

Microwave-Assisted Synthesis of 4-Amino Pyrimidine Analogues Using Eco-Friendly NiTiO₃ Nanoparticles Supported Montmorillonite K30 as heterogeneous catalyst

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Text S1. Materials

The commercial MK30 nano clay, Titanium Butoxide-Ti(C₄H₉O)₄, Nickel acetate (CH₃COO)₂Ni were purchased from Sigma-Aldrich. Acetamidine-hydrochloride was purchased from the BLD pharm India Pvt Ltd. All other chemicals used in this work such as aldehydes, Dicyanomethane, ethanol and other solvents were purchased from Avra synthesis Pvt. Ltd in India. All reagents used were of analytical grade (AR) and used without further purification, and deionized water was made in our lab.

Text S2. Characterization

The structure nature and crystallinity of the synthesized catalyst was examined by x-ray diffraction analysis (XRD, Bruker, Germany) with an angle range 5 to 90°. The functional group present in the synthesized composite as well as functional group present in the synthesized organic compound was analyzed by Fourier-transformed infrared spectroscopy via ATR mode. Morphology of the synthesized composite was identified by Field Emission Scanning Electron microscope (Thermo-Fisher FEI QUANTA 250 FEG) and TEM (FEI – TECNAI G2 – 20 TWIN) analysis. Surface area of the synthesized composite was calculated by Brunauer-Emmett-Teller technique (Quanta-chrome- instrument). The stability of the composite was encountered by using thermogravimetric analysis TA instruments, USA—SDT Q600. The XPS analysis used to examine the chemical state of the synthesized composite present on the surface (PHI 5000 Versa Probe III). To confirm the product formation of organic compounds, ¹H NMR and ¹³C NMR (Bruker 400 MHz was used). The mass of formed product was calculated using HR-MS analysis (XEVO-G2-XS-QTOF) Waters, USA.

Text S3. Quantification of Ni ions in the synthesized composite

Inductive coupled plasma resonance Mass spectrometry study used to measure the concentration of Ni ions Present in the synthesized NiTiO₃ and optimized M3NT20 composite. From the ICPMS analysis we obtained results for pristine NiTiO₃ out of 100% of Ni ions (300 ppb) we observed 91% of Ni ions (275 ppb). For composite 20%NiTiO₃/MK30 composite out of 100% of Ni ions (55 ppb) we get the 90% (50 ppb). For the decreasing concentration of Ni ions in the composite shows little amount leaching of Ni ions present in the composite due to the over loading of NiTiO₃ on the surface of the MK30 clay. From, the ICPMS 20%NiTiO₃ loaded MK30 composite enough for carried out the reaction.

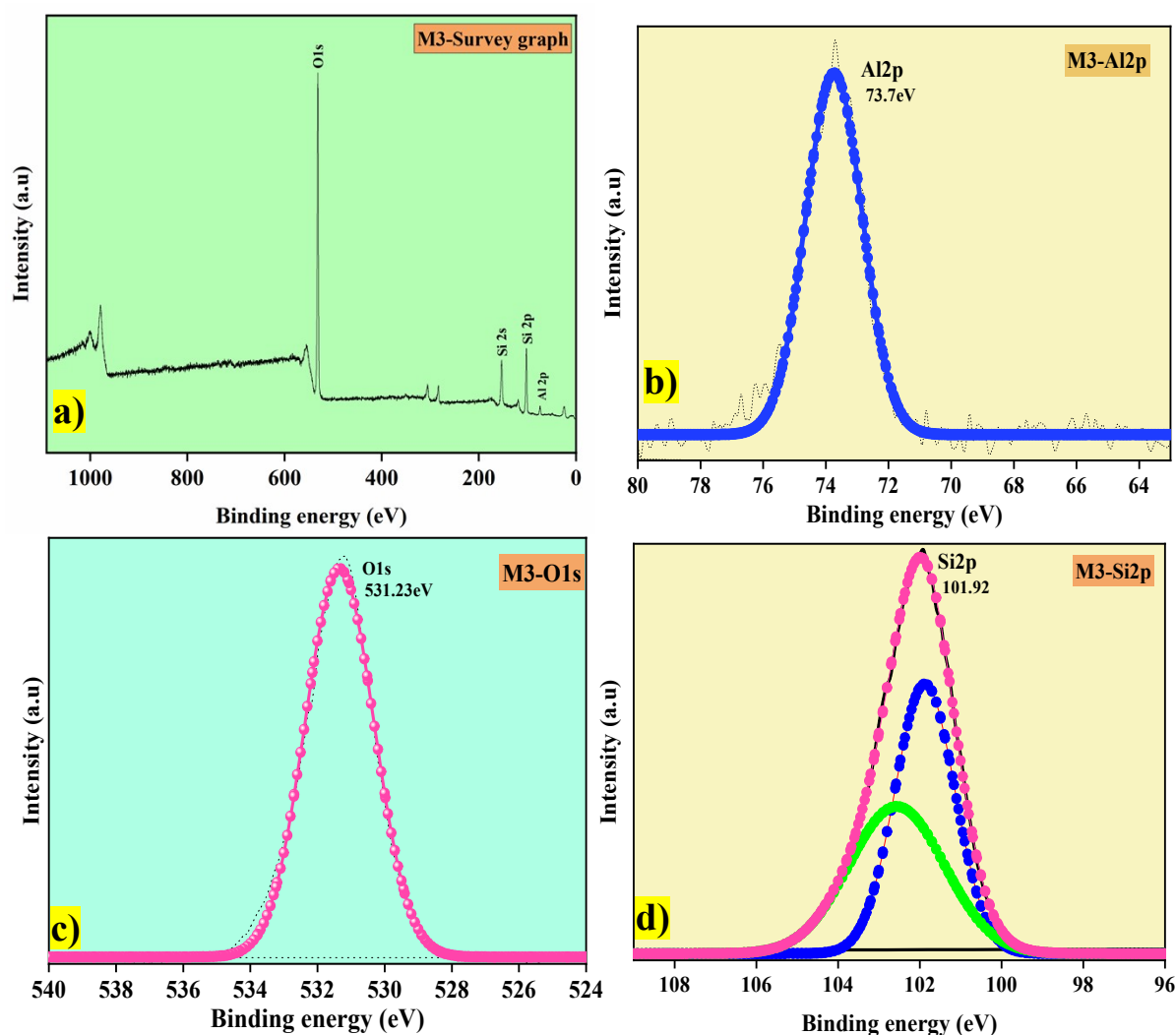


Fig. S1. (a-d) XPS data of MK30 clay

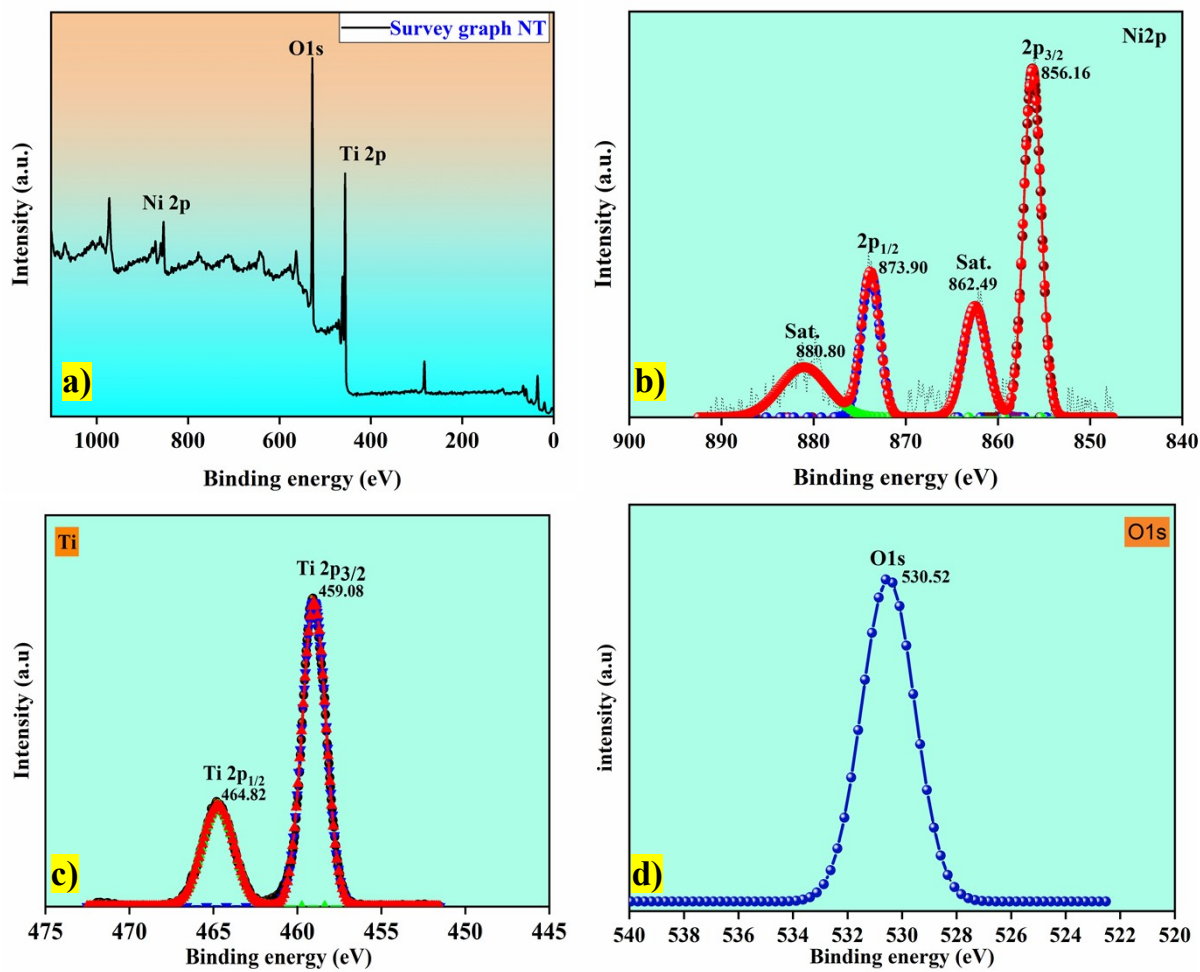


Fig. S2. (a-d) XPS data of NiTiO₃

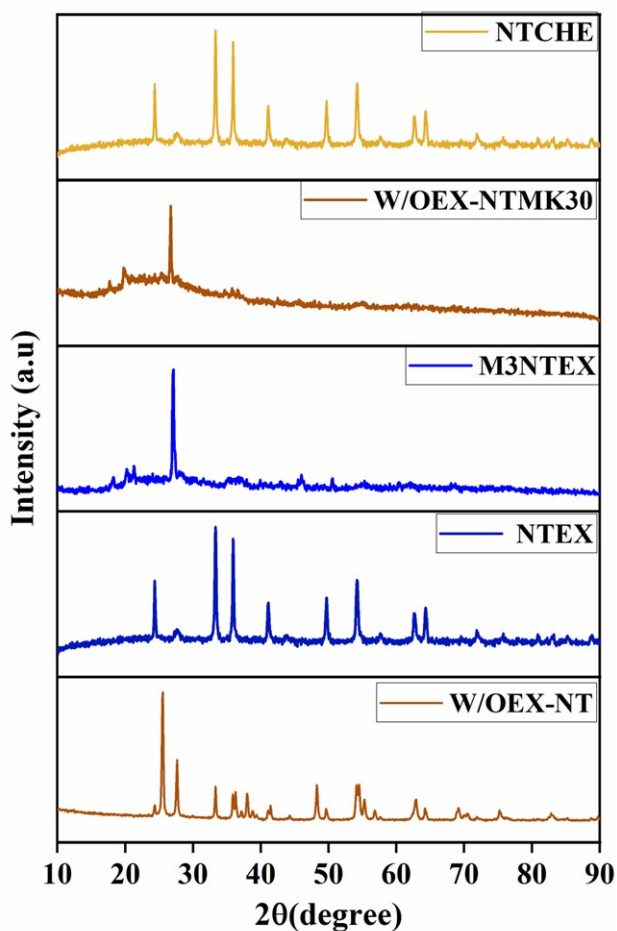
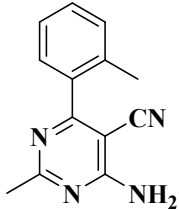
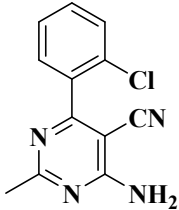
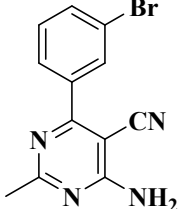
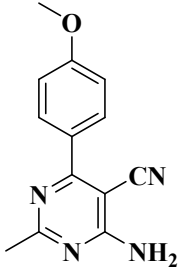
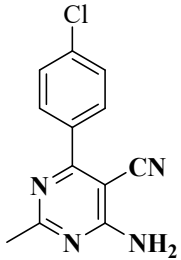
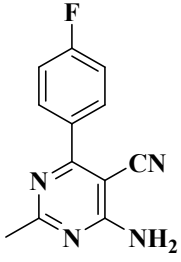
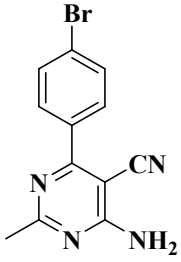


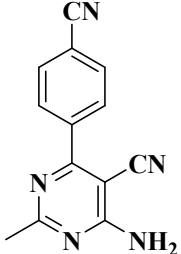
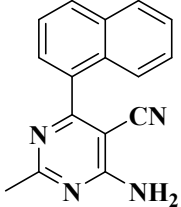
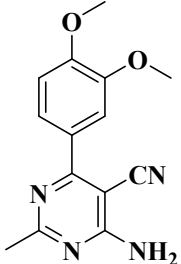
Fig. S3. Comparison XRD datas of NiTiO₃ without extract synthesis (W/OEX-NT), with extract (NTEX), chemical method (NTCHE), without extract composite (W/OEX-NTMK30), with extract composite (M3NTEX)

Characterization data of organic compounds

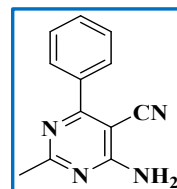
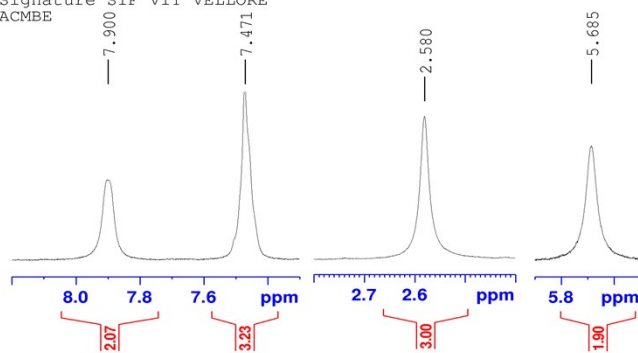
S.No	Structure	Name and molecular formula	Appearance & Melting point (°C)	FT-IR v/cm ⁻¹	HRMS	¹ HNMR	¹³ C NMR
1.		4-amino-2-methyl-6-phenylpyrimidine-5-carbonitrile, C ₁₂ H ₁₀ N ₄	White colour, 230°C	3379, 3134, 2216,	211.0943	δ 5.6 (s, 2H), 7.4 (s, 3H), 7.9 (s, 2H), 2.5 (s, 3H)	δ 163.88, 131.59, 128.84, 128.74, 26.28

2.		4-amino-2-methyl-6-(o-tolyl)pyrimidine-5-carbonitrile, $C_{13}H_{12}N_4$	Light yellow colour, 212°C	3334, 3135, 2211, 573,	225.1016	δ 5.6 (s, 2H), 7.2 (d, 2H), 7.3 (m, 2H), 2.5 (s, 2H), 2.2 (s, 3H)	δ 171.13, 170.18, 163.54, 136.05, 135.72, 131.03, 130.11, 128.56, 126.03, 115.21, 87.75, 26.50, 19.59
3.		4-amino-6-(2-chlorophenyl)-2-methylpyrimidine-5-carbonitrile, $C_{12}H_9ClN_4$	Light yellow colour, 225°C	3382, 3122, 2213, 1681,	245.0598	δ 5.6 (s, 2H), 7.2 (d, 2H), 7.4 (t, 3H), 2.5 (s, 3H)	δ 170.58, 168.19, 163.25, 131.34, 131.28, 130.06, 129.99, 127.95, 127.14, 114.71, 88.44, 26.49
4.		4-amino-6-(3-bromophenyl)-2-methylpyrimidine-5-carbonitrile, $C_{12}H_9BrN_4$	Light yellow colour, 232°C	3366, 3128, 2226, 1675, 1542,	289.0089	δ 5.6 (s, 2H), 7.3 (t, 1H), 7.6 (d, 1H), 7.8 (d, 1H), 8.0 (s, 1H)	δ 169.67, 166.64, 164.61, 135.19, 131.72, 130.40, 125.41, 116.15, 84.40, 26.25

5.		4-amino-6-(4-methoxyphenyl)-2-methylpyrimidine-5-carbonitrile, $C_{13}H_{12}N_4O$	Light yellow colour, 226°C	3328, 3128, 2208, 1548,	241.1091	δ 5.7 (s, 2H), 6.9 (d, 2H), 7.9 (d, 2H), 3.8 (s, 3H), 2.5 (s, 3H)	δ 149.26, 148.76, 122.34, 119.20, 11.23, 117.23, 112.27, 111.68, 110.88, 83.26, 26.54, 22.13
6.		4-amino-6-(4-chlorophenyl)-2-methylpyrimidine-5-carbonitrile, $C_{12}H_9ClN_4$	White colour, 236°C	3382, 3122, 2213, 1681, 1530	245.0598	δ 5.8 (s, 2H), 7.4 (d, 2H), 7.8 (d, 2H), 2.5 (s, 3H)	δ 170.58, 168.19, 163.25, 131.34, 130.28, 130.06, 129.99, 127.95, 127.14, 114.71, 88.44, 26.49
7.		4-amino-6-(4-fluorophenyl)-2-methylpyrimidine-5-carbonitrile, $C_{12}H_9FN_4$	White colour, 248°C	33370, 3146, 2213, 1669, 1548	229.0887	δ 5.7 (s, 2H), 7.1 (t, 2H), 7.9 (q, 2H), 2.5 (s, 3H)	δ 169.69, 167.26, 164.72, 131.57, 131.48, 116.72, 116.06, 115.84, 84.02, 26.47
8.		4-amino-6-(4-bromophenyl)-2-methylpyrimidine-5-carbonitrile, $C_{12}H_9BrN_4$	White colour, 242°C	3377, 3140, 2213, 1675, 1548	289.0089	δ 7.2 (s, 2H), 7.5 (d, 2H), 7.7 (d, 2H), 2.5 (s, 3H)	δ 169.67, 166.64, 164.61, 135.19, 131.72, 130.40,

		$C_{12}H_9BrN_4$					125.41, 116.15, 84.40, 26.25
9.		4-amino-6-(4-cyanophenyl)-2-methylpyrimidine-5-carbonitrile, $C_{13}H_9N_5$	Light yellow colour, 252°C	3382, 3116, 2220, 1663, 1535	236.0938	δ 6.0 (s, 2H), 7.7 (d, 2H), 8.0 (d, 2H), 2.6 (s, 3H)	δ 169.92, 164.52, 141.16, 132.92, 129.89, 116.26, 113.58, 84.75, 26.48
10.		4-amino-2-methyl-6-(naphthalen-1-yl)pyrimidine-5-carbonitrile, $C_{16}H_{12}N_4$	Light yellow colour, 190°C	3377, 3164, 2159, 1602,	261.1146	5.9 (s, 2H), 7.5 (m, 3H), 7.90 (d, 1H), 7.99 (t, 1H), 8.2 (t, 1H), 8.7 (s, 1H)	δ 160.71, 159.38, 130.73, 129.21, 128.99, 126.62, 126.56, 126.20, 126.02, 123.92, 53.39, 22.12
11.		4-amino-6-(3,4-dimethoxyphenyl)-2-methylpyrimidine-5-carbonitrile, $C_{14}H_{14}N_4O_2$	Light yellow colour, 222°C	3370, 3134, 2213, 1675, 1221	271.1196	δ 6.8 (s, 2H), 6.9 (d, 1H), 7.5 (d, 1H), 7.6 (d, 1H), 3.9 (d, 3H), 3.8 (d, 3H), 2.5 (s, 3H)	δ 149.20, 148.76, 122.34, 119.20, 117.23, 112.27, 11.68, 110.88, 83.26, 56.12, 56.07, 56.03, 55.96, 53.68, 26.54,

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Figure S4. ¹H NMR spectrum of 2-methyl-6-phenyl-4-amino-5-carbonitrile (4a)

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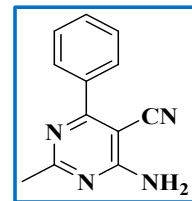
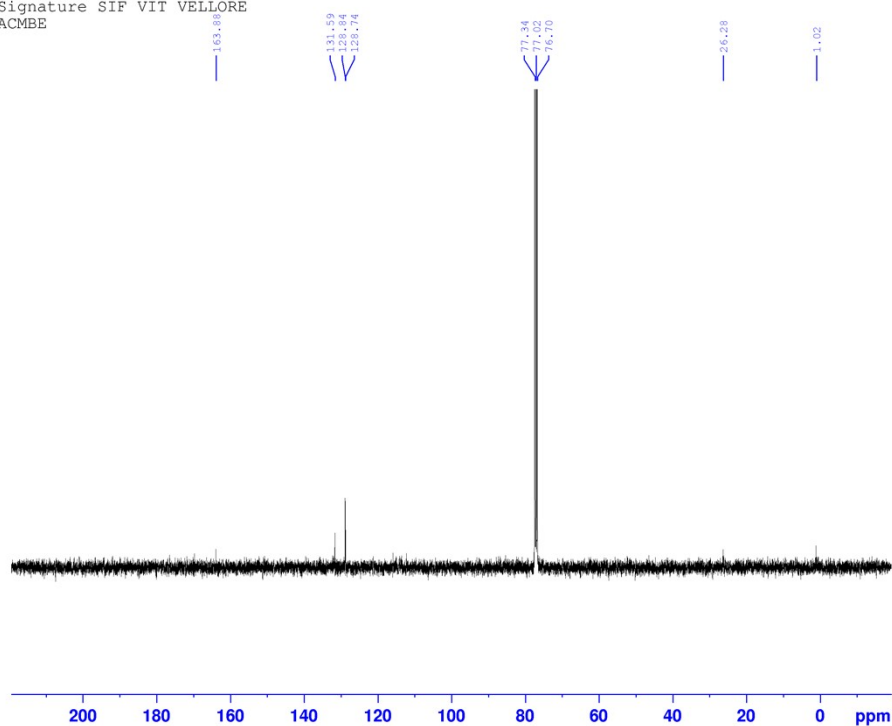


Figure S5. ^{13}C NMR spectrum of 2-methyl-6-phenyl-4-amino-5-carbonitrile (4a)

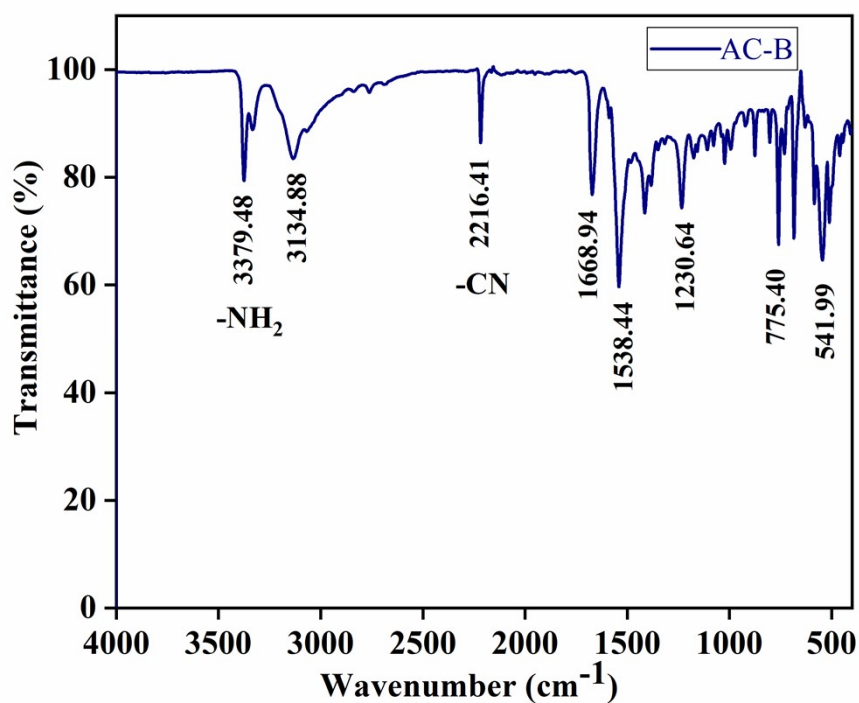


Figure S6. FT-IR spectrum of 2-methyl-6-phenyl-4-amino-5-carbonitrile (4a)

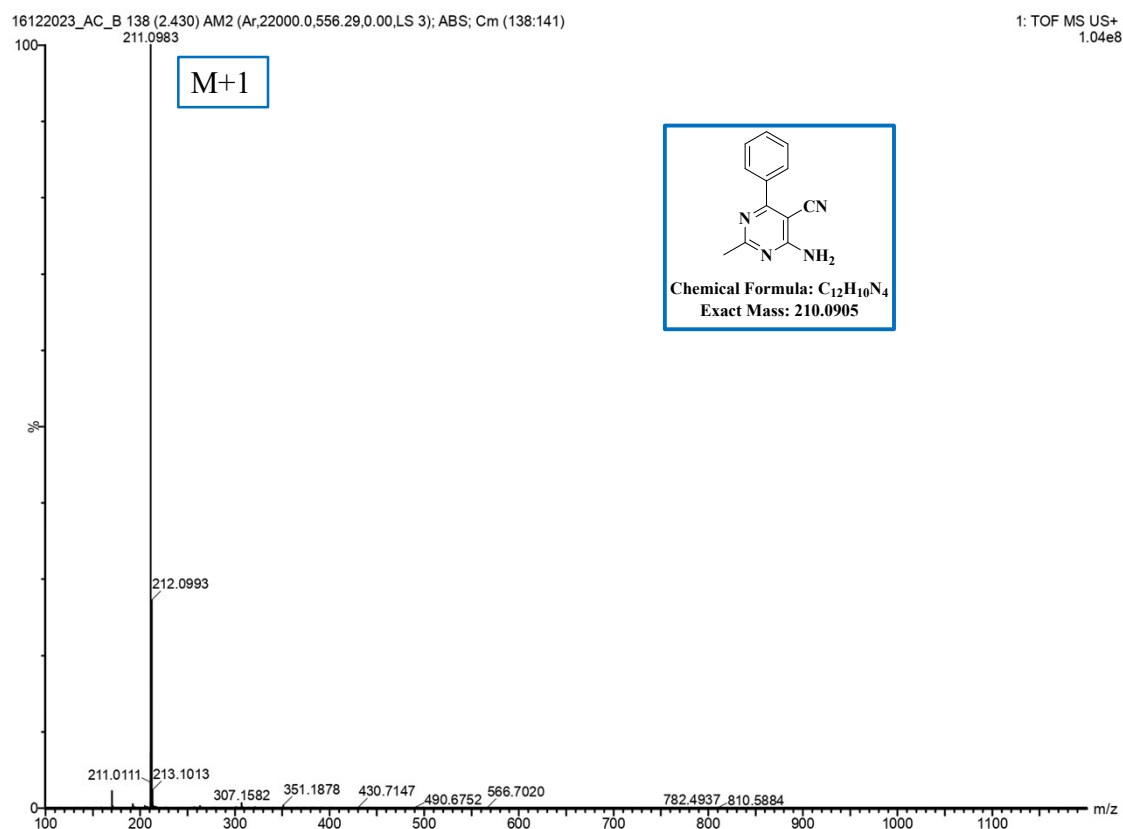


Figure S7. HR-MS spectrum of 2-methyl-6-phenyl-4-amino-5-carbonitrile (4a)

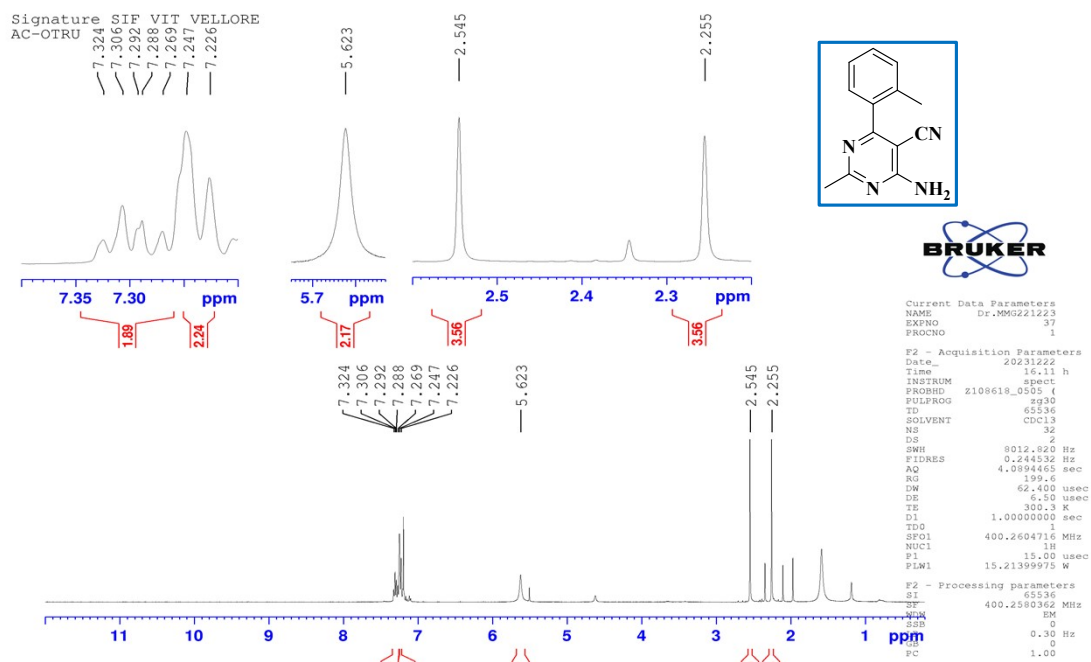


Figure S8. 1H NMR spectrum of 4-amino-2-methyl-6-(o-tolyl) pyrimidine-5-carbonitrile (4b)

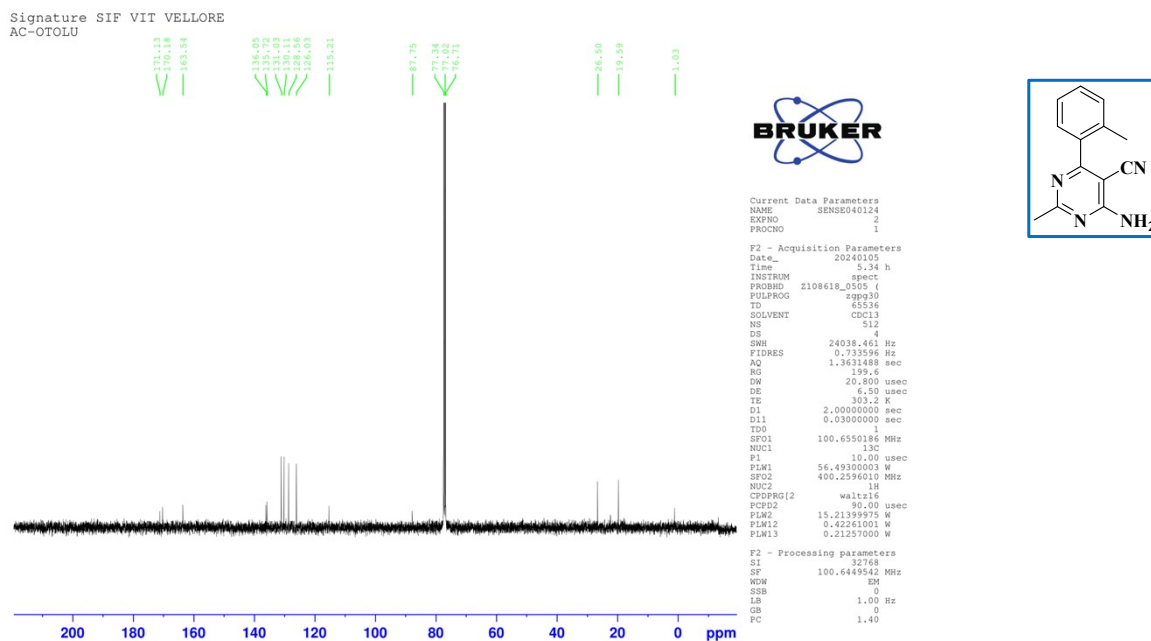


Figure S9. ^{13}C NMR spectrum of 4-amino-2-methyl-6-(o-tolyl) pyrimidine-5-carbonitrile (4b)

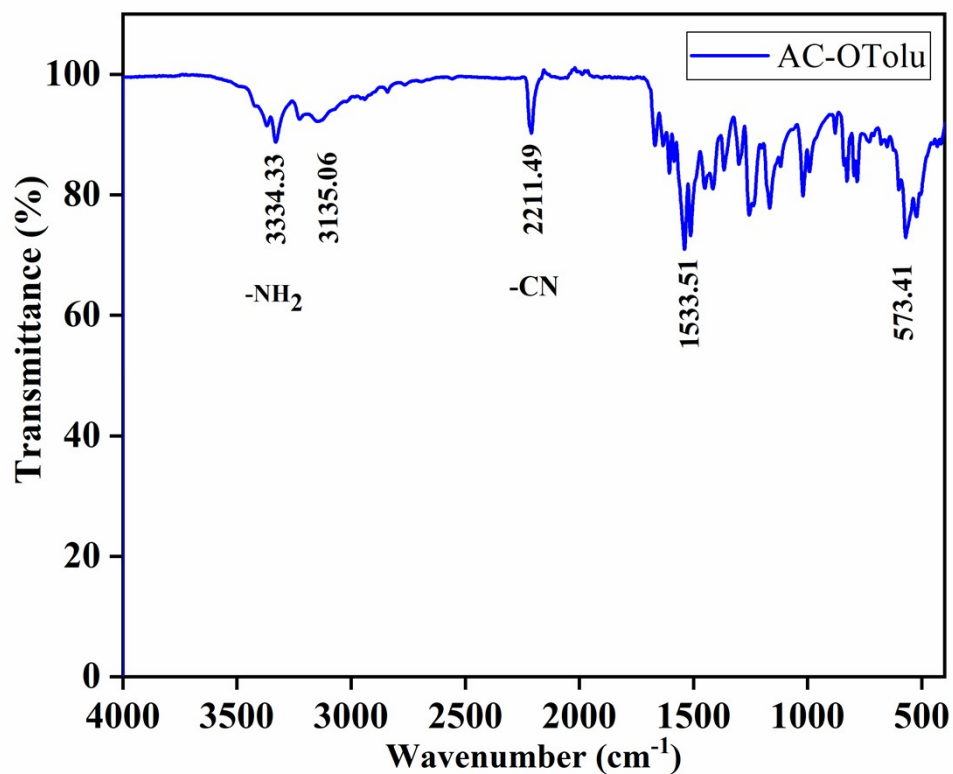


Figure S10. FT-IR spectrum of 4-amino-2-methyl-6-(o-tolyl) pyrimidine-5-carbonitrile (4b)

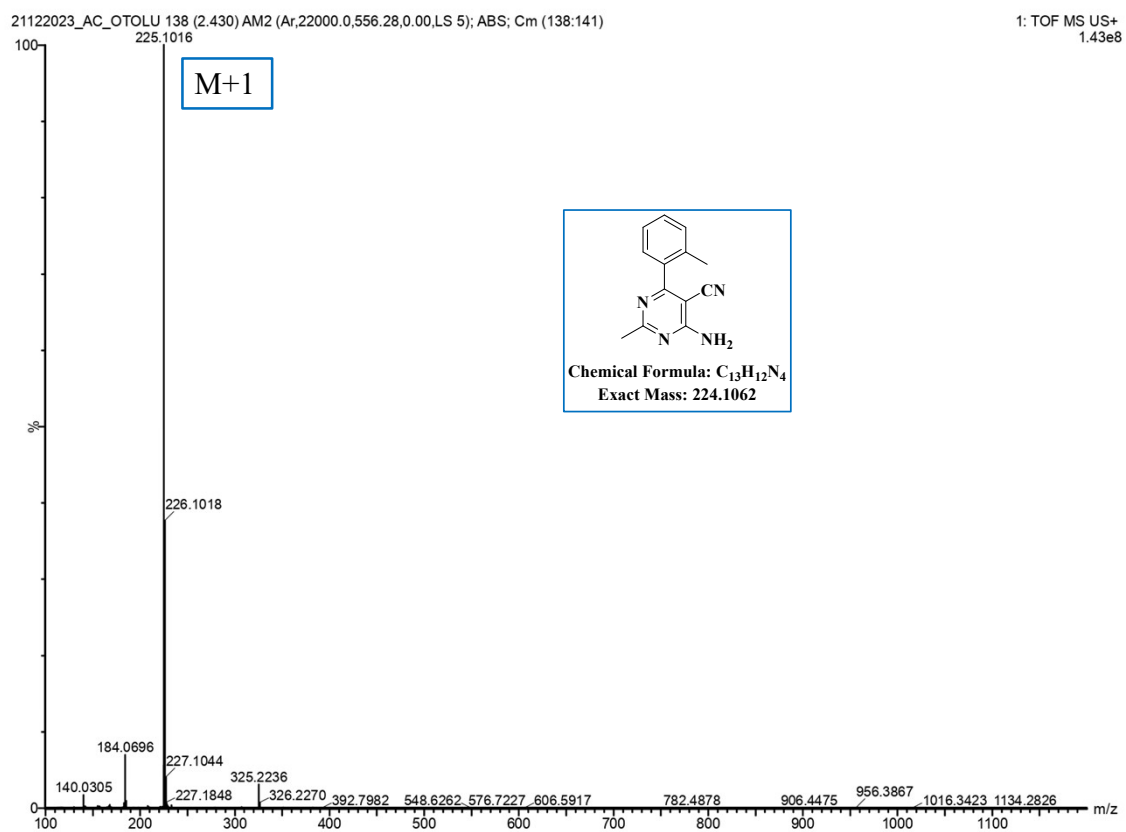


Figure S11. HR-MS spectrum of 4-amino-2-methyl-6-(o-tolyl) pyrimidine-5-carbonitrile (4b)

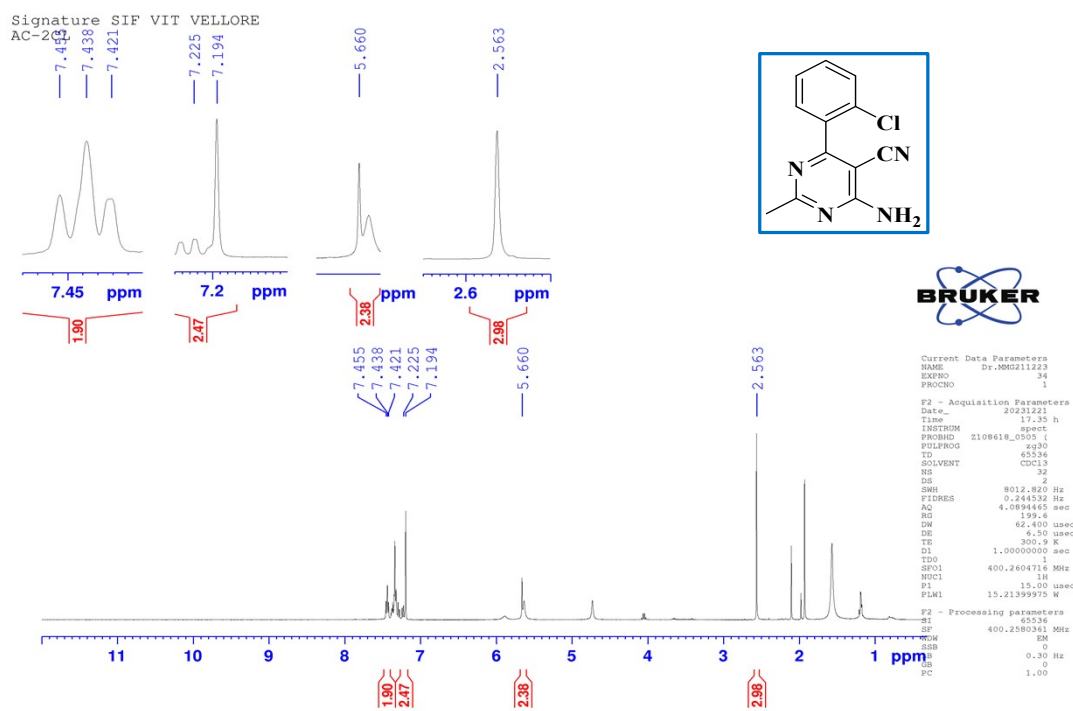


Figure S12. ¹H NMR spectrum of 4-amino-6-(2-chlorophenyl)-2-methylpyrimidine-5-carbonitrile (4C)

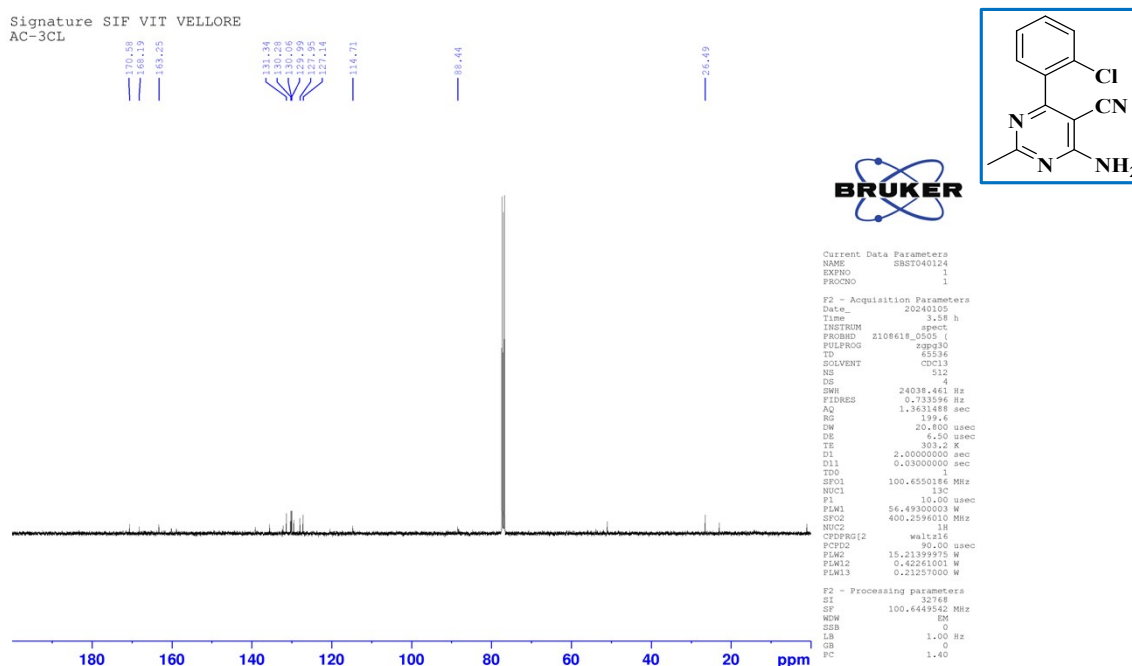


Figure S13. ¹³C NMR spectrum of 4-amino-6-(2-chlorophenyl)-2-methylpyrimidine-5-carbonitrile (4C)

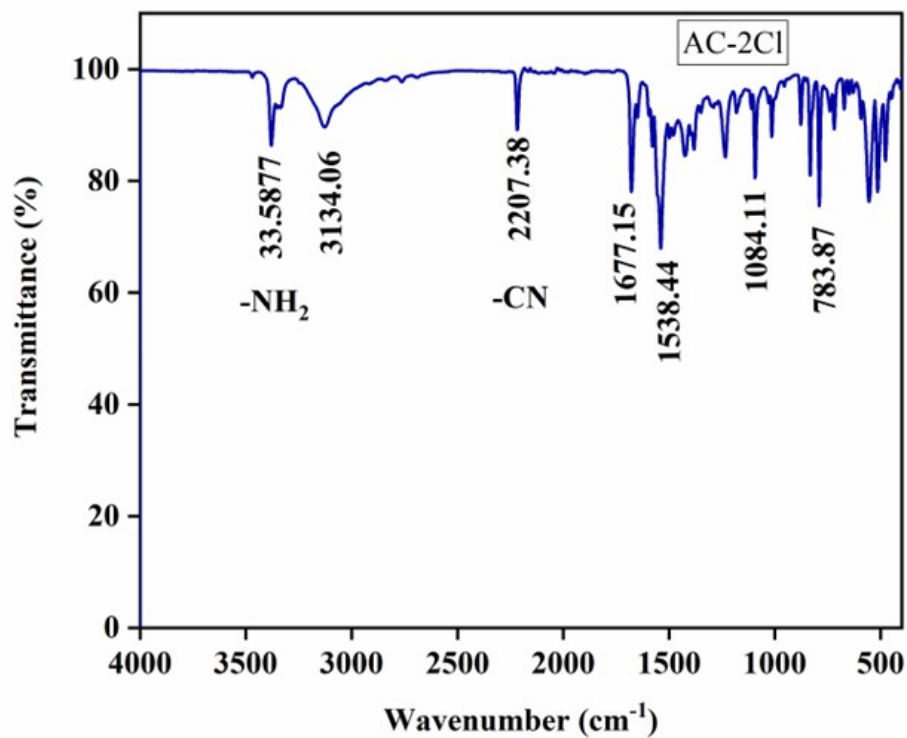


Figure S14. FT-IR spectrum of 4-amino-6-(2-chlorophenyl)-2-methylpyrimidine-5-carbonitrile (4C)

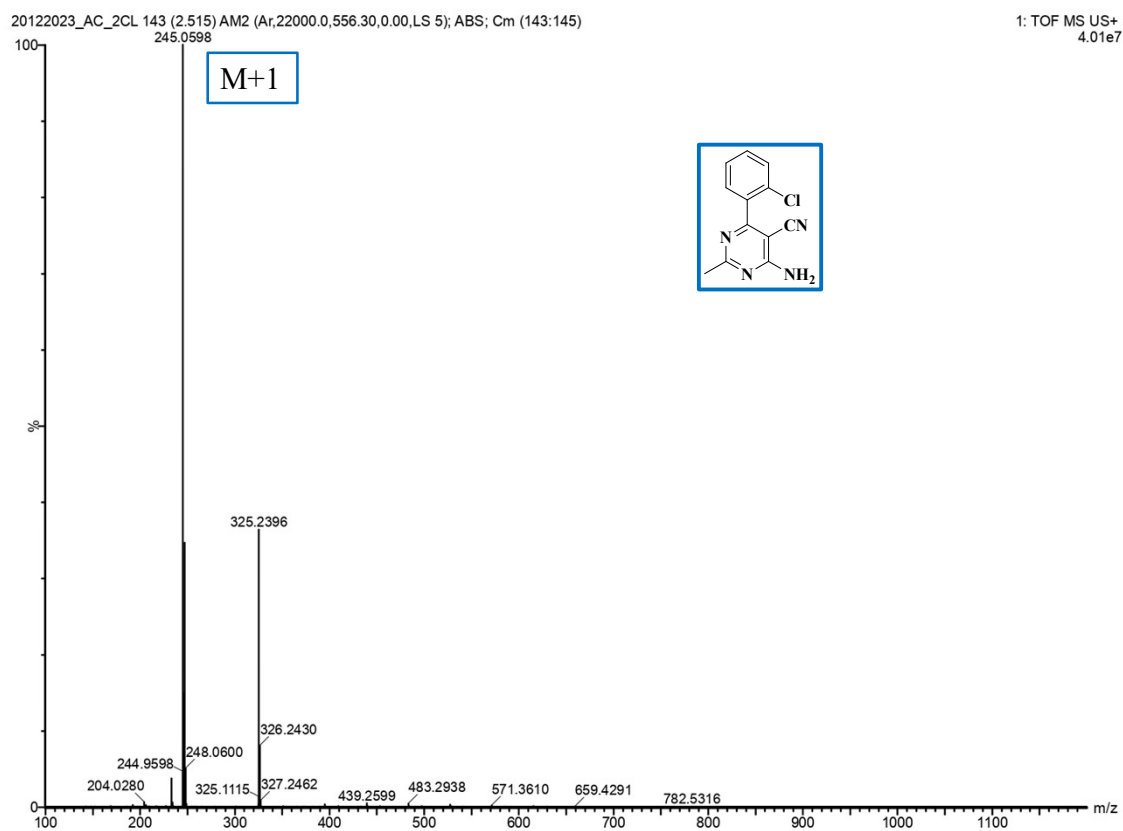


Figure S15. ¹H NMR spectrum of 4-amino-6-(2-chlorophenyl)-2-methylpyrimidine-5-carbonitrile (4C)

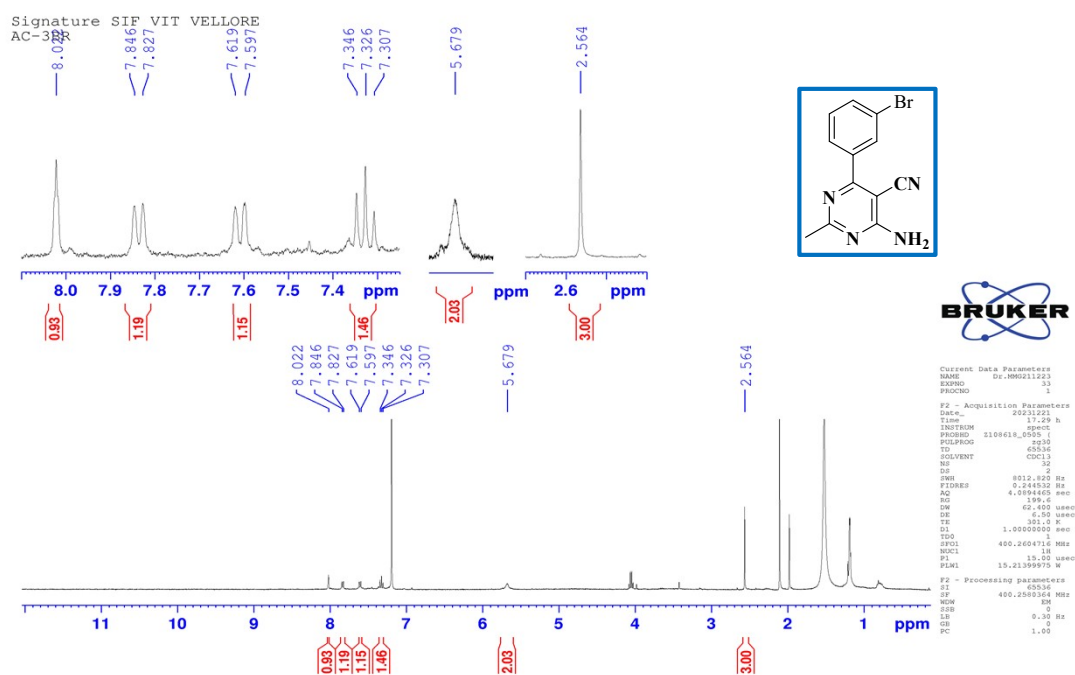


Figure S16. ^1H NMR spectrum of 4-amino-6-(3-bromophenyl)-2-methylpyrimidine-5-carbonitrile (4d)

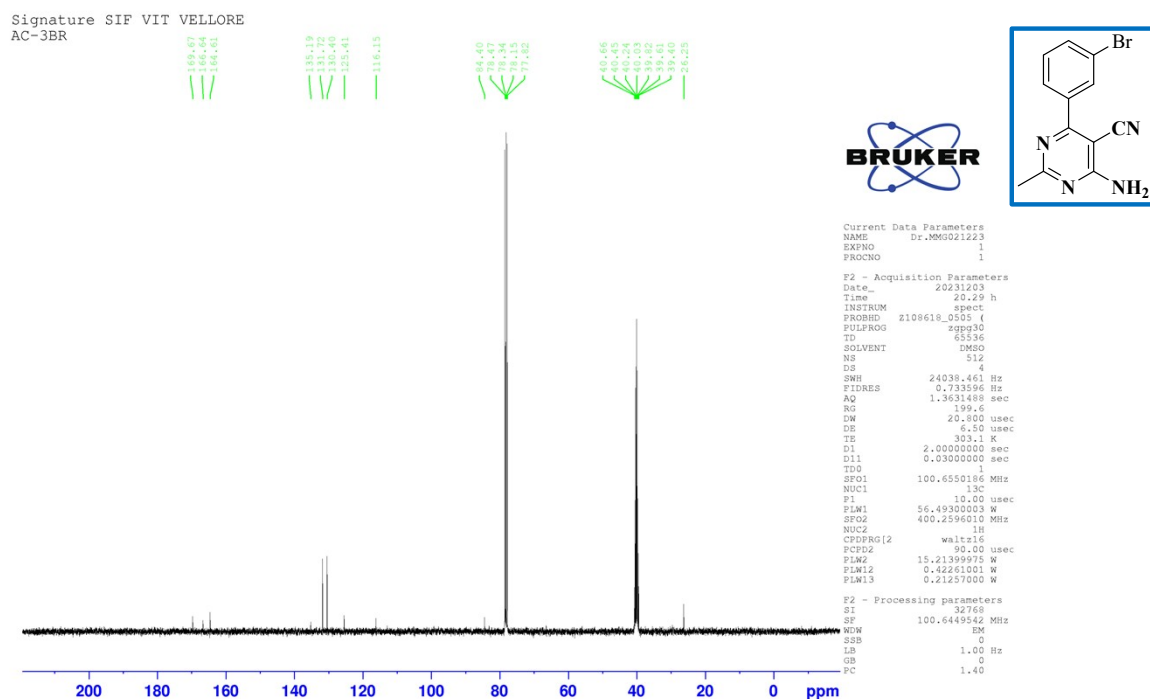


Figure S17. ^{13}C NMR spectrum of 4-amino-6-(3-bromophenyl)-2-methylpyrimidine-5-carbonitrile (4d)

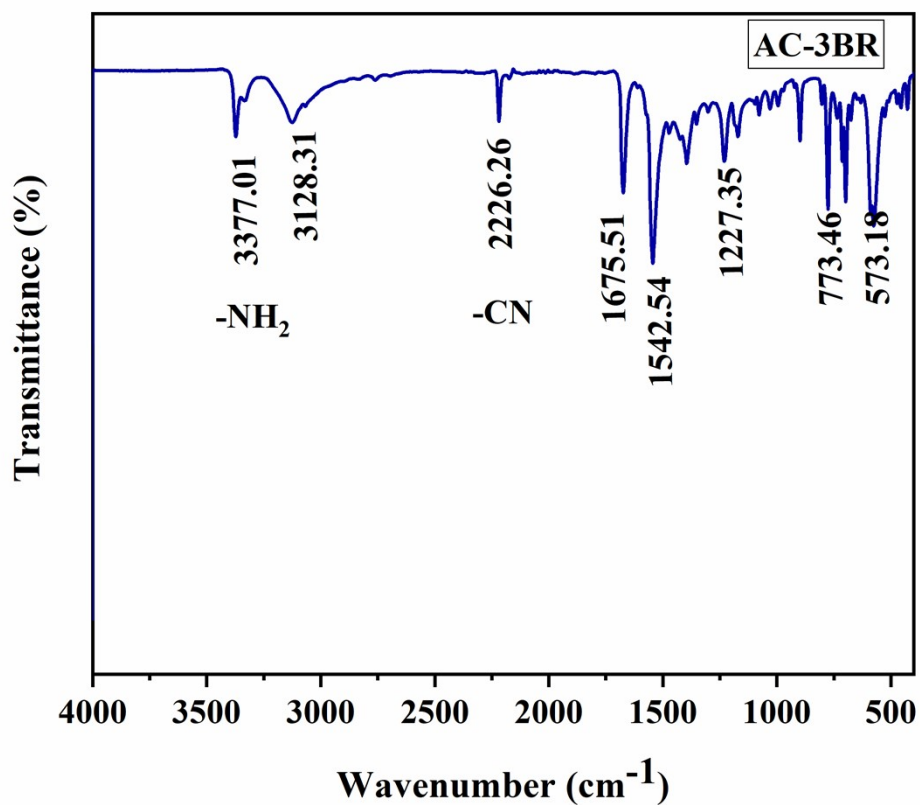


Figure S18. FT-IR spectrum of 4-amino-6-(3-bromophenyl)-2-methylpyrimidine-5-carbonitrile (4d)

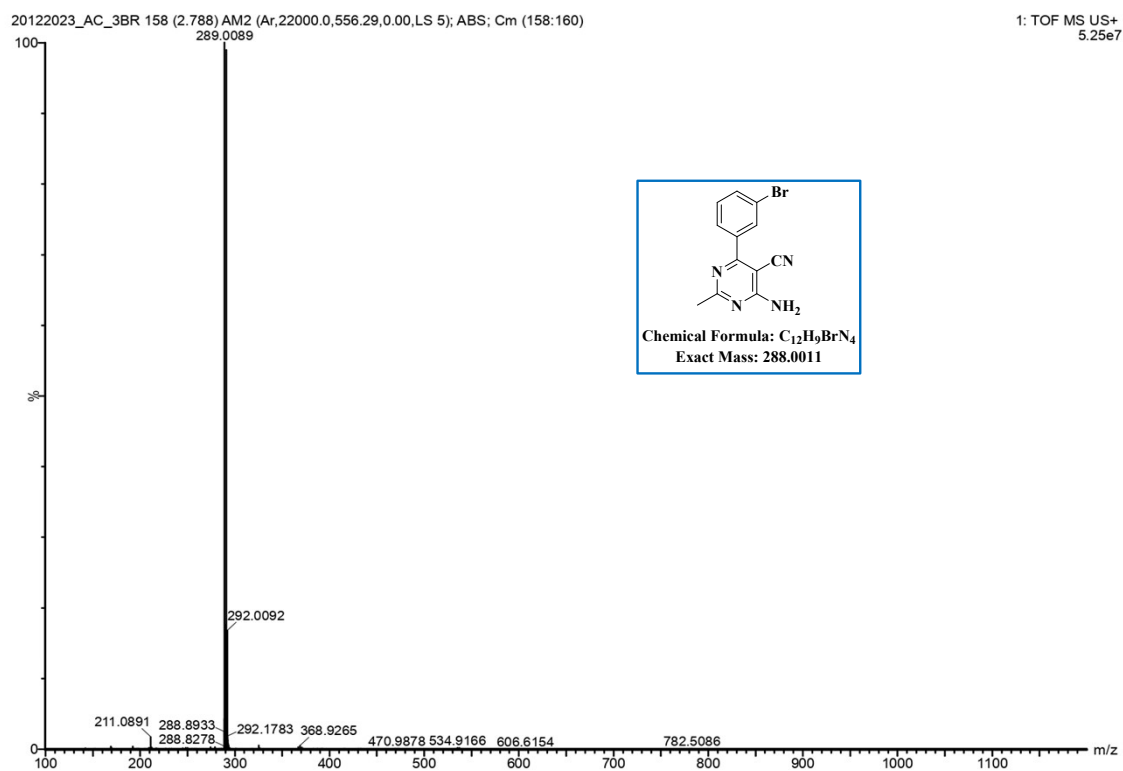


Figure S19. HR-MS spectrum of 4-amino-6-(3-bromophenyl)-2-methylpyrimidine-5-carbonitrile (4d)

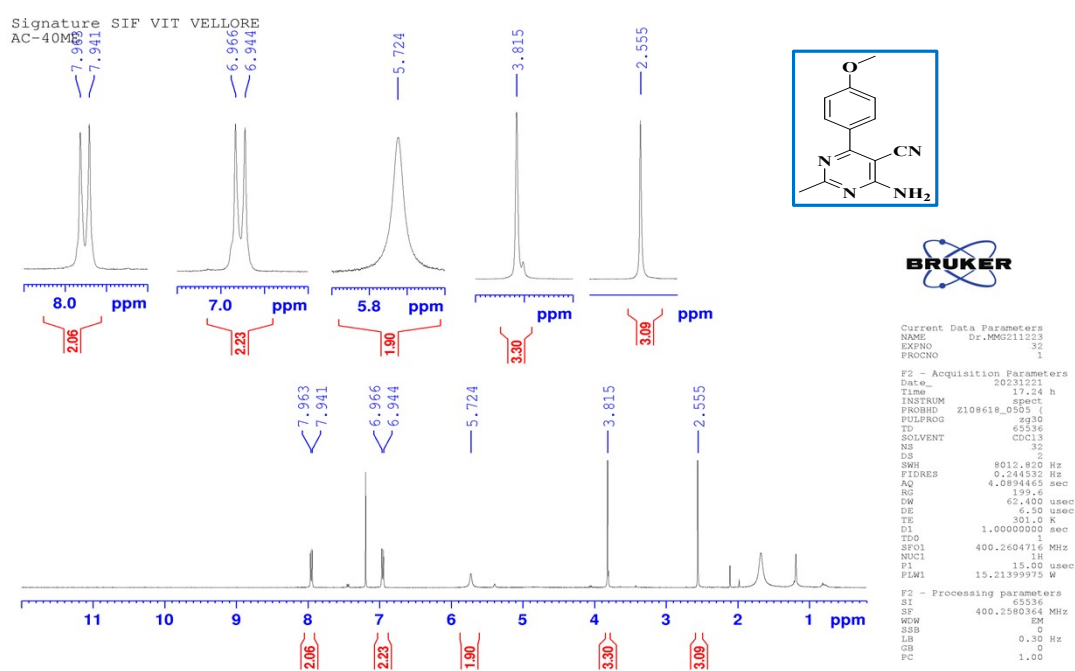


Figure S20. ^1H NMR spectrum of 4-amino-6-(4-methoxyphenyl)-2-methylpyrimidine-5-carbonitrile (4e)

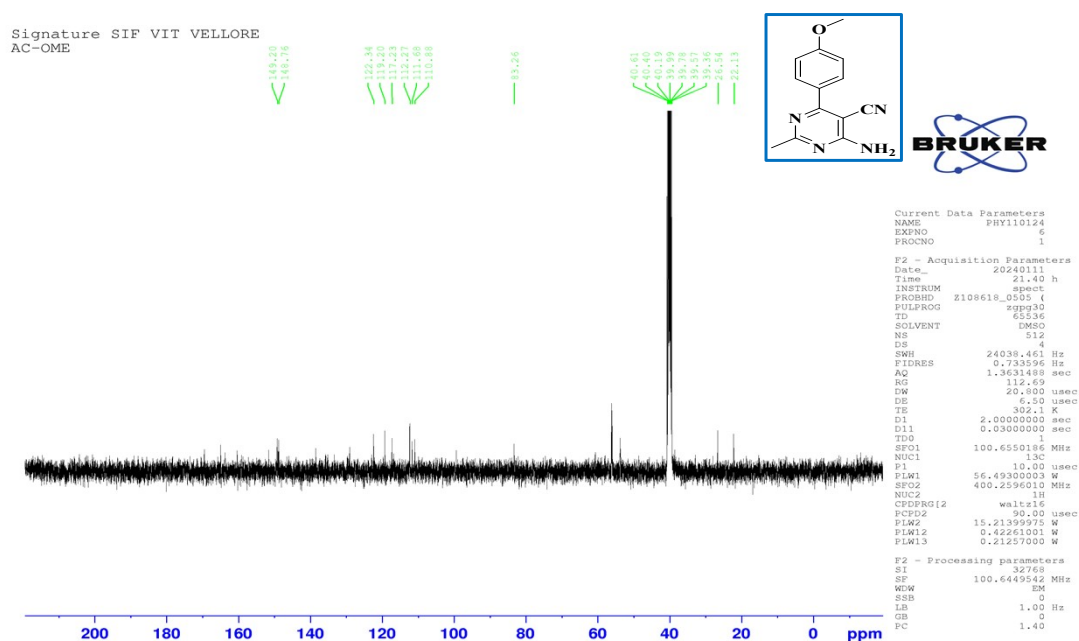


Figure S21. ^{13}C NMR spectrum of 4-amino-6-(4-methoxyphenyl)-2-methylpyrimidine-5-carbonitrile (4e)

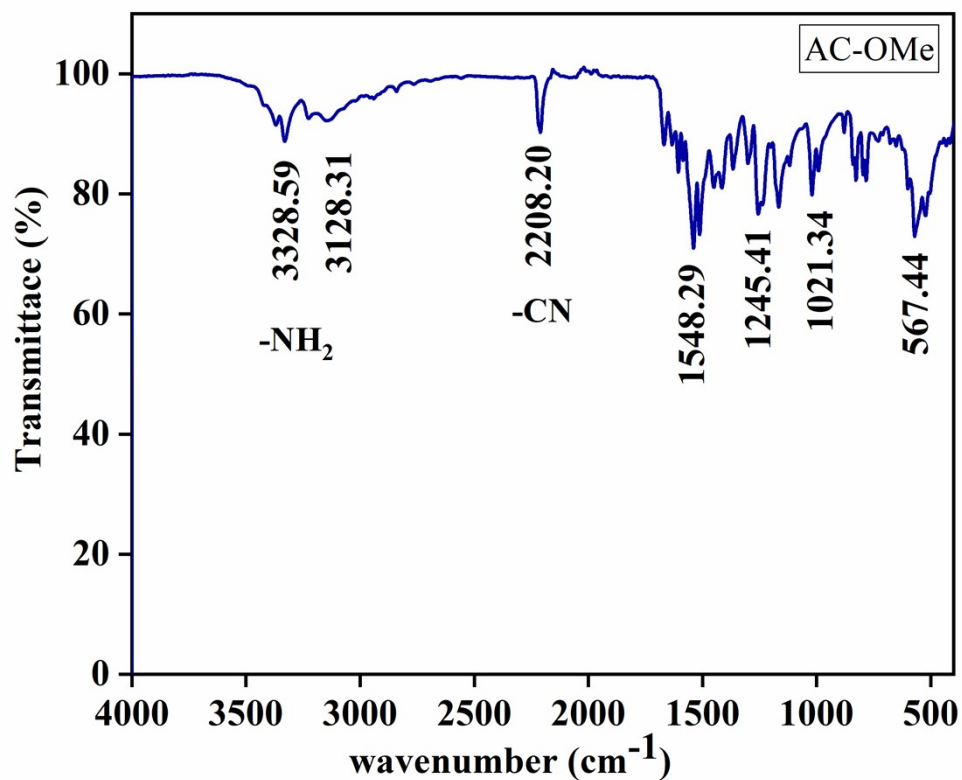


Figure S22. FT-IR spectrum of 4-amino-6-(4-methoxyphenyl)-2-methylpyrimidine-5-carbonitrile (4e)

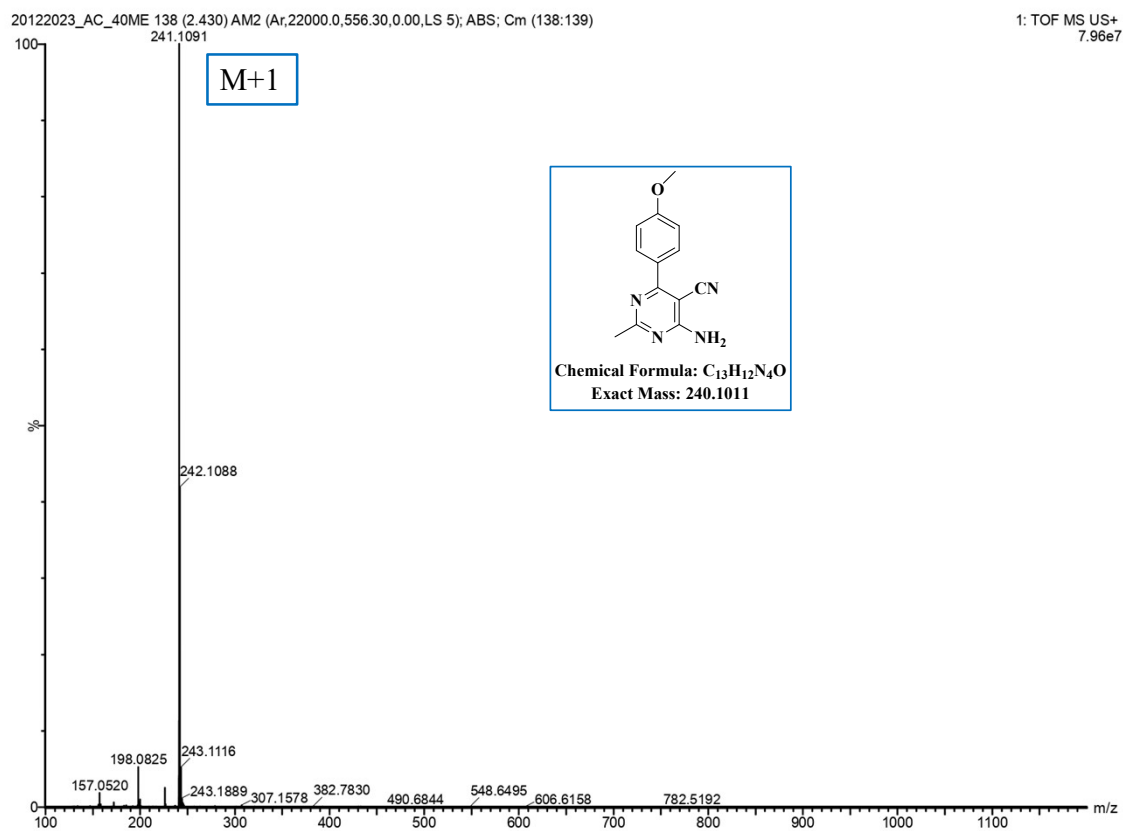


Figure S23. HR-MS spectrum of 4-amino-6-(4-methoxyphenyl)-2-methylpyrimidine-5-carbonitrile (4e)

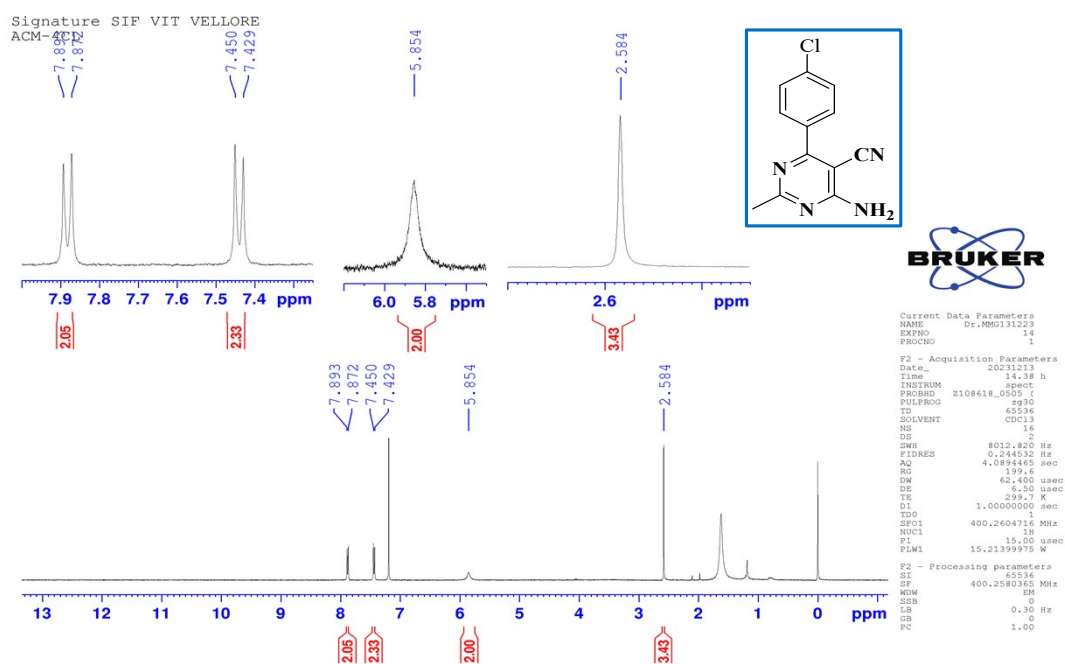


Figure S24. ^1H NMR spectrum of 4-amino-6-(4-chlorophenyl)-2-methylpyrimidine-5-carbonitrile (4f)

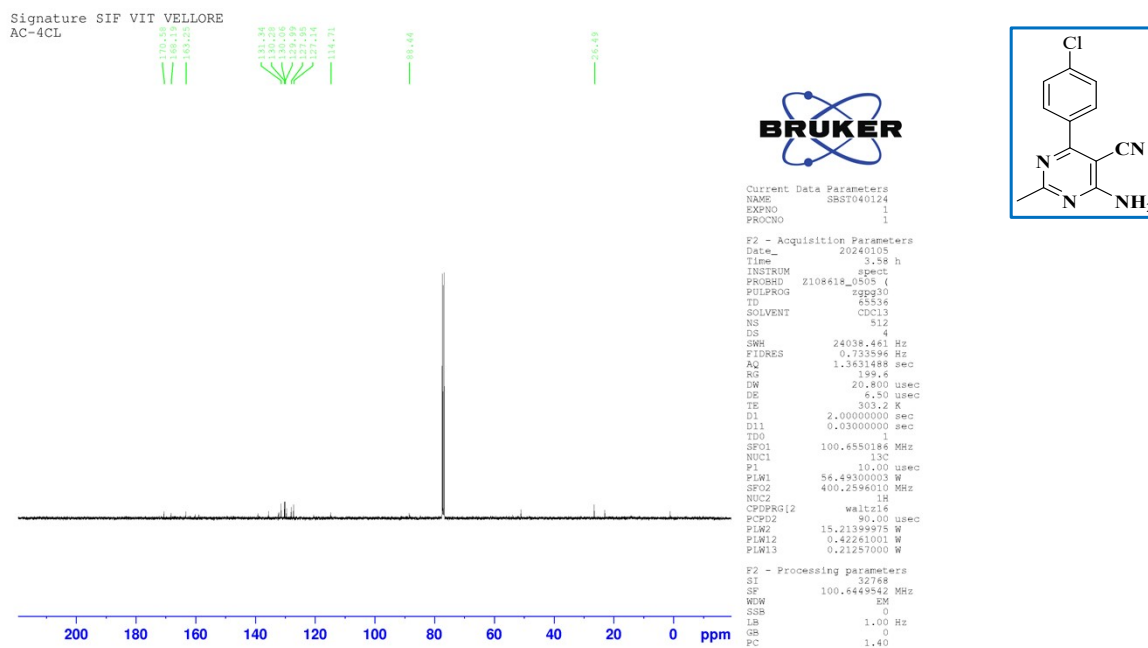


Figure S25. ^{13}C spectrum of 4-amino-6-(4-chlorophenyl)-2-methylpyrimidine-5-carbonitrile (4f)

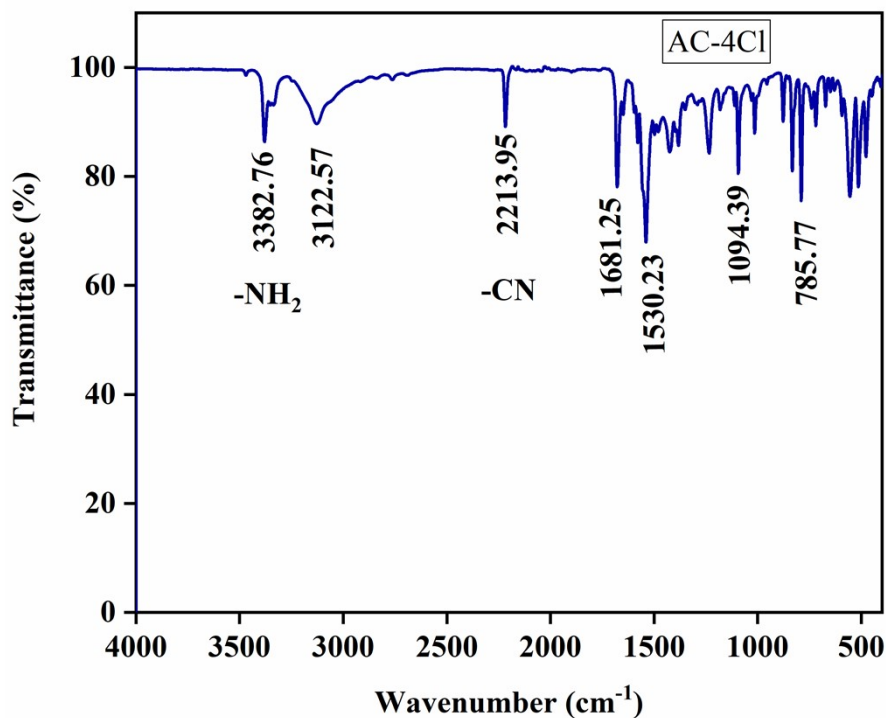


Figure S26. FT-IR spectrum of 4-amino-6-(4-chlorophenyl)-2-methylpyrimidine-5-carbonitrile (4f)

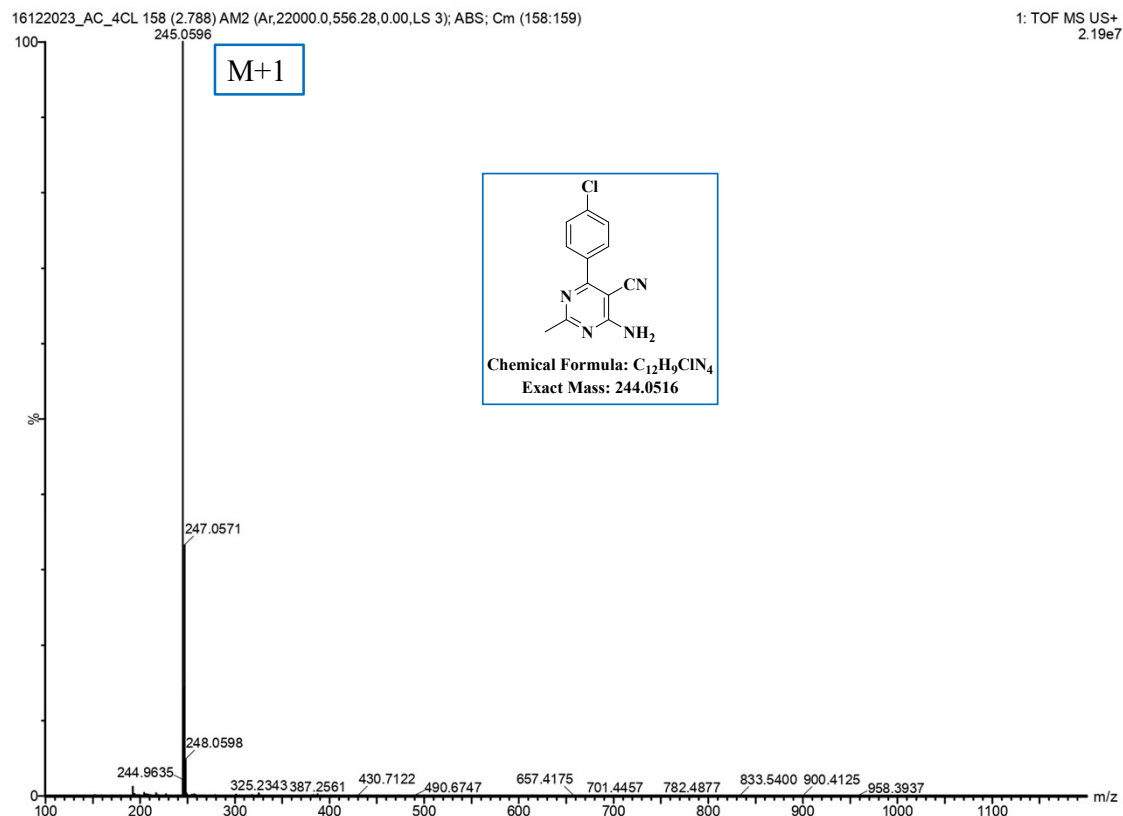


Figure S27. HR-MS spectrum of 4-amino-6-(4-chlorophenyl)-2-methylpyrimidine-5-carbonitrile (4f)

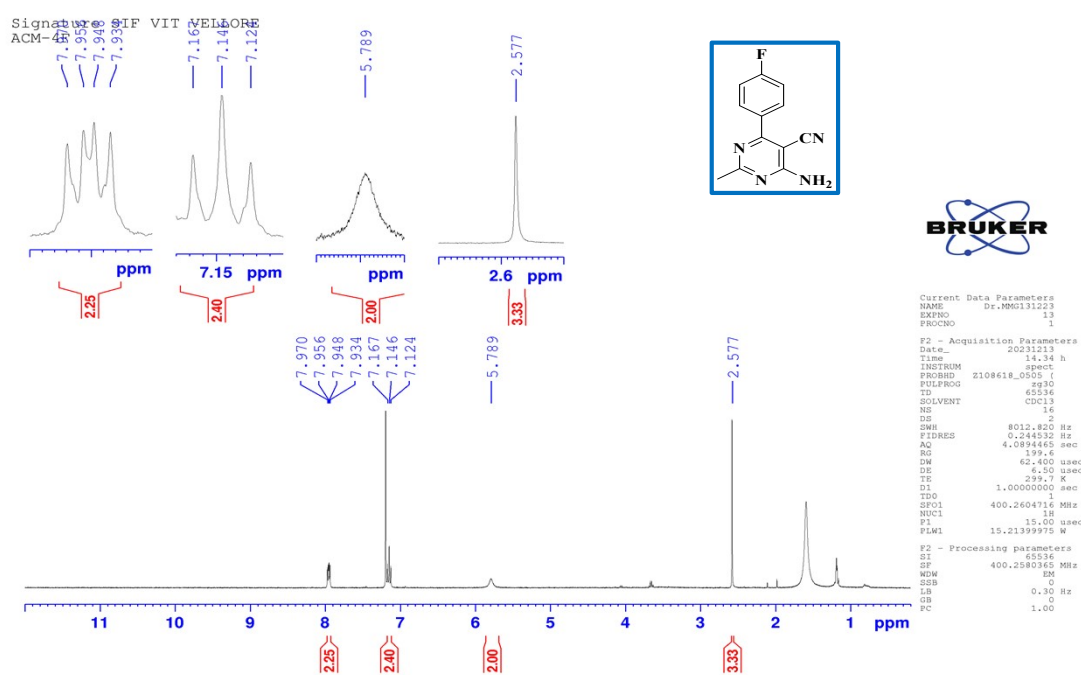


Figure S28. ¹H NMR spectrum of 4-amino-6-(4-Fluorophenyl)-2-methylpyrimidine-5-carbonitrile (4g)

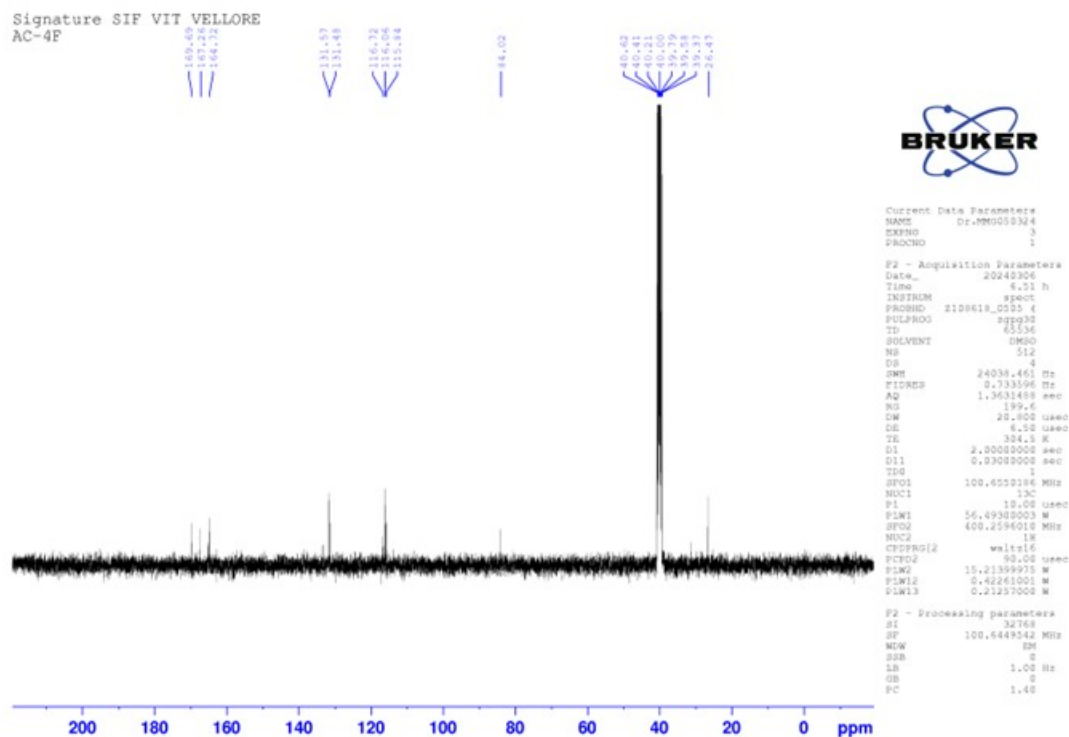


Figure S29. ¹³C NMR spectrum of 4-amino-6-(4-Fluorophenyl)-2-methylpyrimidine-5-carbonitrile (4g)

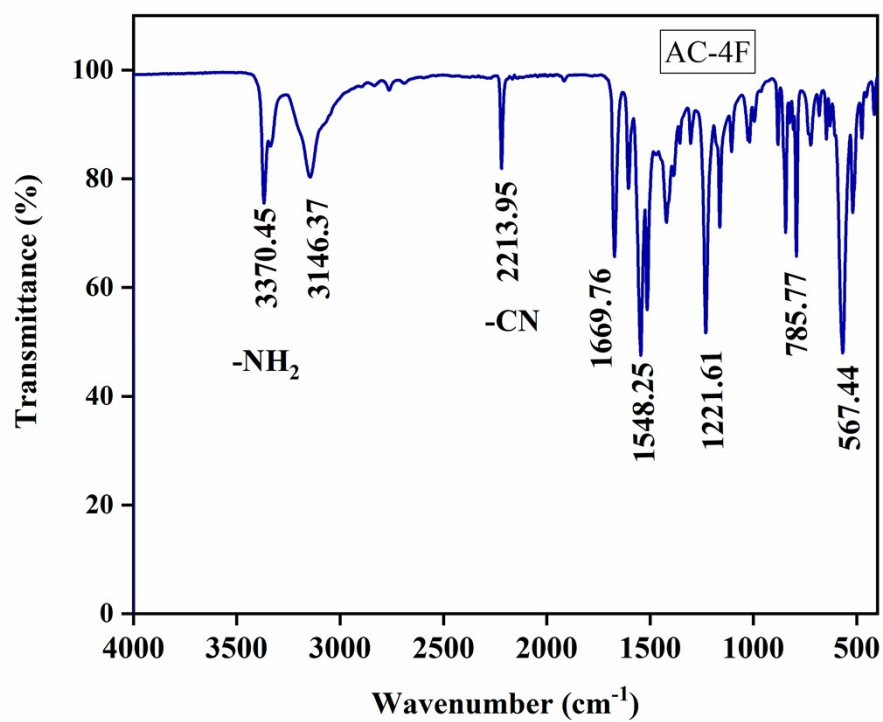


Figure S30. FT-IR spectrum of 4-amino-6-(4-Fluorophenyl)-2-methylpyrimidine-5-carbonitrile (4g)

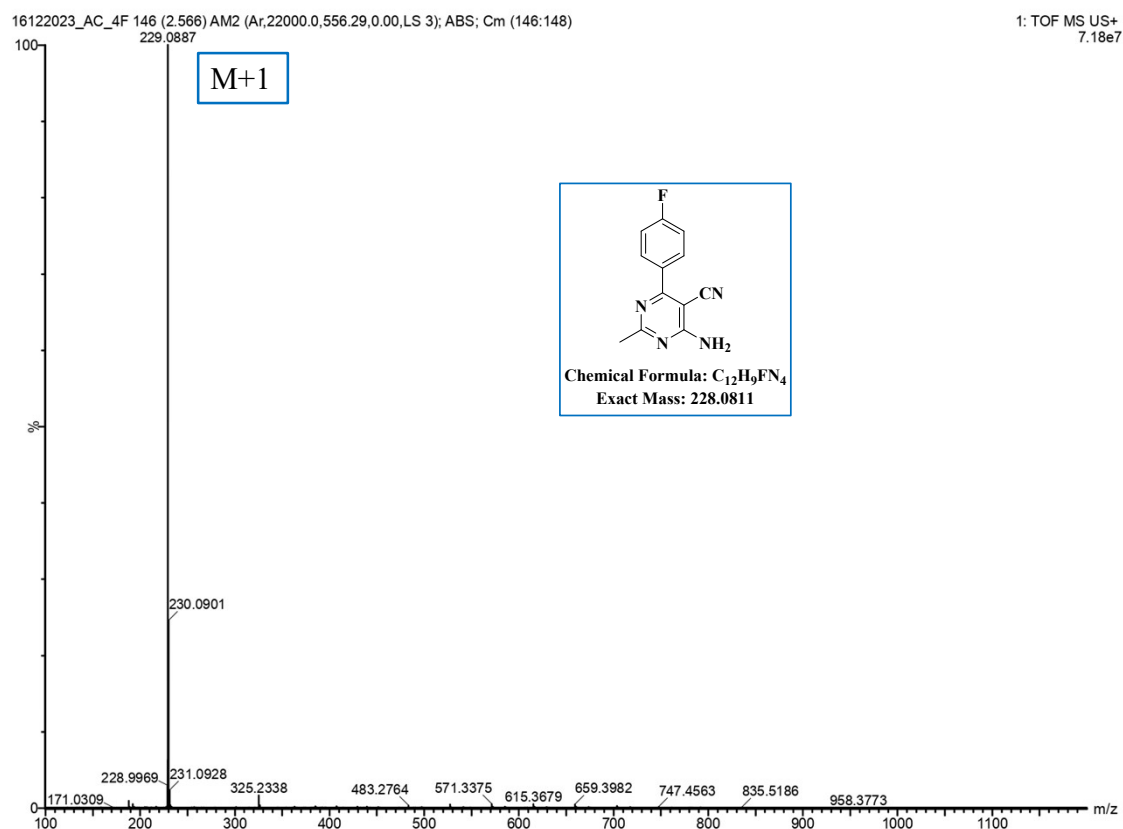


Figure S31. HR-MS spectrum of 4-amino-6-(4-Fluorophenyl)-2-methylpyrimidine-5-carbonitrile (4g)

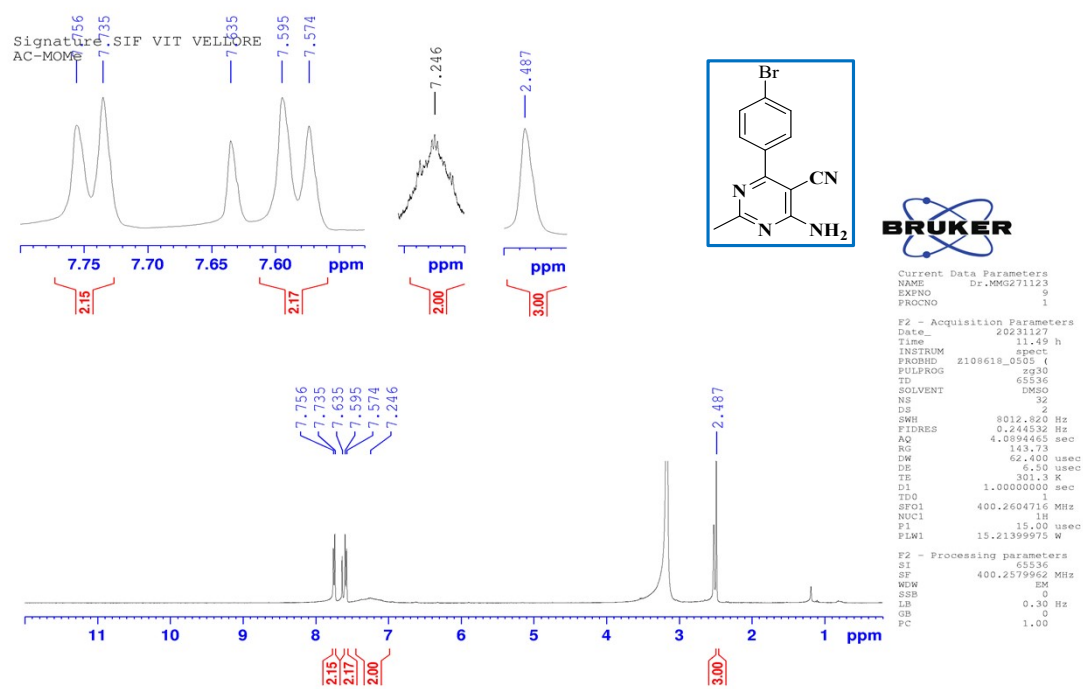


Figure S32. ^1H NMR spectrum of 4-amino-6-(4-bromophenyl)-2-methylpyrimidine-5-carbonitrile (4h)

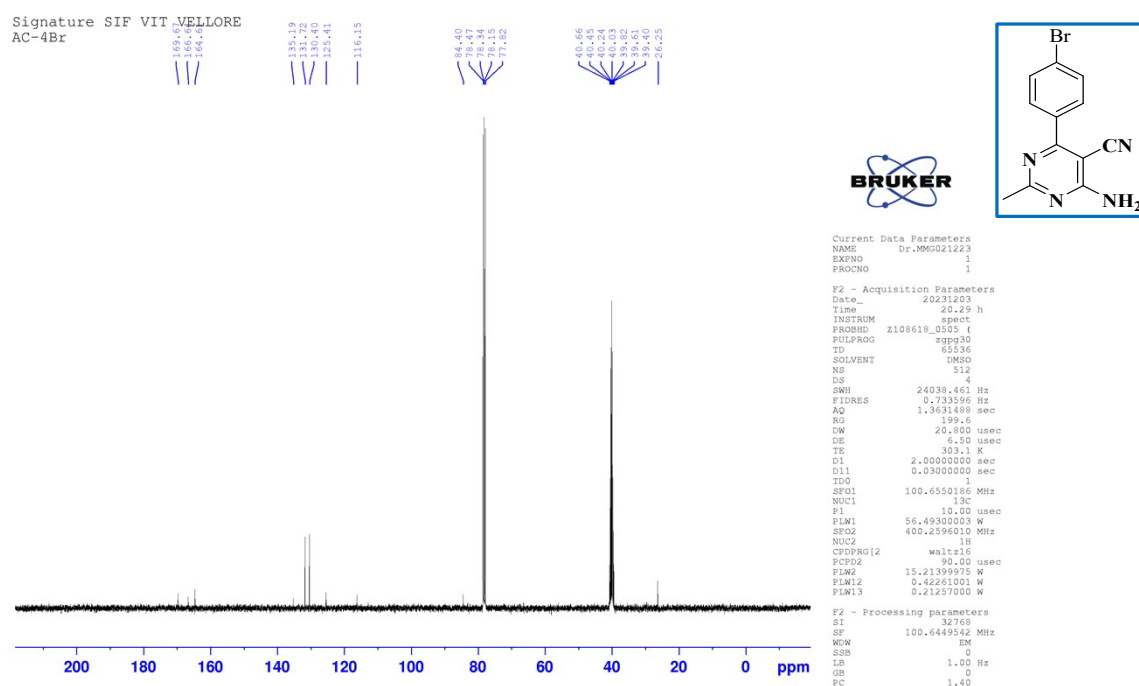


Figure S33. ^{13}C NMR spectrum of 4-amino-6-(4-bromophenyl)-2-methylpyrimidine-5-carbonitrile (4h)

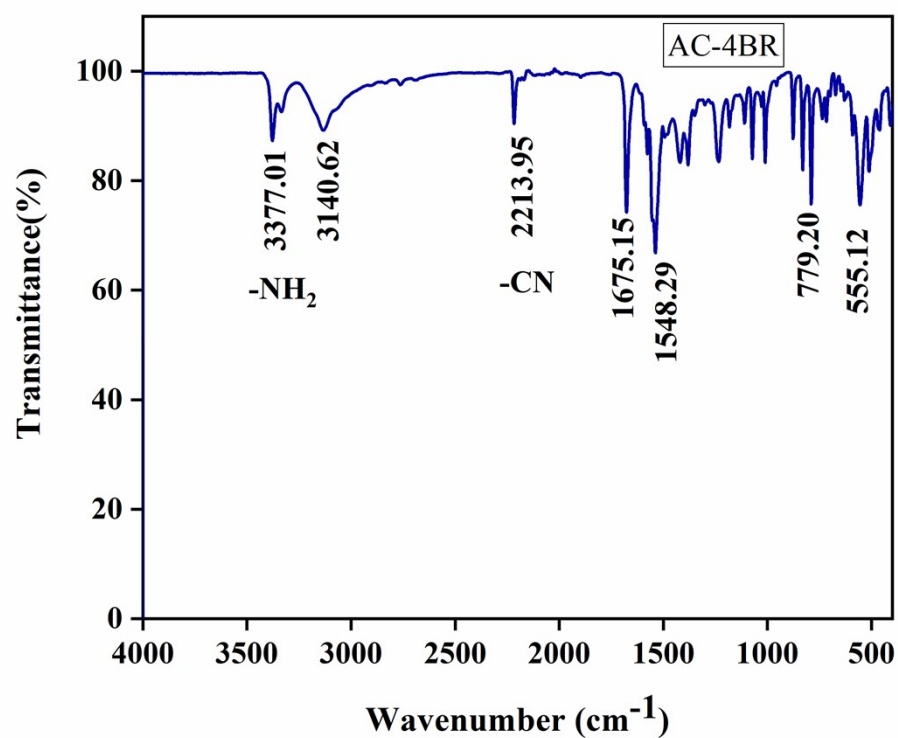


Figure S34. FT-IR spectrum of 4-amino-6-(4-bromophenyl)-2-methylpyrimidine-5-carbonitrile (4h)

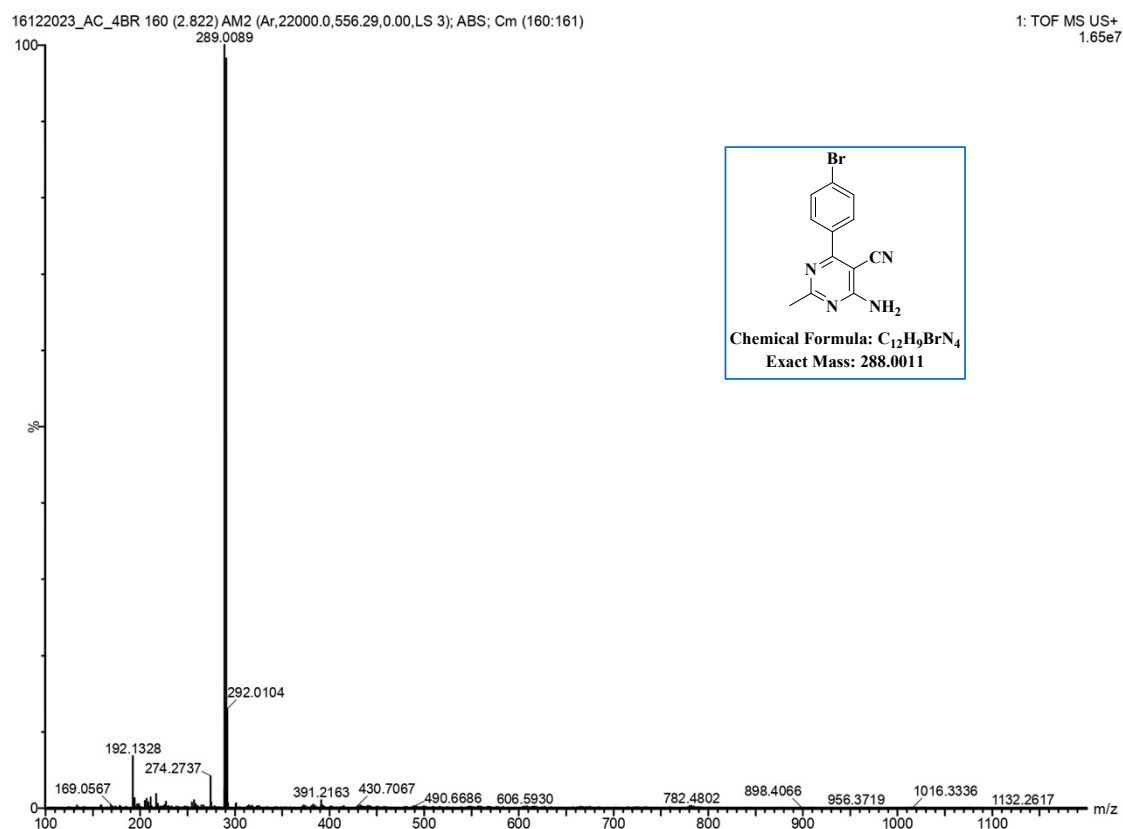


Figure S35. HR-MS spectrum of 4-amino-6-(4-bromophenyl)-2-methylpyrimidine-5-carbonitrile (4h)

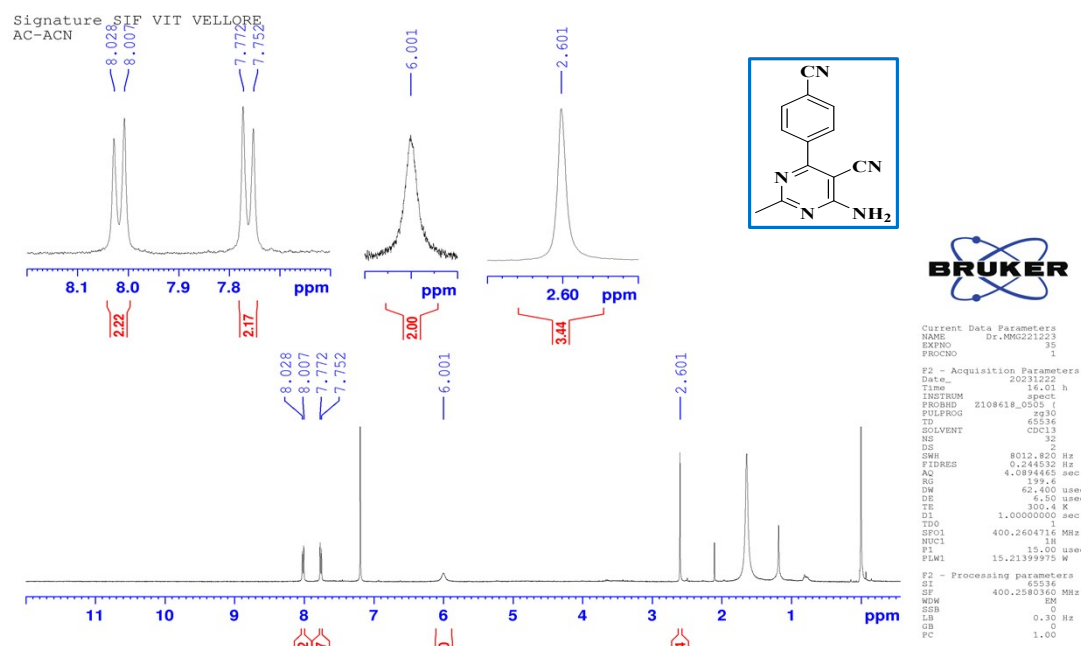


Figure S36. ¹H NMR spectrum of 4-amino-6-(4-cyanophenyl)-2-methylpyrimidine-5-carbonitrile (4i)

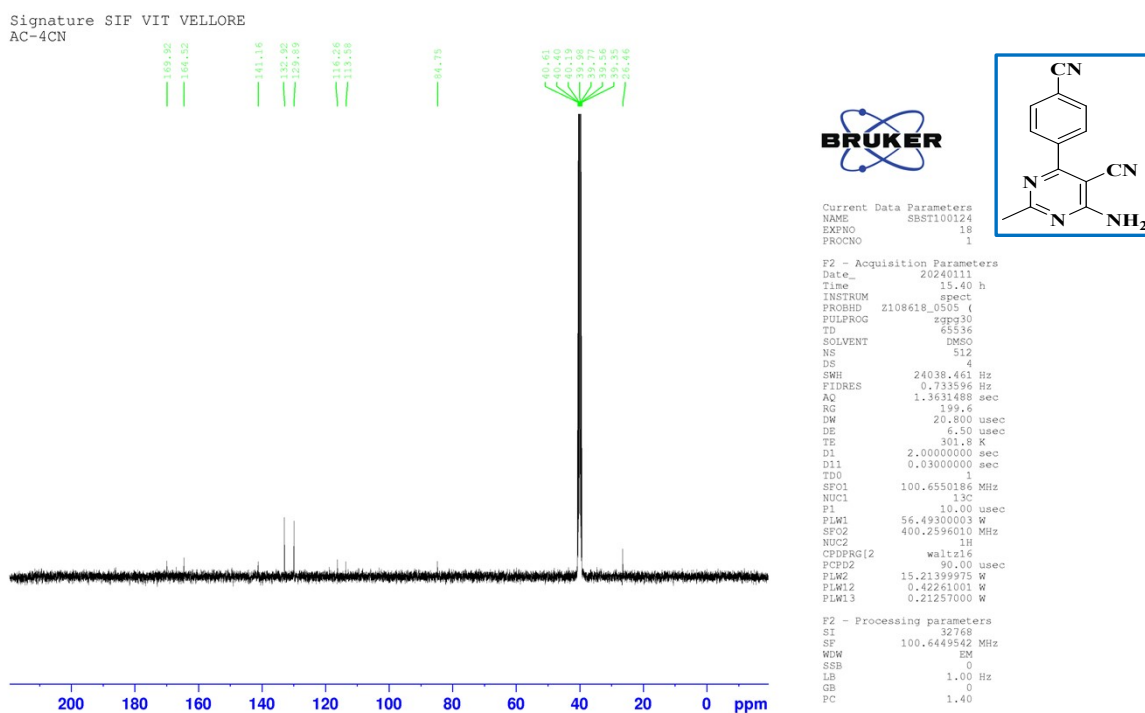


Figure S37. ^{13}C NMR spectrum of 4-amino-6-(4-cyanophenyl)-2-methylpyrimidine-5-carbonitrile (4i)

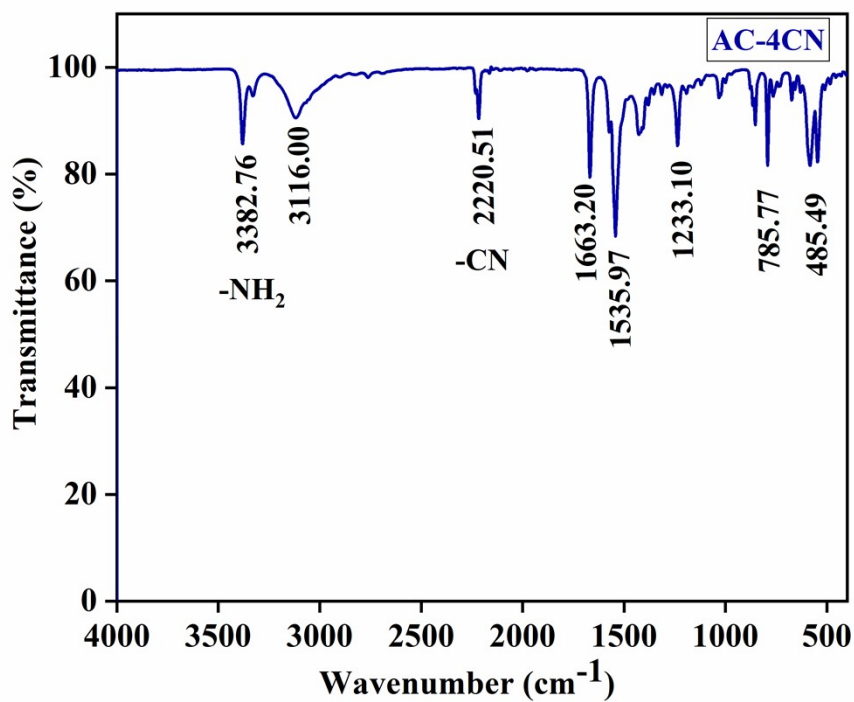


Figure S38. FT-IR spectrum of 4-amino-6-(4-cyanophenyl)-2-methylpyrimidine-5-carbonitrile (4i)

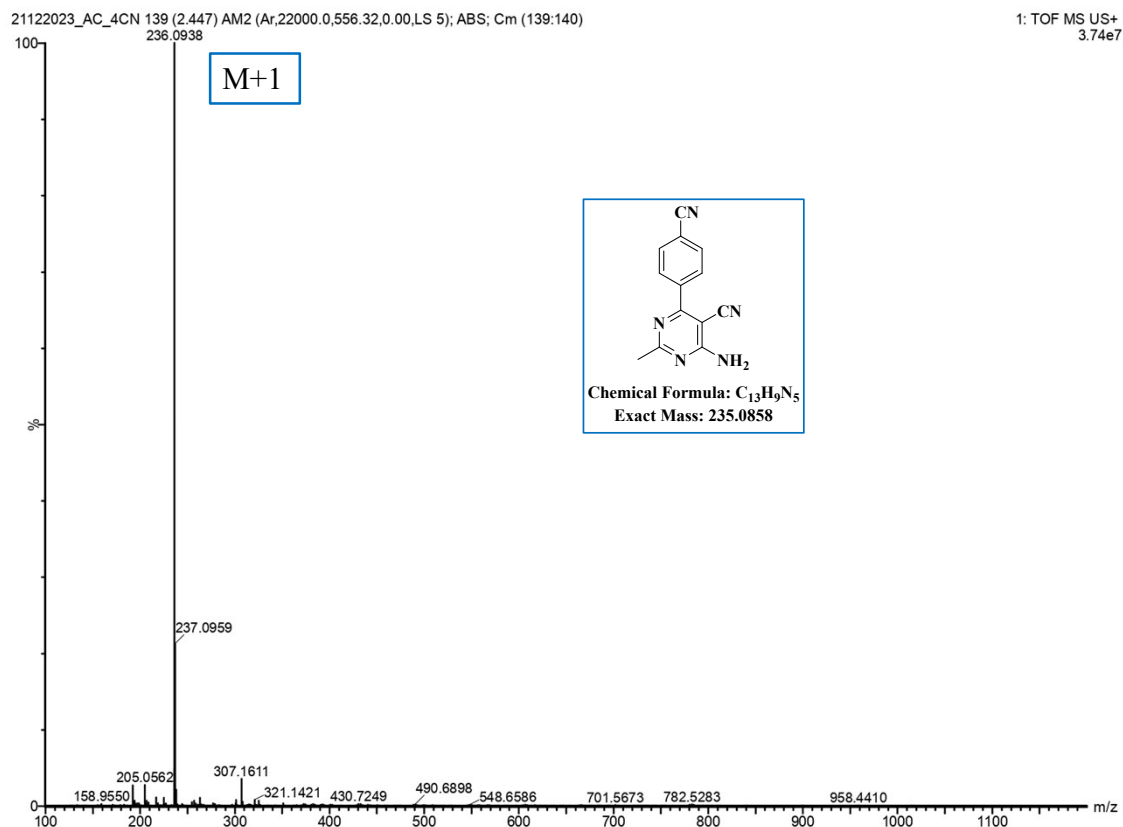


Figure S39. HR-MS spectrum of 4-amino-6-(4-cyanophenyl)-2-methylpyrimidine-5-carbonitrile (4i)

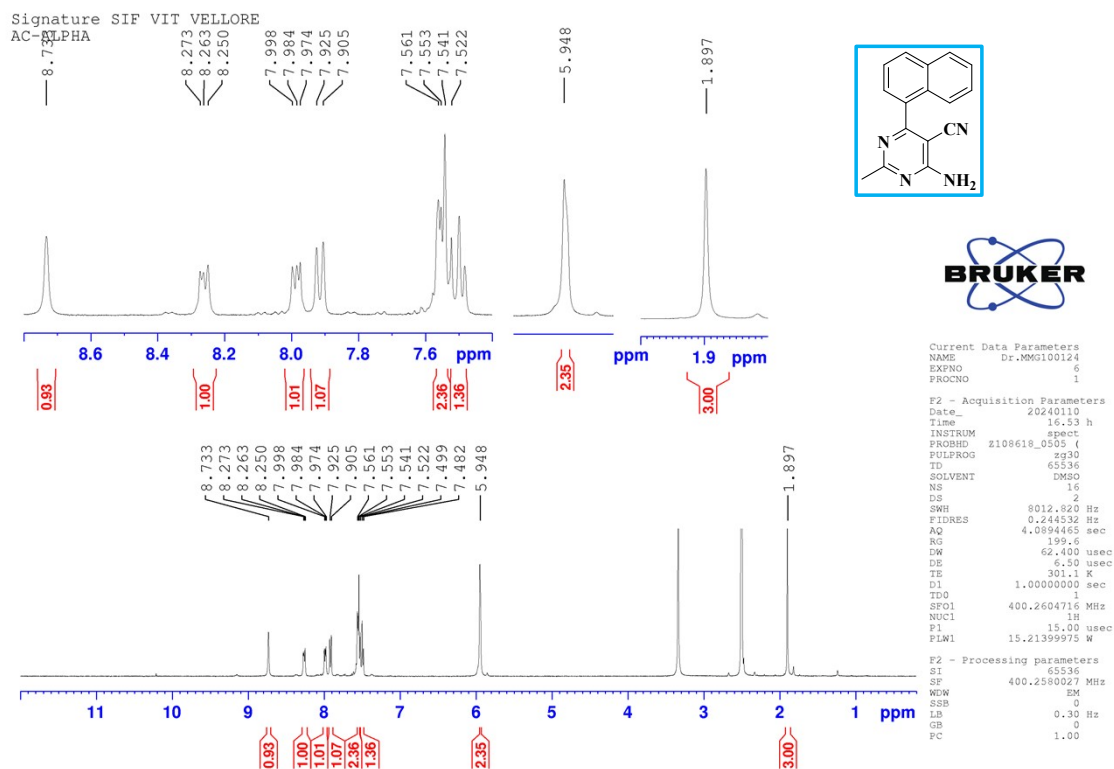


Figure S40. 1H NMR spectrum of 4-amino-2-methyl-6-(naphthalen-1-yl)pyrimidine-5-carbonitrile (4j)

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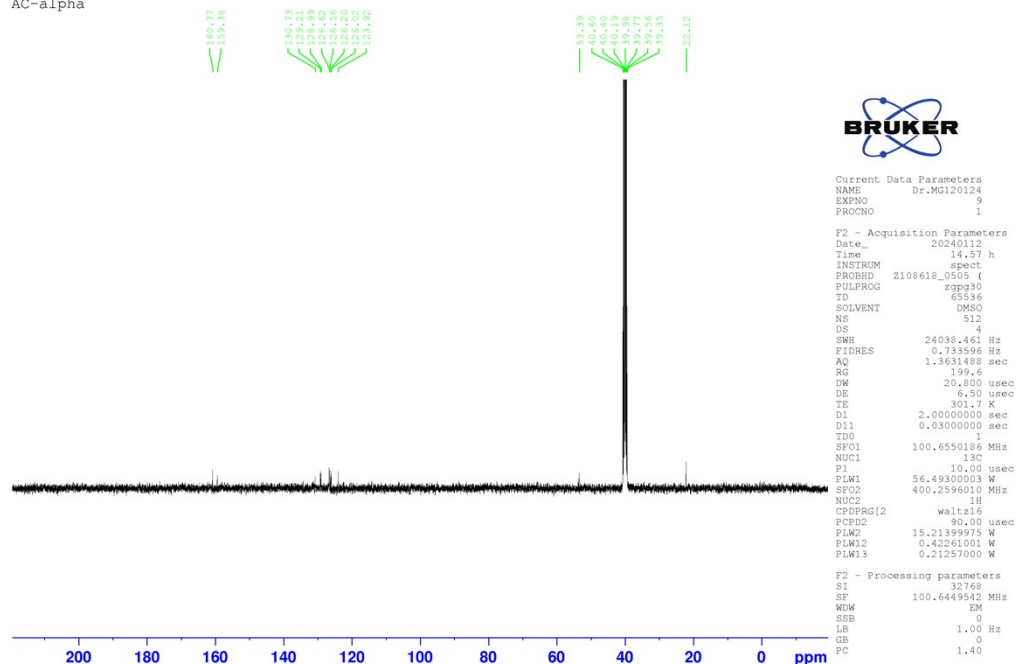


Figure S41. ^{13}C NMR spectrum of 4-amino-2-methyl-6-(naphthalen-1-yl)pyrimidine-5-carbonitrile (4j)

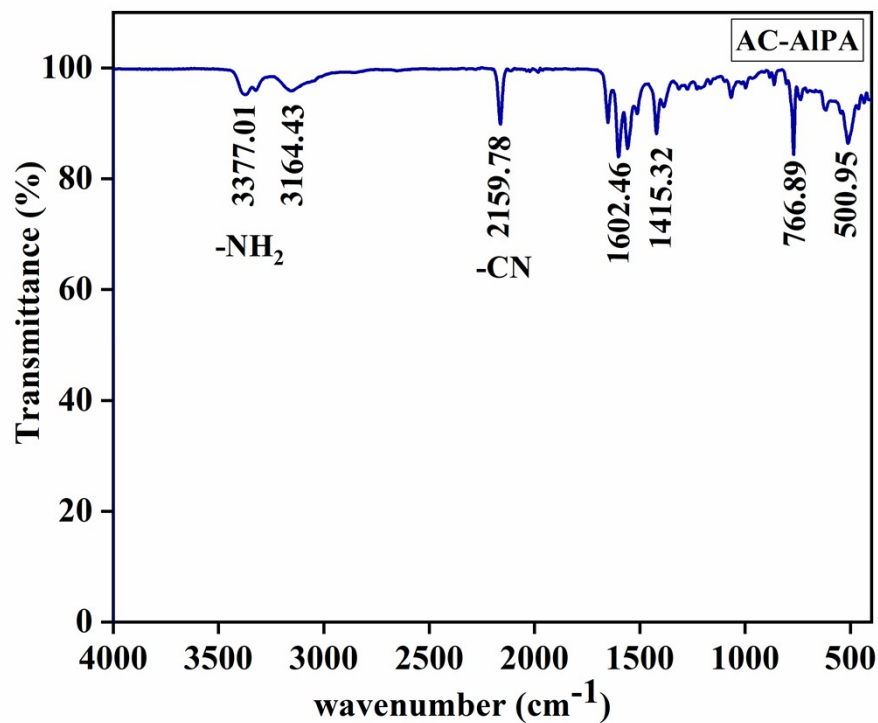


Figure S42. FT-IR spectrum of 4-amino-2-methyl-6-(naphthalen-1-yl)pyrimidine-5-carbonitrile (4j)

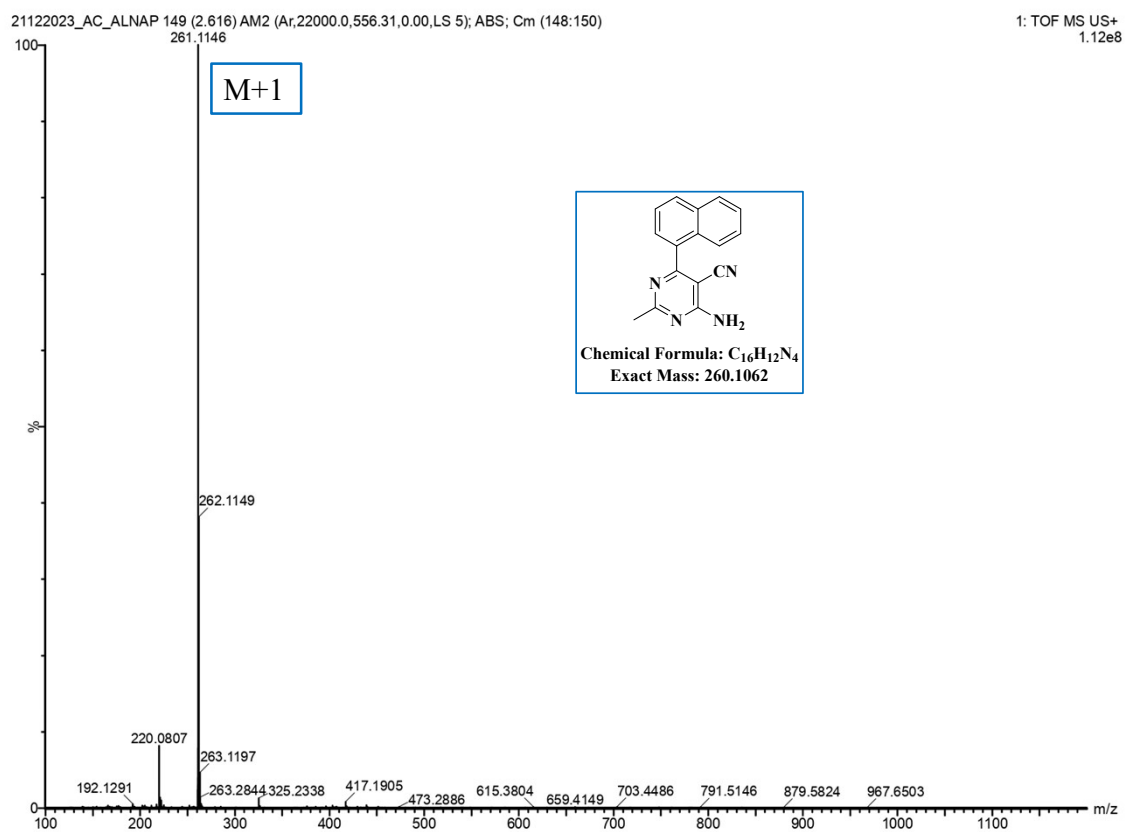


Figure S43. HR-MS spectrum of 4-amino-2-methyl-6-(naphthalen-1-yl)pyrimidine-5-carbonitrile (4j)

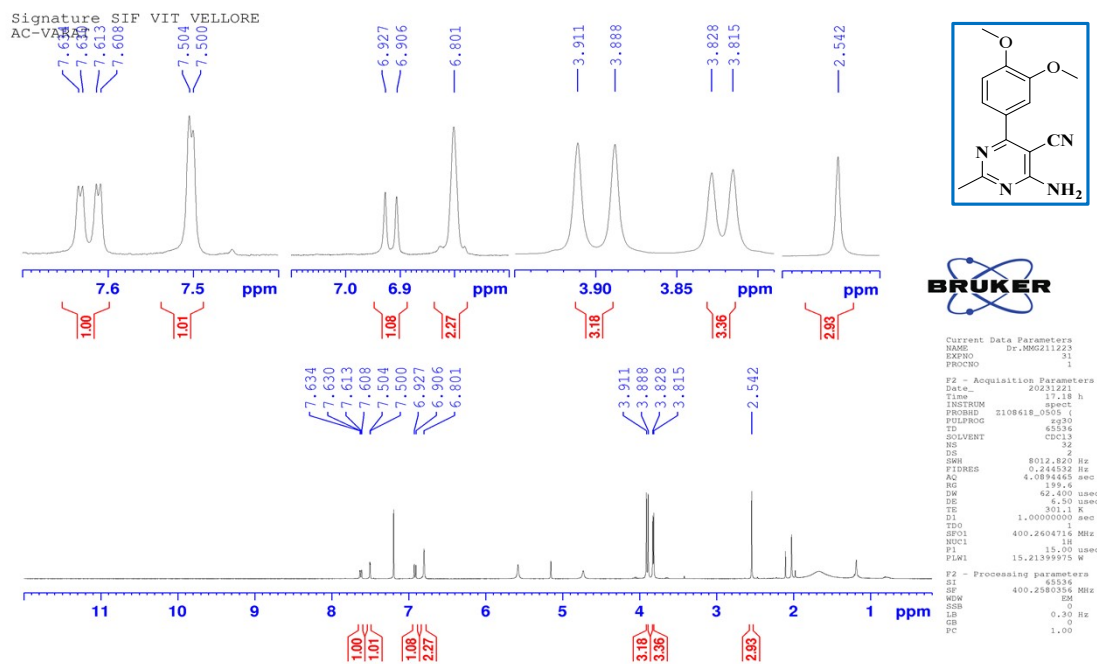


Figure S44. ¹H NMR spectrum of 4-amino-6-(3,4-dimethoxyphenyl)-2-methylpyrimidine-5-carbonitrile (4k)

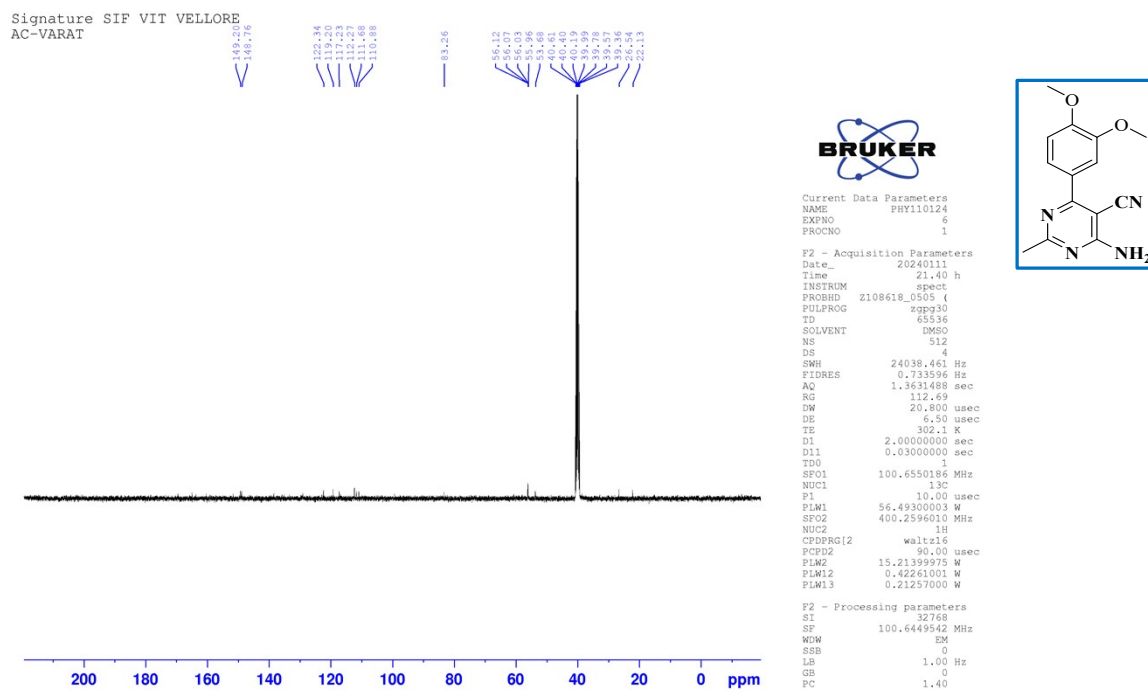


Figure S45. ^{13}C NMR spectrum of 4-amino-6-(3,4-dimethoxyphenyl)-2-methylpyrimidine-5-carbonitrile (4k)

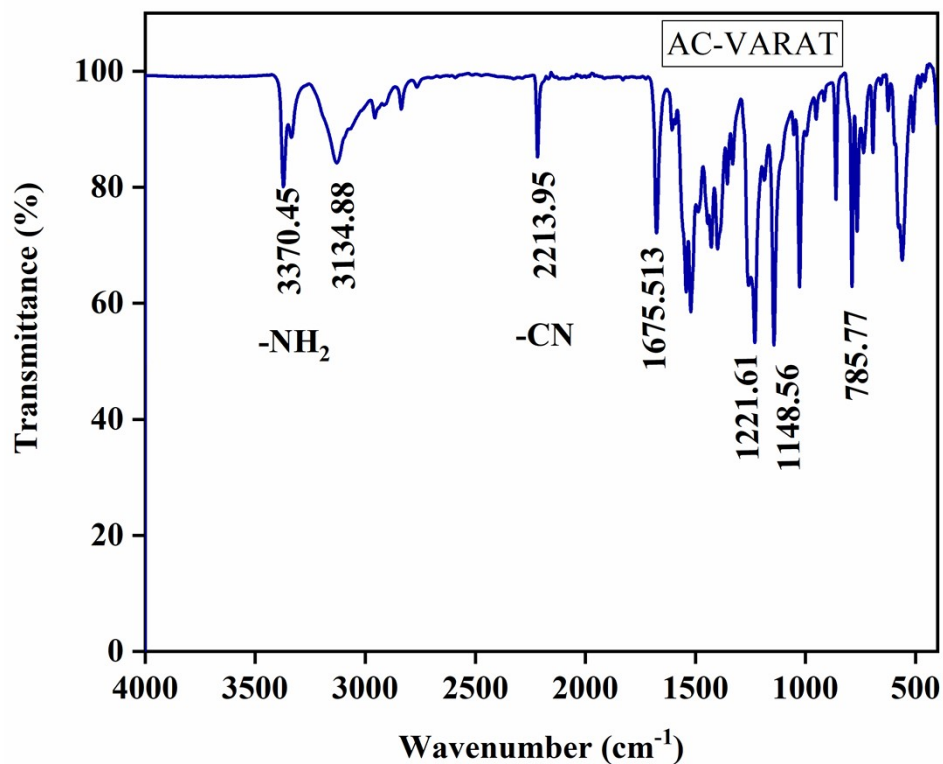


Figure S46. FT-IR spectrum of 4-amino-6-(3,4-dimethoxyphenyl)-2-methylpyrimidine-5-carbonitrile (4k)

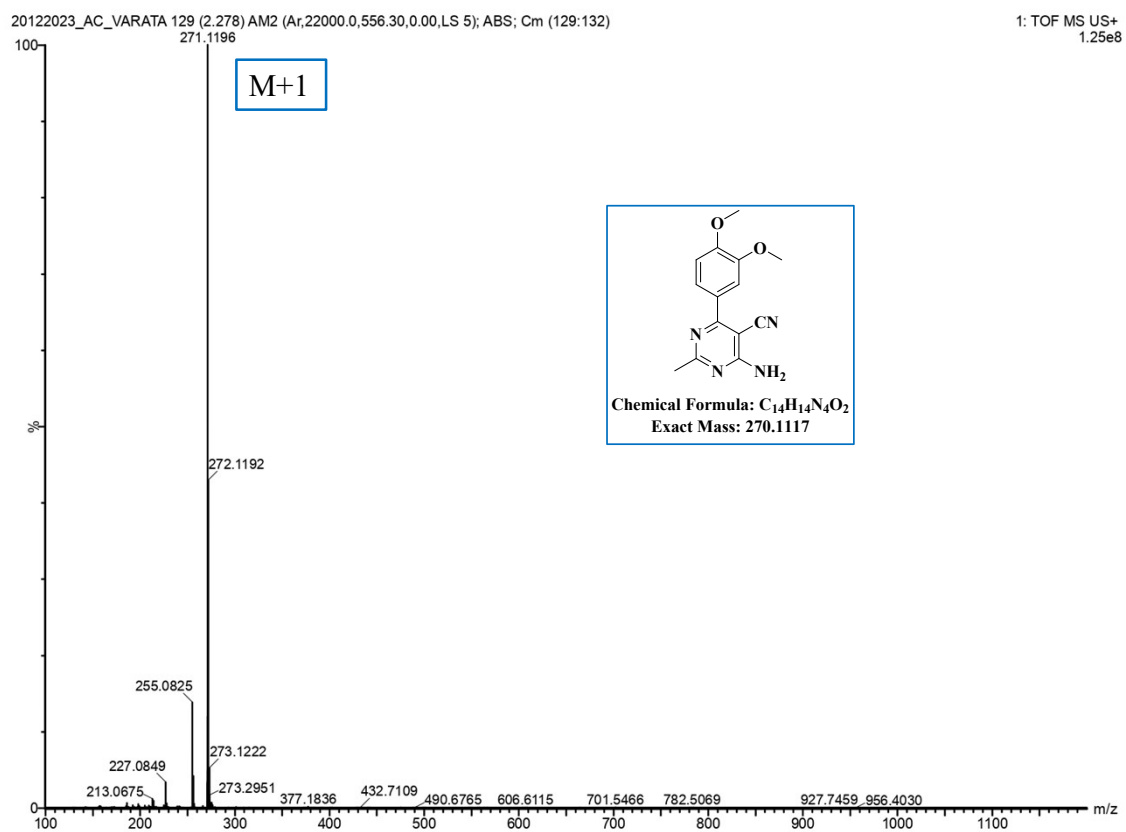


Figure S47. HR-MS spectrum of 4-amino-6-(3,4-dimethoxyphenyl)-2-methylpyrimidine-5-carbonitrile (4k)