

Supporting Information

Cross-Coupling of Acrylamides and Maleimides Under Rhodium Catalysis: Controlled Olefin Migration

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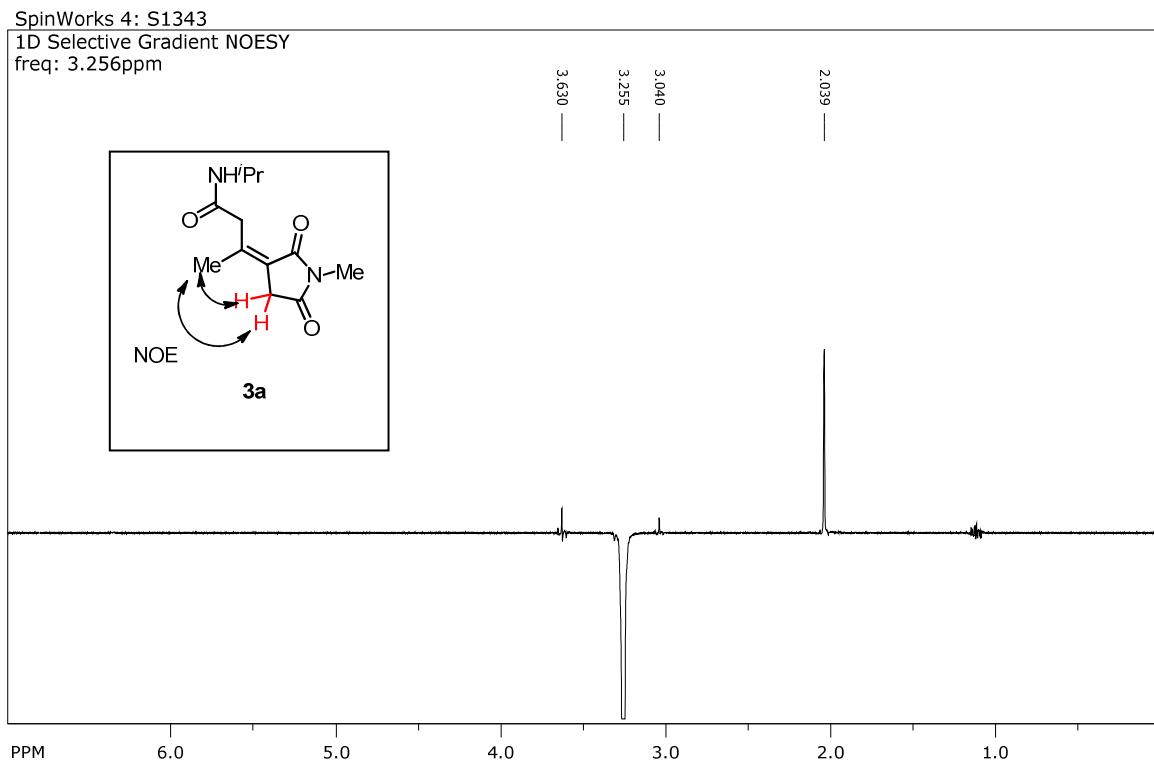
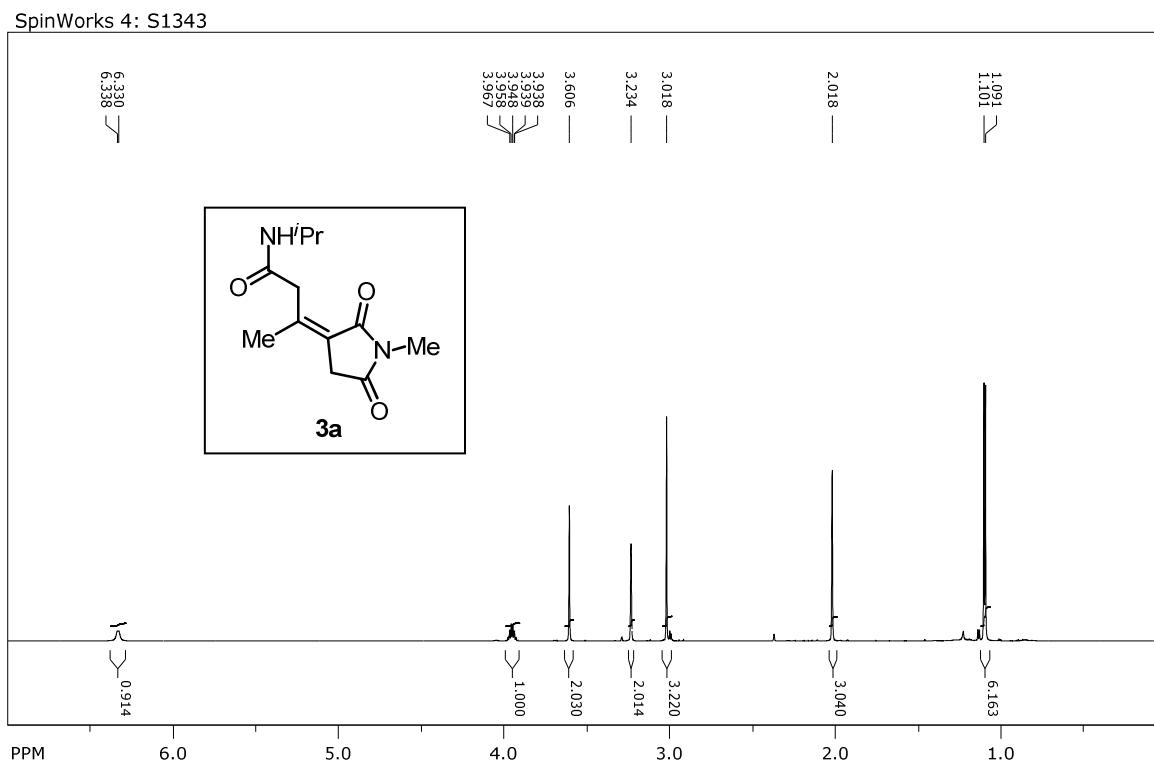
List of the Contents

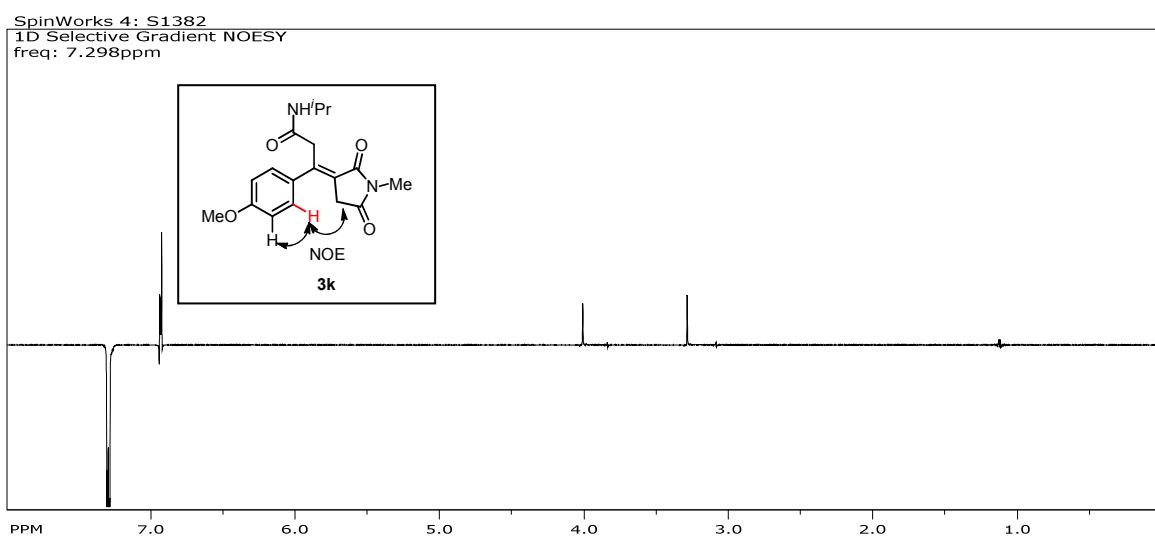
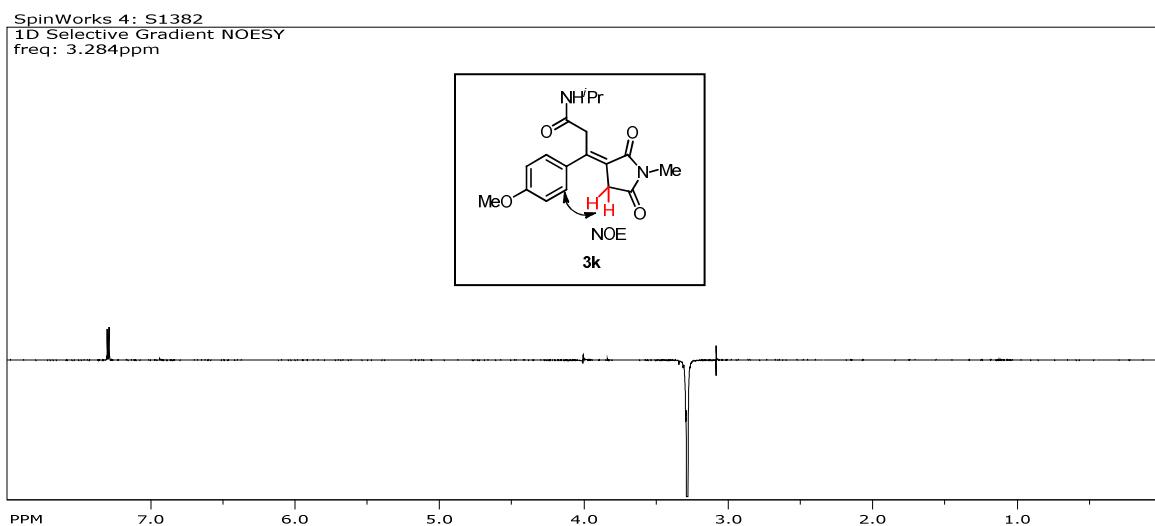
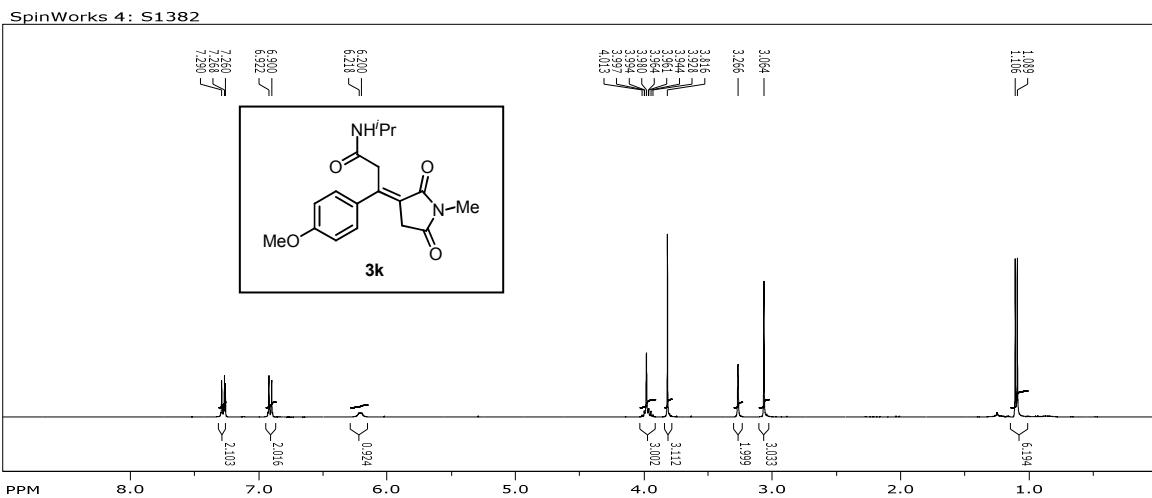
General methods -----	S2
1D NOE spectra of 3a, 3k, 6ab, 6ac and 6bb -----	S3–S7
Typical procedure for the reaction of acrylamides with maleimides (3a–3n, 4b–4j, 6aa, 6ab, 6ac, 6ba, 6bb, 6bc, 6ca, 6cb and 6cc) -----	S8
Characterization data for all products (3a–3n, 4b–4j, 6aa, 6ab, 6ac, 6ba, 6bb, 6bc, 6ca, 6cb and 6cc) -----	S9–S23
¹H NMR and ¹³C NMR spectra of all compounds -----	S24–S55

General methods

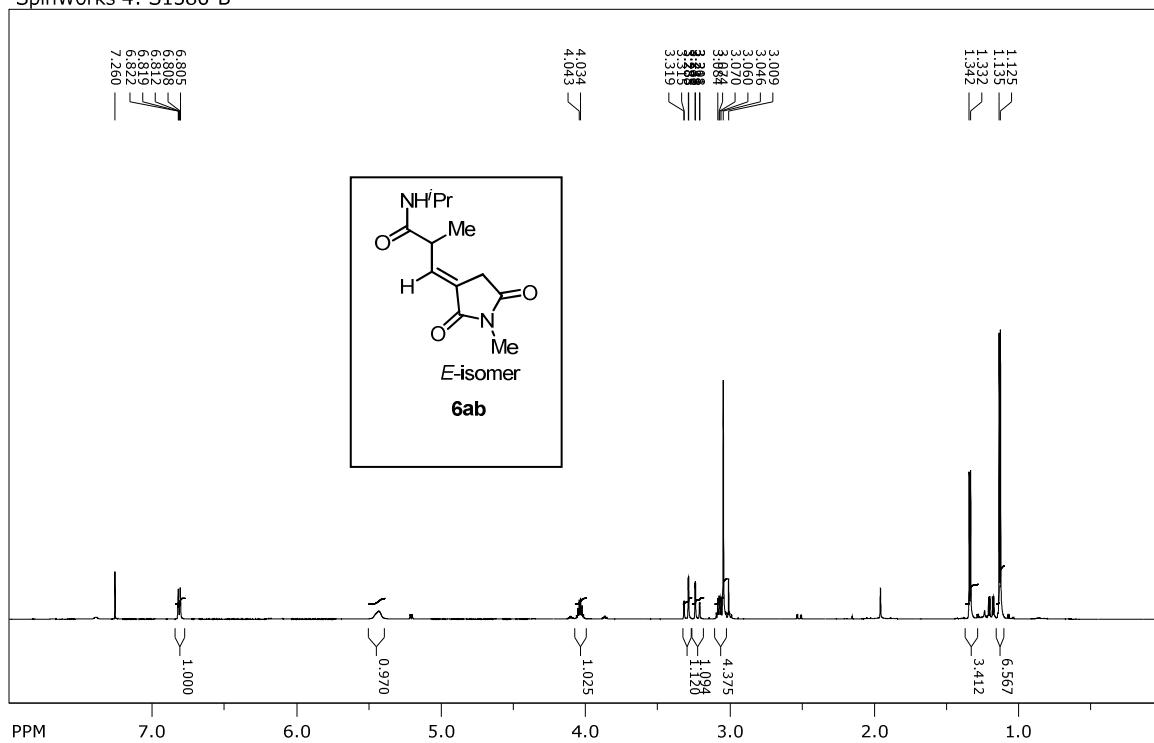
Commercially available reagents were used without additional purification, unless otherwise stated. Sealed tubes ($13 \times 100 \text{ mm}^2$) were purchased from Fischer Scientific and dried in oven for overnight and cooled at room temperature prior to use. Thin layer chromatography was carried out using plates coated with Kieselgel 60 F₂₅₄ (Merck). For flash column chromatography, E. Merck Kieselgel 60 (230–400 mesh) was used. Nuclear magnetic resonance spectra (¹H and ¹³C NMR) were recorded on a Bruker Unity 400 and 500 spectrometers in CDCl₃ and CD₃OD solution and chemical shifts are reported as parts per million (ppm). Resonance patterns are reported with the notations s (singlet), d (doublet), t (triplet), q (quartet), and m (multiplet). In addition, the notation br is used to indicate a broad signal. Coupling constants (*J*) are reported in hertz (Hz). IR spectra were recorded on a Varian 2000 Infrared spectrophotometer and are reported as cm⁻¹. High-resolution mass spectra (HRMS) were recorded on a JEOL JMS-600 spectrometer.

1D NOE spectra of 3a, 3k, 6ab, 6ac, 6bb



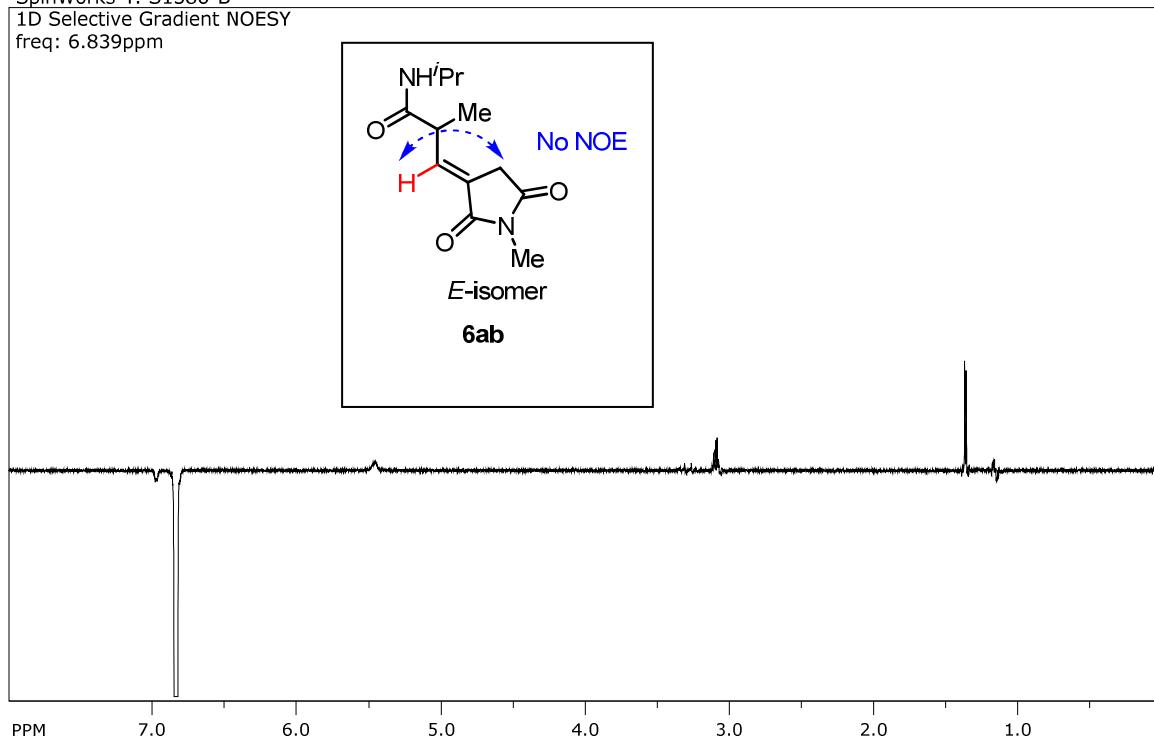


SpinWorks 4: S1386-B

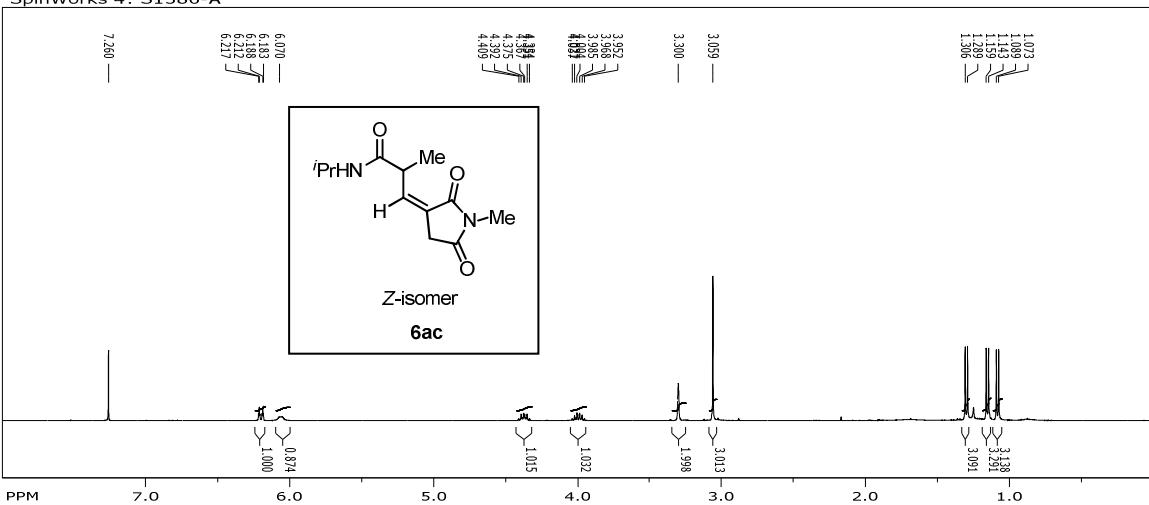


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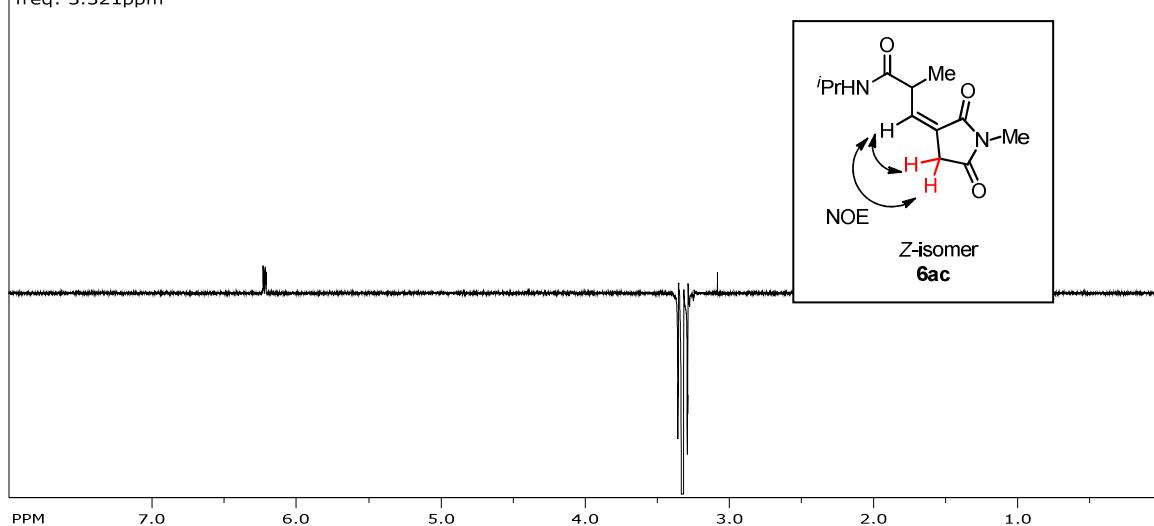


SpinWorks 4: S1386-A



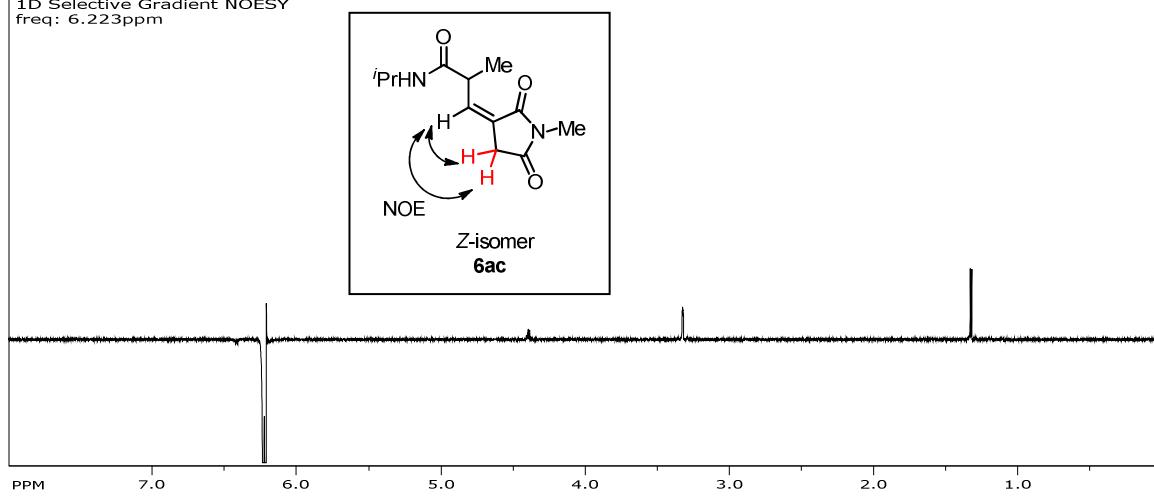
SpinWorks 4: S1386-A

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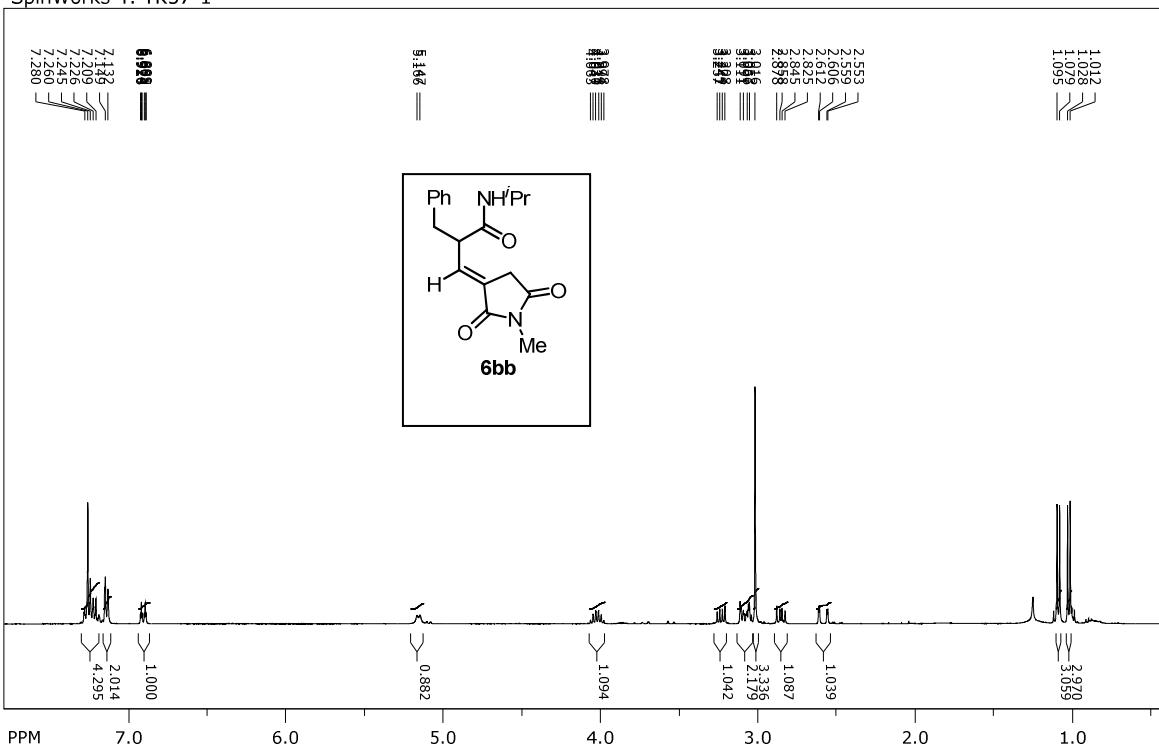


SpinWorks 4: S1386-A

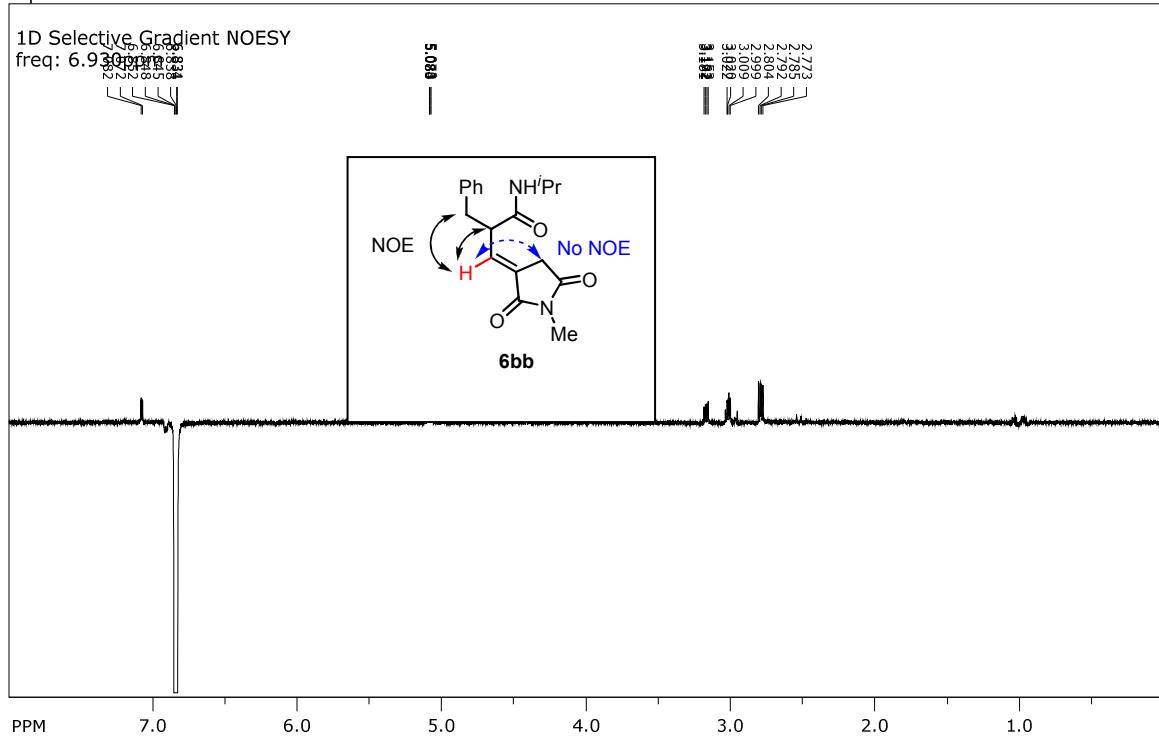
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freq: 6.223ppm



SpinWorks 4: YK57-1



SpinWorks 4: YK-57-1

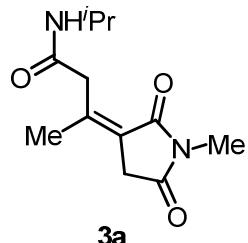


Typical procedure for the reaction of acrylamides with maleimides (3a–3n**, **4b–4j**, **6aa**, **6ab**, **6ac**, **6ba**, **6bb**, **6bc**, **6ca**, **6cb** and **6cc**)**

To an oven-dried sealed tube charged with (*E*)-*N*-isopropylbut-2-enamide (**1a**) (25.4 mg, 0.2 mmol, 100 mol %), [RhCp*Cl₂]₂ (3.1 mg, 0.005 mmol, 2.5 mol %), AgSbF₆ (13.7 mg, 0.02 mmol, 20 mol %) and pivalic acid (40.8 mg, 0.4 mmol, 200 mol %) was added 1-methyl-(1*H*)-pyrrole-2,5-dione (**2a**) (44.4 mg, 0.4 mmol, 200 mol %) and DCE (1 mL). The reaction mixture was allowed to stir for 20 h at 70 °C. The reaction mixture was diluted with EtOAc (3 mL) and concentrated in vacuo. The residue was purified by flash column chromatography (*n*-hexanes/EtOAc = 2:1) to afford **3a** (44.3 mg) in 93% yield.

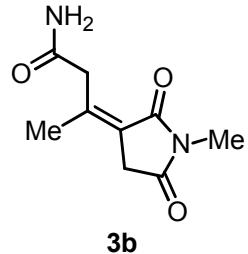
Characterization data for all products (3a–3n, 4b–4j, 6aa, 6ab, 6ac, 6ba, 6bb, 6bc, 6ca, 6cb and 6cc)

(Z)-N-Isopropyl-3-(1-methyl-2,5-dioxopyrrolidin-3-ylidene)butanamide (3a)



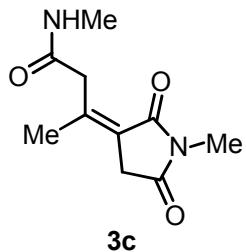
44.3 mg (93%); White solid; mp = 171.7–173.2 °C; ¹H NMR (400 MHz, CDCl₃) δ 6.32 (br s, 1H), 3.98–3.93 (m, 1H), 3.60 (s, 2H), 3.23 (s, 2H), 3.02 (s, 3H), 2.02 (s, 3H), 1.10 (d, *J* = 6.4 Hz, 6H); ¹³C NMR (100 MHz, CDCl₃) δ 173.3, 170.4, 168.0, 147.2, 120.6, 42.0, 41.4, 34.0, 24.5, 23.3, 22.6; IR (KBr) ν 3282, 2969, 2929, 1753, 1698, 1662, 1637, 1553, 1432, 1382, 1279, 1157, 1090, 1017, 985, 714 cm⁻¹; HRMS (Orbitrap, ESI) calcd for C₁₂H₁₉N₂O₃ [M+H]⁺ 231.1396, found 231.1396.

(Z)-3-(1-Methyl-2,5-dioxopyrrolidin-3-ylidene)butanamide (3b)



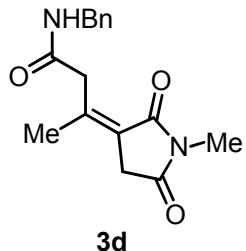
21.5 mg (55%); Light brown solid; mp = 175.3–178.2 °C; ¹H NMR (400 MHz, CDCl₃) δ 6.48 (br s, 1H), 5.40 (br s, 1H), 3.72 (s, 2H), 3.27 (s, 2H), 3.04 (s, 3H), 2.04 (s, 3H); ¹³C NMR (100 MHz, CDCl₃) δ 173.3, 171.1, 170.5, 146.2, 121.3, 34.0, 29.6, 24.6, 23.3; IR (KBr) ν 3393, 3197, 2925, 1780, 1692, 1663, 1432, 1381, 1278, 1157, 1011, 952, 761 cm⁻¹; HRMS (Orbitrap, ESI) calcd for C₉H₁₃N₂O₃ [M+H]⁺ 197.0926, found 197.0925.

(Z)-N-Methyl-3-(1-methyl-2,5-dioxopyrrolidin-3-ylidene)butanamide (3c)



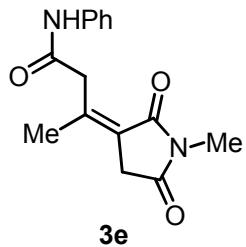
35.3 mg (84%); White solid; mp = 158.2–161.2 °C; ¹H NMR (400 MHz, CDCl₃) δ 6.53 (br s, 1H), 3.66 (s, 2H), 3.25 (s, 2H), 3.05 (s, 3H), 2.77 (d, *J* = 5.2 Hz, 3H), 2.05 (s, 3H); ¹³C NMR (100 MHz, CDCl₃) δ 173.3, 170.6, 169.6, 147.2, 120.8, 41.8, 34.0, 26.3, 24.6, 23.3; IR (KBr) ν 3300, 2923, 1756, 1697, 1636, 1567, 1428, 1375, 1428, 1273, 1151, 1010, 842, 713 cm⁻¹; HRMS (Orbitrap, ESI) calcd for C₁₀H₁₅N₂O₃ [M+H]⁺ 211.1083, found 211.1081.

(Z)-N-Benzyl-3-(1-methyl-2,5-dioxopyrrolidin-3-ylidene)butanamide (3d)



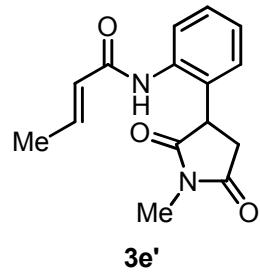
51.5 mg (90%); White solid; mp = 132.1–136.7 °C; ¹H NMR (400 MHz, CDCl₃) δ 7.33–7.22 (m, 5H), 6.86 (br s, 1H), 4.39 (d, *J* = 6.0 Hz, 2H), 3.72 (s, 2H), 3.24 (s, 2H), 3.00 (s, 3H), 2.06 (s, 3H); ¹³C NMR (100 MHz, CDCl₃) δ 173.3, 170.5, 168.9, 146.8, 138.2, 128.6, 127.4, 127.3, 121.0, 43.5, 41.9, 34.0, 24.5, 23.3; IR (KBr) ν 3269, 2923, 1753, 1692, 1662, 1637, 1545, 1430, 1380, 1276, 1153, 1090, 1001, 844, 748 cm⁻¹; HRMS (Orbitrap, ESI) calcd for C₁₆H₁₉N₂O₃ [M+H]⁺ 287.1396, found 287.1396.

(Z)-3-(1-Methyl-2,5-dioxopyrrolidin-3-ylidene)-N-phenylbutanamide (3e)



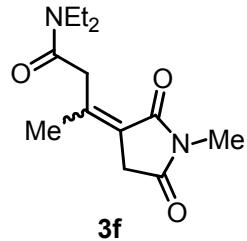
10.9 mg (20%); Light yellow solid; mp = 176.7–179.2 °C; ¹H NMR (400 MHz, CDCl₃) δ 8.83 (br s, 1H), 7.50 (d, *J* = 7.6 Hz, 2H), 7.29 (t, *J* = 7.6 Hz, 2H), 7.07 (t, *J* = 7.6 Hz, 1H), 3.77 (s, 2H), 3.27 (s, 2H), 3.09 (s, 3H), 2.10 (s, 3H); ¹³C NMR (100 MHz, CDCl₃) δ 173.3, 170.6, 169.6, 147.2, 120.8, 41.8, 34.0, 26.3, 24.6, 23.3; IR (KBr) ν 3317, 2924, 2854, 1761, 1695, 1667, 1598, 1541, 1498, 1439, 1382, 1277, 1157, 1011, 960, 754 cm⁻¹; HRMS (Orbitrap, ESI) calcd for C₁₅H₁₇N₂O₃ [M+H]⁺ 273.1239, found 273.1239.

(Z)-N-(2-(1-Methyl-2,5-dioxopyrrolidin-3-yl)phenyl)but-2-enamide (3e')



19.0 mg (35%); Yellow solid; mp = 138.8–140.8 °C; ¹H NMR (400 MHz, CDCl₃) δ 8.62 (br s, 1H), 7.69 (d, *J* = 7.2 Hz, 1H), 7.34 (t, *J* = 8.0 Hz, 1H), 7.21 (t, *J* = 7.6 Hz, 1H), 7.14 (d, *J* = 7.6 Hz, 1H), 7.02–6.94 (m, 1H), 6.00 (d, *J* = 15.2 Hz, 1H), 4.34 (t, *J* = 6.8 Hz, 1H), 3.10 (d, *J* = 7.6 Hz, 2H), 3.02 (s, 3H), 1.92 (d, *J* = 6.4 Hz, 3H); ¹³C NMR (100 MHz, CDCl₃) δ 179.4, 175.9, 164.6, 149.5, 136.5, 129.7, 129.2, 127.2, 126.2, 125.3, 64.2, 41.3, 25.1, 17.9; IR (KBr) ν 3279, 2926, 1777, 1692, 1639, 1518, 1436, 1382, 1282, 1185, 1120, 960, 754 cm⁻¹; HRMS (Orbitrap, ESI) calcd for C₁₅H₁₇N₂O₃ [M+H]⁺ 273.1239, found 273.1241.

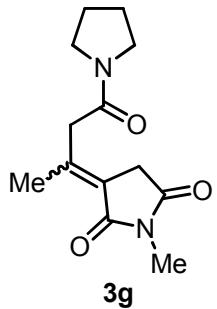
N,N-Diethyl-3-(1-methyl-2,5-dioxopyrrolidin-3-ylidene)butanamide (3f)



47.9 mg (95%); Light yellow oil; ¹H NMR (400 MHz, CDCl₃) **E-isomer:** δ 3.97 (s, 2H), 3.38–3.32 (m, 4H), 3.24 (s, 2H), 2.98 (s, 2H), 1.96 (s, 3H), 1.23 (t, *J* = 6.8 Hz, 3H), 1.10 (t, *J* = 6.8 Hz, 3H); **Z-isomer:** δ 3.38–3.32 (m, 4H), 3.21 (s, 2H), 3.15 (s, 2H), 2.99 (s, 2H), 2.36 (s, 3H), 1.21 (t, *J* = 6.8 Hz, 3H), 1.11 (t, *J* = 6.8 Hz, 3H); ¹³C NMR (100 MHz, CDCl₃) **E-isomer:** δ

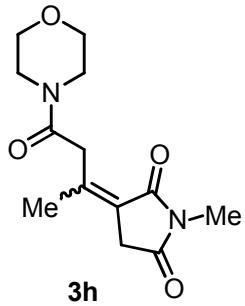
173.6, 169.7, 168.5, 146.5, 121.3, 42.1, 40.3, 37.7, 34.0, 24.3, 22.9, 14.0, 13.0; **Z-isomer:** δ 173.5, 169.6, 167.0, 146.3, 121.9, 42.3, 41.5, 40.5, 33.8, 19.5, 14.3, 12.9; IR (KBr) ν 2952, 2926, 2874, 1760, 1692, 1634, 1427, 1378, 1273, 1159, 1093, 1011, 990, 914, 843, 755 cm^{-1} ; HRMS (Orbitrap, ESI) calcd for $\text{C}_{13}\text{H}_{21}\text{N}_2\text{O}_3$ $[\text{M}+\text{H}]^+$ 253.1552, found 253.1553.

1-Methyl-3-(4-oxo-4-(pyrrolidin-1-yl)butan-2-ylidene)pyrrolidine-2,5-dione (3g)



44.0 mg (88%); Yellow sticky solid; ^1H NMR (400 MHz, CDCl_3) **Z-isomer:** δ 3.91 (s, 2H), 3.50 (t, $J = 6.8$ Hz, 2H), 3.44 (t, $J = 7.2$ Hz, 2H), 3.25 (s, 2H), 2.98 (s, 3H), 1.98 (s, 3H), 1.98–1.95 (m, 2H), 1.89–1.83 (m, 2H); **E-isomer:** δ 3.50 (t, $J = 6.8$ Hz, 2H), 3.44 (t, $J = 7.2$ Hz, 2H), 3.23 (s, 2H), 3.12 (s, 2H), 3.00 (s, 3H), 2.37 (s, 3H), 1.98–1.95 (m, 2H), 1.89–1.83 (m, 2H); ^{13}C NMR (100 MHz, CDCl_3) **Z-isomer:** δ 173.7, 169.7, 167.9, 146.1, 121.5, 46.6, 45.8, 39.0, 34.0, 26.0, 24.4, 24.3, 23.1; **E-isomer:** δ 173.6, 169.6, 166.5, 145.8, 122.1, 46.9, 45.9, 43.1, 33.9, 26.1, 24.4, 24.3, 19.6; IR (KBr) ν 2952, 2926, 2874, 1760, 1692, 1634, 1427, 1378, 1273, 1159, 1093, 1011, 990, 914, 843, 755 cm^{-1} ; HRMS (Orbitrap, ESI) calcd for $\text{C}_{13}\text{H}_{19}\text{N}_2\text{O}_3$ $[\text{M}+\text{H}]^+$ 251.1396, found 251.1395.

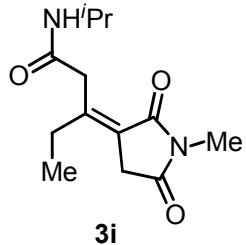
1-Methyl-3-(4-morpholino-4-oxobutan-2-ylidene)pyrrolidine-2,5-dione (3h)



47.9 mg (90%); Yellow sticky solid; ^1H NMR (400 MHz, CDCl_3) **Z-isomer:** δ 3.95 (s, 2H), 3.71–3.66 (m, 4H), 3.61–3.53 (m, 4H), 3.26 (s, 2H), 2.99 (s, 3H), 1.98 (s, 3H); ^{13}C NMR

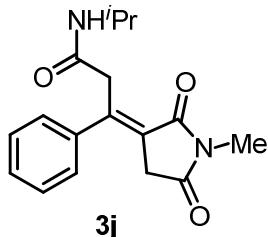
(100 MHz, CDCl₃) **Z-isomer:** δ 173.5, 169.7, 168.2, 145.7, 121.6, 66.8, 66.6, 46.1, 42.1, 37.4, 34.0, 24.4, 23.0; IR (KBr) ν 2956, 2921, 2854, 1759, 1691, 1638, 1429, 1380, 1275, 1228, 1159, 1112, 1063, 1007, 850, 753 cm⁻¹; HRMS (Orbitrap, ESI) calcd for C₁₃H₁₉N₂O₄ [M+H]⁺ 267.1345, found 267.1346.

(Z)-N-Isopropyl-3-(1-methyl-2,5-dioxopyrrolidin-3-ylidene)pentanamide (3i)



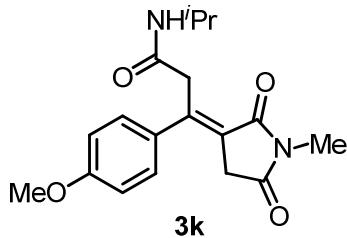
31.2 mg (62%); Light yellow solid; mp = 143.0–148.7 °C; ¹H NMR (400 MHz, CDCl₃) δ 6.41 (br s, 1H), 4.01–3.92 (m, 1H), 3.62 (s, 2H), 3.26 (s, 2H), 3.04 (s, 3H), 2.34 (q, *J* = 7.6 Hz, 2H), 1.12–1.08 (m, 9H); ¹³C NMR (100 MHz, CDCl₃) δ 173.4, 170.8, 168.3, 152.4, 120.3, 41.4, 39.4, 33.4, 29.5, 24.6, 22.6, 11.0; IR (KBr) ν 3283, 2969, 2925, 1753, 1692, 1636, 1555, 1432, 1378, 1278, 1155, 1091, 1038, 997, 716 cm⁻¹; HRMS (Orbitrap, ESI) calcd for C₁₃H₂₁N₂O₃ [M+H]⁺ 253.1552, found 253.1551.

(E)-N-Isopropyl-3-(1-methyl-2,5-dioxopyrrolidin-3-ylidene)-3-phenylpropanamide (3j)



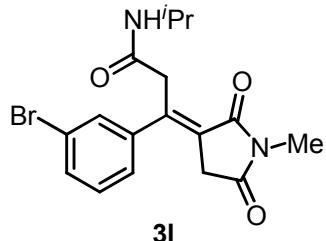
45.0 mg (75%); White solid; mp = 159.2–160.4 °C; ¹H NMR (400 MHz, CDCl₃) δ 7.41–7.34 (m, 3H), 7.29–7.27 (m, 2H), 6.13 (br s, 1H), 4.00–3.93 (m, 3H), 3.20 (s, 2H), 3.07 (s, 3H), 1.10 (d, *J* = 6.8 Hz, 6H); ¹³C NMR (100 MHz, CDCl₃) δ 173.5, 170.7, 167.8, 148.1, 140.3, 128.8, 128.7, 127.0, 123.1, 41.9, 41.5, 35.1, 24.6, 22.6; IR (KBr) ν 3290, 2966, 2927, 1758, 1693, 1638, 1546, 1432, 1383, 1276, 1186, 1092, 1045, 1024, 898, 760 cm⁻¹; HRMS (Orbitrap, ESI) calcd for C₁₇H₂₁N₂O₃ [M+H]⁺ 301.1552, found 301.1554.

(E)-N-Isopropyl-3-(4-methoxyphenyl)-3-(1-methyl-2,5-dioxopyrrolidin-3-ylidene)propanamide (3k)



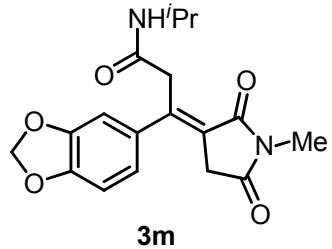
47.5 mg (72%); Light yellow solid; mp = 163.2–166.6 °C; ¹H NMR (400 MHz, CDCl₃) δ 7.27 (d, *J* = 8.8 Hz, 2H), 6.91 (d, *J* = 8.8 Hz, 2H), 6.20 (br s, 1H), 3.99–3.94 (m, 3H), 3.79 (s, 3H), 3.26 (s, 2H), 3.06 (s, 3H), 1.09 (d, *J* = 6.8 Hz, 6H); ¹³C NMR (100 MHz, CDCl₃) δ 173.6, 170.9, 168.0, 159.9, 147.9, 132.3, 128.9, 122.0, 114.1, 55.3, 41.9, 41.5, 35.5, 24.5, 22.6; IR (KBr) ν 3309, 2965, 2929, 1763, 1689, 1644, 1605, 1510, 1433, 1383, 1278, 1249, 1180, 1043, 839, 755 cm⁻¹; HRMS (Orbitrap, ESI) calcd for C₁₈H₂₃N₂O₄ [M+H]⁺ 331.1658, found 331.1659.

(E)-3-(3-Bromophenyl)-N-isopropyl-3-(1-methyl-2,5-dioxopyrrolidin-3-ylidene)propanamide (3l)



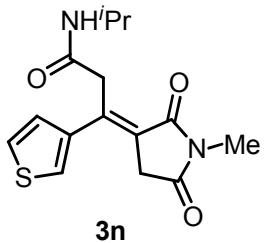
40.9 mg (54%); White solid; mp = 138.8–143.2 °C; ¹H NMR (400 MHz, CDCl₃) δ 7.47 (dt, *J* = 7.6, 1.6 Hz, 1H), 7.43 (t, *J* = 1.6 Hz, 1H), 7.29–7.22 (m, 2H), 6.09 (br s, 1H), 4.01–3.96 (m, 1H), 3.94 (s, 2H), 3.19 (s, 2H), 3.07 (s, 3H), 1.12 (d, *J* = 6.8 Hz, 6H); ¹³C NMR (100 MHz, CDCl₃) δ 173.1, 170.4, 167.5, 146.3, 142.0, 131.8, 130.4, 129.9, 125.8, 123.9, 122.8, 41.7, 41.6, 35.0, 24.7, 22.6; IR (KBr) ν 3297, 2964, 2925, 1766, 1696, 1644, 1556, 1432, 1382, 1278, 1188, 1090, 1042, 900, 781 cm⁻¹; HRMS (Orbitrap, ESI) calcd for C₁₇H₂₀BrN₂O₃ [M+H]⁺ 379.0657, found 379.0662.

(E)-3-(Benzo[d][1,3]dioxol-5-yl)-N-isopropyl-3-(1-methyl-2,5-dioxopyrrolidin-3-ylidene)propanamide (3m)



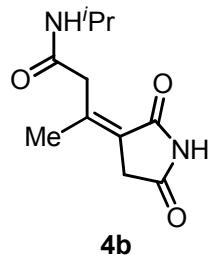
24.1 mg (35%); Light yellow sticky solid; ^1H NMR (400 MHz, CDCl_3) δ 6.83–6.76 (m, 3H), 6.20 (br s, 1H), 5.99 (s, 2H), 4.01–3.95 (m, 1H), 3.94 (s, 2H), 3.25 (s, 2H), 3.06 (s, 3H), 1.11 (d, $J = 6.8$ Hz, 6H); ^{13}C NMR (100 MHz, CDCl_3) δ 173.5, 170.8, 167.9, 148.1, 148.0, 147.9, 133.9, 122.6, 121.4, 108.6, 107.8, 101.4, 42.1, 41.5, 35.4, 24.6, 22.6; IR (KBr) ν 3315, 2964, 2924, 1761, 1692, 1644, 1536, 1486, 1432, 1382, 1277, 1236, 1187, 1033, 932, 813 cm^{-1} ; HRMS (Orbitrap, ESI) calcd for $\text{C}_{18}\text{H}_{21}\text{N}_2\text{O}_5$ [$\text{M}+\text{H}]^+$ 345.1450, found 345.1452.

(E)-N-Isopropyl-3-(1-methyl-2,5-dioxopyrrolidin-3-ylidene)-3-(thiophen-3-yl)propanamide (3n)



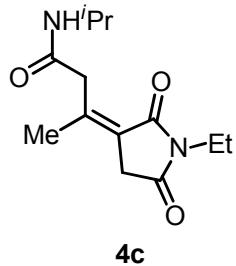
44.7 mg (73%); White solid; mp = 200.4–201.8 °C; ^1H NMR (400 MHz, CDCl_3) δ 7.73 (d, $J = 3.2$ Hz, 1H), 7.37 (dd, $J = 4.8, 2.8$ Hz, 1H), 7.31 (dd, $J = 5.2, 1.6$ Hz, 1H), 6.37 (br s, 1H), 4.05 (s, 2H), 4.00–3.95 (m, 1H), 3.45 (s, 2H), 3.08 (s, 3H), 1.11 (d, $J = 6.8$ Hz, 6H); ^{13}C NMR (100 MHz, CDCl_3) δ 173.4, 171.3, 168.2, 141.7, 140.5, 127.7, 127.2, 126.2, 120.9, 41.5, 40.9, 36.1, 24.7, 22.6; IR (KBr) ν 3289, 2922, 2853, 1755, 1692, 1633, 1545, 1433, 1381, 1278, 1173, 1048, 985, 781 cm^{-1} ; HRMS (Orbitrap, ESI) calcd for $\text{C}_{15}\text{H}_{19}\text{N}_2\text{O}_3\text{S}$ [$\text{M}+\text{H}]^+$ 307.1116, found 307.1115.

(Z)-3-(2,5-Dioxopyrrolidin-3-ylidene)-N-isopropylbutanamide (4b)



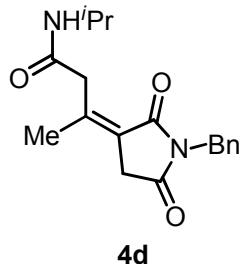
25.5 mg (57%); White solid; mp = 222.8–224.0 °C; ¹H NMR (400 MHz, CDCl₃) δ 8.51 (br s, 1H), 6.28 (br s, 1H), 4.00–3.95 (m, 1H), 3.60 (s, 2H), 3.31 (s, 2H), 2.04 (s, 3H), 1.11 (d, *J* = 6.4 Hz, 6H); ¹³C NMR (100 MHz, CDCl₃) δ 173.2, 170.4, 167.9, 148.8, 121.4, 41.9, 41.5, 35.3, 23.5, 22.6; IR (KBr) ν 3298, 3181, 2974, 1765, 1660, 1639, 1542, 1350, 1276, 1178, 1058, 988, 754 cm⁻¹; HRMS (quadrupole, EI) calcd for C₁₁H₁₆N₂O₃ [M]⁺ 224.1161, found 224.1161.

(Z)-3-(1-Ethyl-2,5-dioxopyrrolidin-3-ylidene)-N-isopropylbutanamide (4c)



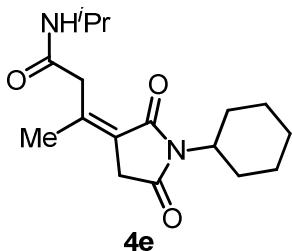
46.9 mg (93%); Light yellow solid; mp = 163.8–165.7 °C; ¹H NMR (400 MHz, CDCl₃) δ 6.42 (br s, 1H), 4.01–3.93 (m, 1H), 3.64–3.58 (m, 3H), 3.24 (s, 2H), 2.04 (s, 3H), 1.81 (t, *J* = 7.2 Hz, 3H), 1.11 (d, *J* = 6.4 Hz, 6H); ¹³C NMR (100 MHz, CDCl₃) δ 173.1, 170.3, 168.2, 147.2, 120.7, 42.1, 41.5, 34.1, 33.5, 23.5, 22.6, 13.1; IR (KBr) ν 3279, 2926, 2361, 1779, 1697, 1636, 1401, 1272, 1222, 1302 cm⁻¹; HRMS (quadrupole, EI) calcd for C₁₃H₂₀N₂O₃ [M]⁺ 252.1474, found 252.1473.

(Z)-3-(1-Benzyl-2,5-dioxopyrrolidin-3-ylidene)-N-isopropylbutanamide (4d)



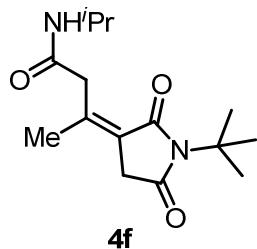
52.1 mg (83%); Pale yellow solid; mp = 171.9–173.0 °C; ¹H NMR (400 MHz, CDCl₃) δ 7.31 (d, *J* = 7.2 Hz, 2H), 7.24–7.20 (m, 3H), 6.33 (br s, 1H), 4.66 (s, 2H), 3.90–3.87 (m, 1H), 3.54 (s, 2H), 3.21 (s, 2H), 1.97 (s, 3H), 1.01 (d, *J* = 6.4 Hz, 6H); ¹³C NMR (100 MHz, CDCl₃) δ 172.9, 170.1, 168.1, 147.9, 135.8, 128.7, 128.6, 127.9, 120.4, 42.2, 42.1, 41.4, 34.1, 23.5, 22.5; IR (KBr) ν 3381, 2973, 2927, 1780, 1693, 1650, 1535, 1429, 1393, 1339, 1165, 975, 932, 893, 754 cm⁻¹; HRMS (quadrupole, EI) calcd for C₁₈H₂₂N₂O₃ [M]⁺ 314.1630, found 314.1628.

(Z)-3-(1-Cyclohexyl-2,5-dioxopyrrolidin-3-ylidene)-*N*-isopropylbutanamide (**4e**)



53.3 mg (87%); Pale yellow solid; mp = 160.1–161.4 °C; ¹H NMR (400 MHz, CDCl₃) δ 6.40 (br s, 1H), 4.03–3.92 (m, 2H), 3.58 (s, 2H), 3.18 (s, 2H), 2.18–2.09 (m, 2H), 2.00 (s, 3H), 1.83–1.80 (m, 2H), 1.63–1.55 (m, 3H), 1.35–1.19 (m, 3H), 1.10 (d, *J* = 6.4 Hz, 6H); ¹³C NMR (100 MHz, CDCl₃) δ 173.3, 170.5, 168.2, 146.6, 120.5, 51.4, 41.8, 41.3, 34.1, 28.8, 25.8, 25.1, 23.4, 22.6; IR (KBr) ν 3311, 2929, 2859, 1758, 1691, 1661, 1641, 1536, 1454, 1370, 1273, 1175, 1153, 1038, 890 cm⁻¹; HRMS (quadrupole, EI) calcd for C₁₇H₂₆N₂O₃ [M]⁺ 306.1943, found 306.1939.

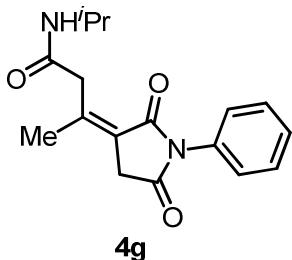
(Z)-3-(1-(tert-Butyl)-2,5-dioxopyrrolidin-3-ylidene)-*N*-isopropylbutanamide (**4f**)



43.7 mg (78%); White solid; mp = 117.1–118.5 °C; ¹H NMR (400 MHz, CDCl₃) δ 6.49 (br s, 1H), 3.98–3.90 (m, 1H), 3.55 (s, 2H), 3.13 (s, 2H), 1.97 (s, 3H), 1.58 (s, 9H), 1.09 (d, *J* = 6.4 Hz, 6H); ¹³C NMR (100 MHz, CDCl₃) δ 174.2, 171.7, 168.4, 145.6, 120.7, 58.5, 41.9, 41.3,

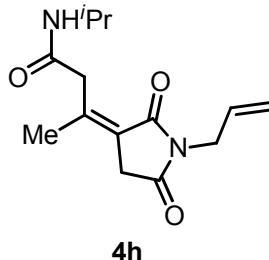
34.9, 28.5, 23.4, 22.6; IR (KBr) ν 3315, 2924, 2359, 1769, 1695, 1667, 1536, 1336, 1261, 1163, 1127, 1033 cm⁻¹; HRMS (quadrupole, EI) calcd for C₁₅H₂₄N₂O₃ [M]⁺ 280.1787, found 280.1787.

(Z)-3-(2,5-Dioxo-1-phenylpyrrolidin-3-ylidene)-N-isopropylbutanamide (4g)



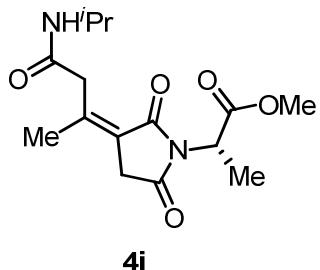
54.6 mg (91%); White solid; mp = 187.9–188.4 °C; ¹H NMR (400 MHz, CDCl₃) δ 7.50 (t, J = 7.2 Hz, 2H), 7.41 (t, J = 7.2 Hz, 1H), 7.28 (d, J = 7.2 Hz, 2H), 6.27 (br s, 1H), 4.03–3.94 (m, 1H), 3.66 (s, 2H), 3.45 (s, 2H), 2.12 (s, 3H), 1.10 (d, J = 6.8 Hz, 6H); ¹³C NMR (100 MHz, CDCl₃) δ 172.3, 169.5, 167.9, 148.9, 131.8, 129.2, 128.7, 126.6, 120.3, 42.2, 41.5, 34.3, 23.7, 22.6; IR (KBr) ν 3297, 2976, 1772, 1699, 1639, 1548, 1501, 1275, 1164, 820 cm⁻¹; HRMS (quadrupole, EI) calcd for C₁₇H₂₀N₂O₃ [M]⁺ 300.1474, found 300.1479.

(Z)-3-(1-Allyl-2,5-dioxopyrrolidin-3-ylidene)-N-isopropylbutanamide (4h)



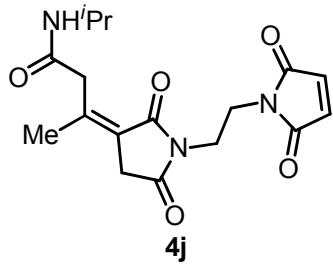
11.6 mg (22%); Light yellow solid; mp = 113.4–115.1 °C; ¹H NMR (400 MHz, CDCl₃) δ 6.38 (br s, 1H), 5.84–5.74 (m, 1H), 5.21–5.16 (m, 2H), 4.15 (d, J = 5.6 Hz, 2H), 3.98–3.93 (m, 1H), 3.61 (s, 2H), 3.27 (s, 2H), 2.05 (s, 3H), 1.10 (d, J = 6.4 Hz, 6H); ¹³C NMR (100 MHz, CDCl₃) δ 172.8, 169.9, 168.1, 147.8, 130.7, 120.5, 118.1, 42.1, 41.4, 40.6, 34.1, 23.5, 22.6; IR (KBr) ν 3284, 2923, 2854, 1764, 1697, 1666, 1641, 1548, 1428, 1390, 1328, 1274, 1169, 1106, 971, 737 cm⁻¹; HRMS (quadrupole, EI) calcd for C₁₄H₂₀N₂O₃ [M]⁺ 264.1474, found 264.1472.

(S,Z)-Methyl 2-(3-(4-(isopropylamino)-4-oxobutan-2-ylidene)-2,5-dioxopyrrolidin-1-yl)propanoate (4i)



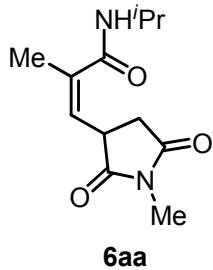
44.0 mg (71%); Light yellow solid; mp = 79.6–80.5 °C; ¹H NMR (400 MHz, CDCl₃) δ 6.31 (br s, 1H), 4.84 (q, *J* = 7.2 Hz, 1H), 3.99–3.90 (m, 1H), 3.71 (s, 3H), 3.59 (s, 2H), 3.29 (s, 2H), 2.04 (s, 3H), 1.55 (d, *J* = 7.2 Hz, 3H), 1.08 (d, *J* = 6.8 Hz, 6H); ¹³C NMR (100 MHz, CDCl₃) δ 172.2, 169.6, 169.3, 167.9, 148.4, 120.1, 52.7, 47.6, 42.1, 41.4, 34.1, 23.5, 22.6, 14.4; IR (KBr) ν 3403, 2923, 2854, 1765, 1698, 1662, 1536, 1459, 1395, 1253, 1176, 1106, 1032, 850 cm⁻¹; HRMS (quadrupole, EI) calcd for C₁₅H₂₂N₂O₅ [M]⁺ 310.1529, found 310.1531.

(Z)-3-(1-(2,5-Dioxo-2,5-dihydro-1*H*-pyrrol-1-yl)ethyl)-2,5-dioxopyrrolidin-3-ylidene)-*N*-isopropylbutanamide (4j)



31.2 mg (45%); White solid; mp = 195.9–197.1 °C; ¹H NMR (400 MHz, CDCl₃) δ 6.66 (s, 2H), 6.29 (br s, 1H), 3.99–3.94 (m, 1H), 3.78–3.76 (m, 4H), 3.60 (s, 2H), 3.17 (s, 2H), 2.01 (s, 3H), 1.10 (d, *J* = 6.4 Hz, 6H); ¹³C NMR (100 MHz, CDCl₃) δ 173.4, 170.6, 170.2, 167.9, 147.8, 134.2, 120.4, 42.1, 41.4, 37.3, 35.7, 33.9, 23.2, 22.6; IR (KBr) ν 3283, 2923, 2854, 1760, 1708, 1666, 1536, 1392, 1329, 1206, 1158, 1120, 896, 826, 754 cm⁻¹; HRMS (quadrupole, EI) calcd for C₁₇H₂₁N₃O₅ [M]⁺ 347.1481, found 347.1479.

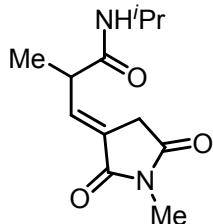
(Z)-*N*-Isopropyl-2-methyl-3-(1-methyl-2,5-dioxopyrrolidin-3-yl)acrylamide (6aa)



6aa

NMR peaks characterized from mixture of **6aa** and **6ab**: ^1H NMR (400 MHz, CDCl_3) δ 7.36 (br s, 1H), 5.20 (d, $J = 9.2$ Hz, 1H), 4.14–4.09 (m, 1H), 3.89–3.87 (m, 1H), 3.02–2.98 (m, 4H), 2.52 (dd, $J = 18.8, 4.4$ Hz, 1H), 1.96 (s, 3H), 1.29–1.17 (m, 6H).

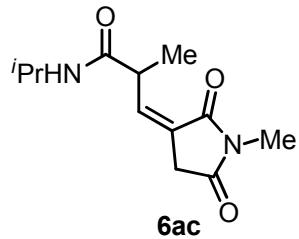
(E)-N-Isopropyl-2-methyl-3-(1-methyl-2,5-dioxopyrrolidin-3-ylidene)propanamide (6ab)



6ab

27.6 mg (58%); White solid; mp = 127.0–133.0 °C; ^1H NMR (400 MHz, CDCl_3) δ 6.81 (d, $J = 9.6$ Hz, 1H), 5.43 (br s, 1H), 4.05–4.01 (m, 1H), 3.30 (d, $J = 12.4$ Hz, 1H), 3.22 (d, $J = 12.0$ Hz, 1H), 3.09–3.01 (m, 4H), 1.34 (d, $J = 4.0$ Hz, 3H), 1.13 (d, $J = 4.0$ Hz, 6H); ^{13}C NMR (100 MHz, CDCl_3) δ 173.6, 170.5, 169.6, 136.6, 127.1, 42.3, 41.7, 31.7, 24.8, 22.7, 22.6, 17.3; IR (KBr) ν 3402, 2973, 2925, 1771, 1703, 1677, 1535, 1436, 1384, 1276, 1231, 1170, 1088, 1008, 970, 737 cm^{-1} ; HRMS (Orbitrap, ESI) calcd for $\text{C}_{12}\text{H}_{19}\text{N}_2\text{O}_3$ [$\text{M}+\text{H}]^+$ 239.1396, found 239.1395.

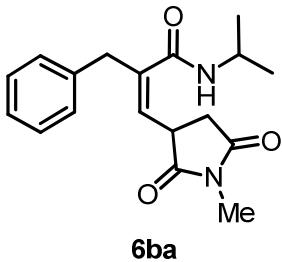
(Z)-N-Isopropyl-2-methyl-3-(1-methyl-2,5-dioxopyrrolidin-3-ylidene)propanamide (6ac)



5.7 mg (12%); White sticky solid; ^1H NMR (400 MHz, CDCl_3) δ 6.20 (d, $J = 9.6$ Hz, 1H), 6.06 (br s, 1H), 4.40–4.33 (m, 1H), 4.03–3.95 (m, 1H), 3.30 (s, 2H), 3.05 (s, 3H), 1.29 (d, $J = 6.8$

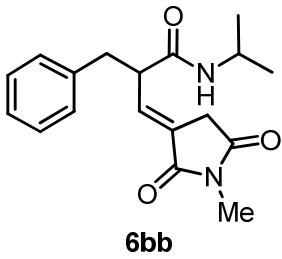
Hz, 3H), 1.15 (d, J = 6.4 Hz, 3H), 1.08 (d, J = 6.4 Hz, 3H); ^{13}C NMR (100 MHz, CDCl_3) δ 173.7, 171.7, 170.3, 143.0, 124.0, 41.4, 39.9, 34.6, 24.5, 22.7, 22.6, 17.4; IR (KBr) ν 3312, 2972, 2930, 1767, 1701, 1649, 1536, 1433, 1383, 1276, 1182, 1039, 890, 706 cm^{-1} ; HRMS (Orbitrap, ESI) calcd for $\text{C}_{12}\text{H}_{19}\text{N}_2\text{O}_3$ [$\text{M}+\text{H}]^+$ 239.1396, found 239.1395.

(Z)-2-Benzyl-N-isopropyl-3-(1-methyl-2,5-dioxopyrrolidin-3-yl)acrylamide (6ba)



32.0 mg (51%); White solid; mp = 170.0–175.0 °C; ^1H NMR (400 MHz, CDCl_3) δ 7.28–7.21 (m, 4H), 7.18 (d, J = 8.0 Hz, 2H), 5.09 (d, J = 9.2 Hz, 1H), 4.04–4.01 (m, 1H), 3.89–3.83 (m, 1H), 3.70 (d, J = 15.2 Hz, 1H), 3.55 (d, J = 15.6 Hz, 1H), 3.03–2.96 (m, 4H), 2.50 (dd, J = 18.8, 4.4 Hz, 1H), 1.11 (d, J = 6.4 Hz, 3H), 0.99 (d, J = 6.4 Hz, 3H); ^{13}C NMR (100 MHz, CDCl_3) δ 179.0, 175.7, 166.8, 144.2, 137.5, 129.1, 128.5, 126.6, 124.7, 41.5, 40.6, 40.5, 35.6, 25.3, 22.6, 22.2; IR (KBr) ν 3309, 2971, 2927, 1775, 1691, 1629, 1536, 1434, 1383, 1280, 1158, 1125, 1028, 959, 747 cm^{-1} ; HRMS (quadrupole, EI) calcd for $\text{C}_{18}\text{H}_{22}\text{N}_2\text{O}_3$ [$\text{M}]^+$ 314.1630, found 314.1632.

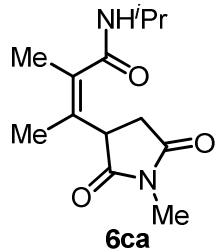
(E)-2-Benzyl-N-isopropyl-3-(1-methyl-2,5-dioxopyrrolidin-3-ylidene)propanamide (6bb)



54.7 mg (87%); White solid; mp = 170.0–175.0 °C; ^1H NMR (400 MHz, CDCl_3) δ 7.26–7.21 (m, 3H), 7.13 (d, J = 8.0 Hz, 2H), 6.92 (dt, J = 10.0, 2.4 Hz, 1H), 5.16 (br s, 1H), 4.06–3.97 (m, 1H), 3.23 (dd, J = 13.2, 6.4 Hz, 1H), 3.11–3.05 (m, 2H), 3.01 (s, 3H), 2.83 (dd, J = 13.2, 8.0 Hz, 1H), 2.58 (dd, J = 21.2, 2.4 Hz, 1H), 1.08 (d, J = 6.4 Hz, 3H), 1.01 (d, J = 6.4 Hz, 3H); ^{13}C NMR (100 MHz, CDCl_3) δ 173.5, 169.3, 169.2, 137.9, 134.8, 129.0, 128.6, 128.0, 126.9, 51.0,

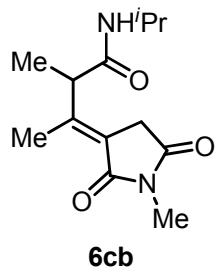
41.7, 38.6, 31.6, 24.7, 22.6, 22.5; IR (KBr) ν 3308, 2971, 2926, 1770, 1708, 1677, 1639, 1536, 1431, 1382, 1273, 1149, 1085, 1007, 910, 731 cm^{-1} ; HRMS (quadrupole, EI) calcd for $\text{C}_{18}\text{H}_{22}\text{N}_2\text{O}_3$ [M] $^+$ 314.1630, found 314.1632.

(Z)-N-Isopropyl-2-methyl-3-(1-methyl-2,5-dioxopyrrolidin-3-yl)but-2-enamide (6ca)



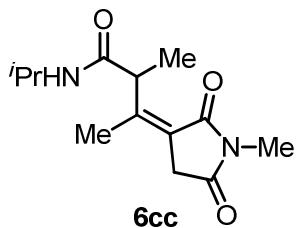
43.9 mg (87%); White solid; mp = 143.8–149.3 °C; ^1H NMR (400 MHz, CDCl_3) δ 6.59 (br s, 1H), 4.12–4.06 (m, 1H), 4.02–3.99 (m, 1H), 3.02 (s, 3H), 2.86 (dd, J = 18.8, 9.2 Hz, 1H), 2.66 (dd, J = 18.8, 4.8 Hz, 1H), 1.90 (s, 3H), 1.53 (s, 3H), 1.19–1.15 (m, 6H); ^{13}C NMR (100 MHz, CDCl_3) δ 179.0, 176.3, 169.8, 134.9, 127.6, 44.9, 41.5, 32.9, 25.2, 22.6, 22.5, 16.5, 13.6; IR (KBr) ν 3340, 2931, 1774, 1691, 1631, 1530, 1436, 1383, 1283, 1123, 953, 792, 658 cm^{-1} ; HRMS (Orbitrap, ESI) calcd for $\text{C}_{13}\text{H}_{21}\text{N}_2\text{O}_3$ [M+H] $^+$ 253.1552, found 253.1554.

(E)-N-Isopropyl-2-methyl-3-(1-methyl-2,5-dioxopyrrolidin-3-ylidene)butanamide (6cb)



22.7 mg (45%); White solid; mp = 131.1–135.0 °C; ^1H NMR (400 MHz, CDCl_3) **E-isomer:** δ 6.22 (br s, 1H), 4.88 (q, J = 6.8 Hz, 1H), 3.98–3.93 (m, 1H), 3.22 (d, J = 6.4 Hz, 2H), 3.04 (s, 3H), 1.89 (s, 3H), 1.25 (d, J = 7.2 Hz, 3H), 1.13 (d, J = 6.4 Hz, 3H), 1.04 (d, J = 6.4 Hz, 3H); ^{13}C NMR (100 MHz, CDCl_3) δ 173.3, 171.0, 170.5, 153.0, 120.1, 41.6, 41.2, 34.3, 24.5, 22.7, 17.6, 14.4; IR (KBr) ν 3309, 2967, 2924, 1771, 1700, 1679, 1528, 1432, 1382, 1275, 1155, 1126, 1084, 1008, 915, 755 cm^{-1} ; HRMS (Orbitrap, ESI) calcd for $\text{C}_{13}\text{H}_{21}\text{N}_2\text{O}_3$ [M+H] $^+$ 253.1552, found 253.1554.

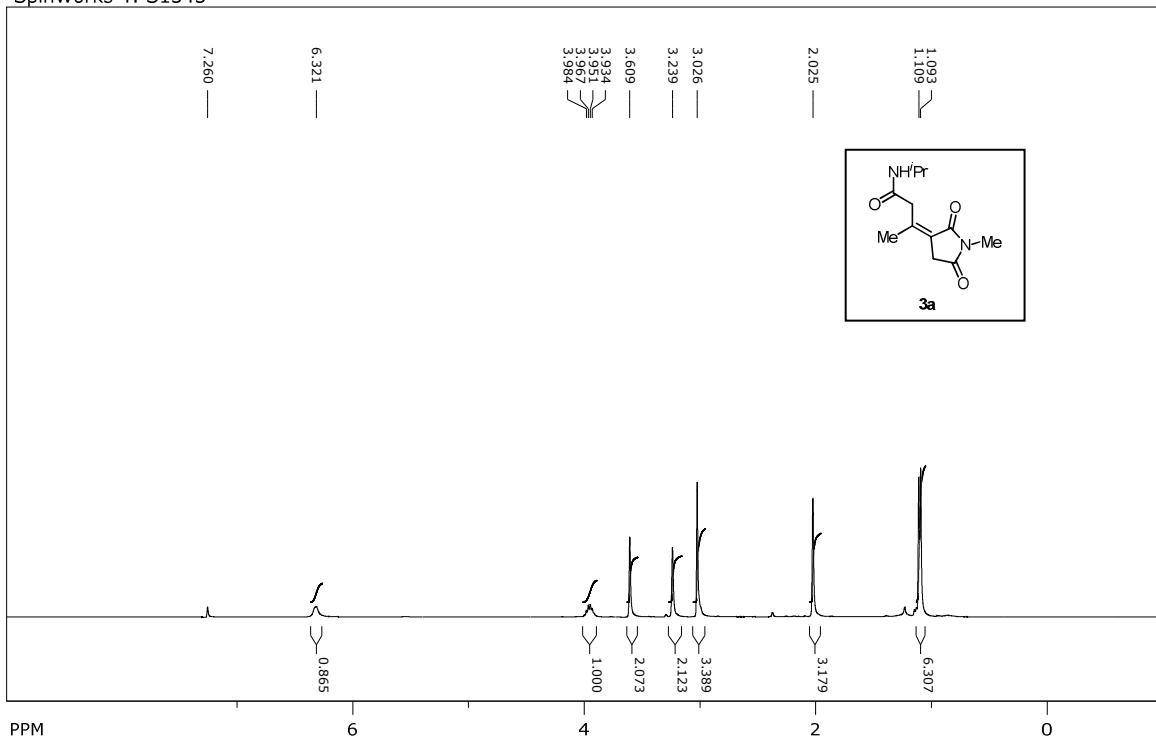
(Z)-N-Isopropyl-2-methyl-3-(1-methyl-2,5-dioxopyrrolidin-3-ylidene)butanamide (6cc)



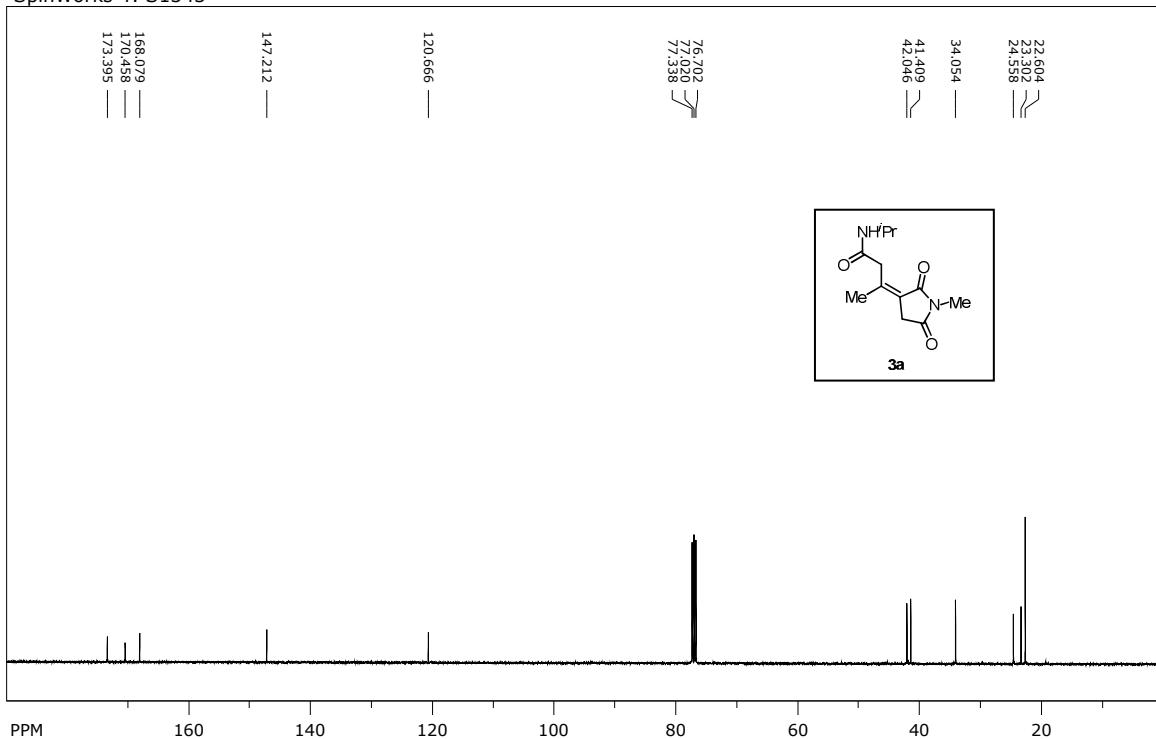
15.1 mg (30%); Yellow sticky solid; ^1H NMR (400 MHz, CDCl_3) δ 5.18 (br s, 1H), 4.10–4.05 (m, 1H), 3.34 (d, J = 20.8 Hz, 1H), 3.24 (d, J = 20.8 Hz, 1H), 3.15 (d, J = 7.2 Hz, 1H), 3.04 (s, 3H), 2.29 (s, 3H), 1.30 (d, J = 7.2 Hz, 3H), 1.14–1.19 (m, 6H); ^{13}C NMR (100 MHz, CDCl_3) δ 17.2, 169.7, 169.6, 151.2, 121.0, 47.0, 41.7, 33.7, 24.5, 22.7, 22.6, 14.6, 14.2; IR (KBr) ν 3309, 2967, 2924, 1771, 1700, 1679, 1528, 1432, 1382, 1275, 1155, 1126, 1084, 1008, 915, 755 cm^{-1} ; HRMS (Orbitrap, ESI) calcd for $\text{C}_{13}\text{H}_{21}\text{N}_2\text{O}_3$ [$\text{M}+\text{H}]^+$ 253.1552, found 253.1554.

¹H NMR and ¹³C NMR spectra of all compounds

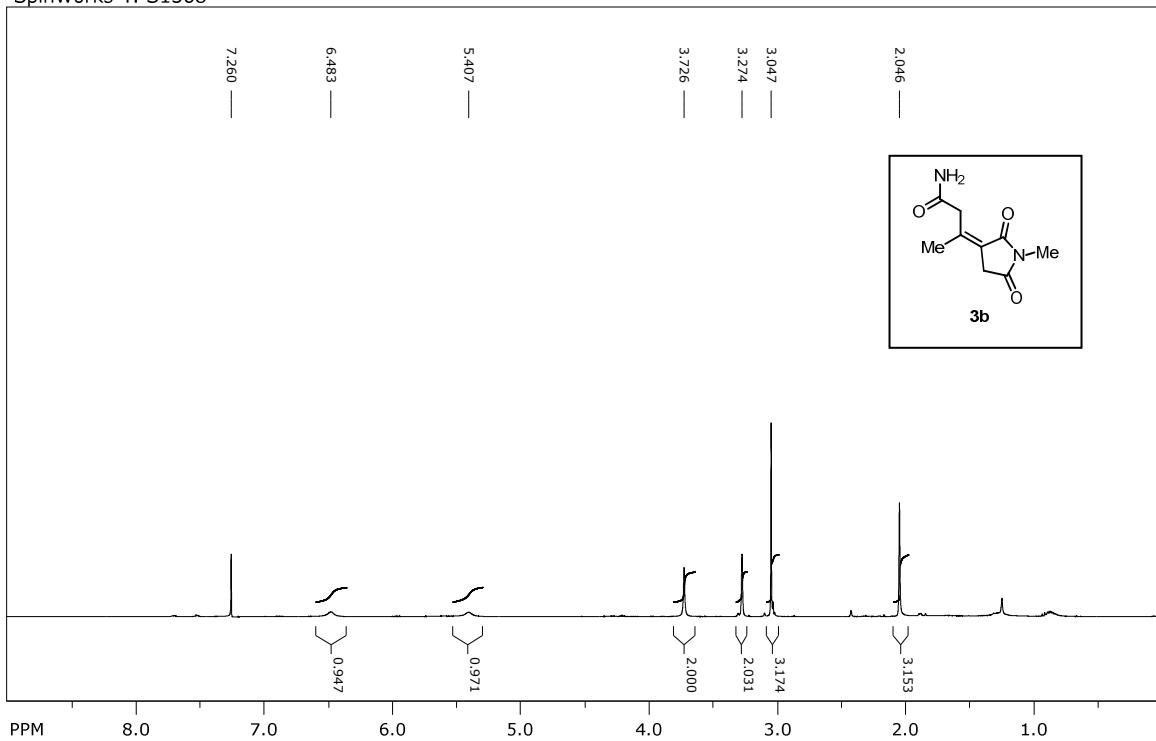
SpinWorks 4: S1343



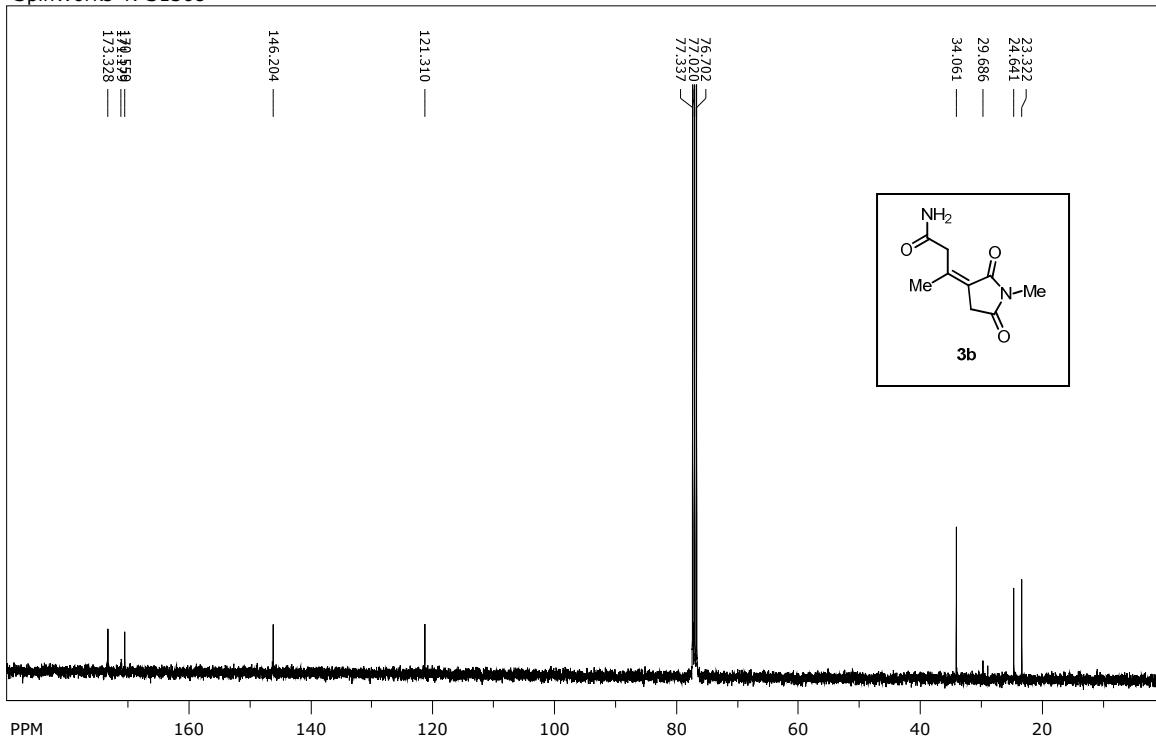
SpinWorks 4: S1343



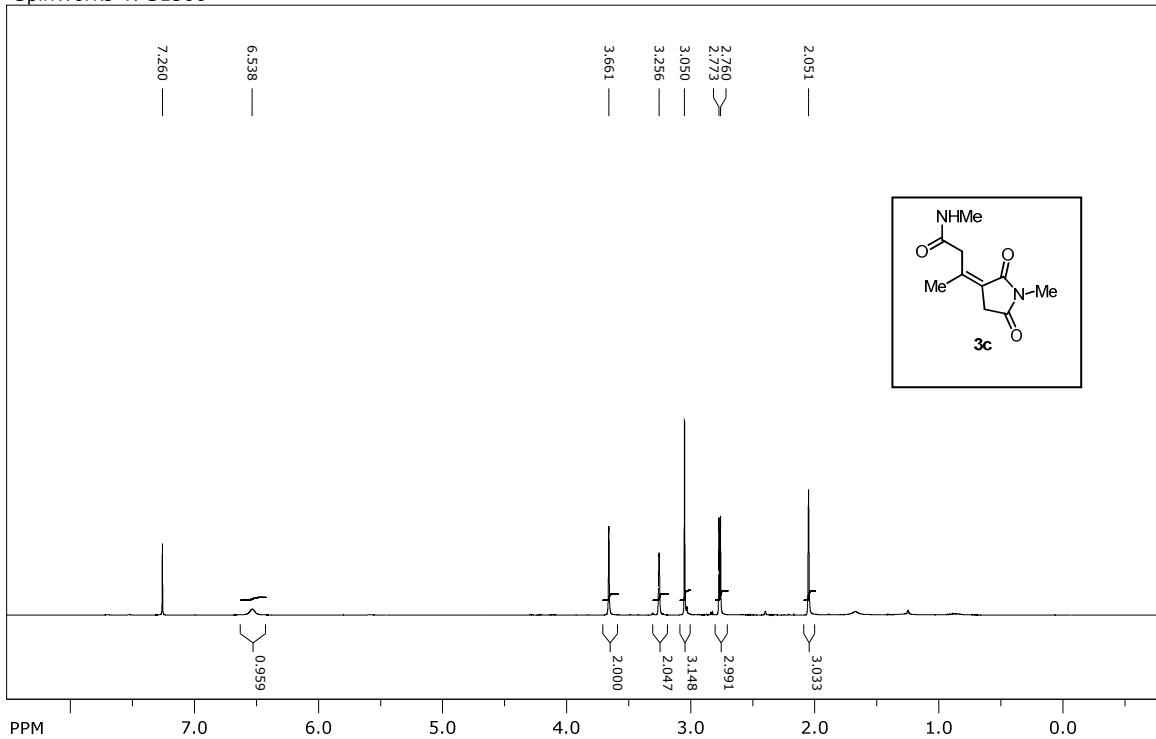
SpinWorks 4: S1368



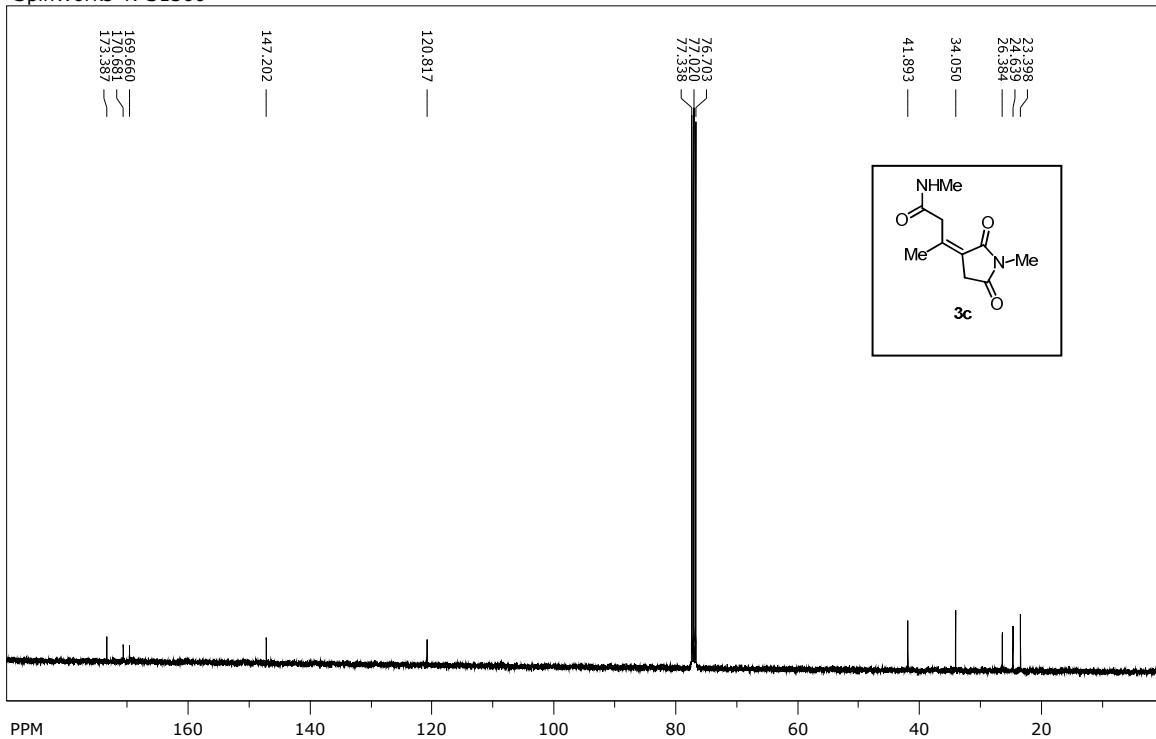
SpinWorks 4: S1368



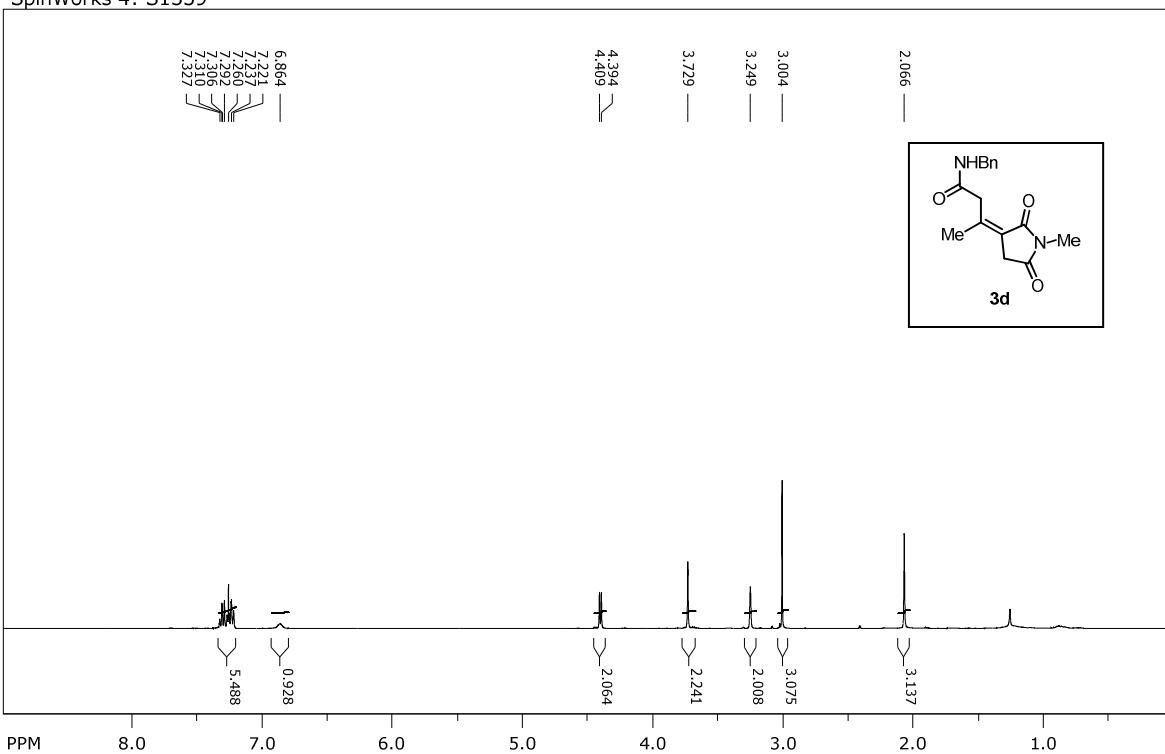
SpinWorks 4: S1366



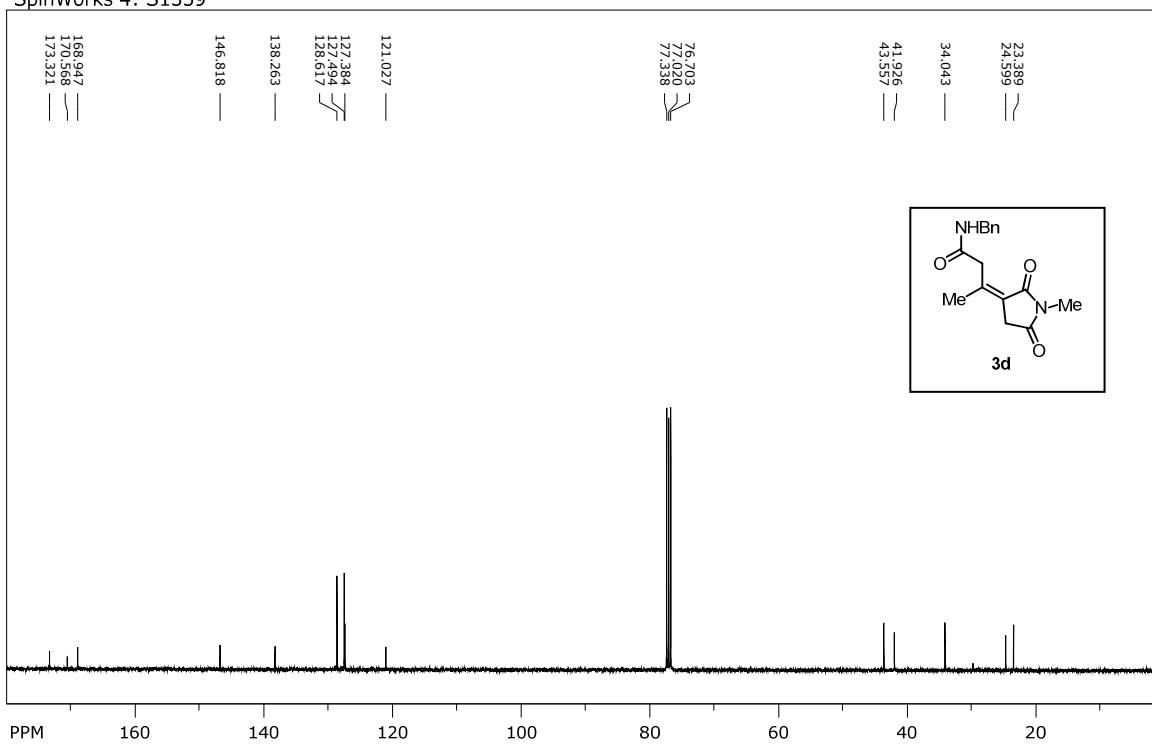
SpinWorks 4: S1366



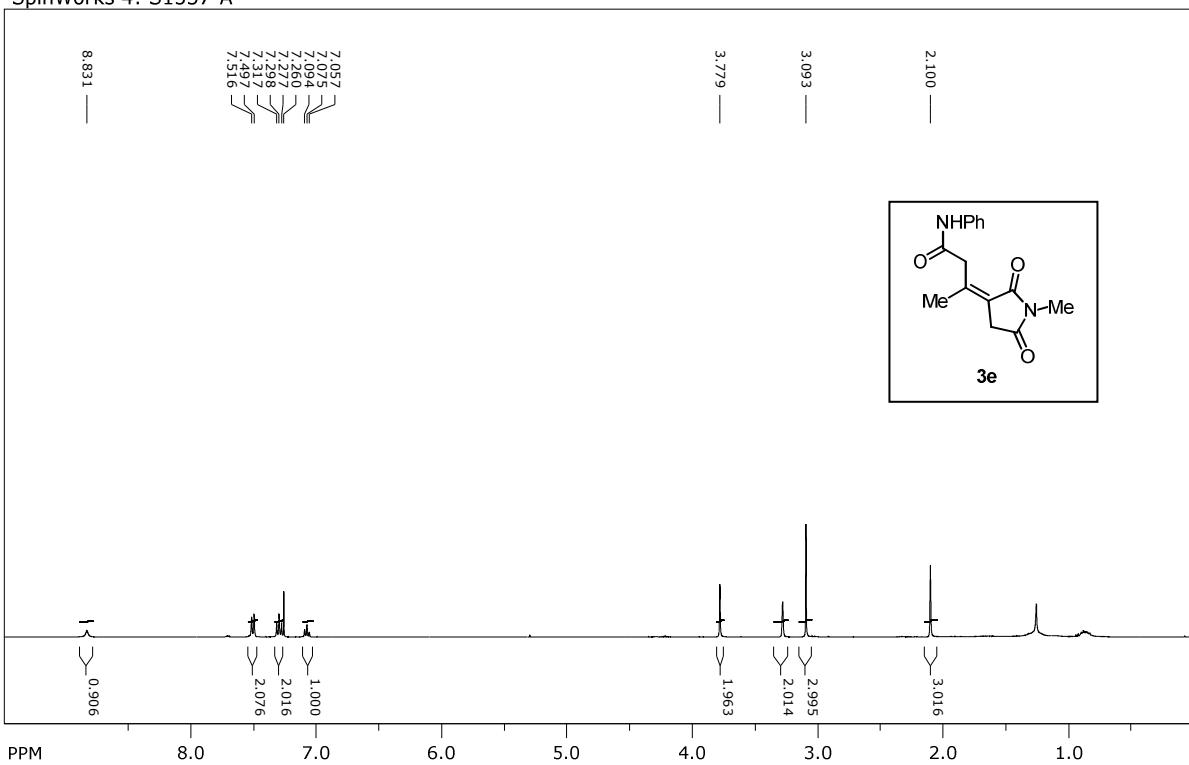
SpinWorks 4: S1359



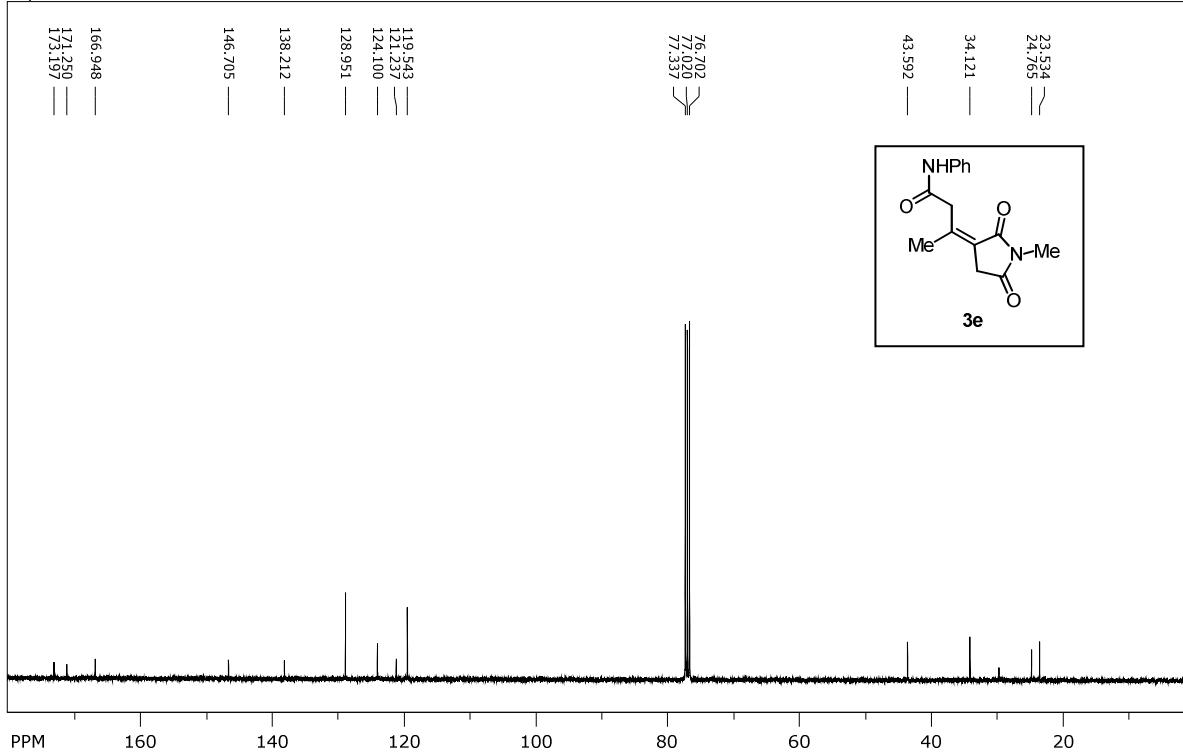
SpinWorks 4: S1359



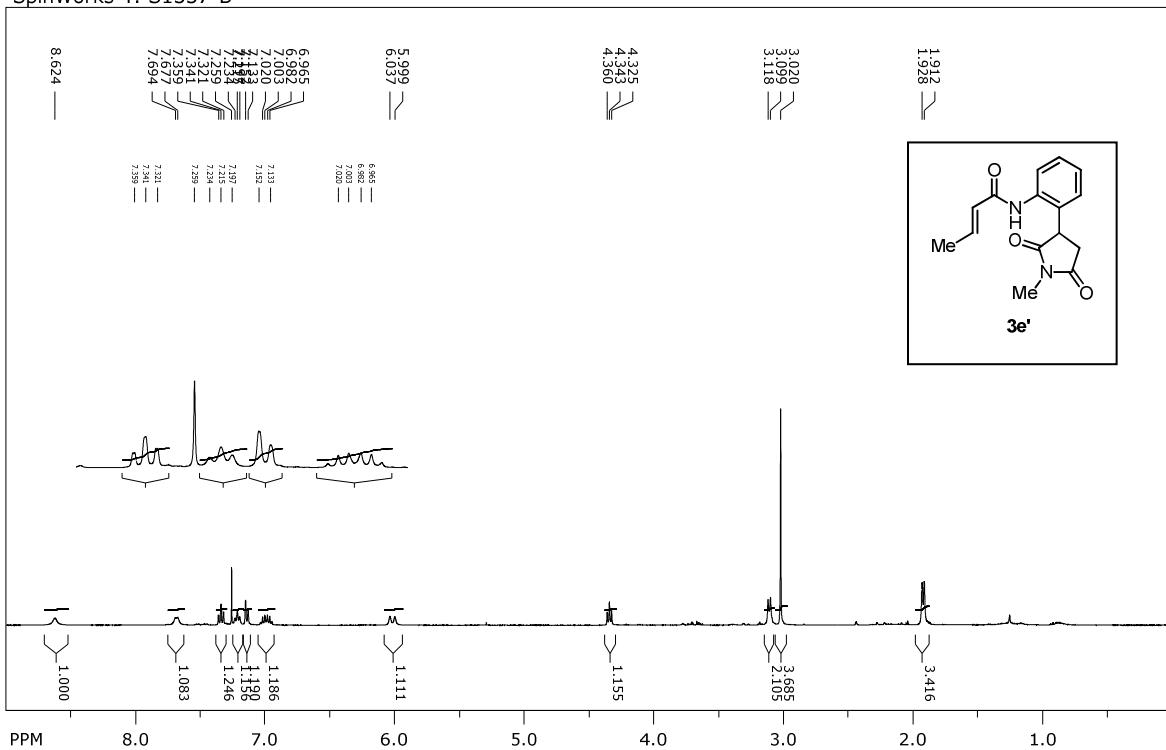
SpinWorks 4: S1357-A



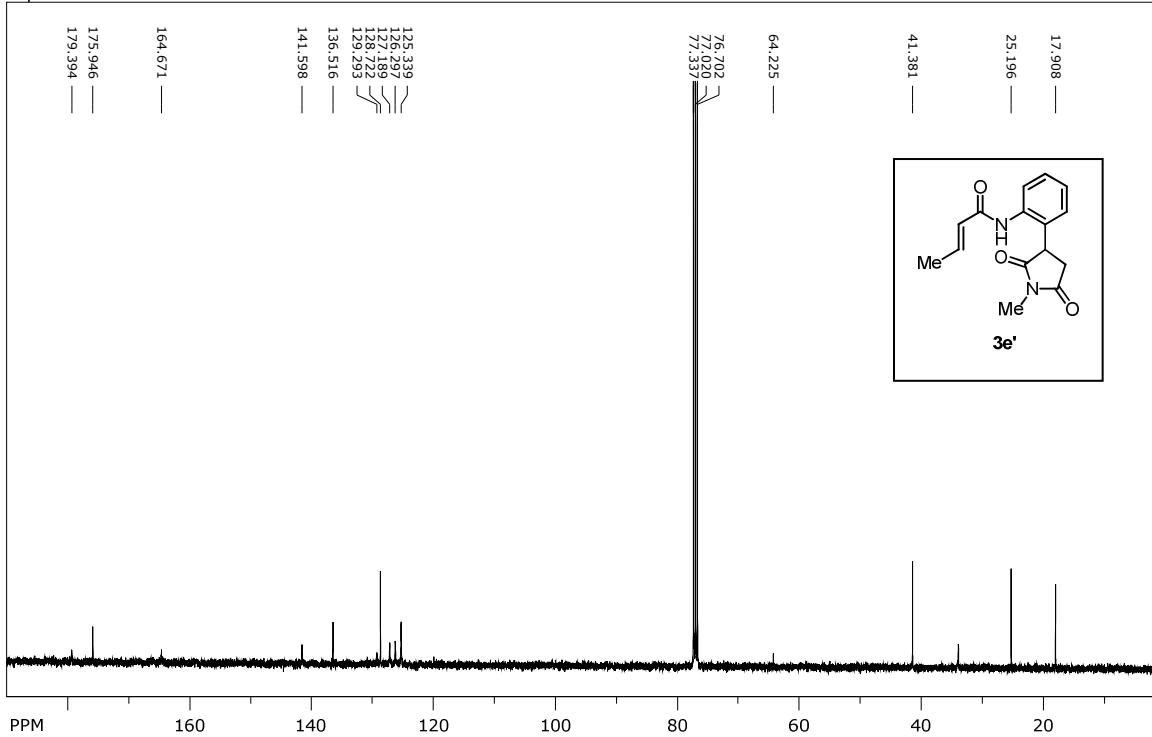
SpinWorks 4: S1357-A



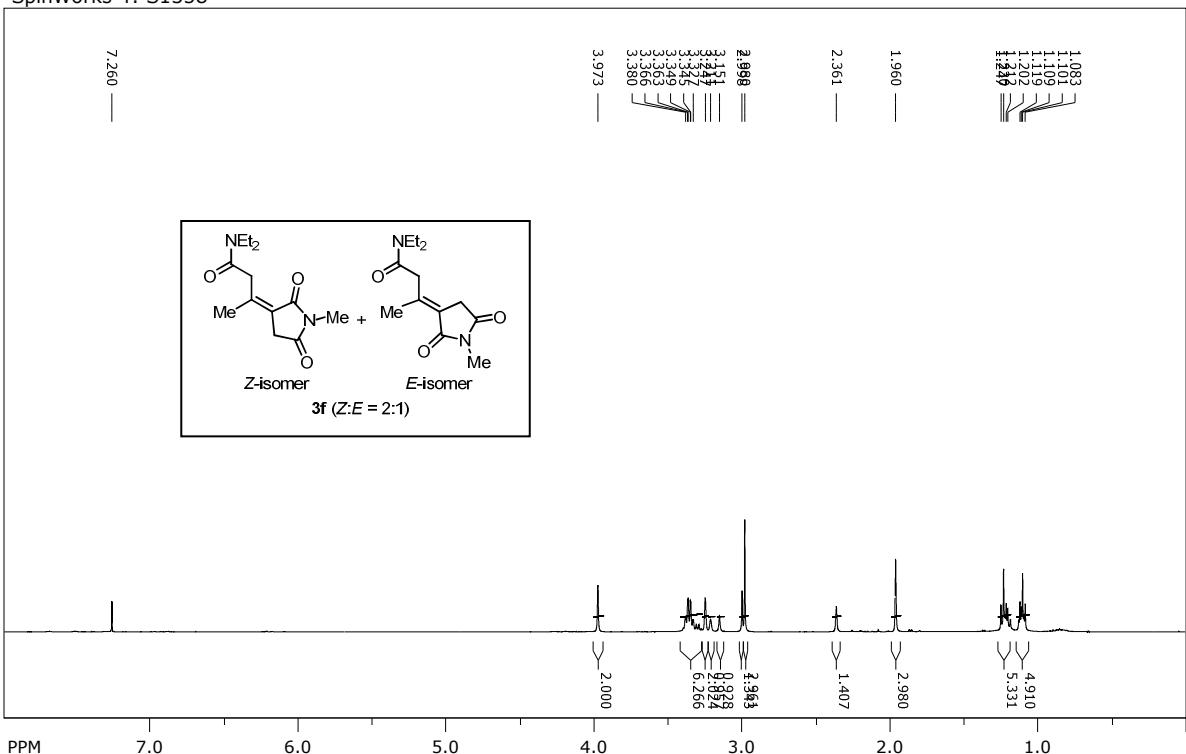
SpinWorks 4: S1357-B



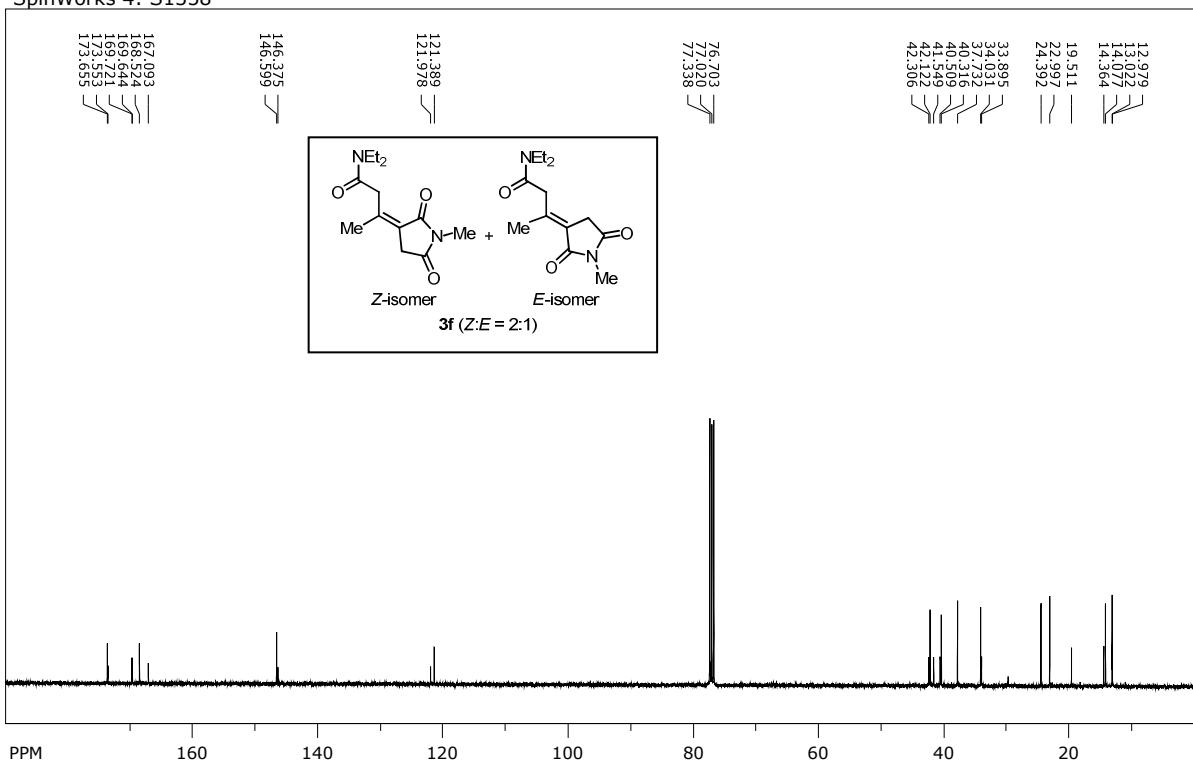
SpinWorks 4: S1357-B

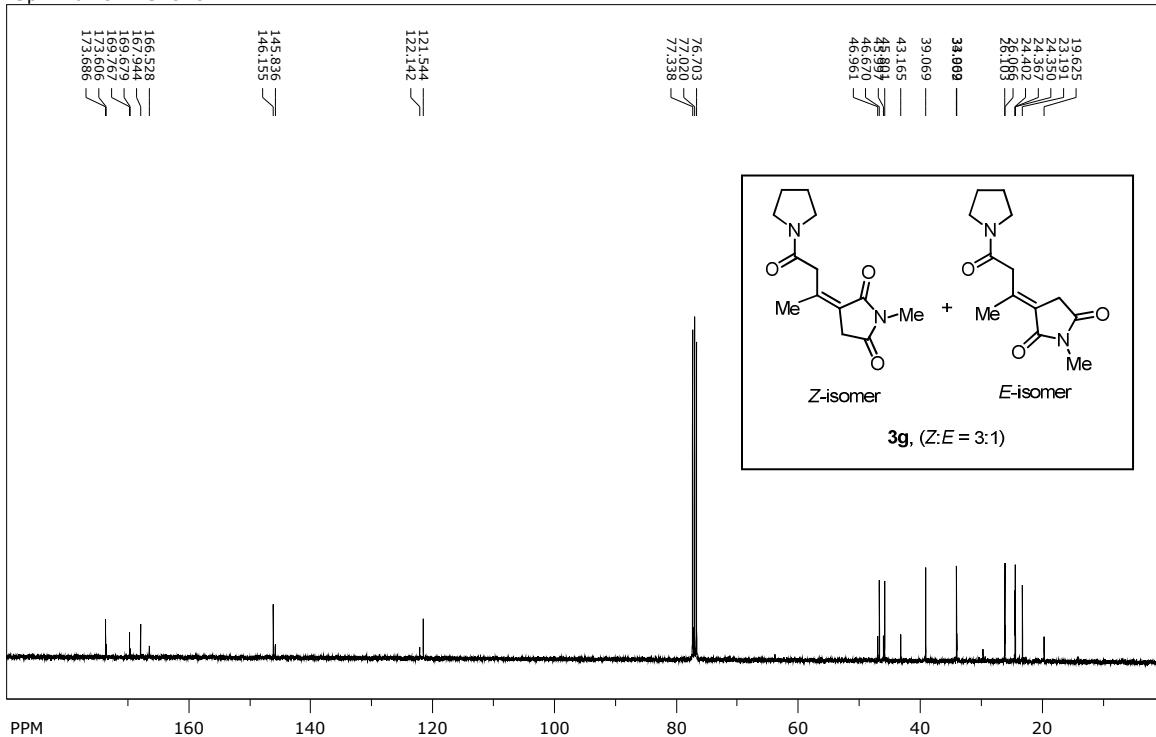
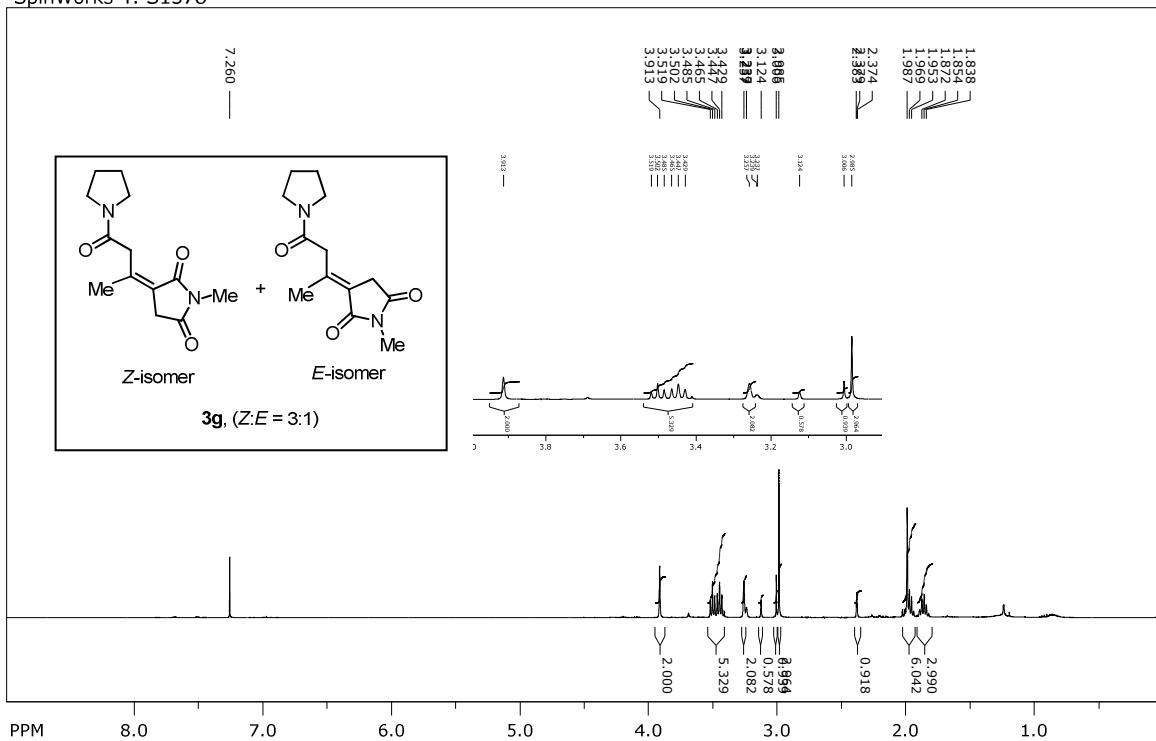


SpinWorks 4: S1358

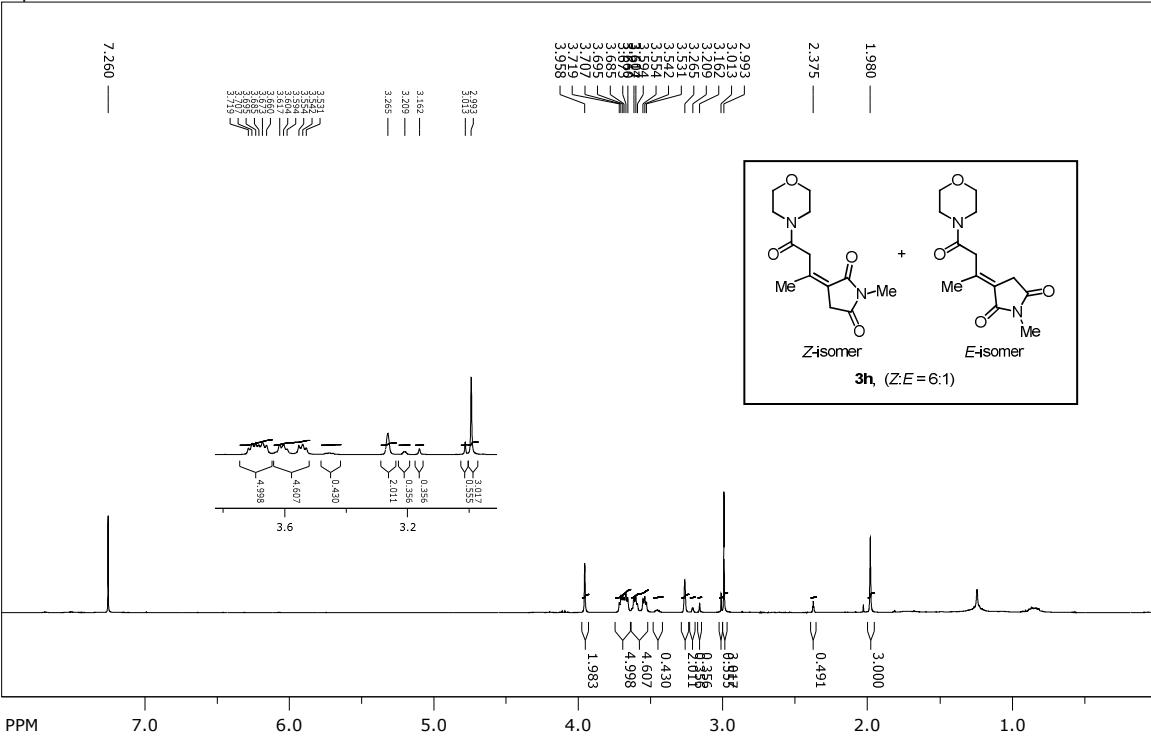


SpinWorks 4: S1358

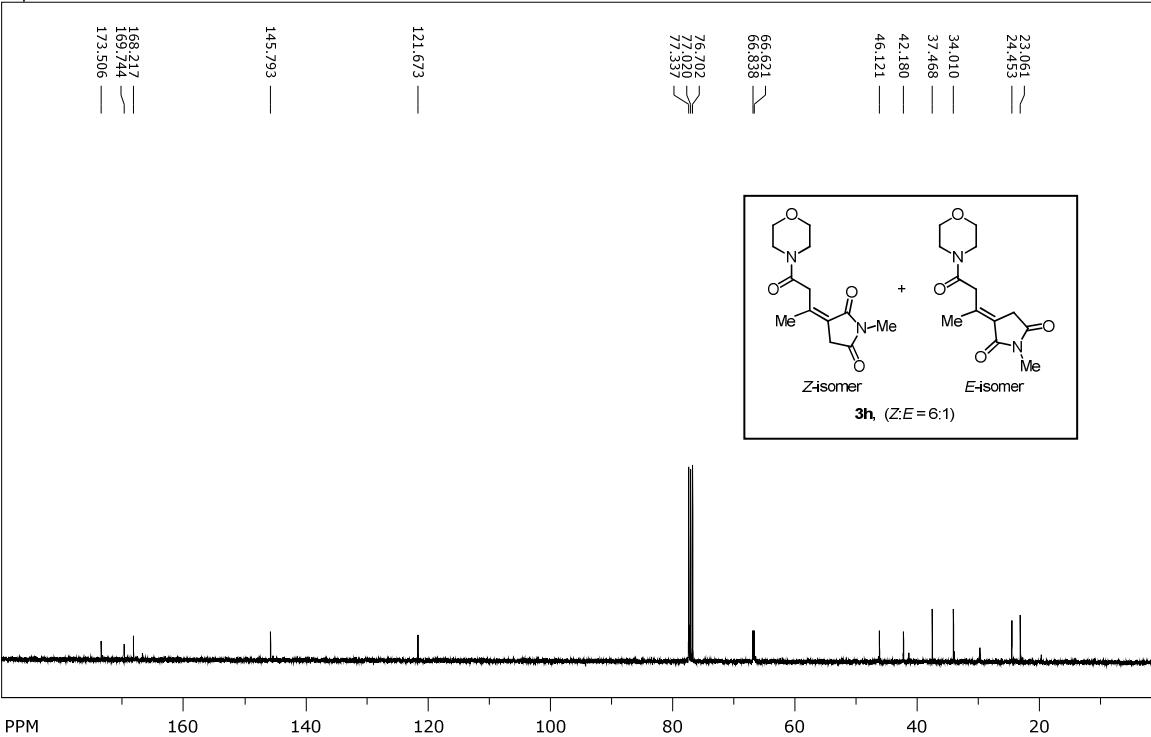




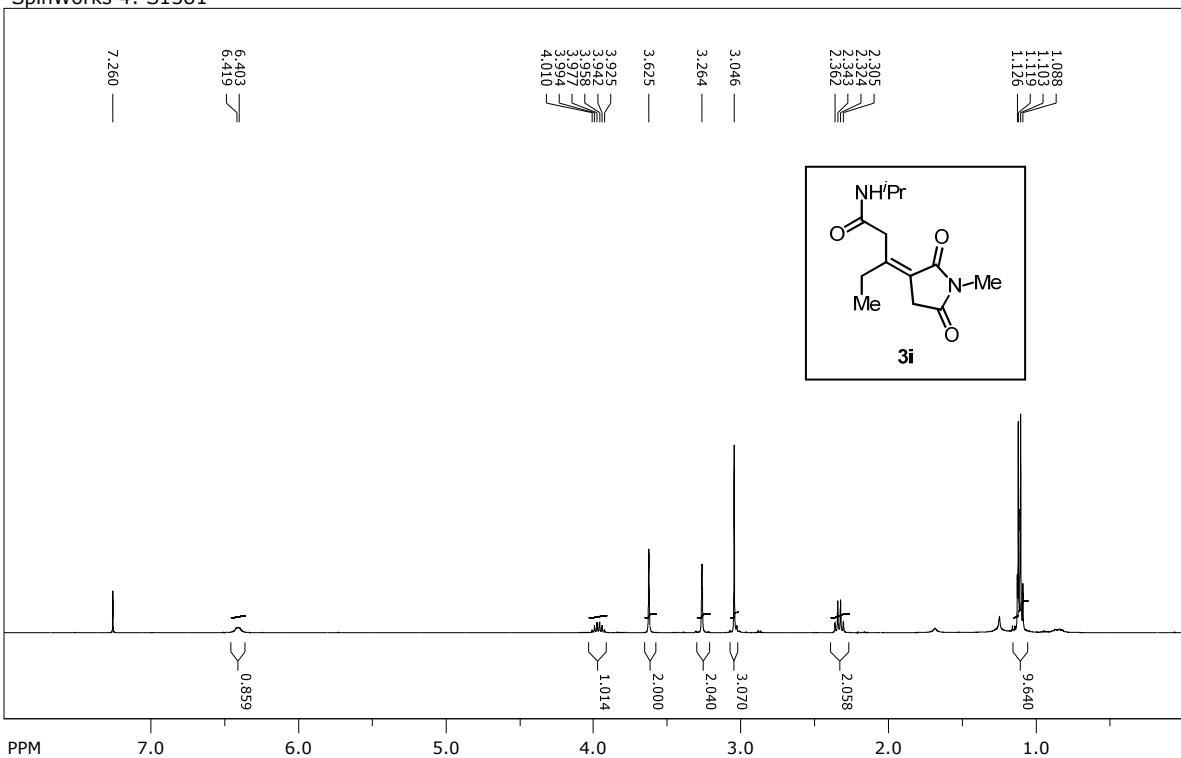
SpinWorks 4: S1379



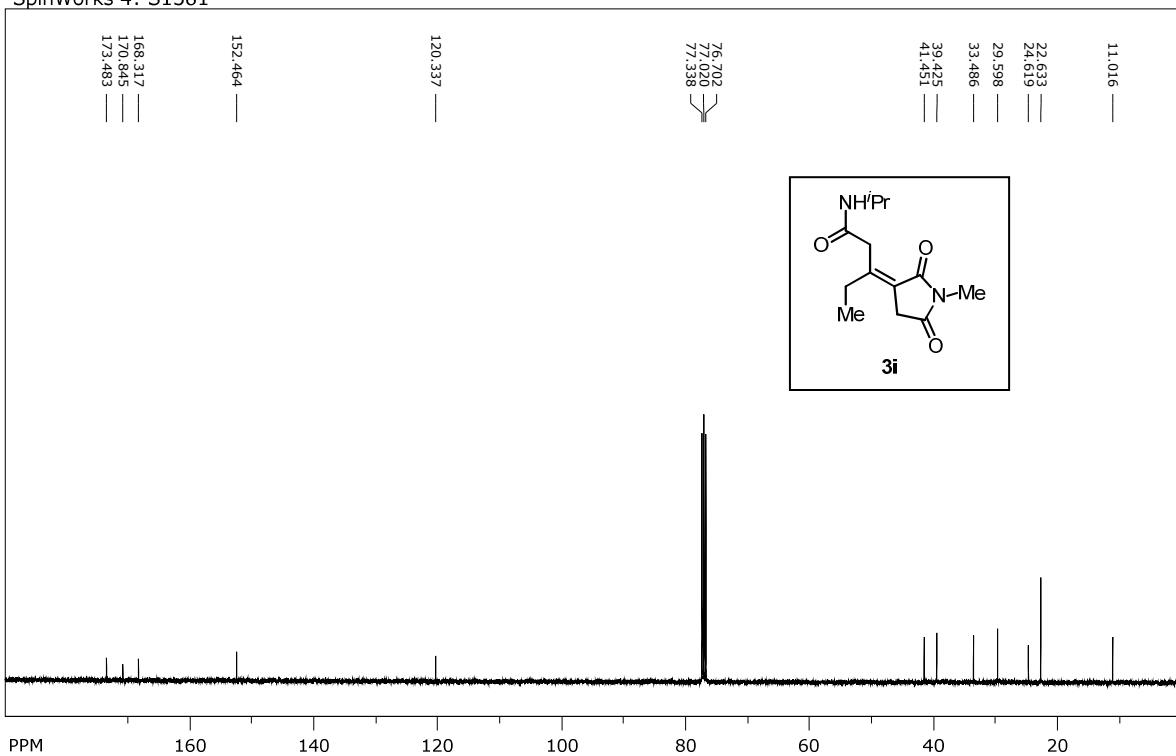
SpinWorks 4: S1379



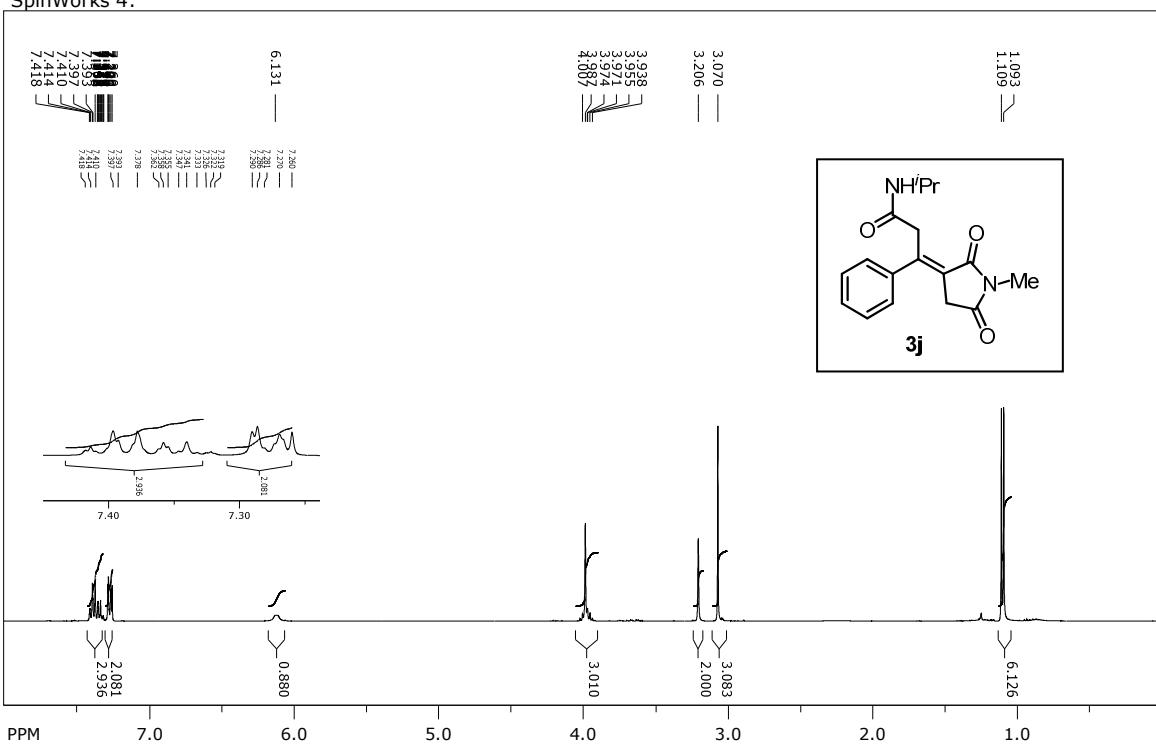
SpinWorks 4: S1381



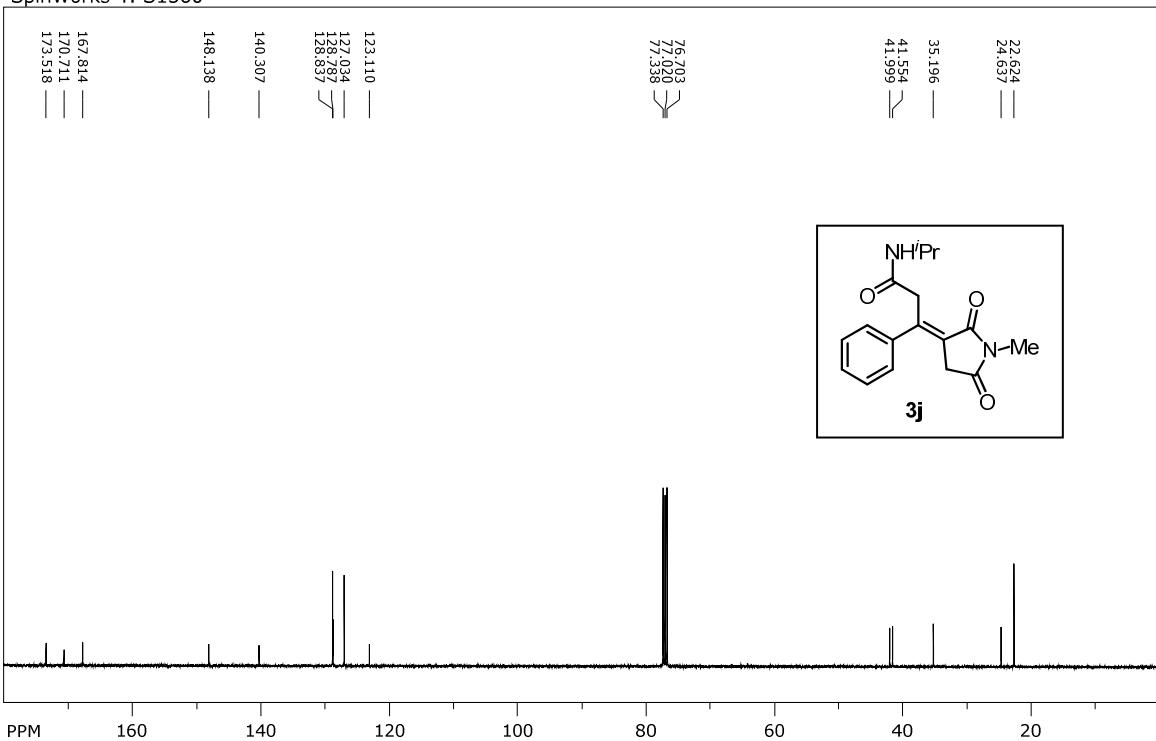
SpinWorks 4: S1381



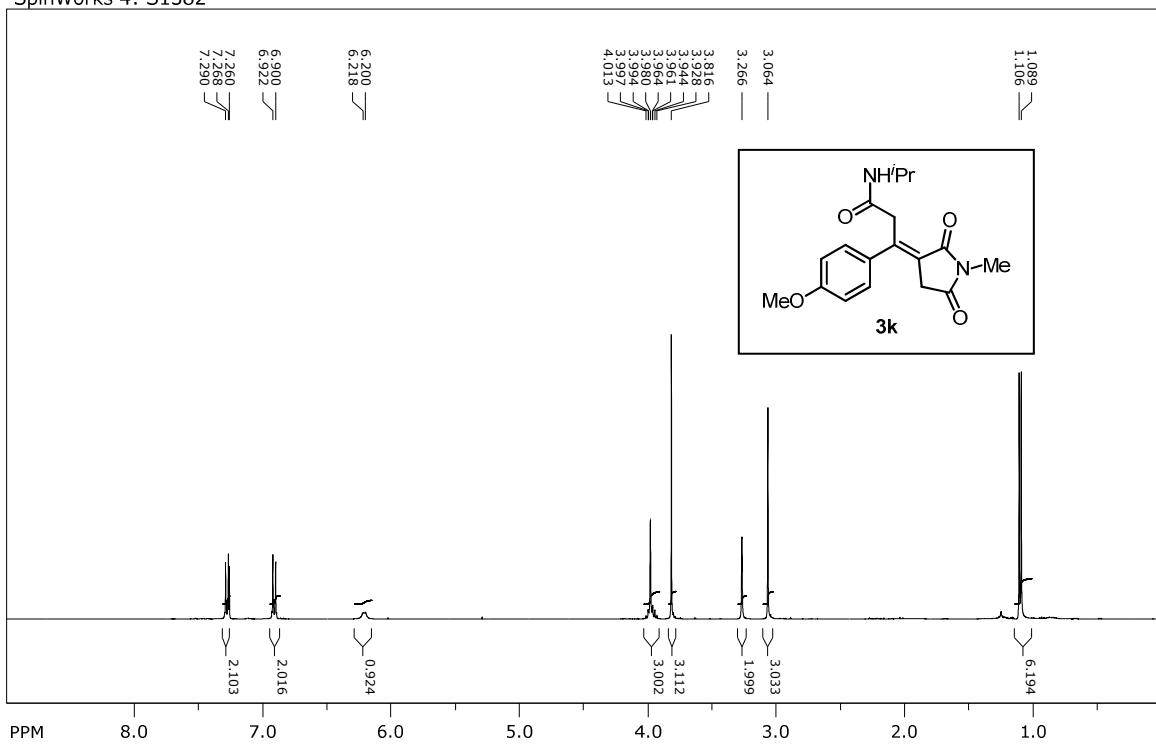
SpinWorks 4:



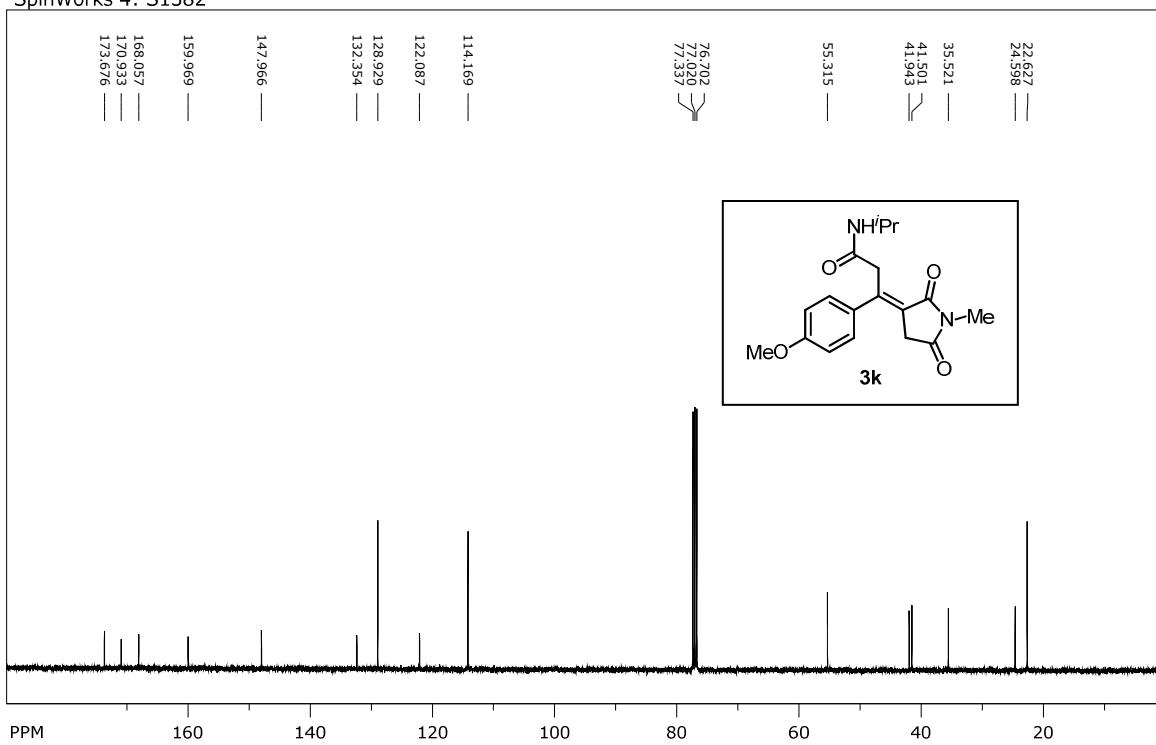
SpinWorks 4: S1360



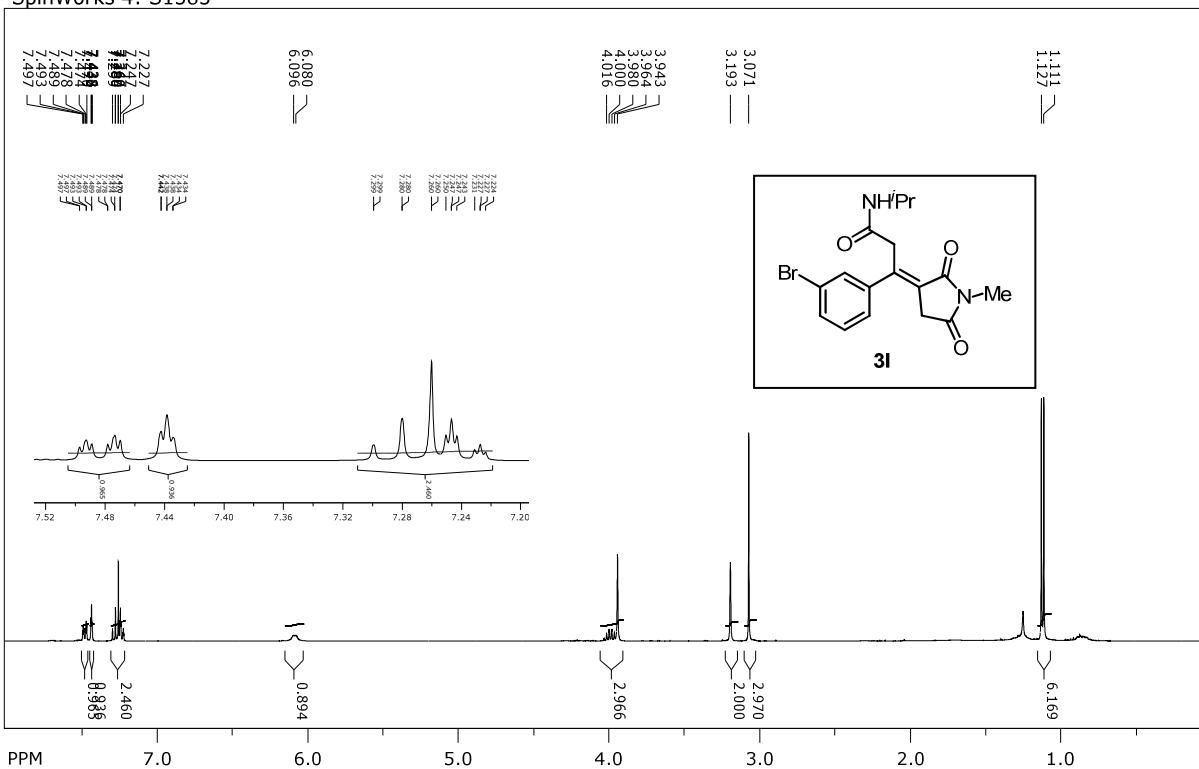
SpinWorks 4: S1382



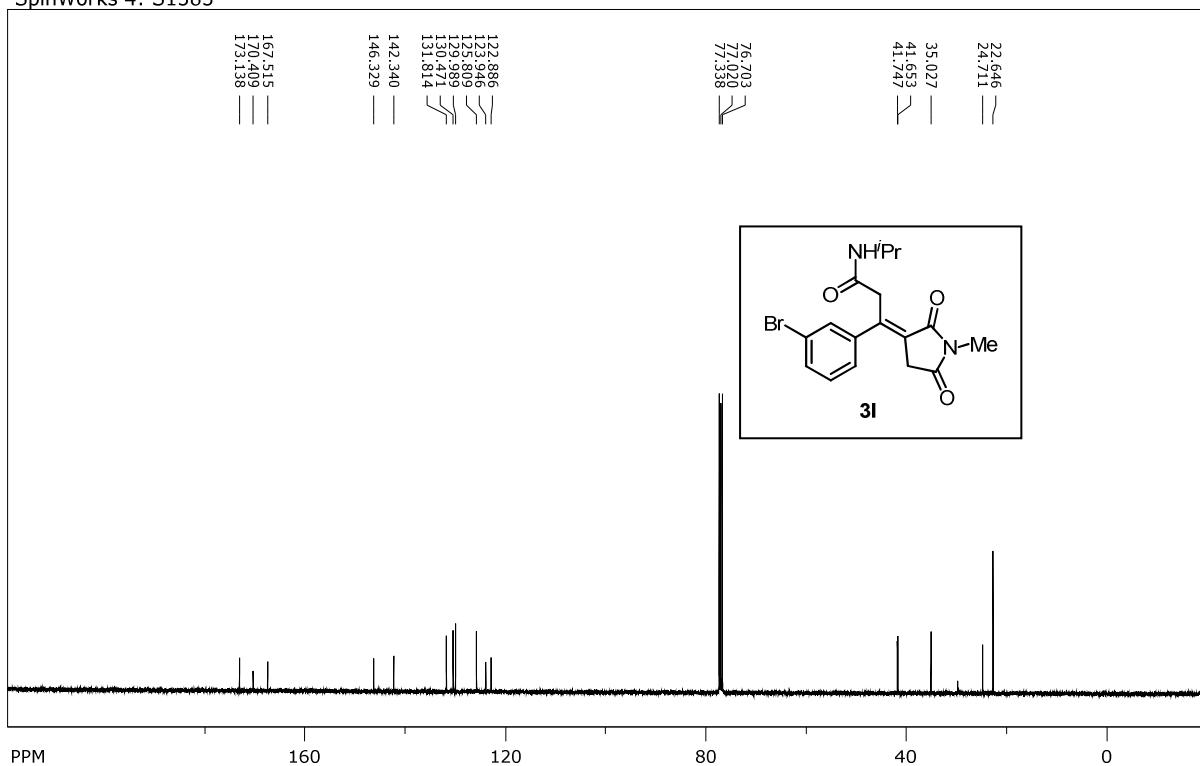
SpinWorks 4: S1382



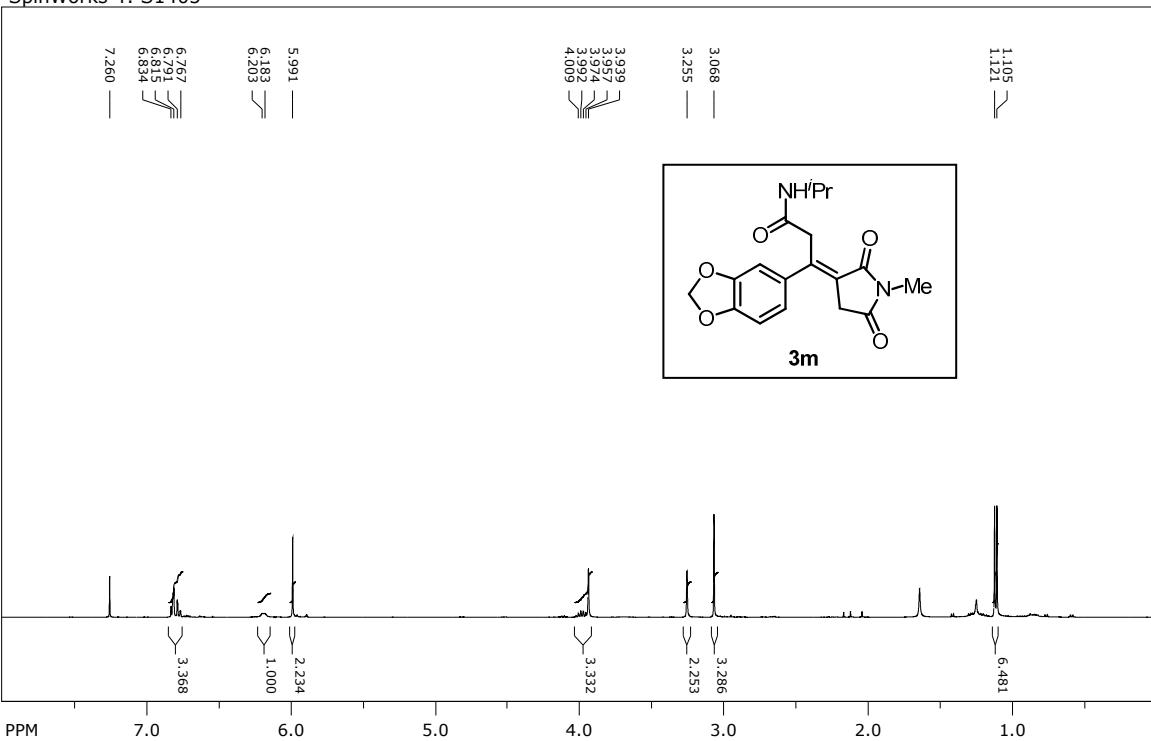
SpinWorks 4: S1383



SpinWorks 4: S1383

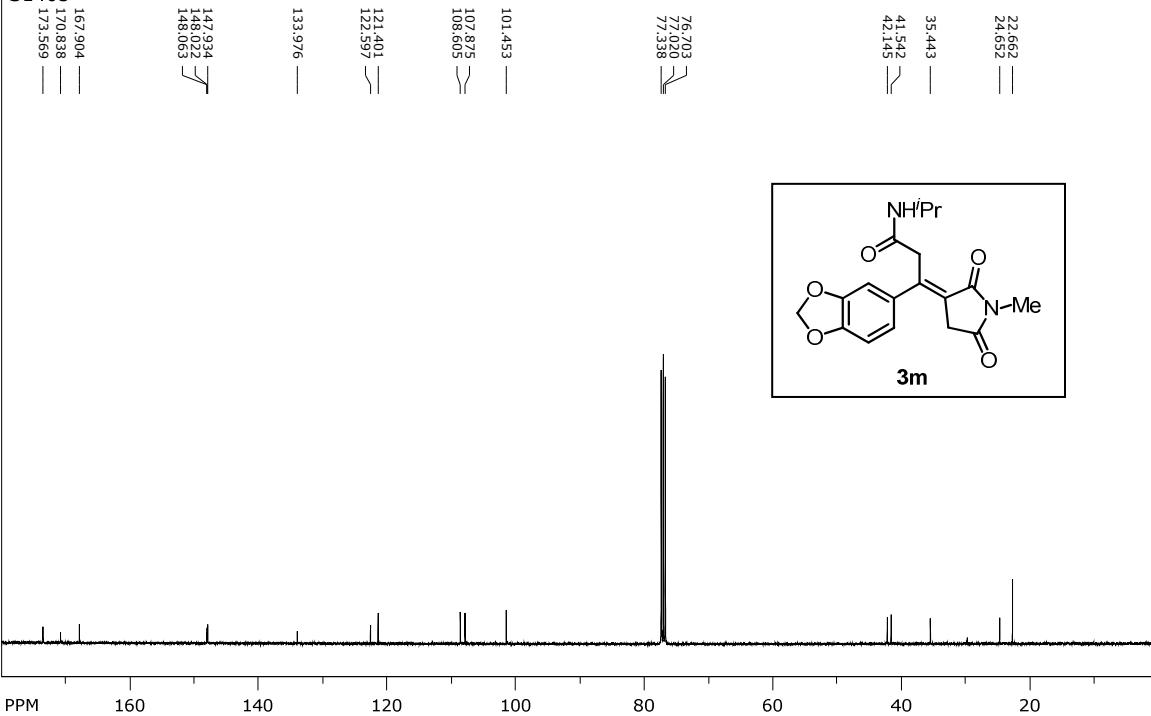


SpinWorks 4: S1405

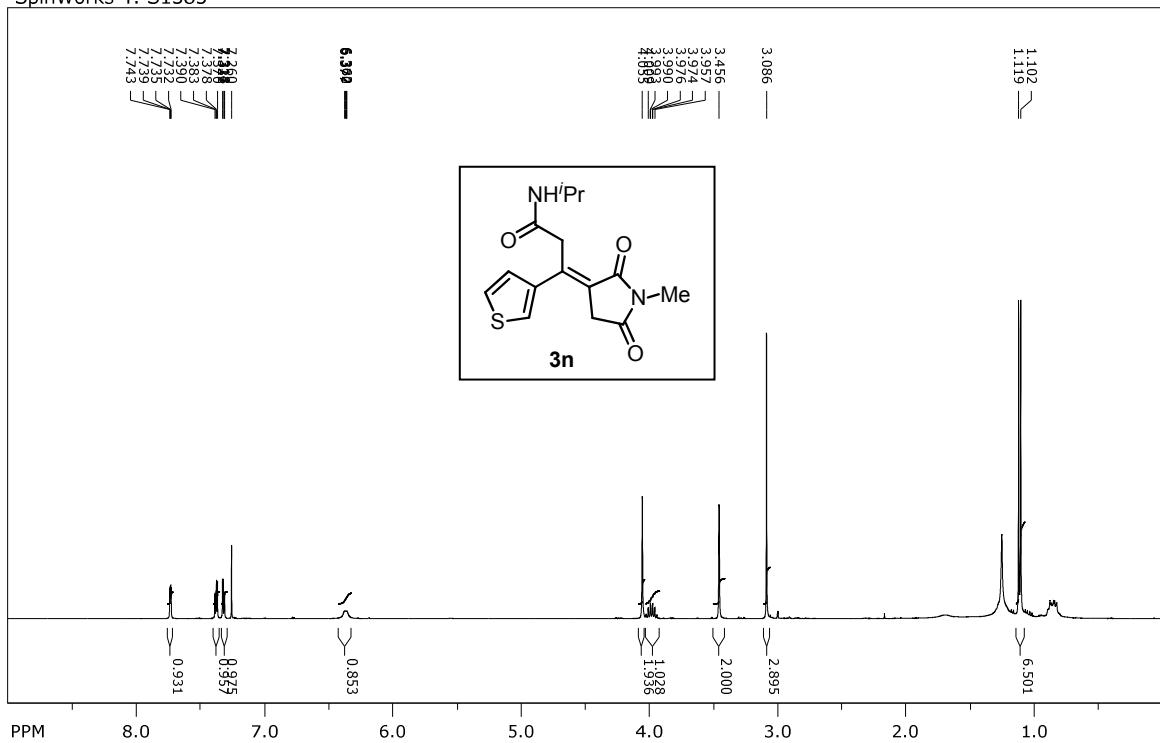


SpinWorks 4:

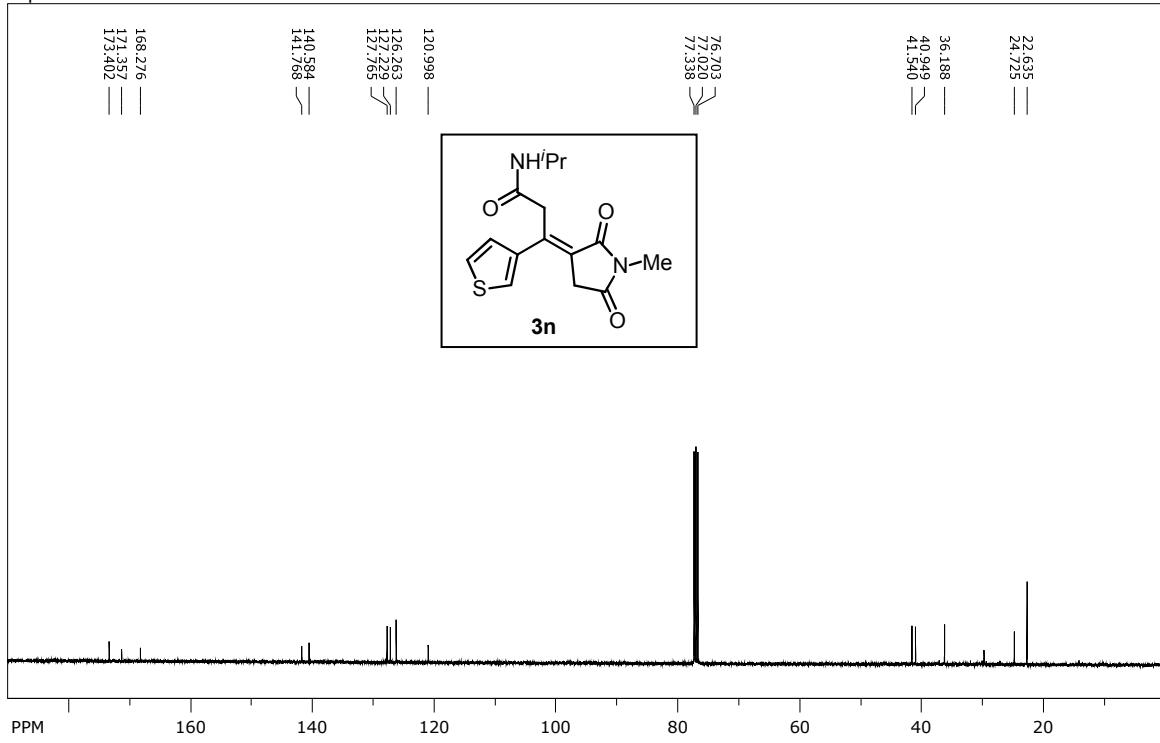
S1405



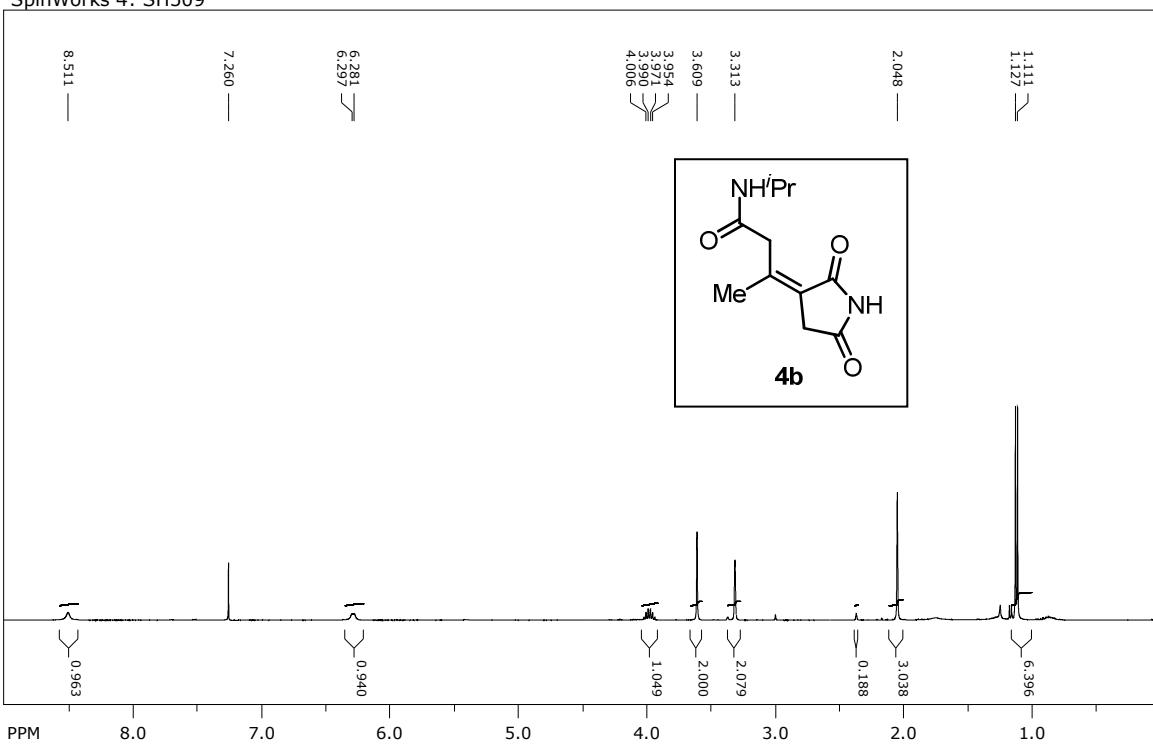
SpinWorks 4: S1385



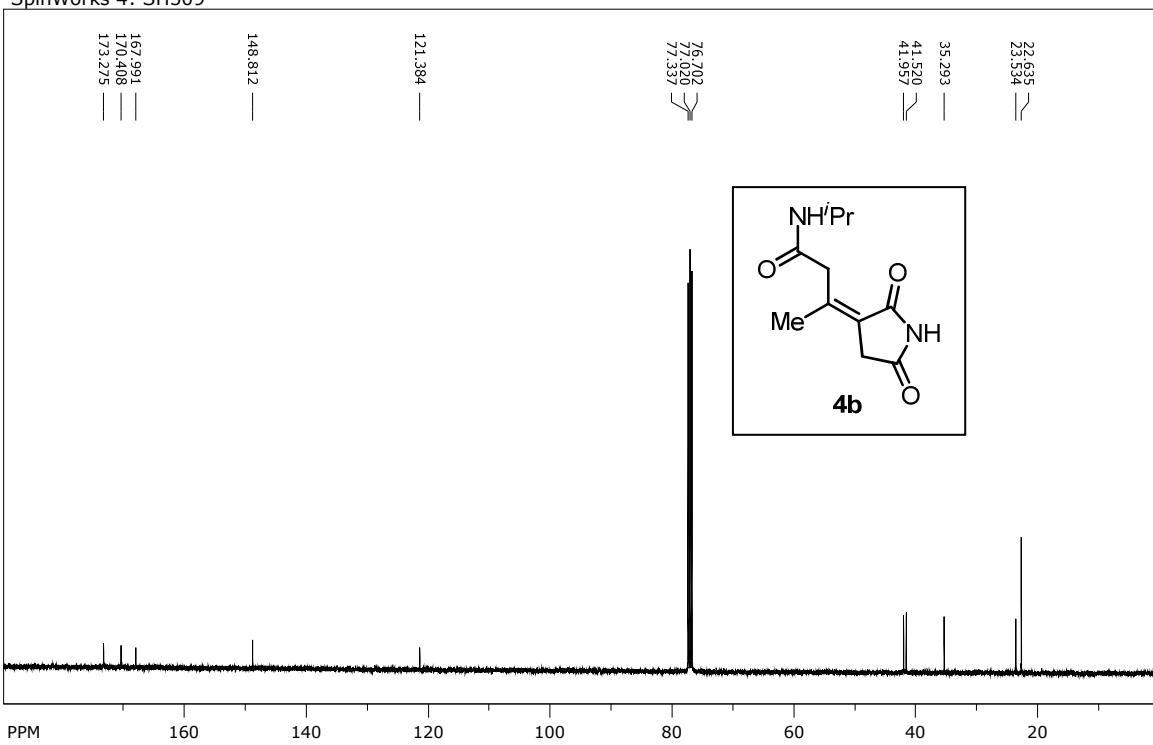
SpinWorks 4: S1385



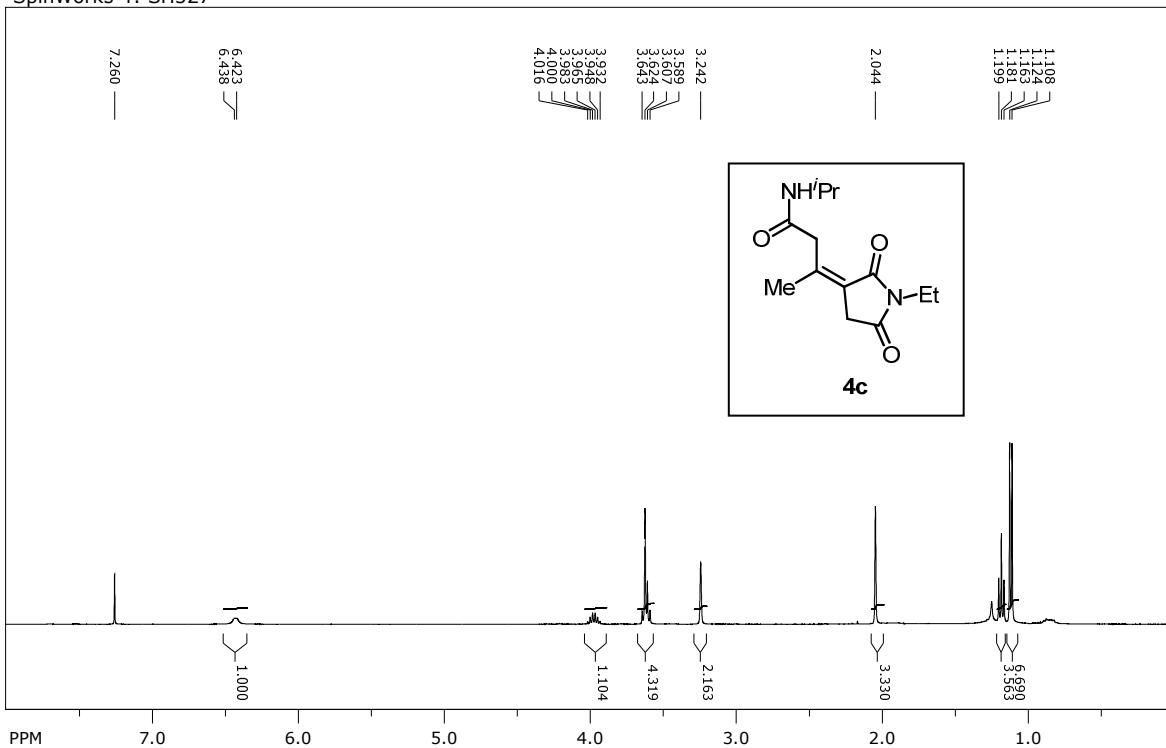
SpinWorks 4: SH509



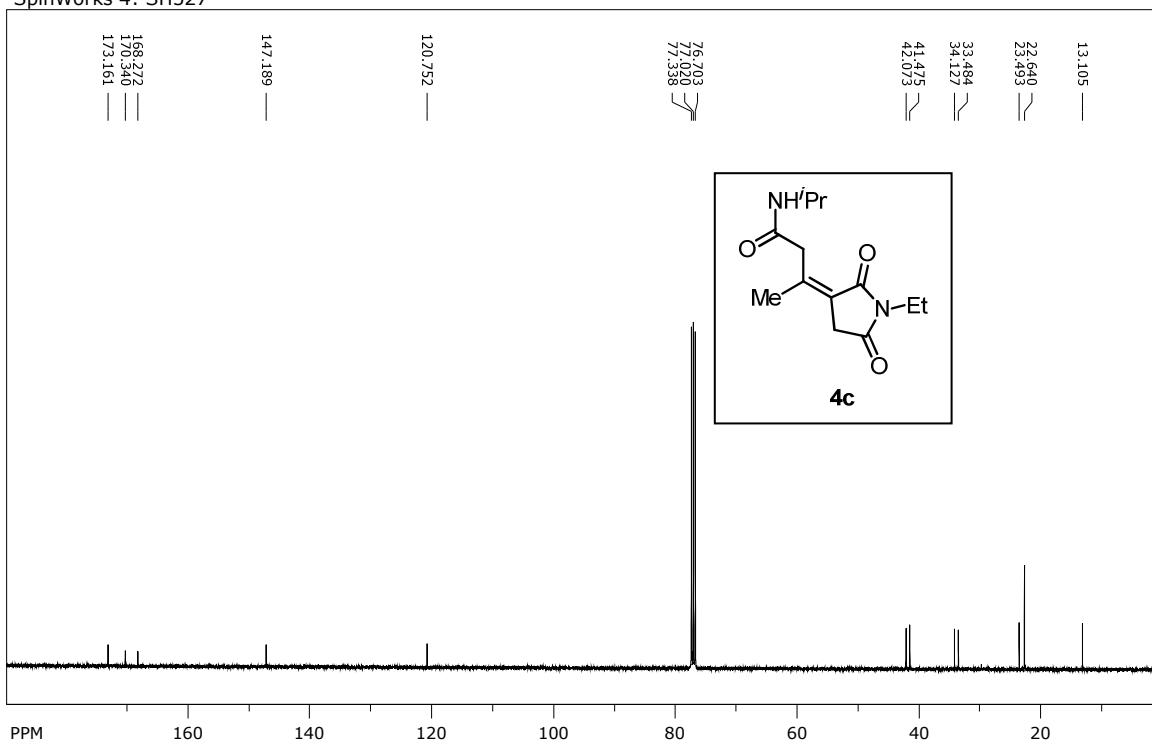
SpinWorks 4: SH509



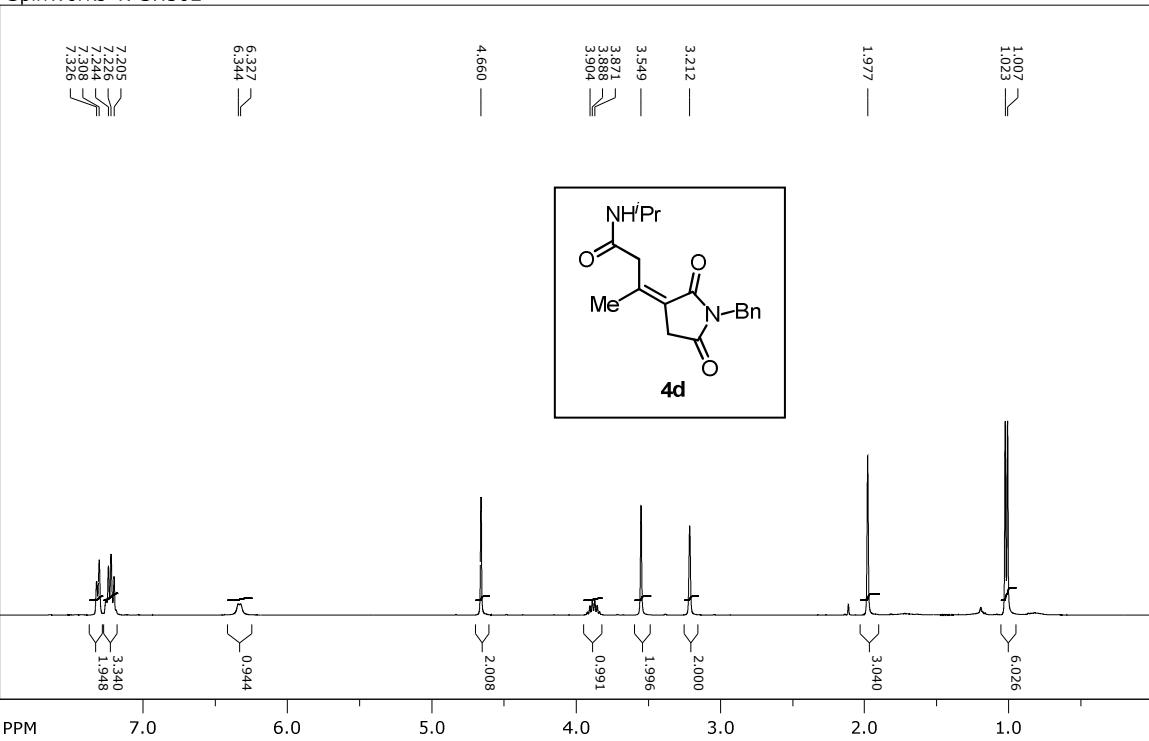
SpinWorks 4: SH527



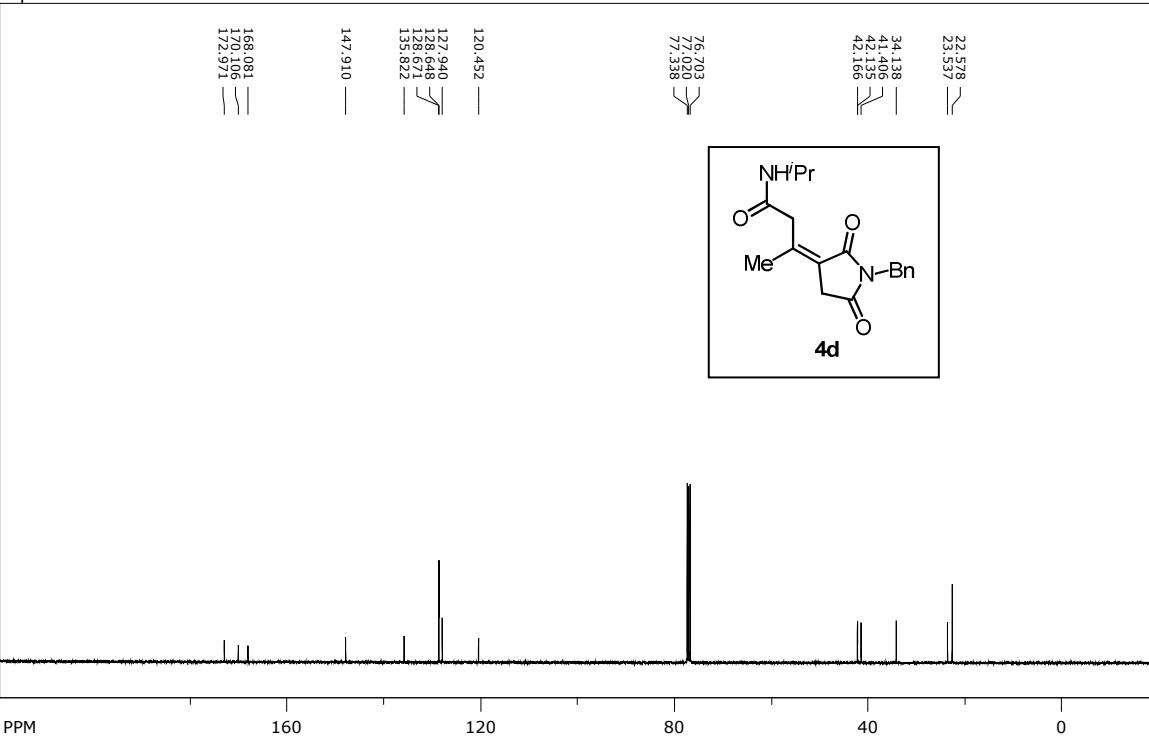
SpinWorks 4: SH527



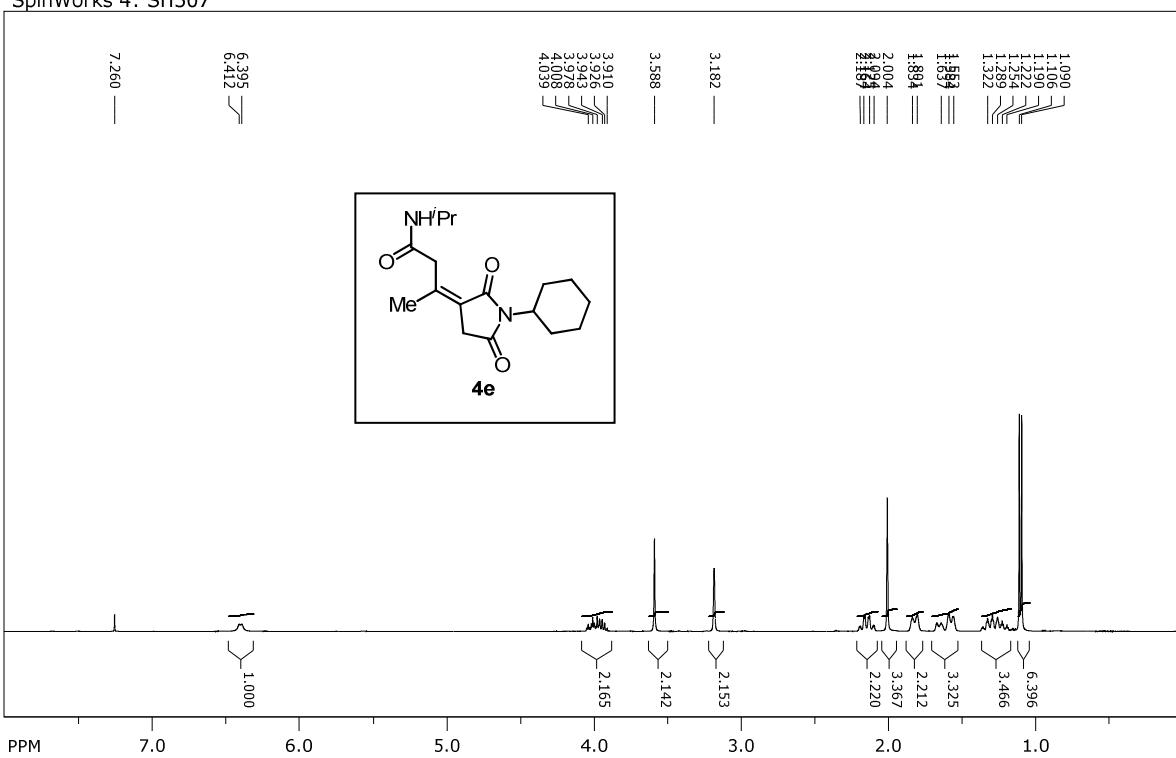
SpinWorks 4: SH502



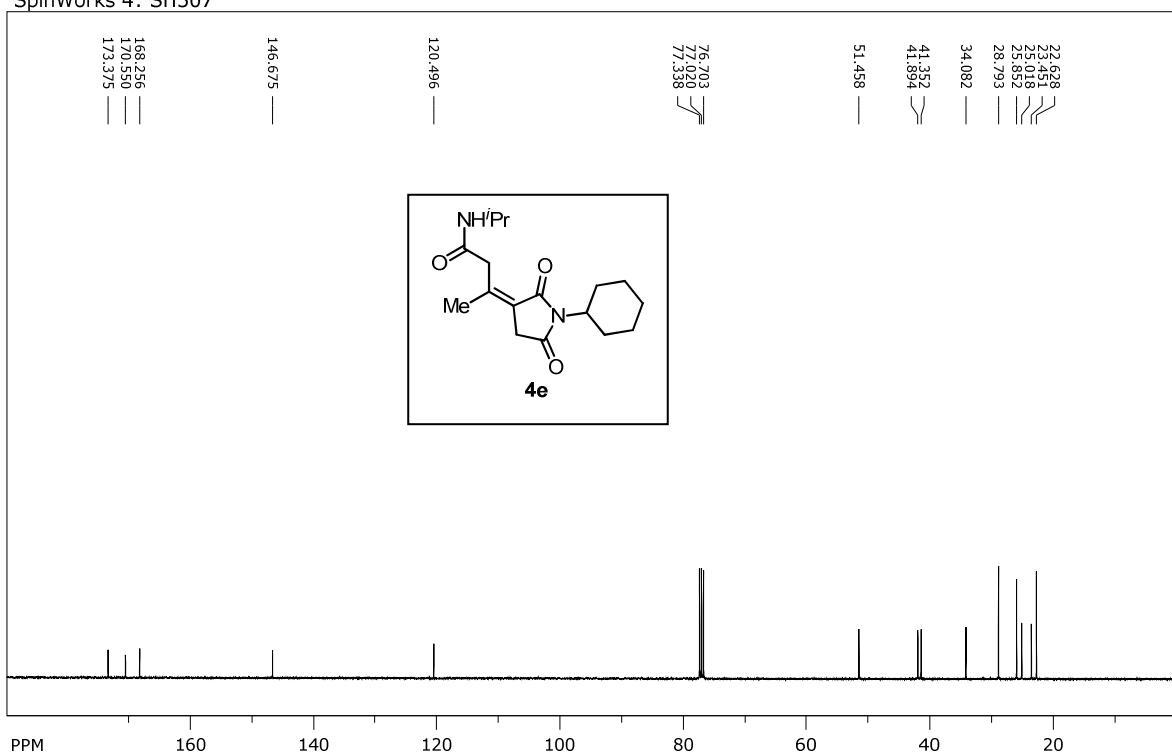
SpinWorks 4: SH502



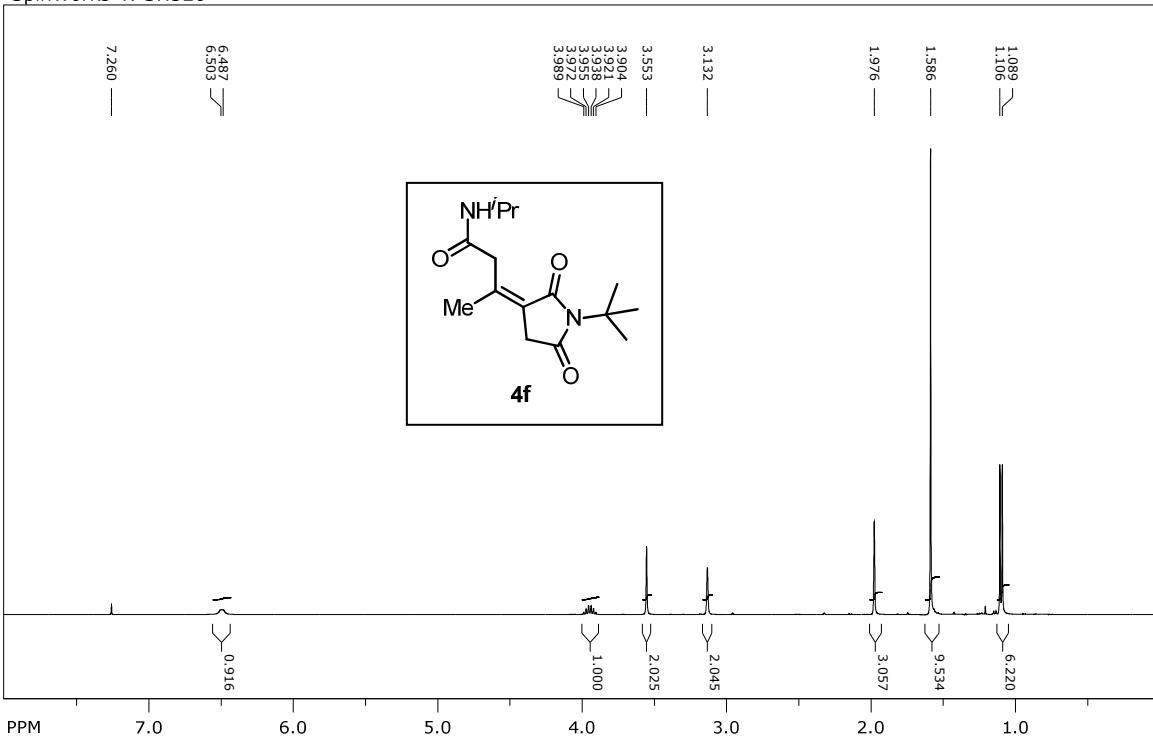
SpinWorks 4: SH507



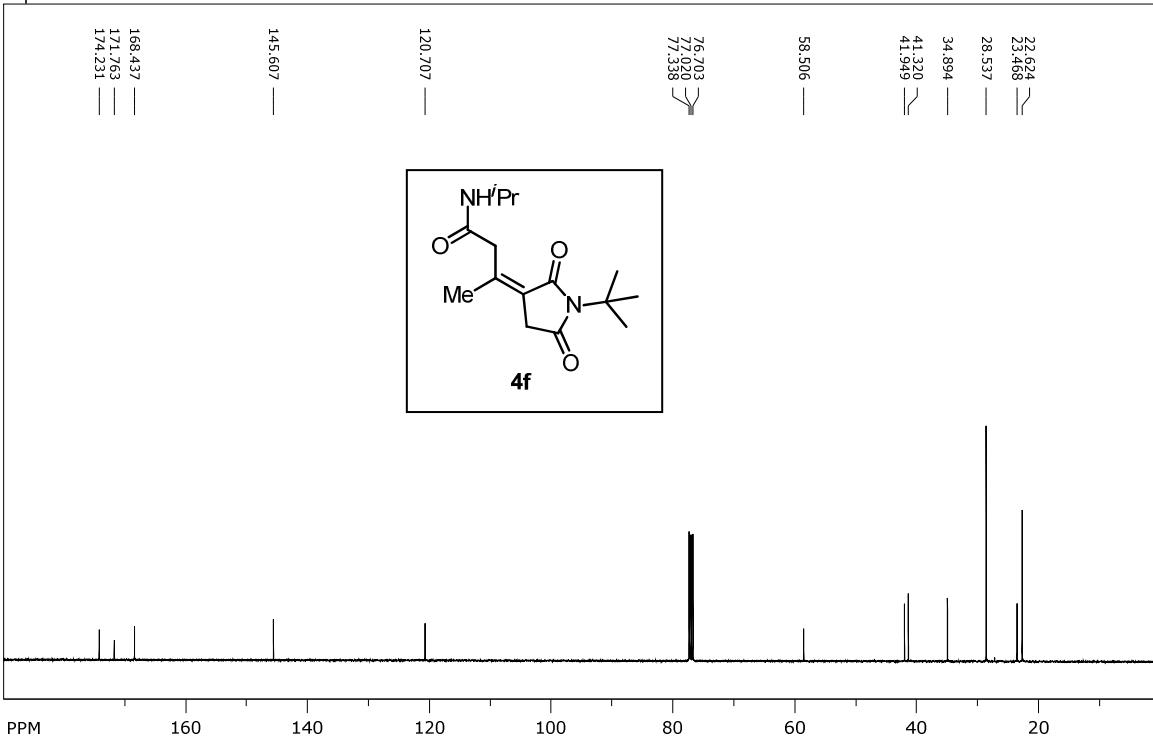
SpinWorks 4: SH507



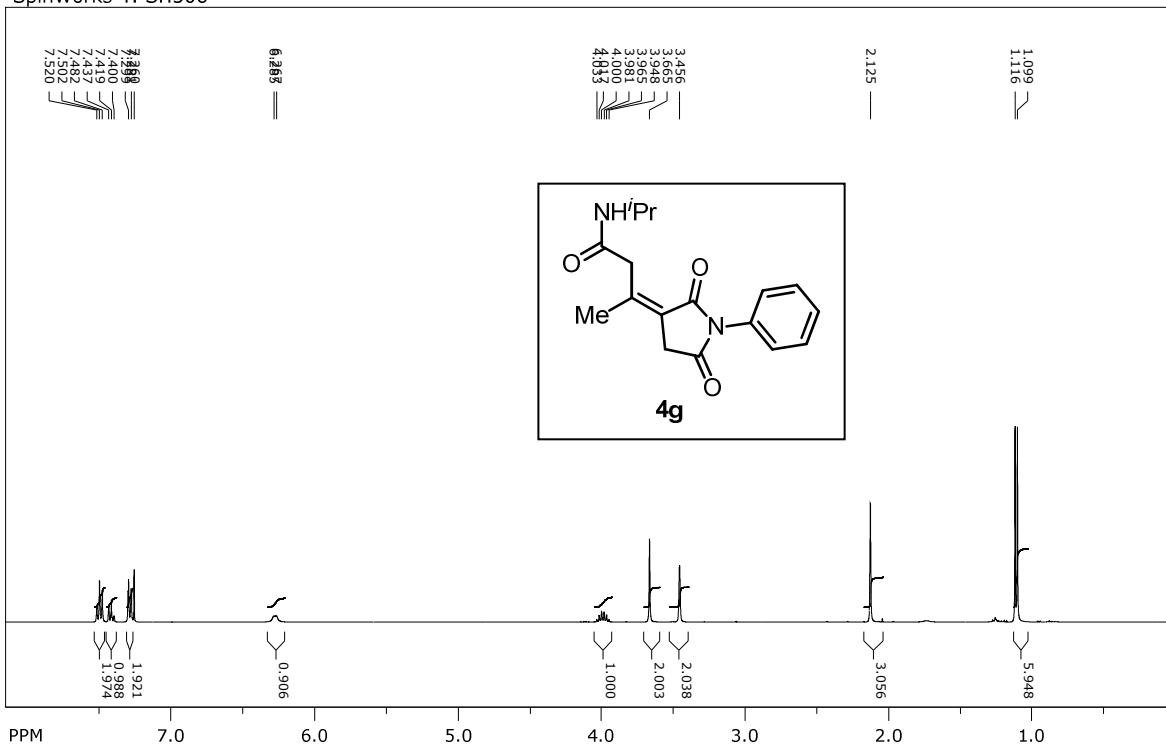
SpinWorks 4: SH526



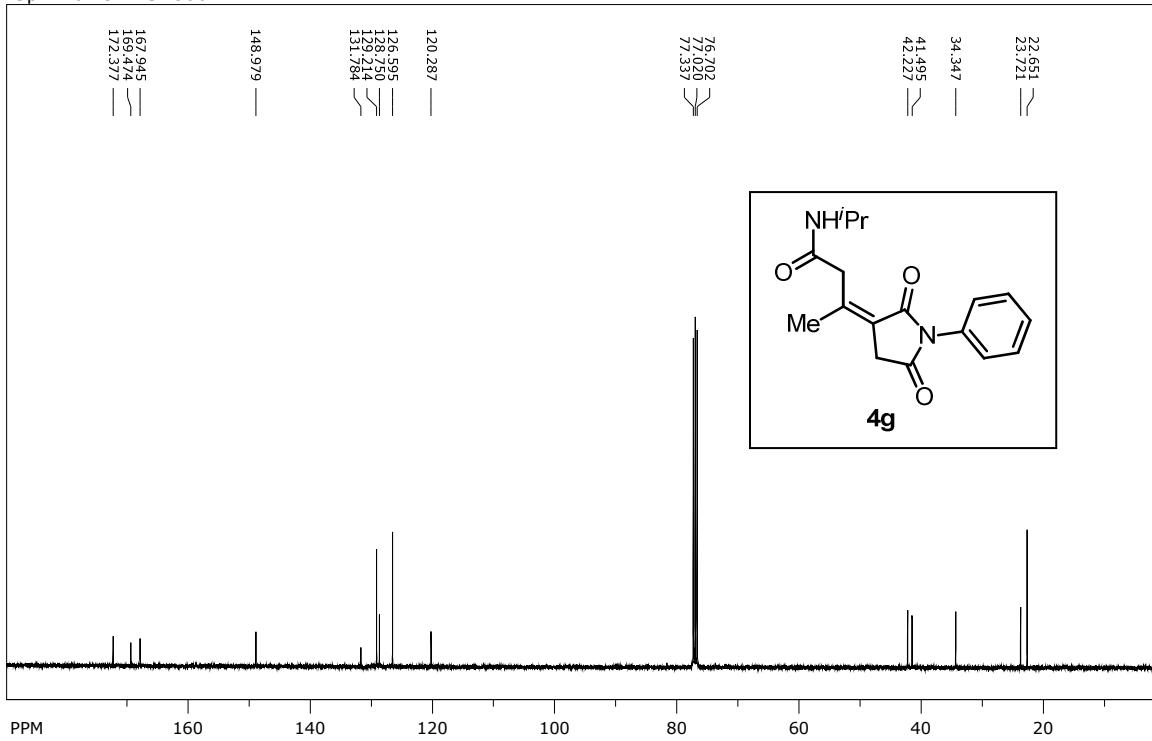
SpinWorks 4: SH526



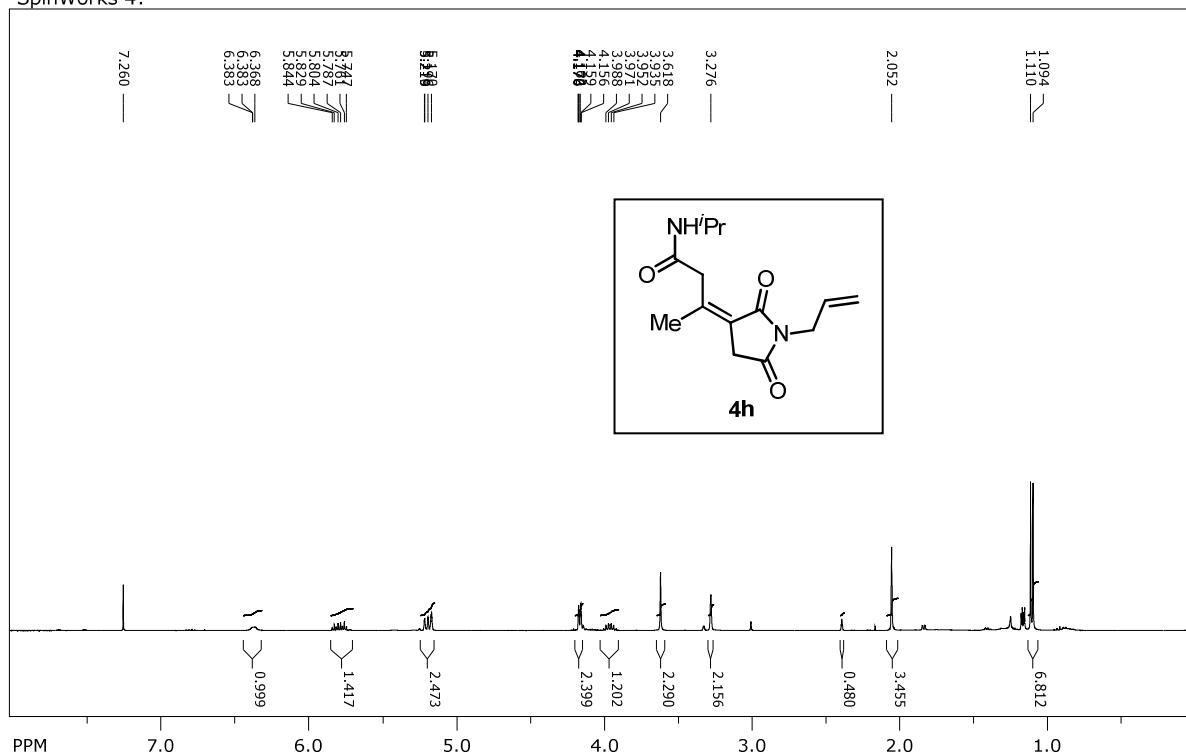
SpinWorks 4: SH506



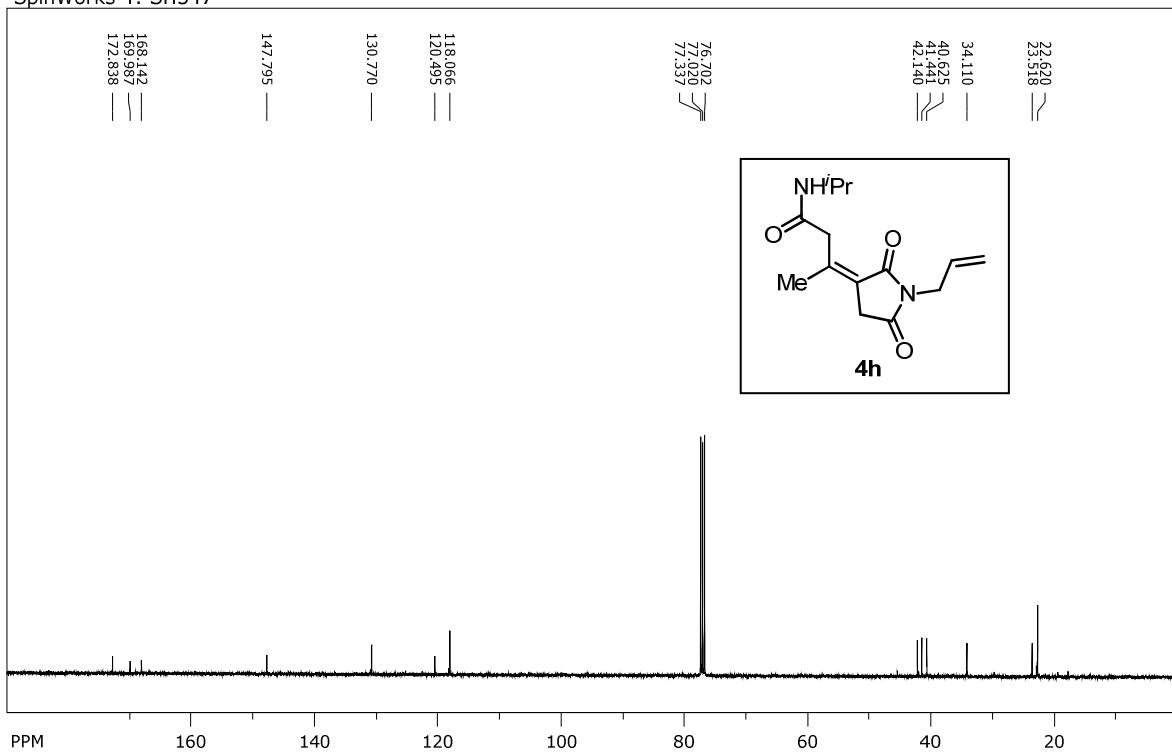
SpinWorks 4: SH506



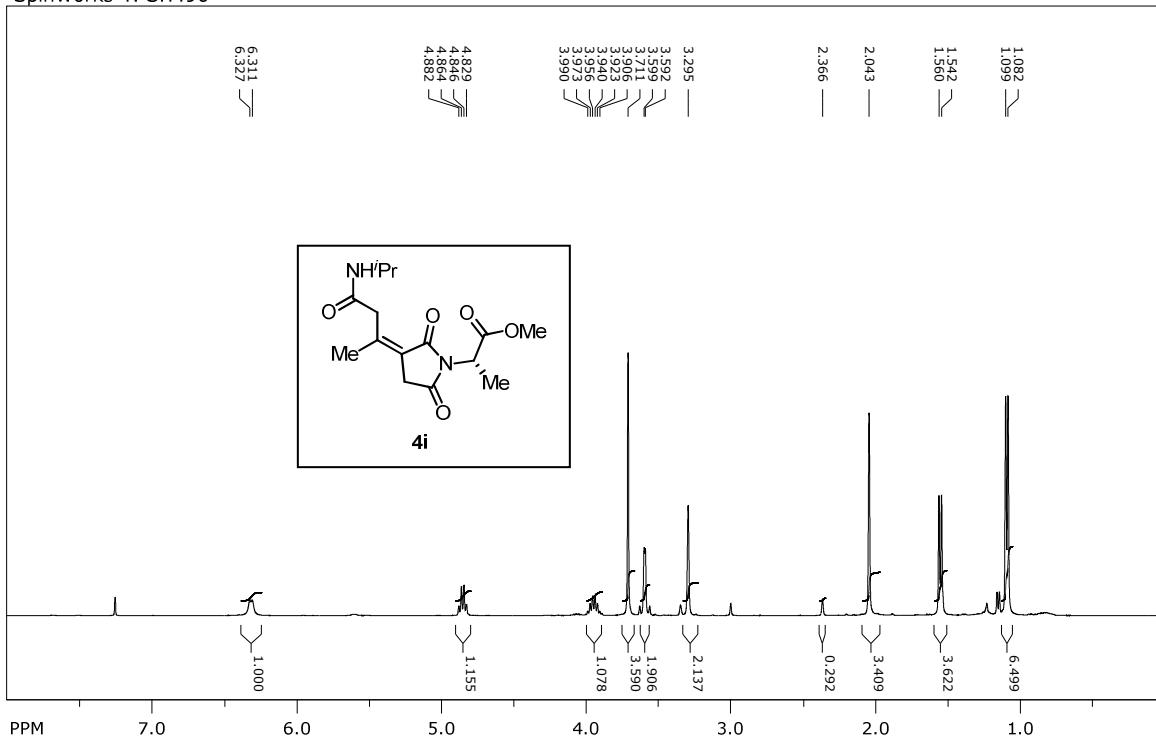
SpinWorks 4:



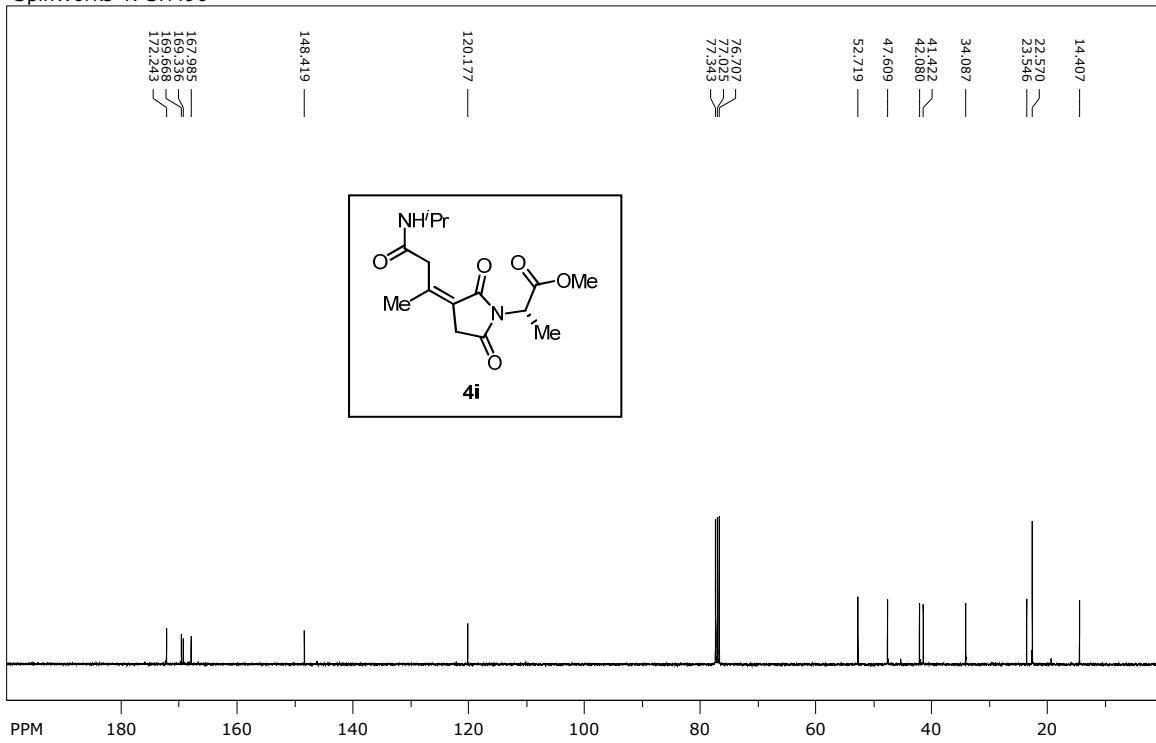
SpinWorks 4: SH547



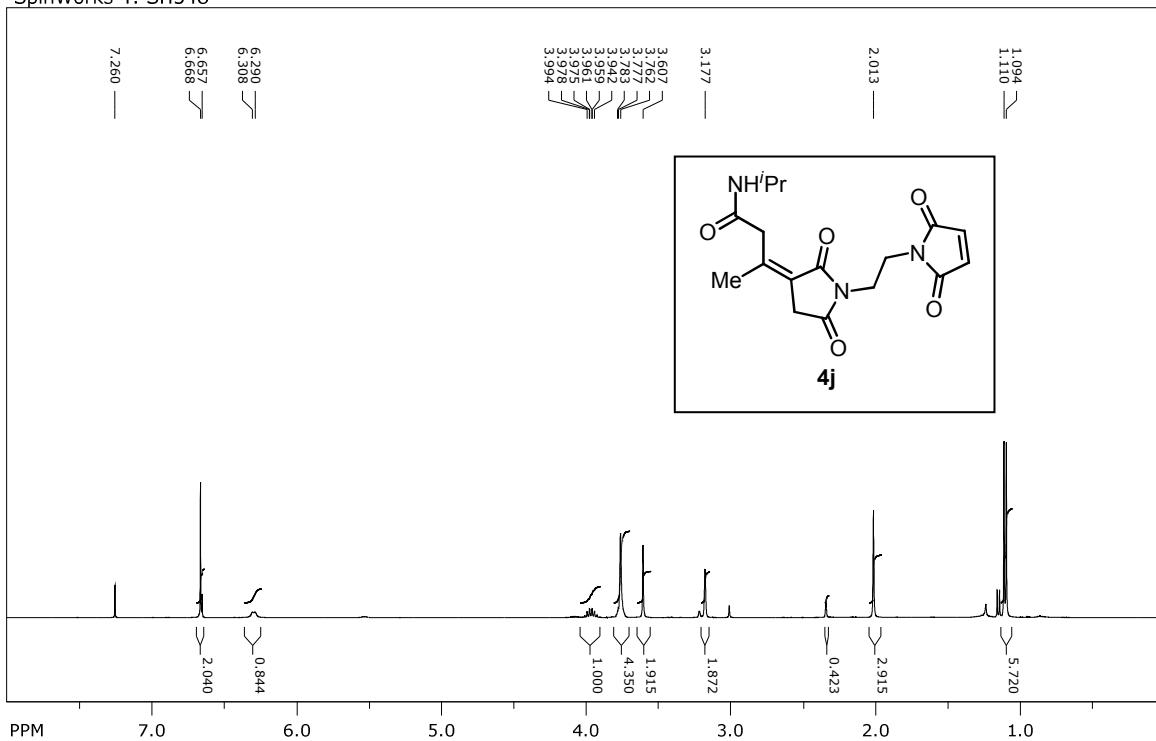
SpinWorks 4: SH496



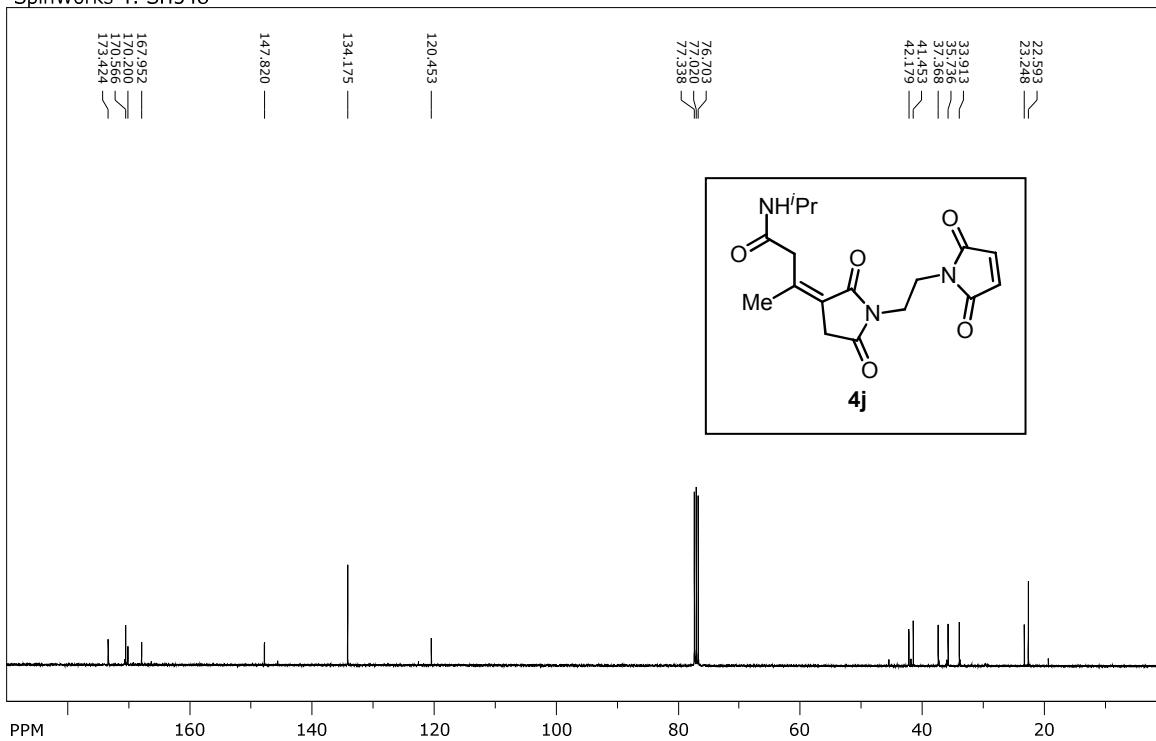
SpinWorks 4: SH496

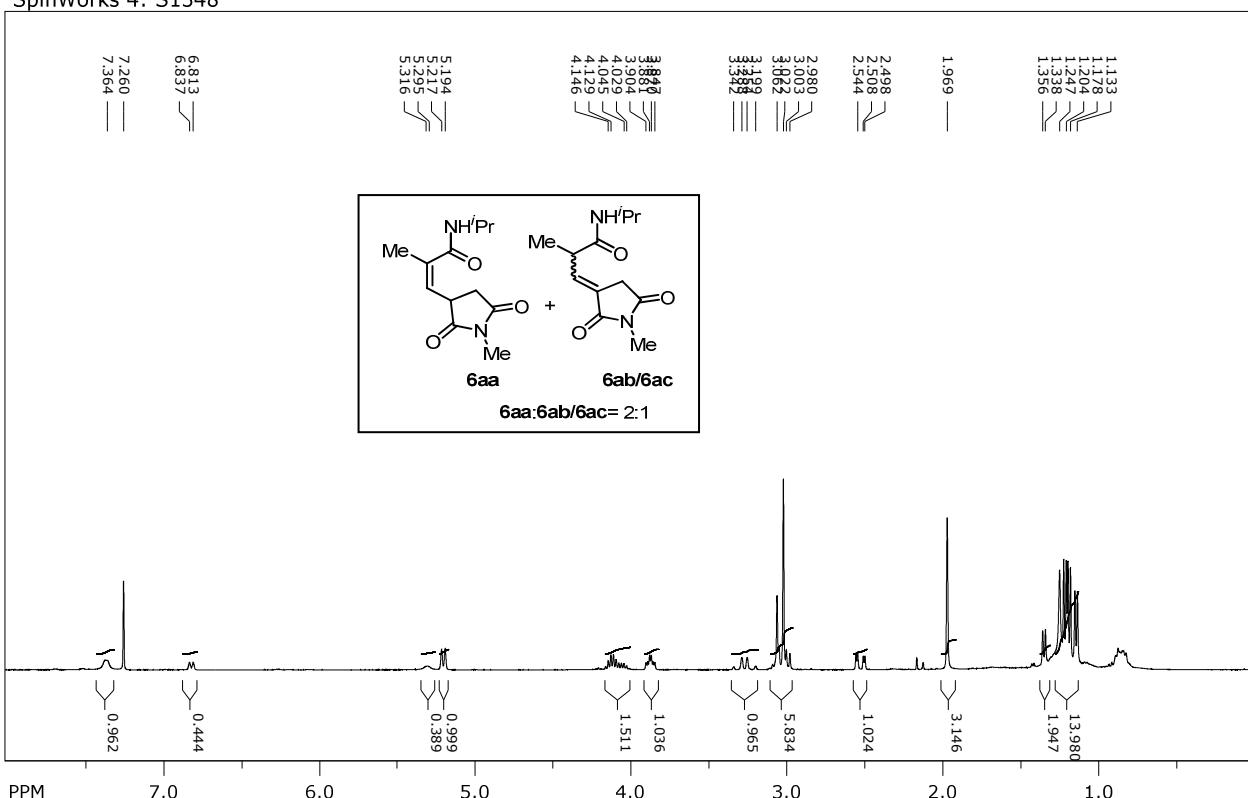


SpinWorks 4: SH548

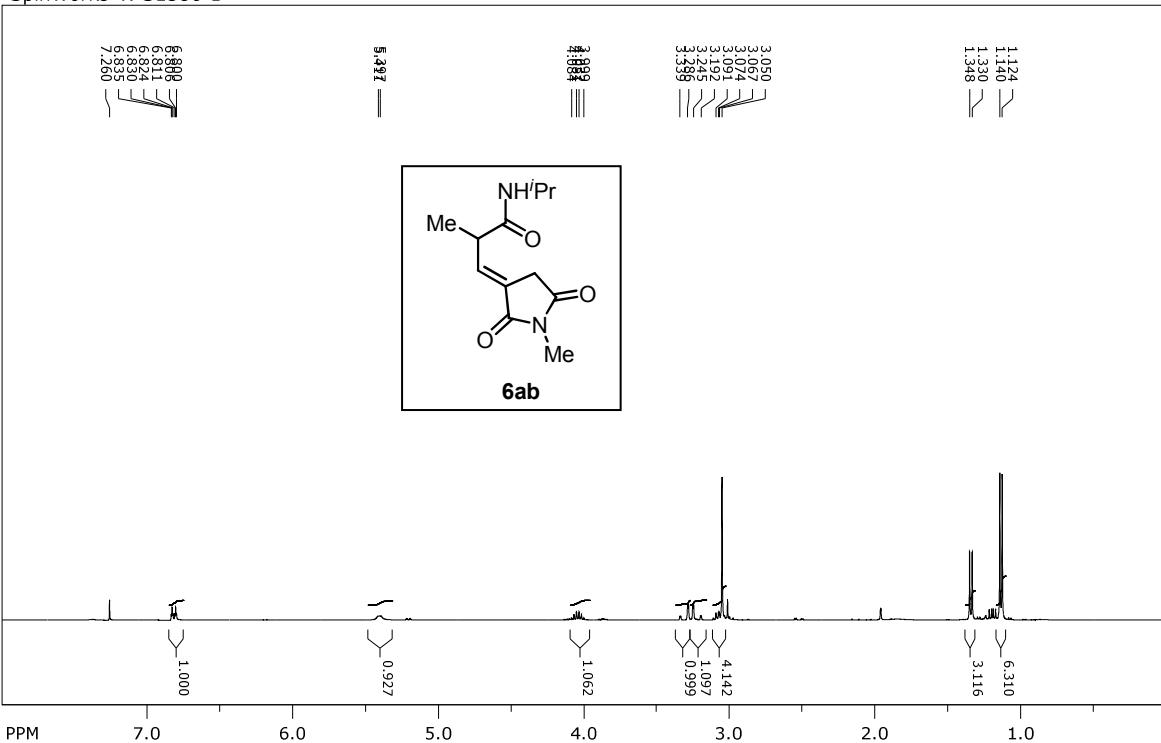


SpinWorks 4: SH548

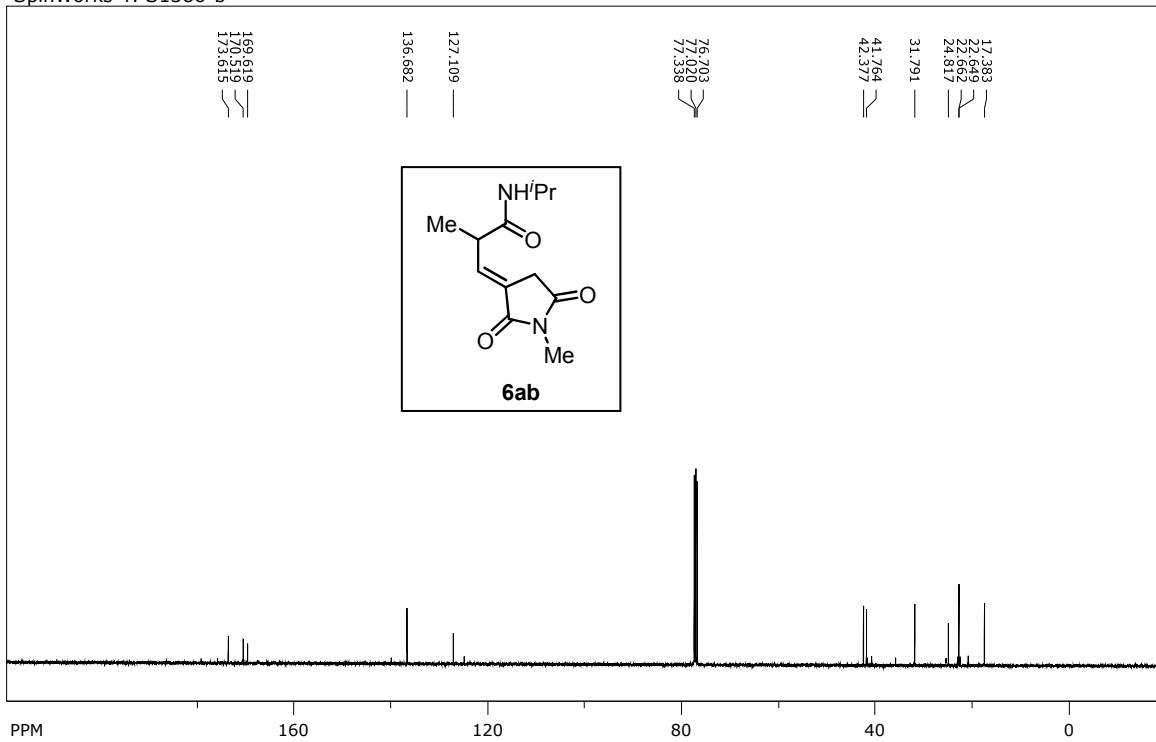




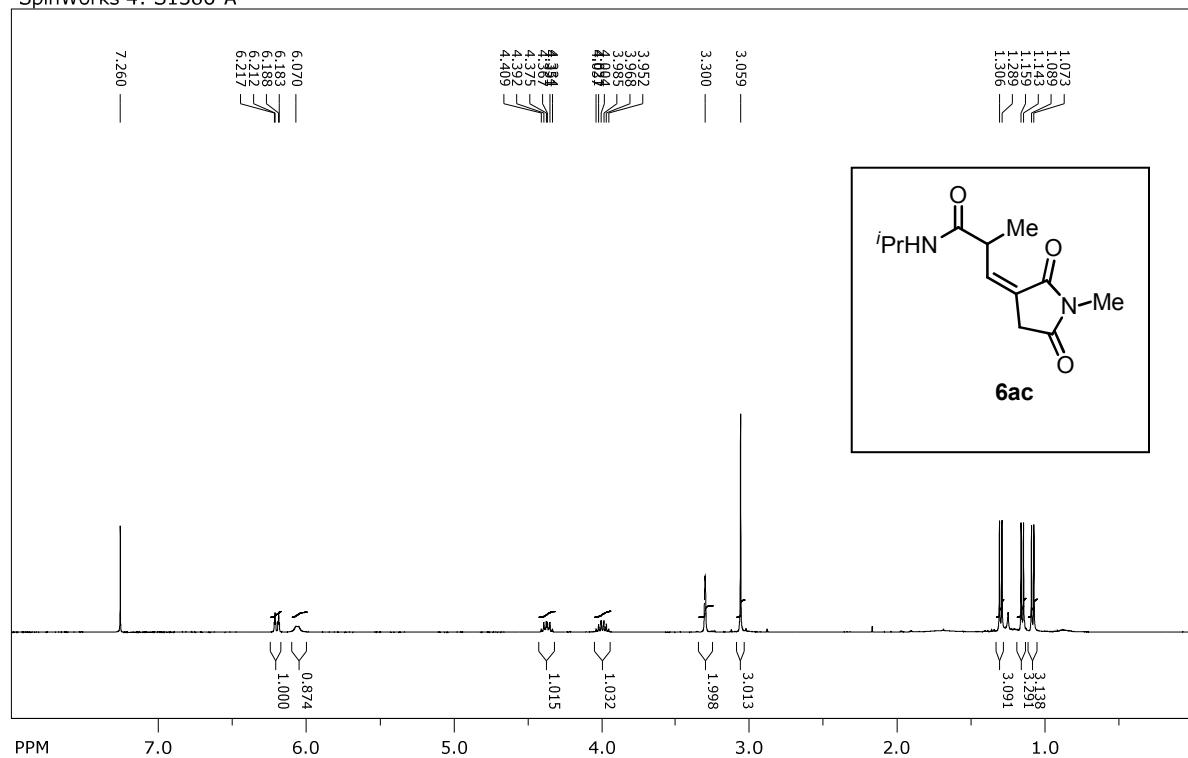
SpinWorks 4: S1386-B



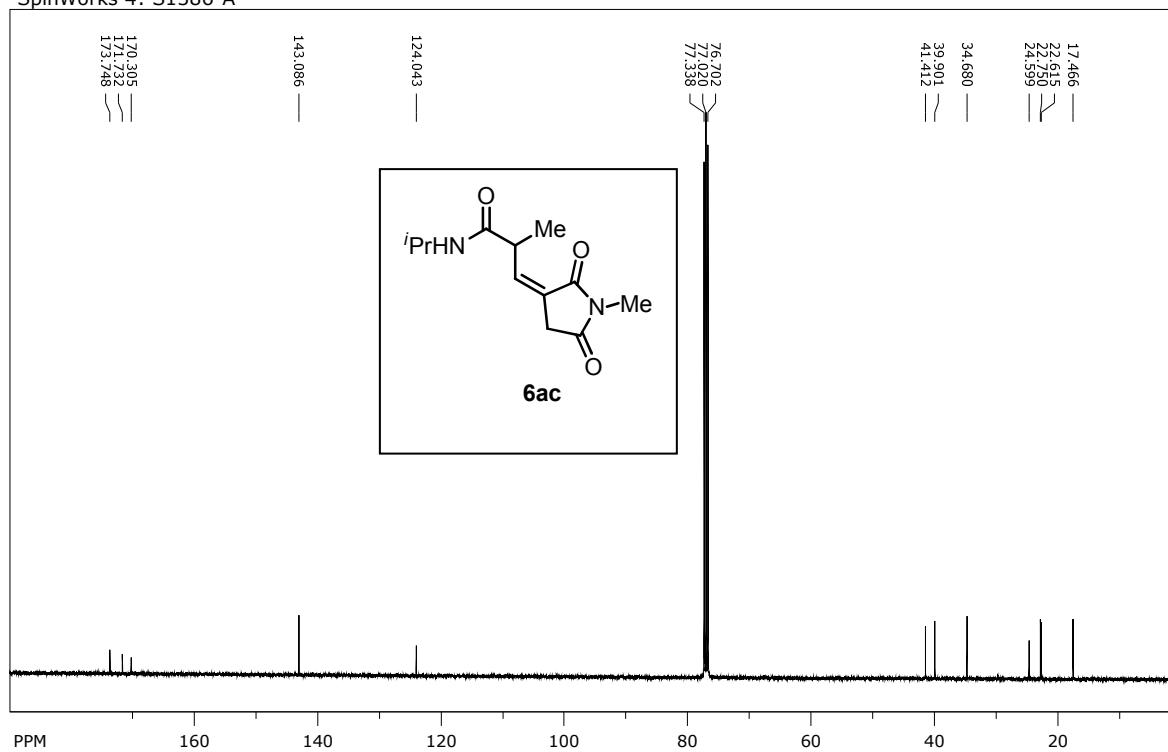
SpinWorks 4: S1386-b



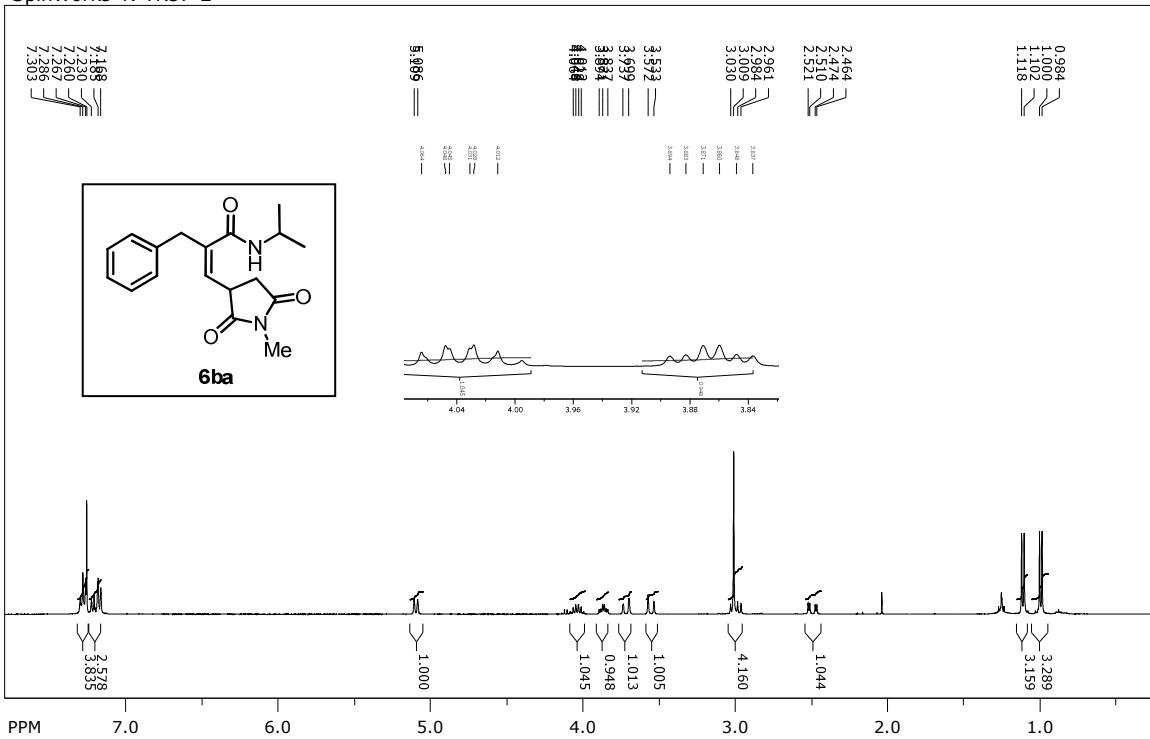
SpinWorks 4: S1386-A



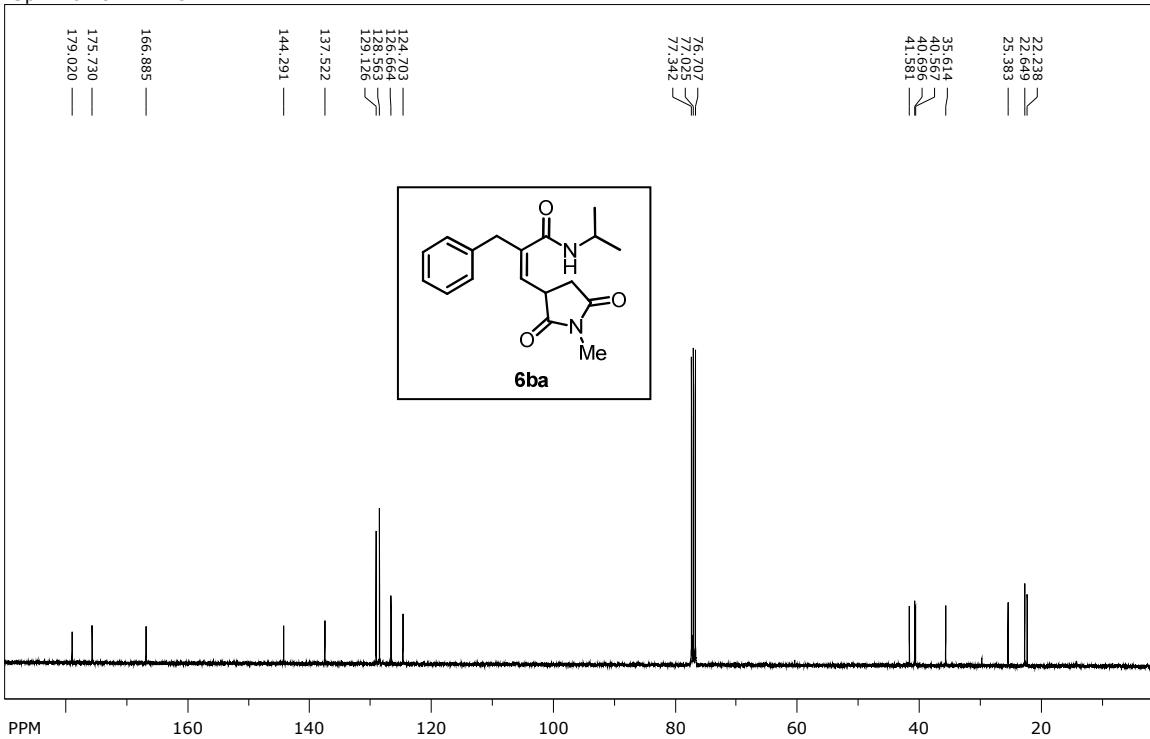
SpinWorks 4: S1386-A



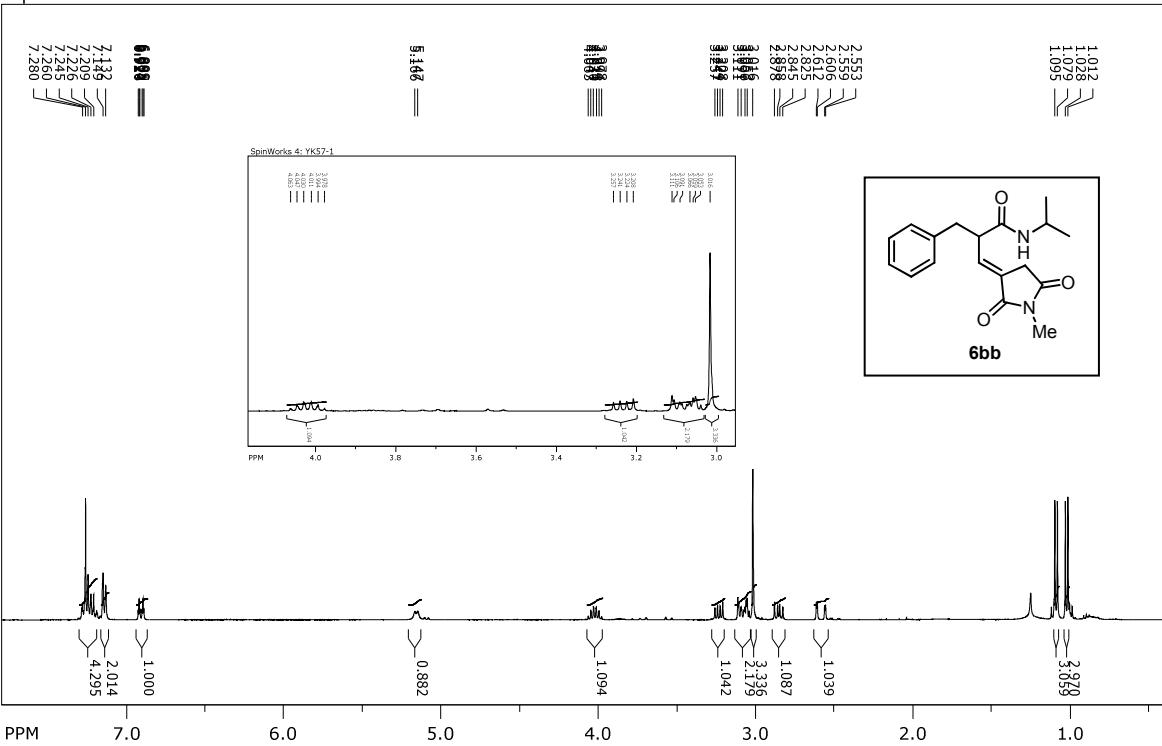
SpinWorks 4: YK57-2



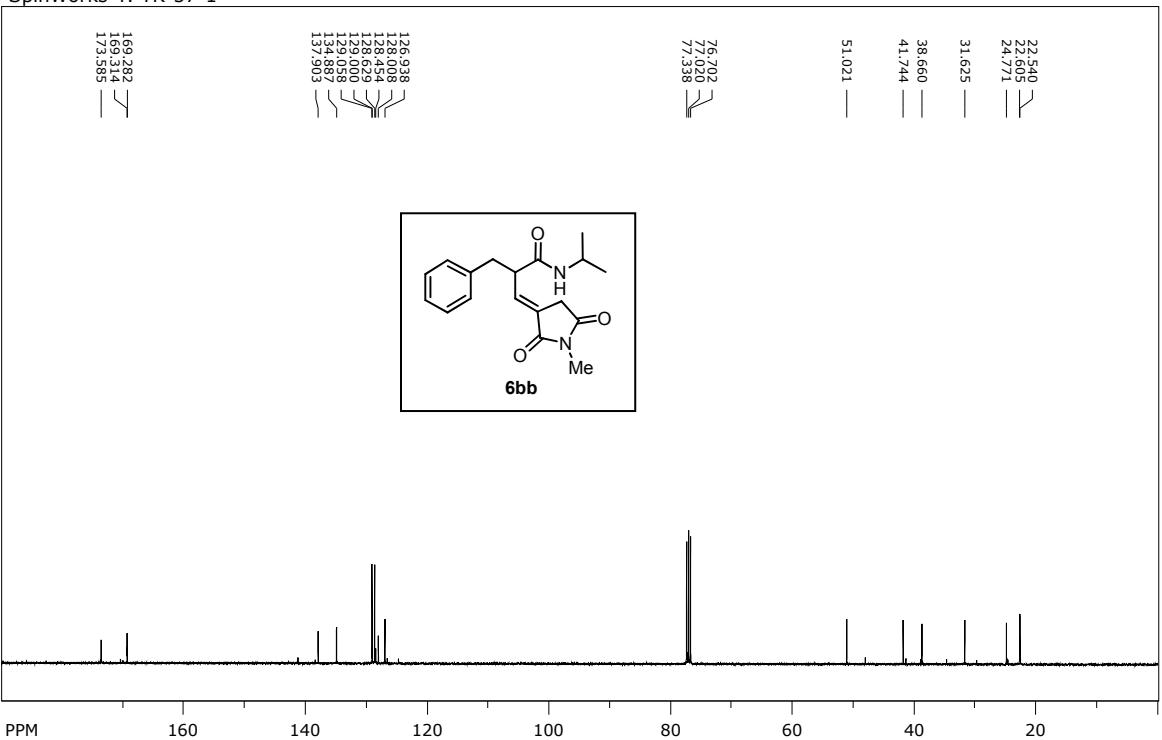
SpinWorks 4: YK-57-2



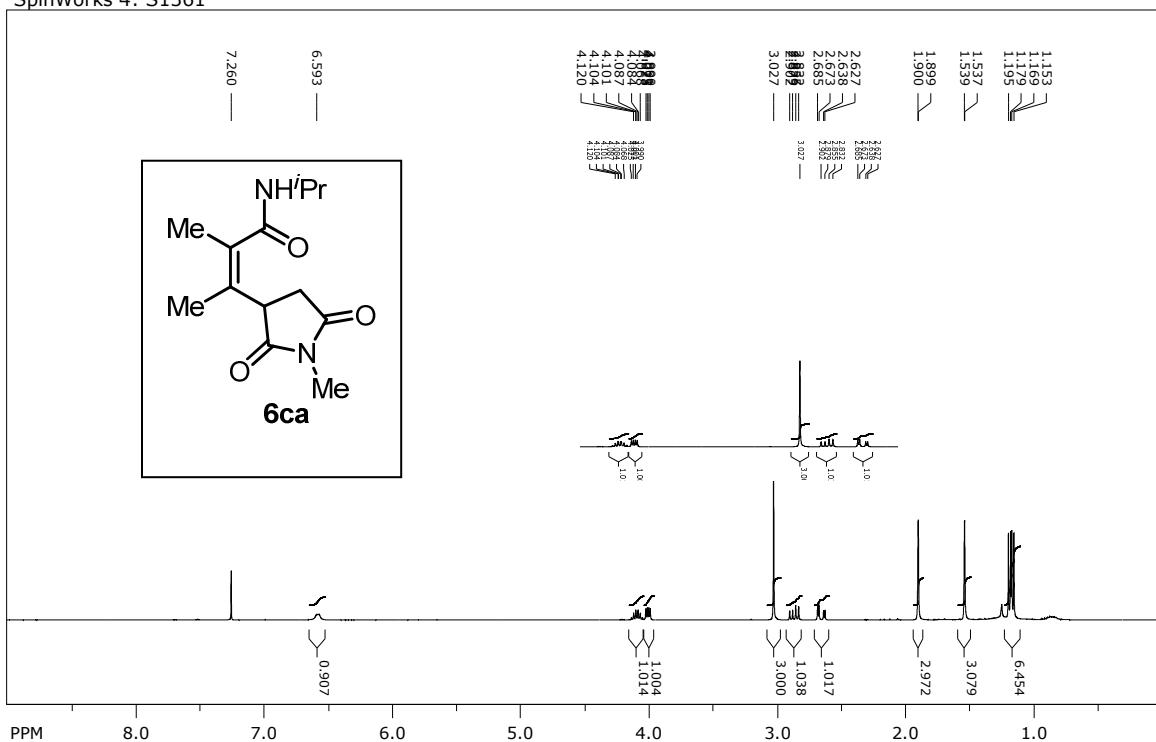
SpinWorks 4: YK57-1



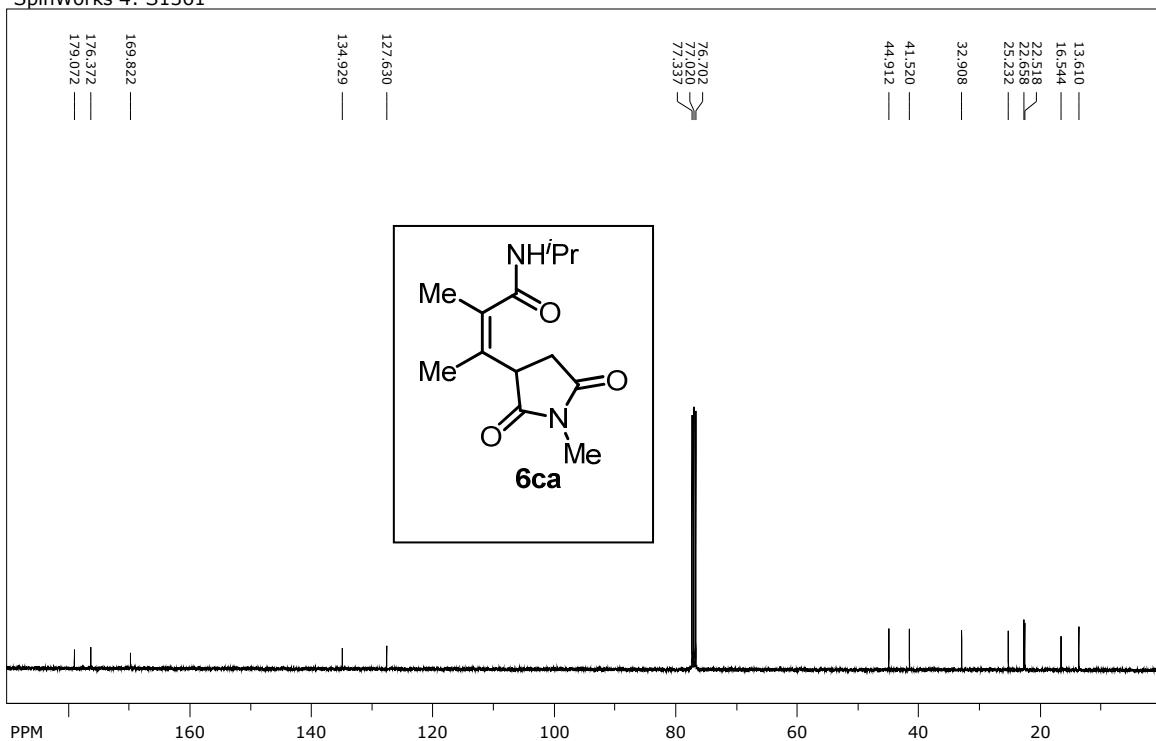
SpinWorks 4: YK-57-1



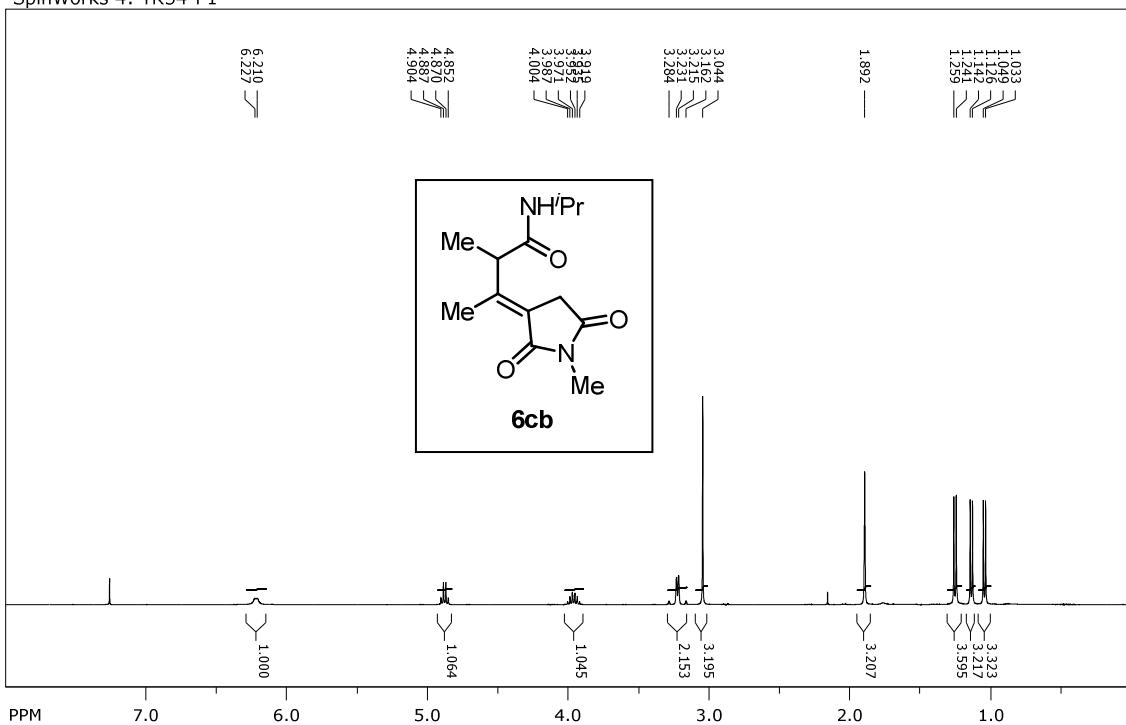
SpinWorks 4: S1361



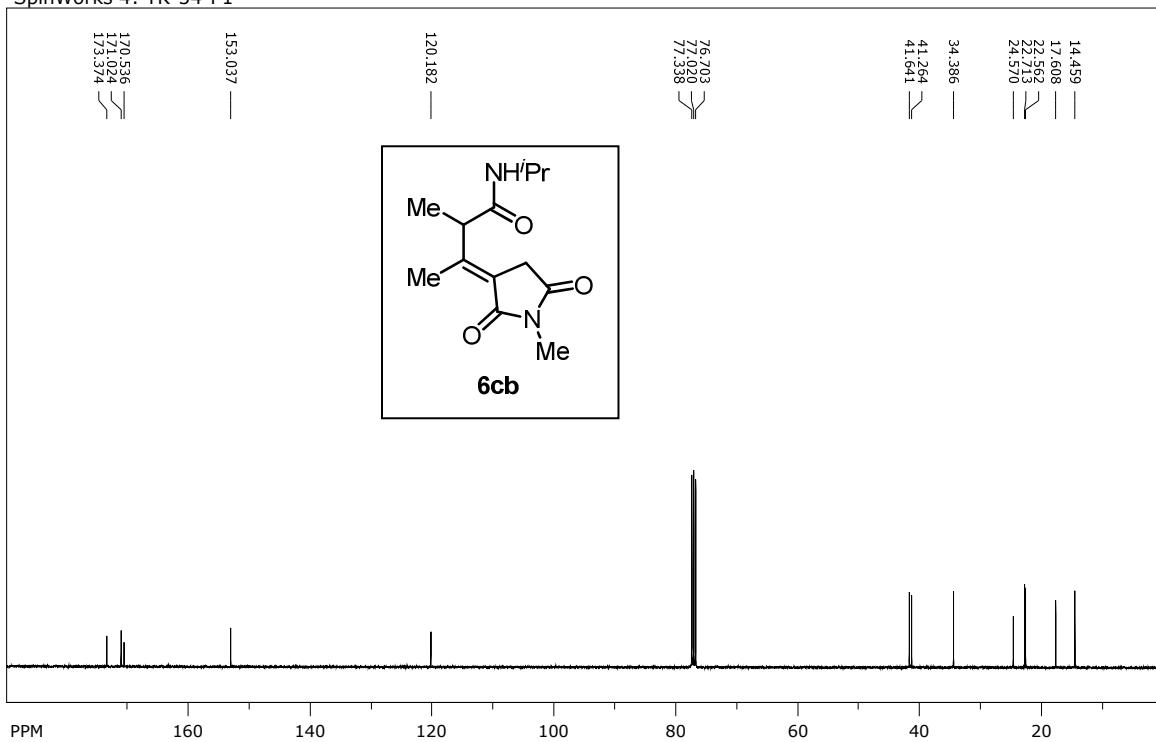
SpinWorks 4: S1361



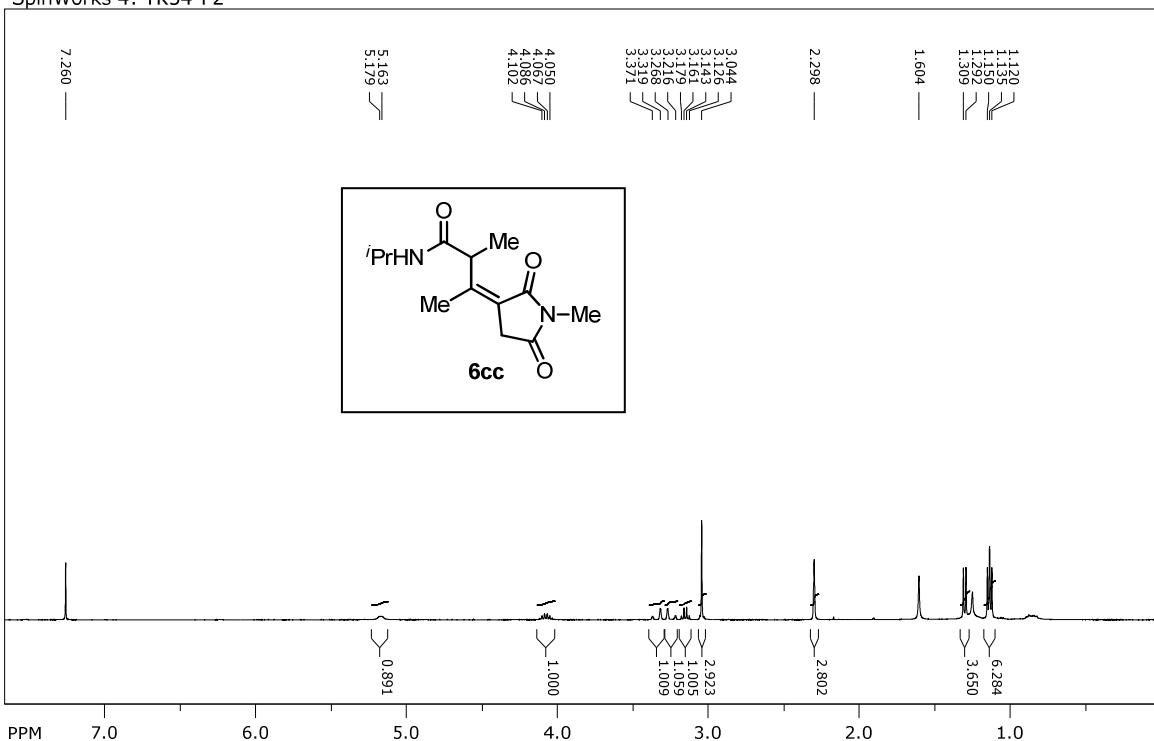
SpinWorks 4: YK54-P1



SpinWorks 4: YK-54-P1



SpinWorks 4: YK54-P2



SpinWorks 4: YK-54-P2

