SUPPORTING INFORMATION

Chiral *N*-Fmoc-β-Amino Alkyl Isonitriles Derived from Amino Acids: First Synthesis and Application in 1-Substituted Tetrazole Synthesis

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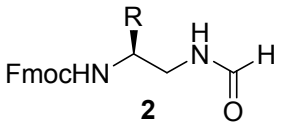
Experimental section

General information:

All solvents were freshly distilled prior to use. Melting points were determined using capillary method and are uncorrected. The TLC was effected with silica gel GF_{254} pre-coated on glass plates using the following solvent systems as mobile phases : (a) Chloroform : Methanol (9:1) for formamides, (b) Ethyl acetate : Hexane (2:8) for isonitriles and (c) Ethyl acetate : Hexane (3:7) for tetrazoles . HPLC particulars: Agilnet 1100 series having G1311A VWD at λ=254 nm, flow 1.00 mL/min, Column: Agilent Eclipse XDB-C18, pore size-5μm, diameter x length = 4.6 x 150 mm; Method: gradient

0.1% TFA water-acetonitrile; acetonitrile 25-90% in 30 min and 90-25% for further 5 min.

Typical Procedure for Formamides 2. To the THF solution containing 10.0 mmol of *N*-Fmoc-β-amino acid at -20 °C were added 1.2 mL (11.0 mmol) of *N*-methylmorpholine and 1.05 mL (11.0 mmol) of ethyl chloroformate. After stirring the mixture for 10 min, 0.98 g (15 mmol) of sodium azide dissolved in a minimum amount of water was added and the stirring was continued until completion of the reaction (TLC). The reaction mixture was concentrated under vacuum and the residue was dissolved in 30.0 mL of CH_2Cl_2. The organic layer was washed with 20 mL each of 5% Na_2CO_3, 10% citric acid, water and brine, dried over anhydrous sodium sulfate and evaporated under reduced pressure. The resulting residue was dissolved in 15.0 mL of toluene and heated at 65 °C for 30 min under argon. Upon complete formation of the isocyanate (strong IR peak at 2225 cm^{-1} and absence of azide peak at 2100 cm^{-1}), toluene was removed *in vacuo*. The isocyanate obtained was dissolved in 15 mL of dry CH_2Cl_2 and the solution was stirred at -15 °C with the addition of 96% formic acid (2.0 mmol) and 0.37 g of DMAP (0.3 mmol) till the end of the reaction when a white solid precipitates. CH_2Cl_2 was evaporated, hexane was added and the resulting solid was filtered. The solid product was washed with 20 mL each of 10% citric acid, 5% Na_2CO_3 and water and purified by recrystallization from DMSO-water.



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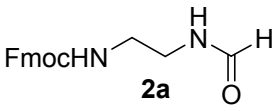
CHARACTERIZATION DATA

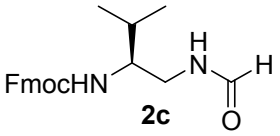
1. (9H-fluoren-9-yl)methyl 2-formamidoethyl carbamate (Fmoc-Gly-ψ[CH_2-NHCHO], 2a). *{Known compound; see ref. 27 in manuscrpit}*: Yield: 90%; R_f 0.22 (n-hexane/AcOEt 5:5);



2a

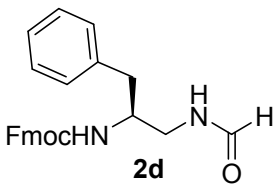
m.p. = 130-132 °C; IR (KBr) υ_{max} = 1712, 1660 cm^{-1} ; ^1H NMR ($CDCl_3$, δ): 3.01-3.09 (d(d), 2H), 3.90 (t, 1H, *J* = 6.4 Hz), 4.11 (d, 2H, *J* = 6.8 Hz), 5.80 (s, 1H), 7.00-7.70 (m, 8H), 7.83 (s, 1H); ^{13}C NMR ($CDCl_3$, δ): 42.16, 45.45, 46.65, 66.53, 119.04, 124.93, 126.08, 127.56, 141.37, 143.61, 155.99, 161.15; HRMS Calc'd for $C_{18}H_{18}N_2O_3$ m/z: 333.1215 (M^++Na), found 333.1209.

2. (S)-(9H-fluoren-9-yl)methyl 1-formamido-3-methylbutan-2-ylcarbamate (Fmoc-Val-ψ[CH_2-NHCHO], 2c). Yield: 88%; R_f 0.23 (n-hexane/AcOEt 5:5); m.p. = 172-174 °C; IR (KBr) υ_{max} = 1709, 1658 cm^{-1} ; ^1H NMR ($CDCl_3$, δ): 0.72 (d, 6H, *J* = 6.81 Hz), 1.87 (m, 1H), 3.09-3.33 (m, 2H), 3.87 (br, 1H), 4.24 (t, 1H, *J* = 6.0 Hz), 4.36 (br, 2H), 6.58 (br, 1H), 7.27-7.73 (m, 8H), 8.10 (s, 1H); ^{13}C NMR ($CDCl_3$; CCl_4, δ): 17.81, 29.04, 40.49, 46.73, 58.96, 67.36, 119.85, 124.89, 126.98, 127.65, 141.25, 143.40, 156.64, 161.34; HRMS Calc'd for $C_{21}H_{24}N_2O_3$ m/z: 375.1685 (M^++Na), found 375.1671.



2c

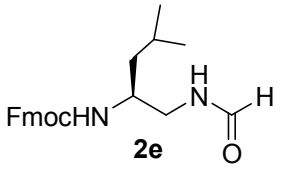
3. (S)-(9H-fluoren-9-yl)methyl 1-formamido-3-phehylpropan-2-ylcarbamate (Fmoc-Phe-ψ[CH_2-NHCHO], 2d). Yield: 94%; R_f 0.23 (n-hexane/AcOEt 5:5); m.p. = 156-158 °C; IR (KBr) υ_{max} = 1710, 1659 cm^{-1} ; ^1H NMR ($CDCl_3$, δ): 2.49-



2d

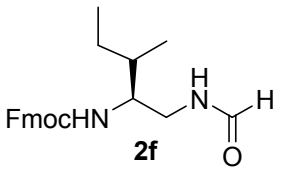
2.60 (m, 2H), 3.40-3.79 (m, 2H), 4.18 (t, 1H, *J* = 6.8 Hz), 4.38 (d, 2H, *J* = 5.6 Hz), 4.73 (br, 1H), 5.43 (d, 1H, *J* = 6.4 Hz), 5.94 (br, 1H), 7.23-7.75 (m, 13H), 8.10 (s, 1H); ^{13}C NMR ($CDCl_3$; CCl_4, δ): 38.57, 40.97, 46.85, 55.79, 67.31, 119.90, 119.93, 124.92, 124.96, 126.79, 127.11, 27.16, 127.70, 128.53, 129.29, 135.95, 141.23, 143.38, 155.76, 161.72; HRMS Calc'd for $C_{25}H_{24}N_2O_3$ m/z: 423.1685 (M^++Na), found 423.1683.

4. (S)-(9H-fluoren-9-yl)methyl 1-formamido-4-methylpentan-2-ylcarbamate (Fmoc-Leu-ψ [CH_2-NHCHO], 2e). Yield: 86%; R_f 0.21 (n-hexane/AcOEt 5:5); m.p. = 164-166 °C; IR (KBr) υ_{max} = 1705, 1662 cm^{-1} ; ^{1}H NMR($CDCl_3$, δ): 0.90 (d, 6H, *J* = 6.8 Hz), 1.25-1.34 (m, 2H), 1.60-1.65 (m, 1H), 3.28 (br, 2H), 3.78 (br, 1H), 4.18 (t, 1H, *J* = 6.4 Hz), 4.44 (m, 2H), 4.84 (d, 1H, *J* = 8.4 Hz), 6.13 (br, 1H), 7.32 (t, 2H, *J* = 6.0 Hz), 7.39 (t, 2H, *J* = 7.6 Hz), 7.56 (d, 2H, *J* = 7.2 Hz), 7.74 (d, 2H, *J* = 7.6 Hz), 8.11 (s, 1H); ^{13}C NMR ($CDCl_3$; CCl_4, δ): 22.67, 23.01, 42.98, 47.18, 53.63, 67.51, 119.86, 124.95, 126.92, 127.67, 141.20, 43.45, 156.87, 161.94; ESI-MS Calc'd for $C_{22}H_{26}N_2O_3$ m/z: 389.2 (M^++Na), found 389.2.



2e

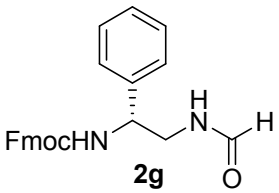
5. (S)-(9H-fluoren-9-yl)methyl 1-formamido-3-methylpentan-2-ylcarbamate (Fmoc-Ile-ψ [CH_2-NHCHO], 2f). Yield: 85%; R_f 0.21 (n-hexane/AcOEt 5:5); m.p. = 162-164 °C; IR (KBr) υ_{max} = 1706, 1660 cm^{-1} ; ^{1}H NMR($CDCl_3$, δ): 0.75-1.26 (m, 9H), 3.13-3.39 (m, 2H), 4.10 (br, 1H), 4.30 (br, 2H), 4.63 (br, 1H), 6.20 (br, 1H), 7.31-7.77 (m, 8H), 8.14 (s, 1H); ^{13}C NMR ($CDCl_3$; CCl_4, δ): 11.51, 11.68, 25.22, 35.77, 37.39,



2f

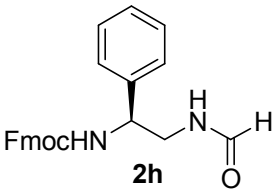
46.88, 53.32, 67.52, 119.94, 125.10, 127.18, 127.76, 141.32, 143.51, 156.60, 161.85; HRMS Calc'd for $C_{22}H_{26}N_2O_3$ m/z: 389.1841 (M^++Na), found 389.1795.

6. (R)-(9H-fluoren-9-yl)methyl 2-formamido-1-phenylethylcarbamate (Fmoc- D-Phg-ψ [CH_2-NHCHO], 2g). Yield: 87%; R_f 0.21 (n-hexane/AcOEt 5:5); m.p. = 130-132 °C; IR (KBr) υ_{max} = 1711, 1657 cm^{-1} ; ^1H NMR ($CDCl_3$, δ): 3.30 (m, 2H), 3.89 (m, 1H), 4.12 (br, 1H), 4.39 (m, 2H), 5.12 (m, 1H), 7.20-7.70 (m, 13H), 8.00 (s, 1H); ^{13}C NMR ($CDCl_3$; CCl_4, δ): 46.12, 46.72, 58.10, 68.17, 119.84, 125.04, 125.20, 125.54, 127.11, 127.15, 128.27, 129.08, 141.18, 143.43, 156.56, 161.32; ESI-MS Calc'd for $C_{24}H_{22}N_2O_3$ m/z: 409.2 (M^++Na), found 409.2.



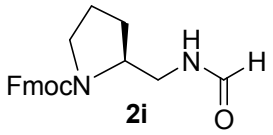
2g

7. (S)-(9H-fluoren-9-yl)methyl 2-formamido-1-phenylethylcarbamate (Fmoc- L-phg-ψ[CH_2-NHCHO], 2h). Yield: 89 %; R_f 0.20 (n-hexane/AcOEt 5:5); m.p. = 136-138 °C; IR (KBr) υ_{max} = 1705, 1657 cm^{-1} ; ^1H NMR ($CDCl_3$, δ): 3.47 (m, 2H), 4.10-4.40 (m, 4H), 4.76 (br, 1H), 5.16 (br, 1H), 7.20-7.78 (m, 13H), 8.07 (s, 1H); ^{13}C NMR ($CDCl_3$,δ): 44.09, 46.22, 55.45, 68.28, 120.10, 125.04, 125.10, 125.69, 127.38, 127.22, 128.10, 129.12, 141.32, 143.60, 156.60, 161.46; HRMS Calc'd for $C_{24}H_{22}N_2O_3$ m/z: 409.1528 (M^++Na), found 409.1516.



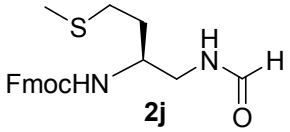
2h

8. (S)-(9H-fluoren-9-yl)methyl 2-(formamidomethyl)pyrrolidine-1-carboxylate (Fmoc-Pro-ψ [CH_2-NHCHO], 2i). Yield: 85 %; R_f 0.24 (n-hexane/AcOEt 5:5); m.p. = 118-120 °C; IR (KBr) υ_{max} = 1702, 1668 cm^{-1} ; ^1H NMR ($CDCl_3$, δ): 1.72-2.02 (br, 4H), 2.86 (s, 1H), 3.18-3.54 (m, 4H), 3.99-4.44 (m, 4H), 7.26-7.75 (m, 8H), 8.11 (s, 1H); ^{13}C NMR ($CDCl_3$; CCl_4, δ): 23.83, 29.46, 43.49, 47.20, 50.21, 57.16, 67.27, 119.89, 124.78, 126.94, 127.66, 41.25, 143.68, 156.50, 161.83; HRMS Calc'd for $C_{21}H_{23}N_2O_3$ m/z: 351.1709 (M^++H), found 351.1709.



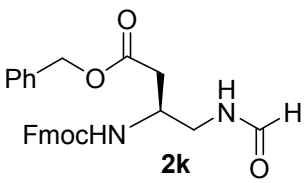
2i

9. (S)-(9H-fluoren-9-yl)methyl 1-formamido-4-(methylthio)butan-2-ylcarbamate (Fmoc-Met-ψ [CH_2-NHCHO], 2j). Yield: 86 %; R_f 0.22 (n-hexane/AcOEt 5:5); m.p. = 144-146 °C; IR (KBr) υ_{max} = 1712, 1653 cm^{-1} ; ^1H NMR ($CDCl_3$, δ): 2.14 (br, 2H), 2.56 (s, 3H), 2.73 (m, 2H), 3.49-3.60 (m, 2H), 4.20-4.38 (m, 3H), 5.03 (br, 1H), 5.43 (br, 1H), 7.31-7.78 (m, H), 8.18 (s, 1H); ^{13}C NMR ($CDCl_3$, δ): 15.52, 30.25, 30.56, 45.58, 47.24, 48.68, 66.78, 120.08, 124.89, 127.17, 127.79, 141.42, 143.61, 156.06, 161.64; HRMS Calc'd for $C_{21}H_{24}N_2O_3S$ m/z: 407.1405 (M^++Na), found 407.1343.



2j

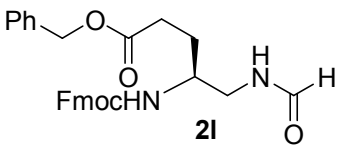
10. (S)-benzyl 3(((9H-fluoren-9-yl)methoxy)cabonyl)-4-formamidobutanoate (Fmoc-Asp(Bzl)-ψ [CH_2-NHCHO], 2k). Yield: 82 %; R_f 0.23 (n-hexane/AcOEt 5:5); m.p. = 140-142 °C; IR (KBr) υ_{max} = 1710, 1664 cm^{-1} ; ^1H NMR ($CDCl_3$, δ): 2.41-2.65 (m, 2H), 3.05-3.51 (m, 2H), 3.89 (m, 1H), 4.17 (t, 1H, J = 6.90 Hz)), 4.33 (d, 2H, J = 7.2 Hz),



2k

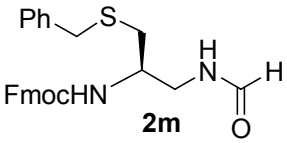
4.94 (s, 2H), 5.56 (br, 1H), 7.18-7.79 (m, 13H), 8.11 (s, 1H); ^{13}C NMR ($CDCl_3$; CCl_4, δ): 36.91, 43.06, 46.82, 51.89, 54.15, 65.83, 69.82, 119.15, 124.90, 126.25, 127.53, 128.12, 128.24, 141.67, 143.53, 143.81, 156.38, 161.79, 171.58; HRMS Calc'd for $C_{27}H_{26}N_2O_5$ m/z: 481.1739 (M^++Na), found481.1739.

11. (S)-benzyl 4-(((9H-fluoren-9-yl)methoxy)carbonyl)-5-formamidopentanoate (Fmoc-Glu(Bzl)-ψ [CH_2-NHCHO], 2l). Yield: 80 %; R_f 0.23(n-hexane/AcOEt 5:5); m.p. = 128-130 °C; IR (KBr) υ_{max} = 1709, 1661 cm^{-1} ; ^{1}H NMR ($CDCl_3$, δ): 1.71-2.42 (m, 4H), 3.27-3.72 (m, 2H), 4.15 (t, 1H, J = 6.40 Hz)), 4.38 (br, 2H), 5.08 (s, 2H), 5.37 (br, 1H), 6.27 (br, 1H), 7.26-7.74 (m, 13H), 8.09 (s, 1H); ^{13}C NMR ($CDCl_3$; CCl_4, δ): 27.36, 30.65, 42.45, 47.25, 51.35, 66.57, 69.99, 119.98, 125.03, 126.98, 127.09, 127.74, 128.25, 141.33, 143.77, 161.93, 172.98; HRMS Calc'd for $C_{28}H_{28}N_2O_5$ m/z: 495.1896 (M^++Na), found 495.1907.



2l

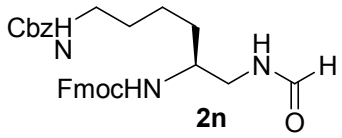
12. (S)-(9H-fluoren-9-yl)methyl 3-(benzylthio)-1-formamidopropan-2-ylcarbamate (Fmoc-Cys(Bzl)- ψ [CH_2-NHCHO], 2 m). Yield: 84 %; R_f 0.21 (n-hexane/AcOEt 5:5); m.p. = 123-125°C; IR (KBr) υ_{max} = 1703, 1660 cm^{-1}; ^{1}H NMR ($CDCl_3$, δ): 2.46-2.80 (m, 2H), 3.27-3.65 (m, 4H), 4.14 (br, 1H), 4.26 (t, 1H, J = 6.80 Hz), 4.52 (br, 2H), 5.81 (s, 1H), 7.25-7.75 (m, 13H), 8.03 (s, 1H); ^{13}C NMR ($CDCl_3$; CCl_4, δ): 35.34, 38.65, 41.03, 46.95, 55.88, 67.45, 120.04, 125.02, 126.90, 127.22, 128.63, 129.39, 136.04, 141.33, 143.55,



2m

155.71, 161.27; HRMS Calc'd for $C_{26}H_{26}N_2O_3S$ m/z: 469.1562 (M^++Na), found 469.1564.

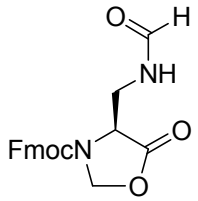
13. (S)-(9H-fluoren-9-yl)methyl 1-formamido-6-(benzylcarbamate)hexan-2-ylcarbamate (Fmoc-Lys(Z)-ψ [CH_2-NHCHO], 2n).



2n

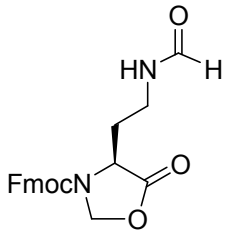
Yield: 80 %; R_f 0.18 (n-hexane/AcOEt 5:5); m.p. = 141-143 °C; IR (KBr) υ_{max} = 1702, 1653 cm^{-1} ; ^1H NMR ($CDCl_3$, δ): 1.22-1.45 (m, 6H), 2.45 (m, 2H), 3.08-4.30 (m, 6H), 4.99-5.52 (m, 3H), 7.23-7.66 (m, 13H), 8.01 (s, 1H); ^{13}C NMR ($CDCl_3$; CCl_4, δ): 22.71, 29.14, 33.54, 40.36, 43.26, 47.07, 47.70, 66.44, 67.85, 119.74, 124.90, 126.85, 127.47, 127.90, 128.26, 141.10, 143.63, 156.40, 161.83; HRMS Calc'd for $C_{30}H_{33}N_3O_5$ m/z: 538.2318 (M^++Na), found 538.2318.

14. (S)-(9H-fluoren-9-yl)methyl 4-(2-formamidomethyl)-5-oxooxazolidine-3-carboxylate (Fmoc-Asp(ψ [CH_2-NHCHO])-5-Oxazolidinone).

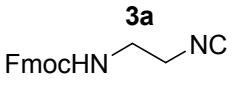


Yield: 75 %; R_f 0.20 (n-hexane/AcOEt 5:5); m.p. = 134-136 °C; IR (KBr) υ_{max} = 1804, 1702, 1653 cm^{-1} ; ^1H NMR($CDCl_3$, δ): 2.30-2.52 (br, 2H), 4.20 (br, 1H), 4.60 (br, 2H), 5.02 (br, 2H), 5.28 (s, 2H), 7.30-7.74 (m, 8H), 8.06 (s, 1H); ^{13}C NMR ($CDCl_3$; CCl_4, δ): 47.01, 53.19, 54.60, 67.49, 70.99, 119.95, 124.62, 127.18, 127.89, 141.27, 143.23, 156.62, 161.61, 171.12; HRMS Calc'd for $C_{20}H_{18}N_2O_5$ m/z: 389.1113 (M^++Na), found 389.1115.

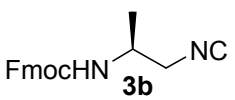
15. (S)-(9H-fluoren-9-yl)methyl 4-(2-formamidoethyl)-5-oxooxazolidine-3-carboxylate (Fmoc-Asp(ψ [$(CH_2)_2$-NHCHO])-5-Oxazolidinone). Yield: 78 %; R_f 0.19 (n-hexane/AcOEt 5:5); m.p. = 144-146 °C; IR (KBr) υ_{max} = 1802, 1702, 1653 cm^{-1} ; ^{1}H NMR($CDCl_3$, δ): 1.78-2.06 (d, 2H), 3.43 (s, 2H), 3.89 (s, 2H), 4.12-4.34 (d, 2H), 4.59-5.16 (br, 3H), 7.20-7.78 (m, 8H), 8.40 (s, 1H); ^{13}C NMR ($CDCl_3$; CCl_4, δ): 22.98, 38.31, 47.07, 53.17, 67.87, 70.12, 119.81, 125.20, 127.05, 127.69, 41.30, 143.30, 156.23, 161.09, 171.76; HRMS Calc'd for $C_{21}H_{20}N_2O_5$ m/z: 403.1270 (M^++Na), found 403.1269.



16. (9H-fluoren-9-yl)methyl 2-isocyanoethylcarbamate (Fmoc-Gly-ψ[CH_2-NC], 3a) *{Known compound; see ref. 27 in manuscrpit}*. Yield: 80%; R_f 0.38 (n-hexane/AcOEt 8:2); m.p. = 164-165 °C; IR (KBr) υ_{max} = 1705, 2158 cm^{-1} ; ^{1}H NMR ($CDCl_3$, δ): 3.42 (br, 2H), 3.52 (br, 2H), 4.19 (t, 1H, J = 12.66 H_z), 4.42 (d, 2H, J = 6.57 Hz), 5.28 (s, 1H), 7.29 (t, 2H, J = 14.45 Hz), 7.38 (t, 2H, J = 14.59 Hz), 7.57 (d, 2H, J = 7.08 Hz), 7.75 (d, 2H, J = 7.38 Hz); ^{13}C NMR ($CDCl_3$, δ): 40.22, 41.81, 47.13, 66.97, 120.01, 124.93, 127.06, 127.76, 141.32, 143.65, 156.18, 157.88; ESI-MS Calc'd for $C_{18}H_{17}N_2O_2$ m/z: 293.1 (M^++H), found 293.4.

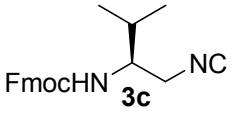


17. (S)-(9H-fluoren-9-yl)methyl 1-isocyanopropan-2-ylcarbamate (Fmoc-Ala-ψ[CH_2-NC], 3b). Yield: 78%; R_f 0.40 (n-hexane/AcOEt 8:2); $[\alpha]_D^{23}$ = -47.0 (c= 1.0, $CHCl_3$); m.p. = 112-114 °C; IR (KBr) υ_{max} = 1705, 2158 cm^{-1} ; ^{1}H NMR ($CDCl_3$, δ): 1.30 (d, 3H, J = 6.53 HZ), 3.42 (d(d), 2H), 3.95 (br, 1H), 4.20 (t, 1H, J = 13.04 Hz), 4.41 (d, 2H, J = 6.62 Hz), 5.29 (s, 1H), 7.31 (t, 2H, J = 14.79 Hz),

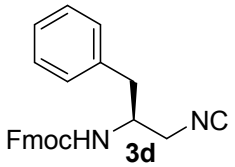


7.39 (t, 2H, *J* = 14.69 Hz), 7.57 (d, 2H, *J* = 7.21 Hz), 7.76 (d, 2H, *J* = 7.48 Hz); ^{13}C NMR ($CDCl_3$, δ): 17.44, 45.35, 46.83, 47.18, 56.18, 66.83, 120.04, 124.93, 127.08, 127.77, 141.34, 143.66, 155.77, 158.315; HRMS Calc'd for $C_{19}H_{18}N_2O_2$ m/z: 329.1266 (M^++Na), found 329.1266.

18. (S)-(9H-fluoren-9-yl)methyl 1-isocyano-3-methylbutan-2-ylcarbamate (Fmoc-Val-ψ[CH$_2$-NC], 3c). Yield:75%; R_f 0.44 (n-hexane/AcOEt 8:2); $[\alpha]_D^{23}$ =-70.9 (*c*=1.1, $CHCl_3$); m.p. = 98-100 °C; IR (KBr) υ_{max} = 1705, 2158 cm^{-1} ; ^{1}H NMR ($CDCl_3$, δ): 0.98 (d, 6H, *J* = 7.81 Hz), 1.91 (m, 1H), 3.52 (br, 3H), 4.20 (t, 1H, *J* = 13.28 Hz), 4.44 (d, 2H, *J* = 6.72 Hz), 4.88 (d, 1H), 7.30 (t, 2H, *J* = 14.78 Hz), 7.40 (t, 2H, *J* = 14.72 Hz), 7.58 (d, 2H, *J* = 7.32 Hz), 7.76 (d, 2H, *J* = 7.44 Hz); ^{13}C NMR ($CDCl_3$, δ): 18.67, 28.98, 44.02, 47.25, 55.11, 66.78, 120.01, 124.93, 127.06, 127.74, 141.34, 143.69, 155.87, 158.42; HRMS Calc'd for $C_{21}H_{22}N_2O_2$ m/z: 357.1579 (M^++Na), found 357.1588.

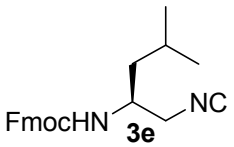


19. (S)-(9H-fluoren-9-yl)methyl 1-isocyano-3-phenylpropan-2-ylcarbamate (Fmoc-Phe-ψ[CH$_2$-NC], 3d). Yield: 81%; R_f 0.42 (n-hexane/AcOEt 8:2); $[\alpha]_D^{23}$ = -24.3 (*c*= 1.4, $CHCl_3$); m.p. = 128-130 °C; IR (KBr) υ_{max} = 1705, 2158 cm^{-1} ; ^{1}H NMR ($CDCl_3$, δ): 2.90 (br, 2H), 3.34-3.60(m, 2H), 4.06 (br, 1H), 4.20 (br, 1H), 4.40 (d, 2H, *J* = 4.0 Hz), 5.02 (br, 1H), 7.22 (m, 9H), 7.53 (d, 2H, *J* = 8.0 Hz), 7.75 (d, 2H, *J* = 8.0 Hz); ^{13}C NMR ($CDCl_3$, δ): 37.30, 44.39, 47.19, 50.79, 66.99, 120.10, 125.04, 127.15, 127.35, 127.84, 129.03,

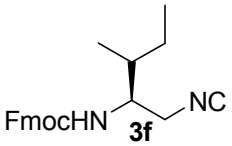


129.10, 135.98, 141.38, 143.65, 155.55, 158.45; HRMS Calc'd for $C_{25}H_{22}N_2O_2$ m/z: 405.1579 (M^++Na), found 405.1550.

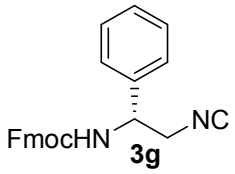
20. (S)-(9H-fluoren-9-yl)methyl 1-isocyano-4-methylpentan-2-ylcarbamate (Fmoc-Leu-ψ[CH_2-NC], 3e). Yield: 70%; R_f 0.45 (n-hexane/AcOEt 8:2); $[\alpha]_D^{23}$ = -60.4 (*c*= 0.5, $CHCl_3$); m.p. = 110-112 °C; IR (KBr) υ_{max} = 1705, 2158 cm^{-1} ; ^1H NMR($CDCl_3$, δ): 0.94 (d, 6H, *J* = 4.0 Hz), 1.37-1.67 (m, 3H), 3.41-3.65 (d(d), 2H, *J* = 12.0 Hz), 3.88 (br, 1H), 4.22 (t, 1H, *J* = 8.0 Hz), 4.45 (d, 2H, *J* = 8.0 Hz), 4.80 (d, 1H, *J* = 8.0 Hz), 7.33 (t, 2H, *J* = 8.0 Hz), 7.42 (t, 2H, *J* = 8.0 Hz), 7.58 (d, 2H, *J* = 8.0 Hz), 7.77 (d, 2H, *J* = 8.0 Hz); ^{13}C NMR ($CDCl_3$, δ): 23.29, 27.94, 40.07, 44.60, 47.20, 53.55, 66.73, 120.00, 124.94, 127.06, 127.70, 141.33, 143.70, 155.79, 158.50; HRMS Calc'd for $C_{22}H_{24}N_2O_2$ m/z: 371.1735 (M^++Na), found 371.1734.



21. (9H-fluoren-9-yl)methyl (2S,3R)-1-isocyano-3-methylpentan-2-ylcarbamate (Fmoc-Ile-ψ[CH_2-NC], 3f). Yield: 75%; R_f 0.44 (n-hexane/AcOEt 8:2); $[\alpha]_D^{23}$ = -72.0 (*c*= 1.0, $CHCl_3$); m.p. = 118-120 °C; IR (KBr) υ_{max} = 1710, 2158 cm^{-1} ; ^1H NMR($CDCl_3$, δ): 0.90-0.96 (m, 6H), 1.50-1.70 (m, 1H), 3.56 (br, 2H), 3.56 (br, 1H), 4.22 (t, 1H, *J* = 8.0 Hz), 4.45 (d, 2H, *J* = 6.0 Hz), 4.92 (br, 1H), 7.32-7.40 (m, 4H), 7.57 (d, 2H, *J* = 6.6 Hz), 7.75 (d, 2H, *J* = 6.9); ^{13}C NMR ($CDCl_3$, δ): 10.76, 15.32, 25.04, 35.21, 44.03, 47.28, 53.64, 66.75, 120.00, 124.94, 127.06, 127.74, 141.36, 143.72, 155.81, 158.52; HRMS Calc'd for $C_{22}H_{24}N_2O_2$ m/z: 371.1735 (M^++Na), found 371.1718.

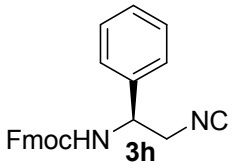


22. (R)-(9H-fluoren-9-yl)methyl 2-isocyano-1-phenylethylcarbamate (Fmoc-D-Phg-ψ[CH_2-NC], 3g). Yield: 80 %; R_f 0.40 (n-hexane/AcOEt 8:2); $[\alpha]_D^{23}$ = 35.1 (*c*= 1.0, $CHCl_3$); m.p. = 84-86 °C; IR (KBr) υ_{max} = 1705, 2158 cm^{-1} ; ^1H NMR ($CDCl_3$, δ): 4.00-4.10 (m, 2H), 4.20 (t, 1H, *J* = 8.4 Hz), 4.50 (m, 3H), 4.95 (br, 1H), 5.35 (br, 1H), 7.20-7.90 (m, 13H), ^{13}C NMR ($CDCl_3$, δ): 44.10, 47.19, 53.40, 66.99, 120.10, 125.04, 127.15, 127.35, 125.84, 129.02, 129.12, 135.99, 141.40, 143.66, 155.56, 158.90; ESI-MS Calc'd for $C_{24}H_{20}N_2O_2$ m/z: 391.1 (M^++Na), found 391.2.



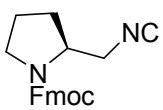
3g

23. (S)-(9H-fluoren-9-yl)methyl 2-isocyano-1-phenylethylcarbamate (Fmoc-Phg-ψ[CH_2-NC], 3h). Yield: 83 %; R_f 0.40 (n-hexane/AcOEt 8:2); $[\alpha]_D^{23}$ = -32.2 (*c*= 1.0, $CHCl_3$); m.p. = 90-92 °C; IR (KBr) υ_{max} = 1705, 2158 cm^{-1} ; ^1H NMR ($CDCl_3$, δ): 4.01 (m, 2H), 4.15 (t, 2H), 4.37 (d, 2H, *J* = 8.2 Hz), 4.92 (br, 1H), 5.55 (br, 1H), 7.20-7.80 (m, 13H), ^{13}C NMR ($CDCl_3$, δ): 47.17, 53.60, 54.33, 67.07, 120.04, 124.95, 126.50, 127.11, 127.14, 127.79, 129.09, 137.14, 141.35, 143.63, 155.57, 156.58; HRMS Calc'd for $C_{24}H_{20}N_2O_2$ m/z: 391.1422 (M^++Na), found 391.1422.



3h

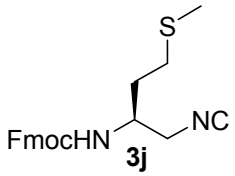
24. (S)-(9H-fluoren-9-yl)methyl 2-(isocyanomethyl)pyrrolidine-1-carboxylate (Fmoc-Pro-ψ[CH_2-NC], 3i). Yield: 70 %; R_f 0.42 (n-hexane/AcOEt 8:2); $[\alpha]_D^{23}$ =-42.2 (*c*=1.0, $CHCl_3$); m.p. = 102-104 °C; IR (KBr) υ_{max} = 1705, 2158 cm^{-1} ; ^1H NMR ($CDCl_3$, δ): 1.60 (br, 4H), 3.30 (m, 2H), 3.40-3.60 (m, 2H),



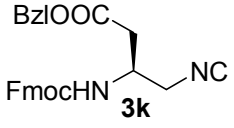
3i

4.22 (t, 1H, *J* = 8.0 Hz), 4.40 (d, 2H, *J* = 8.0 Hz), 5.20 (m, 1H), 5.22 (m, 1H), 7.28-7.77 (m, 8H), ^{13}C NMR ($CDCl_3$, δ): 23.1, 30.8, 45.60, 47.20, 48.20, 64.2, 66.94, 120.0, 124.91, 127.02, 127.70, 141.32, 143.70, 155.80, 158.54; HRMS Calc'd for $C_{21}H_{20}N_2O_2$ m/z: 355.1422 (M^++Na), found 355.1427.

25. (S)-(9H-fluoren-9-yl)methyl 1-isocyano-4-(methylthio)butan-2-ylcarbamate (Fmoc-Met-ψ[CH$_2$-NC], 3j). Yield: 80 %; R_f 0.43 (n-hexane/AcOEt 8:2); $[\alpha]_D^{23}$ = -47.3 (*c*= 1.1, $CHCl_3$); m.p. = 124-126 °C; IR (KBr) υ_{max} = 1705, 2158 cm^{-1} ; ^{1}H NMR ($CDCl_3$, δ): 1.89 (br, 2H), 2.10 (s, 3H), 2.53 (t, 2H, *J* = 12.0 Hz), 3.49-3.65 (d(d, 2H), 3.97 (br, 1H), 4.21 (br, 1H), 4.45 (d, 2H, *J* = 4.0 Hz), 5.02 (d, 1H, *J* = 8.0 Hz), 7.31 (t, 2H, *J* = 12.0 Hz), 7.39 (t, 2H, *J* = 16.0 Hz), 7.57 (d, 2H, *J* = 8.0 Hz); ^{13}C NMR ($CDCl_3$, δ): 15.58, 30.25, 30.53, 45.63, 47.08, 48.75, 66.86, 120.10, 124.97, 127.15, 127.85, 141.40, 143.66, 155.66, 158.75; HRMS Calc'd for $C_{21}H_{22}N_2O_2S$ m/z: 389.1300 (M^++Na), found 389.1291.

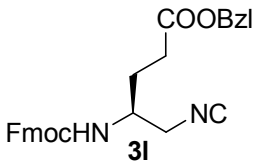


26. (S)-benzyl 3-[{(9H-fluoren-9-yl)methoxy}carbonyl]-4-isocyanobutanoate (Fmoc-Asp(Bzl)-ψ[CH$_2$-NC], 3k). Yield: 75 %; R_f 0.44 (n-hexane/AcOEt 8:2); $[\alpha]_D^{23}$ = -42.3 (*c*=1.2, $CHCl_3$); m.p. = 80-82 °C; IR (KBr) υ_{max} = 1705, 2158 cm^{-1} ; ^{1}H NMR ($CDCl_3$, δ): 2.74 (m, 2H), 3.64 (m, 2H), 3.80 (br, 1H), 4.78 (t, 1H, *J* = 8.0 Hz), 4.24 (br, 1H), 4.40 (br, 2H), 5.14 (br, 2H), 5.45 (d, 1H, 8.0 Hz), 7.20-7.76 (m, 13H), ^{13}C NMR ($CDCl_3$, δ): 34.88, 44.22, 46.21, 46.66, 66.62, 119.64, 124.57, 126.67, 127.38, 127.93, 128.16, 128.26, 134.68,

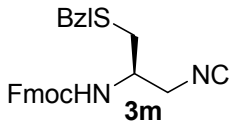


140.88, 143.15, 143.22, 154.99, 158.57, 169.70; HRMS Calc'd for $C_{27}H_{24}N_2O_4$ m/z: 463.1634 (M^++Na), found 463.1630.

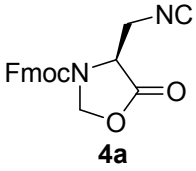
27. (S)-benzyl 4-[{(9H-fluoren-9-yl)methoxy}carbonyl]-5-isocyanopentanoate (Fmoc-Glu(Bzl)-ψ[CH₂-NC], 3l). Yield: 73 %; R_f 0.42 (n-hexane/AcOEt 8:2); $[\alpha]_D^{23}$ = -35.0 (*c*=1.6, $CHCl_3$); m.p. = 54-56 °C; IR (KBr) υ_{max} = 1705, 2158 cm^{-1} ; ^1H NMR ($CDCl_3$, δ): 1.92 (q, 2H, *J* = 8.0 Hz), 2.42 (q, 2H, *J* = 8.0 Hz), 3.45-3.61 (m, 2H), 3.83 (br, 1H), 4.18 (t, 1H, *J* = 6.0 Hz), 4.41 (br, 2H), 5.11 (s, 3H), 7.24-7.40 (m, 9H), 7.55 (d, 2H, *J* = 8.0 Hz), 7.74 (d, 2H, *J* = 8.0 Hz), ^{13}C NMR ($CDCl_3$, δ): 26.36, 30.57, 45.92, 47.21, 49.40, 66.81, 66.94, 120.10, 125.01, 125.06, 127.12, 127.16, 127.85, 128.40, 128.49, 128.69, 135.55, 141.39, 143.67, 155.76, 158.81, 172.65; HRMS Calc'd for $C_{28}H_{26}N_2O_4$ m/z: 477.1790 (M^++Na), found 477.1771.



28. (S)-(9H-fluoren-9-yl)methyl 3-(benzylthio)-1-isocyanopropan-2-ylcarbamate (Fmoc-Cys(Bzl)-ψ[CH₂-NC], 3m). Yield: 76 %; R_f 0.44 (n-hexane/AcOEt 8:2); $[\alpha]_D^{23}$ = -36.4 (c= 1.2, $CHCl_3$); m.p. = 112-114 °C; IR (KBr) υ_{max} = 1705, 2158 cm^{-1} ; ^1H NMR ($CDCl_3$, δ): 2.30-2.80 (m, 2H), 3.10-3.80 (m, 4H), 4.05 (br, 1H), 4.23 (d, 1H, *J* = 7.8 Hz), 4.52 (br, 2H), 6.13 (s, 1H), 7.10-7.81 (m, 13H), ^{13}C NMR ($CDCl_3$, δ): 32.17, 36.48, 44.22, 47.15, 48.95, 53.47, 67.02, 120.08, 124.99, 127.13, 127.48, 127.83, 128.77, 137.37, 141.35, 143.65, 155.58, 158.88; HRMS Calc'd for $C_{26}H_{24}N_2O_2S$ m/z: 451.1456 (M^++Na), found 451.1462.

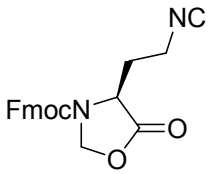


29. (S)-(9H-fluoren-9-yl)methyl 4-(isocyanomethyl)-5-oxooxazolidine-3-carboxylate (Fmoc-Asp(ψ[CH_2-NC])-5-Oxazolidinone, 4a). Yield: 68 %; R_f 0.46 (n-hexane/AcOEt 8:2); $[\alpha]_D^{23}$ = 90.0 (*c*=1.4, $CHCl_3$); m.p. = 142-144 °C; IR (KBr) υ_{max} = 1705, 1805, 2158 cm^{-1} ; ^1H NMR ($CDCl_3$, δ): 2.98 (m, 2H), 4.22 (t, 1H, *J* = 8.0 Hz), 5.08 (m, 1H), 4.44 (d, 2H, *J* = 8.0 Hz), 5.08 (m, 1H), 5.30 (m, 3H), 7.30-7.75 (m, 8.0 Hz), ^{13}C NMR ($CDCl_3$, δ): 47.03, 52.31, 54.53, 67.14, 70.52, 120.19, 124.65, 127.35, 128.01, 141.34, 143.15, 155.34, 156.20, 171.33; HRMS Calc'd for $C_{20}H_{16}N_2O_4$ m/z: 371.1008 (M^++Na), found 371.1020.



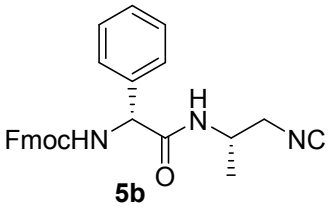
4a

30. (S)-(9H-fluoren-9-yl)methyl 4-(2-isocyanoethyl)-5-oxooxazolidine-3-carboxylate(Fmoc-Glu(ψ[$(CH_2)_2$-NC])-5-Oxazolidinone, 4b). Yield: 65 %; R_f 0.45 (n-hexane/AcOEt 8:2); $[\alpha]_D^{23}$ = 105.3 (*c*= 1.1, $CHCl_3$); m.p. = 106-108 °C; IR (KBr) υ_{max} = 1705, 1804, 2158 cm^{-1} ; ^1H NMR($CDCl_3$, δ): 2.96 (br, 2H), 4.22 (br, 2H), 4.73 (br, 2H), 5.06 (br, 2H), 5.29 (s, 3H), 7.32 (t, 2H, *J* = 8.0 Hz), 7.39 (t, 2H, *J* = 8.0 Hz), 7.52 (d, 2H, *J* = 8.0 Hz), 7.75 (d, 2H, *J* = 12.0 Hz); ^{13}C NMR ($CDCl_3$, δ): 29.75, 47.20, 52.07, 53.51, 66.93, 66.96, 120.05, 124.50, 127.45, 127.77, 141.46, 143.18, 152.77, 158.19, 170.89; HRMS Calc'd for $C_{21}H_{18}N_2O_4$ m/z: 385.1164 (M^++Na), found 385.1151.



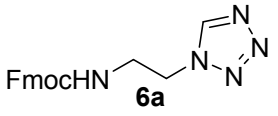
4b

31. (9H-fluoren-9-yl)methyl (R)-2-{(S)-1-isocyanopropan-2-ylamino}-2-oxo-1-phenylethylcarbamate (Fmoc-(R-)Phg-Ala-ψ[CH_2-NC], 5b). Yield: 72 % ; R_f 0.38 (n-hexane/AcOEt 8:2); $[\alpha]_D^{23}$ = -88.9 (c= 0.9, $CHCl_3$); m.p. = 160-162 °C; IR (film/pallet) υ_{max} = 1705, 2158 cm^{-1} ; ^1H NMR($CDCl_3$, δ): 1.17 (d, 3H, J = 4.0 Hz), 3.42-3.69 (m, 2H), 4.13-4.20 (m, 3H), 4.32 (d, 2H, J = 8.0 Hz), 5.24 (br, 1H), 6.10 (br, 1H), 7.28-7.48 (m, 8H), 7.56 (d, 2H, J = 4.0 Hz), 7.74 (d, 2H, J = 8.0 Hz), ^{13}C NMR($CDCl_3$, δ): 17.12, 43.91, 46.31, 53.99, 58.26, 67.18, 120.03, 125.03, 127.09, 127.77, 128.33, 128.40, 128.63, 135.54, 141.30, 143.75, 155.14, 156.29, 171.17; HRMS Calc'd for $C_{27}H_{25}N_3O_3$ m/z: 462.1794 (M^++Na), found 462.1775.



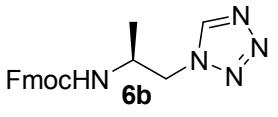
5b

32. (9H-fluoren-9-yl)methyl 2-(1H-tetrazol-1-yl)ethylcarbamate, 6a. Yield: 90 %; R_f 0.32 (n-hexane/AcOEt 5:5); m.p. = 170-172 °C; ^1H NMR ($CDCl_3$, δ): 3.41-3.42 (m, 4H), 4.21 (t, 1H, J = 6.82 Hz), 4.42 (d, 2H, J = 6.9 Hz), 5.28 (br, 1H), 7.31-7.77 (m, 8H), 8.48 (s, 1H), ^{13}C NMR ($CDCl_3$, δ): 40.21, 41.80, 47.13, 66.97, 120.01, 124.92, 127.05, 127.76, 141.30, 143.63, 143.69, 157.87; HRMS Calc'd for $C_{18}H_{18}N_5O_2$ m/z: 336.1460 (M^++H), found 336.1455.



6a

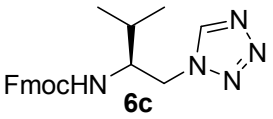
33. (S)-(9H-fluoren-9-yl)methyl 1-(1H-tetrazol-1-yl)propan-2-ylcarbamate, 6b. Yield: 88 %; R_f 0.36 (n-hexane/AcOEt 5:5); m.p. = 125-127 °C; ^1H NMR ($CDCl_3$, δ): 1.25 (d, 3H, J = 6.54 Hz), 4.08-4.18 (m, 2H), 4.43-4.55 (m, 4H), 4.86 (d, 1H), 7.33-7.78 (m, 8H), 8.32 (s, 1H), ^{13}C NMR ($CDCl_3$,



6b

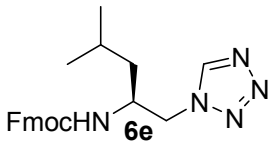
δ): 17.42, 45.33, 46.82, 47.16, 66.82, 120.02, 124.92, 127.07, 127.75, 141.32, 143.64, 143.69 , 157.90; HRMS Calc'd for $C_{19}H_{19}N_5O_2$ m/z: 372.1436 (M^++Na), found 372.1437.

34. (S)-(9H-fluoren-9-yl)methyl 3-methyl-1-(1H-tetrazol-1-yl)butan-2-ylcarbamate, 6c. Yield: 87 %; R_f 0.37 (n-hexane/AcOEt 5:5); m.p. = 120-122 °C; ^{1}H NMR ($CDCl_3$, δ): 0.98 (d, 6H, J = 3.88 Hz), 1.91 (m, 1H), 4.09 (br, 1H), 4.15 (br, 1H), 4.40-4.56 (m, 4H), 4.88 (br, 1H), 7.33-7.77 (m, 8H), 8.34 (s, 1H), ^{13}C NMR ($CDCl_3$, δ): 18.65, 28.99, 44.90, 47.25, 55.11, 66.78, 120.01, 124.94, 127.06, 127.83, 141.30, 142.91, 143.69, 155.87; HRMS Calc'd for $C_{21}H_{23}N_5O_2$ m/z: 400.1749 (M^++Na), found 400.1742.



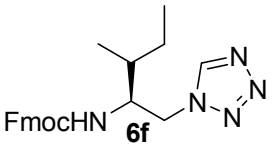
6c

35. (S)-(9H-fluoren-9-yl)methyl 4-methyl-1-(1H-tetrazol-1-yl)pentan-2-ylcarbamate, 6e. Yield: 88 %; R_f 0.37 (n-hexane/AcOEt 5:5); m.p. = 125-127 °C; ^{1}H NMR ($CDCl_3$, δ): 0.94 (d, 6H, J = 4.0 Hz), 1.37-2.00 (m, 3H), 4.01-4.20 (m, 2H), 4.40-4.57 (m, 4H), 4.80 (d, 1H, J = 8.0 Hz), 7.28-7.77 (m, 8H), 8.35 (s, 1H), ^{13}C NMR ($CDCl_3$, δ): 22.81, 24.42, 39.90, 47.21, 49.01, 50.91, 65.90, 119.86, 124.69, 126.98, 127.65, 141.28, 143.40, 143.55, 155.57; HRMS Calc'd for $C_{22}H_{25}N_5O_2$ m/z: 414.1906 (M^++Na), found 414.1899.

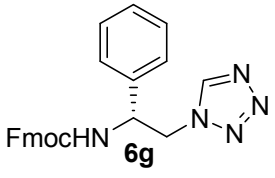


6e

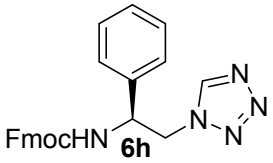
36. (9H-fluoren-9-yl)methyl (2S,3R)-3-methyl-1-(1H-tetrazol-1-yl)pentan-2-ylcarbamate, 6f. Yield: 86 %; R_f 0.37 (n-hexane/AcOEt 5:5); m.p. = 122-124 °C; ^{1}H NMR ($CDCl_3$, δ): 0.90 (m, 7H), 1.56 (m, 2H), 4.01-4.20 (m, 2H), 4.40-4.57 (m, 4H), 4.94 (br, 1H), 7.26-7.78 (m, 8H), 8.42 (s, 1H), ^{13}C NMR ($CDCl_3$, δ): 10.84, 14.12, 25.09, 35.73, 47.28, 49.23, 51.15, 66.30, 120.03, 124.82, 127.14, 127.79, 141.38, 143.25, 143.64, 155.98; HRMS Calc'd for $C_{22}H_{25}N_5O_2$ m/z: 414.1906 (M^++Na), found 414.1902.



37. (R)-(9H-fluoren-9-yl)methyl 1-phenyl-2-(1H-tetrazol-1-yl)ethylcarbamate, 6g. Yield: 89 %; R_f 0.38 (n-hexane/AcOEt 5:5); $[\alpha]_D^{23}$ = -21.1 (*c*=0.6, $CHCl_3$); m.p. = 158-160 °C; IR (KBr) υ_{max} = 1705 cm^{-1} ; ^{1}H NMR ($CDCl_3$, δ): 4.20 (t, 1H, *J* = 8.0 Hz), 4.40-4.65 (m, 5H), 5.29 (br, 1H), 7.22-7.78 (m, 13H), 8.50 (s, 1H); ^{13}C NMR ($CDCl_3$, δ): 47.25, 48.35, 53.00, 66.80, 120.07, 124.80, 127.15, 127.30, 127.87, 128.98, 129.10, 135.84, 141.35, 143.29, 143.62, 158.60; HRMS Calc'd for $C_{24}H_{22}N_5O_2$ m/z: 412.1773(M^+), found 412.1766.

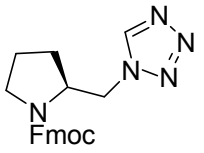


38. (S)-(9H-fluoren-9-yl)methyl 1-phenyl-2-(1H-tetrazol-1-yl)ethylcarbamate, 6h. Yield: 88%; R_f 0.4 (n-hexane/ACOEt 8:2); $[\alpha]_D^{23}$ = 23.8 (*c*=1.3, $CHCl_3$); m.p. = 146-148 °C; ^{1}H NMR ($CDCl_3$, δ): 4.12 (t, 1H, *J* = 8.1 Hz), 4.29 (br, 2H), 4.50-4.90 (br, 3H), 5.17 (s, 1H), 7.12-7.82 (m, 13H), 8.96 (s, 1H), ^{13}C NMR ($CDCl_3$, δ): 47.25, 48.40, 52.89, 66.81, 120.07, 124.81, 127.16, 127.32, 127.88, 128.98, 129.11, 135.83, 141.35, 143.30,



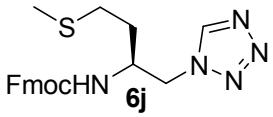
143.60, 158.62; HRMS Calc'd for $C_{24}H_{21}N_5O_2$ m/z: 434.1593 (M^++Na), found 434.1592.

39. (S)-(9H-fluoren-9-yl)methyl 2-{(1H-tetrazol-1-yl)methyl}pyrrolidine-1-carboxylate, 6i. Yield: 86 %; R_f 0.37 (n-hexane/AcOEt 5:5); m.p. = 109-111 °C; ^{1}H NMR ($CDCl_3$, δ): 1.60 (br, 4H), 3.30 (m, 2H), 3.40-3.60 (m, 2H), 4.20-4.63 (m, 6H), 5.15 (m, 1H), 7.20-7.77 (m, 8H), 8.42 (s, 1H), ^{13}C NMR ($CDCl_3$, δ): 23.8, 28.87, 47.47, 50.58, 55.45, 58.92, 67.26, 119.65, 123.93, 126.99, 127.62, 141.30, 143.21, 143.31, 156.30; HRMS Calc'd for $C_{21}H_{21}N_5O_2$ m/z: 398.1593 (M^++Na), found 398.1605.



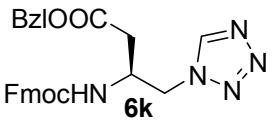
6i

40. (S)-(9H-fluoren-9-yl)methyl 4-(methylthio)-1-(1H-tetrazol-1-yl)butyan-2-ylcarbamate, 6j. Yield: 86 %; R_f 0.38 (n-hexane/AcOEt 5:5); m.p. = 128-130 °C; ^{1}H NMR ($CDCl_3$, δ): 1.89 (m, 2H), 2.11 (s, 3H), 2.53 (t, 2H, J = 6.69 Hz), 2.61-2.74 (m, 2H), 4.03 (br, 1H), 4.21 (t, 1H, J = 6.23 Hz), 4.45 (d, 2H, J = 6.0 Hz), 4.98 (d, 1H, J = 7.55 Hz), 7.33 (t, 2H, J = 6.46 Hz), 7.39 (t, 2H, J = 7.32), 7.57 (d, 2H, J = 7.36 Hz), 7.76 (d, 2H, J = 7.43 Hz), 8.39 (s, 1H), ^{13}C NMR ($CDCl_3$, δ): 15.56, 23.65, 29.69, 32.49, 47.16, 47.29, 66.88, 120.11, 125.00, 127.17, 127.86, 141.37, 144.07, 155.77; HRMS Calc'd for $C_{21}H_{23}N_5O_2S$ m/z: 432.1470 (M^++Na), found 432.1466.



6j

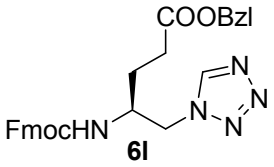
41. (S)-benzyl-3-[{(9H-fluoren-9-yl)methoxy}carbonyl]-4-(1H-tetrazol-1yl)butanoate, 6k. Yield: 86 %; R_f 0.39 (n-hexane/AcOEt 5:5); m.p. = 102-104 °C; ^{1}H NMR ($CDCl_3$, δ): 2.74 (m, 2H), 4.20 (t, 1H, J = 6.8 Hz), 4.40-



6k

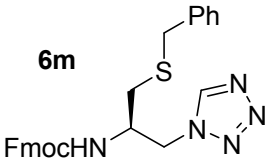
4.68 (m, 6H), 5.09 (s, 2H), 5.40 (br, 1H), 7.20-7.80 (m, 13H), 8.34 (s, 1H); ^{13}C NMR ($CDCl_3$, δ): 34.89, 47.21, 47.68, 49.21, 66.60, 66.72, 120.04, 124.81, 127.10, 127.26, 128.98, 129.10, 135.86, 141.32, 143.35, 143.62, 158.51, 172.59; ESI-MS Calc'd for $C_{27}H_{25}N_5O_4$ m/z: 484.2 (M^++H), found 484.2.

42. (S)-benzyl 4-[{(9H-fluoren-9-yl)methoxy}carbonyl]-5-(1H-tetrazol-1-yl)pentanoate, 6l. Yield: 84 %; R_f 0.38 (n-hexane/AcOEt 5:5); m.p. = 109-111 °C; ^{1}H NMR ($CDCl_3$, δ): 1.90 (m, 2H), 2.42 (m, 2H), 4.20-4.48 (m, 6H), 5.10 (s, 2H), 5.15 (br, 1H), 7.20-7.78 (m, 13H), 8.32 (s, 1H); ^{13}C NMR ($CDCl_3$, δ): 29.64, 31.87, 47.17, 50.79, 53.39, 66.35, 66.72, 120.02, 124.90, 127.11, 127.80, 128.28, 128.59, 141.33, 143.23, 143.50, 156.05, 172.64; HRMS Calc'd for $C_{28}H_{27}N_5O_4$ m/z: 520.1961 (M^++Na), found 520.1952.



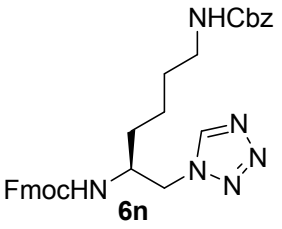
6l

43. (S)-(9H-fluoren-9-yl)methyl 1-(benzylthio)-3-(1H-tetrazol-1yl)propan-2-ylcarbamate, 6m. Yield: 86 %; R_f 0.38 (n-hexane/AcOEt 5:5); m.p. = 120-122 °C; ^{1}H NMR ($CDCl_3$, δ): 3.01 (m, 2H), 3.74 (s, 2H), 4.20-4.98 (m, 6H), 5.20 (br, 1H), 7.20-7.77 (m, 13H), 8.38 (s, 1H); ^{13}C NMR ($CDCl_3$, δ): 35.25, 36.65, 47.20, 50.01, 52.32, 66.58, 120.05, 124.80, 127.12, 127.28, 127.85, 128.95, 129.10, 135.85, 141.33, 143.30, 143.60, 158.51; HRMS Calc'd for $C_{26}H_{25}N_5O_2S$ m/z: 494.1627 (M^++Na), found 494.1624.



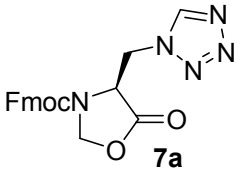
6m

44. (S)-(9H-fluoren-9-yl)methyl 6-(benzyl carbamate)-1-(1H-tetrazol-1-yl)hexan-2-ylcarbamate, 6n. Yield: 85 %; R_f 0.38 (n-hexane/AcOEt 5:5); m.p. = 125-127 °C; ^{1}H NMR ($CDCl_3$, δ): 1.93-2.12 (m, 4H), 2.91-3.12 (m, 2H), 3.51 (br, 2H), 4.09 (d, 2H, *J*=7.7 Hz), 4.35-4.60 (m, 3H), 4.86-4.90 (m, 3H), 5.38 (s, 1H), 7.20-7.80 (m, 13H), 8.29 (s, 1H), ^{13}C NMR ($CDCl_3$, δ): 23.23, 30.26, 32.47, 42.38, 46.42, 47.80, 51.61, 57.63, 67.19, 120.54, 125.46, 127.64, 128.32, 128.59, 129.0, 137.00, 141.85, 144.21, 156.58, 157.29; HRMS Calc'd for $C_{30}H_{32}N_6O_4$ m/z: 563.2383 (M^++Na), found 563.2394.



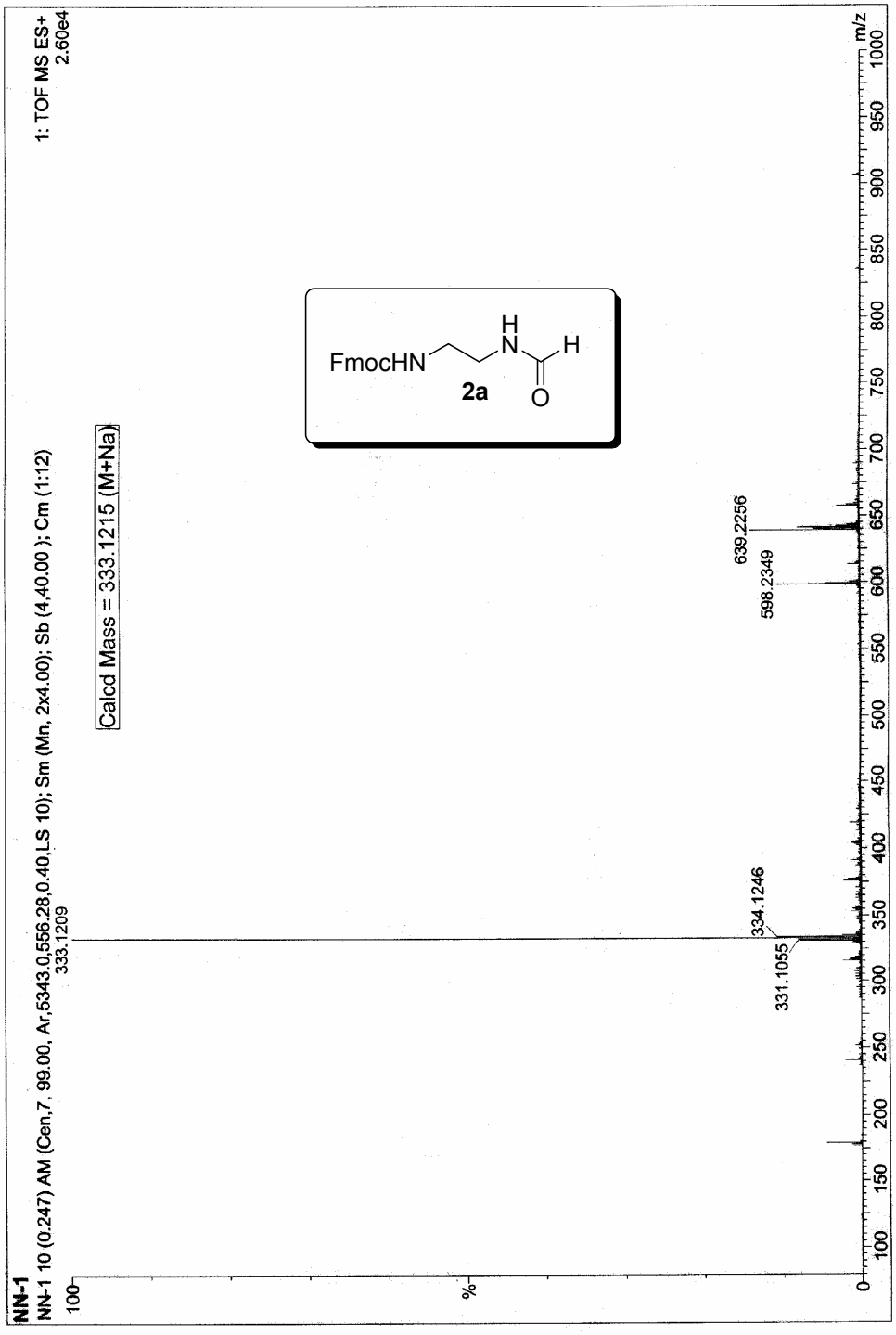
6n

45. (S)-(9H-fluoren-9-yl)methyl 4-{(1H-tetrazol-1-yl)methyl}-5-oxooxazolidine-3-carboxylate, 7a. Yield: 78 %; R_f 0.40 (n-hexane/AcOEt 5:5); m.p. = 45-47 °C; $[\alpha]_D^{23}$ = -31.5 (*c*= 1.1, $CHCl_3$); ^{1}H NMR ($CDCl_3$, δ): 4.14-4.32 (m, 3H), 4.23 -4.58 (m, 4H), 5.23-5.32 (m, 2H), 7.24-7.73 (m, 8H), 8.41 (s, 1H), ^{13}C NMR ($CDCl_3$, δ): 46.90, 47.12, 53.46, 66.91, 72.35, 120.35, 124.40, 127.50, 127.99, 141.22, 143.31, 143.89, 156.31, 170.16; HRMS Calc'd for $C_{20}H_{17}N_5O_4$ m/z: 414.1178 (M^++Na), found 414.1172.

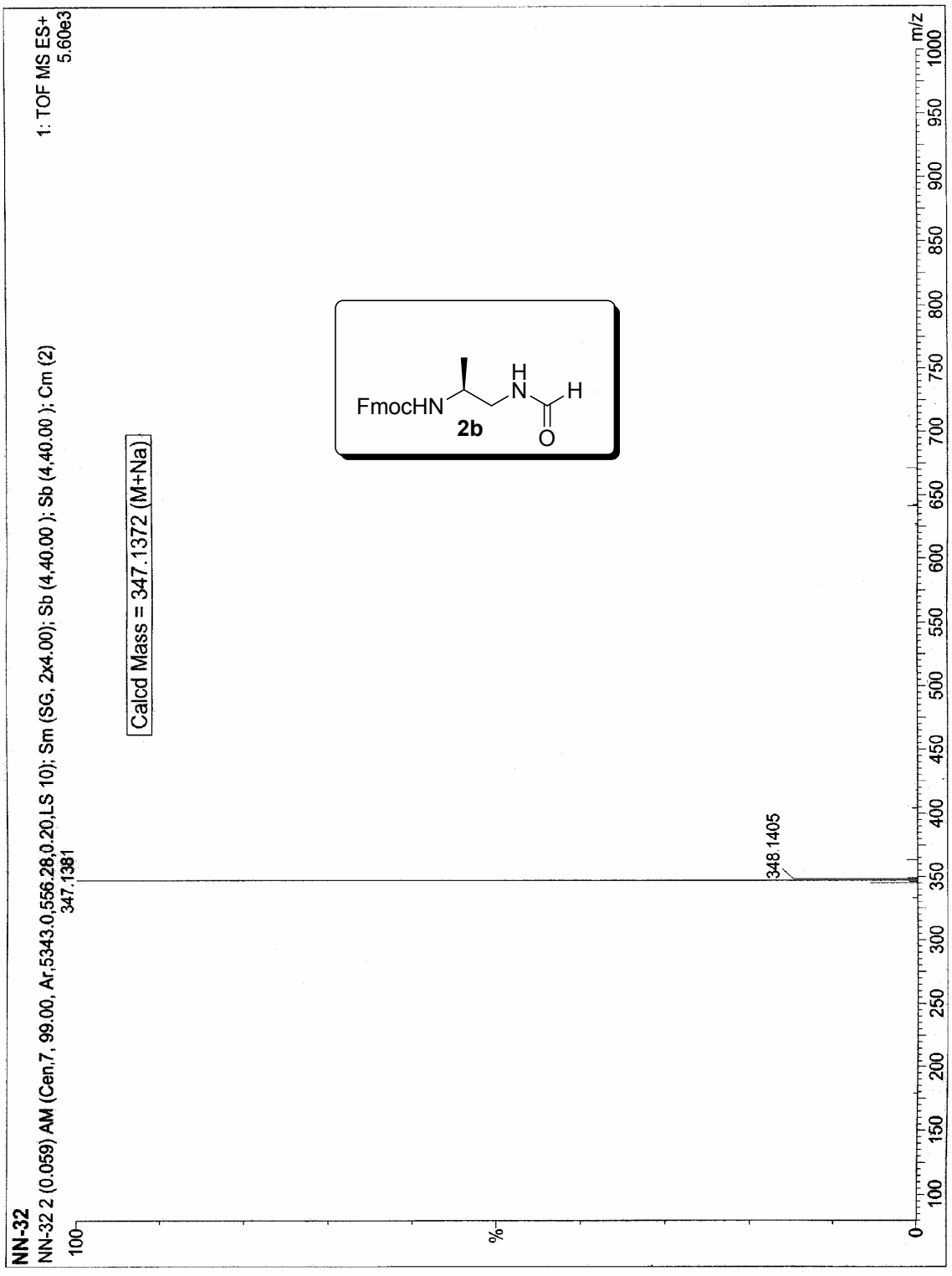


7a

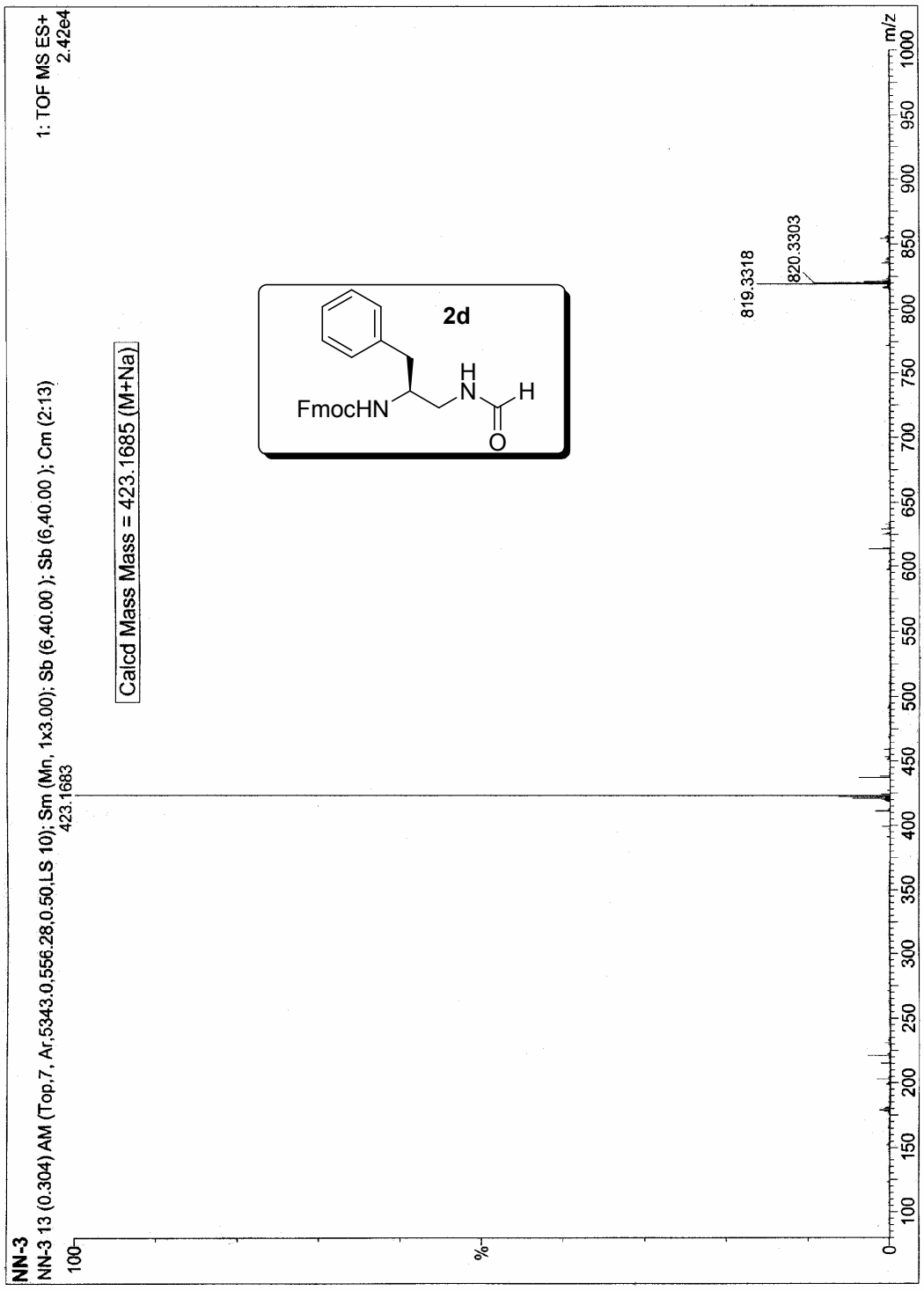
Fmoc-Gly-ψ [CH_2-NHCHO]



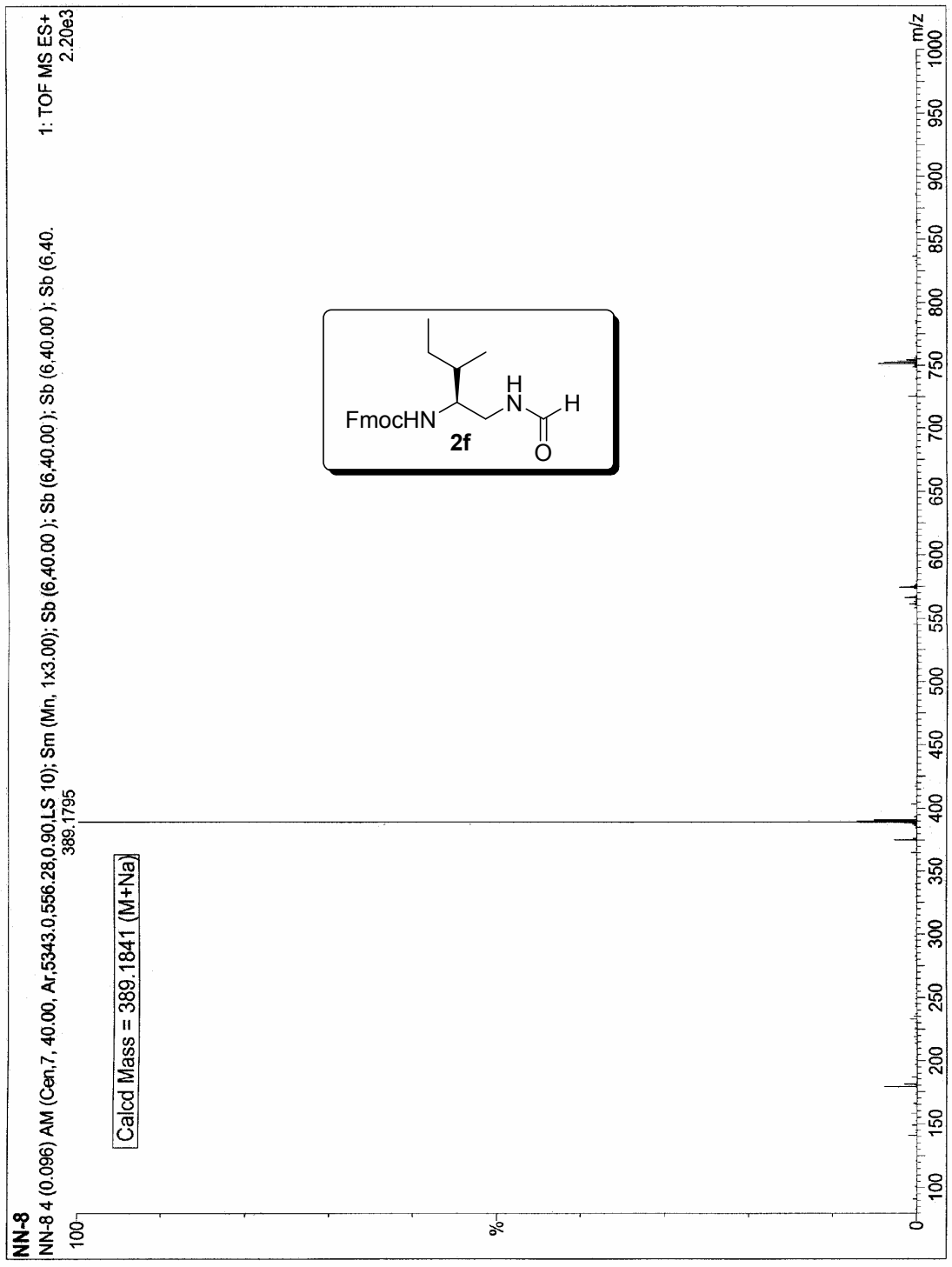
Fmoc-Ala-ψ [CH_2-NHCHO]



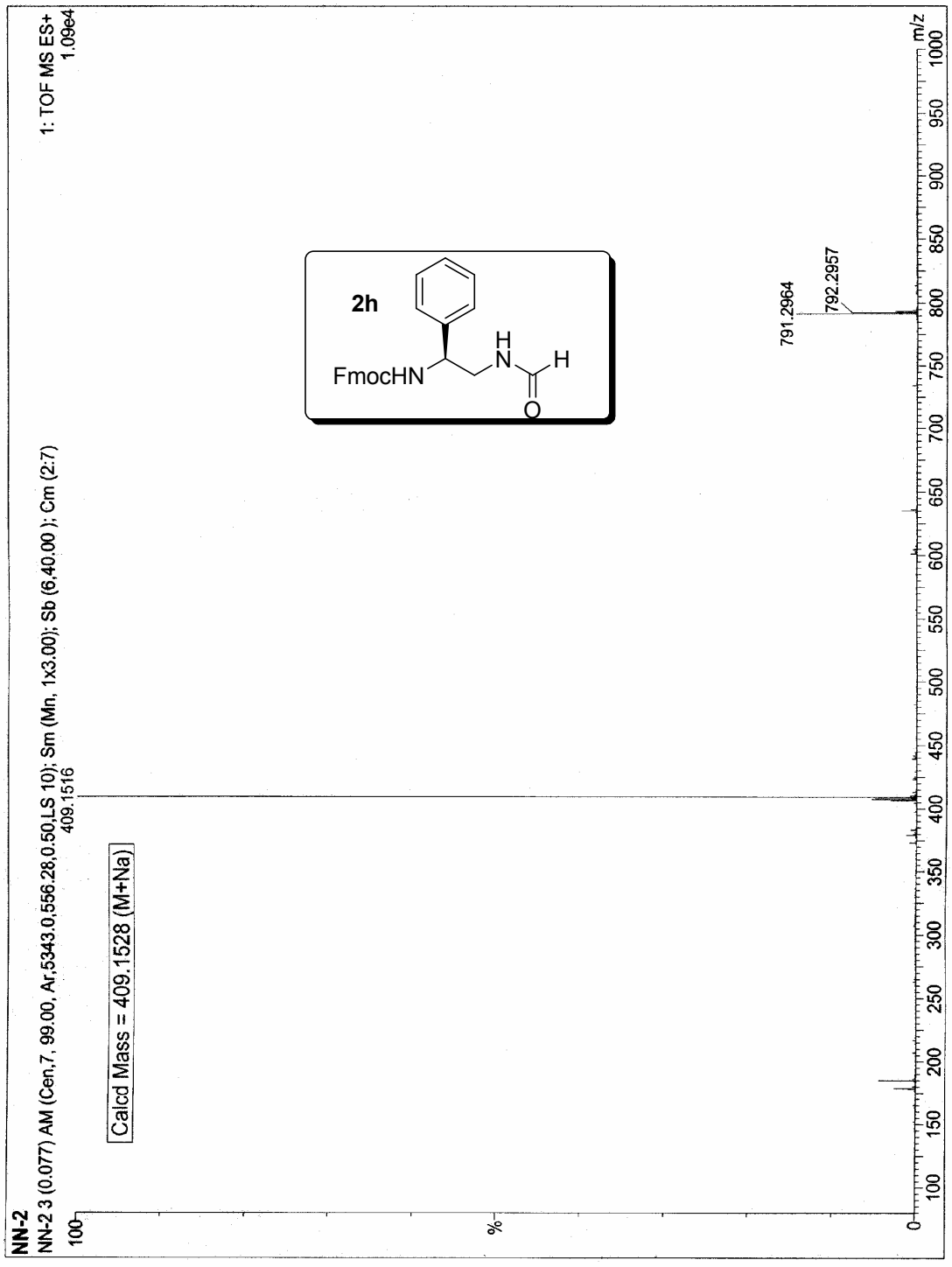
Fmoc-Phe-ψ[CH_2-NHCHO]



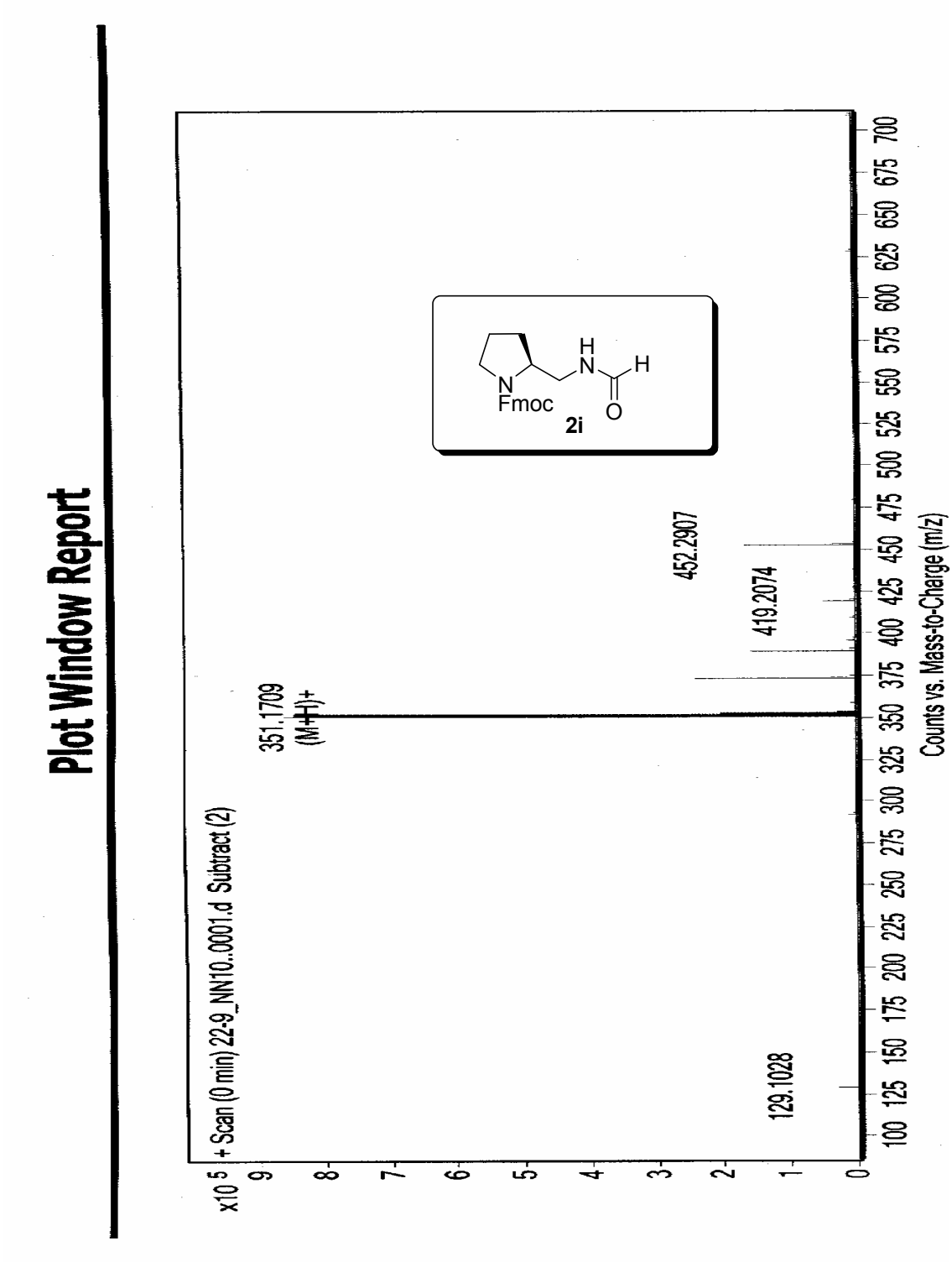
Fmoc-Ile-ψ [CH_2-NHCHO]



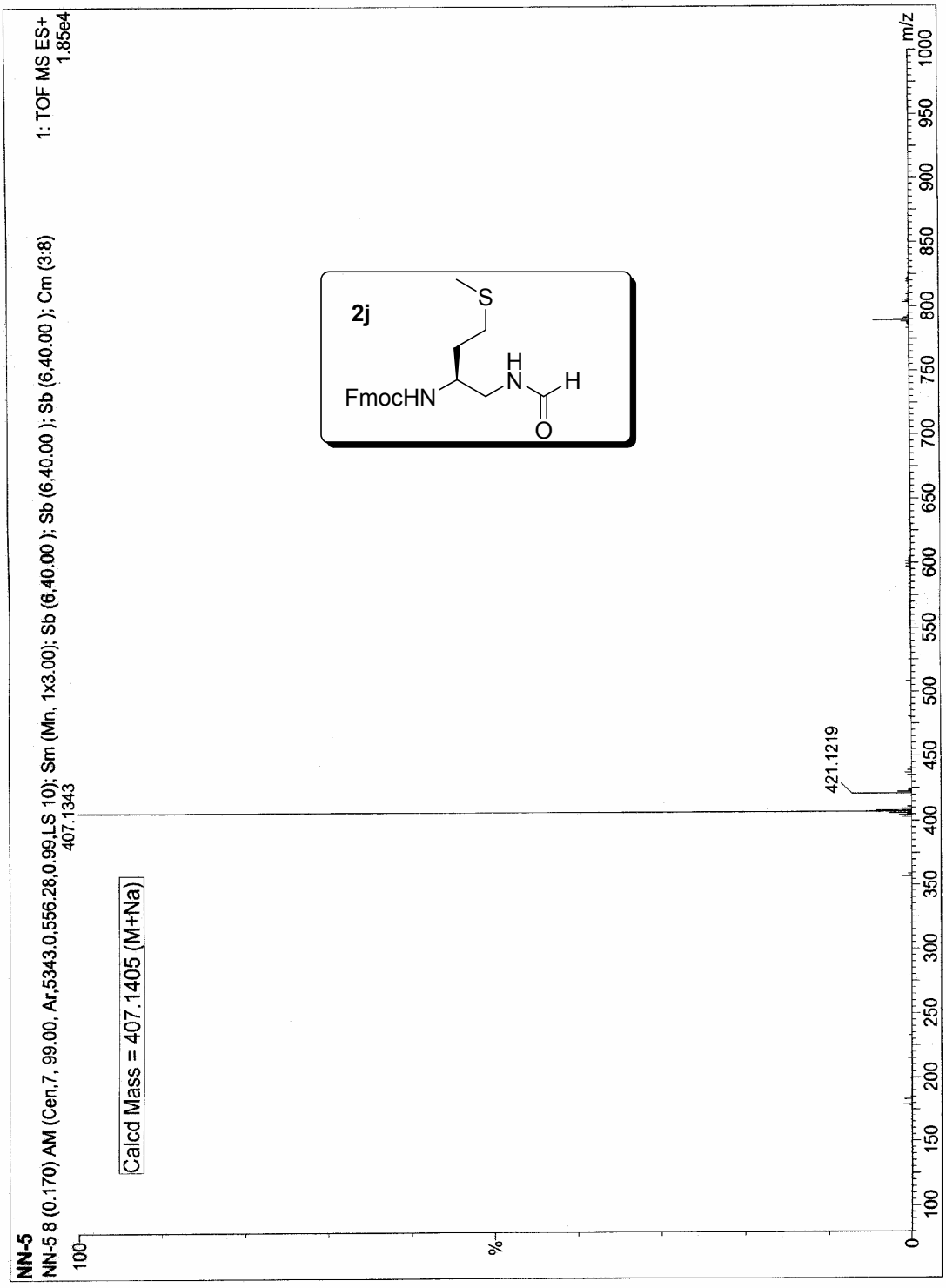
Fmoc-L-Phg-ψ[CH_2-NHCHO]



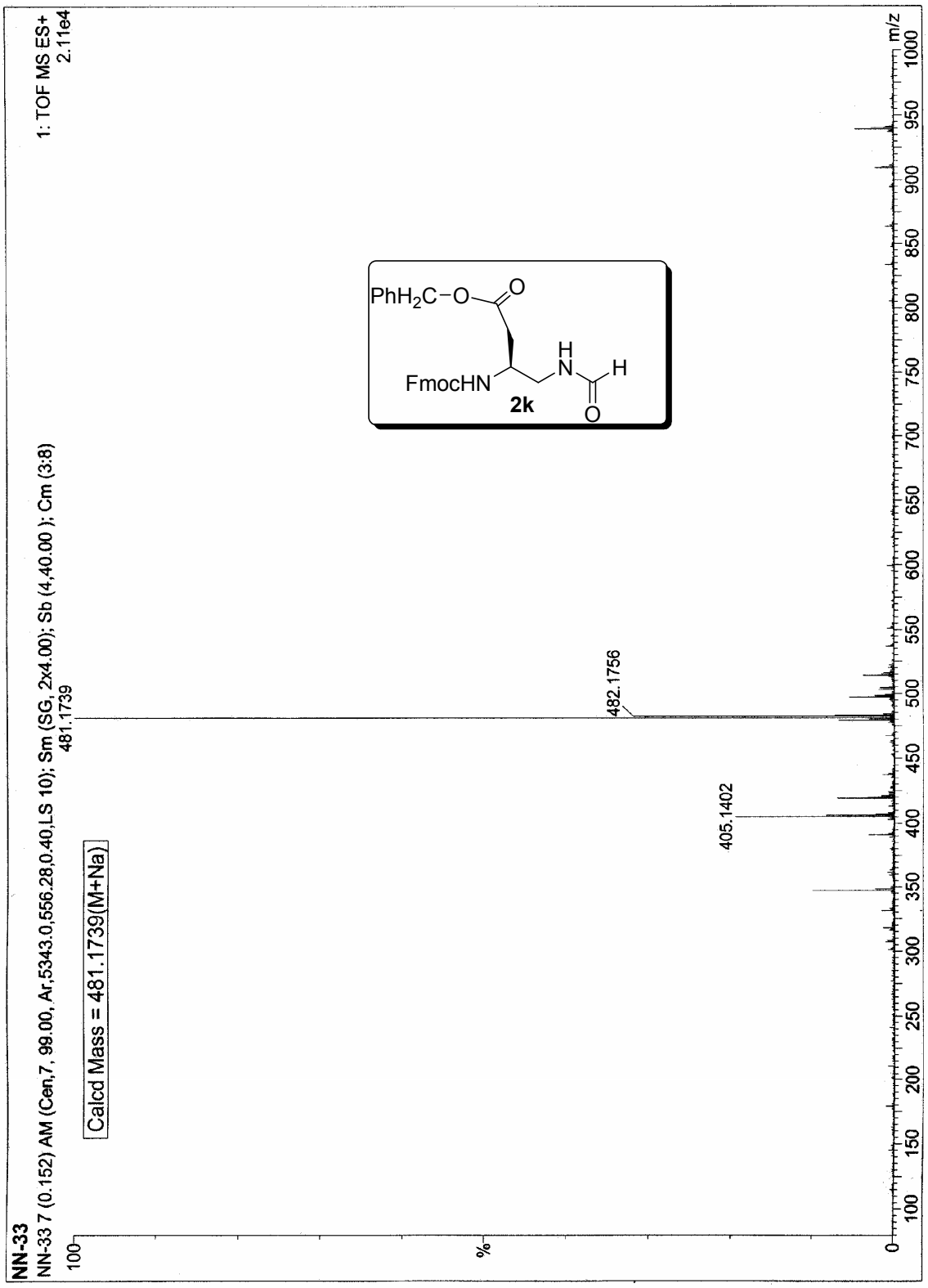
Fmoc-Pro-ψ[CH_2-NHCHO]



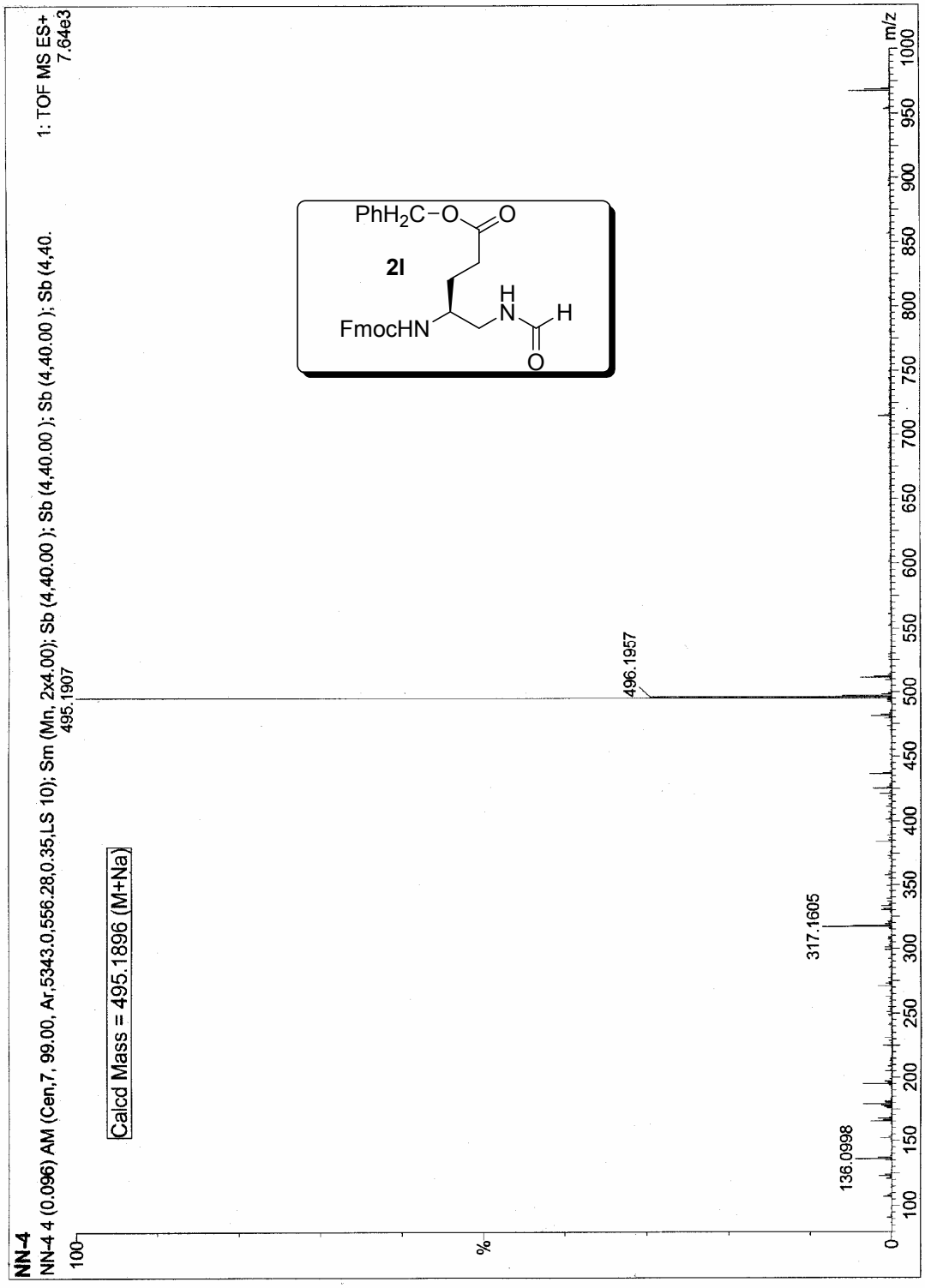
Fmoc- Met-ψ [CH_2-NHCHO]



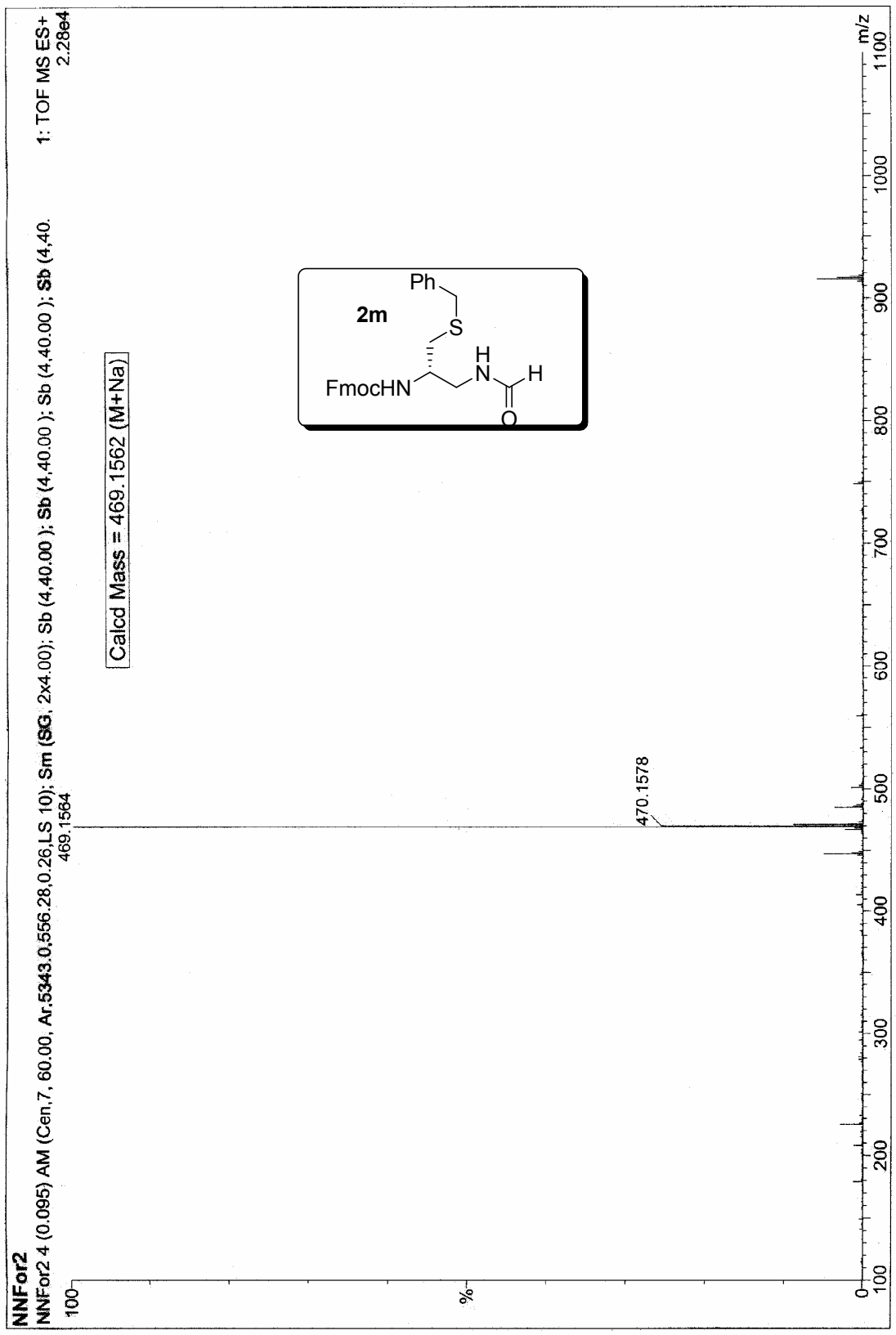
Fmoc-Asp(Bzl)-ψ [CH_2-NHCHO]



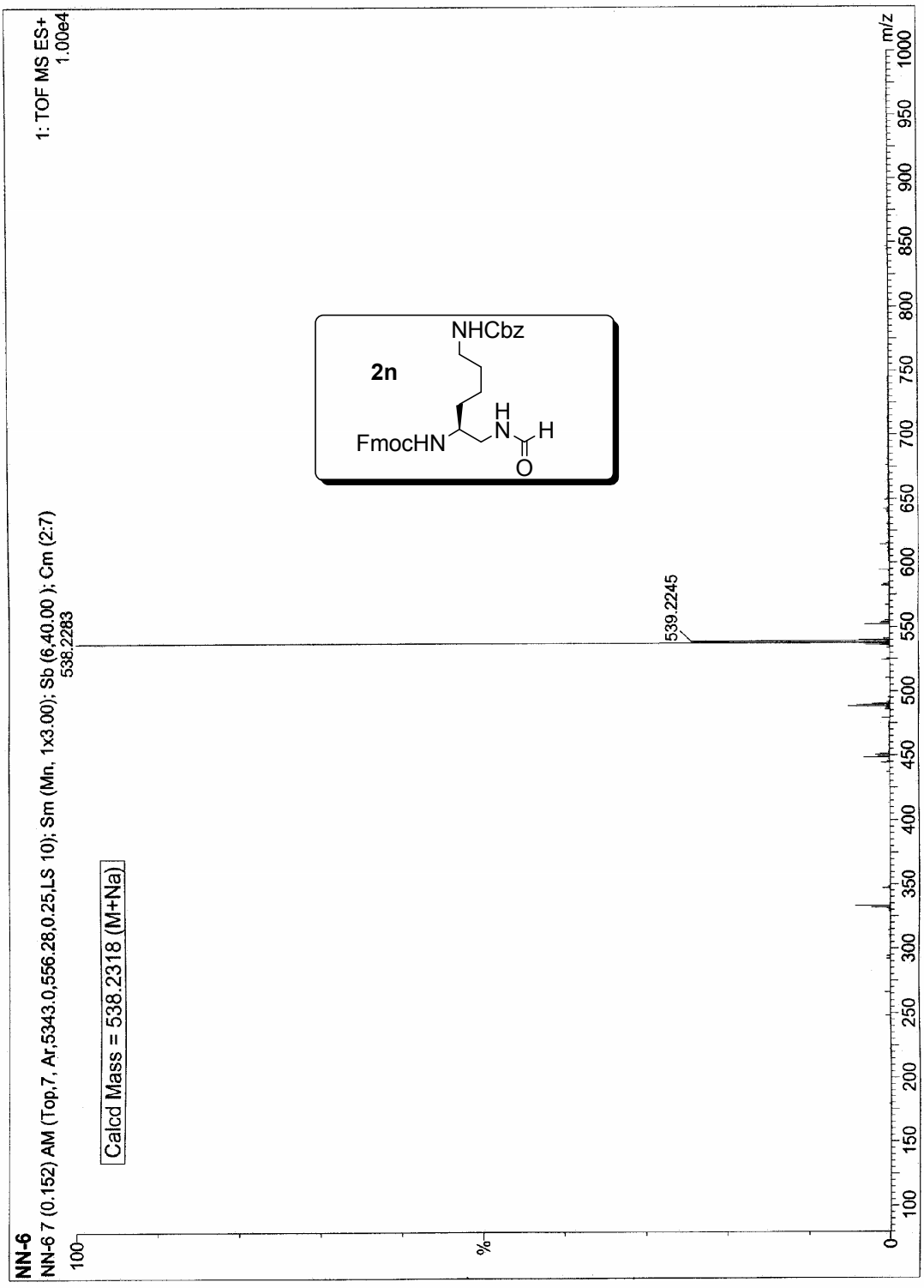
Fmoc-Glu(Bzl)-ψ [CH_2-NHCHO]



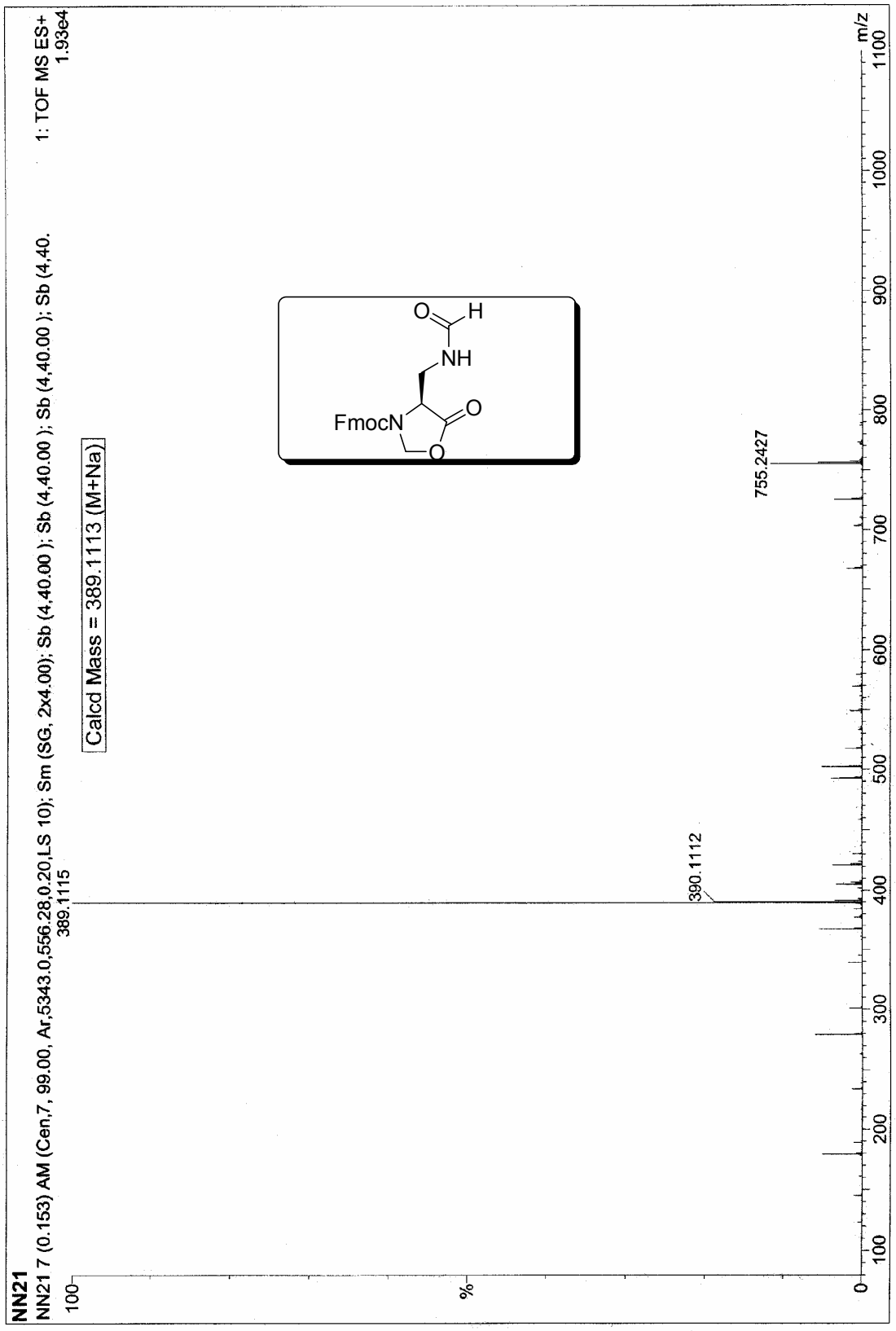
Fmoc-Cys(Bzl)-ψ[CH_2-NHCHO]



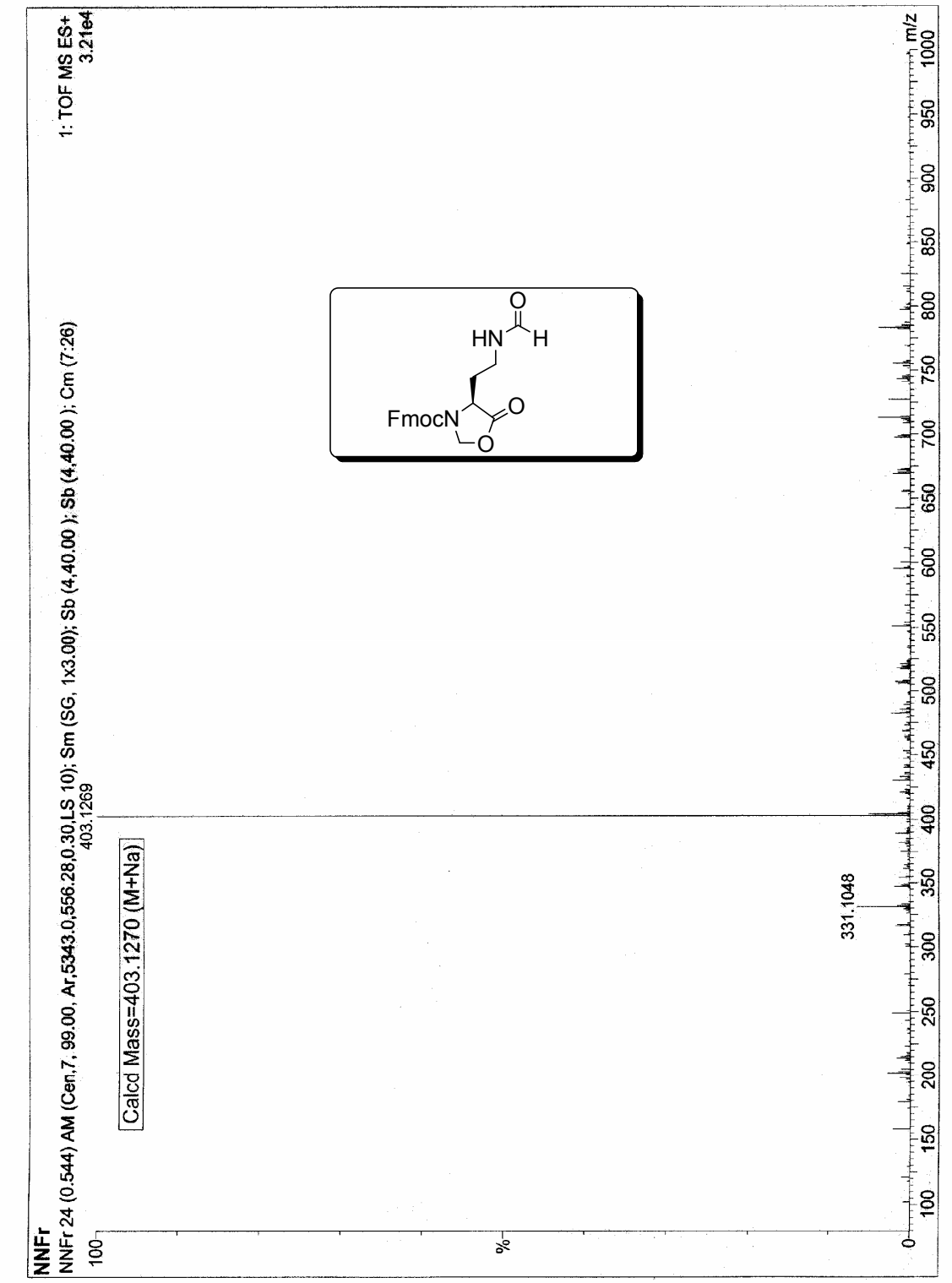
Fmoc-Lys(Cbz)-ψ [CH_2-NHCHO]



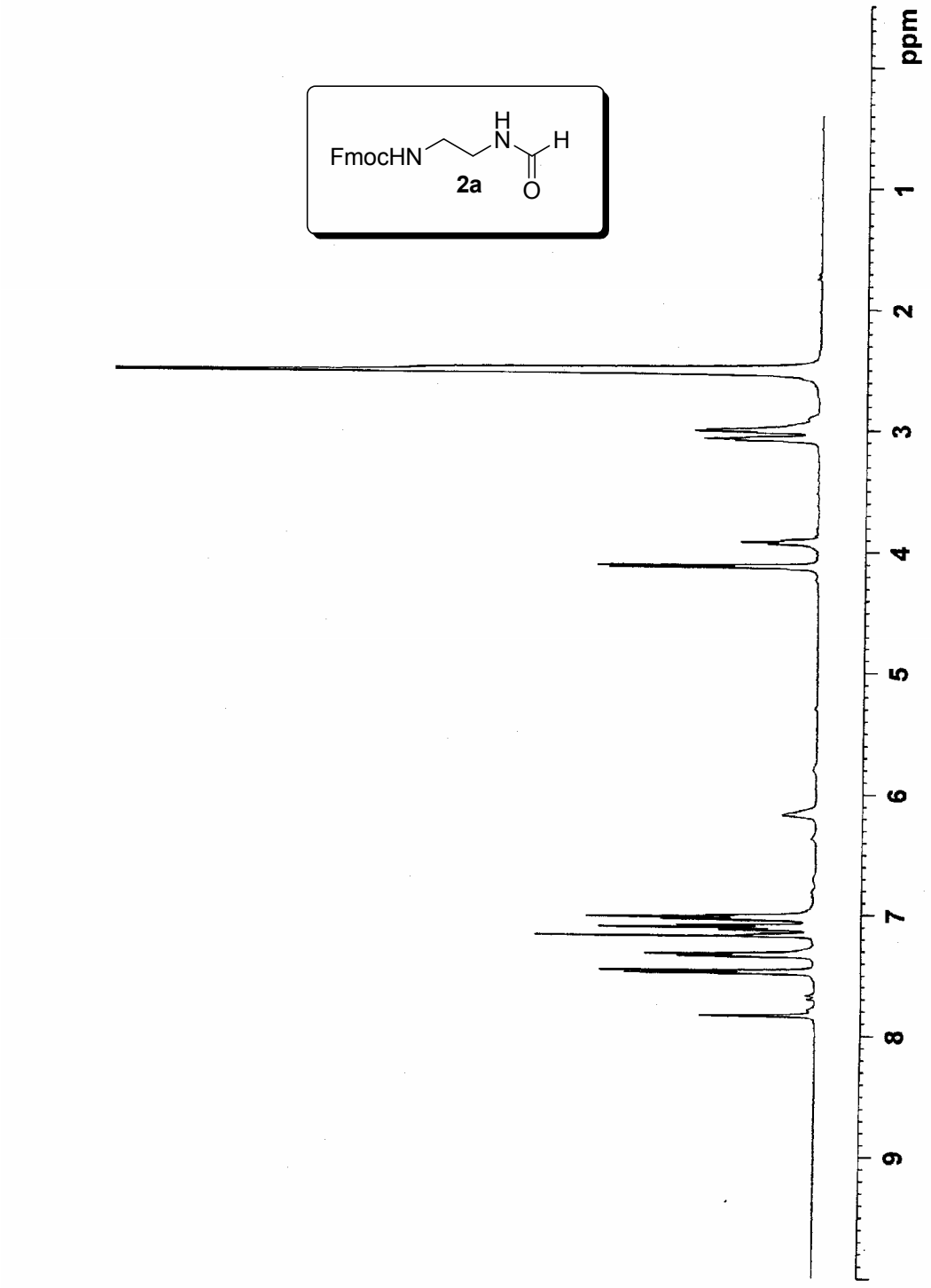
Fmoc-Asp(ψ[CH_2-NHCHO])-5-oxazolidinone



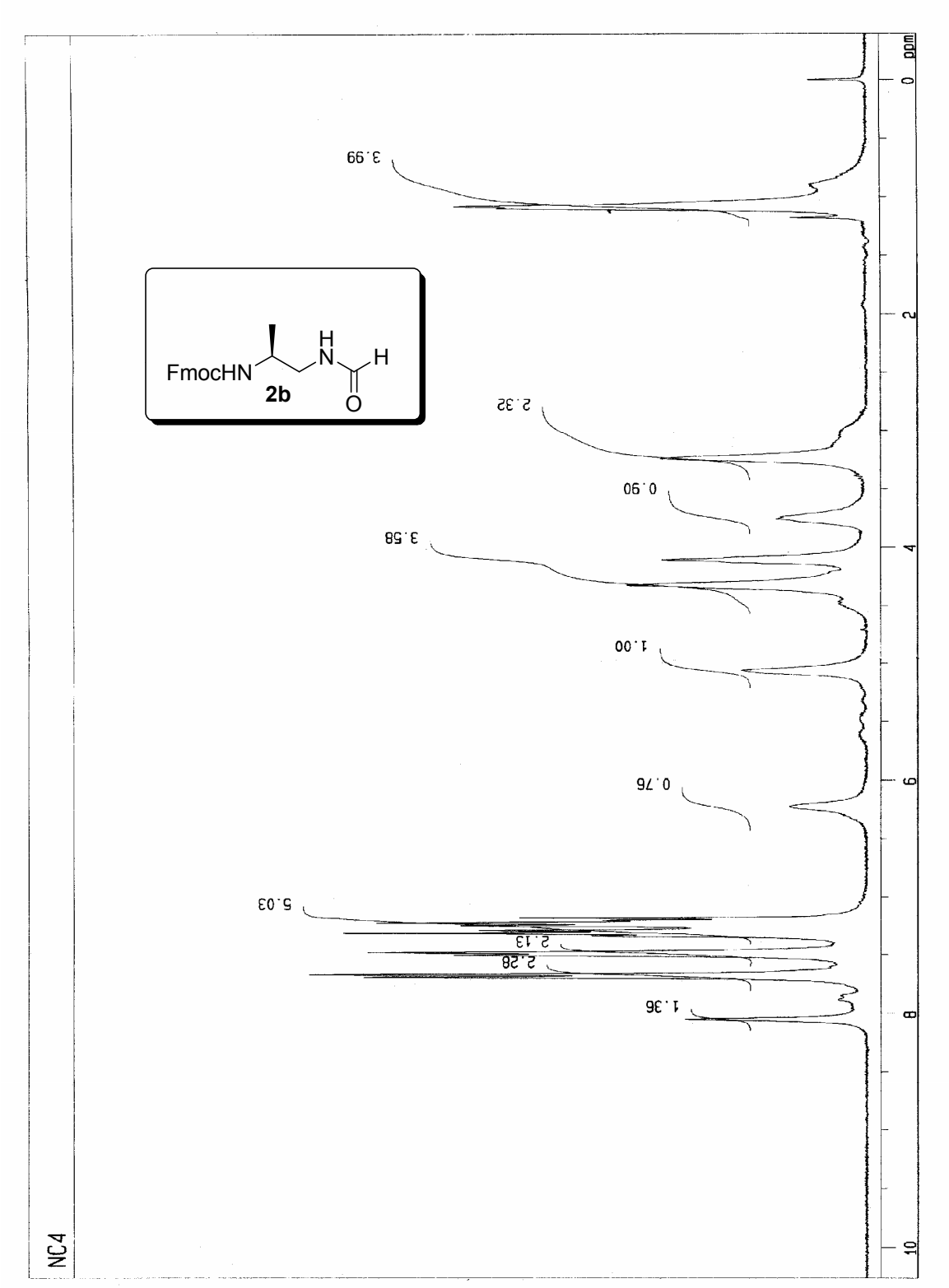
Fmoc-Glu(ψ[$(CH_2)_2$-NHCHO])-5-oxazolidinone



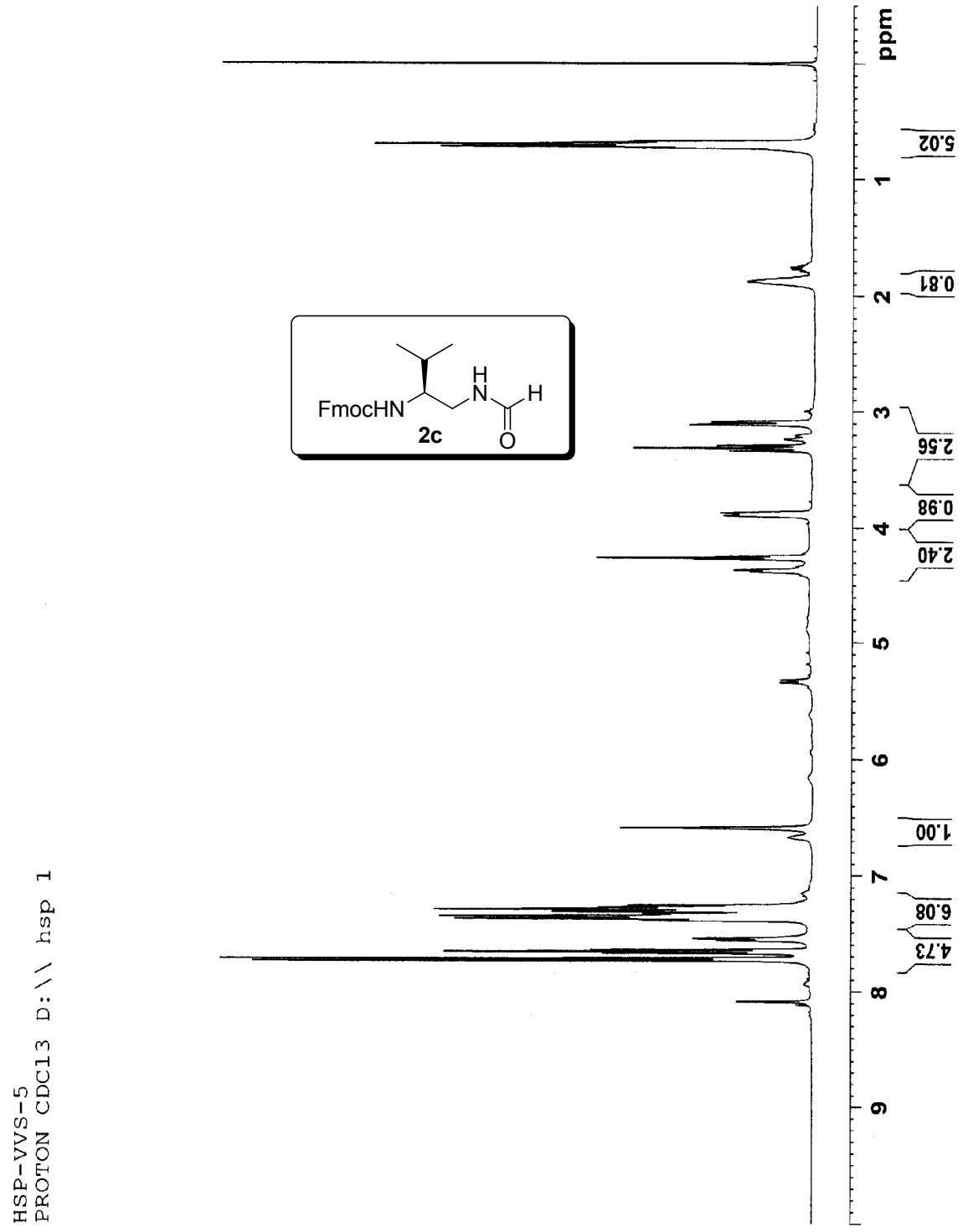
Fmoc-Gly-ψ [CH_2-NHCHO]



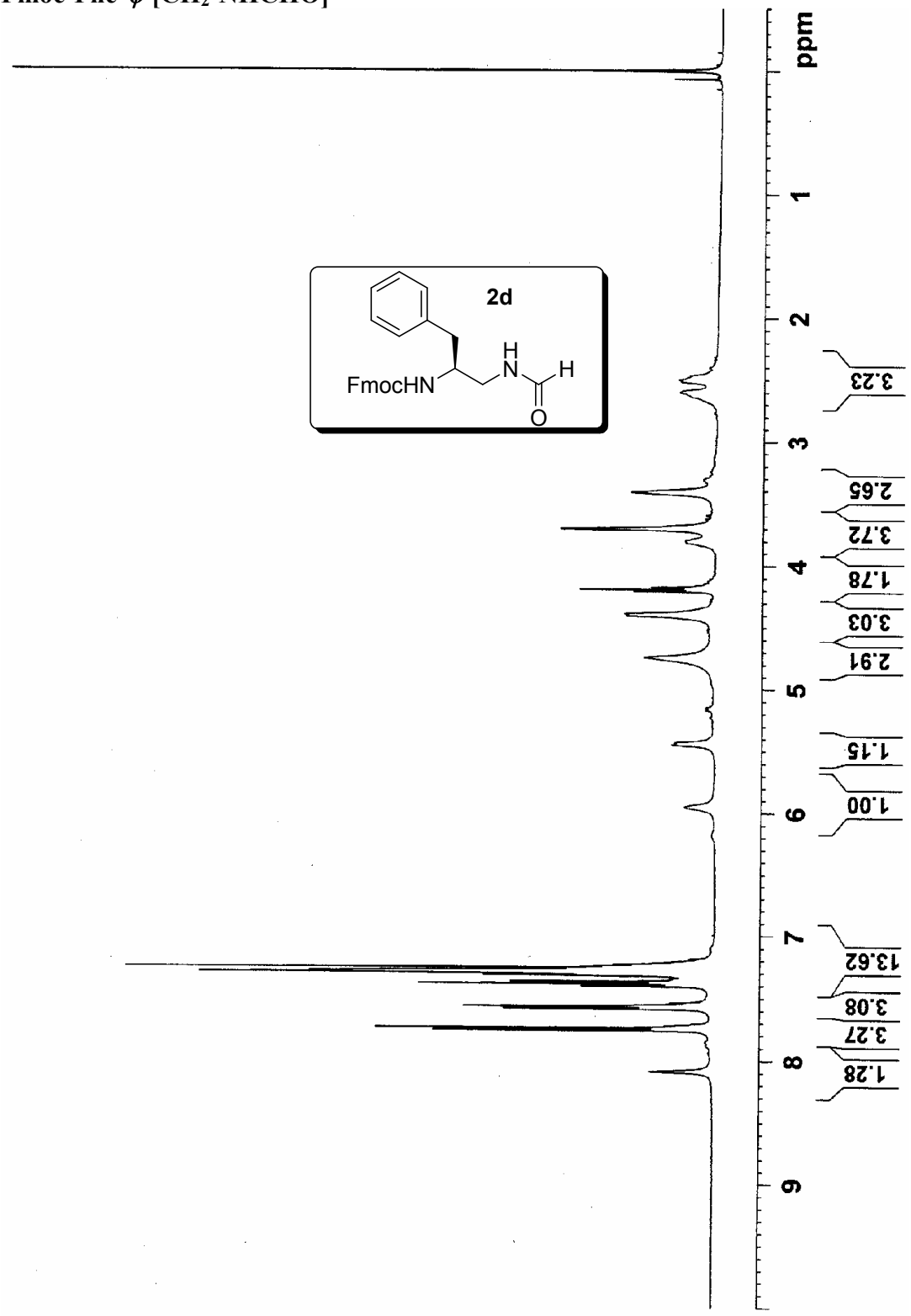
Fmoc-Ala-ψ [CH_2-NHCHO]



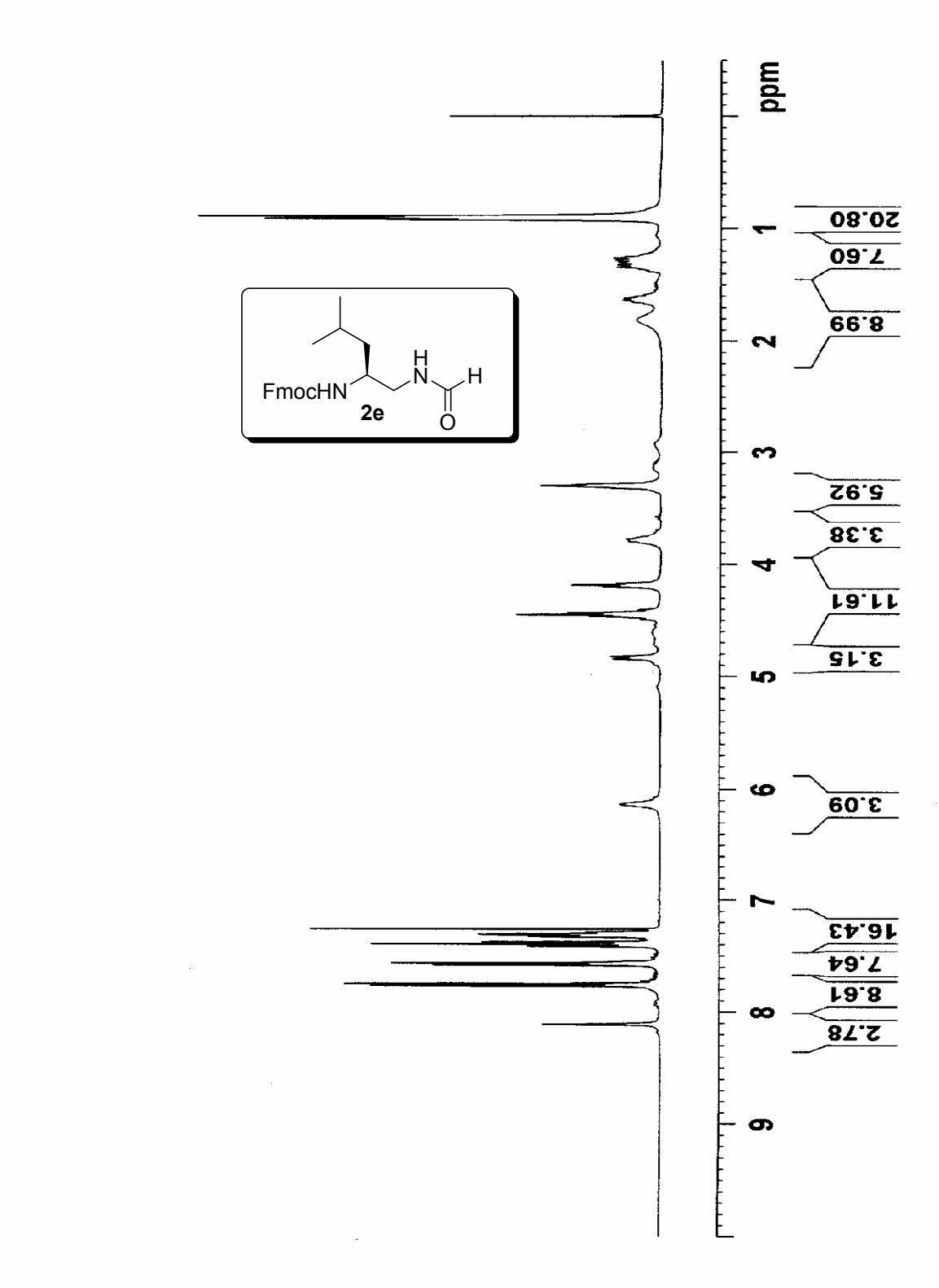
Fmoc-Val-ψ [CH_2-NHCHO]



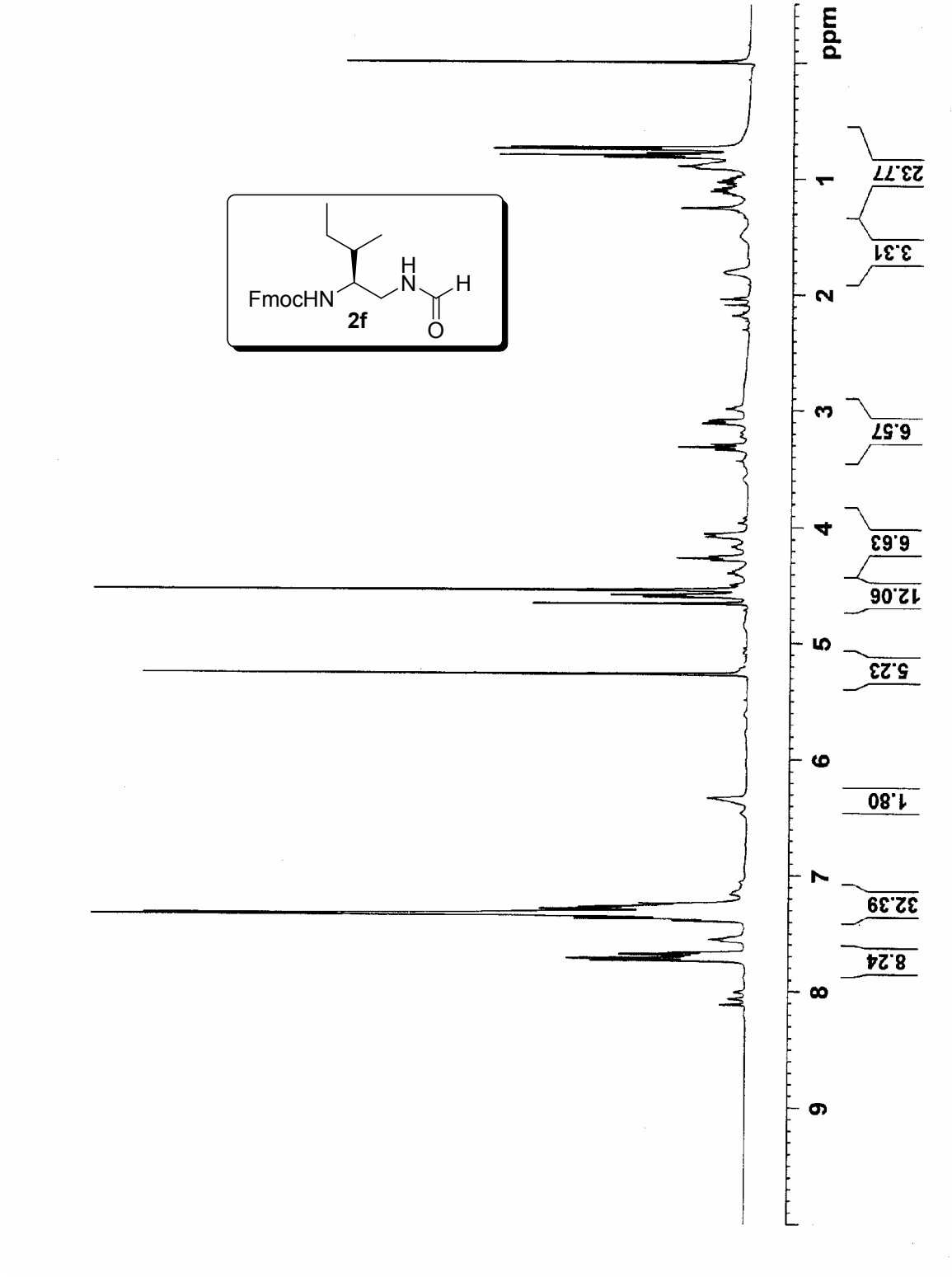
Fmoc-Phe-ψ[CH_2-NHCHO]



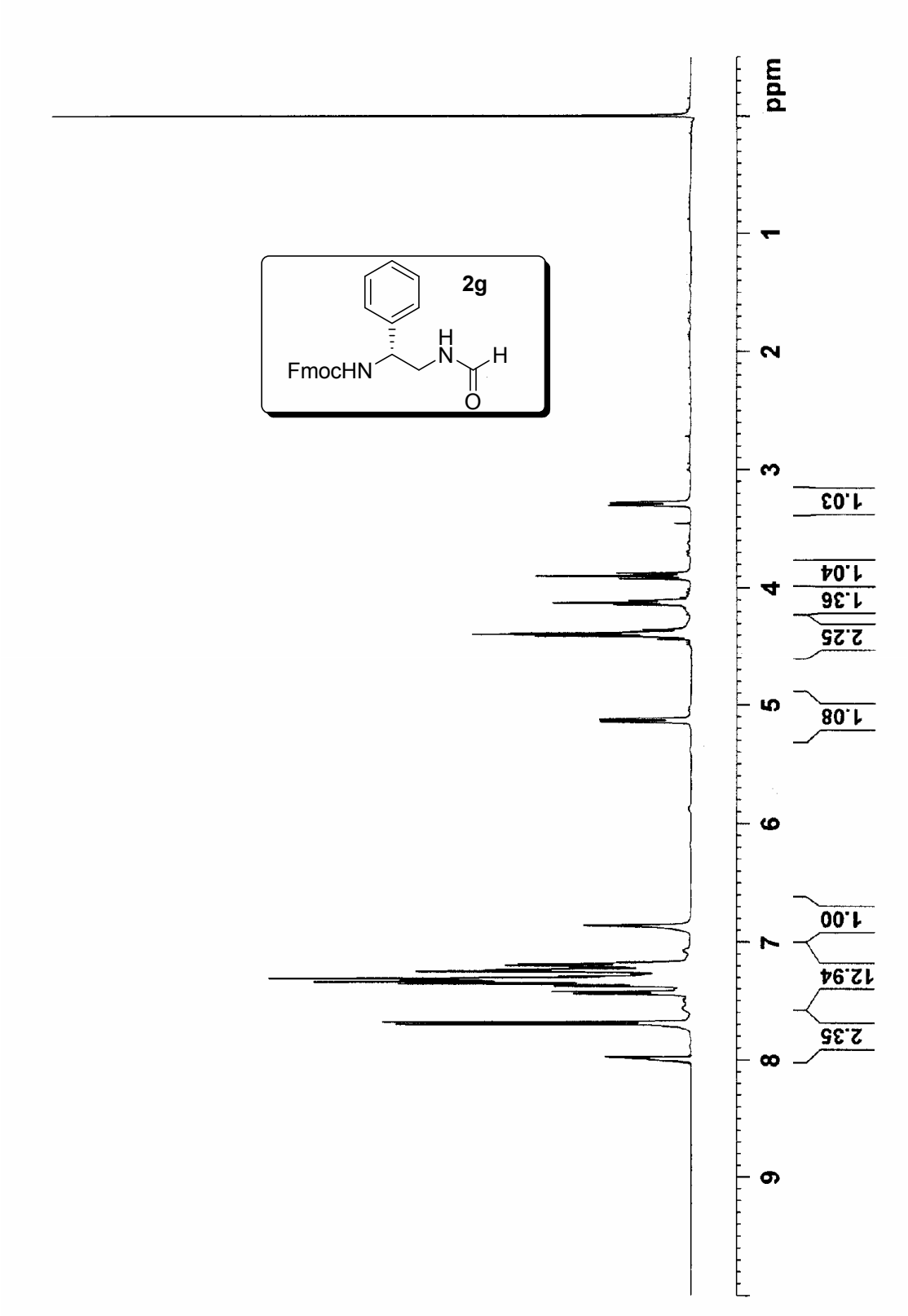
Fmoc-Leu-ψ[CH_2-NHCHO]



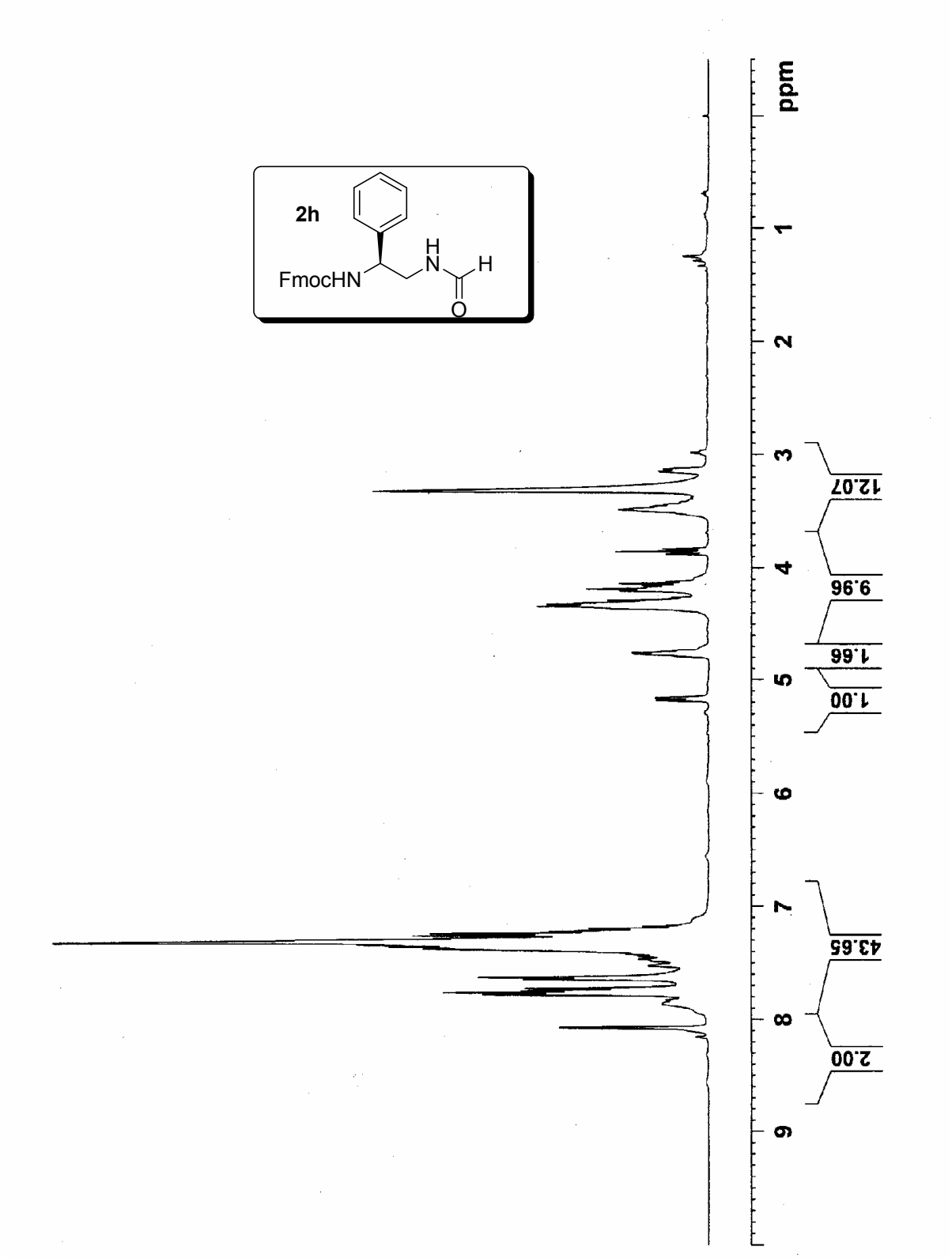
Fmoc-Ile-ψ [CH_2-NHCHO]



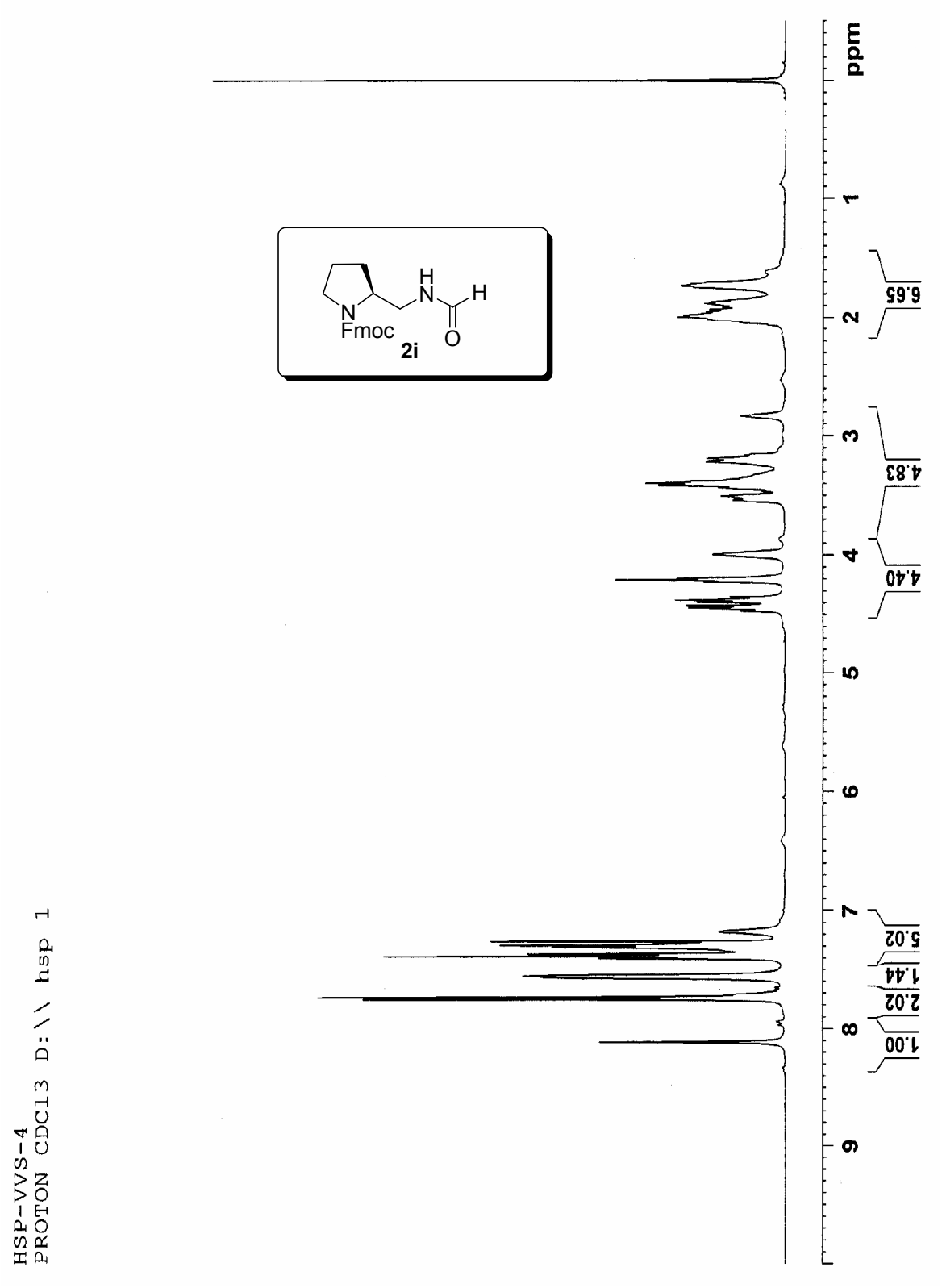
Fmoc-D-Phg-ψ[CH_2-NHCHO]



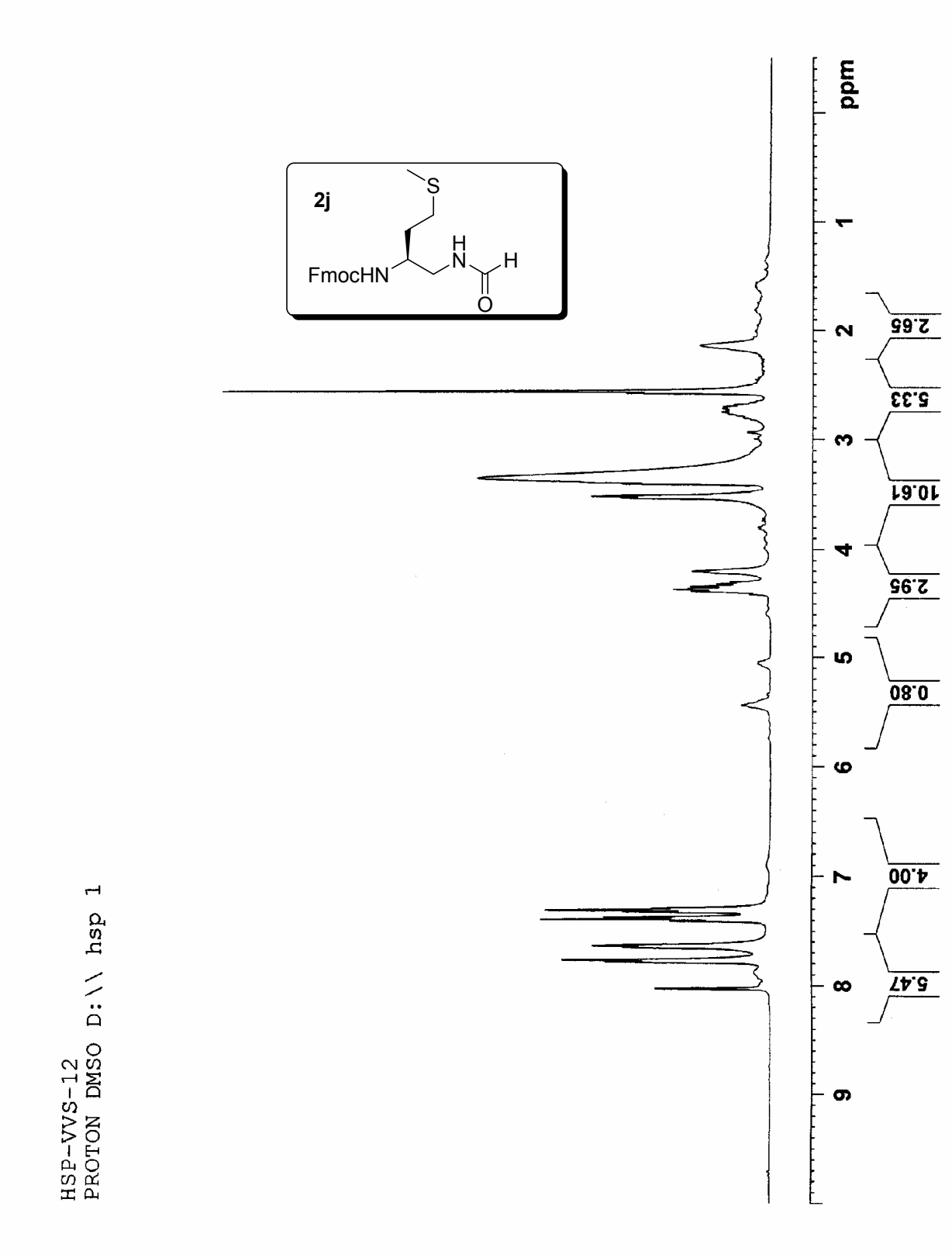
Fmoc-L-Phg-ψ[CH_2-NHCHO]



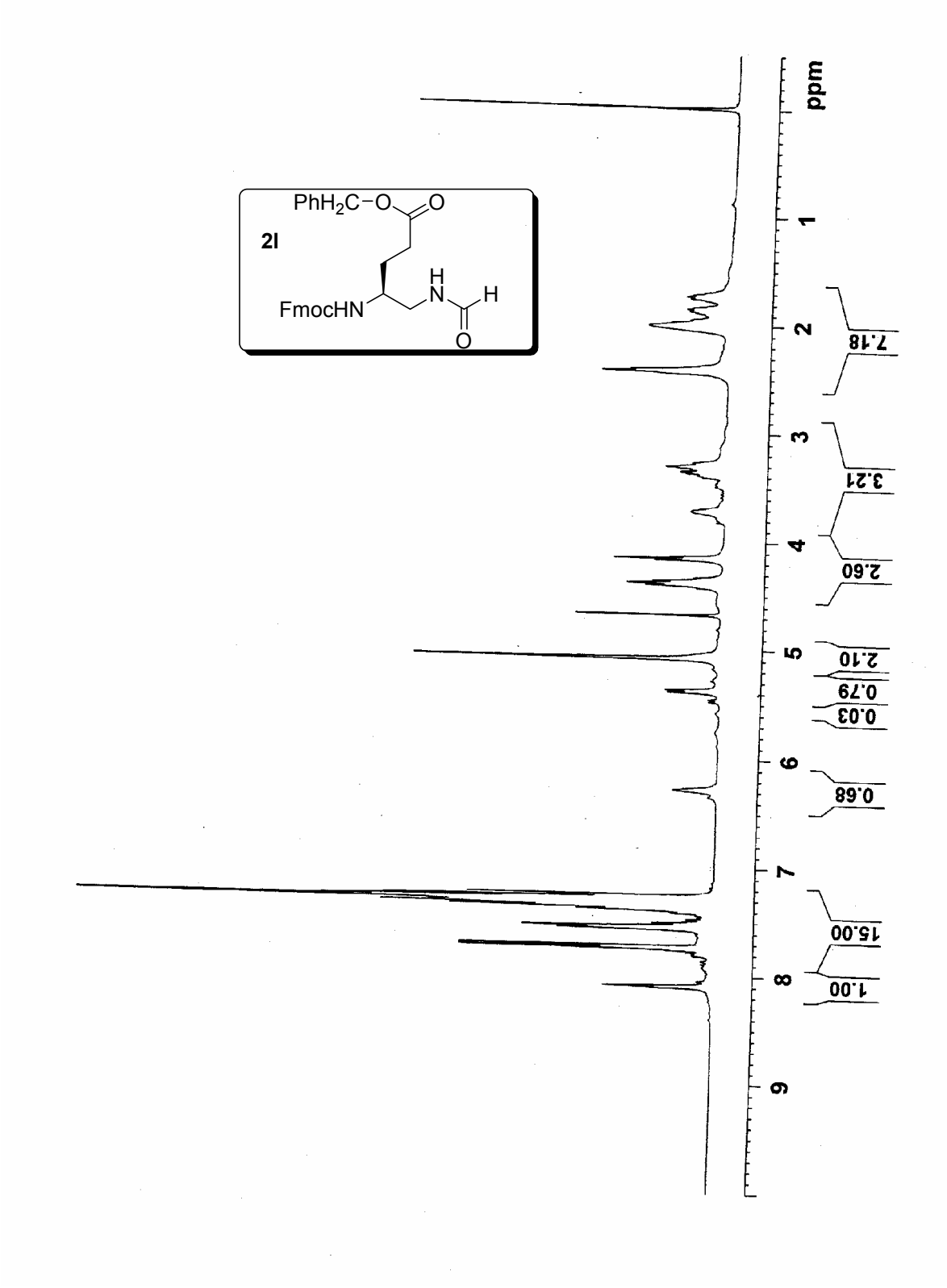
Fmoc-Pro-ψ[CH_2-NHCHO]



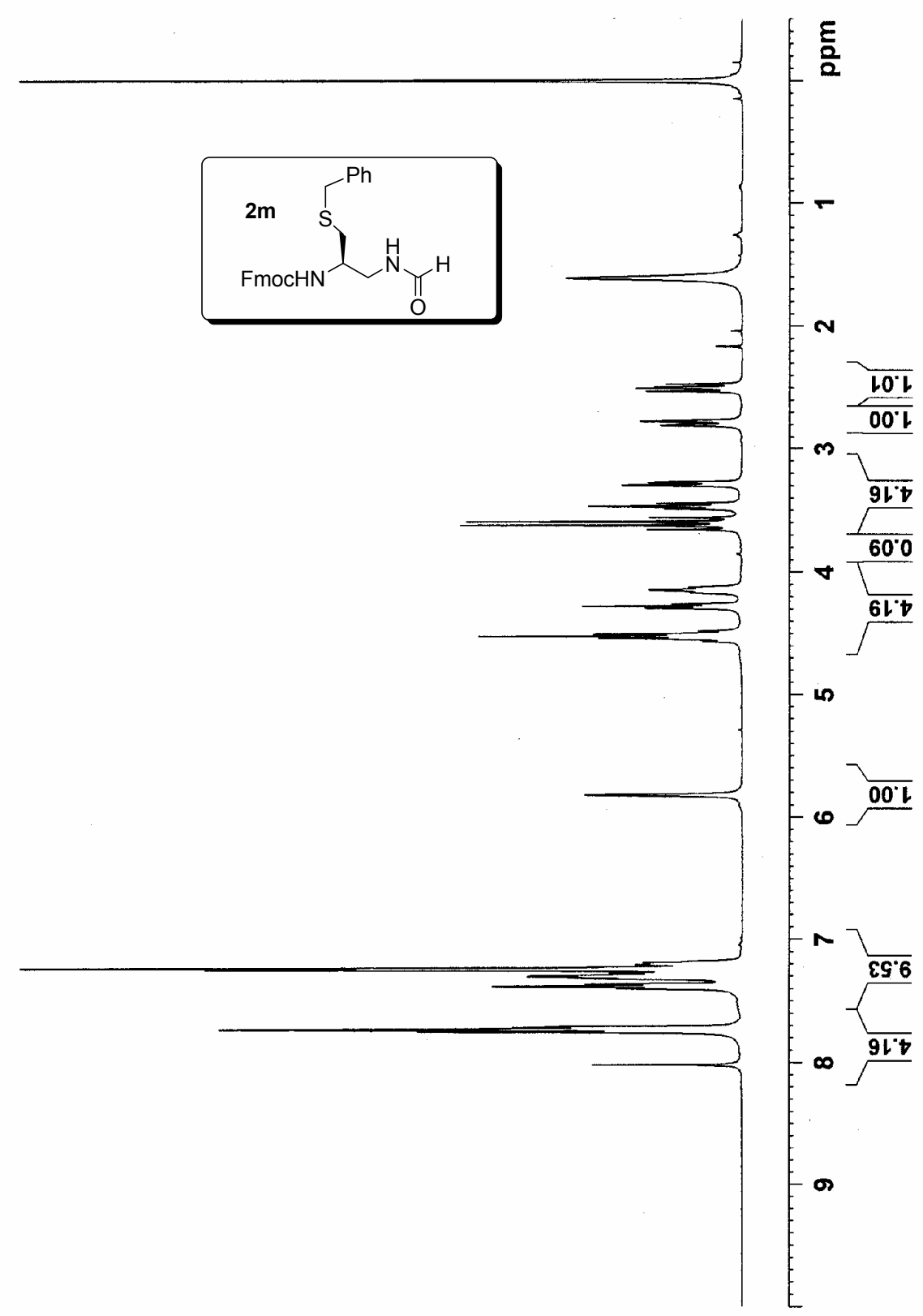
Fmoc-Met-ψ [CH_2-NHCHO]



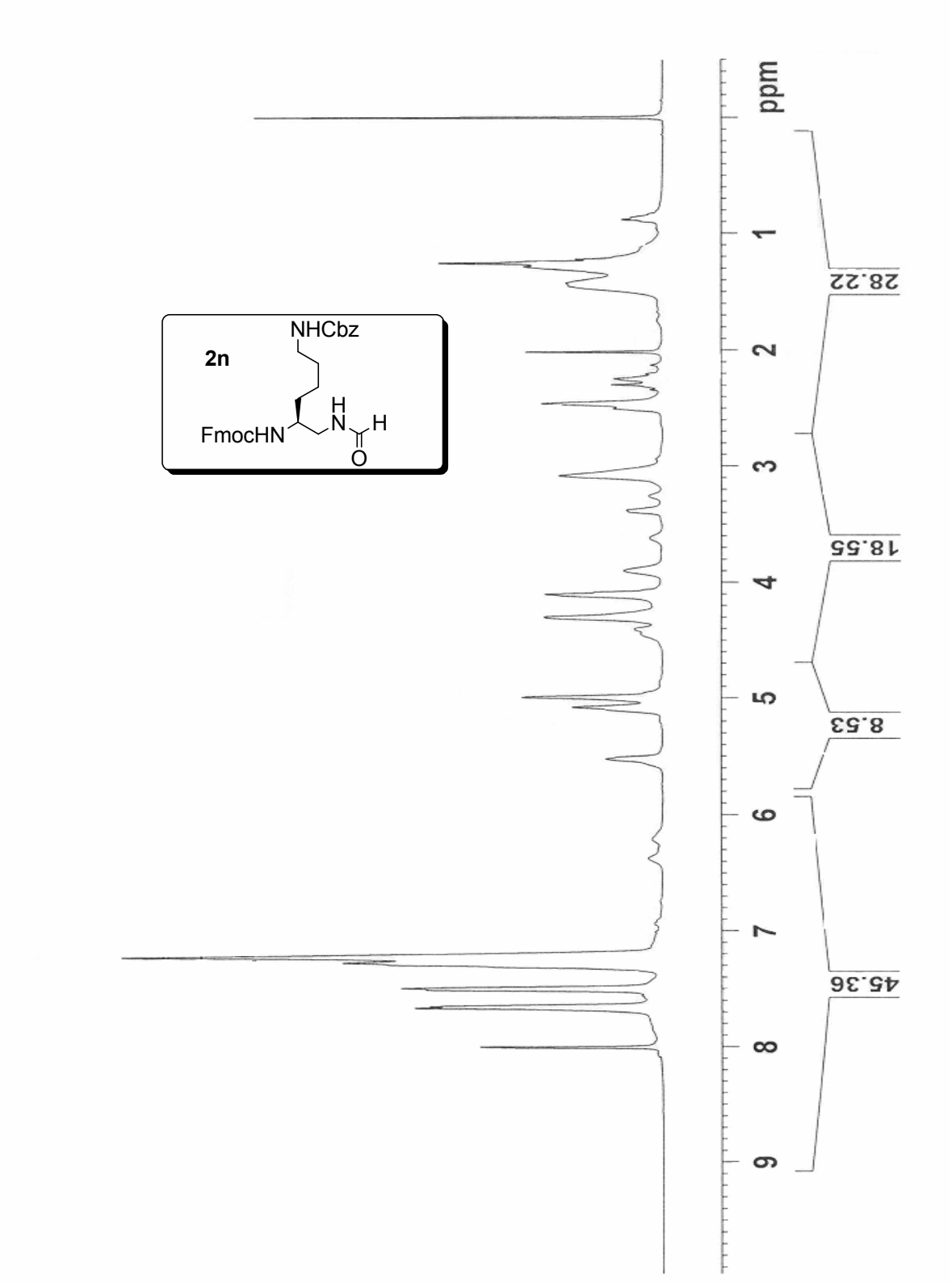
Fmoc-Glu(Bzl)-ψ [CH_2-NHCHO]



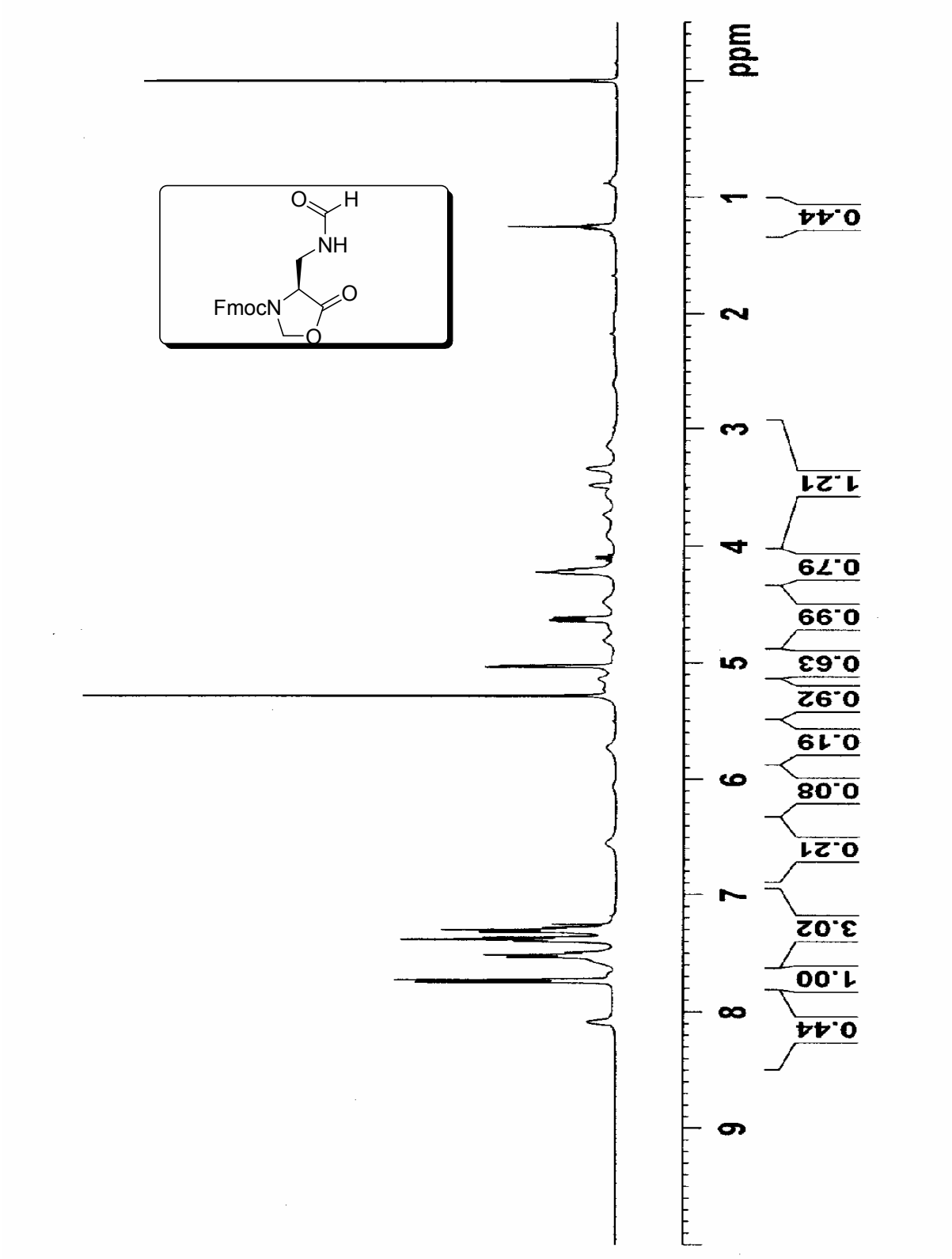
Fmoc-Cys(Bzl)-ψ [CH_2-NHCHO]



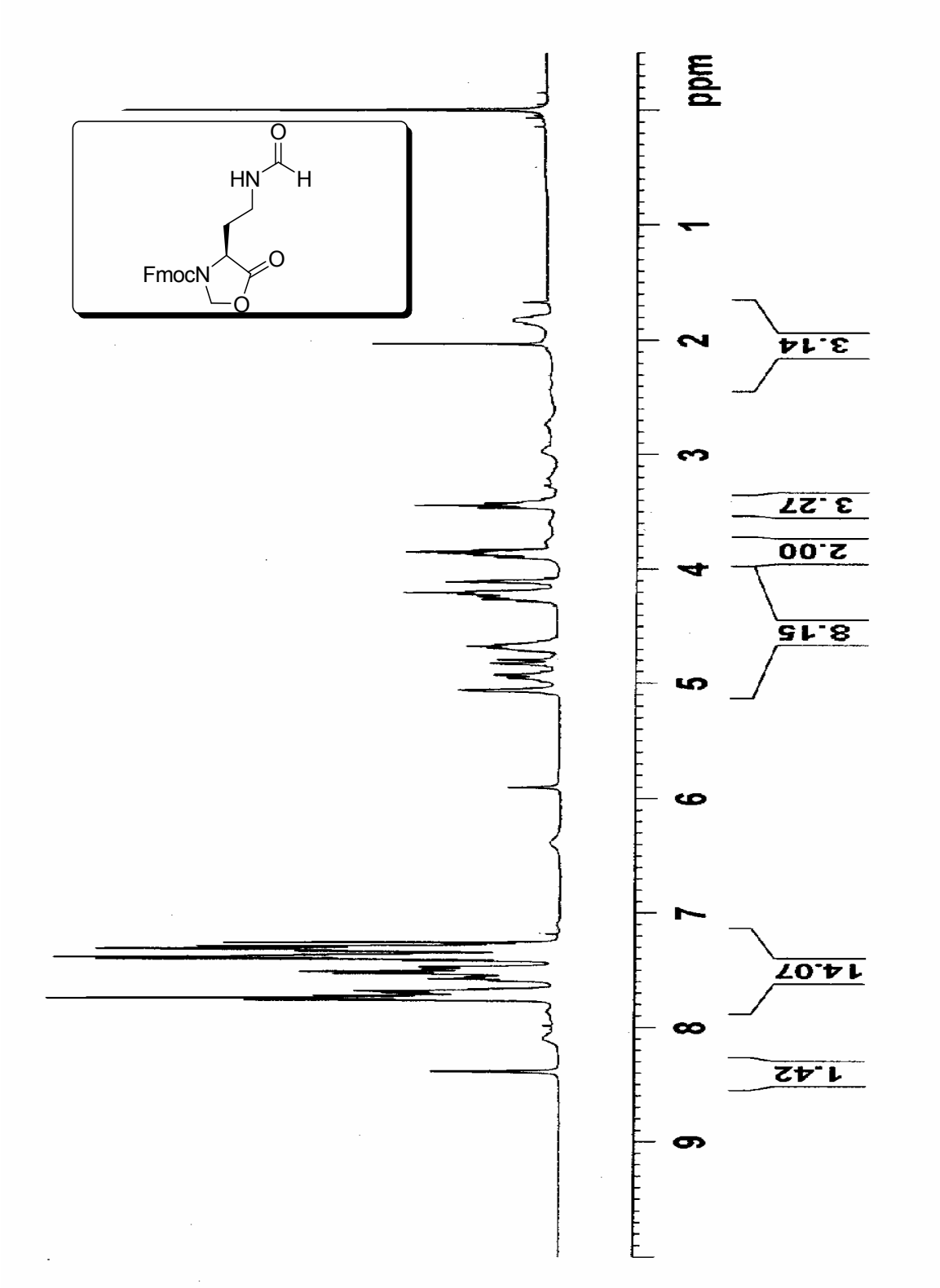
Fmoc-Lys(Cbz)-ψ [CH_2-NHCHO]



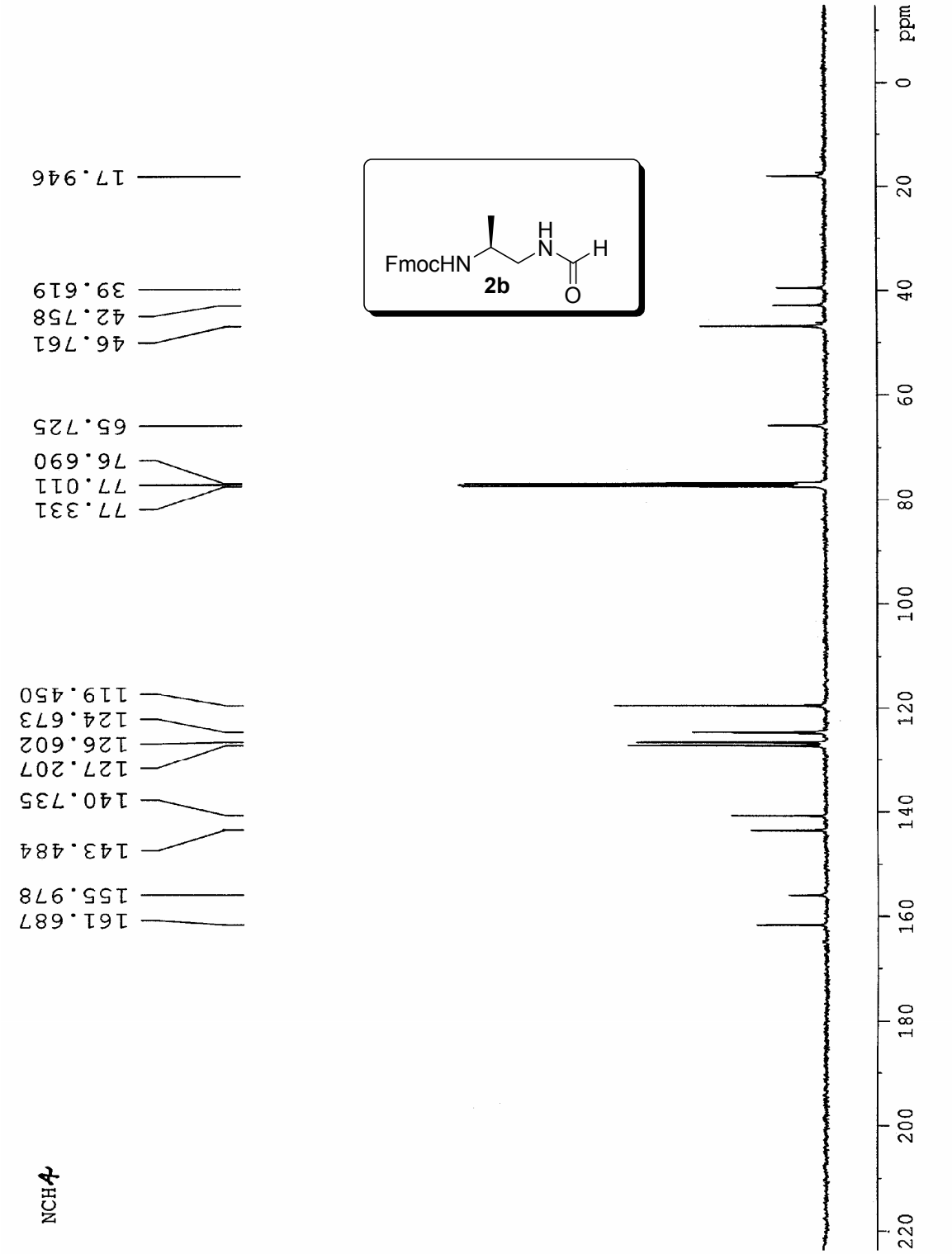
Fmoc-Asp(ψ[CH_2-NHCHO])-5-oxazolidinone



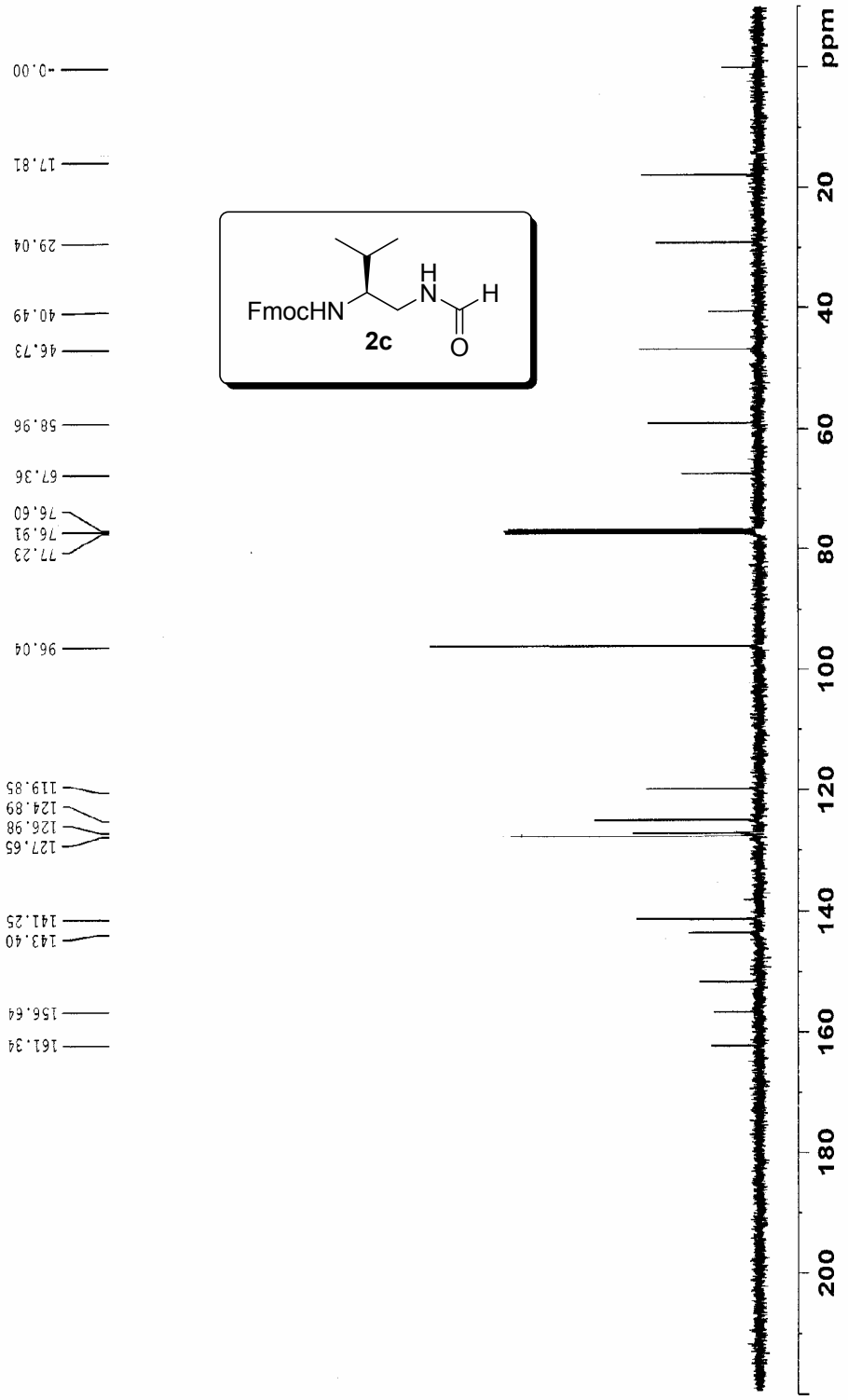
Fmoc-Glu(ψ[$(CH_2)_2$NHCHO])-5-oxazolidinone



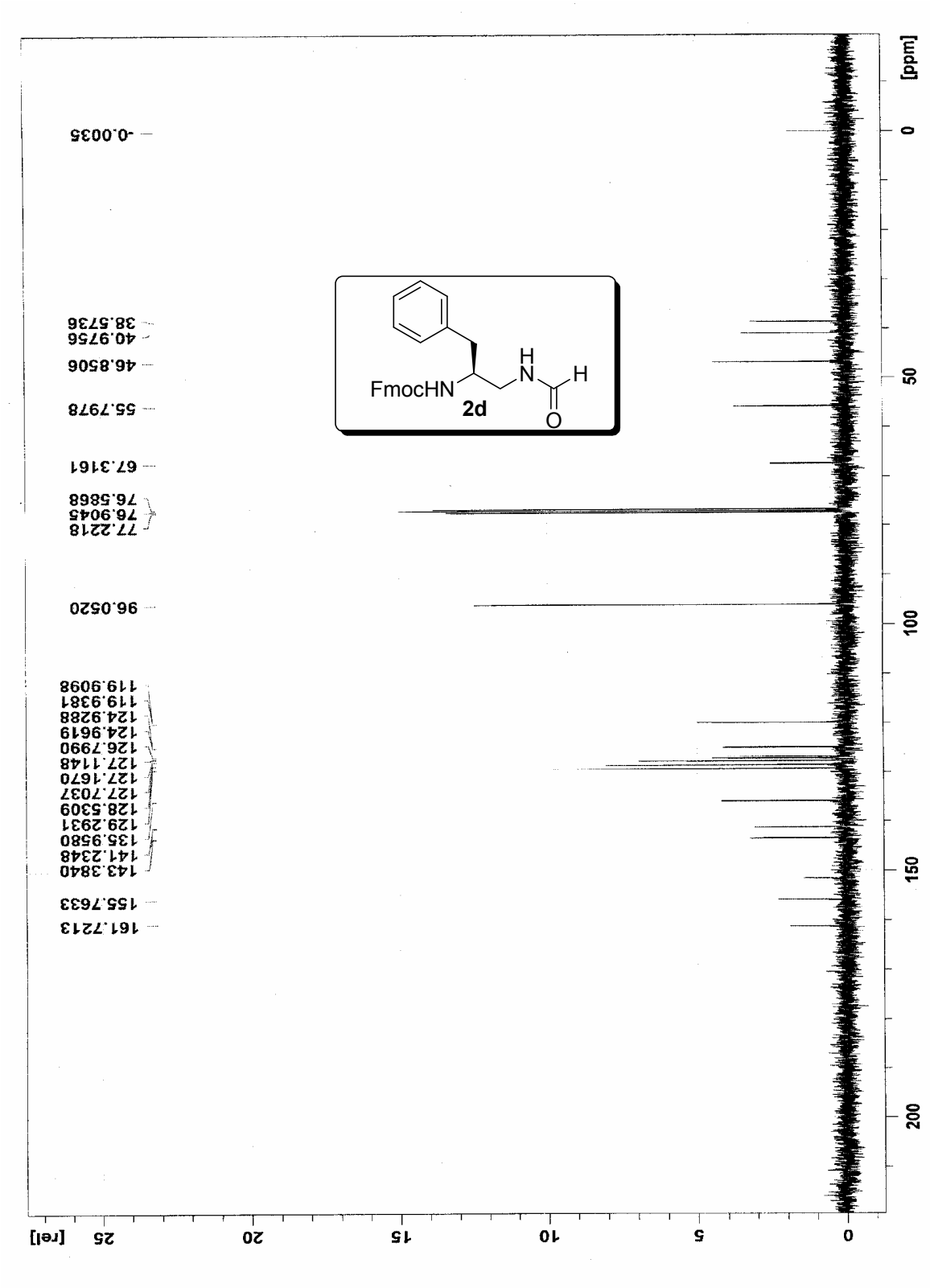
Fmoc-Ala-ψ[CH_2-NHCHO]



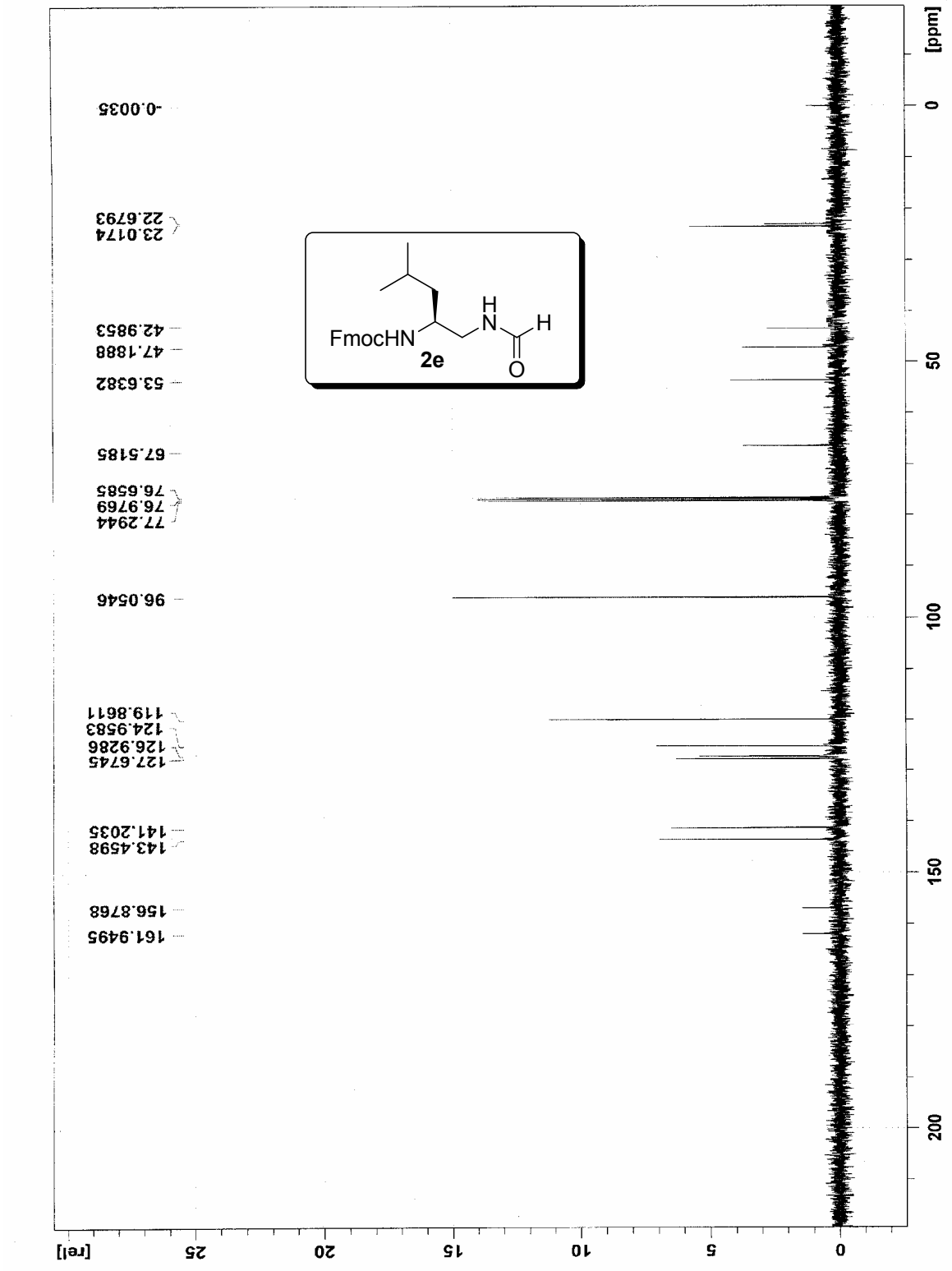
Fmoc-Val-ψ [CH_2-NHCHO]



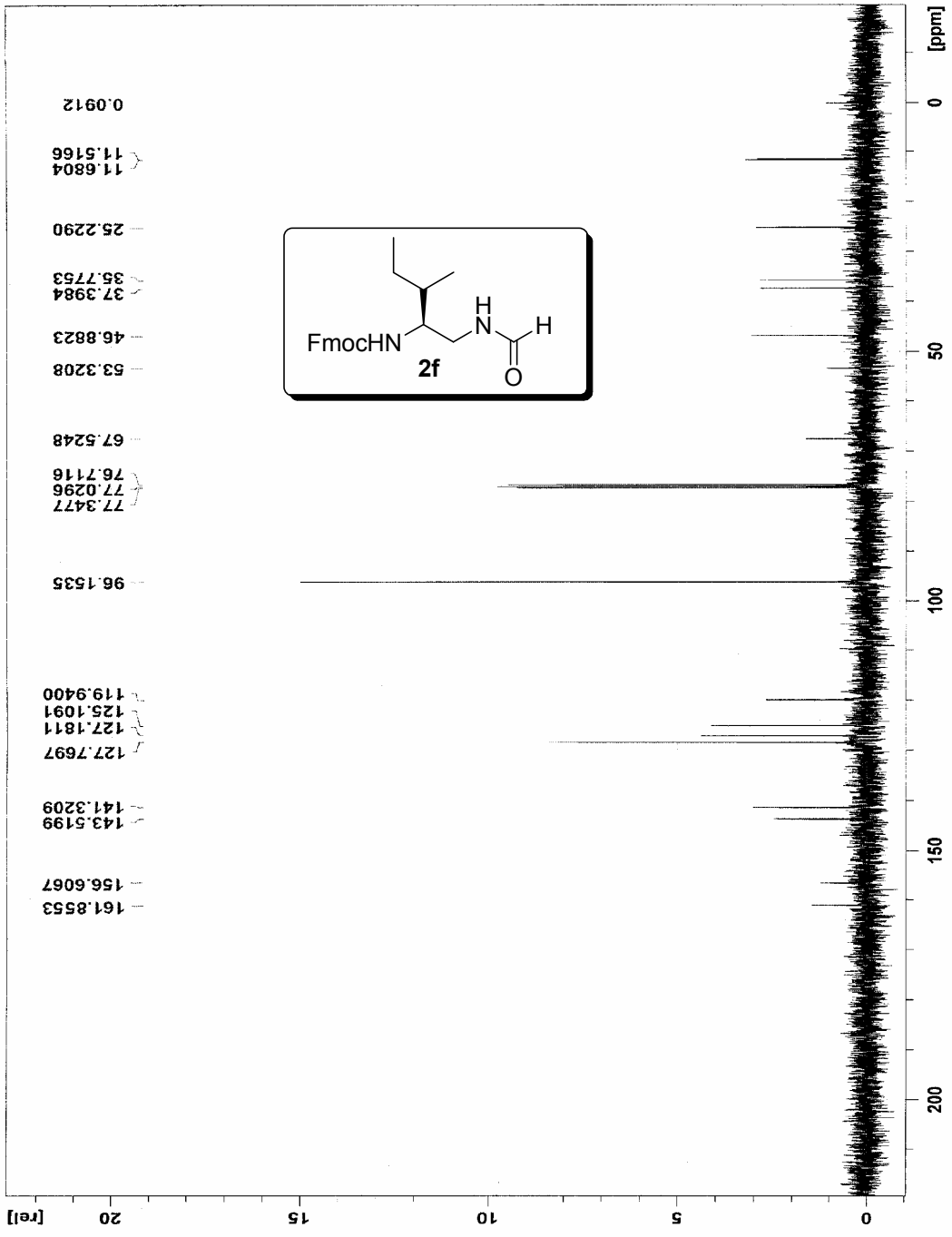
Fmoc-Phe-ψ[CH_2-NHCHO]



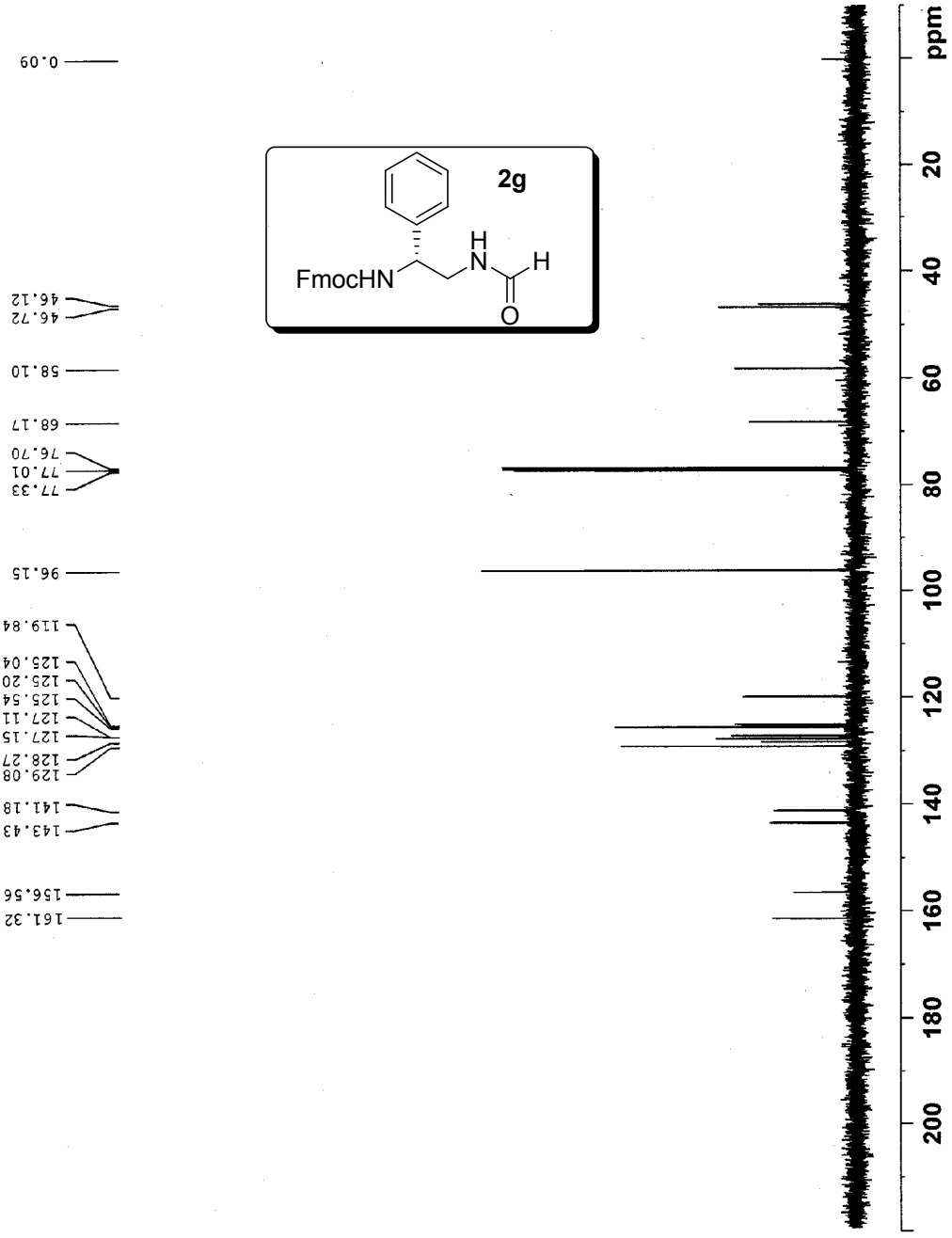
Fmoc-Leu-ψ[CH_2-NHCHO]



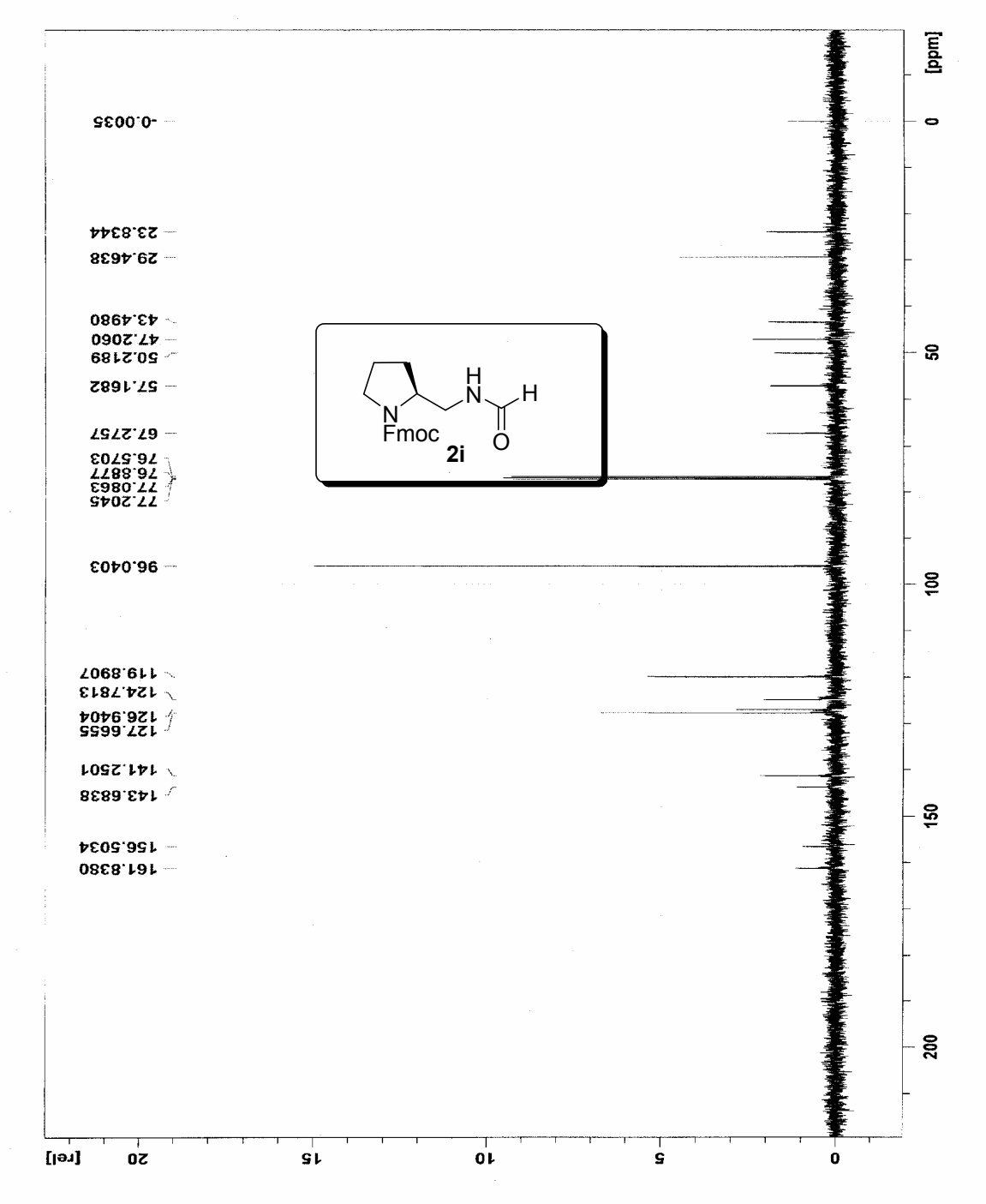
Fmoc-Ile-ψ[CH_2-NHCHO]



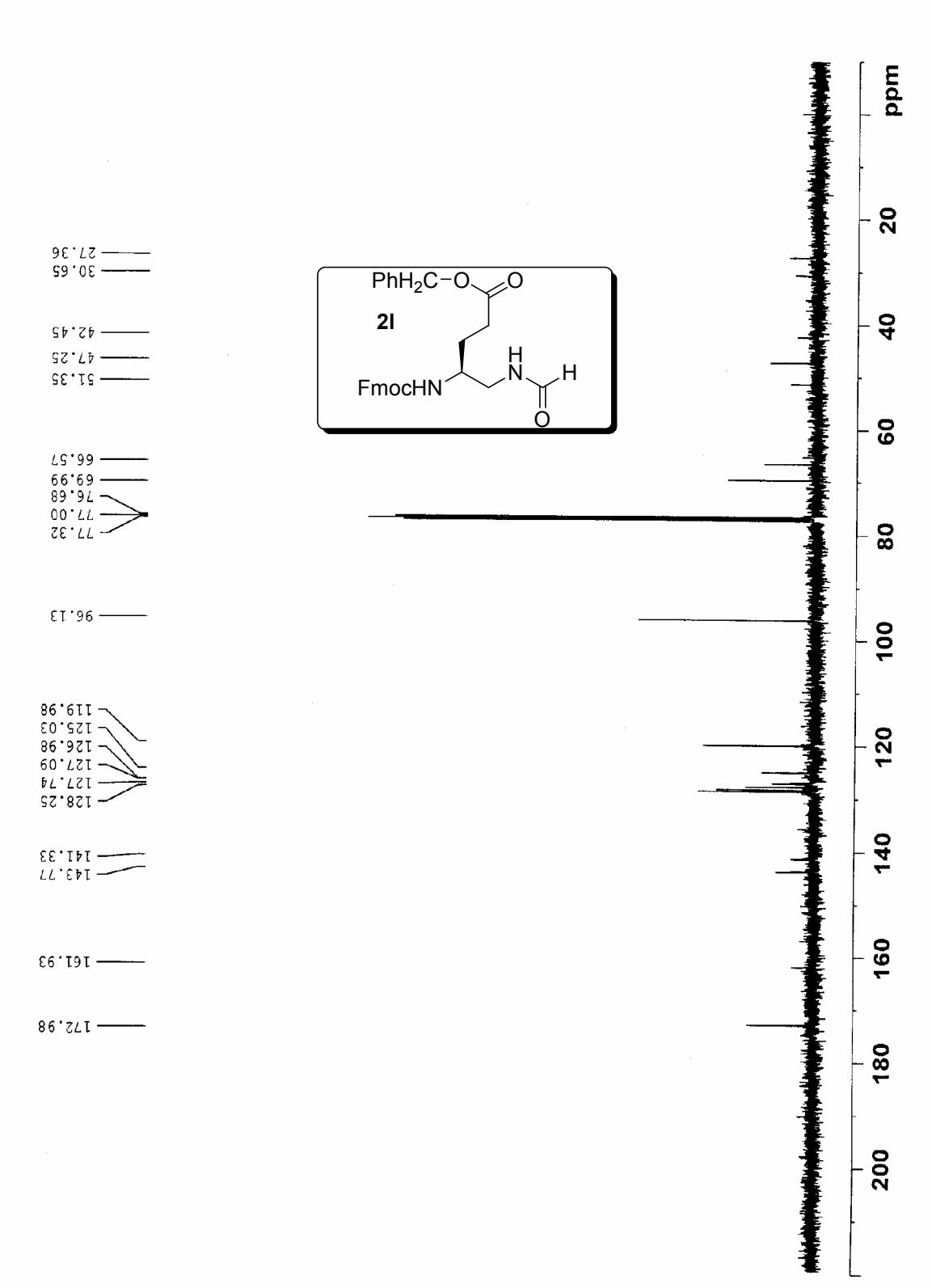
Fmoc-D-Phg-ψ[CH_2-NHCHO]



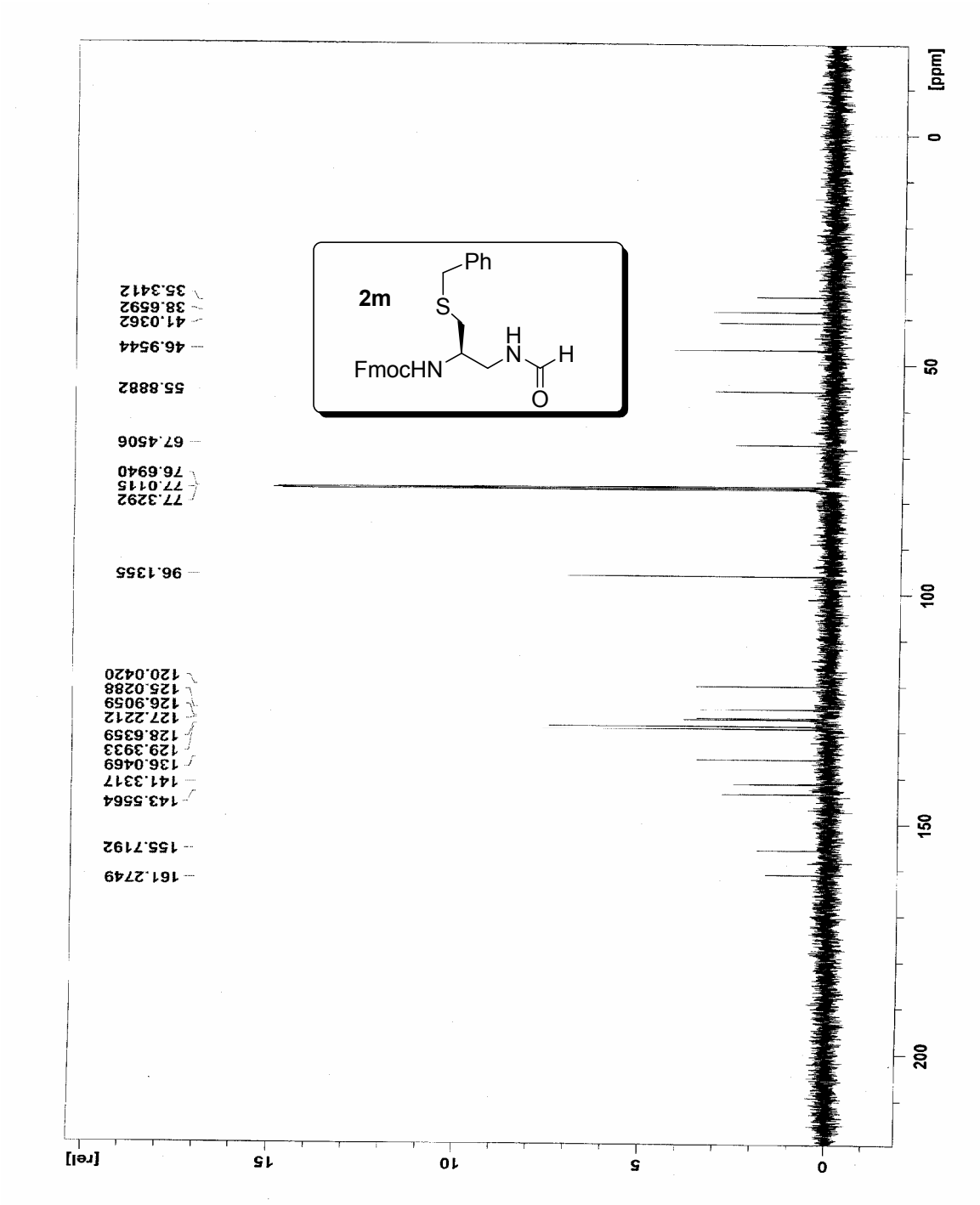
Fmoc-Pro-ψ [CH_2-NHCHO]



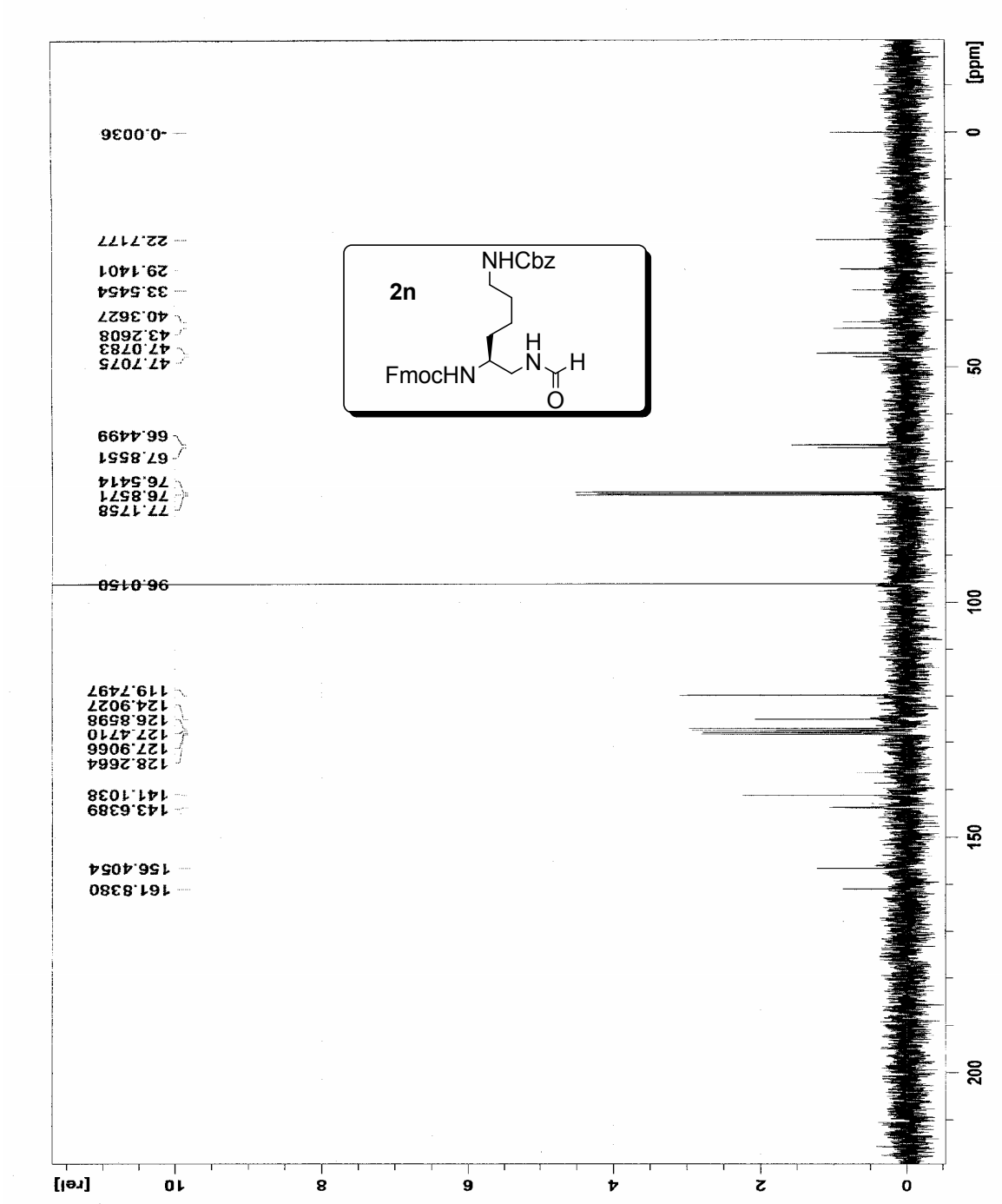
Fmoc-Glu(Bzl)-ψ[CH_2-NHCHO]



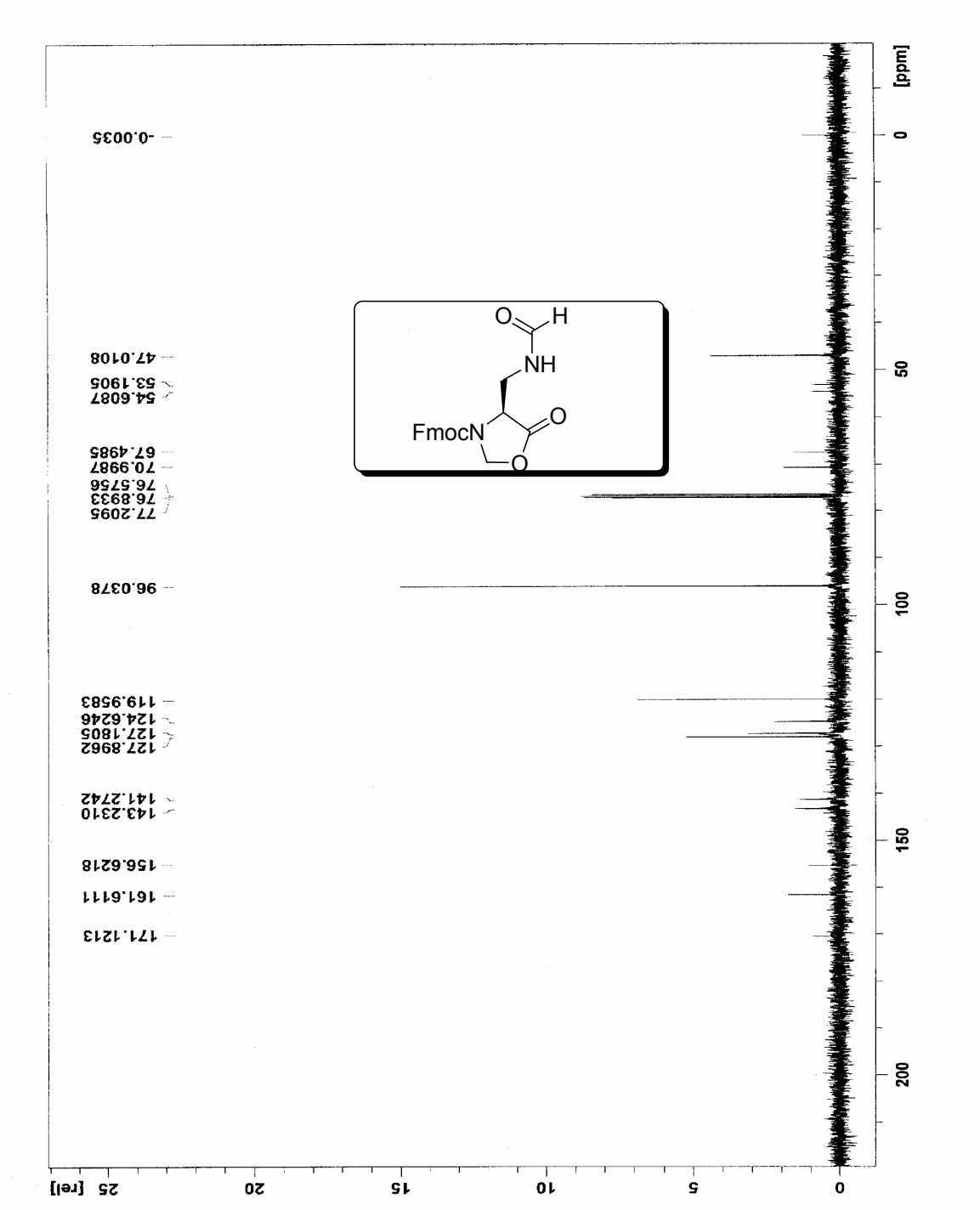
Fmoc-Cys(Bzl)-ψ[CH_2-NHCHO]



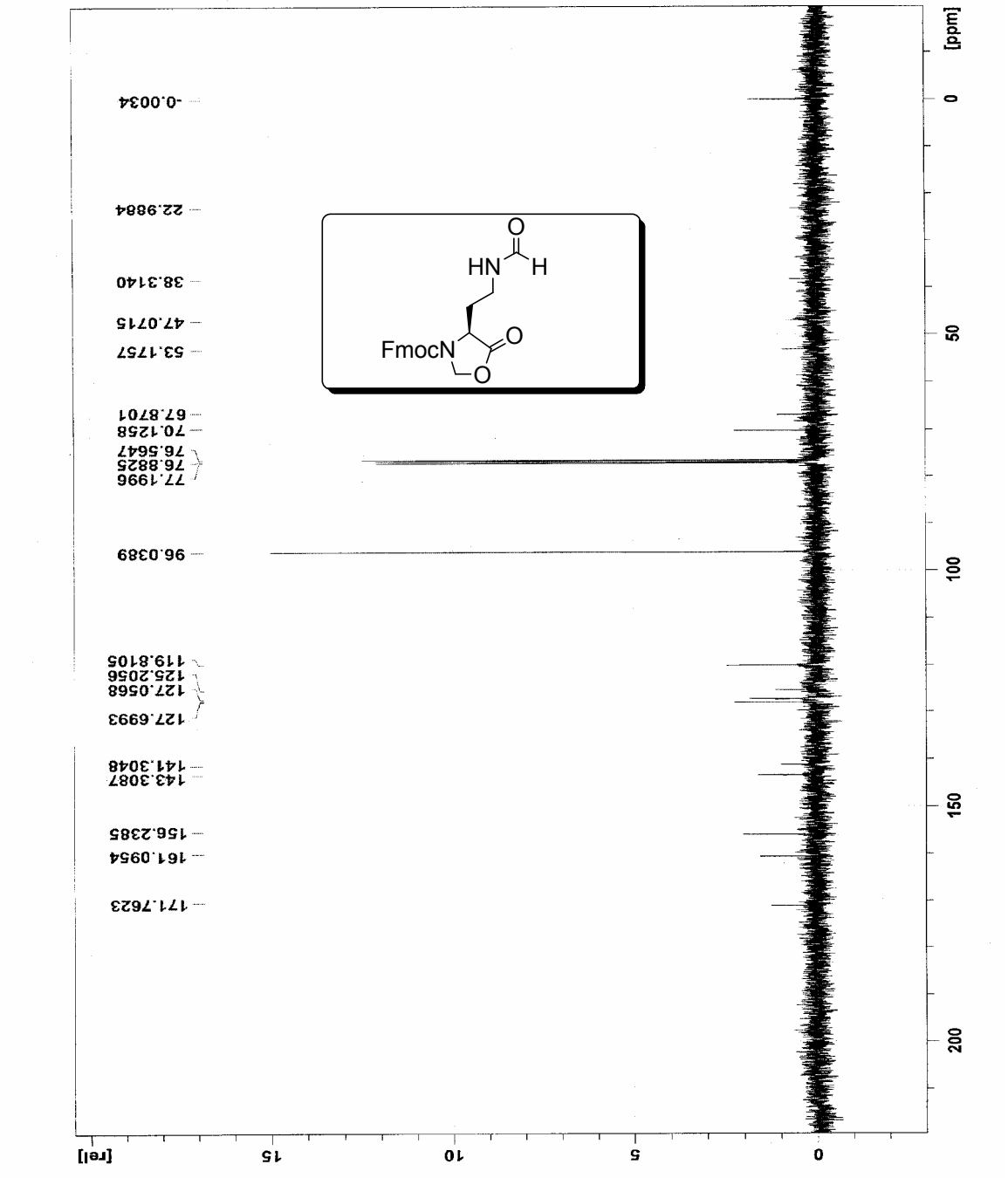
Fmoc-Lys(Cbz)-ψ [CH_2-NHCHO]



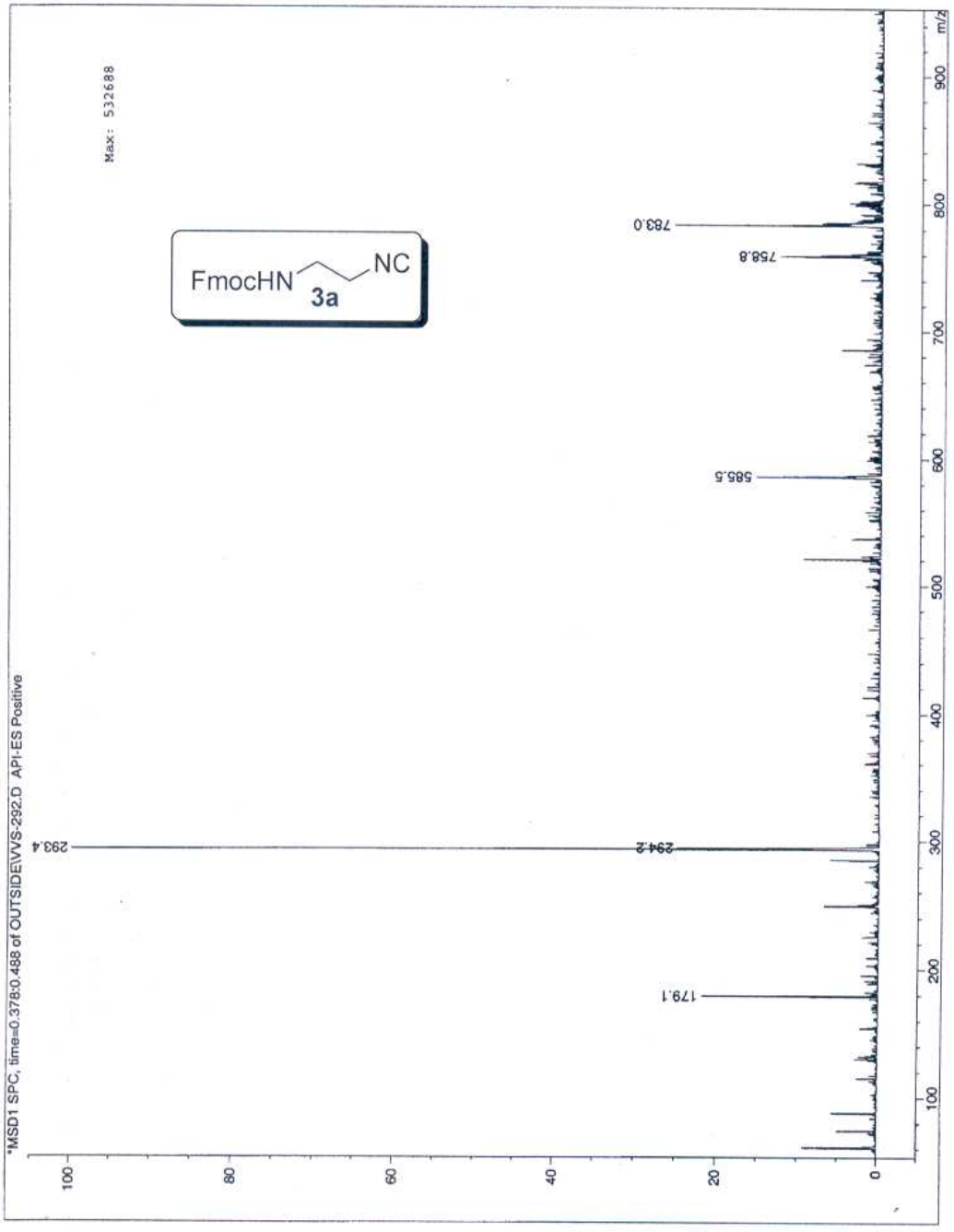
Fmoc-Asp(ψ[CH_2NHCHO])-5-oxazolidinone



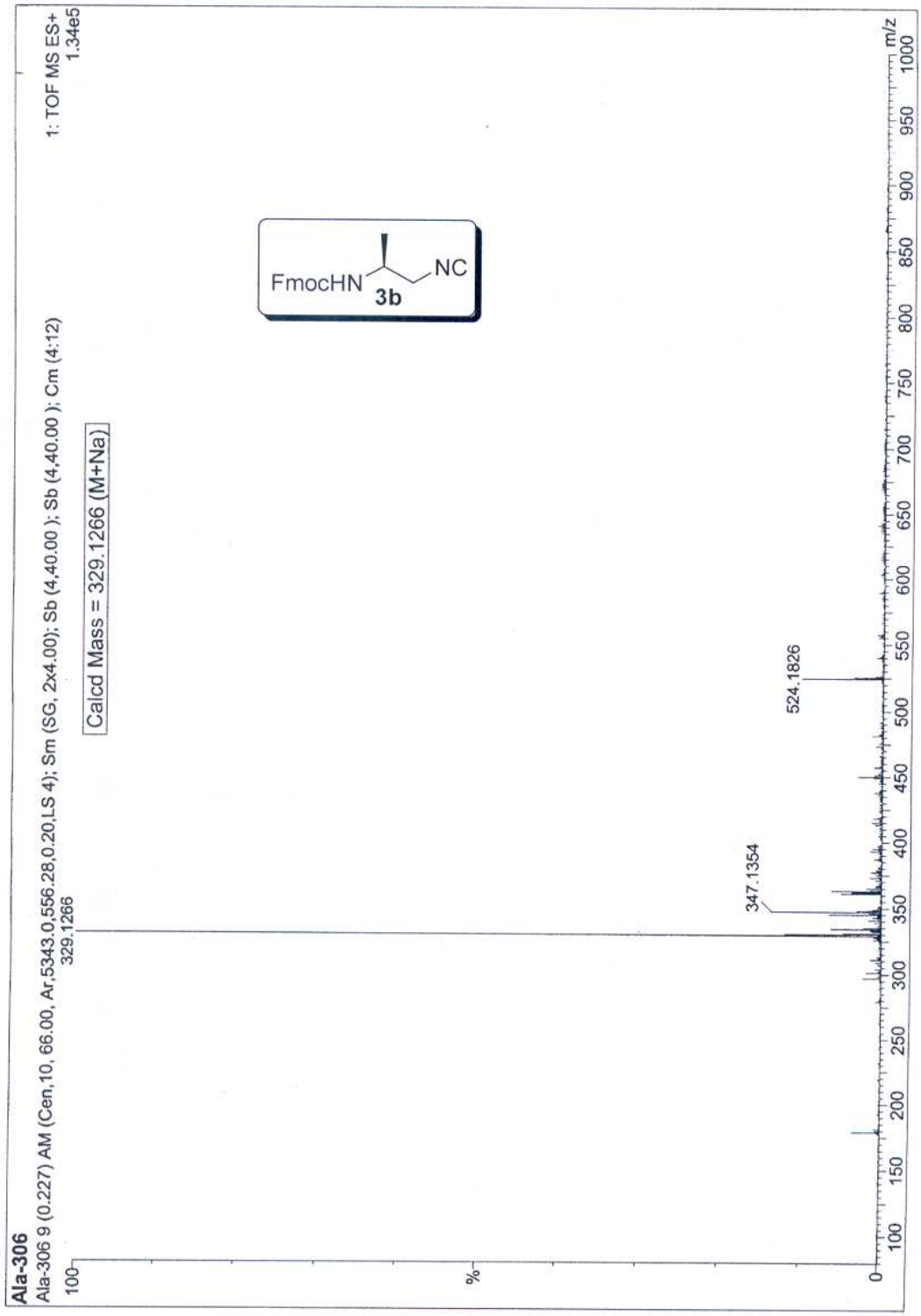
Fmoc-Glu(ψ[$(CH_2)_2$NHCHO])-5-oxazolidinone



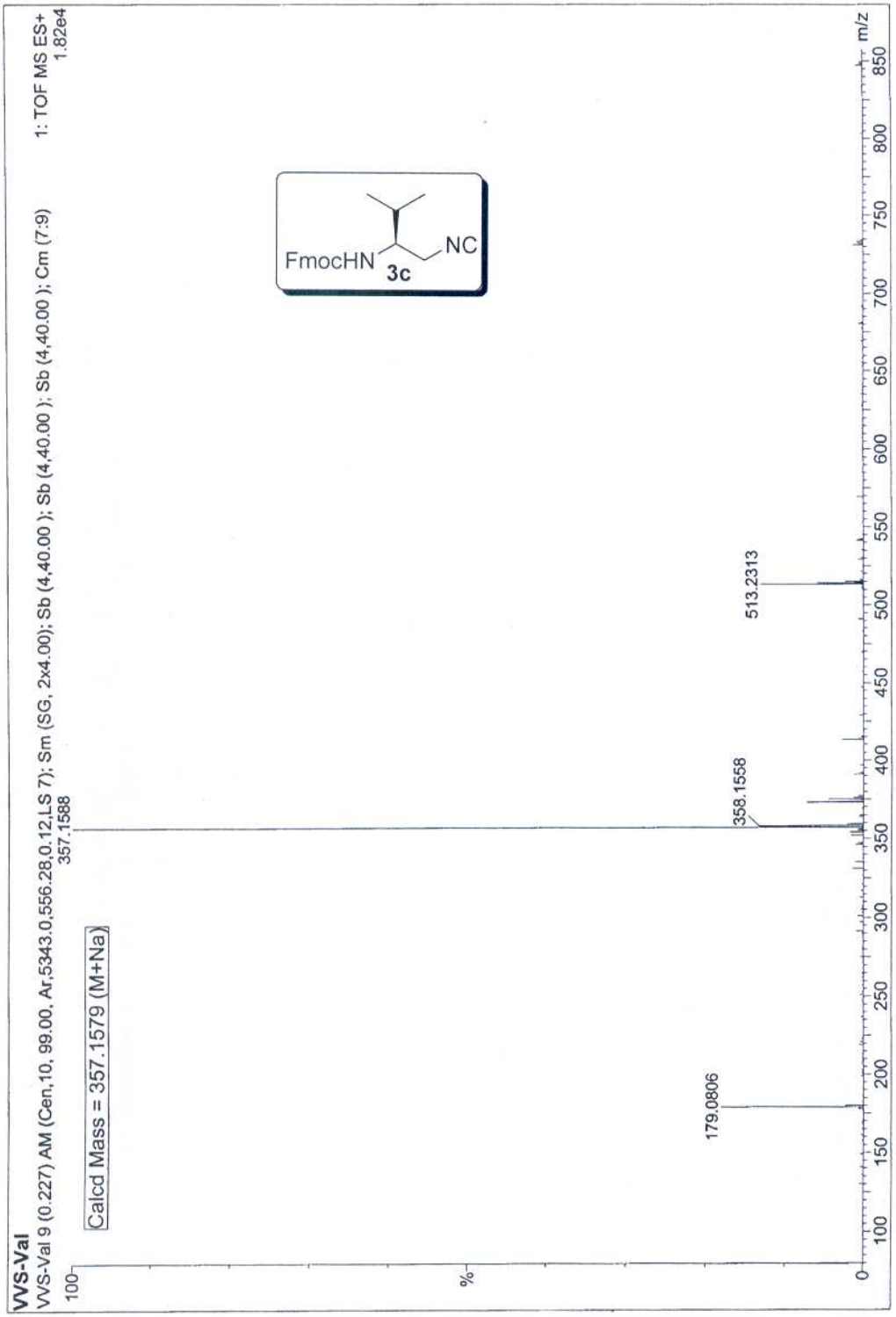
Fmoc-Gly-ψ[CH_2-NC]



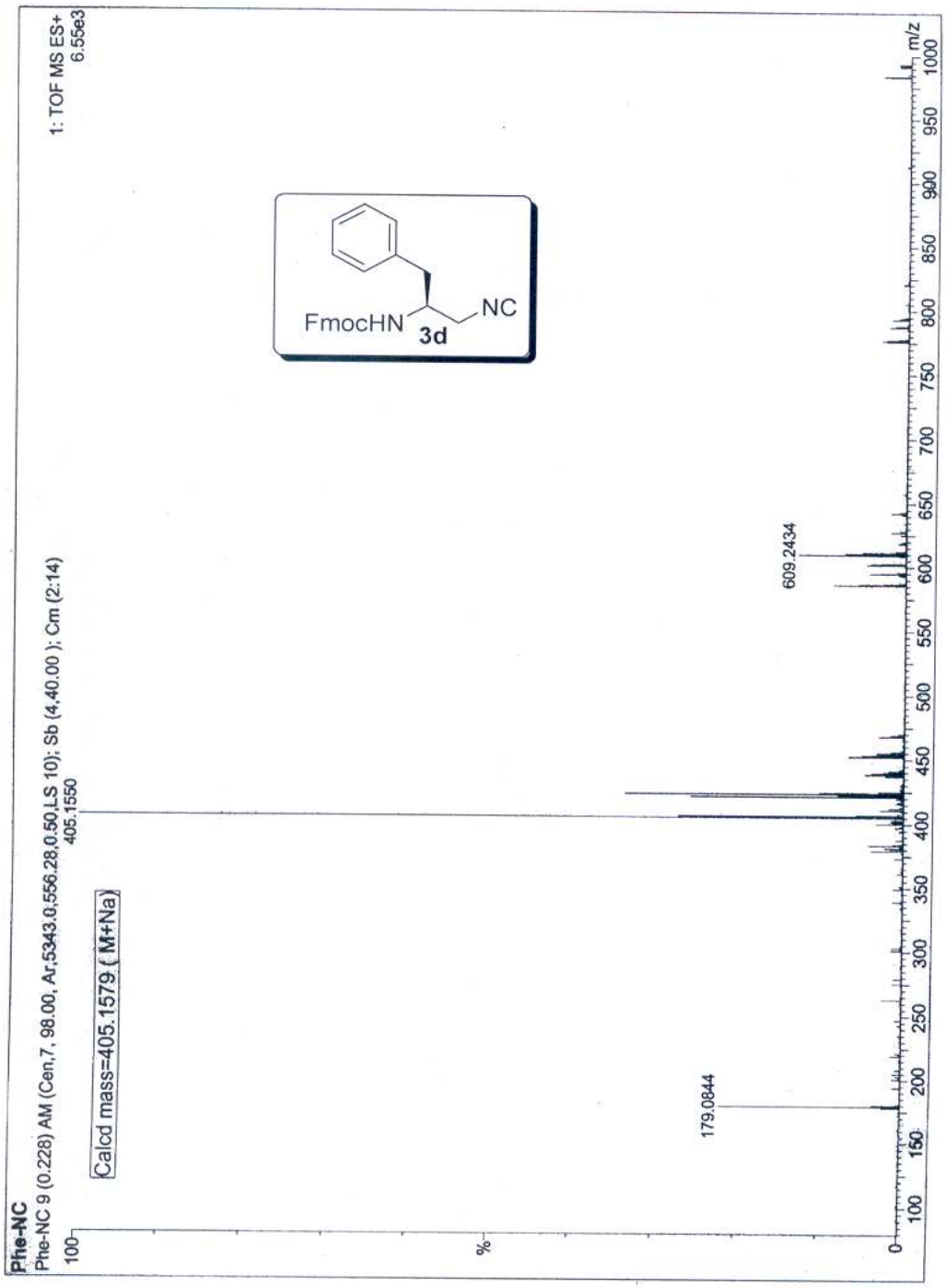
Fmoc-Ala-ψ[CH_2-NC]



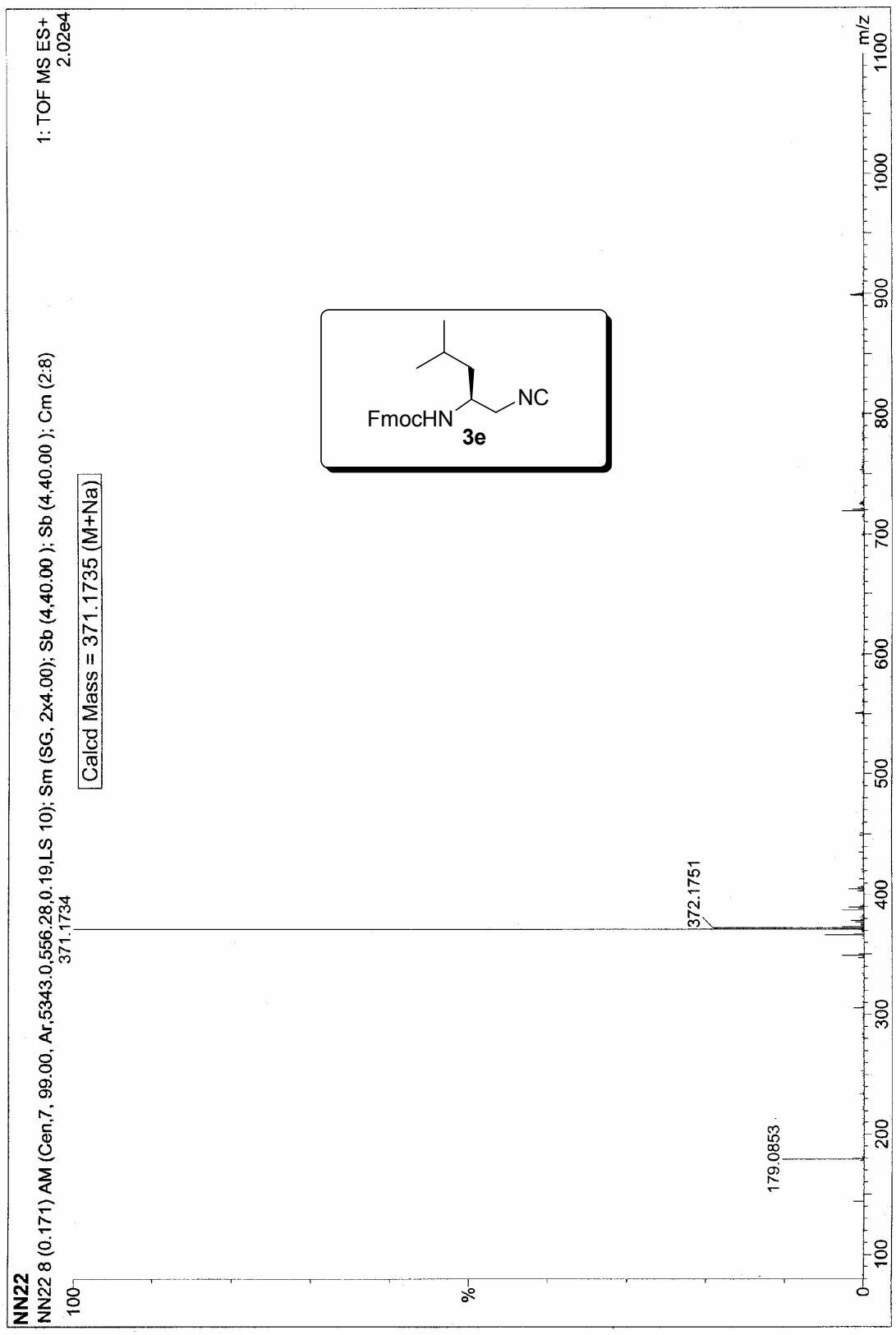
Fmoc-Val-ψ[CH_2-NC]



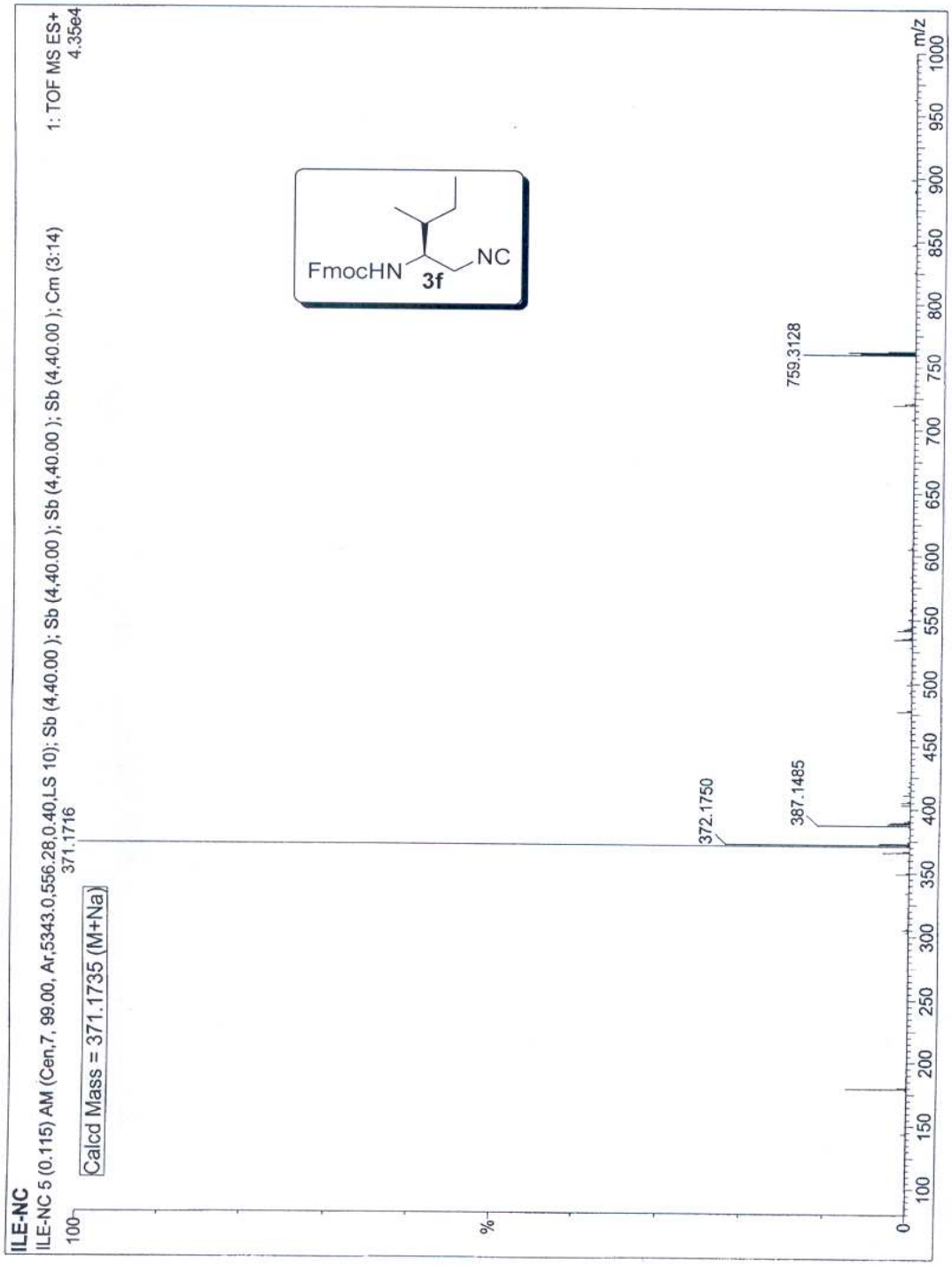
Fmoc-Phe-ψ[CH_2-NC]



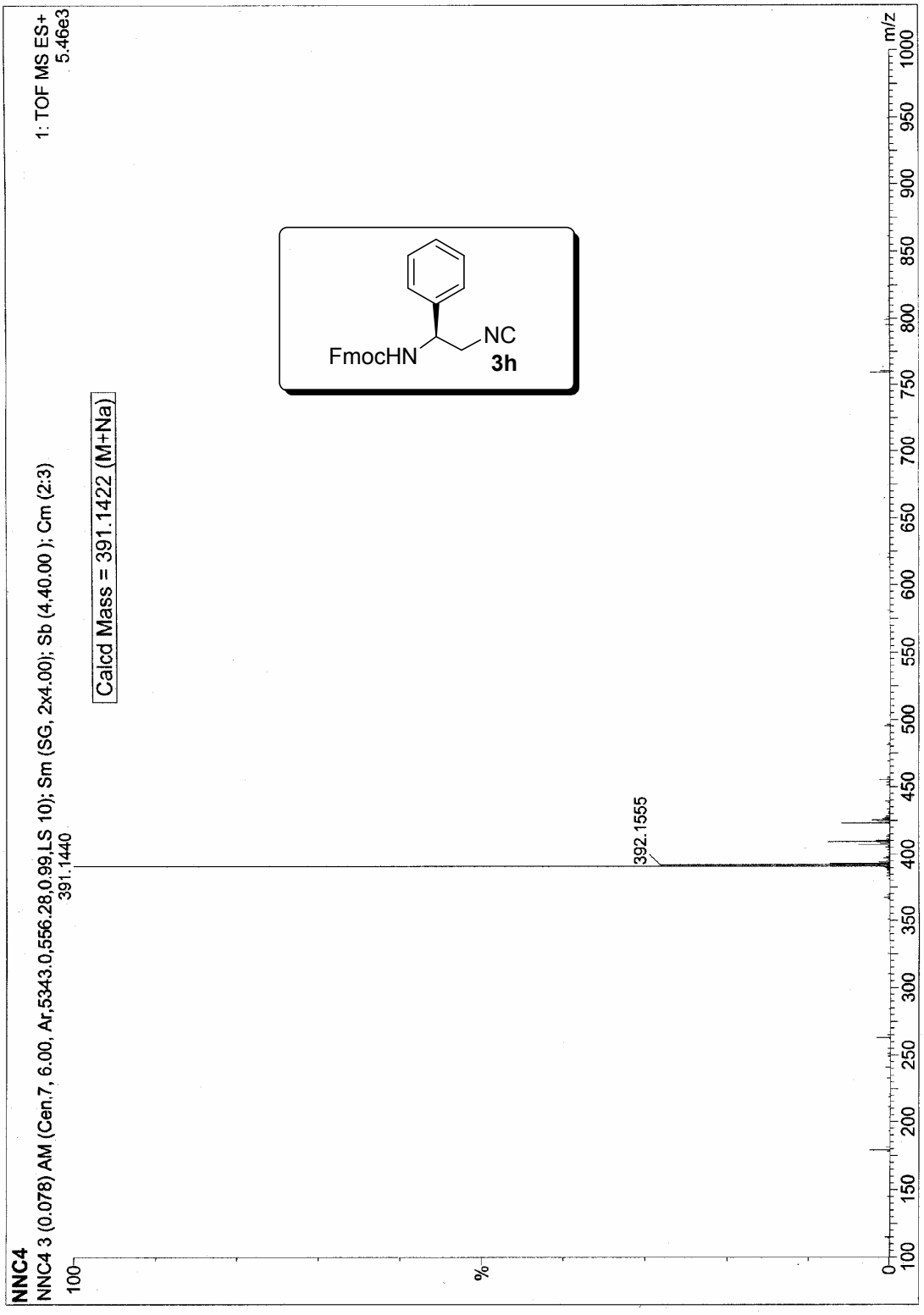
Fmoc-Leu-ψ[CH_2NC]



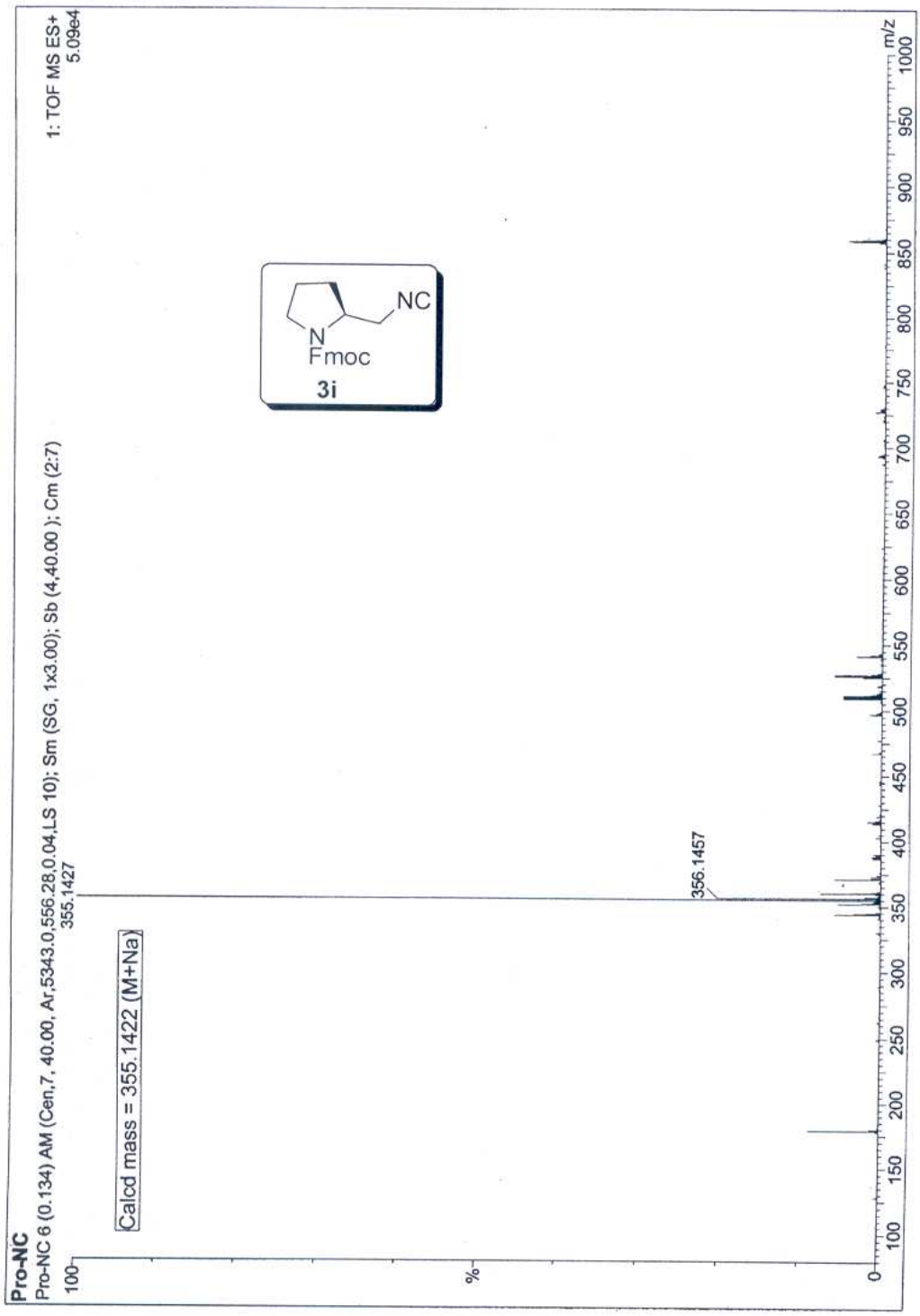
Fmoc-Ile-ψ[CH_2-NC]



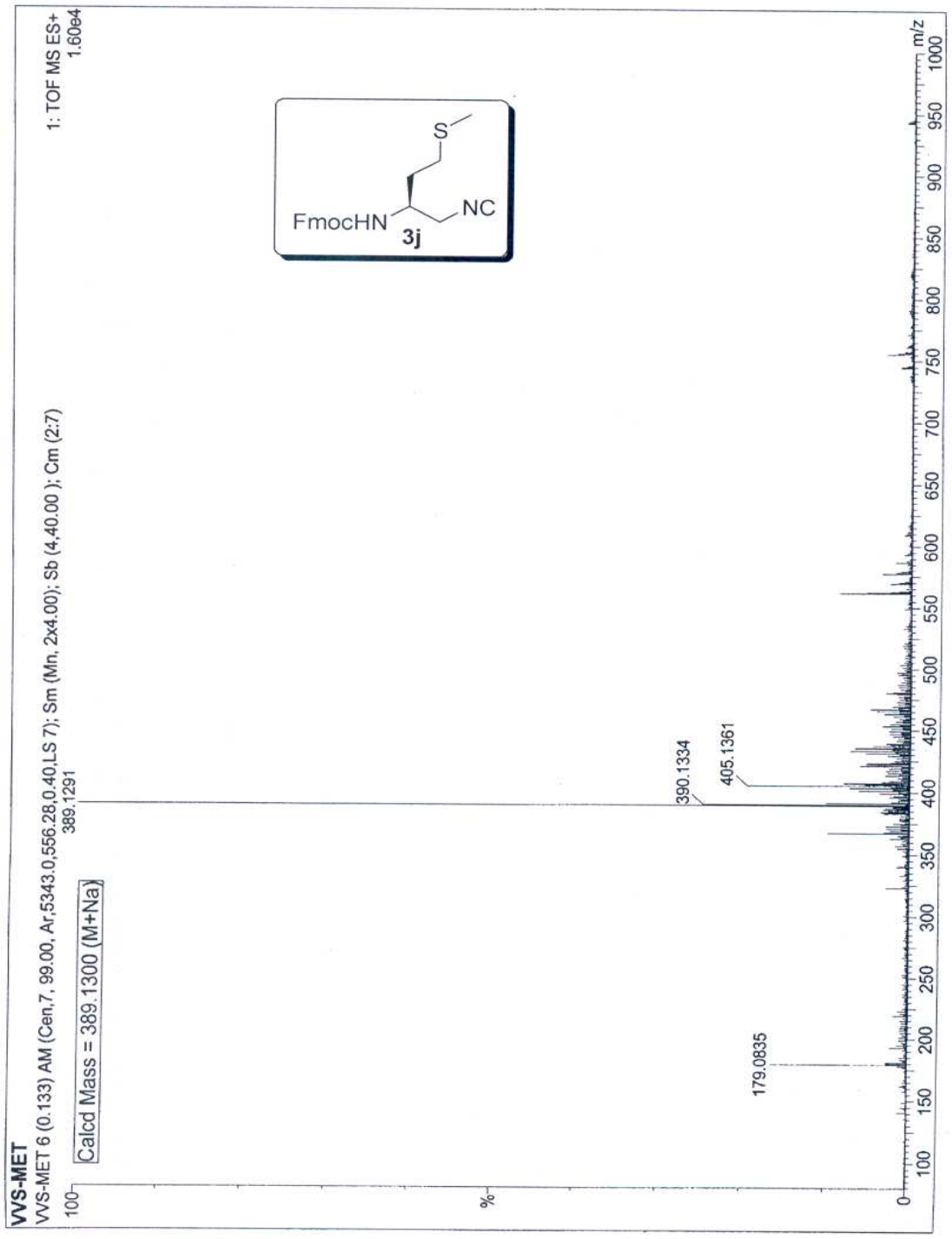
Fmoc-L-Phg-ψ[CH_2NC]



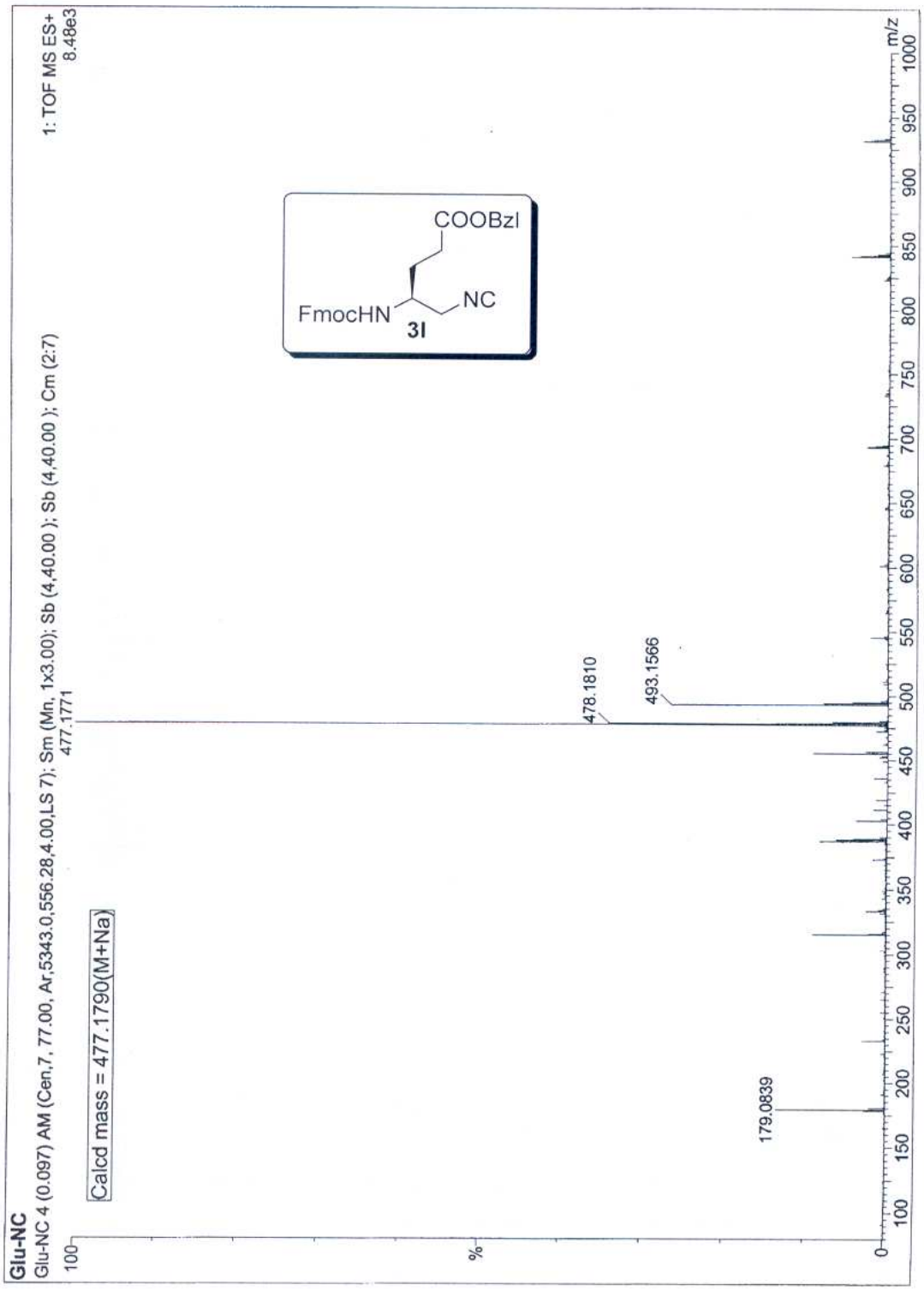
Fmoc-Pro-ψ[CH_2-NC]



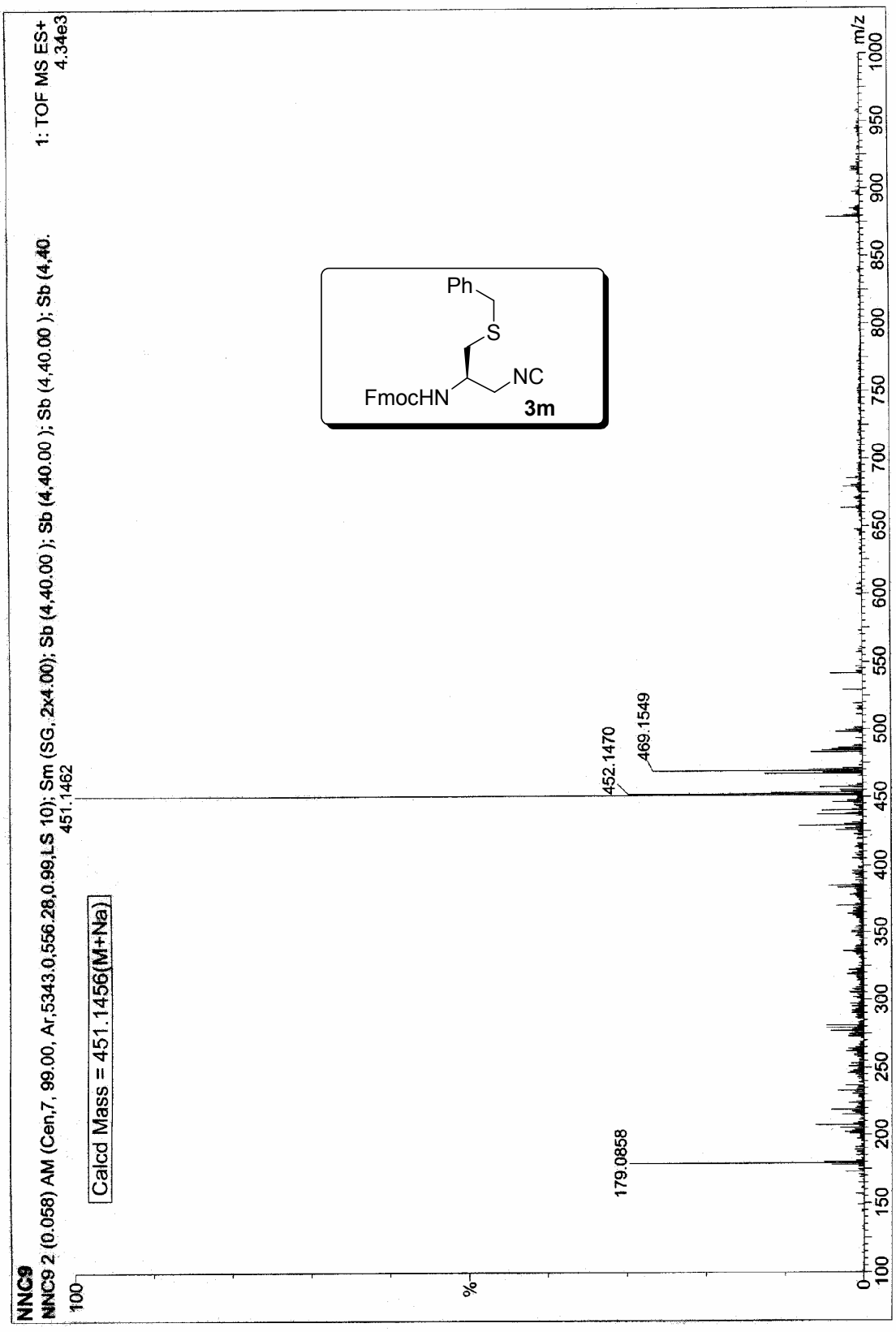
Fmoc-Met-ψ[CH_2-NC]



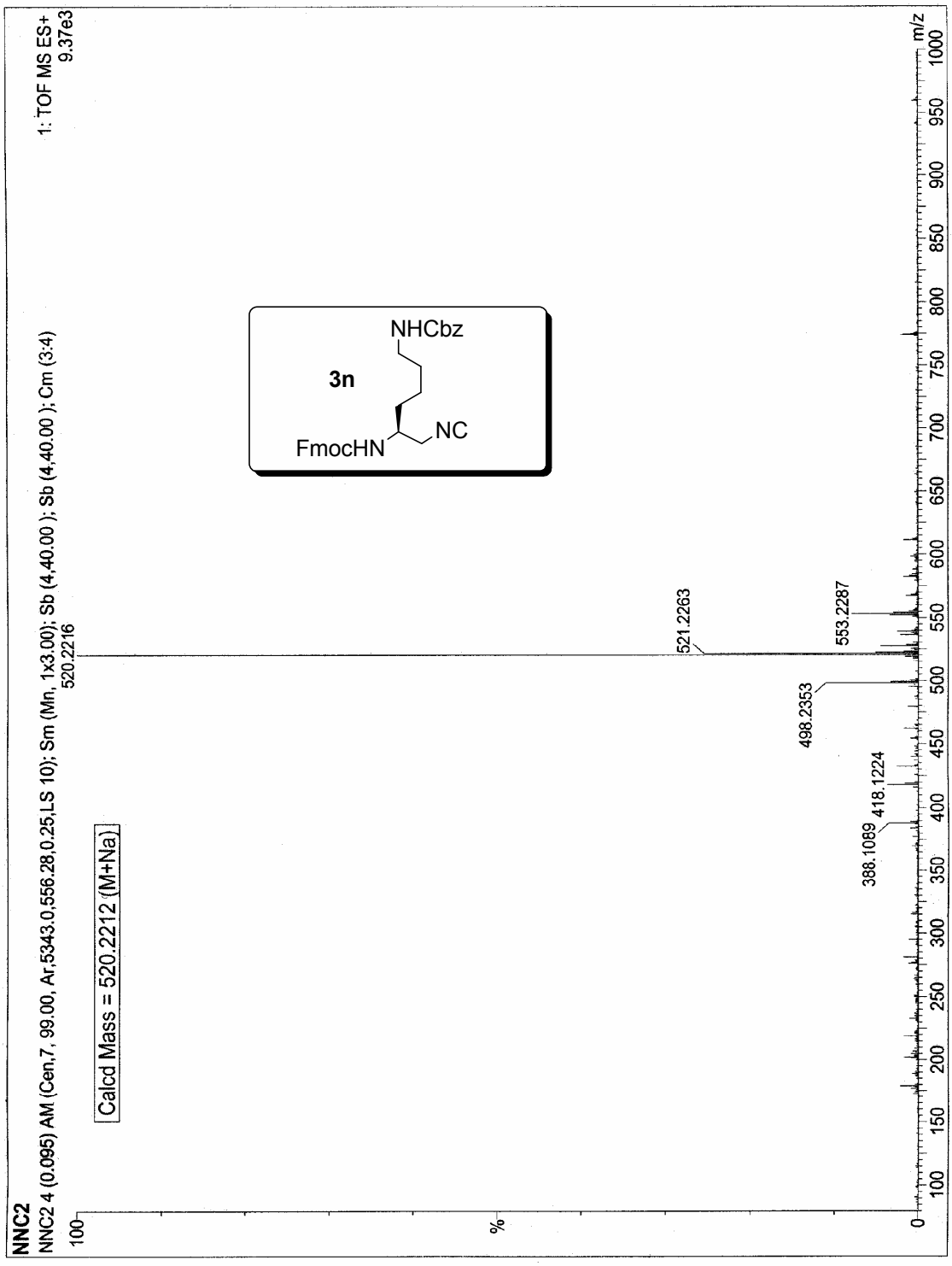
Fmoc-Glu(Bzl)-ψ[CH_2-NC]



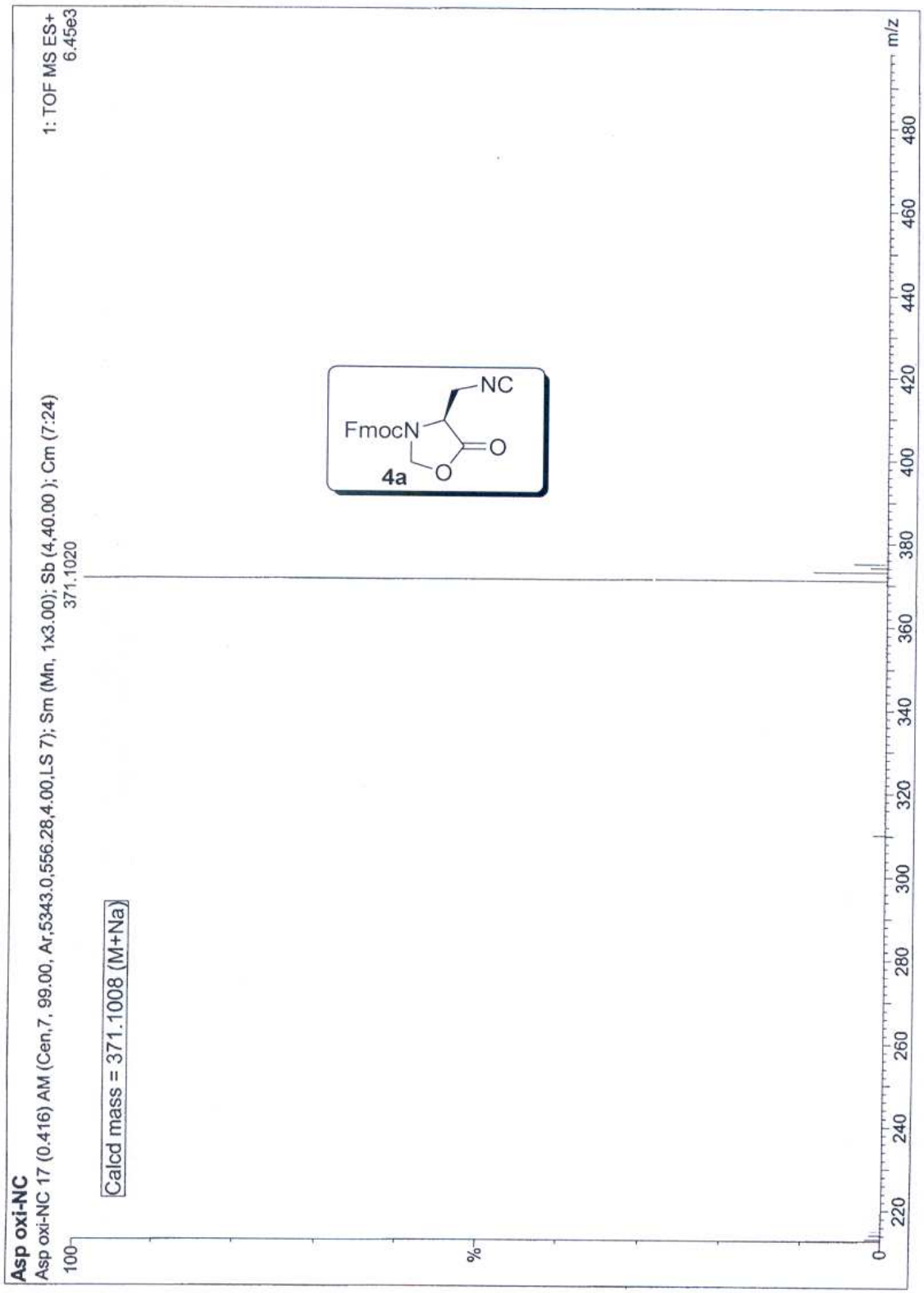
Fmoc-Cys(Bzl)-ψ[CH_2NC]



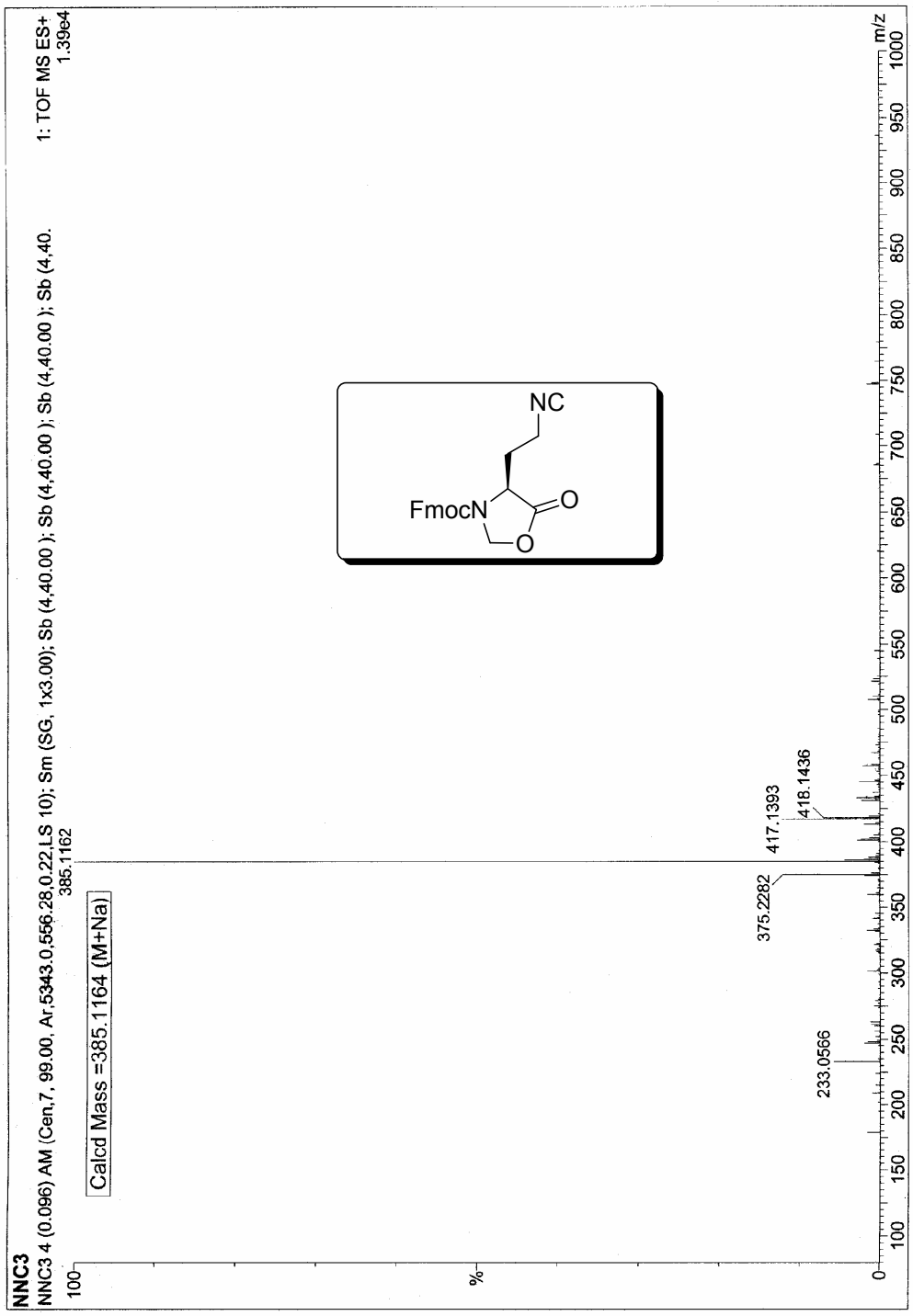
Fmoc-Lys(Cbz)-ψ [CH_2NC]



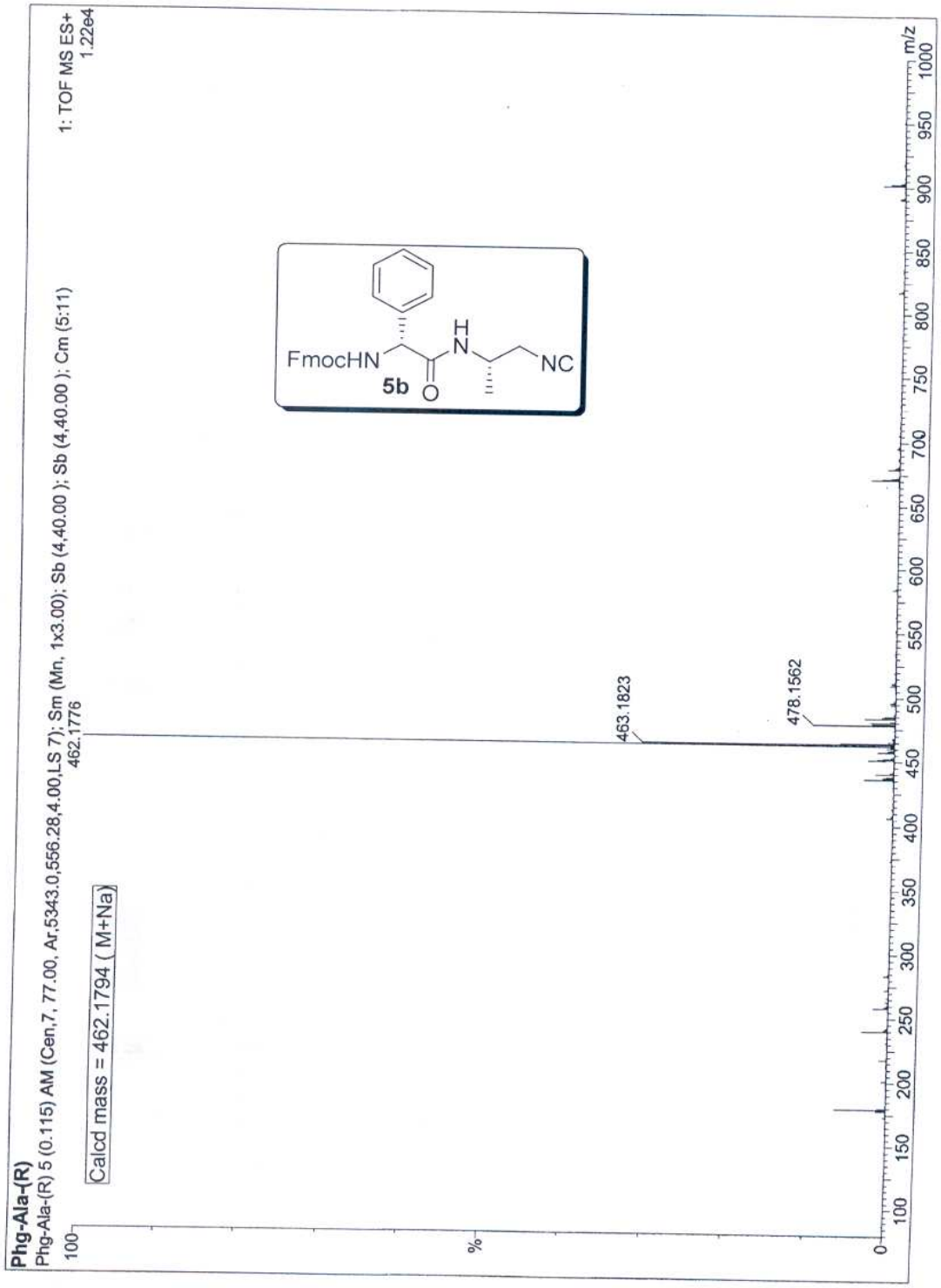
Fmoc-Asp(ψ[CH_2NC])-5-oxazolidinone



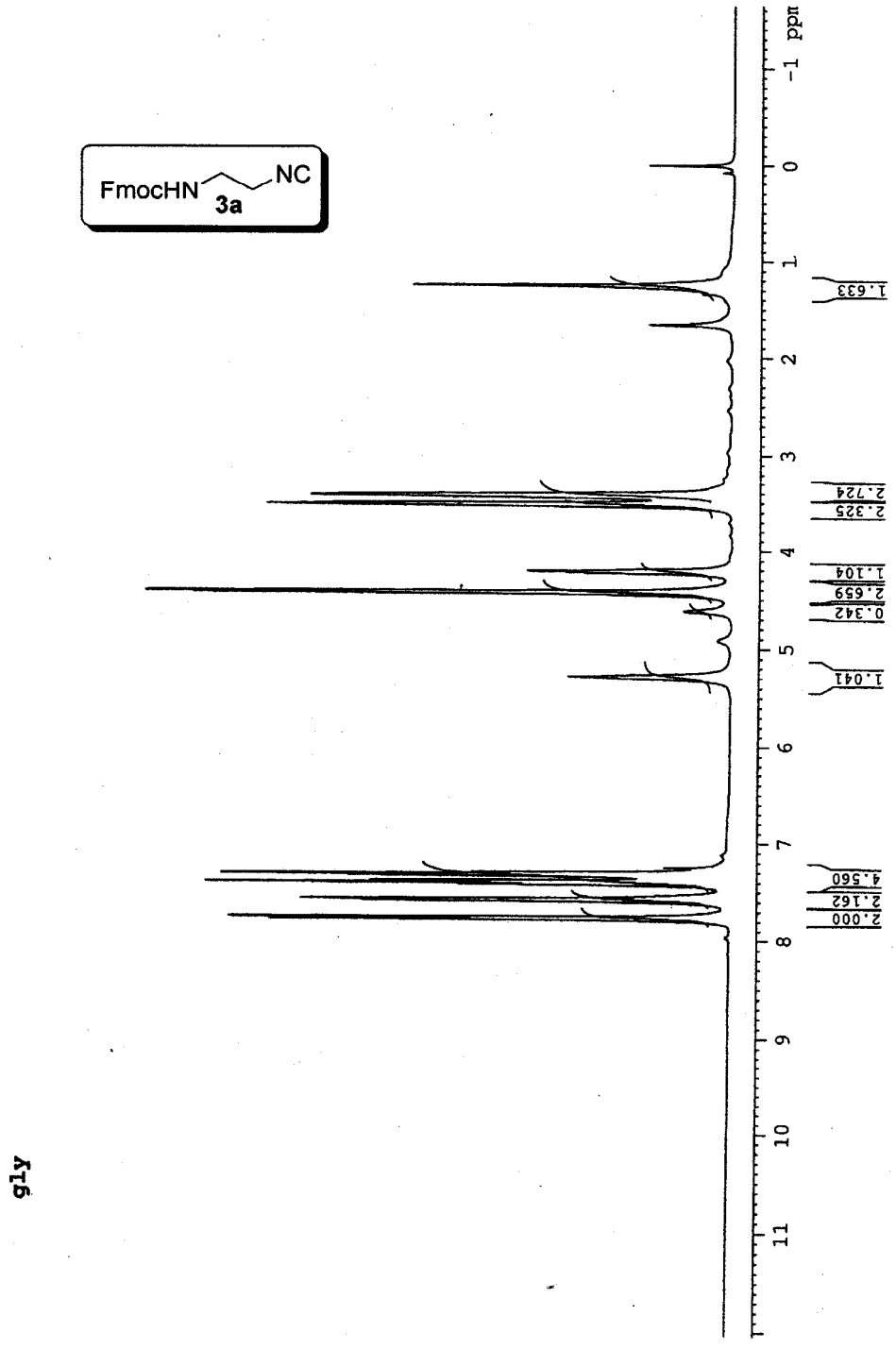
Fmoc-Glu(ψ[$(CH_2)_2$NC])-5-oxazolidinone



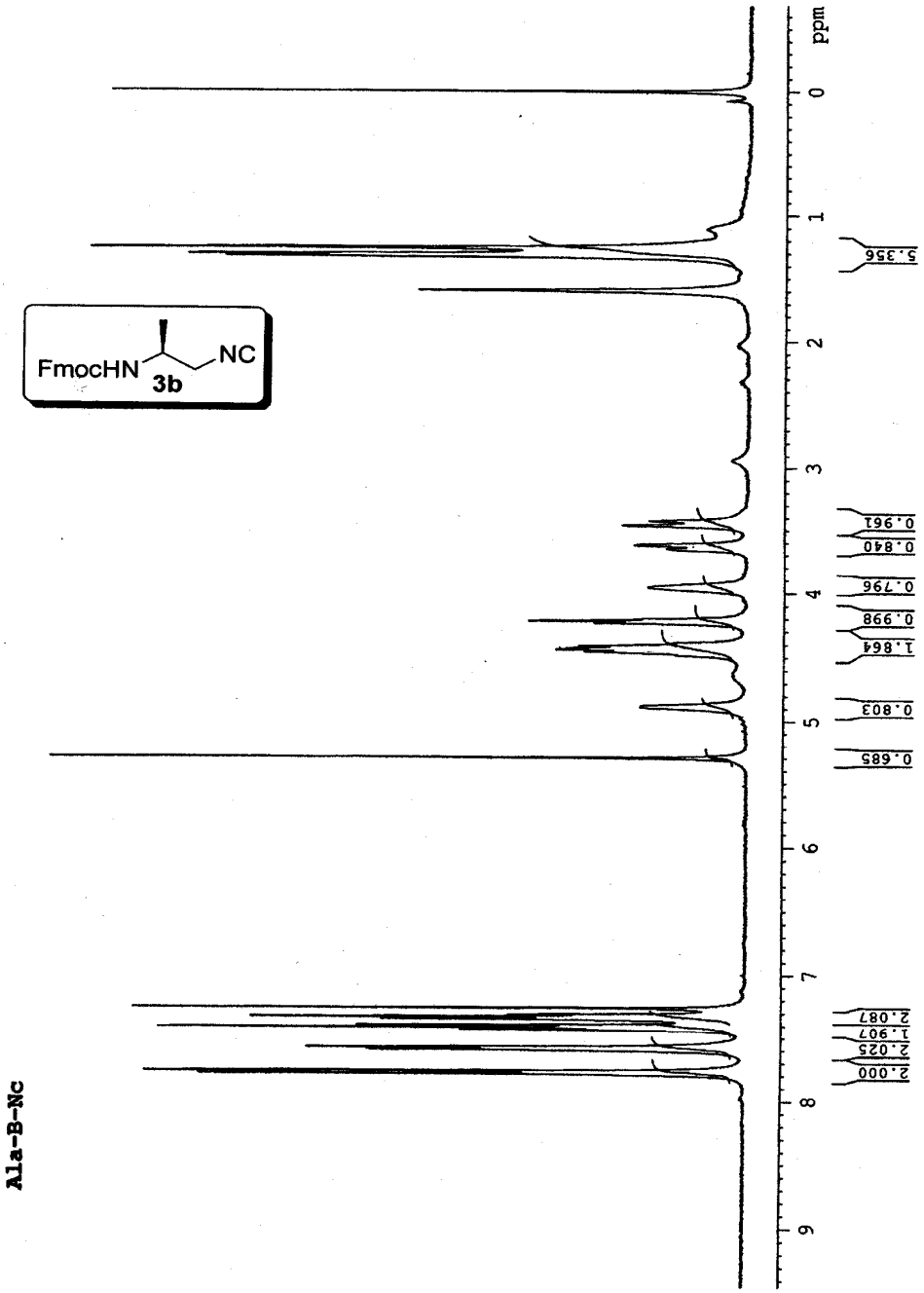
Fmoc-(R-)Phg-Ala-ψ[CH_2-NC]



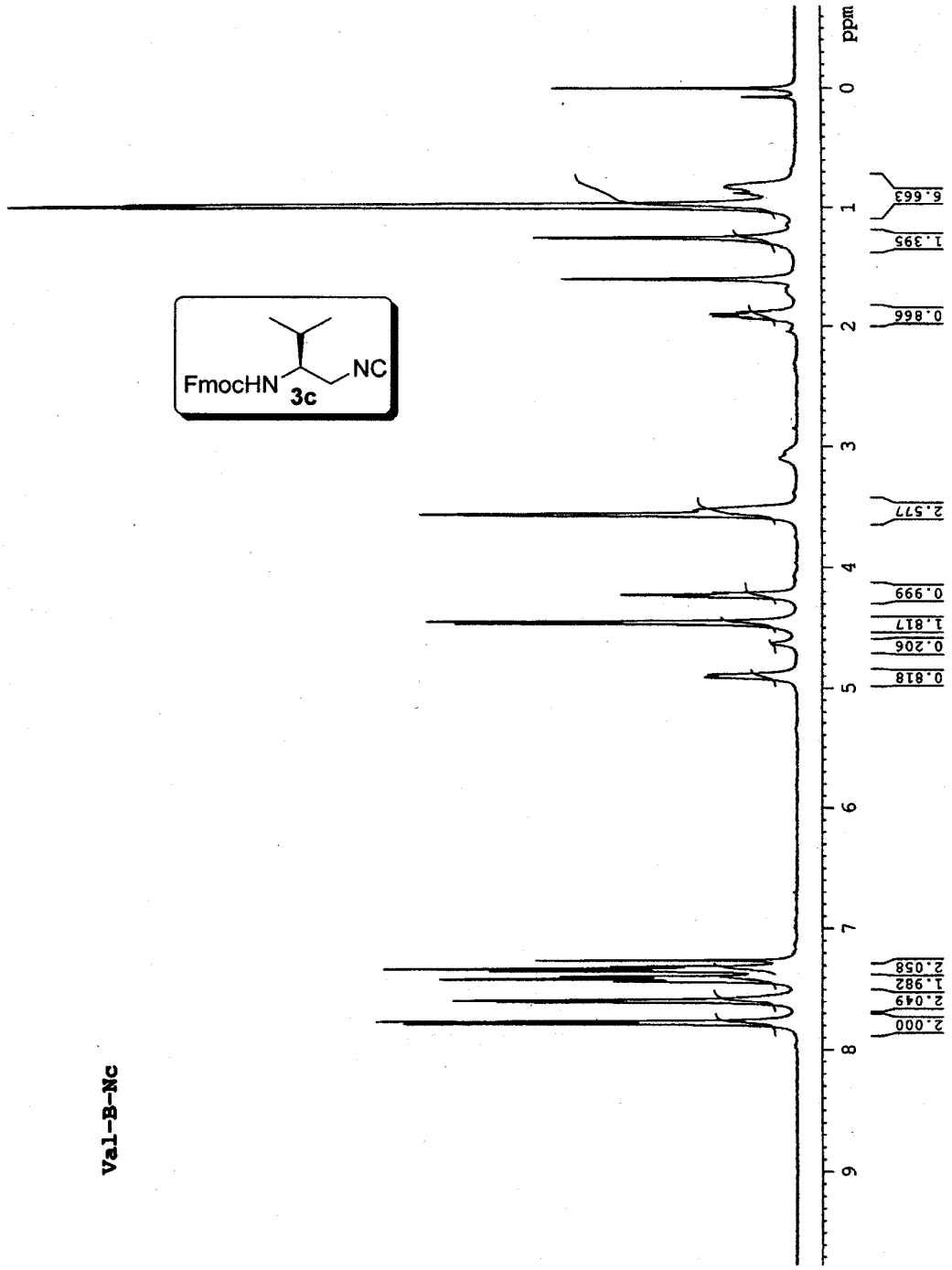
Fmoc-Gly-ψ[CH_2-NC]



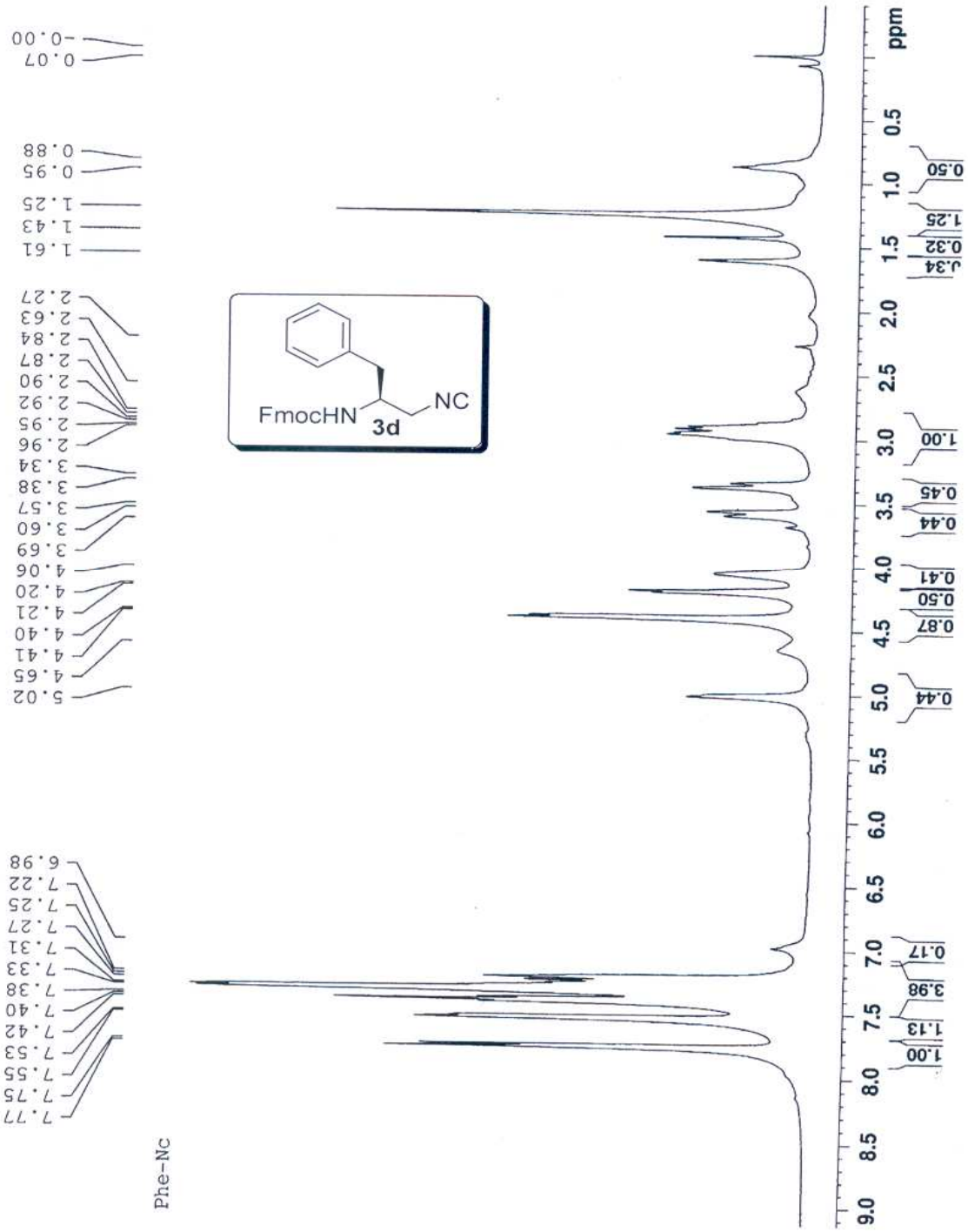
Fmoc-Ala-ψ[CH_2-NC]



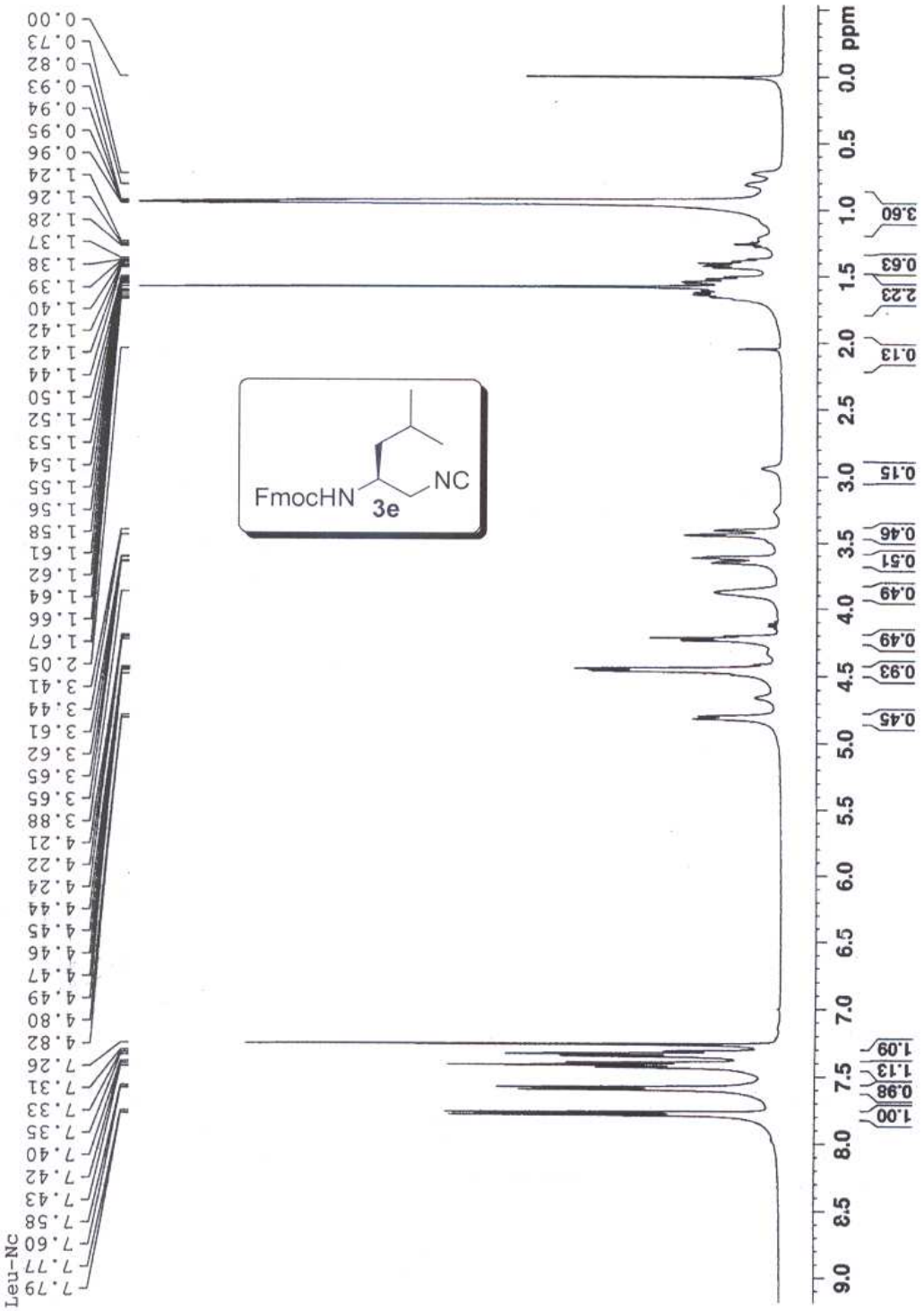
Fmoc-Val-ψ[CH_2-NC]



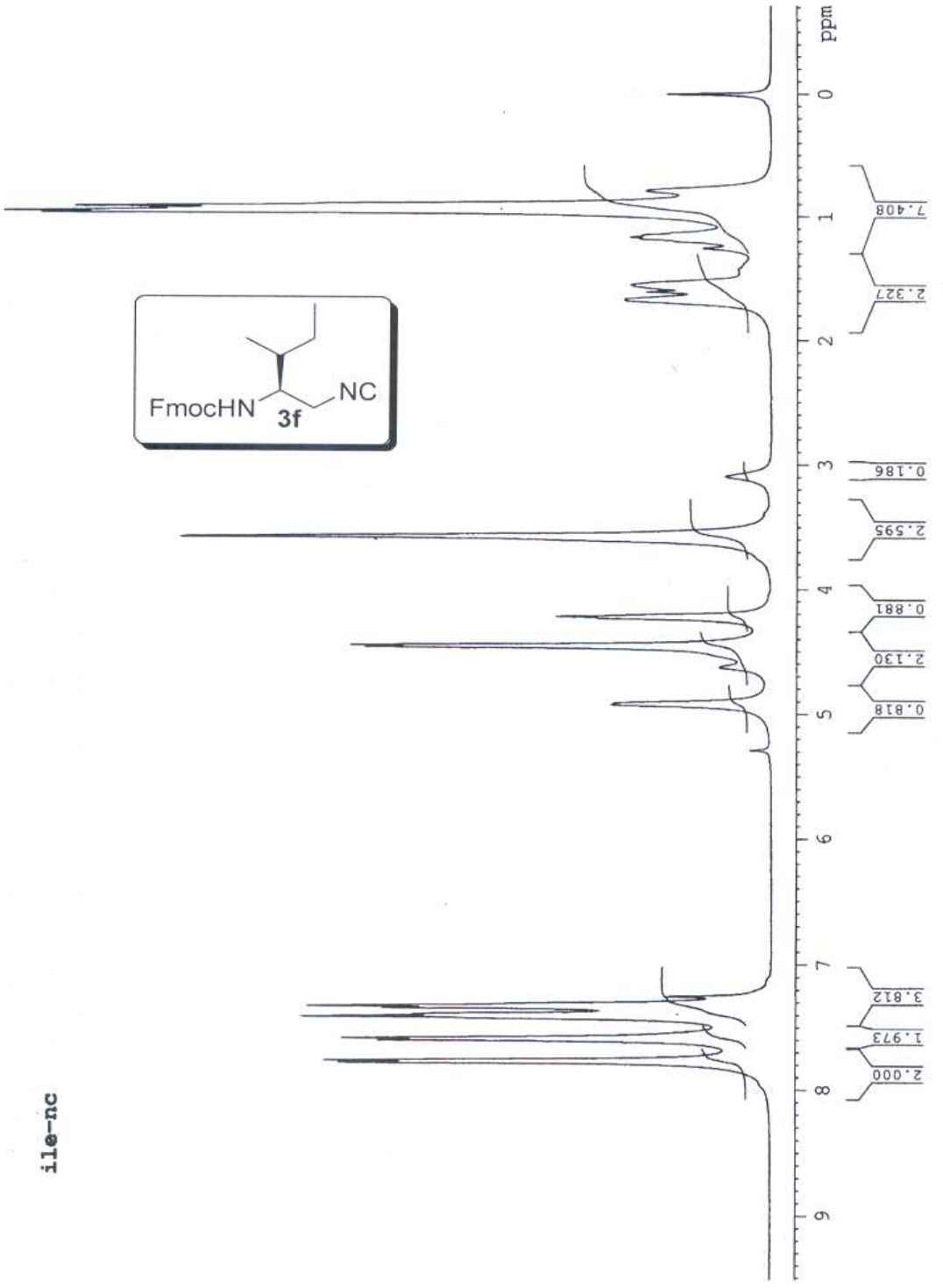
Fmoc-Phe-ψ[CH_2-NC]



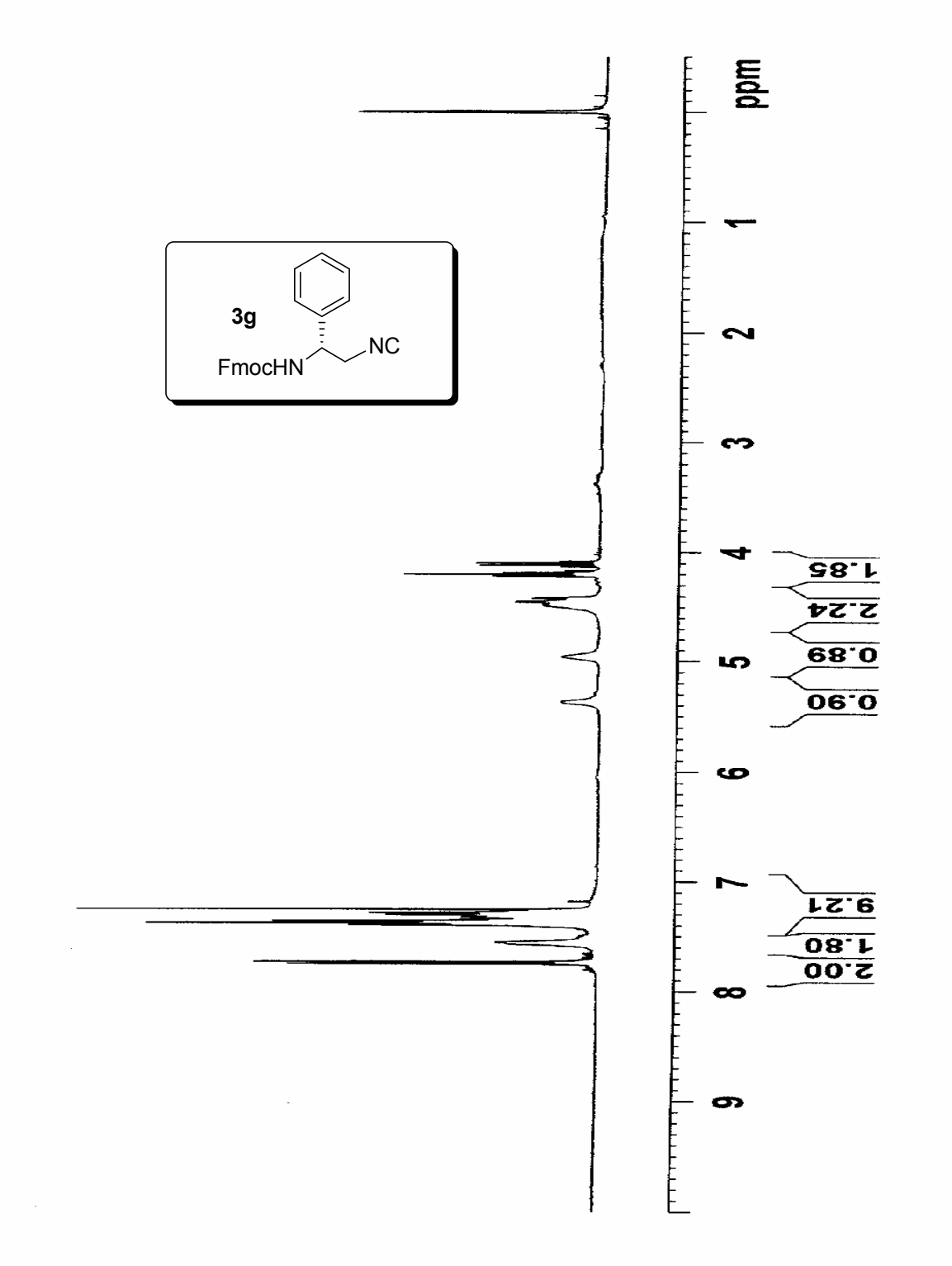
Fmoc-Leu-ψ[CH_2-NC]



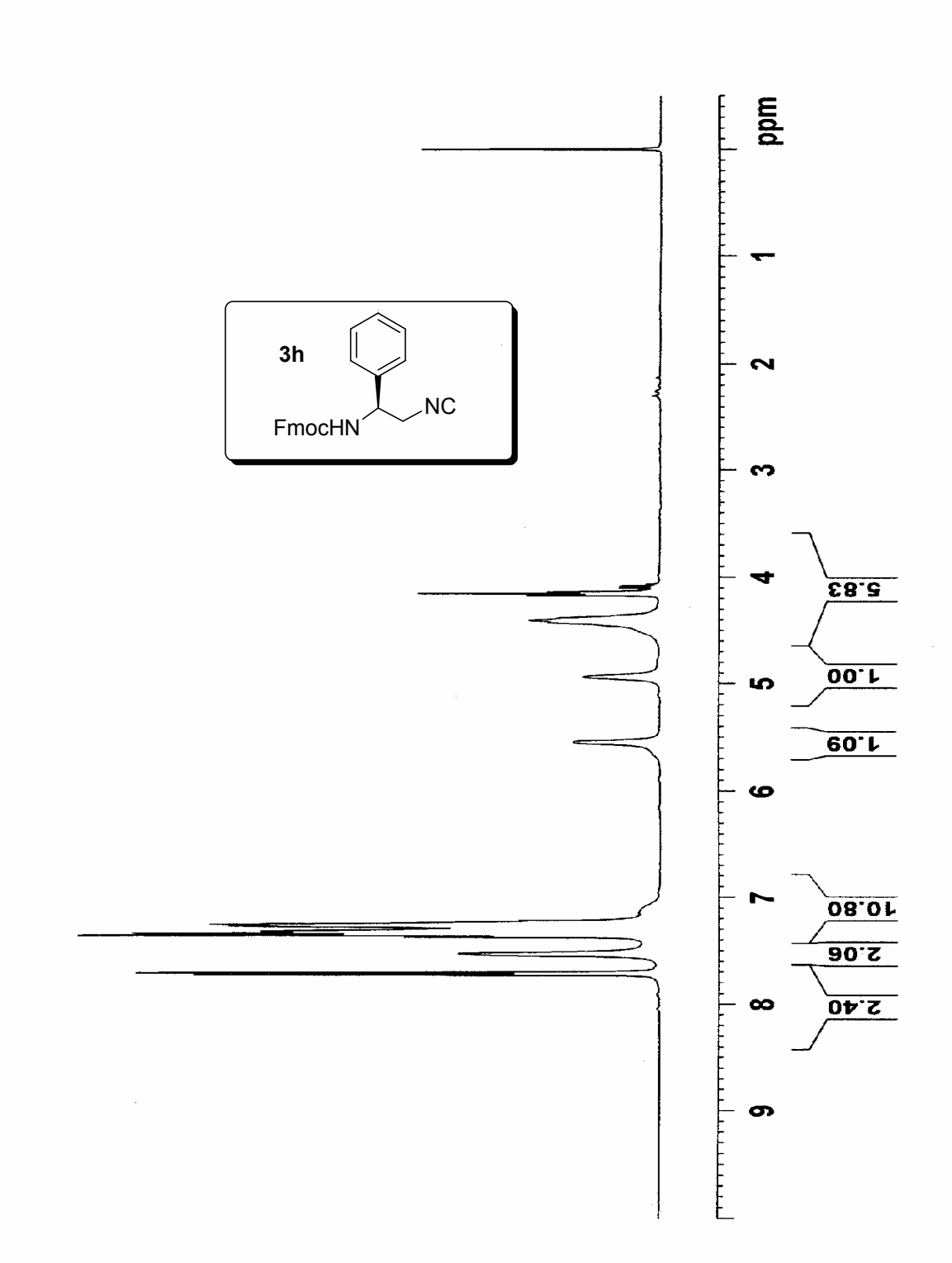
c-Ile-ψ[CH_2-NC]



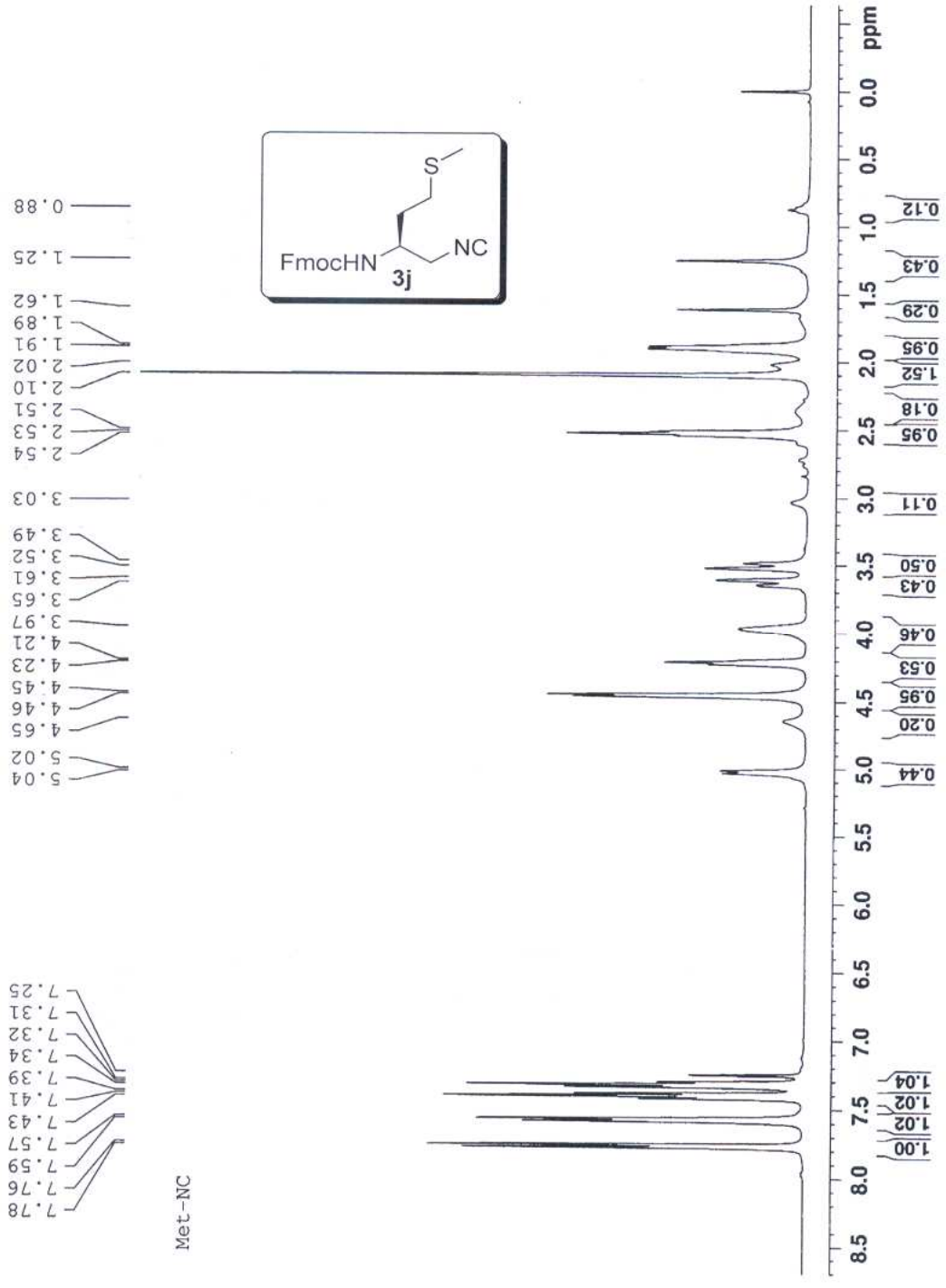
Fmoc-D-Phg-ψ [CH_2NC]



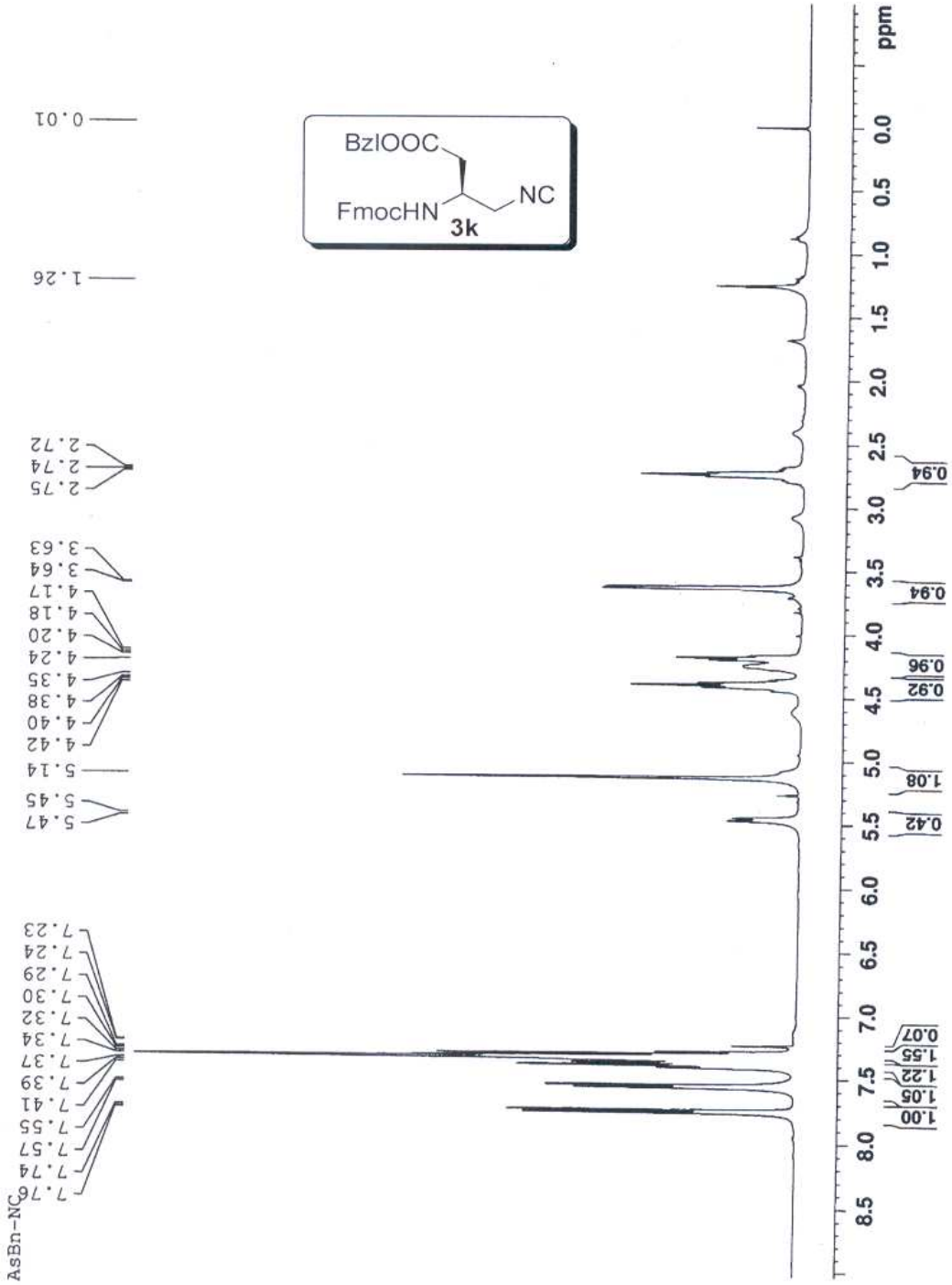
Fmoc-L-Phg-ψ[CH_2NC]



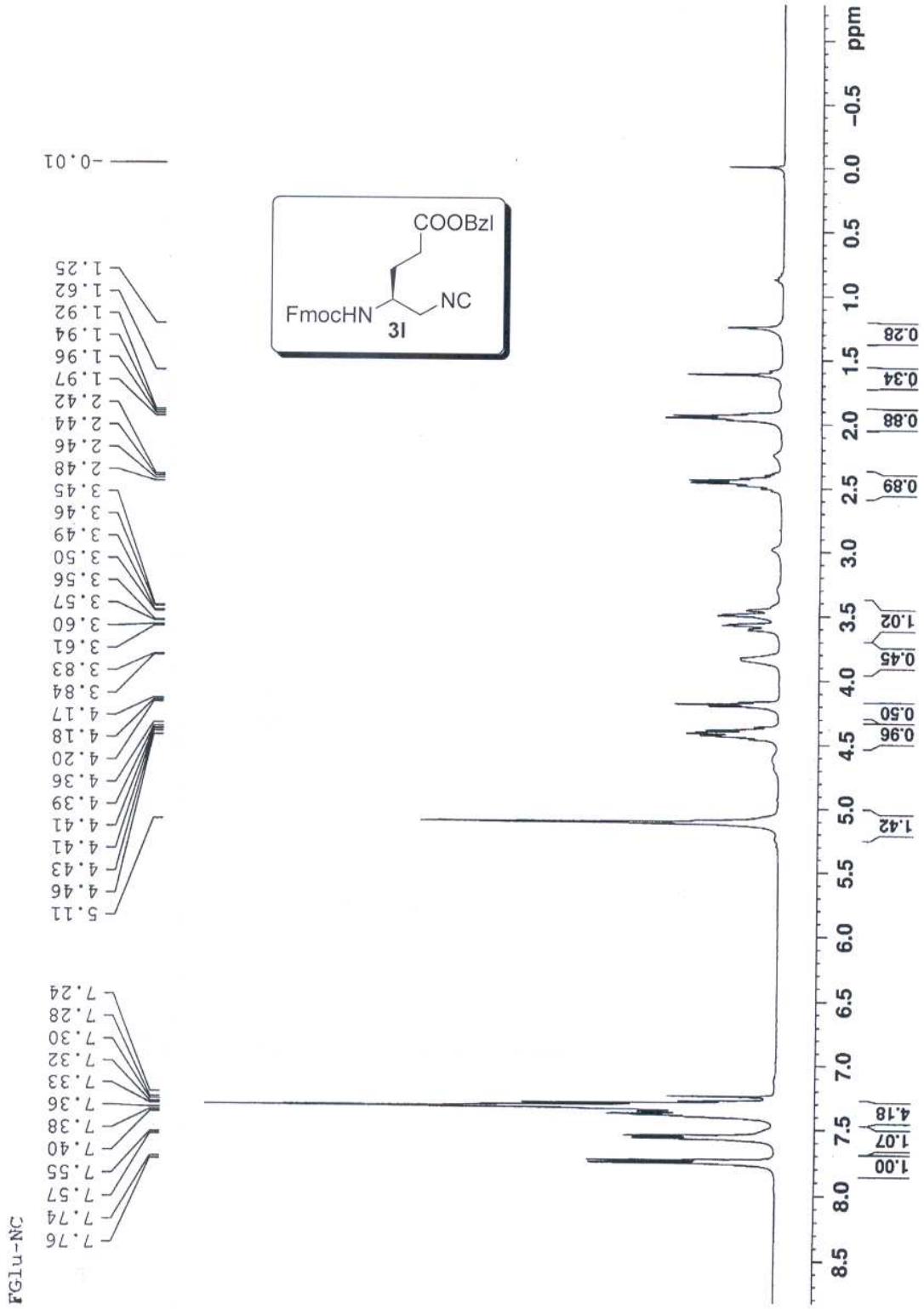
Fmoc-Met-ψ[CH_2-NC]



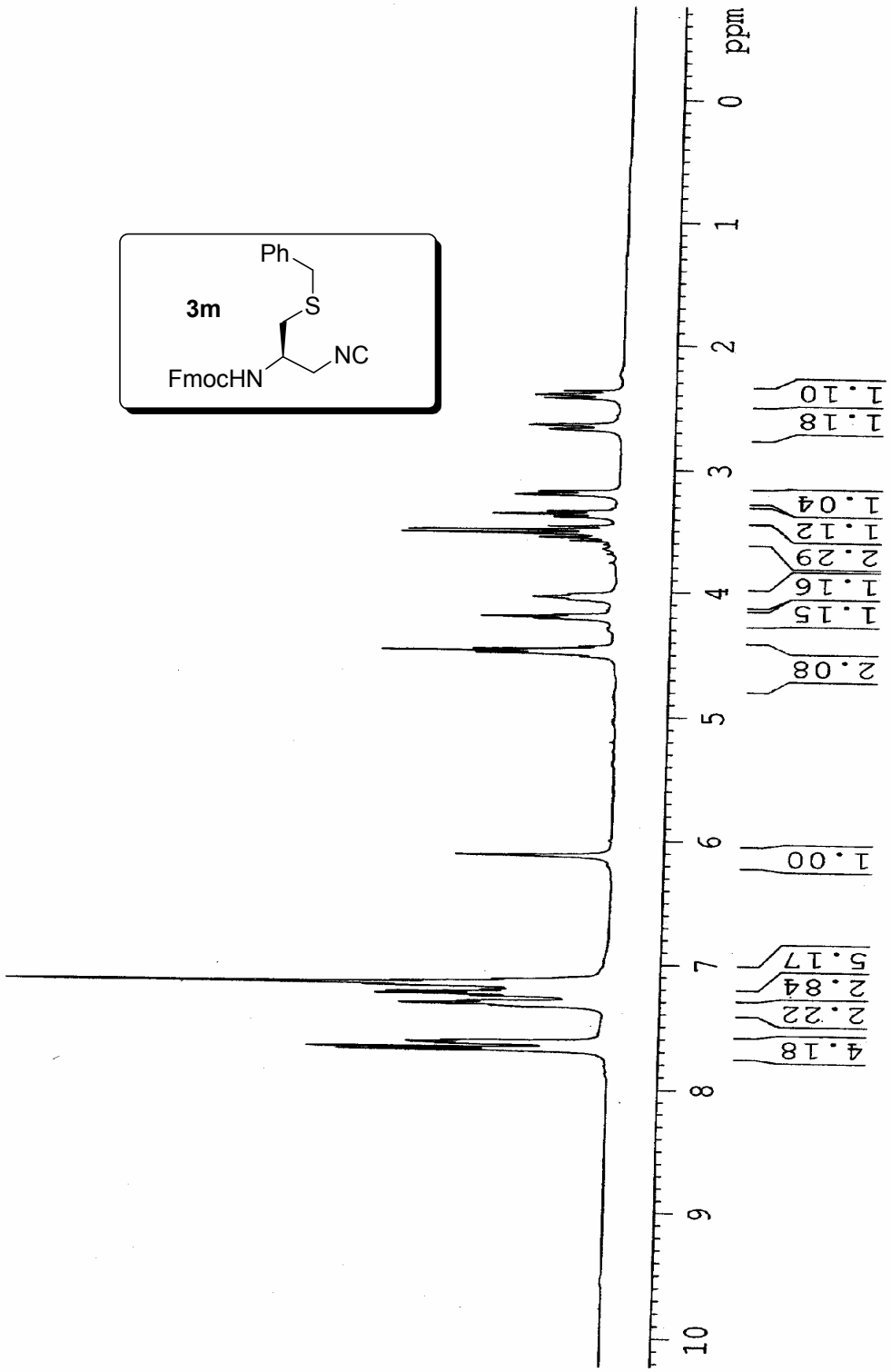
Fmoc-Asp(Bzl)-ψ[CH_2-NC]



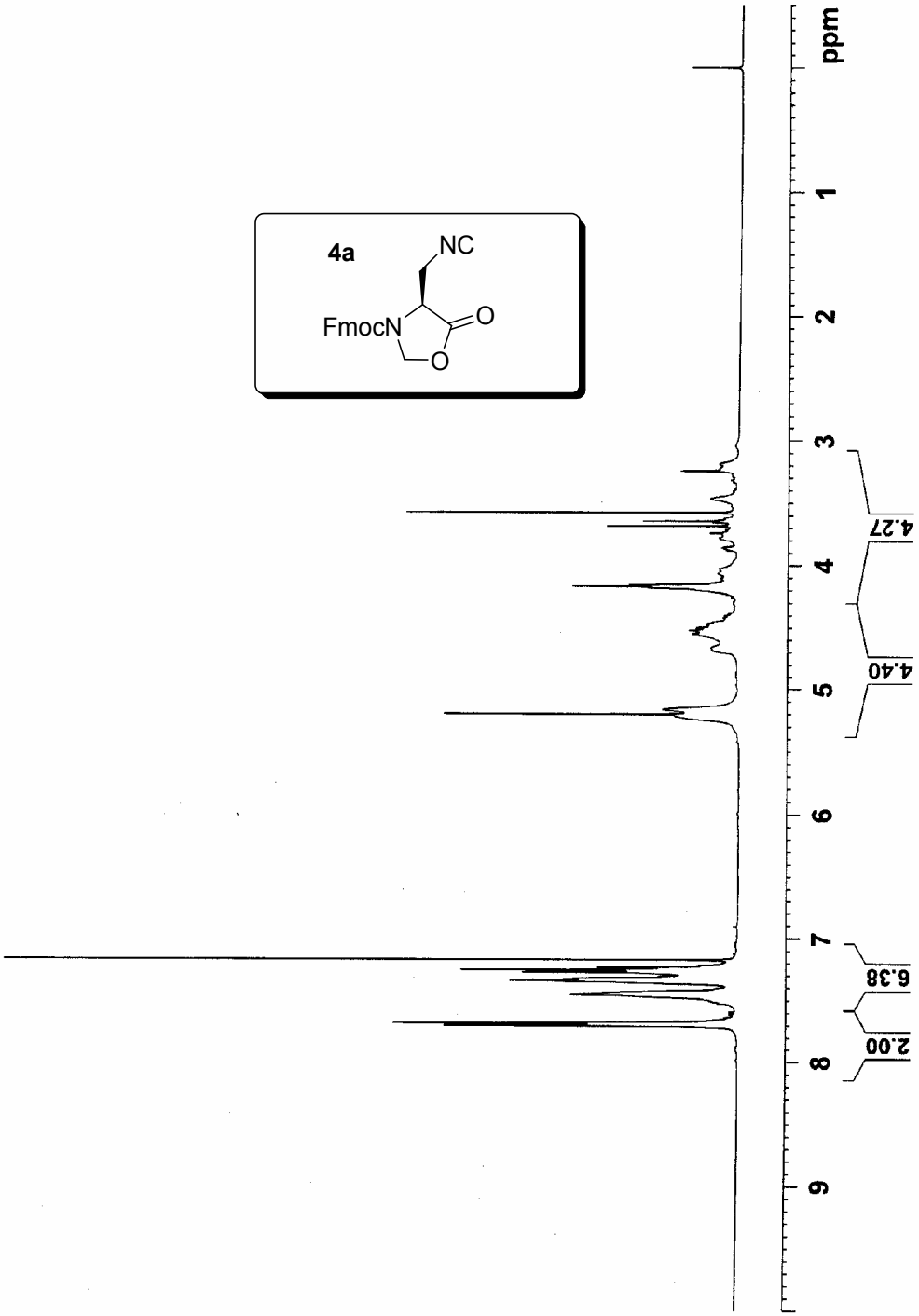
Fmoc- Glu(Bzl)-ψ[CH_2-NC]



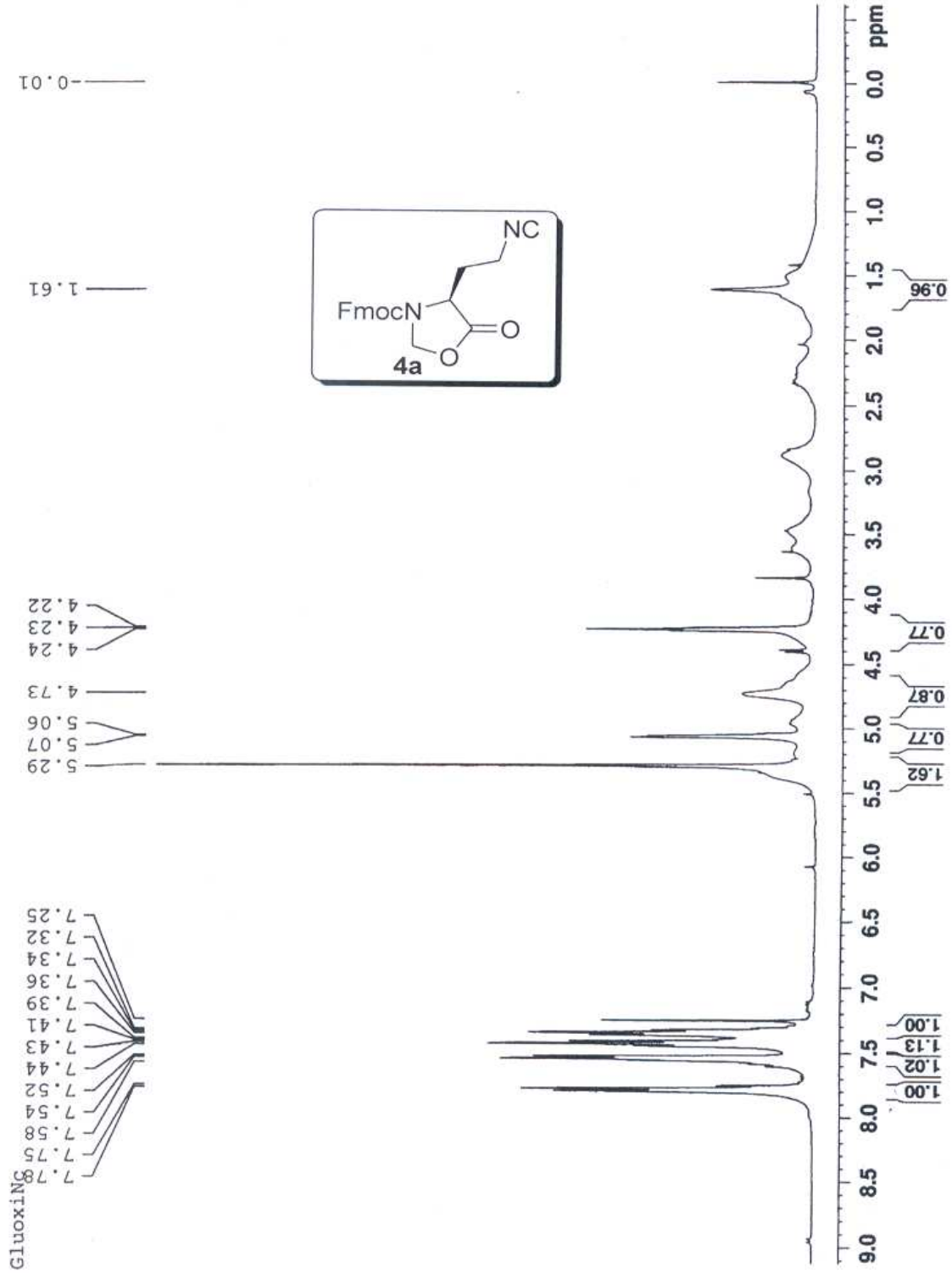
Fmoc-Cys(Bzl)-ψ[CH_2NC]



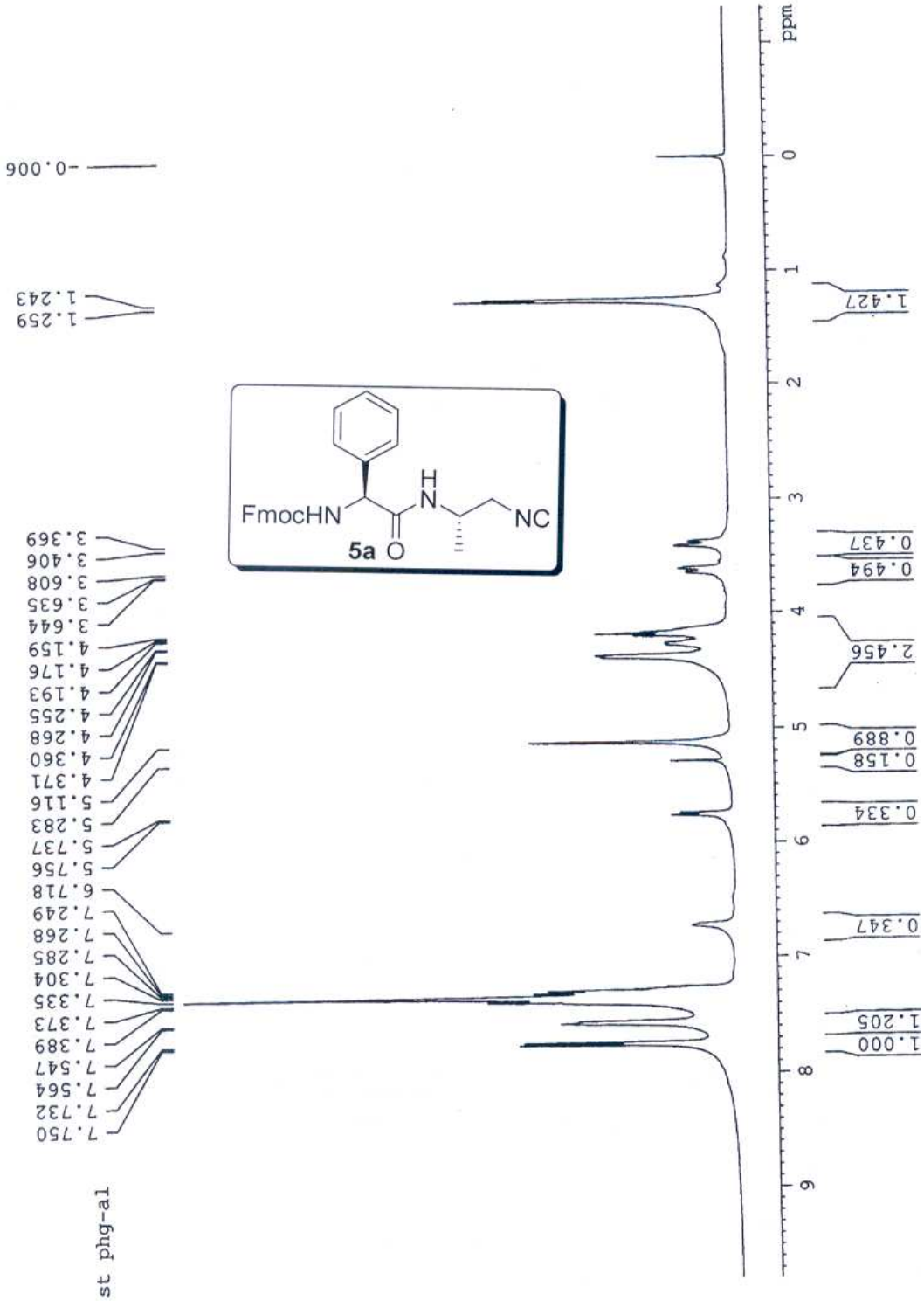
Fmoc-Asp(ψ[CH_2NC])-5-oxazolidinone



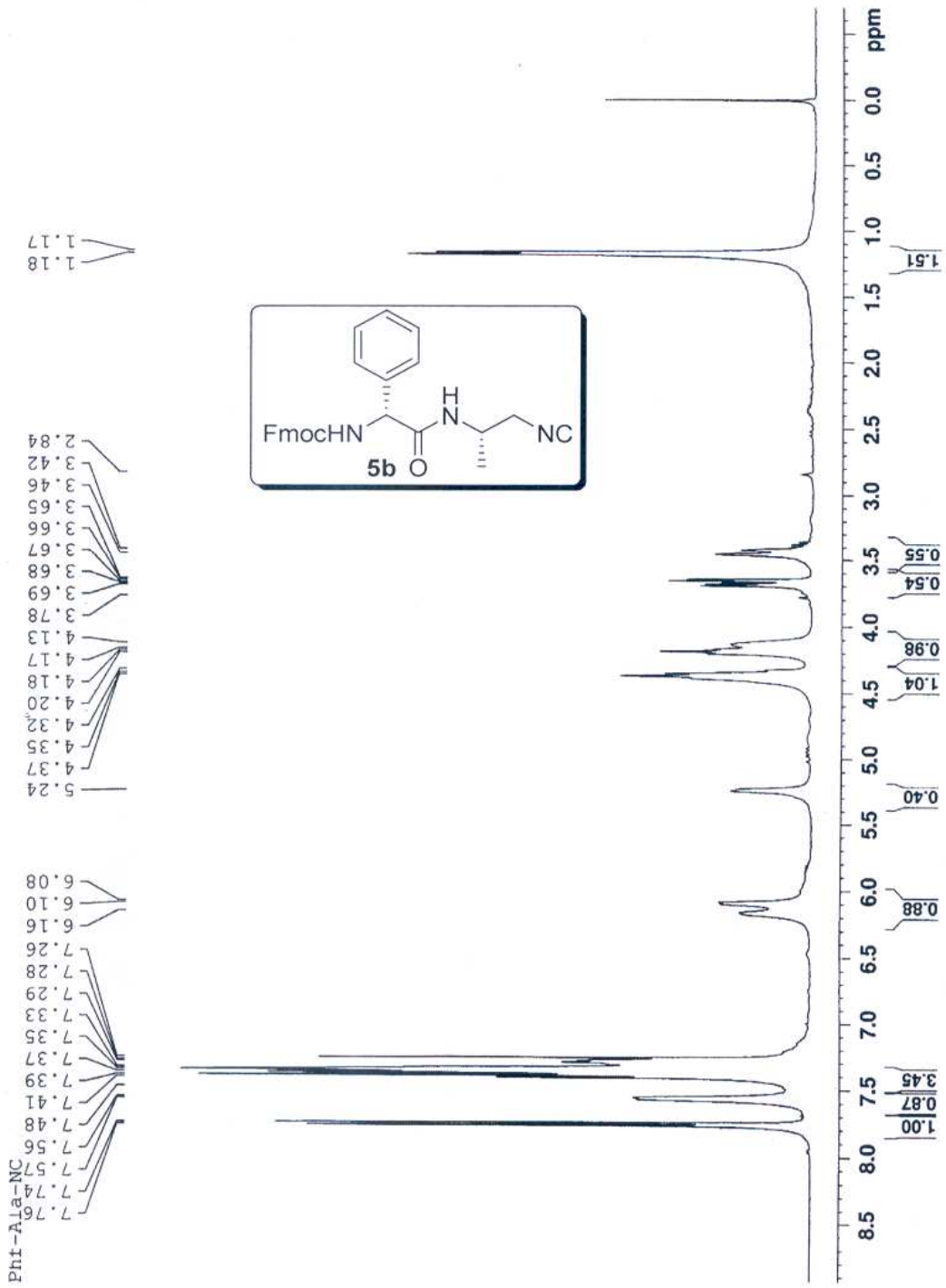
Fmoc-Glu(ψ[$(CH_2)_2NC$])-5-oxazolidinone



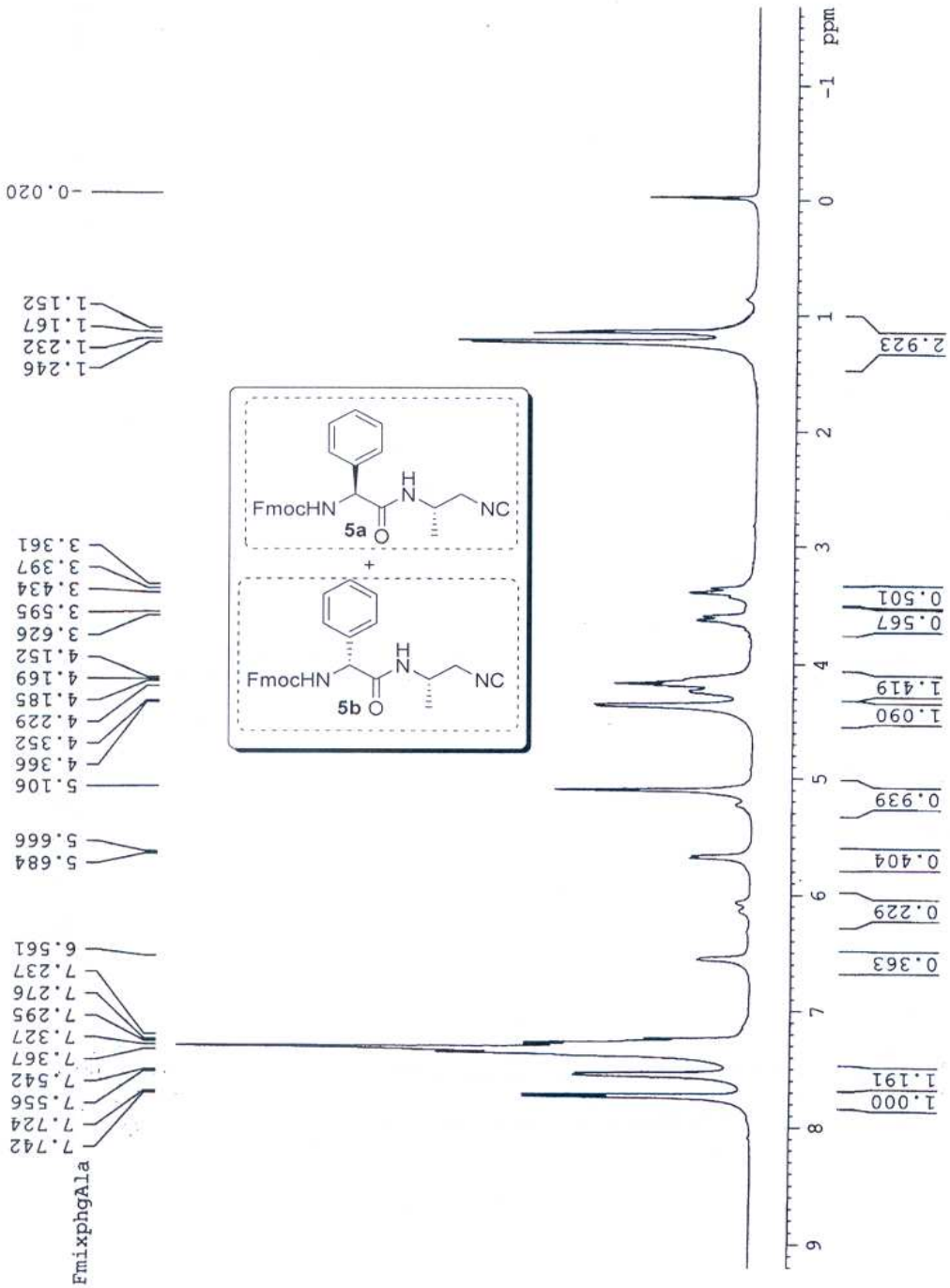
Fmoc-(S+)Phg-Ala-ψ[CH_2-NC]



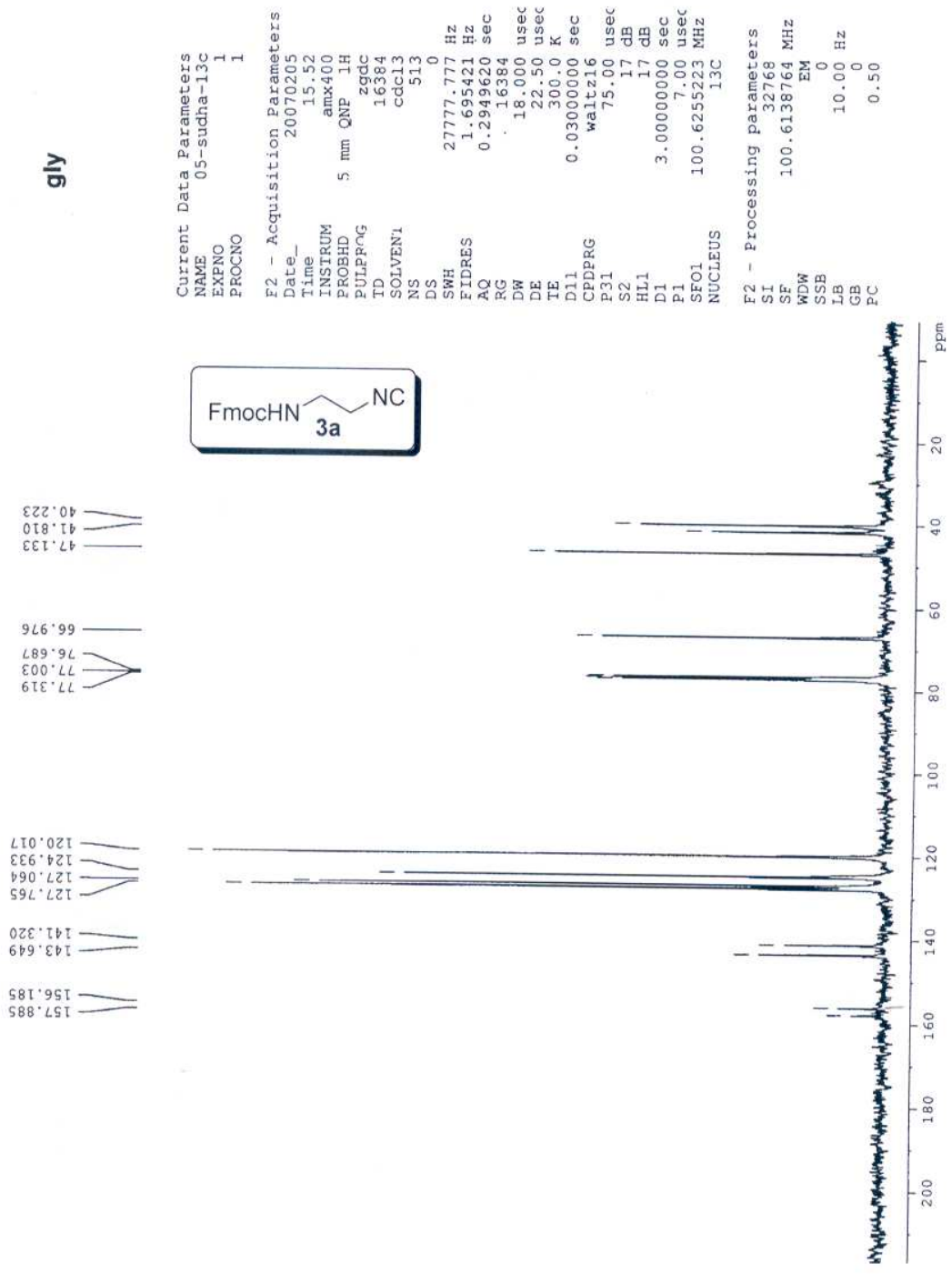
Fmoc-(R-)Phg-Ala-ψ[CH_2-NC]



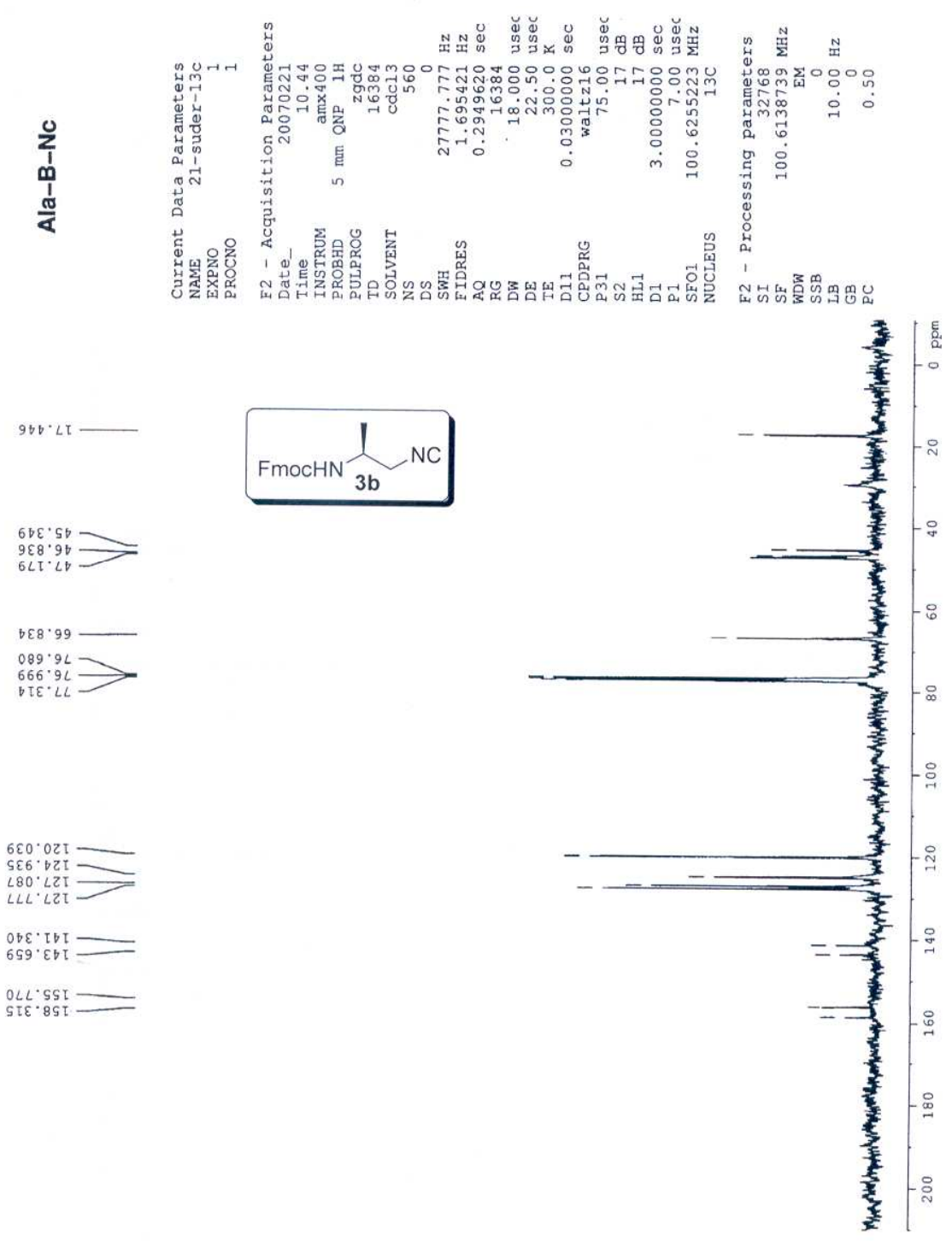
Mixture of Fmoc-(S+)Phg-Ala-ψ[CH_2-NC] and Fmoc-(R-)Phg-Ala-ψ[CH_2-NC]



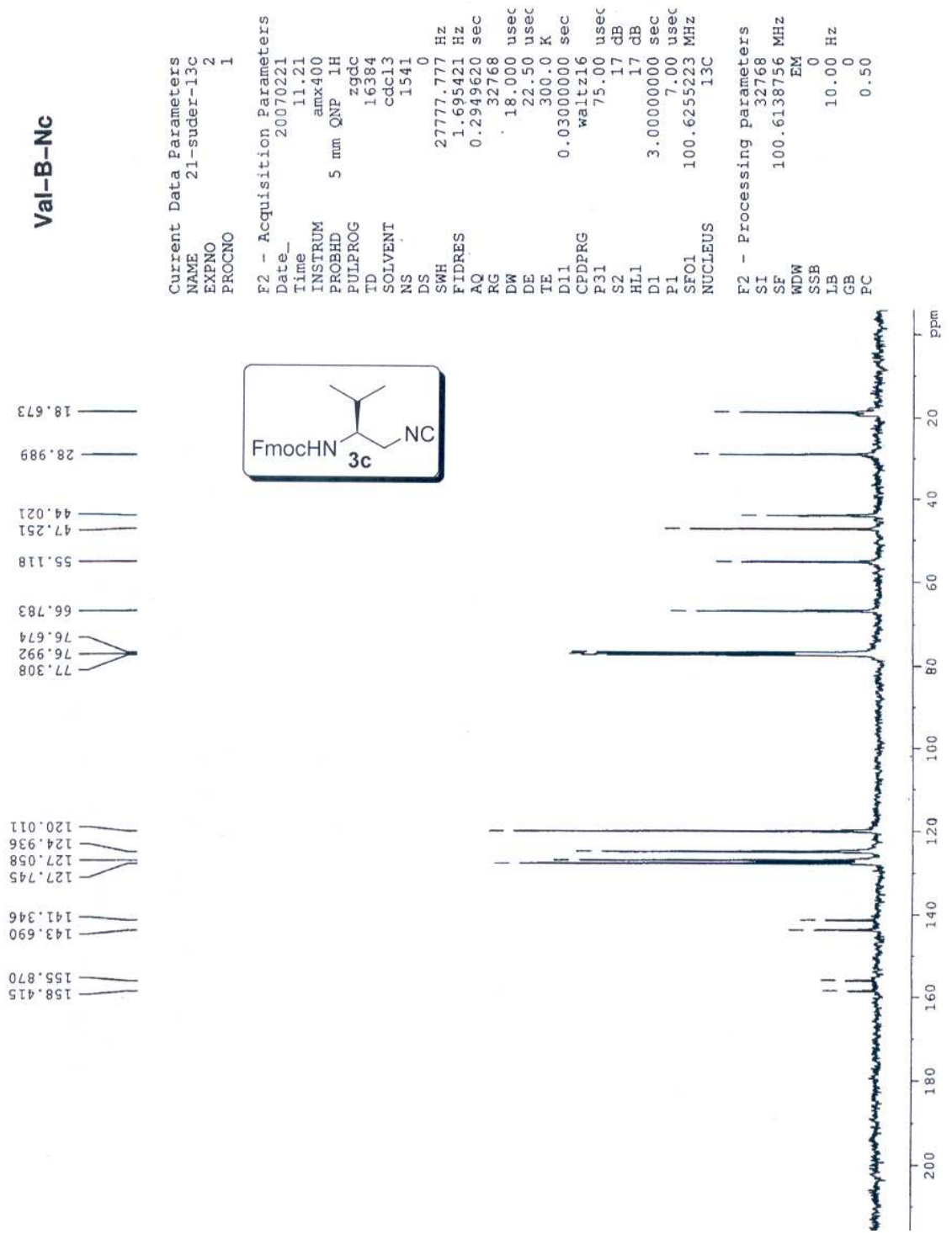
Fmoc-Gly-ψ[CH_2-NC]



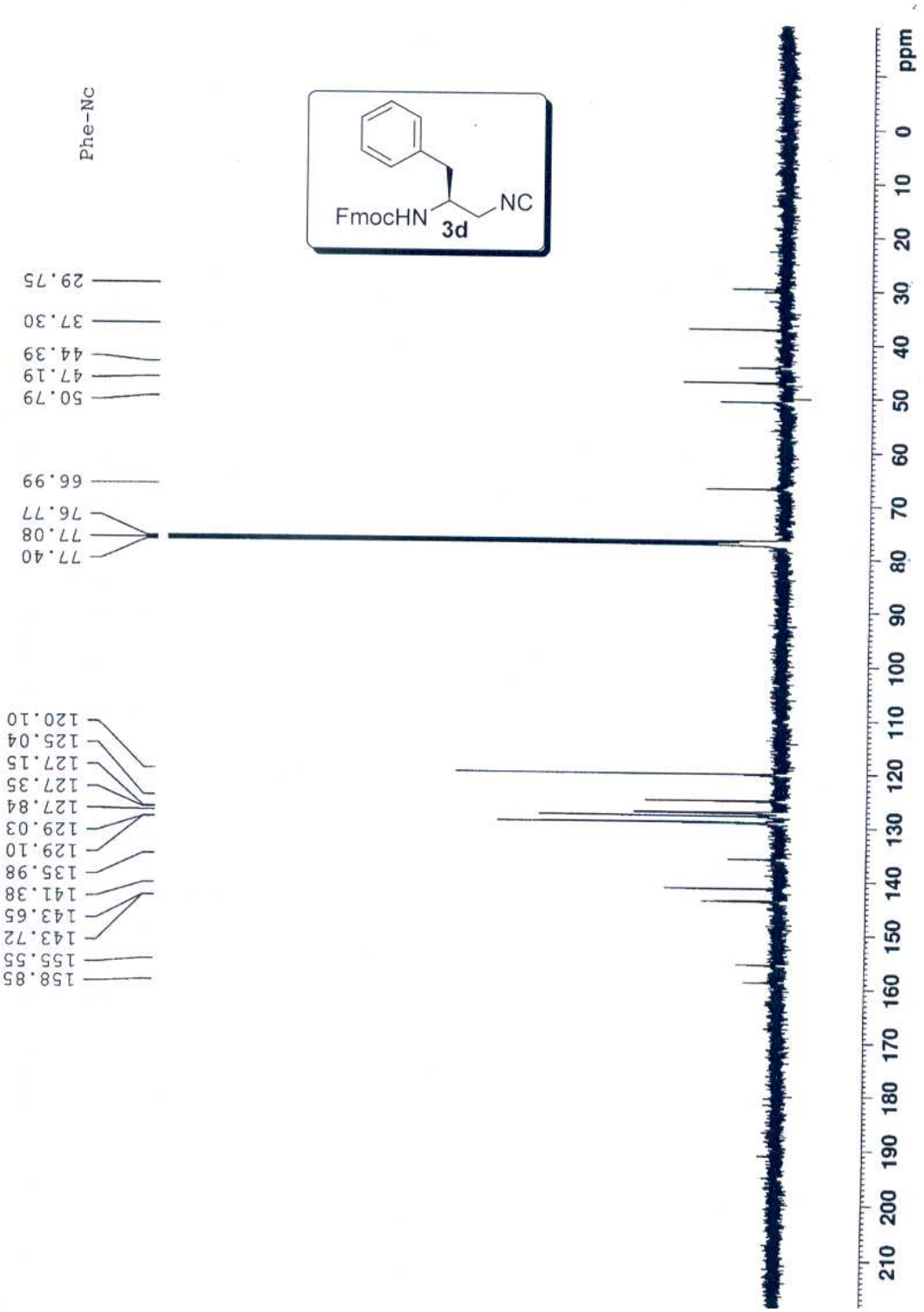
Fmoc-Ala-ψ[CH_2-NC]



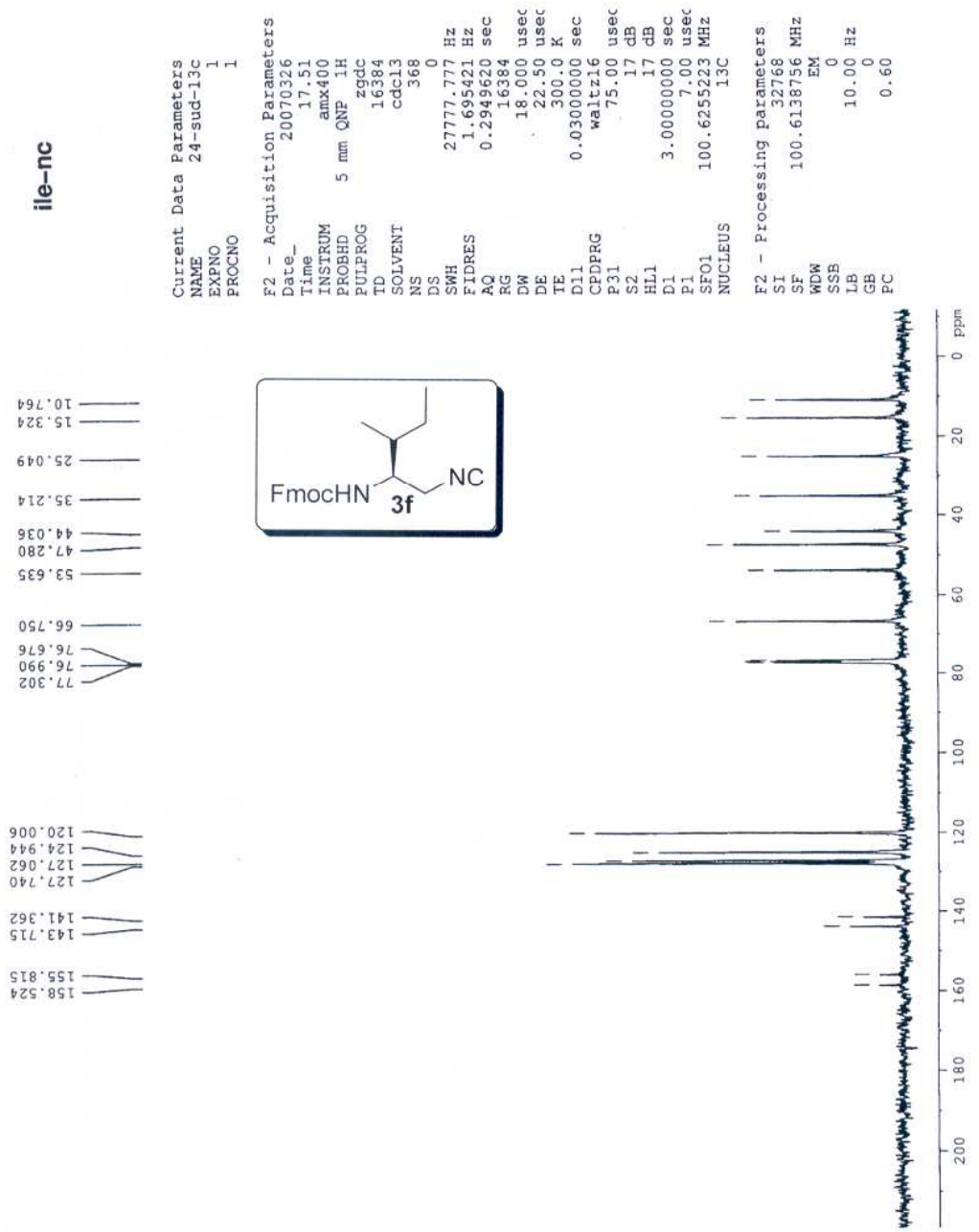
Fmoc-Val-ψ[CH_2-NC]



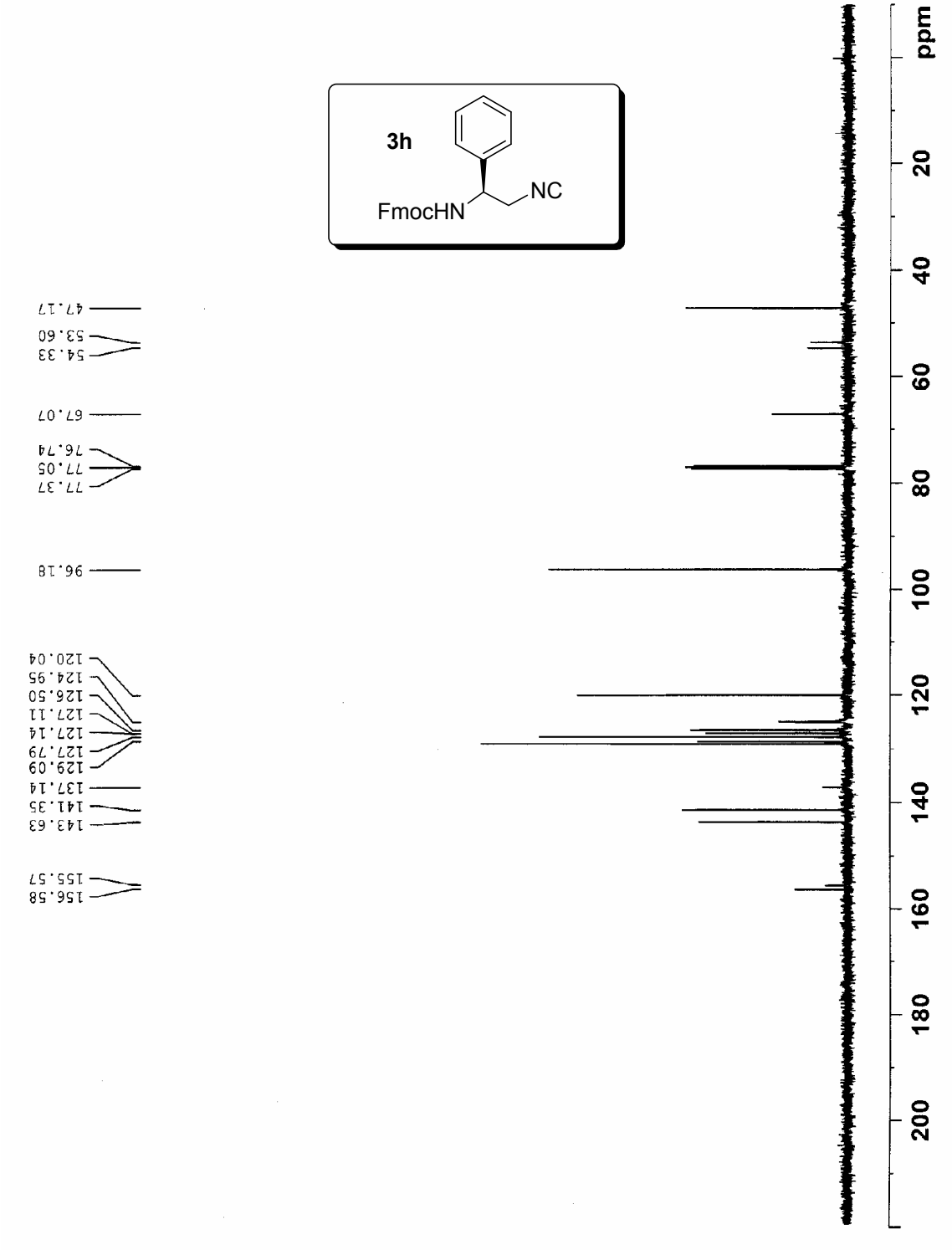
Fmoc-Phe-ψ[CH_2-NC]



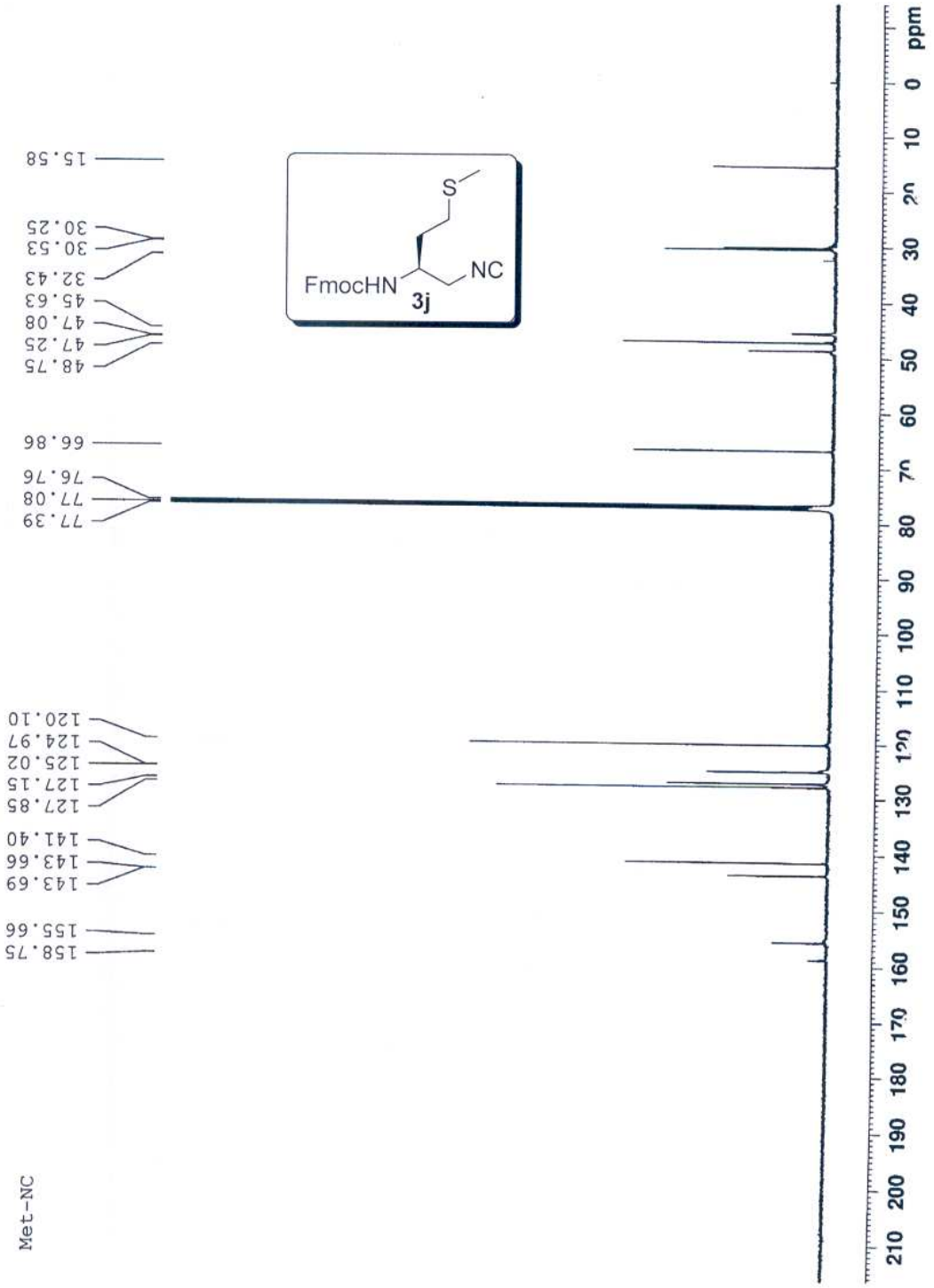
Fmoc-Ile-ψ[CH_2-NC]



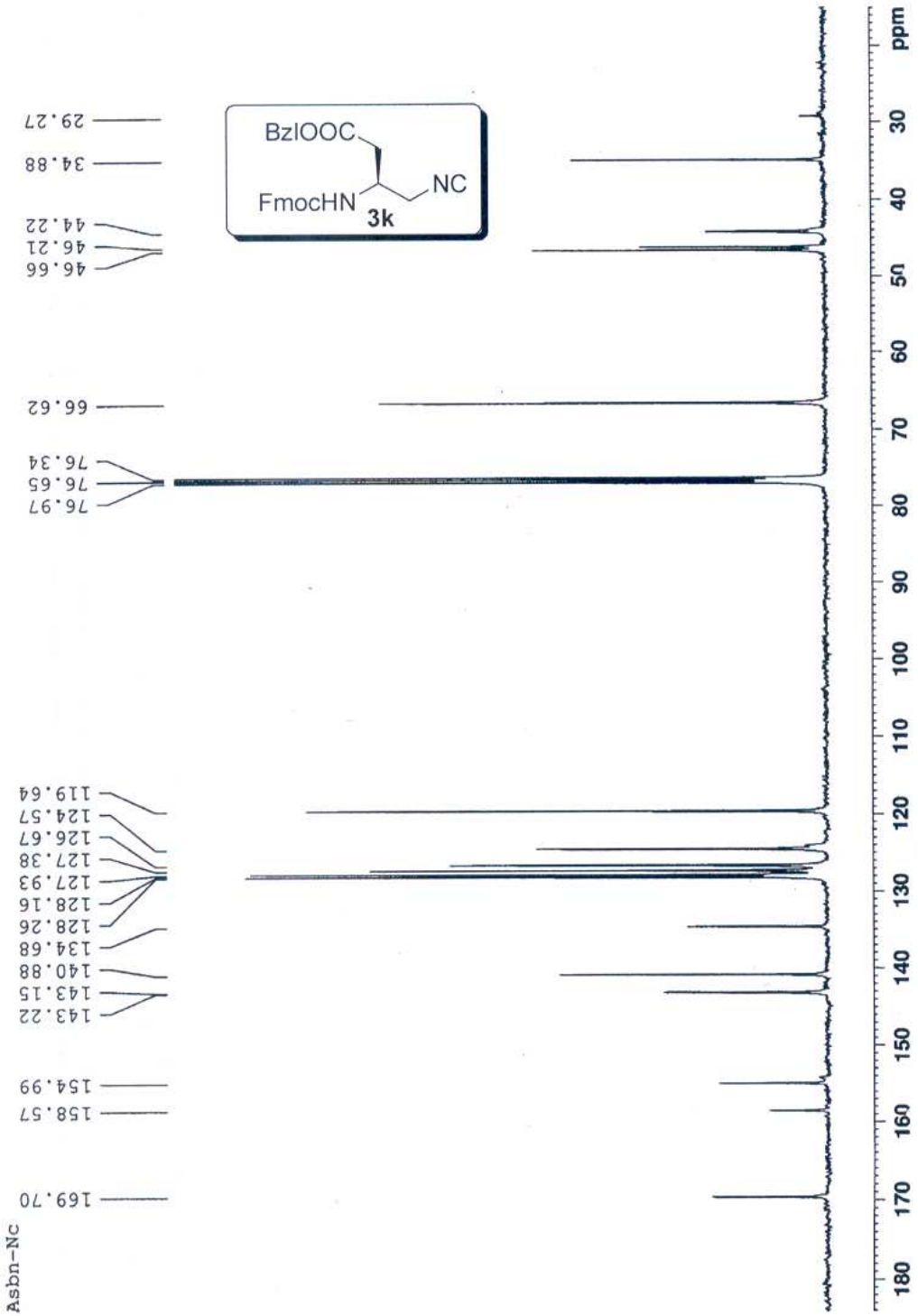
Fmoc-L-Phg-ψ[CH_2NC]



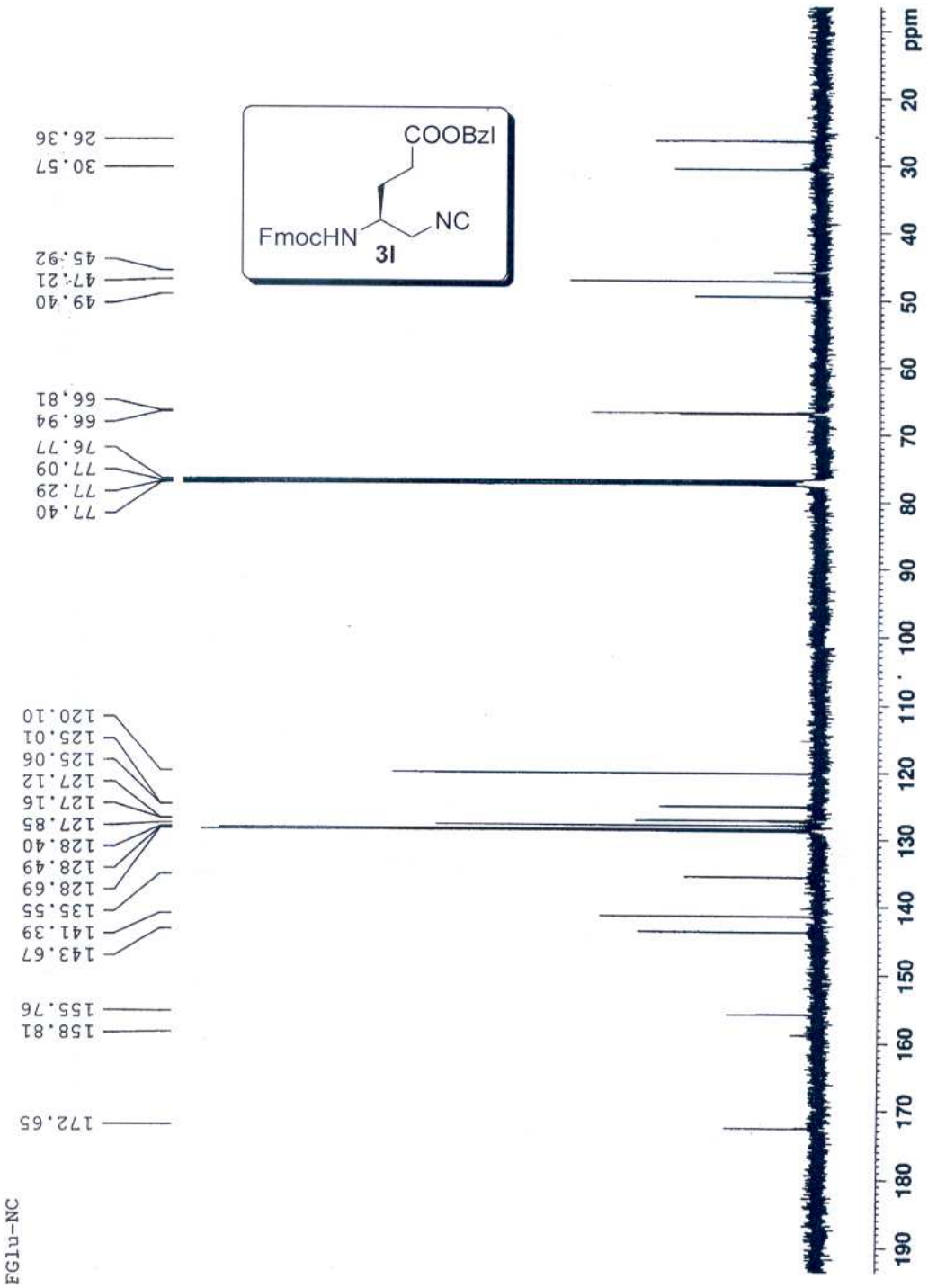
Fmoc-Met-ψ[CH_2-NC]



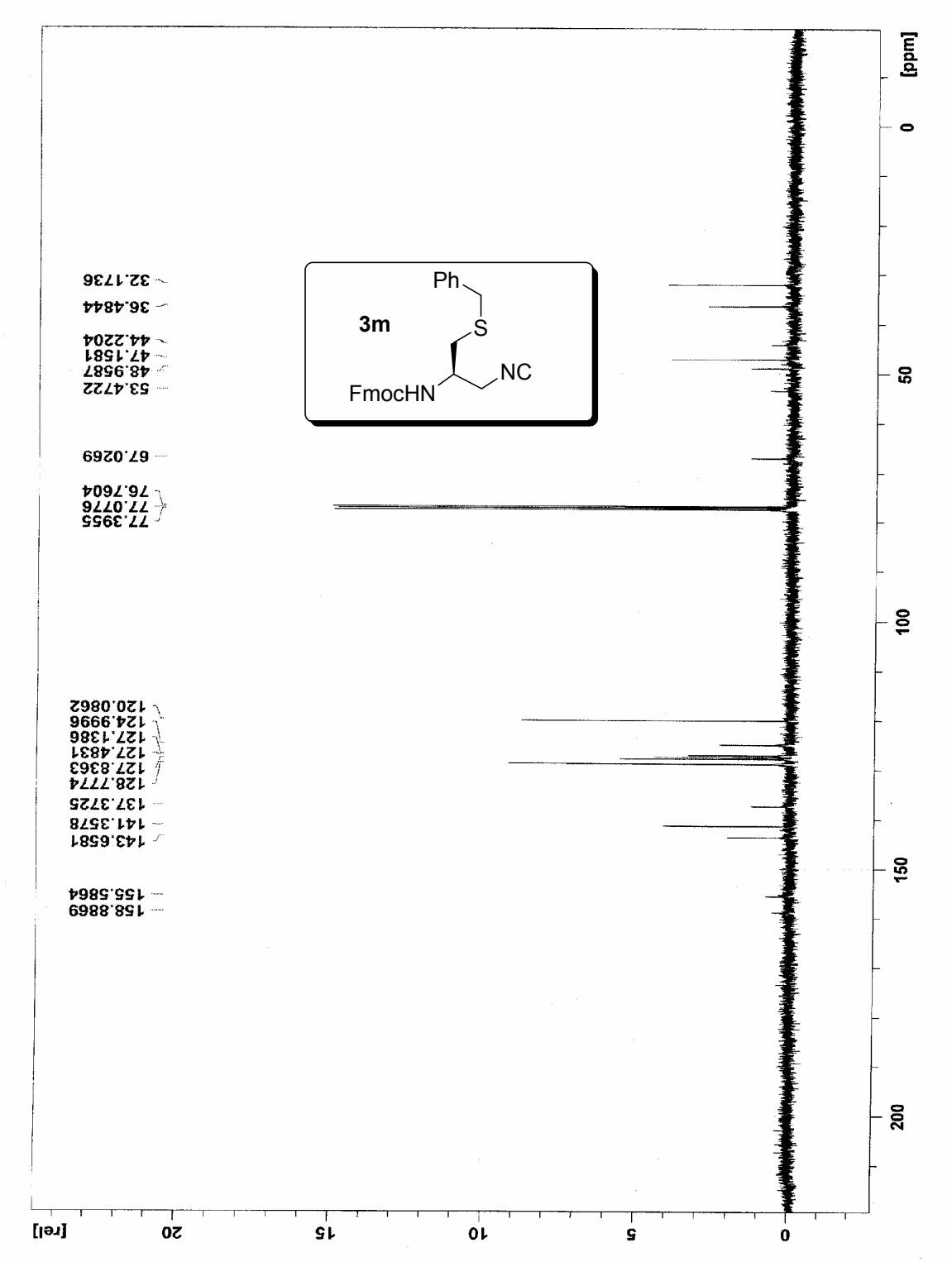
Fmoc-Asp(Bzl)-ψ[CH_2-NC]



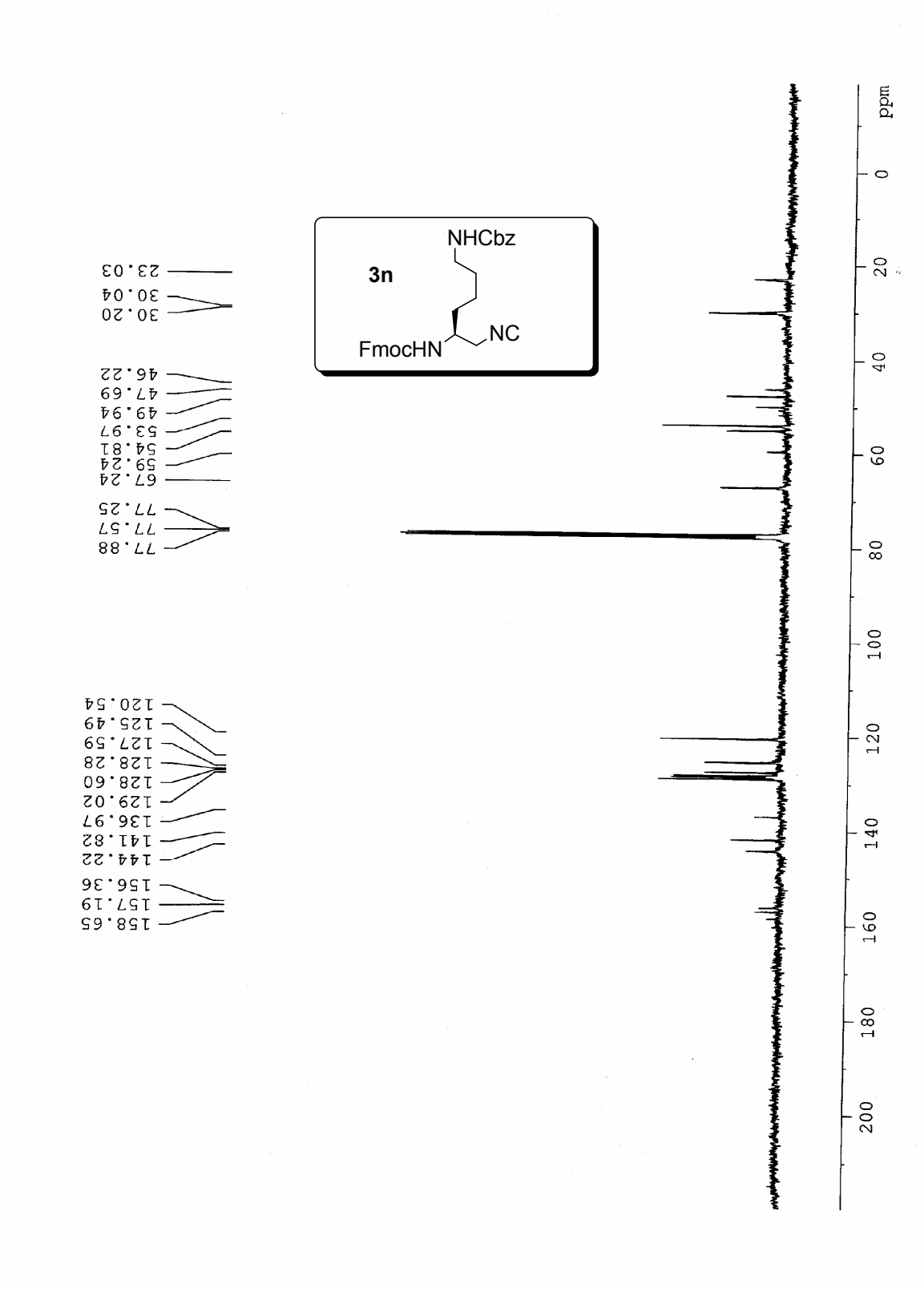
Fmoc-Glu(Bzl)-ψ[CH_2-NC]



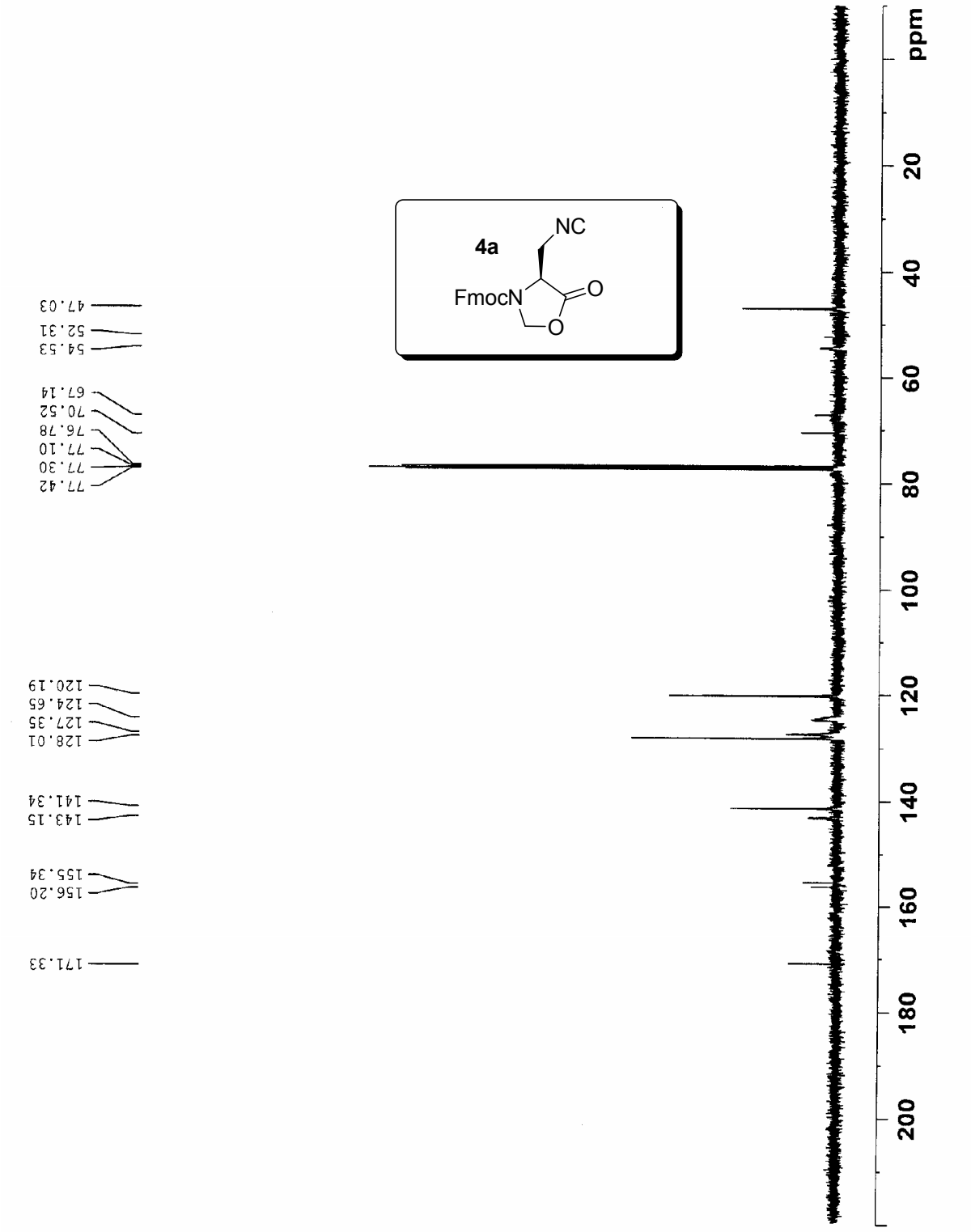
Fmoc-Cys(Bzl)-ψ[CH_2NC]



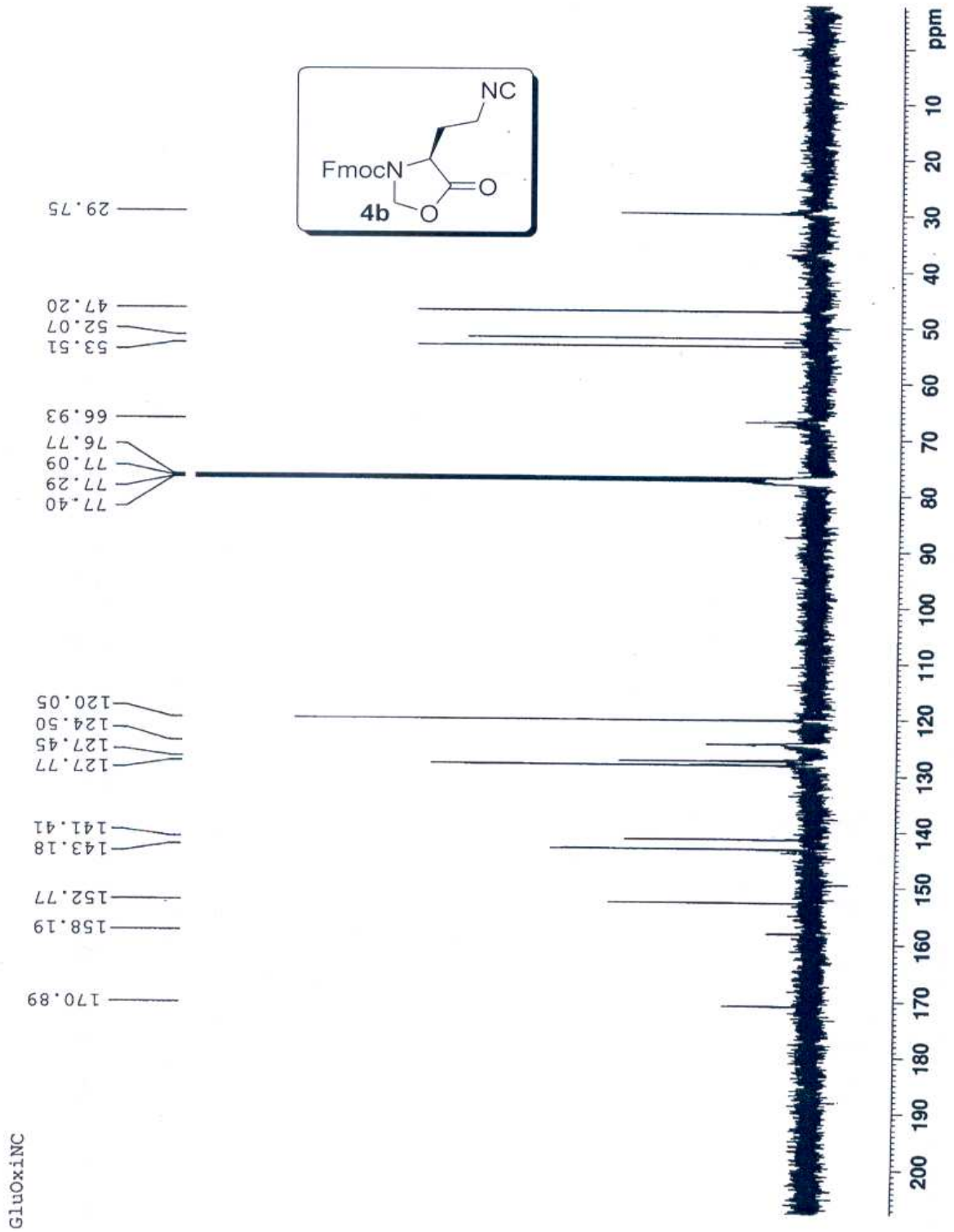
Fmoc-Lys(Cbz)-ψ [CH_2NC]



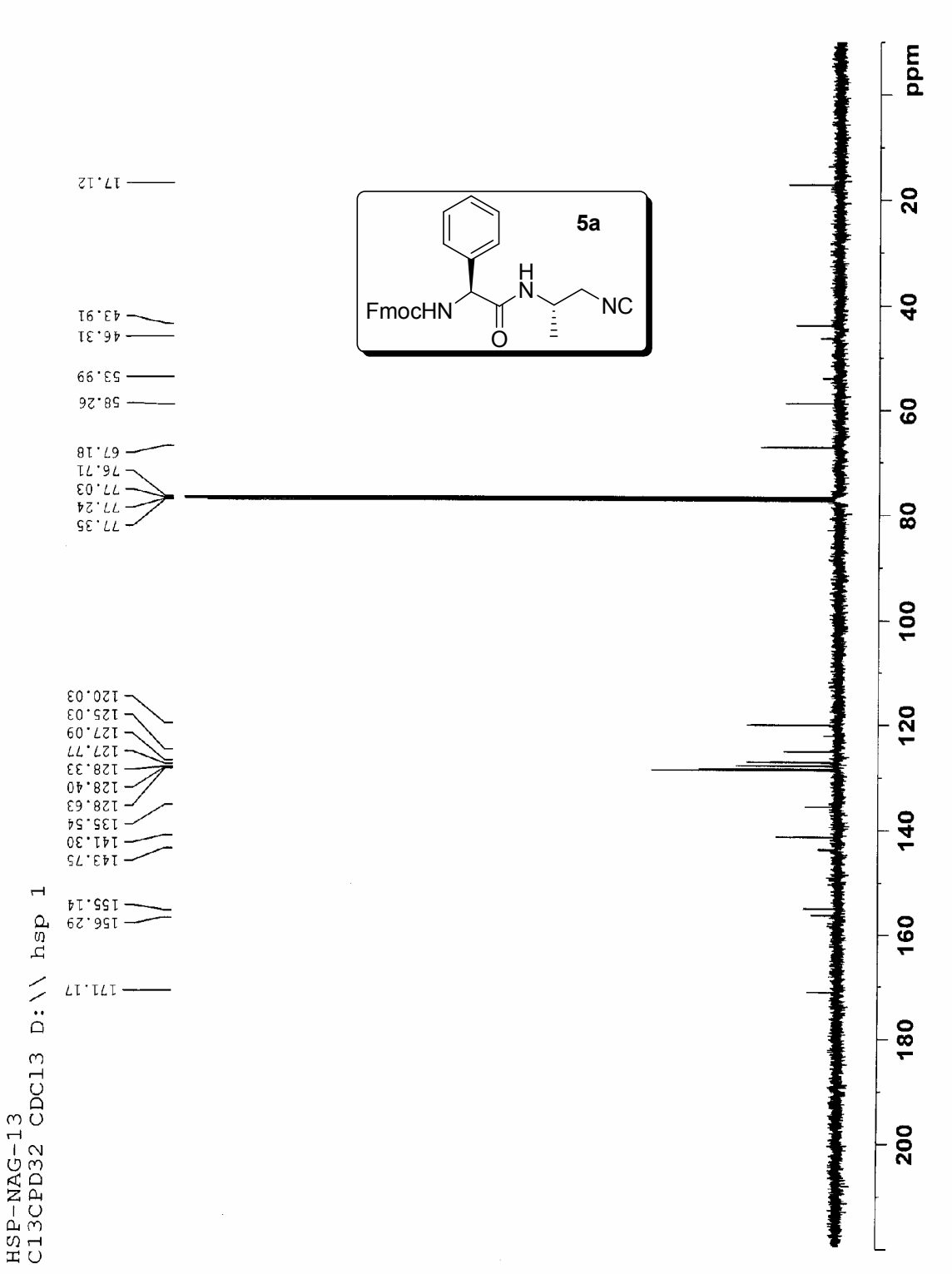
Fmoc-Asp(ψ[CH_2NC])-5-oxazolidinone



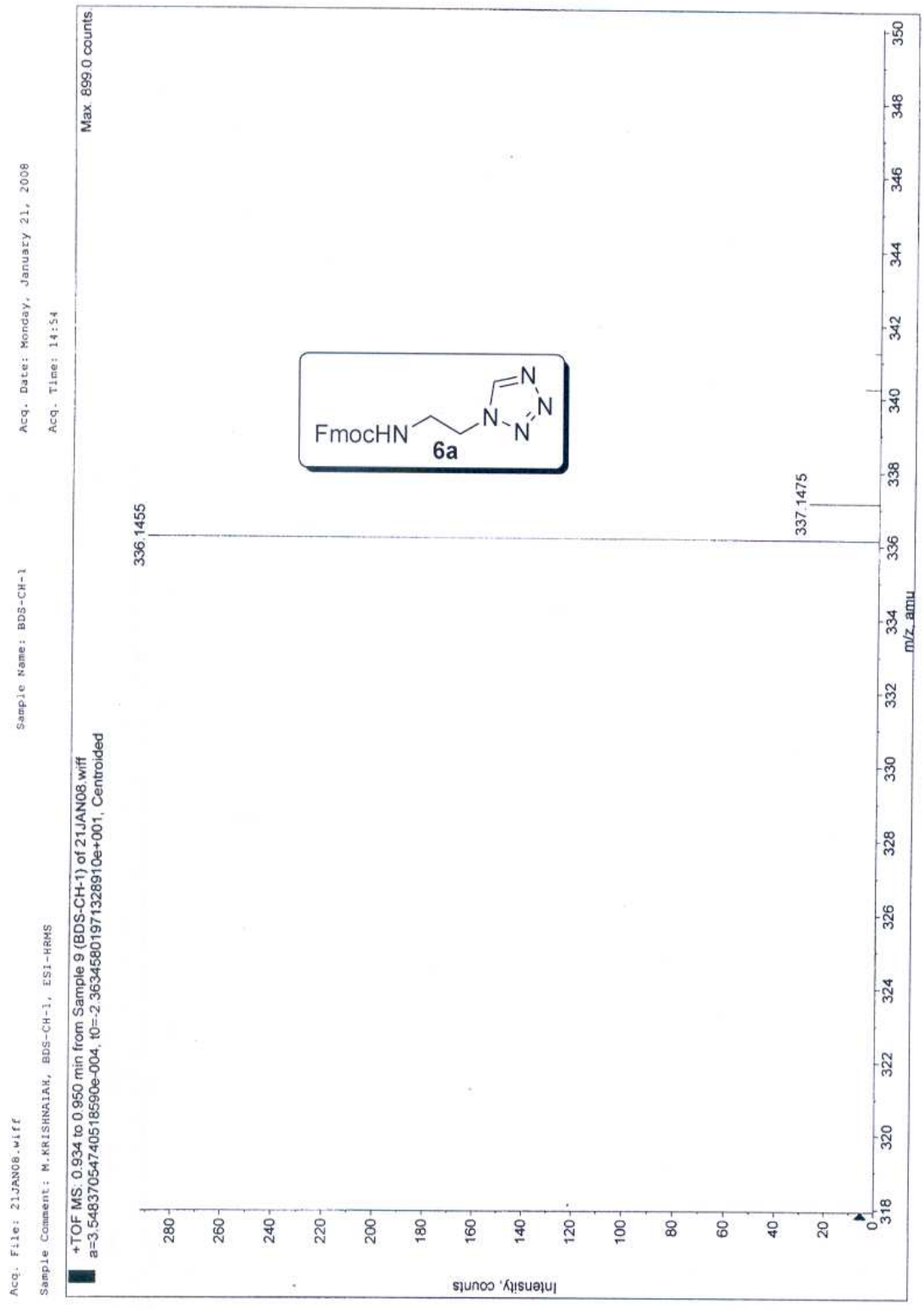
Fmoc-Glu(ψ[$(CH_2)_2$NC])-5-oxazolidinone



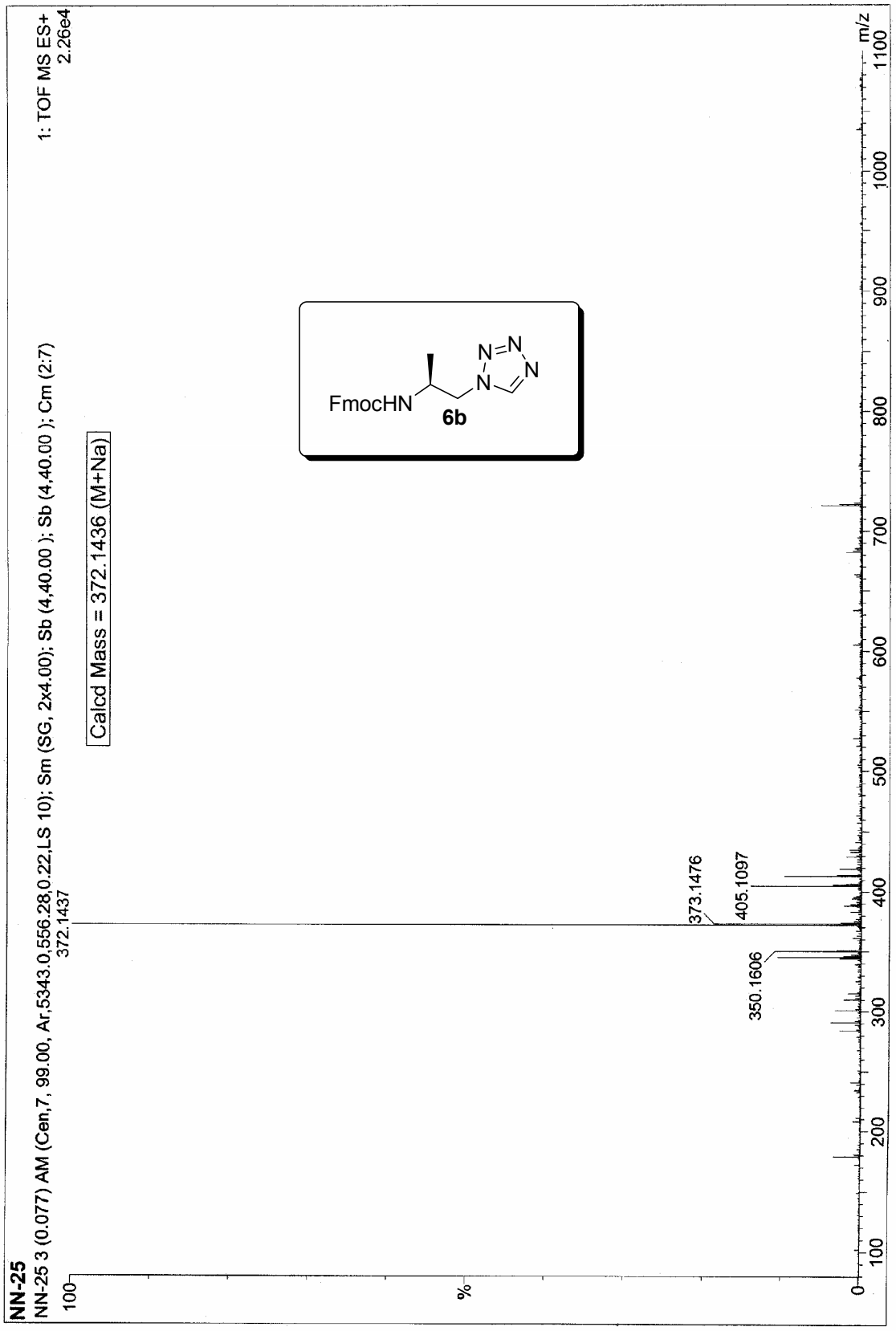
Fmoc-L-Phg-Ala-ψ[CH_2NC]



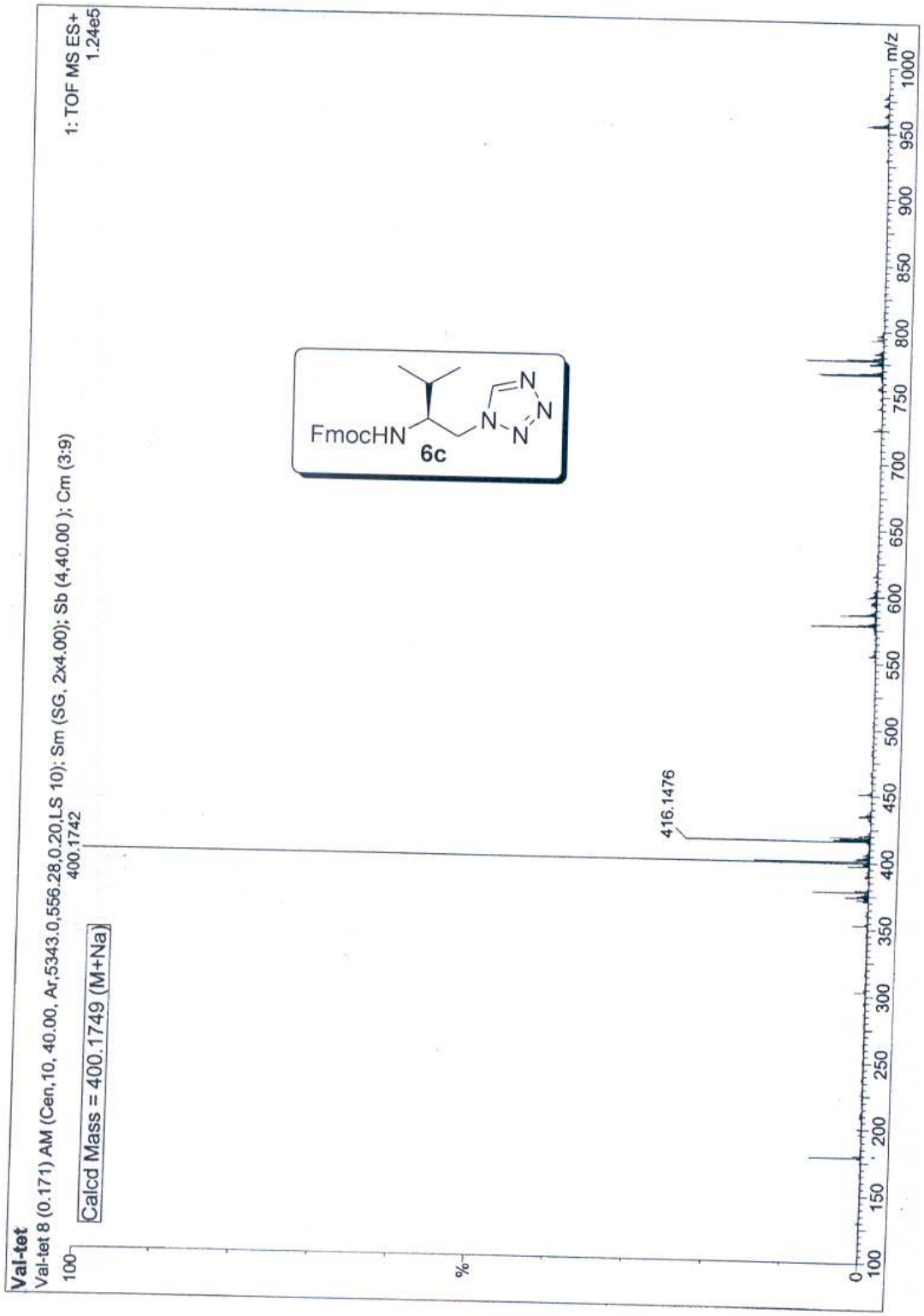
Fmoc-Gly-ψ [CH_2CN_4]



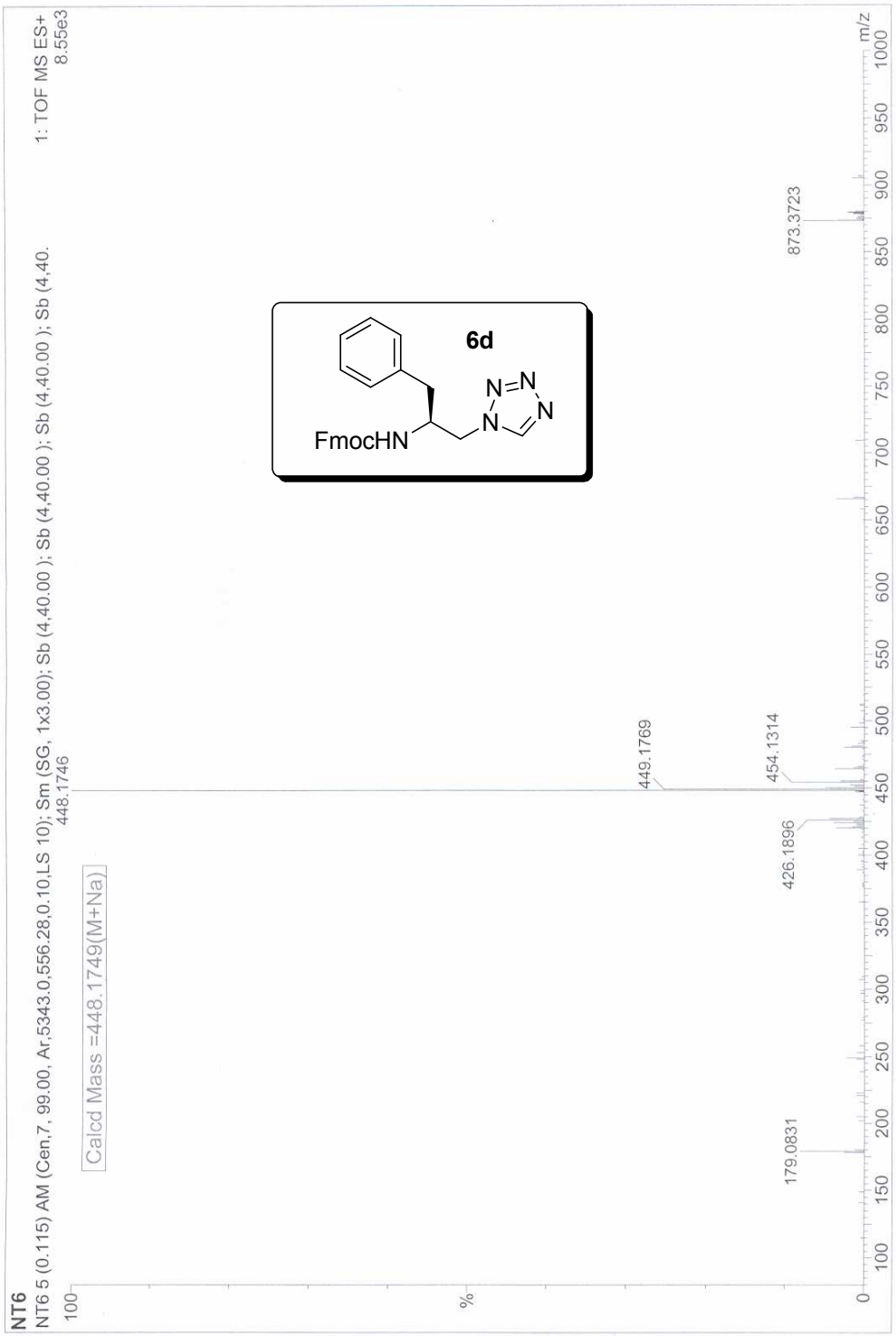
Fmoc-Ala-ψ [CH_2CN_4]



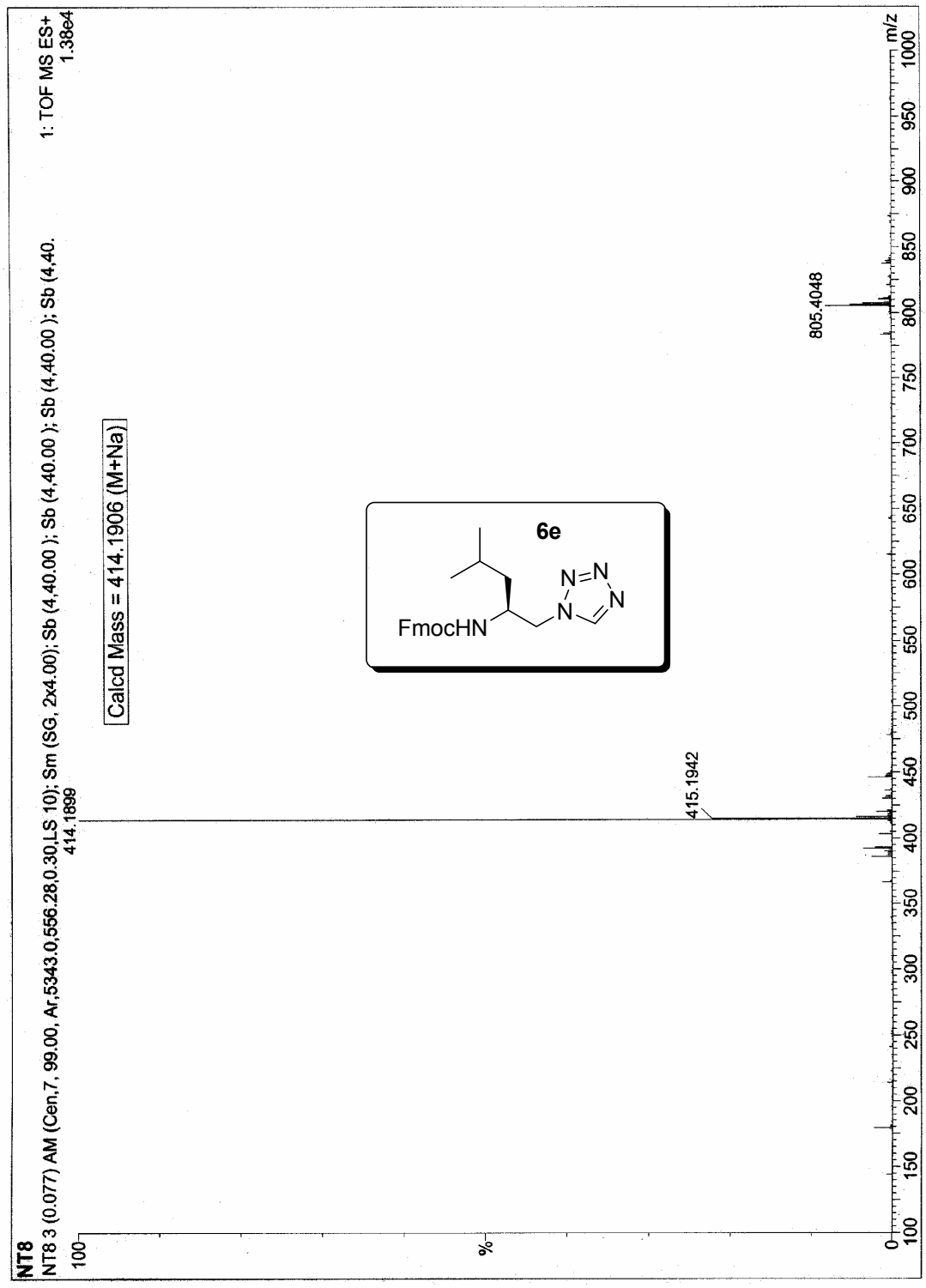
Fmoc-Val-ψ [CH_2CN_4]



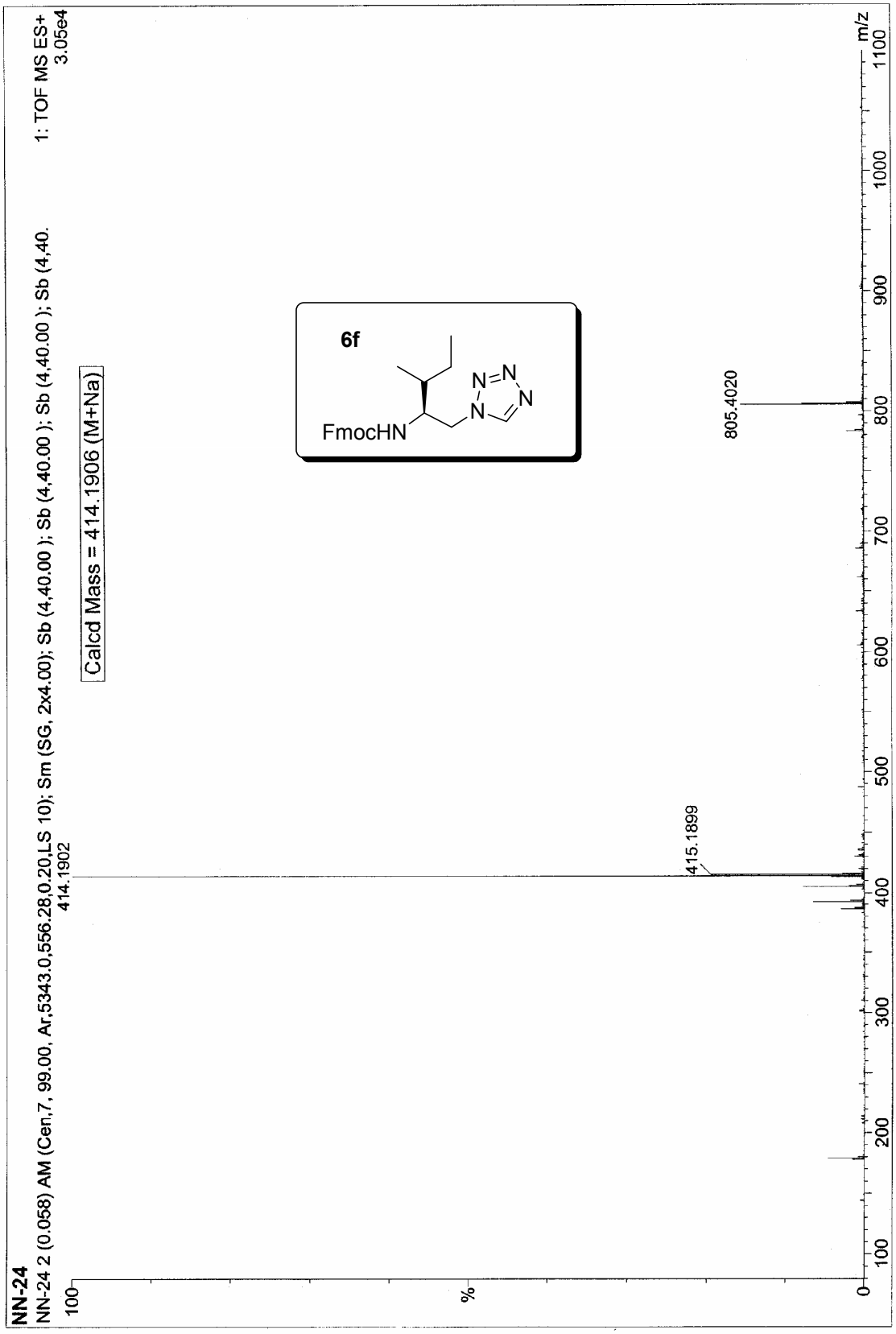
Fmoc-Phe-ψ [CH_2CN_4]



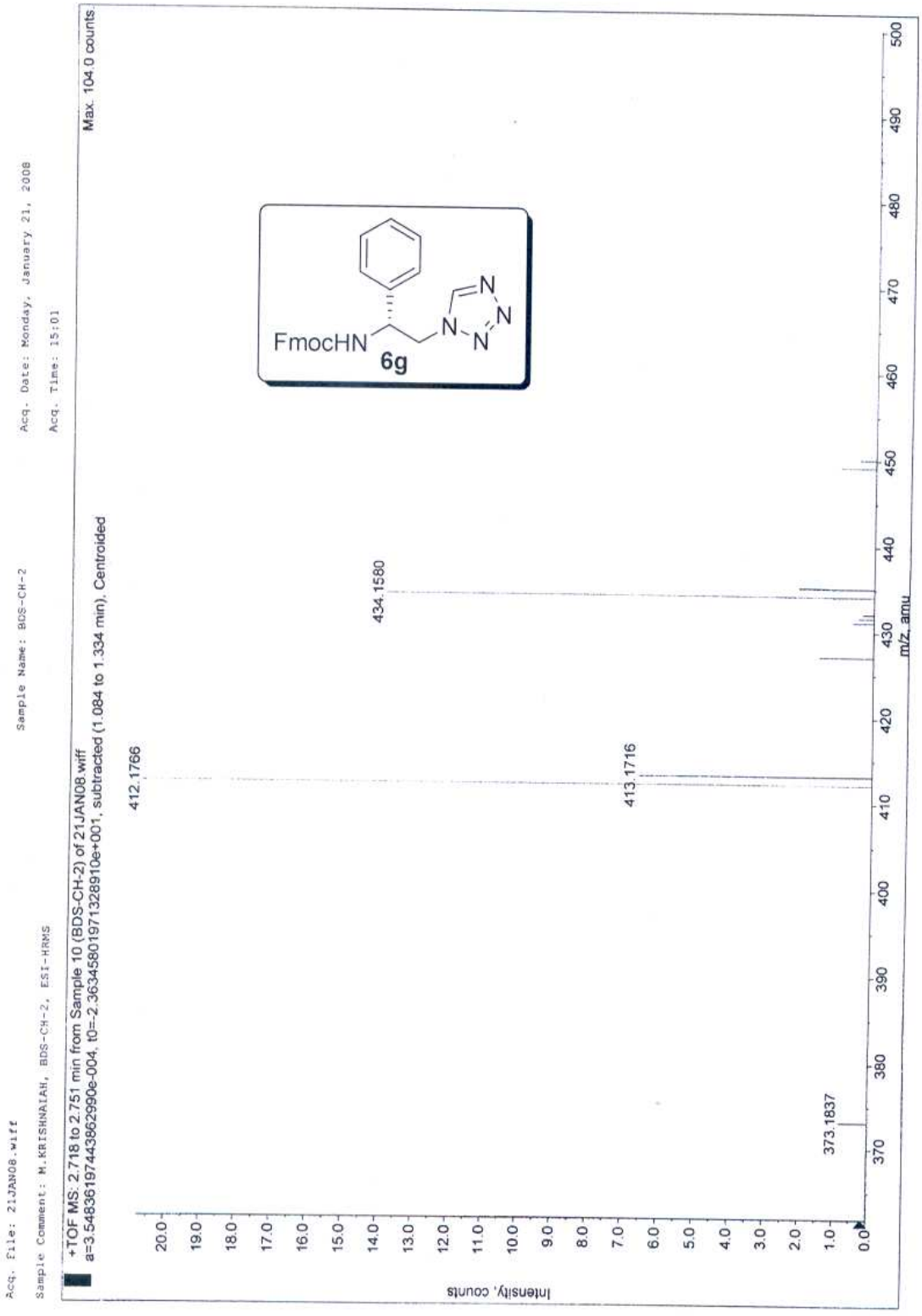
Fmoc-Leu-ψ [CH_2CN_4]



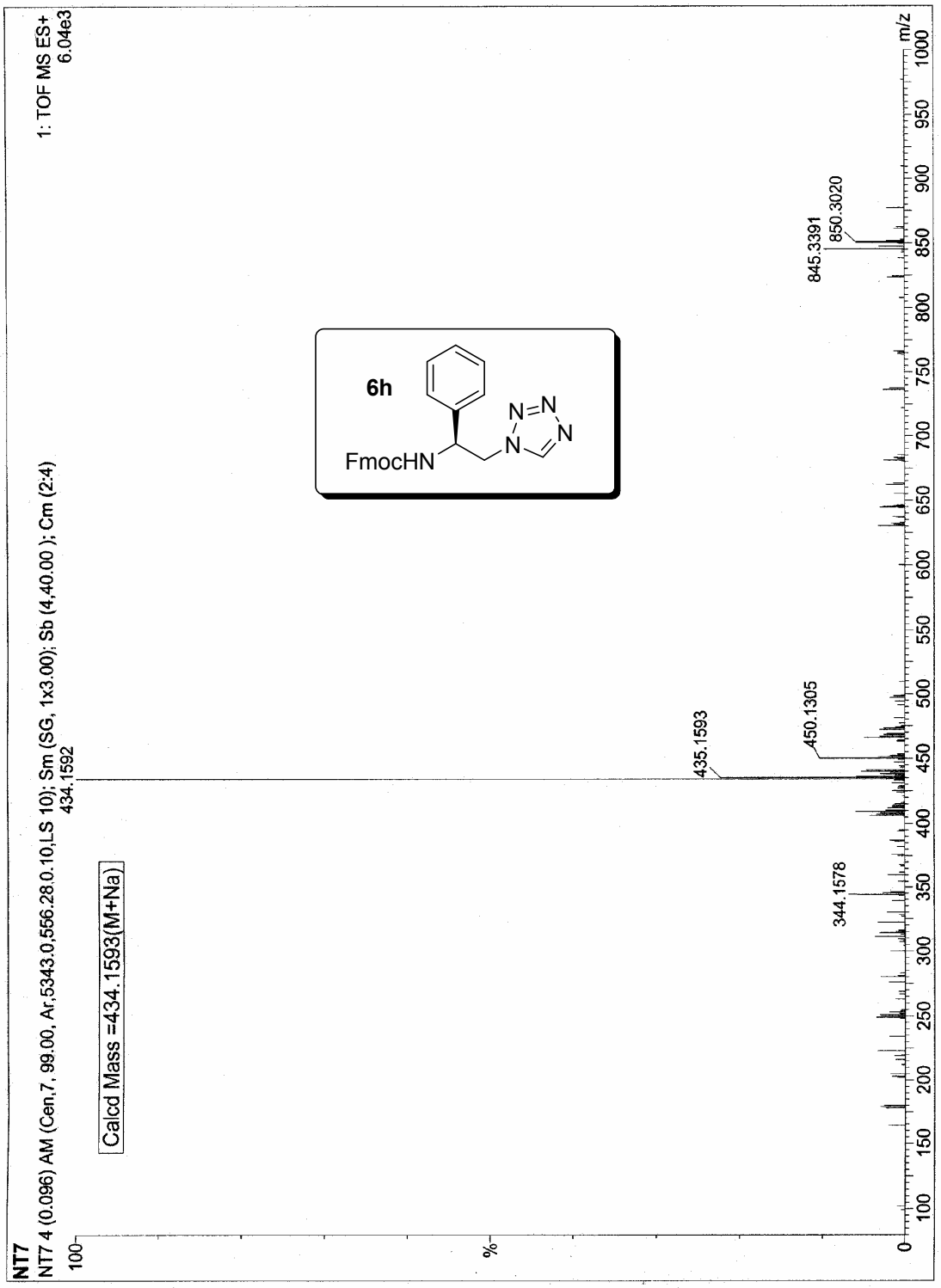
Fmoc-Ile-ψ [CH_2CN_4]



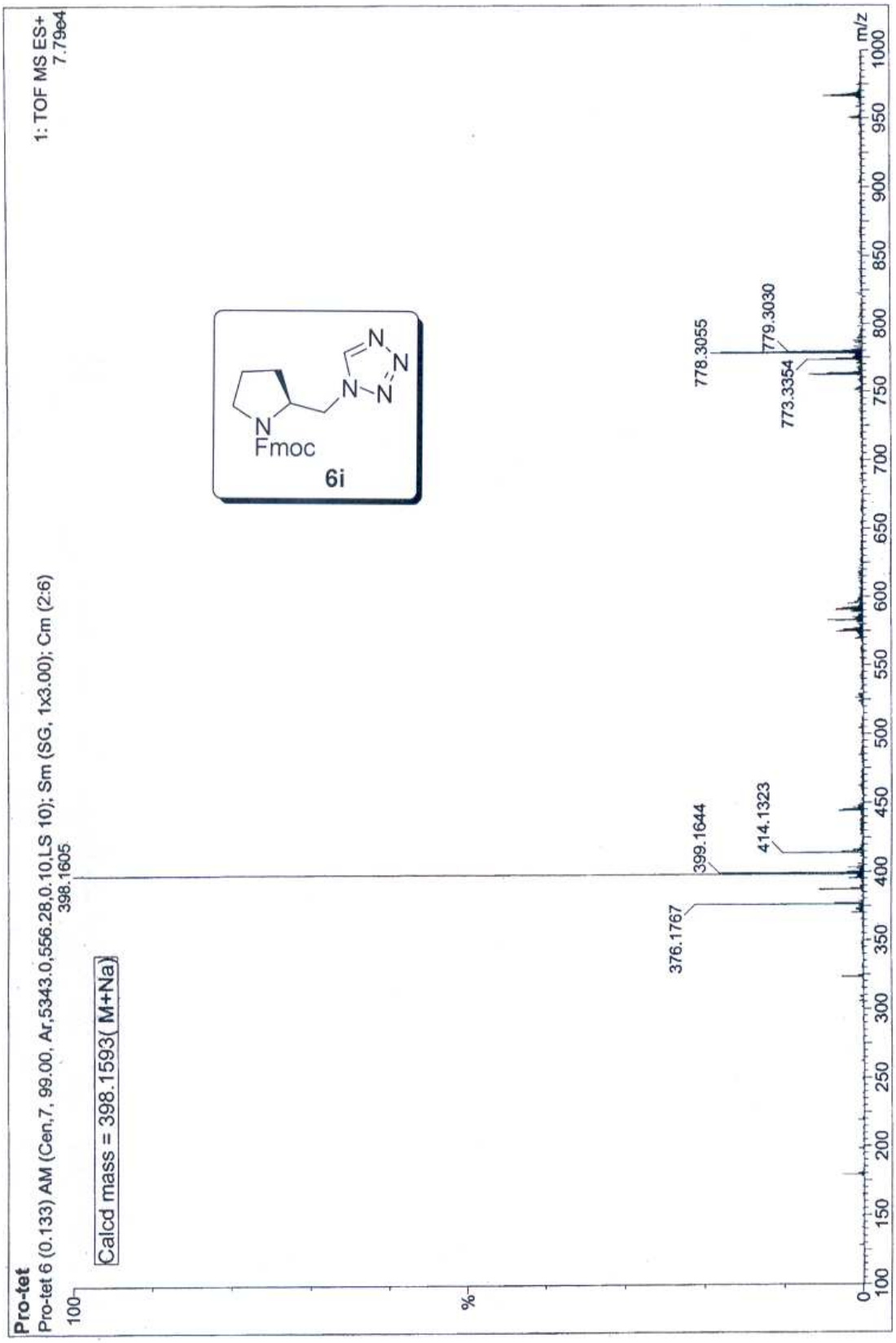
Fmoc-D-Phg-ψ [CH_2CN_4]



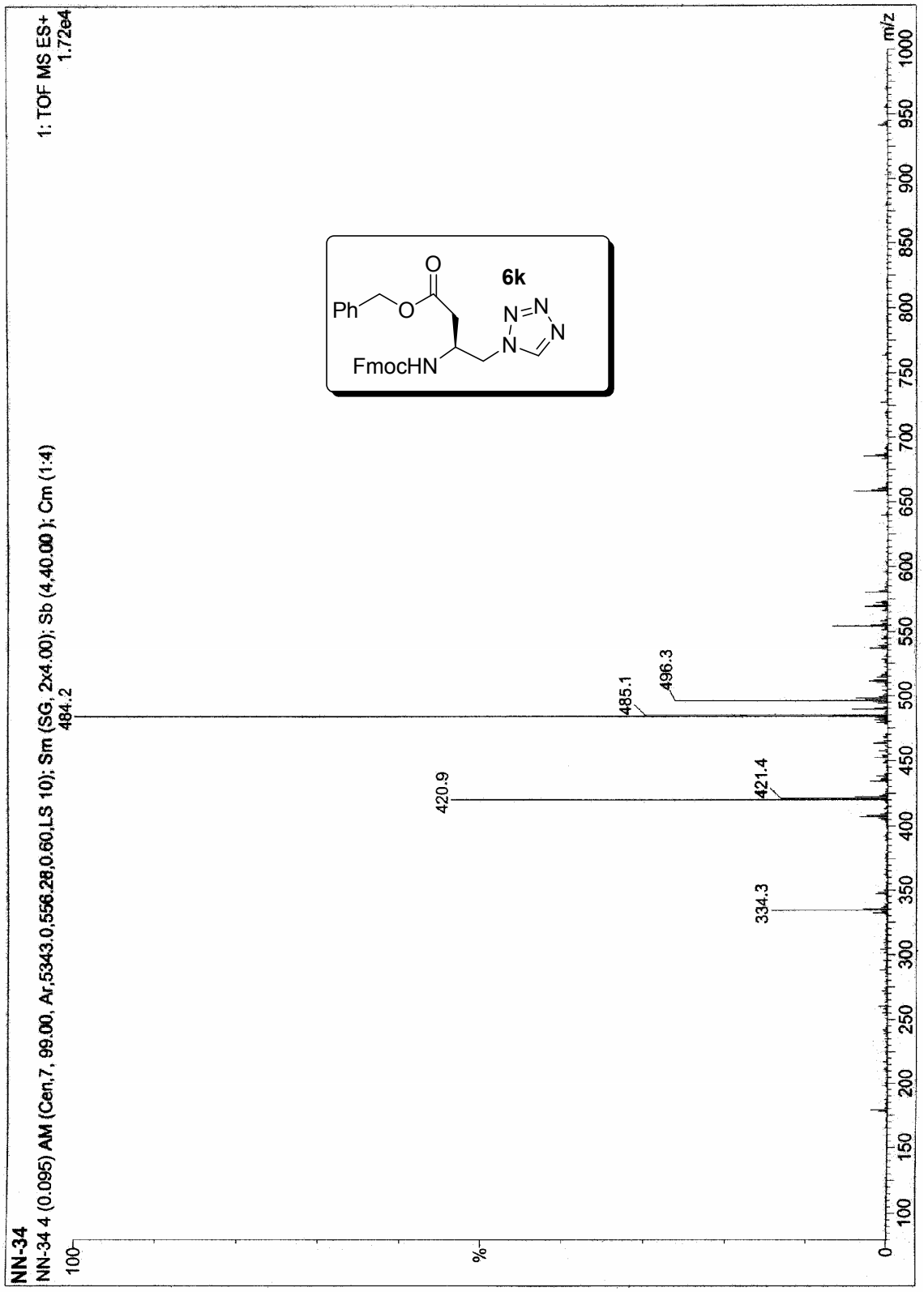
Fmoc-L-Phg-ψ [CH_2CN_4]



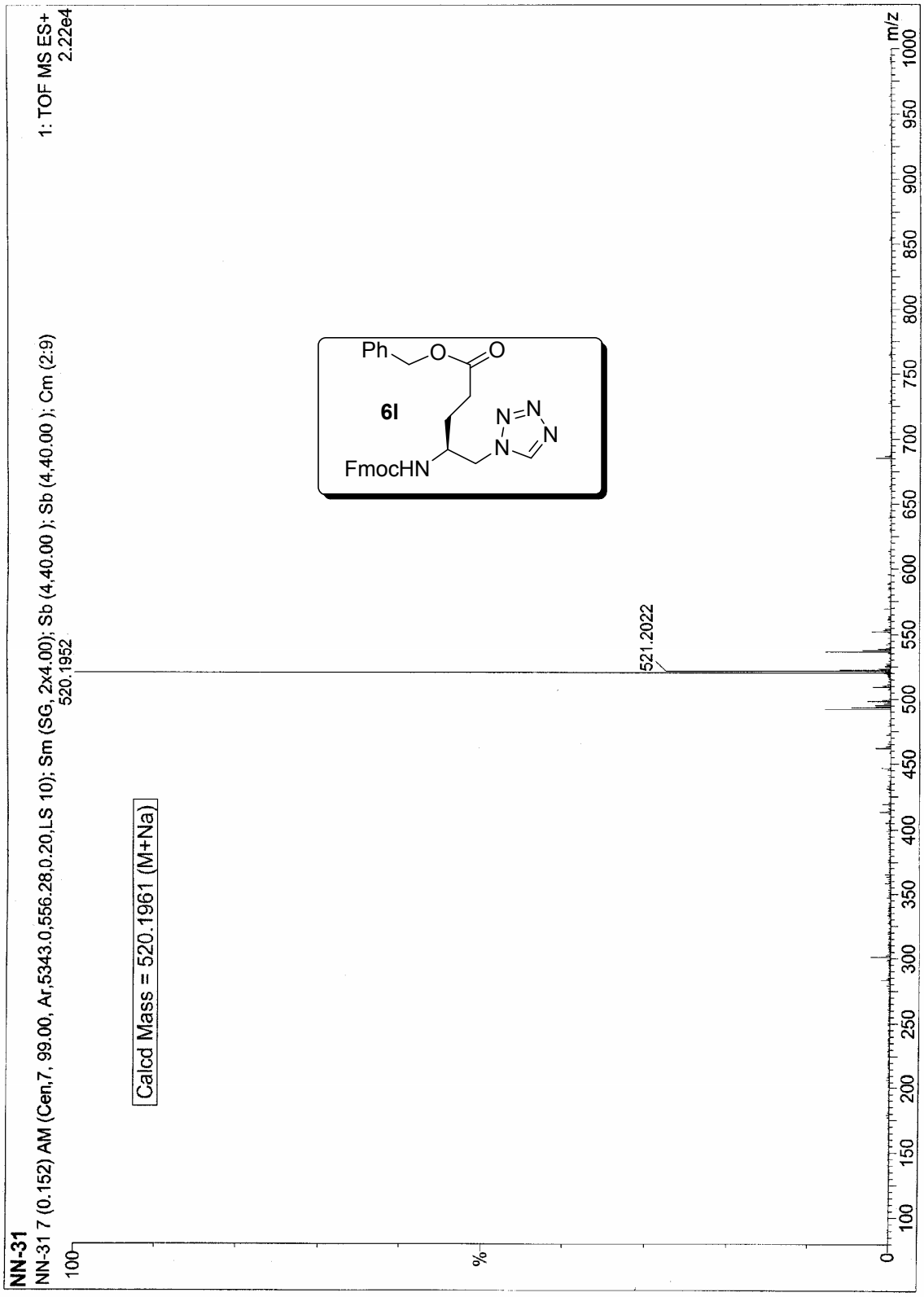
Fmoc-Pro-ψ [CH_2CN_4]



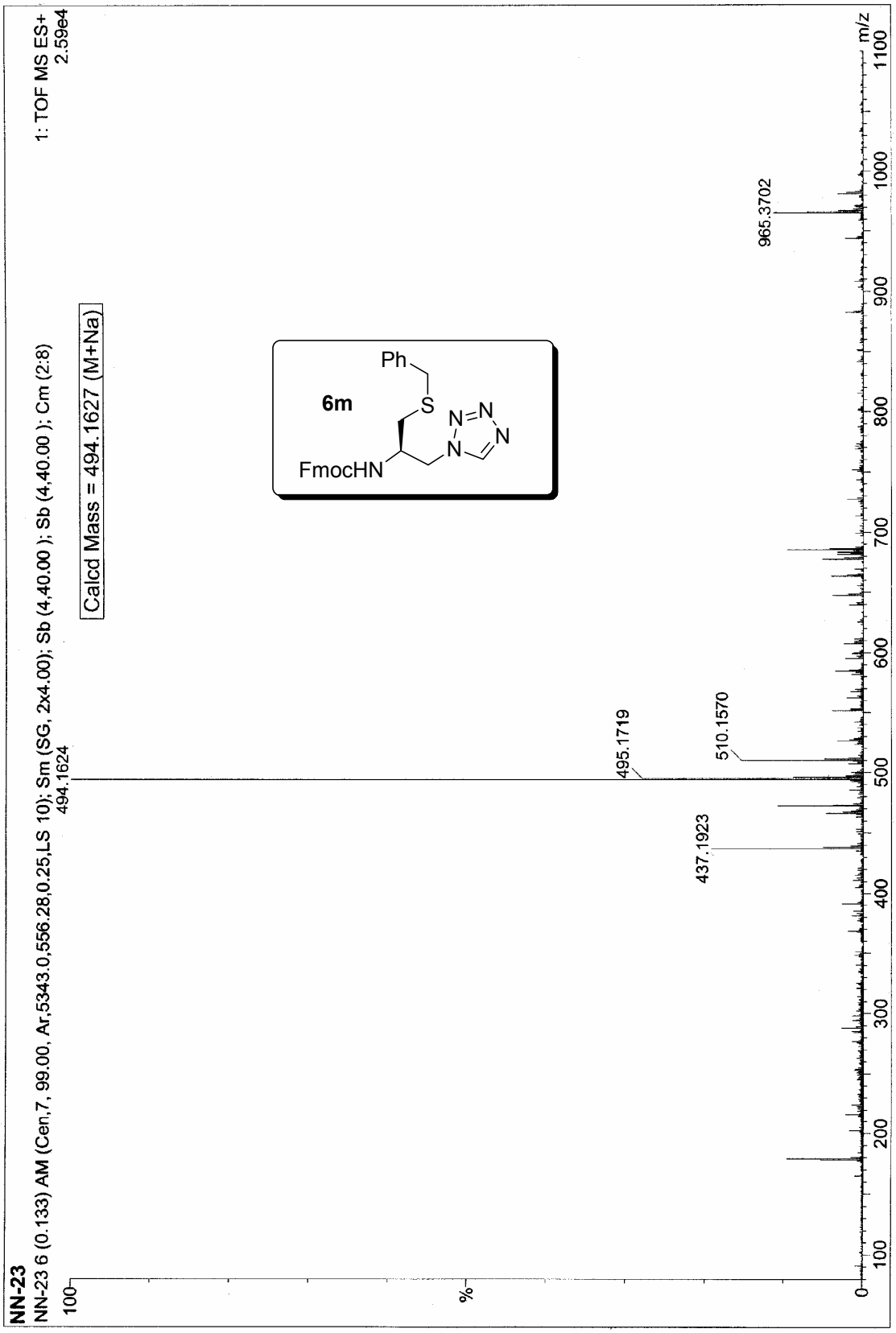
Fmoc-Asp(Bzl)-ψ [CH_2CN_4]



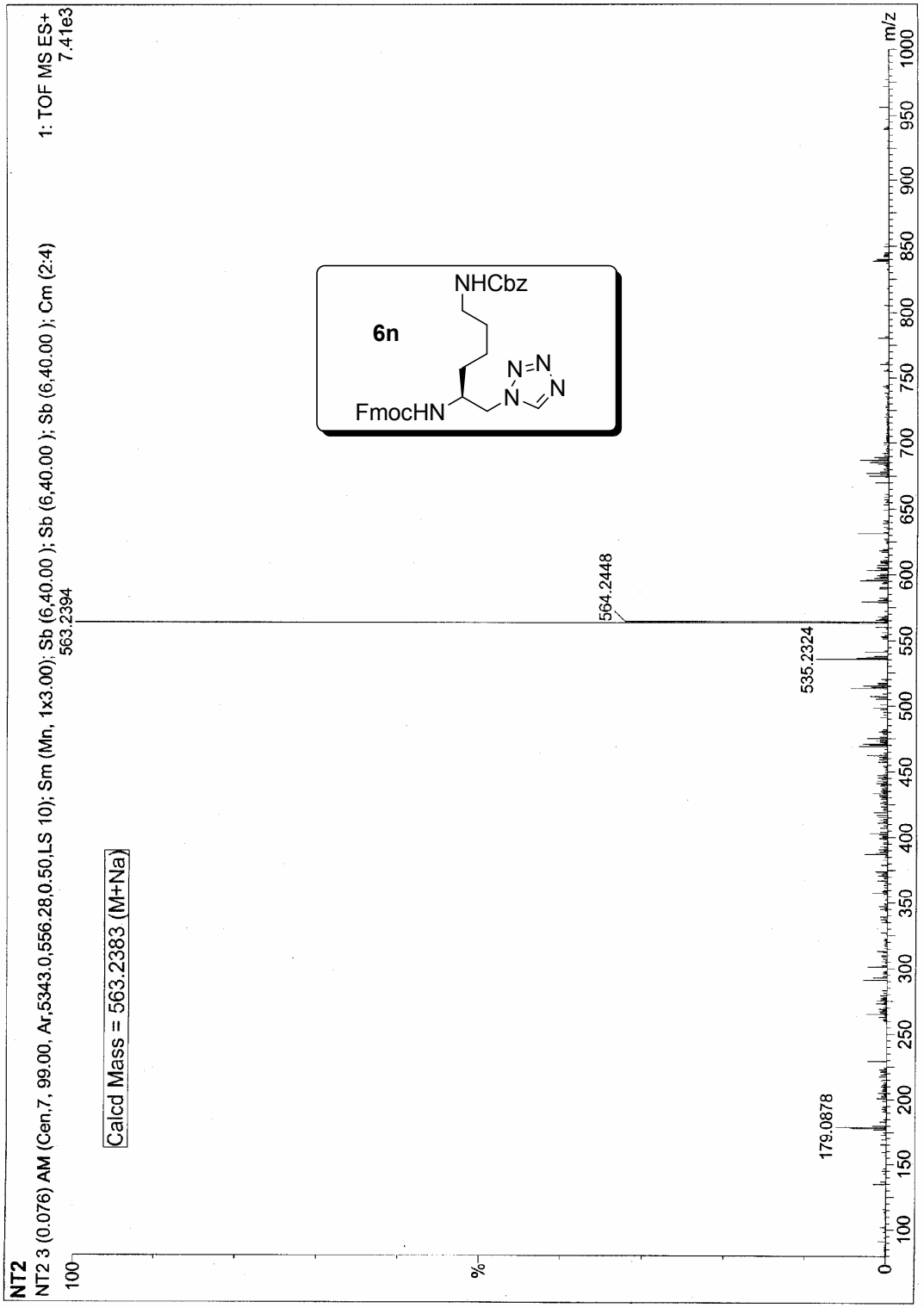
Fmoc-Glu(Bzl)-ψ [CH_2CN_4]



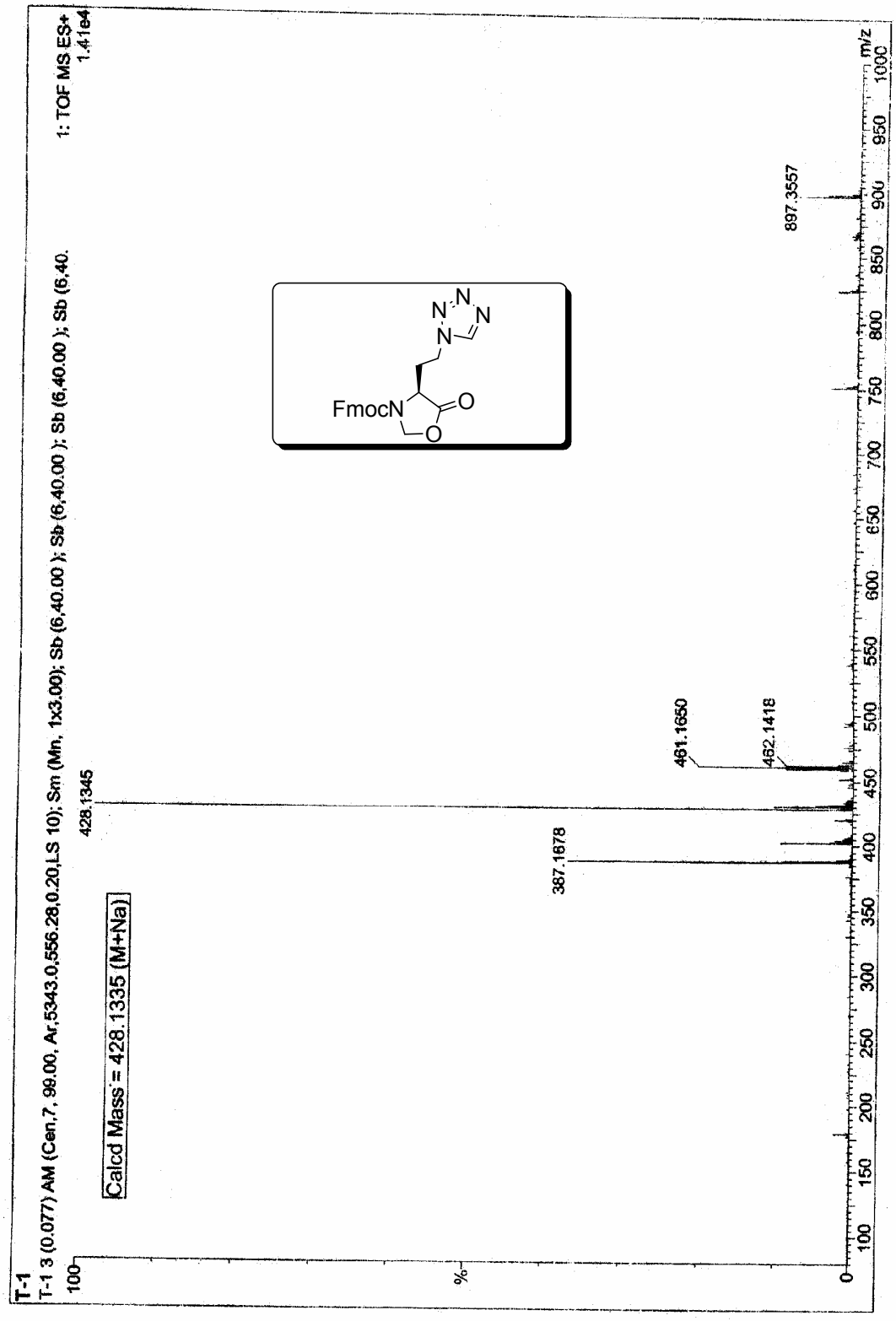
Fmoc-Cys(Bzl)-ψ [CH_2CN_4]



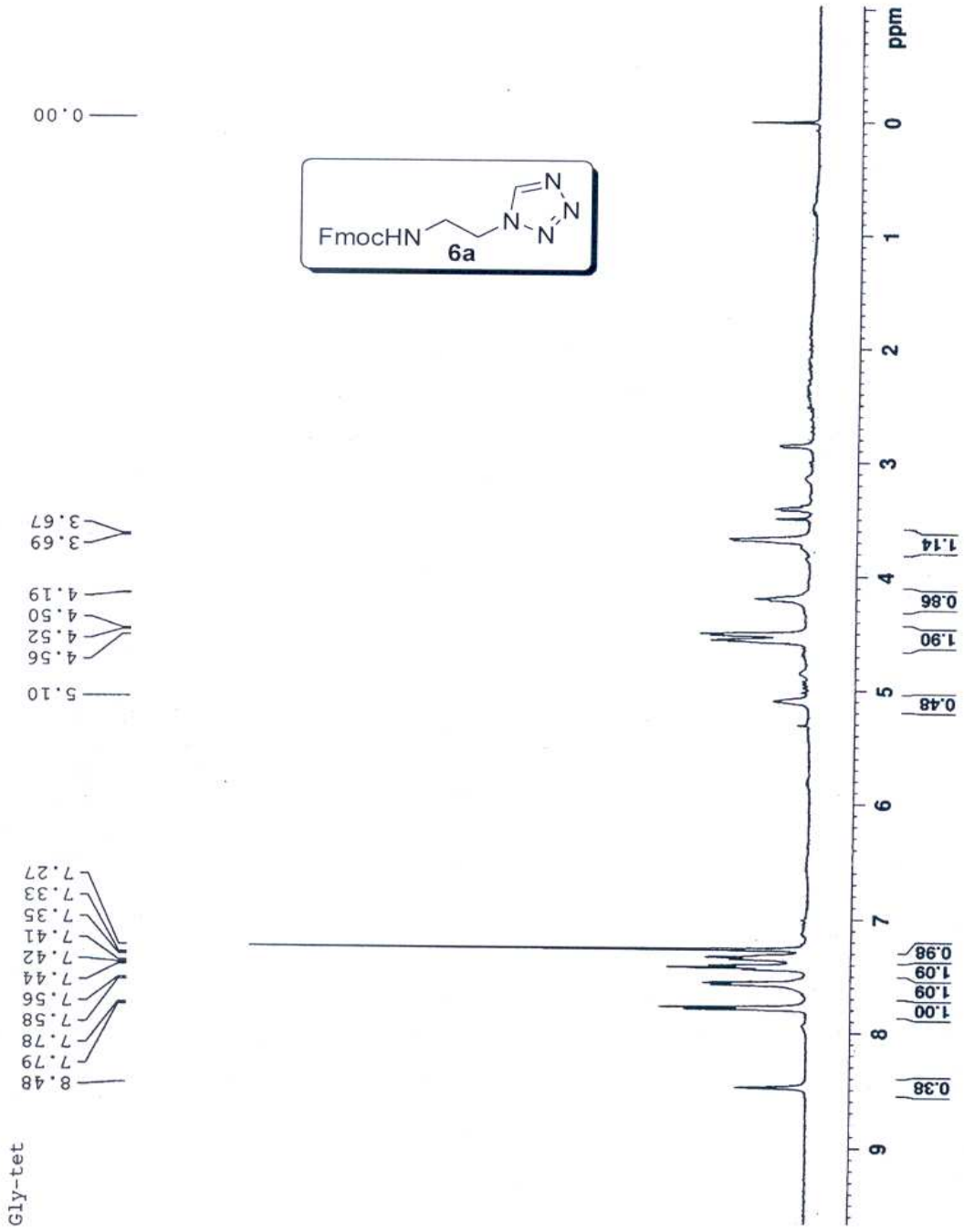
Fmoc-Lys(Cbz)-ψ [CH_2CN_4]



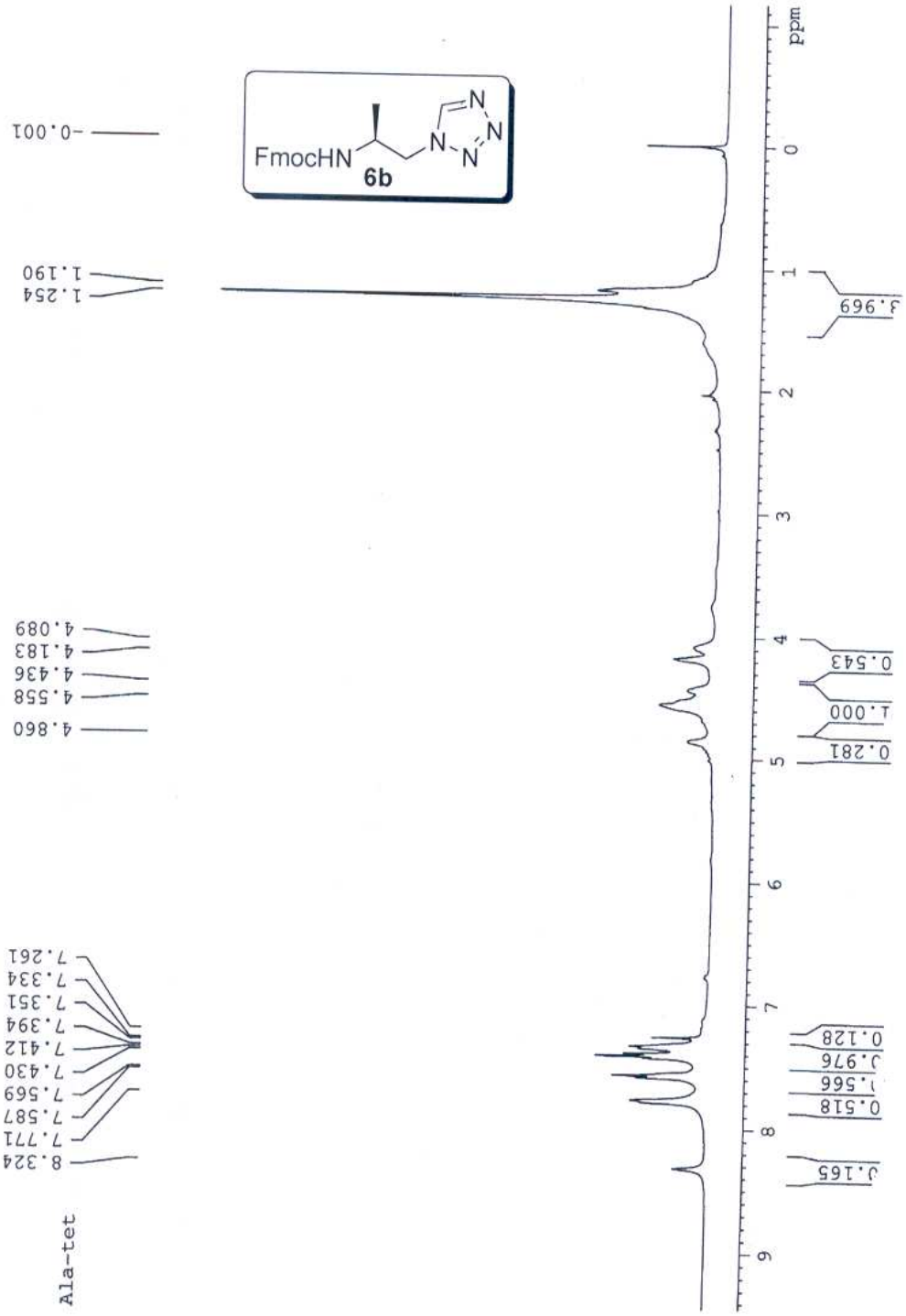
Fmoc-Glu(ψ[$(CH_2)_2CN_4$])-5-Oxazolidinone



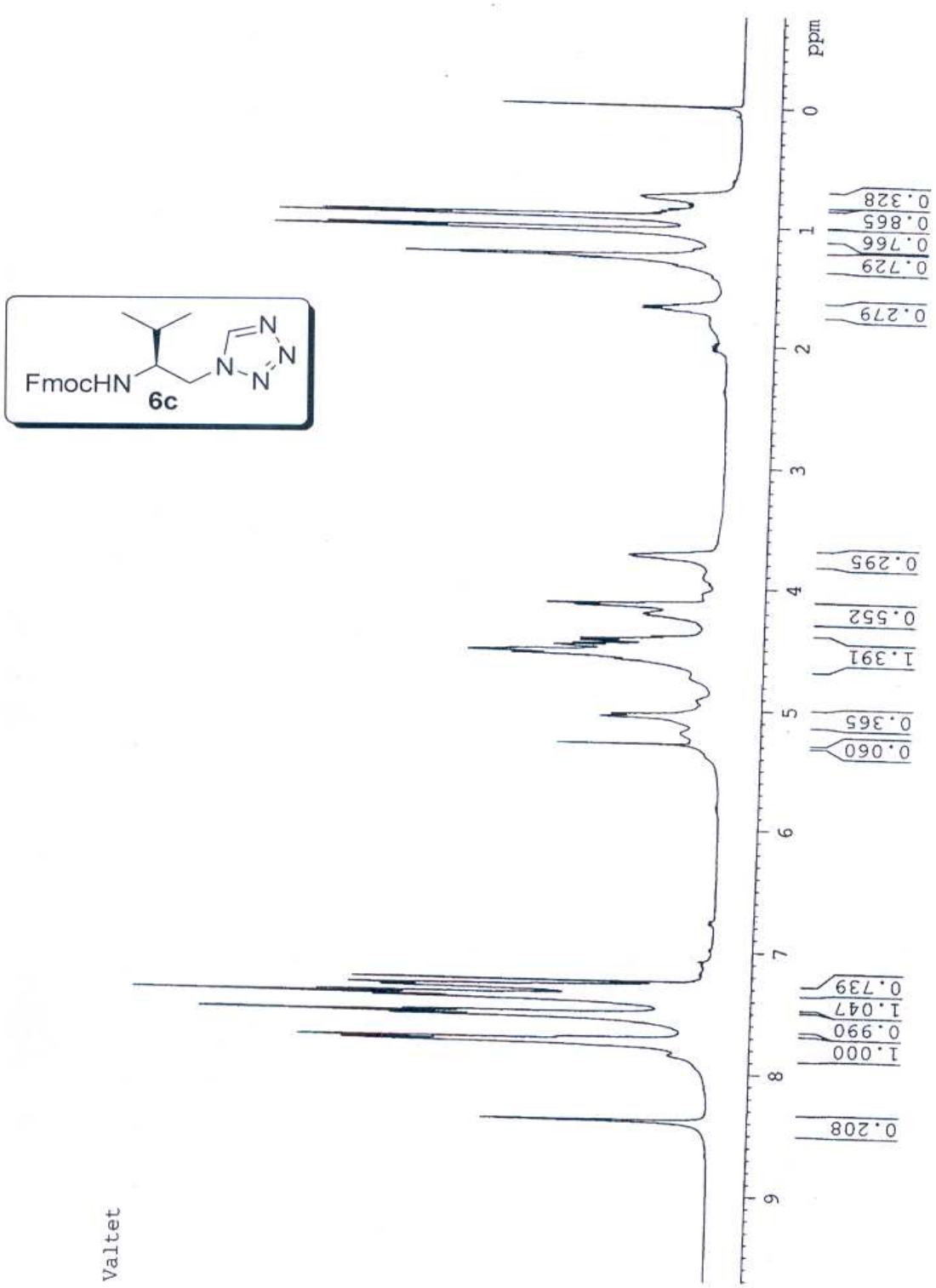
Fmoc-Gly-ψ [CH_2CN_4]



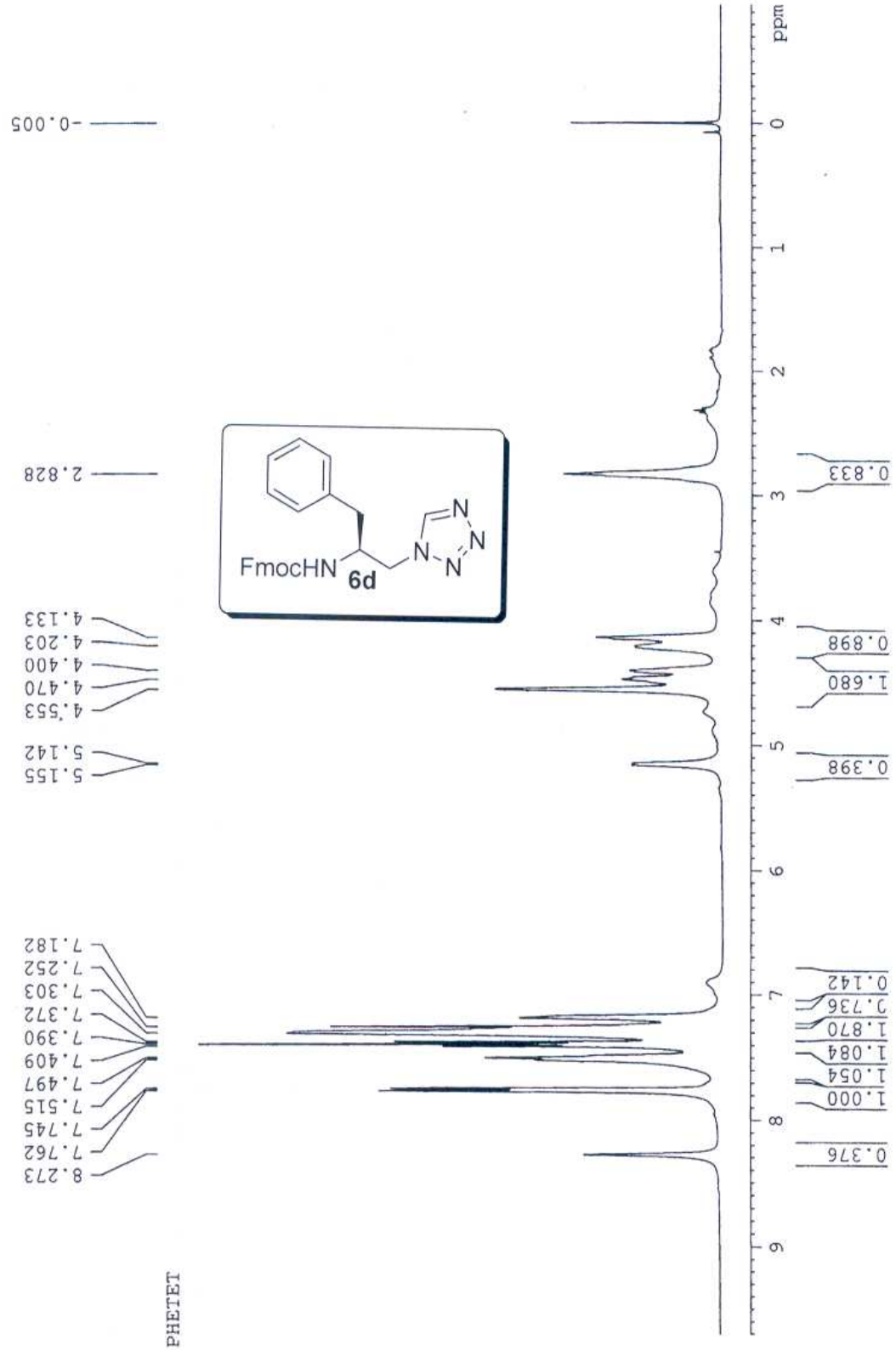
Fmoc-Ala-ψ [CH_2CN_4]



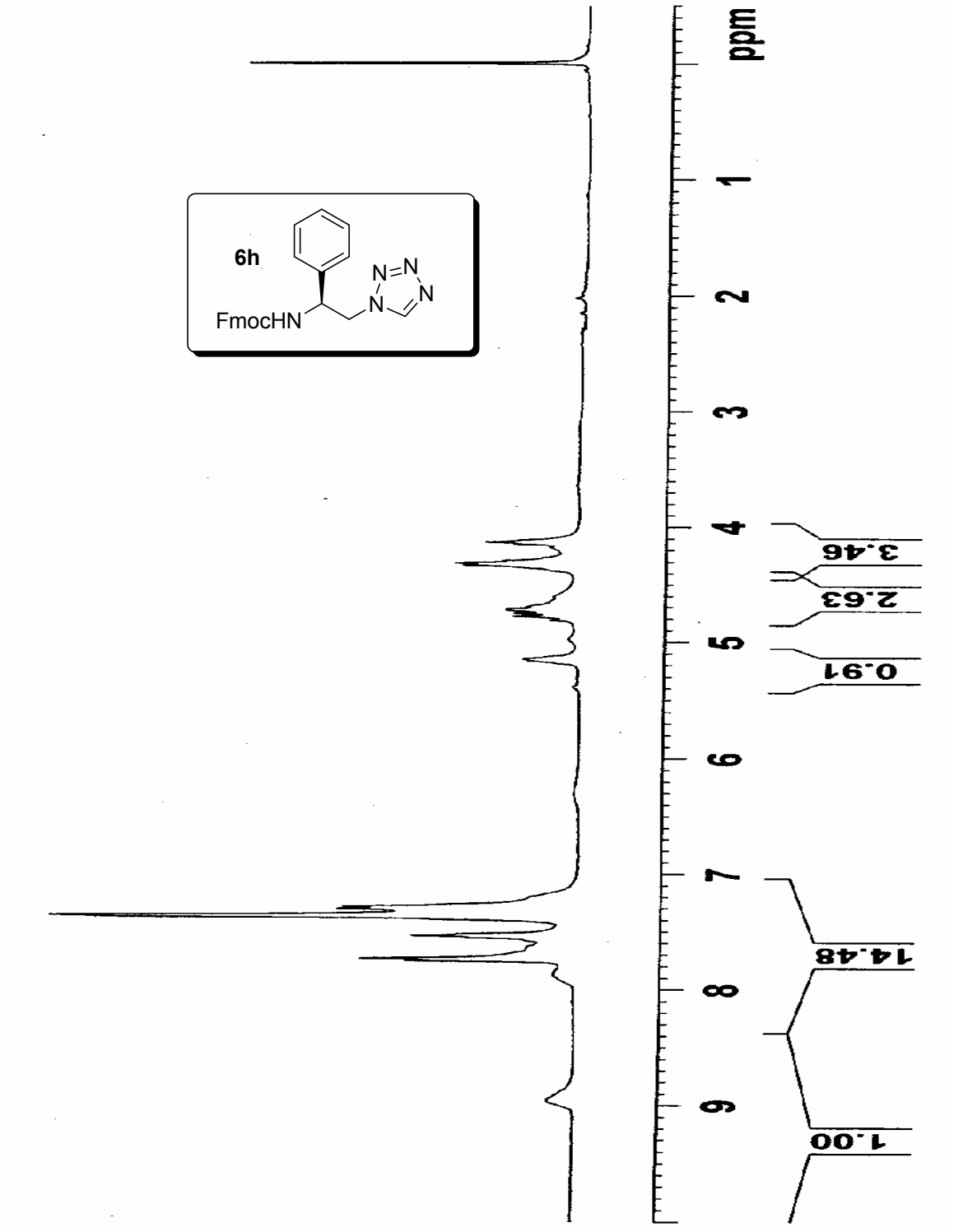
Fmoc-Val-ψ [CH_2CN_4]



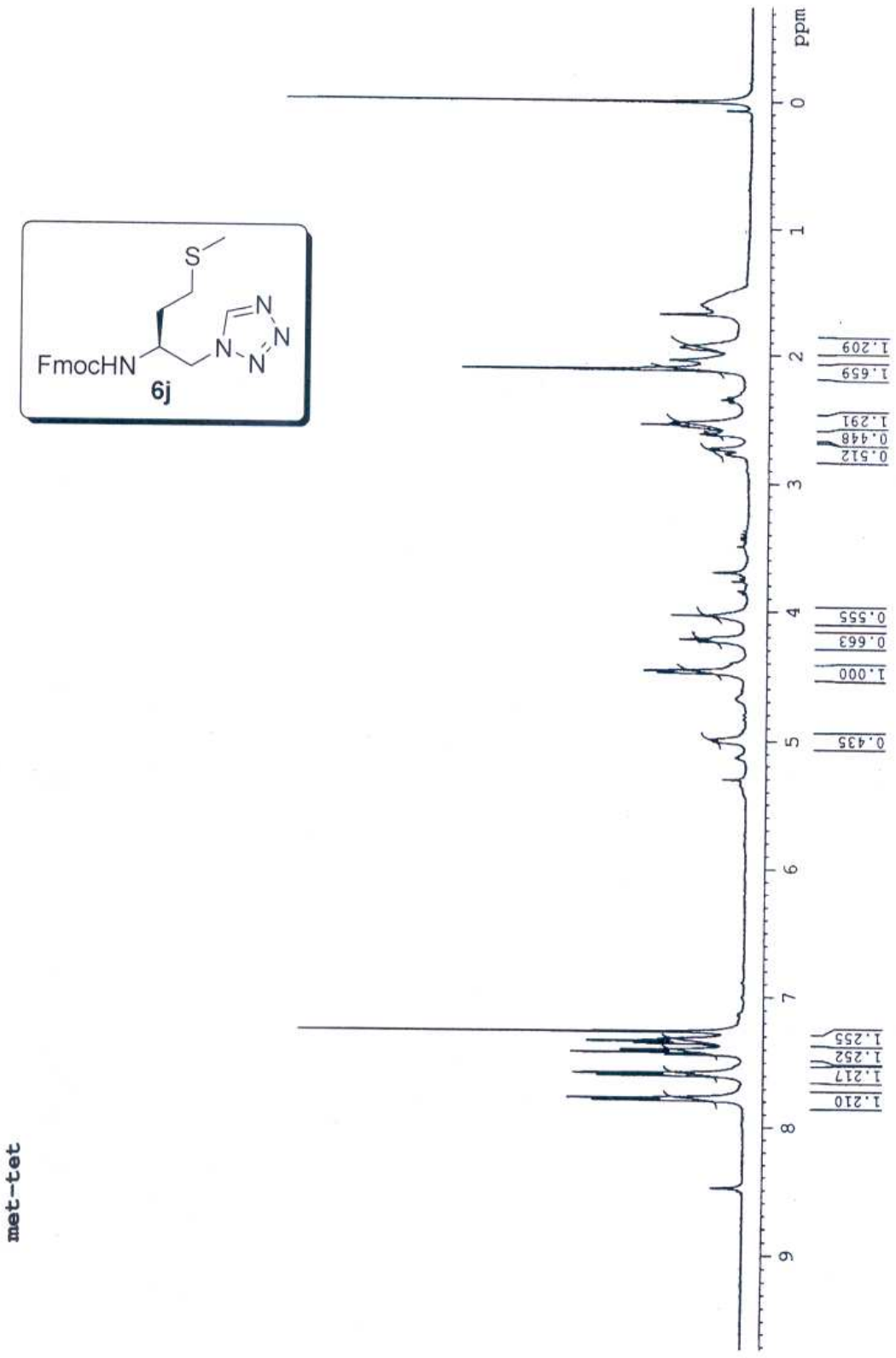
Fmoc-Phe-ψ [CH_2CN_4]



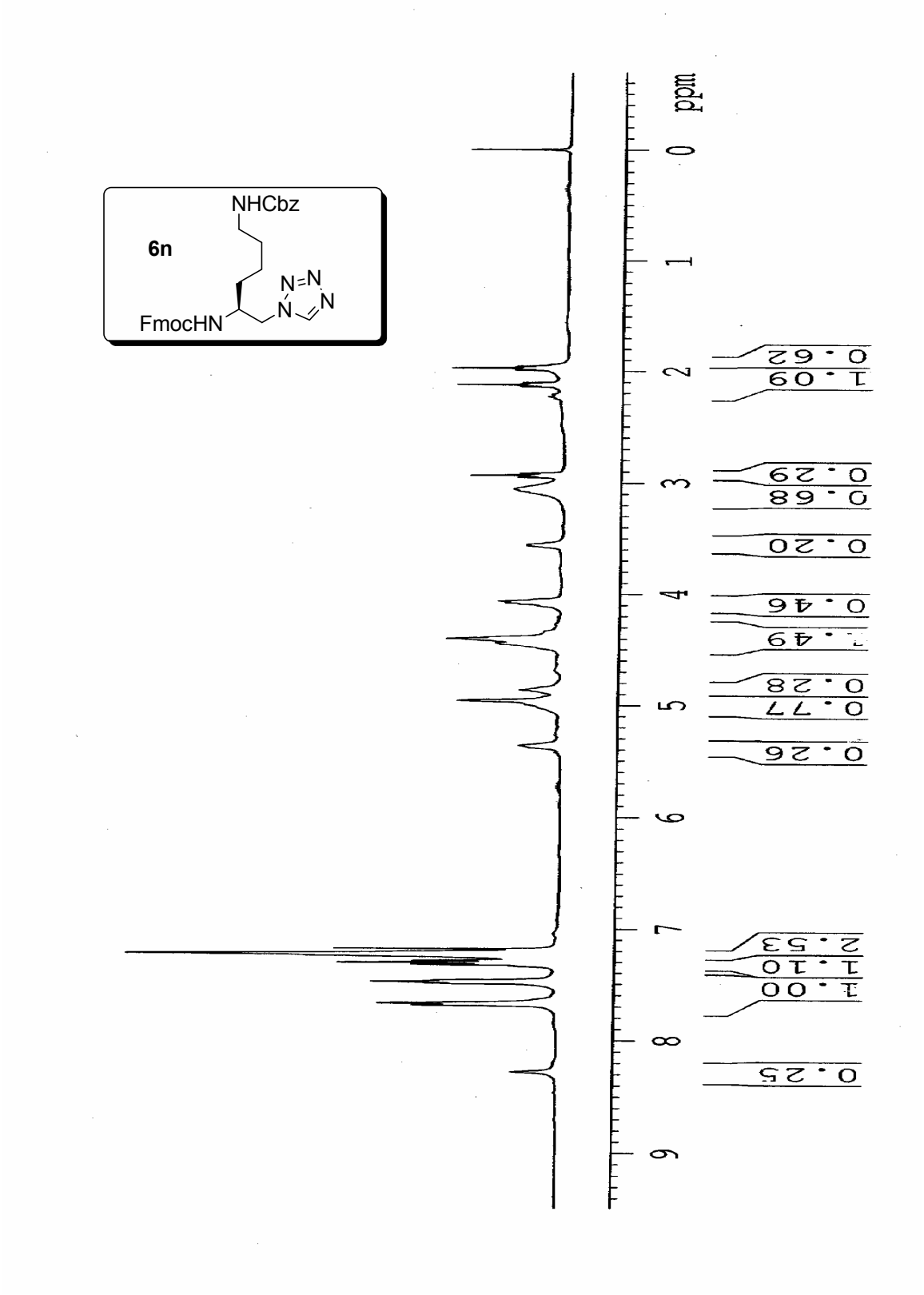
Fmoc-L-Phg -ψ [CH_2CN_4]



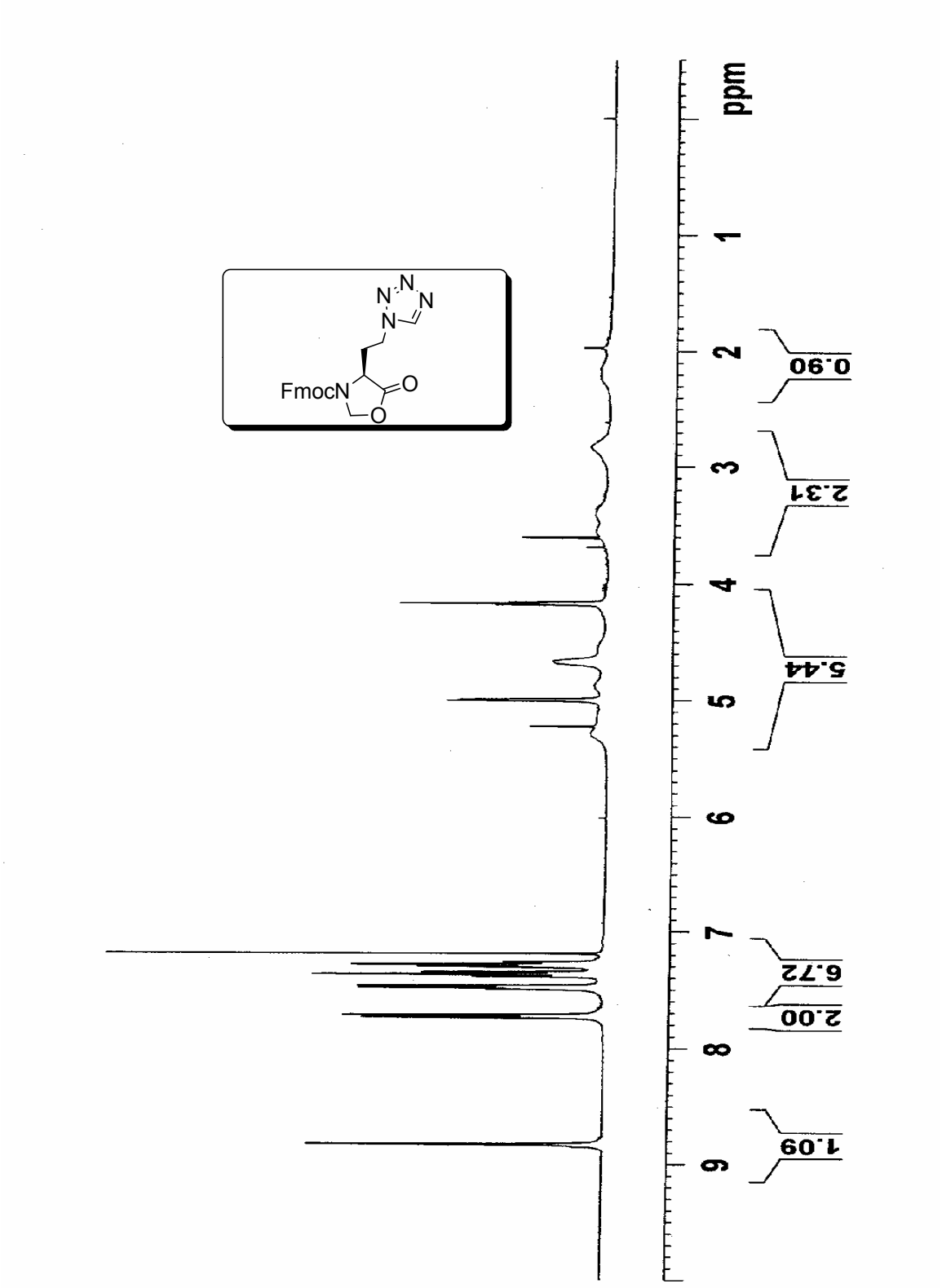
Fmoc-Met-ψ [CH_2CN_4]



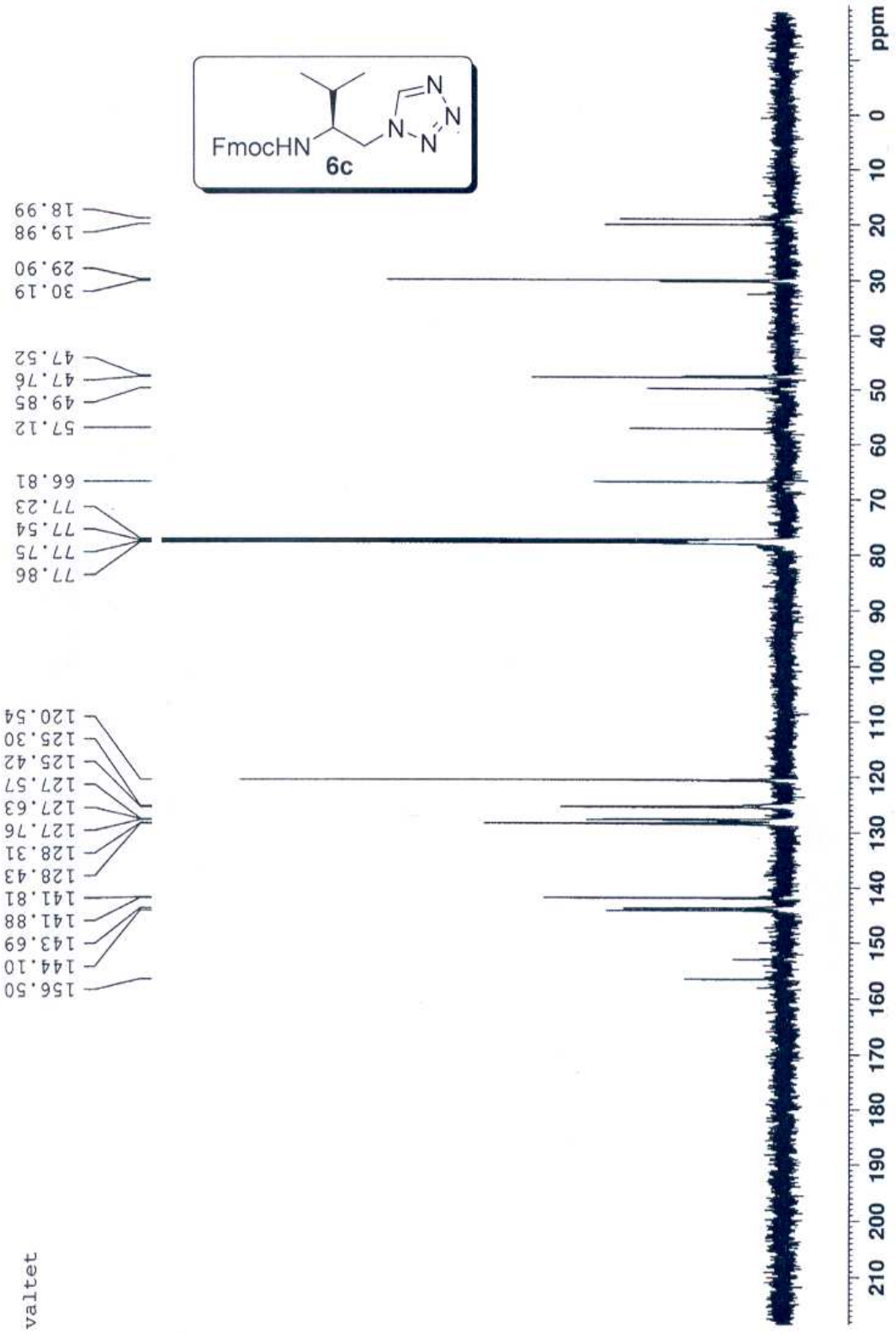
Fmoc-Lys(Cbz)-ψ [CH_2CN_4]



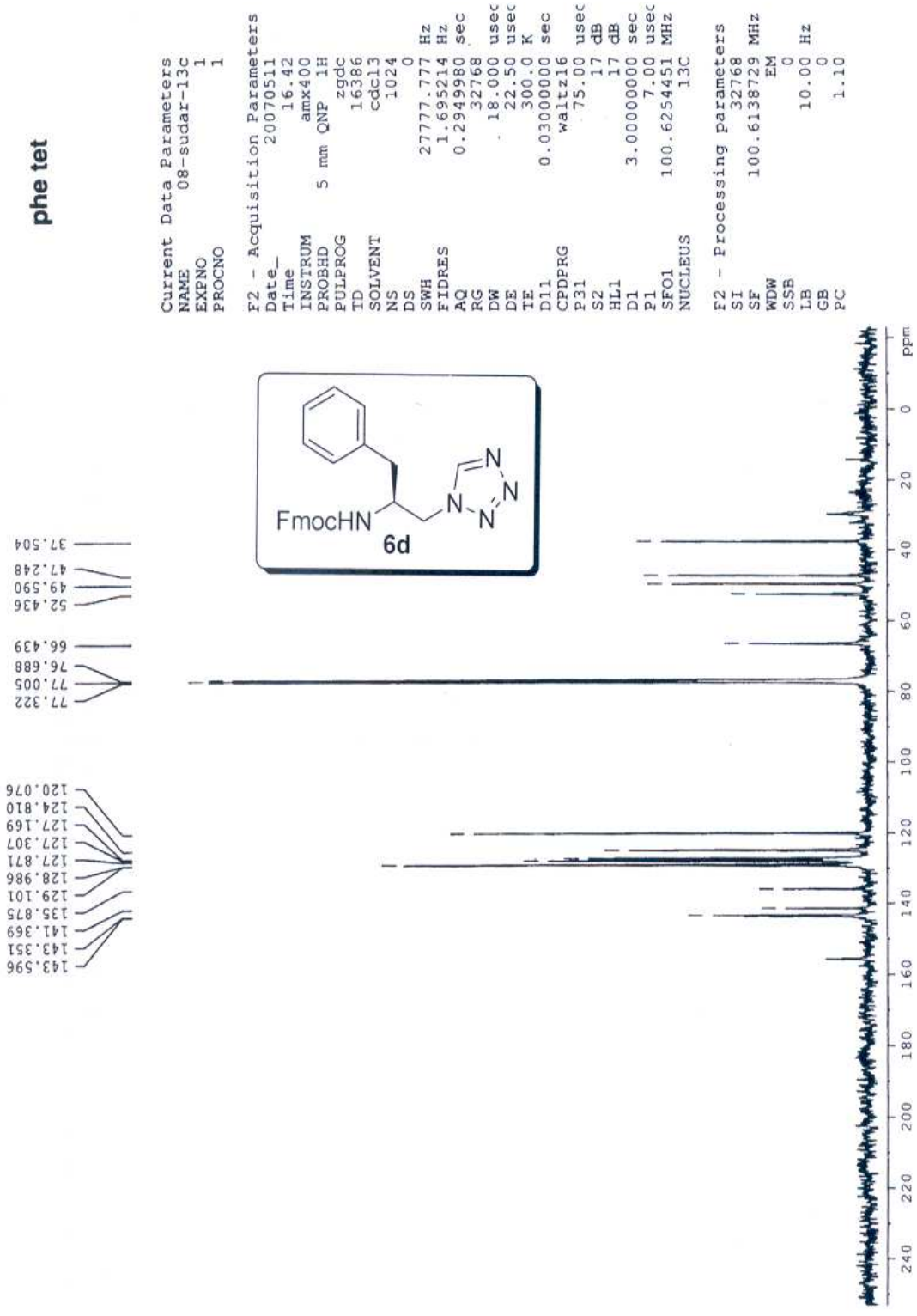
Fmoc-Glu(ψ[$(CH_2)_2CN_4$])-5-Oxazolidinone



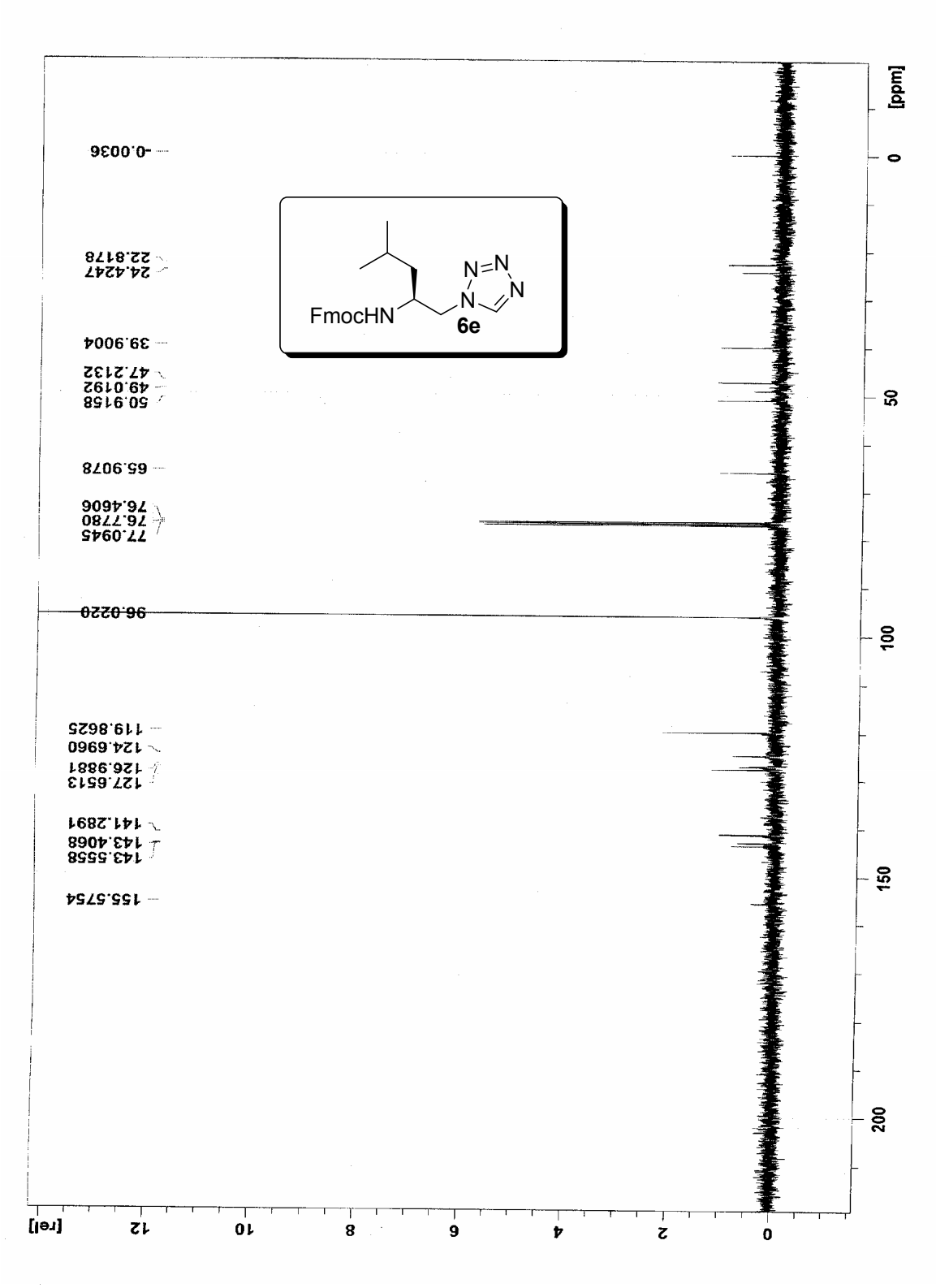
Fmoc-Val-ψ [CH_2CN_4]



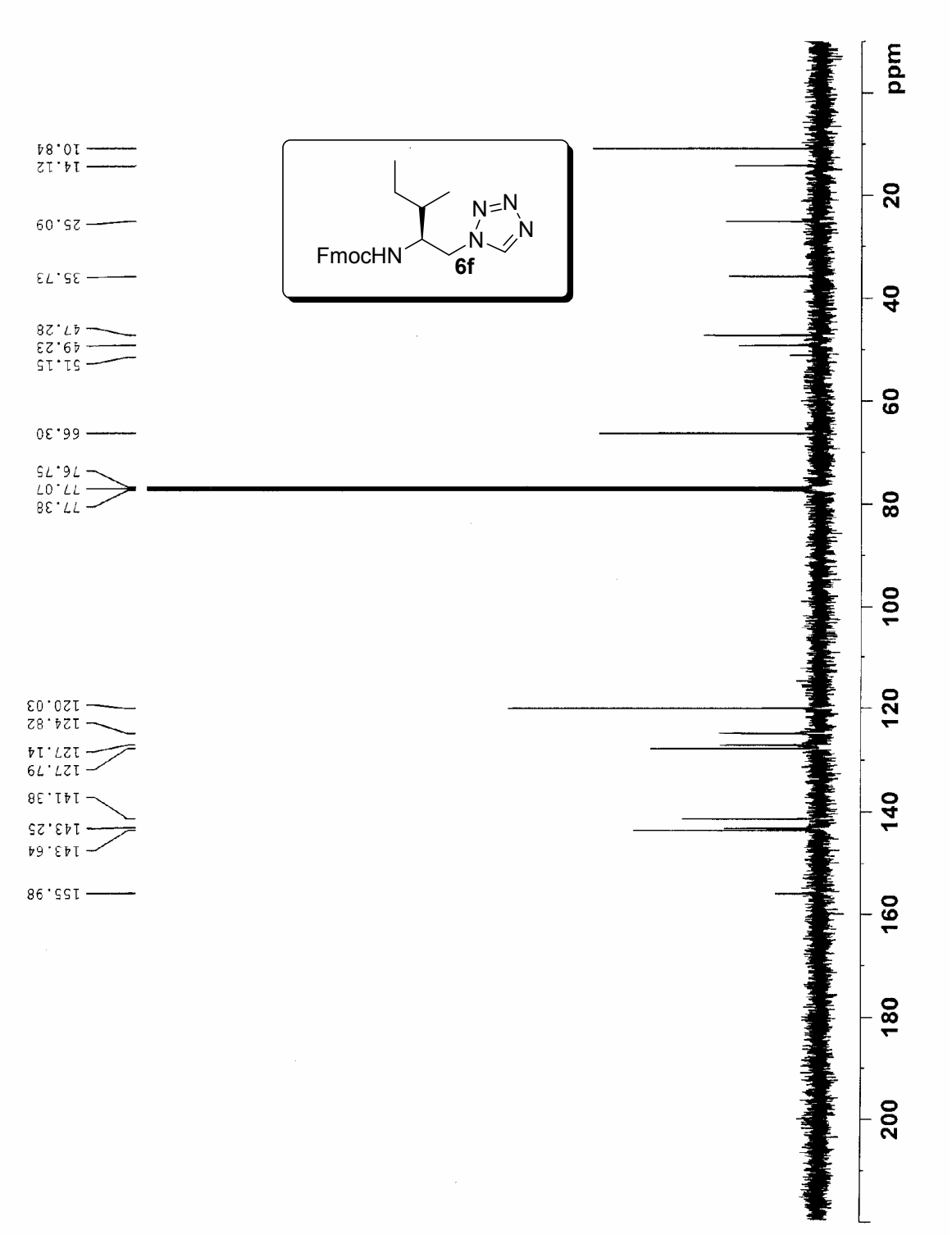
Fmoc-Phe-ψ [CH_2CN_4]



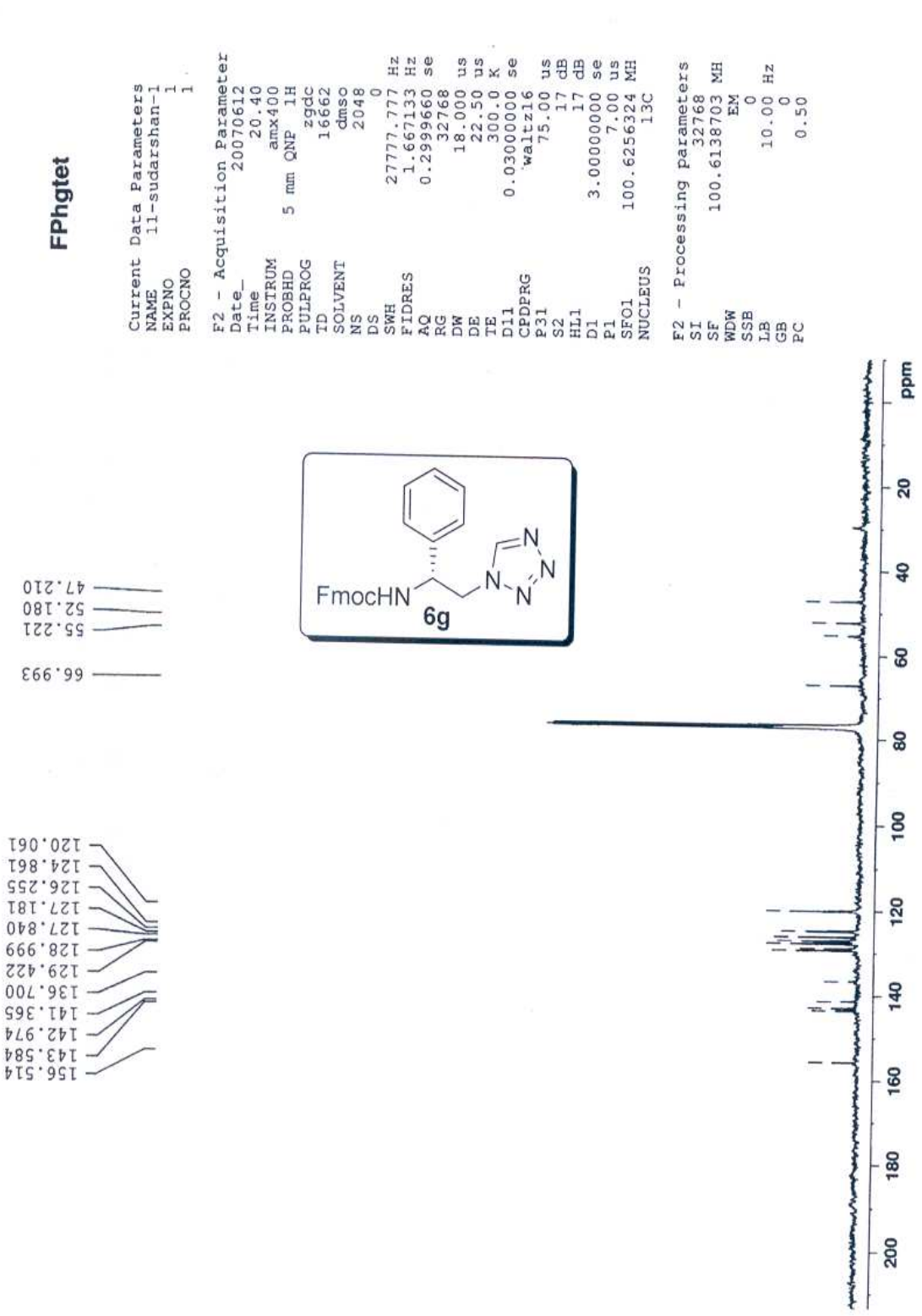
Fmoc-Leu-ψ [CH_2CN_4]



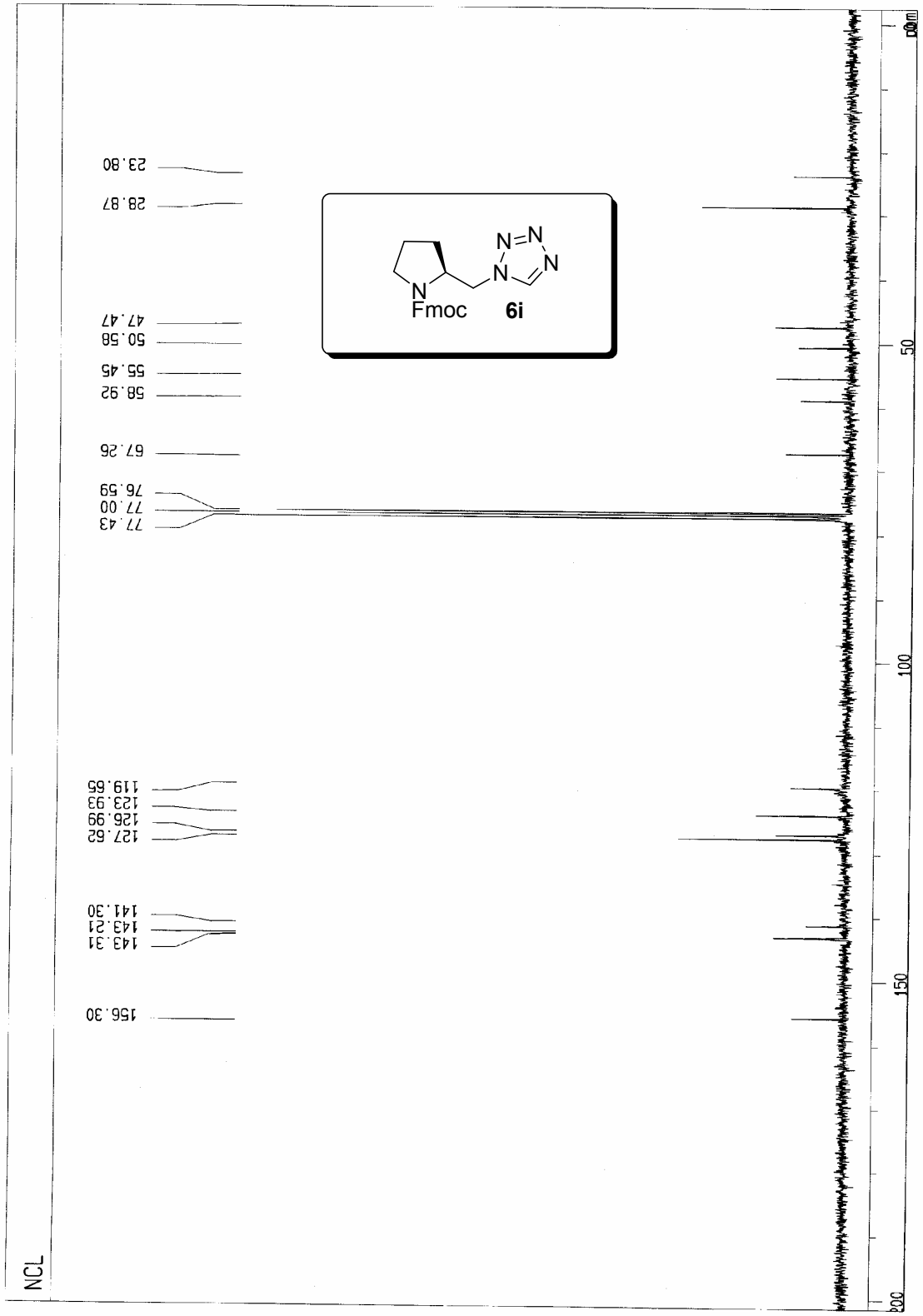
Fmoc-Ile-ψ [CH_2CN_4]



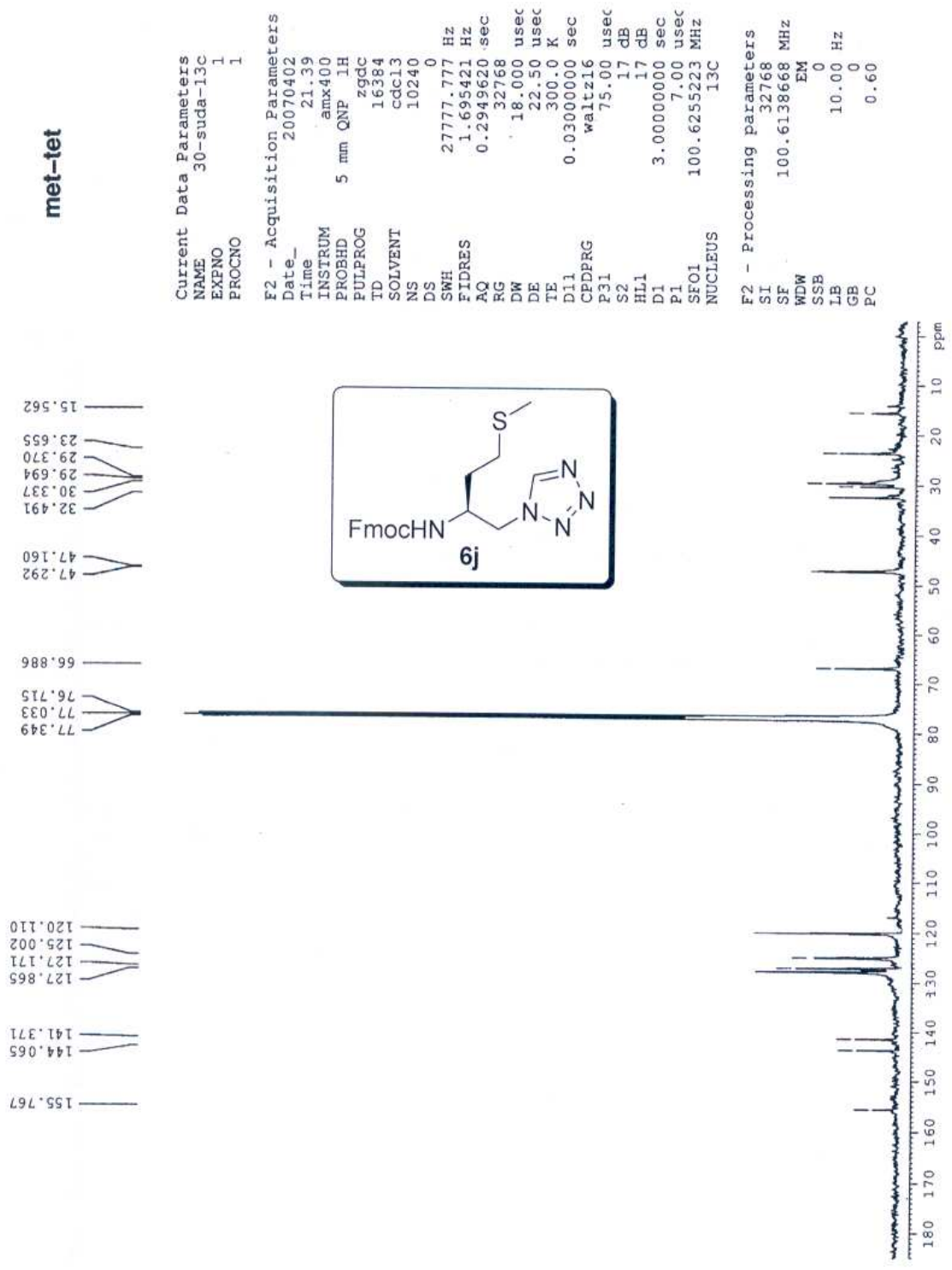
Fmoc-D-Phg-ψ [CH_2CN_4]



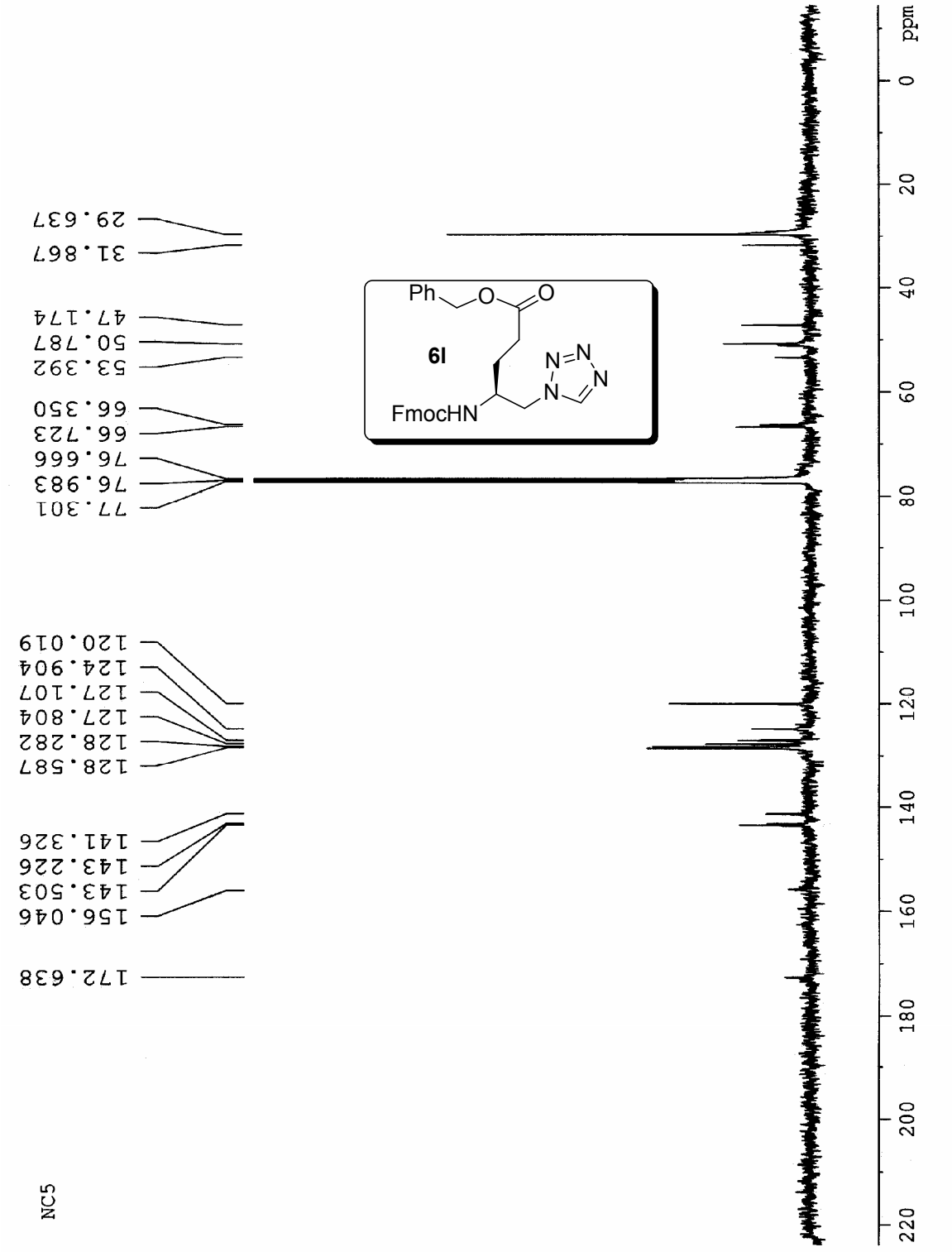
Fmoc-Pro-ψ [CH_2CN_4]



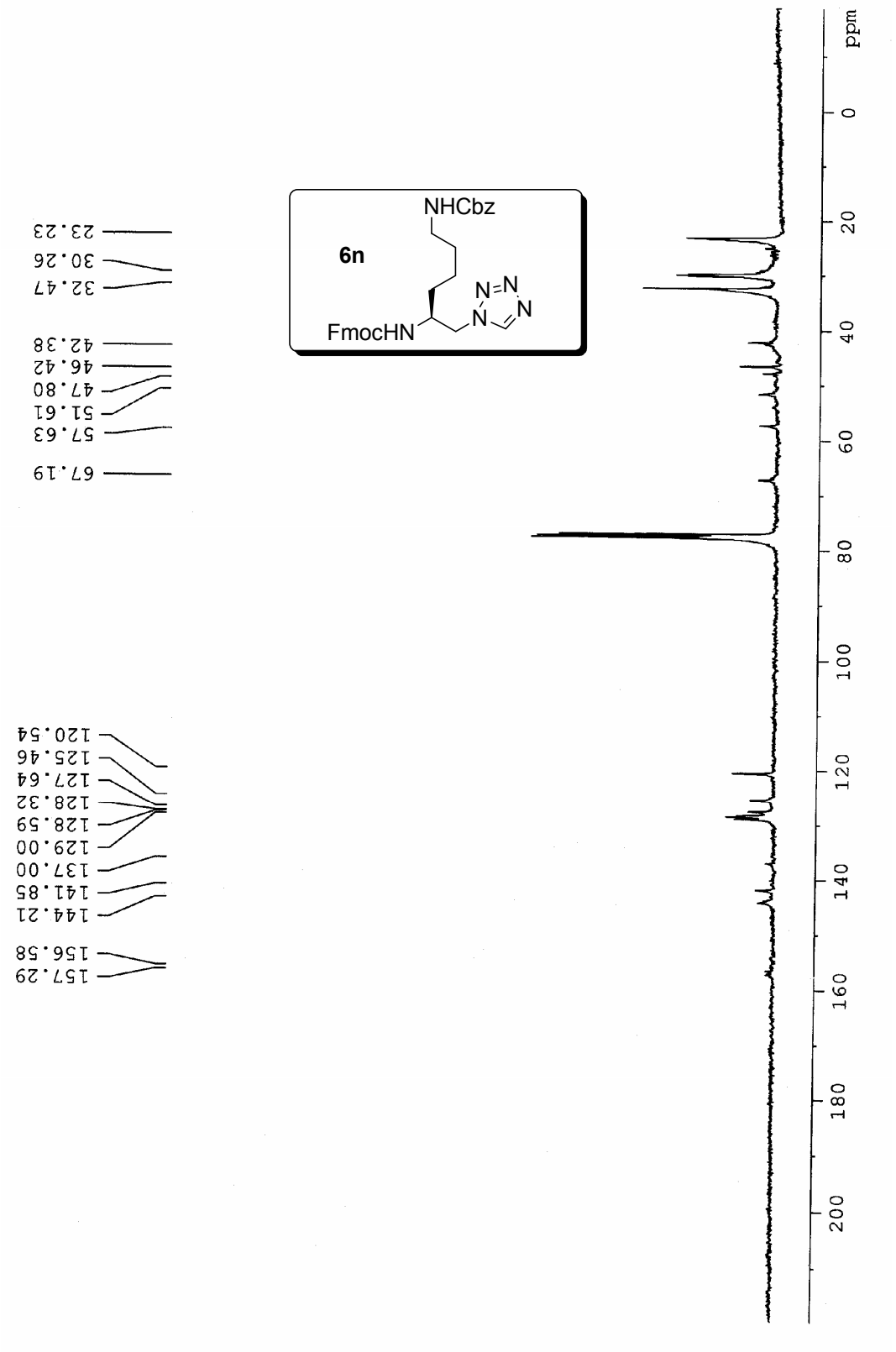
Fmoc-Met-ψ [CH_2CN_4]



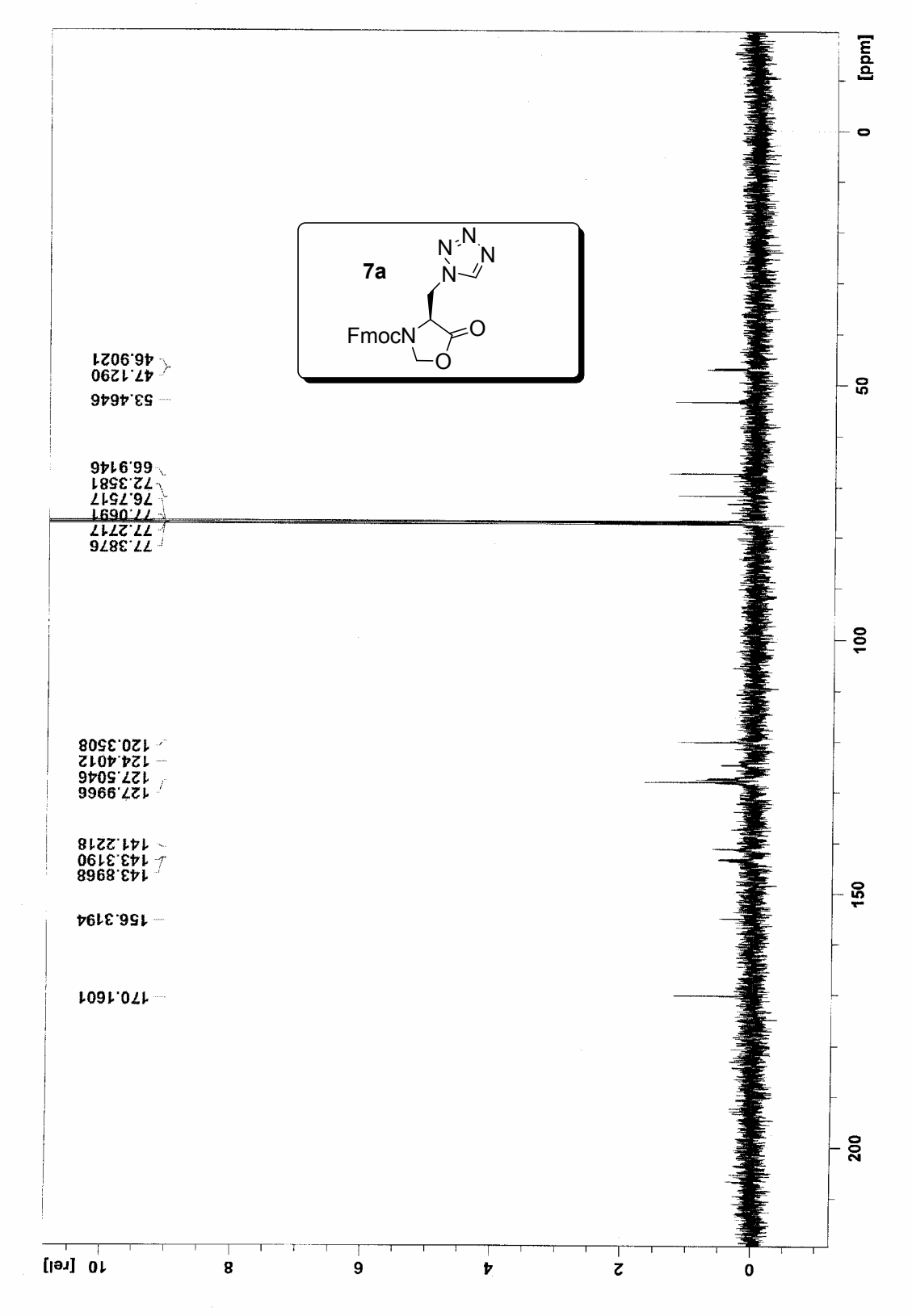
Fmoc-Glu(Bzl)-ψ[CH_2CN_4]



Fmoc-Lys(Cbz)-ψ [CH_2CN_4]



Fmoc-Asp(ψ[CH_2CN_4])-5-Oxazolidinone



Fmoc-Glu(ψ[$(CH_2)_2CN_4$])-5-Oxazolidinone