

Support Information

Direct synthesis of Enone-Hydrazones under solvent free and additives free

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Contents

1. General Procedure for preparing enamines 1.....	5
2. General Procedure for preparing hydrazones 2	6
3. General Procedure for preparing enone-hydrazones.....	7
4. Spectroscopic Data of (3a-3v)	7
5. Spectroscopic Data of (4b-4q)	18
6. General Procedure for preparing 5a.....	29
7. General Procedure for preparing 6a.....	30
8. X-ray Structure and Data of 4g-Z	32
9. X-ray Structure and Data of 4n.....	34
10. Reference	36
¹ H-NMR (600MHz, CDCl ₃) spectrum of compound (3a).....	37
¹³ C-NMR(150MHz, CDCl ₃) spectrum of compound (3a)	37
¹ H-NMR (500MHz, CDCl ₃) spectrum of compound (3b)	38
¹³ C-NMR(125MHz, CDCl ₃) spectrum of compound (3b)	38
¹⁹ F-NMR(565MHz, CDCl ₃) spectrum of compound (3b).....	39
¹ H-NMR (600MHz, CDCl ₃) spectrum of compound (3c).....	40
¹³ C-NMR(150MHz, CDCl ₃) spectrum of compound (3c).....	40
¹ H-NMR (500MHz, CDCl ₃) spectrum of compound (3e).....	41
¹³ C-NMR(125MHz, CDCl ₃) spectrum of compound (3e).....	41

^1H -NMR (400MHz, CDCl_3) spectrum of compound (3f)	42
^{13}C -NMR(100MHz, CDCl_3) spectrum of compound (3f)	42
^1H -NMR (500MHz, CDCl_3) spectrum of compound (3g)	43
^{13}C -NMR(125MHz, CDCl_3) spectrum of compound (3g)	43
^1H -NMR (400MHz, CDCl_3) spectrum of compound (3h)	44
^{13}C -NMR(100MHz, CDCl_3) spectrum of compound (3h)	44
^1H -NMR (500MHz, CDCl_3) spectrum of compound (3i)	45
^{13}C -NMR(125MHz, CDCl_3) spectrum of compound (3i)	45
^1H -NMR (400MHz, CDCl_3) spectrum of compound (3j)	46
^{13}C -NMR(100MHz, CDCl_3) spectrum of compound (3j)	46
^1H -NMR (500MHz, CDCl_3) spectrum of compound (3k)	47
^{13}C -NMR(125MHz, CDCl_3) spectrum of compound (3k)	47
^1H -NMR (400MHz, CDCl_3) spectrum of compound (3l)	48
^{13}C -NMR(100MHz, CDCl_3) spectrum of compound (3l)	48
^{19}F -NMR(565MHz, CDCl_3) spectrum of compound (3l)	49
^1H -NMR (600MHz, CDCl_3) spectrum of compound (3m)	50
^{13}C -NMR(150MHz, CDCl_3) spectrum of compound (3m)	50
^1H -NMR (600MHz, CDCl_3) spectrum of compound (3n)	51
^{13}C -NMR(150MHz, CDCl_3) spectrum of compound (3n)	51
^1H -NMR (400MHz, CDCl_3) spectrum of compound (3o)	52
^{13}C -NMR(100MHz, CDCl_3) spectrum of compound (3o)	52
^1H -NMR (400MHz, CDCl_3) spectrum of compound (3p)	53
^{13}C -NMR(100MHz, CDCl_3) spectrum of compound (3p)	53
^1H -NMR (500MHz, CDCl_3) spectrum of compound (3q)	54
^{13}C -NMR(125MHz, CDCl_3) spectrum of compound (3q)	54
^1H -NMR (500MHz, CDCl_3) spectrum of compound (3r)	55
^{13}C -NMR(125MHz, CDCl_3) spectrum of compound (3r)	55
^1H -NMR (500MHz, CDCl_3) spectrum of compound (3s)	56
^{13}C -NMR(125MHz, CDCl_3) spectrum of compound (3s)	56
^1H -NMR (600MHz, CDCl_3) spectrum of compound (3t)	57

¹³ C-NMR(150MHz, CDCl ₃) spectrum of compound (3t)	57
¹ H-NMR (400MHz, CDCl ₃) spectrum of compound (3u)	58
¹³ C-NMR(100MHz, CDCl ₃) spectrum of compound (3u)	58
¹ H-NMR (400MHz, CDCl ₃) spectrum of compound (3v)	59
¹³ C-NMR(100MHz, CDCl ₃) spectrum of compound (3v)	59
¹ H-NMR (600MHz, CDCl ₃) spectrum of compound (4b - Z + E)	60
¹³ C-NMR(150MHz, CDCl ₃) spectrum of compound (4b- Z + E)	60
¹ H-NMR (600MHz, CDCl ₃) spectrum of compound (4c - Z + E)	61
¹³ C-NMR(150MHz, CDCl ₃) spectrum of compound (4c - Z + E)	61
¹ H-NMR (600MHz, CDCl ₃) spectrum of compound (4d - E)	62
¹³ C-NMR(150MHz, CDCl ₃) spectrum of compound (4d - E)	62
¹⁹ F-NMR(565MHz, CDCl ₃) spectrum of compound (4d - E)	63
¹ H-NMR (600MHz, CDCl ₃) spectrum of compound (4d - Z)	64
¹³ C-NMR(150MHz, CDCl ₃) spectrum of compound (4d - Z)	64
¹⁹ F-NMR(565MHz, CDCl ₃) spectrum of compound (4d - Z)	65
¹ H-NMR (600MHz, CDCl ₃) spectrum of compound (4e - E)	66
¹³ C-NMR(150MHz, CDCl ₃) spectrum of compound (4e - E)	66
¹ H-NMR (600MHz, CDCl ₃) spectrum of compound (4e - Z)	67
¹³ C-NMR(150MHz, CDCl ₃) spectrum of compound (4e - Z)	67
¹ H-NMR (600MHz, CDCl ₃) spectrum of compound (4f - E)	68
¹³ C-NMR(150MHz, CDCl ₃) spectrum of compound (4f - E)	68
¹⁹ F-NMR(565MHz, CDCl ₃) spectrum of compound (4f - E)	69
¹ H-NMR (600MHz, CDCl ₃) spectrum of compound (4f - Z)	70
¹³ C-NMR(150MHz, CDCl ₃) spectrum of compound (4f - Z)	70
¹⁹ F-NMR(565MHz, CDCl ₃) spectrum of compound (4 - Z)	71
¹ H-NMR (600MHz, CDCl ₃) spectrum of compound (4g - E)	72
¹³ C-NMR(150MHz, CDCl ₃) spectrum of compound (4g - E)	72
¹ H-NMR (600MHz, CDCl ₃) spectrum of compound (4g - Z)	73
¹³ C-NMR(150MHz, CDCl ₃) spectrum of compound (4g- E)	73
¹ H-NMR (600MHz, CDCl ₃) spectrum of compound (4i)	74

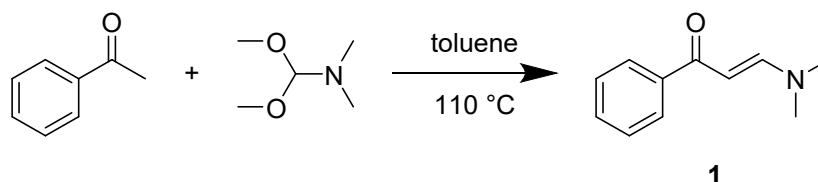
¹³ C-NMR(150MHz, CDCl ₃) spectrum of compound (4i)	74
¹ H-NMR (600MHz, CDCl ₃) spectrum of compound (4j)	75
¹³ C-NMR(150MHz, CDCl ₃) spectrum of compound (4j)	75
¹⁹ F-NMR(565MHz, CDCl ₃) spectrum of compound (4j)	76
¹ H-NMR (600MHz, CDCl ₃) spectrum of compound (4k)	77
¹³ C-NMR(150MHz, CDCl ₃) spectrum of compound (4k)	77
¹ H-NMR (600MHz, CDCl ₃) spectrum of compound (4l)	78
¹³ C-NMR(150MHz, CDCl ₃) spectrum of compound (4l)	78
¹ H-NMR (600MHz, CDCl ₃) spectrum of compound (4m)	79
¹³ C-NMR(150MHz, CDCl ₃) spectrum of compound (4m)	79
¹ H-NMR (600MHz, CDCl ₃) spectrum of compound (4n)	80
¹³ C-NMR(150MHz, CDCl ₃) spectrum of compound (4n)	80
¹ H-NMR (600MHz, CDCl ₃) spectrum of compound (4o)	81
¹³ C-NMR(150MHz, CDCl ₃) spectrum of compound (4o)	81
¹ H-NMR (600MHz, CDCl ₃) spectrum of compound (4p)	82
¹³ C-NMR(150MHz, CDCl ₃) spectrum of compound (4p)	82
¹ H-NMR (600MHz, CDCl ₃) spectrum of compound (4q)	83
¹³ C-NMR(150MHz, CDCl ₃) spectrum of compound (4q)	83
¹ H-NMR (400MHz, CDCl ₃) spectrum of compound (5a)	84
¹³ C-NMR(100MHz, CDCl ₃) spectrum of compound (5a)	84

1. General information

All compounds were fully characterised by spectroscopic data. The NMR spectra were recorded on Bruker DRX600, Bruker DRX500, Bruker DRX400. Chemical shifts (δ) are expressed in ppm, J values are given in Hz, and deuterated CDCl_3 were used as solvent. IR spectra were recorded on a FT-IR Thermo Nicolet Avatar 360 using a KBr pellet. The reactions were monitored by thin layer chromatography (TLC) using silica gel GF254. The melting points were determined on a XT-4A melting point apparatus and are uncorrected. HRMs were performed on an Agilent LC/Msd TOF instrument. Materials used were purchased from Adamas-beta Corporation Limited.

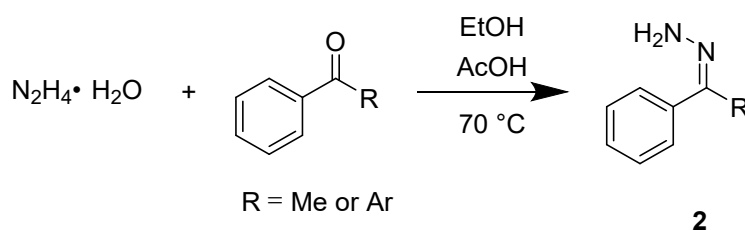
The materials were purchased from Adamas-beta Corporation Limited. All chemicals and solvents were used as received without further purification unless otherwise stated. Column chromatography was performed on silica gel (200–300 mesh).

2. General Procedure for preparing enaminones **1**



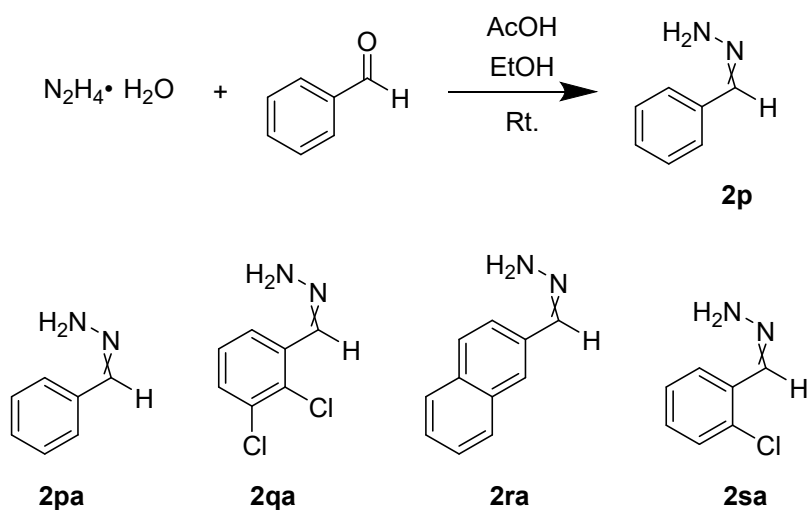
Acetophenone (10 mmol, 1.2 g, 1 eq.) was added in 25 mL round bottom flask, then 15 mmol N,N-Dimethylformamide Dimethyl Acetal and 2 mL toluene were added. Reaction for overnight in 110 °C with toluene as solvent, monitored by TLC. Purification by recrystallization. Other enaminones synthesized by this way.¹

3. General Procedure for preparing hydrazones **2**



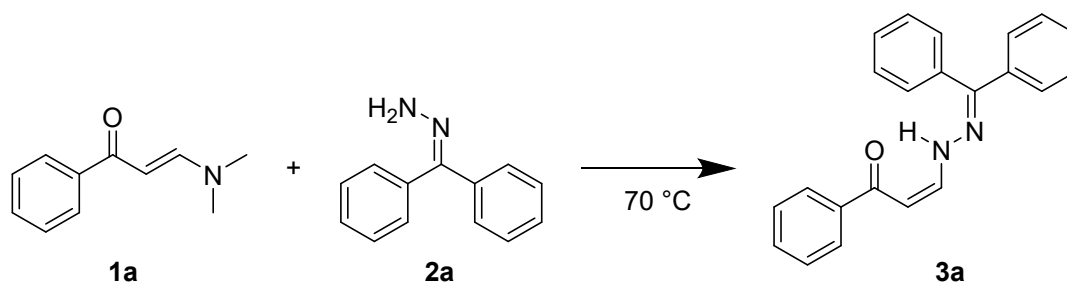
Benzophenone (10 mmol, 1.82 g) was added in 100 mL round bottom flask with 50

mL EtOH as solvent, then 1 mL AcOH was added in this reaction system. Finally, slowly add hydrazine hydrate. rise the temperature up to 70 °C and the reaction was monitored by TLC. After cooling to room temperature, the reaction was quenched with saturated NaCl solution and extracted with 30 mL EtOAc for three times. The organic layers were combined, dried over Na₂SO₄, filtered and evaporated under reduced pressure to obtain **2a**. The crude product is directly subjected to the next reaction without no further purification. **2a-2o** synthesized by this way.²



Benzaldehyde (10 mmol, 1.06 g, 1 eq.) was added in 100 mL round bottom flask with 70 mL EtOH as solvent, then 1 mL AcOH was added in this reaction system, after the hydrazine hydrate (100 mmol, 0.5 g) adding slowly, control the reaction temperature at room temperature and overnight. After cooling to room temperature, the reaction was quenched with saturated NaCl solution and extracted with 30 mL EtOAc for three times. The organic layers were combined, dried over Na₂SO₄, filtered and evaporated under reduced pressure to obtain **2p**. The crude product is directly subjected to the next reaction without no further purification. **2p-2s** synthesized by this way.³

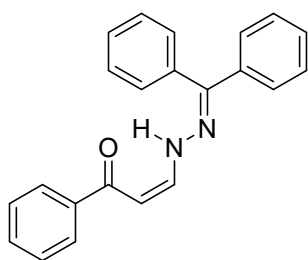
4. General Procedure for preparing enone-hydrazones



Enaminones **1** (0.2 mmol, 35 mg, 1.0 eq.) were added in 10 mL reaction tube with hydrazone **2** (0.24 mmol, 47 mg, 1.2 eq.). Reaction for overnight in 90 °C monitored by TLC. After cooling to room temperature, the reaction was quenched with saturated NaCl solution and extracted with 30 mL EtOAc for three times. The organic layers were combined, dried over Na₂SO₄, filtered and evaporated under reduced pressure. The residues were purified by flash column chromatography on silica gel to provide the products **3**. The products were further identified by X-ray, NMR spectroscopy and HRMS, **3a-3t** and **4b-4l** synthesized by this way. When **4m-4q** were used in this reaction, reduce the reaction time to 8 h, and carefully monitored by TCL.

5. Spectroscopic Data of (**3a-3v**)

3a (Z)-3-(2-(diphenylmethylene)hydrazineyl)-1-phenylprop-2-en-1-one



Yellow solid; Mp: 137-139°C; 62.5 mg, yield: 96%.

IR (KBr): 3461, 3067, 1626, 1580, 1566, 1493, 1467, 11250, 1081, 1016, 763, 691 cm⁻¹.

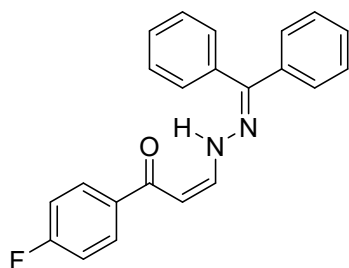
¹H NMR (400 MHz, Chloroform-*d*) δ 12.56 (d, *J* = 10.0 Hz, 1H), 7.80 (d, *J* = 7.6 Hz, 2H), 7.70 – 7.56 (m, 5H), 7.43 (t, *J* = 7.2 Hz, 1H), 7.37 (m, 8H), 5.86 (d, *J* = 8.2 Hz,

1H).

¹³C NMR (150 MHz, CDCl₃) δ 190.4, 152.6, 149.5, 139.2, 137.2, 132.5, 131.3, 130.1, 129.9, 129.5, 128.4, 128.4, 128.2, 127.6, 127.4, 92.2.

HRMS (ESI-TOF) *m/z*: [M + H]⁺ calcd for C₂₂H₁₉N₂O⁺ 327.1492; Found 327.1491.

3b (Z)-3-(2-(diphenylmethylene)hydrazineyl)-1-(4-fluorophenyl)prop-2-en-1-one



Yellow solid; Mp: 133-144°C; 64.6 mg, yield: 94%.

IR (KBr): 3441, 1627, 1578, 1474, 1431, 1319, 1120, 880, 696 cm⁻¹.

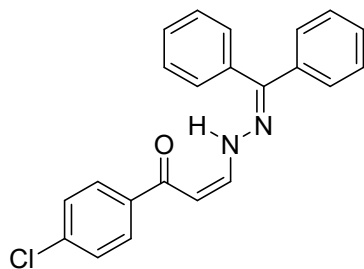
¹H NMR (500 MHz, Chloroform-*d*) δ 12.52 (d, *J* = 10.0 Hz, 1H), 7.81 (dd, *J* = 8.4, 5.6 Hz, 2H), 7.66 (t, *J* = 7.2 Hz, 2H), 7.61 (t, *J* = 9.6 Hz, 4H), 7.38-7.36 (m, 5H), 7.03 (t, *J* = 8.6 Hz, 2H), 5.79 (d, *J* = 8.2 Hz, 1H).

¹³C NMR (125 MHz, CDCl₃) δ 188.9, 164.8 (d, *J* = 251.7 Hz), 152.8, 149.6, 137.14, 135.4, 132.5, 130.1, 129.8 (d, *J* = 8.9 Hz), 129.7, 129.6, 128.4, 128.34, 127.6, 115.2 (d, *J* = 21.7 Hz), 91.8.

¹⁹F NMR (565 MHz, CDCl₃) δ -108.64.

HRMS (ESI-TOF) *m/z*: [M + H]⁺ calcd for C₂₂H₁₈FN₂O⁺ 345.1398; Found 345.1398.

3c (Z)-1-(4-chlorophenyl)-3-(2-(diphenylmethylene)hydrazineyl)prop-2-en-1-one



Yellow solid; Mp: 135-137°C; 70.6 mg, yield: 98%.

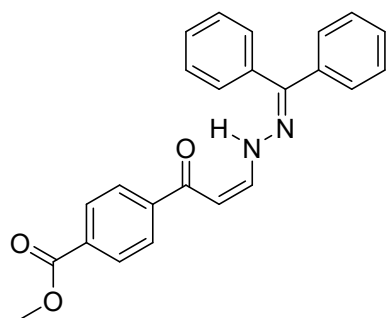
IR (KBr): 3441, 1627, 1578, 1454, 1451, 1319, 1120, 880, 726 cm⁻¹.

¹H NMR (400 MHz, Chloroform-*d*) δ 12.56 (d, *J* = 10.0 Hz, 1H), 7.74 (d, *J* = 8.4 Hz, 2H), 7.70 – 7.58 (m, 6H), 7.43 – 7.30 (m, 7H), 5.80 (d, *J* = 8.2 Hz, 1H).

¹³C NMR (100 MHz, CDCl₃) δ 188.6, 153.1, 149.8, 137.5, 137.1, 132.5, 130.1, 129.9, 129.6, 128.9, 128.5, 128.4, 128.3, 127.6, 91.8.

HRMS (ESI-TOF) *m/z*: [M + H]⁺ calcd for C₂₂H₁₈ClN₂O⁺ 361.1102; Found 361.1103.

3d methyl (Z)-4-(3-(2-(diphenylmethylene)hydrazineyl)acryloyl)benzoate



Yellow solid; Mp: 135-137°C; 72.9 mg, yield: 95%.

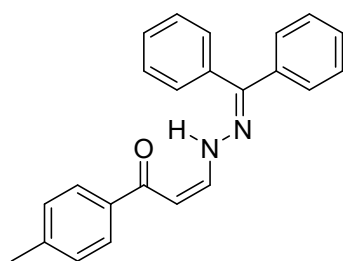
IR (KBr): 3447, 1645, 1787, 1545, 1421, 1399, 1284, 1108, 768 cm⁻¹.

¹H NMR (400 MHz, Chloroform-*d*) δ 8.01 (d, *J* = 8.4 Hz, 2H), 7.81 (d, *J* = 8.4 Hz, 2H), 7.67 – 7.56 (m, 6H), 7.52 – 7.46 (m, 1H), 7.40 – 7.31 (m, 6H), 7.27 (d, *J* = 8.2 Hz, 1H), 5.81 (d, *J* = 8.0 Hz, 1H), 3.87 (s, 3H).

¹³C NMR (100 MHz, CDCl₃) δ 189.1, 166.6, 153.5, 150.2, 142.9, 137.0, 132.5, 132.2, 130.2, 130.0, 129.8, 129.6, 129.5, 129.4, 128.9, 128.8, 128.74, 128.4, 128.4, 128.3, 128.2, 128.1, 128.0, 127.7, 127.4, 126.5, 92.3, 52.3.

HRMS (ESI-TOF) *m/z*: [M + H]⁺ calcd for C₂₄H₂₁N₂O₃⁺ 385.1547; Found 385.1547.

3e (Z)-3-(2-(diphenylmethylene)hydrazineyl)-1-(*p*-tolyl)prop-2-en-1-one



Yellow solid; Mp: 146-148 °C; 64.6 mg, yield: 95%.

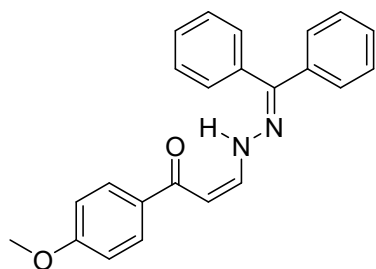
IR (KBr): 3460, 2966, 2729, 1628, 1575, 1550, 1474, 1259, 1079, 1038, 767, 696 cm⁻¹.

¹H NMR (400 MHz, Chloroform-*d*) δ 12.57 (d, J = 10.0 Hz, 1H), 7.74 (d, J = 8.2 Hz, 2H), 7.72 – 7.55 (m, 6H), 7.46 – 7.33 (m, 5H), 7.19 (d, J = 8.0 Hz, 2H), 5.87 (d, J = 8.2 Hz, 1H), 2.38 (s, 3H).

¹³C NMR (100 MHz, CDCl₃) δ 190.2, 152.3, 149.2, 141.8, 137.3, 136.5, 132.6, 130.0, 129.9, 129.4, 129.0, 128.4, 128.4, 127.6, 127.6, 92.2, 21.6.

HRMS (ESI-TOF) m/z : [M + H]⁺ calcd for C₂₃H₂₁N₂O⁺ 341.1648; Found 341.1644.

3f (Z)-3-(2-(diphenylmethylene)hydrazineyl)-1-(4-methoxyphenyl)prop-2-en-1-one



Yellow solid; Mp: 160-162 °C; 66.2 mg, yield: 93%.

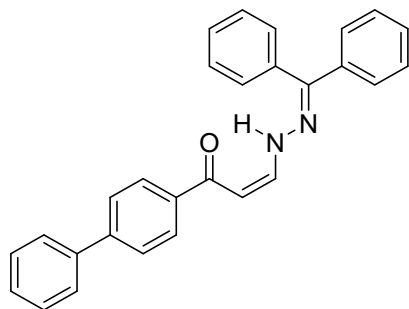
IR (KBr): 3451, 2968, 1627, 1578, 1454, 1411, 1319, 1120, 880, 696 cm⁻¹.

¹H NMR (400 MHz, Chloroform-*d*) δ 12.51 (d, J = 10.0 Hz, 1H), 7.80 (d, J = 8.8 Hz, 2H), 7.65 (m, 3H), 7.62 – 7.52 (m, 3H), 7.42 – 7.32 (m, 5H), 6.86 (d, J = 8.8 Hz, 2H), 5.83 (d, J = 8.2 Hz, 1H), 3.82 (s, 3H).

¹³C NMR (100 MHz, CDCl₃) δ 189.4, 162.3, 152.0, 149.0, 137.4, 132.6, 132.0, 1309.0, 129.9, 129.5, 129.4, 128.4, 128.4, 127.5, 113.4, 92.0, 55.4.

HRMS (ESI-TOF) m/z : [M + H]⁺ calcd for C₂₃H₂₁N₂O₂⁺ 357.1598; Found 357.1597.

3g (Z)-1-([1,1'-biphenyl]-4-yl)-3-(2-(diphenylmethylene)hydrazineyl)prop-2-en-1-one



Yellow solid; Mp: 180-181 °C; 73.1 mg, yield: 91%.

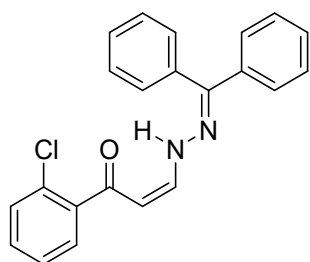
IR (KBr): 3441, 1627, 1558, 1474, 1451, 1319, 1120, 880, 726 cm⁻¹.

¹H NMR (400 MHz, Chloroform-*d*) δ 12.59 (d, *J* = 10.0 Hz, 1H), 7.88 (d, *J* = 8.2 Hz, 2H), 7.69-7.60 (m, 10H), 7.45 (t, *J* = 7.5 Hz, 2H), 7.46-7.33 (m, 6H), 5.90 (d, *J* = 8.1 Hz, 1H).

¹³C NMR (100 MHz, CDCl₃) δ 189.9, 149.5, 144.0, 140.3, 137.9, 132.6, 130.1, 129.9, 129.5, 128.9, 128.4, 128.4, 128.0, 127.8, 127.6, 127.2, 126.9, 92.2.

HRMS (ESI-TOF) *m/z*: [M + H]⁺ calcd for C₂₈H₂₃N₂O⁺ 403.1805; Found 403.1805.

3h (Z)-1-(2-chlorophenyl)-3-(2-(diphenylmethylene)hydrazineyl)prop-2-en-1-one



Yellow solid; Mp: 148-150 °C; 66.2 mg, yield: 92%.

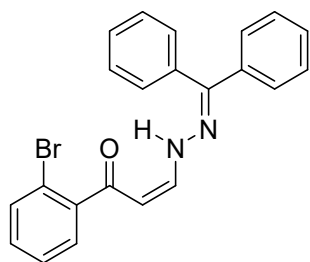
IR (KBr): 3441, 1627, 1568, 1494, 1451, 1319, 1120, 880, 696 cm⁻¹.

¹H NMR (400 MHz, Chloroform-*d*) δ 8.20 (d, *J* = 8.8 Hz, 1H), 7.91 (d, *J* = 8.8 Hz, 2H), 7.73 – 7.63 (m, 4H), 7.61 (dd, *J* = 8.0, 1.8 Hz, 2H), 7.42 – 7.33 (m, 5H), 5.83 (d, *J* = 8.0 Hz, 1H).

¹³C NMR (100 MHz, CDCl₃) δ 187.5, 154.4, 150.7, 149.2, 144.4, 136.8, 132.3, 130.2, 129.9, 129.9, 128.4, 128.3, 128.2, 127.7, 123.5, 92.0.

HRMS (ESI-TOF) *m/z*: [M + H]⁺ calcd for C₂₂H₁₈ClN₂O⁺ 361.1102; Found 361.1102.

3i (Z)-1-(2-bromophenyl)-3-(2-(diphenylmethylene)hydrazineyl)prop-2-en-1-one



Yellow solid; Mp: 100-102 °C; 74.3 mg, yield: 92%.

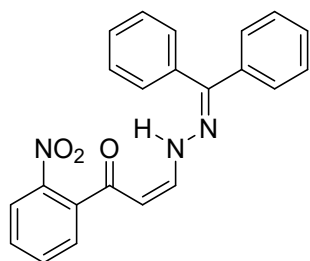
IR (KBr): 3461, 1627, 1598, 1494, 1451, 1319, 1120, 880, 696 cm⁻¹.

¹H NMR (500 MHz, Chloroform-*d*) δ 12.42 (d, J = 10.0 Hz, 1H), 7.64 (dd, J = 8.5, 6.7 Hz, 2H), 7.60 (ddd, J = 10.9, 7.9, 1.8 Hz, 3H), 7.56 (d, J = 7.9 Hz, 1H), 7.52 (d, J = 8.0 Hz, 1H), 7.40 – 7.35 (m, 5H), 7.33 (dd, J = 7.7, 1.9 Hz, 1H), 7.27 (t, J = 7.4 Hz, 1H), 7.17 (td, J = 7.6, 2.0 Hz, 1H), 5.51 (d, J = 8.0 Hz, 1H).

¹³C NMR (125 MHz, CDCl₃) δ 192.4, 153.4, 149.2, 142.7, 137.1, 133.2, 132.3, 130.5, 130.2, 129.9, 129.6, 129.1, 128.4, 128.3, 127.7, 127.2, 119.2, 96.0.

HRMS (ESI-TOF) m/z : [M + H]⁺ calcd for C₂₂H₁₈BrN₂O⁺ 405.0597; Found 405.0598.

3j (Z)-3-(2-(diphenylmethylene)hydrazineyl)-1-(2-nitrophenyl)prop-2-en-1-one



Yellow solid; Mp: 97-98 °C; 67.5 mg, yield: 91%.

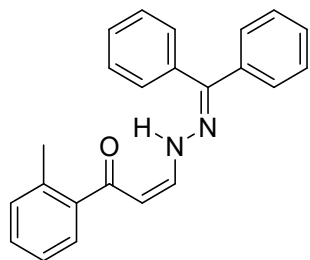
IR (KBr): 3461, 1627, 1578, 1494, 1451, 1319, 1120, 880, 696 cm⁻¹.

¹H NMR (400 MHz, Chloroform-*d*) δ 12.34 (d, J = 10.4 Hz, 1H), 7.88 (d, J = 8.2 Hz, 1H), 7.70 – 7.51 (m, 7H), 7.45 (q, J = 7.6 Hz, 2H), 7.36 (d, J = 7.6 Hz, 5H), 5.34 (dd, J = 8.0, 2.2 Hz, 1H).

¹³C NMR (100 MHz, CDCl₃) δ 189.7, 154.1, 149.9, 147.2, 137.5, 136.9, 132.9, 132.1, 130.2, 129.9, 129.9, 129.8, 128.6, 128.4, 128.4, 128.3, 127.7, 124.08, 94.06.

HRMS (ESI-TOF) m/z : [M + H]⁺ calcd for C₂₂H₁₈N₃O₃⁺ 372.1343; Found 372.1343.

3k (Z)-3-(2-(diphenylmethylene)hydrazineyl)-1-(*o*-tolyl)prop-2-en-1-one



Yellow solid; Mp: 102.2-107.9 °C; 63.2 mg, yield: 93%.

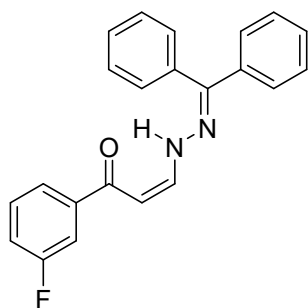
IR (KBr): 3461, 2986, 1627, 1598, 1494, 1451, 1319, 1120, 880, 726 cm⁻¹.

¹H NMR (500 MHz, Chloroform-*d*) δ 12.55 (d, *J* = 10.0 Hz, 1H), 7.68 – 7.59 (m, 3H), 7.59 – 7.51 (m, 1H), 7.44 – 7.32 (m, 5H), 7.23 (t, *J* = 7.5 Hz, 1H), 7.15 (t, *J* = 7.5 Hz, 2H), 5.48 (d, *J* = 7.5 Hz, 1H), 2.36 (s, 2H).

¹³C NMR (125 MHz, CDCl₃) δ 195.3, 152.7, 148.7, 141.2, 137.2, 135.8, 132.5, 130.9, 130.0, 129.8, 129.5, 129.4, 128.4, 127.6, 127.4, 125.4, 96.12, 20.1.

HRMS (ESI-TOF) *m/z*: [M + H]⁺ calcd for C₂₃H₂₁N₂O⁺ 341.1648; Found 341.1644.

3l (Z)-3-(2-(diphenylmethylene)hydrazineyl)-1-(3-fluorophenyl)prop-2-en-1-one



Yellow solid; Mp: 122-124 °C; 64.6 mg, yield: 94%.

IR (KBr): 3462, 1627, 1598, 1494, 1451, 1319, 1120, 880, 696 cm⁻¹.

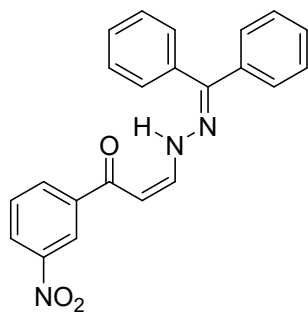
¹H NMR (400 MHz, Chloroform-*d*) δ 12.54 (t, *J* = 14.0 Hz, 1H), 7.75 – 7.41 (m, 7H), 7.40 – 7.27 (m, 6H), 7.09 (dt, *J* = 22.5, 10.0 Hz, 1H), 5.80 (d, *J* = 8.0 Hz, 1H).

¹³C NMR (100 MHz, CDCl₃) δ 188.7, 153.2, 149.9, 141.4, 137.1, 132.4, 130.1, 129.9, 129.8, 129.7, 129.6, 128.4, 128.3, 128.2, 127.6, 123.0, 118.2, 118.0, 114.4, 114.2, 91.9.

¹⁹F NMR (565 MHz, CDCl₃) δ -112.93.

HRMS (ESI-TOF) *m/z*: [M + H]⁺ calcd for C₂₂H₁₈FN₂O⁺ 345.1398; Found 345.1398.

3m (Z)-3-(2-(diphenylmethylene)hydrazineyl)-1-(3-nitrophenyl)prop-2-en-1-one



Yellow solid; Mp: 186-188 °C; 70.4 mg, yield: 95%.

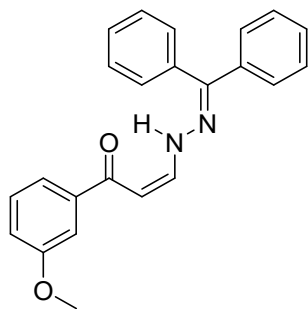
IR (KBr): 3441, 1627, 1598, 1494, 1451, 1319, 1120, 880, 696 cm^{-1} .

^1H NMR (600 MHz, Chloroform-*d*) δ 12.64 (d, J = 10.2 Hz, 1H), 8.63 (t, J = 1.9 Hz, 1H), 8.27 (dd, J = 8.1, 2.3 Hz, 1H), 8.11 (dd, J = 7.7, 1.5 Hz, 1H), 7.74 – 7.64 (m, 4H), 7.64 – 7.59 (m, 2H), 7.54 (t, J = 8.0 Hz, 1H), 7.40 – 7.35 (m, 5H), 5.86 (d, J = 8.0 Hz, 1H), 5.29 (s, 1H).

^{13}C NMR (150 MHz, CDCl_3) δ 187.0, 154.2, 150.7, 148.3, 140.7, 136.9, 133.1, 132.4, 130.2, 130.0, 129.8, 129.3, 128.4, 128.3, 127.7, 125.6, 122.4, 91.4.

HRMS (ESI-TOF) m/z : $[\text{M} + \text{H}]^+$ calcd for $\text{C}_{22}\text{H}_{18}\text{N}_3\text{O}_3^+$ 372.1343; Found 372.1342.

3n (Z)-3-(2-(diphenylmethylene)hydrazineyl)-1-(3-methoxyphenyl)prop-2-en-1-one



Yellow solid; Mp: 147-159 °C; 66.2 mg, yield: 93%.

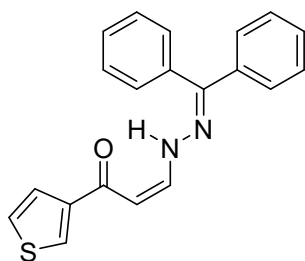
IR (KBr): 3541, 2868, 1627, 1598, 1494, 1451, 1319, 1120, 880, 696 cm^{-1} .

^1H NMR (600 MHz, Chloroform-*d*) δ 12.45 (d, J = 10.0 Hz, 1H), 7.58 (t, J = 7.6 Hz, 2H), 7.53 (q, J = 8.0 Hz, 4H), 7.29 (dd, J = 15.2, 7.2 Hz, 7H), 7.19 (t, J = 8.0 Hz, 1H), 6.92 – 6.88 (m, 1H), 5.75 (d, J = 8.2 Hz, 1H), 3.74 (s, 3H).

^{13}C NMR (150 MHz, CDCl_3) δ 190.1, 159.7, 152.6, 149.4, 140.8, 137.3, 132.6, 130.0, 129.9, 129.5, 129.2, 128.4, 128.3, 127.6, 119.9, 117.7, 112.1, 92.4, 55.4.

HRMS (ESI-TOF) m/z : $[\text{M} + \text{H}]^+$ calcd for $\text{C}_{23}\text{H}_{21}\text{N}_2\text{O}_2^+$ 357.1598; Found 357.1598.

3o (Z)-3-(2-(diphenylmethylene)hydrazineyl)-1-(thiophen-3-yl)prop-2-en-1-one



Yellow solid; Mp: 116-128 °C; 62.4 mg, yield: 94%.

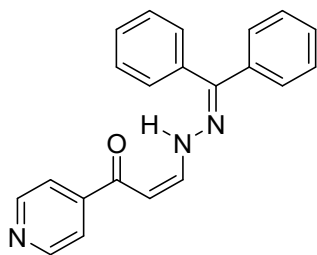
IR (KBr): 3461, 3053, 1623, 1573, 1492, 1458, 1263, 11061, 779, 698 cm^{-1} .

^1H NMR (400 MHz, Chloroform-*d*) δ 12.26 (d, J = 10.1 Hz, 1H), 7.70 – 7.60 (dd, 2H), 7.62 – 7.53 (t, 5H), 7.46 (d, J = 5.0 Hz, 1H), 7.39 – 7.33 (m, 5H), 7.05 – 7.03 (t, 1H), 5.73 (dd, J = 8.2, 1.7 Hz, 1H).

^{13}C NMR (100 MHz, CDCl_3) δ 183.0, 152.4, 149.0, 145.9, 137.3, 132.4, 131.1, 130.1, 129.9, 129.5, 129.1, 128.4, 128.3, 127.8, 127.6, 92.3.

HRMS (ESI-TOF) m/z : $[\text{M} + \text{H}]^+$ calcd for $\text{C}_{20}\text{H}_{17}\text{N}_2\text{OS}^+$ 333.1056; Found 333.1054.

3p (Z)-3-(2-(diphenylmethylene)hydrazineyl)-1-(pyridin-4-yl)prop-2-en-1-one



Yellow solid; Mp: 162-163 °C; 60.8 mg, yield: 93%.

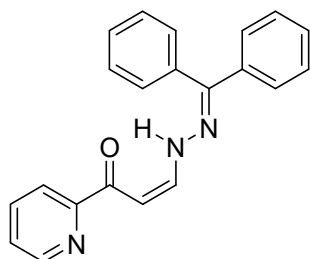
IR (KBr): 3441, 3032, 1627, 1543, 1454, 1325, 1274, 1069, 880, 726 cm^{-1} .

^1H NMR (400 MHz, Chloroform-*d*) δ 8.66 – 8.65 (m, 2H), 7.70 – 7.57 (m, 8H), 7.39 – 7.33 (m, 5H), 5.80 (d, J = 8.0 Hz, 1H).

^{13}C NMR (100 MHz, CDCl_3) δ 188.1, 154.3, 150.7, 150.4, 145.5, 136.8, 132.3, 130.2, 129.9, 129.9, 128.4, 128.2, 127.7, 120.9, 91.7.

HRMS (ESI-TOF) m/z : $[\text{M} + \text{H}]^+$ calcd for $\text{C}_{21}\text{H}_{18}\text{N}_3\text{O}^+$ 328.1444; Found 328.1444.

3q (Z)-3-(2-(diphenylmethylene)hydrazineyl)-1-(pyridin-2-yl)prop-2-en-1-one



Yellow solid; Mp: 169-171 °C; 60.1 mg, yield: 92%.

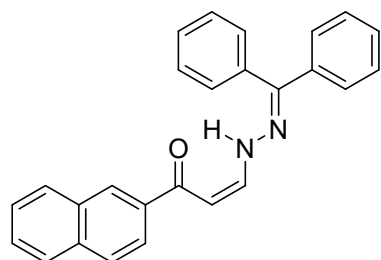
IR (KBr): 3441, 3068, 1627, 1598, 1494, 1451, 1319, 1120, 880, 696 cm⁻¹.

¹H NMR (500 MHz, Chloroform-*d*) δ 12.57 (d, *J* = 10.0 Hz, 1H), 8.60 (d, *J* = 4.6 Hz, 1H), 7.94 (d, *J* = 8.0 Hz, 1H), 7.77-7.59 (m, 7H), 7.39-7.33 (m, 6H), 6.55 (d, *J* = 8.1 Hz, 1H).

¹³C NMR (125 MHz, CDCl₃) δ 188.9, 155.1, 153.0, 150.3, 148.6, 137.1, 136.6, 132.5, 130.0, 129.9, 129.6, 128.4, 127.6, 125.6, 121.9, 91.8.

HRMS (ESI-TOF) *m/z*: [M + H]⁺ calcd for C₂₁H₁₈N₃O⁺ 328.1444; Found 328.1449.

3r (Z)-3-(2-(diphenylmethylene)hydrazineyl)-1-(naphthalen-2-yl)prop-2-en-1-one



Yellow solid; Mp: 134-136 °C; 69.2 mg, yield: 92%.

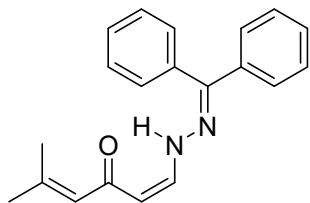
IR (KBr): 3441, 1627, 1598, 1494, 1451, 1319, 1120, 880, 726 cm⁻¹.

¹H NMR (500 MHz, Chloroform-*d*) δ 12.62 (d, *J* = 10.0 Hz, 1H), 8.33 (s, 1H), 7.90 (d, *J* = 8.5 Hz, 2H), 7.86 – 7.79 (m, 2H), 7.69 (t, *J* = 7.0 Hz, 2H), 7.65 (d, *J* = 8.3 Hz, 2H), 7.64 – 7.60 (m, 2H), 7.51 (p, *J* = 7.0 Hz, 2H), 7.41 (d, *J* = 7.5 Hz, 2H), 7.37 (d, *J* = 6.5 Hz, 2H), 6.02 (d, *J* = 8.0 Hz, 1H).

¹³C NMR (125 MHz, CDCl₃) δ 190.2, 152.7, 149.5, 137.3, 136.5, 134.8, 132.7, 132.6, 130.1, 129.9, 129.5, 129.3, 128.4, 128.4, 128.1, 128.0, 127.7, 127.6, 127.5, 126.3, 124.2, 92.5, 77.3, 77.1, 76.8.

HRMS (ESI-TOF) m/z : $[M + H]^+$ calcd for $C_{26}H_{21}N_2O^+$ 377.1648; Found 377.1648.

3s (Z)-1-(2-(diphenylmethylene)hydrazineyl)-5-methylhexa-1,4-dien-3-one



Yellow solid; Mp: 128-130 °C; 55.9 mg, yield: 92%.

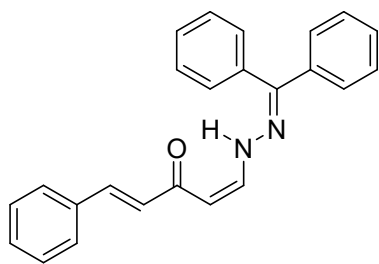
IR (KBr): 3460, 3090, 3053, 2927, 1628, 1575, 1550, 1474, 1259, 1038, 767, 696 cm^{-1} .

1H NMR (500 MHz, Chloroform-*d*) δ 12.49 (d, $J = 9.5$ Hz, 1H), 7.62 (t, $J = 7.5$ Hz, 2H), 7.58-7.56 (m, 3H), 7.42 – 7.36 (m, 1H), 7.36 – 7.32 (m, 5H), 5.85 (s, 1H), 5.12 (d, $J = 8.0$, 1H), 2.04 (s, 3H), 1.80 (s, 3H).

^{13}C NMR (125 MHz, $CDCl_3$) δ 191.3, 151.5, 150.6, 148.0, 137.4, 132.7, 129.7, 129.2, 128.4, 128.3, 127.4, 125.6, 98.0, 27.5, 20.2.

HRMS (ESI-TOF) m/z : $[M + H]^+$ calcd for $C_{20}H_{21}N_2O^+$ 305.1648; Found 305.1641.

3t (1Z,4E)-1-(2-(diphenylmethylene)hydrazineyl)-5-phenylpenta-1,4-dien-3-one



Yellow solid; Mp: 146-157 °C; 66.1 mg, yield: 96%.

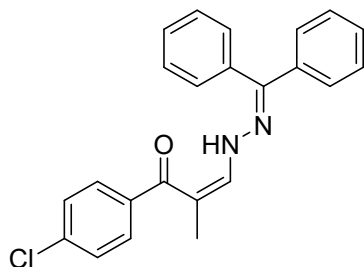
IR (KBr): 3441, 3053, 1627, 1598, 1494, 1451, 1319, 1120, 880, 726 cm^{-1} .

1H NMR (600 MHz, Chloroform-*d*) δ 12.56 (d, $J = 10.0$ Hz, 1H), 7.80 (d, $J = 7.4$ Hz, 2H), 7.66 (t, $J = 7.5$ Hz, 2H), 7.63-7.60 (m, 5H), 7.43 (t, $J = 7.2$ Hz, 1H), 7.40 – 7.35 (m, 8H), 5.86 (d, $J = 8.2$ Hz, 1H).

^{13}C NMR (100 MHz, $CDCl_3$) δ 188.6, 152.7, 149.18, 139.51, 137.23, 135.49, 132.59, 130.09, 129.89, 129.57, 129.53, 128.80, 128.38, 127.98, 127.61, 127.58, 96.03.

HRMS (ESI-TOF) m/z : $[M + H]^+$ calcd for $C_{24}H_{21}N_2O^+$ 353.1648; Found 353.1648.

3u (Z)-1-(4-chlorophenyl)-3-(2-(diphenylmethylene)hydrazineyl)-2-methylprop-2-en-1-one



Yellow solid; Mp: 119-121 °C; 68.8 mg, yield: 92%.

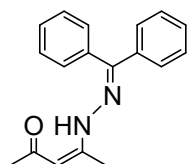
IR (KBr): 3463, 2955, 1627, 1558, 1434, 1421, 1278, 1120, 696 cm^{-1} .

^1H NMR (400 MHz, Chloroform-*d*) δ 7.79 – 7.71 (m, 2H), 7.69 – 7.55 (m, 5H), 7.46 – 7.28 (m, 8H), 5.76 (s, 1H), 2.44 (s, 3H).

^{13}C NMR (100 MHz, CDCl_3) δ 189.0, 160.5, 151.8, 139.9, 137.8, 133.0, 130.8, 129.9, 129.8, 129.3, 128.5, 128.3, 128.1, 127.6, 127.3, 93.7, 19.4.

HRMS (ESI-TOF) m/z : $[\text{M} + \text{H}]^+$ calcd for $\text{C}_{23}\text{H}_{20}\text{ClN}_2\text{O}^+$ 375.1259; Found 375.1256.

3v (Z)-4-(2-(diphenylmethylene)hydrazineyl)pent-3-en-2-one



Yellow solid; Mp: 80-83 °C; 52.2 mg, yield: 94%.

IR (KBr): 3461, 3031, 2975, 2904 1627, 1554, 1454, 1471, 1319, 1124, 696 cm^{-1} .

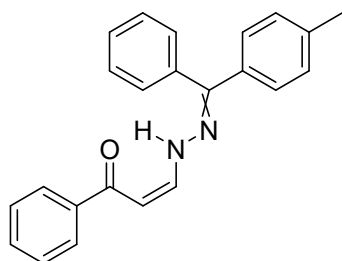
^1H NMR (400 MHz, Chloroform-*d*) δ 7.66 – 7.53 (m, 5H), 7.36 – 7.26 (m, 5H), 5.06 (s, 1H), 2.30 (s, 3H), 1.95 (s, 3H).

^{13}C NMR (100 MHz, CDCl_3) δ 196.5, 158.8, 151.1, 137.7, 133.0, 129.9, 129.8, 129.2, 128.4, 128.3, 127.4, 96.98, 29.2, 18.8.

HRMS (ESI-TOF) m/z : $[\text{M} + \text{H}]^+$ calcd for $\text{C}_{18}\text{H}_{19}\text{N}_2\text{O}^+$ 279.1492; Found 279.1492.

6. Spectroscopic Data of (4b-4q)

4b (Z)-1-phenyl-3-(2-(phenyl(*p*-tolyl)methylene)hydrazineyl)prop-2-en-1-one



Yellow solid; Mp: 136-138 °C; 59.1 mg, yield: 87%, *Z:E*=1.5:1.

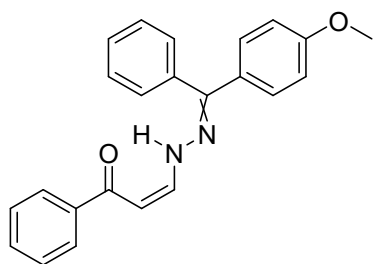
IR (KBr):3441, 2968, 1628, 1598, 1494, 1451, 1319, 1120, 880, 726 cm⁻¹.

¹H NMR (600 MHz, Chloroform-*d*) δ 12.62 (d, *J* = 10.1 Hz, 1H), 12.57 (d, *J* = 10.0 Hz, 1.5H), 7.83 (d, *J* = 8.0 Hz, 2H), 7.81 (d, *J* = 7.9 Hz, 3H), 7.67 (t, *J* = 7.6 Hz, 3H), 7.62 (t, *J* = 8.0 Hz, 6H), 7.51 (d, *J* = 7.8 Hz, 3H), 7.46 (d, *J* = 7.6 Hz, 2H), 7.43 (t, *J* = 7.2 Hz, 2H), 7.41 – 7.35 (m, 11H), 7.29 (d, *J* = 7.6 Hz, 2H), 7.17 (d, *J* = 7.9 Hz, 3H), 5.87 (d, *J* = 9.2 Hz, 1H), 5.86 – 5.83 (m, 1.5H), 2.52 (s, 3H), 2.39 (s, 4.5H).

¹³C NMR (150 MHz, CDCl₃) δ 190.4, 190.3, 152.8, 149.6, 149.5, 139.9, 139.7, 139.3, 137.6, 134.6, 132.8, 131.3, 131.2, 130.5, 130.0, 129.8, 129.5, 129.4, 129.1, 128.4, 128.3, 128.3, 128.2, 127.7, 127.6, 127.4, 127.4, 92.1, 92.0, 21.7, 21.4.

HRMS (ESI-TOF) *m/z*: [M + H]⁺ calcd for C₂₃H₂₁N₂O⁺ 341.1648; Found 341.1644.

4c (2Z)-3-(2-((4-methoxyphenyl)(phenyl)methylene)hydrazineyl)-1-phenylprop-2-en-1-one



Yellow solid; Mp: 149-150 °C; 63.3 mg, yield: 89%, *Z:E* = 1.8 : 1.

IR (KBr):3441, 2968, 1627, 1598, 1494, 1451, 1319, 1120, 880, 726 cm⁻¹.

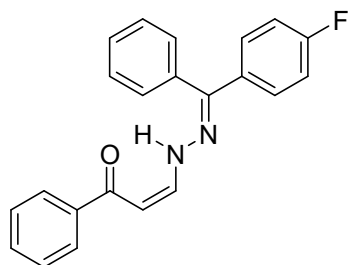
¹H NMR (600 MHz, Chloroform-*d*) δ 12.67 (d, *J* = 10.0 Hz, 1H), 12.53 (d, *J* = 10.1 Hz, 1.8H), 7.85 – 7.81 (m, 2H), 7.81 – 7.76 (m, 3.3H), 7.68 – 7.63 (m, 3.5H), 7.63 – 7.57 (m, 6H), 7.56 – 7.51 (m, 3.3H), 7.41 (dd, *J* = 13.1, 6.2 Hz, 3.6H), 7.39 – 7.31 (m,

12.5H), 7.15 (d, $J = 7.6$ Hz, 2H), 6.89 – 6.85 (m, 3.3H), 5.89 – 5.85 (m, 1H), 5.82 (dd, $J = 8.1, 1.8$ Hz, 1.8H), 3.95 – 3.91 (m, 3H), 3.85 – 3.81 (m, 5.4H).

^{13}C NMR (150 MHz, CDCl_3) δ 190.3, 190.2, 160.9, 160.6, 152.6, 152.6, 149.6, 149.5, 139.3, 137.8, 132.8, 131.3, 131.2, 130.1, 130.0, 129.9, 129.8, 129.4, 129.1, 128.4, 128.3, 128.2, 128.2, 127.8, 127.4, 127.4, 124.5, 115.2, 113.8, 92.0, 91.7, 55.4, 55.4.

HRMS (ESI-TOF) m/z : $[\text{M} + \text{H}]^+$ calcd for $\text{C}_{23}\text{H}_{21}\text{N}_2\text{O}_2^+$ 357.1598; Found 357.1598.

4d-E (Z)-3-(2-((E)-(4-fluorophenyl)(phenyl)methylene)hydrazineyl)-1-phenylprop-2-en-1-one



Yellow solid; Mp: 135-137 °C; 22.0 mg, yield: 32%.

IR (KBr): 3441, 1628, 1598, 1494, 1451, 1319, 1120, 880, 726 cm^{-1} .

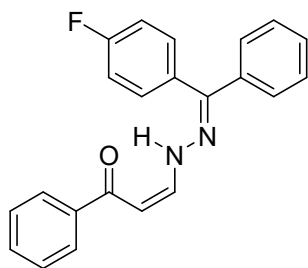
^1H NMR (600 MHz, $\text{Chloroform-}d$) δ 12.55 (d, $J = 10.0$ Hz, 1H), 7.80 (d, $J = 7.7$ Hz, 2H), 7.69 – 7.65 (m, 2H), 7.64 – 7.61 (m, 1H), 7.61 – 7.56 (m, 3H), 7.45 – 7.41 (m, 1H), 7.37 (t, $J = 7.2$ Hz, 4H), 7.07 – 7.01 (m, 2H), 5.86 (dd, $J = 8.1, 1.8$ Hz, 1H).

^{13}C NMR (150 MHz, CDCl_3) δ 190.4, 163.6 (d, $J = 250.0$ Hz), 151.5, 149.4, 139.2, 133.5, 133.5, 132.4, 131.3, 130.2, 130.0, 129.4 (d, $J = 8.4$ Hz), 128.3, 128.2, 127.4, 115.4 (d, $J = 21.9$ Hz), 92.3.

^{19}F NMR (565 MHz, CDCl_3) δ -109.74.

HRMS (ESI-TOF) m/z : $[\text{M} + \text{H}]^+$ calcd for $\text{C}_{22}\text{H}_{18}\text{FN}_2\text{O}^+$ 345.1398; Found 345.1398.

4d-Z (Z)-3-(2-((Z)-(4-fluorophenyl)(phenyl)methylene)hydrazineyl)-1-phenylprop-2-en-1-one



Yellow solid; Mp: 130-141 °C; 37.1 mg, yield: 54%.

IR (KBr): 3441, 1627, 1598, 1494, 1451, 1319, 1120, 880, 726 cm^{-1} .

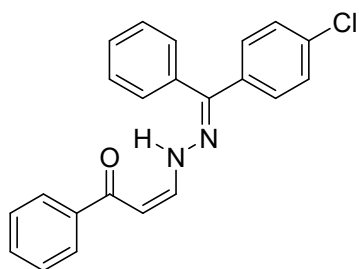
^1H NMR (600 MHz, Chloroform-*d*) δ 12.62 (d, $J = 9.9$ Hz, 1H), 7.81 (d, $J = 7.7$ Hz, 2H), 7.61 (t, $J = 9.1$ Hz, 1H), 7.57 (d, $J = 7.3$ Hz, 2H), 7.44 (d, $J = 7.1$ Hz, 1H), 7.37 (m, 10H), 5.88 (d, $J = 8.1$ Hz, 1H).

^{13}C NMR (150 MHz, CDCl_3) δ 190.5, 163.4 (d, $J = 249.9$ Hz), 151.4, 149.5, 139.1, 137.2, 131.4, 130.6 (d, $J = 8.5$ Hz), 129.6, 128.5, 128.4, 128.3, 127.5, 127.4, 117.2 (d, $J = 21.6$ Hz), 92.4.

^{19}F NMR (565 MHz, CDCl_3) δ -111.40.

HRMS (ESI-TOF) m/z : $[\text{M} + \text{H}]^+$ calcd for $\text{C}_{22}\text{H}_{18}\text{FN}_2\text{O}^+$ 345.1398; Found 345.1398.

4e-E (Z)-3-(2-((E)-(4-chlorophenyl)(phenyl)methylene)hydrazineyl)-1-phenylprop-2-en-1-one



Yellow solid; Mp: 112-114 °C; 25.2 mg, yield: 35%.

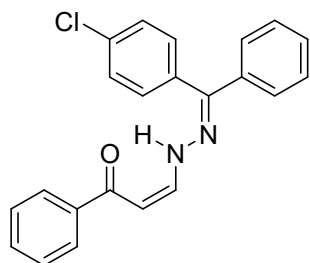
IR (KBr): 3441, 1627, 1598, 1494, 1451, 1319, 1120, 880, 726 cm^{-1} .

^1H NMR (600 MHz, Chloroform-*d*) δ 12.64 (d, $J = 9.8$ Hz, 1H), 7.82 (d, $J = 6.6$ Hz, 2H), 7.64 – 7.62 (m, 2H), 7.61 – 7.59 (m, 1H), 7.46 – 7.43 (m, 1H), 7.41 – 7.37 (m, 3H), 7.37 – 7.32 (m, 4H), 5.89 (d, $J = 8.2$ Hz, 1H).

^{13}C NMR (150 MHz, CDCl_3) δ 190.5, 151.1, 149.5, 139.0, 137.1, 136.1, 131.5, 130.9, 130.2, 130.0, 129.6, 128.7, 128.4, 128.3, 127.5, 127.4, 92.5.

HRMS (ESI-TOF) m/z : $[M + H]^+$ calcd for $C_{22}H_{18}ClN_2O^+$ 361.1102; Found 361.1102.

4e-Z (Z)-3-(2-((Z)-(4-chlorophenyl)(phenyl)methylene)hydrazineyl)-1-phenylprop-2-en-1-one



Yellow solid; Mp: 116-117 °C; 36.7 mg, yield: 51%.

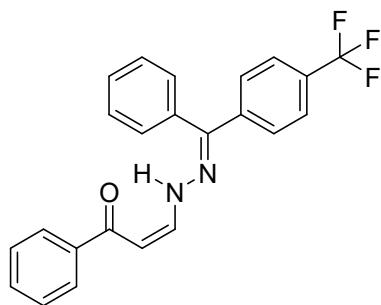
IR (KBr): 3441, 1627, 1598, 1494, 1451, 1319, 1120, 880, 726 cm^{-1} .

1H NMR (600 MHz, Chloroform- d) δ 12.54 (d, J = 10.0 Hz, 1H), 7.84 – 7.76 (m, 2H), 7.70 – 7.64 (m, 2H), 7.64 – 7.60 (m, 1H), 7.60 – 7.55 (m, 1H), 7.54 – 7.50 (m, 2H), 7.43 (t, J = 7.4 Hz, 1H), 7.39 – 7.33 (m, 4H), 7.33 – 7.29 (m, 2H), 5.86 (dd, J = 8.8, 1.8 Hz, 1H).

^{13}C NMR (150 MHz, $CDCl_3$) δ 190.5, 151.3, 149.3, 139.1, 135.8, 135.4, 132.1, 131.4, 130.2, 123.0, 128.7, 128.5, 128.3, 128.2, 127.4, 92.5.

HRMS (ESI-TOF) m/z : $[M + H]^+$ calcd for $C_{22}H_{18}ClN_2O^+$ 361.1102; Found 361.1102.

4f-E (Z)-1-phenyl-3-(2-((E)-phenyl(4(trifluoromethyl)phenyl)methylene)hydrazineyl)prop-2-en-1-one



Yellow solid; Mp: 141-143 °C; 26.0 mg, yield: 33%.

IR (KBr): 3441, 1628, 1598, 1494, 1451, 1319, 1120, 880, 726 cm^{-1} .

1H NMR (600 MHz, Chloroform- d) δ 12.67 (d, J = 9.8 Hz, 1H), 7.93 (d, J = 7.9 Hz, 2H), 7.81 (d, J = 7.6 Hz, 2H), 7.62 (t, J = 8.9 Hz, 1H), 7.56-7.53 (m, 4H), 7.45 (t, J =

7.4 Hz, 1H), 7.39-7.36 (m, 5H), 5.91 (d, $J = 8.1$ Hz, 1H).

^{13}C NMR (150 MHz, CDCl_3) δ 190.5, 150.6, 149.5, 137.8 (d, $J = 324.3$ Hz), 132.0 (d, $J = 32.6$ Hz), 131.6, 129.7, 129.1, 128.5, 128.3, 127.4, 127.4, 126.9 (d, $J = 3.8$ Hz), 123.9 (d, $J = 272.6$ Hz), 92.7.

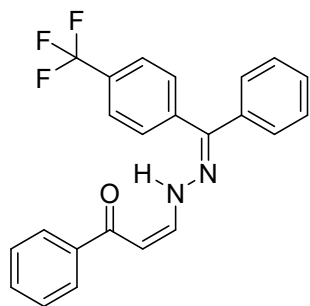
^{19}F NMR (565 MHz, CDCl_3) δ -62.67.

HRMS (ESI-TOF) m/z : $[\text{M} + \text{H}]^+$ calcd for $\text{C}_{23}\text{H}_{18}\text{F}_3\text{N}_2\text{O}^+$ 395.1366; Found 395.1358.

4f-Z

(Z)-1-phenyl-3-(2-((Z)-

phenyl(4(trifluoromethyl)phenyl)methylene)hydrazineyl)prop-2-en-1-one



Yellow solid; Mp: 142-143 °C; 40.2 mg, yield: 51%.

IR (KBr): 3441, 1627, 1598, 1494, 1451, 1319, 1120, 880, 726 cm^{-1} .

^1H NMR (600 MHz, $\text{Chloroform-}d$) δ 12.58 (d, $J = 9.9$ Hz, 1H), 7.80 (d, $J = 7.7$ Hz, 2H), 7.74 – 7.66 (m, 4H), 7.64 (t, $J = 7.5$ Hz, 1H), 7.61-7.58 (m, 3H), 7.44 (d, $J = 7.3$ Hz, 1H), 7.39-7.36 (m, 4H), 5.90 (d, $J = 8.2$ Hz, 1H).

^{13}C NMR (150 MHz, CDCl_3) δ 190.7, 150.6, 149.2, 139.8 (d, $J = 245.4$ Hz), 131.9, 131.5, 130.9 (d, $J = 32.7$ Hz), 130.3, 130.1, 128.3, 128.3, 127.6, 127.5, 125.2 (d, $J = 4.0$ Hz), 124.1 (d, $J = 272.1$ Hz), 93.0.

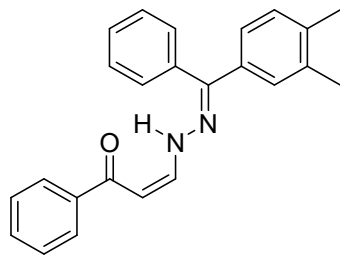
^{19}F NMR (376 MHz, CDCl_3) δ -62.63.

HRMS (ESI-TOF) m/z : $[\text{M} + \text{H}]^+$ calcd for $\text{C}_{23}\text{H}_{18}\text{F}_3\text{N}_2\text{O}^+$ 395.1366; Found 395.1366.

4g-E

(Z)-3-(2-((E)-(3,4-dimethylphenyl)(phenyl)methylene)hydrazineyl)-1-

phenylprop-2-en-1-one



Yellow solid; Mp: 143-145 °C; 24.1 mg, yield: 34%.

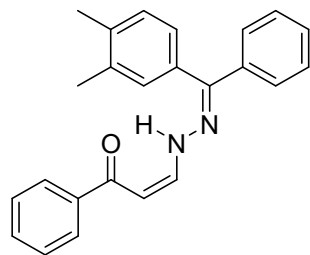
IR (KBr): 3441, 2968, 2908, 1627, 1578, 1494, 1451, 1319, 1120, 880, 726 cm^{-1} .

^1H NMR (600 MHz, Chloroform-*d*) δ 12.65 (d, J = 10.1 Hz, 1H), 7.83 (d, J = 7.6 Hz, 2H), 7.62 (t, J = 5.9 Hz, 1H), 7.44 (t, J = 7.3 Hz, 1H), 7.42 – 7.38 (m, 2H), 7.36 (d, J = 7.0 Hz, 1H), 7.16 (d, J = 7.7 Hz, 1H), 7.12 (s, 1H), 5.86 (d, J = 8.1 Hz, 1H), 2.41 (s, 3H), 2.36 (s, 3H).

^{13}C NMR (150 MHz, CDCl_3) δ 190.2, 152.9, 149.5, 139.4, 138.6, 138.1, 137.7, 131.2, 130.9, 129.8, 129.5, 129.3, 128.3, 128.2, 127.8, 127.4, 125.8, 92.0, 20.0, 19.9.

HRMS (ESI-TOF) m/z : $[\text{M} + \text{H}]^+$ calcd for $\text{C}_{24}\text{H}_{23}\text{N}_2\text{O}^+$ 355.1805; Found 355.1805.

4g-Z (Z)-3-(2-((Z)-(3,4-dimethylphenyl)(phenyl)methylene)hydrazineyl)-1-phenylprop-2-en-1-one



Yellow solid; Mp: 143-145 °C; 36.1 mg, yield: 51%.

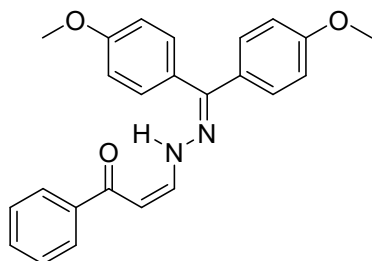
IR (KBr): 3441, 2968, 2907, 1627, 1578, 1494, 1451, 1319, 1120, 880, 726 cm^{-1} .

^1H NMR (600 MHz, Chloroform-*d*) δ 12.52 (d, J = 10.1 Hz, 1H), 7.79 (d, J = 7.7 Hz, 2H), 7.65 (t, J = 7.4 Hz, 2H), 7.61 (t, J = 8.3 Hz, 2H), 7.46 – 7.39 (m, 2H), 7.38 – 7.34 (m, 3H), 7.26 – 7.2 (d, 2H), 7.10 (d, J = 7.9 Hz, 1H), 5.83 (d, J = 8.1 Hz, 1H), 2.28 (s, 3H), 2.27 (s, 3H).

^{13}C NMR (150 MHz, CDCl_3) δ 190.2, 153.1, 149.5, 139.3, 138.5, 136.6, 134.9, 132.8, 131.2, 129.9, 129.8, 129.6, 128.39, 128.35, 128.2, 127.4, 125.4, 91.9, 19.8, 19.7.

HRMS (ESI-TOF) m/z : $[M + H]^+$ calcd for $C_{24}H_{23}N_2O^+$ 355.1805; Found 355.1809.

4i (Z)-3-(2-(bis(4-methoxyphenyl)methylene)hydrazineyl)-1-phenylprop-2-en-1-one



Yellow solid; Mp: 178-181 °C; 69.5 mg, yield: 90%.

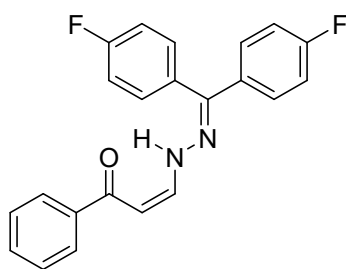
IR (KBr): 3441, 2879, 1627, 1598, 1494, 1451, 1319, 1120, 880, 726 cm^{-1} .

1H NMR (600 MHz, Chloroform- d) δ 12.65 (d, J = 10.2 Hz, 1H), 7.87 – 7.77 (m, 2H), 7.61 (t, J = 9.1 Hz, 1H), 7.53 (dd, J = 8.8, 2.1 Hz, 2H), 7.46 – 7.40 (m, 1H), 7.37 (t, J = 7.6 Hz, 2H), 7.32 (dd, J = 8.6, 2.1 Hz, 2H), 7.19 – 7.11 (m, 2H), 6.91 – 6.83 (m, 2H), 5.83 (d, J = 8.0 Hz, 1H), 3.93 (s, 3H), 3.83 (s, 3H).

^{13}C NMR (150 MHz, $CDCl_3$) δ 190.1, 160.8, 160.6, 152.6, 149.6, 139.4, 131.2, 130.5, 130.0, 129.2, 128.2, 127.4, 124.7, 115.1, 113.7, 91.6, 55.4, 55.4.

HRMS (ESI-TOF) m/z : $[M + H]^+$ calcd for $C_{24}H_{23}N_2O_3^+$ 387.1703; Found 387.1703.

4j (Z)-3-(2-(bis(4-fluorophenyl)methylene)hydrazineyl)-1-phenylprop-2-en-1-one



Yellow solid; Mp: 158-161 °C; 64.4 mg, yield: 89%.

IR (KBr): 3441, 1627, 1598, 1494, 1451, 1319, 1120, 880, 726 cm^{-1} .

1H NMR (600 MHz, Chloroform- d) δ 12.61 (d, J = 9.9 Hz, 1H), 7.81 (d, J = 7.7 Hz, 2H), 7.59 (t, J = 9.3 Hz, 1H), 7.57 – 7.53 (m, 2H), 7.44 (t, J = 7.2 Hz, 1H), 7.40-7.34 (m, 6H), 7.04 (t, J = 8.0 Hz, 2H), 5.88 (d, J = 8.1 Hz, 1H).

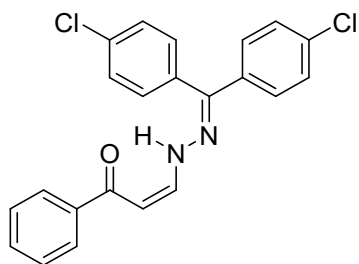
^{13}C NMR (150 MHz, $CDCl_3$) δ 190.5, 163.8 (d, J = 250.66 Hz), 163.5 (d, J = 250.66

Hz), 150.4, 149.4, 139.0, 133.4, 133.4, 131.5, 130.6 (d, $J = 8.4$ Hz), 129.4 (d, $J = 8.3$ Hz), 128.3, 128.3, 128.2, 127.4, 117.3 (d, $J = 21.9$ Hz), 115.4 (d, $J = 21.8$ Hz), 92.4.

^{19}F NMR (565 MHz, CDCl_3) δ -109.41, -111.17.

HRMS (ESI-TOF) m/z : $[\text{M} + \text{H}]^+$ calcd for $\text{C}_{22}\text{H}_{17}\text{F}_2\text{N}_2\text{O}^+$ 363.1303; Found 363.1307.

4k (Z)-3-(2-(bis(4-chlorophenyl)methylene)hydrazineyl)-1-phenylprop-2-en-1-one



Yellow solid; Mp: 157-168 °C; 73.3 mg, yield: 93%.

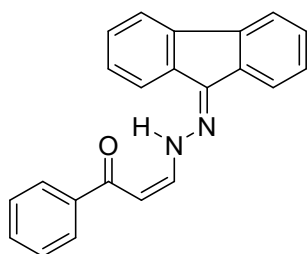
IR (KBr): 3441, 1627, 1578, 1494, 1451, 1319, 1120, 880, 726 cm^{-1} .

^1H NMR (400 MHz, $\text{Chloroform-}d$) δ 12.65 (d, $J = 9.7$ Hz, 1H), 7.82 (d, $J = 8.4$ Hz, 2H), 7.64 (d, $J = 8.4$ Hz, 2H), 7.61 – 7.54 (m, 1H), 7.49 (d, $J = 8.6$ Hz, 2H), 7.45 (d, $J = 7.1$ Hz, 1H), 7.39 (t, $J = 7.3$ Hz, 2H), 7.32 (dd, $J = 8.6, 2.4$ Hz, 4H), 5.90 (d, $J = 8.2$ Hz, 1H).

^{13}C NMR (100 MHz, CDCl_3) δ 190.64, 149.79, 149.40, 138.88, 136.30, 135.63, 135.52, 131.60, 130.41, 130.39, 129.93, 128.68, 128.65, 128.36, 127.47, 92.79.

HRMS (ESI-TOF) m/z : $[\text{M} + \text{H}]^+$ calcd for $\text{C}_{22}\text{H}_{17}\text{ClN}_2\text{O}^+$ 395.0712; Found 395.0712.

4l (Z)-3-(2-(9H-fluoren-9-ylidene)hydrazineyl)-1-phenylprop-2-en-1-one



Yellow solid; Mp: 181-183 °C; 59.6 mg, yield: 92%.

IR (KBr): 3441, 1627, 1528, 1454, 1401, 1319, 1120, 880, 726 cm^{-1} .

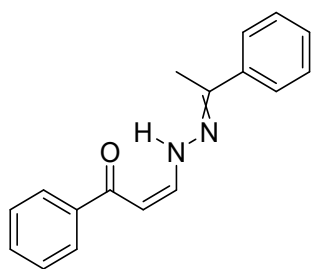
^1H NMR (600 MHz, $\text{Chloroform-}d$) δ 13.73 (d, $J = 9.7$ Hz, 1H), 8.59 (d, $J = 7.7$ Hz,

1H), 8.01 (d, $J = 7.5$ Hz, 2H), 7.83 (d, $J = 7.5$ Hz, 1H), 7.75 (t, $J = 8.0$ Hz, 2H), 7.65 (d, $J = 7.5$ Hz, 1H), 7.58 (s, 1H), 7.52 (t, $J = 7.7$ Hz, 1H), 7.49 (t, $J = 7.3$ Hz, 2H), 7.39 (t, $J = 7.3$ Hz, 1H), 7.33 (d, $J = 7.5$ Hz, 1H), 6.15 (d, $J = 8.1$ Hz, 1H).

^{13}C NMR (150 MHz, CDCl_3) δ 191.3, 150.3, 146.7, 141.8, 139.4, 139.0, 137.2, 131.9, 130.9, 129.7, 129.6, 128.8, 128.5, 128.0, 127.6, 125.1, 121.7, 120.5, 119.7, 94.1.

HRMS (ESI-TOF) m/z : $[\text{M} + \text{H}]^+$ calcd for $\text{C}_{22}\text{H}_{17}\text{N}_2\text{O}^+$ 325.1335; Found 325.1333.

4m (2Z)-1-phenyl-3-(2-(1-phenylethylidene)hydrazineyl)prop-2-en-1-one



Yellow solid; Mp: 144-145 °C; 49.1 mg, yield: 93%.

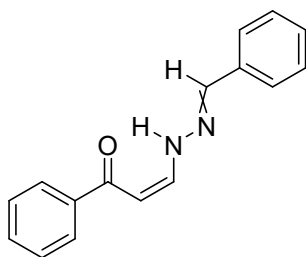
IR (KBr): 3441, 2979, 1627, 1578, 1494, 1451, 1319, 1120, 880, 726 cm^{-1} .

^1H NMR (600 MHz, $\text{Chloroform-}d$) δ 13.18 (d, $J = 9.8$ Hz, 1H), 7.95 (d, $J = 7.6$ Hz, 2H), 7.84 – 7.74 (m, 2H), 7.69 (t, $J = 8.8$ Hz, 1H), 7.53 – 7.48 (m, 1H), 7.46 (t, $J = 7.5$ Hz, 2H), 7.43-7.39 (m, 3H), 6.00 (d, $J = 7.8$ Hz, 1H), 2.44 – 2.38 (m, 3H).

^{13}C NMR (150 MHz, CDCl_3) δ 190.8, 190.8, 150.5, 150.0, 139.2, 137.8, 131.5, 129.4, 128.5, 128.5, 127.4, 126.2, 91.9, 13.8.

HRMS (ESI-TOF) m/z : $[\text{M} + \text{H}]^+$ calcd for $\text{C}_{17}\text{H}_{17}\text{N}_2\text{O}^+$ 265.1335; Found 265.1332.

4n (2Z)-3-(2-benzylidenehydrazineyl)-1-phenylprop-2-en-1-one



Yellow solid; Mp: 152-153 °C; 47.5 mg, yield: 95%.

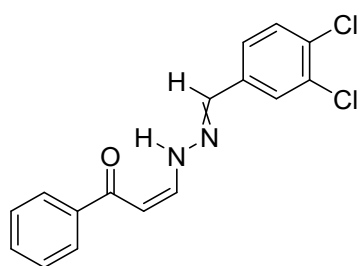
IR (KBr): 3441, 1627, 1598, 1494, 1451, 1319, 1120, 880, 726 cm^{-1} .

¹H NMR (600 MHz, Chloroform-*d*) δ 12.98 (d, J = 10.1 Hz, 1H), 8.00 – 7.88 (m, 3H), 7.66 (d, J = 6.9 Hz, 2H), 7.60 – 7.53 (m, 1H), 7.53 – 7.48 (m, 1H), 7.45 (t, J = 7.5 Hz, 2H), 7.41-7.40 (m, 3H), 5.93 (dd, J = 8.1, 2.1 Hz, 1H).

¹³C NMR (150 MHz, CDCl₃) δ 190.6, 190.6, 149.9, 149.9, 145.7, 139.0, 133.8, 133.7, 131.6, 130.1, 130.1, 128.8, 128.5, 127.4, 127.2, 91.5.

HRMS (ESI-TOF) m/z : [M + H]⁺ calcd for C₁₆H₁₅N₂O⁺ 251.1179; Found 251.1178.

4o (2Z)-3-(2-(2,3-dichlorobenzylidene)hydrazineyl)-1-phenylprop-2-en-1-one



Yellow solid; Mp: 146-148 °C; 57.9 mg, yield: 91%.

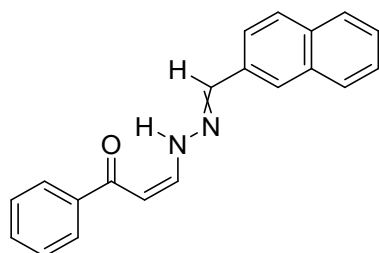
IR (KBr): 3441, 1627, 1598, 1494, 1451, 1319, 1120, 880, 726 cm⁻¹.

¹H NMR (600 MHz, Chloroform-*d*) δ 13.04 (d, J = 10.1 Hz, 1H), 8.38 (d, J = 2.7 Hz, 1H), 7.92 (m, 2H), 7.57 – 7.49 (m, 2H), 7.46 (d, J = 7.6 Hz, 2H), 7.23 (dd, J = 9.2, 6.7 Hz, 2H), 6.00 – 5.95 (m, 1H), 5.30 (d, J = 2.4 Hz, 1H).

¹³C NMR (150 MHz, CDCl₃) δ 191.0, 149.5, 141.6, 138.8, 133.7, 133.5, 132.2, 131.8, 131.2, 128.5, 127.5, 127.3, 125.1, 92.4.

HRMS (ESI-TOF) m/z : [M + H]⁺ calcd for C₁₆H₁₃Cl₂N₂O⁺ 319.0399; Found 319.0399.

4p (2Z)-3-(2-(2-chlorobenzylidene)hydrazineyl)-1-phenylprop-2-en-1-one



Yellow solid; Mp: 137-138 °C; 54.0 mg, yield: 90%.

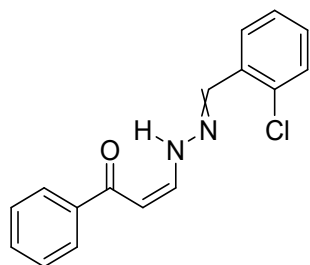
IR (KBr): 3441, 1627, 1578, 1494, 1451, 1319, 1120, 880, 726 cm^{-1} .

^1H NMR (600 MHz, Chloroform-*d*) δ 13.15 (d, J = 10.0 Hz, 1H), 8.67 (d, J = 8.6 Hz, 1H), 8.63 (s, 1H), 7.96 (d, J = 7.6 Hz, 2H), 7.91-7.89 (m, 3H), 7.68 (dd, J = 10.0, 8.2 Hz, 1H), 7.65 – 7.59 (m, 1H), 7.56 (d, J = 7.6 Hz, 1H), 7.54 – 7.50 (m, 2H), 7.47 (t, J = 7.2 Hz, 2H), 5.97 (d, J = 8.0 Hz, 1H).

^{13}C NMR (150 MHz, CDCl_3) δ 190.7, 149.9, 145.3, 139.0, 134.0, 131.6, 130.8, 130.7, 129.2, 128.9, 128.5, 127.5, 127.4, 127.2, 126.2, 125.4, 124.0, 91.6.

HRMS (ESI-TOF) m/z : $[\text{M} + \text{H}]^+$ calcd for $\text{C}_{20}\text{H}_{17}\text{N}_2\text{O}^+$ 301.1335; Found 301.1339.

4q (2*Z*)-3-(2-(2-chlorobenzylidene)hydrazineyl)-1-phenylprop-2-en-1-one



Yellow solid; Mp: 149-161.2 $^{\circ}\text{C}$; 51.7 mg, yield: 91%.

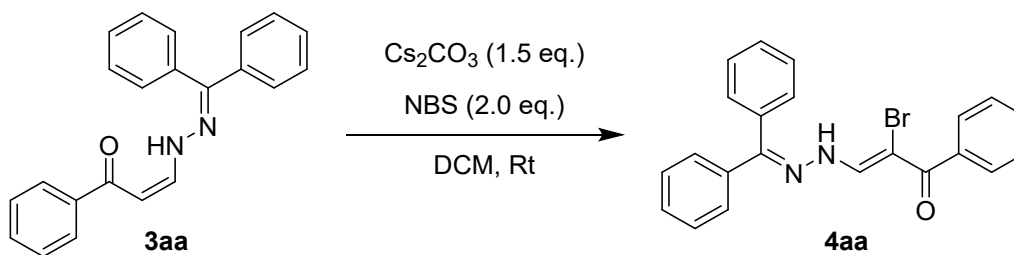
IR (KBr): 3441, 1627, 1598, 1494, 1451, 1319, 1120, 880, 726 cm^{-1} .

^1H NMR (600 MHz, Chloroform-*d*) δ 13.03 (d, J = 10.0 Hz, 1H), 8.39 (s, 1H), 8.00 (dd, J = 6.8, 2.8 Hz, 1H), 7.94 (d, J = 7.6 Hz, 2H), 7.56 (dd, J = 10.0, 8.2 Hz, 1H), 7.51 (t, J = 7.2 Hz, 1H), 7.46 (t, J = 7.6 Hz, 2H), 7.40 – 7.37 (m, 1H), 7.32 – 7.28 (m, 2H), 5.96 (d, J = 8.1 Hz, 1H).

^{13}C NMR (150 MHz, CDCl_3) δ 189.8, 148.6, 141.1, 137.9, 133.2, 130.7, 130.3, 129.8, 129.0, 127.5, 126.4, 126.0, 125.9, 91.0.

HRMS (ESI-TOF) m/z : $[\text{M} + \text{H}]^+$ calcd for $\text{C}_{16}\text{H}_{14}\text{ClN}_2\text{O}^+$ 285.0789; Found 285.0789.

7. General Procedure for preparing **5a**



3a (0,1 mmol, 0.0326 g, 1 eq.), Cs_2CO_3 (1.5 mmol, 0.0489g, 1.5 eq.) and NBS (0.2 mmol, 0.0356 g, 2 eq.) were added in 10 mL reaction tube with 1 mL DCM as solvent, reacting 6 hours, monitored by TLC. The reaction was quenched with saturated NH_4Cl solution and extracted with ethyl acetate for three times. The combined organic layers were dried over Na_2SO_4 , filtered and concentrated in vacuum. The crude materials were purified by flash column chromatography to give the desired products **5a** using EtOAc/petroleum ether 1:50 as the mobile phase. The structure was determined by X-ray, NMR spectroscopy and HRMS.

5a (Z)-2-bromo-3-(2-(diphenylmethylene)hydrazineyl)-1-phenylprop-2-en-1-one

Yellow solid; Mp: 149-161.2 °C; 37.1 mg, yield: 92%.

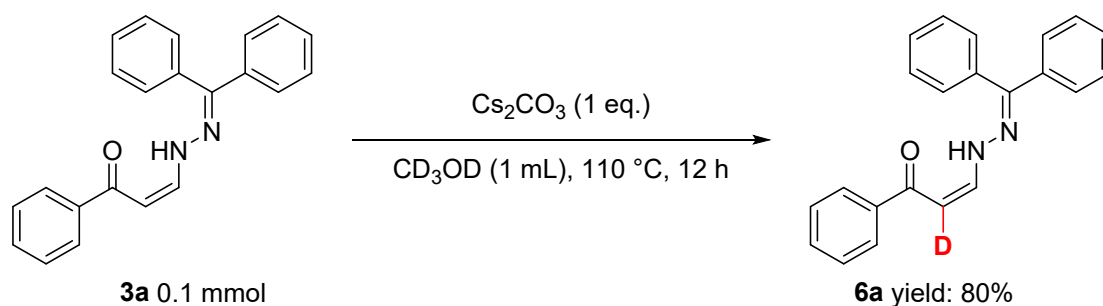
IR (KBr): 3441, 1627, 1598, 1494, 1451, 1319, 1120, 880, 726 cm^{-1} .

^1H NMR (400 MHz, Chloroform-*d*) δ 8.57 (d, $J = 10.9$ Hz, 1H), 8.01 (d, $J = 10.9$ Hz, 1H), 7.69 – 7.62 (m, 2H), 7.62 – 7.59 (m, 1H), 7.59 – 7.55 (m, 2H), 7.51 (m, 3H), 7.49 – 7.43 (m, 2H), 7.36 (d, $J = 6.9$ Hz, 1H), 7.35 – 7.31 (m, 4H).

^{13}C NMR (100 MHz, CDCl_3) δ 188.1, 154.0, 147.8, 138.6, 136.3, 131.3, 130.8, 130.4, 130.1, 130.0, 128.5, 128.5, 128.3, 127.5, 98.4.

HRMS (ESI-TOF) m/z : $[\text{M} + \text{H}]^+$ calcd for $\text{C}_{22}\text{H}_{18}\text{BrN}_2\text{O}^+$ 405.0597; Found 405.0597.

8. General Procedure for preparing **6a**



3a (0.1 mmol, 326 mg), Cs_2CO_3 (32.6 mg, 1 eq.), CD_3OD 1 mL were added to a 10 mL reaction tube, followed by heating at 110 °C for 24 hours. The reaction was quenched with saturated NH_4Cl solution and extracted three times with ethyl acetate. The combined organic layers were dried over Na_2SO_4 , filtered, and concentrated under vacuum. The product was analyzed directly by ^1H NMR without further purification.

6a (Z)-3-(2-(diphenylmethylene)hydrazineyl)-1-phenylprop-2-en-1-one-2-*d*

Yellow solid; Mp: 138.1-140.2 °C; 27.2 mg, yield: 42%.

IR (KBr): 3449, 3064, 1664, 1539, 1487, 1208, 1147, 1343, 1149, 968, 875, 764 cm^{-1} .

^1H NMR (400 MHz, $\text{Chloroform-}d$) δ 8.60 (s, 1H), 8.43 (d, $J = 7.6$ Hz, 2H), 7.68 (m, 4H), 7.54 (m, 5H), 7.33 (m, 4H), 7.29 (d, $J = 7.2$ Hz, 2H).

^{13}C NMR (100 MHz, CDCl_3) δ 190.43, 190.39, 152.6, 149.5, 149.4, 139.2, 139.2, 137.2, 132.5, 131.3, 130.1, 129.9, 129.5, 128.38, 128.37, 128.2, 127.6, 127.4, 92.2.

HRMS (ESI-TOF) m/z : $[\text{M} + \text{H}]^+$ calcd for $\text{C}_{22}\text{H}_{18}\text{DN}_2\text{O}^+$ 328.1555; Found 328.1555.

9. X-ray Structure and Data of **4g-Z**

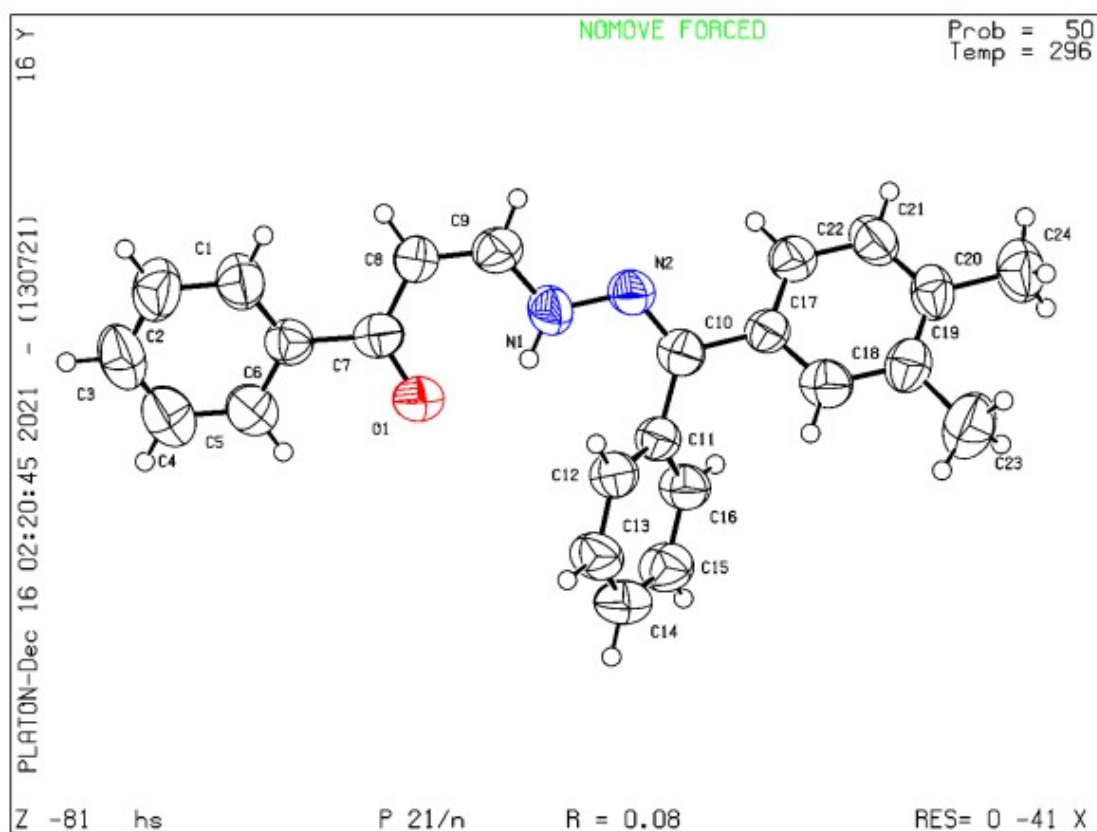


Fig.2 X-ray Structure and Data of **4g-Z**

Bond precision:	C-C = 0.0078 Å	Wavelength=0.71073	
Cell:	a=14.550(19)	b=6.415(9)	c=21.40(3)
	alpha=90	beta=100.555(11)	gamma=90
Temperature:	296 K		

	Calculated	Reported
Volume	1964(5)	1964(5)
Space group	P 21/n	P 21/n
Hall group	-P 2yn	-P 2yn
Moiety formula	C24 H22 N2 O	?
Sum formula	C24 H22 N2 O	C24 H22 N2 O
Mr	354.44	354.43
Dx, g cm-3	1.199	1.199
Z	4	4
Mu (mm-1)	0.074	0.074
F000	752.0	752.0
F000'	752.28	
h,k,lmax	17, 7, 25	17, 7, 25
Nref	3560	3558
Tmin,Tmax	0.987, 0.996	
Tmin'	0.987	

Correction method= Not given

Data completeness= 0.999	Theta(max)= 25.250
--------------------------	--------------------

R(reflections)= 0.0824(1281)	WR2(reflections)=
	0.2388(3558)

S = 1.014	Npar= 250
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The following ALERTS were generated. Each ALERT has the format
test-name_ALERT_alert-type_alert-level.
Click on the hyperlinks for more details of the test.

10. X-ray Structure and Data of **4n**

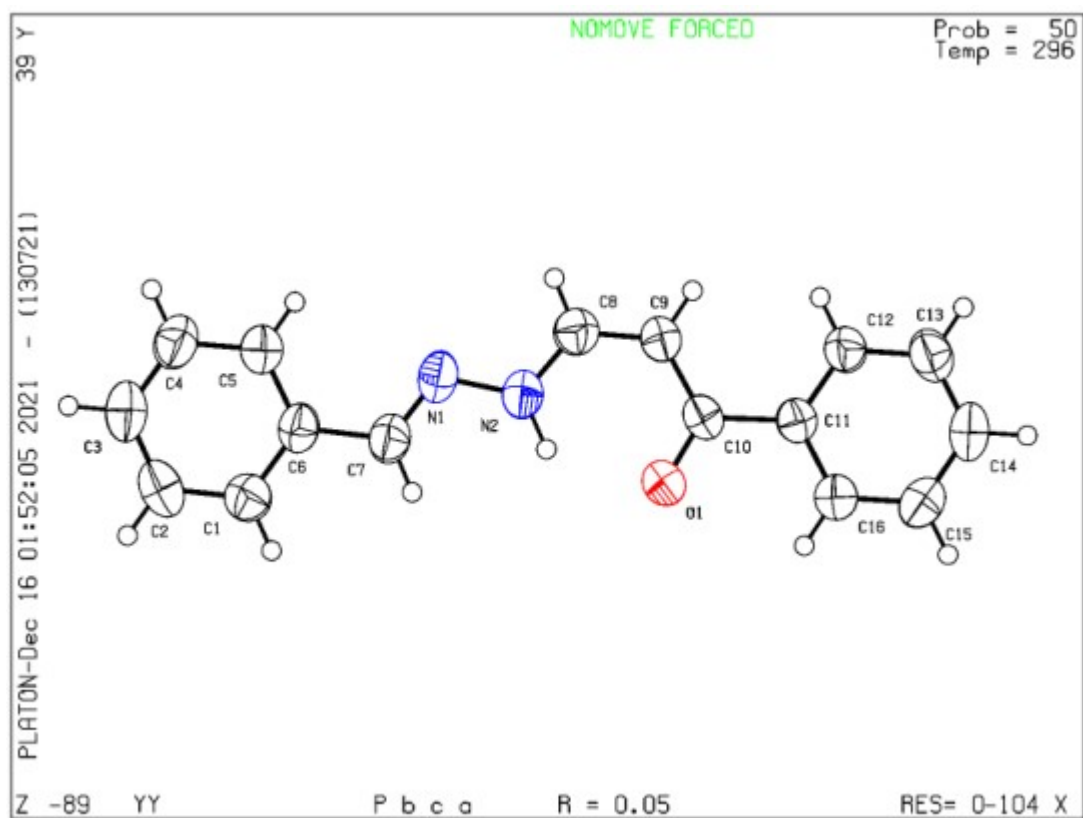


Fig. 3 X-ray Structure and Data of **4n**

11. X-ray Structure and Data of **5a**

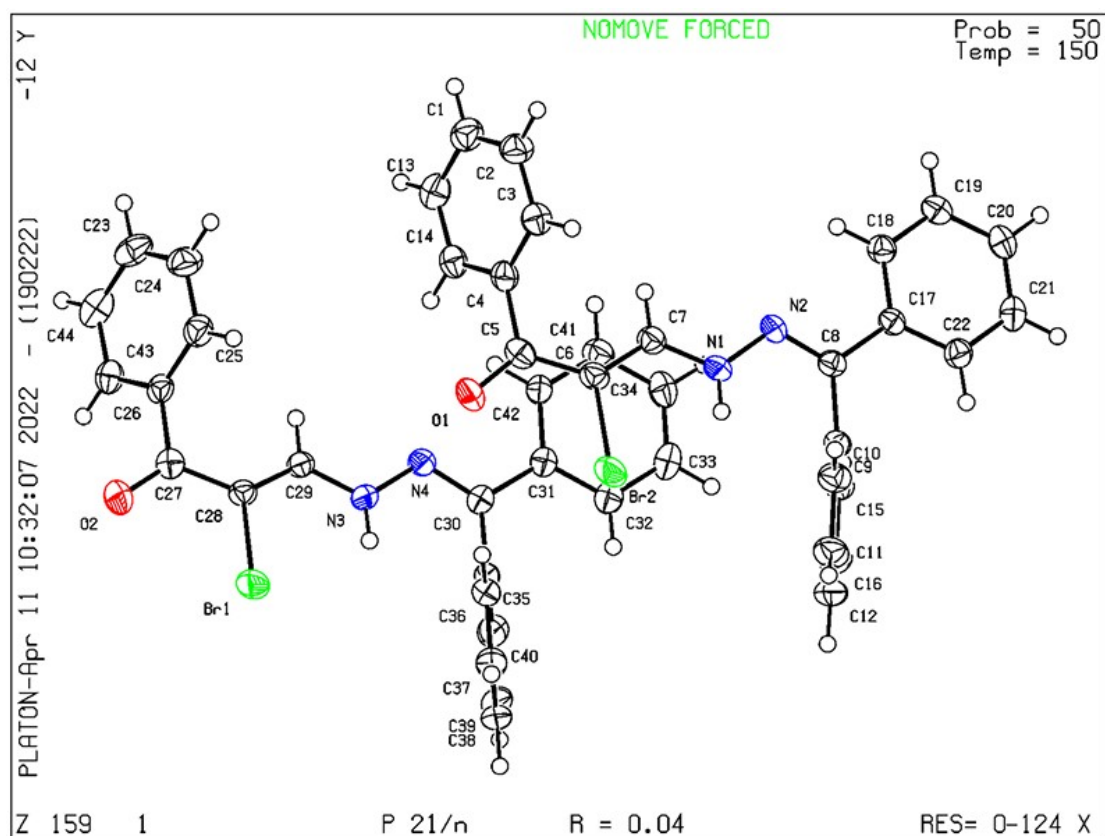


Fig. 4 X-ray Structure and Data of **5a**

Datablock: 1

Bond precision: C-C = 0.0052 Å Wavelength=0.71073

Cell: a=13.4106(8) b=17.0023(11) c=17.4419(9)
alpha=90 beta=110.493(2) gamma=90

Temperature: 150 K

	Calculated	Reported
Volume	3725.3(4)	3725.3(4)
Space group	P 21/n	P 21/n
Hall group	-P 2yn	-P 2yn
Moiety formula	C22 H17 Br N2 O	C22 H17 Br N2 O
Sum formula	C22 H17 Br N2 O	C22 H17 Br N2 O
Mr	405.28	405.28
Dx, g cm ⁻³	1.445	1.445
Z	8	8
Mu (mm ⁻¹)	2.219	2.220
F000	1648.0	1648.0
F000'	1646.27	
h,k,lmax	17,22,23	17,22,23
Nref	9303	9065
Tmin,Tmax	0.620,0.671	0.651,0.746
Tmin'	0.608	

Correction method= # Reported T Limits: Tmin=0.651 Tmax=0.746
AbsCorr = MULTI-SCAN

Data completeness= 0.974 Theta(max)= 28.369

R(reflections)= 0.0444(5463) wR2(reflections)=
S = 1.046 Npar= 475 0.1236(9065)

The following ALERTS were generated. Each ALERT has the format
test-name_ALERT_alert-type_alert-level.
Click on the hyperlinks for more details of the test.

Alert level G

PLAT941_ALERT_3_G Average HKL Measurement Multiplicity 3.2 Low
PLAT965_ALERT_2_G The SHELXL WEIGHT Optimisation has not Converged Please Check

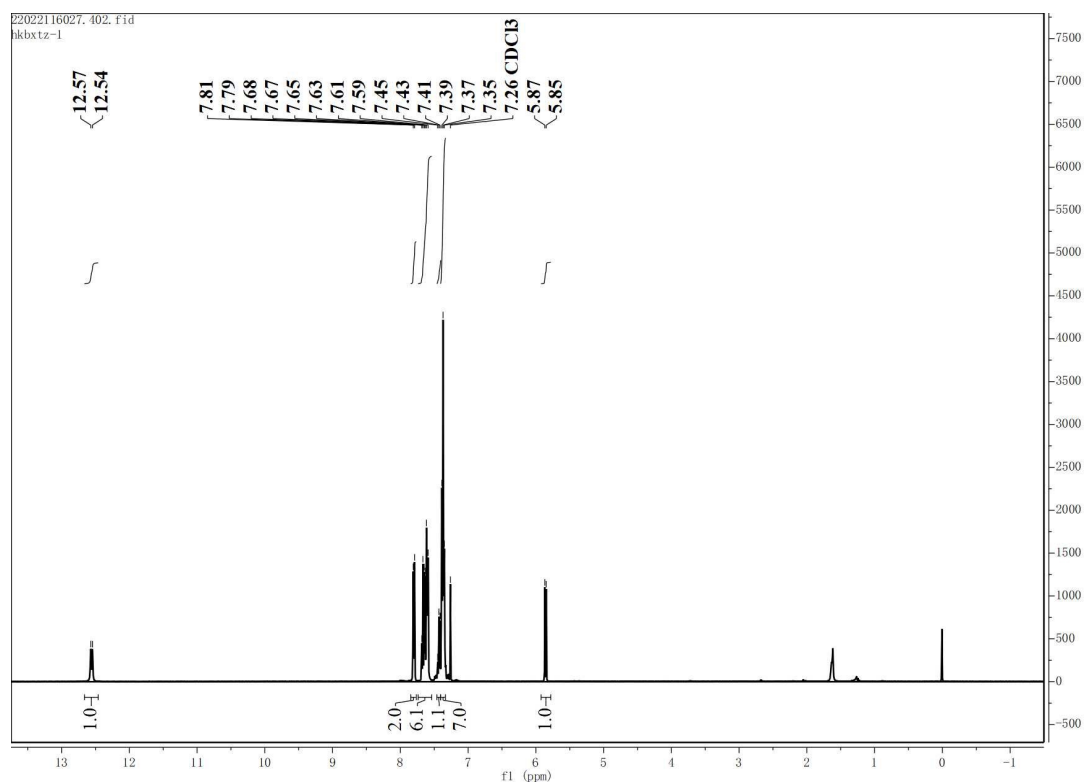
0 **ALERT level A** = Most likely a serious problem - resolve or explain
0 **ALERT level B** = A potentially serious problem, consider carefully
0 **ALERT level C** = Check. Ensure it is not caused by an omission or oversight
2 **ALERT level G** = General information/check it is not something unexpected

0 ALERT type 1 CIF construction/syntax error, inconsistent or missing data
1 ALERT type 2 Indicator that the structure model may be wrong or deficient
1 ALERT type 3 Indicator that the structure quality may be low
0 ALERT type 4 Improvement, methodology, query or suggestion
0 ALERT type 5 Informative message, check

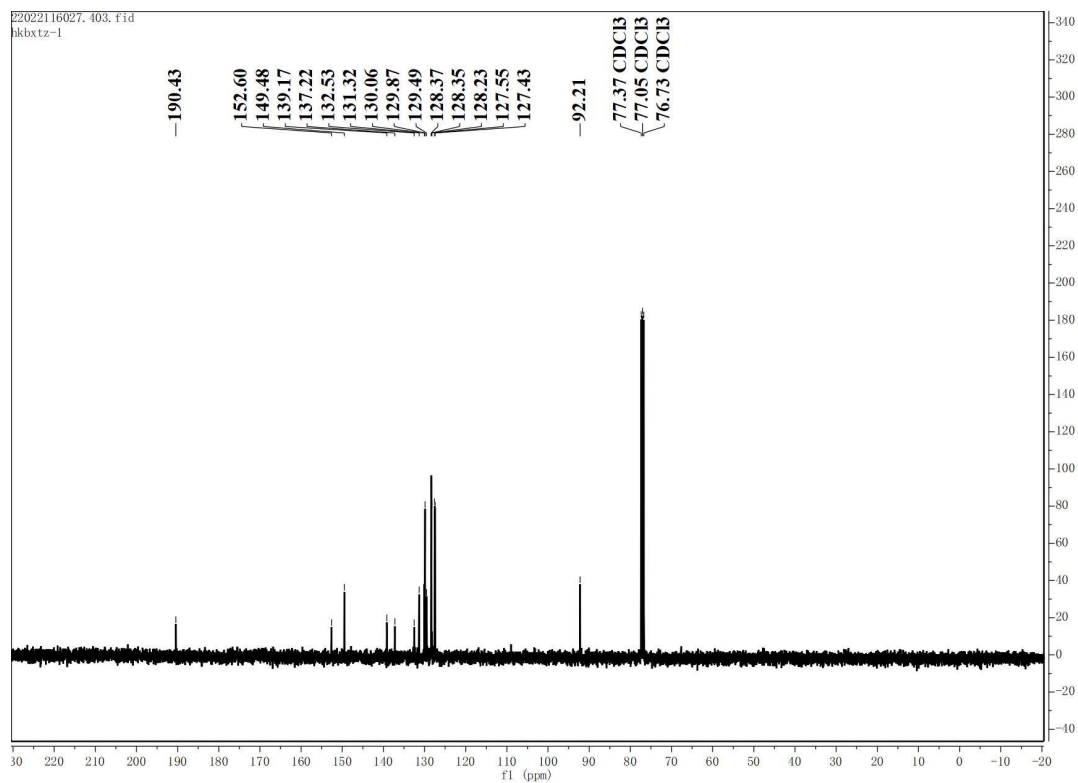
12. Reference

- (1). 1a. Kaixiu Luo, Shuai Mao, Kun He, Xianglin Yu, Junhong Pan, Jun Lin, Zhihui Shao, and Yi Jin, *ACS Catal.*, 2020, 10 (6), 3733-3740. 1b. Jinbiao Ying, Ting Liu, Yunyun Liu, and Jie-Ping Wan, *Organic Letters.*, 2022, 24 (12), 2404-2408
- (2). Wang, Jian; Li, Lianjie; Chai, Minxue; Ding, Shumin; Li, Jing; Shang, Yongjia; Zhao, Haixia; Li, Dan; Zhu, Qiang, *ACS Catal.*, 2021, 11, (19), 12367-12374.
- (3). Kang, Hyotaik; Li, Chao-Jun, *Chem. Sci.*, 2022,13, 118-122
- (4). 4a. Ganesh Shivayogappa Sorabad, Mahagundappa Rachappa Maddani, *New J. Chem.*, 2019, 43, 6563-6568. 4b. Hui Xu, Pan Zhou, Rong Hang, Jie Zhou, Ling-Ling Lu, Yuehai Shen, Fu-Chao Yu, *Tetrahedron Lett.*, 57, 45, 2016, 4965-4968

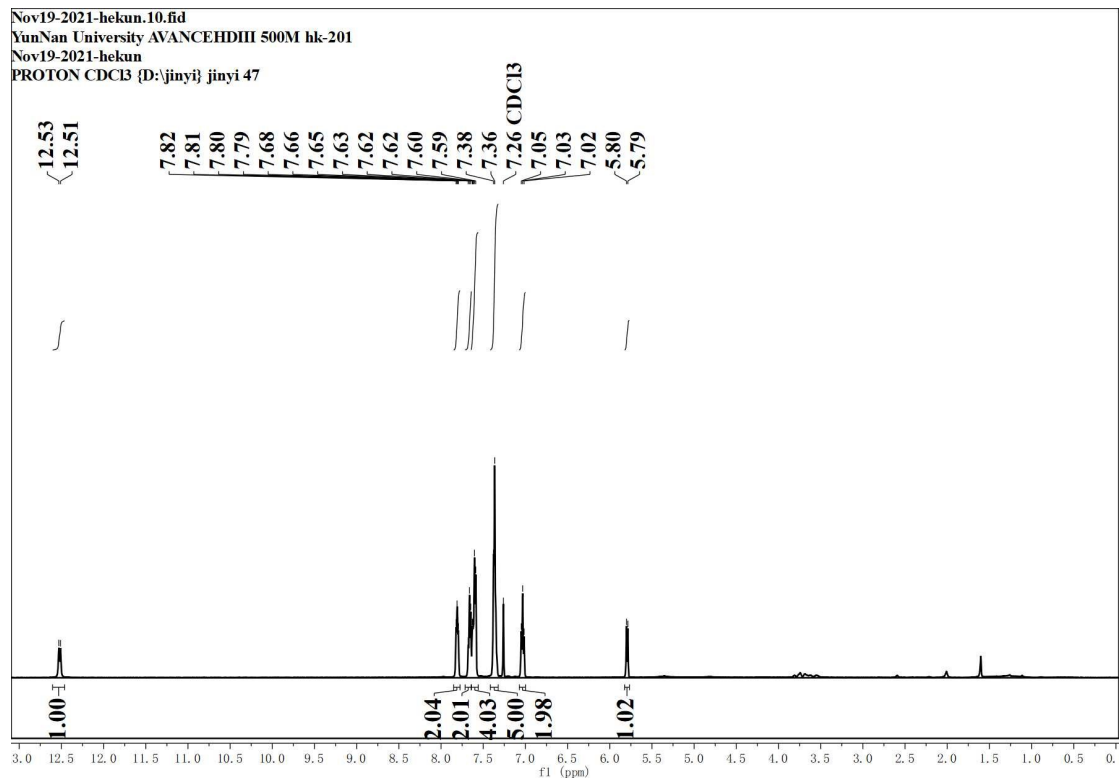
13. ^1H NMR and ^{13}C NMR Spectra of These Compounds



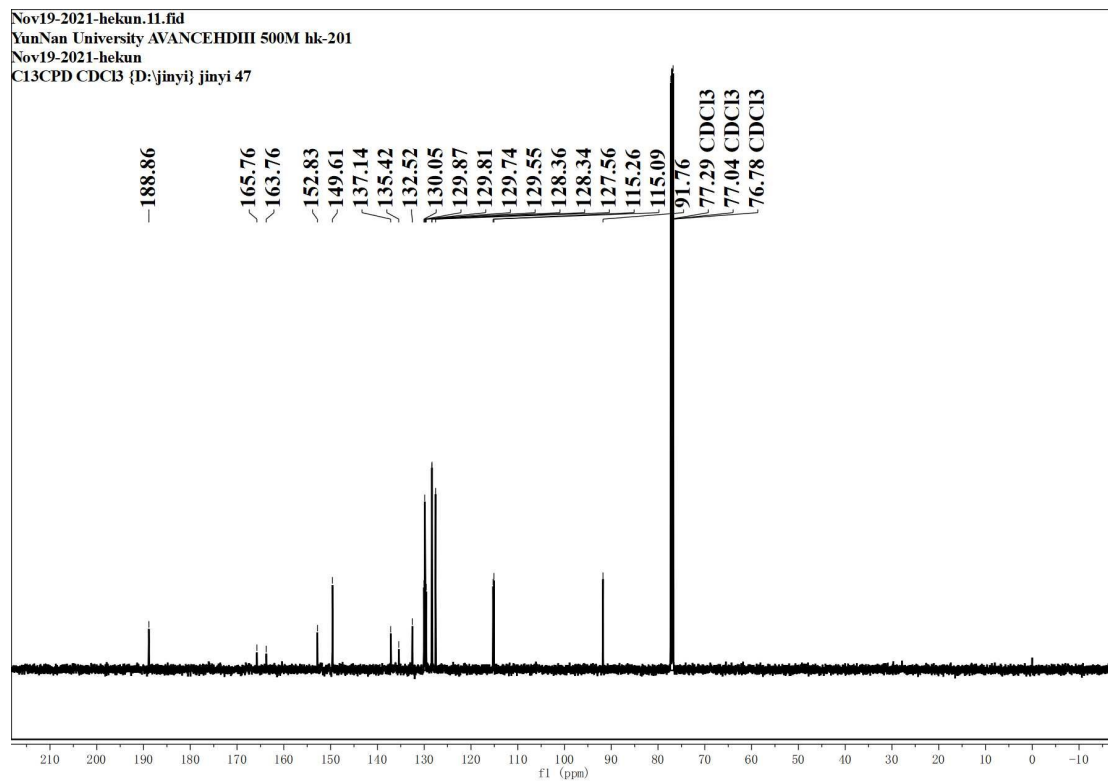
^1H -NMR (600MHz, CDCl_3) spectrum of compound (**3a**)



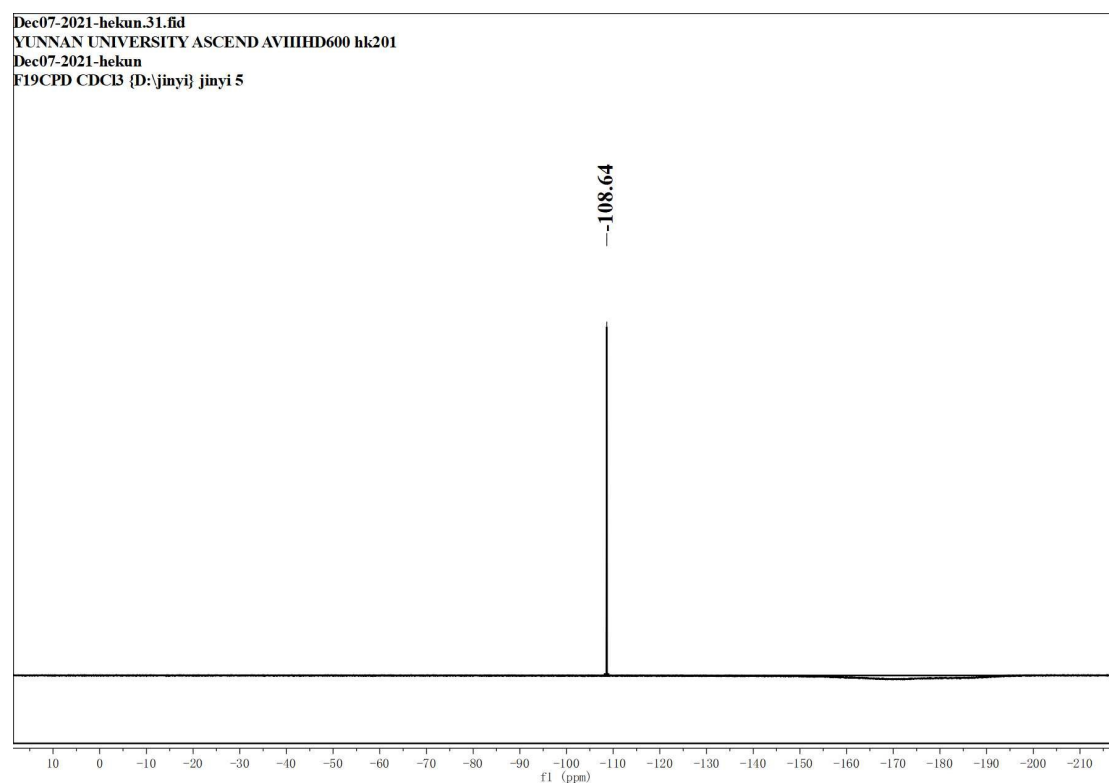
^{13}C -NMR(150MHz, CDCl_3) spectrum of compound (**3a**)



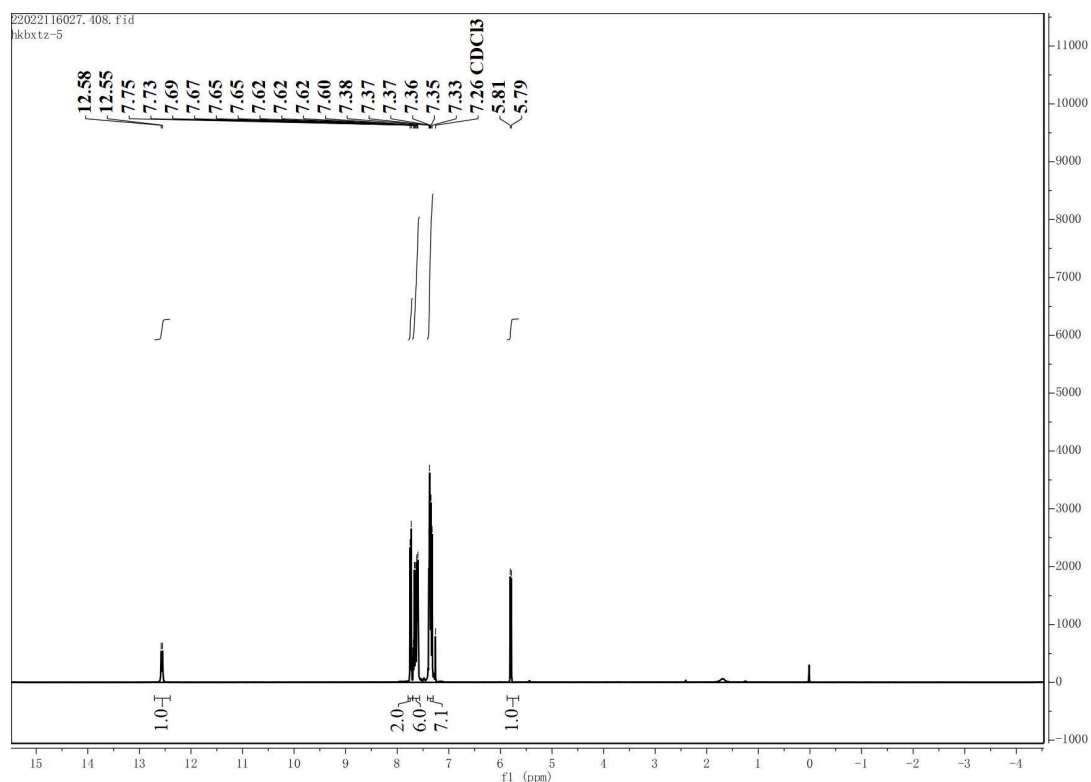
¹H-NMR (500MHz, CDCl₃) spectrum of compound (3b)



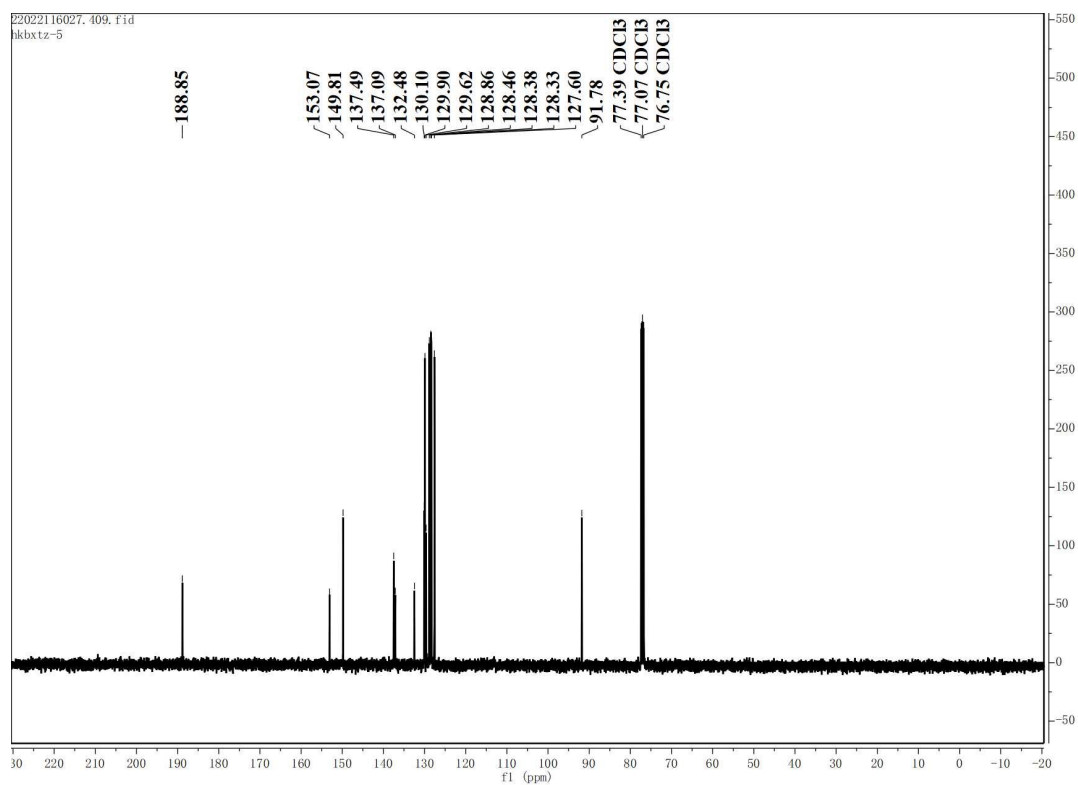
¹³C-NMR(125MHz, CDCl₃) spectrum of compound (3b)



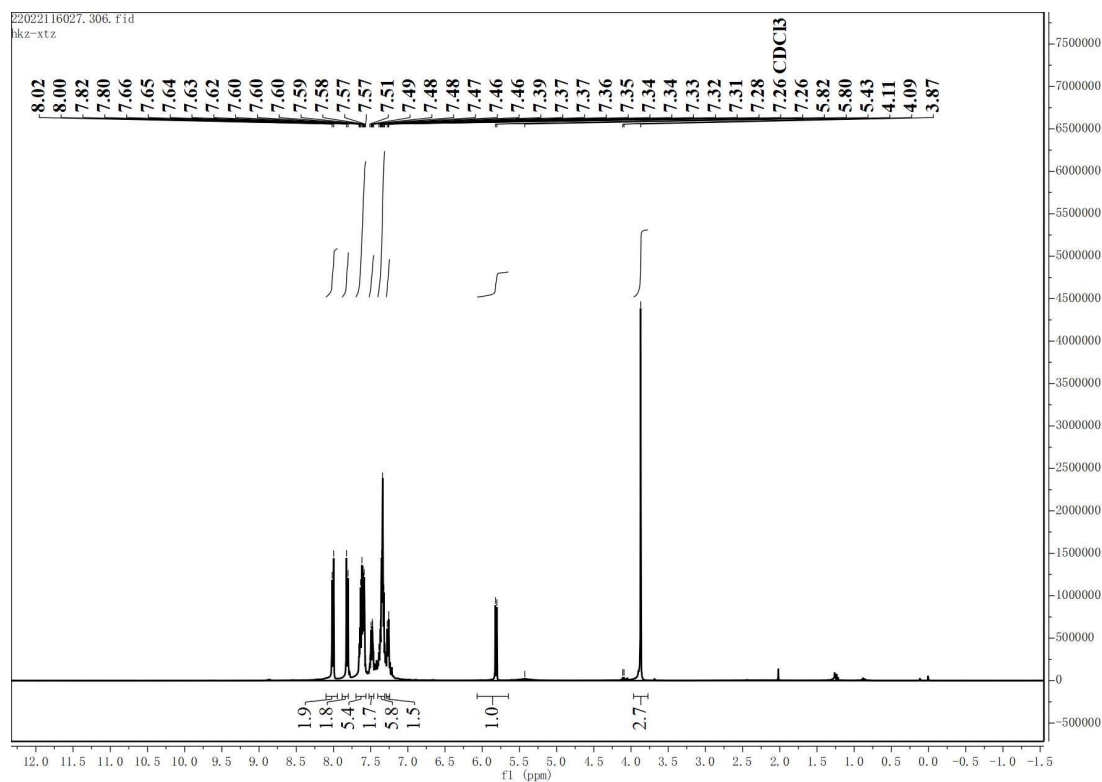
^{19}F -NMR(565MHz, CDCl_3) spectrum of compound (**3b**)



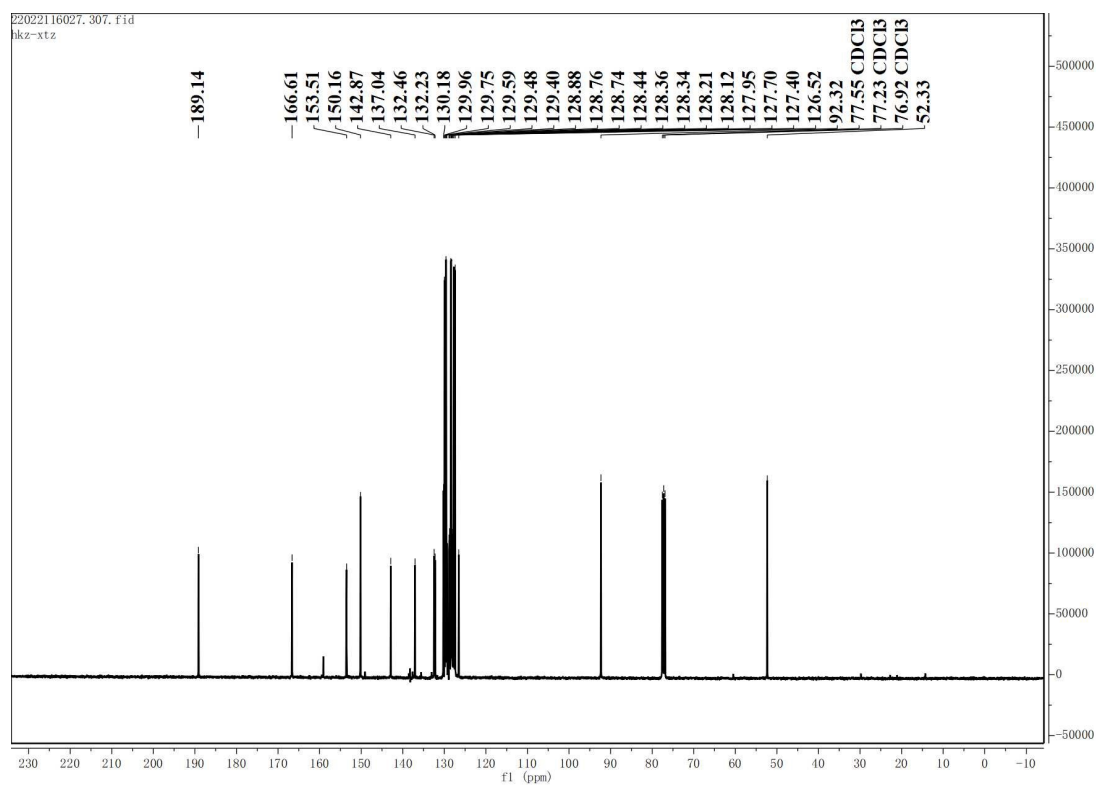
¹H-NMR (600MHz, CDCl₃) spectrum of compound (**3c**)



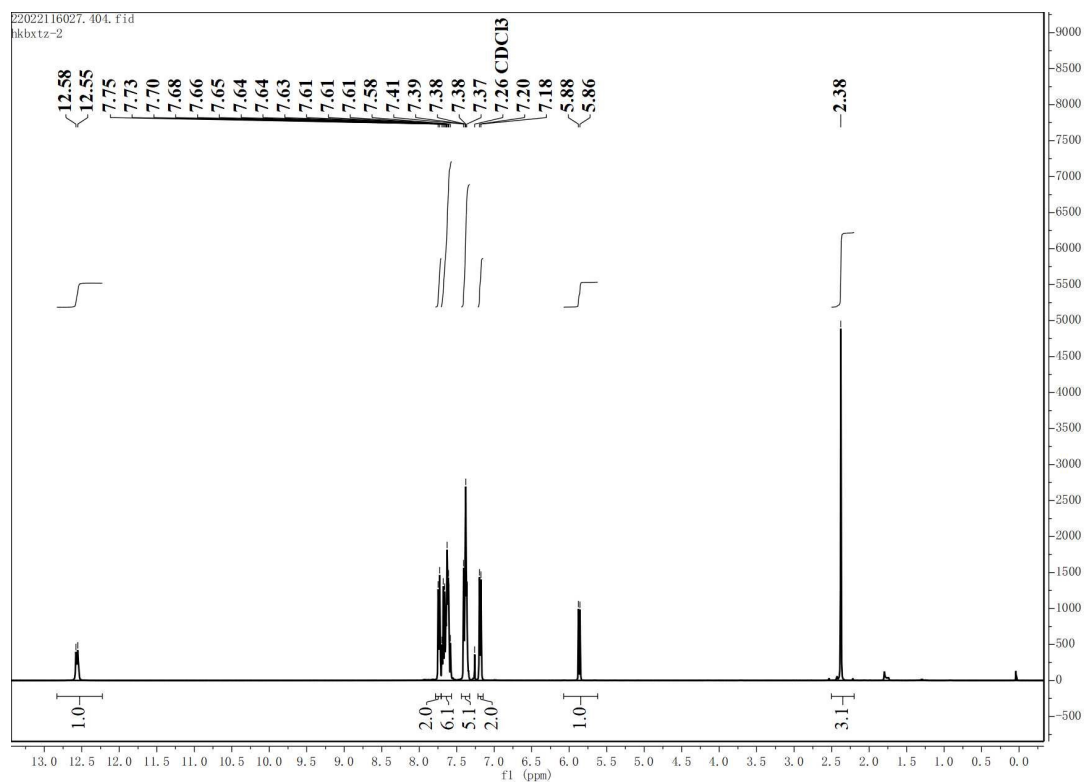
¹³C-NMR(150MHz, CDCl₃) spectrum of compound (**3c**)



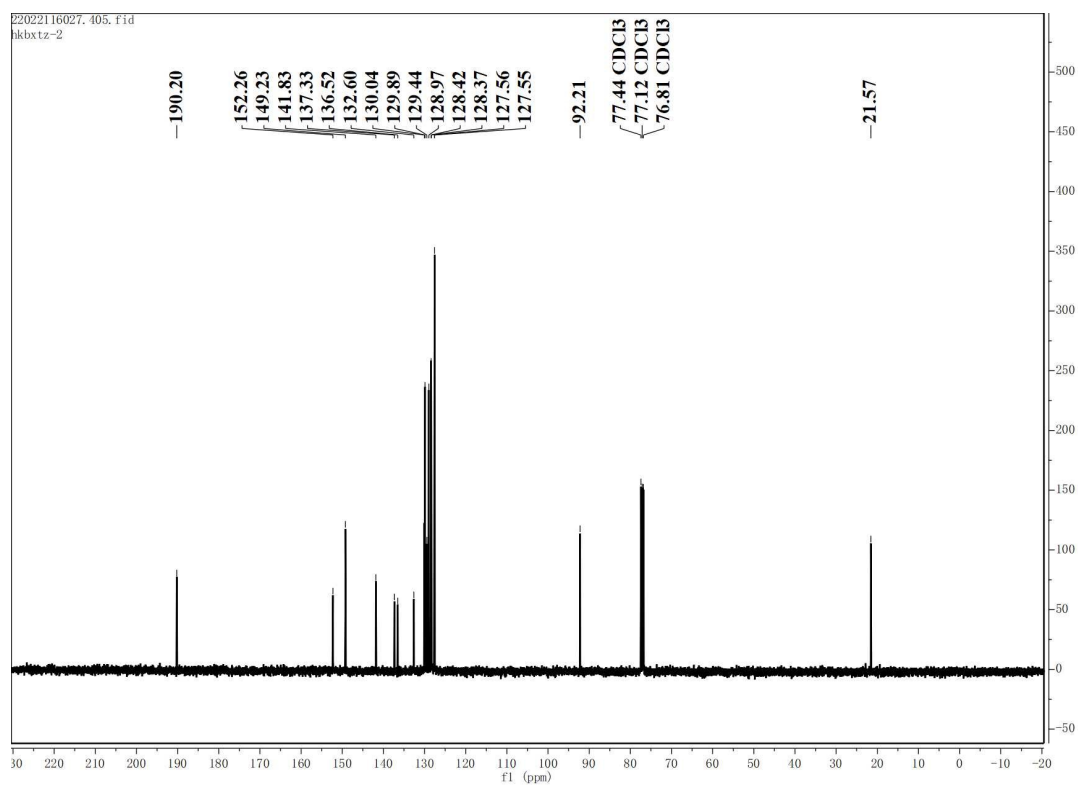
¹H-NMR (600MHz, CDCl₃) spectrum of compound (**3d**)



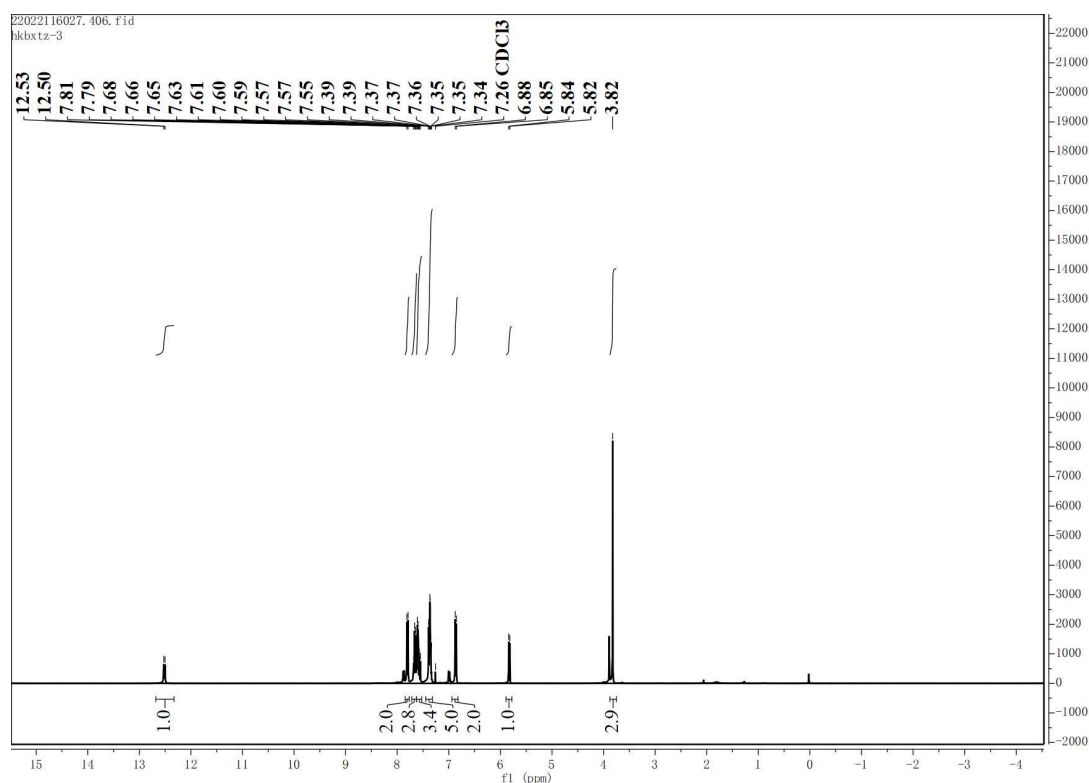
¹³C-NMR(150MHz, CDCl₃) spectrum of compound (**3d**)



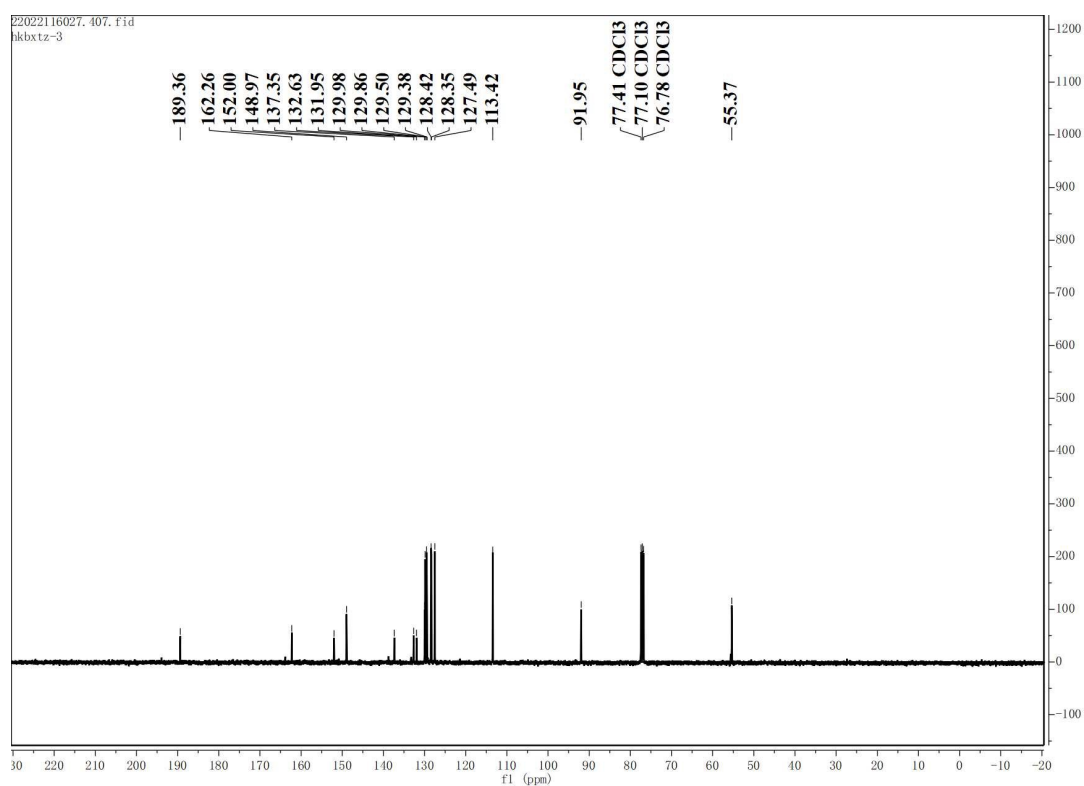
¹H-NMR (500MHz, CDCl₃) spectrum of compound (**3e**)



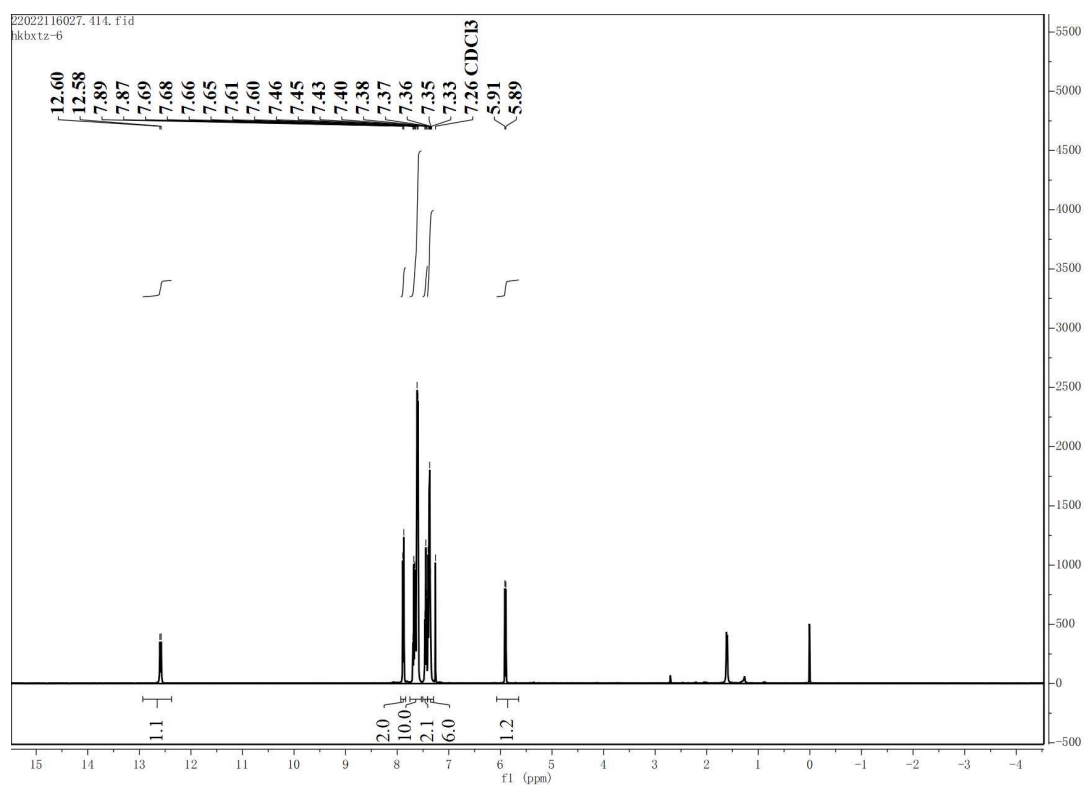
¹³C-NMR(125MHz, CDCl₃) spectrum of compound (**3e**)



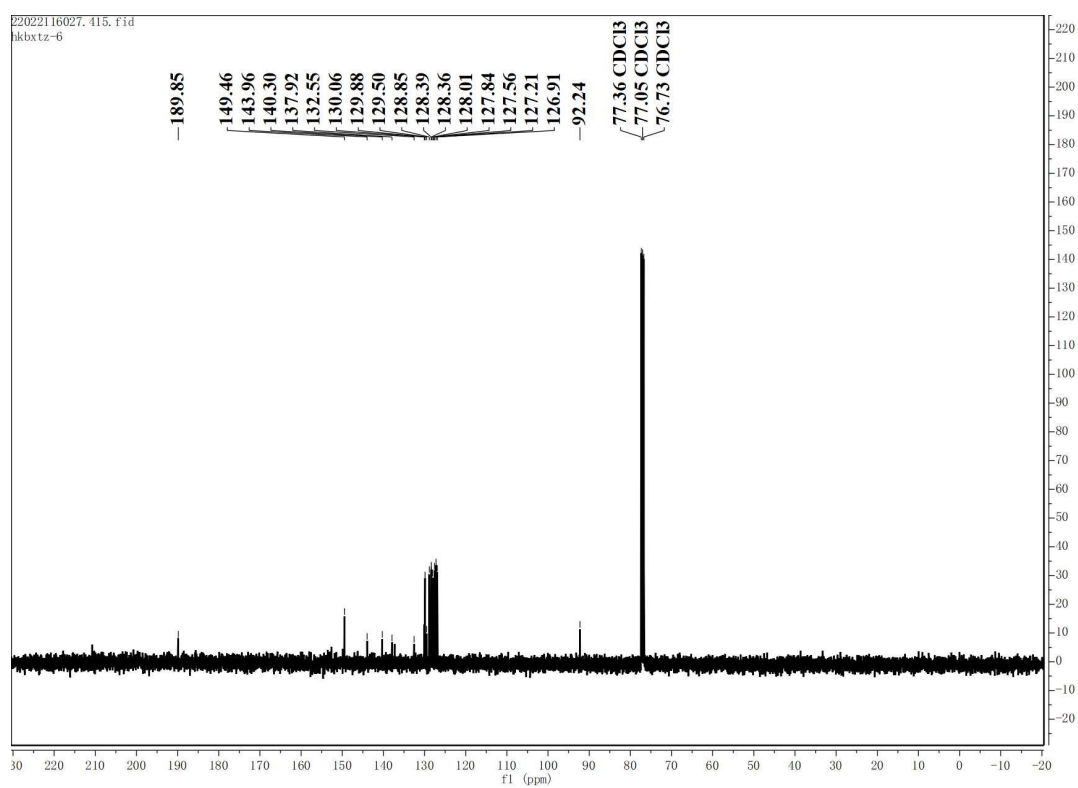
¹H-NMR (400MHz, CDCl₃) spectrum of compound (3f)



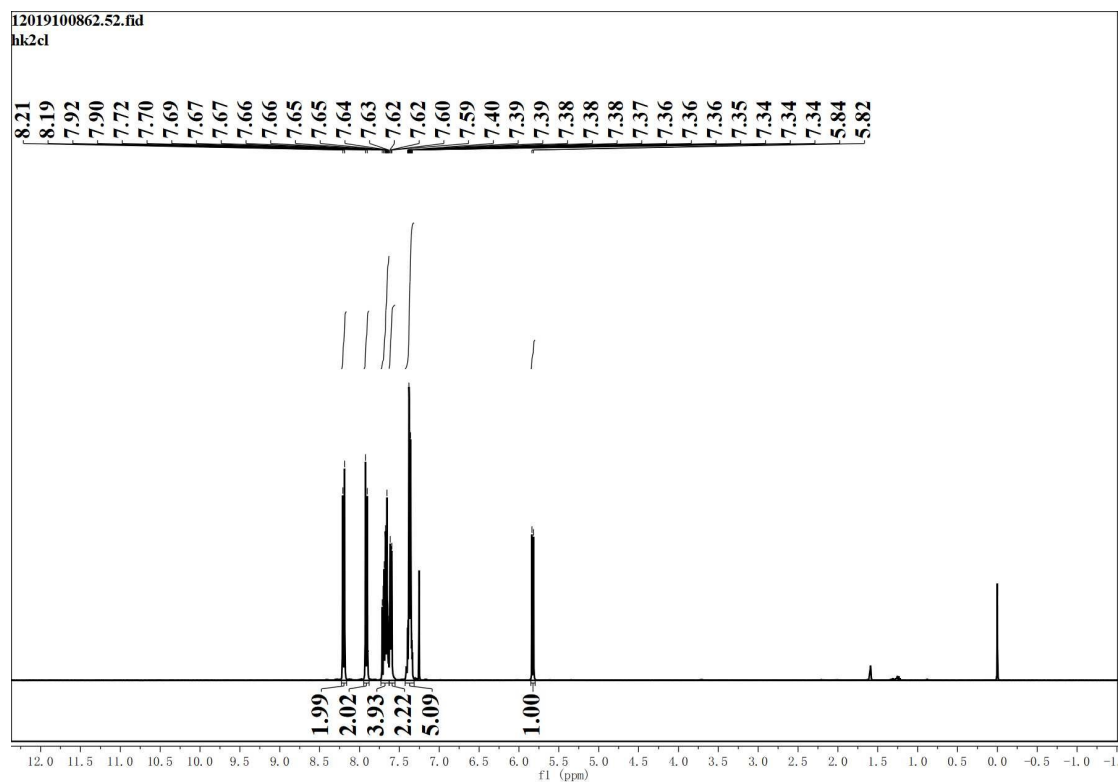
¹³C-NMR(100MHz, CDCl₃) spectrum of compound (3f)



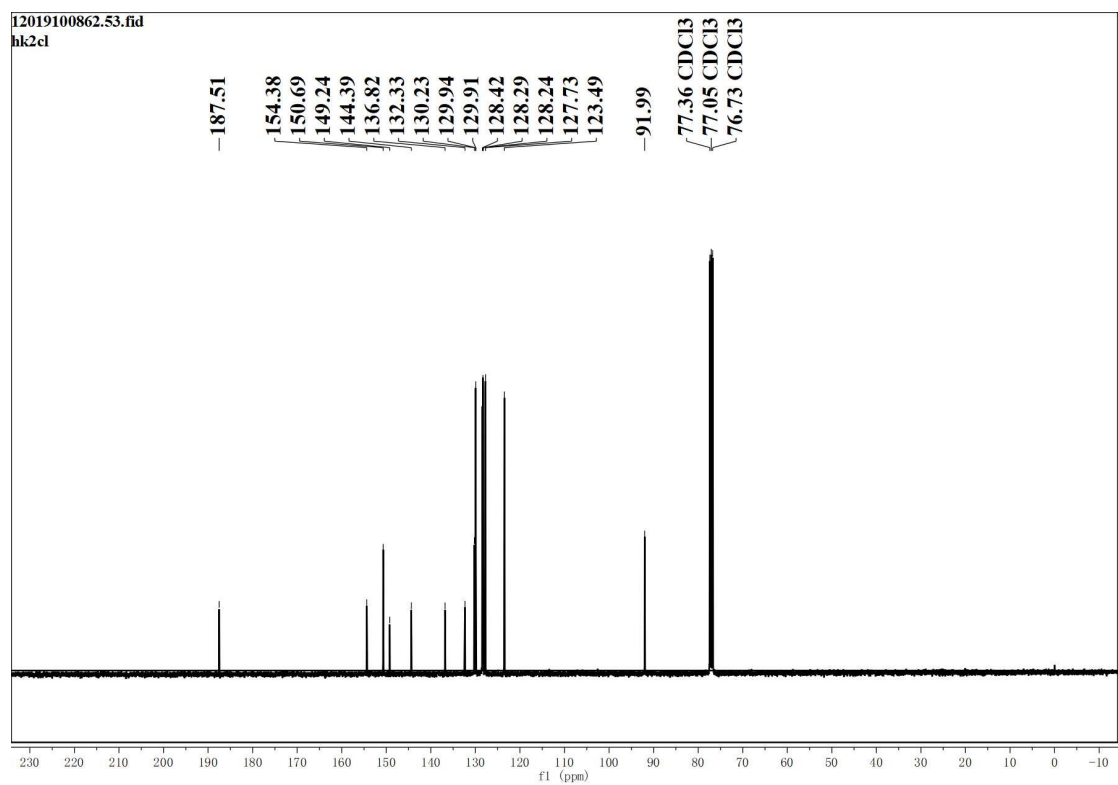
¹H-NMR (500MHz, CDCl₃) spectrum of compound (**3g**)



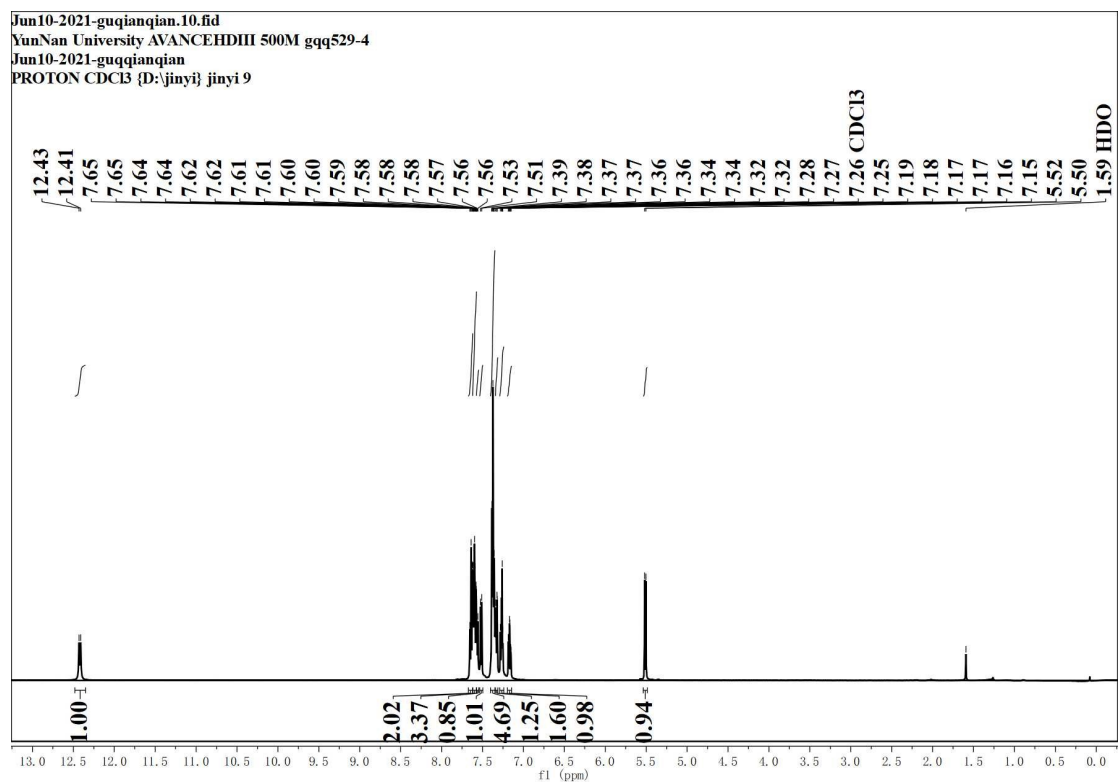
¹³C-NMR(125MHz, CDCl₃) spectrum of compound (**3g**)



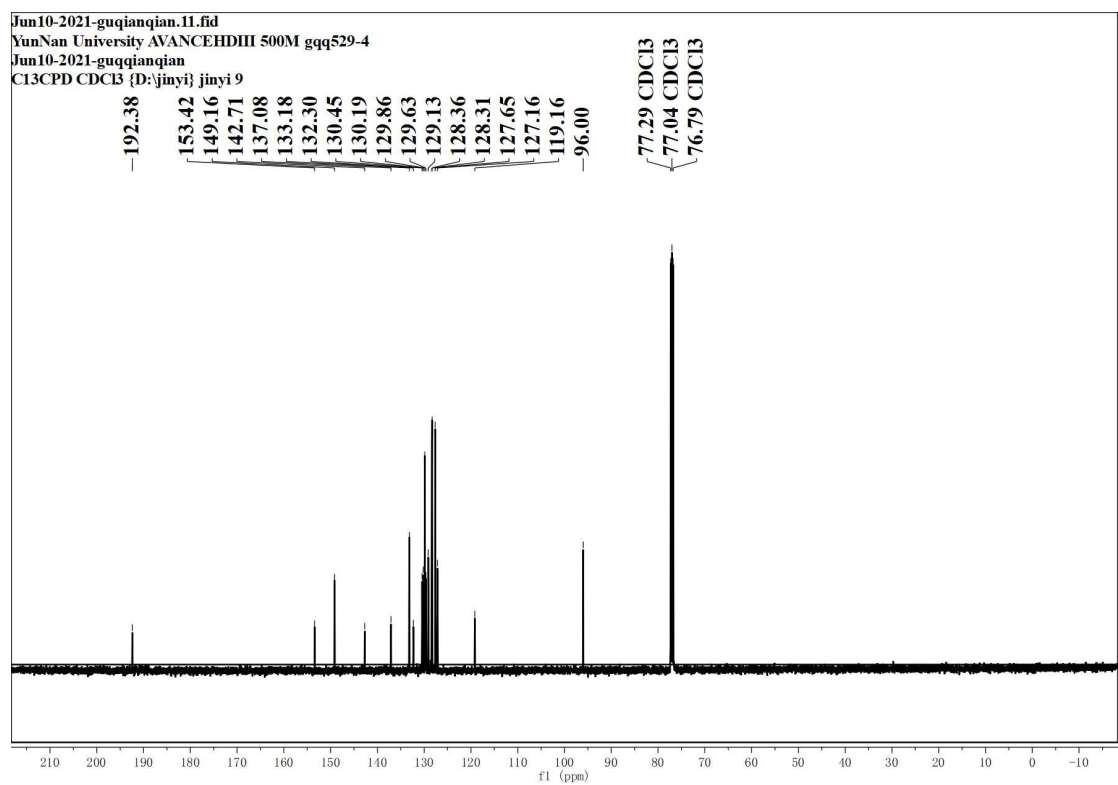
^1H -NMR (400MHz, CDCl_3) spectrum of compound (**3h**)



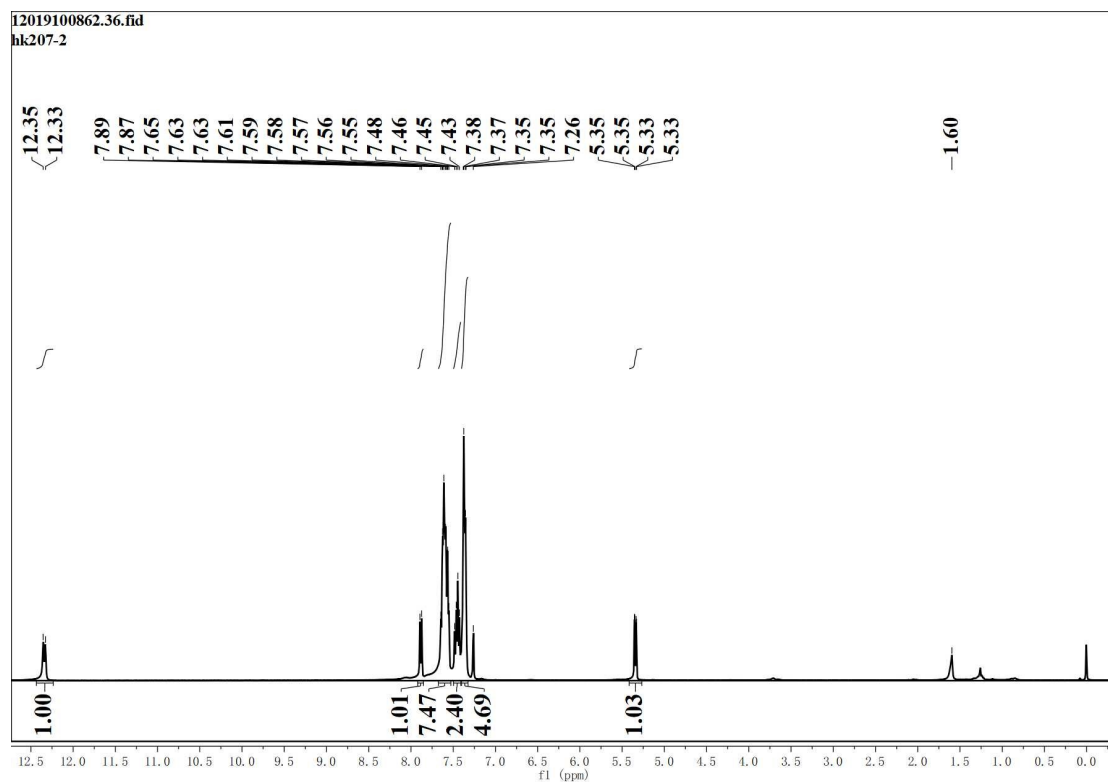
^{13}C -NMR(100MHz, CDCl_3) spectrum of compound (**3h**)



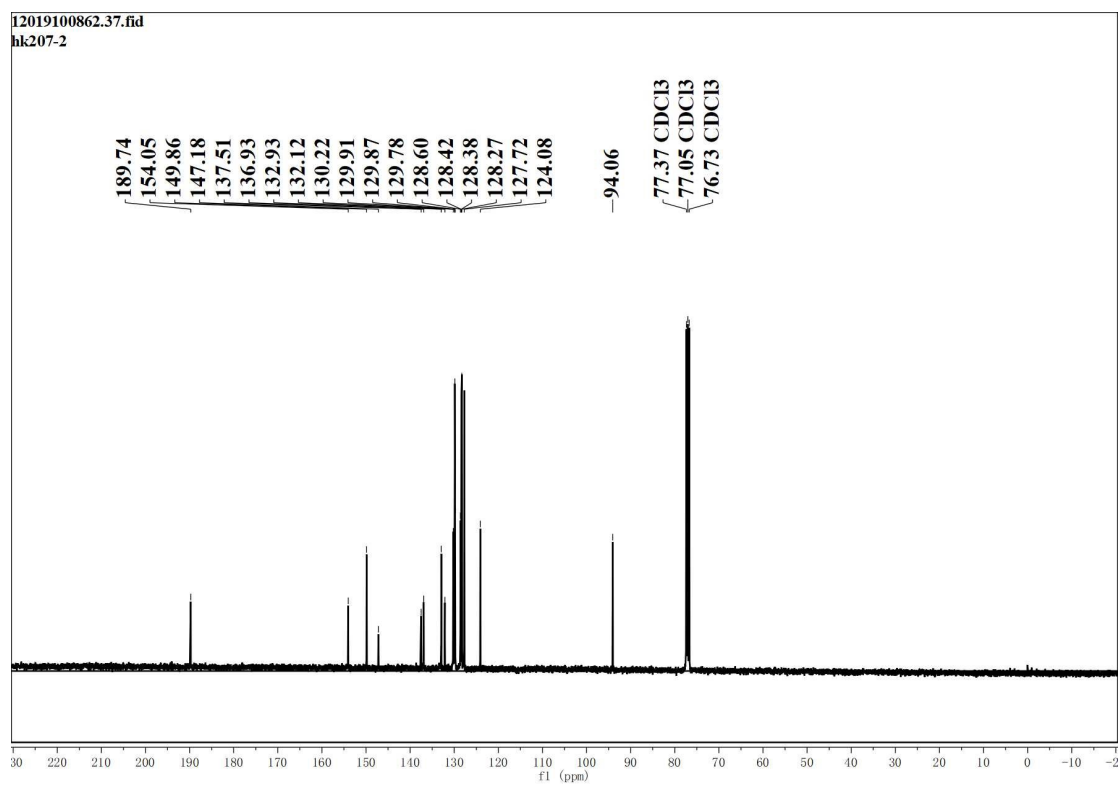
¹H-NMR (500MHz, CDCl₃) spectrum of compound (3i)



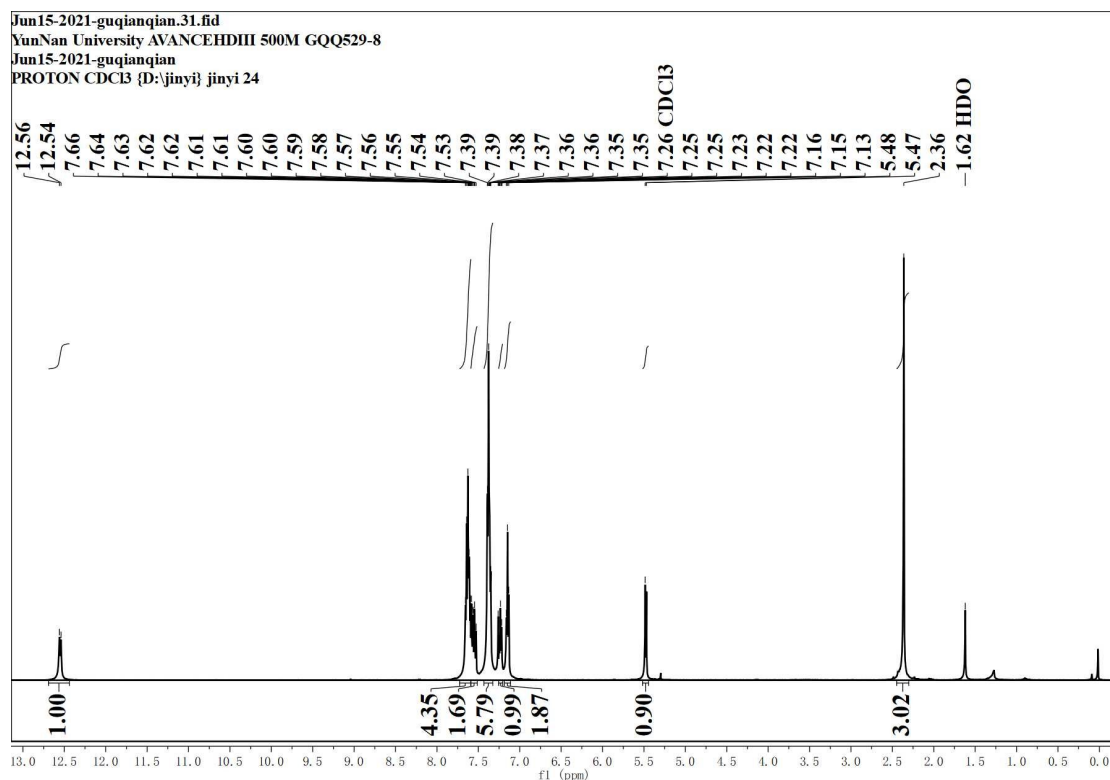
¹³C-NMR(125MHz, CDCl₃) spectrum of compound (3i)



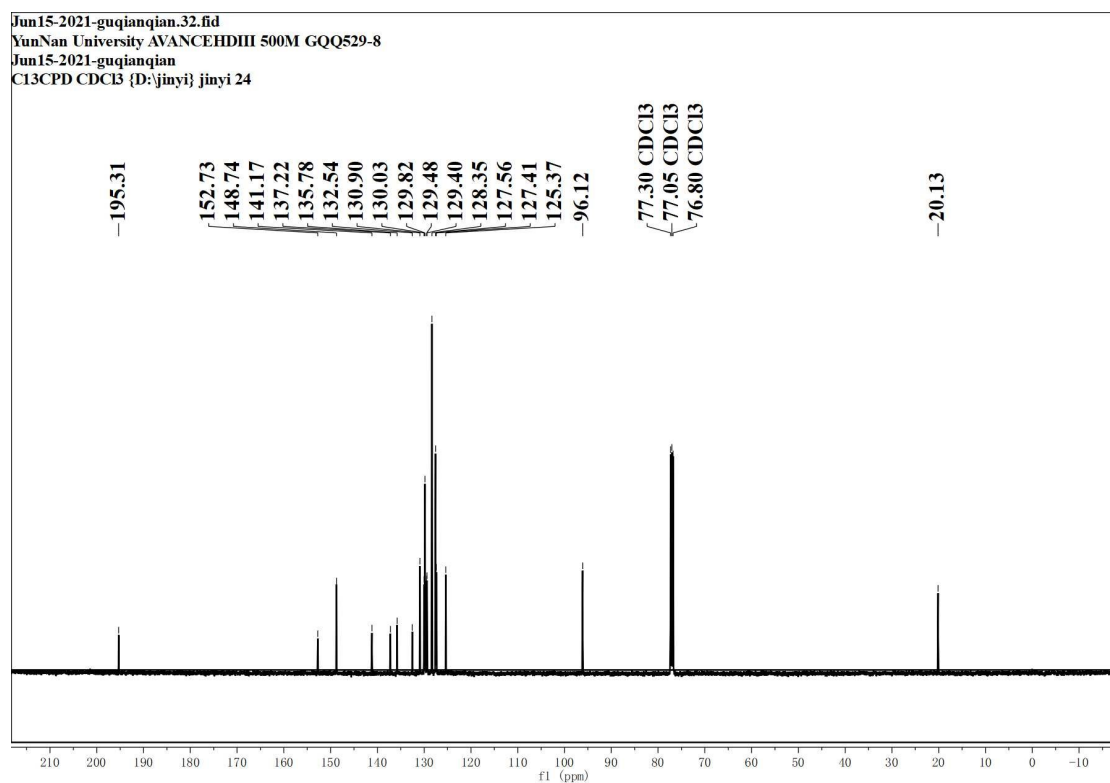
^1H -NMR (400MHz, CDCl_3) spectrum of compound (**3j**)



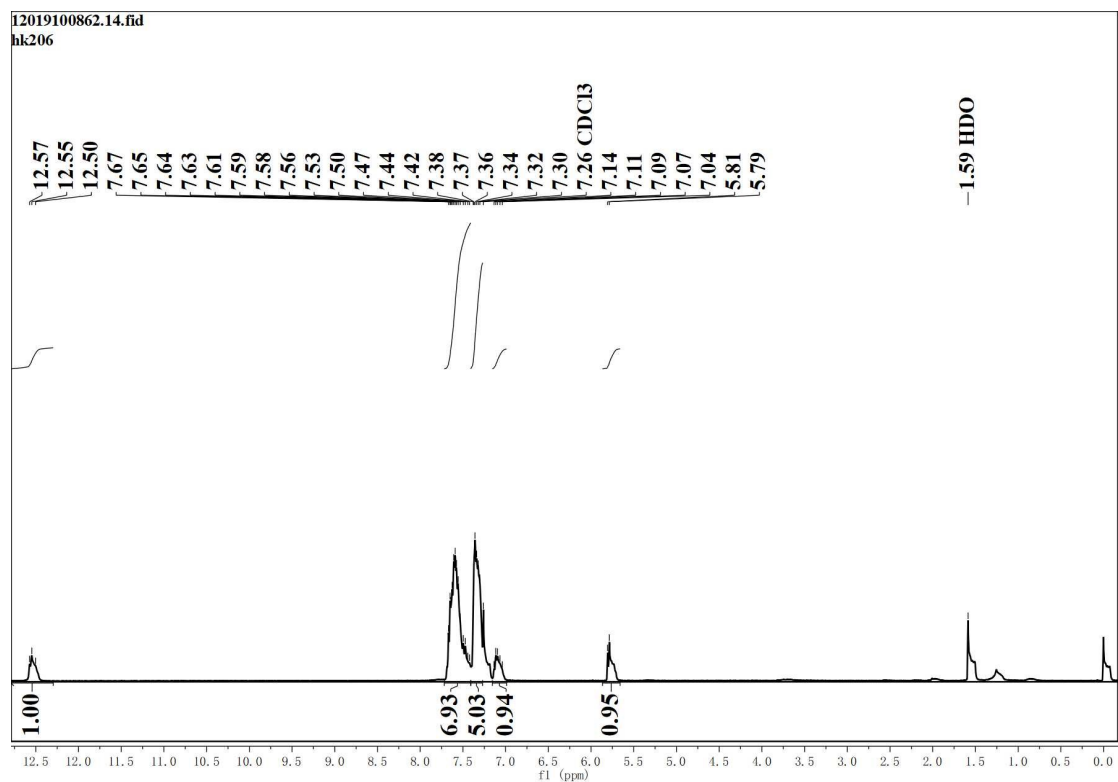
^{13}C -NMR(100MHz, CDCl_3) spectrum of compound (**3j**)



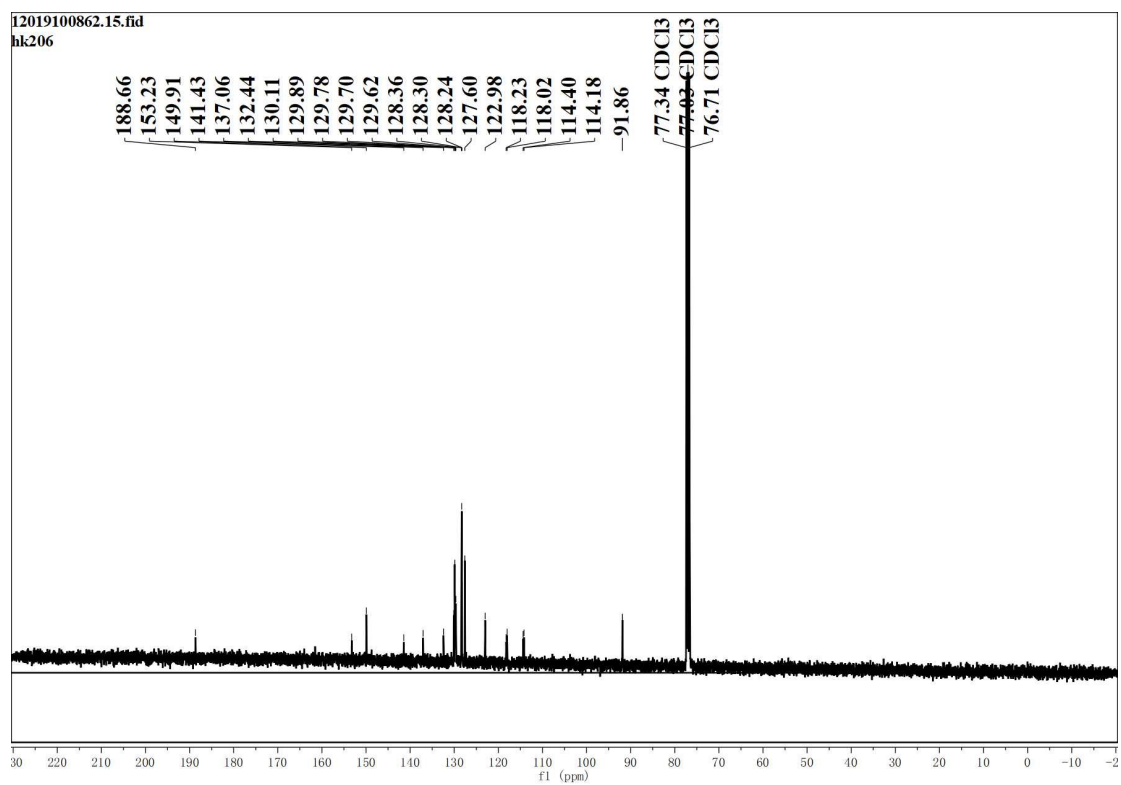
¹H-NMR (500MHz, CDCl₃) spectrum of compound (**3k**)



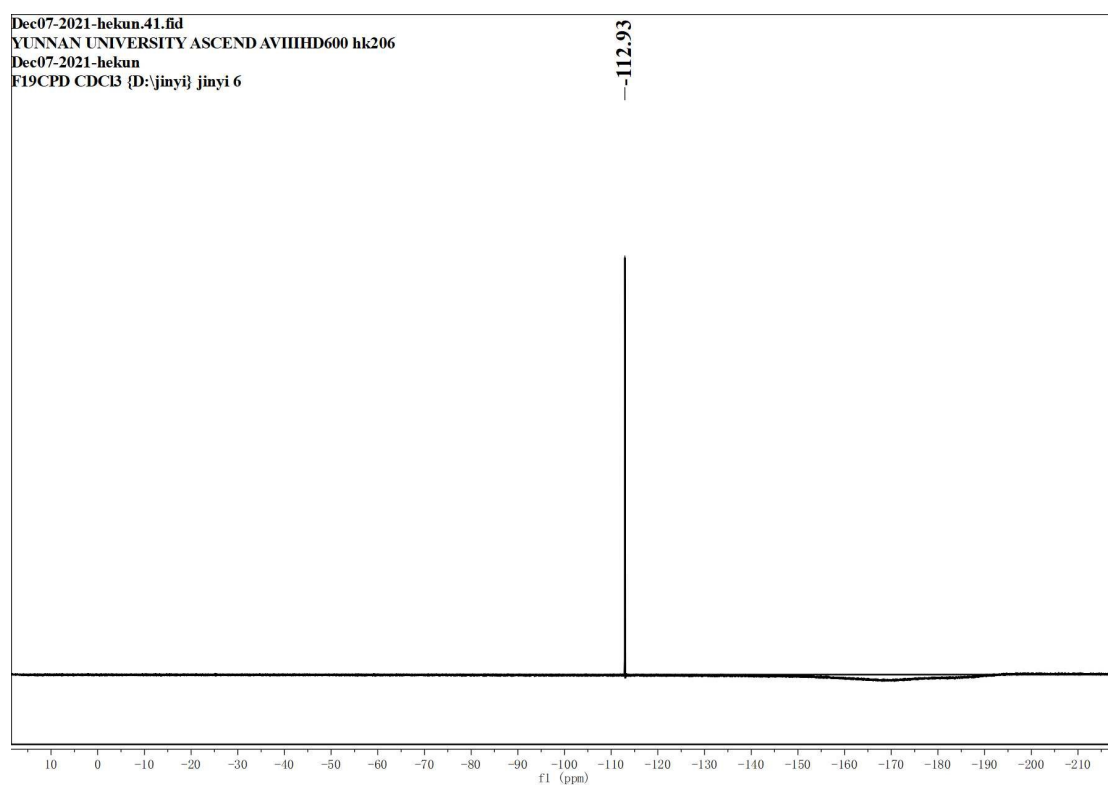
¹³C-NMR(125MHz, CDCl₃) spectrum of compound (**3k**)



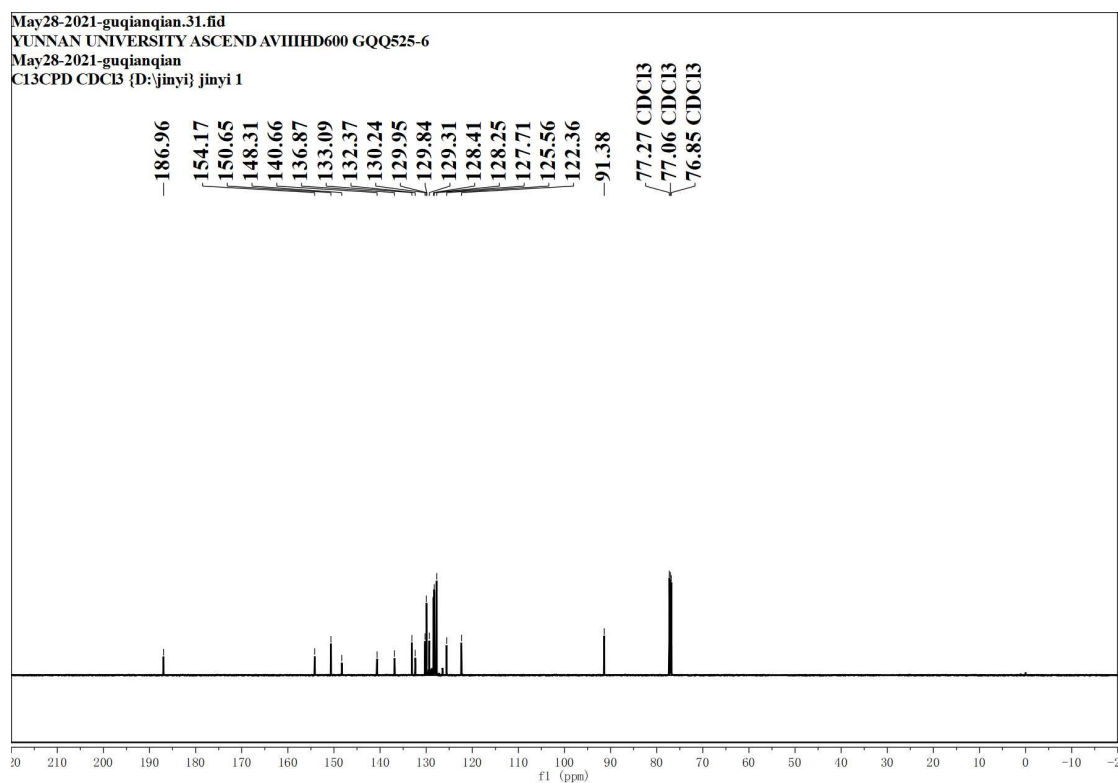
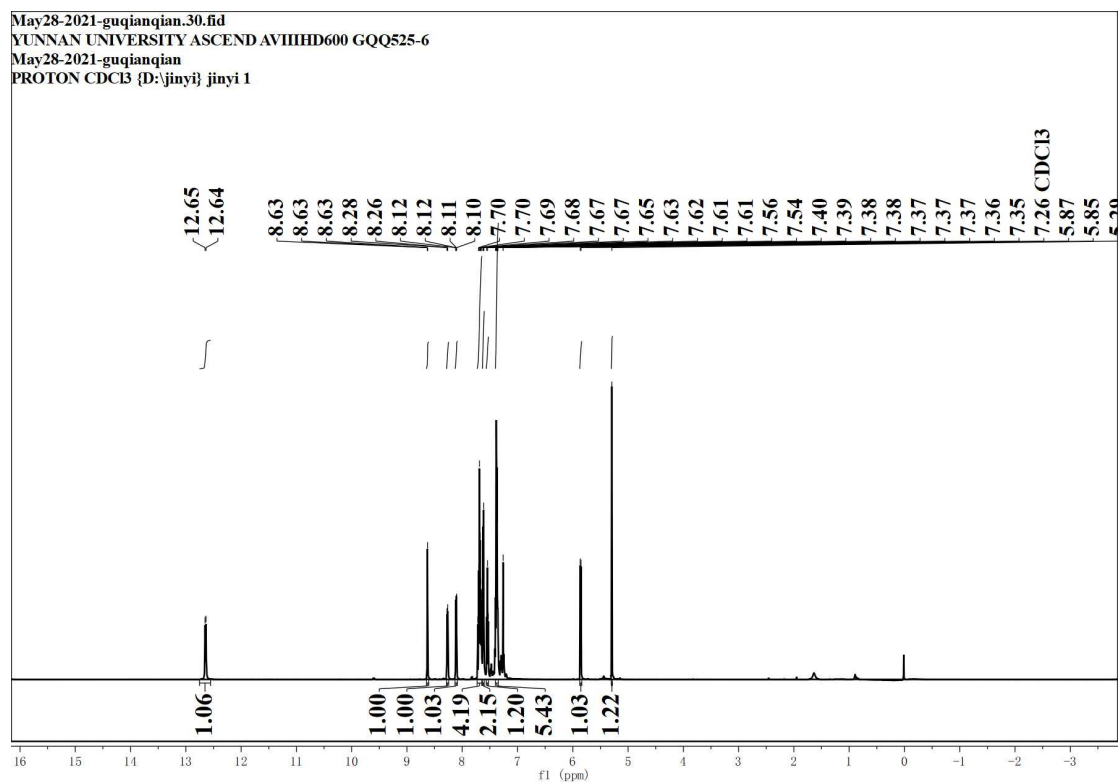
¹H-NMR (400MHz, CDCl₃) spectrum of compound (3I)



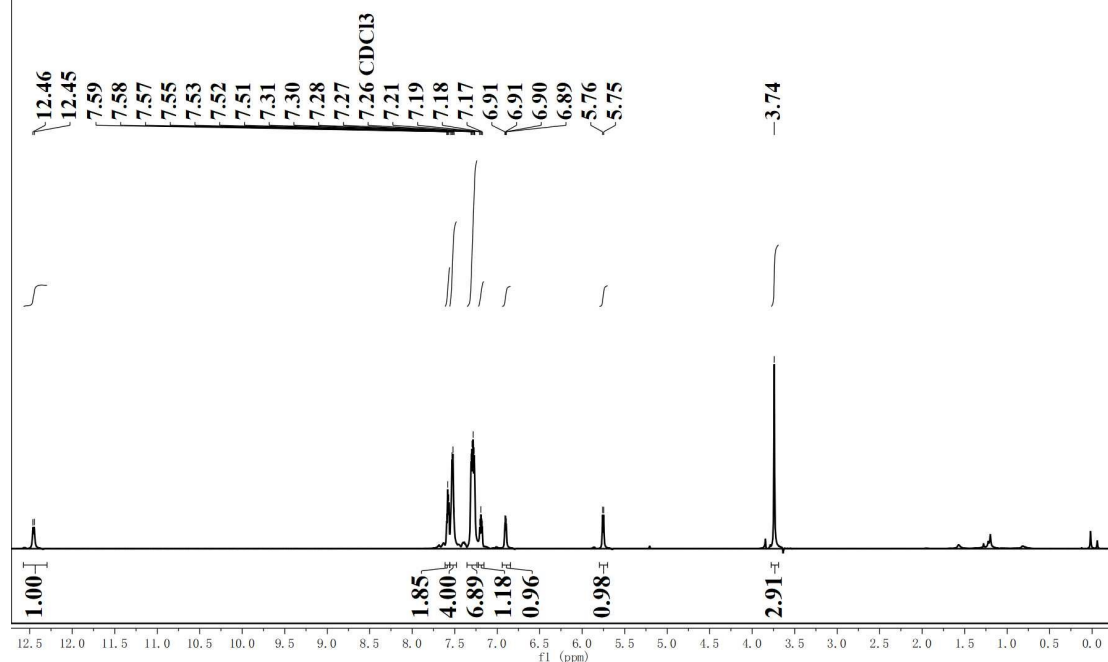
¹³C-NMR(100MHz, CDCl₃) spectrum of compound (3I)



^{19}F -NMR(565MHz, CDCl_3) spectrum of compound **(31)**

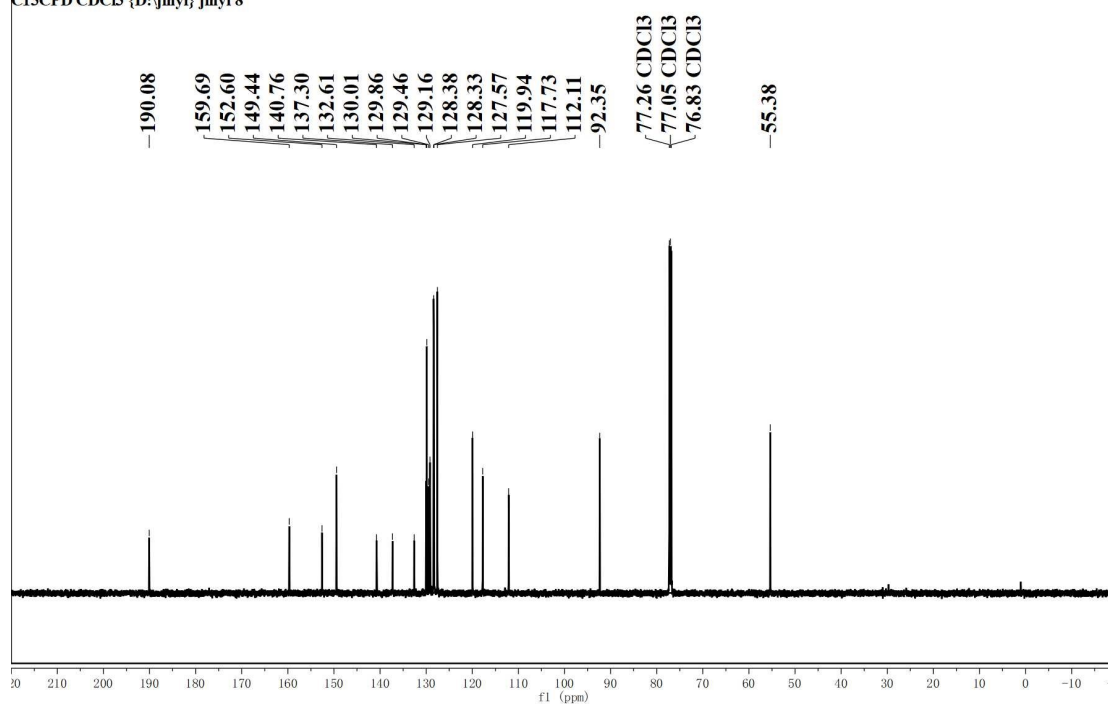


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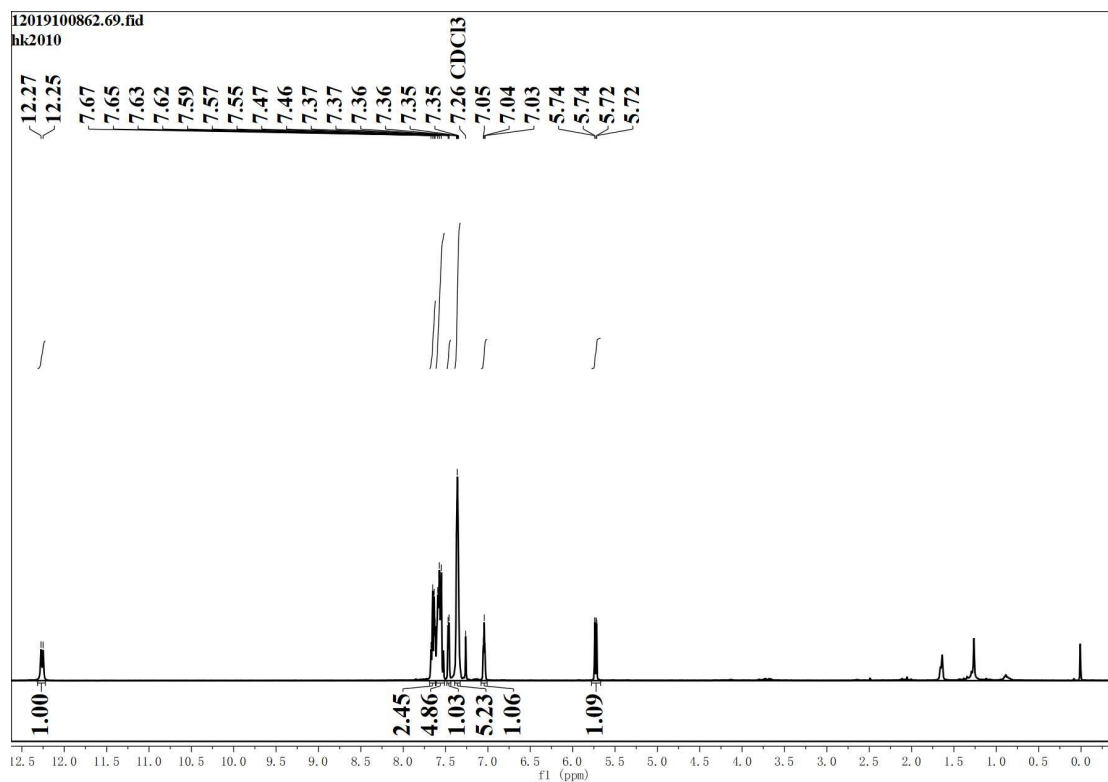


¹H-NMR (600MHz, CDCl₃) spectrum of compound (3n)

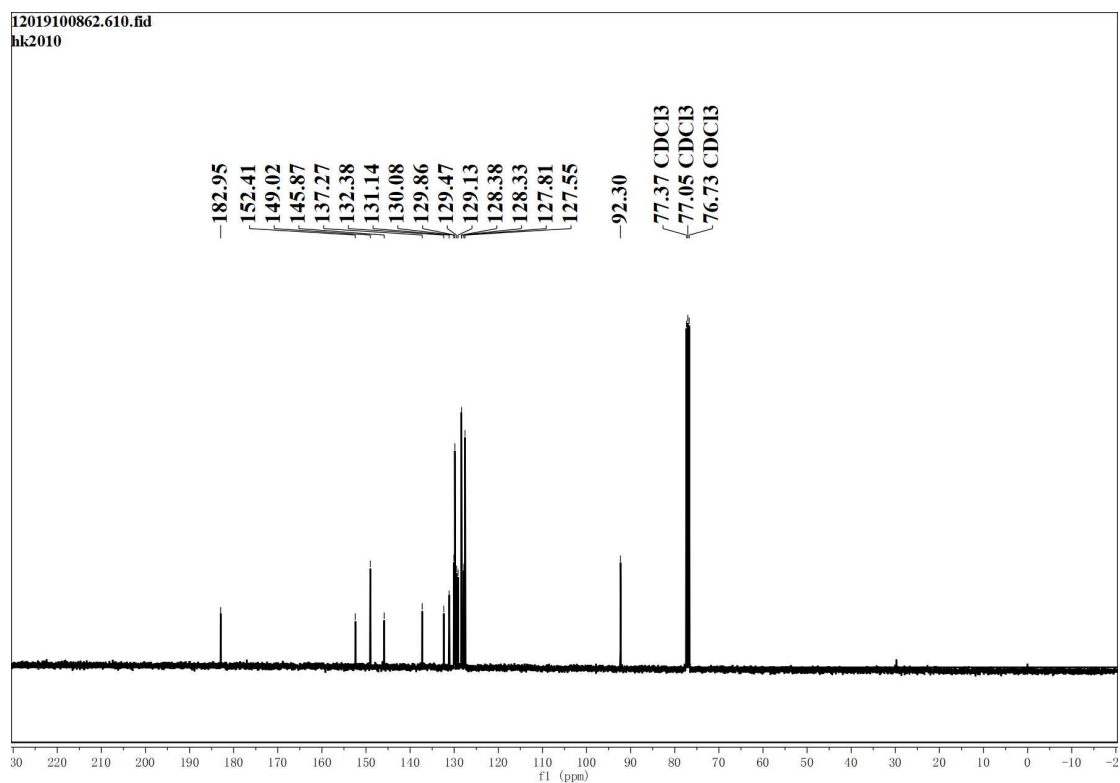
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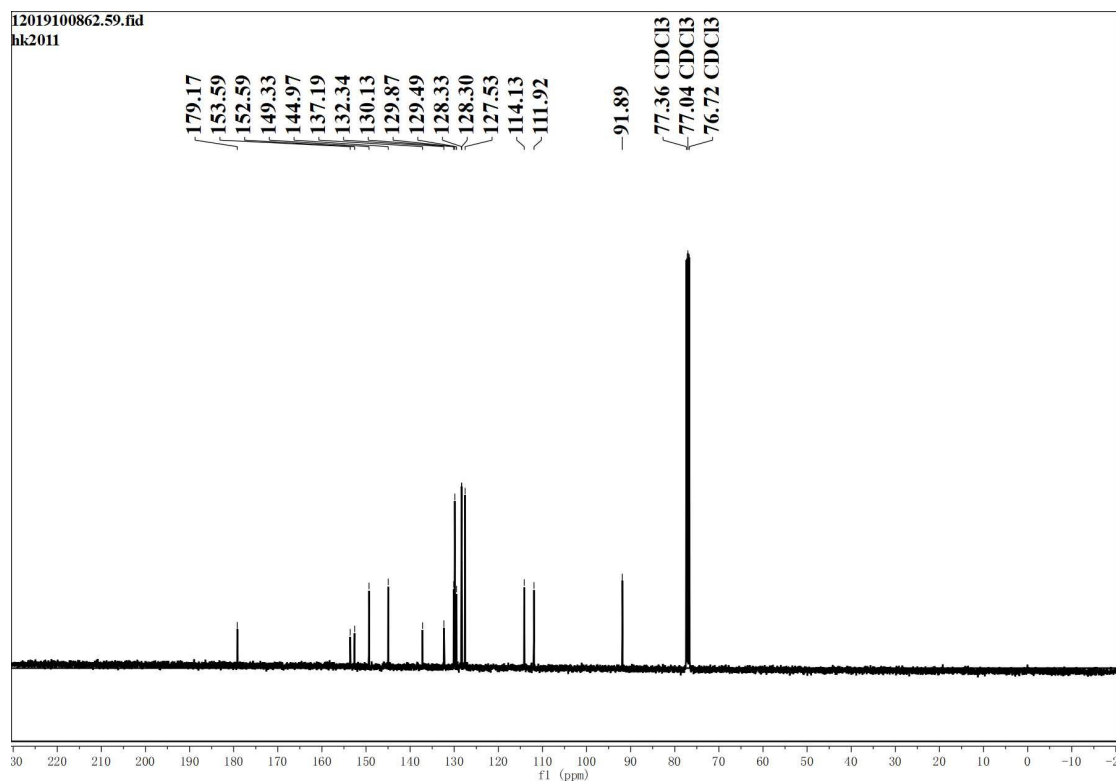
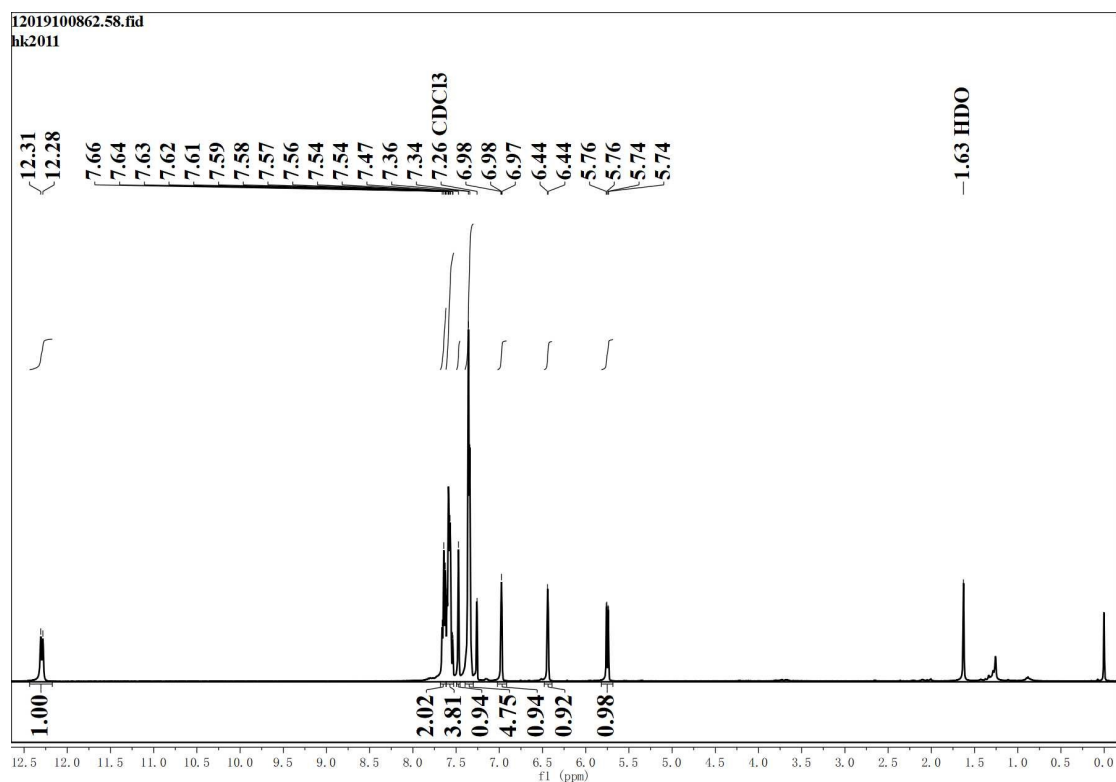
¹³C-NMR(150MHz, CDCl₃) spectrum of compound (3n)

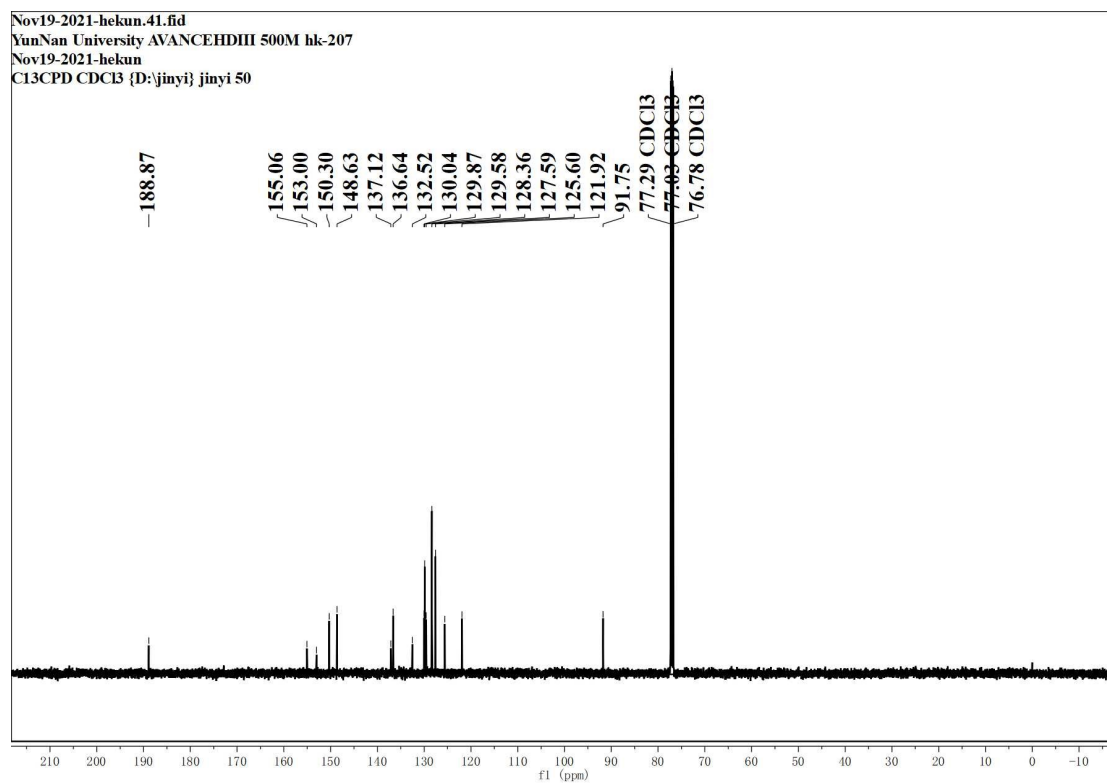
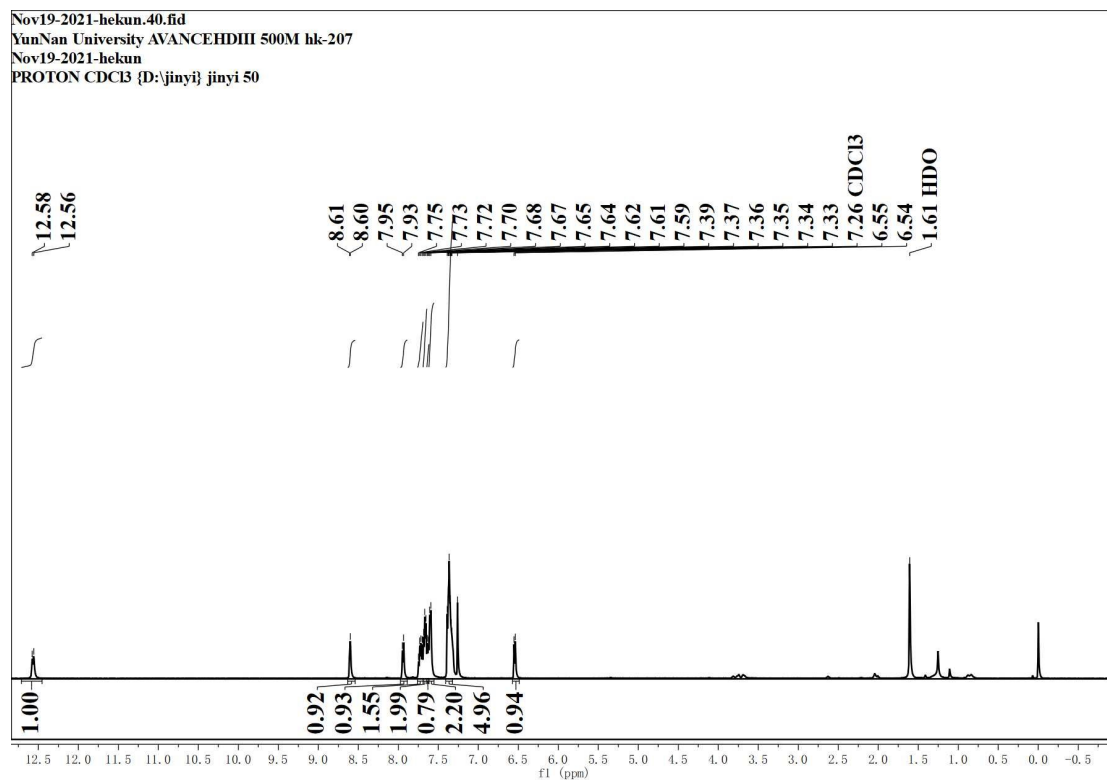


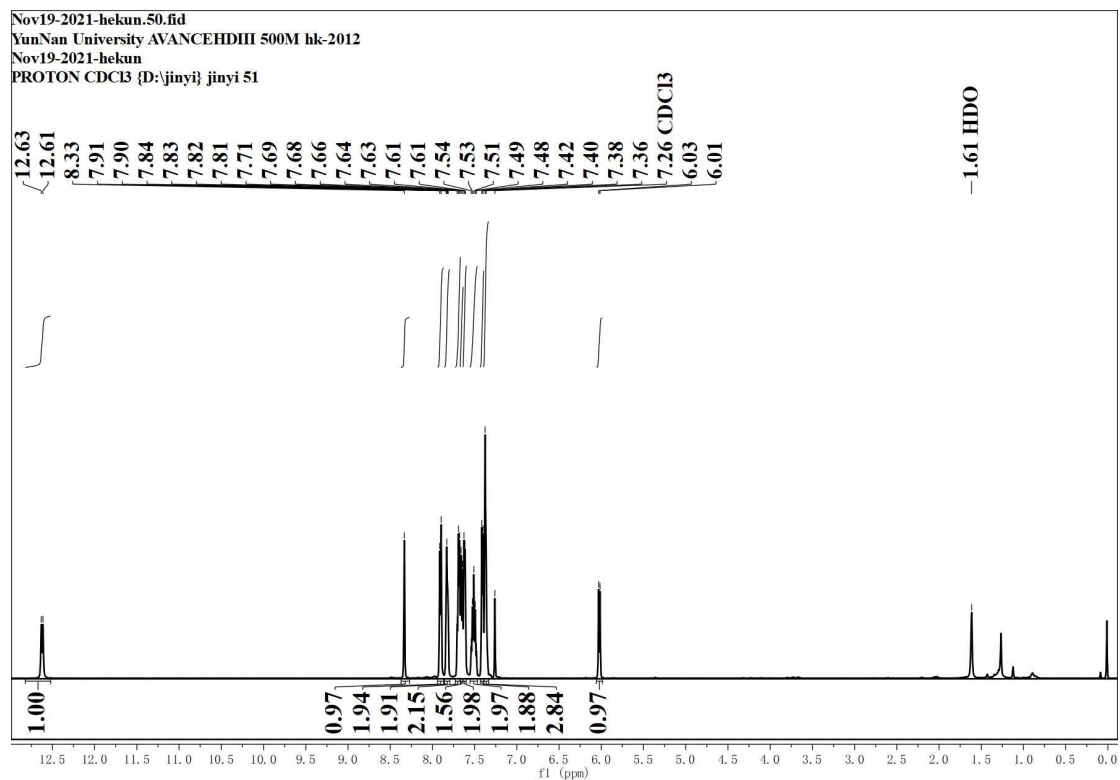
¹H-NMR (400MHz, CDCl₃) spectrum of compound (**30**)



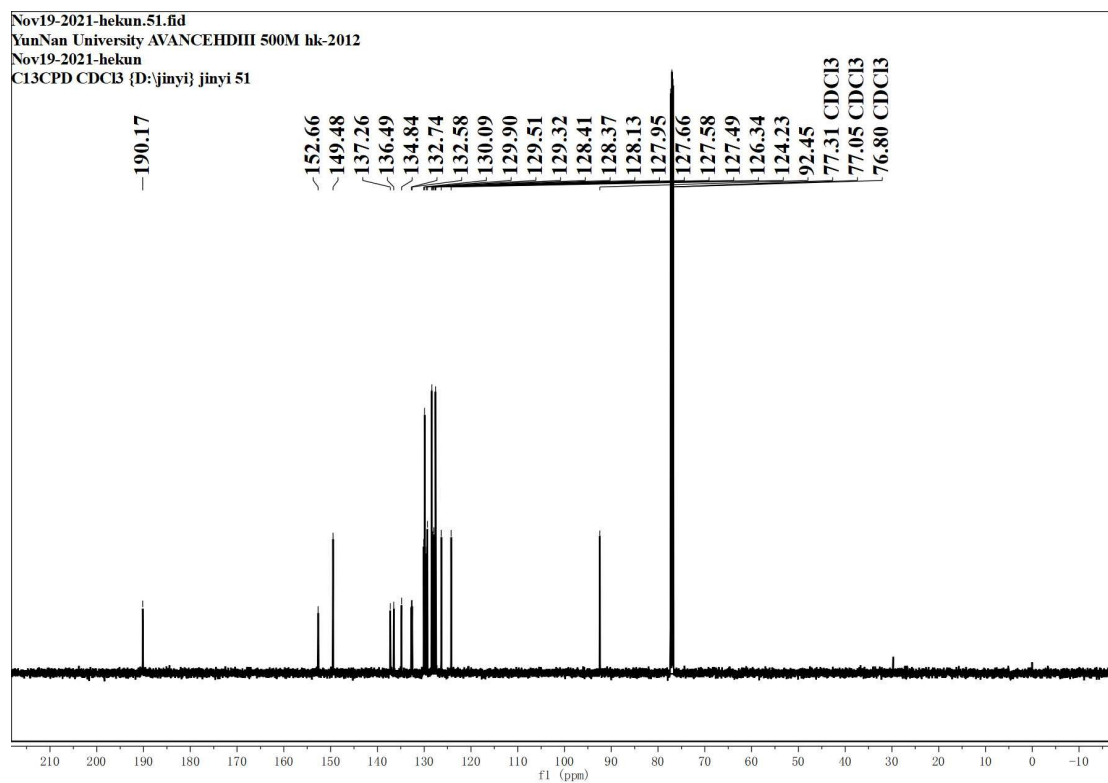
¹³C-NMR(100MHz, CDCl₃) spectrum of compound (**30**)



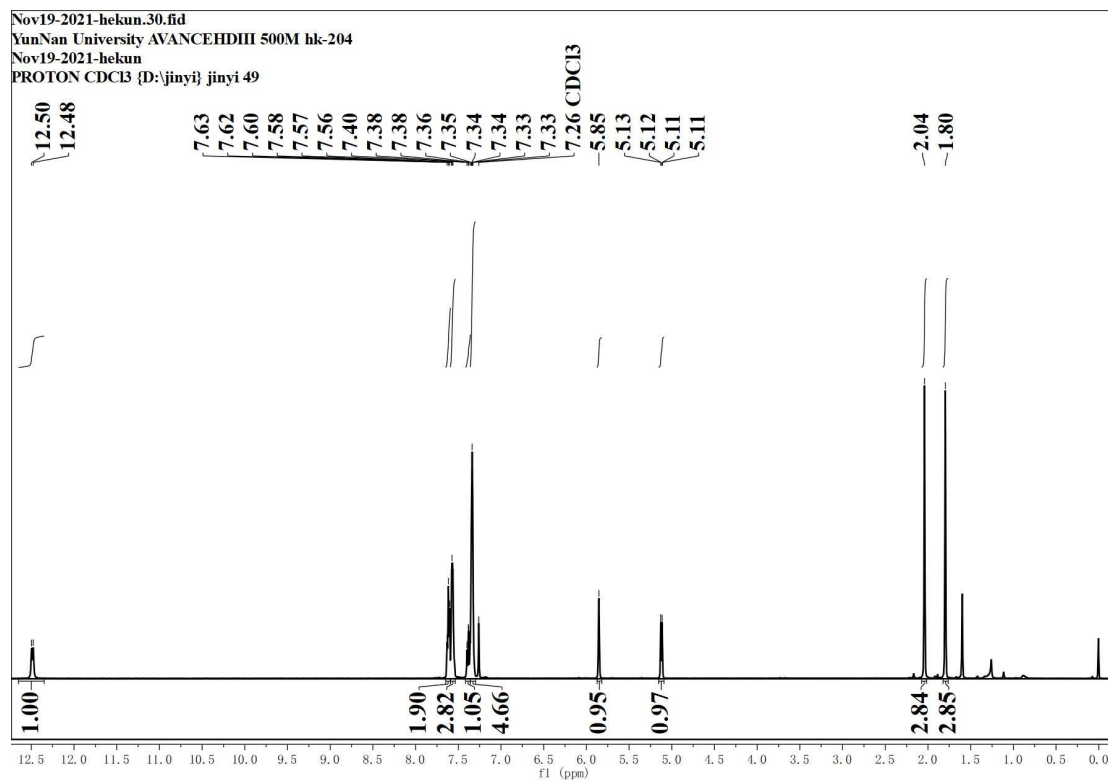




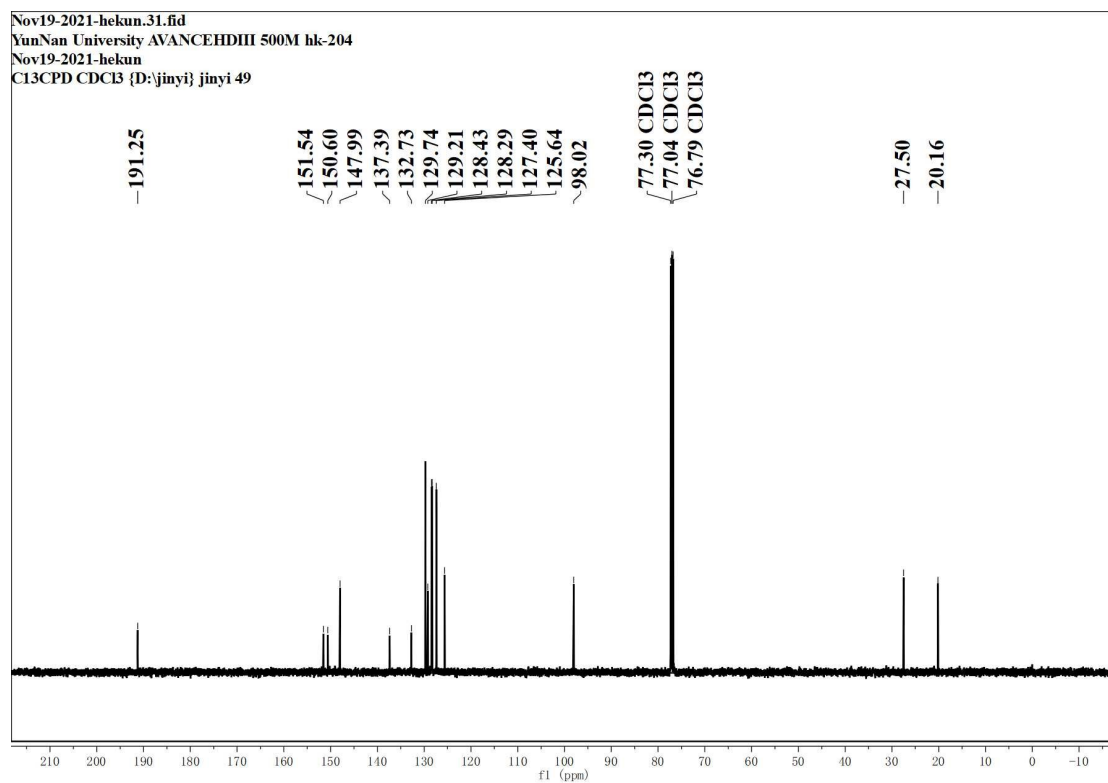
^1H -NMR (500MHz, CDCl_3) spectrum of compound (**3r**)



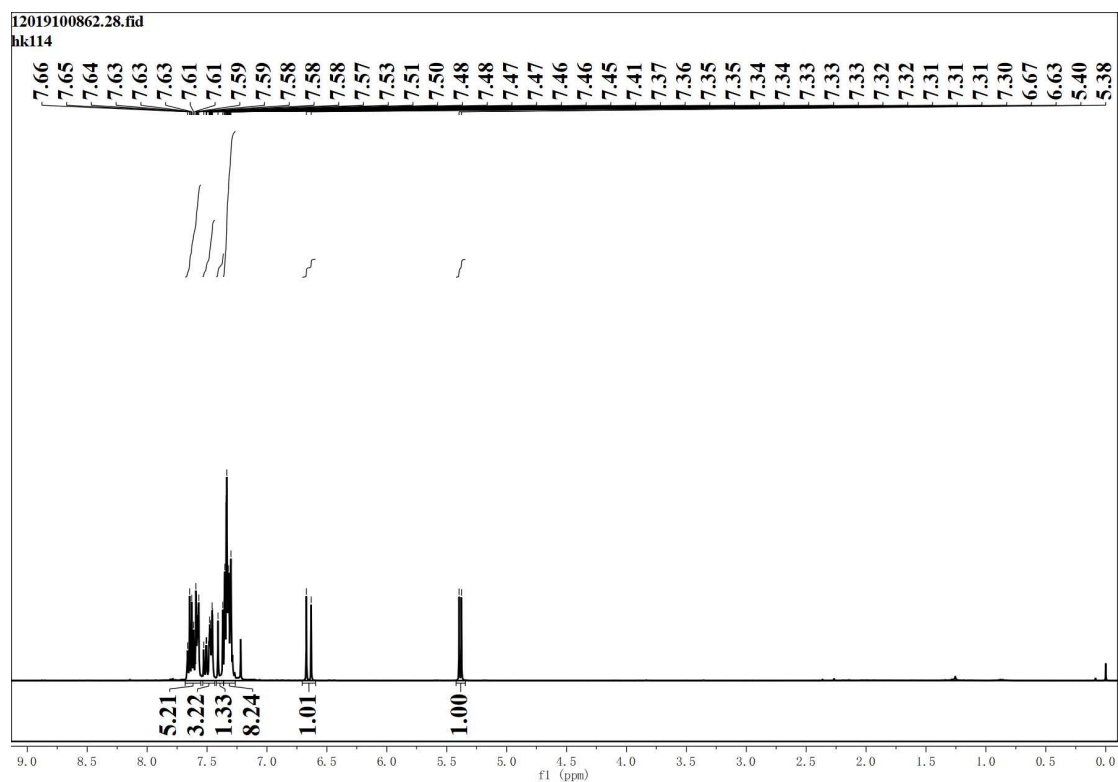
^{13}C -NMR(125MHz, CDCl_3) spectrum of compound (**3r**)



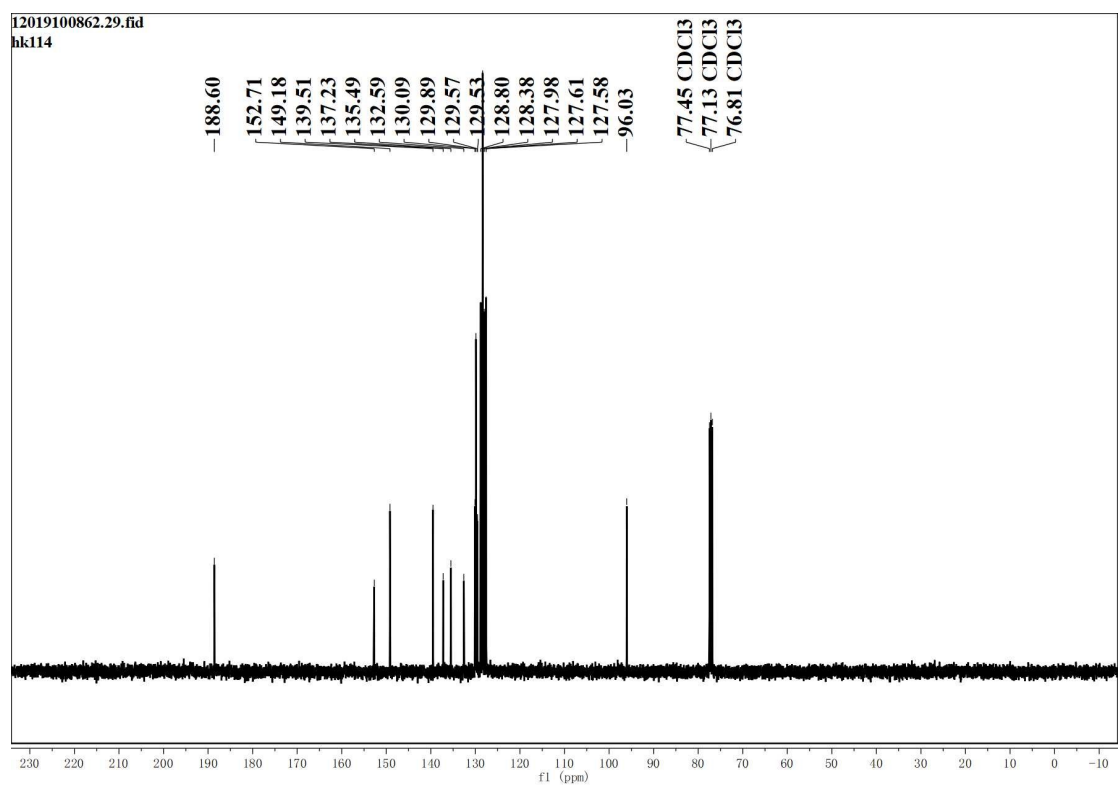
^1H -NMR (500MHz, CDCl_3) spectrum of compound (**3s**)



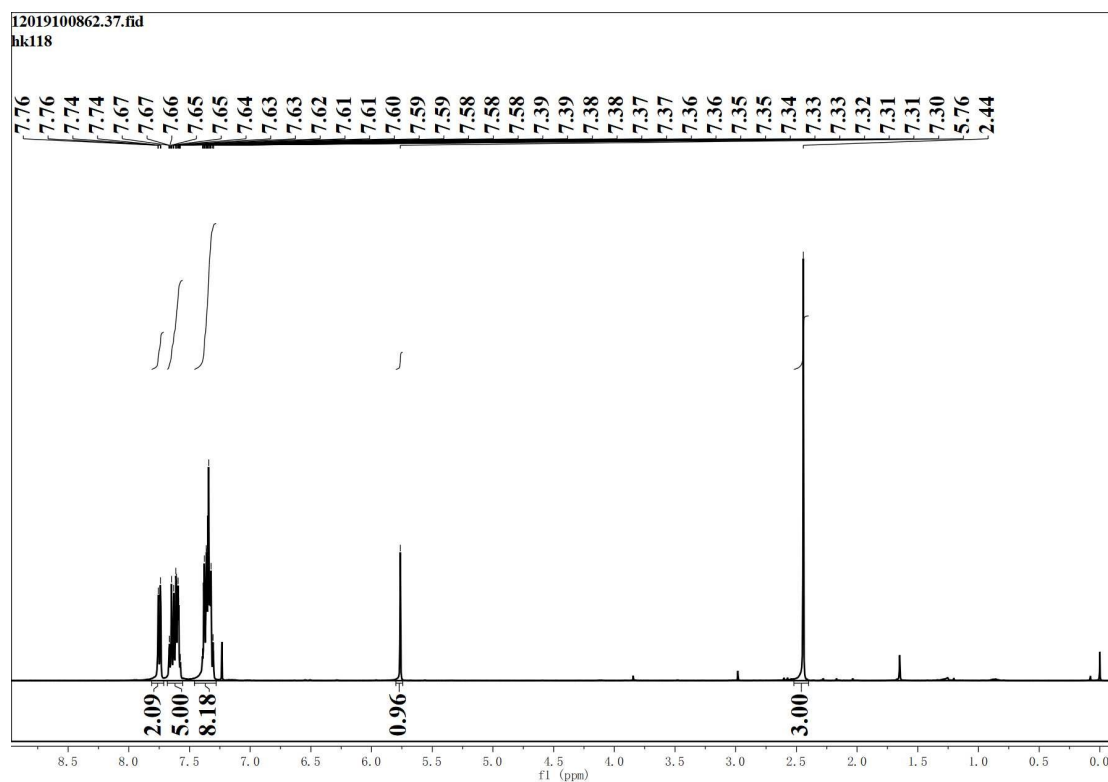
^{13}C -NMR(125MHz, CDCl_3) spectrum of compound (**3s**)



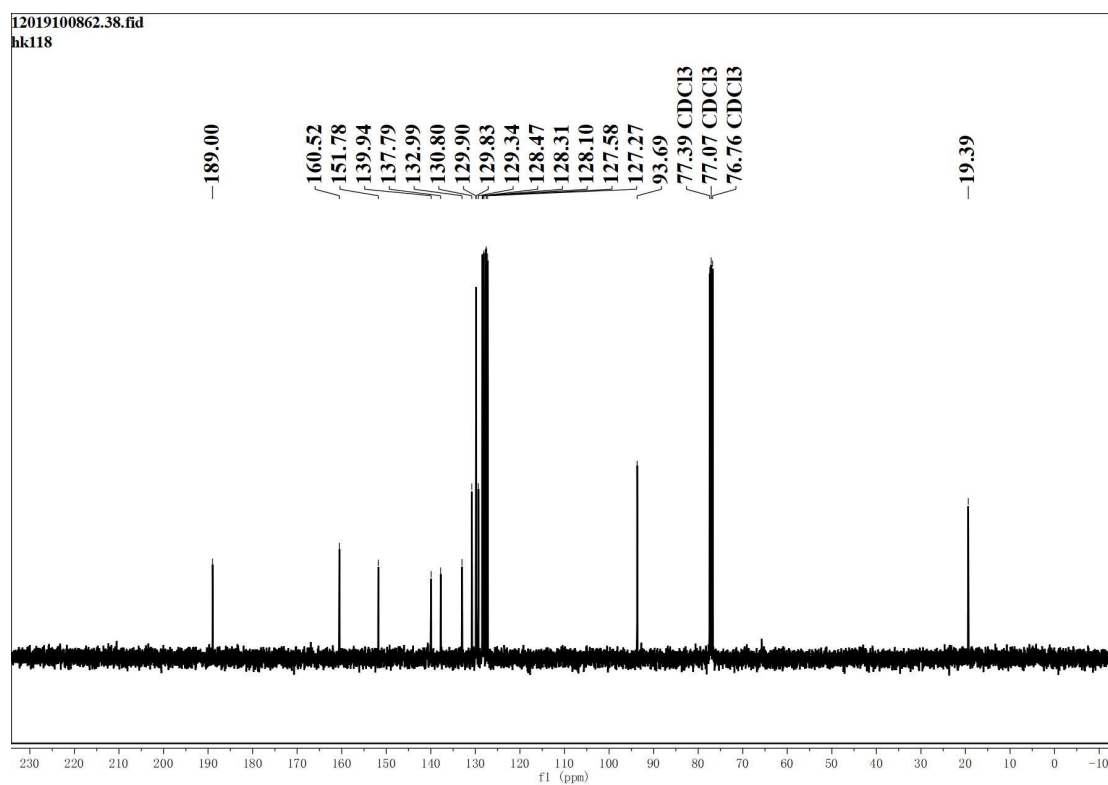
^1H -NMR (600MHz, CDCl_3) spectrum of compound (**3t**)



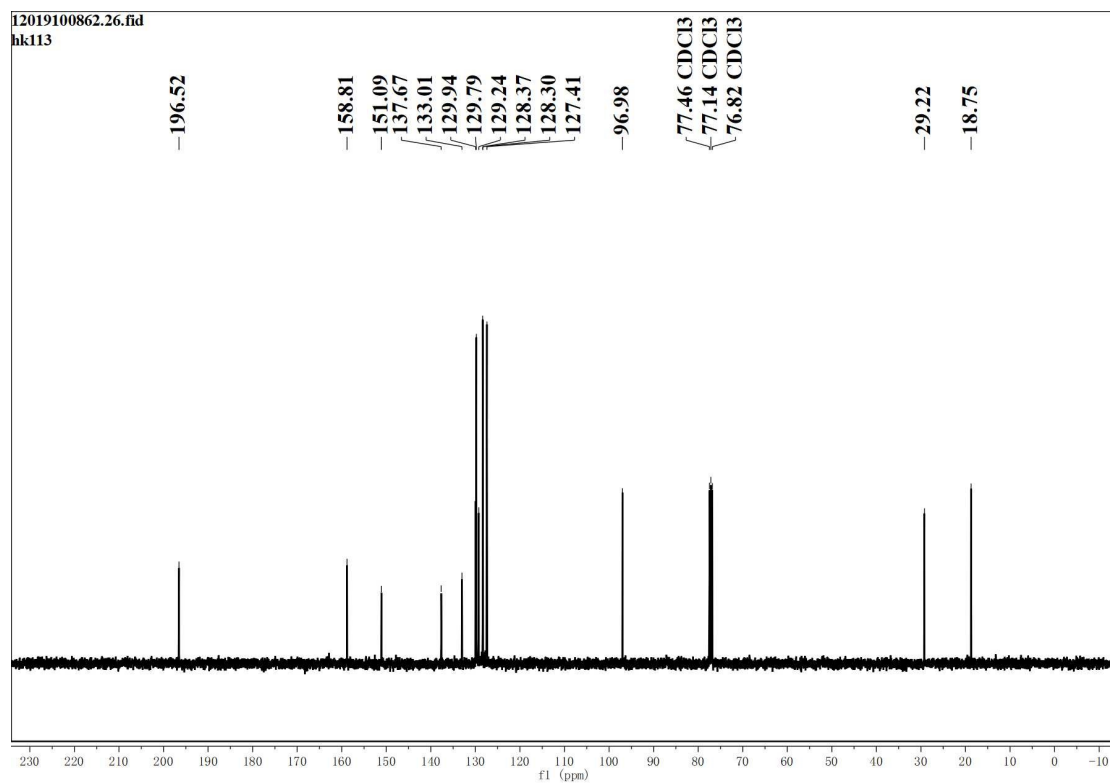
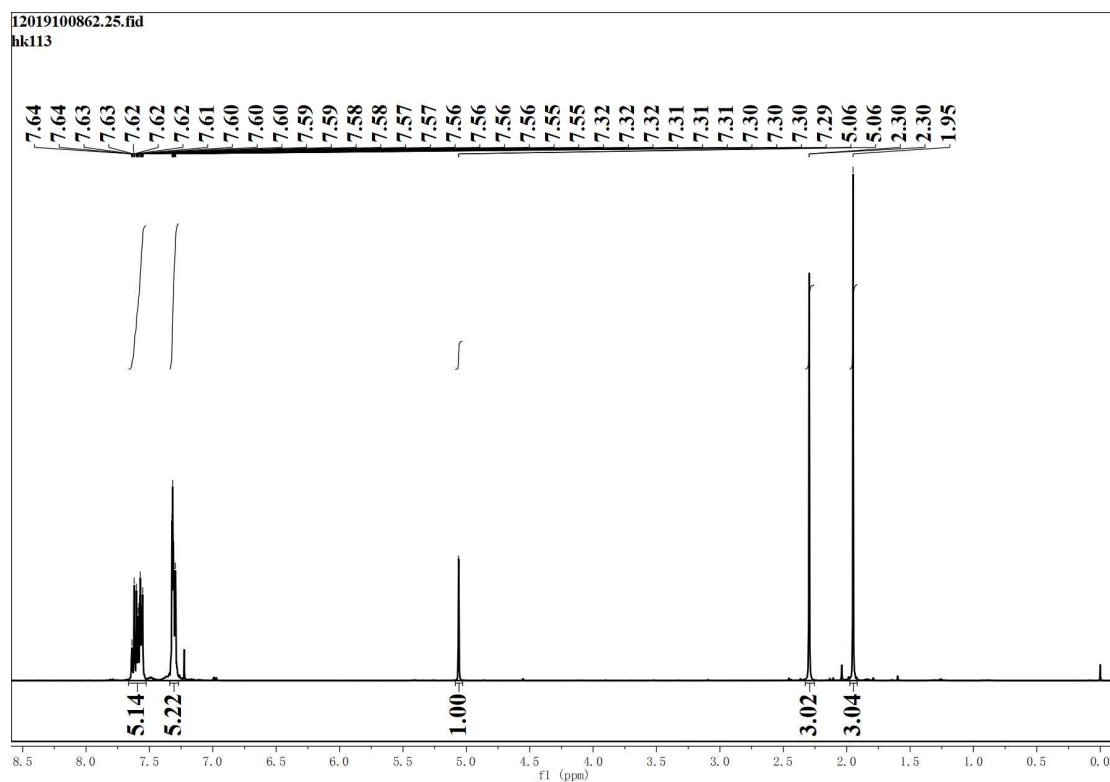
^{13}C -NMR(150MHz, CDCl_3) spectrum of compound (**3t**)

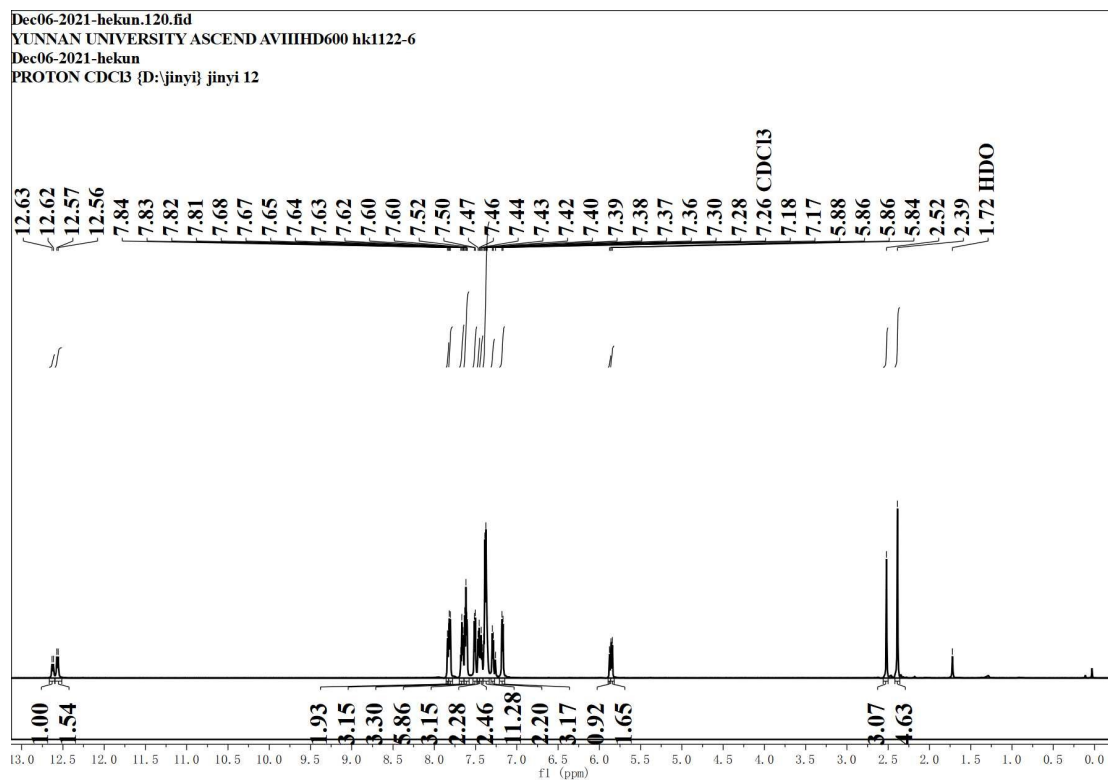


^1H -NMR (400MHz, CDCl_3) spectrum of compound (**3u**)

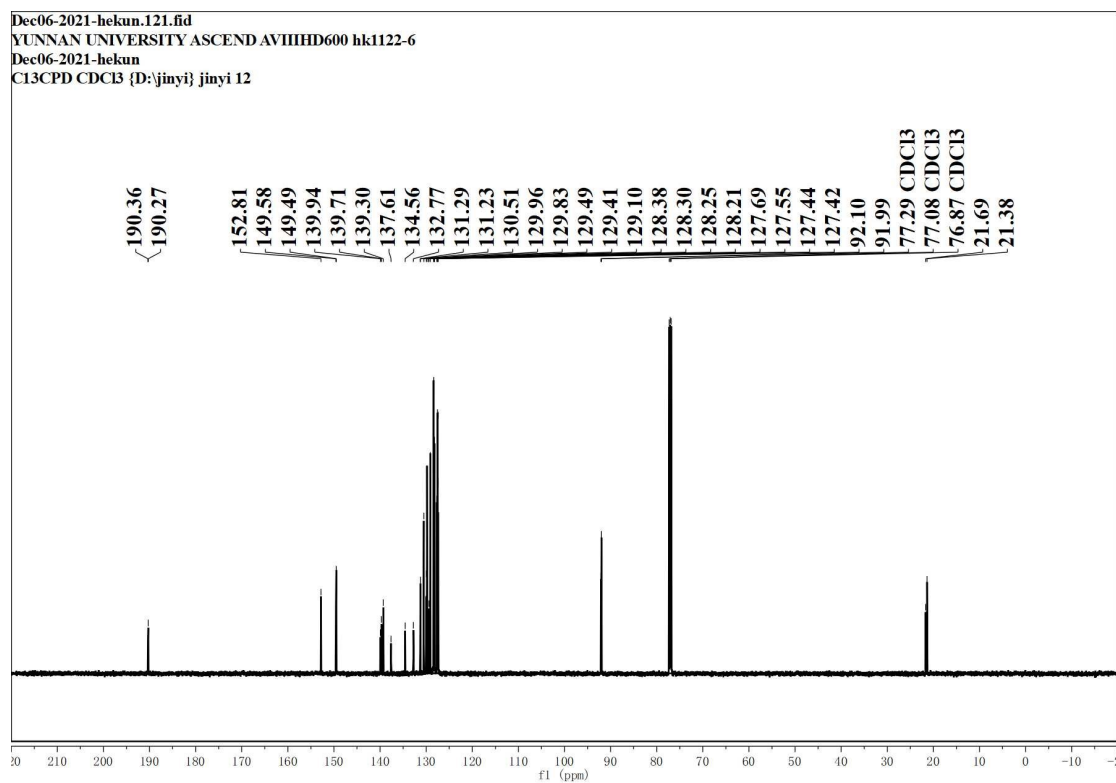


^{13}C -NMR(100MHz, CDCl_3) spectrum of compound (**3u**)

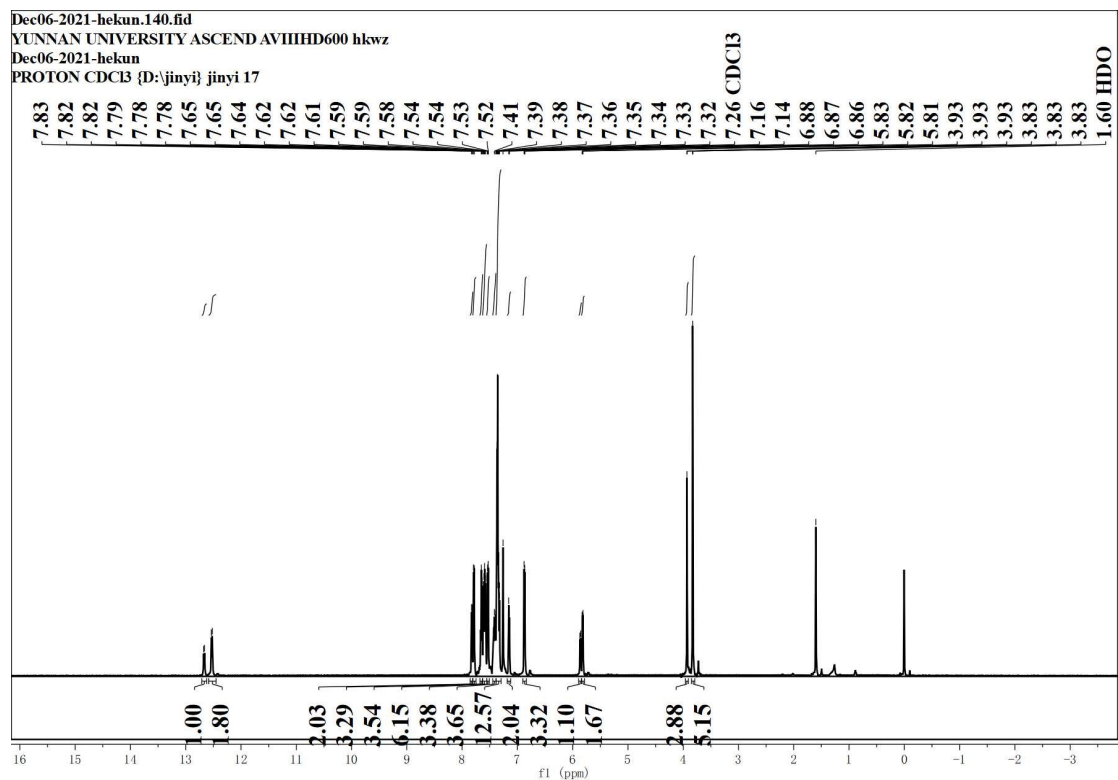




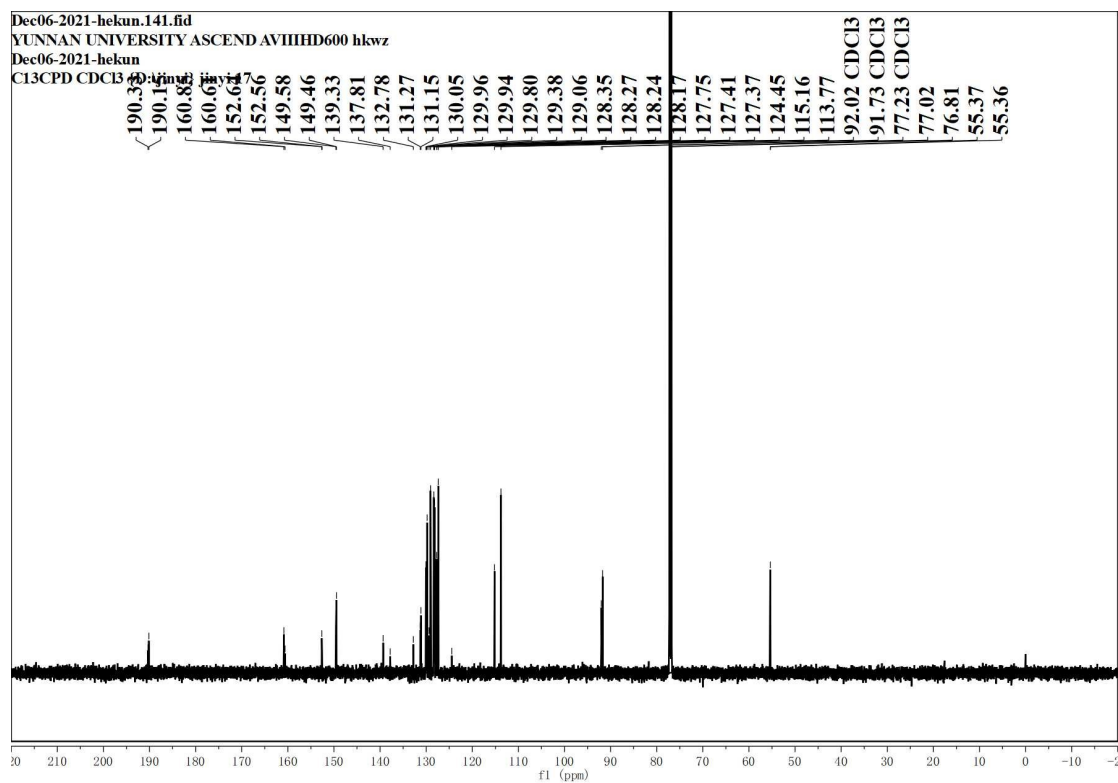
¹H-NMR (600MHz, CDCl₃) spectrum of compound (**4b** - *Z* + *E*)



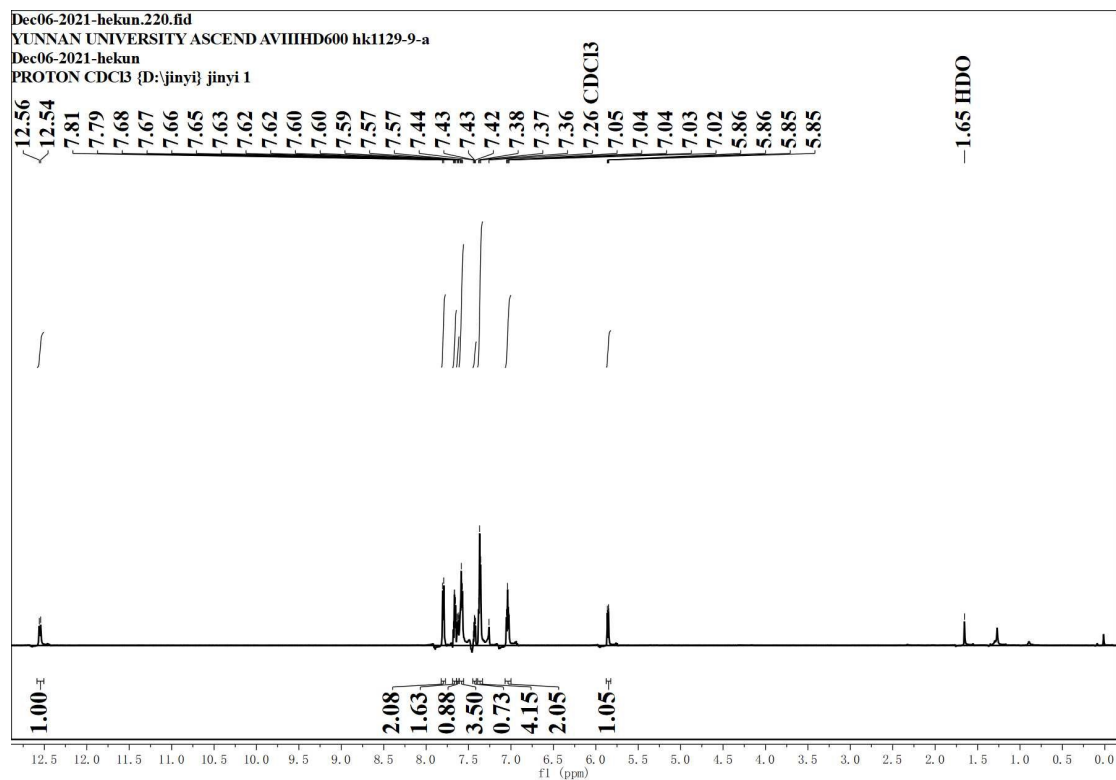
¹³C-NMR(150MHz, CDCl₃) spectrum of compound (**4b**- *Z* + *E*)



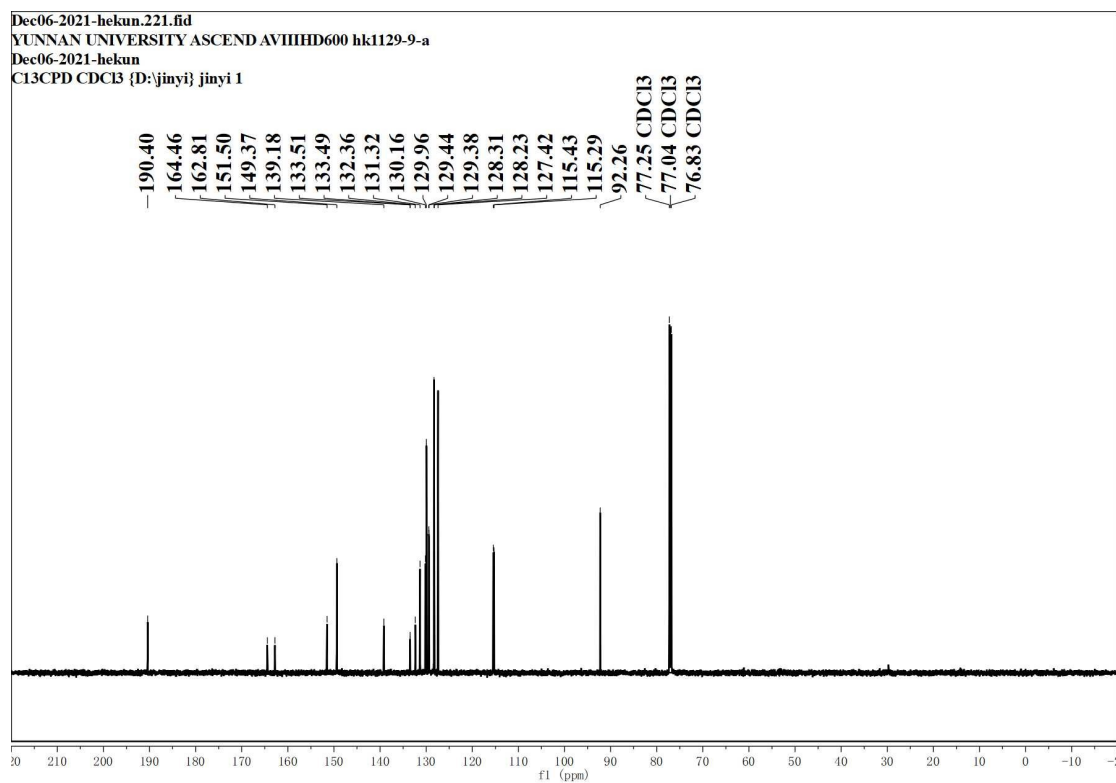
¹H-NMR (600MHz, CDCl₃) spectrum of compound (**4c - Z + E**)



¹³C-NMR(150MHz, CDCl₃) spectrum of compound (**4c - Z + E**)

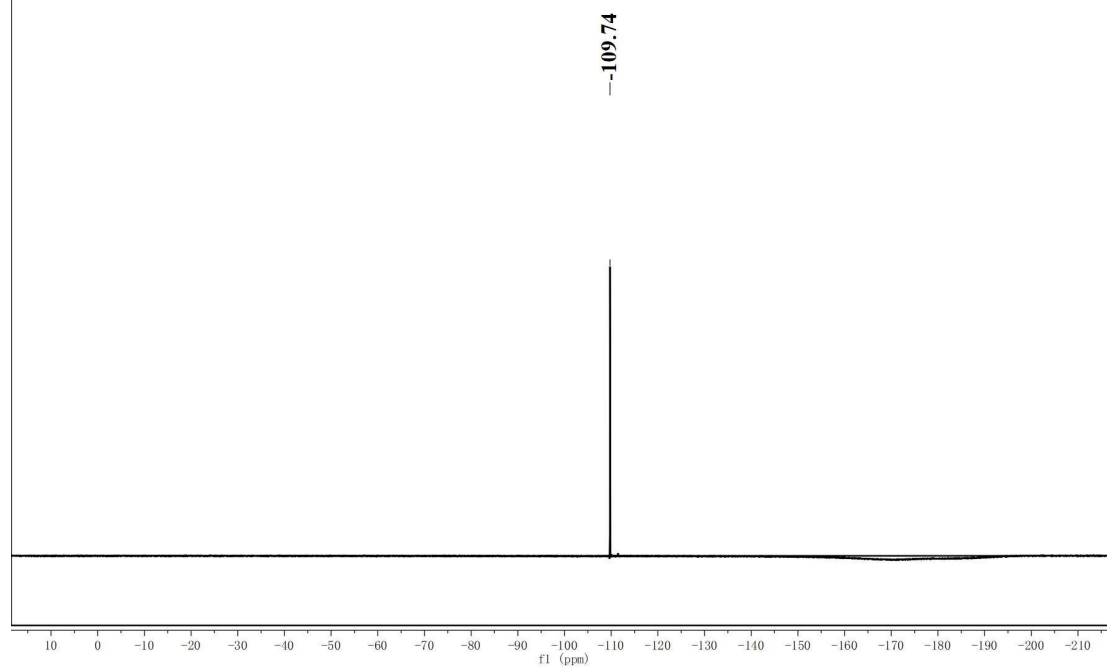


¹H-NMR (600MHz, CDCl₃) spectrum of compound (**4d - E**)

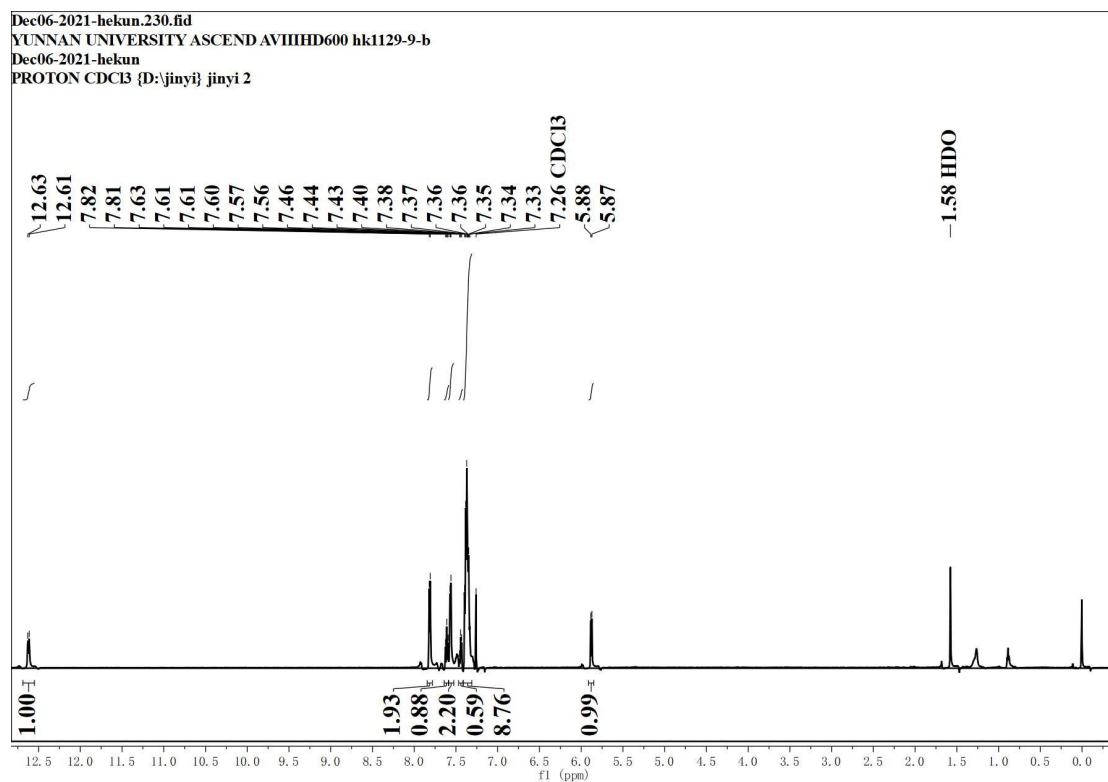


¹³C-NMR(150MHz, CDCl₃) spectrum of compound (**4d - E**)

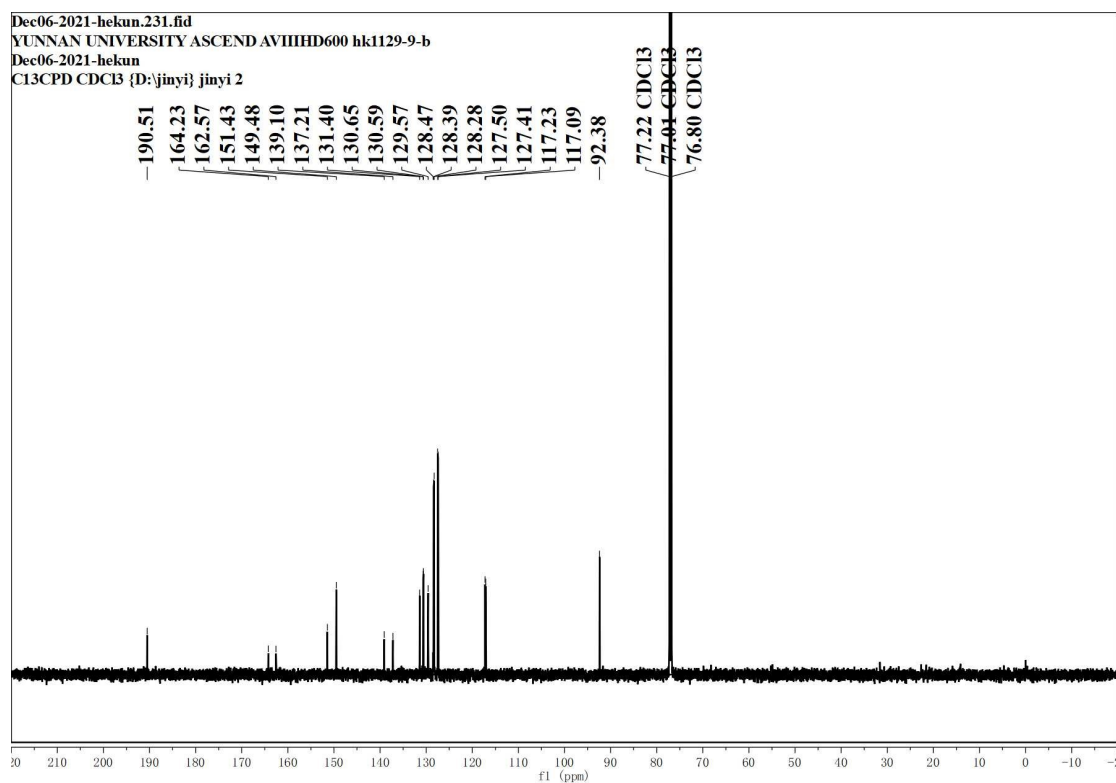
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YUNNAN UNIVERSITY ASCEND AVIIIHD600 hk1129-9-a
Dec07-2021-hekun
F19CPD CDCl3 {D:\jinyi\} jinyi.10



^{19}F -NMR(565MHz, CDCl_3) spectrum of compound (**4d - E**)

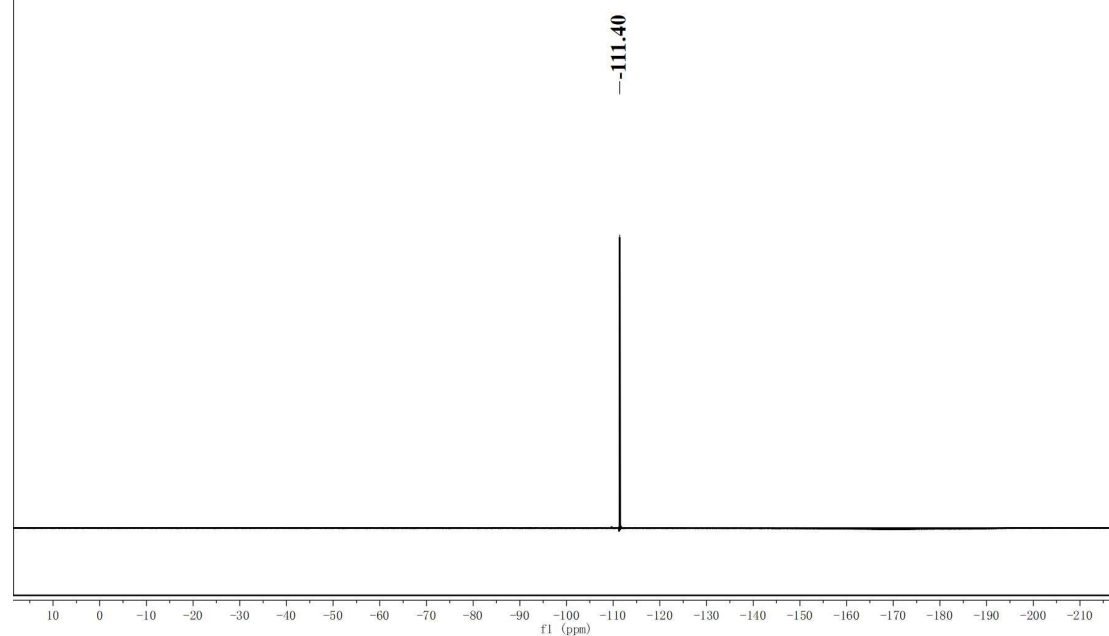


¹H-NMR (600MHz, CDCl₃) spectrum of compound (**4d - Z**)

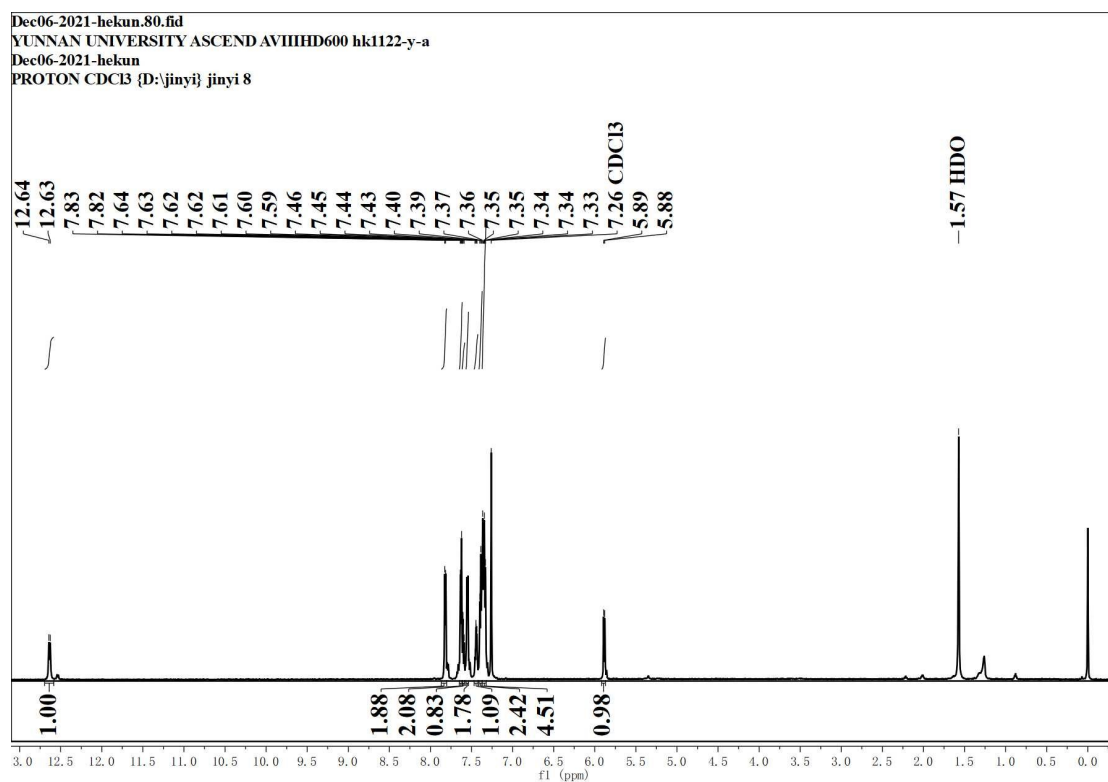


¹³C-NMR(150MHz, CDCl₃) spectrum of compound (**4d - Z**)

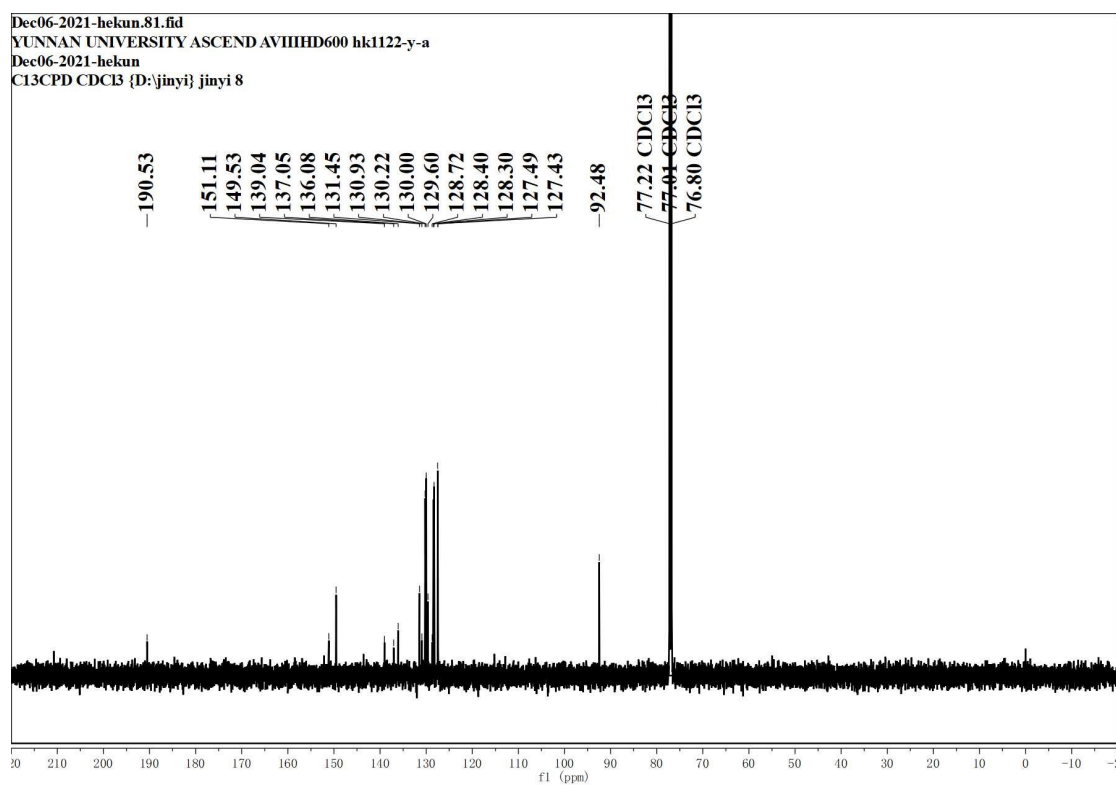
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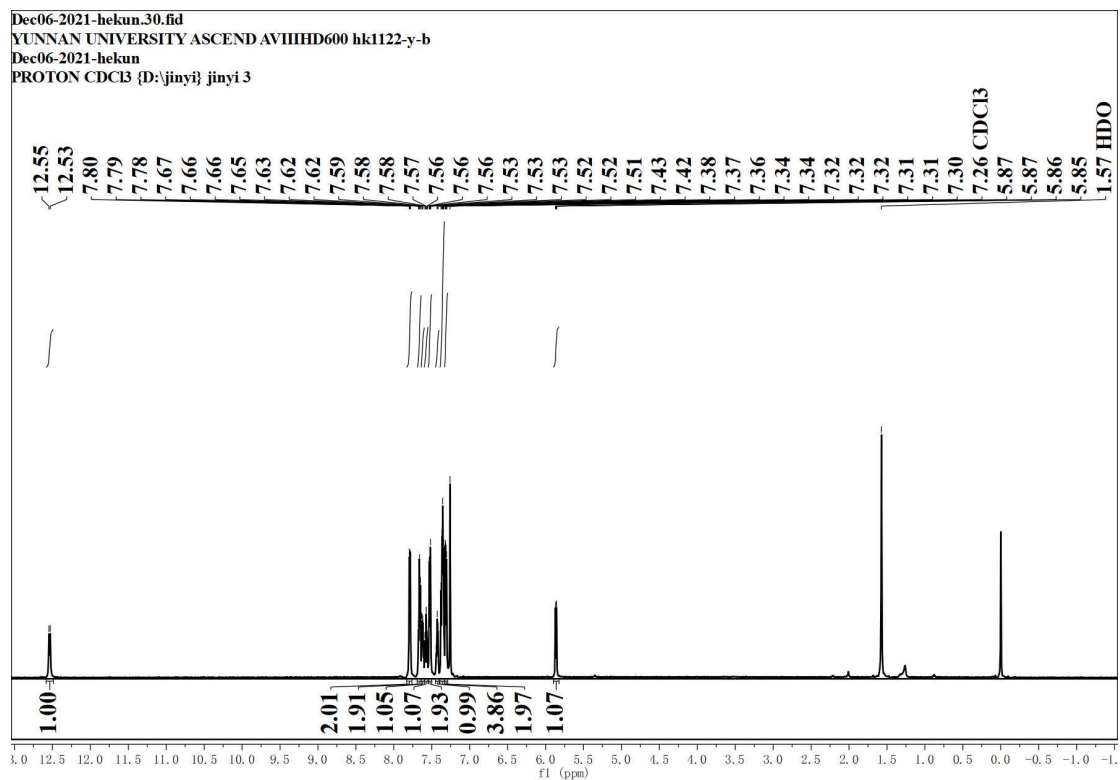
^{19}F -NMR(565MHz, CDCl_3) spectrum of compound (**4d - Z**)



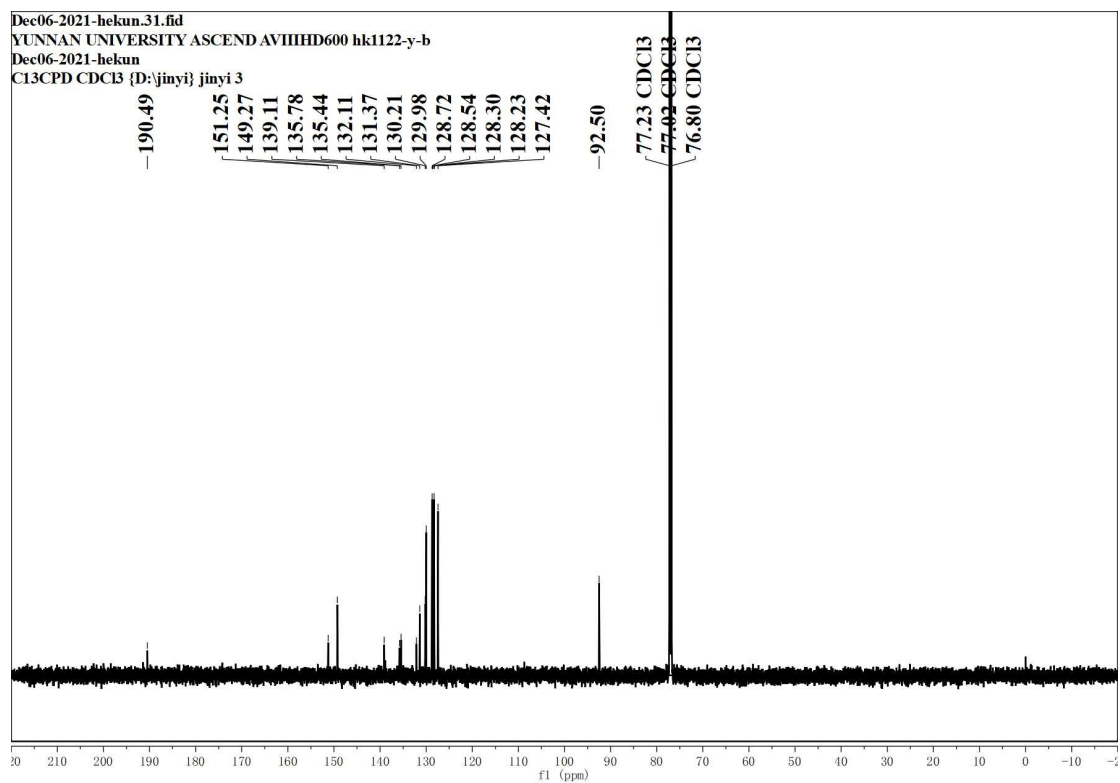
¹H-NMR (600MHz, CDCl₃) spectrum of compound (**4e - E**)



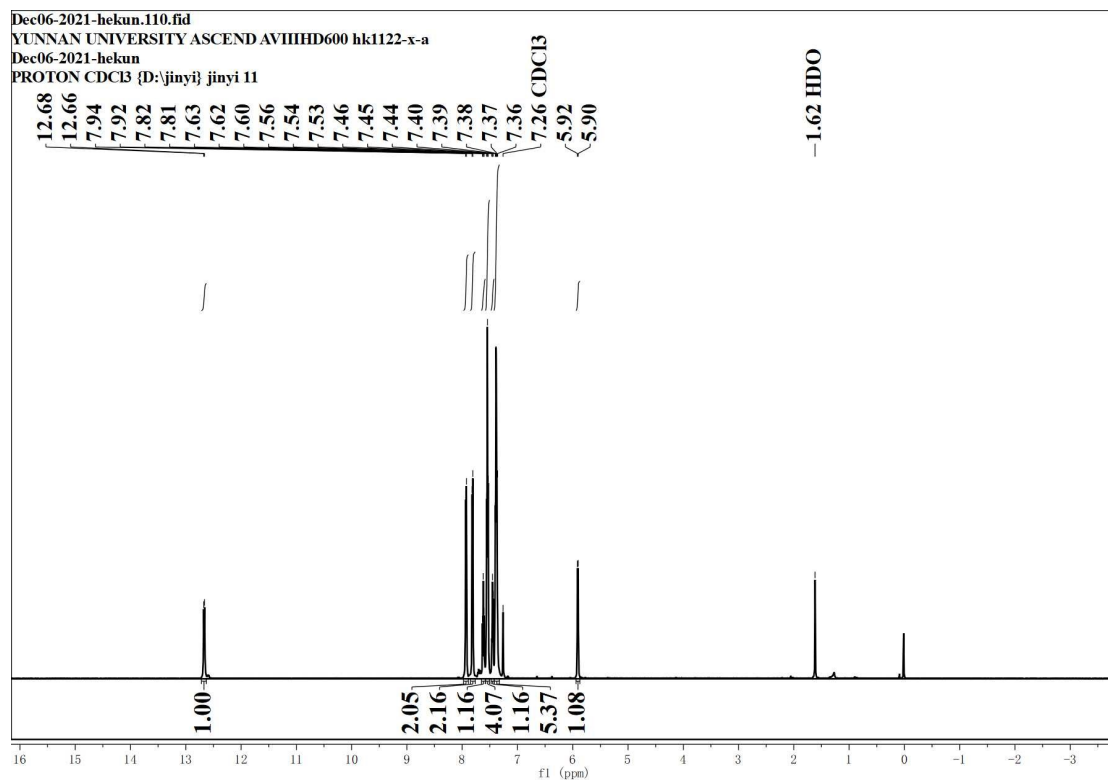
¹³C-NMR(150MHz, CDCl₃) spectrum of compound (**4e - E**)



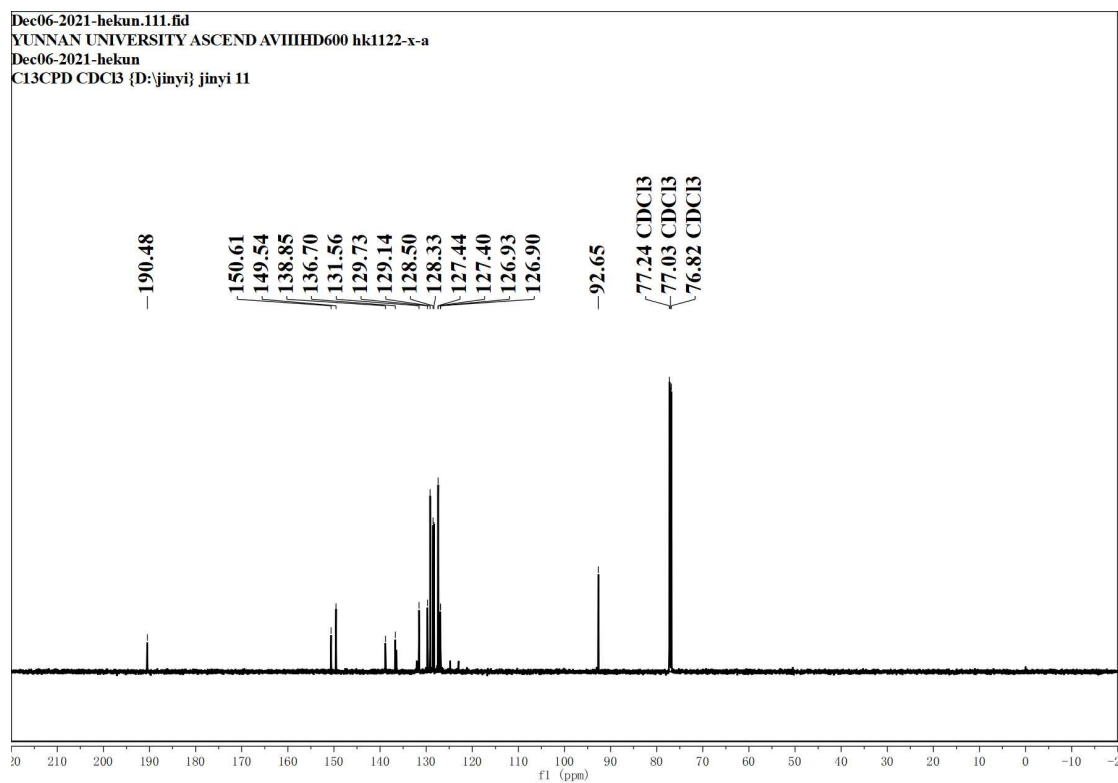
¹H-NMR (600MHz, CDCl₃) spectrum of compound (**4e - Z**)



¹³C-NMR(150MHz, CDCl₃) spectrum of compound (**4e - Z**)

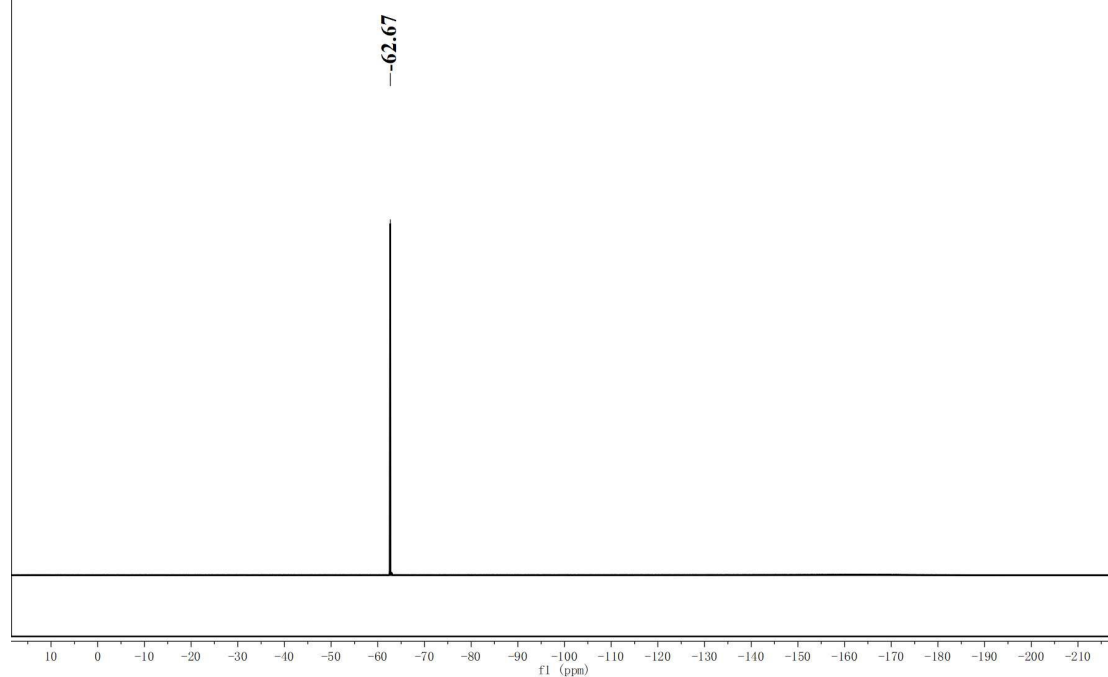


¹H-NMR (600MHz, CDCl₃) spectrum of compound (**4f - E**)

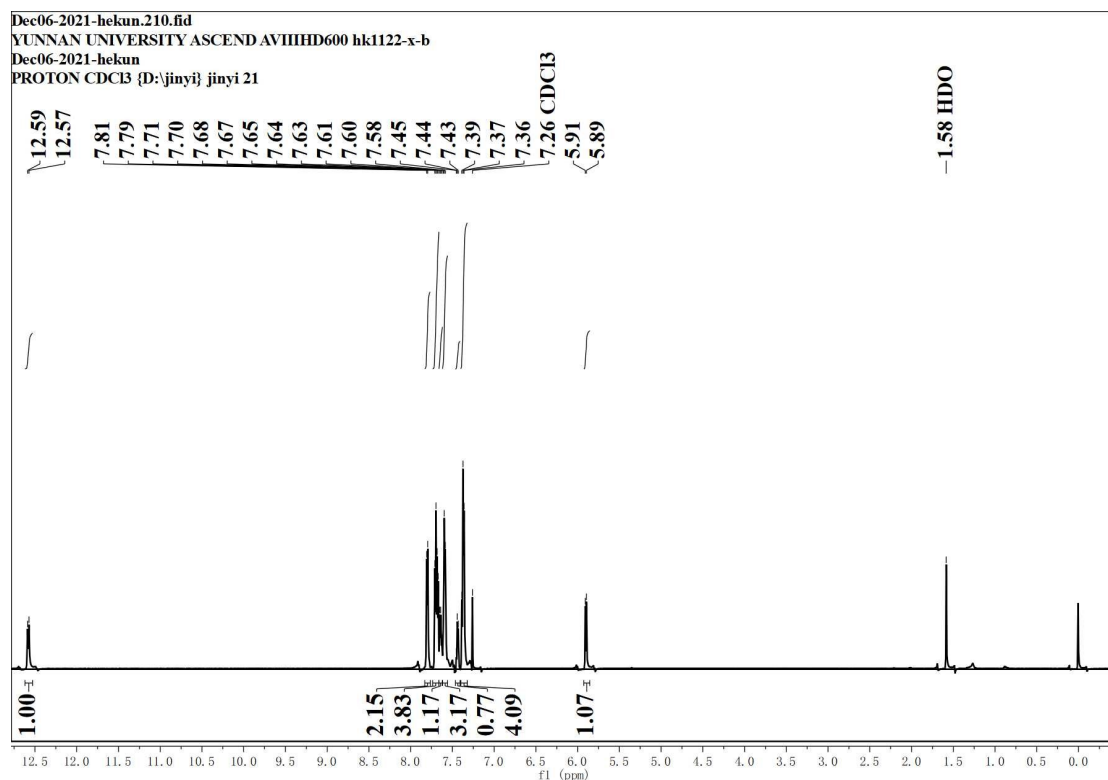


¹³C-NMR(150MHz, CDCl₃) spectrum of compound (**4f - E**)

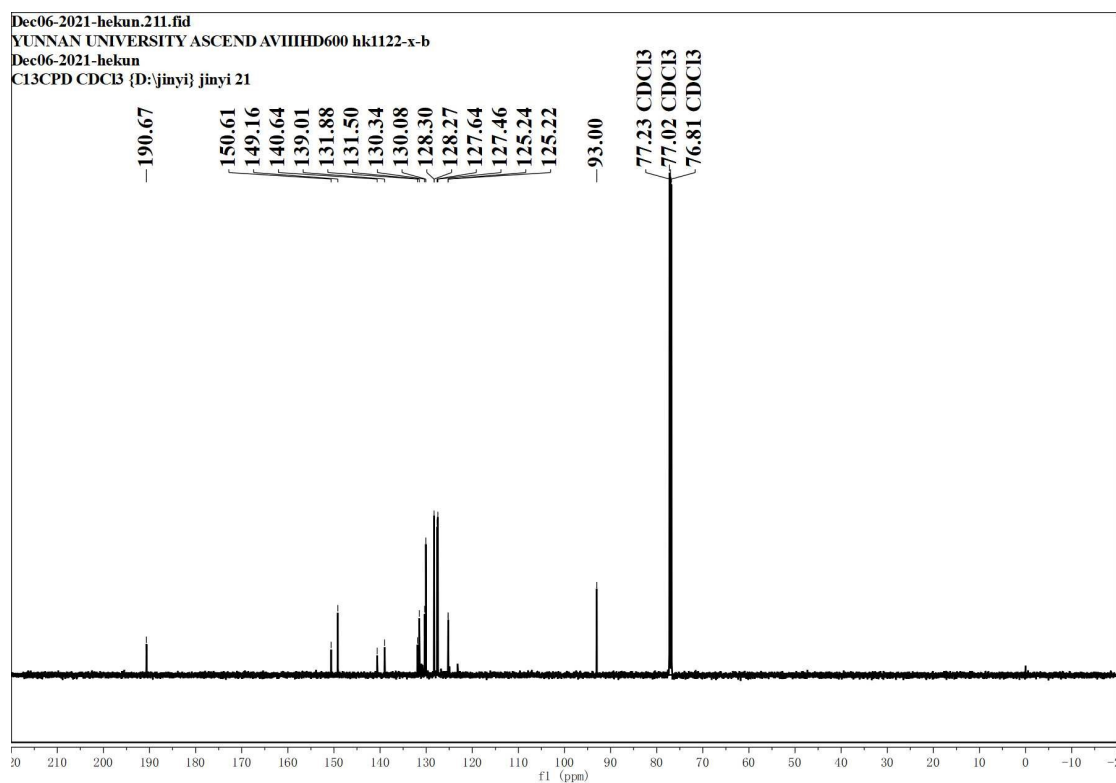
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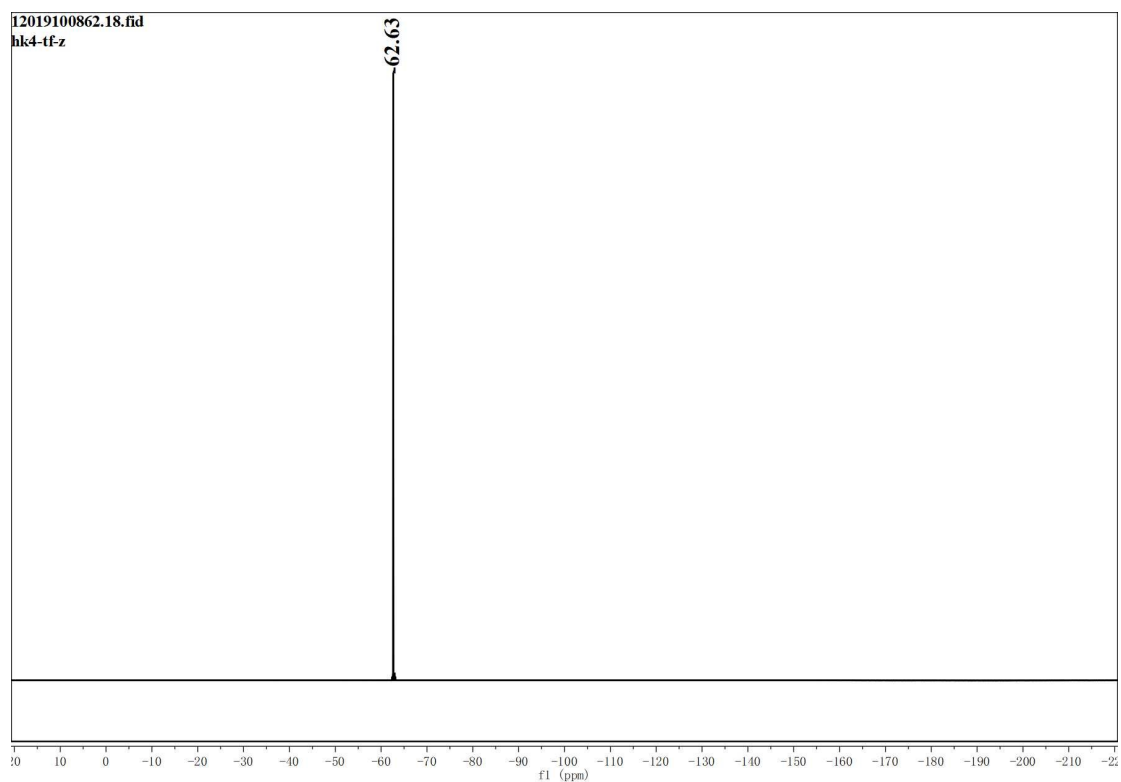
^{19}F -NMR(565MHz, CDCl_3) spectrum of compound (**4f - E**)



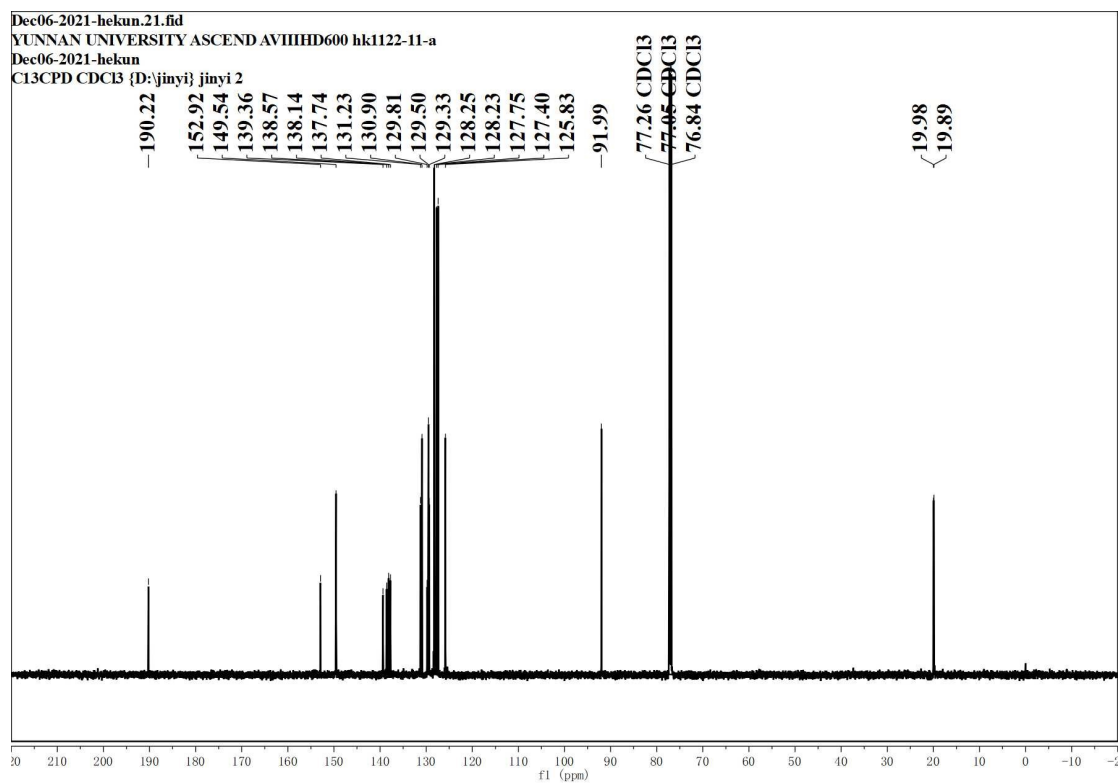
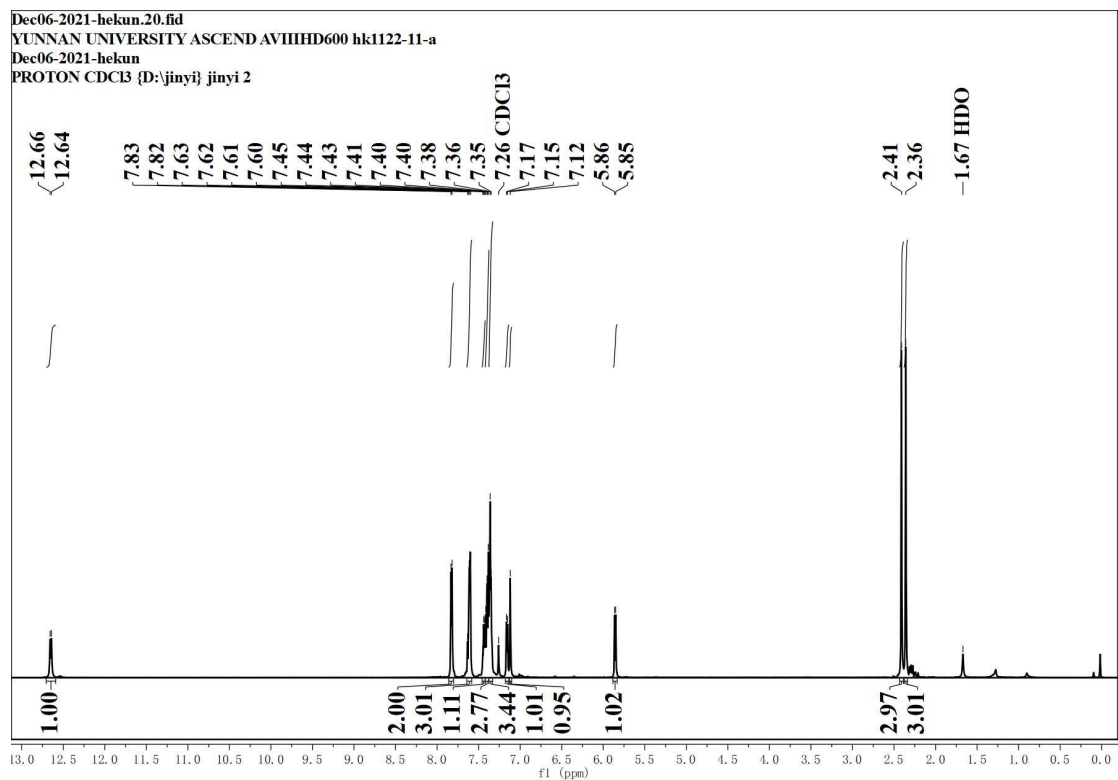
¹H-NMR (600MHz, CDCl₃) spectrum of compound (**4f - Z**)

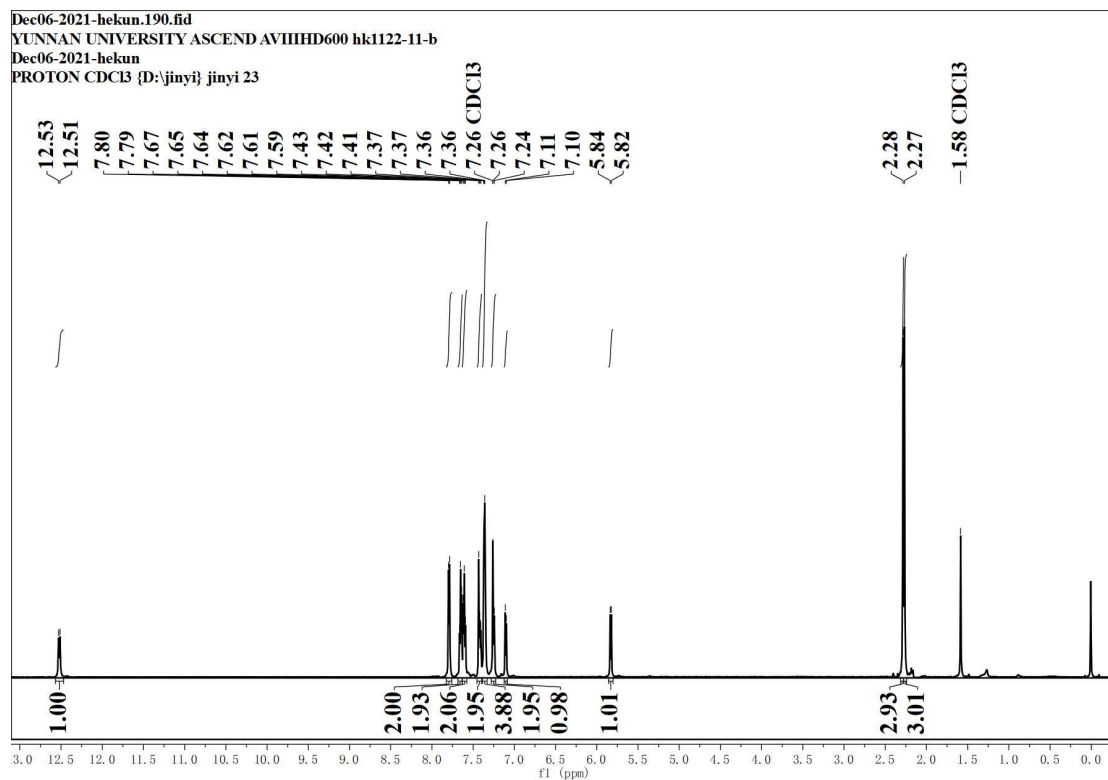


¹³C-NMR(150MHz, CDCl₃) spectrum of compound (**4f - Z**)

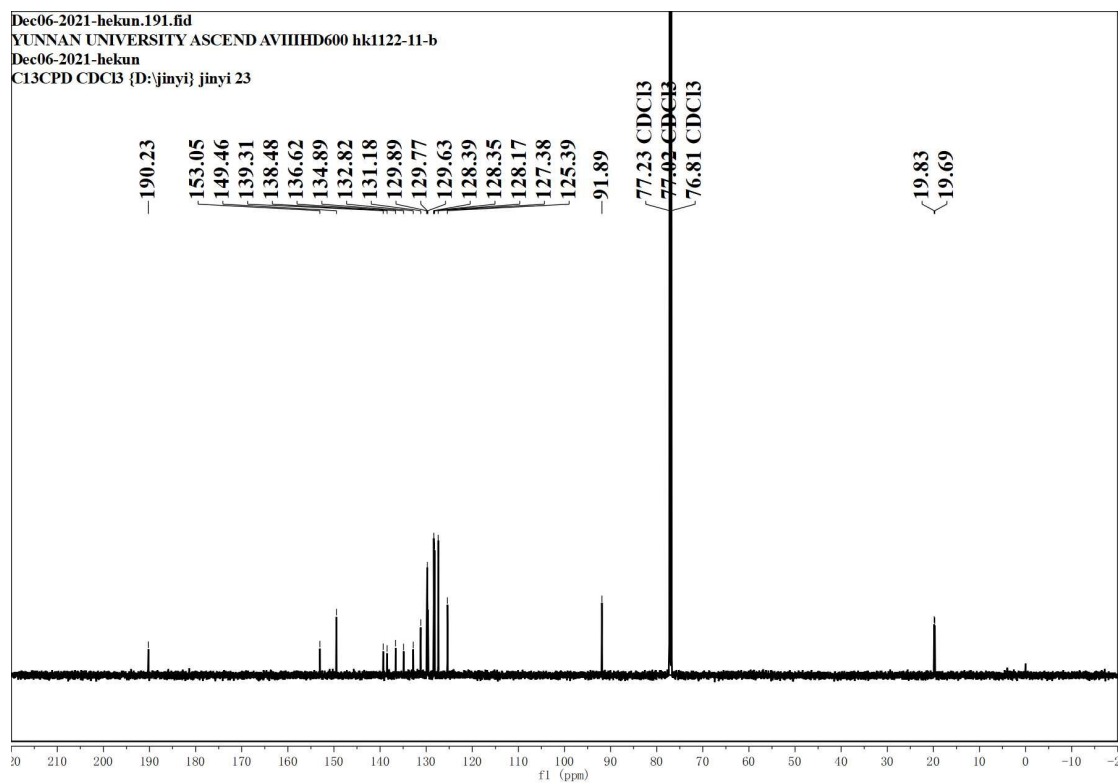


^{19}F -NMR(565MHz, CDCl_3) spectrum of compound (**4 - Z**)

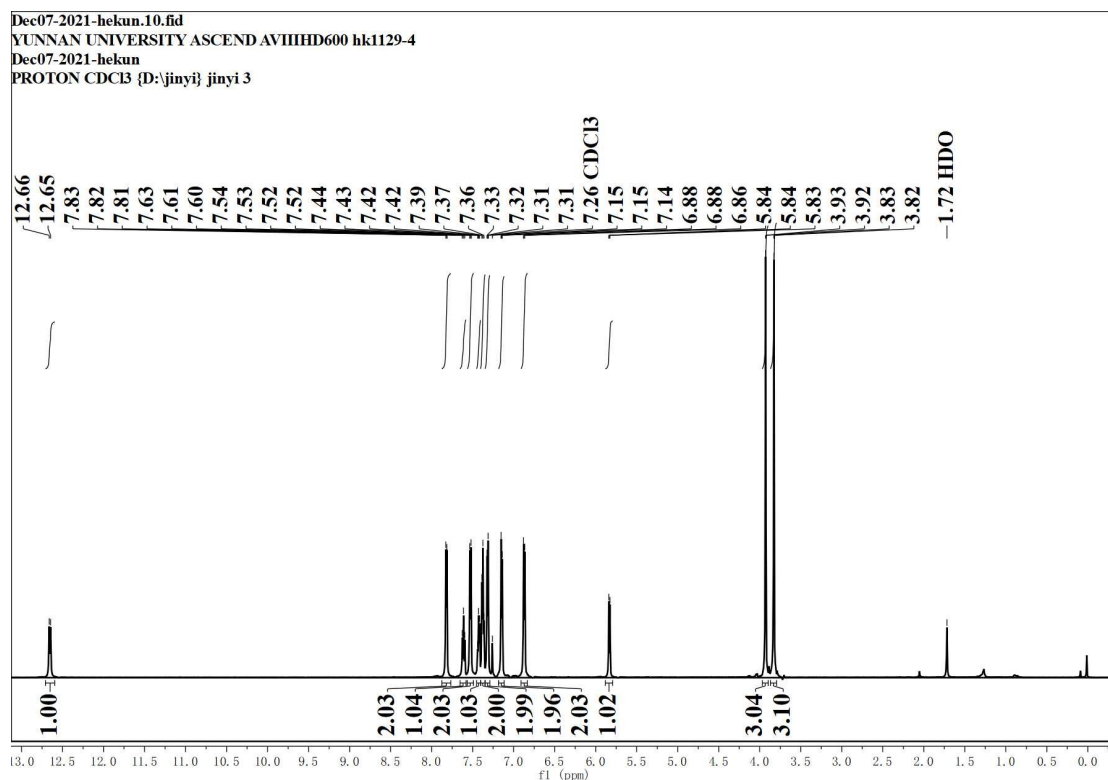




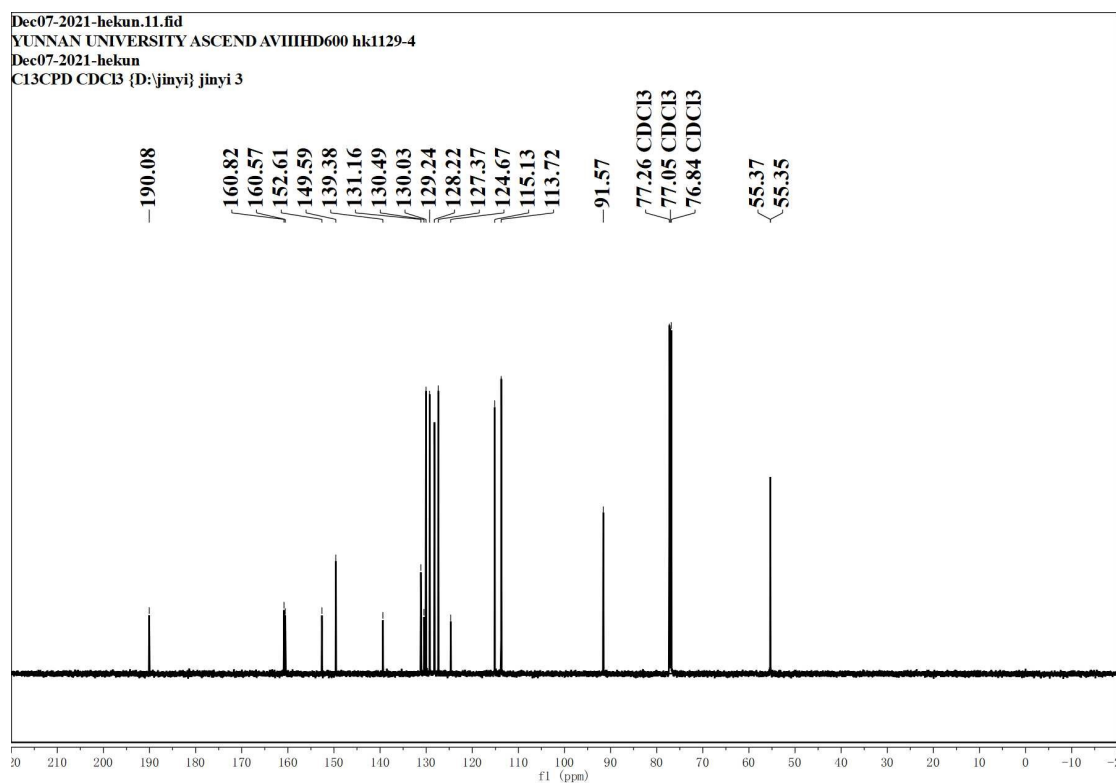
¹H-NMR (600MHz, CDCl₃) spectrum of compound (**4g - Z**)



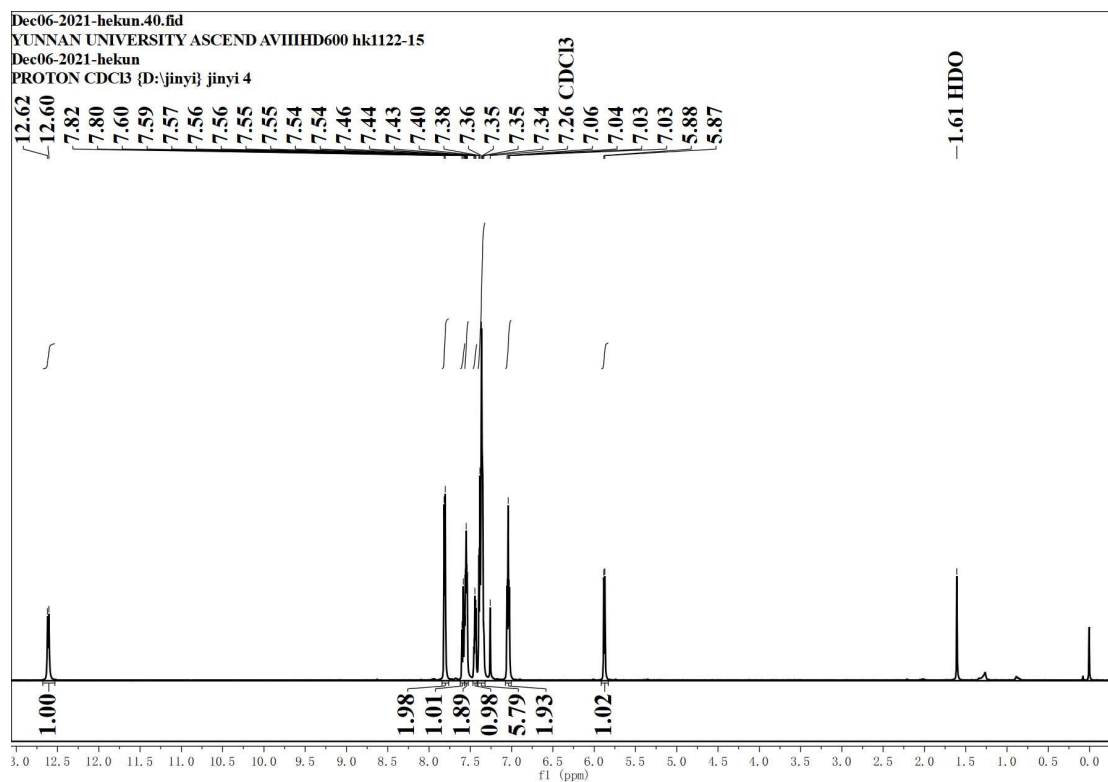
¹³C-NMR(150MHz, CDCl₃) spectrum of compound (**4g- E**)



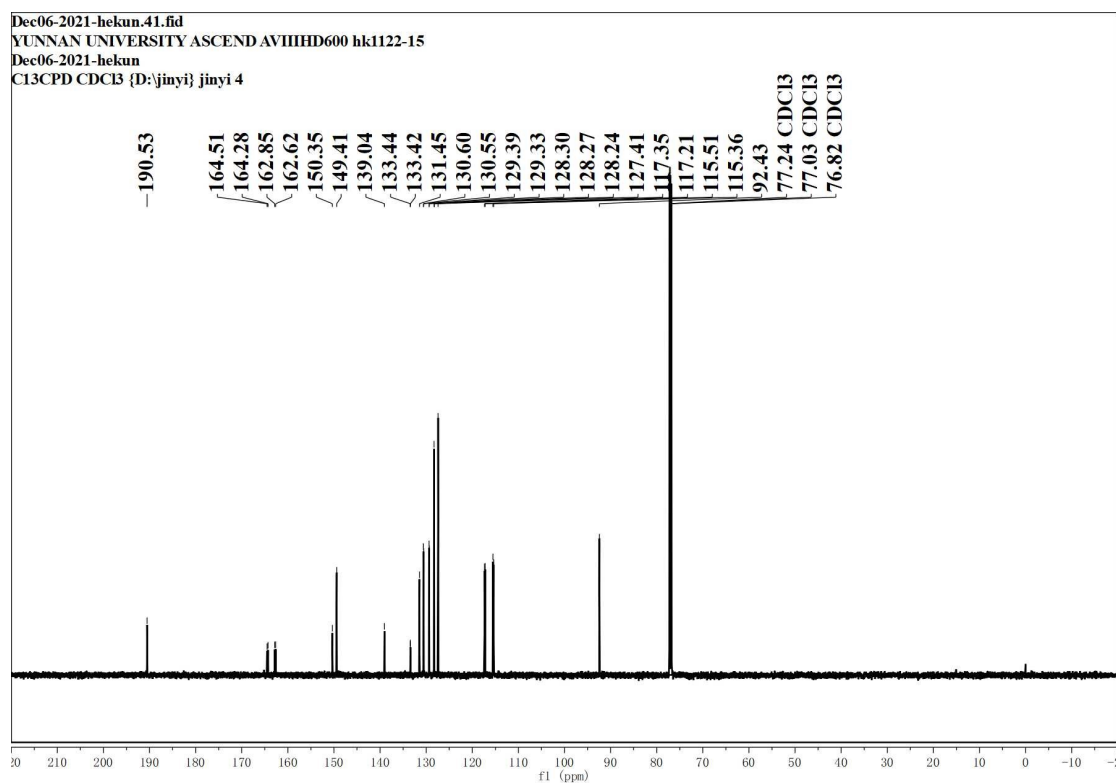
¹H-NMR (600MHz, CDCl₃) spectrum of compound (4i)



¹³C-NMR(150MHz, CDCl₃) spectrum of compound (4i)

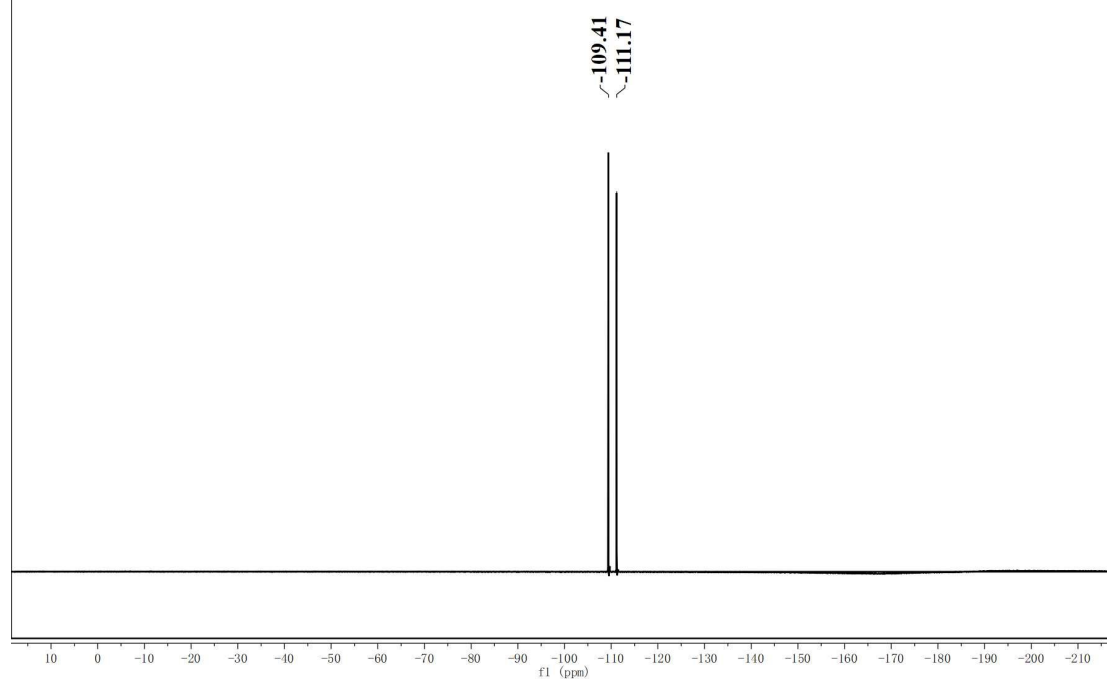


¹H-NMR (600MHz, CDCl₃) spectrum of compound (**4j**)

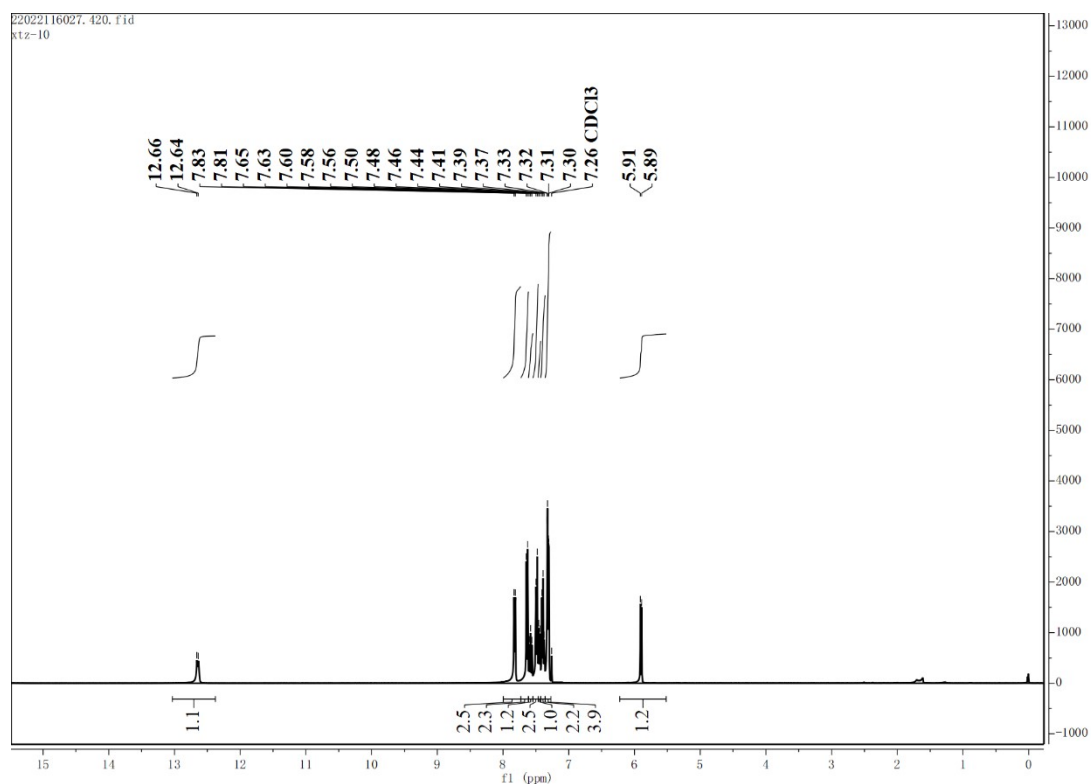


¹³C-NMR(150MHz, CDCl₃) spectrum of compound (**4j**)

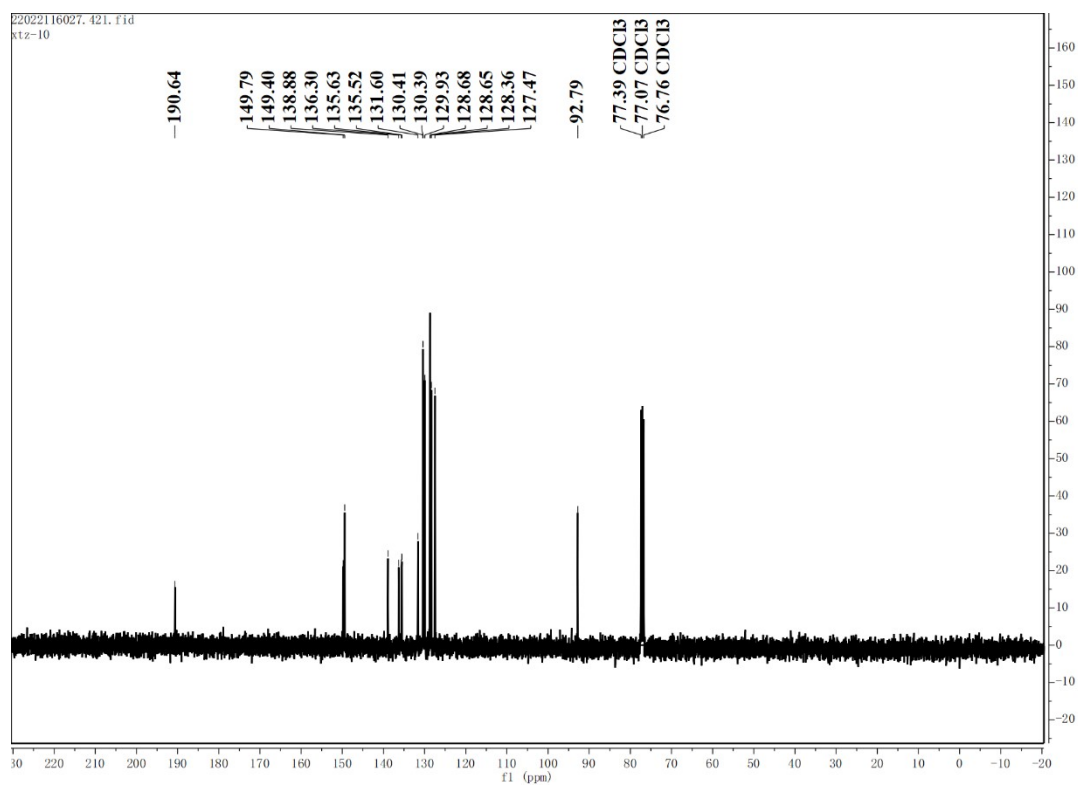
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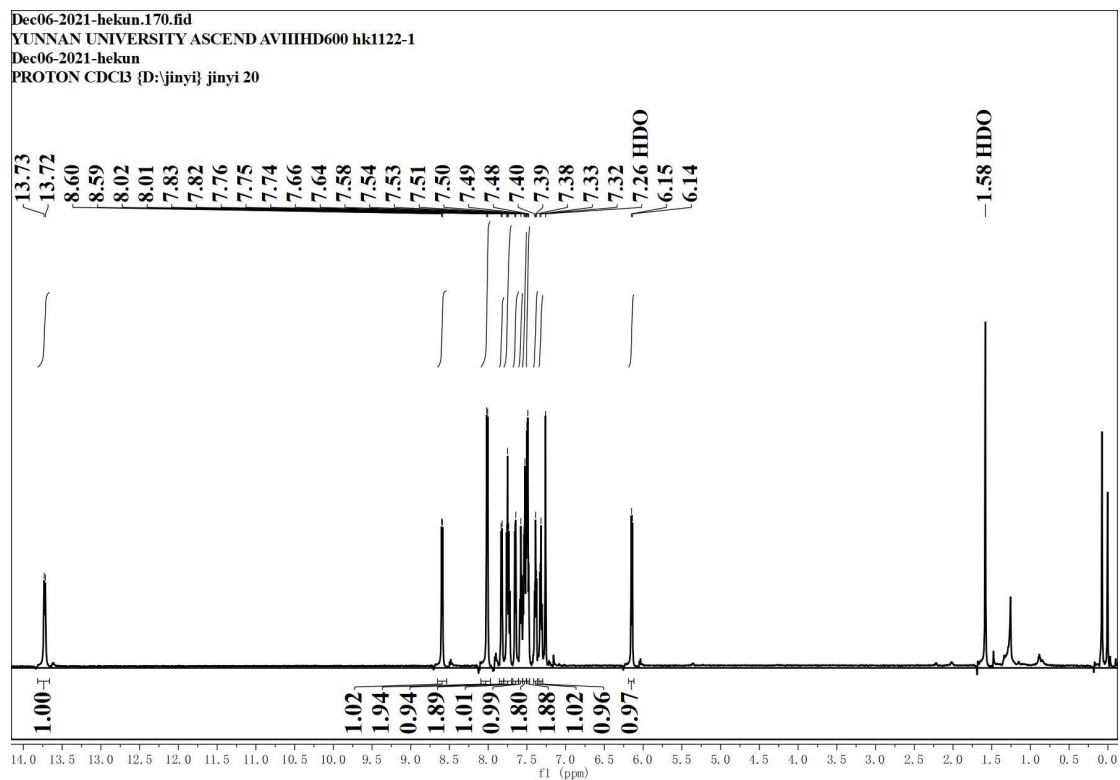
^{19}F -NMR(565MHz, CDCl_3) spectrum of compound (**4j**)



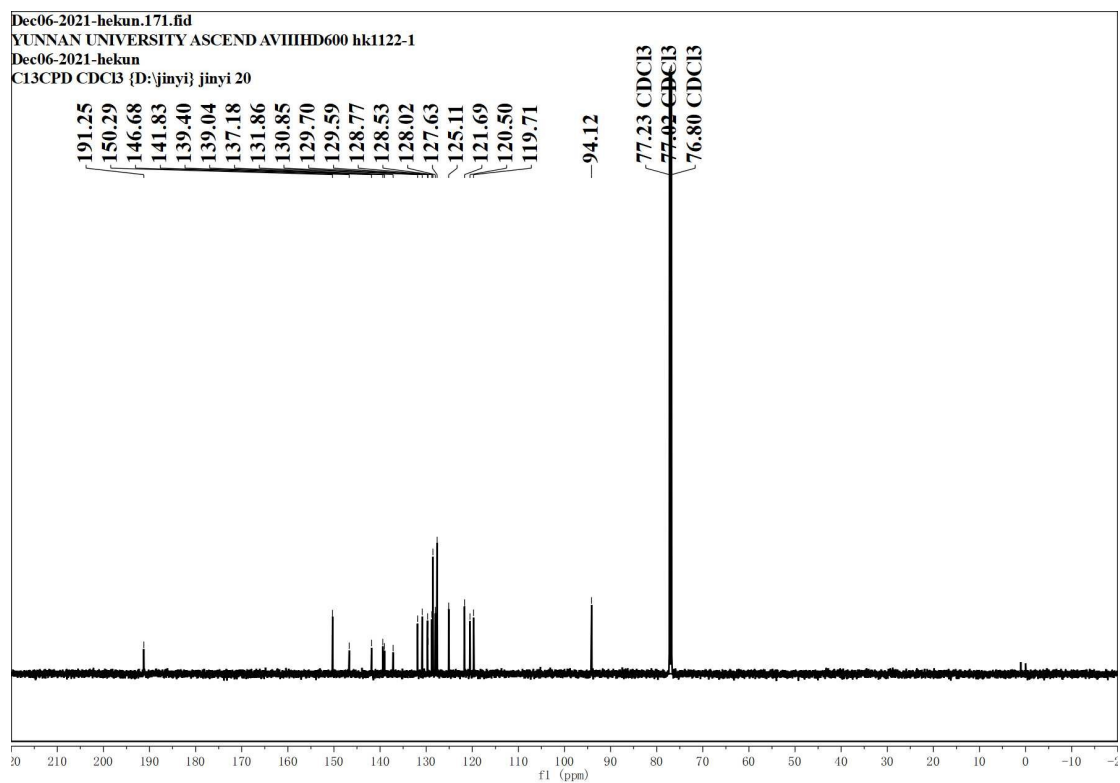
¹H-NMR (600MHz, CDCl₃) spectrum of compound (**4k**)



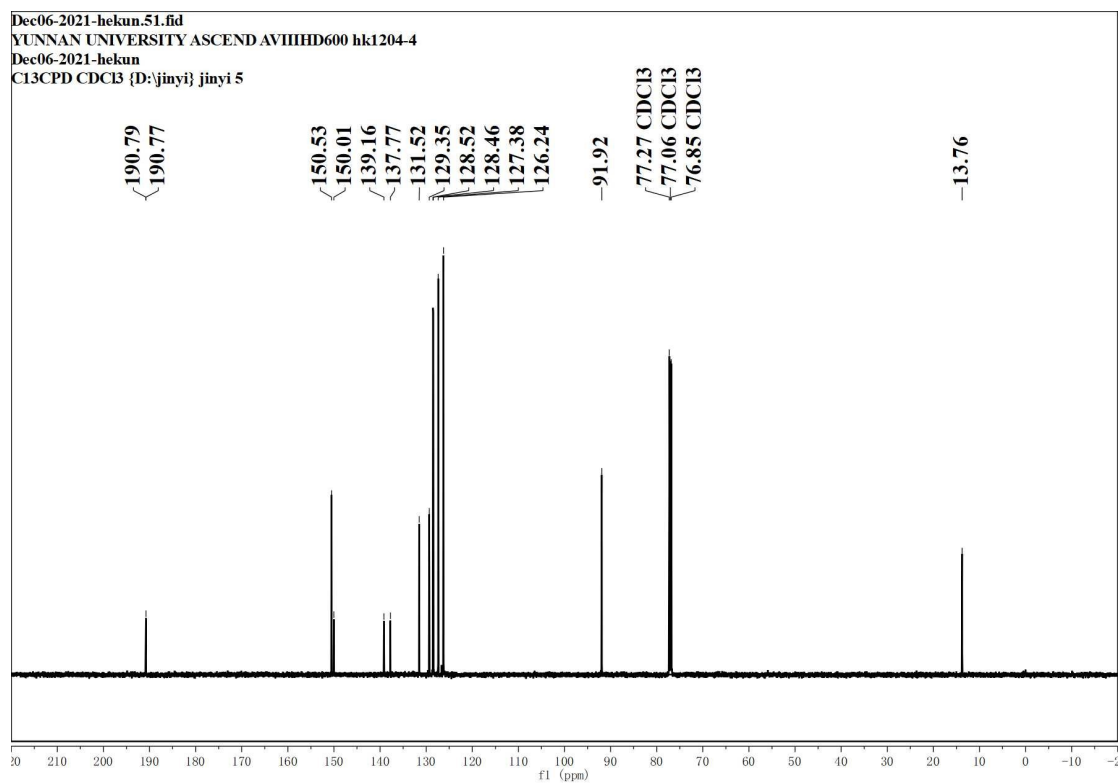
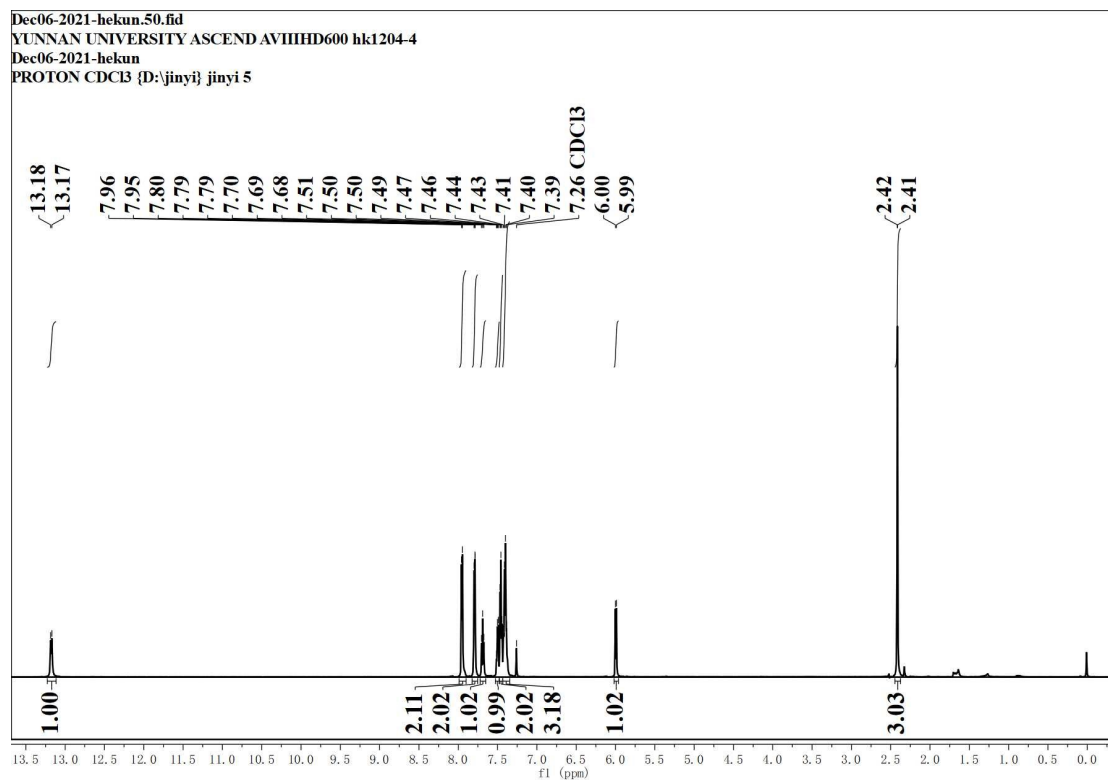
¹³C-NMR(150MHz, CDCl₃) spectrum of compound (**4k**)

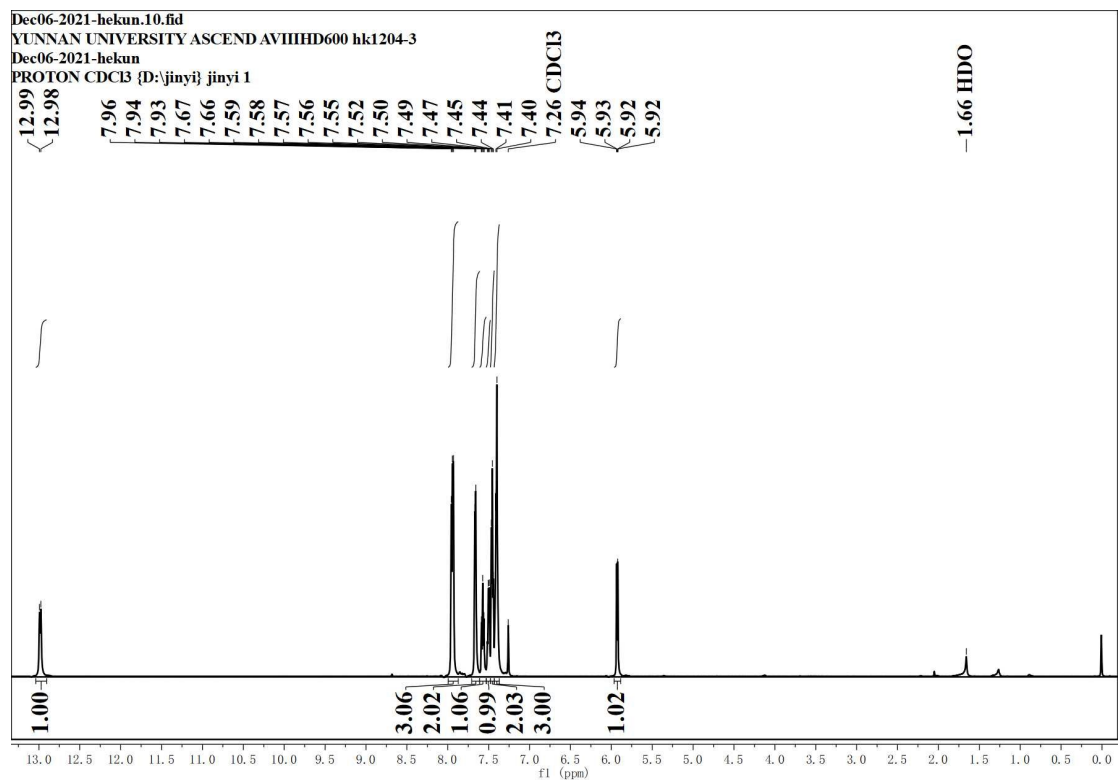


^1H -NMR (600MHz, CDCl_3) spectrum of compound (**4I**)

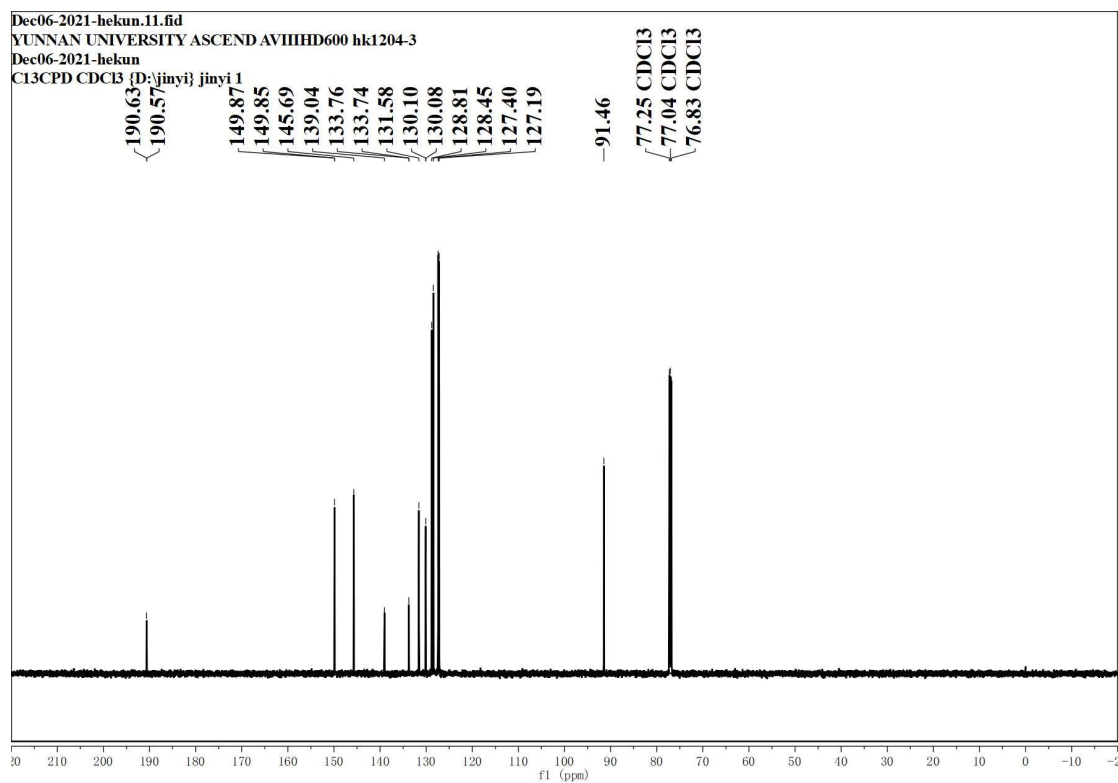


^{13}C -NMR(150MHz, CDCl_3) spectrum of compound (**4I**)

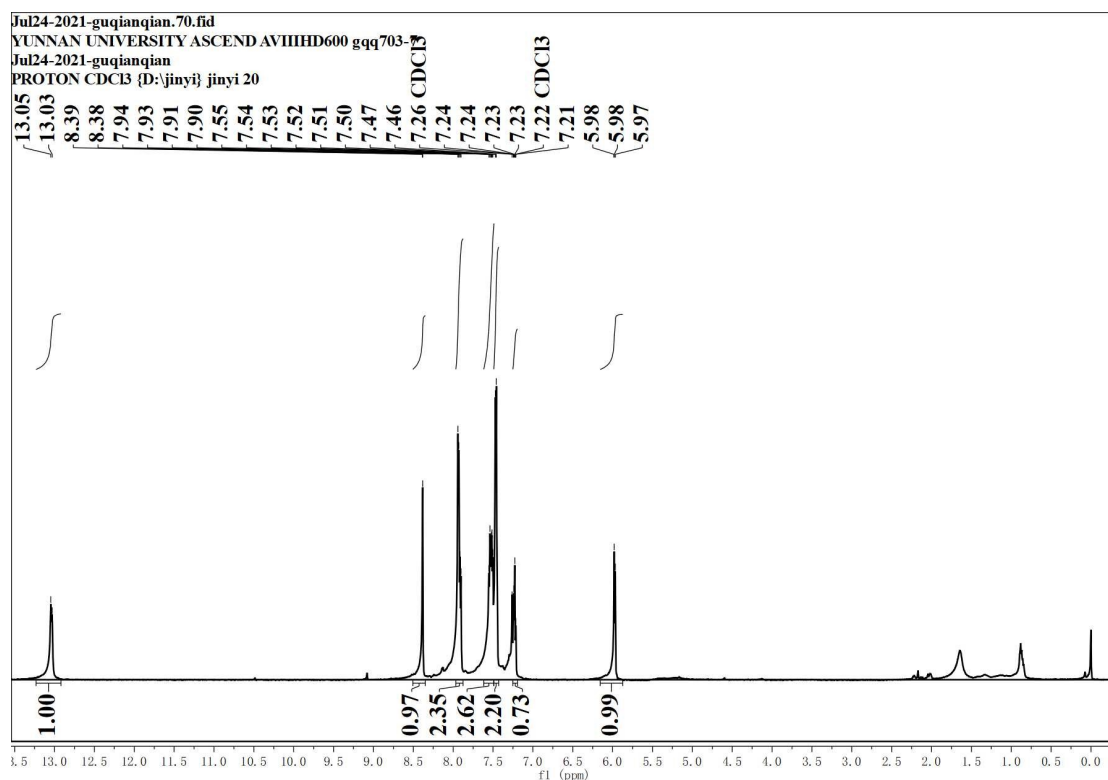




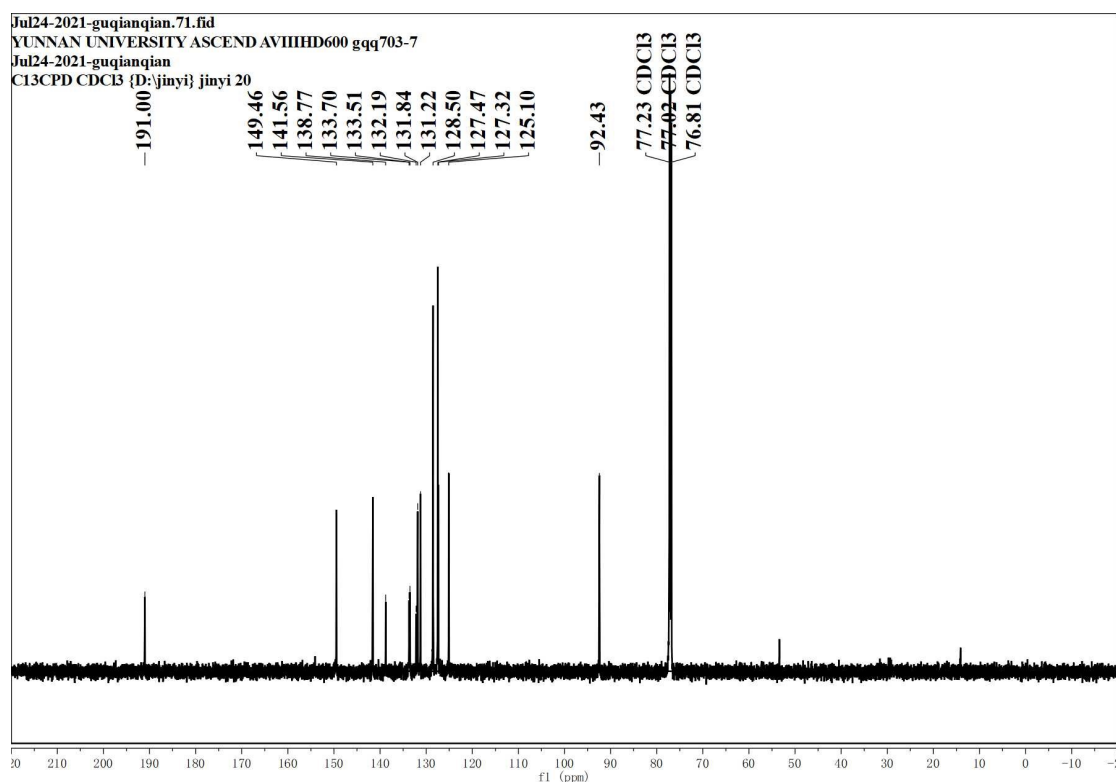
¹H-NMR (600MHz, CDCl₃) spectrum of compound (**4n**)



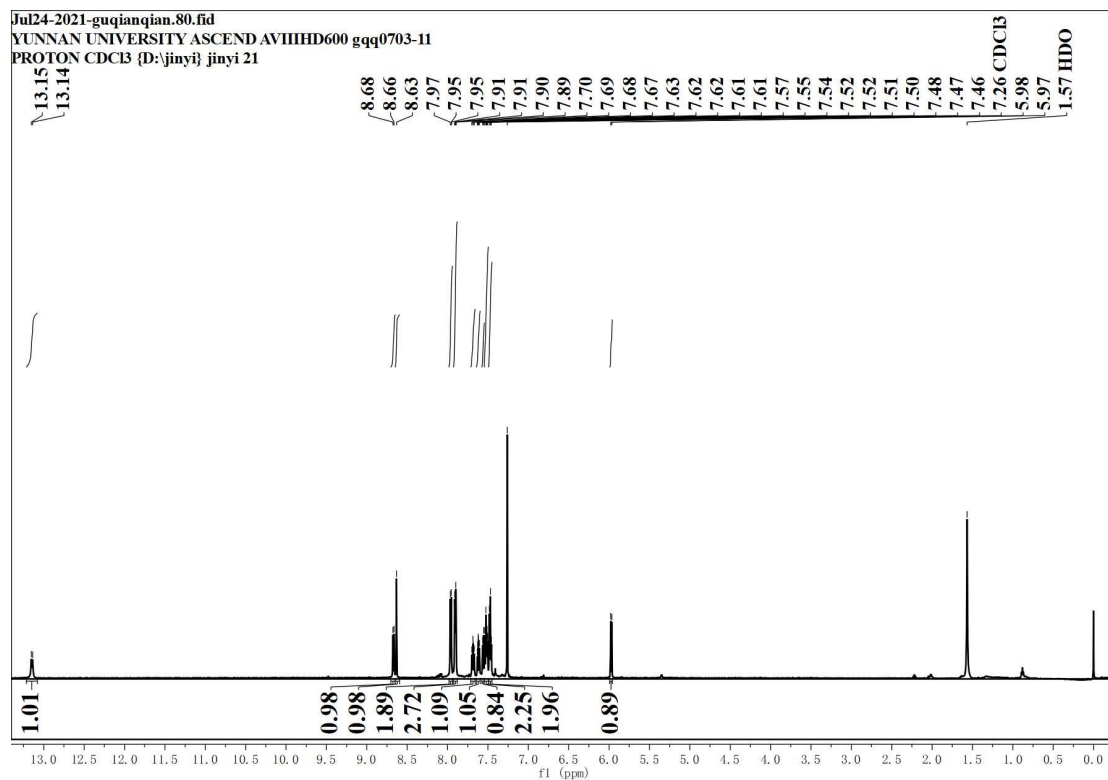
¹³C-NMR(150MHz, CDCl₃) spectrum of compound (**4n**)



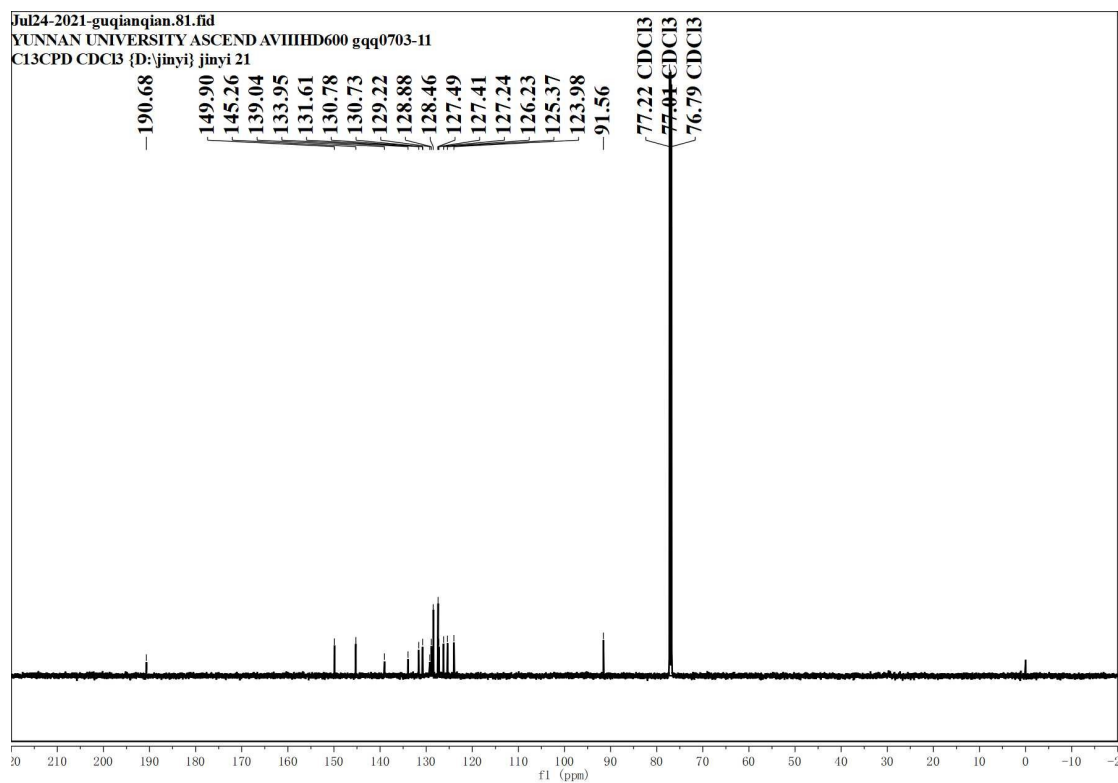
¹H-NMR (600MHz, CDCl₃) spectrum of compound (**4o**)



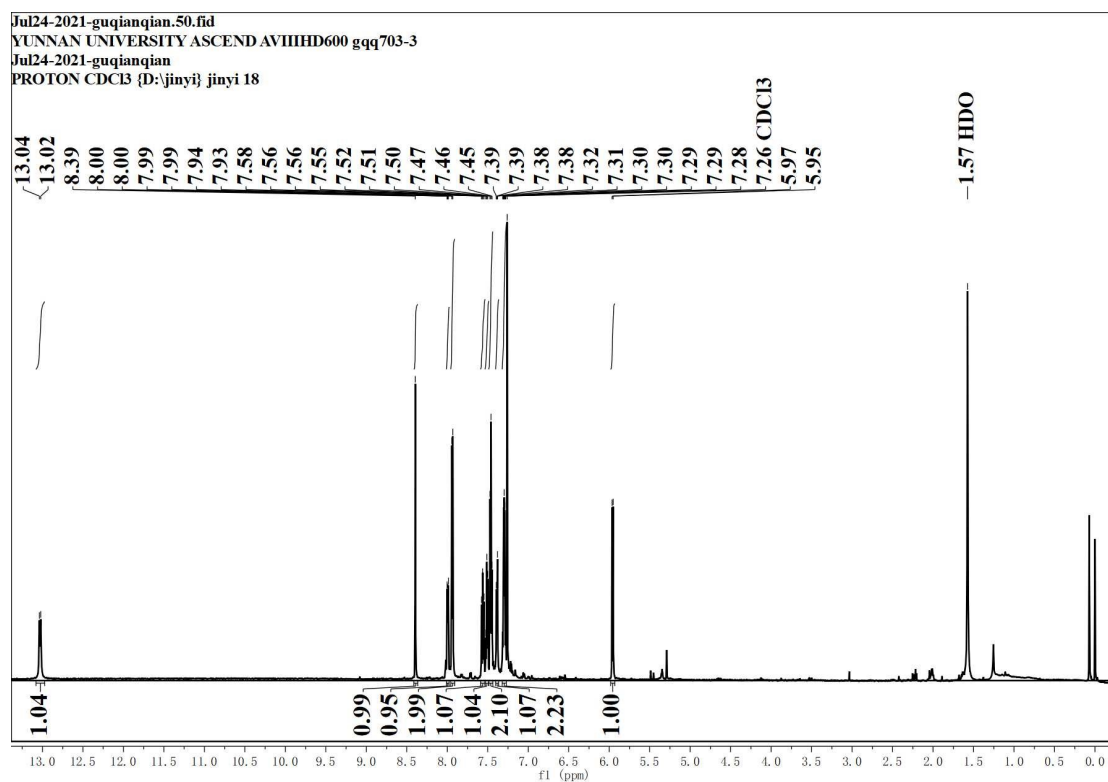
¹³C-NMR(150MHz, CDCl₃) spectrum of compound (**4o**)



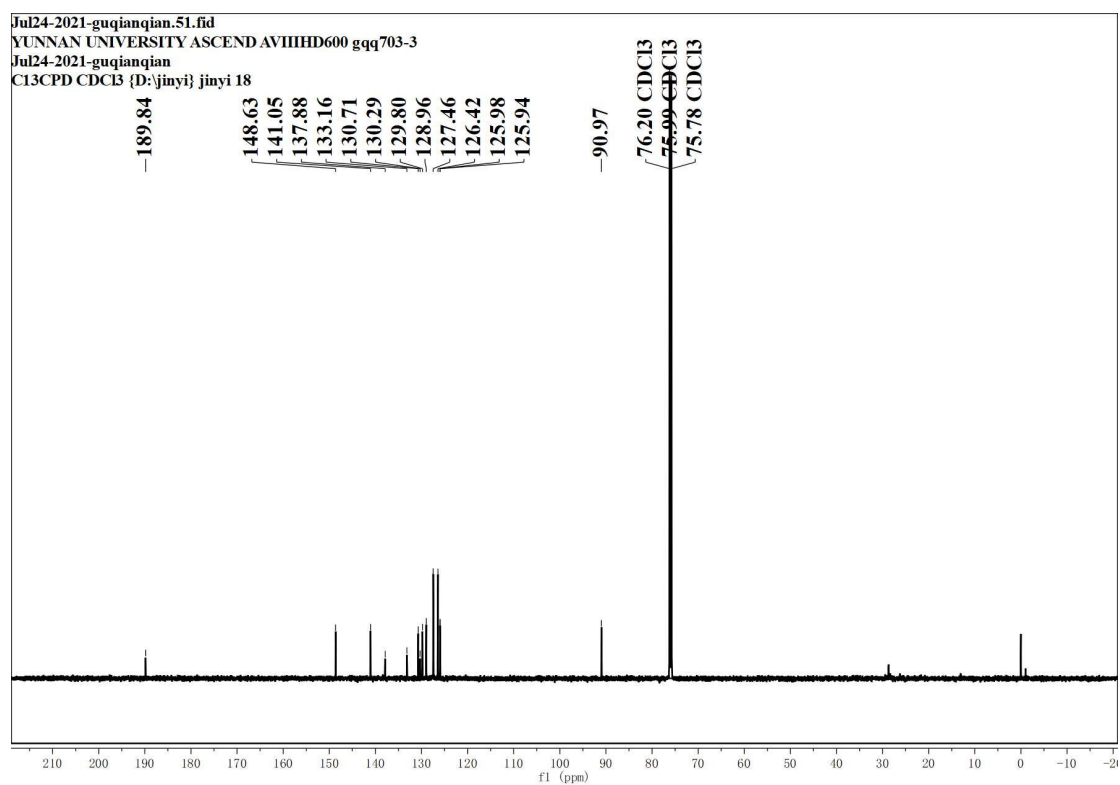
¹H-NMR (600MHz, CDCl₃) spectrum of compound (**4p**)



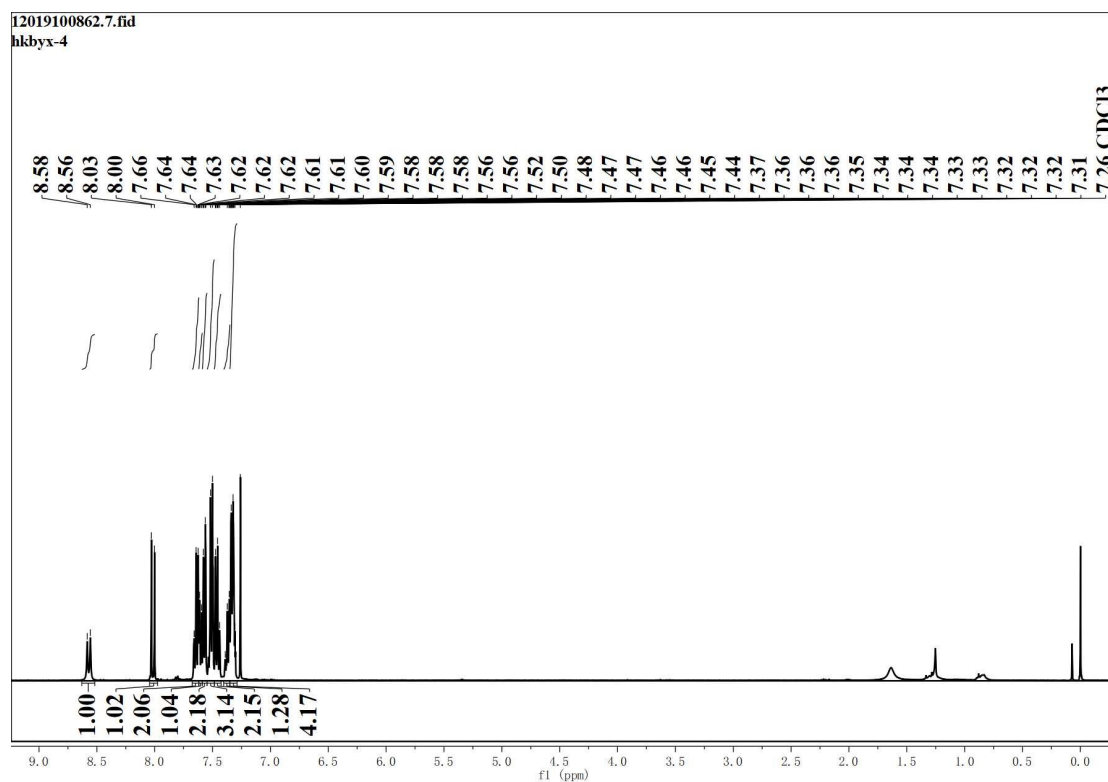
¹³C-NMR(150MHz, CDCl₃) spectrum of compound (**4p**)



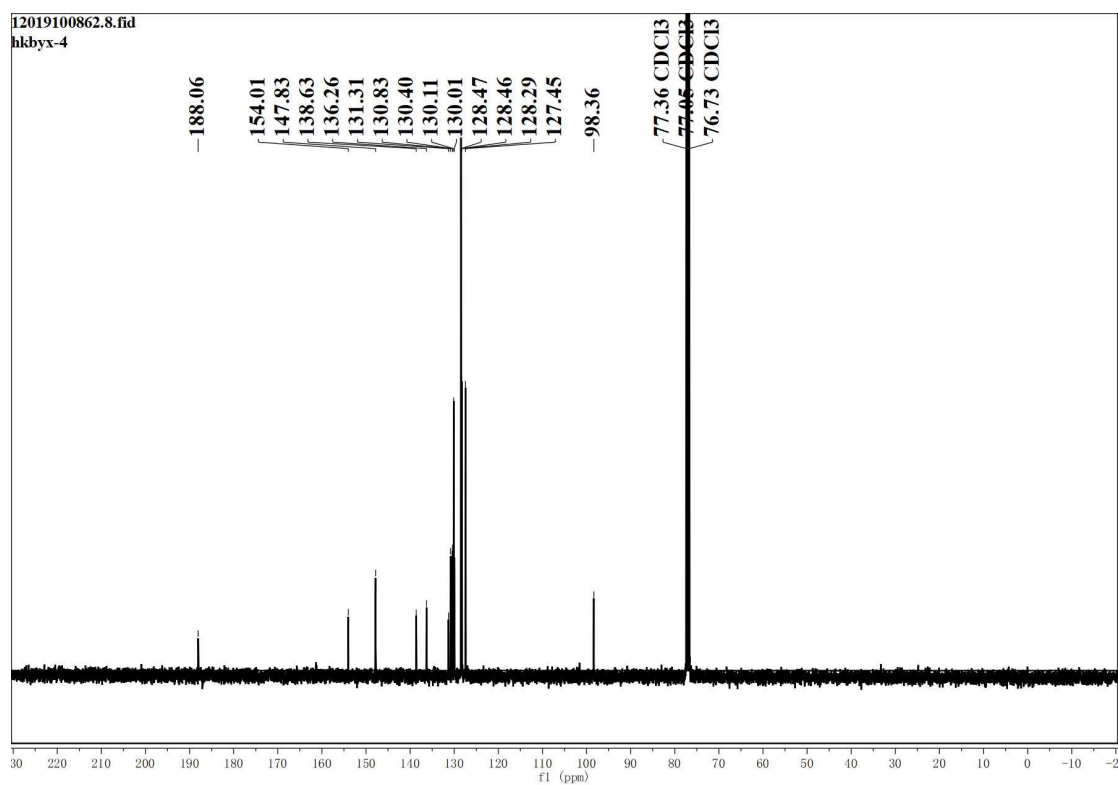
¹H-NMR (600MHz, CDCl₃) spectrum of compound (**4q**)



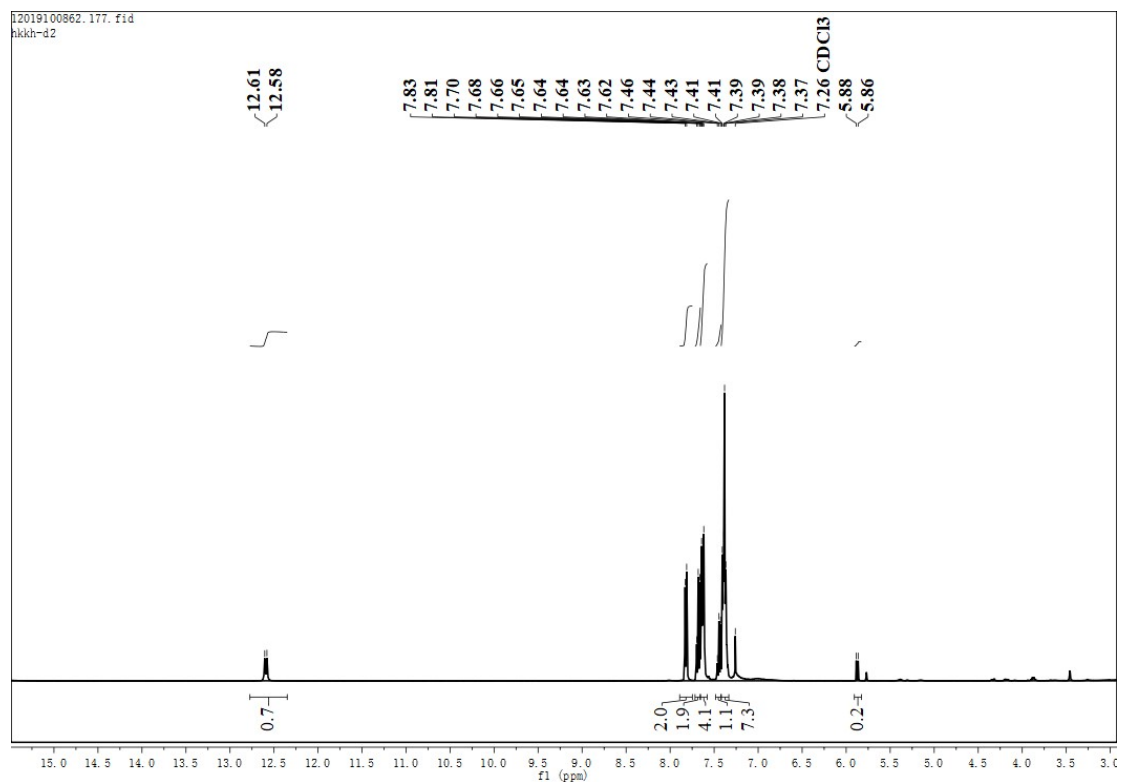
¹³C-NMR(150MHz, CDCl₃) spectrum of compound (**4q**)



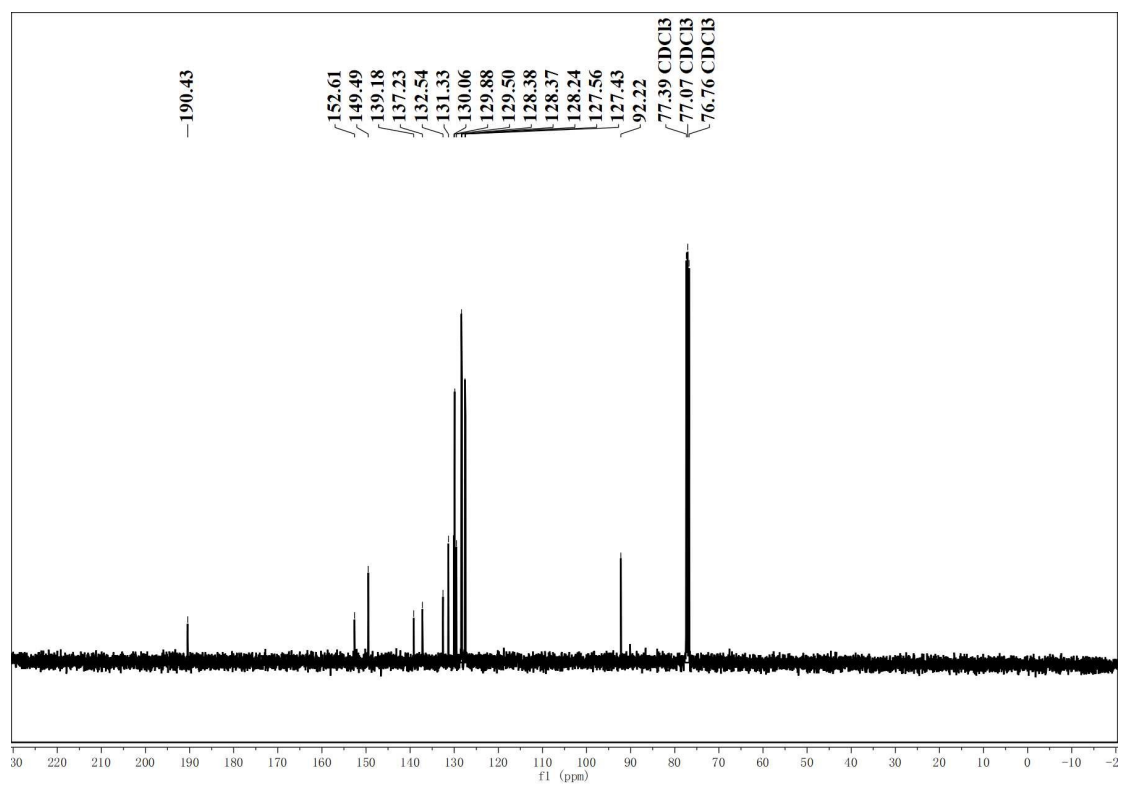
¹H-NMR (400MHz, CDCl₃) spectrum of compound (**5a**)



¹³C-NMR(100MHz, CDCl₃) spectrum of compound (**5a**)



¹H-NMR (400MHz, CDCl₃) spectrum of compound (6a-D)



¹³C-NMR(100MHz, CDCl₃) spectrum of compound (6a-D)