Supporting Information

Synthesis of di/tri-substituted carbazoles involving Pd-Mediated Sonogashira coupling of indolyltriflates with aryl acetylenes

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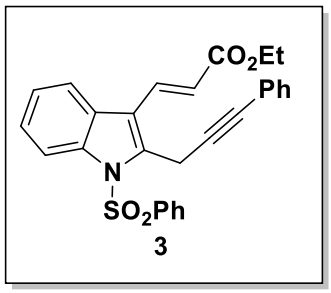
Experimental Procedure

Attempted synthesis of ethyl (*E*)-3-(2-(3-phenylprop-2-yn-1-yl)-1-(phenylsulfonyl)-1*H*-indol-3-yl)acrylate 3 from 2-bromomethyl-3-vinylindole 1



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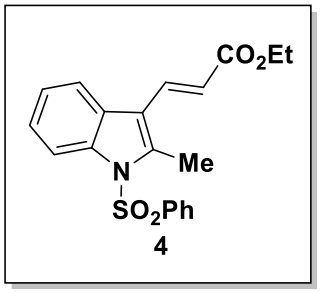

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Using $Pd(PPh_3)_4$ condition

To a solution of 2-bromomethylindole[1] **1** (0.25 g, 0.45 mmol) in dry THF (10 mL), phenylacetylene (91 mg, 0.89 mmol), $Pd(PPh_3)_4$ (52 mg, 0.04 mmol), and K_2CO_3 (62 mg, 0.45 mmol) were added and refluxed for 8 h. Then, the reaction mixture was dissolved in EA (20 mL). It was then diluted with water (30 mL), and the combined organic layer was separated. The aqueous layer was extracted with EA (2 x 10 mL), and the combined organic extract was dried (Na_2SO_4). The solvent was removed under *vacuo* and triturated with MeOH (5 mL), to give the de-brominated indole **4** (165 mg, 80%).

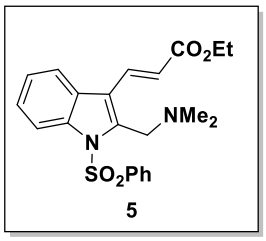
Using LHMDS & CuI condition

To a solution of 2-bromomethylindole[1] **1** (0.2 g, 0.56 mmol) in dry toluene (5 mL), phenylacetylene (0.17 g, 1.67 mmol) copper iodide (11 mg, 0.05 mmol) and LHMDS (0.11 g, 0.67 mmol) were added, the reaction mixture was stirred at 90 ^oC for 8 h. The reaction mixture was then filtered by celite pad and washed with EA (20 mL). The filtrate was quenched with crushed ice (100 g) containing NH_4Cl (2 g), and the combined organic layer was separated. The aqueous layer was extracted with EA (2 x 10mL), and the combined organic extract was dried (Na_2SO_4). The solvent was removed under *vacuo* and triturated with MeOH (5 mL), to give the de-brominated indole **4** (157 mg, 95%).

Ethyl (*E*)-3-(2-methyl-1-(phenylsulfonyl)-1*H*-indol-3-yl)acrylate 4[1]

^1H NMR (300 MHz, $CDCl_3$): δ 8.29 (d, J = 8.7 Hz, 1 H), 7.80-7.87 (m, 4 H), 7.31- 7.60 (m, 5 H), 6.53 (d, J = 16.2 Hz, 1 H), 4.29 (q, J = 7.2 Hz, 2 H), 2.74 (s, 3 H), 1.36 (t, J = 7.2 Hz, 3 H) ppm; ^{13}C NMR (75 MHz, $CDCl_3$): δ 167.3, 138.9, 136.7, 135.4, 134.1, 129.5, 127.5, 126.4, 124.9, 119.9, 118.7, 116.1, 114.7, 60.5, 14.4, 13.2 ppm.

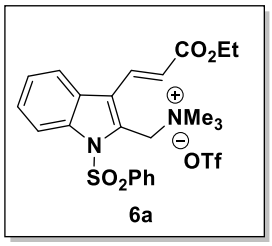
Ethyl (*E*)-3-(2-((dimethylamino)methyl)-1-(phenylsulfonyl)-1*H*-indol-3-yl)acrylate 5



5

To a solution of 2-bromomethyl-3-vinylindole[1] **1** (6 g, 11.13.38 mmol) in dry THF (40 mL), dimethylamine (0.72 g, 16.06 mmol) and K_2CO_3 (2.21 g, 16.06 mmol) were added. The reaction mixture was stirred at room temperature for 3 h. After completion of the reaction (monitored by TLC), the solvent was removed under *vacuo*, and the reaction mixture was dissolved in DCM (50 mL). It was then diluted with water (30 mL), and the combined organic layer was separated. The aqueous layer was extracted with DCM (10 mL), and the combined organic extracts were dried (Na_2SO_4). The solvent was removed under vacuum, and the product was triturated with cold MeOH to afford 2-((dimethylamino)methyl)-3-vinyl indole **5 (**5.02 g, 91%) as a white crystalline solid. mp: 113-115 ^oC; ^1H NMR (300 MHz, $CDCl_3$): δ 8.16 (d, J = 7.8 Hz, 1 H), 7.97 (d, J = 7.2 Hz, 2 H), 7.86 (d, J = 15.9 Hz, 1 H), 7.74 (d, J = 7.5 Hz, 1 H), 7.42 (t, J = 7.5 Hz, 1 H), 7.33-7.20 (m, 4 H), 6.47 (d, J = 16.2 Hz, 1 H), 4.2 (q, J = 6.9 Hz, 2 H), 3.89 (s, 2 H), 2.07 (s, 6 H), 1.26 (t, J = 6.9 Hz, 3H) ppm; ^{13}C NMR (75 MHz, $CDCl_3$): δ 167.1, 140.0, 137.2, 135.5, 133.4, 128.6, 127.0, 126.8, 125.4, 124.0, 120.4, 119.9, 118.1, 115.1, 60.5, 52.1, 44.4, 14.3 ppm; DEPT-135 NMR (75 MHz, $CDCl_3$): δ 135.4, 133.4, 128.6, 127.0, 125.3, 124.0, 120.3, 119.8, 115.0, 60.4, 52.0, 44.4, 14.3 ppm.

(*E*)-1-(3-(3-Ethoxy-3-oxoprop-1-en-1-yl)-1-(phenylsulfonyl)-1*H*-indol-2-yl)-*N*,*N*,*N*-trimethylmethanaminium trifluoromethanesulfonate 6a

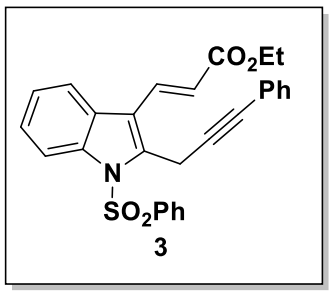


6a

To a solution of amine compound **5** (5.0 g, 12.12 mmol) in dry THF (40 mL), MeOTF (2.19 g, 13.33 mmol) was added dropwise at 0 ^oC, then allowed to stir at rt for 20 minutes. Removal of solvent followed by the trituration of the crude product with diethyl ether (60 mL) afforded amine salt **6a** (6.63 g, 95%) as colorless solid. The amine salt **6a** was stored at 0 ^oC under inert atmosphere. mp: 184-186 ^oC; ^1H NMR (300 MHz, DMSO-d_6): δ 8.21 (d, J = 8.1 Hz, 1 H), 7.98-7.90 (m, 2 H), 7.81 (d, J = 7.8 Hz, 2 H), 7.65 (t, J = 6.9 Hz, 1 H), 7.60-7.44 (m, 4 H),

6.74 (d, J = 16.2 Hz, 1 H), 5.37 (s, 2 H), 4.25 (q, J = 6.6 Hz, 2 H), 3.20 (s, 9 H), 1.29 (t, J = 6.9 Hz, 3 H) ppm; ^{13}C NMR (75 MHz, DMSO-d_6): δ 165.5, 137.5, 135.3, 135.1, 133.3, 129.6, 128.2, 127.6, 127.1, 126.9, 126.5, 125.6, 124.6, 121.5, 116.0, 60.4, 58.1, 53.2, 14.0 ppm.

Attempted synthesis of ethyl (*E*)-3-(2-(3-phenylprop-2-yn-1-yl)-1-(phenylsulfonyl)-1*H*-indol-3-yl)acrylate 3 from amine salt 6a



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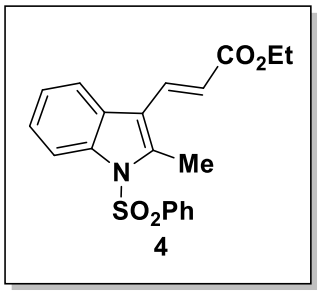
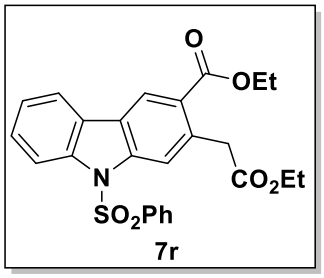


4

The reaction of amine salt **6a** (0.3 g, 0.52 mmol) with phenylacetylene (80 mg, 0.78 mmol) in the presence of $Pd(PPh_3)_4$ (60 mg, 0.05 mmol), K_2CO_3 (72 mg, 0.52 mmol) in a dry toluene (5 mL) at 100 ^oC for 8 h. After the reaction was completion (monitored by TLC), the reaction mixture was cooled to room temperature, the reaction mixture was quenched by water and extracted with ethyl acetate (2 x 20 mL). The combined organic layer was dried (Na_2SO_4) and evaporated under *vacuo* followed by column chromatographic purification on silica gel (230-420 mesh, n-hexane/ethyl acetate, 19:1) afforded 2-methyl-3-vinylindole **4 (**48 mg, 25%) as a colorless solid; mp: 203-205 °C. Further elution of the column (n-hexane/ethyl acetate, 9:1) afforded carbazole **7a (**0.103 g, 42%) as a colorless solid; mp: 145-1148 °C.

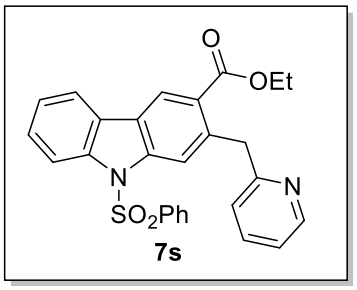
Attempted synthesis of ethyl 2-(2-ethoxy-2-oxoethyl)-9-(phenylsulfonyl)-9*H*-carbazole-3-carboxylate 7r



7r

The reaction of amine salt **6a** (0.3 g, 0.52 mmol) with ethyl propiolate (77 mg, 0.78 mmol) in the presence of $Pd(PPh_3)_4$ (60 mg, 0.05 mmol), K_2CO_3 (36 mg, 0.26 mmol) in a mixture of DMSO (0.8 mL) and dry toluene (4.8 mL) at 100 ^oC for 8 h followed by workup using the above mentioned procedure failed to give the expected carbazole **7r**, instead 2-methyl-3-vinylindole **4** (198 mg, 80%) was isolated.

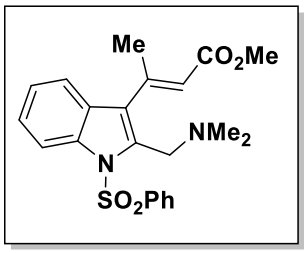
Attempted synthesis of ethyl 9-(phenylsulfonyl)-2-(pyridin-2-ylmethyl)-9*H*-carbazole-3-carboxylate 7s



7s

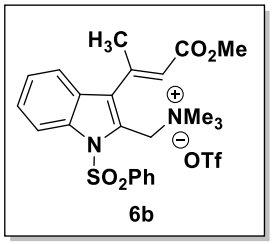
The reaction of amine salt **6a** (0.3 g, 0.52 mmol) with 2-ethynylpyridine (80 mg, 0.78 mmol) in the presence of $Pd(PPh_3)_4$ (60 mg, 0.05 mmol), K_2CO_3 (36 mg, 0.26 mmol) in a mixture of DMSO (0.8 mL) and dry toluene (4.8 mL) at 100 ^oC for 8 h followed by workup using the above mentioned procedure failed to give the expected carbazole **7s.**

Methyl (*E*)-3-(2-((dimethylamino)methyl)-1-(phenylsulfonyl)-1*H*-indol-3-yl)but-2-enoate



A mixture of methyl (*E*)-3-(2-(bromomethyl)-1-(phenylsulfonyl)-1*H*-indol-3-yl)but-2-enoate[2] (5.2 g, 11.59 mmol) in dry THF, dimethylamine (0.63 g, 13.92 mmol) and K_2CO_3 (1.92 g, 13.92 mmol) were added, the reaction mixture was stirred at room temperature for 3 h. Then the THF solvent was removed under *vacuo* and the reaction mixture dissolved in DCM. It was then dilution with water (10 mL) and the combined organic layer was separated. The aqueous layer was extracted with DCM (10 mL) and the combined organic extracts were dried (Na_2SO_4). The crude product methyl (*E*)-3-(2-((dimethylamino)methyl)-1-(phenylsulfonyl)-1*H*-indol-3-yl)but-2-enoate was used as such for next step without any further purification.

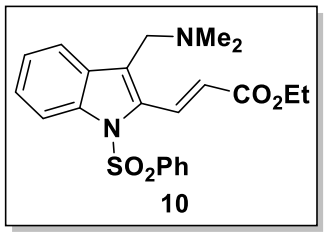
((Trifluoromethyl)sulfonyl)-l1-oxidane, (*E*)-1-(3-(4-methoxy-4-oxobut-2-en-2-yl)-1-(phenylsulfonyl)-1*H*-indol-2-yl)-*N*,*N*,*N*-trimethylmethanaminium salt 6b



6b

A mixture of methyl (*E*)-3-(2-((dimethylamino)methyl)-1-(phenylsulfonyl)-1*H*-indol-3-yl)but-2-enoate (4 g, 9.70 mmol) in dry THF (40 mL), MeOTF (1.75 g, 10.67 mmol) was added dropwise at 0 ^{o}C, then allowed to stir at rt for 20 minutes. Removal of solvent followed by trituration of the crude product with diethyl ether (60 mL) afforded amine salt **6b** (5.14 g, 92%) as pale yellow solid. The amine salt **6b** was stored at 0 ^{o}C under inert atmosphere. mp: 150-152 ^{o}C; ^{1}H NMR (300 MHz, DMSO-d_6): δ 8.20 (d, J = 8.7 Hz, 1 H), 7.81 (d, J = 7.5 Hz, 2 H), 7.68 (t, J = 7.2 Hz, 1 H), 7.61-7.50 (m, 4 H), 7.42 (d, J = 7.8 Hz, 2 H), 6.02 (s, 1 H), 5.15 (broad s, 2 H), 3.77 (s, 3 H), 3.22 (m, 8 H), 2.50 (s, 3 H) ppm; ^{13}C NMR (75 MHz, DMSO-d_6): δ 164.0, 144.5, 136.2, 136.0, 133.7, 133.5, 128.2, 127.3, 126.4, 125.3, 124.2, 122.5, 122.1, 119.9, 115.1, 57.9, 51.9, 49.8, 18.6 ppm.

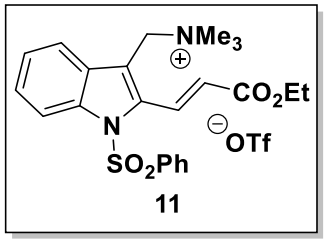
Ethyl (*E*)-3-(3-((dimethylamino)methyl)-1-(phenylsulfonyl)-1*H*-indol-2-yl)acrylate 10



10

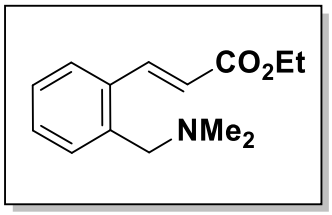
To a solution of ethyl (*E*)-3-(3-(bromomethyl)-1-(phenylsulfonyl)-1H-indol-2-yl)acrylate[1] (1 g, 2.24 mmol) in dry THF (20 mL), dimethylamine (0.121 g, 2.68 mmol) and K_2CO_3 (0.37 g, 2.68 mmol) were added, the reaction mixture was stirred at room temperature for 3 h. Then the THF solvent was removed under *vacuo* and the reaction mixture dissolved in DCM (20 mL). It was then diluted with water (10 mL) and the combined organic layer was separated. The aqueous layer was extracted with DCM (2 x 10 mL) and the combined organic extract was dried (Na_2SO_4). The solvent was removed under *vacuo* and triturated with cold MeOH (10 mL) to afford 3-((dimethylamino)methyl)-2-vinyl indole **10 (**0.84 g, 91%) as a colorless solid. mp: 112-114 ^{o}C; ^{1}H NMR (300 MHz, $CDCl_3$): δ 8.15-8.07 (m, 2 H), 7.58 (d, J = 7.2 Hz, 2 H), 7.38 (t, J = 7.2 Hz, 1 H), 7.31-7.15 (m, 4 H), 6.55 (d, J = 15.9 Hz, 1 H), 4.24 (q, J = 7.2 Hz, 2 H), 3.34 (s, 2 H), 2.06 (s, 6 H), 1.30 (t, J = 7.2 Hz, 3 H) ppm; ^{13}C NMR (75 MHz, $CDCl_3$): δ 166.5, 137.8, 137.3, 134.8, 133.7, 133.6, 131.4, 128.9, 126.6, 126.3, 125.0, 124.6, 124.3, 120.4, 115.6, 60.7, 53.3, 45.0, 14.3 ppm; DEPT-135 NMR (75 MHz, $CDCl_3$): δ 133.7, 133.5, 128.9, 126.6, 126.2, 124.6, 124.2, 120.4, 115.5, 60.6, 53.3, 45.0, 14.3 ppm.

(*E*)-1-(2-(3-ethoxy-3-oxoprop-1-en-1-yl)-1-(phenylsulfonyl)-1*H*-indol-3-yl)-*N,N,N*-trimethylmethanaminium trifluoromethanesulfonate 11



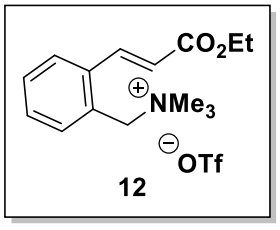
A mixture of 3-((dimethylamino)methyl)-2-vinyl indole **10** (0.5 g, 1.21 mmol) in dry THF (10 mL) and MeOTF (0.22 g, 1.33 mmol) was added dropwise at 0°C, and then allowed to stir for 20 minutes at room temperature. Removal of solvent afforded amine salt as a thick liquid. The ^{1}HNMR spectrum of crude product failed to confirm the formation of salt **11**.

Ethyl (*E*)-3-(2-((dimethylamino)methyl)phenyl)acrylate



To a solution of ethyl (*E*)-3-(2-(bromomethyl)phenyl)acrylate[3] (2 g, 7.43 mmol) in dry THF (20 mL), dimethylamine (0.4 g, 8.92 mmol) and K_2CO_3 (1.23 g, 8.92 mmol) were added, the reaction mixture was stirred at room temperature for 3 h. Then, the THF solvent was removed under *vacuo* and the reaction mixture dissolved in DCM. It was then dilution with water (10 mL) and the combined organic layer was separated. The aqueous layer was extracted with DCM (2 x 10 mL) and the combined organic extract was dried (Na_2SO_4). The crude product ethyl (*E*)-3-(2-((dimethylamino)methyl)phenyl)acrylate was used as such for next step without any further purification.

(*E*)-1-(2-(3-Ethoxy-3-oxoprop-1-en-1-yl)phenyl)-*N,N,N*-trimethylmethanaminium trifluoromethanesulfonate 12

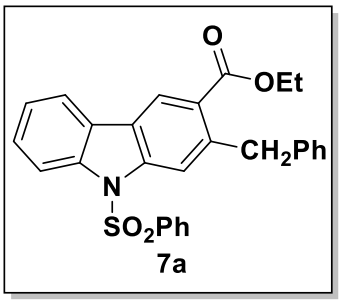


A mixture of ethyl (*E*)-3-(2-((dimethylamino)methyl)phenyl)acrylate (1.5 g, 6.43 mmol) in dry THF (20 mL), MeOTF (1.16 g, 7.07 mmol) was added dropwise at 0 ^{o}C, and allowed to stir for

30 minutes at rt. Subsequent removal of solvent followed by trituration of the crude product with diethyl ether afforded (*E*)-1-(2-(3-ethoxy-3-oxoprop-1-en-1-yl)phenyl)-*N,N,N*-trimethylmethanaminium trifluoromethanesulfonate **12** (1.68 g, 99%) as colorless solid. mp : 110-112 ^{o}C;^{1}H NMR (300 MHz, DMSO-d_6): δ 8.09 (d, J = 15.6 Hz, 1 H), 7.96 (d, J = 7.5 Hz, 1 H), 7.63-7.57 (m, 3 H), 6.67 (d, J = 15.6 Hz, 1 H), 4.78 (s, 2 H), 4.78 (q, J = 7.2 Hz, 2 H), 3.01 (s, 9 H), 1.28 (t, J = 6.9 Hz, 1 H) ppm; ^{13}C NMR (75 MHz, DMSO-d_6): δ 165.8, 140.9, 136.7, 135.2, 131.0, 130.2, 128.1, 127.5, 122.1, 64.3, 60.3, 52.1, 14.1 ppm; DEPT-135 NMR (75 MHz, DMSO-d_6): δ 141.4, 135.7, 131.5, 130.7, 128.6, 122.6, 64.8, 60.8, 52.6, 14.6 ppm.

Representative Gram Scale synthesis

Ethyl 2-benzyl-9-(phenylsulfonyl)-9*H*-carbazole-3-carboxylate 7a

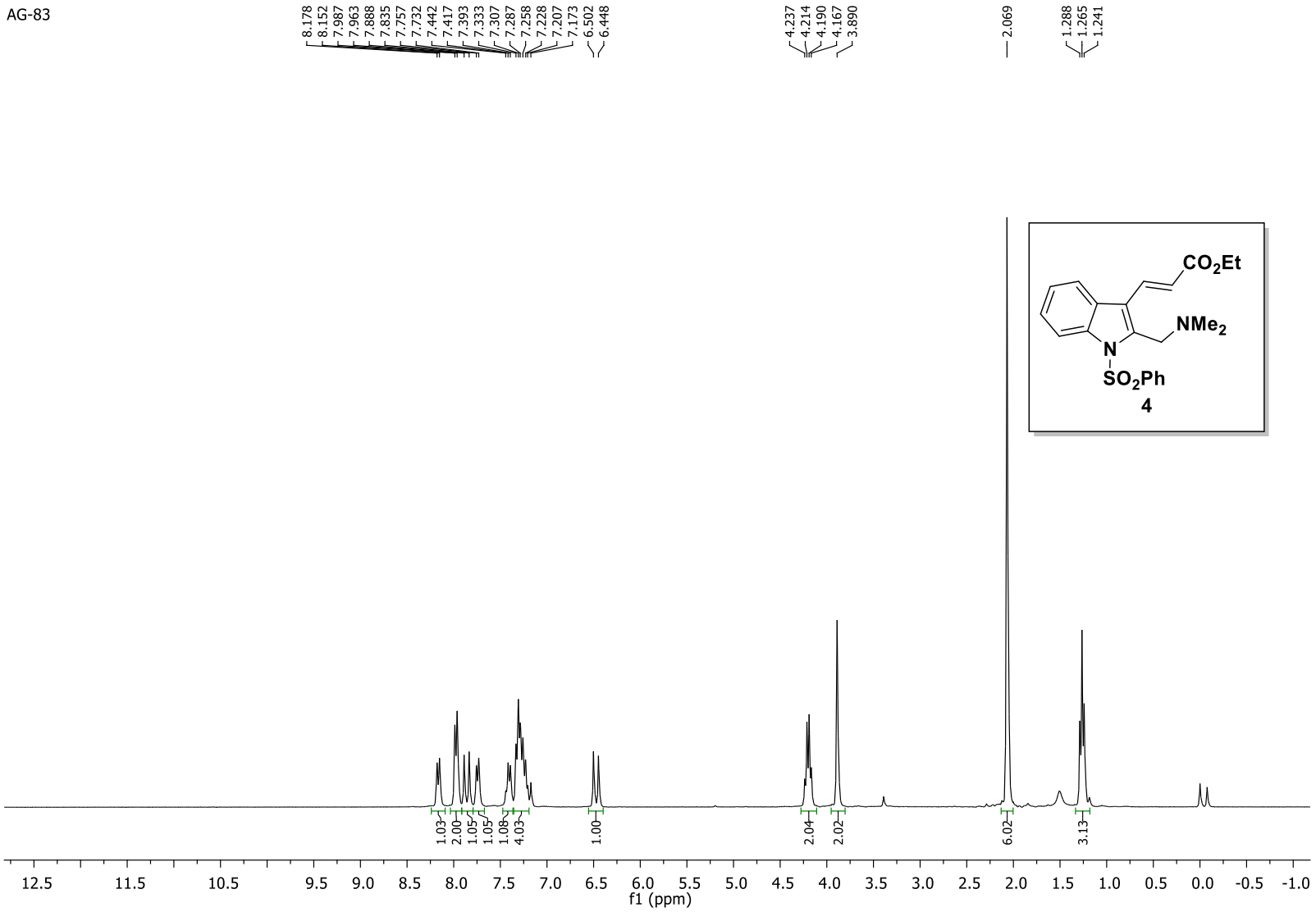


7a

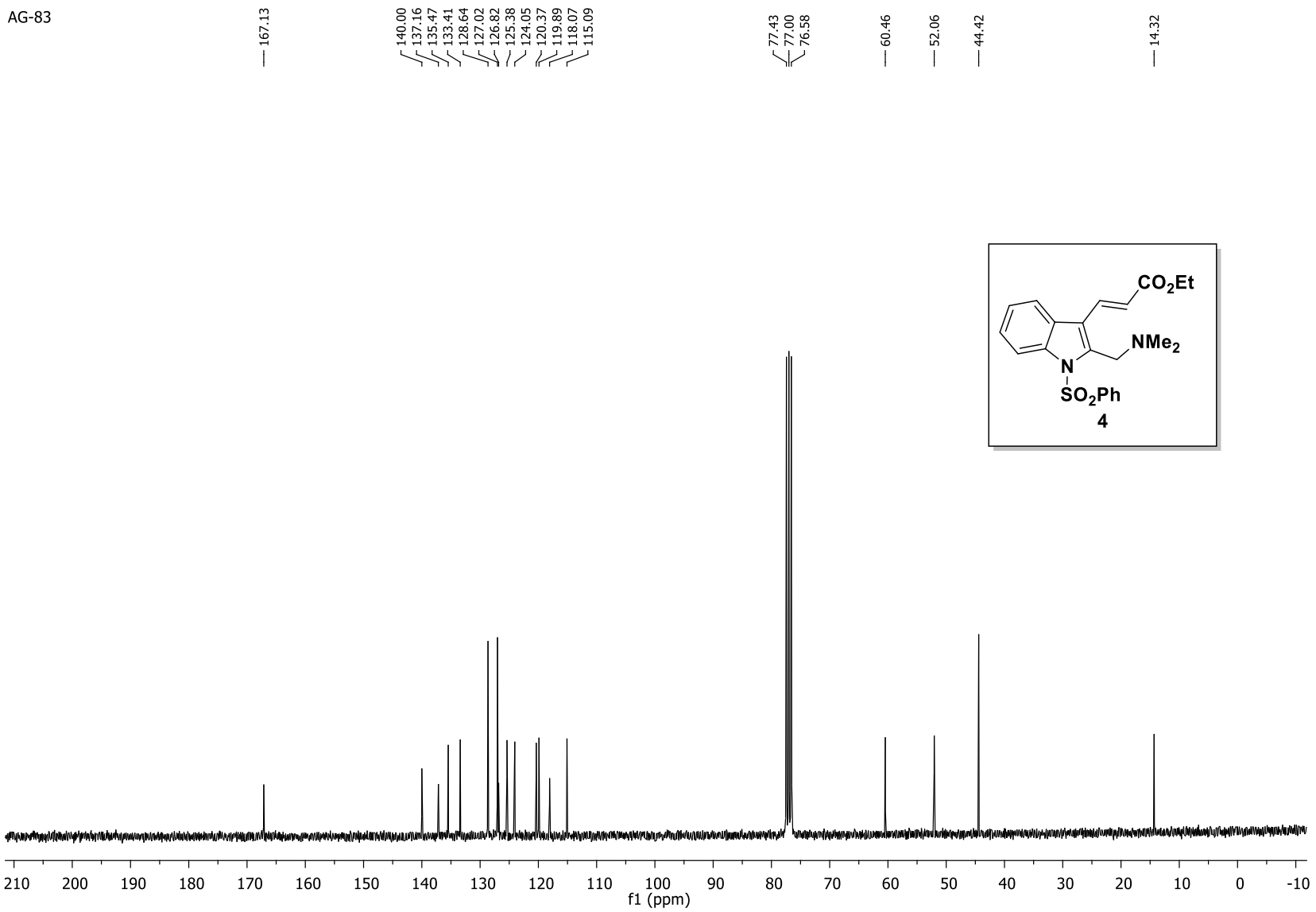
The reaction of amine salt **6a** (0.3 g, 0.52 mmol) with phenylacetylene (80 mg, 0.78 mmol) in the presence of $Pd(PPh_3)_4$ (60 mg, 0.05 mmol), K_2CO_3 (36 mg, 0.26 mmol) in a mixture of DMSO (0.8 mL) and dry toluene (4.8 mL) at 100 ^{o}C for 8 h followed by workup using the above mentioned procedure gave carbazole **7a** (0.218 g, 89%) as a colorless solid.

References

1. A. K. Mohanakrishnan and P. C. Srinivasan, *J. Org. Chem.,* 1995, ***60***, 1939-1946.
2. P. Raju, G. Gobi Rajeshwaran and A. K. Mohanakrishnan, *Eur. J. Org. Chem.,* 2015, 7173-7145**.**
3. M. Grübel, C. Jandl and T. Bach, *Synlett*, 2019, **30**, 1825-1829.

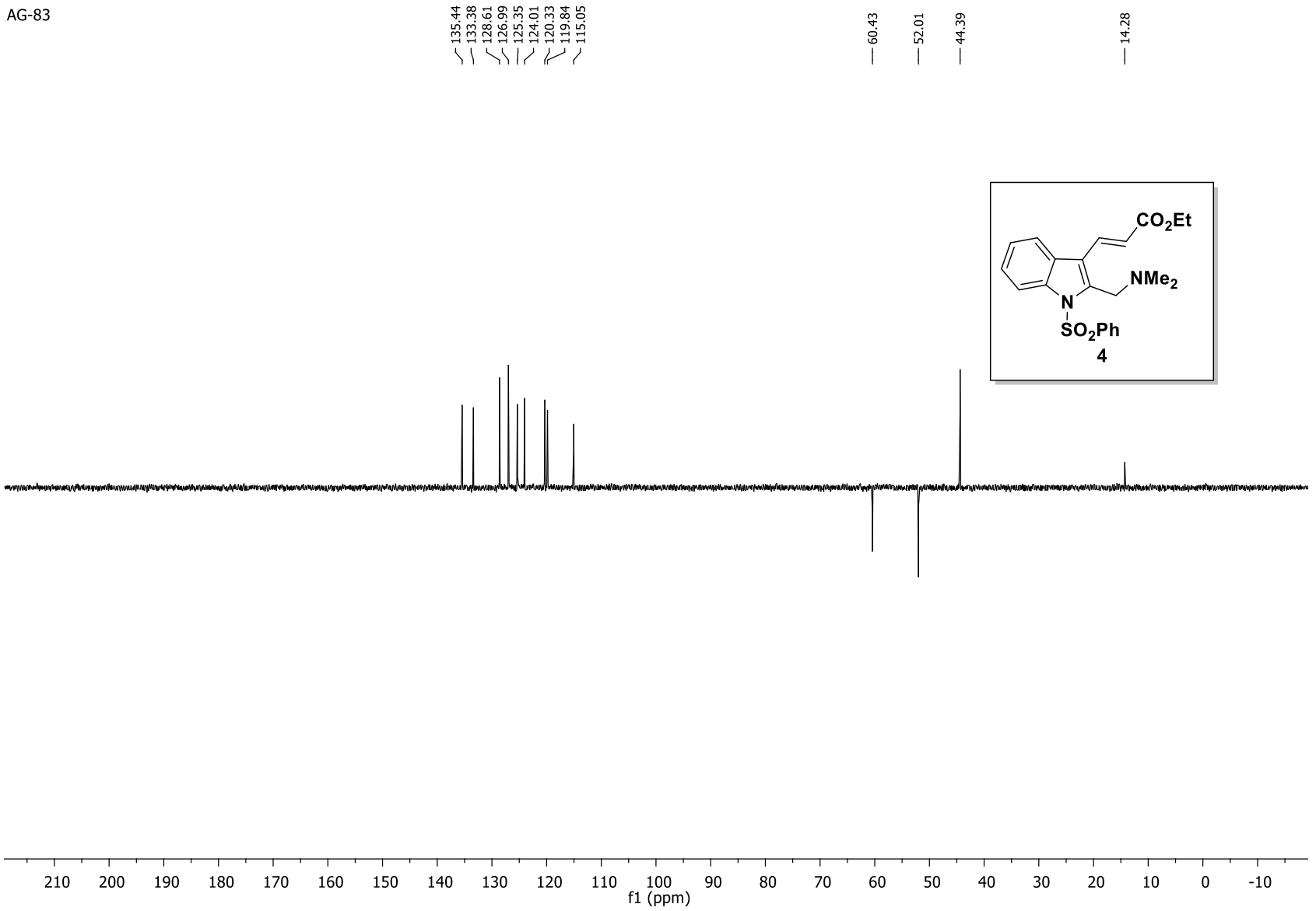


^{1}H NMR (300 MHz, $CDCl_3$) spectrum of compound **4**

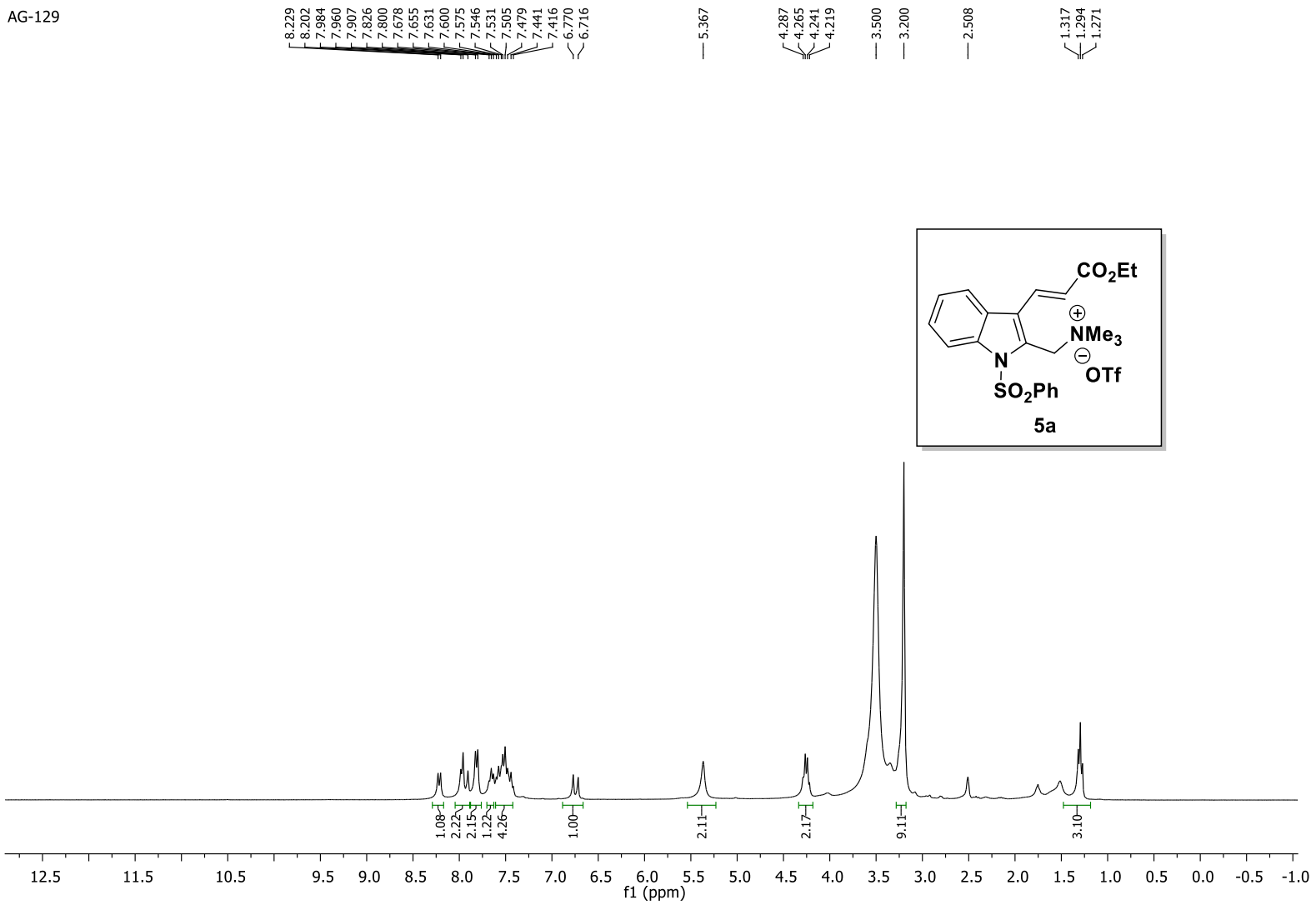


^{13}C {^{1}H} NMR (75 MHz, $CDCl_3$) spectrum of compound **4**

AG-83

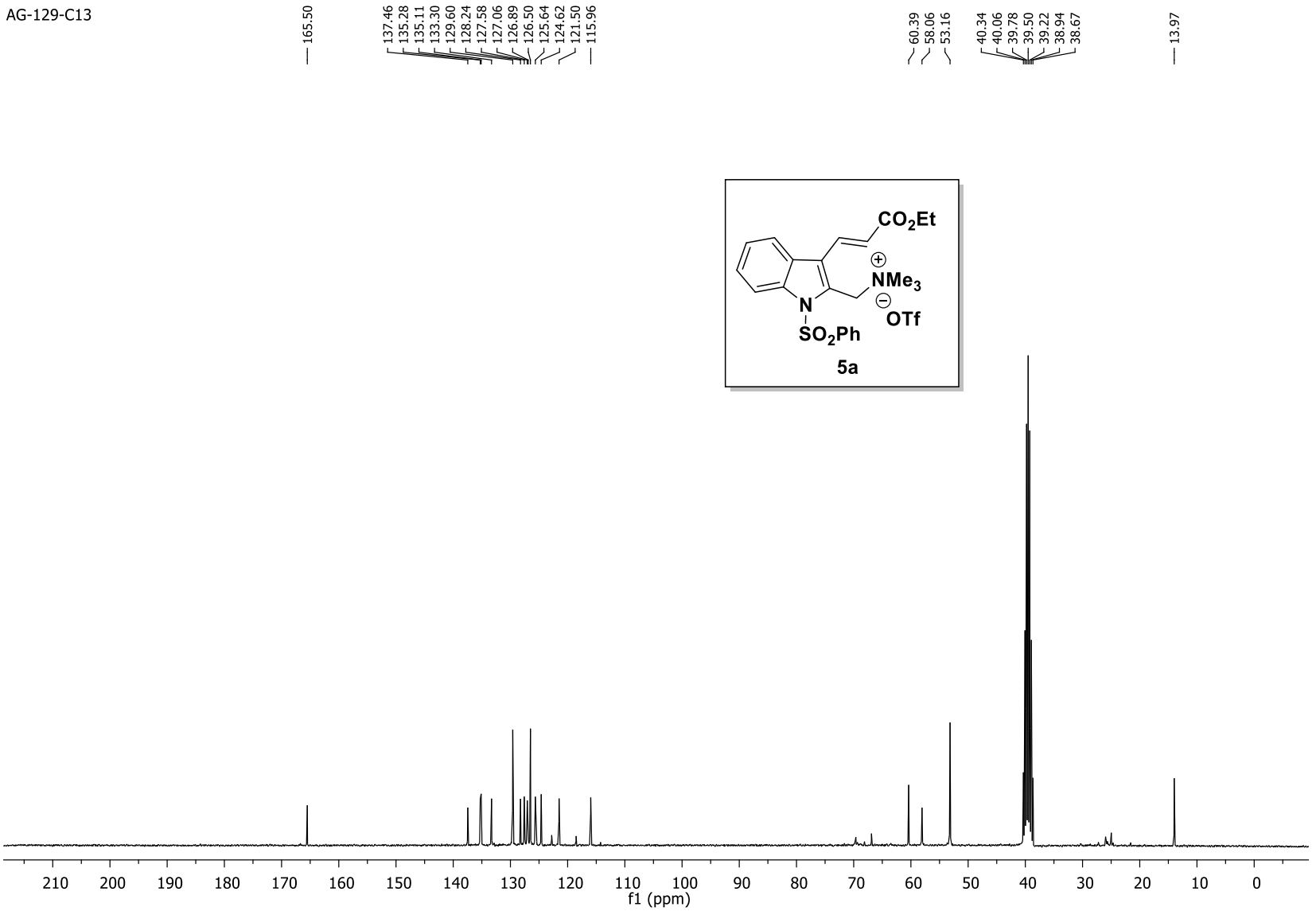


DEPT-135 NMR (75 MHz, $CDCl_3$) spectrum of compound **4**

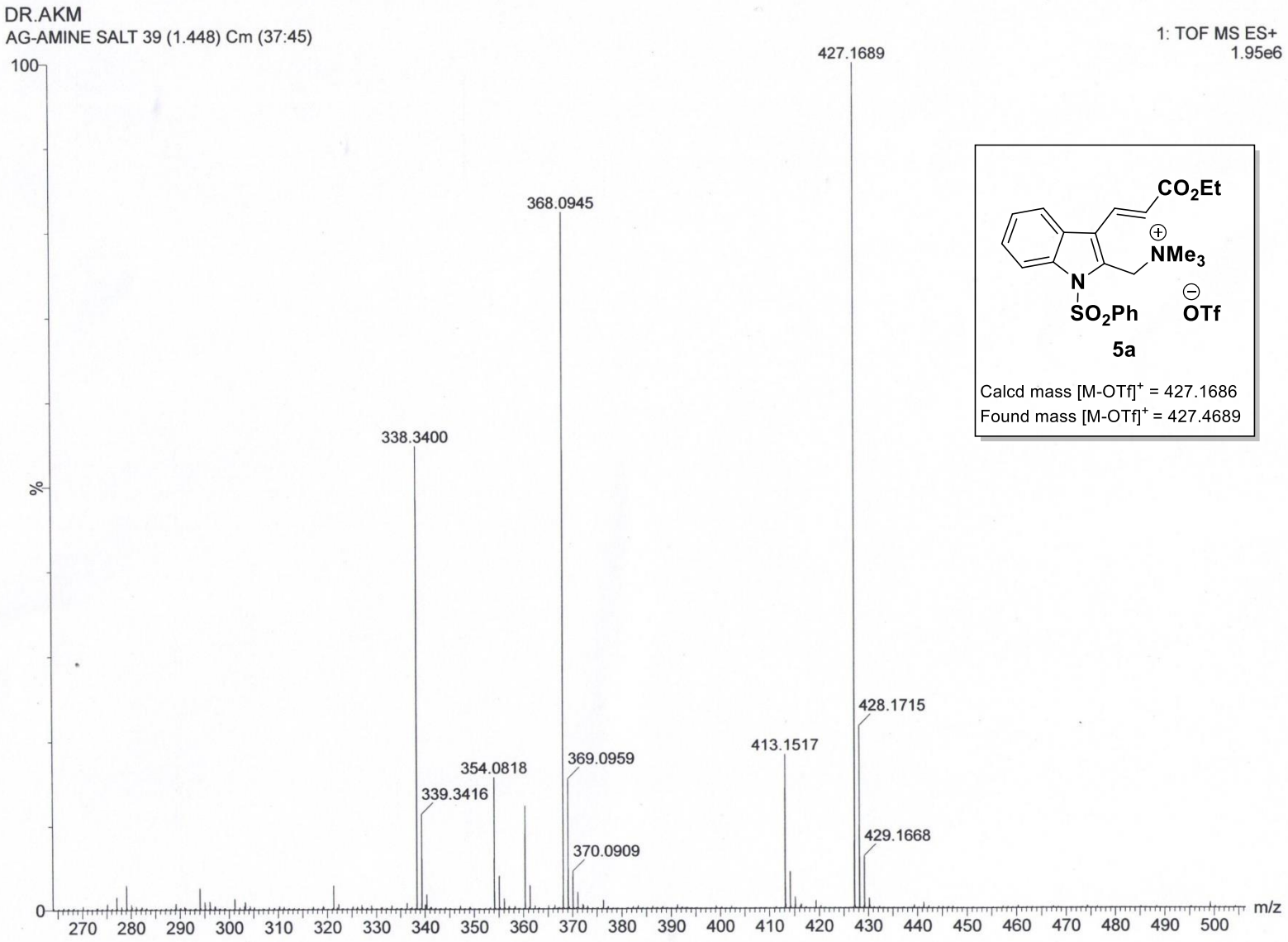


^{1}H NMR (300 MHz, DMSO-d_6) spectrum of compound **5a**

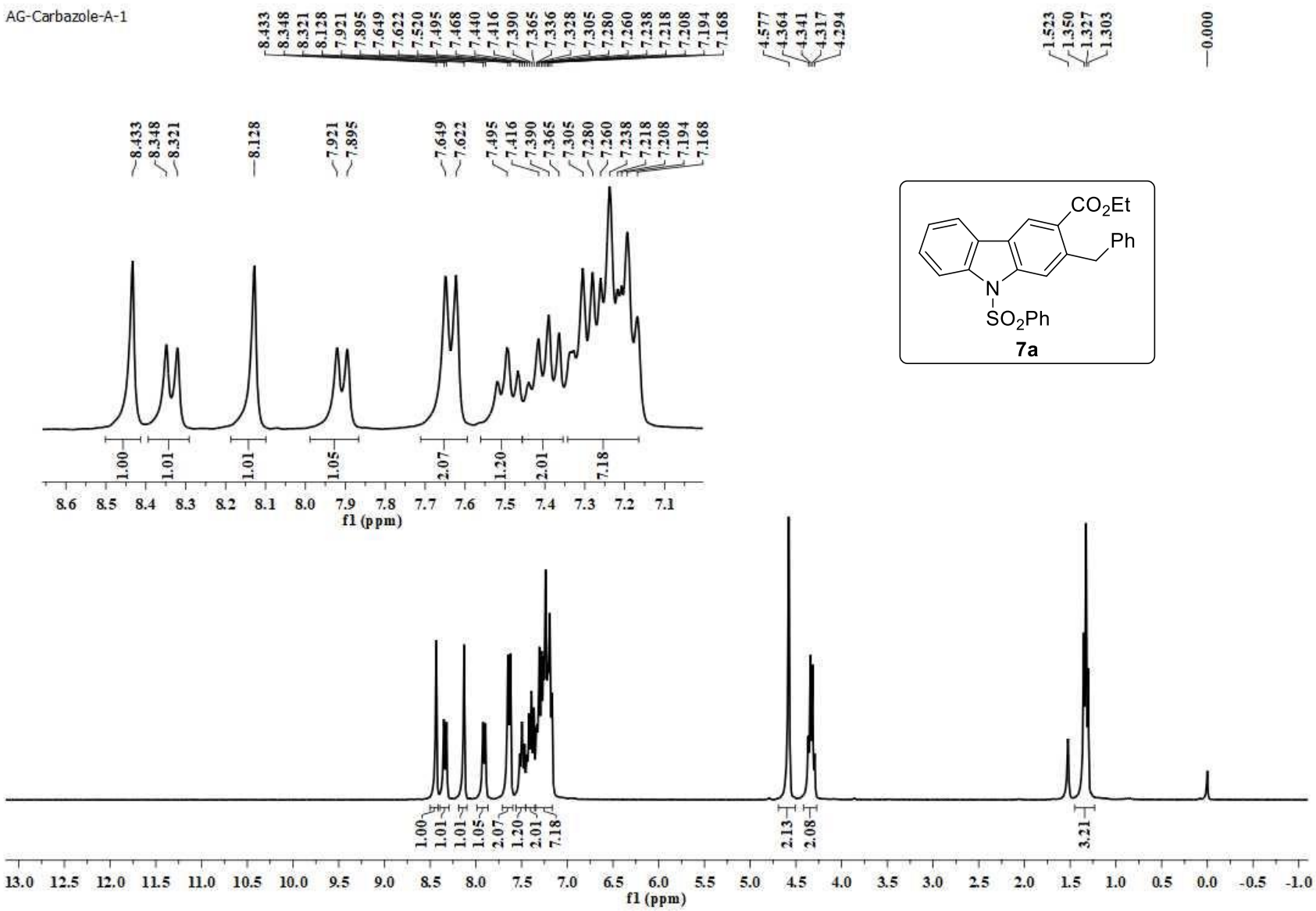
AG-129-C13



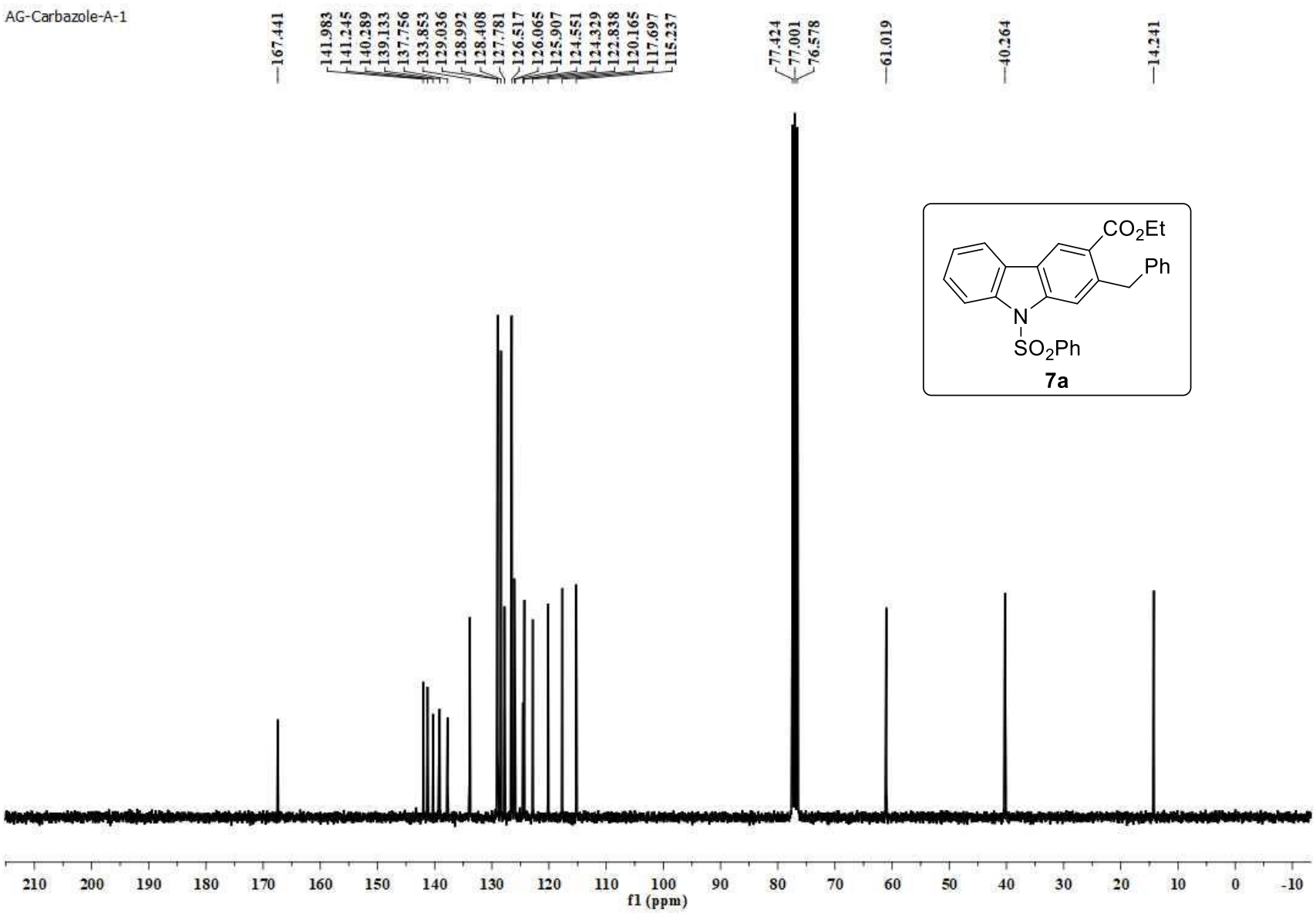
^{13}C {^{1}H} NMR (75 MHz, DMSO-d_6) spectrum of compound **5a**



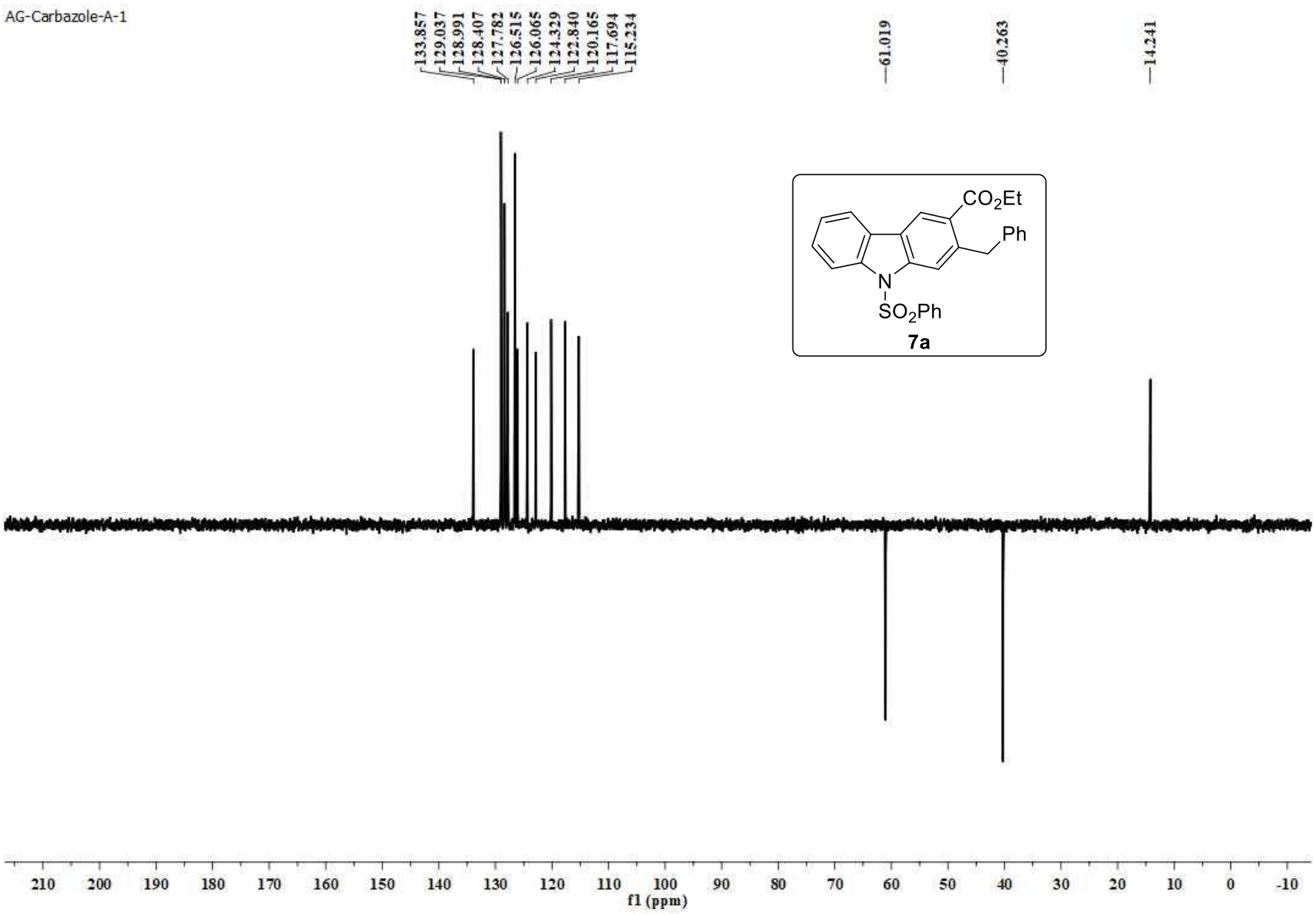
HRMS Spectrum of compound **5a**



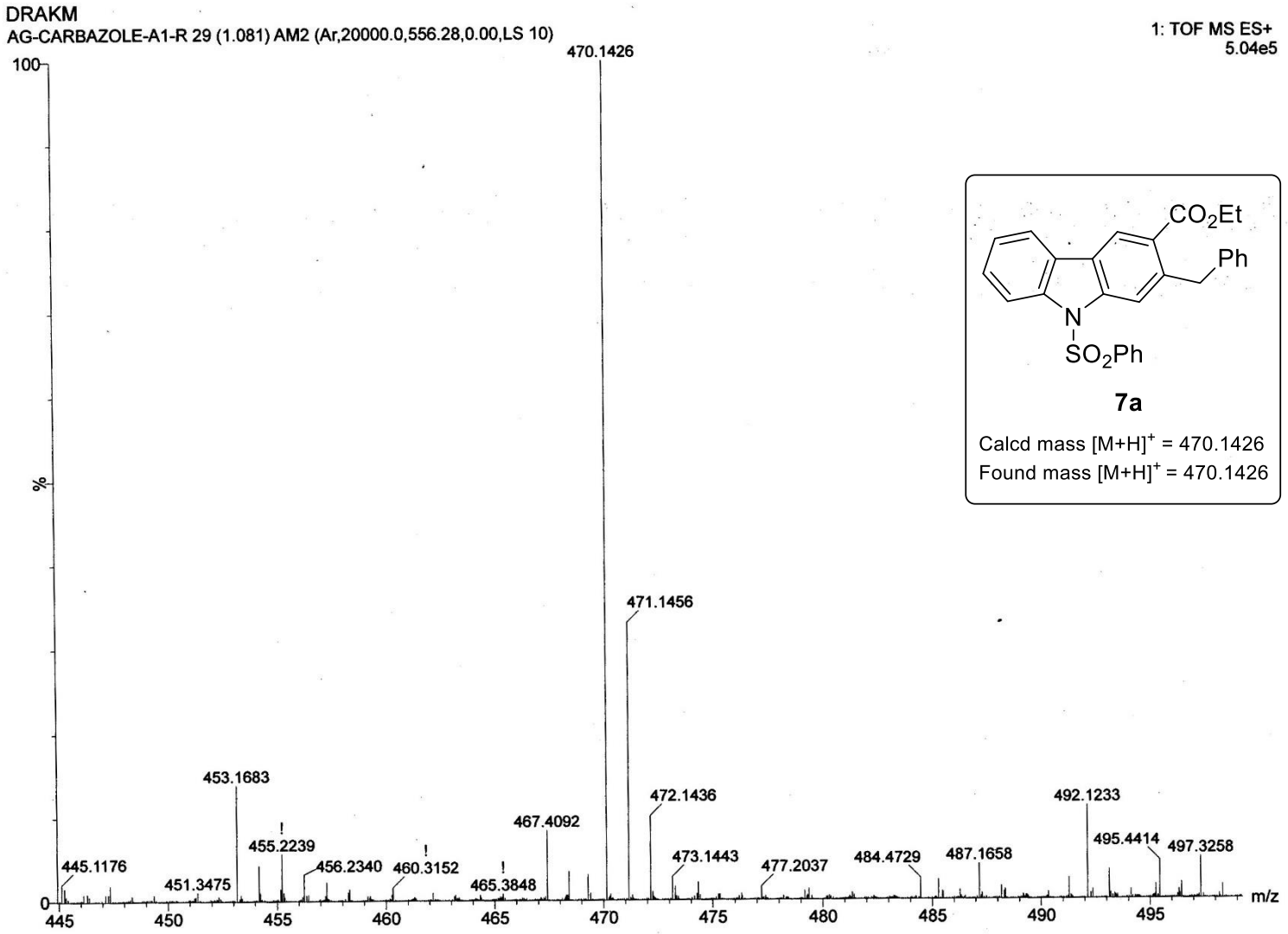
^{1}H NMR (300 MHz, $CDCl_3$) spectrum of compound **7a**



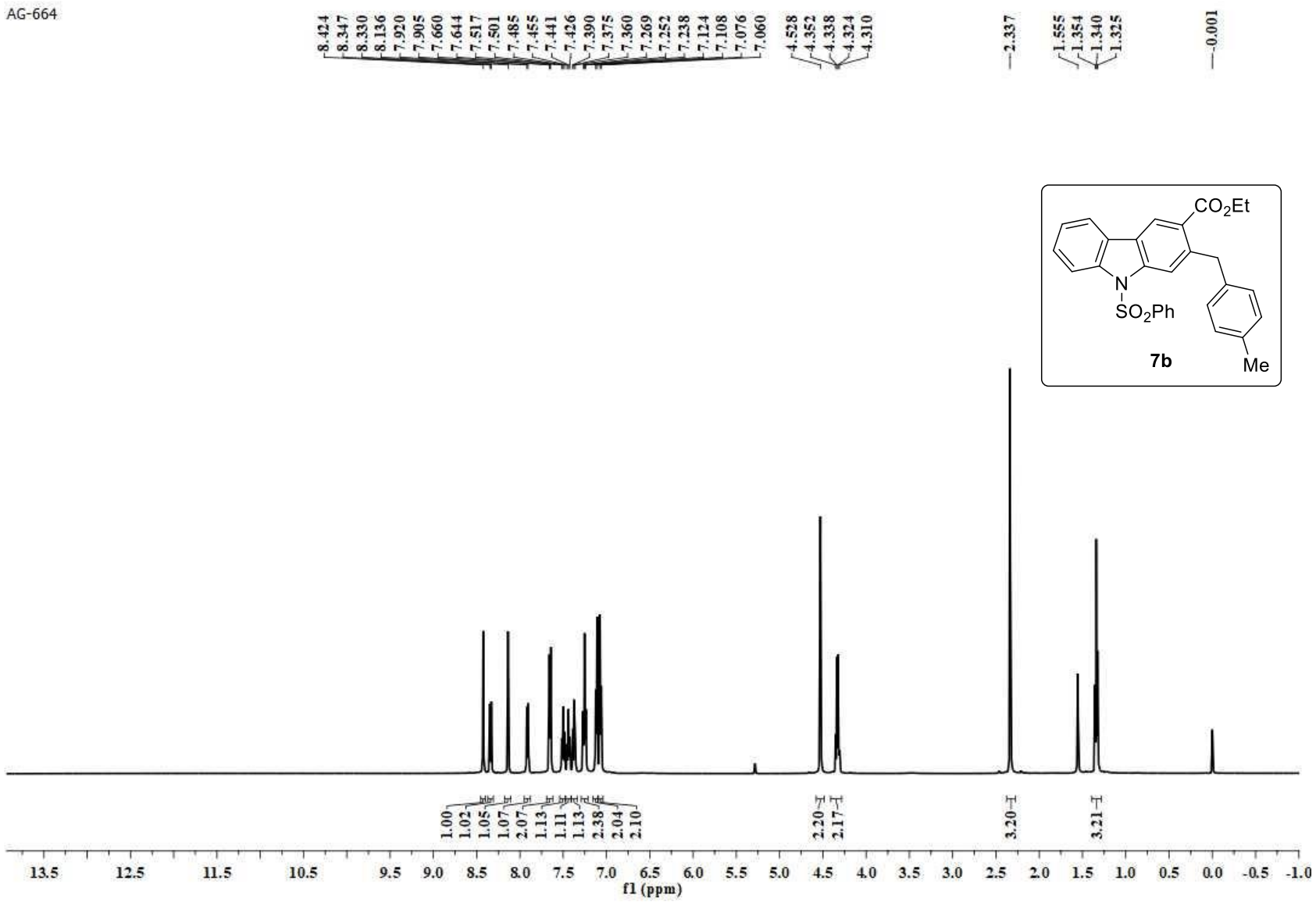
^{13}C {^{1}H} NMR (75 MHz, $CDCl_3$) spectrum of compound **7a**



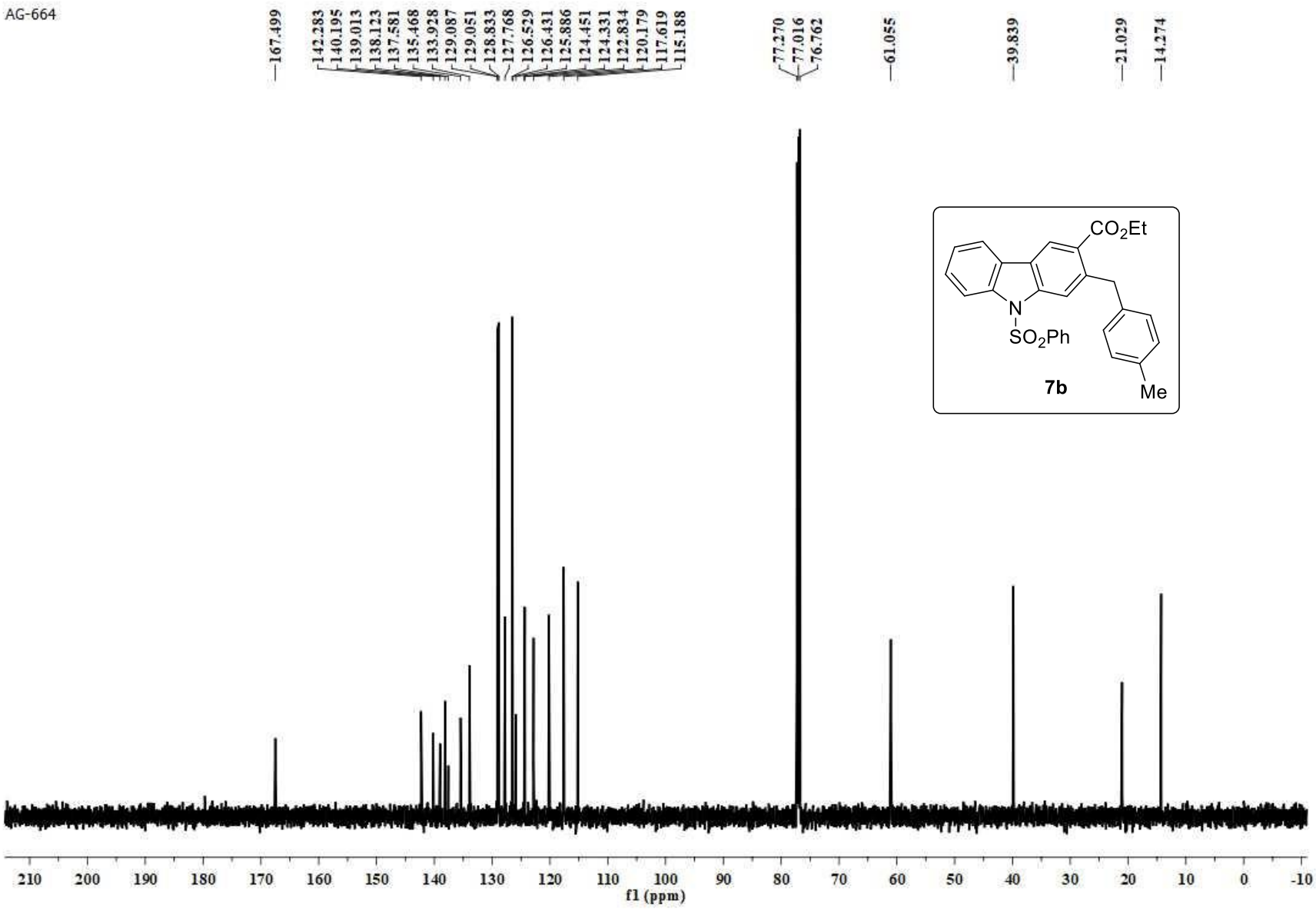
DEPT-135 NMR (75 MHz, $CDCl_3$) spectrum of compound **7a**



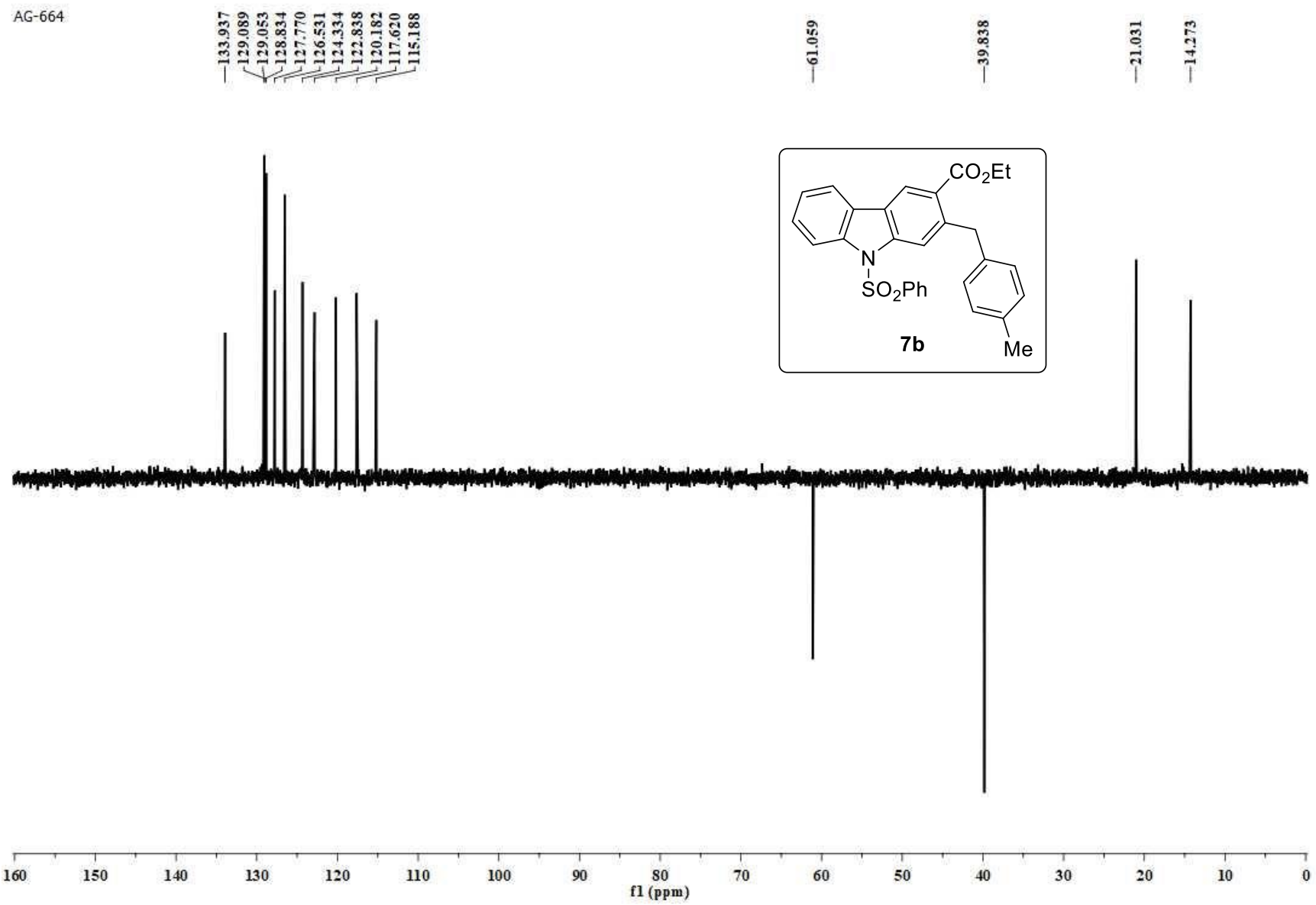
HRMS Spectrum of compound **7a**



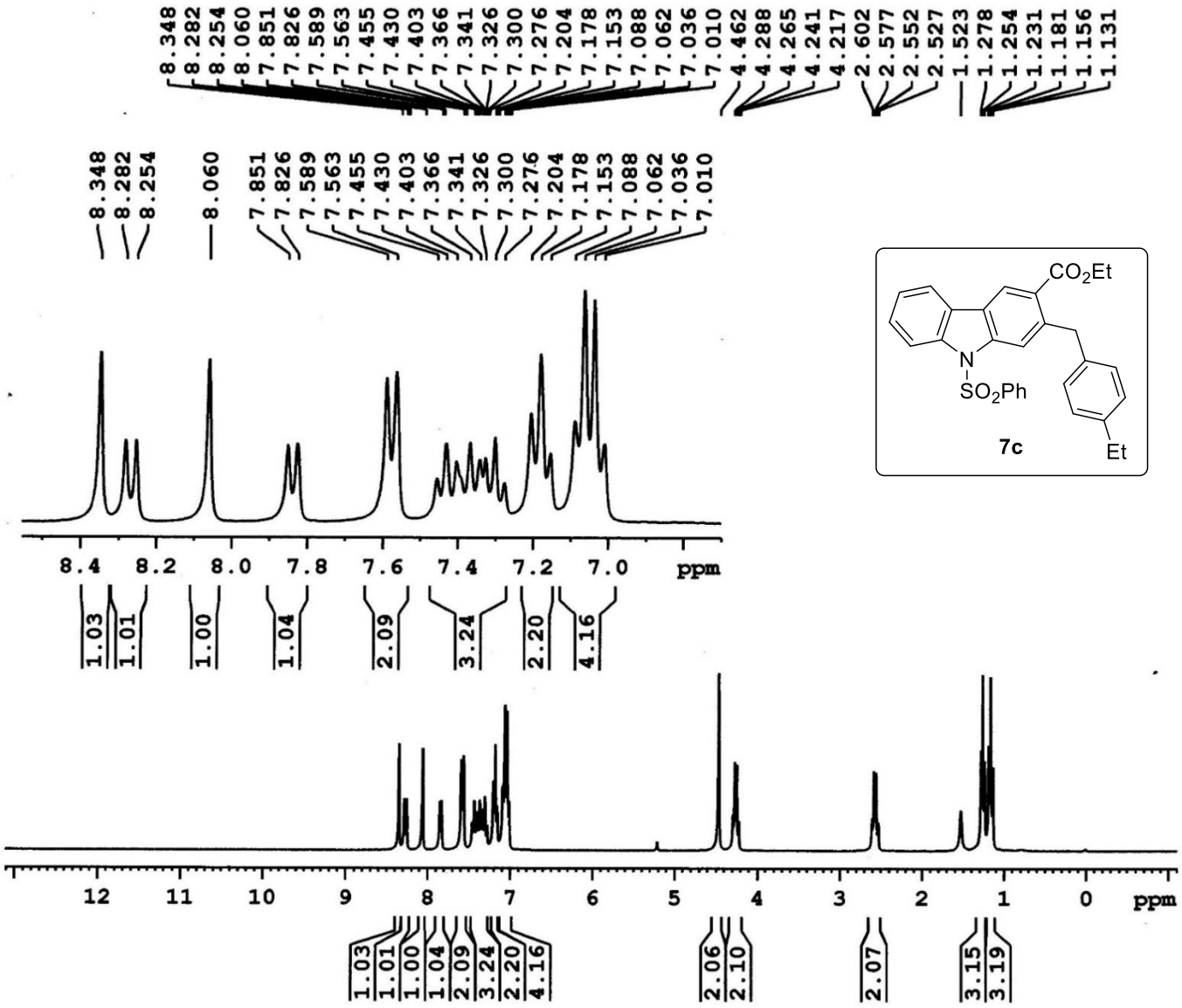
^{1}H NMR (500 MHz, $CDCl_3$) spectrum of compound **7b**



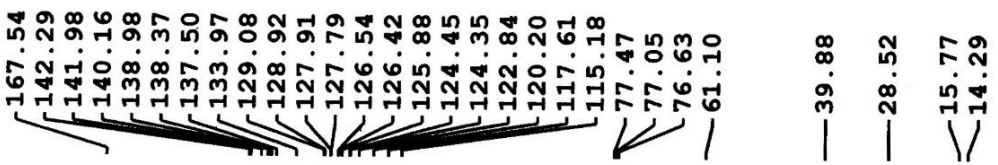
^{13}C {^{1}H} NMR (125 MHz, $CDCl_3$) spectrum of compound **7b**

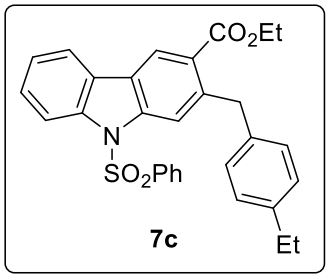


DEPT-135 NMR (125 MHz, $CDCl_3$) spectrum of compound **7b**

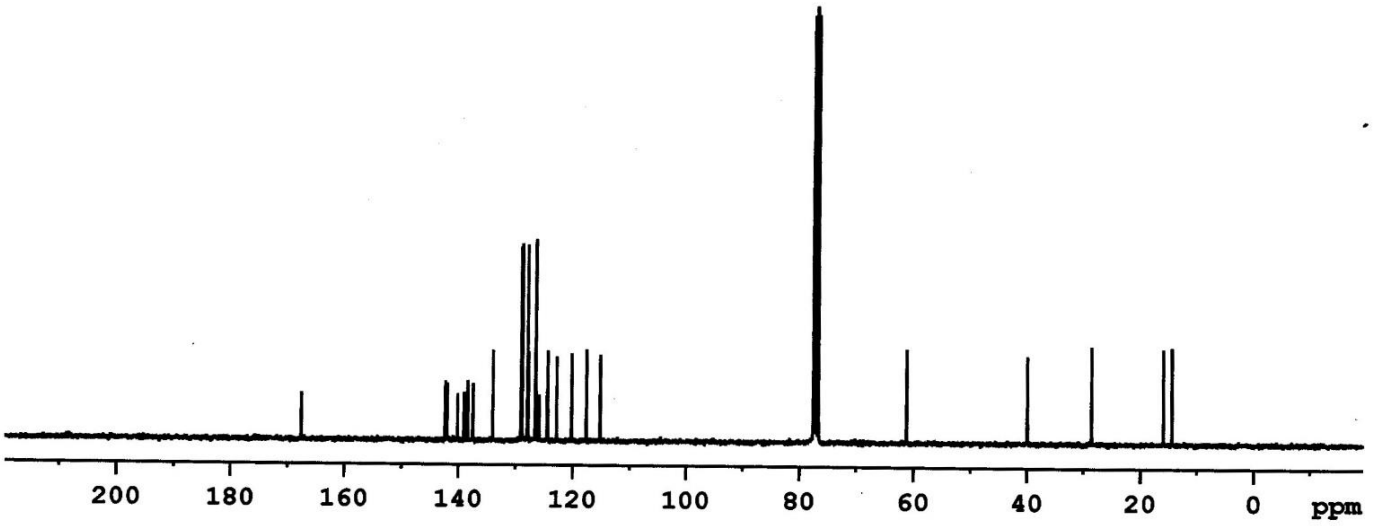


^{1}H NMR (300 MHz, $CDCl_3$) spectrum of compound **7c**

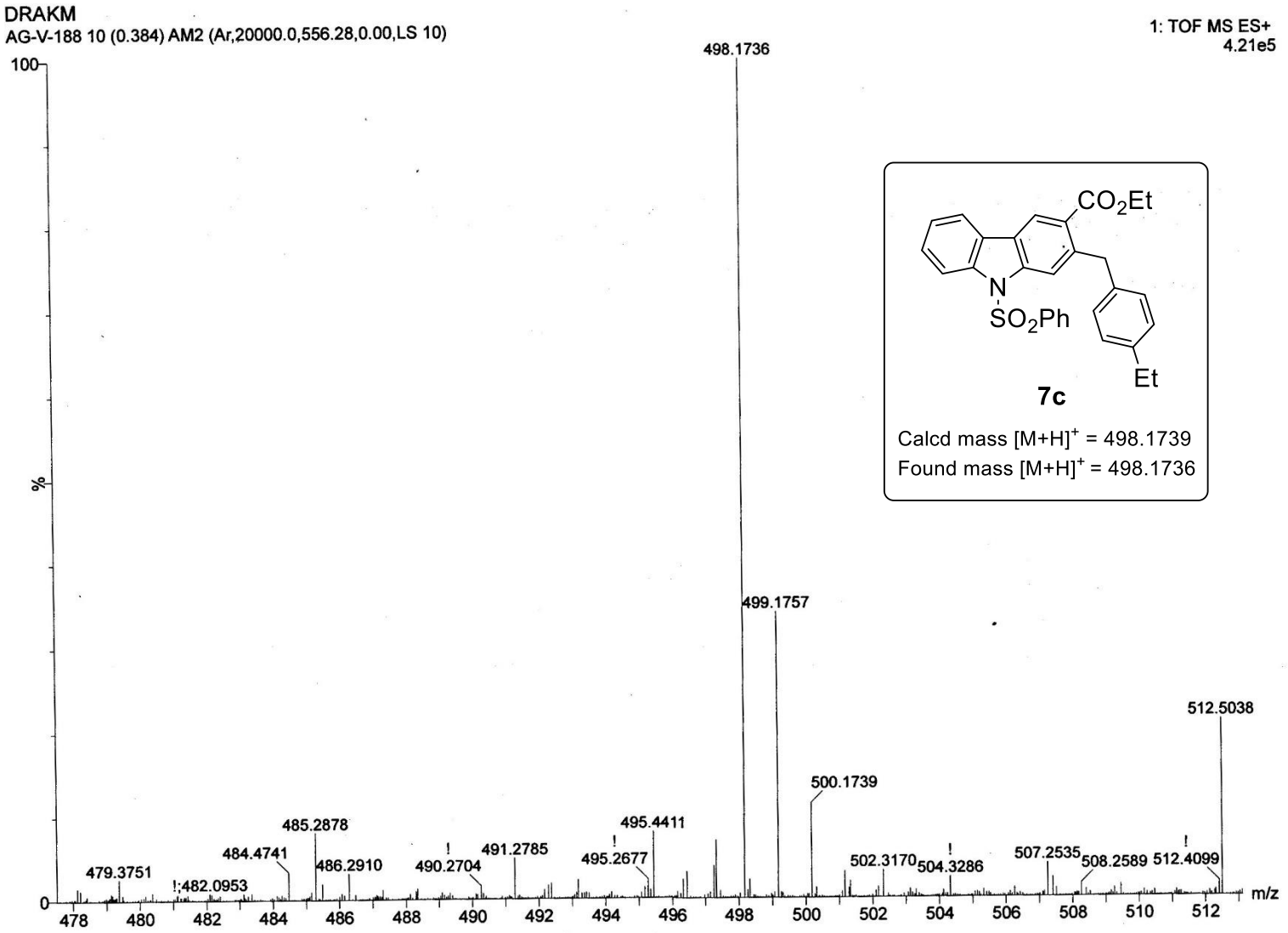




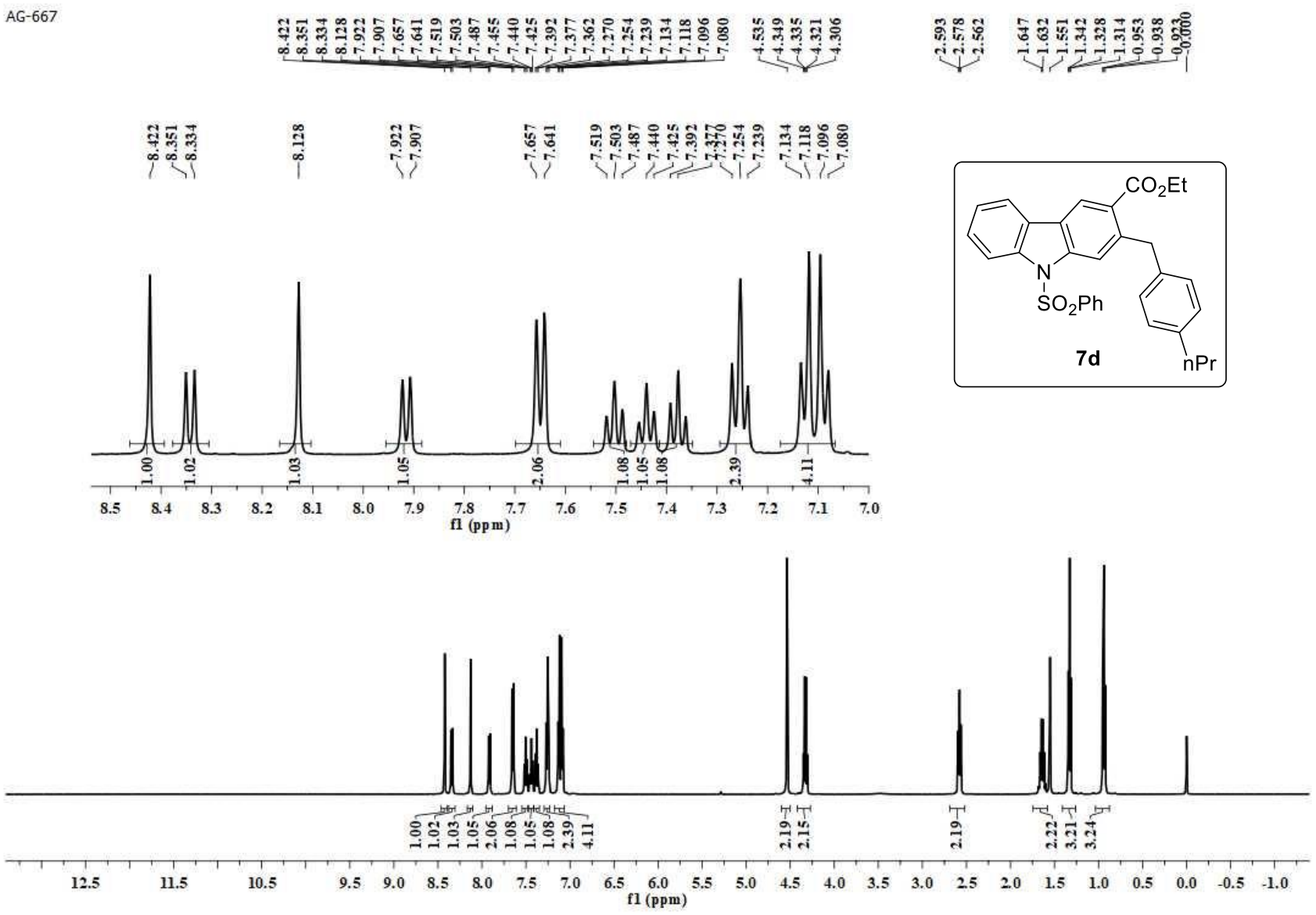
7c



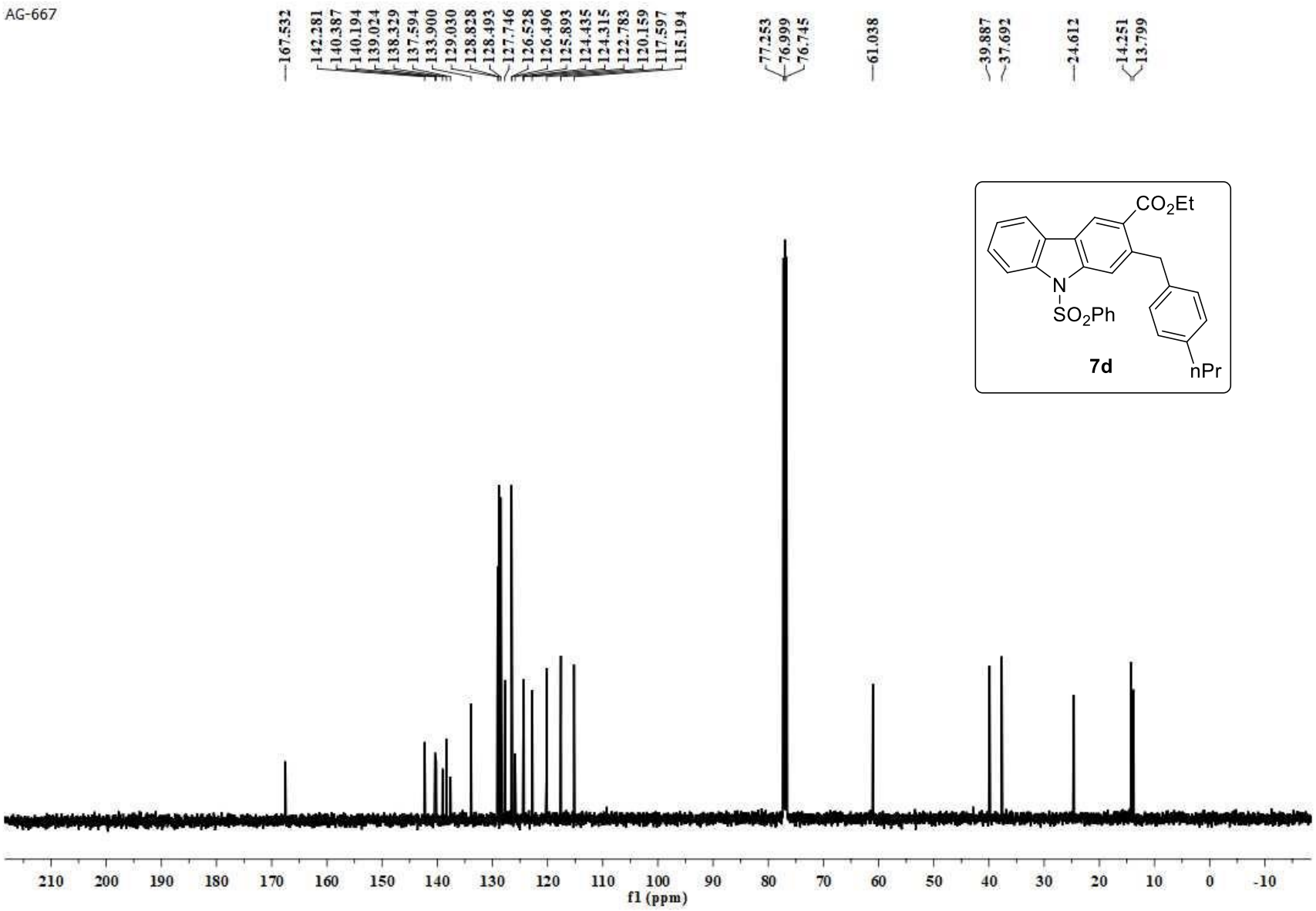
^{13}C {^{1}H} NMR (75 MHz, $CDCl_3$) spectrum of compound **7c**



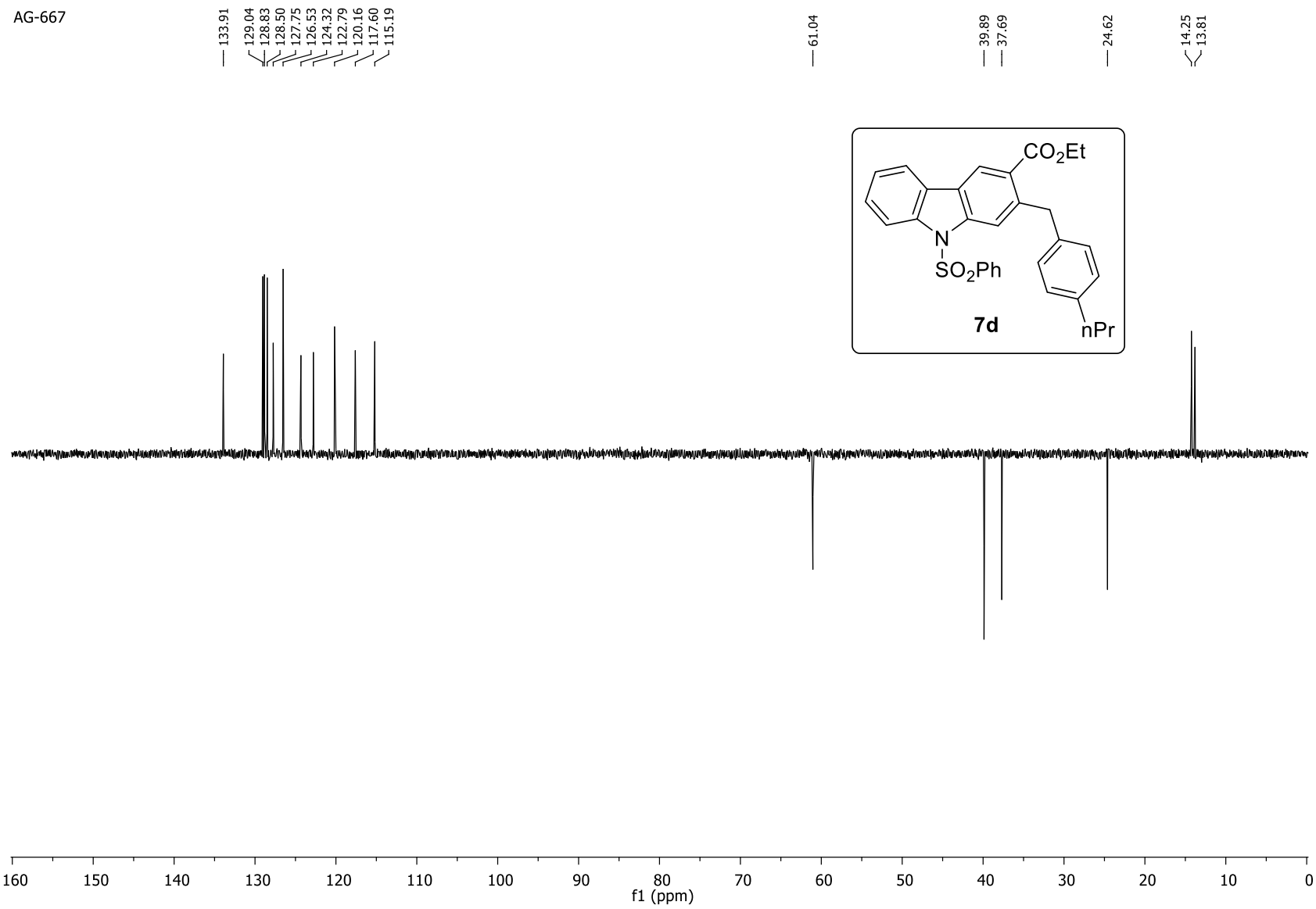
HRMS Spectrum of compound **7c**



^{1}H NMR (500 MHz, $CDCl_3$) spectrum of compound **7d**

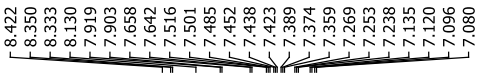


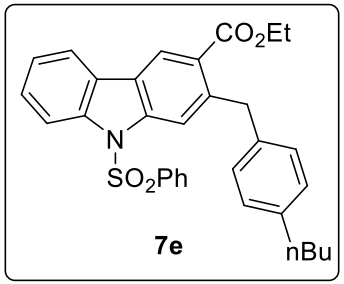
^{13}C {^{1}H} NMR (125 MHz, $CDCl_3$) spectrum of compound **7d**

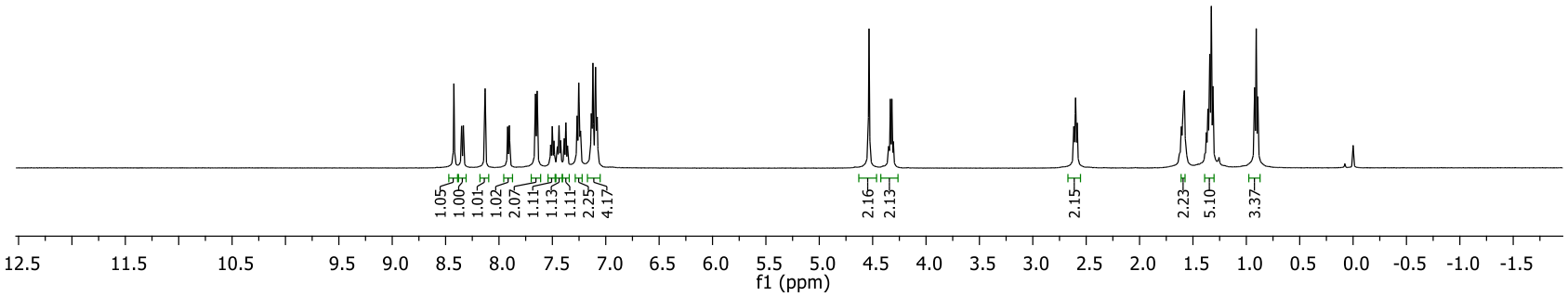


DEPT-135 NMR (125 MHz, $CDCl_3$) spectrum of compound **7d**

AG-821







^{1}H NMR (500 MHz, $CDCl_3$) spectrum of compound **7e**

AG-821

167.55
142.30
140.61
140.17
138.99
138.29
137.52
133.95
129.06
128.85
128.47
127.78
126.53
126.45
125.88
124.44
124.34
122.82
120.19
117.60
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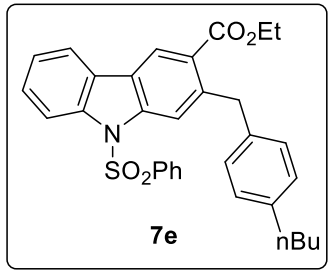
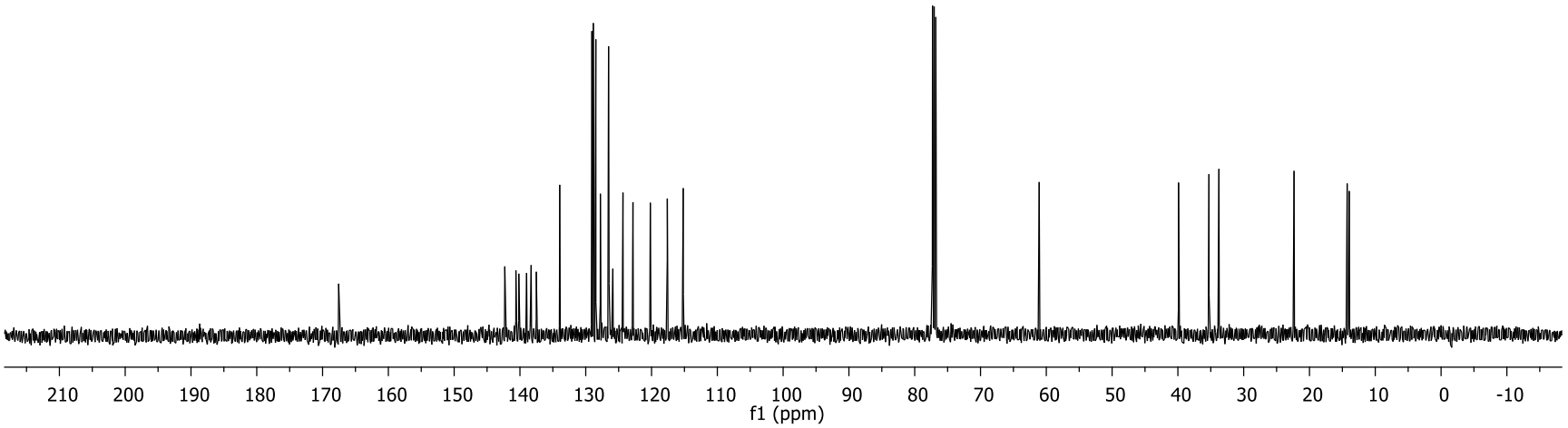
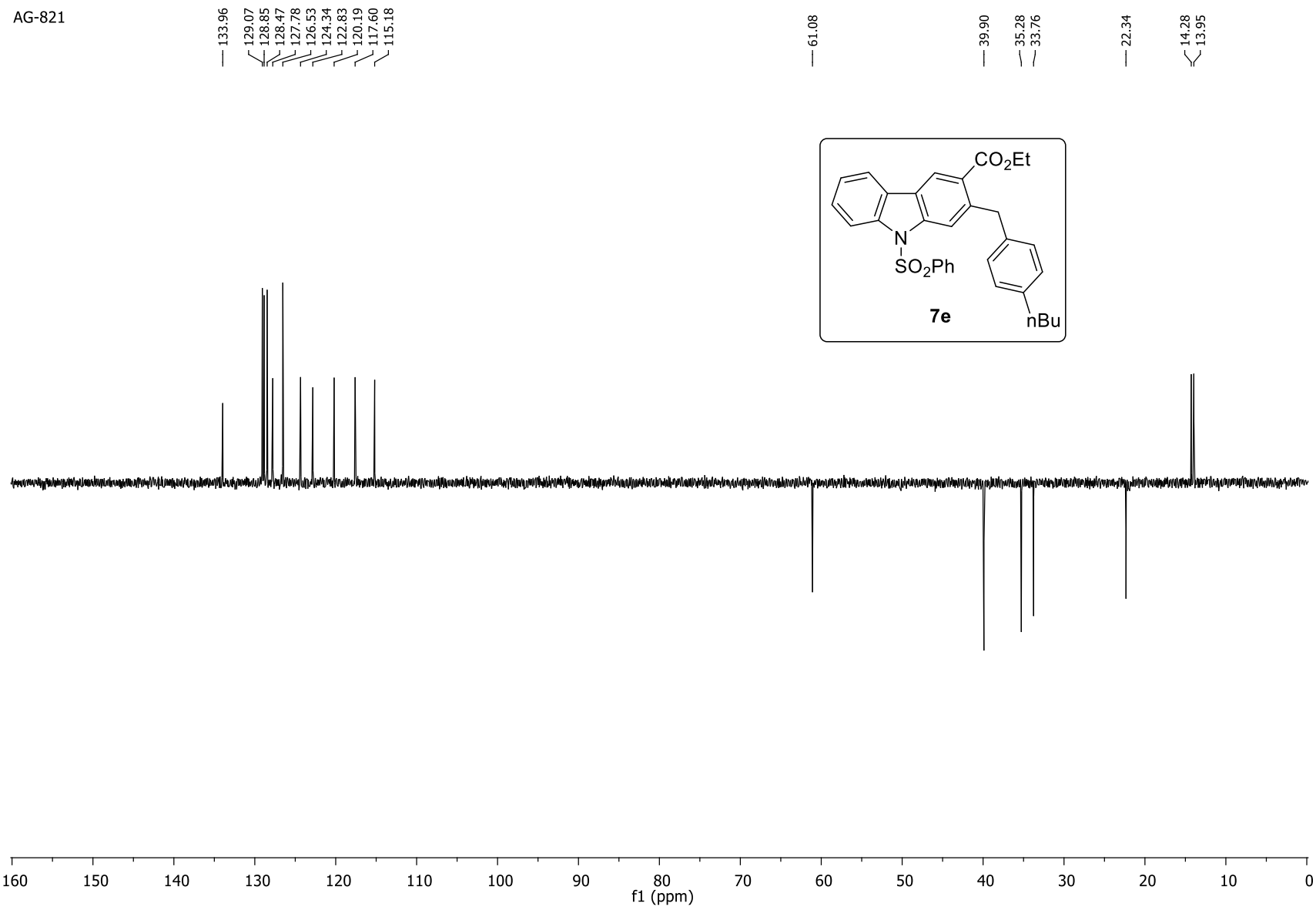
77.29
77.04
76.79
61.08
39.90
35.28
33.76
22.34
14.28
13.95

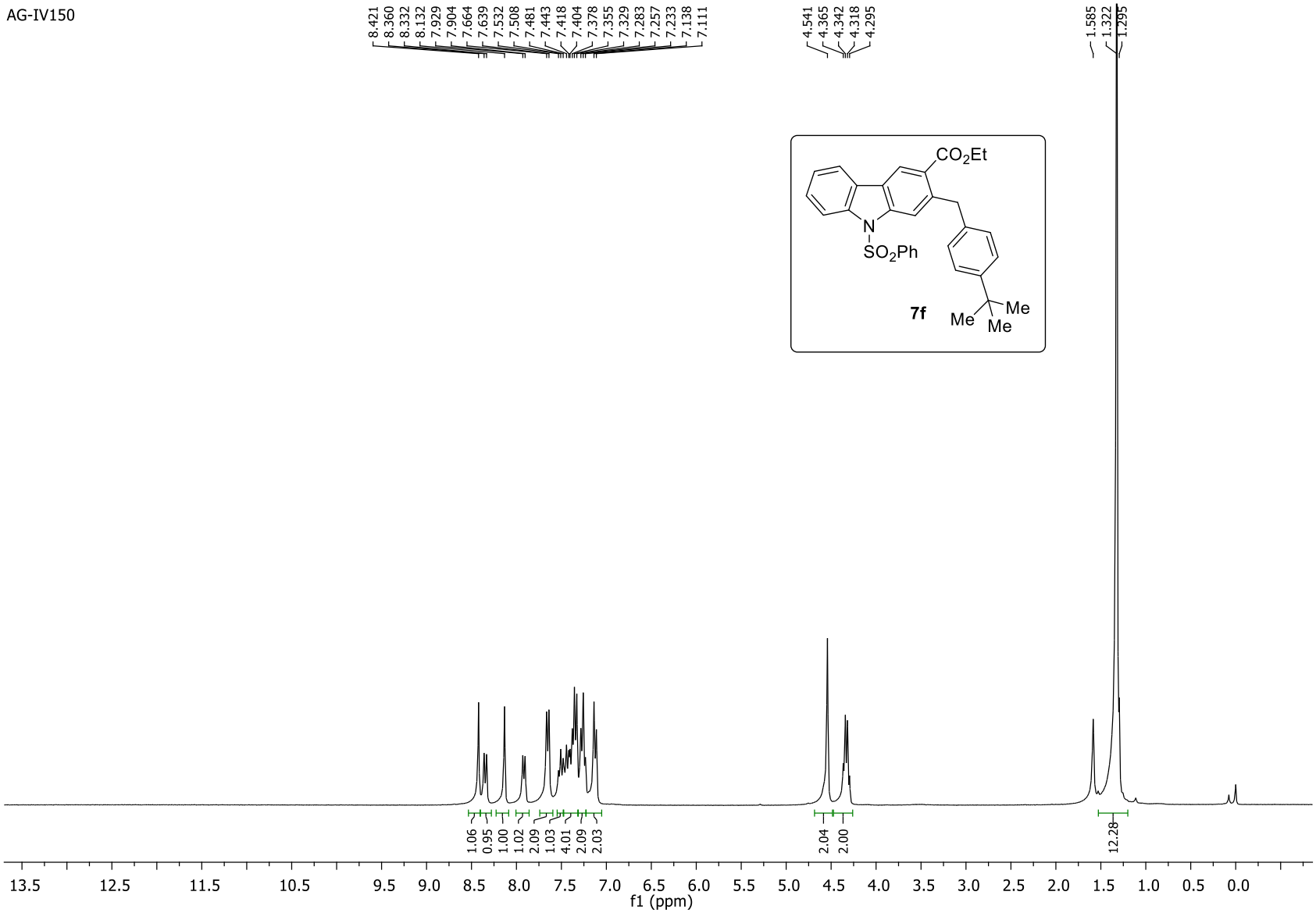




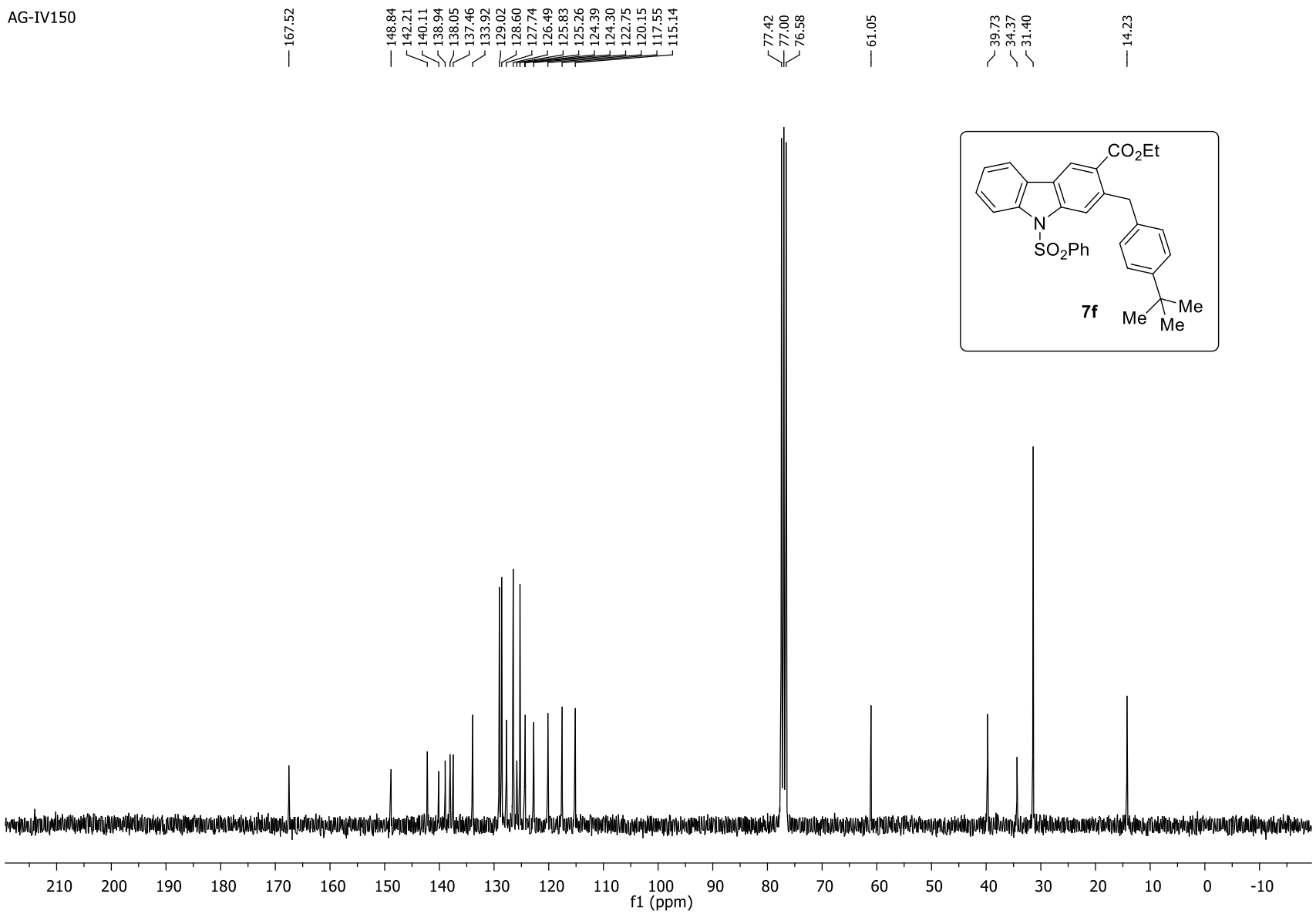
^{13}C {^{1}H} NMR (125 MHz, $CDCl_3$) spectrum of compound **7e**



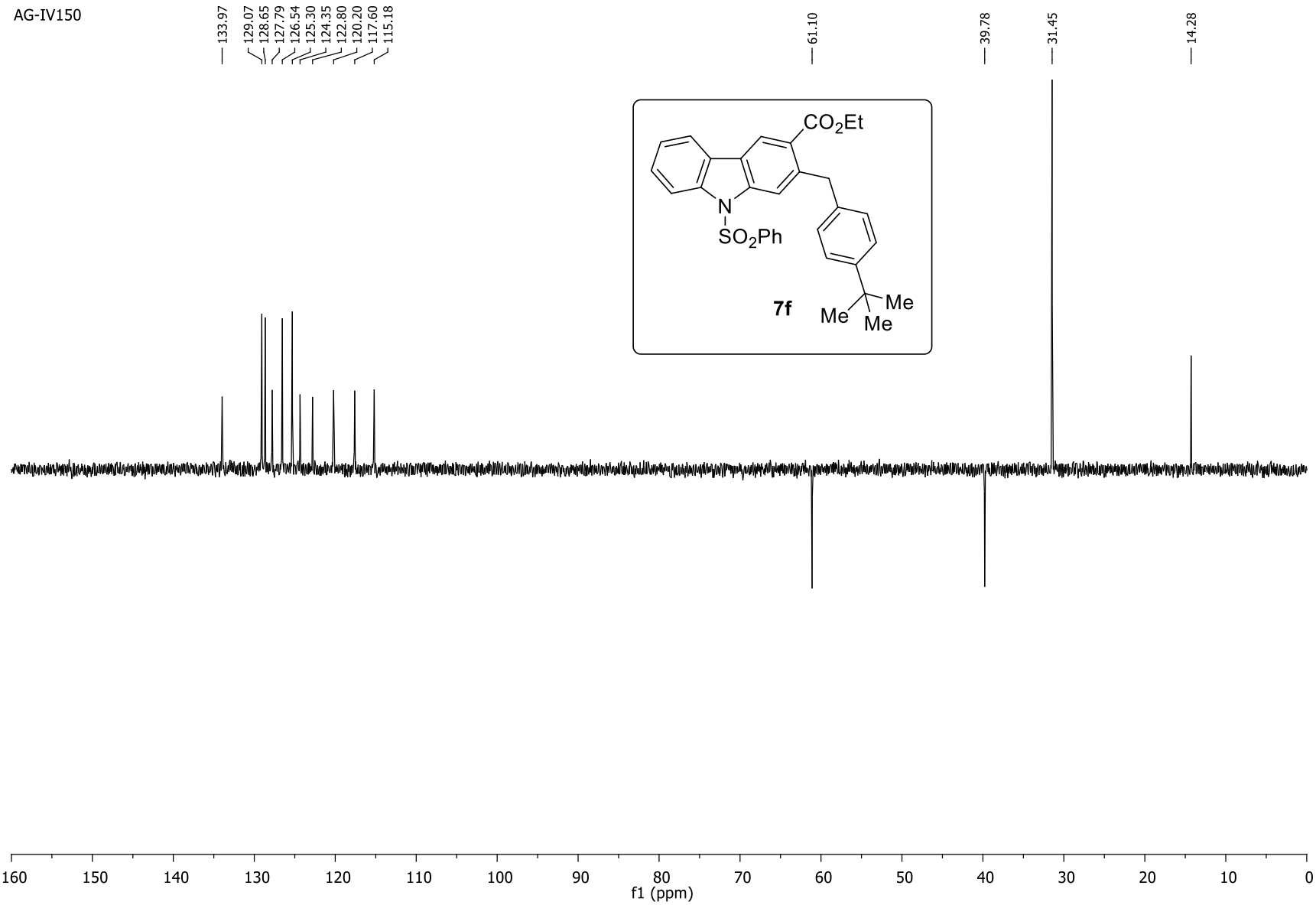
DEPT-135 NMR (125 MHz, $CDCl_3$) spectrum of compound **7e**



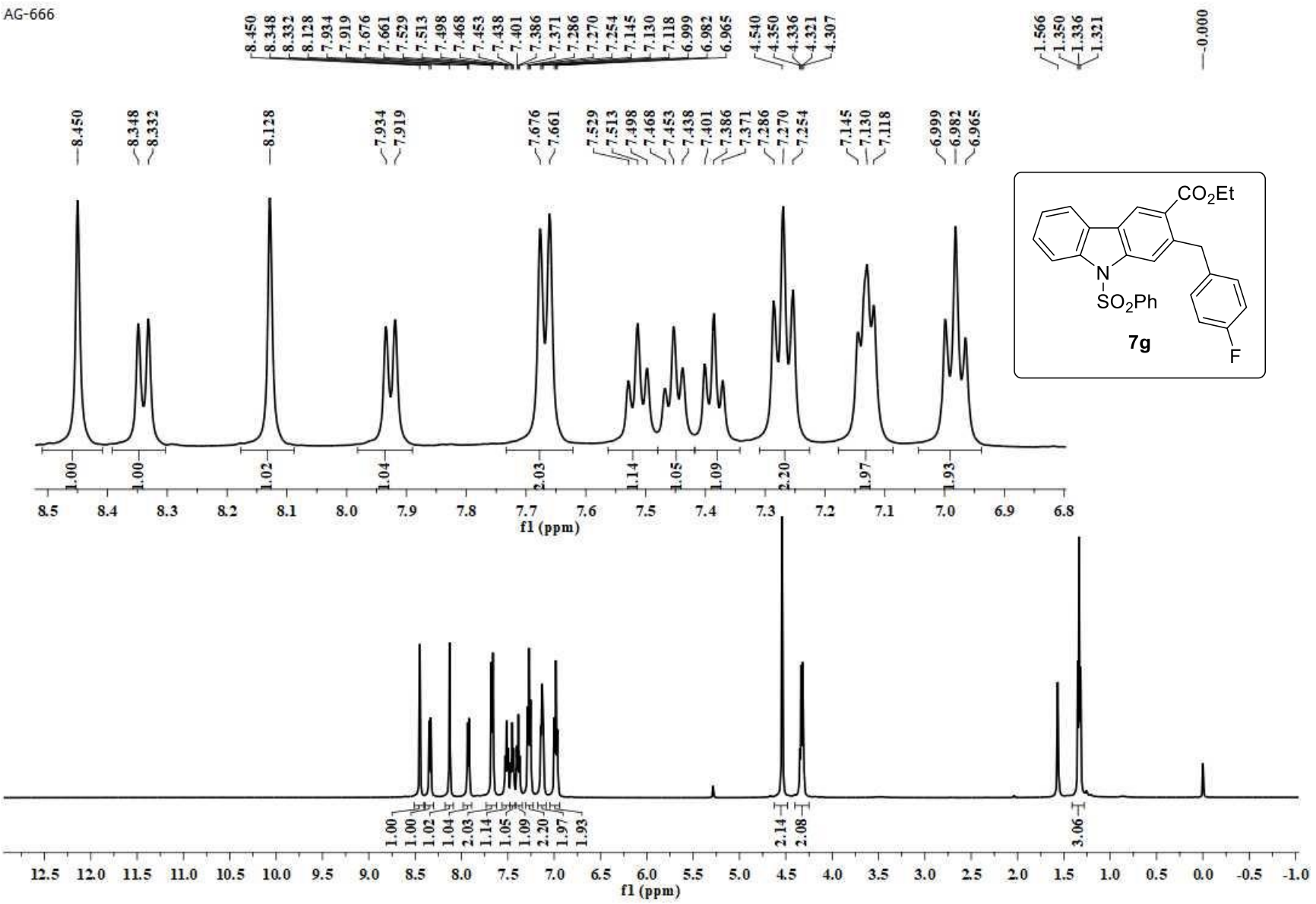
^{1}H NMR (300 MHz, $CDCl_3$) spectrum of compound **7f**



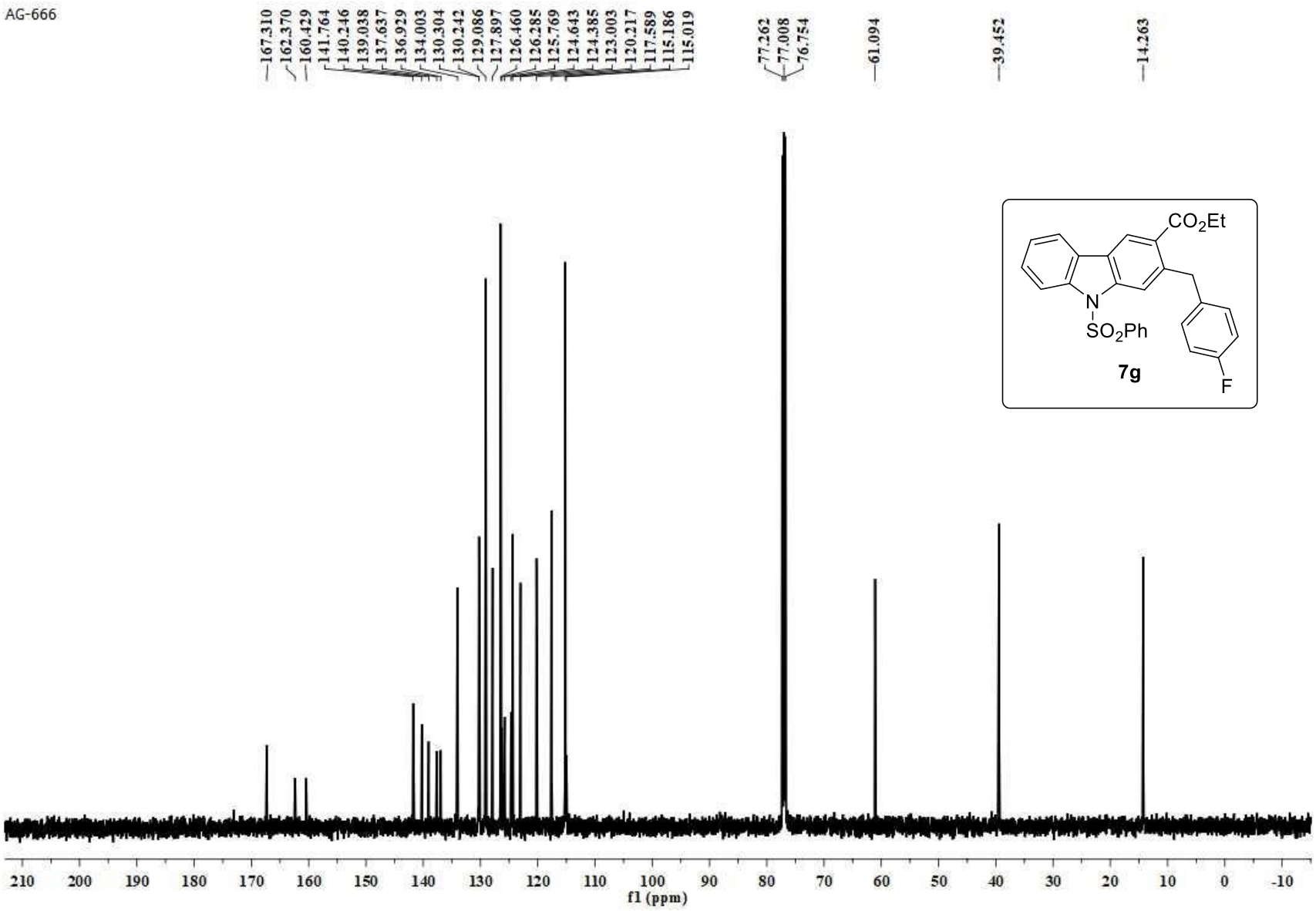
^{13}C {^{1}H} NMR (75 MHz, $CDCl_3$) spectrum of compound **7f**



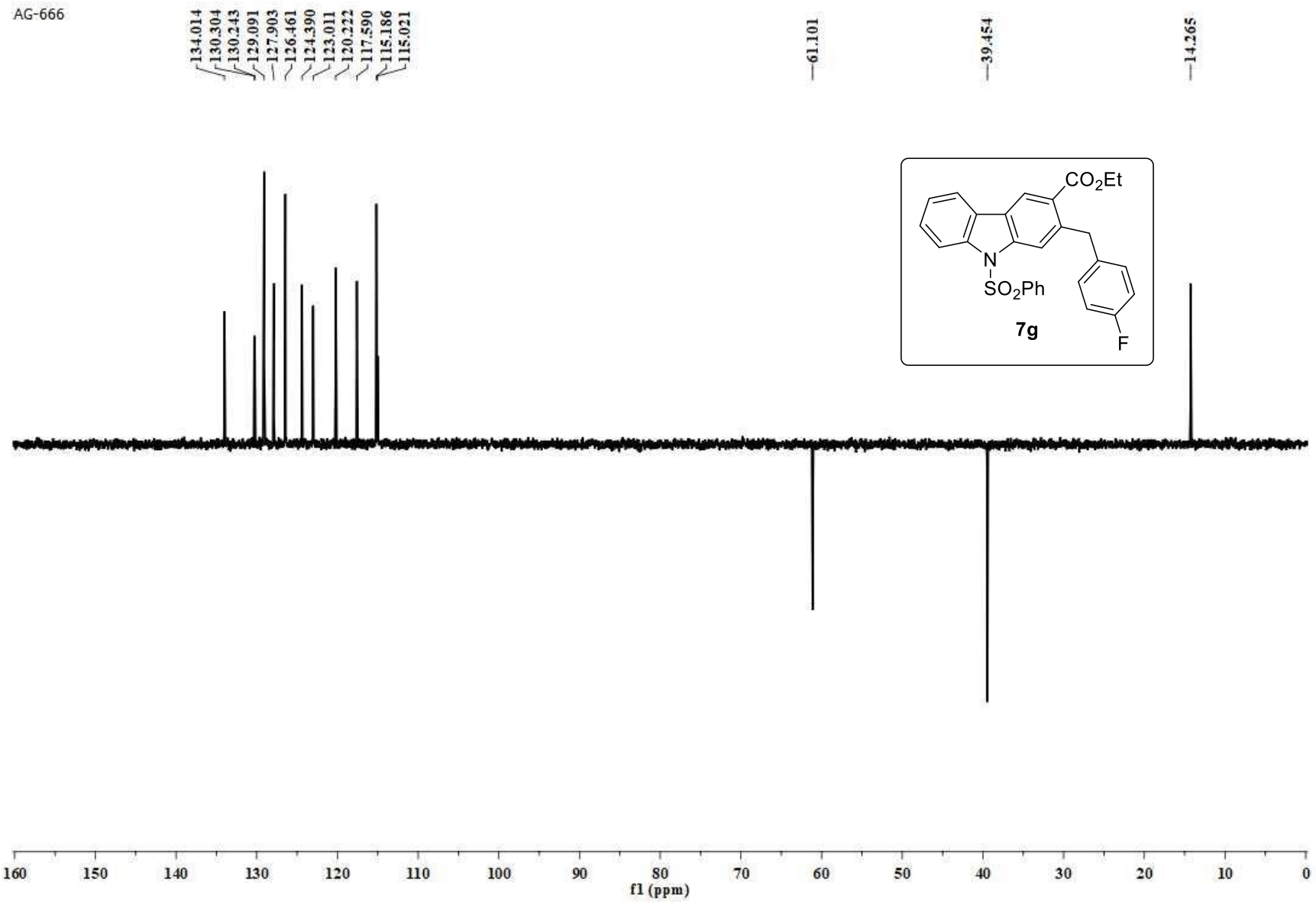
DEPT-135 NMR (75 MHz, $CDCl_3$) spectrum of compound **7f**



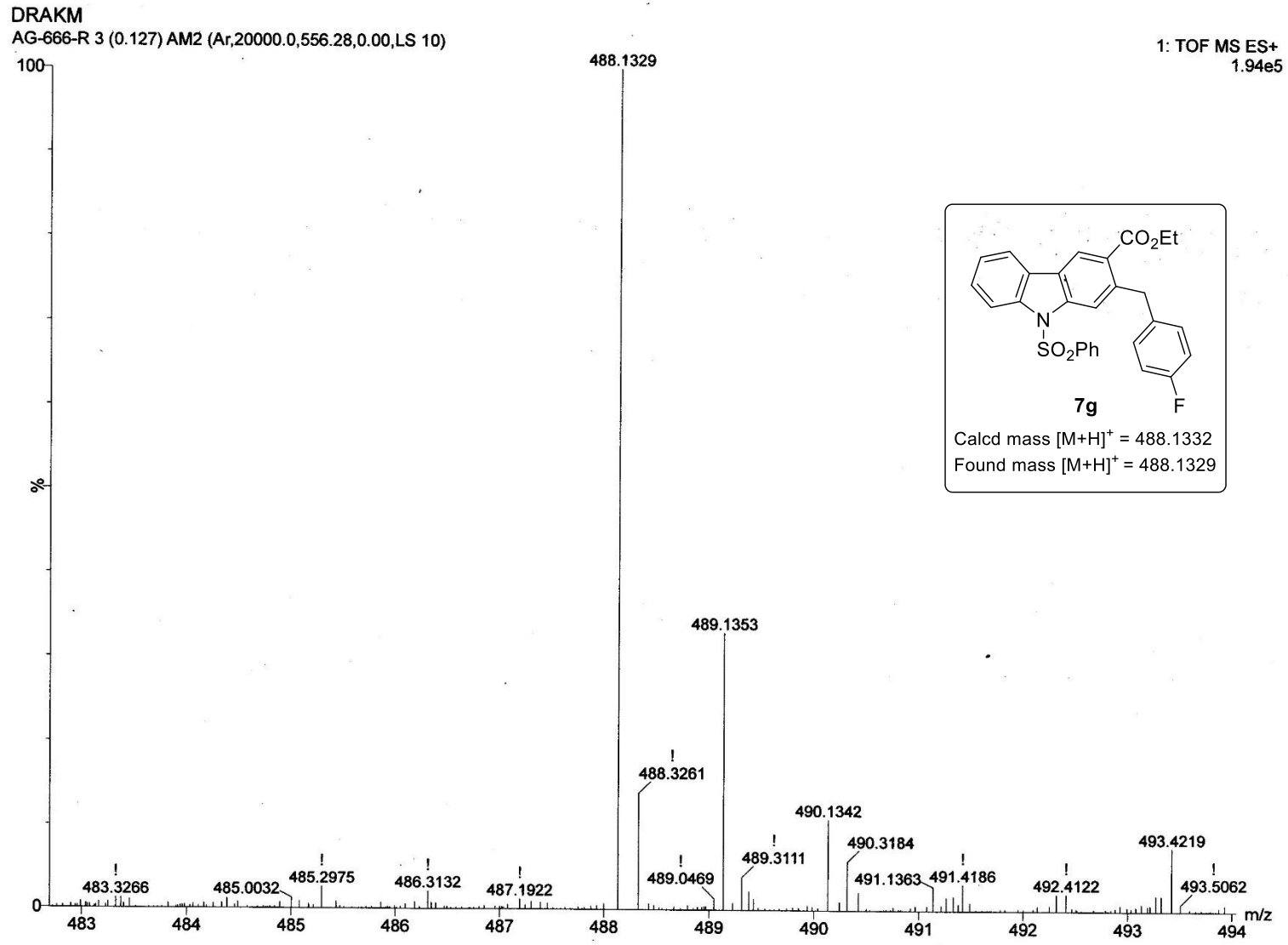
^{1}H NMR (500 MHz, $CDCl_3$) spectrum of compound **7g**



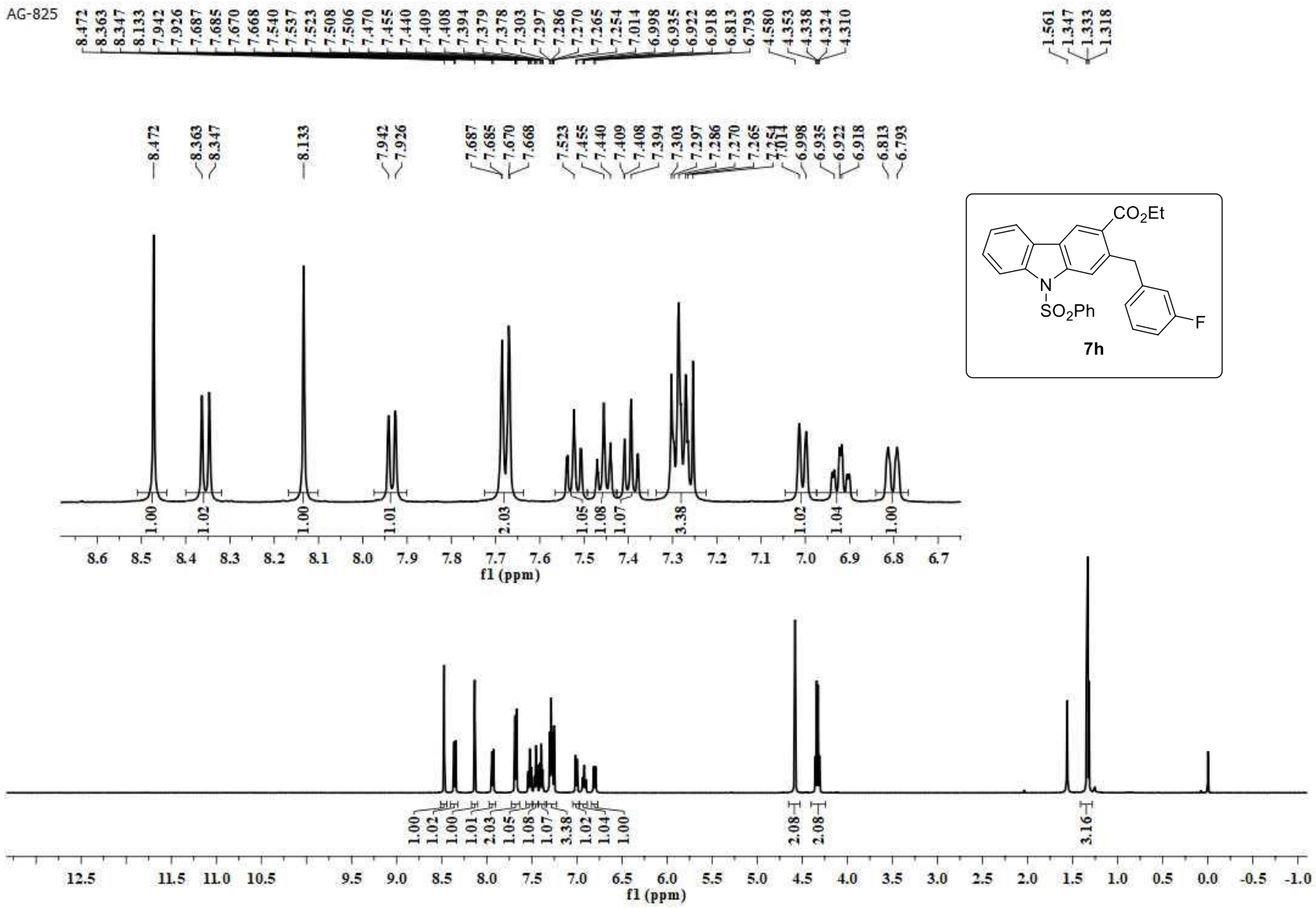
^{13}C {^{1}H} NMR (125 MHz, $CDCl_3$) spectrum of compound **7g**



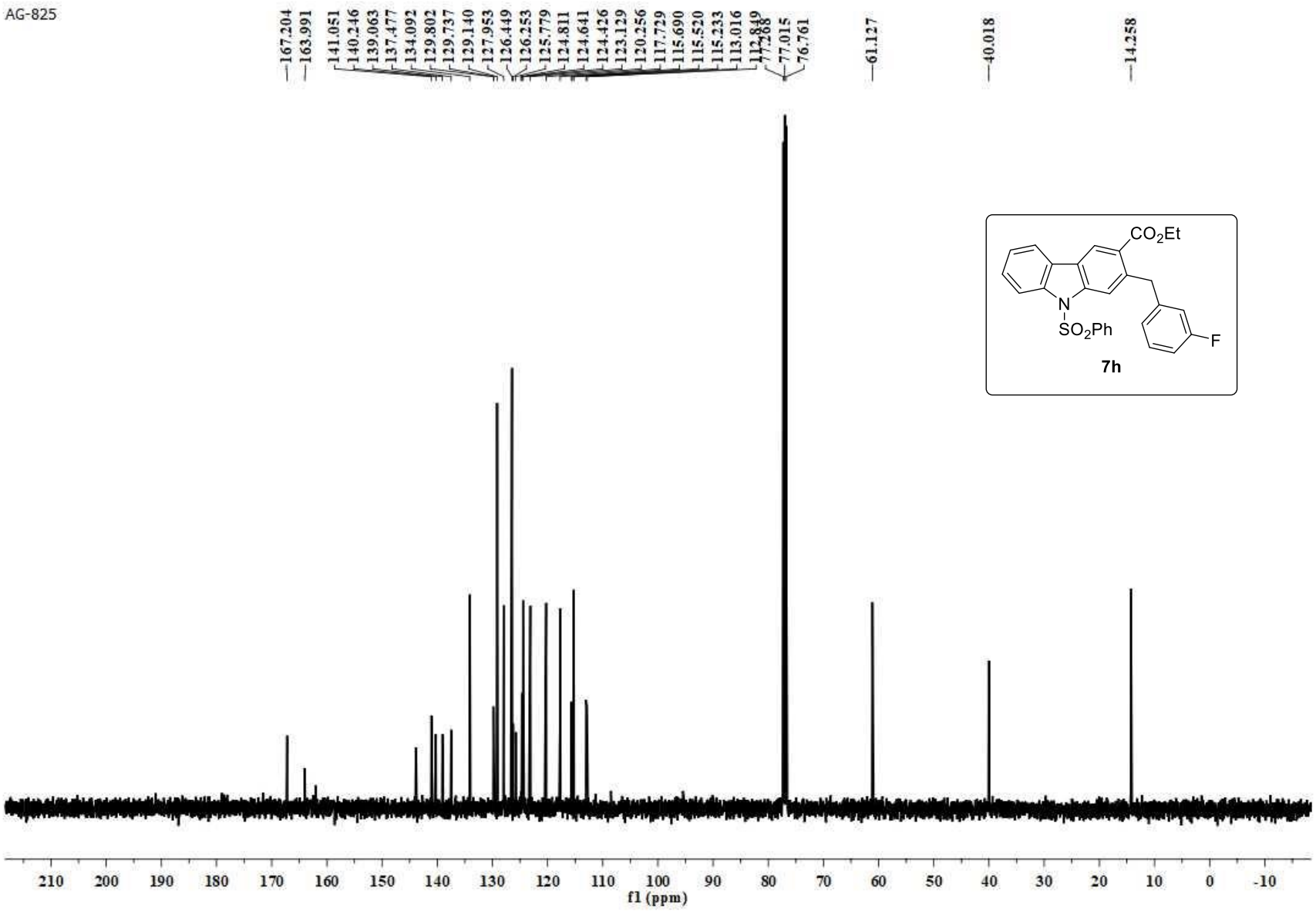
DEPT-135 NMR (125 MHz, $CDCl_3$) spectrum of compound **7g**



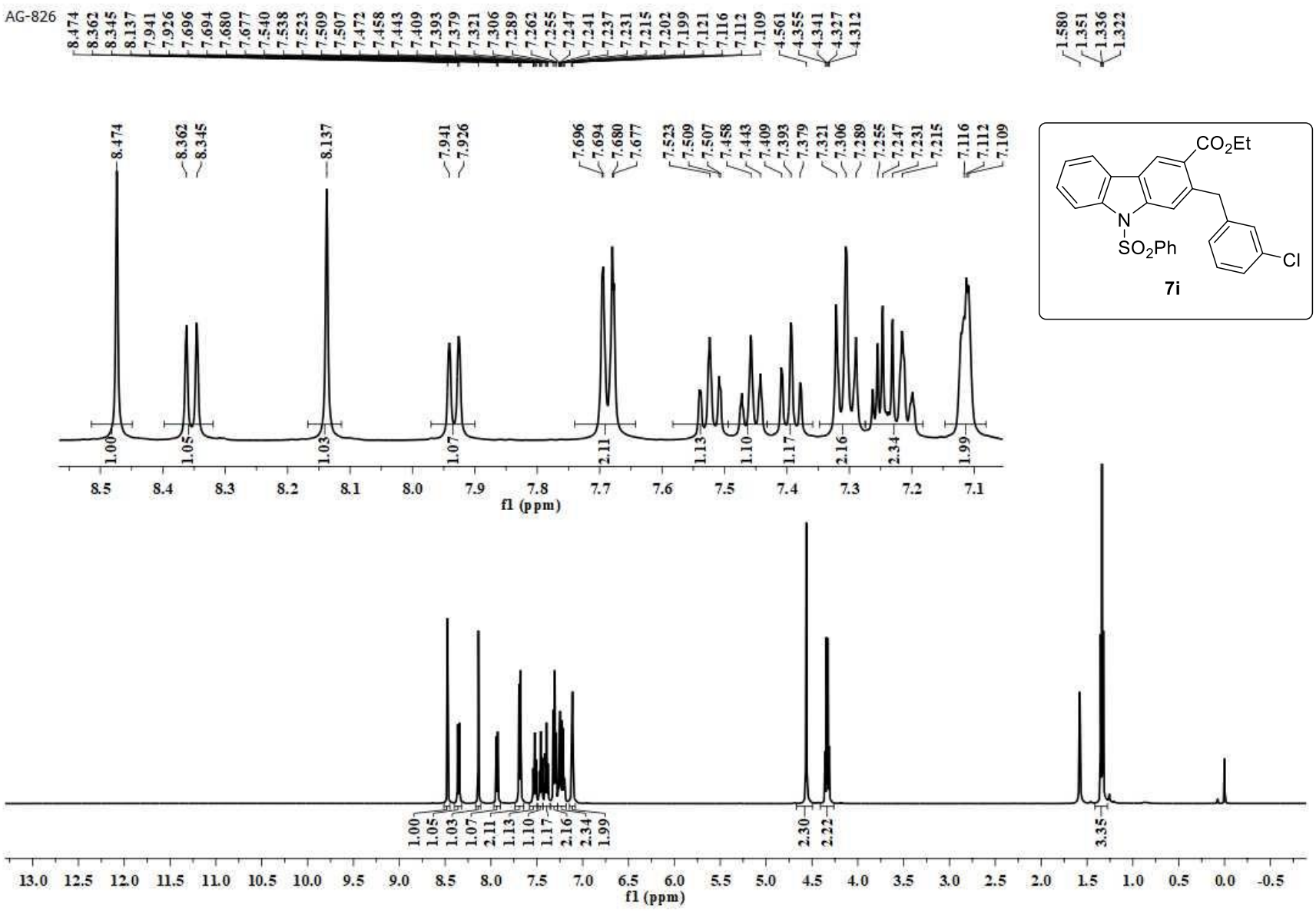
HRMS Spectrum of compound **7g**



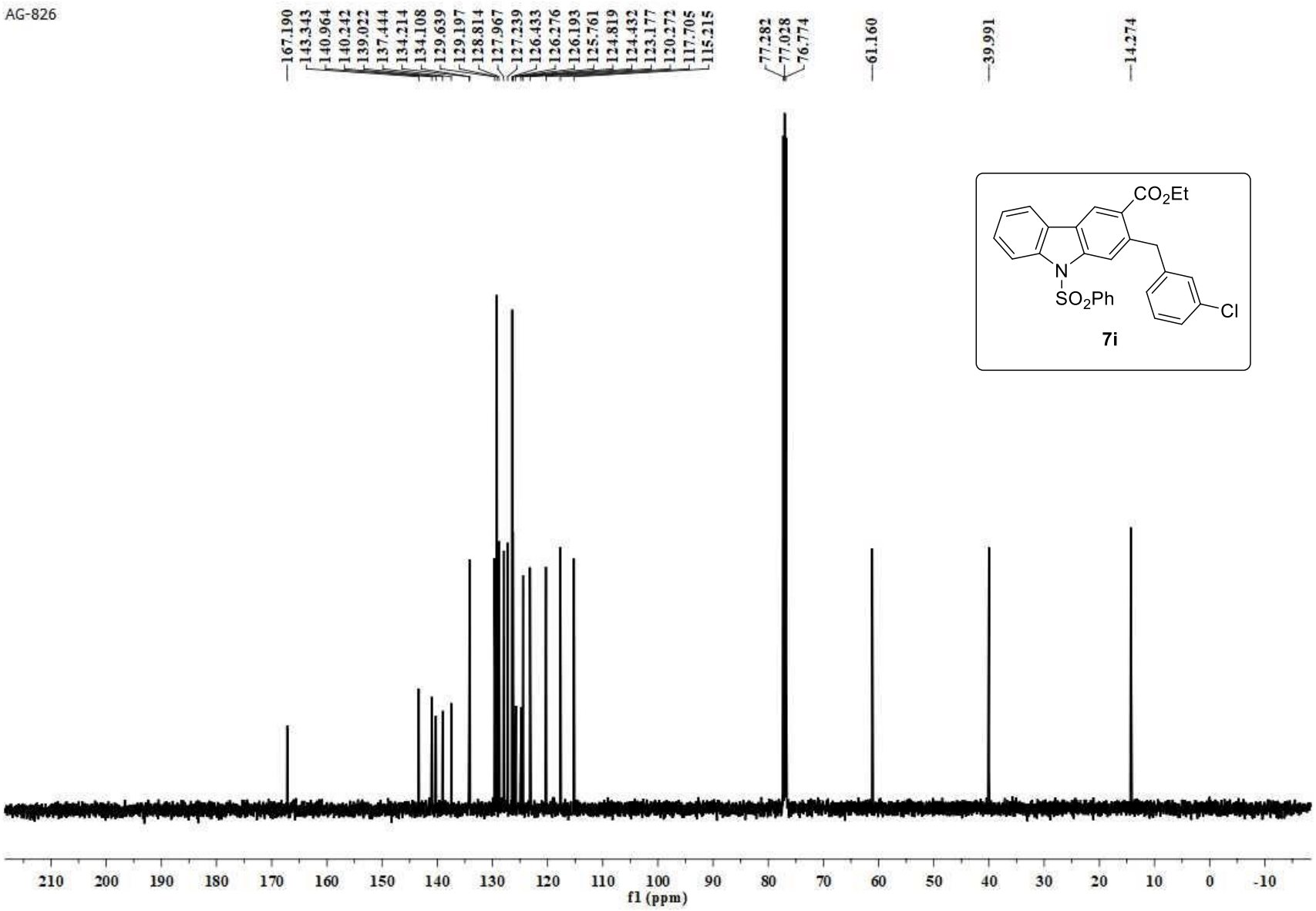
^{1}H NMR (300 MHz, $CDCl_3$) spectrum of compound **7h**



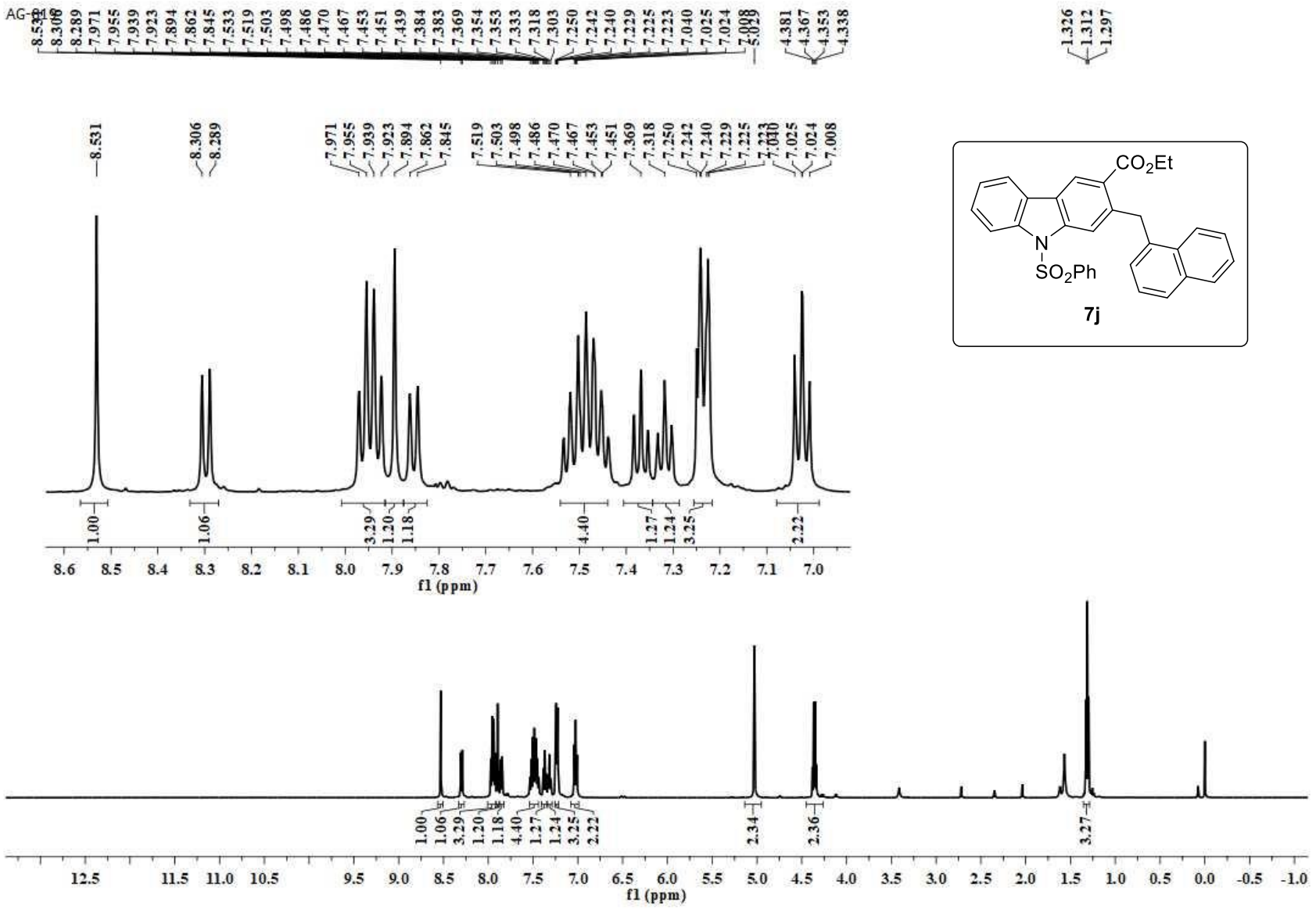
^{13}C {^{1}H} NMR (75 MHz, $CDCl_3$) spectrum of compound **7h**



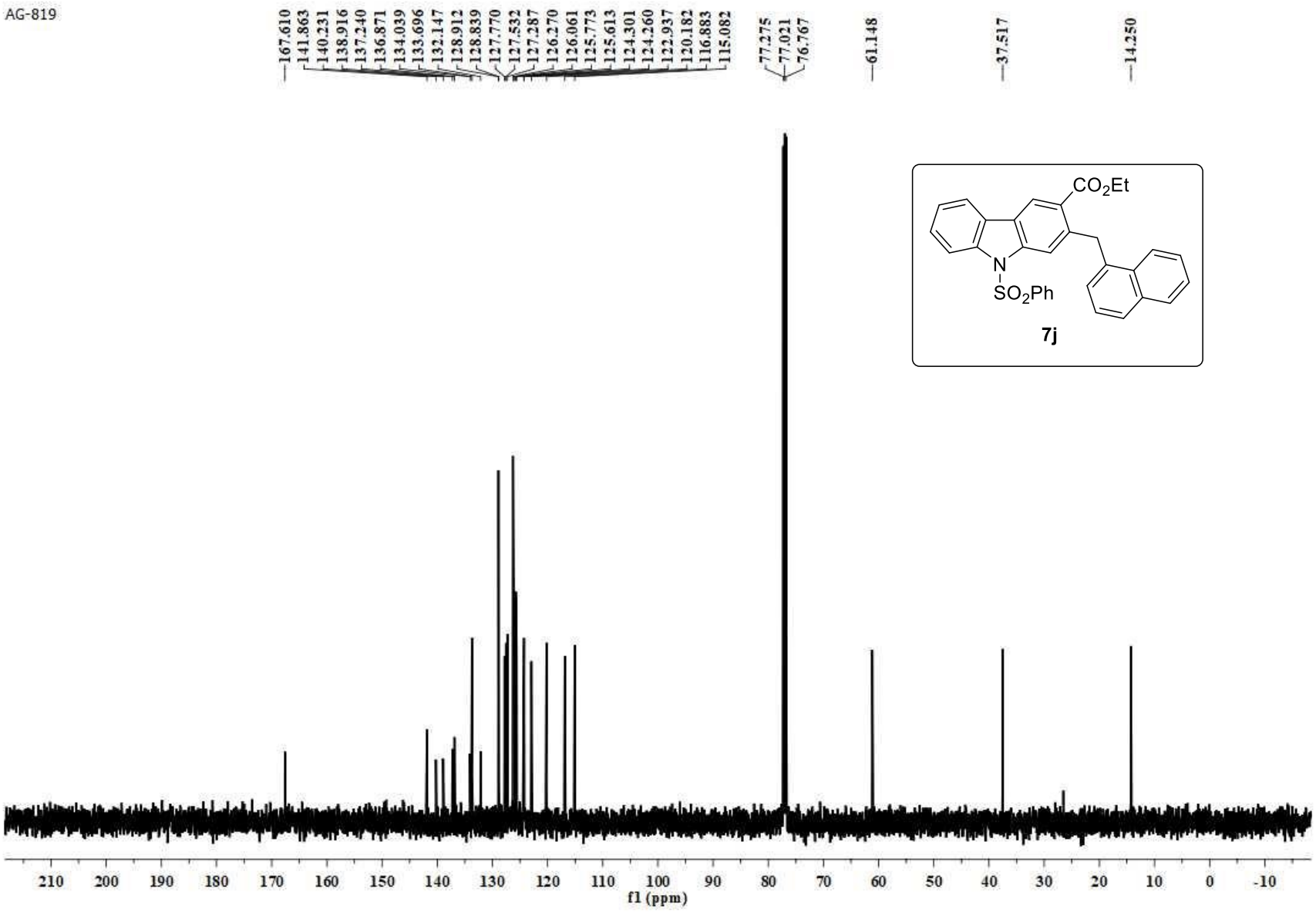
^{1}H NMR (300 MHz, $CDCl_3$) spectrum of compound **7i**



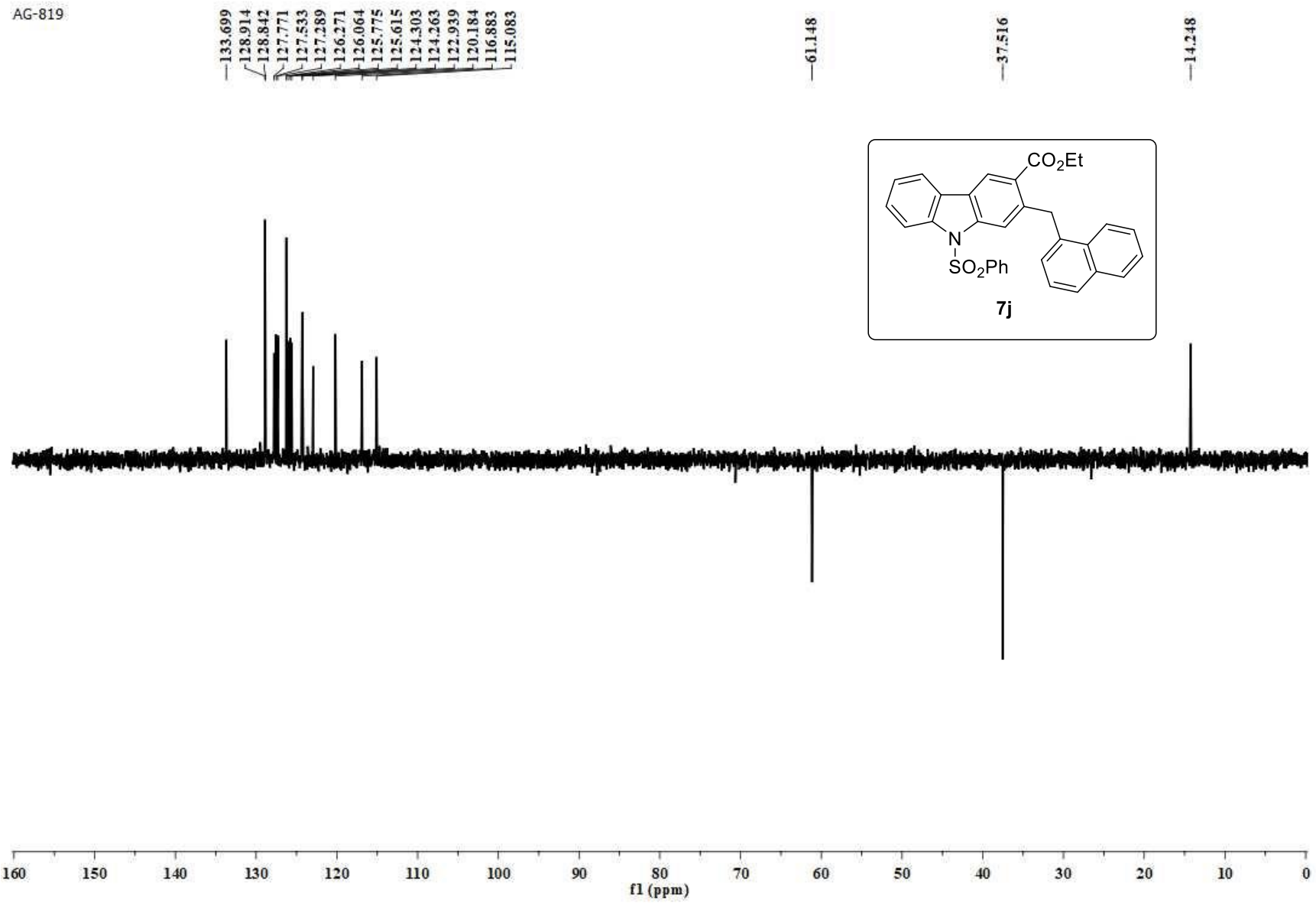
^{13}C {^{1}H} NMR (75 MHz, $CDCl_3$) spectrum of compound **7i**



^{1}H NMR (500 MHz, $CDCl_3$) spectrum of compound **7j**

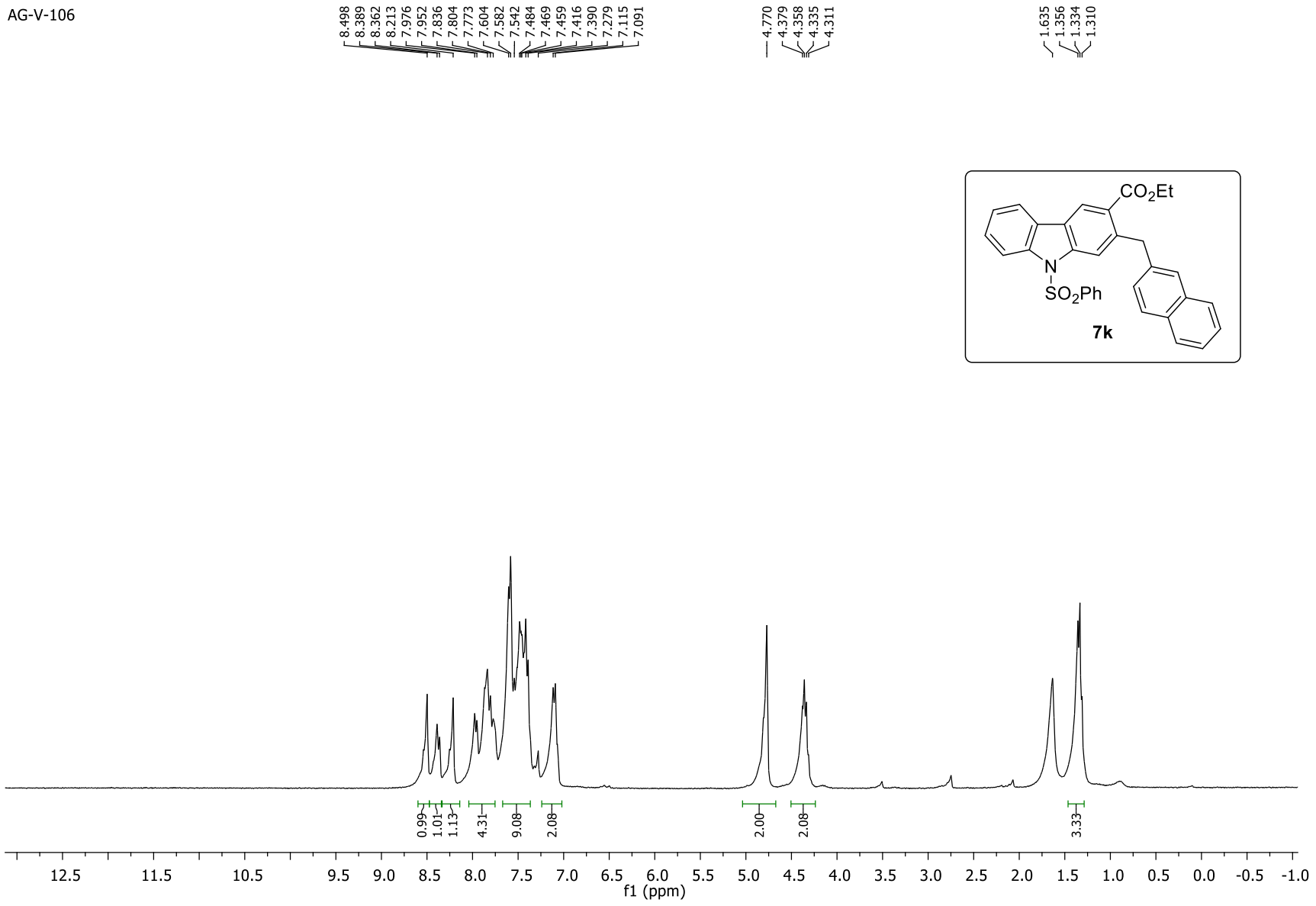


^{13}C {^{1}H} NMR (125 MHz, $CDCl_3$) spectrum of compound **7j**



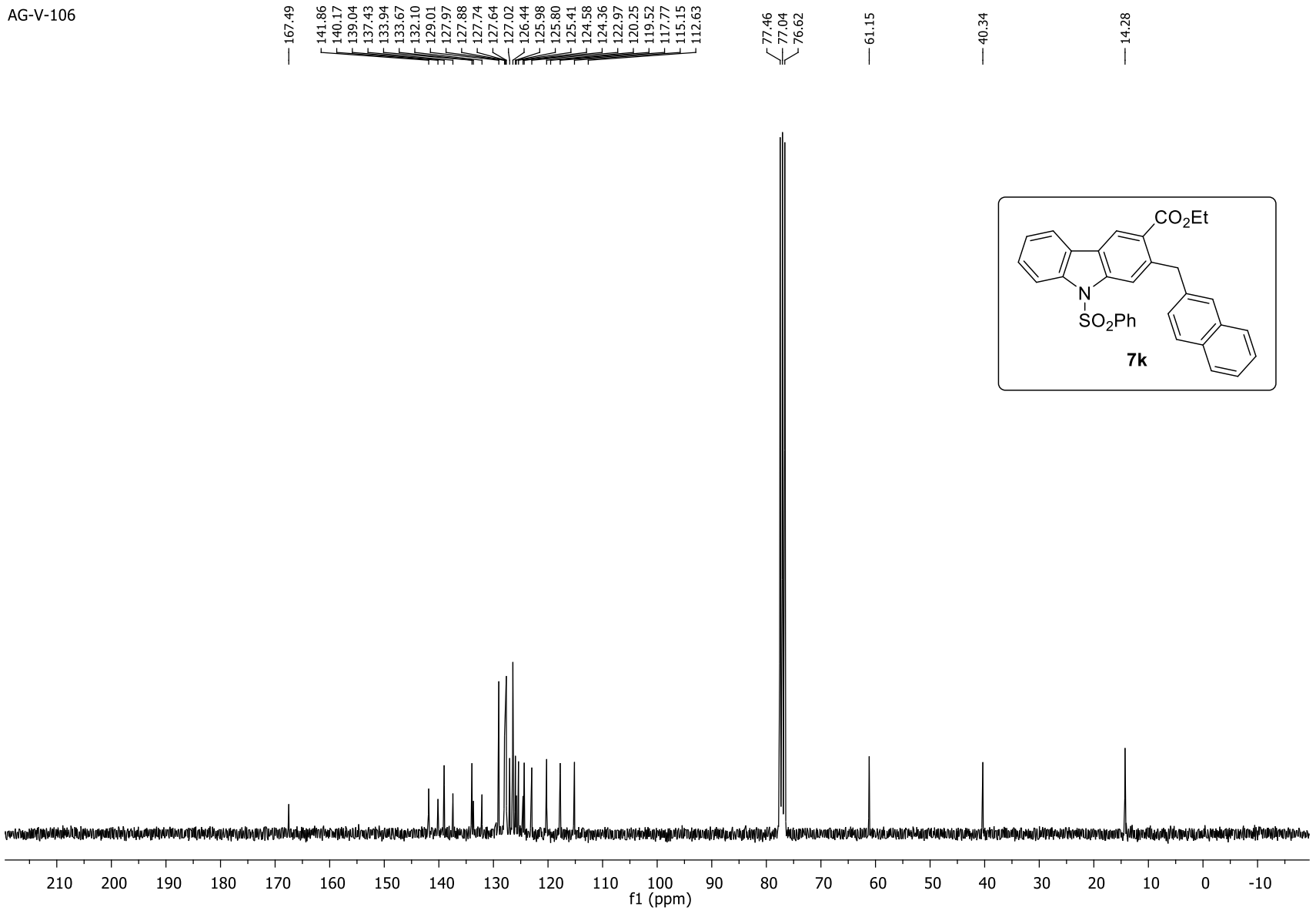
DEPT-135 NMR (125 MHz, $CDCl_3$) spectrum of compound **7j**

AG-V-106

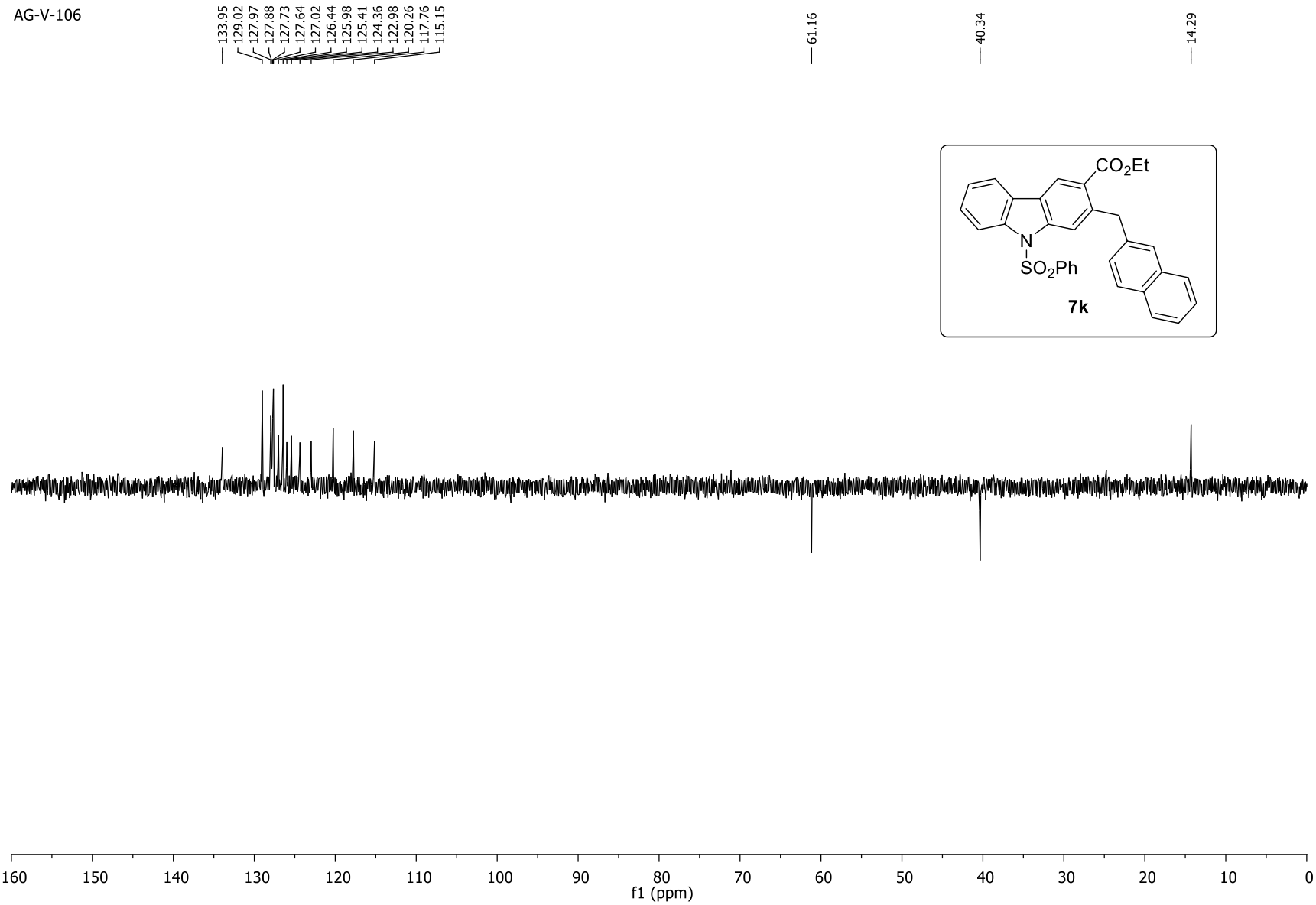


^{1}H NMR (300 MHz, $CDCl_3$) spectrum of compound **7k**

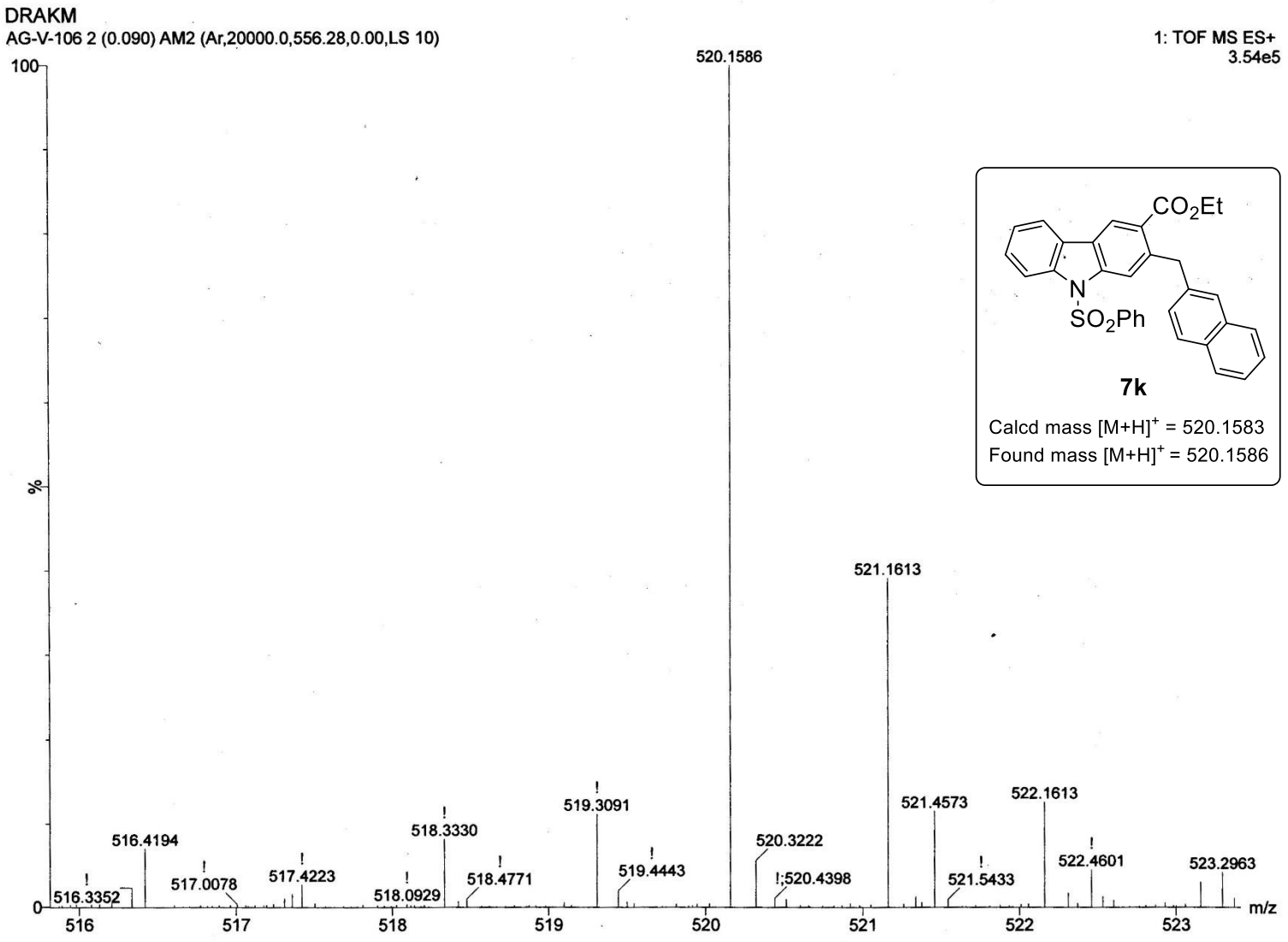
AG-V-106



^{13}C {^{1}H} NMR (75 MHz, $CDCl_3$) spectrum of compound **7k**

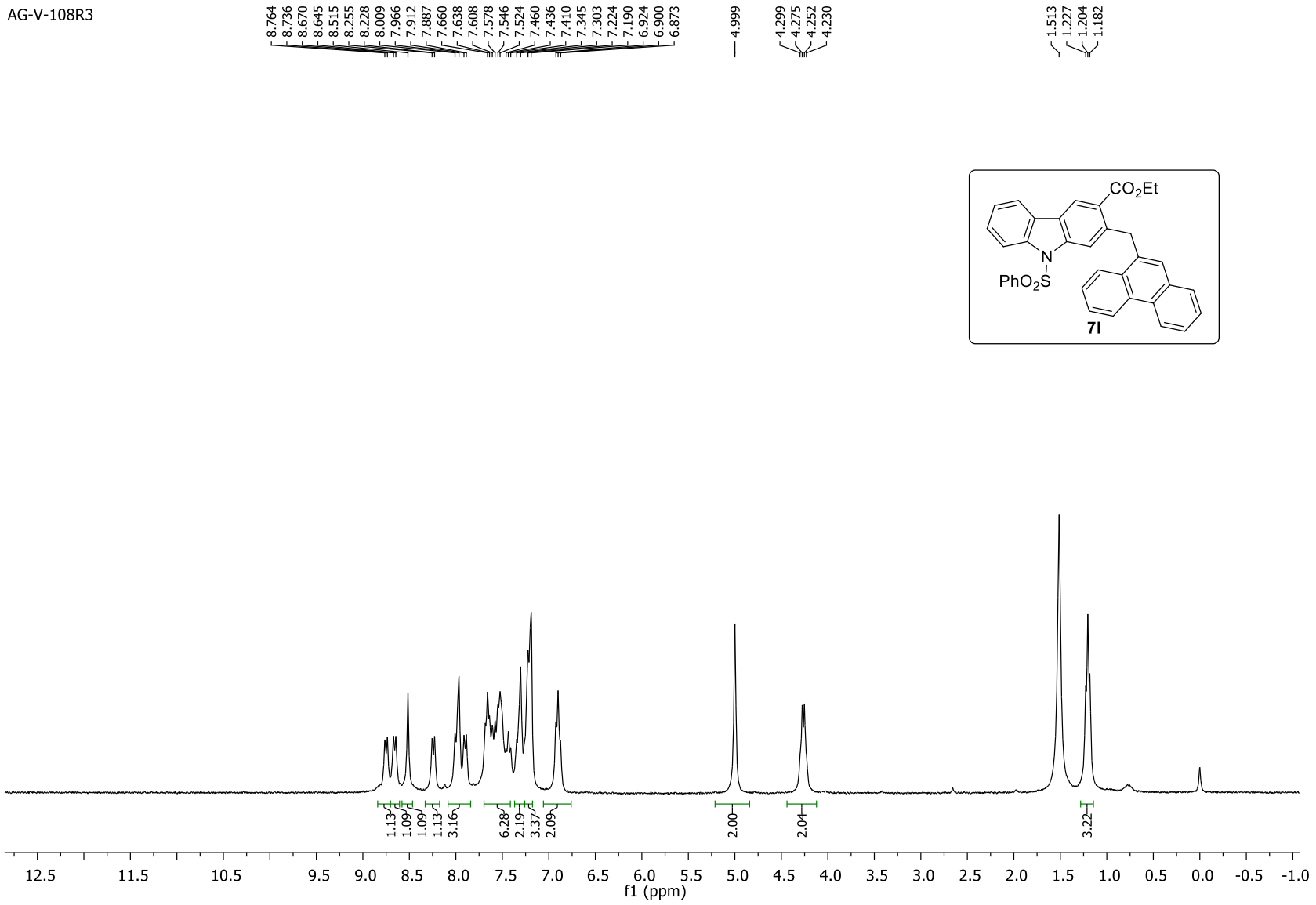


DEPT-135 NMR (75 MHz, $CDCl_3$) spectrum of compound **7k**

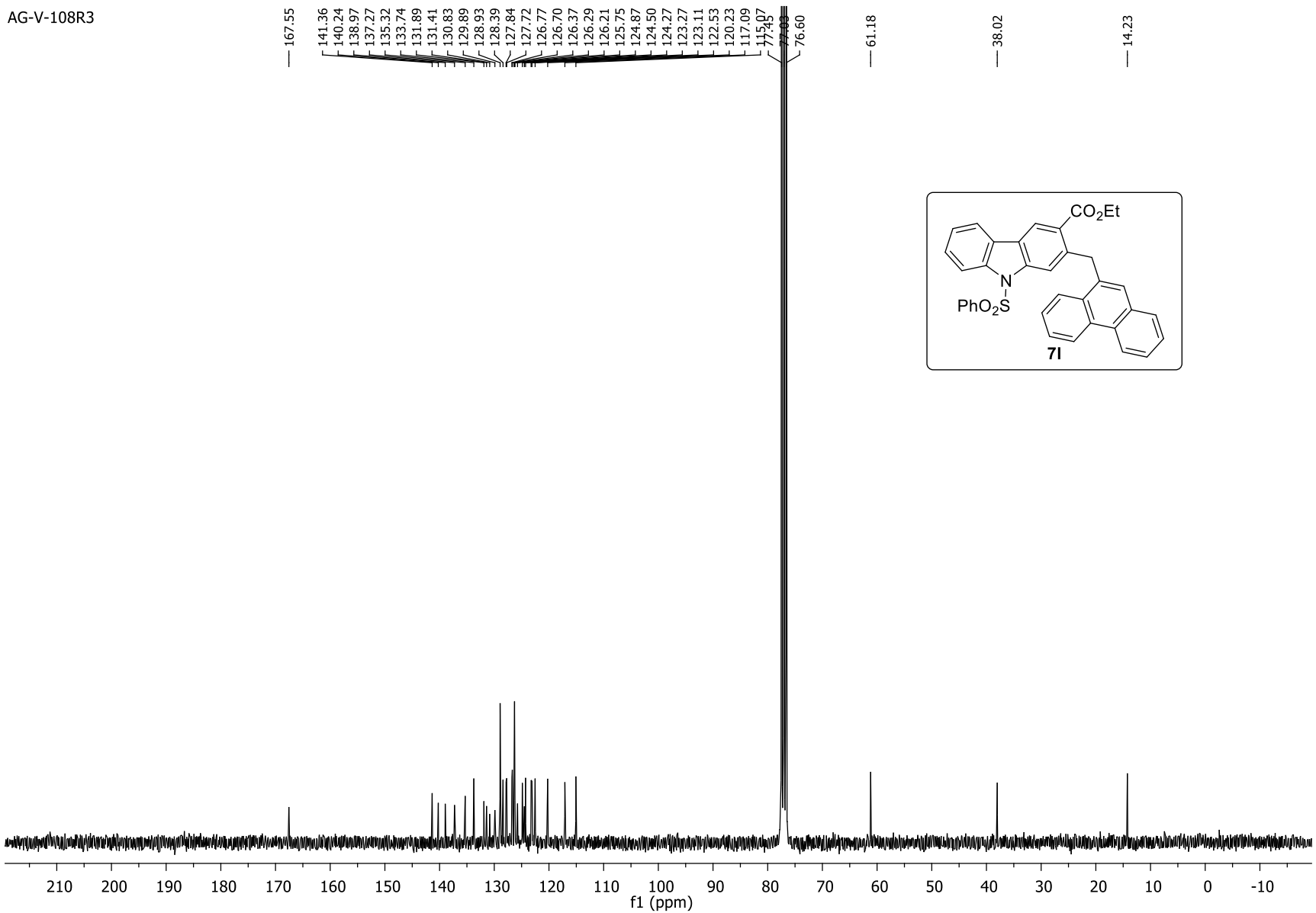


HRMS Spectrum of compound **7k**

AG-V-108R3



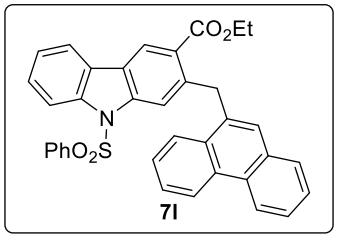
^{1}H NMR (300 MHz, $CDCl_3$) spectrum of compound **7I**



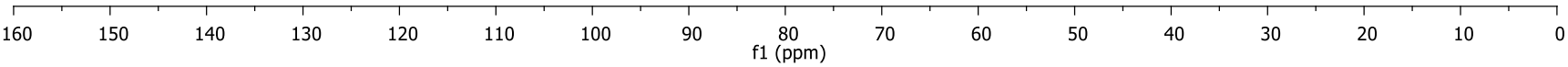
^{13}C {^{1}H} NMR (75 MHz, $CDCl_3$) spectrum of compound **7I**

AG-V-108R3

133.75
128.93
128.39
127.84
127.72
126.71
126.37
126.30
124.87
124.28
123.27
123.11
122.54
120.24
117.09
115.07
61.18
38.03
14.24

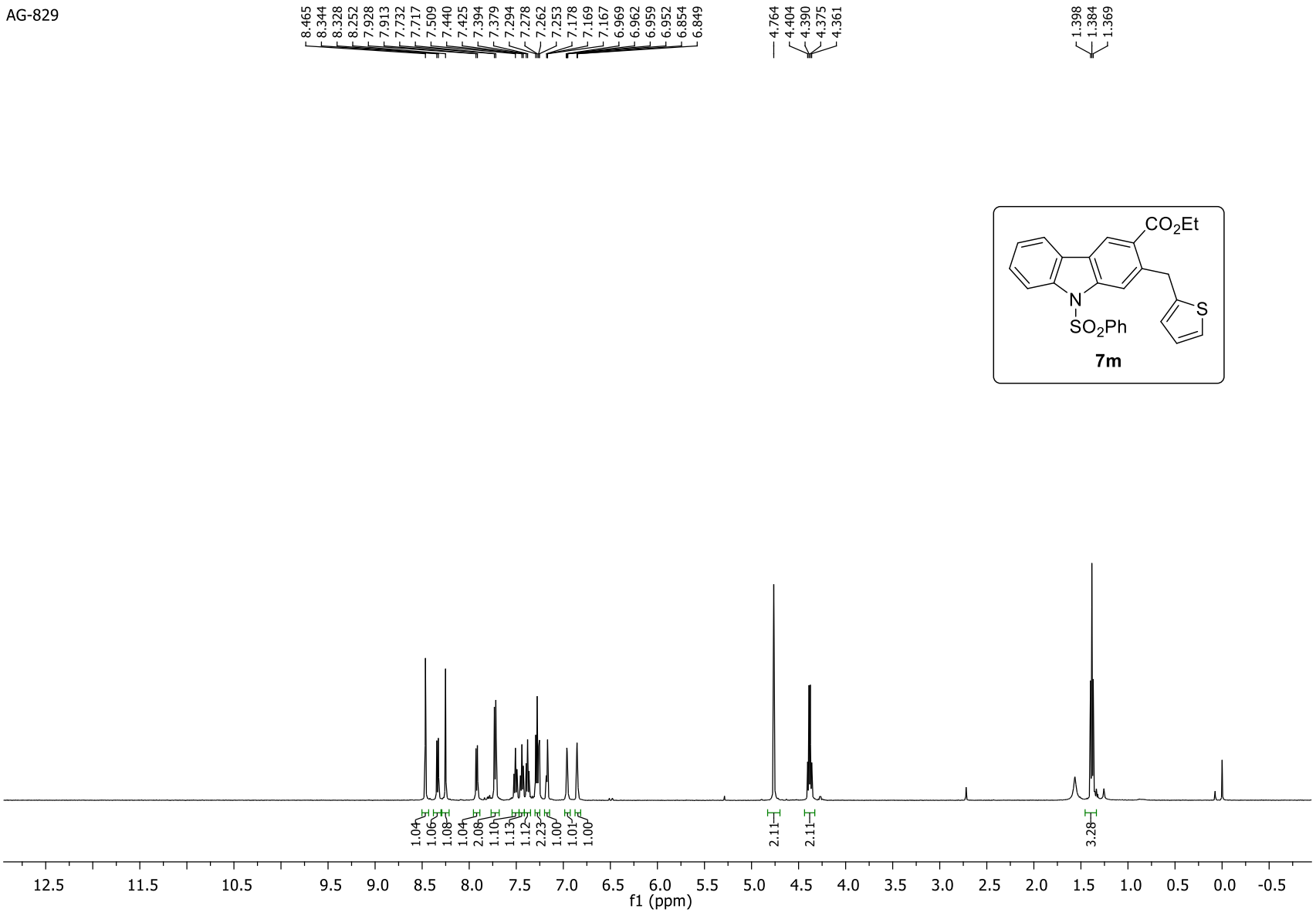


7l



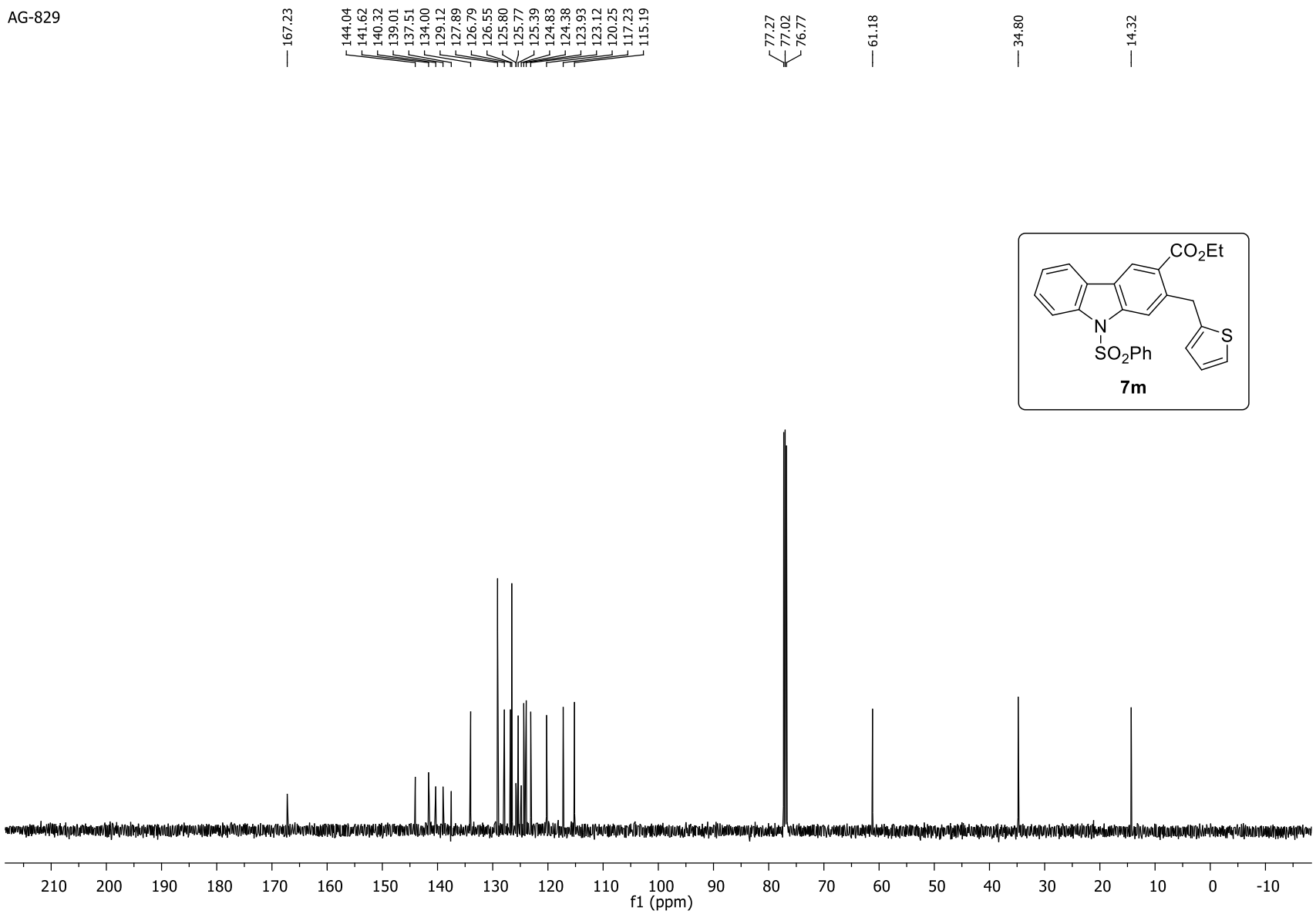
DEPT-135 NMR (75 MHz, $CDCl_3$) spectrum of compound **7l**

AG-829

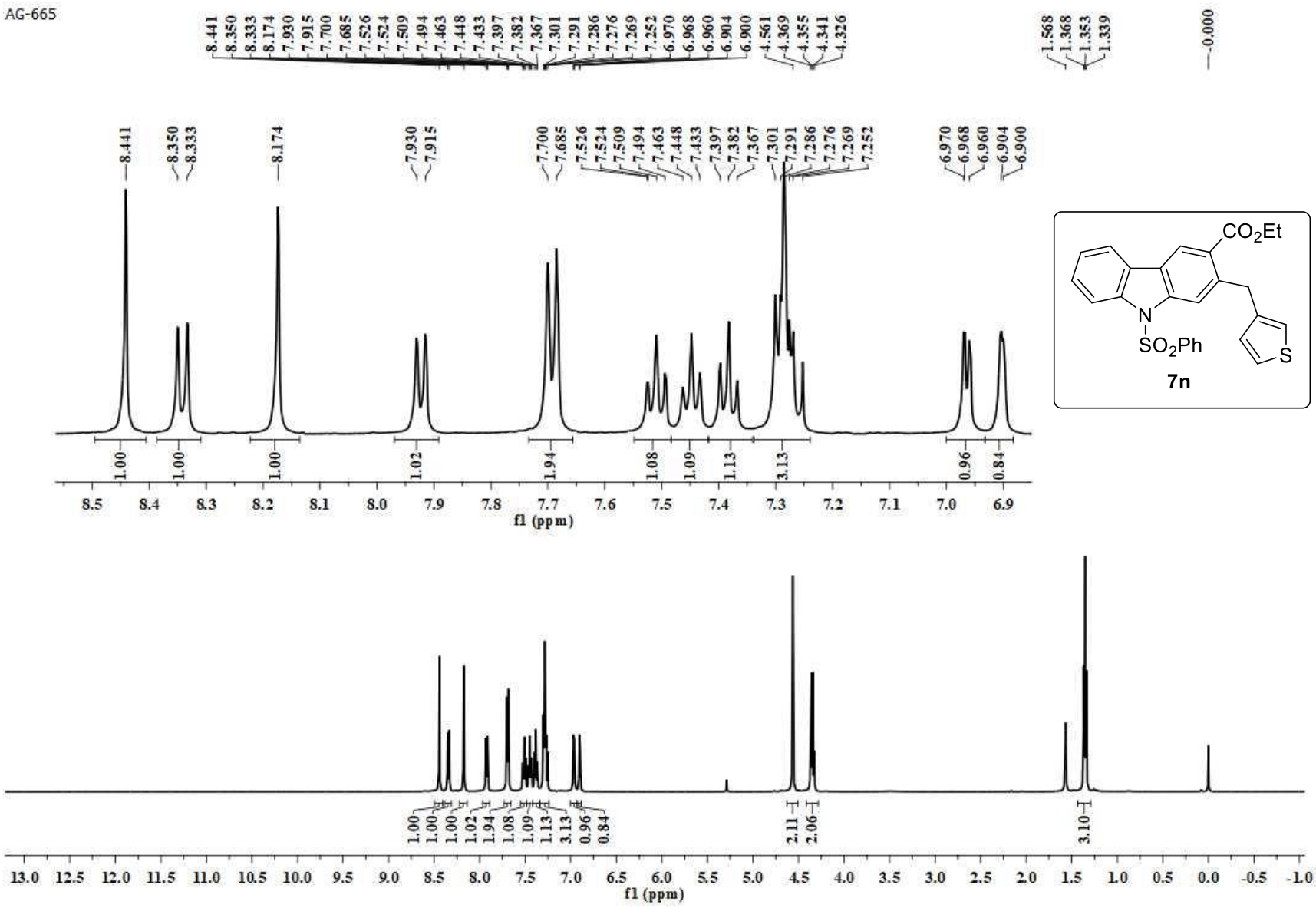


^{1}H NMR (500 MHz, $CDCl_3$) spectrum of compound **7m**

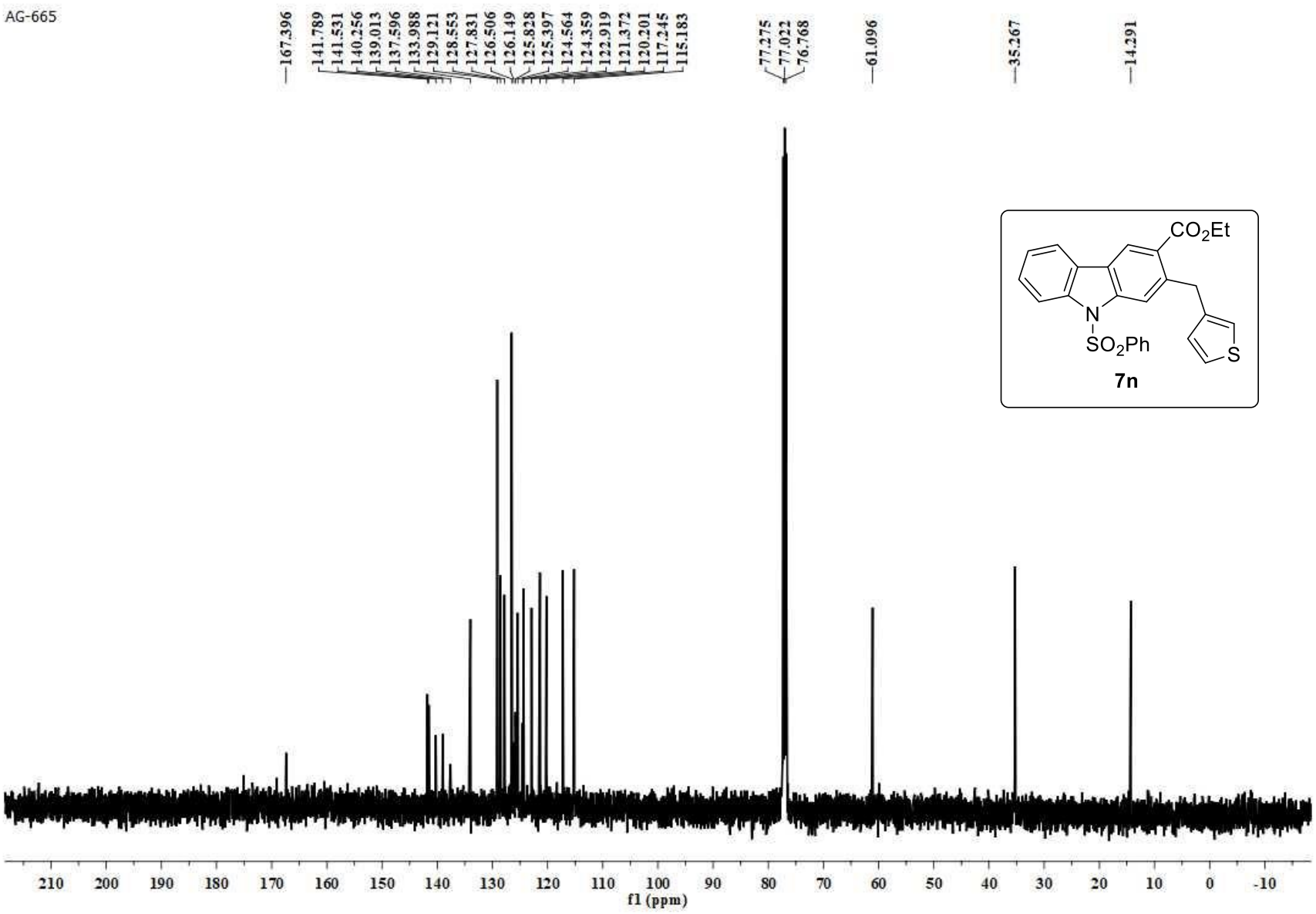
AG-829



^{13}C {^{1}H} NMR (125 MHz, $CDCl_3$) spectrum of compound **7m**

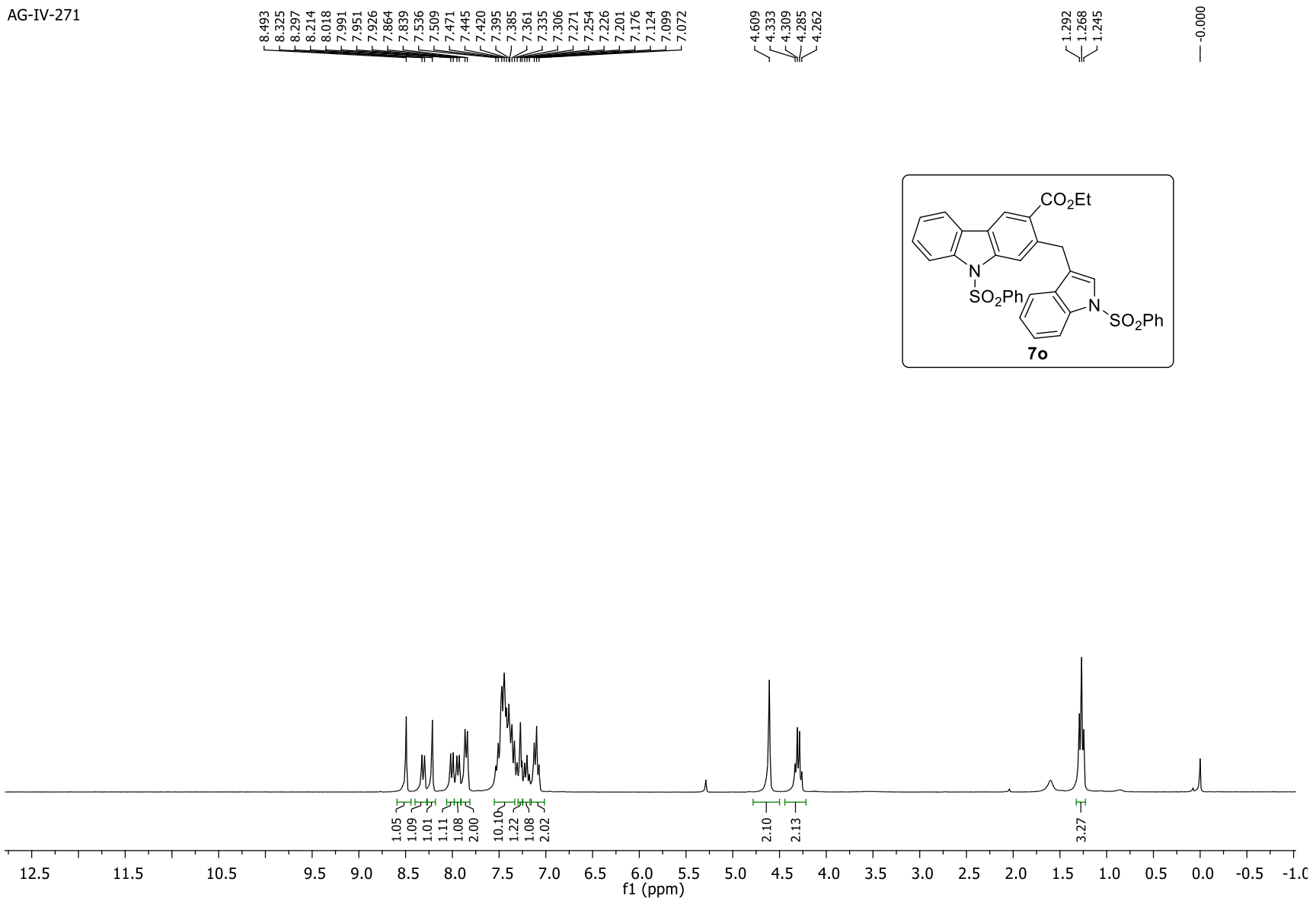


^{1}H NMR (500 MHz, $CDCl_3$) spectrum of compound **7n**



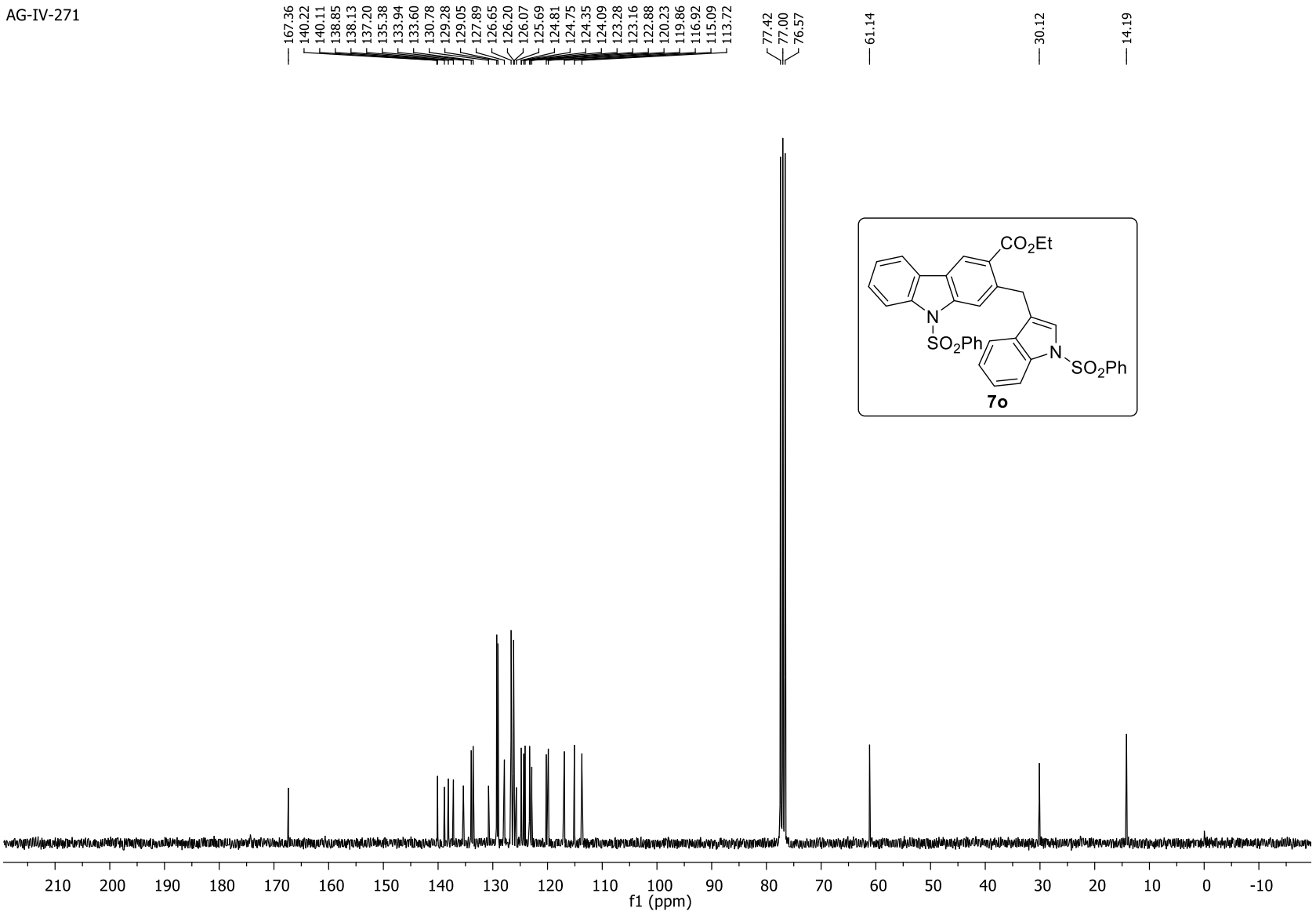
^{13}C {^{1}H} NMR (125 MHz, $CDCl_3$) spectrum of compound **7n**

AG-IV-271



^{1}H NMR (300 MHz, $CDCl_3$) spectrum of compound **7o**

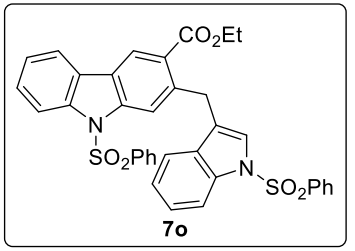
AG-IV-271



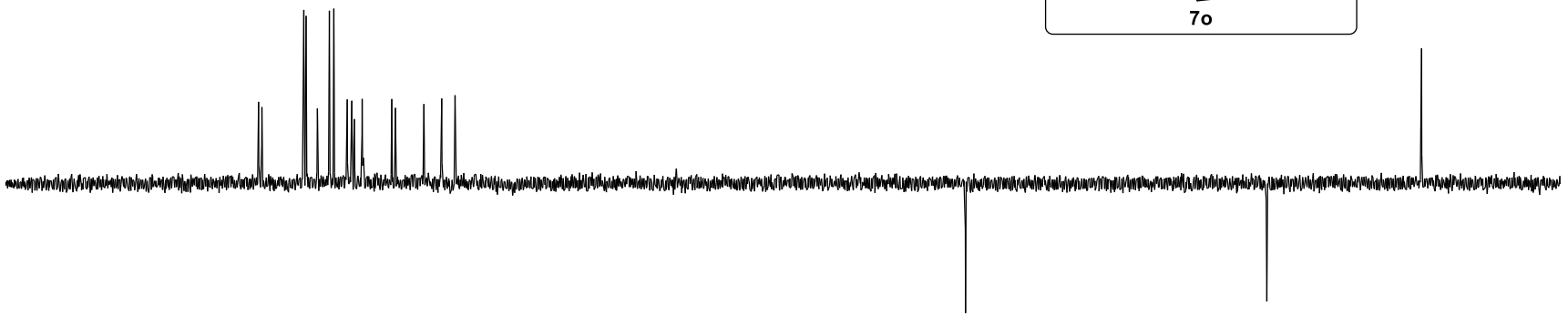
^{13}C {^{1}H} NMR (75 MHz, $CDCl_3$) spectrum of compound **7o**

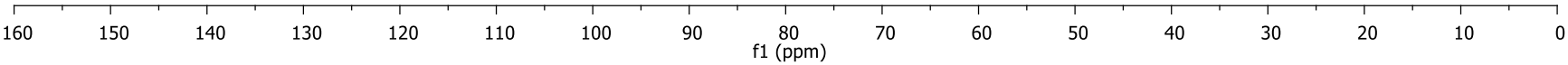
AG-IV-271

133.99
133.65
129.33
129.10
127.93
126.70
126.24
124.86
124.40
124.14
123.32
123.21
120.28
119.90
116.97
115.13
113.76
61.20
30.17
14.24

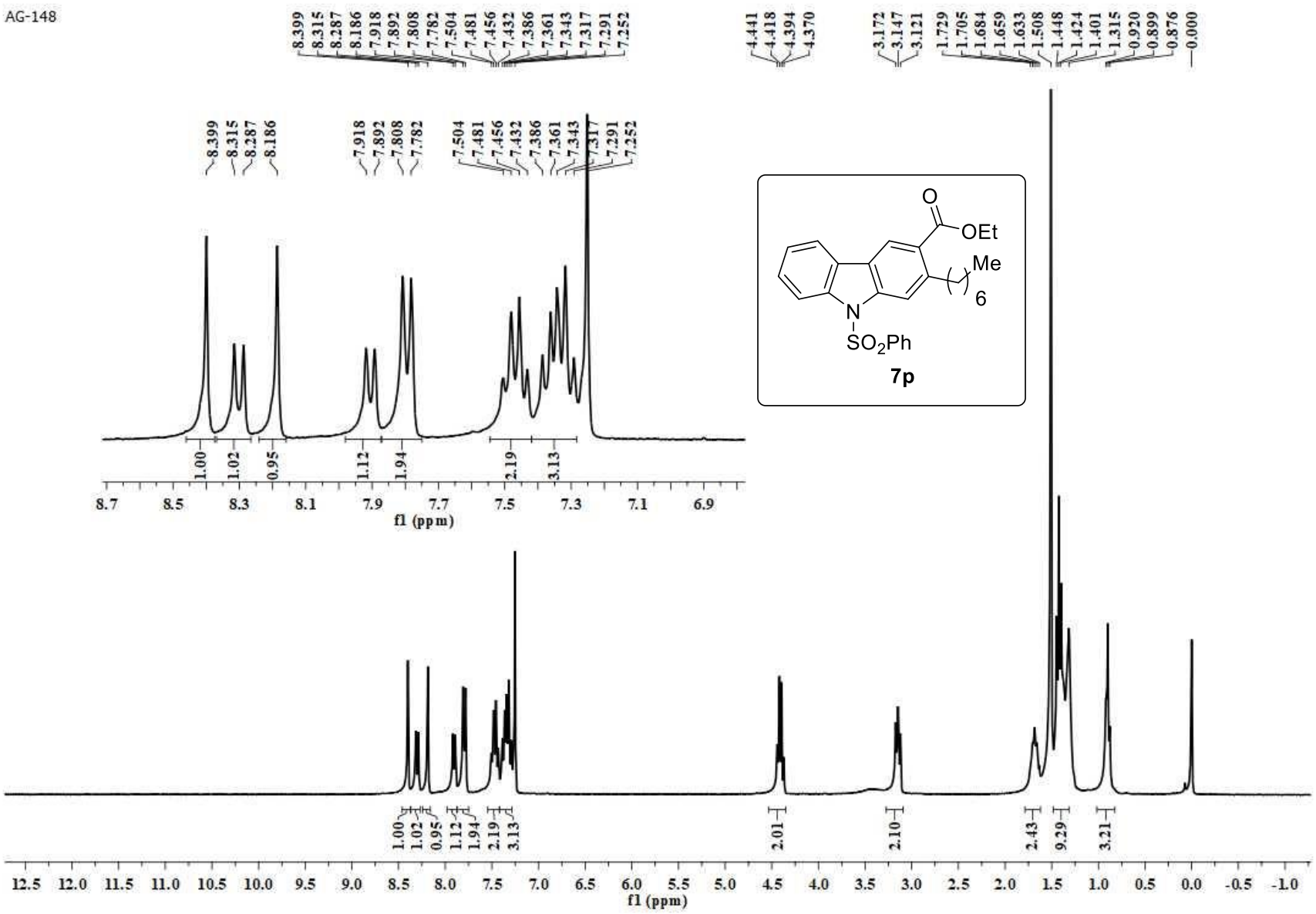


7o

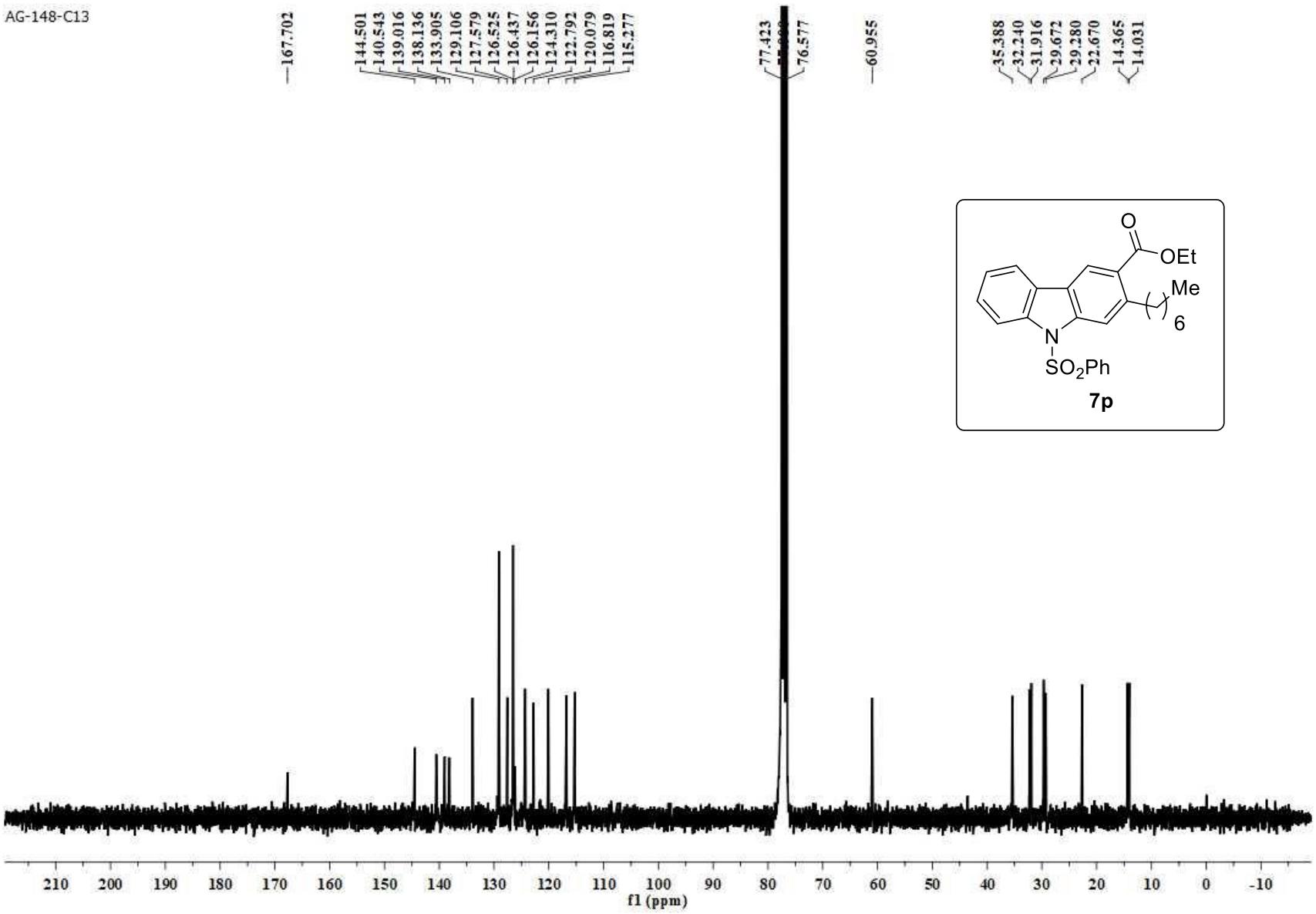




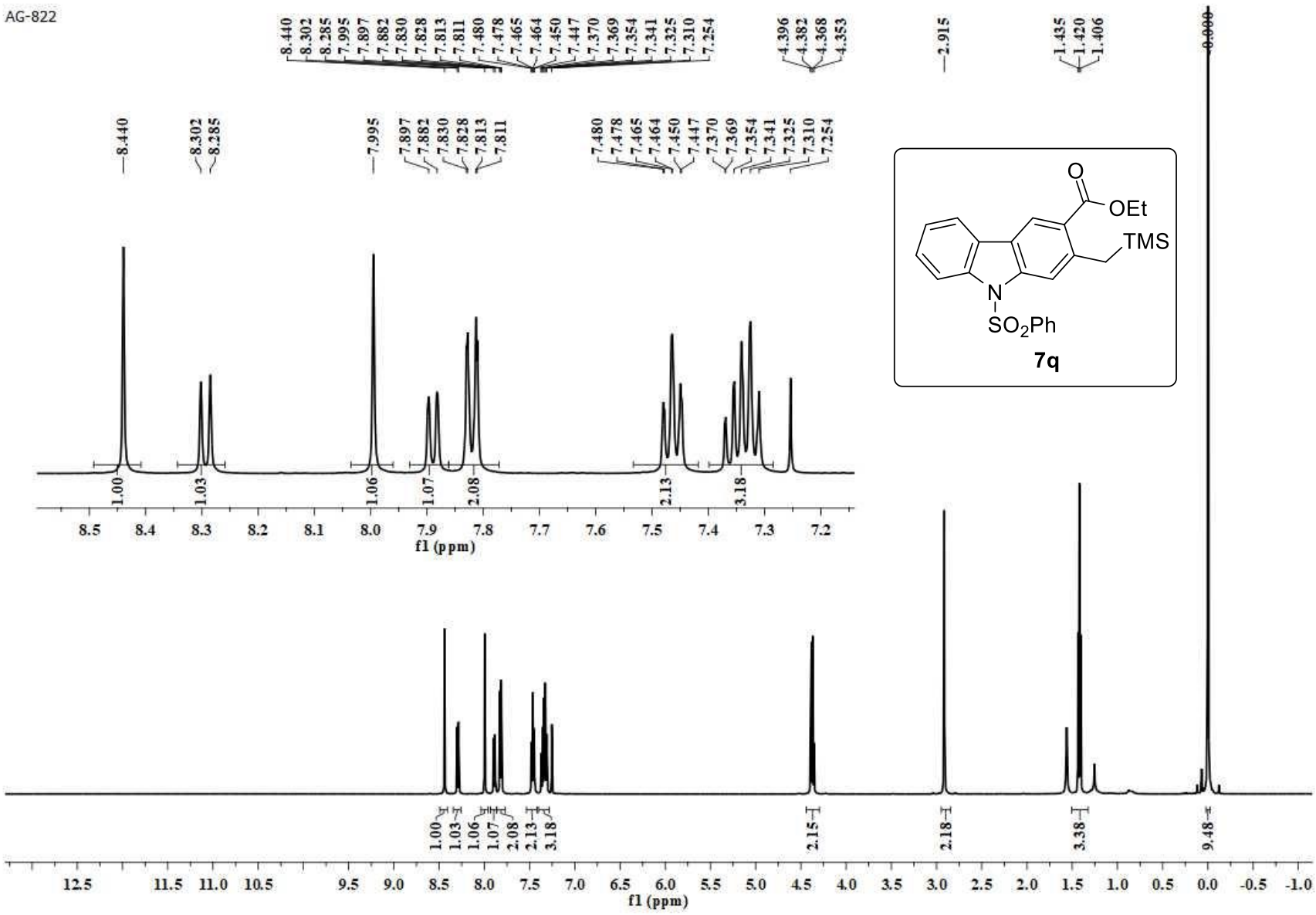
DEPT-135 NMR (75 MHz, $CDCl_3$) spectrum of compound **7o**



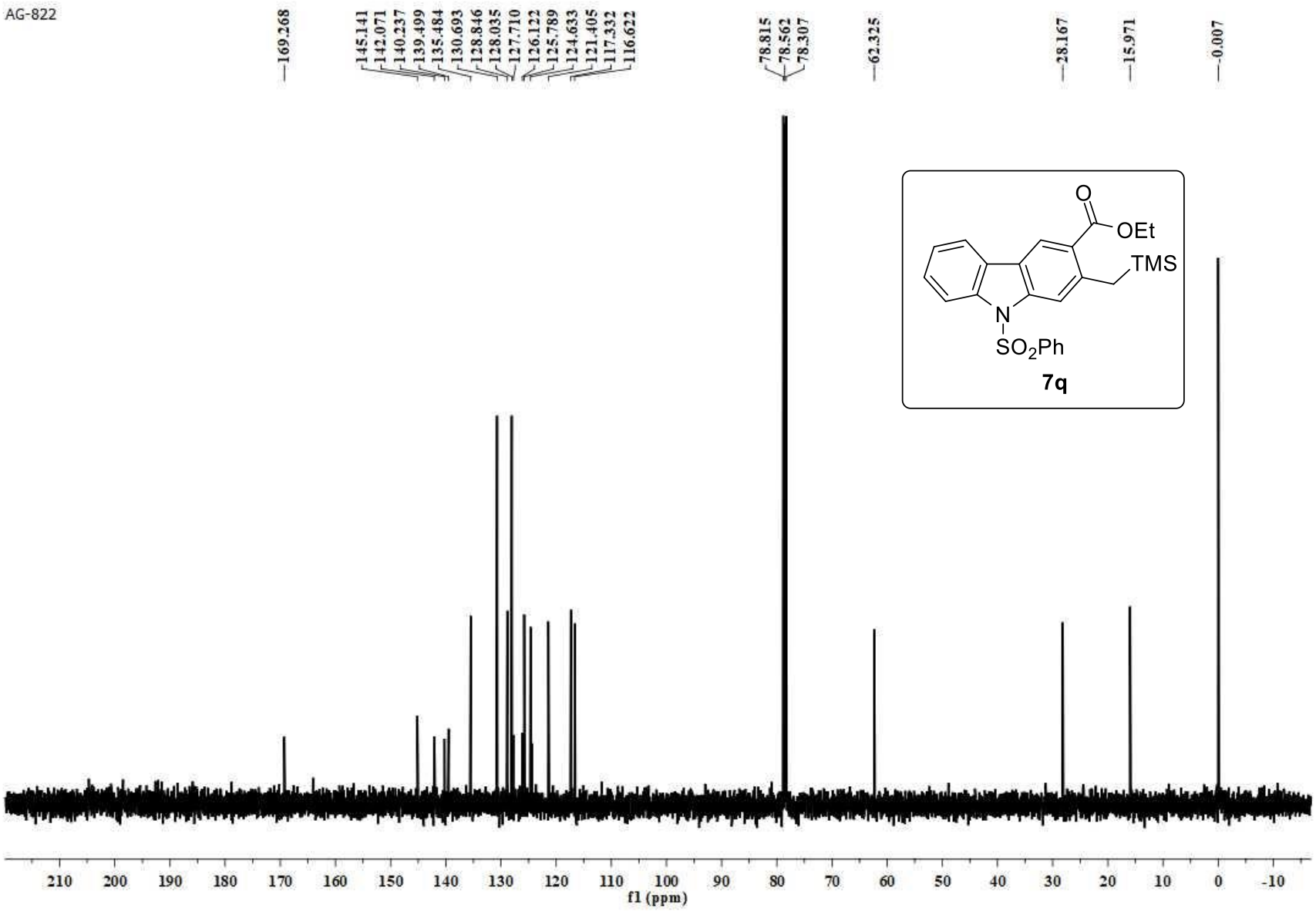
^{1}H NMR (300 MHz, $CDCl_3$) spectrum of compound **7p**



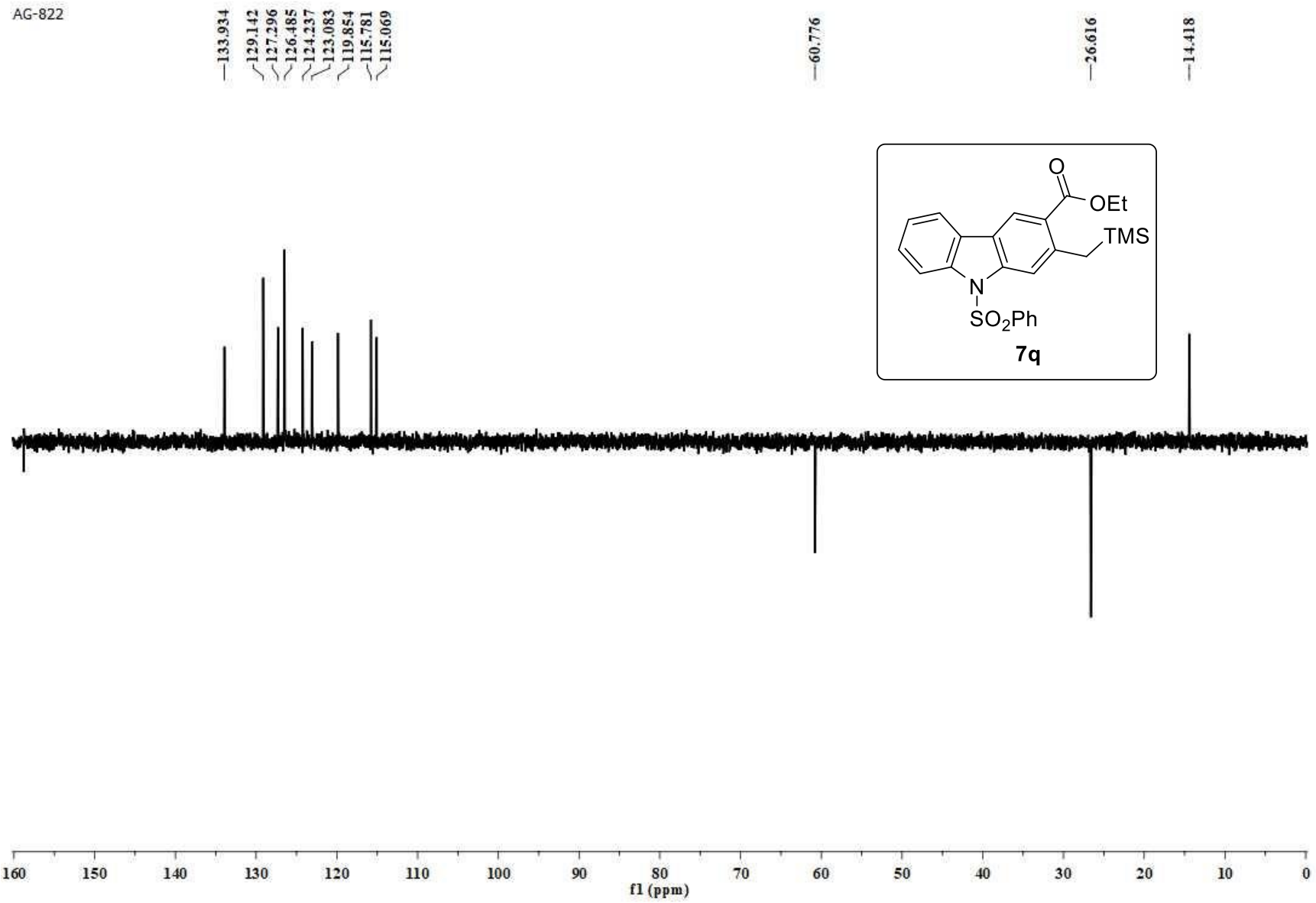
^{13}C {^{1}H} NMR (75 MHz, $CDCl_3$) spectrum of compound **7p**



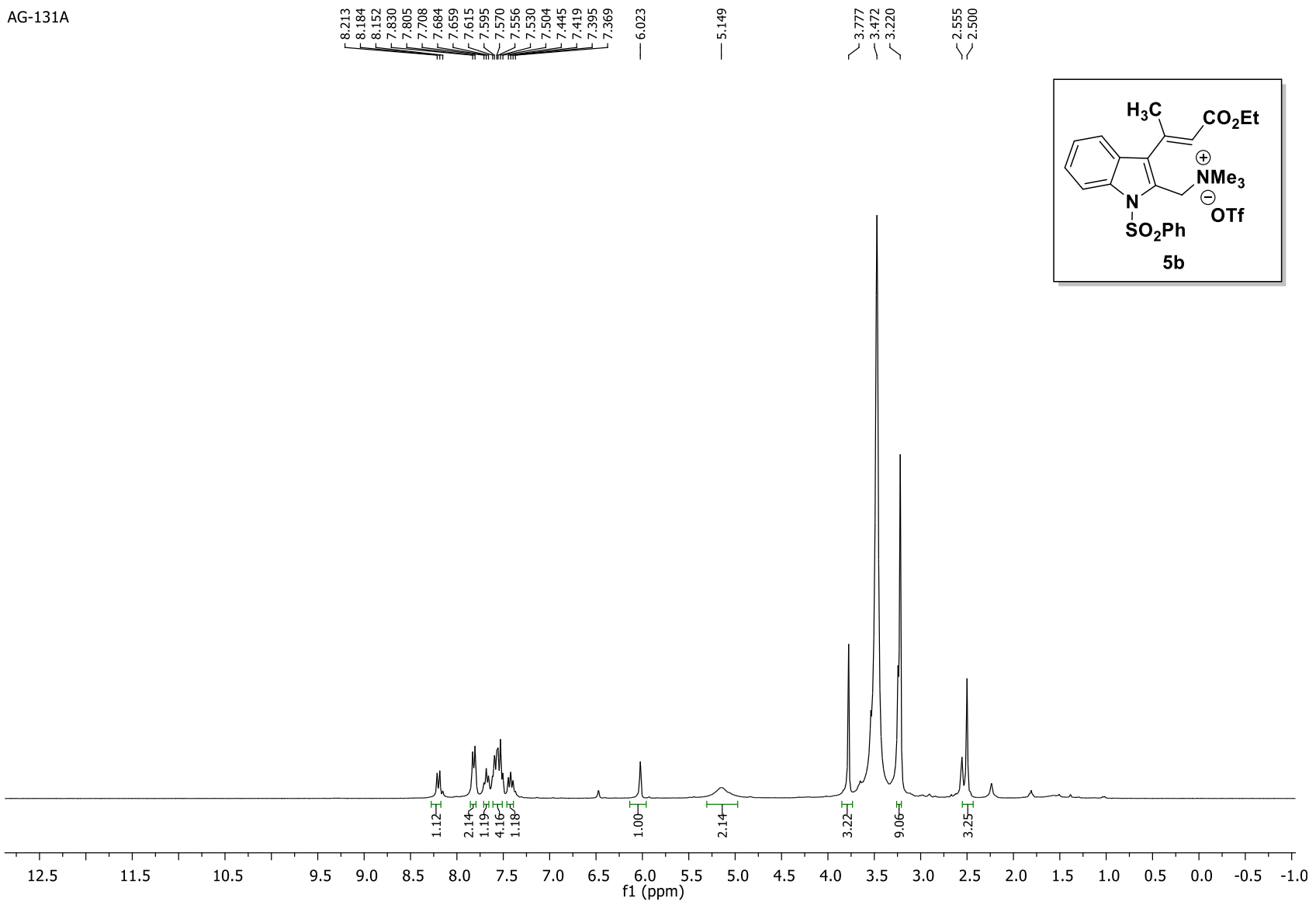
^{1}H NMR (500 MHz, $CDCl_3$) spectrum of compound **7q**



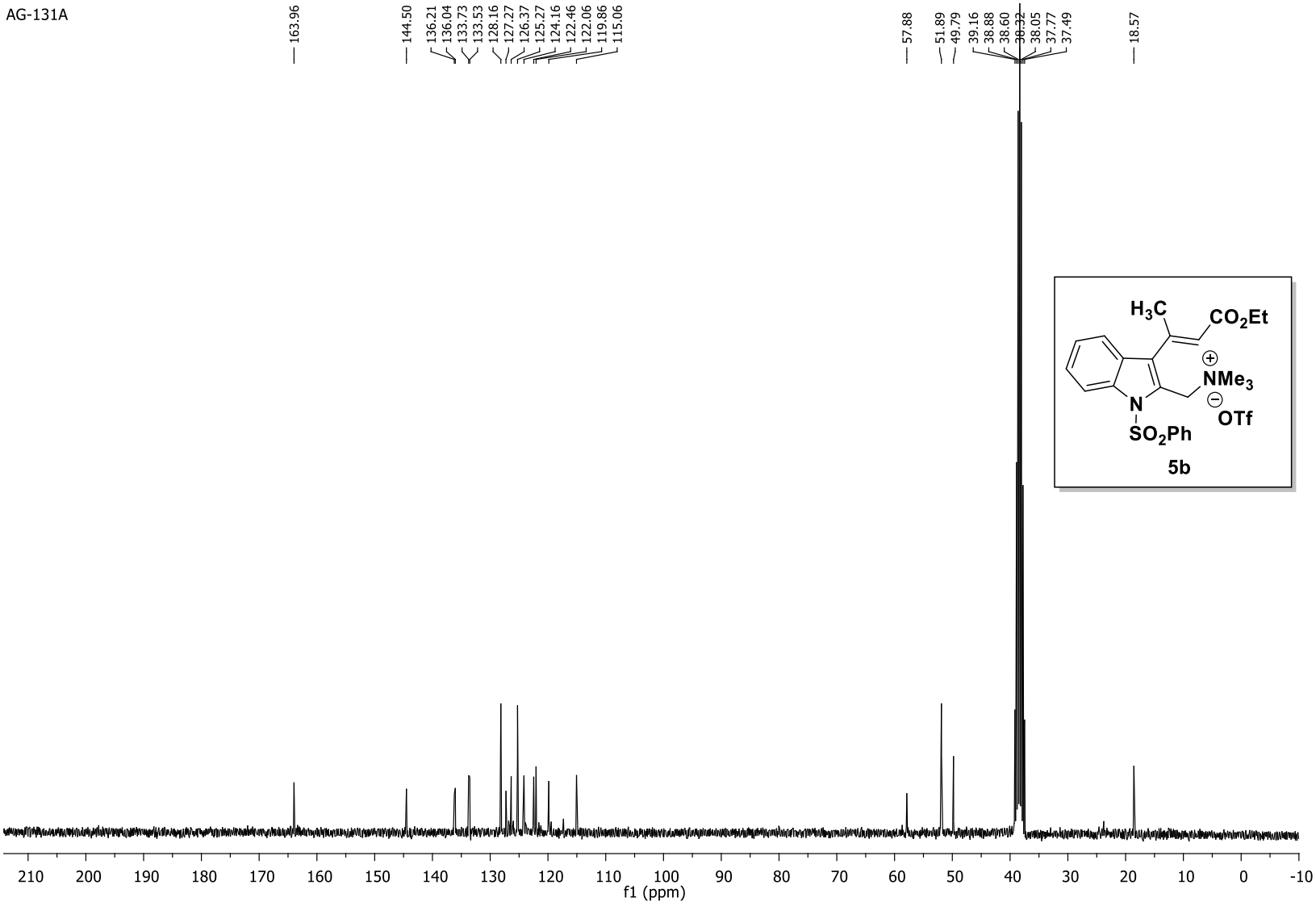
^{13}C {^{1}H} NMR (125 MHz, $CDCl_3$) spectrum of compound **7q**



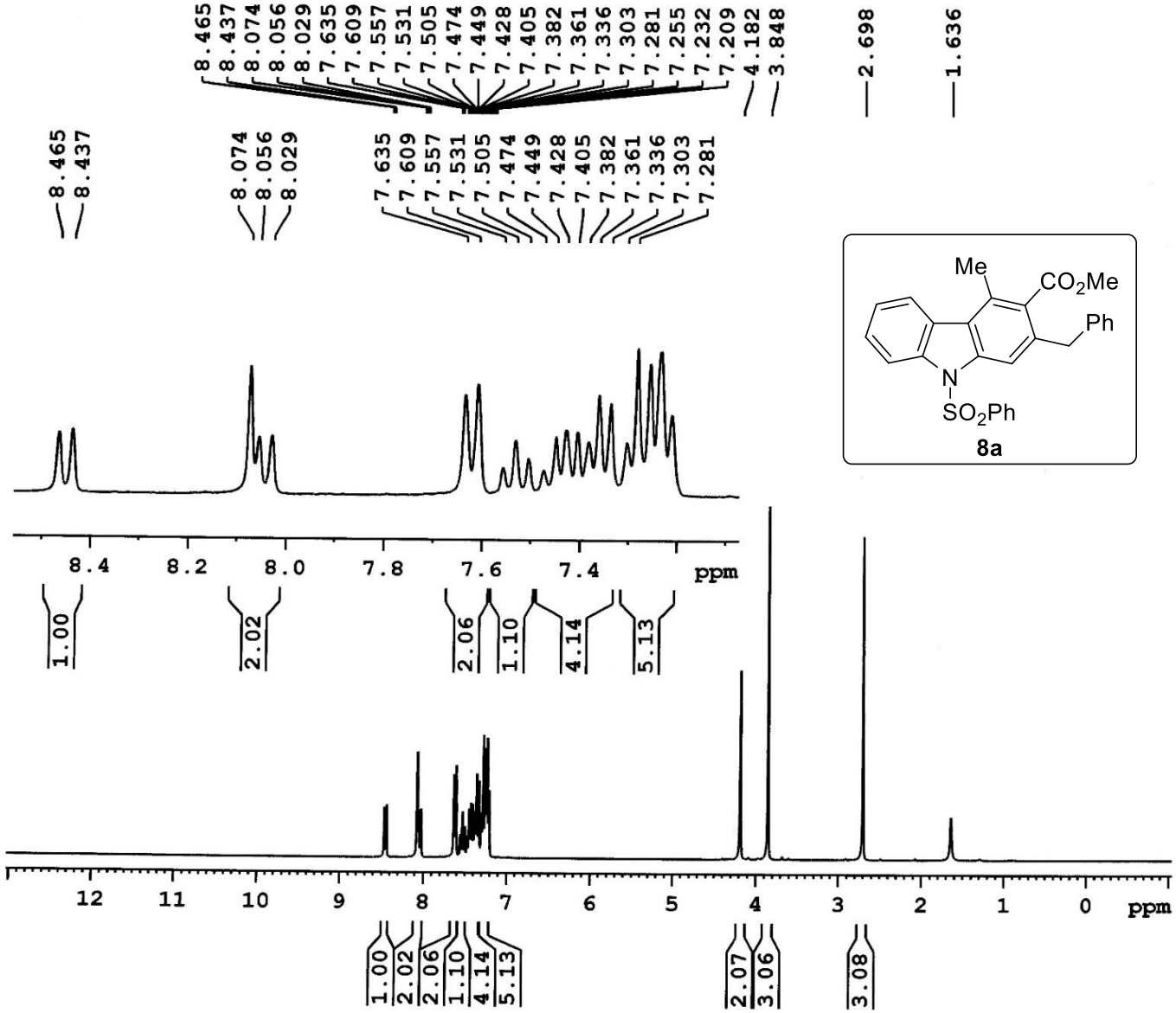
DEPT-135 NMR (125 MHz, $CDCl_3$) spectrum of compound **7q**



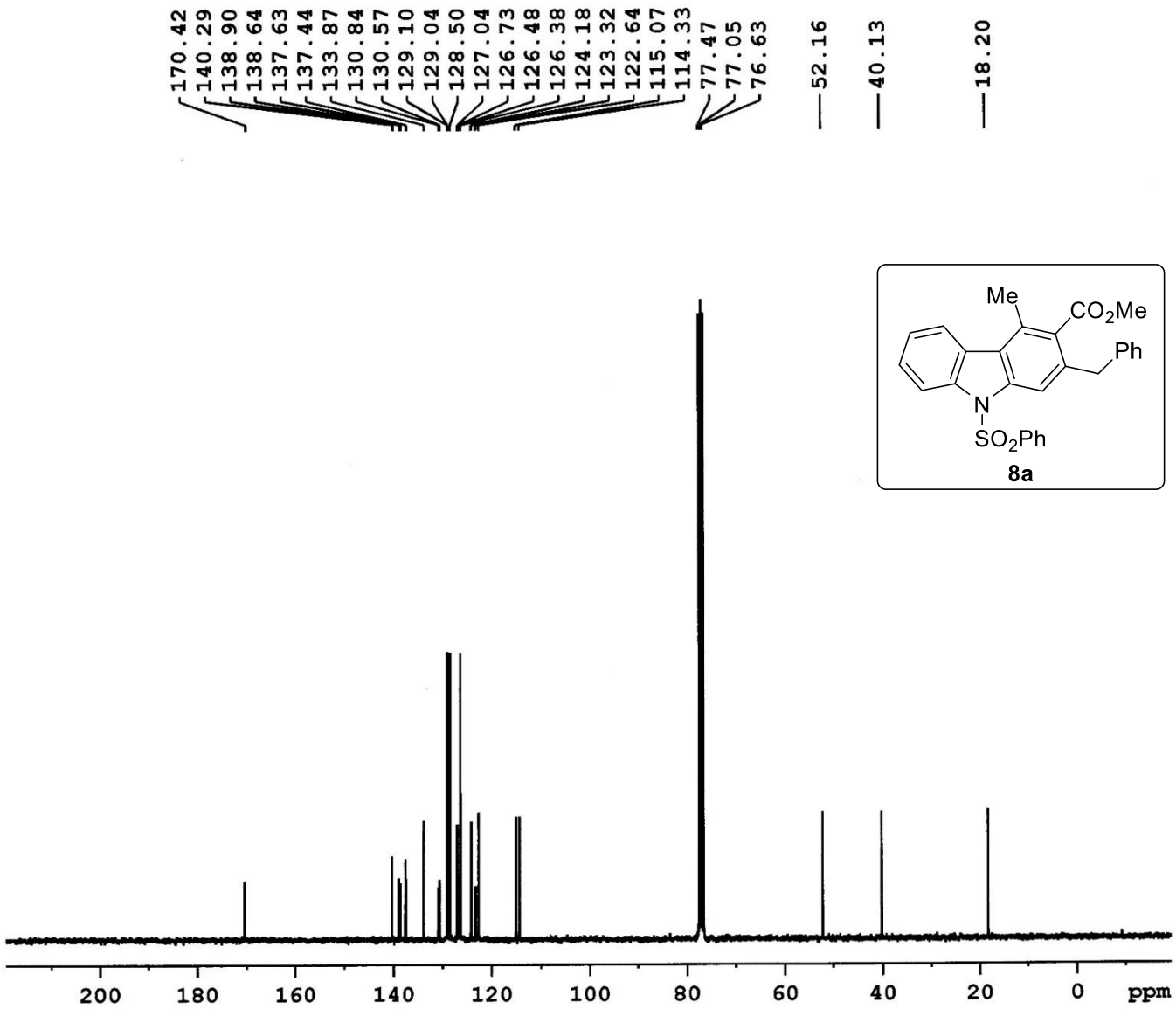
^{1}H NMR (300 MHz, DMSO-d_6) spectrum of compound **5b**



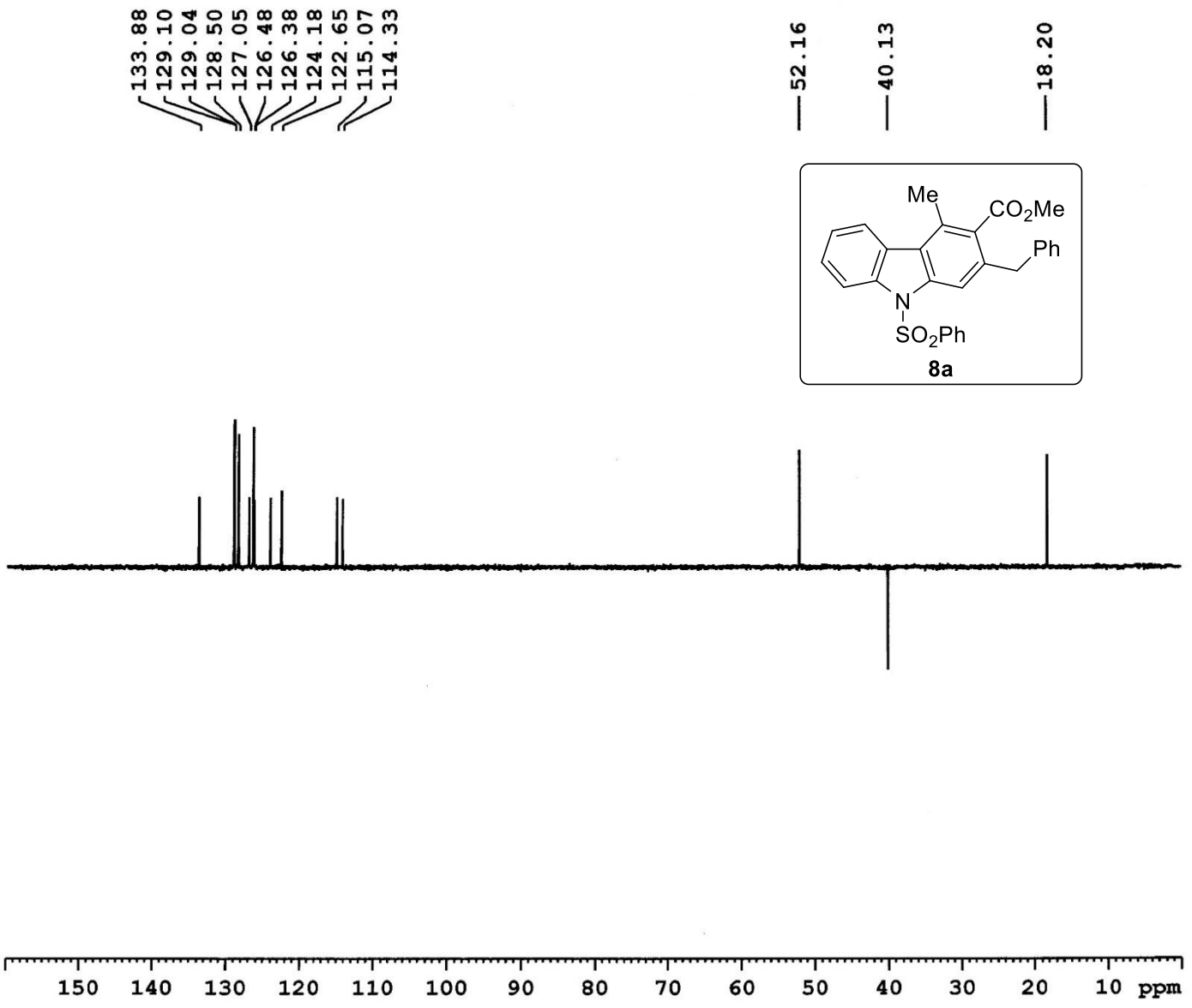
^{13}C {^{1}H} NMR (75 MHz, DMSO-d_6) spectrum of compound **5b**



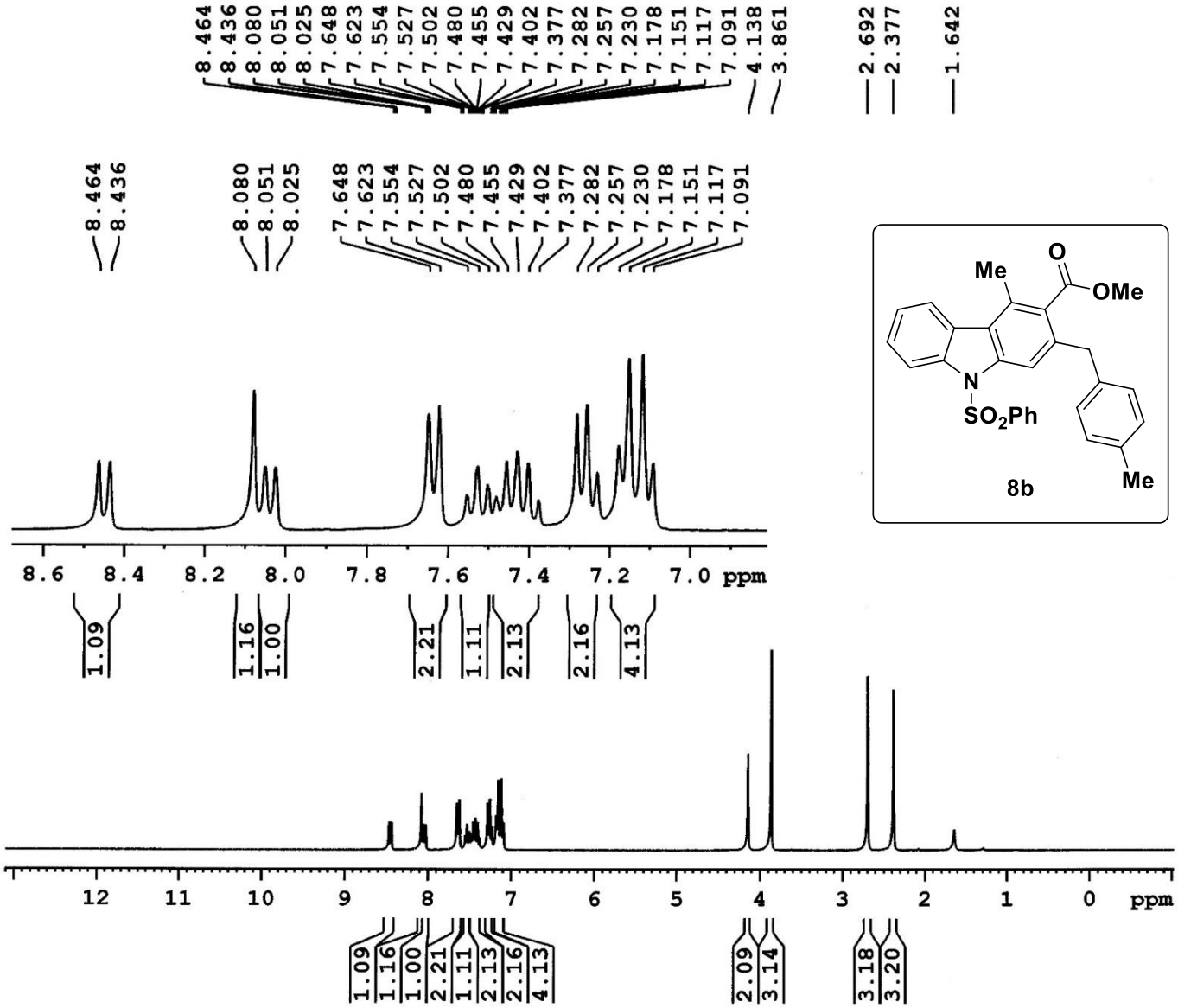
^{1}H NMR (300 MHz, $CDCl_3$) spectrum of compound **8a**



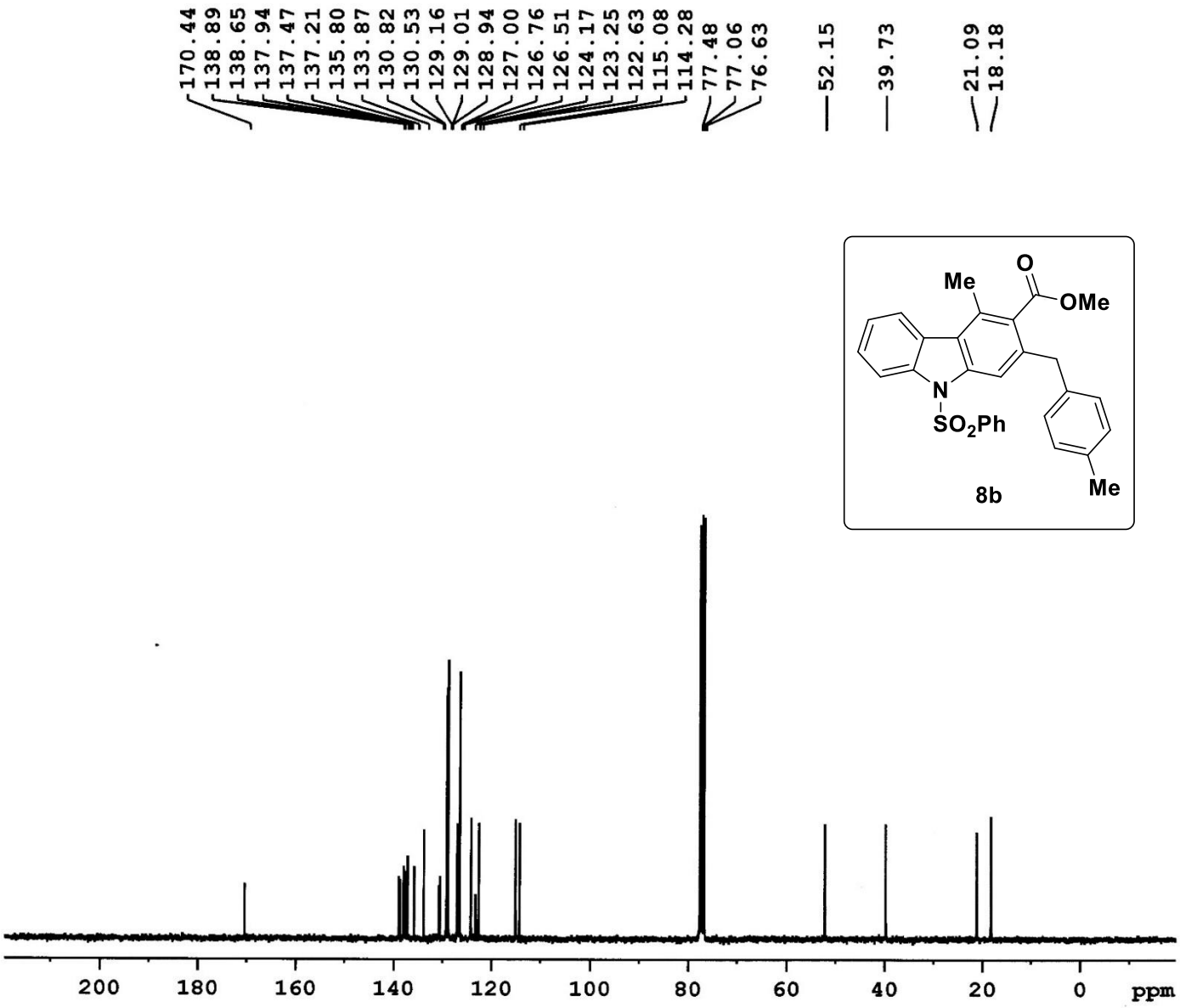
^{13}C {^{1}H} NMR (75 MHz, $CDCl_3$) spectrum of compound **8a**



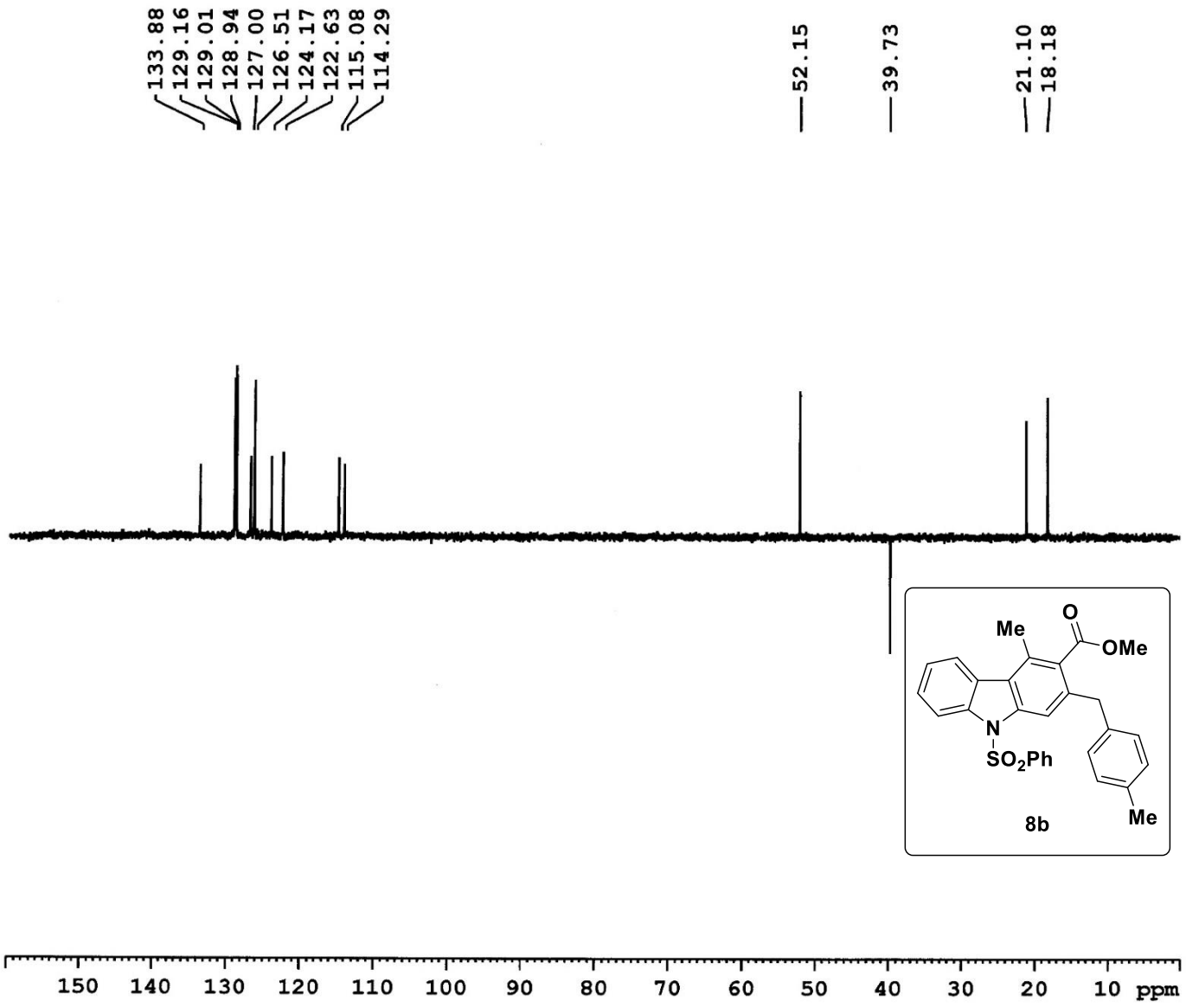
DEPT-135 NMR (75 MHz, $CDCl_3$) spectrum of compound **8a**



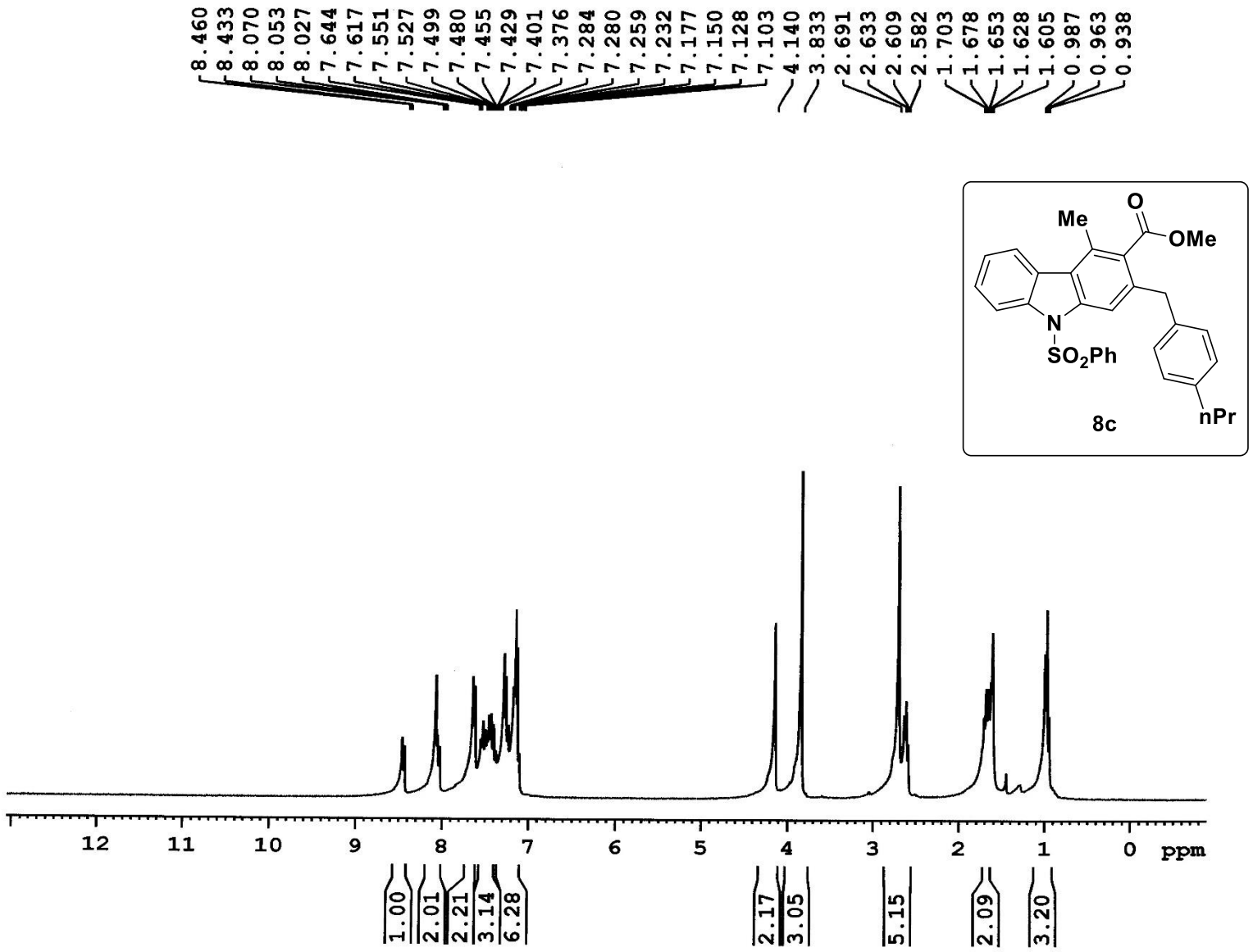
^{1}H NMR (300 MHz, $CDCl_3$) spectrum of compound **8b**



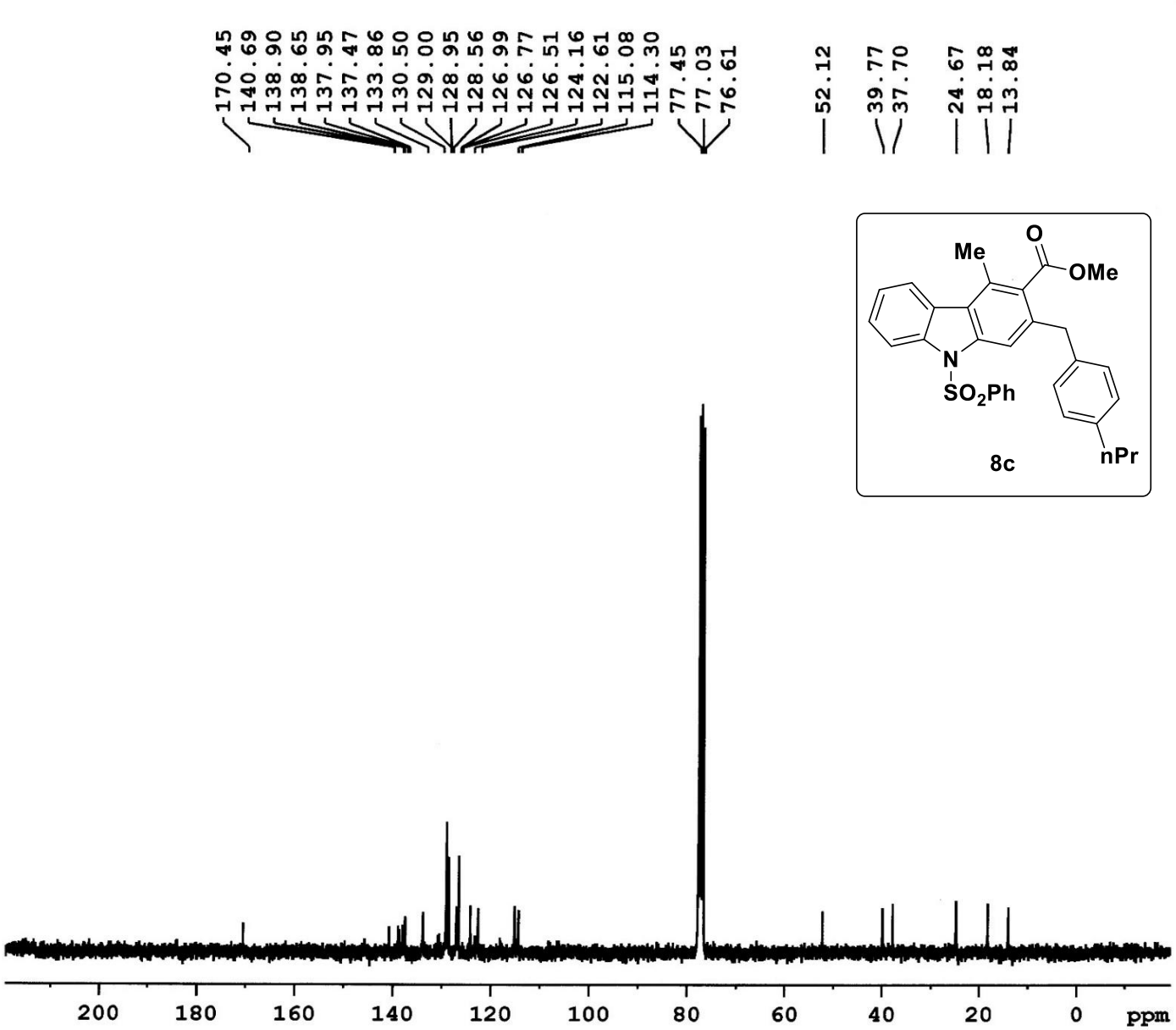
^{13}C {^{1}H} NMR (75 MHz, $CDCl_3$) spectrum of compound **8b**



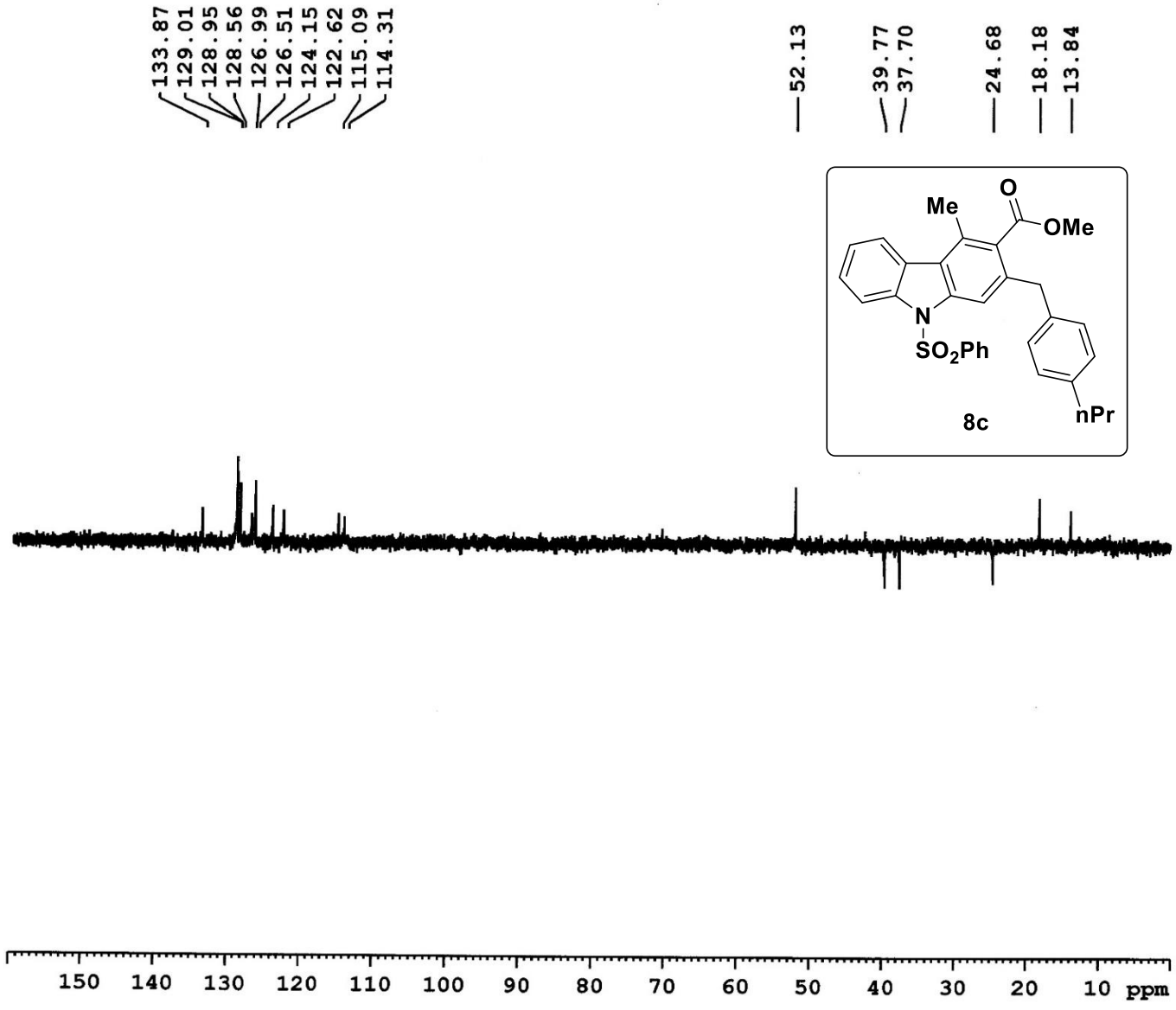
DEPT-135 NMR (75 MHz, $CDCl_3$) spectrum of compound **8b**



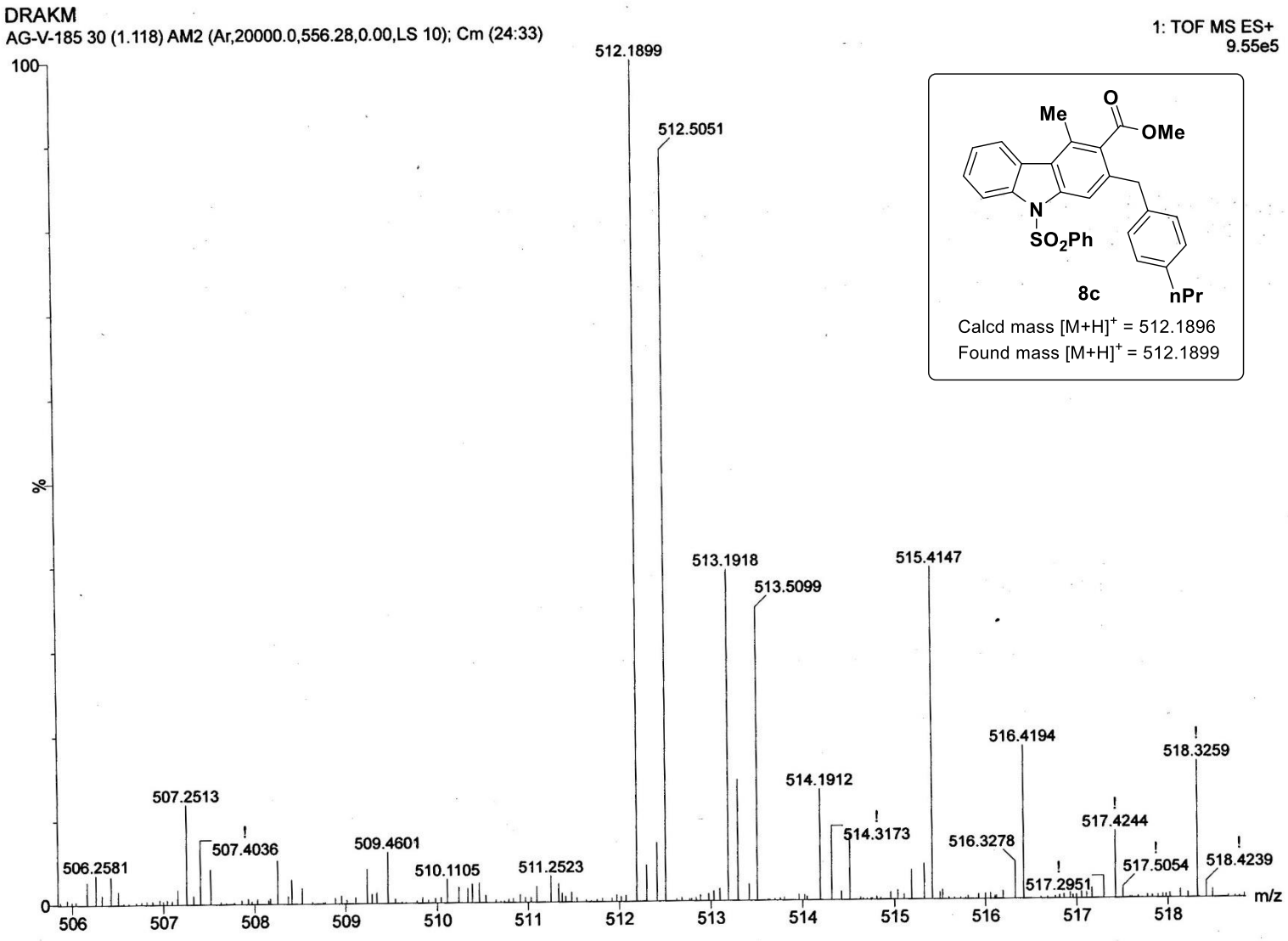
^{1}H NMR (300 MHz, $CDCl_3$) spectrum of compound **8c**



^{13}C {^{1}H} NMR (75 MHz, $CDCl_3$) spectrum of compound **8c**



DEPT-135 NMR (75 MHz, $CDCl_3$) spectrum of compound **8c**



HRMS Spectrum of compound **8c**

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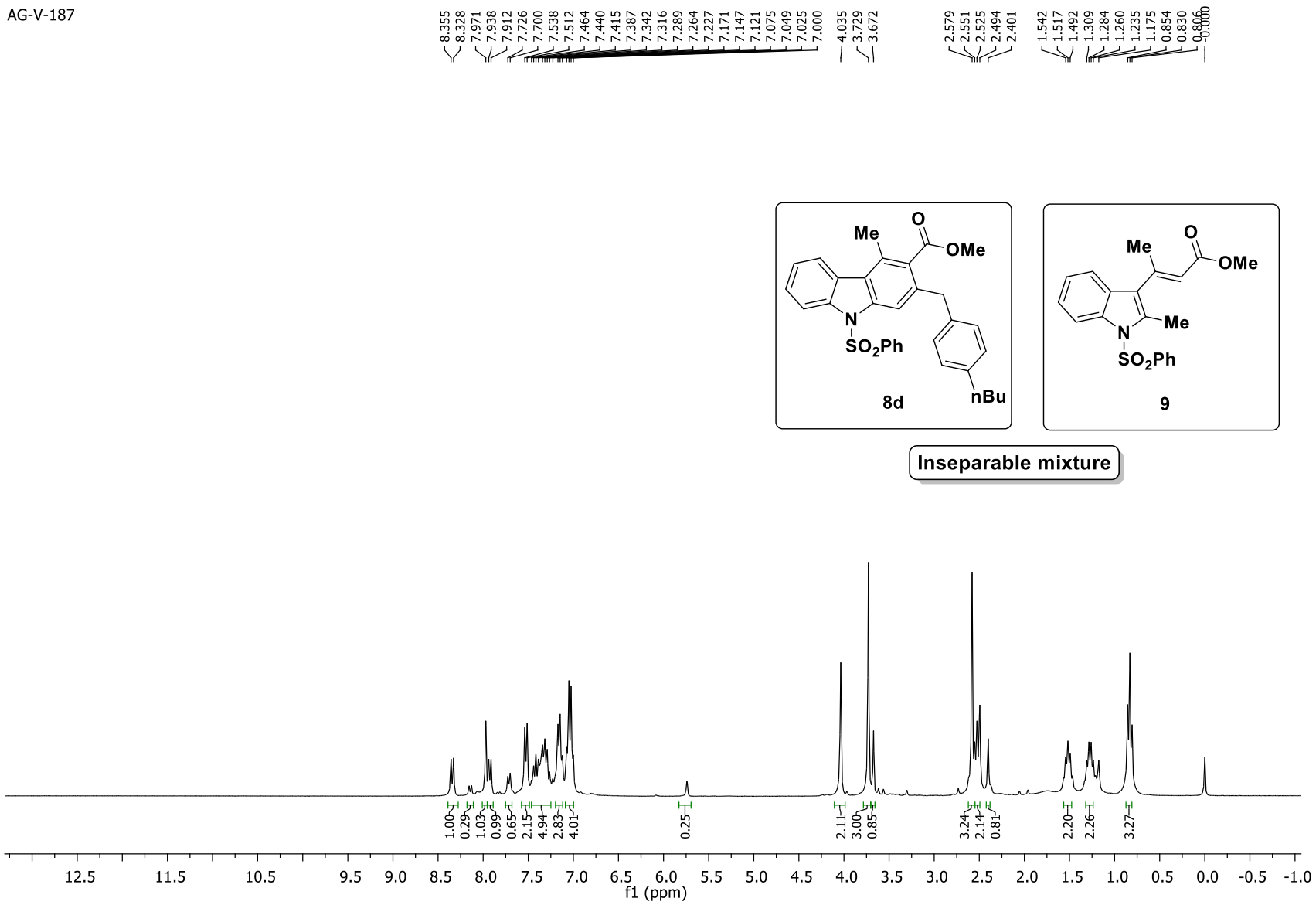
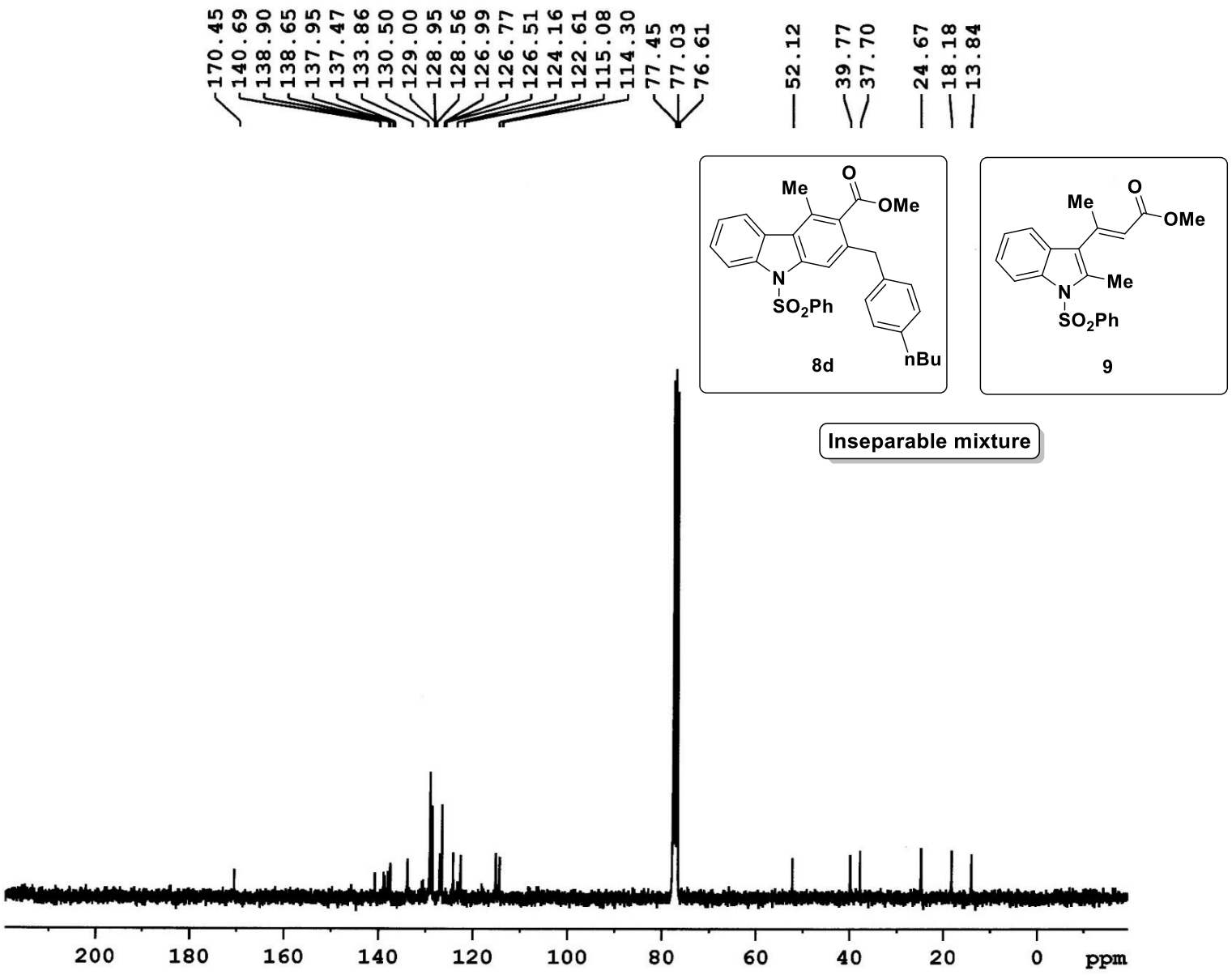
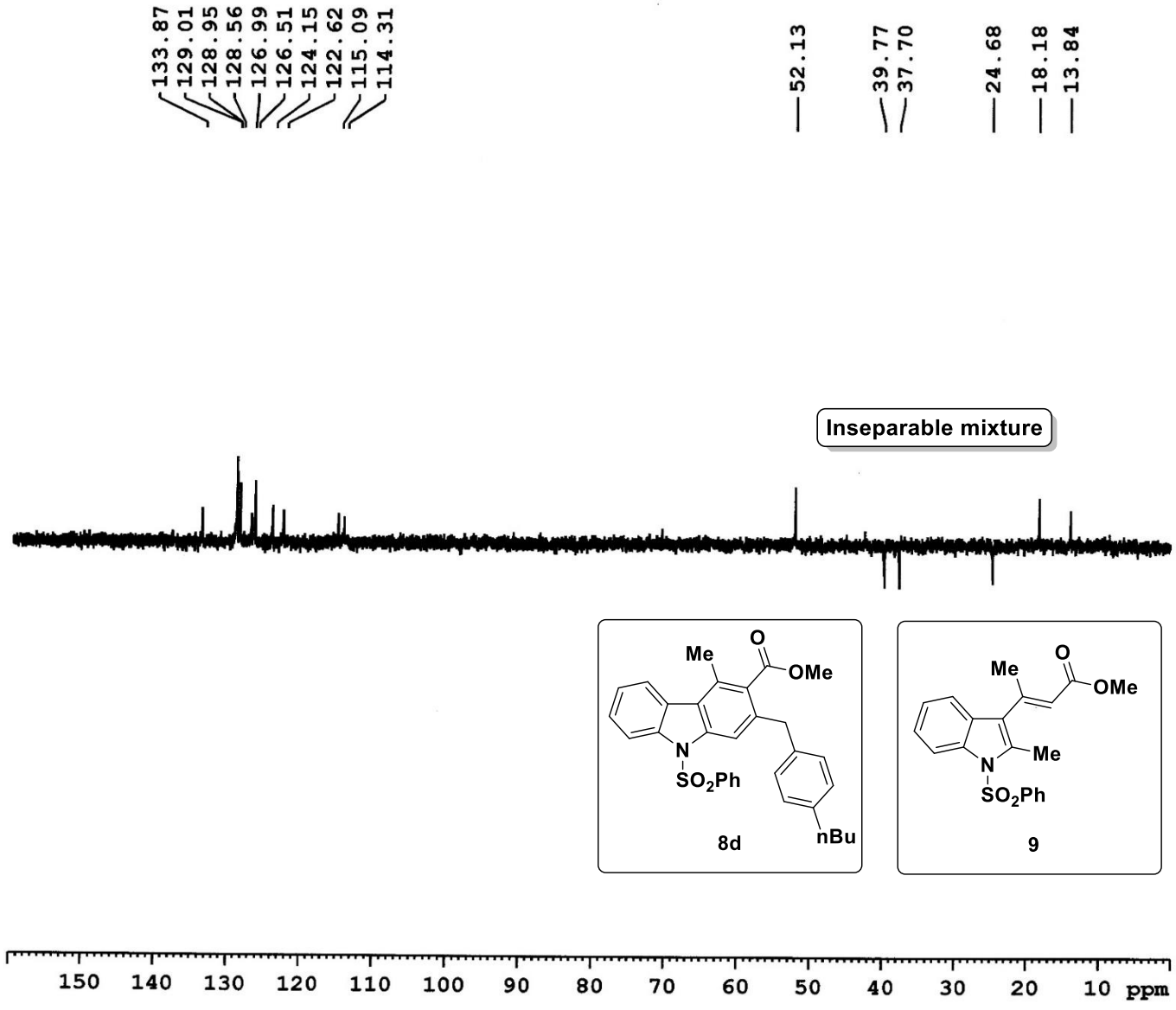


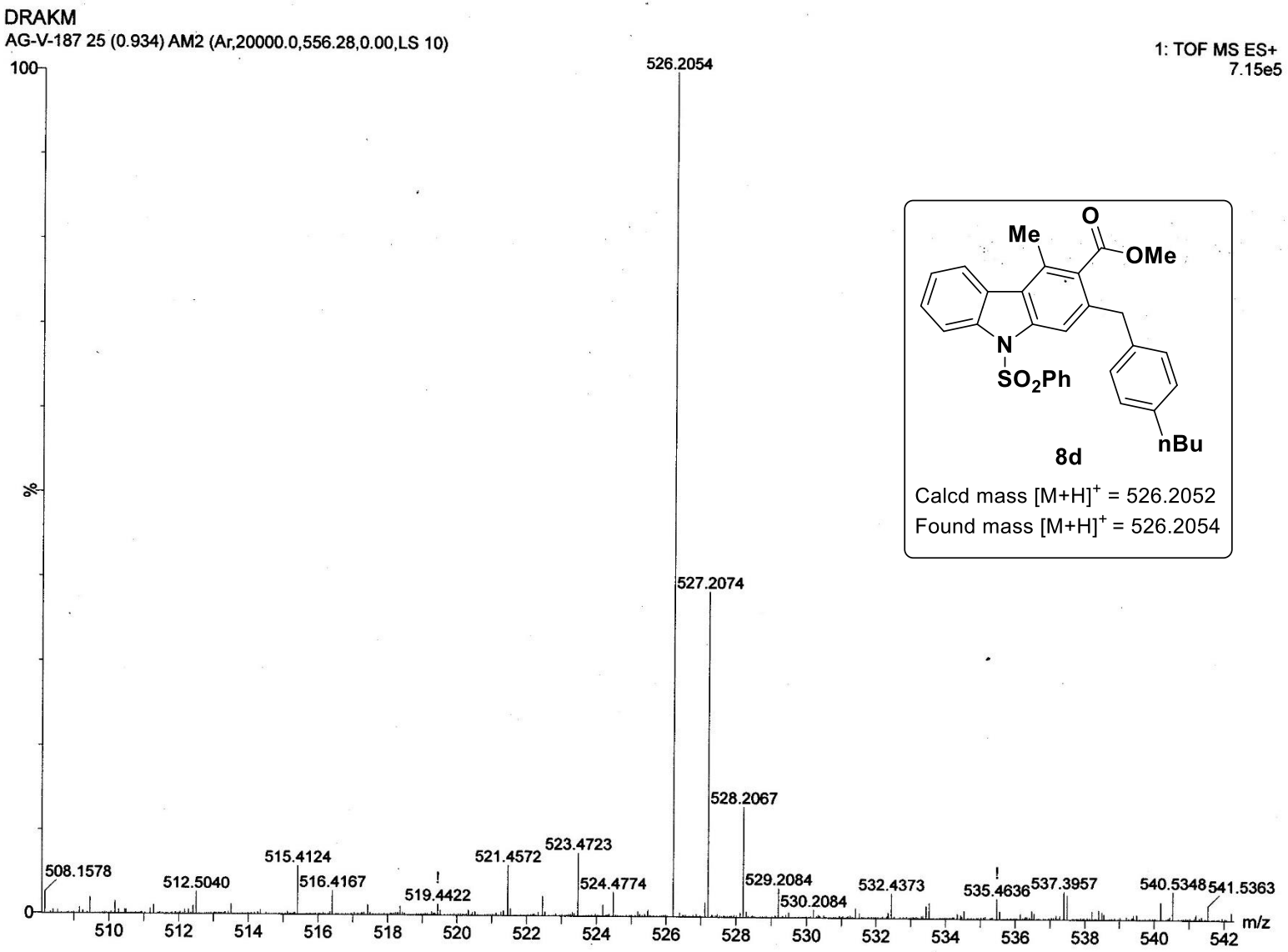
^{1}H NMR ($CDCl_3$, 300 MHz) spectrum of compounds **8d** & **9**



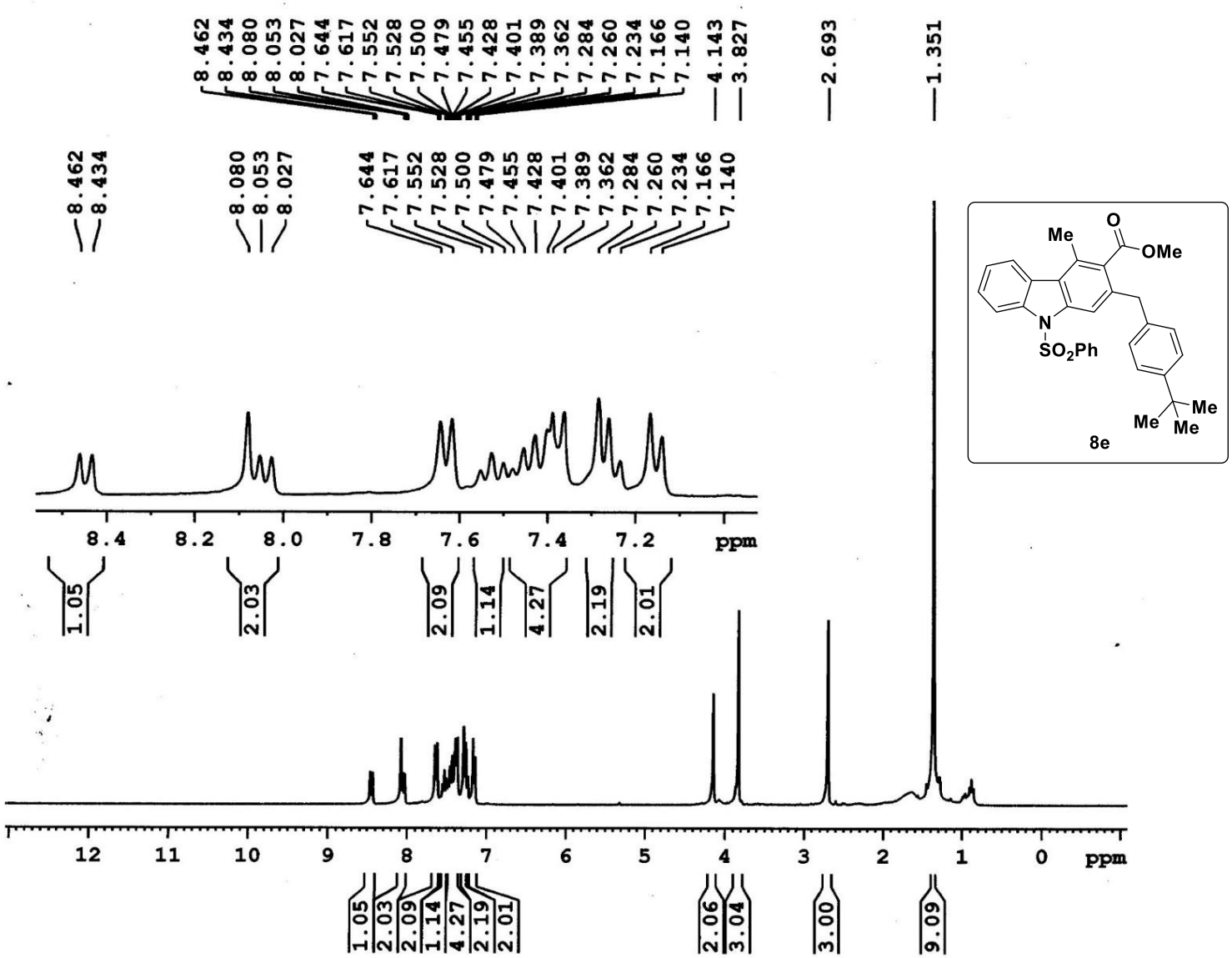
^{13}C {^{1}H} NMR (75 MHz, $CDCl_3$) spectrum of compounds **8d & 9**



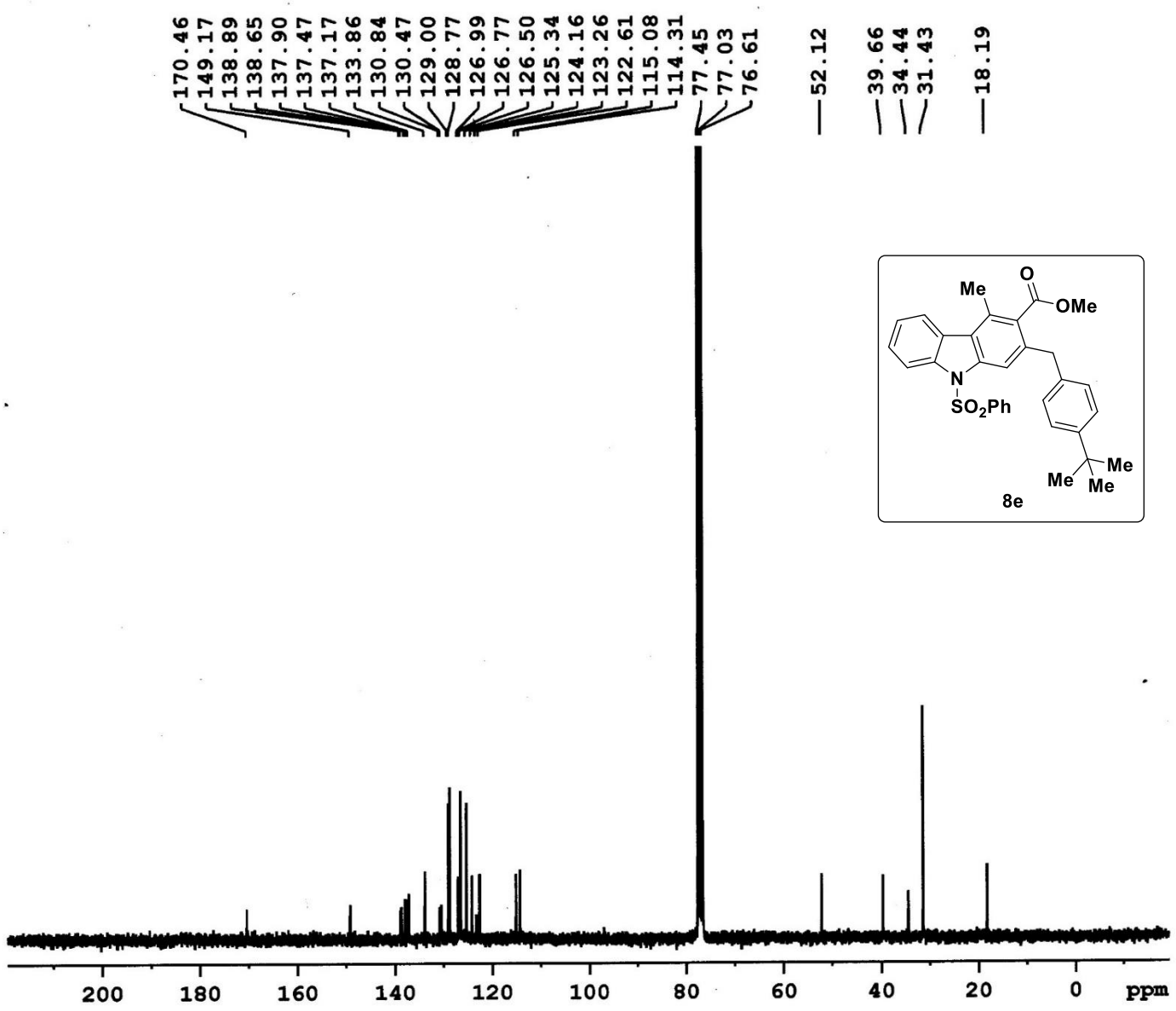
DEPT-135 NMR (75 MHz, $CDCl_3$) spectrum of compounds **8d &9**



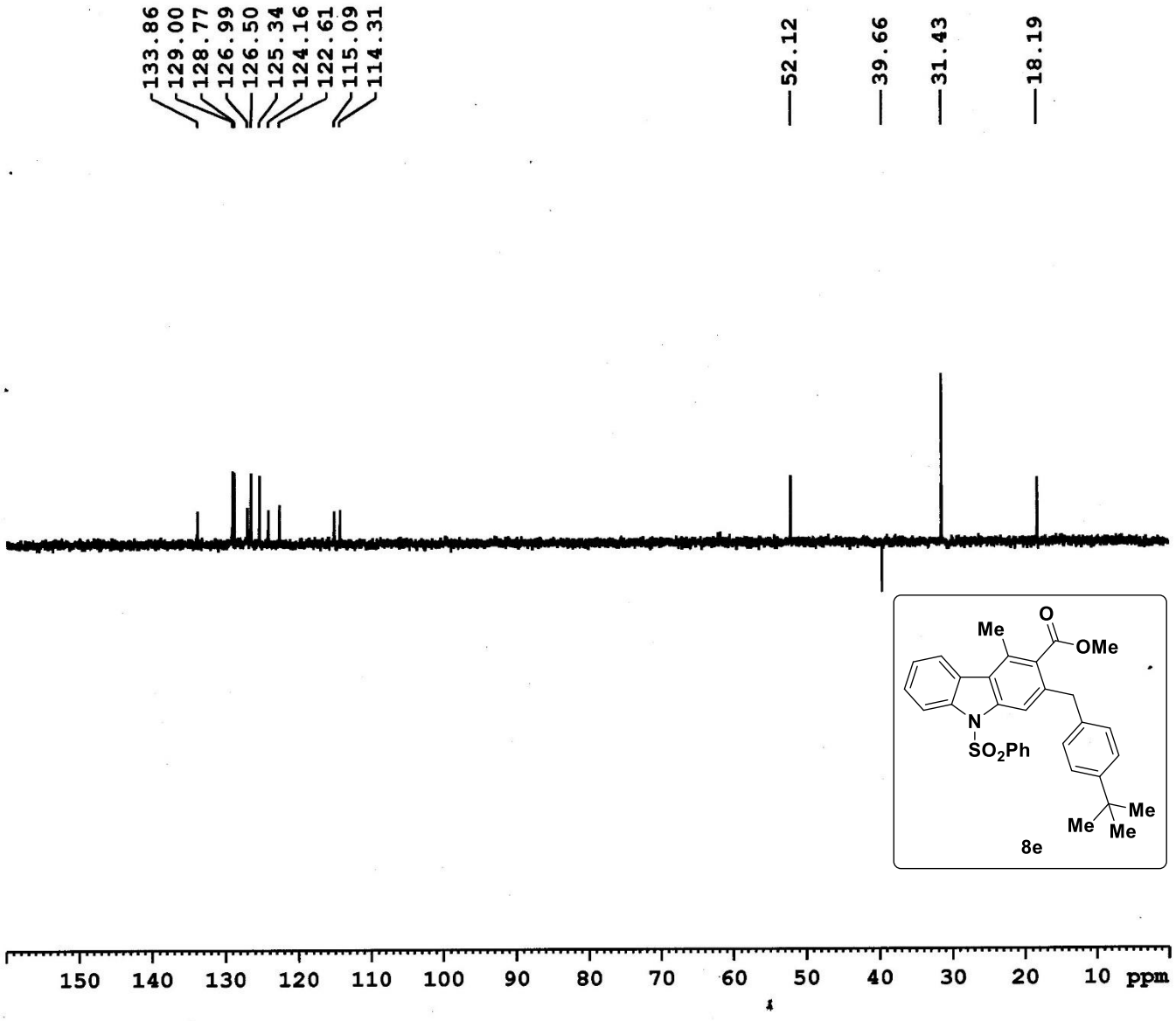
HRMS Spectrum of compound **8d**



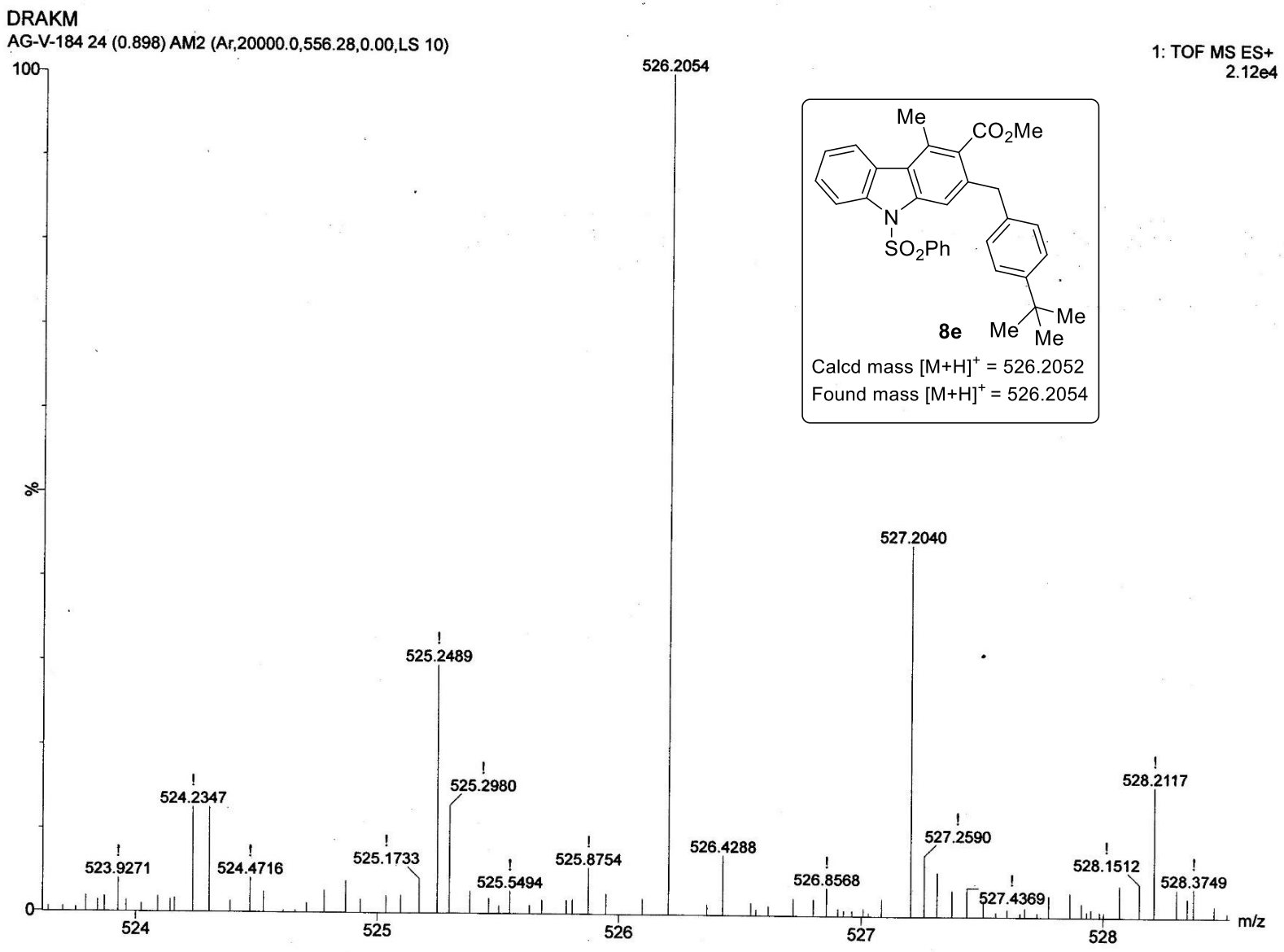
^{1}H NMR (300 MHz, $CDCl_3$) spectrum of compound **8e**



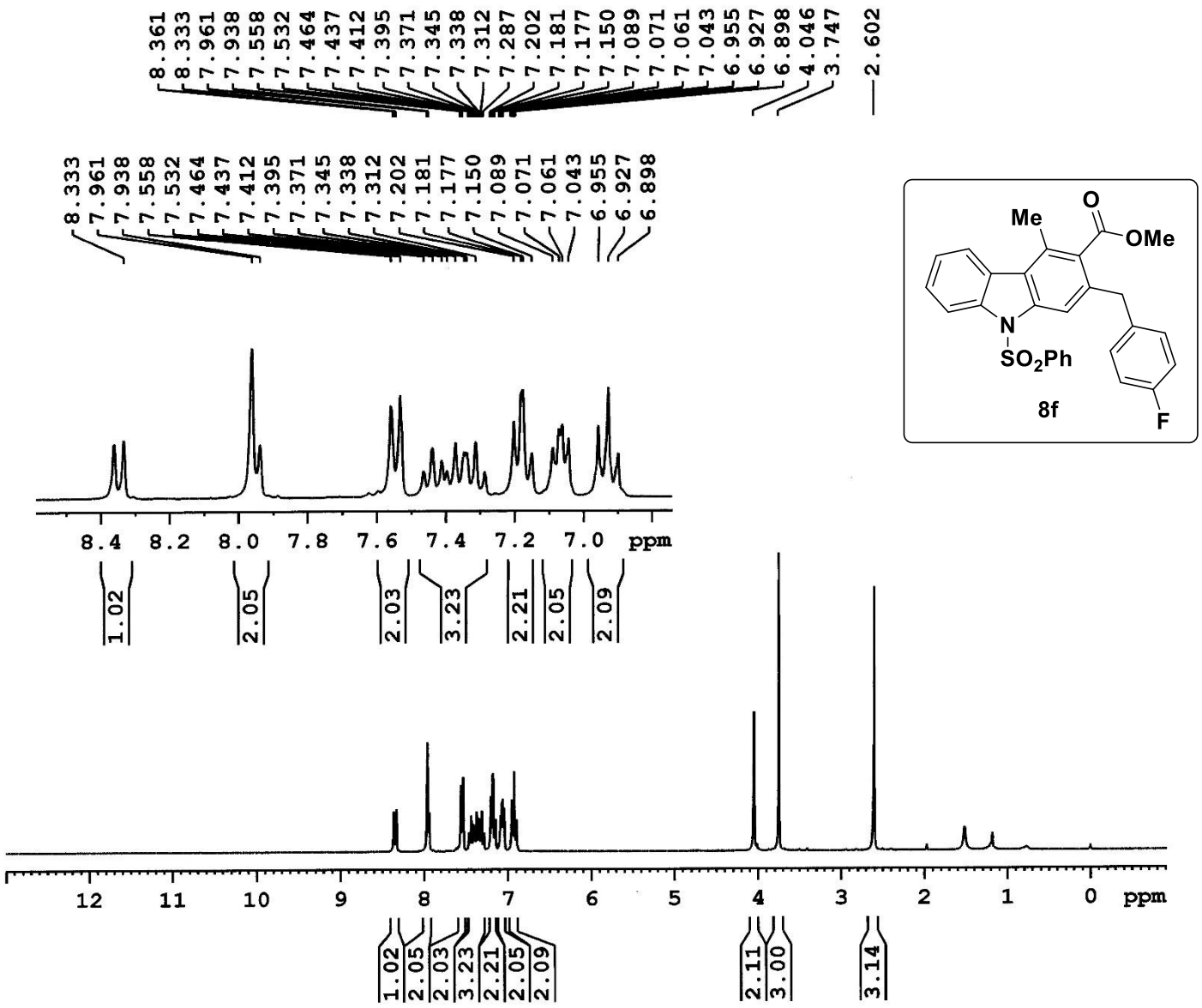
^{13}C {^{1}H} NMR (75 MHz, $CDCl_3$) spectrum of compound **8e**



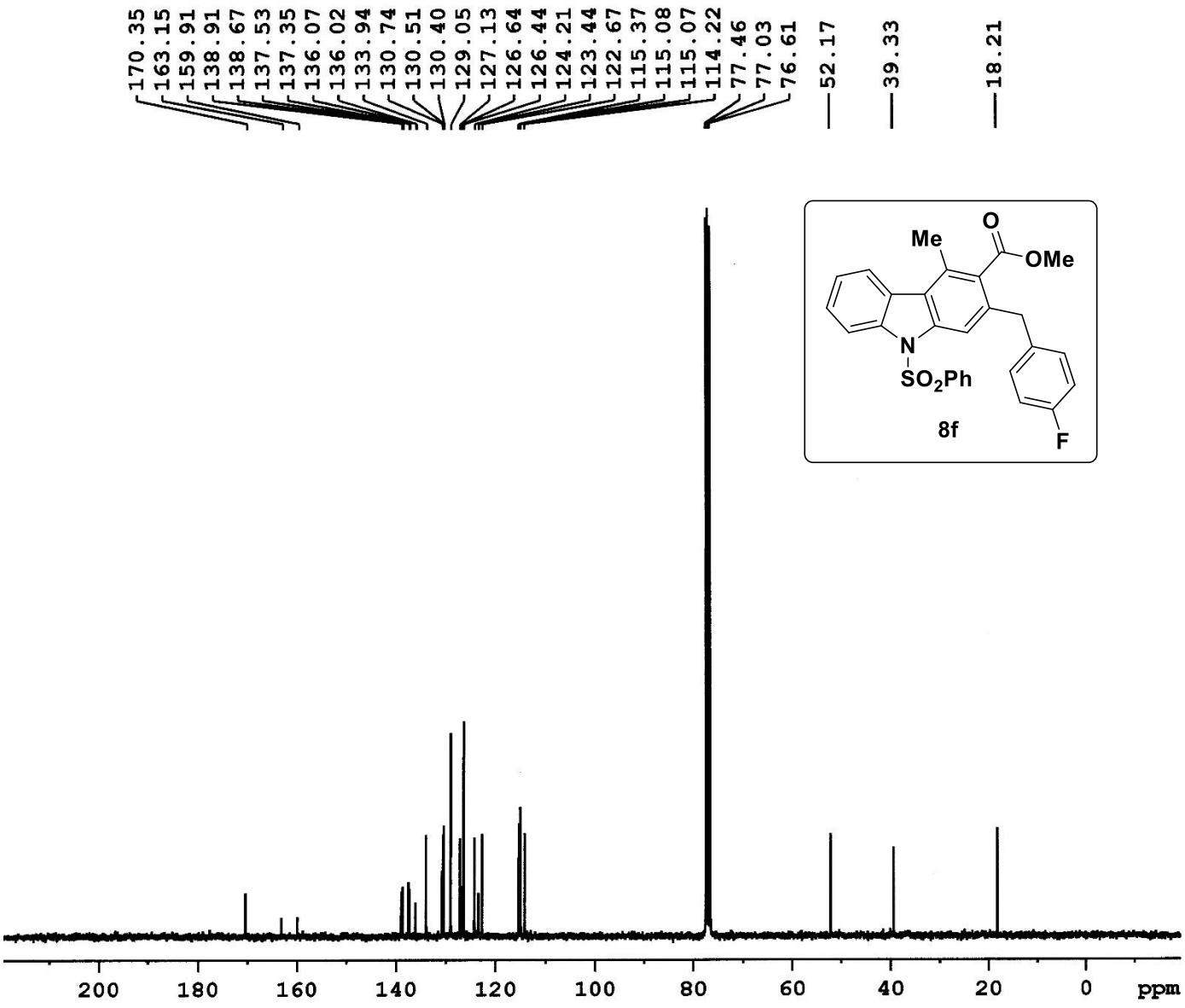
DEPT-135 NMR (75 MHz, $CDCl_3$) spectrum of compound **8e**



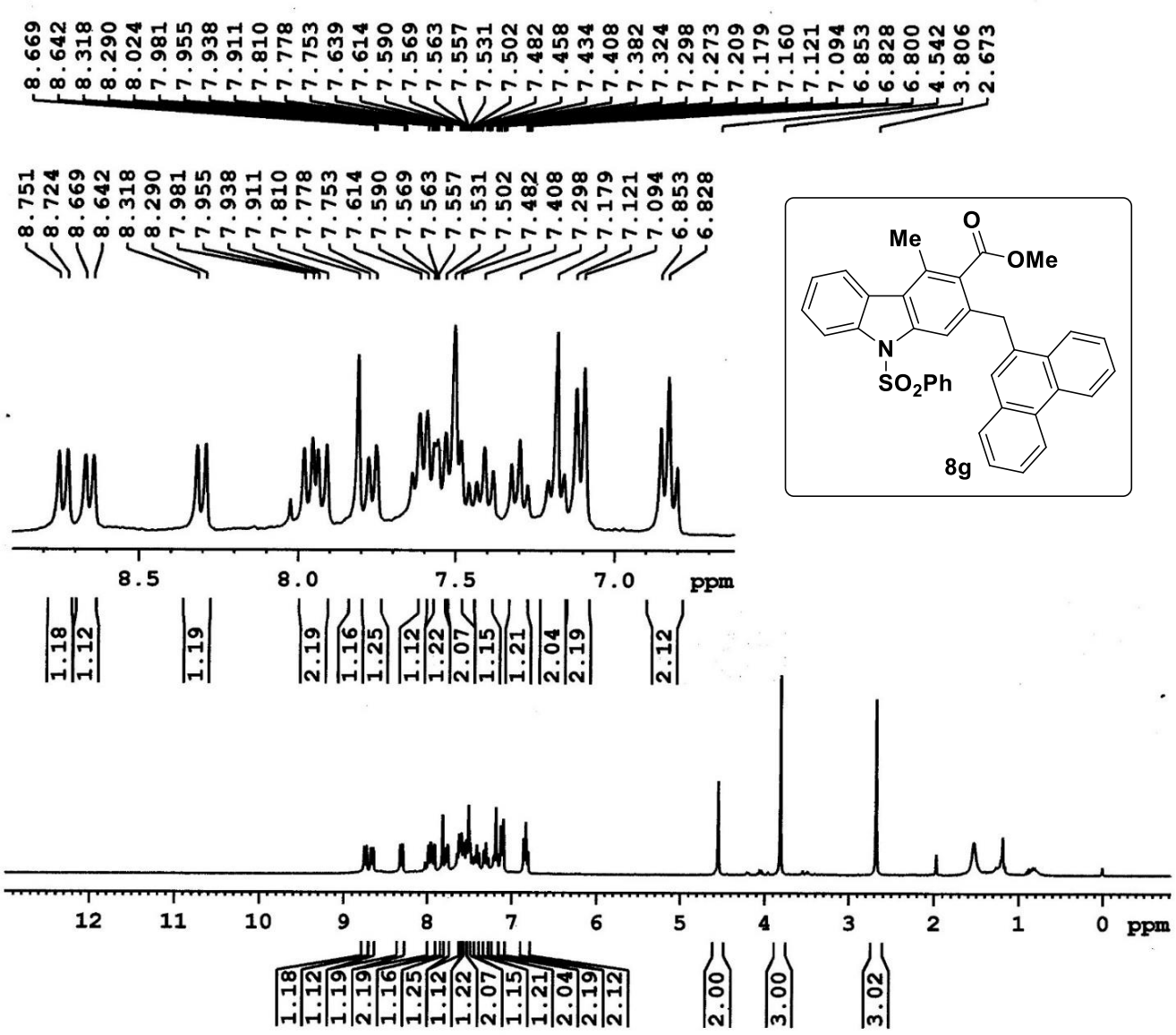
HRMS Spectrum of compound **8e**



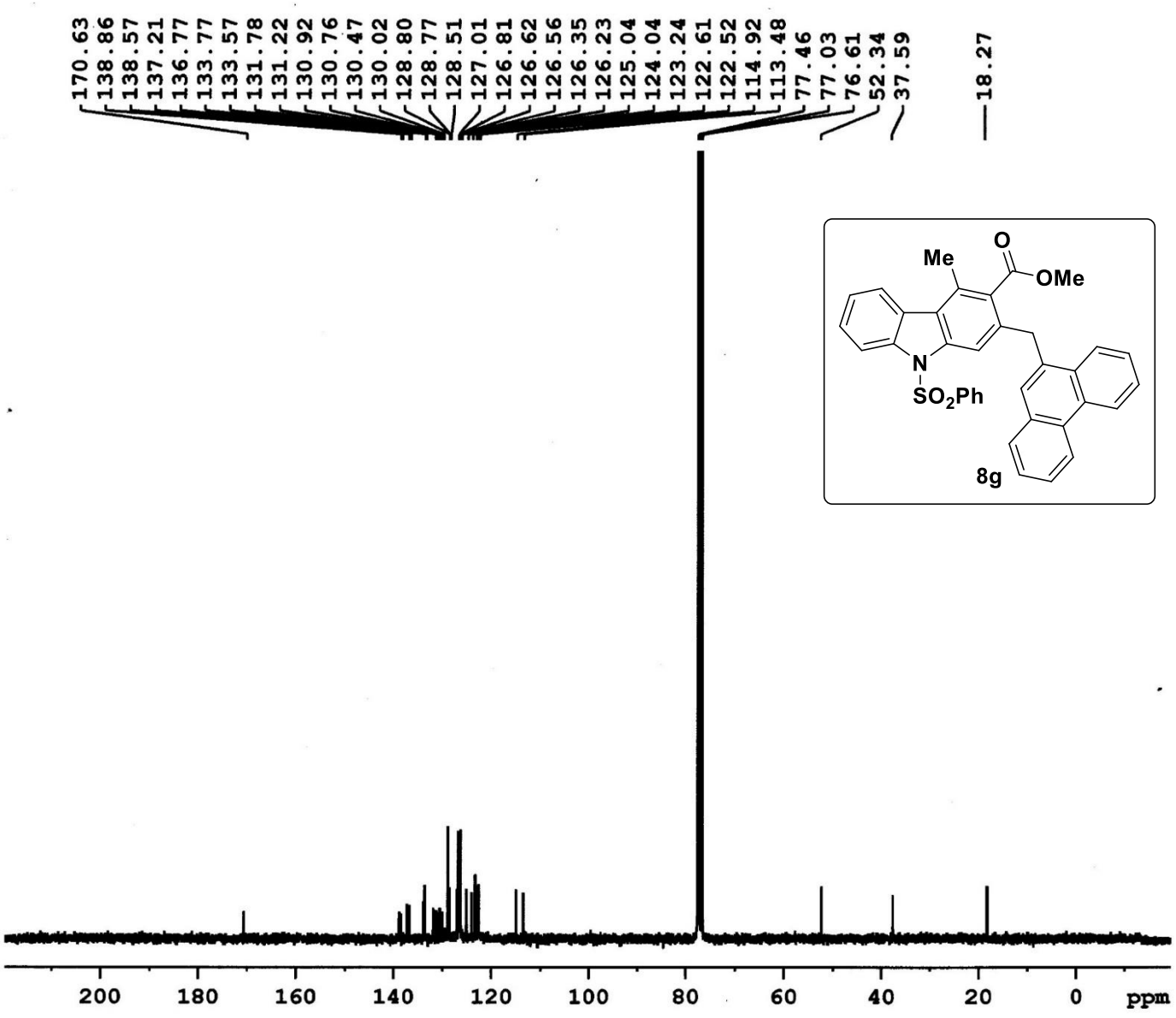
^{1}H NMR (300 MHz, $CDCl_3$) spectrum of compound **8f**



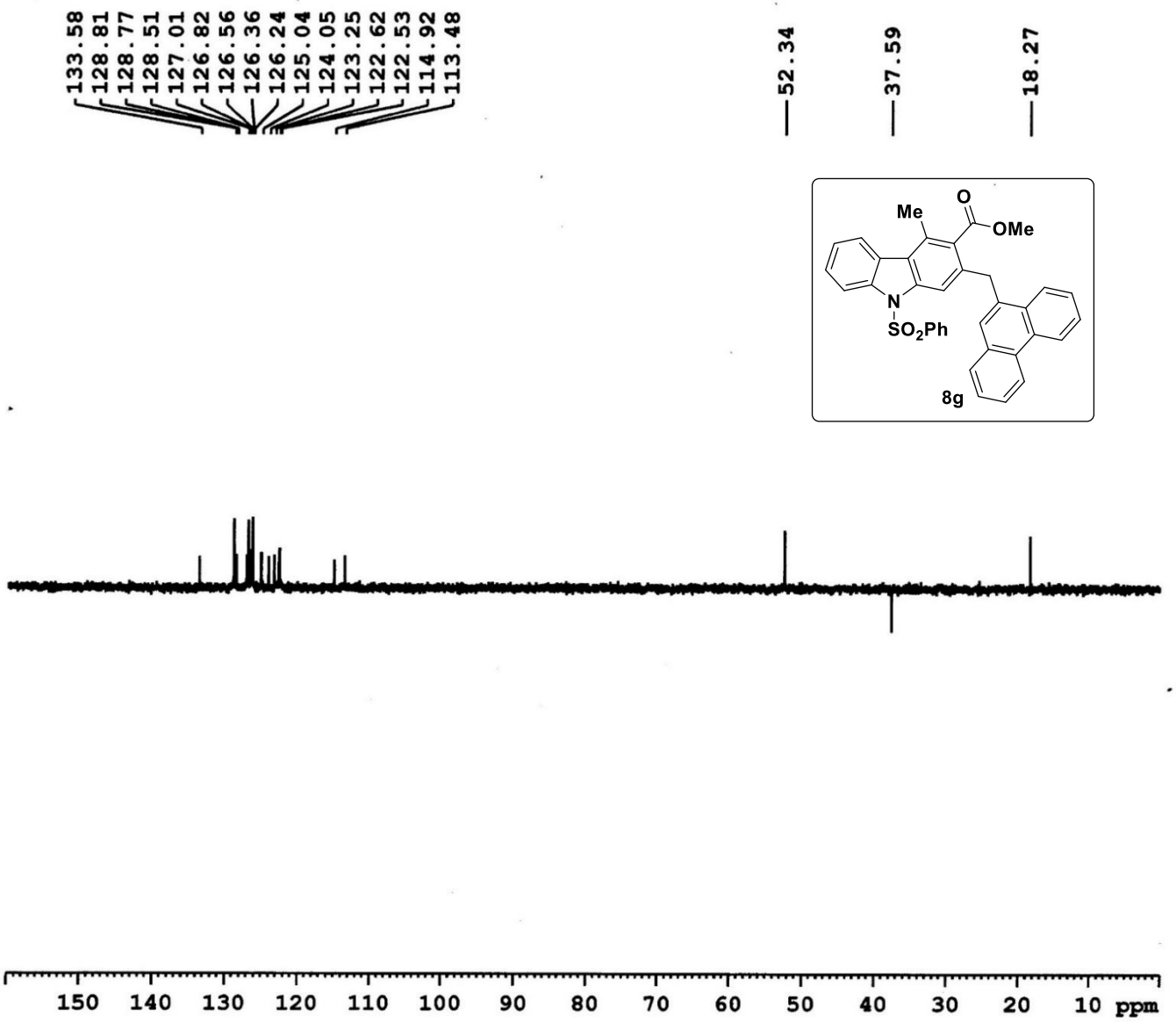
^{13}C {^{1}H} NMR (75 MHz, $CDCl_3$) spectrum of compound **8f**



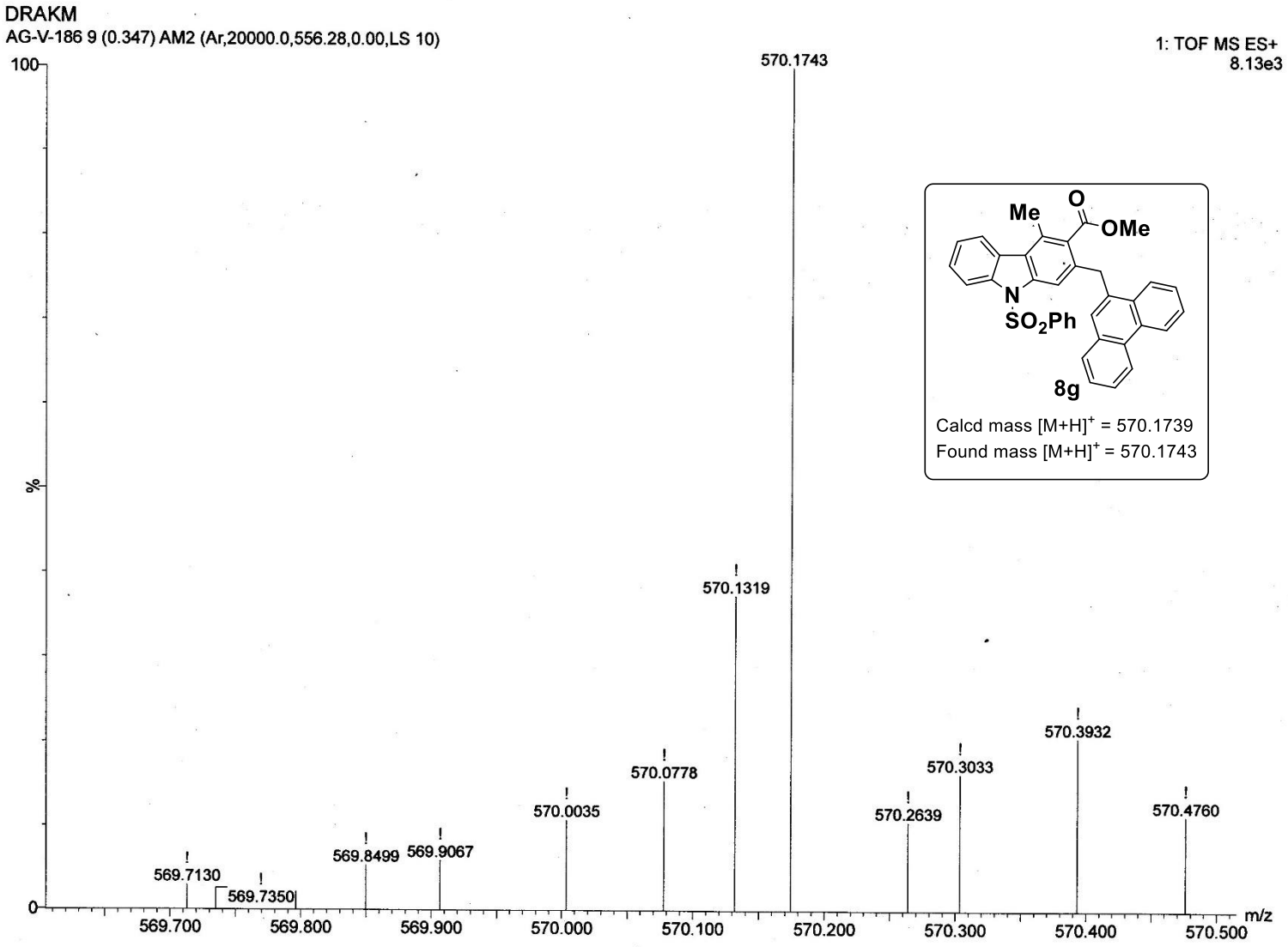
^{1}H NMR (300 MHz, $CDCl_3$) spectrum of compound **8g**



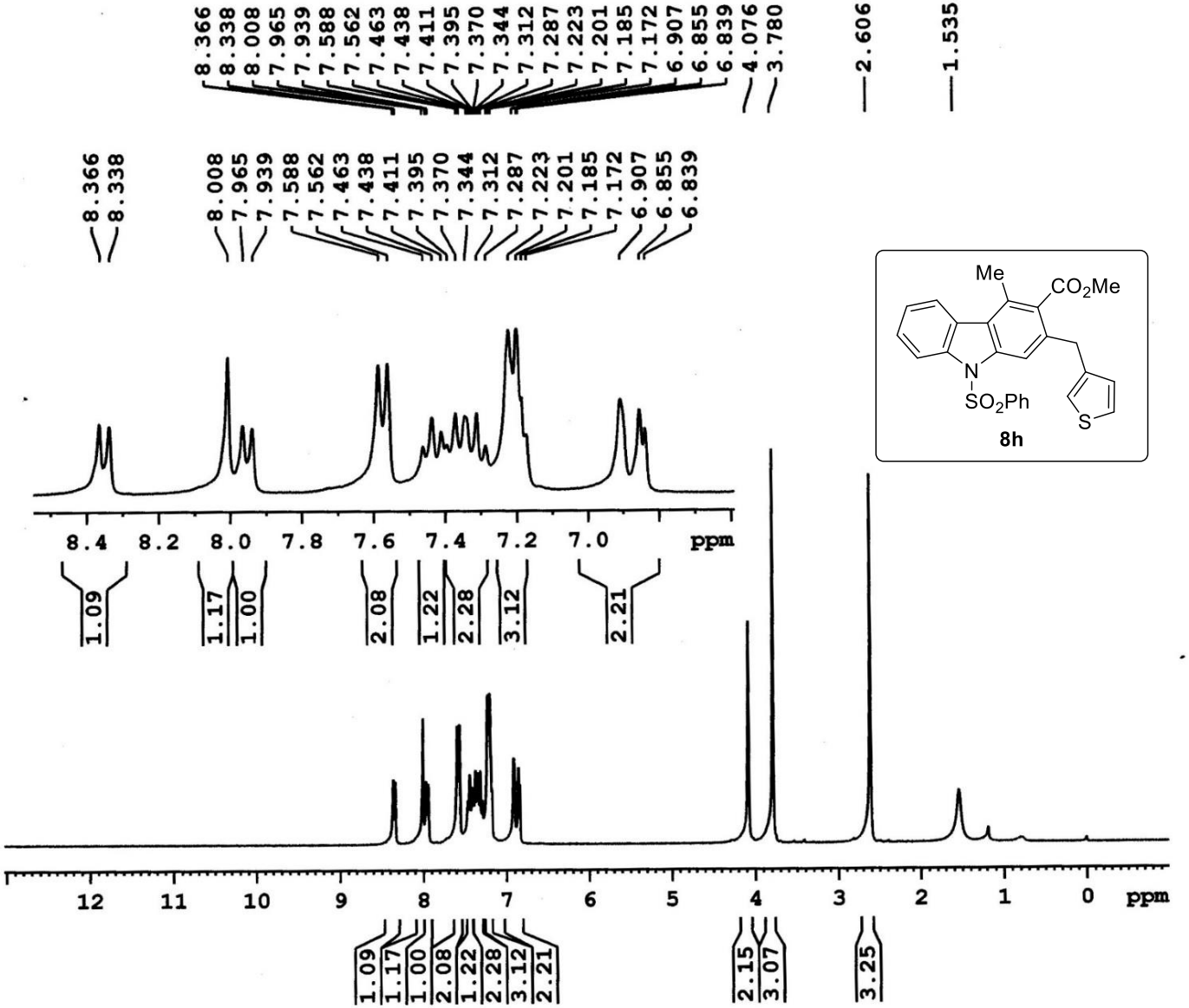
^{13}C {^{1}H} NMR (75 MHz, $CDCl_3$) spectrum of compound **8g**



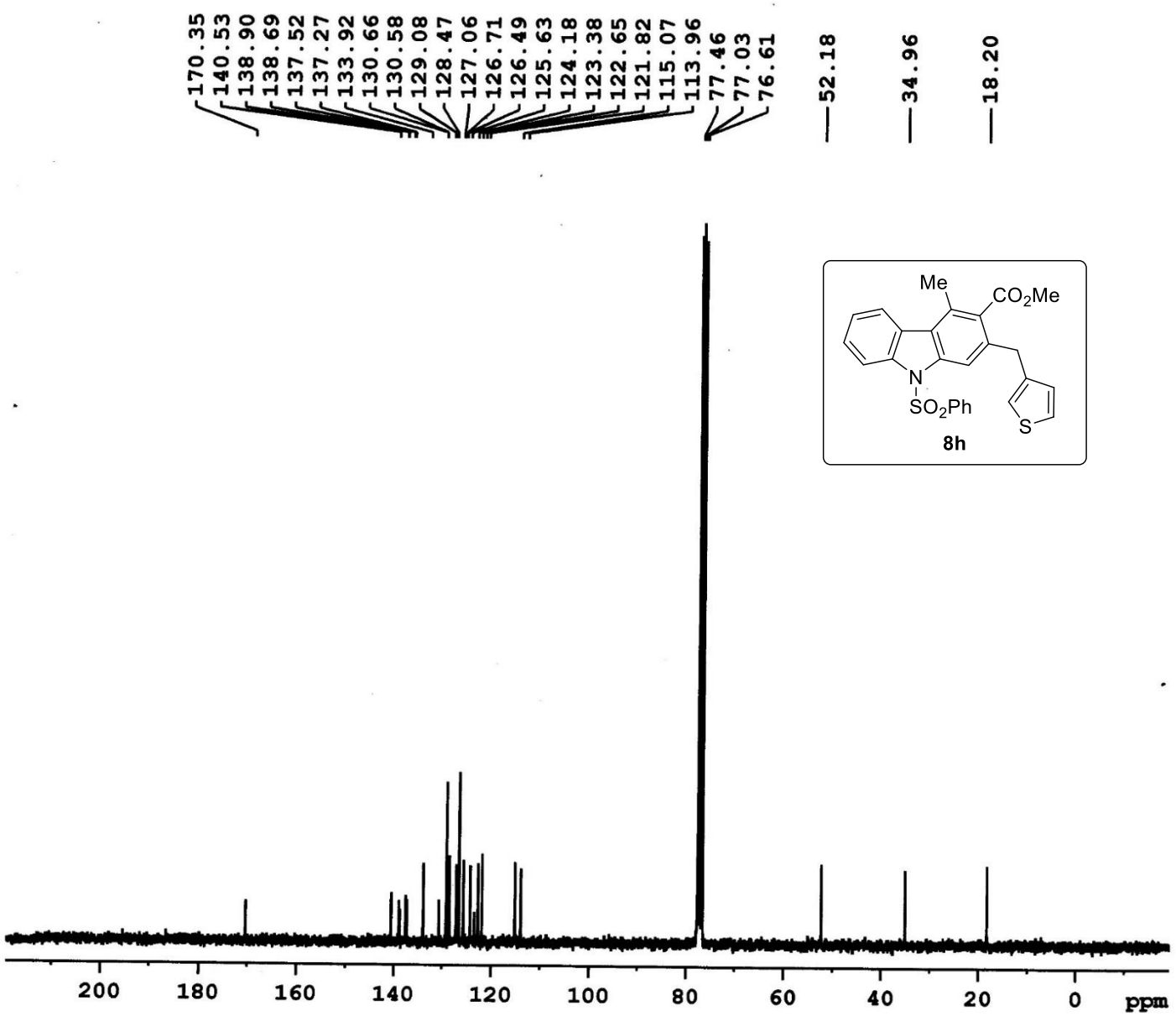
DEPT-135 NMR (75 MHz, $CDCl_3$) spectrum of compound **8g**



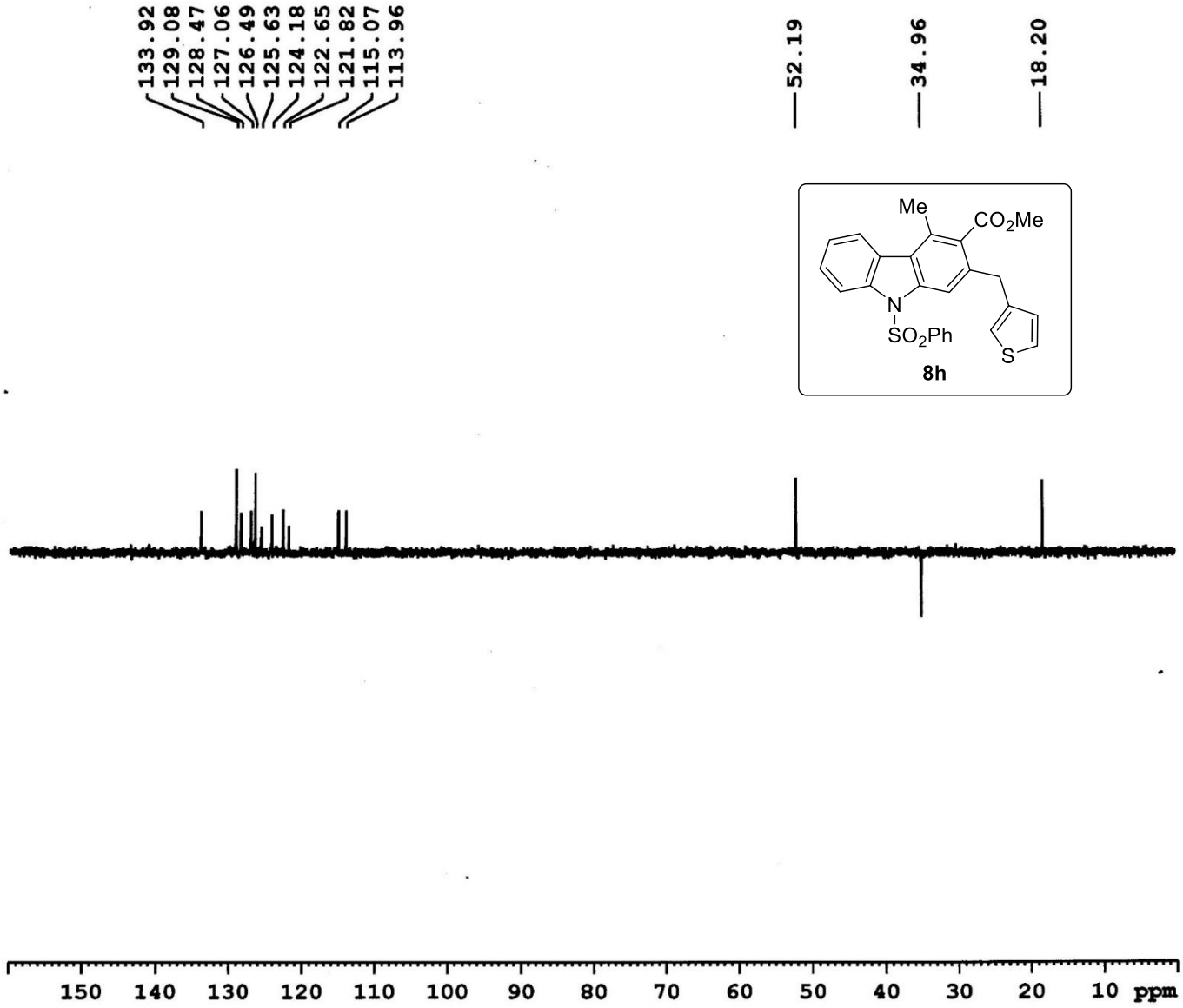
HRMS Spectrum of compound **8g**



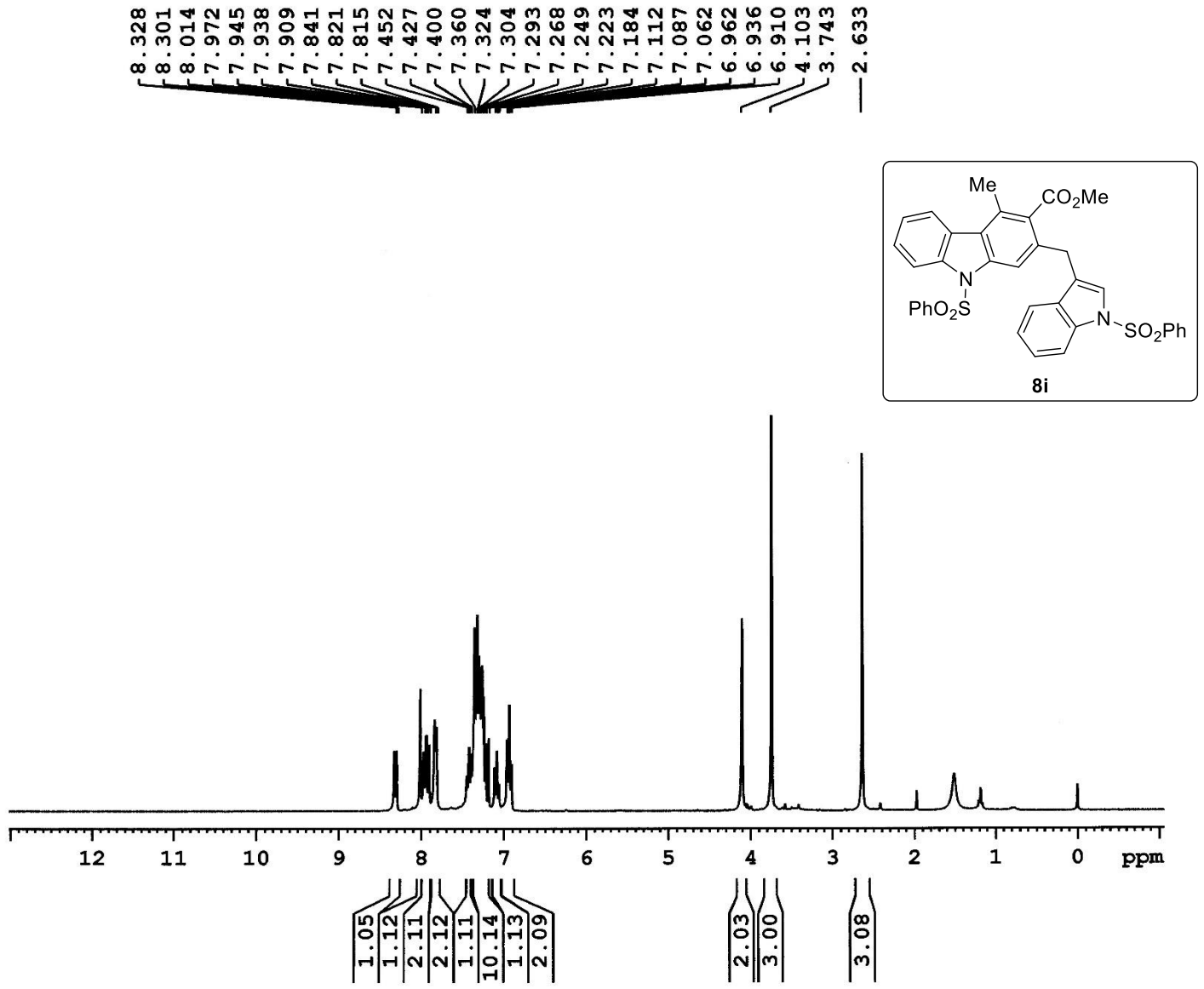
^{1}H NMR (300 MHz, $CDCl_3$) spectrum of compound **8h**



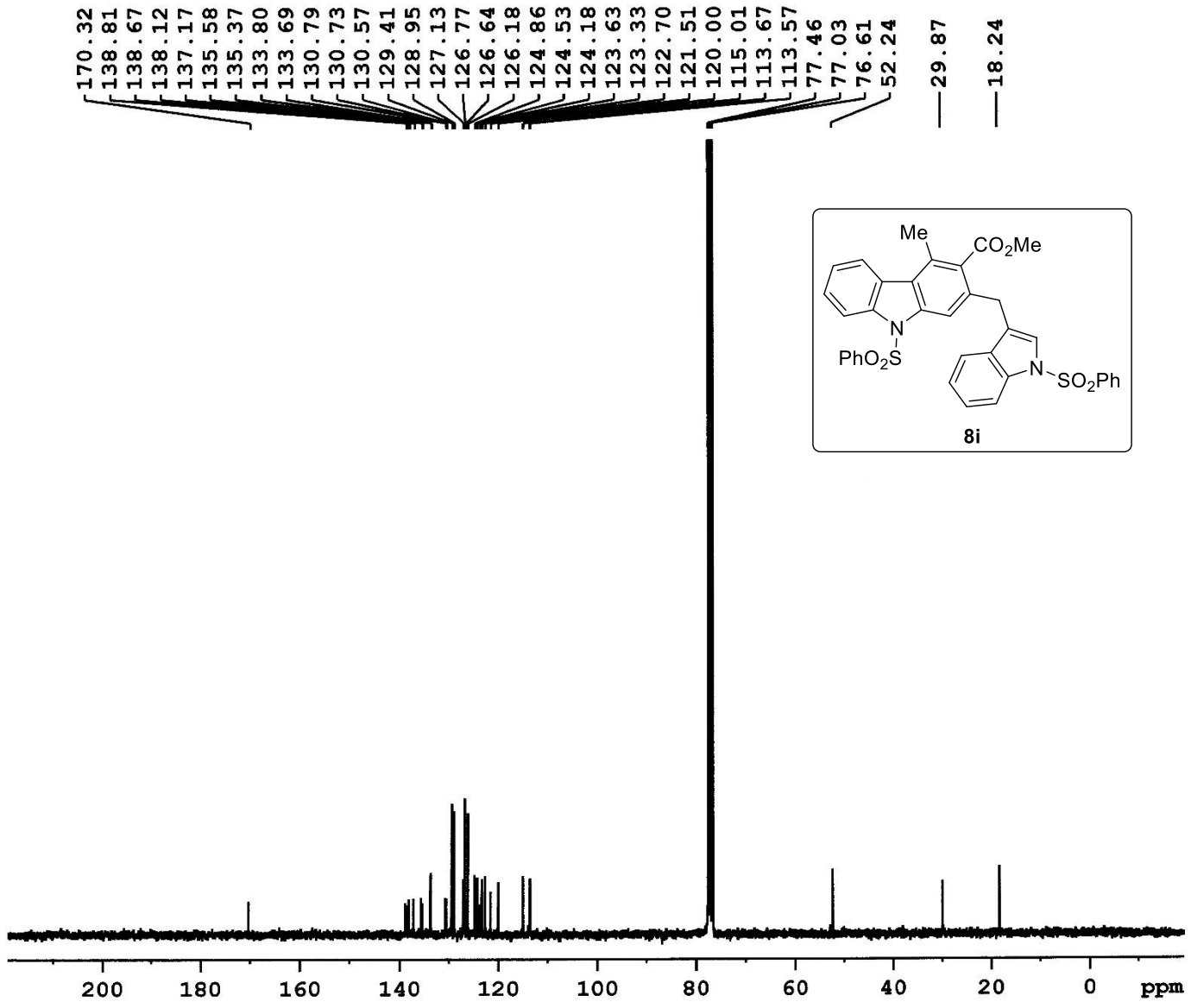
^{13}C {^{1}H} NMR ($CDCl_3$, 75 MHz) spectrum of compound **8h**



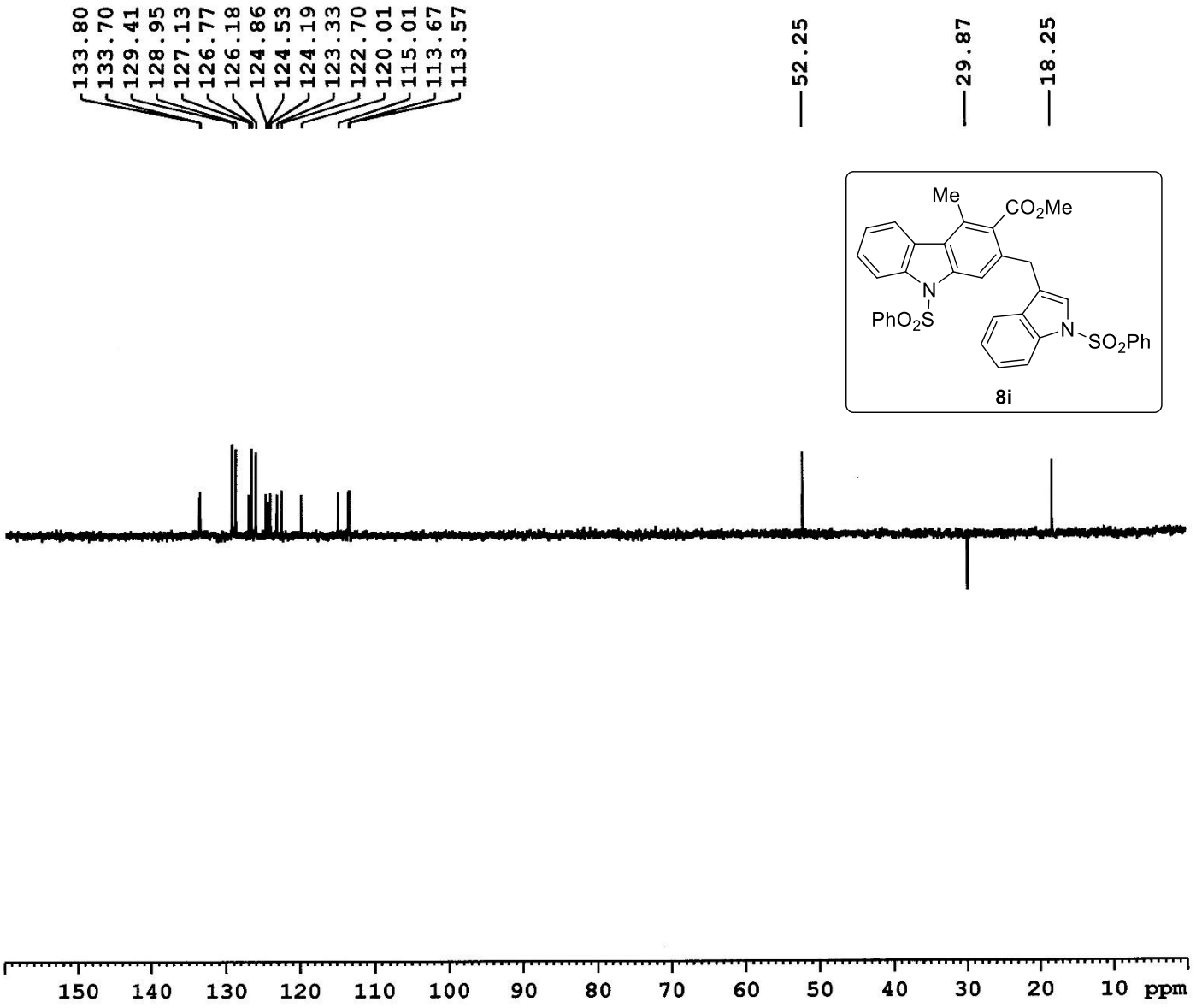
DEPT-135 NMR (75 MHz, $CDCl_3$) spectrum of compound **8h**



^{1}H NMR (300 MHz, $CDCl_3$) spectrum of compound **8i**



^{13}C {^{1}H} NMR ($CDCl_3$, 75 MHz) spectrum of compound **8i**



DEPT-135 NMR (75 MHz, $CDCl_3$) spectrum of compound **8i**

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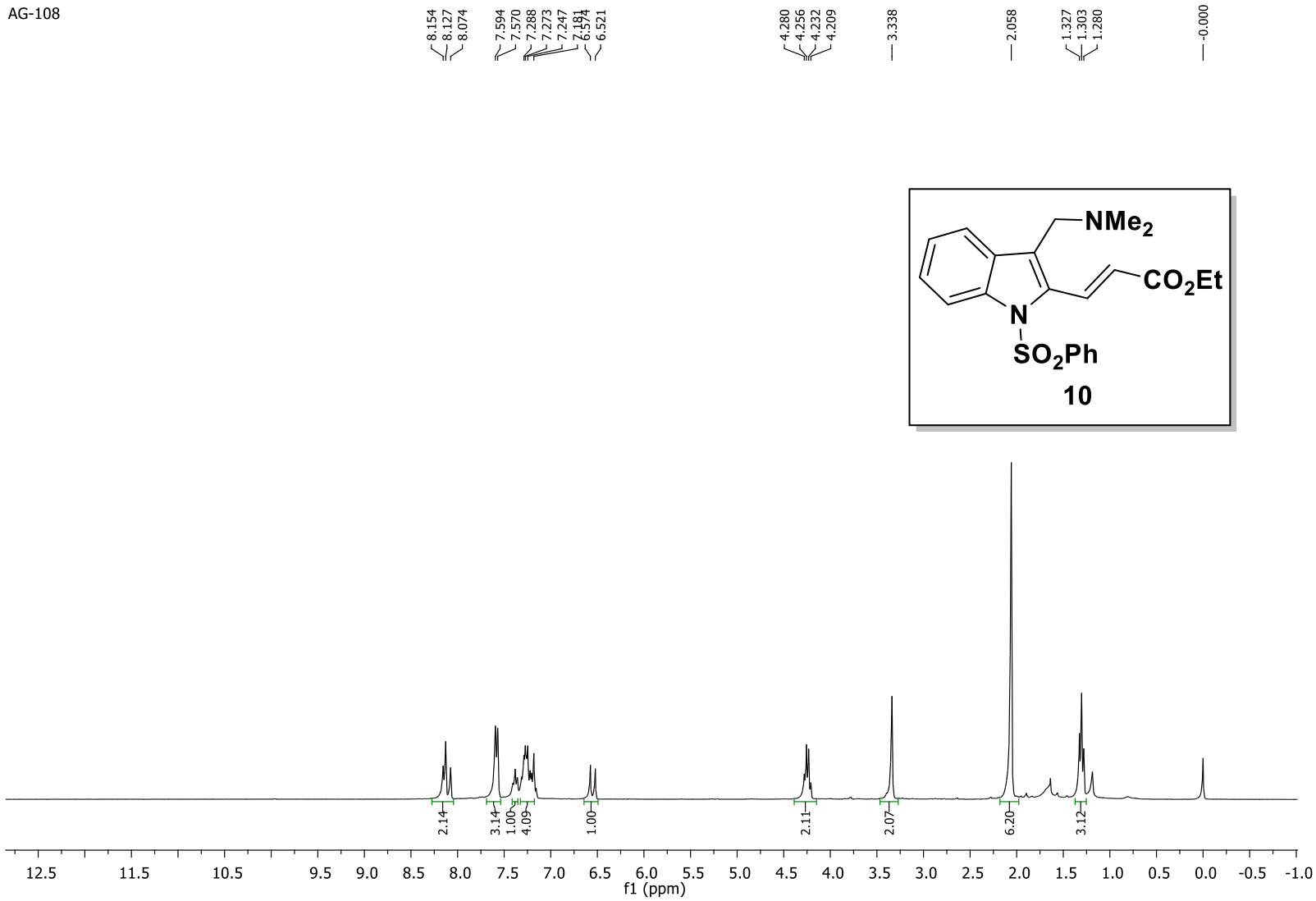
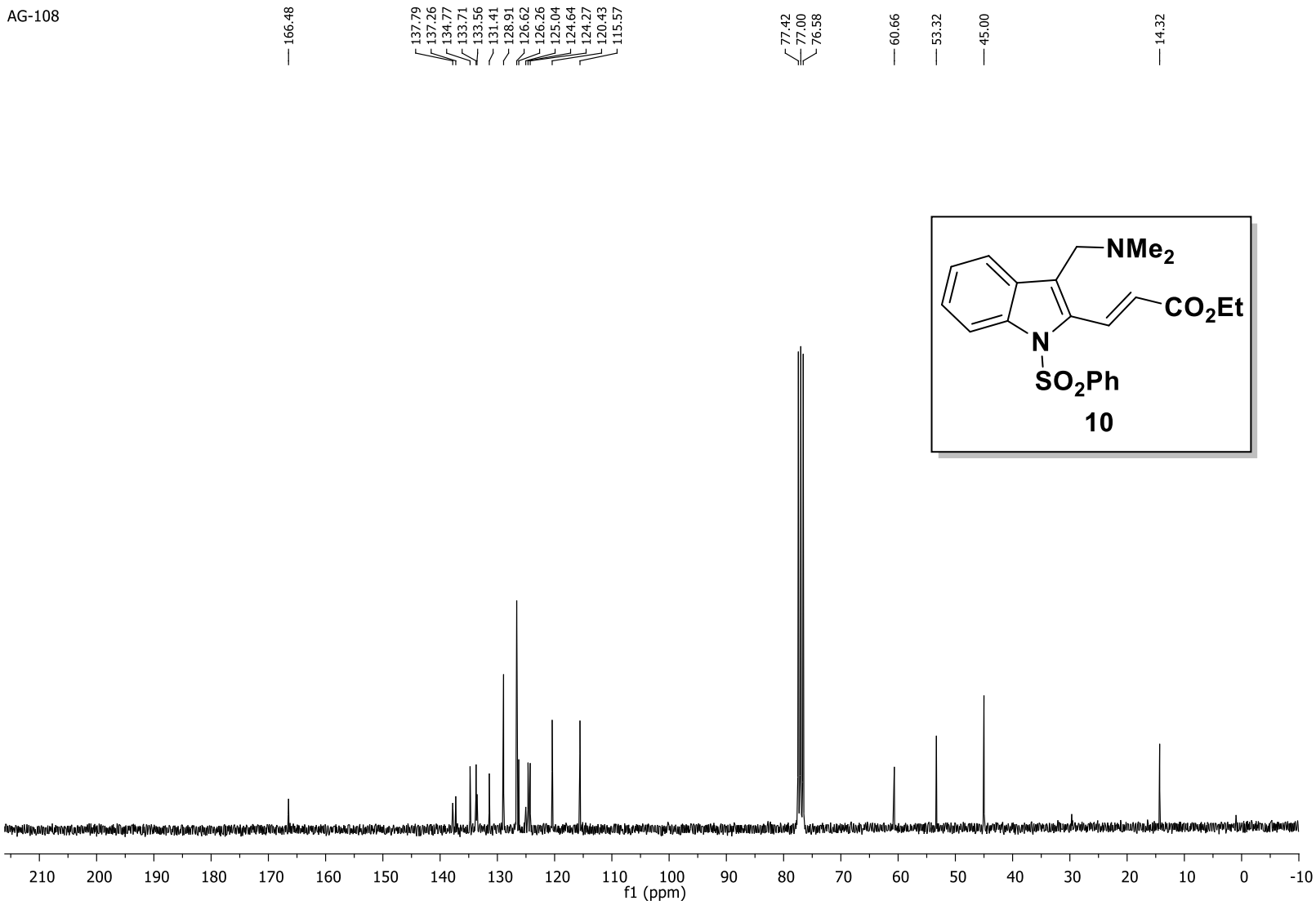
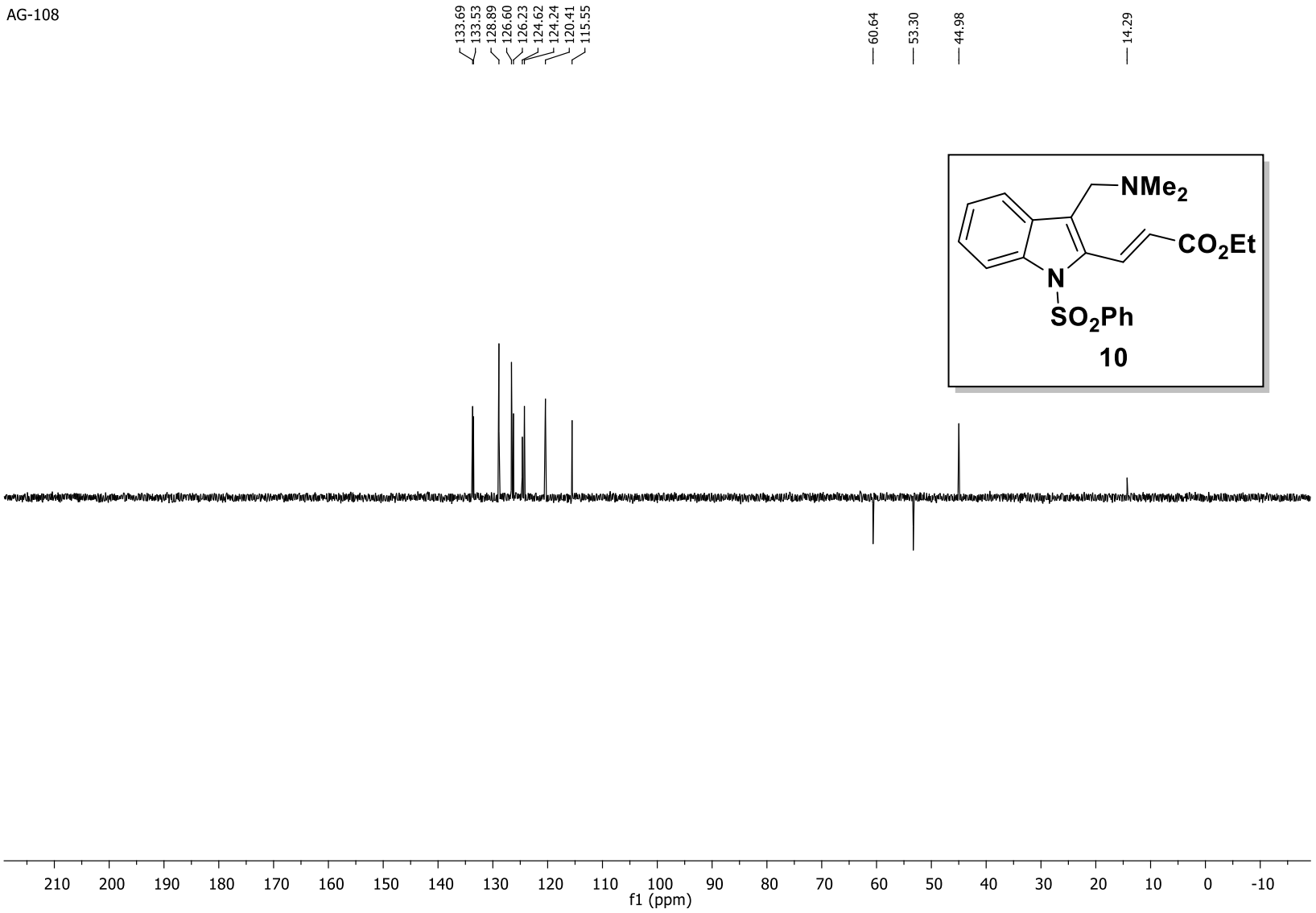


^{1}H NMR (300 MHz, $CDCl_3$) spectrum of compound **10**



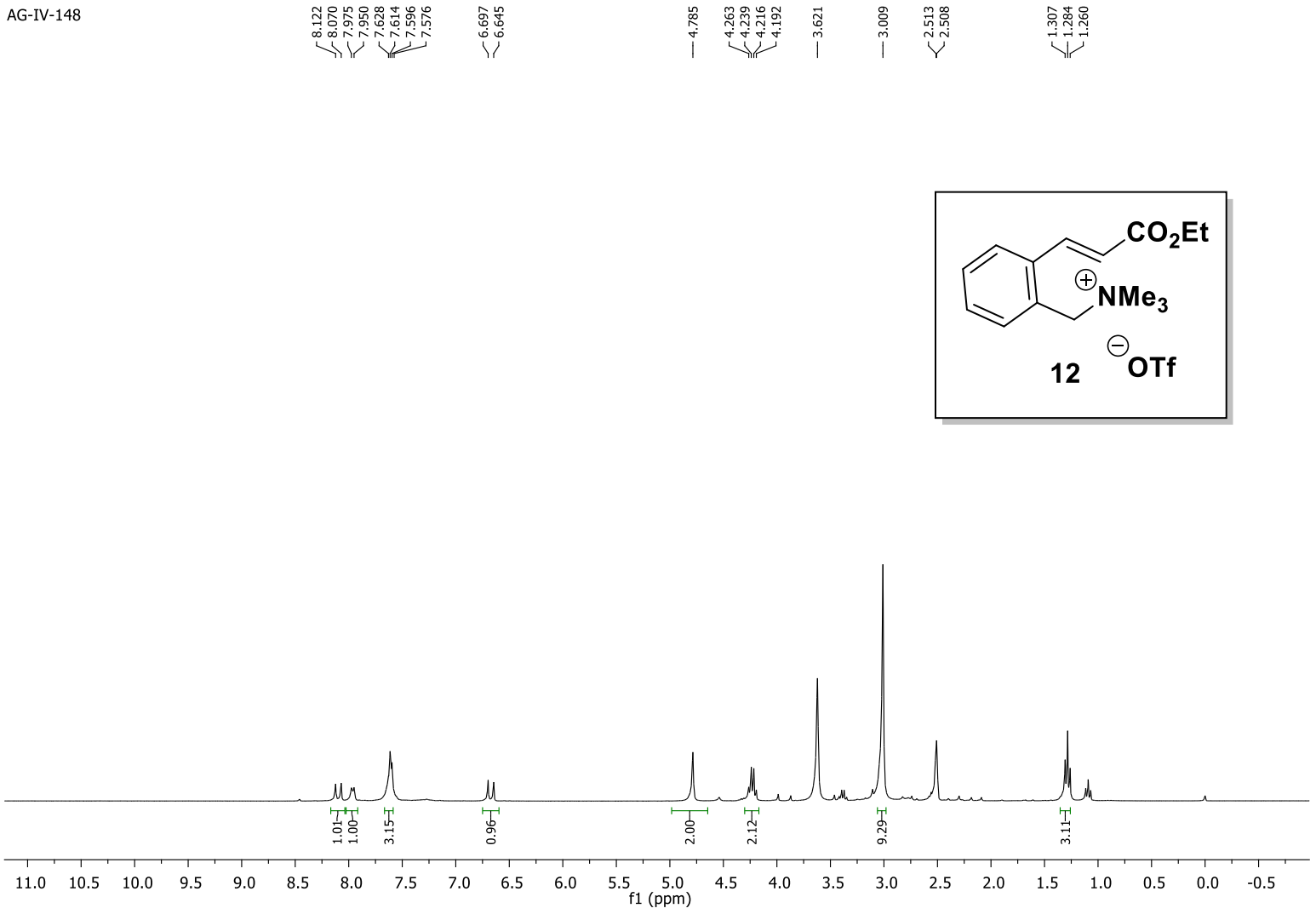
^{13}C {^{1}H} NMR ($CDCl_3$, 75 MHz) spectrum of compound **10**

AG-108



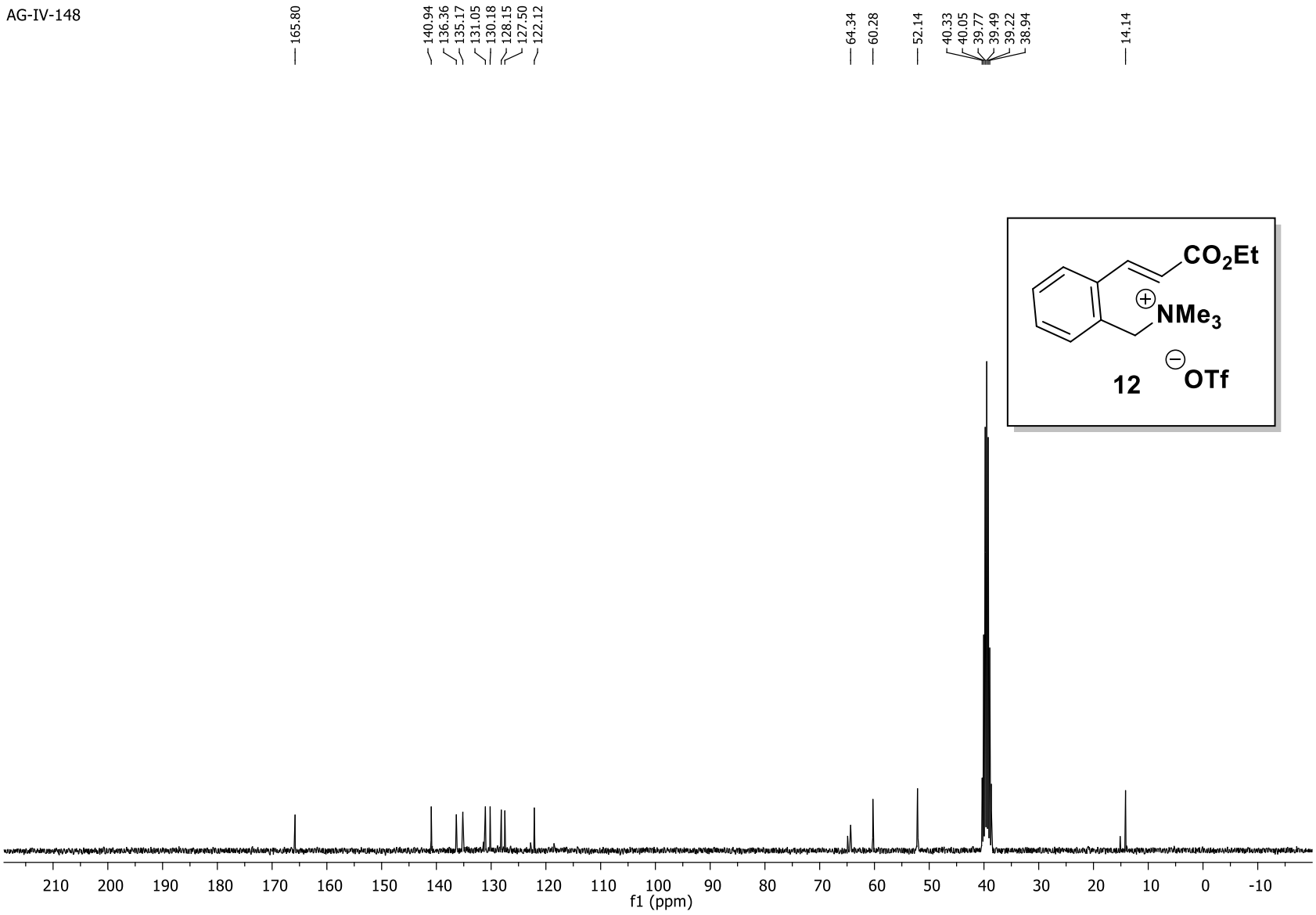
DEPT-135 NMR (75 MHz, $CDCl_3$) spectrum of compound **10**

AG-IV-148

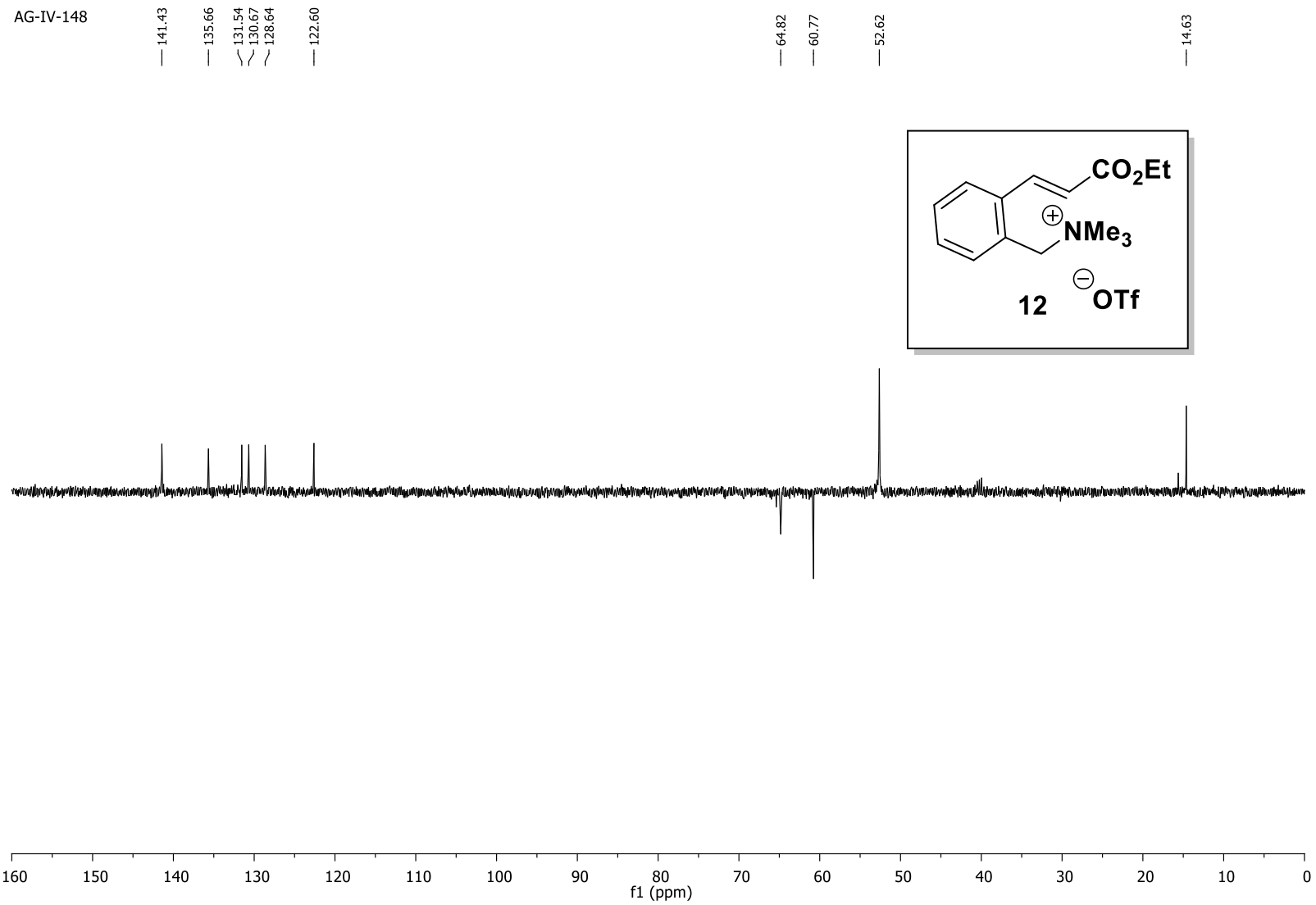


^{1}H NMR (300 MHz, DMSO-d_6) spectrum of compound **12**

AG-IV-148



^{13}C {^{1}H} NMR (75 MHz, DMSO-d_6) spectrum of compound **12**



DEPT-135 NMR (75 MHz, DMSO-d_6) spectrum of compound **12**