambiguously by single crystal X-ray analysis of **5e** (Fig. 1).[15]

The possible mechanism for formation of the pyrroles **5** is indicated in Scheme 2. On the basis of the well established chemistry of isocyanides,[16,17] it is reasonable to assume

Keywords: Pseudo four-component; Isocyanide; Dialkyl acetylenedicarboxylate; Acidic N–H compounds; Highly substituted pyrrole.
* Corresponding author. Fax: +98 21 2403041; e-mail: a-shaabani@cc.sbu.ac.ir

0040-4039/$ - see front matter © 2004 Elsevier Ltd. All rights reserved.
doi:10.1016/j.tetlet.2004.09.039



5	R	R'	Imide	Yield (%)
a	Cyclohexyl	CH_3	Succinimide	72
b	Cyclohexyl	CH_3	Maleimide	78
c	Cyclohexyl	C_2H_5	Succinimide	76
d	Cyclohexyl	C_2H_5	Maleimide	75
e	2,6-Dimethylphenyl	CH_3	Succinimide	84
f	2,6-Dimethylphenyl	CH_3	Maleimide	81

Scheme 1.

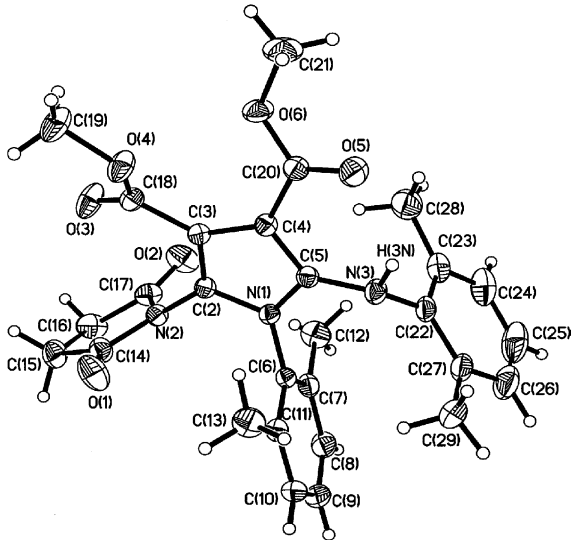


Figure 1. Single crystal X-ray structure of **5e**.

that the initial formation of a reactive 1:1 intermediate by the reaction of the isocyanide with the dialkyl acetylenedicarboxylate is followed by further reaction with the isocyanide, as previously reported[18,19] to generate the bis-ketenimine intermediate **4**. The bis-ketenimine intermediate may then react with compound **3** and cyclize under the reaction conditions to produce **5** (pathway A).

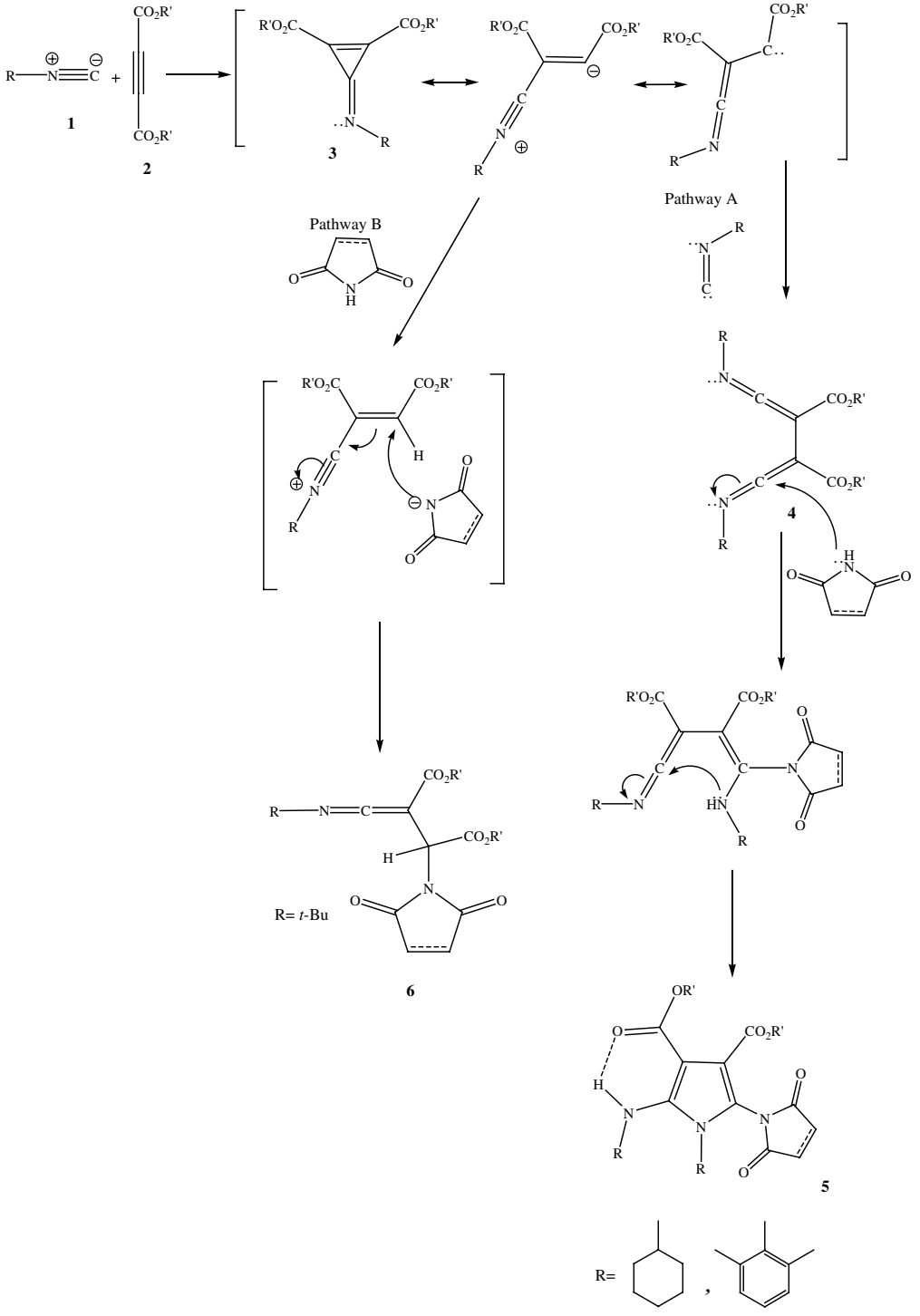
Compounds **5** were produced with cyclohexyl isocyanide and 2,6-dimethylphenyl isocyanide, but the reaction generated ketenimine **6**, when *tert*-butyl isocyanide was used perhaps due to steric effects (Scheme 2, pathway B).

In conclusion, we report an unexpected novel pseudo four-component reaction leading to densely functionalized 2-alkylamino-pyrroles from simple and readily available precursors under neutral conditions.

1. Experimental

1.1. Typical procedure illustrating the preparation of 1′-cyclohexyl-5′-cyclohexylamino-2,5-dioxo-2,3,4,5-tetrahydro-1′*H*-[1,2′]bipyrrolyl-3′,4′-dicarboxylic acid dimethyl ester (5a)

To a magnetically stirred mixture of succinimide (0.099 g, 1.0 mmol) and dimethyl acetylenedicarboxylate (0.142 g, 1.0 mmol) in CH_2Cl_2 (20 mL) was added cyclohexyl isocyanide (0.220 g, 2 mmol) via syringe and the resulting mixture was refluxed for 48 h. The solvent was removed under vacuum and the residue was washed with diethyl ether and crystallized from *n*-hexane–CH_2Cl_2 (4:1) to give cream crystals (0.331 g, 72%). Mp 212–214 °C. IR (KBr) (ν_{max}, cm^{-1}): 3420 (N–H), 1733 and 1728 (C=O), 1669 (C=C). ^1H NMR ($CDCl_3$, Me_4Si): δ_H 1.14–1.90 (20H, m, $10 \times CH_2$), 2.67 (1H, m, NH–C*H*), 2.81–3.01 (4H, m, AA′BB′ type, $2 \times O{=}CCH_2$), 3.71 and 3.77 (6H, 2s, $2 \times OCH_3$), 4.13 (1H, tt, $^3J_{HH} = 12.3$ Hz, $^3J_{HH} = 3.0$ Hz, N–C*H*), 4.92 (1H, br s, NH). ^{13}C NMR ($CDCl_3$, Me_4Si): δ_C 25.3, 25.6, 26.6, 28.8, 32.9 and 34.0 ($10 \times CH_2$ of two cyclohexyl rings and $2 \times O{=}CCH_2$), 51.1 and 51.5 ($2 \times OCH_3$), 56.3 and 59.0 ($2 \times$ N–CH), 102.3, 110.7, 120.5 and 144.2 ($2 \times$ C=C), 163.8 and 165.7 ($2 \times$ C=O ester), 176.8 ($2 \times$ C=O imide). MS (*m*/*z*, %) 459 (M^+, 50), 377 (10), 345 (54), 263 (17), 212 (10), 83 (8), 55 (100). Anal. Calcd for $C_{24}H_{33}N_3O_6$ (459.43): C,



Scheme 2.

62.73; H, 7.23; N, 9.14. Found: C, 62.59; H, 7.26; N, 9.21.

1.2. 1′-Cyclohexyl-5′-cyclohexylamino-2,5-dioxo-2,5-dihydro-1′*H*-[1,2′]bipyrrolyl-3′,4′-dicarboxylic acid dimethyl ester (5b)

Yellow crystals (0.357 g, 78%). Mp 217–219 °C. IR (KBr) (ν_{max}, cm^{-1}): 3305 (N–H), 1730 and 1728 (C=O), 1673 (C=C). ^1H NMR ($CDCl_3$, Me_4Si): δ_H 1.01–1.92 (20H, m, $10 \times CH_2$), 2.69 (1H, m, NH–C*H*), 3.66 and 3.77 (6H, 2s, $2 \times OCH_3$), 4.13 (1H, tt, $^3J_{HH} = 12.2$ Hz, $^3J_{HH} = 3.0$ Hz, N–C*H*), 4.98 (1H, d, $^3J_{HH} = 10.1$ Hz, NH), 6.91 (2H, s, CH=CH). ^{13}C NMR ($CDCl_3$, Me_4Si): δ_C 25.34, 25.41, 25.58, 26.63, 32.83 and 33.99 ($10 \times CH_2$ of two cyclohexyl rings), 51.17 and 51.59 ($2 \times OCH_3$), 56.28 and 59.04 ($2 \times$ N–CH), 102.06, 111.72, 118.91 and 144.38 ($2 \times$ C=C), 135.28 (CH=CH), 163.4 and 165.64 ($2 \times$ C=O ester), 170.18 ($2 \times$ C=O imide). MS (*m*/*z*, %) 457 (M^+,

100), 426 (34), 375 (48), 343 (90), 311 (25), 261 (48), 55 (53). Anal. Calcd for $C_{24}H_{31}N_3O_6$ (457.41): C, 63.01; H, 6.82; N, 9.18. Found: C, 62.91; H, 6.76; N, 9.25.

1.3. 1′-Cyclohexyl-5′-cyclohexylamino-2,5-dioxo-2,3,4,5-tetrahydro-1′*H*-[1,2′]bipyrrolyl-3′,4′-dicarboxylic acid diethyl ester (5c)

White crystals (0.371 g, 76%). Mp 155–157 °C. IR (KBr) (ν_{max}, cm^{-1}): 3315 (N–H), 1734 and 1724 (C=O), 1672 (C=C). ^1H NMR ($CDCl_3$, Me_4Si): δ_H 1.03–1.92 (20H, m, $10\times CH_2$), 1.25 and 1.29 (6H, 2t, $^3J_{HH}$ = 7.0 Hz, $2\times CH_3$), 2.66 (1H, m, NH–C*H*), 2.40–2.68 (4H, m, AA′BB′ type, $2\times O{=}CCH_2$), 4.11 (1H, tt, $^3J_{HH}$ = 12.2 Hz, $^3J_{HH}$ = 3.0 Hz, N–C*H*), 4.16 and 4.23 (4H, 2q, $^3J_{HH}$ = 7.0 Hz, $2\times OCH_2$) 4.97 (1H, br s, NH). ^{13}C NMR ($CDCl_3$, Me_4Si): δ_C 14.2 and 14.42 ($2\times CH_3$), 25.3, 25.6, 26.6, 28.8, 32.9 and 34.0 ($10\times CH_2$ of two cyclohexyl rings and $2\times O{=}CCH_2$), 56.2 and 59.1 ($2\times$ N–CH), 59.9 and 60.3 ($2\times OCH_2$), 102.6, 111.1, 120.1 and 144.1 ($2\times$ C=C), 163.5 and 165.4 ($2\times$ C=O ester), 176.8 ($2\times$ C=O imide). MS (*m*/*z*, %) 487(M^+, 70), 405 (10), 359 (71), 313 (10), 277 (19), 83 (12), 55 (100). Anal. Calcd for $C_{26}H_{37}N_3O_6$ (487.47): C, 64.05; H, 7.64; N, 8.62. Found: C, 63.91; H, 7.56; N, 8.69.

1.4. 1′-Cyclohexyl-5′-cyclohexylamino-2,5-dioxo-2,5-dihydro-1′*H*-[1,2′]bipyrrolyl-3′,4′-dicarboxylic acid diethyl ester (5d)

Cream crystals (0.365 g, 75%). Mp 145–147 °C. IR (KBr) (ν_{max}, cm^{-1}): 3305 (N–H), 1735 and 1724 (C=O), 1671 (C=C). ^1H NMR ($CDCl_3$, Me_4Si): δ_H 1.01–1.93 (20H, m, $10\times CH_2$), 1.20 and 1.29 (6H, 2t, $^3J_{HH}$ = 7.1 Hz, $2\times CH_3$), 2.67 (1H, m, NH–C*H*), 4.13 and 4.26 (4H, 2q, $^3J_{HH}$ = 7.1 Hz, $2\times OCH_2$), 4.14 (1H, tt, $^3J_{HH}$ = 12.2 Hz, $^3J_{HH}$ = 3.0 Hz, N–C*H*), 4.98 (1H, 3d, $^3J_{HH}$ = 10.1 Hz, NH), 6.91 (2H, s, CH=CH). ^{13}C NMR ($CDCl_3$, Me_4Si): δ_C 14.29 and 14.37 ($2\times CH_3$), 25.37, 25.45, 25.63, 26.67, 32.87 and 34.02 ($10\times CH_2$ of two cyclohexyl rings), 56.22 and 59.10 ($2\times$ N–CH), 59.98 and 60.38 ($2\times OCH_2$), 102.41, 112.28, 118.42 and 144.23 ($2\times$ C=C), 135.30 (CH=CH), 163.22 and 165.35 ($2\times$ C=O ester), 170.21 ($2\times$ C=O imide). MS (*m*/*z*, %) 485 (M^+, 98), 440 (31), 403 (35), 357 (100), 311 (28), 275 (32), 174 (17), 83 (25), 55 (97). Anal. Calcd for $C_{26}H_{35}N_3O_6$ (485.45): C, 64.32; H, 7.26; N, 8.65. Found: C, 64.21; H, 7.20; N, 8.70.

1.5. 1′-(2,6-Dimethyl-phenyl)-5′-(2,6-dimethyl-phenyl-amino)-2,5-dioxo-2,3,4,5-tetrahydro-1′*H*-[1,2′]bipyrrolyl-3′,4′-dicarboxylic acid dimethyl ester (5e)

Colourless crystals (0.423 g, 84%). Mp 255–257 °C. IR (KBr) (ν_{max}, cm^{-1}): 3265 (N–H), 1726 and 1699 (C=O), 1661 (C=C). ^1H NMR ($CDCl_3$, Me_4Si): δ_H 1.89 and 1.97 (12H, 2s, $4\times CH_3$), 2.42–2.67 (4H, m, AA′BB′ type, $^2J_{HH}$ = 18.3 Hz, $^3J_{HH}$ = 5.5 Hz, $2\times CH_2$), 3.77 (6H, 2s overlapping, $2\times OCH_3$), 6.74–7.00 (6H, m, arom.), 7.31 (1H, s, NH). ^{13}C NMR ($CDCl_3$, Me_4Si): δ_C 17.69 and 18.30 ($4\times CH_3$), 28.28 ($2\times CH_2$), 51.29 and 51.71 ($2\times OCH_3$), 96.07, 111.91, 120.14, 126.43, 128.22, 128.32, 129.01, 131.84, 137.23, 137.78, 138.26 and 147.07 (arom. and $2\times$ C=C), 163.39 and 166.08 ($2\times$ C=O ester), 175.55 ($2\times$ C=O imide). MS (*m*/*z*, %) 503 (M^+, 100), 472 (75), 373 (27), 274 (10), 105 (7), 55 (37). Anal. Calcd for $C_{28}H_{29}N_3O_6$ (503.44): C, 66.79; H, 5.80; N, 8.34. Found: C, 66.71; H, 5.85; N, 8.40.

1.6. 1′-(2,6-Dimethyl-phenyl)-5′-(2,6-dimethyl-phenyl-amino)-2,5-dioxo-2,5-dihydro-1′*H*-[1,2′]bipyrrolyl-3′,4′-dicarboxylic acid dimethyl ester (5f)

Yellow crystals (0.406 g, 81%). Mp 232–235 °C. IR (KBr) (ν_{max}, cm^{-1}): 3260 (N–H), 1727 (C=O), 1662 (C=C). ^1H NMR ($CDCl_3$, Me_4Si): δ_H 1.90 and 1.98 (12H, 2s, $4\times CH_3$), 3.72 and 3.78 (6H, 2s, $2\times OCH_3$), 6.63 (2H, s, CH=CH), 6.74–7.00 (6H, m, arom.), 7.35 (1H, s, NH). ^{13}C NMR ($CDCl_3$, Me_4Si): δ_C 17.70 and 18.32 ($4\times CH_3$), 51.32 and 51.75 ($2\times OCH_3$), 96.99, 112.58, 118.76, 126.47, 128.18, 128.31, 128.99, 131.91, 134.70, 137.25, 137.77, 138.13 and 147.09 (arom. and $3\times$ C=C), 163.25 and 166.08 ($2\times$ C=O ester), 169.12 ($2\times$ C=O imide). MS (*m*/*z*, %) 501 (M^+, 100), 470 (52), 454 (27), 373 (31), 105 (10). Anal. Calcd for $C_{28}H_{27}N_3O_6$ (501.42): C, 67.06; H, 5.42; N, 8.38. Found: C, 66.91; H, 5.35; N, 8.44.

1.7. Dimethyl 2-[(*tert*-butylimino)methylene]-3-(2,5-dioxo-1-pyrrolidinyl)succinate (6a)

White crystals (0.276 g, 85%). Mp 121–123 °C. IR (KBr) (ν_{max}, cm^{-1}): 2065 (N=C=C), 1771, 1740 and 1706 (C=O). ^1H NMR ($CDCl_3$, Me_4Si): δ_H 1.47 (9H, s, CMe_3), 2.73 (4H, s, $2\times CH_2$), 3.70 and 3.74 (6H, 2s, $2\times OCH_3$), 5.83 (1H, s, N–CH). ^{13}C NMR ($CDCl_3$, Me_4Si): δ_C 28.1 ($2\times CH_2$), 29.37 (CMe_3), 49.8 (N–CH), 51.7 and 53.1 ($2\times OCH_3$), 59.5 (*C*=C=N), 62.4 (*C*Me_3), 163.0 (C=*C*=N), 167.6, 169.7 ($2\times$ C=O of two ester groups), 175.7 ($2\times$ C=O of imide). MS (*m*/*z*, %) 324 (M^+, 2), 309 (6), 253 (25), 209 (10), 177 (27), 138 (10), 57 (100). Anal. Calcd for $C_{15}H_{20}N_2O_6$ (324.24): C, 55.56; H, 6.21; N, 8.63. Found: C, 55.46; H, 6.17; N, 8.70.

1.8. Dimethyl 2-[(*tert*-butylimino)methylene]-3-(2,5-dioxo-2,5-dihydro-1*H*-pyrrol-1-yl)succinate (6b)

White crystals (0.281 g, 87%). Mp 123–125 °C. IR (KBr) (ν_{max}, cm^{-1}): 2060 (N=C=C), 1749, 1704 and 1670 (C=O). ^1H NMR ($CDCl_3$, Me_4Si): δ_H 1.47 (9H, s, CMe_3), 3.70 and 3.74 (6H, 2s, $2\times OCH_3$), 5.79 (1H, s, N–CH), 7.27 (2H, s, CH=CH). ^{13}C NMR ($CDCl_3$, Me_4Si): δ_C 30.18 (CMe_3), 49.14 (N–CH), 51.77 and 53.12 ($2\times OCH_3$), 60.18 (*C*=C=N), 62.48 (*C*Me_3), 134.36 (CH=CH), 163.32 (C=*C*=N), 167.94, 169.61 ($2\times$ C=O of two ester groups), 169.31 ($2\times$ C=O of imide). MS (*m*/*z*, %) 322 (M^+, 5), 309 (6), 267 (28), 251 (75), 234 (10), 207 (90), 175 (98), 147 (12), 82 (97), 57 (99), 41 (100). Anal. Calcd for $C_{15}H_{18}N_2O_6$ (322.22): C, 55.90; H, 5.62; N, 8.69. Found: C, 55.78; H, 5.57; N, 8.75.

Acknowledgements

We gratefully acknowledge the financial support from the Research Council of Shahid Beheshti University.

References and notes

1. For some examples: (a) O'Hagan, D. *Nat. Prod. Rep.* **2000**, *17*, 435–446, and references cited therein; (b) Hoffmann, H.; Lindel, T. *Synthesis* **2003**, 1753–1783; (c) Furstner, A. *Angew. Chem., Int. Ed.* **2003**, *42*, 3582–3603; (d) Lindquist, N.; Fenical, W.; Van Duyne, G. D.; Clardy, J. *J. Org. Chem.* **1988**, *53*, 4570–4574; (e) Boger, D. L.; Boyce, C. W.; Labroli, M. A.; Sehon, C. A.; Jin, Q. *J. Am. Chem. Soc.* **1999**, *121*, 54–62; (f) Iwao, M.; Takeuchi, T.; Fujikawa, N.; Fukuda, T.; Ishibashi, F. *Tetrahedron Lett.* **2003**, *44*, 4443–4446, and references cited therein; (g) Kreipl, A. T.; Reid, C.; Steglich, W. *Org. Lett.* **2002**, *4*, 3287–3288; (h) Furstner, A.; Krause, H.; Thiel, O. R. *Tetrahedron* **2002**, *58*, 6373–6380, and references cited therein.
2. For some biologically active pyrroles, see: (a) Lainton, J. A. H.; Hoffman, J. W.; Martin, B. R.; Compton, D. R. *Tetrahedron Lett.* **1995**, *36*, 1401–1404; (b) De Leon, C. Y.; Ganem, B. *Tetrahedron* **1997**, *53*, 7731–7752.
3. Katritzky, A. R.; Rees, C. W. In *Comprehensive Heterocyclic Chemistry*, Bird, C. W., Cheeseman, G. W. H., Eds.; Pergamon Press: Oxford, Vol. 4, p 370 and references cited therein.
4. (a) Bean, G. P. In *The Chemistry of Heterocyclic Compounds*; Jones, A. R., Ed.; Wiley: New York, 1990; Vol. 48, Part 1, Chapter 2, p 105; (b) Gilchrist, T. L. *J. Chem. Soc., Perkin Trans. 1* **1998**, 615–628, and references cited therein.
5. Dieter, R. K.; Yu, H. *Org. Lett.* **2000**, *2*, 2283–2286.
6. Iwasawa, N.; Maeyama, K.; Saitou, M. *J. Am. Chem. Soc.* **1997**, *119*, 1486–1487.
7. (a) Fuerstner, A.; Weintritt, H.; Huppperts, A. *J. Org. Chem.* **1995**, *60*, 6637–6641; (b) Quiclot-Sire, B.; Thevenot, I.; Zard, S. Z. *Tetrahedron Lett.* **1995**, *36*, 9469–9470.
8. Katritzly, A. R.; Jiang, J.; Steel, P. *J. Org. Chem.* **1994**, *59*, 4551–4555.
9. (a) Nair, V.; Vinod, A. U.; Rajesh, C. *J. Org. Chem.* **2001**, *66*, 4427–4429; (b) Marchand, E.; Morel, G.; Sinbandhit, S. *Eur. J. Org. Chem.* **1999**, 1729–1738; (c) Chen, N.; Lu, Y.; Cadamasetti, K.; Hurt, C. R.; Norman, M. K.; Fotsch, C. *J. Org. Chem.* **2000**, *65*, 2603–2605.
10. Bharadwaj, A. R.; Scheidt, K. A. *Org. Lett.* **2004**, *6*, 2465–2468.
11. (a) Arcadi, A.; Rossi, E. *Tetrahedron* **1998**, *54*, 15253–15272; (b) Periasamy, M.; Srinivas, G.; Bharati, P. *J. Org. Chem.* **1999**, *64*, 4204–4205, and references cited therein; (c) Ranu, B. C.; Dey, S. S. *Tetrahedron Lett.* **2003**, *44*, 2865–2868; (d) Reisser, M.; Maas, G. *J. Org. Chem.* **2004**, *69*, 4913–4924; (e) Katritzky, A. R.; Huang, T.-B.; Voronkov, M. V.; Wang, M.; Kolb, H. *J. Org. Chem.* **2000**, *65*, 8819–8821; (f) Banik, B. K.; Samajdar, S.; Banik, I. *J. Org. Chem.* **2004**, *69*, 213–216; (g) Chien, T.-C.; Meade, E. A.; Hinkley, J. M.; Townsend, L. B. *Org. Lett.* **2004**, *6*, 2857–2859.
12. Weber, L.; Illgen, K.; Almstetter, M. *Synlett* **1999**, 366–374.
13. (a) Shaabani, A.; Teimouri, M. B.; Bijanzadeh, H. R. *Tetrahedron Lett.* **2002**, *43*, 9151–9154; (b) Shaabani, A.; Teimouri, M. B.; Bazgir, A.; Bijanzadeh, H. R. *Mol. Div.* **2003**, *6*, 199–206; (c) Shaabani, A.; Yavari, I.; Teimouri, M. B.; Bazgir, A.; Bijanzadeh, H. R. *Tetrahedron* **2001**, *57*, 1375–1378; (d) Shaabani, A.; Teimouri, M. B.; Bijanzadeh, H. R. *Monatsh. Chem.* **2004**, *135*, 441–446, and 589–593; (e) Shaabani, A.; Teimouri, M. B.; Bijanzadeh, H. R. *J. Chem. Res. (S)* **2002**, 381–383; (f) Shaabani, A.; Teimouri, M. B.; Mirzaei, P.; Bijanzadeh, H. R. *J. Chem. Res. (S)* **2003**, 82–83; (g) Shaabani, A.; Teimouri, M. B.; Bijanzadeh, H. R. *J. Chem. Res. (S)* **2003**, 578–579; (h) Shaabani, A.; Teimouri, M. B. *J. Chem. Res. (S)* **2003**, 732–733; (i) Shaabani, A.; Bazgir, A.; Soleimani, K.; Bijanzadeh, H. R. *J. Flour. Chem.* **2002**, *116*, 93–95.
14. (a) Shaabani, A.; Teimouri, M. B.; Yavari, I.; Norouzi-Arasi, H.; Bijanzadeh, H. R. *J. Flour. Chem.* **2000**, *103*, 155–157; (b) Shaabani, A.; Sadeghi Negat, F. *J. Chem. Res. (S)* **1998**, 584–585; (c) Shaabani, A.; Safaei, H. R.; Hemyari, K.; Moghimi, A. *J. Chem. Res. (S)* **2001**, 192–194; (d) Shaabani, A.; Bazgir, A.; Teimouri, M. B.; Bijanzadeh, H. R. *Phosphorus Sulfur Silicon* **2002**, *177*, 833–837.
15. Crystal data for **5e**: crystal size $0.30 \times 0.24 \times 0.21\,mm^3$; $C_{28}H_{29}N_3O_6$; M 503.54; monoclinic; space group $P2_1/n$; unit cell dimensions $a = 17.099(3)$ Å, $b = 8.5847(17)$ Å, $c = 17.853(4)$ Å, $\alpha = 90°$, $\beta = 94.05(3)°$, $\gamma = 90°$; $V = 2614.2(9)$ Å^3; $Z = 4$; $D_c = 1.279\,Mg/m^3$; $T = 293(2)$ K; R indices (all data) $R_1 = 0.0719$, $wR_2 = 0.1439$; absorptions corrections = none; reflections collected 6330; wavelength 0.71073 A° (CCDC 247024).
16. Ugi, I. *Isonitrile Chemistry*; Academic: London, 1971.
17. Domling, A.; Ugi, I. *Angew. Chem., Int. Ed. Engl.* **2000**, *39*, 3168–3210.
18. Nair, V.; Vinod, A. U.; Abhilash, N.; Menon, R. S.; Santhi, V.; Varma, R. L.; Viji, S.; Mathew, S.; Srinivas, R. *Tetrahedron* **2003**, *59*, 10279–10286.
19. Takizawz, T.; Obata, N.; Suzuki, Y.; Yanagida, T. *Tetrahedron Lett.* **1969**, *39*, 3407–3410.