Electronic Supplementary Material (ESI) for RSC Advances

Supplementary Information

Zinc Iodide: a mild and efficient catalyst for one-pot synthesis of aminoindolizines *via* sequential A^3 coupling/cycloisomerization

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Contents:

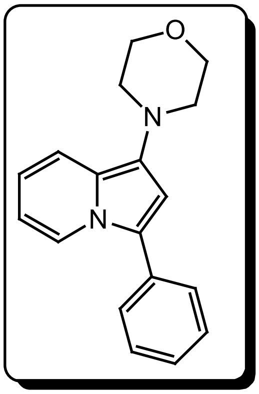
I. General information:

^{1}H NMR spectra were determined on a Bruker 400 (400 MHz) spectrometer as solutions in C_6D_6. Chemical shifts are expressed in parts per million (δ) and the signals were reported as s (singlet), d (doublet), t (triplet), m (multiplet) and coupling constants *J* were given in Hz.. ^{13}C NMR spectra were recorded at 100 MHz in C_6D_6 solution. Chemical shifts are expressed in parts per million (δ) and are referenced to C_6D_6 (δ = 128.06) as internal standard. TLC was done on silica gel coated glass slide (Merck, Silica gel G for TLC). Silica gel (60-120 mesh, SRL, India) was used for column chromatography. Petroleum ether refers to the fraction boiling in the range of 60-80 ^{o}C unless otherwise mentioned. All solvents were dried and distilled before use. Commercially available substrates were freshly distilled before the reaction. Solvents, reagents and chemicals were purchased from Aldrich and Merck Chemicals. All reactions involving moisture sensitive reactants were executed using oven dried glassware.

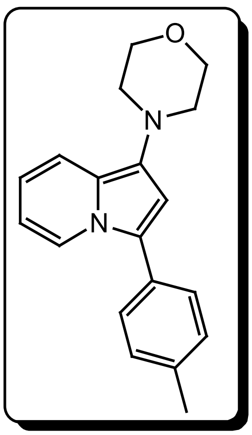
II. General experimental procedure for the synthesis of aminoindolizines (4):

To a solution of ZnI_2 (32mg, 10 mol%) in toluene (3 mL) taken in a reaction tube, pyridine-2-carboxaldehyde/ quinoline-2 carboxaldehyde (1.0 mmol), amine (1.1 mmol), and alkyne (1.2 mmol) were added sequentially. The resulting reaction mixture was then stirred at 100 ^{o}C in oil bath for 1 h. After completion of the reaction (TLC) the reaction mixture was cooled to RT and concentrated under vacuum to get a crude residue which was purified by column chromatography on silica gel column (60–120 mesh) using ethyl acetate-petroleum ether as an eluent to afford the pure aminoindolizine product **(4)** as yellow oil / gummy mass.

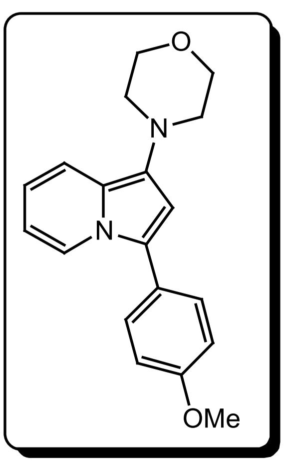
III. Characterization data for the products:



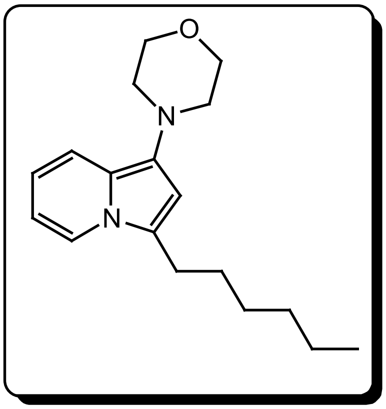
1-Morpholin-4-yl-3-phenyl-indolizine (4aaa):[a] 255 mg, 92% yield; Yellow oil; ^{1}H NMR (C_6D_6, 400 MHz) δ : 7.90 (s, 1H), 7.42 (d, *J* = 8.8 Hz, 1H), 7.34 (d, *J* = 7.2 Hz, 2H), 7.20-7.14 (m, 2H), 7.09-7.04 (m, 1H), 6.64 (s, 7H), 6.34 (s, 1H), 6.03 (s, 1H), 3.74 (s, 4H), 2.86 (s, 4H) ; ^{13}C NMR (C_6D_6, 100 MHz) δ :133.1, 130.6, 129.1, 128.9, 127.0, 126.5, 122.8, 121.8, 118.2, 114.9, 111.1, 106.4.



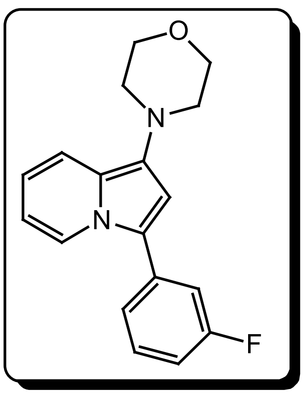
1-Morpholin-4-yl-3-*p*-tolyl-indolizine (4aab):[b] 248 mg, 85% yield; Yellow oil; ^{1}H NMR (C_6D_6, 400 MHz) δ : 7.94 (d, *J* = 6.8 Hz, 1H), 7.43 (d, *J* = 9.2 Hz, 1H), 7.33-7.28 (m, 2H), 7.02 (d, *J* = 8.0 Hz, 2H), 6.67 (s, 1H), 6.36-6.32 (m, 1H), 6.05 (t, *J* = 6.8 Hz, 1H), 3.74 (t, *J* = 4.8 Hz, 4H), 2.87 (t, *J* = 4.8 Hz, 4H), 2.15 (s, 3H) ; ^{13}C NMR (C_6D_6, 100 MHz) δ :136.6, 130.4, 130.2, 129.8, 129.0, 125.9, 122.8, 121.9, 118.2, 114.7, 110.9, 106.2, 67.5, 54.7, 21.2.



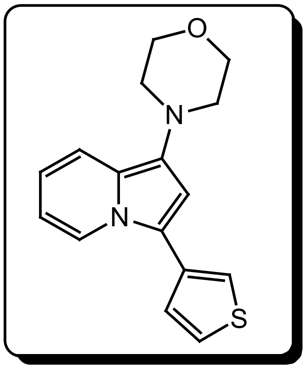
3-(4-Methoxy-phenyl)-1-morpholin-4-yl-indolizine(4aac):[b] 267 mg, 87% yield; Yellow oil; ^{1}H NMR (C_6D_6, 400 MHz) δ : 7.89 (d, *J* = 6.8 Hz, 1H), 7.46 (d, *J* = 8.8 Hz, 1H), 7.26 (d, *J* = 8.8 Hz, 2H), 6.83-6.79 (m, 2H), 6.64 (s, 1H), 6.35 (t, *J* = 7.6 Hz, 1H), 6.07 (t, *J* = 6.8 Hz, 1H), 3.75 (t, *J* = 4.8 Hz, 4H), 3.35 (s, 3H), 2.89 (s, 4H) ; ^{13}C NMR (C_6D_6, 100 MHz) δ : 159.3, 130.2, 129.8, 125.5, 125.4, 122.9, 121.8, 118.2, 114.7, 114.5, 110.9, 106.0, 67.5, 54.9, 54.7.



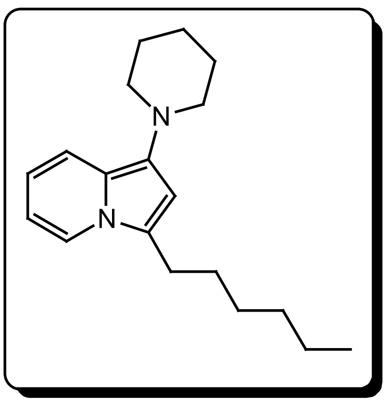
3-Hexyl-1-morpholin-4-yl-indolizine (4aad):[c] 211 mg, 74% yield; Yellow oil; ^{1}H NMR (C_6D_6, 400 MHz) δ : 7.46 (d, *J* = 8.8 Hz, 1H), 7.21 (d, *J* = 7.2 Hz, 1H), 6.43 (s, 1H), 6.37-6.33 (m, 1H), 6.17 (t, *J* = 7.6 Hz, 1H), 3.75 (t, *J* = 4.8 Hz, 4H), 2.90 (t, *J* = 4.8 Hz, 4H), 2.44 (t, *J* = 7.6 Hz, 2H), 1.55-1.50 (m, 2H), 1.27-1.16 (m, 6H), 0.90-0.85 (m, 3H) ; ^{13}C NMR (C_6D_6, 100 MHz) δ : 129.1, 127.8, 121.9, 121.2, 118.1, 113.1, 110.2, 104.2, 67.6, 54.9, 32.0, 29.5, 27.6, 26.2, 23.0, 14.3.



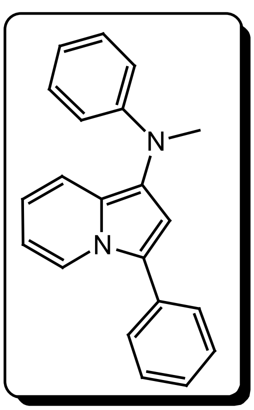
3-(3-Fluoro-phenyl)-1-morpholin-4-yl-indolizine (4aae): 222 mg, 75% yield; Yellow oil; ^{1}H NMR (C_6D_6, 400 MHz) δ : 7.77 (d, *J* = 7.2 Hz, 1H), 7.41 (d, *J* = 9.2 Hz, 1H), 7.07-6.90 (m, 3H), 6.77-6.72 (m, 1H), 6.54 (s, 1H), 6.35-6.31 (m, 1H), 6.02-5.98 (m, 1H), 3.75 (t, *J* = 4.8 Hz, 4H), 2.83 (t, *J* = 4.4 Hz, 4H), 2.15 (s, 3H) ; ^{13}C NMR (C_6D_6, 100 MHz) δ : 163.7 (d, $^1J_{C-F}$ = 244 Hz), 135.1 (d, $^3J_{C-F}$ = 8 Hz), 130.7 (d, $^3J_{C-F}$ = 8 Hz), 127.9, 126.6, 123.3, 121.8, 121.6, 118.2, 115.4, 114.7 (d, $^2J_{C-F}$ = 22 Hz), 113.6 (d, $^2J_{C-F}$ = 21 Hz), 111.4, 106.8, 67.4, 54.6; Anal. Calcd. For (%) $C_{18}H_{17}FN_2O$: C, 72.95; H, 5.78; N, 9.45. Found C, 72.90; H, 5.75; N, 9.40.



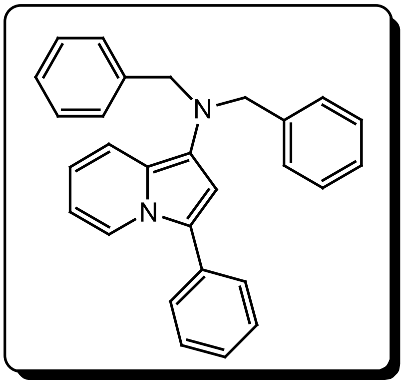
1-Morpholin-4-yl-3-thiophen-3-yl-indolizine (4aaf): 201 mg, 71% yield; Yellow oil; ^{1}H NMR (C_6D_6, 400 MHz) δ : 7.99 (d, *J* = 7.2 Hz, 1H), 7.64 (d, *J* = 9.2 Hz, 1H), 7.21 (d, *J* = 4.8 Hz, 1H), 7.13 (t, *J* = 4.8 Hz, 1H), 7.09 (s, 1H), 6.85 (s, 1H), 6.55 (t, *J* = 8.0 Hz, 1H), 6.28 (t, *J* = 6.8 Hz, 1H), 3.95 (t, *J* = 4.8 Hz, 4H), 3.06 (s, 4H) ; ^{13}C NMR (C_6D_6, 100 MHz) δ : 133.6, 130.6, 128.1, 126.3, 126.0, 123.1, 122.6, 120.9, 118.4, 115.0, 111.4, 106.6, 67.8, 55.0; Anal. Calcd. For (%) $C_{16}H_{16}N_2OS$: C, 67.58; H, 5.67; N, 9.85. Found C, 67.53; H, 5.70; N, 9.79.



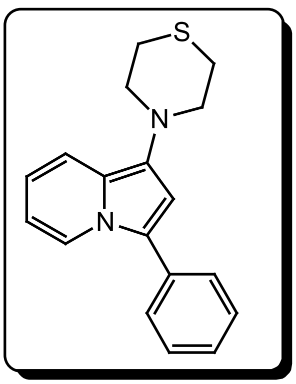
3-Hexyl-1-piperidin-1-yl-indolizine (4abd):[a] 190 mg, 67% yield; Yellow oil; ^{1}H NMR (C_6D_6, 400 MHz) δ : 7.64 (d, *J* = 8.8 Hz, 1H), 7.21 (d, *J* = 6.8 Hz, 1H), 6.50 (s, 1H), 6.37-6.33 (m, 1H), 6.16 (t, *J* = 6.8 Hz, 1H), 2.99 (t, *J* = 4.8 Hz, 4H), 2.45 (t, *J* = 6.8 Hz, 2H), 1.70 (t, *J* = 5.2 Hz, 4H), 1.59-1.51 (m, 2H), 1.45-1.39 (m, 2H), 1.28-1.19 (m, 6H), 0.87 (t, *J* = 6.8 Hz, 3H) ; ^{13}C NMR (C_6D_6, 100 MHz) δ : 128.1, 124.3, 121.7, 121.1, 118.4, 112.9, 110.1, 104.3, 56.1, 32.0, 29.6, 27.6, 26.9, 26.2, 24.7, 23.0, 14.3.



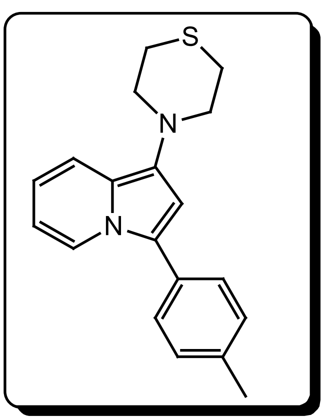
Methyl-phenyl-(3-phenyl-indolizin-1-yl)-amine (4aca):[a] 202 mg, 68% yield; Yellow oil; ^{1}H NMR (C_6D_6, 400 MHz) δ : 7.93 (d, *J* = 6.0 Hz, 1H), 7.32 (d, *J* = 6.8 Hz, 2H), 7.21-7.05 (m, 7H), 6.84-6.77 (m, 3H), 6.68 (s, 1H), 6.27 (s, 1H), 6.01 (t, *J* = 6.4 Hz, 1H), 3.12 (s, 1H) ; ^{13}C NMR (C_6D_6, 100 MHz) δ : 150.7, 132.6, 129.2, 129.2, 128.9, 128.1, 127.2, 124.1, 123.7, 122.3, 117.9, 117.5, 116.7, 113.7, 112.5, 111.1, 40.6.



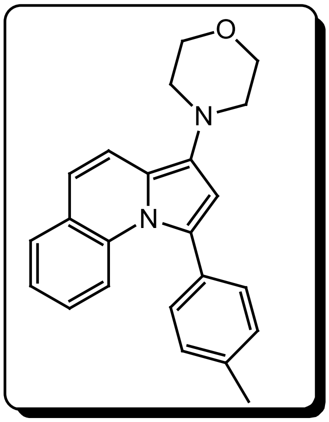
Dibenzyl-(3-phenyl-indolizin-1-yl)-amine (4ada):[a] 349 mg, 90% yield; Yellow oil; ^{1}H NMR (C_6D_6, 400 MHz) δ : 7.80 (d, *J* = 7.2Hz, 1H), 7.54 (d, *J* = 8.4 Hz, 1H), 7.39 (d, *J* = 7.2 Hz, 4H), 7.23 (d, *J* = 8.4 Hz, 2H), 7.15-7.10 (m, 7H), 7.04-7.02 (m, 3H), 6.70 (s, 1H), 6.33-6.29 (m, 2H), 5.95 (t, *J* = 7.2 Hz, 1H), 4.16 (s, 4H) ; ^{13}C NMR (C_6D_6, 100 MHz) δ :139.5, 132.5, 128.6, 127.6, 127.3, 127.0, 126.7, 126.4, 122.6, 121.4, 117.7, 114.7, 110.5, 108.3.



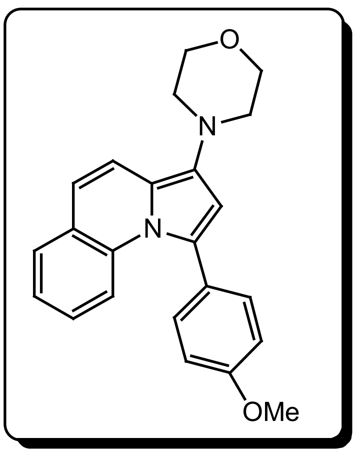
3-Phenyl-1-thiomorpholin-4-yl-indolizine (4aea): 258 mg, 88% yield; Yellow oil; ^{1}H NMR (C_6D_6, 400 MHz) δ : 7.89 (d, *J* = 7.2 Hz, 1H), 7.39 (d, *J* = 9.2 Hz, 1H), 7.33 (d, *J* = 7.6 Hz, 2H), 7.20-7.14 (m, 2H), 7.09-7.05 (m, 1H), 6.64 (s, 1H), 6.36-6.32 (m, 1H), 6.02 (t, *J* = 6.4 Hz, 1H), 3.11 (t, *J* = 5.2 Hz, 4H), 2.58 (t, *J* = 4.8 Hz, 4H) ; ^{13}C NMR (C_6D_6, 100 MHz) δ : 133.0, 131.4, 129.1, 128.2, 127.0, 126.3, 123.0, 121.8, 118.0, 115.1, 111.1, 107.2, 56.5, 28.8; Anal. Calcd. For (%) $C_{18}H_{18}N_2S$: C, 73.43; H, 6.16; N, 9.51. Found C, 73.39; H, 6.10; N, 9.46.



1-Thiomorpholin-4-yl-3-*p*-tolyl-indolizine (4aeb): 255 mg, 83% yield; Yellow oil; ^{1}H NMR (C_6D_6, 400 MHz) δ : 8.14 (d, *J* = 6.8 Hz, 1H), 7.63 (d, *J* = 8.8 Hz, 1H), 7.49 (d, *J* = 8.0 Hz, 2H), 7.23 (d, *J* = 8.0 Hz, 2H), 6.87 (s, 1H), 6.55 (t, *J* = 6.8 Hz, 1H), 6.25 (t, *J* = 6.8 Hz, 1H), 3.34 (s, 4H), 2.80 (t, *J* = 4.8 Hz, 4H), 2.36 (s, 3H) ; ^{13}C NMR (C_6D_6, 100 MHz) δ : 136.9, 132.4, 131.5, 130.5, 130.2, 126.4, 123.4, 122.2, 118.3, 115.2, 111.3, 107.3, 56.9, 29.1, 21.5; Anal. Calcd. For (%) $C_{19}H_{20}N_2S$: C, 73.99; H, 6.54; N, 9.08. Found C, 73.95; H, 6.50; N, 9.02.

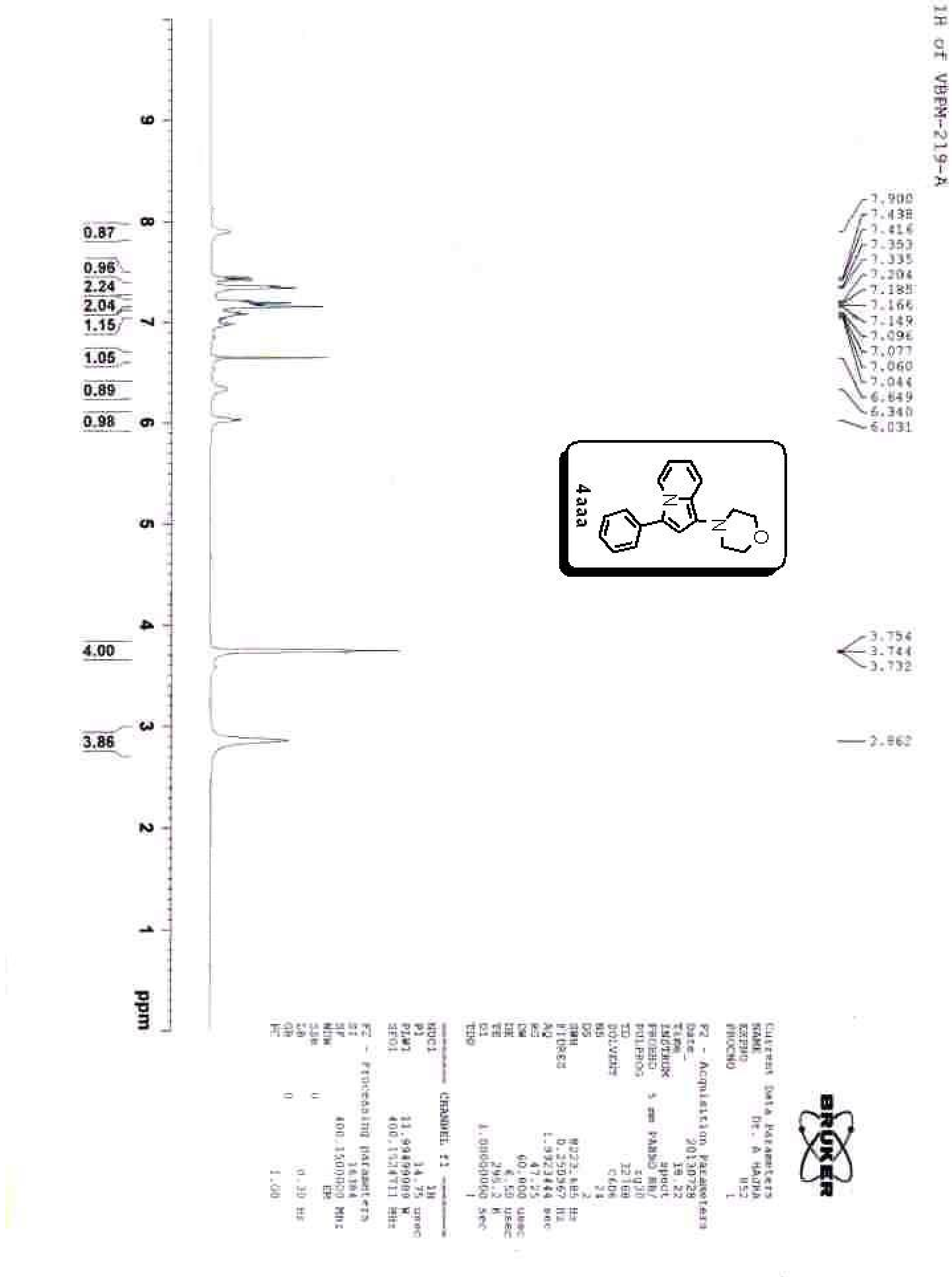


3-Morpholin-4-yl-1-*p*-tolyl-pyrrolo[1,2-a]quinoline (4bab):[c] 290 mg, 85% yield; Yellow gummy mass; ^{1}H NMR (C_6D_6, 400 MHz) δ : 7.65 (d, *J* = 8.8 Hz, 1H), 7.43 (d, *J* = 9.2 Hz, 1H), 7.34 (d, *J* = 8.0 Hz, 1H), 7.27 (d, *J* = 8.0 Hz, 2H), 6.99-6.91 (m, 3H), 6.82-6.78 (m, 1H), 6.71 (d, *J* = 5.2 Hz, 1H), 6.51 (s, 1H), 3.74 (t, *J* = 4.8 Hz, 4H), 2.87 (t, *J* = 4.8 Hz, 4H), 2.12 (s, 3H) ; ^{13}C NMR (C_6D_6, 100 MHz) δ :137.4, 137.0, 134.8, 133.4, 132.8, 129.6, 129.5, 128.6, 126.5, 126.3, 124.7, 123.5, 118.1, 117.8, 117.0, 108.8, 67.5, 54.7, 21.2.



1-(4-Methoxy-phenyl)-3-morpholin-4-yl-pyrrolo[1,2-a]quinoline (4bac): 315 mg, 88% yield; Yellow gummy mass; ^{1}H NMR (C_6D_6, 400 MHz) δ : 7.65 (d, *J* = 8.8 Hz, 1H), 7.45 (d, *J* = 9.2 Hz, 1H), 7.35 (d, *J* = 9.2 Hz, 1H), 7.25 (d, *J* = 8.8 Hz, 2H), 6.94 (t, *J* = 8.0 Hz, 1H), 6.85-6.70 (m, 4H), 6.51 (s, 1H), 3.75 (t, *J* = 4.4 Hz, 4H), 3.29 (s, 3H), 2.89 (t, *J* = 4.8 Hz, 4H) ; ^{13}C NMR (C_6D_6, 100 MHz) δ :159.8, 134.9, 132.7, 131.0, 128.7, 128.6, 128.2, 126.5, 126.4, 124.5, 123.5, 117.9, 117.8, 116.9, 114.3, 108.7, 67.5, 54.8, 54.7 ; Anal. Calcd. For (%) $C_{23}H_{22}N_2O_2$: C, 77.07; H, 6.19; N, 7.82. Found C, 77.03; H, 6.12; N, 7.75.

IV. NMR Spectra: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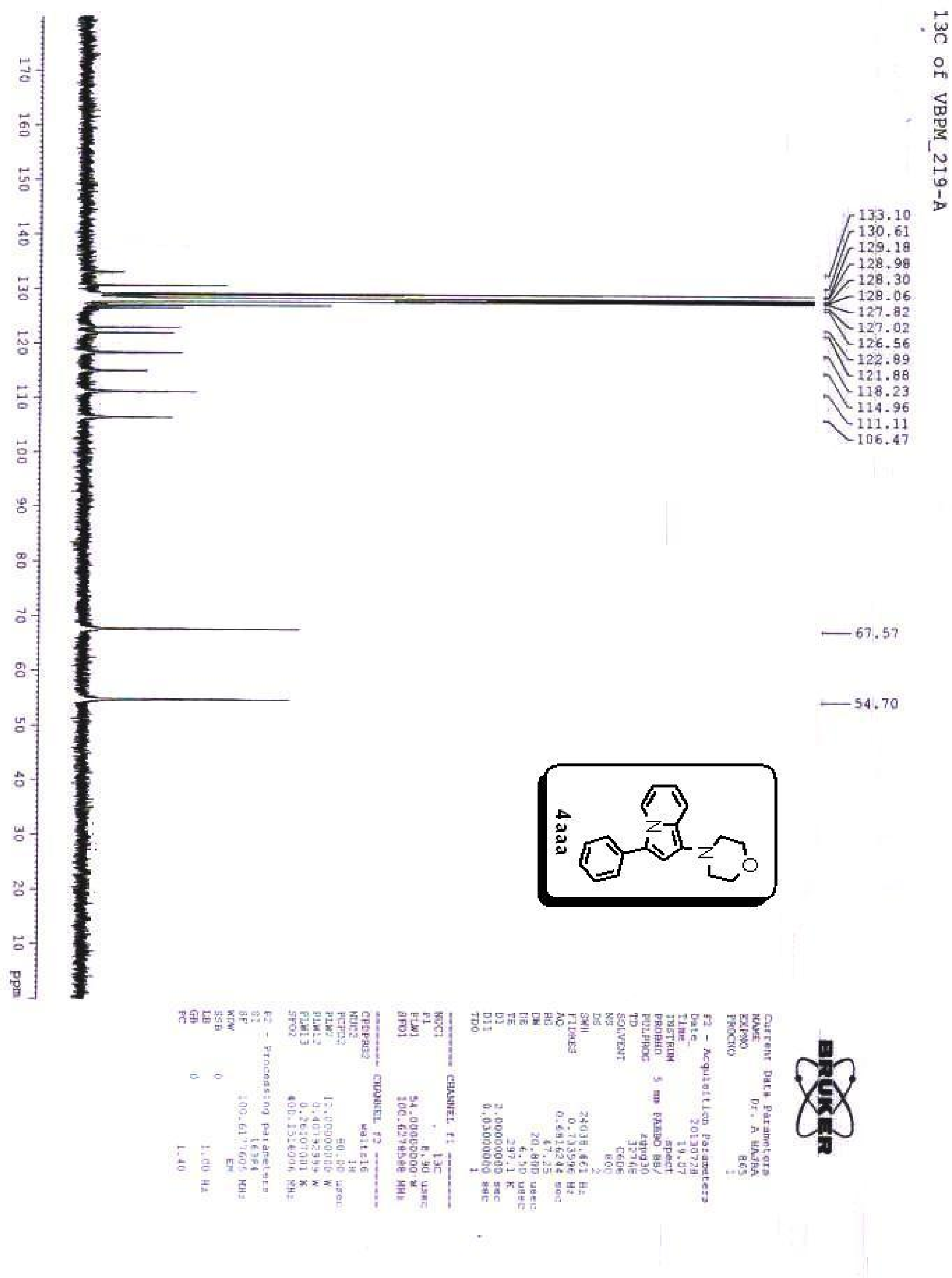
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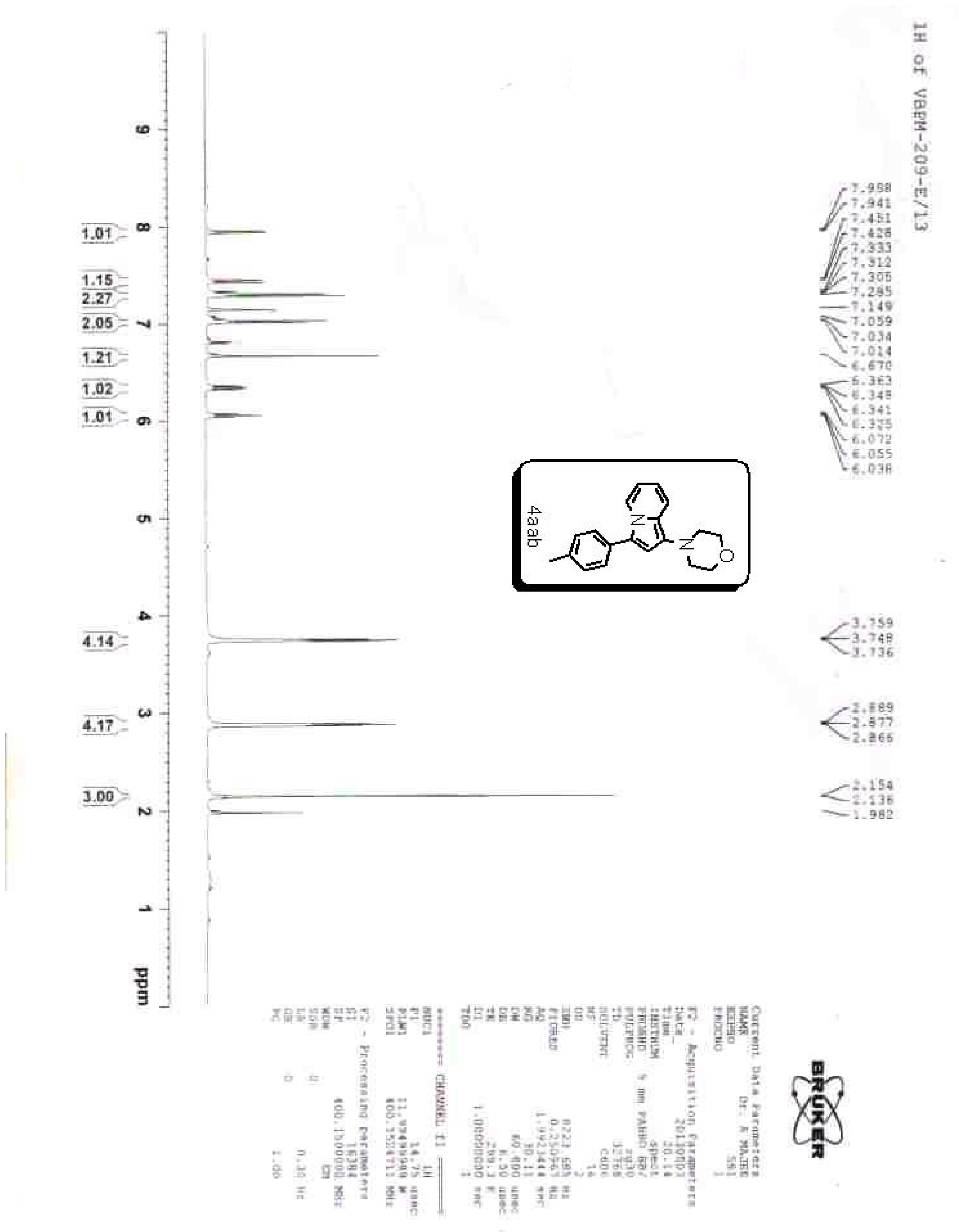
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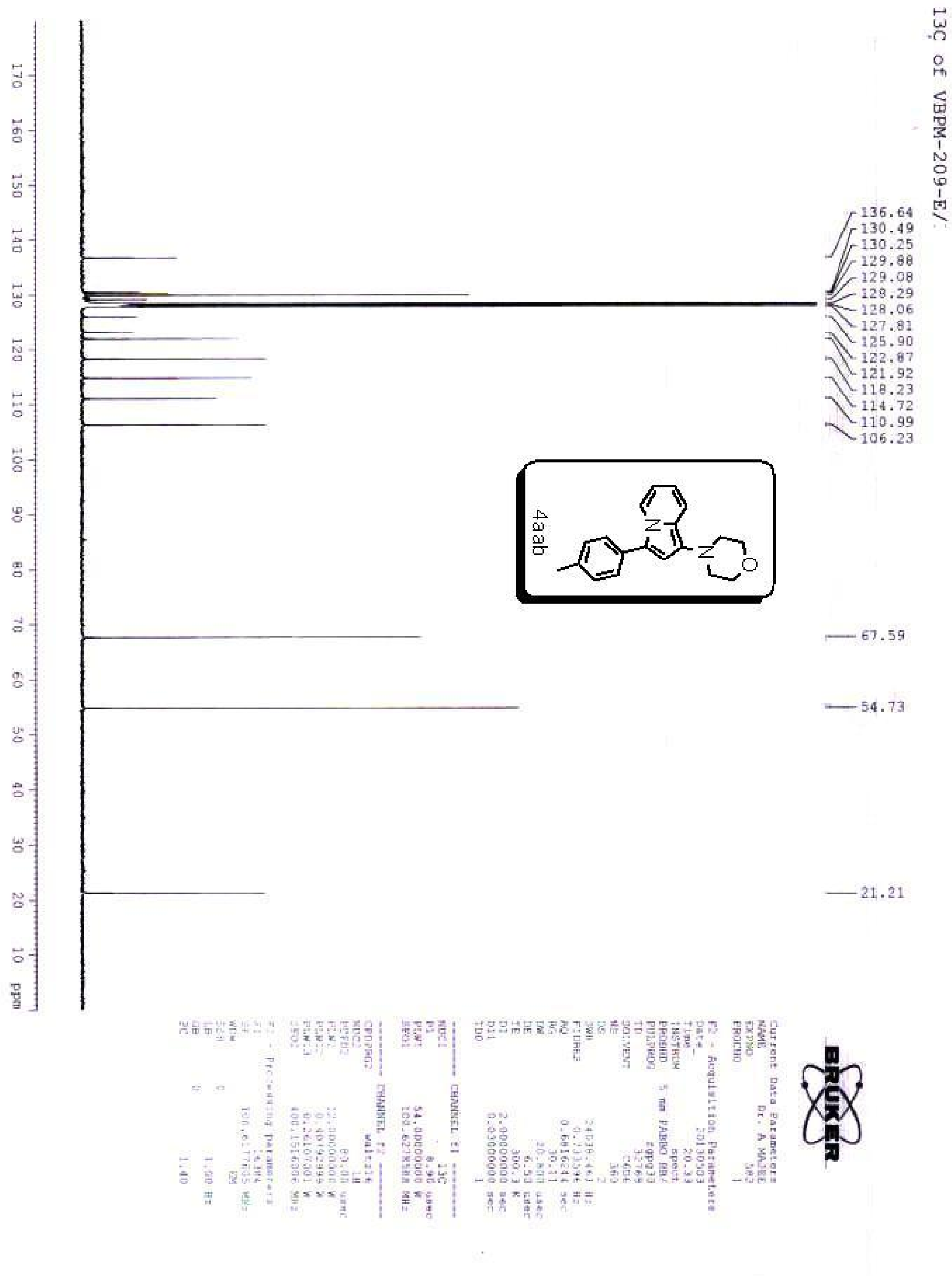
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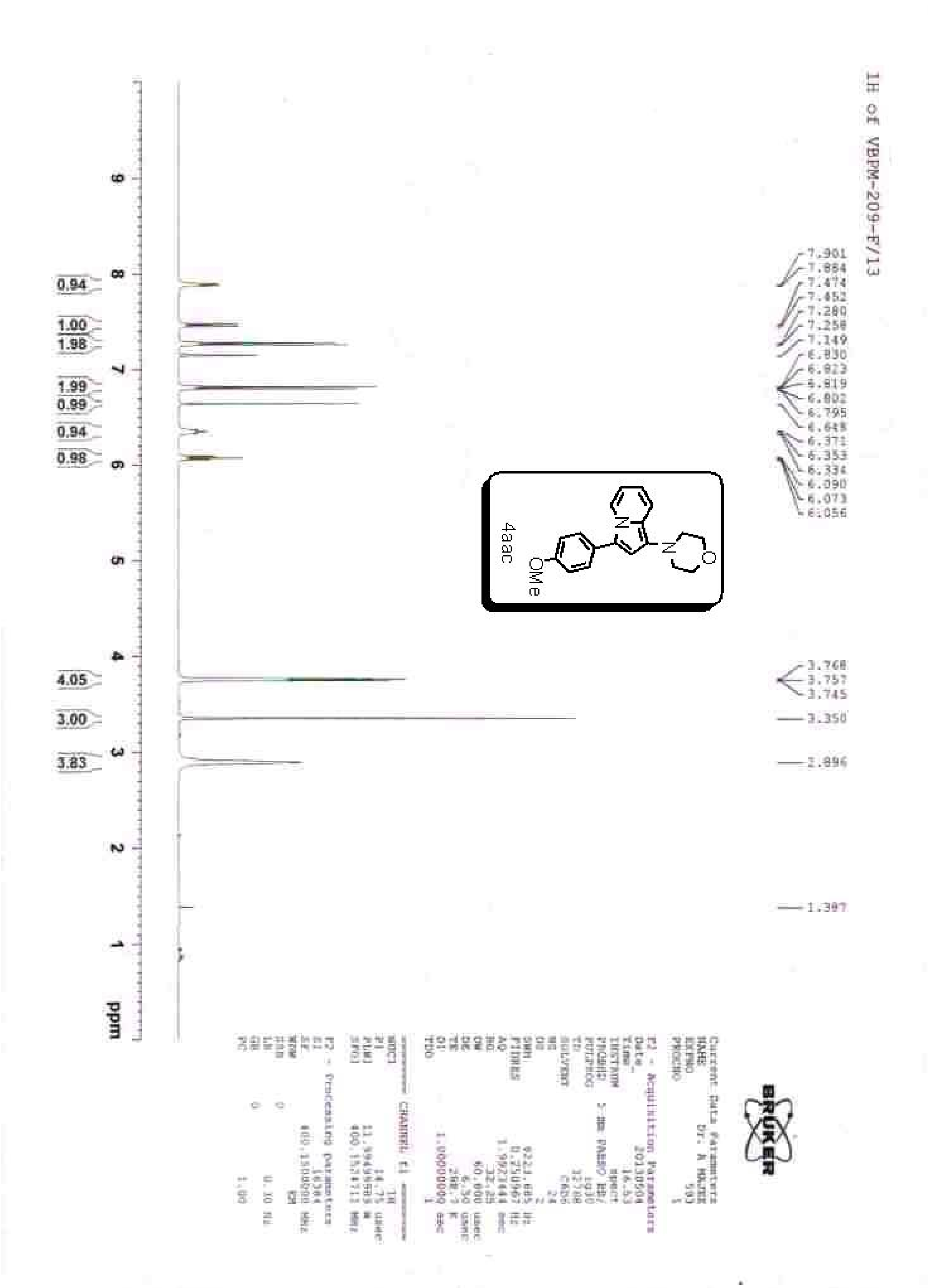
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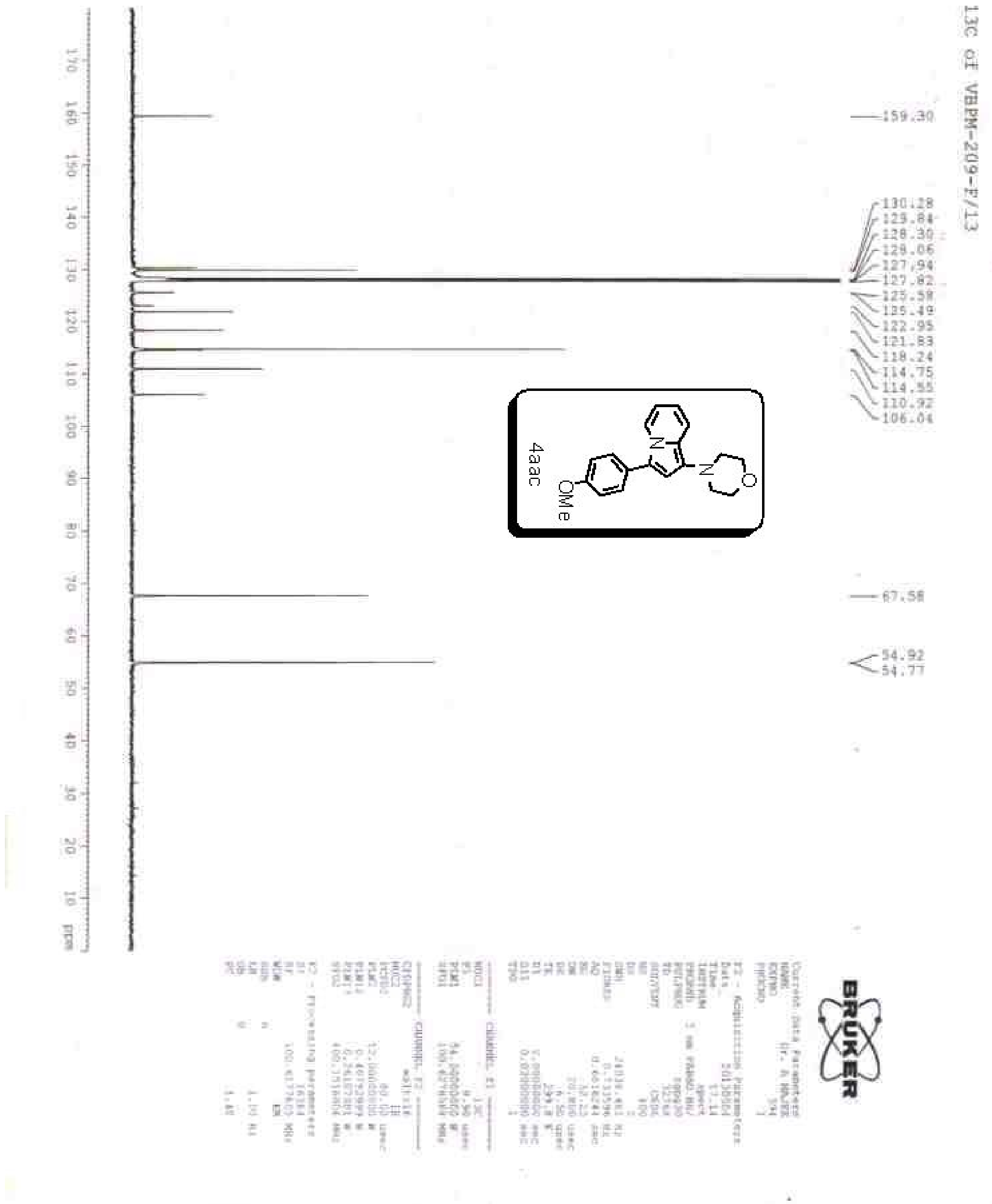
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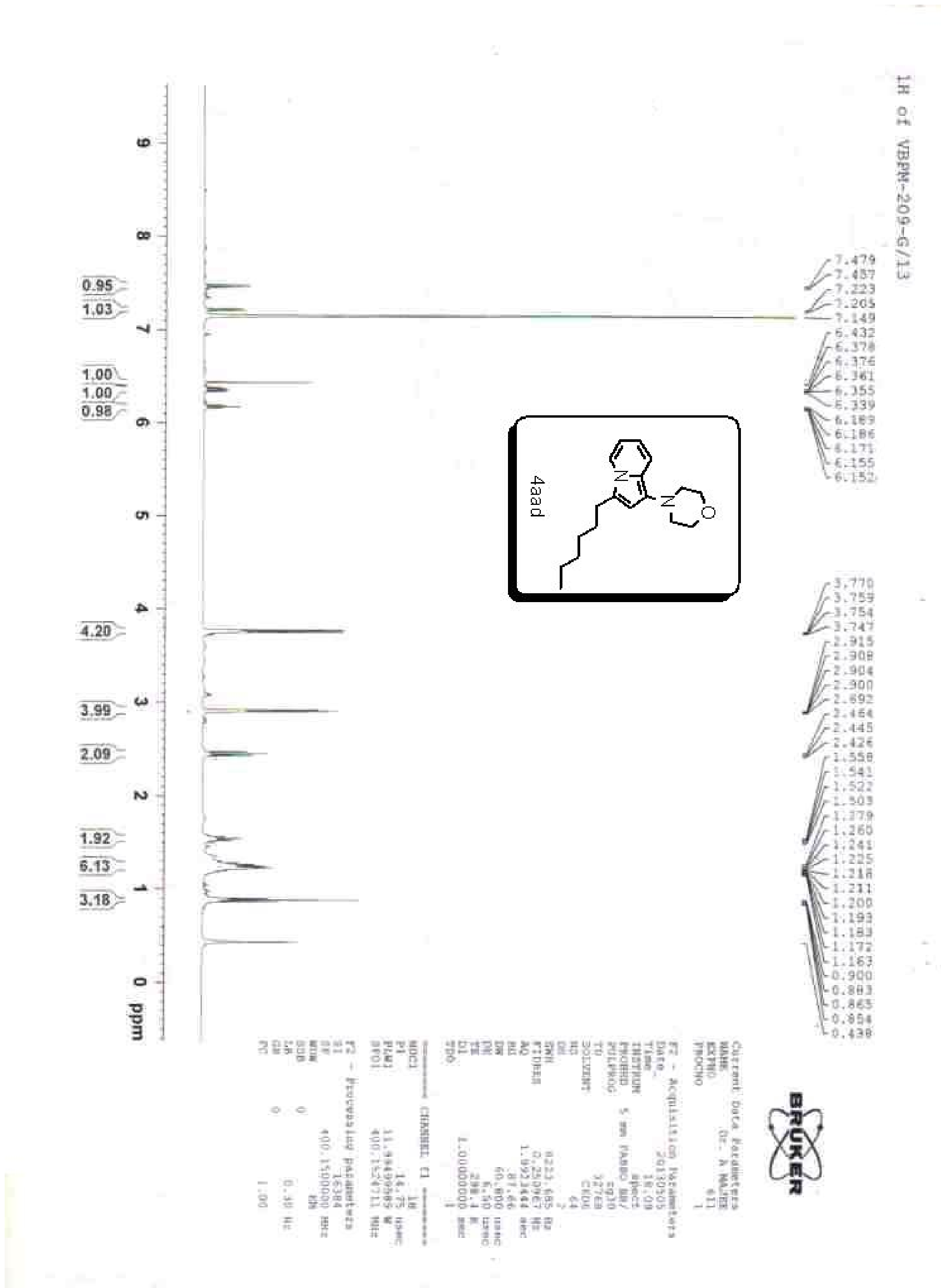
4aac
OMe
BRUKER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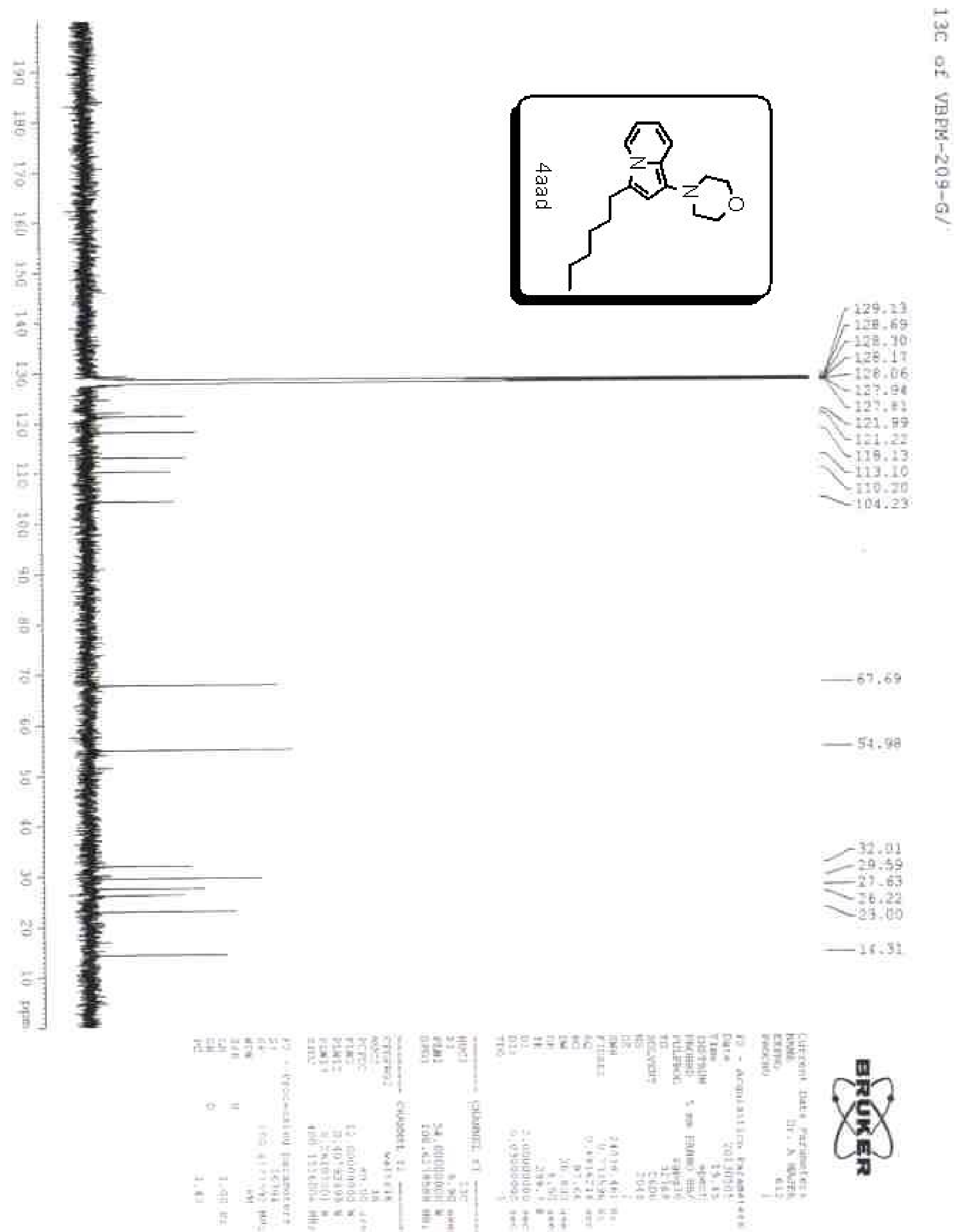
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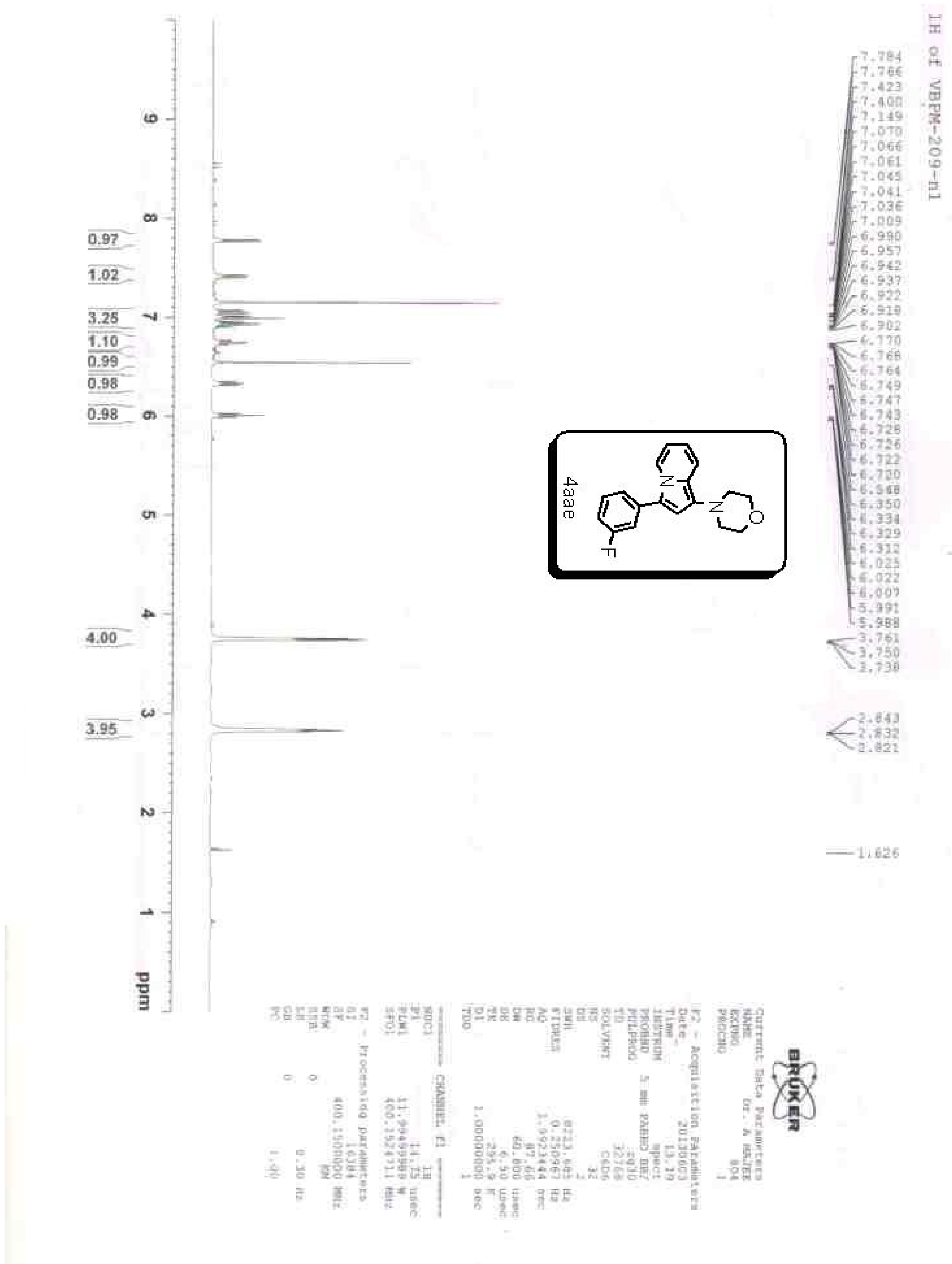
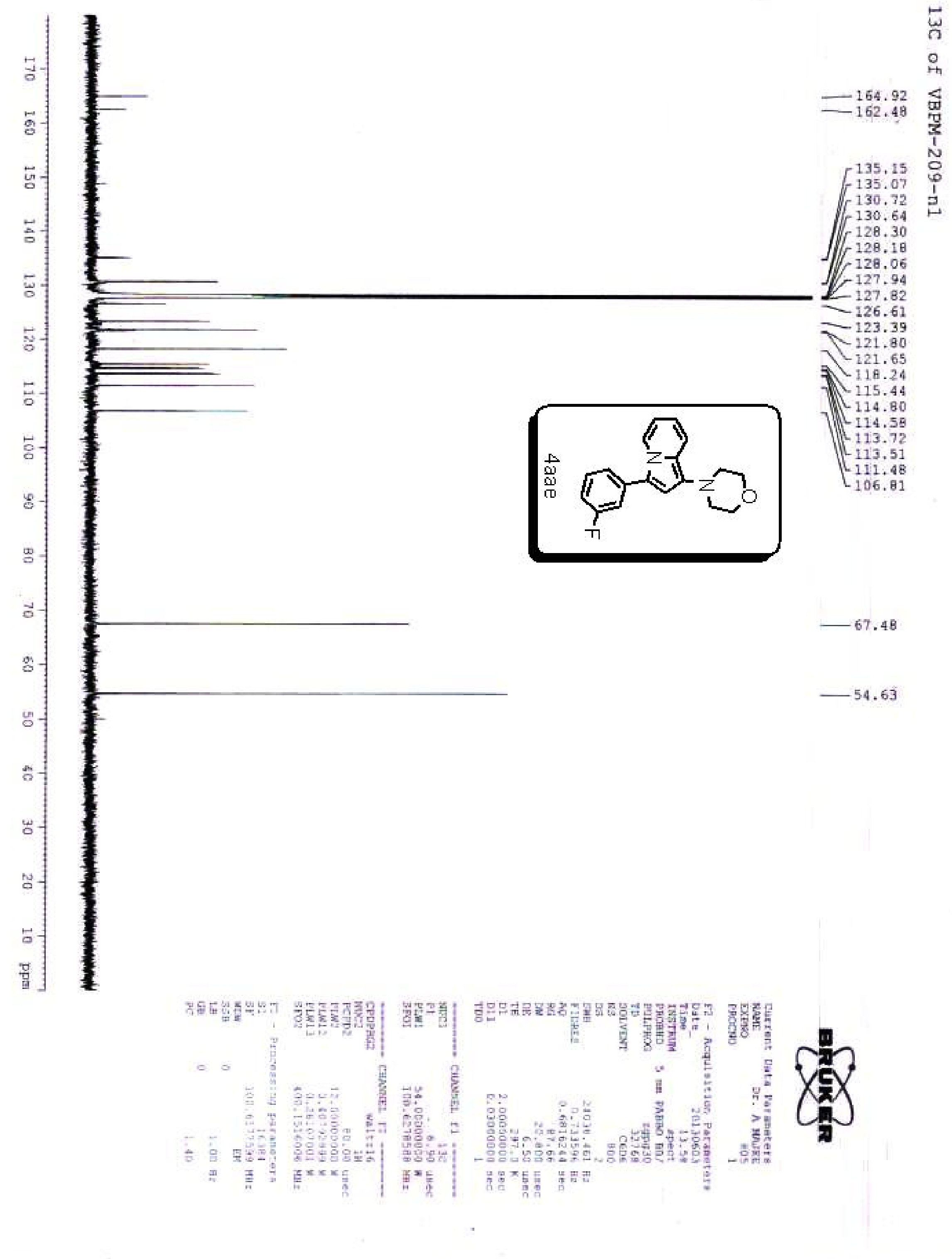
BRUKER

Electronic Supplementary Material (ESI) for RSC Advances

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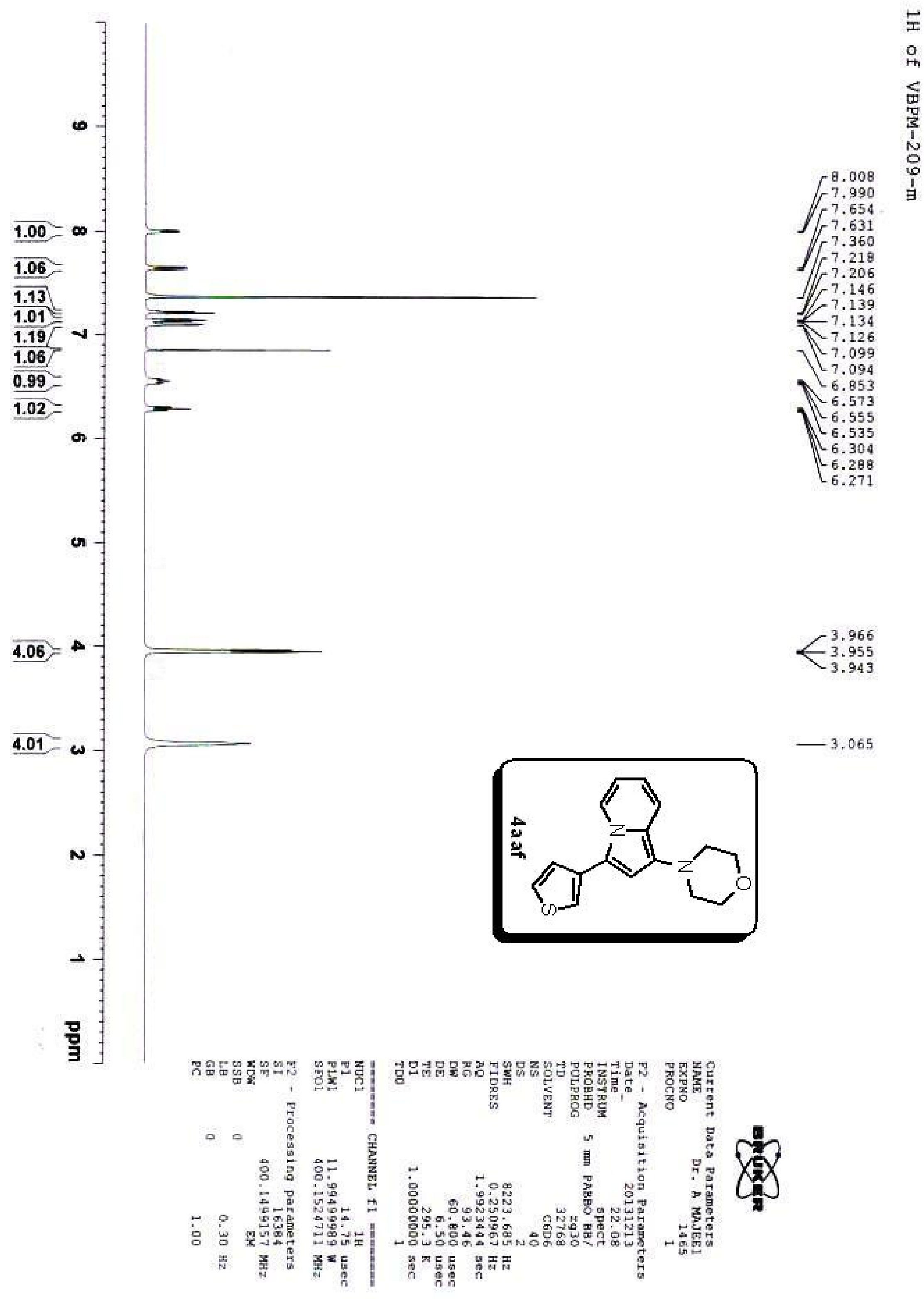
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7.990
7.654
7.631
7.360
7.218
7.206
7.146
7.139
7.134
7.126
7.099
7.094
6.853
6.573
6.555
6.535
6.304
6.288
6.271
3.966
3.955
3.943
3.065
4aaf
N
O
S
Current Data Parameters
NAME Dr. A MAJEE1
EXPNO 1465
PROCNO 1
F2 - Acquisition Parameters
Date_ 20131213
Time 22.08
INSTRUM spect
PROBHD 5 mm PABBO BB/
PULPROG zg30
TD 32768
SOLVENT C6D6
NS 40
DS 2
SWH 8223.685 Hz
FIDRES 0.250967 Hz
AQ 1.9923444 sec
RG 93.46
DW 60.800 usec
DE 6.50 usec
TE 295.3 K
D1 1.00000000 sec
TD0 1
======== CHANNEL f1 ========
NUC1 1H
P1 14.75 usec
PLW1 11.99499989 W
SFO1 400.1524711 MHz
F2 - Processing parameters
SI 16384
SF 400.1499157 MHz
WDW EM
SSB 0
LB 0.30 Hz
GB 0
PC 1.00
1.00
1.06
1.13
1.01
1.19
1.06
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1.02
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4.01
9
8
7
6
5
4
3
2
1
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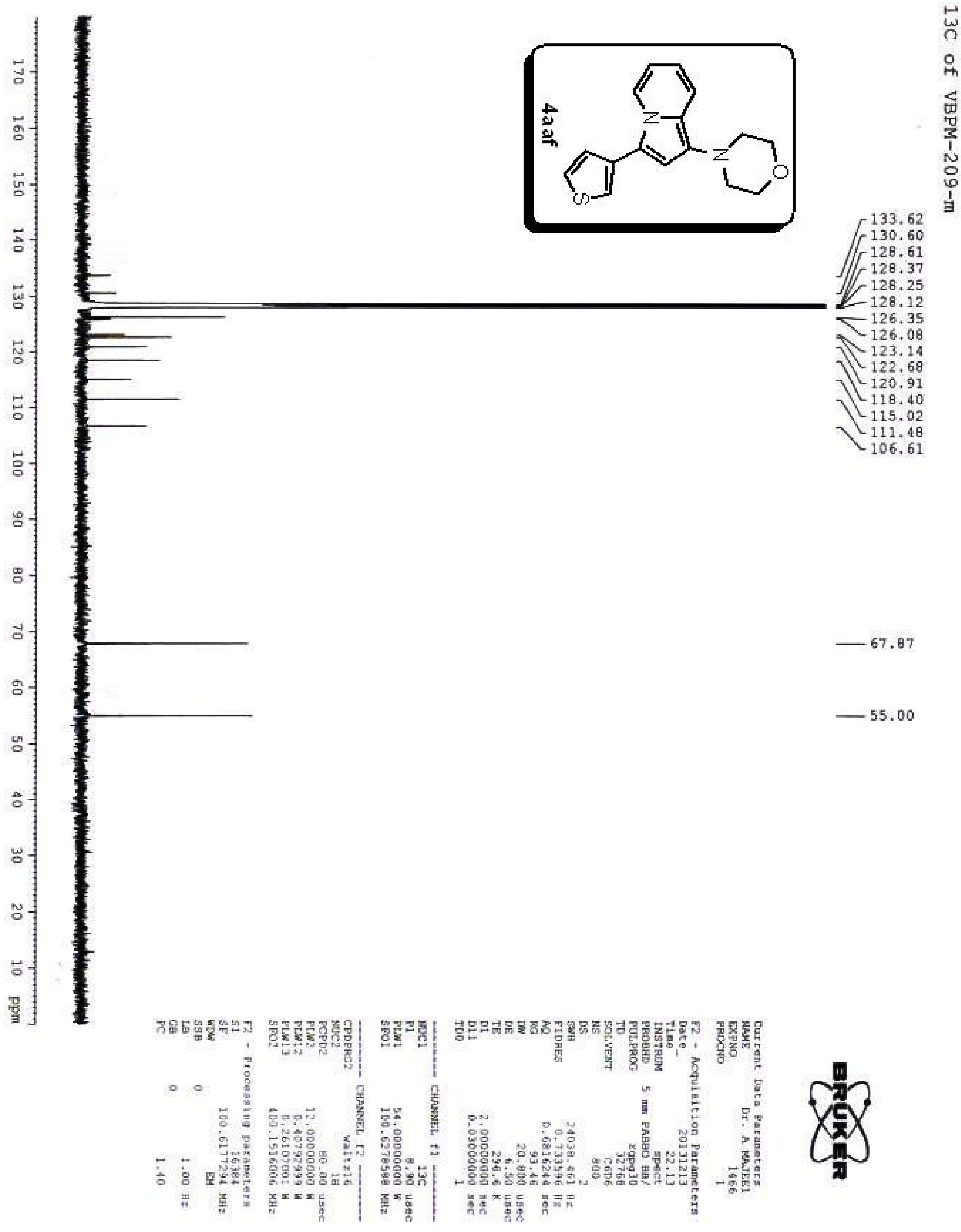
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120.91
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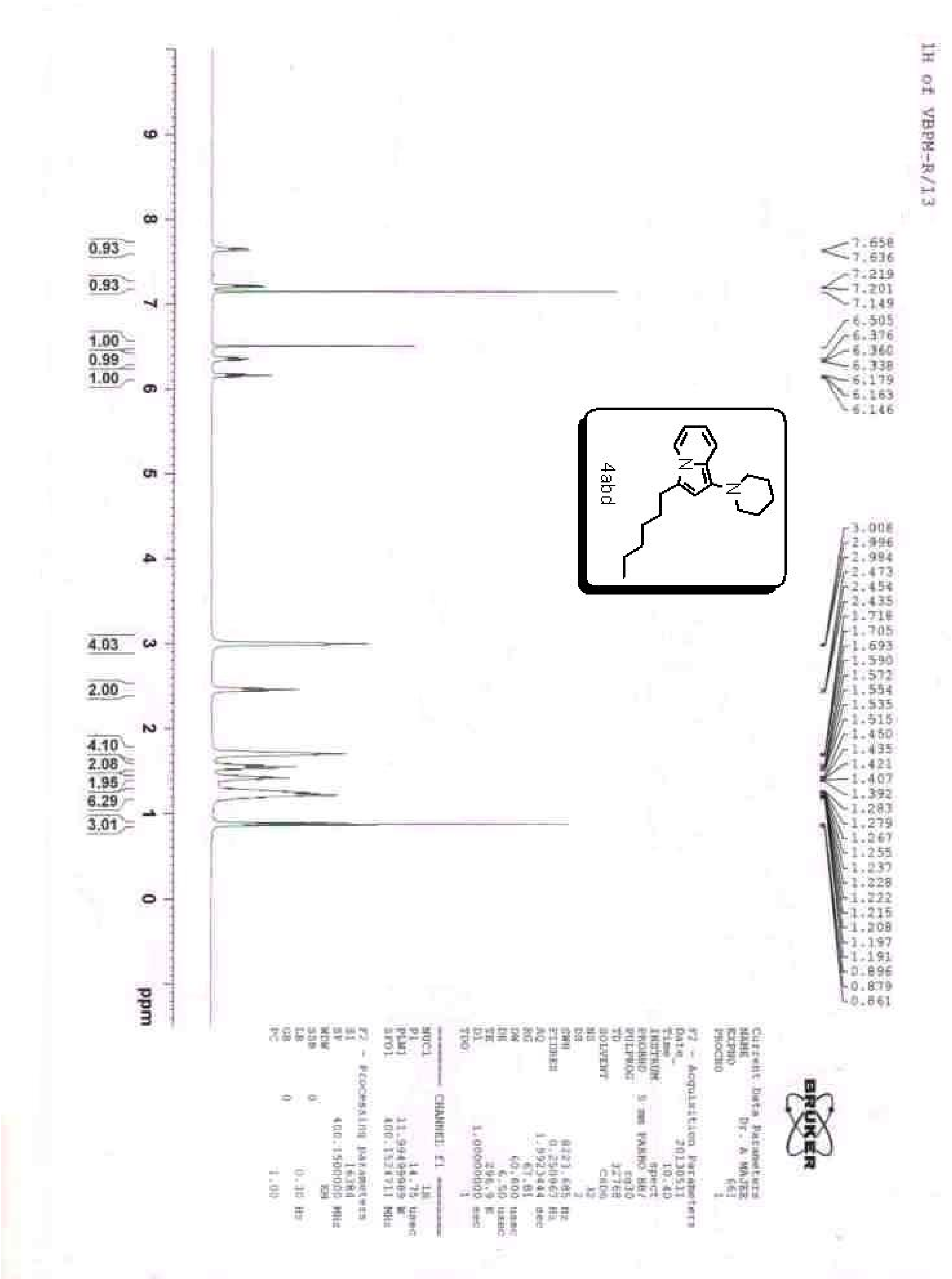
106.61
67.87
55.00
ppm
BRUKER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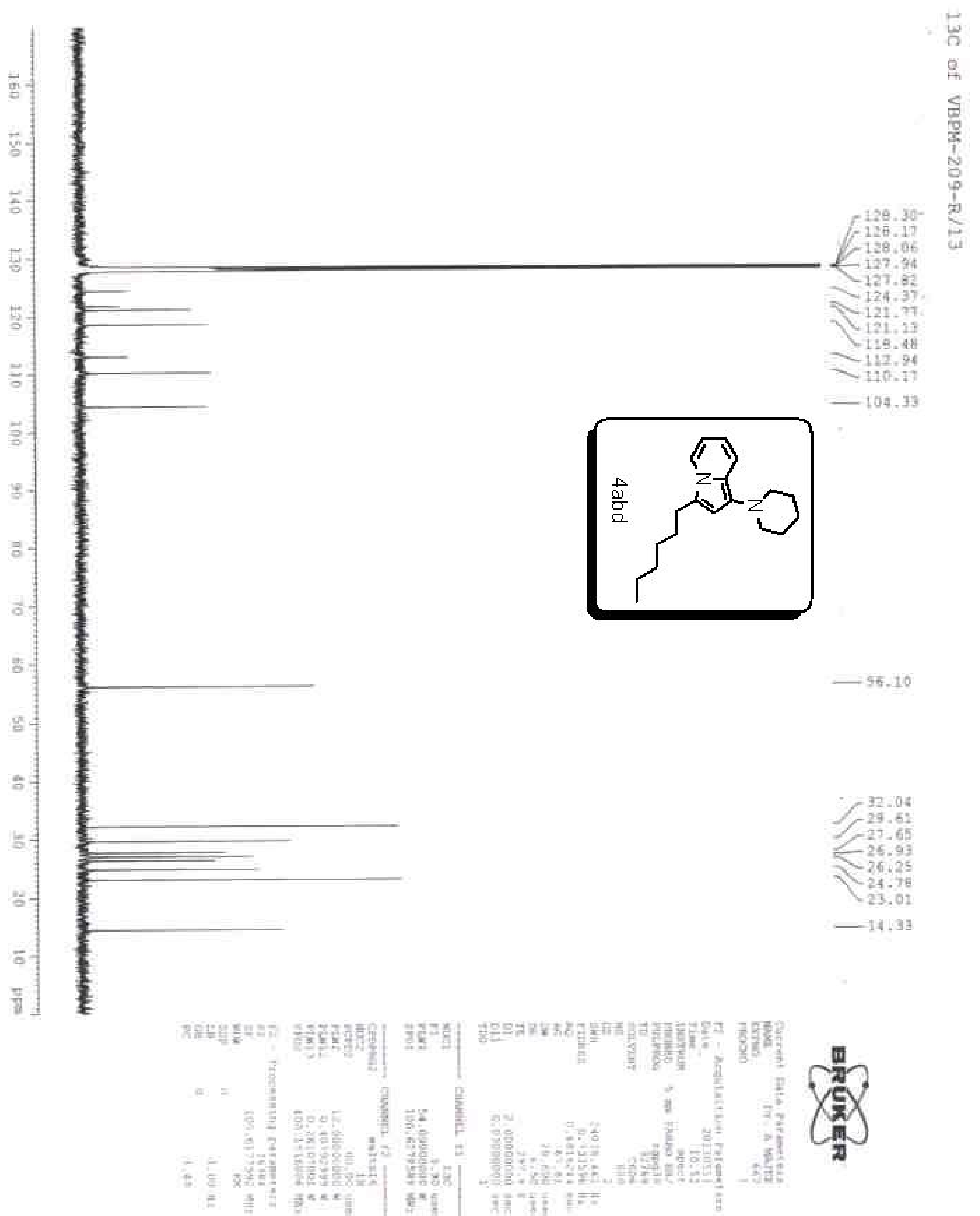
ppm


13C of VBPM-209-R/13
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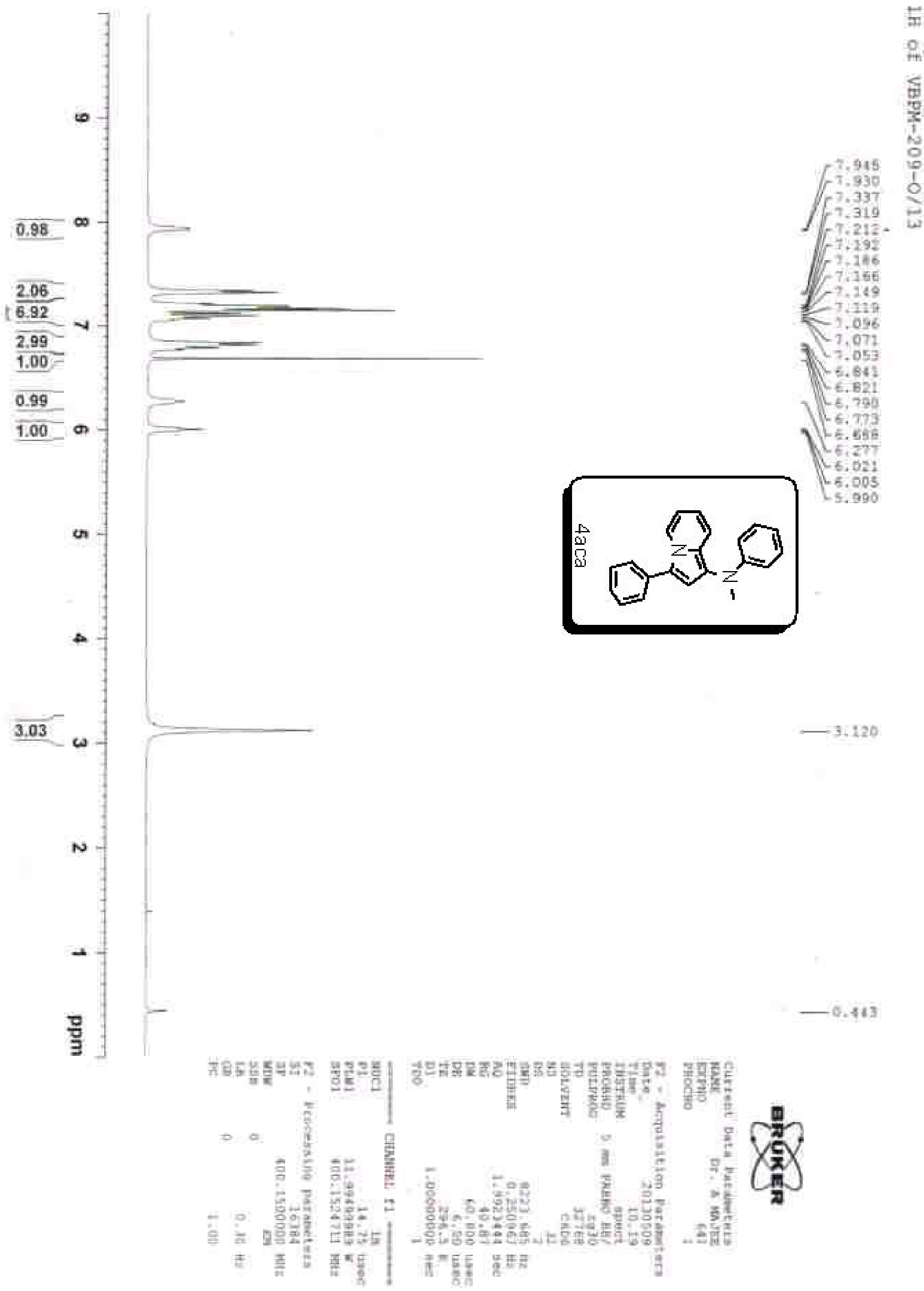
128.17
128.06
127.94
127.82
124.37
121.77
121.13
119.48
112.94
110.17
104.33
56.10
32.04
29.61
27.65
26.93
26.25
24.78
23.01
14.33
4abd
BRUKER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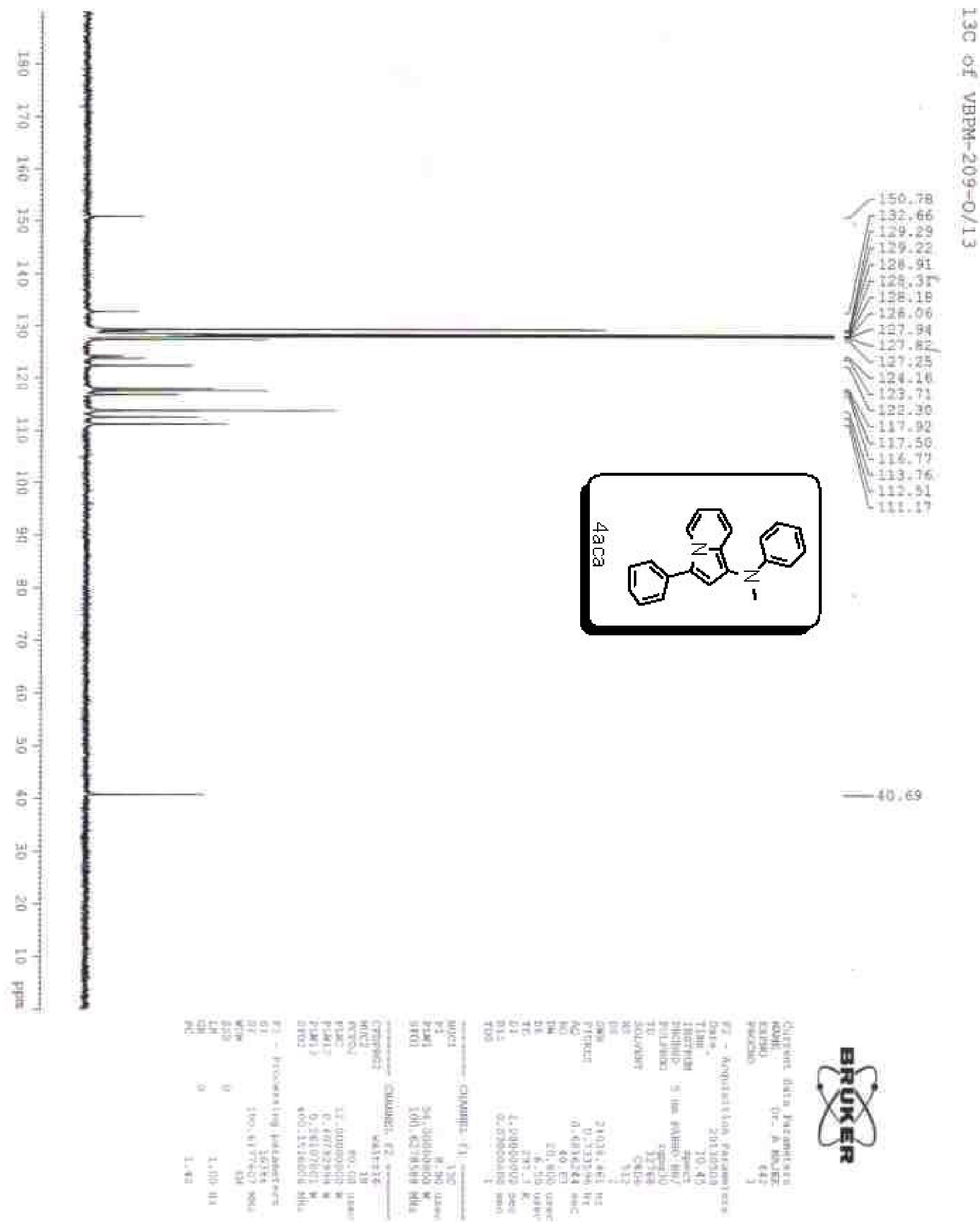
7.930
7.337
7.319
7.212
7.192
7.186
7.166
7.149
7.119
7.096
7.071
7.053
6.841
6.821
6.790
6.773
6.688
6.277
6.021
6.005
5.990
3.120
0.443
4aca
0.98
2.06
6.92
2.99
1.00
0.99
1.00
3.03
ppm
BRUKER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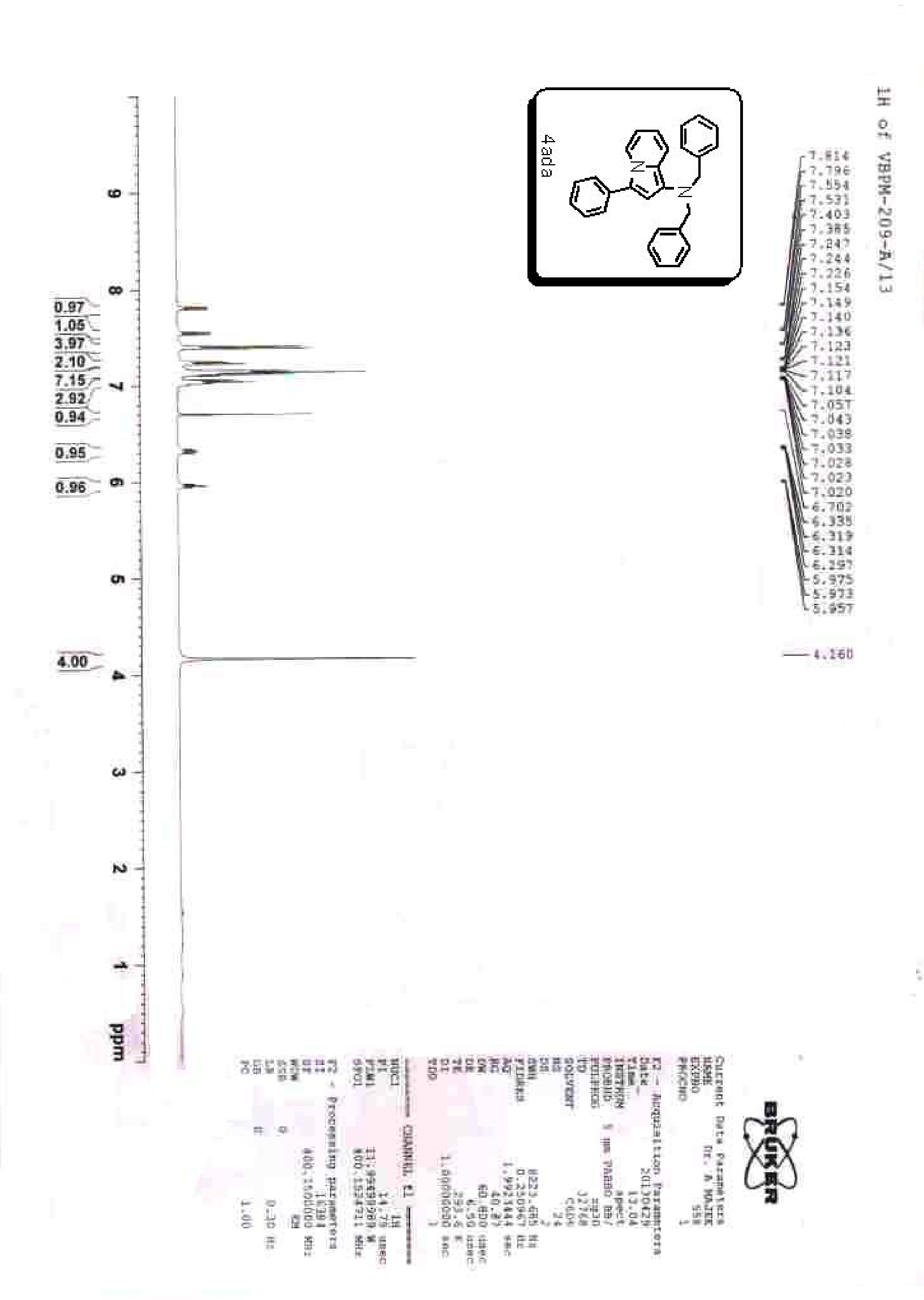
132.66
129.29
129.22
128.91
128.31
128.18
128.06
127.94
127.82
127.25
124.16
123.71
122.30
117.92
117.50
116.77
113.76
112.51
111.17
40.69
4aca
BRUKER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7.796
7.554
7.531
7.403
7.385
7.247
7.244
7.226
7.154
7.149
7.140
7.136
7.123
7.121
7.117
7.104
7.057
7.043
7.038
7.033
7.028
7.023
7.020
6.702
6.335
6.319
6.314
6.297
5.975
5.973
5.957
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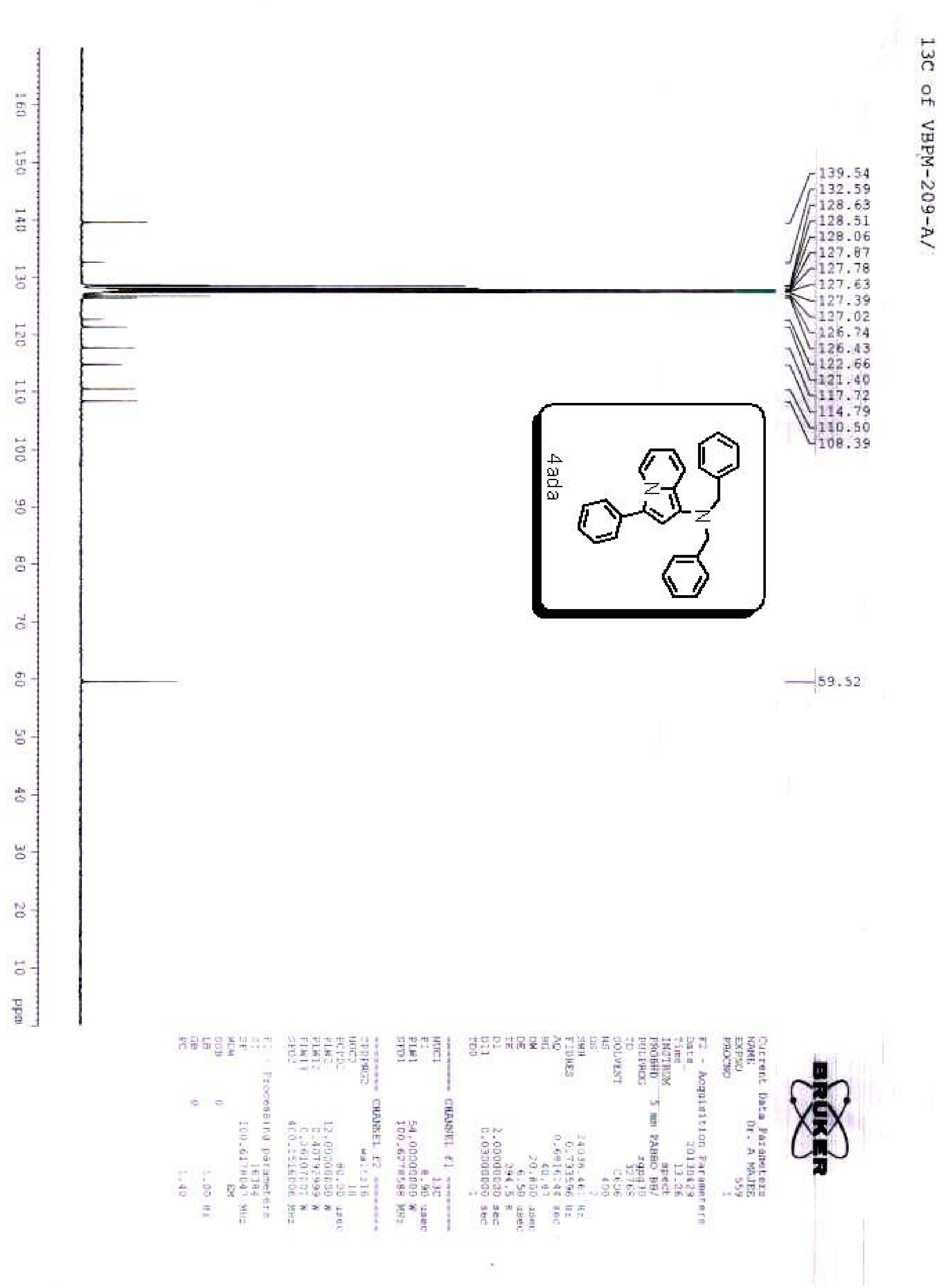
1.05
3.97
2.10
7.15
2.92
0.94
0.95
0.96
4.00
ppm


13C of VBPM-209-A/
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132.59
128.63
128.51
128.06
127.87
127.78
127.63
127.39
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126.43
122.66
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117.72
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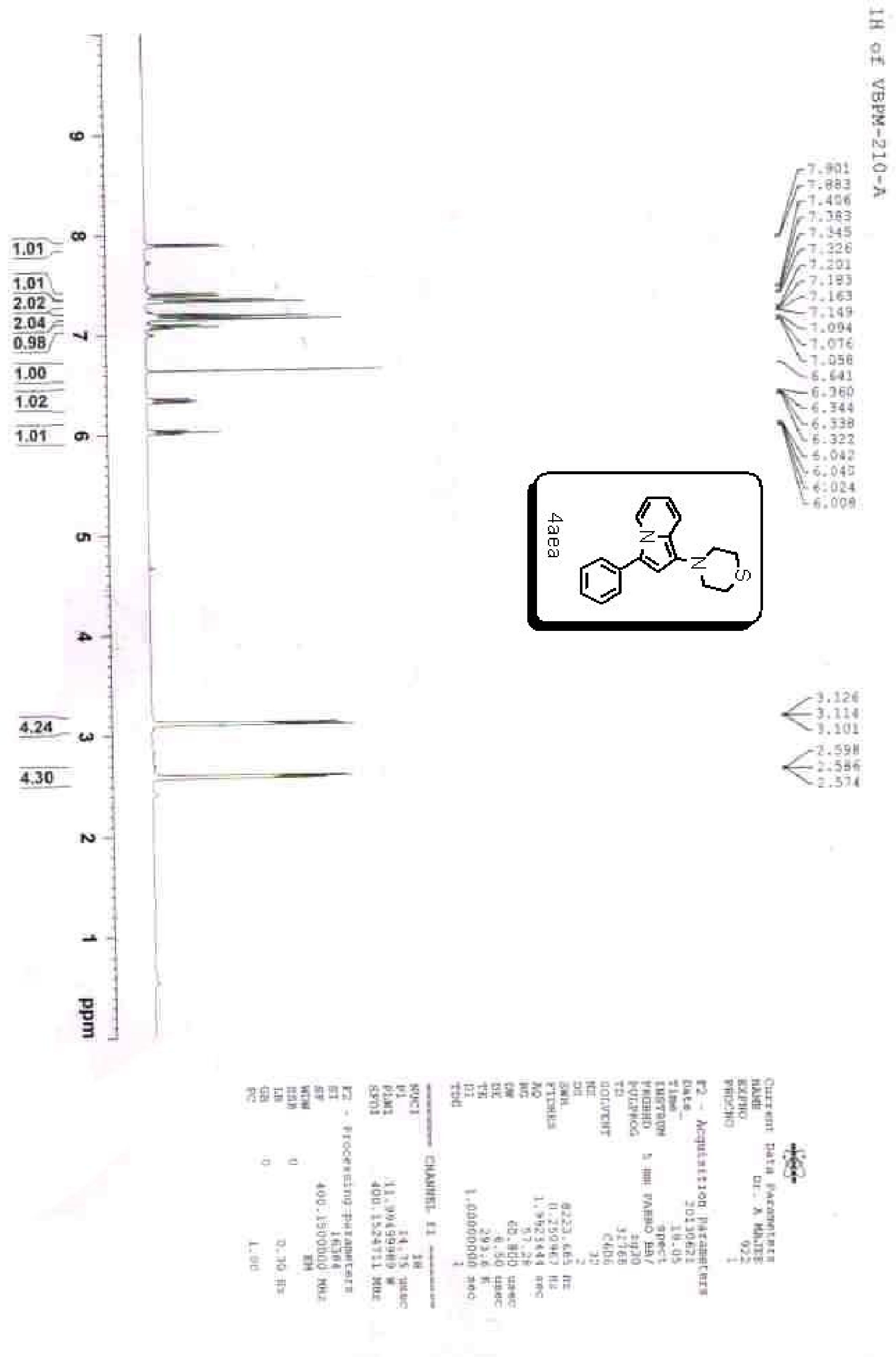
110.50
108.39
59.52
4ada
ppm


1H of VBPM-210-A
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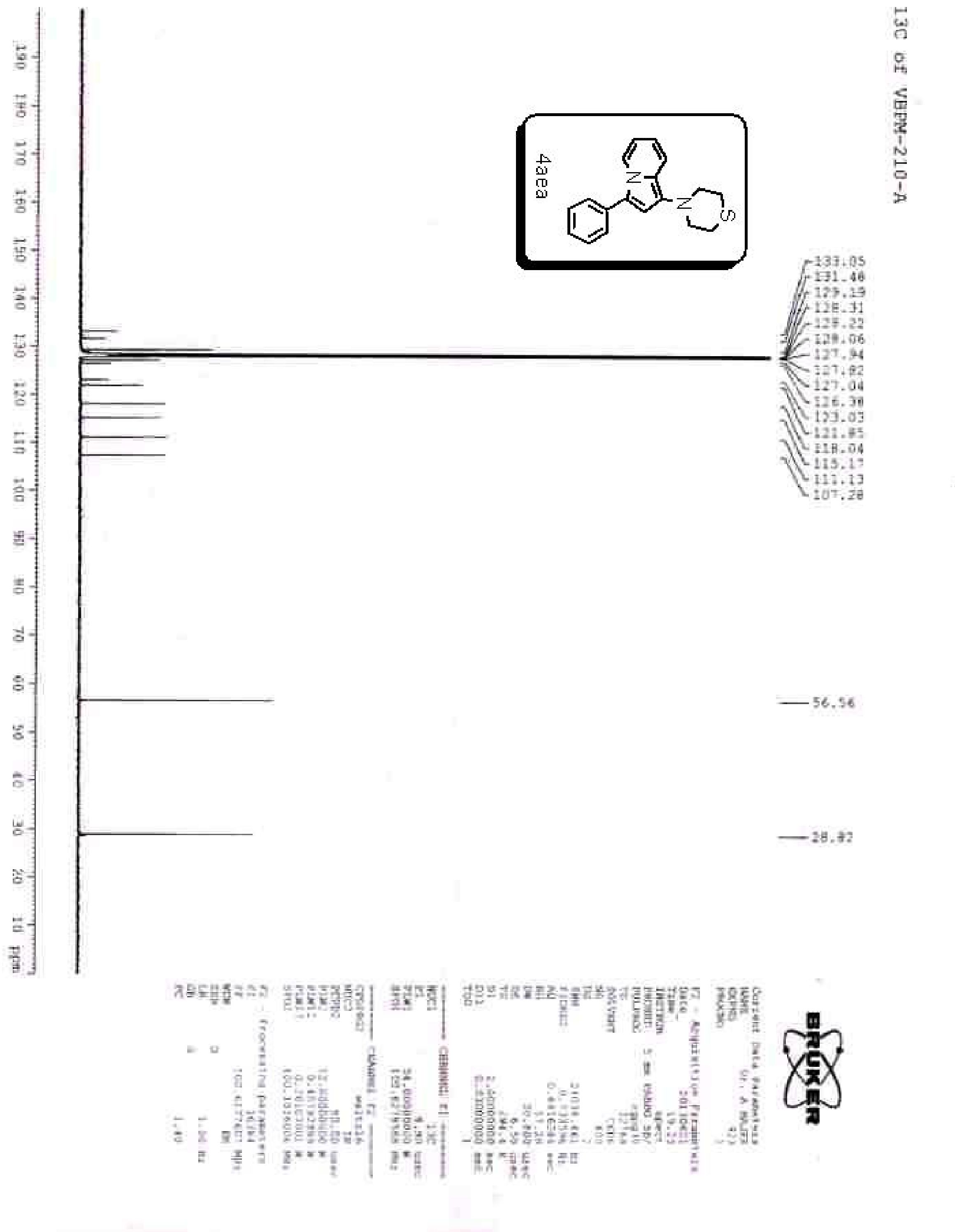
13C of VBPM-210-A
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133.05
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129.19
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128.22
128.06
127.94
127.82
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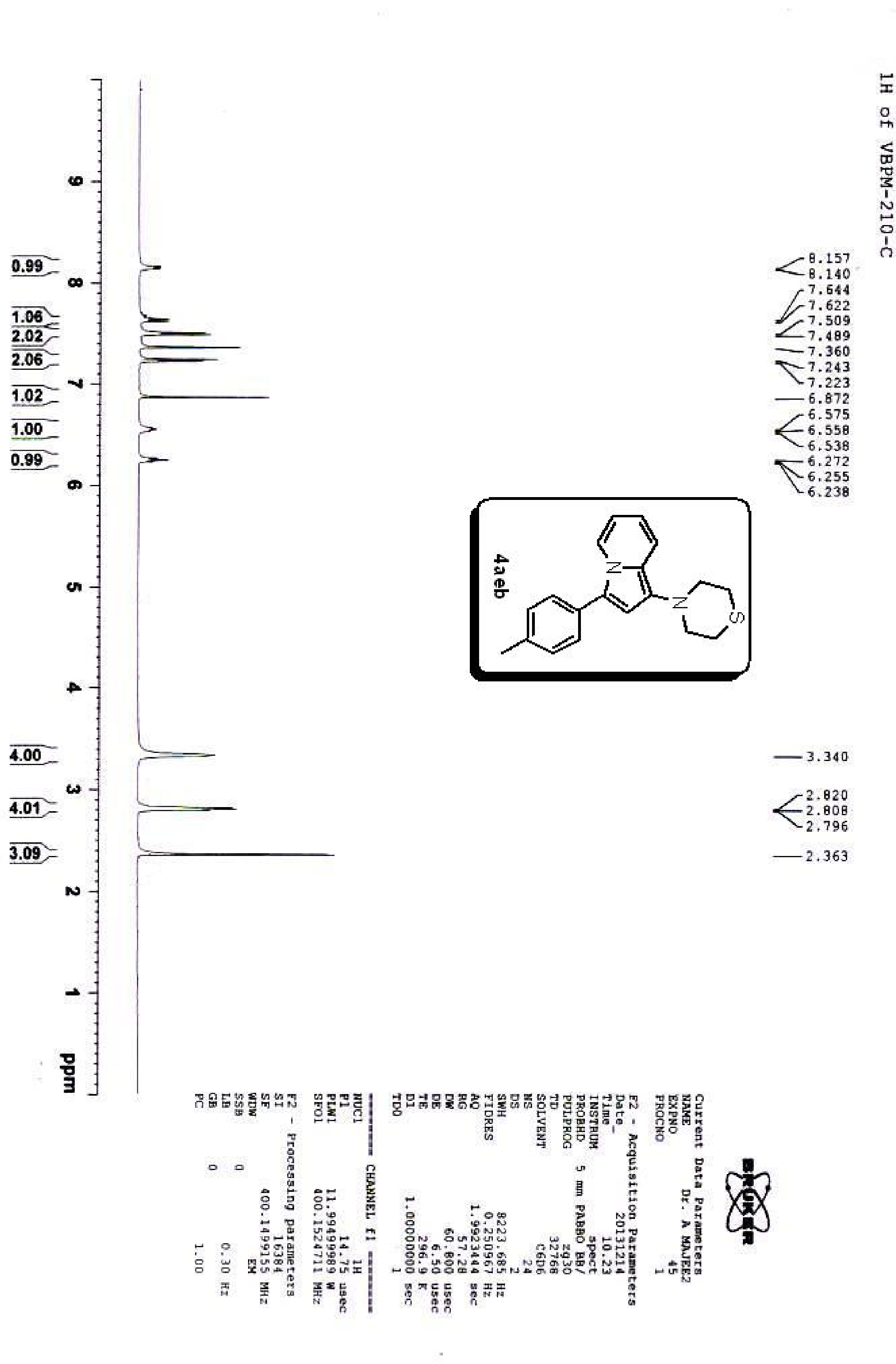
56.56
28.82
ppm


1H of VBPM-210-C
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8.140
7.644
7.622
7.509
7.489
7.360
7.243
7.223
6.872
6.575
6.558
6.538
6.272
6.255
6.238
3.340
2.820
2.808
2.796
2.363
4aeb
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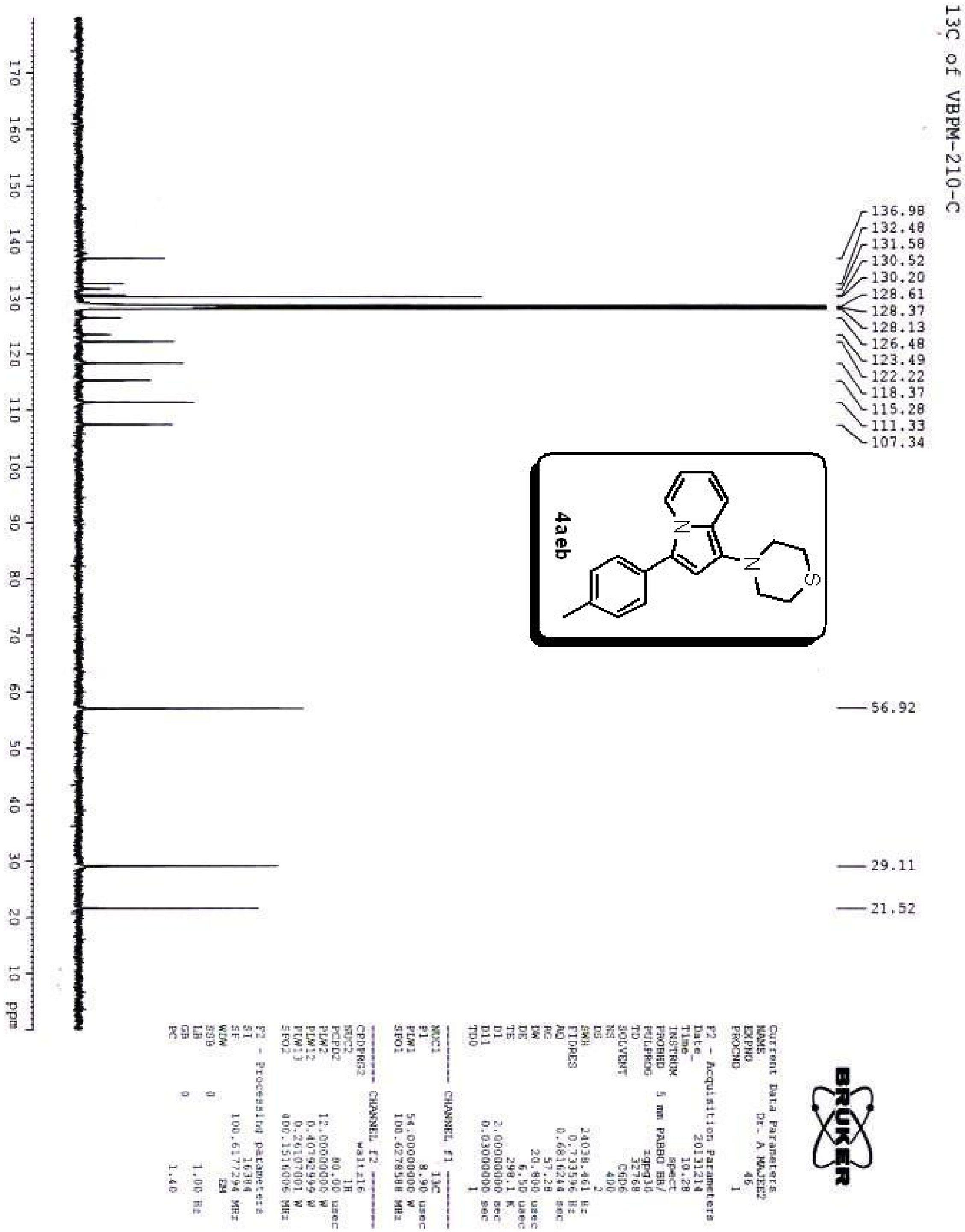
1.06
2.02
2.06
1.02
1.00
0.99
4.00
4.01
3.09
ppm


13C of VBPM-210-C
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130.52
130.20
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128.13
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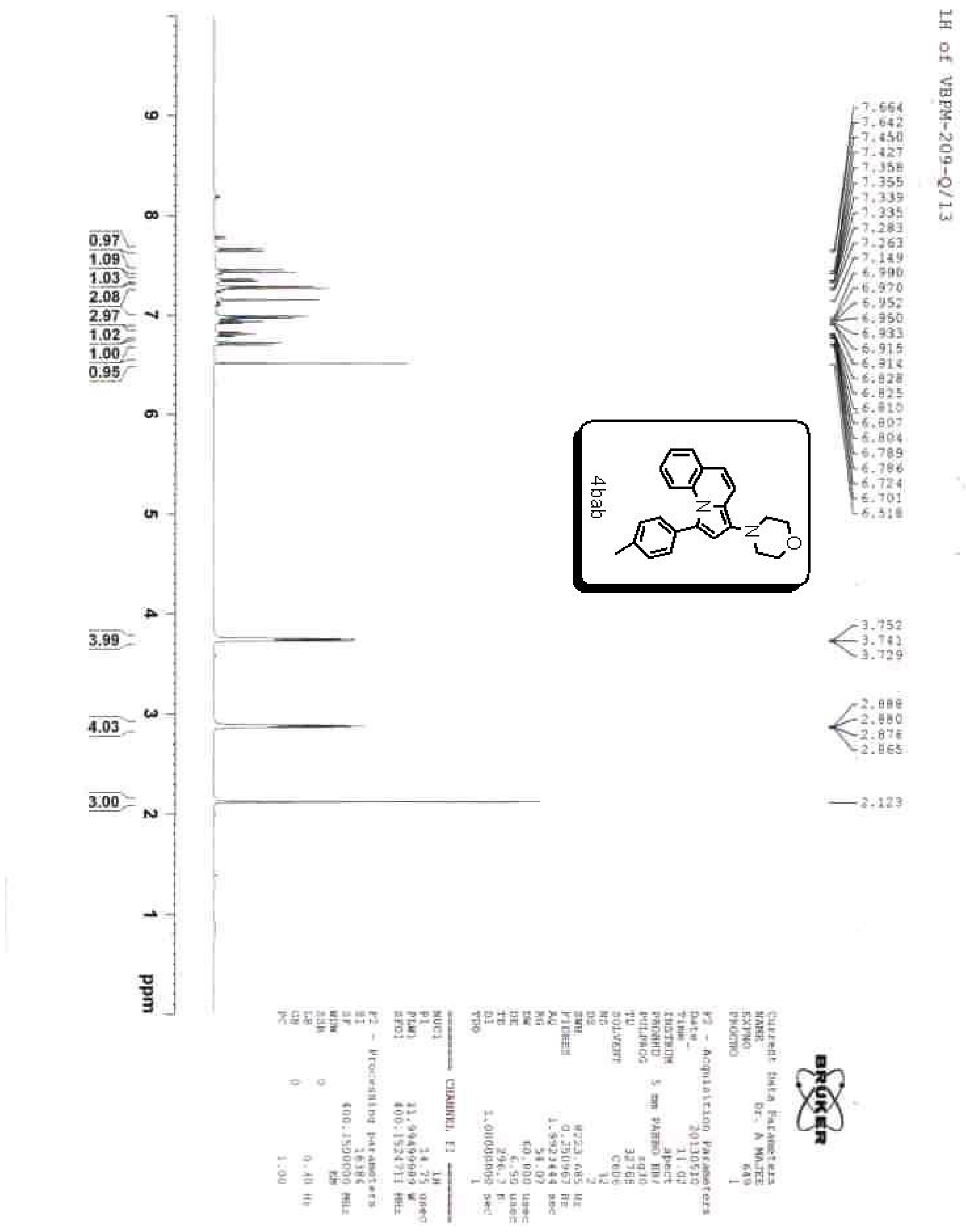
21.52
4aeb
ppm


1H of VBPM-209-Q/13
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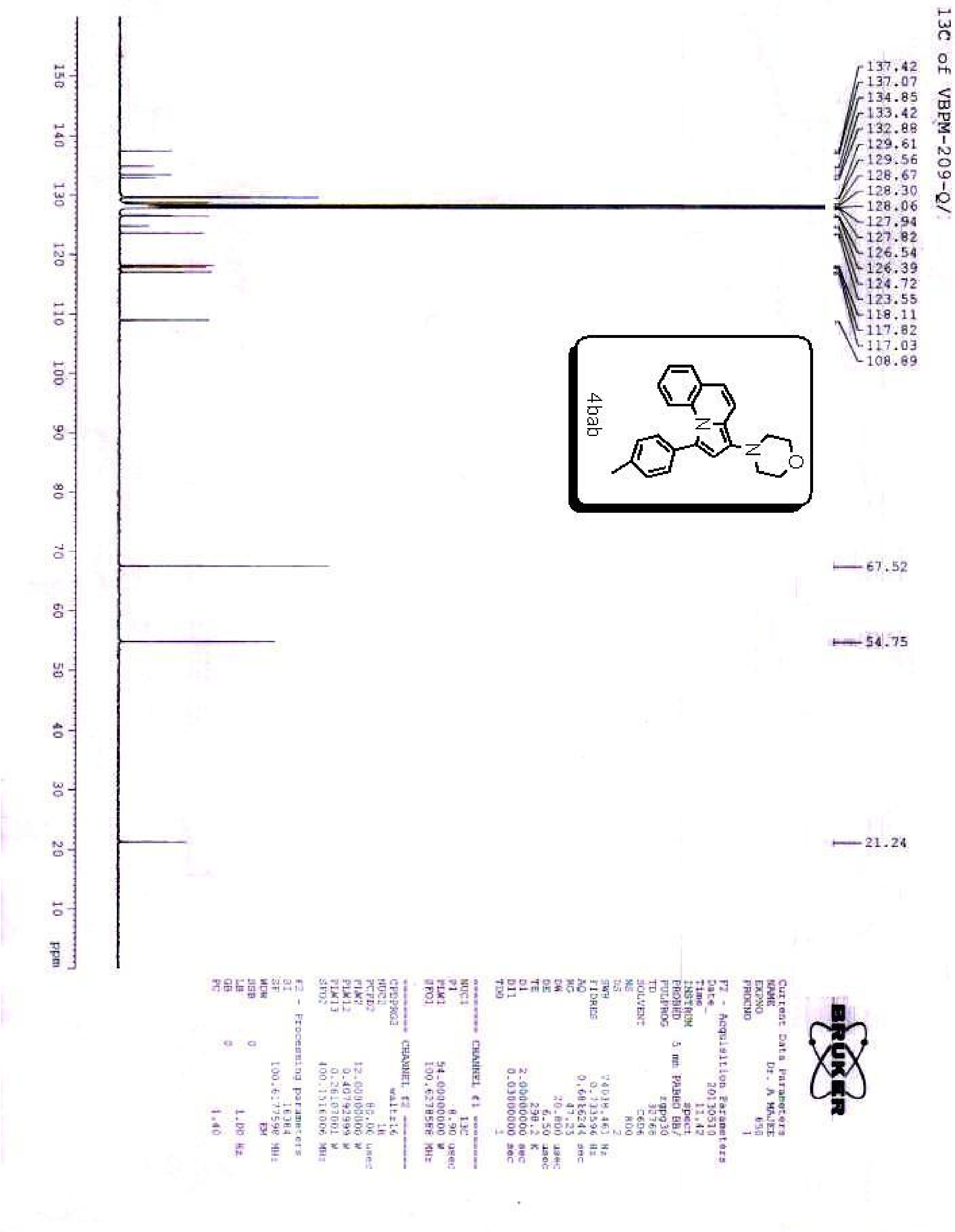
ppm


13C of VBPM-209-Q/
137.42
137.07
134.85
133.42
132.88
129.61
129.56
128.67
128.30
128.06
127.94
127.82
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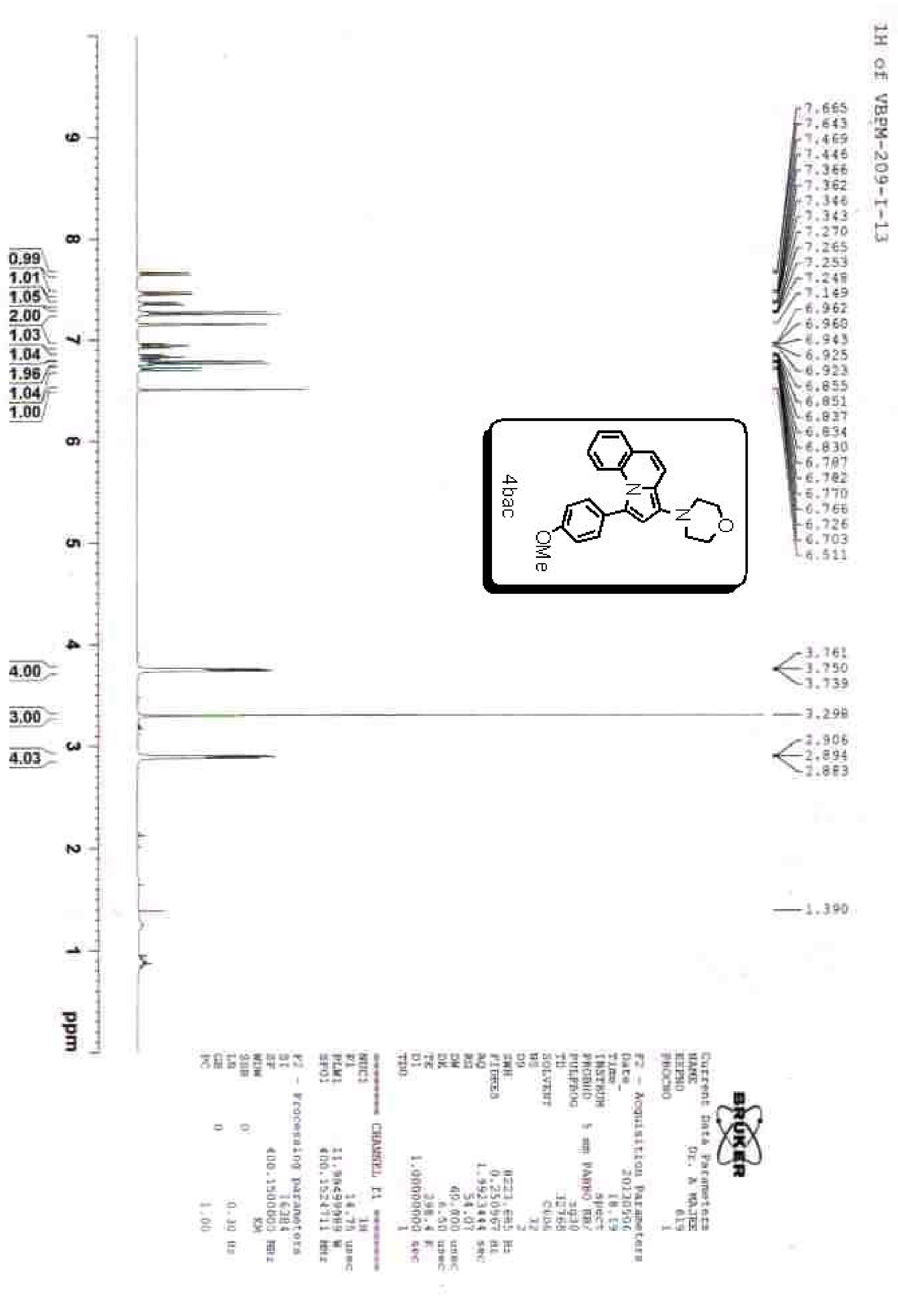
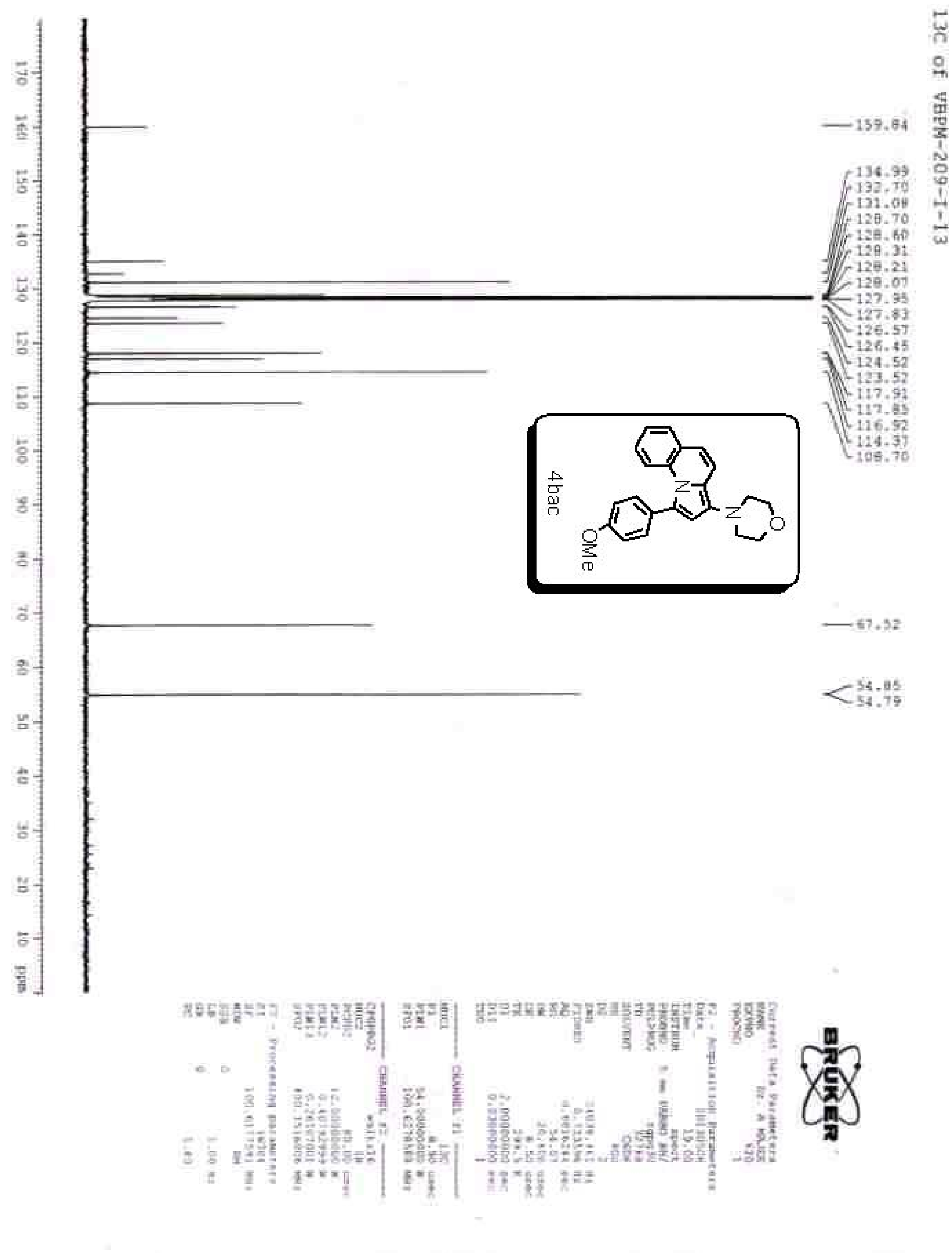
54.75
21.24
4bab
ppm


1H of VBPM-209-I-13
4bac
OMe
ppm


13C of VBPM-209-I-13
159.84
134.99
132.70
131.08
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128.60
128.31
128.21
128.07
127.95
127.83
126.57
126.45
124.52
123.52
117.91
117.85
116.92
114.37
108.70
67.52
54.85
54.79
4bac
OMe
N
O
BRUKER
ppm

V. Photophysical studies:

Spectroscopic apparatus:

The steady state electronic absorption spectra of all the samples were recorded at the ambient temperature (300 K) using 1 cm pathlength rectangular quartz cuvette by Kozima, by means of JASCO V-650 absorption spectrophotometer. Steady state fluorescence spectra of all the samples were recorded by JASCO FP-6500 fluorescence spectrometer at 300 K. Emission was detected at right angles to the direction of excitation light in order to avoid stray light.

Quantum Yield Determination:

To calculate Fluorescence quantum yield (ϕ_f), we used the following formula[d],

$$\varphi_f = \frac{I_f}{I_f^R}\frac{A^R}{A}\left(\frac{n}{n^R}\right)^2 \varphi_f^R$$

Here, φ_f^R is the known fluorescence quantum yield of the reference sample (referred by the superscript '*R*'); I_f and I_f^R are the integrated fluorescence intensities of the unknown sample and reference sample, respectively; A and A^R are the absorbances of the unknown sample and reference sample, respectively; n and n^R are the refractive indices of the solvents for the unknown sample and reference sample, respectively. The unknown sample and reference sample are excited at the same wavelength for measuring I_f and I_f^R, respectively. The fluorescence quantum yield of the samples are measured at 300 K relative to that of ZnTPhP in benzene solution (φ_f^R = 0.033 at 30° C)[e].

Photophysical study of **4bac** in various solvents:

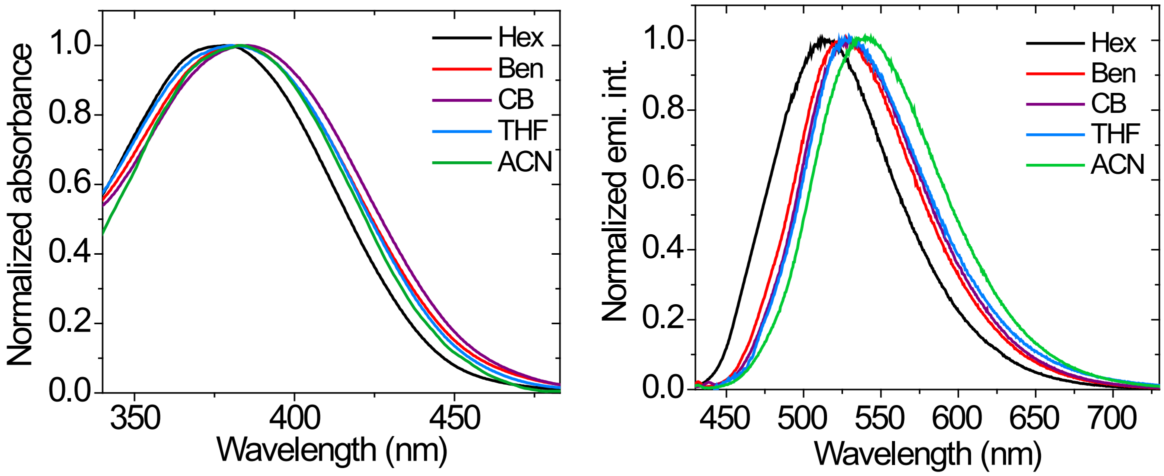


Fig 2 Absorbance and fluorescence emission spectra of **4bac** in various solvents (Concentration ~10^{-4} mol L^{-1}). Hex= Hexane, Ben= Benzene, CB= Chlorobenzene, ACN= Acetonitrile.

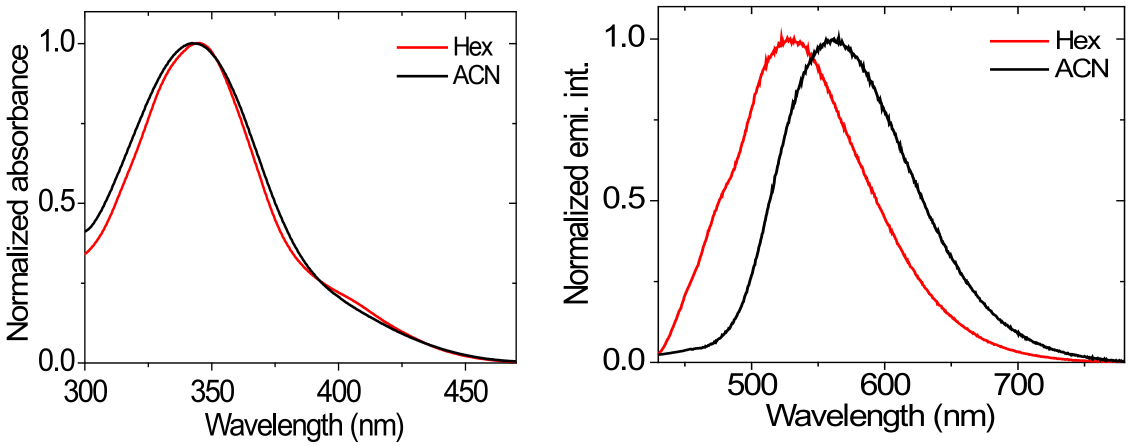
Solvent	λ_{max} **(nm)**	λ_{emi} **(nm)***	ϕ_f	**ε at** λ_{max} **($cm^{-1}M^{-1}$)**	$\bar{\nu}_a - \bar{\nu}_f$ **(cm^{-1})**
Acetonitrile	384	541	0.40	4675	7557
Tetrahydrofuran	382	531	0.34	6005	7277
Chlorobenzene	385	529	0.47	4943	7070
Benzene	382	526	0.44	4733	7166
Hexane	379	514	0.34	3899	7070

* Excitation wavelength was chosen corresponding to their λ_{max} value. (Concentration ~10^{-4} mol L^{-1})

Absorbance and fluorescence emission spectra of **4aaa.**

Absorption Spectra

Fluorescence Emission Spectra



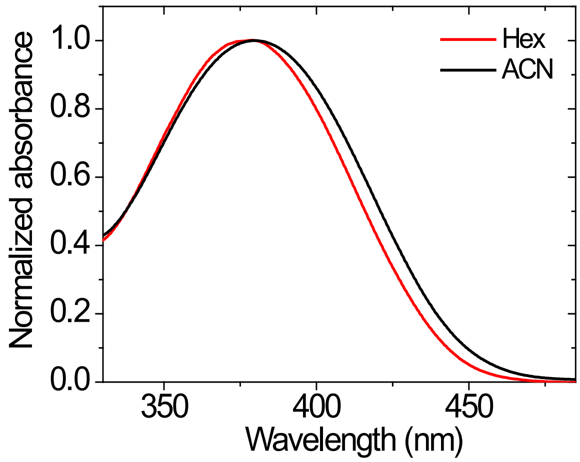
Solvent	**λ_{max}(nm)**	**λ_{emi} (nm)***	**ϕ_f**	**ε at λ_{max} ($cm^{-1}M^{-1}$)**	**$\bar{\nu}_a - \bar{\nu}_f$ (cm^{-1})**
Acetonitrile	344	562	0.006	6423	11329
Hexane	345	529	0.035	9653	10082

* Excitation wavelength was chosen corresponding to their λ_{max} value. (Concentration ~10^{-4} mol L^{-1})

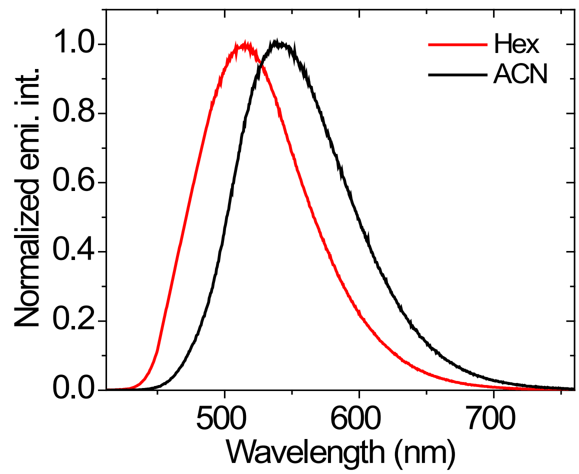
Electronic Supplementary Material (ESI) for RSC Advances

Absorbance and fluorescence emission spectra of **4bab.**

Absorption Spectra



Fluorescence Emission Spectra



Solvent	**λ_{max}(nm)**	**λ_{emi} (nm)***	**ϕ_f**	**ε at λ_{max} ($cm^{-1}M^{-1}$)**	**$\bar{\nu}_a - \bar{\nu}_f$ (cm^{-1})**
Acetonitrile	381	543	0.50	5567	7831
Hexane	378	515	0.75	3914	7038

* Excitation wavelength was chosen corresponding to their λ_{max} value. (Concentration ~10^{-4} mol L^{-1})

VI. References:

(*a*) B. Yan and Y. Liu, *Org. Lett.,* 2007, **9**, 4323.

(*b*) Y. Bai, J. Zeng, J. Ma, B. K. Gorityala, and X.-W. Liu, *J. Comb. Chem.* 2010, **12,** 696.

(*c*) S. Mishra, B. Naskar and R. Ghosh, *Tetrahedron Lett.,* 2012*,* **53**, 5483.

(*d*) J. R. Lakowicz, *Principles of Fluorescence Spectroscopy*, second ed., Kluwer Academic/ Plenum Publishers, New York, 1999.

(*e*) M. Ghosh, A. K. Mora, S. Nath, A. K. Chandra, A. Hajra and S. Sinha, *Spectrochim. Acta Part A: Mol. Biomol. Spectrosc.* 2013, **116**, 466.