Electronic Supplementary Material (ESI) for Chemical Communications

Decarboxylative Benzylation and Arylation of Nitriles

Antonio Recio, III, Jeffrey D. Heinzman, Jon A. Tunge*
Department of Chemistry, University of Kansas, 2010 Malott Hall, 1251 Wescoe Hall Drive, Lawrence, KS 66045

Supporting Information

Table of Contents:

General information:

All reactions were performed in flame-dried glassware under Ar atmosphere using standard Schlenk techniques. All reactions run in tetrahydrofuran were performed in 5 mL biotage microwave vials with sealable septa-caps. The THF was dried over sodium in the presence of benzophenone indicator. Toluene (tol) was dried over activated alumina and distilled over sodium. Other commercially available reagents, solvents, and catalysts were used without additional purification unless otherwise stated. CpPd(allyl) was prepared according to a literature procedure.[1] All imidazole carbamate benzyl esters were prepared via literature protocol.[2] ^{1}H and ^{13}C NMR spectra were obtained on Bruker Avance 500 DRX spectrometer and were referenced to residual protio solvent signals. Compound purification was effected by flash chromatography using 230 x 400 mesh, 60 Å porosity, silica obtained from Sorbent Technologies. Structural assignments were based on ^{1}H, ^{13}C, DEPT-135, COSY, HSQC spectroscopies. Mass spectrometry was run using ESI techniques.

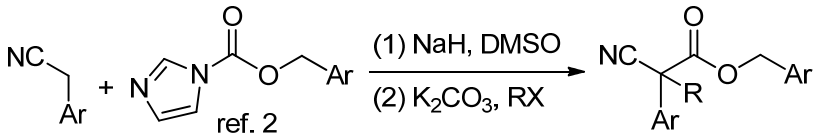
Procedures for the synthesis of *α*-phenyl cyanoacetic acid and esters:[3] A 200 mL flame dried Schlenk flask under Ar was charged with commercially available benzyl cyanide (31.0 mmol, 3.6 mL) via syringe, and *n*-BuLi (18.5 mL, 1.6 M in hexane) was added dropwise over 10 minutes. The solution was then placed in a dry ice/acetone bath and solid CO_2 was added carefully. The solution was stirred at -78 ^{o}C for 1 h. The reaction was then quenched with saturated $NaHCO_3$ (125 mL) and Et_2O (50 mL) was added. The aqueous layer was isolated and ice cold Et_2O (100 mL) was added. Concentrated HCl (0 ^{o}C) was then added until acidic (pH of 6). The organic layer was separated and reduced on rotary evaporator to yield a slightly yellow oil. The oil was then azeotroped with $CHCl_3$ and a white solid formed. ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.40 (ddd, *J* = 7.5, 5.0, 2.6 Hz, 2H), 7.38 – 7.33 (m, 3H), 4.91 (s, 1H), 4.68 (s, 1H). ^{13}C NMR (126 MHz, CDCl3) δ 168.9, 129.5, 129.32, 128.03, 115.2, 43.6. These compounds were converted to the corresponding benzyl[4] esters by standard DCC/DMAP coupling.[5]

Procedure for the synthesis of α,α-disubstituted cyanoacetic *hetero-aromatic* benzyl ester substrates in Table 1:[3] To a solution of α-substituted, benzyl cyanoacetate in dry THF (0.5 M) under argon was added NaH (1.0 equiv.). When the resulting solution became homogeneous, the respective alkyl bromide (1.0 equiv.) was added dropwise via syringe. After 4 h., water was added to the reaction mixture and the resulting mixture was extracted with Et_2O (2 times with twice the amount of solvent required for the reaction). The organic layer was concentrated via a rotary evaporation, and the resulting residue was purified by flash chromatography over silica with Hex/EtOAc (92:8) as eluent.

---

[1] Komiya, S. *Synthesis of Organometallic Compounds. A Practical Guide*; John Wiley & Sons: New York, **1997**, pp 290.
[2] Heller, S. T.; Sarpong, R. *Org. Lett.* **2010**, *12*, 4572.
[3] Recio, III, A.; Tunge, J. A. *Org. Lett.* **2009**, *11*, 630.
[4] Obtained via coupling with aromatic-, heteroaromatic-, and aryl-benzyl alcohols
[5] Neises, B., Steglich, W. *Angew. Chem. Int. Ed. Engl.* **1978**, *17*, 522.

Procedure for the synthesis of α,α-disubstituted cyanoacetic benzenoid benzyl ester substrates in Table 1:[3] To a solution of α-cyanoacetic benzyl ester, or α-substituted cyanoacetic benzyl ester in DMF or DMSO (0.5 M) was added anhydrous K_2CO_3 (3.0 equiv.) and the mixture was stirred vigorously. The respective electrophilic bromide (3.0 equiv.) was added and the reaction was allowed to proceed until completion was indicated by TLC (12-15 h). The reaction was then diluted in CH_2Cl_2 (3 times the volume of solvent used for the reaction). The reaction was then quenched with H_2O (5 times the volume of solvent used for the reaction). The organic layer was then washed 6 times with H_2O (5 times the volume of solvent used for the reaction) and purified via flash column chromatography using Hex/EtOAc (92:8) as eluent.



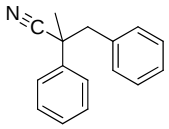
Procedure for the synthesis of α,α-disubstituted cyanoacetic benzyl ester substrates used in Table 3:[2] To a solution of the appropriate variant of benzyl cyanide (6.0 mmol), in DMSO or DMF (0.4M) was added NaH (14.0 mmol). The solution was allowed to stir until H_2 gas evolution no longer evident. The imidazole carbamate benzyl ester (9 mmol) was added and the reaction was allowed to stir for 2h. Next was added solid K_2CO_3 (6.0 mmol). The flask was then charged with the alkyl halide (18.0 mmol) and stirred vigorously for 2h. The reaction was then diluted in 30 mL CH_2Cl_2 and quenched with 60 mL aqueous HCl (.5 M). The organic layer was then washed 5 more times with 60 mL of H_2O. The compounds were purified via flash column chromatography using Hex/EtOAc (ca. 95:5) as eluent.

Procedure for Pd-catalyzed decarboxylative benzylation (Table 1): To a flame-dried flask (Schlenk tube for reactions with toluene or sealable microwave vial for reactions with THF) with stir bar was added the respective substrate (0.5 mmol) and placed under Ar. The catalyst (either: 5 mol% $Pd(PPh_3)_4$, or 10 mol% CpPd(Allyl) and 11 mol% dppf ligand as denoted in Table 1 in manuscript) was then added. The flask was then charged with solvent (THF or Tol, 0.2 M) and heated at 110 ^oC under argon for the amount of time noted in the manuscript in table 2 (4-24h). After the allotted reaction time, the solvent was removed via rotary evaporation. All products were purified via silica gel chromatography (mobile phase for each substrate denoted below).

Procedure for Pd-catalyzed decarboxylative coupling (Table 3): To a flame-dried microwave vial with stir bar was added the appropriate substrate (0.5 mmol), followed by activated (flamed with propane torch in round bottom flask) 3Å molecular sieves (0.2 g) and placed under argon. Toluene or THF (0.2M) was added, the vial was sealed, and the mixture was allowed to stir vigorously at 110 °C for 0.5-1.0 h. Under Ar, the molecular sieves were filtered from the solution and the catalyst (for arylation: 5 mol% $Pd(PPh_3)_4$ for benzylation: 10 mol% CpPd(Allyl) and 11 mol% (*S*)-DTBM SEGPHOS ligand) was added. The reaction was allowed to proceed for the amount time noted in the manuscript (12-24 h), under Ar at 110 °C. After the allotted

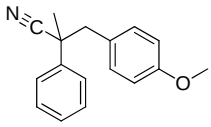
reaction time, the solvent was reduced via rotary evaporator. All products were purified via silica gel chromatography (mobile phase for each substrate denoted below).

^{1}HNMR and ^{13}CNMR Shifts for Compounds Reported in Table 1:



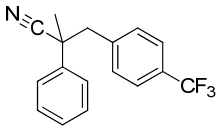
2-methyl-2,3-diphenylpropanenitrile:[6]

Clear liquid isolated via column chromatography 98:2 Hex:EthOAc as eluent. **^{1}H NMR** (500 MHz, $CDCl_3$) δ 7.34 – 7.21 (m, 5H,$R_3C(q)Ar\mathit{H}$), 7.16 (dd, J = 5.0, 1.9 Hz, 3H,$RCH_2Ar\mathit{H}$), 6.98 – 6.93 (m, 2H, $RCH_2Ar\mathit{H}$), 3.11 – 3.02 (m, 2H, $R_3C(q)C\mathit{H}_2Ph$), 1.68 (s, 3H, $R_3C(q)C\mathit{H}_3$). **^{13}C NMR** (126 MHz, $CDCl_3$) δ 139.7 (s, $R_3C(Ar\mathit{C}(q))$, 135.1 (s, $R_3CCH_2(Ar\mathit{C}(q))$, 130.3 (s, $R_3C(Ar\mathit{C}_{(meta)})$, 128.7 (s, R_3CCH_2 ($Ar\mathit{C}_{(ortho)}$), 128.1 (s, $R_3C(Ar\mathit{C}_{(meta)})$, 127.9 (s, $R_3C(Ar\mathit{C}_{(para)})$, 127.4 (s, R_3CCH_2 ($Ar\mathit{C}_{(para)}$), 125.9 (s, R_3CCH_2 ($Ar\mathit{C}_{(ortho)}$), 123.1 (s, $R_3\mathit{C}N$), 48.6 (s, $R_3C\mathit{C}H_2Ph$), 43.5 (s, $\mathit{C}R_4$), 26.0 (s, $R_3C(q)\mathit{C}H_3$). **GC/MS**: 221.1 [M^+], 196.0 [M-CN], 91.0 [base peak]



3-(4-methoxyphenyl)-2-methyl-2-phenylpropanenitrile

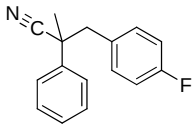
Viscous clear liquid isolated via column chromatography 97:3 Hex:EthOAc as eluent. **^{1}H NMR** (500 MHz, $CDCl_3$) δ 7.35 – 7.19 (m, 5H, $R_3C(q)Ar\mathit{H}$), 6.85 (d, J = 8.7 Hz, 2H, $RCH_2Ar\mathit{H}_{(ortho)}$), 6.68 (d, J = 8.7 Hz, 2H, $RCH_2Ar\mathit{H}_{(meta)}$), 3.69 (s, 3H,$CH_2ArOC\mathit{H}_3$), 3.08 – 2.94 (m, 2H, $R_3C(q)C\mathit{H}_2Ar$), 1.66 (s, $R_3C(q)C\mathit{H}_3$). **^{13}C NMR** (126 MHz, $CDCl_3$) δ 158.9 (s, $CH_2Ar\mathit{C}(q)OCH_3$), 139.7 (s, $R_3CPh\mathit{C}(q)$), 131.4 (s $RCH_2Ar\mathit{C}H_{(ortho)}$), 128.7 (s, $RCH_2Ar\mathit{C}(q)$), 127.8 (s, $R_3CPh\mathit{C}H_{(meta)}$), 127.2 (s, $R_3CPh\mathit{C}H_{(para)}$), 125.9 (s, $R_3CPh\mathit{C}H_{(ortho)}$), 123.3 (s, $R_3\mathit{C}N$), 113.5 (s, $RCH_2Ar\mathit{C}H_{(meta)}$), 55.2 (s, $CH_2ArO\mathit{C}H_3$), 47.8 (s, $R_3C\mathit{C}H_2Ar$), 43.7 (s, $\mathit{C}R_4$), 25.9 (s, $R_3C(q)\mathit{C}H_3$). **GC/MS**: 251.2 [M^+], 226.5 [M-CN], 57.1 [base peak]



2-methyl-2-phenyl-3-(4-(trifluoromethyl)phenyl)propanenitrile

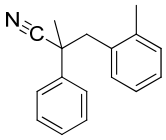
Viscous clear liquid isolated via column chromatography 98:2 Hex:EthOAc as eluent**.** **^{1}H NMR** (500 MHz, $CDCl_3$) δ 7.40 (d, J = 8.0 Hz, 2H, $RCH_2Ar\mathit{H}_{(meta)}$), 7.32 – 7.23 (m, 5H, $R_3C(q)Ar\mathit{H}$), 7.04 (d, J = 8.0 Hz, 2H, $RCH_2Ar\mathit{H}_{(ortho)}$), 3.12 (s, 2H, $R_3C(q)C\mathit{H}_2Ar$), 1.71 (s, 3H, $R_3C(q)C\mathit{H}_3$). **^{13}C NMR** (126 MHz, $CDCl_3$) δ 139.1(s, $R_3C(Ar\mathit{C}(q))$, 138.8 (s, $R_3CCH_2(Ar\mathit{C}(q))$, 130.6 (s, $R_3C(Ar\mathit{C}(m))$, 128.9 (s, $Ar\mathit{C}$), 128.2 (s, $Ar\mathit{C}CF_3$), 125.8 (s, $Ar\mathit{C}$), 125.1 (q, $Ph\mathit{C}F_3$), 122.7 (s, $R_3\mathit{C}N$), 48.2 (s, $R_3C\mathit{C}H_2Ph$), 43.5 (s, $\mathit{C}R_4$), 26.3 (s, $R_3C(q)\mathit{C}H_3$). **GC/MS**: 290.1 [M^+], 264.0 [M-CN], 130.0 [base peak]

[6] Smith, H. A.; Bissell, R. L.; Kenyon, W. G.; MacClarence, J. W.; Hauser, C. R. *J. Org. Chem.* **1971**, *36*, 2132.



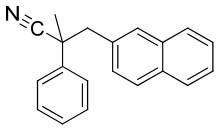
3-(4-fluorophenyl)-2-methyl-2 phenylpropanenitrile

Vicous clear liquid isolated via column chromatography 97:3 Hex:EthOAc as eluent. **^{1}H NMR** (500 MHz, $CDCl_3$) δ 7.27 (d, *J* = 8.0 Hz, 5H, RCH_2ArH), 6.87 (d, *J* = 8.0 Hz, 2H, $R_3C(q)ArH$), 6.83 (d, *J* = 8.0 Hz, 2H, $RCH_2ArH_{(ortho)}$), 3.03 (s, 2H, $R_3C(q)CH_2Ar$), 1.68 (s, 3H, $R_3C(q)CH_3$). **^{13}C NMR** (126 MHz, $CDCl_3$) δ 163.2 (s, Ar*C*F), 161.2 (s, $R_3CCH_2(ArC(q))$, 139.3(s, $R_3C(ArC(q))$, 131.8 (s, R_3CCH_2- $(ArC(_{ortho}))$, 128.8 (s, $R_3C(ArC(_{meta}))$, 128.0 (s, $R_3C(ArC(_{ortho}))$, 125.9 (s, $R_3C(ArC(_{para}))$, 122.8 (s, R_3CN), 115.0(s, $R_3CCH_2(ArC(_{meta})CF)$, 47.8 (s, R_3CCH_2Ph), 43.6 (s, CR_4), 26.1(s, $R_3C(q)CH_3$). **GC/MS**: 239.0 [M^+], 214.0 [M-CN], 109.0 [base peak]



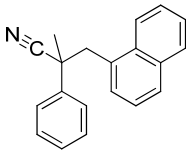
2-methyl-2-phenyl-3-(o-tolyl)propanenitrile

Vicous clear liquid isolated via column chromatography 97:3 Hex:EthOAc as eluent. **^{1}H NMR** (500 MHz, $CDCl_3$) δ 7.33 – 7.21 (m, 5H, $R_3C(q)ArH$), 7.10 – 7.05 (m, 1H, RCH_2-C(q)=C(Me)=$CH_{(meta)}$), 7.05 – 6.99 (m, 1H, $RCH_2ArH_{(meta)}$), 6.99 – 6.94 (m, 2H, RCH_2ArH), 3.11 (q, *J* = 13.9 Hz, 2H, $R_3C(q)CH_2Ar$), 1.99 (s, 3H, $PhCH_3$), 1.74 (s, 3H, $R_3C(q)CH_3$). **^{13}C NMR** (126 MHz, $CDCl_3$) δ 139.8 (s, $R_3C(PhC(q))$, 137.5 (s, $R_3CCH_2(ArC(q))$, 133.4 (s, $PhC(q)CH_3$), 131.1 (s, RCH_2-C(q)=C(Me)=$CH_{(meta)}$), 130.5 (s, Ph*C*), 128.7 (s, Ph*C*), 127.5 (s, Ph*C*), 127.4 (s, Ph*C*), 123.5 (s, R_3CN), 44.6 (s, R_3CCH_2Ph), 43.3 (s, CR_4), 26.0 (s, $R_3C(q)CH_3$), 19.7 (s, $PhCH_3$). **GC/MS**: 235.1 [M^+], 210.9 [M-CN], 105.0 [base peak]



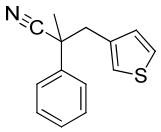
2-methyl-3-(naphthalen-2-yl)-2-phenylpropanenitrile

Brown solid isolated via column chromatography 98:2 Hex:EthOAc as eluent. **^{1}H NMR** (500 MHz, $CDCl_3$) δ 7.71 (dd, *J* = 6.1, 3.4 Hz, 1H, 5-naphthylC*H*), 7.66 (dd, *J* = 6.0, 3.5 Hz, 1H, 8-naphthylC*H*), 7.61 (d, *J* = 8.4 Hz, 1H, 4-naphthylC*H*), 7.43 (s, 1H, 1-naphthylC*H*), 7.37 (dd, *J* = 6.2, 3.2 Hz, 2H, 6-, 7-naphthylC*H*), 7.34 – 7.22 (m, 5H, $R_3C(q)ArH$), 7.02 (dd, *J* = 8.4, 1.7 Hz, 1H, 3-naphthylC*H*), 3.31 – 3.16 (m, 2H, $R_3C(q)CH_2$-β-Naphthyl), 1.72 (s, 3H, $R_3C(q)CH_3$). **^{13}C NMR** (126 MHz, $CDCl_3$) δ 139.6 (s, $R_3C(PhC(q))$, 133.1(s, R_3CCH_2(2-naphthyl*C*(q)), 132.6 (2-naphthyl*C*), 129.4 (2-naphthyl*C*), 128.8 (2-naphthyl*C*), 128.3 (2-naphthyl*C*), 127.9 (2-naphthyl*C*), 127.6 (2-naphthyl*C*), 126.2 – 125.7(s, Ph*C*), 123.2 (s, R_3CN), 48.7 (s, $R_3C(q)CH_2$-*β*-naphthyl), 43.6 (s, CR_4), 26.0 (s, $R_3C(q)CH_3$). **GC/MS**: 271.1 [M^+], 141.0 [base peak]



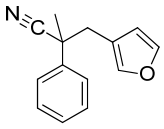
2-methyl-3-(naphthalen-1-yl)-2-phenylpropanenitrile

White solid isolated via column chromatography 98:2 Hex:EthOAc as eluent. **^{1}H NMR** (500 MHz, $CDCl_3$) δ 7.78 – 7.73 (m, 2H, 5-, 8-naphthylC*H*), 7.70 (d, *J* = 8.2 Hz, 1H, 4-naphthylC*H*), 7.38 – 7.28 (m, 5H, R_3C(q)PhC*H*), 7.28 – 7.19 (m, 4H, 2-, 3-, 6-,7-naphthylC*H*), 3.68 – 3.47 (m, 2H, R_3C(q)CH_2(α-Naphthyl), 1.72 (s, 3H, (s, R_3C(q)CH_3)). **^{13}C NMR** (126 MHz, $CDCl_3$) δ 140.0 (s, R_3C(PhC(q)), 133.7 (s, R_3CCH_2(α-naphthylC(q)), 132.6 (s), 131.3 (s), 129.2 (s), 128.9 – 128.7 (m, R_3C(q)(PhC), 128.2 (s, CH_2-α-naphthylC), 128.0 (s, CH_2-α-naphthylC), 126.03 – 125.74 (m, R_3C(PhC), 125.5 (s, CH_2-α-naphthylC), 125.1 (s, CH_2-α-naphthylC), 123.7 (s, R_3CN), 123.5 (s, CH_2-2-naphthylC), 43.8 (s, R_4C(q)), 43.6 (s, R_3C(q)CH_2-β-naphthyl)), 26.0 (s, R_3C(q)CH_3). **GC/MS**: 271.1 [M^+], 141.0 [base peak]



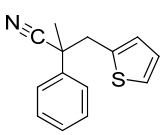
2-methyl-2-phenyl-3-(thiophen-3-yl)propanenitrile:

Clear liquid isolated via column chromatography 95:5 Hex:EthOAc as eluent. **^{1}H NMR** (500 MHz, $CDCl_3$) δ 7.37 – 7.25 (m, 1H, R_3C(q)PhC$H_{(para)}$), 7.25 – 7.20 (m, 1H, R_3C(q)PhC$H_{(para)}$), 7.08 (dd, *J* = 4.9, 3.0 Hz, 1H, 5-thiophenylC*H*), 6.83 (dt, *J* = 2.9, 0.6 Hz, 1H, 4-thiophenylC*H*), 6.65 (dd, *J* = 4.9, 1.3 Hz, 1H, 2-thiophenyl C*H*), 3.11 (s, 2H, R_3C(q)CH_2(3-thiophenyl), 1.65 (s, 3H, (s, R_3C(q)CH_3)). **^{13}C NMR** (126 MHz, $CDCl_3$) δ 139.7(s, R_3CPhC(q)) 135.4 (s, R_3CCH_2(3-thiophenylC(q)), 129.1 (s, R_3C(PhC$_{(meta)}$), 128.8 (s, 4-thiophenylC), 128.0 (s, (s, R_3C(PhC(q)), R_3C(PhC$_{(ortho)}$), 125.8 (s, 5-thiophenylC), 125.2 (s, R_3C(PhC$_{(para)}$), 124.2 (s, 2-thiophenylC), 123.4 (s, R_3CN), 43.3 (s, R_4C(q)), 43.0 (m, R_3C(q)CH_2-3-thiophenyl)), 26.2 (s, R_3C(q)CH_3). **GC/MS**: 227.1 [M^+], 202.6 [M-CN], 97.0 [base peak]



3-(furan-3-yl)-2-methyl-2-phenylpropanenitrile:

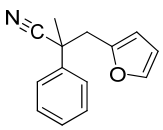
Clear liquid isolated via column chromatography 95:5 Hex:EthOAc as eluent. **^{1}H NMR** (500 MHz, $CDCl_3$) δ 7.36 – 7.31 (m, 3H, Ar$H_{(meta/para)}$), 7.32 – 7.28 (m, 2H, Ar$H_{(ortho)}$), 7.27 – 7.20 (s, 1H, 2-furanyl-*H*), 7.08 (dq, *J* = 1.6, 0.8 Hz, 1H, 5-furanyl-*H*), 6.00 (dd, *J* = 1.7, 0.7 Hz, 1H, 4-furanyl-*H*), 2.94 (s, 2H, -CR_3CH_2-3-furanyl), 1.67 (s, 3H, R_3CCH_3). **^{13}C NMR** (126 MHz, $CDCl_3$) δ 141.6 (s, ArC(q)), 140.2 (s, 5-furanyl-*C*), 138.6 (s, 3-furanyl(2-*C*)), 127.8 (s, Ar$C_{(ortho)}$), 126.9 (s, Ar$C_{(para)}$), 124.7 (s, Ar$C_{(meta)}$), 122.3 (s, R*C*N), 117.6 (s, 3-furanyl(5-*C*)), 110.6 (s, 3-furanyl(4-*C*)), 42.0 (s, *C*R_4), 37.1 (s, R*C*H_2R), 25.3 (s, R*C*H_3). **GC/MS**: 211.0 [M^+], 186.1 [M-CN], 81.0 [base peak]



2-methyl-2-phenyl-3-(thiophen-2-yl)propanenitrile

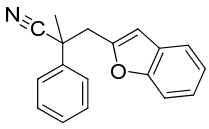
Vicous clear liquid isolated via column chromatography 97:3 Hex:EthOAc as eluent. **^{1}H NMR** (500 MHz, $CDCl_3$) δ 7.45 (d, *J* = 7.3 Hz, 1H, 5-thiophenylC*H*), 7.43 – 7.39 (m, 2H, R_3C(q)PhC$H_{(meta)}$), 7.39 – 7.33 (m, 2H, R_3C(q)PhC$H_{(ortho)}$), 7.15 (dd, *J* = 5.1, 1.1 Hz, 1H, R_3C(q)PhC$H_{(para)}$), 6.93 (dd, *J* = 5.1, 3.5 Hz, 1H, 4-thiophenylC*H*), 6.84 (d, *J* = 3.4 Hz, 1H, 3-thiophenylC*H*), 3.42 (s, 2H, CR_3CH_2 thiophenyl), 1.81 (s, 3H, R_3CCH_3). ^{13}C NMR (126 MHz, $CDCl_3$) δ

139.2 (s, $R_3C(PhC(q))$, 136.5 (s, R_3CCH_2(2-thiophenyl$C$(q)), 128.9 (s, $PhC_{(meta)}$), 128.1 (s, 3-thiophenyl$C$), 128.0 (s, 4-thiophenyl$C$), 126.8 (s, $R_3C(PhC_{(ortho)})$, 125.9 (s, $R_3C(PhC_{(para)})$, 125.1 (s, 2-thiophenyl-5-C), 123.0 (s, RCN), 43.8 (s, CR_4), 42.6 (s, RCH_2R), 26.2 (s, RCH_3). **GC/MS**: 227.0 [M^+], 202.0 [M-CN], 97.0 [base peak]



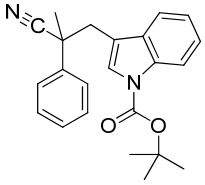
3-(furan-2-yl)-2-methyl-2-phenylpropanenitrile

Vicous clear liquid isolated via column chromatography 97:3 Hex:EthOAc as eluent. **^{1}H NMR** (500 MHz, $CDCl_3$) δ 7.36 (m, 2H, $R_3C(PhCH_{(meta)})$, 7.31 (m, 2H, $R_3C(PhCH_{(ortho)})$, 7.26 (m, 1H, $R_3C(PhCH_{(para)})$, 7.24 (dd, J = 1.8, 0.8 Hz, 1H, 2-furanyl(5-CH)), 6.21 (dd, J = 3.2, 1.9 Hz, 1H, 2-furanyl(4-CH)), 6.01 (d, J = 3.4 Hz, 1H, 2-furanyl(3-CH)), 3.23 – 3.06 (m, 2H, CR_3CH_2-2-furanyl), 1.68 (s, 3H, R_3CCH_3). **^{13}C NMR** (126 MHz, $CDCl_3$) δ 149.7 (s, R_3CCH_2(2-furanyl(2-C(q))), 142.1 (s, $R_3C(PhC(q))$), 139.6 (s, 2-furanyl(5-C)), 128.8 (s, $R_3C(PhC_{(meta)})$, 128.0 (s, $R_3C(PhC_{(ortho)})$, 125.6 (s, $R_3C(PhC_{(para)})$, 123.0 (s, RCN), 110.5 (s, 2-furanyl(4-C)), 109.0 (s, 2-furanyl(3-C)), 42.4, (s, CR_4), 40.8 (s, RCH_2R), 26.1 (s, RCH_3). **GC/MS**: 211.0 [M^+], 186.6 [M-CN], 57.1 [base peak]



3-(benzofuran-2-yl)-2-methyl-2-phenylpropanenitrile

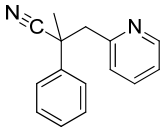
White solid isolated via column chromatography 95:5 Hex:EthOAc as eluent. **^{1}H NMR** (500 MHz, $CDCl_3$) δ 7.41 (d, J = 8.1 Hz, 2H, 2-benzofuranyl(4-,7-CH), 7.32 (t, J = 8.0 Hz, 2H, 2-benzofuranyl(5-,6-CH), 7.29 – 7.22 (m, 4H, $R_3C(PhCH$), 7.19 (s, 1H, $R_3C(PhCH)$, 6.42 (s, 1H, 2-benzofuranyl(3-CH)), 3.38 – 3.21 (m, 2H, CR_3CH_2-2-benzofuranyl), 1.76 (s, 3H, R_3CCH_3). **^{13}C NMR** (126 MHz, $CDCl_3$) δ 154.7(s, 2-benzofuranyl(2-C(q)), 152.6 (s, 2-benzofuranyl(9-C(q)), 139.4 (s, $R_3CPhC(q)$), 129.0 (s, 2-benzofuranyl(8-C(q)), 128.2 (s, $R_3C(PhCH)$, 125.6 (s, $R_3C(PhCH)$, 124.0 (s, 2-benzofuranyl(CH)), 122.7 (s, RCN), 120.9 (s, 2-benzofuranyl(4-CH)) , 111.0 (s, 2-benzofuranyl(7-CH)), 106.0 (s, 2-benzofuranyl(3-CH)), 42.5 (s, CR_4), 41.2 (s, RCH_2R), 26.3(s, RCH_3). **GC/MS**: 261.1 [M^+], 131.0 [base peak]



tert-butyl 3-(2-cyano-2-phenylpropyl)-1H-indole-1-carboxylat

Vicous clear liquid isolated via column chromatography 97:3 Hex:EthOAc as eluent. **^{1}H NMR** (500 MHz, $CDCl_3$) δ 8.03 (d, J = 7.1 Hz, 2H, 3-methylindole(4-, 7-CH)), 7.39 (d, J = 7.1 Hz, 2H, 3-methylindole(6-CH)), 7.34 – 7.22 (m, 5H, R_3CPhCH), 7.22 – 7.13 (m, 1H, 3-methylindole(2-CH)), 7.06 (dd, J = 6.1, 3.4 Hz, 1H, 3-methylindole(5-CH)), 3.22 (s, 2H, CR_3CH_2-3-methyl(N-Boc)indole), 1.73 (s, 3H, R_3CCH_3), 1.57 (s, 9H, $CO_2C(CH_3)_3$). **^{13}C NMR** (126 MHz, $CDCl_3$) δ 149.5 (s, $R_3CPhC(q)$), 130.7 (s, 3-methylindole(9-C(q)), 129.2 (s, 3-methylindole(8-C(q)), 128.8 (s, $R_3C(PhC_{(meta)})$, 128.0 (s, $R_3C(PhC_{(ortho)})$, 125.9 (s, $R_3C(PhC_{(para)})$, 125.4 (s, 3-

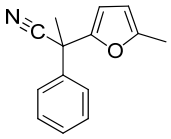
methylindole*C*H), 124.3 (s, RCH_2-3-methylindole(2-*C*(q)), 122.4 (s, R*C*N), 118.9 (s, 3-methylindole(4-*C*H), 115.1 (s, 3-methylindole(7-*C*H), 83.7 (s, CO_2C(q)$(CH_3)_3$), 43.2 (s, CR_4), 38.0 (s, R*C*H_2R), 28.2 (s, $CO_2C(CH_3)_3$), 26.0 (s, R*C*H_3). **GC/MS**: 361.2 [M^+1], 335.8 [M-CN], 57.1 [base peak]



2-methyl-2-phenyl-3-(pyridin-2-yl)propanenitrile

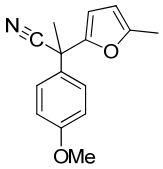
Vicous clear liquid isolated via column chromatography 97:3 Hex:EthOAc as eluent. **^{1}H NMR** (500 MHz, $CDCl_3$) δ 8.48 (d, *J* = 7.8 Hz, 1H, 2-methyl pyridine(6-C*H*)), 7.52 (td, *J* = 7.7, 1.8 Hz, 1H, 2-methyl pyridine(5-C*H*)), 7.39 (m, 2H, R_3C(PhC$H_{(meta)}$), 7.30 (m, 2H, R_3C(PhC$H_{(ortho)}$), 7.26 (m, 1H, R_3C(PhC$H_{(para)}$), 7.10 (td, *J* = 7.7, 1.8 Hz, 1H, 2-methyl pyridine(4-C*H*)), 7.06 (d, *J* = 7.8 Hz, 1H, 2-methyl pyridine(3-C*H*)), 3.28 (s, 2H, CR_3CH_2-2-methyl pyridne), 1.71 (s, 3H, R_3CCH_3). **^{13}C NMR** (126 MHz, $CDCl_3$) δ 155.7 (s, R_3CH_2-2-methyl pyridyl(2-*C*(q))), 149.2 (s, R_3CPhC(q)), 139.9 (s, 2-methyl pyridyl(6-*C*H)), 136.3 (s, 2-methyl pyridyl(4-*C*H)), 128.9 (s, R_3C(Ph$C_{(meta)}$), 127.9 (s, R_3C(Ph$C_{(ortho)}$), 125.7 (s, R_3C(Ph$C_{(para)}$), 124.6 (s, 2-methyl pyridyl(3-*C*H)), 123.0 (s, 2-methyl pyridyl(5-*C*H)), 122.3 (s, R*C*N), 50.0 (s, R*C*H_2R), 42.9 (s, CR_4) 26.1 (s, R*C*H_3). **GC/MS**: 222.1 [M^+], 197.2 [M-CN], 93.0 [base peak]

^{1}HNMR and ^{13}CNMR Shifts for Compounds Reported in Table 3:



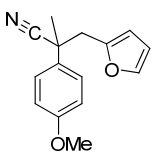
2-(5-methylfuran-2-yl)-2-phenylpropanenitrile

Vicous clear liquid isolated via column chromatography 97:3 Hex:EthOAc as eluent. **^{1}H NMR** (500 MHz, $CDCl_3$) δ 7.31 (m, 2H, $R_3PhCH_{(meta)}$), 7.25 (m, 3H, $R_3PhCH_{(ortho/para)}$), 6.08 (d, *J* = 3.1 Hz, 1H, R_3C-furanyl(3-C*H*)), 5.86 (dq, *J* = 3.1, 1.0 Hz, 1H, R_3C-furanyl(4-C*H)*), 2.18 (s, 3H, furanylCH_3), 1.94 (s, 3H, R_3CCH_3). **^{13}C NMR** (126 MHz, $CDCl_3$) δ 153.3 (s, R_3C-furanyl(2-*C*(q)), 149.9 (s, R_3C-furanyl(5-*C*(q)), 139.3 (s, R_3CPhC(q)), 128.9 (s, $R_3C(PhCH_{(ortho)})$, 128.1 (s, $R_3C(PhCH_{(para)})$, 126.0 (s, $R_3C(PhC_{(meta)})$, 121.2 (s, R*C*N), 108.7 (s, R_3C-furanyl(3-*C*H)), 106.4 (s, R_3C-furanyl(4-*C*H)), 42.2 (s, *C*R_4), 27.0 (s, R*C*H_3), 13.6 (s, furnyl(5-*C*H_3)). **GC/MS**: 211.0 [M^+], 186.6 [M-CN], 57.1 [base peak]



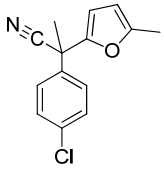
2-(4-methoxyphenyl)-2-(5-methylfuran-2-yl)propanenitrile

Viscous clear liquid isolated via column chromatography 98:2 Hex:EthOAc as eluent. **^{1}H NMR** (500 MHz, $CDCl_3$) δ 7.25 (m, 2H, $R_3PhCH_{(meta)}$), 6.83 (m, 2H, $R_3PhCH_{(ortho)}$), 6.05 (d, *J* = 3.1 Hz, 1H, R_3C-furanyl(3-C*H*)), 5.85 (dq, *J* = 3.1, 1.0 Hz, 1H, R_3C-furanyl(4-C*H)*), 3.74 (s, 3H,CR_3ArOCH_3), 2.19 (s, 3H, furanylCH_3), 1.92 (s, 3H, R_3CCH_3). **^{13}C NMR** (126 MHz, $CDCl_3$) δ 159.3 (s, CR_3ArC(q)OCH_3), 153.2 (s, R_3C-furanyl(2-*C*(q)), 150.3 (s, R_3C-furanyl(5-*C*(q)), 131.3 (s, R_3CPhC(q)), 127.2 (s, $R_3C(PhCH_{(ortho)})$, 121.46 (s, R*C*N), 114.1 (s, $R_3C(PhC_{(meta)})$, 108.5 (s, R_3C-furanyl(3-*C*H)), 106.3 (s, R_3C-furanyl(4-*C*H)), 55.4 (s, CH_2ArOCH_3), 41.6 (s, *C*R_4), 26.9 (s, R*C*H_3), 13.6 (s, furnyl(5-*C*H_3)). **GC/MS**: 241.1 [M^+], 216.2 [M-CN], 226.1 [base peak].



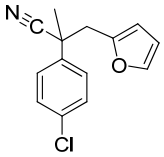
3-(furan-2-yl)-2-(4-methoxyphenyl)-2-methylpropanenitrile

Viscous clear liquid isolated via column chromatography 98:2 Hex:EthOAc as eluent. **^{1}H NMR** (500 MHz, CDCl3) δ 7.27 (dd, *J* = 1.8, 0.8 Hz, 1H, 2-furanyl(5-C*H*)), 7.24 (m, 2H, $R_3PhCH_{(ortho)}$), 6.83 (m, 2H, $R_3PhCH_{(meta)}$), 6.21 (dd, J = 3.2, 1.9 Hz, 1H, R_3C-furanyl(4-C*H)*),), 6.02 (d, J = 3.2 Hz, 1H, R_3C-furanyl(3-C*H*)), 3.74 (s, 3H,CR_3ArOCH_3), 3.11 (m, 2H, CR_3CH_2-2-furanyl), 1.65 (s, 3H, R_3CCH_3). **^{13}C NMR** (126 MHz, $CDCl_3$) δ 159.1 (s, CR_3ArC(q)OCH_3), 149.9 (s, R_3C-furanyl(2-*C*(q)), 142.1 (s, R_3CCH_2(2-furanyl(5-*C*(q)), 127.8 (s, R_3CPhC(q)), 126.8 (s, $R_3C(PhCH_{(ortho)})$, 123.3 (s, R*C*N), 114.1 (s, $R_3C(PhC_{(meta)})$, 110.5 (s, R_3C-furanyl(4-*C*H)), 109.0 (s, R_3C-furanyl(3-*C*H)), 55.3 (s, CR_3ArOCH_3), 41.9 (s, *C*R_4), 40.9 (s, CR_3CH_2-2-furanyl), 26.1 (s, R_3CCH_3). **GC/MS**: 241.1 [M^+], 216.2 [M-CN], 226.1 [base peak].



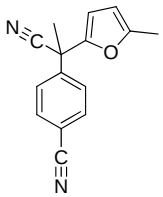
2-(4-chlorophenyl)-2-(5-methylfuran-2-yl)propanenitrile

Vicous clear liquid isolated via column chromatography 98:2 Hex:EthOAc as eluent. **^{1}H NMR** (500 MHz, $CDCl_3$) δ 7.31 – 7.23 (m, 4H, R_3PhCH), 6.10 (d, J = 3.2 Hz, 1H, R_3C-furanyl(3-C*H*)), 5.87 (dt, J = 2.1, 1.0 Hz, 1H, R_3C-furanyl(4-C*H)*), 2.19 (s, 3H, furanylCH_3), 1.93 (s, 3H, R_3CCH_3). **^{13}C NMR** (126 MHz, $CDCl_3$) δ 152.5 (s, R_3C-furanyl(2-*C*(q)), 148.3 (s, R_3C-furanyl(5-*C*(q)), 136.8 (s, CH_2ArC(q)Cl), 133.1 (s, R_3CPhC(q)), 128.0 (s, $R_3C(PhCH_{(ortho)})$, 126.3 (s, $R_3C(PhC_{(meta)})$, 119.8 (s, R*C*N), 107.8 (s, R_3C-furanyl(3-*C*H)), 105.4 (s, R_3C-furanyl(4-*C*H)), 40.8 (s, CR_4), 25.8 (s, R*C*H_3), 12.6 (s, furnyl(5-*C*H_3)). **GC/MS**: 245.1 [M^+], 220.1 [M-CN], 230.1 [base peak].



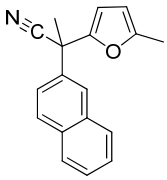
2-(4-chlorophenyl)-3-(furan-2-yl)-2-methylpropanenitrile

Vicous clear liquid isolated via column chromatography 98:2 Hex:EthOAc as eluent. **^{1}H NMR** (500 MHz, $CDCl_3$) δ 7.27 (s, 4H, R_3PhCH), 7.23 (dd, J = 1.8, 0.8 Hz, 1H, 2-furanyl(5-C*H*)), 6.21 (dd, J = 3.2, 1.9 Hz, 1H, R_3C-furanyl(4-C*H)*), 6.02 (d, J = 3.2 Hz, 1H, R_3C-furanyl(3-C*H*)), 3.13 (m, 2H, CR_3CH_2-2-furanyl), 1.67 (s, 3H, R_3CCH_3). **^{13}C NMR** (126 MHz, $CDCl_3$) δ 149.3 (s, R_3C-furanyl(2-*C*(q)), 142.3 (s, R_3CCH_2(2-furanyl(5-*C*(q)), 138.0 (s, CH_2ArC(q)Cl), 134.0 (s, R_3CPhC(q)), 129.0 (s, $R_3C(PhCH_{(meta)})$, 127.1 (s, $R_3C(PhCH_{(ortho)})$, 122.7 (s, R*C*N), 110.5 (s, R_3C-furanyl(4-*C*H)), 109.2 (s, R_3C-furanyl(3-*C*H)), 42.3 (s, CR_4), 40.7 (s, CR_3CH_2-2-furanyl), 26.1 (s, R_3CCH_3). **GC/MS**: 245.1 [M^+], 220.1 [M-CN], 230.1 [base peak].



4-(1-cyano-1-(5-methylfuran-2-yl)ethyl)benzonitrile

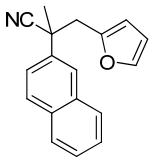
Vicous clear liquid isolated via column chromatography 85:15 Hex:EthOAc as eluent. **^{1}H NMR** (500 MHz, $CDCl_3$) δ 7.61 (m, 2H, $R_3PhCH_{(meta)}$), 7.45 (m, 2H, $R_3PhCH_{(ortho)}$), 6.18 (d, J = 3.2 Hz, 1H, R_3C-furanyl(3-C*H*)), 5.91 (m, 1H, R_3C-furanyl(4-C*H)*), 2.18 (s, furnyl(5-*C*H_3)), 1.95 (s, 3H, R_3CCH_3). **^{13}C NMR** (126 MHz, $CDCl_3$) δ 154.0 (s, R_3C-furanyl(2-*C*(q)), 148.4 (s, R_3C-furanyl(5-*C*(q)), 144.4 (s, R_3CPhC(q)), 132.8 (s, $R_3C(PhCH_{(meta)})$, 126.8 (s, $R_3C(ArCH_{(ortho)})$, 120.1 (s, R*C*N), 118.2 (s, R_3ArCN), 112.4 (s, R_3ArC(q)-CN), 109.3 (s, R_3C-furanyl(3-*C*H)), 106.6 (s, R_3C-furanyl(4-*C*H)), 42.3 (s, CR_4), 26.6 (s, R*C*H_3), 13.6 (s, furnyl(5-*C*H_3)). **GC/MS**: 236.1 [M^+], 211.3 [M-CN], 221.1 [base peak].



2-(5-methylfuran-2-yl)-2-(naphthalen-2-yl)propanenitrile

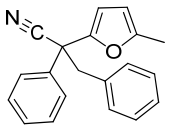
Vicous clear liquid isolated via column chromatography 98:2 Hex:EthOAc as eluent. **^{1}H NMR** (500 MHz, $CDCl_3$) δ 7.88 (d, J = 1.9 Hz, 2H, R_3C-β-naphthyl(5-,8-C*H*), 7.76 (m, 2H, R_3C-β-naphthyl(1-,4-C*H*)), 7.44 (m, 2H, R_3C-β-naphthyl(6-,7-C*H*)), 7.34 (dd, J =

8.7, 2.0 Hz, 1H, R_3C-β-naphthyl(3-C*H*)), 6.12 (d, *J* = 3.2 Hz, 1H, R_3C-furanyl(3-C*H*)), 5.87 ((dq, *J* = 3.1, 1.0 Hz, 1H, R_3C-furanyl(4-C*H)*)), 2.18 (s, 3H, furanylCH_3), 2.03 (s, 3H, R_3CCH_3). **^{13}C NMR** (126 MHz, $CDCl_3$) δ 153.4 (s, R_3C-furanyl(2-*C*(q)), 149.9 (s, R_3C-furanyl(5-*C*(q)), 136.4 (s, R_3C-β-naphthyl(2-*C*(q)), 133.09 (s, R_3C-β-naphthyl*C*(q)), 132.8 (s, R_3C-β-naphthyl*C*(q)), 128.8 (s, R_3C-β-naphthyl(5-*C*)), 128.3 (s, R_3C-β-naphthyl(3-*C*)), 127.6 (s, R_3C-β-naphthyl(8-*C*)), 126.7 (s, R_3C-β-naphthyl(1-, 4-*C*)), 125.0 (s, R_3C-β-naphthyl(7-*C*)), 123.5 (s, R_3C-β-naphthyl(6-*C*)), 121.2 (s, R*C*N), 108.8 (s, R_3C-furanyl(3-*C*H)), 106.5 (s, R_3C-furanyl(4-*C*H)), 42.4 (s, *C*R_4), 26.7 (s, R*C*H_3), 13.6 (s, furnyl(5-*C*H_3)). **GC/MS**: 262.0 [M^+], 237.1 [M-CN], 73.0 [base peak].



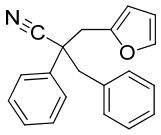
3-(furan-2-yl)-2-methyl-2-(naphthalen-2-yl)propanenitrile

Vicous clear liquid isolated via column chromatography 98:2 Hex:EthOAc as eluent. **^{1}H NMR** (500 MHz, $CDCl_3$) δ 7.84 (d, *J* = 2.0 Hz, 1H, R_3C-β-naphthyl(5-,C*H*)), 7.82 – 7.74 (m, 3H, R_3C-β-naphthylC*H*)), 7.47 – 7.40 (m, 3H, R_3C-β-naphthylC*H*), 7.22 (dd, *J* = 1.8, 0.8 Hz, 1H, 2-furanyl(5-C*H*)), 6.19 (dd, *J* = 3.2, 1.9 Hz, 1H, 2-furanyl(4-C*H*)), 6.02 (d, *J* = 3.4 Hz, 1H, 2-furanyl(3-C*H*)), 3.24 (m, 2H, CR_3CH_2-2-furanyl), 1.77 (s, 3H, R_3CCH_3). **^{13}C NMR** (126 MHz, $CDCl_3$) δ 149.7 (s, R_3CCH_2(2-furanyl(2-*C*(q)), 142.2 (s, R_3CCH_2(2-furanyl(5-*C*(q)), 136.8 (s, R_3C-β-naphthyl2-*C*(q)), 133.1 (s, R_3C-β-naphthyl*C*(q)), 132.7 (s, R_3C-β-naphthyl(5-*C*)), 128.8 (s, R_3C-β-naphthyl(3-*C*)), 128.2 (s, R_3C-β-naphthyl(8-*C*)), 127.6 (s, R_3C-β-naphthyl(1-, 4-*C*)), 126.6 (s, R_3C-β-naphthyl(7-*C*)), 124.88 (s, R_3C-β-naphthyl(6-*C*)), 123.1 (s, R*C*N), 110.5 (s, R_3C-furanyl(4-*C*H)), 109.1 (s, R_3C-furanyl(3-*C*H)), 42.9 (s, *C*R_4), 40.6 (s, CR_3CH_2-2-furanyl), 26.2 (s, R_3CCH_3). **GC/MS**: 262.0 [M^+], 237.1 [M-CN], 73.0 [base peak].



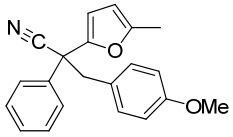
2-(5-methylfuran-2-yl)-2,3-diphenylpropanenitrile

Vicous clear liquid isolated via column chromatography 98:2 Hex:EthOAc as eluent. **^{1}H NMR** (500 MHz, $CDCl_3$) δ 7.28 – 7.18 (m, 4H, PhC$H_{(meta)}$), 7.14 – 7.06 (m, 6H, PhC$H_{(ortho/para)}$), 6.16 (d, *J* = 3.3 Hz, 1H, R_3C-furanyl(3-C*H*)), 5.86 (dq, *J* = 3.0, 0.9 Hz, 1H, R_3C-furanyl(4-C*H*)), 3.65 (d, *J* = 13.3 Hz, 1H, R_3CCH_2furanyl), 3.31 (d, *J* = 13.3 Hz, 1H, R_3CCH_2-2-furanyl), 2.22 (s, 3H, furanyl(5-CH_3). **^{13}C NMR** (126 MHz, $CDCl_3$) δ 152.1 (s, R_3C-furanyl(2-*C*(q)), 147.8 (s, R_3C-furanyl(5-*C*(q)), 136.2 (s, R_3CPhC(q)), 133.7 (s, R_3CCH_2PhC(q)), 129.3 (s, $R_3CPhC_{(ortho)}$), 127.5 (s, $R_3CPhC_{(para)}$), 127.1 (s, $R_3CPhC_{(meta)}$), 126.9 (s, $R_3CCH_2PhC_{(meta)}$), 126.3 (s, $R_3CCH_2PhC_{(ortho)}$), 125.8 (s, $R_3CCH_2PhC_{(para)}$), 118.6 (s, R*C*N), 108.7 (s, R_3C-furanyl(3-*C*H)), 105.5 (s, R_3C-furanyl(4-*C*H)), 48.1 (s, *C*R_4), 44.1 (s, m, 2H, R_3CCH_2Ph)12.6 (s, furanyl5-*C*H_3). **GC/MS**: 287.2 [M^+], 262.8 [M-CN], 81.0 [base peak].



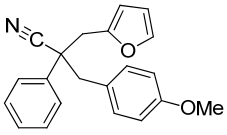
2-benzyl-3-(furan-2-yl)-2-phenylpropanenitrile

Vicous clear liquid isolated via column chromatography 98:2 Hex:EthOAc as eluent. **^{1}H NMR** (500 MHz, $CDCl_3$) δ 7.35 (m, 5H, R_3CCH_2PhCH), 7.24 (m, 5H, R_3CPhCH), 7.05 (dd, *J* = 7.3, 2.1 Hz, 1H, R_3CCH_2-2-furanyl(5-C*H*)), 6.29 (dd, *J* = 3.2, 1.9 Hz, 1H, R_3CCH_2-2-furanyl(4-C*H*)), 6.11 (d, *J* = 3.2 Hz, 1H, R_3CCH_2-2-furanyl(3-C*H*), 3.44 (m, 2H, R_3CCH_2Ph), 3.31 (m, 2H, R_3CCH_2-2-furanyl). **^{13}C NMR** (126 MHz, $CDCl_3$) δ 149.6 (s, R_3CCH_2(2-furanyl(2-*C*(q)), 142.0 (s, R_3CPhC(q)), 137.2 (s, R_3CCH_2(2-furanyl(5-*C*H), 134.7 (s, R_3CCH_2PhC(q)), 130.4 (s, $R_3CPhC_{(ortho)}$), 128.6 (s, $R_3CPhC_{(para)}$), 128.1 (s, $R_3CPhC_{(meta)}$), 128.0 (s, $R_3CCH_2PhC_{(meta)}$), 127.3 (s, $R_3CCH_2PhC_{(ortho)}$), 126.5 (s, $R_3CCH_2PhC_{(para)}$), 121.4 (s, R*C*N), 110.5 (s, R_3C-furanyl(4-*C*H)), 109.1 (s, R_3C-furanyl(3-*C*H)), 49.5 (s, CR_4), 46.3 (s, 2H, R_3CCH_2Ph), 38.2 (s, CR_3CH_2-2-furanyl). **GC/MS**: 287.2 [M^+], 262.8 [M-CN], 81.0 [base peak]



3-(4-methoxyphenyl)-2-(5-methylfuran-2-yl)-2-phenylpropanenitrile

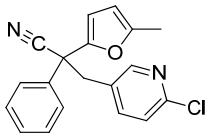
Vicous clear liquid isolated via column chromatography 95:5 Hex:EthOAc as eluent. **^{1}H NMR** (500 MHz, $CDCl_3$) δ 7.24 (m, 5H, CR_3ArH), 6.75 (d, *J* = 8.7 Hz, 2H, $RCH_2ArH_{(ortho)}$), 6.64 (d, *J* = 8.7 Hz, 2H, $RCH_2ArH_{(meta)}$), 6.16 (d, *J* = 3.2 Hz, 1H, R_3C-furnayl(4-C*H*)), 5.88 (m, 1H, R_3C-furnayl(3-C*H*)), 3.66 (s, 3H,$CR_3CH_2ArOCH_3$), 3.60 (d, *J* = 13.4 Hz, 1H, R_3CCH_2-2-furanyl), 3.26 (d, *J* = 13.4 Hz, 1H, R_3CCH_2-2-furanyl), 2.23 (s, 3H, furanyl(5-CH_3). **^{13}C NMR** (126 MHz, $CDCl_3$) δ 158.9 (s, CH_2ArC(q)OCH_3), 153.1 (s, R_3C-furanyl(2-*C*(q)), 149.0 (s, R_3C-furanyl(5-*C*(q)), 137.4 (s, RCH_2ArC(q)), 131.4 (s, R_3CPhC(q)), 128.6 (s, $RCH_2ArCH_{(ortho)}$), 128.1 (s, R_3C-$PhC_{(ortho/para)}$), 126.4 (s, $R_3CPhC_{(meta)}$), 119.8 (s, R*C*N), 113.4 (s, $RCH_2ArCH_{(meta)}$), 109.7 (s, R_3C-furanyl(3-*C*H)), 106.5 (s, R_3C-furanyl(4-*C*H)), 55.1 (s, $CR_3CH_2ArOCH_3$), 49.8 (s, CR_4), 44.4 (s, 2H, R_3CCH_2Ar), 13.7 (s, furanyl5-CH_3). **GC/MS**: 317.1 [M^+], 291.3 [M-CN], 121.0 [base peak]



3-(furan-2-yl)-2-(4-methoxybenzyl)-2-phenylpropanenitrile

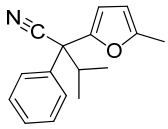
Vicous clear liquid isolated via column chromatography 95:5 Hex:EthOAc as eluent. **^{1}H NMR** (500 MHz, $CDCl_3$) δ 7.25 (m, 2H, $CR_3ArH_{(meta)}$), 7.24 (s, 3H, $CR_3ArH_{(ortho/para)}$), 7.21 (dd, *J* = 1.8, 0.7 Hz, 2H, R_3CCH_2-2-furanyl(5-C*H*)), 6.83 (d, *J* = 8.7 Hz, 2H, $RCH_2ArH_{(ortho)}$), 6.64 (d, *J* = 8.7 Hz, 2H, $RCH_2ArH_{(meta)}$), 6.17 (dd, *J* = 3.2, 1.9 Hz, 1H, R_3CCH_2-2-furanyl(4-C*H*)), 5.97 (d, *J* = 3.2 Hz, 1H, R_3CCH_2-2-furanyl(3-C*H*)), 3.67 (s, 3H,$CR_3CH_2ArOCH_3$), 3.28 (s, 2H, R_3CCH_2-2-furanyl), 3.15 (s, 2H, furanyl(5-CH_3)). **^{13}C NMR** (126 MHz, $CDCl_3$) δ 158.8 (s, CH_2ArC(q)OCH_3), 149.7 (s, R_3C-furanyl(2-*C*(q)), 142.0 (s, R_3C-furanyl(5-*C*(q)), 137.3 (s, $RCH_2ArCH_{(ortho)}$), 131.5 (s, R_3CPhC(q)), 128.6 (s, R_3C-$PhC_{(ortho)}$), 127.9 (s, R_3C-$PhC_{(para)}$), 126.6 (s, R_3C-

Ph*C*$_{(meta)}$), 121.5 (s, R*C*N), 113.5 (s, RCH$_2$Ar*C*H$_{(meta)}$), 110.5 (s, R$_3$C-furanyl(4-*C*H)), 109.1 (s, R$_3$C-furanyl(3-*C*H)), 55.1 (s, CR$_3$CH$_2$ArO*C*H$_3$), 49.7 (s, *C*R$_4$), 45.5 (s, 2H, R$_3$C*C*H$_2$Ar), 38.0 (s, CR$_3$*C*H$_2$-2-furanyl). **GC/MS**: 317.1 [M$^+$], 291.3 [M-CN], 121.0 [base peak]



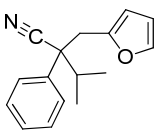
3-(6-chloropyridin-3-yl)-2-(5-methylfuran-2-yl)-2-phenylpropanenitrile

Vicous clear liquid isolated via column chromatography 95:5 Hex:EthOAc as eluent. **^{1}H NMR** (500 MHz, CDCl$_3$) δ 7.75 (s, R$_3$CC*H*$_2$-5-pyridyl(6-C*H*), 7.33 – 7.23 (m, 6H, RCH$_2$Ar/Ph*H*), 7.12 (dd, *J* = 2.4, 0.7 Hz, 1H, R$_3$CC*H*$_2$-5-pyridyl(6-C*H*)), 6.16 (d, *J* = 3.2 Hz, 1H, R$_3$C-furnayl(4-C*H*)), 5.90 (dt, *J* = 3.1, 1.0 Hz, 1H, R$_3$C-furnayl(3-C*H*)), 3.65 (d, *J* = 13.6 Hz, 1H, R$_3$CC*H*$_2$-5-pyridyl), 3.32 (d, *J* = 13.6 Hz, 1H, R$_3$CC*H*$_2$-5-pyridyl), 2.25 (s, 2H, R$_3$C-2-furanyl-5-C*H*$_3$). **^{13}C NMR** (126 MHz, CDCl$_3$) δ 153.6 (s, R$_3$C-furanyl(2-*C*(q)), 159.0 (s, R$_3$C-furanyl(5-*C*(q)), 150.8 (s, R$_3$CC*H*$_2$-5-pyridyl(2-*C*Cl)), 147.8 (s, R$_3$CC*H*$_2$-5-pyridyl(5-*C*(q)), 140.4 (s, R$_3$CC*H*$_2$-5-pyridyl(6-*C*H)), 136.4 (s, R$_3$CPh*C*(q), 129.4 (s, R$_3$CC*H*$_2$-5-pyridyl(4-*C*H)), 129.0 (s, R$_3$CC*H*$_2$-5-pyridyl(3-*C*H)), 128.7 (s, R$_3$CPh*C*$_{(meta)}$), 126.6 (s, R$_3$CPh*C*$_{(ortho)}$), 123.7 (s, R$_3$CPh*C*$_{(para)}$), 119.1 (s, R*C*N), 110.3 (s, R$_3$C-furnayl(4-*C*H)), 106.8 (s, R$_3$C-furnayl(3-*C*H)), 49.2 (s, *C*R$_4$), 41.7 (s, 2H, R$_3$C*C*H$_2$Pyridyl), 13.7 (s, furanyl5-*C*H$_3$). **GC/MS**: 322.2 [M$^+$], 297.2 [M-CN], 196.2 [base peak]



3-methyl-2-(5-methylfuran-2-yl)-2-phenylbutanenitrile

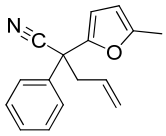
Vicous clear liquid isolated via column chromatography 98:2 Hex:EthOAc as eluent. **^{1}H NMR** (500 MHz, CDCl$_3$) δ 7.47 (m, 2H, R$_3$CPhC*H*$_{(meta)}$), 7.28 (m, 2H, R$_3$CPhC*H*$_{(ortho)}$), 7.22 (m, 1H, R$_3$CPhC*H*$_{(para)}$), 6.24 (d, *J* = 3.1 Hz, 1H, R$_3$C-furnayl(4-C*H*)), 5.83 (dt, *J* = 3.1, 1.0 Hz, 1H, R$_3$C-furnayl(3-C*H*)), 2.70 (hept, *J* = 6.7 Hz, 1H, R3CC*H*(CH$_3$)$_2$), 2.19 (s, 2H, R$_3$C-2-furanyl-5-CH$_3$), 1.03 (d, *J* = 6.6 Hz, 3H, R$_3$CCH(CH$_3$)C*H*$_3$), 0.80 (d, *J* = 6.7 Hz, 3H, R$_3$CCH(CH$_3$)C*H*$_3$). **^{13}C NMR** (126 MHz, CDCl$_3$) δ 152.6 (s, R$_3$C-furanyl(2-*C*(q)), 149.4 (s, R$_3$C-furanyl(5-*C*(q)), 137.7 (s, R$_3$CPh*C*(q)), 128.7 (s, R$_3$CPh*C*$_{(meta)}$), 127.8 (s, R$_3$CPh*C*$_{(ortho)}$), 126.4 (s, R$_3$CPh*C*$_{(para)}$), 118.9 (s, R*C*N), 108.8 (s, R$_3$C-furnayl(4-*C*H)), 106.3 (s, R$_3$C-furnayl(3-*C*H)), 54.8 (s, R3*C*CH(CH$_3$)$_2$), 36.2 (s, *C*R$_4$), 19.3 (s, R$_3$CCH(CH$_3$)*C*H$_3$), 18.3 (s, R$_3$CCH(CH$_3$)*C*H$_3$), 13.7 (s, furanyl5-*C*H$_3$). **GC/MS**: 239.1 [M$^+$], 214.2 [M-CN], 81.0 [base peak]



2-(furan-2-ylmethyl)-3-methyl-2-phenylbutanenitrile

Vicous clear liquid isolated via column chromatography 98:2 Hex:EthOAc as eluent. **^{1}H NMR** (500 MHz, CDCl$_3$) δ 7.24 (m, 5H, R$_3$CPhC*H*), 7.11 (dd, *J* = 1.9, 0.8 Hz, 1H, R$_3$CCH$_2$-2-furanyl(5-C*H*)), 6.07 (dd, *J* = 3.2, 1.9 Hz, 1H, R$_3$CCH$_2$-2-furanyl(4-C*H*)), 5.74 (d, *J* = 3.2 Hz, 1H, R$_3$CCH$_2$-2-furanyl(3-C*H*)), 3.40 (d, *J* = 15.0 Hz, 1H, R$_3$CC*H*$_2$-2-furanyl), 3.15 (d, *J* = 15.0 Hz, 1H, R$_3$CC*H*$_2$-2-furanyl), 1.22 (hept, *J* = 6.7 Hz, 1H, R3CC*H*(CH$_3$)$_2$), 0.97 (d, *J* = 6.7 Hz, 3H,

$R_3CCH(CH_3)CH_3$), 0.77 (d, J = 6.7 Hz, 3H, $R_3CCH(CH_3)CH_3$). **^{13}C NMR** (126 MHz, $CDCl_3$) δ 149.9 (s, R_3CCH_2(2-furanyl(2-*C*(q)), 141.7 (s, R_3CCH_2(2-furanyl(5-*C*H), 137.3 (s, R_3CPhC(q)), 128.4 (s, $R_3CPhCH_{(meta)}$), 127.7 (s, $R_3CPhCH_{(ortho)}$), 126.3 (s, $R_3CPhCH_{(para)}$), 120.8 (s, R*C*N), 110.2 (s, R_3C-furanyl(4-*C*H)), 108.6 (s, R_3C-furanyl(3-*C*H)), 53.8 (s, $R_3CCH(CH_3)CH_3$)), 36.8 (s, CR_3CH_2-2-furanyl), 36.5 (s,CR_4), 18.8 (s, $R_3CCH(CH_3)CH_3$), 18.6 (s, $R_3CCH(CH_3)CH_3$). **GC/MS**: 239.1 [M^+], 214.2 [M-CN], 81.0 [base peak]



(4-290) XX 2-(5-methylfuran-2-yl)-2-phenylpent-4-enenitrile

Vicous clear liquid isolated via column chromatography 98:2 Hex:EthOAc as eluent. **^{1}H NMR** (500 MHz, $CDCl_3$) δ 7.34 (m, 2H, $R_3CPhCH_{(meta)}$), 7.30 (m, 2H, $R_3CPhCH_{(ortho)}$), 7.25 (m, 1H, $R_3CPhCH_{(para)}$), 6.13 (d, J = 3.2 Hz, 1H, R_3C-furnayl(4-C*H*)), 5.86 (dt, J = 3.1, 1.0 Hz, 1H, R_3C-furnayl(3-C*H*)), 5.61 (ddt, J = 17.2, 10.2, 7.1 Hz, 1H, allyl(C*H*)), 5.12 (m, 2H, allyl(CH_2)), 3.08 (ddt, J = 13.9, 7.2, 1.1 Hz, 1H, R_3CCH_2allyl), 2.86 (ddt, J = 14.0, 7.0, 1.1 Hz, 1H, R_3CCH_2allyl), 2.19 (s, 2H, furanylCH_3). **^{13}C NMR** (126 MHz, $CDCl_3$) δ 153.2 (s, R_3C-furanyl(2-*C*(q)), 148.9 (s, R_3C-furanyl(5-*C*(q)), 137.5 (s, R_3CPhC(q)), 131.31 (s, Allyl(*C*H)), 128.79 (s, $R_3CPhCH_{(meta)}$), 128.2 (s, $R_3CPhCH_{(ortho)}$), 126.5 (s, $R_3CPhCH_{(para)}$), 120.6 (s, R*C*N), 119.8 (s, Allyl(CH_2)), 109.3 (s, R_3C-furnayl(4-*C*H)), 106.4 (s, R_3C-furnayl(3-*C*H)), 47.9 (s, CR_4), 43.4 (s, R_3CCH_2-furanyl), 13.6 (s, furanyl5-CH_3). **GC/MS**: 237.2 [M^+], 212.3 [M-CN], 81.0 [base peak]

Electronic Supplementary Material (ESI) for Chemical Communications

Decarboxylative Benzylation and Arylation of Nitriles

Antonio Recio, III, Jeffrey D. Heinzman, Jon A. Tunge*
Department of Chemistry, University of Kansas, 2010 Malott Hall, 1251 Wescoe Hall Drive, Lawrence, KS 66045

Supporting Information

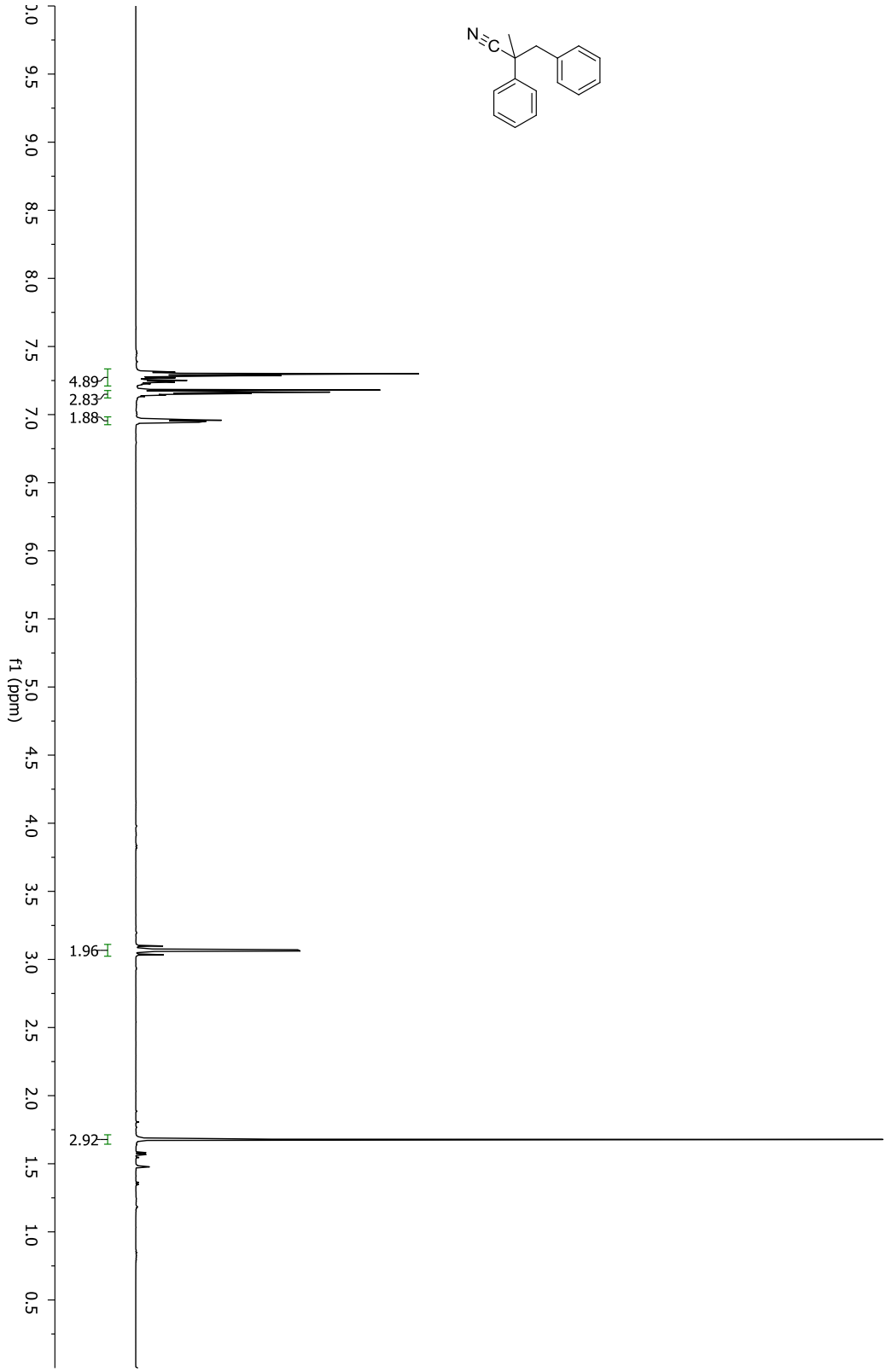
The following contains all ^{1}HNMR and ^{13}CNMR spectra for the reported compounds:

Table of Contents:

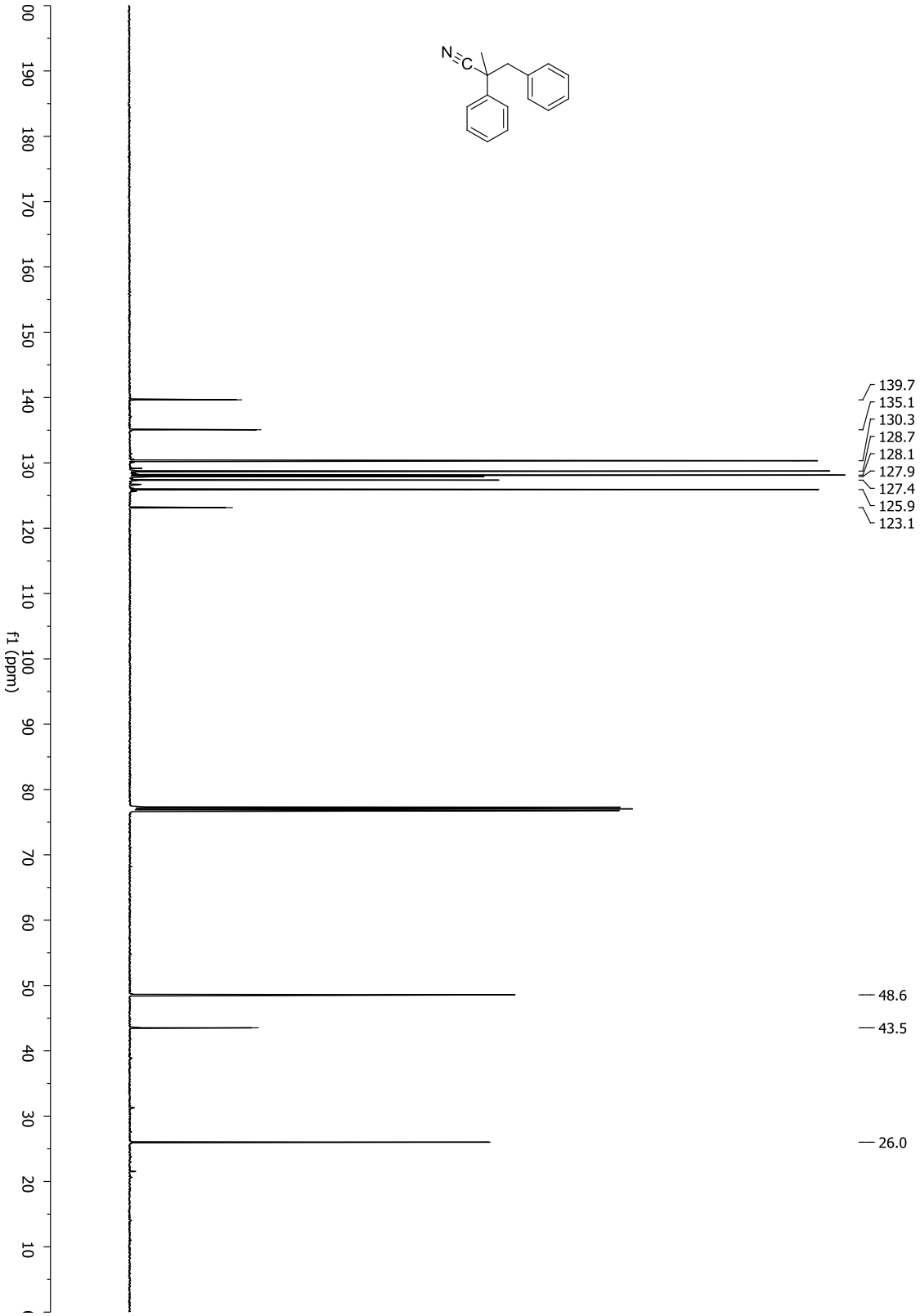
Compounds from Table 1:

Compounds from Table 3:

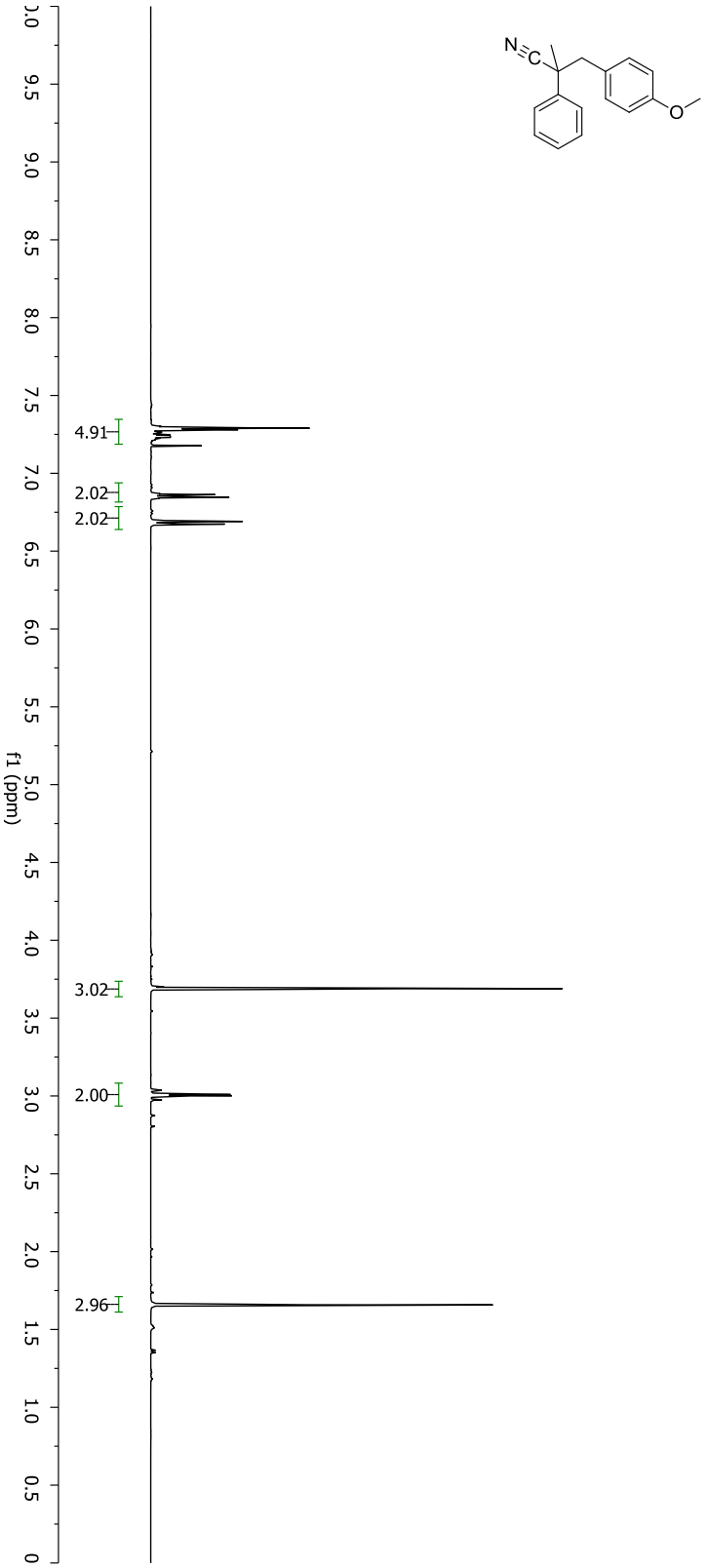
2-methyl-2,3-diphenylpropanenitrile



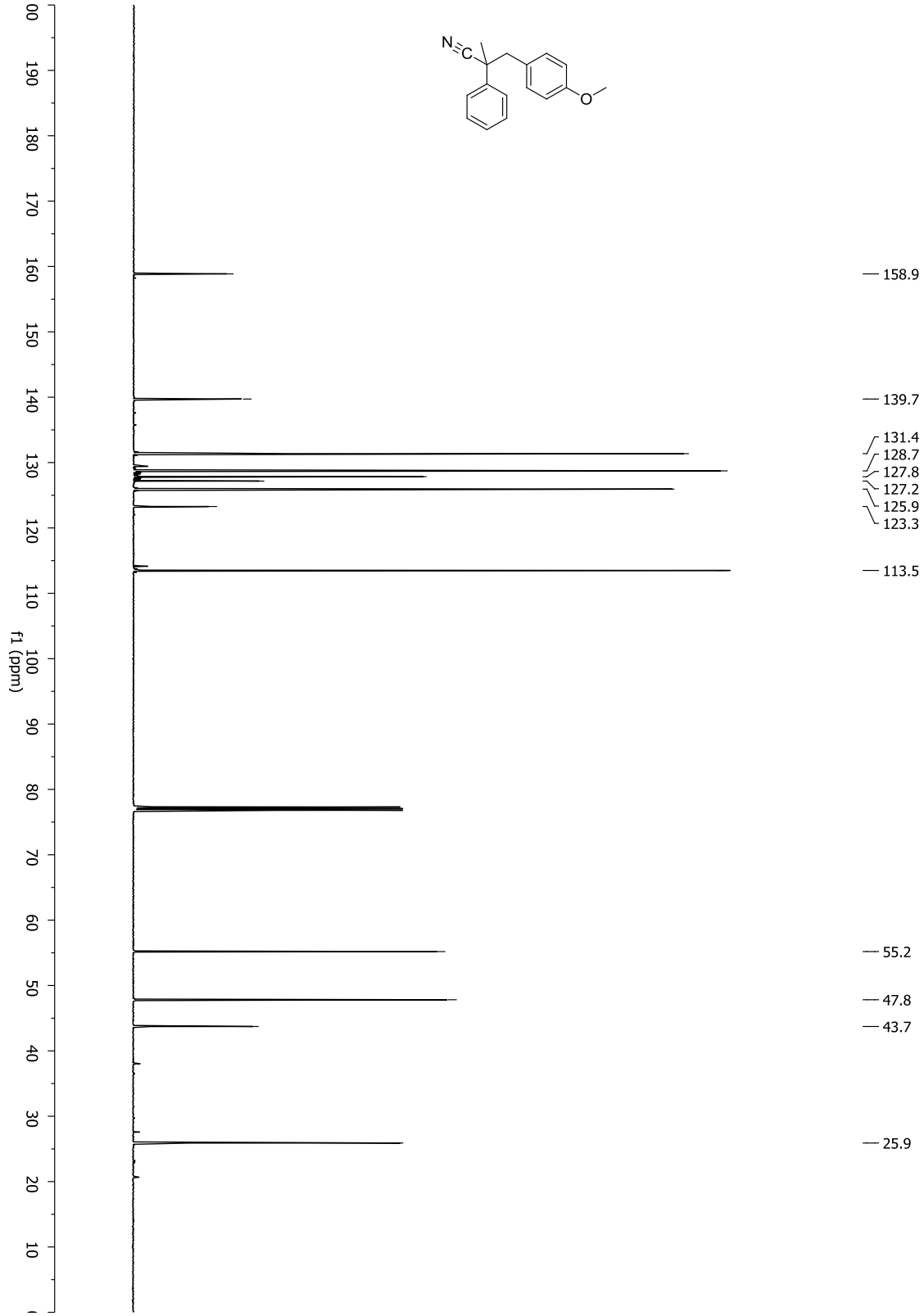
2-methyl-2,3-diphenylpropanenitrile



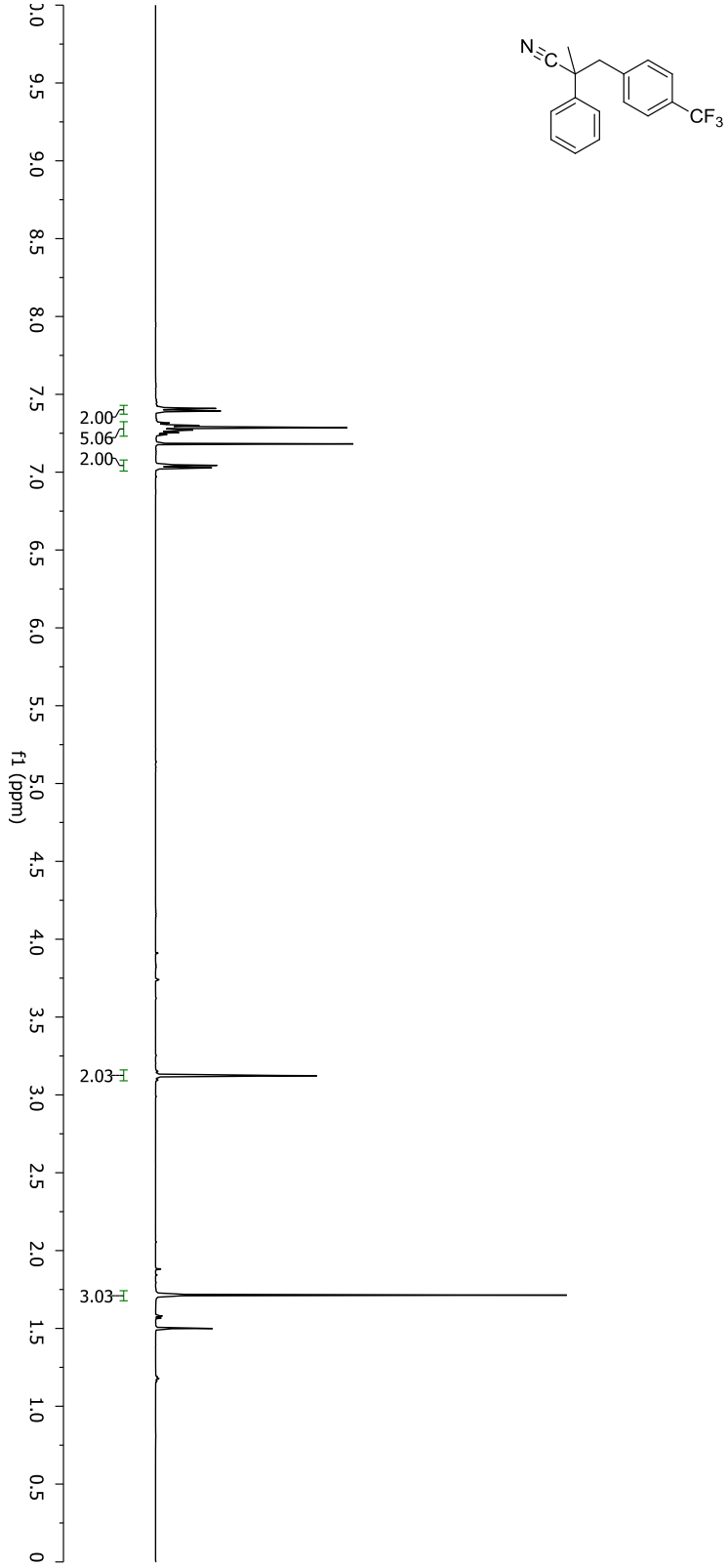
3-(4-methoxyphenyl)-2-methyl-2-phenylpropanenitrile



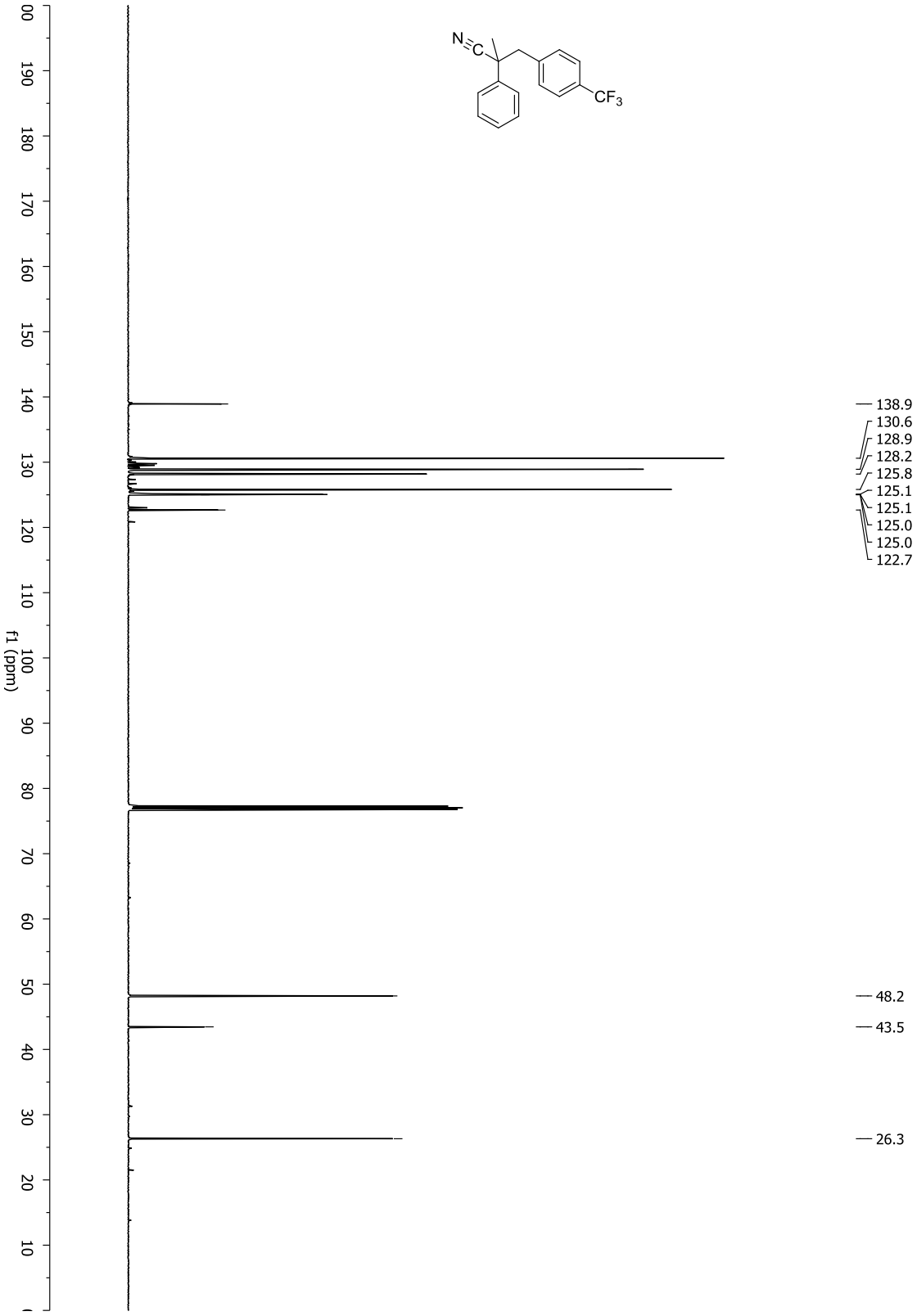
3-(4-methoxyphenyl)-2-methyl-2-phenylpropanenitrile



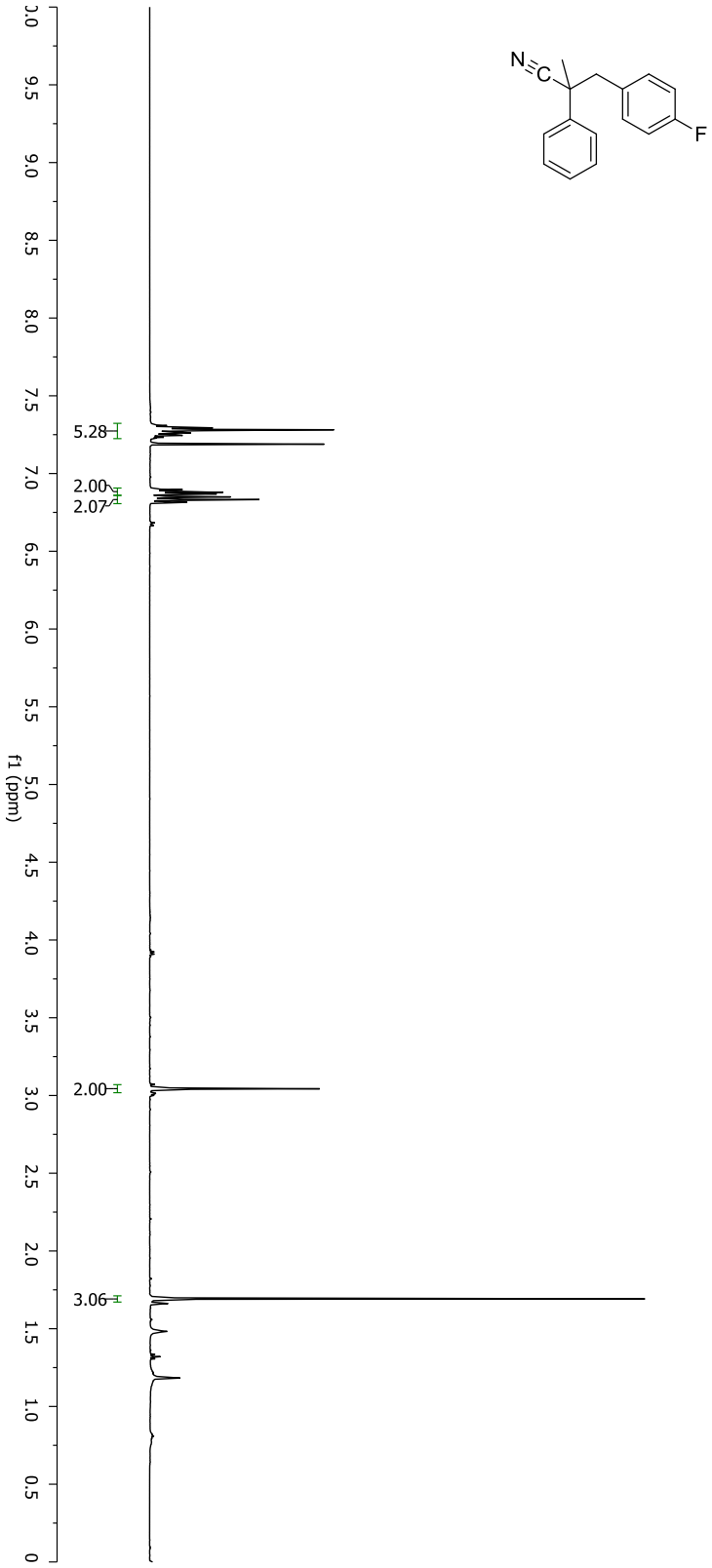
3-(4-fluorophenyl)-2-methyl-2 phenylpropanenitrile



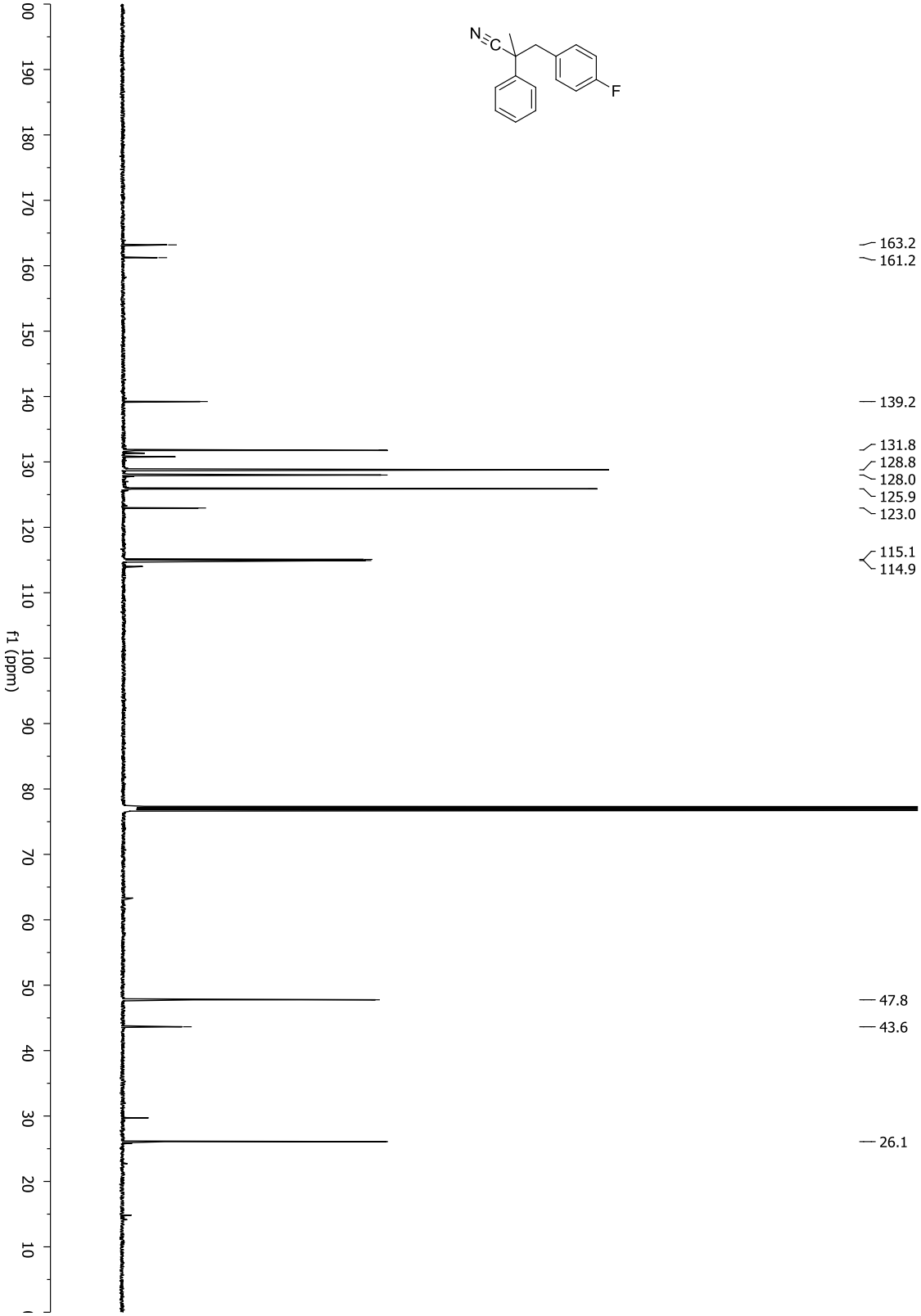
2-methyl-2-phenyl-3-(4-(trifluoromethyl)phenyl)propanenitrile



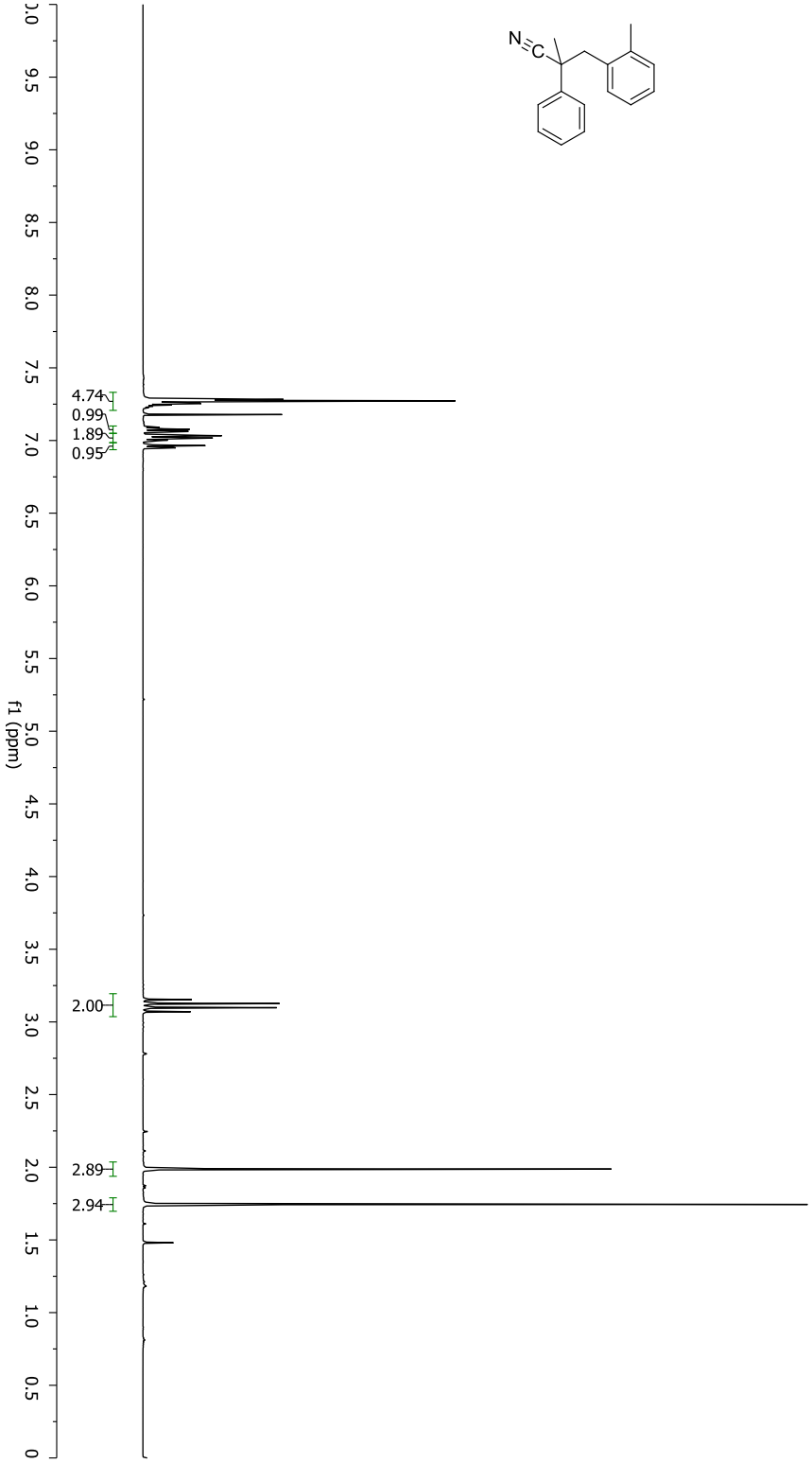
3-(4-fluorophenyl)-2-methyl-2 phenylpropanenitrile



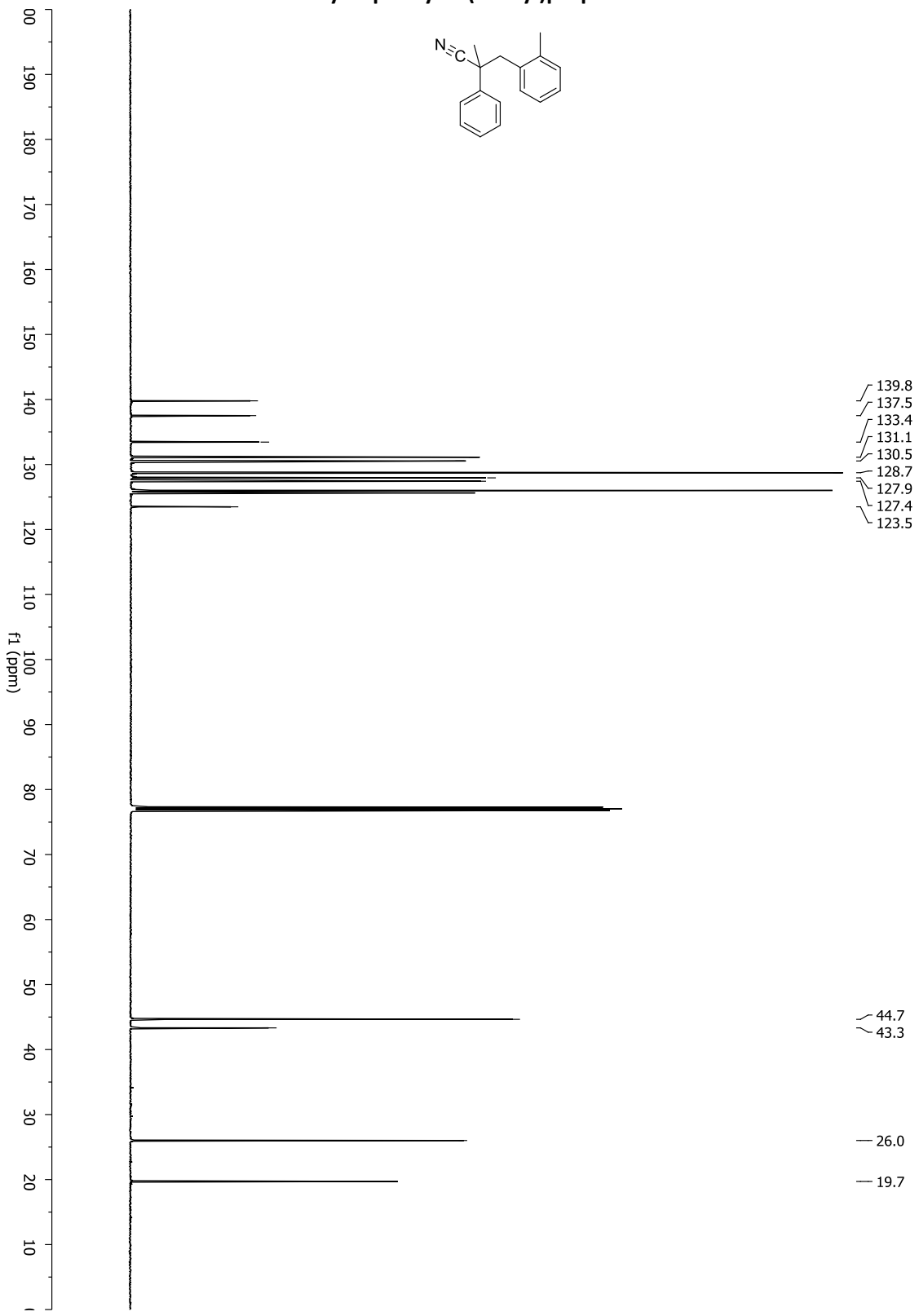
3-(4-fluorophenyl)-2-methyl-2 phenylpropanenitrile



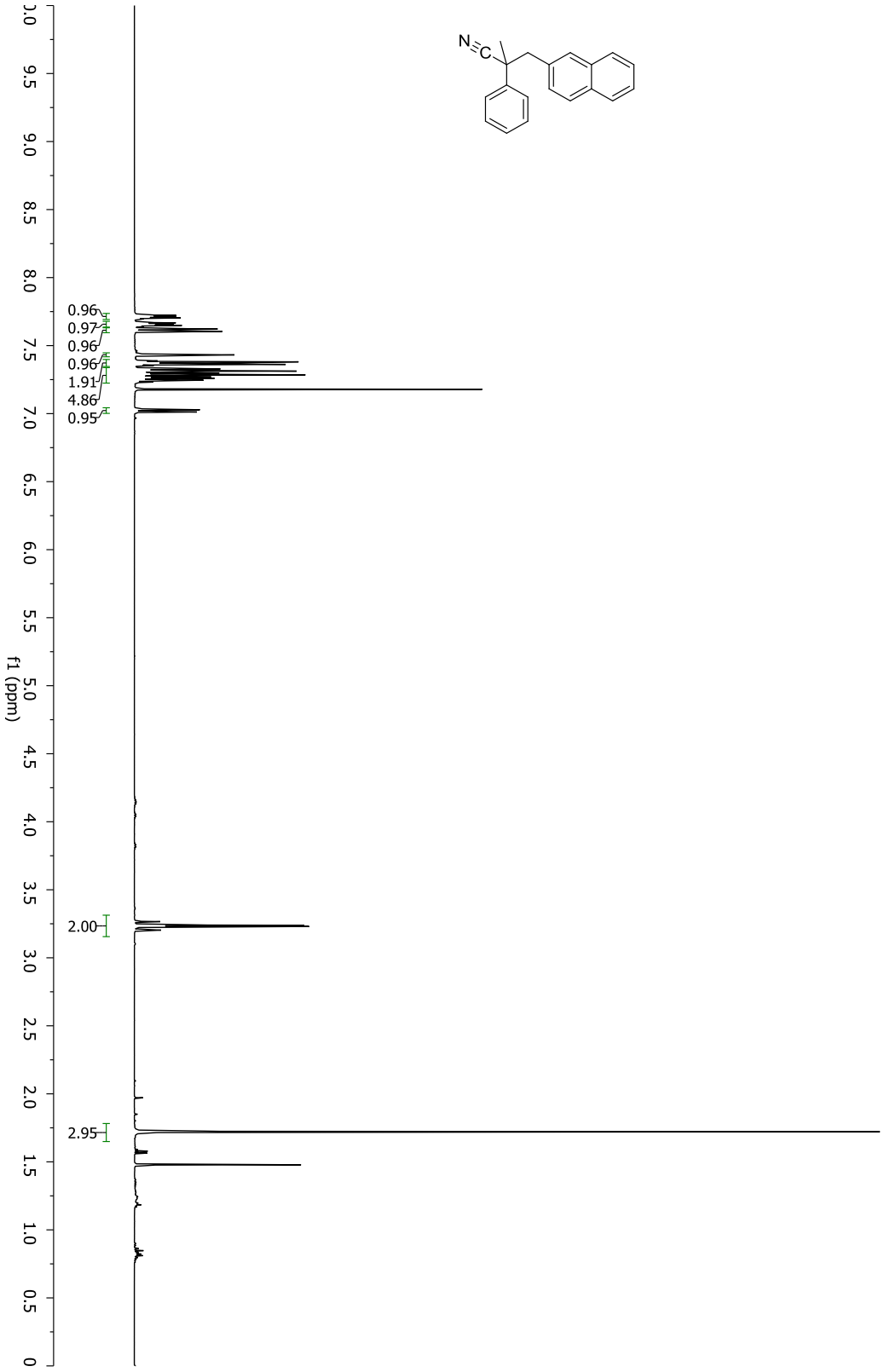
2-methyl-2-phenyl-3-(o-tolyl)propanenitrile



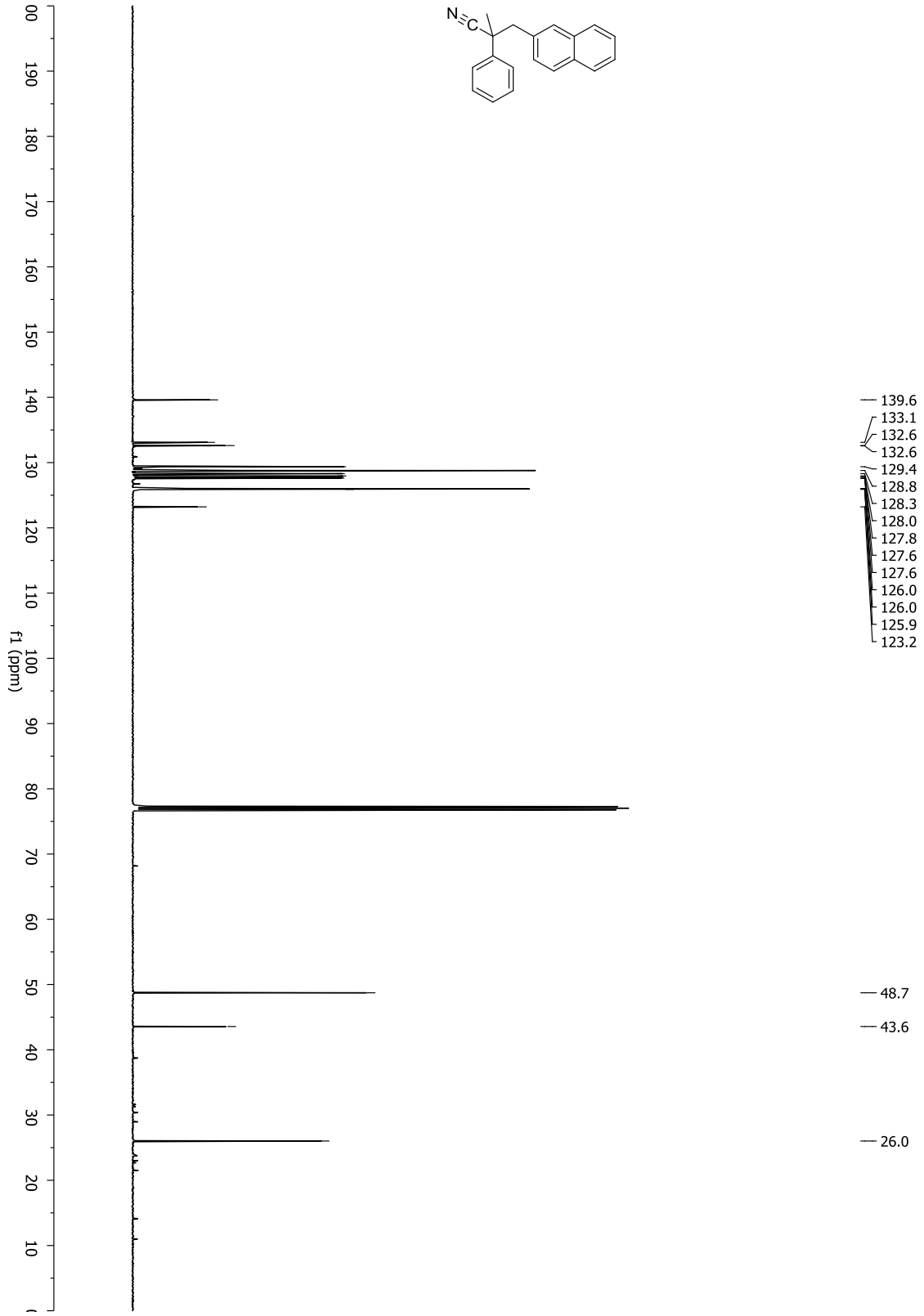
2-methyl-2-phenyl-3-(o-tolyl)propanenitrile



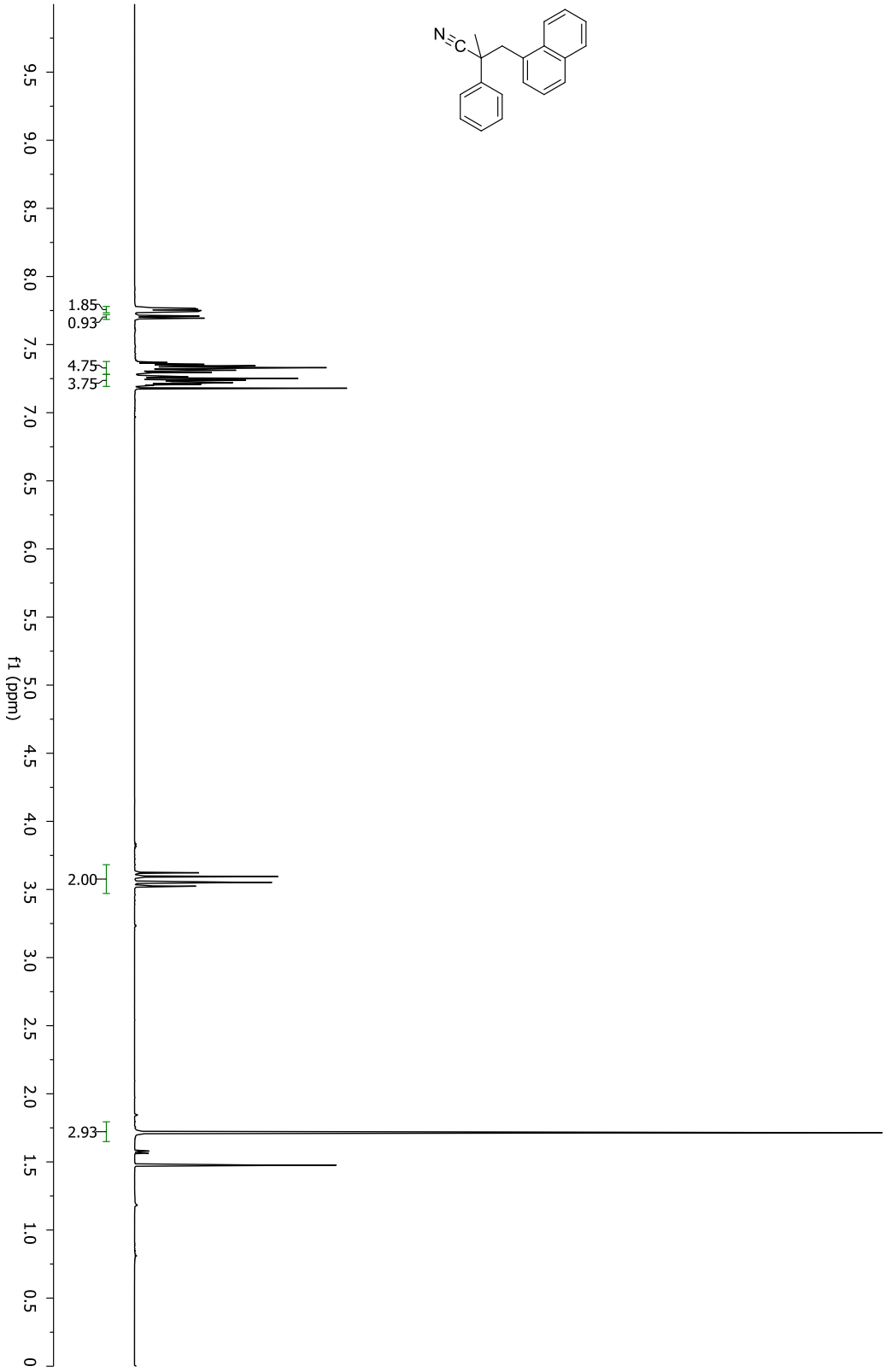
2-methyl-3-(naphthalen-2-yl)-2-phenylpropanenitrile



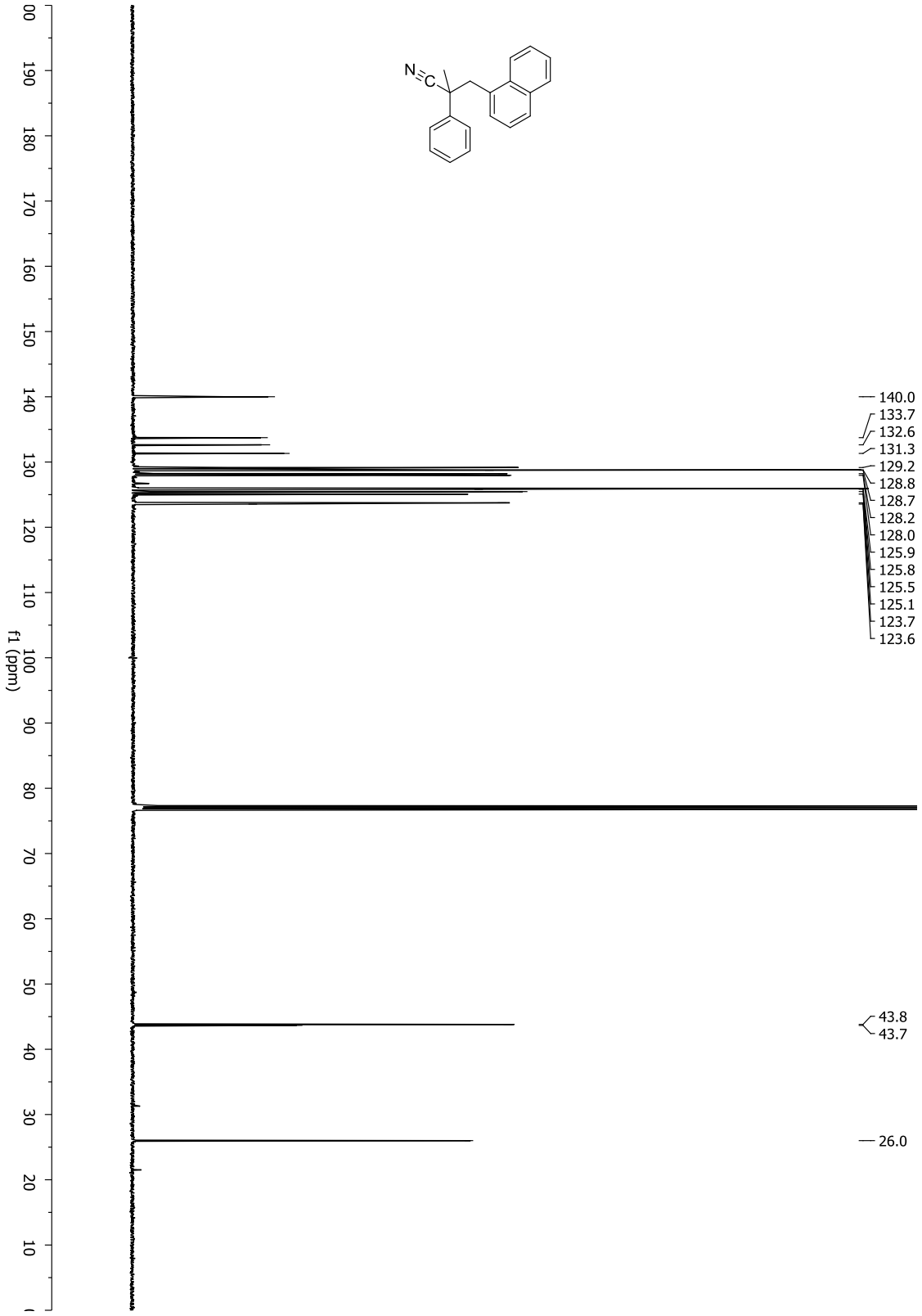
2-methyl-3-(naphthalen-2-yl)-2-phenylpropanenitrile



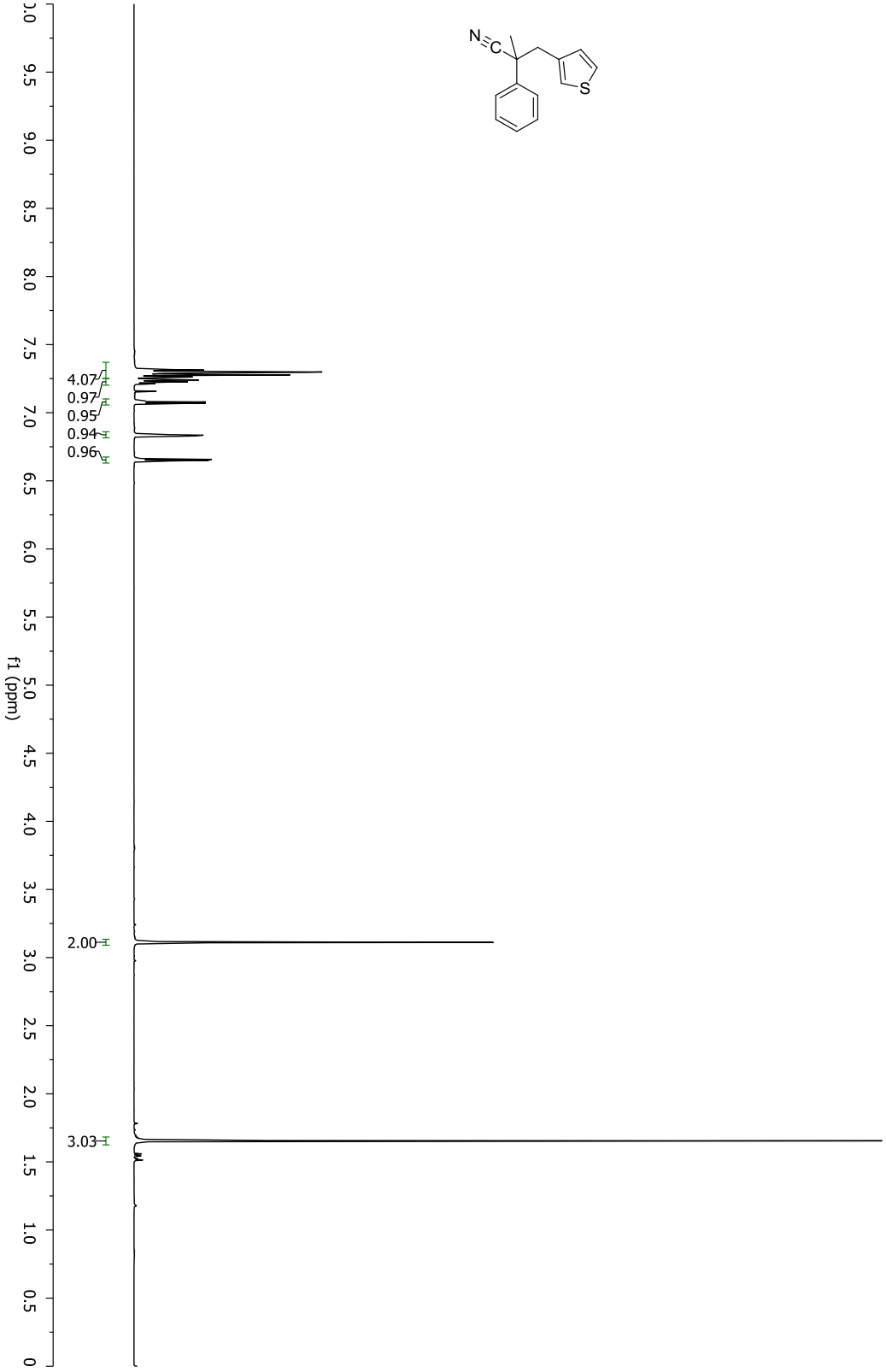
2-methyl-3-(naphthalen-1-yl)-2-phenylpropanenitrile



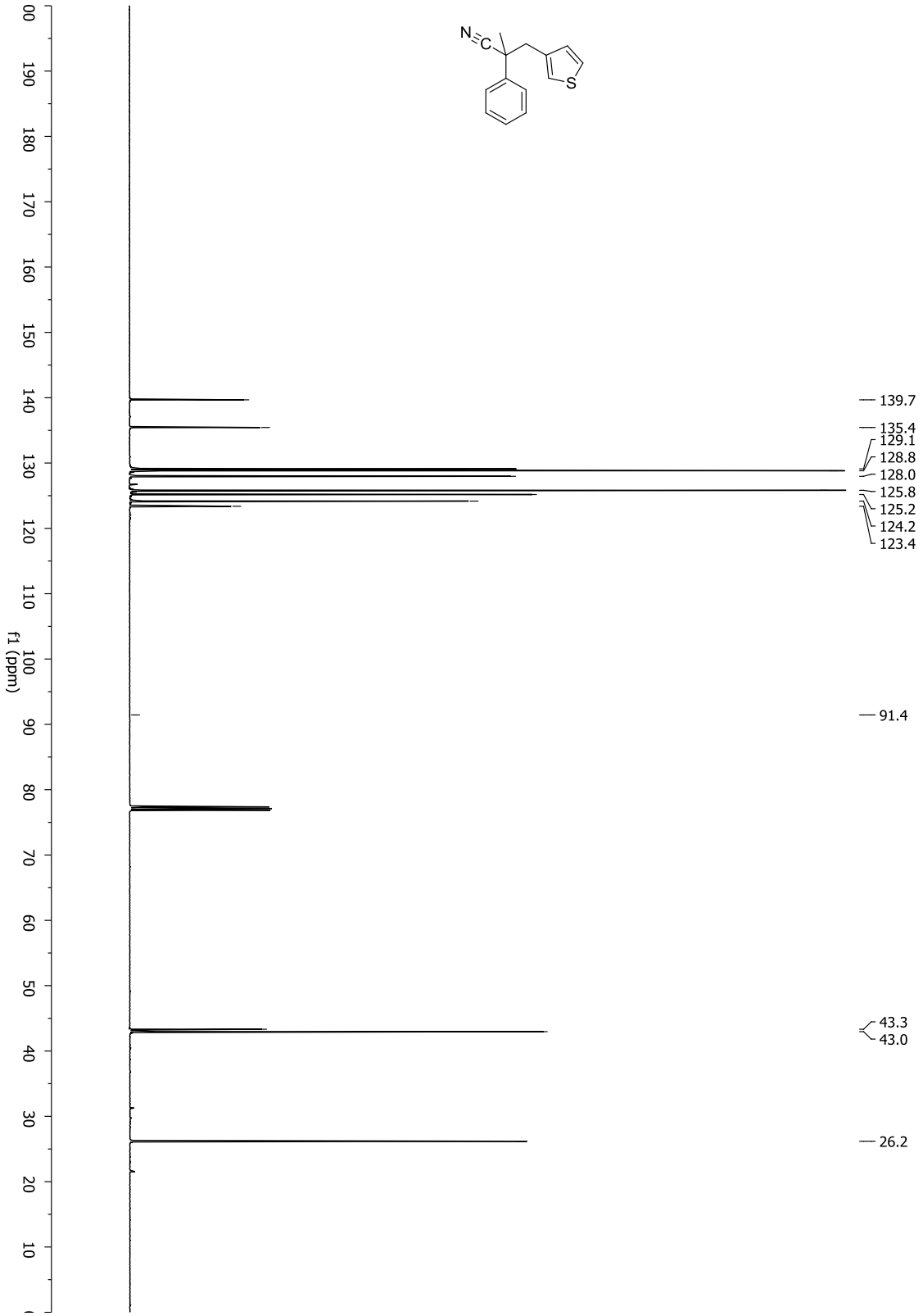
2-methyl-3-(naphthalen-1-yl)-2-phenylpropanenitrile



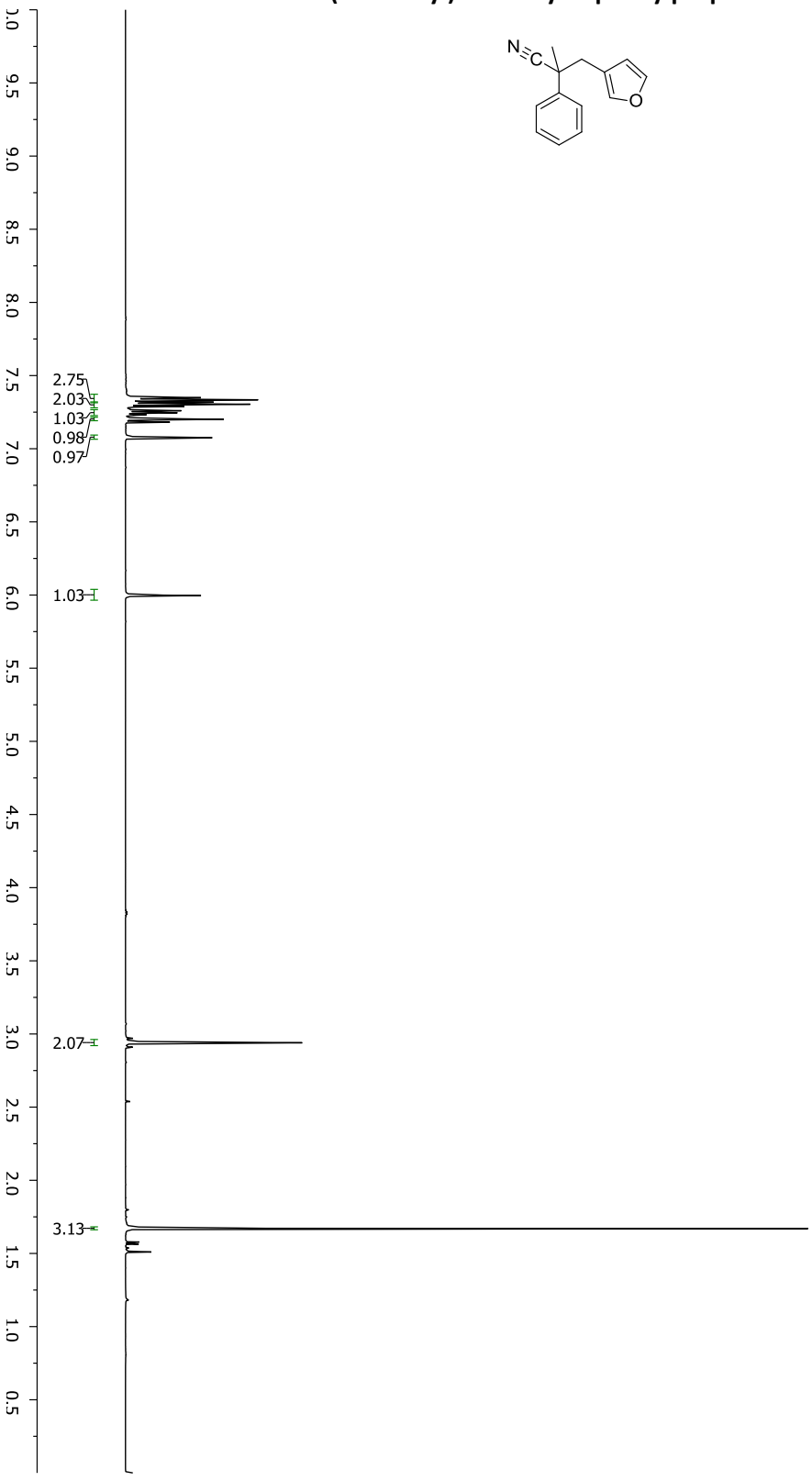
2-methyl-2-phenyl-3-(thiophen-3-yl)propanenitrile



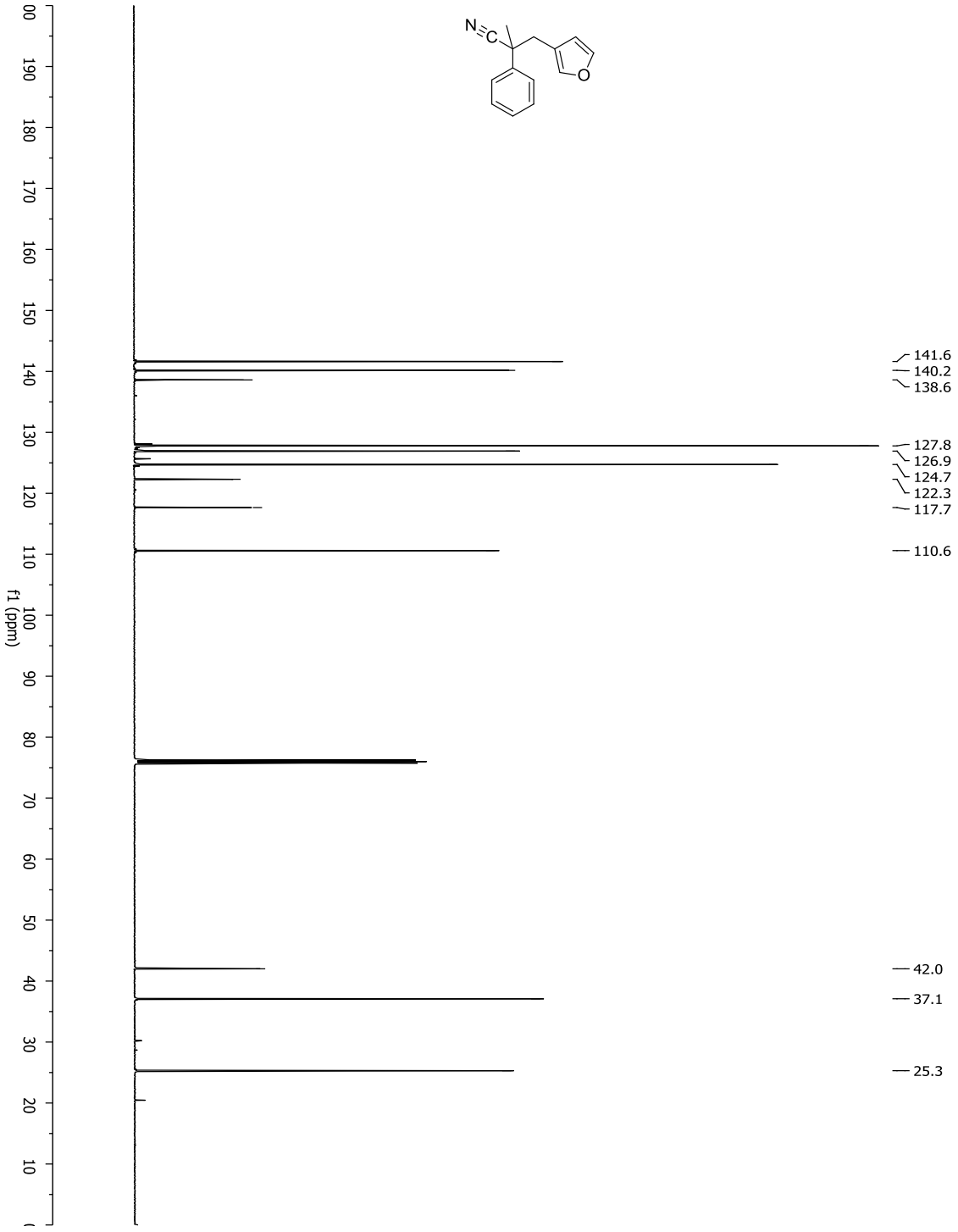
2-methyl-2-phenyl-3-(thiophen-3-yl)propanenitrile



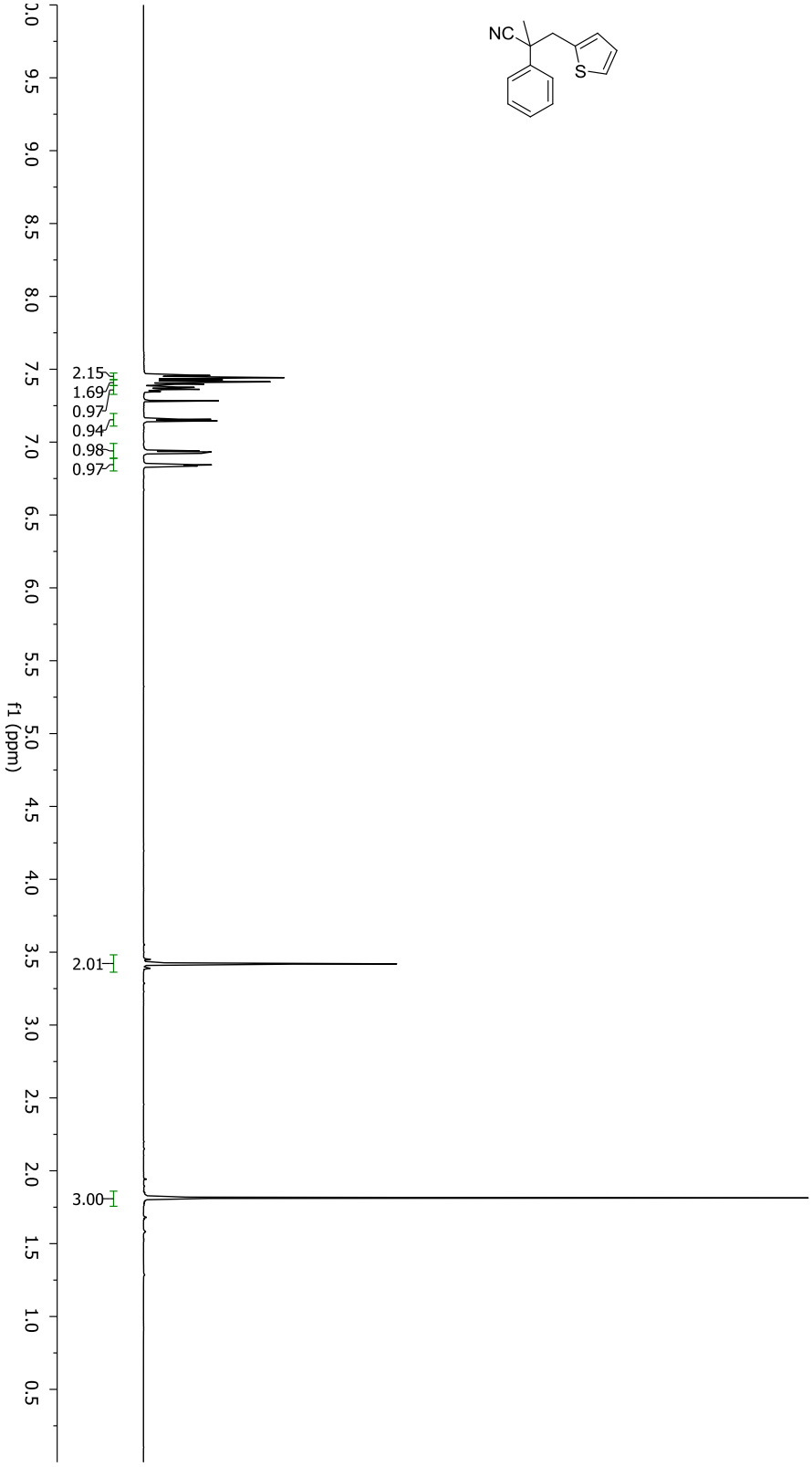
3-(furan-3-yl)-2-methyl-2-phenylpropanenitrile



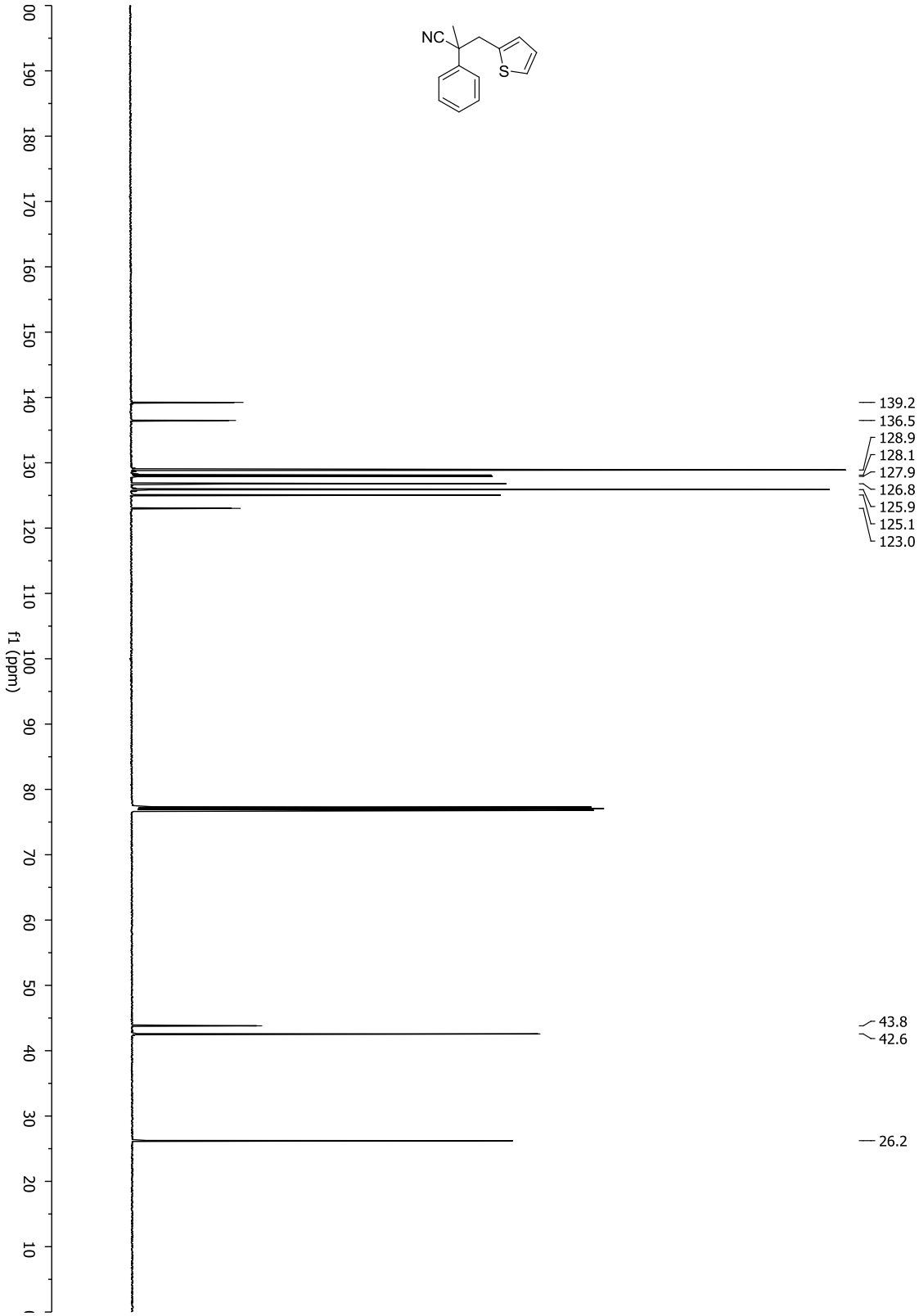
3-(furan-3-yl)-2-methyl-2-phenylpropanenitrile:



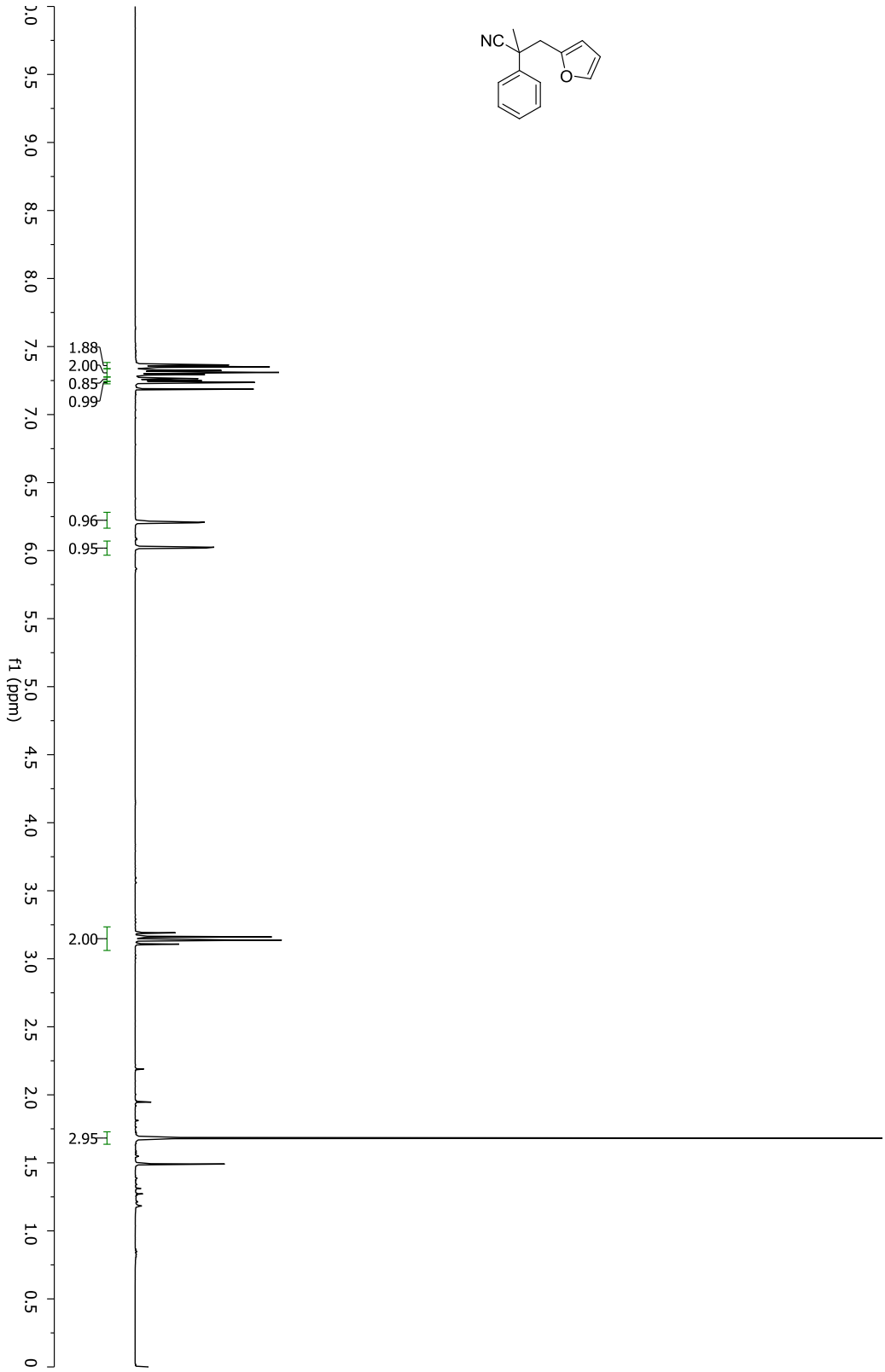
2-methyl-2-phenyl-3-(thiophen-2-yl)propanenitrile



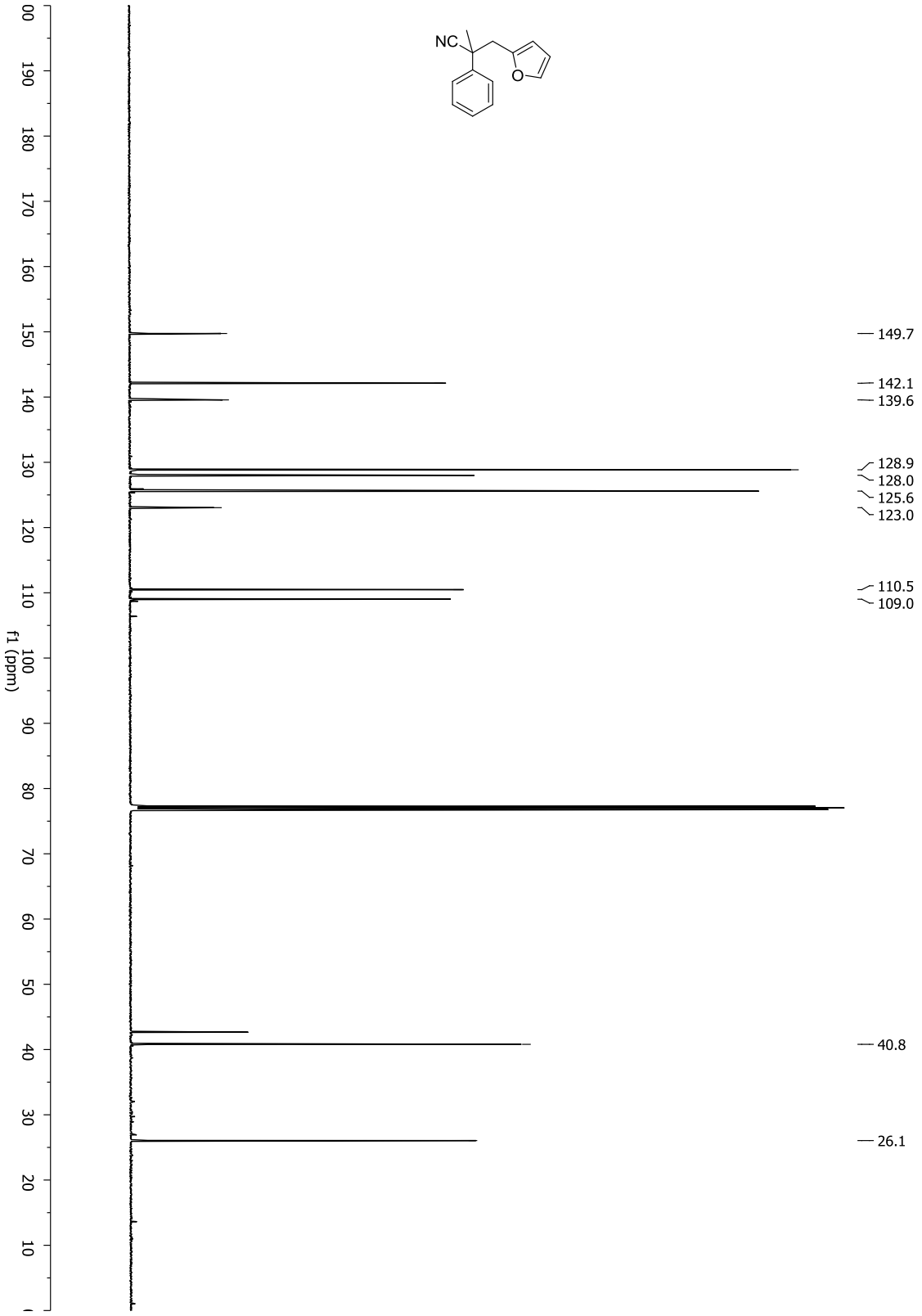
2-methyl-2-phenyl-3-(thiophen-2-yl)propanenitrile



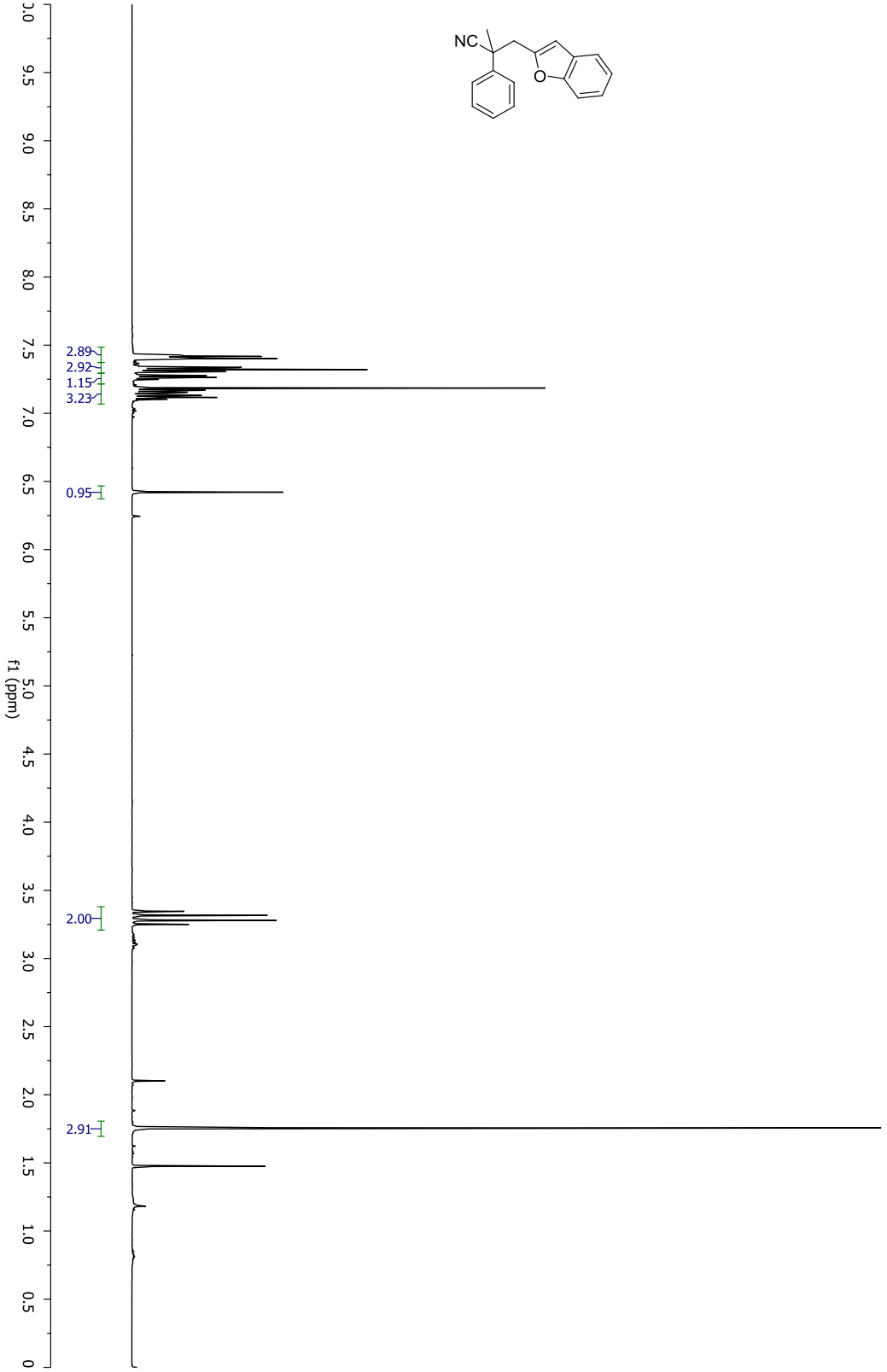
3-(furan-2-yl)-2-methyl-2-phenylpropanenitrile



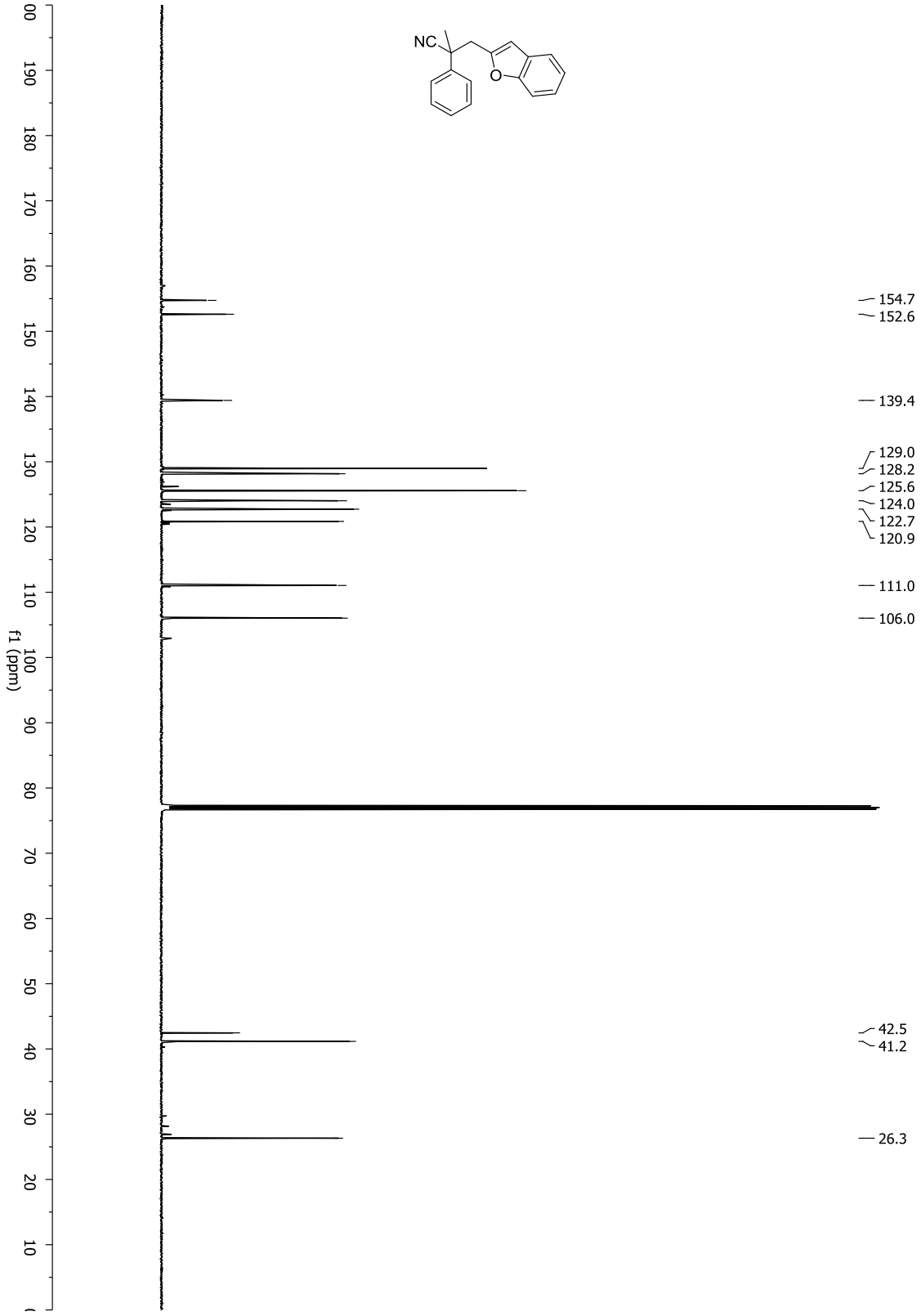
3-(furan-2-yl)-2-methyl-2-phenylpropanenitrile



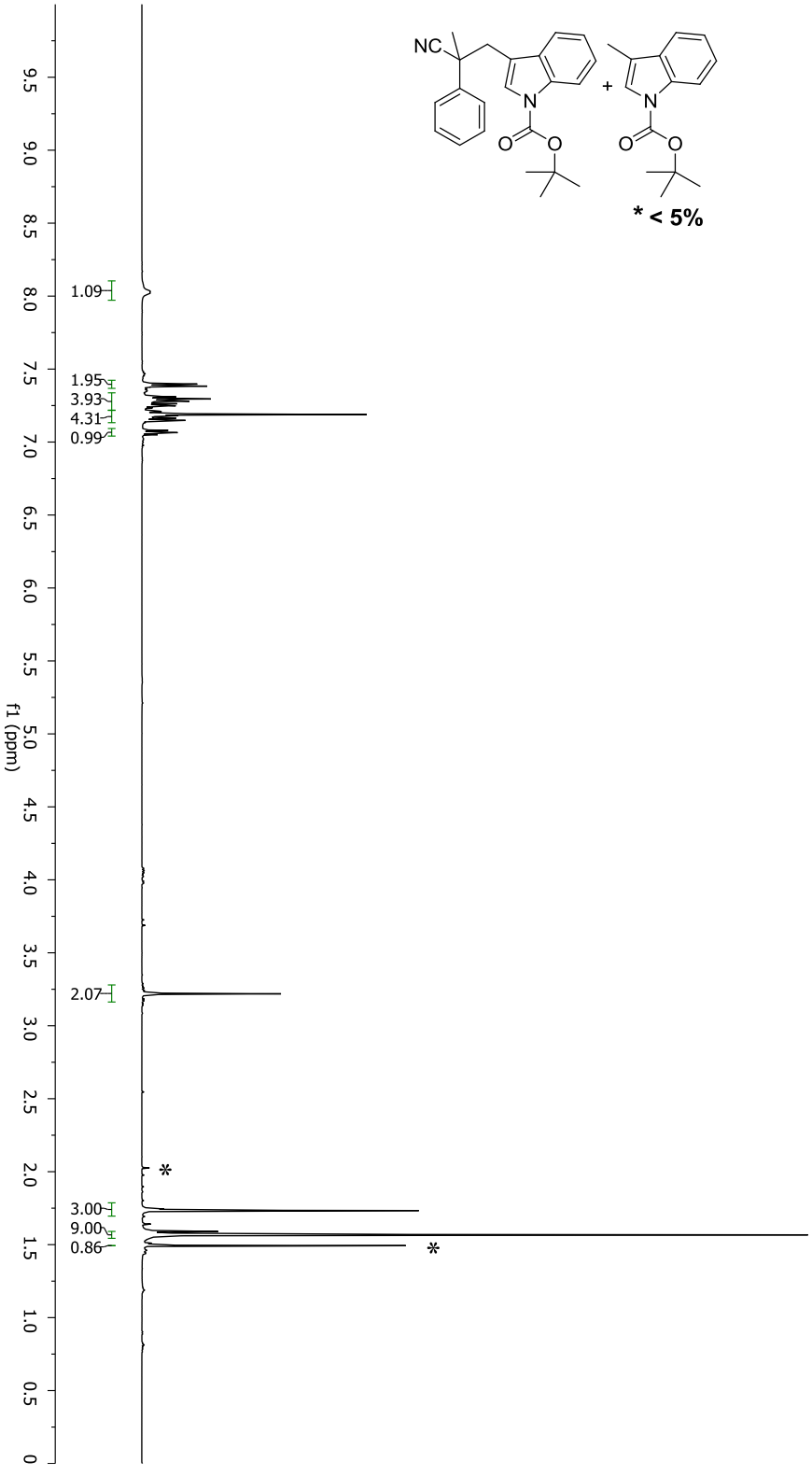
3-(benzofuran-2-yl)-2-methyl-2-phenylpropanenitrile



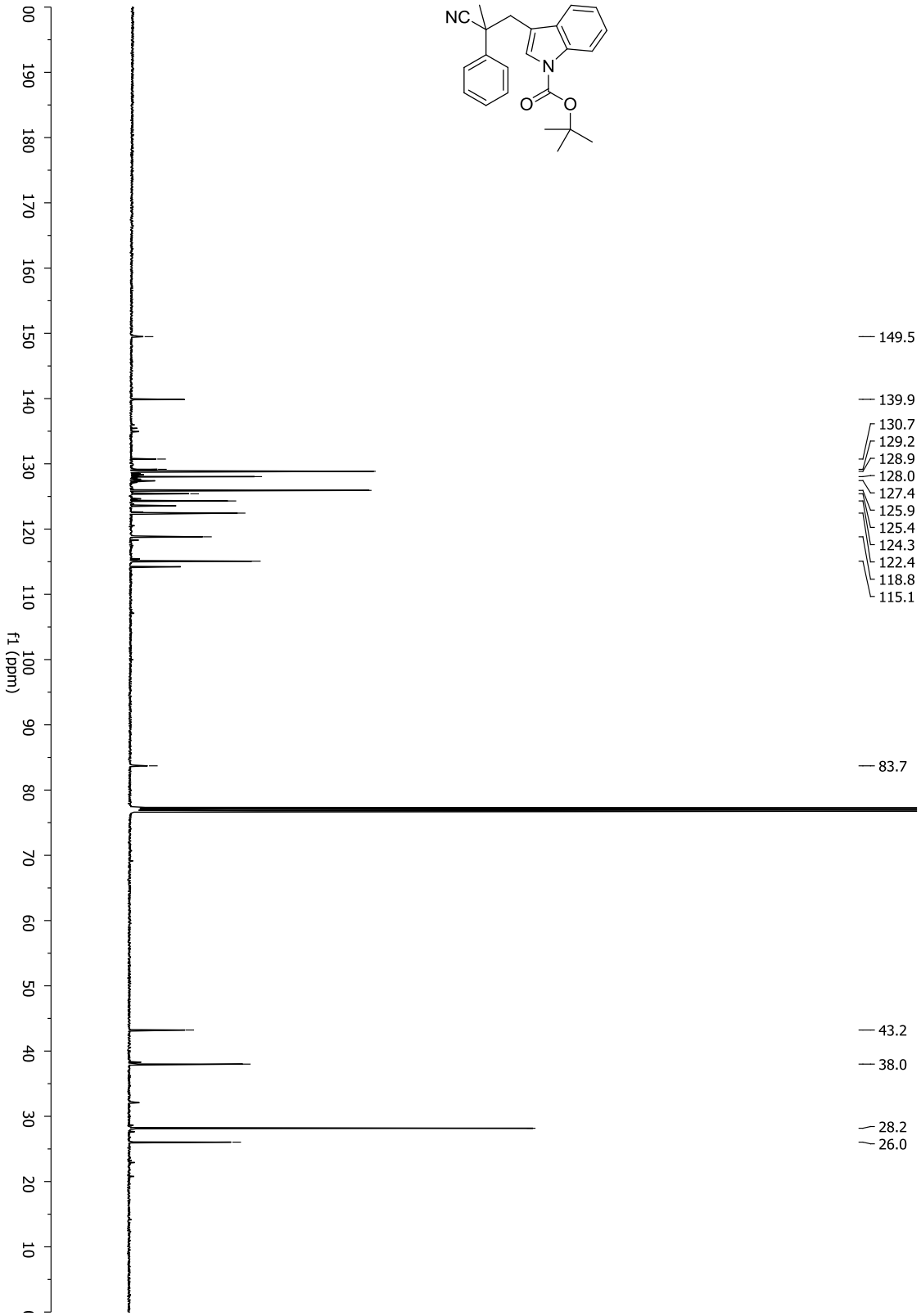
3-(benzofuran-2-yl)-2-methyl-2-phenylpropanenitrile



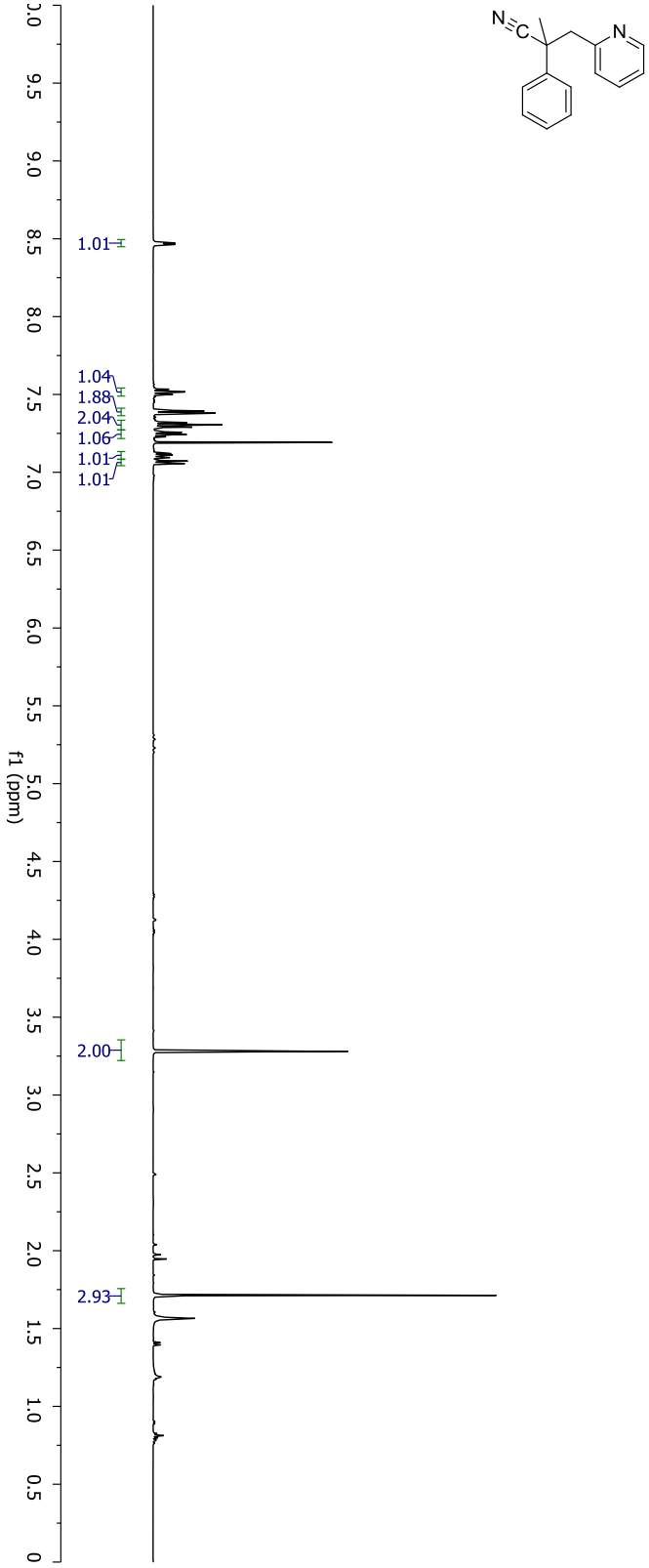
tert-butyl 3-(2-cyano-2-phenylpropyl)-1H-indole-1-carboxylate



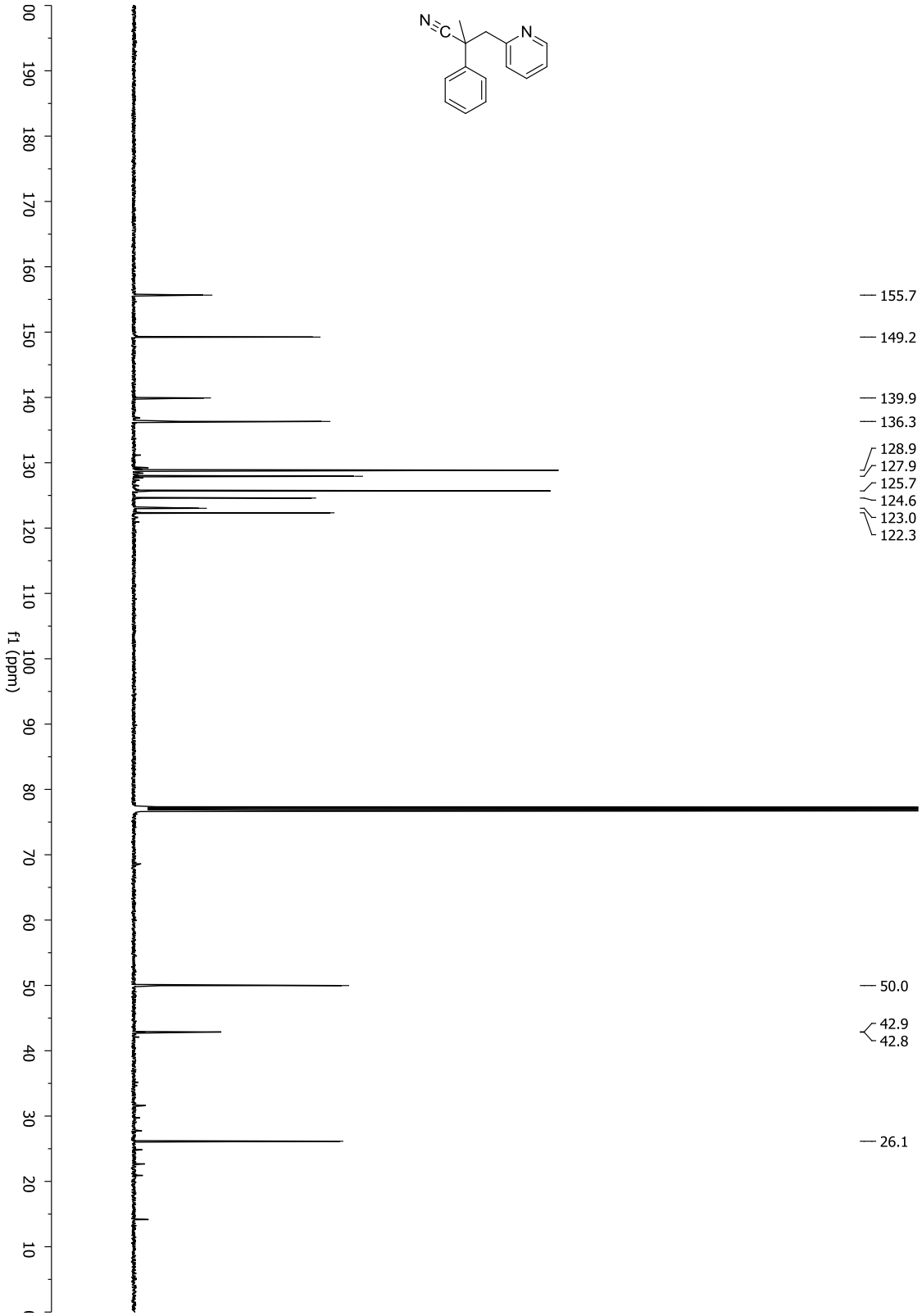
tert-butyl 3-(2-cyano-2-phenylpropyl)-1H-indole-1-carboxylate



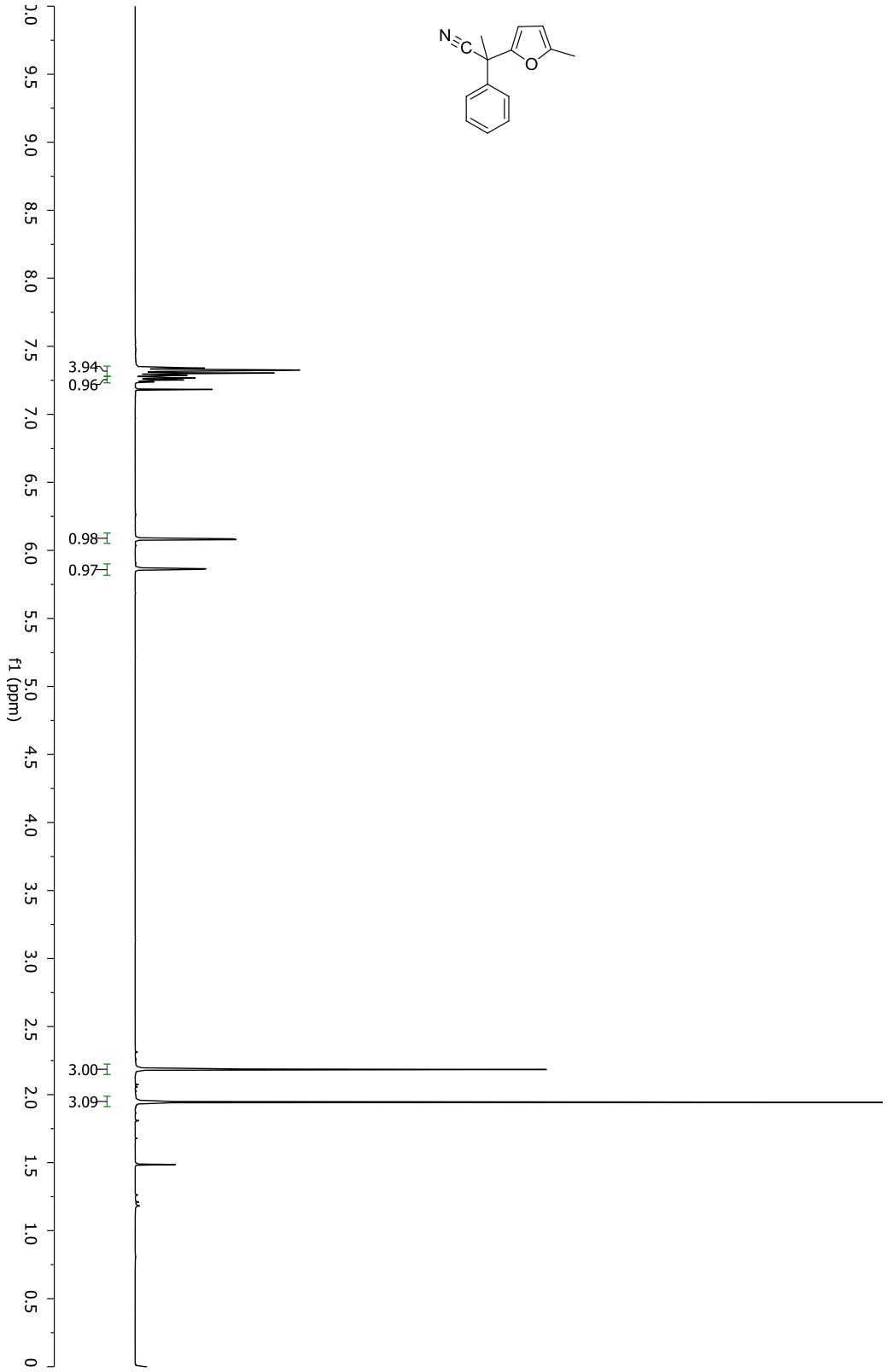
2-methyl-2-phenyl-3-(pyridin-2-yl)propanenitrile



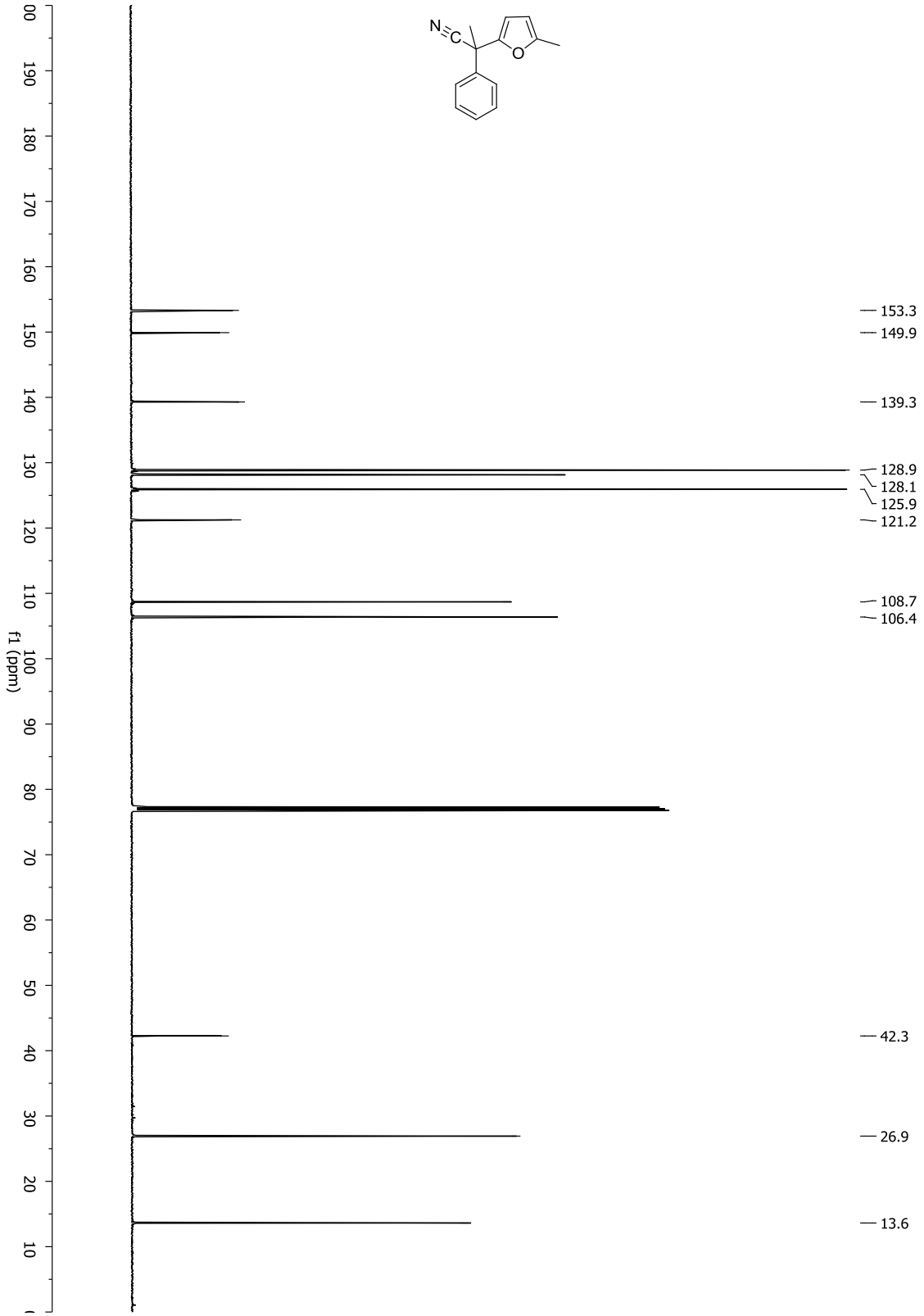
2-methyl-2-phenyl-3-(pyridin-2-yl)propanenitrile



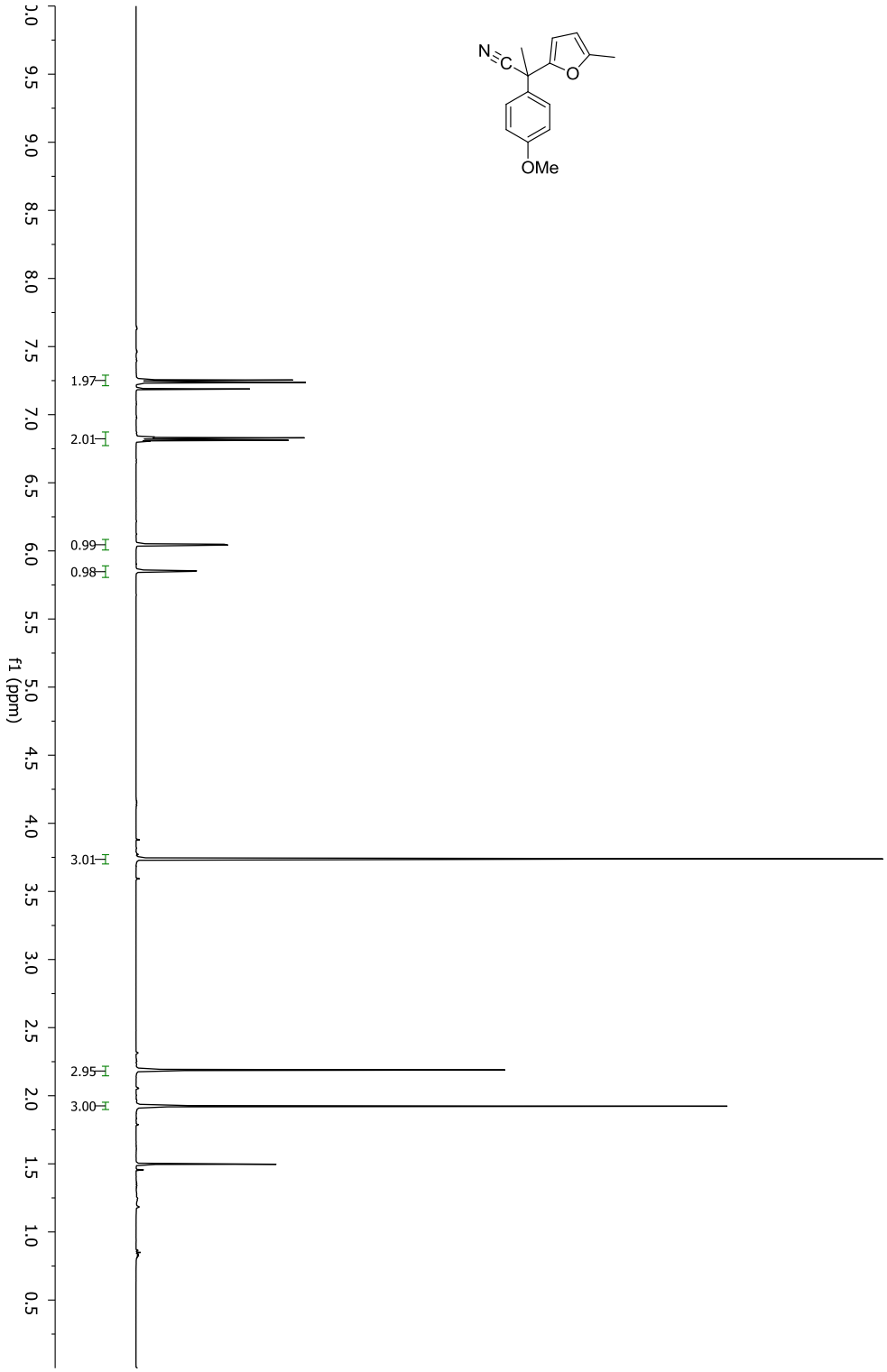
2-(5-methylfuran-2-yl)-2-phenylpropanenitrile



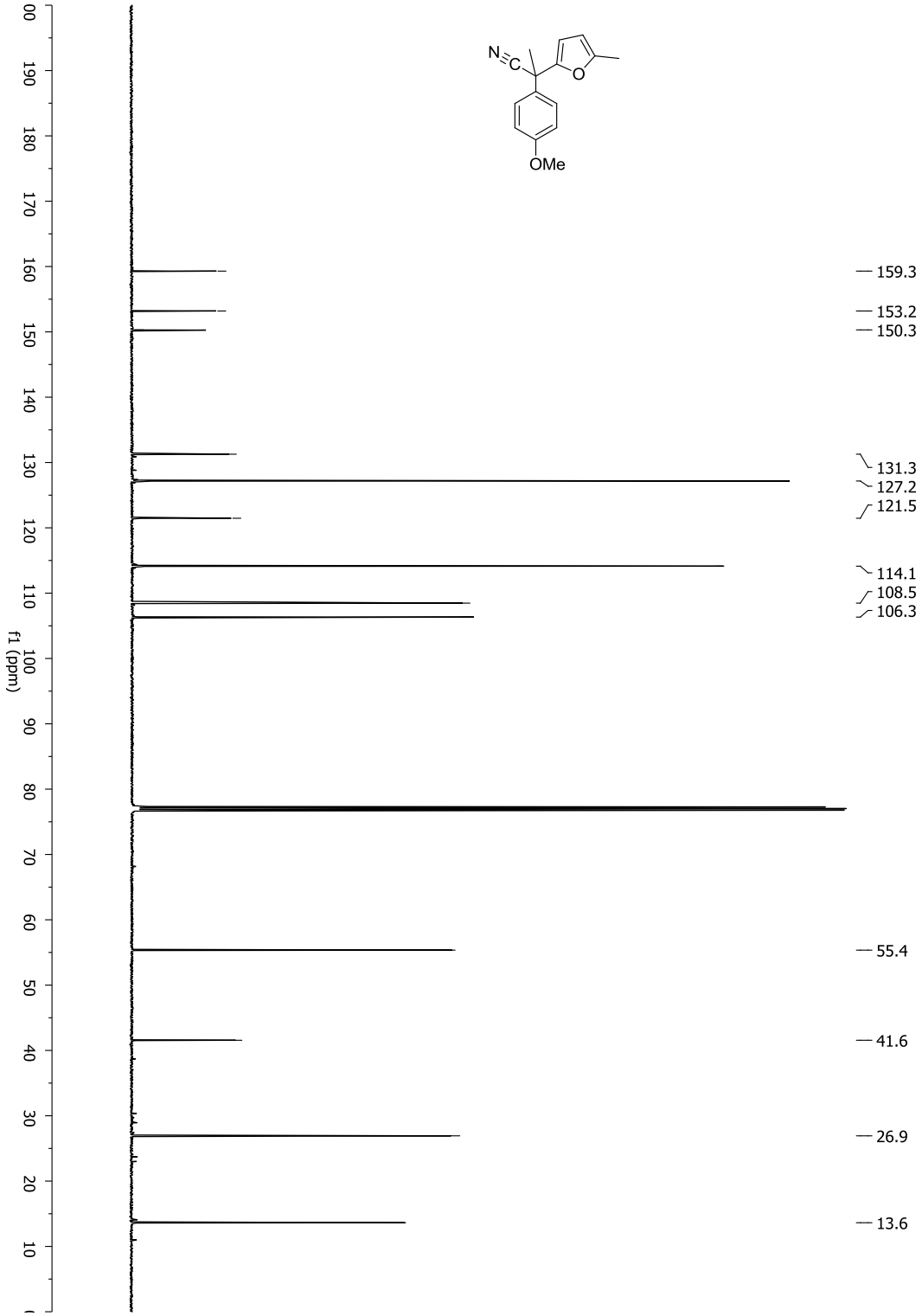
2-(5-methylfuran-2-yl)-2-phenylpropanenitrile



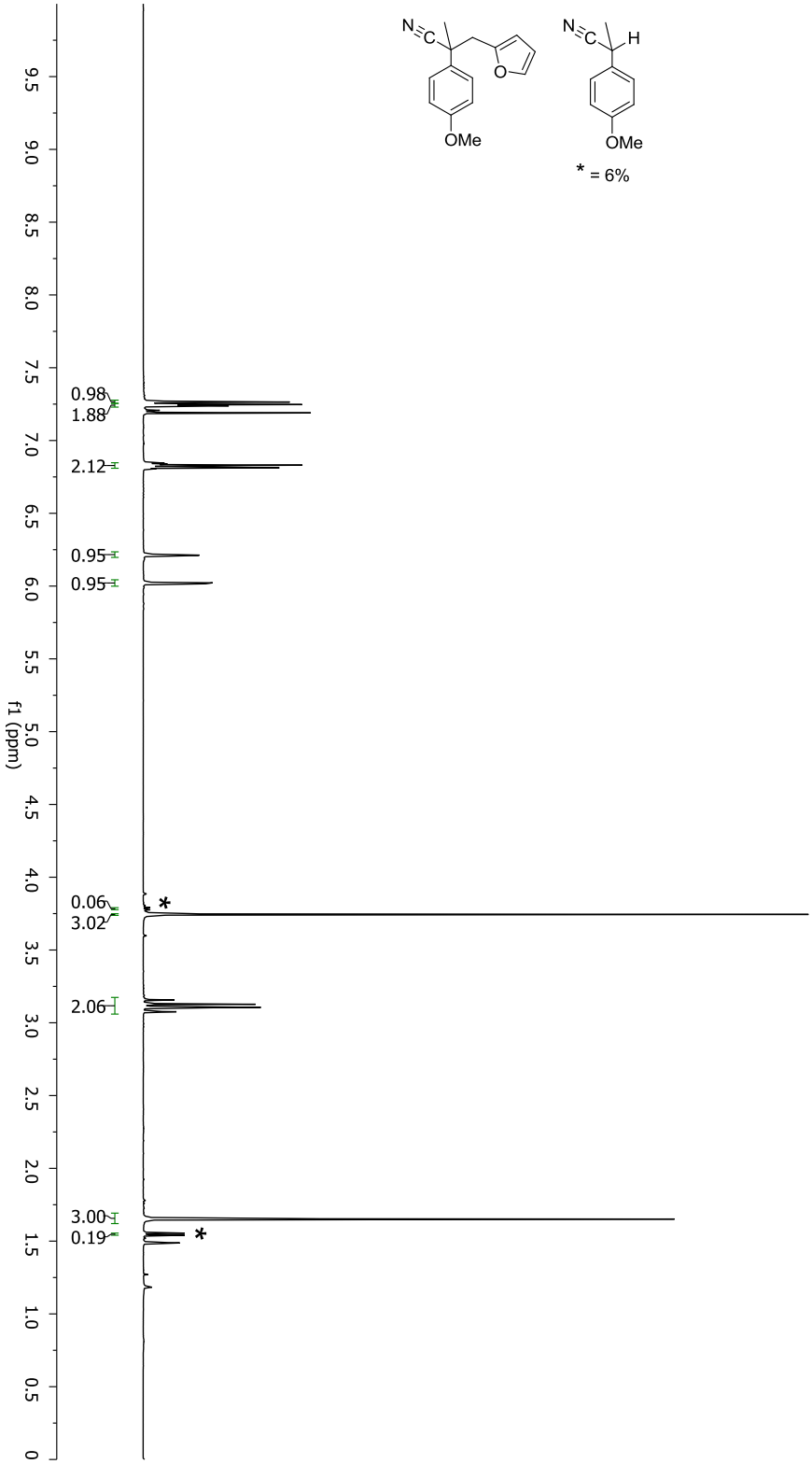
2-(4-methoxyphenyl)-2-(5-methylfuran-2-yl)propanenitrile



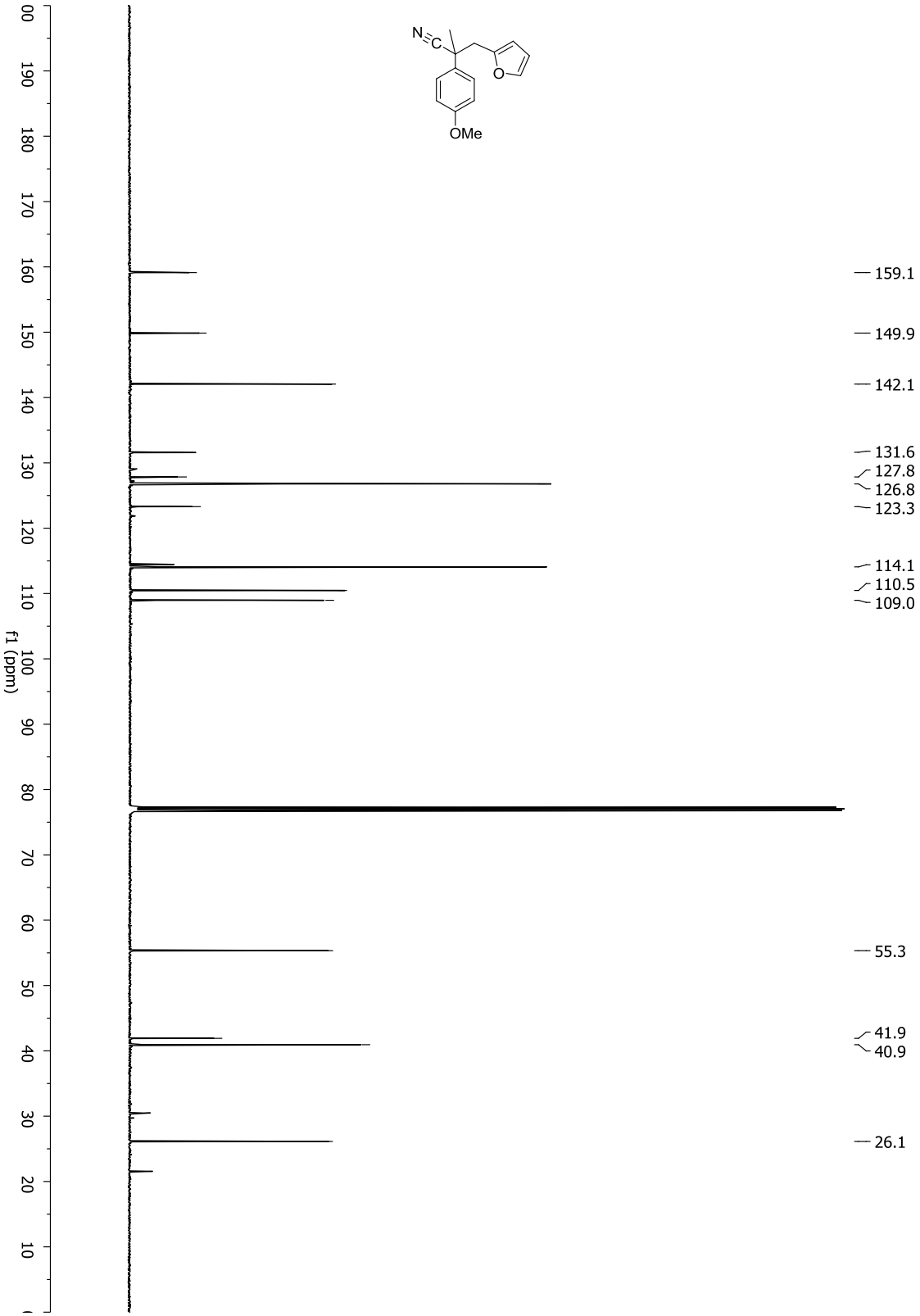
2-(4-methoxyphenyl)-2-(5-methylfuran-2-yl)propanenitrile



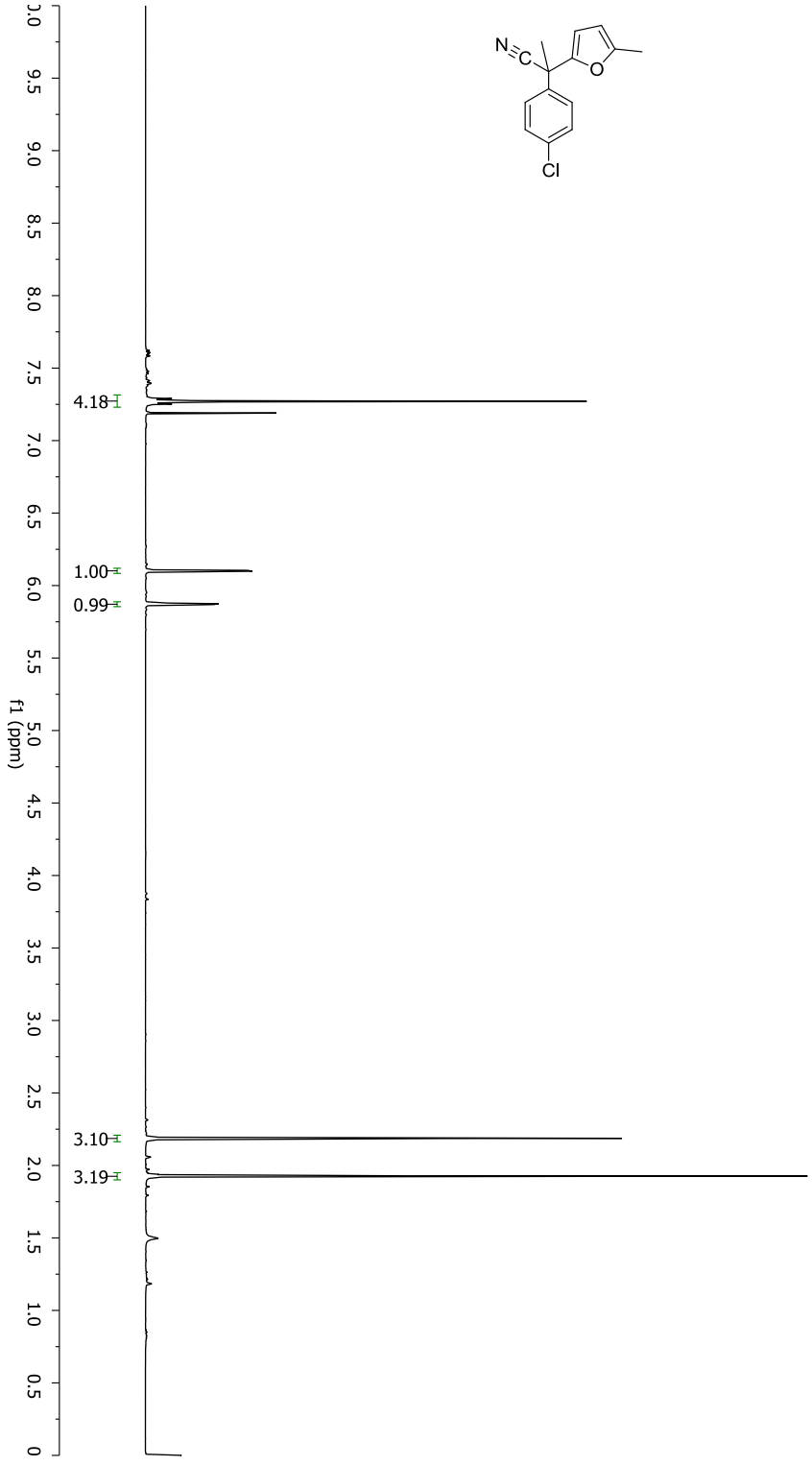
3-(furan-2-yl)-2-(4-methoxyphenyl)-2-methylpropanenitrile



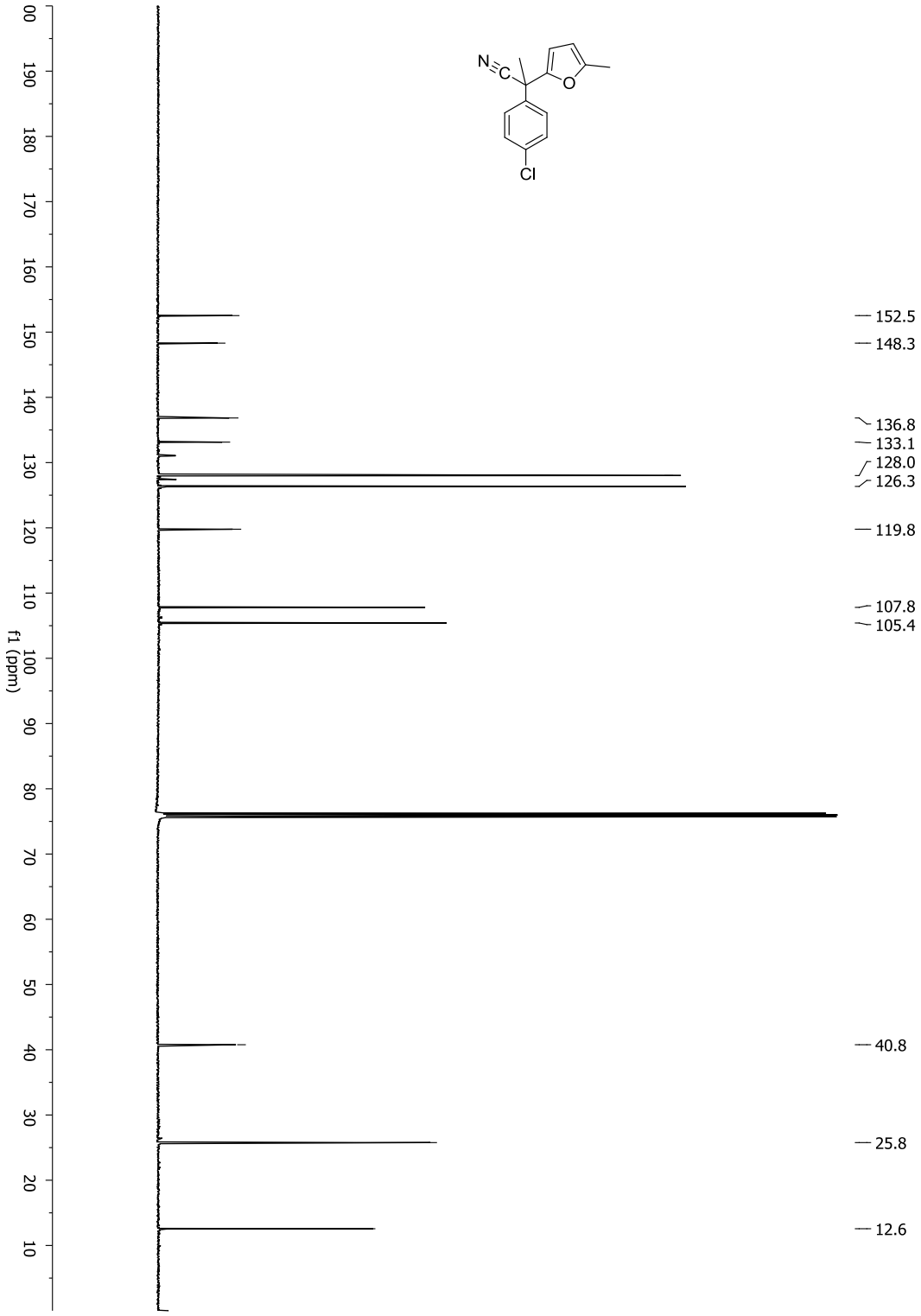
3-(furan-2-yl)-2-(4-methoxyphenyl)-2-methylpropanenitrile



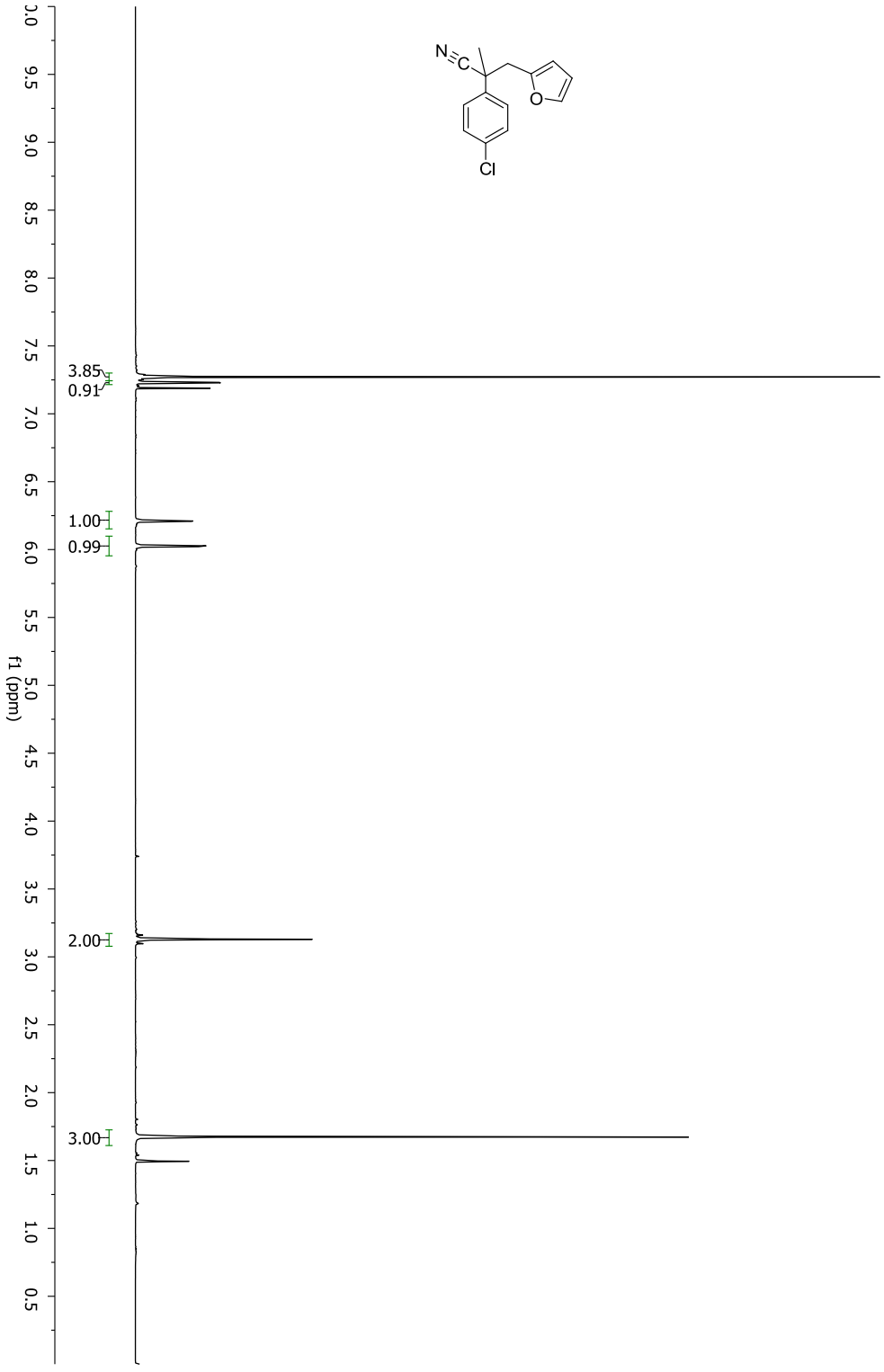
2-(4-chlorophenyl)-2-(5-methylfuran-2-yl)propanenitrile



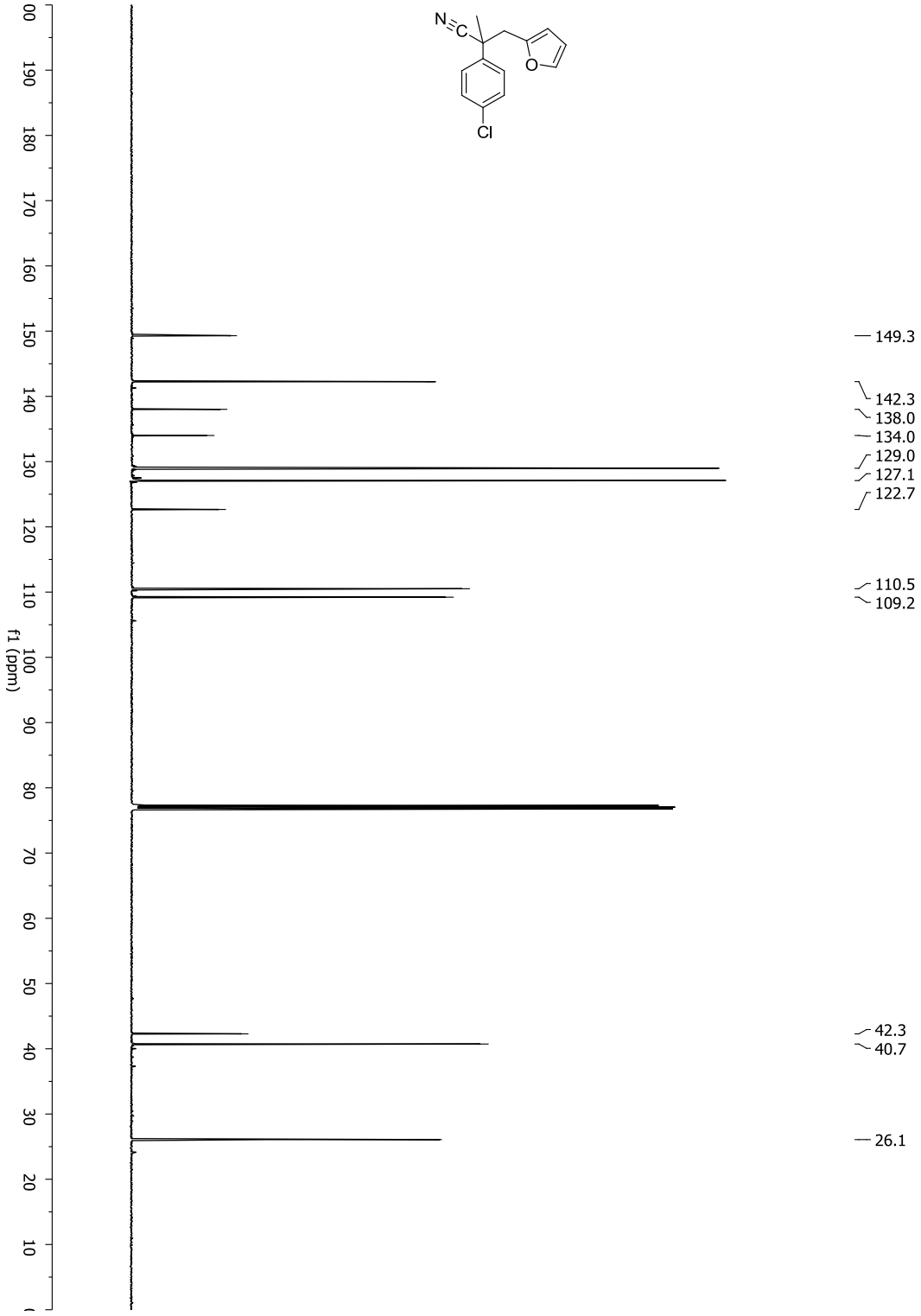
2-(4-chlorophenyl)-2-(5-methylfuran-2-yl)propanenitrile



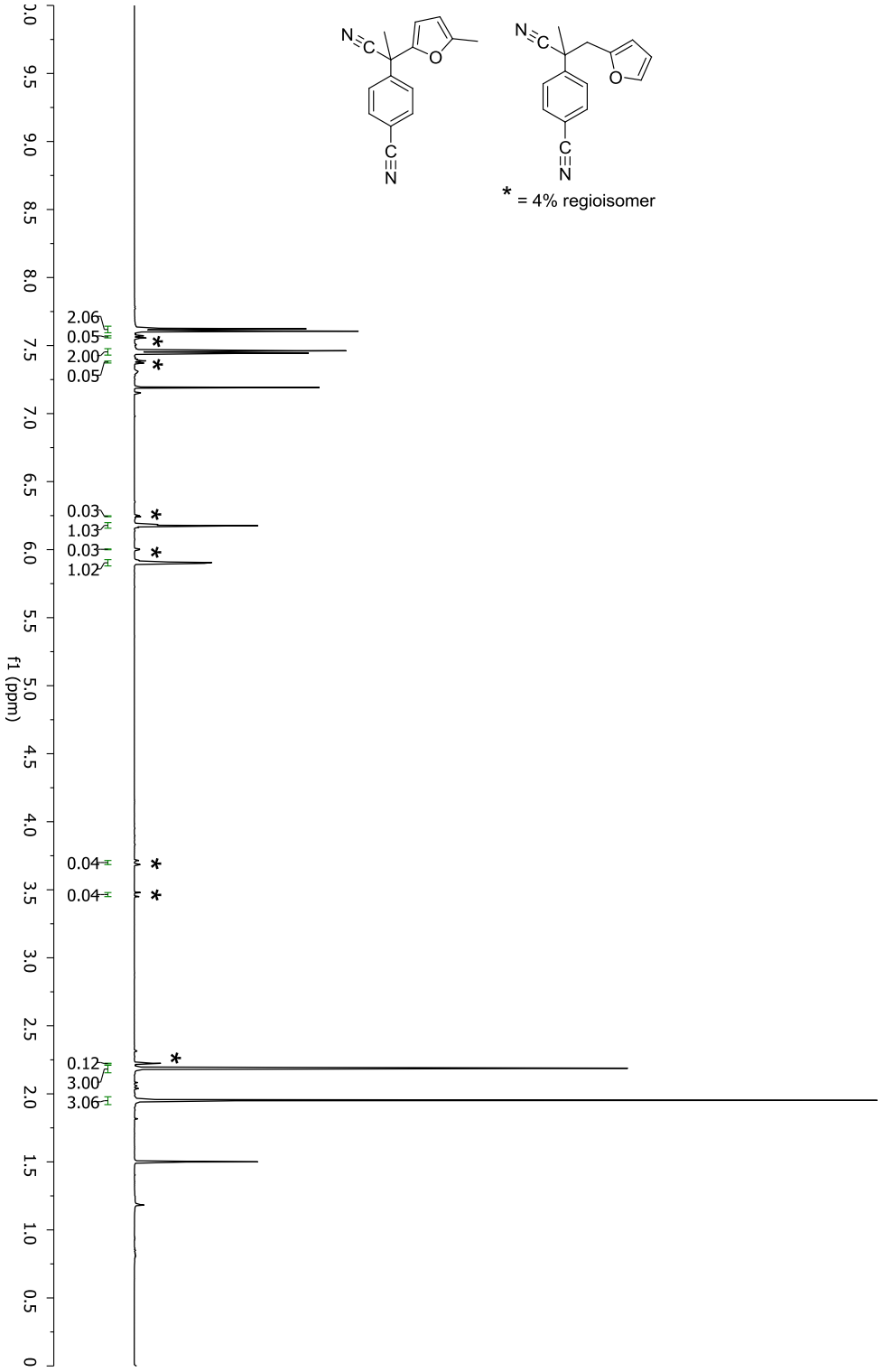
2-(4-chlorophenyl)-3-(furan-2-yl)-2-methylpropanenitrile



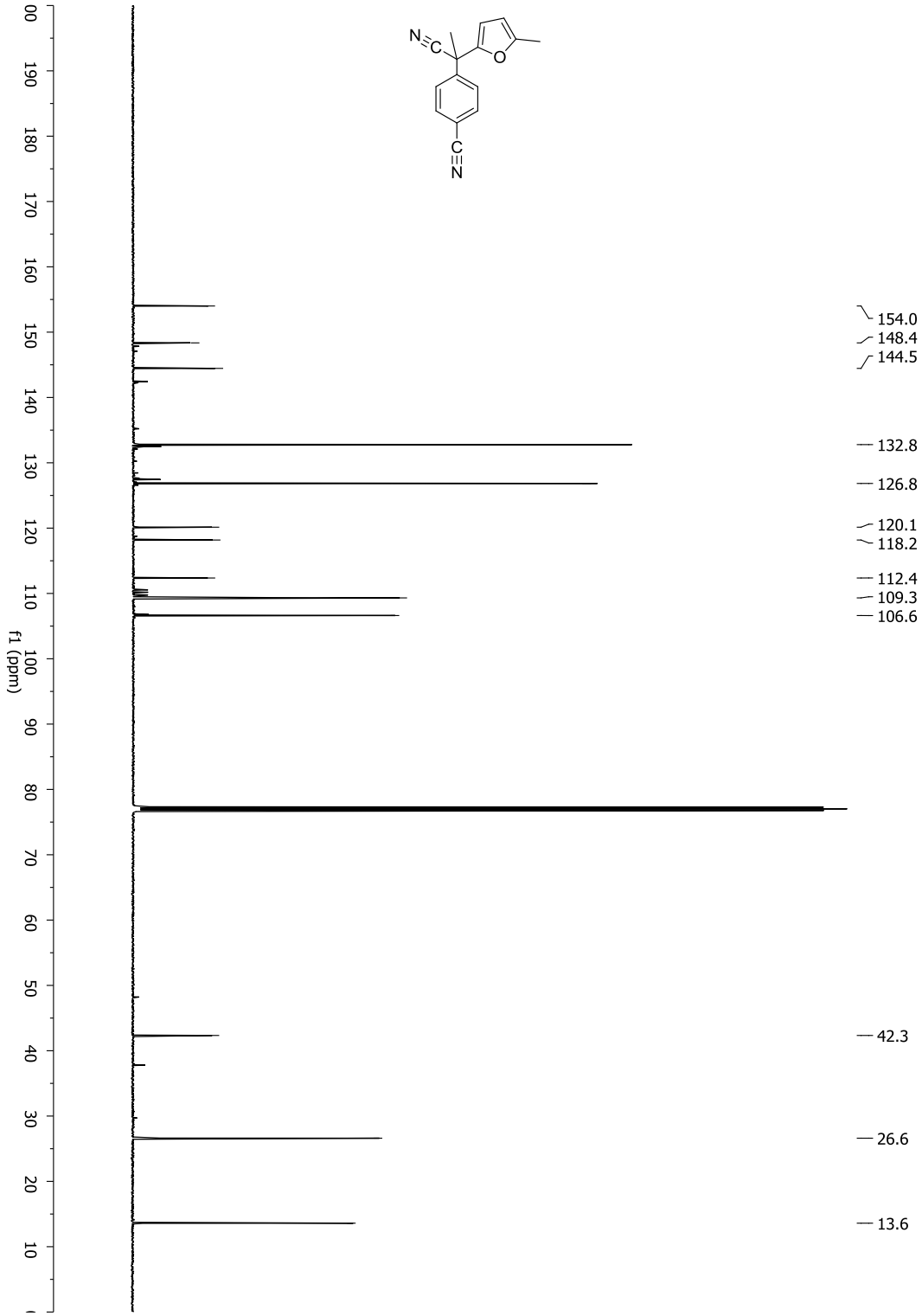
2-(4-chlorophenyl)-3-(furan-2-yl)-2-methylpropanenitrile



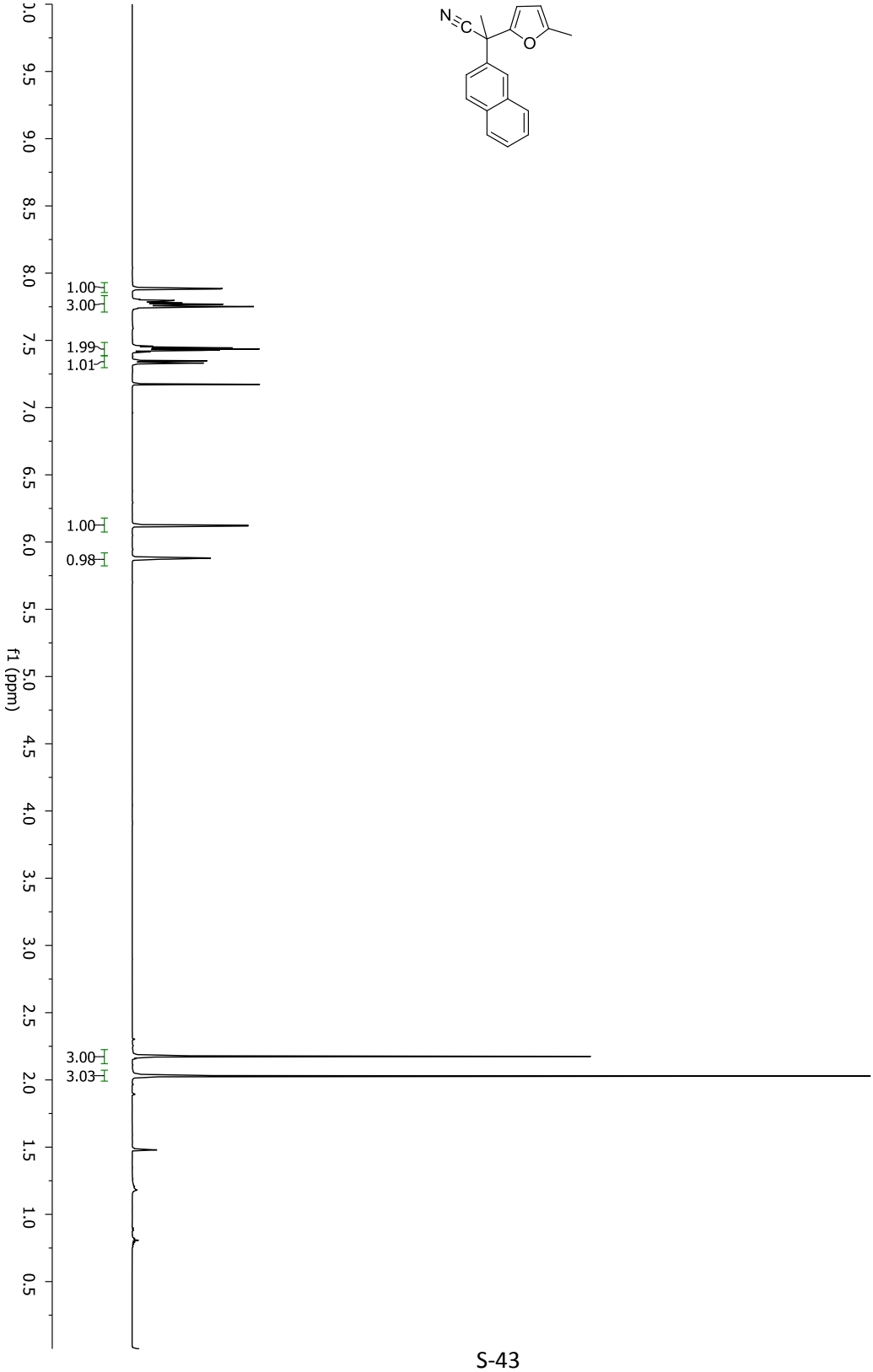
4-(1-cyano-1-(5-methylfuran-2-yl)ethyl)benzonitrile



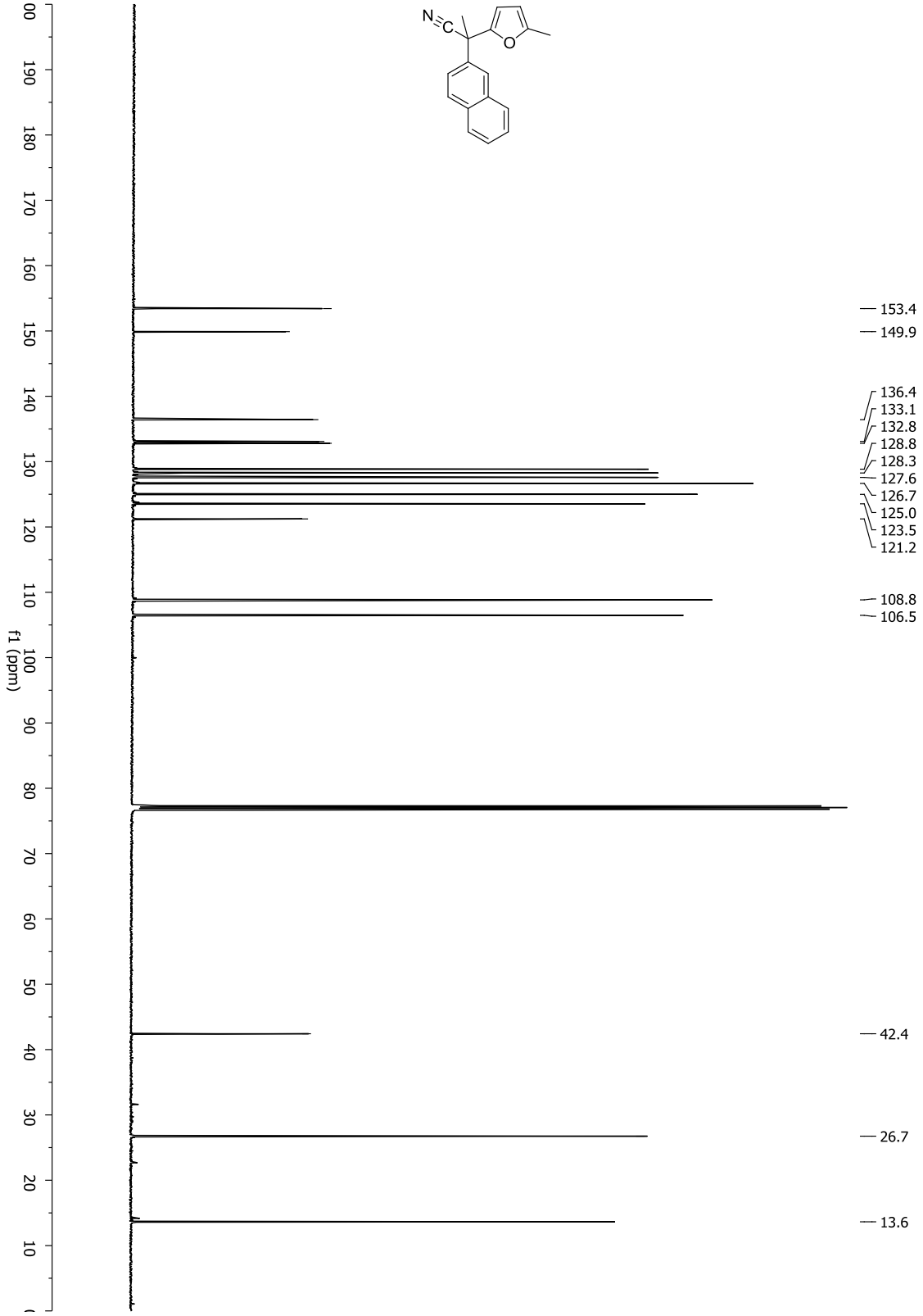
4-(1-cyano-1-(5-methylfuran-2-yl)ethyl)benzonitrile



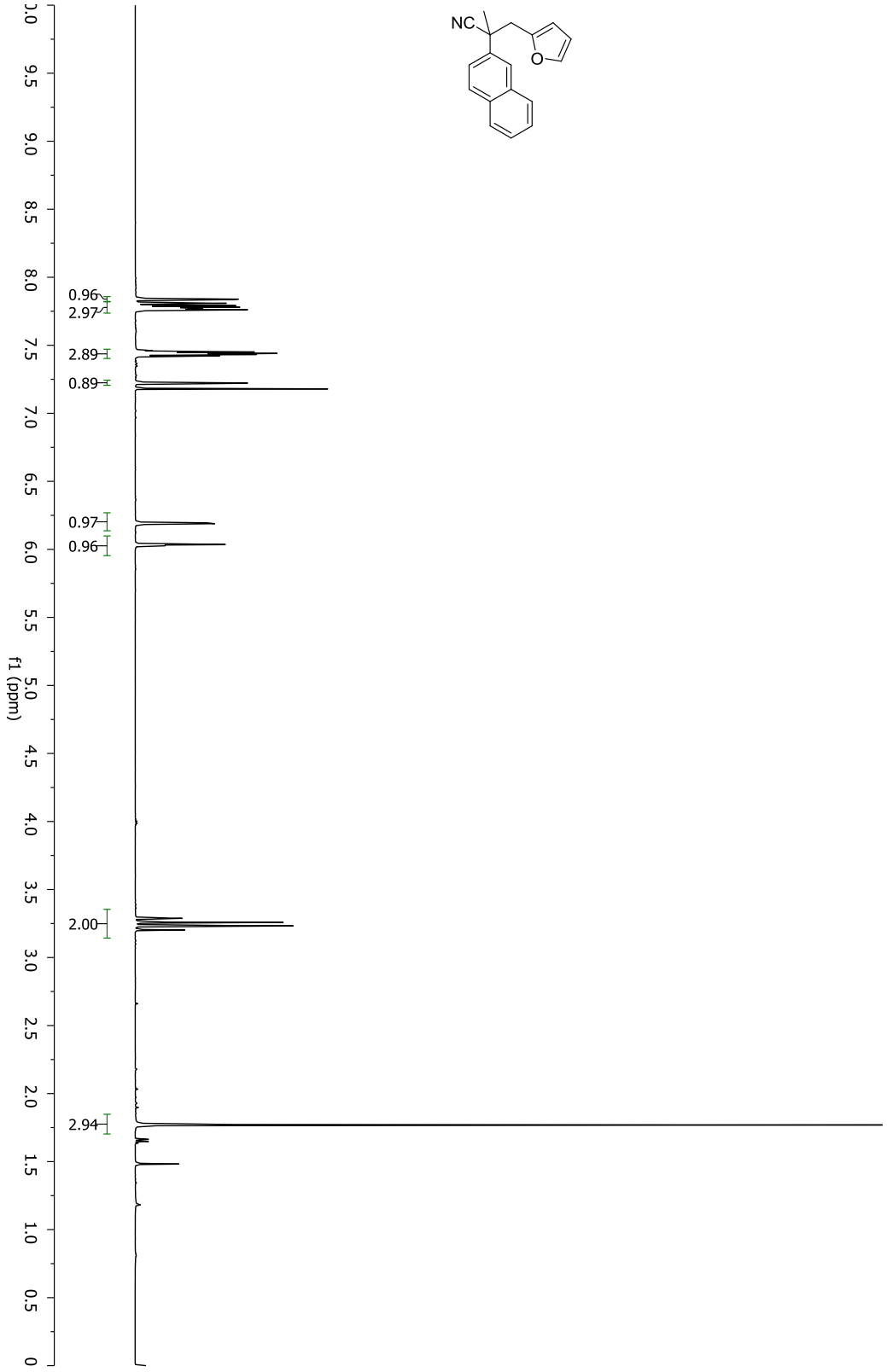
2-(5-methylfuran-2-yl)-2-(naphthalen-2-yl)propanenitrile



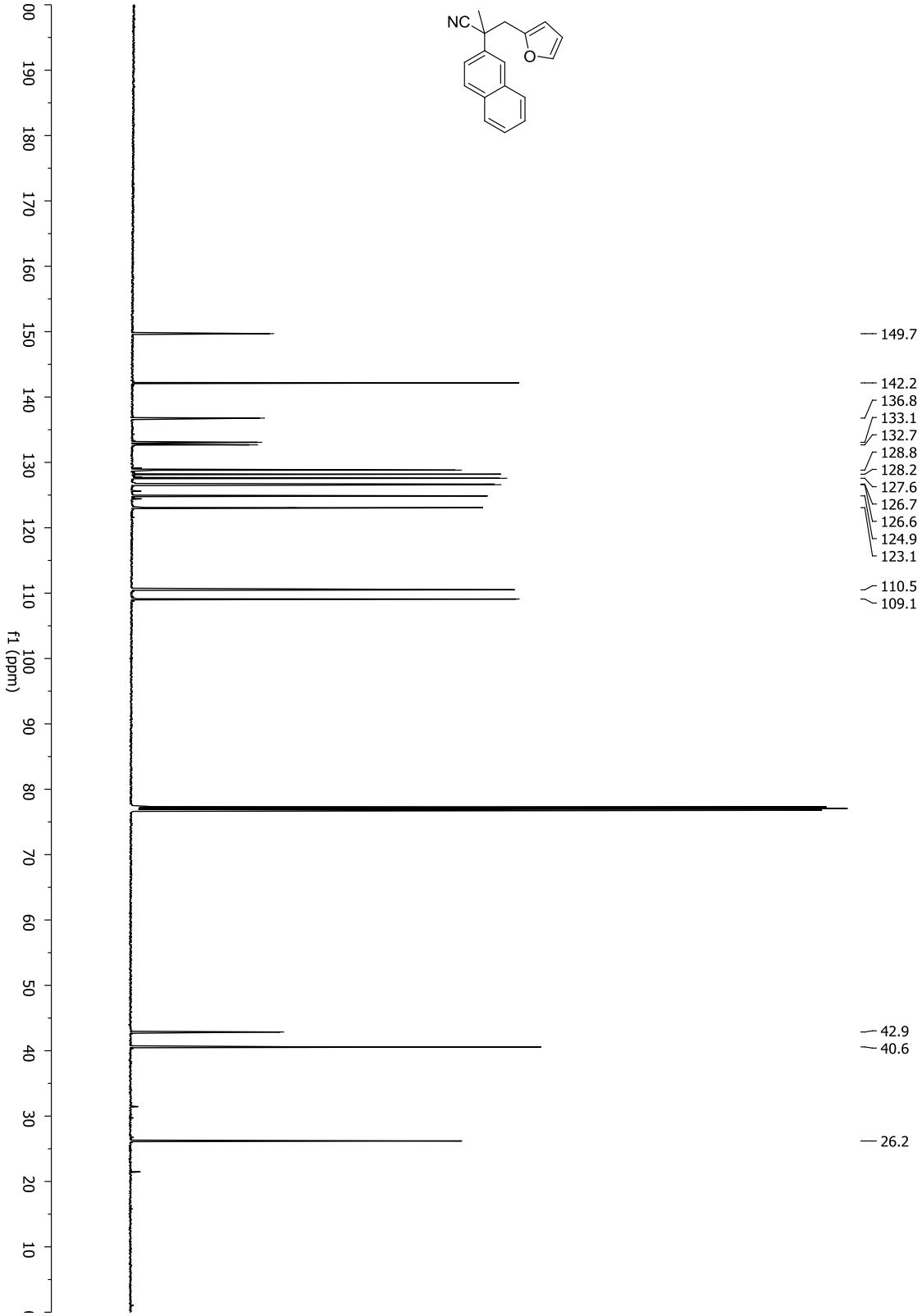
2-(5-methylfuran-2-yl)-2-(naphthalen-2-yl)propanenitrile



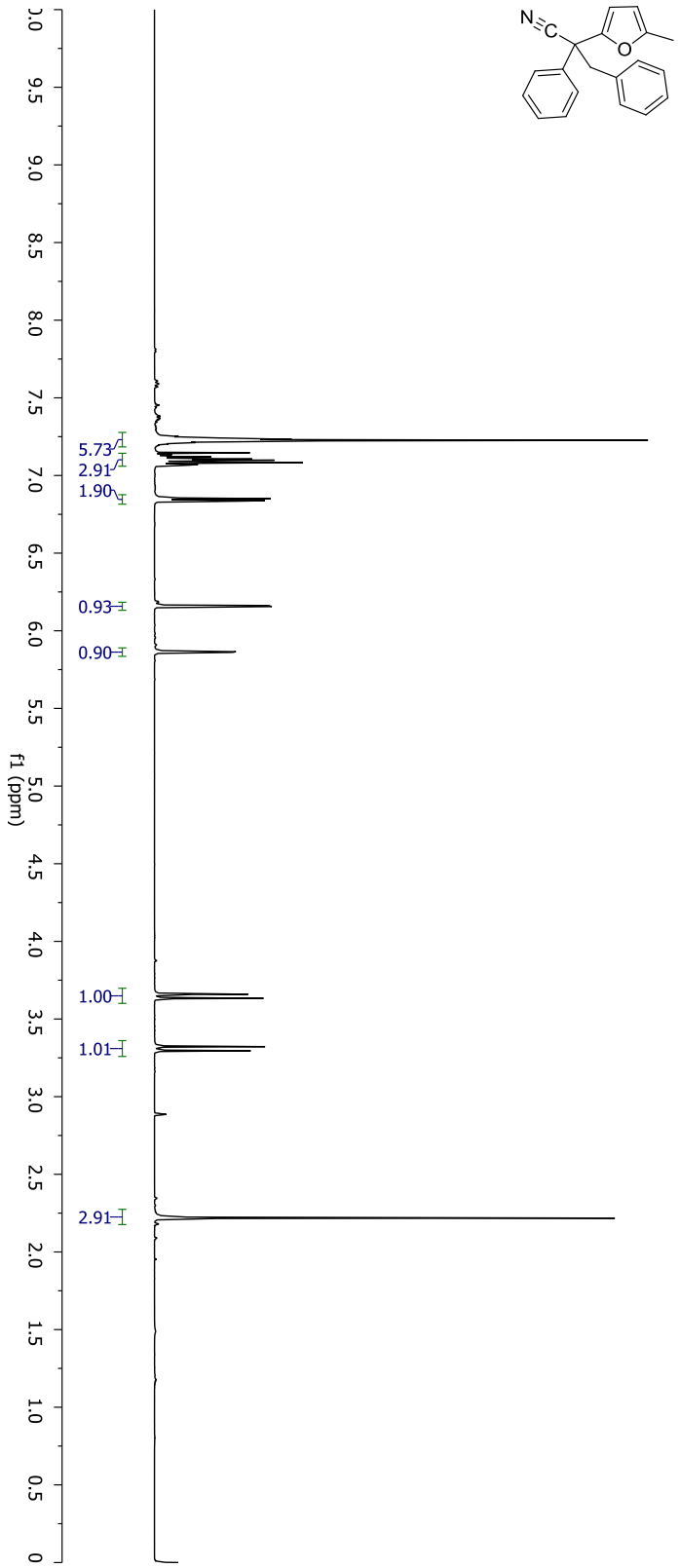
3-(furan-2-yl)-2-methyl-2-(naphthalen-2-yl)propanenitrile



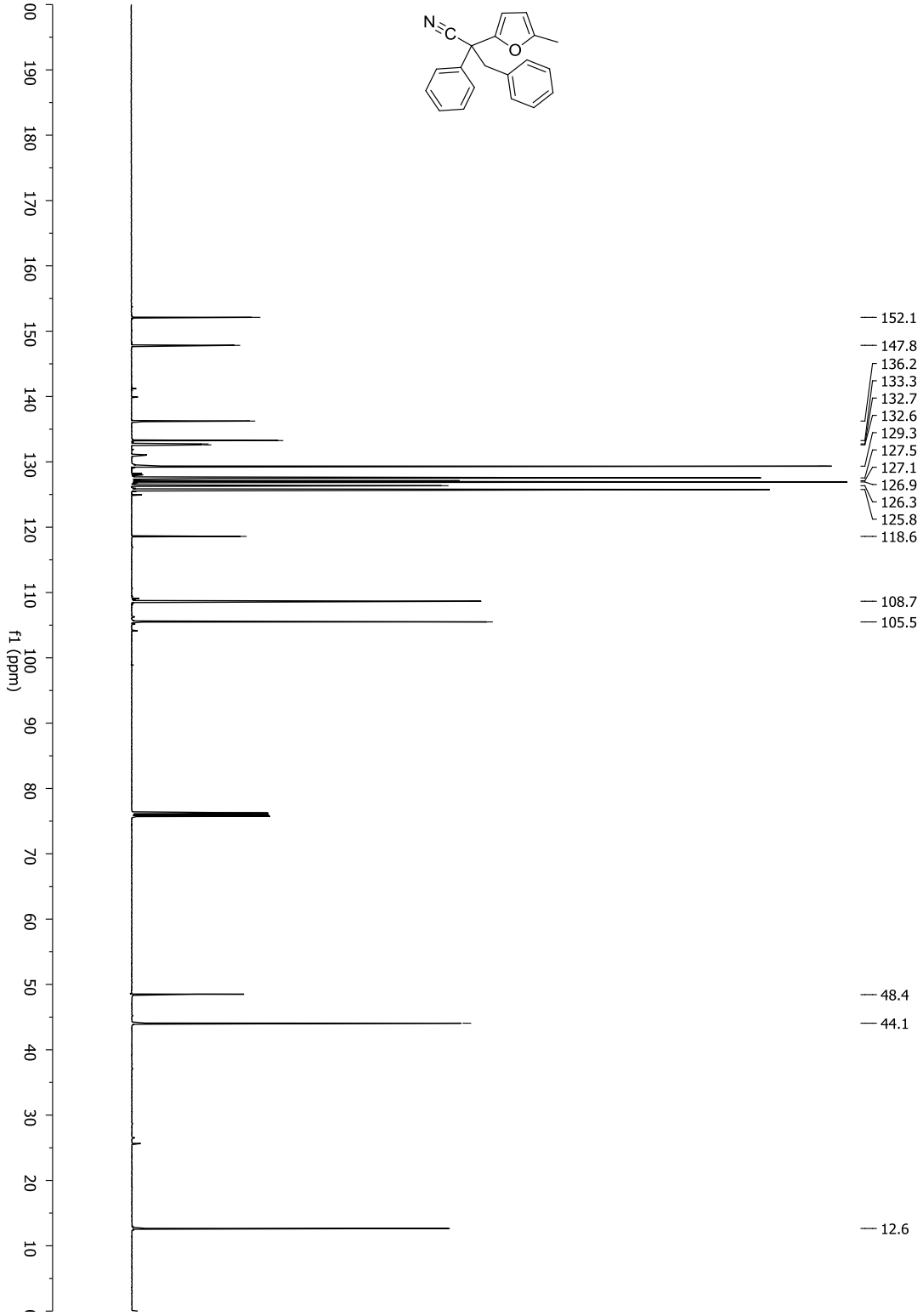
3-(furan-2-yl)-2-methyl-2-(naphthalen-2-yl)propanenitrile



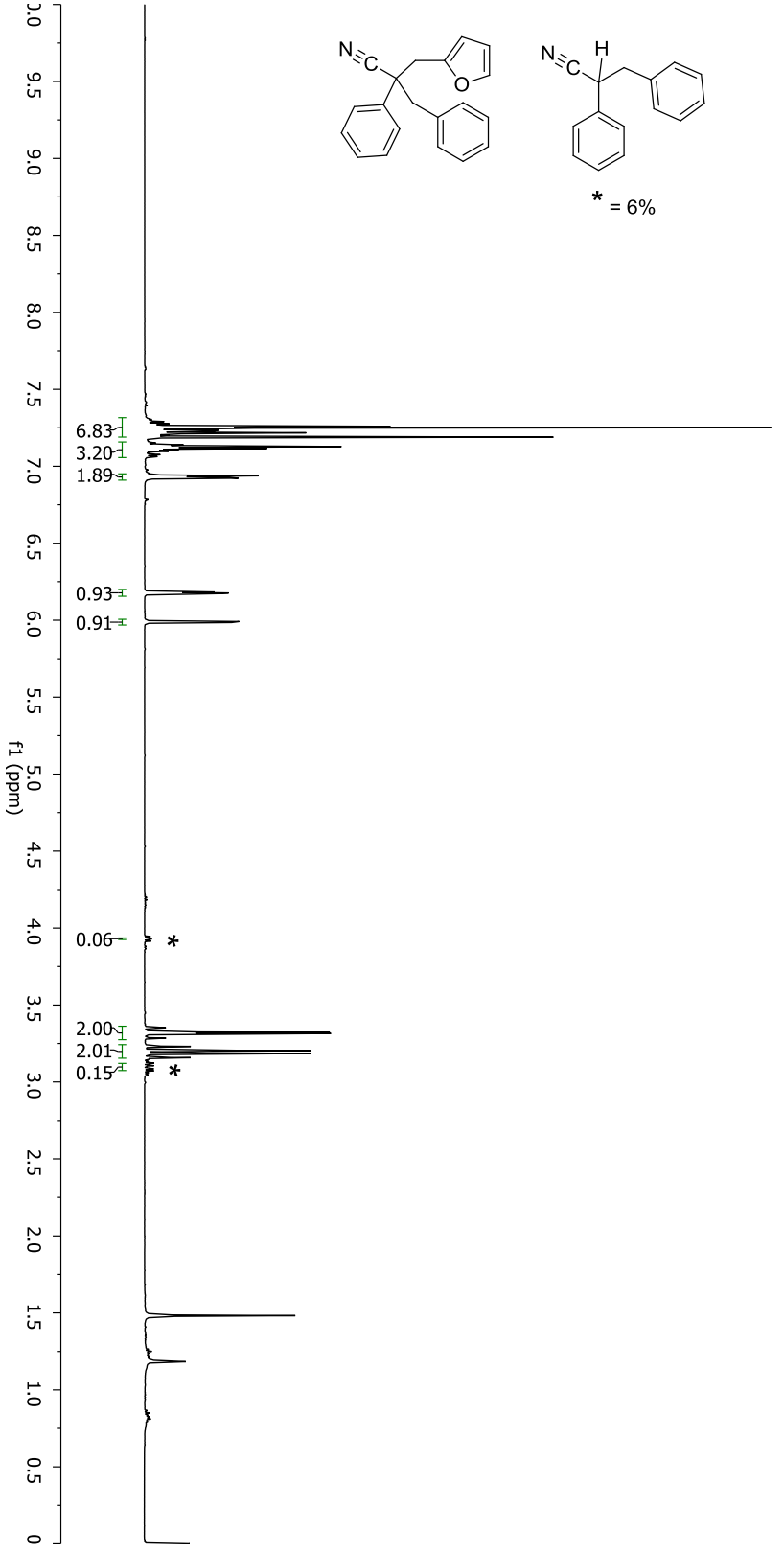
2-(5-methylfuran-2-yl)-2,3-diphenylpropanenitrile



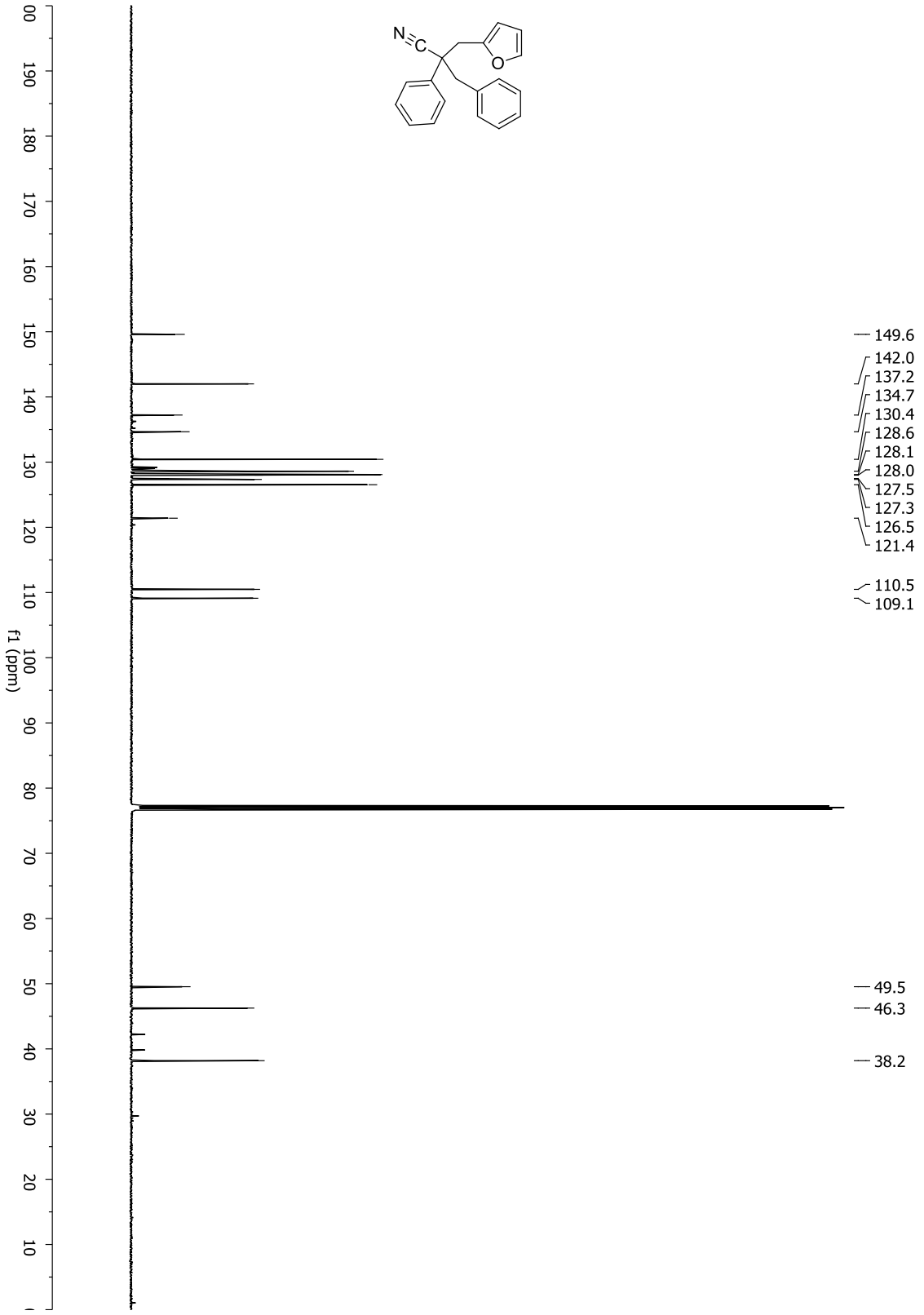
2-(5-methylfuran-2-yl)-2,3-diphenylpropanenitrile



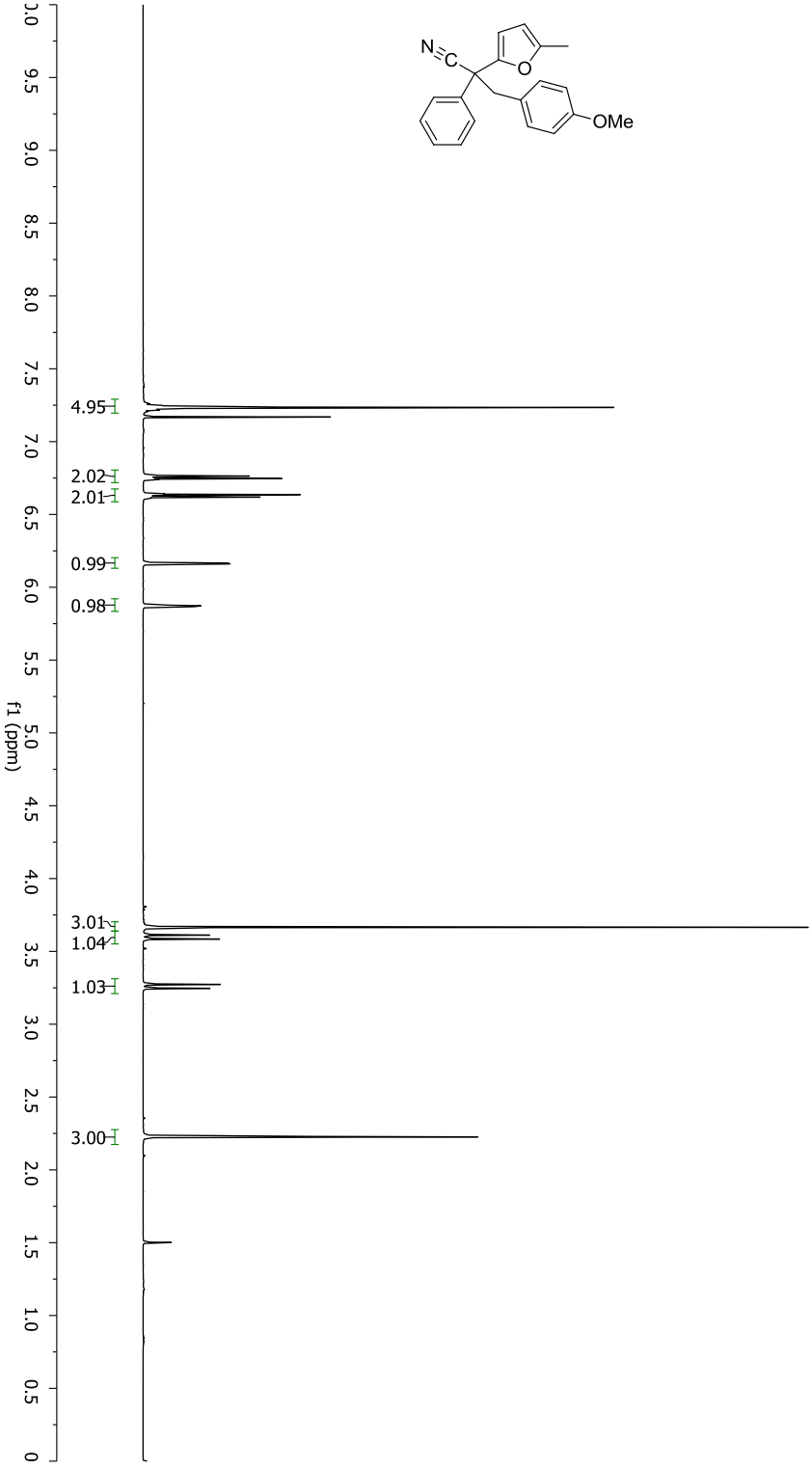
2-benzyl-3-(furan-2-yl)-2-phenylpropanenitrile



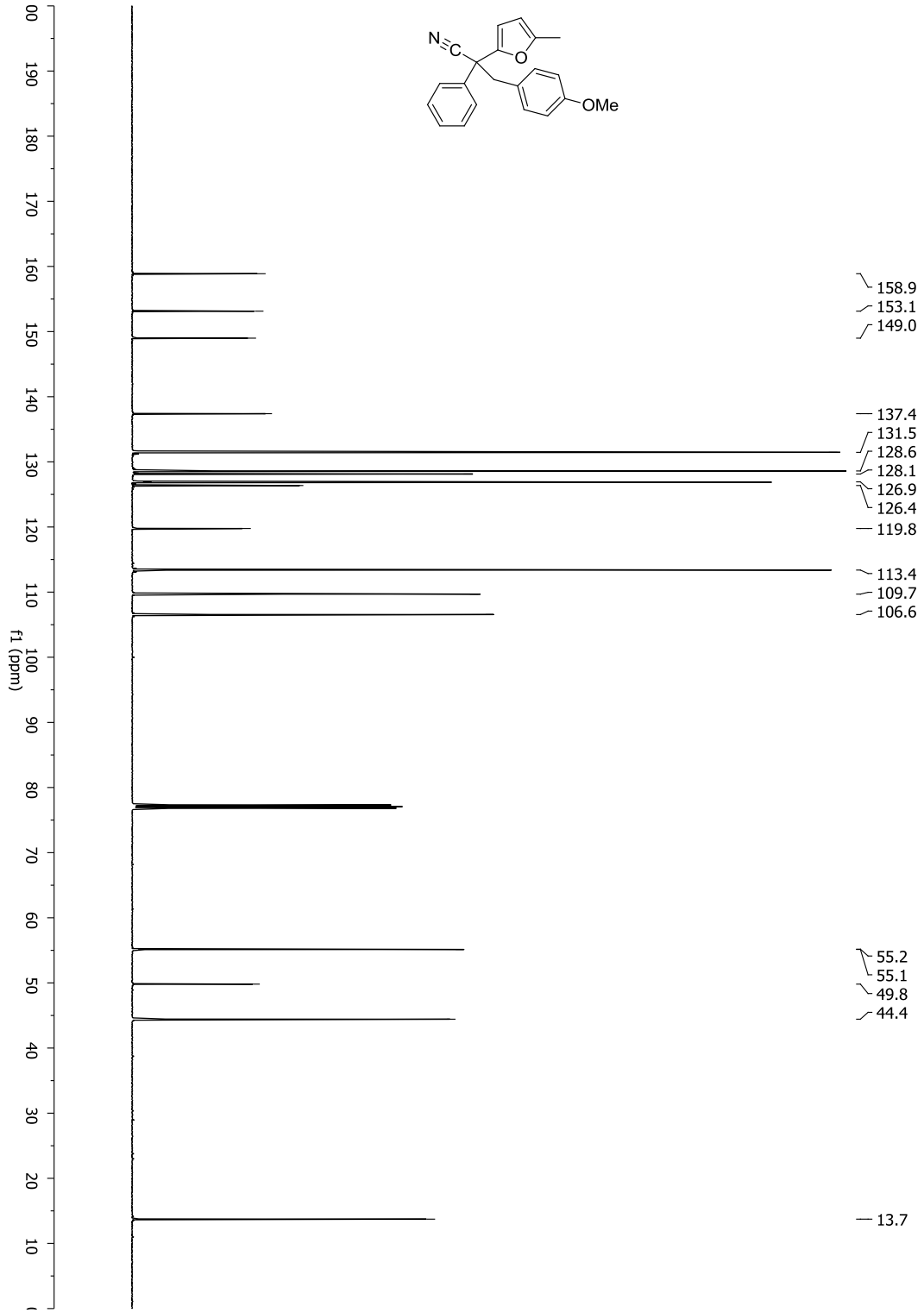
2-benzyl-3-(furan-2-yl)-2-phenylpropanenitrile



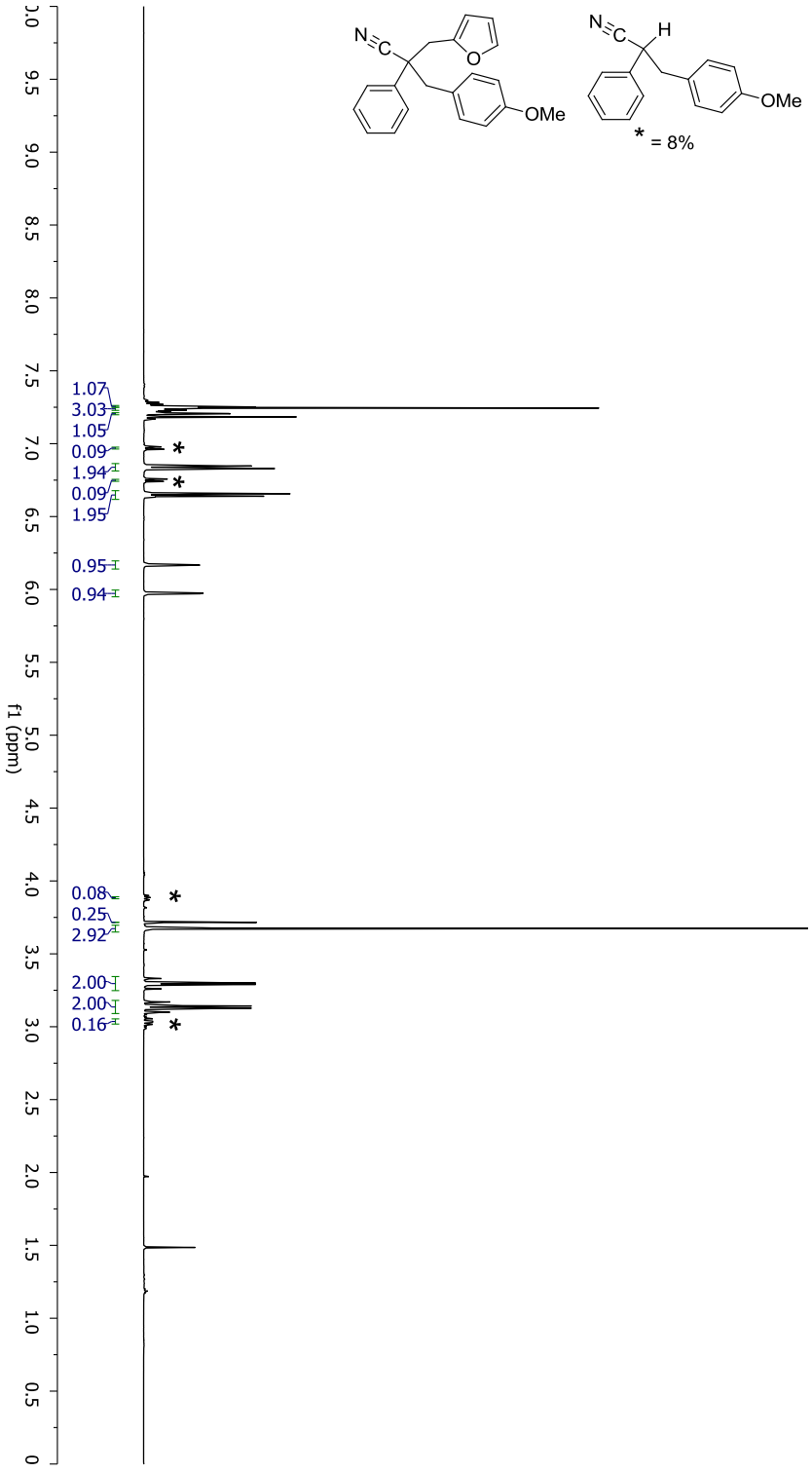
3-(4-methoxyphenyl)-2-(5-methylfuran-2-yl)-2-phenylpropanenitrile



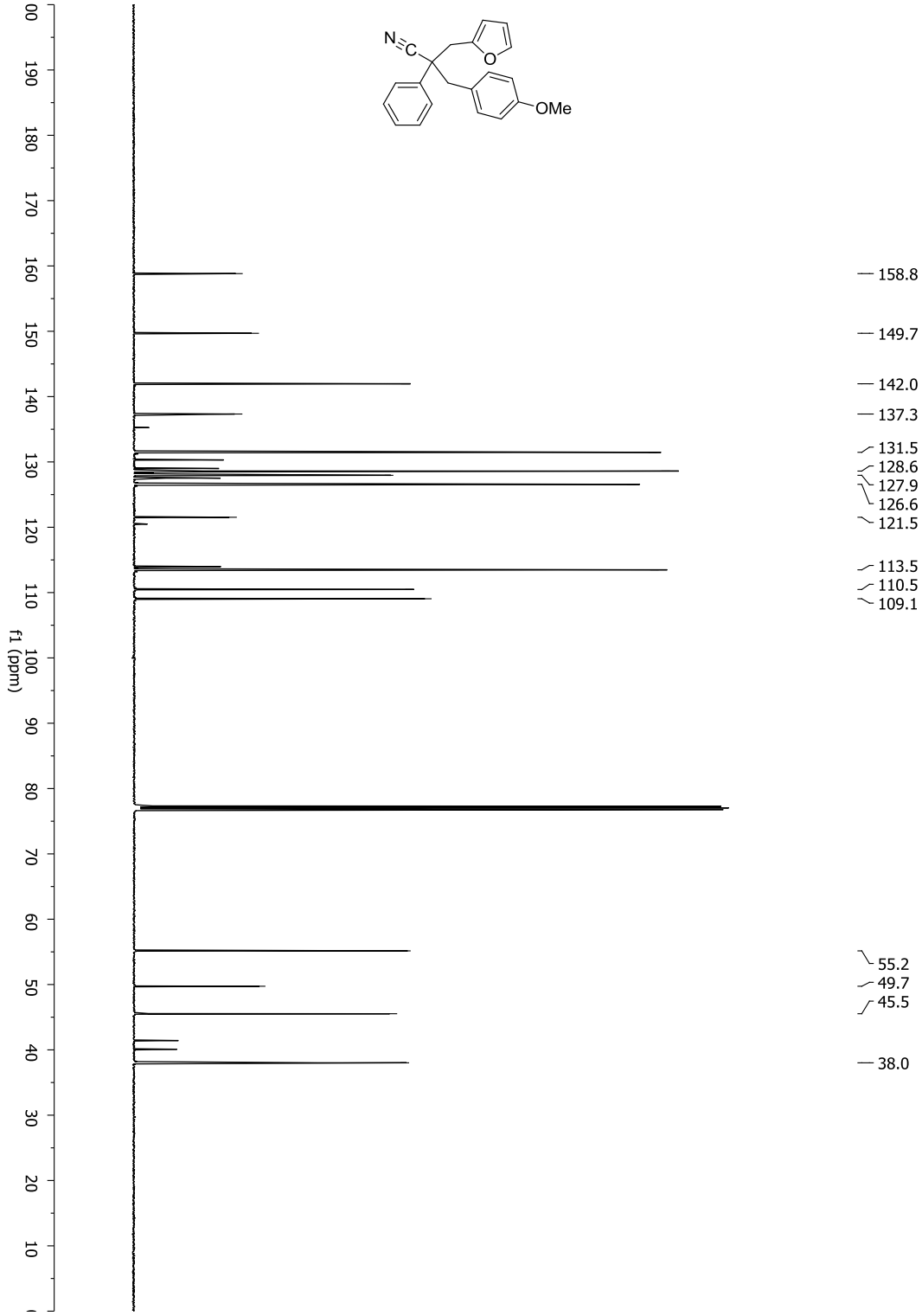
3-(4-methoxyphenyl)-2-(5-methylfuran-2-yl)-2-phenylpropanenitrile



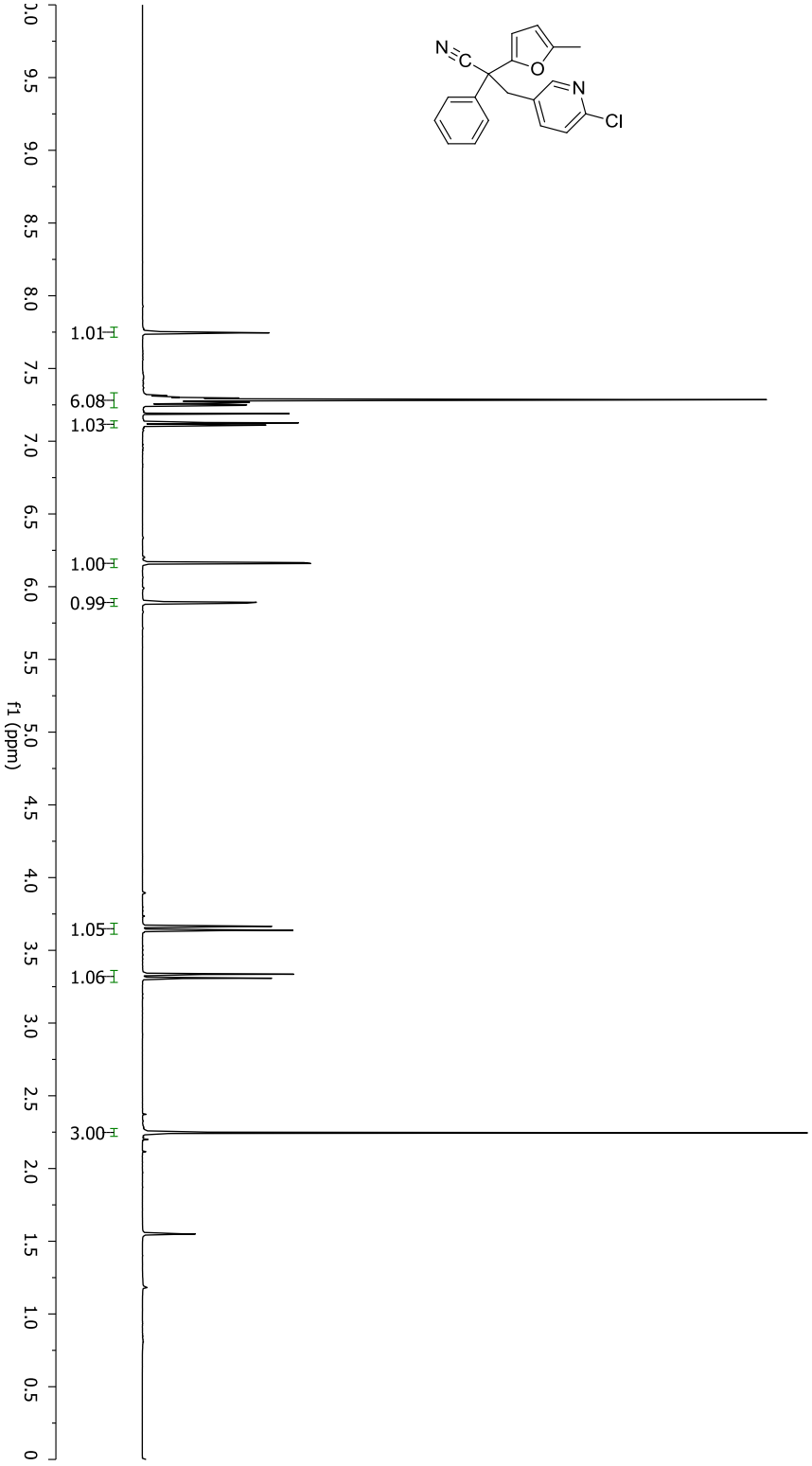
3-(furan-2-yl)-2-(4-methoxybenzyl)-2-phenylpropanenitrile



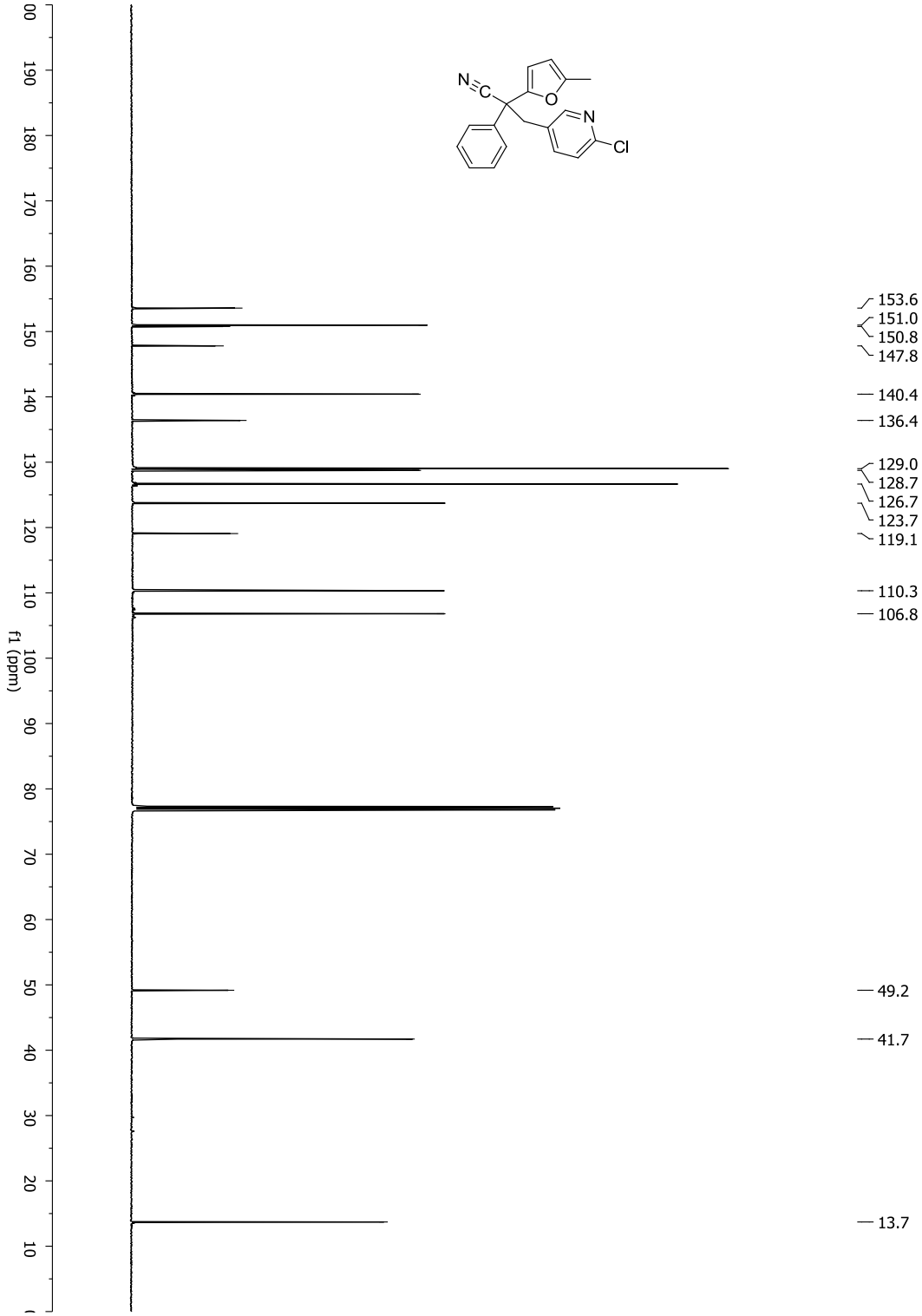
3-(furan-2-yl)-2-(4-methoxybenzyl)-2-phenylpropanenitrile



3-(6-chloropyridin-3-yl)-2-(5-methylfuran-2-yl)-2-phenylpropanenitrile

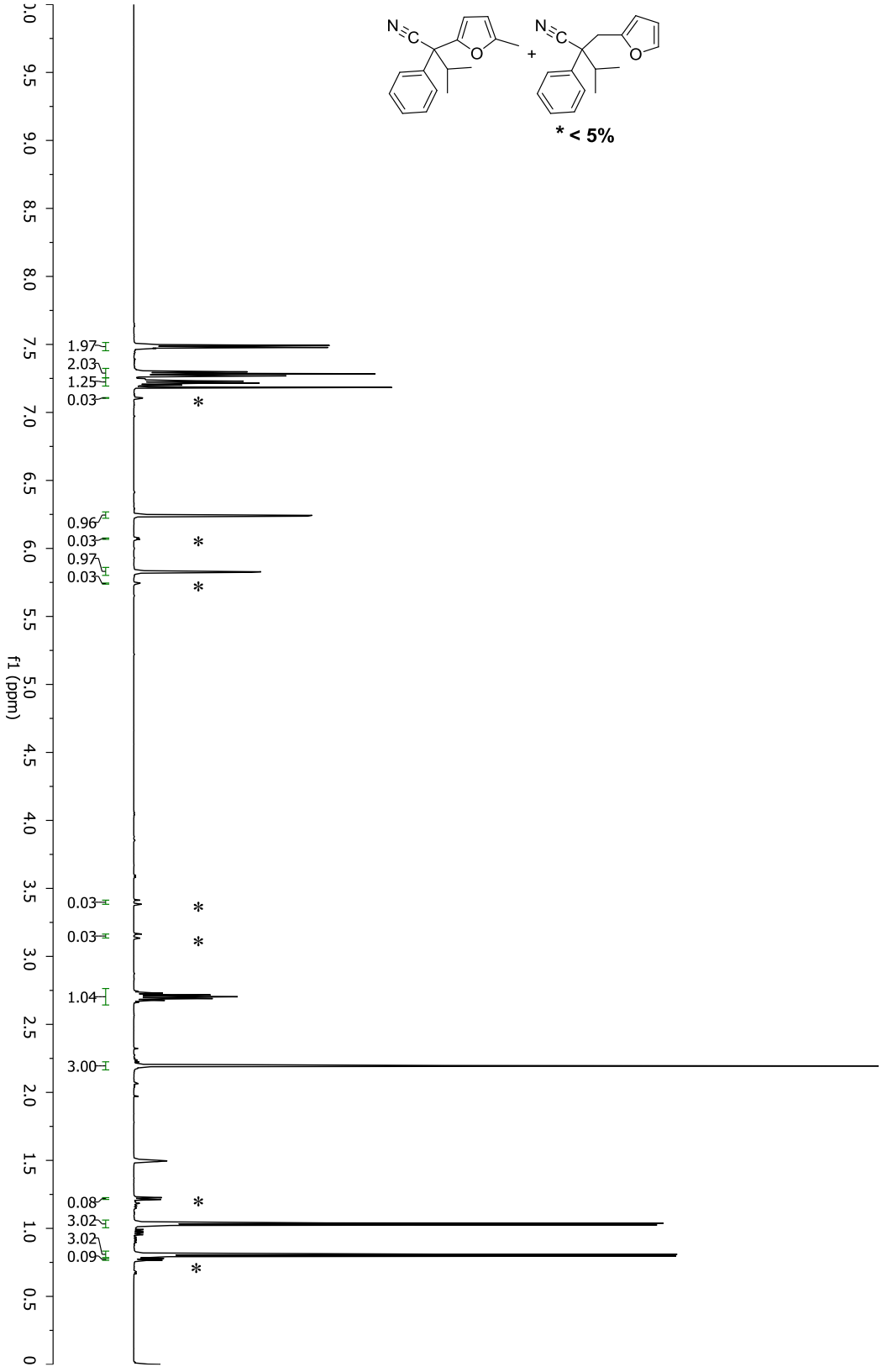


3-(6-chloropyridin-3-yl)-2-(5-methylfuran-2-yl)-2-phenylpropanenitrile

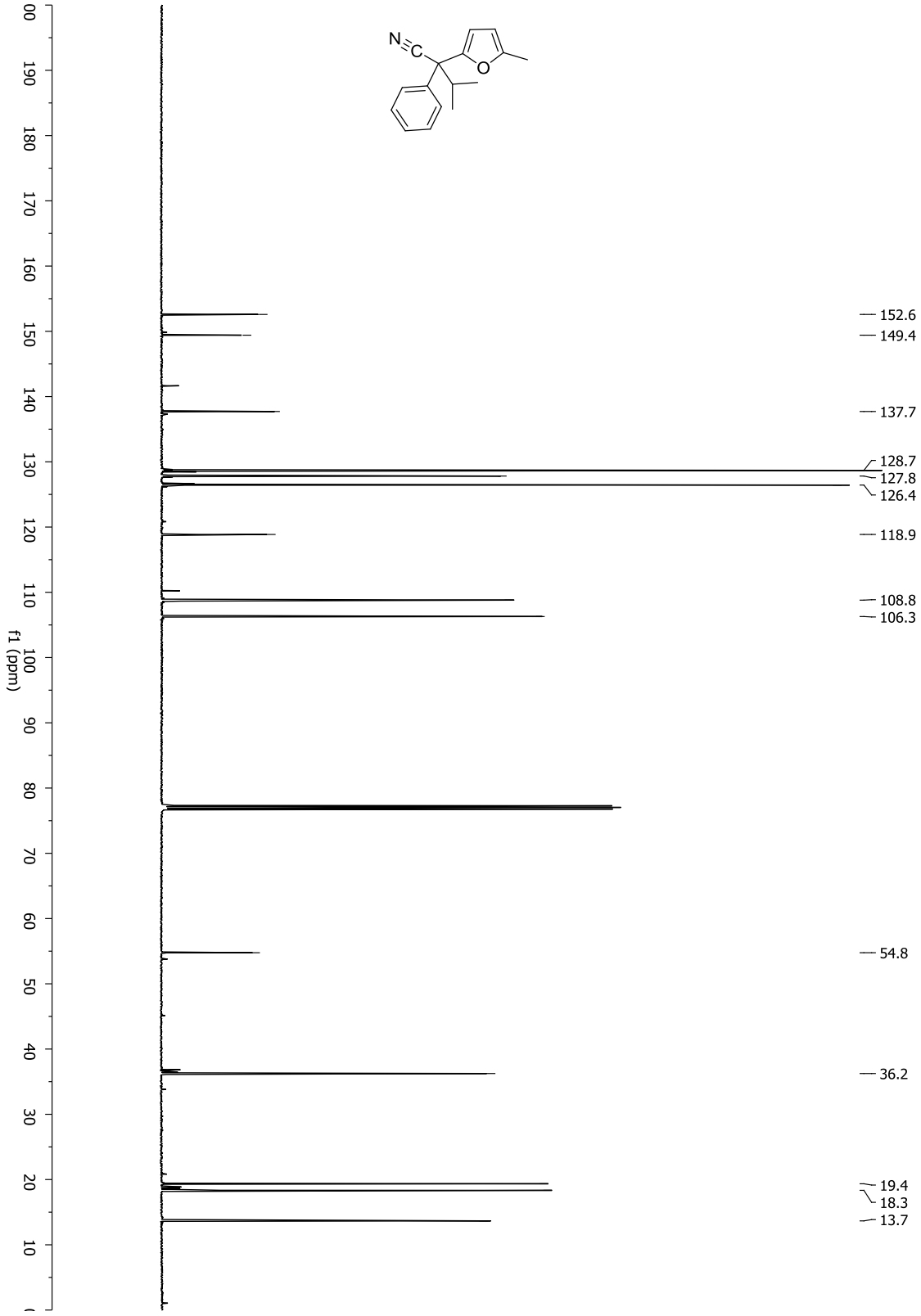


3-methyl-2-(5-methylfuran-2-yl)-2-phenylbutanenitrile

*** < 5%**

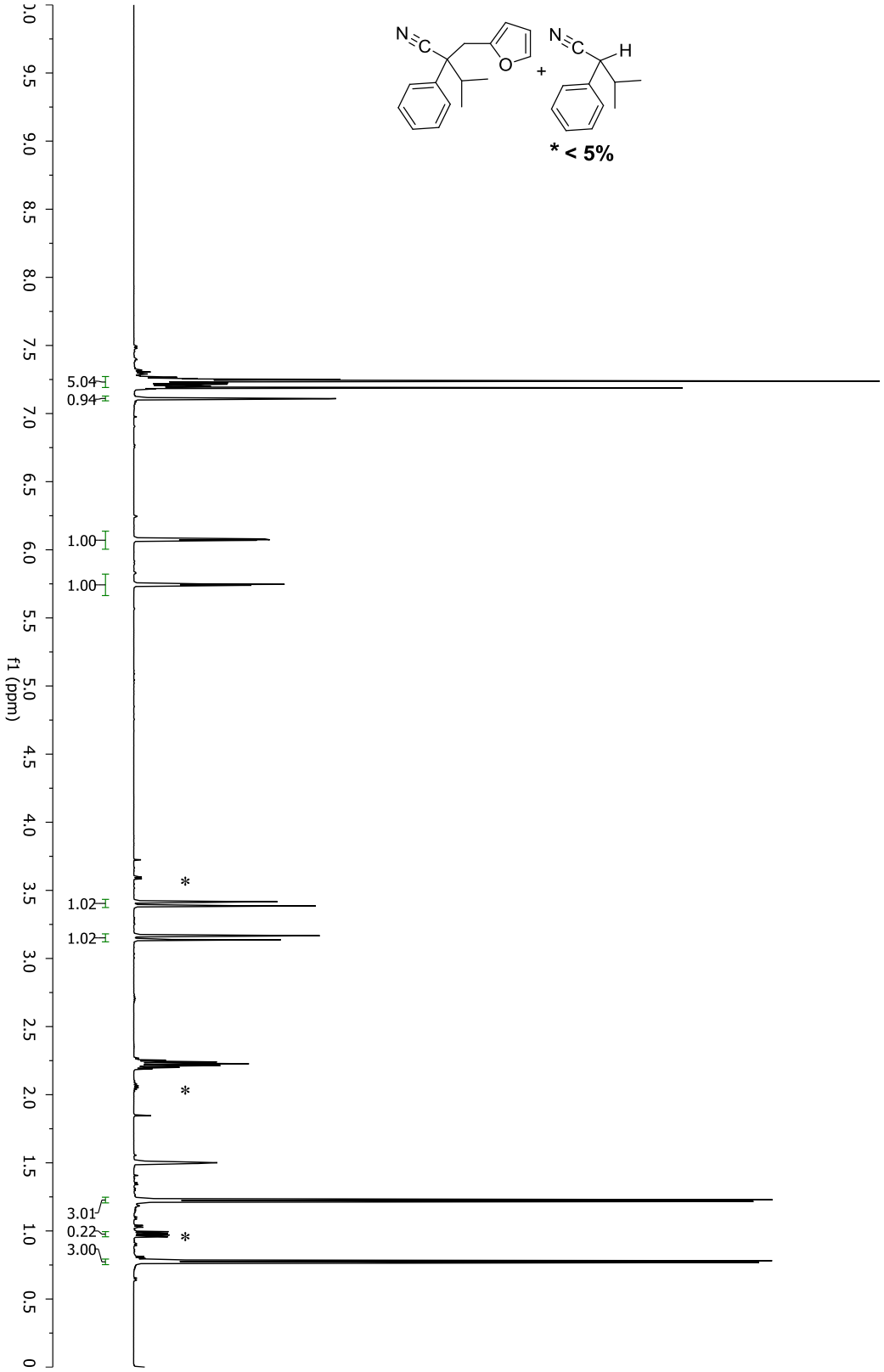


3-methyl-2-(5-methylfuran-2-yl)-2-phenylbutanenitrile

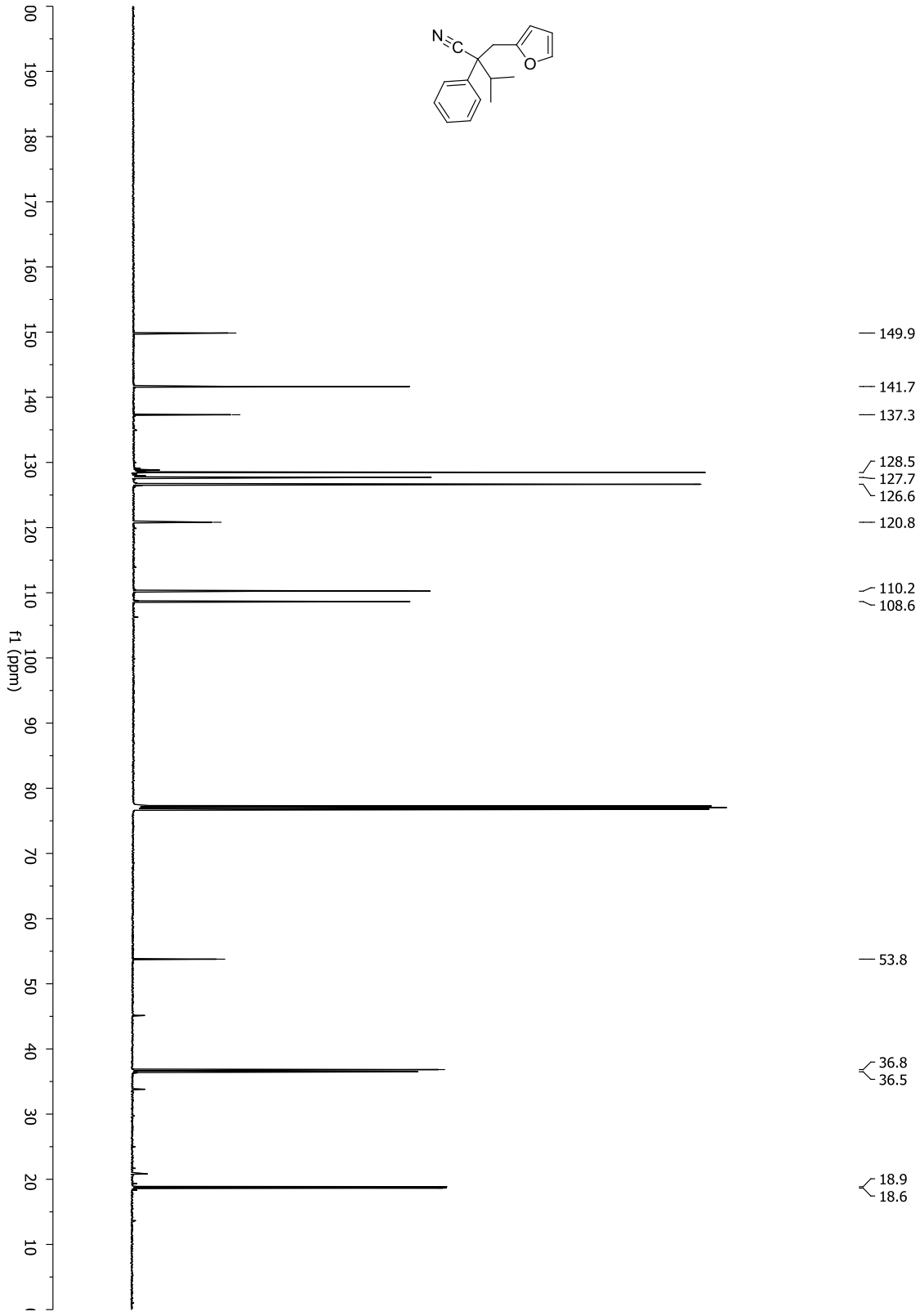


2-(furan-2-ylmethyl)-3-methyl-2-phenylbutanenitrile

*** < 5%**

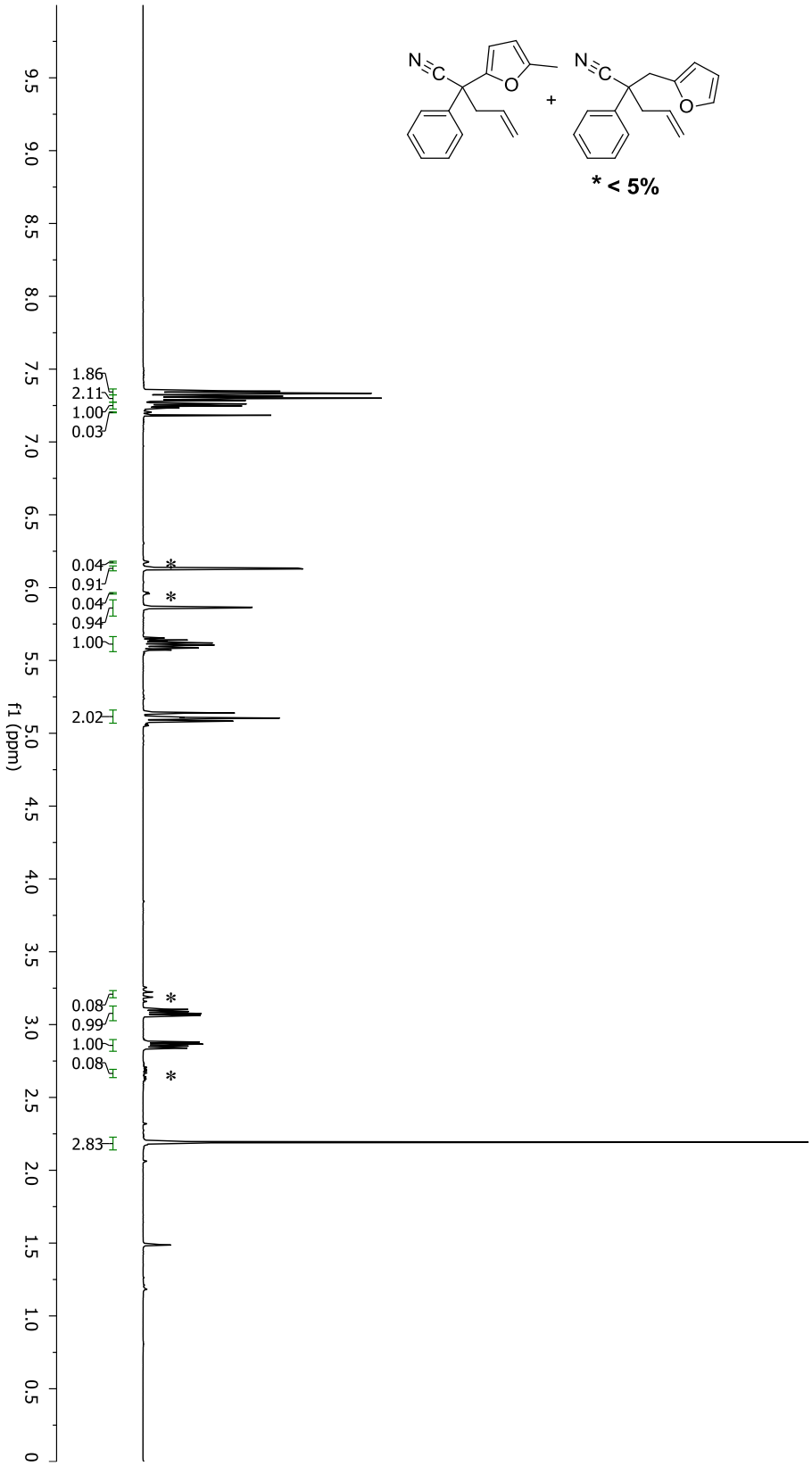


2-(furan-2-ylmethyl)-3-methyl-2-phenylbutanenitrile



2-(5-methylfuran-2-yl)-2-phenylpent-4-enenitrile

*** < 5%**



2-(5-methylfuran-2-yl)-2-phenylpent-4-enenitrile