Domino reaction of *N*-(cyanomethyl)-1,3-azolium quaternary salts with *o*-hydroxybenzaldehydes: scope and limitations

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Supplementary Information

Experimental Section

Reagents were purchased from commercial sources and were used without any additional purification. ^{1}H and ^{13}C NMR spectra were recorded in $CDCl_3$ or DMSO-d_6 solutions at 25ºC, using a 400 or 600 MHz NMR spectrometer; peak positions are given in parts per million (δ) referenced to the appropriate solvent residual peak. Mass spectra were registered using electron ionisation. MW-assisted reactions were carried out in a Monowave 300 MW reactor from Anton Paar GmbH; the reaction temperature was monitored by an IR sensor. Standard 10 mL G10 reaction vials, sealed with silicone septa, were used for the MW irradiation experiments. Only ^{1}H NMR spectra are listed for the earlier reported compounds [*Eur. J. Org. Chem.*, **2012**, 6124].

General procedure A for the MW-assisted synthesis of thiazolium salts 1a–d

A mixture of the corresponding thiazole (8.5 mmol) and chloroacetonitrile (25.5 mmol) was heated to 140ºC by the means of MW irradiation, where it was held for 30 min in a closed vessel. After cooling, the reaction mixture was treated with acetonitrile (2 mL) and mixed thoroughly before it was put into the freezer. After 1 h, the precipitate was filtered off, washed with acetonitrile (3 × 5 mL) and dried *in vacuo* to give thiazolium salts **1a**–**d**.

3-(Cyanomethyl)-1,3-thiazol-3-ium chloride (**1a**). Brown solid. Yield 81%. ^{1}H NMR (DMSO-d_6, 400 MHz) δ: 6.16 (s, 2H), 8.46 (dd, J = 3.7, 2.3 Hz, 1H), 8.80 (dd, J = 3.7, 1.4 Hz, 1H), 10.66 (dd, J = 2.3, 1.4 Hz, 1H); ^{13}C NMR (DMSO-d_6, 100 MHz) δ: 42.2, 114.8, 128.4, 137.4, 163.1.

3-(Cyanomethyl)-4-methyl-1,3-thiazol-3-ium chloride (**1b**). Brown solid. Yield 79%. ^{1}H NMR (DMSO-d_6, 400 MHz) δ: 2.62 (s, 3H), 6.09 (s, 2H), 8.13 (d, J = 2,5 Hz, 1H), 10.46 (d, J = 2.5 Hz, 1H); ^{13}C NMR (DMSO-d_6, 100 MHz) δ: 13.3, 40.5, 114.2, 123.6, 146.1, 162.8.

3-(Cyanomethyl)-4,5-dimethyl-1,3-thiazol-3-ium chloride (**1c**). Brown solid. Yield 82%. ^{1}H NMR (DMSO-d_6, 400 MHz) δ: 2.51 (bs, 6H), 6.09 (s, 2H), 10.35 (s, 1H); ^{13}C NMR (DMSO-d_6, 100 MHz) δ: 11.6, 12.5, 40.9, 114.4, 134.5, 141.9, 159.4.

3-(Cyanomethyl)-5-methyl-1,3-thiazol-3-ium chloride (**1d**). Brown solid. Yield 81%. ^{1}H NMR (DMSO-d_6, 400 MHz) δ: 2.58 (s, 3H), 5.84 (s, 2H), 8.45 (s, 1H), 10.17 (s, 1H); ^{13}C NMR (DMSO-d_6, 100 MHz) δ: 12.9, 42.4, 114.6, 134.3, 141.1, 161.1.

Synthesis of 3-(cyanomethyl)-1-methylimidazolium chloride (2)

Chloroacetonitrile (5.1 mL, 79 mmol) was added to a stirred solution of 1-methylimidazole (5.0 g, 61 mmol) in CH_3CN (10 mL). The reaction mixture was heated to 50°C and, after 1 h, the precipitate was filtered off, washed with CH_3CN (3 × 20 mL) and dried *in vacuo* to give 7.5 g (78%) of salt **2** as a white solid. Mp 180°C (decomp.). ^{1}H NMR (DMSO-d_6, 400 MHz) δ: 3.92 (s, 3H), 5.85 (s, 2H), 7.86-7.89 (m, 1H), 7.99–8.03 (m, 1H), 9.60 (s, 1H); ^{13}C NMR (DMSO- d_6, 100 MHz) δ: 36.7, 37.3, 115.4, 123.1, 124.9, 138.4; Anal Calcd for $C_6H_8ClN_3$ (%): C 45.73, H 5.12, N 26.66. Found (%): C 45.87, H 5.16, N 26.79.

General procedure B for the preparation of 3a, 3b, 3d–i and 3o

To a stirred solution of thiazolium salt (1.1 mmol) and an aldehyde (1 mmol) in a mixture of methanol (*M* mL) and water (*W* mL), DBU (1.1 mmol) was added. The reaction mixture was stirred for 18 h (12 h in the case of **3i**) at room temperature. The formed precipitate was filtered off, washed with water (3×) and with cold methanol (1×) to give the target 10*b*H-6-oxa-1-thia-3*a*,5-diazaacephenanthrylenes **3a**, **3b**, **3d–i** and **3o**.

3-Methyl-10bH-6-oxa-1-thia-3a,5-diazaacephenanthrylene (**3a**) *M* = 3 mL, *W* = 1 mL. Yield 62%. Brown solid. Mp 132°C (decomp.). ^{1}H NMR ($CDCl_3$, 400 MHz) δ: 2.28 (s, 3H), 5.61 (d, *J* = 5.0 Hz, 1H), 5.79 (d, *J* = 5.0 Hz, 1H), 7.07–7.11 (m, 1H), 7.14–7.26 (m, 2H), 7.29 (t, *J* = 6.2 Hz, 1H), 7.38 (d, *J* = 4.8 Hz, 1H). ^{13}C NMR ($CDCl_3$, 100 MHz) δ: 17.8, 32.5, 101.4, 105.7, 118.7, 119.3, 125.0, 129.9, 130.1, 130.2, 130.9, 144.6, 151.9. *m/z* (%) = 243 (22), 242 (100) $[M]^+$, 241 (14), 171 (36), 143 (38), 122 (29), 121 (55), 115 (10), 101 (15), 100 (14), 99 (13), 91 (15), 64 (11), 59 (27), 57 (13), 45 (34), 43 (41), 39 (17). Anal Calcd for $C_{13}H_{10}N_2OS$ (%): C 64.44, H 4.16, N 11.56. Found (%): C 64.61, H 4.22, N 11.47.

2,3-Dimethyl-10bH-6-oxa-1-thia-3a,5-diazaacephenanthrylene (**3b**)**.** *M* = 1 mL, *W* = 1 mL. Yield 61%. Light-brown solid. Mp 165°C (decomp.). ^{1}H NMR ($CDCl_3$, 400 MHz) δ: 2.04 (s, 3H), 2.31 (s, 3H), 5.81 (s, 1H), 7.13 (t, *J* = 8.2 Hz, 1H), 7.21 (d, *J* = 8.2 Hz, 1H), 7.27–7.36 (m, 2H), 7.38 (s, 1H). ^{13}C NMR ($CDCl_3$, 100 MHz) δ: 14.3, 19.2, 33.1, 101.9, 116.7, 118.5, 118.6, 124.0, 124.2, 127.9, 129.2, 129.4, 144.4, 152.2. *m/z* (%) = 257 (12), 256 (100, $[M]^+$), 255 (29), 171 (61), 143 (15), 113 (60), 89 (14), 86 (86), 75 (14), 71 (41), 59 (24), 58 (16), 53 (14), 46 (22), 44 (16), 43 (16). Anal Calcd for $C_{14}H_{12}N_2OS$ (%): C 65.60, H 4.72, N 10.93. Found (%): C 65.46, H 4.53, N 10.86.

9-Bromo-3-methyl-10bH-6-oxa-1-thia-3a,5-diazaacephenanthrylene (**3d**). *M* = 3 mL, *W* = 1 mL. Yield 61%. Light-grey solid. ^{1}H NMR (DMSO-d_6, 400 MHz) δ: 2.34 (s, 3H), 5.96–6.01 (m, 2H), 7.27 (d, *J* = 8.9 Hz, 1H), 7.50 (d, *J* = 2.3 Hz, 1H), 7.59 (dd, *J* = 8.9, 2.3 Hz, 1H), 7.93 (s, 1H).

9-Bromo-2,3-dimethyl-10bH-6-oxa-1-thia-3a,5-diazaacephenanthrylene (**3e**). *M* = 3 mL, *W* = 1 mL. Yield 61%. Light-grey solid. ^{1}H NMR ($CDCl_3$, 400 MHz) *δ*: 2.04 (s, 3H), 2.30 (s, 3H), 5.78 (s, 1H), 7.10 (d, *J* = 8.8 Hz, 1H), 7.36 (s, 1H), 7.40 (dd, *J* = 8.8, 2.3 Hz, 1H), 7.46 (d, *J* = 2.3 Hz, 1H).

9-Bromo-2-methyl-10bH-6-oxa-1-thia-3a,5-diazaacephenanthrylene (**3f**). *M* = 3 mL, *W* = 1 mL. Yield 46%. Brown solid. Mp 186^{o}C. ^{1}H NMR ($CDCl_3$, 400 MHz) *δ*: 2.07 (d, *J* = 1.4 Hz, 3H), 5.88 (s, 1H), 6.99 (d, *J* = 1.4 Hz, 1H), 7.13 (d, *J* = 8.9 Hz, 1H), 7.34 (s, 1H), 7.43 (dd, *J* = 8.9, 2.3 Hz, 1H), 7.48 (d, *J* = 2.3 Hz, 1H). ^{13}C NMR ($CDCl_3$, 100 MHz) *δ*: 20.8, 33.2, 99.7, 116.4, 116.5, 120.5, 120.7, 124.1, 129.5, 131.8, 132.5, 144.9, 151.5. *m/z* (%) = 322 (99), 321 (14), 320 (100, $[M]^+$), 251 (11), 249 (12), 223 (31), 221 (36), 202 (32), 201 (10), 200 (36), 199 (20), 100 (20), 99 (33), 91 (10), 73 (11), 72 (40), 71 (14), 63 (27), 59 (19), 58 (11), 46 (11), 45 (20).43 (29), 42 (16). Anal Calcd for $C_{13}H_9BrN_2OS$ (%): C 48.61, H 2.82, N 8.72. Found (%): C 48.67, H 2.91, N 8.60.

3-Methyl-9-nitro-10bH-6-oxa-1-thia-3a,5-diazaacephenanthrylene (**3g**)**.** *M* = 4.5 mL, *W* = 0.6 mL. Yield 81%. ^{1}H NMR (DMSO-d_6, 400 MHz) *δ*: 2.35 (s, 3H), 6.01 (s, 1H), 6.11 (s, 1H), 7.53 (d, *J* = 9.2 Hz, 1H), 7.97 (s, 1H), 8.18 (d, *J* = 2.6 Hz, 1H), 8.26 (dd, *J* = 9.2, 2.6 Hz, 1H).

2,3-Dimethyl-9-nitro-10bH-6-oxa-1-thia-3a,5-diazaacephenanthrylene (**3h**). *M* = 4.5 mL, *W* = 0.6 mL. Yield 76%. Brown solid. ^{1}H NMR (DMSO-d_6, 400 MHz) *δ*: 2.04 (s, 3H), 2.34 (s, 3H), 6.13 (s, 1H), 7.53 (d, *J* = 9.2 Hz, 1H), 7.92 (s, 1H), 8.20 (d, *J* = 2.7 Hz, 1H), 8.27 (dd, *J* = 9.2, 2.7 Hz, 1H).

2-Methyl-9-nitro-10bH-6-oxa-1-thia-3a,5-diazaacephenanthrylene (**3i**). *M* = 3 mL, *W* = 1 mL. Yield 34%. Yellow solid. Mp 209^{o}C (decomp.). ^{1}H NMR ($CDCl_3$, 400 MHz) *δ*: 1.99 (d, *J* = 1.4 Hz, 3H), 5.90 (s, 1H), 6.97 (d, *J* = 1.4 Hz, 1H), 7.26 (d, *J* = 9.6 Hz, 1H), 7.32, (s, 1H), 8.12 (dd, *J* = 9.6, 2.7 Hz, 1H), 8.20 (d, *J* = 2.7 Hz, 1H). ^{13}C NMR ($CDCl_3$+DMSO-d_6, 100 MHz) *δ*: 20.3, 32.5, 99.2, 108.6, 116.9, 119.2, 119.8, 123.1, 124.7, 125.0, 130.0, 131.6, 147.8. *m/z* (%) = 288 (18), 287 (100, $[M]^+$), 242 (19), 240 (20), 231 (11), 173 (10), 170 (11), 143 (11), 120 (13), 102 (10), 100 (19), 99 (99), 92 (11), 91 (11), 77 (21), 76 (19), 75 (20), 74 (16), 72 (78), 71 (54), 65 (14), 64 (75), 61 (16), 60 (15), 59 (25), 57 (20), 55 (21), 59 (25), 58 (18), 57 (20), 55 (21), 53 (10), 51 (17), 50 (12), 43 (78). Anal Calcd for $FC_{13}H_9N_3O_3S$ (%): C 54.35, H 3.16, N 14.63. Found (%): C 54.20, H 3.07, N 14.68.

2,3-Dimethyl-7-methoxy-9-nitro-10bH-6-oxa-1-thia-3a,5-diazaacephenanthrylene (**3o**). *M* = 3.5 mL, *W* = 2.5 mL. Yield 43%. Yellow solid. Mp 203^{o}C (decomp.). ^{1}H NMR ($CDCl_3$+DMSO-d_6,

400 MHz) δ: 1.98 (s, 3H), 2.27 (s, 3H), 3.95 (s, 3H), 5.87 (s, 1H), 7.49 (s, 1H), 7.70 (d, J = 2.3 Hz, 1H), 7.77 (d, J = 2.3 Hz, 1H). ^{13}C NMR ($CDCl_3$+DMSO-d_6, 100 MHz) δ: 14.5, 19.4, 33.1, 56.8, 101.8, 106.8, 115.3, 116.5, 116.7, 119.9, 125.2, 129.2, 143.4, 147.2, 149.6. IR (KBr): 1340, 1523 cm^{-1} (NO_2). *m/z* (%) = 331 (100), 330 (12), 286 (16), 285 (13), 223 (18), 201 (14), 200 (18), 173 (17), 128 (15), 100 (15), 99 (33), 85 (82), 71 (49), 63 (10), 59 (33), 58 (16), 57 (21), 53 (10), 51 (14), 46 (32), 45 (55), 43 (74). Anal Calcd for $C_{15}H_{13}N_3O_4S$ (%): C 54.37, H 3.95, N 12.68. Found (%): C 54.04, H 3.79, N 12.48.

General procedure C for the synthesis of compounds 3c, 3l-n

To a stirred solution of thiazolium salt (1.1 mmol) and aldehyde (1 mmol) in a mixture of methanol (*M* mL) and water (*W* mL), K_2CO_3 (1.1 mmol) was added. The reaction mixture was heated to 40°C and stirred for 1 h. The formed precipitate was filtered off, washed with water (3×10 mL) and with cold methanol (1×3 mL) to give the target 10*b*H-6-oxa-1-thia-3*a*,5-diazaacephenanthrylenes **3c**, **3l–n**.

2-Methyl-10bH-6-oxa-1-thia-3a,5-diazaacephenanthrylene (**3c**). *M* = 1 mL, *W* = 1 mL. Yield 34%. Light-brown solid. Mp 141°C (decomp.). ^{1}H NMR ($CDCl_3$, 400 MHz) δ: 2.00 (d, J = 1.4 Hz, 3H), 5.86 (s, 1H), 6.92 (d, J = 1.4 Hz, 1H), 7.10 (td, J = 8.0, 1.4 Hz, 1H), 7.18 (dd, J = 8.0, 1.4 Hz, 1H), 7.19 (s, 1H), 7.27–7-31 (m, 2H). ^{13}C NMR ($CDCl_3$, 100 MHz) δ: 20.8, 33.5, 100.0, 116.4, 118.7, 118.8, 124.1, 124.2, 129.1, 129.2, 129.5, 145.0, 152.3. *m/z* (%) = 243 (17), 242 (85, $[M]^+$), 241 (66), 209 (29), 172 (11), 171 (46), 143 (100), 101 (14), 99 (46), 89 (19), 75 (12), 72 (52), 71 (39), 58 (40), 45 (14), 43 (58), 42 (22). . Anal Calcd for $C_{13}H_{10}N_2OS$ (%): C 64.44, H 4.16, N 11.56. Found (%): C 64.56, H 4.25, N, 11.41.

9-Methoxy-3-methyl-10bH-6-oxa-1-thia-3a,5-diazaacephenanthrylene (**3l**). *M* = 2 mL, *W* = 3 mL. Yield 54%. Orange solid. Mp 135°C (decomp.). ^{1}H NMR ($CDCl_3$+DMSO-d_6, 400 MHz) δ: 2.47 (m, 3H), 3.93 (m, 3H), 5.80–5.87 (m, 1H), 5.94–5.99 (m, 1H), 6.94–7.00 (m, 1H), 7.01–7.06 (m, 1H), 7.27–7.32 (m, 1H), 7.60–7.66 (m, 1H). ^{13}C NMR ($CDCl_3$+DMSO-d_6, 100 MHz) δ: 17.8, 33.0, 55.6, 100.0, 105.8, 112.9, 113.0, 115.6, 119.0, 119.2, 128.2, 129.9, 145.9, 155.9. *m/z* (%) = 273 (20), 272 (100, $[M]^+$), 271 (34), 242 (28), 241 (38), 201 (24), 200 (13), 173 (44), 171 (38), 158 (15), 143 (37), 136 (12), 115 (12), 100 (19), 99 (18), 89 (12), 75 (13), 71 (30), 43 (12), 42 (12). Anal Calcd for $C_{14}H_{12}N_2O_2S$ (%): C 61.75, H 4.44, N 10.29. Found (%): C 61.85, H 4.65, N 10.17.

2,3-Dimethyl-9-methoxy-10bH-6-oxa-1-thia-3a,5-diazaacephenanthrylene (**3m**). *M* = 2 mL, *W* = 3 mL. Yield 72%. Beige solid. Mp 166–167°C (decomp.). ^{1}H NMR ($CDCl_3$, 400 MHz) δ: 2.05

(s, 3H), 2.32 (s, 3H), 3.81 (s, 3H), 5.80 (s, 1H), 6.84 (d, *J* = 3.4 Hz, 1H), 6.89 (dd, *J* = 9.0, 3.4 Hz, 1H), 7.17 (d, *J* = 9.0 Hz, 1H), 7.38 (s, 1H). ^{13}C NMR ($CDCl_3$, 100 MHz) *δ*: 14.4, 19.4, 33.7, 55.8, 101.6, 113.0, 115.9, 116.5, 119.0, 119.6, 128.0, 145.0, 146.3, 156.0. *m/z* (%) = 287 (20), 286 (100, $[M]^+$), 285 (58), 271 (18), 253 (26), 201 (42), 173 (77), 158 (11), 143 (30), 114 (14), 113 (21), 102 (12), 85 (87), 84 (20), 71 (41), 62 (11), 59 (14), 45 (26), 44 (12), 43 (33), 42 (23). Anal Calcd for $C_{15}H_{14}N_2O_2S$ (%): C 62.92, H 4.93, N 9.78. Found (%): C 63.06, H 5.05, N, 9.69.

9-Methoxy-2-methyl-10bH-6-oxa-1-thia-3a,5-diazaacephenanthrylene (**3n**). *M* = 2 mL, *W* = 3 mL. Yield 58%. Brown solid. Mp 145°C (decomp.). ^{1}H NMR ($CDCl_3$, 400 MHz) *δ*: 2.07 (s, 3H), 3.81 (s, 3H), 5.89 (s, 1H), 6.84 (d, *J* = 2.9 Hz, 1H), 6.90 (dd, *J* = 9.2, 2.9 Hz, 1H), 6.99 (s, 1H), 7.18 (d, *J* = 9.2 Hz, 1H), 7.34 (s, 1H). ^{13}C NMR ($CDCl_3$, 100 MHz) *δ*: 20.9, 33.9, 55.8, 99.6, 100.0, 112.9, 115.8, 116.4, 119.1, 119.6, 123.9, 129.2, 146.3, 156.0. *m/z* (%) = 274 (10), 273 (11), 272, (100, $[M]^+$), 271 (30), 201 (38), 174 (20), 173 (95), 158 (11), 152 (22), 137 (12), 100 (11), 75 (12), 72 (22), 71 (25), 58 (22), 46 (18), 43 (51). Anal Calcd for $C_{14}H_{12}N_2O_2S$ (%): C 61.75, H 4.44, N 10.29. Found (%): C 61.61, H 4.33, N 10.11.

General procedure D for the synthesis of compounds 3j and 3k

To a stirred solution of thiazolium salt (1.1 mmol) and 2-hydroxynaphtaldehyde (1 mmol) in a mixture of methanol (2 mL) and water (1 mL), K_2CO_3 (0.2 mmol) was added. The reaction mixture was heated at reflux for 45 min. The formed precipitate was filtered off after cooling to room temperature and washed with water (3×10 mL) and with cold methanol (1×3 mL) to give the target 12*cH*-6-oxa-1-thia-3*a*,5-diazabenzo[*l*]acephenanthrylenes **3j** and **3k**.

2,3-Dimethyl-12cH-6-oxa-1-thia-3a,5-diazabenzo[l]acephenanthrylene (**3j**). Beige solid. Yield 30%. Mp 179°C (decomp.). ^{1}H NMR ($CDCl_3$, 400 MHz) *δ*: 2.11 (s, 3H), 2.38 (s, 3H), 6.27 (s, 3H), 7.40 (d, *J* = 8.9 Hz, 1H), 7.45 (s, 1H), 7.50 (t, *J* = 7.9 Hz, 1H), 7.63 (t, *J* = 7.9 Hz, 1H), 7.85 (d, *J* = 8.9 Hz, 1H), 7.87 (d, *J* = 8.2 Hz, 1H), 8.50 (d, *J* = 8.2 Hz, 1H). ^{13}C NMR ($CDCl_3$, 100 MHz) *δ*: 14.6, 19.6, 34.1, 103.1, 110.9, 118.6, 119.3, 124.0, 124.5, 125.1, 127.0, 128.5, 128.6, 130.6, 130.7, 132.8, 144.1, 150.8. *m/z* (%) = 307 (25), 306 (100, $[M]^+$), 279 (36), 273 (30), 221 (51), 220 (27), 194 (15), 193 (69), 164 (14), 153 (16), 139 (17), 85 (20), 84 (11), 43 (11). Anal Calcd for $C_{18}H_{14}N_2OS$ (%): C 70.56, H 4.61, N 9.14. Found (%): C 70.46, H 4.52, N 9.25.

2-Methyl-12cH-6-oxa-1-thia-3a,5-diazabenzo[l]-acephenanthrylene (**3k**). Light-yellow solid. Yield 37%. Mp 207–208°C (decomp.). ^{1}H NMR ($CDCl_3$, 400 MHz) *δ*: 2.12 (s, 3H), 6.35 (s, 1H), 7.07 (s, 1H), 7.40 (d, *J* = 8.9 Hz, 1H), 7.42 (s, 1H), 7.51 (t, *J* = 7.6 Hz, 1H), 7.63 (t, *J* = 7.6 Hz, 1H), 7.85 (d, *J* = 8.9 Hz, 1H), 7.87 (d, *J* = 8.2 Hz, 1H), 8.50 (d, *J* = 8.2 Hz, 1H). ^{13}C NMR

($CDCl_3$, 100 MHz) δ: 21.1, 34.5, 101.1, 110.9, 116.6, 119.3 (2C), 123.9 (2C), 125.2, 126.0, 128.7, 129.7, 130.7, 132.7, 144.5, 150.8. *m/z* (%) = 293 (10), 292 (100, $[M]^+$), 291 (13), 259 (31), 244 (10), 243 (23), 242 (13), 221 (11), 210 (13), 194 (13), 193 (44), 172 (16), 171 (14), 139 (14), 100 (13), 99 (24), 72 (23), 71 (16), 59 (31), 57 (14), 46 (33), 45 (33), 44 (10), 43 (28). Anal Calcd of $C_{17}H_{12}N_2OS$ (%): C 69.84, H 4.14, N 9.58. Found (%): C 69.73, H 4.00, N 9.40.

General procedure for the synthesis of compounds 4

To a stirred solution of imidazolium salt **2** (3.2 mmol) and salicylic aldehyde (2.9 mmol) in a mixture of methanol (4 mL) and water (1 mL), solid K_2CO_3 (0.63 mmol) was added under reflux. The reaction mixture was heated at reflux for 2 h. After cooling to r.t., picric acid (3.8 mmol) was added to the solution. The formed precipitate was filtered off and washed with acetone (3×) to give compounds **4**.

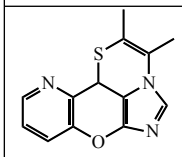
1-Methyl-3-(2-oxo-2H-chromene-3-yl)-1H-imidazoliumpicrate (**4a**). Yield 48%. Yellow crystals. Mp 186°C (decomp.). ^{1}H NMR (DMSO-d_6, 400 MHz) δ: 4.04 (s, 3H), 7.54 (t, J = 7.5 Hz, 1H), 7.63 (d, J = 8.3 Hz, 1H), 7.79–7.85 (m, 1H), 7.87–7.92 (m, 1H), 7.98–8.01 (m, 1H), 8.16–8.19 (m, 1H), 8.61 (s, 2H), 8.70 (s, 1H), 9.71 (bs, 1H). ^{13}C NMR (DMSO-d_6, 100 MHz) δ: 36.2, 116.4, 117.6, 121.6, 122.5, 123.7, 124.2, 125.1 (2C), 125.5, 129.4, 133.5, 137.3, 137.5, 141.8, 152.4 (2C), 156.1, 160.8. Anal Calcd for $C_{13}H_{11}N_2O_2 \cdot C_6H_2N_3O_7$ (%): C 50.12, H 2.88, N 15.38. Found (%): C 50.34, H 3.01, N 15.53.

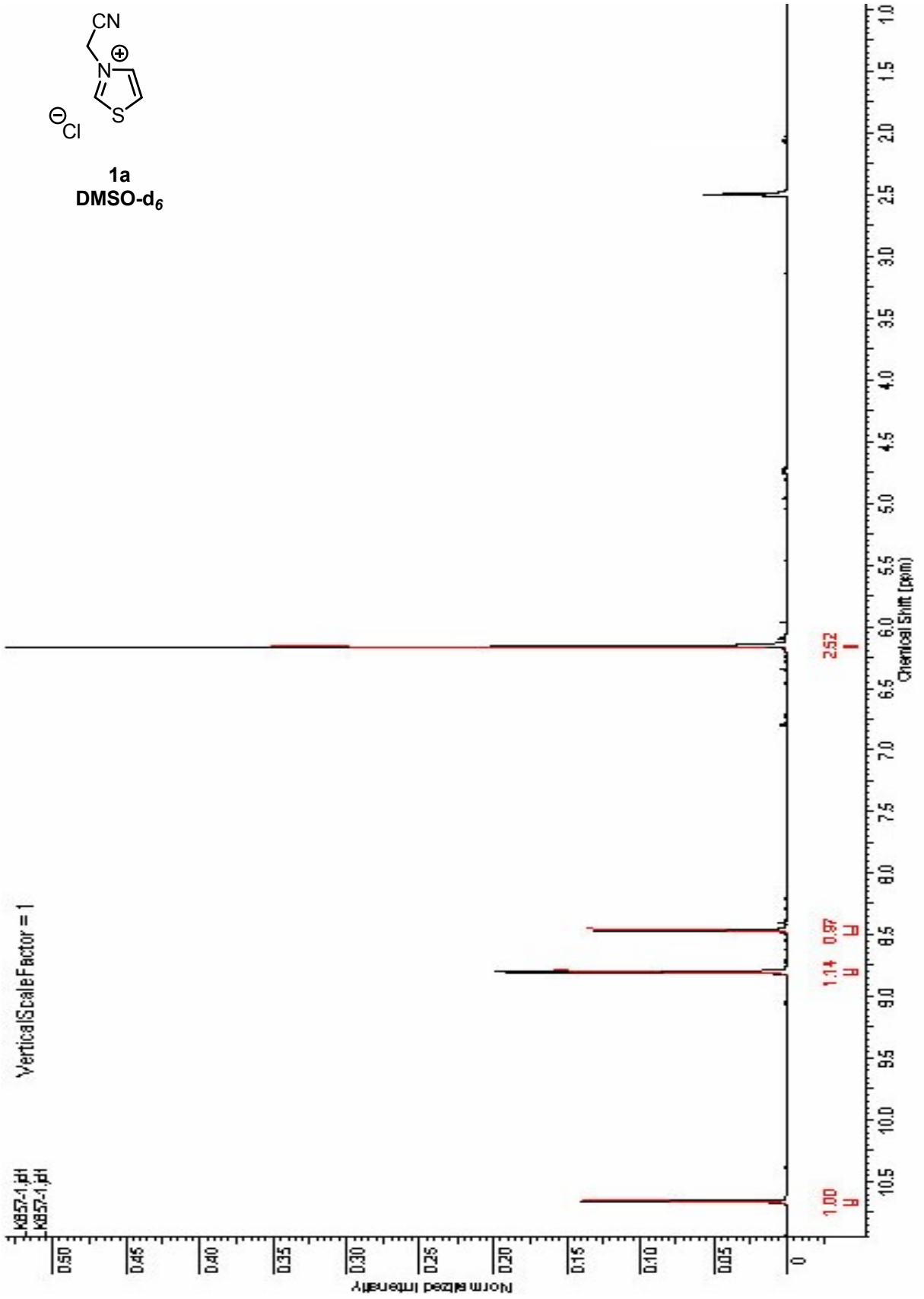
1-Methyl-3-(6-nitro-2-oxo-2H-chromene-3-yl)-1H-imidazolium picrate (**4b**). Yield 42%. Yellow crystals. Mp 175°C (decomp.). ^{1}H NMR (DMSO-d_6, 400 MHz) δ: 3.99 (s, 3H), 7.79 (d, J = 9.2 Hz, 1H), 7.95–7.96 (m, 1H), 8.06 (s, 1H), 8.49–8.55 (m, 3H), 8.68 (s, 1H), 8.76 (d, J = 2.3 Hz, 1H), 9.63 (bs, 1H). ^{13}C NMR (DMSO-d_6, 100 MHz) δ: 37.0, 106.9, 118.7, 118.8, 123.0 (2C), 124.2, 124.7, 125.6, 125.8 (2C), 128.4, 136.2, 136.4, 138.1, 142.3, 144.7, 156.0, 156.4. Anal Calcd for $C_{13}H_{10}N_3O_4 \cdot C_6H_2N_3O_7$ (%): C 45.61, H 2.42, N 16.80. Found (%): C 45.50, H 2.31, N 16.69.

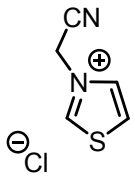
Cytotoxicity assay

Four human cancer cell lines was obtained from the American Type Culture Collection (Manassas, VA) ATCC as MCF7 (breast carcinoma cell line), KB (epidermoid carcinoma cell line), LU (lung cancer cell line), HEPG2 (hepatoma carcinoma cell line). They were grown in medium RPMI 1640 supplemented with 10% FBS (Fetal bovine serum), 50 IU/ml penicillin and 50µg/ml streptomycin. All the cell lines were maintained at 37 ^{o}C in a 5% CO_2 atmosphere with 95% humidity.

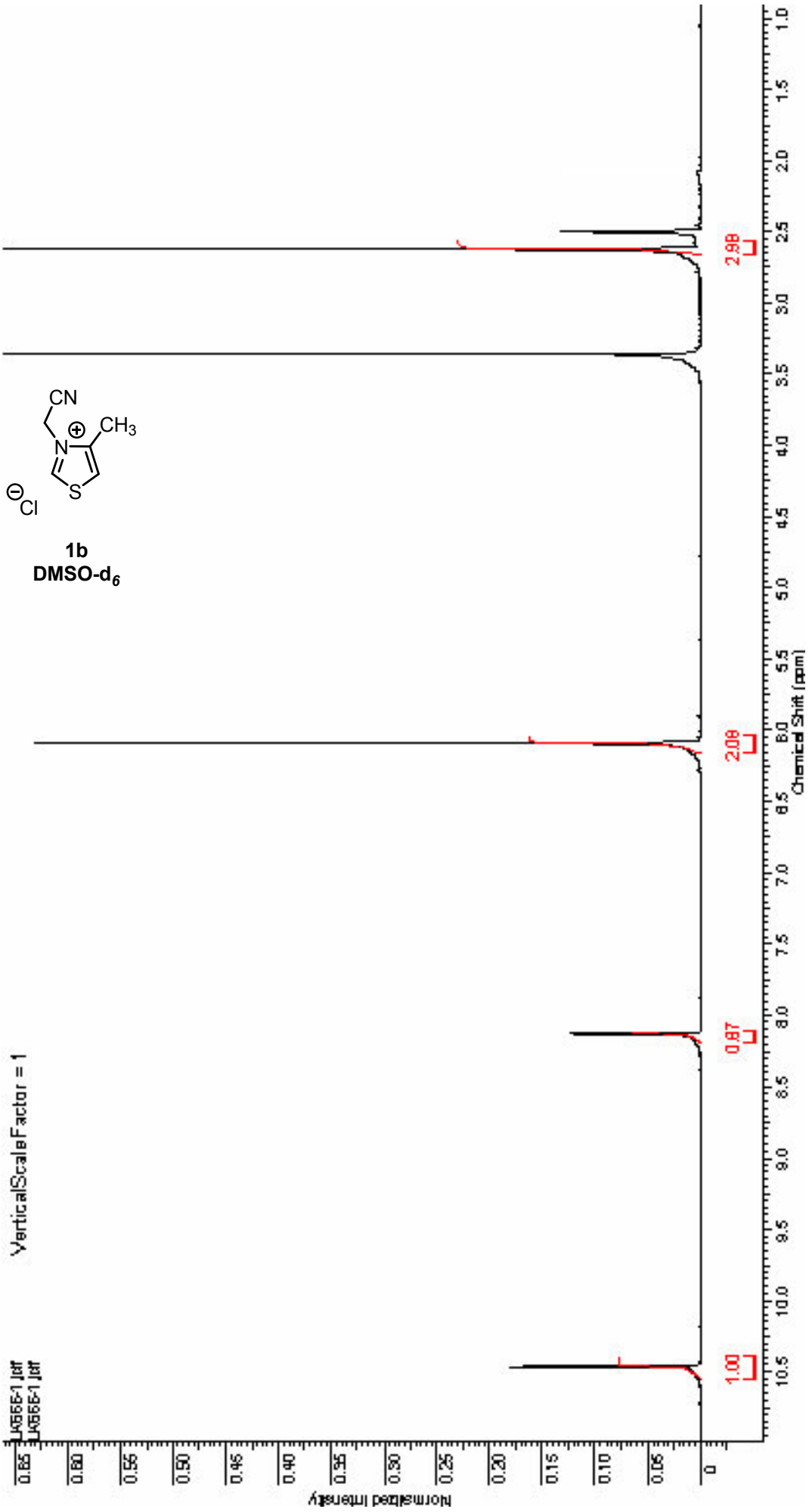
The MTT assay is based on the protocol described for the first time by Mossmann (1983). The test synthetic compounds, dissolved in five concentrations, were added into triplicated available culture cells and culture plates were incubated for 3 days. After the exposure times, the culture cells were treated with MTT [3-(4,5-dimethylthiazol-2-yl)-2,5-diphenyltetrazolium bromide] and measured OD at 450 nm absorbance on microplate reader (TECAN GENIOUS). IC_{50} is the concentration required for 50% inhibition of cell growth as compared to that of untreated control.

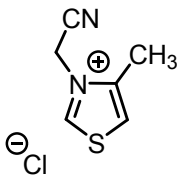
Comp.	Cell line (µg/mL)				Conclusion
	KB	**HepG2**	**Lu**	**MCF7**	
Ellipticin	**0.25**	**0.29**	**1.18**	**0.71**	Positive
	> 128	> 128	> 128	> 128	Negative
3e	**68.0**	**117.5**	> 128	> 128	Positive with KB, HepG2
3b	**32**	>128	>128	>128	Positive with KB
3l	**4**	**80**	>128	>128	Positive with KB, HepG2
3m	**6.32**	>128	**99.76**	>128	Positive with KB, Lu


CN
N
S
Cl
1a
DMSO-d6
VerticalScaleFactor = 1
Norm alized Intensity
Chemical Shift (ppm)
1.00
1.14
0.97
2.52

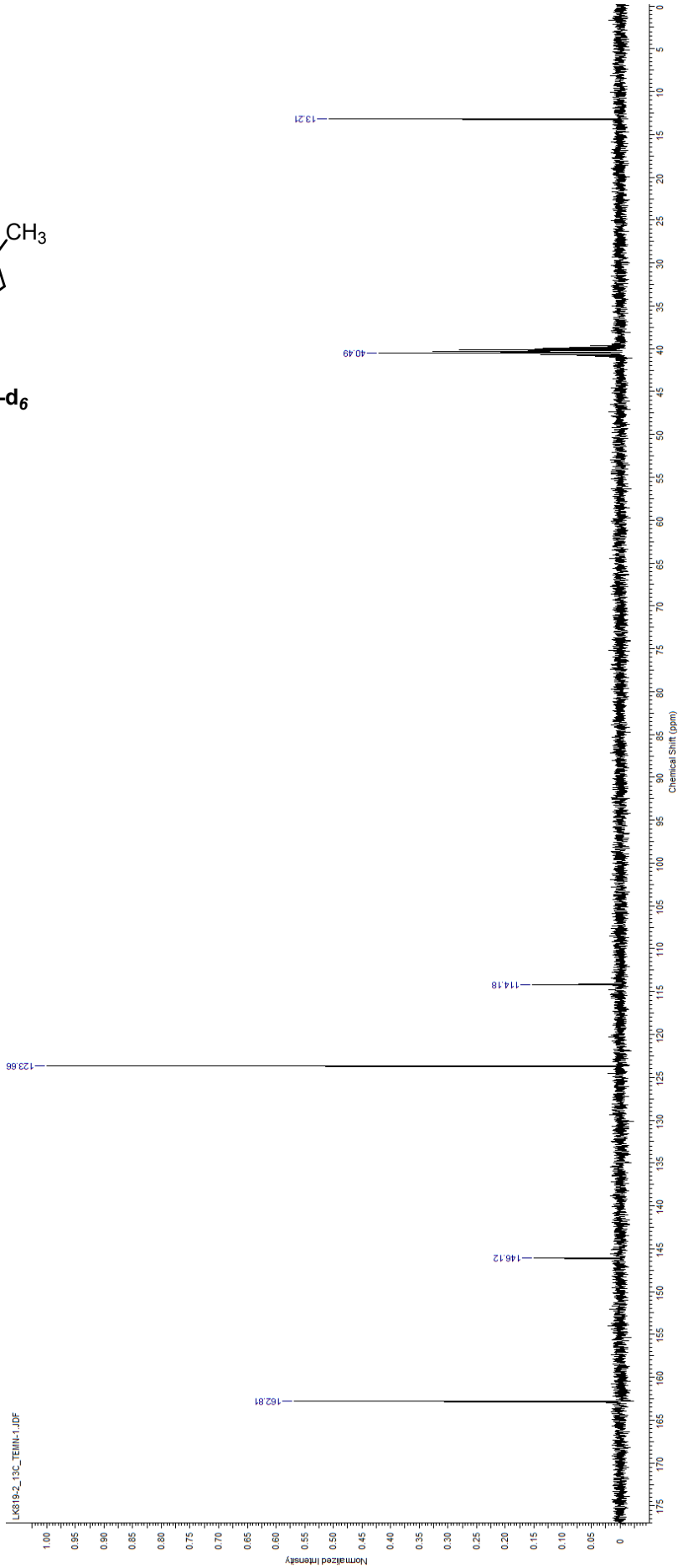


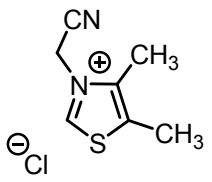
1a
DMSO-d_6


CN
CH3
N
S
Cl
1b
DMSO-d6
VerticalScaleFactor = 1
Normalized Intensity
Chemical Shift (ppm)
1.00
2.08
0.87
2.98


CN
CH3
N
S
Cl

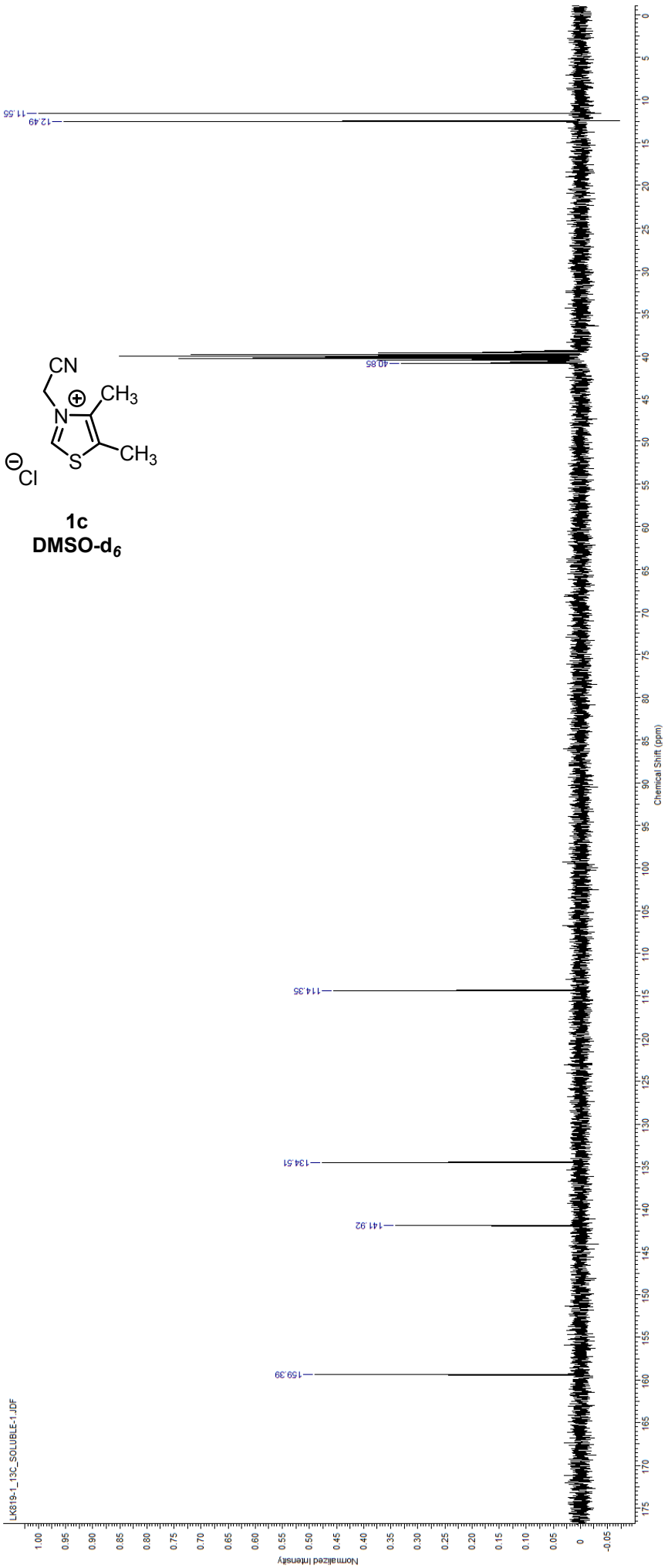
1b
DMSO-d_6


132.1
40.49
114.18
123.66
146.12
162.81
LK819-2_13C_TEMN-1.JDF
Normalized Intensity
Chemical Shift (ppm)

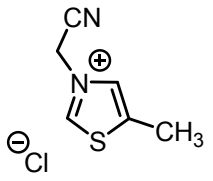

CN
CH3
N
S
CH3
Cl

1c
DMSO-d$_6$

7.43
2.10
1.00
Chemical Shift (ppm)
Normalized Intensity

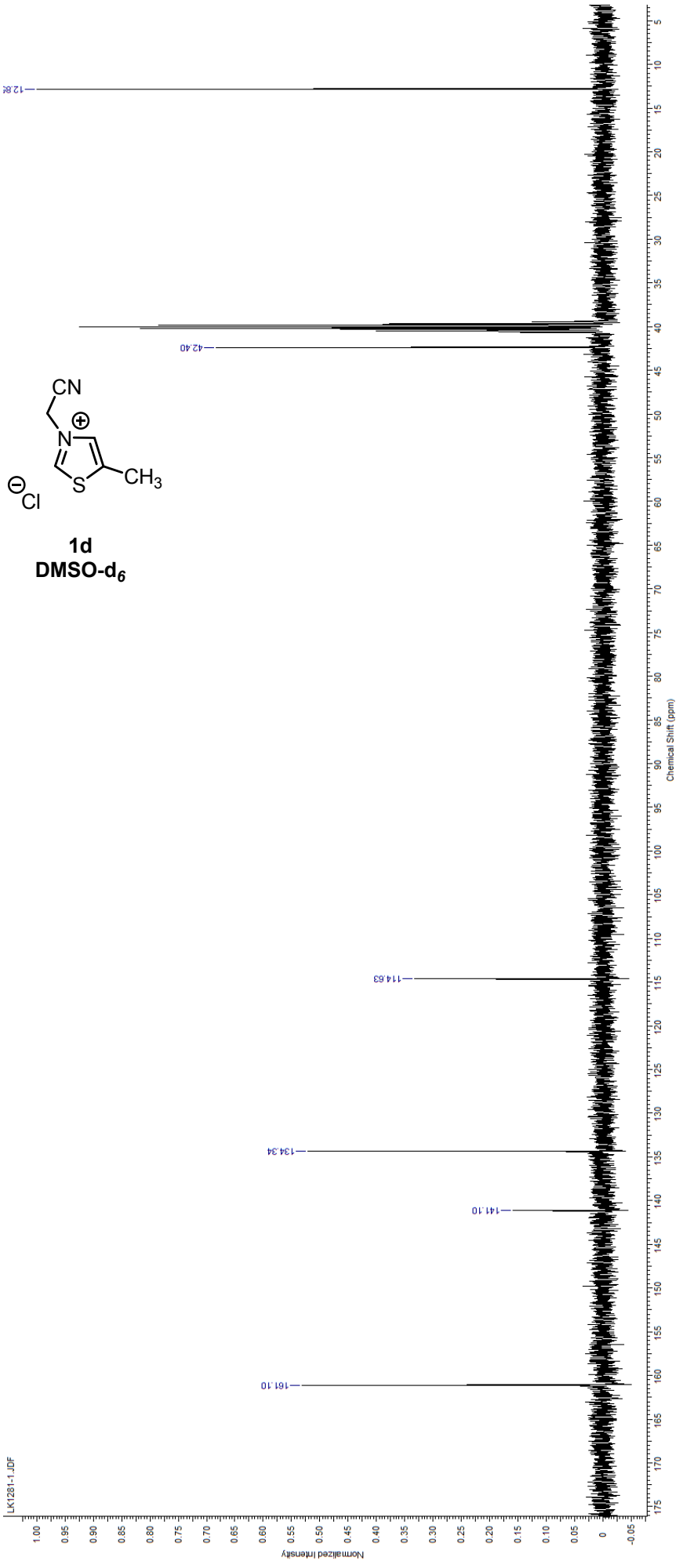

CN
CH3
N
S
CH3
Cl
11.55
12.49
40.85
114.35
134.51
141.92
159.39
Chemical Shift (ppm)
Normalized Intensity
LK819-1_13C_SOLUBLE-1.JDF

1c
DMSO-d$_6$

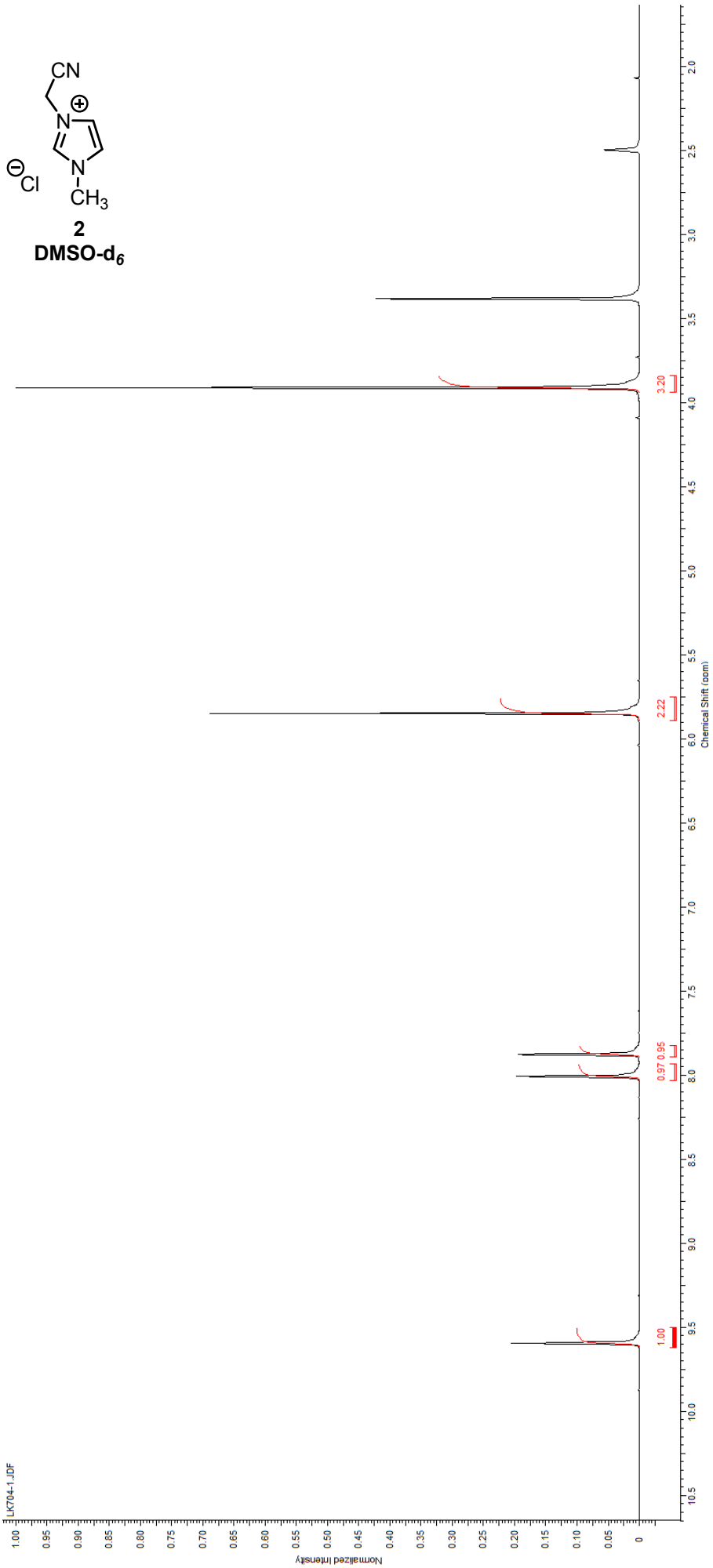

CN
N
S
CH3
Cl

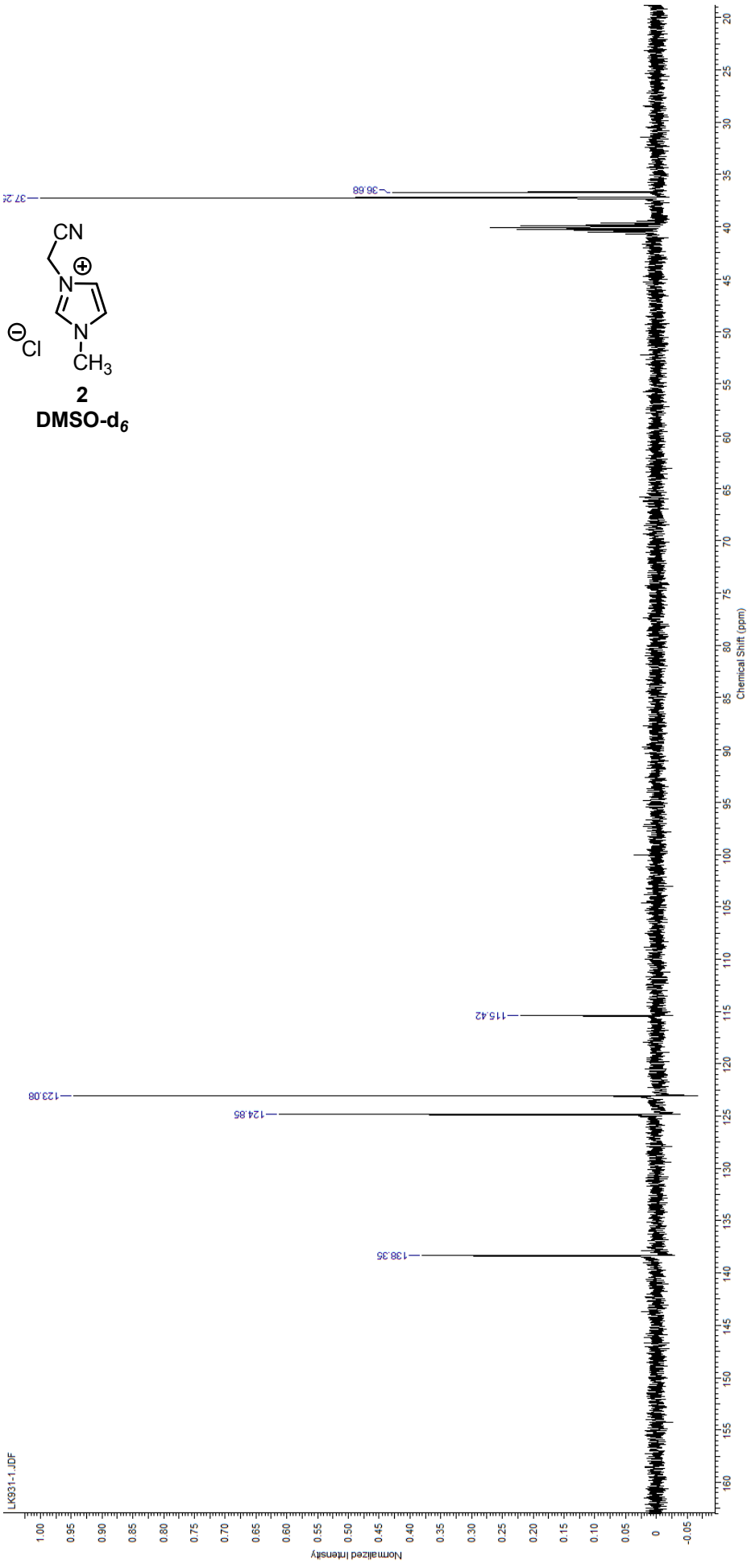
1d
DMSO-d_6

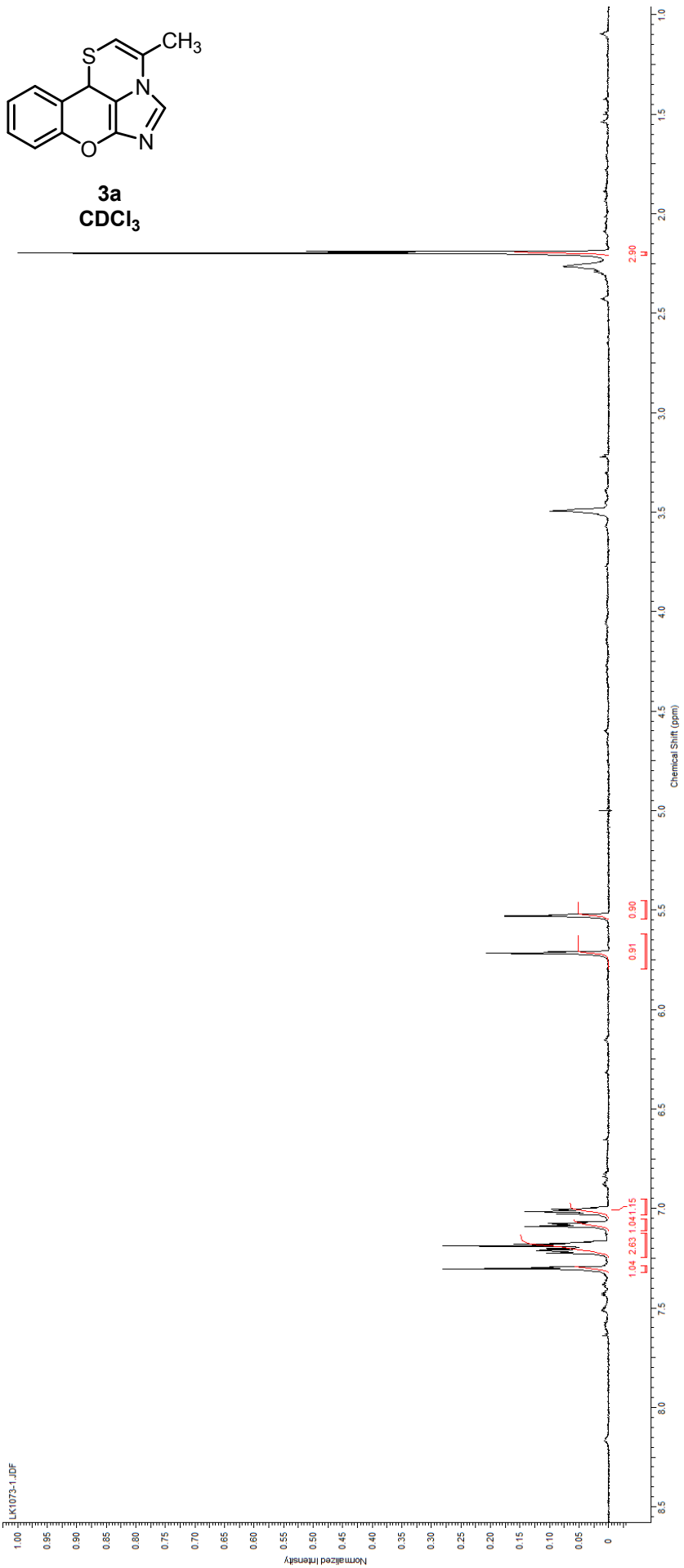
3.21
2.30
0.97
0.89
Chemical Shift (ppm)
Normalized Intensity
LK1281-2.JDF

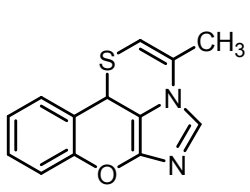

CN
N
S
CH3
Cl
12.86
42.40
114.63
134.34
141.10
161.10
LK1281-1.JDF
Normalized Intensity
Chemical Shift (ppm)

1d
DMSO-d$_6$


CN
N
N
CH3
Cl
2
DMSO-d6
3.20
2.22
0.97
0.95
1.00
Chemical Shift (ppm)
Normalized Intensity
LK704-1.JDF

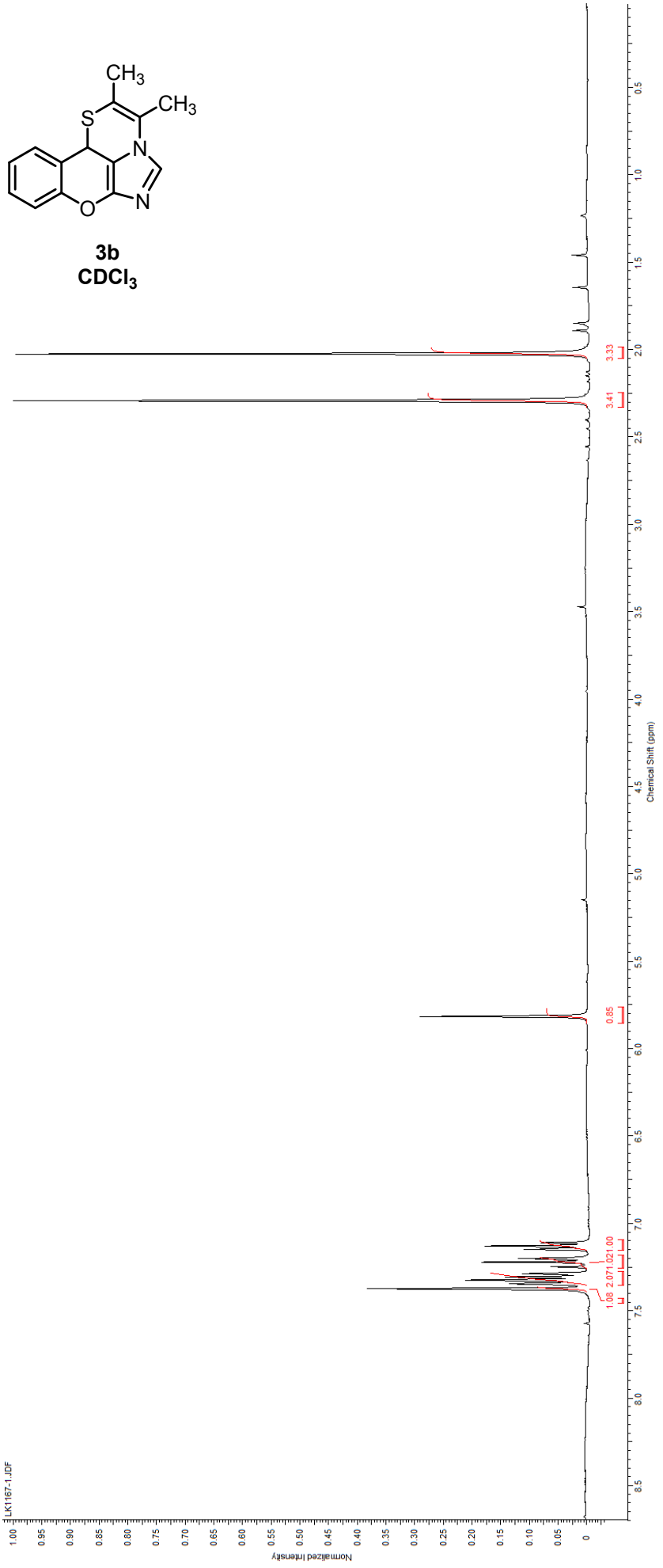

CN
N
N
Cl
CH3
2
DMSO-d6
37.23
36.68
115.42
123.08
124.85
138.35
LK931-1.JDF
Normalized Intensity
Chemical Shift (ppm)

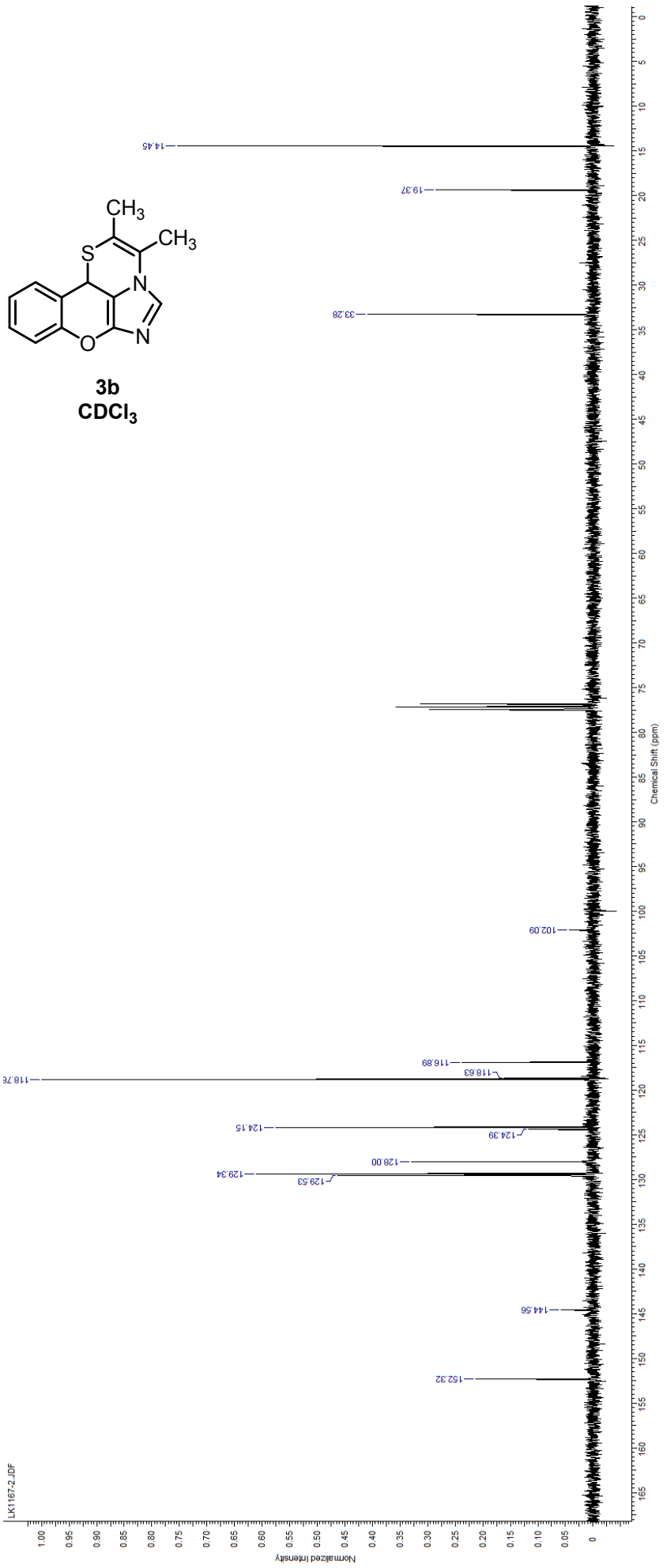

CH3
S
N
O
N
3a
CDCl3
2.90
0.90
0.91
1.04
2.63
1.04
1.15
Chemical Shift (ppm)
Normalized Intensity
LK1073-1.JDF

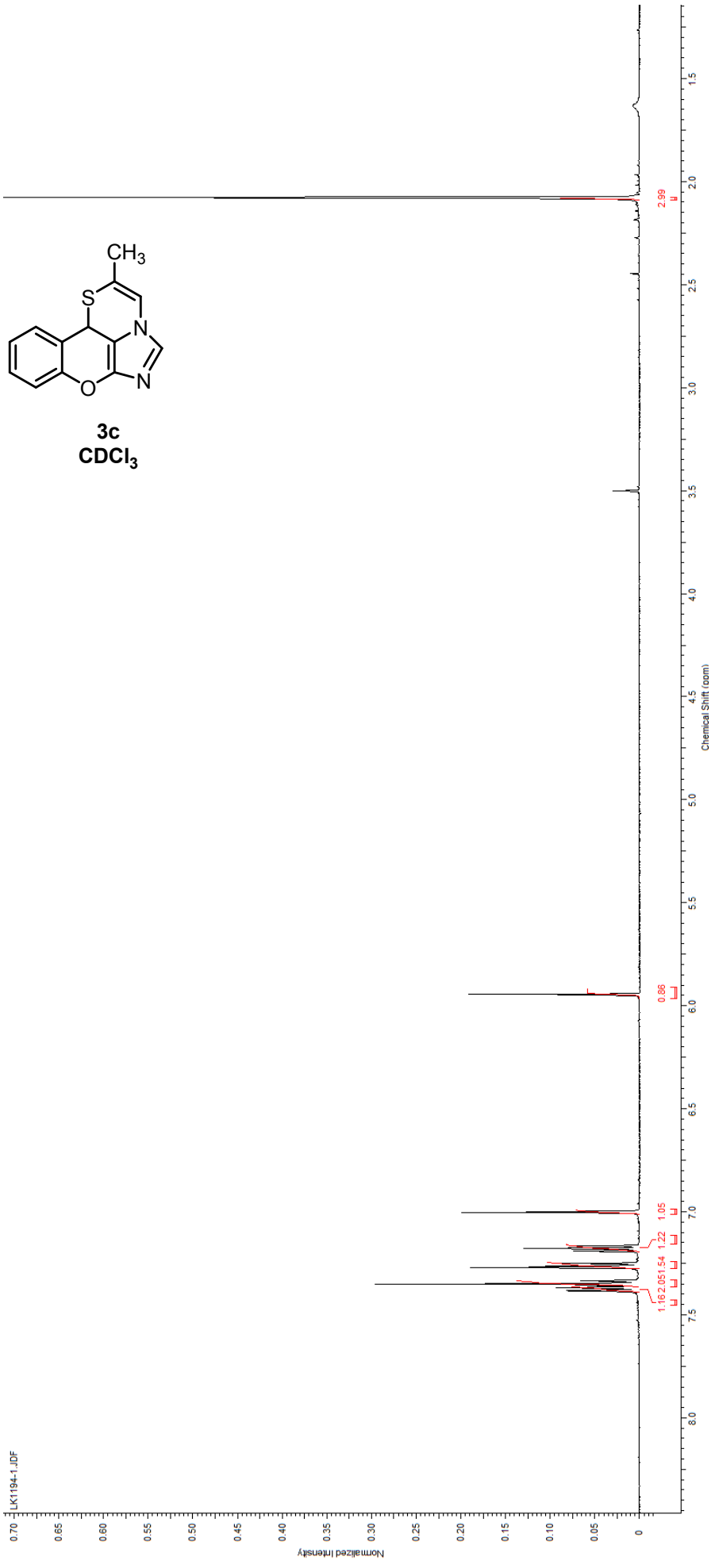

CH3
S
N
N
O

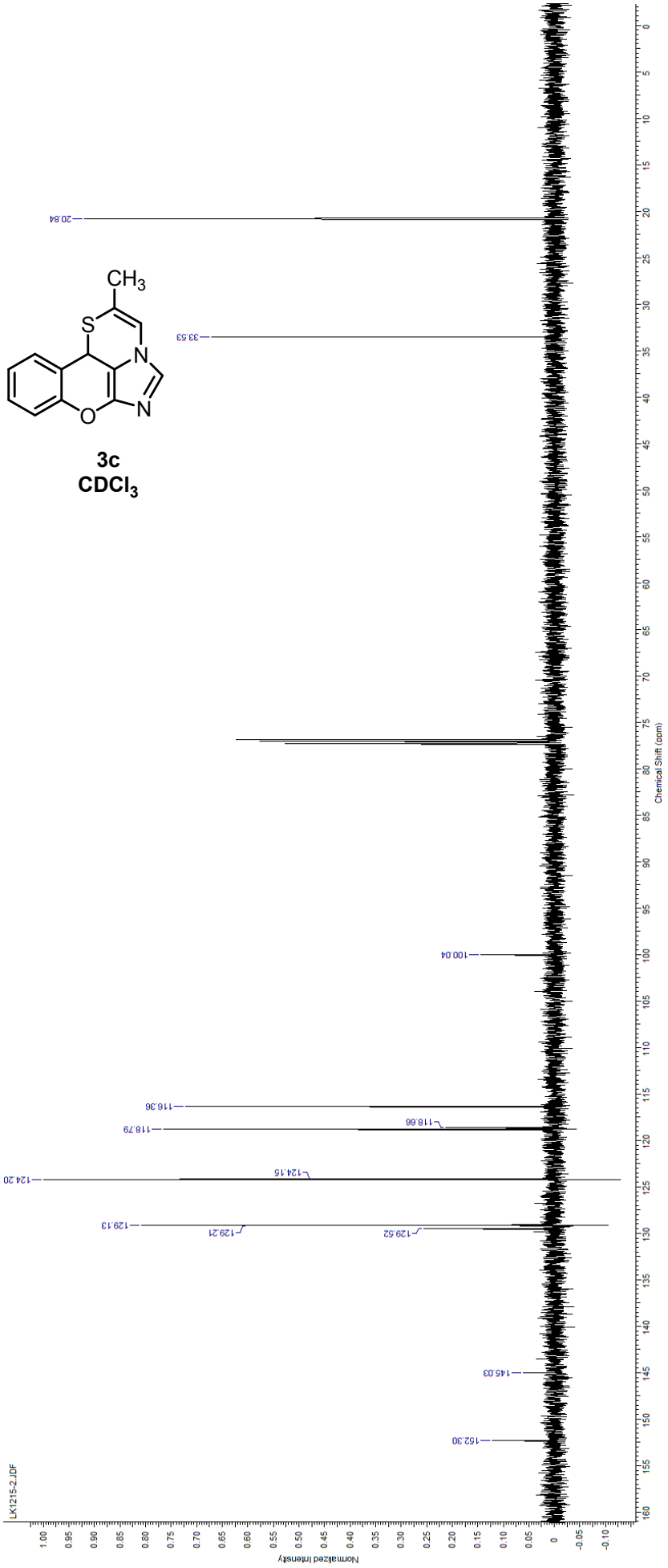
3a
$CDCl_3$

17.84
32.52
101.44
105.74
118.70
119.28
124.97
129.92
130.16
130.89
144.58
151.88
Chemical Shift (ppm)
Normalized Intensity
LK1196 13C-1.JDF

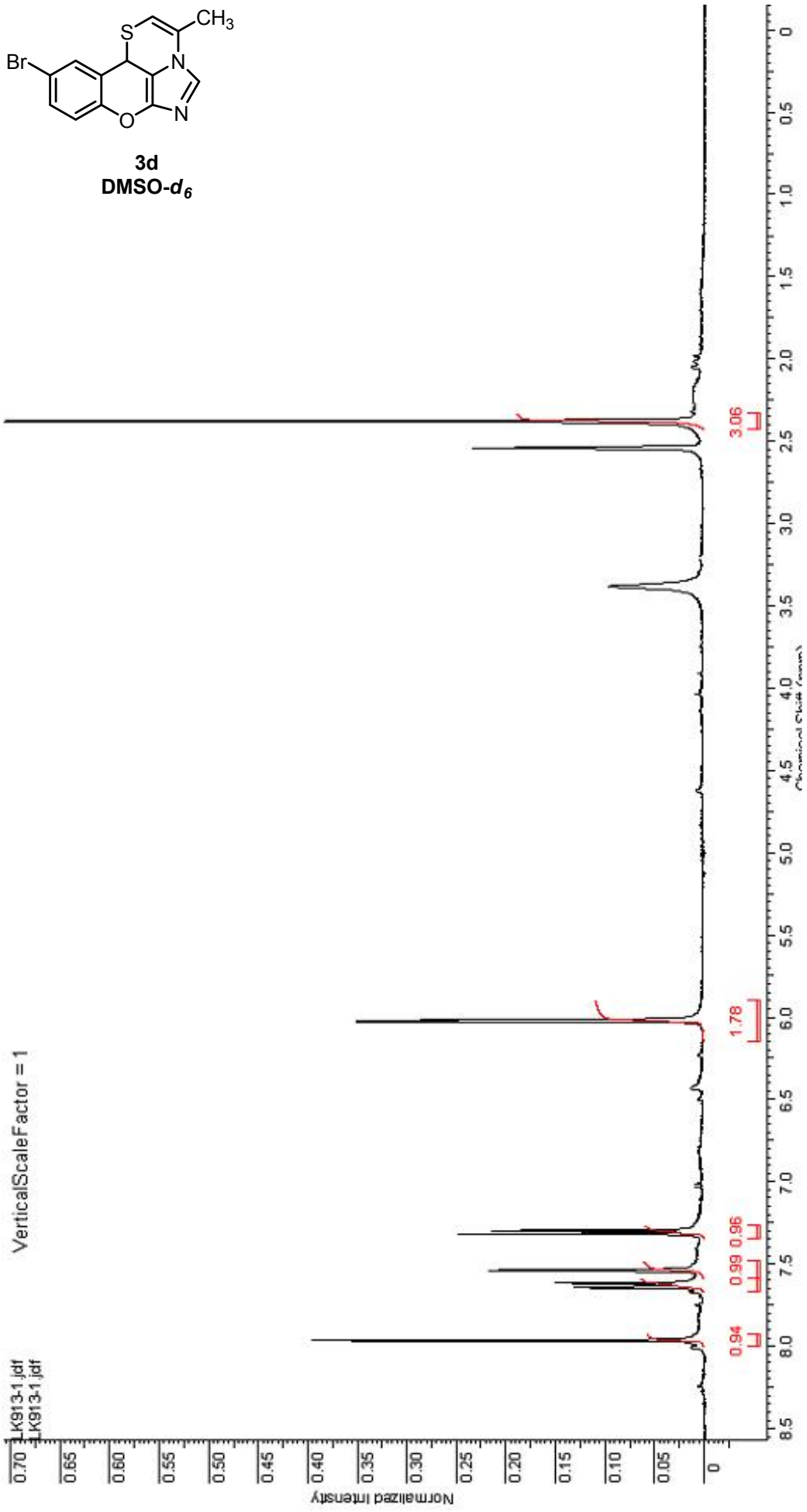

CH3
CH3
S
N
O
N
3b
CDCl3
3.33
3.41
0.85
1.00
2.07
1.02
1.00
Chemical Shift (ppm)
Normalized Intensity
LK1167-1.JDF

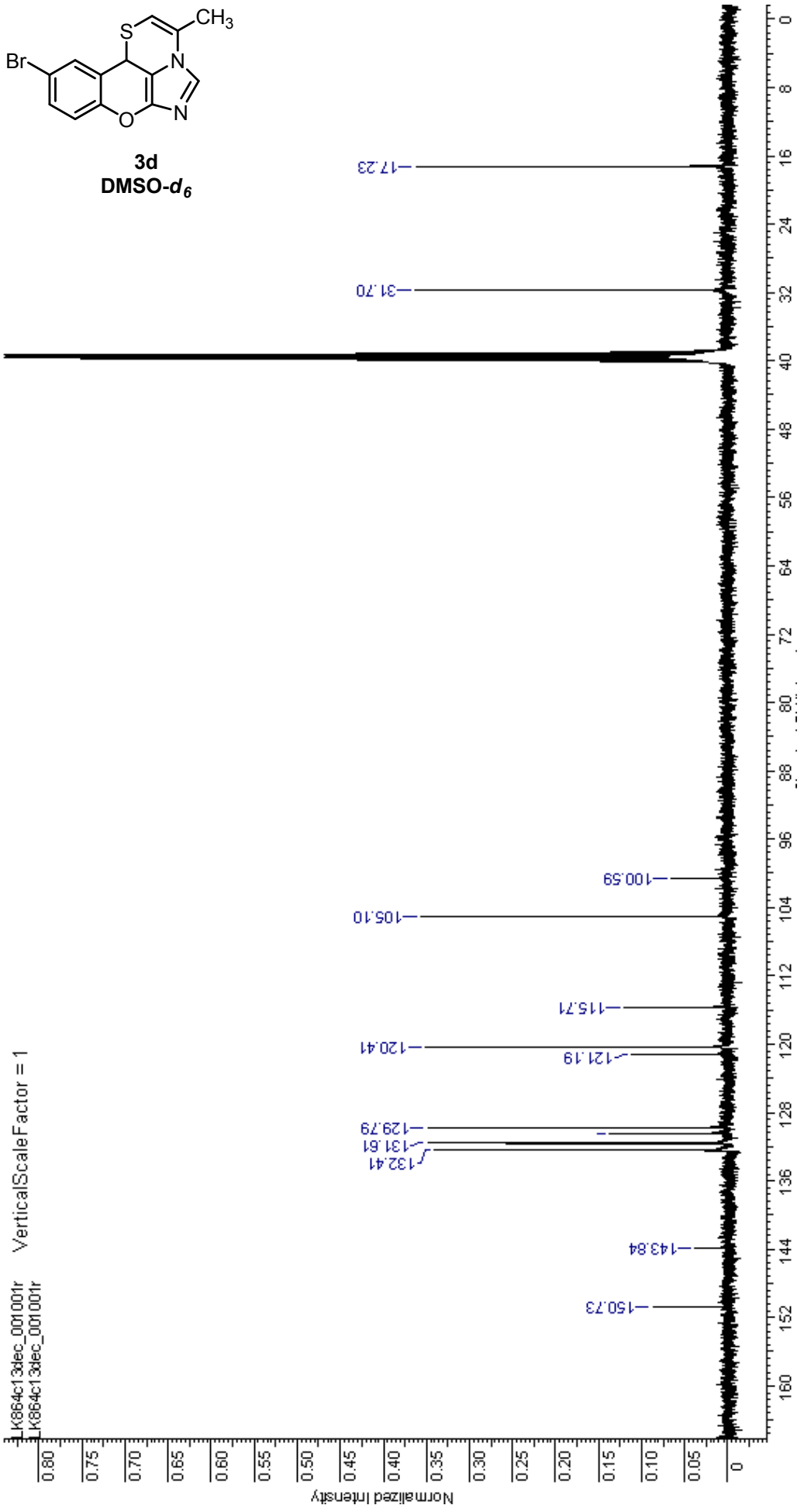

CH3
CH3
S
N
O
N
3b
CDCl3
14.45
19.37
33.28
102.09
116.89
118.63
118.76
124.15
124.39
128.00
129.34
129.53
144.56
152.32
LK1167-2.JDF
Normalized Intensity
Chemical Shift (ppm)

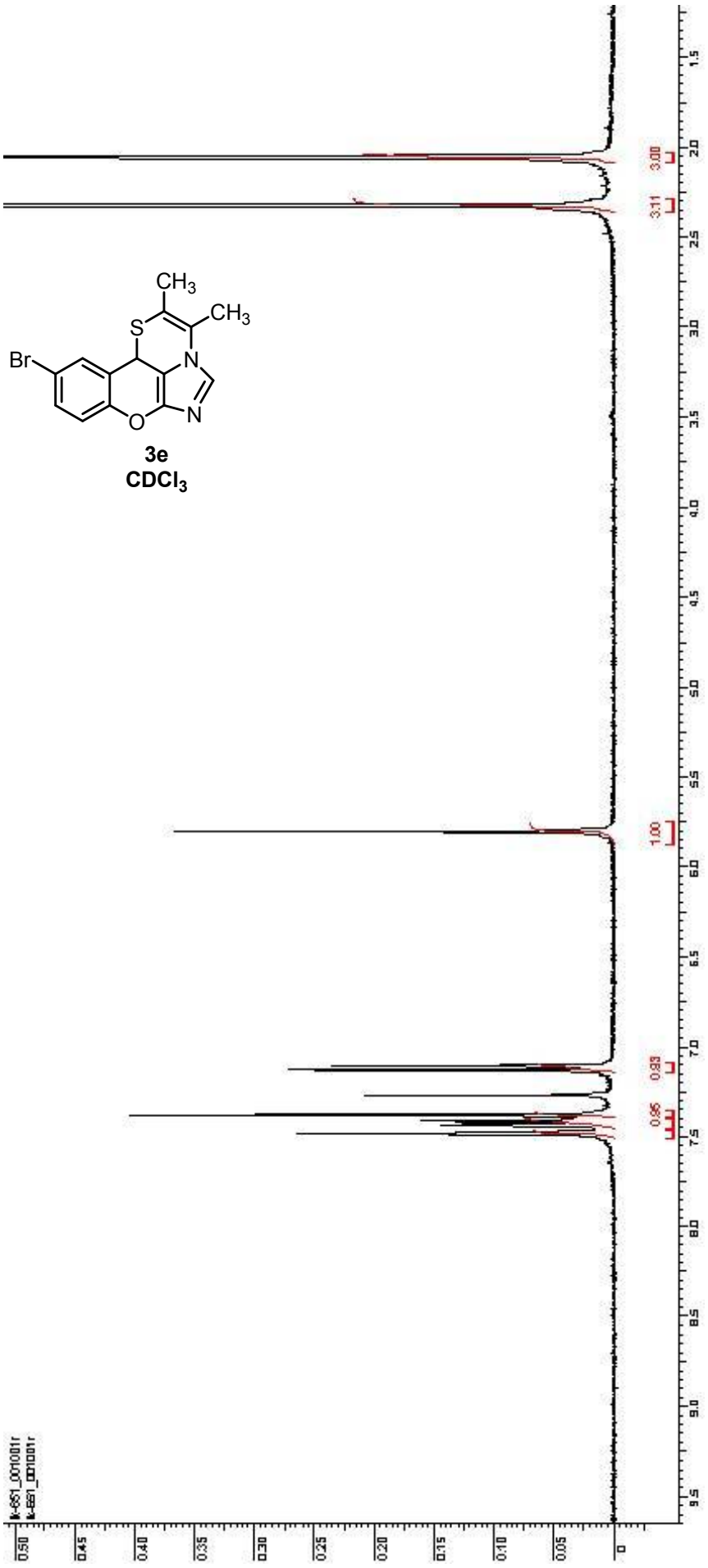

CH3
S
N
N
O
3c
CDCl3
LK1194-1.JDF
Normalized Intensity
Chemical Shift (ppm)
2.99
0.86
1.05
1.22
1.54
2.05
1.16

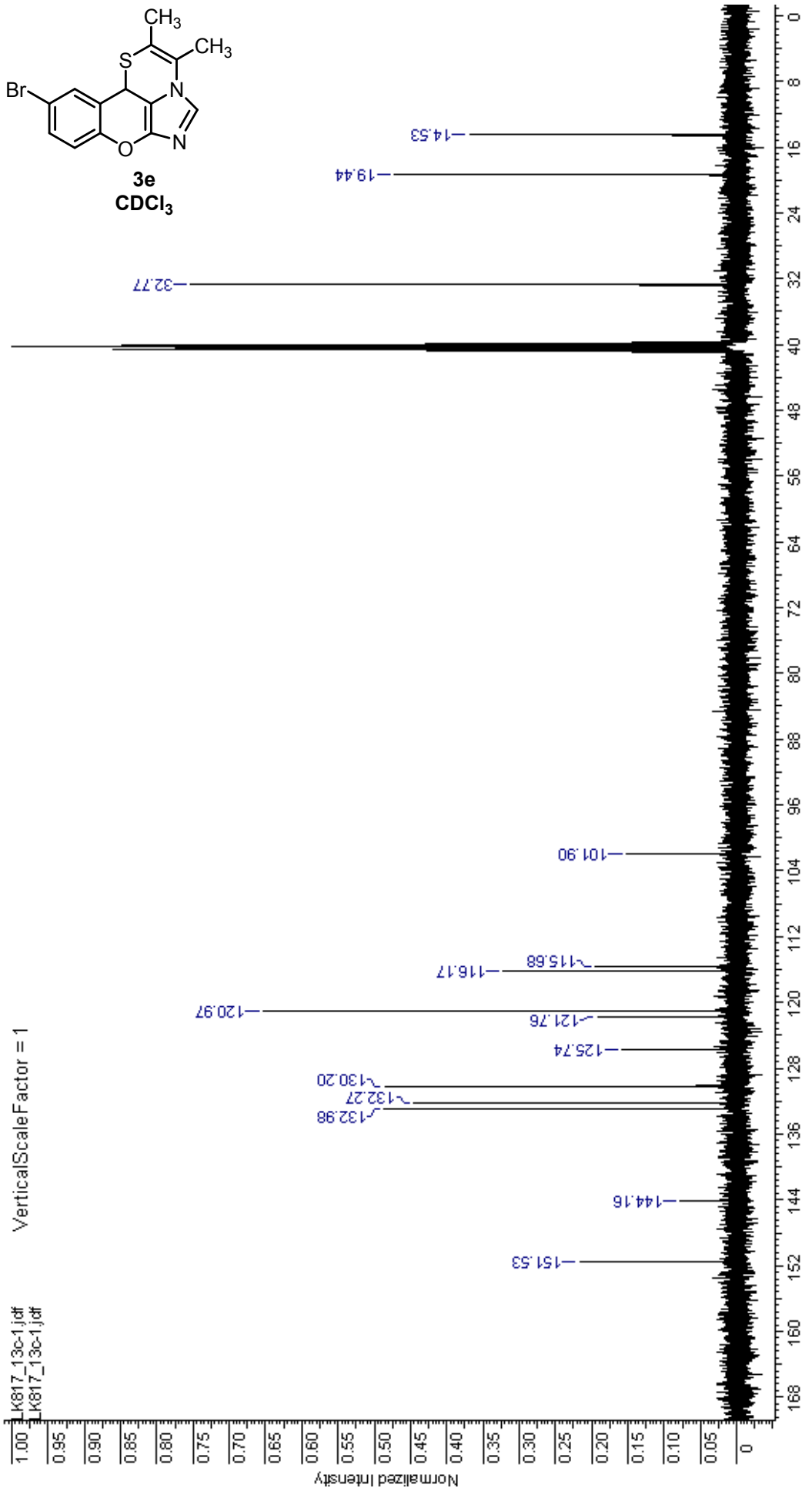

20.84
33.53
100.04
116.36
118.79
118.66
124.20
124.15
129.13
129.21
129.52
145.03
152.30
LK1215-2.JDF
Chemical Shift (ppm)
Normalized Intensity

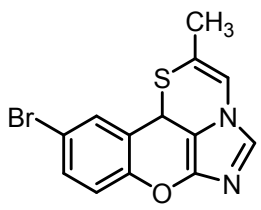
3c
$CDCl_3$


Br
S
CH3
N
N
O
3d
DMSO-d6
VerticalScaleFactor = 1
LK913-1.jdf
LK913-1.jdf
Normalized Intensity
Chemical Shift (ppm)
0.94
0.99
0.96
1.78
3.06


Br
S
CH3
N
N
O
3d
DMSO-d6
17.23
31.70
100.59
105.10
115.71
120.41
121.19
129.79
131.61
132.41
143.84
150.73
LK864c13dec_001001r
LK864c13dec_001001r
VerticalScaleFactor = 1
Normalized Intensity

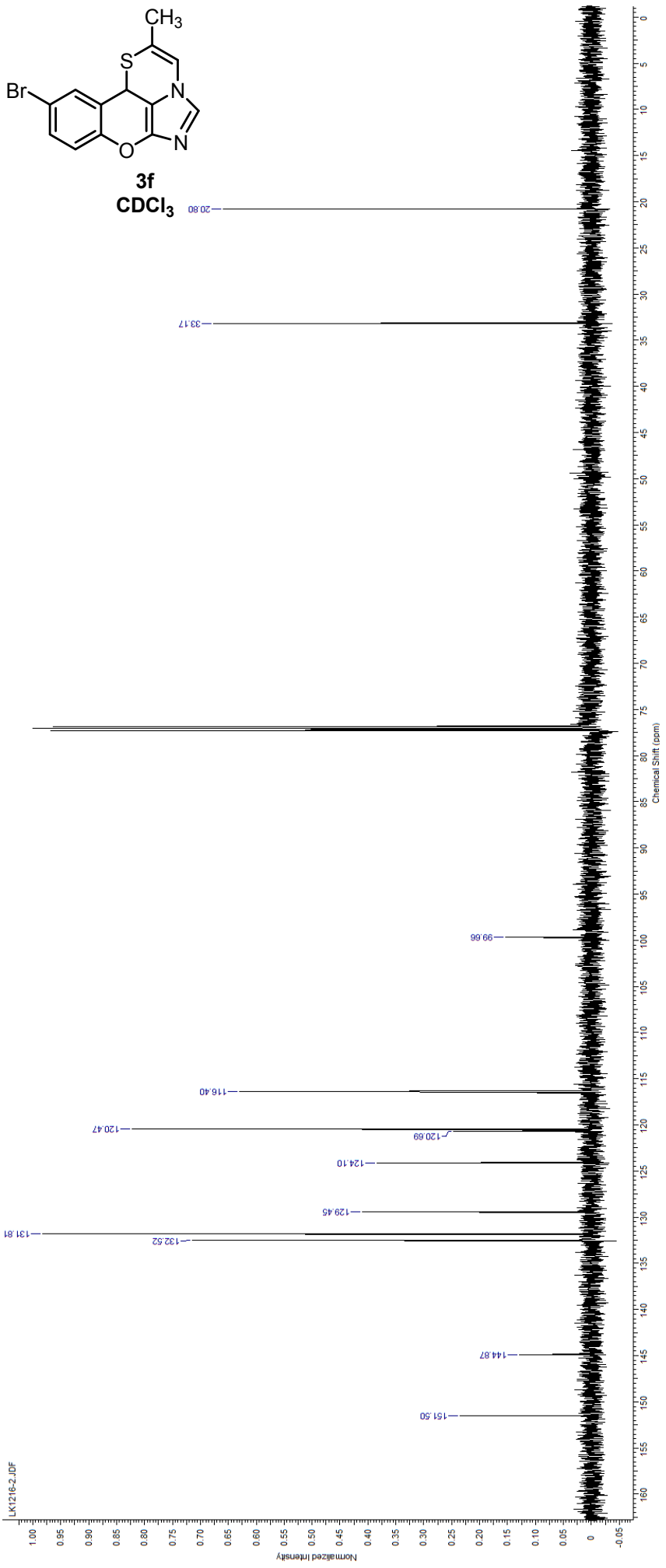

CH3
CH3
S
N
Br
O
N
3e
CDCl3
3.00
3.11
1.00
0.93
0.85

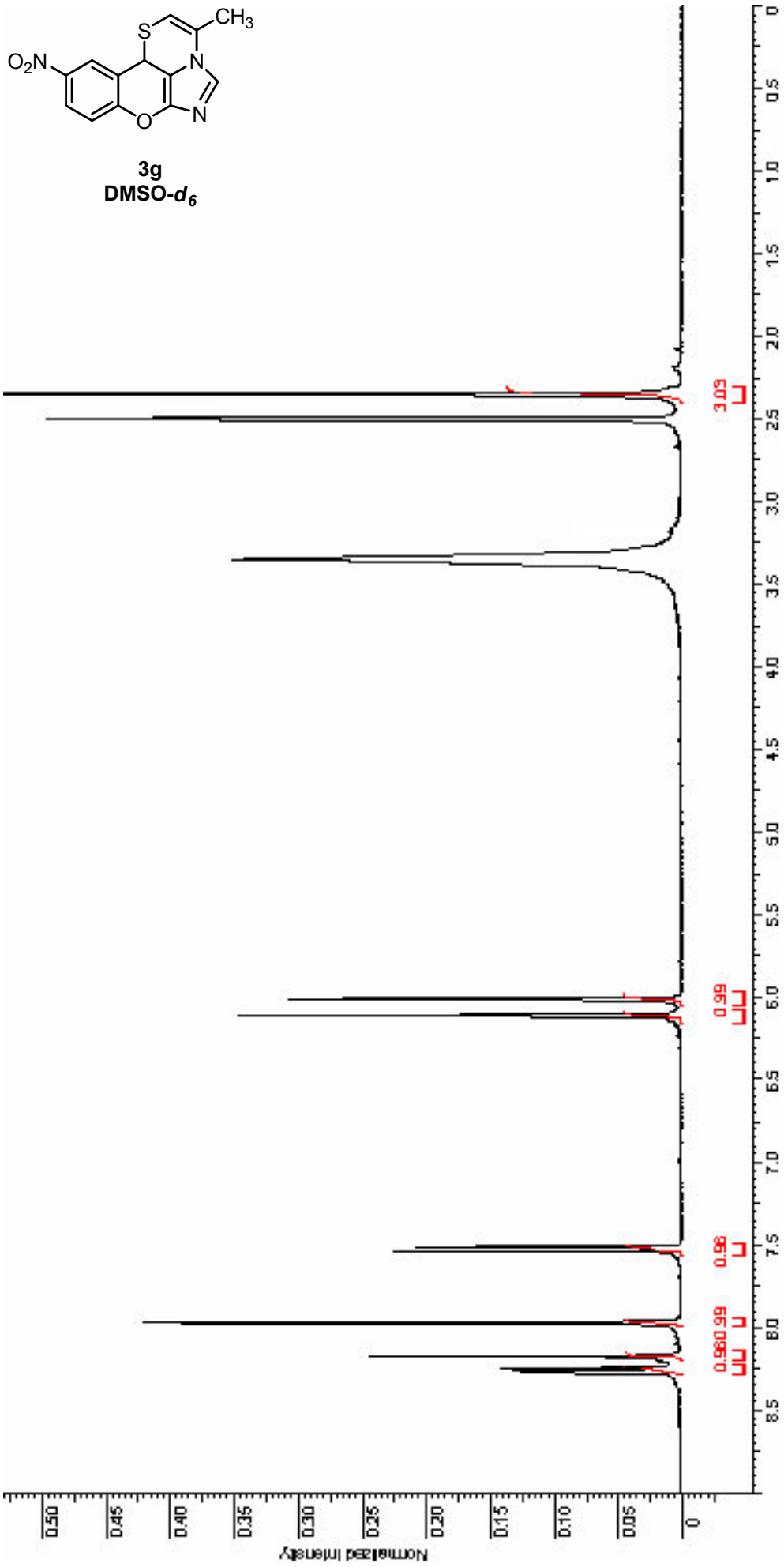

CH3
CH3
S
N
Br
O
N
3e
CDCl3
14.53
19.44
32.77
101.90
115.68
116.17
120.97
121.76
125.74
130.20
132.27
132.98
144.16
151.53
VerticalScaleFactor = 1
LK817_13c-1.jdf
LK817_13c-1.jdf
Normalized Intensity


CH3
S
N
Br
O
N

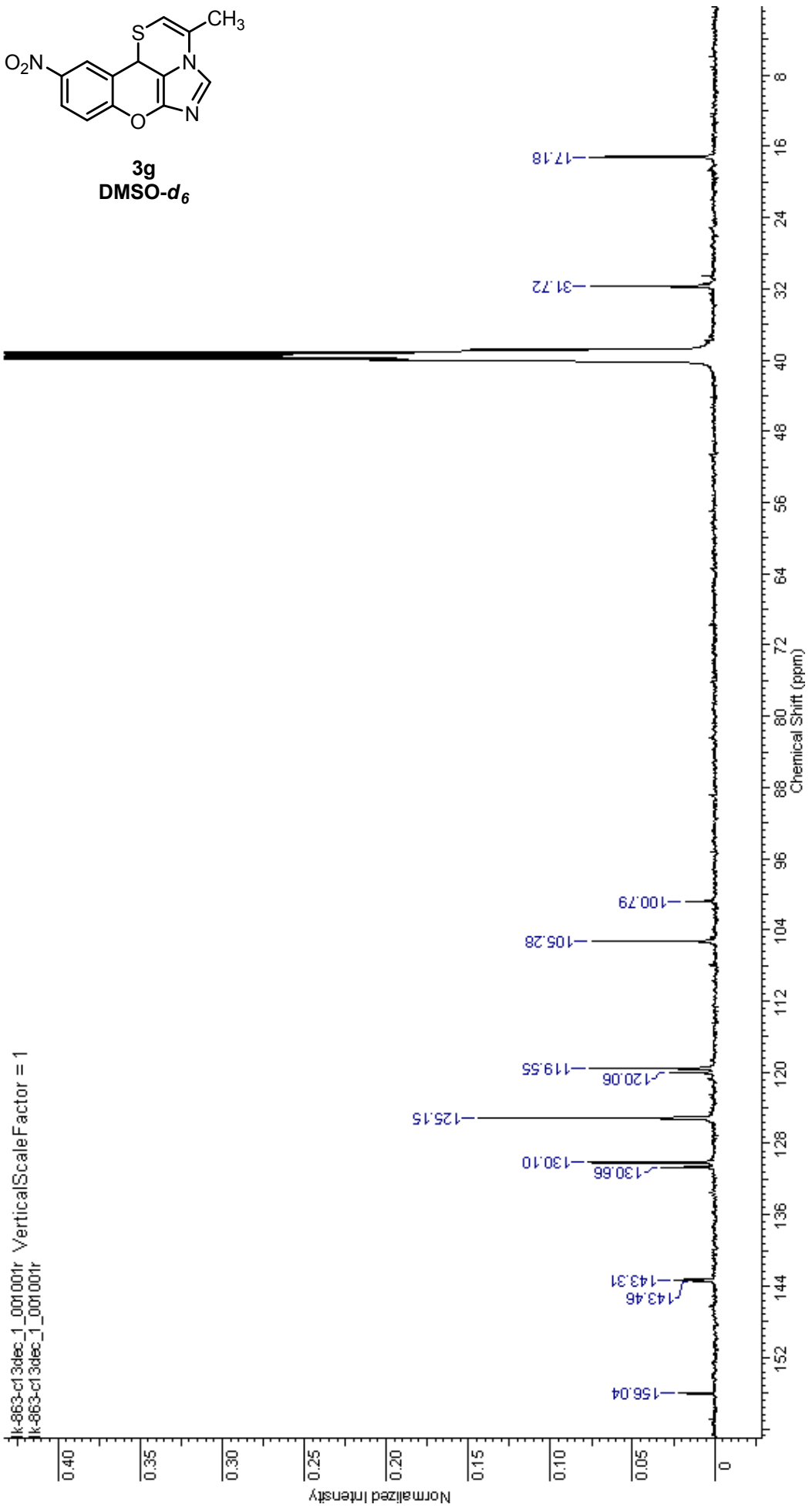
3f
$CDCl_3$

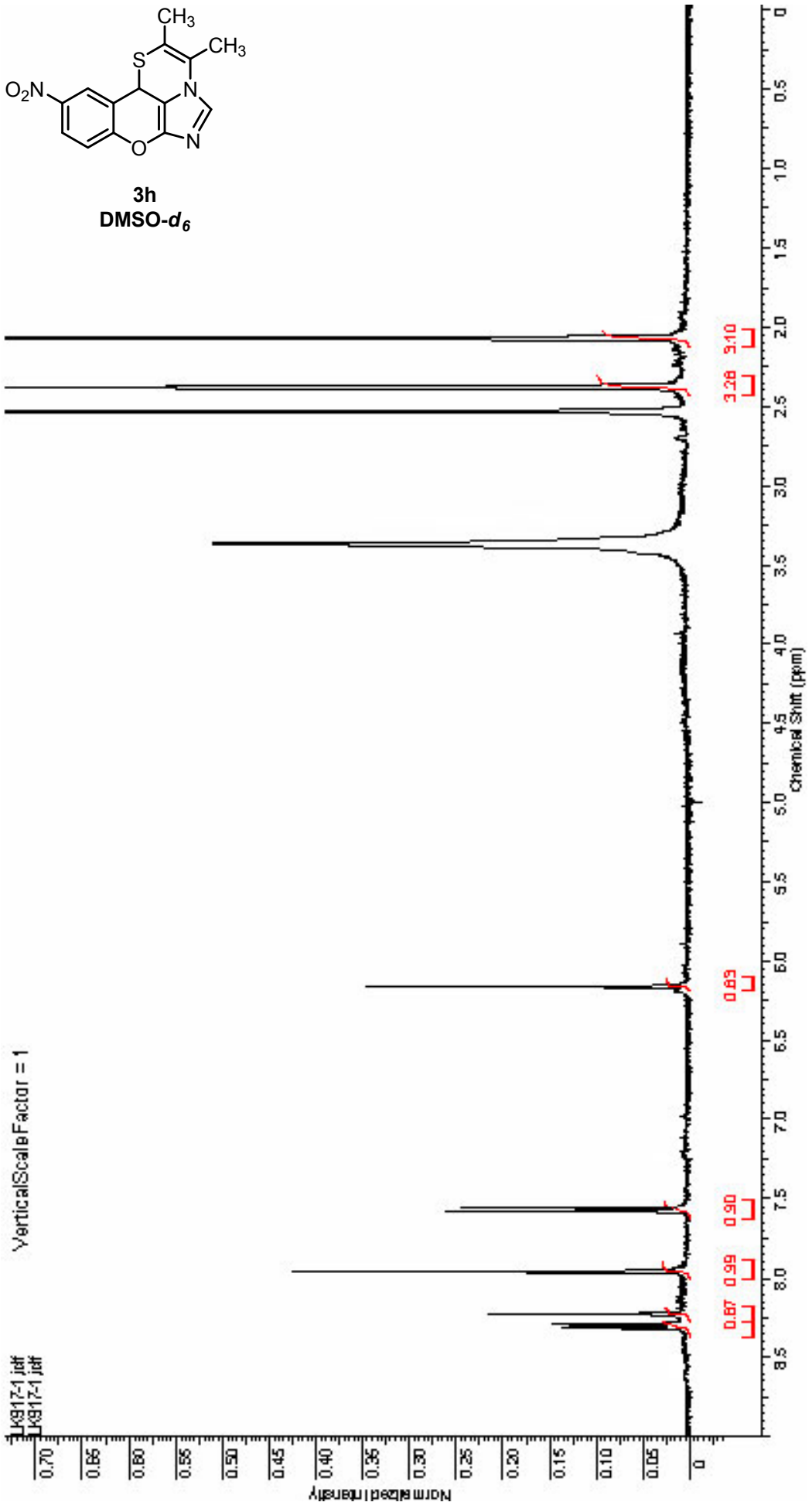
3.52
1.00
1.17
1.18
1.20
1.15
0.98
Chemical Shift (ppm)
Normalized Intensity
LK1216-1.JDF

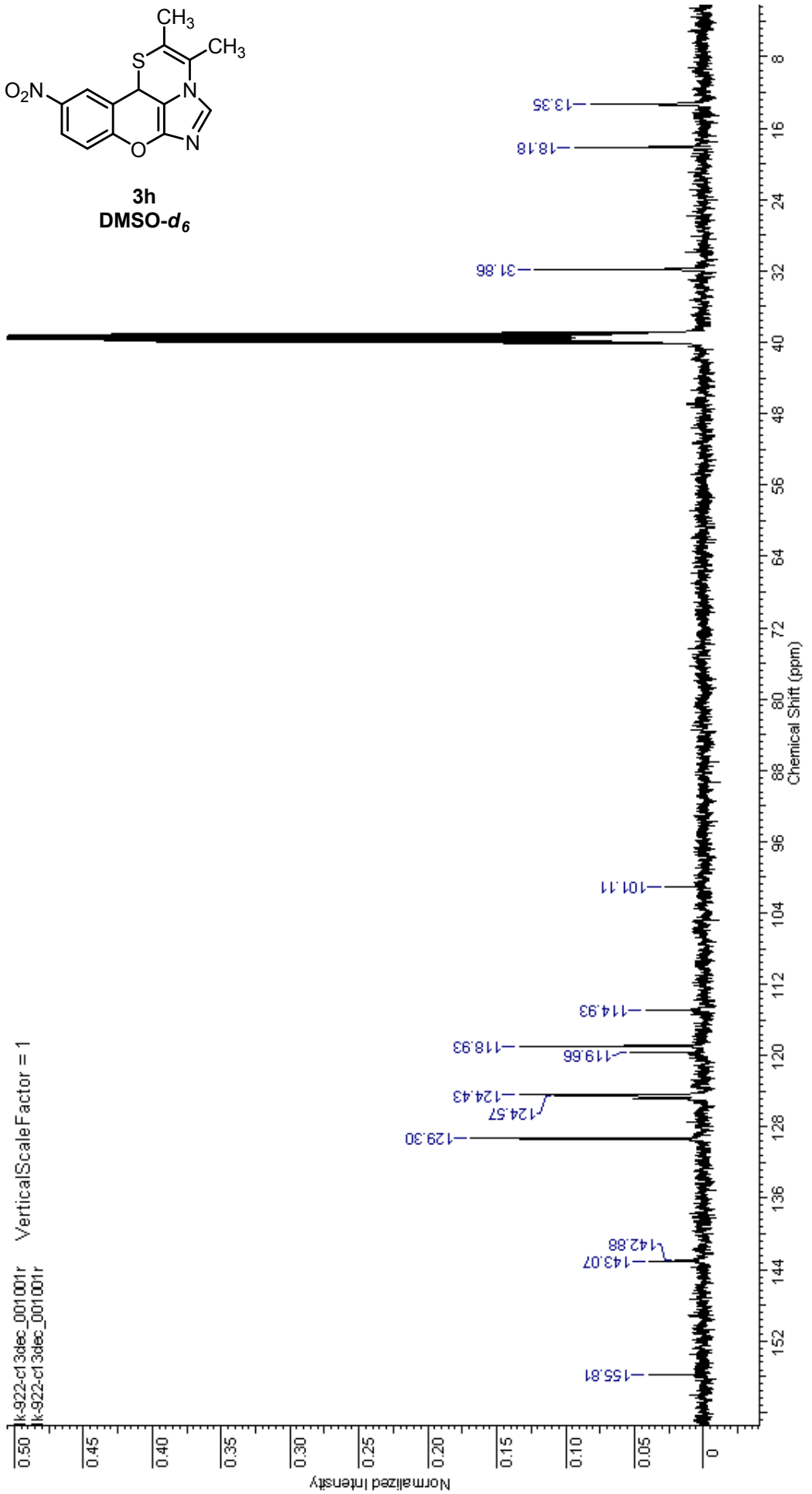

CH3
S
N
Br
N
O
3f
CDCl3
20.80
33.17
99.66
116.40
120.47
120.69
124.10
129.45
131.81
132.52
144.87
151.50
Chemical Shift (ppm)
Normalized Intensity
LK1216-2.JDF

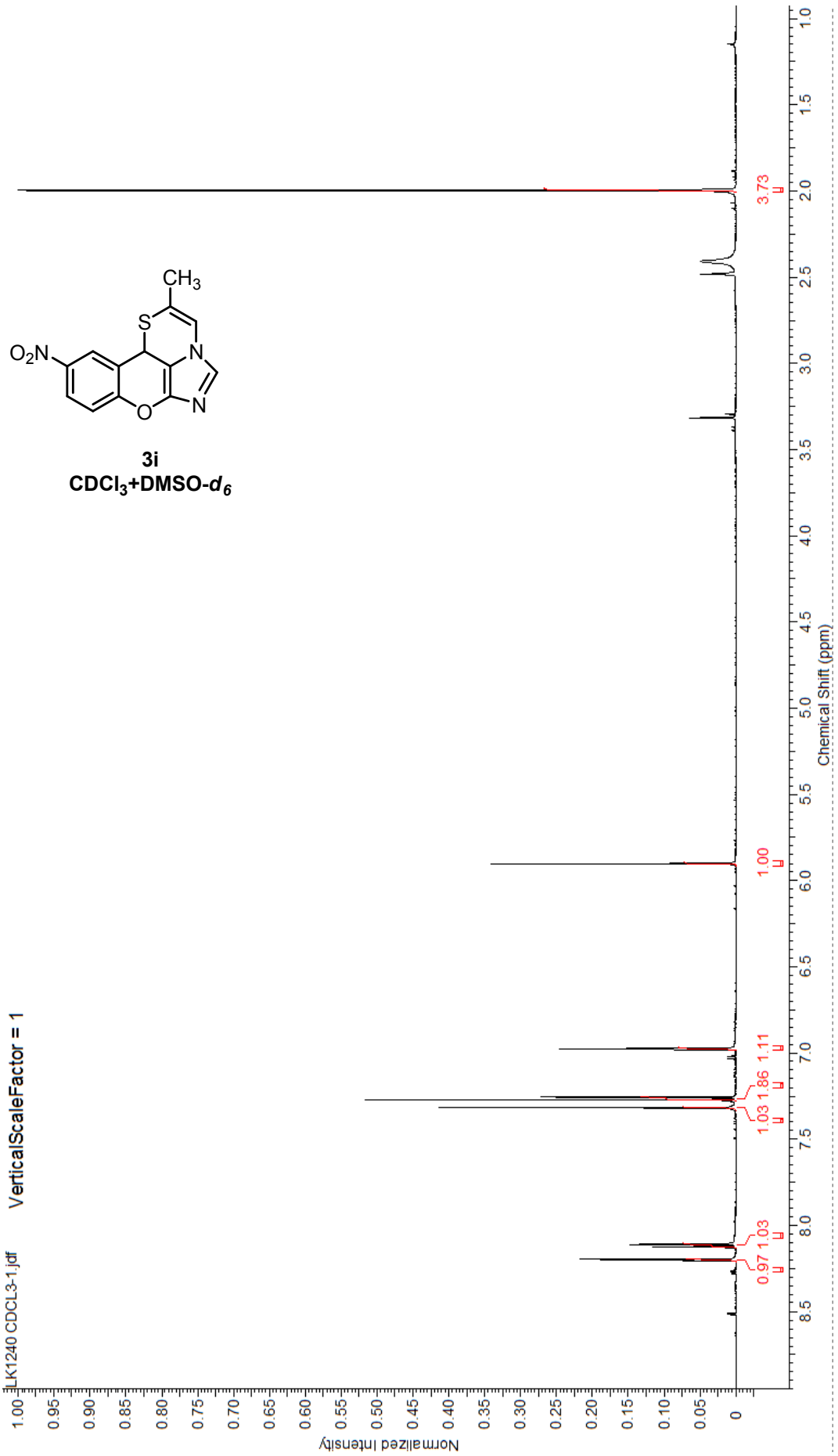


3g
DMSO-*d*$_6$

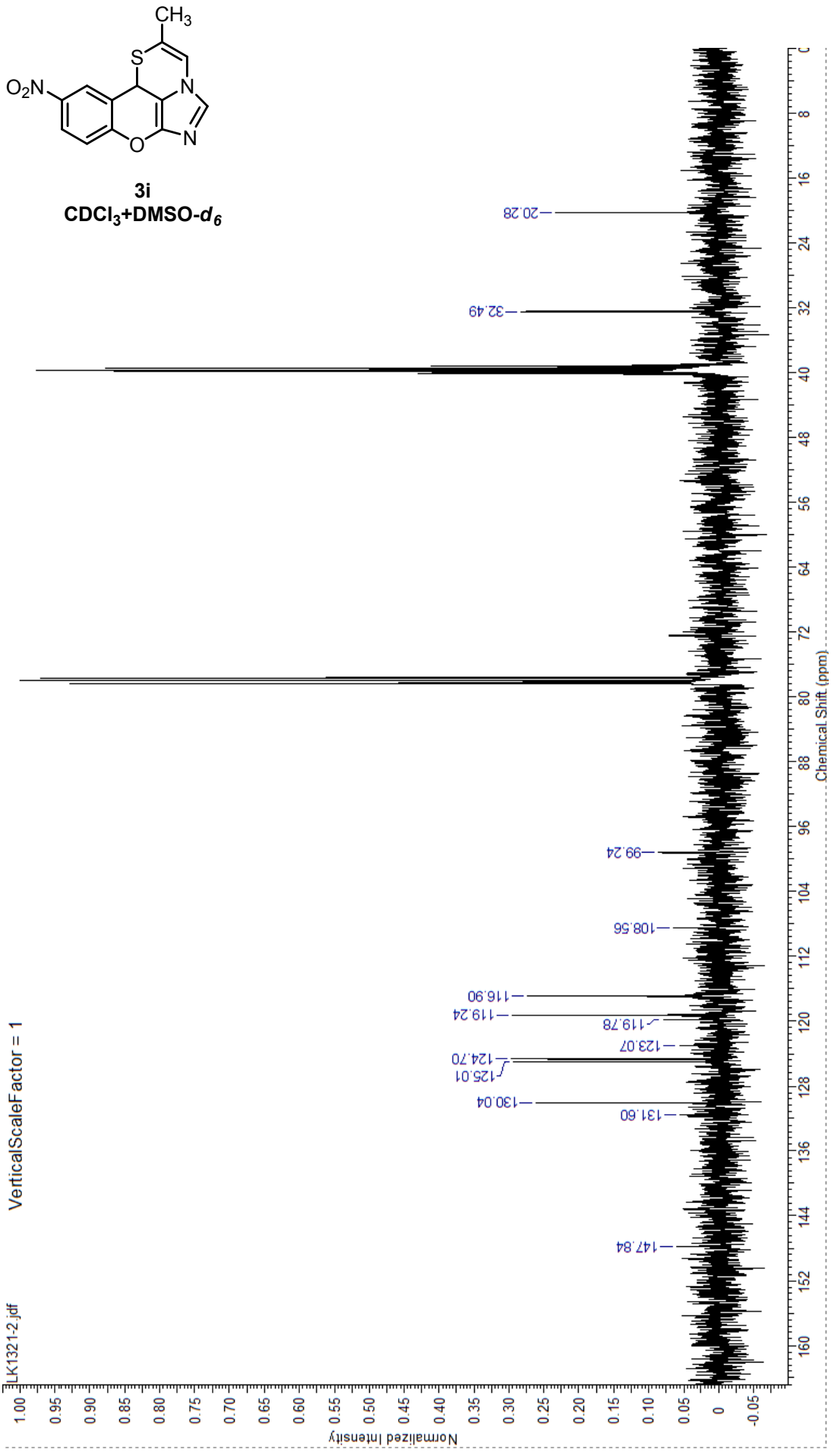

S
CH3
O2N
N
O
N
3g
DMSO-d6
17.18
31.72
100.79
105.28
119.55
120.06
125.15
130.10
130.66
143.31
143.46
156.04
Chemical Shift (ppm)
Normalized Intensity
tk-863-c13dec_1_001001r VerticalScaleFactor = 1
tk-863-c13dec_1_001001r

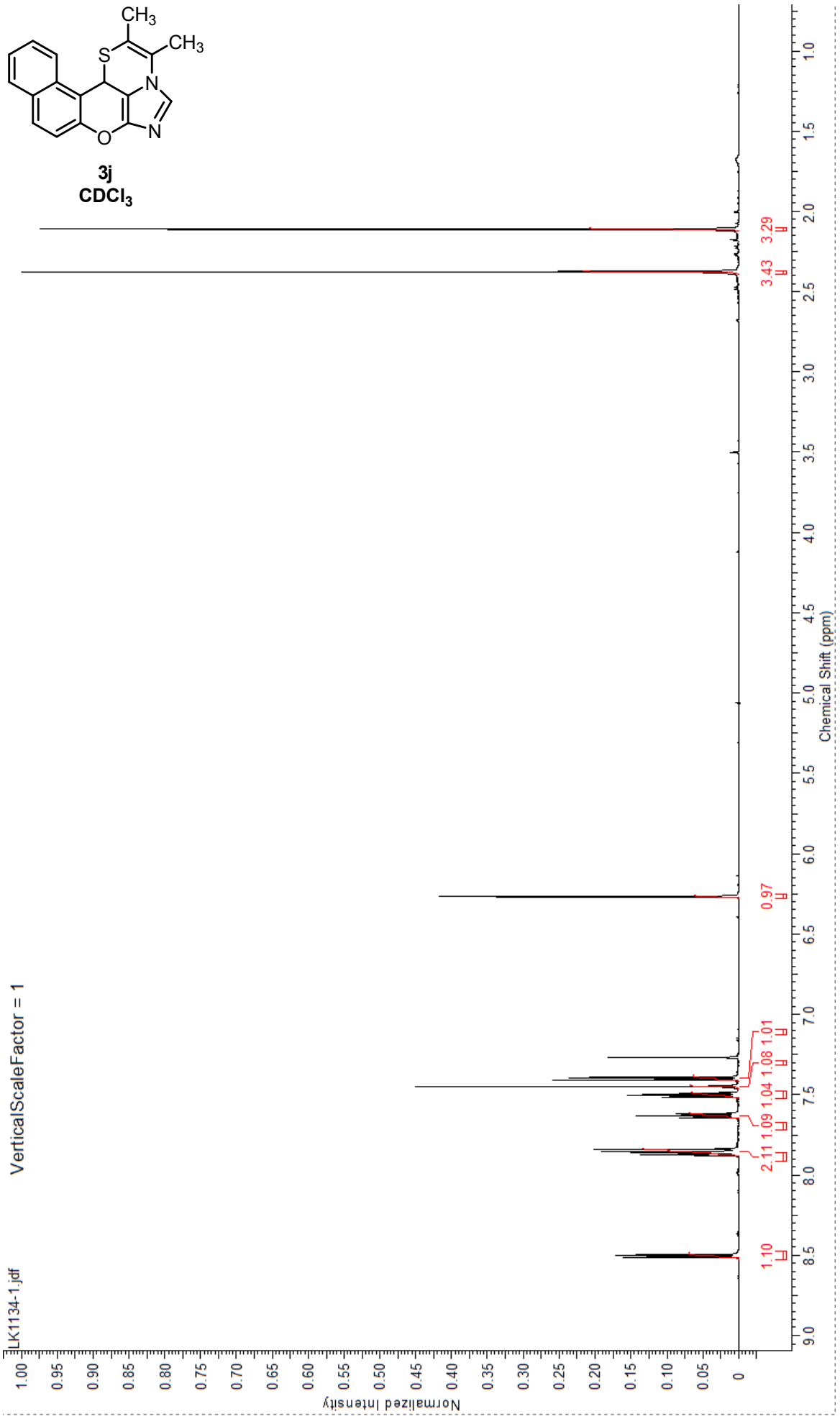

CH3
CH3
S
N
O2N
N
O
3h
DMSO-d6
VerticalScaleFactor = 1
LK917-1.jdf
LK917-1.jdf
Chemical Shift (ppm)
Normalized Intensity
3.10
3.26
0.89
0.90
0.99
0.87

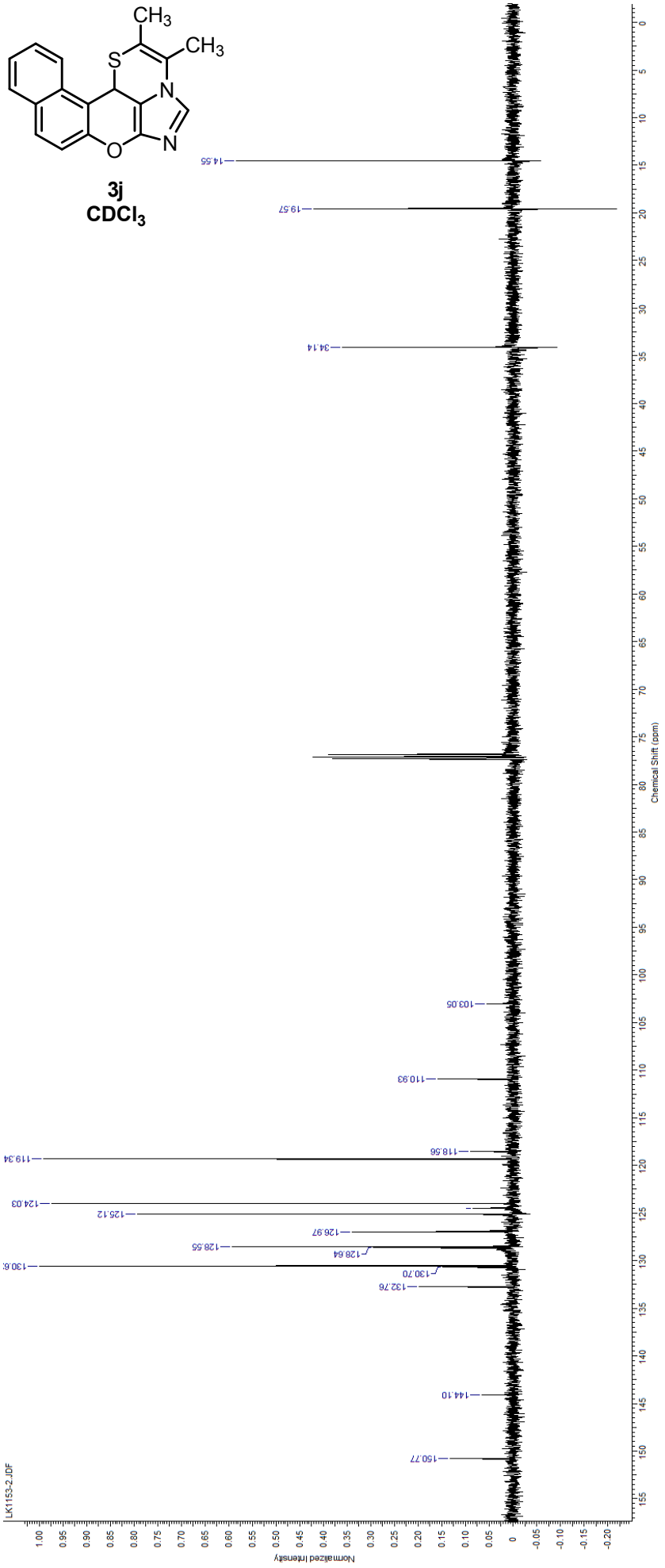

CH3
CH3
S
N
O2N
O
N
3h
DMSO-d6
13.35
18.18
31.86
101.11
114.93
118.93
119.66
124.43
124.57
129.30
142.88
143.07
155.81
k-922-c13dec_001001r
k-922-c13dec_001001r
VerticalScaleFactor = 1
Normalized Intensity
Chemical Shift (ppm)

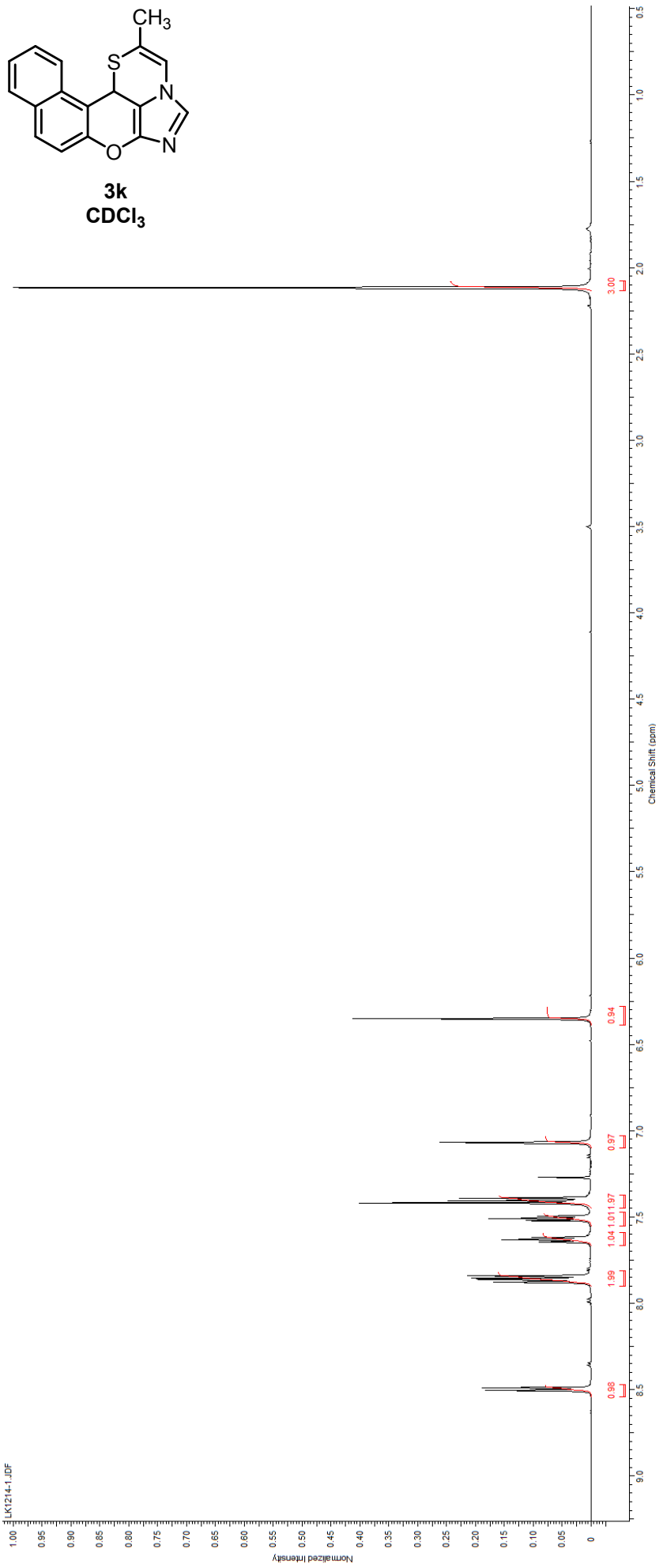


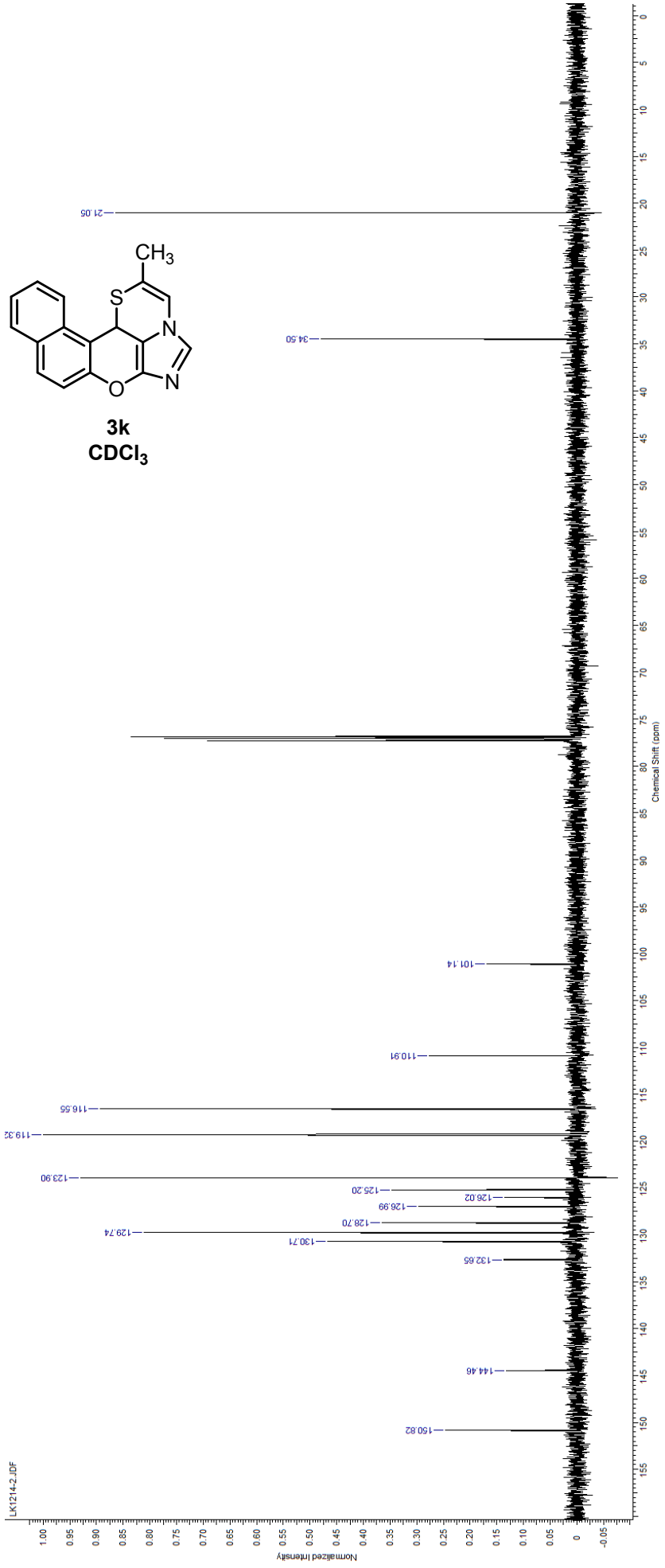
3i
$CDCl_3$+DMSO-d_6

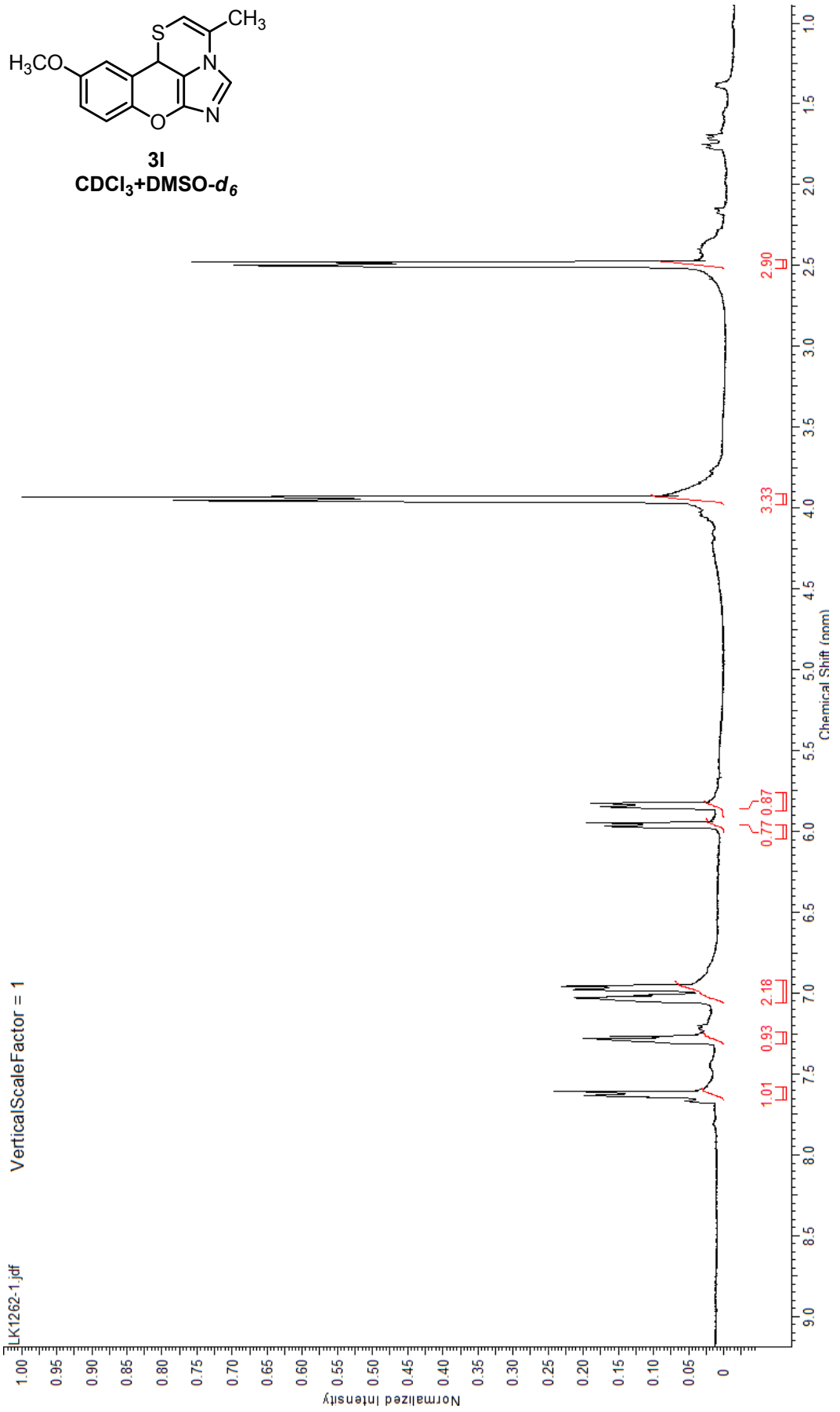

CH3
S
N
O2N
O
N
3i
CDCl3+DMSO-d6
20.28
32.49
99.24
108.56
116.90
119.24
119.78
123.07
124.70
125.01
130.04
131.60
147.84
LK1321-2.jdf
VerticalScaleFactor = 1
Normalized Intensity
Chemical Shift (ppm)

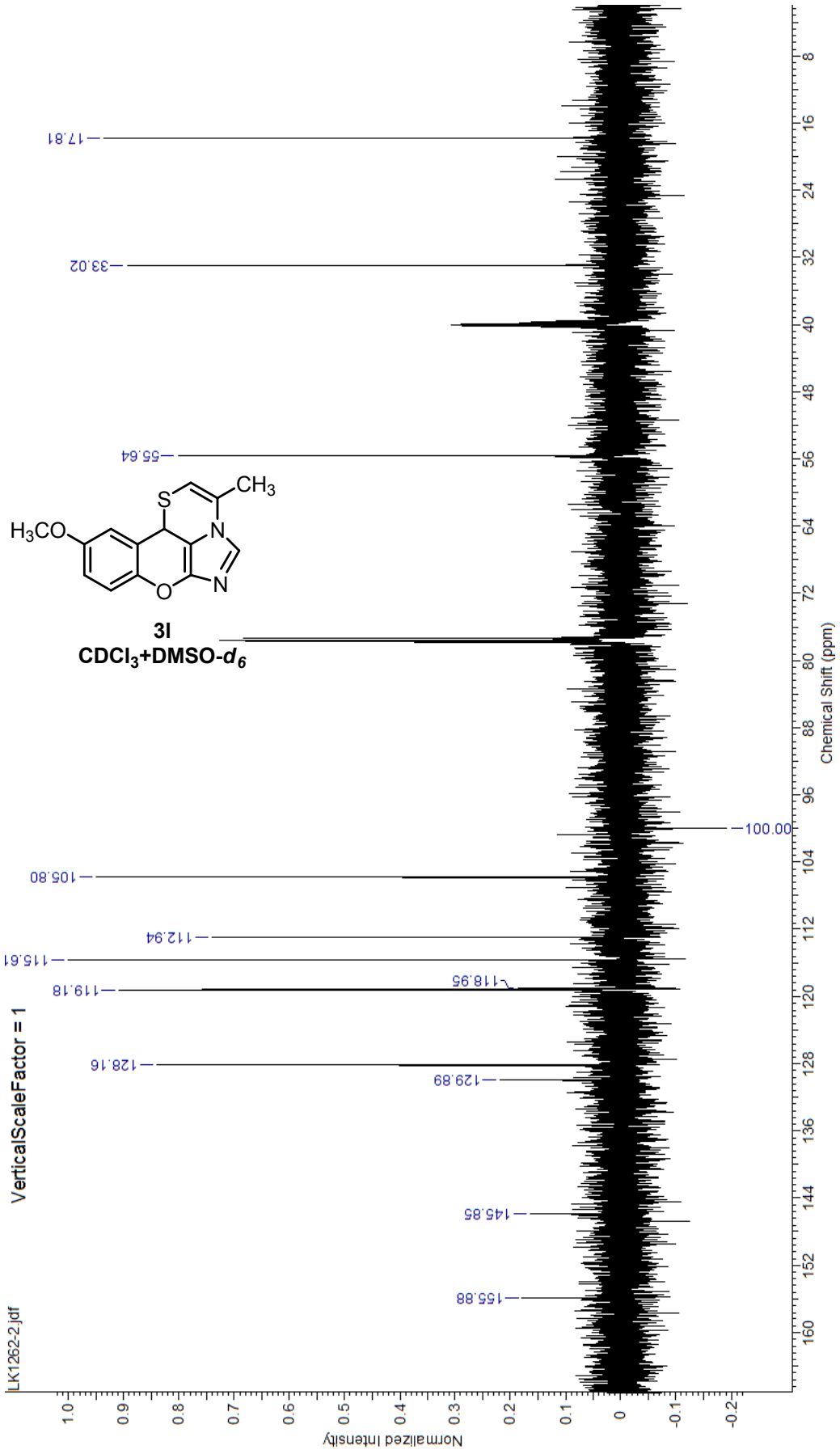

CH3
CH3
S
N
N
O
3j
CDCl3
VerticalScaleFactor = 1
LK1134-1.jdf
Normalized Intensity
Chemical Shift (ppm)
1.10
2.11
1.09
1.04
1.08
1.01
0.97
3.43
3.29

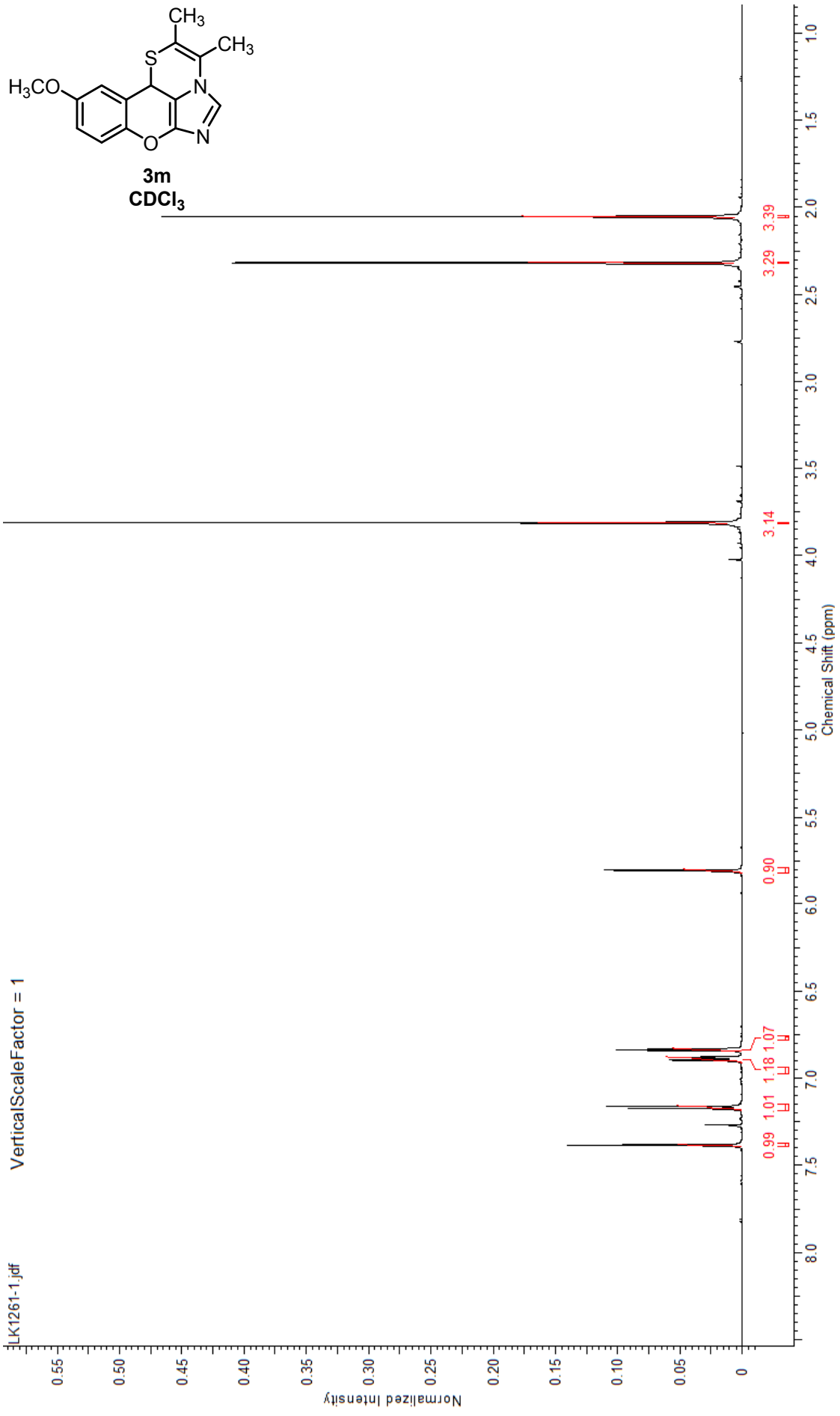

CH3
CH3
S
N
N
O
3j
CDCl3
14.55
19.57
34.14
103.05
110.93
118.56
119.34
124.03
125.12
126.97
128.55
128.64
130.6
130.70
132.76
144.10
150.77
LK1153-2.JDF
Normalized Intensity
Chemical Shift (ppm)

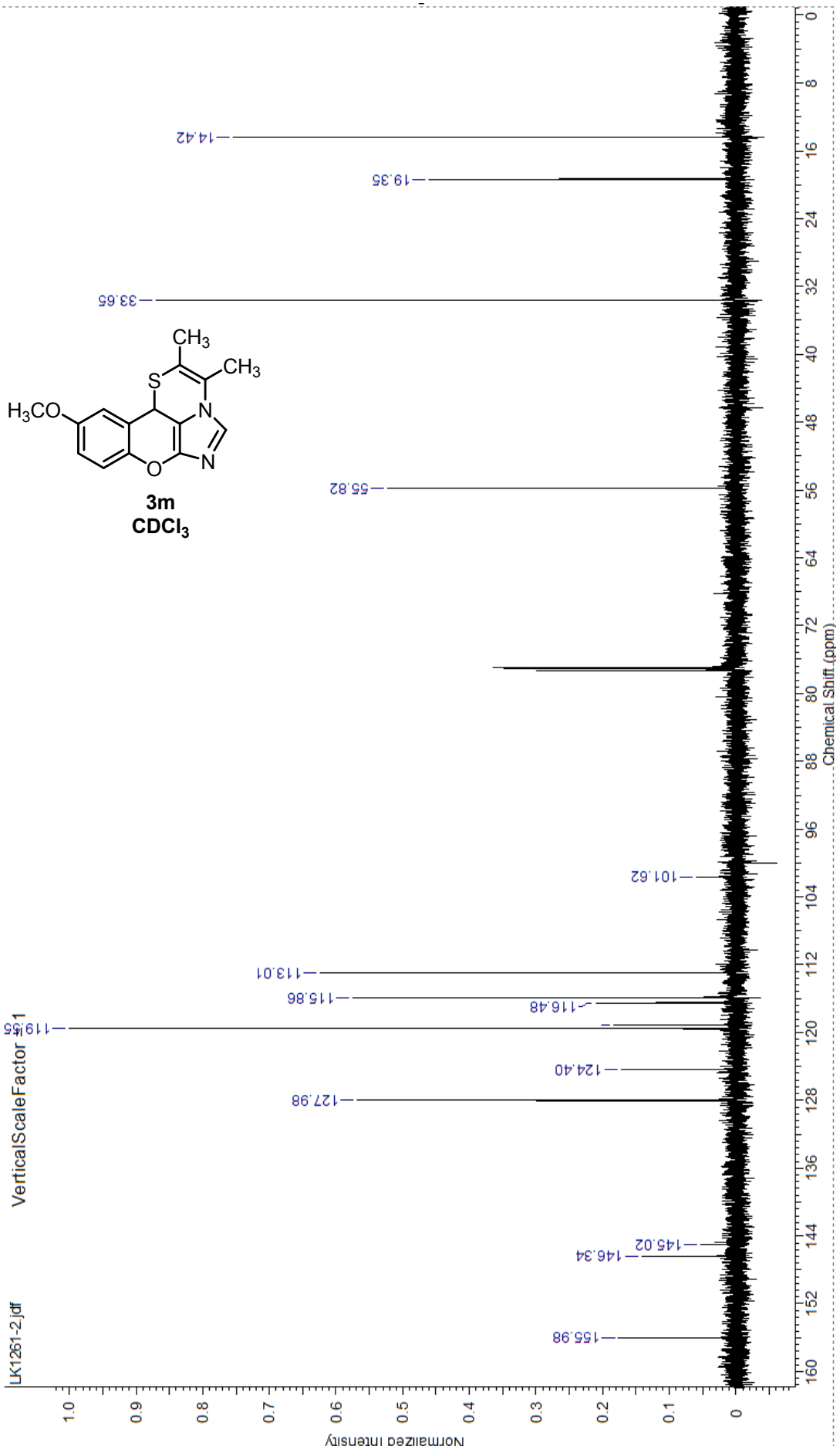

CH3
S
N
N
O
3k
CDCl3
LK1214-1.JDF
Normalized Intensity
Chemical Shift (ppm)
3.00
0.94
0.97
1.97
1.01
1.04
1.99
0.98

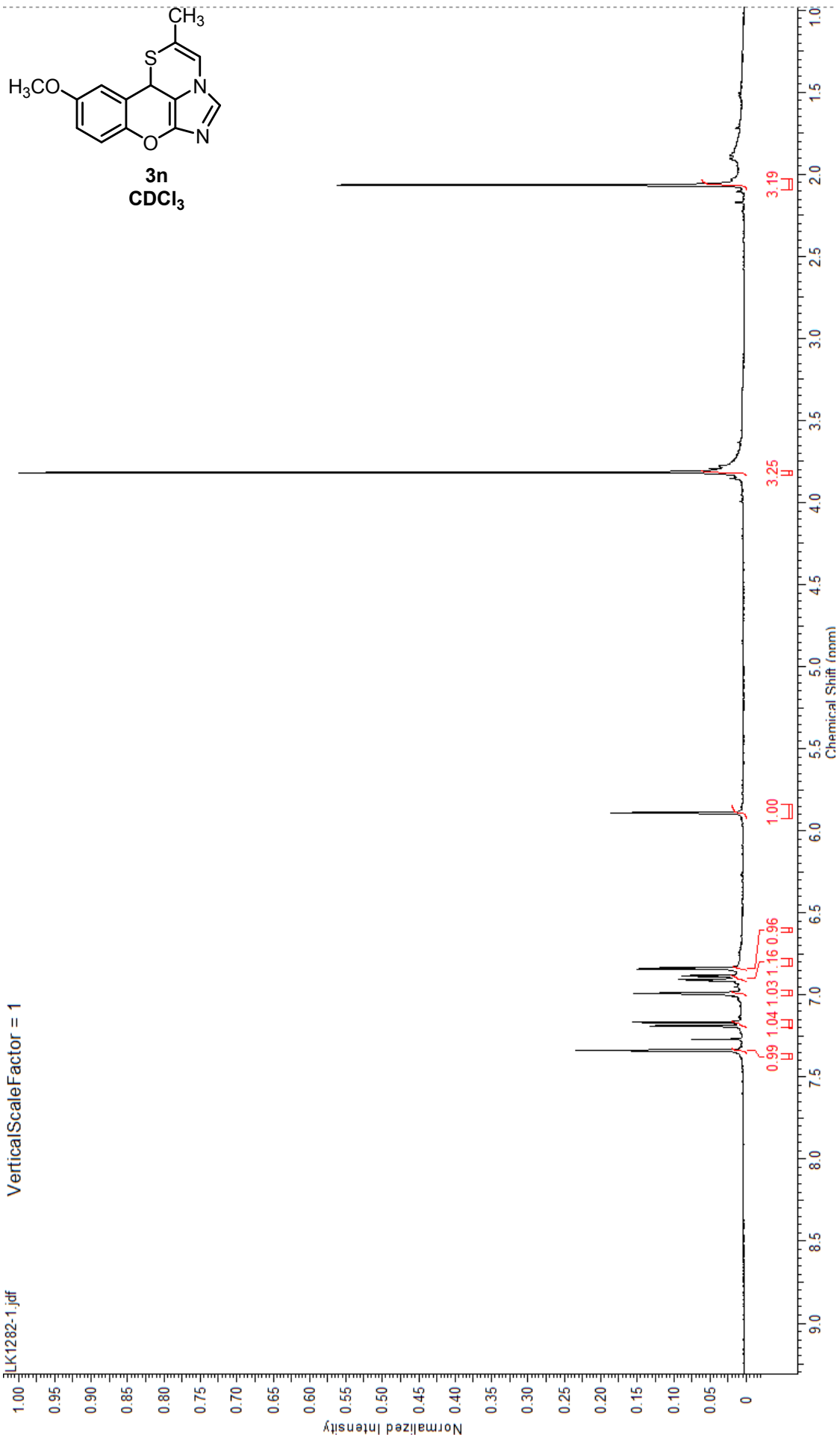

21.06
34.50
101.14
110.91
116.55
119.32
123.90
125.20
126.02
126.99
128.70
129.74
130.71
132.65
144.46
150.82
CH3
S
N
N
O
3k
CDCl3
LK1214-2.JDF
Normalized Intensity
Chemical Shift (ppm)

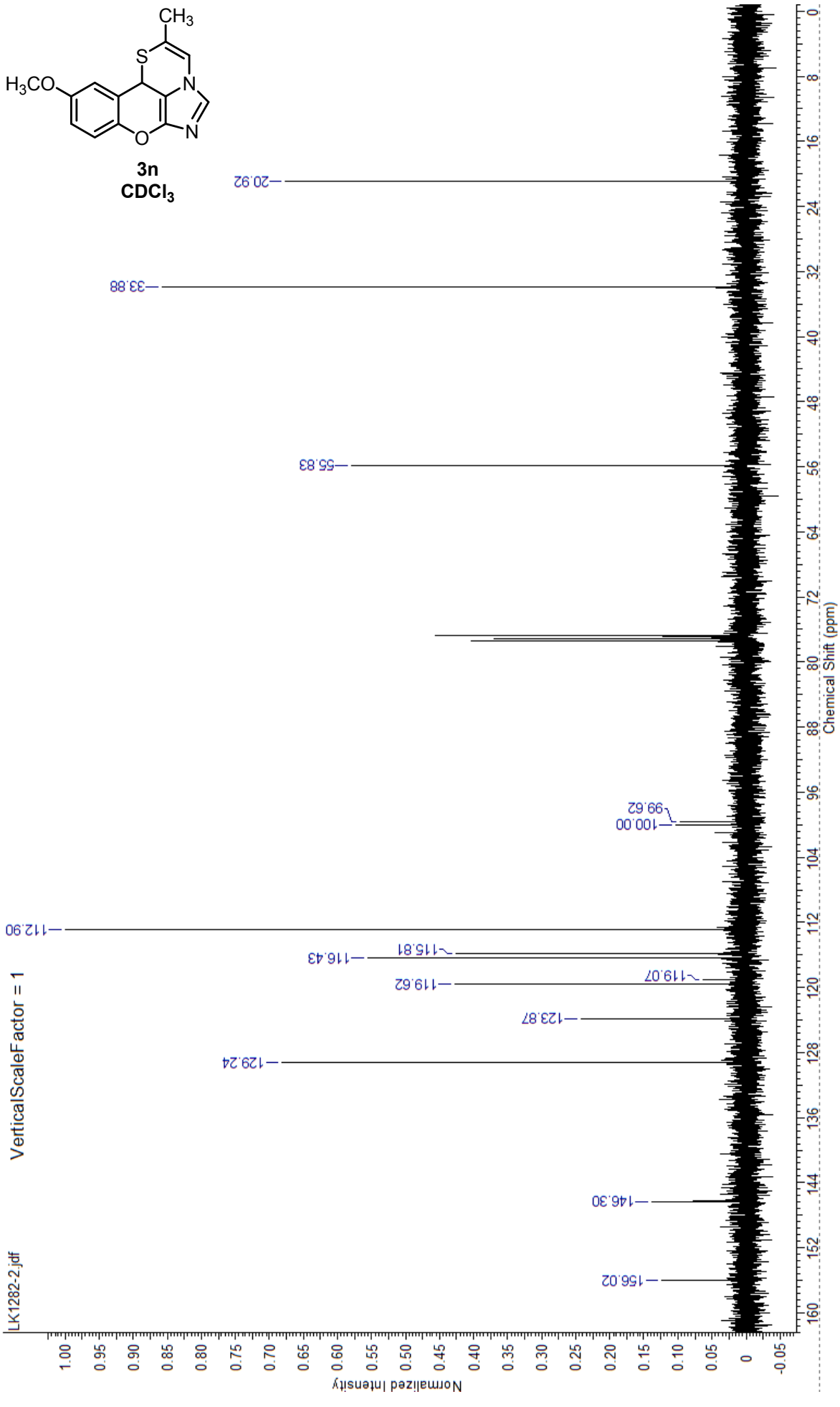

S
CH3
H3CO
N
O
N
3l
CDCl3+DMSO-d6
LK1262-1.jdf
VerticalScaleFactor = 1
Normalized Intensity
Chemical Shift (ppm)
2.90
3.33
0.77
0.87
2.18
0.93
1.01

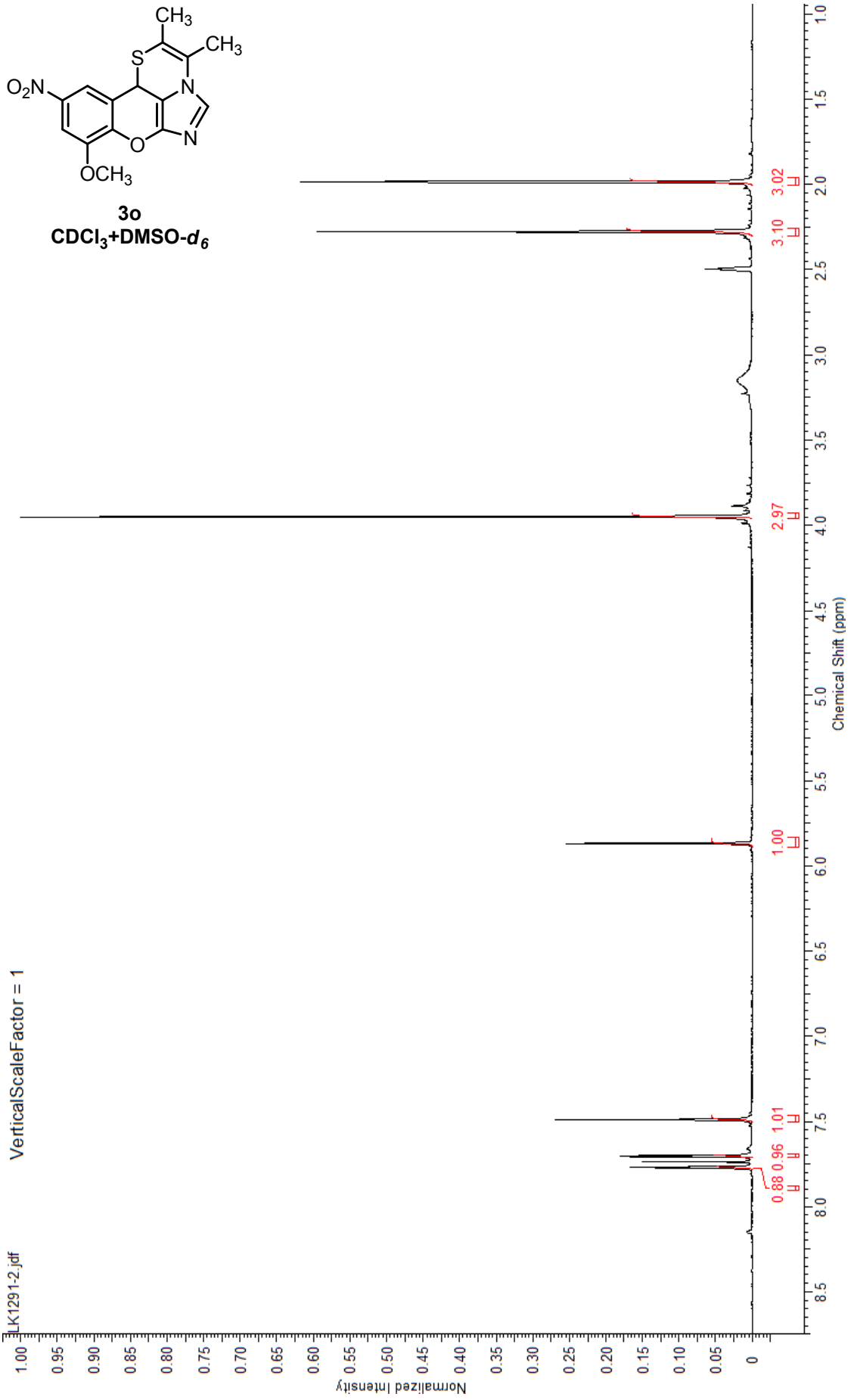

17.81
33.02
55.64
100.00
105.80
112.94
115.61
119.18
118.95
128.16
129.89
145.85
155.88
H3CO
CH3
S
N
N
O
3l
CDCl3+DMSO-d6
LK1262-2.jdf
VerticalScaleFactor = 1
Normalized Intensity
Chemical Shift (ppm)

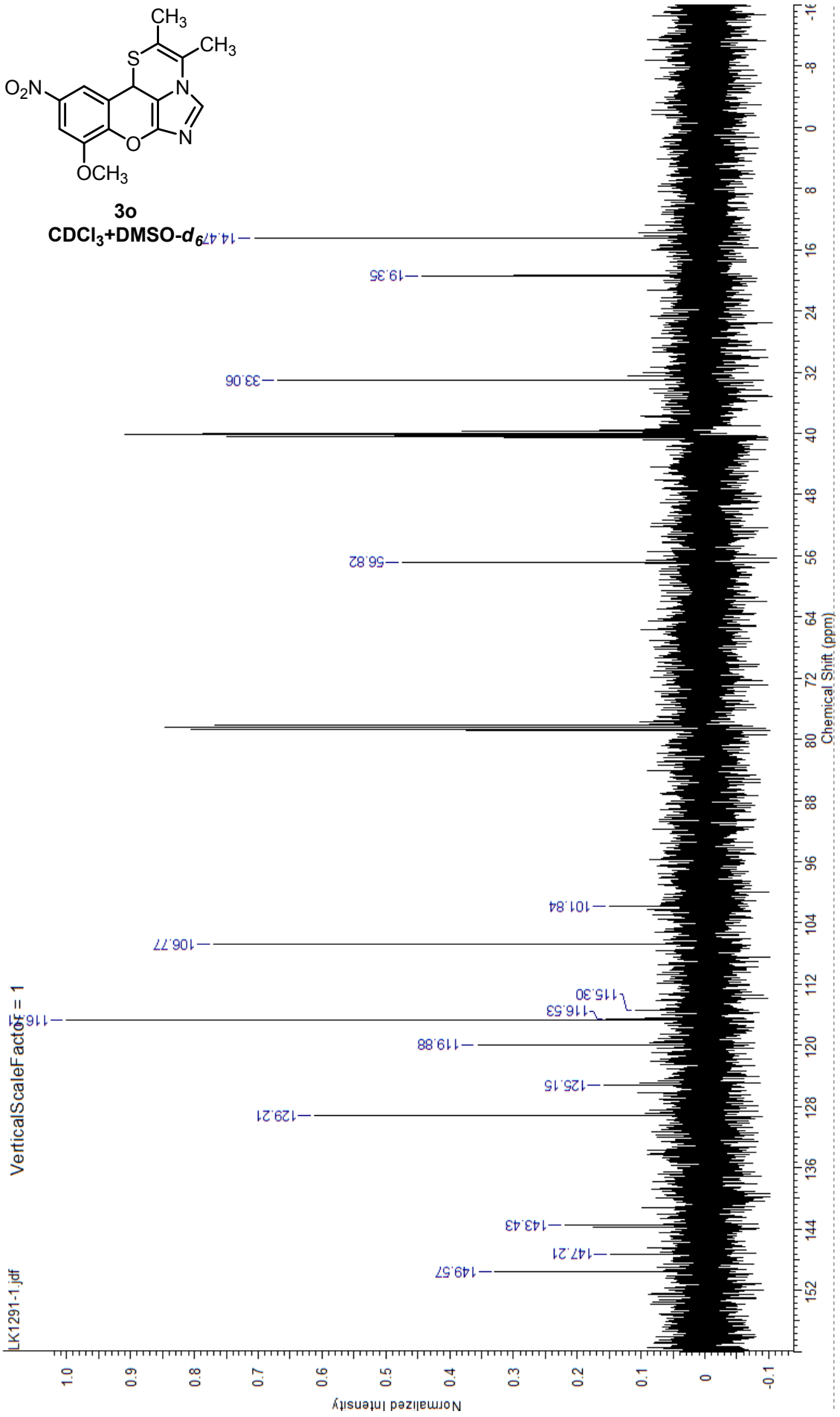

CH3
CH3
S
N
H3CO
N
O
3m
CDCl3
LK1261-1.jdf
VerticalScaleFactor = 1
Normalized Intensity
Chemical Shift (ppm)
3.39
3.29
3.14
0.90
1.07
1.18
1.01
0.99

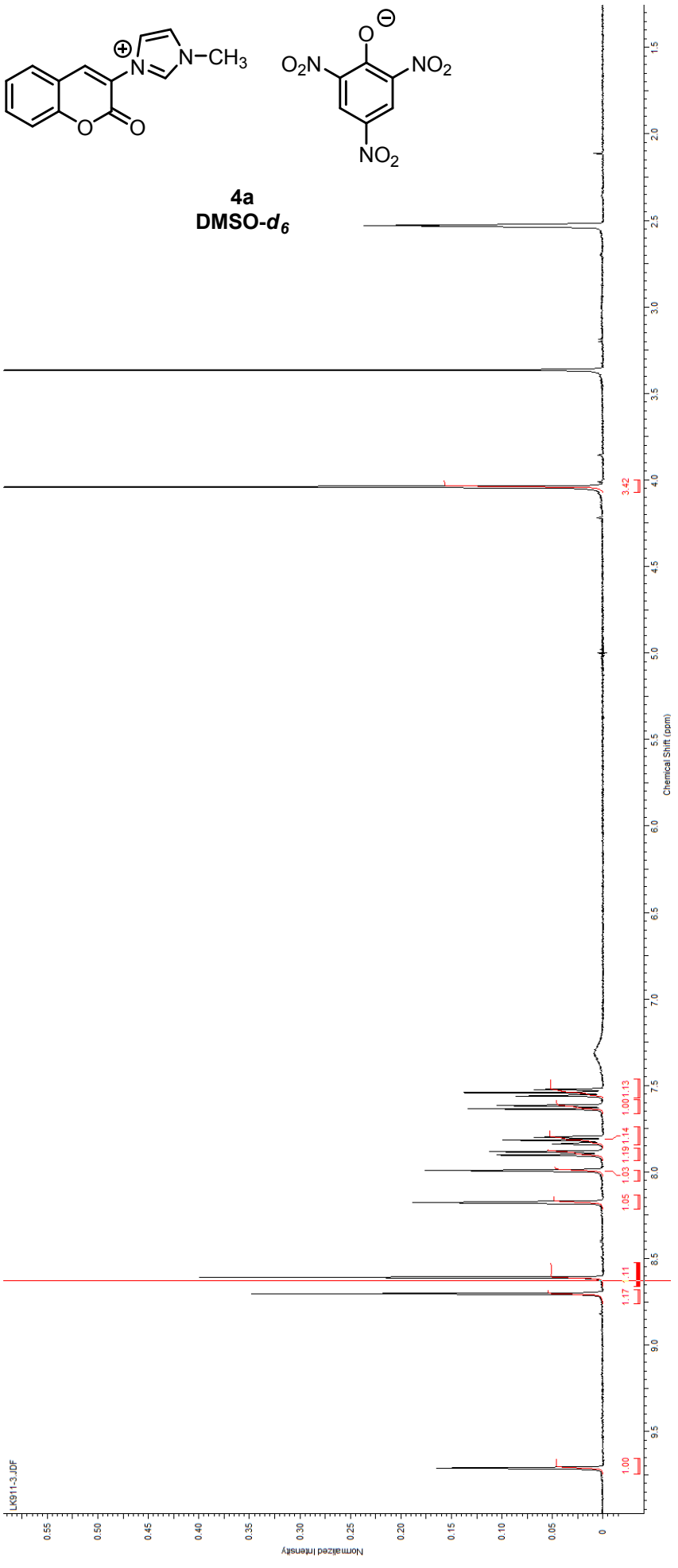

CH3
CH3
S
N
H3CO
N
O
3m
CDCl3
14.42
19.35
33.65
55.82
101.62
113.01
115.86
116.48
119.55
124.40
127.98
145.02
146.34
155.98
LK1261-2.jdf
VerticalScaleFactor 1
Normalized Intensity
Chemical Shift (ppm)

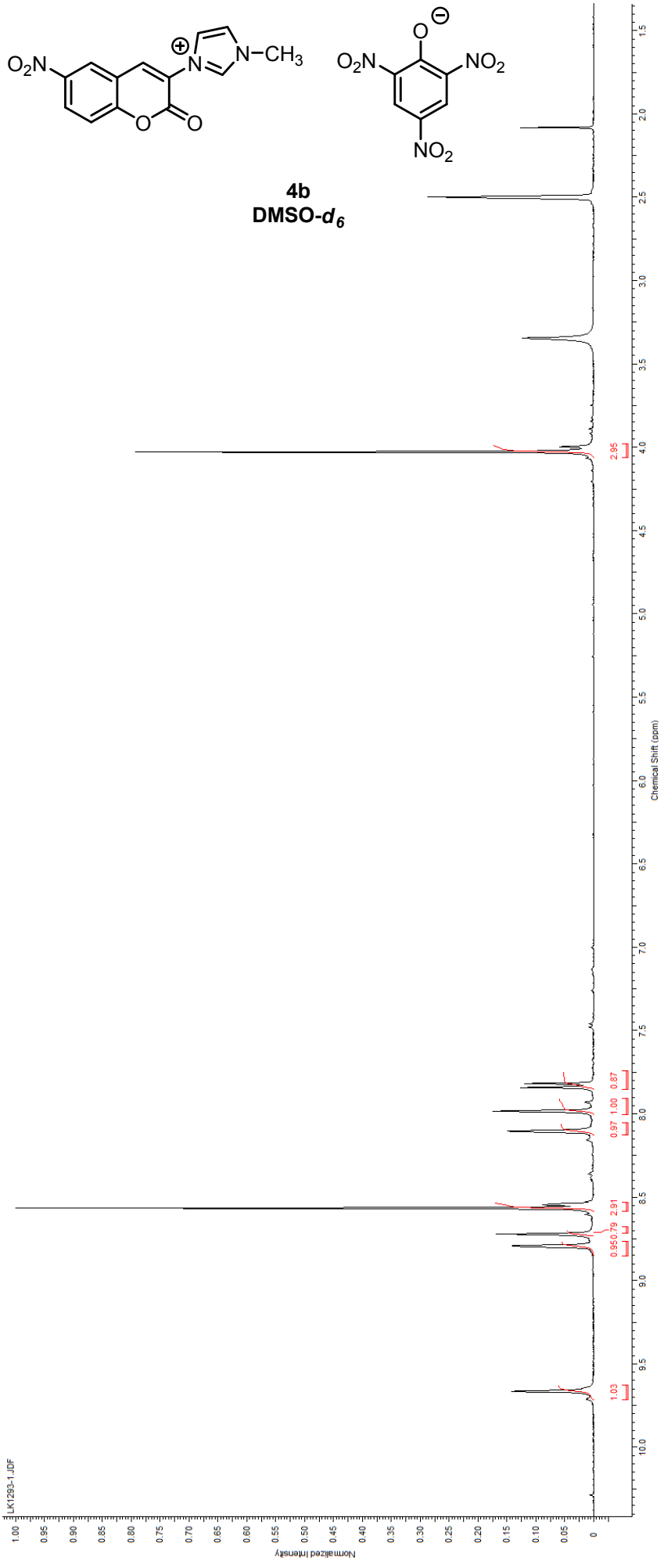

CH3
S
N
H3CO
N
O
3n
CDCl3
LK1282-1.jdf
VerticalScaleFactor = 1
Normalized Intensity
Chemical Shift (ppm)
3.19
3.25
1.00
0.99
1.04
1.03
1.16
0.96

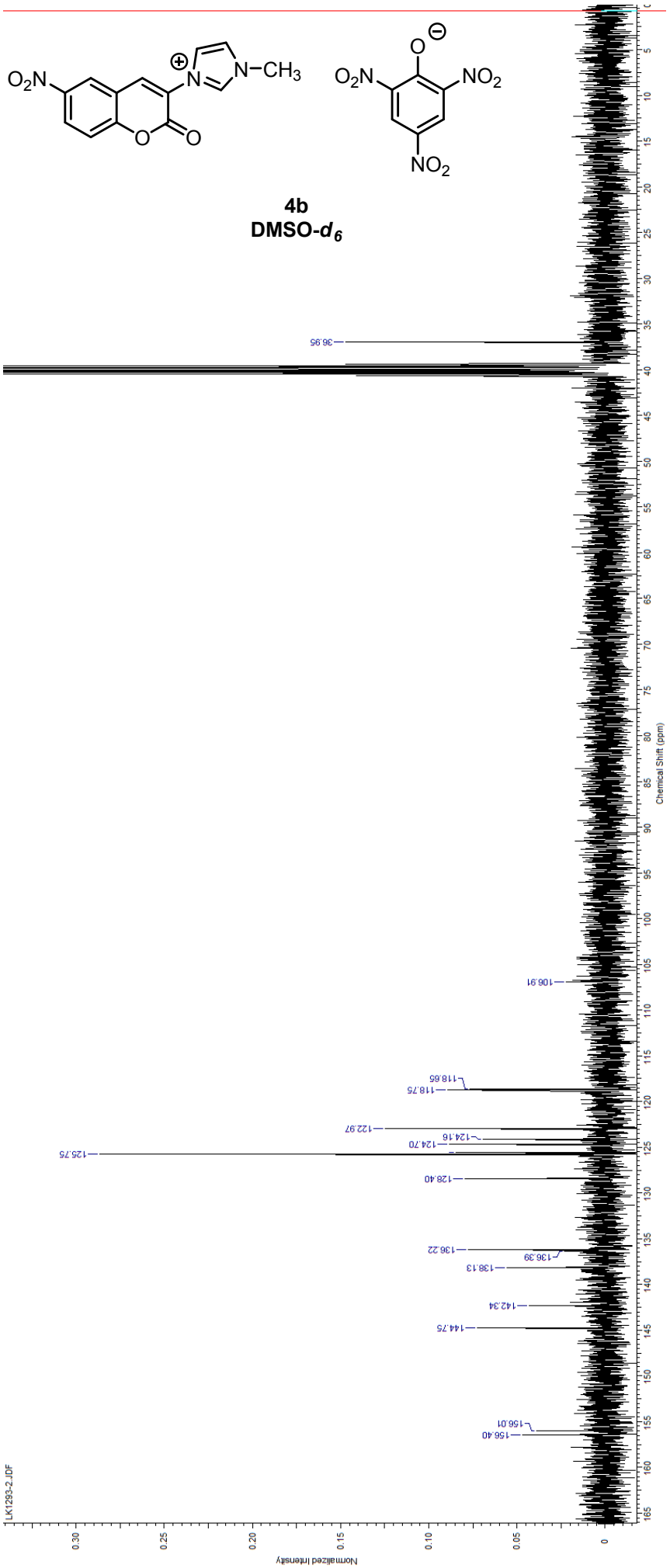

CH3
S
N
H3CO
O
N
3n
CDCl3
20.92
33.88
55.83
99.62
100.00
112.90
115.81
116.43
119.07
119.62
123.87
129.24
146.30
156.02
LK1282-2.jdf
VerticalScaleFactor = 1
Normalized Intensity
Chemical Shift (ppm)


CH3
CH3
S
N
O2N
N
O
OCH3
3o
CDCl3+DMSO-d6
LK1291-2.jdf
VerticalScaleFactor = 1
Normalized Intensity
Chemical Shift (ppm)
0.88
0.96
1.01
1.00
2.97
3.10
3.02


CH3
CH3
S
N
O2N
N
O
OCH3
3o
CDCl3+DMSO-d6
14.47
19.35
33.06
56.82
101.84
106.77
115.30
116.53
116.91
119.88
125.15
129.21
143.43
147.21
149.57
LK1291-1.jdf
VerticalScaleFactor = 1
Normalized Intensity
Chemical Shift (ppm)


4a
DMSO-d_6
Chemical Shift (ppm)
Normalized Intensity
LK911-3.JDF


O2N
N
N–CH3
O
O
O2N
NO2
NO2
O
4b
DMSO-d6
LK1293-1.JDF
Normalized Intensity
Chemical Shift (ppm)
2.95
0.87
1.00
0.97
2.91
0.79
0.95
1.03


O2N
N
N–CH3
O
O
O2N
O
NO2
NO2
4b
DMSO-d6
36.95
106.91
118.65
118.75
122.97
124.16
124.70
125.75
128.40
136.22
136.39
138.13
142.34
144.75
156.01
156.40
Chemical Shift (ppm)
Normalized Intensity
LK1293-2.JDF