Supplementary Material

Combination of pyridinium and isoquinolinium ylides with phenylisocyanate and isothiocyanates: Unexpected formation of a novel subclass of mesoionic monosubstituted 3-oxo-propanamide or thioamide compounds

Mohammad Seifi ¹, S. Yousef Ebrahimpour ¹, Jim Simpson², Michal Dusek³, Vaclav Eigner ³ and Hassan Sheibani*¹

¹Department of Chemistry, Shahid Bahonar University of Kerman, Kerman 76169, Iran
²Department of Chemistry, University of Otago, P.O. Box 56, Dunedin 9054, New Zealand
³Institute of Physics of the ASCR, v.v.i., Na Slovance 2, 182 21 Prague 8, Czech Republic

E-mail: hsheibani@mail.uk.ac.ir

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2-(Isoquinolin-2-ium-2-yl)-1,3-dioxo-1-phenyl-3-(phenylamino)propan-2-ide (5a):

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- Figure 26. $^1$H NMR 5a.
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Table 1. Solvent and base effects on the reaction of pyridinium or isoquinolinium bromides with phenylisocyanate

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<th>Base</th>
<th>Time (min)</th>
<th>Yield (%)</th>
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<td>95</td>
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<td>92</td>
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<td>92</td>
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Scheme 1

Scheme 1. Reaction of pyridinium salts 1a, b with phenylisocyanate 2a, phenylisothiocyanate 2b and methylisothiocyanate in the presence of triethylamine.
Scheme 2. Synthesis of 2-(Isoquinolin-2-ium-2-yl)-1-oxo-3-(phenylaminopropan-2-ide derivatives 5a-c.

5a: R=Ph, R'=Ph, X=O
5b: R=Ph, R'=Ph, X=S
5c: R=OCH₃, R'=Ph, X=O
Experimental part

Materials and methods

Melting points were measured on an Electrothermal-9100 apparatus and are uncorrected. IR spectra were recorded on a Brucker FT-IR Tensor 27 infrared spectrophotometer. $^1$H NMR and spectra were recorded on a Avance III 400 or 300 MHz Bruker spectrometer. $^{13}$C NMR spectra were recorded on the same instruments at 100 or 75 MHz using TMS as an internal standard. Mass spectra were measured on a GCMS-QP1000 EX spectrometer at 70 eV. Elemental analyses were performed using a Heracus CHN-O-Rapid analyzer. Pyridinium and isoquinolinium salts were prepared according to a literature procedure.

Typical procedure for the preparation of compounds 3a-f and 5a-c in acetonitrile.

A solution of the pyridinium salts (1a, b) or the isoquinolinium salts (4a, b) (2 mmol), phenylisocyanate or isothiocyanates (2 mmol) and triethylamine (0.2 mL) in acetonitrile (20 mL) was stirred at room temperature for about 15 minute (the progress of the reaction was monitored by TLC, using n-hexane/ethyl acetate as the eluent). The solvent was diluted with 50 mL of water and the resulting precipitate was collected by filtration. The crude product was recrystallized with dichloromethane/n-hexane (60/40) to give the pure solid sample for analysis.
1,3-Dioxo-1-phenyl-3-(phenylamino)-2-(pyridin-1-ium-1-yl)propan-2-ide (3a). Greenish yellow crystals; yield: 95%. mp 219 °C; IR (KBr, \( \nu_{\text{max}}/\text{cm}^{-1} \)): 3444 (broad, NH), 1639, 1619 (C=O), 1587, 1503 (C=C). \(^1\)H NMR (400 MHz, CDCl\(_3\)): 12.4 (s, 1H, NH, amide), 8.52-7.01 (m, 15H, Ar). \(^1\)C NMR (100 MHz, CDCl\(_3\)): 178.22, 163.58 (C=O), 149.12, 141.66, 140.46, 129.04, 128.82, 128.76, 128.43, 127.01, 119.85. MS (m/z): 316 (M\(^+\)) (5), 235(21), 196 (100), 167 (19), 119 (80), 105 (30), 91 (68), 77 (62), 65 (94), 51 (50). Anal. calcd. for C\(_{20}\)H\(_{16}\)N\(_2\)O\(_2\): C, 75.93; H, 5.10; N, 8.86%. Found: C, 75.79; H, 5.01; N, 8.52%.

Figure 1. IR 3a.
Figure 2. $^1$H NMR 3a.
Figure 3. $^{13}$C NMR 3a.
Figure 4. Mass 3a.
1-Methoxy-1,3-dioxo-3-(phenylamino)-2-(pyridin-1-ium-1-yl)propan-2-ide (3b). Yellow crystals; yield: 93%; mp 178-181 °C; IR (KBr, \( \nu_{\text{max}}/\text{cm}^{-1} \)): 3411 (broad, NH), 1627 (C=O), 1580, 1520, 1482 (C=C). \(^1\)H NMR (300 MHz, CDCl\(_3\)): 10.62 (s, 1H, NH, amide), 8.57-6.95 (m, 10H, Ar), 3.62 (s, 3H, CH\(_3\)). \(^13\)C NMR (75 MHz, CDCl\(_3\)): 174.87, 164.14 (C=O), 149.69, 141.21, 128.71, 125.69, 119.34, 50.14 (OCH\(_3\)). MS (m/z): 270 (M\(^+\)) (6), 213 (9), 178 (13), 152 (68), 119 (100), 101 (14), 91 (94), 86 (24), 79 (24), 64 (53), 52 (30). Anal. calcd. for \( \text{C}_{15}\text{H}_{14}\text{N}_{2}\text{O}_3 \): C, 66.66; H, 5.22; N, 10.36%. Found: C, 66.57; H, 5.19; N, 10.15%.

**Figure 5.** IR 3b.
Figure 6. $^1$H NMR 3b.
Figure 7. $^{13}$C NMR 3b.
Figure 8. Mass 3b.
1-Oxo-1-phenyl-3-(phenylamino)-2-(pyridin-1-ium-1-yl)-3-thioxopropan-2-ide (3c). Greenish yellow crystals; yield: 90%, mp 179-180 °C; IR (KBr, ν max/cm⁻¹): 3424 (broad, NH), 1618 (C=O), 1570 (C=C). ¹H NMR (300 MHz, DMSO): 14.54 (s, 1H, NH, thioamide), 8.95-7.10 (m, 15H, Ar). ¹³C NMR (75 MHz, DMSO): 184.59 (C=S), 177.81 (C=O), 151.85, 145.61, 141.42, 141.29, 128.81, 128.61, 128.28, 126.88, 123.27. MS (m/z): 332 (M⁺) (6), 253 (7), 251 (10), 236 (5), 196 (12), 162 (57), 135 (100), 105 (61), 91 (12), 77 (98), 51 (44). Anal. calcd. for C₂₀H₁₈N₂OS: C, 72.26; H, 4.85; N, 8.43%. Found: C, 72.01; H, 4.75; N, 8.22%.

Figure 9. IR 3c.
Figure 10. $^1$H NMR 3c.
Figure 11. $^{13}$C NMR 3c.
Figure 12. Mass 3c.
1-Methoxy-1-oxo-3-(phenylamino)-2-(pyridin-1-ium-1-yl)-3-thioxopropan-2-ide (3d). Yellow crystals; yield: 93%; mp 170 °C; IR (KBr, \( \nu_{\text{max}} \)/cm\(^{-1}\)): 3444 (broad, NH), 1640 (C=O), 1592 (C=S), 1564 (C=C). \(^1\)H NMR (300 MHz, CDCl\(_3\)): 11.83 (s, 1H, NH, thioamide), 8.61-7.09 (m, 10H, Ar), 3.59 (s, 3H, CH\(_3\)). \(^13\)C NMR (75 MHz, CDCl\(_3\)): 182.87 (C=S), 162.79 (C=O), 151.30, 143.47, 128.26, 126.23, 109.67, 50.49 (OCH\(_3\)). MS (m/z): 286 (M\(^+\)) (4), 260 (6), 234 (12), 207 (7), 205 (13), 191 (12), 176 (13), 135 (100), 119 (32), 104 (11), 91 (28), 77 (87), 64 (18), 51 (58). Anal. calcd. for C\(_{15}\)H\(_{14}\)N\(_2\)O\(_2\)S: C, 62.92; H, 4.93; N, 9.78%. Found: C, 62.75; H, 4.85; N, 9.67%.

Figure 13. IR 3d.
Figure 14. $^1$H NMR 3d.
Figure 15. $^{13}$C NMR 3d.
Figure 16. Mass 3d.
1-(Methylamino)-3-oxo-3-phenyl-2-(pyridin-1-ium-1-yl)-1-thioxopropan-2-ide (3e). Russet brown crystals; yield: 90%. mp 95 °C; IR (KBr, ν_max/cm⁻¹): 3493 (NH), 1639 (C=O), 1619 (C=N). \(^1\)H NMR (400 MHz, DMSO-d6): 8.83 (d, 2H, H\textsubscript{α}-py, \(^3\)J\textsubscript{H-H}=8 Hz), 8.32 (t, 1H, H\textsubscript{γ}-py, \(^3\)J\textsubscript{H-H}=8 Hz), 7.79 (t, 2H, H\textsubscript{β}-py, \(^3\)J\textsubscript{H-H}=8 Hz), 3.10 (d, 3H, CH\textsubscript{3}, \(^3\)J\textsubscript{H-H}=4 Hz). \(^1\)C NMR (100 MHz, DMSO-d6): 183.34 (C=S), 163.83 (C=O), 151.29 (C=N), 144.67, 141.49, 127.75, 127.68, 126.15, 126.06, 112.02 (C), 31.16 (N-CH\textsubscript{3}). MS (m/z): 270 (M\textsuperscript{+}) (35), 269 (14), 237 (16), 191 (21), 163 (8), 118 (15), 105 (100), 77 (85), 51 (43). Anal. calcd. for C\textsubscript{15}H\textsubscript{14}N\textsubscript{2}OS: C, 66.64; H, 5.22; N, 10.36%. Found: C, 66.48; H, 5.04; N, 10.09%.

Figure 13. IR 3d.
Figure 18. $^1$H NMR 3e.
Figure 19. $^{13}$C NMR 3e.
Figure 20. Mass 3e.
1-Methoxy-3-(methylamino)-1-oxo-2-(pyridin-1-ium-1-yl)-3-thioxopropan-2-ide (3f). Yellow crystals; yield: 90%, mp 174-175 °C; IR (KBr, ν max/cm⁻¹): 3493 (NH), 1695 (C=O), 1632 (C=N). ¹H NMR (300 MHz, DMSO-d₆): 9.70 (q, 1H, NH, ³JH-H=6 Hz), 8.74 (d, 2H, Hα-py, ³JH-H=6 Hz), 8.47 (t, 1H, Hγ-py, ³JH-H=6 Hz), 7.96 (t, 2H, Hβ-py, ³JH-H=6 Hz), 3.39 (s, 3H, OCH₃), 3.02 (d, 3H, N-CH₃, ³JH-H=6 Hz). ¹³C NMR (75 MHz, DMSO-d₆): 185.71 (C=S), 164.14 (C=O), 151.91 (C=N), 144.96, 127.15, 107.45 (C), 50.11 (OCH₃), 31.51 (N-CH₃). MS (m/z): 224 (M⁺) (100), 223 (66), 191 (49), 164 (13), 113 (11), 93 (10), 80 (93), 52 (34). Anal. calc. for C₉H₁₂N₂O₃S: C, 53.55; H, 5.39; N, 12.49%. Found: C, 51.08; H, 5.19; N, 12.22%.

Figure 21. IR 3f.
Figure 22. $^1$H NMR 3f.
Figure 23. $^{13}$C NMR 3f.
Figure 24. Mass 3f.
2-(Isoquinolin-2-ium-2-yl)-1,3-dioxo-1-phenyl-3-(phenylamino)propan-2-ide (5a). Orange crystals; yield: 96%. mp 191-193 °C; IR (KBr, ν/cm⁻¹): 3411 (broad, NH), 1632, 1590 (C=O), 1536, 1501 (C=C). ¹H NMR (300 MHz, CDCl₃): 12.57 (s, 1H, NH), 9.20 (s, 1H, H-C=)=N), 8.19-6.99 (m, 16H, Ar). ¹³C NMR (75 MHz, CDCl₃): 178.52, 164.03 (C=O), 152.21, 140.65, 140.47, 140.03, 136.01, 130.55, 129.65, 128.78, 128.73, 128.37, 127.16, 127.02, 126.82, 123.37, 122.43, 120.07, 119.06, 116.06. MS (m/z): 366 (M⁺) (2), 363 (59), 347 (8), 247 (41), 204 (12), 144 (10), 129 (60), 105 (100), 91 (10), 77 (93), 51 (35). Anal. calcd. for C₂₄H₁₈N₂O₂: C, 78.67; H, 4.95; N, 7.65%. Found: C, 78.49; H, 4.80; N, 7.37%.

Figure 25. IR 5a.
Figure 26. $^1$H NMR 5a.
Figure 27. $^{13}$C NMR 5a.
Figure 28. Mass 5a.
2-(Isoquinolin-2-ium-2-yl)-1-oxo-1-phenyl-3-(phenylamino)-3-thioxopropan-2-ide (5b). Brown crystals; yield: 95% mp 149-151°C; IR (KBr, νmax/cm⁻¹): 3444 (broad, NH), 1635 (C=O), 1619, 1597 (C=C). ¹H NMR (300 MHz, DMSO-d₆): 14.61 (s, 1H, NH), 10.09 (s, 1H, H-C=NN), 8.58-6.80 (m, 16H, Ar). ¹³C NMR (75 MHz, DMSO-d₆): 184.80 (C=S), 178.14 (C=O), 156.64, 142.14, 141.53, 141.36, 137.28, 137.02, 130.93, 130.66, 129.94, 129.31, 128.83, 128.61, 128.24, 127.37, 127.24, 126.62, 124.05, 123.33. MS (m/z): 382 (M⁺) (5), 380 (18), 362 (12), 351 (17), 298 (13), 241 (9), 129 (15), 105 (100), 77 (94), 51 (23). Anal. calcd. for C₂₄H₁₈N₂O₃S: C, 75.37; H, 4.74; N, 7.32%. Found: C, 75.14; H, 4.55; N, 7.01%.

Figure 29. IR 5b.
Figure 30. $^1$H NMR 5b.
Figure 31. $^{13}$C NMR 5b.
Figure 32. Mass 5b.
2-(Isoquinolin-2-ium-2-yl)-1-methoxy-1,3-dioxo-3-(phenylamino)propan-2-ide (5c). Orange crystals; yield: 93%. mp 135 °C; IR (KBr, \textit{v}_{\text{max}}/\text{cm}^{-1}): 3443 (broad, NH), 1638, 1617 (C=O), 1581, 1526 (C=C). \textsuperscript{1}H NMR (300MHz, CDCl\textsubscript{3}): 10.72 (s, 1H, NH), 9.28 (s, 1H, H-\text{C}=N), 8.30-6.94 (m, 11H, Ar), 3.65 (s, 3H, OCH\textsubscript{3}). \textsuperscript{13}C NMR (75MHz, CDCl\textsubscript{3}): 177.53, 164.46 (C=O), 152.88, 141.04, 140.47, 136.13, 135.53, 130.16, 129.75, 128.72, 127.48, 126.74, 123.31, 121.72, 119.39, 98.20, 50.19 (OCH\textsubscript{3}). MS (\textit{m}/\textit{z}): 320 (M\textsuperscript{+}) (9), 260 (8), 228 (19), 201 (87), 170 (17), 143 (100), 130 (59), 119 (86), 102 (18), 91 (64), 77 (26), 64 (40), 51 (26). Anal. calcd. for C\textsubscript{19}H\textsubscript{16}N\textsubscript{2}O\textsubscript{3}: C, 71.24; H, 5.03; N, 8.74 %. Found: C, 70.94; H, 4.88; N, 8.46%.

![Figure 33. IR 5c.](image)
Figure 34. NMR 5c.
Figure 35. $^{13}$C NMR 5c.
Figure 36. Mass 5c.