Electronic Supplementary Material (ESI) for New Journal of Chemistry.

Green synthesis and characterization of silver nanoparticles using *Ferula Latisecta* leaf extract and its application as catalyst for the safe and simple one-pot preparation of spirooxindoles in water

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SUPPORTING INFORMATION

Experimental Part

General. The chemicals used in this work were obtained from Fluka and Merck and were used without purification. Melting points were measured on an Electrothermal 9200 apparatus. IR spectra were recorded as KBr pellets on a Perkin-Elmer 781 spectrophotometer and an Impact 400 Nicolet FT-IR spectrophotometer. ^{1}H NMR and ^{13}C NMR spectra were recorded in DMSO–d_6 solvents on a Bruker DRX-400 spectrometer. The elemental analyses (C, H, N) were obtained from a Carlo ERBA Model EA 1108 analyzer. Nanostructures were characterized using a Holland Philips Xpert X-ray powder diffraction (XRD) diffractometer (Cu K, radiation, k = 0.154056 nm), at a scanning speed of 2°/min from 10° to 100° /(2θ). Transmission electron microscopic (TEM) was performed with a Jeol JEM- 2100UHR, operated at 200 kV that were previously air-dried. The purity determination of the substrates and reaction monitoring were accomplished by TLC on silica-gel polygram SILG/UV 254 plates (from Merck Company). *Ferula Latisecta* was collected from Hezar masjed mountain-Khorasan-Iran.

a) Preparation of plant aqueous extracts

Aqueous extract was prepared by mixing 5 g of dried fresh leaves powder of *Ferula Latisecta* with 100 mL of water with constant stirring on a magnetic stirrer. The mixture was boiled for 15 min before being decanted, and was cooled and filtered through Whatman No. 1 filter paper. The boiled extract was refrigerated and used for further experimental procedures.

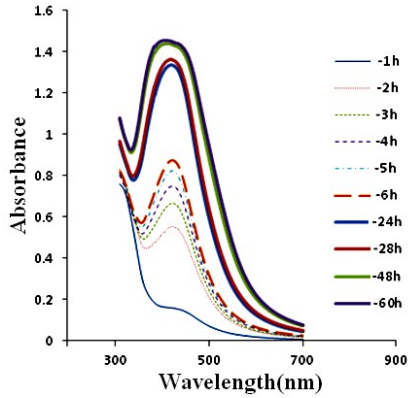
b) Synthesis of AgNPs

Silver nanoparticles were prepared by adding 0.5 ml of *Ferula Latisecta* leaf extract to 20 ml of 1 mM aqueous silver nitrate solution. The reaction mixture containing silver nitrate solution and plant extract was agitated and incubated at 70 °C, 500 rpm for 48 h. The solution turned from yellowish to dark brown. The obtained nanoparticles solution was purified by repeated centrifugation at 12,000 rpm for 20 min followed decanted and dried at 60 °C in oven over night.

Characterization of silver nanoparticles

UV-Vis spectrophotometer analysis:

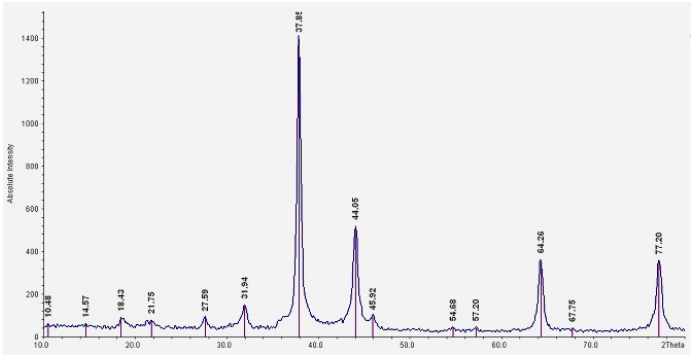
The UV–Vis spectra showed maximum absorbance peak at 420 nm, which increased with time of incubation of silver nitrate with the plant extract (**S1**). The curves show increased absorbance in various time intervals (8 h, 20 h, and 40 h) and the peaks were noticed at 420 nm corresponding to the surface plasmon resonance of silver nanoparticles. The observation indicated that the reduction of the Ag^{+} ions took place.



S1: UV–Visible spectra of aqueous 1 mM silver nitrate with *F. Latisecta* leaf extract at different time intervals in 70 °C with 0.5/20 concentration.

X-ray diffraction (XRD)

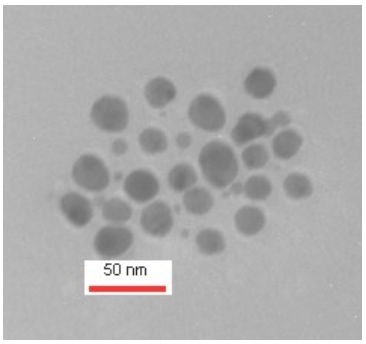
The X-ray diffraction (XRD) has proven to be a valuable research tool to prove the formation of AgNPs. The X-ray diffraction pattern of Ag NPs produced by leaf extract is shown in **S2**. The XRD pattern shows four characteristic peaks in the whole spectrum. The peaks at 2Θ values of 38.68°, 44.1°, 64.11°, and 77.4° corresponding to 111, 200, 220, and 311 crystalline planes of face centered cubic (fcc) crystalline structure of metallic silver which was matched with the database of Joint Committee on Powder Diffraction Standards (JCPDS) file No. 04–0783. The mean size of Ag NPs was also calculated using the Debye–Scherrer's equation it shows that diameter of produced Ag NPs is about 20 nm.



|**S2**: The X-ray diffraction patterns of biosynthesized Silver nanoparticles.

Transmission Electron Microscopy (TEM)

Morphology and particle size of Ag NPs were characterized using TEM technique. As can be seen in S3, the morphology of nanoparticles is spherical without aggregation of particles. Additionally the TEM image shows that the AgNPs nanoparticles have a mean diameter of about 20–30 nm.



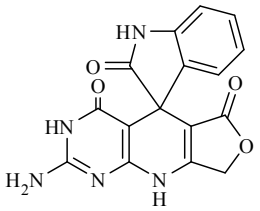
S3: The TEM image of biosynthesized silver nanoparticles

c) Synthesis of 2-Amino-3*H*-spiro[furo[3,4-*g*]pyrido[2,3-*d*]pyrimidine-5,3'-indoline]-2',4,6(8*H*,9*H*) -trione in the presence of Ag NPs (4a)

A mixture of isatin **1a**, tetronic acid **3a**, 2, 6-diaminopyrimidin-4(3*H*)-one **2c,** and Ag NPs (2 mol%) in water (5 ml) was stirred at reflux conditions for an appropriate time. After completion of the reaction as indicated by TLC, the solution was cooled to room temperature, then the precipitated product was filtered and washed with water (10 mL), dried to afford the crude product. The crude precipitate dissolved in DMF and centrifuged to separate the catalyst and latter the catalyst was washed several times

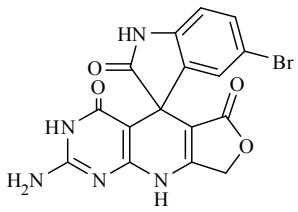
with EtOH, then dried and reutilized four times for the same reaction. After separation of catalyst, 10 ml water was poured in the mixture of reaction to precipitate of the product. Then, the precipitate was filtered and washed with water and recrystallized by EtOH to afford the pure product.

2-Amino-3H-spiro[furo[3,4-g]pyrido[2,3-d]pyrimidine-5,3'-indoline]-2',4,6(8H,9H) -trione **(4a):**



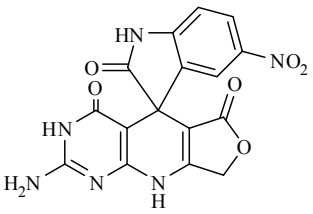
White powder (Yield: 87%, 0.421 g). mp: >350 ˚C. IR (KBr) (ν_{max}/ cm^{-1}): 3420, 3156, 1751, 1713, 1638; ^{1}H NMR (DMSO-d_6, 400 MHz): δ_{ppm}: 4.85 (2H, s, OCH_2), 6.59-7.08 (6H, m, ArH and NH_2), 10.08 (1H, s, NH), 10.22 (1H, s, NH), 10.49 (1H, s, NH); ^{13}C NMR (DMSO-d_6, 100 MHz): δ_{ppm}: 47.4, 65.7, 91.0, 98.6, 108.9, 121.5, 123.8, 127.9, 136.0, 142.7, 155.0, 155.4, 158.8, 161.1, 170.2, 179.0; MS: m/z 337.

2-Amino-5'-bromo-3H-spiro[furo[3,4-g]pyrido[2,3-d]pyrimidine-5,3'-indoline]- 2',4,6 8H,9H)-trione **(4b):**



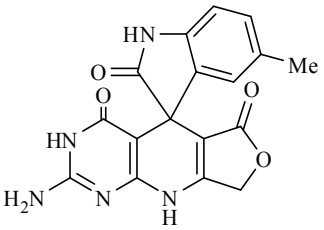
Cream powder (Yield: 85%, 0.352 g). mp: >350 ˚C. IR (KBr) (ν_{max}/ cm^{-1}): 3465, 3249, 1729, 1645, 1519; ^{1}H NMR (DMSO-d_6, 400 MHz): δ_{ppm}: 4.87 (2H, s, OCH_2), 6.65-7.26 (5H, m, ArH and NH_2), 10.16 (1H, s, NH), 10.38 (1H, s, NH), 10.53 (1H, s, NH); ^{13}C NMR (DMSO-d_6, 100 MHz): δ_{ppm}: 48.8, 65.9, 88.2, 94.2, 117.8, 122.3, 125.2, 135.9, 142.5, 142.8, 153.5, 158.3, 159.2, 162.5, 170.6, 178.9; MS: m/z, 416, 414**.**

2-Amino-5'-nitro-5'-nitro-3H-spiro[furo[3,4-g]pyrido[2,3-d]pyrimidine-5,3'- indoline]-2',4,6(8H,9H)-trione **(4c):**



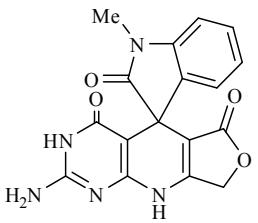
Yellow powder (Yield: 91%, 0.346 g). mp: >350 ˚C. IR (KBr) (ν_{max}/ cm^{-1}): 3449, 3173, 1727, 1640, 1594; ^{1}H NMR (DMSO-d_6, 400 MHz): δ_{ppm}: 4.90 (2H, s, OCH_2), 6.70-8.10 (5H, m, ArHw and NH_2), 10.29 (1H, s, NH), 10.60 (1H, s, NH), 11.02 (1H, s, NH); ^{13}C NMR (DMSO-d_6, 100 MHz): δ_{ppm}: 47.4, 66.1, 90.0, 97.3, 109.0, 119.3, 125.8, 136.8, 142.4, 149.5, 155.2, 155.7, 159.8, 161.3, 170.3, 179.7; MS: m/z 382.

2-Aamino-5'-methyl-3H-spiro[furo[3,4-g]pyrido[2,3-d]pyrimidine-5,3'-indoline]-2',4,6(8H,9H)-trione **(4d):**



Cream powder (Yield: 86%, 0.301 g). mp: >350 ˚C. IR (KBr) (ν_{max}/ cm^{-1}): 3392, 3271, 1732, 1641, 1518 ^{1}H NMR (DMSO-d_6, 400 MHz): δ_{ppm}: 2.13 (3H, s, CH_3), 4.82 (2H, s, OCH_2), 6.55-6.84 (5H, m, ArH and NH_2), 10.04 (1H, s, NH), 10.08 (1H, s, NH), 10.45 (1H, s, NH); ^{13}C NMR (DMSO-d_6, 100 MHz): δ_{ppm}: 21.0, 47.4, 65.6, 91.1, 98.7, 108.6, 124.4, 128.2, 130.1, 136.1, 140.3, 154.9, 155.3, 158.7, 161.1, 170.2, 178.9; MS: m/z 351.

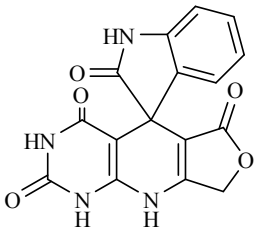
2-Amino-1'-methyl-3H-spiro[furo[3,4-g]pyrido[2,3-d]pyrimidine-5,3'-indoline]-2',4,6(8H,9H)-trione **(4e):**



Cream powder (Yield: 79%, 0.277 g). mp: >350 ˚C. IR (KBr) (ν_{max}/ cm^{-1}): 3490, 3376, 3211, 1680, 1647; ^{1}H NMR (DMSO-d_6, 400 MHz): δ_{ppm}: 3.10 (3H, s, CH_3), 4.87 (2H, s, OCH_2), 6.64-7.20- (6H, m, ArH and NH_2), 10.14 (1H, s, NH), 10.41 (1H,

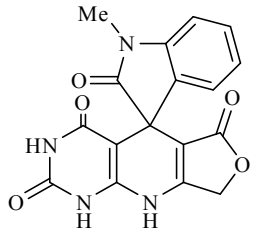
s, NH); ^{13}C NMR (DMSO-d_6, 100 MHz): δ_{ppm}: 26.6, 46.9, 65.8, 90.8, 98.4, 107.7, 122.2, 123.5, 128.2, 135.1, 144.2, 155.3, 155.4, 158.9, 161.1, 170.1, 177.5; MS: m/z 351.

1H-Spiro[furo[3,4-g]pyrido[2,3-d]pyrimidine-5,3'-indoline]-2,2',4,6(3H,8H,9H)-tetraone **(4f):**



White powder (Yield: 84%, 0.283 g). mp: >350 °C. IR (KBr) (ν_{max}/ cm^{-1}): 3175, 3103, 1693, 1650, 1538; ^{1}H NMR (DMSO-d_6, 400 MHz): δ_{ppm}: 4.90 (2H, s, OCH_2), 6.69-7.08 (4H, m, ArH), 10.02 (1H, s, NH), 10.33 (1H, s, NH), 10.83 (1H, s, NH), 11.59 (1H, s, NH); ^{13}C NMR (DMSO-d_6, 100 MHz): δ_{ppm}: 46.8, 66.4, 89.1, 101.0, 109.1, 121.6, 124.0, 128.4, 135.1, 142.8, 146.0, 150.4, 157.3, 162.3, 169.6, 178.3; MS: m/z 338.

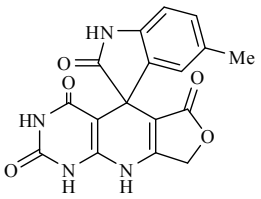
1'-Mmethyl-1H-spiro[furo[3,4-g]pyrido[2,3-d]pyrimidine-5,3'-indoline]-2,2',4,6 (3H,8H,9H)-tetraone **(4g):**



White powder (Yield: 80%, 0.281 g). mp: >350 °C. IR (KBr) (ν_{max}/ cm^{-1}): 3495, 3350, 3211, 1755, 1683; ^{1}H NMR (DMSO-d_6, 400 MHz): δ_{ppm}: 3.13 (3H, s, CH_3), 4.95 (2H, s, OCH_2), 6.94-7.26 (4H, m, ArH), 10.84 (1H, s, NH); ^{13}C NMR (DMSO-d_6, 100 MHz): δ_{ppm}: 26.7, 46.3, 66.5, 89.0, 100.8, 108.0, 122.4, 123.7, 128.6, 134.2, 144.3, 146.0, 150.4, 157.5, 162.2, 169.6, 177.0; MS: m/z 352.

Due to very low solubility of the products **4h**, we can not report the ^{13}C NMR data for this product.

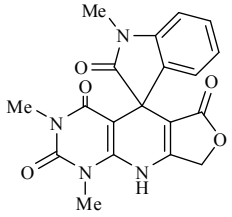
5'-Methyl-1H-spiro[furo[3,4-g]pyrido[2,3-d]pyrimidine-5,3'-indoline]-2,2',4,6 (3H,8H,9H)-tetraone **(4h):**



Cream powder (Yield: 82%, 0.288 g). mp: >350 ˚C. IR (KBr) (ν_{max}/ cm^{-1}): 3483, 3176, 1759, 1694; ^{1}H NMR (DMSO-d_6, 400 MHz): δ_{ppm}: 2.15 (3H, s, CH_3), 4.89 (2H, s, OCH_2), 6.59-6.88 (3H, m, ArH), 9.97 (1H, s, NH), 10.22 (1H, s, NH), 10.81 (1H, s, NH), 11.53 (1H, s, NH); MS: m/z 352.

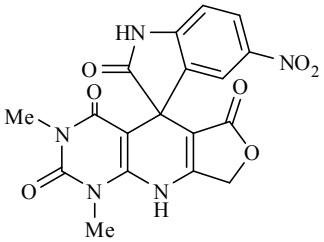
Due to very low solubility of the products **4i**, we cannot report the ^{13}C NMR data for this product.

1,1',3-Trimethyl-1H-spiro[furo[3,4-g]pyrido[2,3-d]pyrimidine-5,3'-indoline]2,2',4,6(3H,8H,9H)-tetraone **(4i):**



White powder (Yield: 77%, o.292 g). mp: >350 ˚C. IR (KBr) (ν_{max}/ cm^{-1}): 3447, 3252, 1680, 1642; ^{1}H NMR (DMSO-d_6, 400 MHz): δ_{ppm}: 3.05 (3H, s, CH_3), 3.19 (3H, s, CH_3), 3.51 (3H, s, CH_3), 5.03 (2H, s, CH_2), 6.94-7.29 (4H, m, ArH), 10.64 (1H, s, NH); Anal. Calcd for $C_{19}H_{16}N_4O_5$: C, 60.00; H, 4.24; N, 14.73. Found C, 60.04; H, 4.21; N, 14.68; MS: m/z 380.

1,3-Dimethyl-5'-nitro-1H-spiro[furo[3,4-g]pyrido[2,3-d]pyrimidine-5,3'-indoline] 2,2',4,6(3H,8H,9H)-tetraone **(4j):**

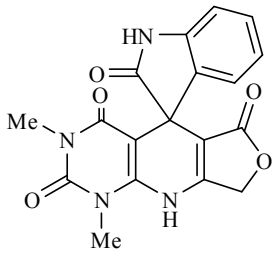


Yellow powder (Yield: 86%, 0.353 g). mp: >350 ˚C. IR (KBr) (ν_{max}/ cm^{-1}): 3525, 3114, 1739, 1651. ^{1}H NMR (DMSO-d_6, 400 MHz): δ_{ppm}: 3.01 (3H, s, CH_3), 3.39 (3H, s, CH_3), 5.05 (2H, s, OCH_2), 7.14-8.10 (3H, m, ArH), 11.02 (1H, s, NH), 11.86 (1H, s, NH); ^{13}C NMR (DMSO-d_6, 100 MHz): δ_{ppm}: 27.6, 31.9, 49.8, 66.0, 94.1, 95.7,

117.7, 122.2, 124.3, 125.3, 142.9, 143.3, 151.6, 153.4, 157.5, 159.3, 170.6, 179.7; MS: m/z 411.

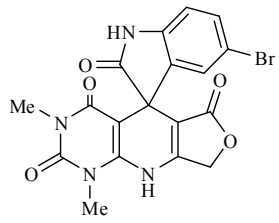
Due to very low solubility of the products **4k**, we cannot report the ^{13}C NMR data for this product.

1,3-Dimethyl-1H-spiro[furo[3,4-g]pyrido[2,3-d]pyrimidine-5,3'-indoline]-2,2',4,6 (3H,8H,9H)-tetraone **(4k):**



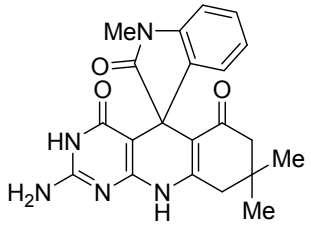
White powder (Yield: 81%, 0.296 g). mp: >350 °C. IR (KBr) (ν_{max}/ cm^{-1}): 3543, 3234, 1725, 1648; ^1H NMR (DMSO-d_6, 400 MHz): δ_{ppm}: 3.04 (3H, s, CH_3), 3.33 (3H, s, CH_3), 4.95 (2H, s, CH_2), 6.90-7.23 (4H, m, ArH), 10.33 (1H, s, NH), 11.65 (1H, s, NH); MS: m/z 366.

5'-Bbromo-1,3-dimethyl-1H-spiro[furo[3,4-g]pyrido[2,3-d]pyrimidine-5,3'-indoline] -2,2',4,6(3H,8H,9H)-tetraone **(4l):**



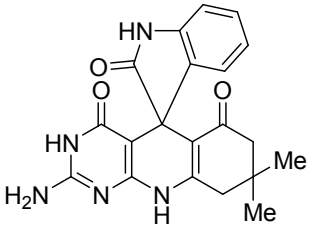
Cream powder (Yield: 84%, 0.373 g). mp: >350 °C. IR (KBr) (ν_{max}/ cm^{-1}): 3443, 3162, 1765, 1645; ^1H NMR (DMSO-d_6, 400 MHz): δ_{ppm}: 3.12 (3H, s, CH_3), 3.38 (3H, s, CH_3), 3.44 (3H, s, CH_3), 4.97 (2H, s, OCH_2), 6.91-7.39 (3H, m, ArH), 10.45 (1H, s, NH), 11.66 (1H, s, NH); ^{13}C NMR (DMSO-d_6, 100 MHz): δ_{ppm}: 27.59, 31.8, 49.8. 65.7, 92.1, 95.2, 115.4, 119.1, 123.8, 130.4, 132.0, 136.6, 151.6, 153.3, 157.4, 159.4, 170.9, 180.0; MS: m/z 446, .444.

2'-Amino-1,8',8'-trimethyl-8',9'-dihydro-3'*H*-spiro[indoline-3,5'-pyrimido[4,5-*b*] quinoline]-2,4',6'(7'*H*, 10'*H*)-trione (4m).



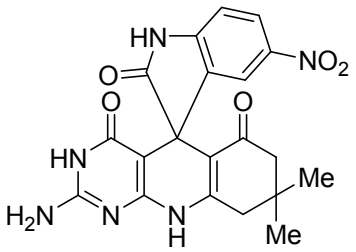
Cream powder (Yield: 94%, 0.367 g); mp >300 ˚C dec. IR (KBr) (ν_{max}/ cm^{-1}): 3330, 3176, 2940, 1691, 1652. ^{1}H NMR (300 MHz, DMSO-d_6): δ_H (ppm) 0.89 (3H, s, CH_3), 0.97 (3H, s, CH_3), 1.81-2.05 (2H, m, CH_2), 2.34-2.49 (2H, m, CH_2), 3.05 (3H, s, NCH_3), 6.40 (2H, s, NH_2), 6.86-7.07 (4H, m, H-Ar), 9.51 (1H, s, NH), 10.13 (1H, s, NH). ^{13}C NMR (75 MHz, DMSO-d_6): δ_C (ppm) 26.6, 27.0, 28.9, 32.3, 48.3, 50.9, 91.8, 106.8, 109.1, 121.4, 122.5, 127.3, 136.4, 145.1, 152.4, 153.9, 154.6, 160.4, 179.4, 193.1.

2'-Amino-8',8'-dimethyl-8',9'-dihydro-3'*H*-spiro[indoline-3,5'-pyrimido[4,5-*b*]quinoline] -2,4',6'(7'*H*,10'*H*)-trione (4n).



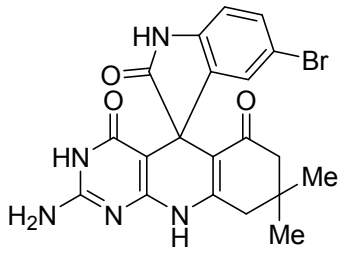
Cream powder (Yield: 95%, 0.358 g); mp >300 ˚C dec. IR (KBr) (ν_{max}/ cm^{-1}): 3334, 3189, 2938, 1697, 1655. ^{1}H NMR (300 MHz, DMSO-d_6): δ_H (ppm) 0.90 (3H, s, CH_3), 0.98 (3H, s, CH_3), 1.82-2.08 (2H, m, CH_2), 2.32-2.50 (2H, m, CH_2), 6.35 (2H, s, NH_2), 6.57-6.99 (4H, m, H-Ar), 9.45 (1H, s, NH), 9.92 (1H, s, NH), 10.24 (1H, s, NH). ^{13}C NMR (75 MHz, DMSO-d_6): δ_C (ppm) 26.9, 28.9, 32.3, 48.8, 51.0, 92.1, 108.1, 109.3, 120.6, 122.8, 127.0, 137.3, 143.6, 152.2, 153.9, 154.5, 160.5, 180.7, 193.1.

2'-Amino-8',8'-dimethyl-5-nitro-8',9'-dihydro-3'*H*-spiro[indoline-3,5'-pyrimido[4,5-*b*] quinoline]-2,4',6'(7'*H*,10'*H*)-trione (4o).



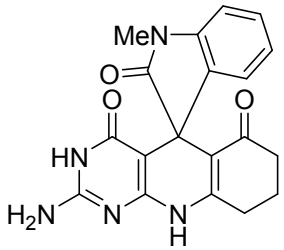
Cream powder (Yield: 92%, 0.388 g); mp >300 ˚C dec. IR (KBr) (ν_{max}/ cm^{-1}): 3427, 3185, 2923, 1720, 1662. ^{1}H NMR (300 MHz, DMSO-d_6): δ_H (ppm) 0.92 (3H, s, CH_3), 0.97 (3H, s, CH_3), 1.90-2.06 (2H, m, CH_2), 2.47 (2H, brs, CH_2), 6.49 (2H, s, NH_2), 6.80-8.03 (3H, m, H-Ar), 9.70 (1H, s, NH), 10.38 (1H, s, NH), 10.79 (1H, s, NH). ^{13}C NMR (75 MHz, DMSO-d_6): δ_C (ppm) 27.4, 28.3, 32.4, 49.0, 50.7, 91.0, 108.0, 108.3, 117.8, 125.1, 138.3, 141.7, 150.6, 153.5, 154.2, 154.8, 160.7, 181.4, 193.6.

2'-Amino-5-bromo-8',8'-dimethyl-8',9'-dihydro-3'*H*-spiro[indoline-3,5'-pyrimido[4,5-*b*] quinoline]-2,4',6'(7'*H*,10'*H*)-trione (4p).



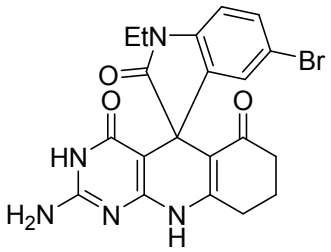
Cream powder (Yield: 96%, 0.436 g); mp >300 ˚C dec. IR (KBr) (ν_{max}/ cm^{-1}): 3416, 3164, 2959, 1701, 1645. ^{1}H NMR (300 MHz, DMSO-d_6): δ_H (ppm) 0.91 (3H, s, CH_3), 0.97 (3H, s, CH_3), 1.88-2.06 (2H, m, CH_2), 2.41 (2H, brs, CH_2), 6.42 (2H, s, NCH_2), 6.54-7.15 (3H, m, H-Ar), 9.55 (1H, s, NH), 10.12 (1H, s, NH), 10.31 (1H, s, NH). ^{13}C NMR (75 MHz, DMSO-d_6): δ_C (ppm) 27.3, 28.5, 32.3, 49.2, 50.9, 91.5, 108.7, 110.0, 112.2, 125.4, 129.7, 139.8, 143.2, 152.8, 154.0, 154.7, 160.5, 180.3, 193.3.

2'-Amino-1-methyl-8',9'-dihydro-3'*H*-spiro[indoline-3,5'-pyrimido[4,5-*b*]quinoline]-2,4',6'(7'*H*,10'*H*)-trione (4q).



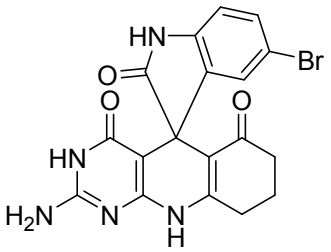
Cream powder (80%); mp >300 ˚C dec. IR (KBr) (ν_{max}/ cm^{-1}): 3438, 3288, 2933, 1677, 1652. ^{1}H NMR (300 MHz, DMSO-d_6): δ_H (ppm) 1.79 (2H, brs, CH_2), 2.03 (2H, brs, CH_2), 2.52 (2H, brs, CH_2), 3.04 (3H, s, NCH_3), 6.40 (2H, s, NH_2), 6.75-7.07 (4H, m, H-Ar), 9.55 (1H, s, NH), 10.12 (1H, s, NH). ^{13}C NMR (75 MHz, DMSO-d_6): δ_C (ppm) 21.2, 26.6, 27.3, 37.5, 48.4, 91.8, 106.8, 110.5, 121.4, 122.7, 127.3, 136.6, 145.1, 153.8, 154.4, 154.6, 160.4, 179.5, 193.4. Anal. Calcd for $C_{19}H_{17}N_5O_3$: C, 62.80; H, 4.72; N, 19.27%. Found: C, 62.72; H, 4.77; N, 19.21%.

2'-Amino-5-bromo-1-ethyl-8',9'-dihydro-3'*H*-spiro[indoline-3,5'-pyrimido[4,5-*b*] quinoline]-2,4',6'(7'*H*,10'*H*)-trione (4r).

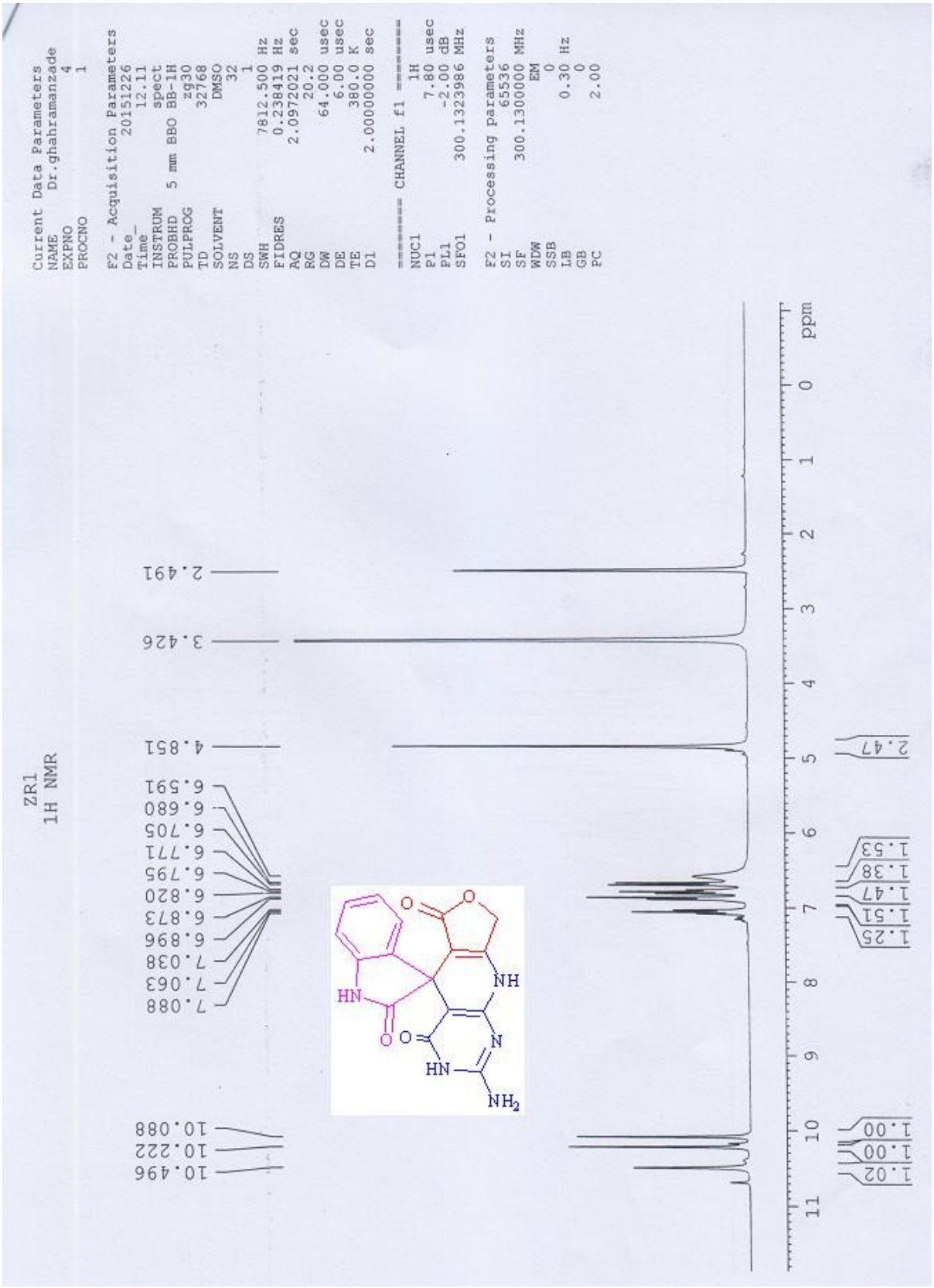


Cream powder (72%); mp >300 ˚C dec. IR (KBr) (ν_{max}/ cm^{-1}): 3437, 3298, 2938, 1663, 1672. ^{1}H NMR (300 MHz, DMSO-d_6): δ_H (ppm) 1.13-1.17 (3H, m, CH_3), 1.79-1.81 (2H, m, CH_2), 2.07 (2H, brs, CH_2), 2.54 (2H, brs, CH_2), 3.57-3.66 (2H, m, NCH_2), 6.46 (2H, s, NH_2), 6.75-7.24 (3H, m, H-Ar), 9.61 (1H, s, NH), 10.17 (1H, s, NH). ^{13}C NMR (75 MHz, DMSO-d_6): δ_C (ppm) 12.0, 21.1, 27.3, 34.4, 37.4, 38.2, 48.8, 91.3, 108.7, 109.9, 112.8, 125.5, 129.8, 139.2, 140.7, 153.9, 154.7, 154.9, 160.4, 178.2, 193.5. Anal. Calcd for $C_{20}H_{18}BrN_5O_3$: C, 52.64; H, 3.98; N, 15.35%. Found: C, 52.59; H, 3.93; N, 15.41%.

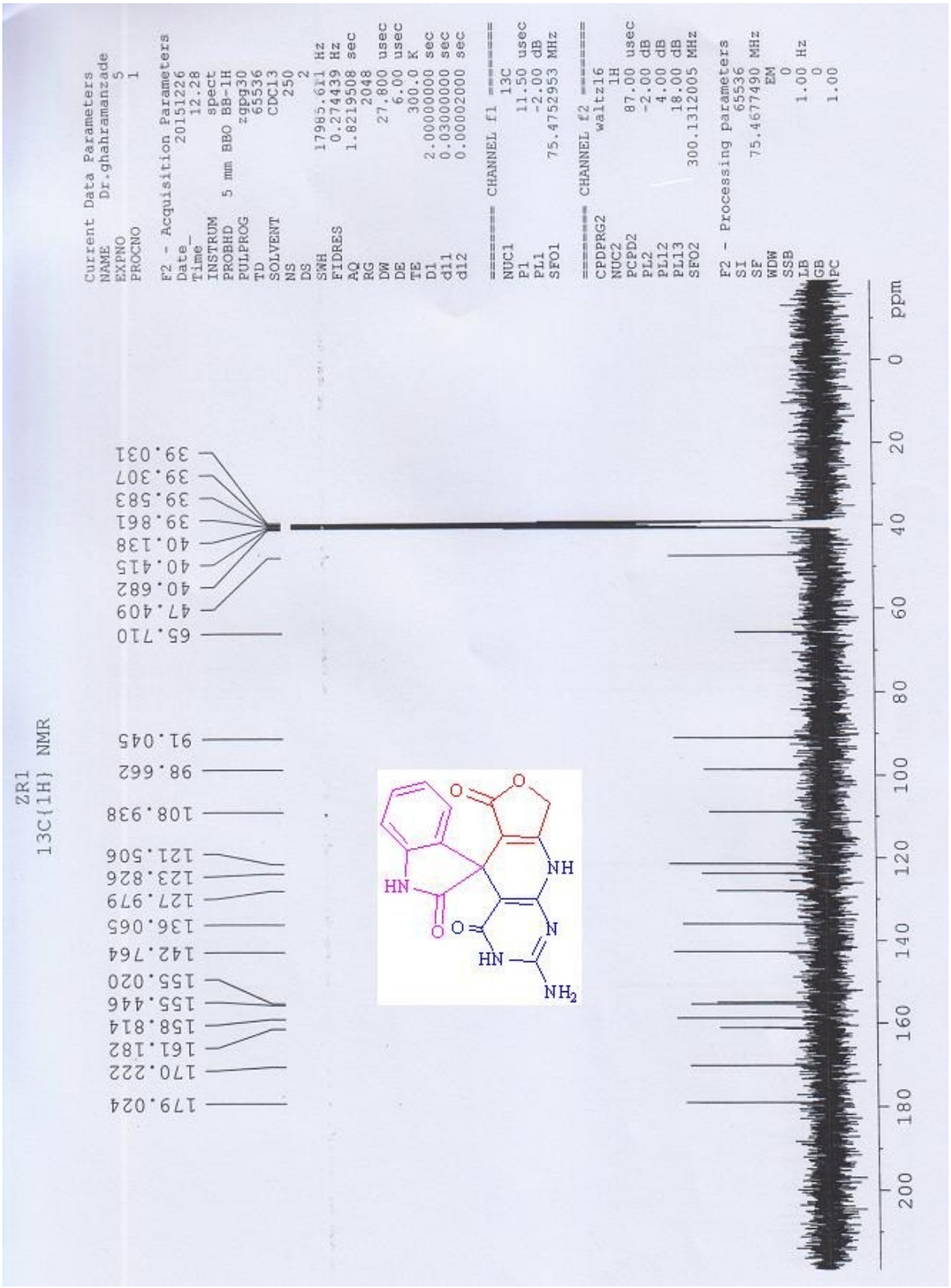
2'-Amino-5-bromo-8',9'-dihydro-3'*H*-spiro[indoline-3,5'-pyrimido[4,5-*b*]quinoline]-2,4',6'(7'*H*,10'*H*)-trione (4s).



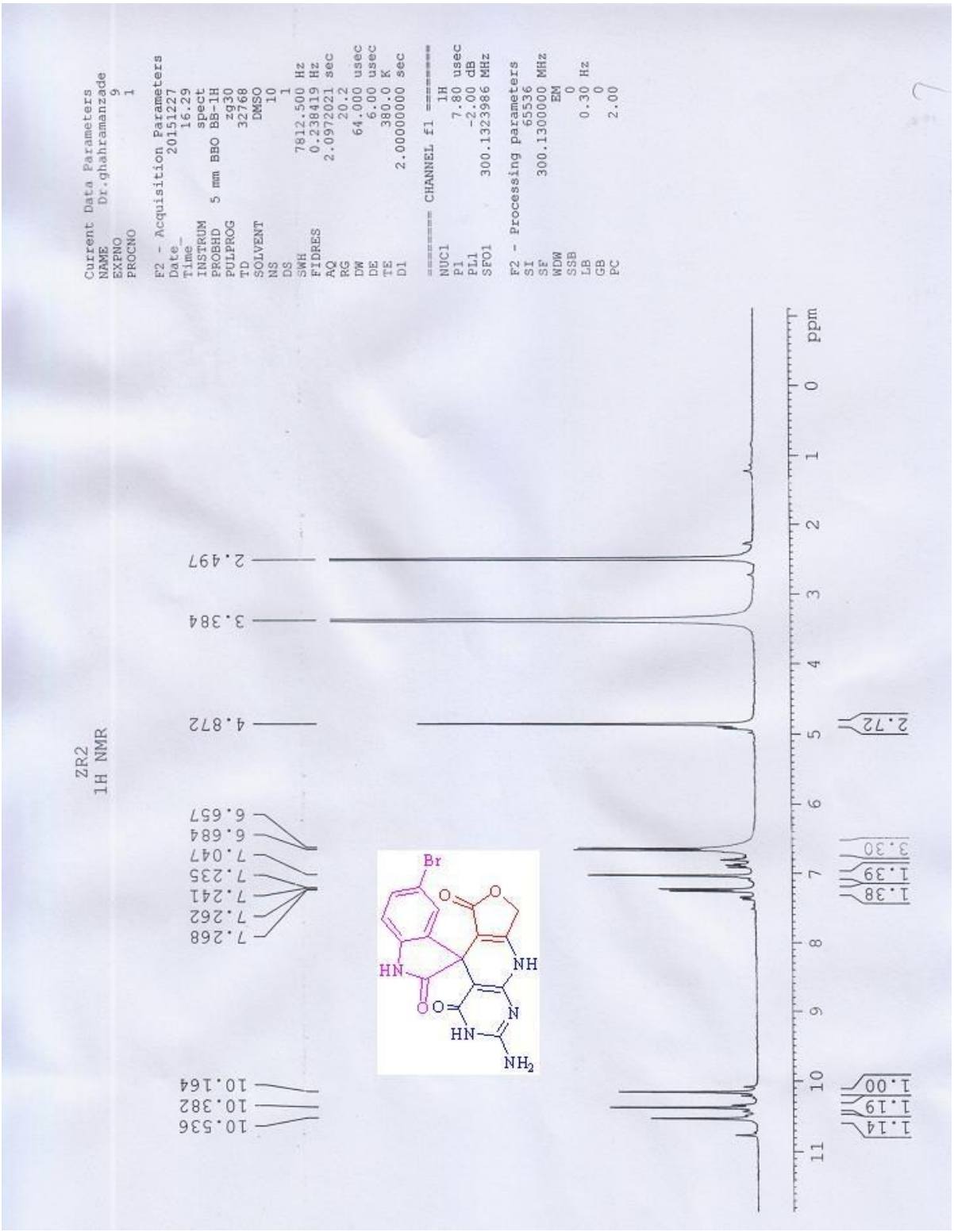
Cream powder (78%); mp >300 ˚C dec. IR (KBr) (ν_{max}/ cm^{-1}): 3345, 3185, 2943, 1709, 1649. ^{1}H NMR (300 MHz, DMSO-d_6): δ_H (ppm) 1.78 (2H, brs, CH_2), 2.06 (2H, brs, CH_2), 2.49 (2H, brs, CH_2), 6.42 (2H, s, NH_2), 6.52-7.13 (3H, m, H-Ar), 9.59 (1H, s, NH), 10.11 (H, s, NH), 10.29 (H, s, NH). ^{13}C NMR (75 MHz, DMSO-d_6): δ_C (ppm) 24.2, 27.3,37.5, 49.3, 91.5, 109.9, 110.1, 112.2, 125.5, 129.7, 139.8, 143.2, 153.9, 154.7, 154.8, 160.5, 180.4, 193.6. Anal. Calcd for $C_{18}H_{14}BrN_5O_3$: C, 50.48; H, 3.30; N, 16.35%. Found: C, 50.54; H, 3.35; N, 16.29%.



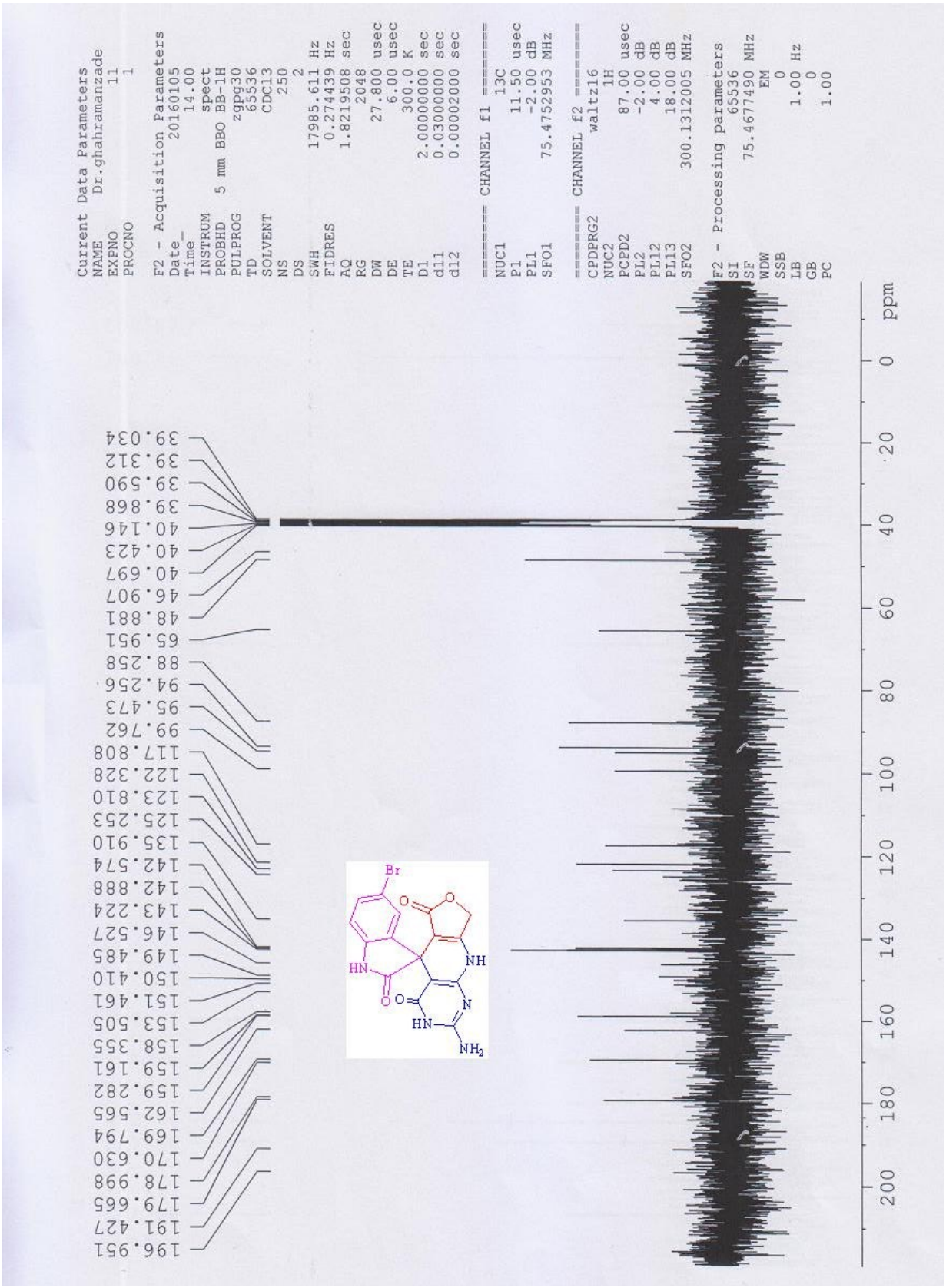
***[1]H NMR spectrum of 2-amino-3H-spiro[furo[3,4-g]pyrido[2,3-d]pyrimidine-5,3'-indoline]-2',4,6(8H,9H) -trione* (4a).**



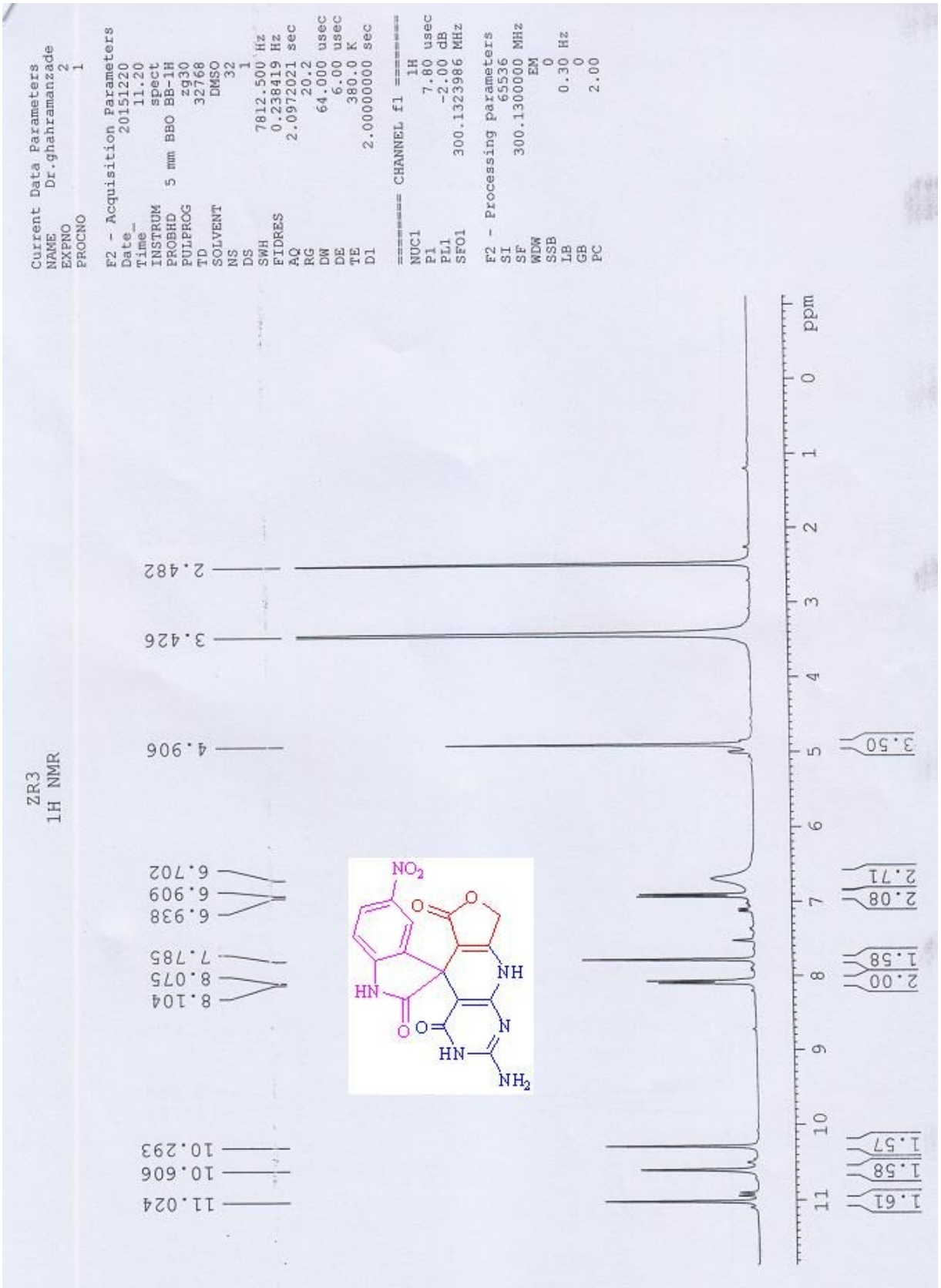
^{13}C NMR spectrum of 2-amino-3H-spiro[furo[3,4-g]pyrido[2,3-d]pyrimidine-5,3'-indoline]-2',4,6(8H,9H) -trione **(4a).**



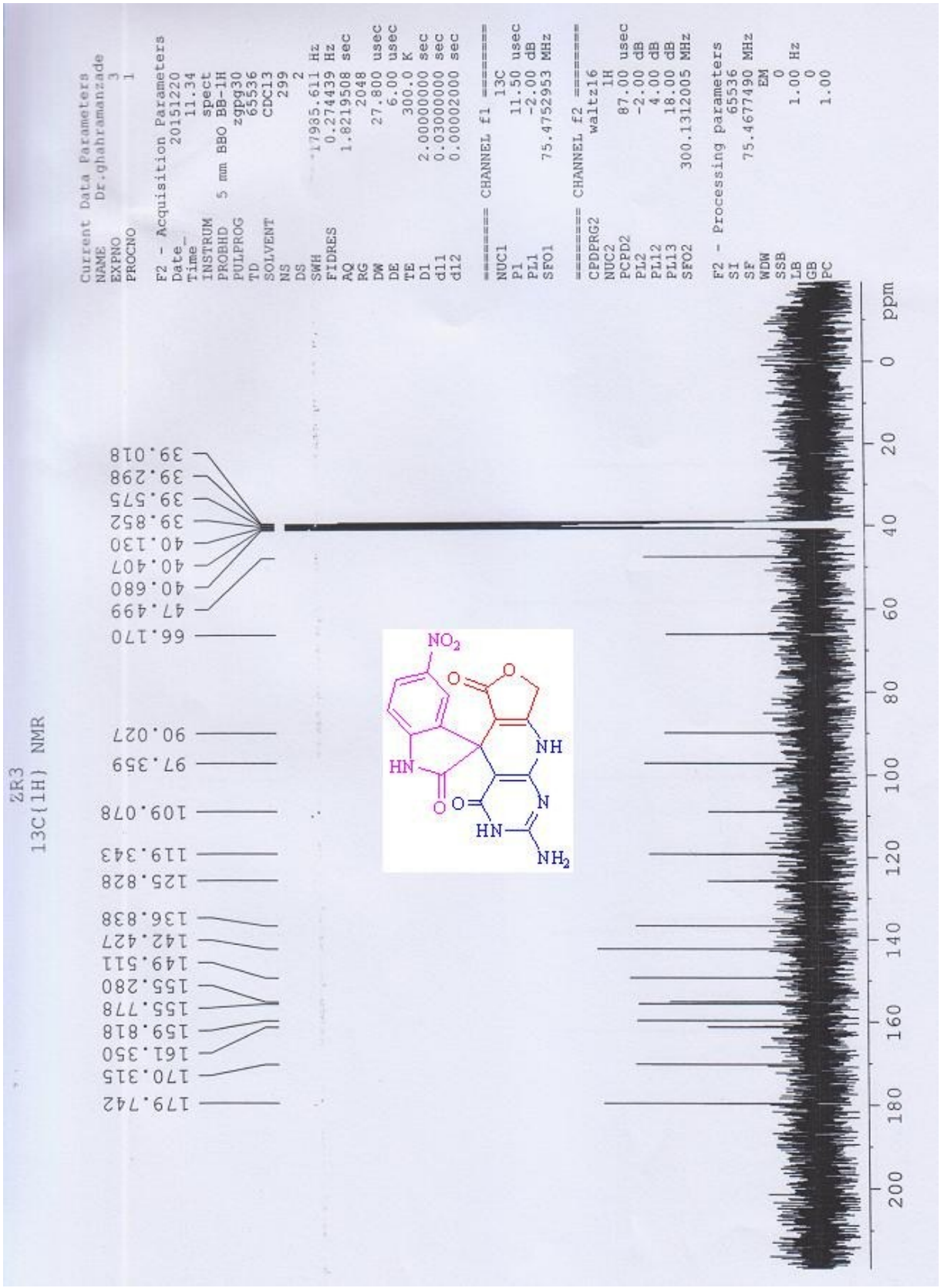
[1]H NMR spectrum of 2-amino-5'-bromo-3H-spiro[furo[3,4-g]pyrido[2,3-d]pyrimidine-5,3'-indoline]-2',4,6 8H,9H)-trione **(4b).**



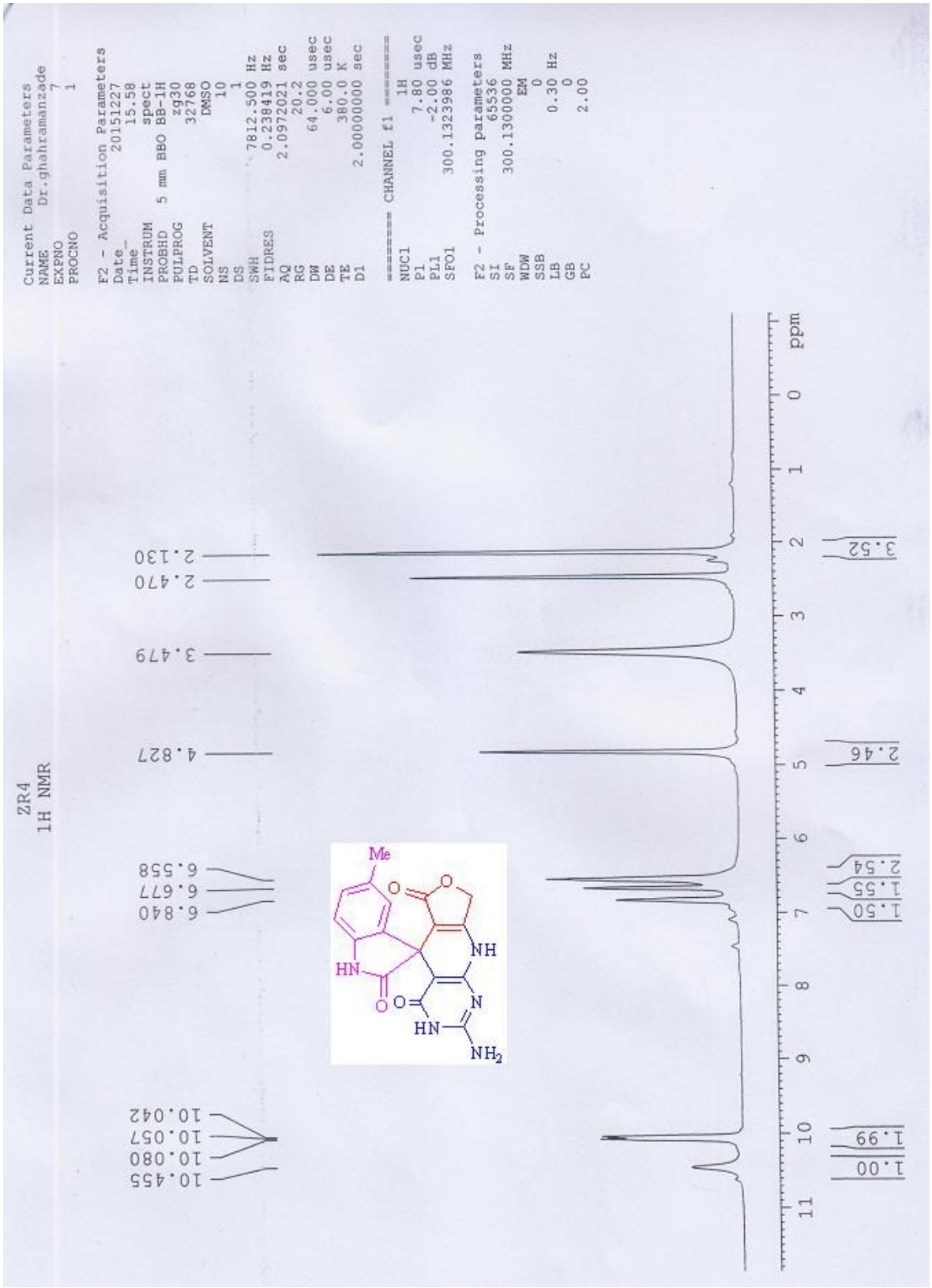
^{13}C NMR spectrum of 2-amino-5'-bromo-3H-spiro[furo[3,4-g]pyrido[2,3-d]pyrimidine-5,3'-indoline]-2',4,6 8H,9H)-trione **(4b).**



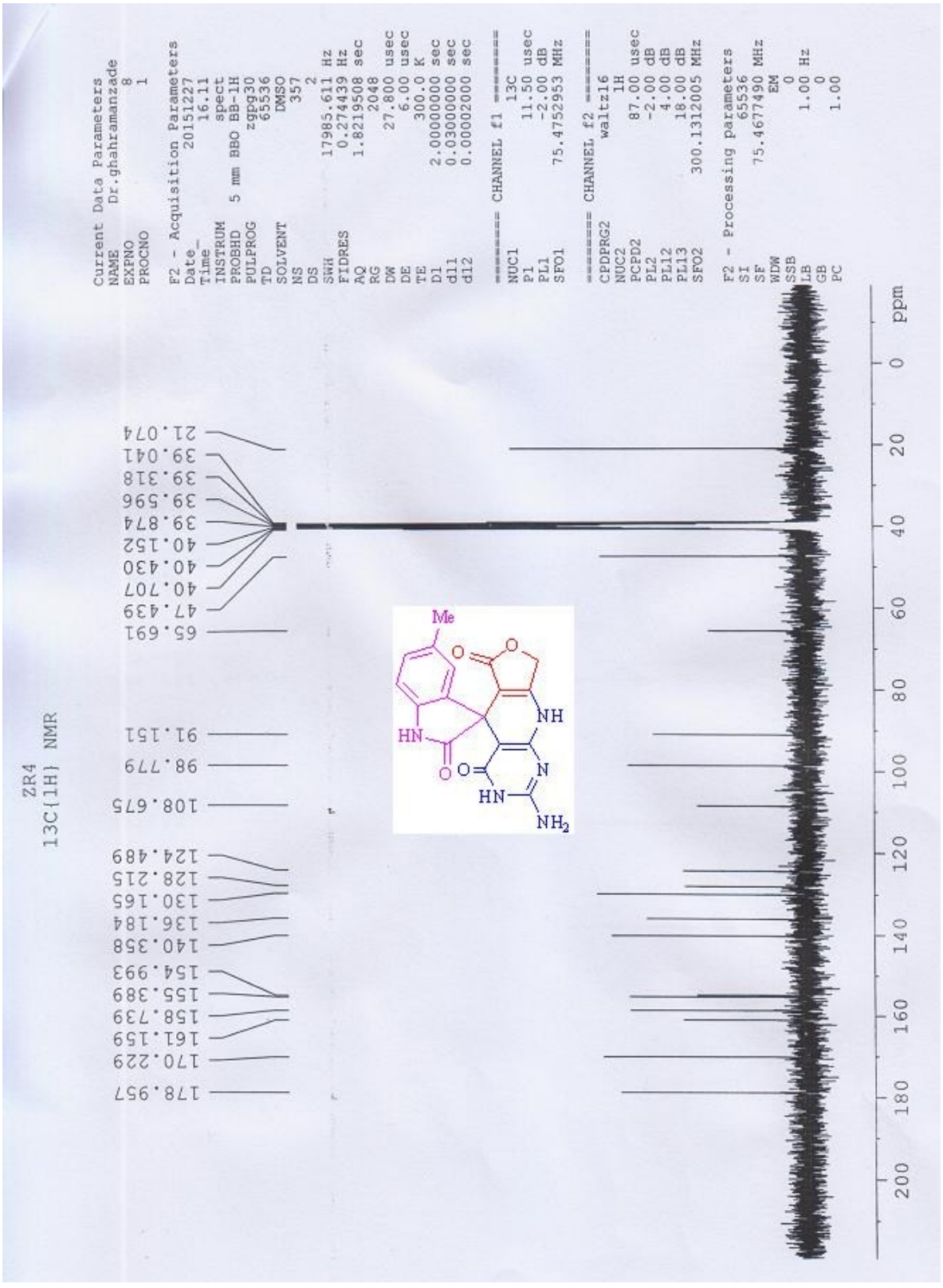
[1]H NMR spectrum of 2-amino-5'-nitro-5'-nitro-3H-spiro[furo[3,4-g]pyrido[2,3-d]pyrimidine-5,3'-indoline]-2',4,6(8H,9H)-trione **(4c).**



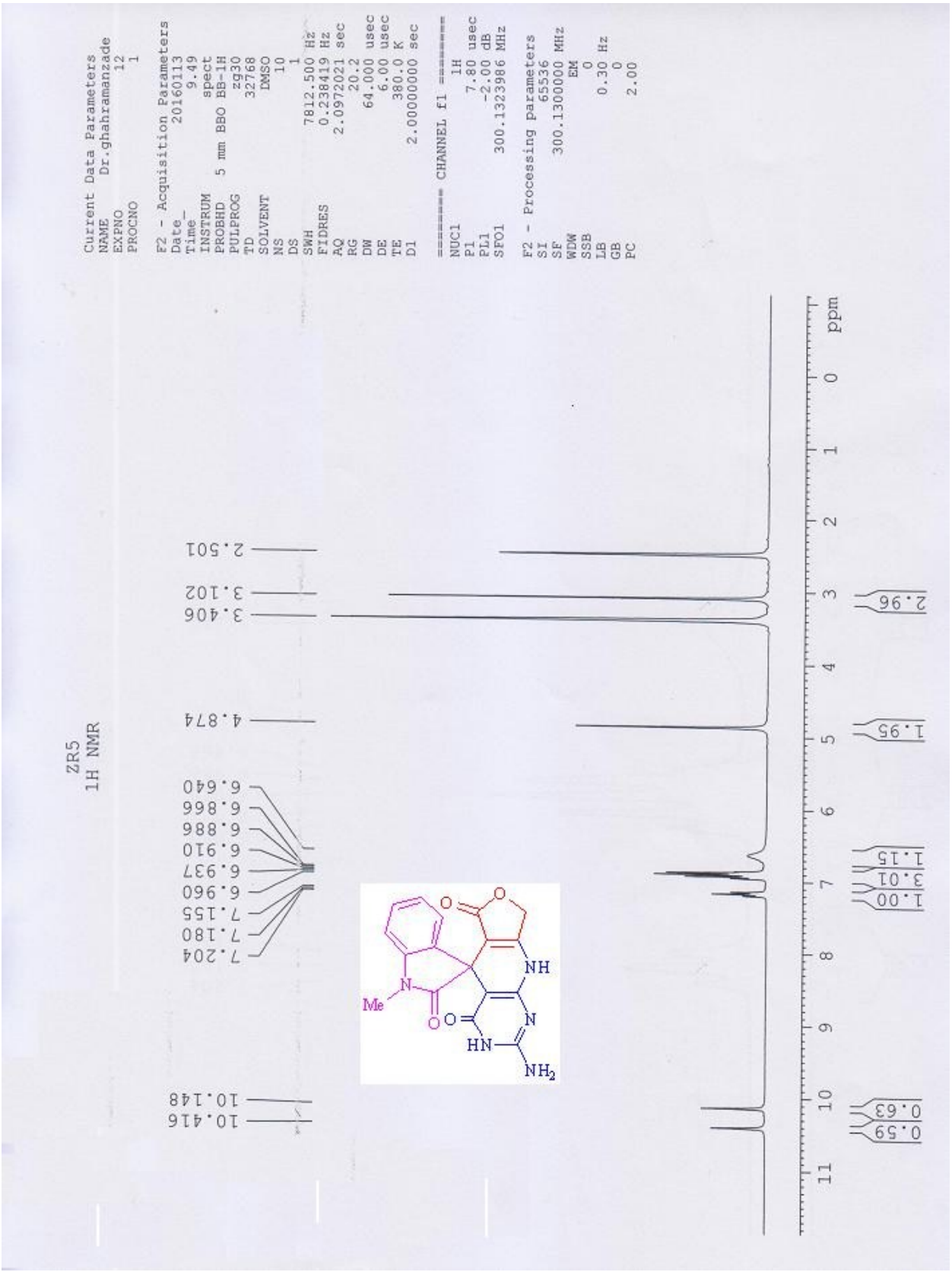
^{13}C NMR spectrum of 2-amino-5'-nitro-5'-nitro-3H-spiro[furo[3,4-g]pyrido[2,3-d]pyrimidine-5,3'-indoline]-2',4,6(8H,9H)-trione **(4c).**



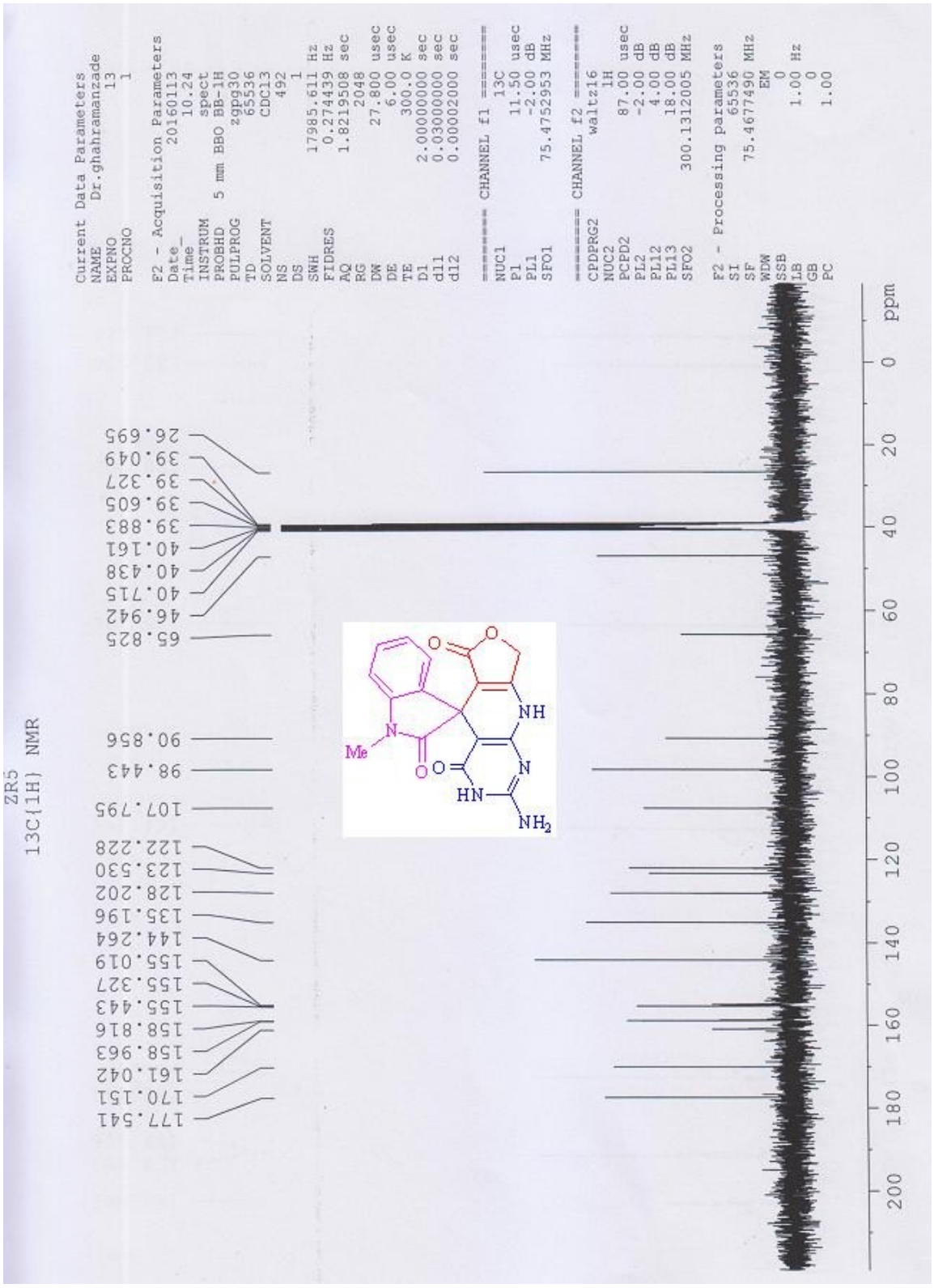
[1]H NMR spectrum of 2 -amino-5'-methyl-3H-spiro[furo[3,4-g]pyrido[2,3-d]pyrimidine-5,3'-indoline]-2',4,6(8H,9H)-trione **(4d).**



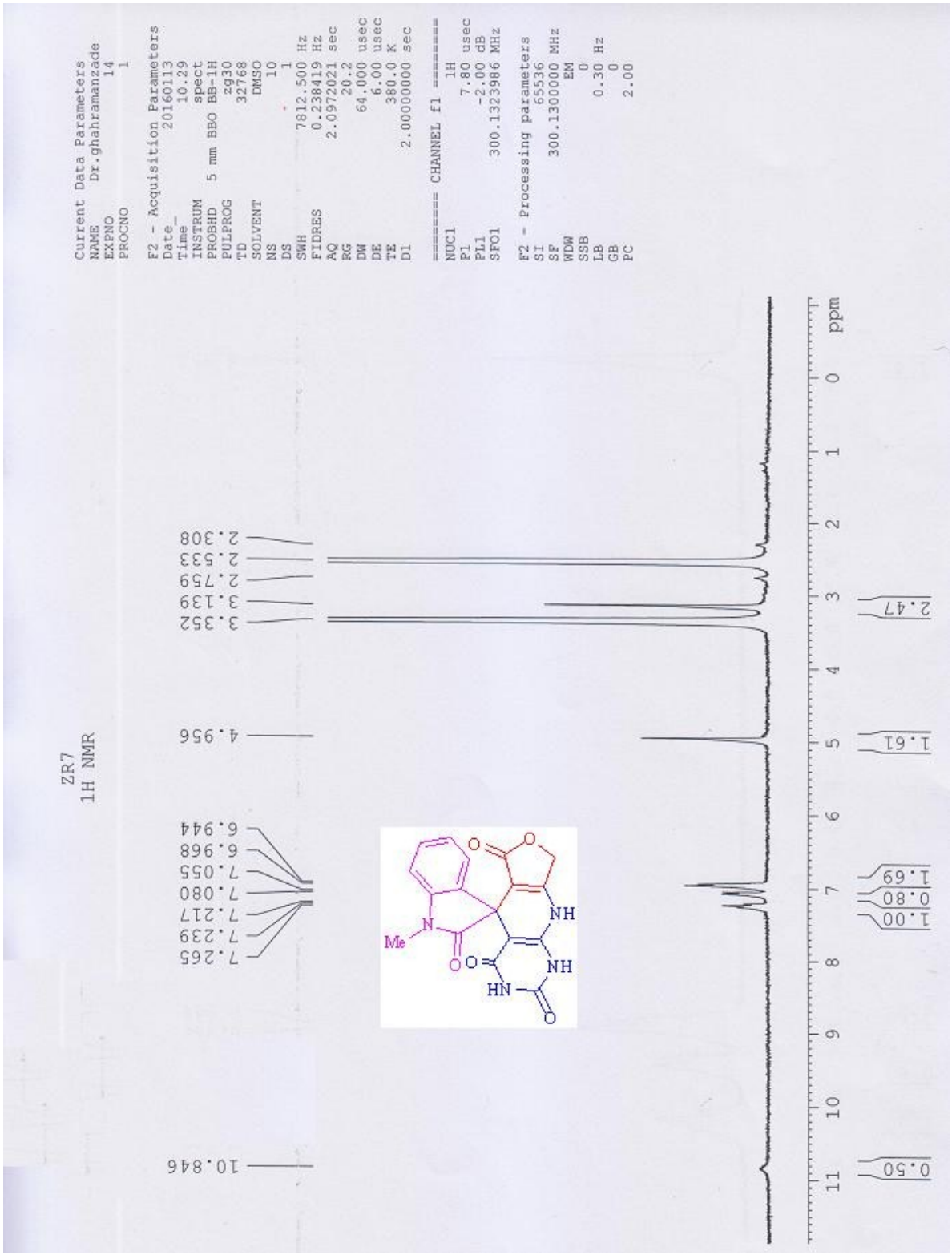
^{13}C NMR spectrum of 2-amino-5'-methyl-3H-spiro[furo[3,4-g]pyrido[2,3-d]pyrimidine-5,3'-indoline]-2',4,6(8H,9H)-trione **(4d).**



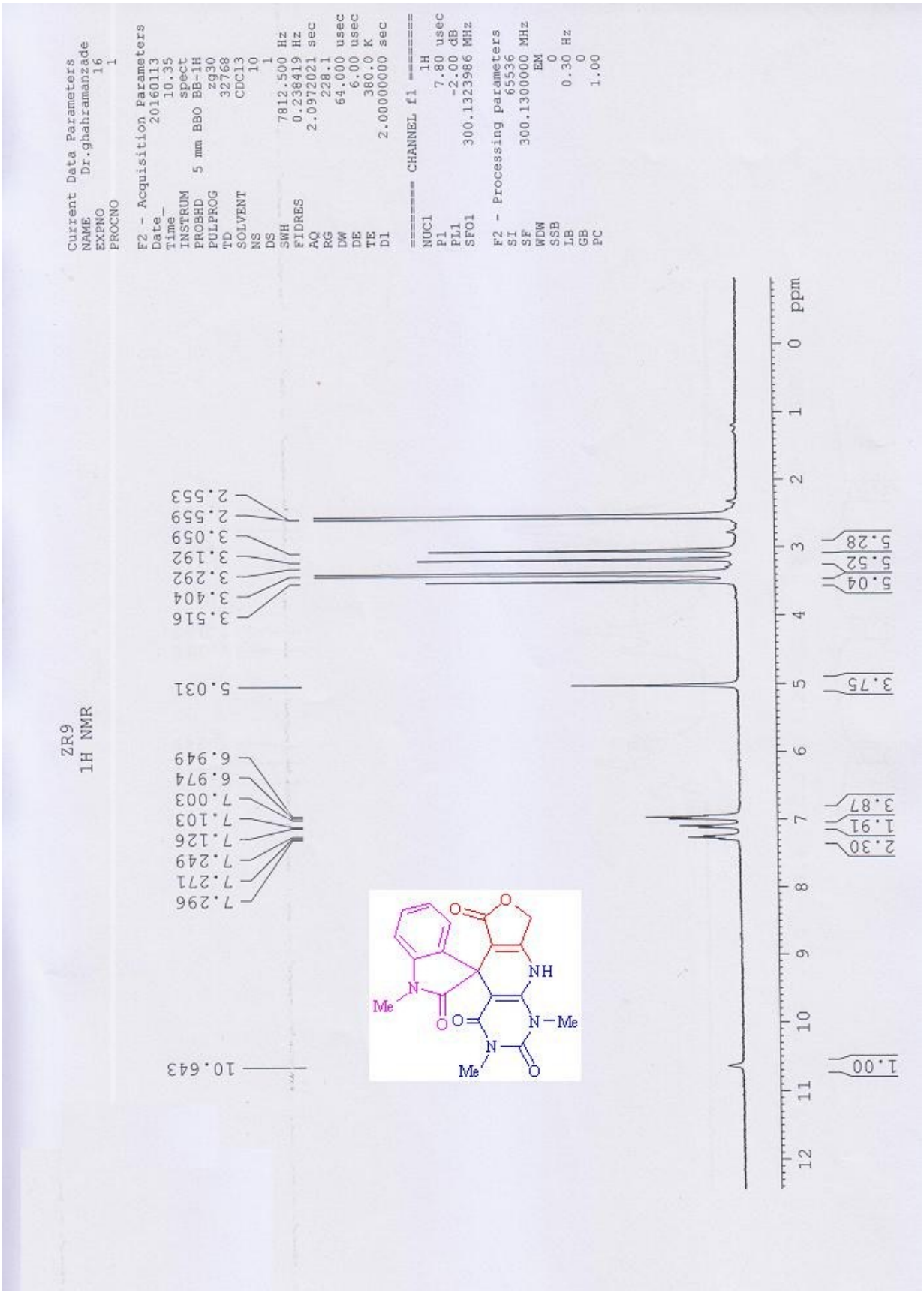
[1]H NMR spectrum of 2-amino-1'-methyl-3H-spiro[furo[3,4-g]pyrido[2,3-d]pyrimidine-5,3'-indoline]-2',4,6(8H,9H)-trione **(4e).**



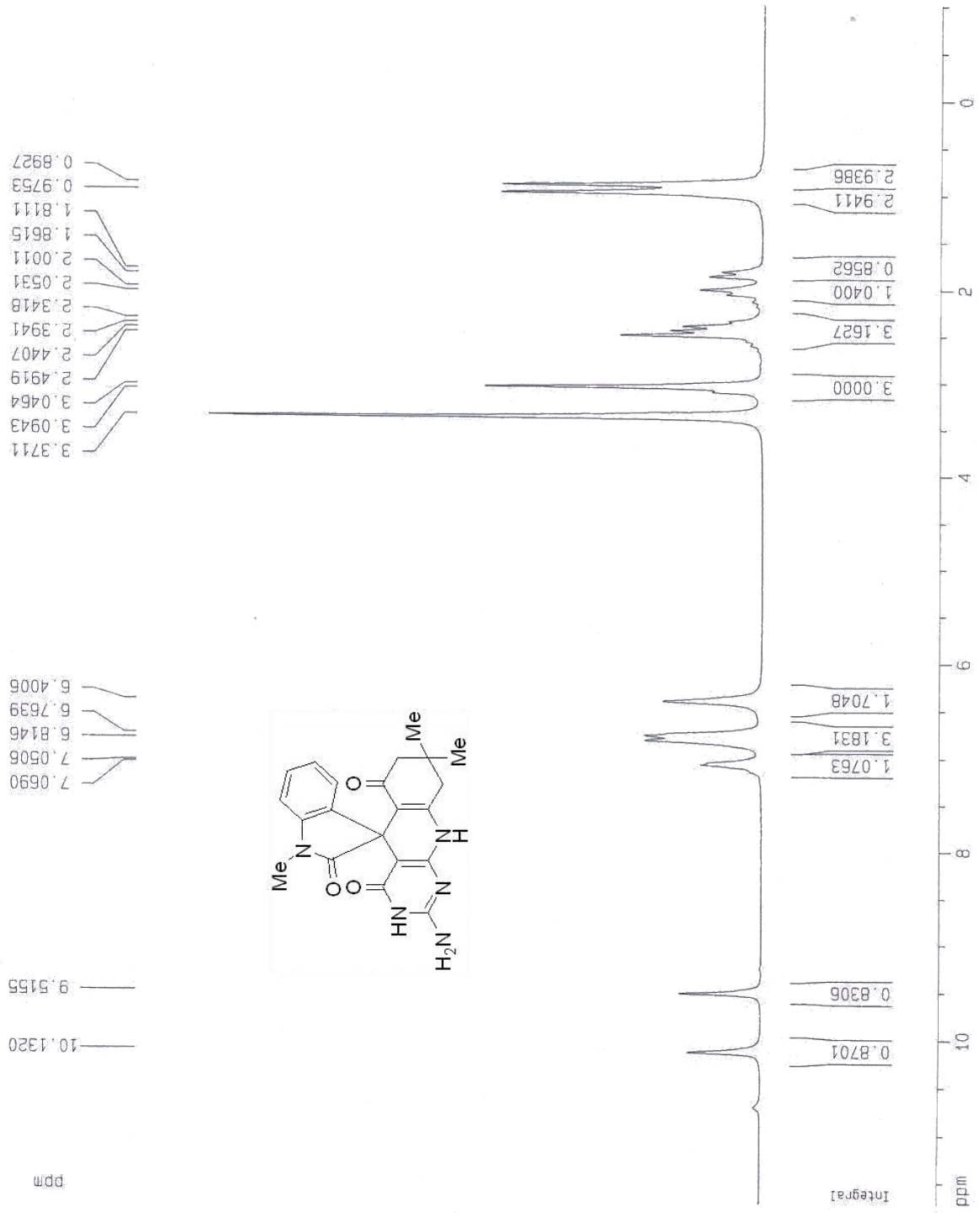
^{13}C NMR spectrum of 2-amino-1'-methyl-3H-spiro[furo[3,4-g]pyrido[2,3-d]pyrimidine-5,3'-indoline]-2',4,6(8H,9H)-trione **(4e).**



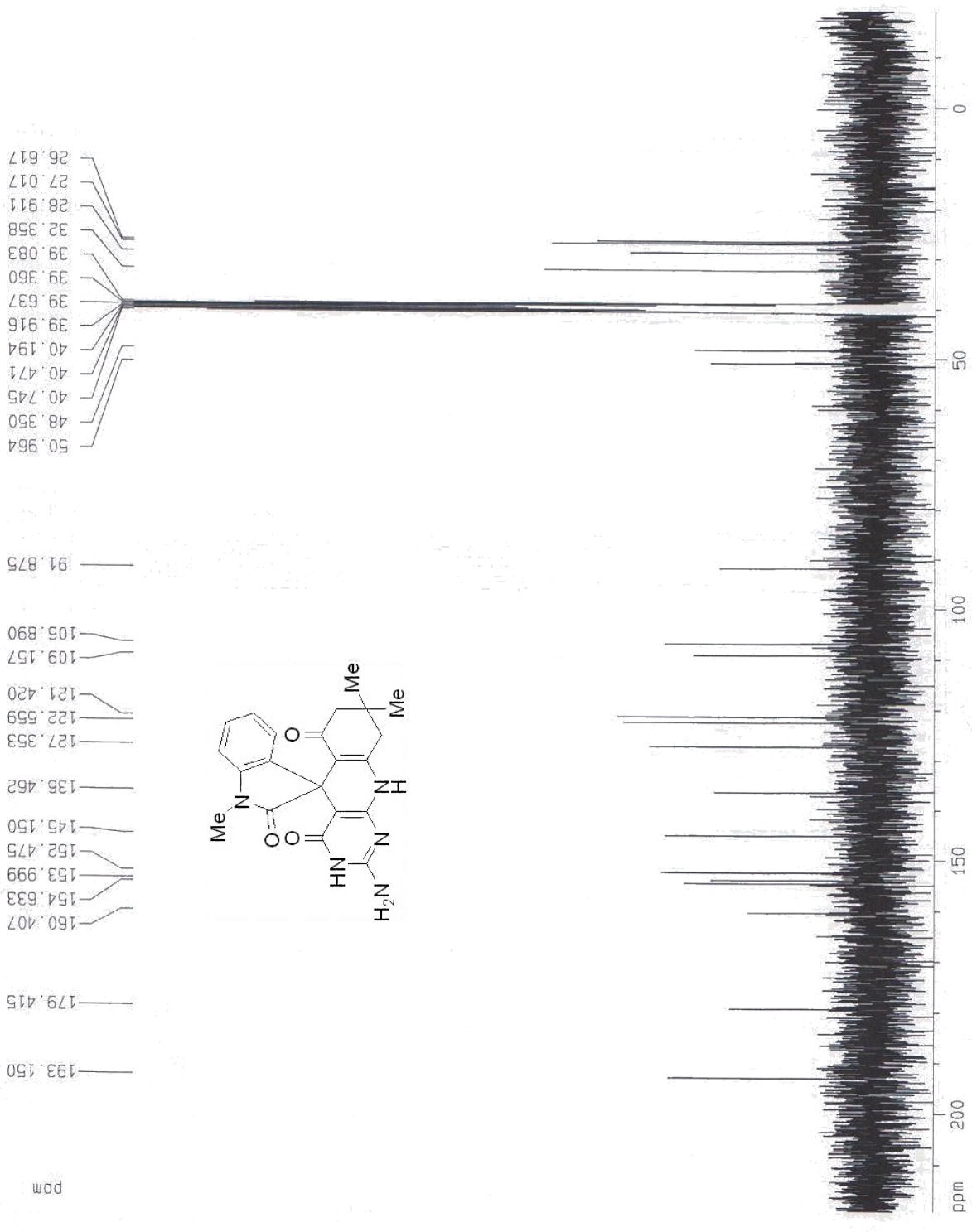
***[1]H NMR spectrum of 1'-methyl-1H-spiro[furo[3,4-g]pyrido[2,3-d]pyrimidine-5,3'-indoline]-2,2',4,6 (3H,8H,9H)-tetraone* (4g).**



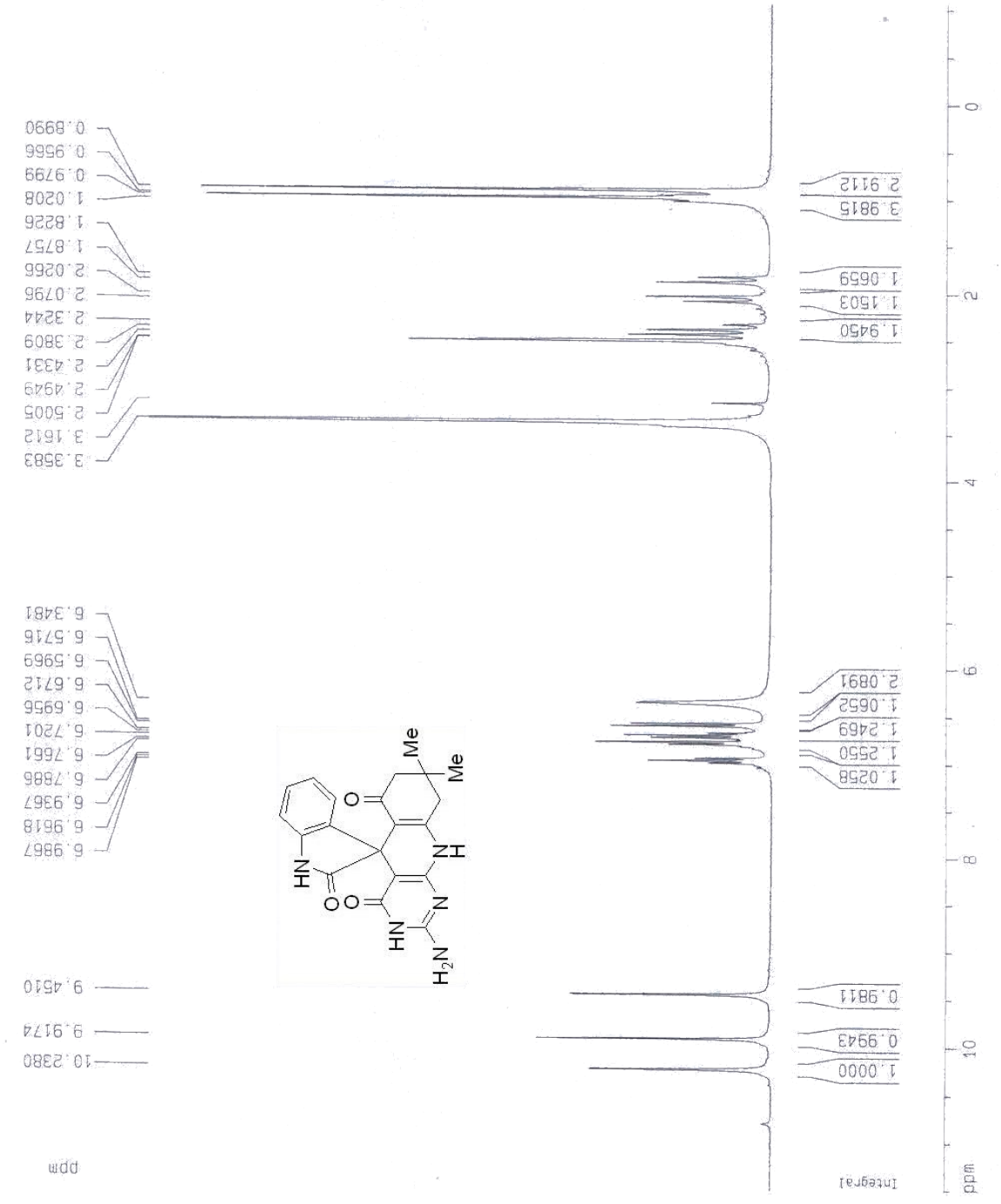
***[1]H NMR spectrum of 5'-bromo-1,3-dimethyl-1H-spiro[furo[3,4-g]pyrido[2,3-d]pyrimidine-5,3'-indoline] -2,2',4,6(3H,8H,9H)-tetraone* (4i).**



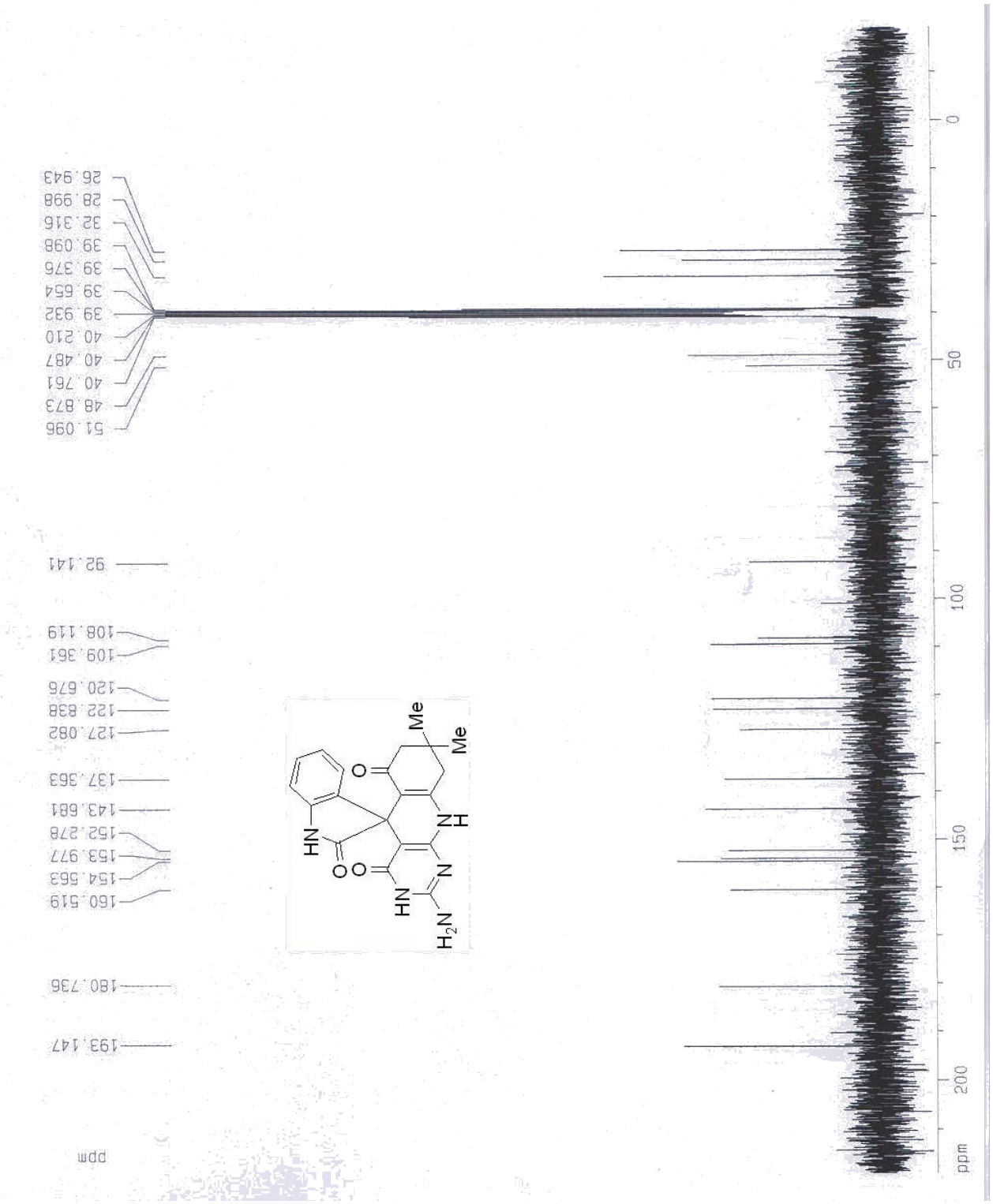
[1]H NMR of spectrum 2'-Amino-1,8',8'-trimethyl-8',9'-dihydro-3'H-spiro[indoline-3,5'-pyrimido[4,5-b] quinoline]-2,4',6'(7'H, 10'H)-trione (4m).



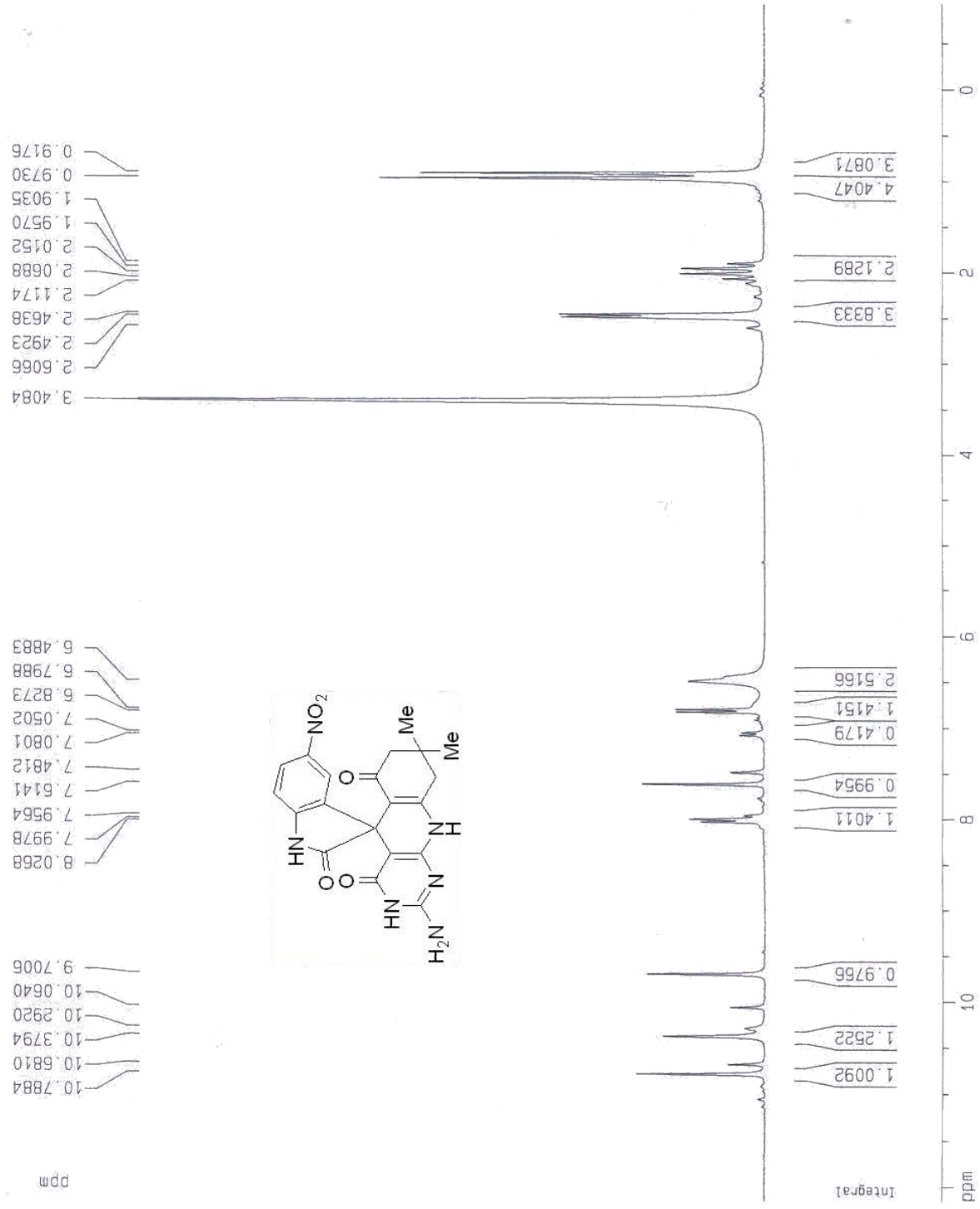
^{13}C NMR spectrum of 2'-Amino-1,8',8'-trimethyl-8',9'-dihydro-3'H-spiro[indoline-3,5'-pyrimido[4,5-b] quinoline]-2,4',6'(7'H, 10'H)-trione (4m).



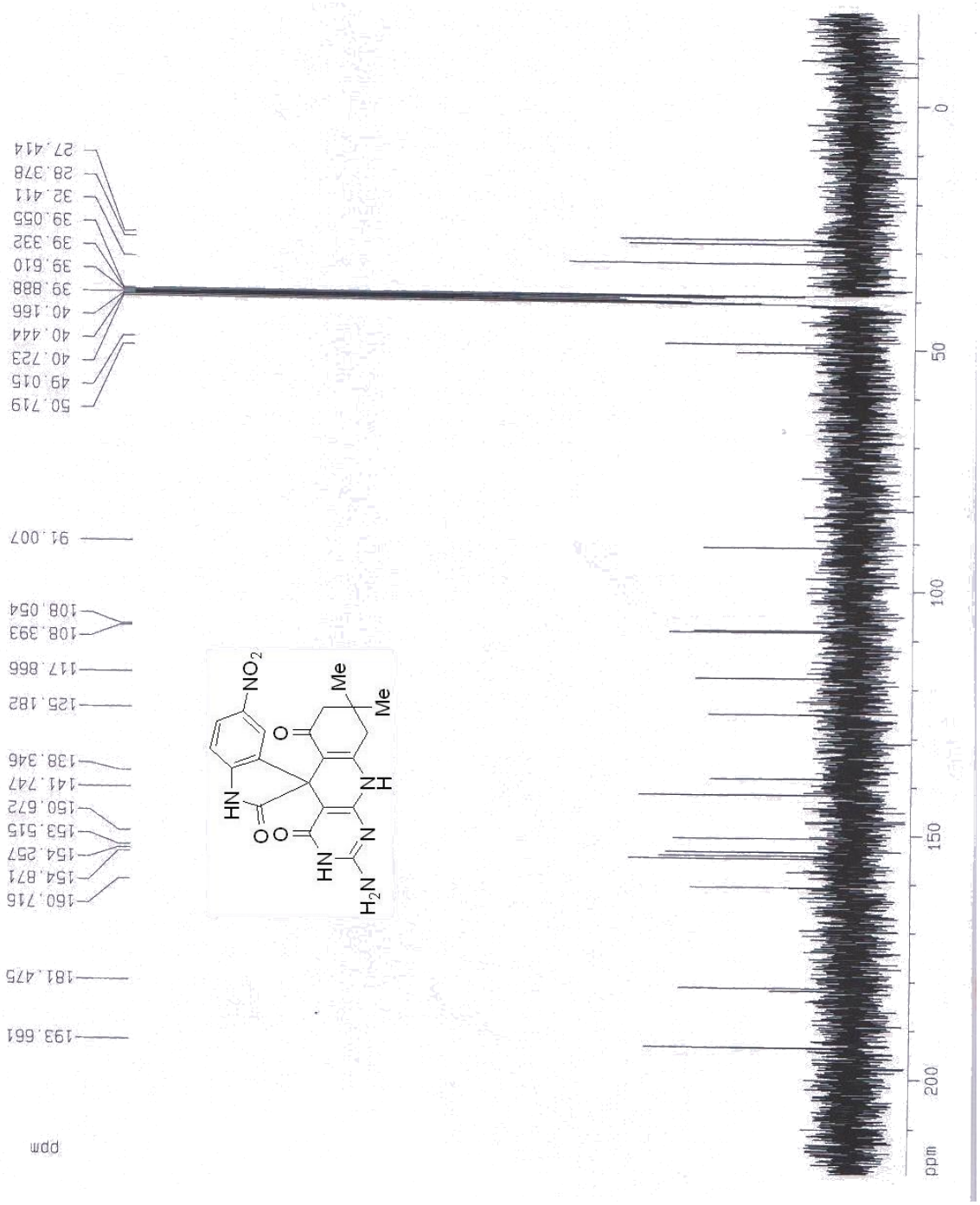
^{1}H NMR spectrum of 2'-Amino-8',8'-dimethyl-8',9'-dihydro-3'H-spiro[indoline-3,5'-pyrimido[4,5-b]quinoline] -2,4',6'(7'H,10'H)-trione (4n).



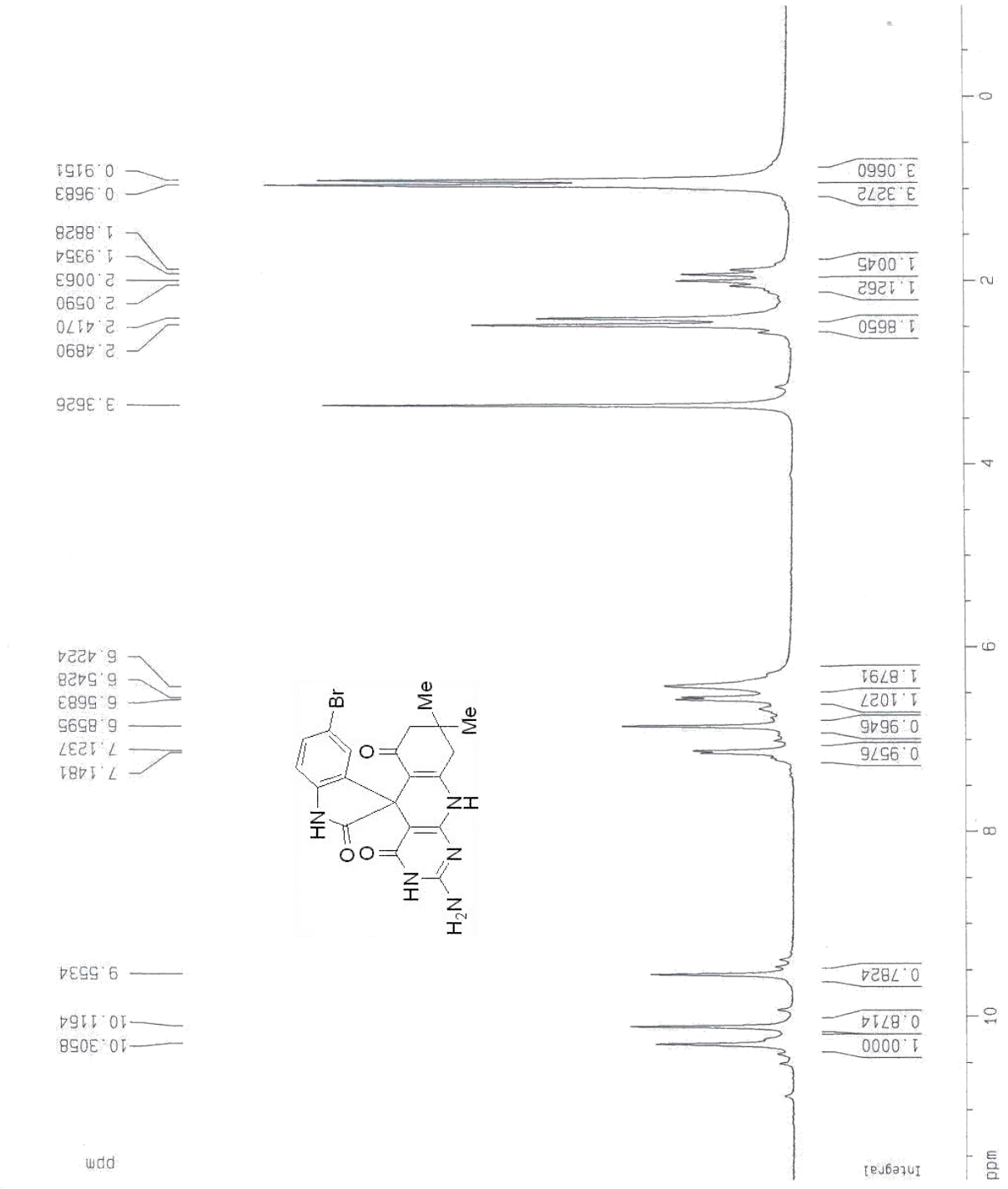
^{13}C NMR spectrum of 2'-Amino-8',8'-dimethyl-8',9'-dihydro-3'H-spiro[indoline-3,5'-pyrimido[4,5-b]quinoline] -2,4',6'(7'H,10'H)-trione (4n).



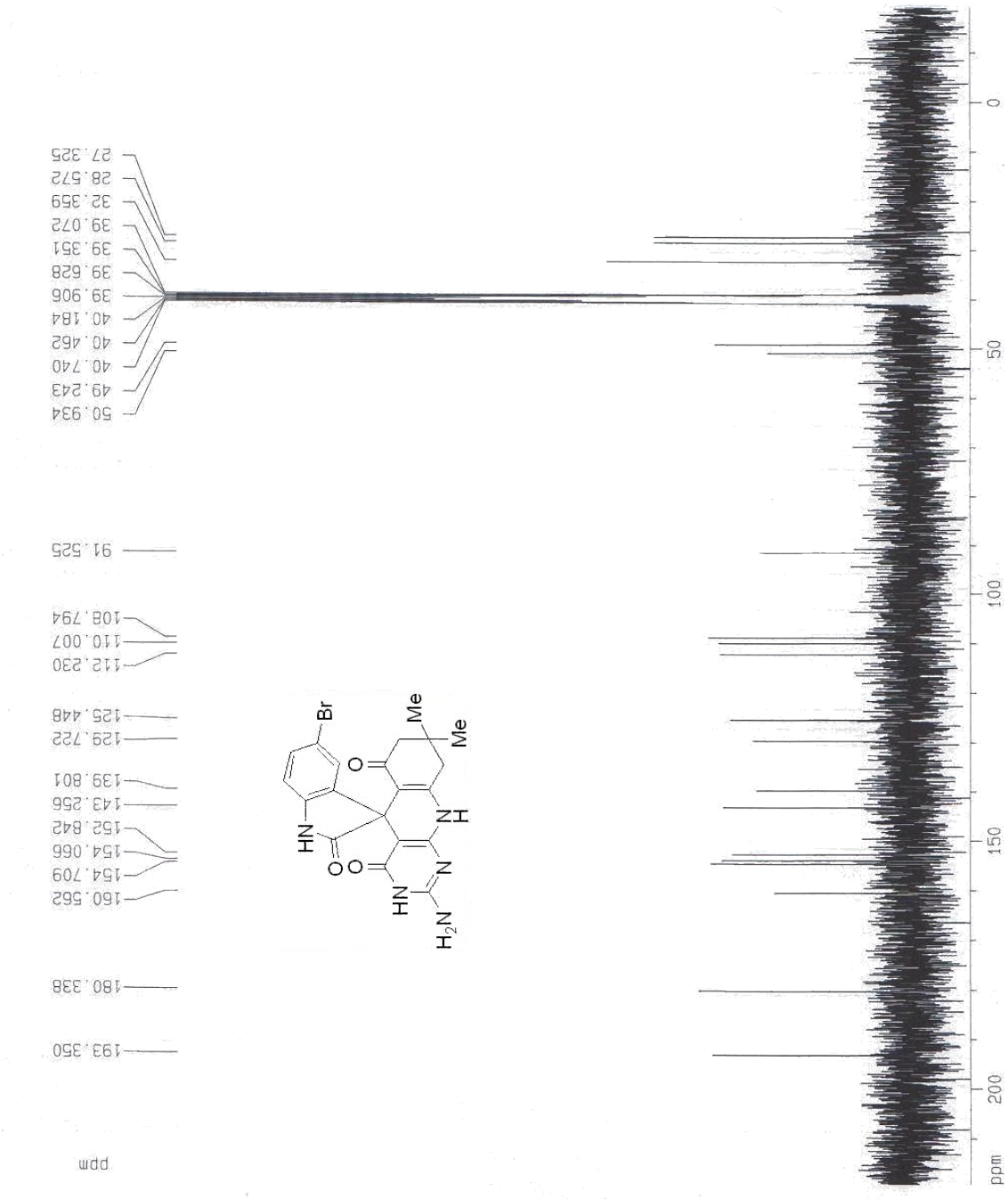
[1]H NMR spectrum of 2'-Amino-5-bromo-8',8'-dimethyl-8',9'-dihydro-3'H-spiro[indoline-3,5'-pyrimido[4,5-b] quinoline]-2,4',6'(7'H,10'H)-trione (4o).



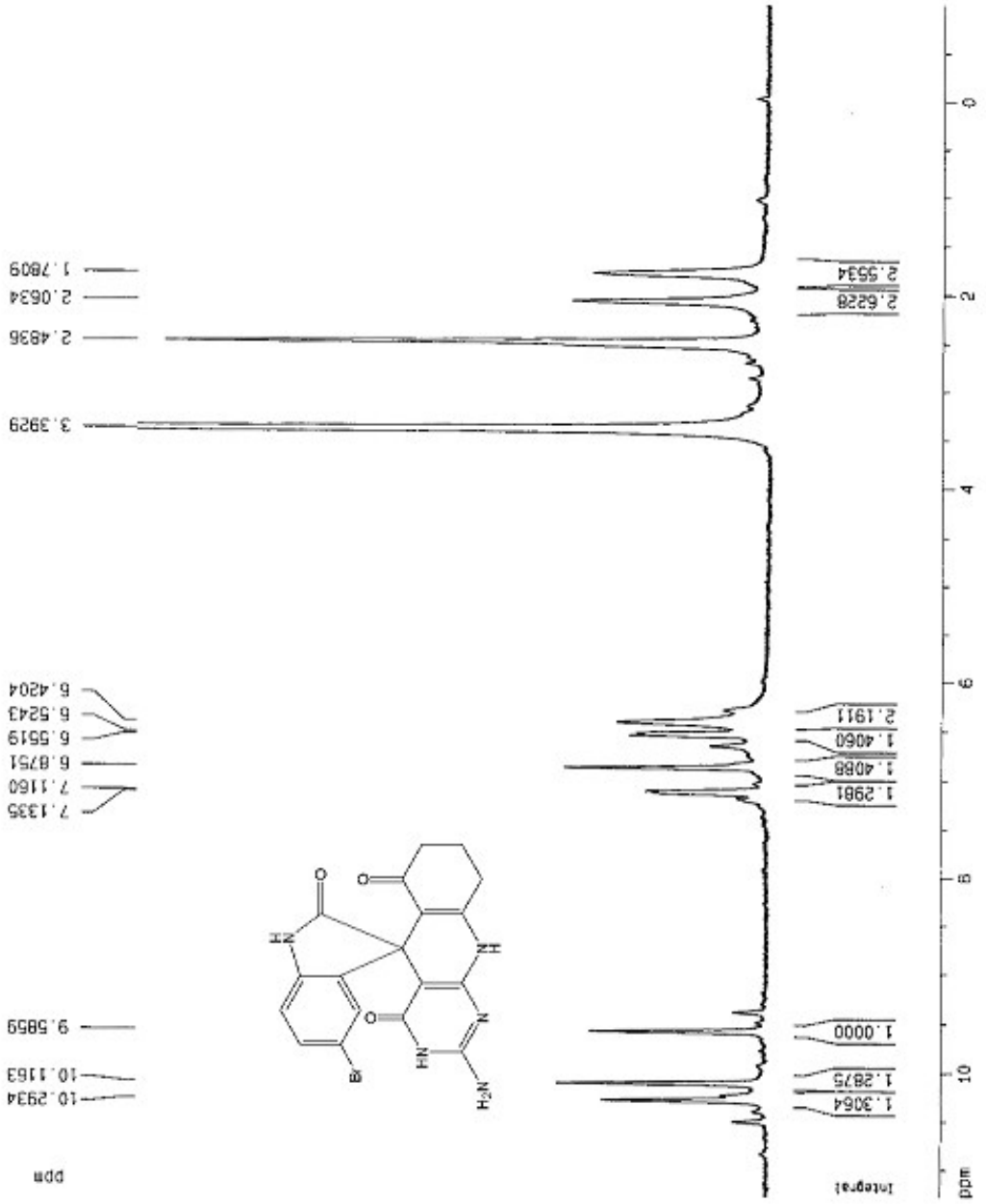
^{13}C NMR spectrum of 2'-Amino-5-bromo-8',8'-dimethyl-8',9'-dihydro-3'H-spiro[indoline-3,5'-pyrimido[4,5-b] quinoline]-2,4',6'(7'H,10'H)-trione (4o).



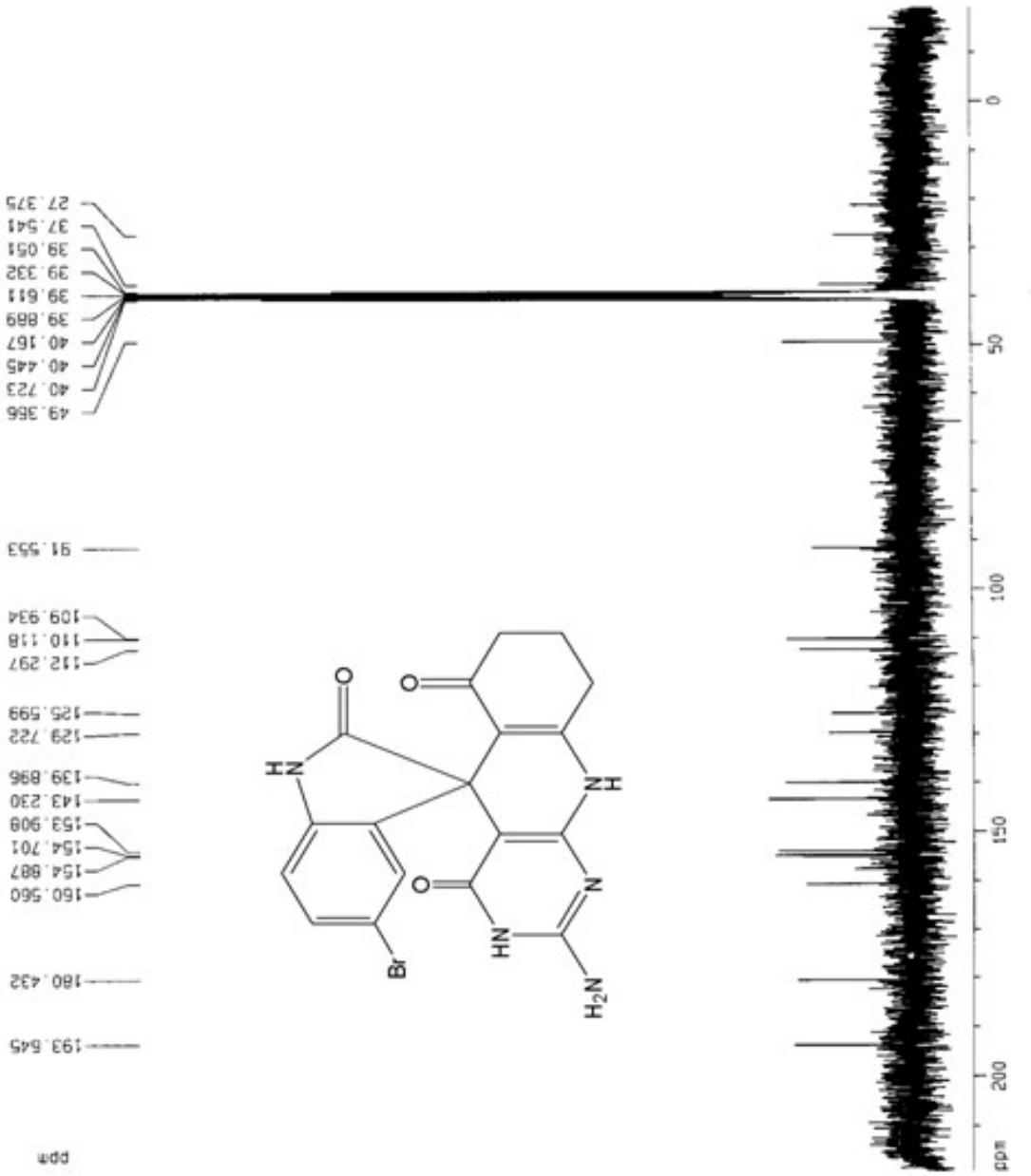
[1]H NMR spectrum of 2'-Amino-5-bromo-8',8'-dimethyl-8',9'-dihydro-3'H-spiro[indoline-3,5'-pyrimido[4,5-b] quinoline]-2,4',6'(7'H,10'H)-trione (4p).



^{13}C NMR spectrum 2'-Amino-5-bromo-8',8'-dimethyl-8',9'-dihydro-3'H-spiro[indoline-3,5'-pyrimido[4,5-b] quinoline]-2,4',6'(7'H,10'H)-trione (4p).



[1]H NMR spectrum of 2'-Amino-5-bromo-8',9'-dihydro-3'H-spiro[indoline-3,5'-pyrimido[4,5-b]quinoline]-2,4',6'(7'H,10'H)-trione (4s).



^{13}C NMR spectrum 2'-Amino-5-bromo-8',9'-dihydro-3'H-spiro[indoline-3,5'-pyrimido[4,5-b]quinoline]-2,4',6'(7'H,10'H)-trione (4s).