Electronic Supplementary Material (ESI) for RSC Advances.

Mn doped ZrO_2 as a green, efficient and reusable heterogeneous catalyst for the multicomponent synthesis of pyrano[2,3-*d*]-pyrimidine derivatives

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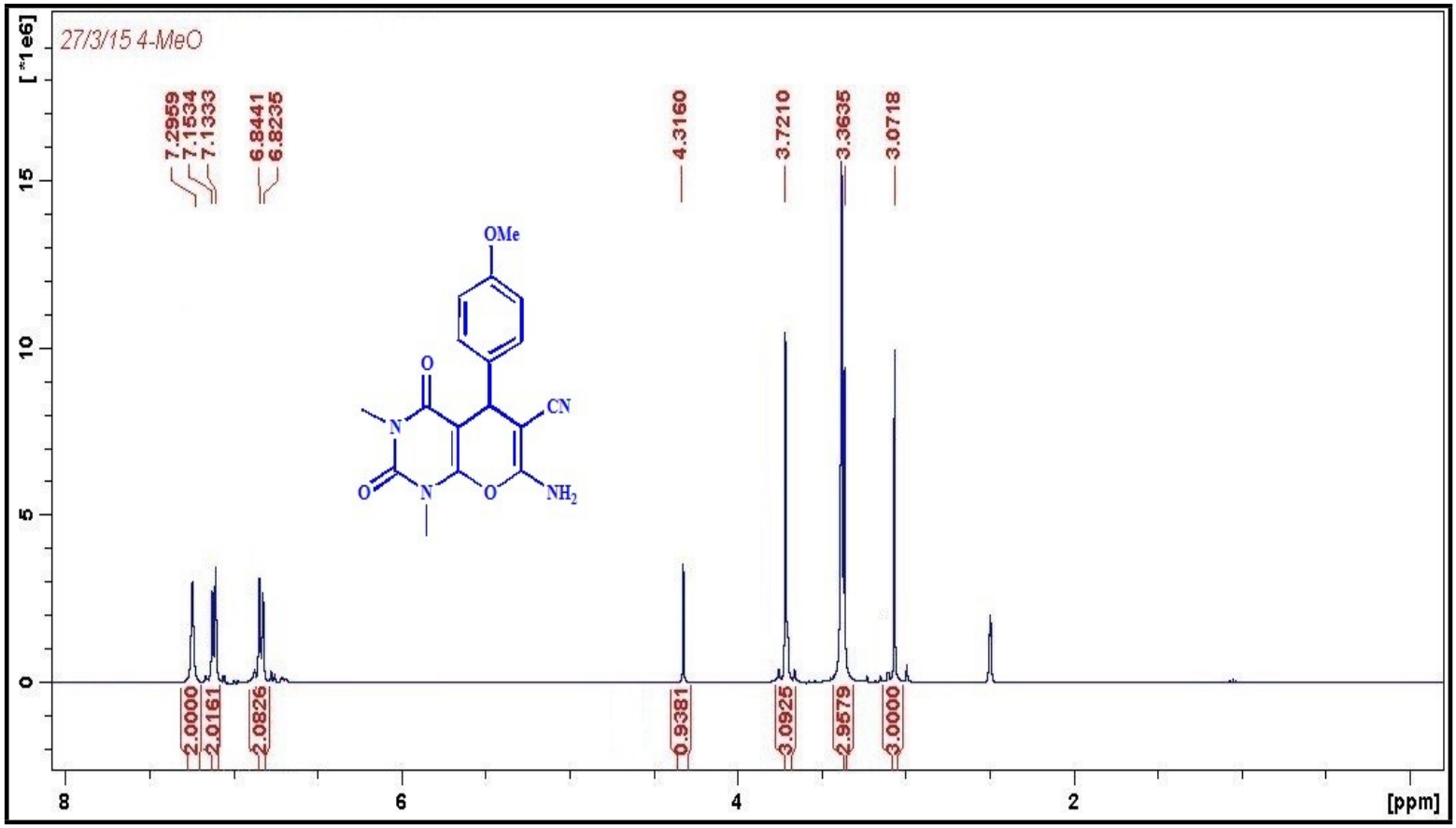
Materials, methods and instruments

All chemicals and reagents required for the reaction were of analytical grade and were used without any further purification. Bruker AMX NMR spectrometer was used to record the ^{1}H NMR, ^{13}C NMR and ^{15}N NMR spectral values. The DMSO−d_6 solution was utilized for this while TMS served as the internal standard. TMS was further used as an internal standard for reporting the all chemical shifts in δ (ppm). The FT-IR spectrum for the samples was established using a Perkin Elmer Perkin Elmer Precisely 100 FT-IR spectrometer at the 400-4000 cm^{-1} area. Purity of all the reaction products was confirmed by TLC using aluminum plates coated with silica gel (Merck Kieselgel 60 F254).

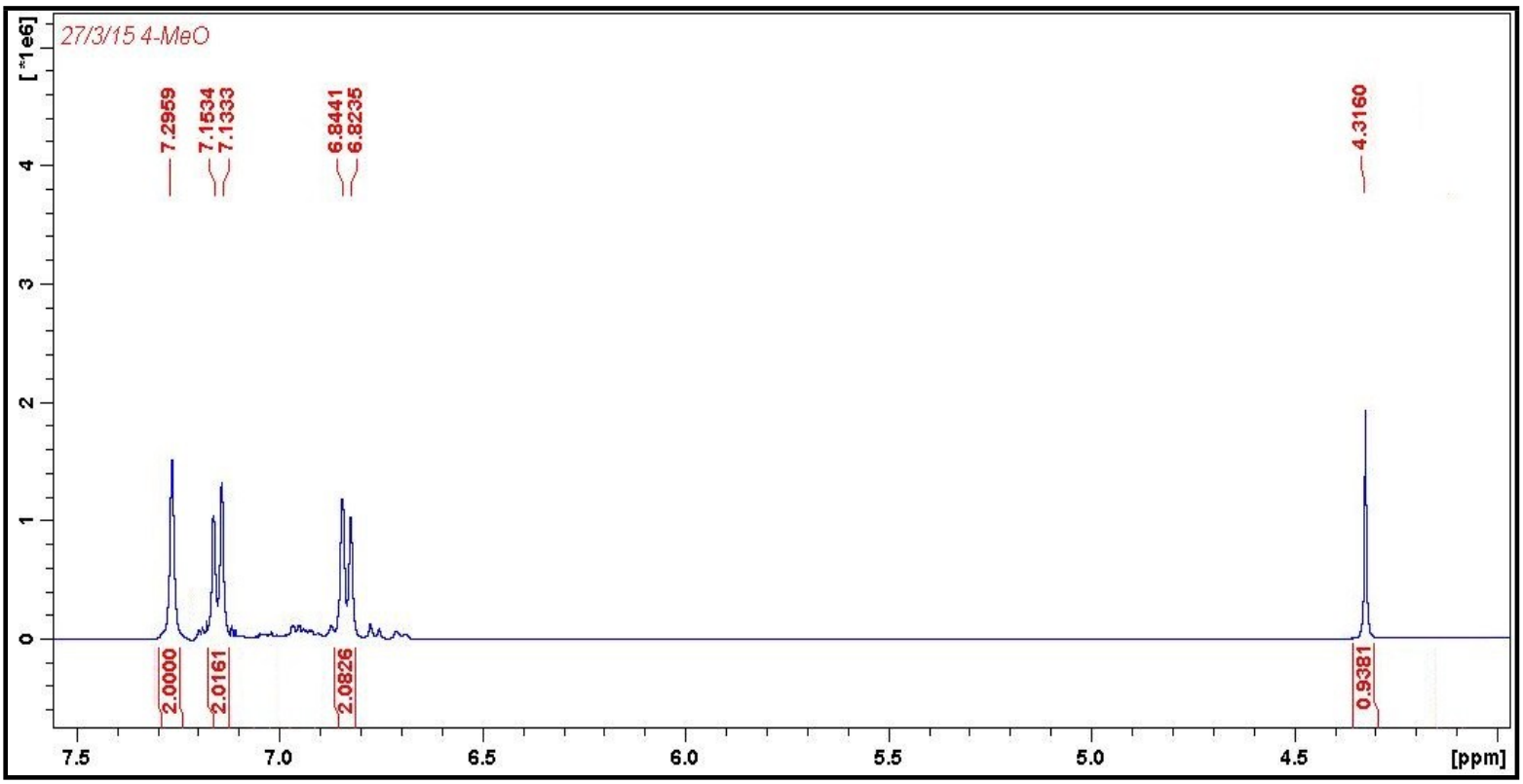
Characterization of Catalysts

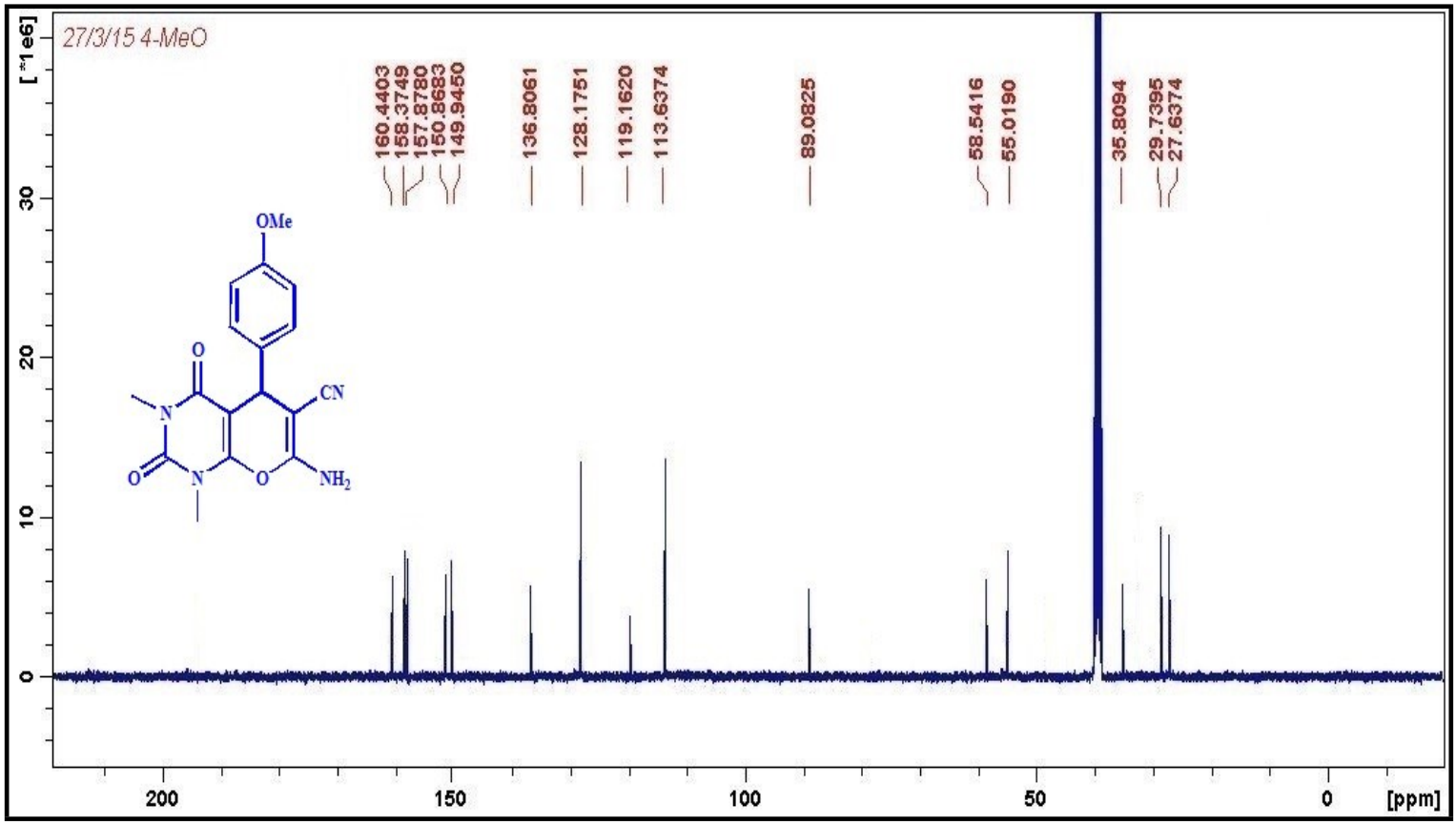
Micromeritics Tristar-II porosity and surface area analyzer was used estimation of pore size, pore volume and surface area of the catalysts. BJH adsorption-desorption curves were obtained at -196 °C, to assess the particulate properties of the catalyst. All the catalyst materials were degassed by passing nitrogen overnight at 200 °C. Bruker D8 advance instrument with a Cu K radiation source by λ = 1.5406 was used for the X-ray diffraction data for the catalyst. Jeol JEM-1010 electron microscope and JEOL JSM-6100 microscope were used for TEM and SEM analysis respectively. In TEM analysis for particles distribution, size of 40-60 particles were averaged and with standard deviation. An emission current (100 μA) by a Tungsten (W) filament with 12 kV accelerator voltage was employed for EDX-analysis of the SEM images. Elemental composition of the catalyst materials was established by using Inductively Coupled Plasma Optical Emission Spectrometer (Optima 5300 DV).

Spectra's of substituted pyrano[2,3-*d*]-pyrimidine derivatives (4a-k).

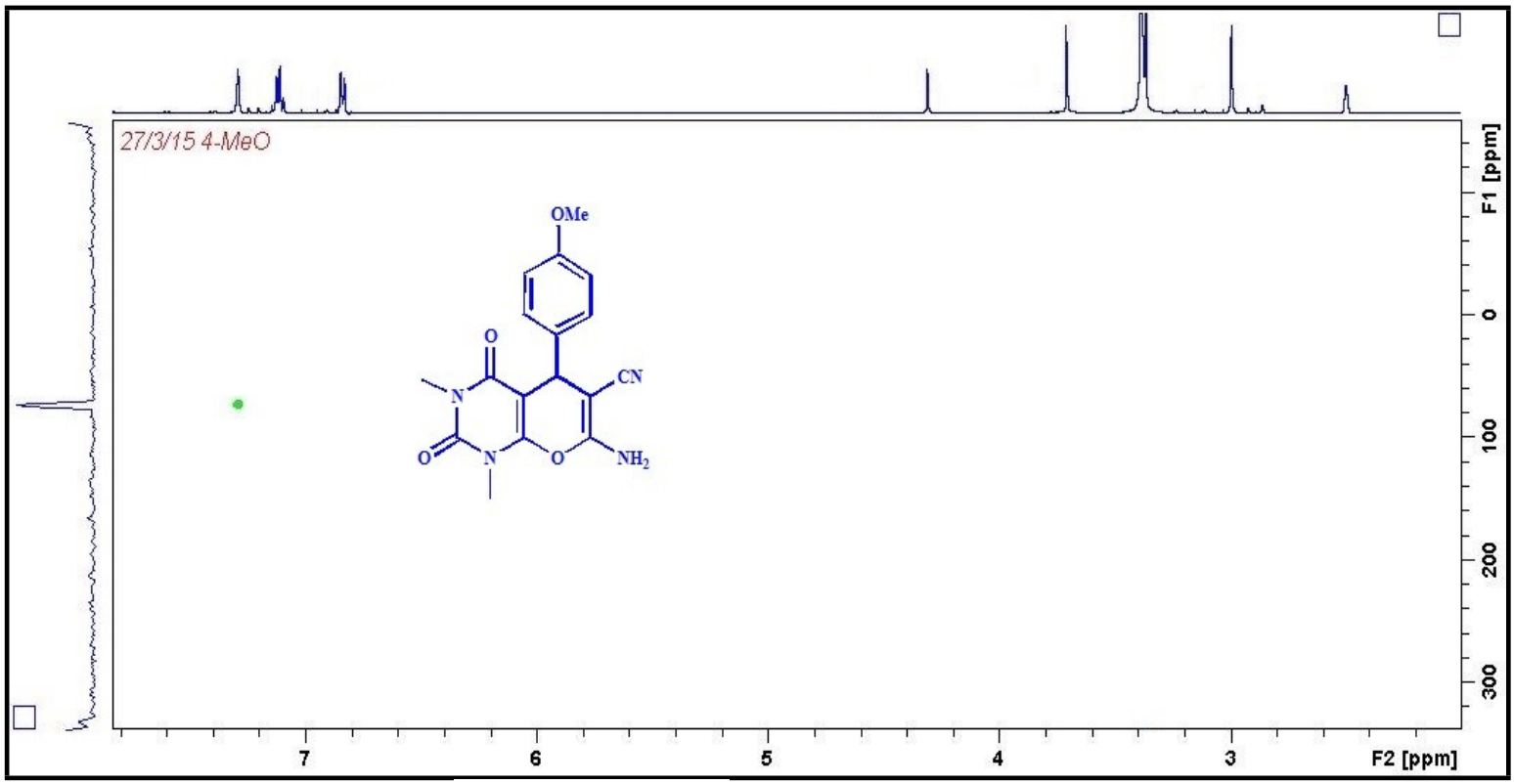


^{1}H NMR spectra of compound 4a

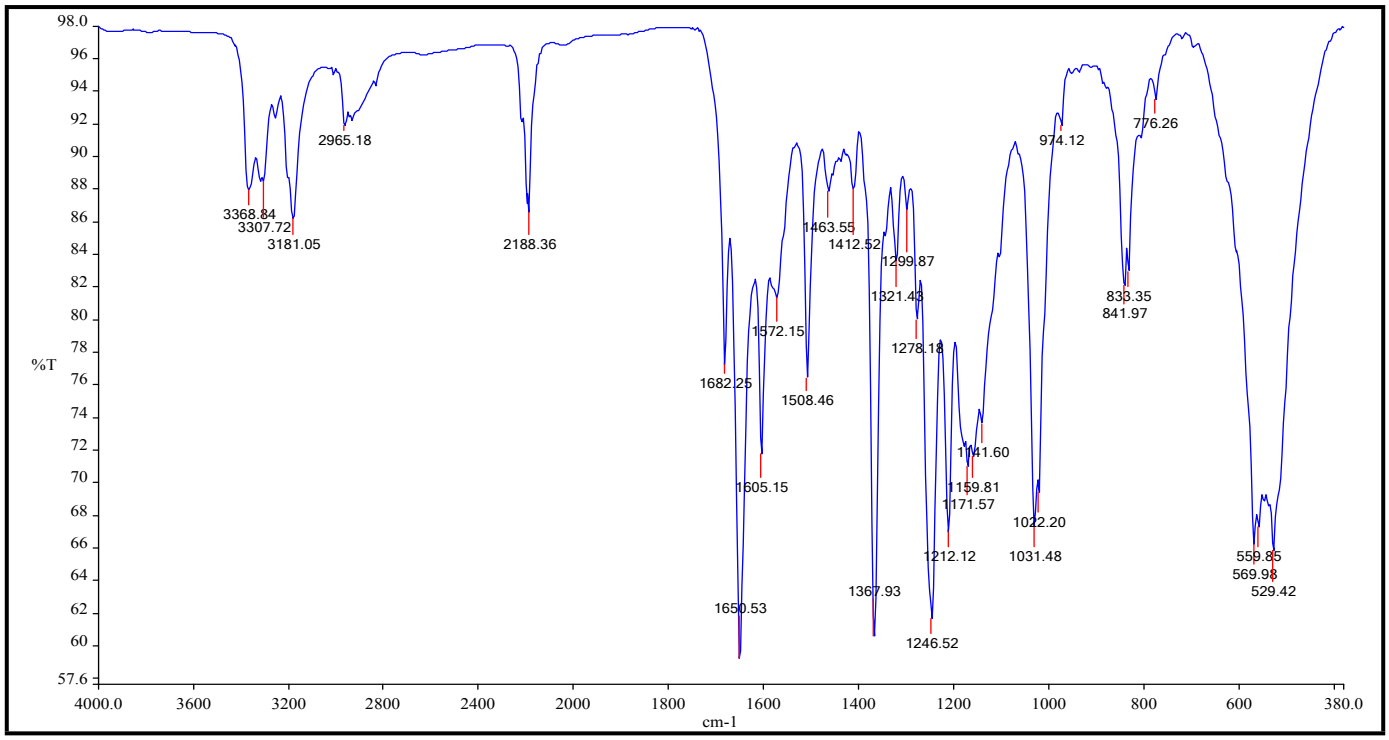




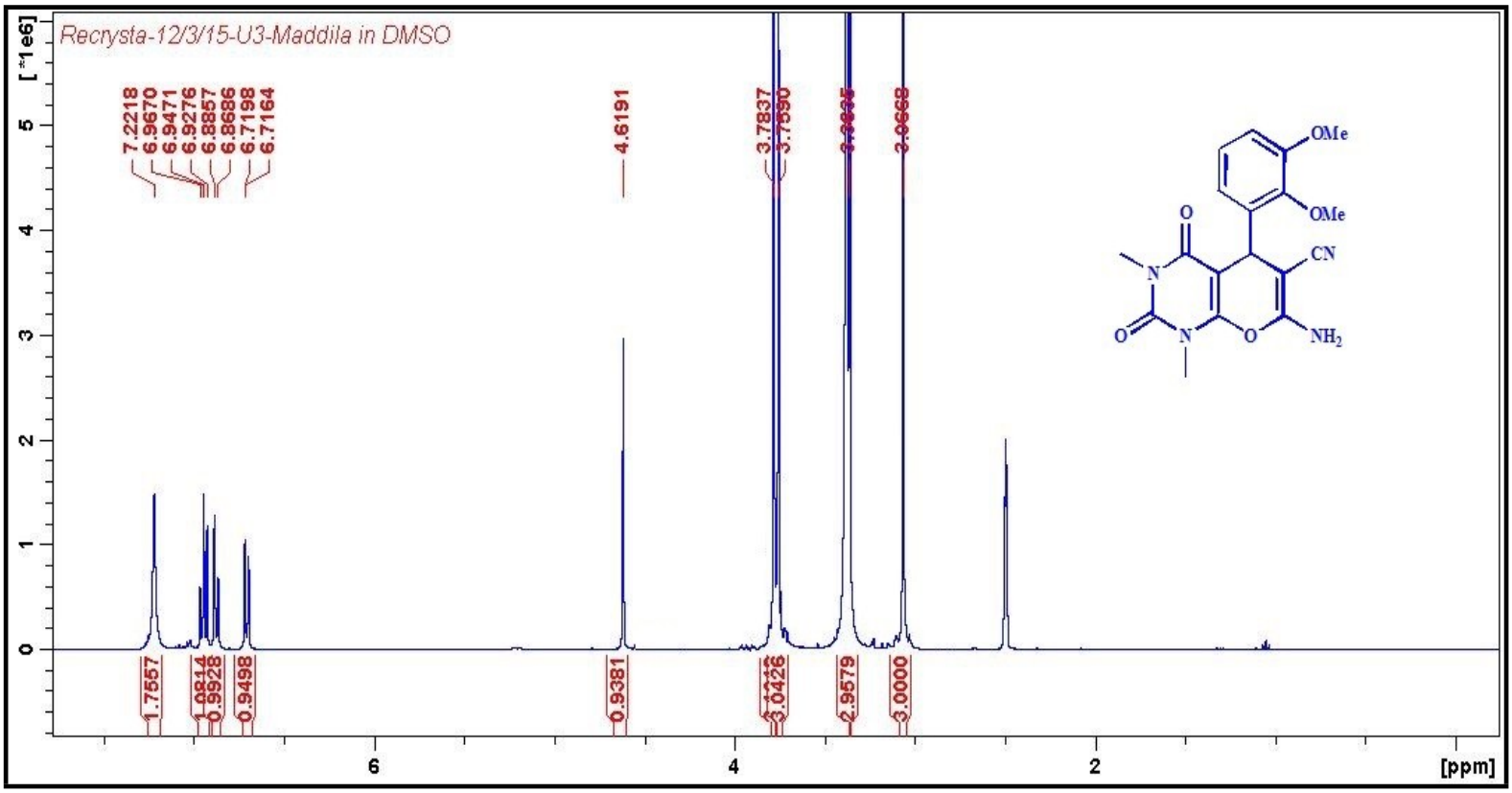
^{13}C NMR spectra of compound 4a



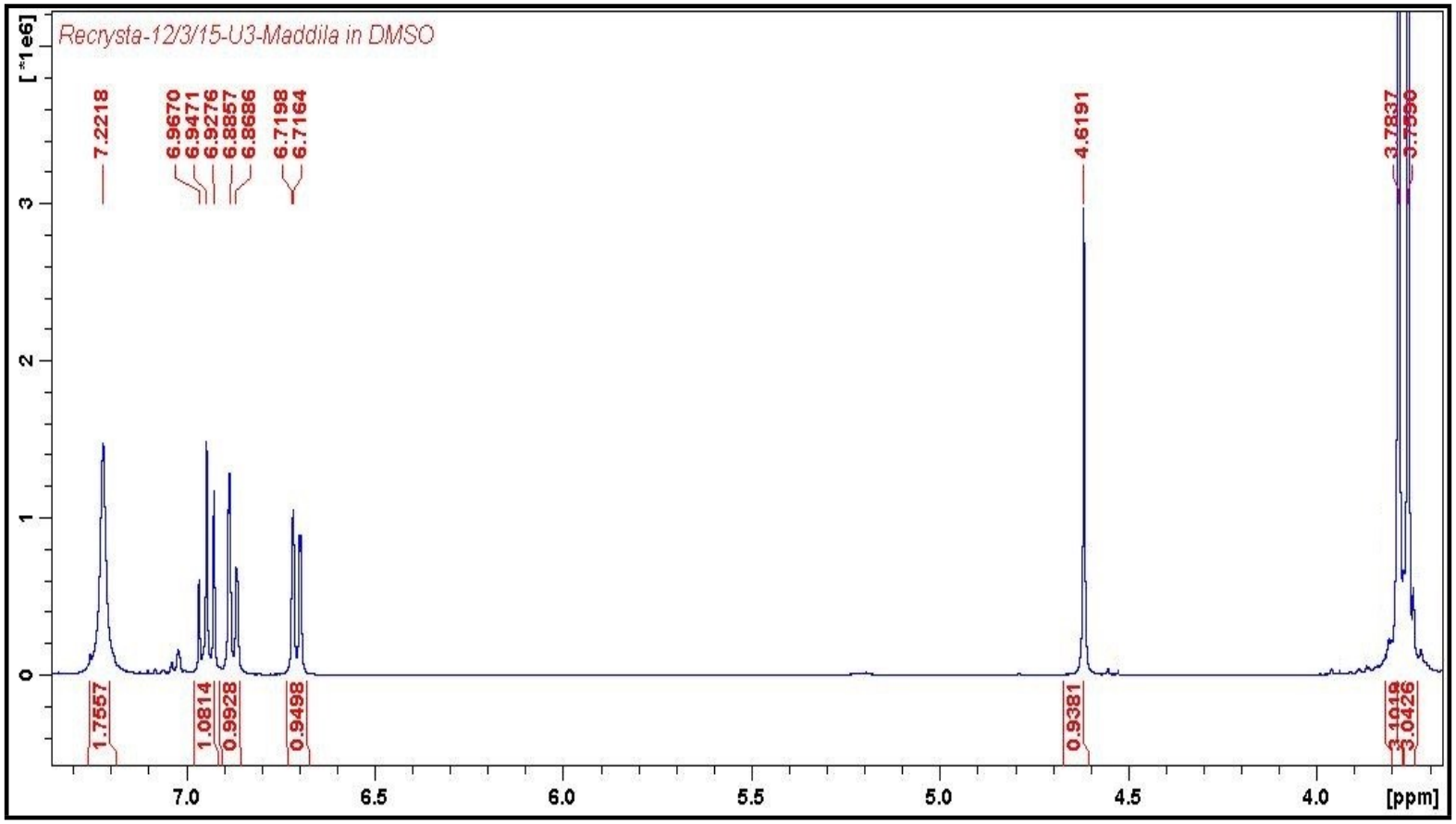
^{15}N NMR (GHSQC) spectra of compound 4a

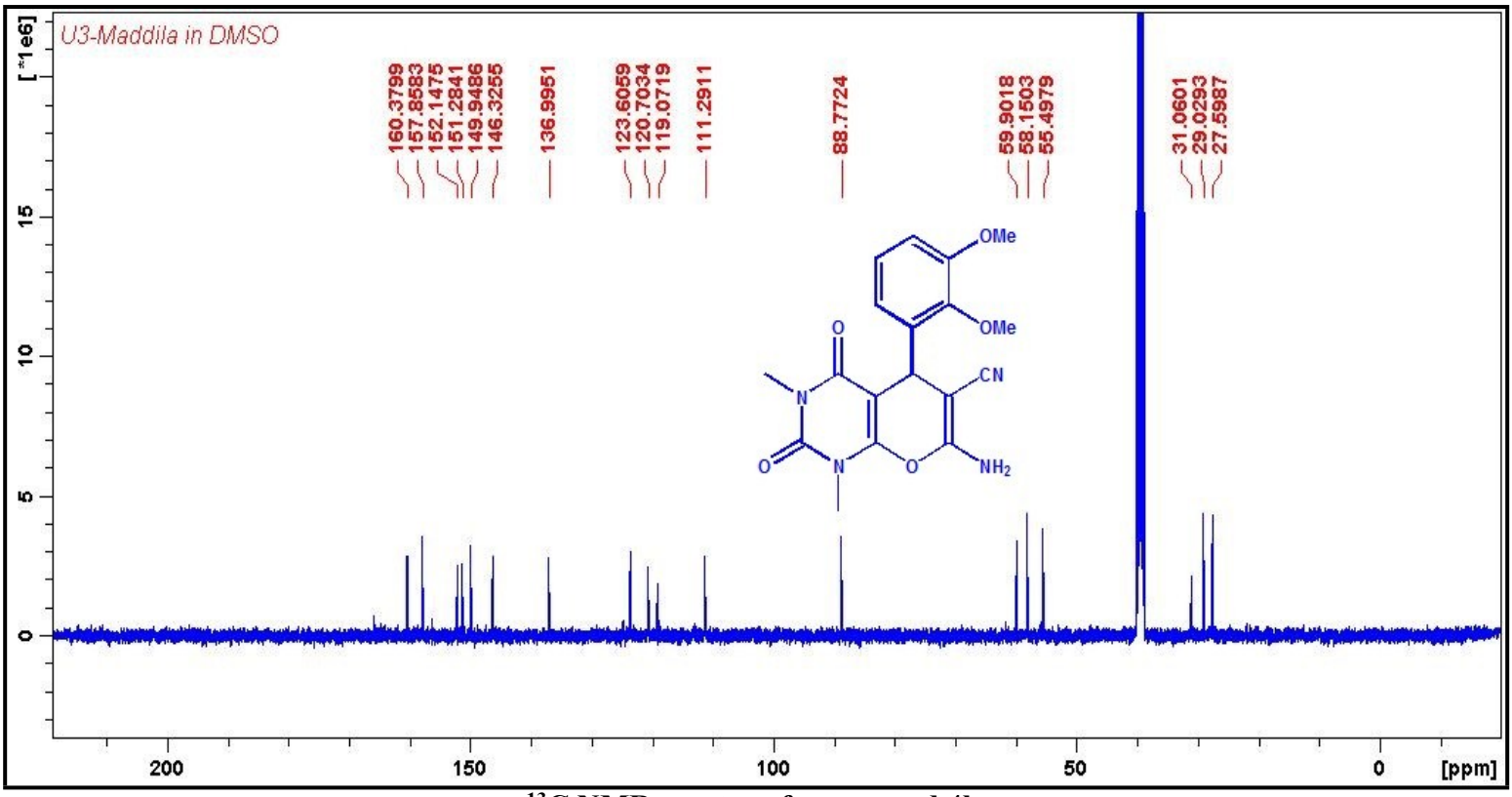


FT-IR spectra of compound 4a

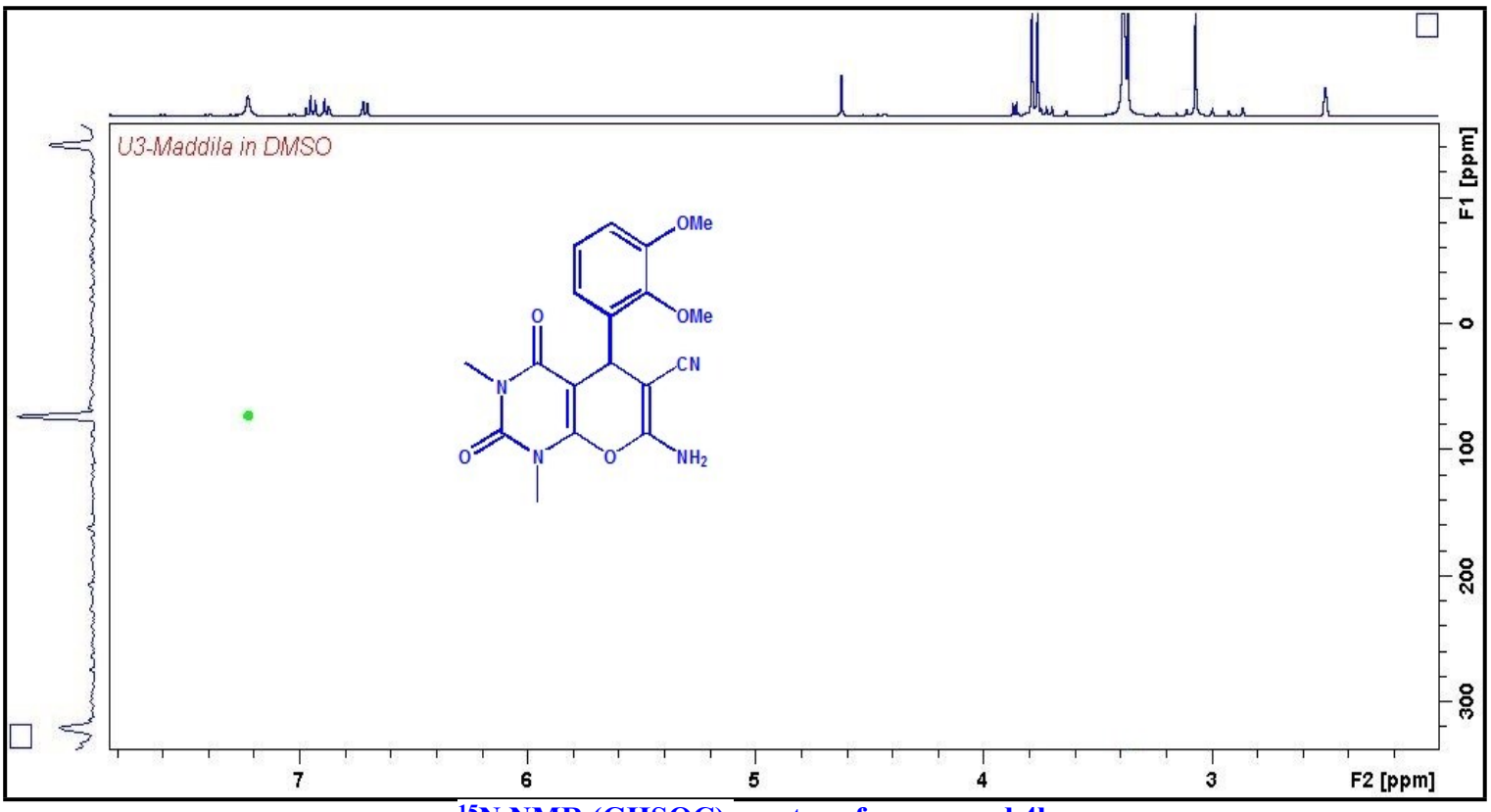


^{1}H NMR spectra of compound 4b

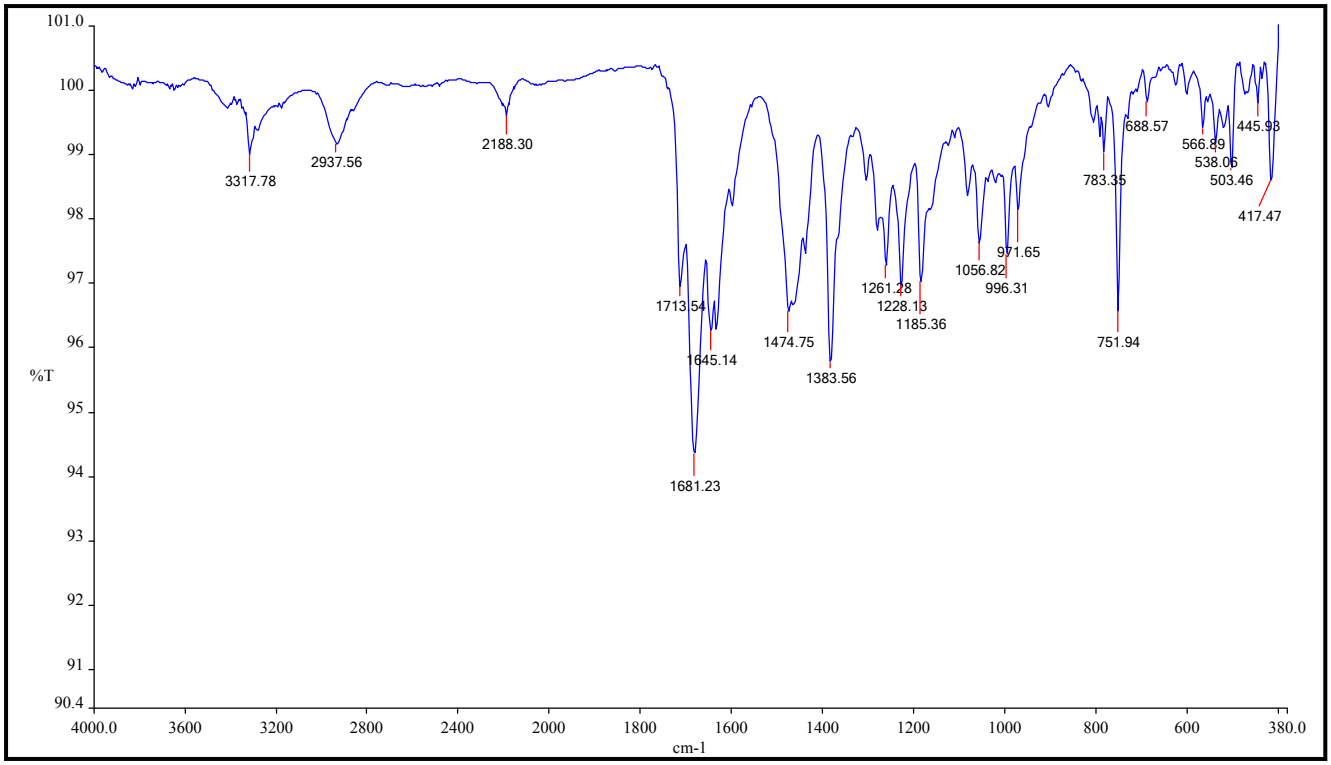




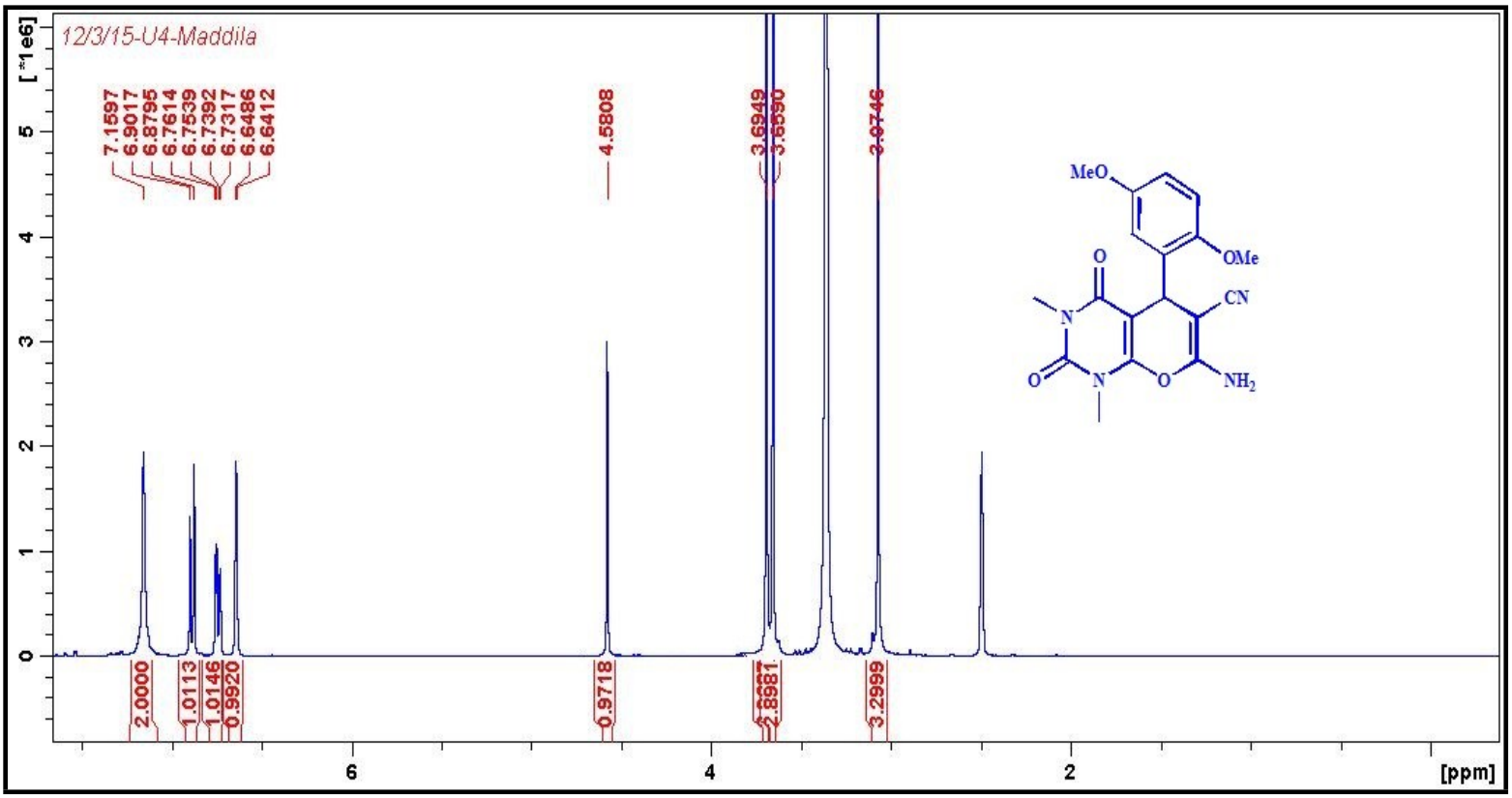
^{13}C NMR spectra of compound 4b



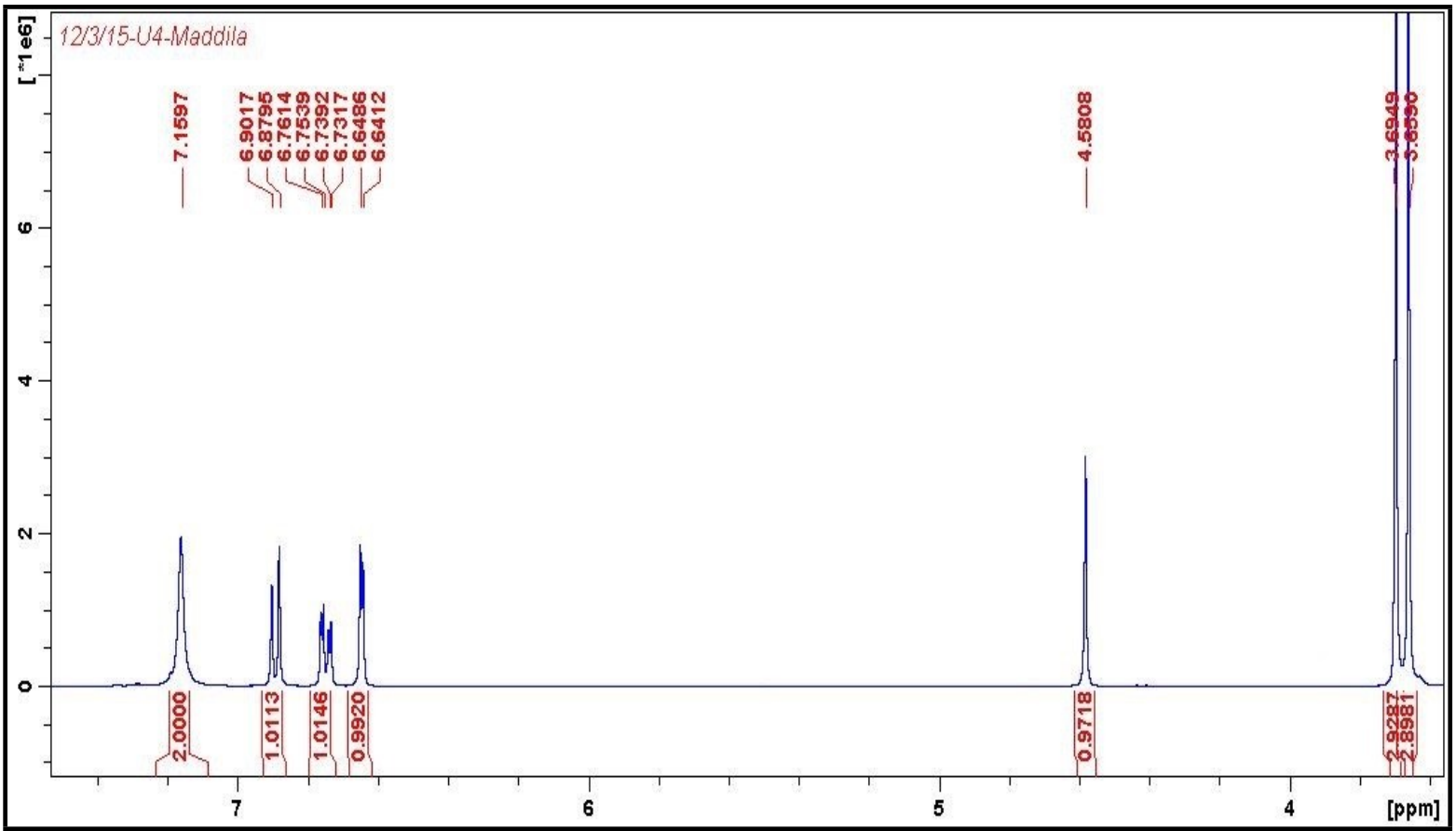
^{15}N NMR (GHSQC) spectra of compound 4b

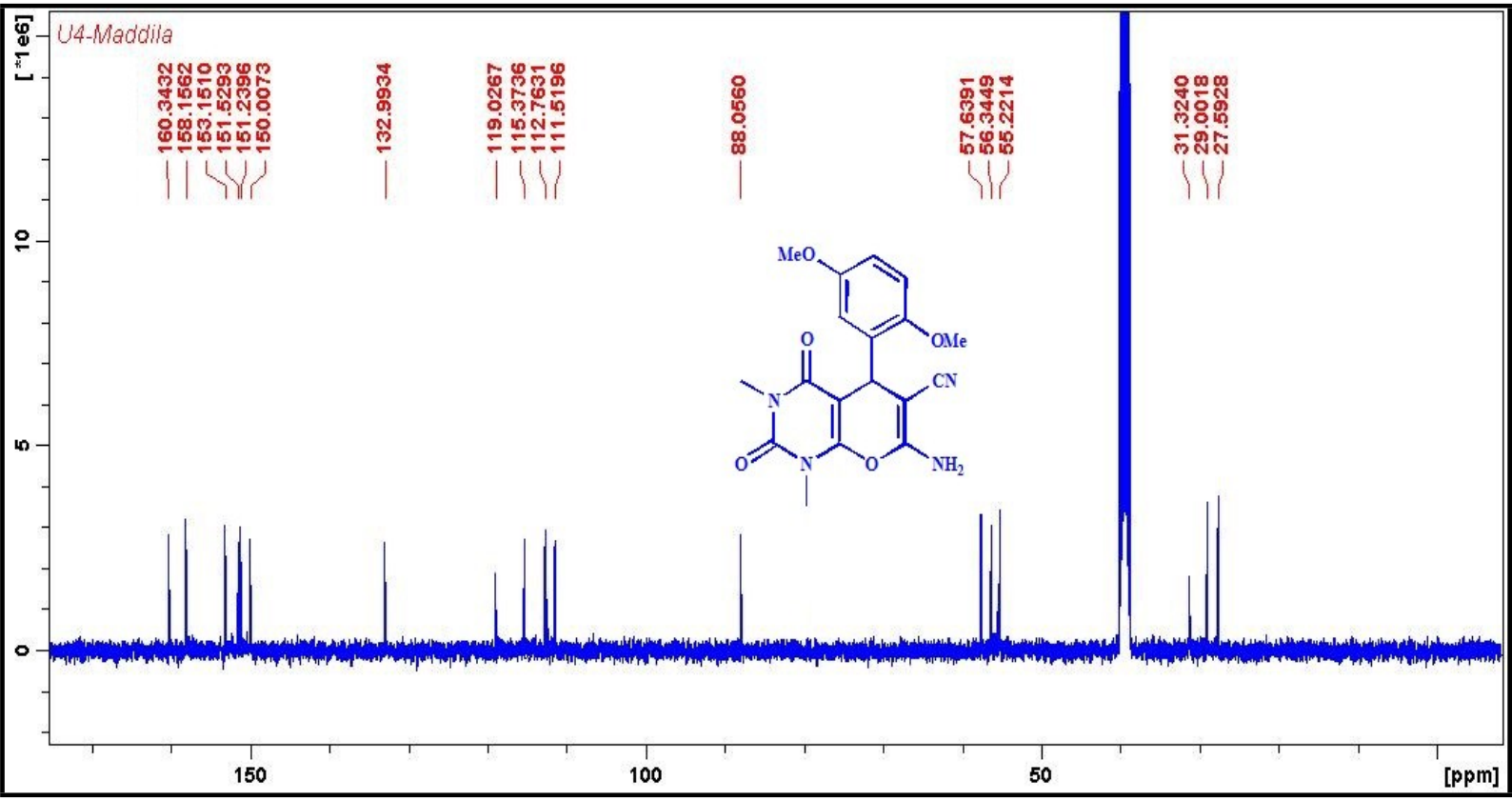


FT-IR spectra of compound 4b

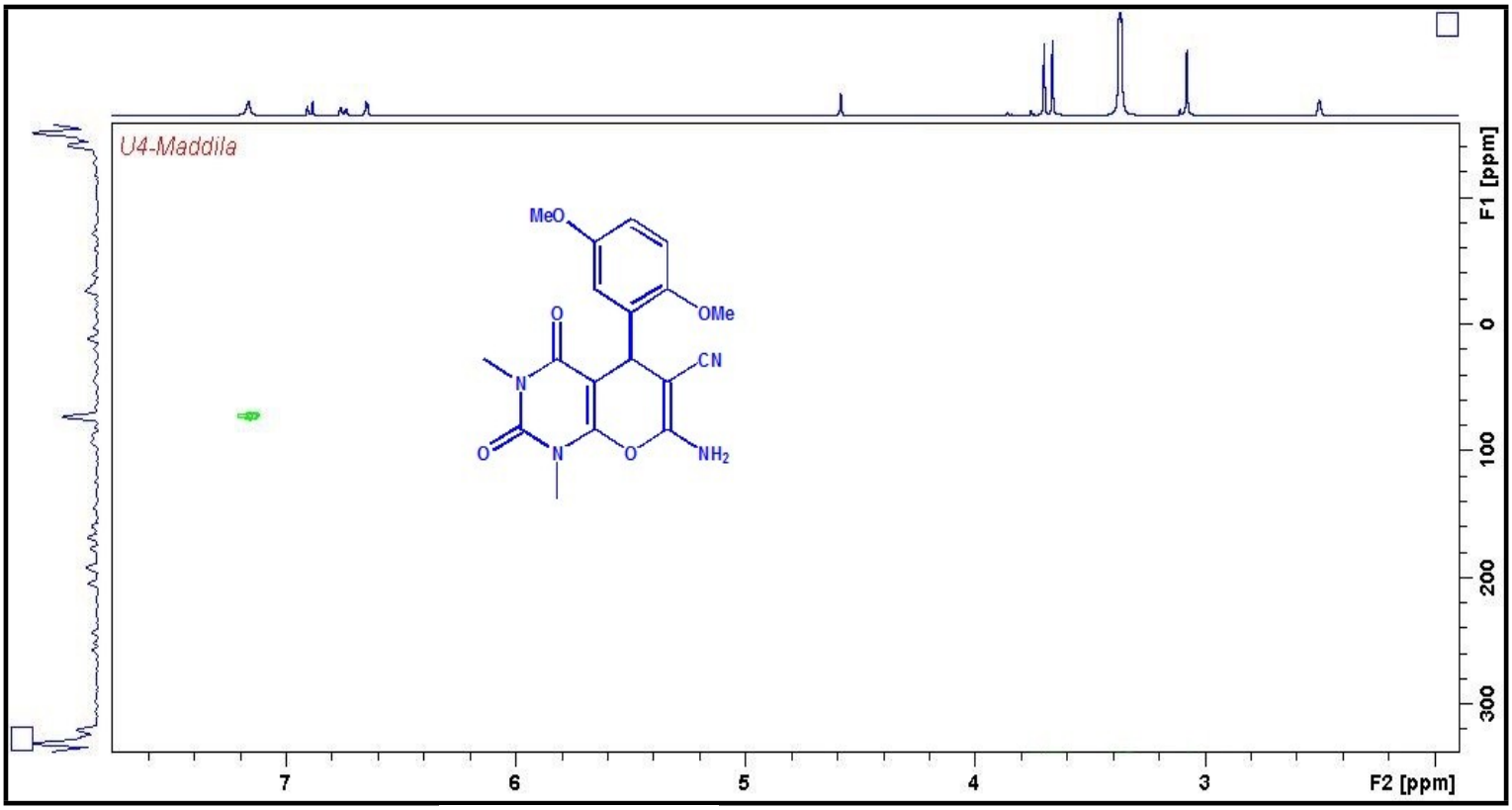


^{1}H NMR spectra of compound 4c

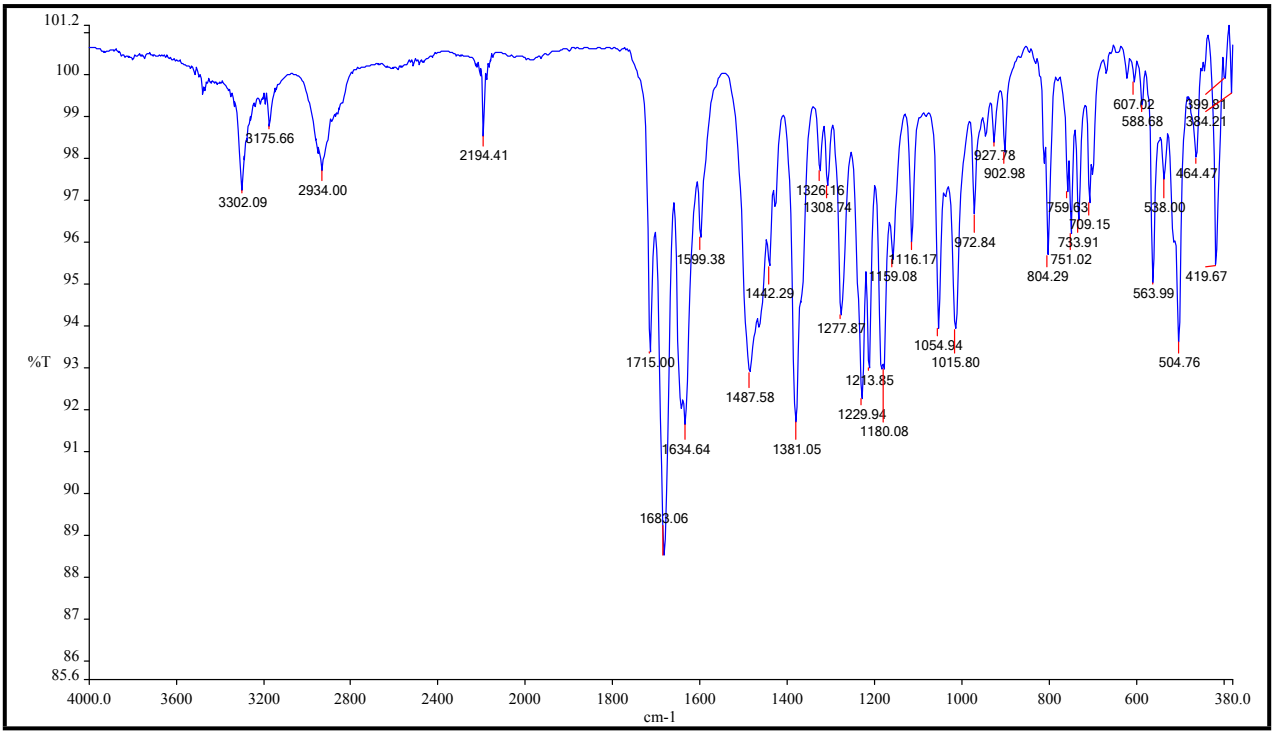




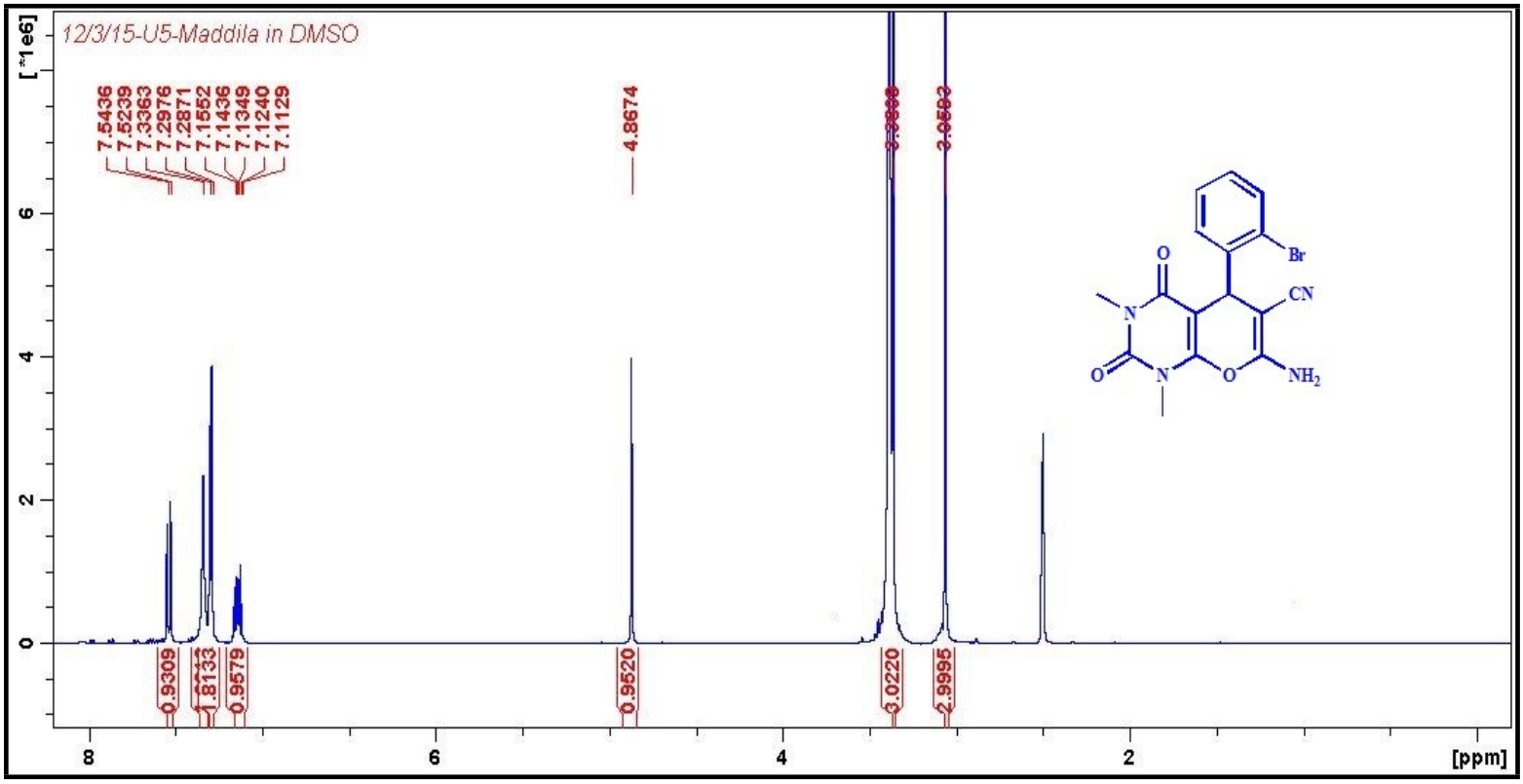
^{13}C NMR spectra of compound 4c



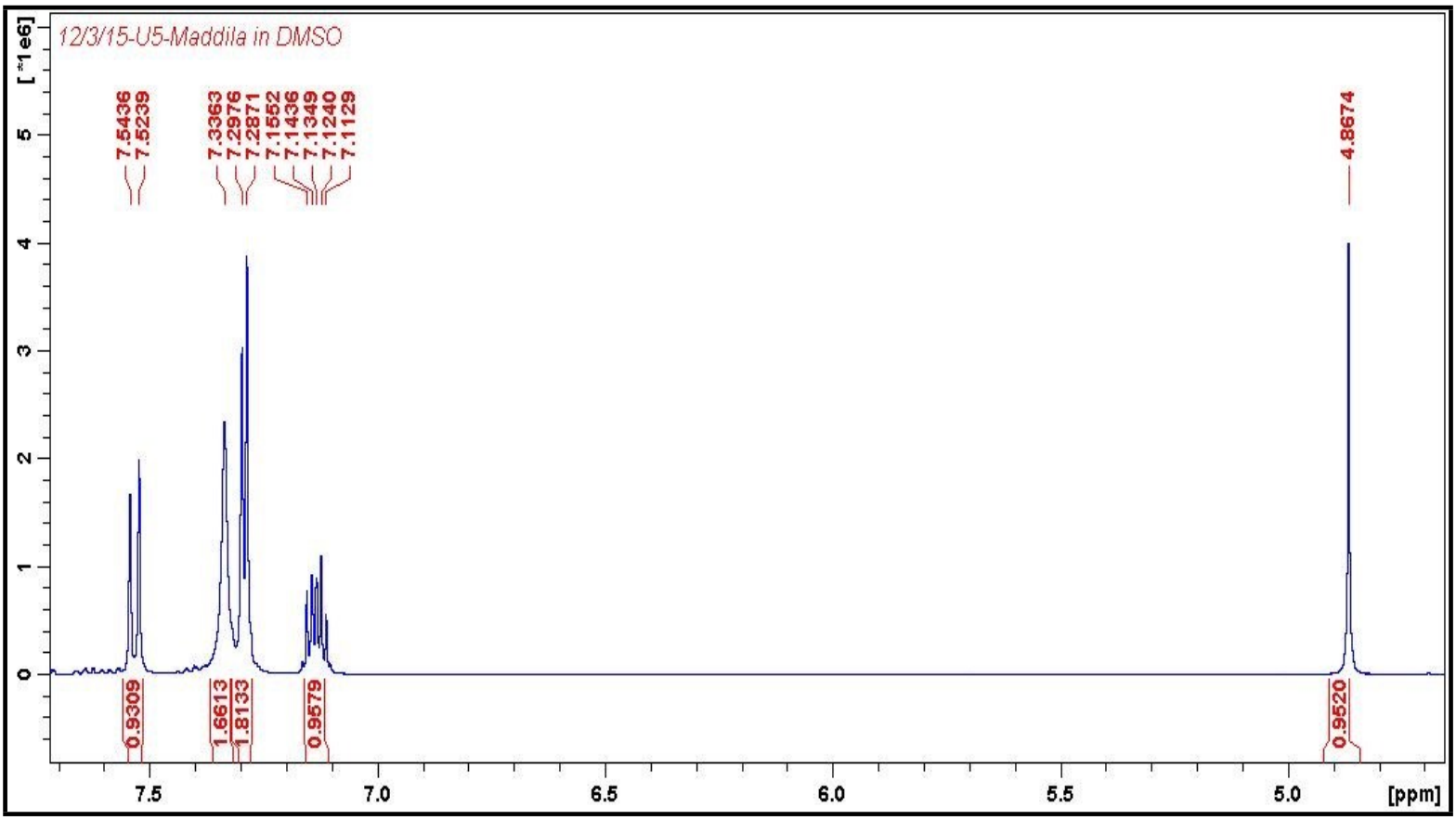
^{15}N NMR (GHSQC) spectra of compound 4c

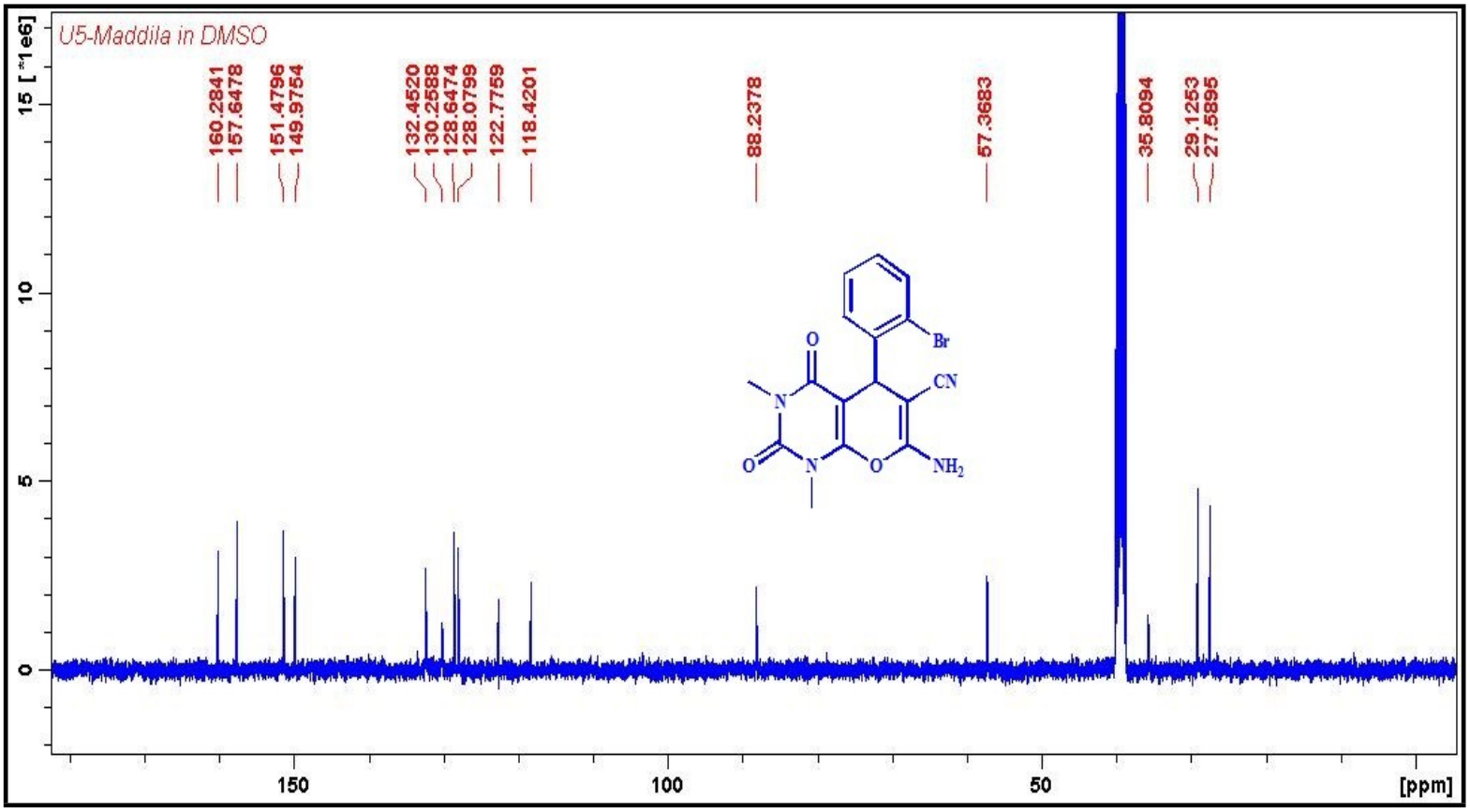


FT-IR spectra of compound 4c



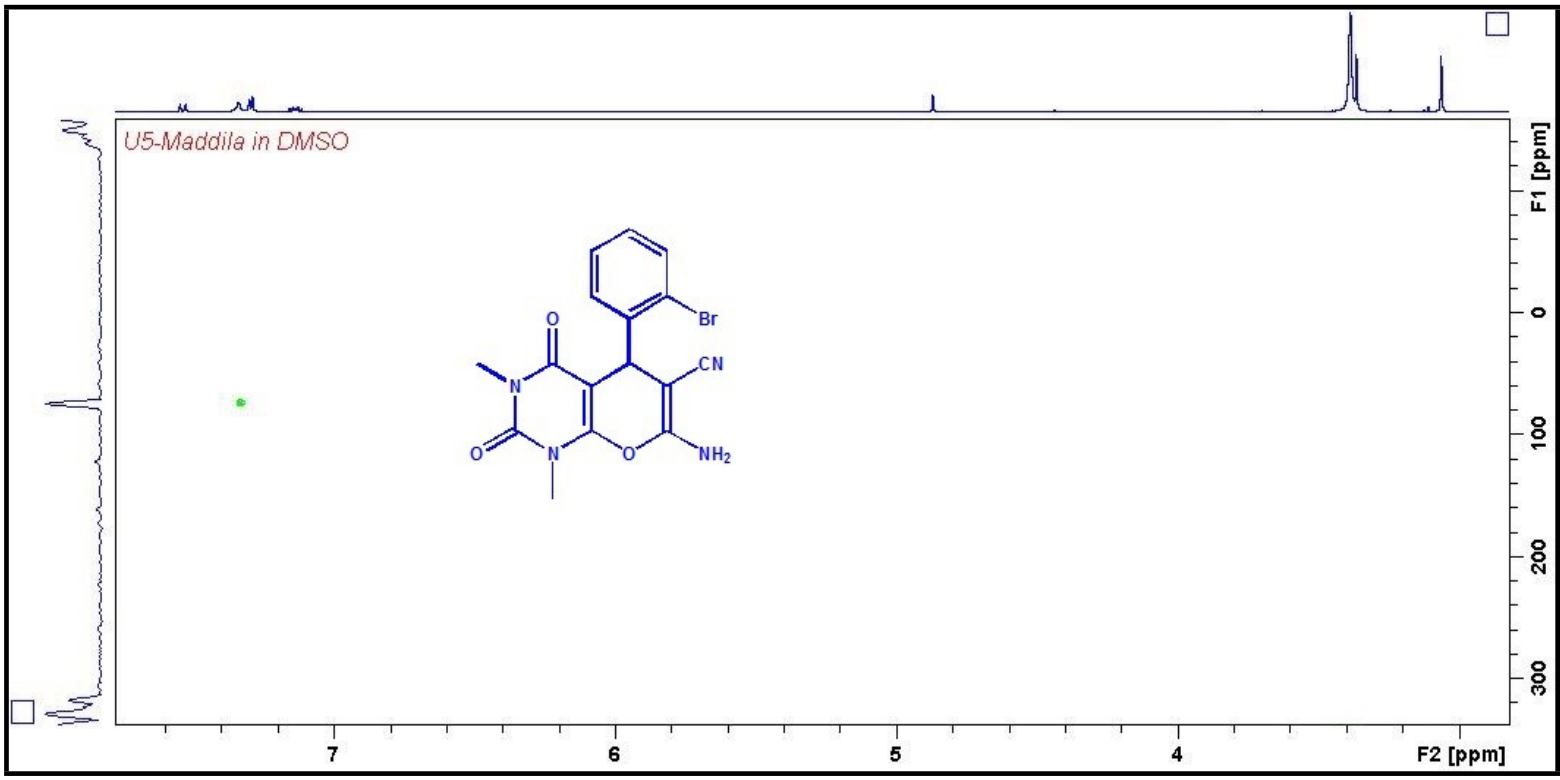
^{1}H NMR spectra of compound 4d

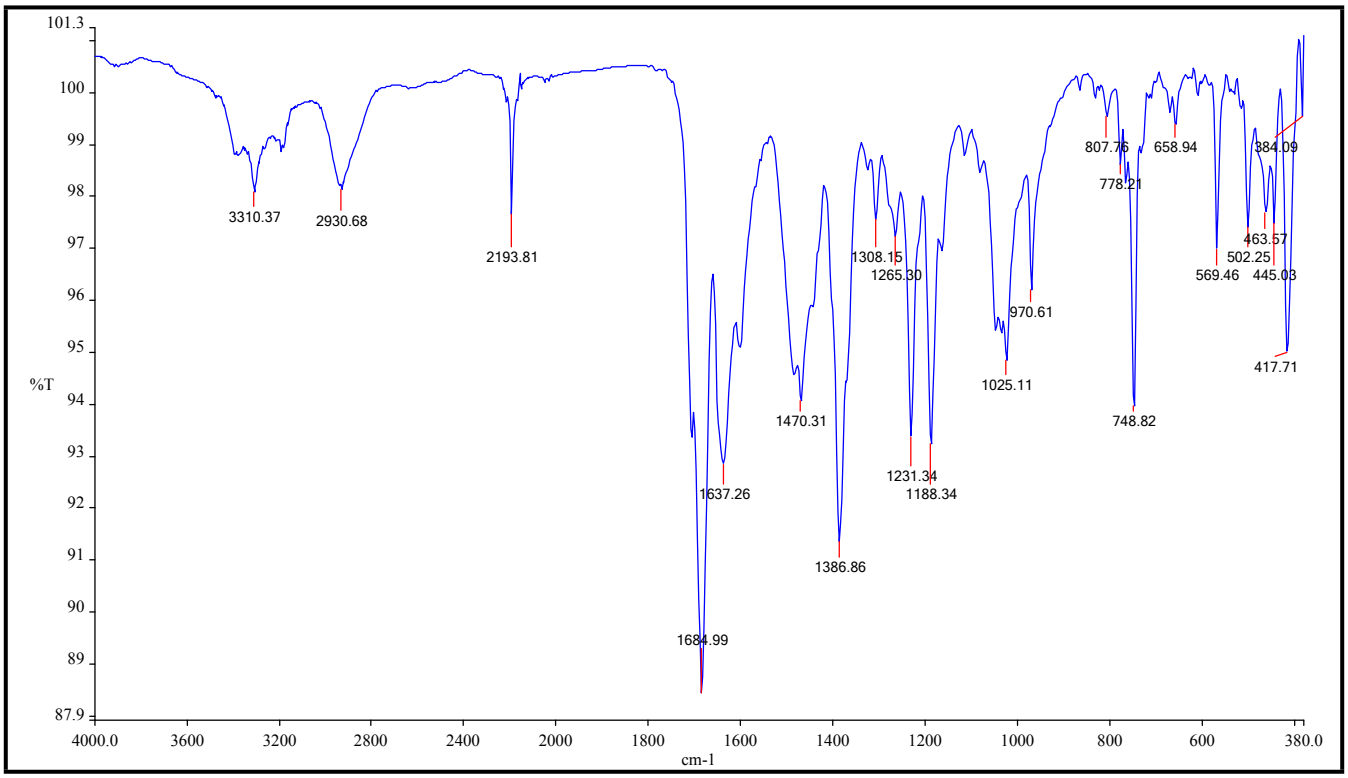




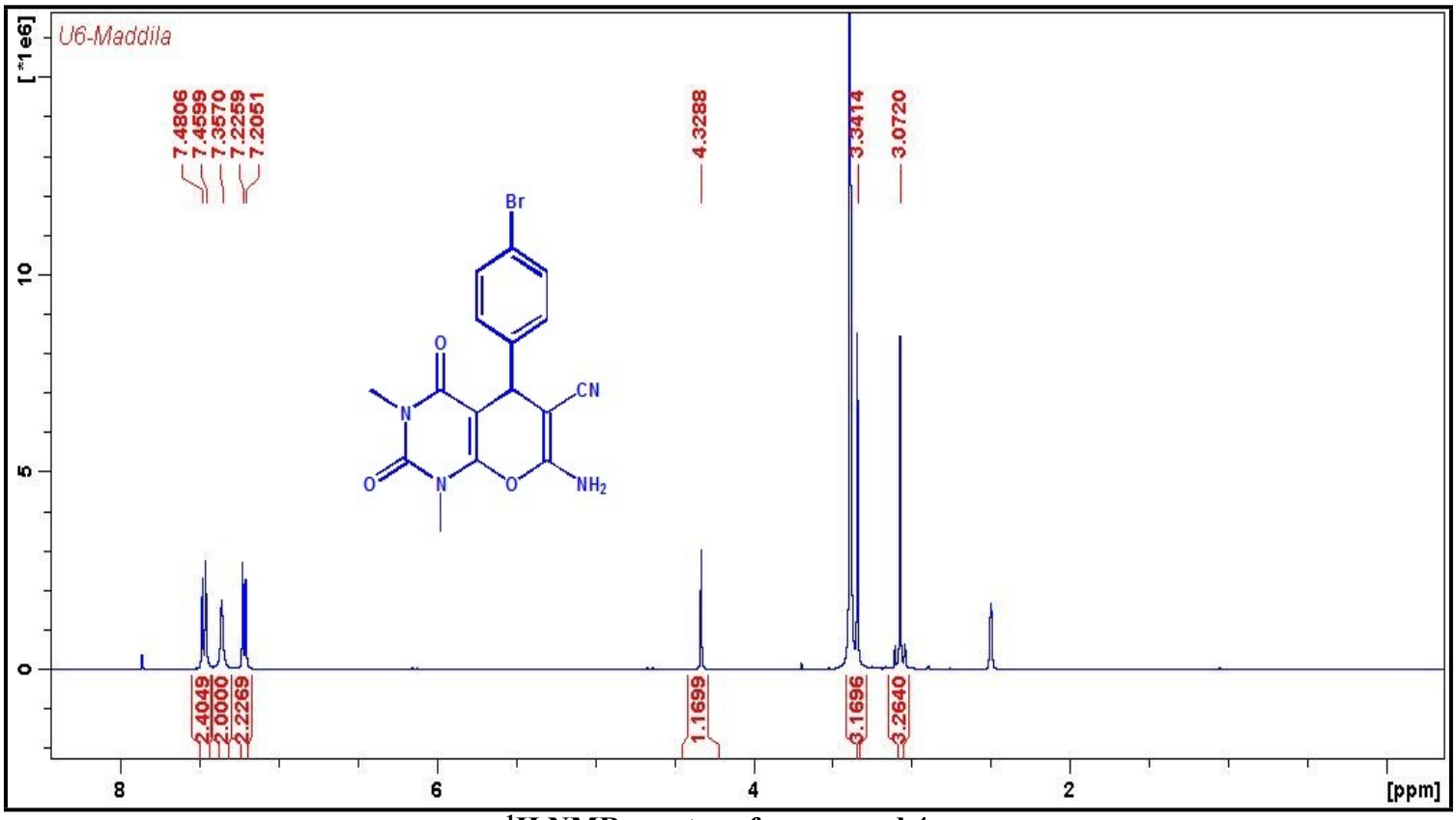
^{13}C NMR spectra of compound 4d

^{15}N NMR (GHSQC) spectra of compound 4d

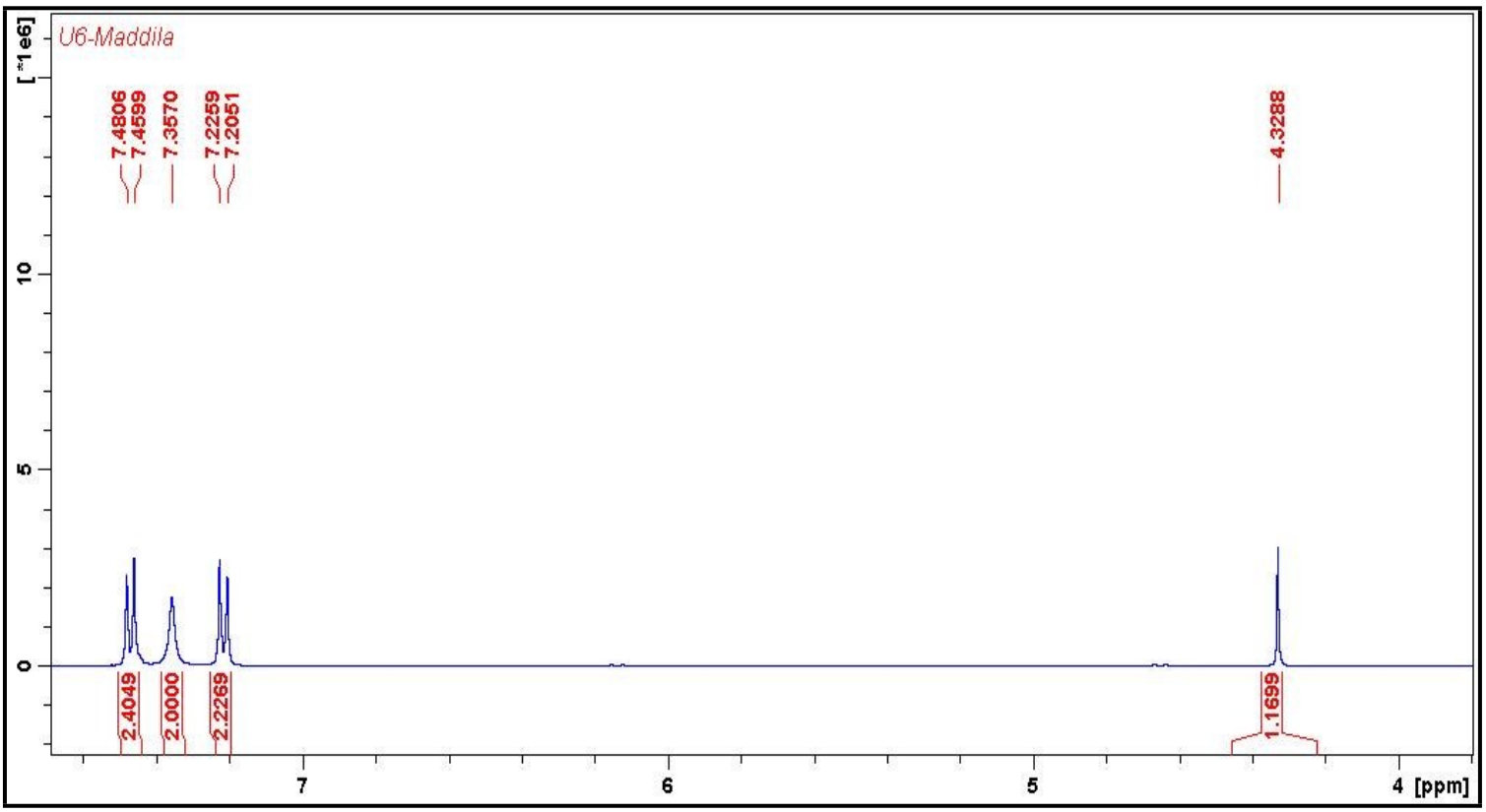


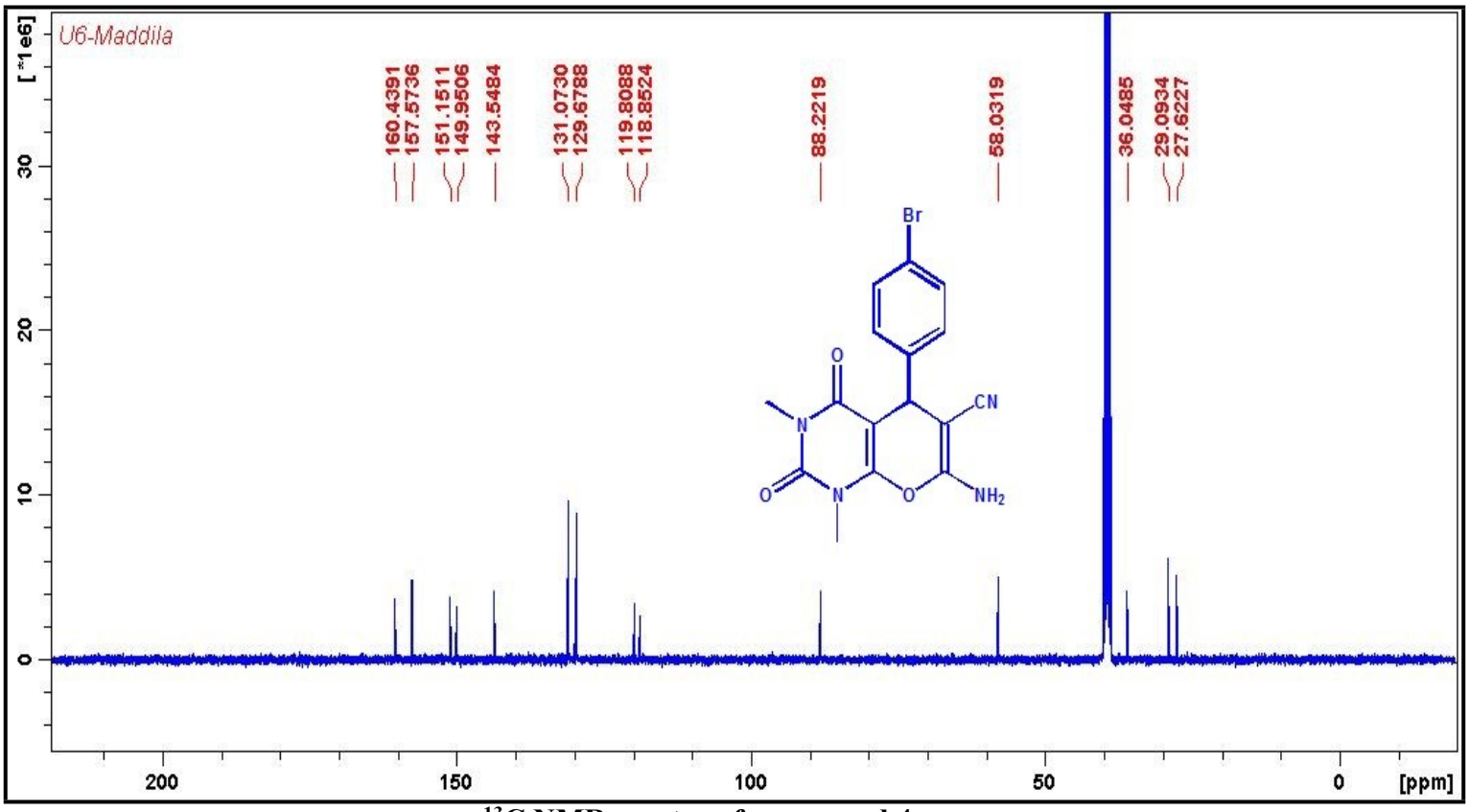


FT-IR spectra of compound 4d

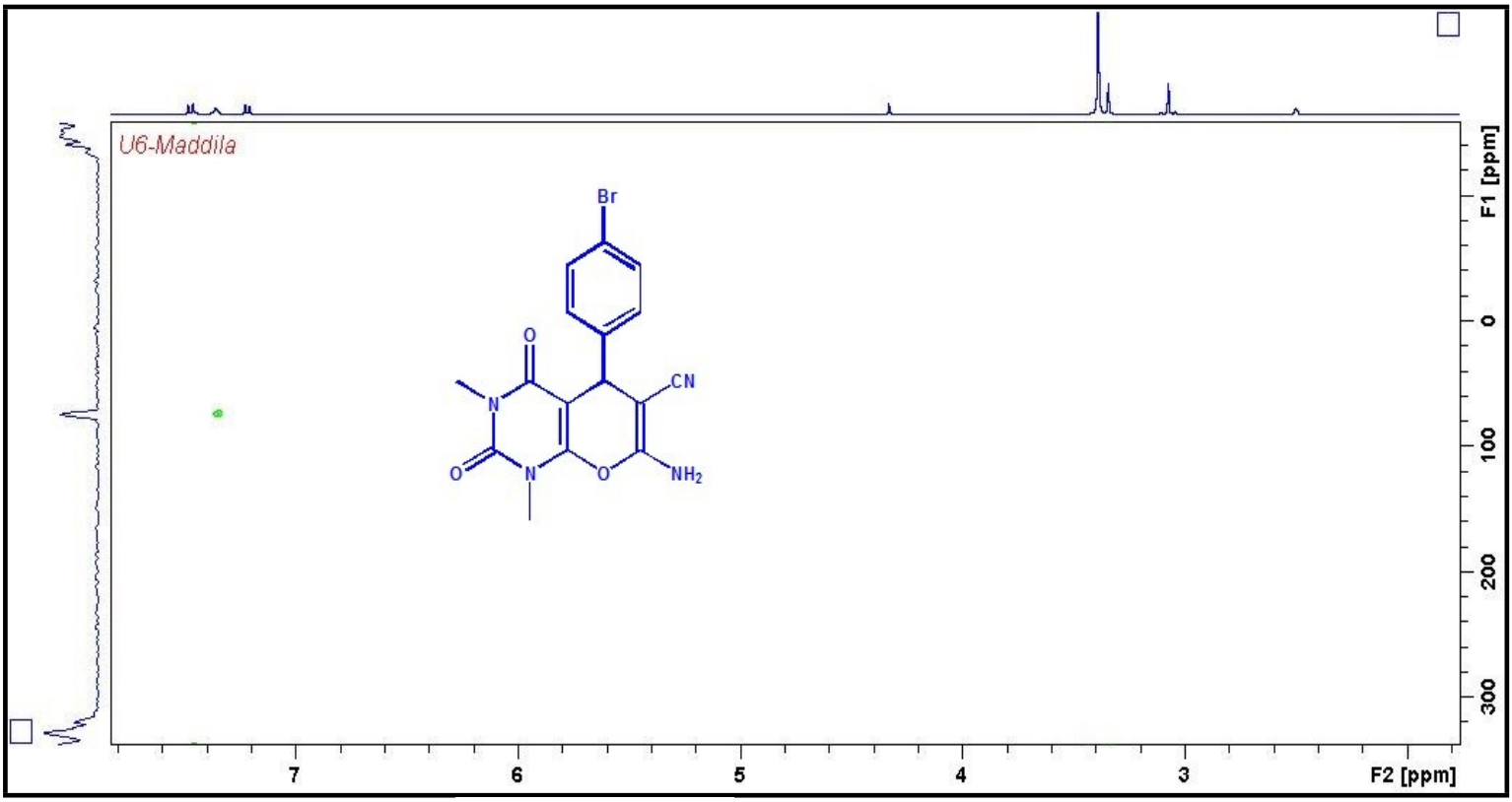


^{1}H NMR spectra of compound 4e

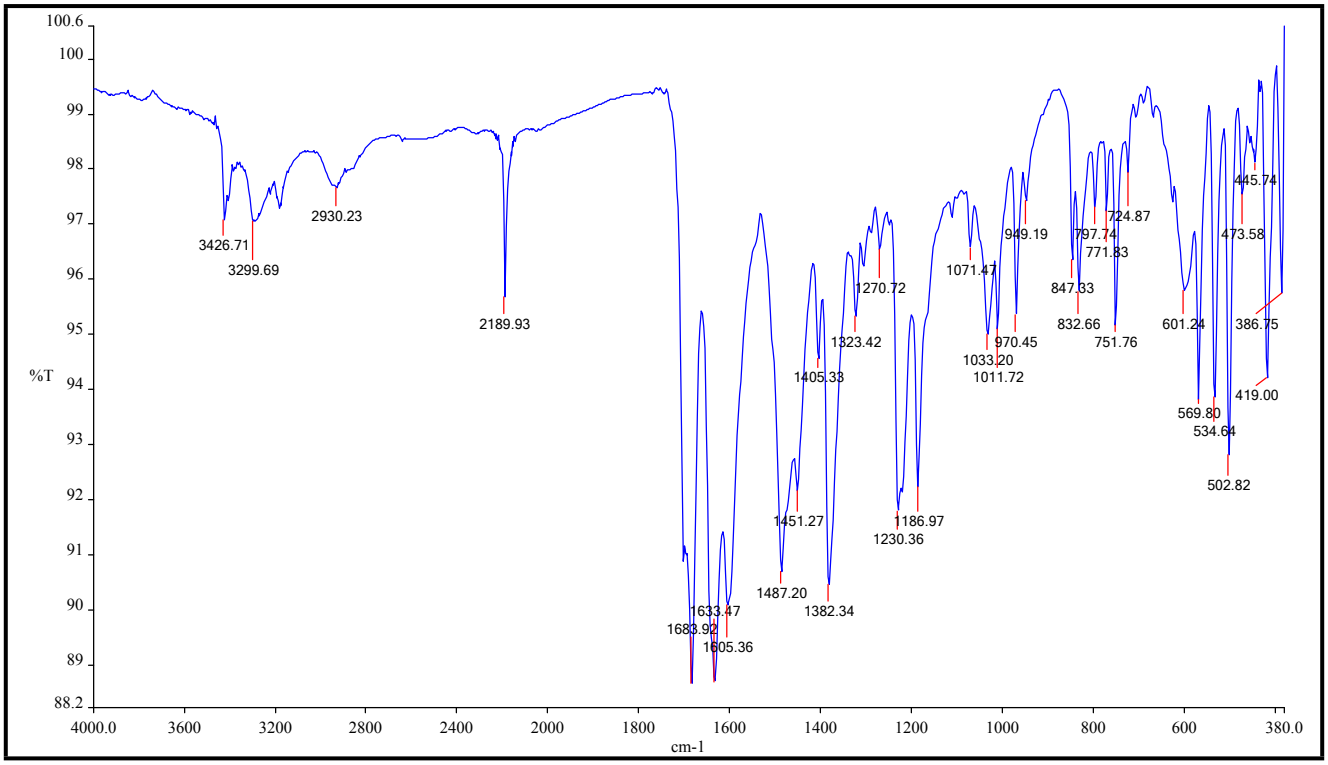




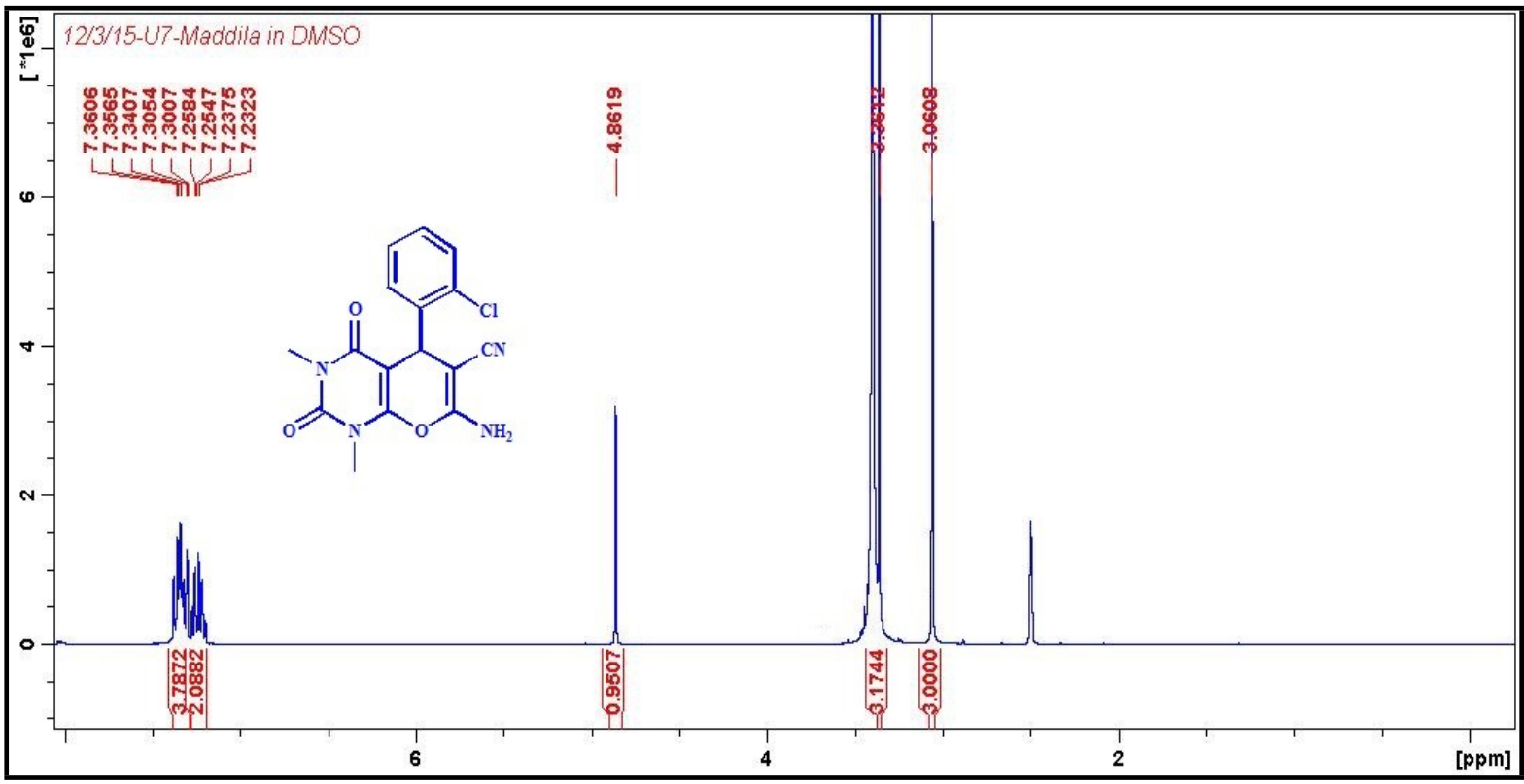
^{13}C NMR spectra of compound 4e



^{15}N NMR (GHSQC) spectra of compound 4e

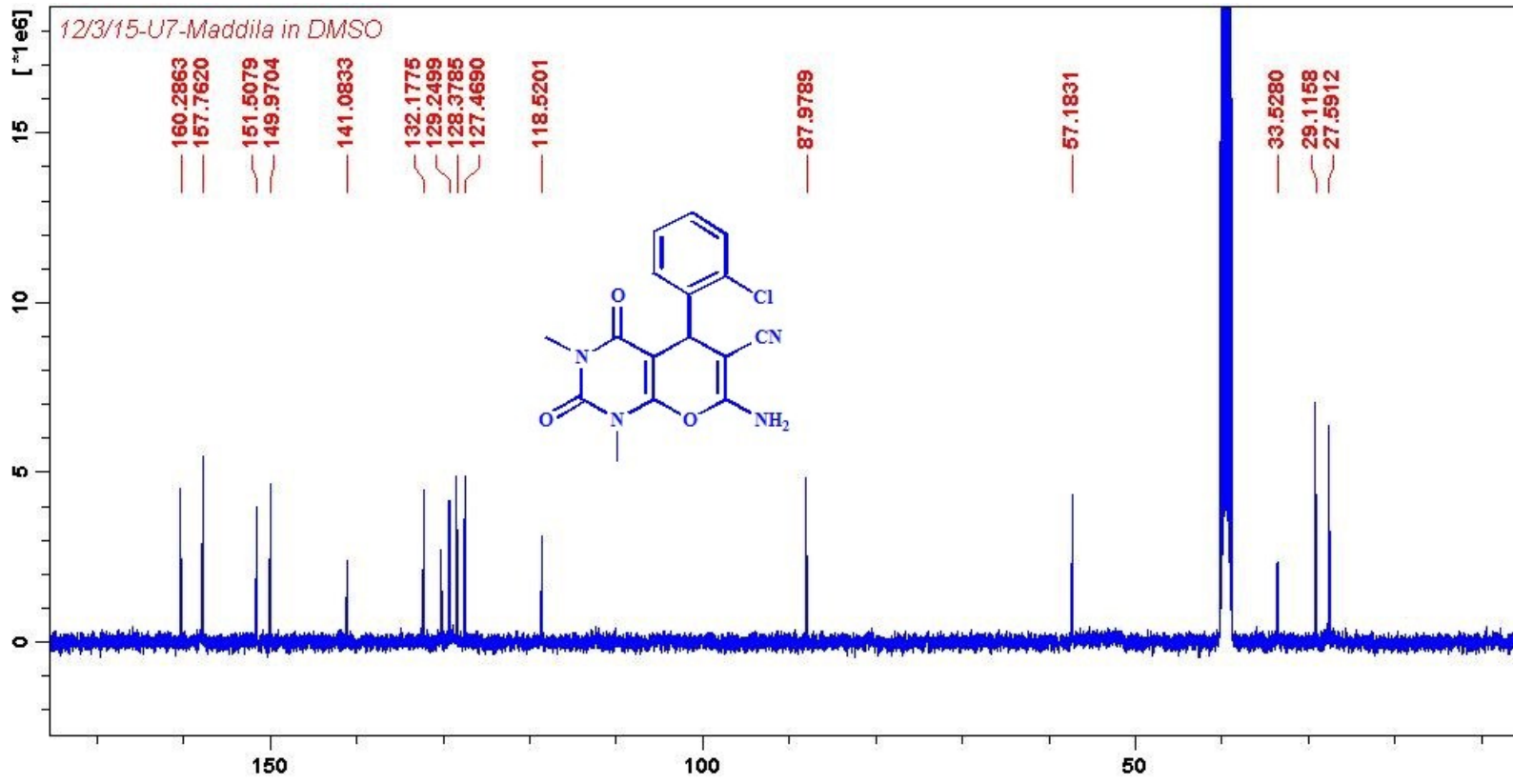


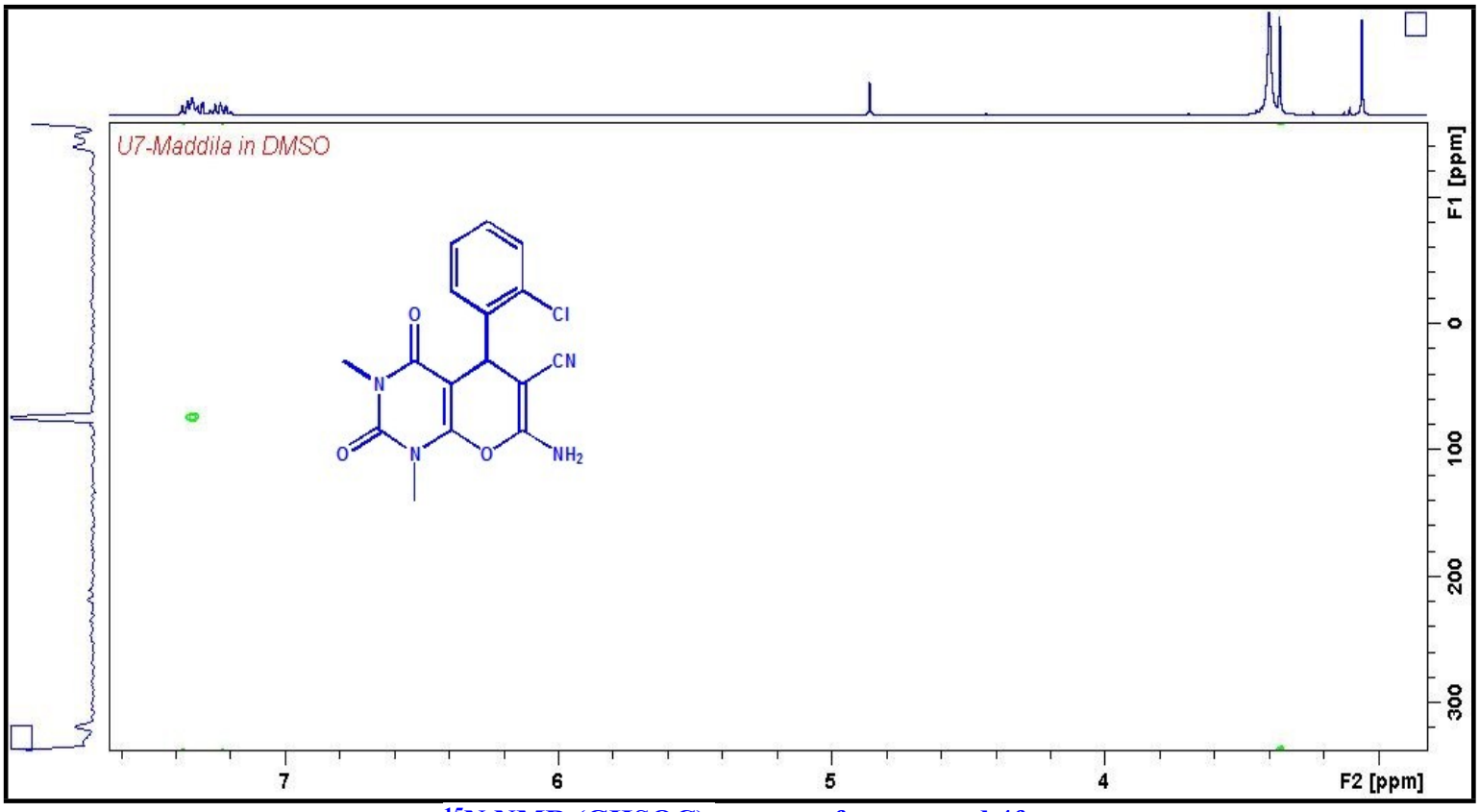
FT-IR spectra of compound 4e



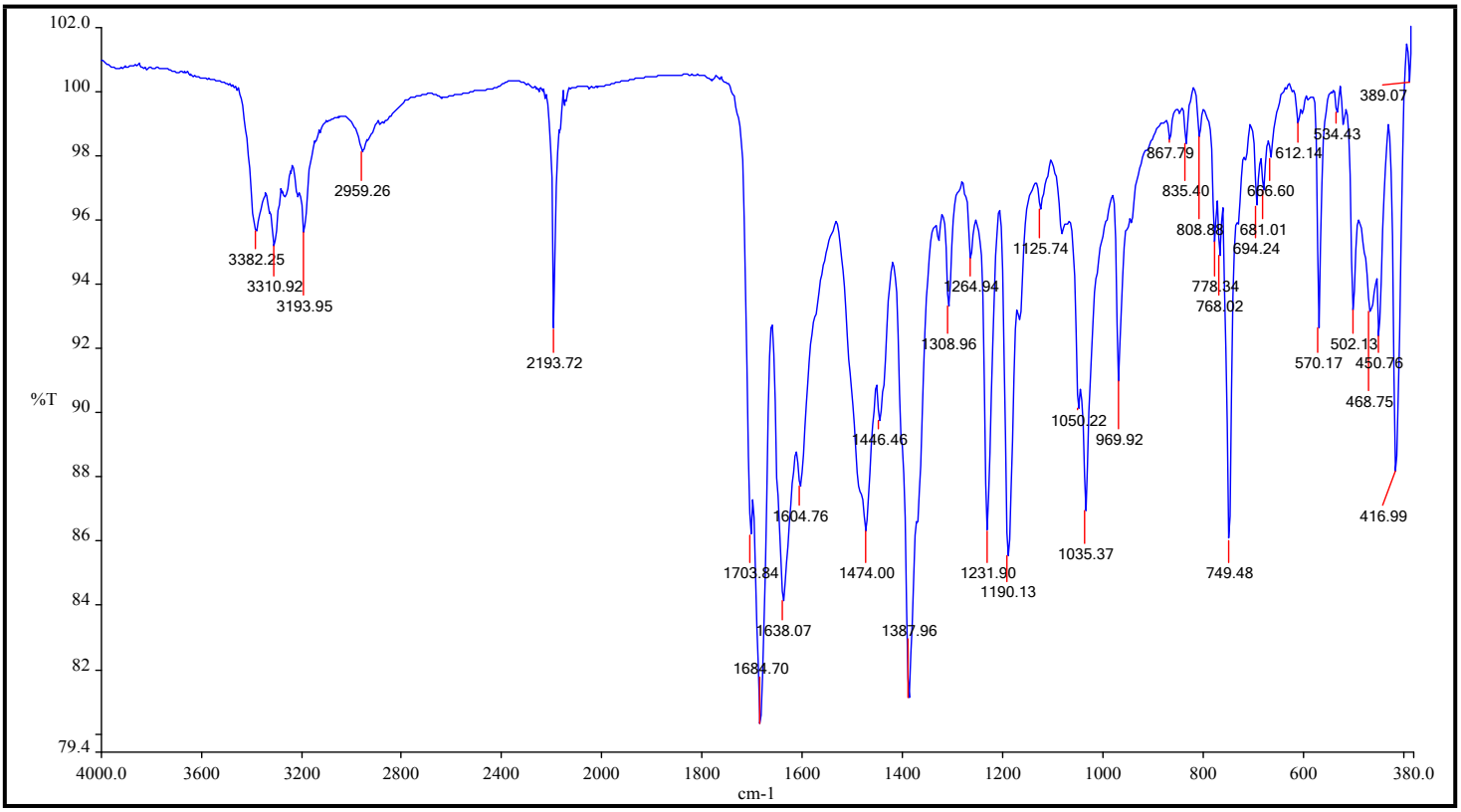
^{1}H NMR spectra of compound 4f

^{13}C NMR spectra of compound 4f

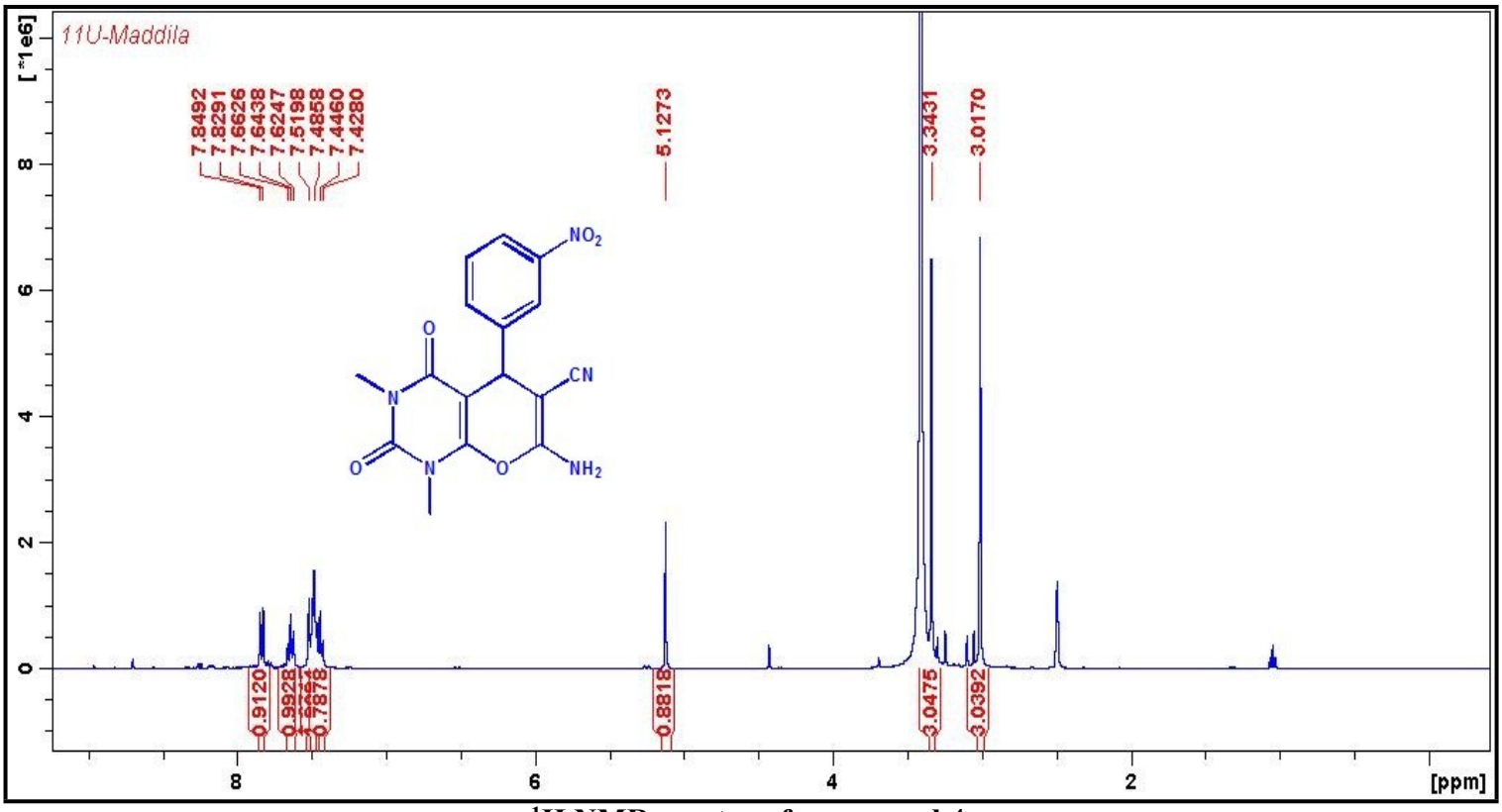




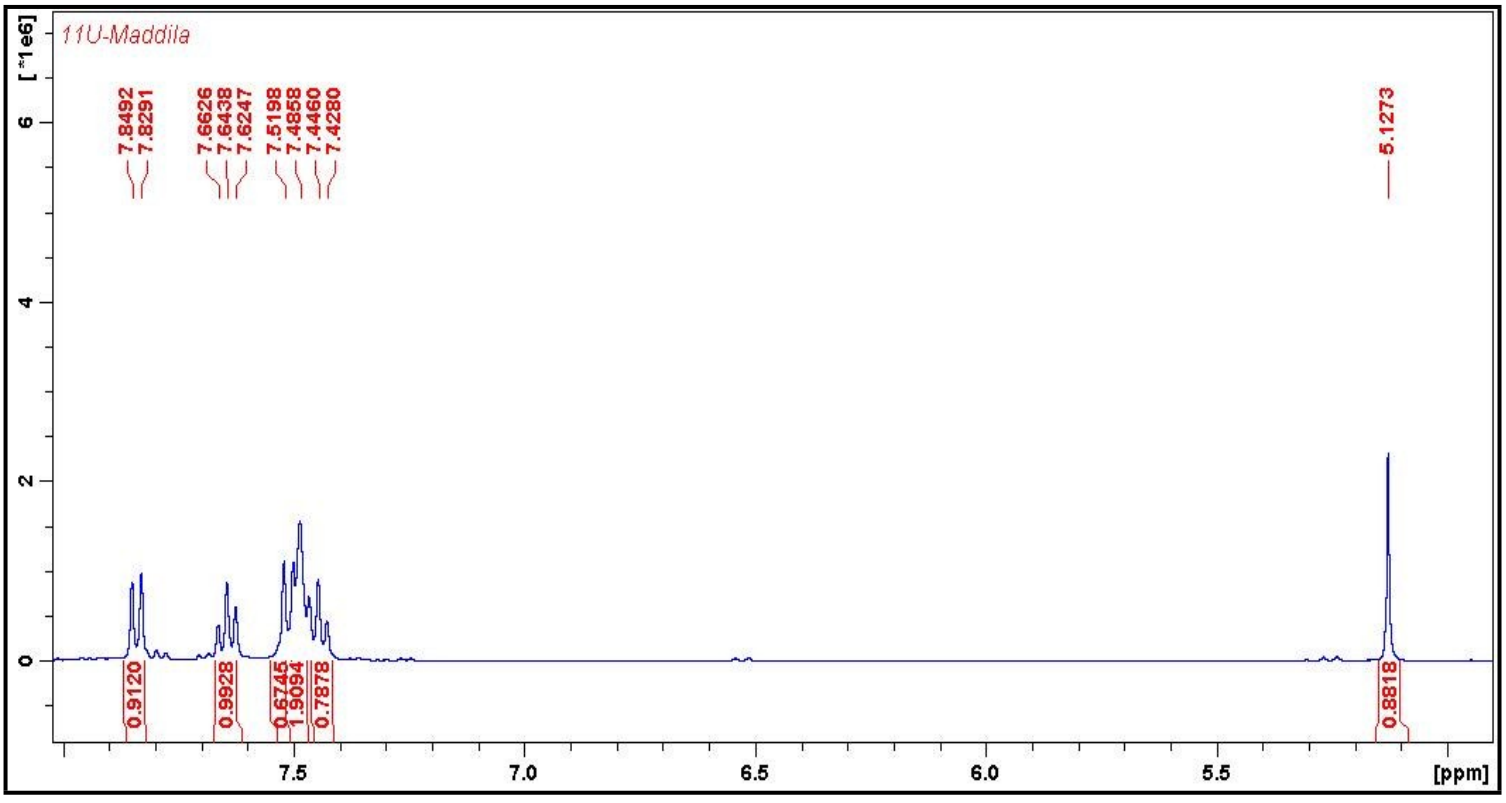
^{15}N NMR (GHSQC) spectra of compound 4f

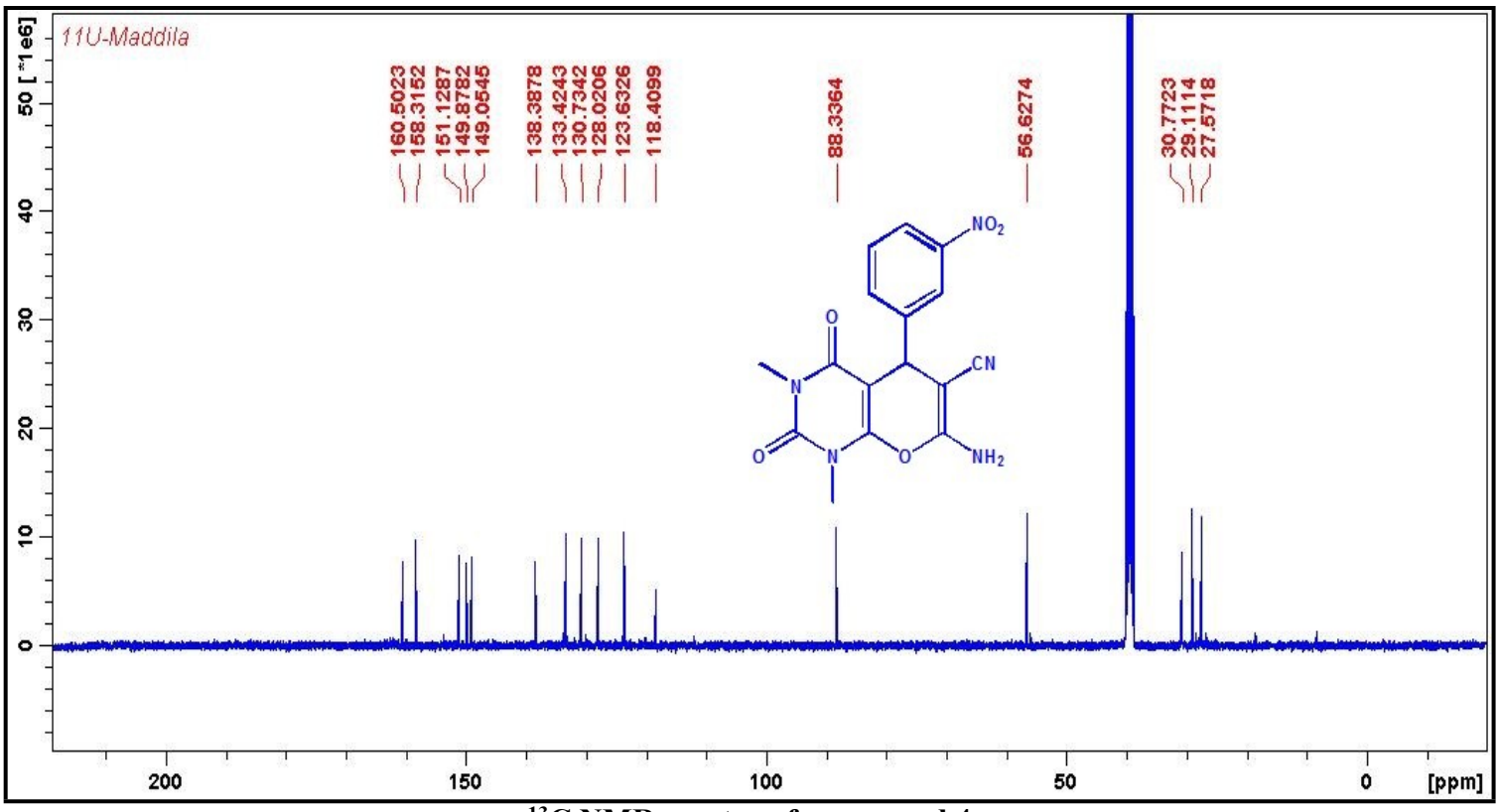


FT-IR spectra of compound 4f

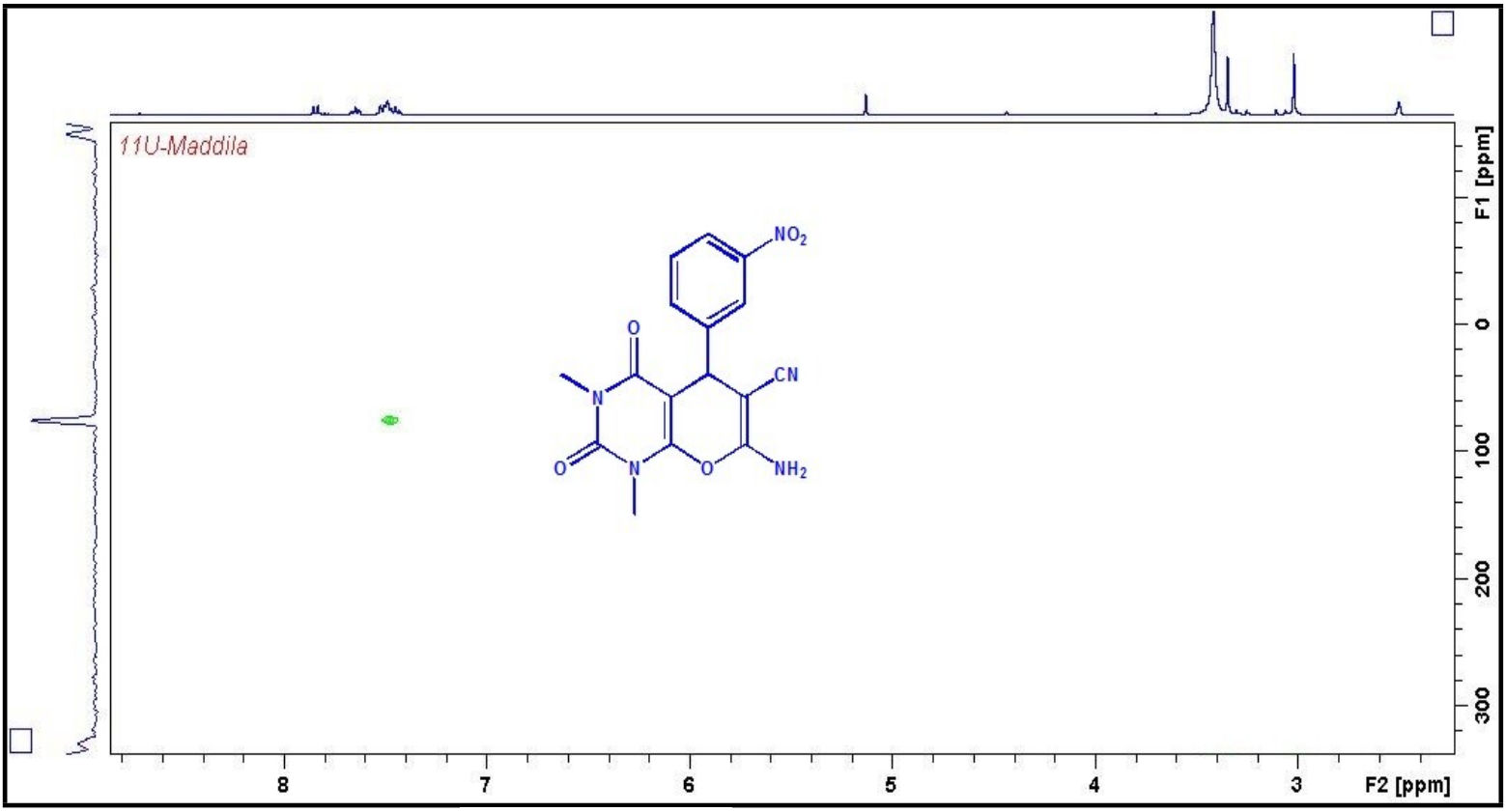


^{1}H NMR spectra of compound 4g

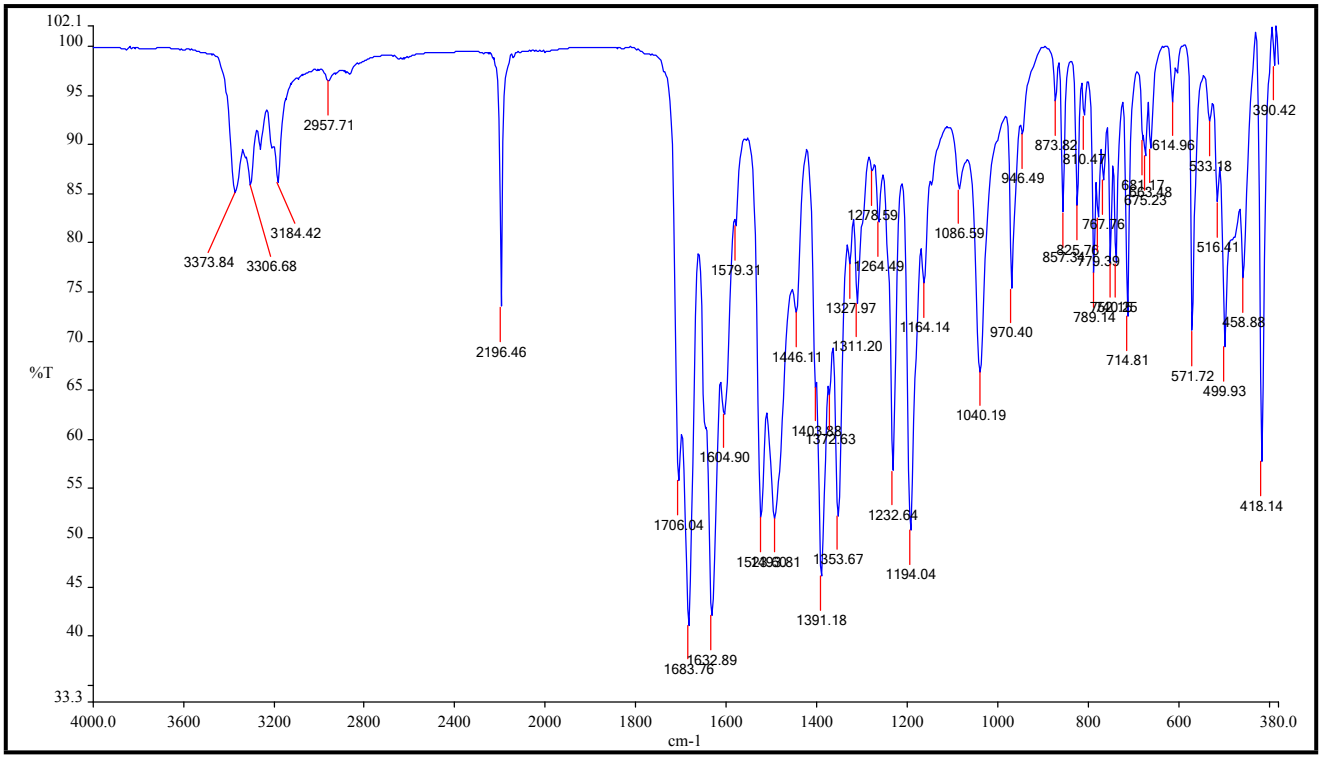




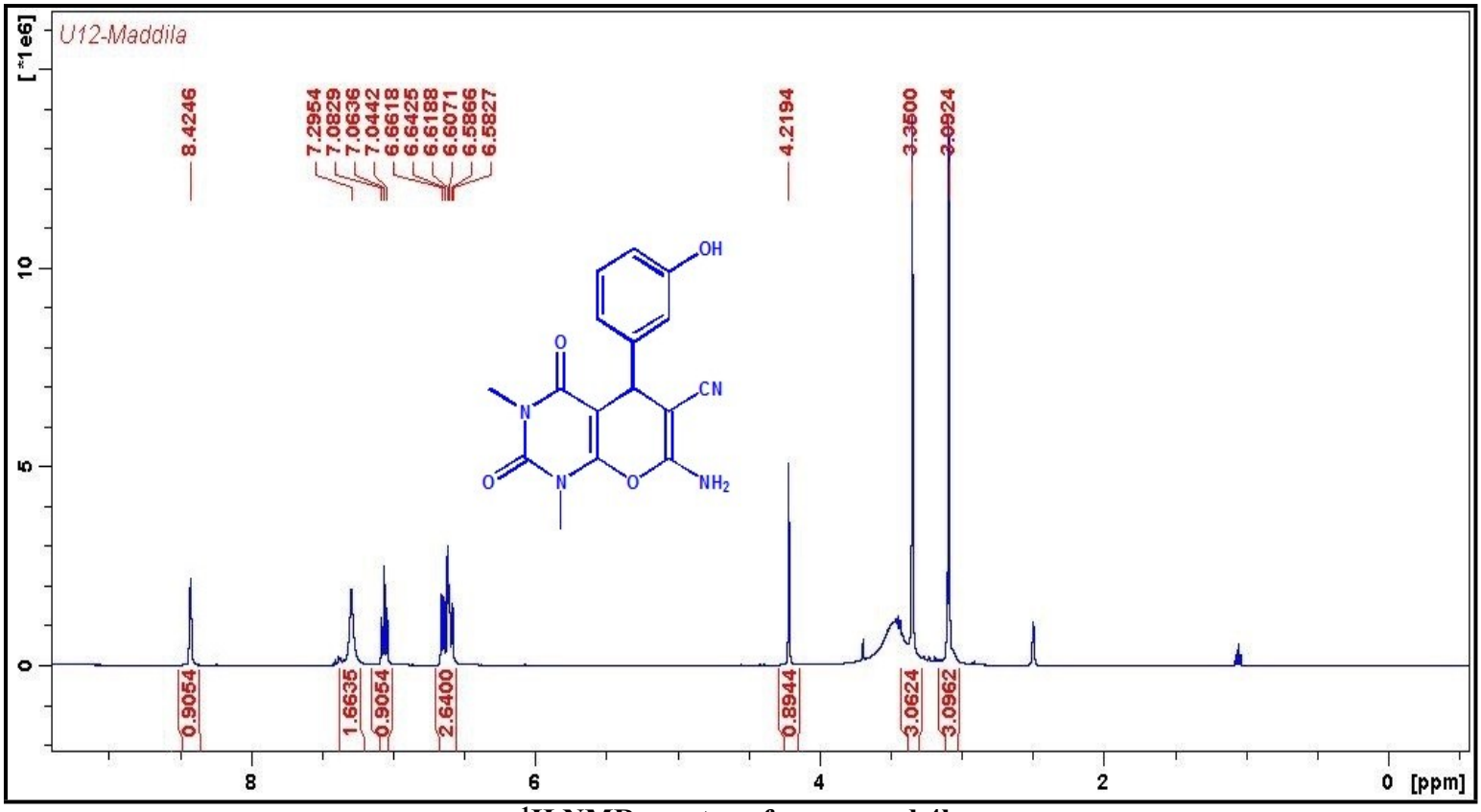
^{13}C NMR spectra of compound 4g



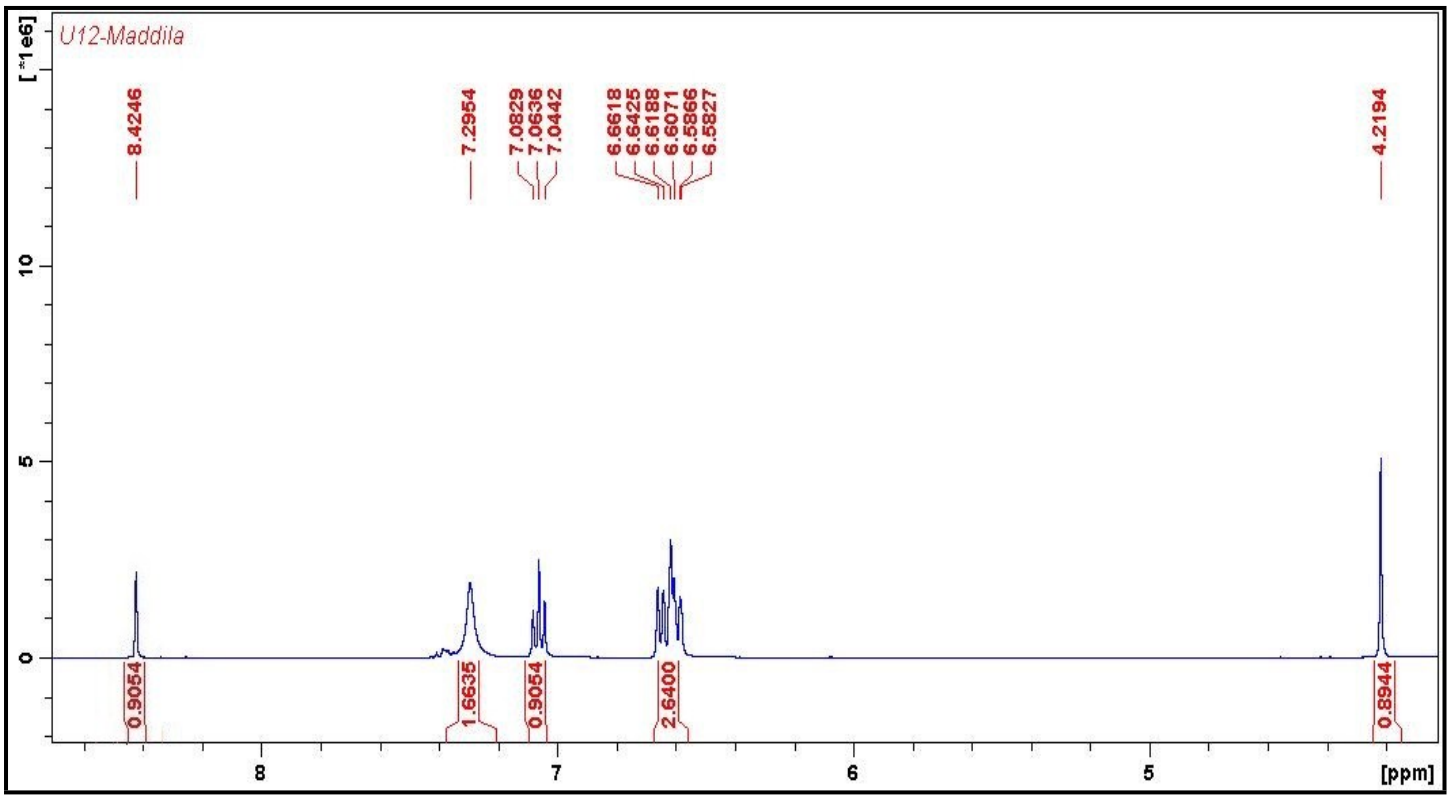
^{15}N NMR (GHSQC) spectra of compound 4g

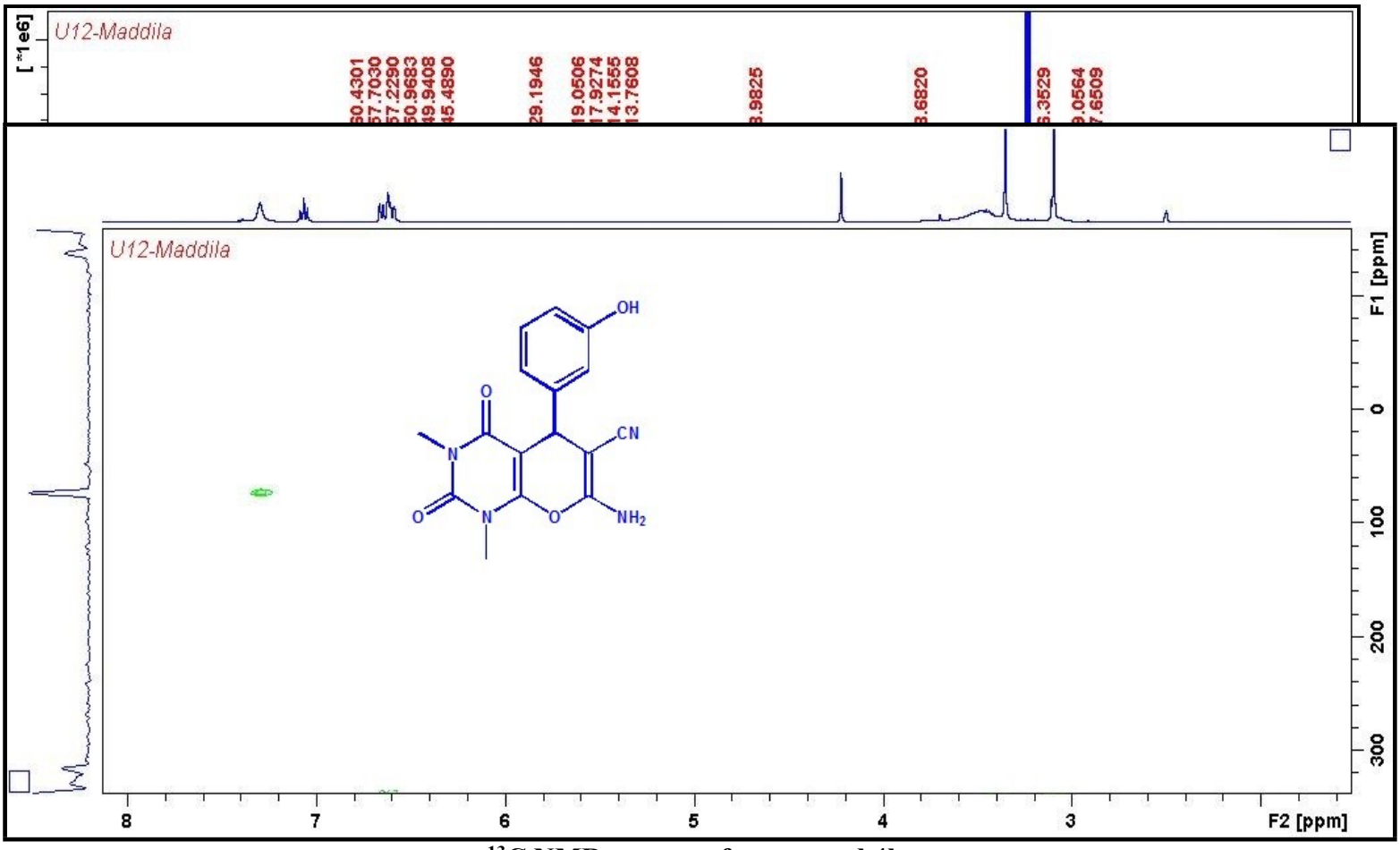


FT-IR spectra of compound 4g



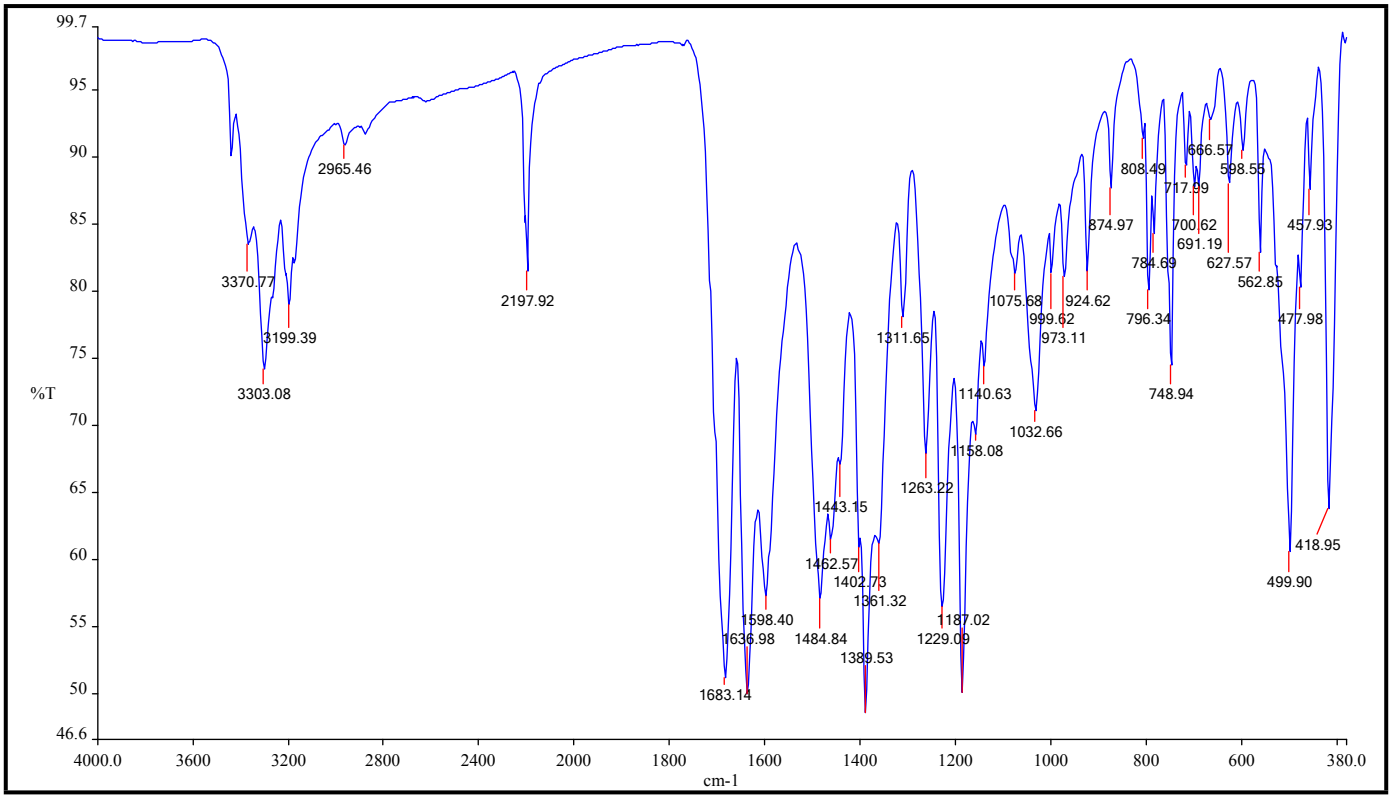
^{1}H NMR spectra of compound 4h



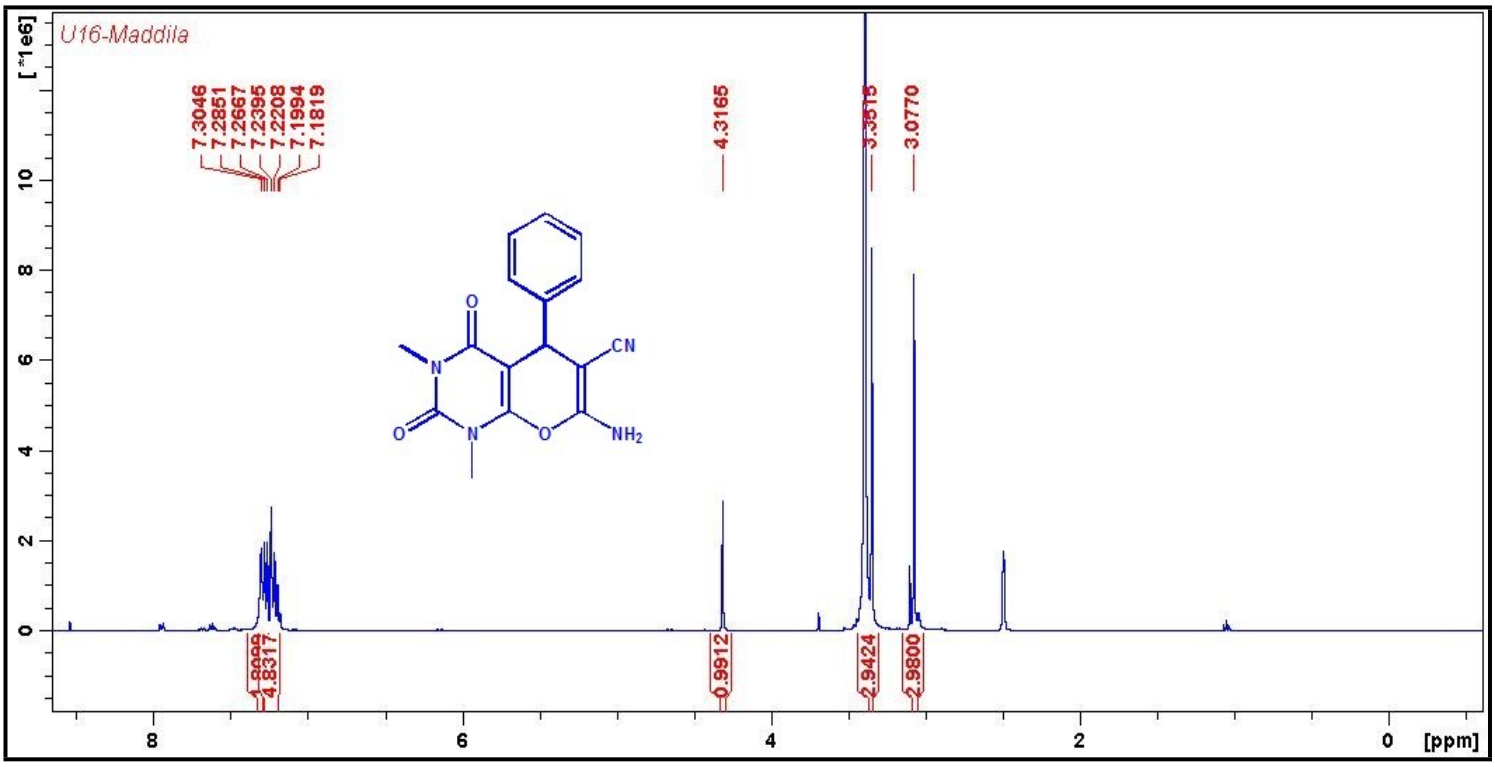


^{13}C NMR spectra of compound 4h

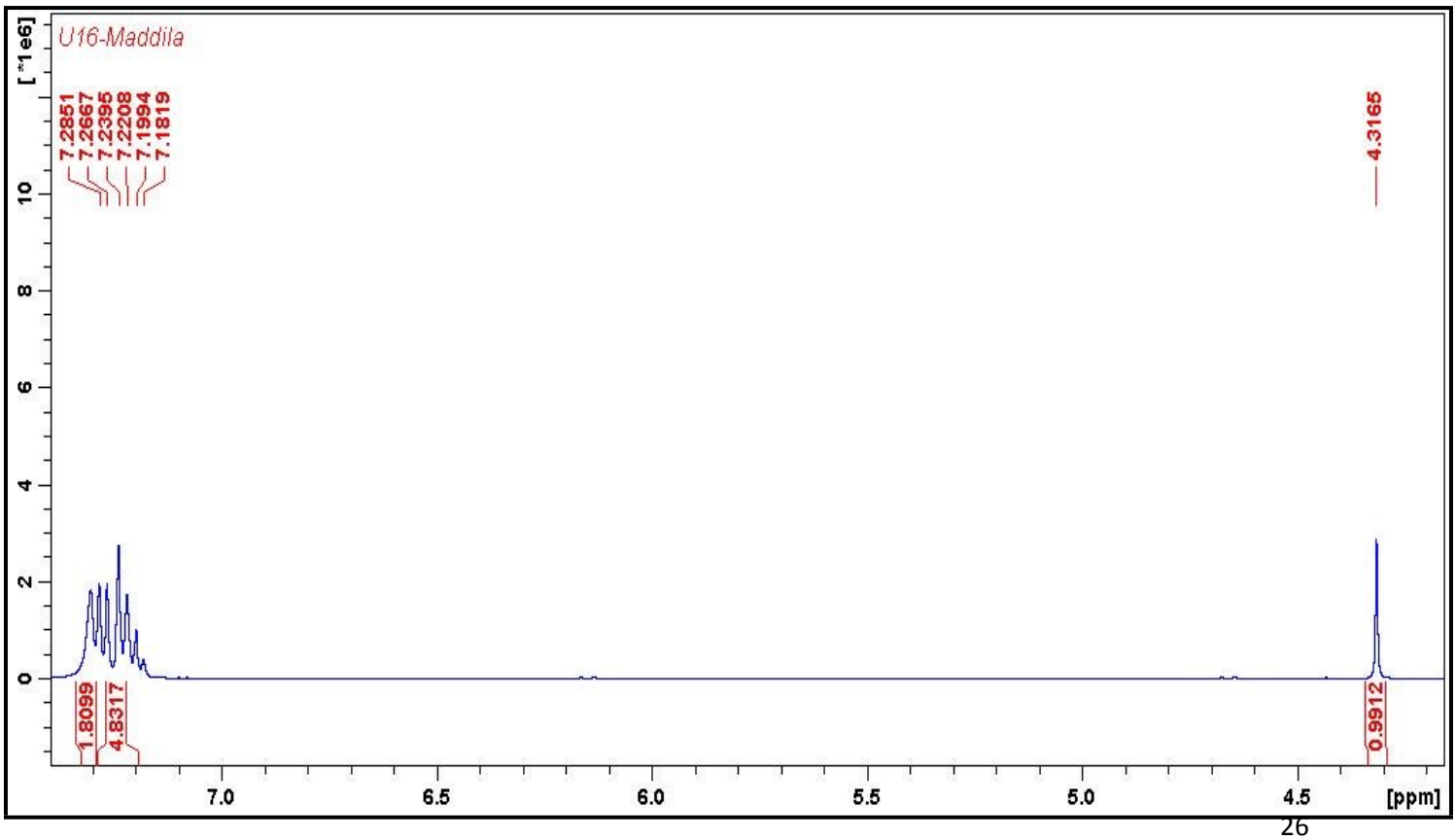
^{15}N NMR (GHSQC) spectra of compound 4h

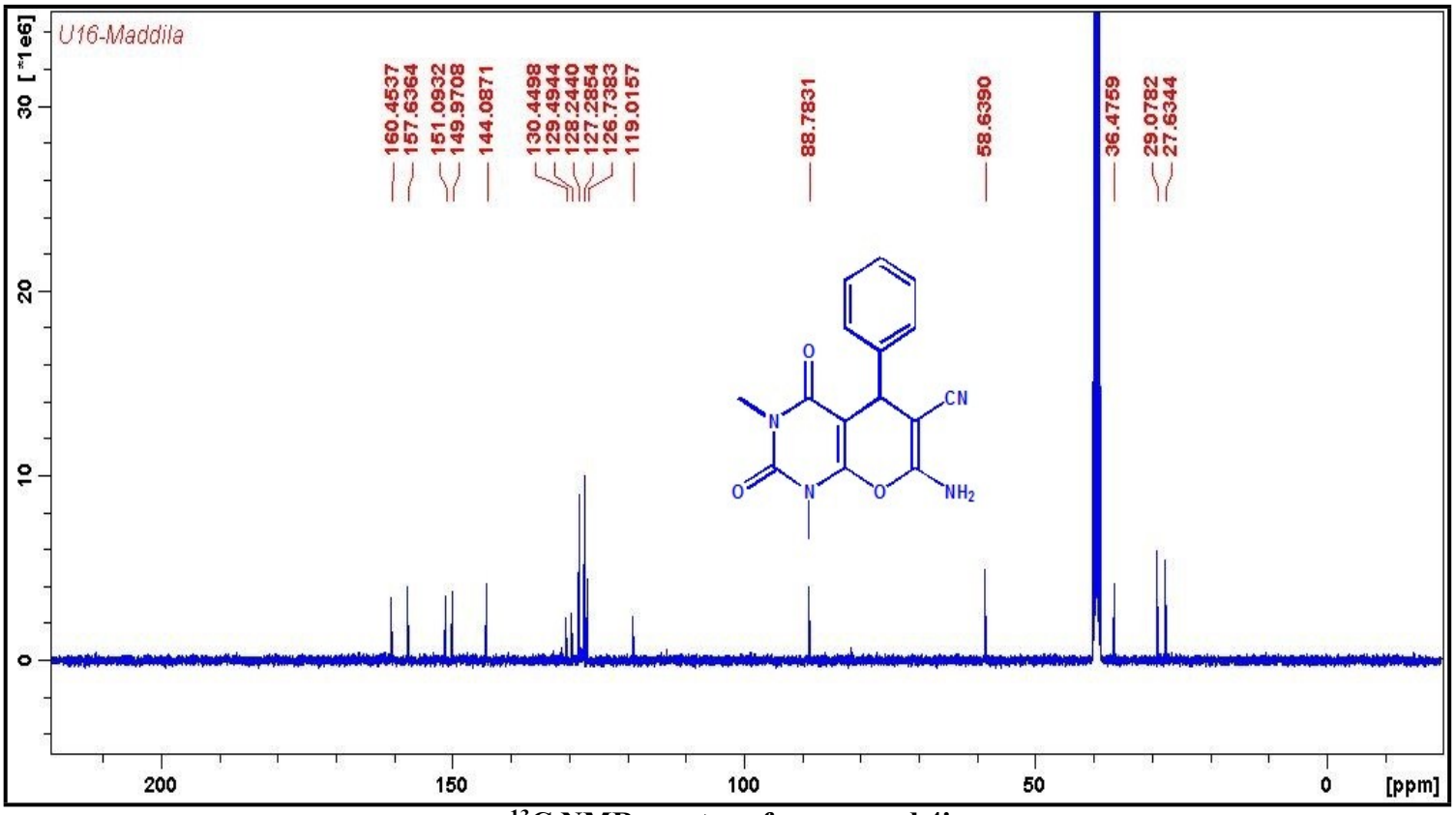


FT-IR spectra of compound 4h

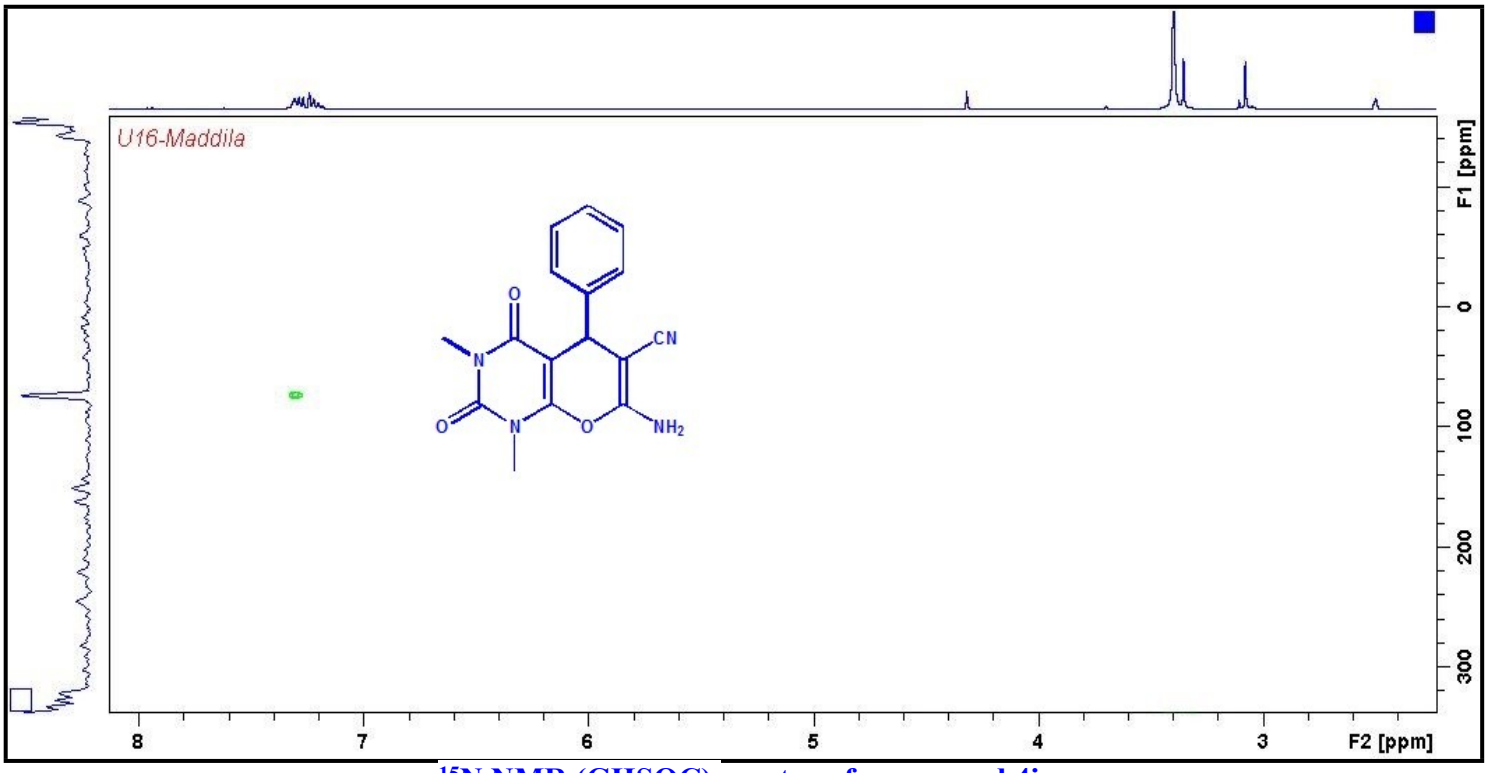


^{1}H NMR spectra of compound 4i

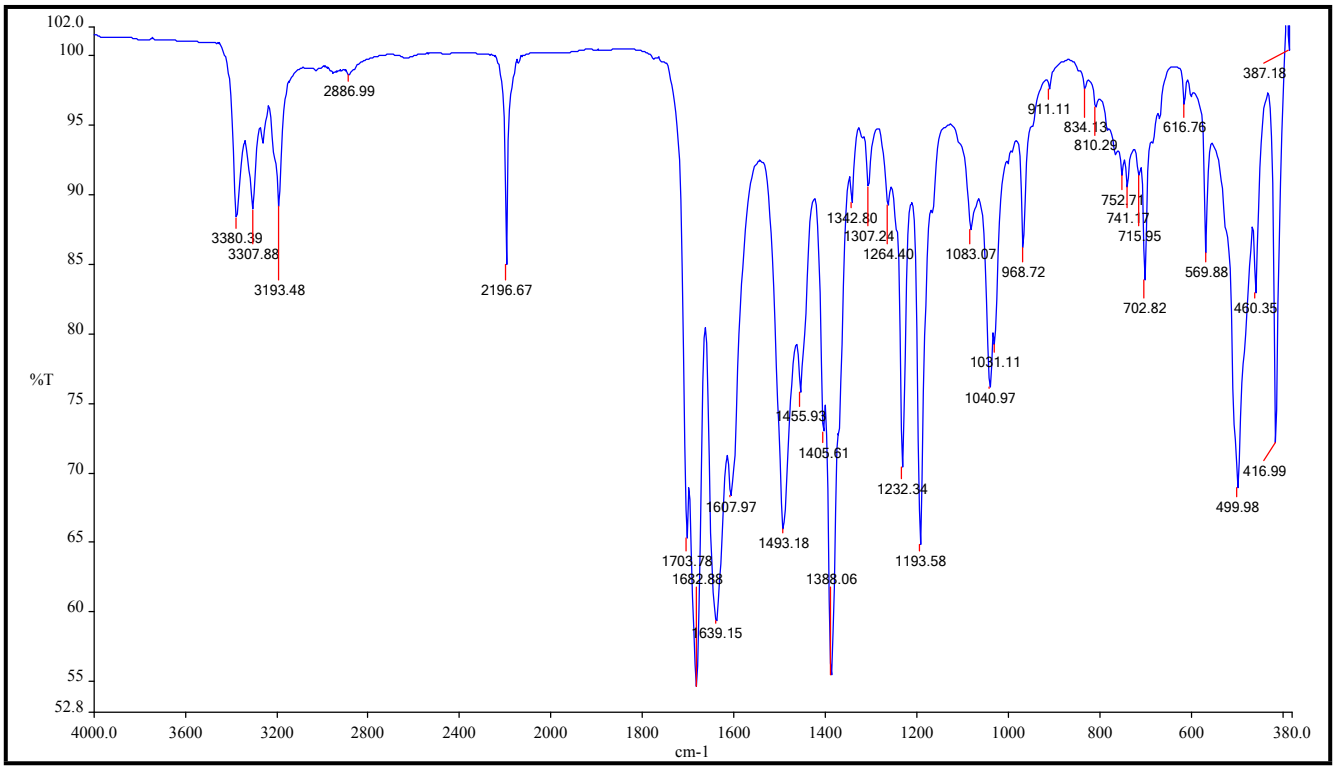




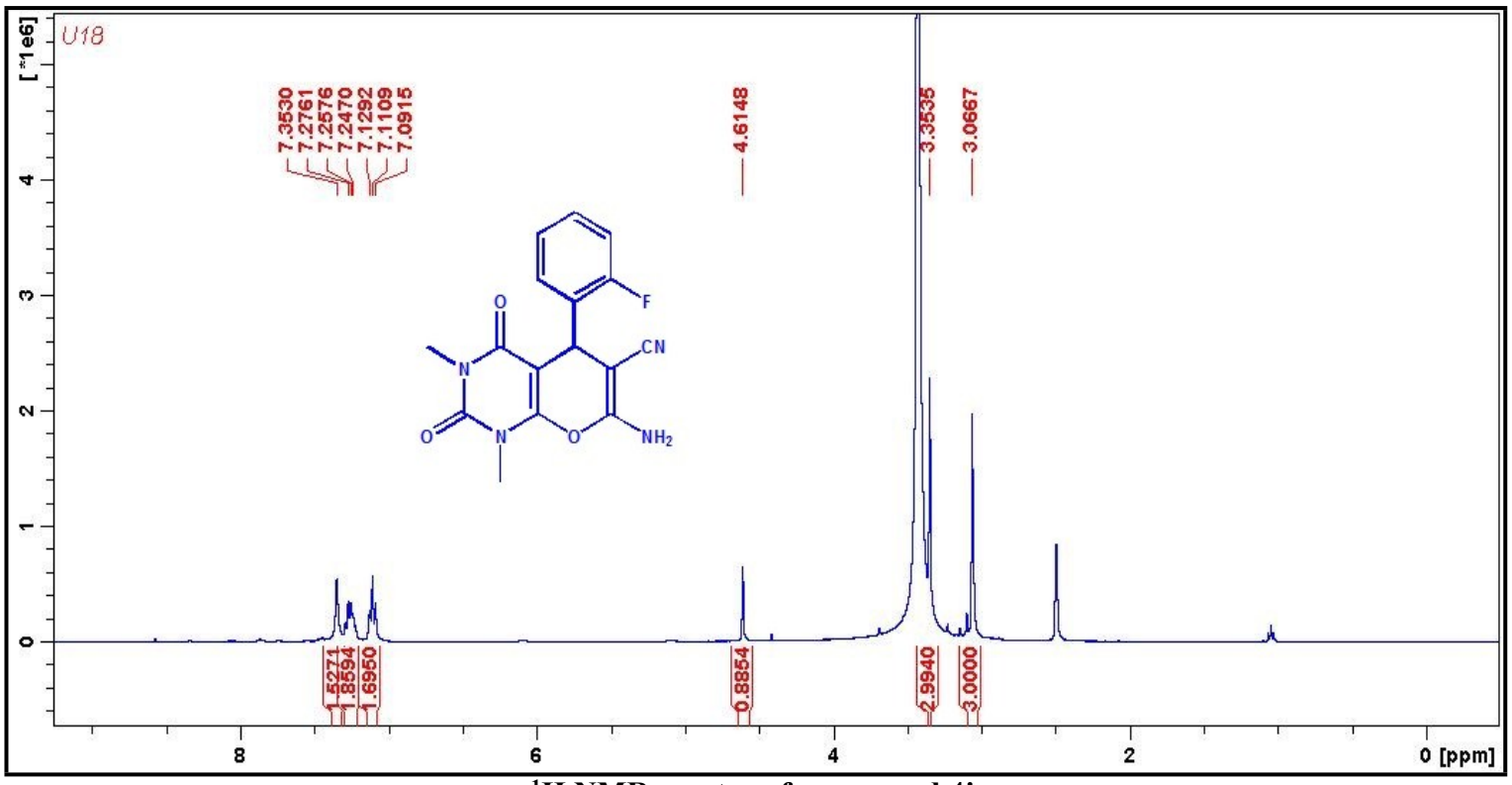
^{13}C NMR spectra of compound 4i



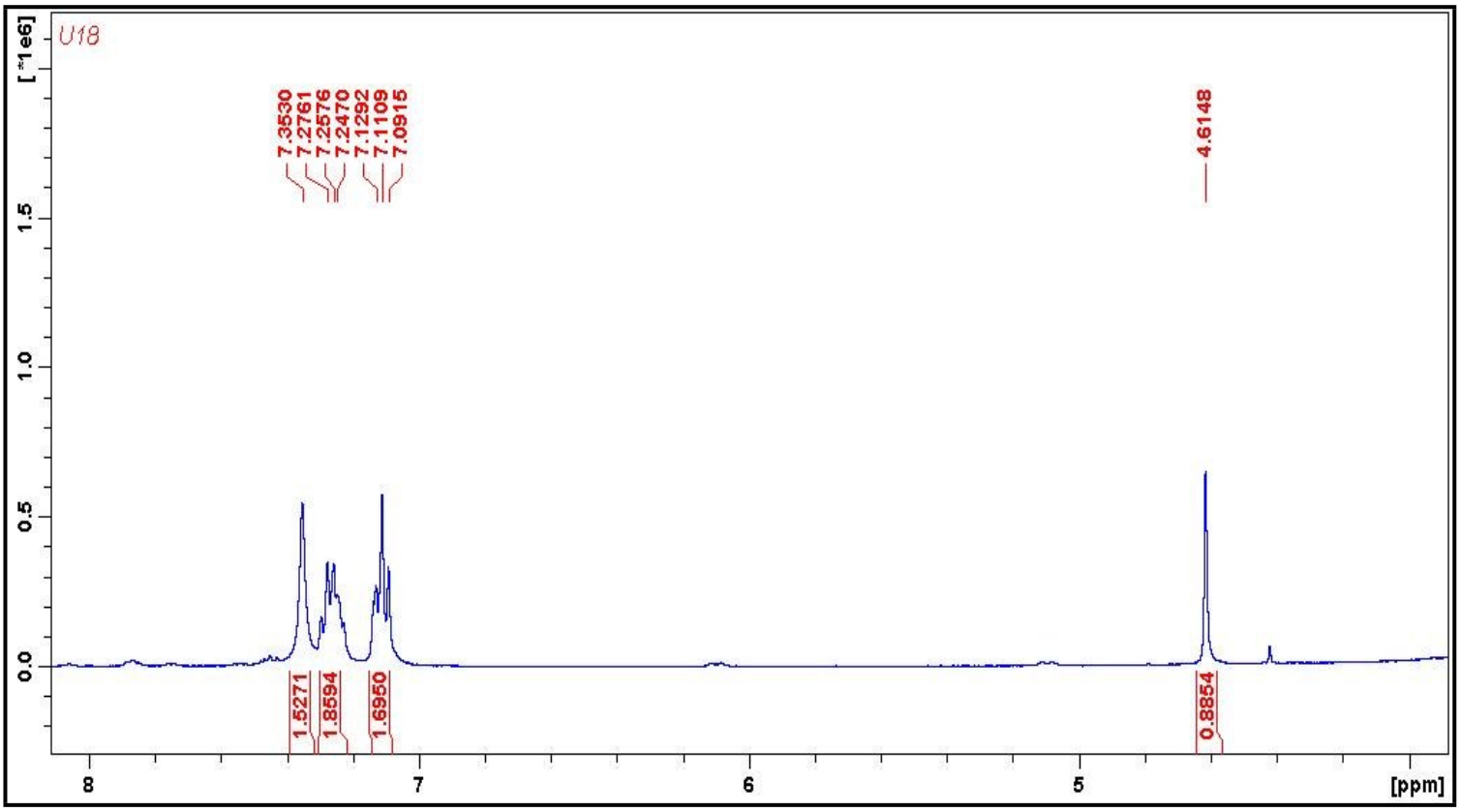
^{15}N NMR (GHSQC) spectra of compound 4i

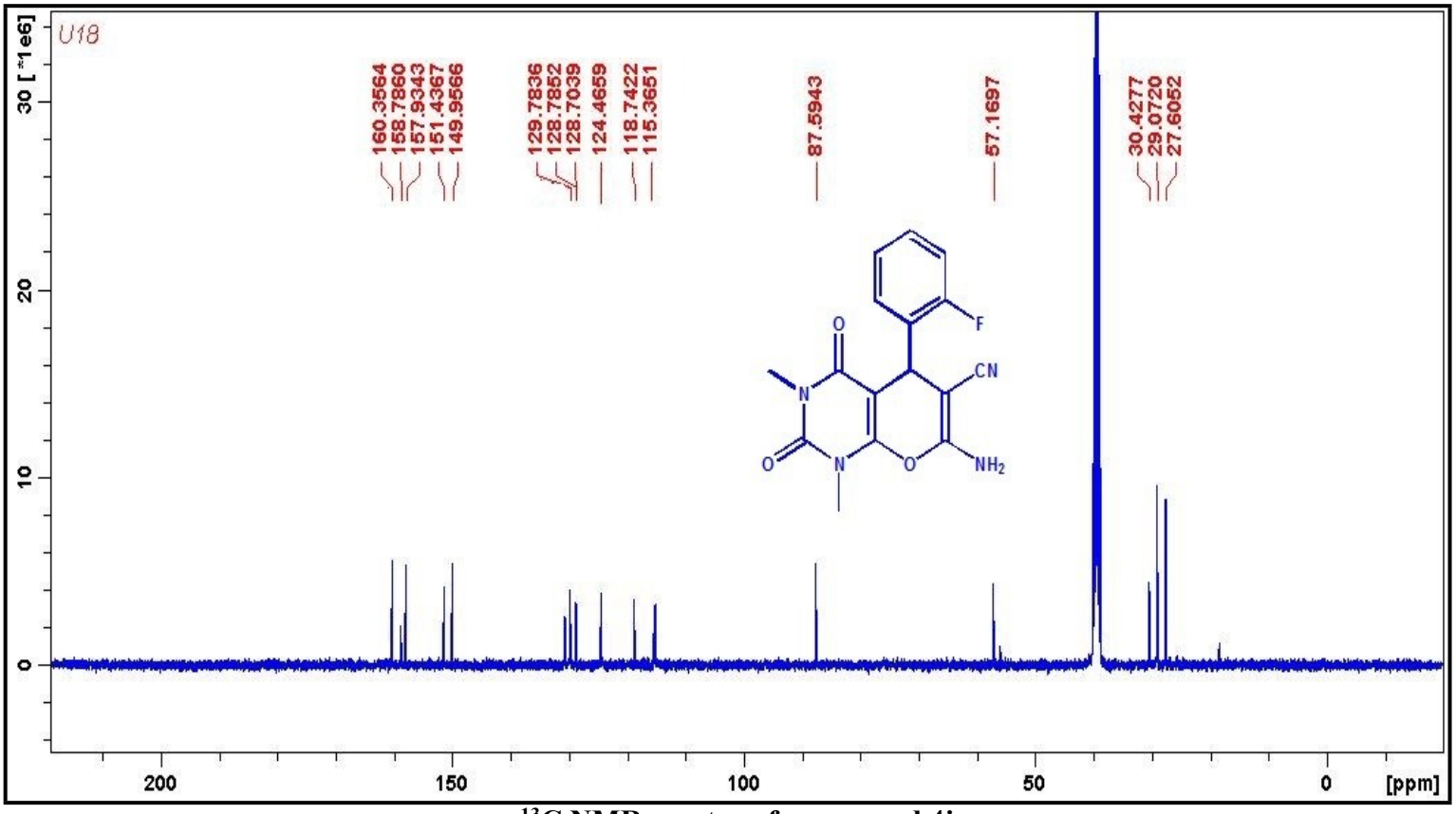


FT-IR spectra of compound 4i

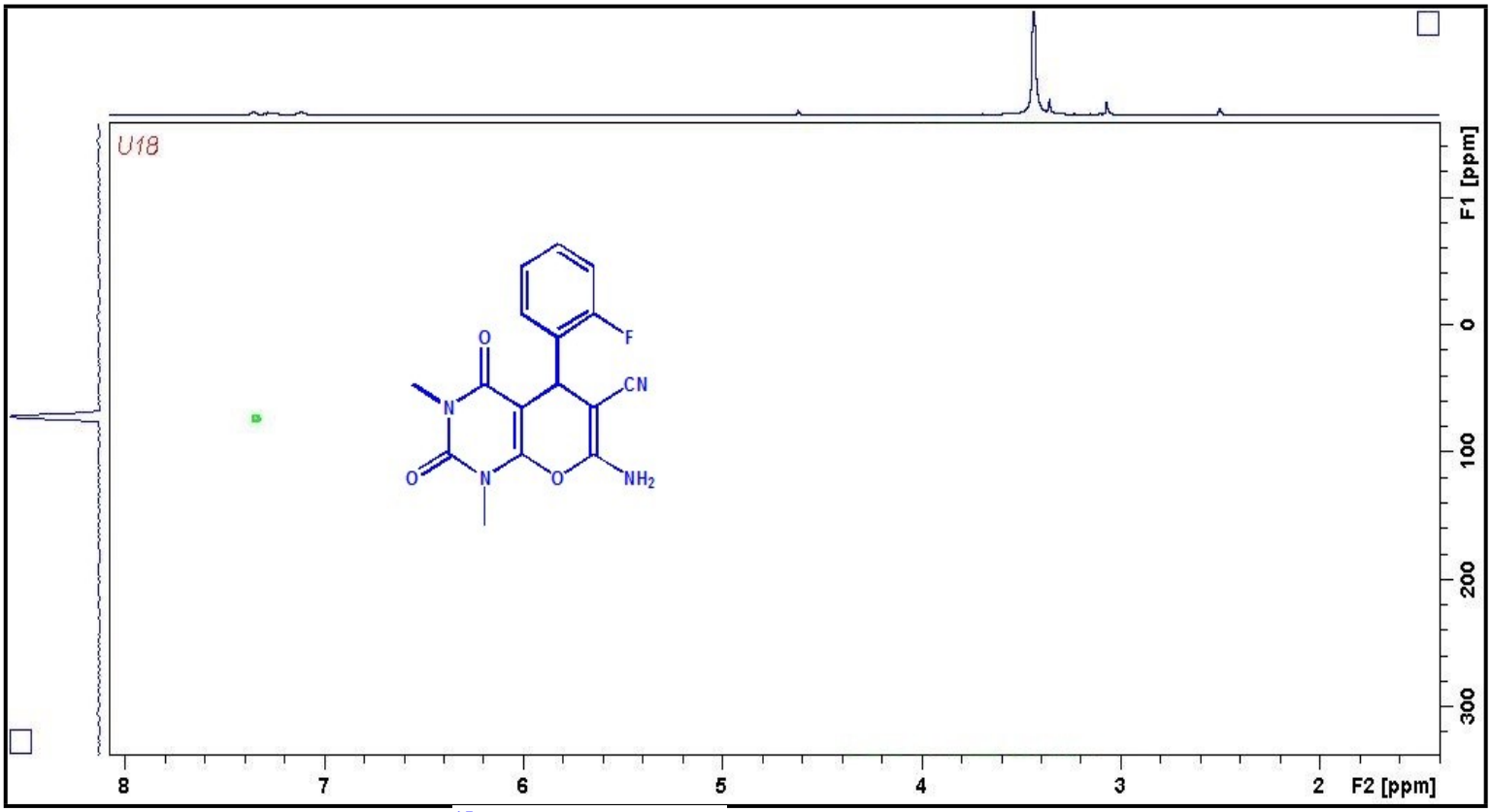


^{1}H NMR spectra of compound 4j

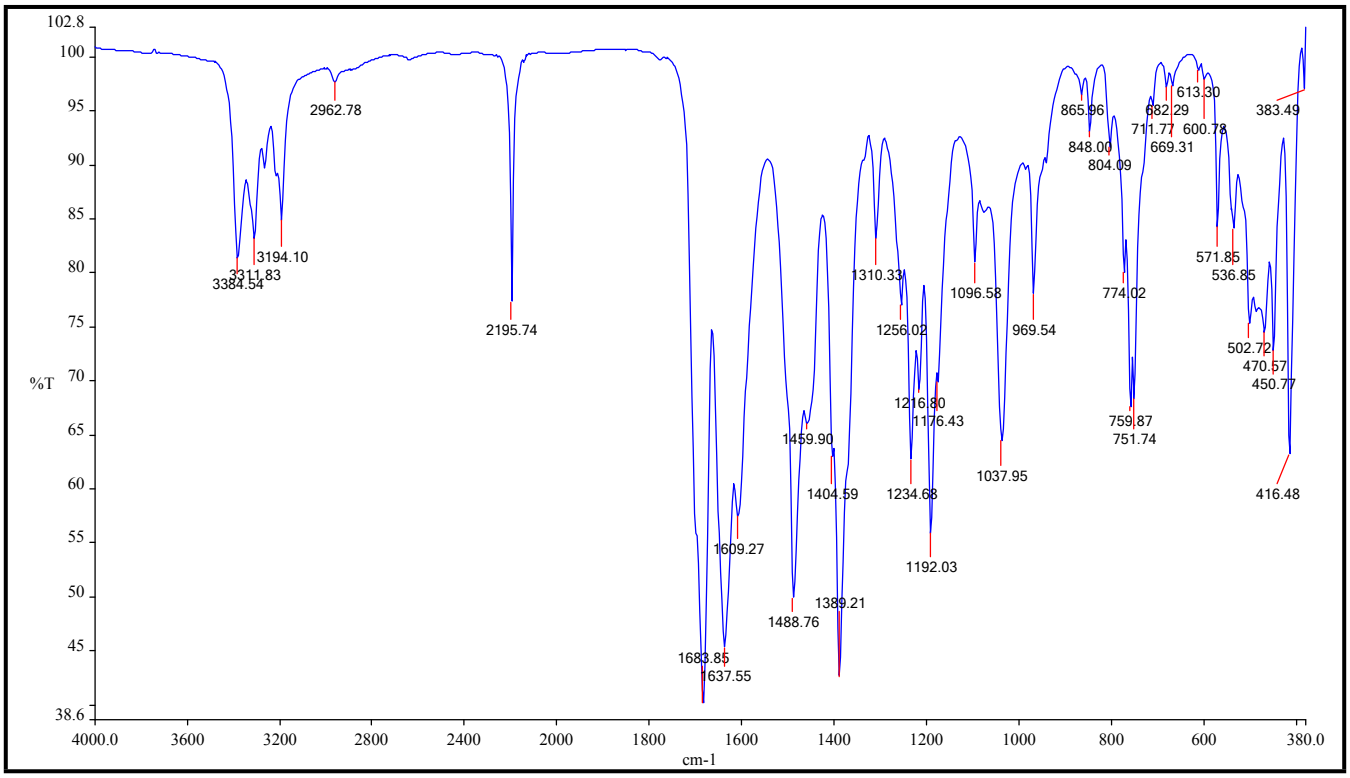




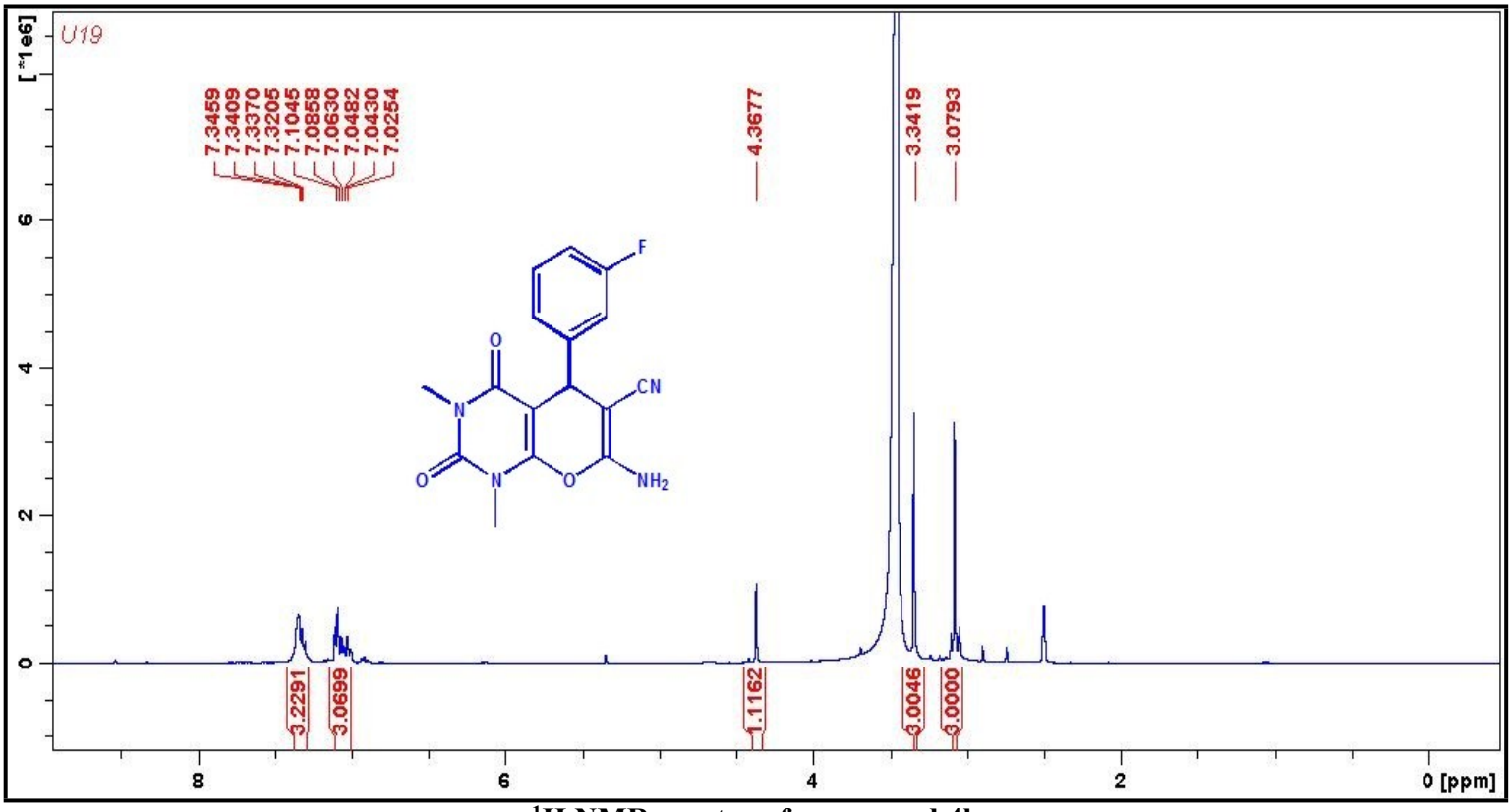
^{13}C NMR spectra of compound 4j



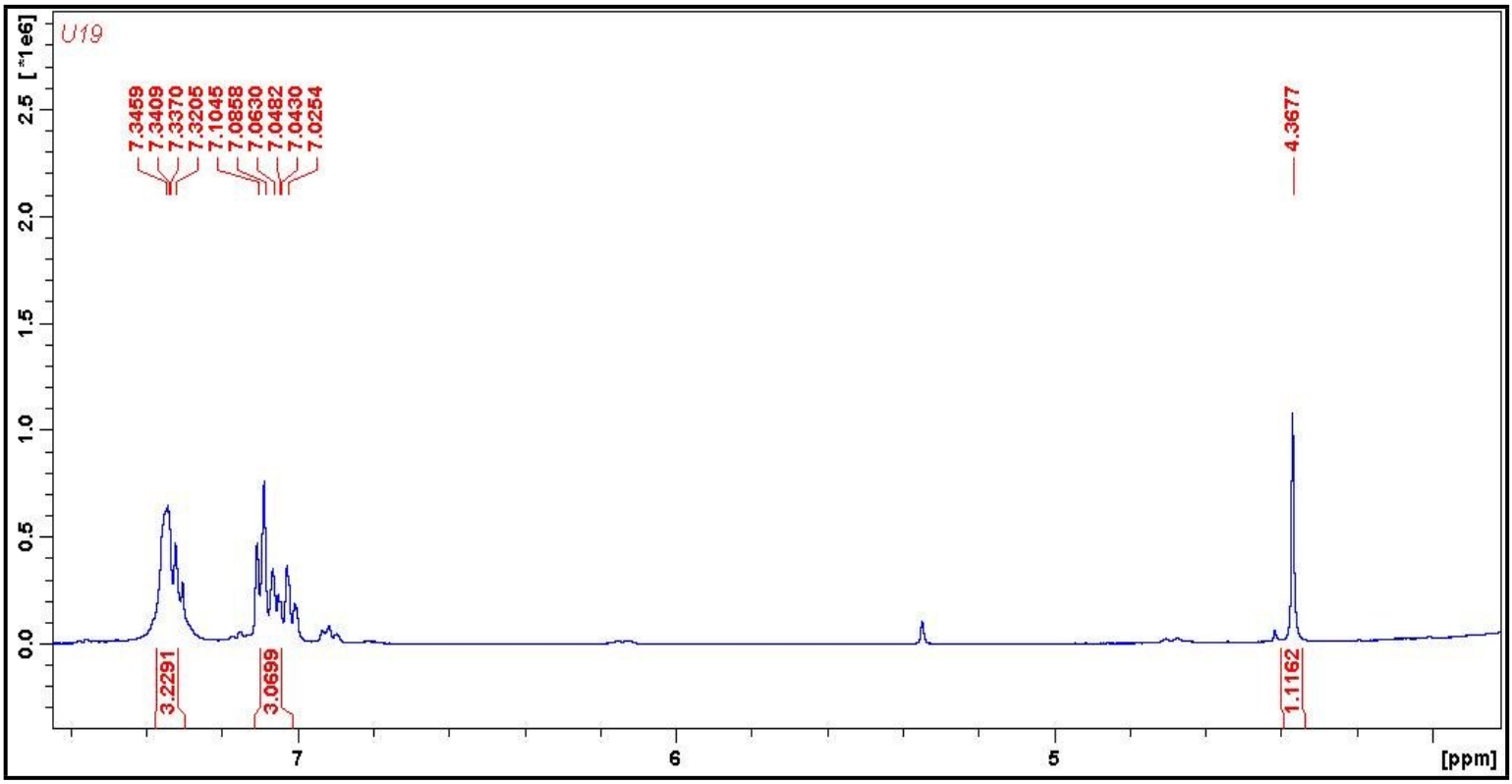
^{15}N NMR (GHSQC) spectra of compound 4j

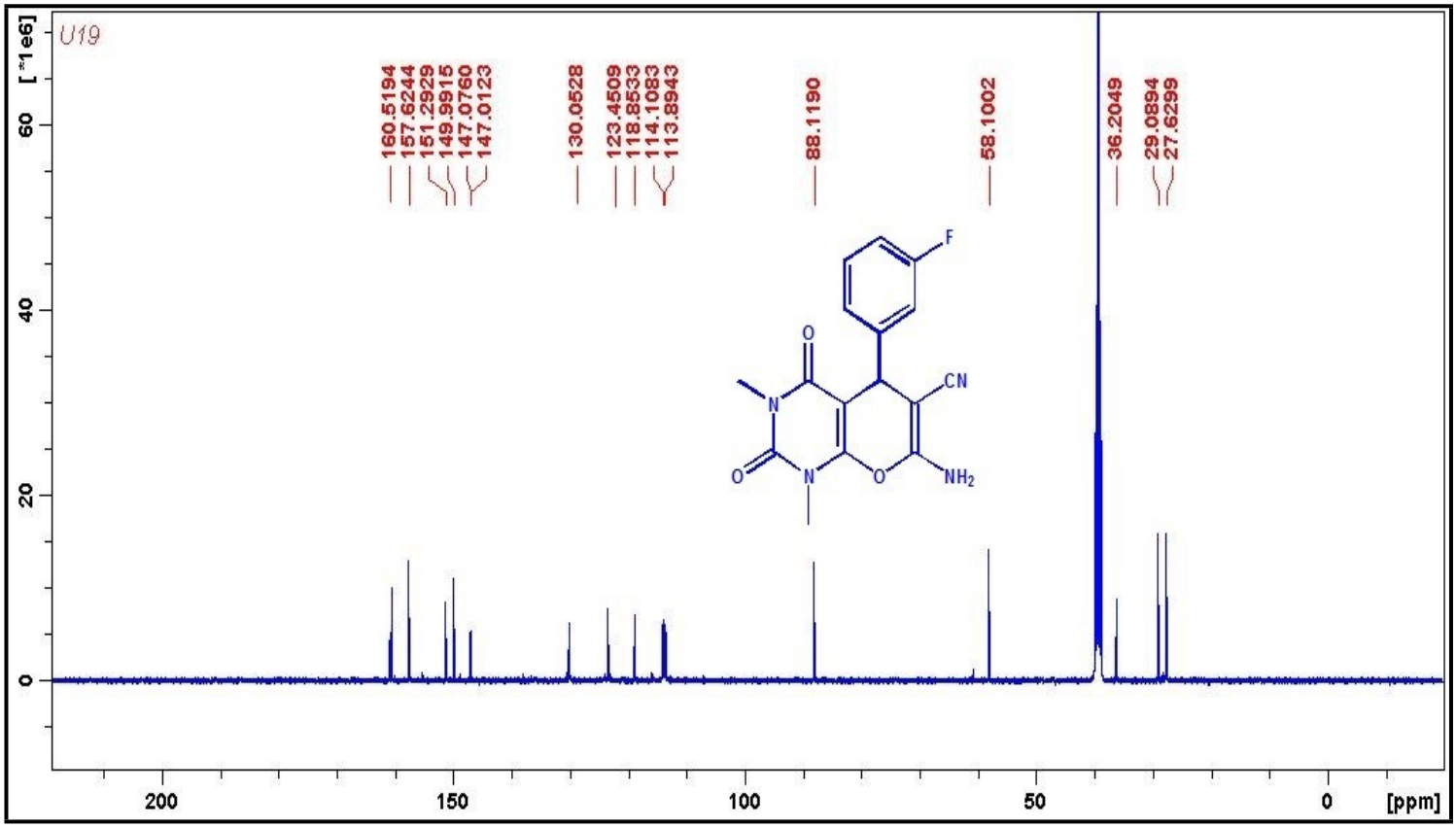


FT-IR spectra of compound 4j

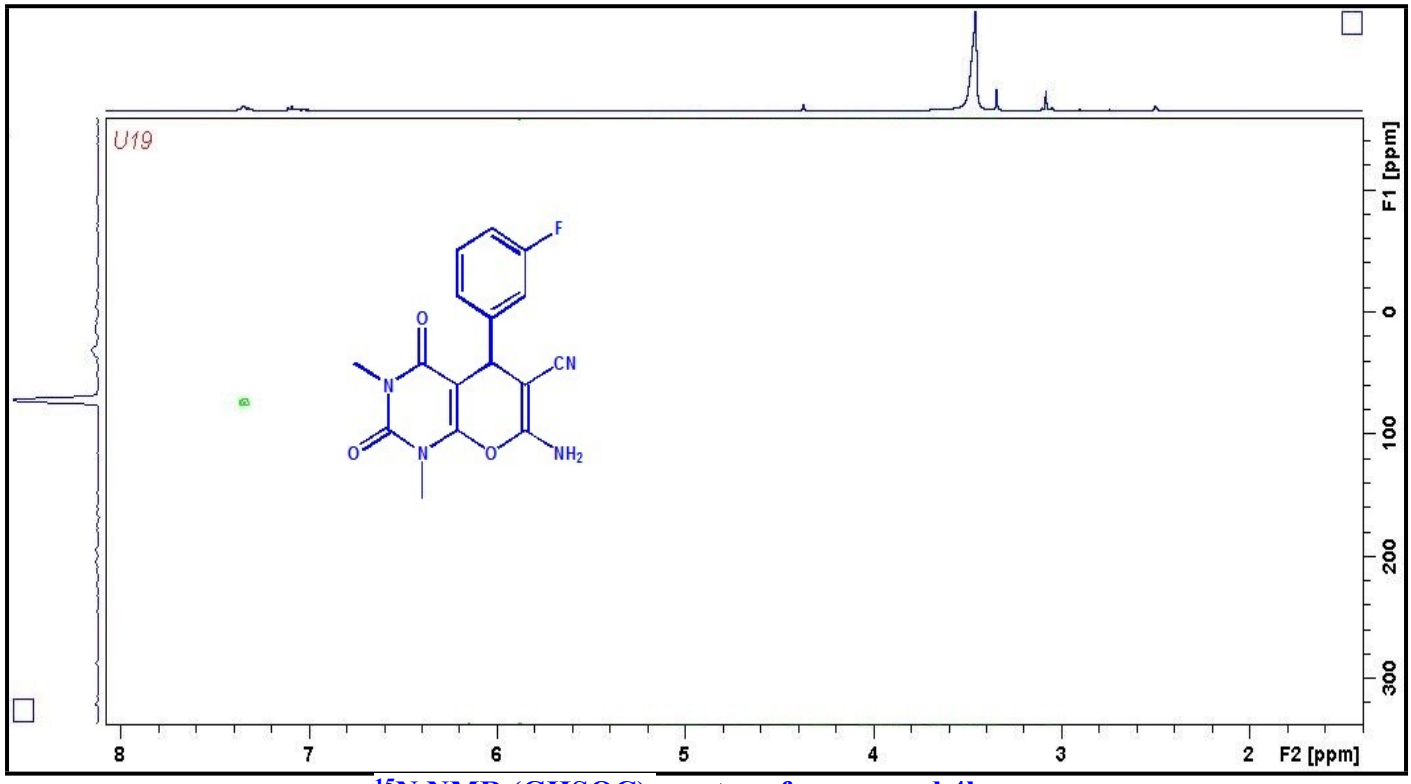


^{1}H NMR spectra of compound 4k

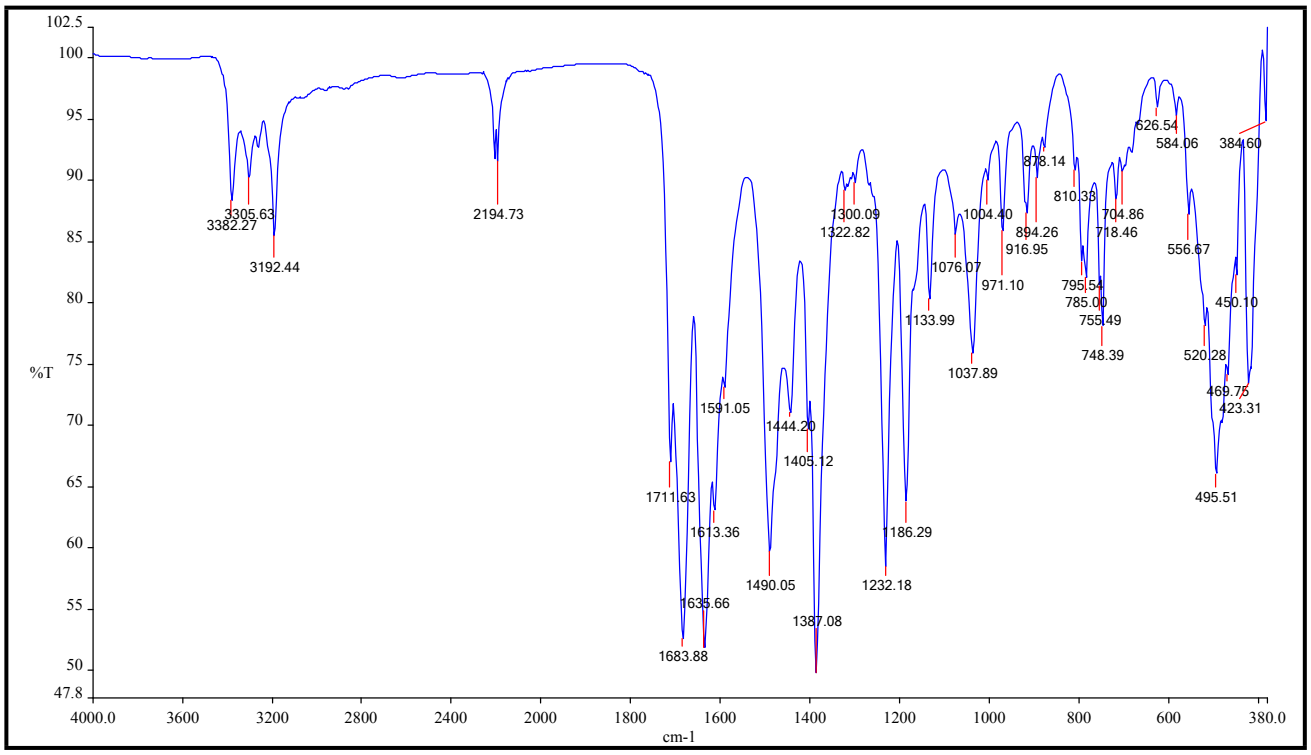




^{13}C NMR spectra of compound 4k



^{15}N NMR (GHSQC) spectra of compound 4k



FT-IR spectra of compound 4k