Electronic Supplementary Information for

Aza-Henry and Aza-Knoevenagel Reactions of Nitriles for the Synthesis of Pyrido[1,2-*a*]indoles

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Contents

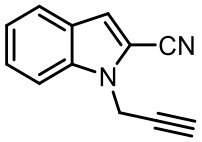
Experimental

Solvents were distilled and dried according to standard procedures. ^{1}H and ^{13}C NMR spectra were acquired on 400 or 600 MHz spectrometers and referenced to the residual signals of the solvent (for ^{1}H and ^{13}C). The solvents used for NMR were DMSO-d_6 and $CDCl_3$. Chemical shifts are reported in parts per million (δ/ppm). Coupling constants are reported in Hertz (*J*/Hz). The peak patterns are indicated as follows: s, singlet; d, doublet; t, triplet; q, quadruplet; m, multiplet; dd, doublet of doublets and br s, broad singlet. Infrared spectra were measured on a FT/IR instrument. The wavelengths are reported in reciprocal centimeters (λ_{max}/cm^{-1}). HRMS spectra were recorded on Bruker MicrOTOF-Q II. 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. The reaction progress was monitored by TLC and the spots were visualized under UV light (254 or 365 nm). Column chromatography was performed using silica gel (230-400 mesh), neutralized with ammonia, mixtures of hexane with ethyl acetate used as a mobile phase. Melting points were determined on a SMP-10 apparatus. The starting propargylated indoles **1a-j** were prepared through a literature procedure. [S1]

General procedure for preparation of propargylated indoles 1a-e:

The solution of corresponding 1*H*-indole-2-carbonitrile (1.00 g, 7.0 mmol) in 10 mL of anhydrous DMF was treated with K_2CO_3 (1.06 g, 7.7 mmol) and stirred at RT for 10 min. Propargyl bromide solution in toluene (0.64 mL, 7.7 mmol) was added dropwise, the reaction mixture was heated at 60ºC for 3 h. Reaction progress was monitored by TLC. After completion, the reaction mixture was treated with 50 mL of water and extracted with ethyl acetate (3x20 mL). Organic layer was washed with brine (20 mL) and dried over sodium sulfate, evaporated under high-vacuum to get crude product, which was purified by column chromatography on silica, eluting with 20% ethyl acetate in hexane solution

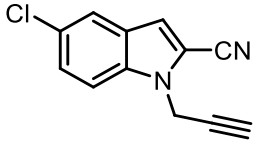
1-(Prop-2-yn-1-yl)-1*H*-indole-2-carbonitrile (1a)



White solid, yield 1.11 g (88%); m.p. 132°C;

^{1}H NMR ($CDCl_3$, 600MHz): 2.41 (1H, t, *J* = 2.5), 5.05 (2H, d, *J* = 2.5), 7.22 (1H, s), 7.24-7.28 (1H, m), 7.45-7.48 (1H, m), 7.52 (1H, d, *J* = 8.2), 7.69 (1H, d, *J* = 8.1);

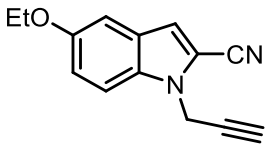
5-Chloro-1-(prop-2-yn-1-yl)-1*H*-indole-2-carbonitrile (1b)



White solid, yield 474 mg (78%), m.p. 125°C;

^{1}H NMR ($CDCl_3$, 600MHz): 2.43 (1H, t, *J* = 2.5), 5.02 (2H, d, *J* = 2.5), 7.14 (1H, s), 7.41 (1H, dd, *J* = 8.7, 2.0), 7.45 (1H, d, *J* = 8.7), 7.67 (1H, d, *J* = 2.0).

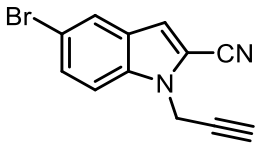
5-Ethoxy-1-(prop-2-yn-1-yl)-1*H*-indole-2-carbonitrile (1c)



Pale yellow solid, yield 469 mg (78%), m.p. 141°C;

^{1}H NMR (DMSO-d_6, 600MHz): 1.21 (3H, t, *J* = 7.6, $CH_2\underline{CH_3}$), 2.69 (2H, q, *J* = 7.6, $\underline{CH_2}CH_3$), 3.46 (1H, d, *J* = 2.5), 5.21 (2H, d, *J* = 2.5, CH_2), 7.33 (1H, dd, *J* = 8.6, 1.8), 7.43 (1H, s), 7.50-7.51 (1H, m), 7.63 (1H, d, *J* = 8.6).

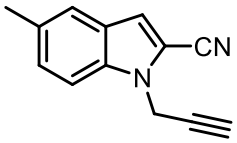
5-Bromo-1-(prop-2-yn-1-yl)-1*H*-indole-2-carbonitrile (1d)



White solid, yield 398 mg (68%), m.p. 119°C;

^{1}H NMR ($CDCl_3$, 600 MHz): 2.43 (1H, t, *J* = 2.5), 5.02 (2H, d, *J* = 2.5), 7.14 (1H, s), 7.40 (1H, dd, *J* = 9.0, 1.7), 7.45 (1H, d, *J* = 9.0), 7.66 (1H, d, *J* = 2.0).

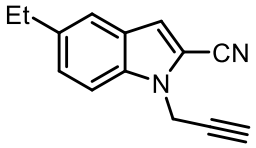
5-Methyl-1-(prop-2-yn-1-yl)-1*H*-indole-2-carbonitrile (1e)



White solid, yield 453 mg (73%), m.p. 145°C;

^{1}H NMR (DMSO-d_6, 600 MHz): 2.39 (3H, s), 3.46 (1H, t, *J* = 2.5), 5.21 (2H, d, *J* = 2.5), 7.27-7.29 (1H, m), 7.41 (1H, s), 7.48 (1H, s), 7.60 (1H, d, *J* = 8.5).

5-Ethyl-1-(prop-2-yn-1-yl)-1*H*-indole-2-carbonitrile (1f)



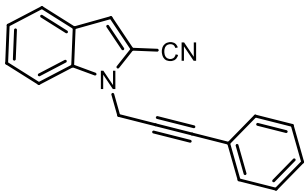
White solid, yield 485 mg (79%), m.p. 152°C;

^{1}H NMR (DMSO-d_6, 600 MHz): 1.21 (3H, t, J=7.0), 7.68-7.72 (2H, m), 3.45 (1H s), 5.21 (2H, d, J=2.5), 7.32 (1H, d, J=8.5), 7.45 (1H, s), 7.50 (1H, s), 7.62 (1H, d, J= 8.5).

General Procedure for preparation of 1-(3-phenylprop-2-ynyl)-1*H*-indole-2-carbonitriles 1g-j:

The solution of propargylated indole **1** (2.76 mmol) and iodobenzene (0.62 ml, 3.0 mmol) in 5.0 ml of triethylamine in a Schlenk flask was purged with nitrogen for 10 min, and then $PdCl_2(PPh_3)_2$ (39 mg, 0.055 mmol) and CuI (26 mg, 0.136 mmol) were added. The reaction mixture was heated for 1 h at 80°C under nitrogen. Reaction was monitored by TLC. Reaction mixture was diluted with water, extracted with ethyl acetate (3x20mL), organic layer was dried over sodium sulfate and evaporated to obtain crude compound. Crude compound was purified over silica gel with help of column chromatography and eluted in 20% ethyl acetate in hexane.

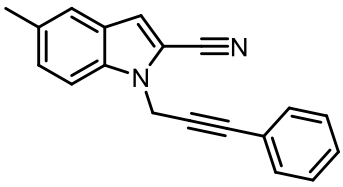
1-(3-Phenylprop-2-ynyl)-1*H*-indole-2-carbonitrile (1g)



White solid, yield 565 mg (80%);

^{1}H NMR (DMSO-d_6, 600MHz): 5.51 (2H, s), 7.24 (1H, t, *J*=7.5), 7.34 -7. 41(5H, m) 7.47 (2H, d, *J*=7.5), 7.54 (1H, s) 7.73 (1H, d, *J*= 8.0), 7.80 (1H, d, *J*= 8.5).

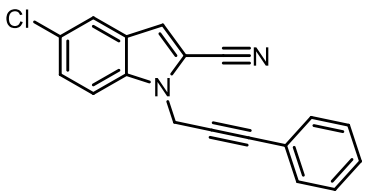
5-methyl-1-(3-phenylprop-2-ynyl)-1*H*-indole-2-carbonitrile (1h)



White solid, yield 570 mg (82%);

^{1}H NMR (DMSO-d_6, 600MHz): 2.40 (3H, s), 5.47 (2H, s), 7.30 (1H, d, J=8.58), 7.34-4.40 (5H, m) 7.43 (1H, s), 7.49 (1H, s), 7.68 (1H, d, *J*=8.58).

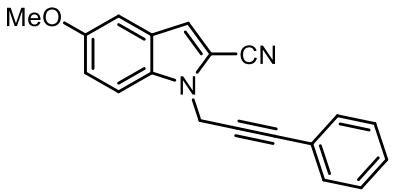
5-chloro-1-(3-phenylprop-2-ynyl)-1*H*-indole-2-carbonitrile (1i)



White Solid, yield 525 mg (78%);

^{1}H NMR (DMSO-d_6, 600MHz): 5.54 (2H, s), 7.34-7.38 (3H, m), 7.39-7.41 (2H, m), 7.49 (1H, dd, *J* = 9.0. 1.8), 7.52 (1H, s), 7.82 (1H, d, *J* = 1.7), 7.86 (1H, d, *J* = 9.1).

5-chloro-1-(3-phenylprop-2-ynyl)-1*H*-indole-2-carbonitrile (1j)



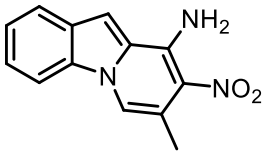
White Solid, yield 510 mg (75%);

^{1}H NMR (DMSO-d_6, 600MHz): 3.79 (3H, s), 5.47 (2H, s), 7.12 (1H, dd, *J* = 9.0, 2.5), 7.18 (1H, d, *J* = 2.0), 7.35-7.42 (6H, m), 7.71 (1H, d, *J* = 9.0).

General procedure for the preparation of 7-methyl-8-nitropyrido[1,2-*a*]indol-9-amines 2a-k and indolizine 3:

The solution of a propargylated indole **1** (0.55 mmol) and DBU (4.2 mg, 0.0277 mmol) in 2.0 ml nitromethane was heated at reflux for 1 h. The reaction progress was monitored by TLC. After completion, the reaction mass was evaporated to get crude compound. Purification of the crude compound was performed by column chromatography, eluting with 50% ethyl acetate in hexane.

7-Methyl-8-nitropyrido[1,2-*a*]indol-9-amine (2a)



Brown solid, yield 122 mg (92%), m.p. 129°C;

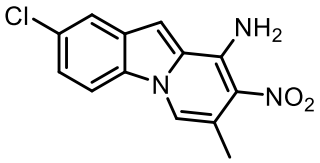
^{1}H NMR (DMSO-d_6, 600MHz): 2.44 (3H, s), 7.29-7.31 (1H, m), 7.36-7.38 (1H, m), 7.65 (1H, s), 7.80 (1H, d, *J* = 8.0), 7.97 (1H, s), 8.09 (1H, d, *J* = 8.0), 8.62 (2H, s).

^{13}C NMR (DMSO-d_6, 150 MHz): δ_C ppm = 19,1, 99.1, 111.5, 111.7, 113.5, 121.2, 121.4, 121.7, 122.6, 123.0, 127.4, 131.3, 141.9.

HRMS (TOF ES$^+$): m/z calcd for $C_{13}H_{10}N_3O_2$ [(M-H)$^-$], 240.0778; found, 240.0781.

IR (KBr): 3275, 3120, 1518, 1453, 1444, 1400, 1368, 1332, 1273, 1216, 1156, 1137, 1064.

2-Chloro-7-methyl-8-nitropyrido[1,2-*a*]indol-9-amine (2b)



Brown solid, yield 144 mg (95%), m.p. 146°C;

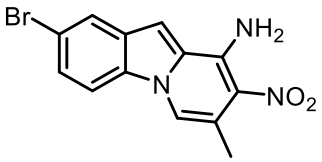
^{1}H NMR (DMSO-d_6, 600 MHz): 2.41 (3H, s, CH_3), 7.32 (1H, d, J = 8.1), 7.58 (1H, s), 7.86 (1H, s), 7.92 (1H, s), 8.08 (1H, d, J = 8.0), 8.56 (2H, s).

^{13}C NMR (DMSO-d_6, 150 MHz): δ_C ppm = 19.0, 98.4, 112.4, 113.2, 113.4, 120.3, 121.5, 112.8, 127.2, 128.1, 128.6, 129.6, 141.3.

HRMS (TOF ES$^+$): m/z calcd for $C_{13}H_9ClN_3O_2$ [(M-H)$^-$] 274.0389; found, 274.0391.

IR (KBr): 3428, 3312, 3115, 1592, 1529, 1454, 1408.

2-Bromo-7-methyl-8-nitropyrido[1,2-*a*]indol-9-amine (2c)



Brown solid, yield 153 mg (87%), m.p. 170°C;

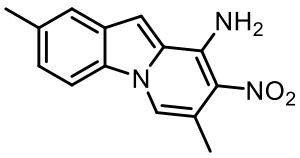
^{1}H NMR (DMSO-d_6, 600MHz): 2.42 (3H, s, CH_3), 7.46 (1H, dd, J = 8.5, 1.1), 7.61 (1H, s), 7.97 (1H, s), 8.05 (1H, d, J = 1.2), 8.08 (1H, d, J = 8.5), 8.57 (2H, s).

^{13}C NMR (DMSO-d_6, 150 MHz): δ_C ppm = 19.0, 98.3, 112.5, 113.4, 113.6, 115.4, 121.6, 123.5, 125.3, 128.5, 128.8, 129.8, 141.3.

HRMS (TOF ES$^+$): m/z calcd for $C_{13}H_9BrN_3O_2$ [(M-H)$^-$] 317.9884; found, 317.9887.

IR (KBr): 3451, 3362, 3347, 3026, 2974, 1678, 1590, 1492, 1454, 1426.

2,7-Dimethyl-8-nitropyrido[1,2-*a*]indol-9-amine (2d)



Brown solid, yield 121 mg (86%), m.p. 166°C;

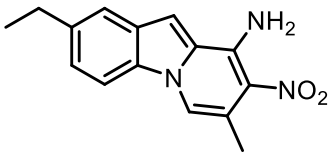
^{1}H NMR (DMSO-*d*$_6$, 600MHz):): 2.43 (3H, s), 2.45 (3H, s), 7.19 (1H, d, *J* = 8.2), 7.55 (1H, s), 7.57 (1H, s), 7.91 (1H, s), 7.96 (1H, d, *J* = 8.3), 8.57 (2H, s).

^{13}C NMR (DMSO-*d*$_6$, 150 MHz): δ_C ppm = 19.1, 21.2, 98.6, 111.2, 111.5, 113.6, 120.5, 121.2, 125.0, 127.3, 127.7, 129.9, 131 7, 141.9.

HRMS (TOF ES$^+$): m/z calcd for $C_{14}H_{12}N_3O_2$ [(M-H)$^-$] 254.0935; found, 254.0936.

IR (KBr): 3489, 3336, 2982, 2935, 2906, 1659, 1631, 1583, 1469, 1428, 1281, 1259.

2-Ethyl-7-methyl-8-nitropyrido[1,2-*a*]indol-9-amine (2e)



White solid, yield 123 mg (83%), m.p. 151°C;

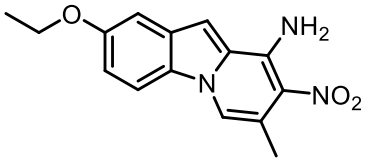
^{1}H NMR (DMSO-*d*$_6$, 600MHz): 1.26 (3H, t, *J* = 7.5), 2.43 (3H, s), 2.75 (2H, q, *J* = 7.5), 7.24 (1H, d, *J* = 7.5), 7.56-7.58 (2H, m), 7.92 (1H, s), 7.99 (1H, d, *J* = 8.5), 8.57 (2H, s).

^{13}C NMR (DMSO-*d*$_6$, 150 MHz): δ_C ppm = 16.0, 19.1, 28.3, 98.8, 111.3, 111.5, 129.2, 129.6, 121.2, 124.0, 127.3, 127.7, 130.1, 138.3, 141.9.

HRMS (TOF ES$^+$): m/z calcd for $C_{15}H_{14}N_3O_2$ [(M-H)$^-$] 268.1092; found, 268.1095.

IR (KBr): 3489, 3336, 2982, 2935, 2906, 1659, 1631, 1583, 1469, 1428.

2-Ethoxy-7-methyl-8-nitropyrido [1,2-*a*]indol-9-amine (2f)



Brown solid, yield 130 mg (83%), m.p. 165°C;

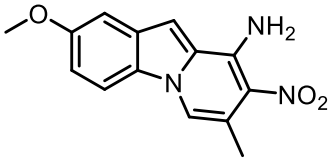
^{1}H NMR (DMSO-*d*$_6$, 600MHz):): 1.25 (3H, t, *J* = 7.5), 2.43 (3H, s), 2.73 (2H, q, *J* = 7.5), 7.22 (1H, d, *J* = 8.5), 7.56-7.58 (2H, m), 7.89 (1H, s), 7.96 (1H, d, *J* = 8.5), 8.57 (2H, s).

^{13}C NMR (DMSO-*d*$_6$, 150 MHz): δ_C ppm – 16.0, 19.1, 28.3, 98.7, 111.2, 111.5, 113.6, 119.2, 121.2, 124.0, 127.3, 127.7, 130.1, 138.2, 141.9.

HRMS (TOF ES$^+$): m/z calcd for $C_{15}H_{14}N_3O_3$ [(M-H)$^-$] 284.1041; found, 284.1044

IR (KBr) - 3451, 1520, 1455, 1444, 1400, 1368, 1332, 1273, 1216, 1064.

2-Methoxy-7-methyl-8-nitropyrido[1,2-*a*]indol-9-amine (2g)



Brown solid, yield 134 mg (90%), m.p. 170°C

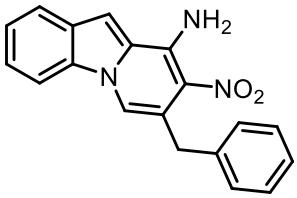
^{1}H NMR (DMSO-d$_6$, 600MHz): 2.43 (3H, s), 3.83 (3H, s), 6.99 (1H, d, *J* = 8.5), 7.23 (1H, s), 7.55 (1H, s), 7.91 (1H, s), 7.98 (1H, d, *J* = 8.5), 8.54 (2H, s).

^{13}C NMR (DMSO-*d*$_6$, 150 MHz): δ_C ppm = 19.1, 55.3, 98.6, 101.0, 111.5, 112.5, 113.1, 114.7, 121.2, 126.8, 127.5, 128.1, 141.5, 155.76.

HRMS (TOF ES$^+$): m/z calcd for $C_{14}H_{13}N_3O_3$ [(M+H)$^+$] 270.0884; found, 270.0887.

IR (KBr): 3450, 3336, 1659, 1631, 1583, 1468, 1428, 1281, 1260, 1147, 1112, 1060.

7-Benzyl-8-nitropyrido[1,2-*a*]indol-9-amine (2h)



Brown solid, yield 133 mg (76%), m.p. 173°C

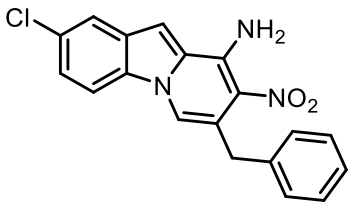
^{1}H NMR (DMSO-*d*$_6$, 600MHz): 4.25 (2H, s), 7.13-7.16 (3H, m), 7.23 (2H, t, *J* = 7.0), 7.41 (1H, dd *J* = 8.5, 1.5), 7.66 (2H, s), 7.93 (1H, d, *J* = 1.5), 8.16 (1H, d, *J* = 8.5), 8.22 (1H, s). 8.53 (2H, s).

^{13}C NMR (DMSO-*d*$_6$, 150 MHz): δ_C ppm = 37.4, 98.9, 78.1, 113.4, 115.0, 120.5, 120.7, 123.1, 125.9, 126.8, 127.4, 128.0, 128.1, 128.2, 128.4, 128.9, 130.0, 140.3, 141.7.

HRMS (TOF ES$^+$): m/z calcd for $C_{19}H_{14}N_3O_2$ [(M-H)$^-$] 316.1092; found, 316.1093.

IR (KBr): 3433, 3310, 3061, 1599, 1552, 1531.

7-Benzyl-2-chloro-8-nitropyrido [1,2-*a*]indol-9-amine (2i)



Brown solid, yield 159 mg (82%), m.p. 222°C

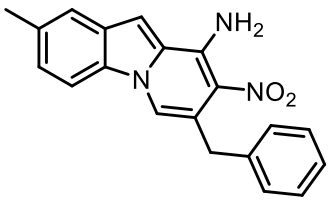
^{1}H NMR (DMSO-*d*$_6$, 600MHz): 4.25 (2H, s, CH_2), 7.12-7.16 (3H, m), 7.23 (2H, t, *J* = 7.0), 7.40 (2H, dd, *J* = 8.5, 2.0), 7.66 (1H, s), 7.93 (1H, d, *J* = 2.0), 8.16 (1H, d *J* = 8.5), 8.21 (2H, s).

^{13}C NMR (DMSO-*d*$_6$, 150 MHz): δ_C ppm = 37.4, 59.7, 99.0, 113.4, 115.1, 120.5, 120.5, 120.5, 120.7, 123.1, 125.9, 127.4, 128.0, 128.4, 128.9, 130.0, 140.3, 141.7, 170.3.

HRMS (TOF ES$^+$): m/z calcd for $C_{19}H_{13}ClN_3O_2$ [(M-H)$^-$] 350.0703 found, 350.0701

IR (KBr): 3478, 3346, 3291, 3108, 1729, 1601, 1551, 1535, 1452, 1416, 1369, 1264.

7-Benzyl-2-methyl-8-nitropyrido [1,2-*a*]indol-9-amine (2j)



Yellow solid, yield 155 mg (85%), m.p. 170°C.

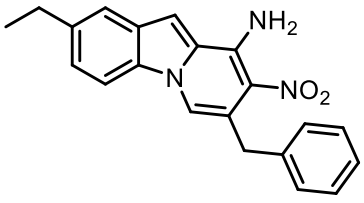
^{1}H NMR (DMSO-*d*$_6$, 600MHz): 2.46 (3H, s), 4.25 (2H, s), 7.13-7.16 (3H, m), 7.21-7.23 (3H, m), 7.6 (2H, s), 7.99 (1H, d, *J* =8.5), 8.14 (1H, s), 8.52 (2H, s).

^{13}C NMR (DMSO-*d*$_6$, 150 MHz): 21.4, 37.0, 99.1, 111.2, 114.2, 115.2, 120.3, 120.6, 125.2, 125.9, 127.4, 127.8, 127.8, 127.9, 128.1, 128.2, 130.2, 131.9, 140.6, 142.2.

HRMS (TOF ES$^+$): m/z calcd for $C_{20}H_{16}N_3O_2$ [(M-H)$^-$] 330.1248; found, 330.1249.

IR (KBr): 3429, 3314, 3117, 2973, 2930, 1720, 1592, 1529, 1454, 1408, 1382, 1332, 1262, 1240.

7-Benzyl-2-ethyl-8-nitropyrido[1,2-a]indol-9-amine (2k)



Brown solid, yield 123 mg (65%), m.p. 173°C

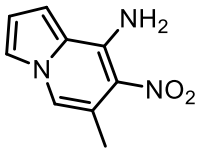
^{1}H NMR (DMSO-d_6, 600MHz): 1.26 (3H, t, J = 7.0), 2.74-2.77 (2H, q, J = 7.0), 4.26 (2H, s), 7.13-7.15 (3H, m), 7.22 (2H, d, J = 7.6), 7.27 (1H, d, J = 8.2), 7.62 (2H, s), 8.01 (1H, d, J = 8.6), 8.14 (1H, s), 8.54 (2H, s).

^{13}C NMR (DMSO-d_6, 150 MHz): δ_C ppm = 16.1, 28.4, 37.5, 99.4, 111.4, 114.2, 115.2, 119.2, 119.4, 120.3, 124.3, 124.2, 125.9, 127.5, 127.8, 127.9, 128.1, 130.4,138.4, 140.6, 142.2.

HRMS (TOF ES$^+$): m/z calcd for $C_{21}H_{18}N_3O_2$ [(M-H)$^-$] 344.1404; found, 344.1407.

IR (KBr): 3429, 3315, 3117, 2982, 2935, 2906, 1659, 1631, 1583, 1469, 1428, 1382, 1332, 1262, 1240.

6-Methyl-7-nitroindolizin-8-amine (3)



Brown solid, yield 86 mg (82%), m.p. 114°C

^{1}H NMR (DMSO-d_6, 600MHz): 2.35 (3H, s), 6.64-6.65 (1H, m), 7.31-7.33 (1H, m), 7.38-7.40 (1H, m), 7.49 (1H, s), 8.42 (2H, s).

^{13}C NMR (DMSO-d_6, 150 MHz): δ_C ppm = 19.4, 107.7, 113.2, 115.1, 118.9, 119.9, 119.4, 122.4, 141.9.

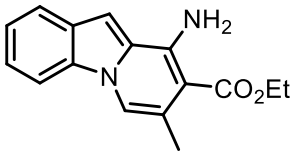
HRMS (TOF ES$^+$): m/z calcd for $C_9H_8N_3O_2$ [(M-H)$^-$] 190.0622 found, 190.0616

IR (KBr): 3480, 3115, 1580, 1516, 1332.

General procedure for the preparation of ethyl 9-amino-7-methylpyrido[1,2-*a*]indole-8-carboxylates 4a-k.

The solution of a propargylated indole **1** (0.55 mmol), DBU (17 mg, 0.111 mmol), and diethyl malonate (888 mg, 5.5 mmol) in 2 ml of DMF was heated at 140°C for 5 h. The reaction progress was monitored by TLC. After completion, the reaction mass was diluted with water (30 mL) and extracted with ethyl acetate (3x20 mL). Organic layer was dried over sodium sulfate and evaporated under reduced pressure. The product was purified by column chromatography on silica, eluting with 40 % EtOAc/hexane.

Ethyl 9-amino-7-methylpyrido [1,2-*a*]indole-8-carboxylate (4a)



Yellow solid, yield 127 mg (86%), m.p. 128°C;

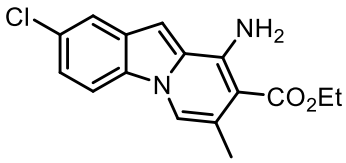
^{1}H NMR (DMSO-*d*$_6$, 600MHz): 1.33 (3H, t, *J* = 7.0), 2.39 (3H, s), 4.28 (2H, q, *J* = 7.0), 7.24 (1H, s), 7.26-7.28 (2H, m), 7.58 (2H, s), 7.75-7.77 (1H, m), 7.90 (1H, s), 8.06-8.08 (2H, m).

^{13}C NMR (DMSO-*d*$_6$, 150 MHz): δ_C ppm = 14.20, 20.6, 59.7, 93.8, 96.5, 111.3, 112.1, 116.1, 120.9, 121.1, 122.1, 127.3, 128.4, 130.3, 144.8, 168.2.

HRMS (TOF ES$^+$): m/z calcd for $C_{16}H_{17}N_2O_2$ [(M+H)$^+$] 269.1284; found, 269.1287.

IR (KBr), - 3330, 3295, 3120, 3051, 2930, 1697,146, 1194, 1143, 1049, 1026, 1004.

Ethyl 9-amino-2-chloro-7-methylpyrido[1,2-*a*]indole-8-carboxylate (4b)



Yellow solid, yield 153 mg (92%), m.p. 129°C;

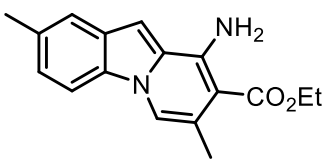
^{1}H NMR (DMSO-*d*$_6$, 600MHz): 1.33 (3H, t, *J* = 7.0), 2.38 (3H, s), 4.28 (2H, q, *J* = 7.0), 7.23 (1H, s), 7.24-7.25-7.27 (1H, m), 7.58 (2H, s), 7.84 (1H, d, *J* = 2.0), 7.94 (1H, s), 8.11-8.13 (1H, m).

^{13}C NMR (DMSO-*d*$_6$, 150 MHz): δ_C ppm = 14.1, 20.5, 59.8, 93.4, 97.1, 112.1, 113.1, 116.9, 119.8, 121.0, 126.8, 128.1, 128.8, 129.7, 144.4, 168.1.

HRMS (TOF ES$^+$): m/z calcd for $C_{16}H_{16}ClN_2O_2$ [(M+H)$^+$] 303.0895 found, 303.0892.

IR (KBr): 3325, 3291, 3115, 3048, 1520, 1449, 1346, 1246, 1190, 1143, 1122.

Ethyl 9-amino-2,7-dimethylpyrido[1,2-*a*]indole-8-carboxylate (4c)



Yellow solid, yield 107 mg (69%), m.p. 135°C;

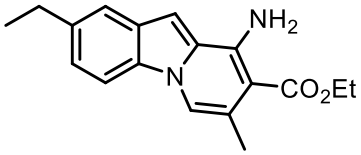
^{1}H NMR (DMSO-*d*$_6$, 600MHz): 1.33 (3H, t, *J* = 7.0), 2.37 (3H, s), 2.44 (3H, s), 4.28 (2H, q, *J* = 7.0), 7.09 (1H, s), 7.14 (1H, s), 7.53 (2H, d, *J* = 7.5), 7.85 (1H, s), 7.94 (1H, d, *J* = 7.5).

^{13}C NMR (DMSO-d_6, 150 MHz): δ_C ppm = 14.2, 20.6, 21.3, 59.6, 93.2, 96.4, 111.0, 112.1, 115.8, 120.0, 123.0, 127.6, 128.5, 128.9, 131.0, 144.8, 168.3.

HRMS (TOF ES$^+$): m/z calcd for $C_{17}H_{19}N_2O_2$ [(M+H)$^+$] 283.1441; found, 283.1442.

IR (KBr): 3329, 3295, 3277, 2931, 1697, 1616, 1521, 1452, 1402, 1346, 1246, 1194.

Ethyl 9-amino-2-ethyl-7-methylpyrido[1,2-a]indole-8-carboxylate (4d).



Yellow solid, yield 134 mg (82%), m.p. 129°C;

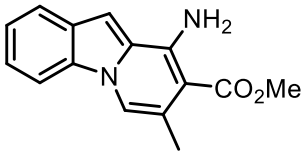
^{1}H NMR (DMSO-d_6, 600MHz): 1.26 (3H, t, *J* = 7.5), 1.33 (3H, t, *J* = 7.5), 2.38 (3H, s), 2.74 (2H, q, J = 7.5), 4.28 (2H, q, *J* = 7.5), 7.13-7.15 (2H, m), 7.52-7.55 (3H, m), 7.85 (1H, s), 7.96 (1H, d, *J* = 8.5).

^{13}C NMR (DMSO-d_6, 150 MHz): δ_C ppm = 14.2, 16.1, 20.6, 28.4, 59.6, 93.4, 96.4, 111.1, 112.1, 115.8, 118.8, 122.0, 127.6, 128.4, 129.12, 137.6, 144.8, 168.3,

HRMS (TOF ES$^+$): m/z calcd for $C_{18}H_{21}N_2O_2$ [(M+H)$^+$] 297.1597; found, 297.1599.

IR (KBr): 3329, 3295, 3277, 3120, 3053, 2931, 1697, 1616, 1521, 1452, 1402, 1346, 1246, 1194.

Methyl 9-amino-7-methylpyrido[1,2-*a*]indole-8-carboxylate (4e)



Yellow solid, yield 99 mg (71%), m.p. 124°C;

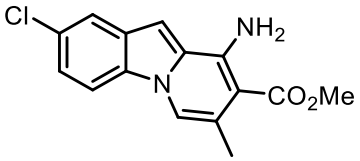
^{1}H NMR (DMSO-d_6, 600MHz): 2.37 (3H, s), 3.80 (3H, s), 7.26-7.28 (3H, m), 7.57 (1H, s) 7.75-7.77 (1H, m), 7.90 (1H, s), 8.06-8.08 (2H, m).

^{13}C NMR (DMSO-d_6, 150 MHz): δ_C ppm = 20.5, 59.8, 93.4, 97.1, 112.1, 113.1, 116.9, 119.8, 121.0, 126.8, 128.1, 128.8, 129.7, 144.4, 168.1.

HRMS (TOF ES$^+$): m/z calcd for $C_{15}H_{15}N_2O_2$ [(M+H)$^+$] 255.1128; found, 255.1131.

IR (KBr): 3330, 3295, 3120, 3051, 2930, 1697,146, 1194, 1049.

Methyl 9-amino-2-chloro-7-methylpyrido[1,2-a]indole-8-carboxylate (4f)



Yellow solid, yield 138 mg (87%), m. p. 132°C;

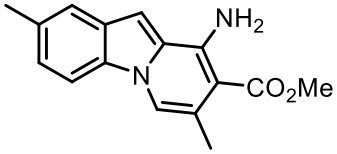
^{1}H NMR (DMSO-*d*$_6$, 600MHz): 2.35 (3H, s), 3.80 (3H, s) 7.24-7.26 (2H, m), 7.57 (2H, s), 7.84 (1H, d, *J* = 1.5) 7.94 (1H, s), 8.09-8.11 (1H, m).

^{13}C NMR (DMSO-*d*$_6$, 150 MHz): δ_{C} ppm = 20.4, 51.0, 93.5, 97.1, 112.1, 113.1, 116.8, 119.8, 121.0, 126.8, 128.2, 128.8, 129.7, 144.3, 166.5.

HRMS (TOF ES$^+$): m/z calcd for $C_{15}H_{14}ClN_2O_2$ [(M+H)$^+$] 289.0738; found, 289.0741.

IR (KBr): 3325, 3291, 3115, 3048, 1520, 1449, 1346, 1246, 1190, 1143.

Methyl 9-amino-2,7-dimethylpyrido[1,2-*a*]indole-8-carboxylate (4g)



Yellow solid, yield 122 mg (83%), m.p. 124°C;

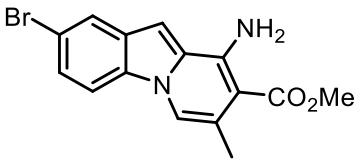
^{1}H NMR (DMSO-*d*$_6$, 600MHz): 2.35 (3H, s), 2.44 (3H, s), 3.79 (3H, s), 7.09 (1H, d, *J* = 8.5), 7.15 (1H, s) 7.52-7.54 (3H, m), 7.85 (1H, s), 7.94 (1H, d, *J* = 8.1).

^{13}C NMR (DMSO-*d*$_6$, 150 MHz): δ_C ppm = 20.5, 21.4, 59.8, 93.4, 97.1, 112.1, 113.1, 116.9, 119.8, 121.0, 126.8, 128.1, 128.8, 129.7, 144.4, 168.1.

HRMS (TOF ES$^+$): m/z calcd for $C_{16}H_{17}N_2O_2$ [(M+H)$^+$] 269.1284; found, 269.1287.

IR (KBr): 3439, 1665, 1643.

Methyl 9-amino-2-bromo-7-methylpyrido[1,2-*a*]indole-8-carboxylate (4h)



Yellow solid, yield 147 mg (80%), m.p. 138°C;

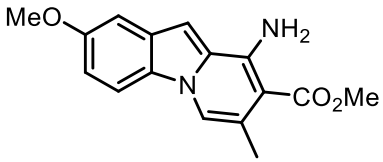
^{1}H NMR (DMSO-*d*$_6$, 600MHz): 2.35 (3H, s), 3.80 (3H, s) 7.24-7.26 (2H, m), 7.57 (2H, s) 7.84 (1H, d, *J* = 1.5) 7.93 (1H, s), 8.12 (1H, d, *J* = 8.5).

^{13}C NMR (DMSO-*d*$_6$, 150 MHz): δ_C ppm = 20.4, 51.0, 93.5, 97.0, 112.1, 113.1, 116.8, 119.8, 121.0, 126.8, 128.2, 128.8, 129.6, 144.3, 168.5.

HRMS (TOF ES$^+$): m/z calcd for $C_{15}H_{14}BrN_2O_2$ [(M+H)$^+$] 333.0233; found, 333.0236.

IR (KBr): 3324, 3292, 3115, 3048, 1520, 1449, 1346, 1246.

Methyl 9-amino-2-methoxy-7-methylpyrido[1,2-*a*]indole-8-carboxylate (4i)



Yellow solid, yield 125 mg (80%), m.p. 138°C;

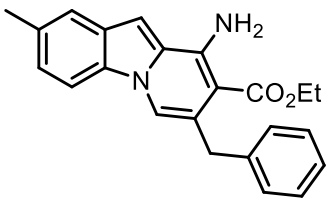
^{1}H NMR (DMSO-*d*$_6$, 600MHz): 2.35 (3H, s), 3.80 (3H, s), 3.82, (3H, s), 6.89 (1H, dd, *J* = 6.5, 2.5), 7.15 (1H, s), 7.18 (1H, d, *J* = 2.5), 7.50 (2H, s), 7.85 (1H, s), 7.6 (1H, d, *J* = 7.0).

^{13}C NMR (DMSO-*d*$_6$, 150 MHz): δ_C ppm = 20.4, 50.9, 55.2, 93.5, 96.4, 100.8, 112.1, 112.2, 112.5, 115.8, 125.8, 128.0, 128.6, 144.4, 155.5, 168.7,

HRMS (TOF ES$^+$): m/z calcd for $C_{16}H_{17}N_2O_3$ [(M+H)$^+$] 285.1234; found, 285.1235.

IR (KBr): 3330, 3295, 3115, 3048, 2931, 1520, 1449, 1346, 1246, 1190, 1140, 1122.

Ethyl 9-amino-7-benzyl-2-methylpyrido[1,2-*a*]indole-8-carboxylate (4j)



Yellow solid, yield 158 mg (80%), m.p. 165°C;

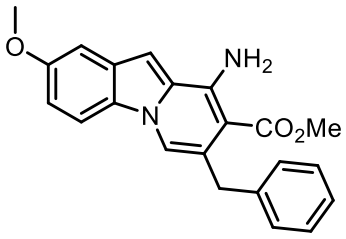
^{1}H NMR (DMSO-*d*$_6$, 600MHz): 1.08 (3H, t, *J* = 7.0), 2.41 (3H, s), 4.02 (2H, q, *J* = 7.0), 4.19 (2H, s), 7.09-7.14 (4H, m), 1.03 (1H, s), 7.25 (2H, t, *J* = 7.6), 7.40 (2H, s), 7.56 (1H, s), 7. 95 (1H, d, *J* = 8.6), 8.04 (1H, s).

^{13}C NMR (DMSO-*d*$_6$, 150 MHz): δ_C ppm = 13.8, 21.3, 38.5, 59.5, 93.5, 96.1, 111.0, 113.8, 118.1, 120.1, 123.2, 125.5, 127.7, 127.8, 128.0, 128.2, 128.6 (2C), 129.2, 131.2, 141.8, 144.6, 167.7.

HRMS (TOF ES$^+$): m/z calcd for $C_{23}H_{23}N_2O_2$ [(M+H)$^+$] 359.1754; found, 359.1757.

IR (KBr): 3329, 3295, 3277, 2930, 1697, 1616, 1521, 1452, 1402, 1346, 1246, 1190.

Methyl 9-amino-7-benzyl-2-methoxypyrido[1,2-*a*]indole-8-carboxylate (4k)



Yellow solid, yield 156 mg (79%), m.p. 146°C;

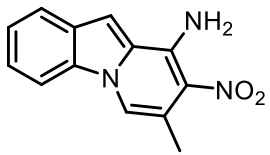
^{1}H NMR (DMSO-*d*$_6$, 600MHz): 2.46 (3H, s), 3.58 (3H, s), 4.15 (2H, s), 7.11- 7.40 (4H, m) 7.18 (1H, s), 7.23 (1H, t, *J* = 7.5), 7.38 (2H, s), 7.56 (1H, s), 7.97 (2H, d, *J* = 8.5), 8.07 (1H, s)

^{13}C NMR (DMSO-*d*$_6$, 150 MHz): δ_C ppm = 21.4, 38.6, 50.8, 93.6, 95.8, 111.0, 113.8, 118.5, 120.1, 123.2, 125.6, 125.8, 128.0 (2C), 128.5 (2C), 129.2, 131.2, 131.3, 141.6, 144.6, 168.1

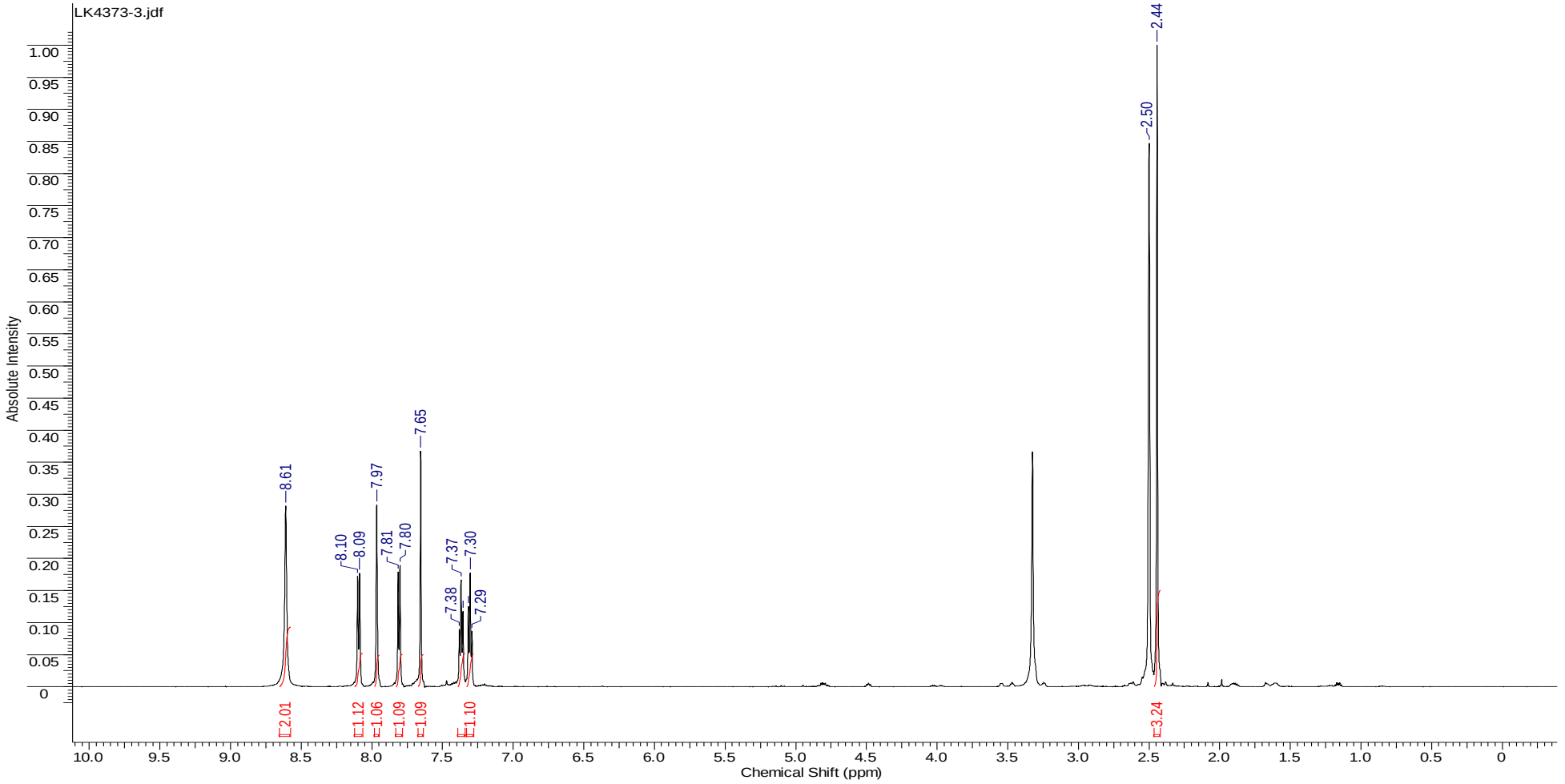
HRMS (TOF ES$^+$): m/z calcd for $C_{22}H_{21}N_2O_3$ [(M+H)$^+$] 361.1547; found, 361.1543.

IR (KBr): 3330, 3295, 3115, 3048, 2931, 1520, 1449, 1346, 1246, 1190, 1140, 1122.

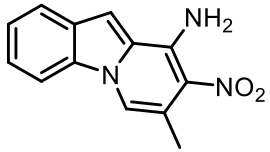
(2a)



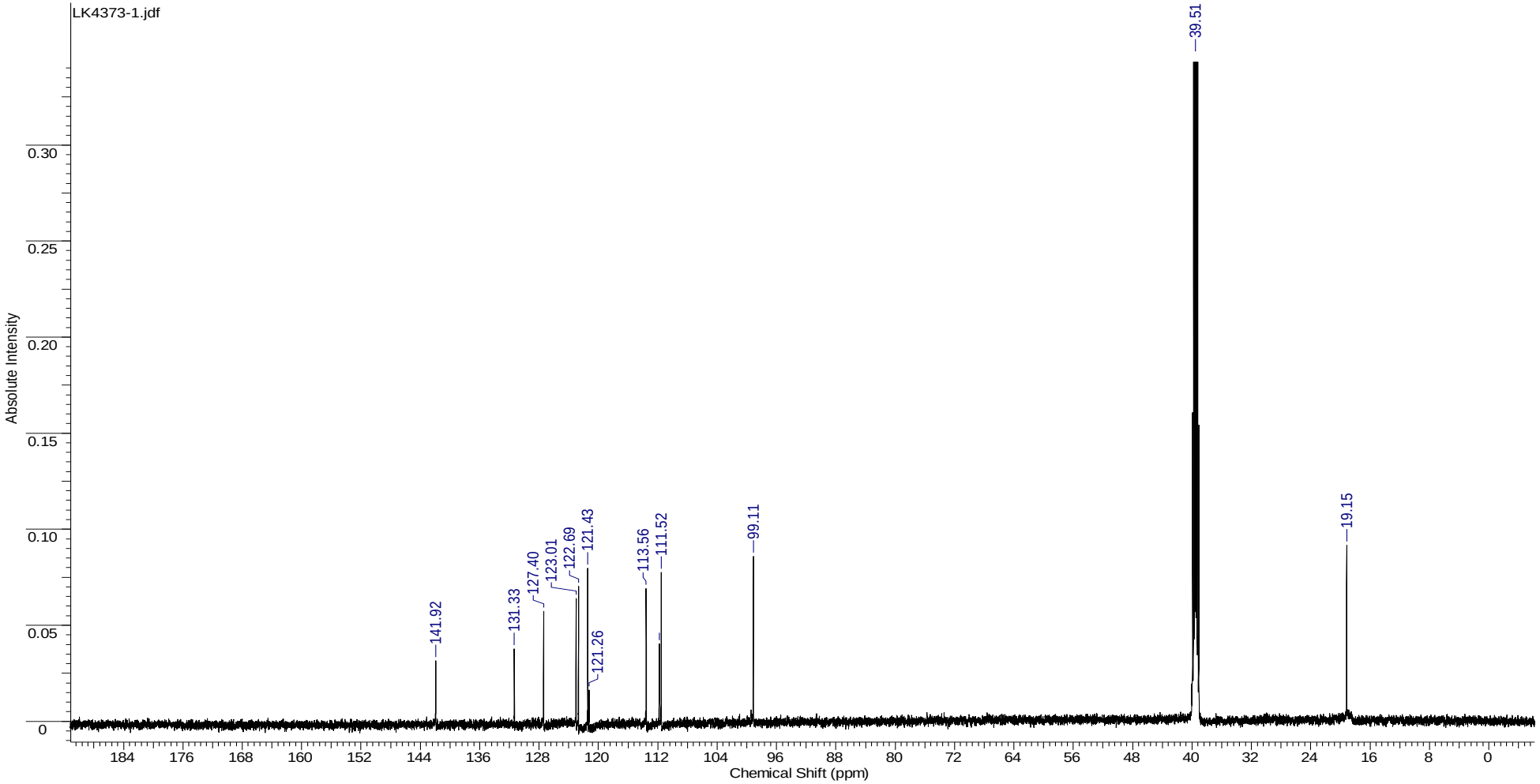
^{1}H NMR (DMSO, 600 MHz):



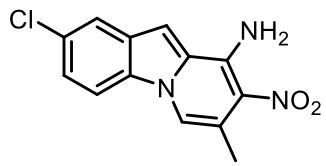
(2a)



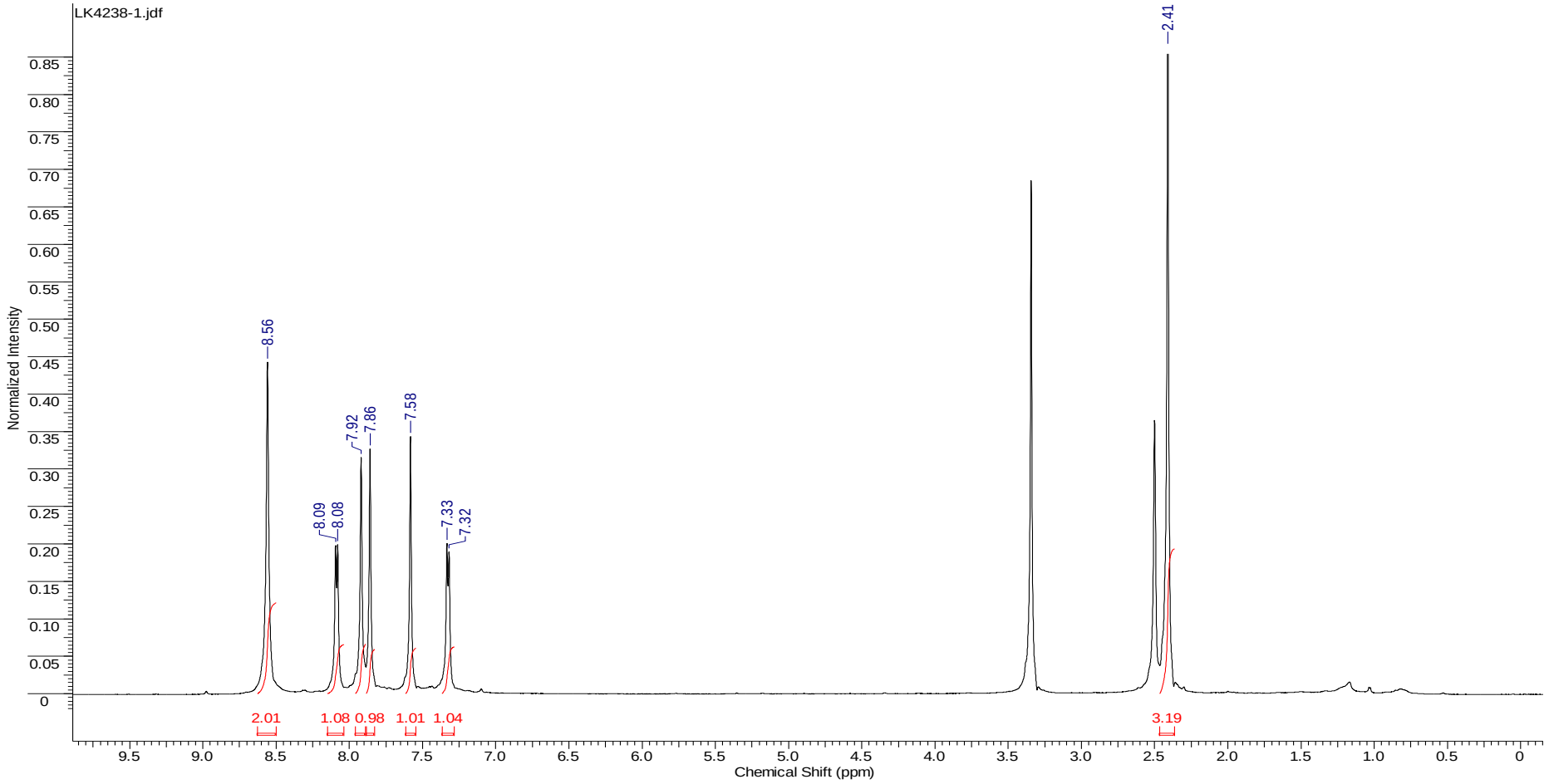
^{13}C NMR (DMSO, 150 MHz):-



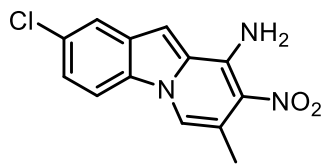
(2b)



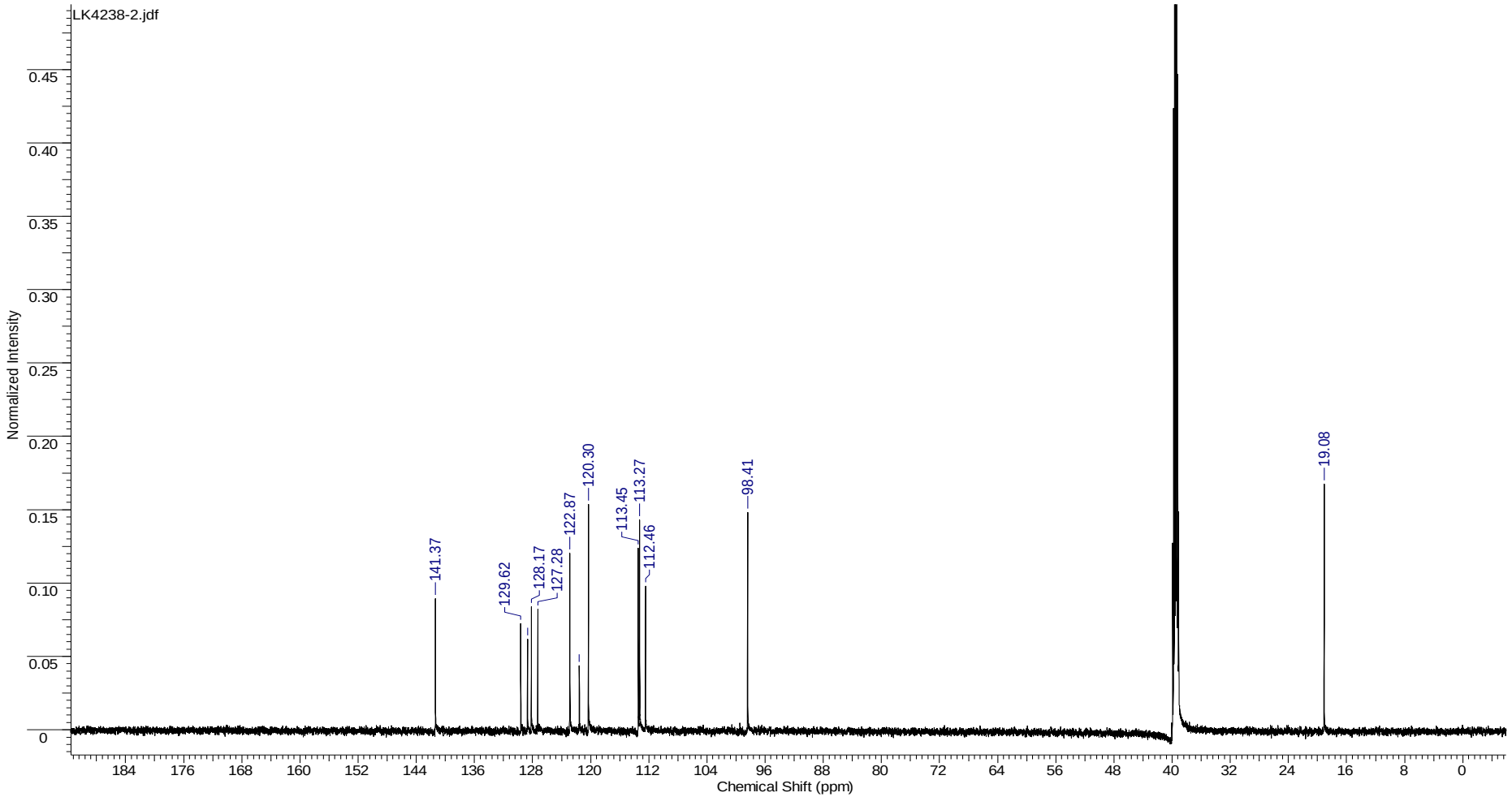
^{1}H NMR (DMSO, 600 MHz):



(2b)



^{13}C NMR (DMSO, 150 MHz):-



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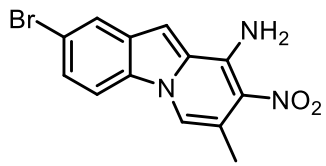
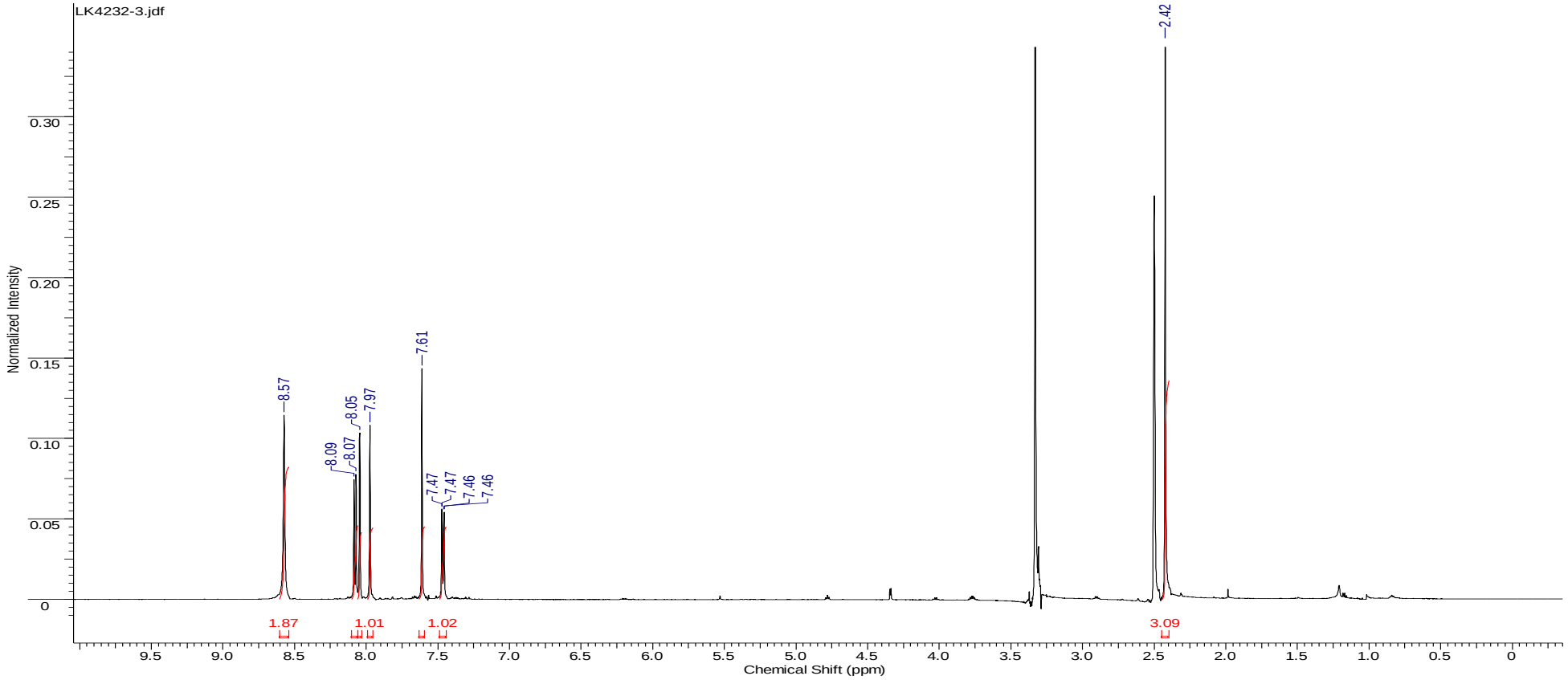
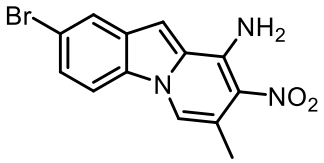


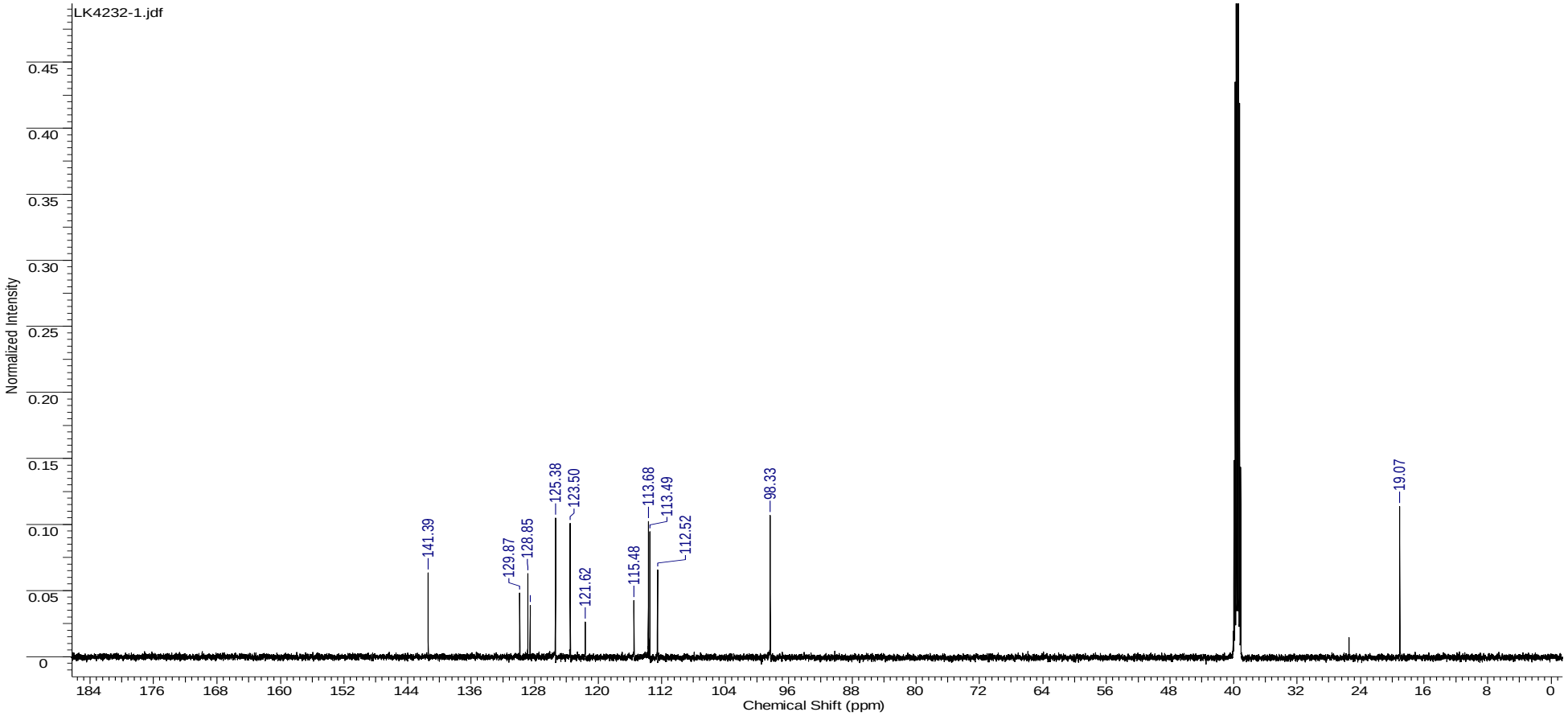
^{1}H NMR (DMSO, 600MHz):-



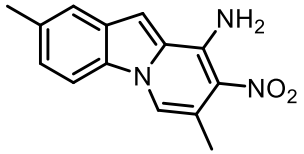
(2c)



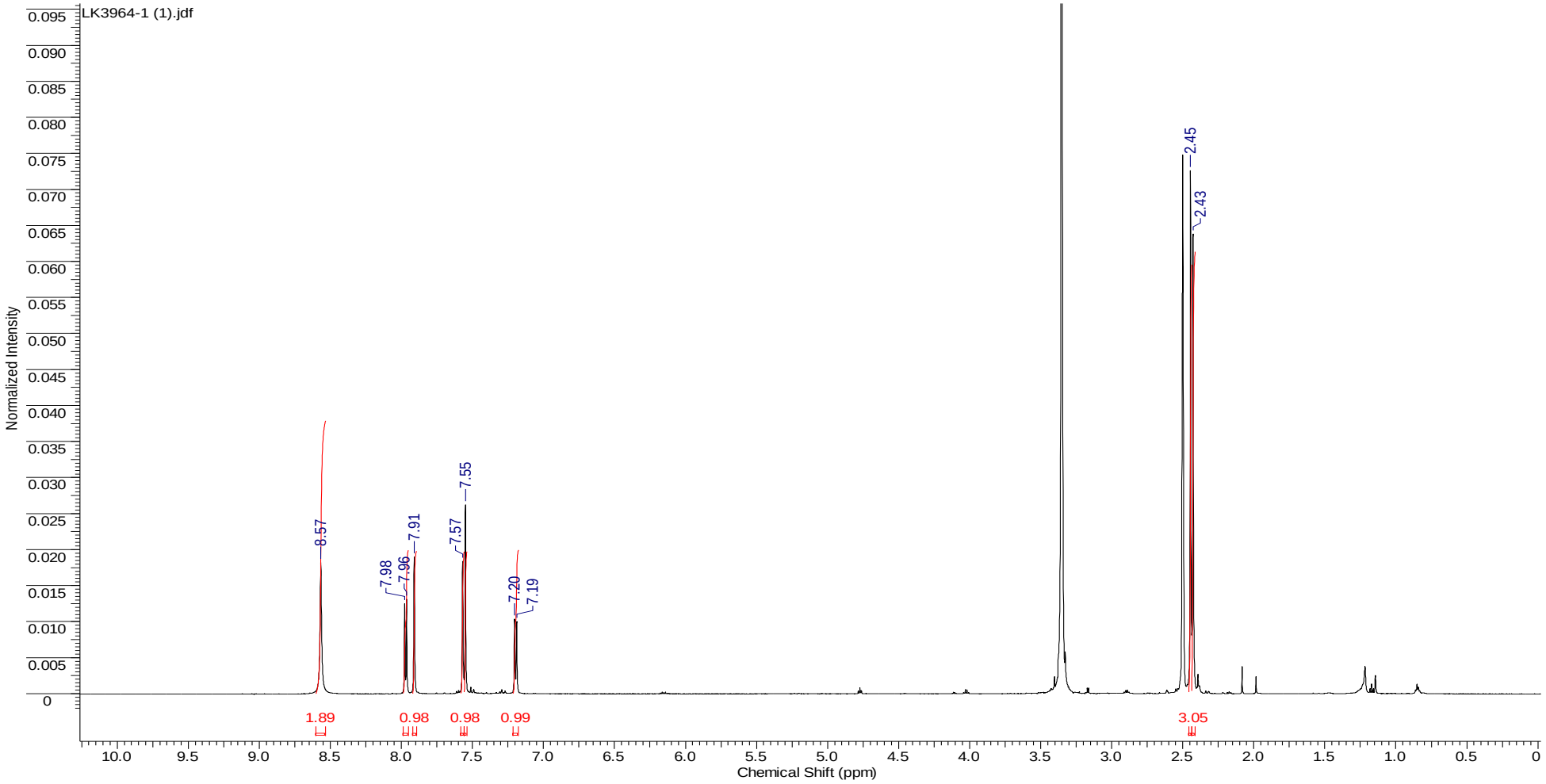
^{13}C NMR (DMSO, 150 MHz):



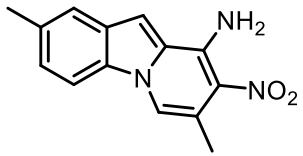
(2d)



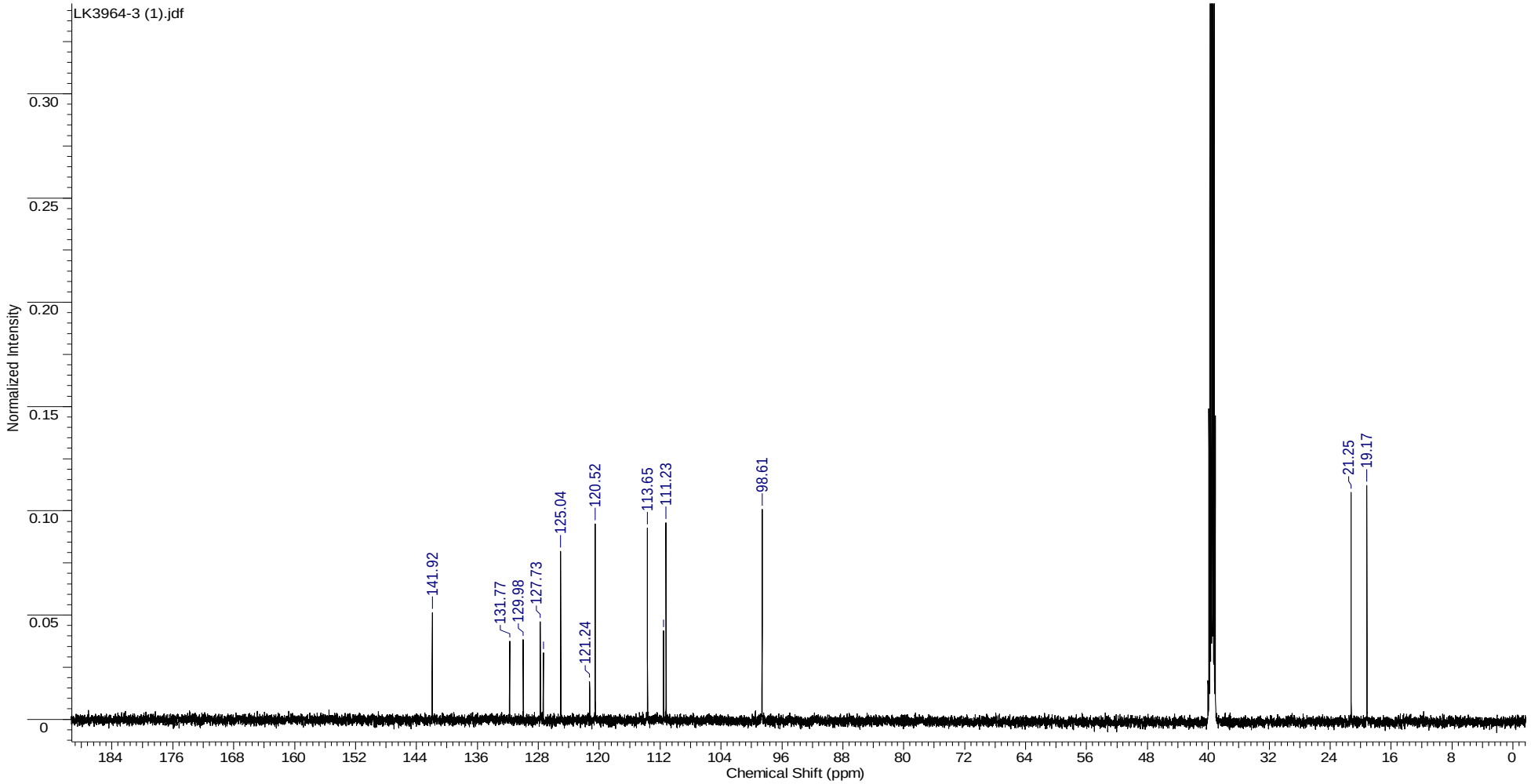
NMR (DMSO, 600MHz):-



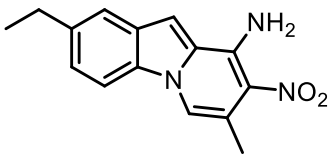
(2d)



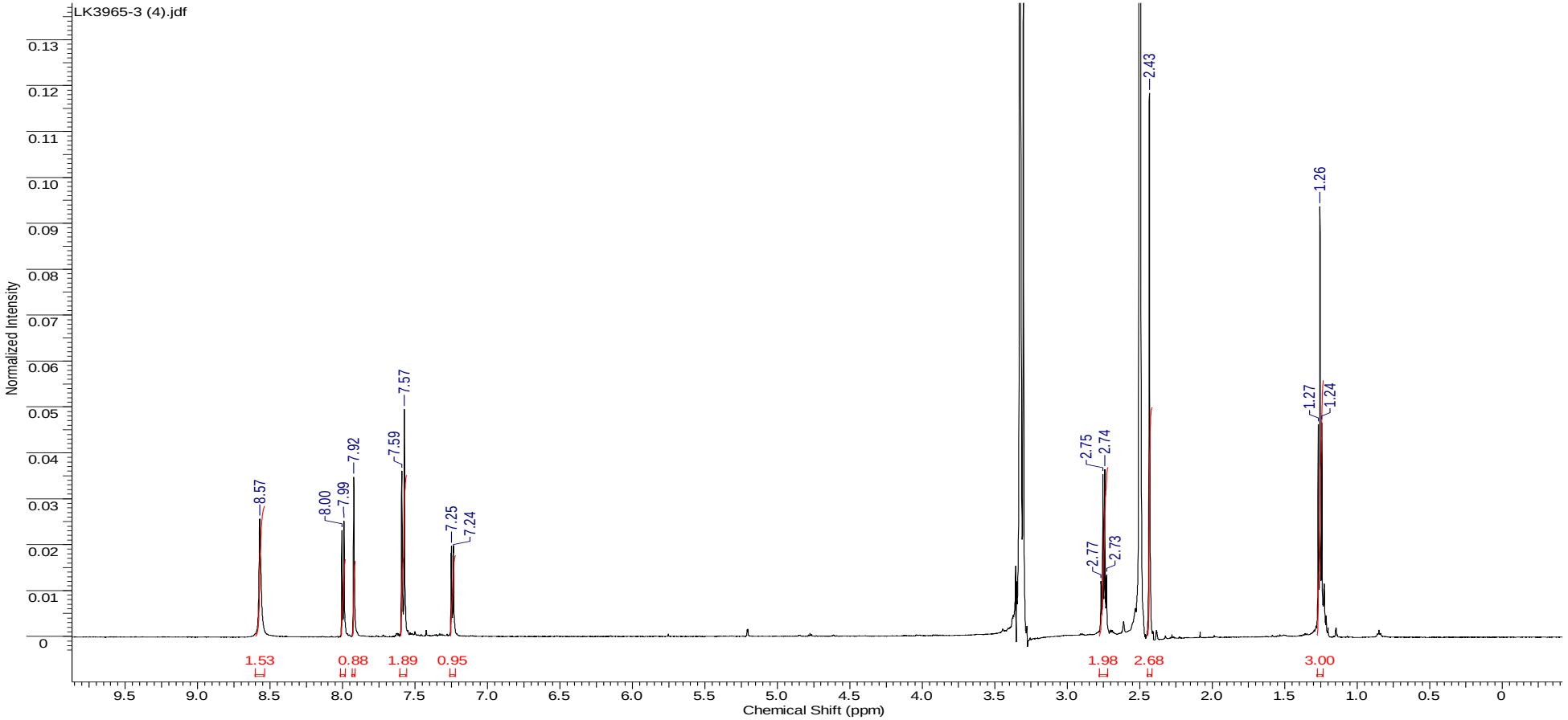
^{13}C NMR (DMSO, 150 MHz):-



(2e)



^{1}H NMR (DMSO, 600MHz):-



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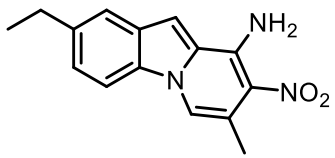
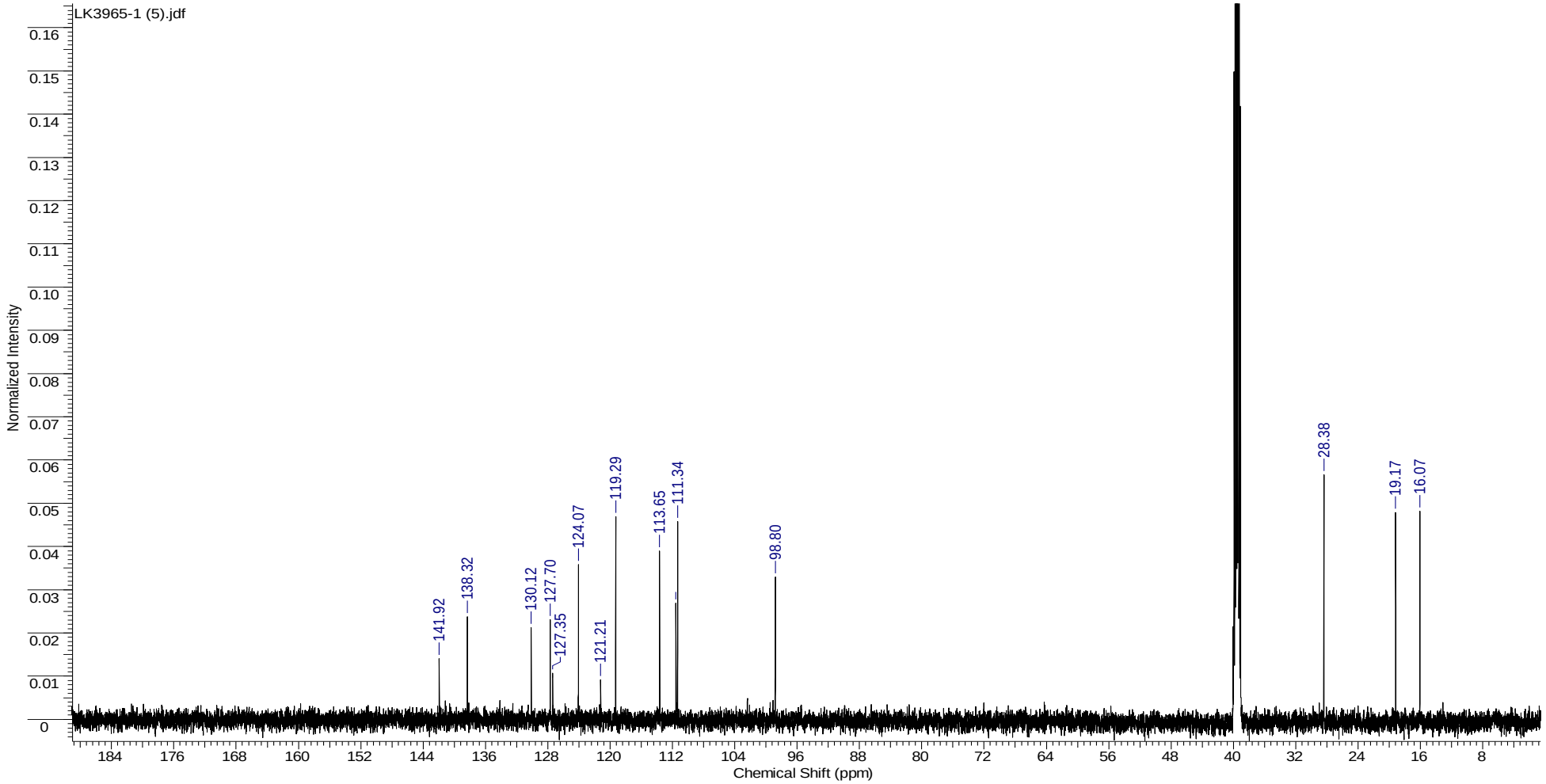
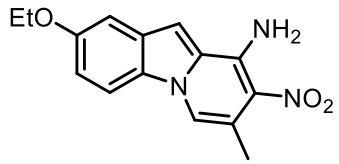


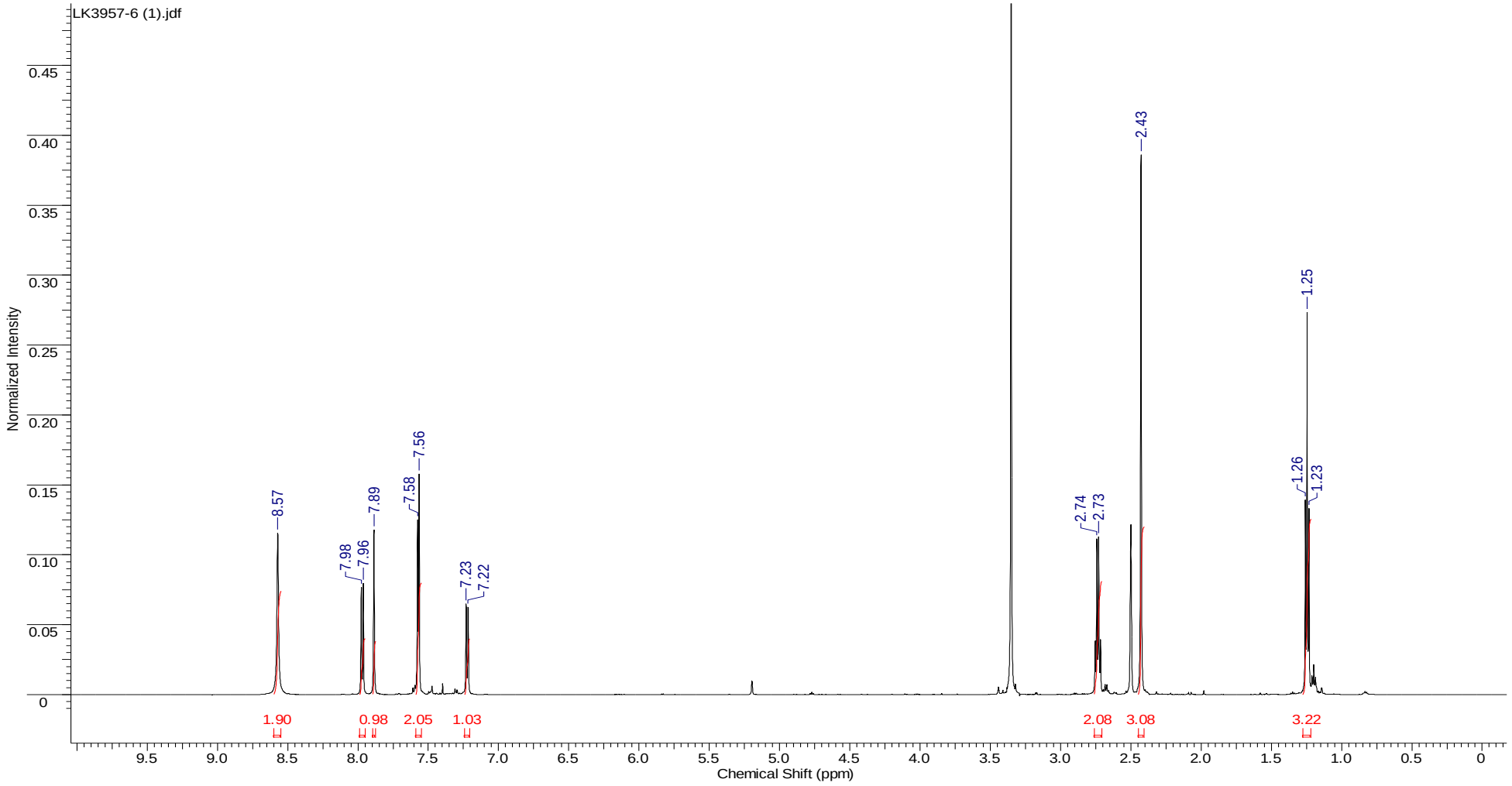
^{13}C NMR (DMSO, 150 MHz):-



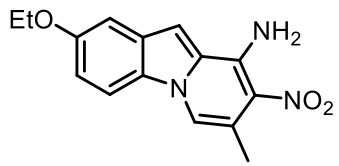
(2f)



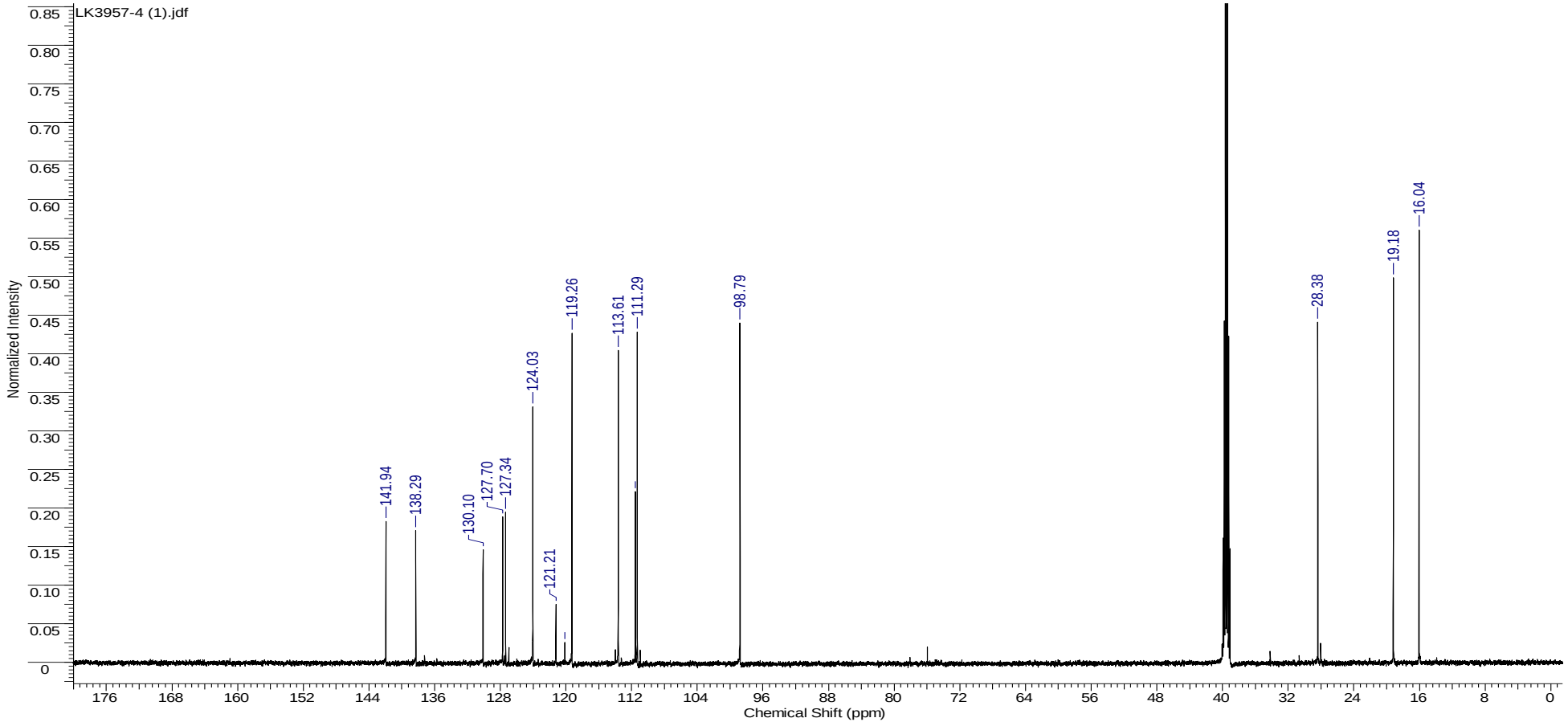
^{1}H NMR (DMSO, 600MHz):-



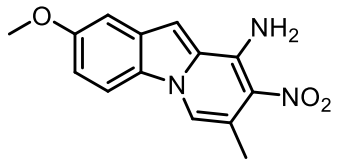
(2f)



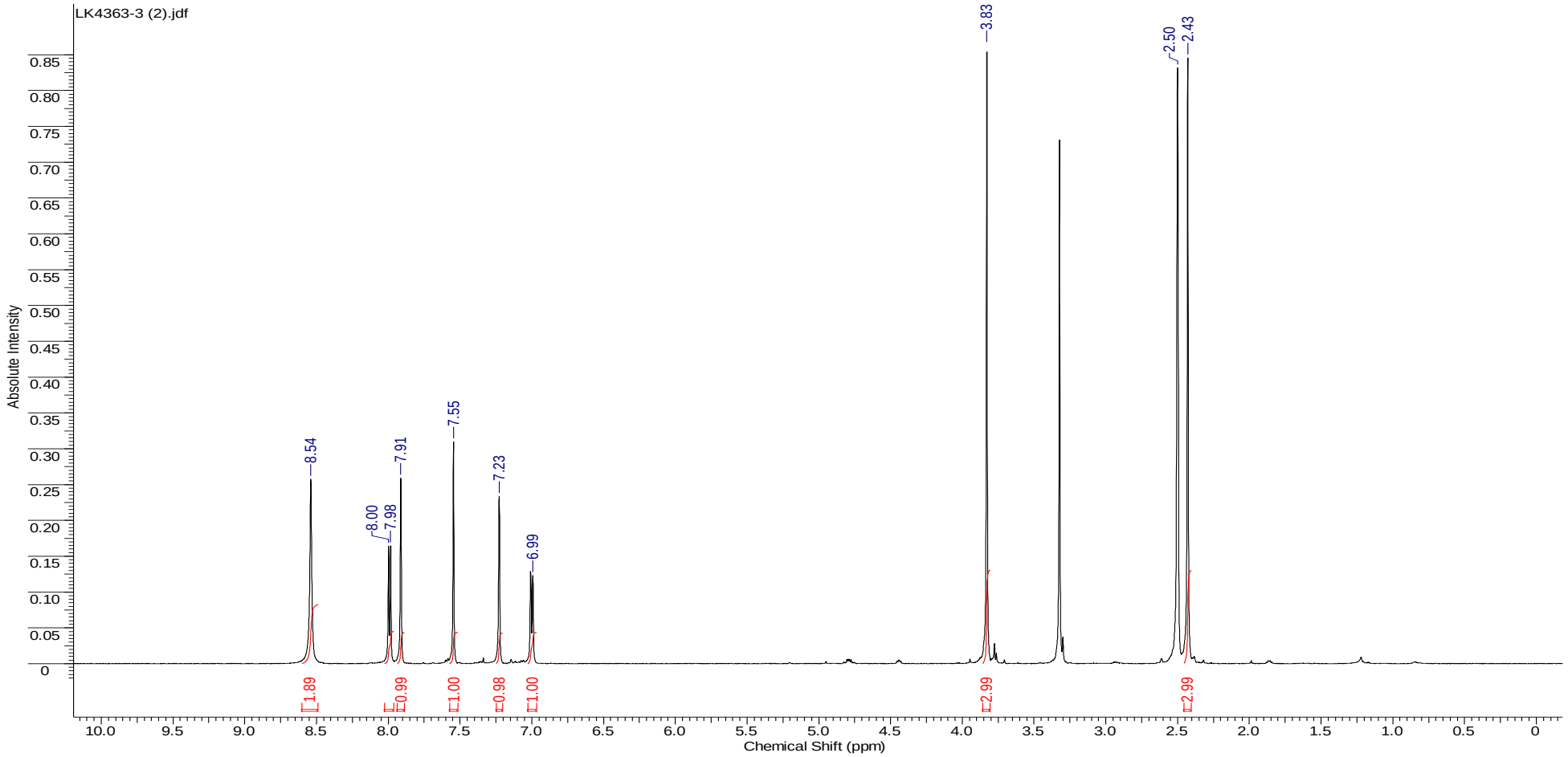
^{13}C NMR ($CDCl_3$, 150 MHz):-



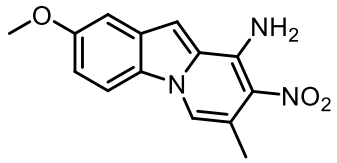
(2g)



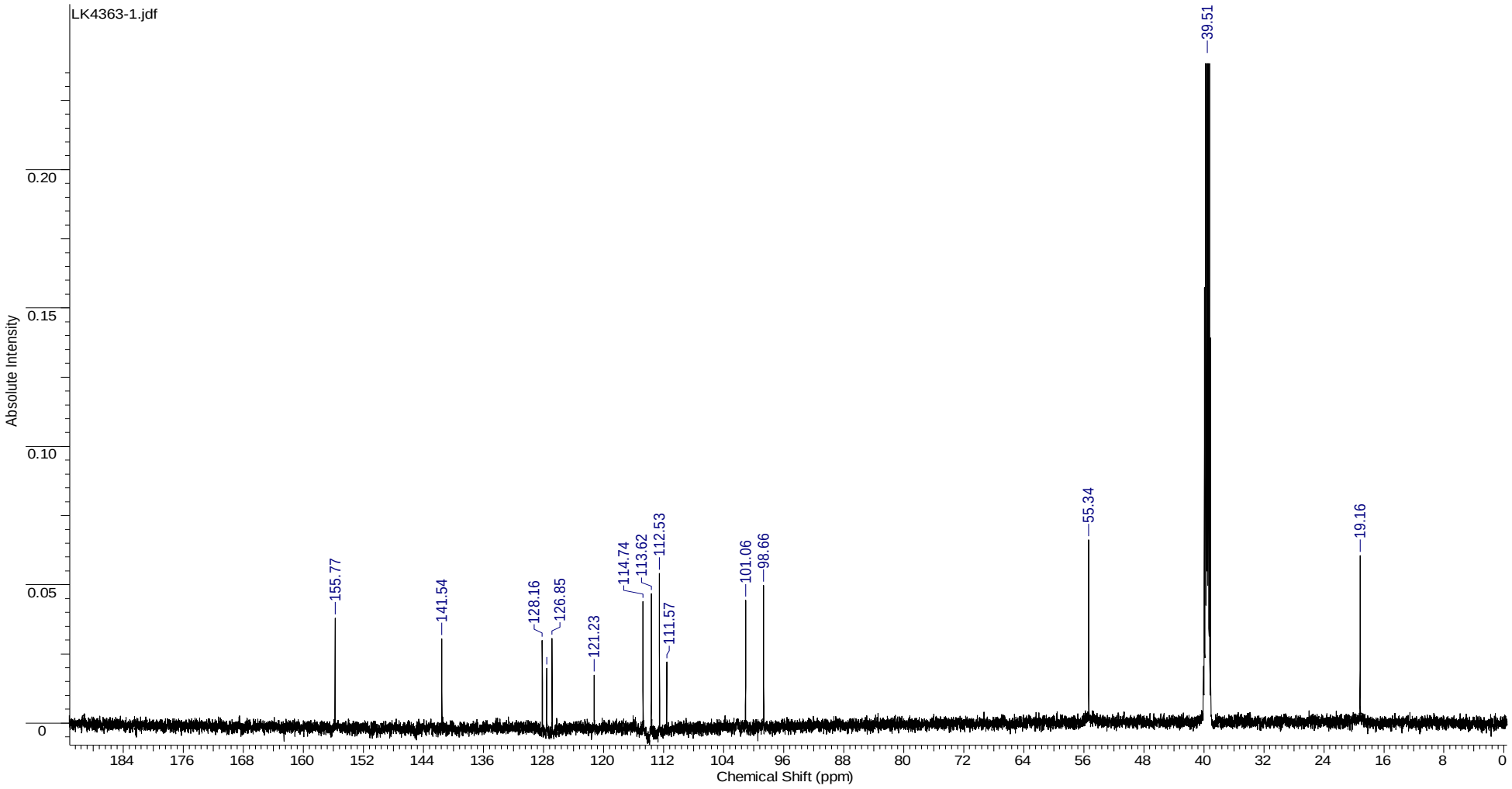
^{1}H NMR (DMSO, 600MHz):-



(2g)



^{13}C NMR (DMSO, 600MHz):



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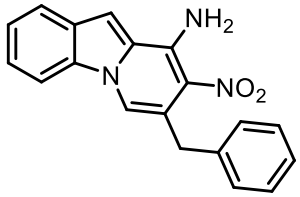
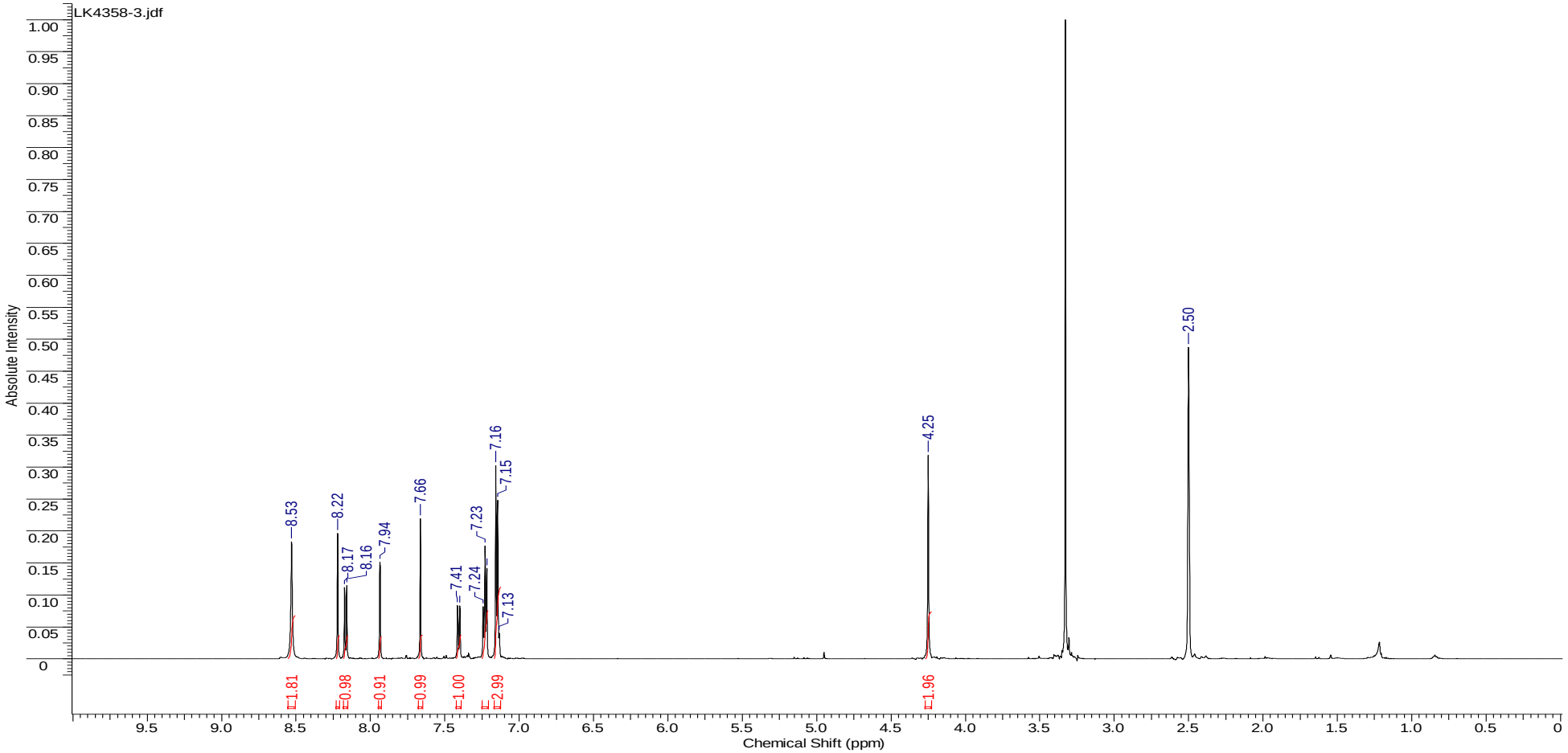
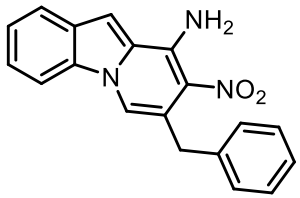


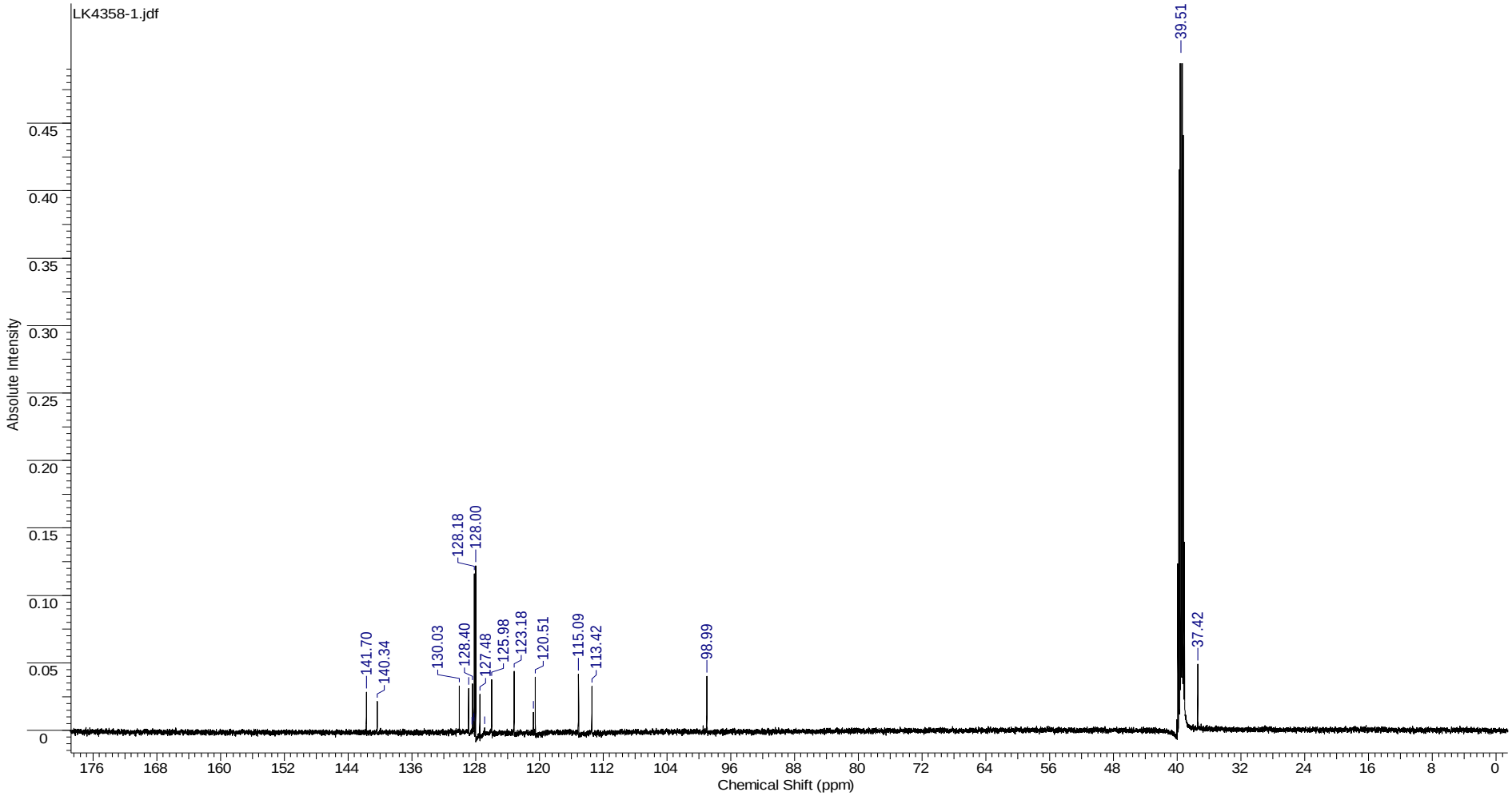
^{1}H NMR (DMSO-d_6, 600MHz):-



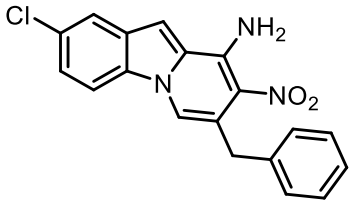
(2h)



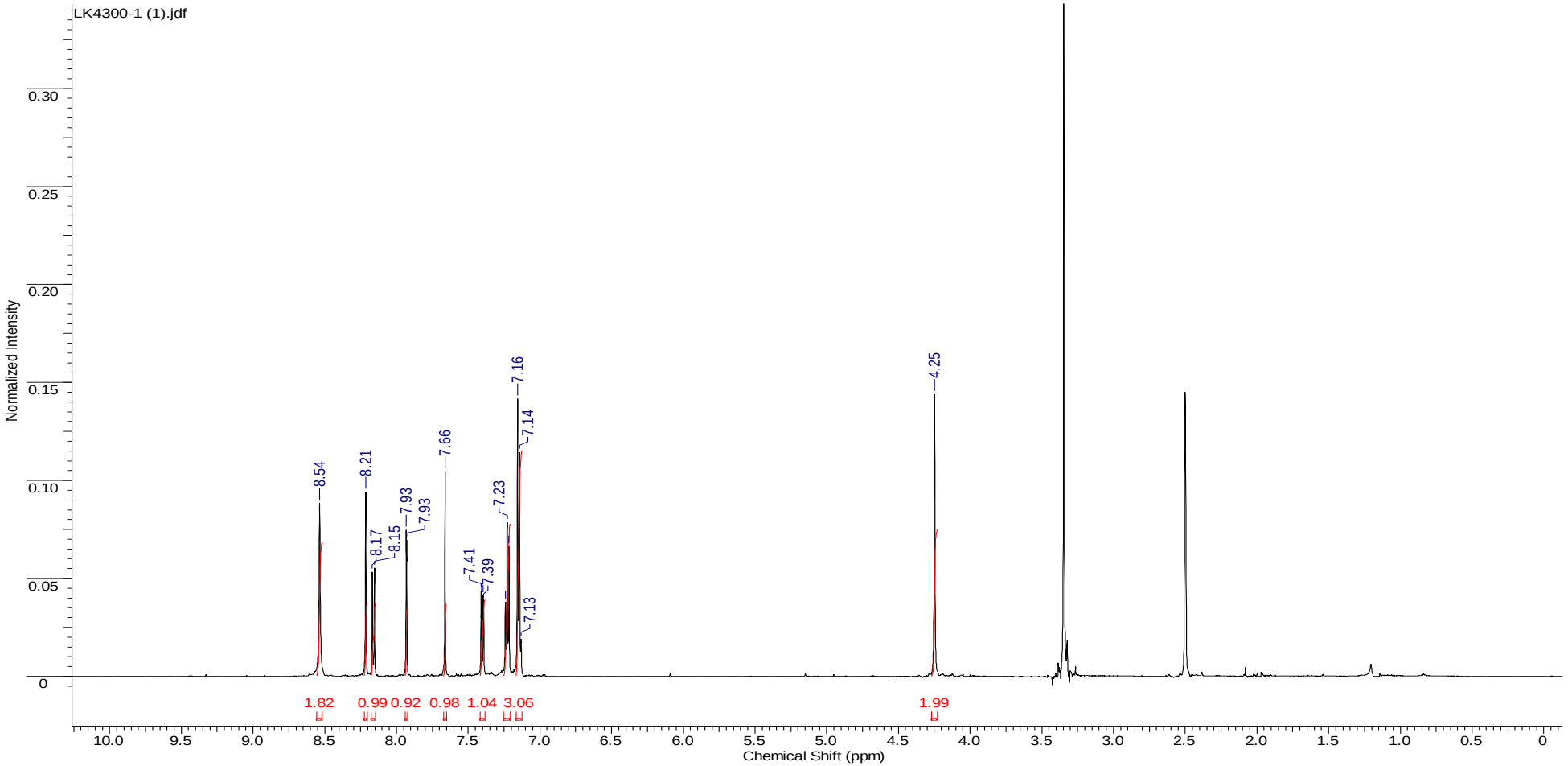
^{13}C NMR (DMSO-d$_6$, 150 MHz):



(2i)



^{1}H NMR (DMSO-d_6, 600MHz):-



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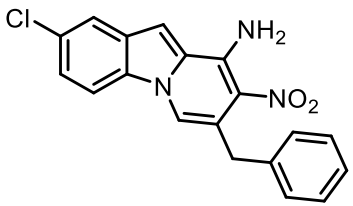
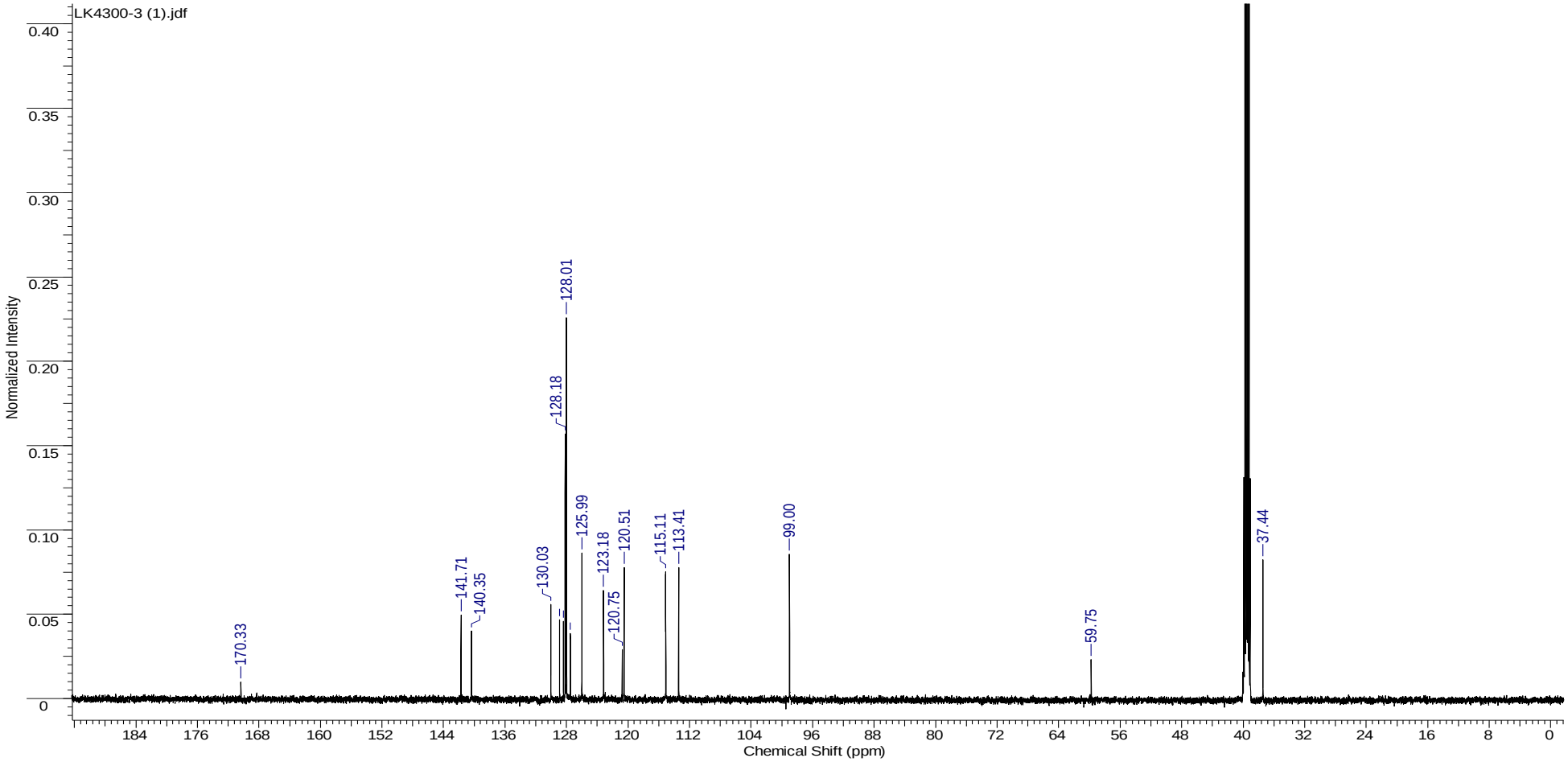


^{13}C NMR (DMSO-d_6, 150 MHz):



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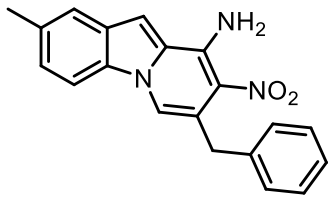
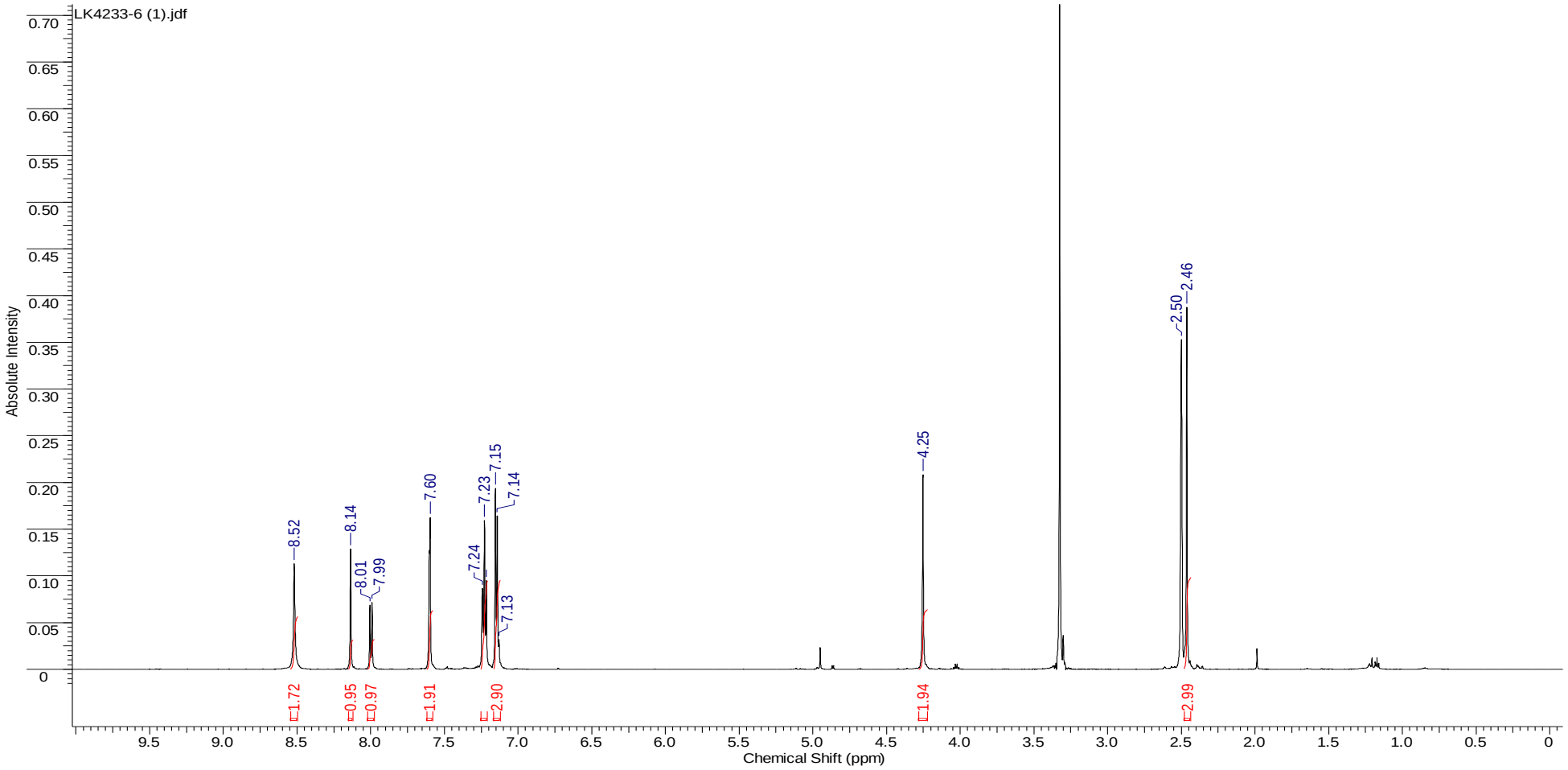


^{1}H NMR (DMSO-d_6, 600MHz):-



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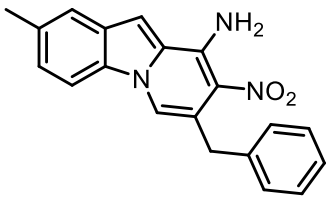
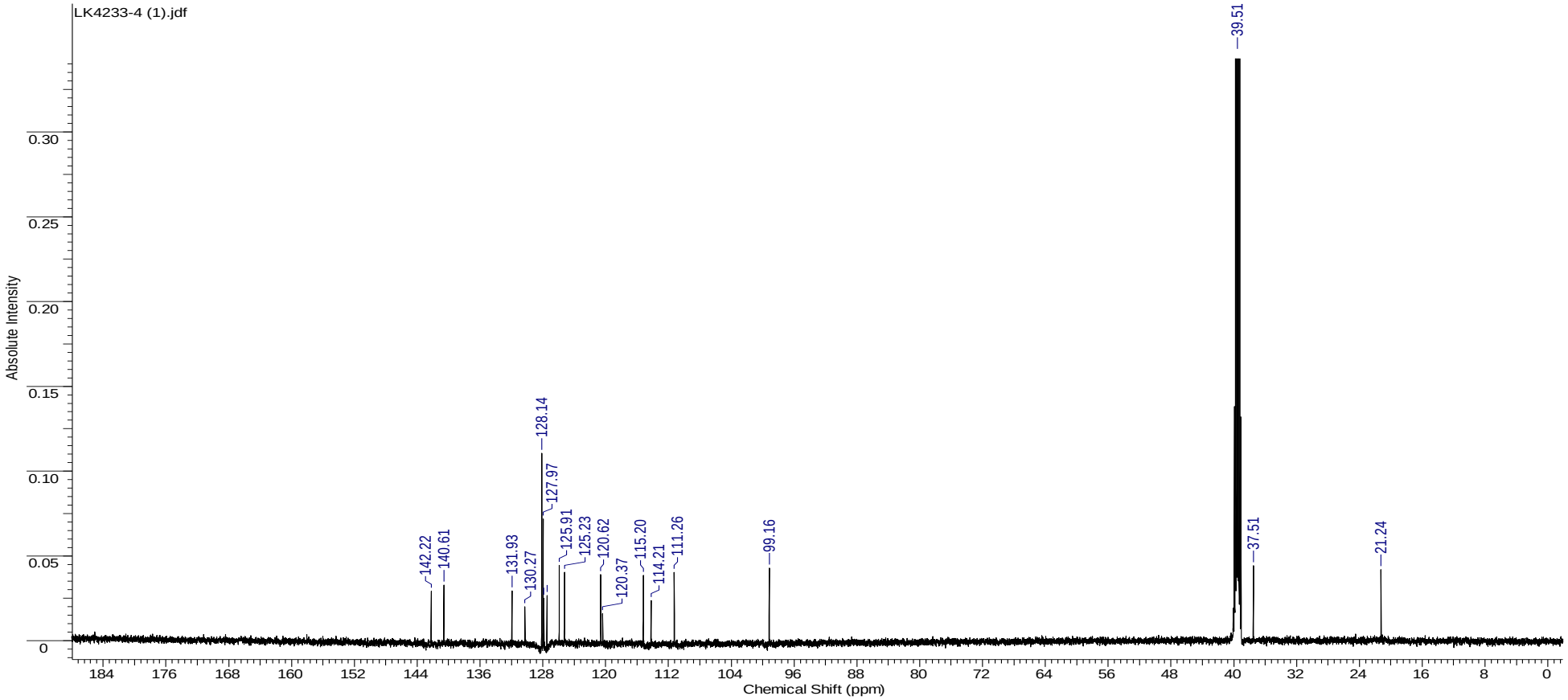
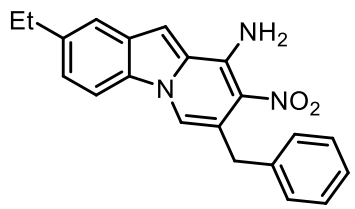


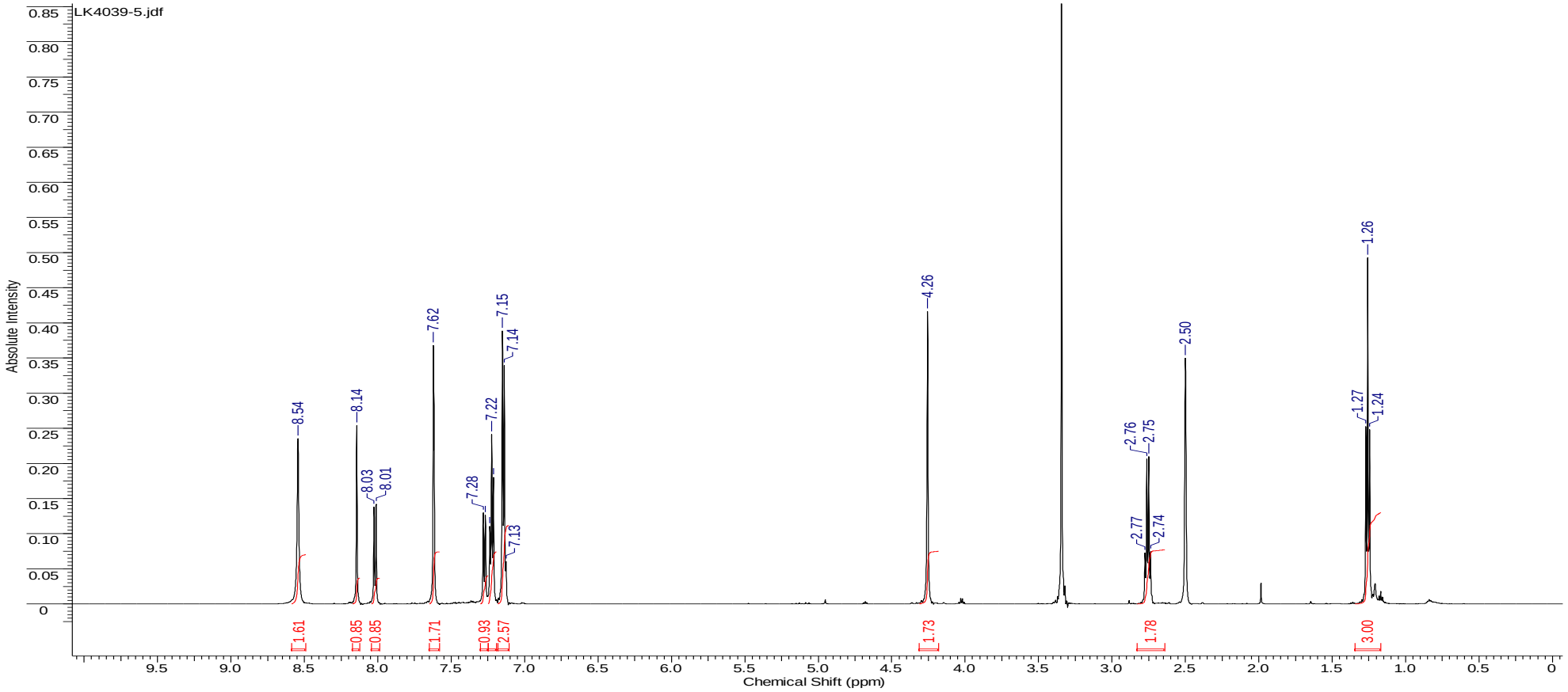
^{13}C NMR (DMSO-d$_6$, 150 MHz):



(2k)



^{1}H NMR (DMSO-d_6, 600MHz):-



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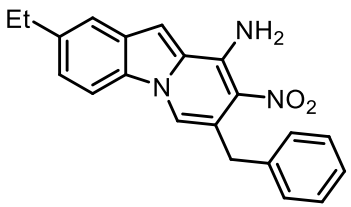
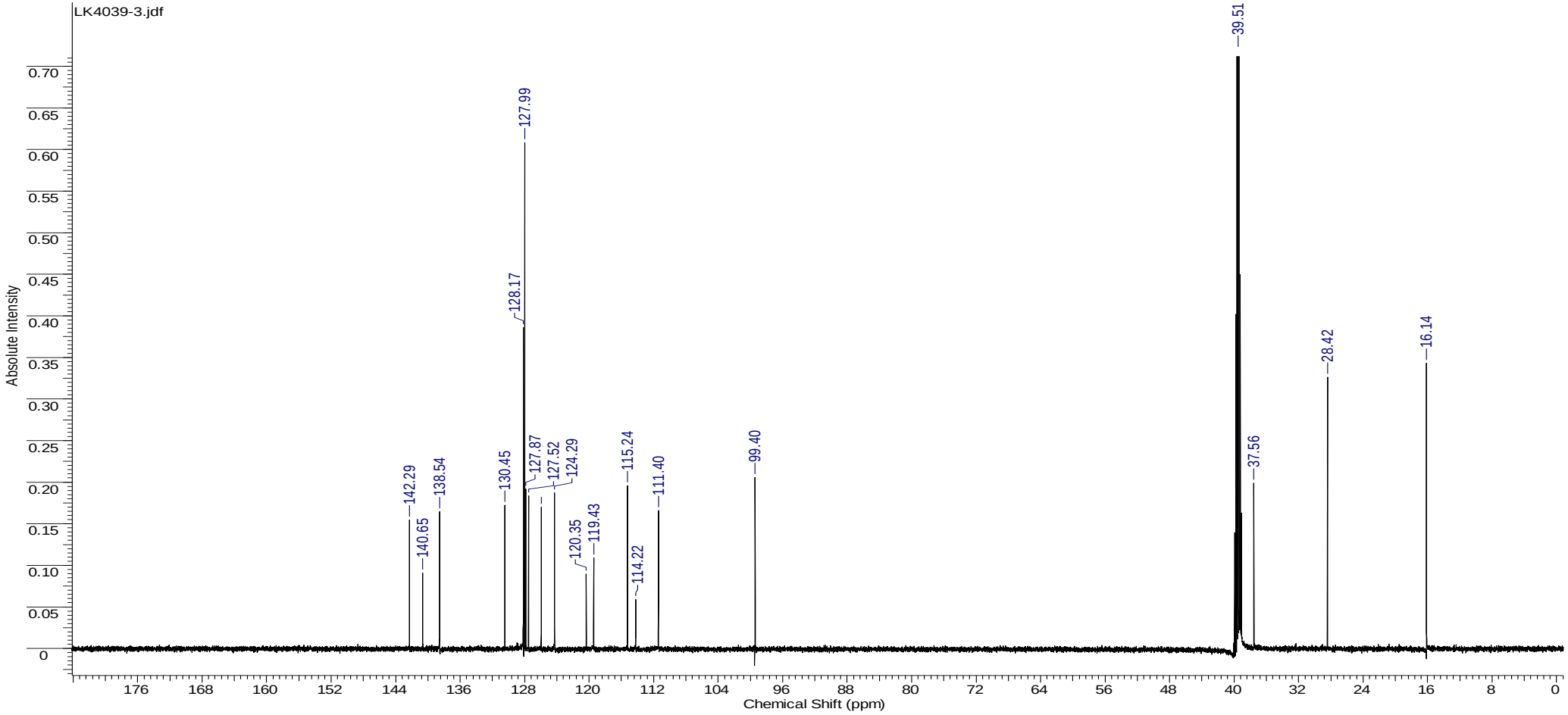
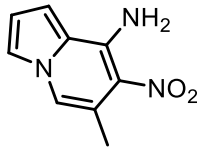


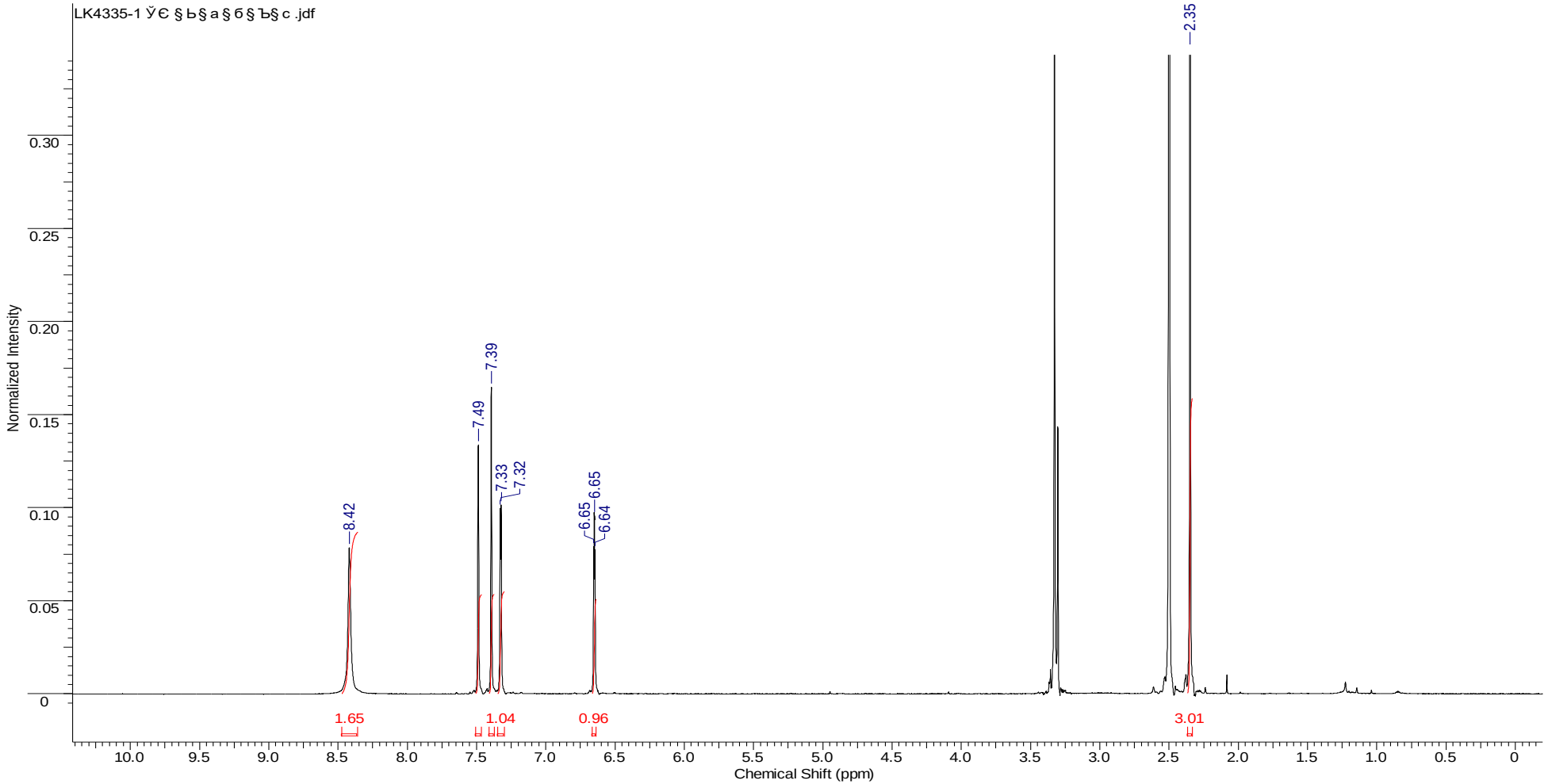
^{13}C NMR (DMSO-d_6, 150 MHz):



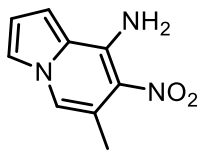
(3)



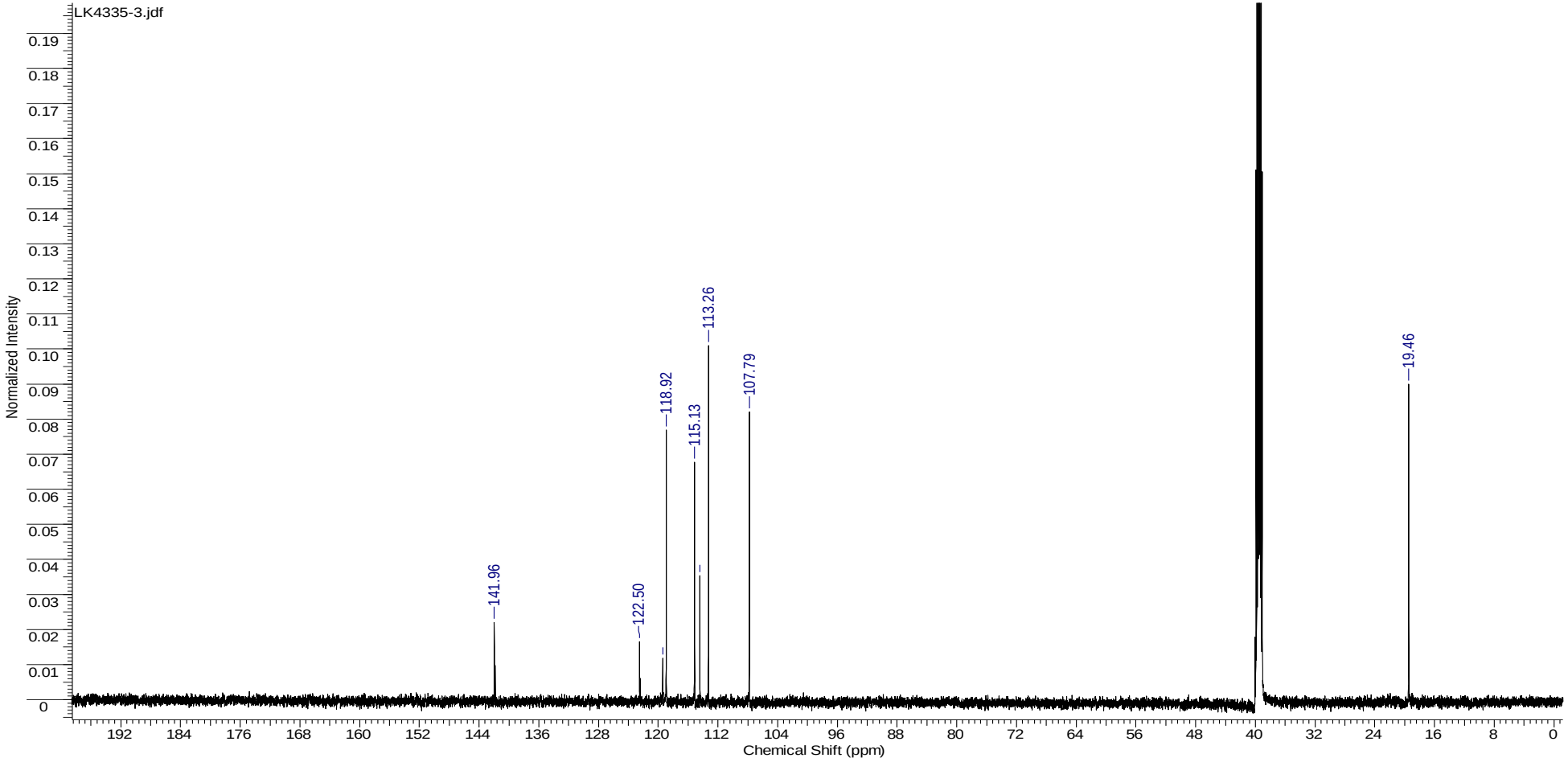
^{1}H NMR (DMSO-d_6, 600MHz):-



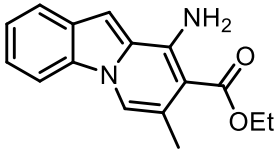
(3)



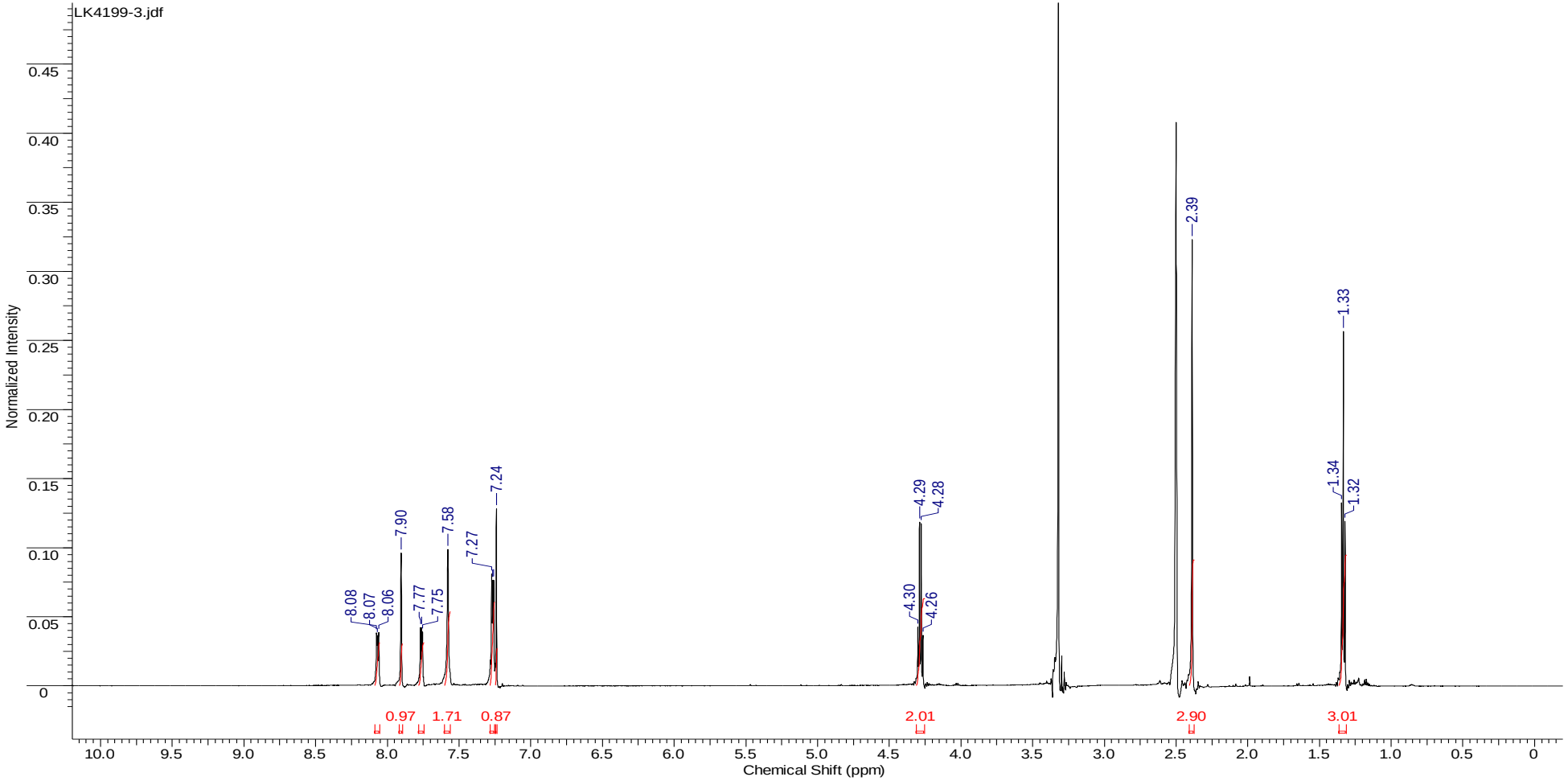
^{13}C NMR (DMSO-d$_6$, 150 MHz)



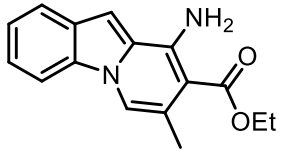
(4a)



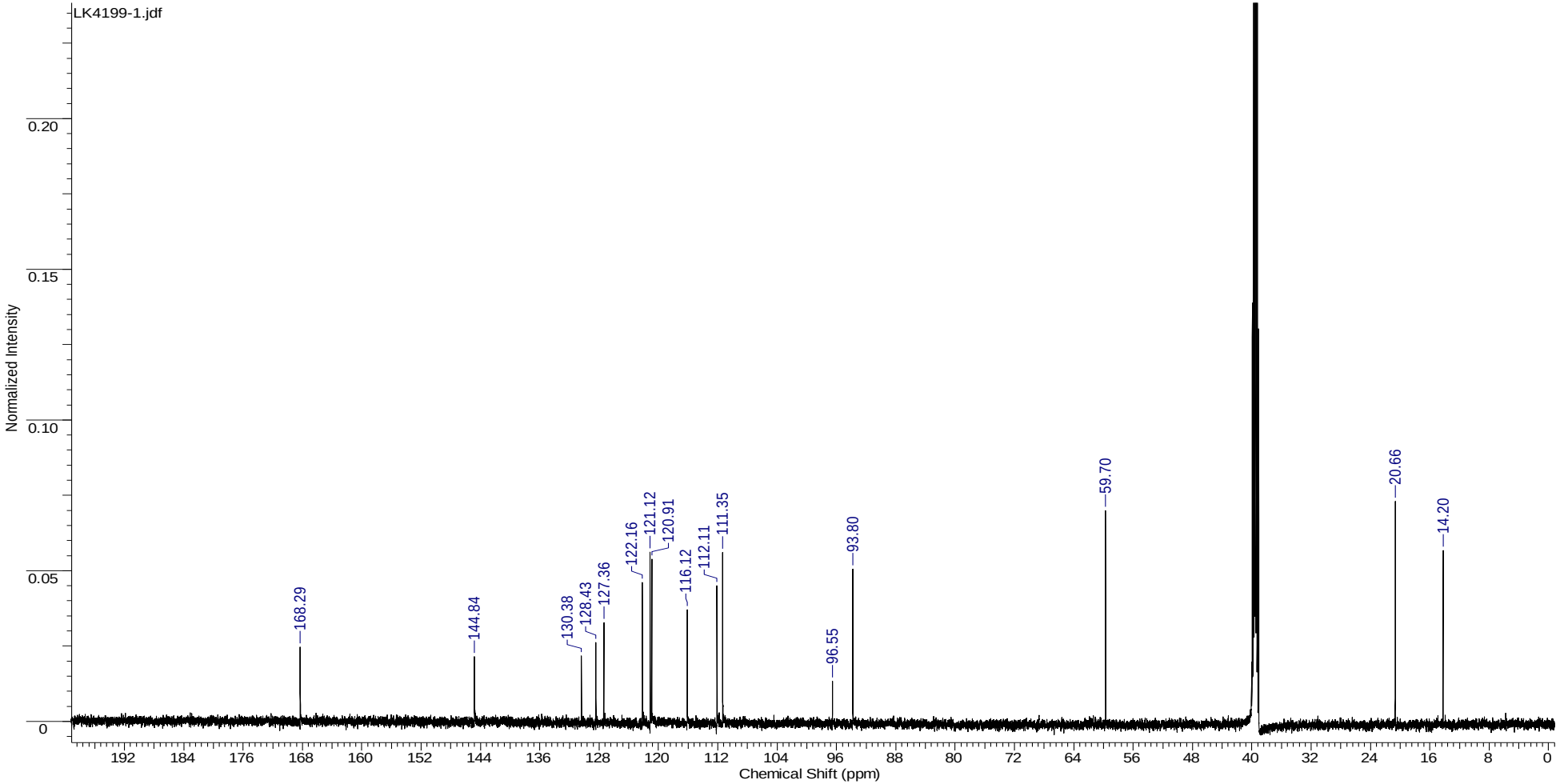
^{1}H NMR (DMSO-d_6, 600MHz):-



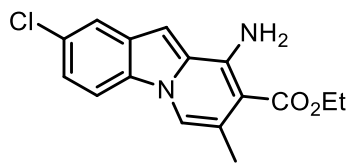
(4a)



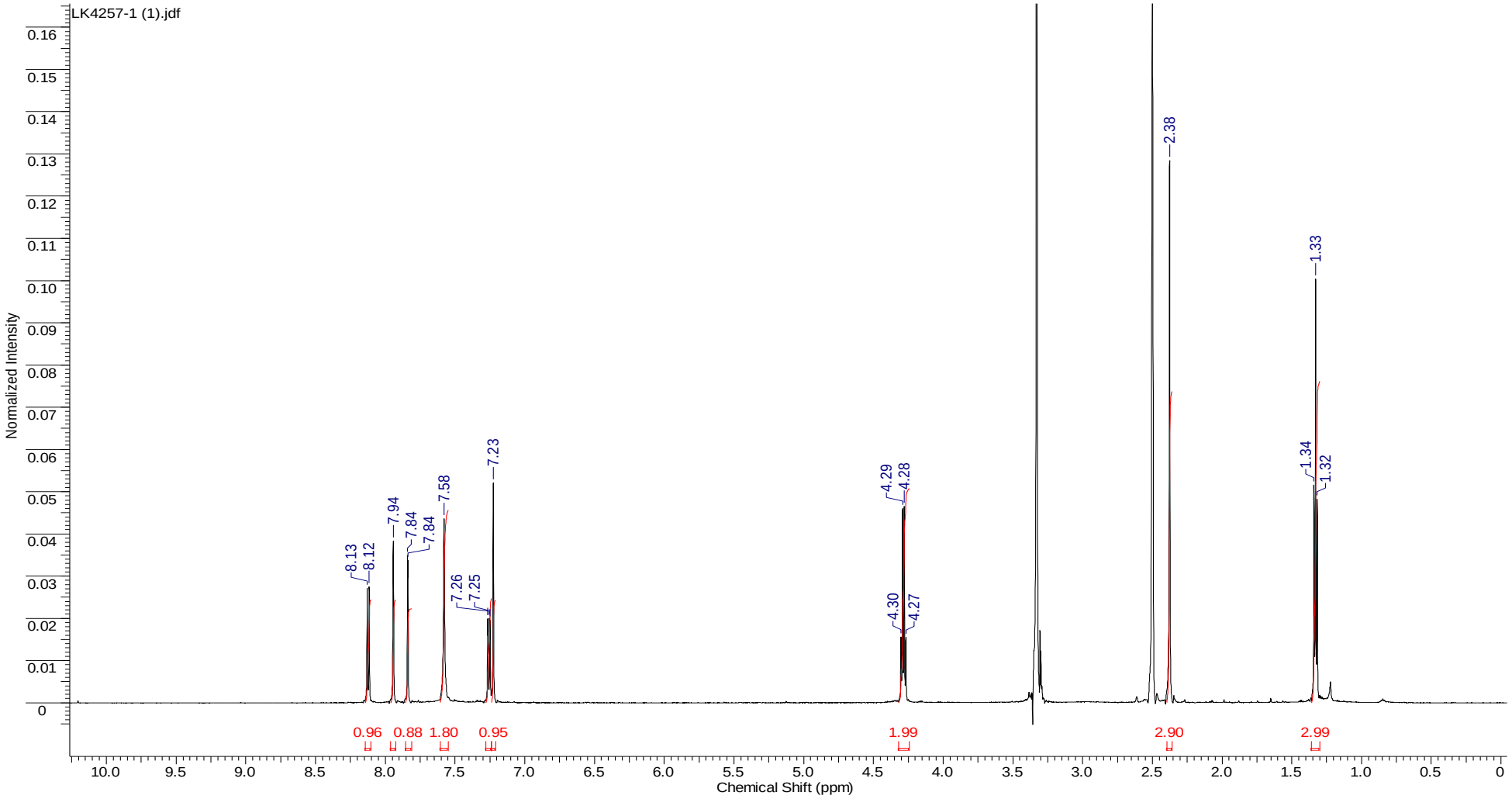
^{13}C NMR (DMSO-d_6, 150 MHz



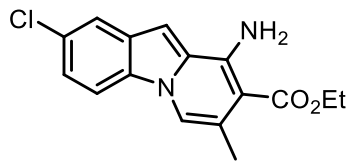
(4b)



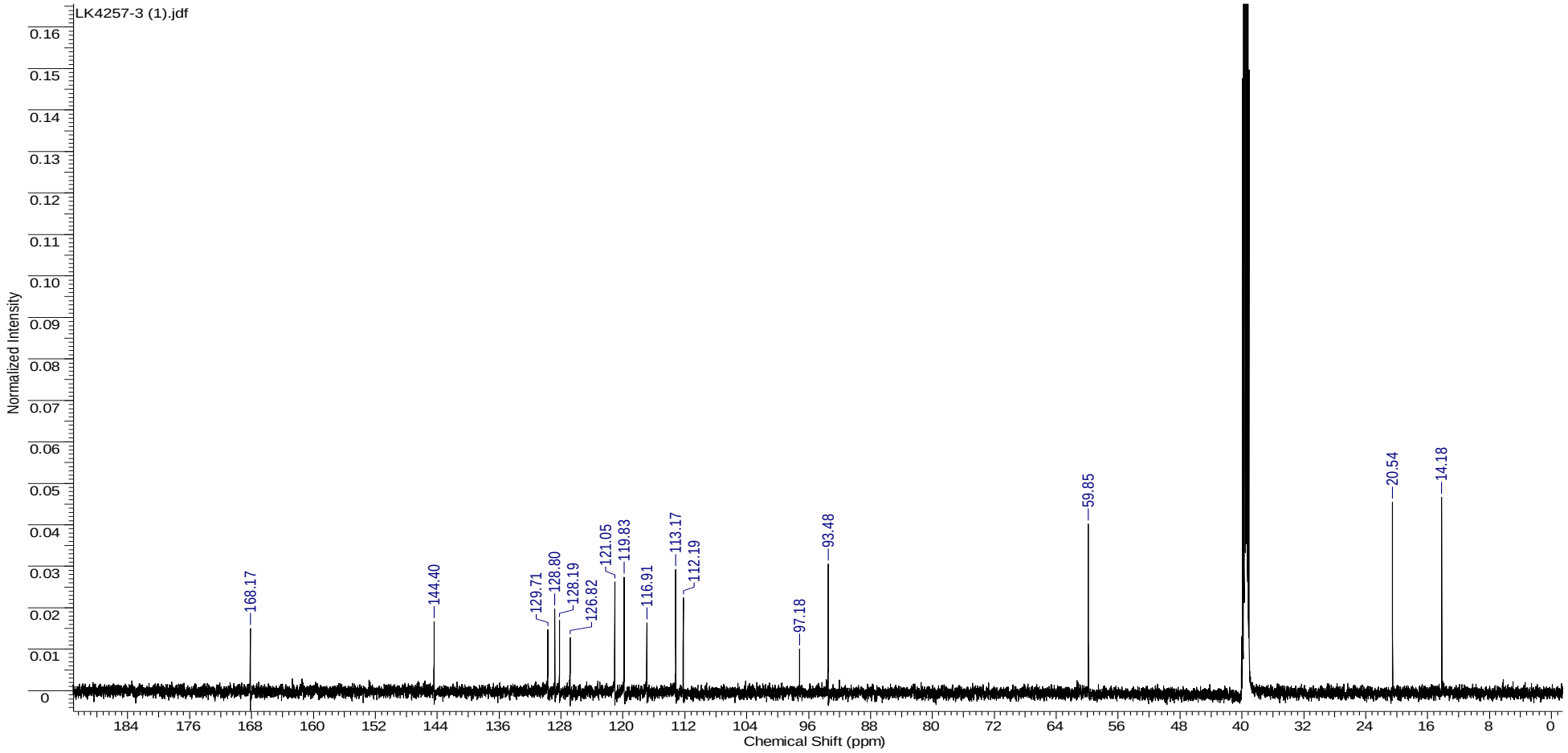
^{1}HNMR(DMSO-d_6,600MHz):-



(4b)



^{13}C NMR (DMSO-d_6, 150 MHz)



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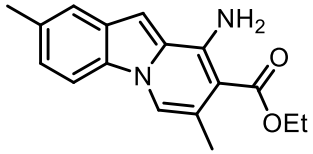
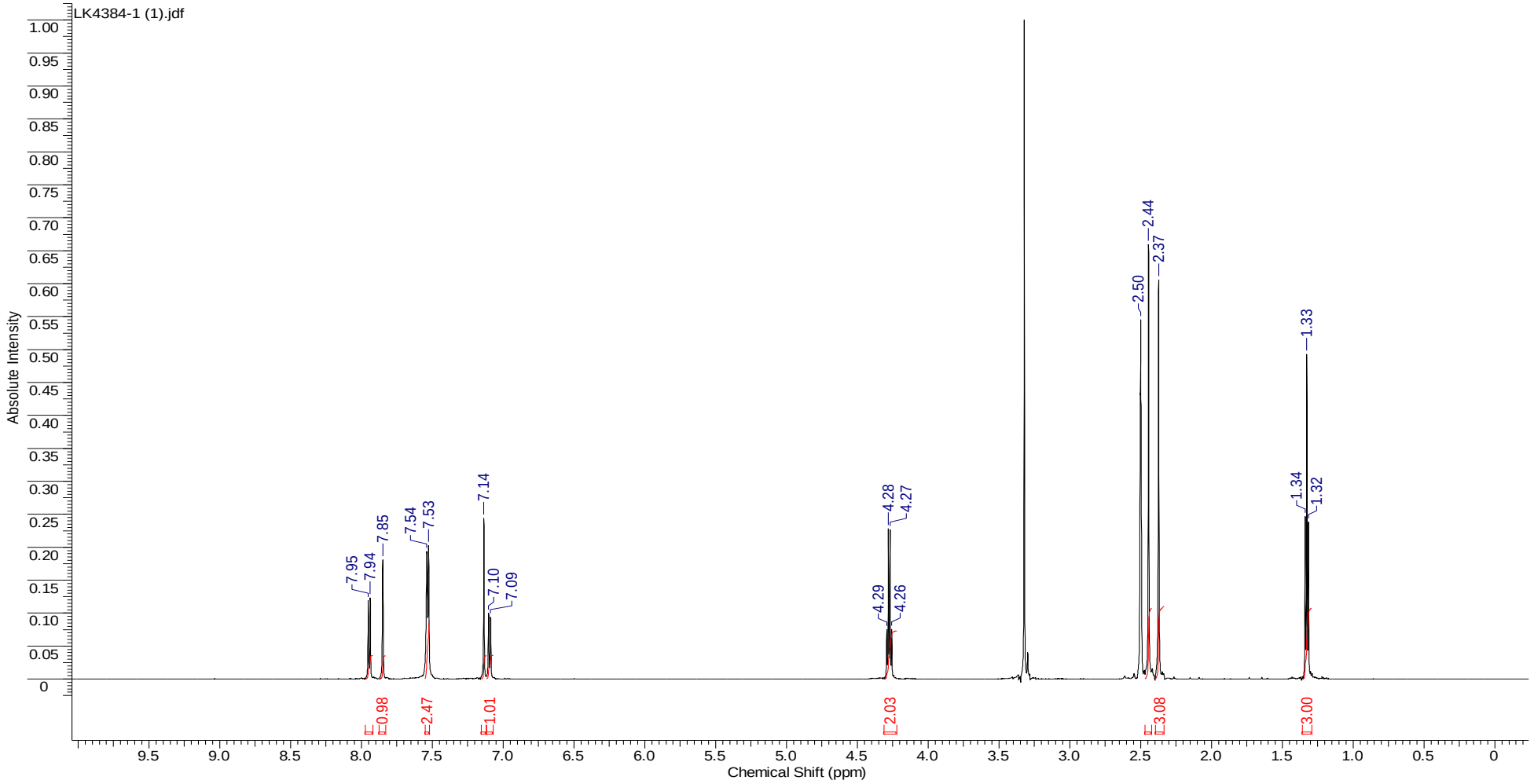
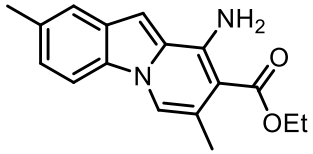


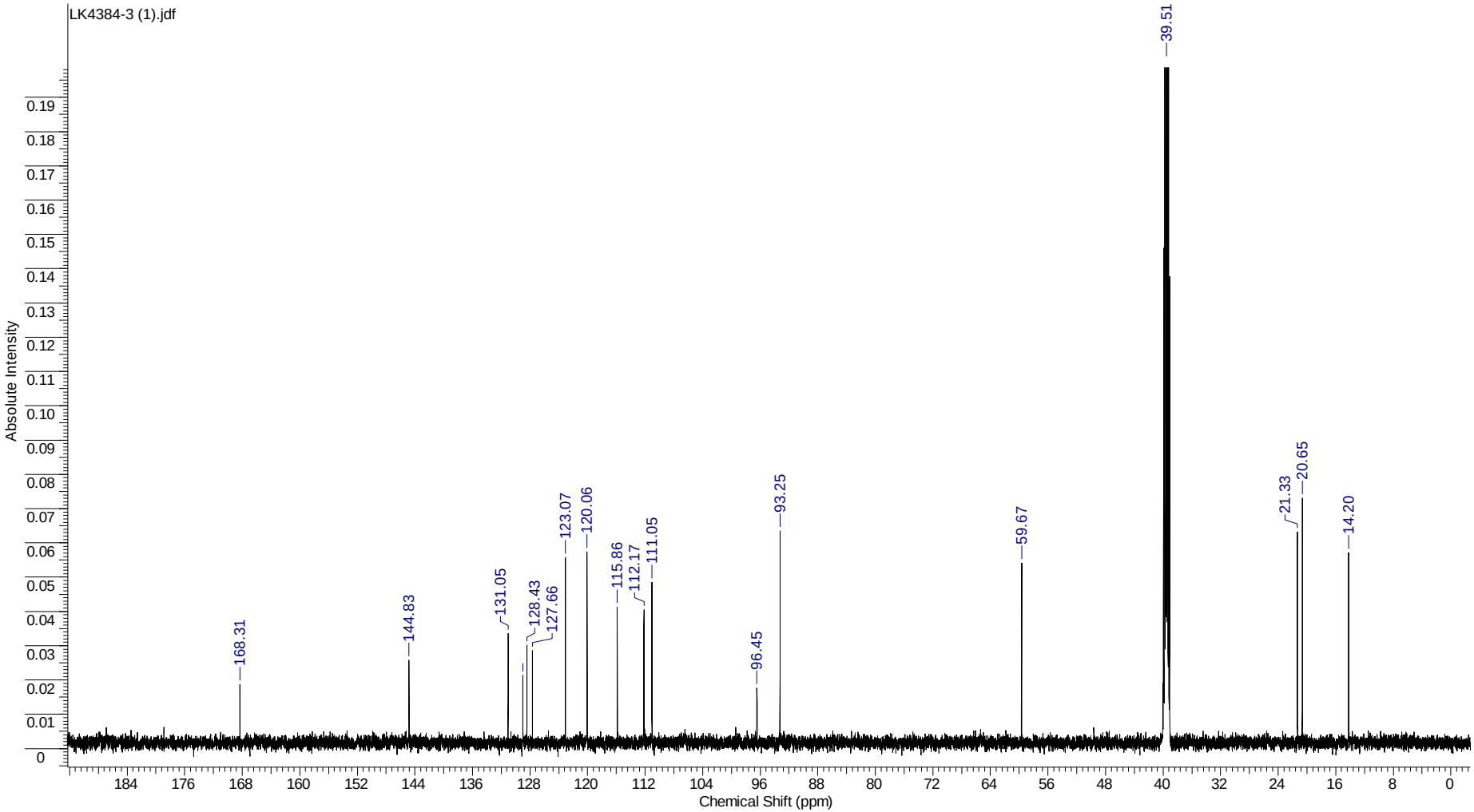
^{1}H NMR (DMSO-d_6, 600MHz):-



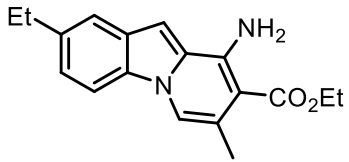
(4c)



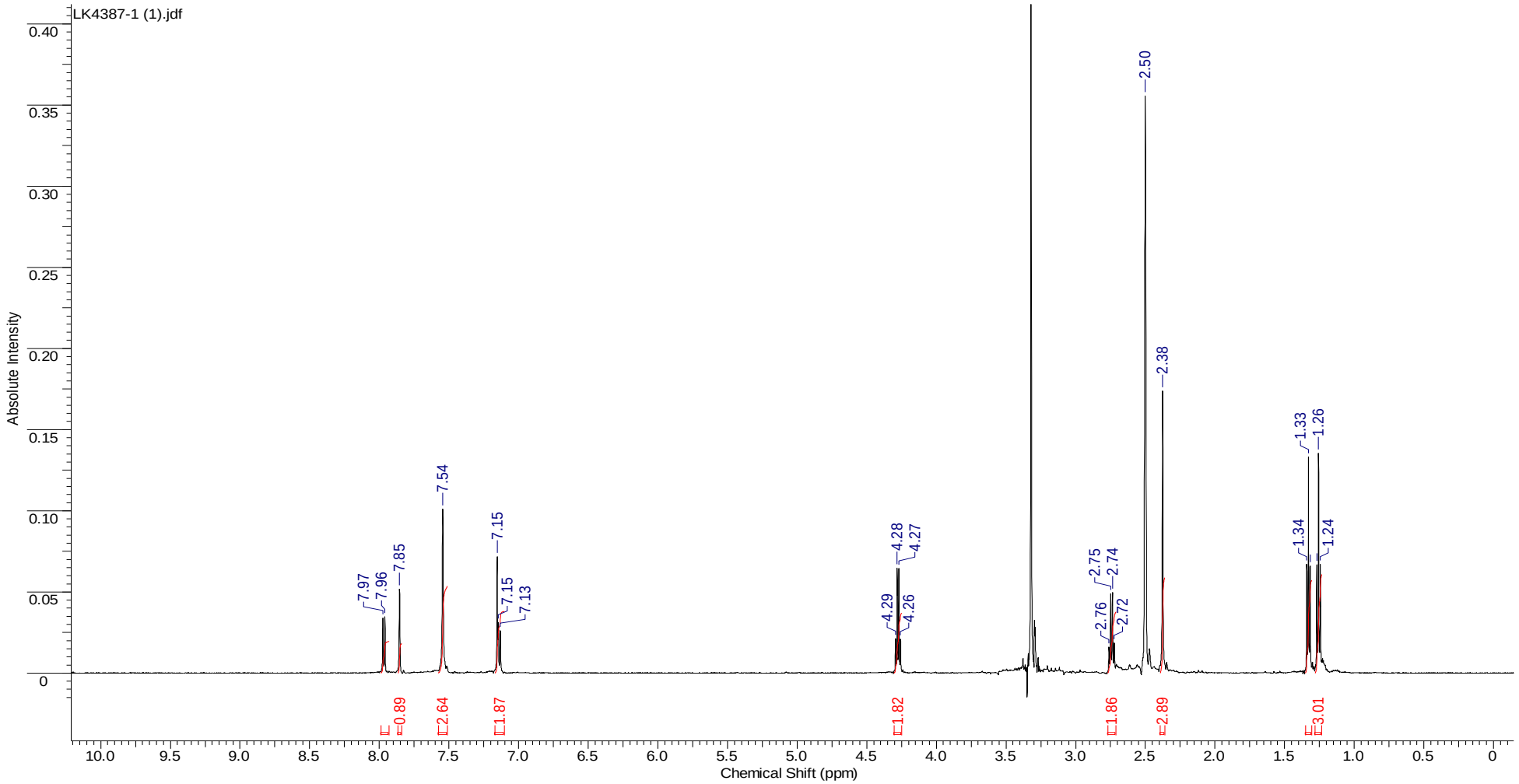
^{13}C NMR (DMSO-d_6, 150 MHz)



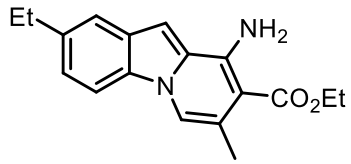
(4d)



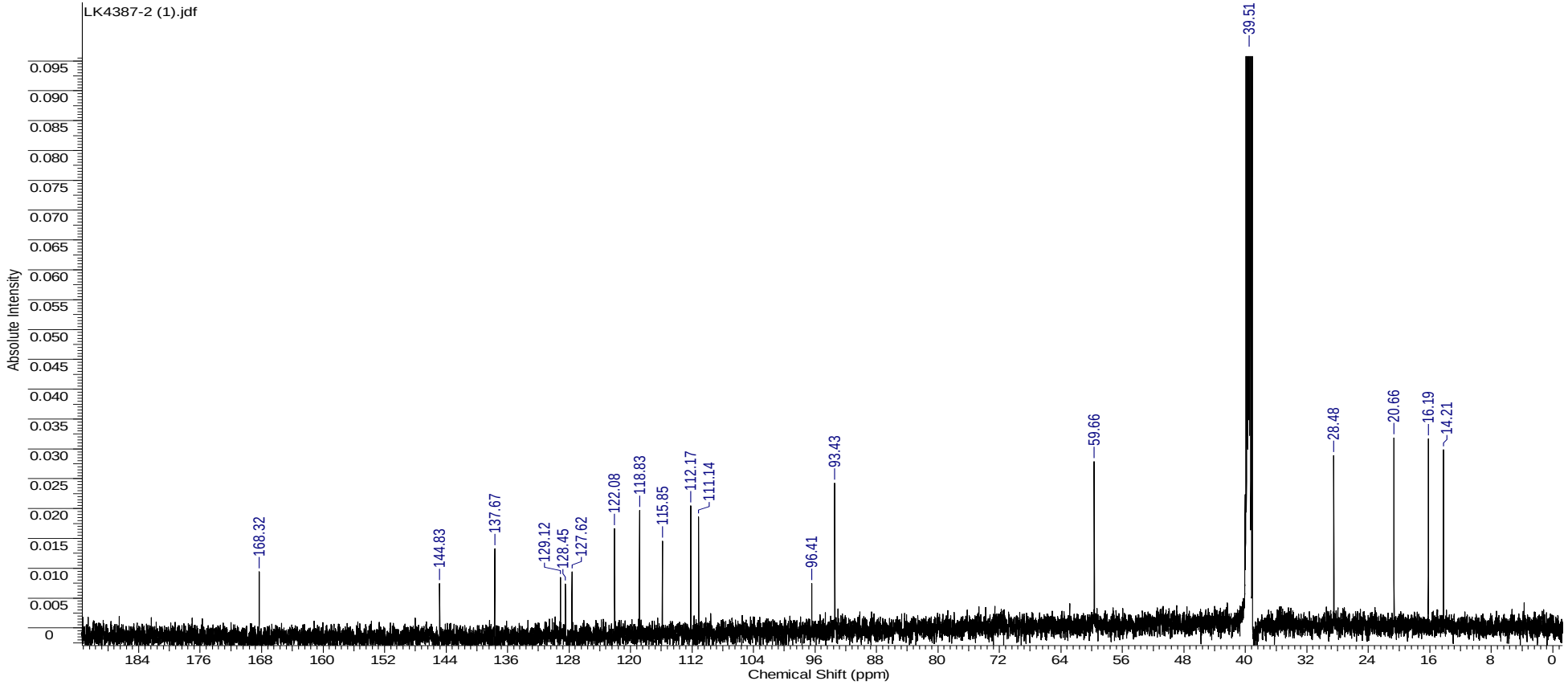
^{1}H NMR (DMSO-d_6, 600MHz):-



(4d)



^{13}C NMR (DMSO-d_6, 150 MHz)



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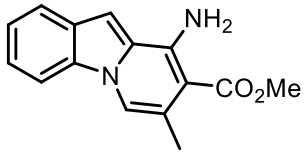
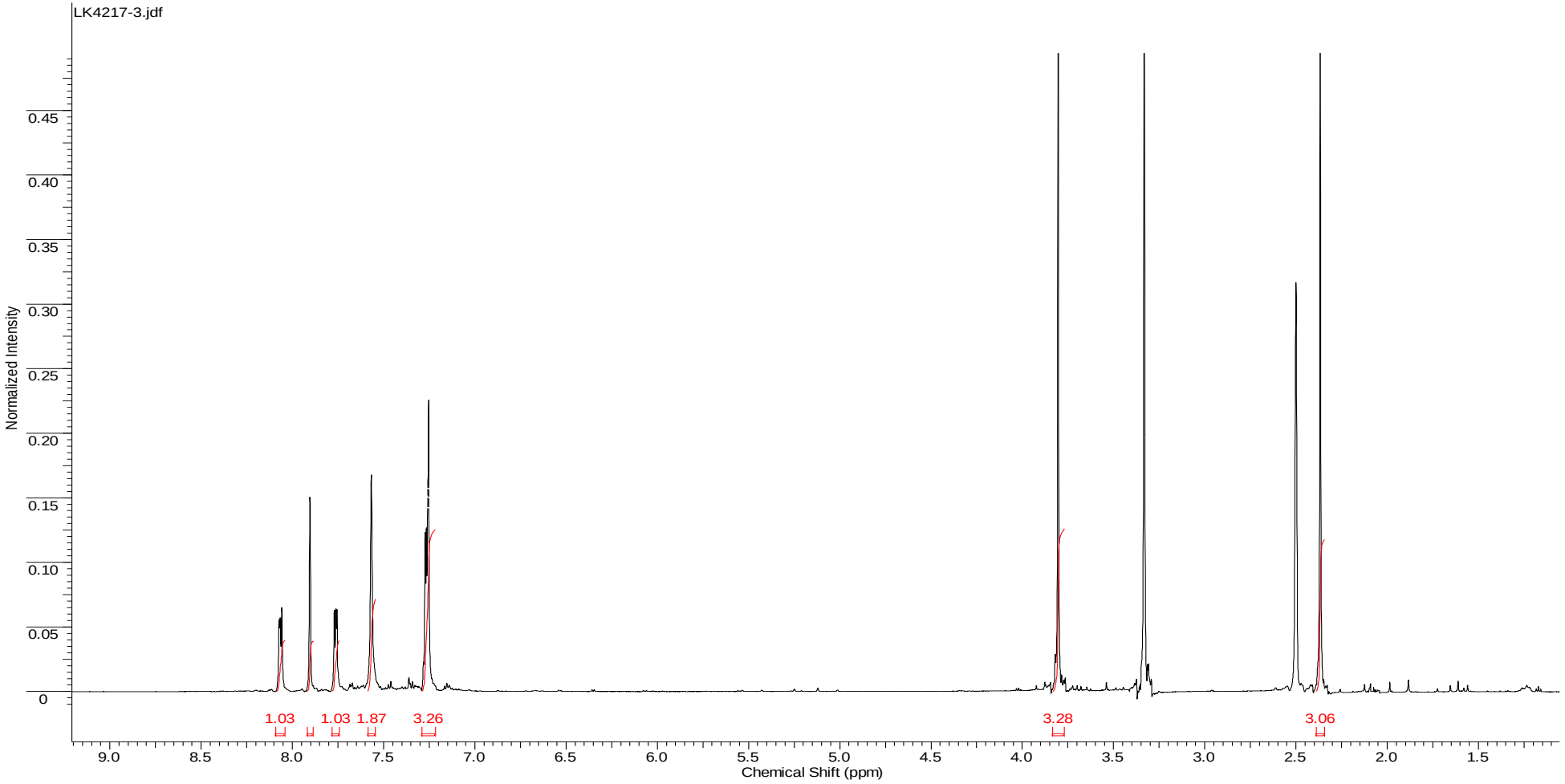


^{1}H NM (DMSO-d_6, 600MHz):-



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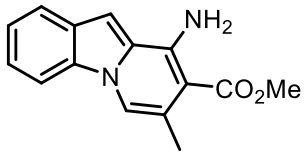
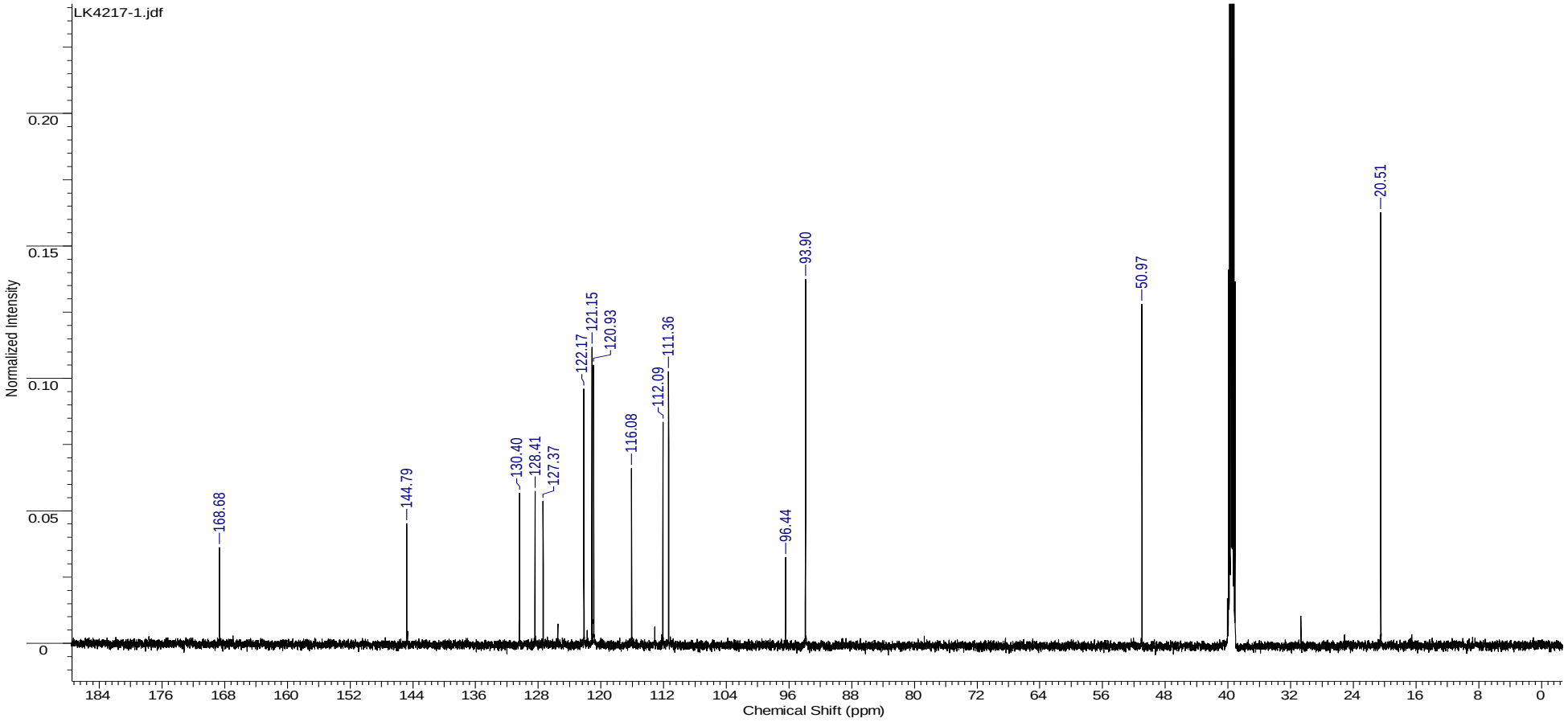


^{13}C NMR (DMSO-d_6, 150 MHz)



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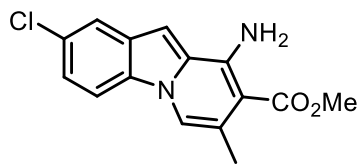
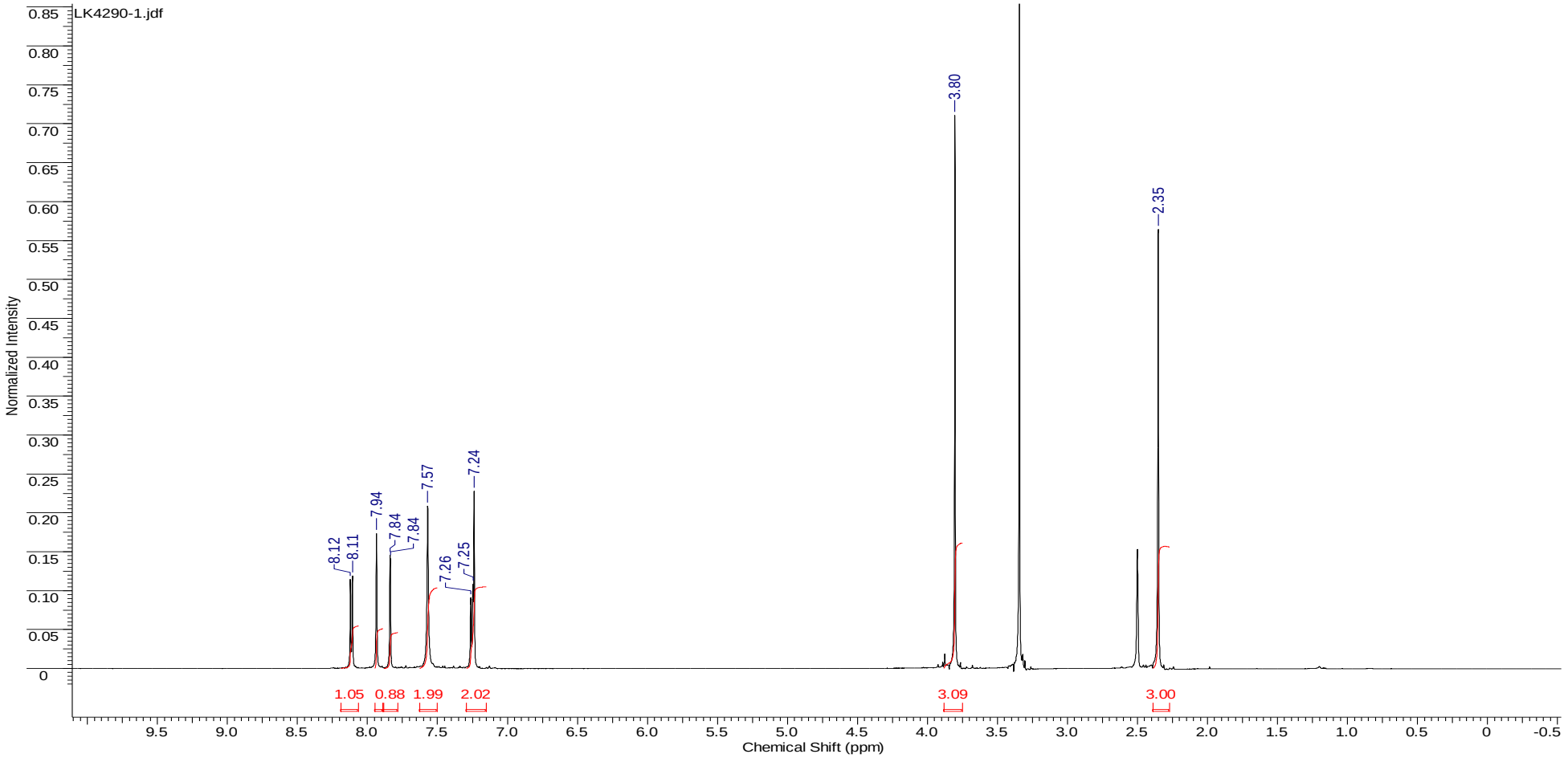


^{1}H NMR (DMSO-d_6, 600MHz):-



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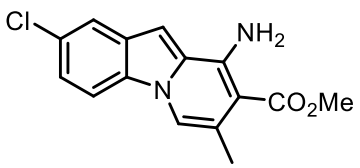
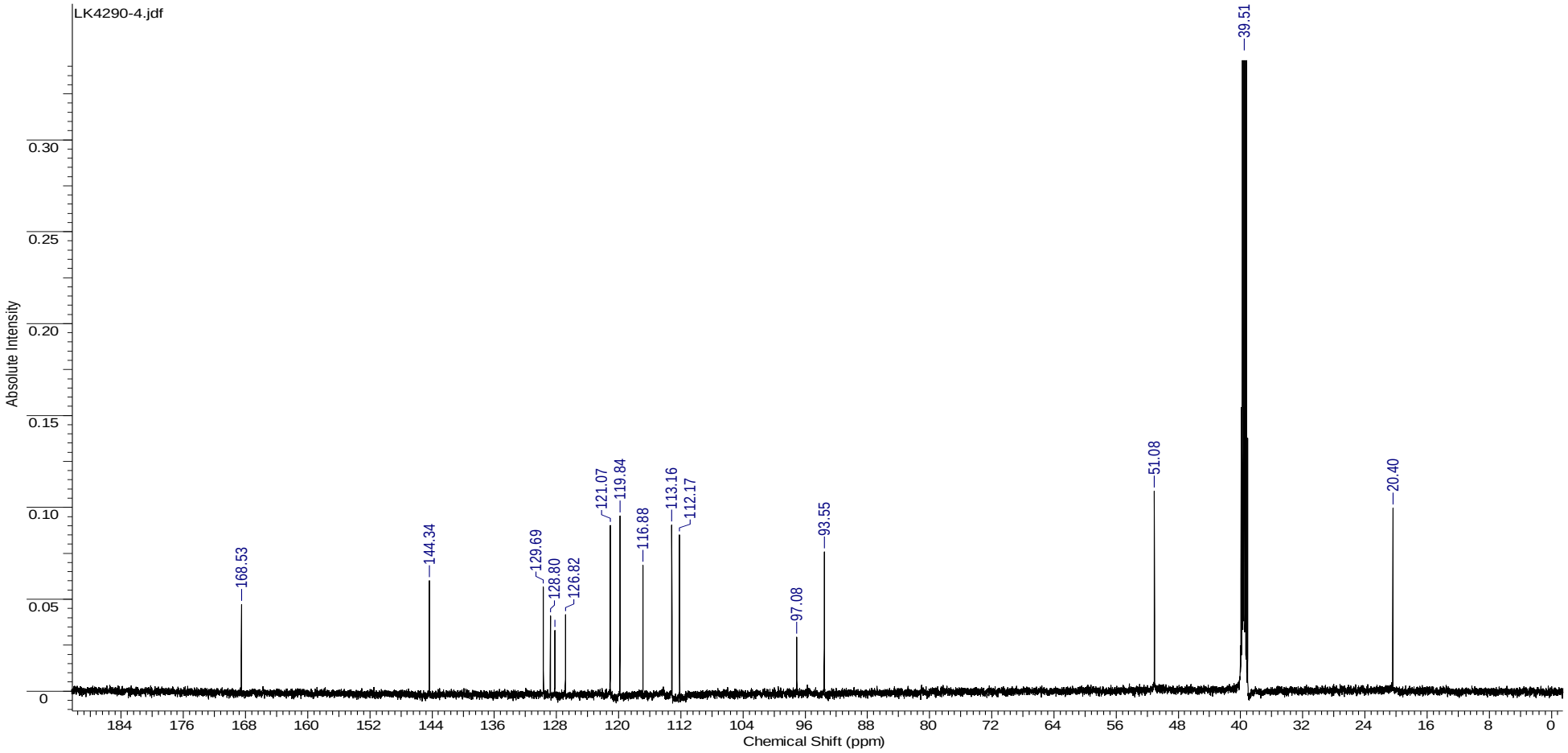


^{13}C NMR (DMSO-d_6, 150 MHz)



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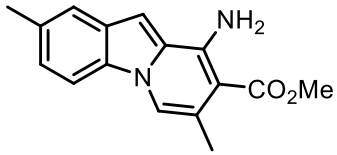
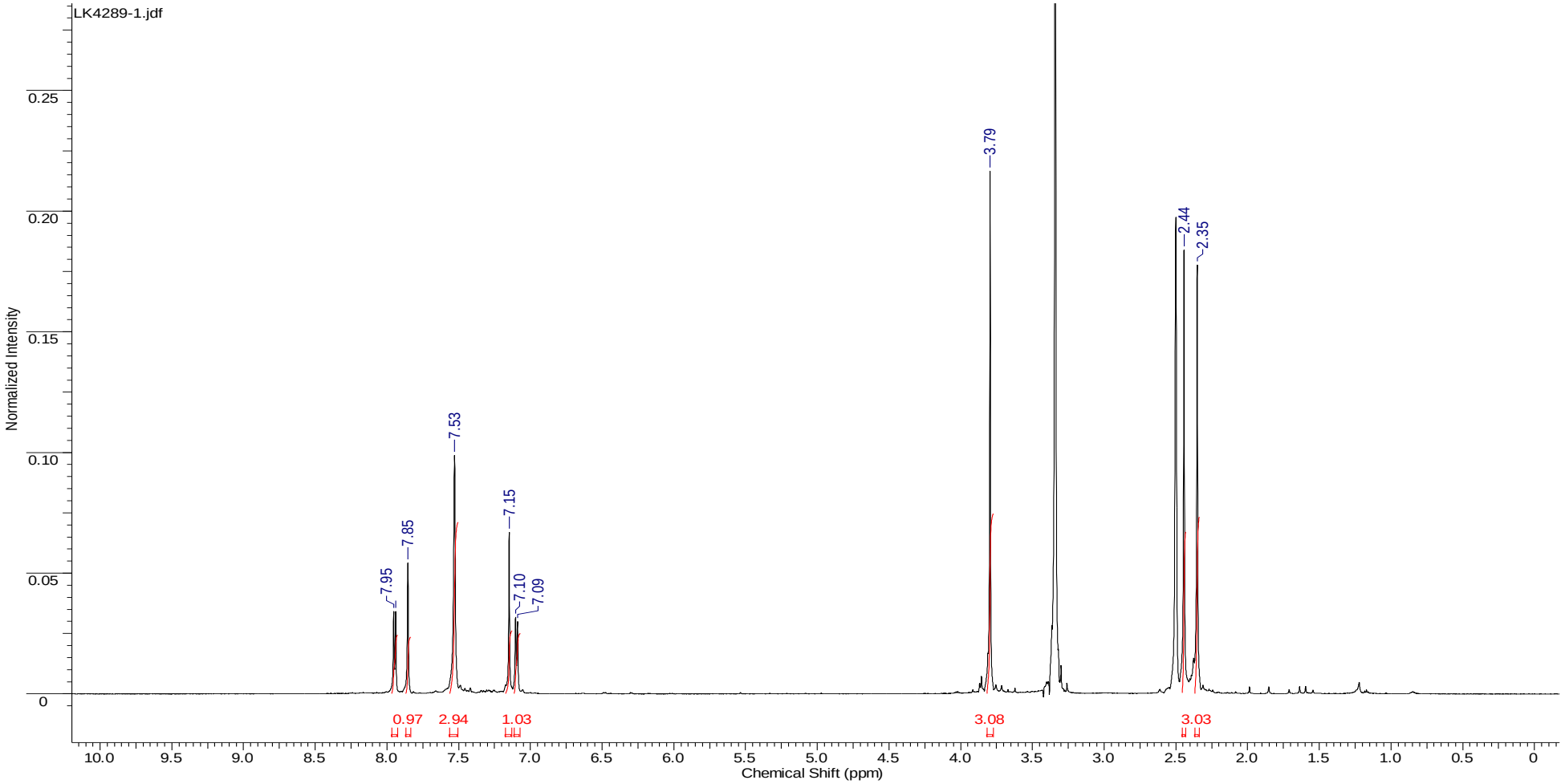


^{1}H NMR (DMSO-d_6, 150 MHz)



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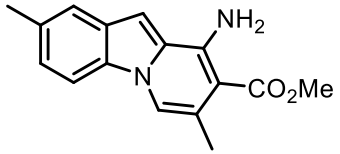
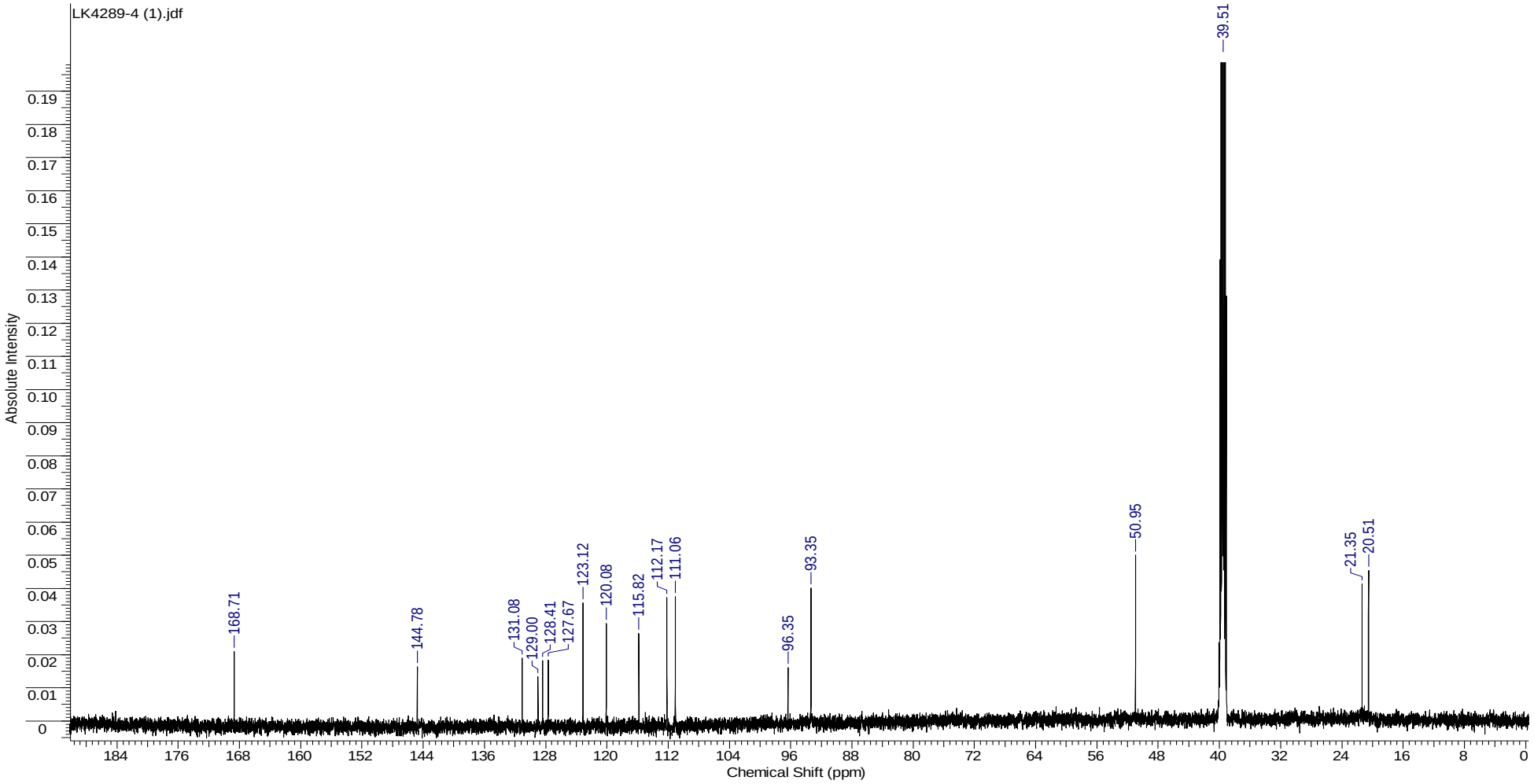


^{13}C NR (DMSO-d_6, 150 MHz)



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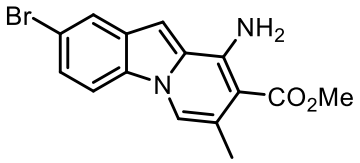
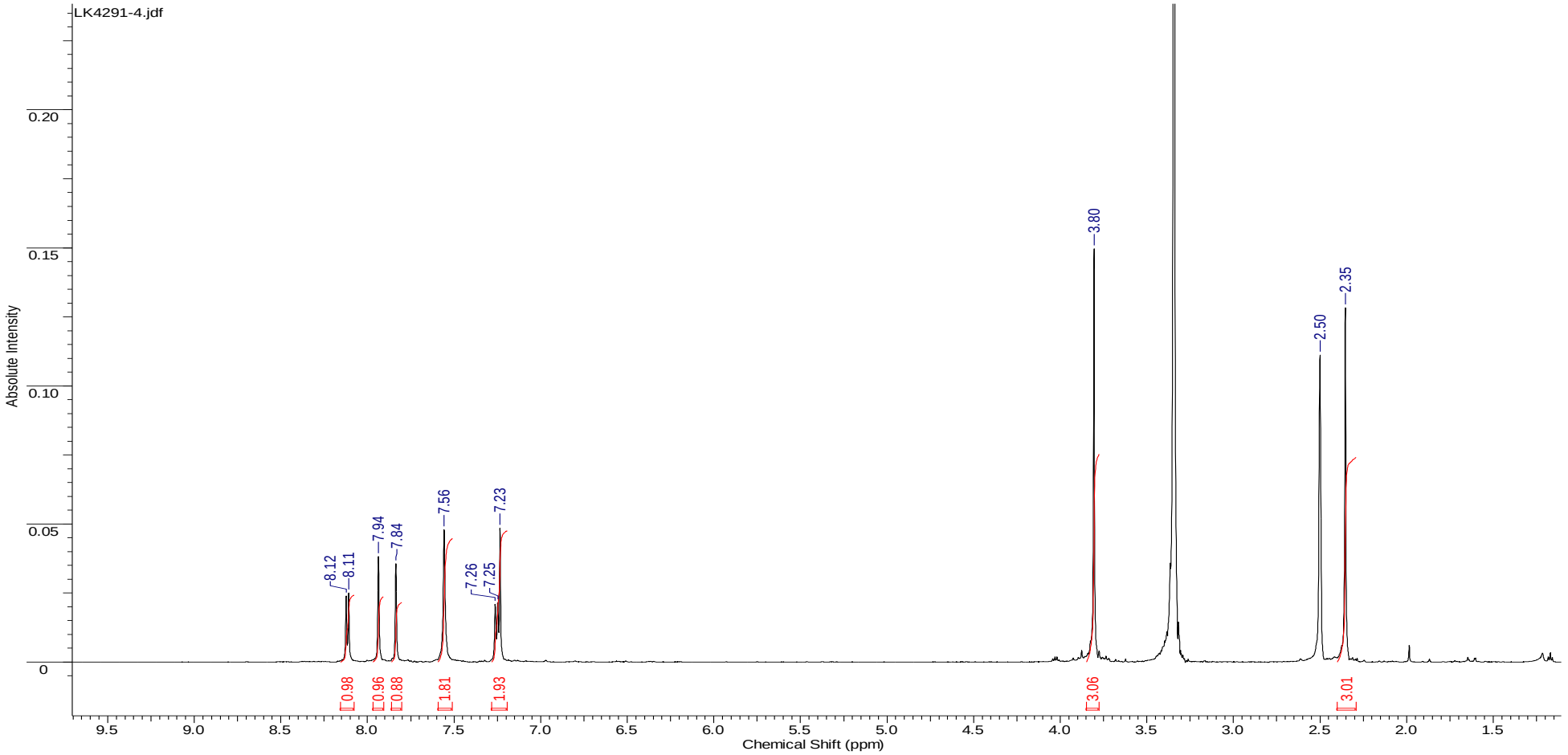


^{1}H NMR (DMSO-d_6, 600MH):-



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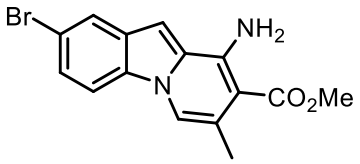
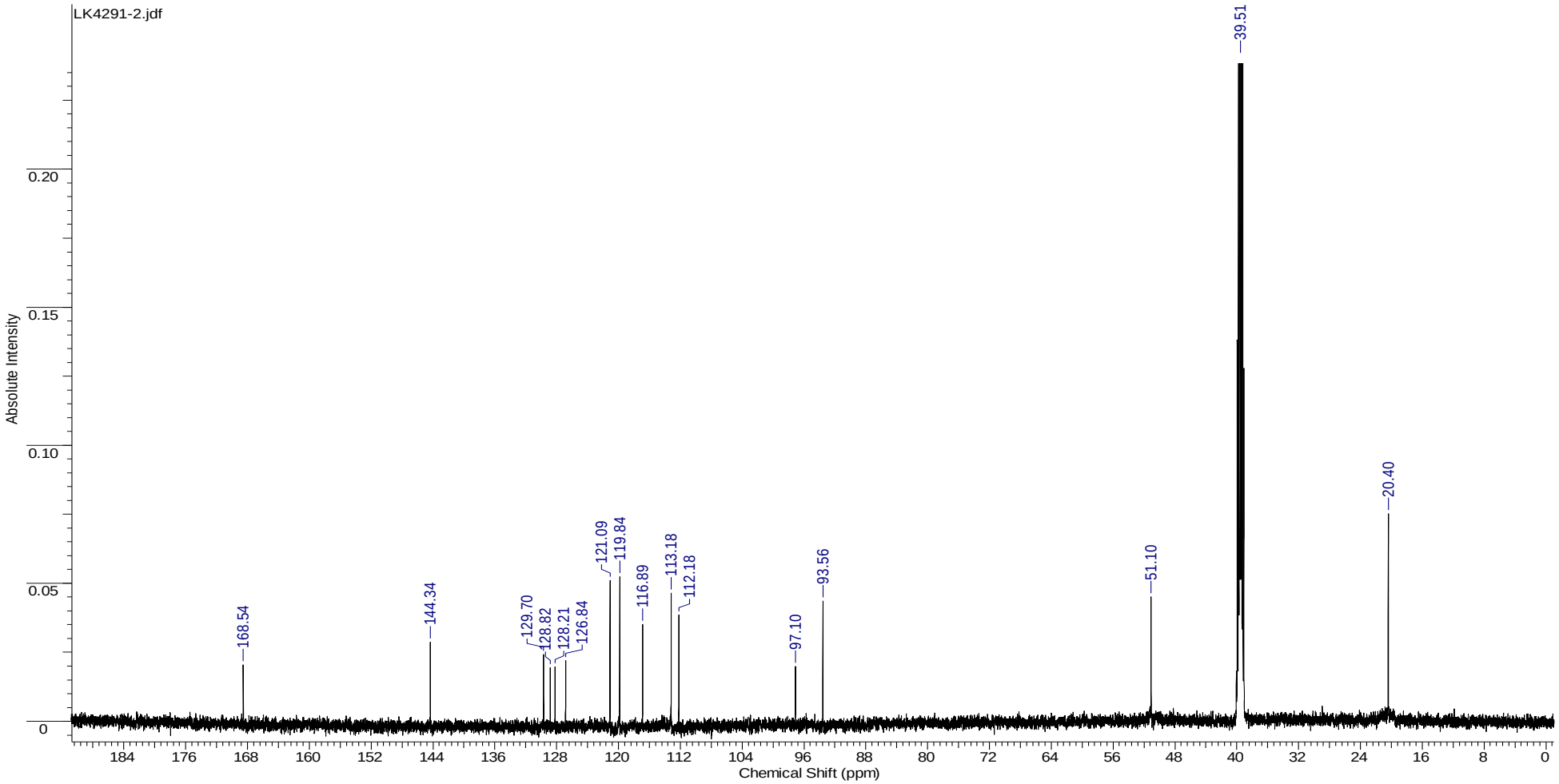


^{13}C NMR (DMSO-d_6, 150 MHz)



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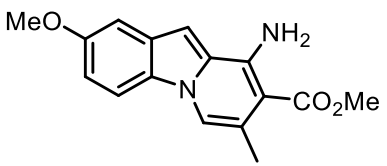
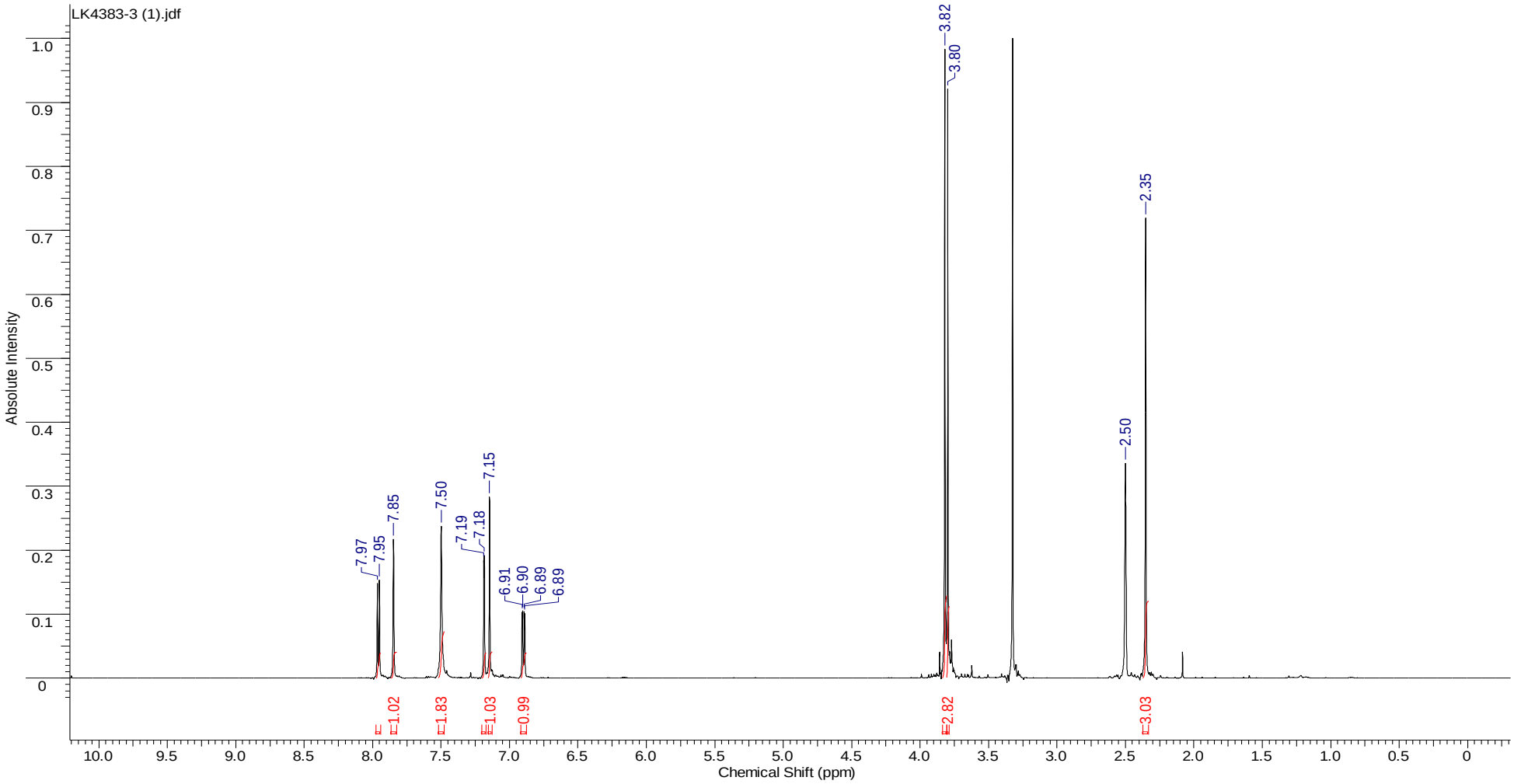


^{1}H NMR (DMSO-d_6, 600MH):-



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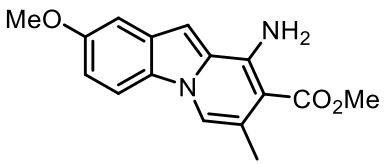
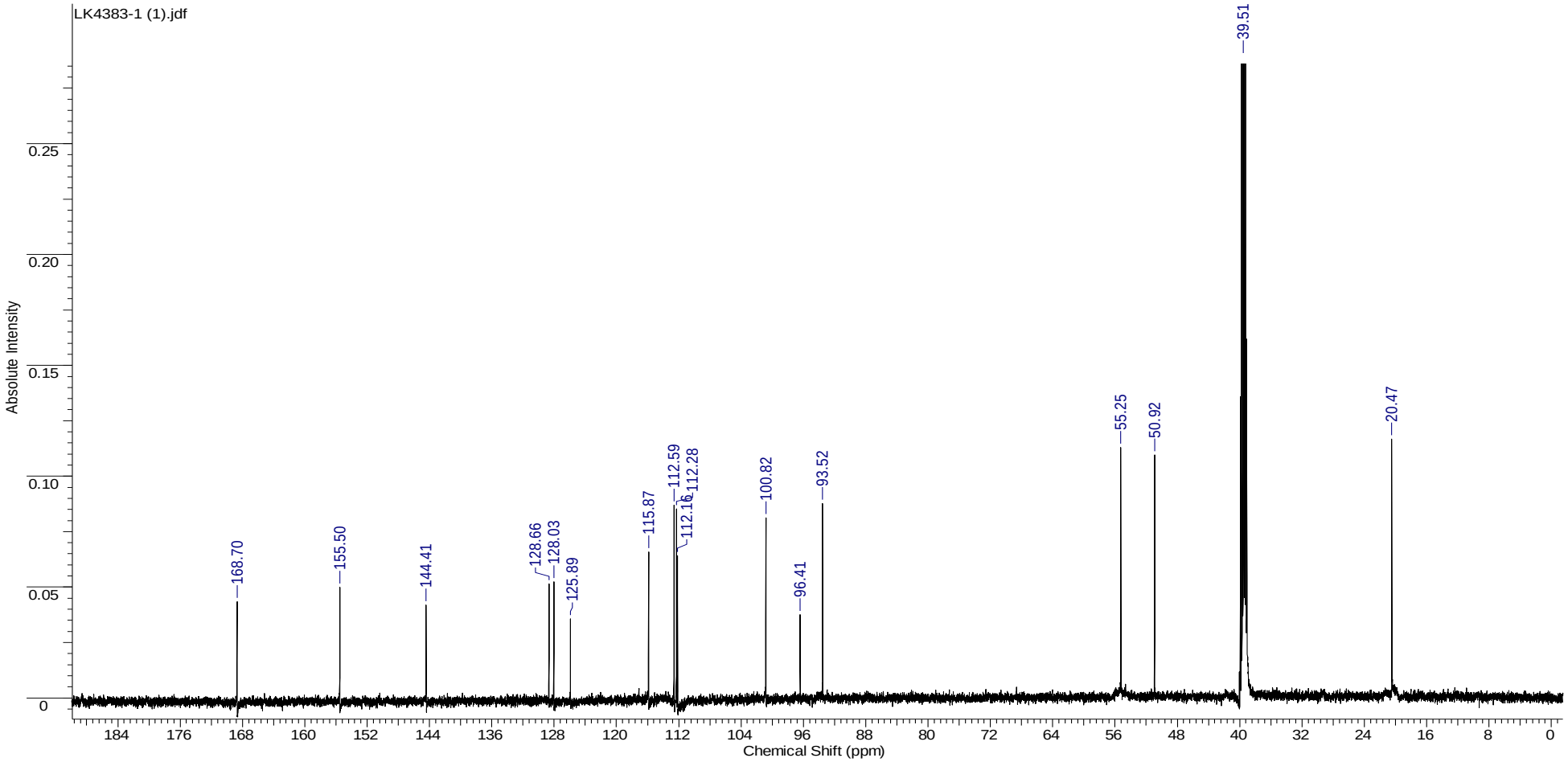


^{13}C NMR (DMSO-d_6, 150 MHz)



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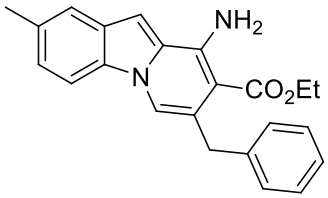
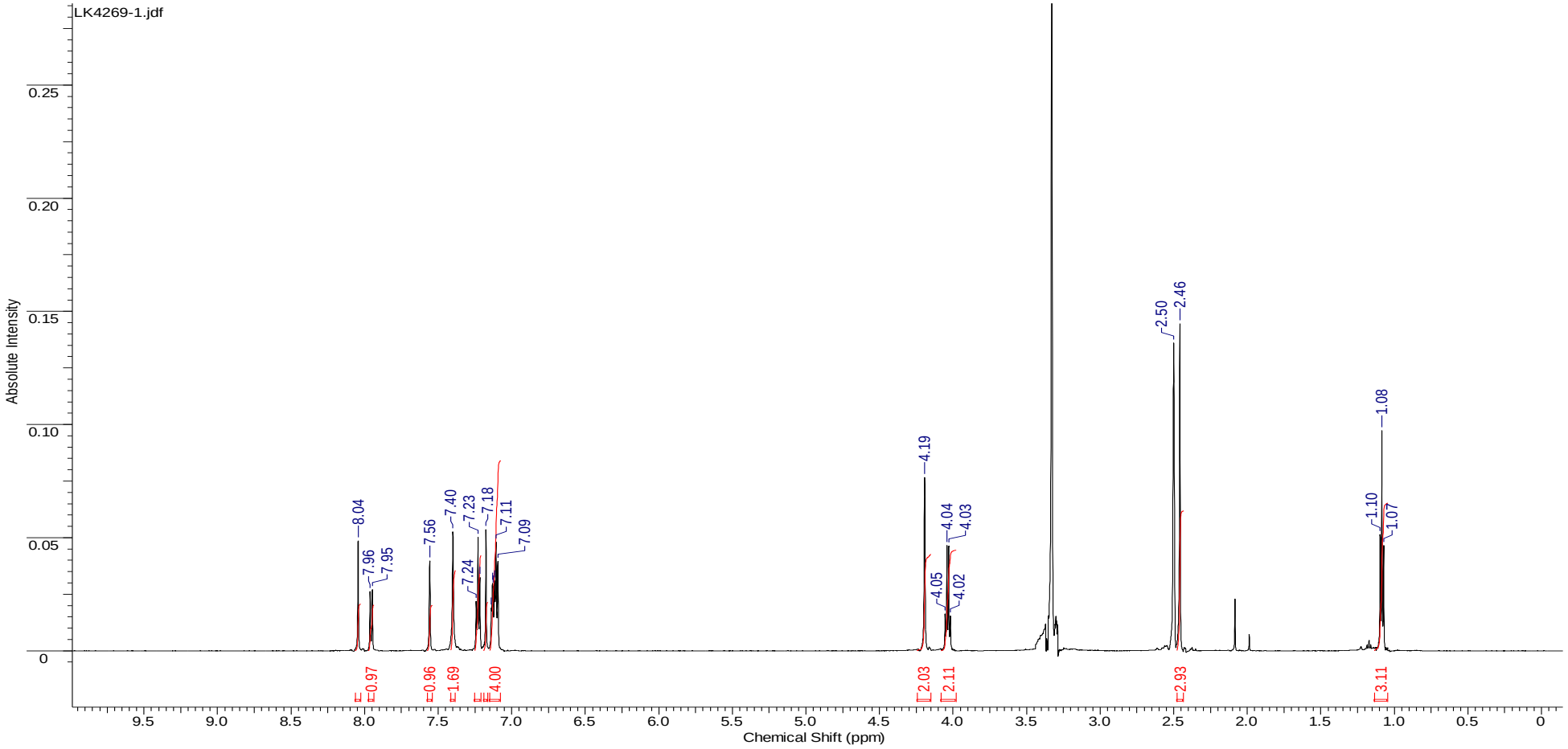


^{1}H NMR (DMSO-d_6, 600MH)



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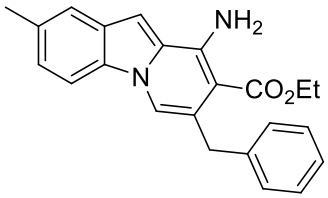
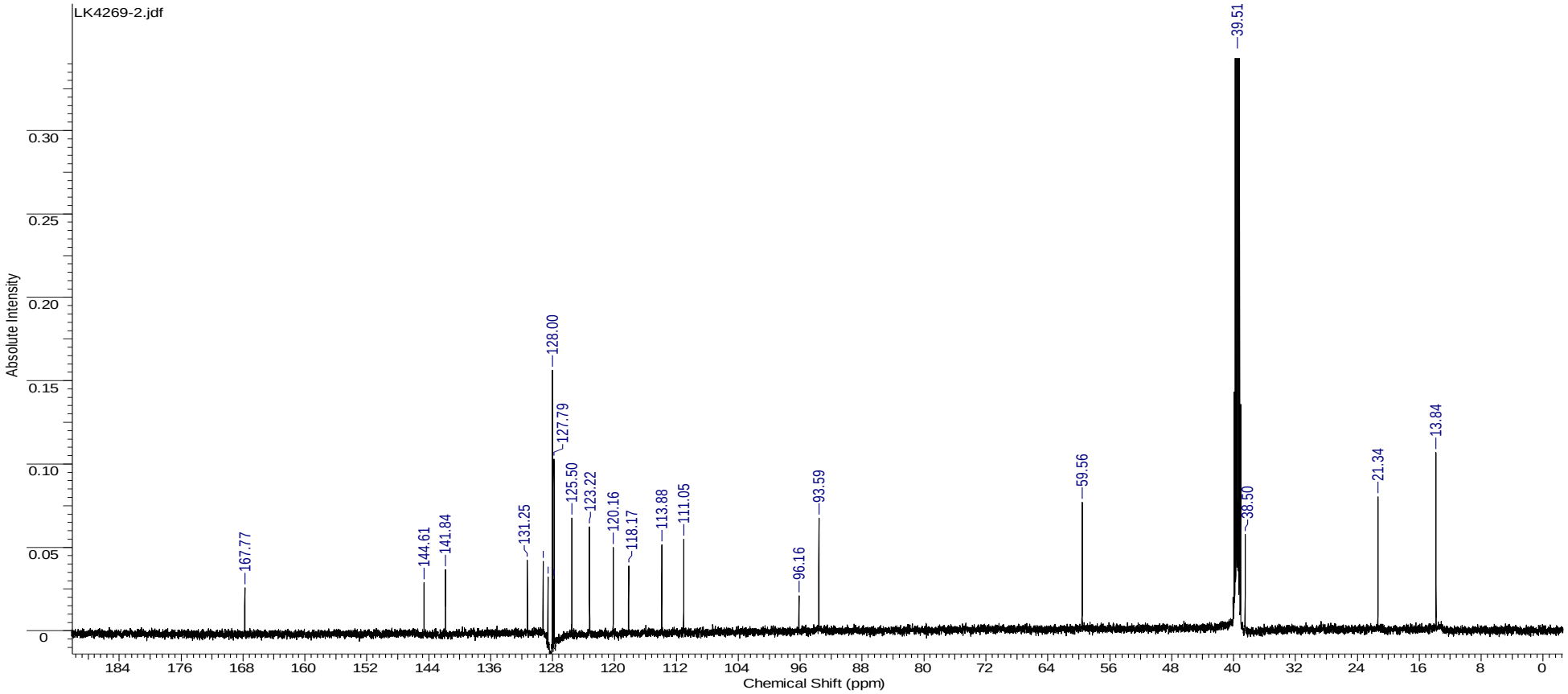


^{13}C NMR (DMSO-d_6, 150 MHz)



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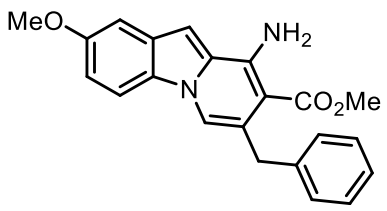

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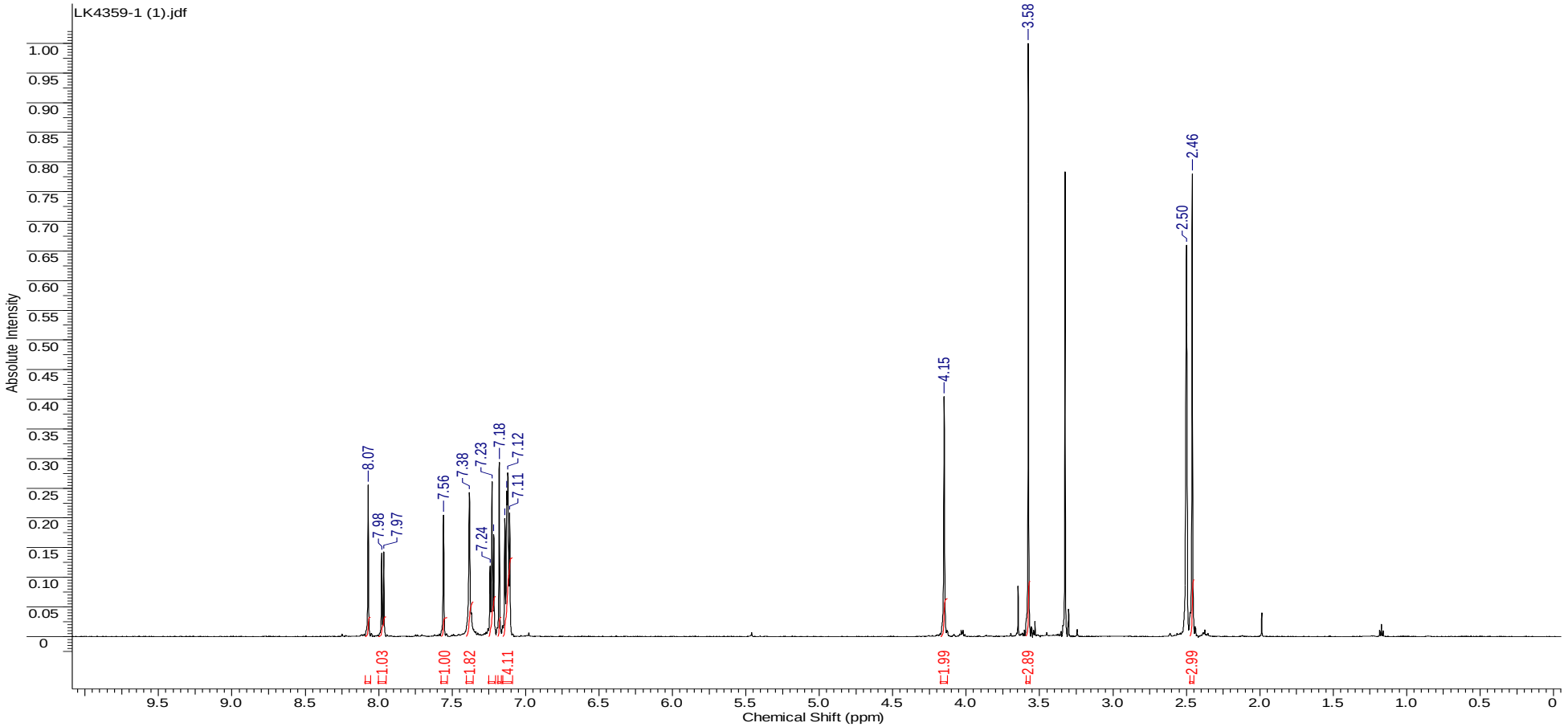

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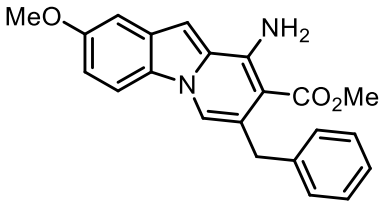
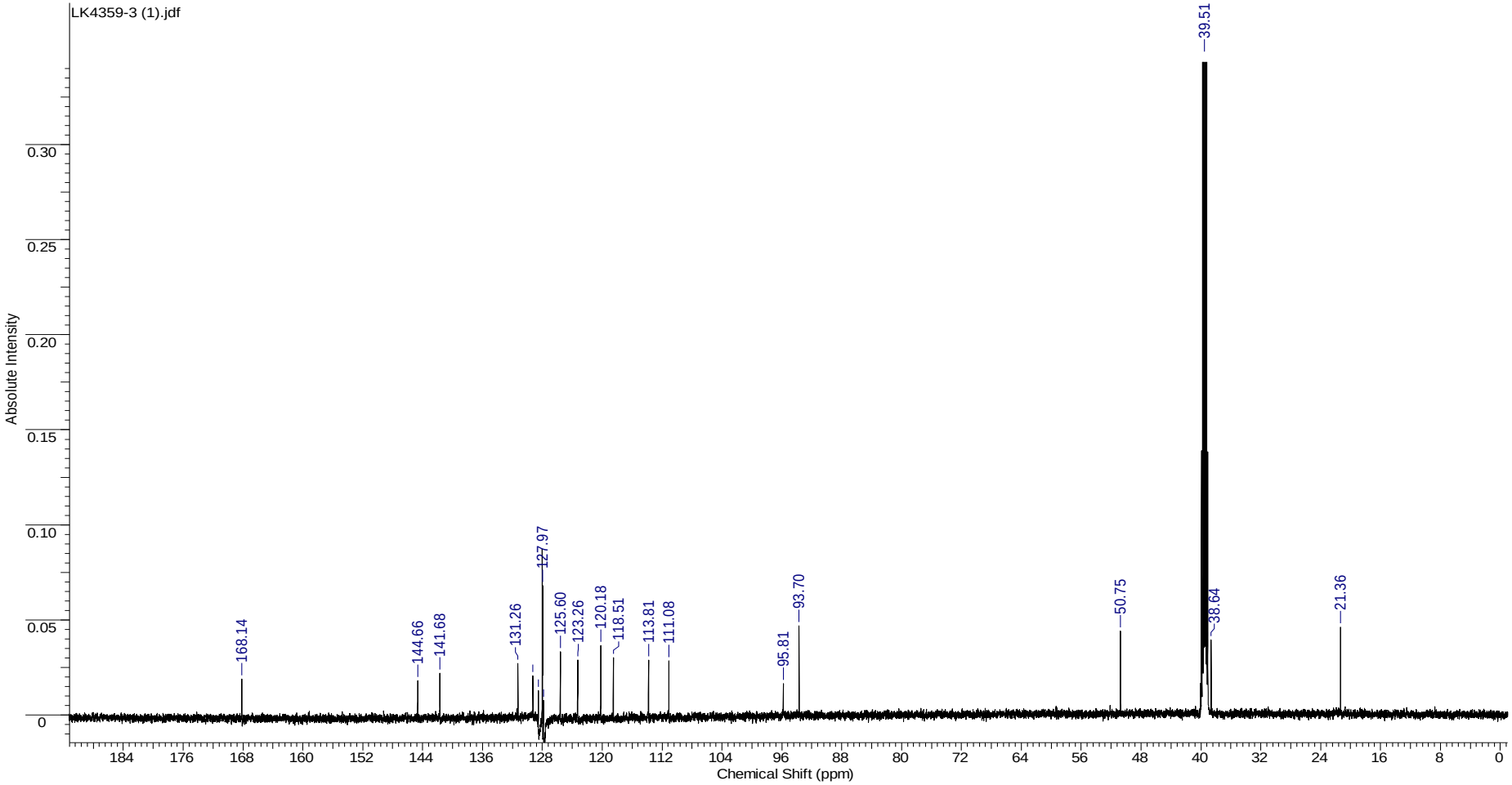


^{13}C NMR (DMSO-d_6, 150 MHz)



Optical Properties Studies

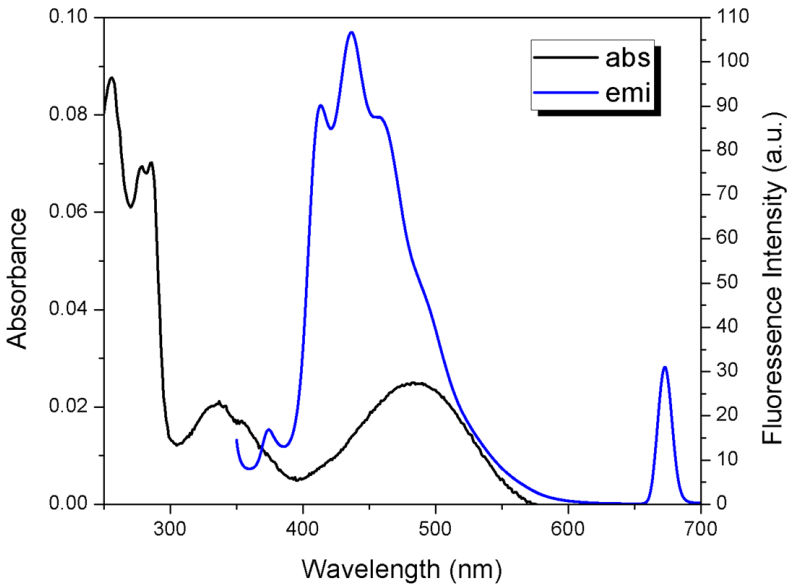
The absorption and fluorescence spectra were recorded using Varian Cary 100 UV/Vis, Hitachi F-7100 Spectrophotometer at 190 nm – 1100 nm wavelength range. The samples were dissolved in ethanol in a cuvette for fluorescence measurements. The optical path lengths for the absorption measurement was 0.5 cm and for the fluorescence measurement 10 mm. Excitation were performed at respective absorption OD wavelength of each compound (Table 2) with the 150 W xenon lamp, self-deozonating lamp house (slit with for both excitation emission is 5.0 nm).

The fluorescence quantum yields of the samples were determined by the relative method using coumarin 153 (97% purity) in ethanol as the reference (quantum yield = 0.546 [S2]) according to the following equation [S3]:

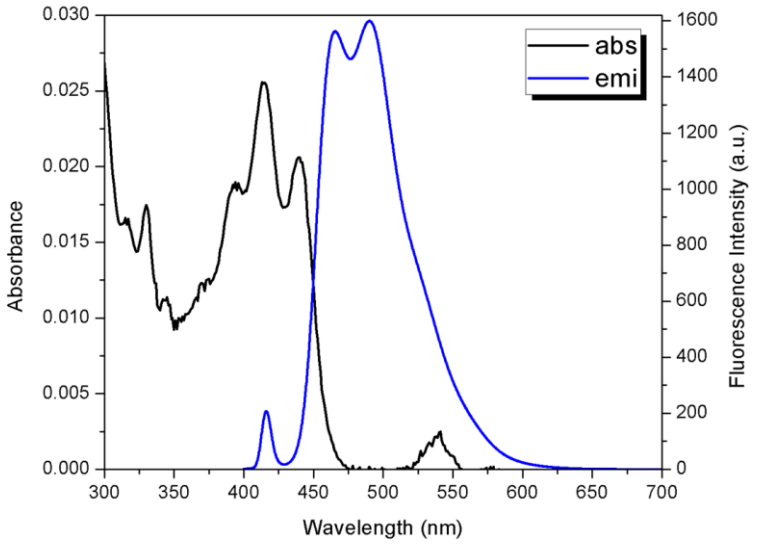
$$\Phi_{f,x} = \Phi_{f,st} \times \frac{F_x}{F_{st}} \times \frac{A_{st}}{A_x} \times \frac{\eta_x^2}{\eta_{st}^2}$$

where x denotes sample and st – the reference; F is the integral photon flux in relative units for the spectrally- and blank-corrected spectra; A is the integral absorbance in the range of 400±10 nm, n is the refractive index of the solvent (1.3614 for ethanol).

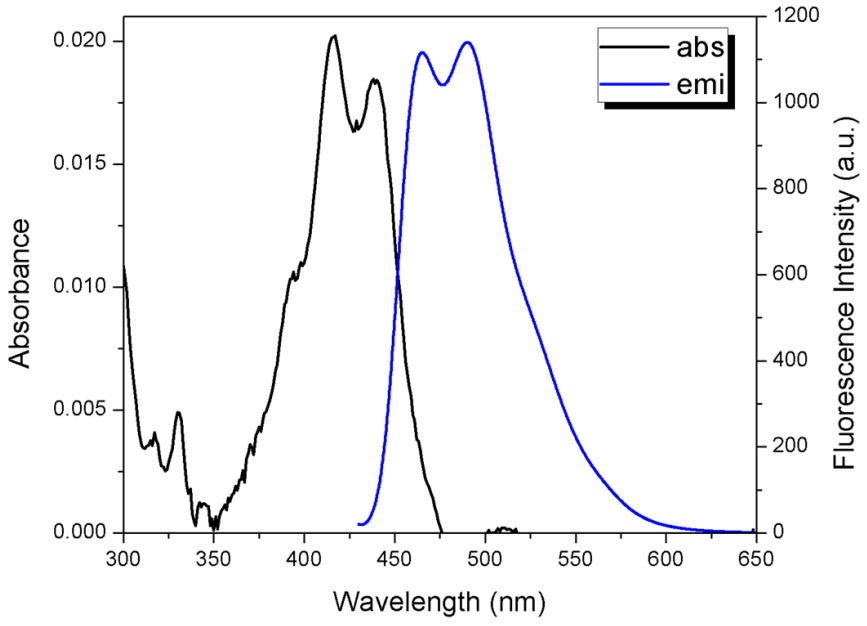
Absorption and fluorescence spectra for studied compounds in ethanol



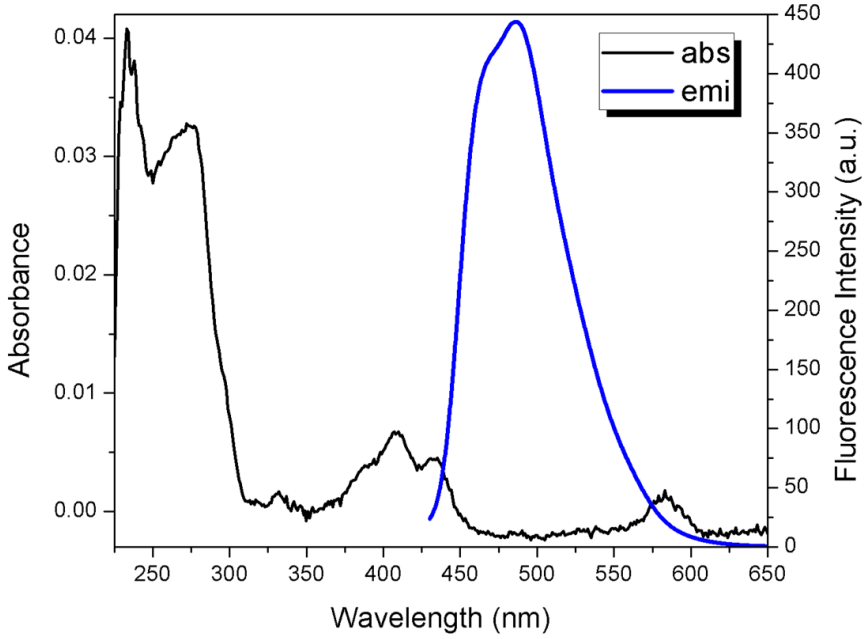
2b



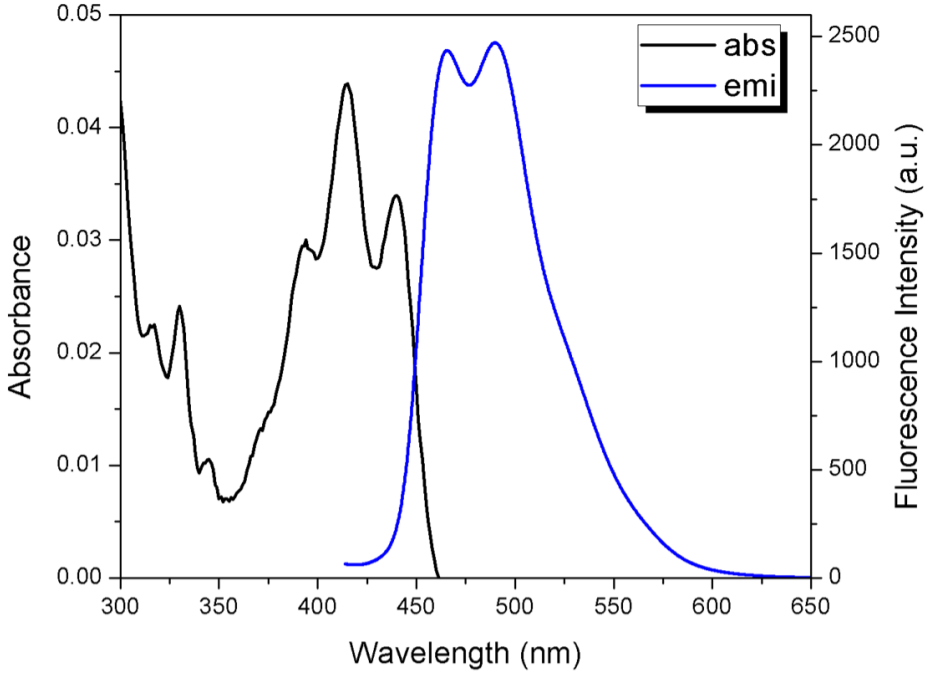
4a


abs
emi
Absorbance
Fluorescence Intensity (a.u.)
Wavelength (nm)
0.020
0.015
0.010
0.005
0.000
1200
1000
800
600
400
200
0
300
350
400
450
500
550
600
650

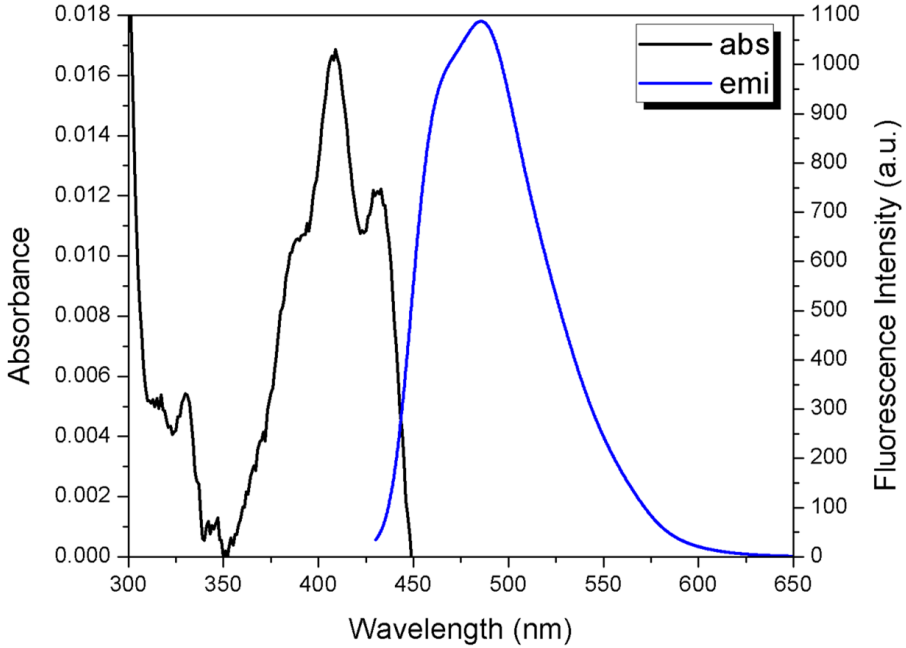
4b


abs
emi
Absorbance
Fluorescence Intensity (a.u.)
Wavelength (nm)
0.04
0.03
0.02
0.01
0.00
450
400
350
300
250
200
150
100
50
0
250
300
350
400
450
500
550
600
650

4 e


abs
emi
Absorbance
Fluorescence Intensity (a.u.)
Wavelength (nm)
0.05
0.04
0.03
0.02
0.01
0.00
2500
2000
1500
1000
500
0
300
350
400
450
500
550
600
650

4 f


abs
emi
Absorbance
Fluorescence Intensity (a.u.)
Wavelength (nm)
0.018
0.016
0.014
0.012
0.010
0.008
0.006
0.004
0.002
0.000
1100
1000
900
800
700
600
500
400
300
200
100
0
300
350
400
450
500
550
600
650

4 j

References

[S1] A. A. Festa, R. Z. Zalte, N. E. Golantsov, A. V. Varlamov, E. V. Van der Eycken, L. G. Voskressensky, *J. Org. Chem.*, **2018**, *83*, 9305-9311.

[S2] K. Rurack, M. Spieles, *Anal. Chem.* **2011**, *83*, 1232–1242.

[S3] C. Würth, M. Grabolle, J. Pauli, M. Spieles, U. Resch-Genger, *Nat. Protoc.* **2013**, *8*, 1535– 1550.