Supplementary Data

Magnetization of biochar nanoparticles as novel support for fabrication of organo nickel as selective, reusable and magnetic nanocatalyst in organic reactions

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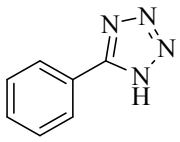
Abstract:

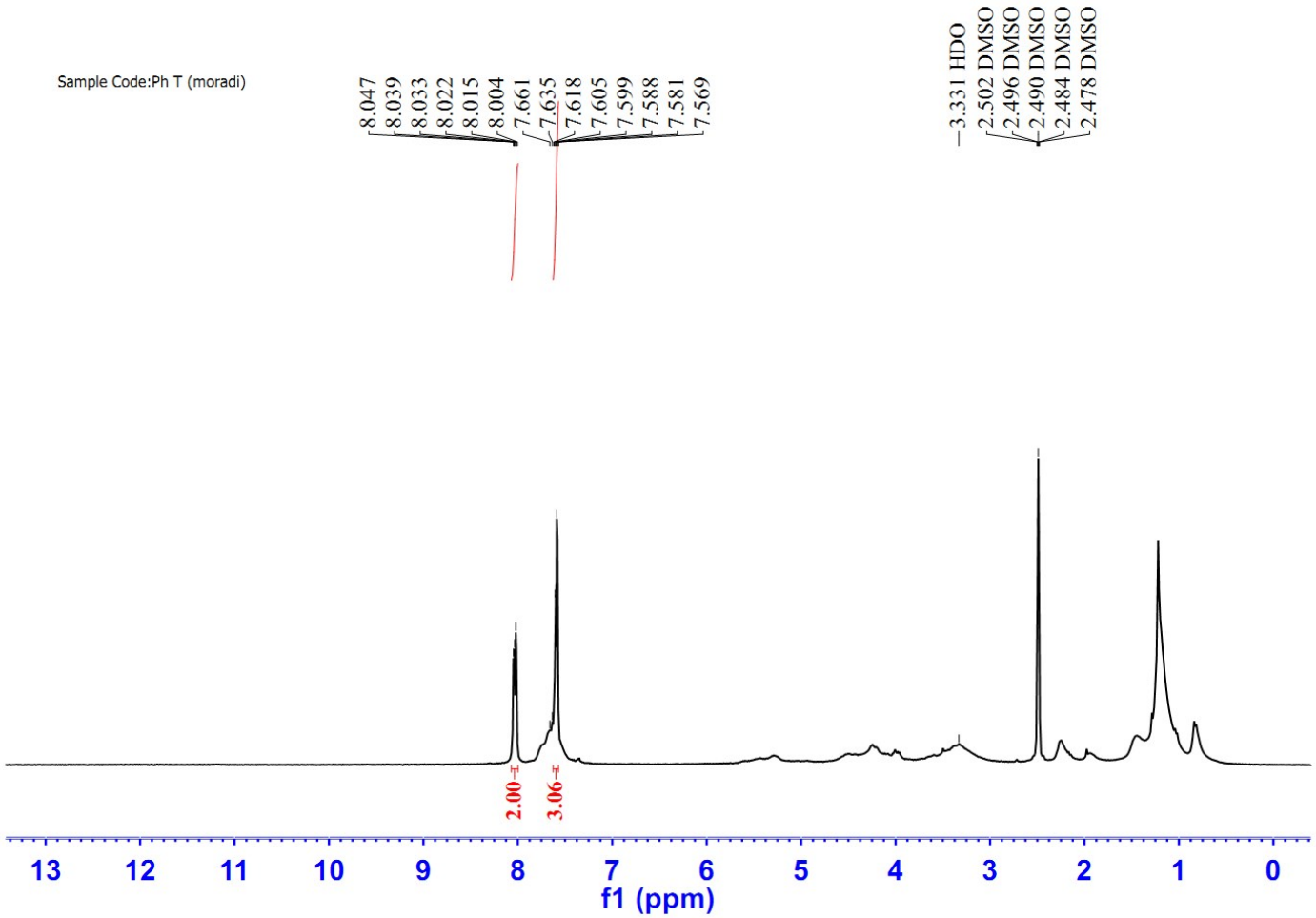
Catalyst species are important class of materials in chemistry, industrial, medicinal and biotechnology. Also, waste recycling is important process in green chemistry and economic efficiency. Therefore, in order to waste recycling, biochar nanoparticles were prepared from chicken manure. Then, biochar nanoparticles were magnetized under green and environmentally friendly method. Finally, the surface of magnetic biochar nanoparticles were modified and further were applied as a novel support for fabrication of nickel as homoselective and reusable catalyst in organic reactions. Structure of this organic-inorganic catalyst has been characterized by N_2 adsorption–desorption isotherms, SEM, EDS, WDX, XRD, TGA, AAS, FT-IR and VSM techniques. This magnetically recyclable catalyst was used in the homoselective synthesis of tetrazole and pyranopyrazole derivatives. This catalyst can be reused for several times without significant loss of its catalytic efficiency. Heterogeneity and stability of this nanocatalyst was studied by hot filtration and AAS technique. Also, reused catalyst was characterized by SEM, EDS, AAS and BET techniques.

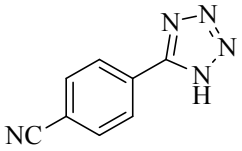
^{1}H NMR spectral data



5-phenyl-1H-tetrazole

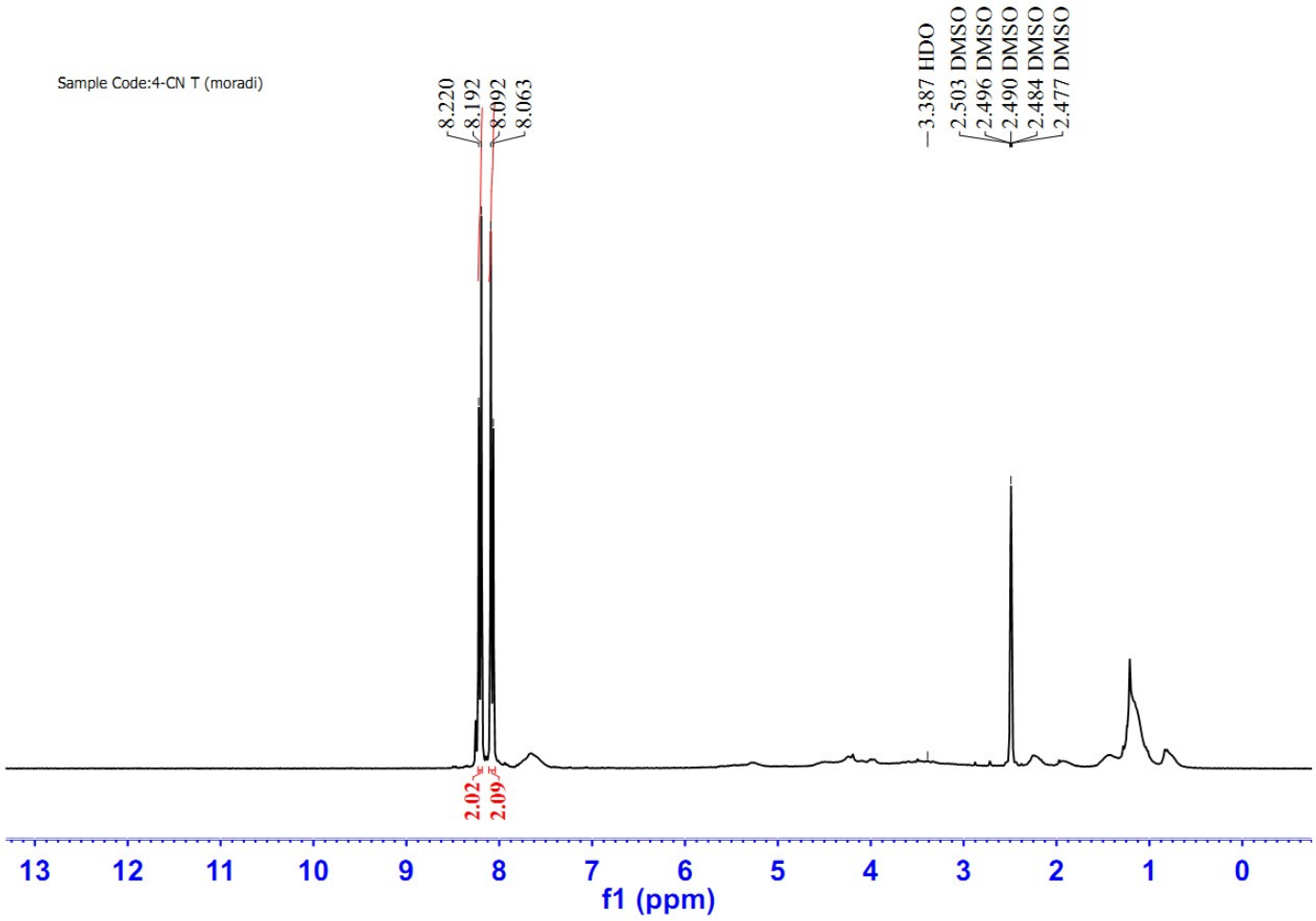
^{1}H NMR (400 MHz, DMSO): δ_H= 8.05-8.00 (m, 2H), 7.66-7.57 (m, 3H) ppm.

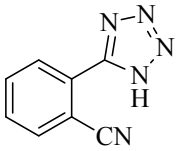




4-(1H-tetrazol-5-yl)benzonitrile

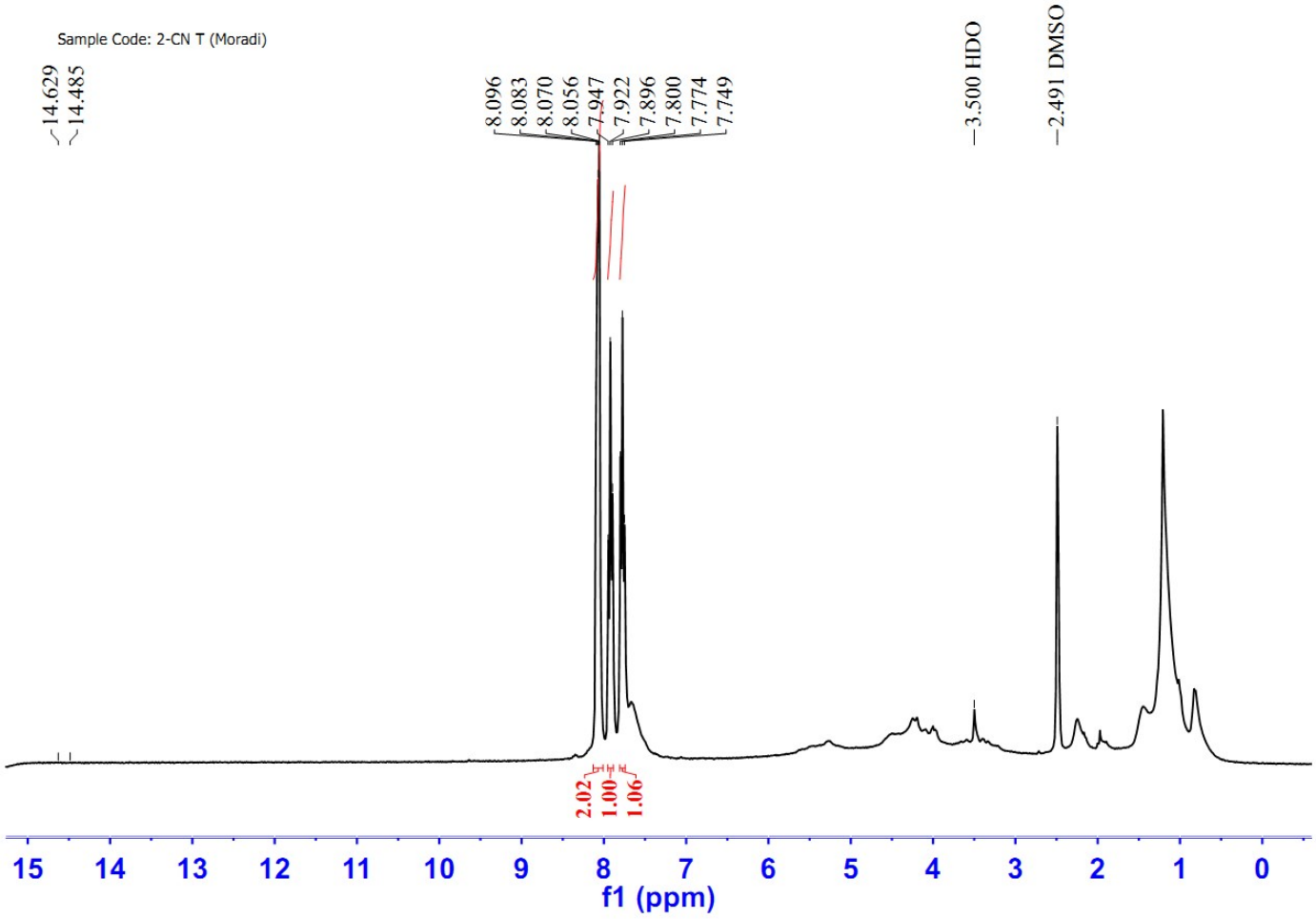
^{1}H NMR (400 MHz, DMSO): δ_H= 8.22-8.20 (d, *J*= 8 Hz, 2H), 8.09-8.07 (d, *J*= 8 Hz, 2H) ppm.

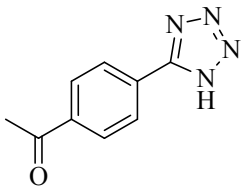




2-(1H-tetrazol-5-yl)benzonitrile

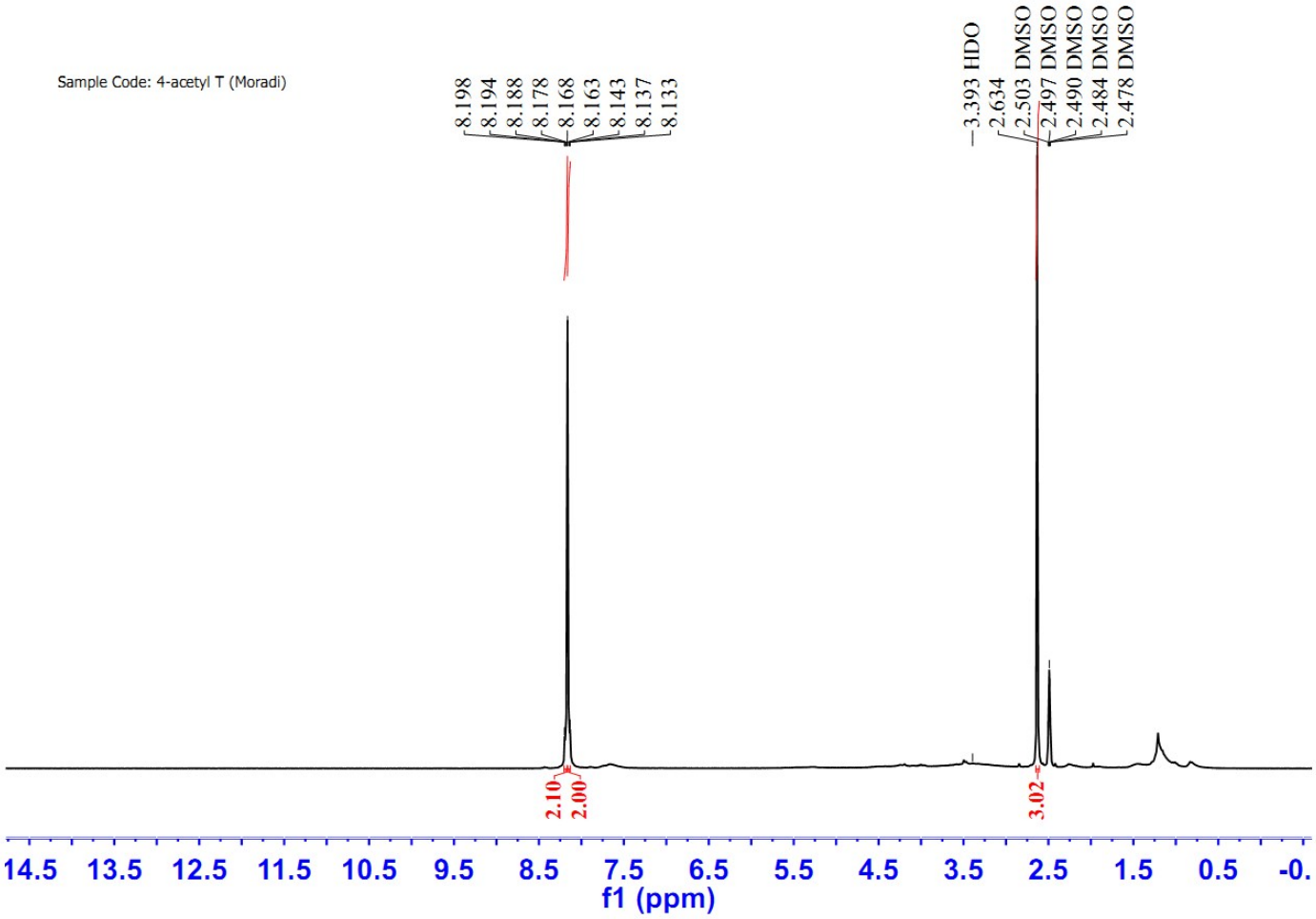
^{1}H NMR (400 MHz, DMSO): δ_H= 8.09-8.05 (t, *J*= 8 Hz, 2H), 7.95-7.90 (t, *J*= 8 Hz, 1H), 7.80-7.75 (t, *J*= 8 Hz, 1H) ppm.

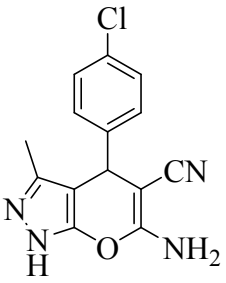




1-(4-(1H-tetrazol-5-yl)phenyl)ethanone

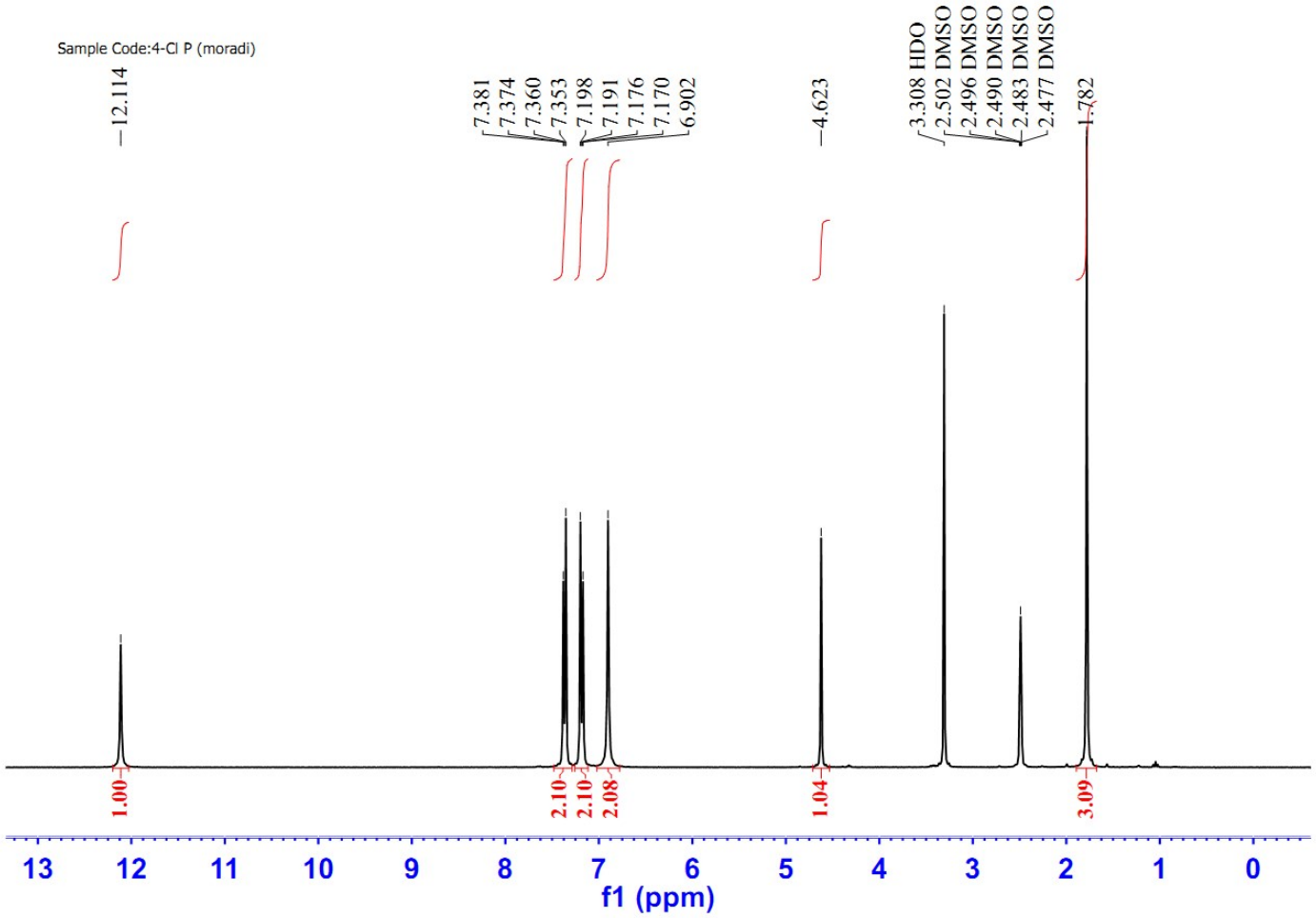
^{1}H NMR (400 MHz, DMSO): δ_H= 8.20-8.17 (m, 2H), 8.16-8.13 (m, 2H), 2.63 (s, 3H) ppm.

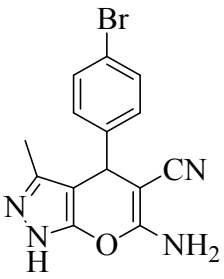




6-amino-4-(4-chlorophenyl)-3-methyl-2,4-dihydropyrano[2,3-c]pyrazole-5-carbonitrile

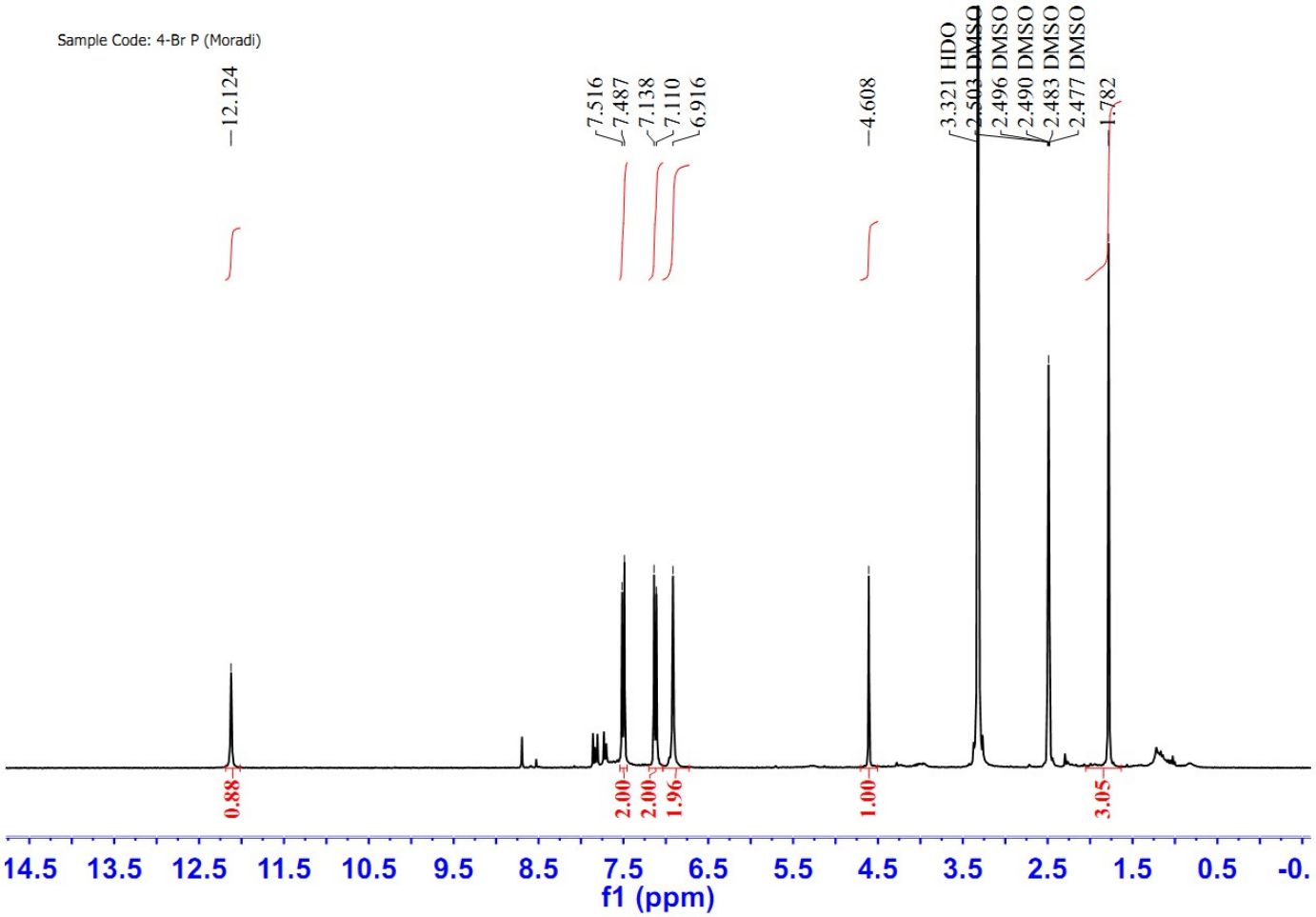
^{1}H NMR (400 MHz, DMSO): δ_H= 12.11 (s, 1H), 7.38-7.35 (d, *J*= 12 Hz, 2H), 7.20-7.17 (d, *J*= 12 Hz, 2H), 6.90 (s, 2H), 4.62 (s, 1H), 1.78 (s, 3H) ppm.

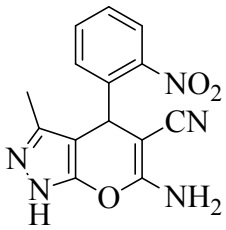




6-amino-4-(4-bromophenyl)-3-methyl-1,4-dihydropyrano[2,3-c]pyrazole-5-carbonitrile

^{1}H NMR (400 MHz, DMSO): δ_H= 12.12 (s, 1H), 7.52-7.49 (d, *J*= 12 Hz, 2H), 7.14-7.11 (d, *J*= 12 Hz, 2H), 6.92 (s, 2H), 4.61 (s, 1H), 1.78 (s, 3H) ppm.





6-amino-3-methyl-4-(2-nitrophenyl)-1,4-dihydropyrano[2,3-c]pyrazole-5-carbonitrile

^{1}H NMR (400 MHz, DMSO): δ_H= 12.19 (s, 1H), 7.86-7.83 (d, *J*= 12 Hz, 1H), 7.68-7.63 (t, *J*= 10 Hz, 1H), 7.51-7.45 (t, *J*= 12 Hz, 1H), 7.33-7.30 (d, *J*= 12 Hz, 1H), 7.02 (s, 2H), 5.09 (s, 1H), 1.76 (s, 3H) ppm.