

Diastereoselective Multi-Component tandem condensation: Synthesis of 2-amino-4-(2-furanone)-4*H*-chromene-3-carbonitriles

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Supporting Information

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1. General Information: Bruker 300 MHz or 400 MHz have been used to record ^1H NMR and ^{13}C NMR in deuterated solvents with residual protonated solvent signal as internal signal. ^1H NMR data are reported as follows: Chemical shifts are reported in parts per million (δ , ppm), multiplicity (s = singlet, d = doublet, t = triplet, q = quartet, m = multiplet, br = broad), integration, coupling constant (J) in hertz (Hz). ^{13}C NMR are recorded in terms of chemical shifts (δ , ppm). Column chromatography were carried out on silica gel (100-200 mesh). Perkin Elmer FT-IR spectrometer used to record infrared spectra on KBr pellets and data are reported in terms of frequency of absorption. All solvents were dried and stored over microwave activated 4A° molecular sieves. Melting points were obtained with open capillary tubes and are uncorrected. Commercially available compounds were used without further purification.

Materials: Salicylaldehydes **1a-n** and **1s** were purchased from commercial source and used without further purification. Malononitrile **2** and α -Angelica **3a** lactone were purchased from Sigma Aldrich and Alfa Aesar respectively and used without purification. γ -crotonolactone **5a** was purchased from TCI company. Salicylaldehydes **1o-r** was prepared according to the Suzuki-Miyaura coupling reaction of **1c** with corresponding aryl boronic acids.¹ Unsaturated β,γ -butenolides **3b-d**,² **3e**³ and α,β -butenolides **5a-b**² and **5c**⁴ were prepared according to the known literature procedure.²

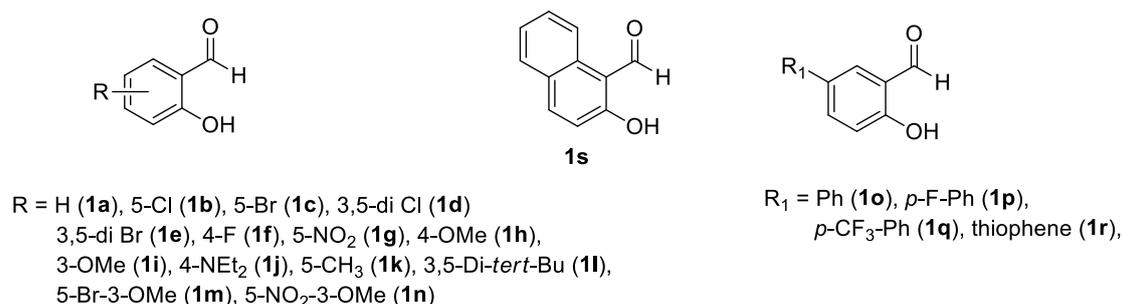
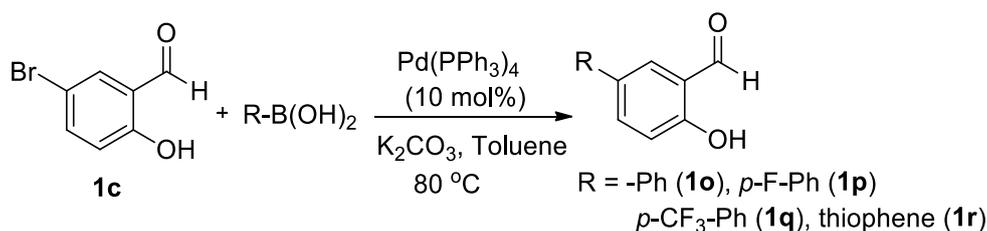


Figure S1. Structure of salicylaldehydes **1**



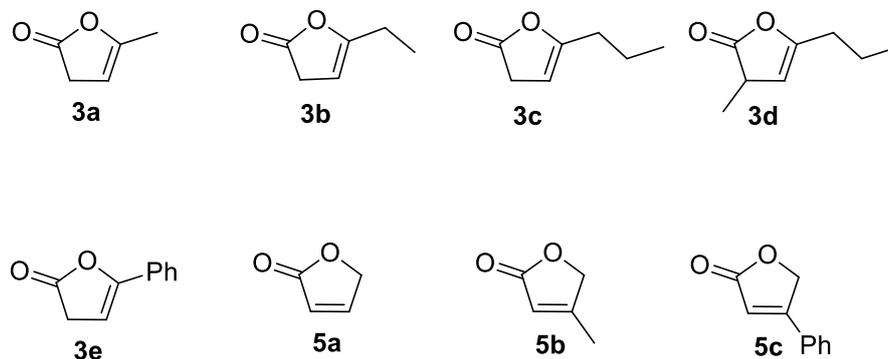
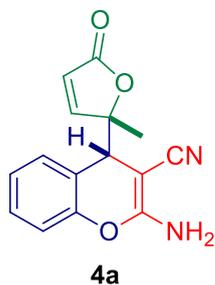


Figure S2. Structure of γ -butenolides

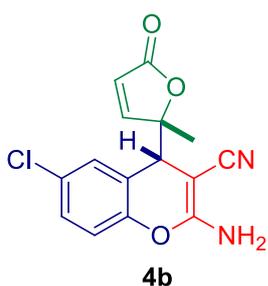
2. Characterizations of Products

2-amino-4-(2-methyl-5-oxo-2,5-dihydrofuran-2-yl)-4H-chromene-3-carbonitrile (4a).



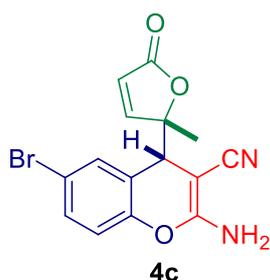
Salicylaldehyde **1a** (24.4 mg, 0.2 mmol), malononitrile (13.2 mg, 0.2 mmol) and α -Angelica lactone **3a** (27 μ L, 0.3 mmol) were taken in 1 ml of dry 1,4-dioxane. To this, sodium tert-butoxide (19.2 mg, 0.2 mmol) was added under nitrogen gas atmosphere. The reaction was run for 16 h. The reaction was quenched by adding water (5 ml) and the product was extracted with ethyl acetate (10 ml x 3). The ratio of diastereomers were determined by ¹H NMR analysis of crude reaction mixture (δ major: 3.68 ppm, δ minor: 3.84 ppm) and found to be 7.33:1 (major *syn* adduct). The crude mixture was purified by column chromatography on silica gel (eluent: ethylacetate/DCM = 1/3, v/v) afforded inseparable mixture of diastereomers as white solid (43 mg, 81% yield, mp 132-134 °C). ¹H-NMR (300 MHz, DMSO-*d*₆) δ 7.66 (d, *J* = 5.7 Hz, 1H), 7.30 (t, *J* = 8.5 Hz, 2H), 7.18 (s, 2H), 7.14 (d, *J* = 7.4 Hz, 1H), 7.02 (d, *J* = 8.0 Hz, 1H), 6.02 (d, *J* = 5.7 Hz, 1H), 3.88 (s, 1H), 1.40 (s, 3H). ¹³C-NMR (75 MHz, CDCl₃) δ 171.7, 163.1, 158.7, 150.5, 130.6, 129.4, 125.2, 121.9, 120.4, 118.9, 116.5, 92.2, 54.1, 44.9, 19.5. FTIR (KBr) cm⁻¹: 3392, 3316, 2928, 2188, 1741, 1643, 1608, 1412, 1267, 1224, 1110, 1049, 822, 762. HRMS-ESI [M+Na]⁺, calcd for C₁₅H₁₂N₂NaO₃ 291.0740, found 291.0740.

2-amino-6-chloro-4-(2-methyl-5-oxo-2,5-dihydrofuran-2-yl)-4H-chromene-3-



carbonitrile (4b). Salicylaldehyde **1b** (31.3 mg, 0.2 mmol), malononitrile (13.2 mg, 0.2 mmol) and α -Angelica lactone **3a** (27 μ L, 0.3 mmol) were taken in 1ml of dry 1,4-dioxane. To this, sodium *tert*-butoxide (19.2 mg, 0.2 mmol) was added under nitrogen gas atmosphere. The reaction was run for 16 h. The reaction was quenched by adding water (5 ml) and the product was extracted with ethyl acetate (10 ml x 3). The ratio of diastereomers were determined by ¹H NMR analysis of crude reaction mixture (δ major: 3.62 ppm, δ minor: 3.78 ppm) and found to be 6.14:1 (major *syn* adduct). The crude mixture was purified by column chromatography on silica gel (eluent: ethylacetate/DCM = 1/3, v/v) afforded inseparable mixture of diastereomer as white solid (38 mg, 63% yield, mp 145-147 °C). ¹H-NMR (400 MHz, DMSO-*d*₆) δ 7.72 (d, *J* = 5.2 Hz, 1H), 7.34 (d, *J* = 8.6 Hz, 1H), 7.29-7.25 (m, 3H), 7.06 (d, *J* = 8.6 Hz, 1H), 6.08 (d, *J* = 5.3 Hz, 1H), 3.92 (s, 1H), 1.41 (s, 3H). ¹³C-NMR (100 MHz, DMSO-*d*₆) δ 171.3, 163.5, 159.7, 149.4, 129.4, 128.6, 127.4, 122.1, 121.0, 120.7, 117.8, 91.8, 49.3, 42.7, 20.5. FTIR (KBr) cm⁻¹: 3388, 3316, 3190, 2926, 2186, 1750, 1646, 1606, 1420, 1187, 1111, 824. HRMS-ESI [*M*+Na]⁺, calcd for C₁₅H₁₁ClN₂NaO₃ 325.0350, found 325.0344.

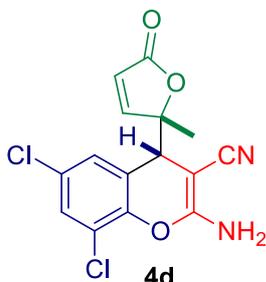
2-amino-6-bromo-4-(2-methyl-5-oxo-2,5-dihydrofuran-2-yl)-4H-chromene-3-



carbonitrile (4c). Salicylaldehyde **1c** (40 mg, 0.2 mmol), malononitrile (13.2 mg, 0.2 mmol) and α -Angelica lactone **3a** (27 μ L, 0.3 mmol) were taken in 1ml of dry 1,4-dioxane. To this, sodium *tert*-butoxide (19.2 mg, 0.2 mmol) was added under nitrogen gas atmosphere. The reaction was run for 16 h. The reaction was quenched by adding water (5 ml) and the product was extracted with ethyl acetate (10 ml x 3). The ratio of diastereomers were determined by ¹H NMR analysis of crude reaction mixture (δ major: 3.64 ppm, δ minor: 3.78 ppm) and found to be 5.25:1 (major *syn* adduct). The crude mixture was purified by column chromatography on silica gel (eluent: ethylacetate/DCM = 1/3, v/v) afforded inseparable mixture of diastereomers as white solid (45 mg, 65% yield, mp 160-163 °C). ¹H-NMR (400 MHz, DMSO-*d*₆) δ 7.72 (d, *J* = 5.7 Hz, 1H), 7.47 (dd, *J* = 8.7, 2.3 Hz, 1H), 7.42 (d, *J* = 2.2 Hz, 1H), 7.32 (s, 2H), 7.01 (d, *J* = 8.7 Hz, 1H), 6.08 (d, *J* = 5.7 Hz, 1H), 3.92 (s, 1H), 1.41 (s, 3H). ¹³C-NMR (75 MHz, DMSO-*d*₆) δ 171.4, 163.5, 159.7, 149.9, 132.3, 131.5, 122.5, 121.0

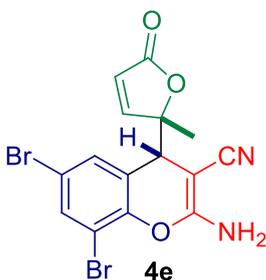
120.7, 118.2, 115.4, 91.9, 49.3, 42.6, 20.6. FTIR (KBr) cm^{-1} : 3395, 3323, 3099, 2927, 2852, 2187, 1751, 1642, 1605, 1412, 1262, 1188, 1109, 914, 823. HRMS-ESI $[\text{M}+\text{Na}]^+$, calcd for $\text{C}_{15}\text{H}_{11}\text{BrN}_2\text{NaO}_3$ 368.9845, found 368.9869.

2-amino-6,8-dichloro-4-(2-methyl-5-oxo-2,5-dihydrofuran-2-yl)-4H-chromene-3-carbonitrile (**4d**).



Salicylaldehyde **1d** (38 mg, 0.2 mmol), malononitrile (13.2 mg, 0.2 mmol) and α -Angelica lactone **3a** (27 μL , 0.3 mmol) were taken in 1ml of dry DCM. To this, sodium tert-butoxide (19.2 mg, 0.2 mmol) was added under nitrogen gas atmosphere. The reaction was run for 16 h. The reaction was quenched by adding water (5 ml) and the product was extracted with dichloromethane (10 ml x 3). The ratio of diastereomers were determined by ^1H NMR analysis of crude reaction mixture (δ major: 3.63 ppm, δ minor: 3.81 ppm) and found to be 7.33:1 (major syn adduct). The crude mixture was purified by column chromatography on silica gel (eluent: ethylacetate/DCM = 1/3, v/v) afforded inseparable mixture of diastereomer as white solid (48 mg, 64% yield, mp 155-157 $^\circ\text{C}$). ^1H -NMR (300 MHz, $\text{DMSO}-d_6$) δ 7.74 (d, $J = 5.8$ Hz, 1H), 7.67 (s, 1H), 7.47 (s, 2H), 7.30 (s, 1H), 6.09 (d, $J = 5.3$ Hz, 1H), 4.00 (s, 1H), 1.43 (s, 3H). ^{13}C -NMR (100 MHz, CDCl_3) δ 171.2, 162.6, 158.1, 145.2, 130.3, 129.9, 128.7, 122.7, 122.4, 122.2, 119.5, 91.6, 54.2, 45.3, 19.4. FTIR (KBr) cm^{-1} : 3402, 3345, 3202, 2925, 2850, 2187, 1745, 1647, 1608, 1418, 1234, 1167, 1112, 962, 828. HRMS-ESI $[\text{M}+\text{Na}]^+$, calcd for $\text{C}_{15}\text{H}_{10}\text{Cl}_2\text{N}_2\text{NaO}_3$ 358.9960, found 358.9964.

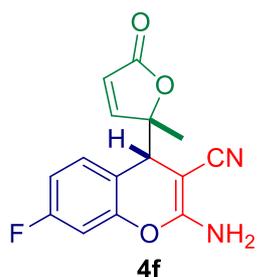
2-amino-6,8-dibromo-4-(2-methyl-5-oxo-2,5-dihydrofuran-2-yl)-4H-chromene-3-carbonitrile (**4e**).



Salicylaldehyde **1e** (60 mg, 0.2 mmol), malononitrile (13.2 mg, 0.2 mmol) and α -Angelica lactone **3a** (27 μL , 0.3 mmol) were taken in 1ml of dry DCM. To this, sodium tert-butoxide (19.2 mg, 0.2 mmol) was added under nitrogen gas atmosphere. The reaction was run for 16 h. The reaction was quenched by adding water (5 ml) and the product was extracted with dichloromethane (10 ml x 3). The ratio of diastereomers were determined by ^1H NMR analysis of crude reaction mixture (δ major: 3.66 ppm, δ minor: 3.80 ppm) and found to be 4.88:1 (major syn adduct). The crude mixture was purified by column chromatography on silica gel (eluent: ethylacetate/DCM = 1/3, v/v) afforded inseparable mixture of diastereomers as white solid (61 mg, 71% yield, mp 109-111 $^\circ\text{C}$). ^1H -NMR (300

MHz, DMSO- d_6) δ 7.83 (d, J = 3 Hz, 1H), 7.72 (d, J = 5.7 Hz, 1H), 7.50-7.39 (m, 3H), 6.08 (d, J = 5.7 Hz, 1H), 3.99 (s, 1H), 1.41 (s, 3H). ^{13}C -NMR (75 MHz, DMSO- d_6) δ 171.3, 163.1, 159.5, 147.0, 134.0, 131.8, 123.9, 120.8, 120.5, 115.5, 110.5, 91.7, 49.7, 43.0, 20.6. FTIR (KBr) cm^{-1} : 3455, 3346, 3201, 2926, 2853, 2187, 1742, 1645, 1520, 1415, 1245, 1173, 1078, 912. HRMS-ESI $[\text{M}+\text{Na}]^+$, calcd for $\text{C}_{15}\text{H}_{10}\text{Br}_2\text{N}_2\text{NaO}_3$ 446.8950, found 446.8946.

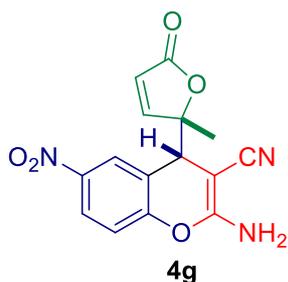
2-amino-7-fluoro-4-(2-methyl-5-oxo-2,5-dihydrofuran-2-yl)-4H-chromene-3-



carbonitrile (4f). Salicylaldehyde **1f** (28 mg, 0.2 mmol), malononitrile (13.2 mg, 0.2 mmol) and α -Angelica lactone **3a** (27 μL , 0.3 mmol) were taken in 1ml of dry 1,4-dioxane. To this, sodium *tert*-butoxide (19.2 mg, 0.2 mmol) was added under nitrogen gas atmosphere. The reaction was run for 16 h. The reaction was quenched by adding water (5 ml) and the product was extracted with ethyl acetate (10 ml x 3). The ratio of diastereomers

were determined by ^1H NMR analysis of crude reaction mixture (δ major: 3.67 ppm, δ minor: 3.76 ppm) and found to be 4.55:1 (major syn adduct). The crude mixture was purified by column chromatography on silica gel (eluent: ethylacetate/DCM = 1/3, v/v) afforded inseparable mixture of diastereomer as white solid (35 mg, 61% yield, mp 154-157 $^\circ\text{C}$). ^1H -NMR (400 MHz, DMSO- d_6) δ 7.68 (d, J = 5.7 Hz, 1H), 7.26 (s, 2H), 7.23 (dd, J = 8.4, 6.7 Hz, 1H), 7.01 (td, J = 8.6, 2.4 Hz, 1H), 6.93 (dd, J = 9.4, 2.3 Hz, 1H), 6.03 (d, J = 5.7 Hz, 1H), 3.90 (s, 1H), 1.41 (s, 3H). ^{13}C -NMR (100 MHz, DMSO- d_6) δ 171.5, 163.4, 162.7 ($J_{\text{C-F}}$ = 243 Hz), 159.8, 151.3 (d, $J_{\text{C-F}}$ = 12.4 Hz), 131.5 (d, $J_{\text{C-F}}$ = 9.6 Hz), 121.1, 120.7, 116.4 (d, $J_{\text{C-F}}$ = 3.1 Hz), 111.0 (d, $J_{\text{C-F}}$ = 21 Hz), 103.6 (d, $J_{\text{C-F}}$ = 26 Hz), 92.0, 49.9, 42.5, 20.6. FTIR (KBr) cm^{-1} : 3476, 3314, 3191, 2924, 2196, 1745, 1648, 1501, 1409, 1294, 1145, 1112, 960, 839. HRMS-ESI $[\text{M}+\text{Na}]^+$, calcd for $\text{C}_{15}\text{H}_{11}\text{FN}_2\text{NaO}_3$ 309.0646, found 309.0660.

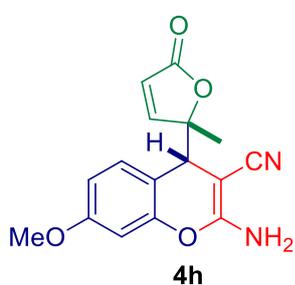
2-amino-4-(2-methyl-5-oxo-2,5-dihydrofuran-2-yl)-6-nitro-4H-chromene-3-carbonitrile



(4g). Salicylaldehyde **1g** (33.4 mg, 0.2 mmol), malononitrile (13.2 mg, 0.2 mmol) and α -Angelica lactone **3a** (27 μL , 0.3 mmol) were taken in 1ml of dry 1,4-dioxane. To this, sodium *tert*-butoxide (19.2 mg, 0.2 mmol) was added under nitrogen gas atmosphere. The reaction was run for 16 h. The reaction was quenched by adding water (5 ml) and the product was extracted with ethyl acetate (10 ml x 3). The ratio of diastereomers were determined by ^1H NMR analysis of

crude reaction mixture (δ major: 3.77 ppm, δ minor: 3.90 ppm) and found to be 1.22:1 (major *syn* adduct). The crude mixture was purified by column chromatography on silica gel (eluent: ethylacetate/DCM = 1/3, v/v) afforded inseparable mixture of diastereomer as yellow solid (28 mg, 46% yield, mp 184-186 °C). $^1\text{H-NMR}$ (300 MHz, DMSO- d_6) δ 8.20-8.15 (m, 2H), 7.79 (d, J = 5.6 Hz, 1H), 7.47 (s, 2H), 7.29 (d, J = 8.5 Hz, 1H), 6.04 (d, J = 5.6 Hz, 1H), 4.14 (s, 1H), 1.45 (s, 3H). $^{13}\text{C-NMR}$ (75 MHz, DMSO- d_6) δ 171.2, 162.9, 159.5, 155.0, 143.0, 125.8, 124.6, 121.3, 120.9, 120.6, 117.3, 91.8, 49.3, 42.3, 20.4. FTIR (KBr) cm^{-1} : 3419, 3323, 3205, 2926, 2191, 1740, 1649, 1525, 1413, 1344, 1257, 1094, 959, 828. HRMS-ESI $[\text{M}+\text{Na}]^+$, calcd for $\text{C}_{15}\text{H}_{11}\text{N}_3\text{NaO}_5$ 336.0591, found 336.0591.

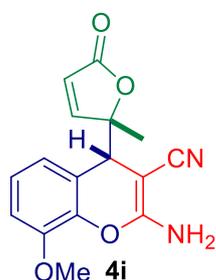
2-amino-7-methoxy-4-(2-methyl-5-oxo-2,5-dihydrofuran-2-yl)-4H-chromene-3-



carbonitrile (4h). Salicylaldehyde **1h** (30.4 mg, 0.2 mmol), malononitrile (13.2 mg, 0.2 mmol) and α -Angelica lactone **3a** (27 μL , 0.3 mmol) were taken in 1ml of dry 1,4-dioxane. To this, sodium *tert*-butoxide (19.2 mg, 0.2 mmol) was added under nitrogen gas atmosphere. The reaction was run for 16 h. The reaction was quenched by adding water (5 ml) and the product was

extracted with ethyl acetate (10 ml x 3). The ratio of diastereomers were determined by ^1H NMR analysis of crude reaction mixture (δ major: 3.62 ppm, δ minor: 3.75 ppm) and found to be 4.2:1 (major *syn* adduct). The crude mixture was purified by column chromatography on silica gel (eluent: ethylacetate/DCM = 1/3, v/v) afforded inseparable mixture of diastereomer as white solid (43 mg, 72% yield, mp 152-154 °C). $^1\text{H-NMR}$ (300 MHz, DMSO- d_6) δ 7.63 (d, J = 5.7 Hz, 1H), 7.13 (s, 2H), 7.09 (d, J = 8.6 Hz, 1H), 6.72 (dd, J = 8.5, 2.6 Hz, 1H), 6.53 (d, J = 2.5 Hz, 1H), 6.03 (d, J = 5.7 Hz, 1H), 3.90 (s, 1H), 3.78 (s, 3H), 1.39 (s, 3H). $^{13}\text{C-NMR}$ (75 MHz, DMSO- d_6) δ 171.5, 163.6, 159.8, 159.4, 151.3, 130.6, 121.3, 120.7, 111.9, 110.2, 101.1, 92.2, 55.4, 50.1, 42.6, 20.6. FTIR (KBr) cm^{-1} : 3446, 3331, 3213, 2924, 2851, 2183, 1744, 1654, 1507, 1409, 1254, 1160, 1112, 961, 815. HRMS-ESI $[\text{M}+\text{Na}]^+$, calcd for $\text{C}_{16}\text{H}_{14}\text{N}_2\text{NaO}_4$ 321.0846, found 321.0852.

2-amino-8-methoxy-4-(2-methyl-5-oxo-2,5-dihydrofuran-2-yl)-4H-chromene-3-

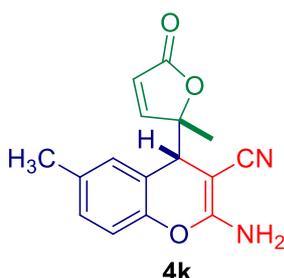


carbonitrile (4i). Salicylaldehyde **1i** (30.4 mg, 0.2 mmol), malononitrile (13.2 mg, 0.2 mmol) and α -Angelica lactone **3a** (27 μL , 0.3 mmol) were taken in 1ml of dry 1,4-dioxane. To this, sodium *tert*-butoxide (19.2 mg, 0.2 mmol) was added under nitrogen gas

atmosphere. The reaction was run for 16 h. The reaction was quenched by adding water (5 ml) and the product was extracted with ethyl acetate (10 ml x 3). The ratio of diastereomers were determined by ^1H NMR analysis of crude reaction mixture (δ major: 3.62 ppm, δ minor: 3.78 ppm) and found to be 1.70:1 (major *syn* adduct). The crude mixture was purified by column chromatography on silica gel (eluent: ethylacetate/DCM = 1/3, v/v) afforded inseparable mixture of diastereomer as white solid (45 mg, 75% yield, mp 179-181 °C).

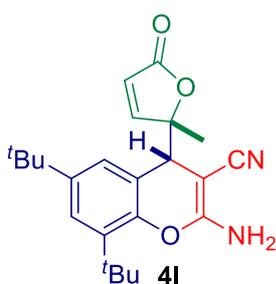
^1H -NMR (400 MHz, DMSO- d_6) δ 7.63 (d, J = 4.7 Hz, 1H), 7.18 (s, 2H), 7.12 – 6.95 (m, 2H), 6.76 (d, J = 6.6 Hz, 1H), 6.02 (d, J = 4.6 Hz, 1H), 3.85 (s, 1H), 3.80 (s, 3H), 1.40 (s, 3H). ^{13}C -NMR (100 MHz, DMSO- d_6) δ 171.5, 163.7, 159.7, 147.0, 139.9, 123.7, 121.2, 121.0, 120.6, 111.6, 92.0, 55.7, 49.6, 43.3, 20.8. FTIR (KBr) cm^{-1} : 3362, 3333, 3203, 2923, 2854, 2192, 1746, 1652, 1584, 1422, 1279, 1206, 1108, 963, 826. HRMS-ESI $[\text{M}+\text{Na}]^+$, calcd for $\text{C}_{16}\text{H}_{14}\text{N}_2\text{NaO}_4$ 321.0846, found 321.0849.

2-amino-6-methyl-4-(2-methyl-5-oxo-2,5-dihydrofuran-2-yl)-4H-chromene-3-



carbonitrile (4k). Salicylaldehyde **1k** (27.2 mg, 0.2 mmol), malononitrile (13.2 mg, 0.2 mmol) and α -Angelica lactone **3a** (27 μL , 0.3 mmol) were taken in 1ml of dry 1,4-dioxane. To this, sodium *tert*-butoxide (19.2 mg, 0.2 mmol) was added under nitrogen gas atmosphere. The reaction was run for 16 h. The reaction was quenched by adding water (5 ml) and the product was extracted with ethyl acetate (10 ml x 3). The ratio of

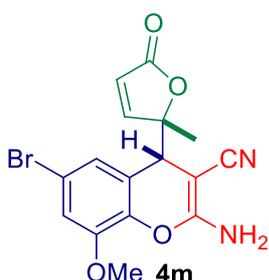
diastereomers were determined by ^1H NMR analysis of crude reaction mixture (δ major: 3.65 ppm, δ minor: 3.82 ppm) and found to be 9:1 (major *syn* adduct). The crude mixture was purified by column chromatography on silica gel (eluent: ethylacetate/DCM = 1/3, v/v) afforded inseparable mixture of diastereomers as white solid (41 mg, 72% yield, mp 161-163 °C). ^1H -NMR (400 MHz, DMSO- d_6) δ 7.63 (d, J = 5.6 Hz, 1H), 7.15 (s, 2H), 7.15–7.07 (m, 1H), 7.00 (s, 1H), 6.91 (d, J = 8.3 Hz, 1H), 6.05 (d, J = 5.6 Hz, 1H), 3.81 (s, 1H), 2.26 (s, 3H), 1.39 (s, 3H). ^{13}C -NMR (75 MHz, DMSO- d_6) δ 171.5, 163.8, 159.7, 148.6, 132.9, 130.1, 129.2, 121.3, 120.7, 119.8, 115.6, 92.1, 49.6, 43.3, 20.7, 20.4. FTIR (KBr) cm^{-1} : 3418, 3328, 3205, 2927, 2856, 2188, 1749, 1648, 1428, 1255, 1189, 1107, 962, 823. HRMS-ESI $[\text{M}+\text{Na}]^+$, calcd for $\text{C}_{16}\text{H}_{14}\text{N}_2\text{NaO}_3$ 305.0897, found 305.0888.



2-amino-6,8-di-*tert*-butyl-4-(2-methyl-5-oxo-2,5-dihydrofuran-2-yl)-4H-chromene-3-carbonitrile (4l). Salicylaldehyde **1l** (46.8

mg, 0.2 mmol), malononitrile (13.2 mg, 0.2 mmol) and α -Angelica lactone **3a** (27 μ L, 0.3 mmol) were taken in 1ml of dry THF. To this, sodium *tert*-butoxide (19.2 mg, 0.2 mmol) was added under nitrogen gas atmosphere. The reaction was run for 16 h. The reaction was quenched by adding water (5 ml) and the product was extracted with ethyl acetate (10 ml x 3). The ratio of diastereomers was determined by ^1H NMR analysis of crude reaction mixture (δ major: 3.71 ppm, δ minor: 3.81 ppm) and found to be 11.5:1 (major *syn* adduct). The crude mixture was purified by column chromatography on silica gel (eluent: ethylacetate/DCM = 1/3, v/v) afforded inseparable mixture of diastereomer as white solid (48 mg, 64% yield, mp 139-141 $^\circ\text{C}$). ^1H -NMR (400 MHz, CDCl_3) δ 7.45 (d, $J = 5.3$ Hz, 1H), 7.29 (s, 1H), 7.01 (s, 1H), 5.99 (d, $J = 5.3$ Hz, 1H), 4.80 (s, 2H), 3.68 (s, 1H), 1.56 (s, 3H), 1.40 (s, 9H), 1.30 (s, 9H). ^{13}C -NMR (100 MHz, CDCl_3) δ 171.7, 162.9, 158.3, 147.4, 147.1, 136.8, 125.4, 123.7, 121.9, 120.3, 119.0, 92.3, 54.6, 45.6, 35.1, 34.7, 31.5, 30.4, 20.2. FTIR (KBr) cm^{-1} : 3394, 3329, 3207, 2959, 2869, 2188, 1752, 1648, 1590, 1408, 1225, 1168, 1109, 957, 821. HRMS-ESI $[\text{M}+\text{Na}]^+$, calcd for $\text{C}_{23}\text{H}_{28}\text{N}_2\text{NaO}_3$ 403.1992, found 403.1995.

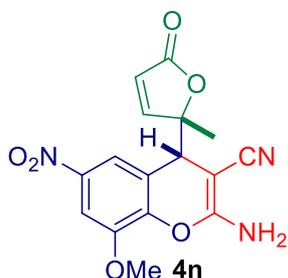
2-amino-6-bromo-8-methoxy-4-(2-methyl-5-oxo-2,5-dihydrofuran-2-yl)-4H-chromene-3-



carbonitrile (4m). Salicylaldehyde **1m** (46.2 mg, 0.2 mmol), malononitrile (13.2 mg, 0.2 mmol) and α -Angelica lactone **3a** (27 μ L, 0.3 mmol) were taken in 1ml of dry 1,4-dioxane. To this, sodium *tert*-butoxide (19.2 mg, 0.2 mmol) was added under nitrogen gas atmosphere. The reaction was run for 16 h. The reaction was quenched by adding water (5 ml) and the product was extracted with ethyl acetate (10 ml x 3). The ratio of diastereomers

was determined by ^1H NMR analysis of crude reaction mixture (δ major: 3.61 ppm, δ minor: 3.78 ppm) and found to be 2.1:1 (major *syn* adduct). The crude mixture was purified by column chromatography on silica gel (eluent: ethylacetate/DCM = 1/3, v/v) afforded inseparable mixture of diastereomers as white solid (41 mg, 70% yield, mp 138-140 $^\circ\text{C}$). ^1H -NMR (300 MHz, $\text{DMSO}-d_6$) δ 7.69 (d, $J = 5.7$ Hz, 1H), 7.29 (s, 2H), 7.20 (d, $J = 2.0$ Hz, 1H), 6.99 (d, $J = 2.0$ Hz, 1H), 6.08 (d, $J = 5.7$ Hz, 1H) 3.88 (s, 1H), 3.83 (s, 3H), 1.40 (s, 3H). ^{13}C -NMR (100 MHz, $\text{DMSO}-d_6$) δ 171.9, 164.0, 160.1, 148.4, 139.8, 123.9, 123.3, 121.4, 121.1, 115.7, 115.2, 92.3, 56.7, 49.8, 43.3, 21.1. FTIR (KBr) cm^{-1} : 3404, 3325, 3203, 2925, 2854, 2187, 1752, 1651, 1575, 1483, 1421, 1263, 2114, 1098, 961, 824. HRMS-ESI $[\text{M}+\text{Na}]^+$, calcd for $\text{C}_{16}\text{H}_{13}\text{BrN}_2\text{NaO}_4$ 398.9951, found 398.9956.

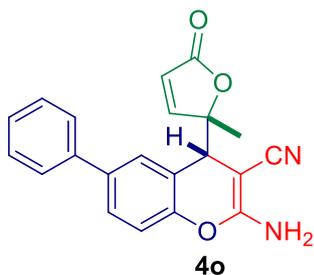
2-amino-8-methoxy-4-(2-methyl-5-oxo-2,5-dihydrofuran-2-yl)-6-nitro-4H-chromene-3-



carbonitrile (4n). Salicylaldehyde **1n** (39.4 mg, 0.2 mmol), malononitrile (13.2 mg, 0.2 mmol) and α -Angelica lactone **3a** (27 μ L, 0.3 mmol) were taken in 1ml of dry 1,4-dioxane. To this, sodium *tert*-butoxide (19.2 mg, 0.2 mmol) was added under nitrogen gas atmosphere. The reaction was run for 16 h. The reaction was quenched by adding water (5 ml) and the product was extracted with ethyl acetate (10 ml x 3). The ratio of

diastereomers were determined by ^1H NMR analysis of crude reaction mixture (δ major: 3.74 ppm, δ minor: 3.87 ppm) and found to be 1.86:1 (major *syn* adduct). The crude mixture was purified by column chromatography on silica gel (eluent: ethylacetate/DCM = 1/3, v/v) afforded inseparable mixture of diastereomer as yellow solid (31 mg, 45% yield, mp 186-188 $^\circ\text{C}$). ^1H -NMR (300 MHz, DMSO- d_6) δ 7.78 (dd, $J = 7.4, 4.1$ Hz, 3H), 7.49 (s, 2H), 6.05 (d, $J = 5.7$ Hz, 1H), 4.11 (s, 1H), 3.94 (s, 3H), 1.44 (s, 3H). ^{13}C -NMR (75 MHz, DMSO- d_6) δ 171.3, 162.9, 159.5, 147.5, 144.7, 142.8, 121.5, 120.8, 120.6, 117.1, 106.6, 91.7, 56.5, 49.4, 42.6, 20.5. FTIR (KBr) cm^{-1} : 3381, 3329, 2924, 2854, 2194, 1746, 1655, 1529, 1416, 1344, 1227, 1104, 960, 825. HRMS-ESI $[\text{M}+\text{Na}]^+$, calcd for $\text{C}_{16}\text{H}_{13}\text{N}_3\text{NaO}_6$ 366.0697, found 366.0708.

2-amino-4-(2-methyl-5-oxo-2,5-dihydrofuran-2-yl)-6-phenyl-4H-chromene-3-

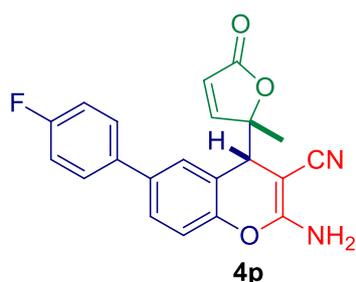


carbonitrile (4o). Salicylaldehyde **1o** (30.4 mg, 0.2 mmol), malononitrile (13.2 mg, 0.2 mmol) and α -Angelica lactone **3a** (27 μ L, 0.3 mmol) were taken in 1ml of dry 1,4-dioxane. To this, sodium *tert*-butoxide (19.2 mg, 0.2 mmol) was added under nitrogen gas atmosphere. The reaction was run for 5 h. The reaction was quenched by adding water (5 ml) and the product

was extracted with ethyl acetate (10 ml x 3). The ratio of diastereomers were determined by ^1H NMR analysis of crude reaction mixture (δ major: 3.68 ppm, δ minor: 3.85 ppm) and found to be 4.6:1 (major *syn* adduct). The crude mixture was purified by column chromatography on silica gel (eluent: ethylacetate/DCM = 1/3, v/v) afforded inseparable mixture of diastereomer as yellow solid (49 mg, 72% yield, mp 152-154 $^\circ\text{C}$). ^1H -NMR (300 MHz, DMSO- d_6) δ 7.77 (d, $J = 5.6$ Hz, 1H), 7.59 (t, $J = 8.9$ Hz, 3H), 7.53 – 7.40 (m, 3H), 7.37 (d, $J = 6.5$ Hz, 1H), 7.25 (s, 2H), 7.11 (d, $J = 8.5$ Hz, 1H), 6.05 (d, $J = 5.6$ Hz, 1H), 3.97 (s, 1H), 1.46 (s, 3H). ^{13}C -NMR (75 MHz, DMSO- d_6) δ 171.5, 163.7, 159.9, 150.1, 139.2,

135.8, 129.0, 128.3, 127.4, 127.0, 126.6, 126.5, 121.2, 120.6, 120.4, 116.3, 92.1, 49.6, 43.2, 20.8. FTIR (KBr) cm^{-1} : 3395, 3323, 3198, 2985, 2928, 2189, 1746, 1644, 1577, 1455, 1409, 1345, 1287, 1110, 1049, 961, 822. HRMS-ESI $[\text{M}+\text{Na}]^+$, calcd for $\text{C}_{21}\text{H}_{16}\text{N}_2\text{NaO}_3$ 367.1053, found 367.1064.

2-amino-6-(4-fluorophenyl)-4-(2-methyl-5-oxo-2,5-dihydrofuran-2-yl)-4H-chromene-3-



carbonitrile (4p). Salicylaldehyde **1p** (43.2 mg, 0.2 mmol),

malononitrile (13.2 mg, 0.2 mmol) and α -Angelica lactone **3a**

(27 μL , 0.3 mmol) were taken in 1ml of dry 1,4-dioxane. To

this, sodium *tert*-butoxide (19.2 mg, 0.2 mmol) was added

under nitrogen gas atmosphere. The reaction was run for 5 h.

The reaction was quenched by adding water (5 ml) and the

product was extracted with ethyl acetate (10 ml x 3). The ratio of diastereomers were

determined by ^1H NMR analysis of crude reaction mixture (δ major: 3.71 ppm, δ minor: 3.91

ppm) and found to be 4.9:1 (major syn adduct). The crude mixture was purified by column

chromatography on silica gel (eluent: ethylacetate/DCM = 1/3, v/v) afforded inseparable

mixture of diastereomer as white solid (47 mg, 65% yield, mp 167-169 $^\circ\text{C}$). ^1H -NMR (400

MHz, DMSO-d_6) δ 7.76 (d, $J = 5.5$ Hz, 1H), 7.64 (d, $J = 2.5$ Hz, 2H), 7.58 – 7.50 (m, 1H),

7.47 (s, 1H), 7.30 (t, $J = 8.7$ Hz, 2H), 7.24 (s, 2H), 7.11 (d, $J = 8.4$ Hz, 1H), 6.05 (d, $J = 5.5$

Hz, 1H), 3.95 (s, 1H), 1.46 (s, 3H). ^{13}C -NMR (75 MHz, DMSO-d_6) δ 171.47, 163.68, 163.41

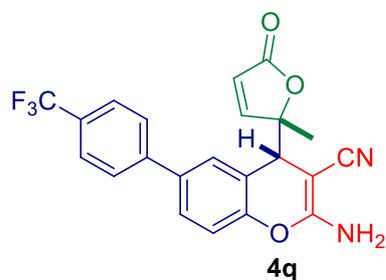
(d, $J_{\text{C-F}} = 240$ Hz), 159.89, 150.09, 135.7 (d, $J_{\text{C-F}} = 3$ Hz), 134.8, 128.6, 128.5, 128.2, 127.0,

121.2, 120.6 (d, $J_{\text{C-F}} = 9.8$ Hz) , 116.4, 115.9 (d, $J_{\text{C-F}} = 22$ Hz), 92.0, 62.0, 49.6, 43.2, 20.8.

FTIR (KBr) cm^{-1} : 3476, 3315, 3202, 2923, 2855, 2189, 1746, 1645, 1520, 1408, 1295, 1174,

1108, 962, 822. HRMS-ESI $[\text{M}+\text{Na}]^+$, calcd for $\text{C}_{21}\text{H}_{15}\text{FN}_2\text{NaO}_3$ 385.0959, found 385.0954.

2-amino-4-(2-methyl-5-oxo-2,5-dihydrofuran-2-yl)-6-(4-(trifluoromethyl)phenyl)-4H-



chromene-3-carbonitrile (4q). Salicylaldehyde **1q** (53.2

mg, 0.2 mmol), malononitrile (13.2 mg, 0.2 mmol) and α -

Angelica lactone (27 μL , 0.3 mmol) were taken in 1ml of dry 1,4-dioxane. To this, sodium *tert*-butoxide (19.2 mg,

0.2 mmol) was added under nitrogen gas atmosphere. The

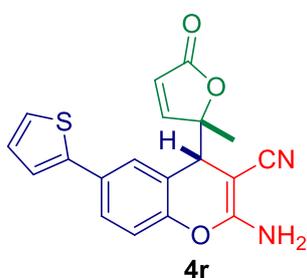
reaction was run for 5 h. The reaction was quenched by

adding water (5 ml) and the product was extracted with ethyl acetate (10 ml x 3). The ratio of

diastereomers were determined by ^1H NMR analysis of crude reaction mixture (δ major: 3.77

ppm, δ minor: 3.97 ppm) and found to be 7.3:1 (major *syn* adduct). The crude mixture was purified by column chromatography on silica gel (eluent: ethylacetate/DCM = 1/3, v/v) afforded inseparable mixture of diastereomer as white solid (62 mg, 75% yield, mp 165 °C). $^1\text{H-NMR}$ (400 MHz, DMSO- d_6) δ 7.91–7.78 (m, 4H), 7.77 (d, J = 5.7 Hz, 1H), 7.67 (dd, J = 8.5, 1.9 Hz, 1H), 7.58 (d, J = 2.0 Hz, 1H), 7.28 (s, 2H), 7.16 (d, J = 8.5 Hz, 1H), 6.04 (d, J = 5.7 Hz, 1H), 3.99 (s, 1H), 1.47 (s, 3H). $^{13}\text{C-NMR}$ (75 MHz, DMSO- d_6) δ 171.5, 163.6, 159.9, 150.8, 143.1, 134.1, 128.8, 128.0, 127.5, 127.3, 126.1, 125.9 (q, $J_{\text{C-F}}$ = 3.75 Hz), 122.5, 121.2, 120.7, 120.6, 116.6, 92.0, 62.0, 49.6, 43.1, 20.7. FTIR (KBr) cm^{-1} : 3478, 3314, 3191, 2924, 2855, 2188, 1745, 1644, 1502, 1410, 1298, 1148, 1112, 1040, 961. 841. HRMS-ESI $[\text{M}+\text{K}]^+$, calcd for $\text{C}_{22}\text{H}_{15}\text{F}_3\text{N}_2\text{KO}_3$ 451.0666, found 3451.0653.

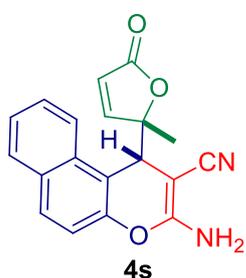
2-amino-4-(2-methyl-5-oxo-2,5-dihydrofuran-2-yl)-6-(thiophen-2-yl)-4H-chromene-3-carbonitrile (**4r**).



Salicylaldehyde **1r** (40.8 mg, 0.2 mmol), malononitrile (13.2 mg, 0.2 mmol) and α -Angelica lactone (27 μL , 0.3 mmol) were taken in 1ml of dry 1,4-dioxane. To this, sodium *tert*-butoxide (19.2 mg, 0.2 mmol) was added under nitrogen gas atmosphere. The reaction was run for 24 h. The reaction was quenched by adding water (5 ml) and the product

was extracted with ethyl acetate (10 ml x 3). The ratio of diastereomers were determined by $^1\text{H NMR}$ analysis of crude reaction mixture (δ major: ppm, δ minor: ppm) and found to be 5.66:1 (major *syn* adduct). The crude mixture was purified by column chromatography on silica gel (eluent: ethylacetate/DCM = 1/3, v/v) afforded inseparable mixture of diastereomer as yellow solid (49 mg, 70% yield, mp 148-150 °C). $^1\text{H-NMR}$ (300 MHz, DMSO- d_6) δ 7.74 (d, J = 5.7 Hz, 1H), 7.58 – 7.52 (m, 2H), 7.48 (s, 1H), 7.42 (d, J = 2.8 Hz, 1H), 7.23 (s, 2H), 7.14 – 7.12 (m, 1H), 7.07 (d, J = 8.5 Hz, 1H), 6.04 (d, J = 5.6 Hz, 1H), 3.95 (s, 1H), 1.45 (s, 3H). $^{13}\text{C-NMR}$ (75 MHz, DMSO- d_6) δ 171.4, 163.6, 159.8, 149.9, 142.3, 129.5, 128.5, 126.9, 125.9, 125.7, 123.7, 121.1, 120.7, 120.6, 116.6, 92.0, 49.5, 43.0, 20.7. FTIR (KBr) cm^{-1} : 3458, 3338, 3198, 2923, 2854, 2183, 1747, 1645, 1504, 1410, 1291, 1142, 961, 840. HRMS-ESI $[\text{M}+\text{Na}]^+$, calcd for $\text{C}_{19}\text{H}_{14}\text{N}_2\text{NaO}_3\text{S}$ 373.0617, found 373.0628.

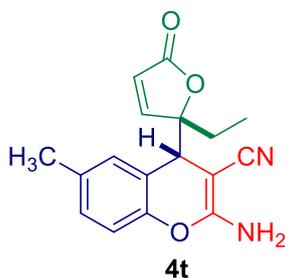
3-amino-1-(2-methyl-5-oxo-2,5-dihydrofuran-2-yl)-1H-benzo[f]chromene-2-carbonitrile (**4s**).



Salicylaldehyde **1s** (30.4 mg, 0.2 mmol), malononitrile (13.2 mg, 0.2 mmol) and α -Angelica lactone **3a** (27 μL , 0.3 mmol) were taken in 1ml of dry 1,4-dioxane. To this, sodium *tert*-butoxide (19.2

mg, 0.2 mmol) was added under nitrogen gas atmosphere. The reaction was run for 24 h. The reaction was quenched by adding water (5 ml) and the product was extracted with ethyl acetate (10 ml x 3). The ratio of diastereomers was determined by ¹H NMR analysis of crude reaction mixture (δ major: 4.57 ppm, δ minor: 4.47 ppm) and found to be 4:1 (major syn adduct). The crude mixture was purified by column chromatography on silica gel (eluent: ethylacetate/DCM = 1/3, v/v) afforded inseparable mixture of diastereomer as yellow solid (34 mg, 54% yield, mp 146-148 °C). ¹H-NMR (400 MHz, DMSO-*d*₆) δ 8.22 (d, *J* = 8.3 Hz, 1H), 7.98–7.80 (m, 2H), 7.60 (d, *J* = 4.7 Hz, 2H), 7.48 (d, *J* = 6.4 Hz, 1H), 7.31 (s, 2H), 7.24 (d, *J* = 8.6 Hz, 1H), 5.61 (d, *J* = 5.0 Hz, 1H), 4.62 (s, 1H), 1.54 (s, 3H). ¹³C-NMR (100 MHz, DMSO-*d*₆) δ 171.4, 164.1, 159.2, 149.0, 130.7, 130.4, 129.4, 128.4, 126.9, 124.9, 123.9, 121.4, 119.3, 116.6, 113.8, 93.0, 50.4, 39.0, 21.0. FTIR (KBr) cm⁻¹: 3446, 3325, 3205, 2925, 2854, 2183, 1744, 1643, 1585, 1415, 1243, 1107, 959, 818. HRMS-ESI [M+Na]⁺, calcd for C₁₉H₁₄N₂NaO₃ 341.0896, found 341.0902.

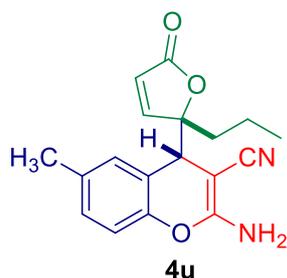
2-amino-4-(2-ethyl-5-oxo-2,5-dihydrofuran-2-yl)-6-methyl-4*H*-chromene-3-carbonitrile



(**4t**). Salicylaldehyde **1k** (27.2 mg, 0.2 mmol), malononitrile (13.2 mg, 0.2 mmol) and 5-ethylfuran-2(3*H*)-one **3b** (33.6 mg, 0.3 mmol) were taken in 1ml of dry 1,4-dioxane. To this, sodium tert-butoxide (19.2 mg, 0.2 mmol) was added under nitrogen gas atmosphere. The reaction was run for 16 h. The reaction was quenched by adding water (5 ml) and the product

was extracted with ethyl acetate (10 ml x 3). The ratio of diastereomers were determined by ¹H NMR analysis of crude reaction mixture (δ major: 3.68 ppm, δ minor: 3.85 ppm) and found to be 4:1 (major syn adduct). The crude mixture was purified by column chromatography on silica gel (eluent: ethylacetate/DCM = 1/3, v/v) afforded inseparable mixture of diastereomer as sticky solid (35 mg, 60% yield). ¹H-NMR (400 MHz, CDCl₃) δ 7.40 (d, *J* = 5.3 Hz, 1H), 6.99 (s, 2H), 6.84 (d, *J* = 8.0 Hz, 1H), 4.81 (s, 2H), 3.61 (s, 1H), 2.27 (s, 3H), 2.08 – 1.82 (m, 2H), 0.63 (t, *J* = 7.1 Hz, 3H). ¹³C-NMR (100 MHz, CDCl₃) δ 171.1, 163.3, 157.2, 155.7, 148.7, 134.9, 134.7, 130.6, 129.9, 129.7, 124.1, 123.2, 118.8, 116.1, 115.9, 95.1, 54.3, 44.9, 29.8, 21.0, 7.3. FTIR (KBr) cm⁻¹: 3448, 3325, 3199, 2924, 2854, 2188, 1749, 1648, 1428, 1255, 1189, 1107, 962, 823. HRMS-ESI [M+Na]⁺, calcd for C₁₆H₁₄N₂NaO₃ 305.0897, found 305.0896.

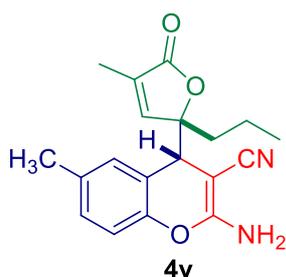
2-amino-6-methyl-4-(5-oxo-2-propyl-2,5-dihydrofuran-2-yl)-4H-chromene-3-



carbonitrile (4u). Salicylaldehyde **1k** (27.2 mg, 0.2 mmol), malononitrile (13.2 mg, 0.2 mmol) and 5-propylfuran-2(3H)-one **3c** (37.8 mg, 0.3 mmol) were taken in 1ml of dry 1,4-dioxane. To this, sodium *tert*-butoxide (19.2 mg, 0.2 mmol) was added under nitrogen gas atmosphere. The reaction was run for 12 h. The reaction was quenched by adding water (5 ml) and the product was extracted with ethyl acetate (10 ml x 3). The ratio of

diastereomers were determined by ¹H NMR analysis of crude reaction mixture (δ major: 3.65 ppm, δ minor: 3.78 ppm) and found to be 7.33:1 (major syn adduct). The crude mixture was purified by column chromatography on silica gel (eluent: ethylacetate/DCM = 1/3, v/v) afforded inseparable mixture of diastereomer as sticky solid (43 mg, 65% yield). ¹H-NMR (400 MHz, CDCl₃) δ 7.50 (d, *J* = 5.2 Hz, 1H), 7.10 – 7.05 (m, 2H), 6.91 (d, *J* = 8.1 Hz, 1H), 6.11 (d, *J* = 5.5 Hz, 1H), 4.95 (s, 2H), 3.65 (s, 1H), 2.34 (s, 3H), 1.76-1.54 (m, 2H), 1.31 – 1.04 (m, 2H), 0.82 (t, *J* = 7.0 Hz, 3H). ¹³C-NMR (100 MHz, CDCl₃) δ 172.1, 163.4, 157.6, 148.7, 134.9, 130.6, 129.9, 122.8, 120.5, 118.8, 116.2, 94.9, 54.3, 45.1, 33.5, 21.0, 16.5, 14.2. FTIR (KBr) cm⁻¹: 3444, 3332, 3216, 2928, 2852, 2184, 1744, 1655, 1616, 1508, 1408, 1256, 1162, 961, 825. HRMS-ESI [M+Na]⁺, calcd for C₁₈H₁₈N₂NaO₃ 333.1210, found 333.1220.

2-amino-6-methyl-4-(4-methyl-5-oxo-2-propyl-2,5-dihydrofuran-2-yl)-4H-chromene-3-

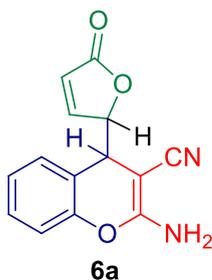


carbonitrile (4v). Salicylaldehyde **1k** (27.2 mg, 0.2 mmol), malononitrile (13.2 mg, 0.2 mmol) and 3-methyl-5-propylfuran-2(3H)-one **3d** (42 mg, 0.3 mmol) were taken in 1ml of dry 1,4-dioxane. To this, sodium *tert*-butoxide (19.2 mg, 0.2 mmol) was added under nitrogen gas atmosphere. The reaction was run for 16 h. The reaction was quenched by adding water (5 ml) and the

product was extracted with ethyl acetate (10 ml x 3). The ratio of diastereomers were determined by ¹H NMR analysis of crude reaction mixture (δ major: 3.79 ppm, δ minor: 3.59 ppm) and found to be 2.33:1 (major syn adduct). The crude mixture was purified by column chromatography on silica gel (eluent: ethylacetate/DCM = 1/3, v/v) afforded inseparable mixture of diastereomer as sticky solid (42 mg, 65% yield). ¹H-NMR (300 MHz, CDCl₃) δ 7.06 – 6.97 (m, 2H), 6.85-6.77 (m, 2H), 4.90 (s, 2H), 3.78 (s, 1H), 2.39-2.30 (m, 6H), 1.89 (t, *J* = 14.0 Hz, 4H), 0.92 (t, *J* = 7.3 Hz, 3H). ¹³C-NMR (75 MHz, CDCl₃) δ 173.2, 163.1, 149.9, 148.5, 148.4, 134.5, 132.3, 130.5, 129.5, 118.9, 115.7, 91.8, 54.4, 45.1, 36.2, 21.0, 20.9, 17.0,

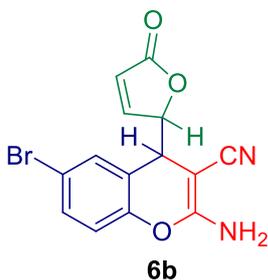
14.2. FTIR (KBr) cm^{-1} : 3456, 3401, 3314, 3195, 2975, 2927, 2186, 1742, 1748, 1658, 1418, 1265, 1190, 1112, 1047, 963, 822. HRMS-ESI $[\text{M}+\text{K}]^+$, calcd for $\text{C}_{19}\text{H}_{20}\text{N}_2\text{KO}_3$ 363.1106, found 363.1111.

2-amino-4-(5-oxo-2,5-dihydrofuran-2-yl)-4H-chromene-3-carbonitrile (6a).



Salicylaldehyde **1a** (24.4 mg, 0.2 mmol), malononitrile (13.2 mg, 0.2 mmol) and γ -crotonolactone **5a** (21.3 μL , 0.3 mmol) were taken in 1 ml of dry 1,4-dioxane. To this, sodium tert-butoxide (19.2 mg, 0.2 mmol) was added under nitrogen gas atmosphere. The reaction was run for 16 h. The reaction was quenched by adding water (5 ml) and the product was extracted with ethyl acetate (10 ml x 3). The ratio of diastereomers were determined by ^1H NMR analysis of crude reaction mixture (δ major: 3.82 (d, $J = 5.1$ Hz) ppm, δ minor: 4.05 (d, $J = 3.0$ Hz) and found to be 3.8:1 (major:minor). The crude mixture was purified by column chromatography on silica gel (eluent: ethylacetate/DCM = 1/3, v/v) afforded inseparable mixture of diastereomer as yellow solid (30.5 mg, 60% yield, mp 124-126 $^\circ\text{C}$). ^1H -NMR (300 MHz, CDCl_3) δ 7.46 (d, $J = 5.8$ Hz, 1H), 7.33-7.27 (m, 1H), 7.19-7.12 (m, 2H), 7.03 (d, $J = 8.2$ Hz, 1H), 6.18 (dd, $J = 6.0$ Hz, 2.0 Hz, 1H), 5.08 (d, $J = 5.4$ Hz, 1H), 3.89 (d, $J = 5.5$ Hz, 1H). ^{13}C -NMR (75 MHz, CDCl_3) δ 172.2, 162.4, 153.1, 152.7, 150.0, 129.6, 128.7, 125.1, 124.0, 118.1, 116.8, 86.6, 53.5, 39.7. FTIR (KBr) cm^{-1} : 3434, 3335, 3199, 2924, 2855, 2185, 1746, 1641, 1582, 1416, 1227, 1175, 1097, 916, 762. HRMS-ESI $[\text{M}+\text{Na}]^+$, calcd for $\text{C}_{14}\text{H}_{10}\text{N}_2\text{NaO}_3$ 277.0584, found 277.0583.

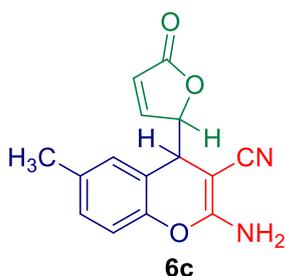
2-amino-6-bromo-4-(5-oxo-2,5-dihydrofuran-2-yl)-4H-chromene-3-carbonitrile (6b).



Salicylaldehyde **1c** (40 mg, 0.2 mmol), malononitrile (13.2 mg, 0.2 mmol) and γ -crotonolactone **5a** (21.3 μL , 0.3 mmol) were taken in 1 ml of dry 1,4-dioxane. To this, sodium tert-butoxide (19.2 mg, 0.2 mmol) was added under nitrogen gas atmosphere. The reaction was run for 16 h. The reaction was quenched by adding water (5 ml) and the product was extracted with ethyl acetate (10 ml x 3). The ratio of diastereomers were determined by ^1H NMR analysis of crude reaction mixture (δ major: 4.07 (d, $J = 3.0$ Hz) ppm, δ minor: 3.88 (d, $J = 5.2$ Hz) ppm) and found to be 1.77:1 (major:minor). The crude mixture was purified by column chromatography on silica gel (eluent: ethylacetate/DCM = 1/3, v/v) afforded inseparable mixture of diastereomer as yellow solid (40 mg, 61% yield, mp 145-147 $^\circ\text{C}$). ^1H -NMR (400 MHz, $\text{DMSO}-d_6$) δ 7.63 (d, $J = 4.0$

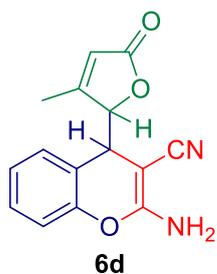
Hz, 1H), 7.49 (s, 2H), 7.19 (s, 2H), 7.00 (d, $J = 8.0$ Hz, 1H), 6.24 (d, $J = 3.8$ Hz, 1H), 5.27 (s, 1H), 4.10 (s, 1H). ^{13}C -NMR (100 MHz, DMSO- d_6) δ 172.2, 162.6, 155.1, 149.5, 131.8, 131.8, 122.4, 120.8, 120.0, 118.3, 115.5, 86.2, 49.3, 38.0. FTIR (KBr) cm^{-1} : 3434, 3335, 3199, 2924, 2855, 2185, 1746, 1641, 1582, 1416, 1227, 1175, 1097, 916, 762. HRMS-ESI $[\text{M}+\text{Na}]^+$, calcd for $\text{C}_{14}\text{H}_9\text{BrN}_2\text{NaO}_3$ 354.9688, found 354.9694.

2-amino-6-methyl-4-(5-oxo-2,5-dihydrofuran-2-yl)-4H-chromene-3-carbonitrile (6c).



Salicylaldehyde **1k** (27.2 mg, 0.2 mmol), malononitrile (13.2 mg, 0.2 mmol) and γ -crotonolactone **5a** (21.3 μL , 0.3 mmol) were taken in 1ml of dry 1,4-dioxane. To this, sodium tert-butoxide (9.6 mg, 0.1 mmol) was added under nitrogen gas atmosphere. The reaction was run for 16 h. The reaction was quenched by adding water (5 ml) and the product was extracted with ethyl acetate (10 ml x 3). The ratio of diastereomers were determined by ^1H NMR analysis of crude reaction mixture (δ major: 3.78 (d, $J = 5.4$ Hz) ppm, δ minor: 4.05 (d, $J = 3.0$ Hz) ppm) and found to be 1.8:1 (major:minor). The crude mixture was purified by column chromatography on silica gel (eluent: ethylacetate/DCM = 1/3, v/v) afforded inseparable mixture of diastereomer as yellow solid (30 mg, 56% yield, mp 124-126 $^\circ\text{C}$). ^1H -NMR (500 MHz, CDCl_3) δ 7.47 – 7.35 (m, 1H), 7.10 – 7.06 (m, 1H), 6.98 (d, $J = 14.6$ Hz, 1H), 6.91 (d, $J = 8.3$ Hz, 1H), 6.18 (dd, $J = 5.7, 1.7$ Hz, 1H), 5.07 (d, $J = 5.5$ Hz, 1H), 4.97 (d, $J = 4.9$ Hz, 2H), 3.86 (d, $J = 5.5$ Hz, 1H), 2.30 (s, 3H). ^{13}C -NMR (100 MHz, CDCl_3) δ 172.3, 162.6, 153.1, 147.9, 134.9, 130.1, 129.6, 128.8, 123.9, 117.8, 116.5, 86.7, 53.2, 39.7, 20.9. FTIR (KBr) cm^{-1} : 3445, 3325, 3198, 2923, 2853, 2178, 1741, 1642, 1412, 1252, 1165, 1107, 965, 821. HRMS-ESI $[\text{M}+\text{Na}]^+$, calcd for $\text{C}_{15}\text{H}_{12}\text{N}_2\text{NaO}_3$ 291.0740, found 291.0740.

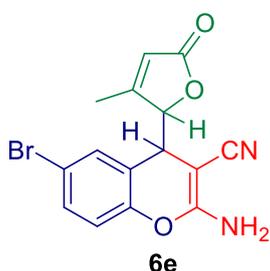
2-amino-4-(3-methyl-5-oxo-2,5-dihydrofuran-2-yl)-4H-chromene-3-carbonitrile (6d).



Salicylaldehyde **1a** (24.4 mg, 0.2 mmol), malononitrile (13.2 mg, 0.2 mmol) and 4-methylfuran-2(5H)-one **5b** (29.4 mg, 0.3 mmol) were taken in 1ml of dry 1,4-dioxane. To this, sodium tert-butoxide (19.2 mg, 0.2 mmol) was added under nitrogen gas atmosphere. The reaction was run for 16 h. The reaction was quenched by adding water (5 ml) and the product was extracted with ethyl acetate (10 ml x 3). The ratio of diastereomers were determined by ^1H NMR analysis of crude reaction mixture (δ major: 5.69 ppm, δ minor: 5.87 ppm) and found to be 2.3:1 (major *syn* adduct).

The crude mixture was purified by column chromatography on silica gel (eluent: ethylacetate/DCM = 1/3, v/v) afforded inseparable mixture of diastereomer as yellow solid (24 mg, 51% yield, mp 124-126 °C). ¹H-NMR (300 MHz, DMSO-*d*₆) δ 7.49 (d, *J* = 7.6 Hz, 0.5H), 7.39 – 7.16 (m, 2H), 7.18 – 6.94 (m, 4.5H), 5.83 (d, *J* = 1.4 Hz, 1H), 5.09 (d, *J* = 5.8 Hz, 1H), 4.18 (d, *J* = 2.1 Hz, 1H), 2.09 (s, 3H). ¹³C-NMR (75 MHz, DMSO-*d*₆) δ 171.9, 167.2, 162.7, 150.4, 129.0, 128.7, 123.8, 120.3, 118.0, 117.1, 115.9, 87.6, 50.5, 37.2, 14.0. FTIR (KBr) cm⁻¹: 3448, 3328, 3198, 2928, 2851, 2172, 1748, 1648, 1412, 1265, 1147, 1105, 961, 828. HRMS-ESI [M+Na]⁺, calcd for C₁₅H₁₂N₂NaO₃ 291.0746, found 291.0740.

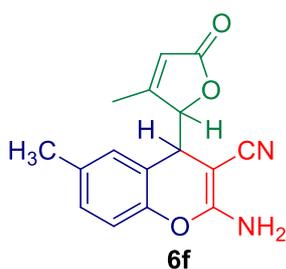
2-amino-6-bromo-4-(3-methyl-5-oxo-2,5-dihydrofuran-2-yl)-4*H*-chromene-3-



carbonitrile (6e). Salicylaldehyde **1c** (40 mg, 0.2 mmol), malononitrile (13.2 mg, 0.2 mmol) and 4-methylfuran-2(5*H*)-one **5b** (29.4 mg, 0.3 mmol) were taken in 1ml of dry 1,4-dioxane. To this, sodium *tert*-butoxide (19.2 mg, 0.2 mmol) was added under nitrogen gas atmosphere. The reaction was run for 16 h. The reaction was quenched by adding water (5 ml) and the product

was extracted with ethyl acetate (10 ml x 3). The ratio of diastereomers were determined by ¹H NMR analysis of crude reaction mixture (δ major: 5.83 ppm, δ minor: 6.00 ppm) and found to be 2.3:1 (*major:minor*). The crude mixture was purified by column chromatography on silica gel (eluent: ethylacetate/DCM = 1/3, v/v) afforded inseparable mixture of diastereomers as yellow solid (37 mg, 53% yield, mp 124-126 °C). ¹H-NMR (300 MHz, DMSO-*d*₆) δ 7.80 (d, *J* = 2.0 Hz, 0.5H), 7.51 – 7.45 (m, 1H), 7.24 – 7.22 (m, 2H), 7.18 (s, 0.5H), 6.99 (t, *J* = 8.1 Hz, 1H), 5.90 (s, 1H), 5.13 (s, 1H), 4.20 (s, 1H), 2.09 (s, 3H). ¹³C-NMR (75 MHz, DMSO-*d*₆) δ 171.8, 167.1, 162.5, 149.7, 131.8, 131.0, 120.0, 119.8, 118.1, 115.3, 87.5, 50.2, 37.0, 14.0. FTIR (KBr) cm⁻¹: 3398, 3328, 3095, 2922, 2851, 2182, 1756, 1648, 1604, 1408, 1265, 1189, 1107, 923, 824. HRMS-ESI [M+Na]⁺, calcd for C₁₅H₁₁BrN₂NaO₃ 368.9845, found 368.9851.

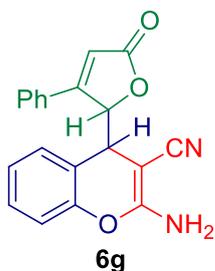
2-amino-6-methyl-4-(3-methyl-5-oxo-2,5-dihydrofuran-2-yl)-4*H*-chromene-3-



carbonitrile (6f). Salicylaldehyde **1k** (27.2 mg, 0.2 mmol), malononitrile (13.2 mg, 0.2 mmol) and 4-methylfuran-2(5*H*)-one **5b** (29.4 mg, 0.3 mmol) were taken in 1ml of dry 1,4-dioxane. To this, sodium *tert*-butoxide (9.6 mg, 0.1 mmol) was added under nitrogen gas atmosphere. The reaction was run for 16 h. The ratio

of diastereomers was determined by ^1H NMR analysis of crude reaction mixture (δ major: 5.78 ppm, δ minor: 5.98 ppm) and found to be 3.3:1 (major:minor). The crude mixture was purified by column chromatography on silica gel (eluent: ethylacetate/DCM = 1/3, v/v) afforded inseparable mixture of diastereomer as yellow solid (31 mg, 55% yield, mp 124-126 °C). ^1H -NMR (300 MHz, CDCl_3) δ 7.07 – 7.03 (m, 1H), 6.88 (d, J = 8.3 Hz, 1H), 6.67 (s, 1H), 5.78 – 5.77 (m, 1H), 5.03 (s, 1H), 4.89 (s, 2H), 4.01 (d, J = 3.0 Hz, 1H), 2.27 (s, 3H), 2.08 (d, J = 0.7 Hz, 3H). ^{13}C -NMR (75 MHz, CDCl_3) δ 172.3, 165.2, 162.4, 148.5, 134.2, 130.2, 128.3, 119.6, 116.6, 116.0, 87.8, 54.1, 38.1, 20.9, 14.6. FTIR (KBr) cm^{-1} : 3444, 3326, 3202, 2922, 2858, 2182, 1744, 1641, 1423, 1251, 1182, 1102, 965, 828. HRMS-ESI $[\text{M}+\text{Na}]^+$, calcd for $\text{C}_{16}\text{H}_{14}\text{N}_2\text{NaO}_3$ 305.0896, found 305.0901.

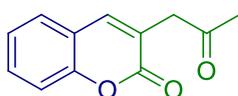
2-amino-4-(5-oxo-3-phenyl-2,5-dihydrofuran-2-yl)-4H-chromene-3-carbonitrile (6g).



Salicylaldehyde **1a** (24.4 mg, 0.2 mmol), malononitrile (13.2 mg, 0.2 mmol) and 4-phenylfuran-2(5*H*)-one **5c** (29.4 mg, 0.3 mmol) were taken in 1ml of dry 1,4-dioxane. To this, sodium *tert*-butoxide (19.2 mg, 0.2 mmol) was added under nitrogen gas atmosphere. The reaction was run for 16 h. The reaction was quenched by adding water (5 ml) and the product was extracted with ethyl acetate (10 ml x 3).

The ratio of diastereomers was determined by ^1H NMR analysis of crude reaction mixture (δ major: 4.07 ppm, δ minor: 4.12 ppm) and found to be 1.5:1. The crude mixture was purified by column chromatography on silica gel (eluent: ethylacetate/DCM = 1/3, v/v) afforded inseparable mixture of diastereomer as solid (35 mg, 54% yield). ^1H -NMR (300 MHz, CDCl_3) δ 7.53 (s, 5H), 7.34-7.18 (m, 2H), 6.98-6.92 (m, 1.5H), 6.49 (d, J = 9 Hz, 0.5H), 6.16 (s, 1H), 5.71 (s, 1H), 4.87 (s, 2H), 4.07 (s, 1H). ^{13}C -NMR (75 MHz, CDCl_3) δ 171.8, 164.3, 162.4, 150.8, 150.1, 131.9, 129.9, 129.5, 129.3, 128.5, 128.0, 127.7, 127.3, 125.5, 124.2, 117.6, 116.8, 116.4, 115.9, 84.9, 77.6, 77.4, 77.2, 76.7, 55.2, 39.4. FTIR (KBr) cm^{-1} : 3454, 3315, 3198, 2928, 2856, 2187, 1744, 1647, 1608, 1417, 1268, 1148, 1054, 963, 841. HRMS-ESI $[\text{M}+\text{K}]^+$, calcd for $\text{C}_{20}\text{H}_{14}\text{KN}_2\text{O}_3$ 369.0636, found 369.0640.

3-(2-oxopropyl)-2H-chromen-2-one (7a). Salicylaldehyde **1a** (24.4 mg, 0.2 mmol), α -



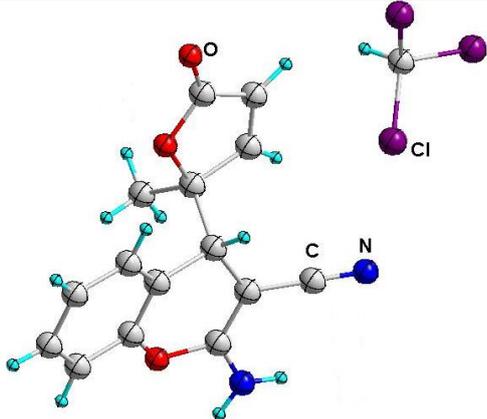
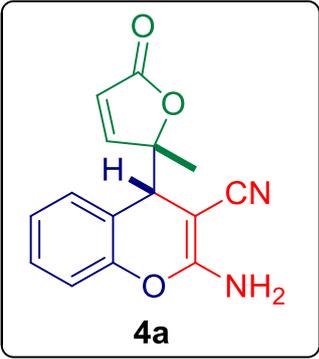
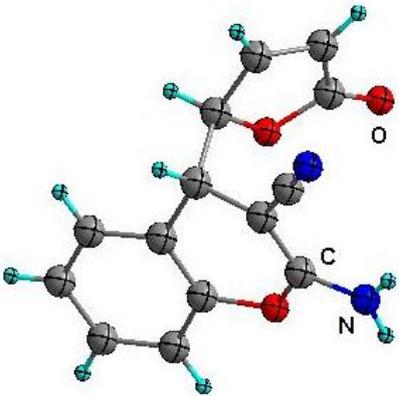
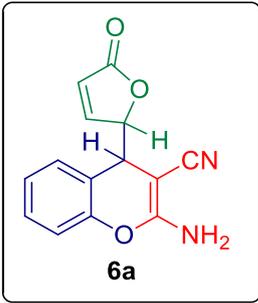
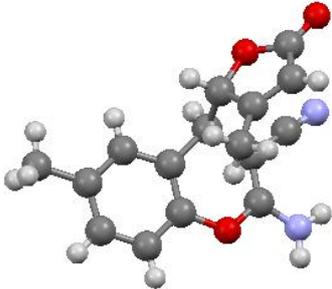
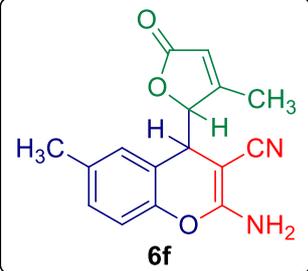
Angelica lactone **3a** (27 μL , 0.3 mmol) were taken in 1 ml of dry 1,4-dioxane. To this, sodium *tert*-butoxide (19.2 mg, 0.2 mmol) was added under nitrogen gas atmosphere. The reaction was run for 2 h. The reaction was quenched by adding water (5 ml) and the product was extracted with ethyl

acetate (10 ml x 3). The crude mixture was purified by column chromatography on silica gel (eluent: ethylacetate/hexane = 3/7, v/v) afforded solid product **7a** (32 mg, 80% yield). ¹H-NMR (300 MHz, CDCl₃) δ 7.55 (s, 1H), 7.46-7.34 (m, 2H), 7.29-7.18 (m, 2H), 3.62 (s, 2H), 2.25 (s, 3H).

Scale up MCR for the synthesis of compound 4a: Salicylaldehyde **1a** (5.0 mmol) and malononitrile **2** (5.0 mmol) were taken in 25 ml of dry 1,4-Dioxane, to this γ -butenolide **3a** (7.5 mmol) and then sodium *tert*-butoxide (5.0 mmol) were added under nitrogen gas atmosphere. The resulting reaction mixture was stirred at room temperature and the progress of reaction was monitored by TLC. The reaction was quenched by adding water (25 ml) and the product was extracted with ethyl acetate. The combined organic layer was dried over Na₂SO₄, filtered and concentrated under reduce pressure to give sticky solid which was purified by column chromatography on silica gel (eluent: ethylacetate/DCM = 1/3, v/v). The ratio of diastereomers was determined by ¹H NMR of crude reaction mixture and found to be 7.3:1. The crude mixture was purified by column chromatography on silica gel (eluent: ethylacetate/DCM = 1/3, v/v) afforded inseparable mixture of diastereomers as solid (0.8 g, 60% yield).

3. Single Crystal X-ray Structures

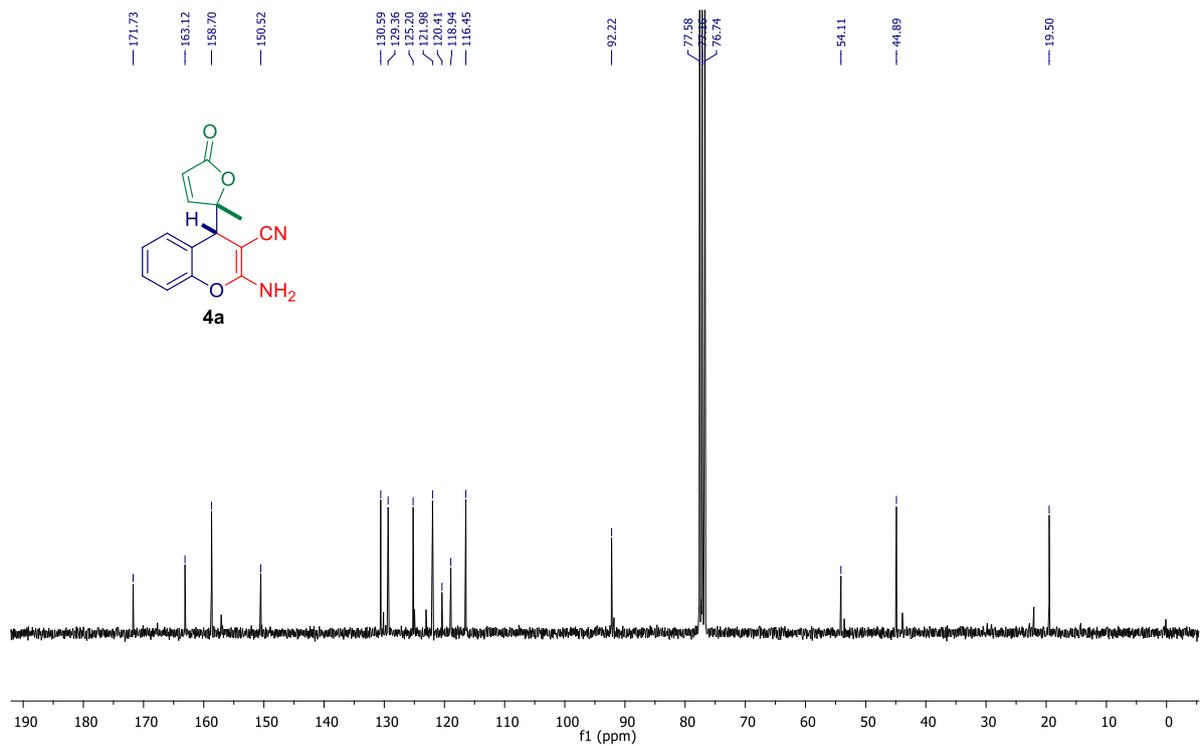
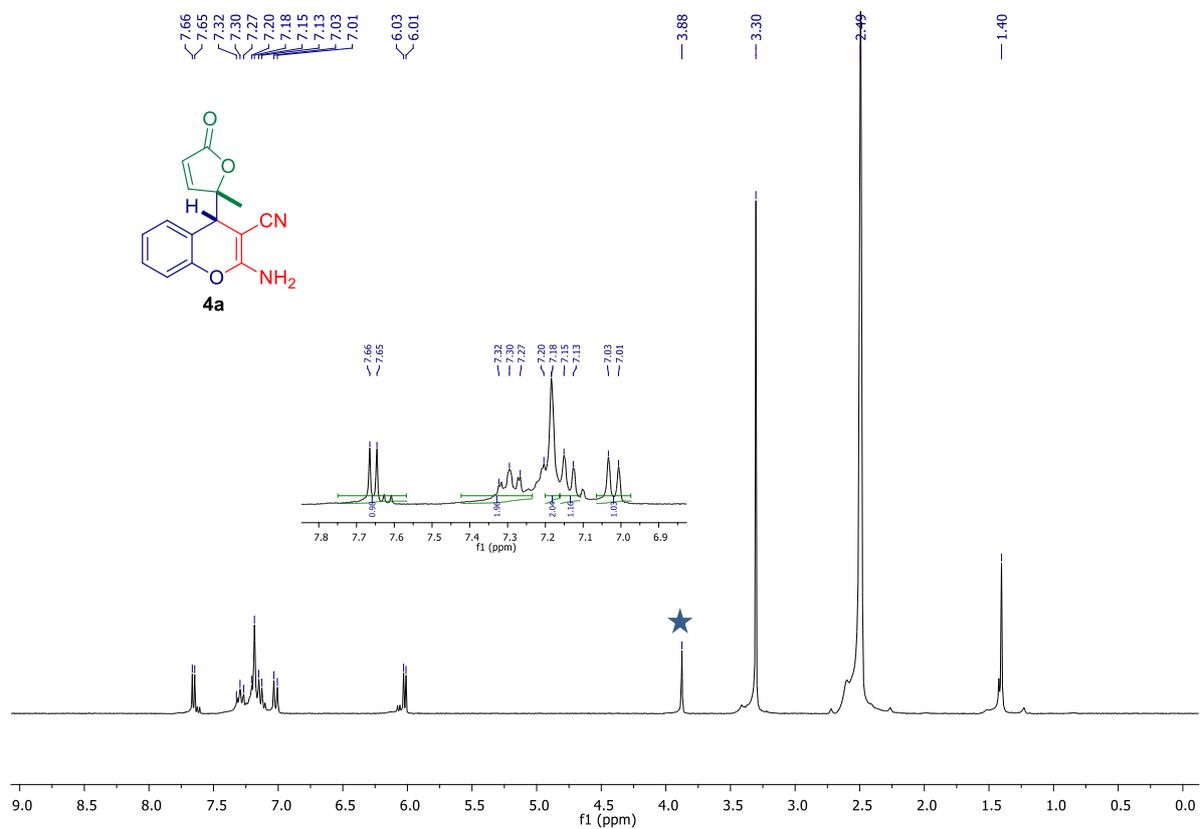
Thermal ellipsoids are drawn at the 50% probability level. Molecular structure of compound **4a** crystallized out with solvent (chloroform).

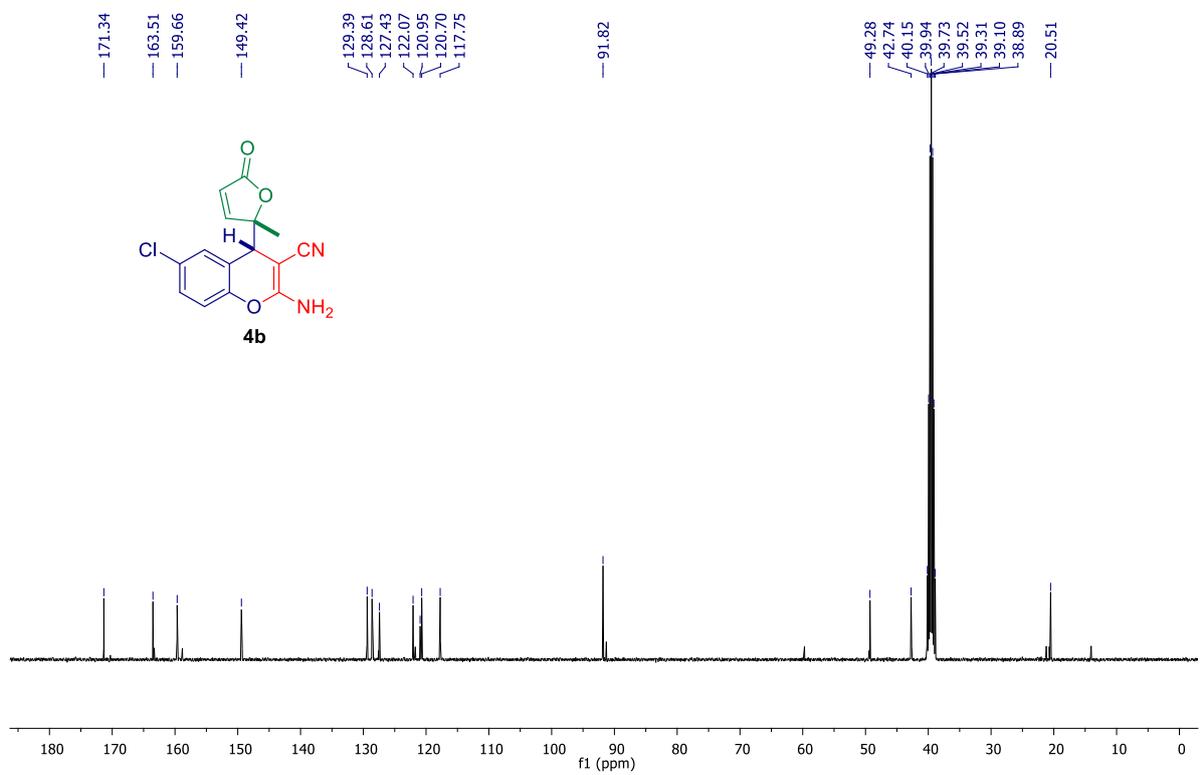
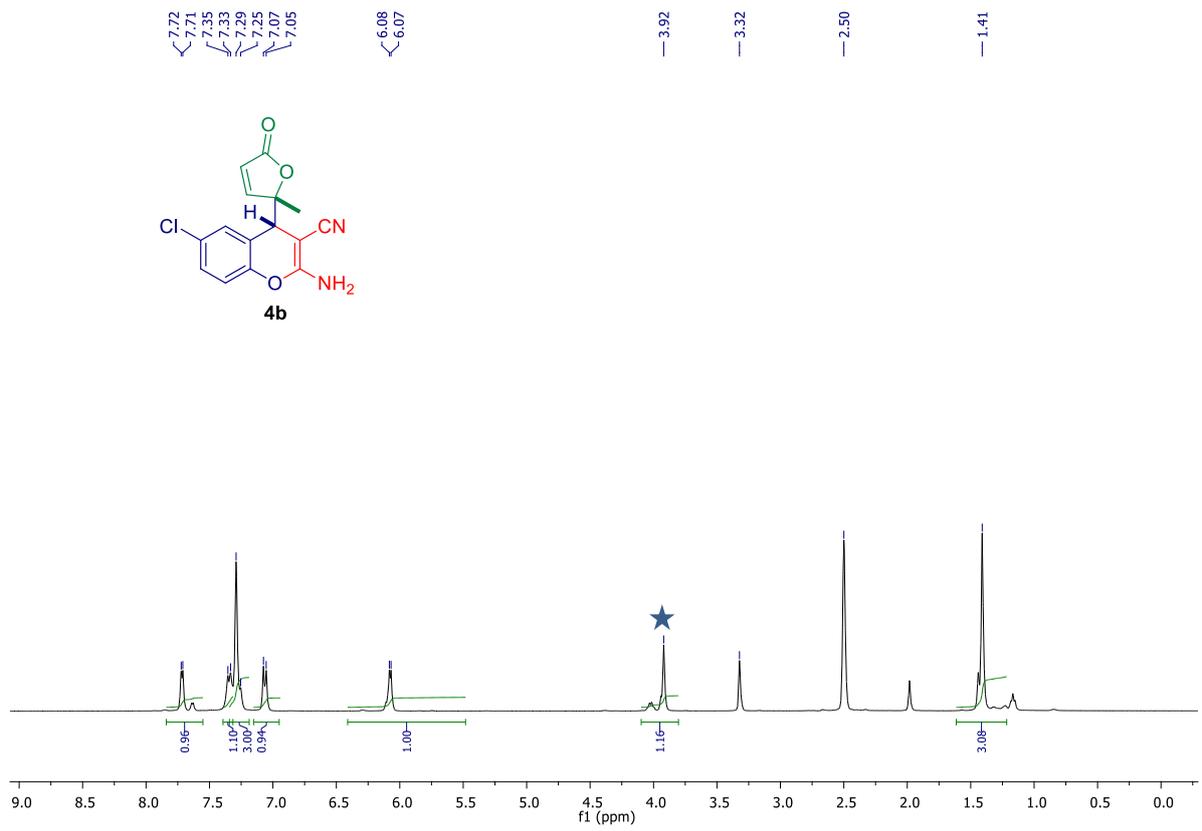
Sr. No.	ORTEP Diagram	Compound Structure
1.		 <p>4a</p> <p>CCDC No. 1889050</p>
2.		 <p>6a</p> <p>CCDC No. 1889052</p>
3.		 <p>6f</p> <p>CCDC No. 1889053</p>

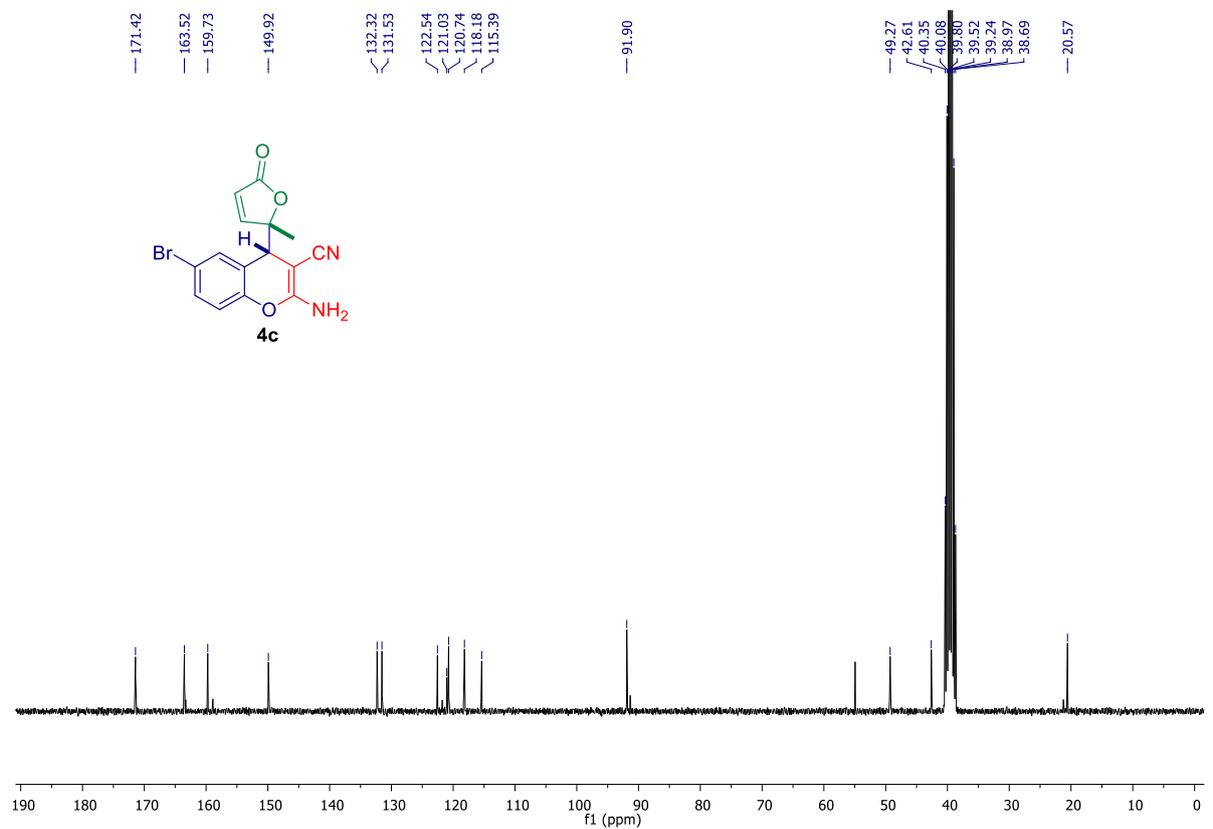
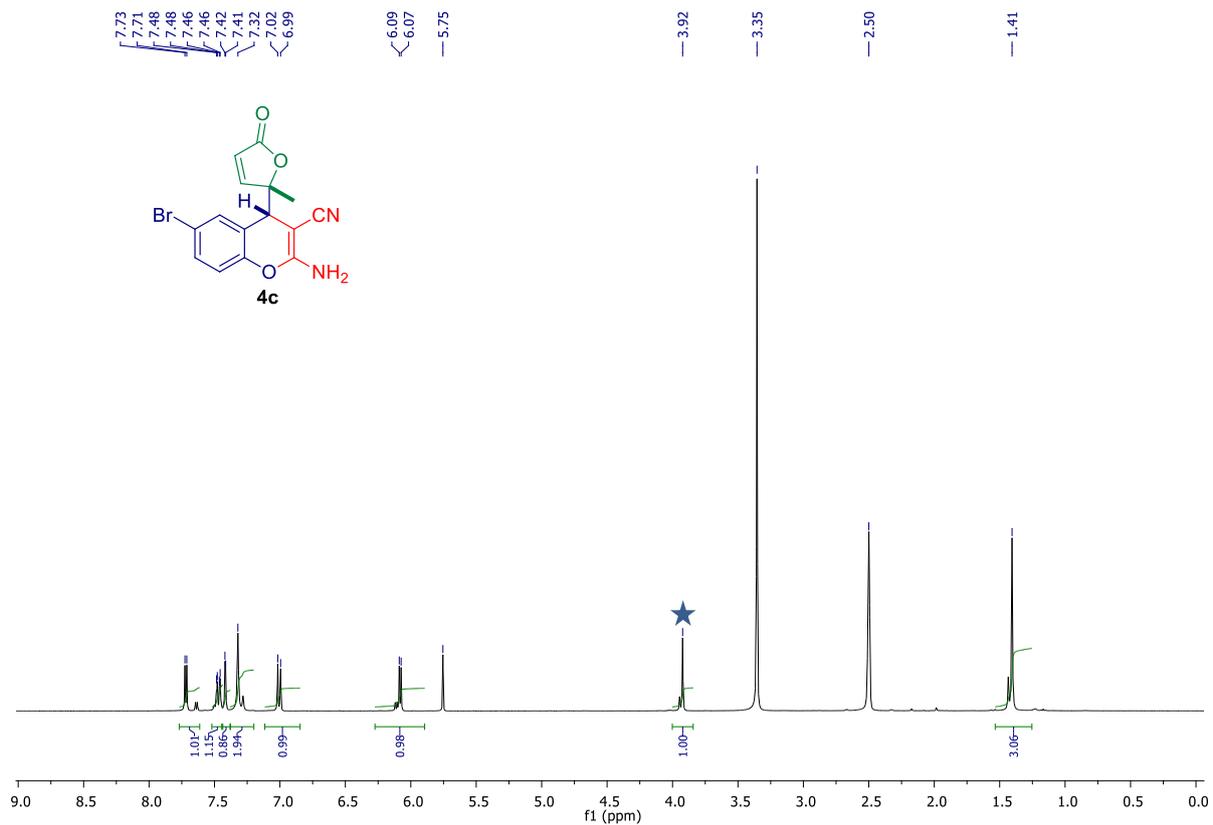
4. References

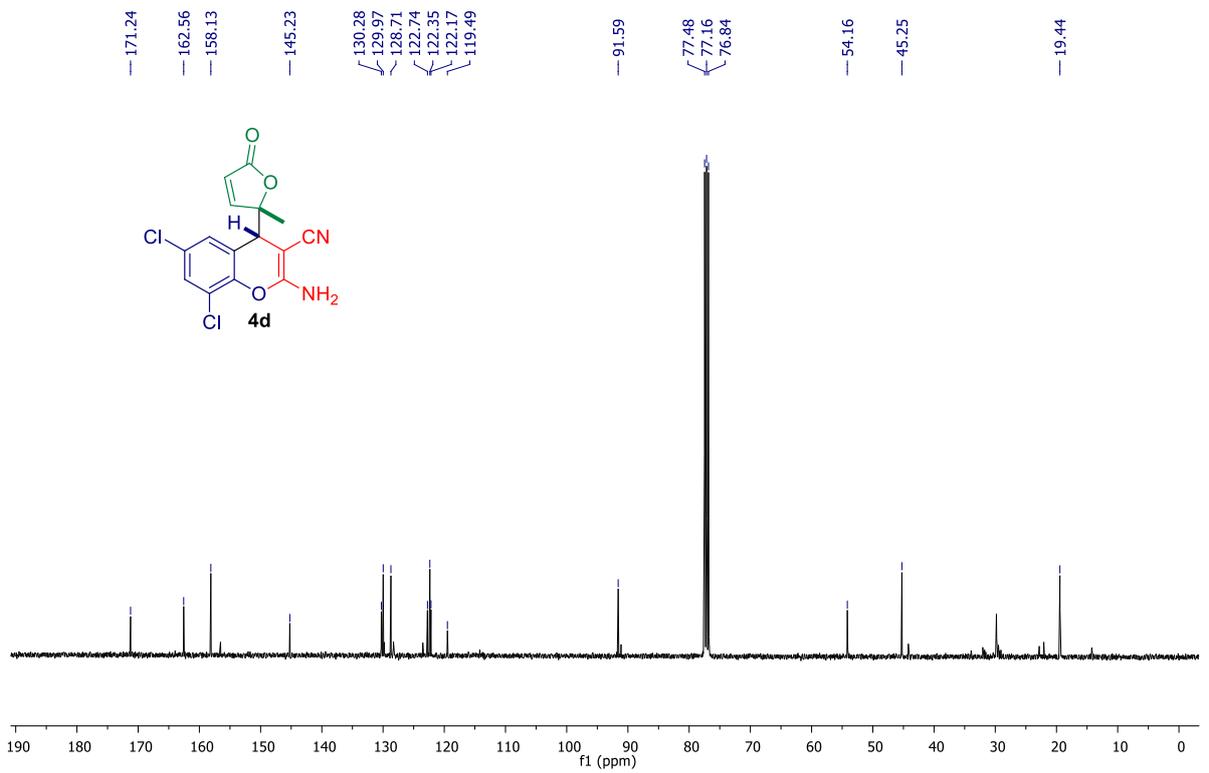
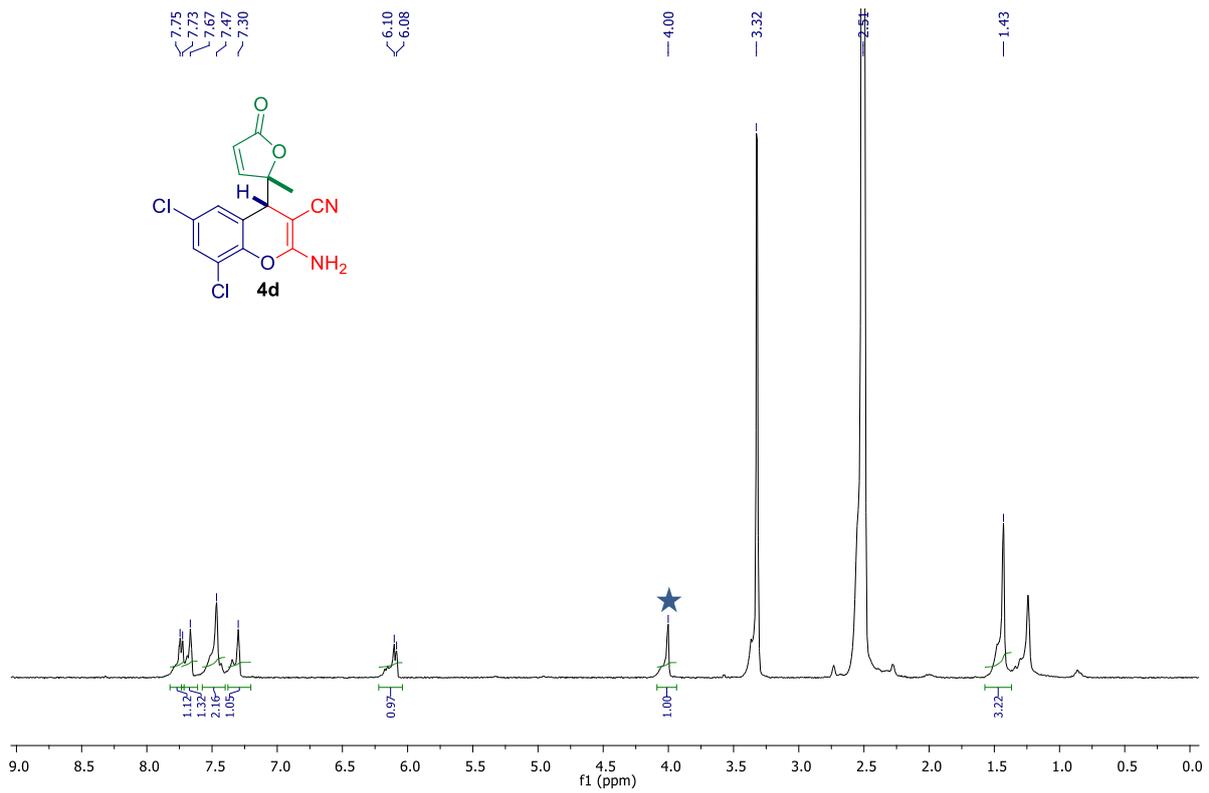
1. (a) B. C. Raju, A. K. Tiwari, J. A. Kumar, A. Z. Ali, S. B. Agawane, G. Saidachary and K. Madhusudana, *Bioorg. Med. Chem.* 2010, 18, 358.
- 2 R. P. Singh, B. M. Foxman and L. Deng, *J. Am. Chem. Soc.*, 2010, 132, 9558.
3. Z.-H. Wang, Z.-J. Wu, X.-Q. Huang, D.-F. Yue, Y. You, X.-Y. Xu, X.-M. Zhanga and W.-C. Yuan, *Chem. Commun.*, 2015, 51, 15835.
4. J. Wu, Q. Zhu, L. Wang, R. Fathi and Z. Yang, *J. Org. Chem.*, 2003, 68, 670.

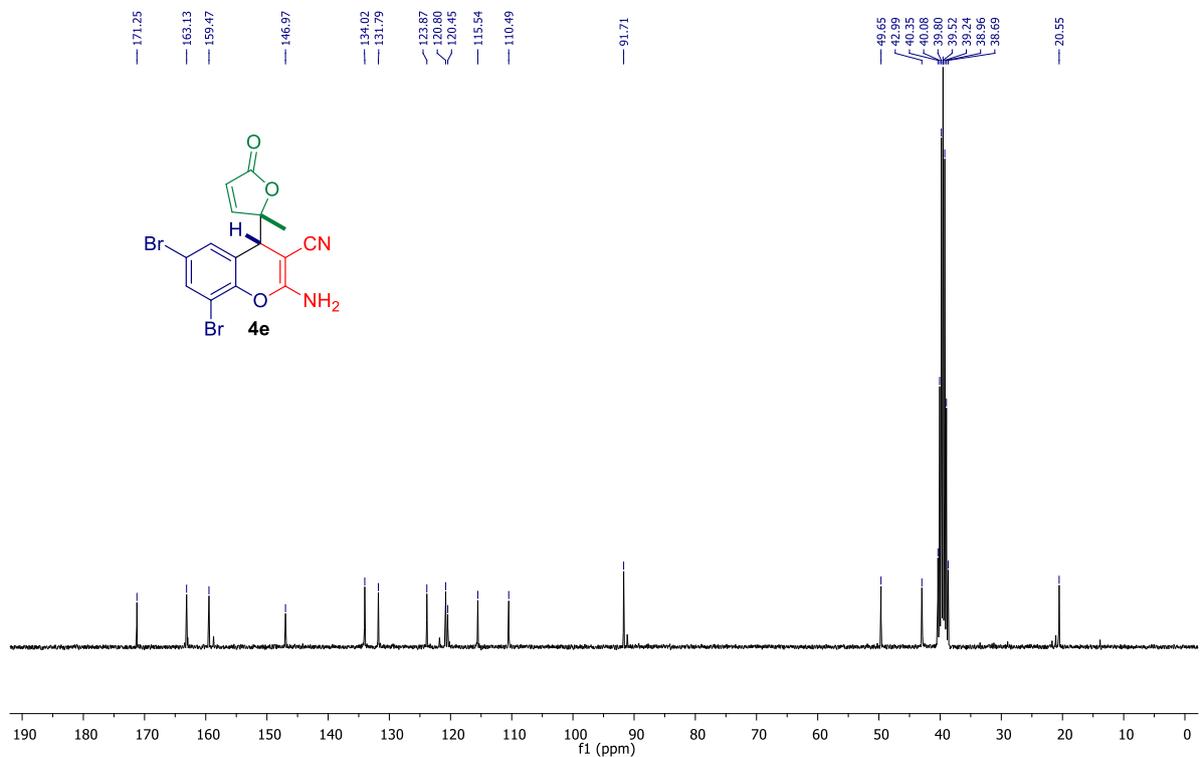
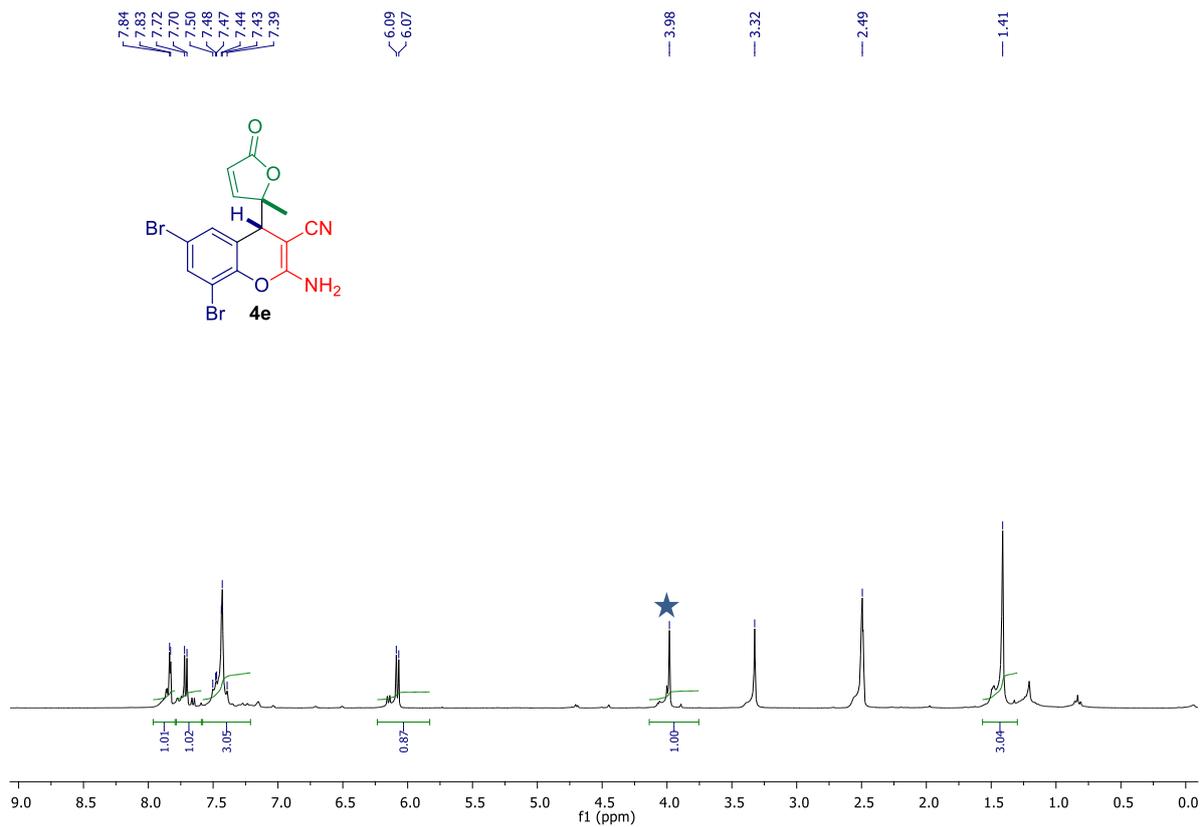
5. Copies of ^1H and ^{13}C NMR Spectra

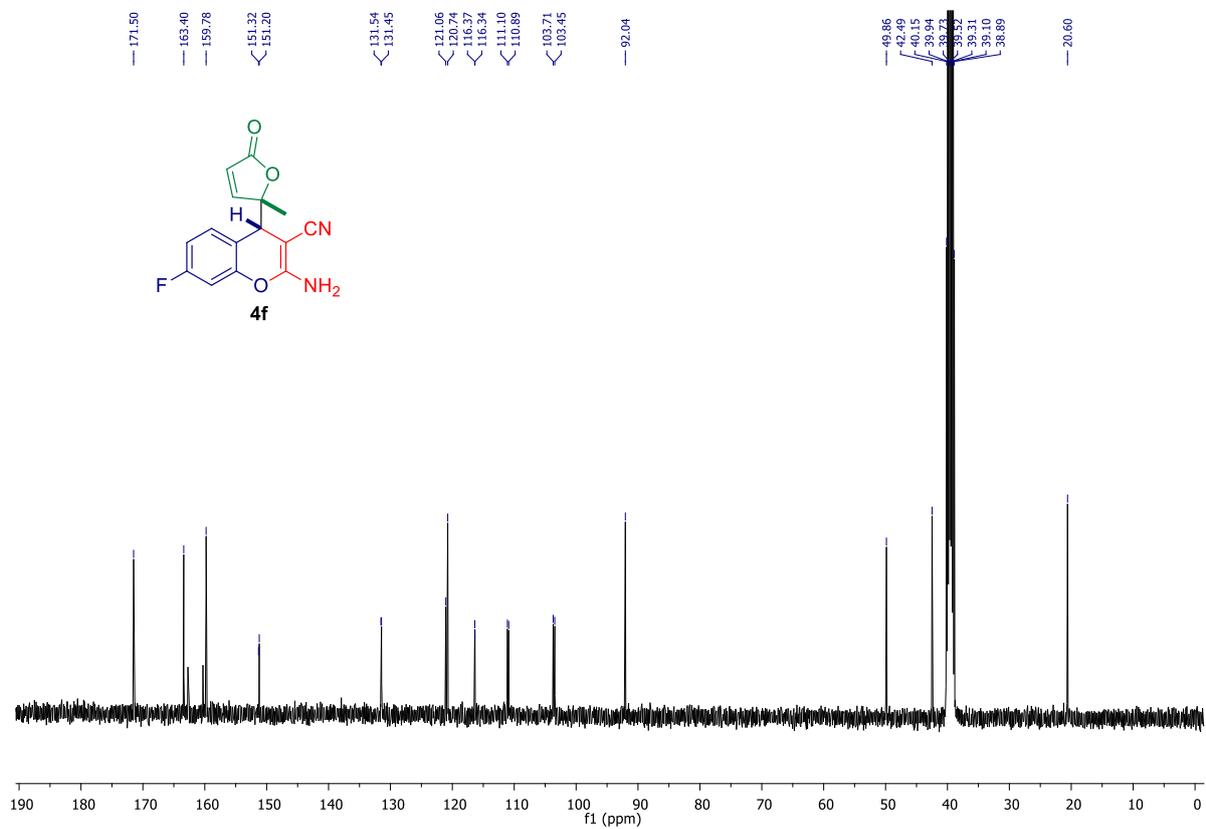
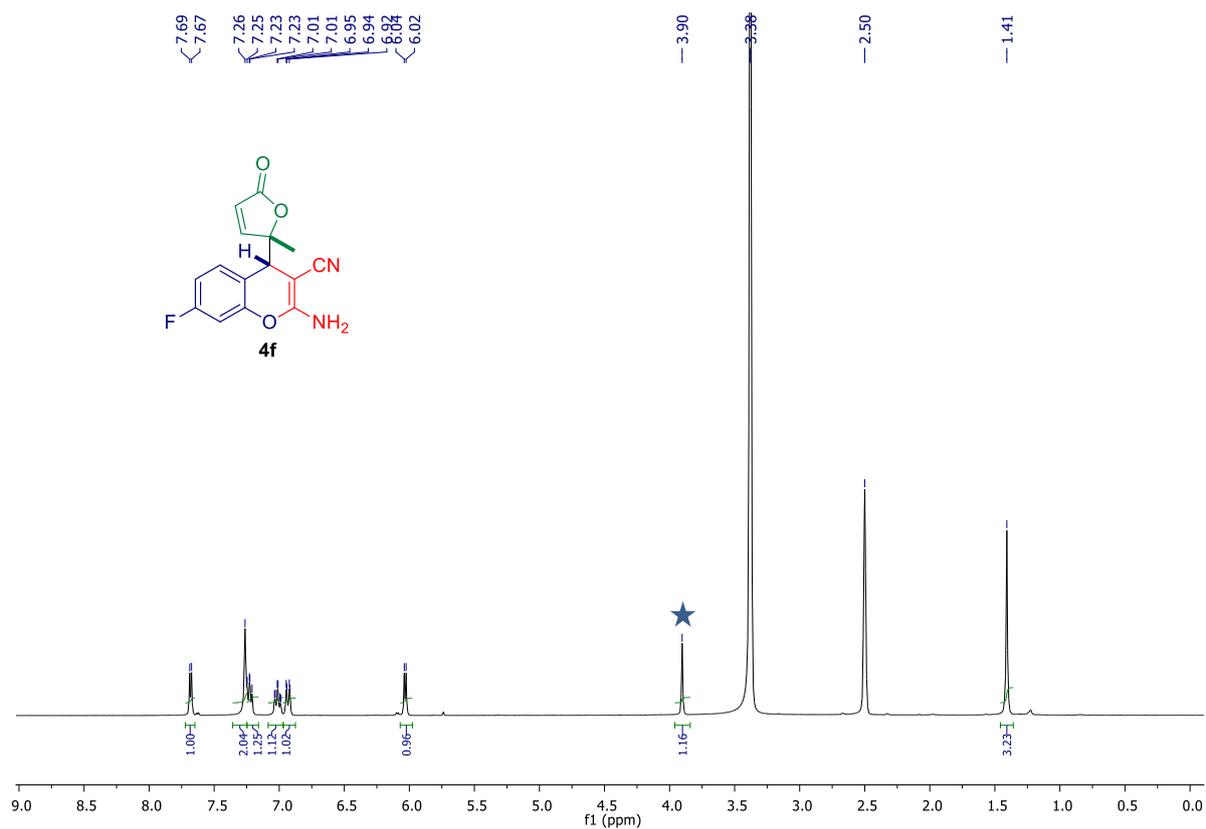


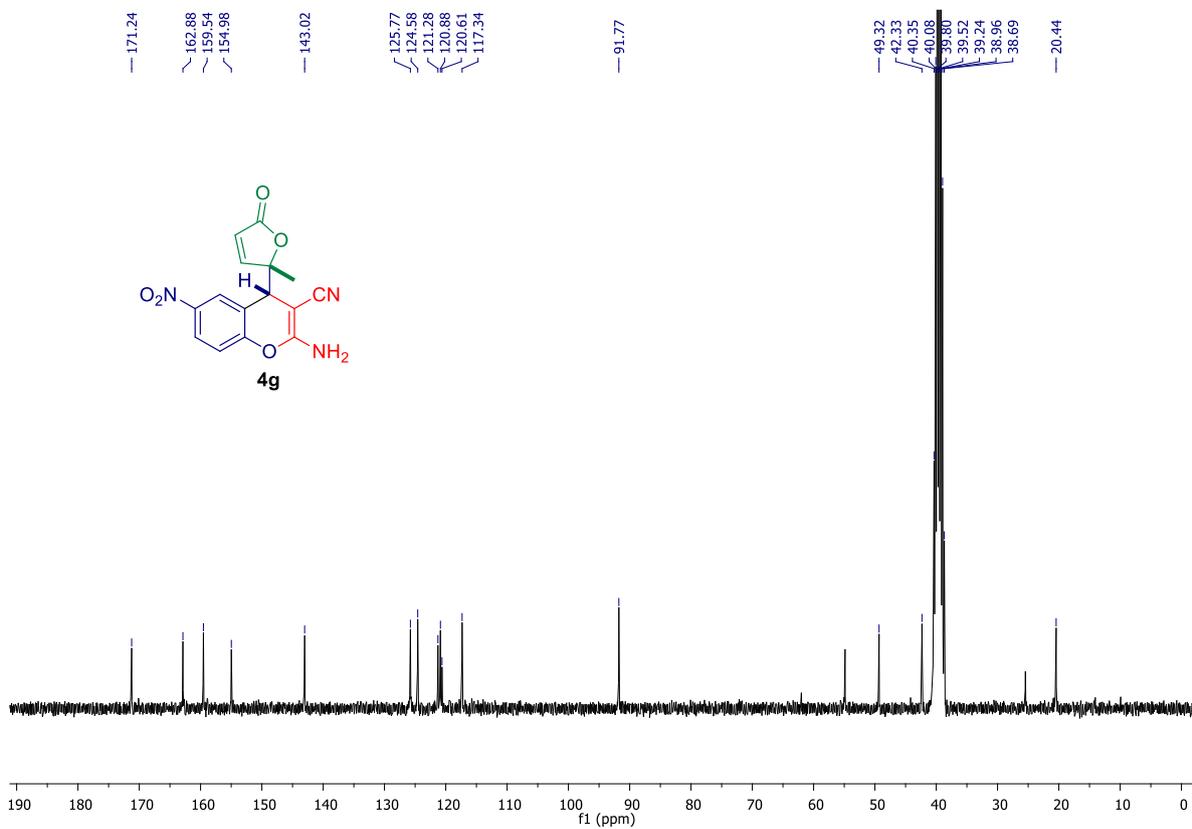
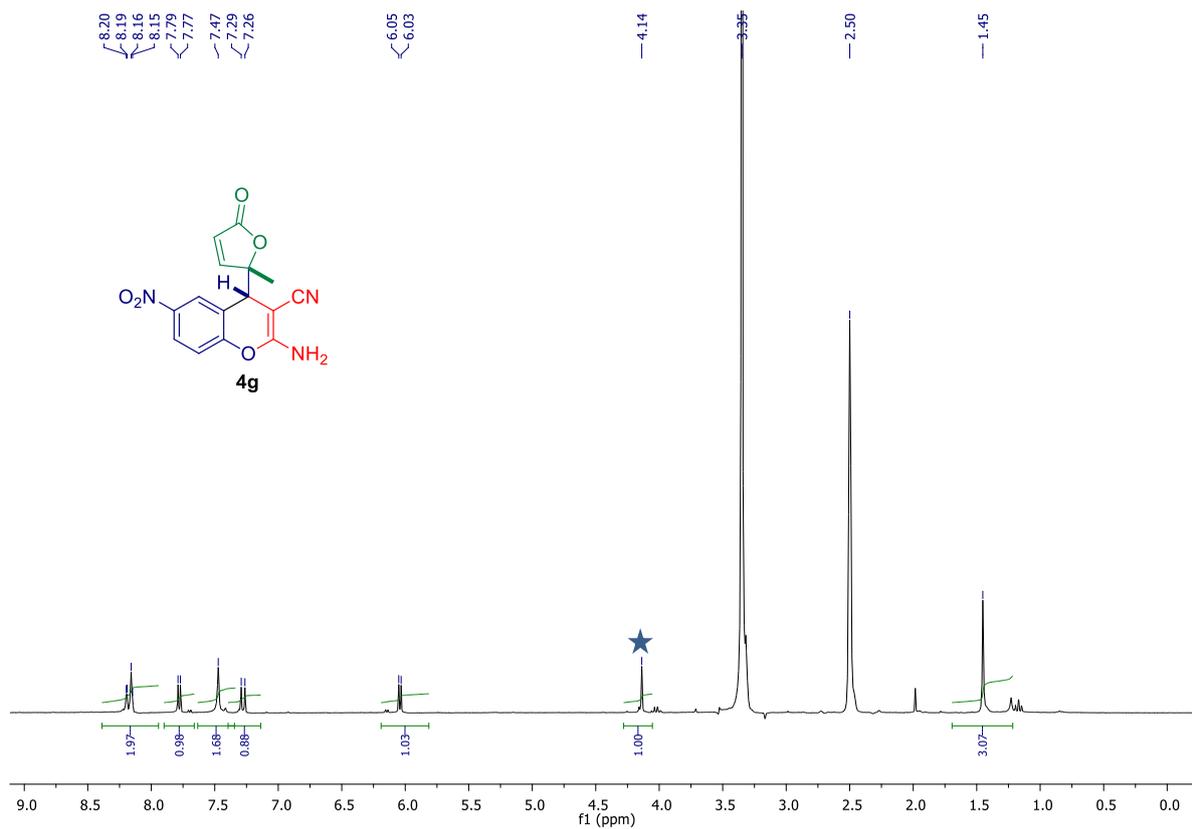


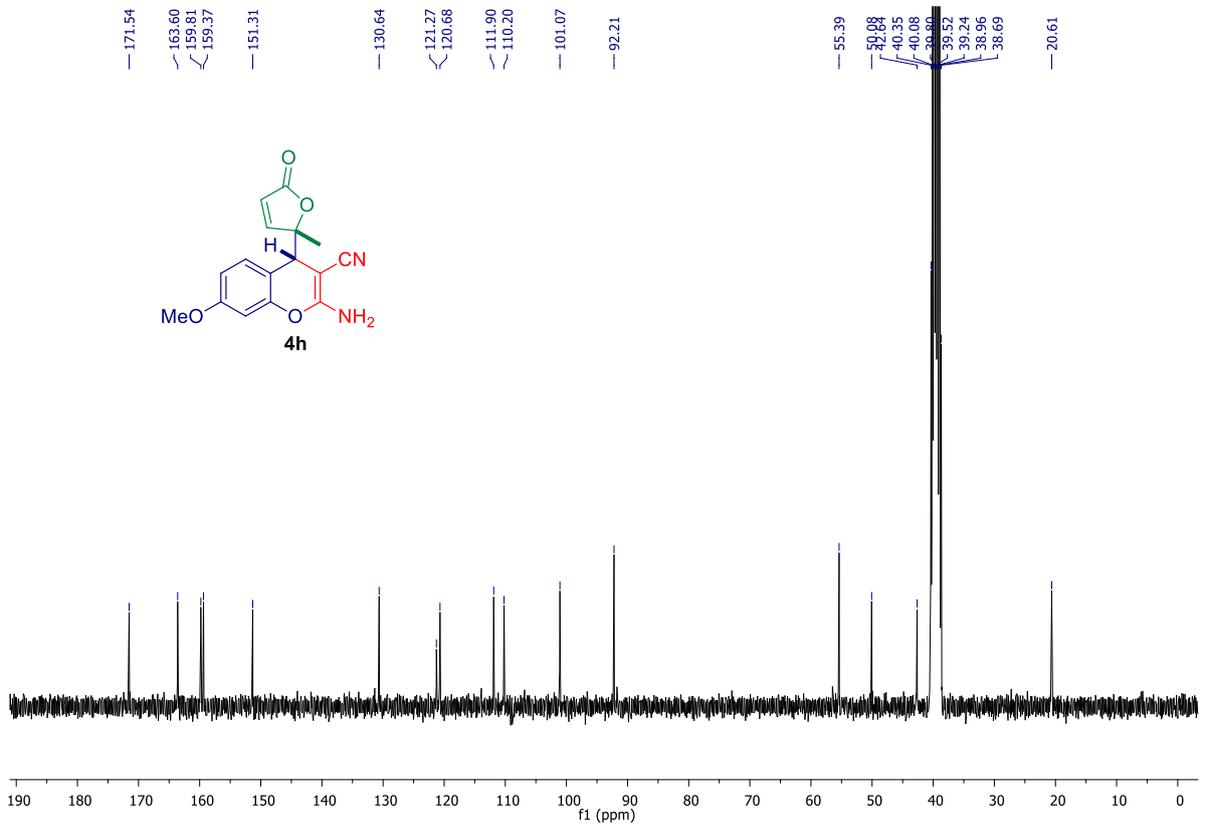
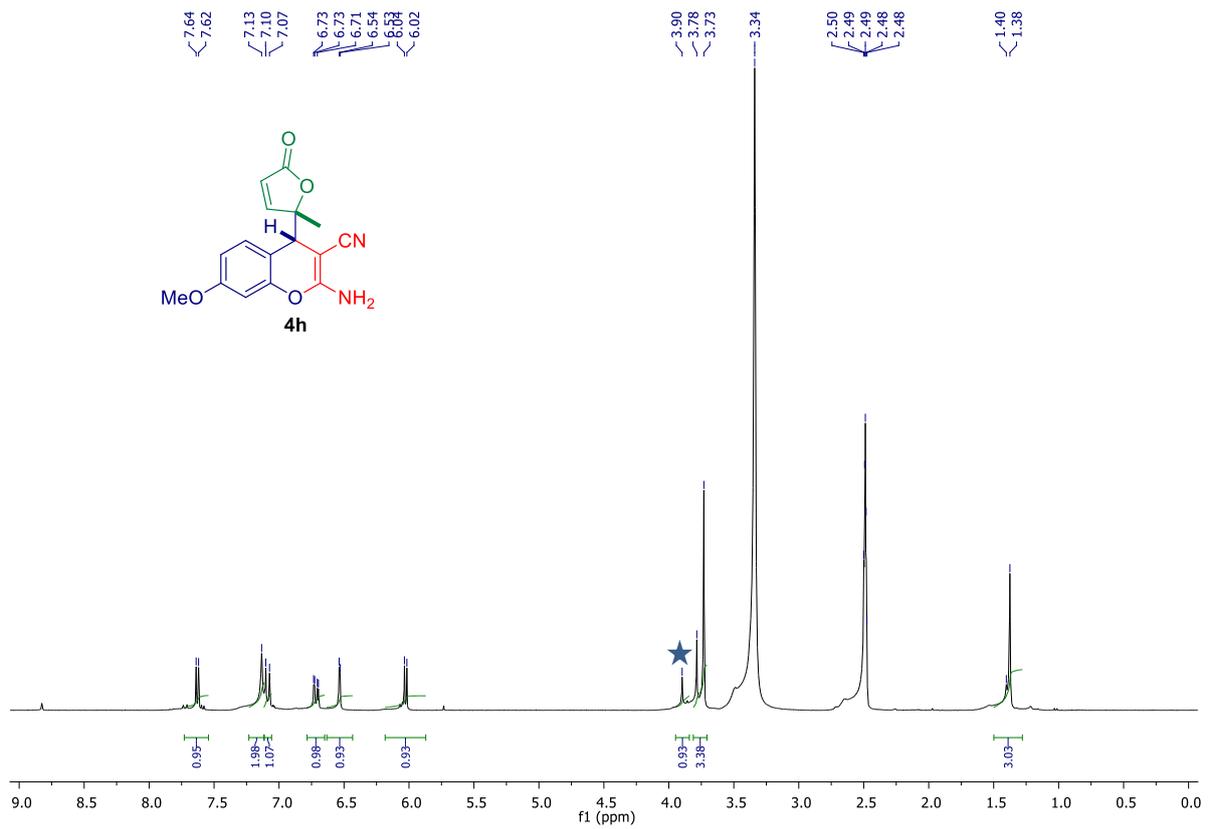


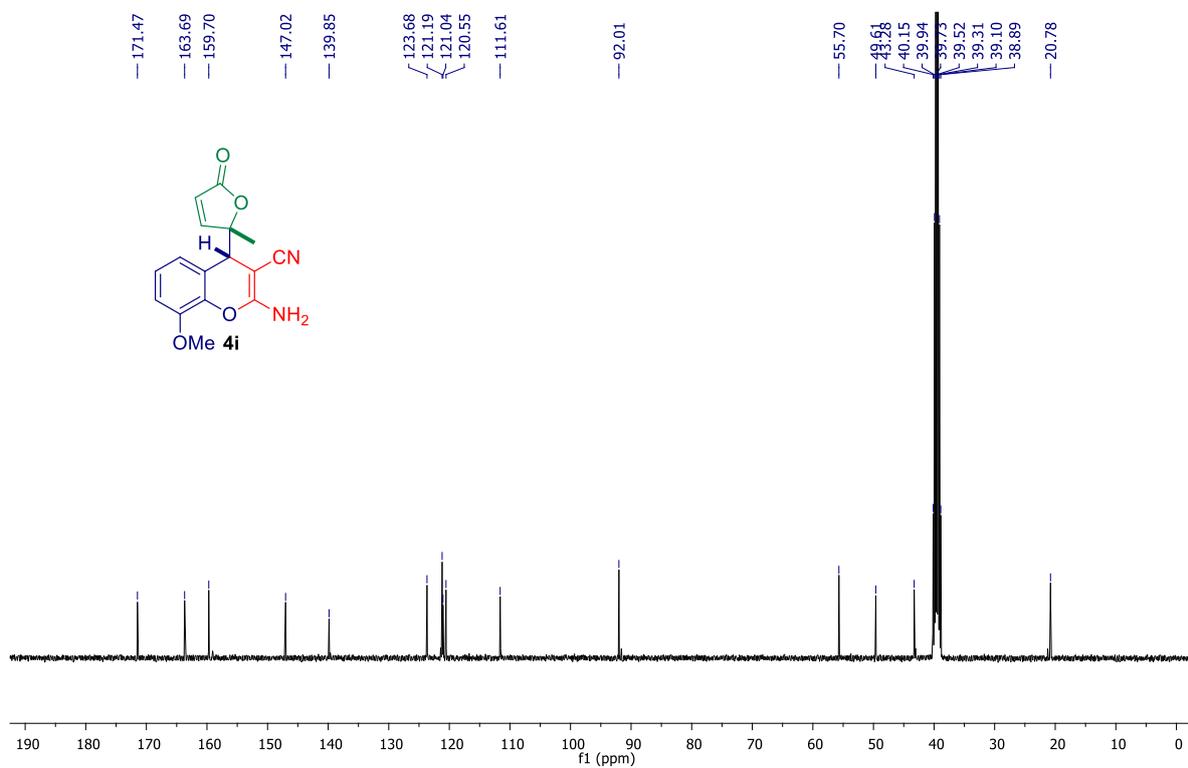
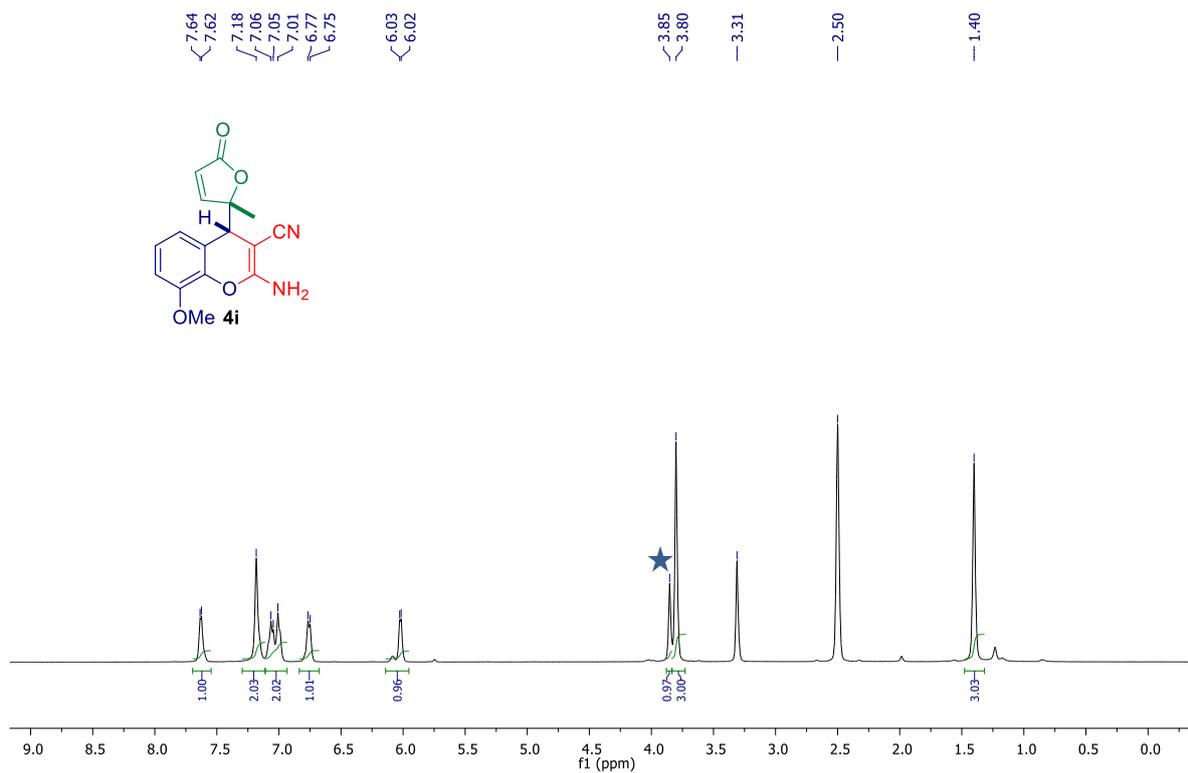


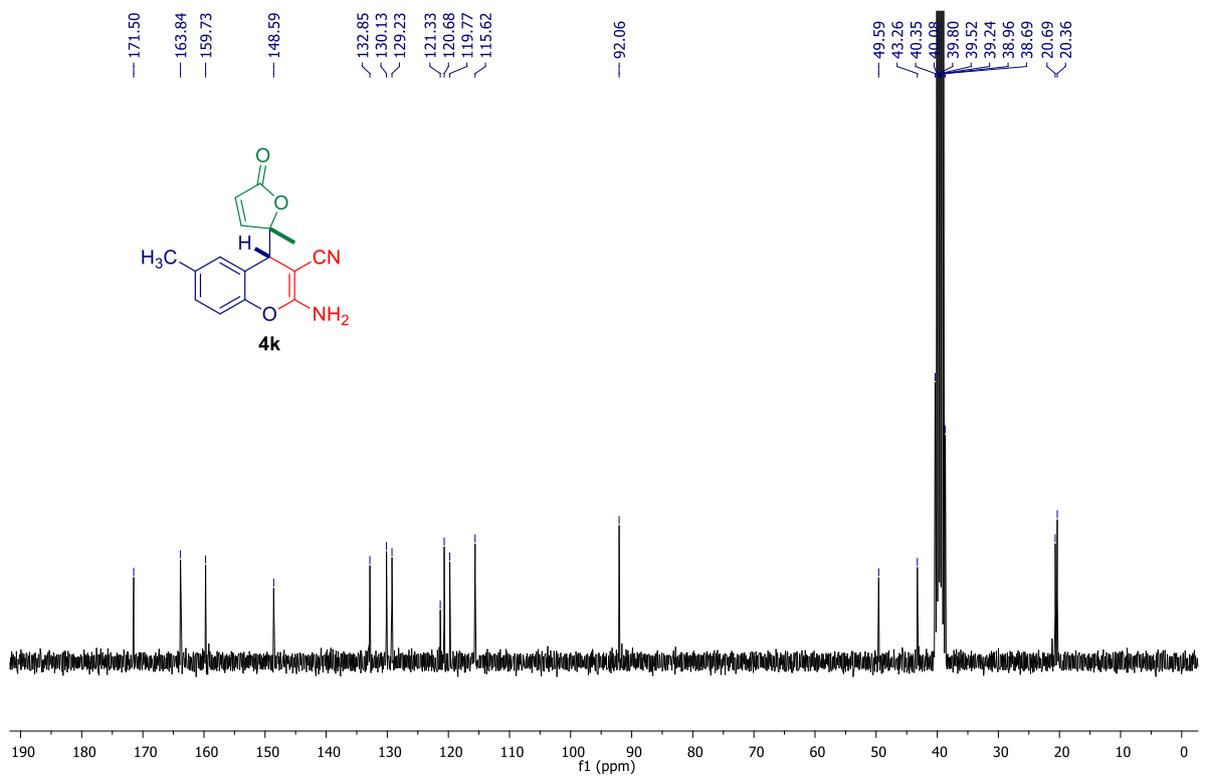
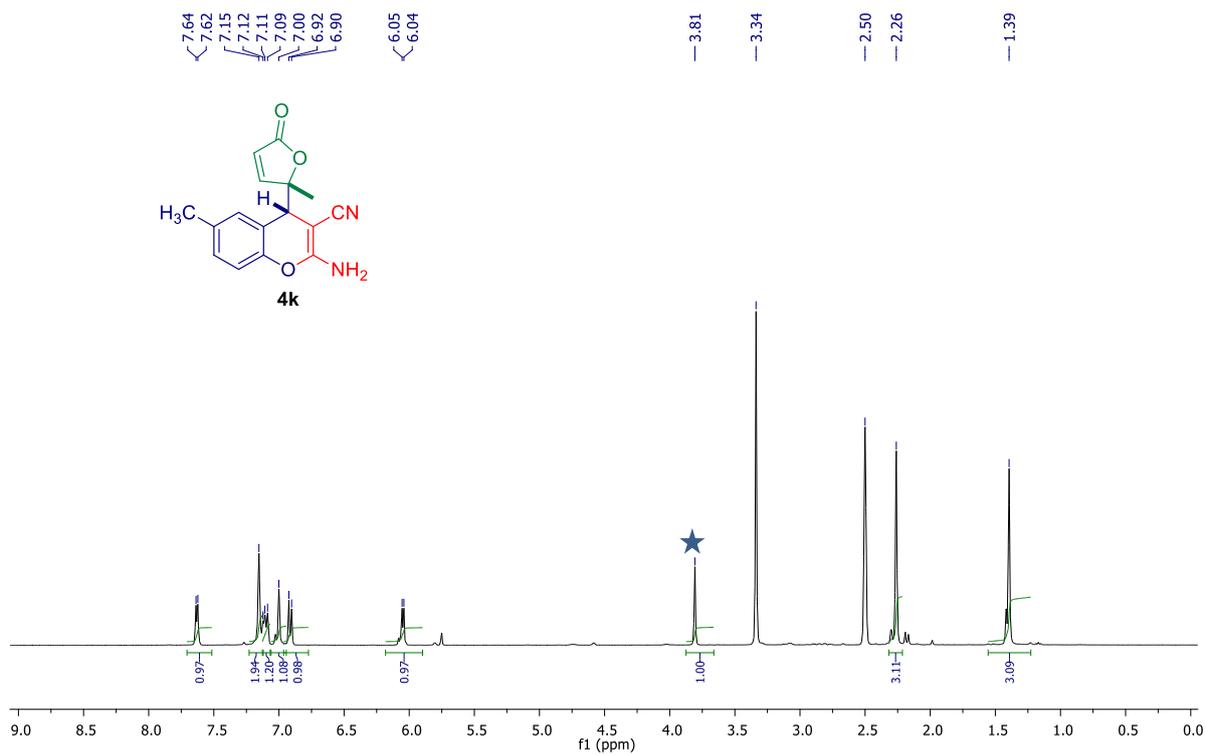


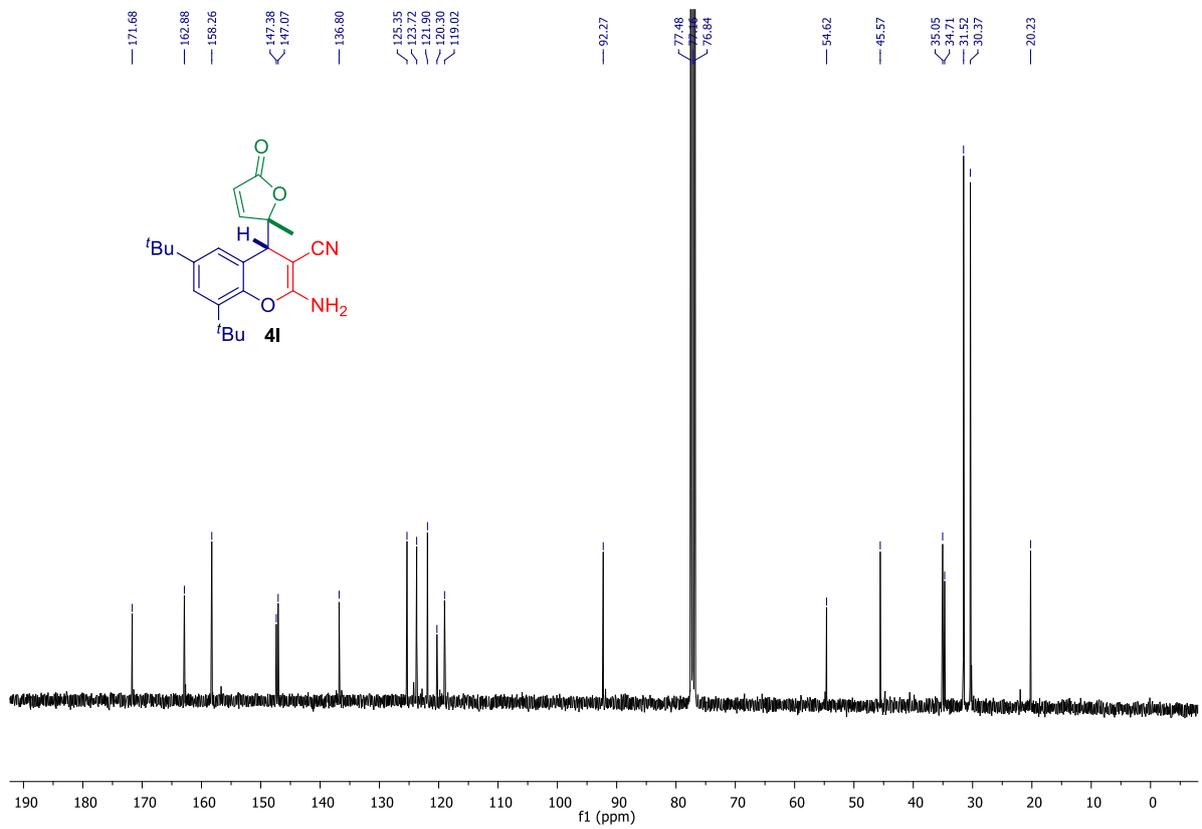
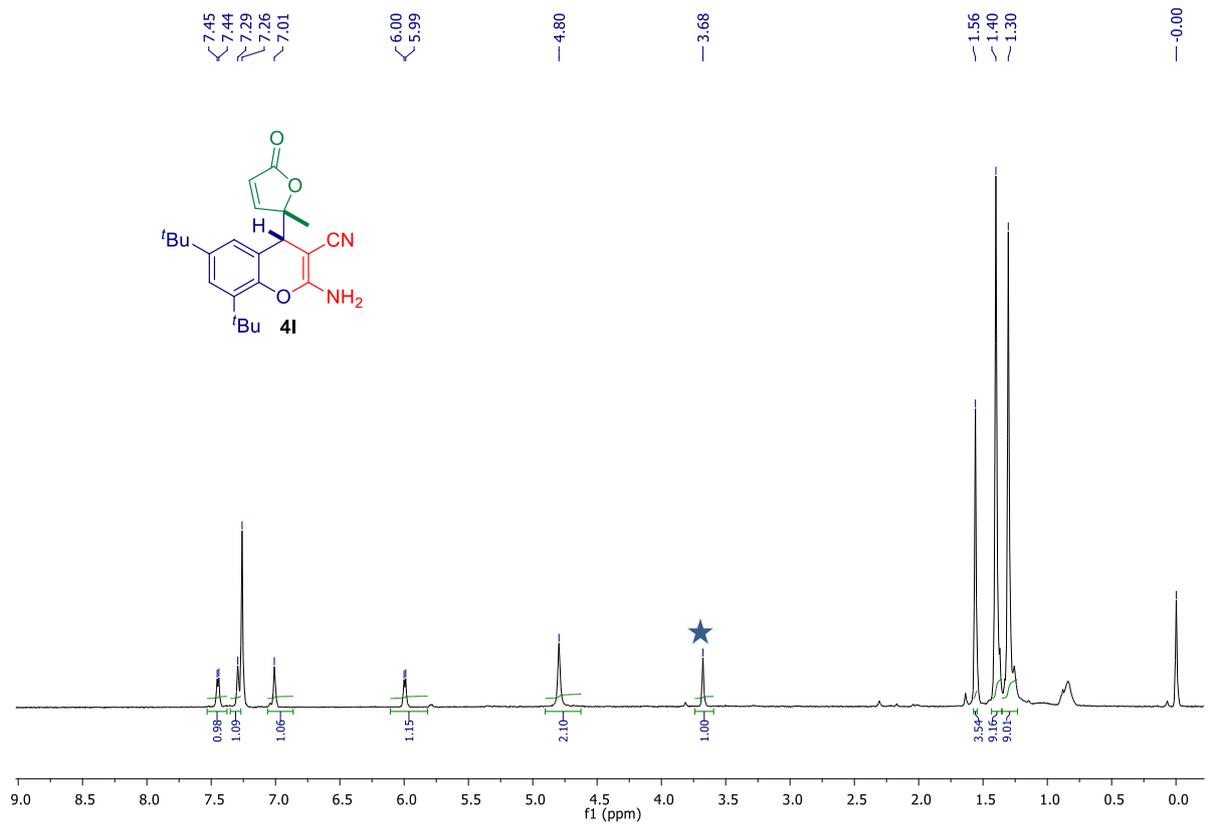


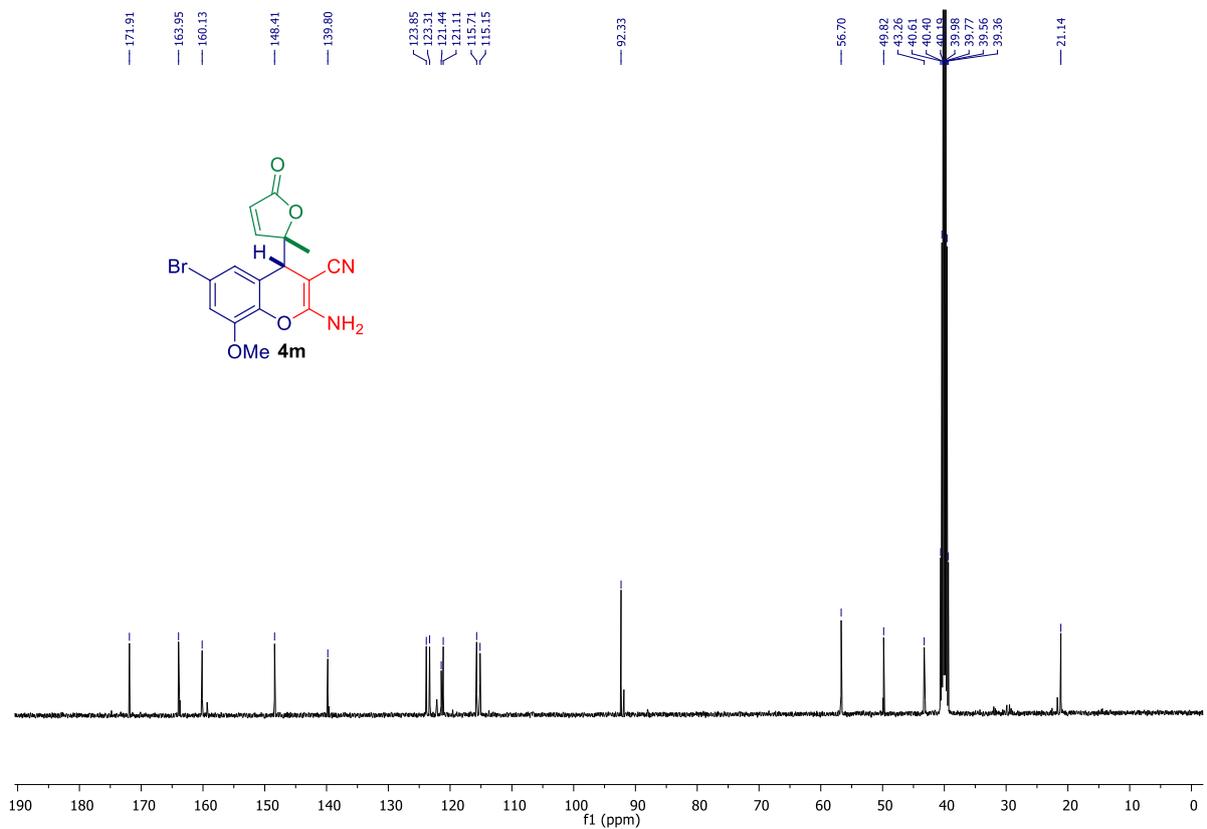
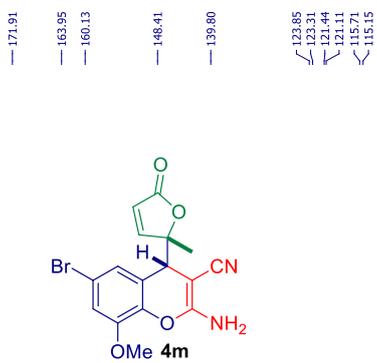
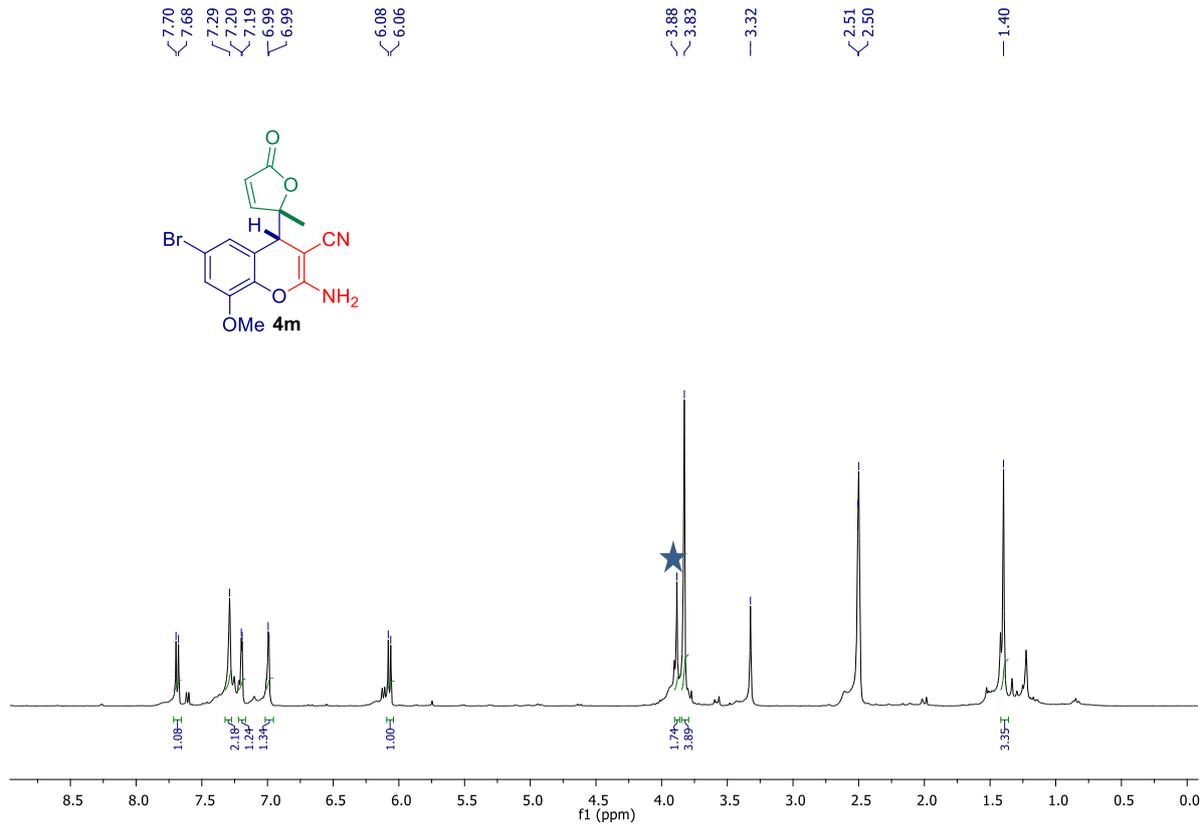
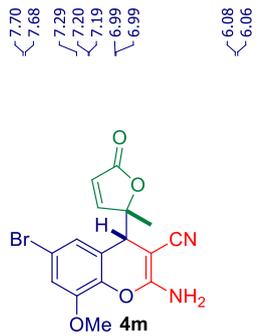


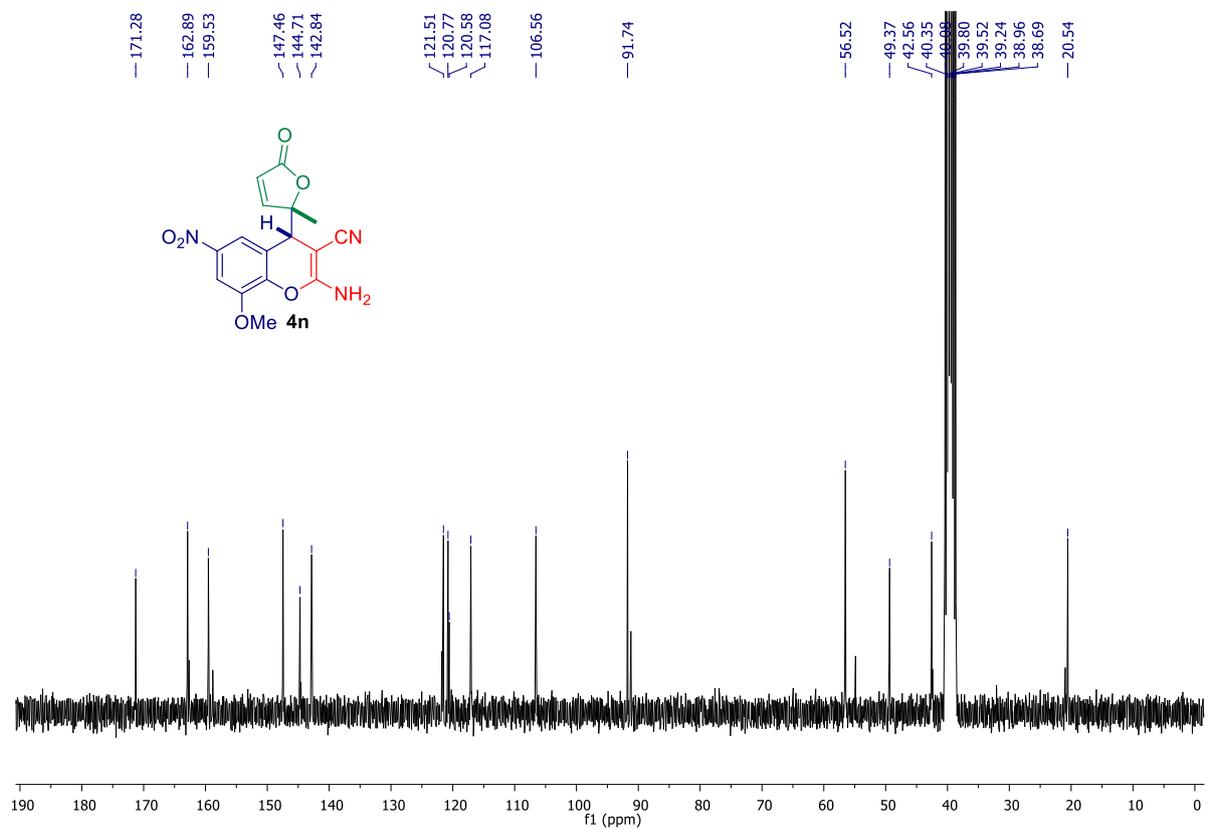
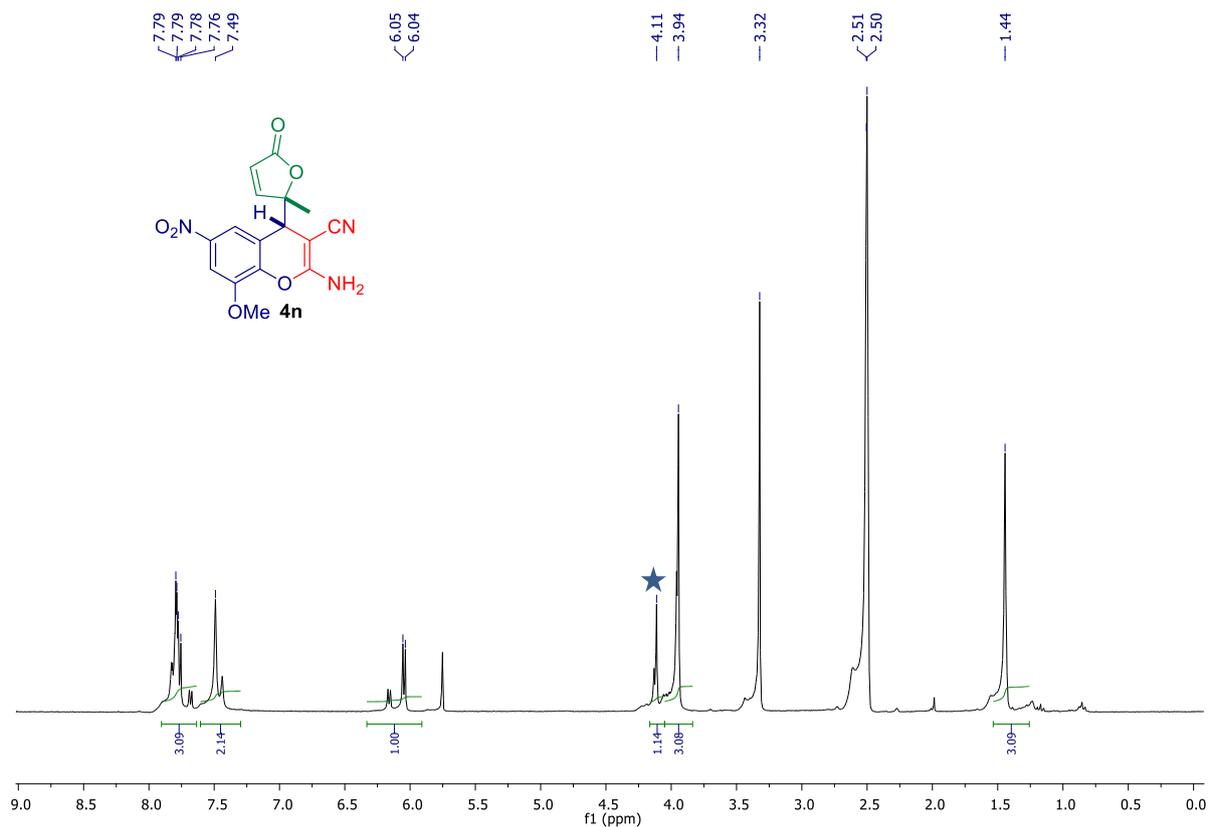


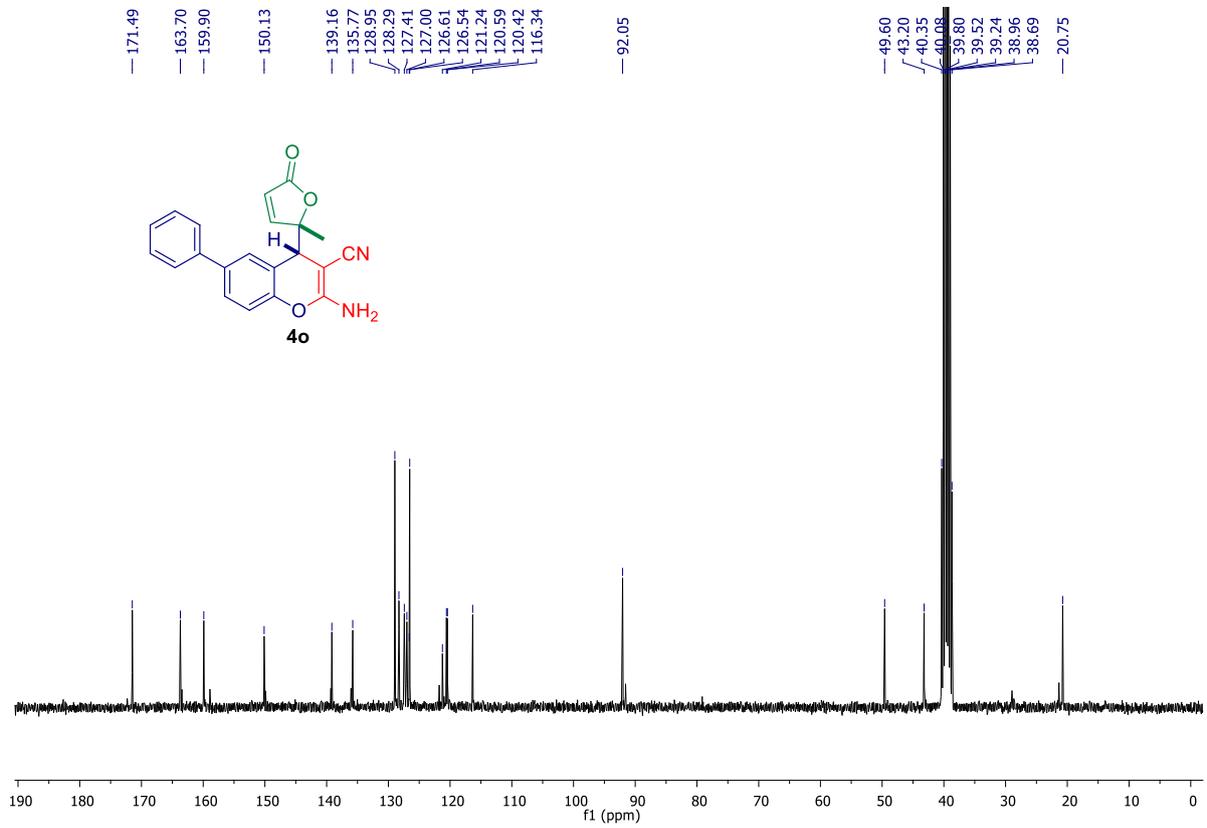
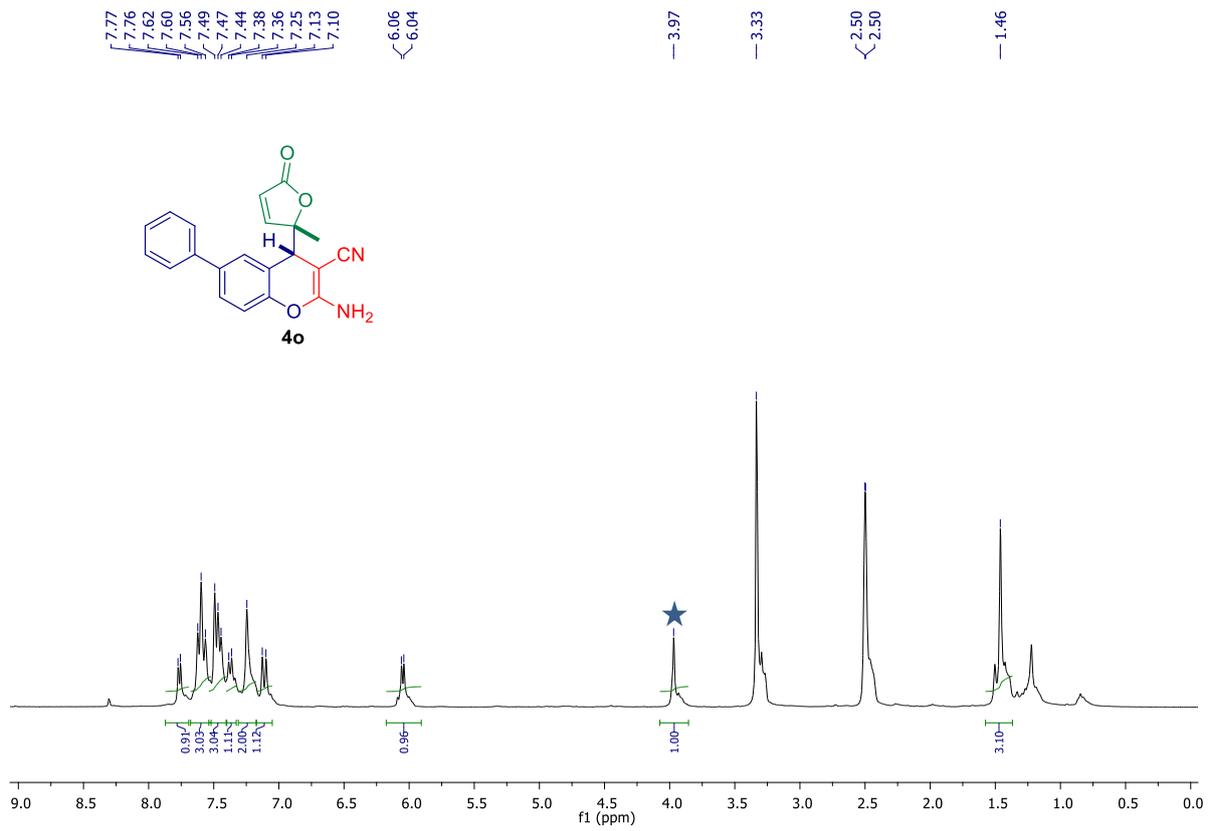


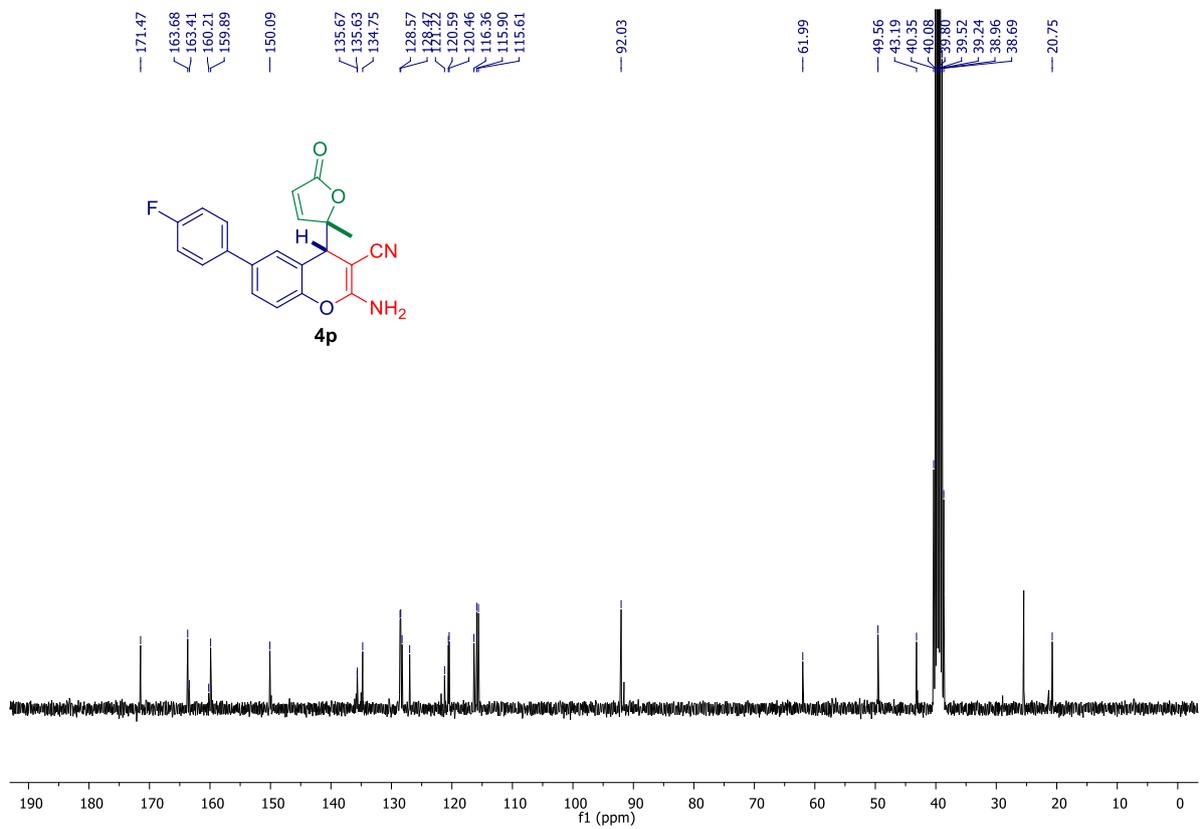
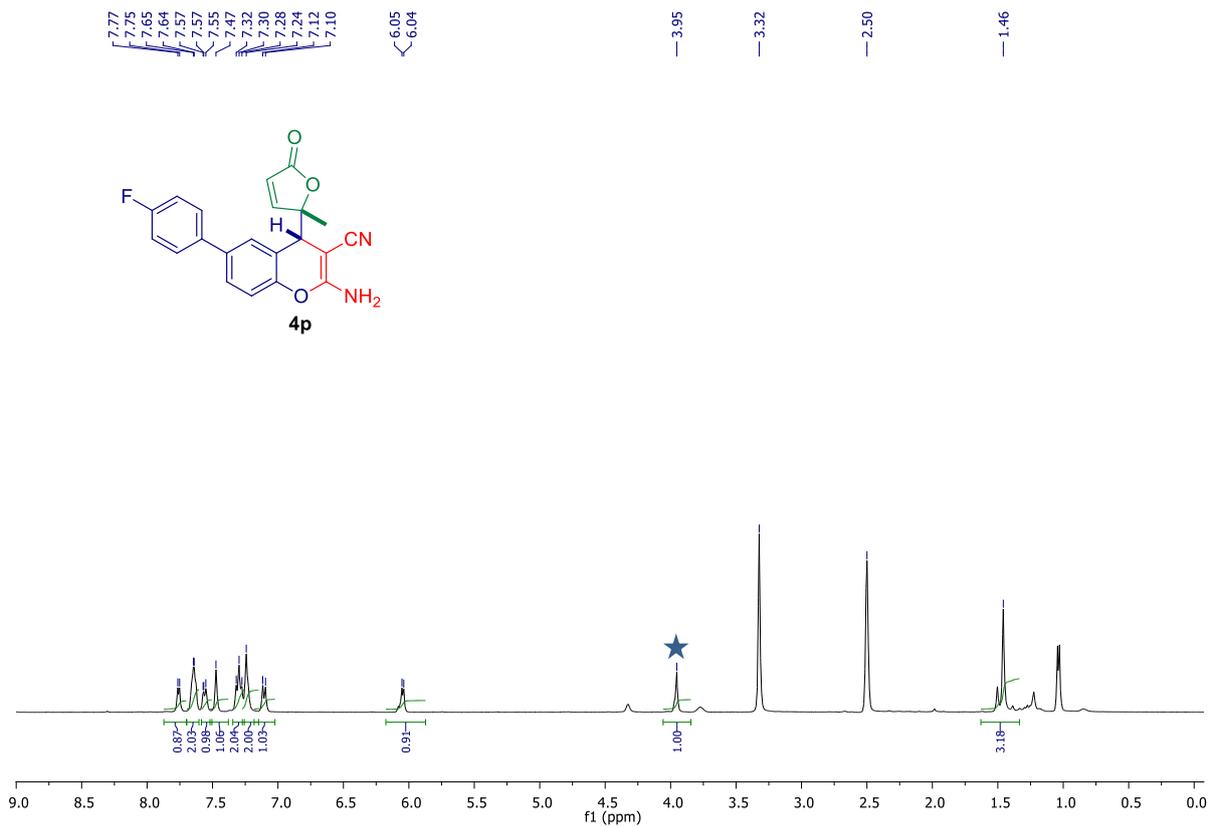


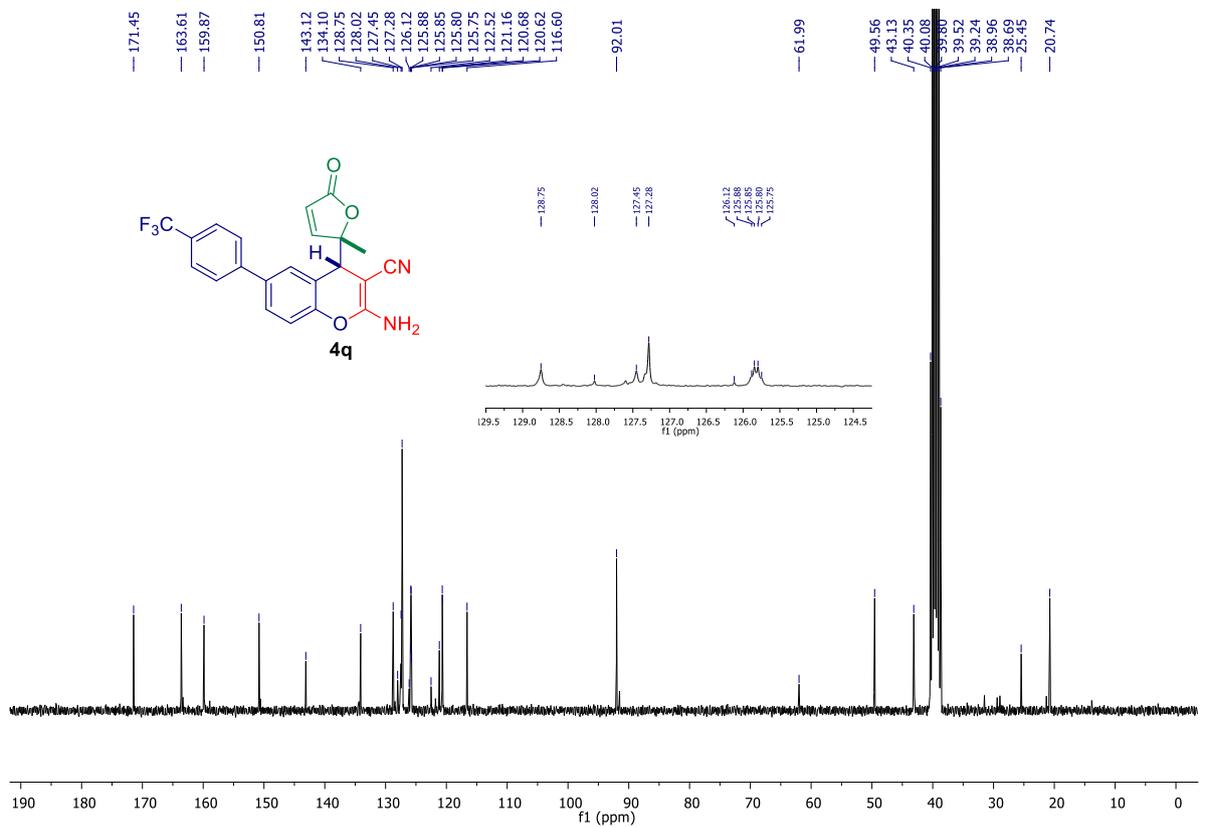
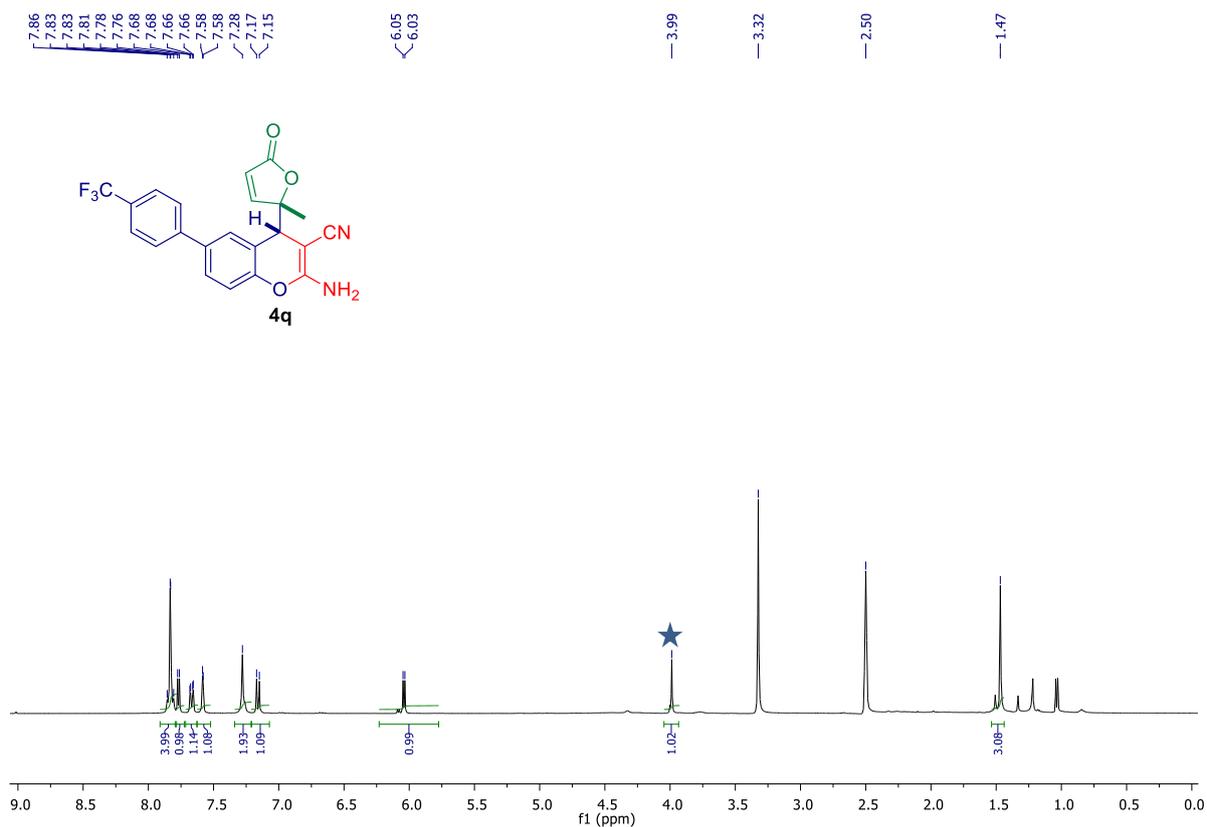


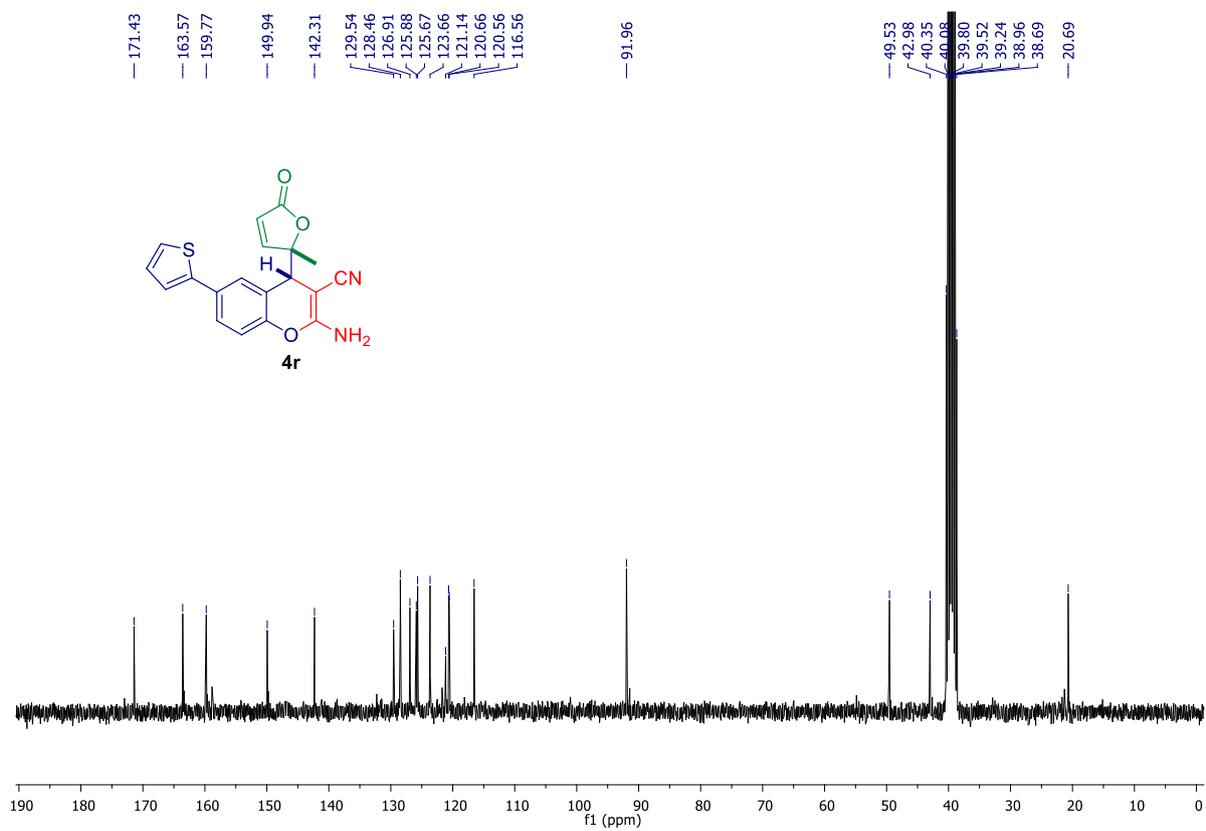
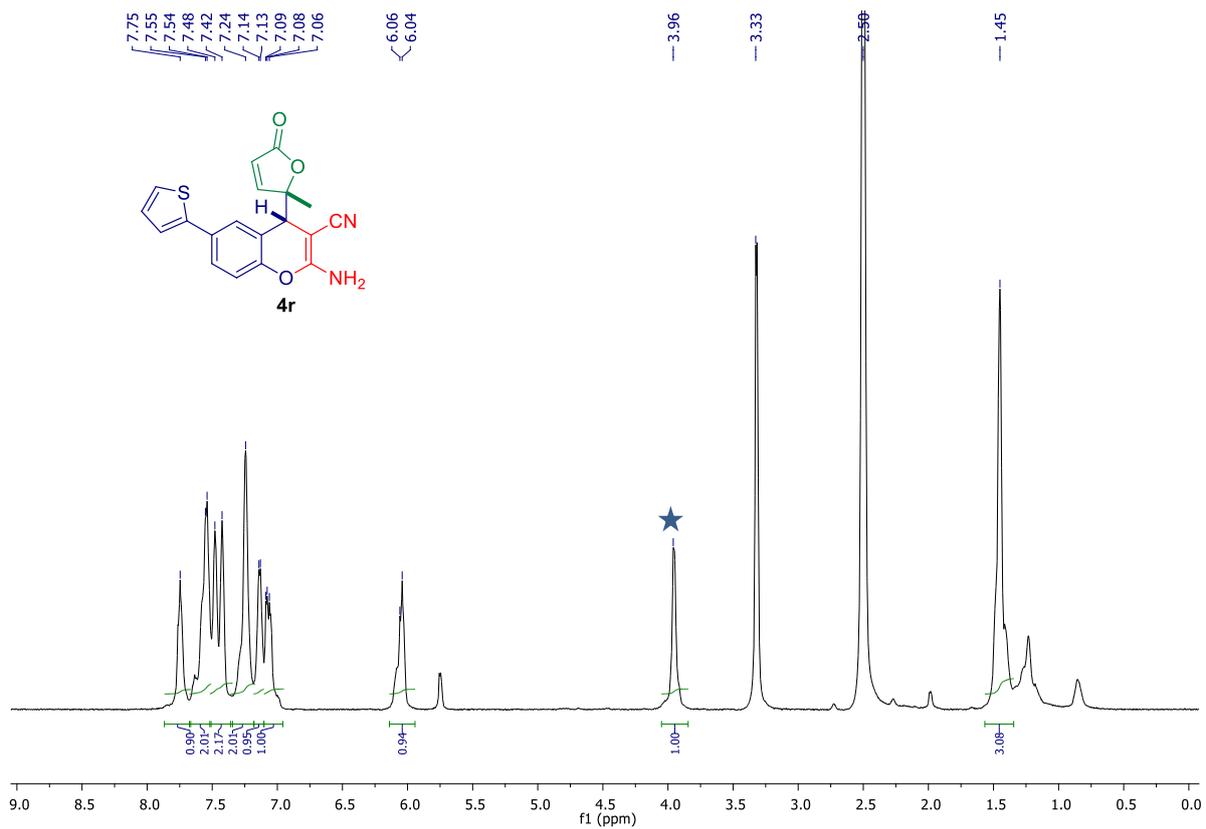


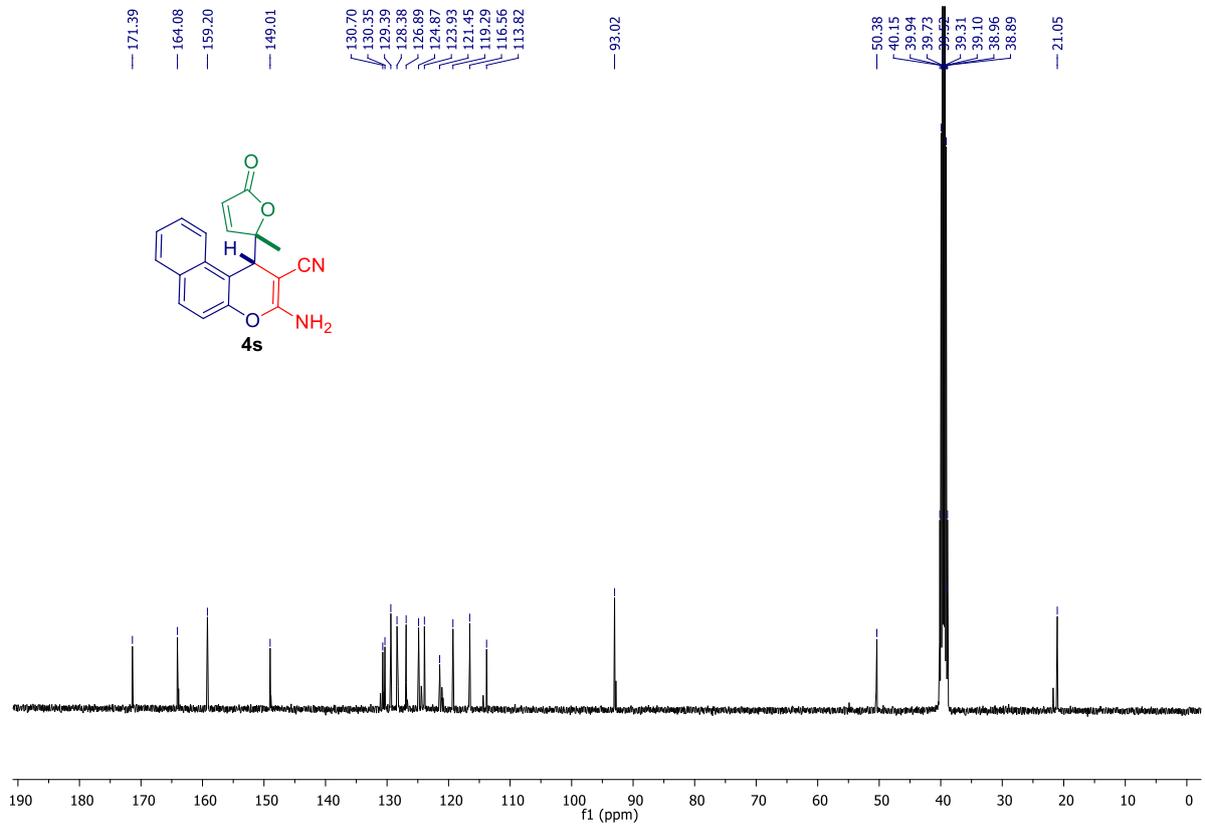
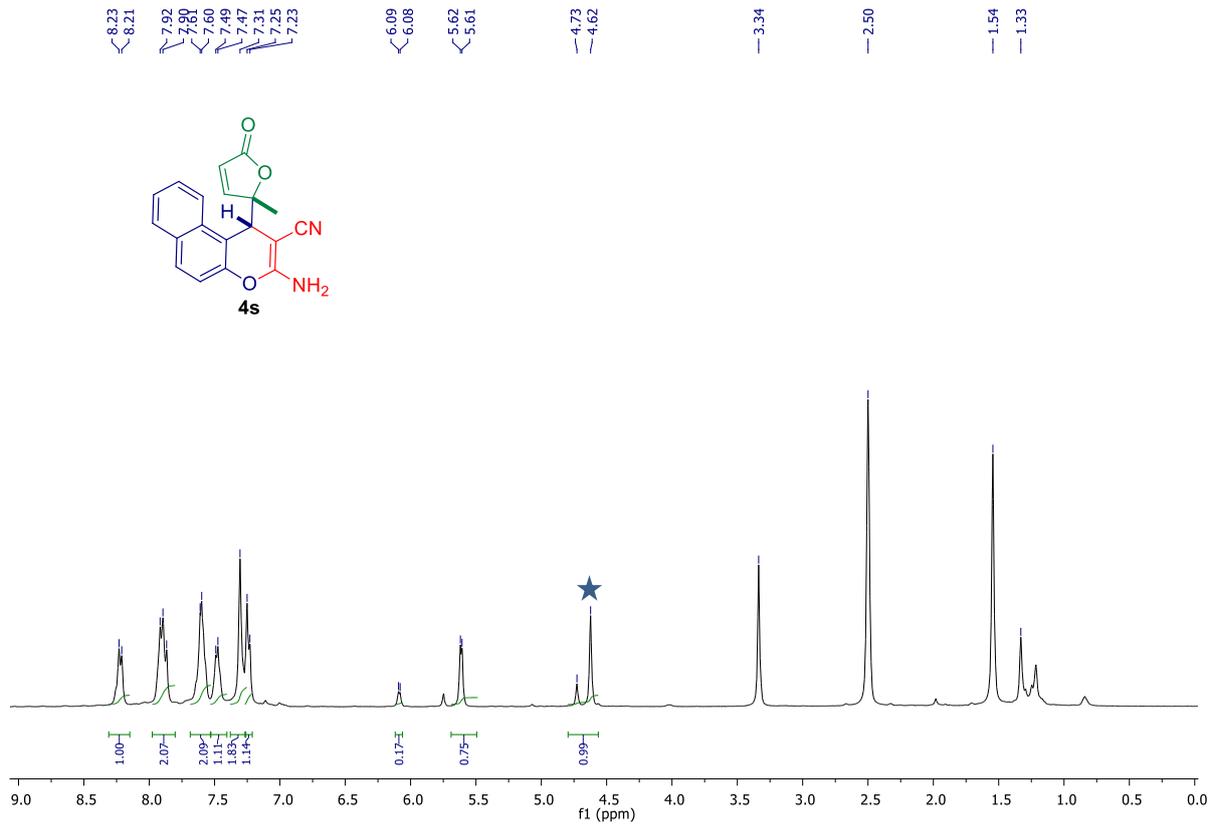


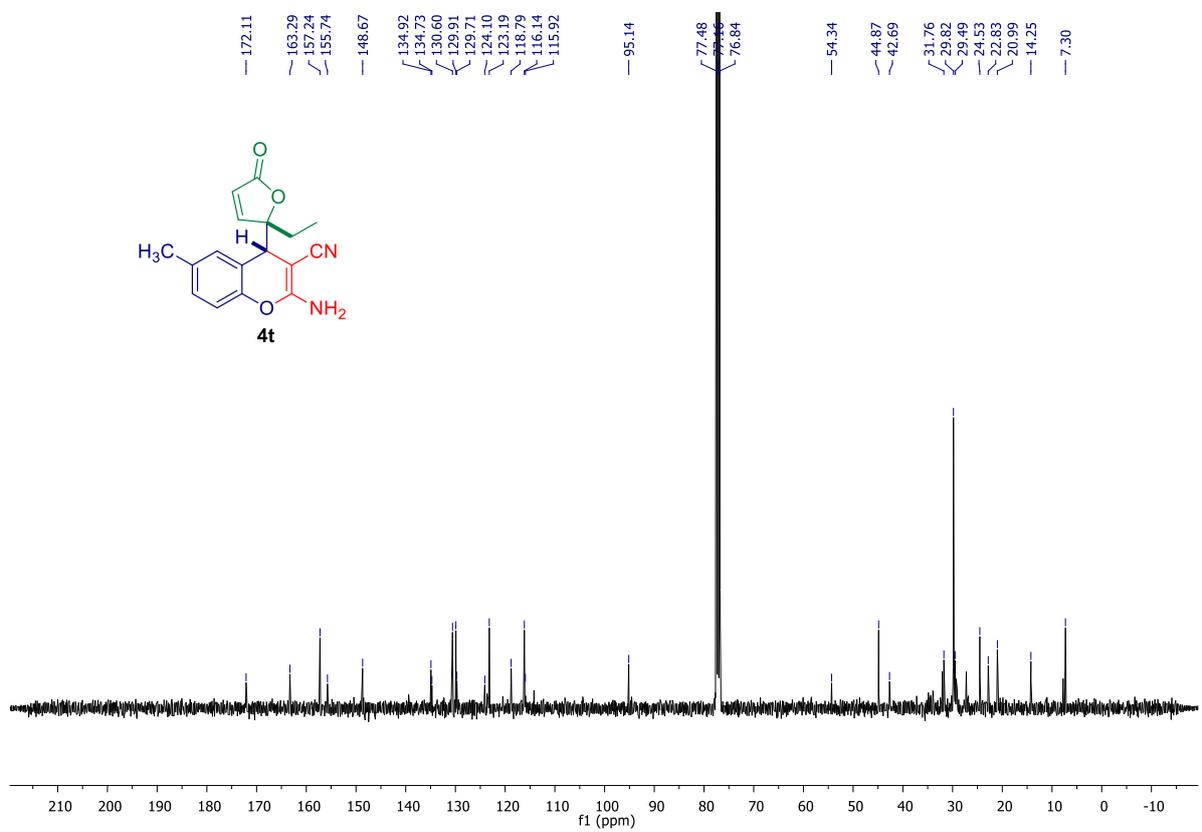
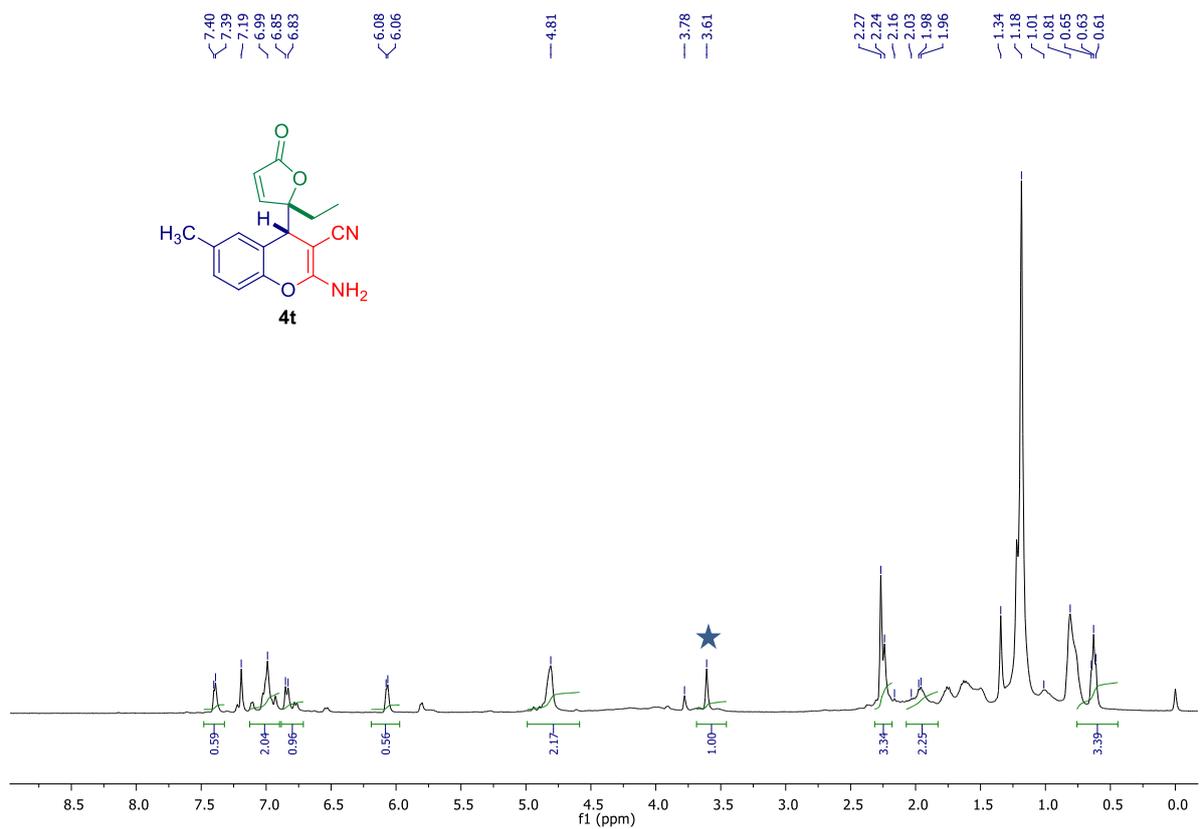


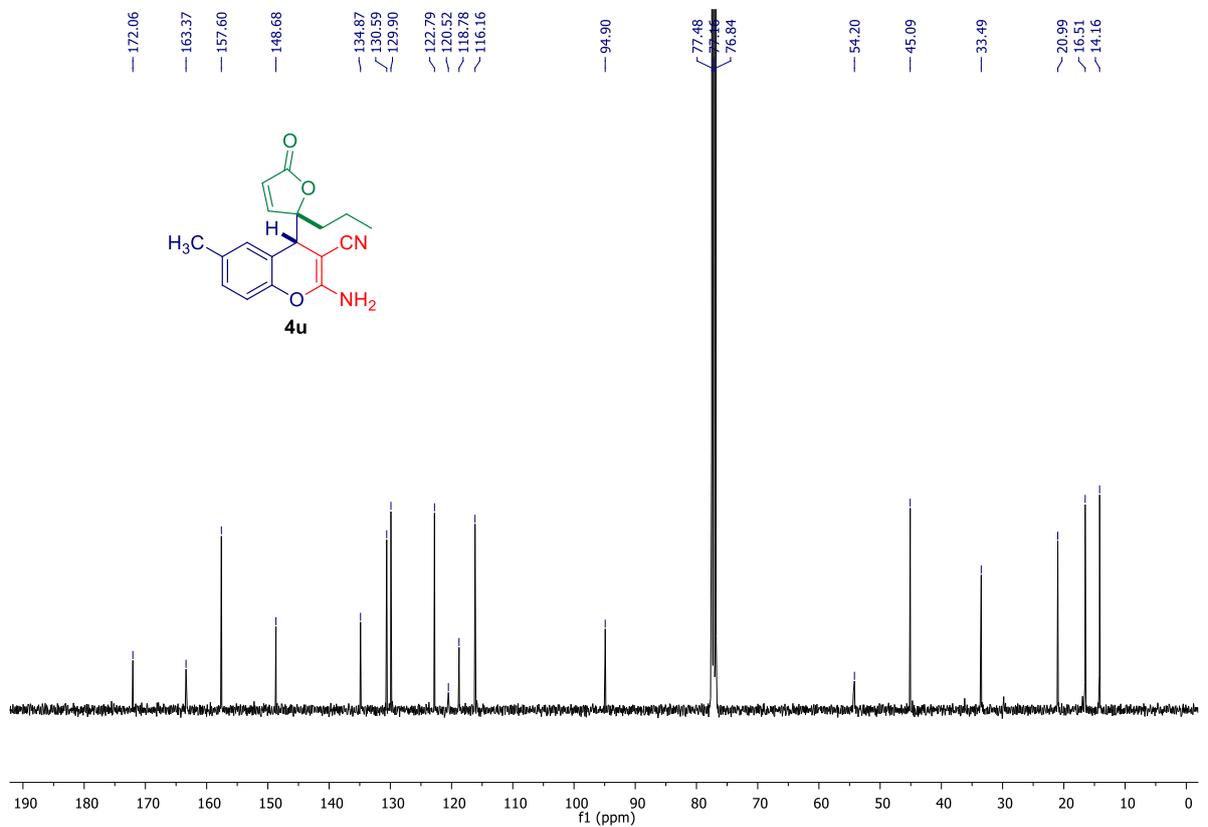
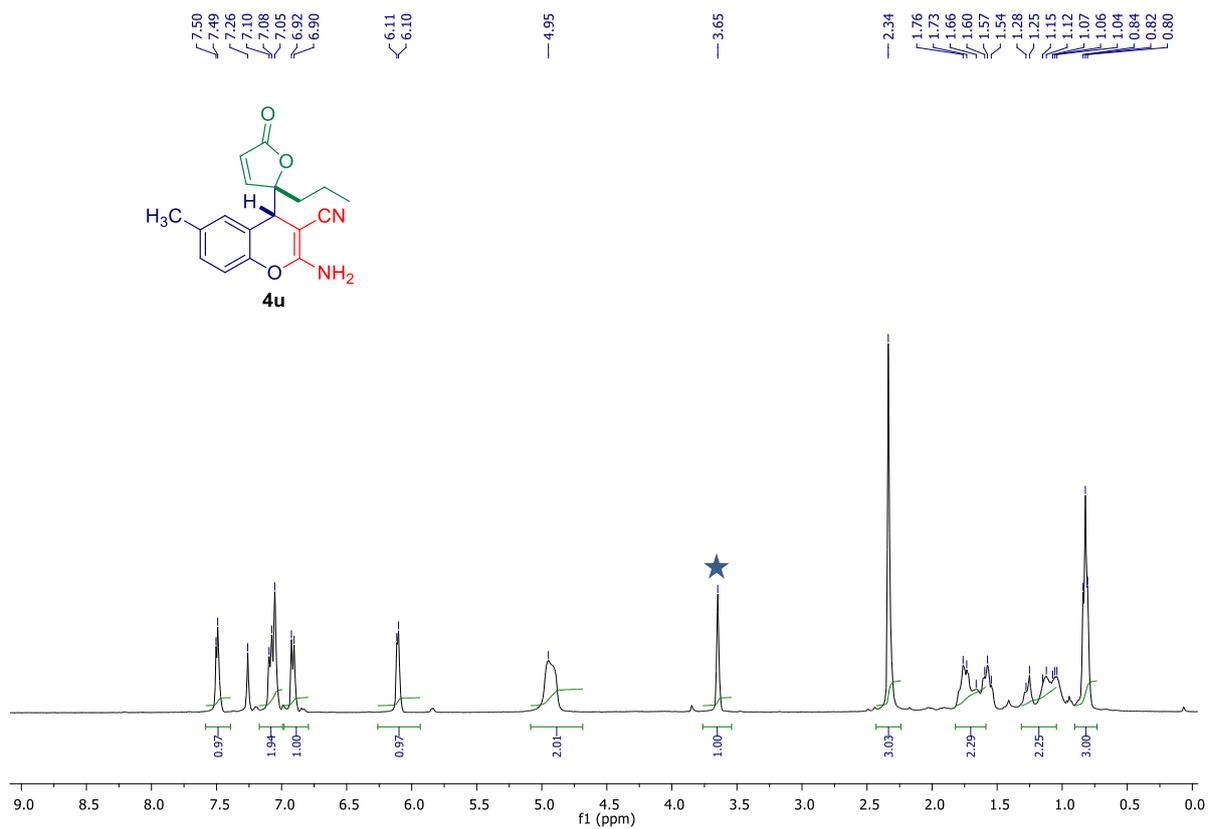


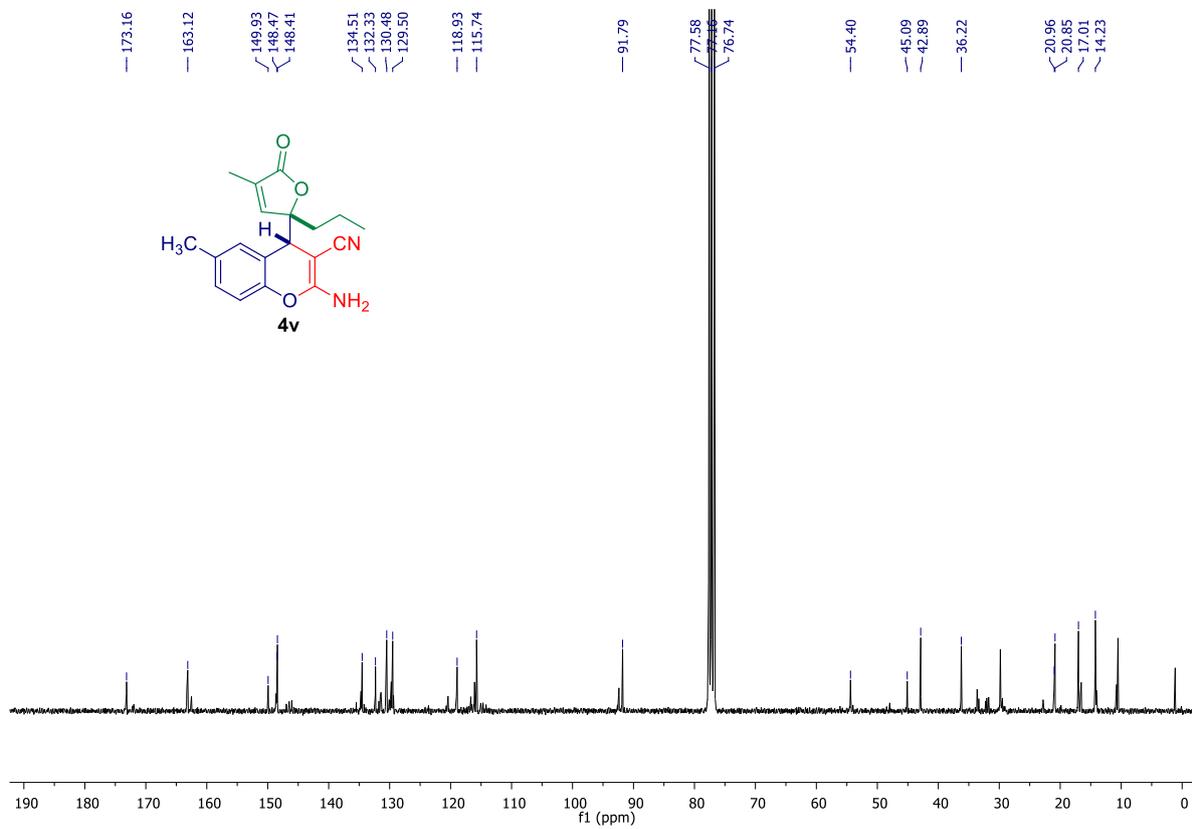
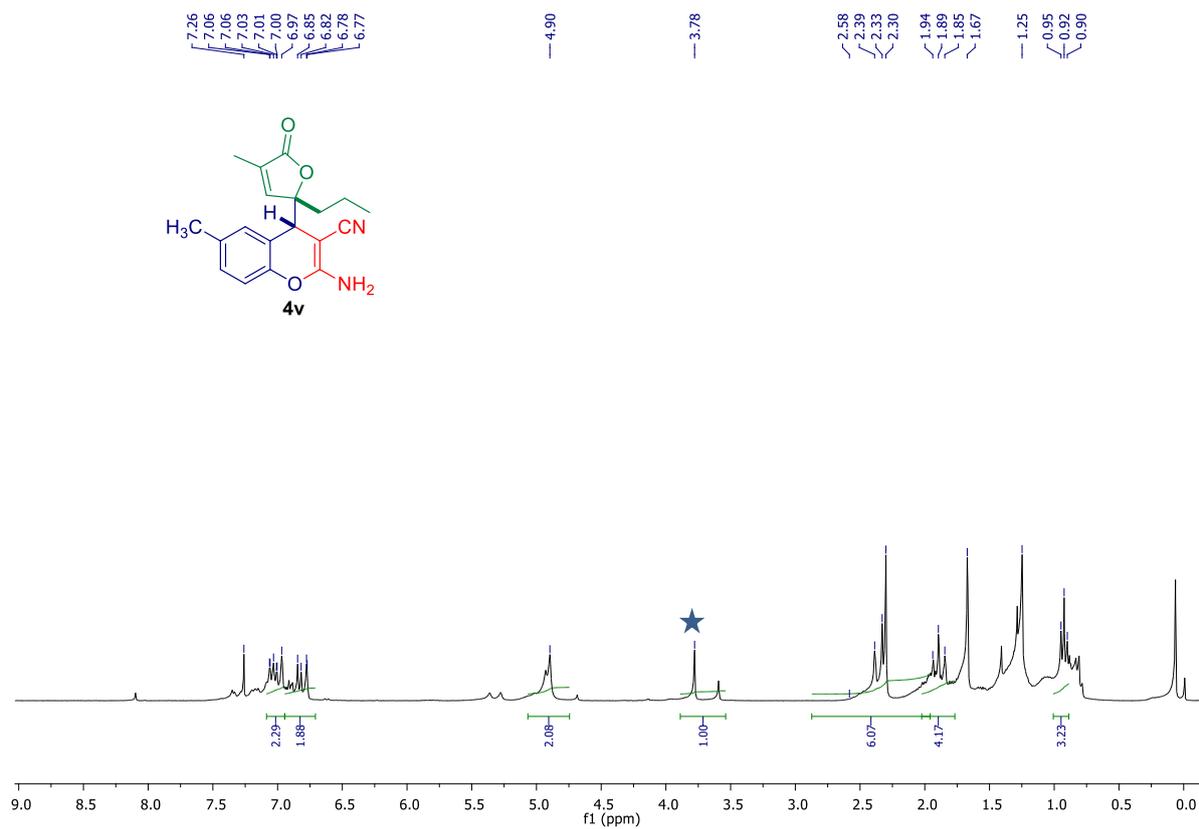


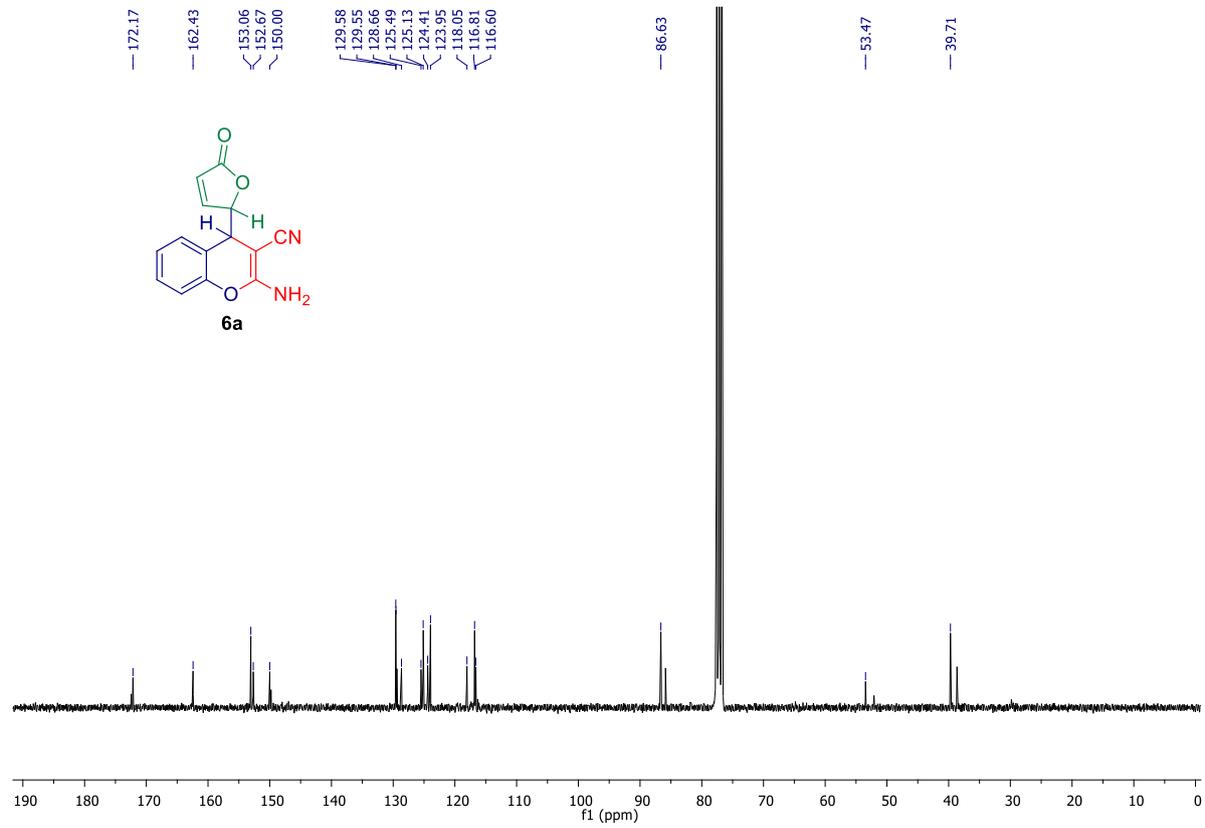
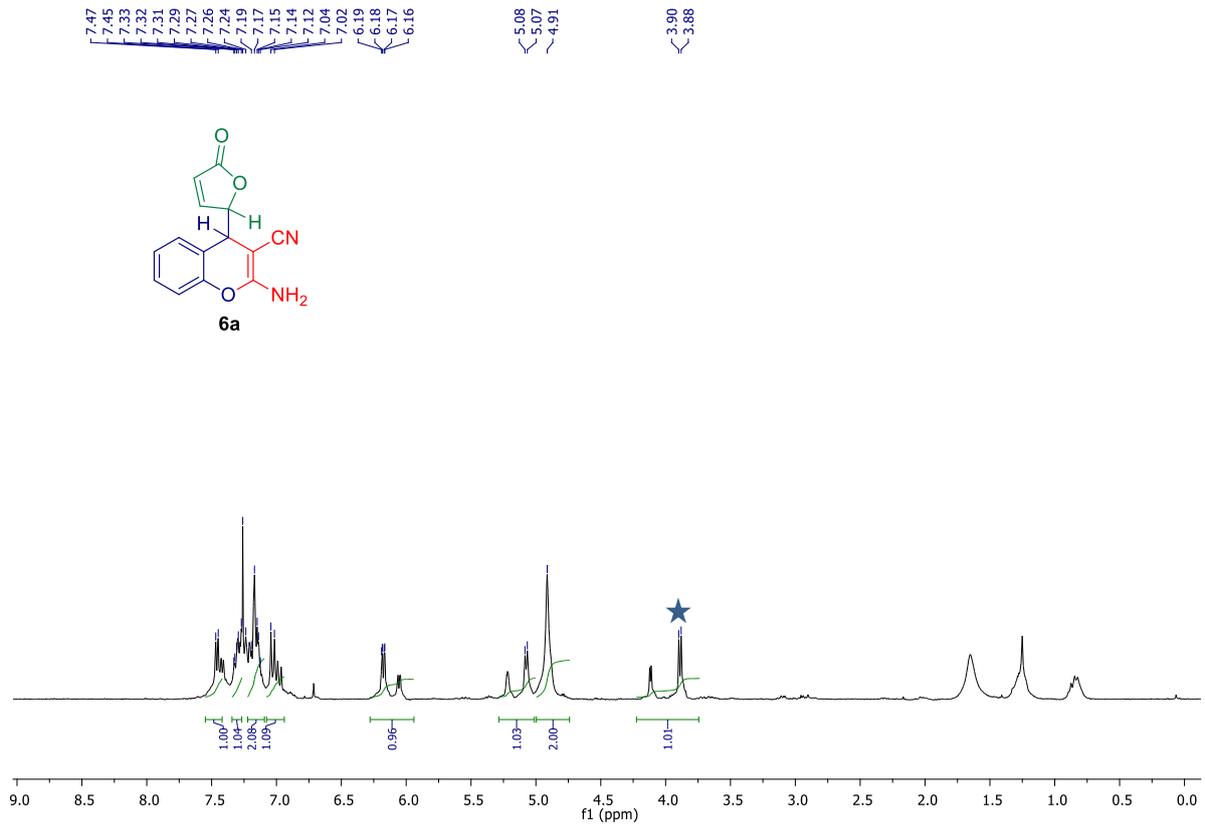


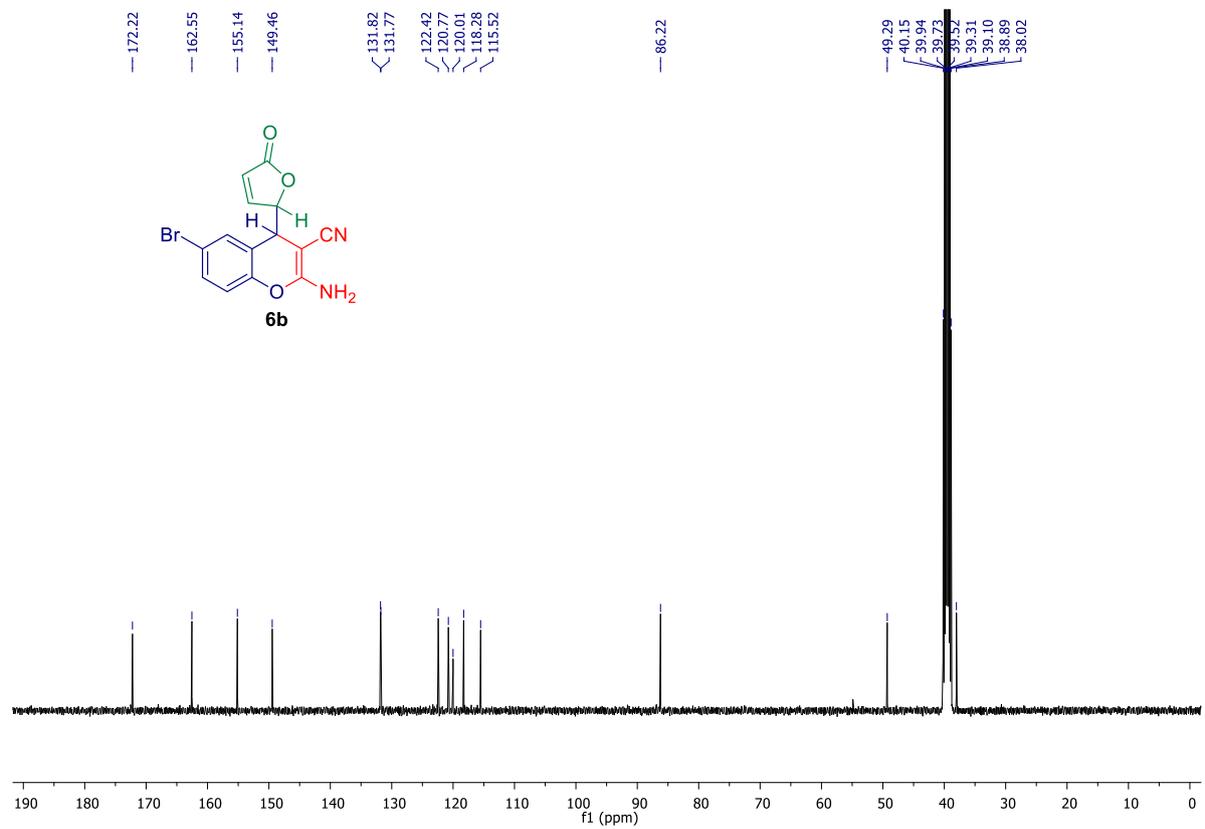
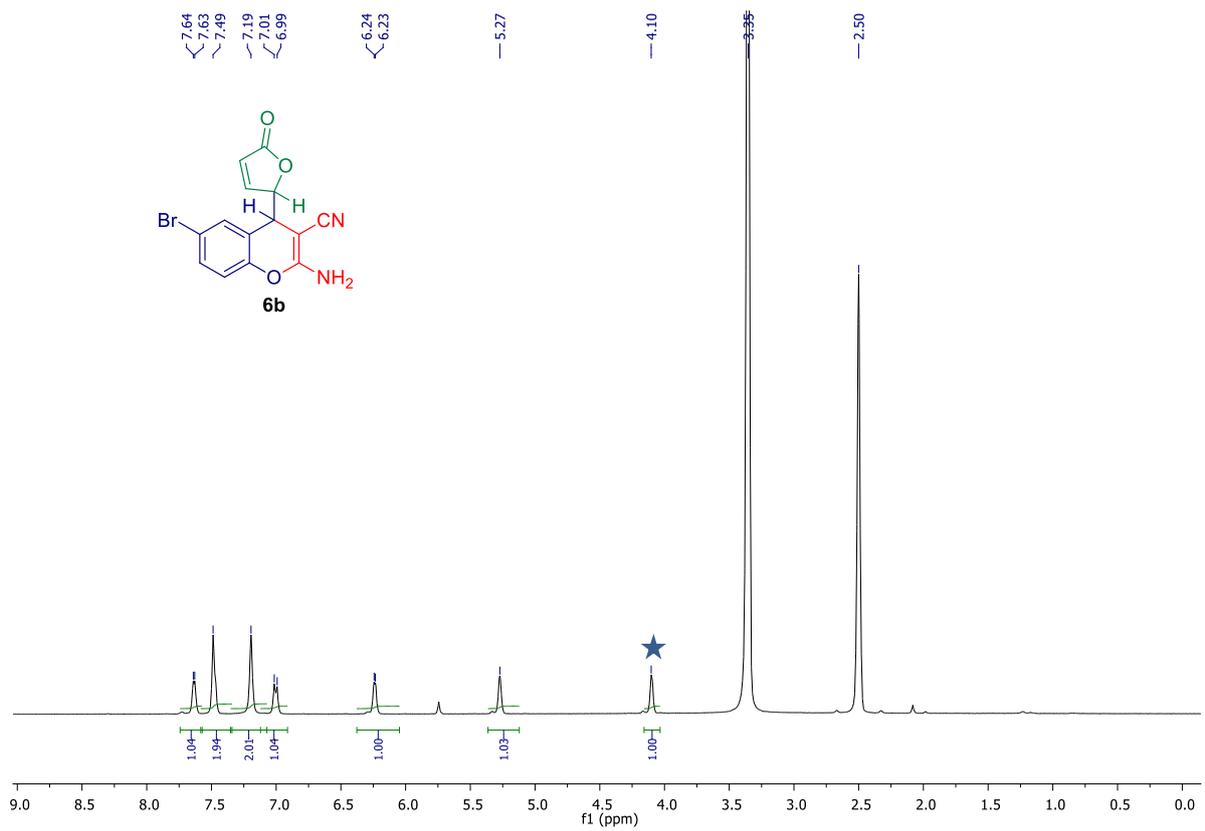


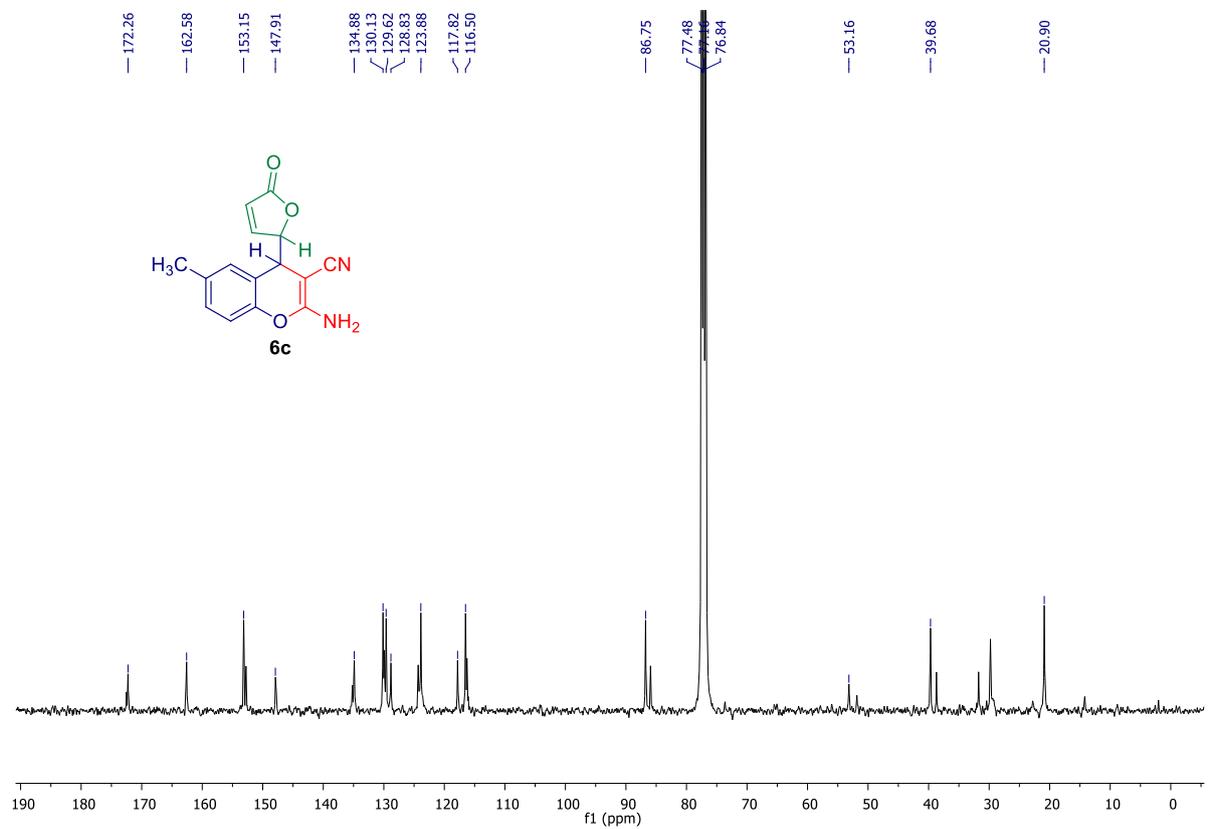
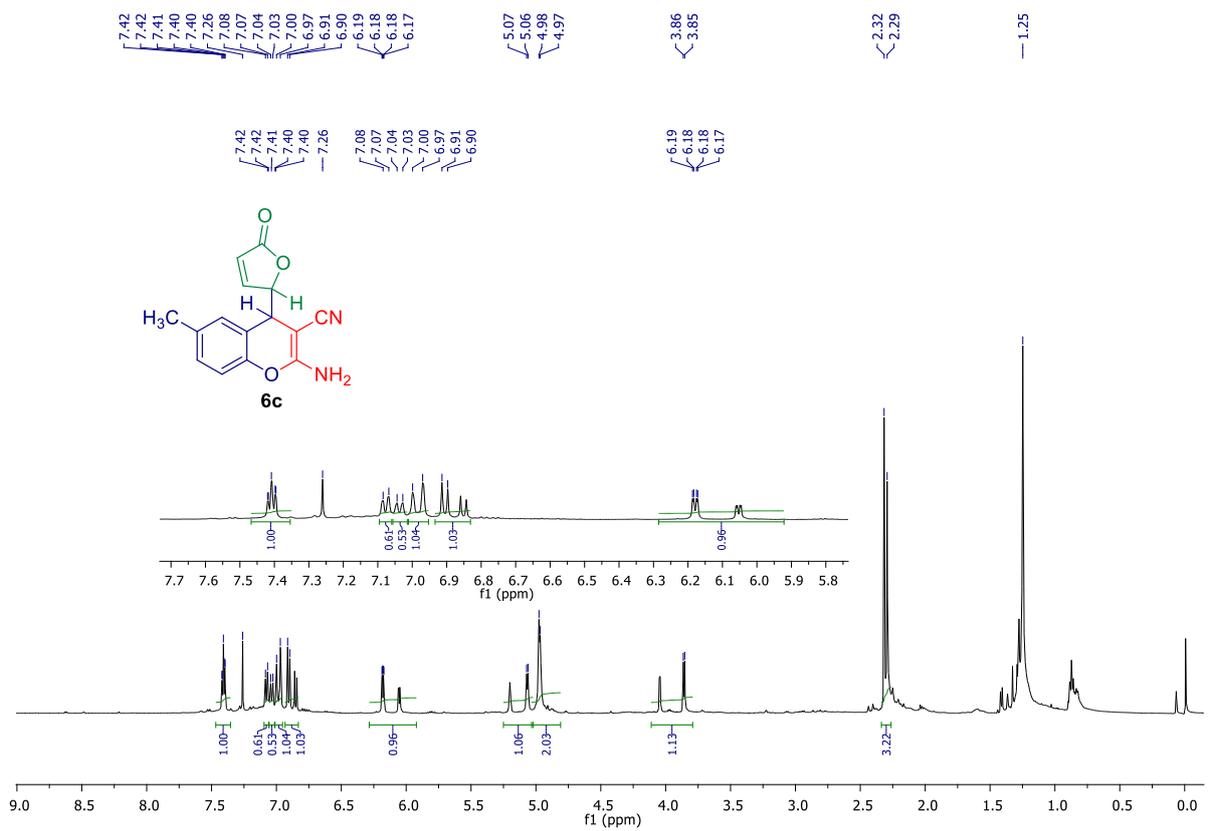


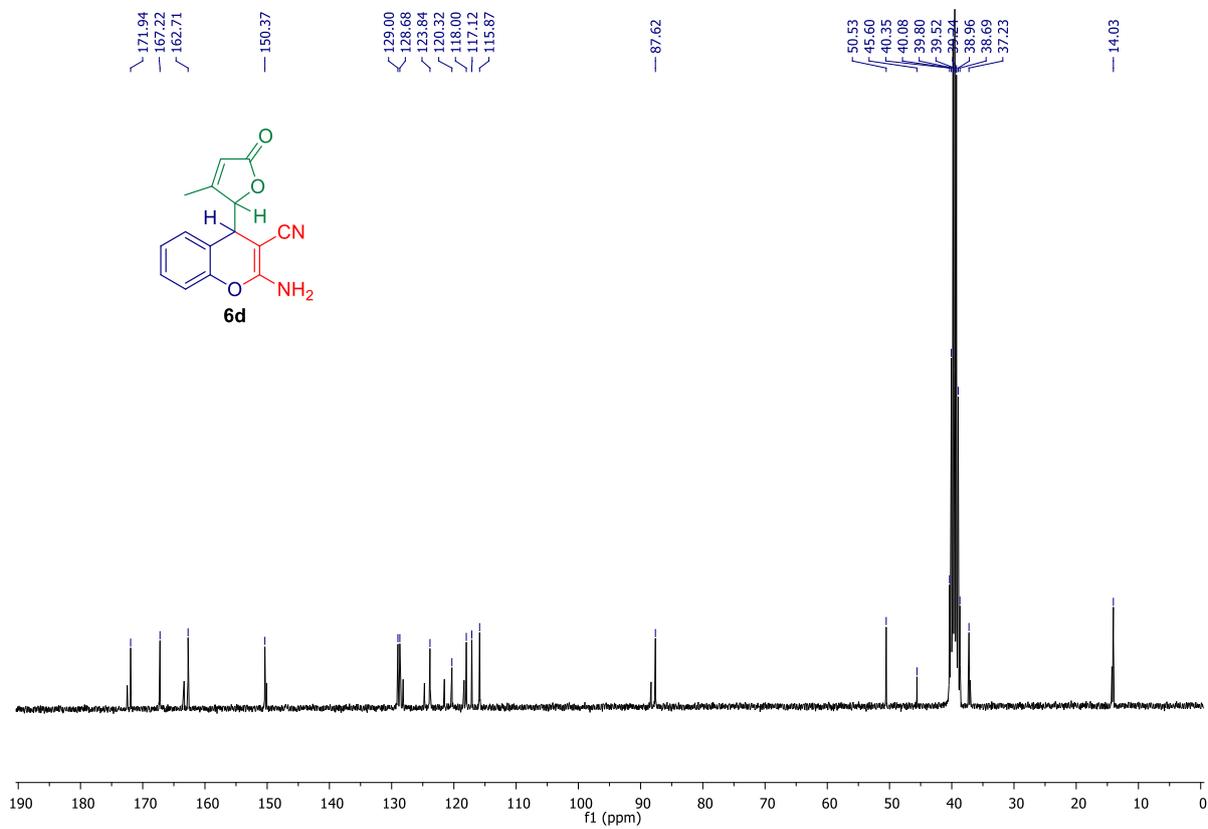
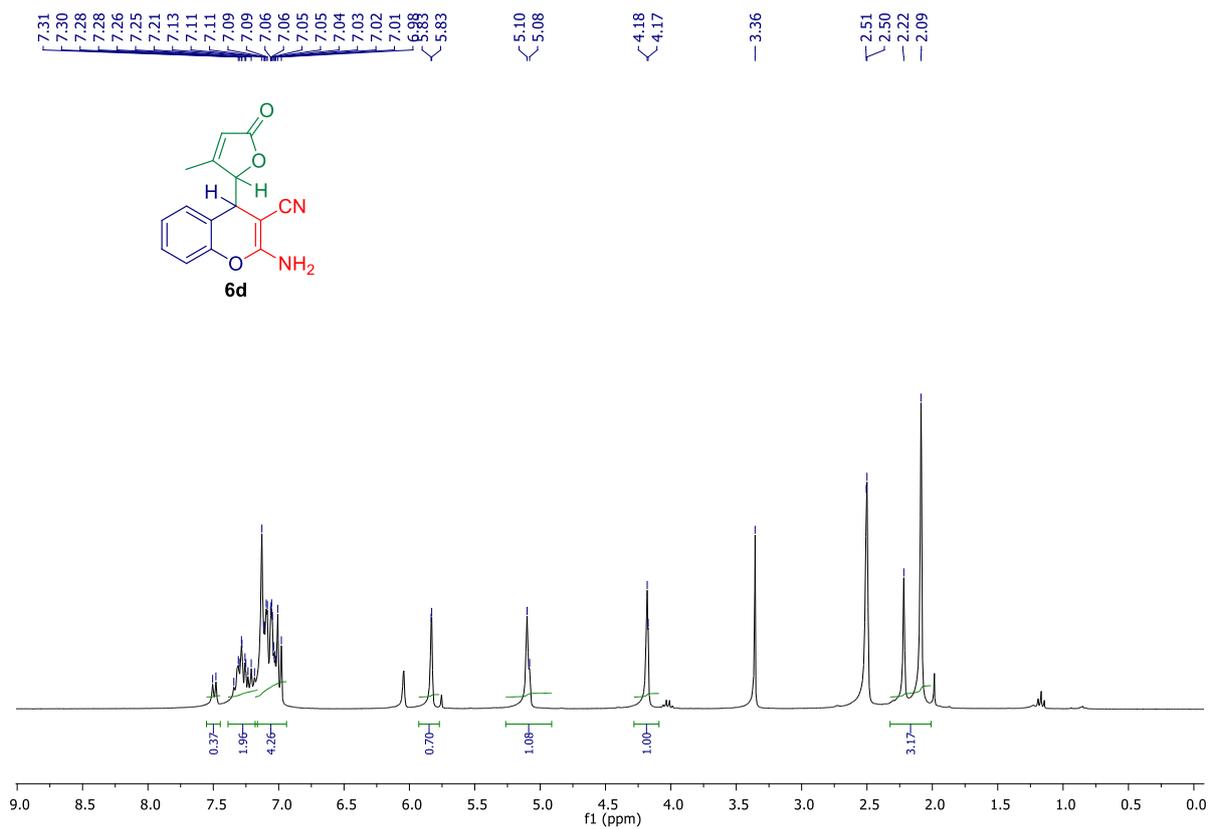


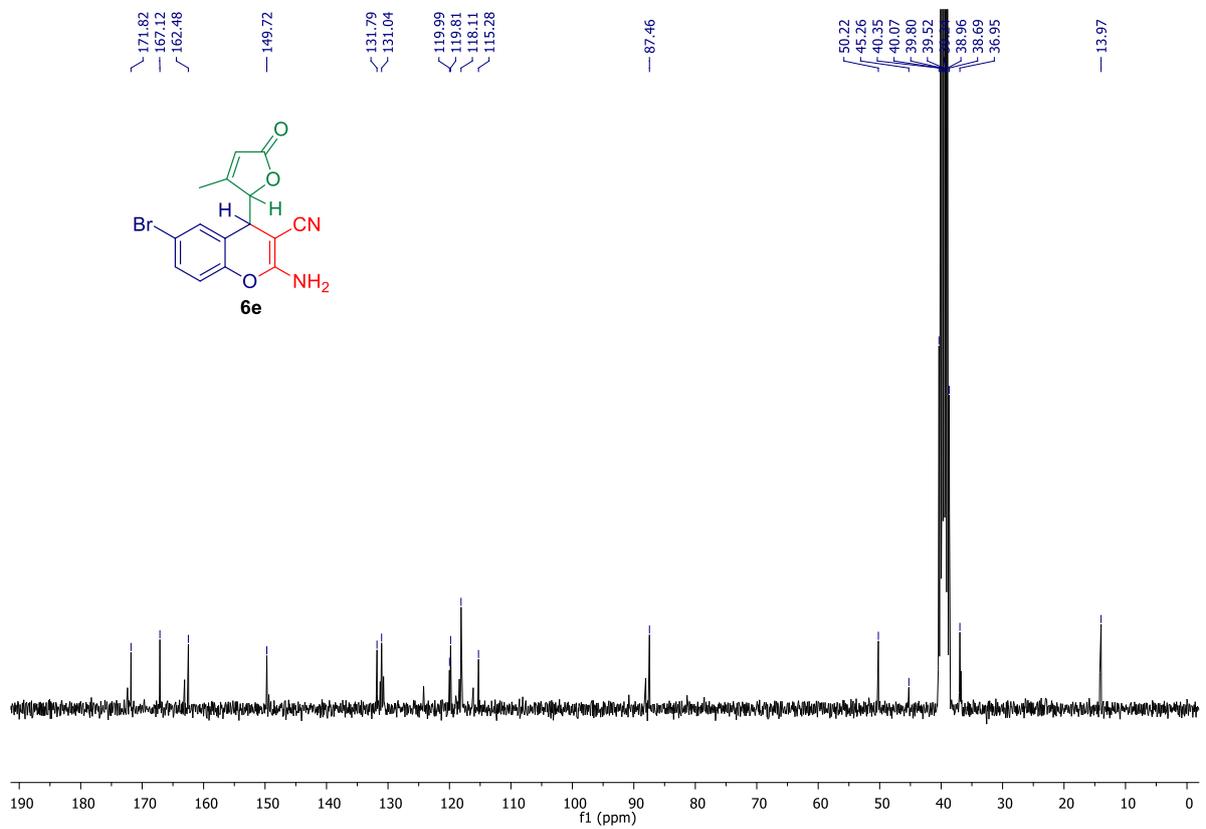
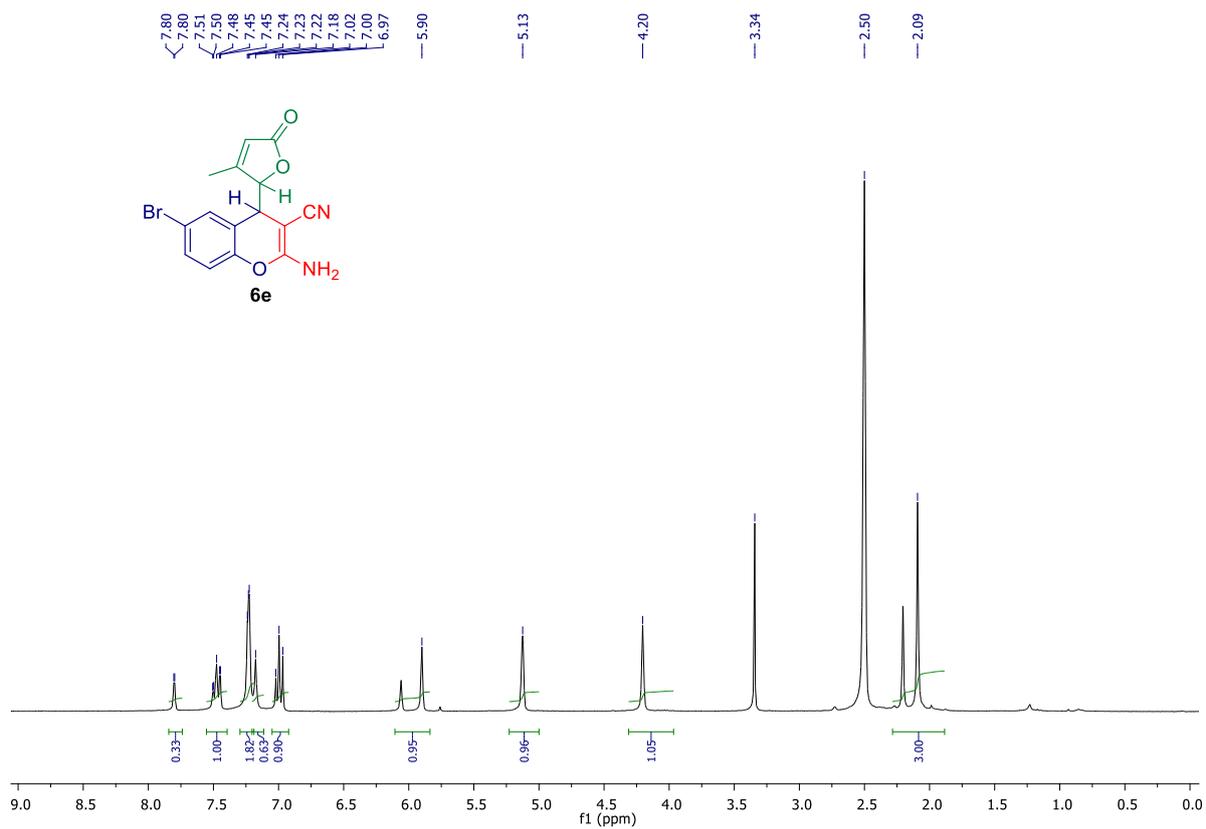


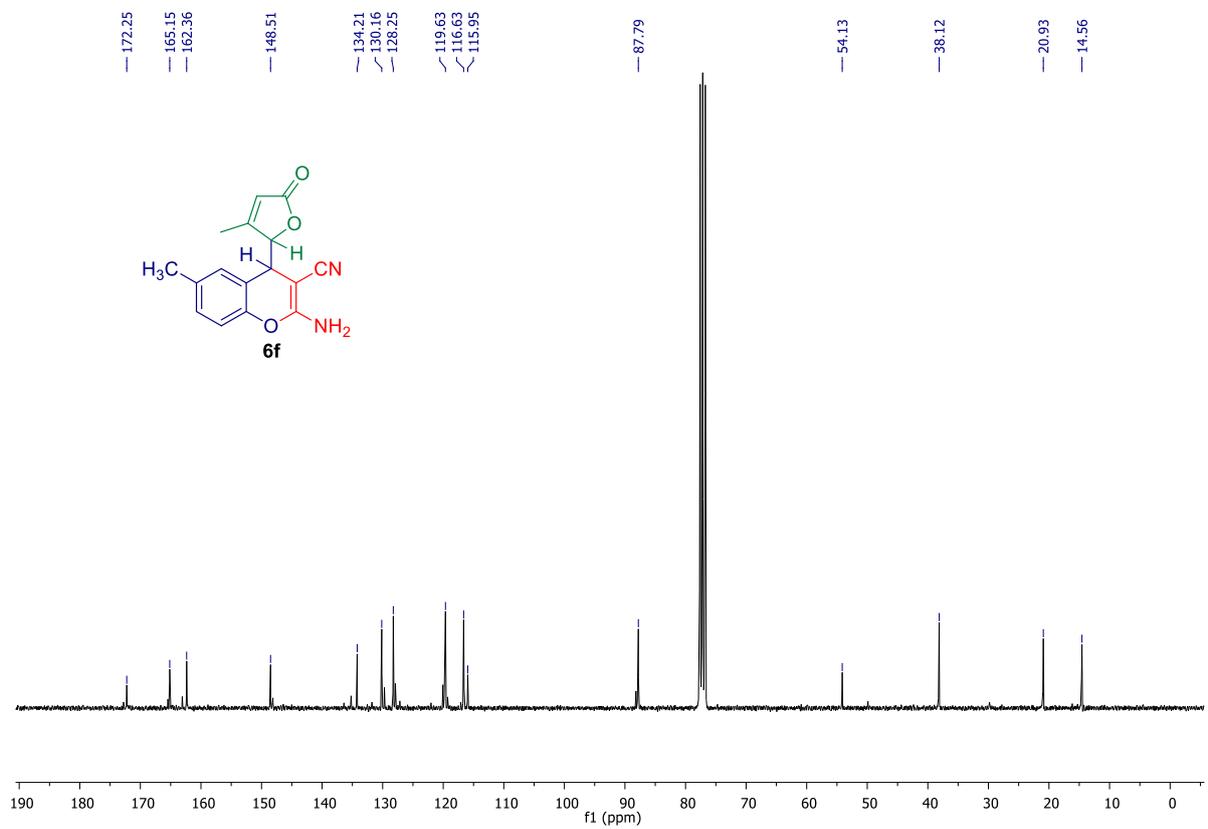
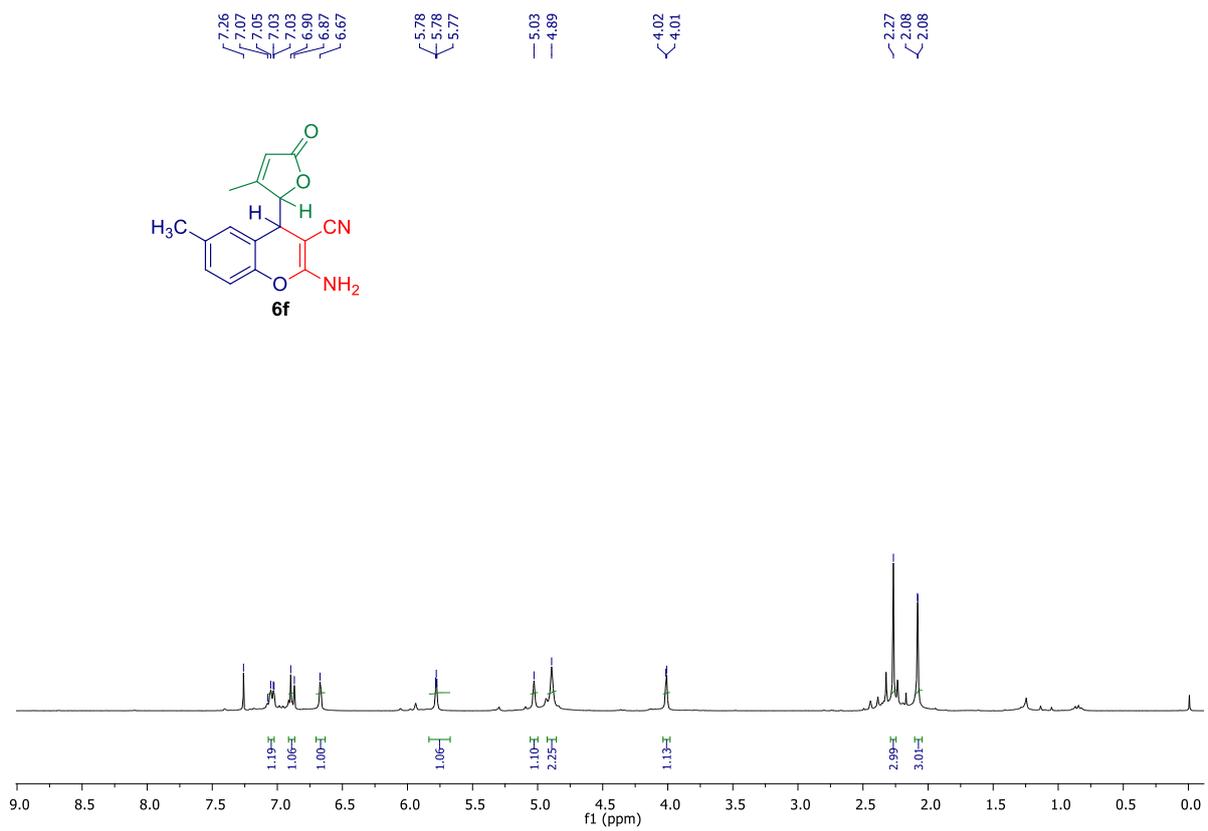


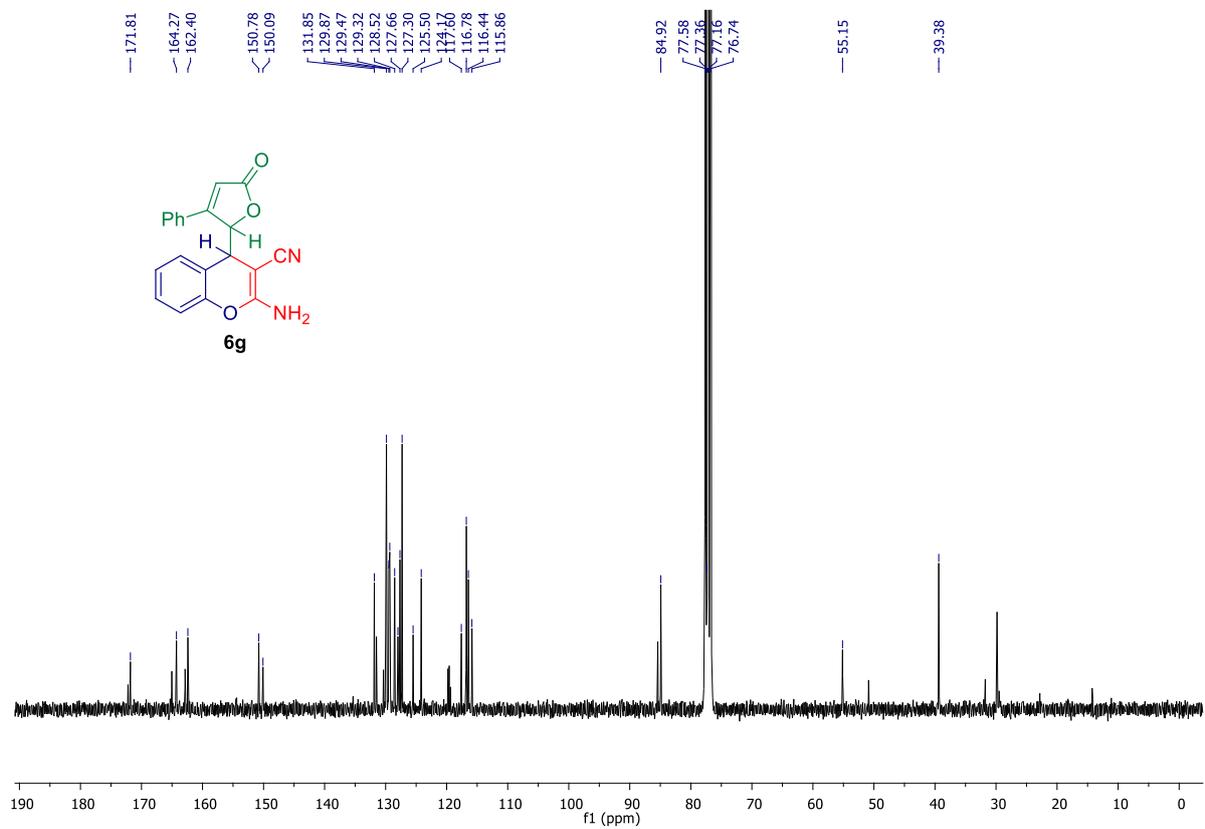
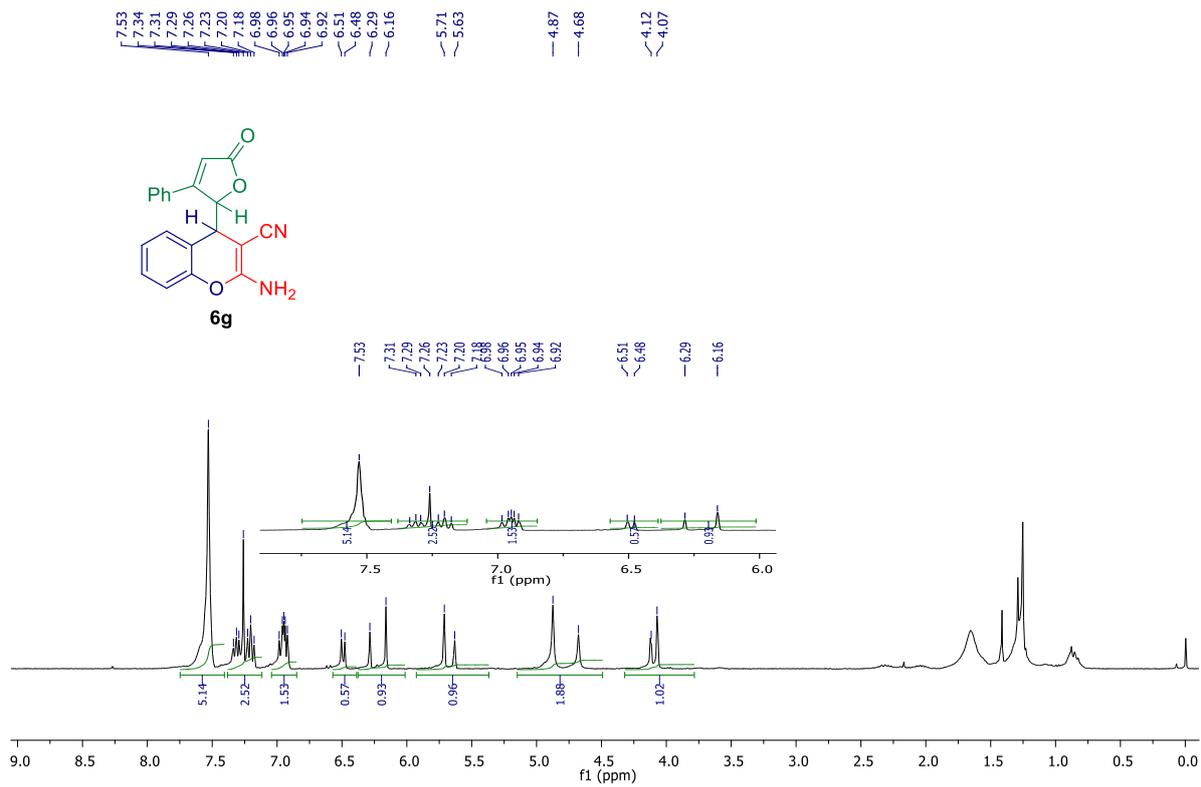




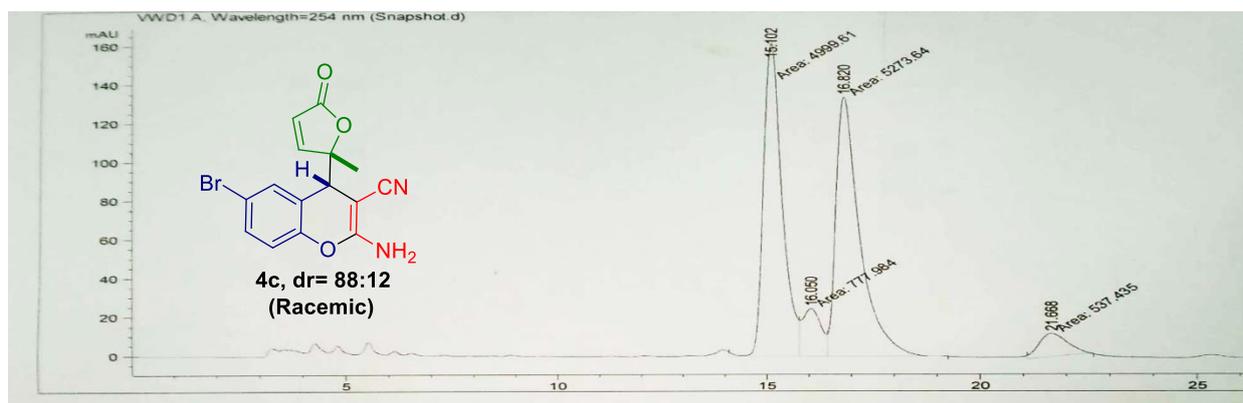






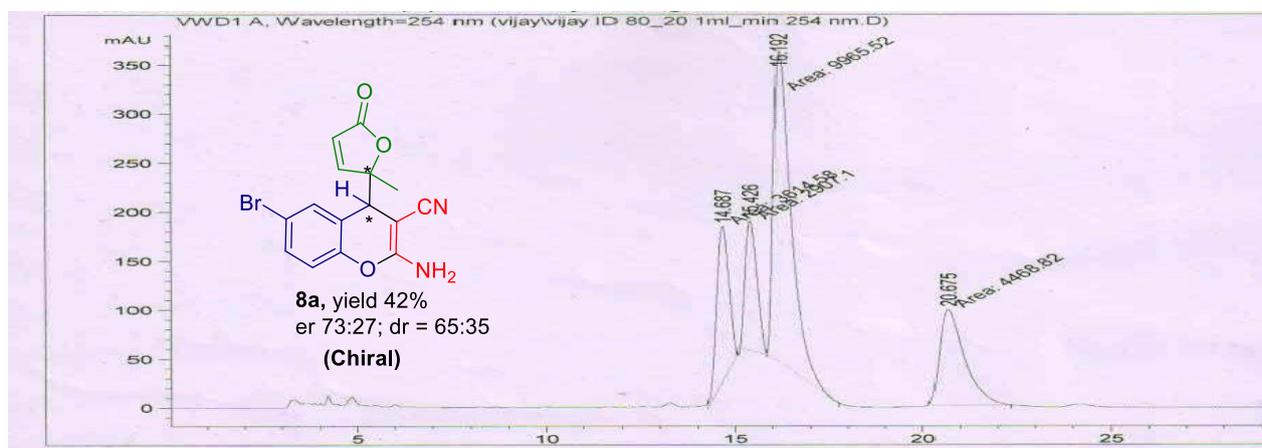


6. HPLC data for compound 4c and 8a



Signal 1: VWD1 A, Wavelength=254 nm

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	15.102	MF	0.5151	4999.61182	161.76991	43.1423
2	16.050	MF	0.5238	777.98352	24.75528	6.7133
3	16.820	FM	0.6539	5273.63672	134.42325	45.5068
4	21.668	MM	0.7582	537.43457	11.81440	4.6376
Totals :				1.15887e4	332.76284	



Signal 1: VWD1 A, Wavelength=254 nm

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	14.687	MM	0.3811	3614.57959	158.08736	17.2484
2	15.426	MM	0.3662	2907.09790	132.30377	13.8724
3	16.192	MM	0.5222	9965.52051	318.09244	47.5544
4	20.675	MM	0.7615	4468.82422	97.80679	21.3248
Totals :				2.09560e4	706.29035	

7. Computational Details

All the calculations in this study have been performed with density functional theory (DFT), with the aid of the Turbomole 7.2 suite of programs,¹ using the PBE functional.² The TZVP³ basis set has been employed. The resolution of identity (RI),⁴ along with the multipole accelerated resolution of identity (marij)⁵ approximations have been employed for an accurate and efficient treatment of the electronic Coulomb term in the DFT calculations. Solvent correction were incorporated with optimization calculations using the COSMO model,⁶ with 1,4-dioxane ($\epsilon = 2.25$) as the solvent. The values reported are ΔG values, with zero point energy corrections, internal energy and entropic contributions included through frequency calculations on the optimized minima, with the temperature taken to be 298.15 K. Harmonic frequency calculations were performed for all stationary points to confirm them as a local minima or transition state structures.

To confirm the negative charge on oxygen, we have performed NBO charge analysis.

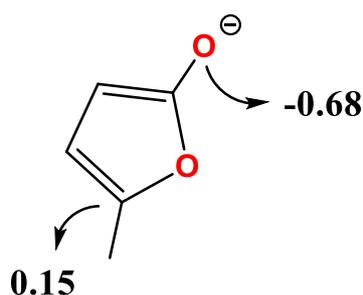


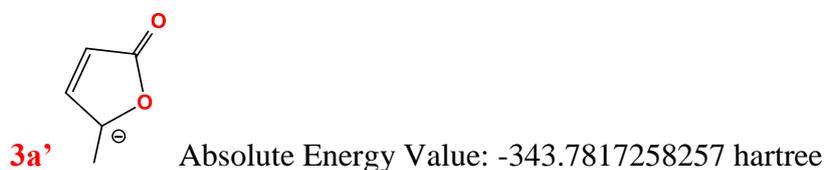
Figure S3. Charge values obtained by NBO analysis. Which shows that anion on the oxygen (-0.68) atom is more stable than a carbon atom (0.15).

References:

- (1) Ahlrichs, R.; Bar, M.; Häser, M.; Horn, H.; Kölmel, C. *Chem. Phys. Lett.* **1989**, *162*, 165–169.
- (2) Perdew, J. P.; Burke, K.; Ernzerhof, M. *Phys. Rev. Lett.* **1996**, *77*, 3865.
- (3) Ansgar, S.; Christian, H.; Reinhart, A. *J. Chem. Phys.* **1994**, *100*, 5829–5835.
- (4) Eichkorn, K.; Treutler, O.; Öhm, H.; Haser, M.; Ahlrichs, R. *Chem. Phys. Lett.* **1995**, *240*, 283–289.
- (5) Sierka, M.; Hogeckamp, A.; Ahlrichs, R. *J. Chem. Phys.* **2003**, *118*, 9136–9148.

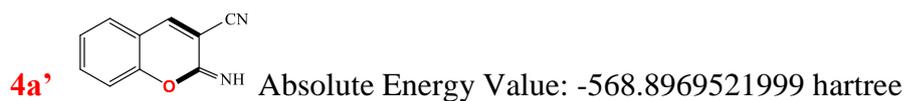
(6) Klamt, A.; Schuurmann, G. *J. Chem. Soc., Perkin Trans.* **21993**, 799–805.

PBE/TZVP optimized geometries for all the compounds and transition states



Number of Imaginary Frequency: 0

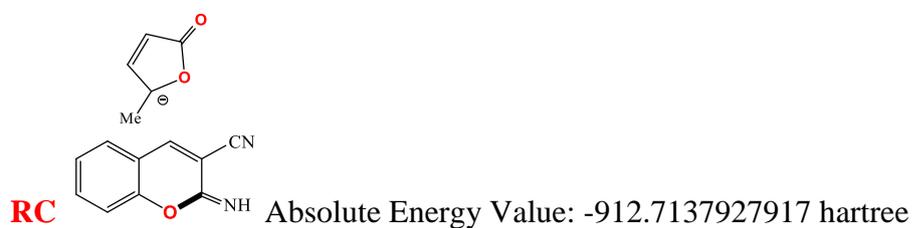
H	3.158875	2.915487	2.549474
C	2.860049	3.938536	2.847982
H	1.982215	4.204281	2.227622
H	2.528976	3.898122	3.896918
C	3.969769	4.917753	2.714131
O	4.516711	5.080277	1.450360
C	5.577504	6.090164	1.540506
O	6.199658	6.377328	0.494779
C	5.603541	6.485324	2.888930
H	6.294140	7.223015	3.289203
C	4.599814	5.747754	3.602523
H	4.361804	5.821130	4.664002



Number of Imaginary Frequency: 0

C	2.911472	3.180980	2.092306
C	3.132274	4.290216	2.925204

C	2.441915	5.485991	2.726086
C	1.522379	5.566983	1.680704
C	1.278463	4.465902	0.830514
C	1.990804	3.268958	1.054876
O	0.863049	6.759920	1.511057
C	-0.084828	6.960370	0.499447
C	-0.348657	5.812073	-0.378559
C	0.310560	4.625724	-0.213959
C	-1.316908	5.974881	-1.408825
N	-2.106238	6.066800	-2.263426
N	-0.671062	8.082880	0.369100
H	-0.351198	8.756001	1.076598
H	0.099659	3.787264	-0.880427
H	3.852857	4.221324	3.741889
H	2.603453	6.354129	3.365929
H	1.804093	2.415438	0.399444
H	3.459904	2.253629	2.261447

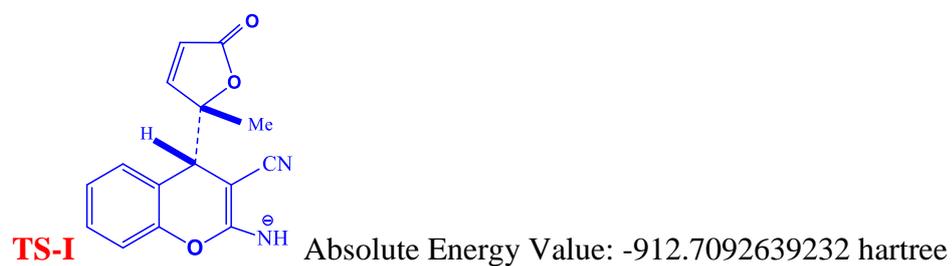


Number of Imaginary Frequency: 0

O	-1.394493	-1.105136	-1.151823
C	-2.077002	-0.201206	-0.374780

C	-2.534206	-0.817746	0.779556
C	-2.100908	-2.158812	0.759207
C	-1.389994	-2.385119	-0.451698
C	0.079211	0.962164	1.255291
C	0.808081	-0.216353	0.938235
C	1.680069	-0.180162	-0.177487
O	1.859273	0.982756	-0.903348
C	1.234673	2.190805	-0.563860
C	0.315879	2.151301	0.563090
C	2.397793	-1.297727	-0.582446
C	2.251884	-2.496610	0.129643
C	1.419640	-2.560045	1.250538
C	0.686032	-1.440668	1.639962
N	1.498153	3.243217	-1.251971
C	-0.351574	3.341490	0.931222
N	-0.930086	4.301340	1.275282
C	-2.351073	1.127179	-0.963178
O	-0.828154	-3.349422	-0.976944
H	0.028283	-1.480618	2.507948
H	-0.591498	0.961163	2.113758
H	1.302578	-3.500764	1.790318
H	-2.873108	1.038574	-1.930756
H	-3.122172	-0.322151	1.549884

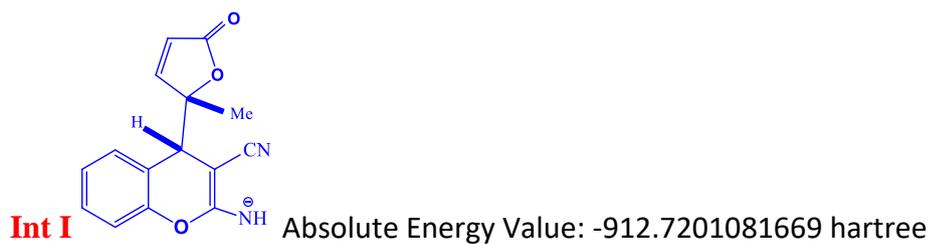
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H	-2.973127	1.721251	-0.279782
H	-1.422250	1.699880	-1.143227
H	3.045747	-1.228035	-1.457163
H	2.173575	3.014301	-1.991545
H	-2.275380	-2.931479	1.502236



Number of Imaginary Frequency: 1 (-185.00 cm⁻¹)

O	5.090353	8.219743	1.006431
C	3.831034	8.417135	1.592574
C	3.385919	7.156860	2.076092
C	4.395273	6.232456	1.916075
C	5.496461	6.879123	1.239171
C	4.264238	9.485315	3.476331
C	5.547669	8.884681	3.788354
C	6.712739	9.573105	3.392985
O	6.647928	10.796444	2.764431
C	5.452645	11.550541	2.726643
C	4.262402	10.885781	3.196038
C	7.983067	9.043949	3.621245

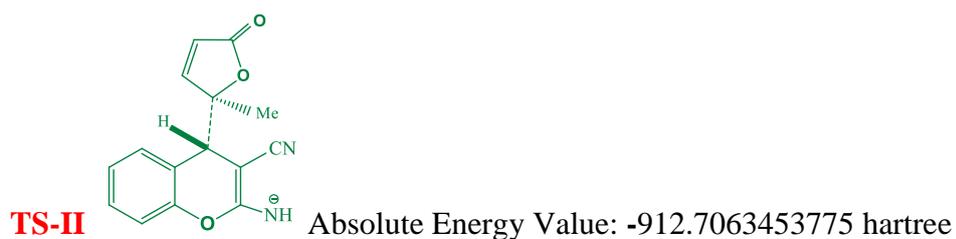
C	8.107289	7.804353	4.254198
C	6.968470	7.109102	4.674634
C	5.701752	7.644279	4.433770
N	5.516481	12.758416	2.283340
C	3.072412	11.626024	3.318344
N	2.053963	12.197279	3.453236
C	2.986821	9.429400	0.895944
O	6.601685	6.490782	0.872963
H	4.806288	7.106496	4.749180
H	3.394924	9.089669	4.000763
H	7.066608	6.142304	5.171588
H	2.804476	9.134561	-0.151155
H	2.410785	6.999806	2.536710
H	9.101242	7.385696	4.425752
H	2.018442	9.531591	1.406334
H	3.475756	10.416142	0.898861
H	8.858048	9.607143	3.293219
H	6.492131	12.991609	2.061699
H	4.423574	5.195753	2.237694



Number of Imaginary Frequency: 0

O	-1.280017	-0.407932	-1.278738
C	-1.684408	0.172135	-0.003258
C	-2.337641	-0.966141	0.707874
C	-2.273465	-2.081268	-0.040311
C	-1.595550	-1.751354	-1.305563
C	-0.369371	0.690730	0.769592
C	0.668970	-0.395050	0.831081
C	1.662239	-0.415965	-0.162935
O	1.741914	0.547743	-1.131188
C	1.160145	1.841609	-0.907442
C	0.238083	1.929244	0.172160
C	2.616901	-1.441059	-0.201576
C	2.599720	-2.441023	0.770940
C	1.642613	-2.414709	1.792351
C	0.686719	-1.395290	1.810202
N	1.546366	2.790414	-1.697596
C	-0.177241	3.175650	0.642379
N	-0.560294	4.194377	1.099503
C	-2.638951	1.326932	-0.278307
O	-1.327960	-2.459825	-2.261919
H	-0.075260	-1.376548	2.594416
H	-0.729099	0.913504	1.787375

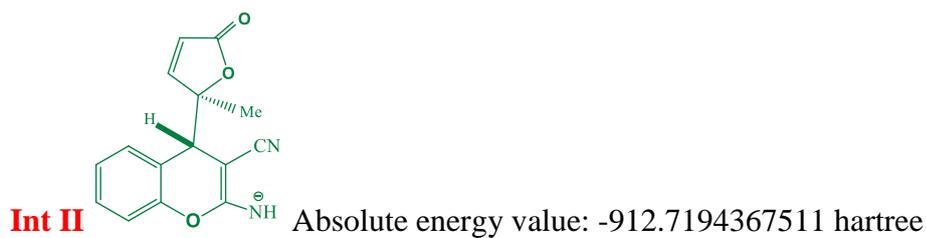
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H	-2.772560	-0.854749	1.701280
H	3.346221	-3.237830	0.737263
H	-2.954802	1.791799	0.666534
H	-2.122438	2.087510	-0.878376
H	3.365935	-1.430031	-0.995360
H	2.306443	2.445192	-2.295686
H	-2.626813	-3.083201	0.190381



Number of Imaginary Frequency: 0 (-71.92 cm⁻¹)

C	5.222751	5.351532	-1.657819
C	4.453721	4.405349	-0.962984
O	3.618007	5.079468	-0.077485
C	3.790736	6.488283	-0.280423
C	4.803704	6.625660	-1.287781
C	4.793331	3.007365	-0.601497
O	3.110947	7.287838	0.364430
C	2.841891	3.908419	-2.679146
C	3.632967	3.776029	-3.884681

C	3.940913	2.480577	-4.346501
O	3.481198	1.356082	-3.693476
C	2.483923	1.440120	-2.698393
C	2.148315	2.769598	-2.227584
C	4.106476	4.868480	-4.639144
C	4.886609	4.674777	-5.776898
C	5.210550	3.374096	-6.192490
C	4.731650	2.273116	-5.479200
N	1.963732	0.347284	-2.266229
C	1.126628	2.878737	-1.257036
N	0.260083	2.993033	-0.476411
H	2.365695	-0.451765	-2.771454
H	2.478652	4.898377	-2.401532
H	5.983839	5.095170	-2.392185
H	5.826177	3.215772	-7.080136
H	4.950199	1.250255	-5.790541
H	3.864533	5.876541	-4.296625
H	5.143913	7.585315	-1.666197
H	5.353754	2.961248	0.347852
H	5.411859	2.558351	-1.392101
H	3.883610	2.395519	-0.483086
H	5.245258	5.535964	-6.343972



Number of Imaginary Frequency: 0

C	0.732958	1.777922	1.439184
C	0.704616	0.309584	1.165838
O	0.372527	-0.274401	2.463101
C	0.152021	0.727080	3.386133
C	0.381928	2.018282	2.715700
C	2.050707	-0.240435	0.716607
O	-0.162808	0.487894	4.540508
C	-0.486397	-0.100008	0.160523
C	-0.439560	0.726687	-1.098832
C	0.203157	0.194874	-2.229110
O	0.745385	-1.062008	-2.224228
C	0.234380	-2.056840	-1.307162
C	-0.504798	-1.557859	-0.200493
C	-1.010541	2.002779	-1.200017
C	-0.910940	2.754714	-2.374465
C	-0.227857	2.224051	-3.476211
C	0.322194	0.943096	-3.409384
N	0.512429	-3.286622	-1.597153

C	-1.203630	-2.453299	0.614909
N	-1.830766	-3.171115	1.307565
H	0.964637	-3.324571	-2.517831
H	-1.397018	0.158049	0.723834
H	0.993388	2.504444	0.671496
H	-0.138088	2.802161	-4.398584
H	0.833147	0.496353	-4.264226
H	-1.536088	2.410725	-0.332415
H	0.282403	2.971217	3.230084
H	2.827241	-0.001541	1.456429
H	2.332702	0.198275	-0.250910
H	1.976033	-1.329981	0.601034
H	-1.363522	3.746592	-2.429904