

A Phosphine-Catalyzed Construction of Sulfur Heterocycles.

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Supporting Information

Table of Contents

General Experimental:	p2
Phosphine-catalysed synthesis of heterocycles 1a-i :	p2-6
Phosphine-catalysed construction of Rhodanines 3a-s :	p6-15
Spectra for products:	p16-44
RX structure of compound 1e :	p45

• **General methods** : Dry methanol, isopropyl alcohol and toluene (Aldrich) were used without further purification. Purifications of reactions products were carried out by flash chromatography using Merck silica gel (40-63 μ m). Analytical thin layer chromatographies were performed on Merck silica gel 60-F plates. Visualization was accomplished with UV light and iodine. Infrared spectra (IR) were obtained on a Perkin Elmer system 2000 FTIR spectrophotometer and are reported as wavelength numbers (cm⁻¹). Infrared spectra for liquid products were obtained as a thin film on a NaCl disk, and spectra for solid products were collected by preparing a KBr pellet containing the title compound. ¹H NMR (400 MHz), ¹³C NMR (100 MHz) and ³¹P NMR (160 MHz) were measured on a Bruker Avance 400 MHz spectrometer. Chemical shifts are reported in parts per million (ppm, δ) downfield from residual solvents peaks and coupling constants are reported as Hertz (Hz). Splitting patterns are designated as singlet (s), doublet (d), triplet (t), Splitting patterns that could not be interpreted or easily visualized are designated as multiplet (m). Electrospray mass spectra were obtained using a ESI/TOF Mariner Mass Spectrometer. Unless otherwise noted, all other commercially available reagents and solvents were used without further purification.

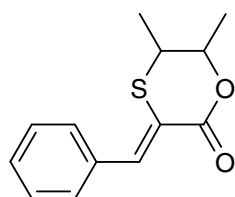
• **Aryl propiolates** were prepared according to our previously described protocole.¹

• **Typical procedure for the preparation of heterocycles 1a, b, e, f, g, h, and i** :

To a solution of bifunctional S-O or S-N pronucleophile (1.1 mmol, 1.1 eq.) and tributylphosphine (50 μ L, 0.2 eq.) in 2 mL of dry toluene was added drop wise and under argon aryl propiolate (1 mmol, 1eq.). The mixture was heated at the temperature indicated in the table and then evaporated under reduced pressure. The resulting mixture was purified by flash chromatography on silica gel.

(Z)-3-Benzylidene-5,6-dimethyl-[1,4]oxathian-2-one (1a)

The starting mercaptoalcohol was used as racemate, product **1a** was obtained as a mixture of inseparable *syn/anti* isomers (*syn/anti* ratio : 40/60).



Colorless oil

¹H NMR (CDCl₃, 400 MHz) (δ ppm) : 1.32 (d, J = 6.8 Hz, 1.8 H, *anti*), 1.41 (d, J = 6.8 Hz, 1.2 H, *syn*), 1.44 (d, J = 6.8 Hz, 1.2 H, *syn*), 1.46 (d, J = 6.8 Hz, 1.8 H, *anti*), 3.25-3.34 (m, 2 H, *anti* and *syn*), 4.42 (qd, J = 6.8 Hz, J = 8.8 Hz, 0.6 H, *anti*), 4.83 (qd, J = 2.0 Hz, J = 6.8 Hz, 0.4 H, *syn*), 7.31-7.38 (m, 1 H), 7.39-7.46 (m, 2 H), 7.61 (d, J = 7.6 Hz, 2 H), 7.73 (s, 0.6 H, *anti*), 7.77 (s, 0.4 H, *syn*).

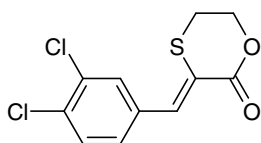
¹³C NMR (CDCl₃, 100 MHz) (δ ppm) : 15.3 (*syn*), 16.7 (*anti*), 18.0 (*syn*), 19.0 (*anti*), 38.3 (*syn*), 40.2 (*anti*), 78.1 (*syn*), 80.9 (*anti*), 119.8 (*syn*), 121.2 (*anti*), 128.4 (*syn*), 128.5 (*anti*), 129.0, 130.3, 134.6 (*anti*), 134.7 (*syn*), 135.8, 136.3, 163.6 (*syn*), 163.9 (*anti*).

IR (NaCl) : ν 692, 763, 936, 1092, 1194, 1247, 1380, 1445, 1492, 1564, 1582, 1709, 2934, 2980 cm⁻¹.

MS (ESI) m/z : 235 [M + H⁺].

¹ D. Lecerclé, C. Mothes, F. Taran. *Synth. Commun.* **2007**, 37, 1301-1311.

(Z)-3-(3,4-dichloro-benzylidene)-[1,4]oxathian-2-one (1b)



White solid; mp 120°C

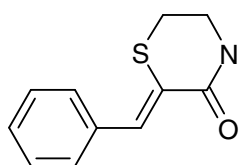
¹H NMR (400 MHz, CDCl₃) (δ ppm) : 3.17 (m, 2H), 4.65 (m, 2H), 7.41 (m, 1H), 7.46 (m, 1H), 7.60 (s, 1H), 7.72 (m, 1H).

¹³C NMR (400 MHz, CDCl₃) (δ ppm) : 26, 68, 122, 129, 130, 131, 132, 133, 133.8, 134, 163.

IR (KBr, cm⁻¹) : 693, 734, 807, 1000, 1029, 1085, 1176, 1245, 1280, 1302, 1387, 1469, 1567, 1695, 2902.

MS (ESI) *m/z*: 277

(Z)-2-Benzylidene-thiomorpholin-3-one (1e)



White solid; mp 126°C

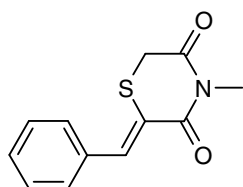
¹H NMR (CDCl₃, 400 MHz) (δ ppm): 3 (m, 2 H), 3.78 (m, 2 H), 6.96 (broad s, 1 H), 7.3-7.45 (m, 3 H), 7.62 (d, J = 7.5 Hz, 2 H), 7.89 (s, 1H).

¹³C NMR (CDCl₃, 100 MHz) (δ ppm): 26.7, 43.3, 123.9, 128.3, 128.4, 130.2, 133.1, 135.1, 163.6.

IR (KBr): ν 513, 663, 686, 785, 998, 1123, 1180, 1230, 1283, 1339, 1404, 1472, 1644, 1728, 1947, 3021, 3175 cm⁻¹.

MS (ESI): *m/z* = 206 [M+H⁺].

(Z)-2-benzylidene-4-methyl-thiomorpholine-3,5-dione (1f)



Beige needle; mp 117°C

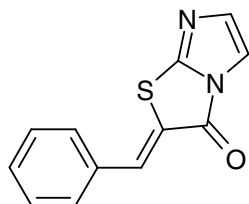
¹H NMR (CDCl₃, 400 MHz) (δ ppm): 3.31 (s, 3 H), 3.57 (s, 2 H), 7.40-7.46 (m, 3 H), 7.64 (d, J = 7.1 Hz, 2 H), 8.17 (s, 1H).

¹³C NMR (CDCl₃, 100 MHz) (δ ppm): 28.7, 31.0, 121.1, 128.5, 129.9, 130.6, 134.0, 140.7, 163.9, 167.4

IR (KBr): ν 520, 547, 573, 592, 613, 648, 692, 733, 762, 803, 894, 927, 969, 988, 1066, 1121, 1177, 1240, 1298, 1350, 1391, 1420, 1444, 1468, 1489, 1563, 1579, 1650, 1714, 2947, 3007, 3050, cm⁻¹.

MS (ESI): *m/z* = 234 [M+H⁺].

(Z)-2-Benzylidene-imidazo[2,1-*b*]thiazol-3-one (1g)



Cream solid

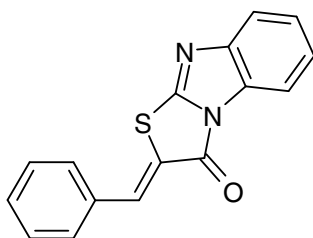
¹H NMR (CDCl₃, 400 MHz) (δ ppm) : 6.90 (s, 1 H), 7.44 (d, J = 1.6 Hz, 1 H), 7.54-7.58 (m, 3 H), 7.67 (d, J = 8 Hz, 2 H), 8.01 (d, J = 1.6 Hz, 1 H).

¹³C NMR (CDCl₃, 100 MHz) (δ ppm) : 112.0, 114.7, 126.9, 129.5, 131.6, 131.7, 134.8, 140.3, 152.5, 158.1.

IR (KBr) : ν 626, 665, 687, 741, 764, 843, 1125, 1291, 1367, 1435, 1508, 1563, 1688, 3028, 3120, 3146 cm⁻¹.

MS (ESI) *m/z* : 229 [M + H⁺].

(Z)-2-Benzylidene-benzo[4,5]imidazo[2,1-*b*]thiazol-3-one (1h)



Cream solid; mp 187°C

¹H NMR (CDCl₃, 400 MHz) (δ ppm) : 6.94 (s, 1 H), 7.45-7.59 (m, 5 H), 7.71 (d, J = 6.4 Hz, 2 H), 7.81 (d, J = 8 Hz, 1 H), 8.61 (d, J = 8 Hz, 1 H).

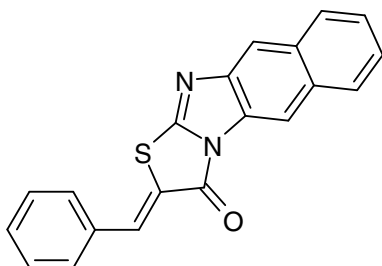
¹³C NMR (CDCl₃, 100 MHz) (δ ppm) : 113.7, 116.1, 118.6, 124.3, 125.9, 126.8, 129.5, 130.9, 131.7, 134.5, 142.5, 146.7, 150.6, 159.9.

IR (KBr) : ν 690, 743, 856, 1185, 1361, 1443, 1473, 1568, 1605, 1680, 3053 cm⁻¹.

MS (ESI) *m/z* : 279 [M + H⁺].

Known compound (Allan, V. *J. Org. Chem.* **1956**, 21, 24-27)

(Z)-2-benzylidene-1-thia-3a,10-diaza-pentaleno[1,2-b] naphthalen-3-one (1i)



Yellow solid; mp >265°C

¹H NMR (CDCl₃, 400 MHz) (δ ppm) : 6.97 (s, 1 H), 7.54-7.61 (m, 5 H), 7.73 (d, J = 6.8 Hz, 2 H), 8.04-8.11 (m, 2 H), 8.24 (s, 1 H), 9.09 (s, 1 H).

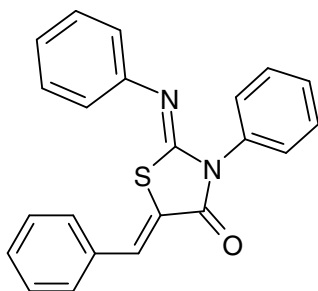
¹³C NMR (CDCl₃, 100 MHz) (δ ppm) : 113.8, 114.2, 115.5, 125.3, 125.5, 126.9, 128.2, 128.6, 129.6, 130.3, 130.9, 131.9, 134.3, 141.0, 150.0, 150.3, 159.6.

IR (KBr) : ν 673, 742, 866, 1114, 1206, 1293, 1373, 1440, 1483, 1675, 3051 cm⁻¹.

MS (ESI) *m/z* : 329 [M + H⁺].

HRMS (ESI) : *m/z* calcd for C₂₀H₁₃N₂OS : 329.0749; found: 329.0746.

(Z)- 5-Benzylidene-3-phenyl-2-phenylimino-thiazolidin-4-one (1j)



Yellowish solid; mp 216°C

¹H NMR (400MHz, CDCl₃) (δ ppm): 6.95-7.6 (m, 15H); 7.87 (s, 1H).

¹³C NMR (100MHz, CDCl₃) (δ ppm): 121, 121.3, 124.8, 128, 128.9, 129, 129.2, 129.3, 129.8, 130, 131.4, 133.6, 134.7, 148.2, 150.9, 166.4

IR(KBr, cm⁻¹) : 547, 692, 761, 866, 1153, 1269, 1369, 1446, 1493, 1591, 1609, 1641, 1712, 3058.

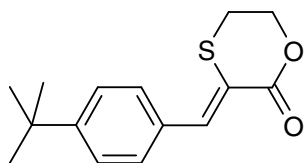
MS (ESI) : *m/z* 357 [M+H⁺].

Known compound (Gaber, A. M.; El-Dean, A.M.; Kamal, A.M.; Atalla, A.A. *Phosphorus, Sulfur, Silicon, Relat. Elem.* **1993**, 80, 101-108)

• Typical procedure for the preparation of heterocycles 1c and 1d :

To a solution of aryl propiolate (1 mmol, 1 eq.) and mercapto-alcohol pronucleophile (1.1 mmol, 1.1 eq.) in 2 mL of dry toluene was added tributylphosphine (50 μL, 0.2 eq.) under argon. The mixture was stirred at room temperature for 2 hours and then *p*-toluenesulfonic acid (0.2 mmol, 0.2 eq.) was added. After heating at 110°C for 1 hour, the resulting mixture was evaporated under reduced pressure and purified by flash chromatography on silica gel.

(Z)-3-(4-tert-butyl-benzylidene)-[1,4]oxathian-2-one (1c)



White solid; mp 139°C

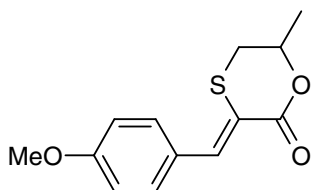
¹H NMR (400 MHz, CDCl₃) (δ ppm) : 1.35 (m, 9H) 3.14 (m, 2H), 4.62 (m, 2H), 7.44 (d, J=7.75 Hz, 2H), 7.56 (d, J=7.75 Hz, 2H), 7.77 (s, 1H).

¹³C NMR (400 MHz, CDCl₃) (δ ppm) : 26.43, 31.13, 31.15, 34.83, 68.29, 119.08, 125.41, 125.44, 130.14, 130.15, 130.19, 130.22, 131.70, 137.03, 152.65, 163.98.

IR (KBr, cm⁻¹) : 571, 748, 826, 865, 941, 1006, 1079, 1177, 1203, 1227, 1253, 1305, 1390, 1584, 1707, 2957.

MS (ESI) *m/z*: 263

(Z)-3-(4-methoxy-benzylidene)-6-methyl-[1,4]oxathian-2-one (1d)



Cream powder; mp 85°C

¹H NMR (CDCl₃, 400 MHz) (δ ppm) : 1.52 (d, J = 6.0 Hz, 3H), 2.93 (dd, J = 1.6 Hz, J = 13.2 Hz, 1H), 3.06 (dd, J = 10.0 Hz, J = 13.2 Hz, 1H), 3.85 (s, 3H), 4.70-4.76 (m, 1H), 6.95 (d, J = 8.6 Hz, 2H), 7.60 (d, J = 8.6 Hz, 2H), 7.78 (s, 1H).

¹³C NMR (CDCl₃, 100 MHz) (δ ppm) : 21.0, 31.6, 55.3, 75.9, 113.9, 116.9, 127.4, 132.2, 136.4, 160.2, 164.0.

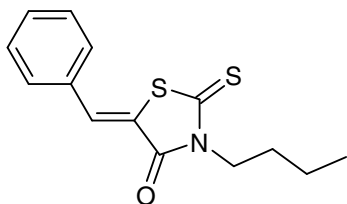
IR (KBr) : ν 533, 826, 946, 1008, 1060, 1135, 1175, 1248, 1417, 1509, 1601, 1694, 2843, 2929, 2972 cm⁻¹.

MS (ESI) *m/z* : 251 [M + H⁺].

• Typical procedure for *n*PBu₃-catalyzed Rhodanines preparation:

To a solution of amine (2.2 mmol, 2.2 eq) in 10 mL of dry propan-2-ol was added carbon disulfide (1.1 mmol, 1.1 eq). The mixture was stirred at room temperature for 6 h. Then, tributylphosphine (0.2 mmol, 0.2 eq) and the alkyne (1 mmol, 1 eq) were added under argon and the mixture was stirred overnight at room temperature. The resulting precipitate was recovered by filtration, washed by propan-2-ol affording the desired product as pure *Z*-isomer.

(Z)-5-Benzylidene-3-butyl-2-thioxo-thiazolidin-4-one (3a)



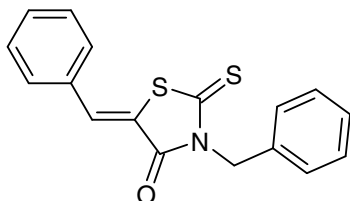
Yellow solid; mp 113°C

$^1\text{H NMR}$ (CDCl_3 , 400 MHz) (δ ppm) : 0.97 (t, $J = 7.6$ Hz, 3 H), 1.36-1.45 (m, 2 H), 1.67-1.74 (m, 2 H), 4.14 (t, $J = 7.6$ Hz, 2 H), 7.44-7.52 (m, 5 H), 7.73 (s, 1 H).

$^{13}\text{C NMR}$ (CDCl_3 , 100 MHz) (δ ppm) : 13.6, 20.0, 29.0, 44.4, 123.1, 129.3, 130.5, 130.6, 132.8, 133.3, 167.8, 193.3.

IR(KBr): ν 517, 528, 681, 762, 1138, 1203, 1275, 1332, 1390, 1427, 1446, 1601, 1704, 2872, 2932, 2957 cm^{-1} . **MS (ESI)** m/z : 278 [$\text{M} + \text{H}^+$].

(Z)- 3-Benzyl-5-benzylidene-2-thioxo-thiazolidin-4-one (3b)



Yellow solid; mp 156°C

$^1\text{H NMR}$ (CDCl_3 , 400 MHz) (δ ppm) : 5.30 (s, 2 H), 7.28-7.36 (m, 3 H), 7.43-7.52 (m, 7 H), 7.75 (s, 1 H).

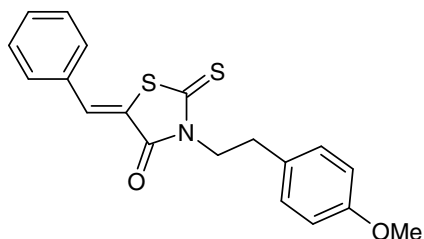
$^{13}\text{C NMR}$ (CDCl_3 , 100 MHz) (δ ppm) : 47.5, 122.9, 128.1, 128.5, 128.9, 129.3, 130.6, 130.7, 133.2, 133.3, 134.8, 167.8, 193.1.

IR (NaCl) : ν 678, 759, 1191, 1293, 1342, 1381, 1491, 1594, 1707, 2379 cm^{-1} .

MS (ESI) m/z : 312 [$\text{M} + \text{H}^+$].

Known compound (Hanefeld, W.; Schlitzer, M. *Arch. Pharm.* **1994**, 7, 413-416)

(Z)-5-Benzylidene-3-[2-(4-methoxy-phenyl)-ethyl]-2-thioxo-thiazolidin-4-one (3c)



Yellow solid; mp 146°C

$^1\text{H NMR}$ (CDCl_3 , 400 MHz) (δ ppm) : 2.93-2.97 (m, 2 H), 3.80 (s, 3 H), 4.29-4.33 (m, 2 H), 6.86 (d, $J = 8.4$ Hz, 2 H), 7.21 (d, $J = 8.4$ Hz, 2 H), 7.44-7.53 (m, 5 H), 7.72 (s, 1 H).

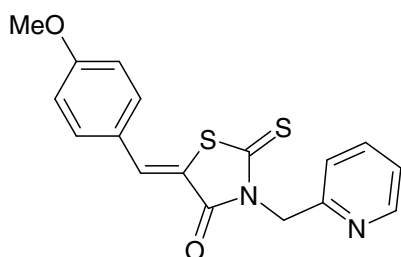
^{13}C NMR (CDCl_3 , 100 MHz) (δ ppm) : 32.0, 45.8, 55.2, 114.0, 122.9, 129.3, 129.4, 129.9, 130.6, 130.7, 133.0, 133.3, 158.4, 167.5, 193.1.

IR(KBr): ν 511, 691, 764, 1035, 1048, 1163, 1247, 1263, 1332, 1446, 1513, 1602, 1704, 2836, 2952, 3015 cm^{-1} .

MS (ESI) m/z : 356 [$\text{M} + \text{H}^+$].

HRMS (ESI) : m/z calcd for $\text{C}_{19}\text{H}_{17}\text{NO}_2\text{NaS}_2$: 378.0598; found: 378.0607.

(Z)-5-(4-Methoxy-benzylidene)-3-pyridine-2-ylmethyl-2-thioxo-thiazolidin-4-one (3d)



Yellow solid; mp 153°C

^1H NMR (CDCl_3 , 400 MHz) (δ ppm) : 3.90 (s, 3 H), 5.60 (s, 2 H), 7.02 (d, $J = 8.8$ Hz, 2 H), 7.32 (d, $J = 8.0$ Hz, 1 H), 7.34-7.44 (m, 1 H), 7.50 (d, $J = 8.8$ Hz, 2 H), 7.78 (s, 1 H), 7.81-7.91 (m, 1 H), 8.61 (d, $J = 4.4$ Hz, 1 H).

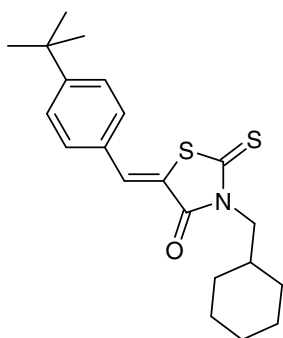
^{13}C NMR (CDCl_3 , 100 MHz) (δ ppm) : 48.6, 55.5, 114.9, 119.9, 121.5, 122.5, 126.0, 132.8, 133.7, 136.6, 149.6, 154.0, 161.7, 167.9, 193.3.

IR (KBr) : ν 519, 753, 823, 1020, 1046, 1100, 1421, 1508, 1565, 1589, 1709, 2839, 2933 cm^{-1} .

MS (ESI) m/z : 343 [$\text{M} + \text{H}^+$].

HRMS (ESI) : m/z calcd for $\text{C}_{17}\text{H}_{15}\text{N}_2\text{O}_2\text{S}_2$: 343.0575; found: 343.0564.

(Z)-5-(4-tert-Butyl-benzylidene)-3-cyclohexylmethyl-2-thioxo-thiazolidin-4-one (3e)



Yellow solid; mp 156°C

^1H NMR (CDCl_3 , 400 MHz) (δ ppm) : 1.02-1.27 (m, 5 H), 1.35 (s, 9 H), 1.60-1.78 (m, 5 H), 1.94-2.07 (m, 1 H), 3.99 (d, $J = 7.2$ Hz, 2 H), 7.45 (d, $J = 8.4$ Hz, 2 H), 7.51 (d, $J = 8.4$ Hz, 2 H), 7.71 (s, 1 H).

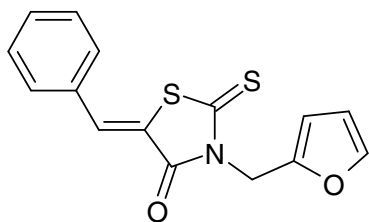
^{13}C NMR (CDCl_3 , 100 MHz) (δ ppm) : 25.6, 26.1, 30.6, 31.0, 35.0, 35.9, 50.4, 121.9, 126.3, 130.6, 133.0, 154.5, 168.3, 193.9.

IR(KBr): ν 559, 821, 1021, 1102, 1142, 1193, 1250, 1307, 1328, 1428, 1598, 1705, 2850, 2920, 2963 cm^{-1} .

MS (ESI) m/z : 373 [$\text{M} + \text{H}^+$].

HRMS (ESI) : m/z calcd for $\text{C}_{21}\text{H}_{28}\text{NOS}_2$: 374.1612; found: 374.1627.

(Z)-5-Benzylidene-3-furan-2-ylmethyl-2-thioxo-thiazolidin-4-one (3f)



Yellow solid; mp 134°C

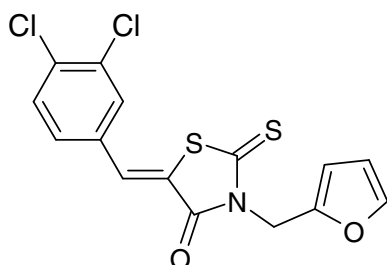
¹H NMR (CDCl₃, 400 MHz) (δ ppm) : 5.33 (s, 2 H), 6.32 (dd, J = 1.2 Hz, J = 3.2 Hz, 1 H), 6.44 (d, J = 3.2 Hz, 1 H), 7.36 (d, J = 1.2 Hz, 1 H), 7.44-7.51 (m, 5 H), 7.77 (s, 1 H).

¹³C NMR (CDCl₃, 100 MHz) (δ ppm) : 40.3, 110.3, 110.4, 122.7, 129.3, 130.6, 130.7, 133.2, 133.4, 142.6, 147.8, 167.3, 192.6.

IR (KBr) : ν 513, 681, 733, 745, 768, 1007, 1144, 1173, 1246, 1318, 1340, 1370, 1414, 1571, 1592, 1711, 2992 cm⁻¹.

HRMS (ESI) : *m/z* calcd for C₁₅H₁₁NO₂NaS₂ : 324.0129; found: 324.0144.

(Z)-5-(3,4-dichloro-benzylidene)-3-furan-2-ylmethyl-2-thioxo-thiazolidin-4-one (3g)



Yellow solid; mp 156°C

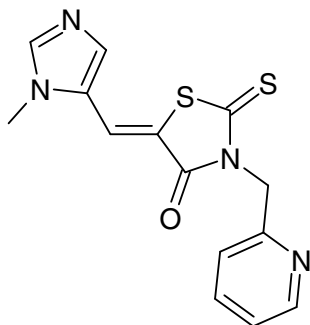
¹H NMR (CDCl₃, 400 MHz) (δ ppm) : 5.30 (s, 2 H), 6.33 (dd, J = 1.6 Hz, J = 3.2 Hz, 1 H), 6.44 (d, J = 3.2 Hz, 1 H), 7.32 (dd, J = 2.0 Hz, J = 8.4 Hz, 1 H), 7.35-7.36 (m, 1 H), 7.56 (d, J = 10.8 Hz, 1 H), 7.57 (s, 1 H), 7.63 (s, 1 H).

¹³C NMR (CDCl₃, 100 MHz) (δ ppm) : 40.4, 110.4, 110.5, 124.8, 129.0, 131.2, 131.9, 133.1, 133.8, 134.9, 142.7, 147.5, 167.0, 191.4.

IR (KBr) : ν 664, 737, 805, 934, 1011, 1030, 1077, 1097, 1176, 1244, 1323, 1341, 1368, 1546, 1600, 1702, 3014 cm⁻¹.

MS (ESI) *m/z* : 370 [M + H⁺].

(Z)-5-(3-Methyl-3H-imidazol-4-ylmethylene)-3-pyridin-2-ylmethyl-2-thioxo-thiazolidin-4-one
(3h)



Yellow powder; mp 196°C

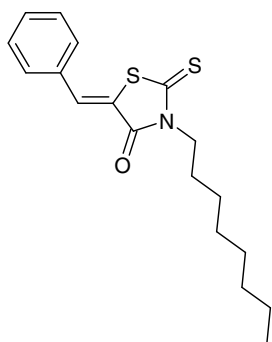
¹H NMR ((CD₃)₂SO, 400 MHz) (δ ppm) : 3.80 (s, 3 H), 5.354 (s, 2 H), 7.26 (dd, J = 5.2 Hz, J = 8.0 Hz, 1 H), 7.37 (d, J = 8.0 Hz, 1 H), 7.47 (s, 1 H), 7.64 (s, 1 H), 7.77 (dd, J = 2.0 Hz, J = 8.0 Hz, 1 H), 8.01 (s, 1 H), 8.43 (dd, J = 2.0 Hz, J = 5.2 Hz, 1 H).

¹³C NMR ((CD₃)₂SO, 100 MHz) (δ ppm) : 32.3, 48.6, 118.6, 120.3, 122.0, 123.0, 128.3, 133.6, 137.3, 142.7, 149.5, 153.9, 166.8, 192.8.

IR(KBr):ν 537, 655, 755, 915, 1038, 1144, 1201, 1232, 1292, 1323, 1408, 1478, 1600, 1708, 2928, 3107, 3404 cm⁻¹.

MS (ESI) *m/z* : 317 [M + H⁺].

(Z)-5-Benzylidene-3-octyl-2-thioxo-thiazolidin-4-one (3i)



Yellow solid; mp 76°C

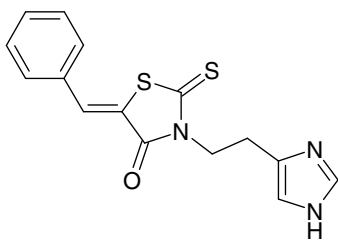
¹H NMR (CDCl₃, 400 MHz) (δ ppm) : 0.88 (t, J = 6.8 Hz, 3 H), 1.27-1.34 (m, 10 H), 1.71 (qd, J = 7.6 Hz, 2 H), 4.10-4.14 (m, 2 H), 7.43-7.52 (m, 5 H), 7.73 (s, 1 H).

¹³C NMR (CDCl₃, 100 MHz) (δ ppm) : 14.1, 22.6, 26.7, 26.9, 29.1, 31.7, 44.7, 123.1, 129.3, 130.5, 130.6, 132.8, 133.3, 167.7, 193.3.

IR (KBr) : ν 516, 678, 761, 1005, 1141, 1180, 1231, 1272, 1359, 1387, 1427, 1446, 1599, 1704, 2853, 2926, 3015, 3393 cm⁻¹.

HRMS (ESI) : *m/z* calcd for C₁₈H₂₄NOS₂ : 334.1299; found: 334.1301.

(Z)-5-Benzylidene-3-[2-(1H-imidazol-4-yl)-ethyl]-2-thioxo-thiazolidin-4-one (3j)



Yellow solid; mp 188°C

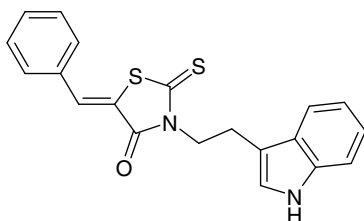
¹H NMR (DMSO, 400 MHz) (δ ppm) : 2.85 (t, J = 7.6 Hz, 2 H), 4.23 (t, J = 7.6 Hz, 2 H), 6.84 (s, 1 H), 7.49-7.57 (m, 4 H), 7.61-7.66 (m, 2 H), 7.79 (s, 1 H), 11.84 (s, 1 H).

¹³C NMR (CD₂Cl₂, 100MHz) (δ ppm) : 24.2, 44.0, 117.0, 122.8, 129.2, 130.5, 130.7, 133.0, 133.2, 133.3, 135.0, 167.5, 193.5.

IR(KBr): ν 520, 685, 768, 826, 1170, 1226, 1277, 1333, 1358, 1420, 1447, 1604, 1710, 2618, 2854, 3061 cm⁻¹.

MS (ESI) *m/z* : 316 [M + H⁺].

(Z)-5-Benzylidene-3-[2-(1H-indol-3-yl)-ethyl]-2-thioxo-thiazolidin-4-one (3k)



Yellow solid; mp 166°C

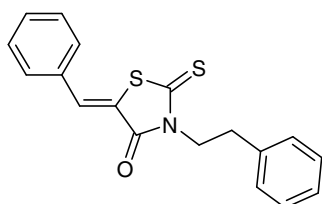
¹H NMR (CDCl₃, 400 MHz) (δ ppm) : 3.17-3.21 (m, 2 H), 4.41-4.45 (m, 2 H), 7.12-7.13 (m, 1 H), 7.16-7.24 (m, 2 H), 7.38 (d, J = 8.0 Hz, 1 H), 7.45-7.53 (m, 5 H), 7.74 (s, 1 H), 7.84 (d, J = 7.6 Hz, 1 H), 7.95-9.00 (m, 1 H).

¹³C NMR (CDCl₃, 100 MHz) (δ ppm) : 22.9, 45.1, 111.07, 111.9, 119.0, 119.6, 122.2, 122.3, 123.1, 127.3, 129.3, 130.6, 130.7, 133.0, 133.3, 136.2, 167.7, 193.3.

IR(KBr): ν 506, 682, 739, 762, 1075, 1095, 1166, 1242, 1272, 1319, 1337, 1388, 1594, 1712, 2944, 3013, 3055, 3361, 3418 cm⁻¹.

HRMS (ESI) : *m/z* calcd for C₂₀H₁₆N₂ONaS₂ : 387.0602; found: 387.0593.

(Z)-5-Benzylidene-3-phenethyl-2-thioxo-thiazolidin-4-one (3l)



Yellow solid; mp 127°C

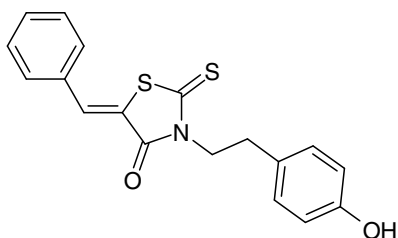
¹H NMR (CDCl₃, 400 MHz) (δ ppm) : 3.00-3.04 (m, 2 H), 4.33-4.37 (m, 2 H), 7.23-7.35 (m, 5 H), 7.44-7.53 (m, 5 H), 7.72 (s, 1 H).

¹³C NMR (CDCl₃, 100 MHz) (δ ppm) : 33.0, 45.7, 122.9, 126.8, 128.6, 128.9, 129.0, 129.3, 130.6, 130.7, 133.0, 133.3, 137.5, 167.4, 193.0.

IR(KBr): ν 504, 673, 687, 699, 761, 1045, 1110, 1165, 1258, 1283, 1329, 1382, 1424, 1493, 1599, 1705, 2952, 3014, 3062 cm⁻¹.

MS (ESI) *m/z* : 326 [M + H⁺].

(Z)-5-Benzylidene-3-[2-(4-hydroxyphenyl)-ethyl]-2-thioxo-thiazolidin-4-one (3m)



Yellow solid; mp 156°C

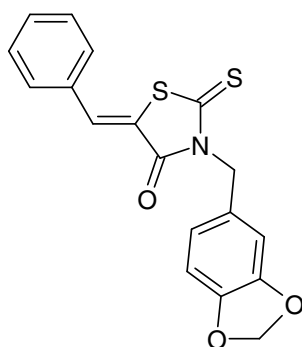
¹H NMR (CDCl₃, 400 MHz) (δ ppm) : 2.93-2.97 (m, 2 H), 4.29-4.33 (m, 2 H), 6.78 (d, J = 8.4 Hz, 2 H), 7.16 (d, J = 8.4 Hz, 2 H), 7.44-7.52 (m, 5 H), 7.72 (s, 1 H).

¹³C NMR (CDCl₃, 100 MHz) (δ ppm) : 32.0, 45.8, 115.4, 122.9, 129.3, 129.6, 130.1, 130.6, 130.7, 133.1, 133.3, 154.3, 167.5, 193.2.

IR(KBr): ν 517, 687, 763, 826, 1165, 1256, 1335, 1383, 1446, 1513, 1599, 1702, 2968, 3016, 3343, 3461 cm⁻¹.

MS (ESI) *m/z* : 342 [M + H⁺].

(Z)-3-Benzo[1,3]dioxol-5-ylmethyl-5-benzylidene-2-thioxo-thiazolidin-4-one (3n)



Yellow solid; mp 163°C

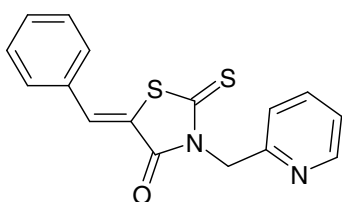
¹H NMR (CDCl₃, 400 MHz) (δ ppm) : 5.23 (s, 2 H), 5.94 (s, 2 H), 6.75 (d, J = 8.0 Hz, 1 H), 7.01 (d, J = 8.0 Hz, 1 H), 7.02 (s, 1 H), 7.43-7.53 (m, 5 H), 7.74 (s, 1 H).

¹³C NMR (CDCl₃, 100 MHz) (δ ppm) : 47.2, 101.1, 108.1, 109.7, 122.9, 123.0, 128.5, 129.3, 130.6, 130.7, 133.2, 133.3, 147.4, 147.6, 167.7, 193.1.

IR(KBr): ν 519, 679, 761, 773, 924, 1041, 1105, 1192, 1251, 1310, 1338, 1420, 1489, 1589, 1705, 1908, 2985 cm⁻¹.

MS (ESI) *m/z* : 356 [M + H⁺].

(Z)-5-Benzylidene-3-pyridin-2-ylmethyl-2-thioxo-thiazolidin-4-one (3o)



Yellow solid; mp 150°C

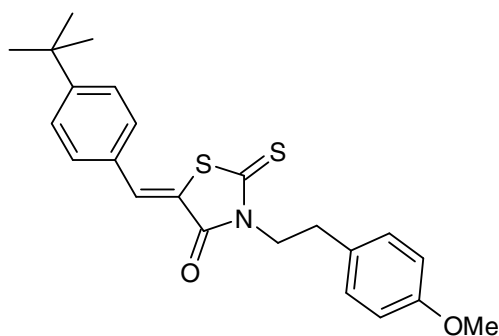
¹H NMR (CDCl₃, 400 MHz) (δ ppm) : 5.47 (s, 2 H), 7.17-7.20 (m, 1 H), 7.24 (d, J = 7.6 Hz, 1 H), 7.44-7.55 (m, 5 H), 7.63-7.66 (m, 1 H), 7.81 (s, 1 H), 8.55 (d, J = 4.8 Hz, 1 H).

¹³C NMR (CDCl₃, 100 MHz) (δ ppm) : 48.7, 121.6, 122.5, 123.0, 129.3, 130.6, 130.7, 133.2, 133.5, 136.5, 149.6, 153.8, 167.7, 193.3.

IR(NaCl):ν 525, 673, 760, 836, 933, 1028, 1187, 1286, 1321, 1374, 1412, 1443, 1475, 1490, 1569, 1592, 1716, 2934, 3012, 3054 cm⁻¹.

MS (ESI) *m/z* : 313 [M + H⁺].

(Z)-5-(4-tert-Butyl-benzylidene)-3-[2-(4-methoxy-phenyl)-ethyl]-2-thioxo-thiazolidin-4-one (3p)



Yellow solid; mp 125°C

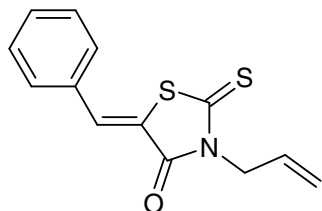
¹H NMR (CDCl₃, 400 MHz) (δ ppm) : 1.35 (s, 9 H), 2.93-2.99 (m, 2 H), 3.80 (s, 3 H), 4.29-4.33 (m, 2 H), 6.85 (d, J = 8.8 Hz, 2 H), 7.21 (d, J = 8.4 Hz, 2 H), 7.46 (d, J = 8.4 Hz, 2 H), 7.52 (d, J = 8.8 Hz, 2 H), 7.71 (s, 1 H).

¹³C NMR (CDCl₃, 100 MHz) (δ ppm) : 31.0, 32.0, 35.1, 45.8, 55.2, 113.9, 121.8, 126.4, 129.5, 129.9, 130.5, 130.6, 133.1, 154.6, 158.4, 167.6, 193.2.

IR(KBr):ν 558, 822, 1033, 1051, 1097, 1163, 1243, 1263, 1332, 1352, 1381, 1427, 1512, 1594, 1700, 2836, 2866, 2906, 2960, 3013 cm⁻¹.

HRMS (ESI) : *m/z* calcd for C₂₃H₂₅NO₂NaS₂ : 434.1224; found: 434.1220.

(Z)-3-Allyl-5-benzylidene-2-thioxo-thiazolidin-4-one (3q)



Yellow solid; mp 142°C

¹H NMR (CDCl₃, 400 MHz) (δ ppm) : 4.76 (d, J = 6.0 Hz, 2 H), 5.23-5.36 (m, 2 H), 5.81- 5.94 (m, 1 H), 7.44-7.52 (m, 5 H), 7.75 (s, 1 H).

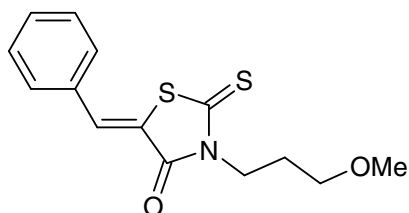
¹³C NMR (CDCl₃, 100 MHz) (δ ppm) : 46.3, 119.3, 122.9, 129.3, 129.5, 130.6, 130.7, 133.1, 133.2, 167.3, 192.8.

IR(KBr): ν 517, 681, 762, 935, 1134, 1203, 1223, 1314, 1373, 1415, 1446, 1597, 1706, 2934, 3013 cm⁻¹.

MS (ESI) m/z : 262 [M + H⁺].

Known compound (Hanefeld, W.; Schlitzer, M. *Arch. Pharm.* **1994**, 7, 413-416).

(Z)-5-Benzylidene-3-(3-methoxy-propyl)-2-thioxo-thiazolidin-4-one (3r)



Yellow solid; mp 98°C

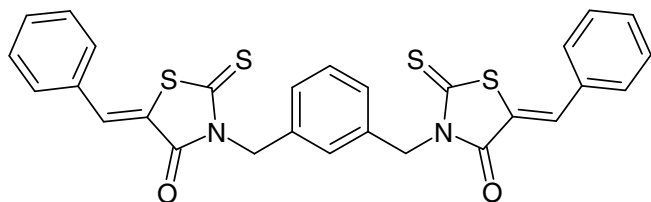
¹H NMR (CDCl₃, 400 MHz) (δ ppm) : 2.00 (qt, J = 6.0 Hz, 2 H), 3.33 (s, 3 H), 3.47 (t, J = 6.0 Hz, 2 H), 4.25 (t, J = 7.2 Hz, 2 H), 7.45-7.52 (m, 5 H), 7.74 (s, 1 H).

¹³C NMR (CDCl₃, 100 MHz) (δ ppm) : 27.0, 42.3, 58.6, 70.0, 123.0, 129.3, 130.5, 130.6, 132.8, 133.3, 167.8, 193.3.

IR (KBr) : ν 517, 681, 763, 935, 990, 1134, 1203, 1223, 1313, 1373, 1415, 1446, 1492, 1572, 1597, 1706, 3013, 3396 cm⁻¹.

MS (ESI) m/z : 293 [M + H⁺].

(Z)-5-Benzylidene-3[3-(5-benzylidene-4-oxo-2-thioxo-thiazolidin-3-yl)-benzyl]-2-thioxo-thiazolidin-4-one (3s)



Yellow solid; mp 202°C

¹H NMR (CDCl₃, 400 MHz) (δ ppm) : 5.31 (s, 4 H), 7.29 (d, J = 8.0 Hz, 1 H), 7.36-7.40 (m, 2 H), 7.43-7.51 (m, 10 H), 7.60-7.63 (m, 1 H), 7.74 (s, 2 H).

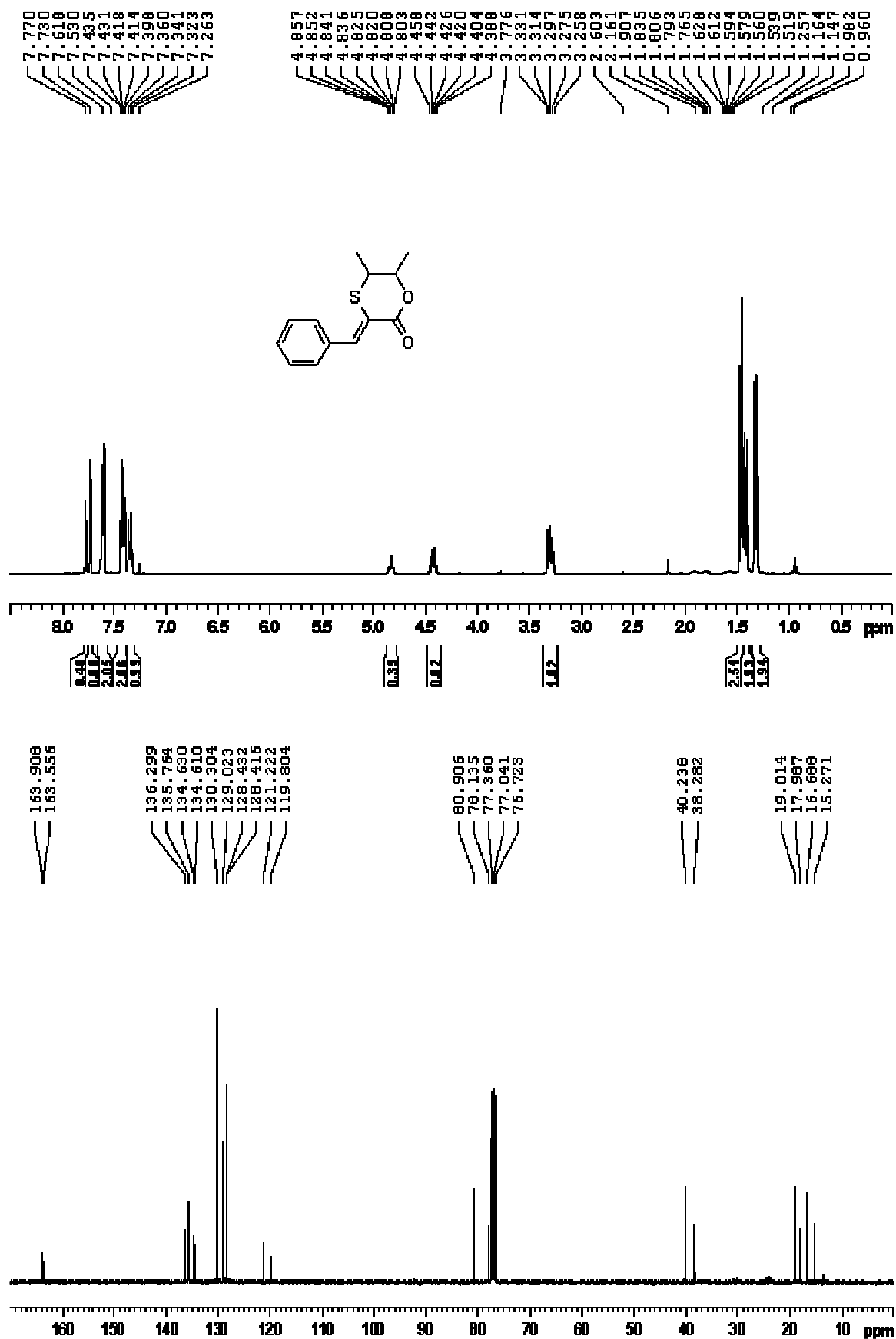
¹³C NMR (CDCl₃, 100 MHz) (δ ppm) : 47.2, 122.9, 128.5, 128.9, 129.3, 129.6, 130.6, 130.7, 133.2, 133.3, 135.1, 167.7, 193.0.

IR (KBr) : ν 518, 679, 699, 760, 1049, 1189, 1288, 1310, 1336, 1381, 1415, 1444, 1571, 1600, 1707, 3024, 3396 cm⁻¹.

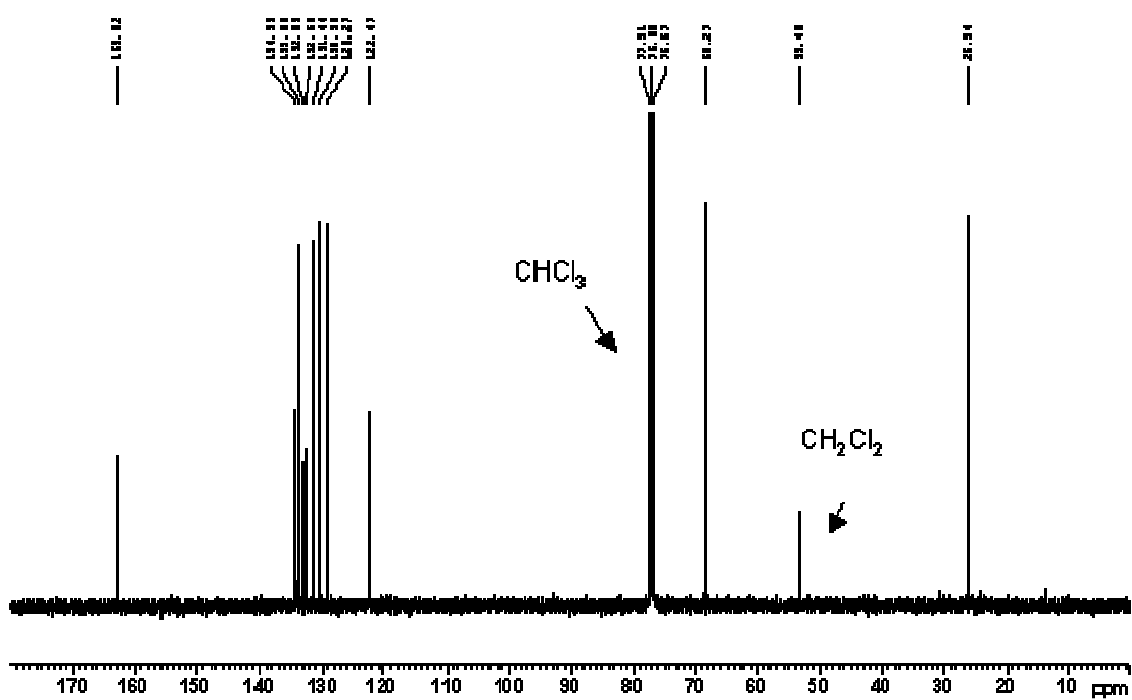
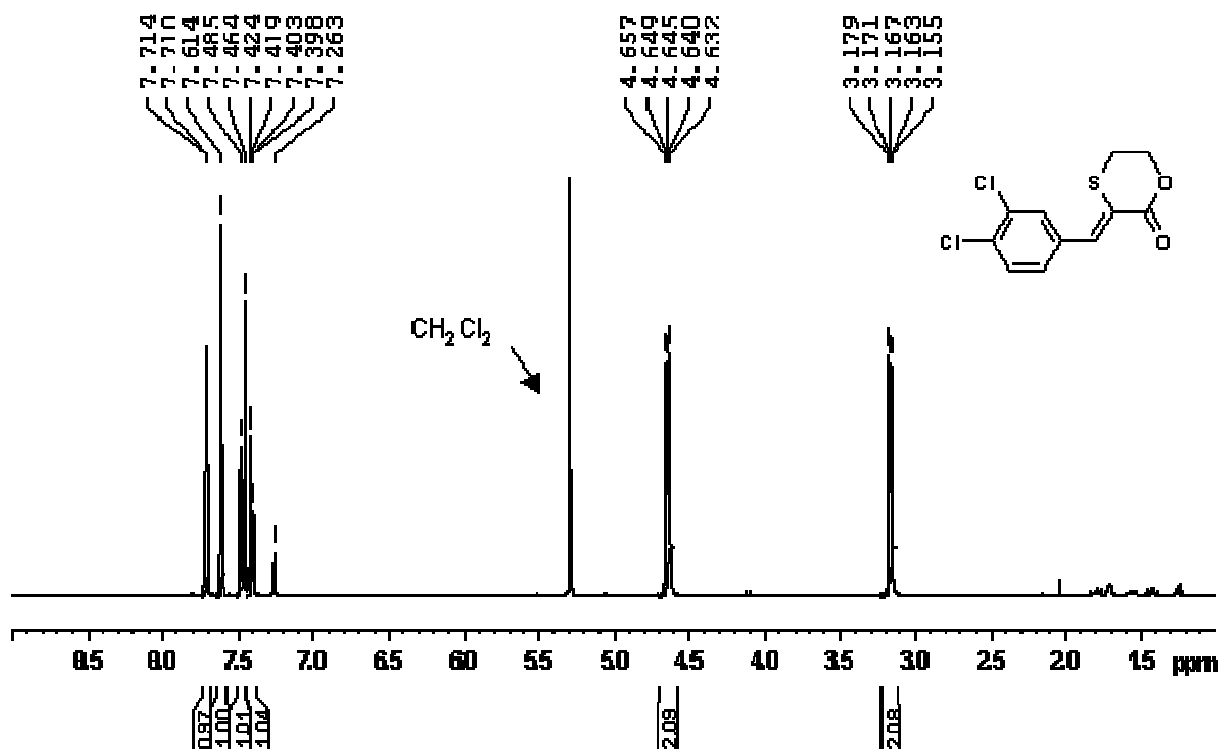
MS (ESI) *m/z* : 545 [M + H⁺].

• ^1H NMR and ^{13}C NMR of products

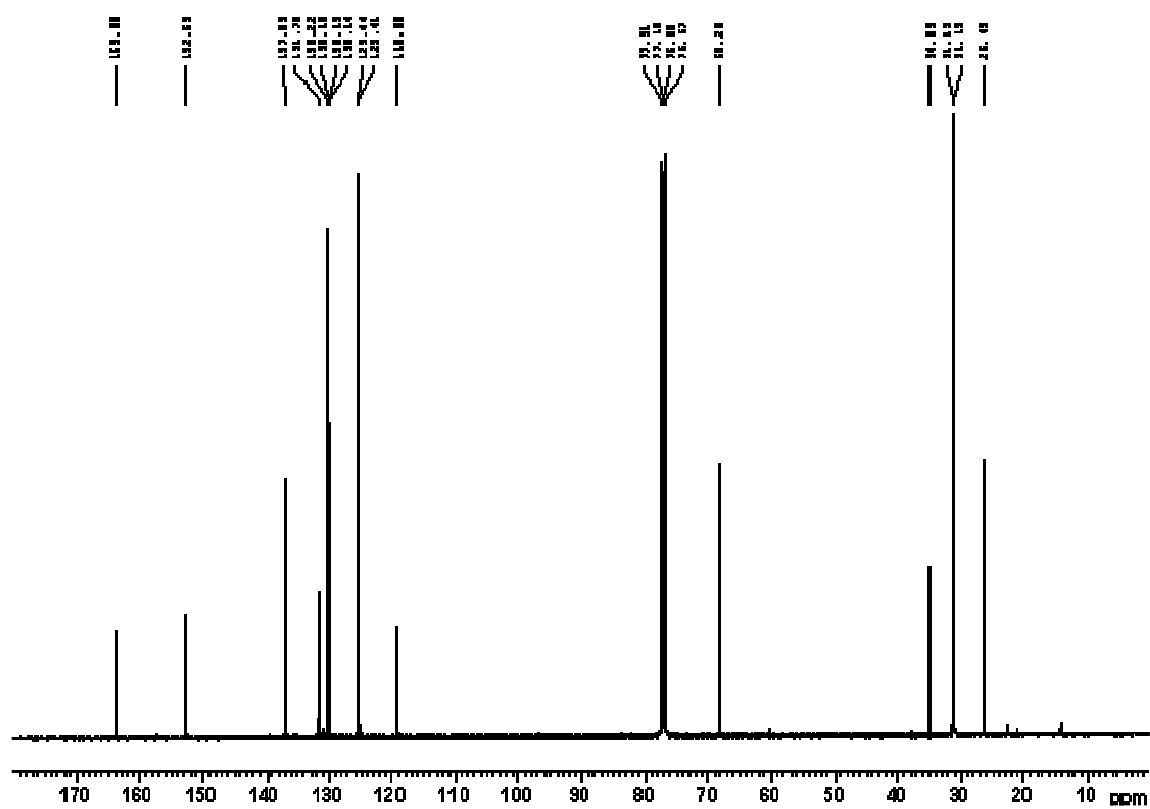
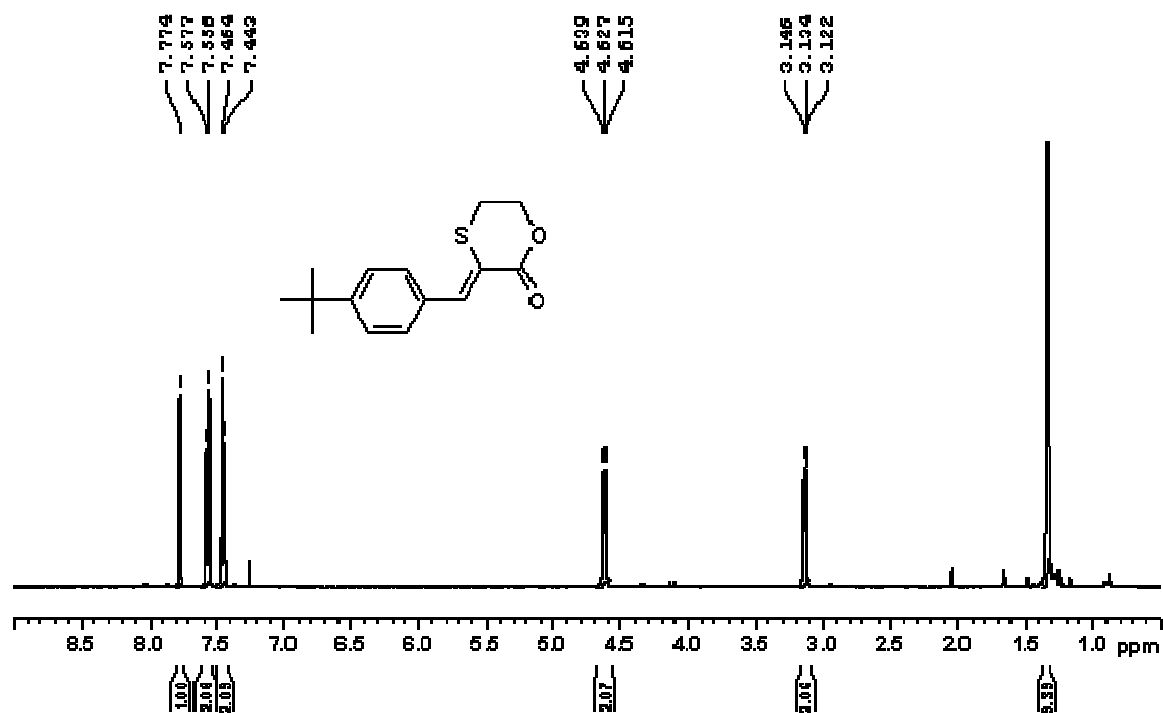
^1H NMR and ^{13}C NMR of 1a



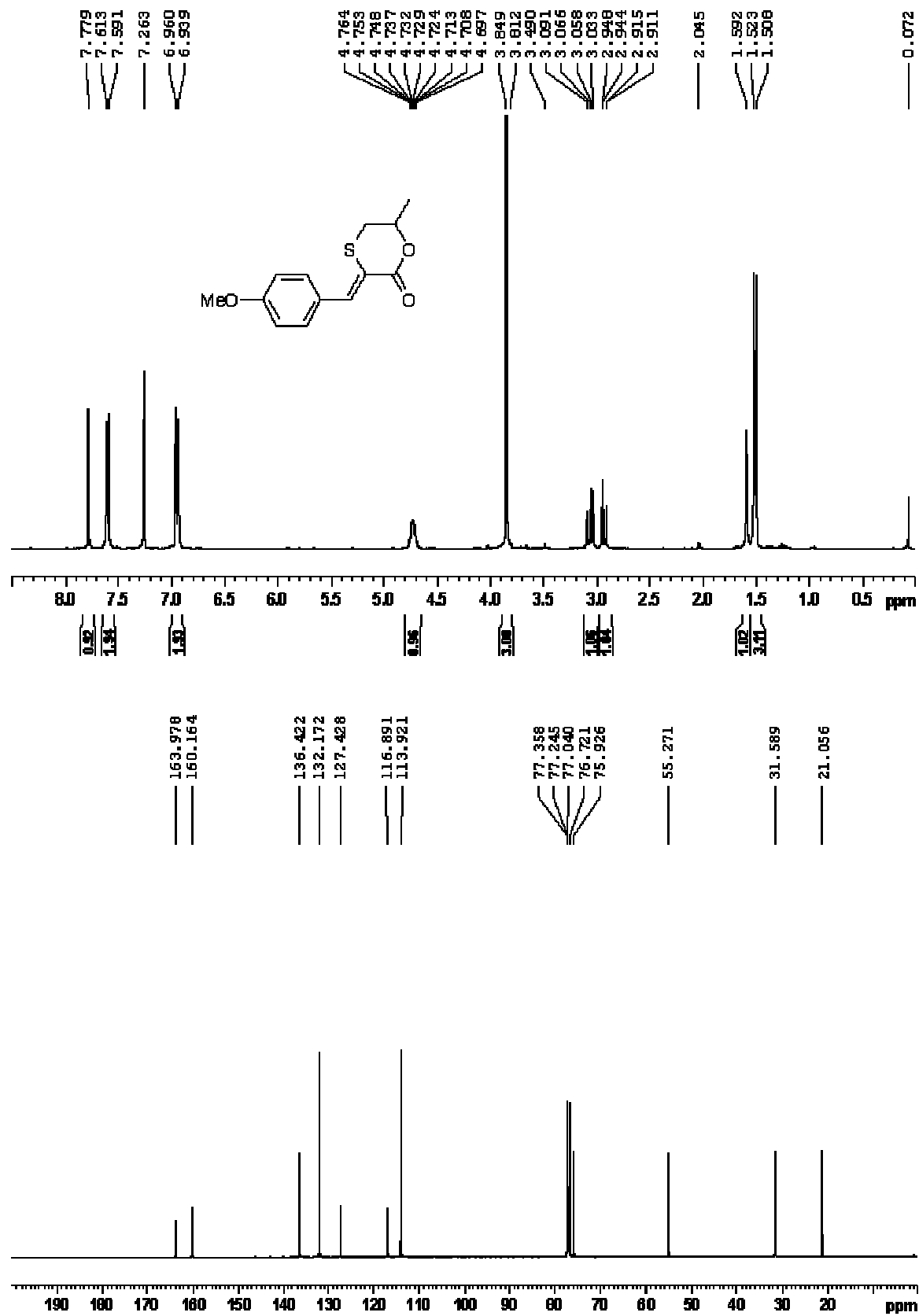
^1H NMR and ^{13}C NMR of **1b**



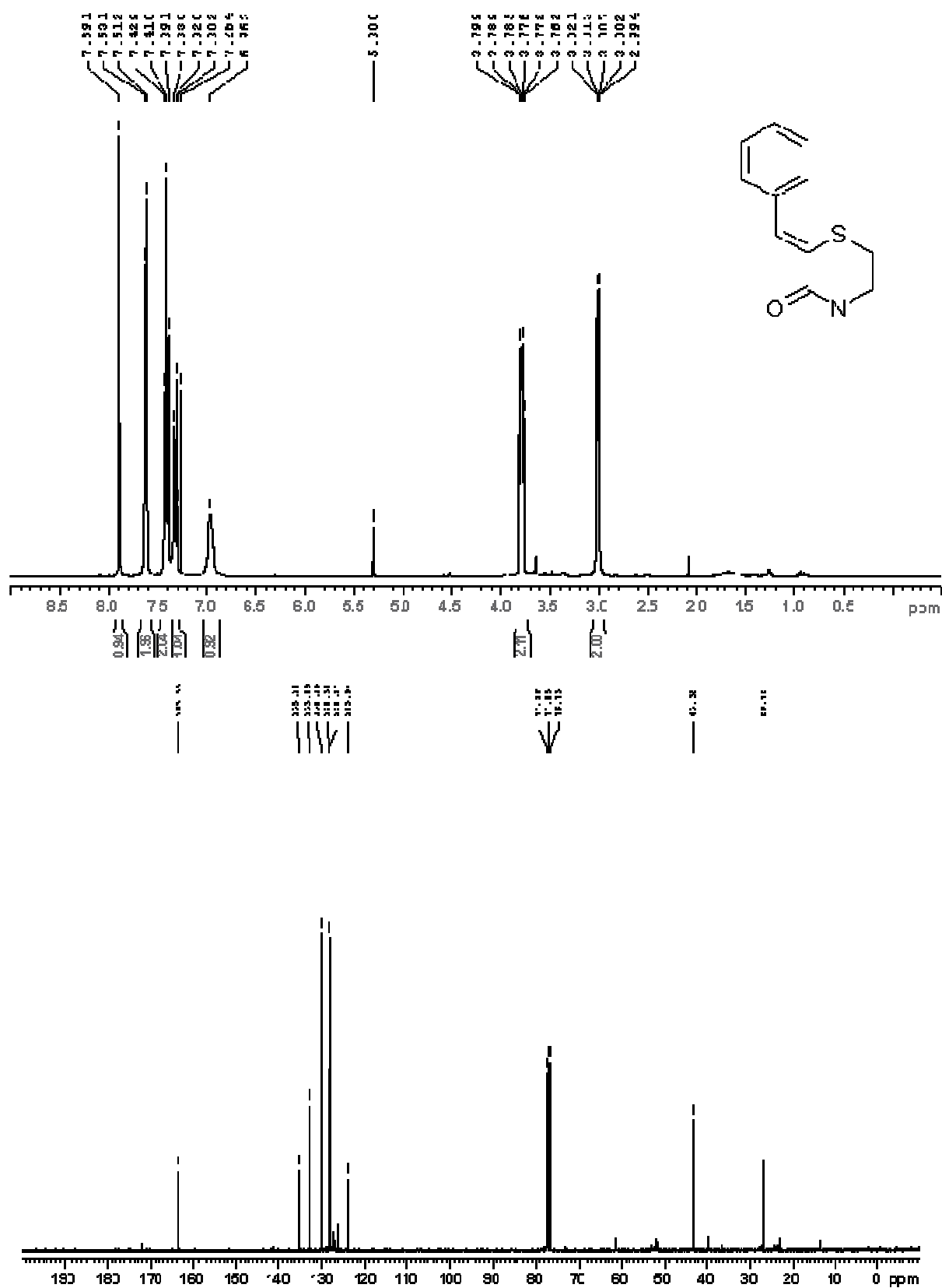
^1H NMR and ^{13}C NMR of **1c**



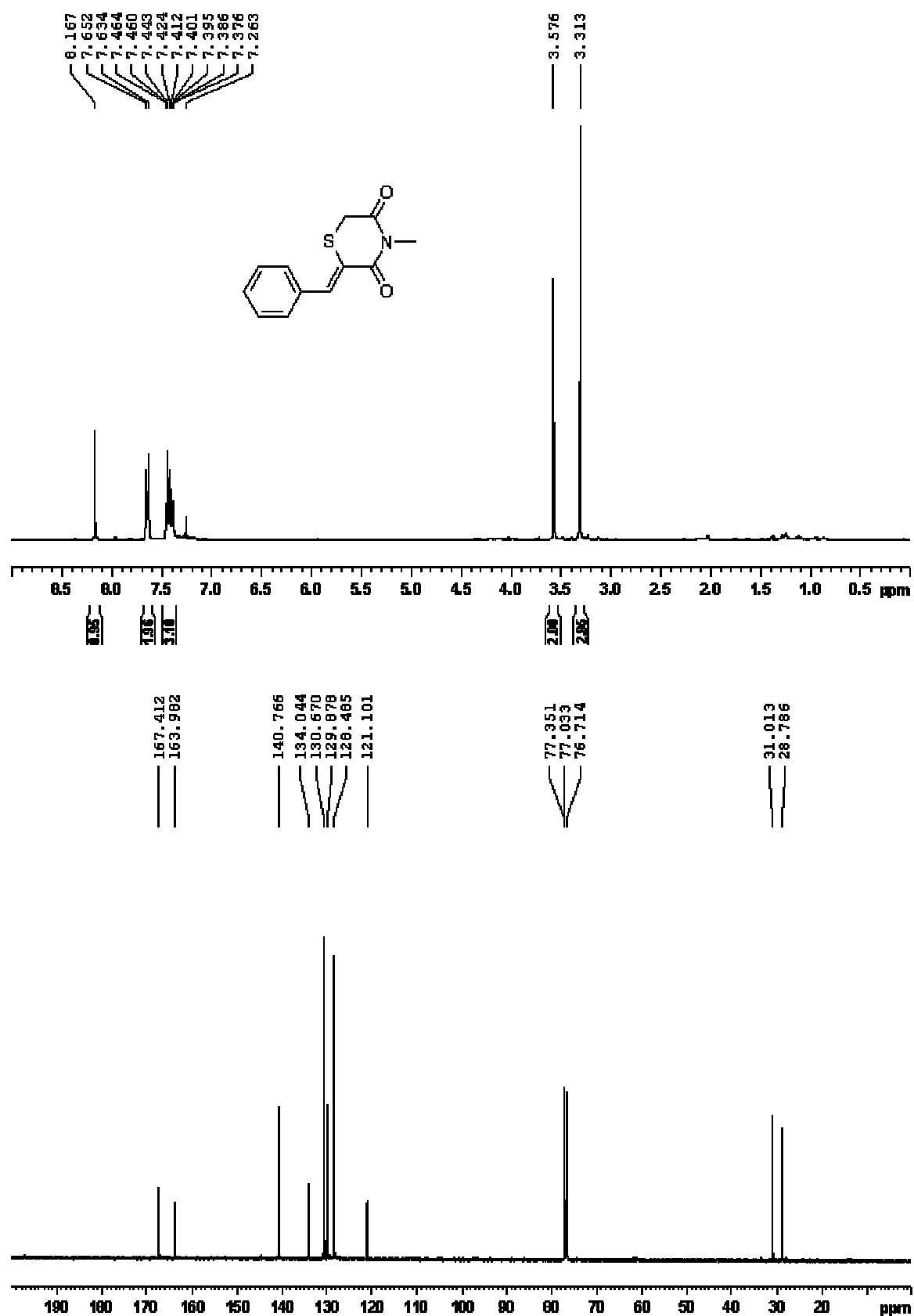
^1H NMR and ^{13}C NMR of **1d**



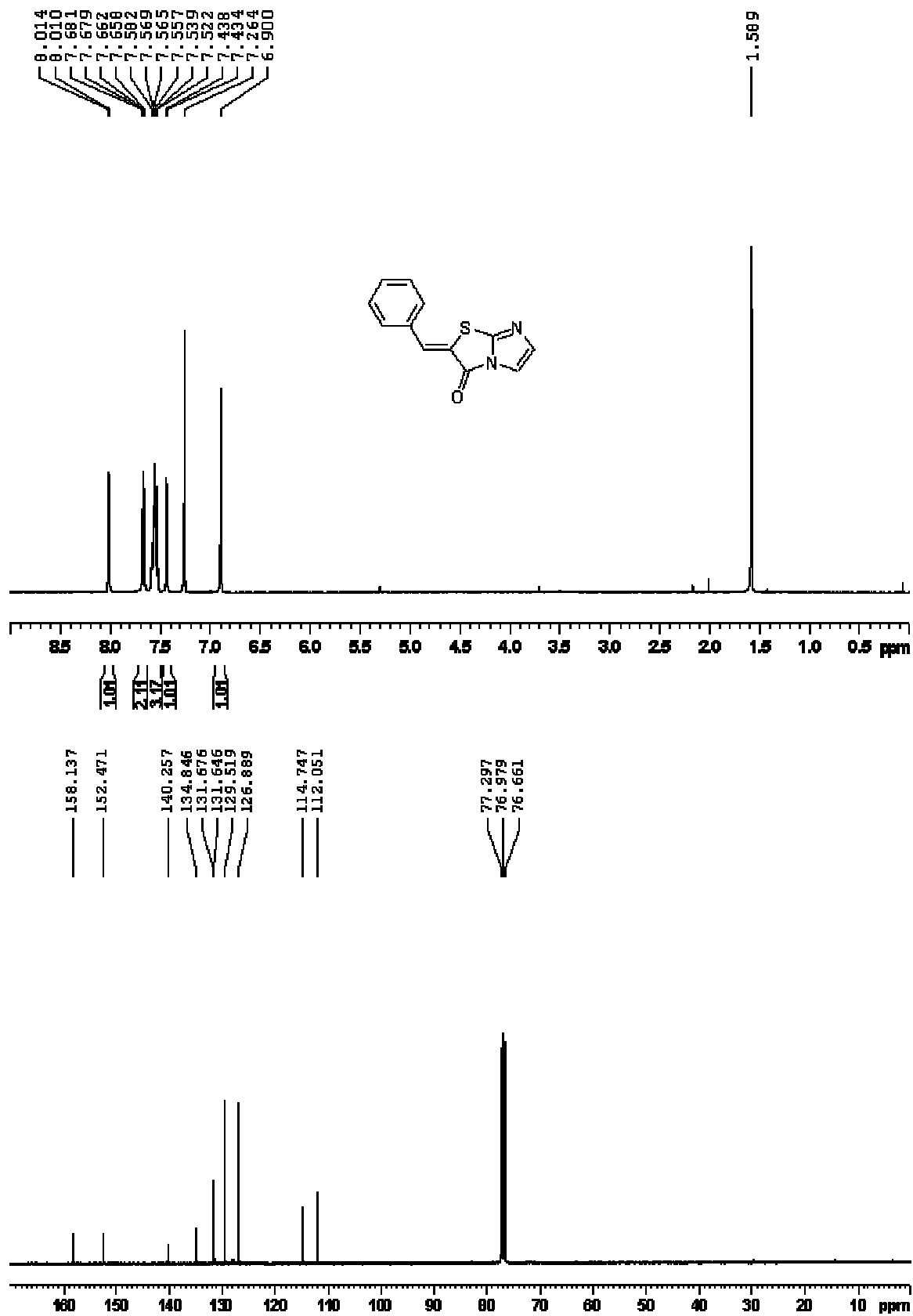
^1H NMR and ^{13}C NMR of **1e**



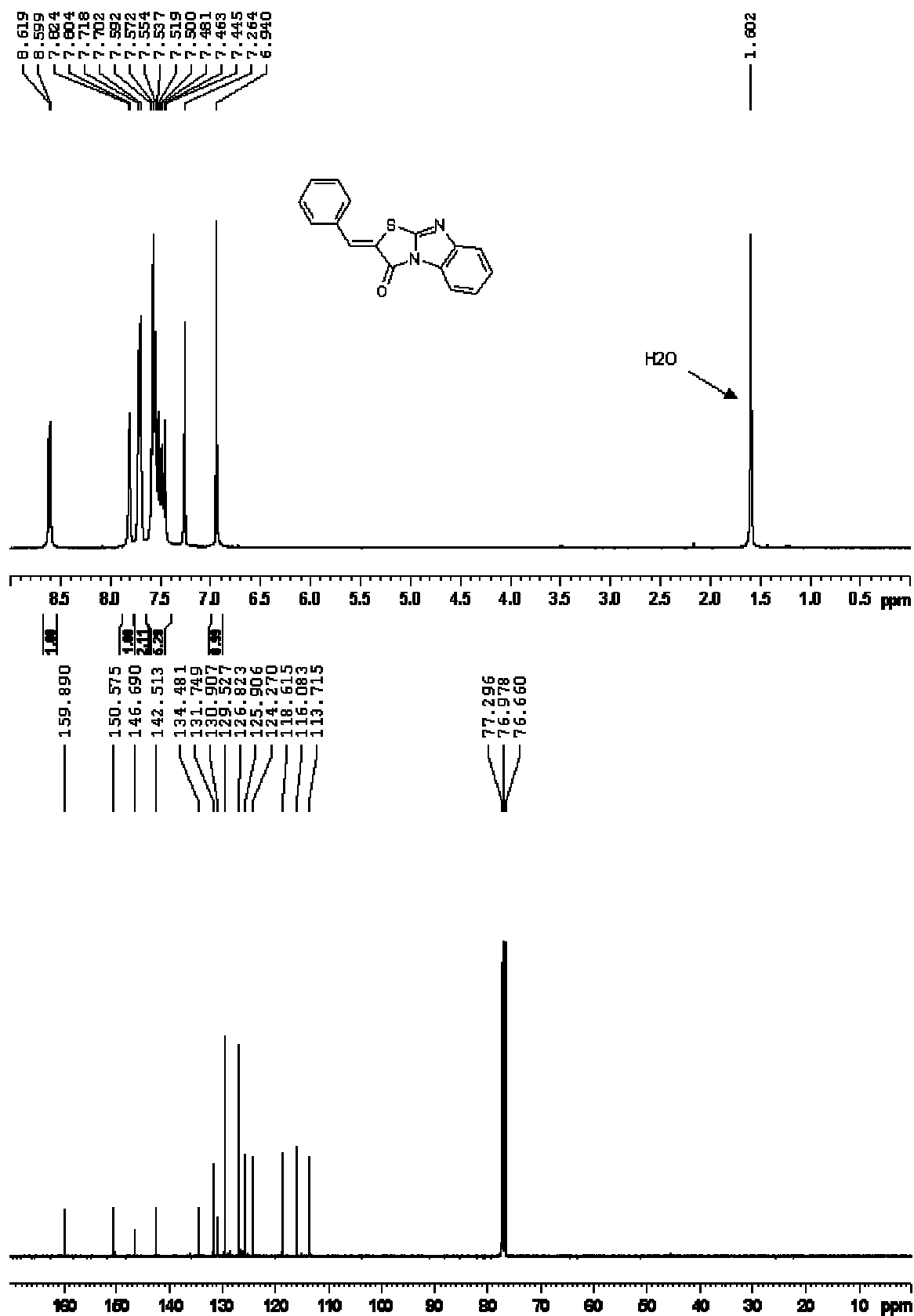
^1H NMR and ^{13}C NMR of **1f**



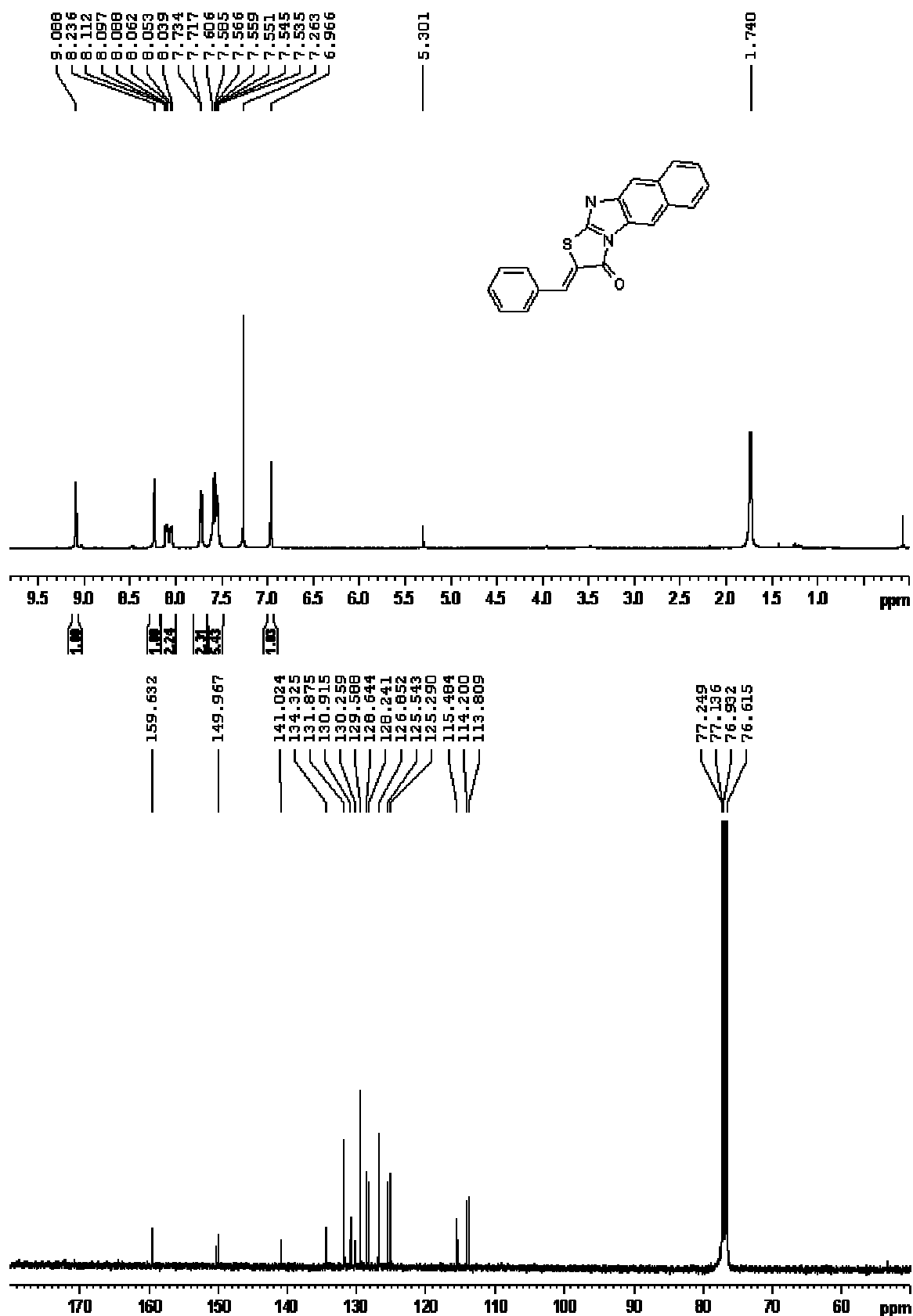
^1H NMR and ^{13}C NMR of **1g**



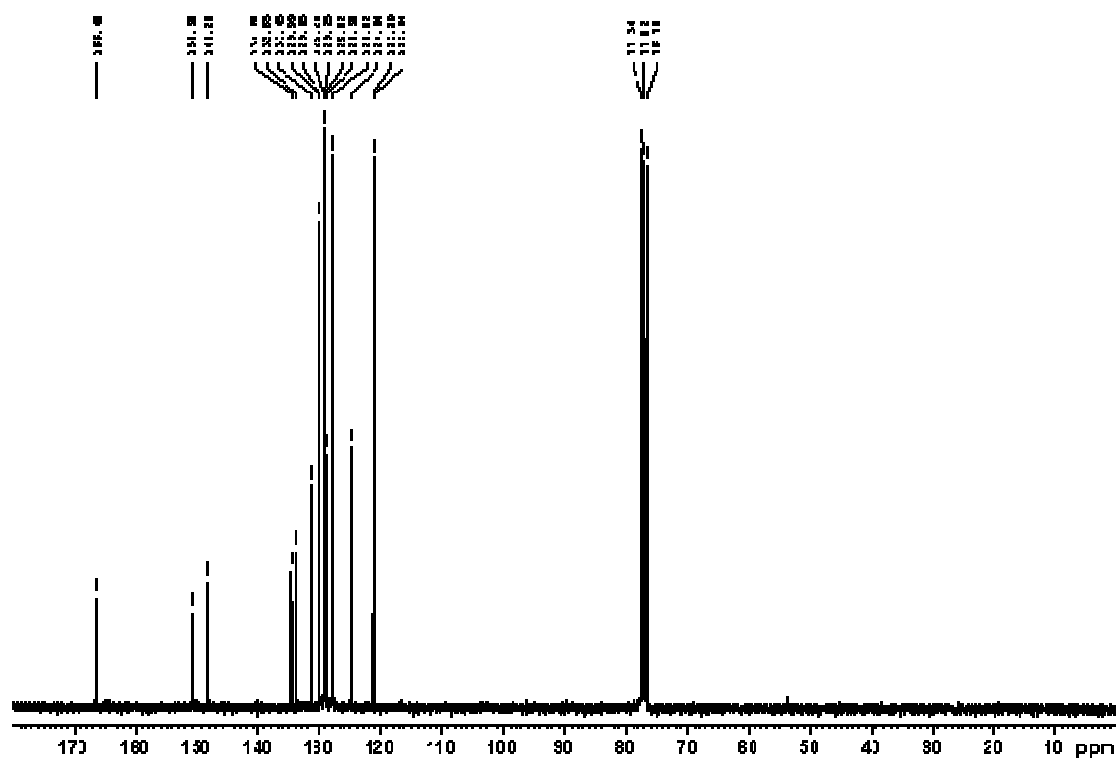
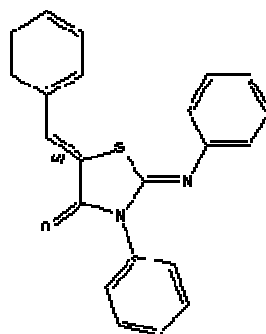
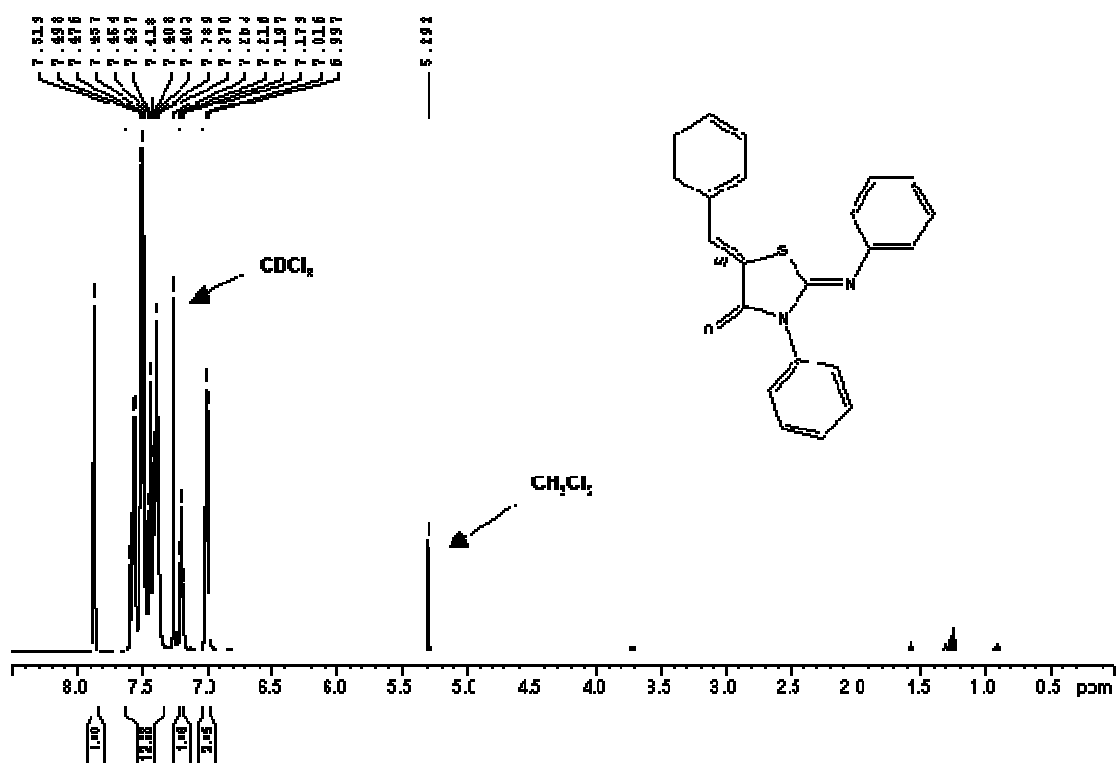
^1H NMR and ^{13}C NMR of **1h**



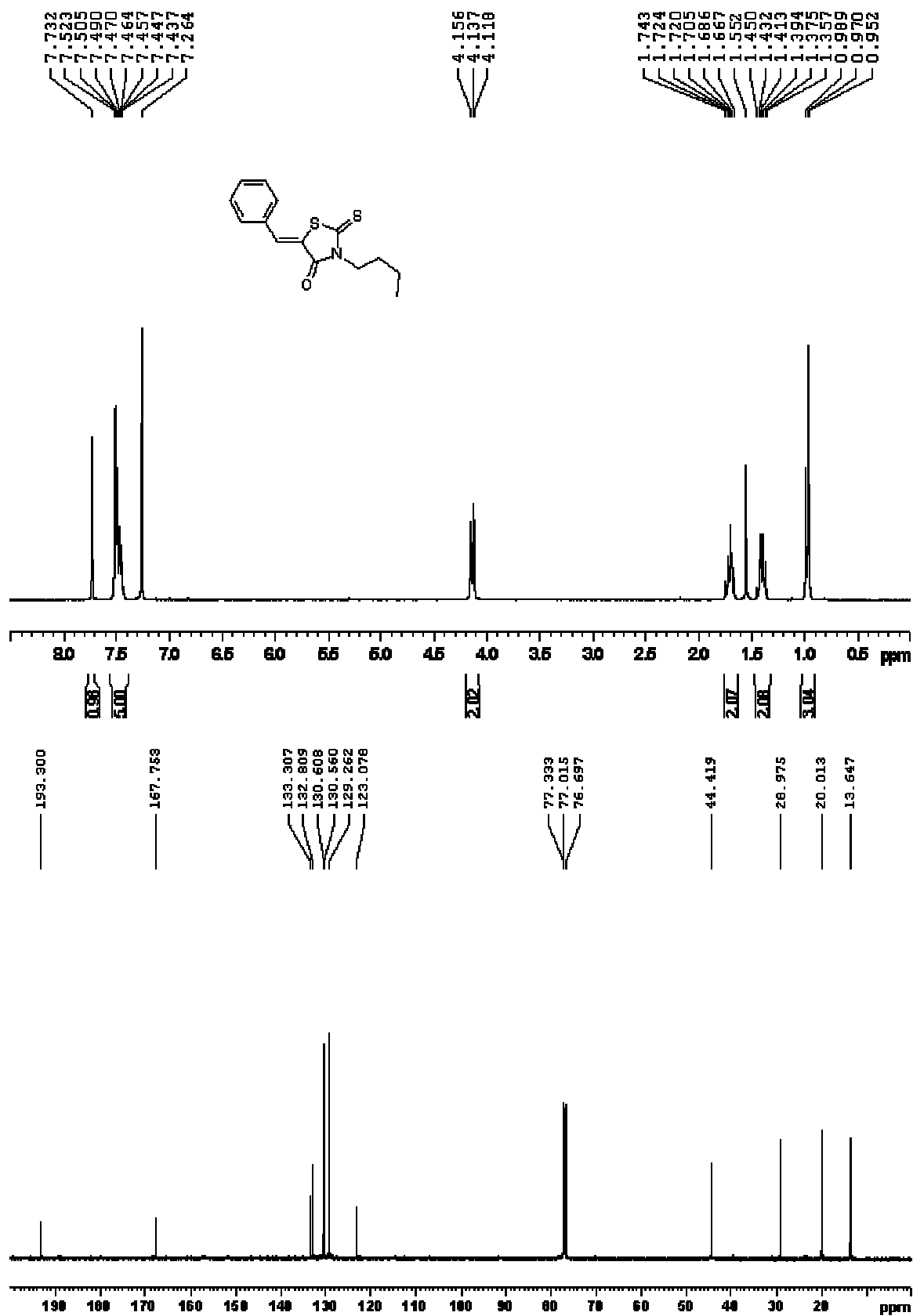
^1H NMR and ^{13}C NMR of **1i**



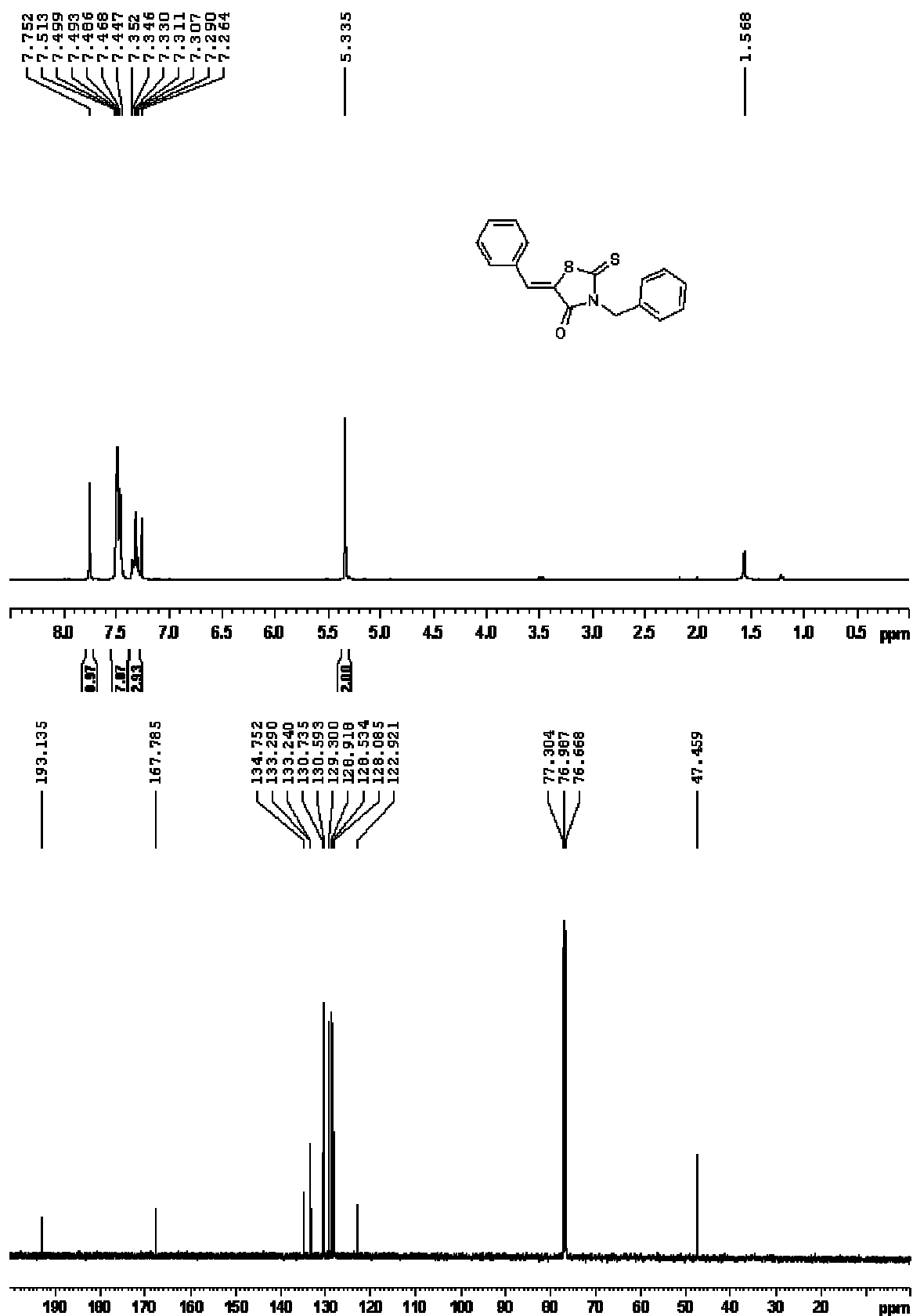
^1H NMR and ^{13}C NMR of **1j**



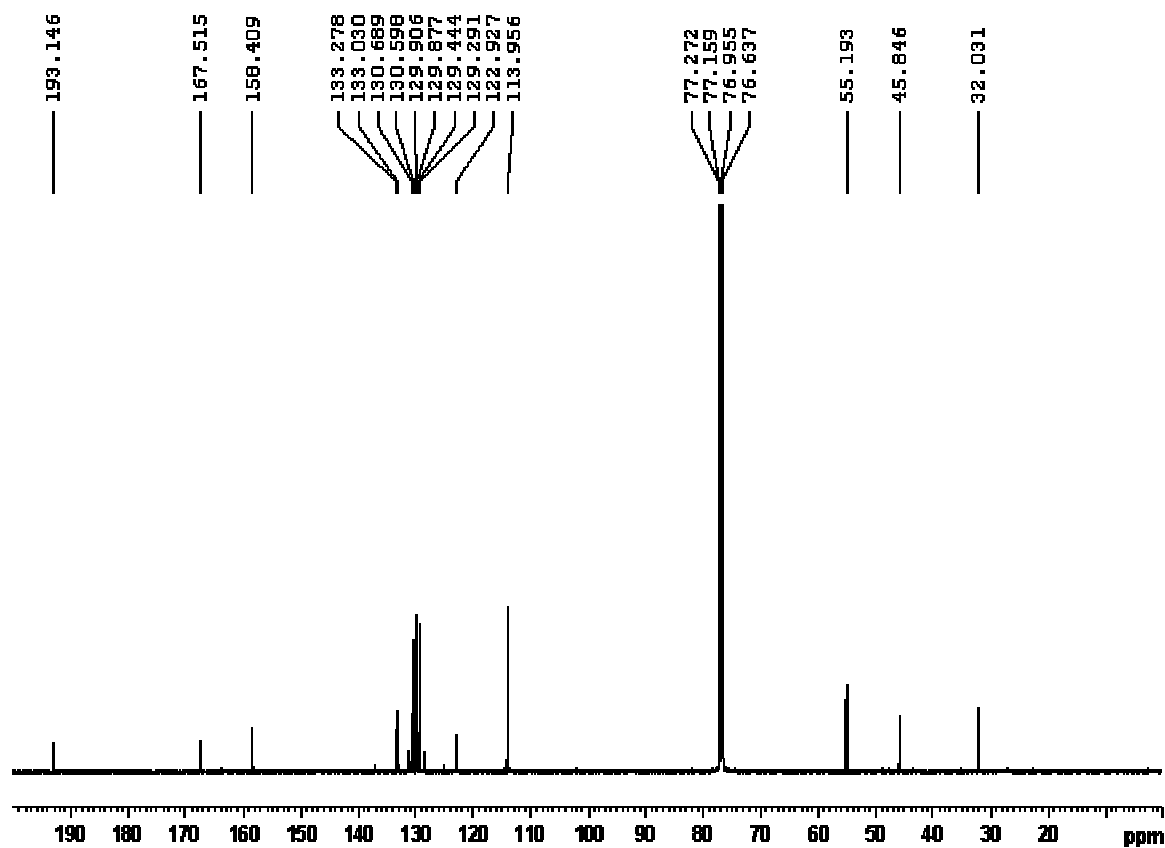
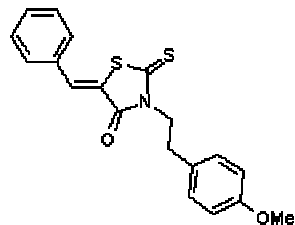
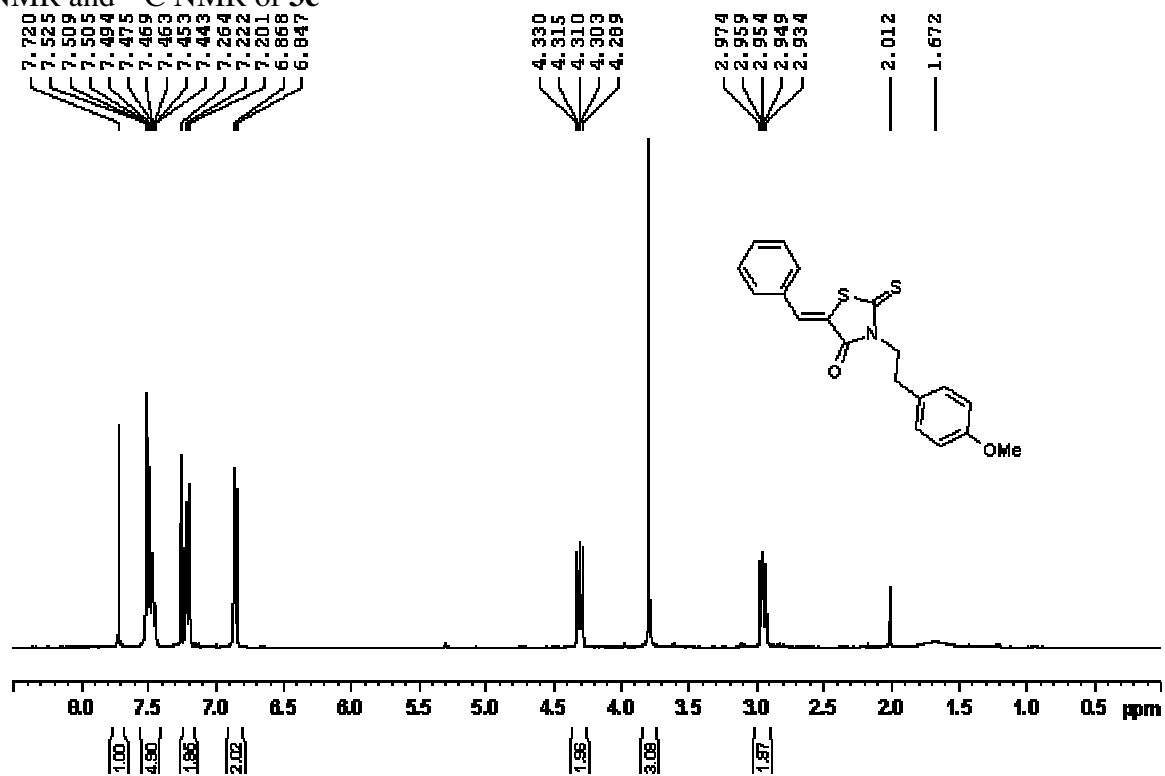
^1H NMR and ^{13}C NMR of 3a



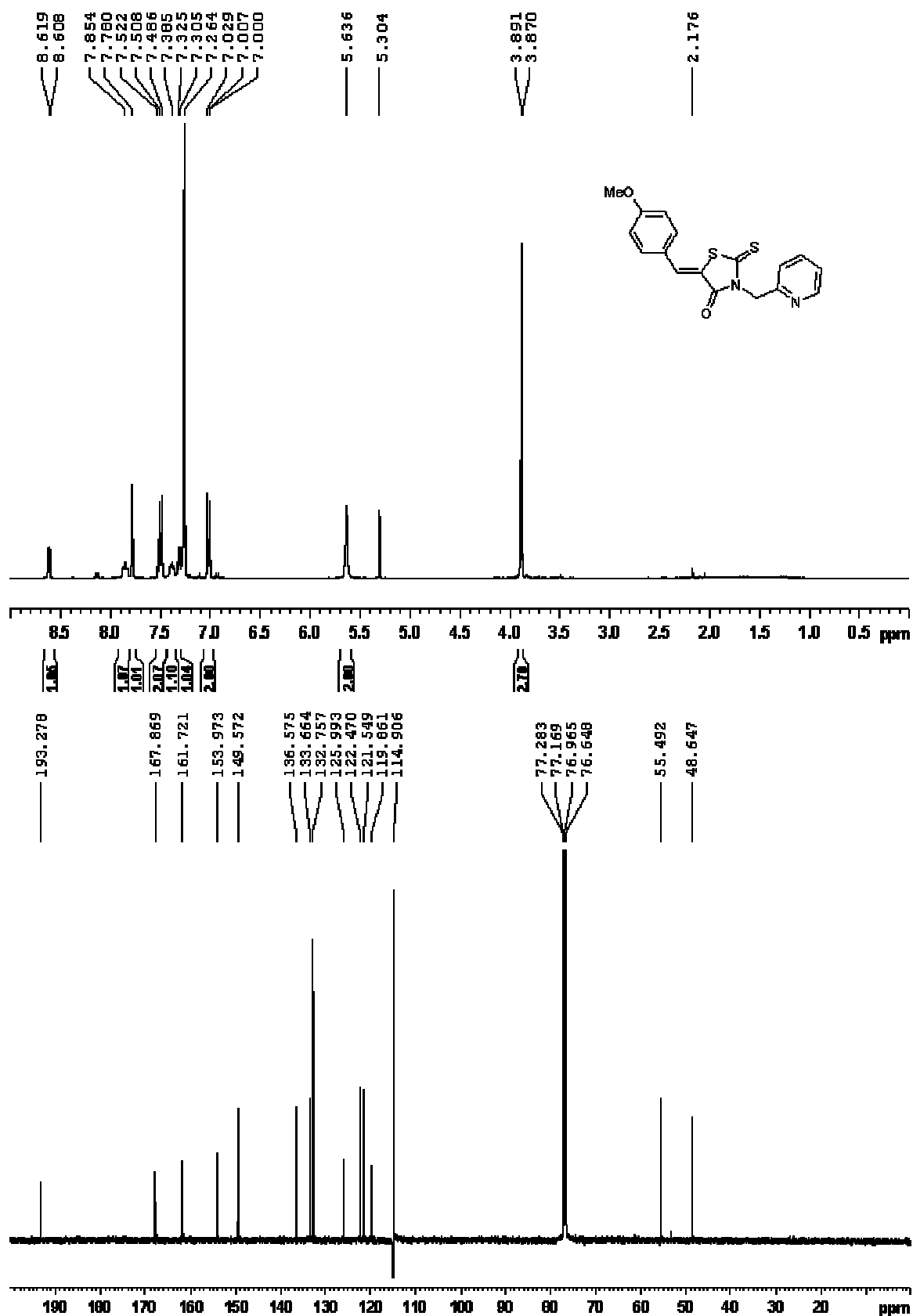
^1H NMR and ^{13}C NMR of **3b**



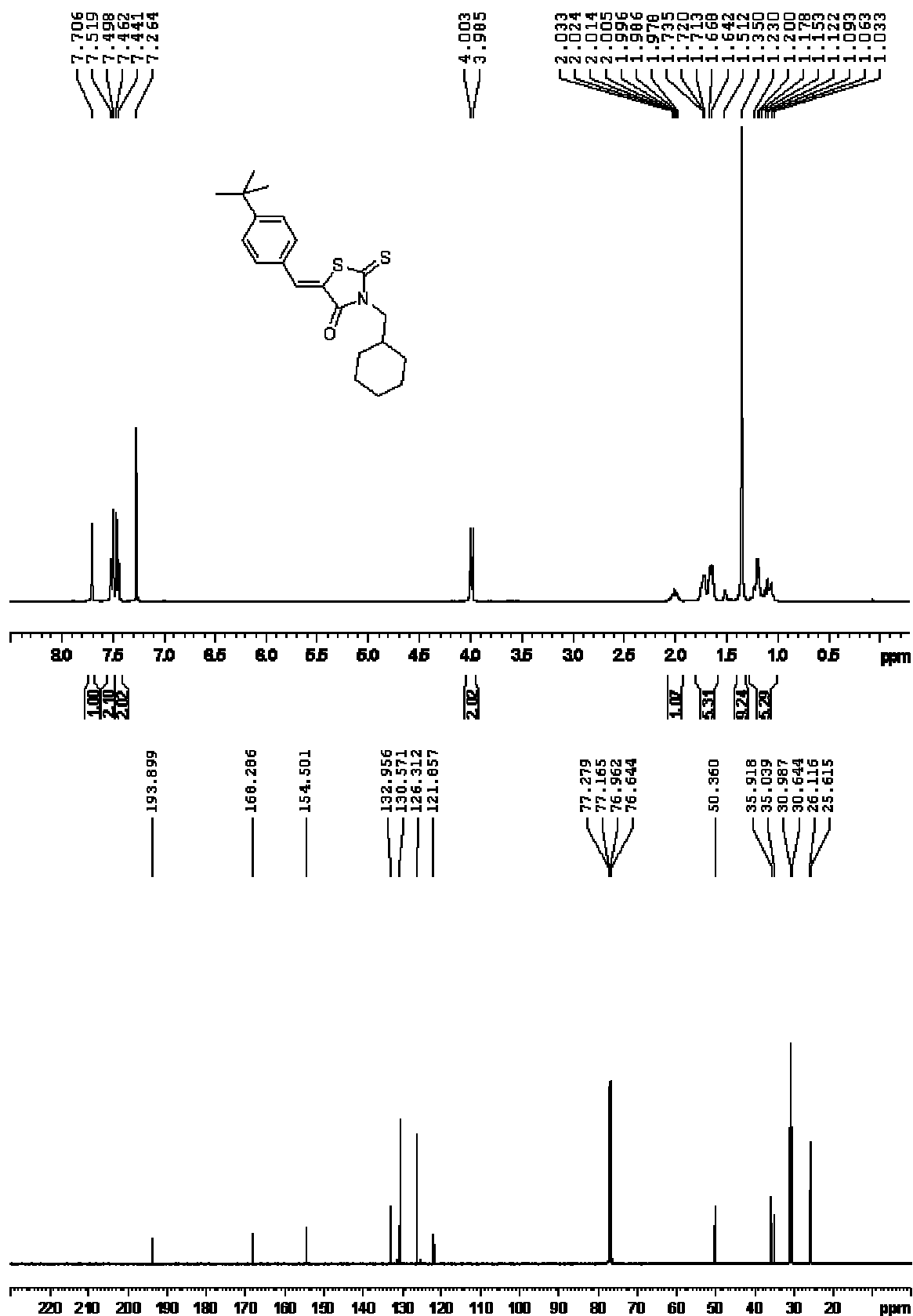
¹H NMR and ¹³C NMR of 3c



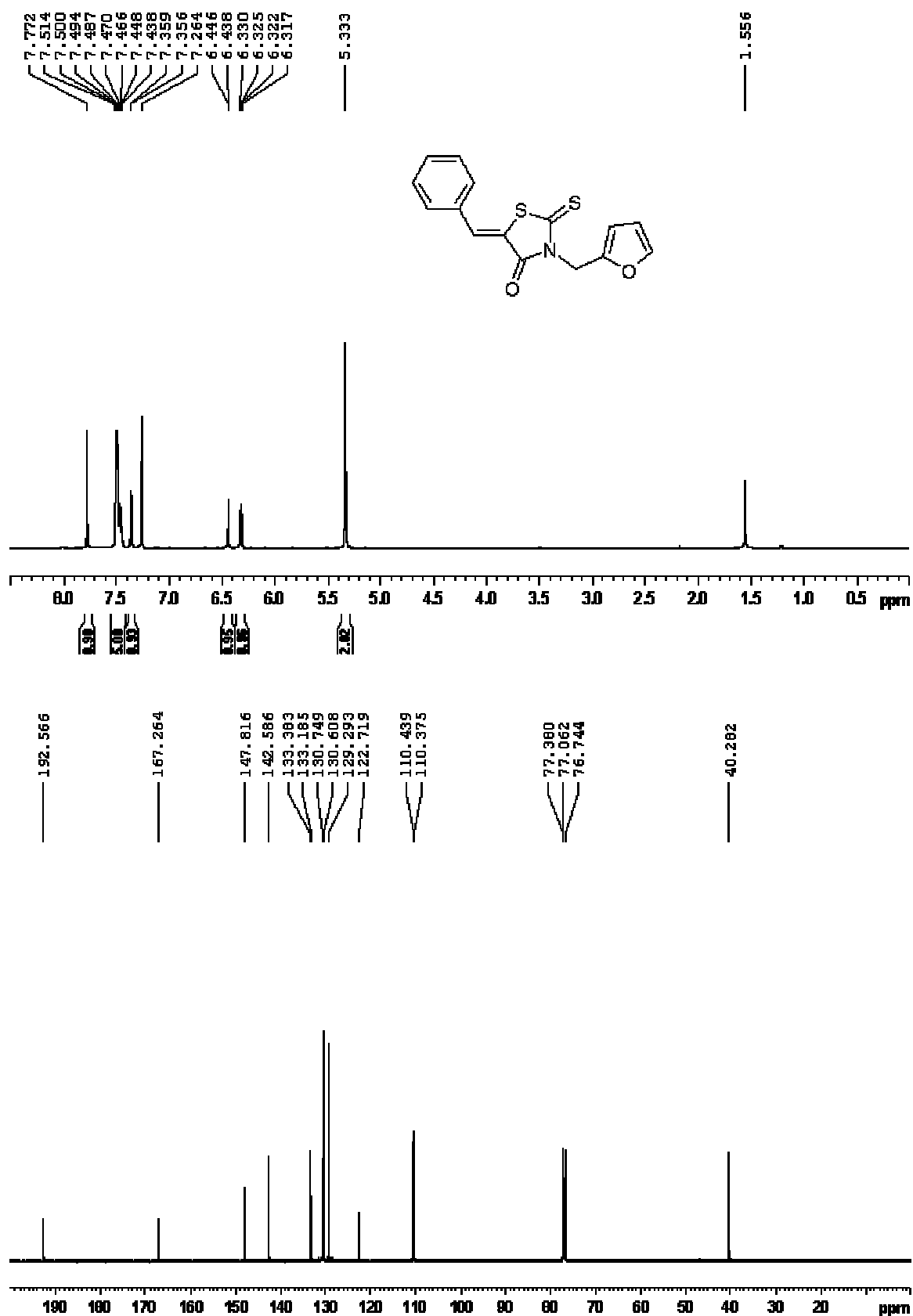
^1H NMR and ^{13}C NMR of **3d**



^1H NMR and ^{13}C NMR of **3e**



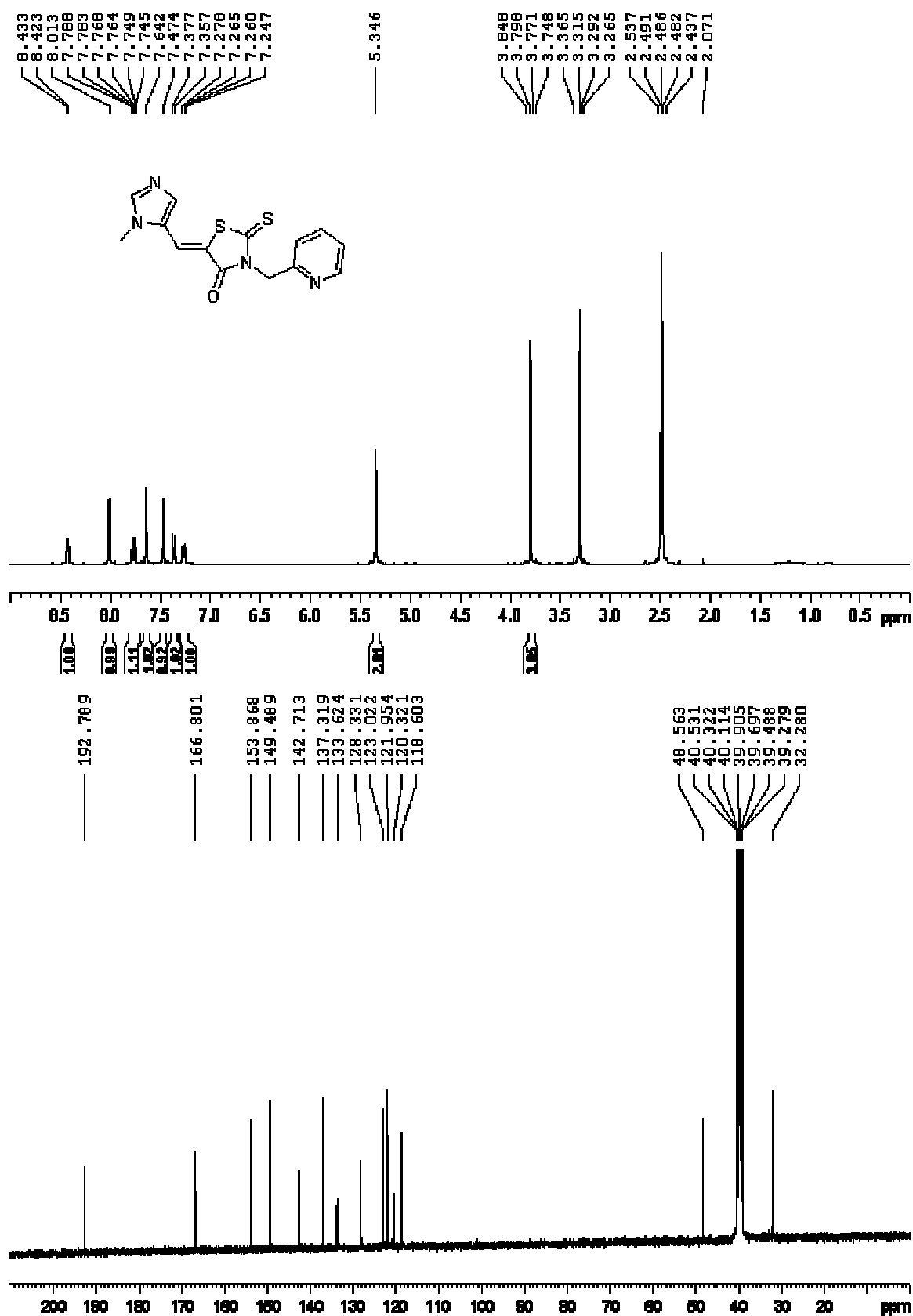
^1H NMR and ^{13}C NMR of **3f**



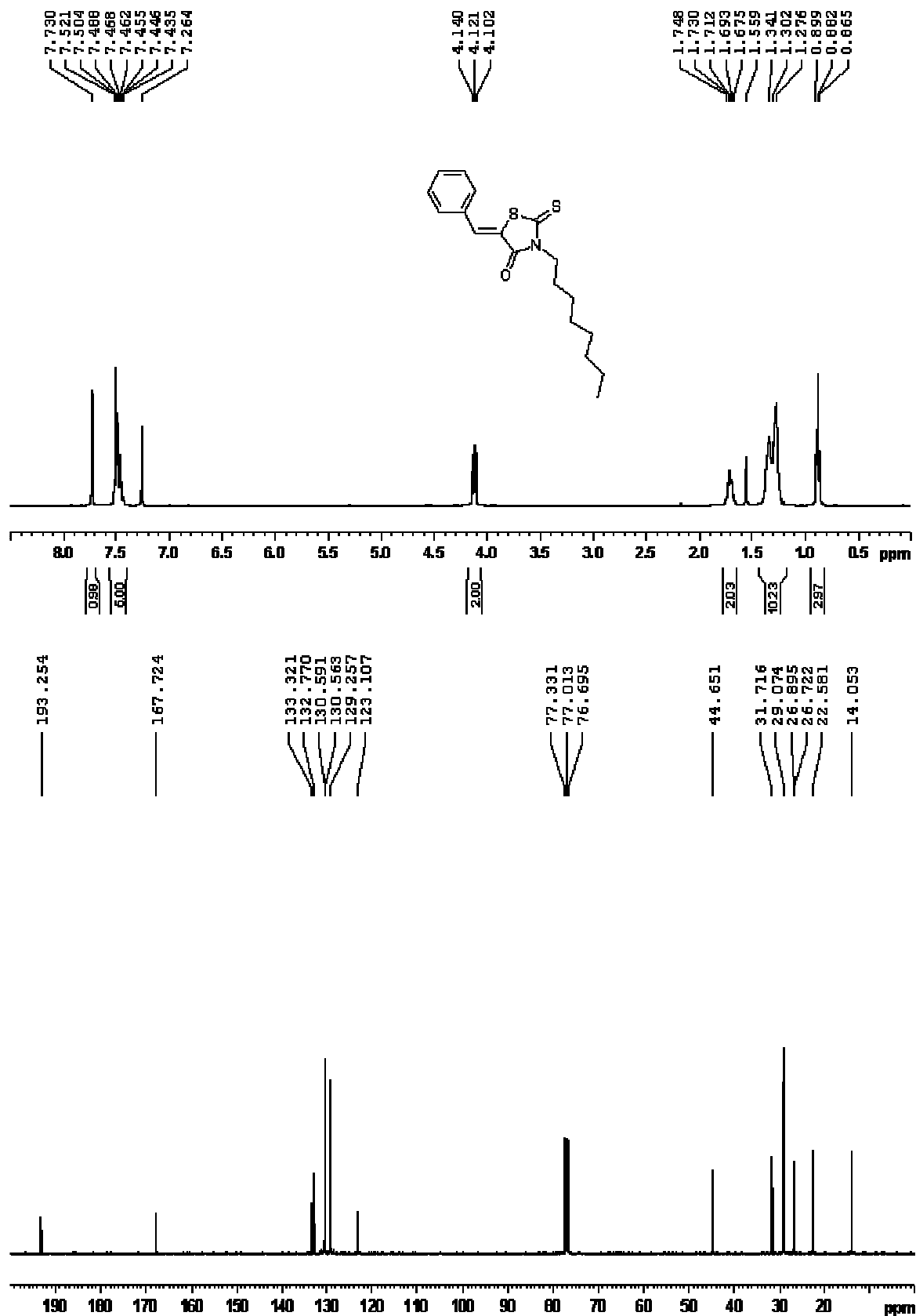
^1H NMR and ^{13}C NMR of **3g**



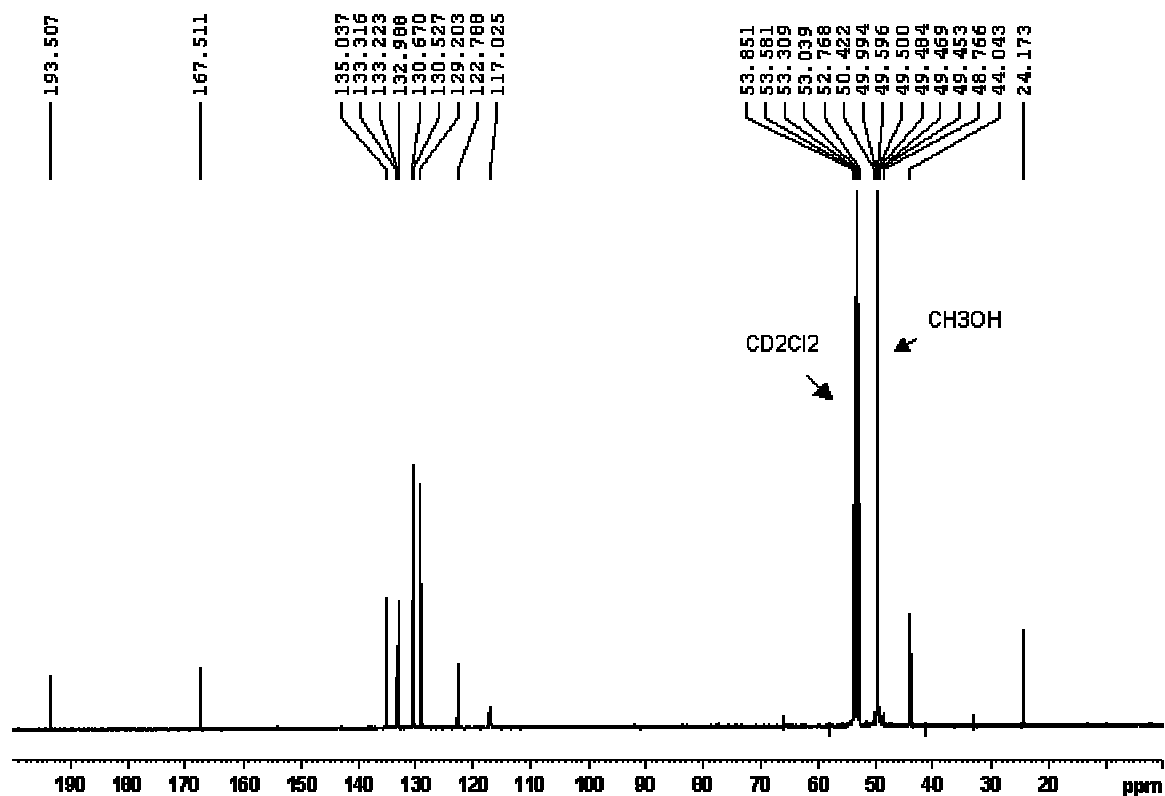
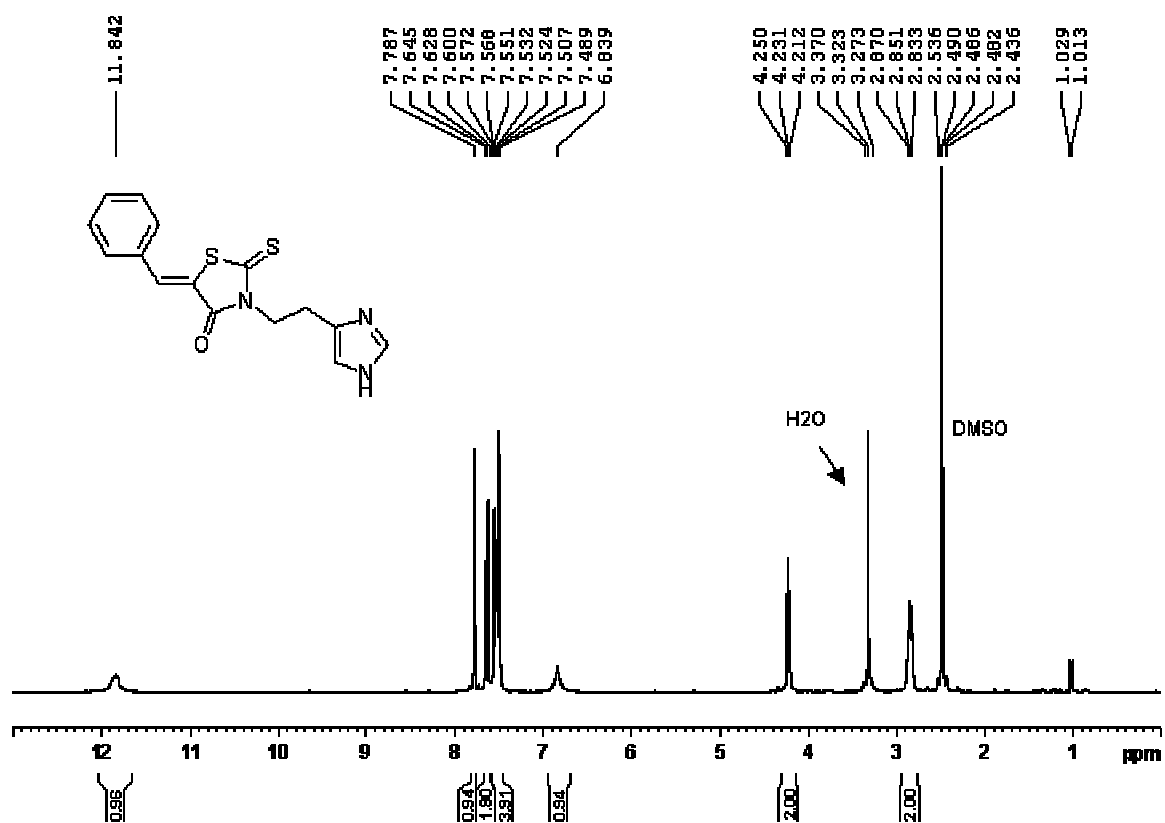
^1H NMR and ^{13}C NMR of **3h**



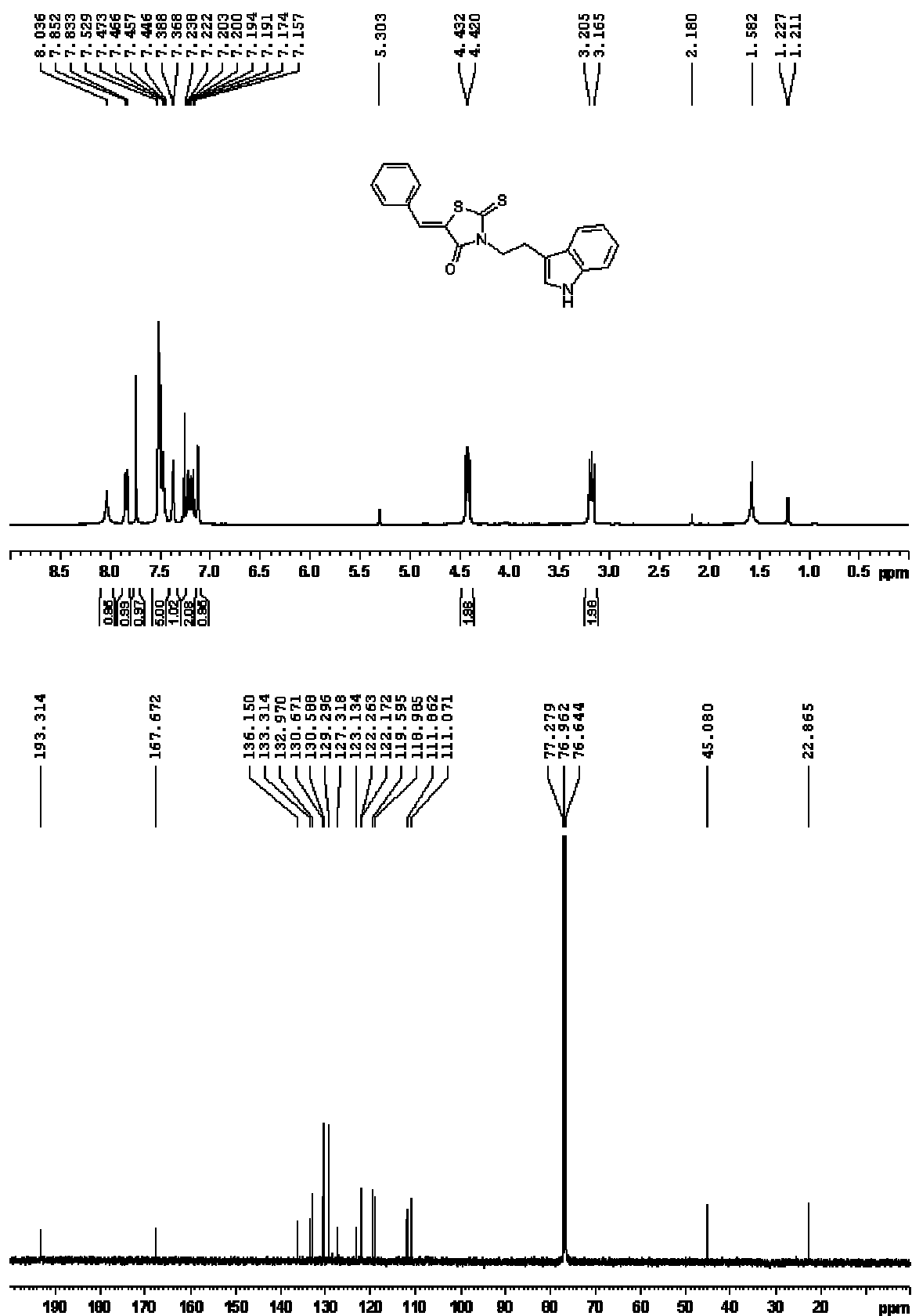
^1H NMR and ^{13}C NMR of **3i**



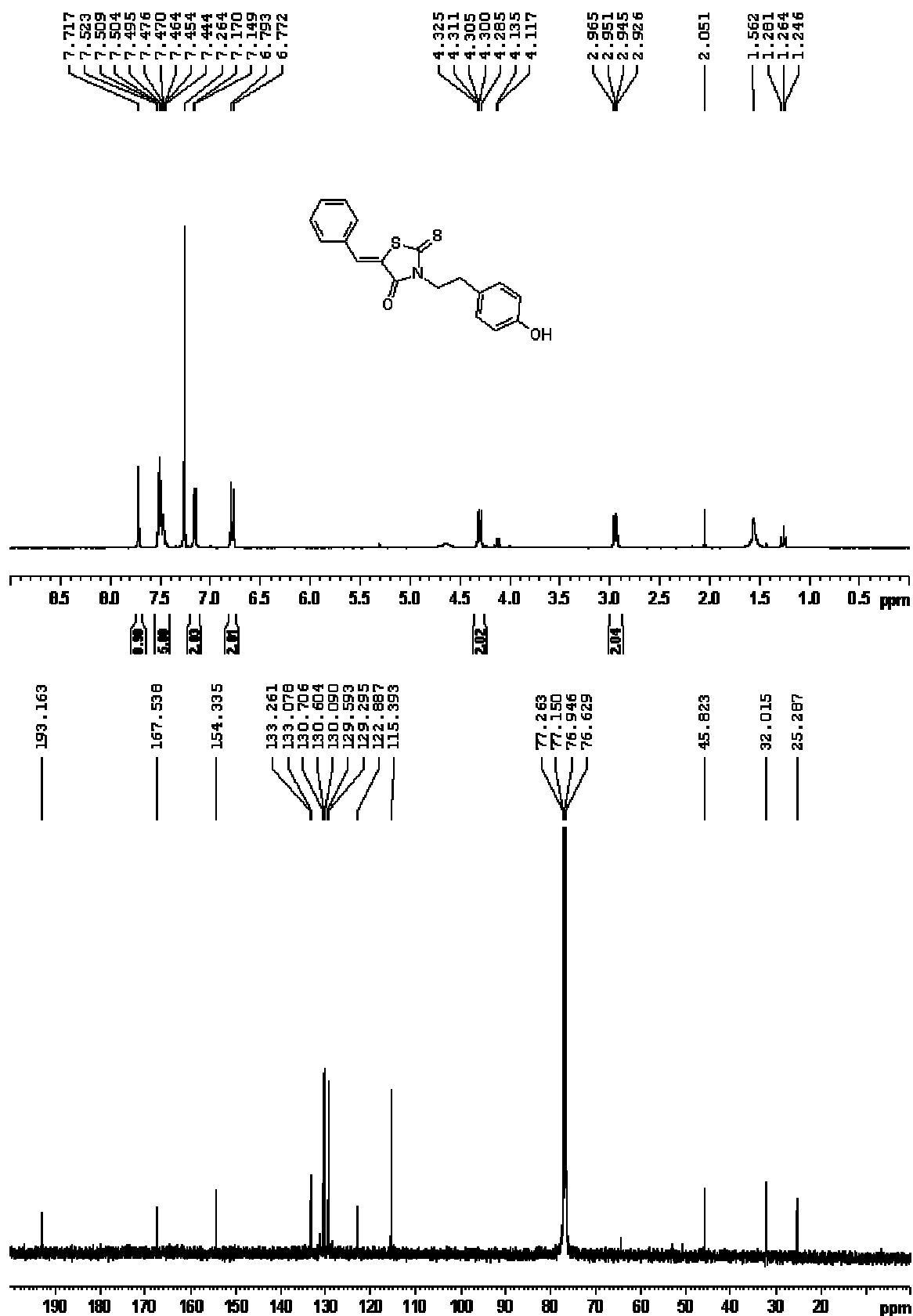
^1H NMR and ^{13}C NMR of **3j**



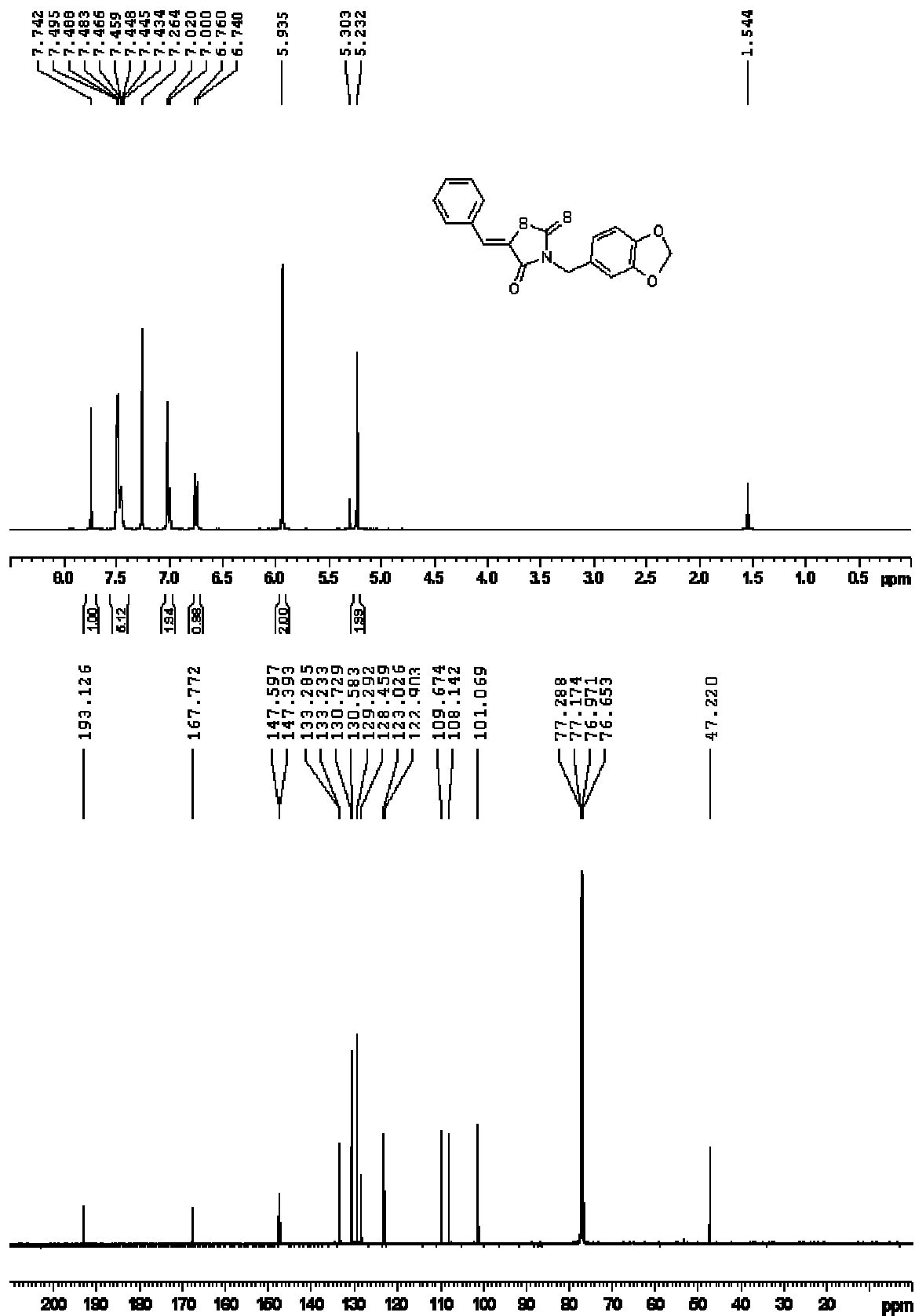
^1H NMR and ^{13}C NMR of **3k**



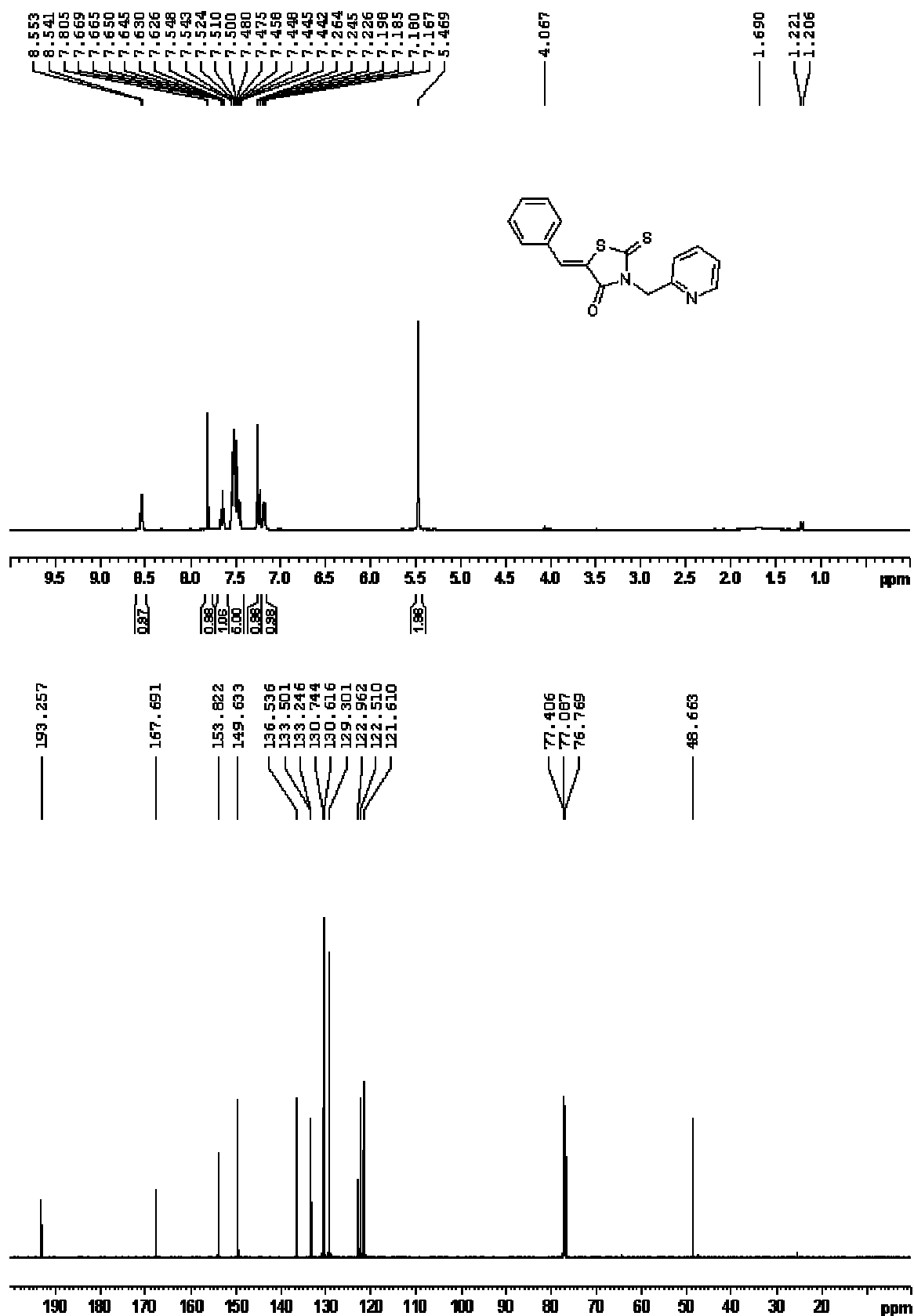
^1H NMR and ^{13}C NMR of **3m**



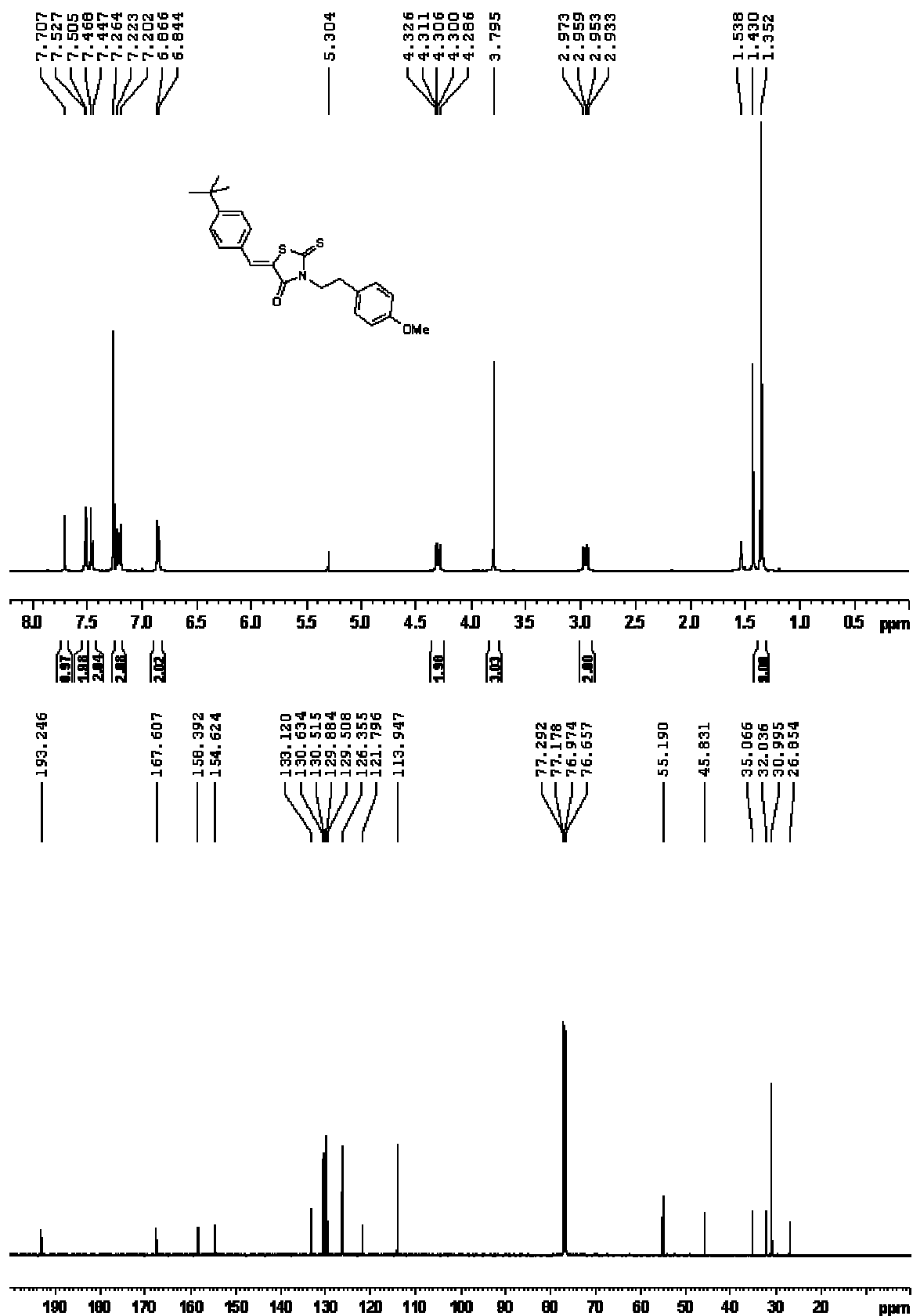
^1H NMR and ^{13}C NMR of **3n**



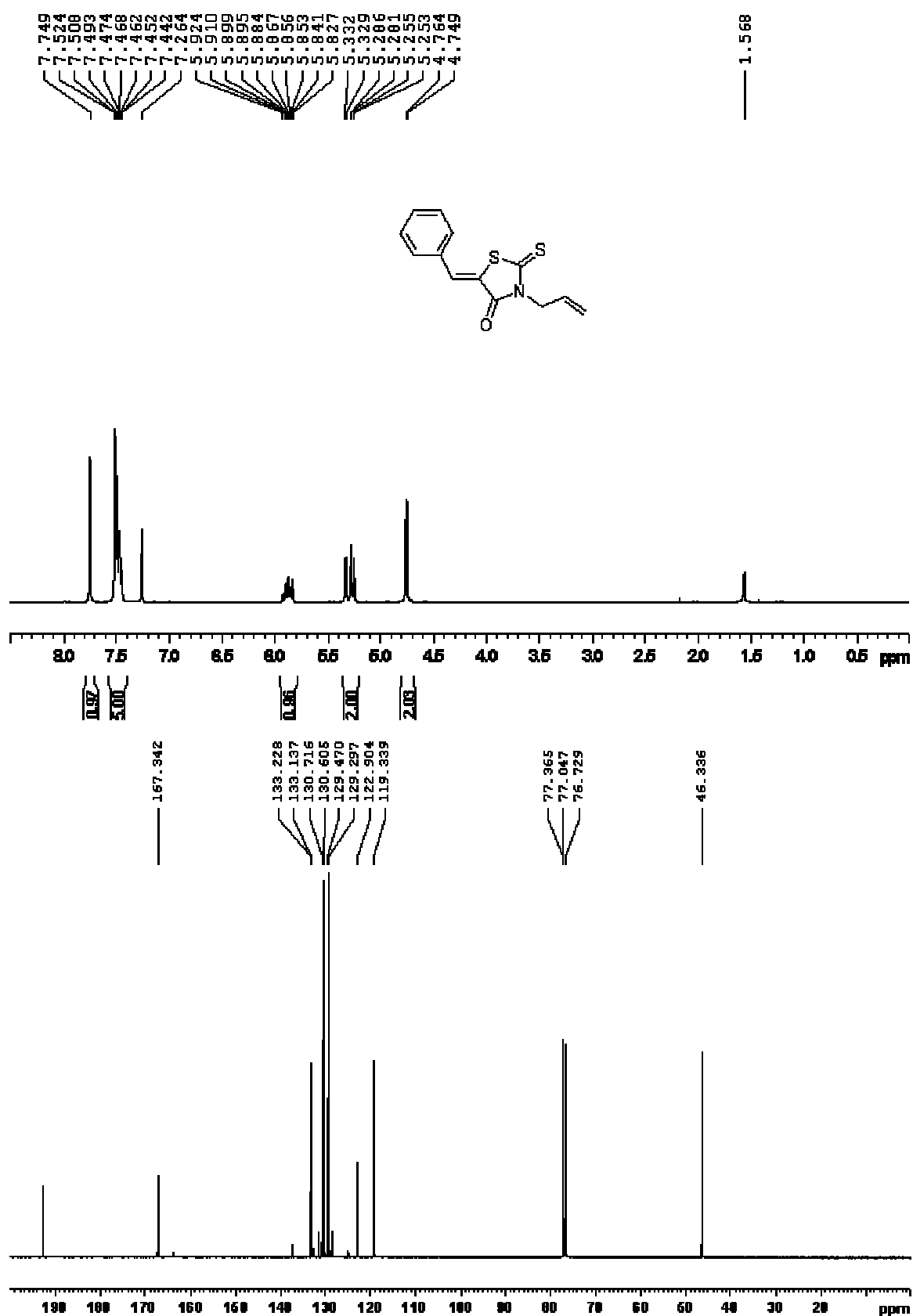
^1H NMR and ^{13}C NMR of **30**



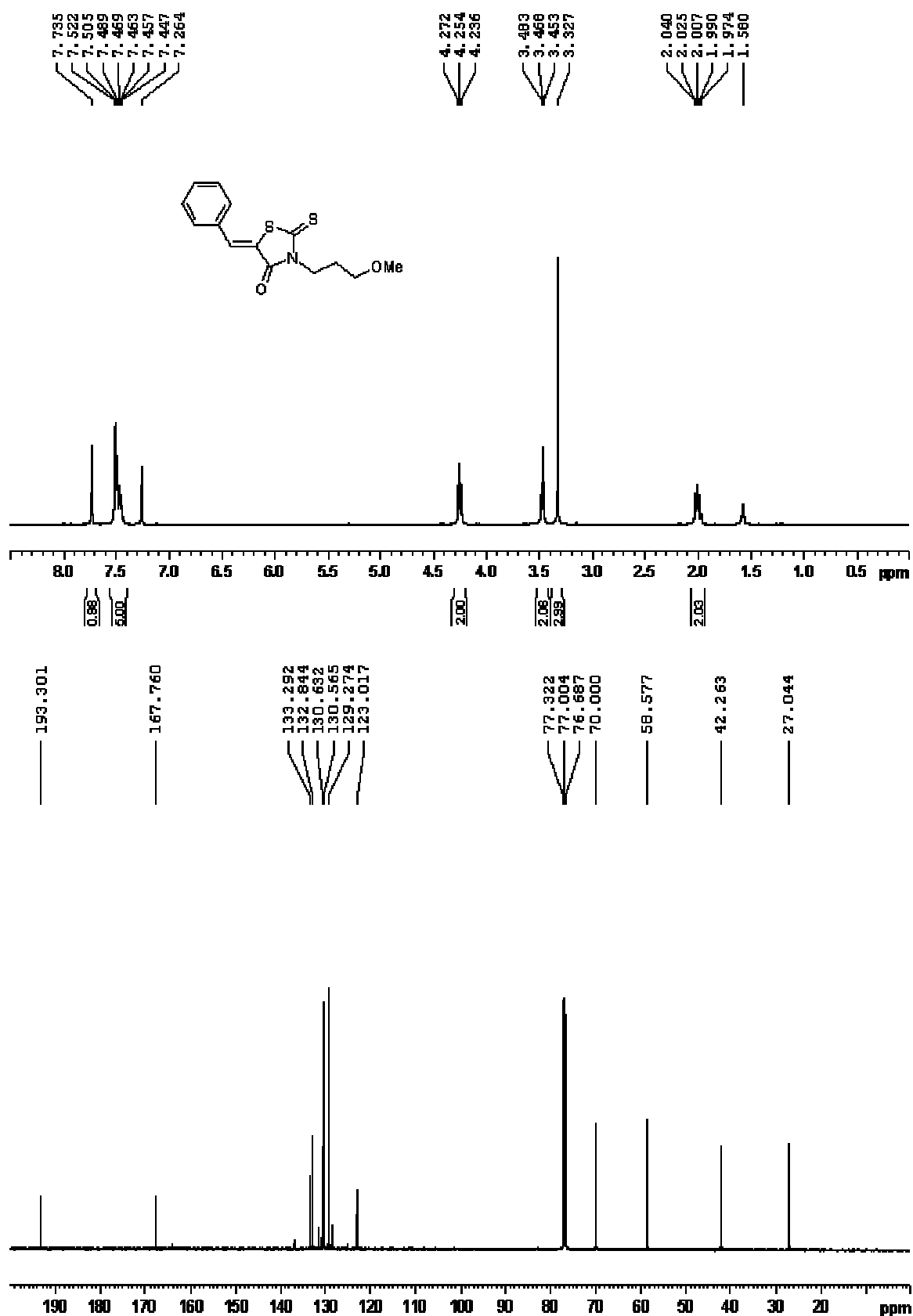
^1H NMR and ^{13}C NMR of **3p**



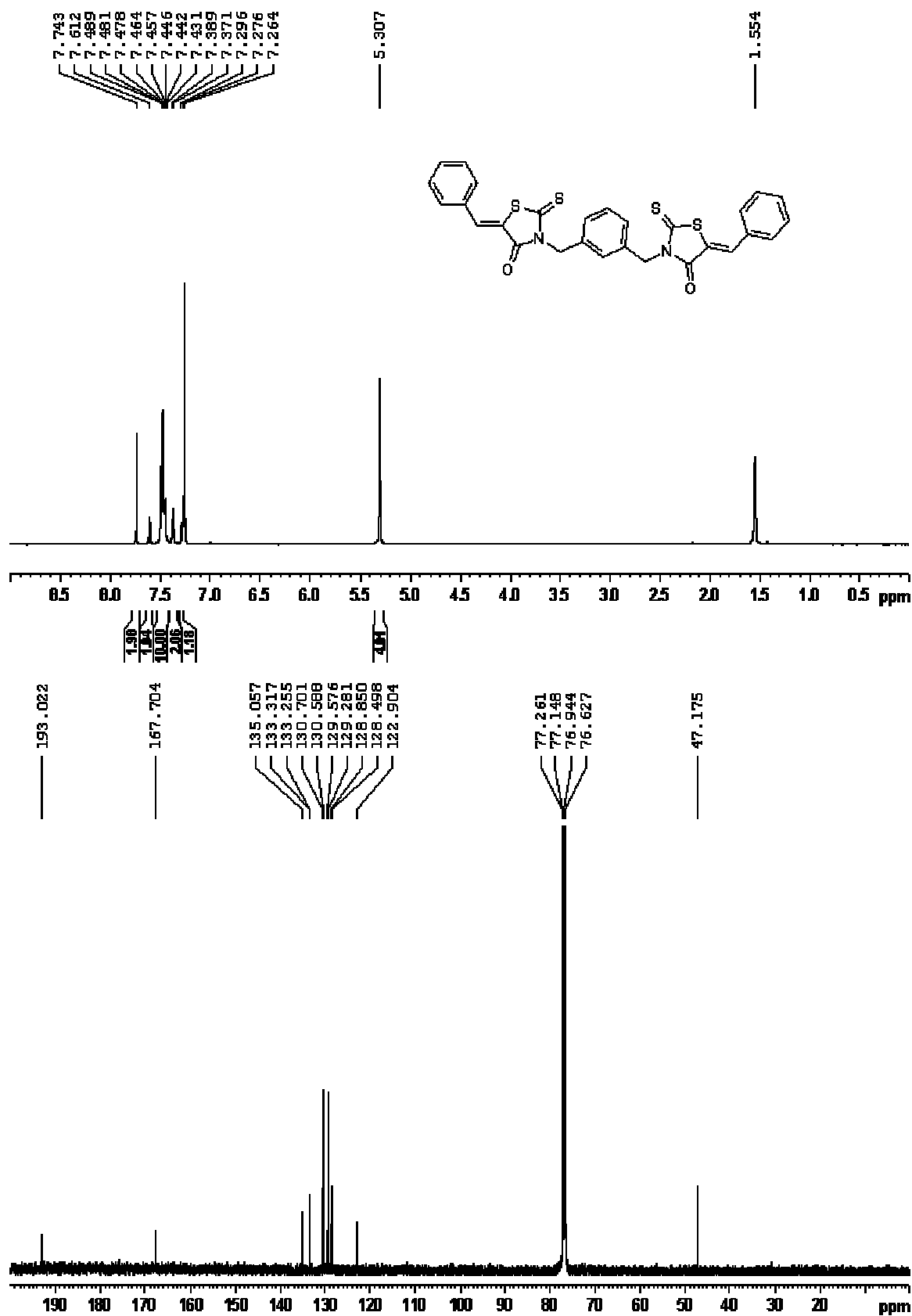
^1H NMR and ^{13}C NMR of **3q**



^1H NMR and ^{13}C NMR of **3r**



^1H NMR and ^{13}C NMR of 3s



• **X-ray crystal structure data for 1e:** Empirical formula: $C_{11}H_{11}NOS$; Formula weight: 205.27; $T = 293(2)$ K, $\lambda = 0.71073$ Å; Crystal system = monoclinic; Space group: $P 21/a$; Unit cell dimensions: $a = 7.104$ (5) Å, $b = 7.533$ (5) Å, $c = 18.827$ (9) Å, $\alpha = \gamma = 90.00^\circ$, $\beta = 94.10$ (4) $^\circ$; $V = 1004.9$ Å³; $Z = 4$; $D_{\text{calc}} = 1.357$ g/cm³; Absorption coefficient: 0.286 mm⁻¹; $F(000) = 432$; Crystal size: $0.50 \times 0.33 \times 0.16$ mm; Reflections collected: 7565; Independent reflections: 2277 [$R(\text{int}) = 0.0322$]; Refinement method, full-matrix least-squares on F^2 ; Goodness-of-fit on F^2 : 1.056; Final R indices [$I > 2\sigma(I)$] $R1 = 0.0435$, $wR2 = 0.1028$; R indices (all data) $R1 = 0.0577$, $wR2 = 0.1118$; Extinction coefficient: 0.031 (10); Largest diff. peak and hole: 0.255 and -0.196 e Å⁻³.

