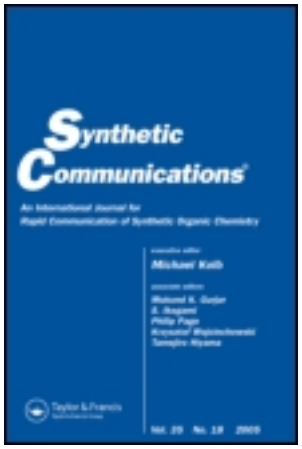

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Three-Component Synthesis of Functionalized 1-Azabuta-1,3-dienes from Alkyl Isocyanides, Activated Acetylenes, and Pyridin-2(1H)-one or Isoquinolin-1(2H)-one

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THREE-COMPONENT SYNTHESIS OF FUNCTIONALIZED 1-AZABUTA-1,3-DIENES FROM ALKYL ISOCYANIDES, ACTIVATED ACETYLENES, AND PYRIDIN-2(1*H*)-ONE OR ISOQUINOLIN-1(2*H*)-ONE

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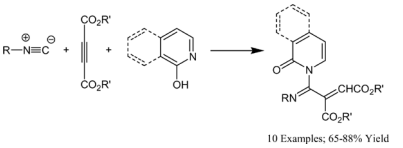
GRAPHICAL ABSTRACT



Abstract *The 1:1 reactive intermediates generated by the addition of alkyl isocyanides to dialkyl acetylenedicarboxylates were trapped by pyridin-2(1*H*)-one and isoquinolin-1(2-*H*)-one to yield highly functionalized 1-azabuta-1,3-dienes and, in some cases, minor amounts of ketenimines.*

Keywords Acetylenic esters; alkyl isocyanides; 1-azadienes; ketenimines; multicomponent reaction; NH acids

INTRODUCTION

Isocyanides are compounds with an extraordinary functional group; its unusual valence structure and reactivity have been discussed for more than 150 years. The fascinating chemistry that stems from the addition of isocyanides to activated acetylenic compounds has evoked considerable interest.[1] Usually, the addition of isocyanides devoid of an acidic hydrogen atom leads to a 1:1 zwitterionic intermediate that can undergo further transformations, culminating in a stabilized product.[2–4] Of importance in this area are the isocyanide-based multicomponent reactions (MCRs) such as the versatile Ugi and Passerini reactions.[5–8] The reactions

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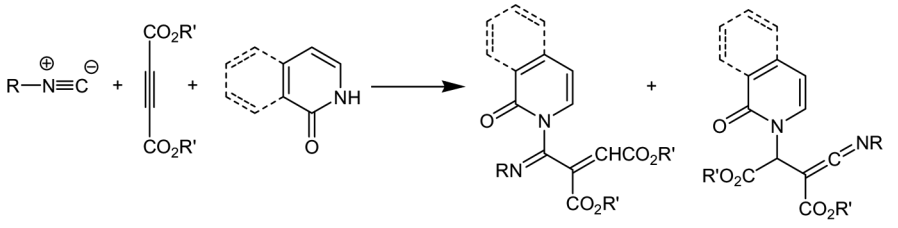
of 1-azadienes with various chiral dienophiles, which lead to substituted pyridines, have been reported.[9] Recently, we described a convenient method for preparation of 1-azadienes, by three-component reaction of 3-chloropentan-2,4-dione, dialkyl acetylenedicarboxylates, and 2,6-dimethylphenyl isocyanide.[10]

RESULTS AND DISCUSSION

In continuation of our interest in the application of isocyanides in MCRs,[11–14] we report herein an efficient synthesis of 1-azadienes **4** from alkyl isocyanides **1**, dialkyl acetylenedicarboxylates **2**, and strong NH acids, such as pyridin-2(1*H*)-one or isoquinolin-1(2*H*)-one. In some cases, minor amounts (13–25%) of ketenimines **5** are obtained (Scheme 1).

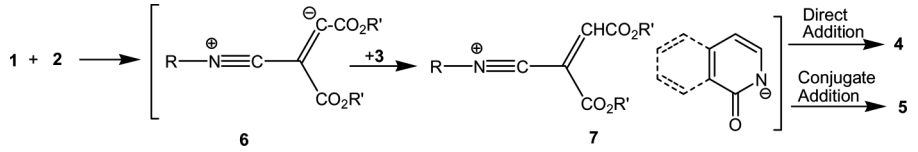
The reaction proceeded spontaneously in CH_2Cl_2 and was completed within a few hours. The ^1H and ^{13}C NMR spectra of the crude products clearly indicated the formation of **4** and **5**. The structures of compounds **4a–j** were deduced from their elemental analyses and their infrared (IR), ^1H NMR, and ^{13}C NMR spectra. The mass spectra of these compounds displayed molecular ion peaks at appropriate m/z values, and the ^1H NMR spectrum of **4a** exhibited four sharp lines for *tert*-butyl ($\delta = 1.29$ ppm), methoxy ($\delta = 3.66$ and 3.90 ppm), and vinyl ($\delta = 6.77$ ppm) protons. The pyridinol moiety appeared at $\delta = 6.19$–8.00 ppm. The ^{13}C NMR spectrum of **4a** showed 14 distinct resonances in agreement with the dimethyl 2-{(*tert*-butylimino)[2-oxopyridin-1(2*H*)-yl]methyl}but-2-enedioate assignment. Structural partial assignments of these resonances are given in the Experimental section. The ^1H NMR spectra of **4b–f** are similar to that of **4a**, except for the signals of the cyclohexyl, ester, and heterocyclic moieties. Each pair of compounds **4a–d** and **5a–d** was



1 **2** **3** **4** **5**

	R		R'					Yield (%)
1a	*t*-Bu	**2a**	Me	**3a**	pyridin-2(1*H*)-one			
1b	c-hexyl	**2b**	Et	**3b**	isoquinolin-1(2*H*)-one			
		2c	*t*-Bu					
4a; 5a						pyridinonyl	*t*-Bu	Me	88
4b; 5b						pyridinonyl	*t*-Bu	*t*-Bu	93
4c; 5c						isoquinolinonyl	*t*-Bu	Me	92
4d; 5d						isoquinolinonyl	*t*-Bu	*t*-Bu	87
4e						pyridinonyl	c-hexyl	Me	78
4f						pyridinonyl	c-hexyl	Et	75
4g						pyridinonyl	c-hexyl	*t*-Bu	76
4h						isoquinolinonyl	c-hexyl	Me	88
4i						isoquinolinonyl	c-hexyl	Et	82
4j						isoquinolinonyl	c-hexyl	*t*-Bu	84

Scheme 1.



Scheme 2.

analyzed as a mixture. The structural assignments of **5a–d** made on the basis of their NMR spectra were supported by their IR spectra. Of special interest is the strong ketenimine absorption band at about $\nu = 2060\,\mathrm{cm}^{-1}$.

On the basis of the well-established chemistry of isocyanides,[14] it is reasonable to assume that **4** and **5** result from initial addition of the alkyl isocyanide to the acetylenic ester and subsequent protonation of the 1:1 adduct **6** by the NH-acidic compound **3**. Then, the positively charged ion can be attacked by the nitrogen atom of the anion of the NH-acidic compound at two positions. Direct addition leads to 1-azadienes **4** and conjugate addition produces ketenimines **5** (Scheme 2).

In conclusion, we have found a simple and efficient method for the preparation of highly functionalized 1-azadienes. The present method carries the advantages that not only is the reaction performed under neutral conditions, but also the starting materials and reagents can be mixed without any activation or modification.

EXPERIMENTAL

Melting points were measured on an Electrothermal 9100 apparatus. Elemental analyses for C, H, and N were performed using a Heraeus CHNO-Rapid analyzer. IR spectra were measured on a Shimadzu IR-460 spectrometer. ^{1}H and ^{13}C NMR spectra were measured with a Bruker DRX-500 Avance instrument with $CDCl_3$ (300.1 and 75.5 MHz, respectively). Mass spectra were recorded on a Finnigan-Matt 8430 mass spectrometer operating at an ionization potential of 70 eV. Alkyl isocyanides, dialkyl acetylenedicaboxylates, and compounds **3a** and **3b** (Fluka) were used without further purification.

General Procedure for the Preparation of Compounds 4: Dimethyl 2-{(*t*-Butylimino)[2-oxopyridin-1(2*H*)-yl]methyl}but-2-enedioate (4a)

To a stirred solution of pyridin-2-ol (0.38 ml, 2 mmol) and dimethyl acetylenedicarboxylate (0.28 ml, 2 mmol) in 10 mL of CH_2Cl_2, *tert*-butyl isocyanide (0.26 g, 2 mmol) was added dropwise at $-10\,^{\circ}$C over 10 min. The reaction mixture was then allowed to warm to room temperature and stand for 24 h. The solvent was removed under reduced pressure, and the residual solid was recrystallized from diethyl ether. Oily products were purified by preparative thin-layer chromatography (TLC) on silica gel (Merck silica gel DC-Fertigplatten 60/Kieselgur F_{254}) 20×20-cm plates using *n*-hexane–AcOEt (2:1) as eluent.

Data

Dimethyl 2-{(*t*-butylimino)[2-oxopyridin-1(2*H*)-yl]methyl}but-2-enedioate (4a) and dimethyl 2-{(*t*-butylimino-methylene)-3-[2-oxopyridin-1(2*H*)-yl]}succinate (5a). Yellow oil. IR (KBr) (υ_{max}/cm^{-1}): 2062 (C=C=N), 1740 (C=O), 1725 (C=O), 1677 (C=O), 1663 (C=O), 1593 (C=N). MS (EI, 70 eV): *m/z* (%): 320 (M^+, 15), 263 (14), 226 (39), 143 (64), 94 (70), 57 (100), 41 (87). Anal. calcd. for $C_{16}H_{20}N_2O_5$ (320.35): C, 59.99; H, 6.29; N, 8.74. Found: C, 59.90; H, 6.33; N, 8.71. NMR data for **4a** (75%): ^{1}H NMR: $\delta = 1.29$ (9 H, s, Me_3C), 3.66 (3 H, s, MeO), 3.90 (3 H, s, MeO), 6.20 (1 H, t, ^3J 7.3 Hz, CH), 6.37 (1 H, d, ^3J 9.2 Hz, CH), 6.77 (1 H, s, CH), 7.29 (1 H, t, ^3J 9.0 Hz, CH), 8.00 (1 H, d, ^3J 7.1 Hz, CH). ^{13}C NMR: $\delta = 30.2$ (Me_3C), 52.3 (MeO), 52.1 (MeO), 57.5 (C−N), 105.8 (CH=), 121.5 (CH=), 124.7 (CH=), 136.0 (CH=), 140.6 (CH=), 142.6 (C=), 142.8 (C−N), 162.3 (C=O), 163.9 (C=O), 164.7 (C=O). NMR data for **5a** (13%): ^{1}H NMR: $\delta = 1.19$ (9 H, s, Me_3C), 3.68 (3 H, s, MeO), 3.86 (3 H, s, MeO), 5.73 (1 H, s, CH), 6.26 (1 H, t, ^3J 6.8 Hz, CH), 6.58 (1 H, d, ^3J 8.9 Hz, CH), 7.42 (1 H, t, ^3J 8.8 Hz, CH), 7.60 (1 H, d, ^3J 6.8 Hz, CH). ^{13}C NMR: $\delta = 29.6$ (Me_3C), 52.3 (MeO), 52.6 (MeO), 57.5 (C−N), 59.9 (CH), 61.3 (*C*=C=N), 105.4 (CH=), 122.0 (CH=), 135.3 (CH=), 140.8 (CH=), 161.5 (C=O), 162.39 (C=O), 164.70 (C=O), 168.7 (C=*C*=N).

Di-*t*-butyl 2-{(*t*-butylimino)[2-oxopyridin-1(2*H*)-yl]methyl}but-2-enedioate (4b) and di-*t*-butyl 2-{(*t*-butylimino-methylene)-3-[2-oxopyridin-1(2*H*)-yl]}succinate (5b). Yellow oil. IR (KBr) (υ_{max}/cm^{-1}): 2071 (C=C=N), 1748 (C=O), 1714 (C=O), 1661 (C=O). 1656 (C=O), 1596 (C=N). MS (EI, 70 eV): *m/z* (%): 404 (M^+, 13), 310 (14), 236 (33), 192 (57), 142 (34), 95 (56), 57 (100), 41 (87). Anal. calcd. for $C_{22}H_{32}N_2O_5$ (404.51): C, 65.32; H, 7.97; N, 6.93. Found: C, 65.35; H, 7.93; N, 6.96. NMR data for **4b** (68%): ^{1}H NMR: $\delta = 1.34$ (9 H, s, Me_3C), 1.36 (9 H, s, Me_3C), 1.58 (9 H, s, Me_3C), 6.16 (1 H, t, ^3J 7.4 Hz, CH), 6.41 (1 H, d, ^3J 9.2 Hz, CH), 6.67 (1 H, s, CH), 7.28 (1 H, t, ^3J 9.0 Hz, CH), 8.05 (1 H, d, ^3J 7.1 Hz, CH). ^{13}C NMR: $\delta = 28.2$ (Me_3C), 28.4 (Me_3C), 30.6 (Me_3C), 57.7 (C−N), 82.0 (C−O), 83.0 (C−O), 105.5 (CH=), 122.2 (CH=), 127.2 (CH=), 136.8 (CH=), 140.5 (CH=), 143.1 (C=), 143.8 (C=N), 162.6 (C=O), 162.8 (C=O), 164.1 (C=O). NMR data for **5b** (25%): ^{1}H NMR: $\delta = 1.27$ (9 H, s, Me_3C), 1.45 (9 H, s, Me_3C), 1.56 (9 H, s, Me_3C), 5.81 (1 H, s, CH), 6.15 (1 H, t, ^3J 6.7 Hz, CH), 6.53 (1 H, d, ^3J 9.0 Hz, CH), 7.32 (1 H, t, ^3J 8.8 Hz, CH), 7.63 (1 H, d, ^3J 6.8 Hz, CH). ^{13}C NMR: $\delta = 28.2$ (Me_3C), 28.7 (Me_3C), 30.5 (Me_3C), 57.7 (C−N), 60.0 (CH), 62.5 (*C*=C=N), 80.9 (C−O), 82.9 (C−O), 105.7 (CH=), 120.5 (CH=), 138.0 (CH=), 140.0 (CH=), 164.8 (C=O), 165.6 (C=O), 166.6 (C=O), 168.1 (C=*C*=N).

Dimethyl 2-{(*t*-butylimino)[1-oxoisoquinolin-1(2*H*)-yl]methyl}but-2-enedioate (4c) and dimethyl 2-{(*t*-butylimino-methylene)-3-[2-oxoisoquinolin-1(2*H*)-yl]}succinate (5c). Yellow oil. IR (KBr) (υ_{max}/cm^{-1}): 2068 (C=C=N), 1745 (C=O), 1724 (C=O), 1655 (C=O), 1654 (C=O), 1624 (C=N). MS (EI, 70 eV): *m/z* (%): 370 (M^+, 4), 313 (31), 226 (29), 143 (85), 57 (100), 41 (34). Anal. calcd. for $C_{20}H_{22}N_2O_5$ (370.41): C, 64.85; H, 5.99; N, 7.56. Found: C, 64.89; H, 5.94; N, 7.60. NMR data for **4c** (77%): ^{1}H NMR: $\delta = 1.33$ (9 H, s, Me_3C), 3.65 (3 H, s, MeO), 3.96 (3 H, s, MeO), 6.54 (1 H, d, ^3J 7.8, Hz CH), 6.84 (1 H, s, CH), 7.42

(1 H, t, ^3J 8.1 Hz, CH), 7.48 (1 H, d, ^3J 7.8 Hz, CH), 7.62 (1 H, t, ^3J 7.8 Hz, CH), 7.97 (1 H, d, ^3J 7.9 Hz, CH), 8.32 (1 H, d, ^3J 8.2 Hz, CH). ^{13}C NMR: $\delta = 30.8$ (*Me*$_3$C), 52.6 (MeO), 53.3 (MeO), 57.6 (C−N), 106.8 (CH=), 125.1 (CH=), 126.2 (CH=), 126.8 (C=), 127.1 (CH=), 128.6 (CH=), 130.3 (CH=), 133.3 (CH=), 137.6 (C=), 143.5 (C=), 152.6 (C=N), 162.5 (C=O), 164.6 (C=O), 165.1 (C=O). NMR data for **5c** (15%): ^{1}H NMR: $\delta = 1.48$ (9 H, s, Me$_3$C), 3.70 (3 H, s, MeO), 3.76 (3 H, s, MeO), 5.85 (1 H, s, CH), 6.52 (1 H, d, ^3J 7.5 Hz, CH), 7.32 (1 H, d, ^3J 7.5 Hz, CH), 7.44 (1 H, t, ^3J 7.8 Hz, CH), 7.52 (1 H, d, ^3J 7.8 Hz, CH), 7.63 (1 H, t, ^3J 7.7 Hz, CH), 8.38 (1 H, d, ^3J 7.9 Hz, CH). ^{13}C NMR: $\delta = 30.5$ (C*Me*$_3$), 52.2 (OMe), 53.3 (OMe), 59.9 (CN), 61.1 (CH), 62.9 (*C*=C=N), 106.3 (CH=), 126.3 (CH=), 126.8 (CH=), 128.2 (CH=), 131.7 (CH=), 132.7 (CH=), 133.3 (C=), 137.6 (C=), 162.2 (C=O), 165.9 (C=O), 168.8 (C=O), 170.6 (C=*C*=N).

Di-*t*-butyl 2-{(*t*-butylimino)[1-oxoisoquinolin-1(2*H*)-yl]methyl}but-2-enedioate (4d) and di-*t*-butyl 2-{(*t*-butylimino-methylene)-3-[2-oxoisoquinolin-1(2*H*)-yl]}succinate (5d). Yellow oil. IR (KBr) (υ_{max}/cm^{-1}): 2061 (C=C=N), 1742 (C=O), 1709 (C=O), 1658 (C=O), 1654 (C=O), 1626 (C=N). MS (EI, 70 eV): *m*/*z* (%): 454 (M$^+$, 2), 310 (24), 254 (23), 198 (35), 145 (82), 57 (100), 41 (30). Anal. calcd. for $C_{26}H_{34}N_2O_5$ (454.57): C, 68.70; H, 7.54; N, 6.16. Found: C, 68.73; H, 7.50; N, 6.12. NMR data for **4d** (63%): ^{1}H NMR: $\delta = 1.32$ (9 H, s, Me$_3$C), 1.35 (9 H, s, Me$_3$C), 1.59 (9 H, s, Me$_3$C), 6.50 (1 H, d, ^3J 7.8 Hz, CH), 6.71 (1 H, s, CH), 7.41 (1 H, t, ^3J 7.9 Hz, CH), 7.47 (1 H, d, ^3J 7.6 Hz, CH), 7.60 (1 H, t, ^3J 7.8 Hz, CH), 8.04 (1 H, d, ^3J 7.9 Hz, CH), 8.35 (1 H, d, ^3J 8.1 Hz, CH). ^{13}C NMR: $\delta = 28.2$ (*Me*$_3$C), 28.4 (*Me*$_3$C), 30.9 (*Me*$_3$C), 57.2 (*C*-N), 81.9 (C−O), 82.9 (C−O), 106.3 (CH=), 126.0 (CH=), 126.9 (CH=), 127.0 (CH=), 127.1 (C=), 128.8 (CH=), 130.3 (CH=), 133.0 (CH=), 137.6 (C=), 143.5 (C=), 143.9 (C=N), 162.3 (C=O), 163.2 (C=O), 164.2 (C=O). NMR data for **5d** (24%): ^{1}H NMR: $\delta = 1.23$ (9 H, s, Me$_3$C), 1.43 (9 H, s, Me$_3$C), 1.56 (9 H, s, Me$_3$C), 5.66 (1 H, s, CH), 6.48 (1 H, d, ^3J 7.5 Hz, CH), 7.43 (1 H, d, ^3J 7.5 Hz, CH), 7.45 (1 H, t, ^3J 7.8 Hz, CH), 7.50 (1 H, d, ^3J 7.8 Hz, CH), 7.62 (1 H, t, ^3J 7.8 Hz, CH), 8.41 (1 H, d, ^3J 7.9 Hz, CH). ^{13}C-NMR: $\delta = 28.3$ (*Me*$_3$C), 28.7 (*Me*$_3$C), 30.6 (*Me*$_3$C), 60.1 (C−N), 62.5 (CH), 64.2 (*C*=C=N), 81.0 (C−O), 82.8 (C−O), 105.8 (CH=), 126.1 (CH=), 126.3 (CH=), 126.7 (CH=), 128.4 (CH=), 131.5 (CH=), 132.5 (C=), 137.6 (C=), 162.1 (C=O), 167.5 (C=O), 167.6 (C=O), 169.0 (C=*C*=N).

Dimethyl 2-{(cyclohexylimino)[2-oxopyridin-1(2*H*)-yl]methyl}but-2-enedioate (4e). Yellow powder; yield: 0.54 g (78%), mp 164–168 °C. IR (KBr) (υ_{max}/cm^{-1}): 1725 (C=O), 1664 (C=O), 1595 (C=N). MS (EI, 70 eV): *m*/*z* (%): 346 (M$^+$, 11), 252 (100), 170 (92), 138 (20), 83 (48), 55 (38), 41 (26). Anal. calcd. for $C_{18}H_{22}N_2O_5$ (346.38): C, 62.42; H, 6.40; N, 8.09. Found: C, 62.39; H, 6.44; N, 8.01. H NMR: $\delta = 1.26$–1.88 (10 H, m, 5 CH$_2$), 3.27 (1 H, m, HC-N), 3.65 (3 H, s, MeO), 3.89 (3 H, s, MeO), 6.24 (1 H, t, ^3J 7.1, CH), 6.40 (1 H, d, ^3J 9.2 Hz, CH), 6.79 (1 H, s, CH), 7.32 (1 H, t, ^3J 9.2 Hz, CH), 8.01 (1 H, d, ^3J 7.1 Hz, CH). ^{13}C NMR: $\delta = 23.9$ (CH$_2$), 24.0 (CH$_2$), 25.5 (CH$_2$), 32.8 (2 CH$_2$), 52.2 (MeO), 52.9 (MeO), 60.4 (C−N), 106.0 (CH=), 121.3 (CH=), 124.7 (CH=), 135.7 (CH=), 140.7 (CH=), 140.8 (C=), 147.5 (C=N), 162.2 (C=O), 163.3 C=O), 164.4 (C=O).

Diethyl 2-{(cyclohexylimino)[2-oxopyridin-1(2*H*)-yl]methyl}but-2-enedioate (4f). Yellow powder; yield: 0.56 g (75%), mp 167–171 °C. IR (KBr) (υ max/cm^{-1}): 1741 (C=O), 1660 (C=O), 1596 (C=N). MS (EI, 70 eV): *m/z* (%): 374 (M^+, 9), 277 (100), 171 (86), 97 (22), 83 (50), 77 (35), 29 (30). Anal. calcd. for $C_{20}H_{26}N_2O_5$ (374.43): C, 64.15; H, 7.00; N, 7.48. Found: C, 64.19; H, 7.04; N, 7.42.^{1}H NMR: δ = 1.20 (3 H, t, ^3J 7.1 Hz, *Me*-CH_2), 1.28–1.88 (10 H, m, 5 CH_2), 1.35 (3 H, t, ^3J 7.1 Hz, *Me*-CH_2), 3.32 (1 H, m, H-CN), 4.10 (2 H, q, ^3J 7.1 Hz, CH_2O), 4.39 (2 H, m, CH_2O), 6.24 (1 H, t, ^3J 7.2 Hz, CH), 6.42 (1 H, d, ^3J 9.1 Hz, CH), 6.80 (1 H, s, CH), 7.32 (1 H, t, ^3J 9.2 Hz, CH), 8.05 (1 H, d, ^3J 7.3 Hz, CH). ^{13}C NMR: δ = 14.0 (*Me*-CH_2), 14.1 (*Me*-CH_2), 23.9 (CH_2), 24.1 (CH_2), 25.6 (CH_2), 31.2 (2 CH_2), 60.3 (C−N), 61.2 (CH_2O), 62.2 (CH_2O), 106.0 (CH=), 121.4 (CH=), 125.3 (CH=), 135.8 (CH=), 140.7 (CH=), 140.8 (C=), 148.2 (C=N), 162.2 (C=O), 162.9 (C=O), 164.1 (C=O).

Di-*t*-butyl 2-{(cyclohexylimino)[2-oxopyridin-1(2*H*)-yl]methyl}but-2-enedioate (4g). Yellow powder; yield: 0.65 g (76%), mp 170–174 °C. IR (KBr) (υ_{max}/cm^{-1}): 1716 (C=O), 1665 (C=O), 1628 (C=N). MS (EI, 70 eV): *m/z* (%): 430 (M^+, 7), 397 (100), 227 (83), 107 (25), 83 (45), 42 (20). Anal. calcd. for $C_{24}H_{34}N_2O_5$ (430.54): C, 66.95; H, 7.96; N, 6.51. Found: C, 66.90; H, 7.95; N, 6.58. ^{1}H NMR: δ = 1.26–1.78 (10 H, m, 5CH_2), 1.34 (9 H, s, Me_3C), 1.55 (9 H, s, Me_3C), 3.30 (1 H, m, N-CH), 6.19 (1 H, t, ^3J 7.3 Hz, CH), 6.42 (1 H, d, ^3J 9.5 Hz, CH), 6.70 (1 H, s, CH), 7.29 (1 H, t, ^3J 9.2 Hz, CH), 8.50 (1 H, d, ^3J 7.2 Hz, CH). ^{13}C NMR: δ = 24.0 (CH_2), 24.2 (CH_2), 25.6 (CH_2), 27.8 (*Me*$_3$C), 27.9 (*Me*$_3$C), 32.7 (2CH_2), 60.2 (C−N), 81.7 (C−O), 82.6 (C−O), 105.5 (CH=), 121.6 (CH=), 127.2 (CH=), 136.1 (CH=), 140.4 (CH=), 140.6 (C=), 148.5 (C=N), 161.9 (C=O), 162.1 (C=O), 163.5 (C=O).

Dimethyl 2-{(cyclohexylimino)[1-oxoisoquinolin-1(2*H*)-yl]methyl}but-2-enedioate (4h). Yellow powder; yield: 0.69 g (88%), mp 173–177 °C. IR (KBr) (υ_{max}/cm^{-1}): 1726 (C=O), 1657 (C=O), 1626 (C=N). MS (EI, 70 eV): *m/z* (%): 396 (M^+, 10), 280 (37), 227 (100), 170 (55), 83 (45), 55 (38). Anal. calcd. for $C_{22}H_{24}N_2O_5$ (396.44): C, 66.65; H, 6.10; N, 7.07. Found: C, 66.69; H, 6.13; N, 7.02. ^{1}H NMR: δ = 1.27–1.85 (10 H, m, 5 CH_2), 3.32 (1 H, m, HC-N), 3.65 (3 H, s, MeO), 3.96 (3 H, s, MeO), 6.59 (1 H, d, ^3J 7.8 Hz, CH), 6.87 (1 H, s, CH), 7.44 (1 H, t, ^3J 7.9 Hz, CH), 7.51 (1 H, d, ^3J 7.8 Hz, CH), 7.64 (1 H, t, ^3J 7.8 Hz, CH), 7.96 (1 H, d, ^3J 7.8 Hz, CH), 8.33 (1 H, d, ^3J 7.8 Hz, CH). ^{13}C NMR: δ = 24.4 (CH_2), 24.6 (CH_2), 26.1 (CH_2), 33.5 (2 CH_2), 52.6 (MeO), 53.5 (MeO), 60.6 (C−N), 107.2 (CH=), 125.2 (CH=), 126.4 (CH=), 126.5 (C=), 127.3 (CH=), 128.6 (CH=), 129.9 (CH=), 133.4 (CH=), 137.6 (C=), 141.5 (C=), 147.9 (C=N), 162.5 (C=O), 164.1 (C=O), 164.9 (C=O).

Diethyl 2-{(cyclohexylimino)[1-oxoisoquinolin-1(2*H*)-yl]methyl}but-2-enedioate (4i). Yellow powder; yield: 0.69 g (82%), mp 178–180 °C. IR (KBr) (υ_{max}/cm^{-1}): 1728 (C=O), 1665 (C=O), 16245 (C=N). MS (EI, 70 eV): *m/z* (%): 424 (M^+, 7), 280 (31), 253 (56), 227 (100), 171 (48), 83 (41), 29 (35). Anal. calcd. for $C_{24}H_{28}N_2O_5$ (424.49): C, 67.91; H, 6.65; N, 6.60. Found: C, 67.88; H, 6.68; N, 6.63.^{1}H NMR: δ = 1.16 (3 H, t, ^3J 7.1 Hz, *Me*-CH_2), 1.20–1.85 (10 H, m, 5 CH_2), 1.36 (3 H, t, ^3J 7.1 Hz, *Me*-CH_2), 3.32 (1 H, m, H-CN), 4.07 (2 H, q, ^3J 7.1 Hz,

CH_2O), 4.38 (2 H, m, CH_2O), 6.56 (1 H, d, ^3J 7.8 Hz, CH), 6.85 (1 H, s, CH), 7.42 (1 H, t, ^3J 7.9 Hz, CH), 7.48 (1 H, d, ^3J 7.7 Hz, CH), 7.62 (1 H, t, ^3J 7.9 Hz, CH), 7.96 (1 H, d, ^3J 7.8 Hz, CH), 8.33 (1 H, d, ^3J 8.0 Hz, CH). ^{13}C NMR: $\delta = 14.1$ (*Me*-CH_2), 14.2 (*Me*-CH_2), 24.1 (CH_2), 24.3 (CH_2), 25.8 (CH_2), 33.1 (CH_2), 33.4 (CH_2), 60.2 (C−N), 61.3 (CH_2O), 62.3 (CH_2O), 106.8 (CH=), 125.3 (CH=), 126.0 (CH=), 126.3 (C=), 126.9 (CH=), 128.3 (CH=), 129.6 (CH=), 133.1 (CH=), 137.3 (C=), 141.2 (C=), 147.8 (C=N), 162.1 (C=O), 163.3 (C=O), 164.2 (C=O).

Di-*t*-butyl 2-{(cyclohexylimino)[1-oxoisoquinolin-1(2*H*)-yl]methyl}but-2-enedioate (4j). Yellow powder; yield: 0.82 g (84%), mp 181–184 °C. IR (KBr) (υ_{max}/cm^{-1}): 1725 (C=O), 1662 (C=O), 1626 (C=N). MS (EI, 70 eV): *m/z* (%): 480 (M^+, 11), 336 (37), 253 (48), 227 (100), 144 (45), 83 (47), 57 (35). Anal. calcd. for $C_{28}H_{36}N_2O_5$ (480.60): C, 69.98; H, 7.55; N, 5.83. Found; C, 69.94; H, 7.58; N, 5.79. ^{1}H NMR: $\delta = 1.29$–1.85 (10 H, m, 5 CH_2), 1.29 (9 H, s, Me_3C), 1.55 (9 H, s, Me_3C), 3.32–3.35 (1 H, m, N-CH), 6.51 (1 H, d, ^3J 7.8 Hz, CH), 6.74 (1 H, s, CH), 7.41 (1 H, t, ^3J 8.0 Hz, CH), 7.46 (1 H, d, ^3J 7.7 Hz, CH), 7.60 (1 H, t, ^3J 7.8 Hz, CH), 8.02 (1 H, d, ^3J 7.8 Hz, CH), 8.34 (1 H, d, ^3J 8.0 Hz, CH). ^{13}C NMR: $\delta = 24.2$ (CH_2), 24.3 (CH_2), 25.8 (CH_2), 27.9 (*Me*$_3$C), 28.1 (*Me*$_3$C), 33.1 (CH_2), 33.5 (CH_2), 59.9 (C−N), 81.7 (C−O), 82.6 (C−O), 106.4 (CH=), 125.8 (CH=), 126.6 (CH=), 126.7 (C=), 126.8 (CH=), 128.4 (CH=), 129.6 (CH=), 132.8 (CH=), 137.2 (C=), 140.9 (C=), 148.4 (C=N), 161.8 (C=O), 162.3 (C=O), 163.7 (C=O).

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