An Efficient Construction of N,N – bicyclic Pyrazolidinones comprising Enaminonitriles via Asymmetric [3 + 2] Cycloaddition.

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Supporting Information

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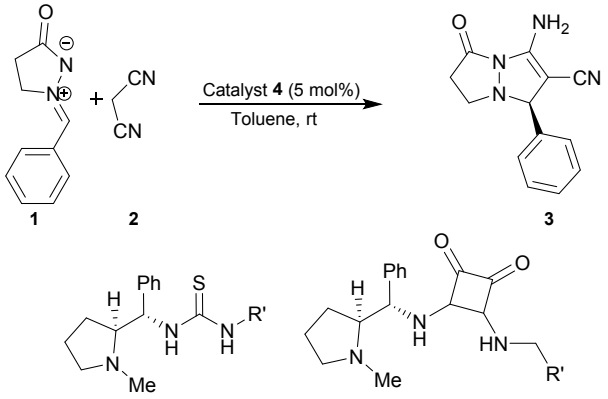
General remarks

All reactions were carried out in a flame dried flask. Solvents used for reactions and column chromatography were commercial grade and distilled prior to use. THF, toluene and dioxane were dried over sodium/benzophenone, whereas dichloromethane (DCM) and dichloroethane (DCE) were dried over CaH_2. Solvents (hexane, ethyl acetate) TLC was performed on pre-coated Merck silica gel aluminium plates with 60F254 indicator, visualised by irradiation with UV light. Dragendorff, ceric ammonium molybdate (CAM), and alkaline $KMNO_4$ were used as TLC staining solution. Column chromatography was performed using silica gel Merck 100-200 and 230-400 mesh. ^{1}H-NMR and ^{13}C NMR were recorded on 500 MHz and 125 MHz using $CDCl_3$, DMSO-d_6 as solvent and multiplicity indicated as follows: s (singlet), d (doublet), t (triplet), q (quartet), m (multiplet), dd (doublet of doublet), dt (doublet of triplet), td (triplet of doublet), ddd (doublet of doublet of doublet) qd (quartet of doublet). Coupling constants *J* are reported in Hz. Chemical shift are represent in δ. High resolution mass spectra were obtained by ESI using orbitrap elite mass spectrometer; IR spectra were recorded on a FT/IR-420 spectrometer and are reported in terms of frequency of absorption (ν , cm^{-1}). Melting points were measured in open capillaries.

II. Typical experimental procedure for [3 + 2] Cycloaddition of Azomethineimines with Malanonitriles:

To a solution of Azomethine imine (1.10 g, 5.97 mmol) in dry toluene (12 mL) at room temperature was added catalyst **4**. The resulting mixture was stirred for 10 mins at room temperature and then malanonitrile was added to the reaction mixture. The reaction mixture was stirred at room temperature for 24 h. After the reaction was completed (monitored by TLC), the resulting mixture was concentrated under reduced pressure and the residue was purified through column chromatography on silica gel to give the product **3.**

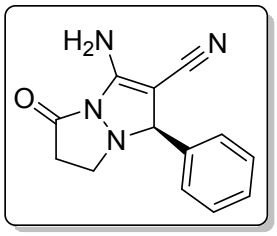
Table 1: Screening of organocatalysts for [3 + 2] Cycloaddition of Azomethineimine 1 with Malanonitriles 2:



entry	catalyst	yield	ee
1	Proline thiourea **4a**	64	92
2	Proline Squaramide **4b**	53	27
3	Cinchonine **4c**	43	12
4	Cinchonine thiourea **4d**	45	62
5	Quinidine **4e**	53	36
6	Quinidine squaramide **4f**	45	66

(R)-3-amino-5-oxo-1-phenyl-6,7-dihydro-1*H*,5*H*-pyrazolo[1,2-*a*]pyrazole-2-carbonitrile (3):

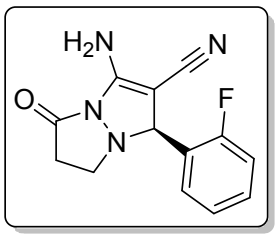
The product **3** was synthesized according to the general experimental procedure, white solid,



Isolated yield 19.8 mg (82 %), m.p. 132-136 °C. ^{1}H NMR (400MHz, DMSO-d_6) δ = 7.41 - 7.38 (m, 3H), 7.38 - 7.32 (m, 2H), 7.21 (s, 2H), 4.89 (s, 1H), 3.35 - 3.27 (m, 1H), 3.12 (td, *J* = 8.2, 12.6 Hz, 1H), 2.96 - 2.82 (m, 1H), 2.75 - 2.63 (m, 1H)^{13}C NMR (101MHz, DMSO-d_6) δ = 166.2, 148.3, 139.0, 128.5, 128.3, 127.9, 117.4, 71.8, 62.1, 51.6, 35.5; IR(ν, cm^{-1}): 3074, 2961, 2947, 2223, 1765, 1618, 1252, 1081, 933, 746; HRMS (ESI): Exact mass calcd $C_{13}H_{12}ON_4$ $[M+Na]^+$: 263.0903, Found: 263.0893; 92% ee was determined by HPLC on Diacel OD-H column, 10/90: 2-propanol/hexane, 1.0 mL/min, UV 254 nm, t_{minor} = 29.8 min, t_{major} = 31.5 min.

(S)-3-amino-1-(2-fluorophenyl)-5-oxo-6,7-dihydro-1*H*,5*H*-pyrazolo[1,2-*a*]pyrazole-2-carbonitrile (3a):

The product **3a** was synthesized according to the general experimental procedure, white solid,

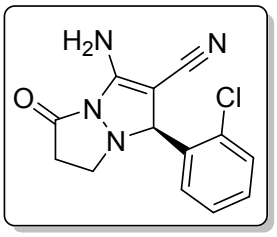


Isolated yield 20.4 mg (79 %), m.p. 135-138 °C. ^{1}H NMR (500MHz, DMSO-d_6) δ = 7.56 (dt, *J* = 1.6, 7.6 Hz, 1H), 7.44 - 7.38 (m, 1H), 7.34 - 7.26 (m, 3H), 7.23 (ddd, *J* = 0.9, 8.4, 10.8 Hz, 1H), 5.24 (s, 1H), 3.43 - 3.38 (m, 1H), 3.25 - 3.16 (m, 1H), 2.91 (ddd, *J* = 8.4, 12.5, 16.7 Hz, 1H), 2.73 - 2.66 (m, 1H); ^{13}C NMR (126MHz, DMSO-d_6) δ = 167.2, 161.2 (d, *J* = 245.7 Hz), 149.2, 130.7 (d, *J* = 7.5 Hz), 129.8 (d, *J* = 37.8 Hz), 126.5 (d, *J* = 11.3 Hz), 125.2 (d, *J* = 3.8 Hz), 117.7, 116.0 (d, *J* = 20.42 Hz), 65.5, 60.5, 52.6, 35.8; IR(ν, cm^{-1}): 3361, 2781, 2637, 2233, 1732, 1617, 1222, 1056, 953, 744; HRMS (ESI): Exact mass calcd: $C_{13}H_{11}ON_4$ F $[M+Na]^+$: 281.0809, Found: 281.0804; 91% ee was determined by HPLC on Phenomenex Amylose 2 column, 10/90: 2-propanol/hexane, 1.0 mL/min, UV 254 nm, t_{minor} = 37.46 min, t_{major} = 47.6 min.

(S)-3-amino-1-(2-chlorophenyl)-5-oxo-6,7-dihydro-1*H*,5*H*-pyrazolo[1,2-*a*]pyrazole-2-carbonitrile (3b):

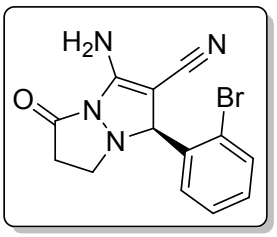
The product **3b** was synthesized according to the general experimental procedure, white solid, Isolated yield 23.3 mg (85 %), m.p. 129-132 °C. ^{1}H NMR (500MHz, DMSO-d_6) δ =

7.64 (m, 2H), 7.51 - 7.46 (m, 1H), 7.31 (dd, *J* = 1.4, 7.7 Hz, 1H), 7.30 - 7.24 (br s, 2H), 5.36 (s, 1H), 3.45 - 3.39 (m, 1H), 3.28 - 3.22 (m, 1H), 2.91 (ddd, *J* = 8.4, 12.5, 16.7 Hz, 1H), 2.74 - 2.66 (m, 1H); ^{13}C NMR (126MHz, DMSO-d_6) δ = 167.2, 149.3, 138.3, 133.2, 130.7, 130.7, 128.7, 123.9, 117.6, 70.7, 61.2, 52.8, 35.9; IR(ν, cm^{-1}): 3461, 2581, 2957, 2133, 1755, 1511, 1352, 1086, 946, 745; HRMS (ESI): Exact mass calcd: $C_{13}H_{11}ON_4Cl$ $[M+Na]^+$: 297.0514, Found: 297.0507; 80% ee was determined by HPLC on Phenomenex Amylose 2 column, 10/90: 2-propanol/hexane, 1.0 mL/min, UV 254 nm, t_{minor} = 38.73 min, t_{major} = 53.0 min.



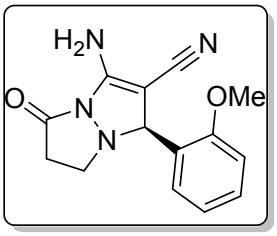
(S)-3-amino-1-(2-bromophenyl)-5-oxo-6,7-dihydro-1*H*,5*H*-pyrazolo[1,2-*a*]pyrazole-2-carbonitrile (3c):

The product **3c** was synthesized according to the general experimental procedure, white solid, Isolated yield 28.0 mg (82 %), m.p. 142 -145 °C. ^{1}H NMR (500MHz, DMSO-d_6) δ = 7.69 - 7.59 (m, 2H), 7.48 (t, *J* = 6.9 Hz, 1H), 7.31 - 7.29 (m, 3H), 5.36 (s, 1H), 3.46 - 3.39 (m, 1H), 3.30 - 3.18 (m, 1H), 2.96 - 2.84 (m, 1H), 2.69 (dd, *J* = 7.5, 16.6 Hz, 1H); ^{13}C NMR (126MHz, DMSO-d_6) δ = 167.1, 149.3, 138.3, 133.2, 130.8, 130.7, 128.7, 124.0, 117.7, 70.7, 61.2, 52.8, 35.9; IR(ν, cm^{-1}): 3361, 2911, 2437, 2233, 1725, 1615, 1262, 1083, 953, 764; HRMS (ESI): Exact mass calcd $C_{13}H_{11}ON_4$ Br $[M+H]^+$: 341.0008, Found: 340.9999; 77% ee was determined by HPLC on Diacel OD-H column, 7/93: 2-propanol/hexane, 1.0 mL/min, UV 254 nm, t_{minor} = 50.1 min, t_{major} = 56.8 min.



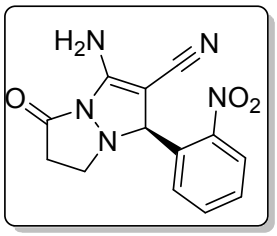
(S)-3-amino-1-(2-methoxyphenyl)-5-oxo-6,7-dihydro-1*H*,5*H*-pyrazolo[1,2-*a*]pyrazole-2-carbonitrile (3d):

The product **3d** was synthesized according to the general experimental procedure, white solid, Isolated yield 24.9 mg (82 %), m.p. 125 -128 °C. ^{1}H NMR (500MHz, DMSO-d_6) δ = 7.44 (d, *J* = 7.3 Hz, 1H), 7.32 (t, *J* = 7.6 Hz, 1H), 7.16 (br. s., 2H), 7.07 - 6.99 (m, 2H), 5.27 (s, 1H), 3.79 (s, 3H), 3.33 - 3.24 (m, 1H), 3.22 - 3.04 (m, 1H), 2.91 - 2.78 (m, 1H), 2.68 (dd, *J* = 6.3, 16.4 Hz, 1H); ^{13}C NMR (126MHz, DMSO-d_6) δ = 167.0, 157.9, 149.2, 129.8, 128.3, 127.0, 121.0, 118.0, 111.6, 65.3, 61.2, 55.9, 52.5, 36.0; IR(ν, cm^{-1}): 3061, 2981, 2937, 2233, 1735, 1611, 1252, 1086, 943, 744; HRMS (ESI): Exact mass calcd: $C_{14}H_{14}O_2N_4$[M+H]$^+$: 271.119, Found: 271.1185; 90% ee was determined by HPLC on Diacel AD-H column, 10/90: 2-propanol/hexane, 0.5 mL/min, UV 254 nm, t_{minor} = 73.94 min, t_{major} = 82.71 min.



(S)-3-amino-1-(2-nitrophenyl)-5-oxo-6,7-dihydro-1*H*,5*H*-pyrazolo[1,2-*a*]pyrazole-2-carbonitrile (3e):

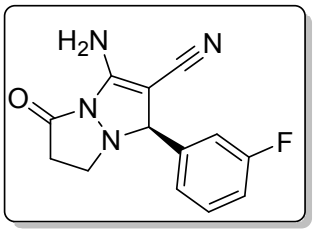
The product **3e** was synthesized according to the general experimental procedure, white solid,



Isolated yield 22.8 mg (80 %), m.p. 148 -151 °C. ^{1}H NMR (500MHz, DMSO-d_6) δ = 8.28 (t, *J* = 1.9 Hz, 1H), 8.23 (ddd, *J* = 1.0, 2.4, 8.2 Hz, 1H), 7.93 - 7.84 (m, 1H), 7.73 (t, *J* = 7.9 Hz, 1H), 7.35 (s, 2H), 5.13 (s, 1H), 3.46 - 3.42 (m, 1H), 3.21 (ddd, *J* = 7.7, 8.8, 12.9 Hz, 1H), 2.96 (ddd, *J* = 8.5, 12.9, 16.7 Hz, 1H), 2.73 – 2.07 (m, 1H); ^{13}C NMR (126MHz, DMSO-d_6) δ = 167.3, 149.0, 147.9, 142.1, 137.0, 134.6, 130.2, 122.2, 116.9, 70.5, 61.1, 51.9, 35.2; IR(ν, cm^{-1}): 3055, 2967, 2937, 2233, 1753, 1631, 1232, 1186, 953, 64; HRMS (ESI): Exact mass calcd $C_{13}H_{11}O_3N_5$[M+Na]$^+$: 308.0754, Found: 308.0748; 78% ee was determined by HPLC on Phenomex Amylose 2 column, 50/50: 2-propanol/hexane, 1 mL/min, UV 254 nm, t_{minor} = 17.11 min, t_{major} = 24.8 min.

(R)-3-amino-1-(3-fluorophenyl)-5-oxo-6,7-dihydro-1*H*,5*H*-pyrazolo[1,2-*a*]pyrazole-2-carbonitrile (3f):

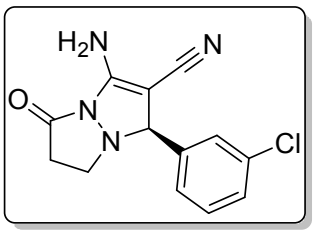
The product **3f** was synthesized according to the general experimental procedure, white solid,



Isolated yield 20.1 mg (78 %), m.p. 133 -136 °C. ^{1}H NMR (500MHz, DMSO-d_6) δ = 7.45 (dt, *J* = 6.3, 7.9 Hz, 1H), 7.28 (s, 2H), 7.27 - 7.21 (m, 2H), 7.21 - 7.16 (m, 1H), 4.94 (s, 1H), 3.15 (td, *J* = 8.1, 12.8 Hz, 1H), 2.92 (ddd, *J* = 8.4, 12.8, 16.7Hz, 1H), 2.75 - 2.66 (m, 1H); ^{13}C NMR (126MHz, DMSO-d_6) δ = 166.9, 162.27(d, *J* = 244.44 Hz), 148.9, 142.9 (d, *J* = 7.56 Hz), 130.04 (d, *J* = 8.82 Hz), 124.36 (d, *J* = 2.52 Hz), 117.8, 115.6 (d, *J* = 21.42 Hz), 114.8 (d, *J* = 21.42 Hz), 65.5, 60.5, 52.6, 35.8; IR(ν, cm^{-1}): 3456, 2951, 2927, 2232, 1733, 1531, 1352, 1186, 953, 774; HRMS (ESI): Exact mass calcd $C_{13}H_{11}ON_4F$ [M+Na]$^+$: 281.0809, Found: 281.0805; 90% ee was determined by HPLC on Phenomex Amylose 2 column, 10/90: 2-propanol/hexane, 1 mL/min, UV 254 nm, t_{minor} = 43.34 min, t_{major} = 51.05 min.

(R)-3-amino-1-(3-chlorophenyl)-5-oxo-6,7-dihydro-1*H*,5*H*-pyrazolo[1,2-*a*]pyrazole-2-carbonitrile (3g):

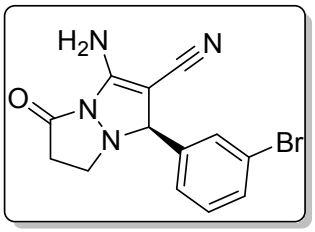
The product **3g** was synthesized according to the general experimental procedure, white solid,



Isolated yield 21.6 mg (79 %), m.p. 142 -145 °C. ^{1}H NMR (500MHz, DMSO-d_6) δ = 7.48 - 7.46 (m, 2H), 7.45 - 7.42 (m, 1H), 7.40 - 7.36 (m, 1H), 7.30 (s, 2H), 4.94 (s, 1H), 3.43 - 3.38 (m, 1H), 3.15 (td, *J* = 8.2, 12.8 Hz, 1H), 2.93 (ddd, *J* = 8.5, 12.7, 16.6 Hz, 1H), 2.70 (ddd, *J* = 1.1, 7.5, 16.6 Hz, 1H); ^{13}C NMR (126MHz, DMSO-d_6) δ = 167.0, 148.9, 142.6, 133.7, 131.0, 128.8, 128.0, 127.1, 117.8, 71.4, 61.9, 52.3, 35.8; IR(ν, cm^{-1}): 3361, 2481, 2337, 2243, 1731, 1623, 1296, 986, 943; HRMS (ESI): Exact mass calcd $C_{13}H_{11}ON_4Cl$[M+Na]$^+$: 297.0514, Found: 297.0524; 82% ee was determined by HPLC on Phenomex Amylose 2 column, 10/90: 2-propanol/hexane, 1 mL/min, UV 254 nm, t_{minor} = 30.69 min, t_{major} = 34.36 min.

(R)-3-amino-1-(3-bromophenyl)-5-oxo-6,7-dihydro-1*H*,5*H*-pyrazolo[1,2-*a*]pyrazole-2-carbonitrile (3h):

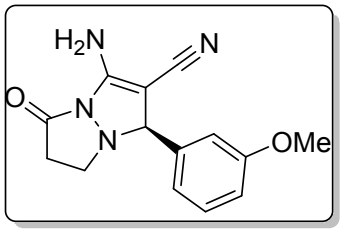
The product **3h** was synthesized according to the general experimental procedure, white



solid, Isolated yield 28.4 mg (83%), m.p. 126 -129 °C. ^{1}H ^{1}H NMR (500MHz, DMSO-d_6) δ = 7.61 (t, *J* = 1.7 Hz, 1H), 7.57 - 7.54 (m, 1H), 7.45 - 7.35 (m, 2H), 7.29 (s, 2H), 4.93 (s, 1H), 3.40 (dt, *J* = 1.3, 8.5 Hz, 1H), 3.20 - 3.07 (m, 1H), 2.93 (ddd, *J* = 8.5, 12.7, 16.6 Hz, 1H), 2.79 - 2.63 (m, 1H); ^{13}C NMR (126MHz, DMSO-d_6) δ = 167.0, 148.9, 142.8, 161.6, 131.7, 131.2, 130.9, 127.5, 122.3, 117.8, 71.4, 62.0, 52.3, 35.8; IR(ν, cm^{-1}): 3364, 3181, 2977, 2283, 1736, 1641, 1422, 1086, 953, 764; HRMS (ESI): Exact mass calcd: $C_{13}H_{11}ON_4Br$ $[M+H]^+$: 341.0008, Found: 340.9999; 88% ee was determined by HPLC on Diacel OD-H column, 10/90: 2-propanol/hexane, 1 mL/min, UV 254 nm, t_{minor} = 47.28 min, t_{major} = 57.9 min.

(R)-3-amino-1-(3-methoxyphenyl)-5-oxo-6,7-dihydro-1*H*,5*H* -pyrazolo[1,2-*a*]pyrazole-2-carbonitrile (3i):

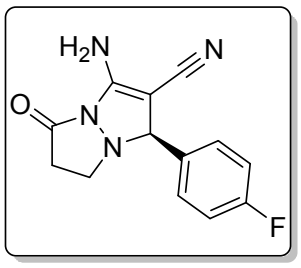
The product **3i** was synthesized according to the general experimental procedure, white solid,



Isolated yield 25 mg (92%), m.p. 136 -138 °C. ^{1}H NMR (500MHz, DMSO-d_6) δ = 7.32 (t, *J* = 7.9 Hz, 1H), 7.23 (s, 2H), 7.01 - 6.90 (m, 3H), 4.87 (s, 1H), 3.77 (s, 3H), 3.39 - 3.36 (m, 1H), 3.13 (td, *J* = 8.1, 12.8 Hz, 1H), 2.91 (ddd, *J* = 8.5, 12.6, 16.7 Hz, 1H), 2.75 - 2.66 (m, 1H); ^{13}C NMR (126MHz, DMSO-d_6) δ = 166.7, 159.8, 148.8, 141.2, 130.1, 120.5, 117.9, 114.2, 113.8, 72.2, 62.4, 55.5, 52.1, 35.9; IR(ν, cm^{-1}): 3561, 3281, 2937, 2233, 1935, 1811, 1742, 1126, 943, 744; HRMS (ESI): Exact mass calcd: $C_{14}H_{14}O_2$ $N_4[M+H]^+$: 271.119, Found: 271.1185; 68% ee was determined by HPLC on Diacel AD-H column, 10/90: 2-propanol/hexane, 1 mL/min, UV 254 nm, t_{minor} = 12.4 min, t_{major} = 18.6 min.

(R)-3-amino-1-(4-fluorophenyl)-5-oxo-6,7-dihydro-1*H*,5*H*-pyrazolo[1,2-*a*]pyrazole-2-carbonitrile (3j):

The product **3j** was synthesized according to the general experimental procedure, white solid,

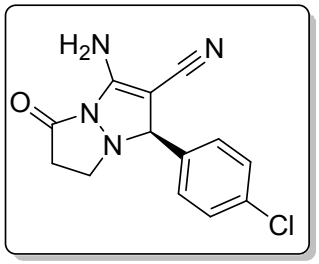


Isolated yield 23 mg (89 %), m.p. 126 -128 °C. ^{1}H NMR (500MHz, DMSO-d_6) d = 7.46 (dd, *J* = 5.7, 8.5 Hz, 2H), 7.26 (s, 2H), 7.25 - 7.20 (m, 2H), 4.92 (s, 1H), 3.37 (br. s., 1H), 3.13 (td, *J* = 8.1, 12.8 Hz, 1H), 2.90 (ddd, *J* = 8.5, 12.7, 16.6 Hz, 1H), 2.70 (dd, *J* = 6.9, 16.7 Hz, 1H); ^{13}C NMR (126MHz, DMSO-d_6) d = 166.7, 162.5 (d, *J* = 244.44 Hz), 148.8, 135.9 (d, *J* = 2.5 Hz), 130.4 (d, *J* = 7.56 Hz), 117.9, 115.8 (d, *J* = 21.42 Hz), 71.5, 62.3, 52.0, 35; IR(ν, cm^{-1}): 3061, 2981, 2937, 2233, 1735, 1611, 1252, 1086, 943, 744; HRMS (ESI): Exact mass calcd: $C_{13}H_{11}ON_4F[M+Na]^+$: 281.0809, Found: 281.0802; 90% ee was

determined by HPLC on Phenomenex Amylose 2 column, 10/90: 2-propanol/hexane, 0.8 mL/min, UV 254 nm, t_{minor} = 18.4 min, t_{major} = 21.0 min.

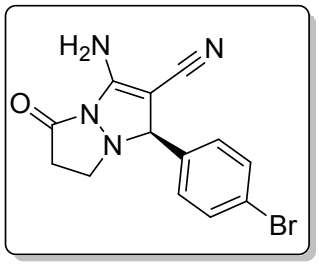
(R)-3-amino-1-(4-chlorophenyl)-5-oxo-6,7-dihydro-1*H*,5*H*-pyrazolo[1,2-*a*]pyrazole-2-carbonitrile (3k):

The product **3k** was synthesized according to the general experimental procedure, white solid, Isolated yield 21.6 mg (79 %), m.p. 135 -138 °C. ^{1}H NMR (500MHz, DMSO-d_6) d = 7.46 (dd, *J* = 5.7, 8.5 Hz, 2H), 7.26 (s, 2H), 7.25 - 7.20 (m, 2H), 4.92 (s, 1H), 3.37 (br. s., 1H), 3.13 (td, *J* = 8.1, 12.8 Hz, 1H), 2.90 (ddd, *J* = 8.5, 12.7, 16.6 Hz, 1H), 2.70 (dd, *J* = 6.9, 16.7 Hz, 1H); ^{13}C NMR (101MHz, DMSO-d_6) d = 166.8, 148.8, 138.8, 133.4, 130.2, 129.0, 117.8, 71.5, 62.1, 51.1, 35.9; IR(ν, cm^{-1}): 3523, 3181, 2867, 2453, 1762, 1671, 1252, 1086, 943, 744; HRMS (ESI): Exact mass calcd $C_{13}H_{11}ON_4$ Cl Na $[M+Na]^+$: 297.0514, Found: 297.0507; 96% ee was determined by HPLC on Phenomenex Amylose 2 column, 10/90: 2-propanol/hexane, 1.0 mL/min, UV 254 nm, t_{minor} = 33.6 min, t_{major} = 35.3 min.



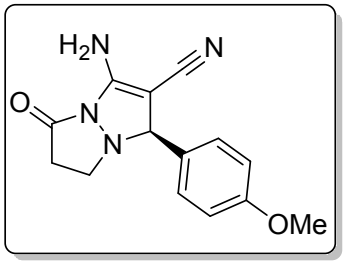
(R)-3-amino-1-(4-bromophenyl)-5-oxo-6,7-dihydro-1*H*,5*H*-pyrazolo[1,2-*a*]pyrazole-2-carbonitrile (3l):

The product **3l** was synthesized according to the general experimental procedure, white solid, Isolated yield 27.4 mg (80 %), m.p. 132 -135 °C. ^{1}H NMR (500MHz,CHLOROFORM-d) δ = 7.60 - 7.50 (m, *J* = 8.2 Hz, 2H), 7.35 - 7.30 (m, *J* = 8.5 Hz, 2H), 5.73 (br. s., 2H), 4.85 (s, 1H), 3.51 (t, *J* = 8.4 Hz, 1H), 3.12 (td, *J* = 8.0, 12.6 Hz, 1H), 3.02 - 2.92 (m, 1H), 2.78 (dd, *J* = 7.1, 16.6 Hz, 1H); ^{13}C NMR (126MHz,CHLOROFORM-d) δ = 166.0, 148.0, 136.9, 132.1, 129.4, 123.0, 116.2, 72.1, 64.9, 52.6, 36.1; IR(ν, cm^{-1}): 3521, 2992, 2457, 2233, 1655, 1641, 1285, 1246, 983, 654; HRMS (ESI): Exact mass calcd $C_{13}H_{11}ON_4$ Br $[M+H]^+$: 341.0008, Found: 342.9979; 88% ee was determined by HPLC on Phenomenex Amylose 2 column, 10/90: 2-propanol/hexane, 1.0 mL/min, UV 254 nm, t_{minor} = 45.7 min, t_{major} = 63.9 min.



(R)-3-amino-1-(4-methoxyphenyl)-5-oxo-6,7-dihydro-1*H*,5*H*-pyrazolo[1,2-*a*]pyrazole-2-carbonitrile (3m):

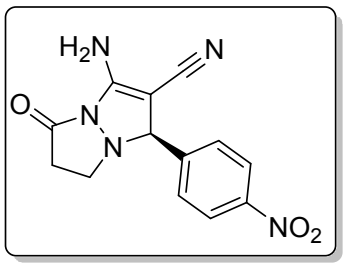
The product **3m** was synthesized according to the general experimental procedure, white solid, Isolated yield 23.3 mg (86 %), m.p. 119 -122 °C. ^{1}H NMR (500MHz, DMSO-d_6) δ = 7.34 - 7.29 (m, 2H), 7.23 (s, 2H), 6.98 - 6.93 (m, 2H), 4.83 (s, 1H), 3.76 (s, 3H), 3.33 - 3.27 (m, 1H), 3.09 (td, *J* = 8.2, 12.6 Hz, 1H), 2.88 (ddd, *J* = 8.4, 12.5, 16.7 Hz, 1H), 2.73 - 2.66 (m,



1H); ^{13}C NMR (126MHz, DMSO-d_6) δ = 166.4, 159.8, 148.7, 131.2, 129.7, 118.0, 114.4, 71.9, 62.7, 55.6, 51.8, 36.0; IR(ν, cm^{-1}): 3661, 2961, 2967, 2233, 1765, 1691, 1250, 1186, 942, 754; HRMS (ESI): Exact mass calcd $C_{14}H_{14}O_2N_4$ $[M+H]^+$: 271.119, Found: 271.1185; 91% ee was determined by HPLC on Diacel OD-H column, 7/93: 2-propanol/hexane, 0.7 mL/min, UV 254 nm, t_{minor} = 84.5 min, t_{major} = 95.4 min.

(R)-3-amino-1-(4-nitrophenyl)-5-oxo-6,7-dihydro-1*H*,5*H*-pyrazolo[1,2-*a*]pyrazole-2-carbonitrile (3n):

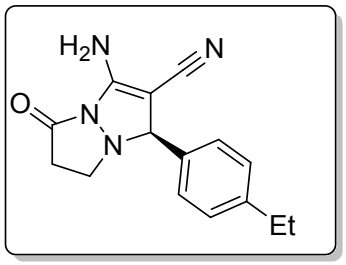
The product **3l** was synthesized according to the general experimental procedure, white solid,



Isolated yield 22.8 mg (80 %), m.p. 147 -149 °C. ^{1}H NMR (500MHz, DMSO-d6) d = 8.27 (d, *J* = 8.8 Hz, 1H), 7.71 (d, *J* = 8.8 Hz, 1H), 7.34 (s, 2H), 5.01 (s, 1H), 3.44 - 3.40 (m, 1H), 3.21 (ddd, *J* = 7.7, 8.8, 12.9 Hz, 1H), 2.96 (ddd, *J* = 8.5, 12.9, 16.7 Hz, 1H), 2.73 – 2.68 (m, 1H); ^{13}C NMR (126MHz, DMSO-d_6) δ = 163.8, 149.8, 148.3, 140.3, 129.6, 124.1, 118.1, 71.7, 61.7, 52.7, 35.7; IR(ν, cm^{-1}): 3665, 2931, 2837, 2653, 1755, 1671, 1552, 1096, 753, 744; HRMS (ESI): Exact mass calcd $C_{13}H_{11}O_3N_5Na$ $[M+Na]^+$: 308.0754, Found: 308.0748; 98% ee was determined by HPLC on Phenomenex Amylose 2 column, 30/70: 2-propanol/hexane, 1 mL/min, UV 254 nm, t_{minor} = 29.1 min, t_{major} = 39.3 min.

(R)-3-amino-1-(4-ethylphenyl)-5-oxo-6,7-dihydro-1*H*,5*H*-pyrazolo[1,2-*a*]pyrazole-2-carbonitrile (3o):

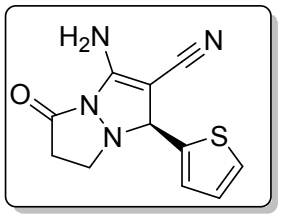
The product **3o** was synthesized according to the general experimental procedure, white solid,



Isolated yield 21.2 mg (86 %), m.p. 135 -138 °C. ^{1}H NMR (500MHz, $CDCl_3$) δ = 7.34 (d, *J* = 8.1 Hz, 2H), 7.26 (d, *J* = 8.1 Hz, 2H), 5.68 (s, 2H), 4.88 (s, 1H), 3.49 (dt, *J* = 1.9, 8.4 Hz, 1H), 3.10 (ddd, *J* = 7.4, 8.7, 12.3 Hz, 1H), 2.99 - 2.91 (m, 1H), 2.80 - 2.75 (m, 1H), 2.69 (q, *J* = 7.6 Hz, 2H), 1.28 - 1.25 (m, 3H); ^{13}C NMR (126MHz,CHLOROFORM-d) δ = 166.0, 147.9, 145.2, 134.7, 128.4, 127.8, 116.5, 72.5, 65.5, 52.4, 36.2, 28.6, 15.4; IR(ν, cm^{-1}): 3661, 3281, 2934, 2533, 1765, 1618, 1602, 1286, 843, 744; HRMS (ESI): Exact mass calcd $C_{15}H_{16}ON_4$ $[M+H]^+$: 269.1397, Found: 269.1387; 82% ee was determined by HPLC on Phenomenex Amylose 2 column, 8/92: 2-propanol/hexane, 0.8 mL/min, UV 254 nm, t_{minor} = 40.2 min, t_{major} = 43.0 min.

(S)-3-amino-5-oxo-1-(thiophen-2-yl)-6,7-dihydro-1*H*,5*H*-pyrazolo[1,2-*a*]pyrazole-2-carbonitrile (3p):

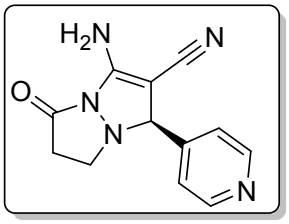
The product **3p** was synthesized according to the general experimental procedure, white solid, isolated yield 19.9 mg (81 %), m.p. 127 -129 °C. ^{1}H NMR (500MHz ,DMSO-d_6) δ = 7.56 (d, *J* = 4.7 Hz, 1 H), 7.27 (br. s., 2 H), 7.11 (d, *J* = 3.2 Hz, 1 H), 7.03 (t, *J* = 4.3 Hz, 1 H), 5.25 (s, 1 H), 3.42 - 3.36 (m, 1 H), 3.21 - 3.10 (m, 1 H), 2.91 (ddd, *J* = 8.8, 11.8, 16.9 Hz, 1



H), 2.77 - 2.67 (m, 1 H); ^{13}C NMR (126MHz, DMSO-d_6) δ = 166.7, 148.6, 144.3, 127.4, 127.3, 126.8, 117.7, 67.5, 63.1, 51.4, 35.8; IR(ν, cm^{-1}): 3531, 3184, 2923, 2543, 1695, 1603, 1652, 1341, 956, 741; HRMS (ESI): Exact mass calcd $C_{11}H_{10}N_4OS$ $[M+Na]^+$: 269.0473, Found: 269.0464; 83% ee was determined by HPLC on Phenomenex Amylose 2 column, 10/90: 2-propanol/hexane, 1.0 mL/min, UV 254 nm, t_{minor} = 56.7 min, t_{major} = 63.8 min.

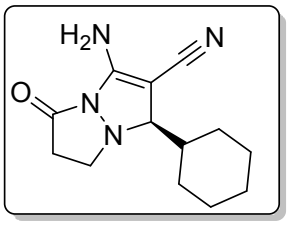
(R)-3-amino-5-oxo-1-(pyridin-4-yl)-6,7-dihydro-1*H*,5*H*-pyrazolo[1,2-*a*]pyrazole-2-carbonitrile (3q):

The product **3q** was synthesized according to the general experimental procedure, white solid, Isolated yield 17.8 mg (74%), m.p. 141 -144 °C. ^{1}H NMR (400MHz, DMSO-d_6) δ = 8.60 (br. s., 2 H), 7.42 (br. s, 2 H), 7.31 (br. s, 2 H), 4.94 (br. s., 1 H), 3.47 - 3.40 (m, 1 H), 3.23 - 3.13 (m, 1 H), 2.99 - 2.87 (m, 1 H), 2.75 - 2.66 (m, 1 H); ^{13}C NMR (101MHz, DMSO-d_6) δ = 166.8, 149.8, 148.6, 148.3, 122.6, 117.1, 70.3, 60.7, 52.1, 35.3; IR(ν, cm^{-1}): 3652, 3451, 2854, 2643, 1761, 1648, 1598, 985, 789, 684; HRMS (ESI): Exact mass calcd $C_{12}H_{11}ON_5$ $[M+H]^+$: 242.1036, Found: 242.1035; 72% ee was determined by HPLC on Daicel AD-H column, 10/90: 2-propanol/hexane, 1.0 mL/min, UV 254 nm, t_{minor} = 77.6 min, t_{major} = 55.9 min.



(R)-3-amino-1-cyclohexyl-5-oxo-6,7-dihydro-1*H*,5*H*-pyrazolo[1,2-*a*]pyrazole-2-carbonitrile (3r):

The product **3r** was synthesized according to the general experimental procedure, white solid, Isolated yield 16.7 mg (68 %), m.p. 122 -125 °C. ^{1}H NMR (400MHz, DMSO-d_6) δ = 6.97 (s, 2 H), 3.72 (d, *J* = 3.5 Hz, 1 H), 3.49 (t, *J* = 8.1 Hz, 1 H), 3.07 - 2.96 (m, 1 H), 2.96 - 2.82 (m, 1 H), 2.58 (dd, *J* = 6.7, 16.2 Hz, 1 H), 1.74 - 1.64 (m, 4 H), 1.47 - 1.34 (m, 1 H), 1.28 - 1.14 (m, 4 H), 1.13 - 0.97 (m, 2 H); ^{13}C NMR (101MHz ,DMSO-d_6) δ = 167.9, 149.6, 118.4, 73.6, 58.7, 55.4, 41.7, 35.5, 29.5, 27.5, 26.6, 26.3, 26.2; IR(ν, cm^{-1}): 3545, 3185, 2887, 2324, 1695, 1556, 1452, 1025, 958, 862; HRMS (ESI): Exact mass calcd $C_{13}H_{18}ON_4$ $[M+Na]^+$: 269.13783, Found: 269.1372; 41% ee was determined by HPLC on Daicel AD-H column, 5/95: 2-propanol/hexane, 0.7 mL/min, UV 254 nm, t_{minor} = 51.7 min, t_{major} = 31.3 min.



(1R)-3-imino-2-methyl-5-oxo-1-phenyltetrahydro-1*H*,5*H*-pyrazolo[1,2-*a*]pyrazole-2-carbonitrile (3s):

The product **3r** was synthesized according to the general experimental procedure, white solid, Isolated yield 19.8 mg (78 %), m.p. 136 -139 °C. ^{1}H NMR (400MHz ,DMSO-d_6) δ = 9.00 (s, 1 H), 7.63 - 7.53 (m, 2 H), 7.53 - 7.43 (m, 4 H), 4.22 (s, 1 H), 3.48 (t, *J* = 8.6 Hz, 1 H), 3.16 (ddd, *J* = 9.2, 12.3, 16.4 Hz, 1 H), 3.01 - 2.87 (m, 1 H), 2.79 (dd, *J* = 7.6, 16.3 Hz, 1 H), 1.57

(s, 3 H); ^{1}H NMR (400MHz, DMSO-d_6) δ = 9.00 (s, 1 H), 7.63 - 7.53 (m, 2 H), 7.53 - 7.43 (m, 3 H), 4.22 (s, 1 H), 3.48 (t, *J* = 8.6 Hz, 1 H), 3.16 (ddd, *J* = 9.2, 12.3, 16.4 Hz, 1 H), 3.01 - 2.87 (m, 1 H), 2.79 (dd, *J* = 7.6, 16.3 Hz, 1 H), 1.57 (s, 3 H); ^{13}C NMR (101MHz, DMSO-d_6) δ = 166.8, 149.8, 148.6, 148.3, 122.6, 117.13, 70.31, 60.71, 52.13, 35.25; IR(ν, cm^{-1}): 3548, 3247, 2647, 2478, 1678, 1656, 976, 823, 654; HRMS (ESI): Exact mass calcd $C_{14}H_{14}ON_4$ $[M+Na]^+$: 277.1060, Found: 277.1061; 70% ee was determined by HPLC on Daicel OD-H column, 5/95: 2-propanol/hexane, 0.5 mL/min, UV 254 nm, t_{minor} = 38.4 min, t_{major} = 43.1 min.

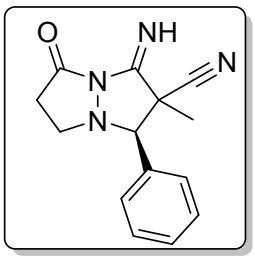


Table 1. Crystal data and structure refinement for compound 3g

Bond precision: C-C = 0.0047 A Wavelength=0.71073

Cell: a=6.1447(4) b=8.6445(6) c=12.6178(9)

alpha=90 beta=101.032(3) gamma=90

Temperature: 293 K

	Calculated	Reported
Volume	657.85(8)	657.84(8)
Space group	P 21	P 21
Hall group	P 2yb	P 2yb
Moiety formula	C13 H11 Cl N4 O	C13 H11 Cl N4 O
Sum formula	C13 H11 Cl N4 O	C13 H11 Cl N4 O
Mr	274.71	274.71
Dx,g cm-3	1.387	1.387
Z	2	2
Mu (mm-1)	0.287	0.287
F000	284.0	284.0
F000'	284.39	
h,k,lmax	7,10,14	7,10,14
Nref	2318[1243]	2303
Tmin,Tmax	0.933,0.944	0.928,0.954
Tmin'	0.931	

Correction method= # Reported T Limits: Tmin=0.928 Tmax=0.954 AbsCorr = MULTI-SCAN

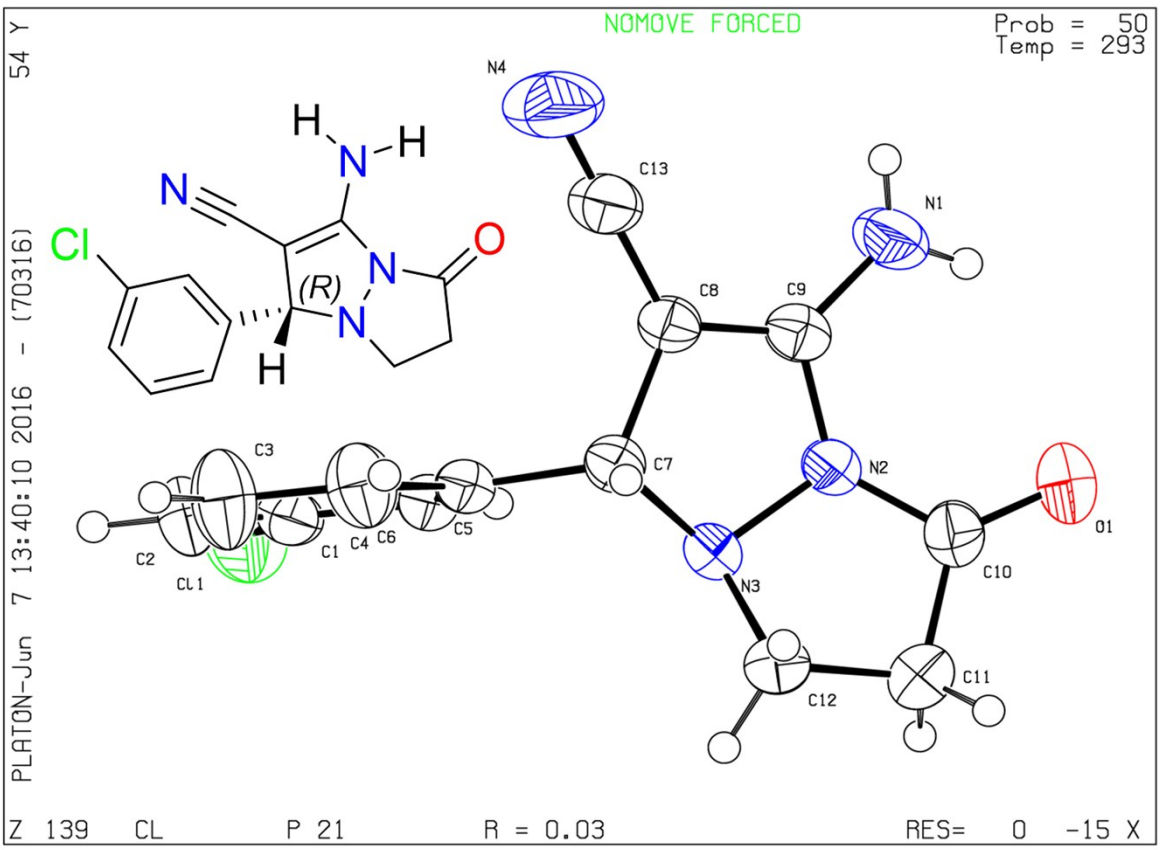
Data completeness= 1.85/0.99 Theta(max)= 24.989

R(reflections)= 0.0344(1926) wR2(reflections)= 0.0666(2303)

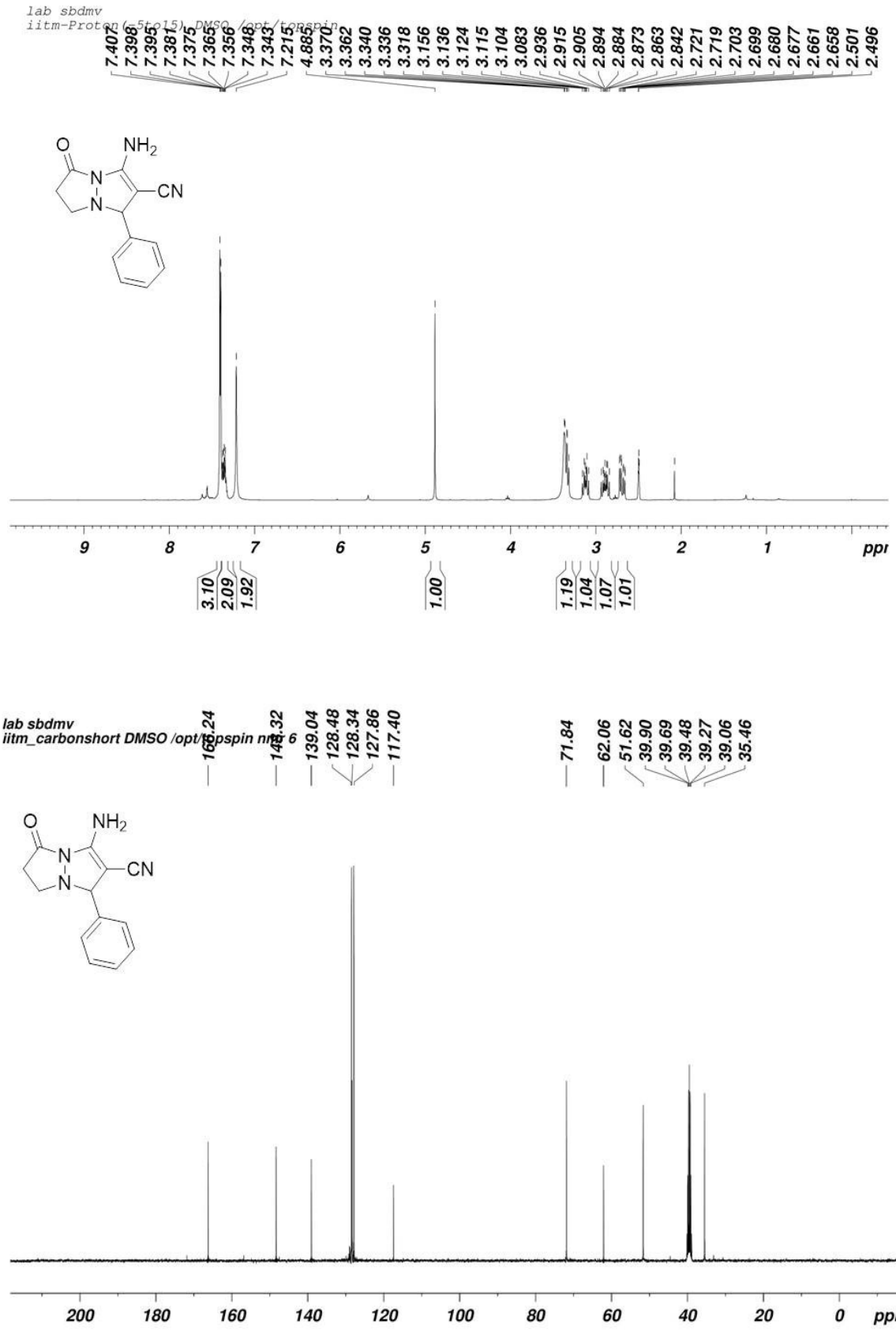
S = 1.134 Npar= 181

X-ray Crystal Structure of Compound 4f and CCDC Number 1486491

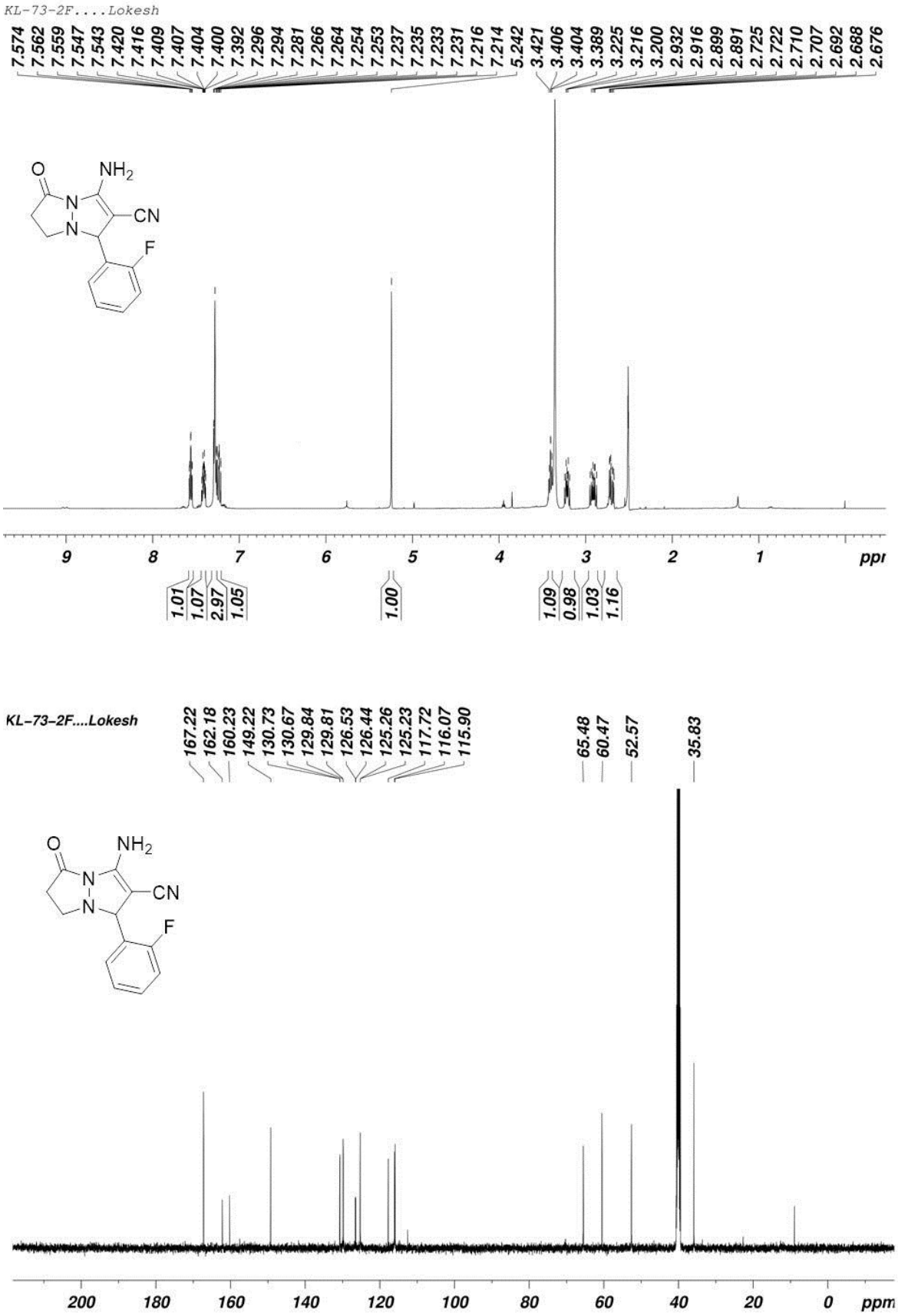
Datablock CL - ellipsoid plot



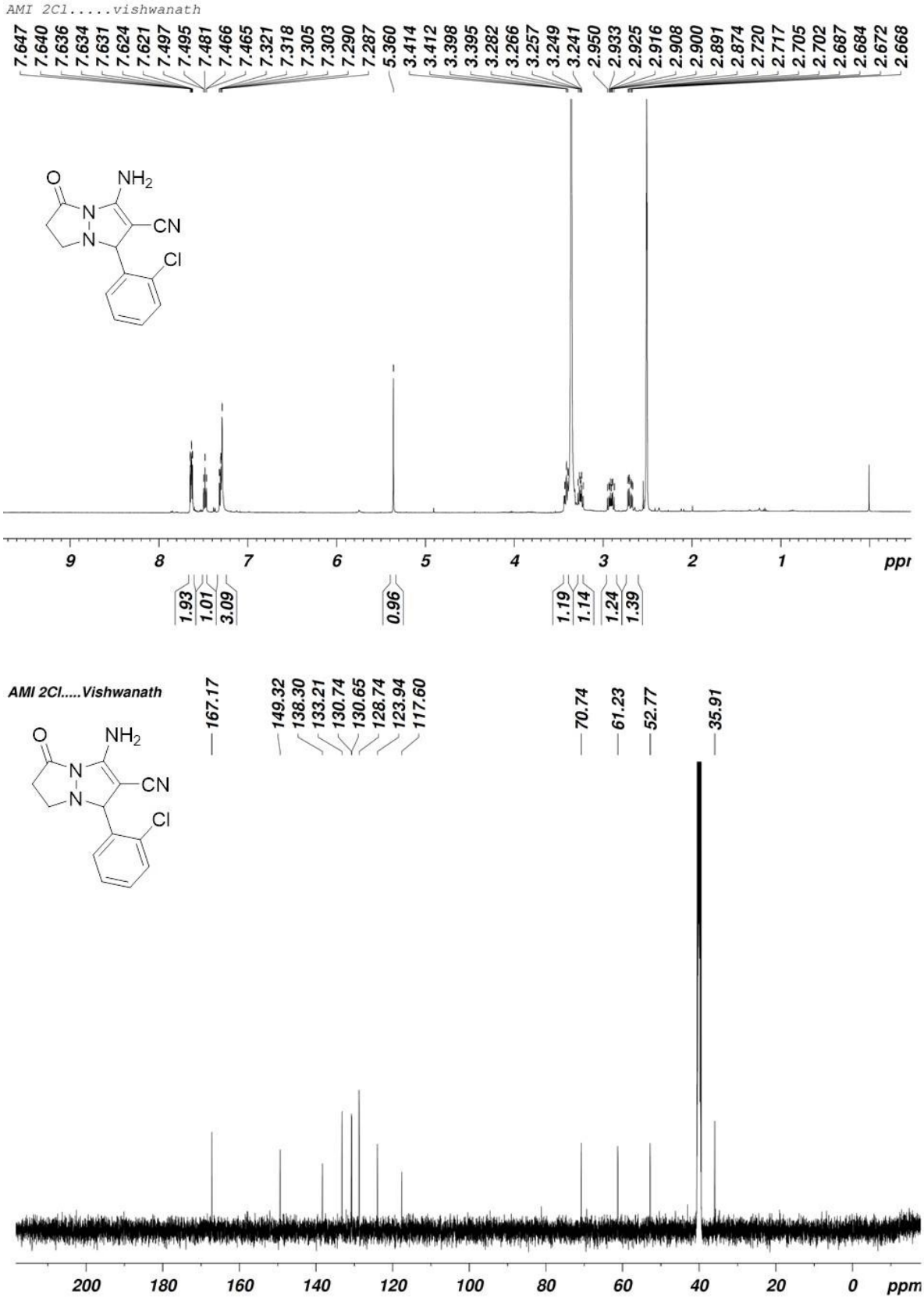
^{1}H and ^{13}C-NMR spectra of compound (R)-3-amino-5-oxo-1-phenyl-6,7-dihydro-1*H*,5*H*-pyrazolo[1,2-*a*]pyrazole-2-carbonitrile 3



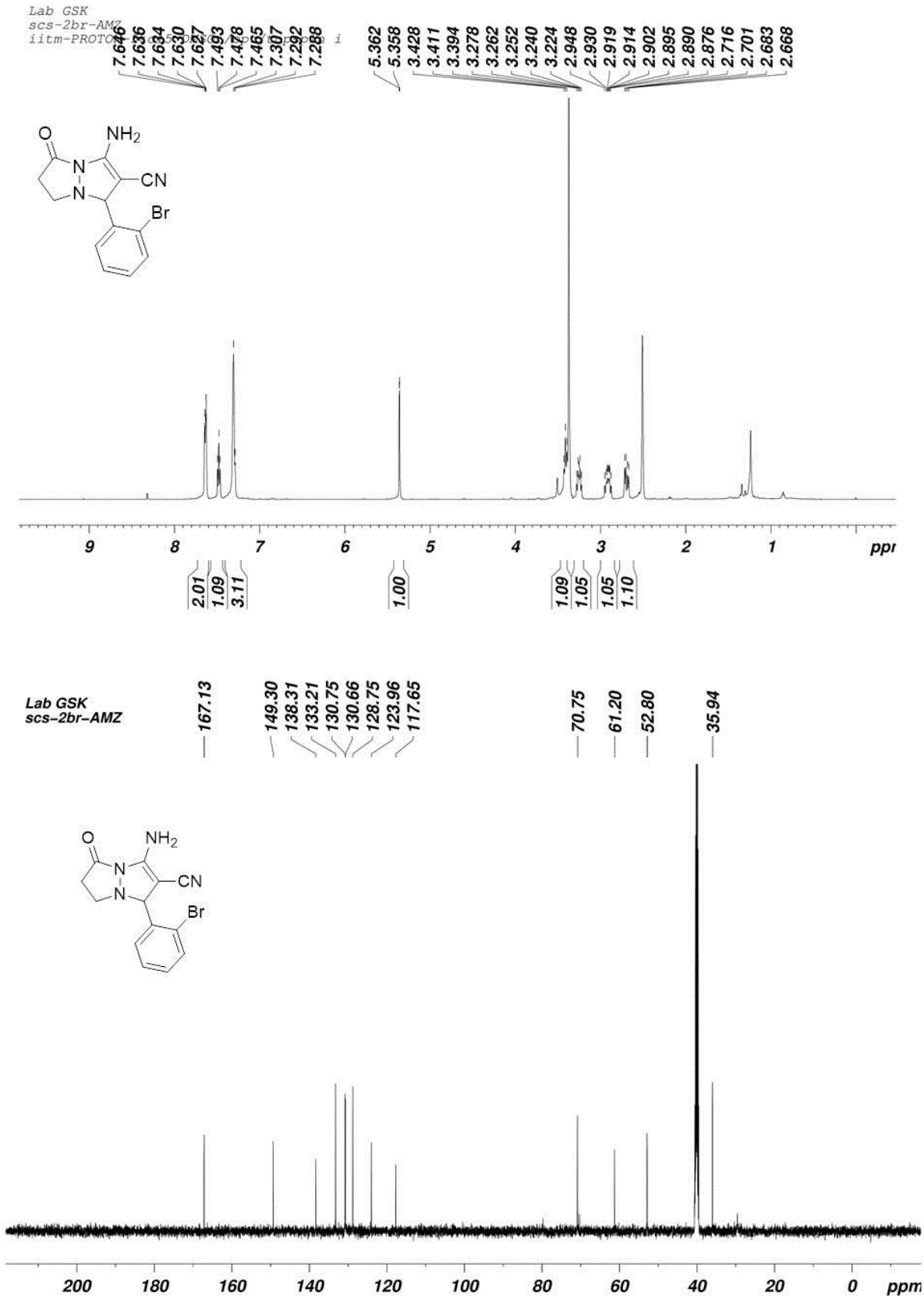
^{1}H and ^{13}C-NMR spectra of compound (S)-3-amino-1-(2-fluorophenyl)-5-oxo-6,7-dihydro-1*H*,5*H*-pyrazolo[1,2-*a*]pyrazole-2-carbonitrile 3a



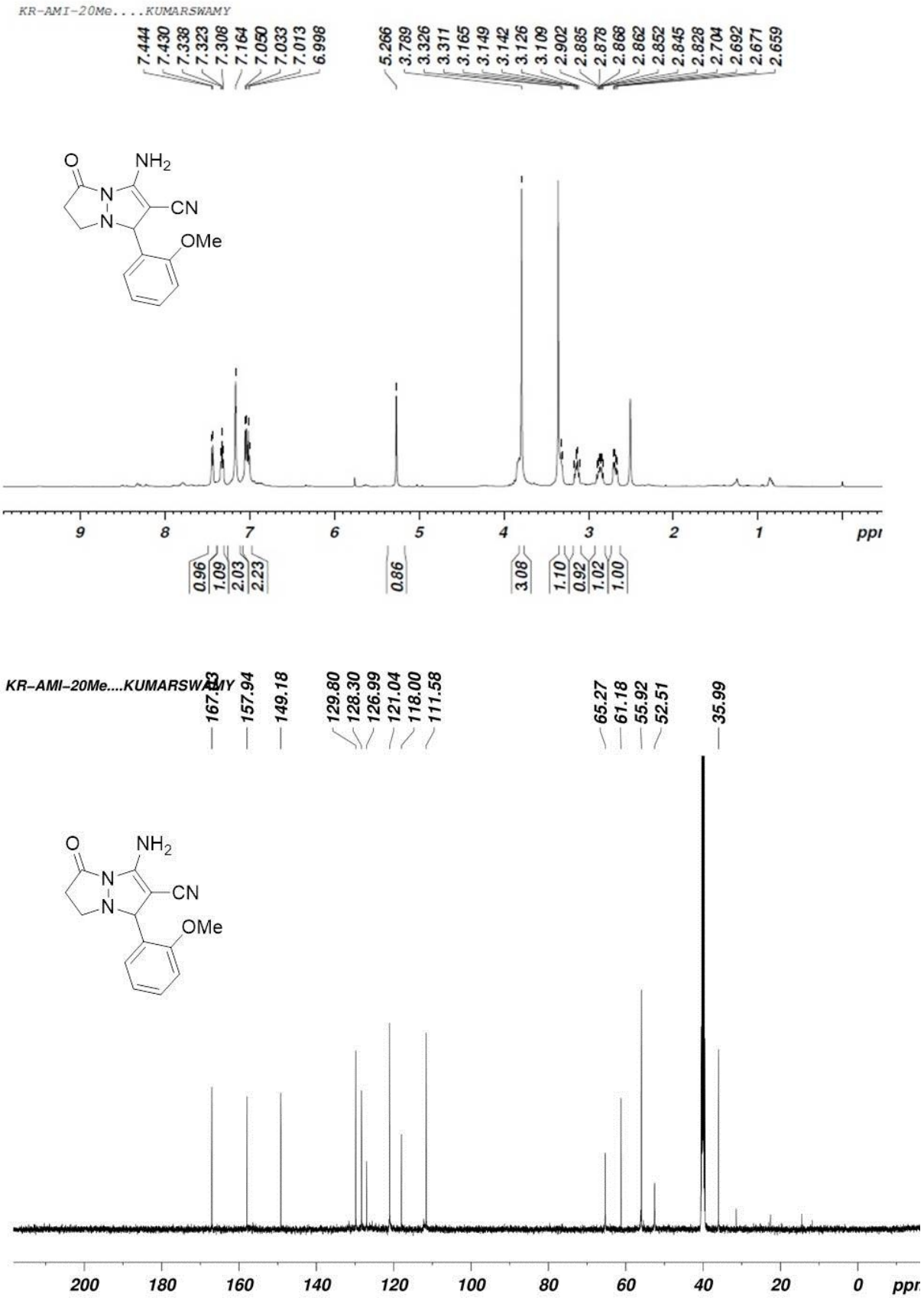
^{1}H and ^{13}C-NMR spectra of compound (S)-3-amino-1-(2-chlorophenyl)-5-oxo-6,7-dihydro-1*H*,5*H*-pyrazolo[1,2-*a*]pyrazole-2-carbonitrile 3b



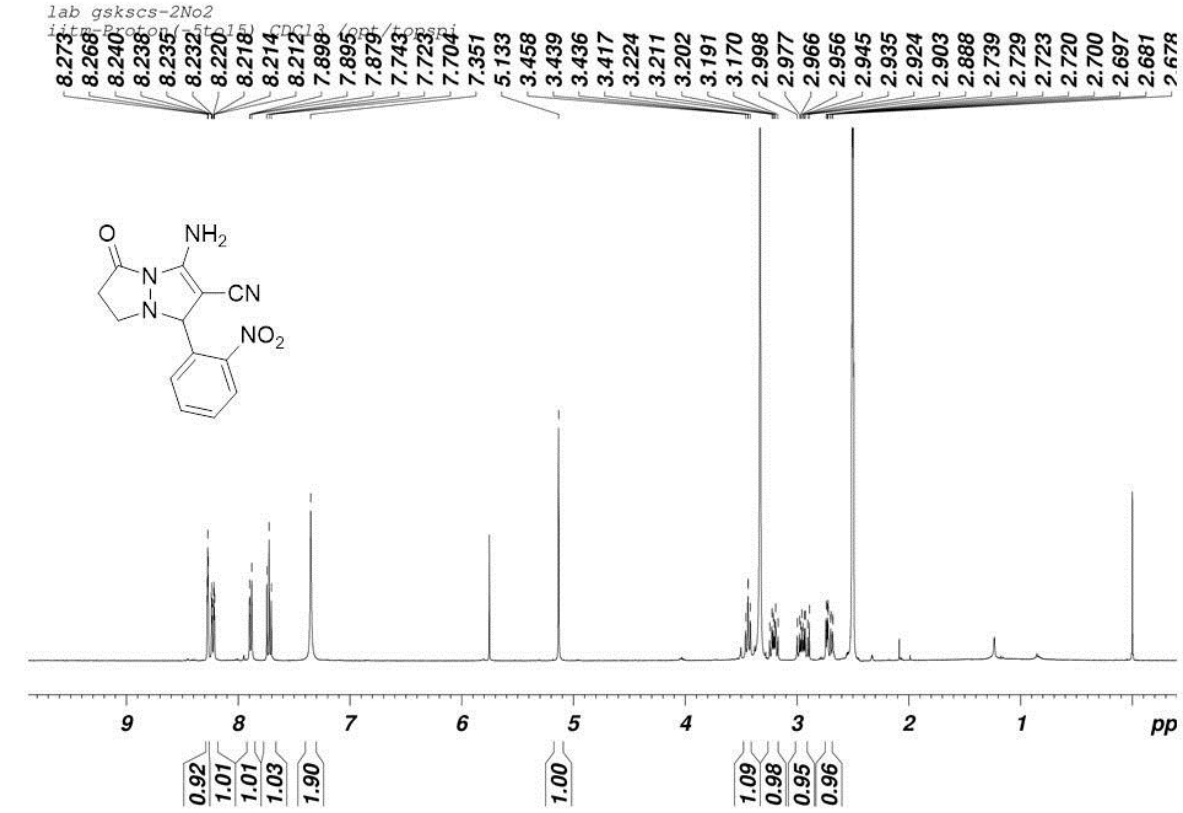
^{1}H and ^{13}C-NMR spectra of compound (S)-3-amino-1-(2-bromophenyl)-5-oxo-6,7-dihydro-1*H*,5*H*--pyrazolo[1,2-*a*]pyrazole-2-carbonitrile 3c

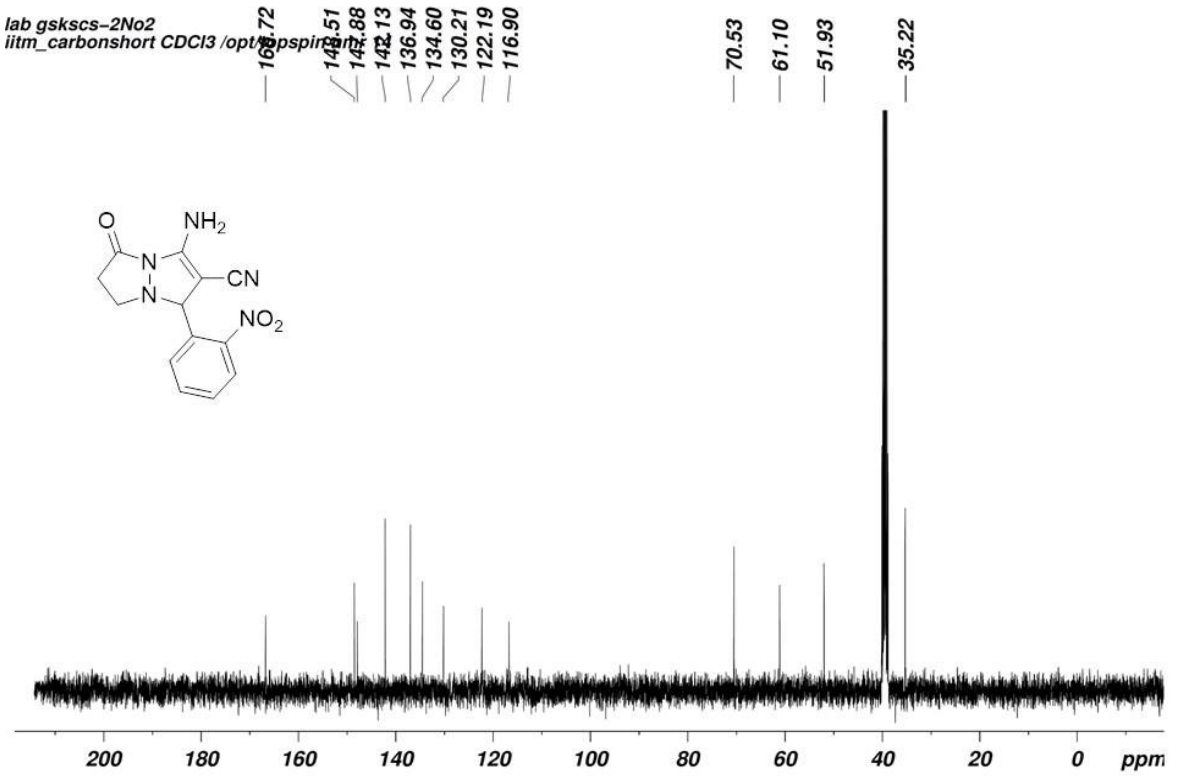


^{1}H and ^{13}C-NMR spectra of compound (S)-3-amino-1-(2-methoxyphenyl)-5-oxo-6,7-dihydro-1*H*,5*H*-pyrazolo[1,2-*a*]pyrazole-2-carbonitrile 3d

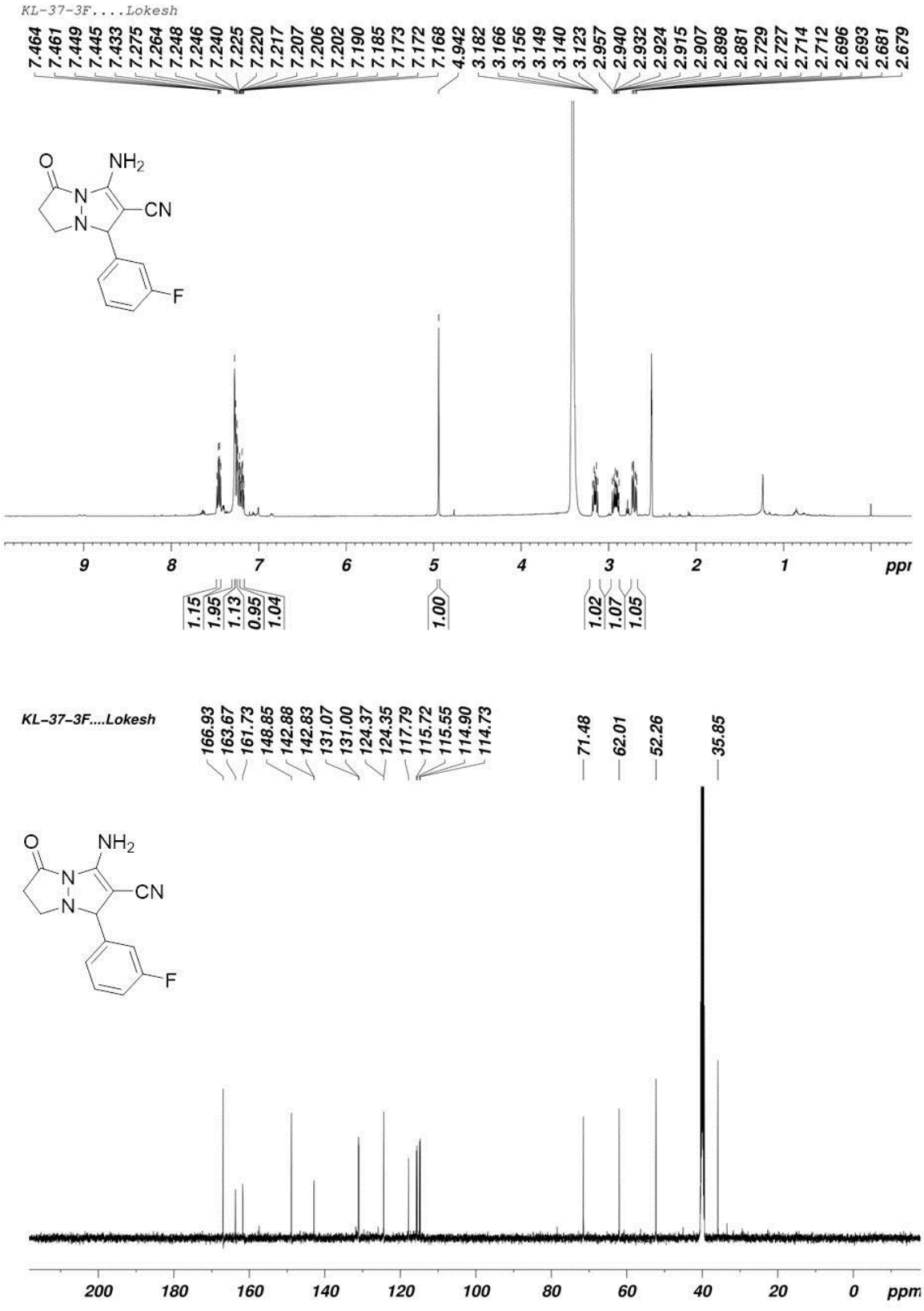


^{1}H and ^{13}C-NMR spectra of compound (S)-3-amino-1-(2-nitrophenyl)-5-oxo-6,7-dihydro-1*H*,5*H*-pyrazolo[1,2-*a*]pyrazole-2-carbonitrile 3e

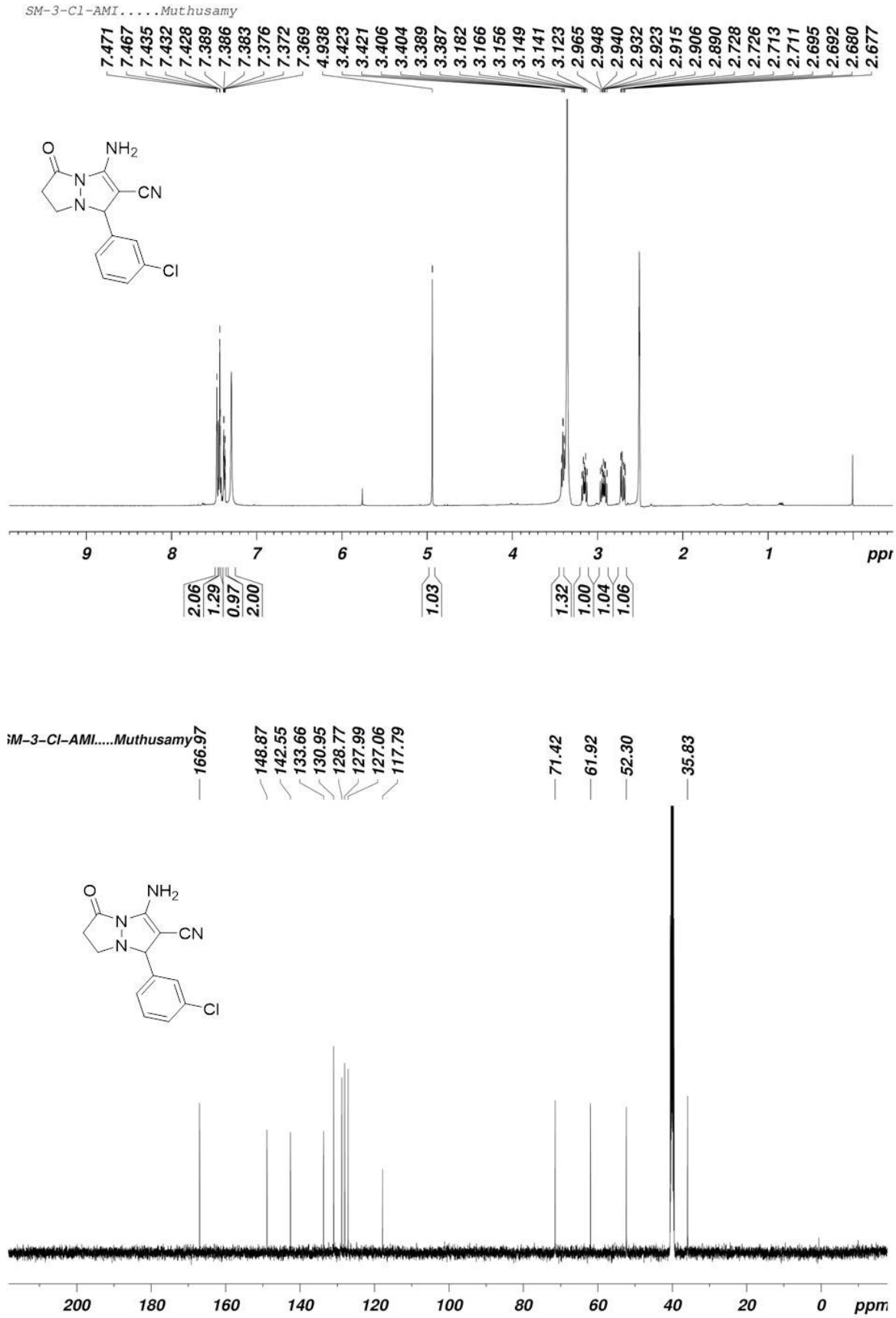




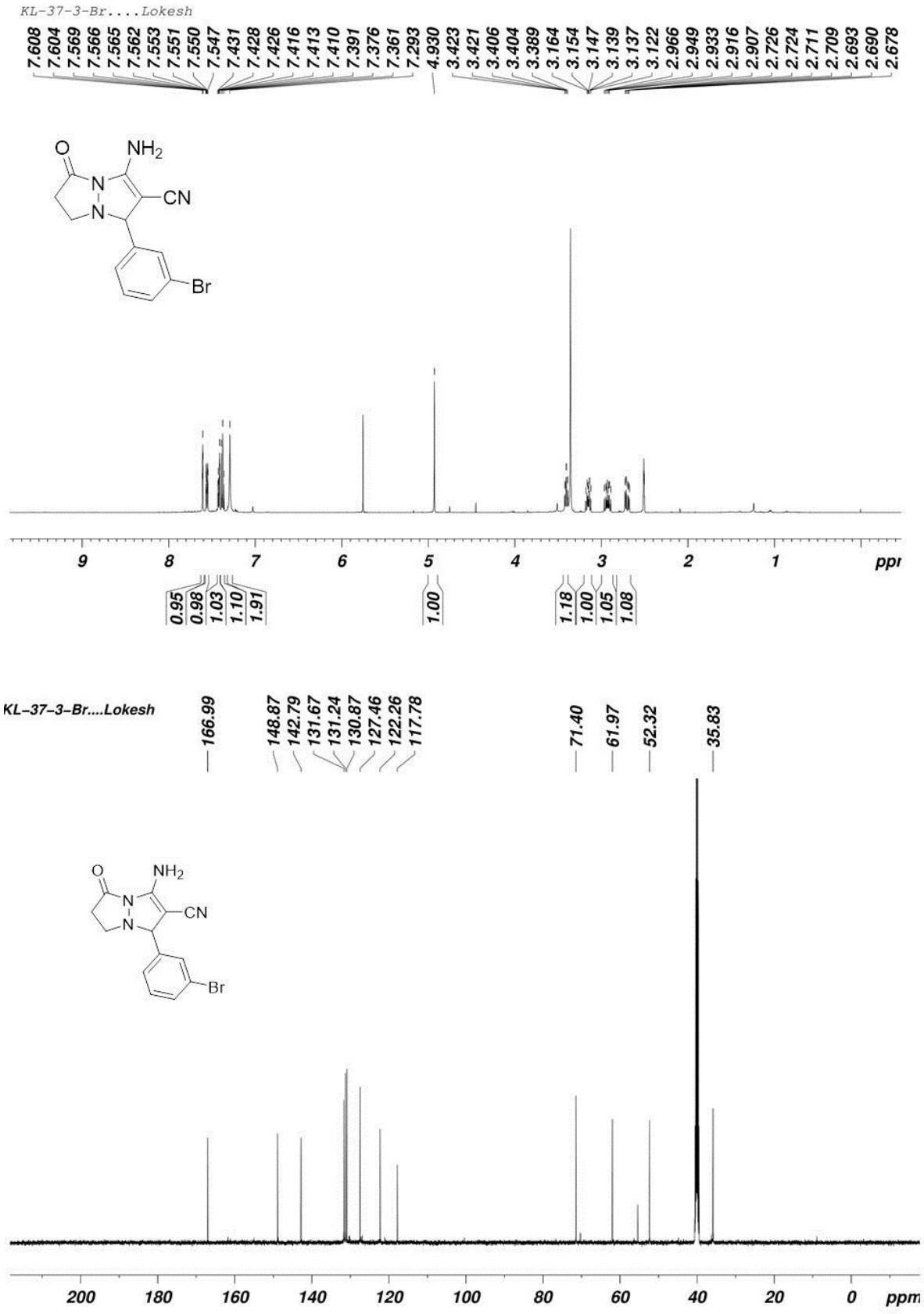
^{1}H and ^{13}C-NMR spectra of compound (R)-3-amino-1-(3-fluorophenyl)-5-oxo-6,7-dihydro-1*H*,5*H*-pyrazolo[1,2-*a*]pyrazole-2-carbonitrile 3f



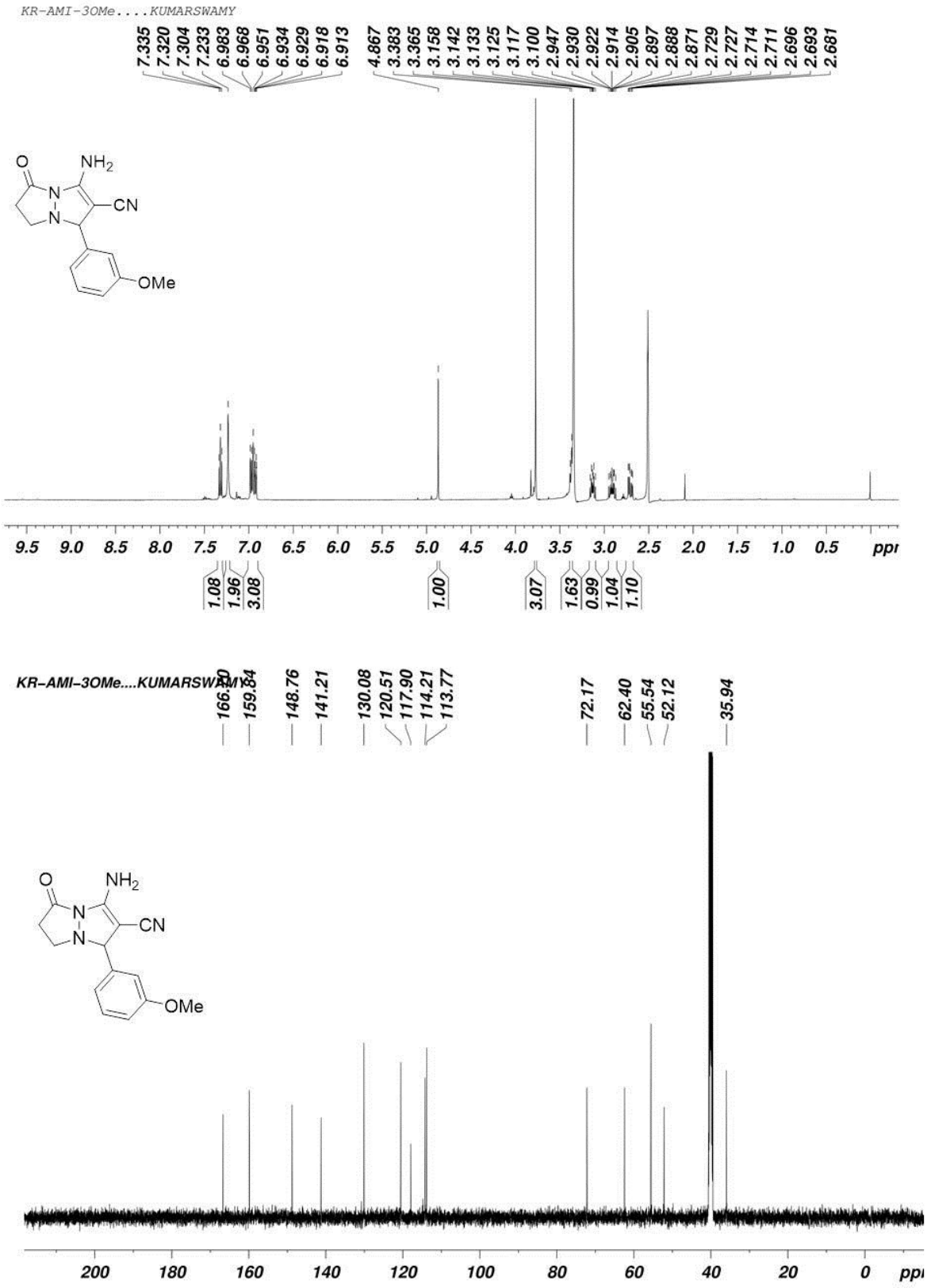
^{1}H and ^{13}C-NMR spectra of compound (R)-3-amino-1-(3-chlorophenyl)-5-oxo-6,7-dihydro-1*H*,5*H*-pyrazolo[1,2-*a*]pyrazole-2-carbonitrile 3g



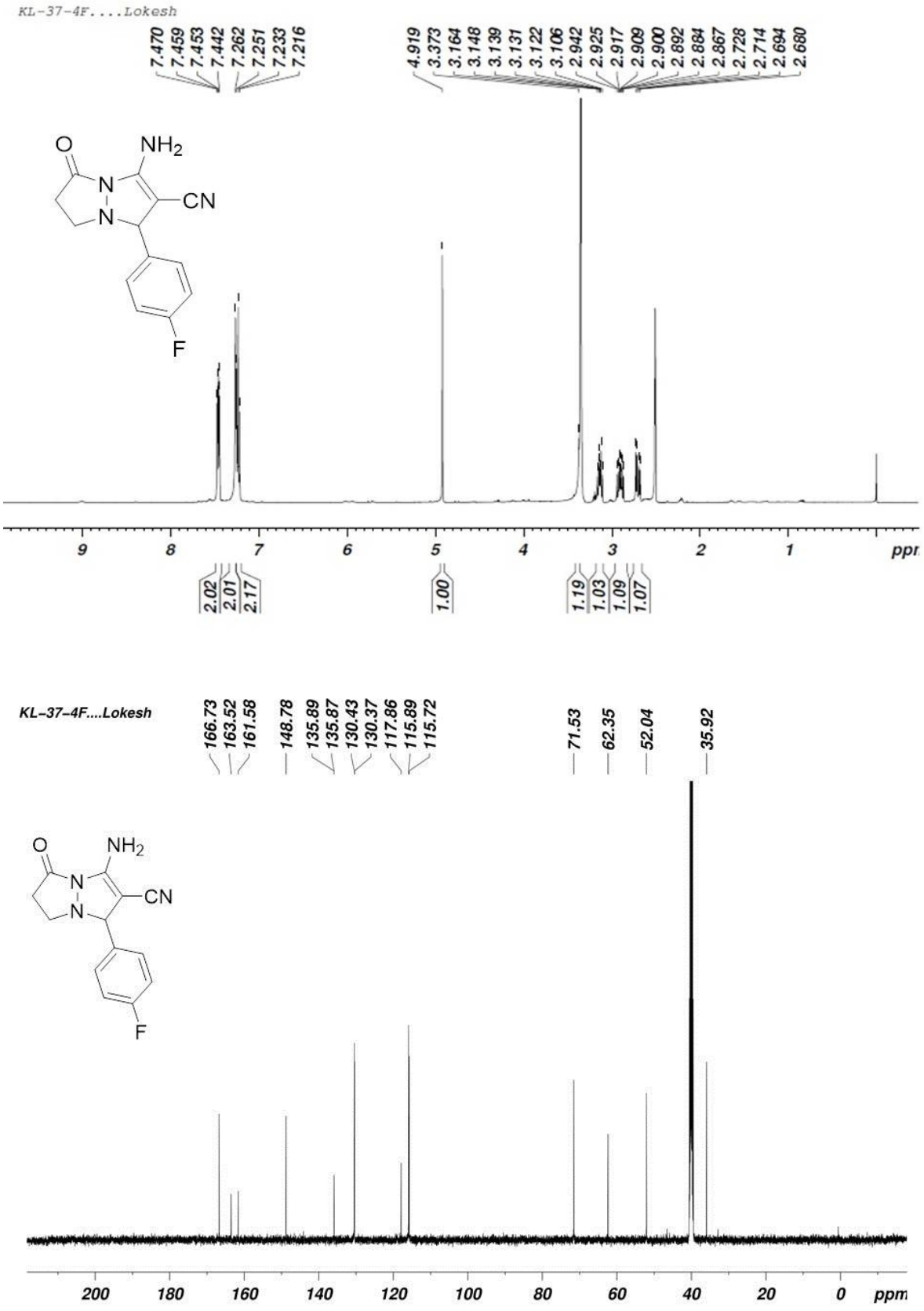
^{1}H and ^{13}C-NMR spectra of compound (R)-3-amino-1-(3-bromophenyl)-5-oxo-6,7-dihydro-1*H*,5*H*-pyrazolo[1,2-*a*]pyrazole-2-carbonitrile 3h



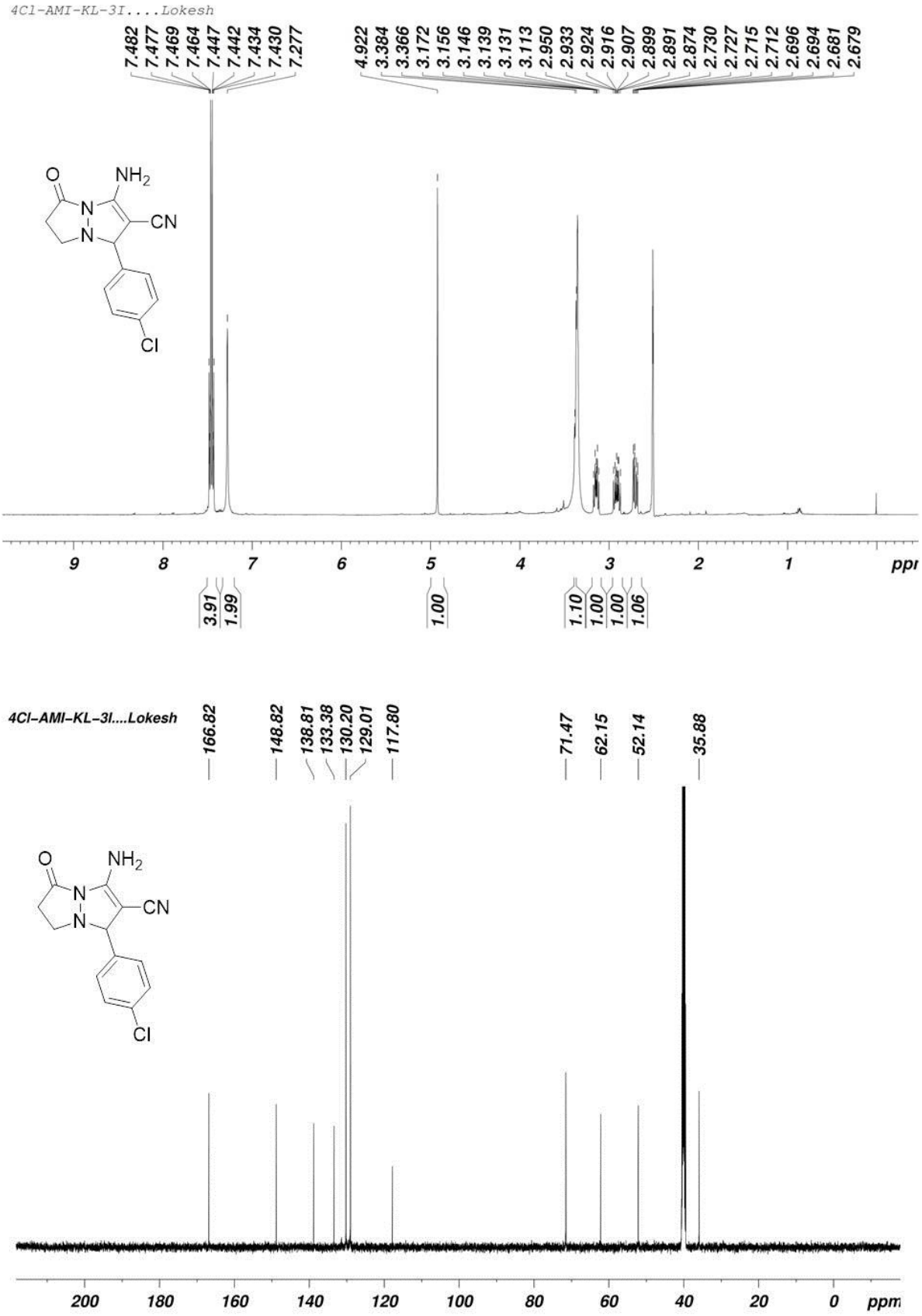
^{1}H and ^{13}C-NMR spectra of compound (R)-3-amino-1-(3-methoxyphenyl)-5-oxo-6,7-dihydro-1*H*,5*H*-pyrazolo[1,2-*a*]pyrazole-2-carbonitrile 3i



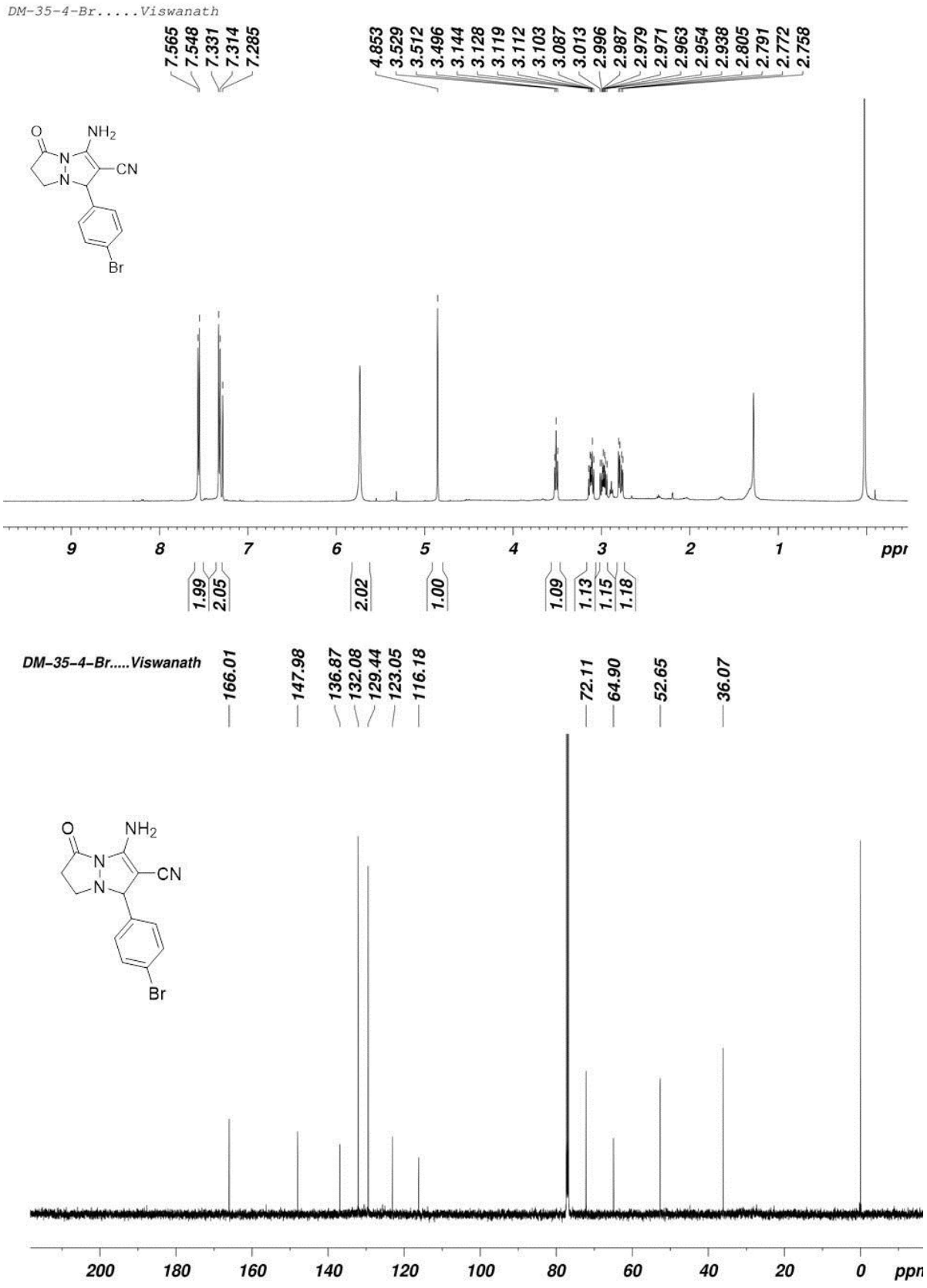
^{1}H and ^{13}C-NMR spectra of compound (R)-3-amino-1-(4-fluorophenyl)-5-oxo-6,7-dihydro-1*H*,5*H*-pyrazolo[1,2-*a*]pyrazole-2-carbonitrile 3j



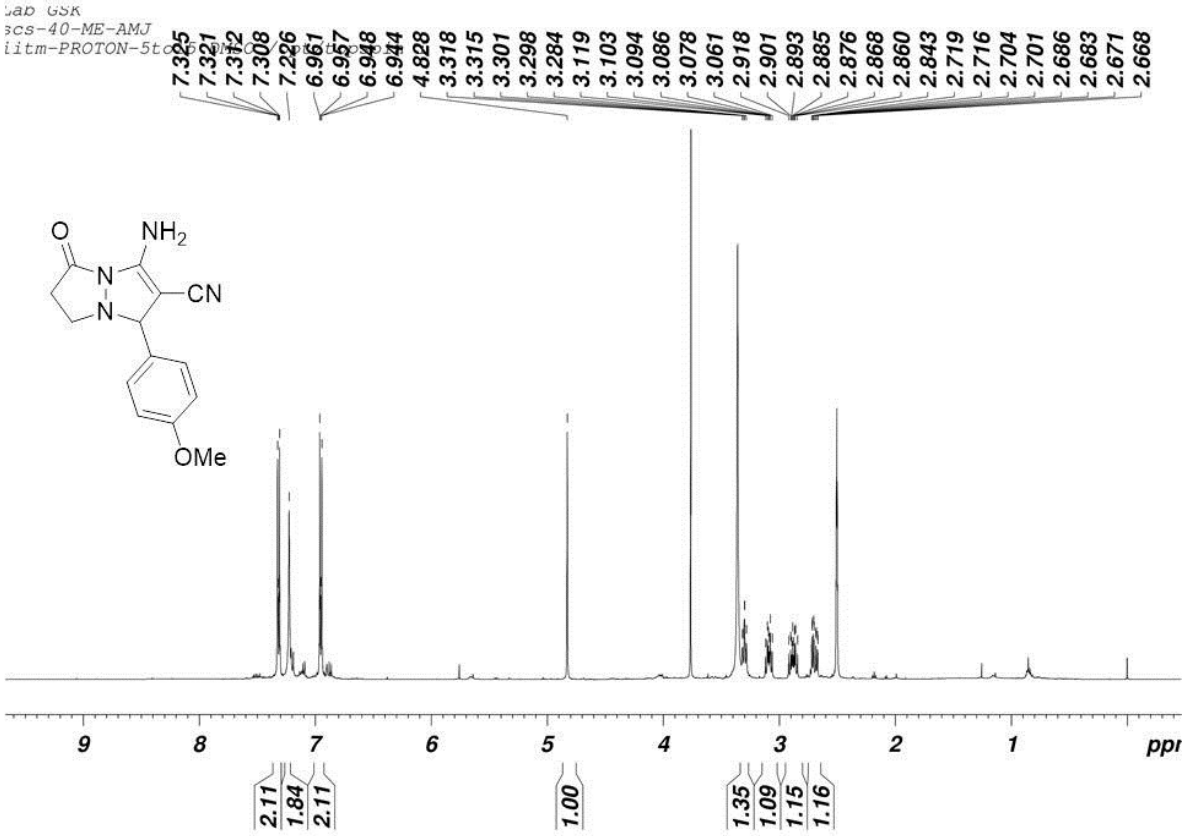
^{1}H and ^{13}C-NMR spectra of compound (R)-3-amino-1-(4-chlorophenyl)-5-oxo-6,7-dihydro-1*H*,5*H*-pyrazolo[1,2-*a*]pyrazole-2-carbonitrile 3k

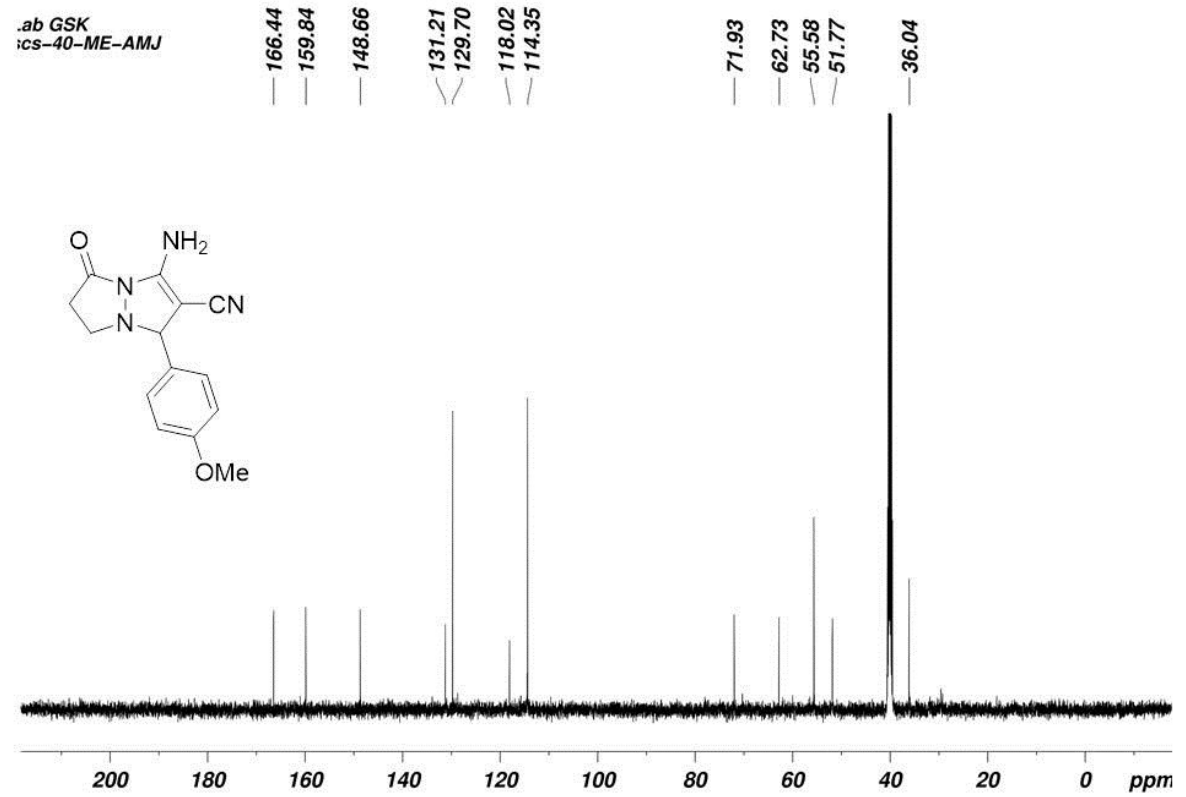


^{1}H and ^{13}C-NMR spectra of compound (R)-3-amino-1-(4-bromophenyl)-5-oxo-6,7-dihydro-1*H*,5*H*-pyrazolo[1,2-*a*]pyrazole-2-carbonitrile 3l

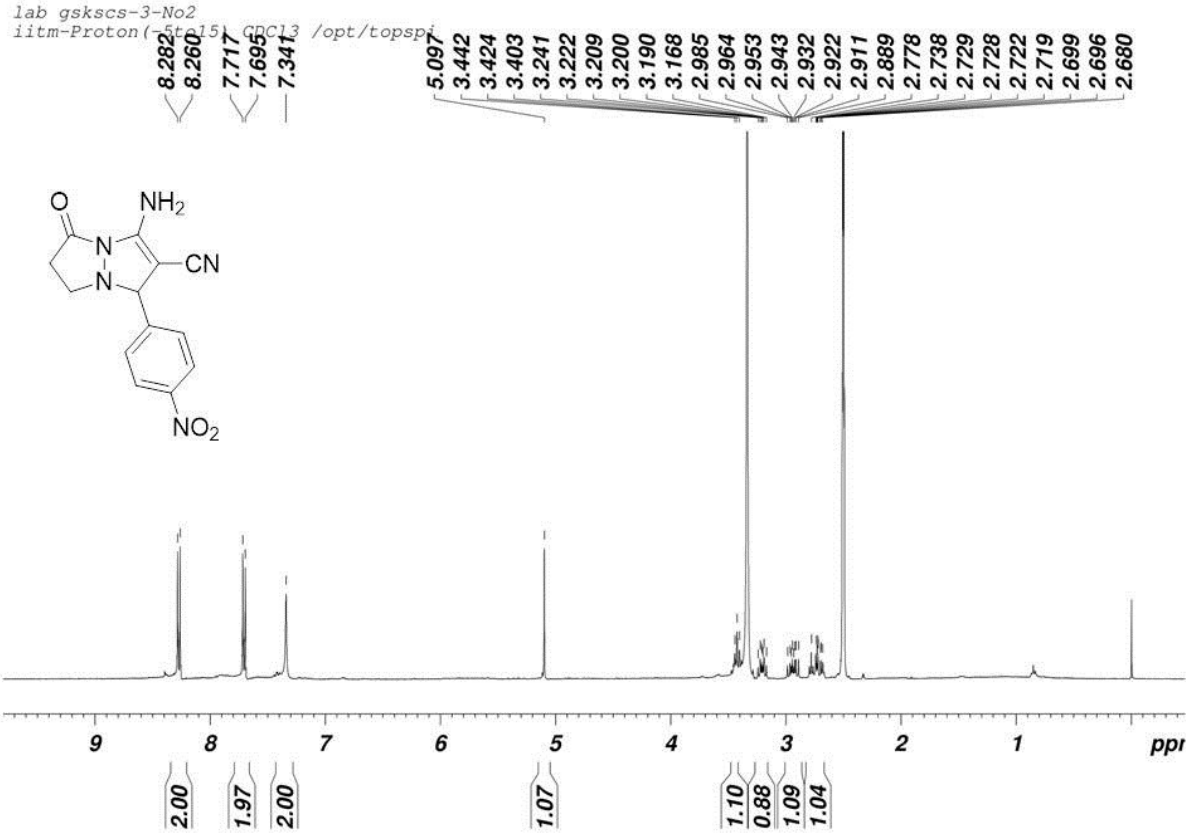


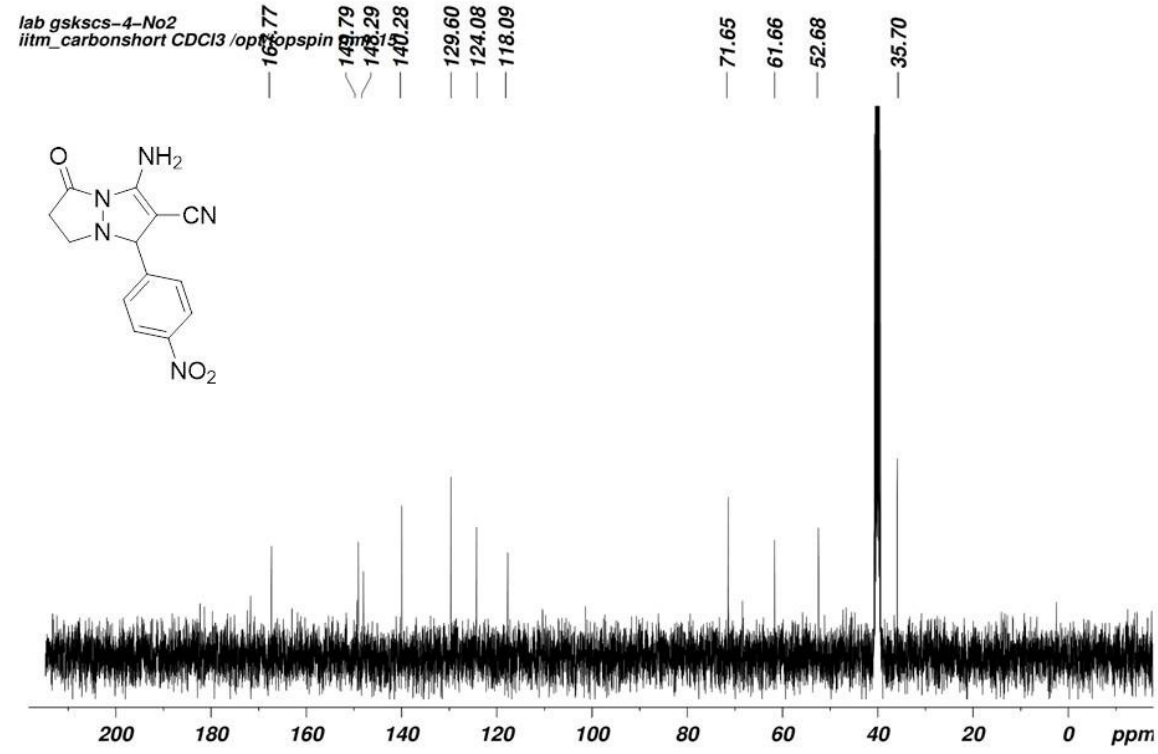
^{1}H and ^{13}C-NMR spectra of compound (R)-3-amino-1-(4-methoxyphenyl)-5-oxo-6,7-dihydro-1*H*,5*H*-pyrazolo[1,2-*a*]pyrazole-2-carbonitrile 3m



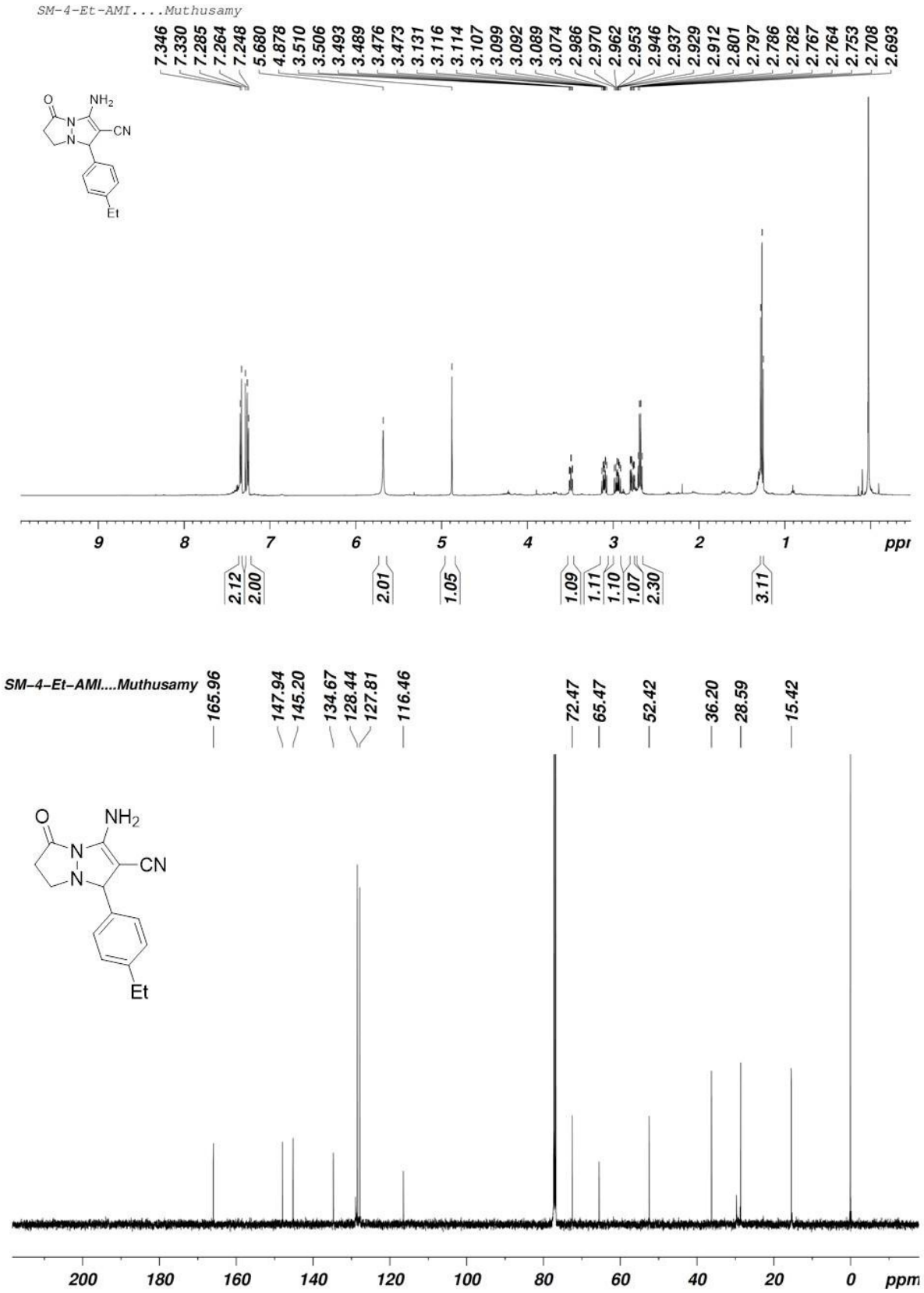


^{1}H and ^{13}C-NMR spectra of compound (R)-3-amino-1-(4-nitrophenyl)-5-oxo-6,7-dihydro-1*H*,5*H*-pyrazolo[1,2-*a*]pyrazole-2-carbonitrile 3n

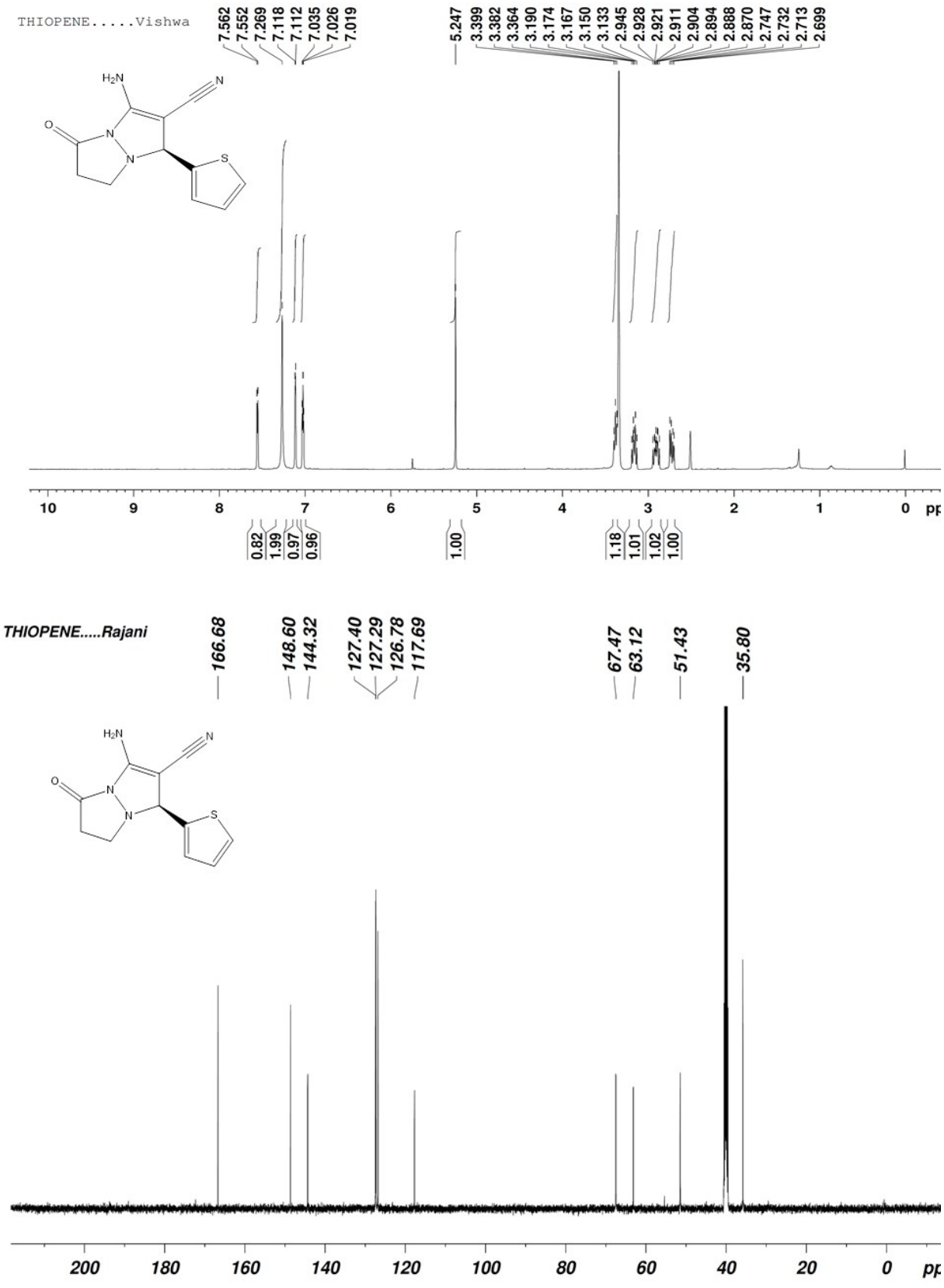




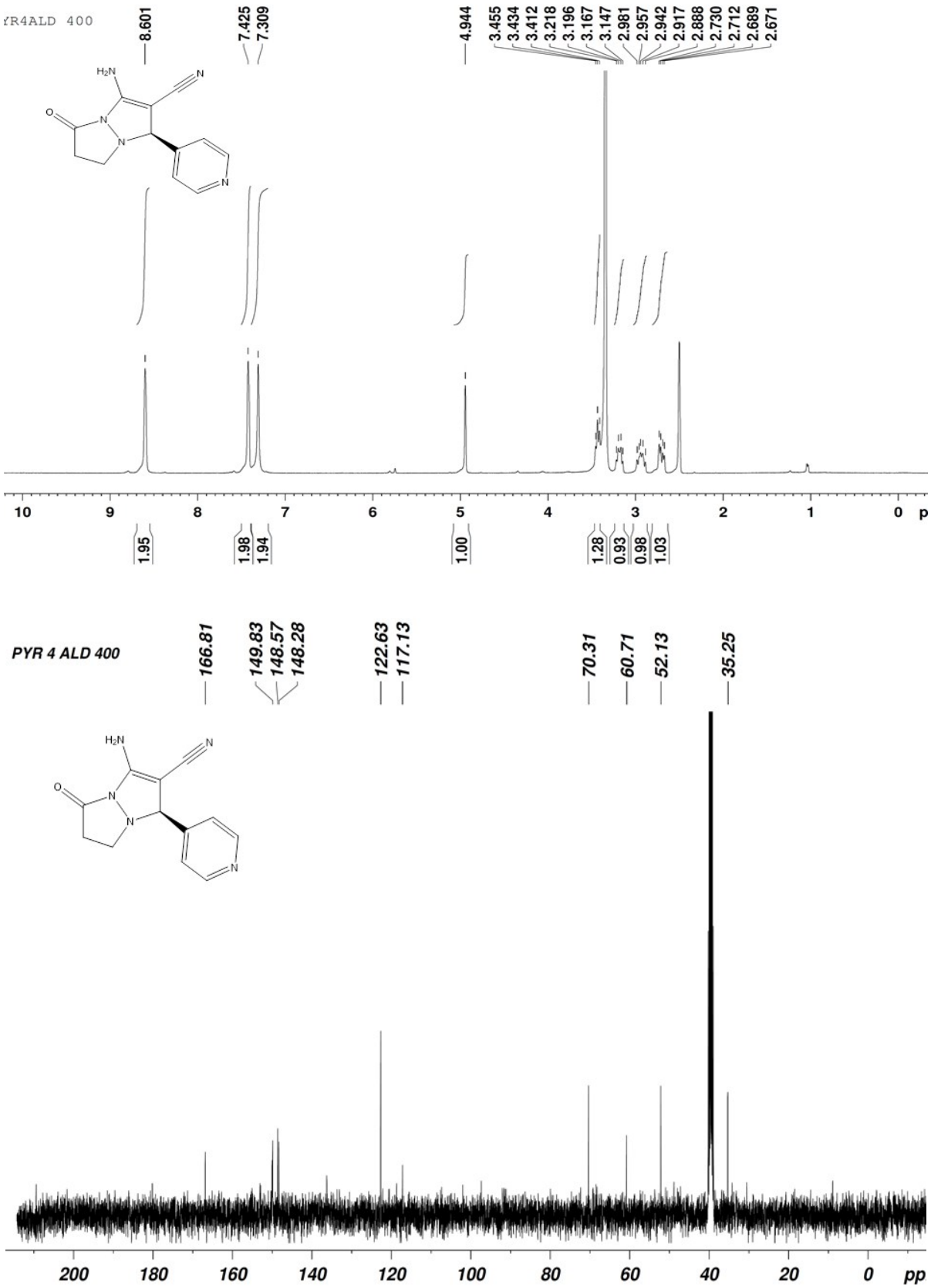
^{1}H and ^{13}C-NMR spectra of compound (R)-3-amino-1-(4-ethylphenyl)-5-oxo-6,7-dihydro-1*H*,5*H*-pyrazolo[1,2-*a*]pyrazole-2-carbonitrile 3o



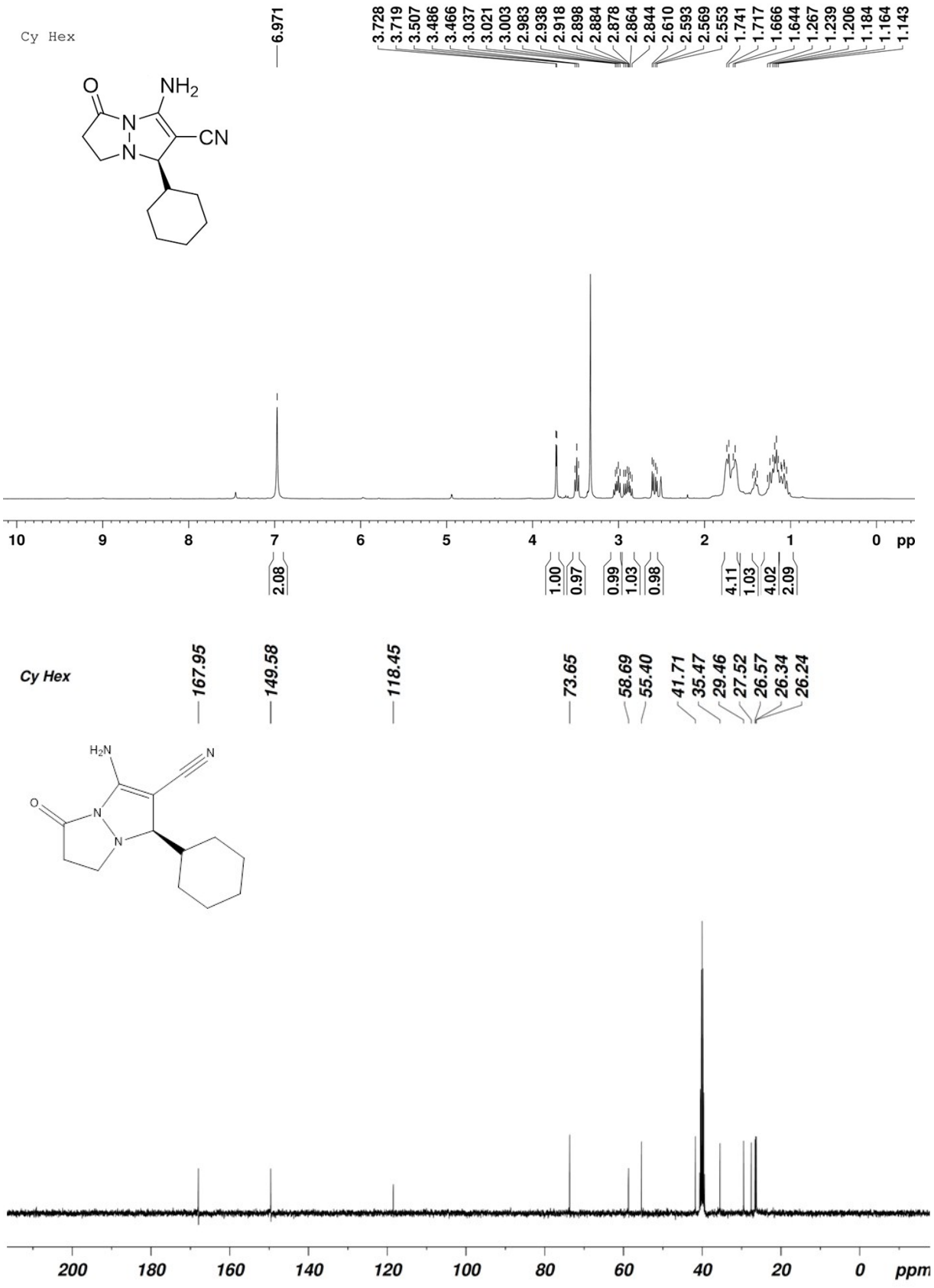
^{1}H and ^{13}C-NMR spectra of compound (S)-3-amino-5-oxo-1-(thiophen-2-yl)-6,7-dihydro-1*H*,5*H*-pyrazolo[1,2-*a*]pyrazole-2-carbonitrile 3p



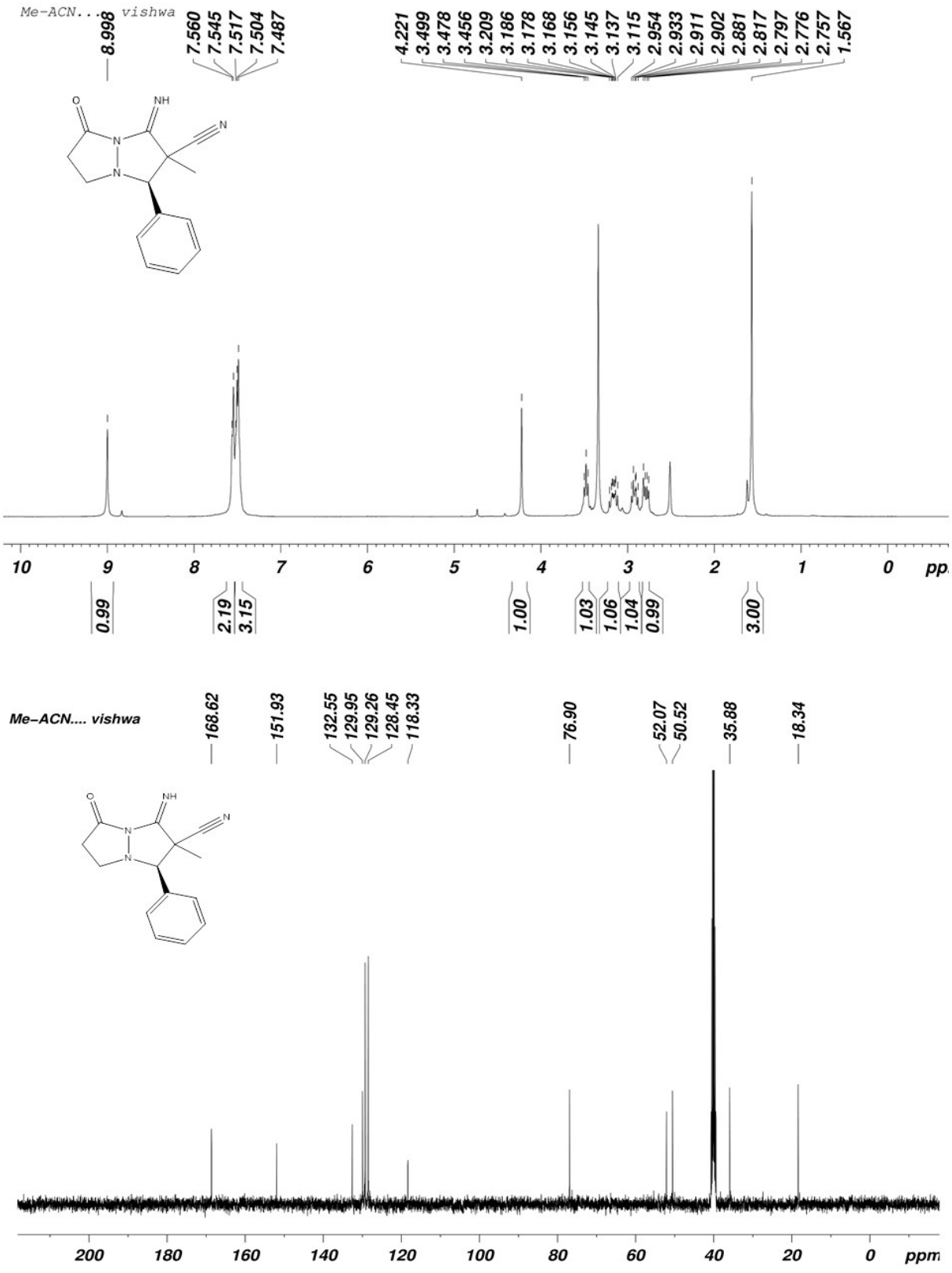
^{1}H and ^{13}C-NMR spectra of compound (R)-3-amino-5-oxo-1-(pyridin-4-yl)-6,7-dihydro-1*H*,5*H*-pyrazolo[1,2-*a*]pyrazole-2-carbonitrile 3q



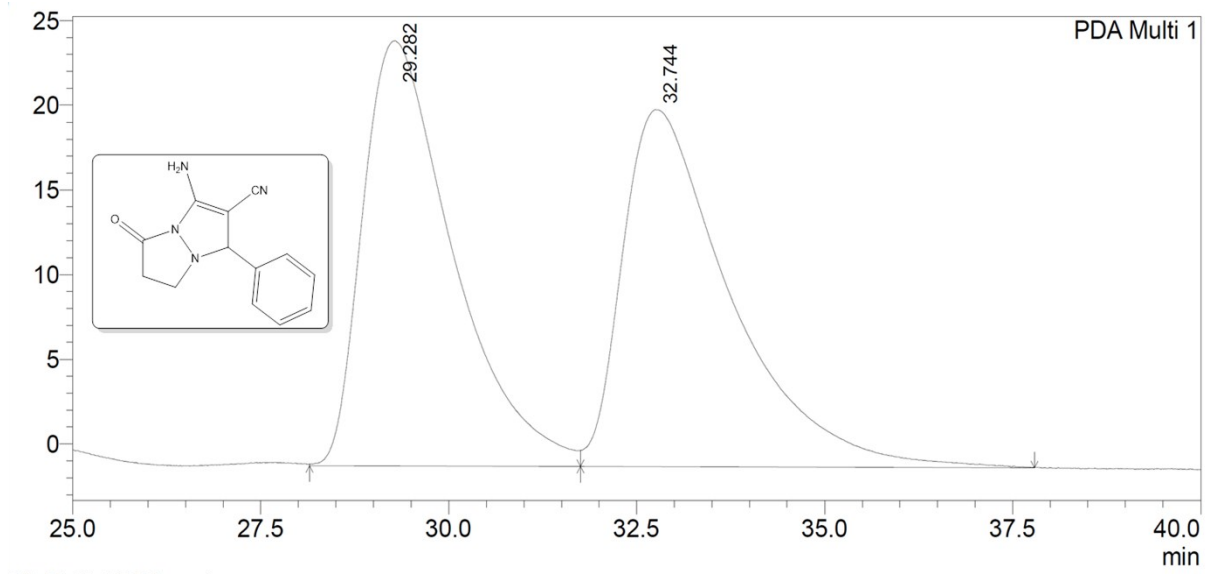
^{1}H and ^{13}C-NMR spectra of compound (R)-3-amino-1-cyclohexyl-5-oxo-6,7-dihydro-1*H*,5*H*-pyrazolo[1,2-*a*]pyrazole-2-carbonitrile 3r



^{1}H and ^{13}C-NMR spectra of compound (R)-3-amino-1-cyclohexyl-5-oxo-6,7-dihydro-1*H*,5*H*-pyrazolo[1,2-*a*]pyrazole-2-carbonitrile 3s



HPLC profile for 3-amino-5-oxo-1-phenyl-6,7-dihydro-1*H*,5*H*-pyrazolo[1,2-*a*]pyrazole-2-carbonitrile 3

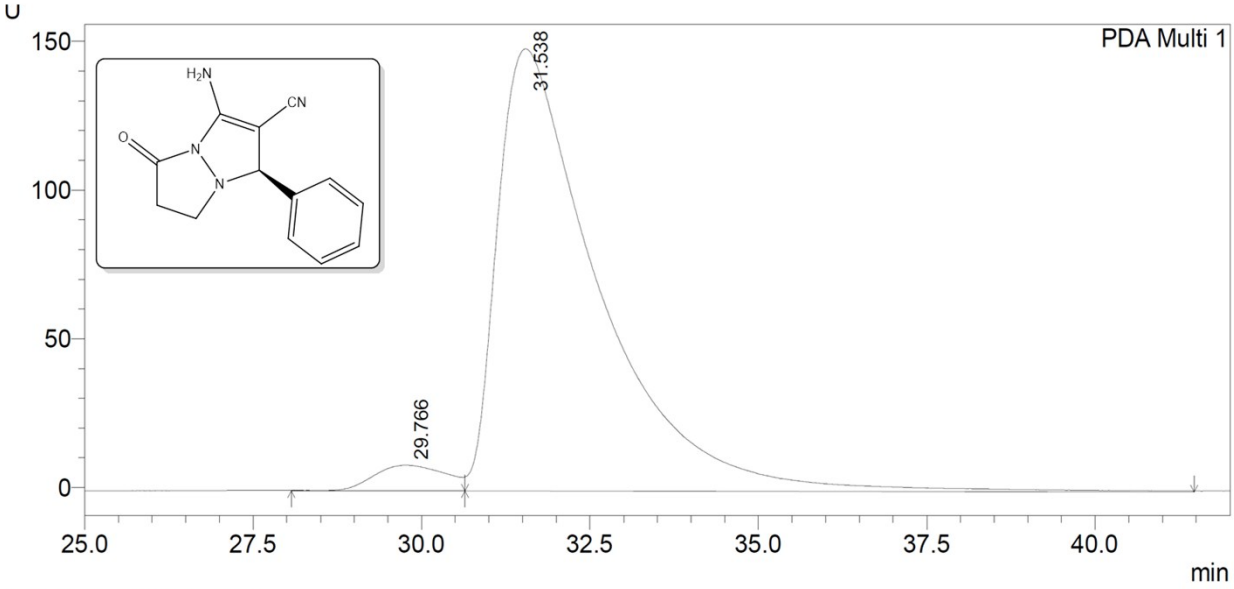


DA Multi 1/254nm 4nm

PeakTable

PDA Ch1 254nm 4nm

Peak#	Ret. Time	Area	Height	Area %	Height %
1	29.282	2096404	25106	49.805	54.352
2	32.744	2112843	21086	50.195	45.648
3	58.560	-0	0	-0.000	0.000
4	72.384	-0	0	-0.000	0.000
Total		4209248	46192	100.000	100.000



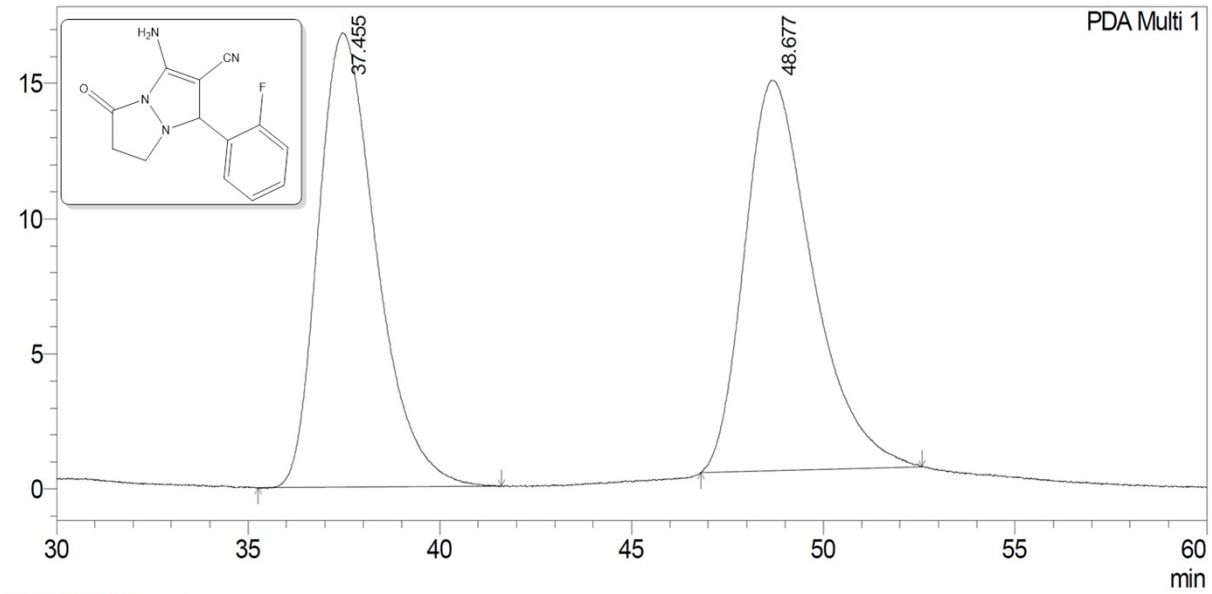
PDA Multi 1/254nm 4nm

PeakTable

PDA Ch1 254nm 4nm

Peak#	Ret. Time	Area	Height	Area %	Height %
1	29.766	644513	8644	3.943	5.496
2	31.538	15701209	148642	96.057	94.504
3	58.560	-0	0	-0.000	0.000
4	72.384	-0	0	-0.000	0.000
Total		16345722	157286	100.000	100.000

HPLC profile for 3-amino-1-(2-fluorophenyl)-5-oxo-6,7-dihydro-1H,5H-pyrazolo[1,2-a]pyrazole-2-carbonitrile 3a

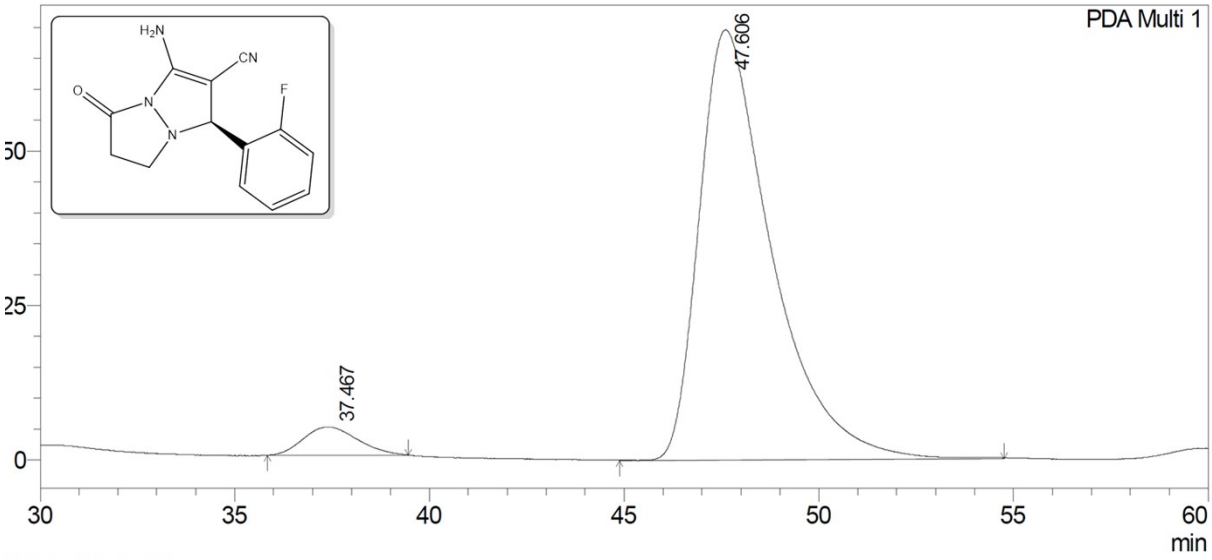


)A Multi 1/254nm 4nm

PeakTable

PDA Ch1 254nm 4nm

Peak#	Ret. Time	Area	Height	Area %	Height %
1	37.455	1773375	16795	49.898	53.792
2	48.677	1780601	14428	50.102	46.208
Total		3553977	31223	100.000	100.000



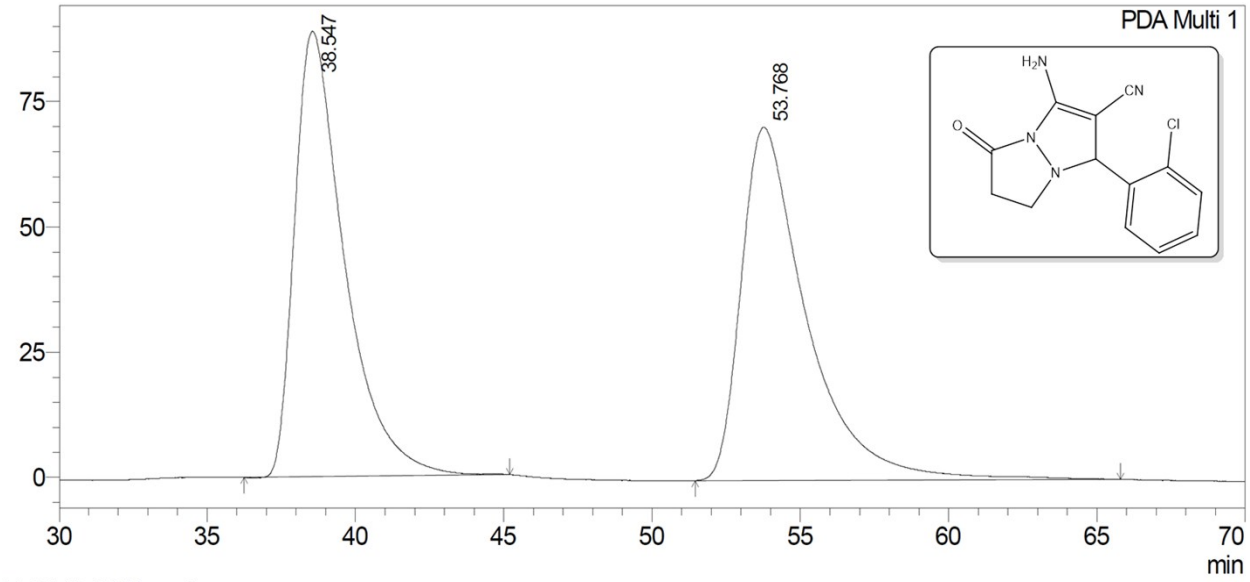
Multi 1/254nm 4nm

PeakTable

PDA Ch1 254nm 4nm

Peak#	Ret. Time	Area	Height	Area %	Height %
1	37.467	442738	4581	4.679	6.171
2	47.606	9019975	69650	95.321	93.829
Total		9462712	74231	100.000	100.000

HPLC profile for 3-amino-1-(2-chlorophenyl)-5-oxo-6,7-dihydro-1H,5H-pyrazolo[1,2-a]pyrazole-2-carbonitrile 3b

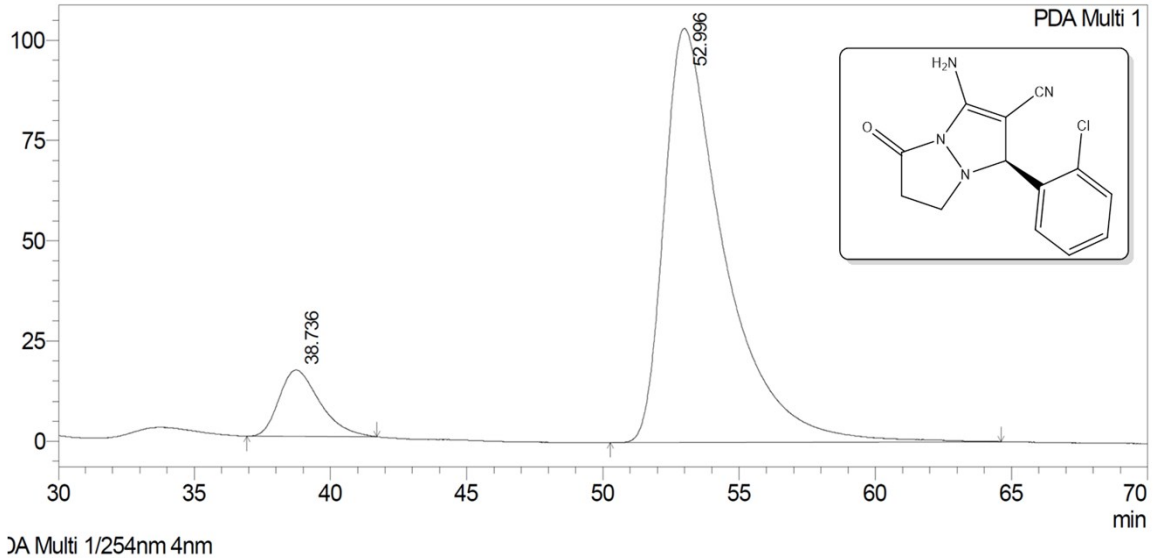


DA Multi 1/254nm 4nm

PeakTable

PDA Ch1 254nm 4nm

Peak#	Ret. Time	Area	Height	Area %	Height %
1	38.547	10396353	88943	48.951	55.799
2	53.768	10842078	70455	51.049	44.201
Total		21238432	159398	100.000	100.000



DA Multi 1/254nm 4nm

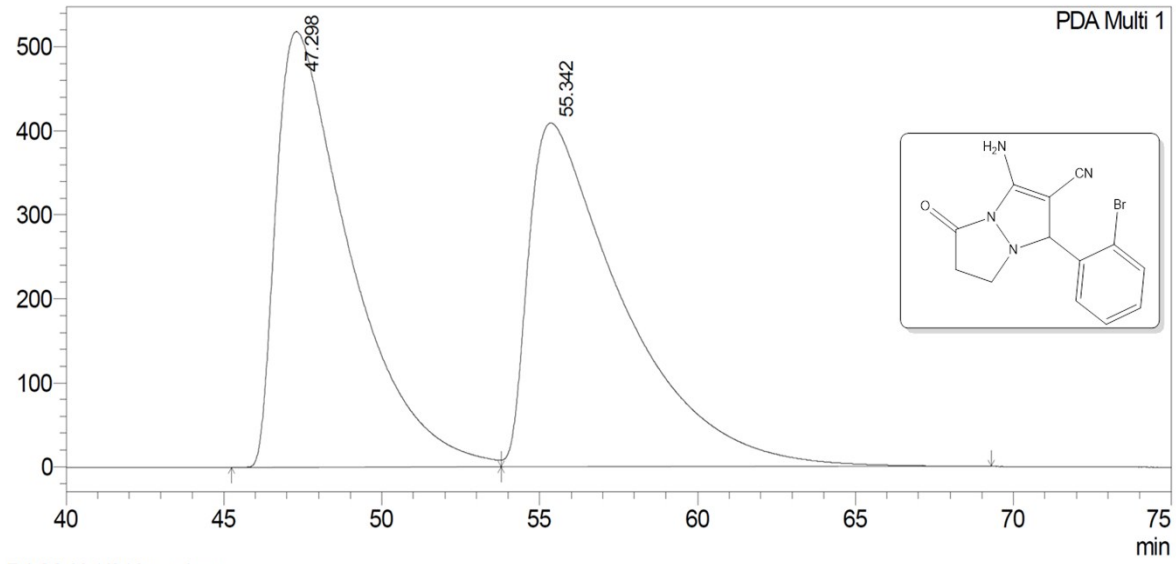
PeakTable

PDA Ch1 254nm 4nm

Peak#	Ret. Time	Area	Height	Area %
1	38.736	1721049	16536	9.786
2	52.996	15864945	103293	90.214
Total		17585994	119829	100.000

Height %
13.800
86.200
100.000

HPLC profile for 3-amino-1-(2-bromophenyl)-5-oxo-6,7-dihydro-1H,5H-pyrazolo[1,2-a]pyrazole-2-carbonitrile 3c

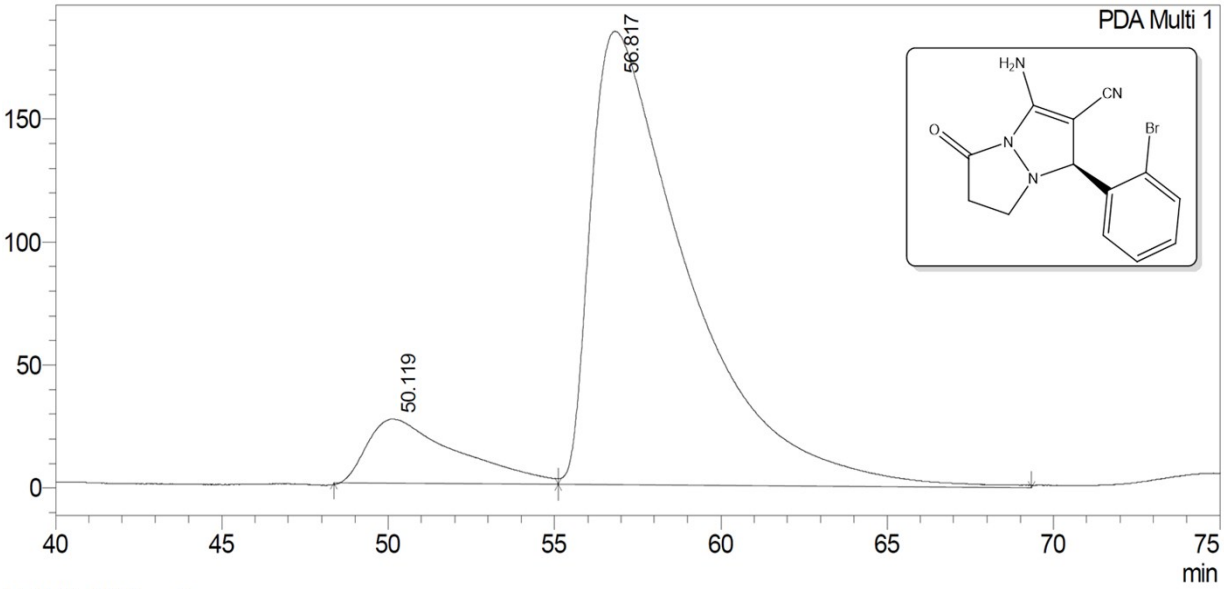


DA Multi 1/210nm 4nm

PeakTable

PDA Ch1 210nm 4nm

Peak#	Ret. Time	Area	Height	Area %	Height %
1	47.298	84579678	518749	49.716	55.882
2	55.342	85546748	409553	50.284	44.118
Total		170126426	928302	100.000	100.000



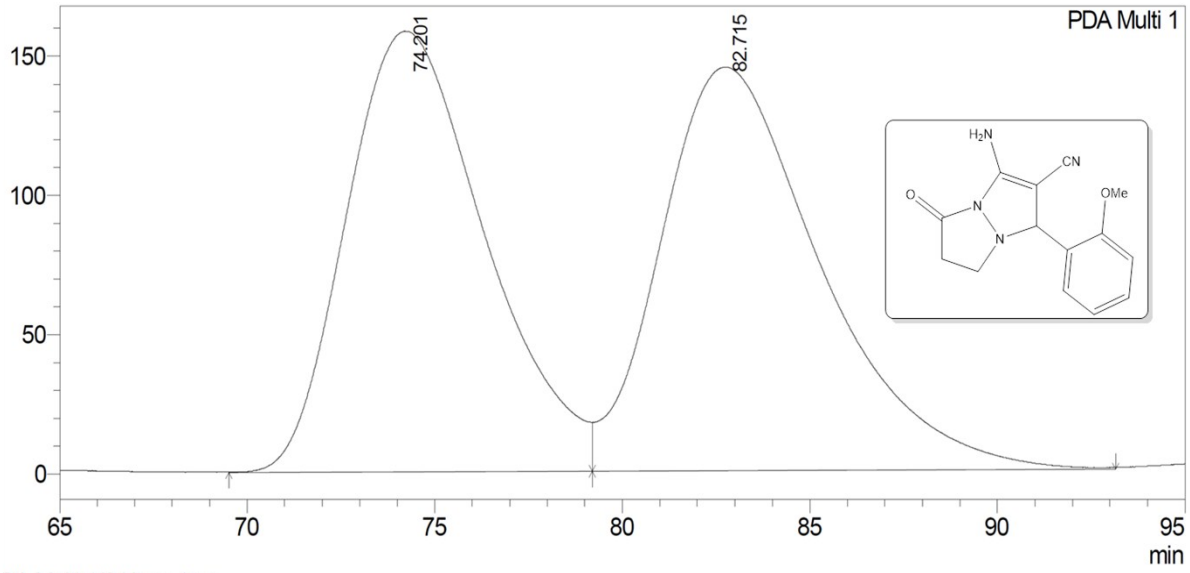
DA Multi 1/210nm 4nm

PeakTable

PDA Ch1 210nm 4nm

Peak#	Ret. Time	Area	Height	Area %	Height %
1	50.119	4857012	25948	11.438	12.343
2	56.817	37606799	184278	88.562	87.657
Total		42463810	210226	100.000	100.000

HPLC profile for 3-amino-1-(2-methoxyphenyl)-5-oxo-6,7-dihydro-1H,5H-pyrazolo[1,2-a]pyrazole-2-carbonitrile 3d

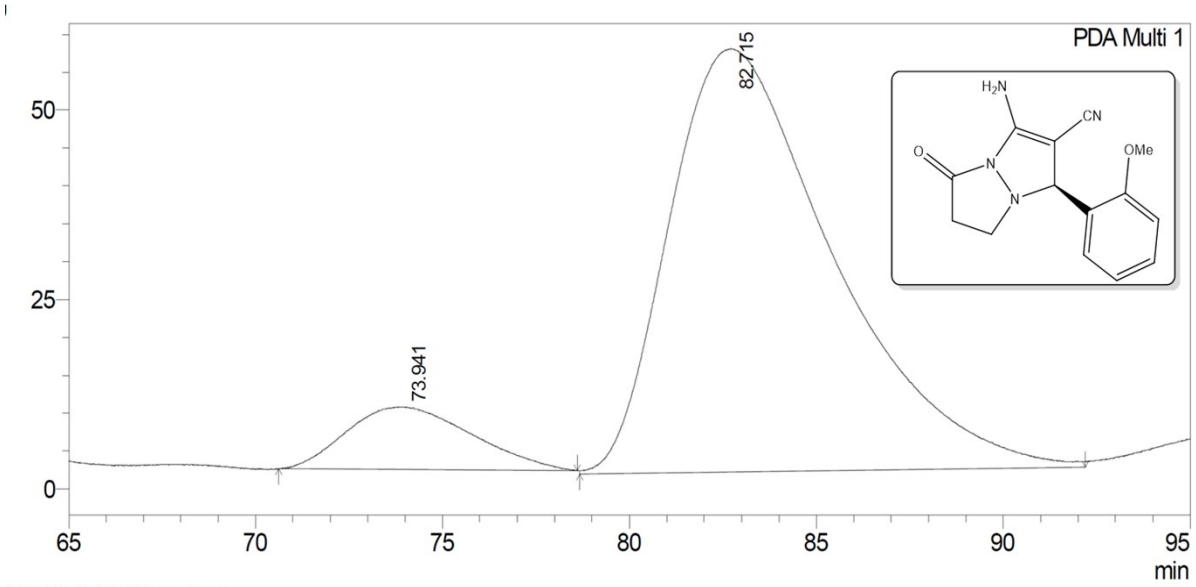


DA Multi 1/210nm 4nm

PeakTable

PDA Ch1 210nm 4nm

Peak#	Ret. Time	Area	Height	Area %	Height %
1	74.201	40698719	158337	48.717	52.199
2	82.715	42842230	144998	51.283	47.801
Total		83540950	303335	100.000	100.000



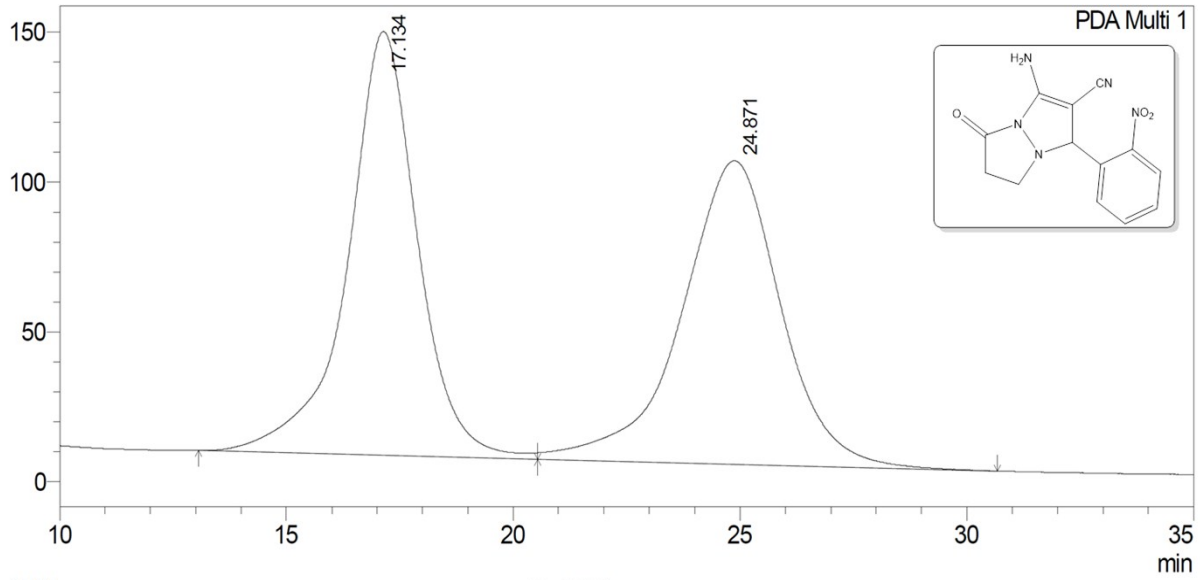
DA Multi 1/210nm 4nm

PeakTable

PDA Ch1 210nm 4nm

Peak#	Ret. Time	Area	Height	Area %	Height %
1	73.941	1917185	8262	10.105	12.880
2	82.715	17054773	55890	89.895	87.120
Total		18971959	64152	100.000	100.000

HPLC profile for 3-amino-1-(2-nitrophenyl)-5-oxo-6,7-dihydro-1H,5H-pyrazolo[1,2-a]pyrazole-2-carbonitrile 3e

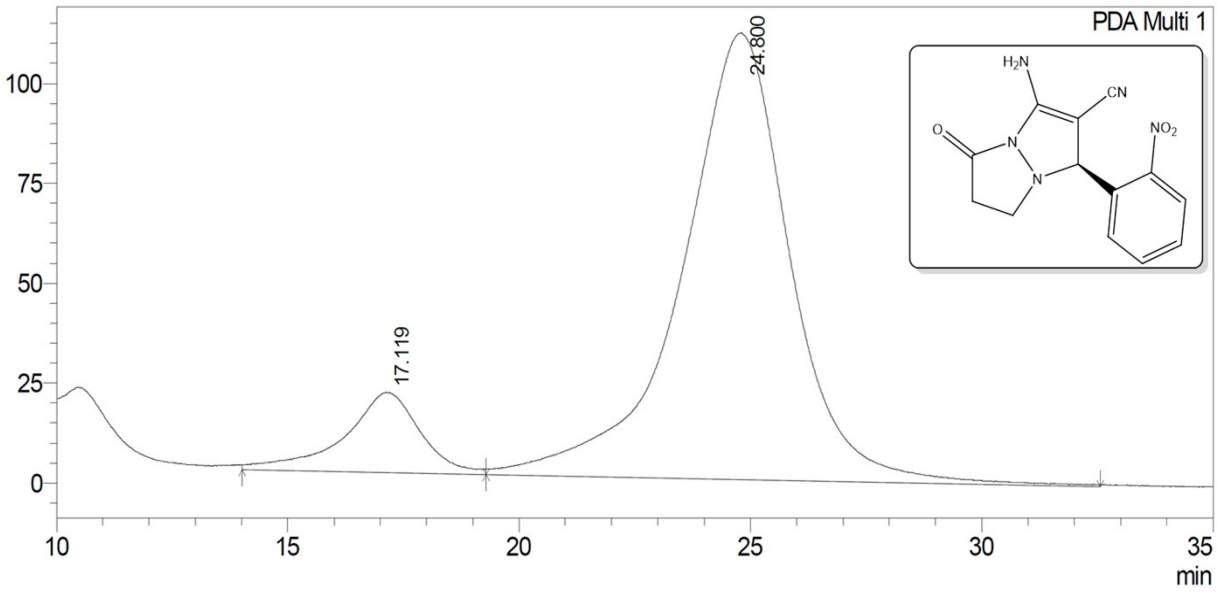


)A Mu

PeakTable

PDA Ch1 254nm 4nm

Peak#	Ret. Time	Area	Height	Area %	Height %
1	17.134	15178017	141345	49.528	58.255
2	24.871	15467034	101285	50.472	41.745
Total		30645051	242630	100.000	100.000



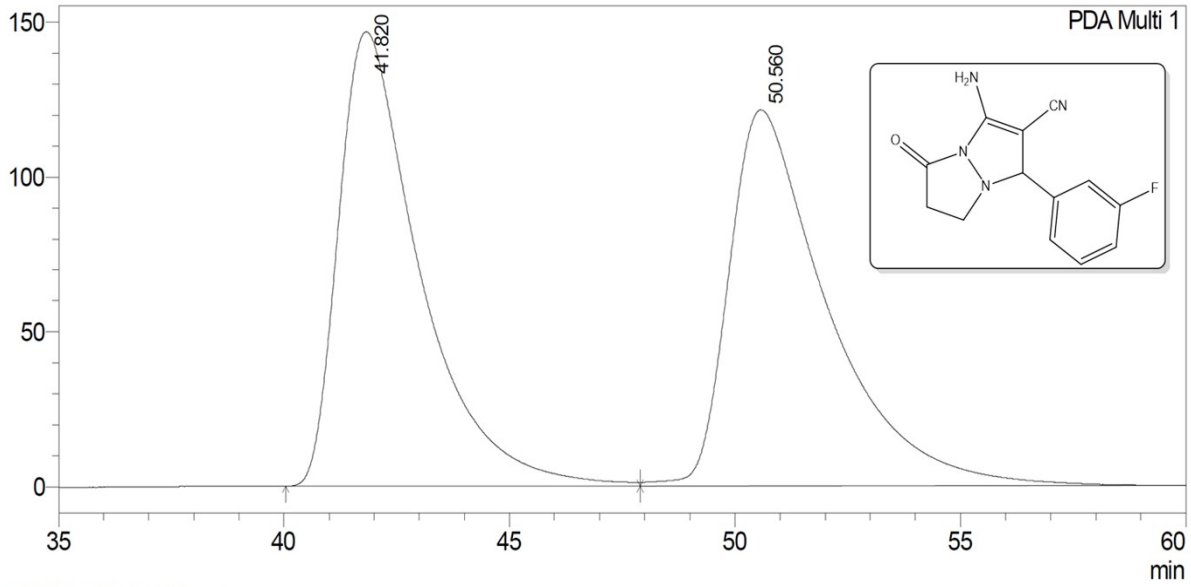
)A Multi 1/210nm 4nm

PeakTable

PDA Ch1 210nm 4nm

Peak#	Ret. Time	Area	Height	Area %	Height %
1	17.119	2326375	20124	11.315	15.254
2	24.800	18232898	111801	88.685	84.746
Total		20559273	131925	100.000	100.000

HPLC profile for 3-amino-1-(3-fluorophenyl)-5-oxo-6,7-dihydro-1H,5H-pyrazolo[1,2-a]pyrazole-2-carbonitrile 3f

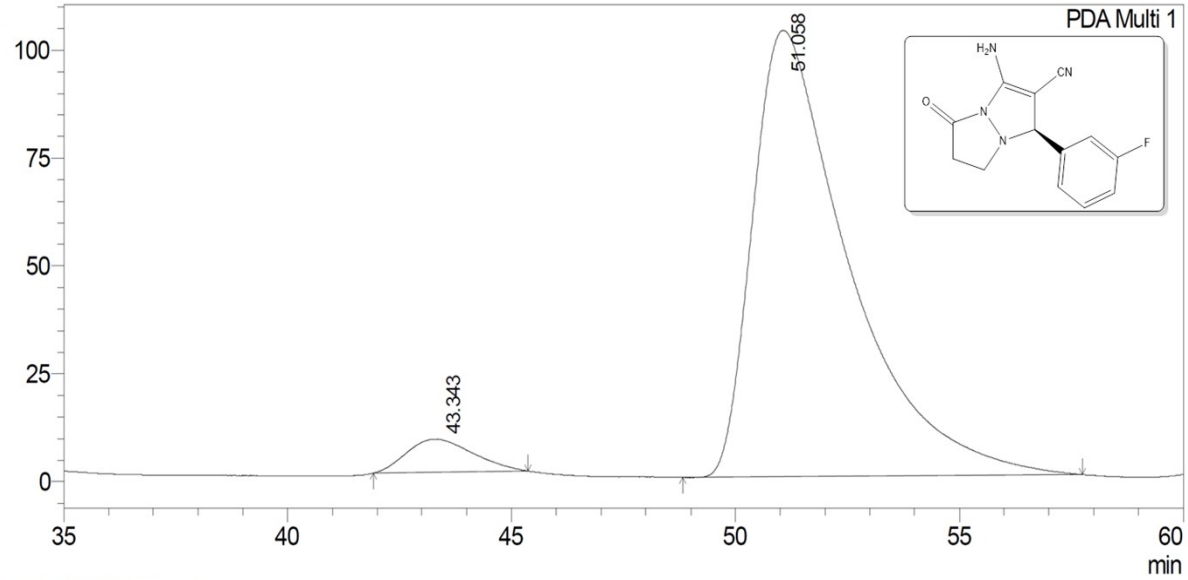


DA Multi 1/254nm 4nm

PeakTable

PDA Ch1 254nm 4nm

Peak#	Ret. Time	Area	Height	Area %	Height %
1	41.820	18425402	146713	49.823	54.731
2	50.560	18555974	121351	50.177	45.269
Total		36981376	268064	100.000	100.000



DA Multi 1/254nm 4nm

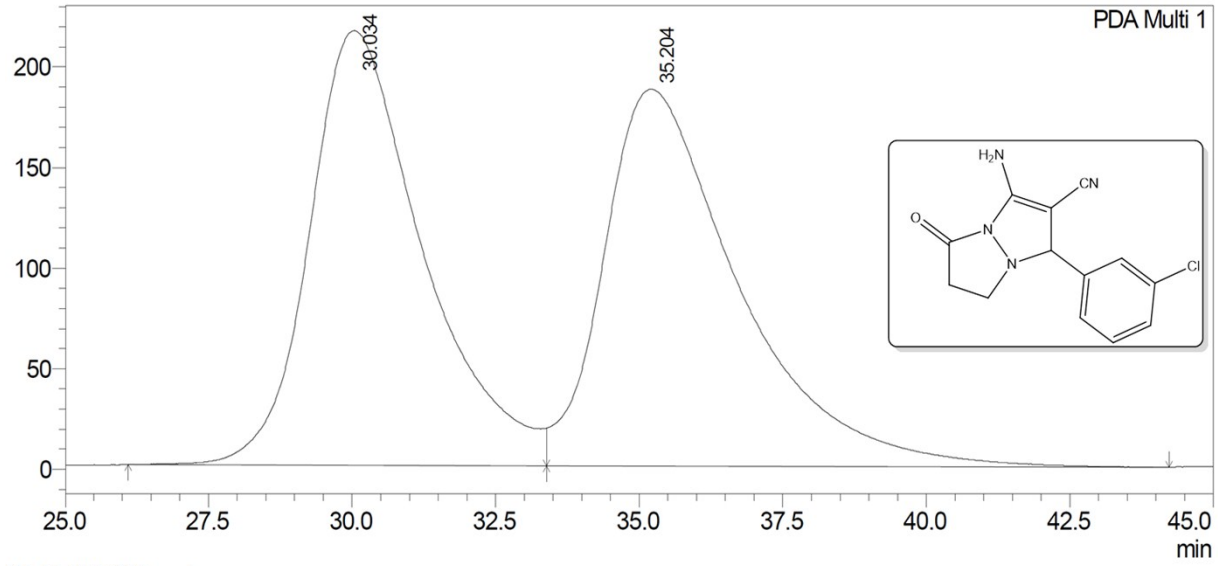
PeakTable

PDA Ch1 254nm 4nm

Peak#	Ret. Time	Area	Height	Area %	Height %
1	43.343	789548	7691	4.855	6.920
2	51.058	15473312	103448	95.145	93.080
Total		16262860	111139	100.000	100.000

HPLC profile for 3-amino-1-(3-chlorophenyl)-5-oxo-6,7-dihydro-1H,5H-

pyrazolo[1,2-a]pyrazole-2-carbonitrile 3g

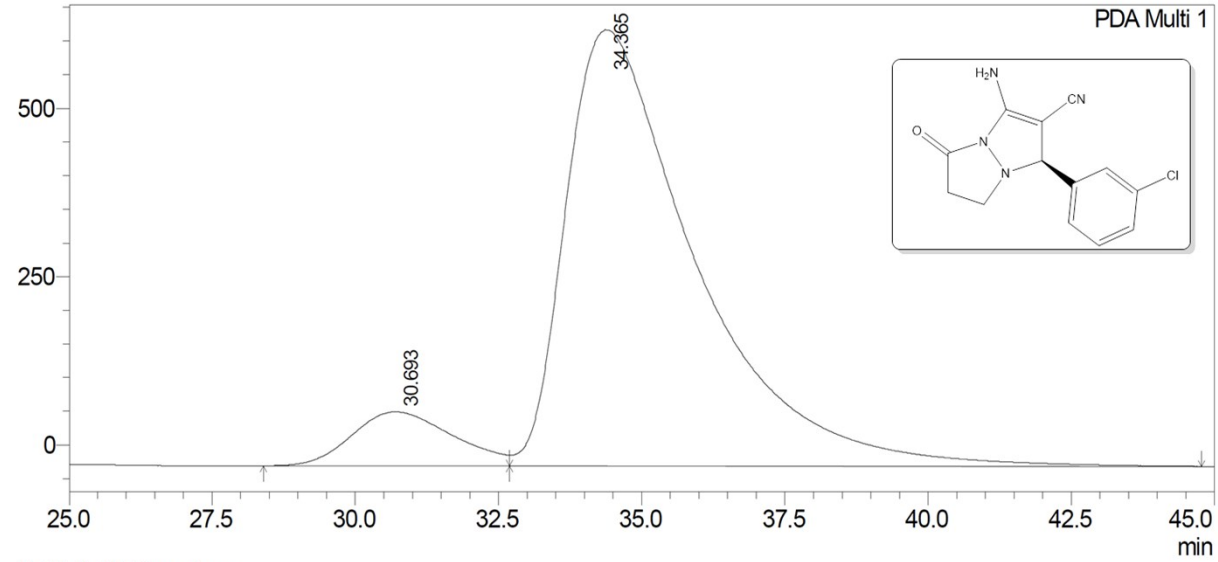


DA Multi 1/210nm 4nm

PeakTable

PDA Ch1 210nm 4nm

Peak#	Ret. Time	Area	Height	Area %	Height %
1	30.034	29697270	216232	49.269	53.578
2	35.204	30577944	187355	50.731	46.422
Total		60275214	403587	100.000	100.000



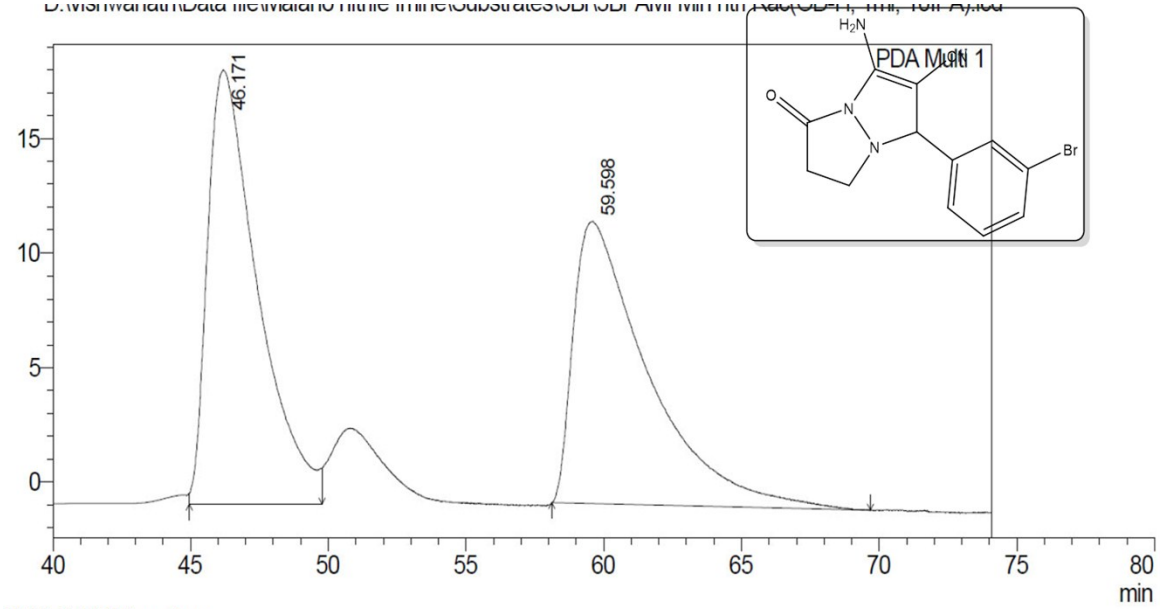
)A Multi 1/210nm 4nm

PeakTable

PDA Ch1 210nm 4nm

Peak#	Ret. Time	Area	Height	Area %	Height %
1	30.693	9820866	80260	8.770	11.018
2	34.365	102155433	648156	91.230	88.982
Total		111976299	728416	100.000	100.000

HPLC profile for 3-amino-1-(3-bromophenyl)-5-oxo-6,7-dihydro-1H,5H-pyrazolo[1,2-a]pyrazole-2-carbonitrile 3h

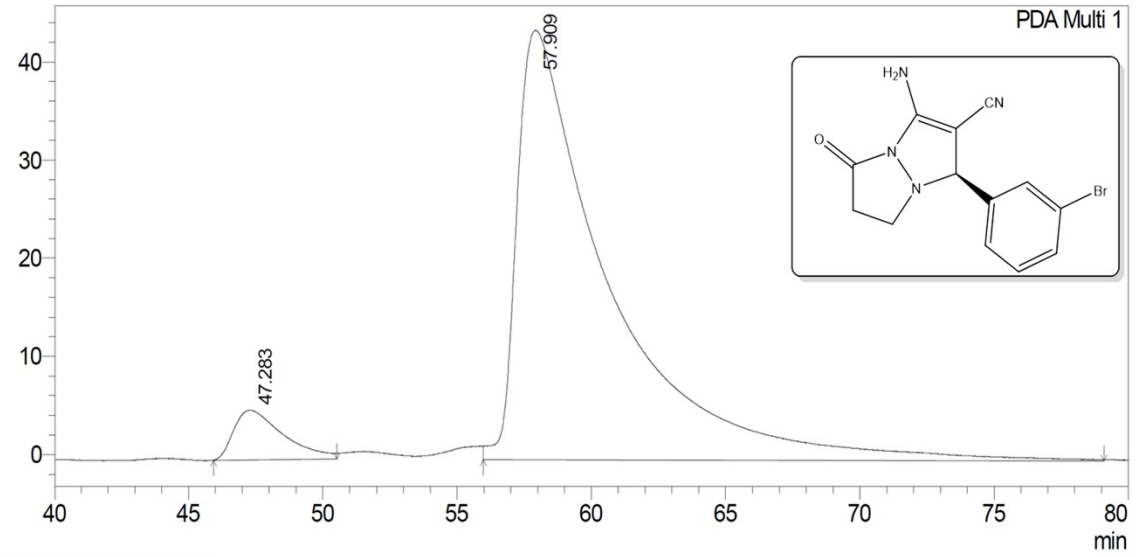


)A Multi 1/254nm 4nm

PeakTable

PDA Ch1 254nm 4nm

Peak#	Ret. Time	Area	Height	Area %	Height %
1	46.171	2454502	19156	51.404	60.863
2	59.598	2320458	12318	48.596	39.137
Total		4774960	31474	100.000	100.000



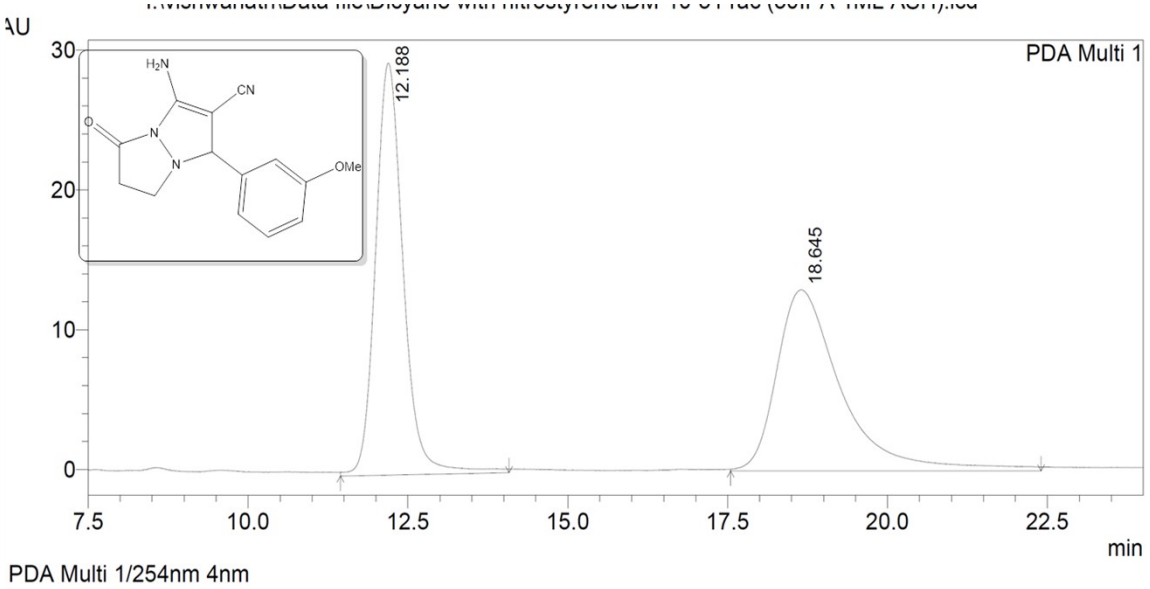
)A Multi 1/254nm 4nm

PeakTable

PDA Ch1 254nm 4nm

Peak#	Ret. Time	Area	Height	Area %	Height %
1	47.283	659939	5102	5.962	10.438
2	57.909	10408396	43775	94.038	89.562
Total		11068335	48877	100.000	100.000

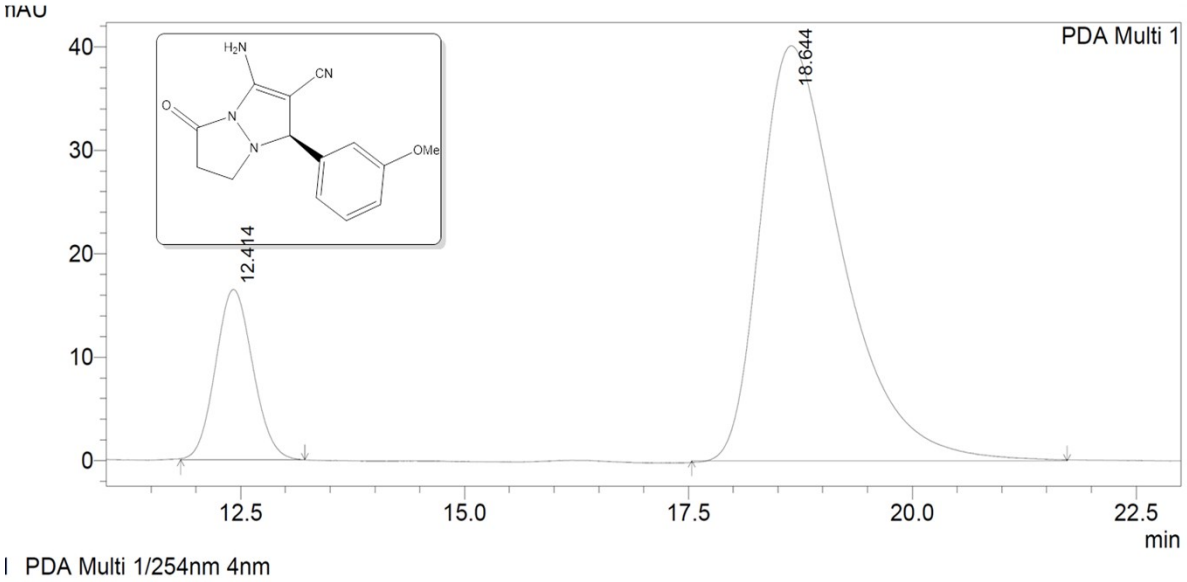
HPLC profile for 3-amino-1-(3-methoxyphenyl)-5-oxo-6,7-dihydro-1H,5H-pyrazolo[1,2-a]pyrazole-2-carbonitrile 3i



PeakTable

PDA Ch1 254nm 4nm

Peak#	Ret. Time	Area	Height	Area %	Height %
1	12.188	891032	29487	49.296	69.452
2	18.645	916467	12970	50.704	30.548
Total		1807499	42457	100.000	100.000

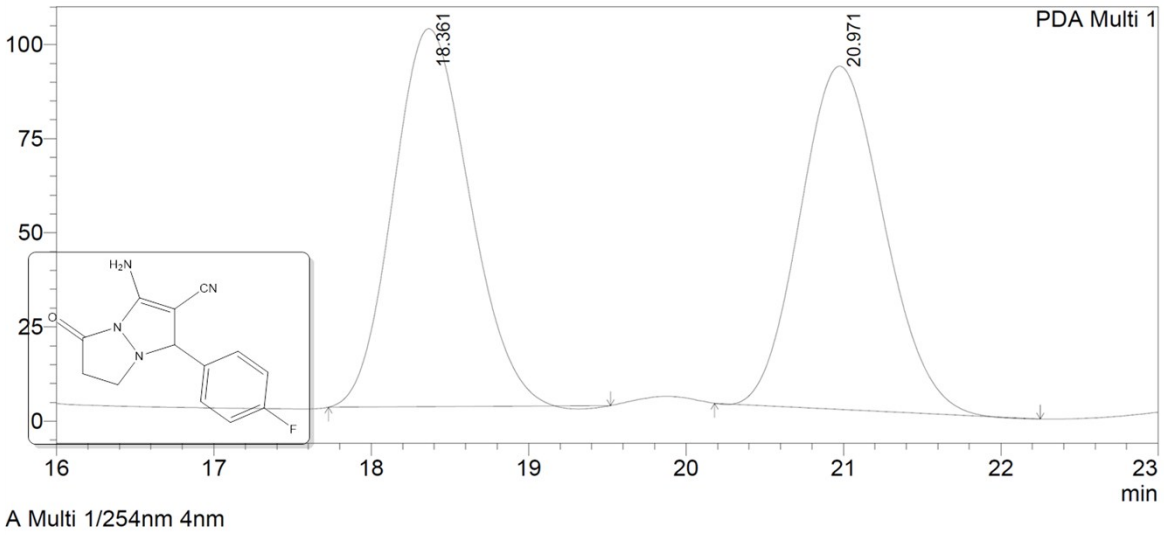


PeakTable

PDA Ch1 254nm 4nm

Peak#	Ret. Time	Area	Height	Area %	Height %
1	12.414	477536	16461	15.745	29.102
2	18.644	2555446	40104	84.255	70.898
Total		3032982	56565	100.000	100.000

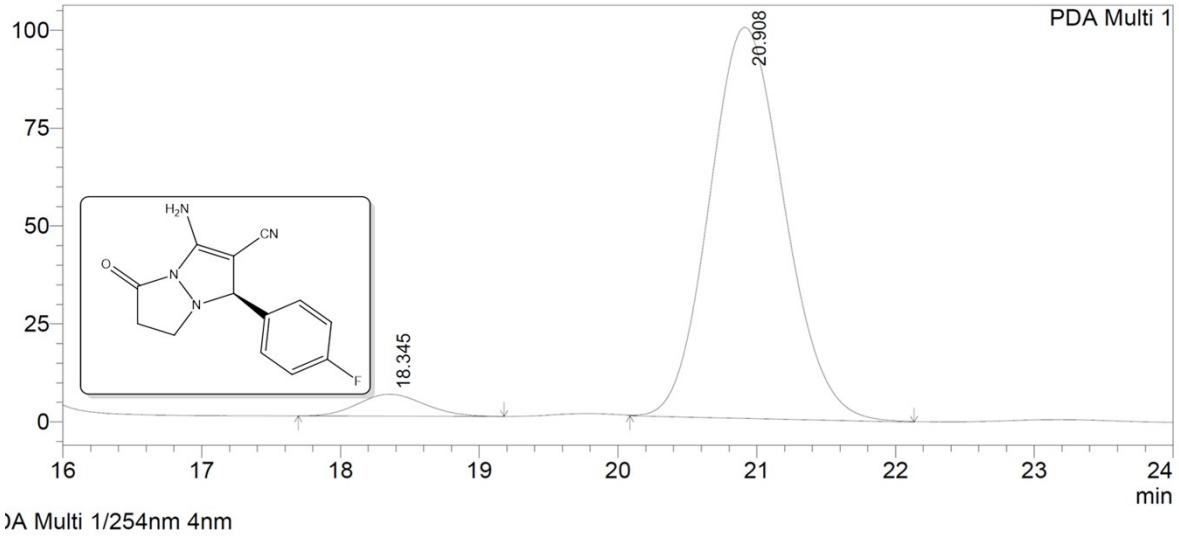
HPLC profile for 3-amino-1-(4-fluorophenyl)-5-oxo-6,7-dihydro-1H,5H-pyrazolo[1,2-a]pyrazole-2-carbonitrile 3j



PeakTable

PDA Ch1 254nm 4nm

Peak#	Ret. Time	Area	Height	Area %	Height %
1	18.361	3382550	100386	50.075	52.415
2	20.971	3372374	91134	49.925	47.585
Total		6754924	191519	100.000	100.000

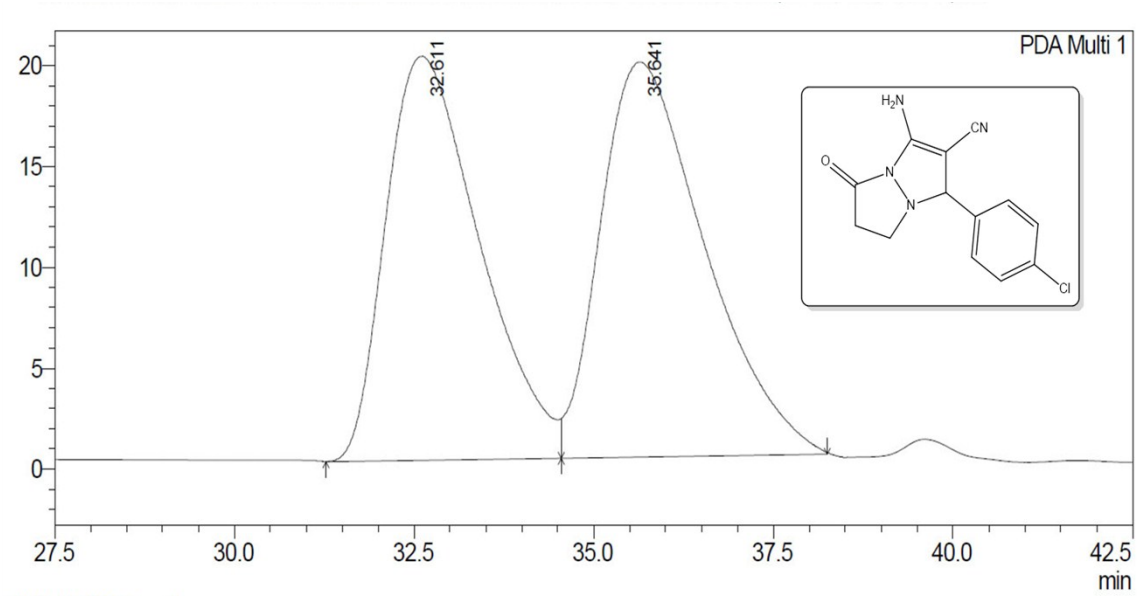


PeakTable

PDA Ch1 254nm 4nm

Peak#	Ret. Time	Area	Height	Area %	Height %
1	18.345	186310	5616	4.725	5.325
2	20.908	3756978	99858	95.275	94.675
Total		3943287	105474	100.000	100.000

HPLC profile for 3-amino-1-(4-chlorophenyl)-5-oxo-6,7-dihydro-1H,5H-pyrazolo[1,2-a]pyrazole-2-carbonitrile 3k

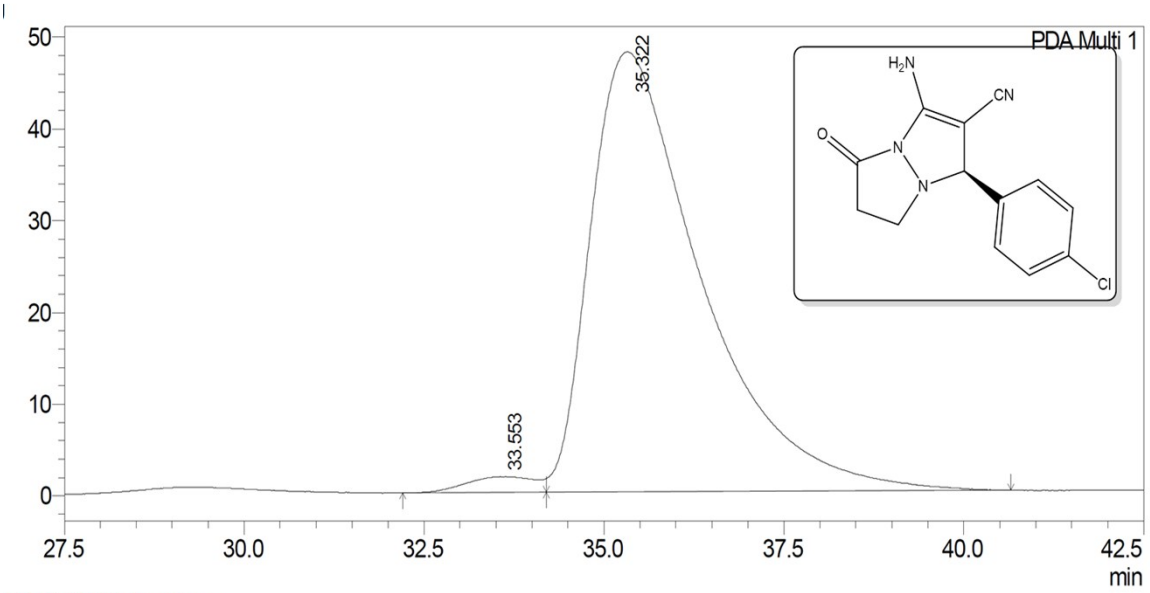


)A Multi 1/254nm 4nm

PeakTable

PDA Ch1 254nm 4nm

Peak#	Ret. Time	Area	Height	Area %	Height %
1	32.611	1821601	20037	47.943	50.550
2	35.641	1977877	19601	52.057	49.450
Total		3799478	39637	100.000	100.000



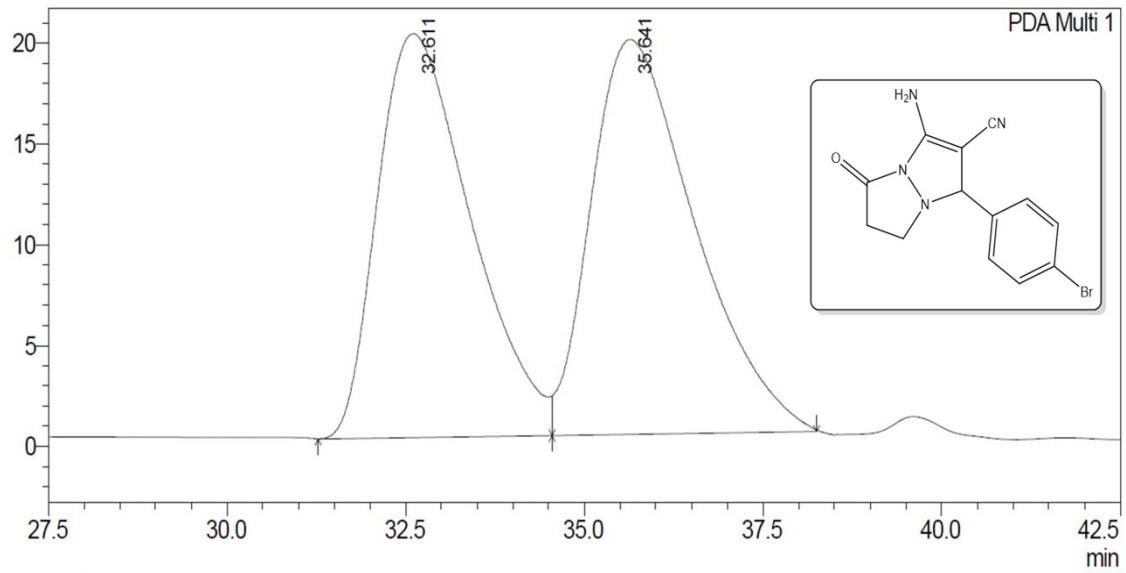
'DA Multi 1/254nm 4nm

PeakTable

PDA Ch1 254nm 4nm

Peak#	Ret. Time	Area	Height	Area %	Height %
1	33.553	116112	1726	2.206	3.472
2	35.322	5148265	47991	97.794	96.528
Total		5264377	49717	100.000	100.000

HPLC profile for 3-amino-1-(4-bromophenyl)-5-oxo-6,7-dihydro-1H,5H-pyrazolo[1,2-a]pyrazole-2-carbonitrile 3l

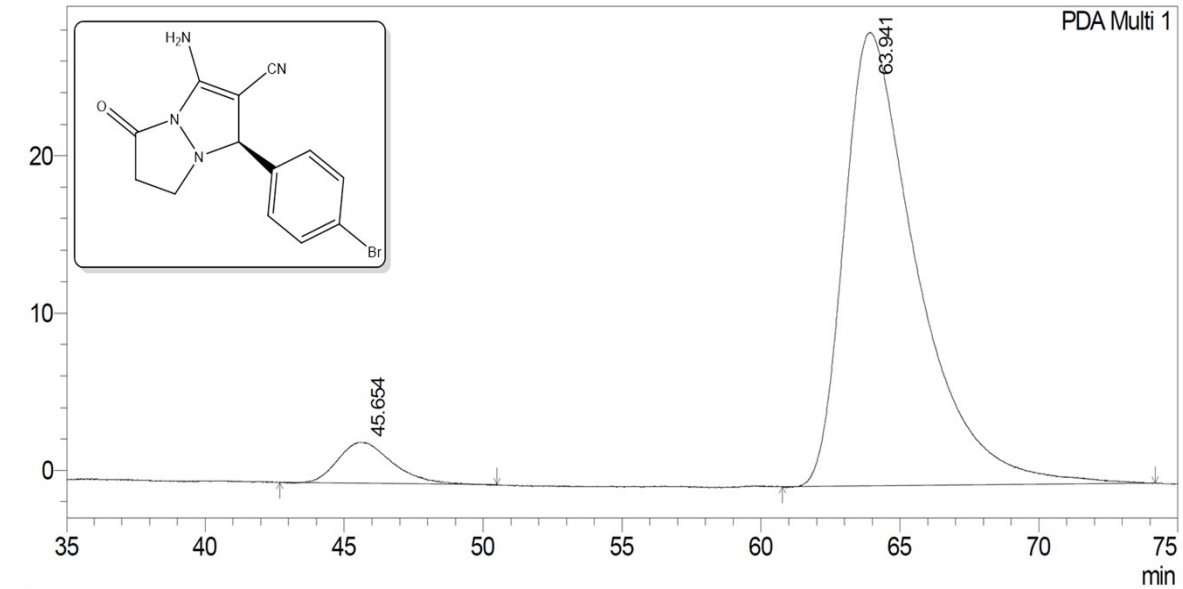


DA Multi 1/254nm 4nm

PeakTable

PDA Ch1 254nm 4nm

Peak#	Ret. Time	Area	Height	Area %	Height %
1	32.611	1821601	20037	47.943	50.550
2	35.641	1977877	19601	52.057	49.450
Total		3799478	39637	100.000	100.000



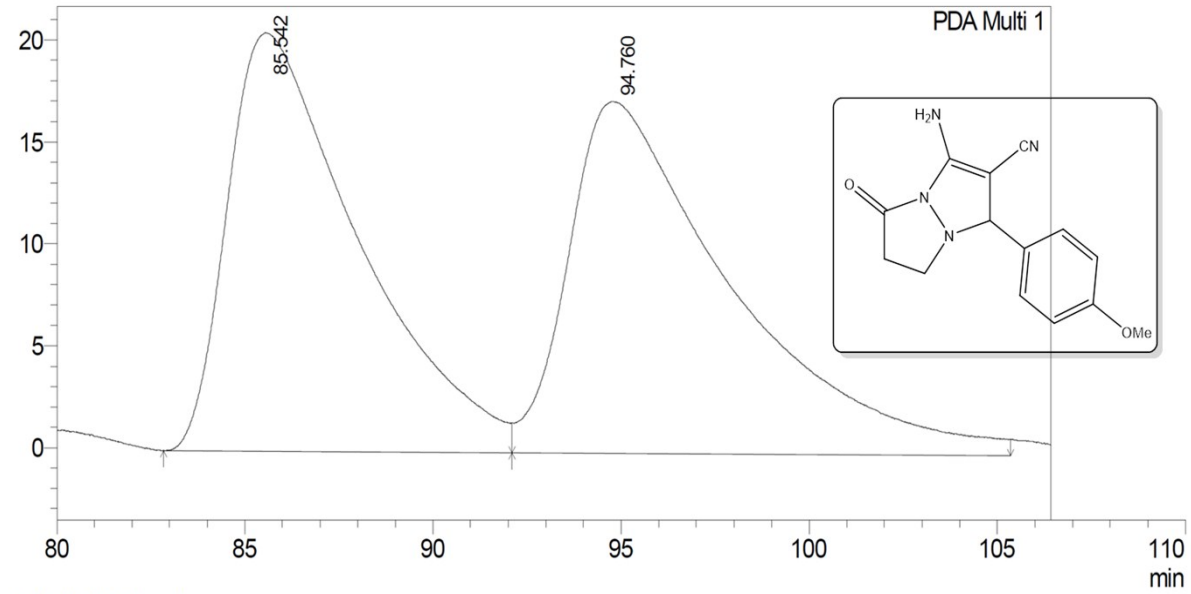
DA M

PeakTable

PDA Ch1 254nm 4nm

Peak#	Ret. Time	Area	Height	Area %	Height %
1	45.654	354241	2612	6.297	8.304
2	63.941	5271212	28841	93.703	91.696
Total		5625453	31453	100.000	100.000

HPLC profile for 3-amino-1-(4-methoxyphenyl)-5-oxo-6,7-dihydro-1H,5H-pyrazolo[1,2-a]pyrazole-2-carbonitrile 3m

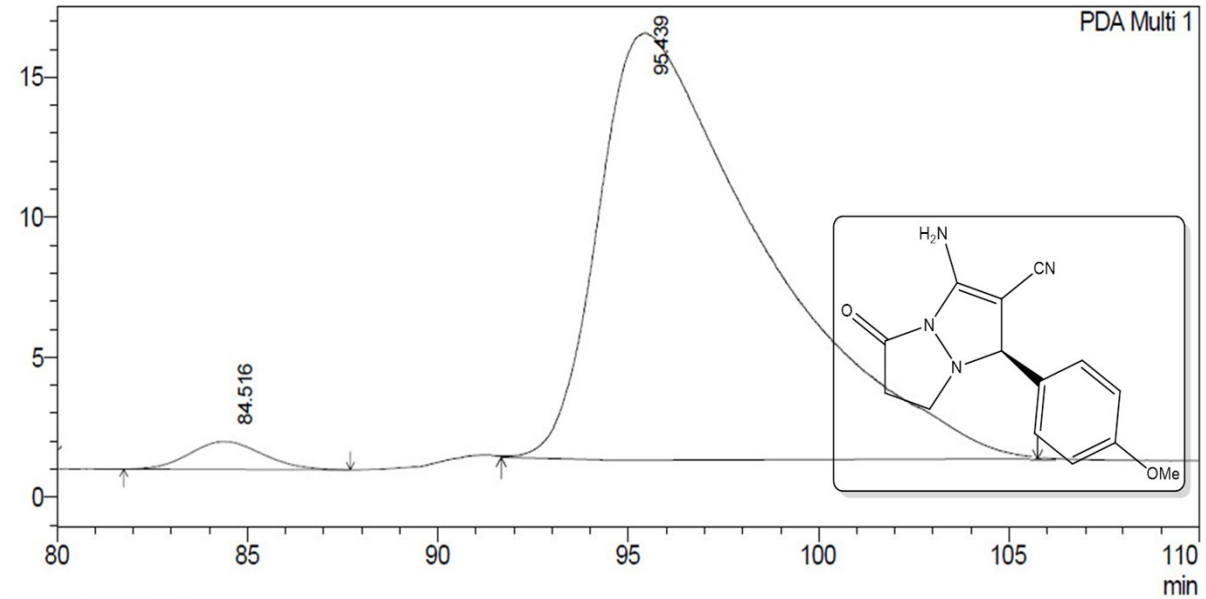


)A Multi 1/254nm 4nm

PeakTable

PDA Ch1 254nm 4nm

Peak#	Ret. Time	Area	Height	Area %	Height %
1	85.542	4981176	20556	48.851	54.327
2	94.760	5215455	17282	51.149	45.673
Total		10196631	37838	100.000	100.000



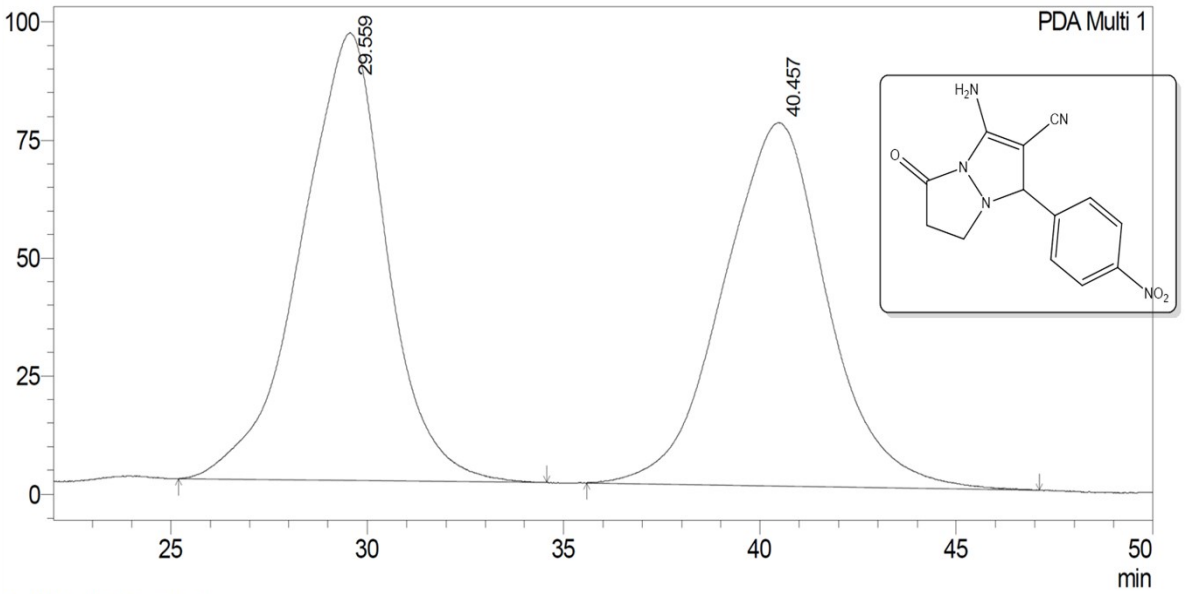
)A Multi 1/254nm 4nm

PeakTable

PDA Ch1 254nm 4nm

Peak#	Ret. Time	Area	Height	Area %	Height %
1	84.516	312062	1262	5.939	8.626
2	95.439	4942350	15486	94.061	91.374
Total		5254411	16948	100.000	100.000

HPLC profile for 3-amino-1-(4-nitrophenyl)-5-oxo-6,7-dihydro-1H,5H-pyrazolo[1,2-a]pyrazole-2-carbonitrile 3n

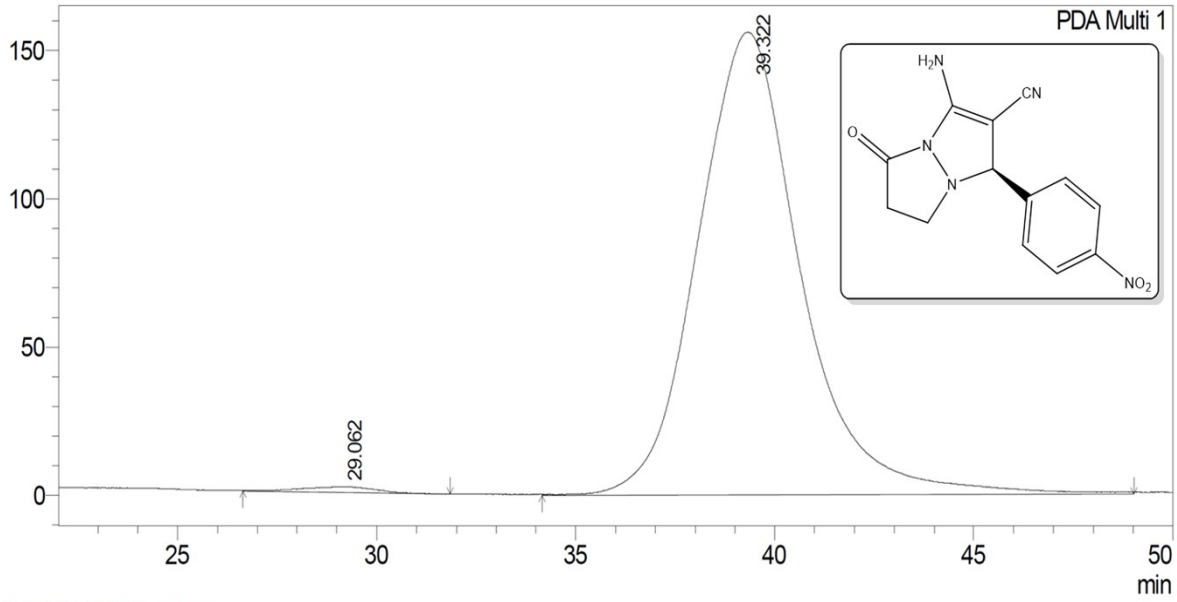


DA Multi 1/210nm 4nm

PeakTable

PDA Ch1 210nm 4nm

Peak#	Ret. Time	Area	Height	Area %	Height %
1	29.559	14464636	94787	50.404	55.182
2	40.457	14232516	76985	49.596	44.818
Total		28697153	171772	100.000	100.000



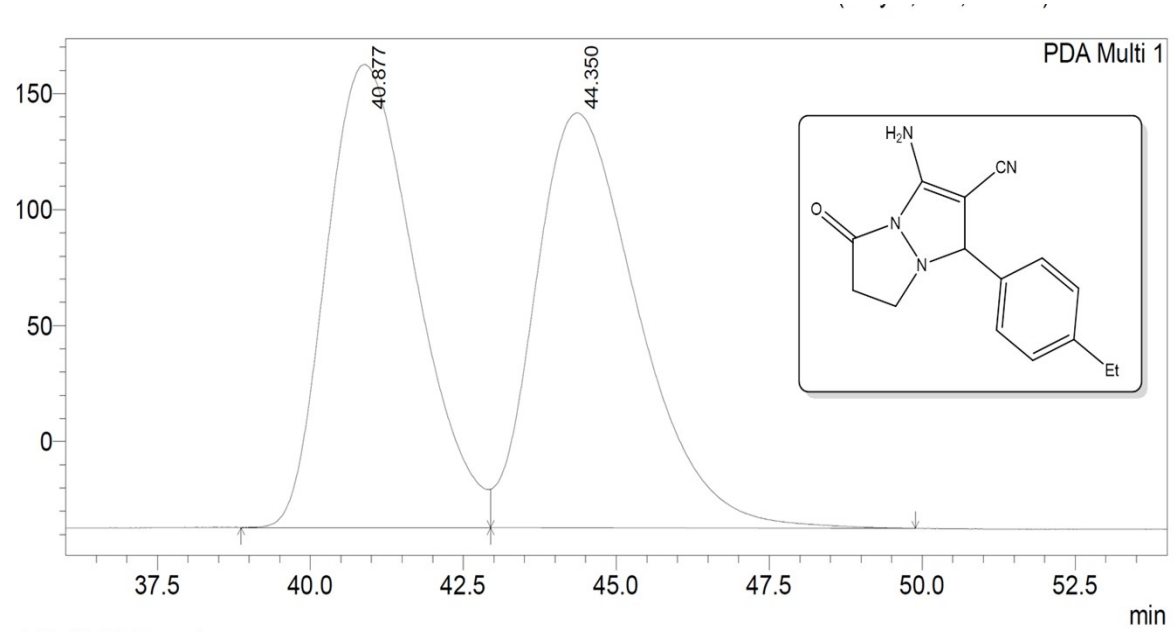
DA Multi 1/210nm 4nm

PeakTable

PDA Ch1 210nm 4nm

Peak#	Ret. Time	Area	Height	Area %	Height %
1	29.062	258454	1996	0.913	1.264
2	39.322	28035107	155914	99.087	98.736
Total		28293561	157910	100.000	100.000

HPLC profile for 3-amino-1-(4-ethylphenyl)-5-oxo-6,7-dihydro-1H,5H-pyrazolo[1,2-a]pyrazole-2-carbonitrile 3o

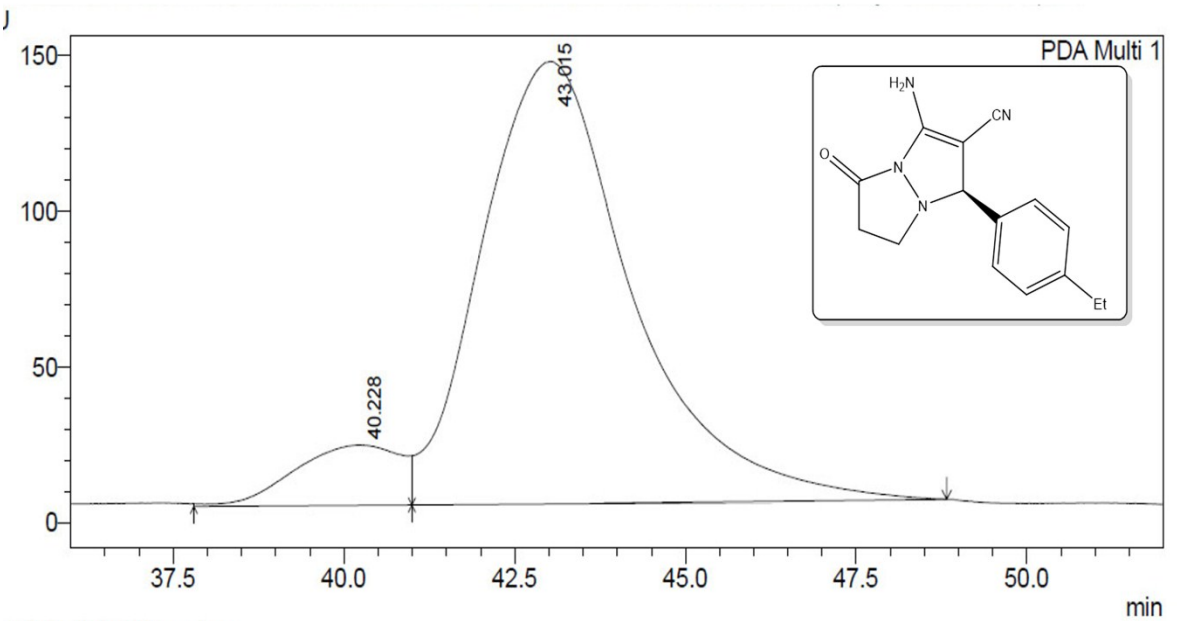


A Multi 1/210nm 4nm

PeakTable

PDA Ch1 210nm 4nm

Peak#	Ret. Time	Area	Height	Area %	Height %
1	40.877	20268685	199705	49.119	52.740
2	44.350	20996093	178954	50.881	47.260
Total		41264779	378658	100.000	100.000



DA Multi 1/210nm 4nm

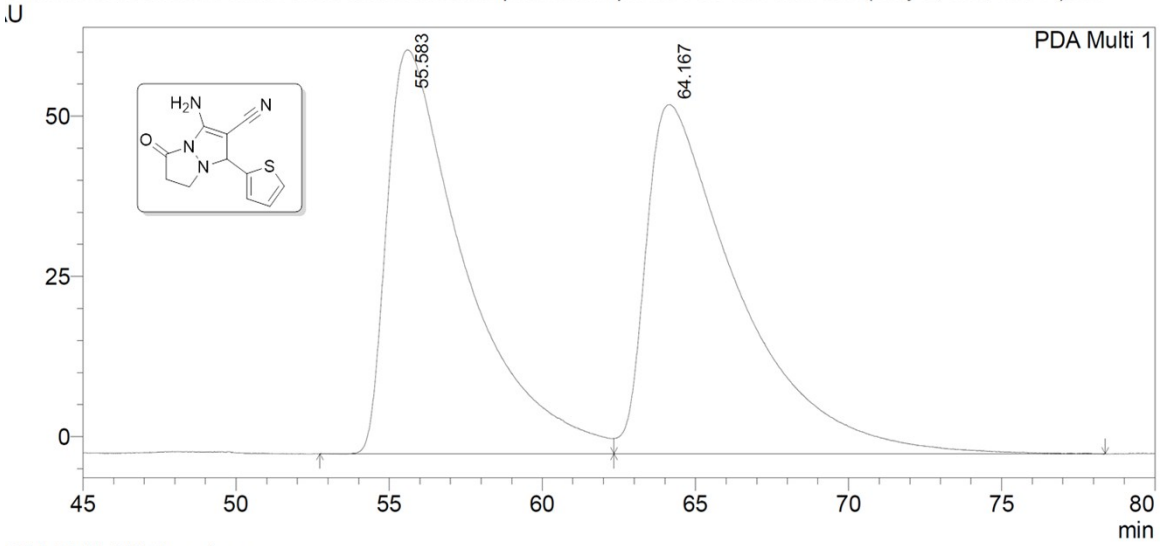
PeakTable

PDA Ch1 210nm 4nm

Peak#	Ret. Time	Area	Height	Area %	Height %
1	40.228	2080306	19390	8.842	12.004
2	43.015	21446122	142140	91.158	87.996
Total		23526428	161530	100.000	100.000

HPLC profile for 3-amino-5-oxo-1-(thiophen-2-yl)-6,7-dihydro-1H,5H-pyrazolo[1,2-a]pyrazole-2-carbonitrile 3p

D:\...\Data file\Malano nitrile Imine\Substrates\thiophene\Thiophene AMI Mln ntrl Rac2(Amy 2, 1ml, 10IPA).lcd



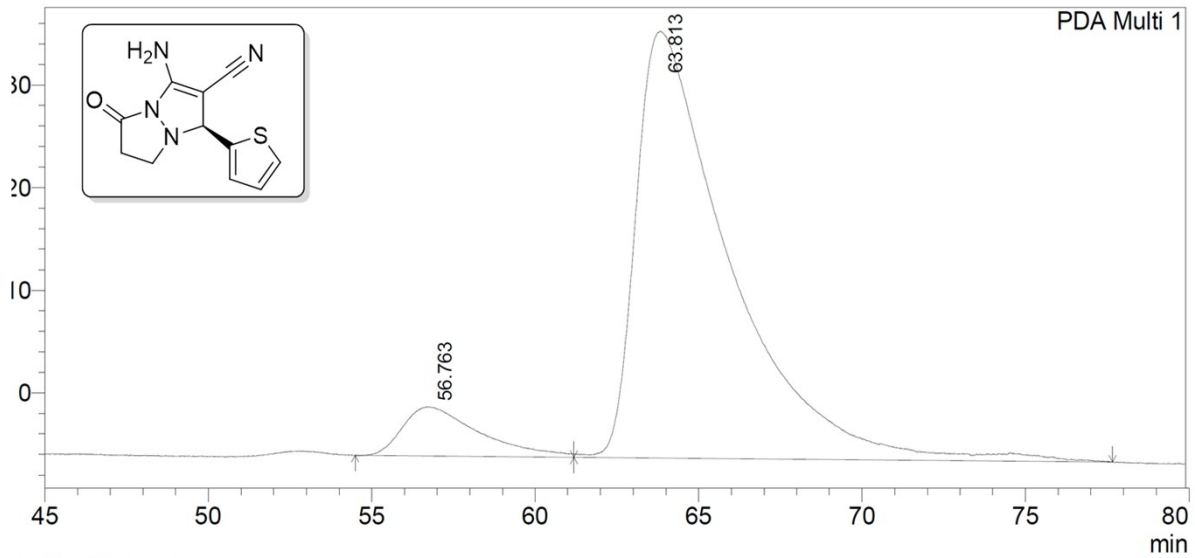
PDA Multi 1/254nm 4nm

PeakTable

PDA Ch1 254nm 4nm

Peak#	Ret. Time	Area	Height	Area %	Height %
1	55.583	11171727	62987	49.259	53.634
2	64.167	11507829	54452	50.741	46.366
Total		22679556	117439	100.000	100.000

wanath\Data file\Malano nitrile Imine\Substrates\thiophene\Furan AMI Mln ntrl chi6tlc(AD-H, 1ml, 10IPA).lcd



Multi 1/254nm 4nm

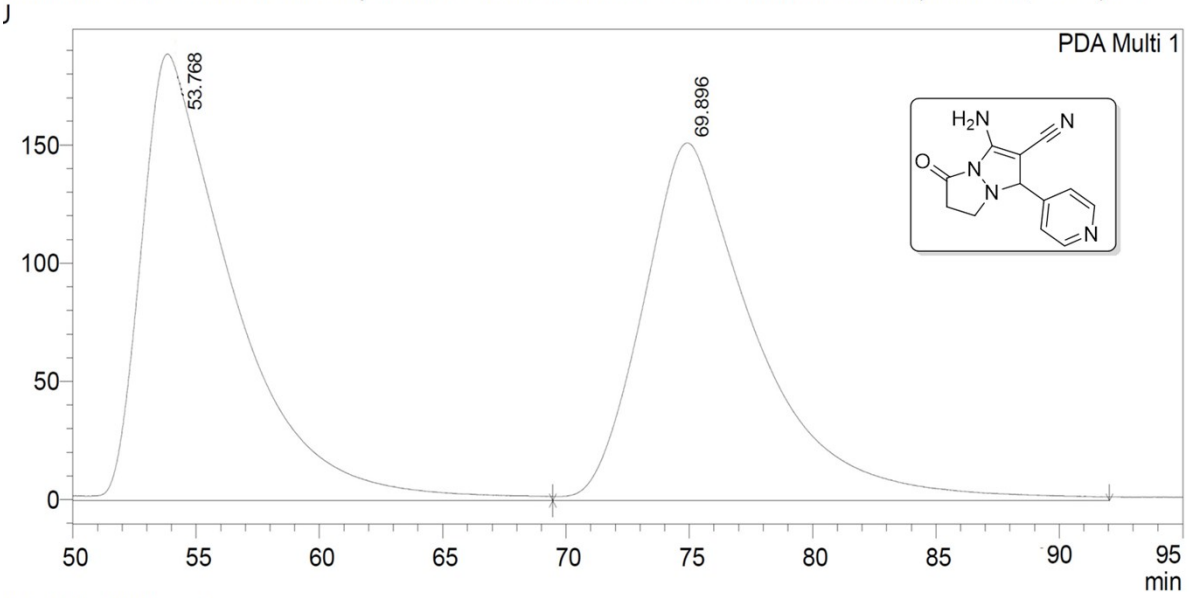
PeakTable

PDA Ch1 254nm 4nm

Peak#	Ret. Time	Area	Height	Area %	Height %
1	56.763	773500	4785	8.501	10.324
2	63.813	8325570	41560	91.499	89.676
Total		9099071	46344	100.000	100.000

HPLC profile for 3-amino-5-oxo-1-(pyridin-4-yl)-6,7-dihydro-1H,5H-pyrazolo[1,2-a]pyrazole-2-carbonitrile 3q

\...\Malano nitrile Imine\Substrates\pYRIDINE 4ALDE\PYRIDINE4ALDE AMI Mln ntrl Rac(AD H 1ml, 10IPA).lcd



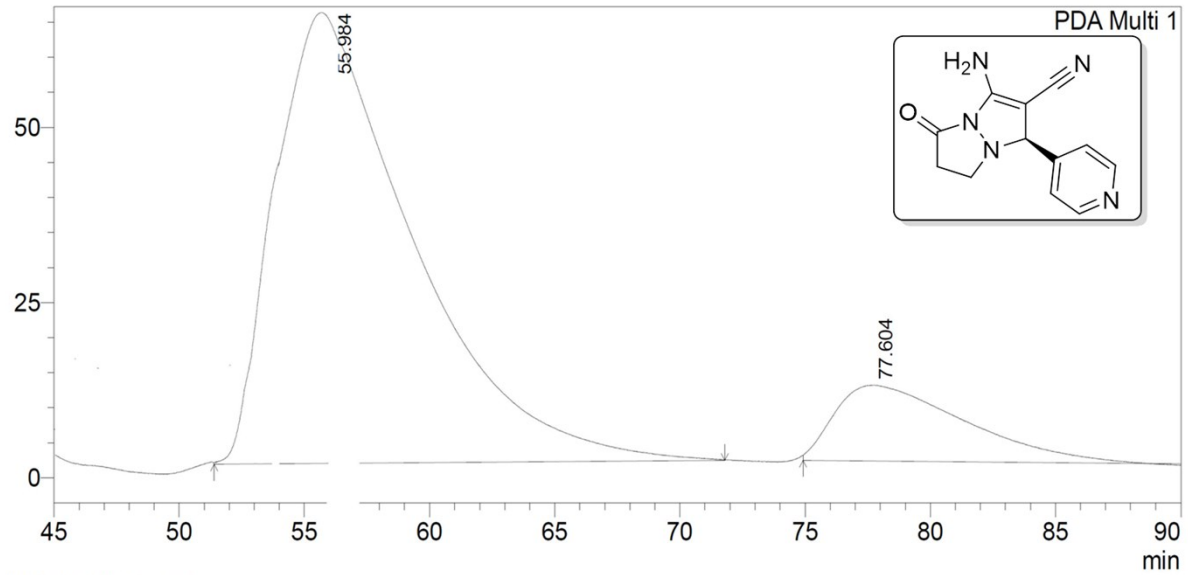
'DA Multi 1/254nm 4nm

PeakTable

PDA Ch1 254nm 4nm

Peak#	Ret. Time	Area	Height	Area %	Height %
1	48.838	49287293	189049	50.125	55.526
2	69.896	49041722	151422	49.875	44.474
Total		98329015	340472	100.000	100.000

\Malano nitrile Imine\Substrates\pYRIDINE 4ALDE\PYRIDINE4ALDE AMI Mln ntrl Chi(AD H 1ml, 10IPA).lcd



A Multi 1/254nm 4nm

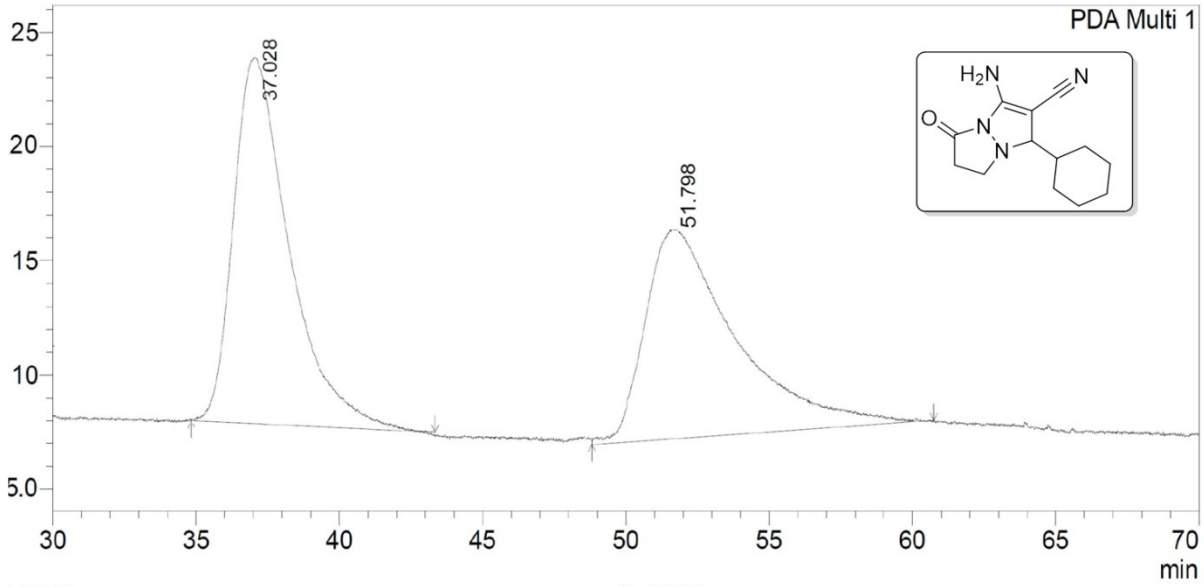
PeakTable

PDA Ch1 254nm 4nm

Peak#	Ret. Time	Area	Height	Area %	Height %
1	55.984	24202442	61643	86.089	85.079
2	77.604	3910823	10811	13.911	14.921
Total		28113264	72454	100.000	100.000

HPLC profile for 3-amino-1-cyclohexyl-5-oxo-6,7-dihydro-1H,5H-pyrazolo[1,2-a]pyrazole-2-carbonitrile 3r

shwanath\Data file\Malano nitrile Imine\Substrates\Cyclo Hexyl\Cyhex AMI Mln ntrl Rac(AD H 1ml, 5IPA).lcd



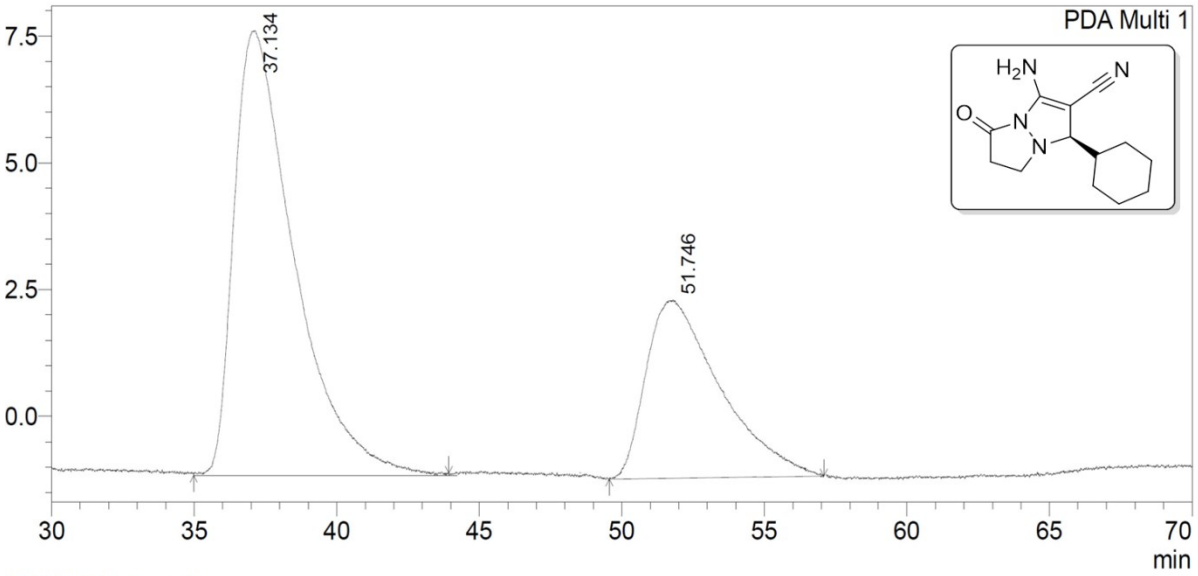
A Multi

PeakTable

PDA Ch1 254nm 4nm

Peak#	Ret. Time	Area	Height	Area %	Height %
1	37.028	1327841	16606	48.199	65.466
2	54.798	1427075	9540	51.801	34.534
Total		2754916	26146	100.000	100.000

shwanath\Data file\Malano nitrile Imine\Substrates\Cyclo Hexyl\Cyhex AMI Mln ntrl Chi(AD H 0.7ml, 5IPA).lcd



A Multi 1/254nm 4nm

PeakTable

PDA Ch1 254nm 4nm

Peak#	Ret. Time	Area	Height	Area %	Height %
1	37.134	1392154	8773	70.686	72.168
2	51.746	577347	3383	29.314	27.832
Total		1969501	12156	100.000	100.000

HPLC profile for 3-imino-5-oxo-1-phenyltetrahydro-1H,5H-pyrazolo[1,2-a]pyrazole-2-carbonitrile 3s

<Chromatogram>

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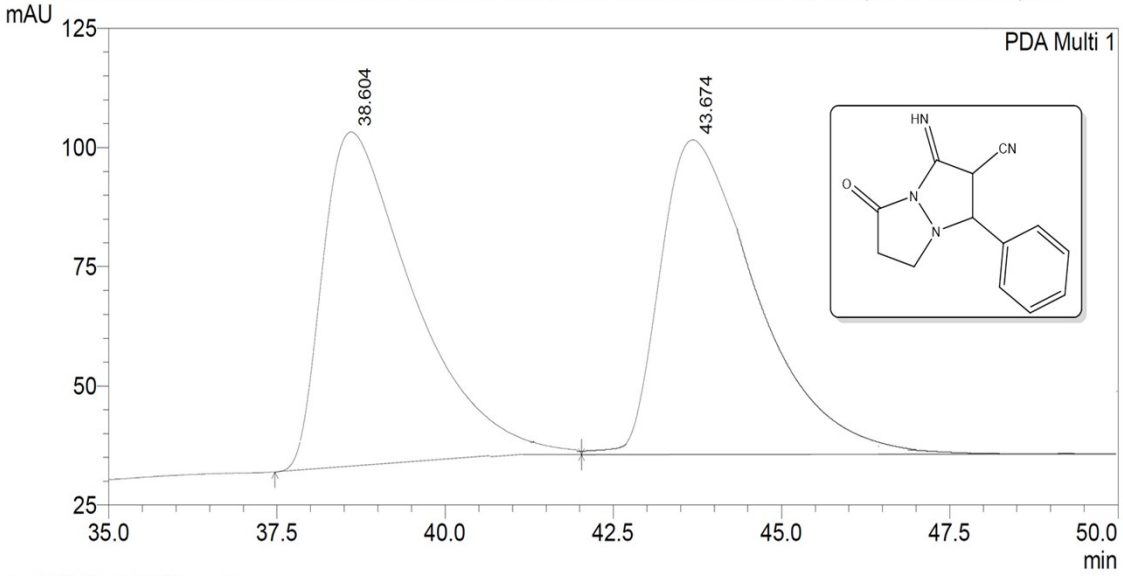


1 PDA Multi 1/254nm 4nm

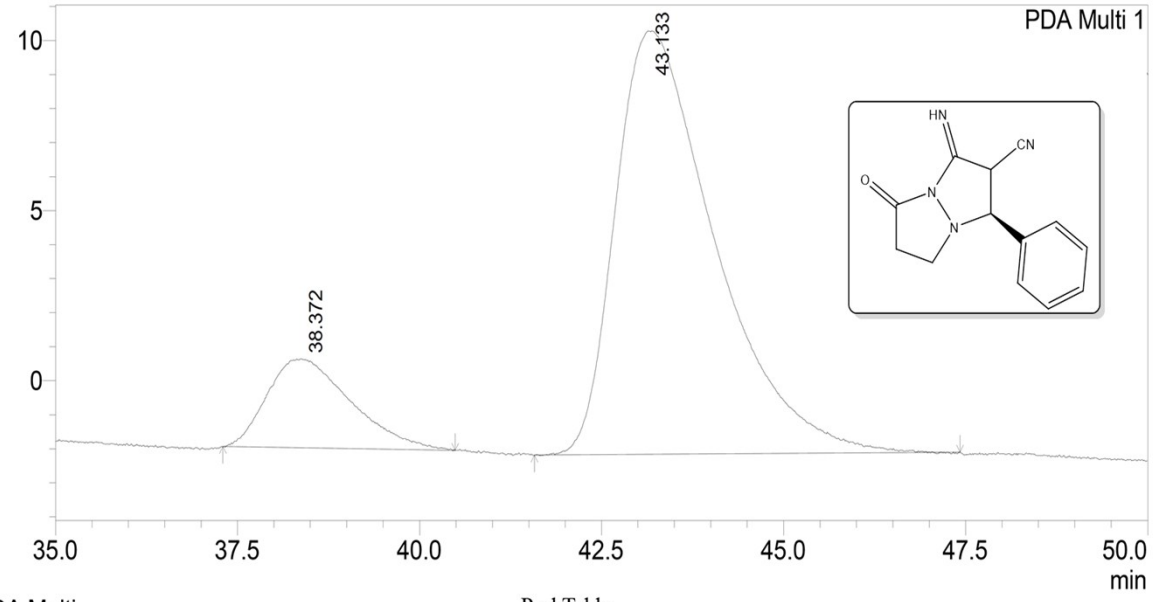
PeakTable

PDA Ch1 254nm 4nm

Peak#	Ret. Time	Area	Height	Area %	Height %
1	38.604	6287285	69491	50.463	52.370
2	43.674	6171878	63202	49.537	47.630
Total		12459163	132692	100.000	100.000

D:\vishwanath\Data file\Malano nitrile Imine\Substrates\2Me acn\2Me AMI Mln ntrl Chi2(OD H 1ml, 5IPA).lcd

J



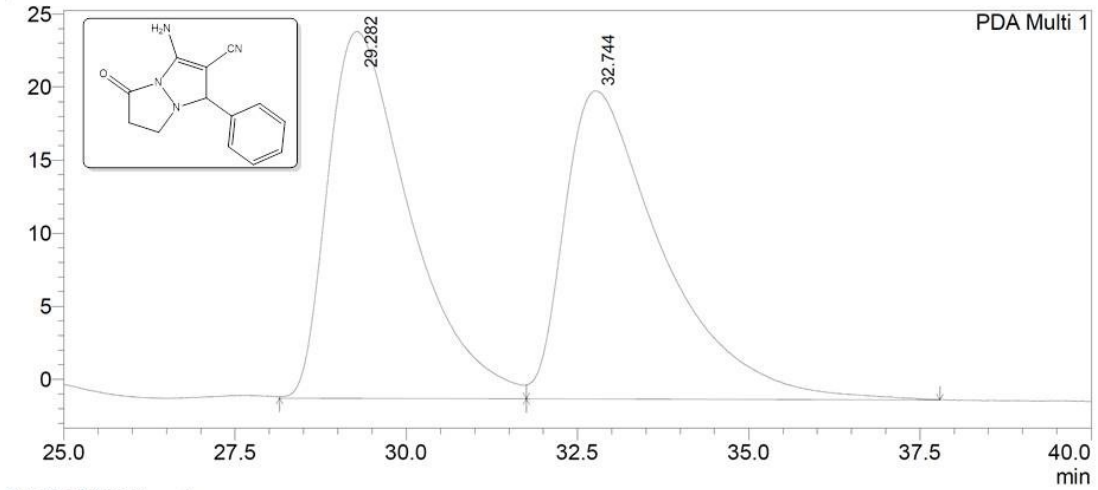
'DA Multi

PeakTable

PDA Ch1 254nm 4nm

Peak#	Ret. Time	Area	Height	Area %	Height %
1	38.372	208448	2612	15.005	17.350
2	43.133	1180732	12444	84.995	82.650
Total		1389180	15056	100.000	100.000

HPLC profile Catalyst screening for 3-amino-5-oxo-1-phenyl-6,7-dihydro-1H,5H-pyrazolo[1,2-a]pyrazole-2-carbonitrile 3

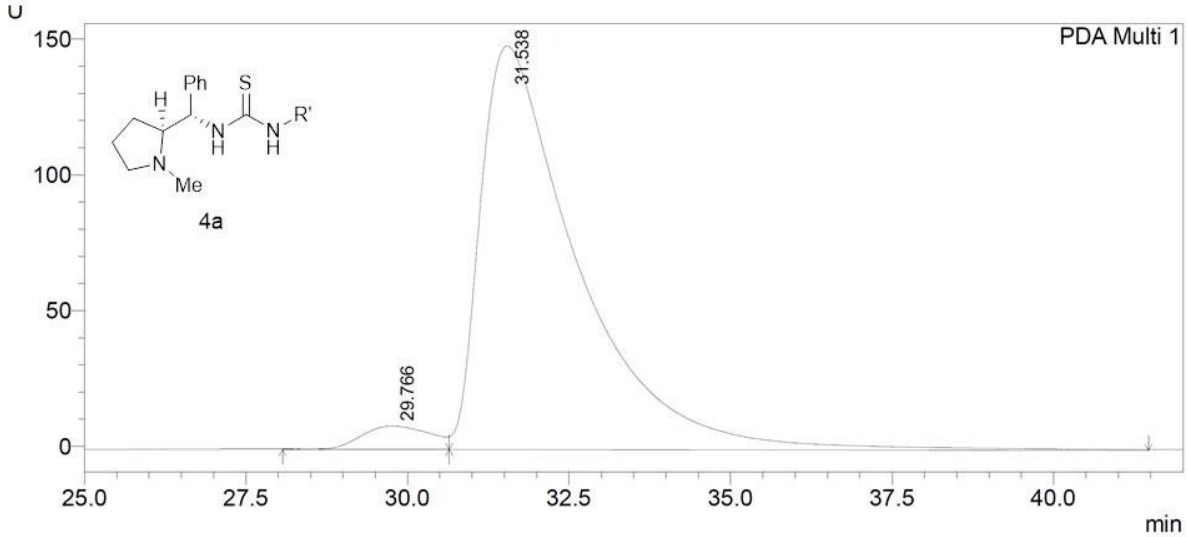


DA Multi 1/254nm 4nm

PeakTable

PDA Ch1 254nm 4nm

Peak#	Ret. Time	Area	Height	Area %	Height %
1	29.282	2096404	25106	49.805	54.352
2	32.744	2112843	21086	50.195	45.648
3	58.560	-0	0	-0.000	0.000
4	72.384	-0	0	-0.000	0.000
Total		4209248	46192	100.000	100.000

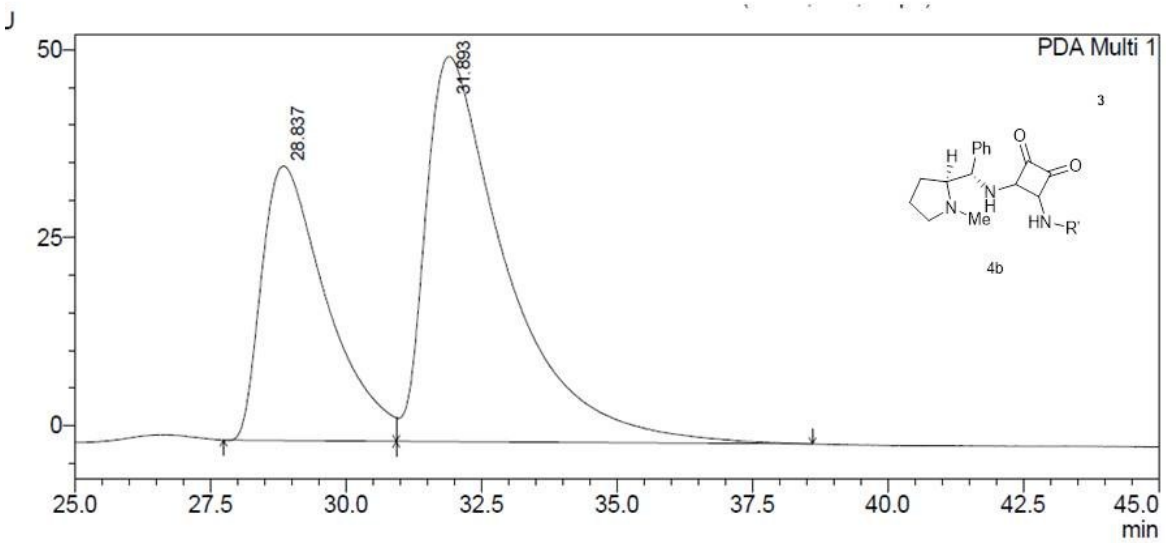


PDA Multi 1/254nm 4nm

PeakTable

PDA Ch1 254nm 4nm

Peak#	Ret. Time	Area	Height	Area %	Height %
1	29.766	644513	8644	3.943	5.496
2	31.538	15701209	148642	96.057	94.504
3	58.560	-0	0	-0.000	0.000
4	72.384	-0	0	-0.000	0.000
Total		16345722	157286	100.000	100.000

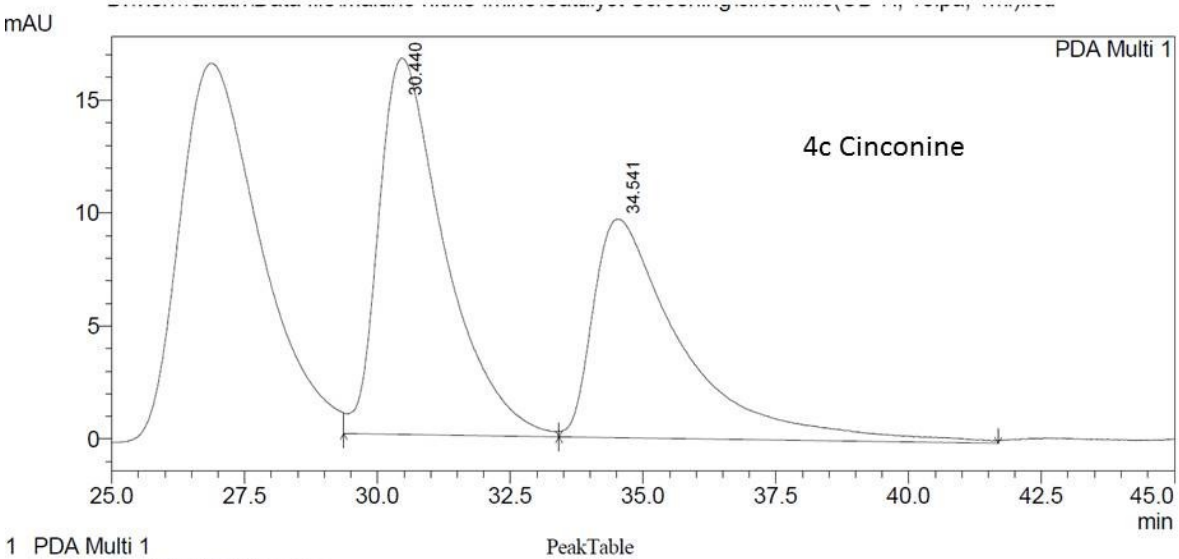


PDA Multi 1/254nm 4nm

PeakTable

PDA Ch1 254nm 4nm

Peak#	Ret. Time	Area	Height	Area %	Height %
1	28.837	3056066	36518	36.385	41.606
2	31.893	5343074	51253	63.615	58.394
Total		8399140	87772	100.000	100.000

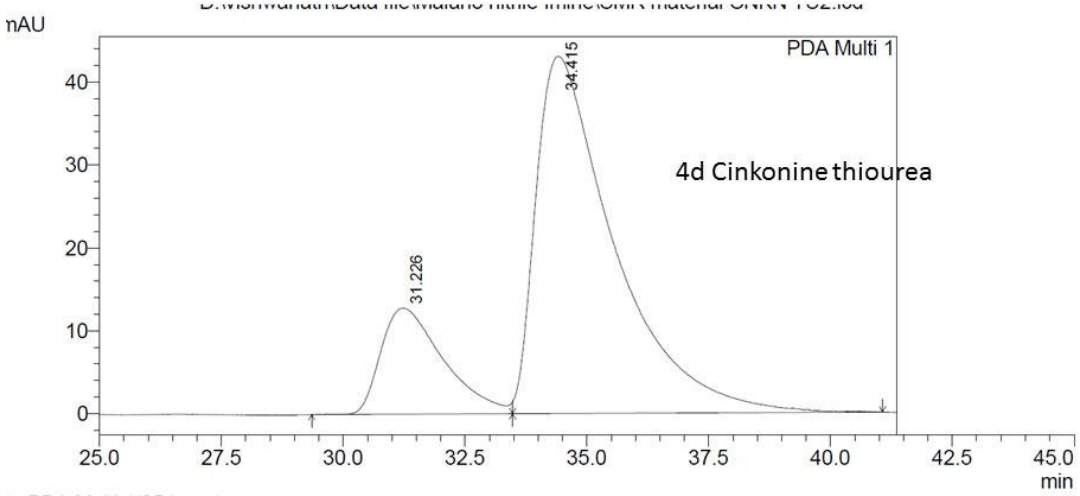


1 PDA Multi 1

PeakTable

PDA Ch1 254nm 4nm

Peak#	Ret. Time	Area	Height	Area %	Height %
1	30.440	1445503	16650	56.101	63.256
2	34.541	1131098	9672	43.899	36.744
Total		2576601	26322	100.000	100.000



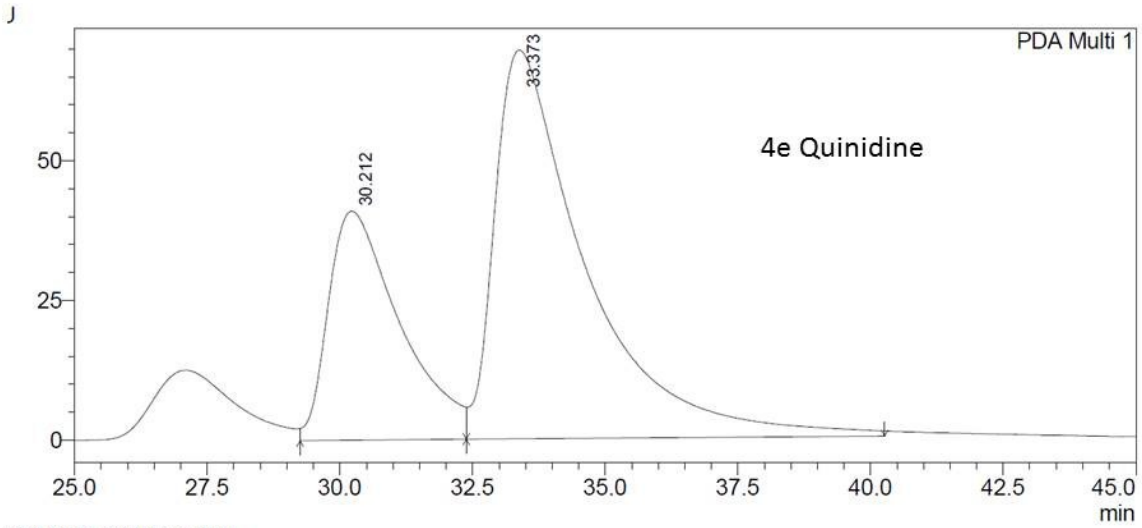
1 PDA Multi 1/254nm 4nm

PeakTable

PDA Ch1 254nm 4nm

Peak#	Ret. Time	Area	Height	Area %
1	31.226	1140631	12781	19.146
2	34.415	4817009	43047	80.854
Total		5957640	55828	100.000

Height %
22.893
77.107
100.000

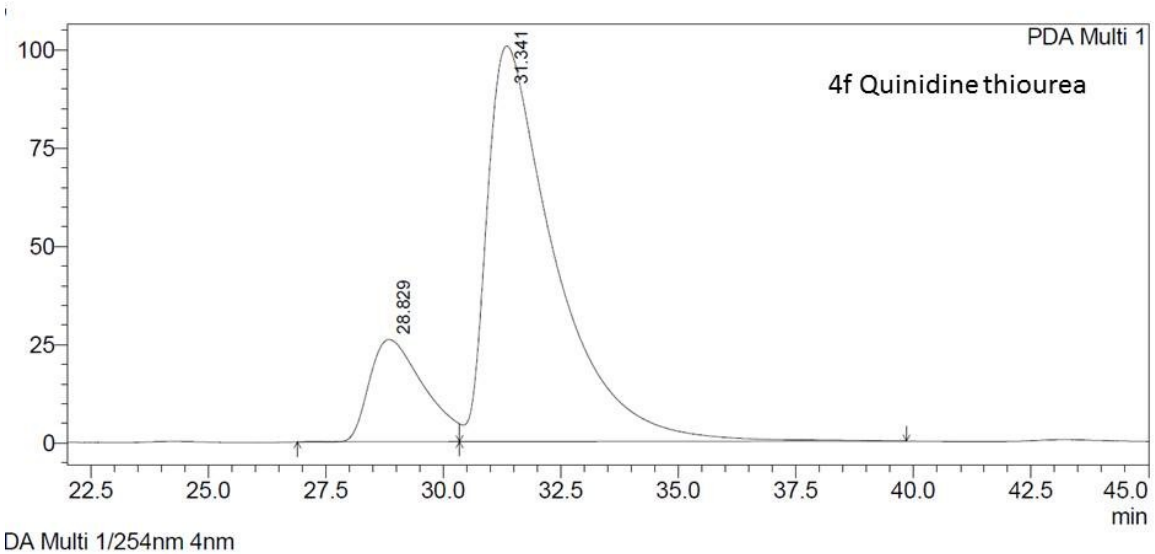


DA Multi 1/254nm 4nm

PeakTable

PDA Ch1 254nm 4nm

Peak#	Ret. Time	Area	Height	Area %	Height %
1	30.212	3845291	40949	31.555	37.048
2	33.373	8340847	69581	68.445	62.952
Total		12186138	110530	100.000	100.000



DA Multi 1/254nm 4nm

PeakTable

PDA Ch1 254nm 4nm

Peak#	Ret. Time	Area	Height	Area %	Height %
1	28.829	2072136	26012	16.981	20.541
2	31.341	10130769	100625	83.019	79.459
Total		12202905	126637	100.000	100.000