Electronic Supplementary Material (ESI) for RSC Advances.

Supporting Information

Biocatalytic one-pot three-component synthesis of 3,3'-disubstituted oxindoles and spirooxindole pyrans using α-amylase from hog pancreas

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1 General information

Reactions were monitored by thin-layer chromatography (TLC) on silica gel precoated glass plates (GF254 silica gel plates) from Haiyang chemical industry Co Ltd, Qingdao, China. Flash column chromatography was performed using silica gel (100–200 mesh) from Haiyang chemical industry Co Ltd, Qingdao, China. Melting points were taken on a YuHua X-4 apparatus and were uncorrected. Organic solutions were concentrated under reduced pressure on rotary evaporator. ^{1}H (600 and 300 MHz) NMR, as well as ^{13}C (150 and 75 MHz) NMR spectra were recorded in d_6-DMSO on Bruker-AM 300 (300 MHz) or Bruker Ascend 600 (600 MHz) (Bruker BioSpin AG Ltd., Beijing, China). Chemical shifts were reported in ppm from TMS with the solvent resonance as the internal standard and coupling constants (*J*) in Hz. HRMS were recorded on a Varian 7.0T FTICR-MS spectrometer. X-ray crystal structures were tested in Agilent SuperNova X-ray single-crystal diffractometer. Purity of new products is measured by Shimadzu LC-20AT HPLC with Daicel AD-H chiral column or ELITE Hypersil NH_2 column.

2 Materials

α-Amylase from hog pancreas, EC Number 3.2.1.1, CAS number: 9000-90-2, powder, ~50 U/mg, product number: 10080, 1 U will liberate 1.0 mg of maltose from starch in 3 minutes at pH 6.9 at 20 ºC), was purchased from Sigma-Aldrich.

α-Amylase from *Aspergillus oryzae*, EC Number 3.2.1.1, CAS number: 9001-19-8, powder, ~30 U/mg, Product number: 10065-10G, 1 U will liberate 1.0 mg of maltose from starch in 3 minutes at pH 6.9 at 20 ºC), was purchased from Sigma-Aldrich.

α-Amylase from *Bacilus Subtilis*, EC Number 3.2.1.1, powder, ~4 U/mg, 1 U will liberate 1.0 mg of maltose from starch in 3 minutes at pH 6.9 at 20 ºC), was purchased from Shanghai kayon Biological Technology Co., Ltd, China.

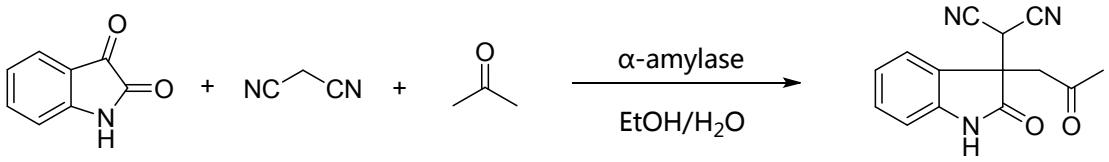
Unless otherwise stated, all reagents were purchased from commercial suppliers and used without further purification.

3 Comparison of different forms of α-amylase for the catalysis on the three-component reaction

In our initial study, to find out an enzyme for the reaction, we have screened several enzymes

which included three α-amylases (α-amylase from hog pancreas, α-amylase from *Aspergillus oryzae*, and α-amylase from *Bacilus Subtilis*). Only the reaction with α-amylase from hog pancreas gave the product in a good yield of 55%. The other two α-amylases gave low yields of 7% and 2%. Thus, α-amylase from hog pancreas was selected as the catalyst for the investigation in this study. The results were represented in **S-Table 1**.

S-Table 1. Comparison of different forms of α-amylase for the catalysis on the three-component reaction [a]



1 **2** **3** **4a**

Entry	α-amylase	Time [d]	Yield [%] [b]
1	α-amylase from hog pancreas	2	55
2	α-amylase from *Aspergillus oryzae*	3	7
3	α-amylase from *Bacilus Subtilis*	3	2

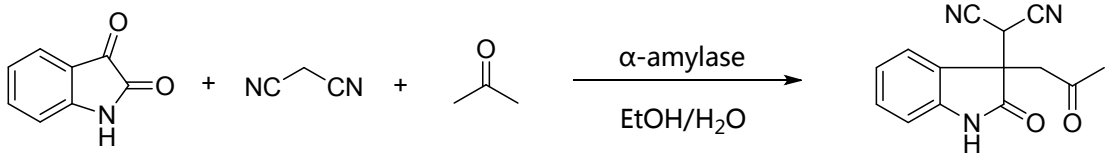
[a] Reaction conditions: isatin (0.25 mmol), malononitrile (0.25 mmol), acetone (2.5 mmol), α-amylase (30 mg), ethanol (0.90 mL), and deionized water (0.10 mL) at 25 ºC.

[b] Yield of the isolated product.

4 Optimization of reaction conditions

The influence of the amounts of acetone on the yield of α-amylase-catalyzed reaction was investigated (**S-Table 2**). Initially the yield of the product increased with increasing the amount of acetone (**S-Table 2,** entries 1-6). After acetone reached 30 equivalents (the molar ratio of isatin/malononitrile/acetone = 1:1:30), continuous increase in the amount of acetone did not have an obvious effect on the yield (**S-Table 2,** entries 7 and 8). Thus, we choose 30 equivalents of acetone as the best molar ratio of substrates for the further studies.

S-Table 2 Influence of the amounts of acetone on the α-amylase-catalyzed three-component reaction[a]



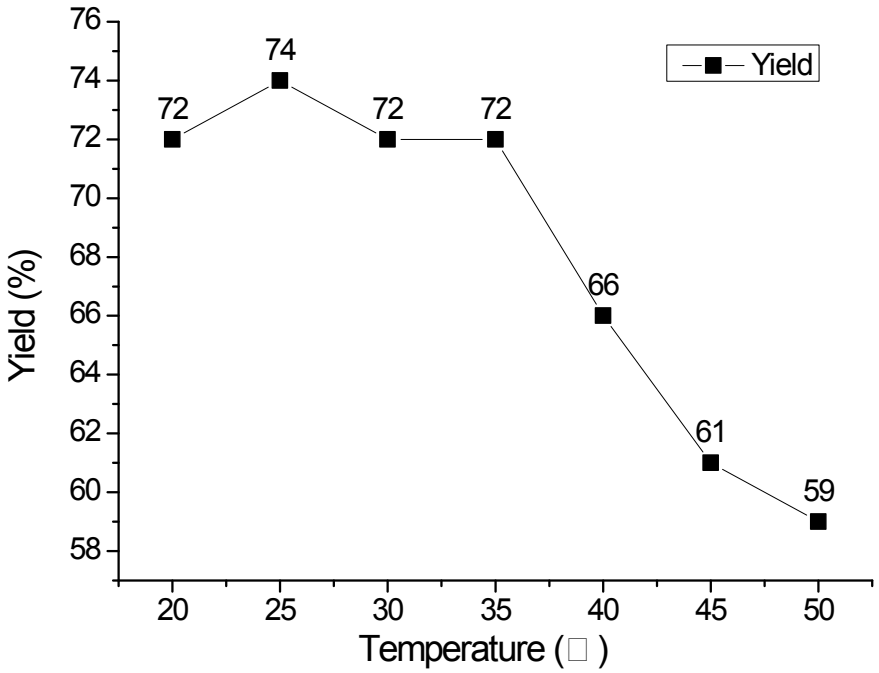
1 **2** **3** **4a**

Entry	Molar ratio of 1/2/3	Yield [%] [b]
1	1:1:5	48
2	1:1:10	58
3	1:1:15	65
4	1:1:20	67
5	1:1:25	67
6	1:1:30	73
7	1:1:35	74
8	1:1:40	73

[a] Reaction conditions: isatin (0.25 mmol), malononitrile (0.25 mmol), acetone, α-amylase (738 U), ethanol (0.90 mL), and deionized water (0.10 mL) at 25 ºC for 2 d.

[b] Yield of the isolated product.

Temperature has a significant effect on enzyme stability and activity. It is crucial to confirm the optimal temperature for this α-amylase catalyzed reaction. Thus, the effect of temperature on the product yield was investigated (**S- Figure 1**). The reaction proceeded faster at higher temperatures than at room temperature but afforded lower yield, due to the formation of some side products. So 25 ºC was selected as the optimal temperature for the reaction.

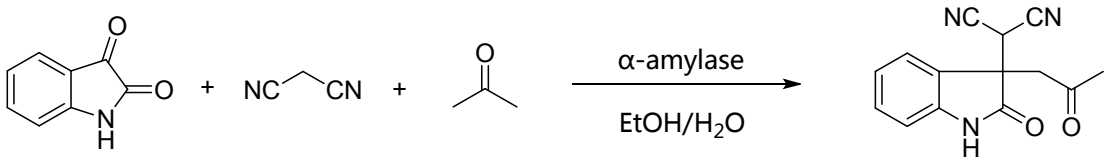


S-Figure 1 Influence of temperature on the α-amylase-catalyzed reaction

The reactions were carried out with isatin (0.25 mmol), malononitrile (0.25 mmol) and acetone (7.5 mmol) in the presence of α-amylase (738 U) in ethanol (0.90 mL) and deionized water(0.10 ml) for 2 d. Yield of the isolated product.

The influence of enzyme loading on the α-amylase catalyzed three-component reaction was also surveyed (**S-Table 3**). When 49 U of α-amylase was used, the model reaction only gave the product in a low yield of 25% (**S-Table 3**, entry 1). Increasing the enzyme loading from 49 U to 246 U led to an obvious increase in yield (**S-Table 3**, entries 1-5). Further increasing the enzyme loading hardly improved the results. Thus we chose 246 U as the optimal enzyme loading for the three-component reaction.

S-Table 3 Effect of enzyme loading on the α-amylase-catalyzed three-component reaction [a]



1 **2** **3** **4a**

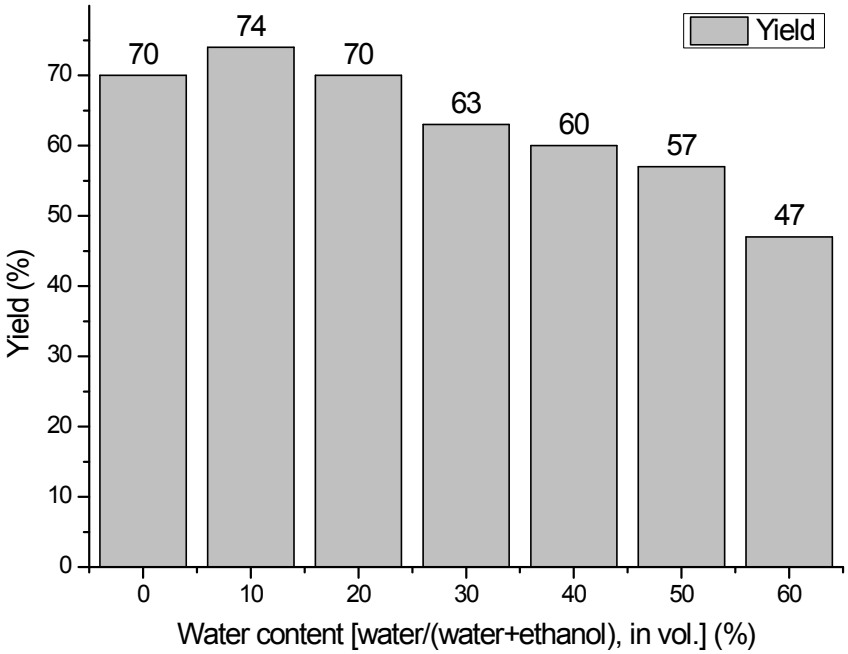
Entry	Enzyme loading (U)	Yield [%] [b]

1	49	25
2	98	43
3	148	53
4	197	68
5	246	75
6	492	72
7	738	74

[a] Reaction conditions: isatin (0.25 mmol), malononitrile (0.25 mmol), acetone (7.5 mmol), ethanol (0.90 mL), and deionized water (0.10 mL) at 25 ºC for 2 d.

[b] Yield of the isolated product.

The effect of water content in the system on the reaction yield was also investigated (**S-Figure 2**). The water content [water/(water+ethanol), in vol.] (%) has been screened from 0 to 60%. The increase of water content from 0 to 10% led to a slight rise in the yield (from 70% to 74%). However, further increasing the water content caused a decrease in yield. Thus we chose a water content of 10% as the optimal condition for the next investigation.

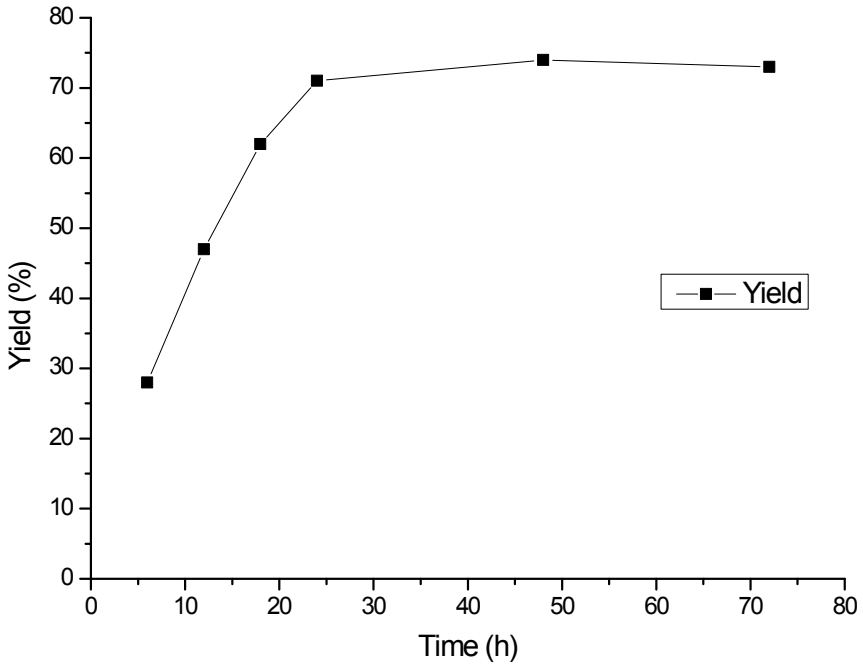


S-Figure 2 Influence of water content on the α-amylase-catalyzed three-component reaction.

The reactions were carried out with isatin (0.25 mmol), malononitrile (0.25 mmol) and acetone (7.5 mmol) in the presence of α-amylase (246 U) in ethanol and deionized water (ethanol + deionized water = 1.0 mL) at 25 ºC for 2

d. Yield of the isolated product.

In order to investigate the relationship between time and yield, we tested the time course of the α-amylase-catalyzed model three-component reaction (**S-Figure 3**). The product yield increased obviously within the first 24 hours, and after that the yield almost kept constant.



S-Figure 3 Time course of the α-amylase-catalyzed three-component reaction.

The reactions were carried out with isatin (0.25 mmol), malononitrile (0.25 mmol) and acetone (7.5 mmol) in the presence of α-amylase (246 U) in ethanol (0.90 mL) and deionized water (0.10 mL) at 25 ºC for 6-72 h. Yield of the isolated product.

5 Crystallographic data

X-ray crystal structure analysis of 6d

Crystal	6d
Empirical formula	$C_{13}H_{10}N_4O_3$
Formula weight	270.25
Temperature/K	288.91(10)
Crystal system	monoclinic

Space group	$P2_1/c$
a/Å	9.21681(17)
b/Å	7.14117(12)
c/Å	19.9378(3)
α/°	90
β/°	92.7636(15)
γ/°	90
Volume/Å^3	1310.76(4)
Z	4
ρ_{calc}g/cm^3	1.369
μ/mm^{-1}	0.848
F(000)	560.0
Crystal size/mm^3	0.06 × 0.05 × 0.05
Radiation	CuKα (λ = 1.54184)
2Θ range for data collection/°	9.608 to 142.806
Index ranges	$-11 \leq h \leq 7$, $-8 \leq k \leq 8$, $-24 \leq l \leq 24$
Reflections collected	9919
Independent reflections	2514 [R_{int} = 0.0241, R_{sigma} = 0.0169]
Data/restraints/parameters	2514/0/182
Goodness-of-fit on F^2	1.019
Final R indexes [I>=2σ (I)]	R_1 = 0.0448, wR_2 = 0.1217
Final R indexes [all data]	R_1 = 0.0462, wR_2 = 0.1231
Largest diff. peak/hole / e Å^{-3}	0.30/-0.33

Crystallographic data (excluding structure factors) for the structures reported in this work have been deposited with the Cambridge Crystallographic Data Centre as supplementary publication no. CCDC: 1053771. Copy of the data can be obtained free of charge on application to The Director, CCDC, 12 Union Road, Cambridge DB2 1EZ,UK (fax:+ 44 (1223) 336033; e-mail: deposit@ccdc.cam.ac.uk).

X-ray crystal structure analysis of 11b

Crystal	11b
Empirical formula	$C_{34}H_{30}N_6O_6$
Formula weight	614.61
Temperature/K	288.02(10)
Crystal system	monoclinic
Space group	$P2_1/c$
a/Å	8.82662(14)
b/Å	27.6395(4)
c/Å	13.1668(2)

α/°	90
β/°	105.9160(17)
γ/°	90
Volume/Å^3	3089.08(9)
Z	4
ρ_{calc}g/cm^3	1.322
μ/mm^{-1}	0.769
F(000)	1280.0
Crystal size/mm^3	0.13 × 0.12 × 0.11
Radiation	CuKα (λ = 1.54184)
2Θ range for data collection/°	9.474 to 142.996
Index ranges	-10 ≤ h ≤ 10, -33 ≤ k ≤ 33, -16 ≤ l ≤ 13
Reflections collected	22707
Independent reflections	5944 [R_{int} = 0.0351, R_{sigma} = 0.0237]
Data/restraints/parameters	5944/0/437
Goodness-of-fit on F^2	1.158
Final R indexes [I>=2σ (I)]	R_1 = 0.0639, wR_2 = 0.1699
Final R indexes [all data]	R_1 = 0.0663, wR_2 = 0.1714
Largest diff. peak/hole / e Å^{-3}	0.60/-0.22

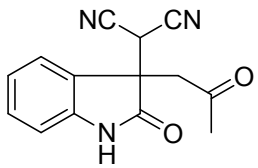
Crystallographic data (excluding structure factors) for the structures reported in this work have been deposited with the Cambridge Crystallographic Data Centre as supplementary publication no. CCDC: 1053772. Copy of the data can be obtained free of charge on application to The Director, `CCDC, 12 Union Road, Cambridge DB2 1EZ,UK (fax:+ 44 (1223) 336033; e-mail: deposit@ccdc.cam.ac.uk).

6 Enzymatic assay of α-amylase

Unit definition (U mg^{-1}), One unit will liberate 1.0 mg of maltose from starch in 3 minutes at pH 6.9 at 20 ºC.

The enzymatic assay was conducted according to the literature[1].

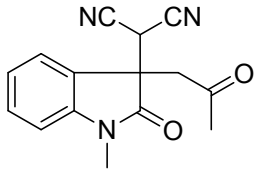
7 Characterization data of the products



4a

2-(2-oxo-3-(2-oxopropyl)indolin-3-yl)malononitrile[2, 3]

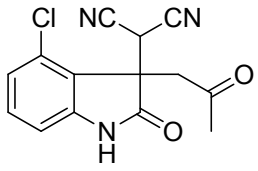
Mp 198-199 °C (lit. **2** 199-200 °C), ^{1}H NMR (300 MHz, DMSO-d6) δ 11.02 (s, 1H), 7.51 – 7.18 (m, 2H), 7.14 – 6.75 (m, 2H), 5.54 (s, 1H), 3.62 (d, J = 18.0 Hz, 1H), 3.29 (d, J = 18.0 Hz, 1H), 2.05 (s, 3H). ^{13}C NMR (75 MHz, DMSO-d6) δ 204.01, 175.77, 143.42, 130.31, 126.93, 123.77, 122.37, 112.00, 111.64, 110.52, 48.60, 46.04, 30.44, 30.23.



4b

2-(1-methyl-2-oxo-3-(2-oxopropyl)indolin-3-yl)malononitrile[2, 3]

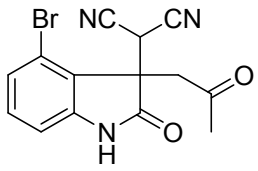
Mp 210-211 °C, ^{1}H NMR (300 MHz, DMSO-d6) δ 7.47 – 7.38 (m, 2H), 7.18 – 7.11 (m, 2H), 5.58 (s, 1H), 3.69 (d, J = 18.1 Hz, 1H), 3.32 (s, 1H), 3.21 (s, 3H), 3.15 (d, J = 6.0 Hz, 1H), 2.04 (s, 3H). ^{13}C NMR (75 MHz, DMSO-d6) δ 203.97, 174.17, 144.85, 130.46, 126.19, 123.48, 123.08, 111.87, 111.55, 109.55, 48.22, 46.17, 30.42, 30.15, 26.89.



4c

2-(4-chloro-2-oxo-3-(2-oxopropyl)indolin-3-yl)malononitrile[2, 3]

Mp 206-207 °C (lit. **2** 205-206 °C), ^{1}H NMR (300 MHz, DMSO-d6) δ 11.31 (s, 1H), 7.25 (t, J = 7.9 Hz, 1H), 7.16 (d, J = 7.7 Hz, 1H), 6.95 (d, J = 7.4 Hz, 1H), 5.53 (s, 1H), 3.91 (d, J = 18.1 Hz, 1H), 3.30 (d, J = 18.1 Hz, 1H), 2.08 (s, 3H). ^{13}C NMR (75 MHz, DMSO-d6) δ 203.81, 174.63, 146.09, 132.55, 126.20, 124.57, 117.92, 111.28, 110.91, 110.14, 50.35, 44.69, 29.93, 28.76.

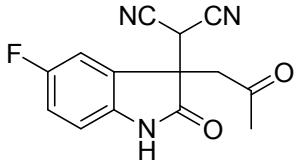


4d

2-(4-bromo-2-oxo-3-(2-oxopropyl)indolin-3-yl)malononitrile[2, 3]

Mp 197-199 °C (lit. **2** 200-201 °C), ^{1}H NMR (300 MHz, DMSO-d6) δ 11.32 (s, 1H), 7.32 (t, J =

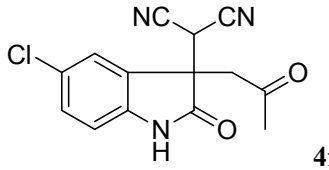
8.0 Hz, 1H), 7.02 (d, J = 8.1 Hz, 1H), 6.91 (d, J = 7.7 Hz, 1H), 5.56 (s, 1H), 3.84 (d, J = 18.1 Hz, 1H), 3.33 (d, J = 18.2 Hz, 1H), 2.07 (s, 3H). ^{13}C NMR (75 MHz, DMSO-d6) δ 203.89, 174.70, 145.80, 132.34, 129.62, 123.06, 122.94, 111.37, 111.02, 109.70, 49.70, 44.72, 29.93, 28.84.



4e

2-(5-fluoro-2-oxo-3-(2-oxopropyl)indolin-3-yl)malononitrile[2, 3]

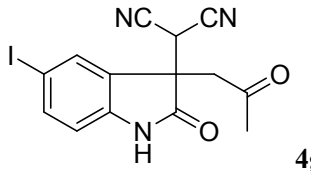
Mp 204-206 ^{o}C (lit. **2** 205-206 ^{o}C), ^{1}H NMR (300 MHz, DMSO-d6) δ 11.03 (s, 1H), 7.27 (m, 1H), 7.13 (m, 1H), 6.92 (m, 1H), 5.55 (s, 1H), 3.66 (d, J = 18.2 Hz, 1H), 3.30 (d, J = 18.2 Hz, 1H), 2.05 (s, 3H). ^{13}C NMR (75 MHz, DMSO-d6) δ 204.04, 175.72, 159.74, 156.59, 139.74, 128.61, 128.49, 116.79, 116.49, 112.16, 111.83, 111.74, 111.41, 111.32, 48.99, 45.99, 30.26, 30.06.



4f

2-(5-chloro-2-oxo-3-(2-oxopropyl)indolin-3-yl)malononitrile[2, 3]

Mp 210-211 ^{o}C (lit. **2** 209-210 ^{o}C), ^{1}H NMR (300 MHz, DMSO-d6) δ 11.14 (s, 1H), 7.45 (s, 1H), 7.35 (d, J = 8.3 Hz, 1H), 6.94 (d, J = 8.3 Hz, 1H), 5.56 (s, 1H), 3.69 (d, J = 18.3 Hz, 1H), 3.31 (d, J = 18.3 Hz, 1H), 2.05 (s, 3H). ^{13}C NMR (75 MHz, DMSO-d6) δ 204.13, 175.53, 142.47, 130.18, 129.00, 126.21, 124.23, 111.91, 111.72, 111.39, 48.73, 46.04, 30.23, 30.01.

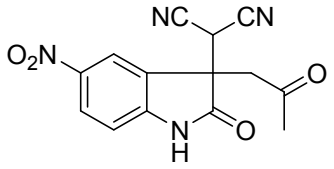


4g

2-(5-iodo-2-oxo-3-(2-oxopropyl)indolin-3-yl)malononitrile[3]

Mp 218-220 ^{o}C, ^{1}H NMR (300 MHz, DMSO-d6) δ 11.21 (s, 1H), 7.44 (s, 1H), 7.31 (d, J = 8.4 Hz, 1H), 7.01 (d, J = 8.5 Hz, 1H), 5.58 (s, 1H), 3.72 (d, J = 18.2 Hz, 1H), 3.32 (d, J = 18.2 Hz, 1H), 2.04 (s, 3H). ^{13}C NMR (75 MHz, DMSO-d6) δ 204.19, 175.80, 143.43, 142.69, 128.56, 123.57,

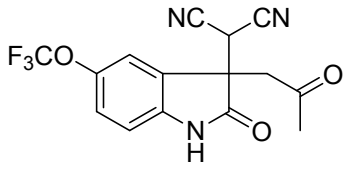
118.02, 111.62, 111.35, 48.81, 45.92, 30.16, 30.02.



4h

2-(5-nitro-2-oxo-3-(2-oxopropyl)indolin-3-yl)malononitrile[2]

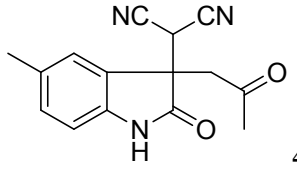
Mp 233-234 °C (lit. **2** 233-234 °C), ^{1}H NMR (300 MHz, DMSO-d6) δ 11.75 (s, 1H), 8.37 (d, J = 2.1 Hz, 1H), 8.27 (dd, J = 8.7, 2.2 Hz, 1H), 7.15 (d, J = 8.7 Hz, 1H), 5.71 (s, 1H), 3.88 (d, J = 18.4 Hz, 1H), 3.41 (d, J = 18.5 Hz, 1H), 2.06 (s, 3H). ^{13}C NMR (75 MHz, DMSO-d6) δ 204.34, 176.32, 150.00, 142.65, 127.98, 127.57, 120.21, 111.48, 111.18, 110.62, 48.53, 46.28, 29.94, 29.82.



4i

2-(2-oxo-3-(2-oxopropyl)-5-(trifluoromethoxy)indolin-3-yl)malononitrile[3]

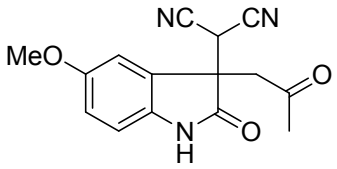
Mp 147-149 °C, ^{1}H NMR (300 MHz, DMSO-d6) δ 11.13 (s, 1H), 7.70 (s, 1H), 7.63 (d, J = 8.2 Hz, 1H), 6.78 (d, J = 8.2 Hz, 1H), 5.54 (s, 1H), 3.68 (d, J = 18.3 Hz, 1H), 3.29 (d, J = 18.3 Hz, 1H), 2.05 (s, 3H). ^{13}C NMR (75 MHz, DMSO-d6) δ 204.17, 175.26, 143.29, 138.80, 132.22, 129.63, 112.86, 111.75, 111.42, 85.13, 48.45, 46.06, 30.26, 30.04.



4j

2-(5-methyl-2-oxo-3-(2-oxopropyl)indolin-3-yl)malononitrile[2, 3]

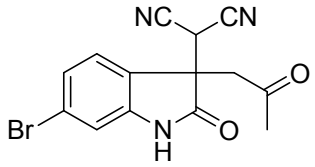
Mp 207-208 °C (lit. **2** 206-207 °C), ^{1}H NMR (300 MHz, DMSO-d6) δ 10.89 (s, 1H), 7.18 (s, 1H), 7.09 (d, J = 7.9 Hz, 1H), 6.81 (d, J = 7.9 Hz, 1H), 5.49 (s, 1H), 3.57 (d, J = 18.0 Hz, 1H), 3.25 (d, J = 18.1 Hz, 1H), 2.24 (s, 3H), 2.03 (s, 3H). ^{13}C NMR (75 MHz, DMSO-d6) δ 203.97, 175.72, 140.97, 131.25, 130.56, 127.02, 124.31, 112.04, 111.66, 110.29, 48.65, 46.07, 30.49, 30.23, 21.15.



4k

2-(5-methoxy-2-oxo-3-(2-oxopropyl)indolin-3-yl)malononitrile[2, 3]

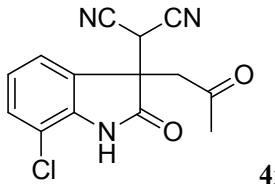
Mp 203-204 ^{o}C (lit. 202-203 ^{o}C), ^{1}H NMR (300 MHz, DMSO-d6) δ 10.81 (s, 1H), 7.01 (s, 1H), 6.84 (s, 2H), 5.50 (s, 1H), 3.69 (s, 3H), 3.60 (d, J = 18.1 Hz, 1H), 3.24 (d, J = 18.1 Hz, 1H), 2.03 (s, 3H). ^{13}C NMR (75 MHz, DMSO-d6) δ 203.98, 175.57, 155.22, 136.54, 128.18, 114.33, 111.97, 111.62, 111.22, 110.88, 55.76, 48.94, 46.00, 30.46, 30.22.



4l

2-(6-bromo-2-oxo-3-(2-oxopropyl)indolin-3-yl)malononitrile[3]

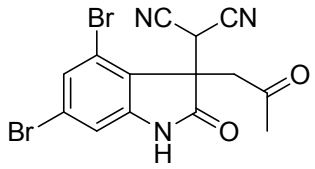
Mp 202-204 ^{o}C, ^{1}H NMR (300 MHz, DMSO-d6) δ 11.17 (s, 1H), 7.32 (d, J = 8.0 Hz, 1H), 7.23 (d, J = 8.0 Hz, 1H), 7.09 (s, 1H), 5.55 (s, 1H), 3.64 (d, J = 18.2 Hz, 1H), 3.31 (d, J = 18.2 Hz, 1H), 2.04 (s, 3H). ^{13}C NMR (75 MHz, DMSO-d6) δ 204.10, 175.67, 145.12, 126.35, 125.70, 125.05, 123.11, 113.32, 111.77, 111.42, 48.40, 46.03, 30.12, 30.08.



4m

2-(7-chloro-2-oxo-3-(2-oxopropyl)indolin-3-yl)malononitrile[2]

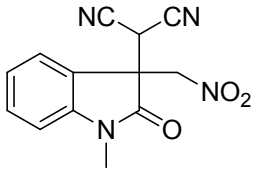
Mp 197-199 ^{o}C (lit. **2** 200-201 ^{o}C), ^{1}H NMR (300 MHz, DMSO-d6) δ 11.47 (s, 1H), 7.36 (t, J = 8.4 Hz, 2H), 7.04 (t, J = 7.9 Hz, 1H), 5.58 (s, 1H), 3.67 (d, J = 18.2 Hz, 1H), 3.35 (d, J = 18.2 Hz, 1H), 2.04 (s, 3H). ^{13}C NMR (75 MHz, DMSO-d6) δ 204.12, 175.75, 141.24, 130.38, 128.81, 123.70, 122.47, 114.71, 111.72, 111.41, 49.31, 46.23, 30.34, 30.07.



4n

2-(4,6-dibromo-2-oxo-3-(2-oxopropyl)indolin-3-yl)malononitrile[3]

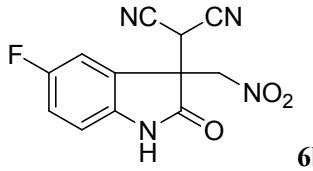
Mp 207-209 ^{o}C, ^{1}H NMR (300 MHz, DMSO-d6) δ 11.50 (s, 1H), 7.45 (d, J = 1.1 Hz, 1H), 7.12 (d, J = 1.1 Hz, 1H), 5.55 (s, 1H), 3.84 (d, J = 22.0 Hz, 1H), 3.33 (d, J = 18.3 Hz, 1H), 2.09 (s, 3H). ^{13}C NMR (75 MHz, DMSO-d6) δ 203.98, 174.61, 147.19, 127.98, 124.25, 118.81, 113.01, 111.17, 110.68, 50.20, 44.74, 29.83, 28.54.



6a

2-(1-methyl-3-(nitromethyl)-2-oxoindolin-3-yl)malononitrile

Mp 162-164 ^{o}C, ^{1}H NMR (300 MHz, DMSO-d6) δ 7.56 (d, J = 7.3 Hz, 1H), 7.49 (t, J = 7.7 Hz, 1H), 7.27 – 7.15 (m, 2H), 5.78 (s, 1H), 5.49 (q, J = 14.1 Hz, 2H), 3.24 (s, 3H). ^{13}C NMR (75 MHz, DMSO-d6) δ 171.80, 144.65, 131.80, 124.33, 123.83, 122.59, 111.11, 110.70, 110.36, 75.73, 49.69, 28.79, 27.17. HRMS (QFT-ESI): calcd for $C_{13}H_9N_4O_3$ $[M-H]^-$: 369.0680, found 369.0677. The purity was determined by HPLC on Daicel AD-H chiral column with *i*-PrOH /Hexane (20:80) as the eluent. Flow: 1.0 mL/min; λ = 254 nm: t_1 = 12.877 min; t_2 = 16.696 min

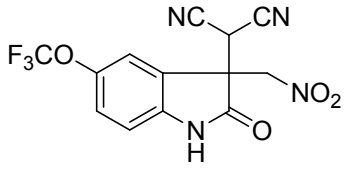


6b

2-(5-fluoro-3-(nitromethyl)-2-oxoindolin-3-yl)malononitrile

Mp 154-156 ^{o}C, ^{1}H NMR (300 MHz, DMSO-d6) δ 11.39 (s, 1H), 7.45 (dd, J = 8.1, 2.4 Hz, 1H), 7.25 (td, J = 9.2, 2.5 Hz, 1H), 7.01 (dd, J = 8.6, 4.3 Hz, 1H), 5.74 (s, 1H), 5.48 (dd, J = 39.5, 14.3 Hz, 2H). ^{13}C NMR (151 MHz, DMSO-d6) δ 173.43, 159.23, 157.65, 139.80, 124.99, 118.37, 118.22, 112.88, 112.71, 112.50, 112.44, 111.04, 110.57, 75.63, 50.49, 28.71. HRMS (QFT-ESI): calcd for $C_{12}H_6FN_4O_3$ $[M-H]^-$: 273.0430, found 273.0427. The purity was determined by HPLC

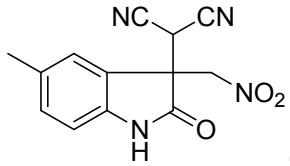
on Daicel AD-H chiral column with *i*-PrOH /Hexane (8:92) as the eluent. Flow: 1.0 mL/min; λ = 254 nm: t_1 = 48.874 min; t_2 = 55.111 min



6c

2-(3-(nitromethyl)-2-oxo-5-(trifluoromethoxy)indolin-3-yl)malononitrile

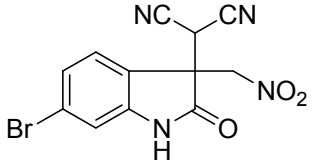
Mp 130-132 °C, ^{1}H NMR (300 MHz, DMSO-d6) δ 11.56 (s, 1H), 7.63 (s, 1H), 7.41 (d, J = 8.5 Hz, 1H), 7.09 (d, J = 8.6 Hz, 1H), 5.78 (s, 1H), 5.52 (dd, J = 46.7, 14.3 Hz, 2H). ^{13}C NMR (151 MHz, DMSO-d6) δ 173.51, 143.88, 142.69, 125.05, 121.43, 119.73, 118.80, 112.42, 110.94, 110.50, 75.58, 50.33, 28.61. HRMS (QFT-ESI): calcd for $C_{13}H_6F_3N_4O_4$ $[M-H]^-$: 339.0347, found 339.0345. The purity was determined by HPLC on Daicel AD-H chiral column with *i*-PrOH /Hexane (10:90) as the eluent. Flow: 1.0 mL/min; λ = 254 nm: t_1 = 14.710 min; t_2 = 16.237 min



6d

2-(5-methyl-3-(nitromethyl)-2-oxoindolin-3-yl)malononitrile

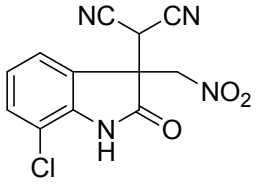
Mp 185-187 °C, ^{1}H NMR (300 MHz, DMSO-d6) δ 11.24 (s, 1H), 7.32 (s, 1H), 7.18 (d, J = 7.9 Hz, 1H), 6.88 (d, J = 7.9 Hz, 1H), 5.70 (s, 1H), 5.50 – 5.33 (m, 2H), 2.26 (s, 3H). ^{13}C NMR (75 MHz, DMSO-d6) δ 173.38, 140.88, 132.16, 131.95, 124.95, 123.39, 111.25, 111.04, 110.79, 75.82, 50.11, 28.78, 21.08. HRMS (QFT-ESI): calcd for $C_{13}H_9N_4O_3$ $[M-H]^-$: 269.0680, found 369.0678. The purity was determined by HPLC on Daicel AD-H chiral column with *i*-PrOH /Hexane (20:80) as the eluent. Flow: 1.0 mL/min; λ = 254 nm: t_1 = 6.061 min; t_2 = 7.630 min



6e

2-(6-bromo-3-(nitromethyl)-2-oxoindolin-3-yl)malononitrile

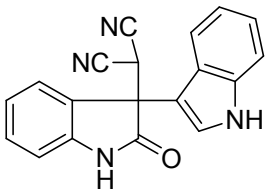
Mp 47-49 °C, ^{1}H NMR (300 MHz, DMSO-d6) δ 11.52 (s, 1H), 7.46 (d, J = 8.1 Hz, 1H), 7.35 (dd, J = 8.1, 1.7 Hz, 1H), 7.16 (d, J = 1.6 Hz, 1H), 5.75 (s, 1H), 5.47 (dd, J = 30.6, 14.2 Hz, 2H). ^{13}C NMR (75 MHz, DMSO-d6) δ 173.36, 144.94, 126.55, 125.93, 124.56, 122.74, 114.12, 111.05, 110.54, 75.54, 49.86, 28.49. The purity was determined by HPLC on Daicel AD-H chiral column with *i*-PrOH /Hexane (20:80) as the eluent. Flow: 1.0 mL/min; λ = 254 nm: t_1 = 26.809 min; t_2 = 31.815 min



6f

2-(7-chloro-3-(nitromethyl)-2-oxoindolin-3-yl)malononitrile

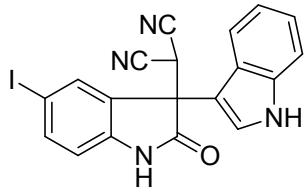
Mp 153-155 °C, ^{1}H NMR (300 MHz, DMSO-d6) δ 11.84 (s, 1H), 7.49 (dd, J = 7.2, 5.9 Hz, 2H), 7.15 (t, J = 7.9 Hz, 1H), 5.78 (s, 1H), 5.51 (q, J = 14.3 Hz, 2H). ^{13}C NMR (75 MHz, DMSO-d6) δ 173.49, 141.18, 131.72, 125.22, 124.50, 123.35, 115.40, 111.00, 110.53, 75.69, 50.73, 28.72. HRMS (QFT-ESI): calcd for $C_{12}H_6ClN_4O_3$ $[M-H]^-$: 289.0134, found 289.0135. The purity was determined by HPLC on Daicel AD-H chiral column with *i*-PrOH /Hexane (20:80) as the eluent. Flow: 1.0 mL/min; λ = 254 nm: t_1 = 14.154 min; t_2 = 24.643 min



8a

2-(3-(1H-indol-3-yl)-2-oxoindolin-3-yl)malononitrile

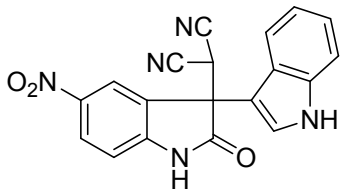
Brown oil, ^{1}H NMR (300 MHz, DMSO-d6) δ 11.45 (s, 1H), 11.24 (s, 1H), 7.43 (t, J = 8.1 Hz, 4H), 7.10 (ddd, J = 22.8, 15.4, 8.0 Hz, 4H), 6.89 (t, J = 7.5 Hz, 1H), 6.30 (s, 1H). ^{13}C NMR (75 MHz, DMSO-d6) δ 175.08, 142.65, 137.20, 130.91, 128.01, 125.63, 125.08, 124.62, 123.15, 122.28, 119.80, 119.54, 113.01, 112.56, 112.29, 111.15, 108.29, 60.17, 52.86, 30.17, 21.14, 14.46. HRMS (QFT-ESI): calcd for $C_{19}H_{11}N_4O$ $[M-H]^-$: 311.0938, found 311.0935. The purity was determined by HPLC on Elite Hypersil NH_2 column with methanol as the eluent. Flow: 1.0 mL/min; λ = 254 nm: t = 6.784 min.



8b

2-(3-(1H-indol-3-yl)-5-iodo-2-oxoindolin-3-yl)malononitrile

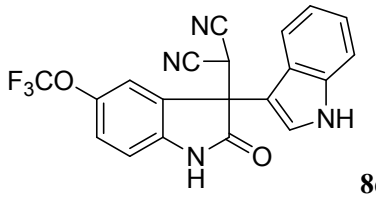
Brown oil, ^{1}H NMR (300 MHz, DMSO-d6) δ 11.47 (s, 1H), 11.41 (s, 1H), 7.76 (d, J = 8.2 Hz, 1H), 7.63 (s, 1H), 7.44 (dd, J = 11.5, 5.3 Hz, 2H), 7.15 – 7.01 (m, 2H), 6.93 (dd, J = 12.8, 7.8 Hz, 2H), 6.35 (s, 1H). ^{13}C NMR (75 MHz, DMSO-d6) δ 174.47, 142.29, 139.46, 137.12, 133.07, 130.63, 125.55, 124.37, 122.42, 120.01, 119.06, 113.60, 112.72, 112.04, 107.75, 85.90, 52.49, 29.81. HRMS (QFT-ESI): calcd for $C_{19}H_{10}IN_4O$ $[M-H]^-$: 436.9905, found 436.9901. The purity was determined by HPLC on Elite Hypersil NH_2 column with methanol as the eluent. Flow: 1.0 mL/min; λ = 254 nm: t = 19.035 min.



8c

2-(3-(1H-indol-3-yl)-5-nitro-2-oxoindolin-3-yl)malononitrile

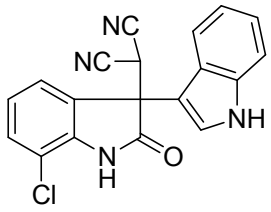
Brown oil, ^{1}H NMR (300 MHz, DMSO-d6) δ 12.03 (s, 1H), 11.56 (s, 1H), 8.39 (dd, J = 8.7, 2.2 Hz, 1H), 8.31 (d, J = 2.1 Hz, 1H), 7.54 (d, J = 2.6 Hz, 1H), 7.45 (d, J = 8.1 Hz, 1H), 7.37 – 7.25 (m, 2H), 7.13 (t, J = 7.5 Hz, 1H), 6.98 (t, J = 7.5 Hz, 1H), 6.53 (s, 1H). ^{13}C NMR (75 MHz, DMSO-d6) δ 175.44, 148.68, 143.23, 137.30, 128.78, 127.99, 126.14, 124.21, 122.54, 120.70, 120.18, 119.27, 112.82, 112.48, 111.88, 111.60, 106.93, 52.70, 29.72. HRMS (QFT-ESI): calcd for $C_{19}H_{10}N_5O_3$ $[M-H]^-$: 356.0789, found 356.0785. The purity was determined by HPLC on Elite Hypersil NH_2 column with methanol as the eluent. Flow: 1.0 mL/min; λ = 254 nm: t = 51.267 min.



8d

2-(3-(1H-indol-3-yl)-2-oxo-5-(trifluoromethoxy)indolin-3-yl)malononitrile

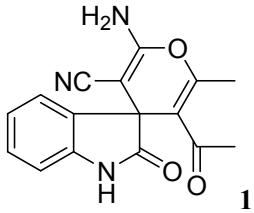
Brown oil, ^{1}H NMR (300 MHz, DMSO-d6) δ 11.51 (s, 2H), 7.55 – 7.36 (m, 4H), 7.23 (d, J = 8.5 Hz, 1H), 7.10 (dd, J = 14.9, 7.5 Hz, 2H), 6.93 (t, J = 7.5 Hz, 1H), 6.41 (s, 1H). ^{13}C NMR (75 MHz, DMSO-d6) δ 175.05, 143.93, 143.90, 141.86, 137.19, 129.48, 125.75, 124.40, 124.33, 122.42, 119.96, 119.18, 118.67, 112.71, 112.66, 112.37, 111.98, 107.41, 53.01, 29.94. HRMS (QFT-ESI): calcd for $C_{20}H_{10}F_3N_4O_2$ $[M-H]^-$: 395.0761, found 395.0758. The purity was determined by HPLC on Elite Hypersil NH_2 column with methanol as the eluent. Flow: 1.0 mL/min; λ = 254 nm: t = 18.902 min.



8e

2-(7-chloro-3-(1H-indol-3-yl)-2-oxoindolin-3-yl)malononitrile

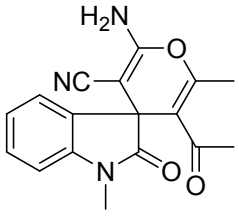
Brown oil, ^{1}H NMR (300 MHz, DMSO-d6) δ 11.74 (s, 1H), 11.50 (d, J = 1.4 Hz, 1H), 7.53 (d, J = 8.1 Hz, 1H), 7.42 (dd, J = 6.6, 3.4 Hz, 3H), 7.14 (dt, J = 19.8, 6.8 Hz, 3H), 6.94 (t, J = 7.5 Hz, 1H), 6.38 (s, 1H). ^{13}C NMR (75 MHz, DMSO-d6) δ 175.04, 140.37, 137.22, 130.95, 129.67, 125.79, 124.58, 128.41, 123.75, 122.41, 120.00, 119.37, 115.39, 112.70, 112.09, 107.61, 60.17, 53.63, 30.10. HRMS (QFT-ESI): calcd for $C_{19}H_{10}ClN_4O$ $[M-H]^-$: 345.0548, found 345.0544. The purity was determined by HPLC on Elite Hypersil NH_2 column with methanol as the eluent. Flow: 1.0 mL/min; λ = 254 nm: t = 14.718 min.



11a

3'-acetyl-6'-amino-2'-methyl-2-oxospiro[indoline-3,4'-pyran]-5'-carbonitrile[4]

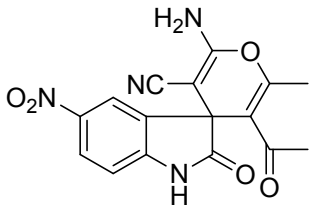
Mp 243-244 °C (lit. **4** 240 °C), ^{1}H NMR (300 MHz, DMSO-d6) δ 10.38 (s, 1H), 7.19 – 7.07 (m, 3H), 7.02 (d, J = 7.2 Hz, 1H), 6.90 (t, J = 7.4 Hz, 1H), 6.77 (d, J = 7.6 Hz, 1H), 2.27 (s, 3H), 2.07 (s, 3H). ^{13}C NMR (75 MHz, DMSO-d6) δ 197.89, 178.92, 159.60, 156.61, 142.34, 134.49, 128.89, 123.72, 122.26, 117.96, 115.22, 109.81, 57.02, 49.76, 31.73, 19.76.



11b

3'-acetyl-6'-amino-1,2'-dimethyl-2-oxospiro[indoline-3,4'-pyran]-5'-carbonitrile[4]

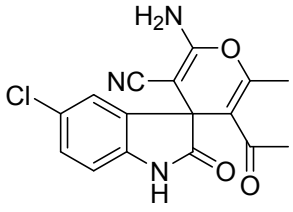
Mp 248-250 °C (lit. **4** 250-252 °C), ^{1}H NMR (300 MHz, DMSO-d6) δ 7.24 (t, J = 7.6 Hz, 1H), 7.17 (s, 2H), 7.08 (d, J = 7.0 Hz, 1H), 6.98 (t, J = 7.9 Hz, 2H), 3.11 (s, 3H), 2.30 (s, 3H), 2.07 (s, 3H). ^{13}C NMR (75 MHz, DMSO-d6) δ 197.15, 176.95, 159.16, 156.81, 143.37, 133.39, 128.57, 122.91, 122.48, 117.36, 114.76, 108.28, 56.27, 48.91, 31.31, 26.33, 19.47.



11c

3'-acetyl-6'-amino-2'-methyl-5-nitro-2-oxospiro[indoline-3,4'-pyran]-5'-carbonitrile[4]

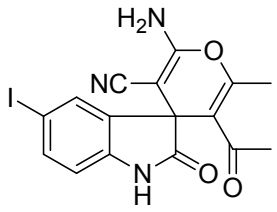
Mp >300 °C, ^{1}H NMR (300 MHz, DMSO-d6) δ 11.11 (s, 1H), 8.12 (dd, J = 8.6, 2.2 Hz, 1H), 7.93 (d, J = 2.0 Hz, 1H), 7.33 (s, 2H), 6.98 (d, J = 8.6 Hz, 1H), 2.42 (s, 3H), 2.24 (s, 3H). ^{13}C NMR (75 MHz, DMSO-d6) δ 197.34, 179.58, 160.12, 159.44, 148.97, 142.68, 136.44, 126.14, 119.00, 117.58, 114.60, 109.78, 55.93, 49.93, 32.00, 20.57.



11d

3'-acetyl-6'-amino-5-chloro-2'-methyl-2-oxospiro[indoline-3,4'-pyran]-5'-carbonitrile[4]

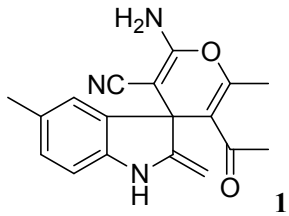
Mp 276 °C, ^{1}H NMR (300 MHz, DMSO-d6) δ 10.80 (s, 1H), 7.20 (d, J = 10.7 Hz, 3H), 7.00 (d, J = 7.0 Hz, 1H), 6.91 (t, J = 7.7 Hz, 1H), 2.33 (s, 3H), 2.16 (s, 3H). ^{13}C NMR (75 MHz, DMSO-d6) δ 197.65, 178.94, 159.47, 157.96, 140.17, 136.63, 128.80, 123.47, 122.21, 117.77, 115.10, 113.93, 56.60, 50.66, 31.93, 20.08.



11e

3'-acetyl-6'-amino-5-iodo-2'-methyl-2-oxospiro[indoline-3,4'-pyran]-5'-carbonitrile[4]

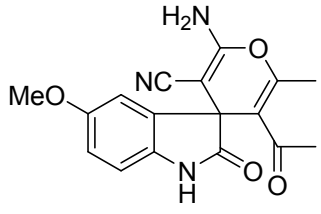
Mp >300 ^{o}C, ^{1}H NMR (300 MHz, DMSO-d6) δ 10.49 (s, 1H), 7.46 (d, J = 8.1 Hz, 1H), 7.32 (s, 1H), 7.19 (s, 2H), 6.63 (d, J = 8.1 Hz, 1H), 2.33 (s, 3H), 2.17 (s, 3H). ^{13}C NMR (75 MHz, DMSO-d6) δ 197.42, 178.44, 159.39, 158.58, 142.14, 137.79, 137.26, 131.68, 117.82, 114.86, 112.24, 84.91, 56.69, 49.82, 31.98, 20.27.



11f

3'-acetyl-6'-amino-2',5-dimethyl-2-methylenespiro[indoline-3,4'-pyran]-5'-carbonitrile[4]

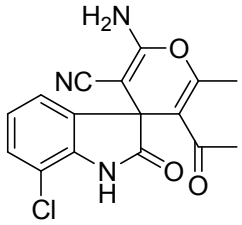
Mp 280-281 ^{o}C, ^{1}H NMR (300 MHz, DMSO-d6) δ 10.29 (s, 1H), 7.10 (s, 2H), 6.94 (d, J = 7.7 Hz, 1H), 6.83 (s, 1H), 6.66 (d, J = 7.8 Hz, 1H), 2.27 (s, 3H), 2.20 (s, 3H), 2.07 (s, 3H). ^{13}C NMR (75 MHz, DMSO-d6) δ 197.75, 178.90, 159.52, 156.69, 139.82, 134.70, 131.11, 129.17, 124.26, 118.01, 115.23, 109.58, 57.28, 49.82, 31.70, 21.04, 19.79.



11g

3'-acetyl-6'-amino-5-methoxy-2'-methyl-2-oxospiro[indoline-3,4'-pyran]-5'-carbonitrile[4]

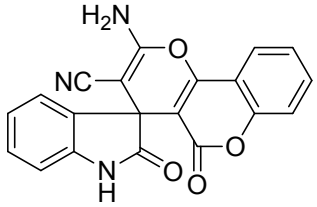
Mp 275-277 ^{o}C, ^{1}H NMR (600 MHz, DMSO-d6) δ 10.22 (s, 1H), 7.11 (s, 2H), 6.74 (dt, J = 17.9, 5.4 Hz, 2H), 6.68 (d, J = 2.5 Hz, 1H), 3.68 (s, 3H), 2.29 (s, 3H), 2.11 (s, 3H). ^{13}C NMR (151 MHz, DMSO-d6) δ 197.95, 178.88, 159.67, 156.57, 155.55, 135.82, 135.73, 118.04, 115.20, 113.55, 110.71, 110.31, 57.27, 55.87, 50.35, 31.75, 19.80.



11h

3'-acetyl-6'-amino-7-chloro-2'-methyl-2-oxospiro[indoline-3,4'-pyran]-5'-carbonitrile[4]

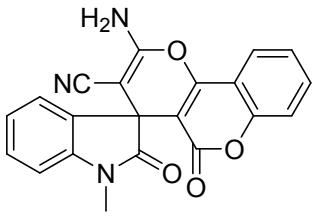
Mp 276-277 °C, ^{1}H NMR (300 MHz, DMSO-d6) δ 10.80 (s, 1H), 7.20 (d, J = 9.4 Hz, 3H), 7.00 (d, J = 7.0 Hz, 1H), 6.91 (t, J = 7.7 Hz, 1H), 2.33 (s, 3H), 2.16 (s, 3H). ^{13}C NMR (75 MHz, DMSO-d6) δ 197.66, 178.95, 159.47, 157.98, 140.16, 136.63, 128.80, 123.48, 122.21, 117.78, 115.09, 113.93, 56.59, 50.66, 31.93, 20.08.



13a

2'-amino-2,5'-dioxo-5'H-spiro[indoline-3,4'-pyrano[3,2-c]chromene]-3'-carbonitrile[5, 6]

Mp >300 °C (lit. **6** >300 °C), ^{1}H NMR (300 MHz, DMSO-d6) δ 10.69 (s, 1H), 7.92 (dd, J = 7.8, 1.1 Hz, 1H), 7.80 – 7.71 (m, 1H), 7.68 (s, 2H), 7.57 – 7.43 (m, 2H), 7.20 (dt, J = 7.4, 3.6 Hz, 2H), 6.92 (t, J = 7.4 Hz, 1H), 6.84 (d, J = 7.8 Hz, 1H). ^{13}C NMR (75 MHz, DMSO-d6) δ 177.58, 158.84, 158.69, 155.48, 152.43, 142.57, 134.08, 133.45, 129.34, 125.42, 124.54, 123.07, 122.47, 117.41, 117.07, 112.85, 109.92, 101.80, 57.37, 48.00.

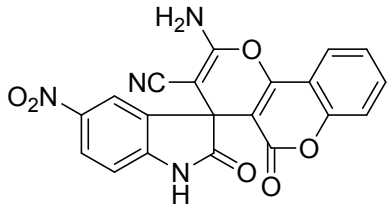


13b

2'-amino-1-methyl-2,5'-dioxo-5'H-spiro[indoline-3,4'-pyrano[3,2-c]chromene]-3'-carbonitril[6]

Mp 227-229 °C (lit. **6** 225 °C), ^{1}H NMR (600 MHz, DMSO-d6) δ 7.96 (d, J = 7.8 Hz, 1H), 7.74 (s, 2H), 7.53 (t, J = 7.7 Hz, 1H), 7.47 (d, J = 8.3 Hz, 1H), 7.34 (d, J = 7.8 Hz, 1H), 7.29 (d, J = 7.3 Hz, 1H), 7.09 (d, J = 7.8 Hz, 1H), 7.04 (t, J = 7.5 Hz, 1H), 3.23 (s, 3H). ^{13}C NMR (151 MHz, DMSO-

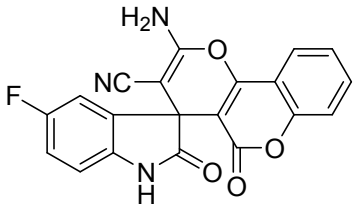
d6) δ 176.16, 159.07, 158.76, 155.65, 152.52, 144.14, 134.17, 132.71, 129.62, 125.46, 124.34, 123.32, 123.19, 117.36, 117.12, 112.89, 108.97, 101.77, 57.18, 56.55, 47.74, 27.03.



13c

2'-amino-5-nitro-2,5'-dioxo-5'H-spiro[indoline-3,4'-pyrano[3,2-c]chromene]-3'-carbonitrile[6]

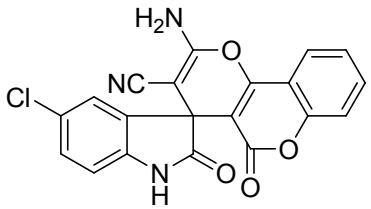
Mp 200-202 °C (lit. **6** 198 °C), ^{1}H NMR (600 MHz, DMSO-d6) δ 11.46 (s, 1H), 8.37 (d, J = 2.0 Hz, 1H), 8.23 (dd, J = 8.7, 2.1 Hz, 1H), 7.97 (d, J = 7.9 Hz, 1H), 7.87 (s, 2H), 7.77 (t, J = 7.8 Hz, 1H), 7.55 (t, J = 7.6 Hz, 1H), 7.49 (d, J = 8.3 Hz, 1H), 7.12 (d, J = 8.7 Hz, 1H). ^{13}C NMR (151 MHz, DMSO-d6) δ 178.41, 159.30, 159.19, 156.31, 152.61, 149.10, 143.25, 134.48, 134.22, 126.79, 125.47, 123.29, 121.01, 117.32, 117.14, 113.13, 110.20, 100.71, 56.54, 56.14, 48.28.



13d

2'-amino-5-fluoro-2,5'-dioxo-5'H-spiro[indoline-3,4'-pyrano[3,2-c]chromene]-3'-carbonitrile[6]

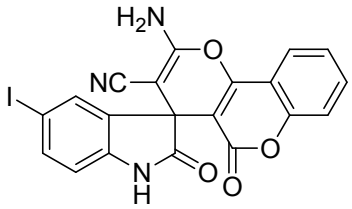
Mp >300 °C (lit. **6** >300 °C), ^{1}H NMR (600 MHz, DMSO-d6) δ 10.73 (s, 1H), 7.96 (d, J = 7.8 Hz, 1H), 7.73 (s, 2H), 7.54 (t, J = 7.6 Hz, 1H), 7.50 (d, J = 8.3 Hz, 1H), 7.27 (d, J = 7.5 Hz, 1H), 7.07 (t, J = 8.7 Hz, 1H), 6.88 (dd, J = 8.1, 3.9 Hz, 1H). ^{13}C NMR (151 MHz, DMSO-d6) δ 177.74, 159.64, 159.04, 158.88, 158.06, 155.82, 152.58, 138.90, 135.20, 135.15, 134.16, 125.45, 123.21, 117.35, 117.12, 115.75, 113.01, 112.71, 112.54, 110.74, 110.69, 101.41, 57.13, 48.61.



13e

2'-amino-5-chloro-2,5'-dioxo-5'H-spiro[indoline-3,4'-pyrano[3,2-c]chromene]-3'-carbonitrile[5, 6]

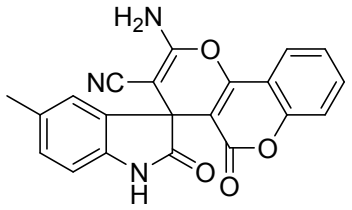
Mp 277-279 °C (lit. **6** 275 °C), ^{1}H NMR (300 MHz, DMSO-d6) δ 10.85 (s, 1H), 7.97 – 7.87 (m, 1H), 7.81 – 7.69 (m, 3H), 7.56 – 7.39 (m, 3H), 7.26 (dd, J = 8.3, 2.1 Hz, 1H), 6.88 (d, J = 8.3 Hz, 1H). ^{13}C NMR (75 MHz, DMSO-d6) δ 177.48, 158.98, 158.91, 155.84, 152.48, 141.50, 135.44, 134.07, 129.23, 126.53, 125.36, 125.00, 123.13, 117.37, 117.04, 112.96, 111.31, 101.15, 56.74, 48.28.



13f

2'-amino-5-iodo-2,5'-dioxo-5'H-spiro[indoline-3,4'-pyrano[3,2-c]chromene]-3'-carbonitrile[6]

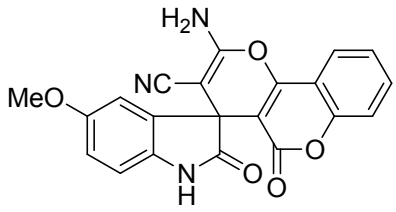
Mp >300 °C, ^{1}H NMR (600 MHz, DMSO-d6) δ 10.85 (s, 1H), 7.95 (d, J = 7.8 Hz, 1H), 7.75 (s, 2H), 7.67 (s, 1H), 7.58 (d, J = 8.1 Hz, 1H), 7.52 (t, J = 7.6 Hz, 1H), 7.48 (d, J = 8.3 Hz, 1H), 6.76 (d, J = 8.1 Hz, 1H). ^{13}C NMR (151 MHz, DMSO-d6) δ 177.24, 159.06, 159.00, 155.92, 152.55, 142.48, 137.97, 136.11, 134.10, 133.08, 125.42, 123.23, 117.48, 117.10, 113.08, 112.48, 101.31, 85.49, 56.99, 56.59, 48.12.



13g

2'-amino-5-methyl-2,5'-dioxo-5'H-spiro[indoline-3,4'-pyrano[3,2-c]chromene]-3'-carbonitrile[7]

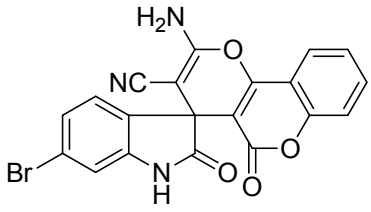
Mp >300 °C, ^{1}H NMR (300 MHz, DMSO-d6) δ 10.59 (s, 1H), 7.96 – 7.88 (m, 1H), 7.78 – 7.70 (m, 1H), 7.66 (s, 2H), 7.49 (dd, J = 18.9, 8.0 Hz, 2H), 7.01 (d, J = 10.0 Hz, 2H), 6.74 (d, J = 7.7 Hz, 1H), 2.18 (s, 3H). ^{13}C NMR (75 MHz, DMSO-d6) δ 177.55, 158.81, 158.70, 155.42, 152.41, 140.10, 134.03, 133.57, 131.41, 129.59, 125.40, 125.07, 123.05, 117.48, 117.04, 112.86, 109.66, 101.92, 57.57, 48.03, 20.98.



13h

2'-amino-5-methoxy-2,5'-dioxo-5'H-spiro[indoline-3,4'-pyrano[3,2-c]chromene]-3'-carbonitrile[6]

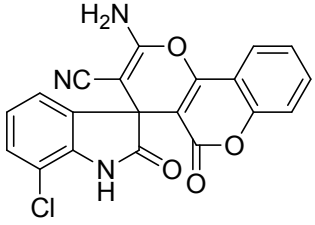
Mp 271-273 ^{o}C (lit. **6** 269 ^{o}C), ^{1}H NMR (600 MHz, DMSO-d6) δ 10.53 (s, 1H), 7.95 (dd, J = 7.9, 1.4 Hz, 1H), 7.78 – 7.72 (m, 1H), 7.67 (s, 2H), 7.52 (dd, J = 11.4, 4.1 Hz, 1H), 7.48 (d, J = 8.3 Hz, 1H), 6.94 (s, 1H), 6.80 (d, J = 1.4 Hz, 2H), 3.67 (s, 3H). ^{13}C NMR (151 MHz, DMSO-d6) δ 177.62, 158.92, 158.82, 155.78, 155.61, 152.53, 135.93, 134.79, 134.03, 125.38, 123.16, 117.55, 117.08, 114.26, 113.04, 111.40, 110.40, 101.89, 57.71, 55.89, 48.61



13i

2'-amino-6-bromo-2,5'-dioxo-5'H-spiro[indoline-3,4'-pyrano[3,2-c]chromene]-3'-carbonitrile[7]

Mp >300 ^{o}C, ^{1}H NMR (600 MHz, DMSO-d6) δ 10.88 (s, 1H), 7.95 (d, J = 7.9 Hz, 1H), 7.75 (s, 2H), 7.54 (t, J = 7.6 Hz, 1H), 7.49 (d, J = 8.3 Hz, 1H), 7.24 (d, J = 7.9 Hz, 1H), 7.15 (d, J = 7.9 Hz, 1H), 7.04 (s, 1H). ^{13}C NMR (151 MHz, DMSO-d6) δ 177.59, 159.02, 158.89, 155.80, 152.54, 144.34, 134.23, 132.81, 126.60, 125.51, 125.22, 123.19, 122.02, 117.37, 117.16, 112.91, 112.81, 101.30, 56.78, 56.53, 47.92.

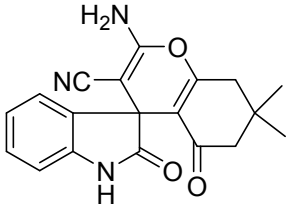


13j

2'-amino-7-chloro-2,5'-dioxo-5'H-spiro[indoline-3,4'-pyrano[3,2-c]chromene]-3'-

carbonitrile[6]

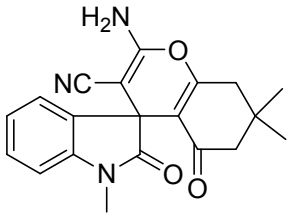
Mp >300 °C (lit. **6** >300 °C), ^{1}H NMR (300 MHz, DMSO-d6) δ 11.17 (s, 1H), 8.00 – 7.88 (m, 1H), 7.78 (s, 2H), 7.76 – 7.70 (m, 1H), 7.50 (dd, J = 16.7, 8.1 Hz, 2H), 7.25 (dd, J = 16.2, 7.7 Hz, 2H), 6.96 (t, J = 7.8 Hz, 1H). ^{13}C NMR (75 MHz, DMSO-d6) δ 177.67, 158.92, 158.84, 155.68, 152.45, 140.34, 135.15, 134.21, 129.43, 125.46, 123.82, 123.35, 123.14, 117.29, 117.10, 114.14, 112.78, 101.29, 56.80, 56.45, 48.87, 18.93.



15a

2-amino-7,7-dimethyl-2',5-dioxo-5,6,7,8-tetrahydrospiro[chromene-4,3'-indoline]-3-carbonitrile[5, 8-10]

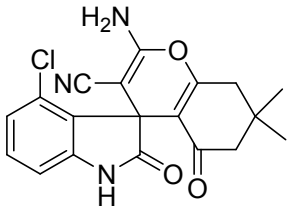
Mp >300 °C (lit. **10** >300 °C), ^{1}H NMR (300 MHz, DMSO-d6) δ 10.41 (s, 1H), 7.23 (s, 2H), 7.12 (t, J = 7.5 Hz, 1H), 6.97 (d, J = 7.0 Hz, 1H), 6.88 (t, J = 7.4 Hz, 1H), 6.78 (d, J = 7.6 Hz, 1H), 2.59 – 2.47 (m, 2H), 2.12 (q, J = 16.0 Hz, 2H), 0.99 (d, J = 9.8 Hz, 6H). ^{13}C NMR (75 MHz, DMSO-d6) δ 195.34, 178.48, 164.58, 159.17, 142.42, 134.81, 128.59, 123.41, 122.12, 117.78, 111.16, 109.67, 57.84, 50.38, 47.20, 32.34, 28.01, 27.40, 18.96.



15b

2-amino-1',7,7-trimethyl-2',5-dioxo-5,6,7,8-tetrahydrospiro[chromene-4,3'-indoline]-3-carbonitrile[9]

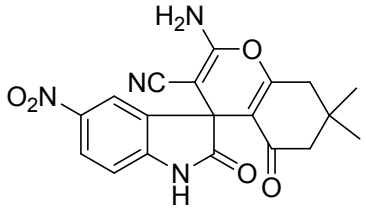
Mp 237-239 °C, ^{1}H NMR (300 MHz, DMSO-d6) δ 7.34 – 7.19 (m, 3H), 7.03 (d, J = 7.0 Hz, 1H), 6.96 (t, J = 7.5 Hz, 2H), 3.12 (s, 3H), 2.52 (d, J = 19.8 Hz, 2H), 2.10 (q, J = 16.0 Hz, 2H), 0.99 (d, J = 10.1 Hz, 6H). ^{13}C NMR (75 MHz, DMSO-d6) δ 195.35, 176.97, 164.69, 159.28, 143.93, 133.93, 128.82, 123.17, 122.87, 117.64, 111.10, 108.60, 57.37, 50.31, 46.84, 32.38, 27.93, 27.44, 26.77.



15c

2-amino-4'-chloro-7,7-dimethyl-2',5-dioxo-5,6,7,8-tetrahydrospiro[chromene-4,3'-indoline]-3-carbonitrile[8]

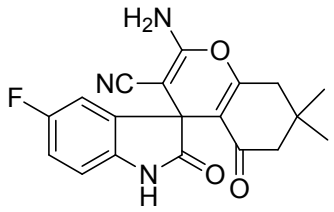
Mp >300 ^{o}C, ^{1}H NMR (300 MHz, DMSO-d6) δ 10.70 (s, 1H), 7.36 (s, 2H), 7.18 (t, J = 8.0 Hz, 1H), 6.89 (d, J = 8.1 Hz, 1H), 6.78 (d, J = 7.6 Hz, 1H), 2.64 – 2.38 (m, 2H), 2.15 (dd, J = 51.2, 16.1 Hz, 2H), 1.01 (d, J = 11.7 Hz, 6H). ^{13}C NMR (75 MHz, DMSO-d6) δ 195.52, 177.67, 165.53, 160.23, 144.40, 130.47, 129.49, 129.38, 122.51, 117.56, 109.73, 108.82, 54.79, 50.25 47.68, 32.16, 28.55, 26.96, 18.97.



15d

2-amino-7,7-dimethyl-5'-nitro-2',5-dioxo-5,6,7,8-tetrahydrospiro[chromene-4,3'-indoline]-3-carbonitrile[8, 9]

Mp >300 ^{o}C, ^{1}H NMR (300 MHz, DMSO-d6) δ 11.20 (s, 1H), 8.14 (dd, J = 8.6, 2.2 Hz, 1H), 7.96 (d, J = 2.1 Hz, 1H), 7.47 (s, 2H), 7.01 (d, J = 8.6 Hz, 1H), 2.57 (dd, J = 43.3, 17.5 Hz, 2H), 2.23 – 2.06 (m, 2H), 1.02 (d, J = 10.7 Hz, 6H). ^{13}C NMR (75 MHz, DMSO-d6) δ 195.81, 179.05, 165.63, 159.49, 149.04, 142.80, 135.76, 126.21, 119.27, 117.50, 110.14, 109.85, 56.44, 56.22, 50.17, 47.35, 32.45, 28.05, 27.38, 18.93.

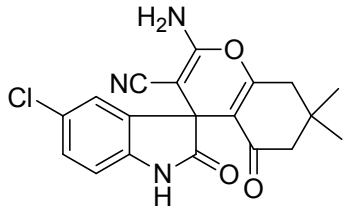


15e

2-amino-5'-fluoro-7,7-dimethyl-2',5-dioxo-5,6,7,8-tetrahydrospiro[chromene-4,3'-indoline]-

3-carbonitrile[8, 9]

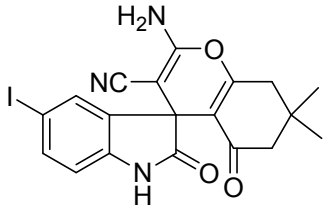
Mp 300 °C, ^{1}H NMR (300 MHz, DMSO-d6) δ 10.44 (s, 1H), 7.30 (s, 2H), 6.95 (t, J = 7.5 Hz, 2H), 6.84 – 6.70 (m, 1H), 2.53 (s, 2H), 2.13 (s, 2H), 1.02 (d, J = 11.6 Hz, 6H). ^{13}C NMR (75 MHz, DMSO-d6) δ 195.44, 195.41, 178.51, 164.88, 160.16, 159.28, 157.03, 138.69, 138.67, 136.53, 136.43, 117.62, 114.94, 114.64, 111.48, 111.15, 110.72, 110.36, 110.26, 57.36, 56.46, 50.37, 47.76, 47.74, 32.32, 27.77,27.72, 18.93.



15f

2-amino-5'-chloro-7,7-dimethyl-2',5-dioxo-5,6,7,8-tetrahydrospiro[chromene-4,3'-indoline]-3-carbonitrile[5, 8-10]

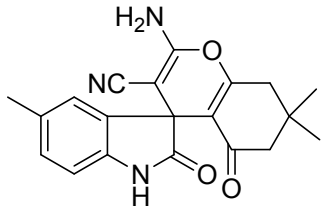
Mp 289-291 °C (lit. **10** 286-288 °C), ^{1}H NMR (300 MHz, DMSO-d6) δ 10.56 (s, 1H), 7.32 (s, 2H), 7.18 (dd, J = 8.2, 1.6 Hz, 1H), 7.09 (s, 1H), 6.80 (d, J = 8.2 Hz, 1H), 2.63 – 2.47 (m, 2H), 2.13 (s, 2H), 1.02 (d, J = 13.3 Hz, 6H). ^{13}C NMR (75 MHz, DMSO-d6) δ 195.55, 177.90, 165.01, 159.24, 142.30, 137.44, 137.17, 131.77, 117.68, 112.19, 110.61, 84.89, 57.16, 56.47, 50.33, 47.22, 32.41, 27.91, 27.59, 18.98.



15g

2-amino-5'-iodo-7,7-dimethyl-2',5-dioxo-5,6,7,8-tetrahydrospiro[chromene-4,3'-indoline]-3-carbonitrile[9]

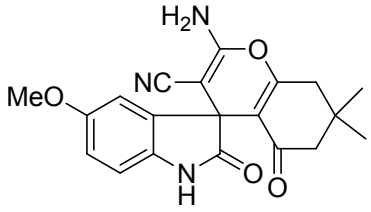
Mp 298-300 °C, ^{1}H NMR (300 MHz, DMSO-d6) δ 10.54 (s, 1H), 7.47 (d, J = 8.1 Hz, 1H), 7.31 (d, J = 3.1 Hz, 3H), 6.65 (d, J = 8.1 Hz, 1H), 2.53 (q, J = 17.5 Hz, 2H), 2.14 (s, 2H), 1.02 (d, J = 14.1 Hz, 6H). ^{13}C NMR (75 MHz, DMSO-d6) δ 195.55, 177.90, 165.01, 159.24, 142.30, 137.44, 137.17, 131.77, 117.68, 112.19, 110.61, 84.89, 57.16, 56.47, 50.33, 47.22, 32.41, 27.91, 27.59, 18.98.



15h

2-amino-5',7,7-trimethyl-2',5-dioxo-5,6,7,8-tetrahydrospiro[chromene-4,3'-indoline]-3-carbonitrile[9-11]

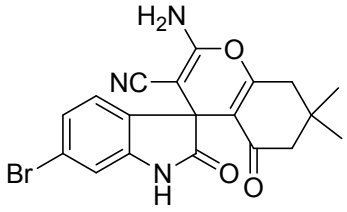
Mp 279-281 °C (lit. **11** 279-280 °C), ^{1}H NMR (300 MHz, DMSO-d6) δ 10.29 (s, 1H), 7.20 (s, 2H), 6.92 (d, J = 7.8 Hz, 1H), 6.77 (s, 1H), 6.66 (d, J = 7.8 Hz, 1H), 2.54 (s, 2H), 2.15 (d, J = 18.9 Hz, 5H), 1.00 (d, J = 6.0 Hz, 6H). ^{13}C NMR (75 MHz, DMSO-d6) δ 195.32, 178.43, 164.47, 159.11, 139.99, 134.91, 130.87, 128.85, 124.00, 117.82, 111.22, 109.40, 58.03, 50.41, 47.23, 32.36, 27.86, 27.60, 21.07.



15i

2-amino-5'-methoxy-7,7-dimethyl-2',5-dioxo-5,6,7,8-tetrahydrospiro[chromene-4,3'-indoline]-3-carbonitrile[8]

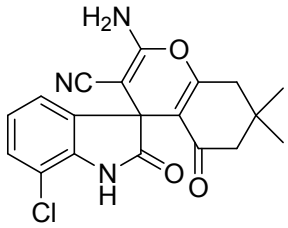
Mp 289-291 °C (lit. **8** 287-289 °C), ^{1}H NMR (300 MHz, DMSO-d6) δ 10.23 (s, 1H), 7.23 (s, 2H), 6.69 (s, 2H), 6.59 (s, 1H), 3.63 (s, 3H), 2.53 (s, 2H), 2.21 – 2.03 (m, 2H), 1.00 (d, J = 5.3 Hz, 6H). ^{13}C NMR (75 MHz, DMSO-d6) δ 195.34, 178.36, 164.56, 159.14, 155.35, 136.13, 135.75, 117.81, 112.91, 111.09, 110.48, 109.96, 57.89, 55.69, 50.40, 47.65, 32.34, 27.95, 27.49.



15j

2-amino-6'-bromo-7,7-dimethyl-2',5-dioxo-5,6,7,8-tetrahydrospiro[chromene-4,3'-indoline]-3-carbonitrile[7, 11]

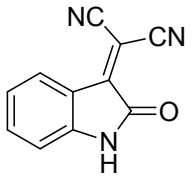
Mp >300 °C, (lit. **11** >300 °C) ^{1}H NMR (300 MHz, DMSO-d6) δ 10.58 (s, 1H), 7.32 (s, 2H), 7.07 (d, J = 7.9 Hz, 1H), 6.94 (dd, J = 10.0, 4.5 Hz, 2H), 2.51 (d, J = 15.1 Hz, 2H), 2.12 (q, J = 16.1 Hz, 2H), 0.99 (d, J = 8.1 Hz, 6H). ^{13}C NMR (75 MHz, DMSO-d6) δ 195.50, 178.33, 164.92, 159.23, 144.15, 134.09, 125.36, 124.75, 121.15, 117.63, 112.41, 110.67, 57.00, 56.45, 50.28, 47.00, 32.37, 27.87, 27.52, 18.96.



15k

2-amino-7'-chloro-7,7-dimethyl-2',5-dioxo-5,6,7,8-tetrahydrospiro[chromene-4,3'-indoline]-3-carbonitrile[9-11]

Mp >300 °C, (lit. **11** >300 °C), ^{1}H NMR (300 MHz, DMSO-d6) δ 10.86 (s, 1H), 7.34 (s, 2H), 7.20 (d, J = 7.8 Hz, 1H), 6.97 (d, J = 6.9 Hz, 1H), 6.90 (t, J = 7.6 Hz, 1H), 2.51 (d, J = 18.4 Hz, 2H), 2.13 (q, J = 16.0 Hz, 2H), 0.99 (d, J = 10.1 Hz, 6H). ^{13}C NMR (75 MHz, DMSO-d6) δ 195.51, 178.46, 164.90, 159.23, 140.17, 136.50, 128.69, 123.47, 122.19, 117.62, 113.91, 110.81, 57.17, 56.45, 50.25, 48.07, 32.38, 27.90, 27.44, 18.95.

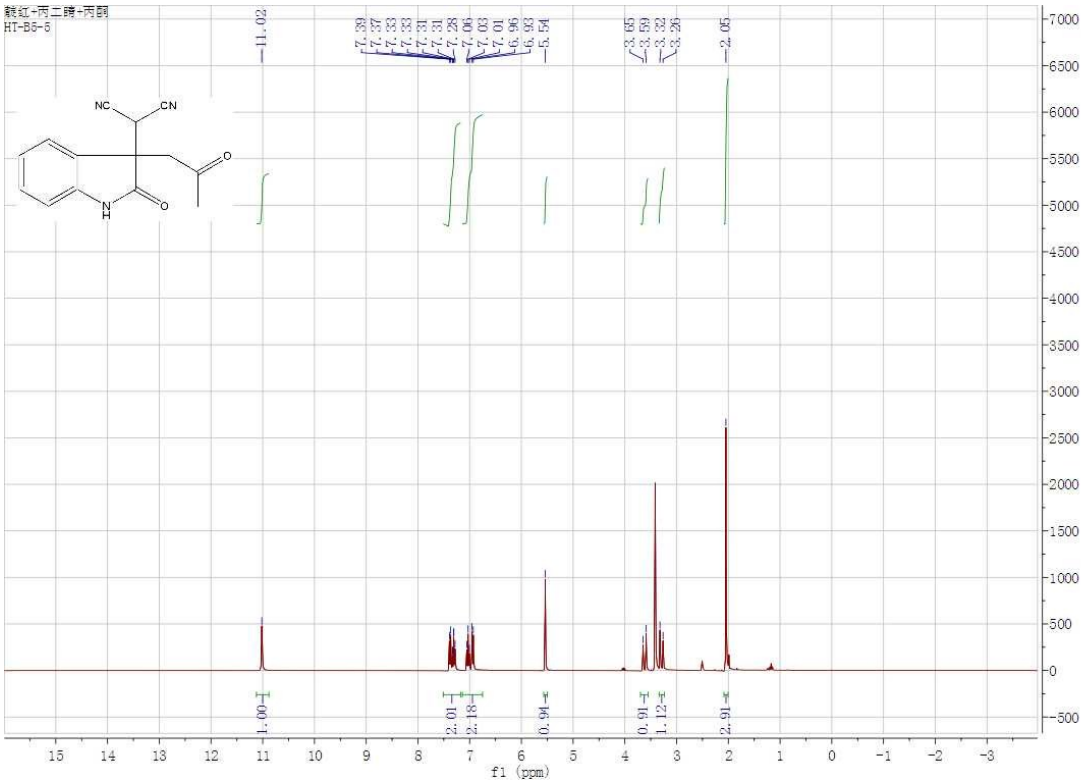


2-(2-oxoindolin-3-ylidene)malononitrile[12]

Mp 234-235 °C (lit. 232-233 °C), ^{1}H NMR (600 MHz, DMSO-d6) δ 11.20 (s, 1H), 7.88 (d, *J* = 7.8 Hz, 1H), 7.58 (td, *J* = 7.9, 0.9 Hz, 1H), 7.14 (t, *J* = 7.7 Hz, 1H), 6.94 (d, *J* = 7.9 Hz, 1H).

8 ^{1}H NMR, ^{13}C NMR, HRMS Spectra Copies and HPLC traces of the products

4a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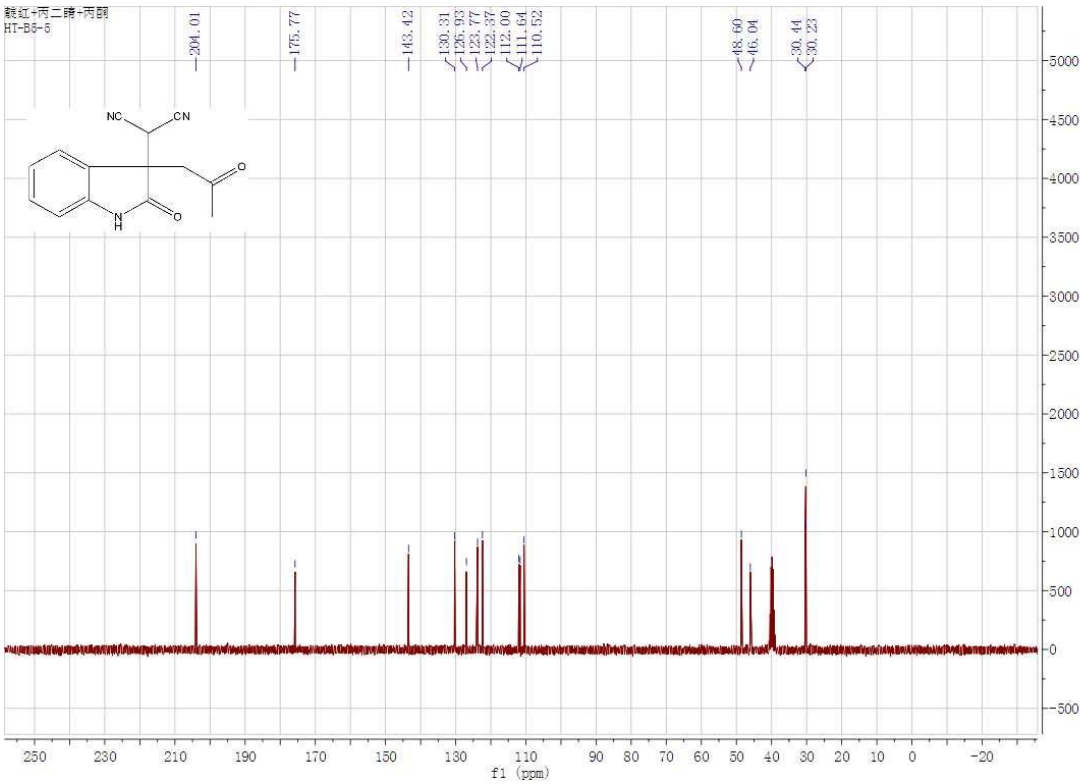
7.37
7.33
7.33
7.31
7.31
7.28
7.06
7.03
7.01
6.96
6.93
5.54
3.65
3.59
3.32
3.26
2.05
1.00
2.01
2.18
0.94
0.91
1.12
2.91
f1 (ppm)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175.77
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130.31
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123.77
122.37
122.00
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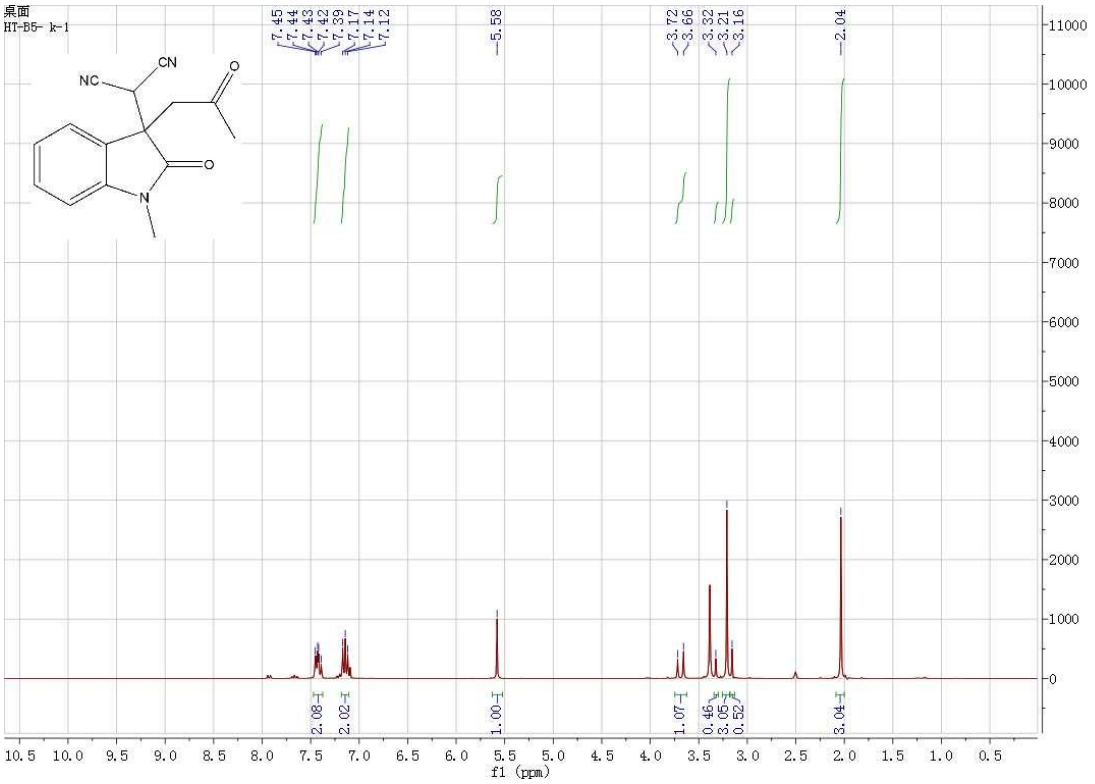
110.52
48.60
46.04
30.44
30.23
f1 (ppm)

4b


桌面
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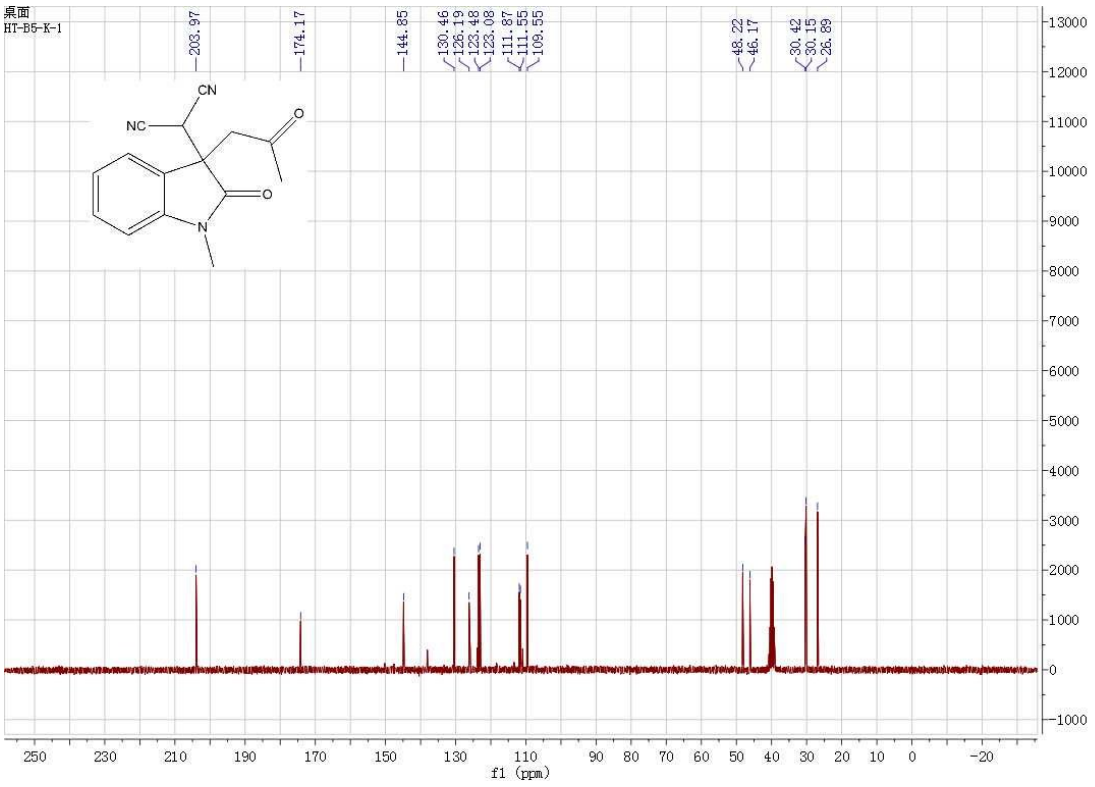
7.45
7.44
7.43
7.42
7.39
7.17
7.14
7.12
5.58
3.72
3.66
3.32
3.21
3.16
2.04
CN
NC
O
O
N
2.08
2.02
1.00
1.07
0.46
3.05
0.52
3.04
f1 (ppm)


桌面
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144.85
130.46
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123.48
123.08
111.87
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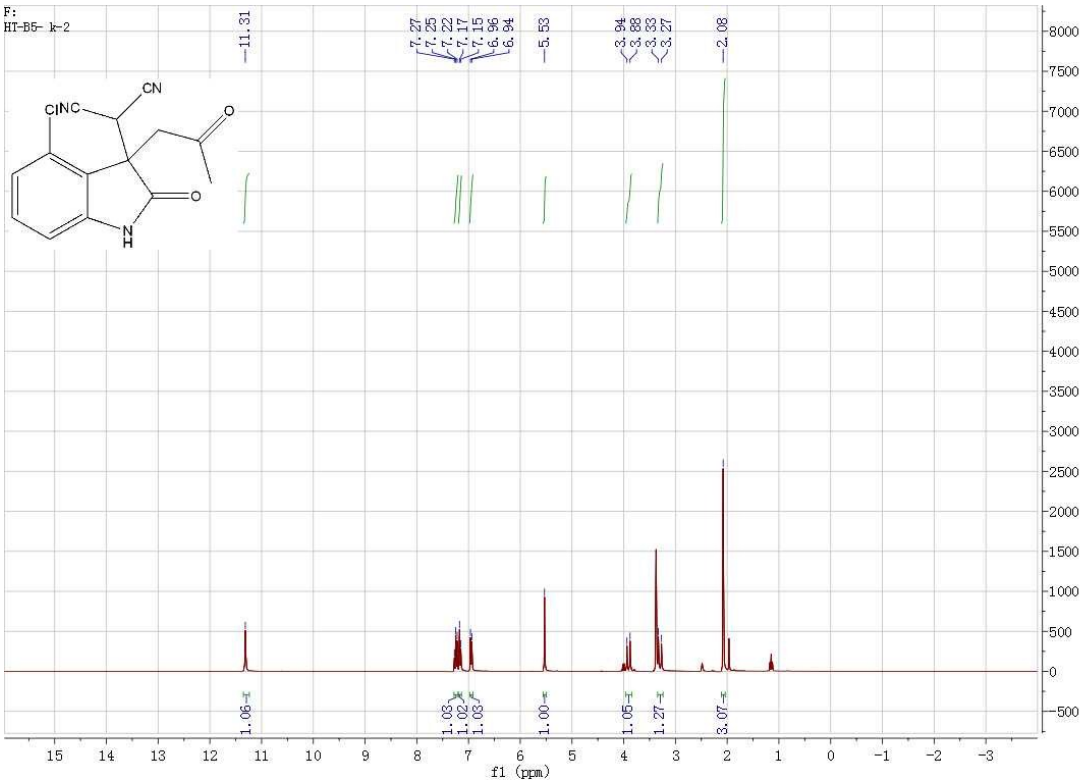
46.17
30.42
30.15
26.89
CN
NC
O
O
N
f1 (ppm)

4c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7.22
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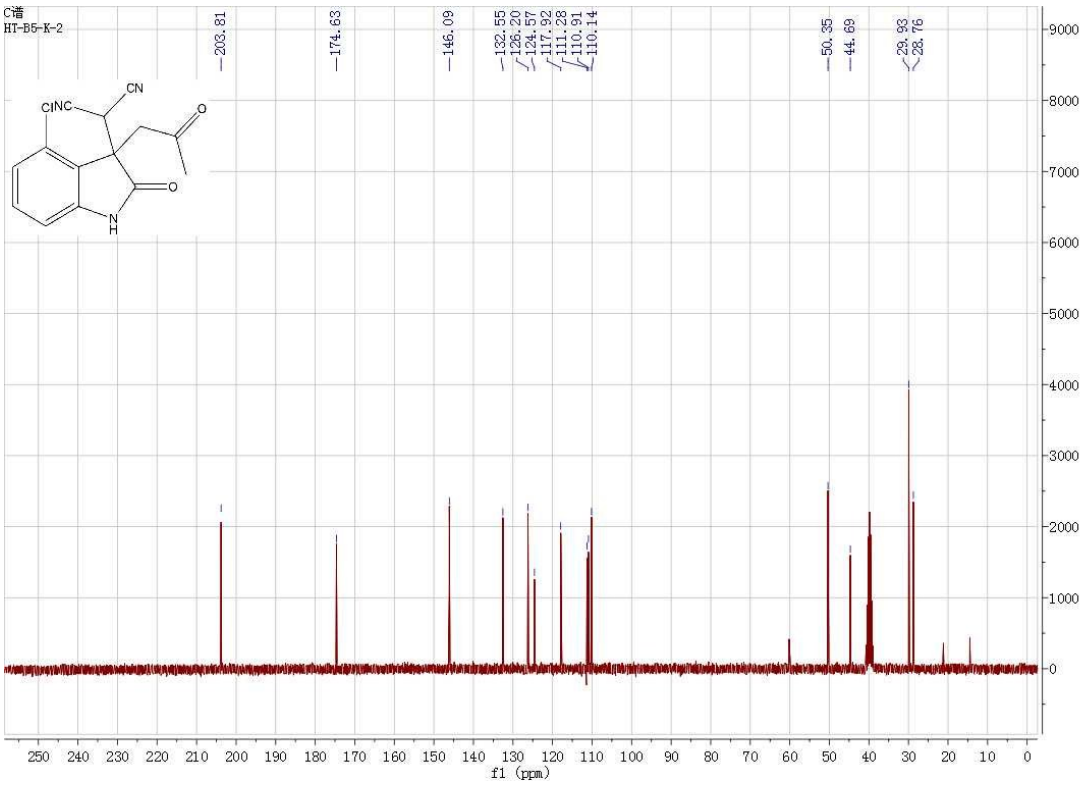
7.15
6.96
6.94
5.53
3.94
3.88
3.33
3.27
2.08
1.06
1.03
1.02
1.03
1.00
1.05
1.27
3.07
f1 (ppm)


C谱
HT-B5-K-2
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174.63
146.09
132.55
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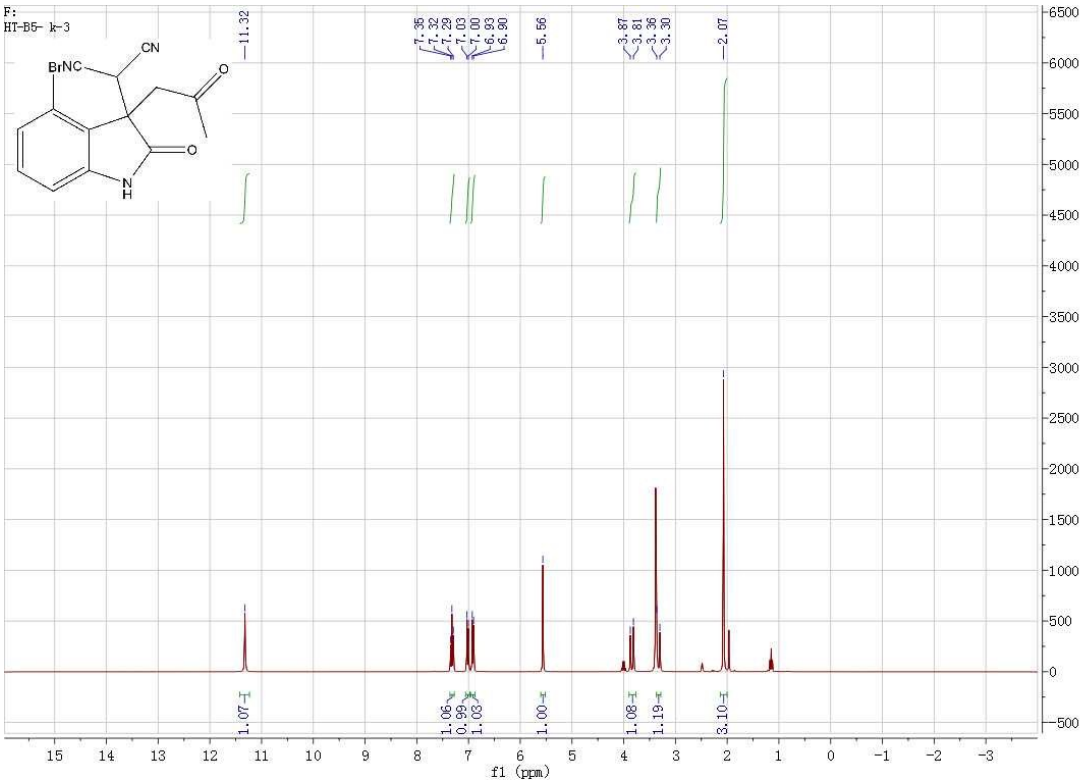
124.57
117.92
111.28
110.91
110.14
50.35
44.69
29.93
28.76
f1 (ppm)

4d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CN
O
O
N
H
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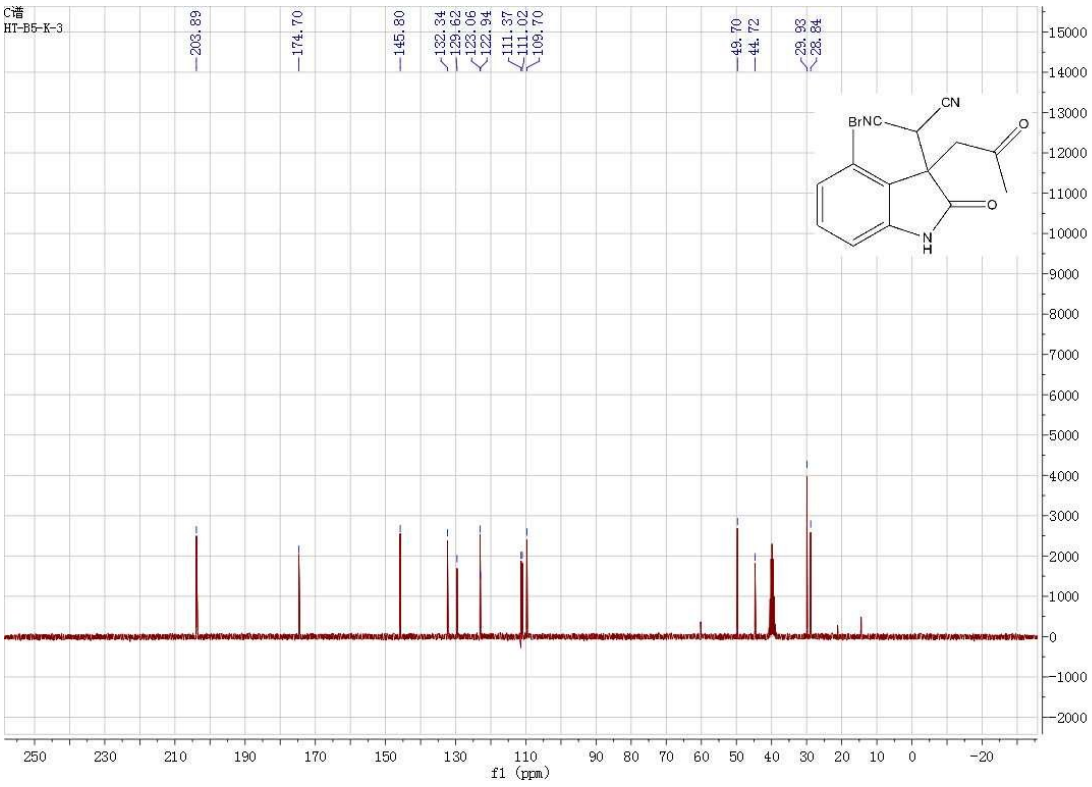
7.35
7.32
7.29
7.03
7.00
6.93
6.90
5.56
3.87
3.81
3.36
3.30
2.07
1.07
1.06
0.99
1.03
1.00
1.08
1.19
3.10
f1 (ppm)


C谱
HT-B5-K-3
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174.70
145.80
132.34
129.62
123.06
122.94
111.37
111.02
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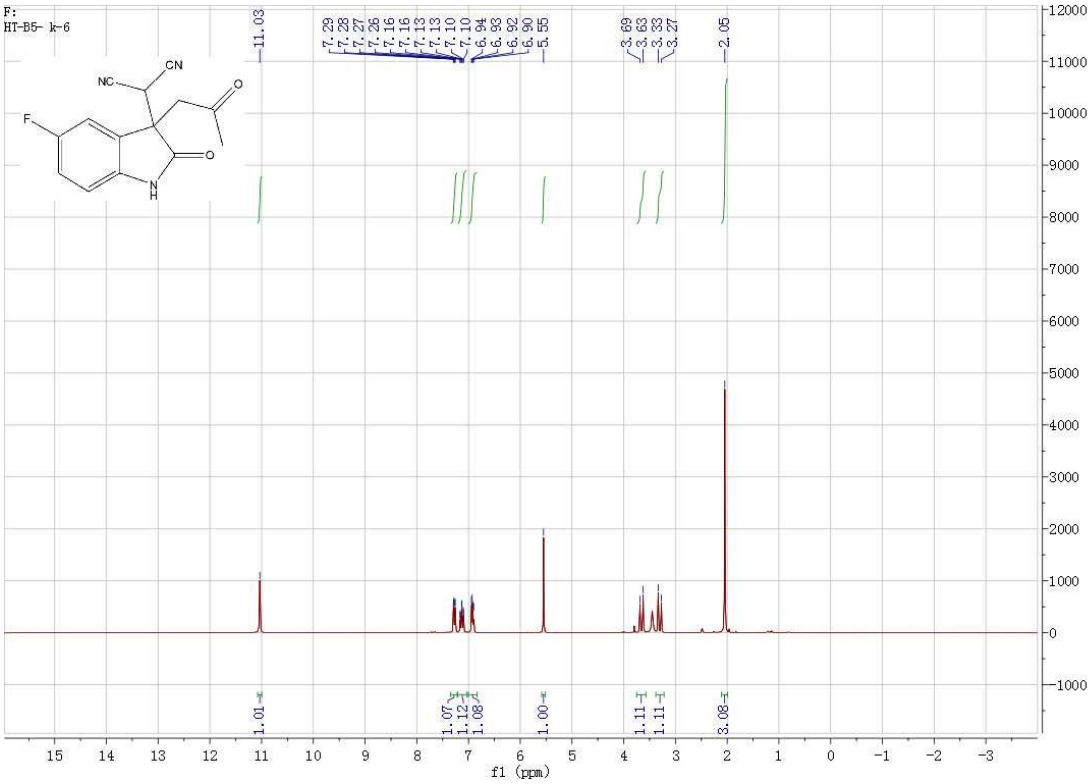
49.70
44.72
29.93
28.84
BrNC
CN
O
O
N
H
f1 (ppm)

4e


F:
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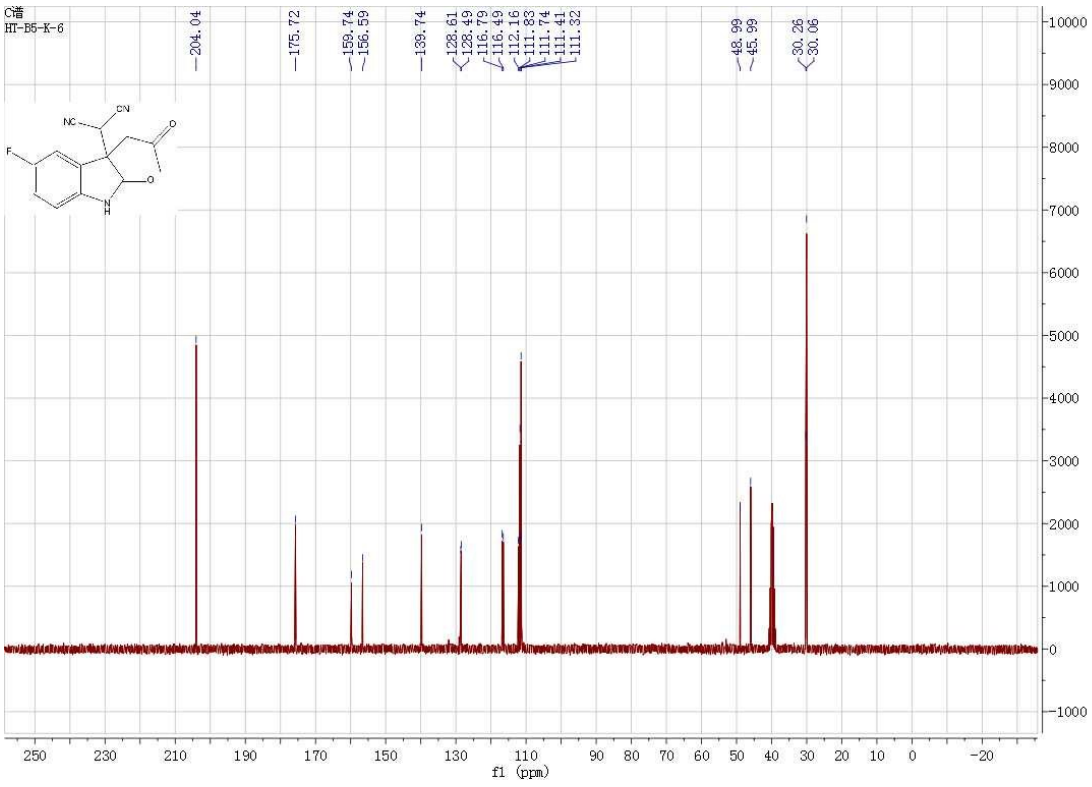
7.29
7.28
7.27
7.26
7.16
7.13
7.13
7.10
7.10
6.94
6.93
6.92
6.90
5.55
3.69
3.63
3.33
3.27
2.05
1.01
1.07
1.12
1.08
1.00
1.11
1.11
3.08
f1 (ppm)


C谱
HT-B5-K-6
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175.72
159.74
156.59
139.74
128.61
128.49
116.79
116.49
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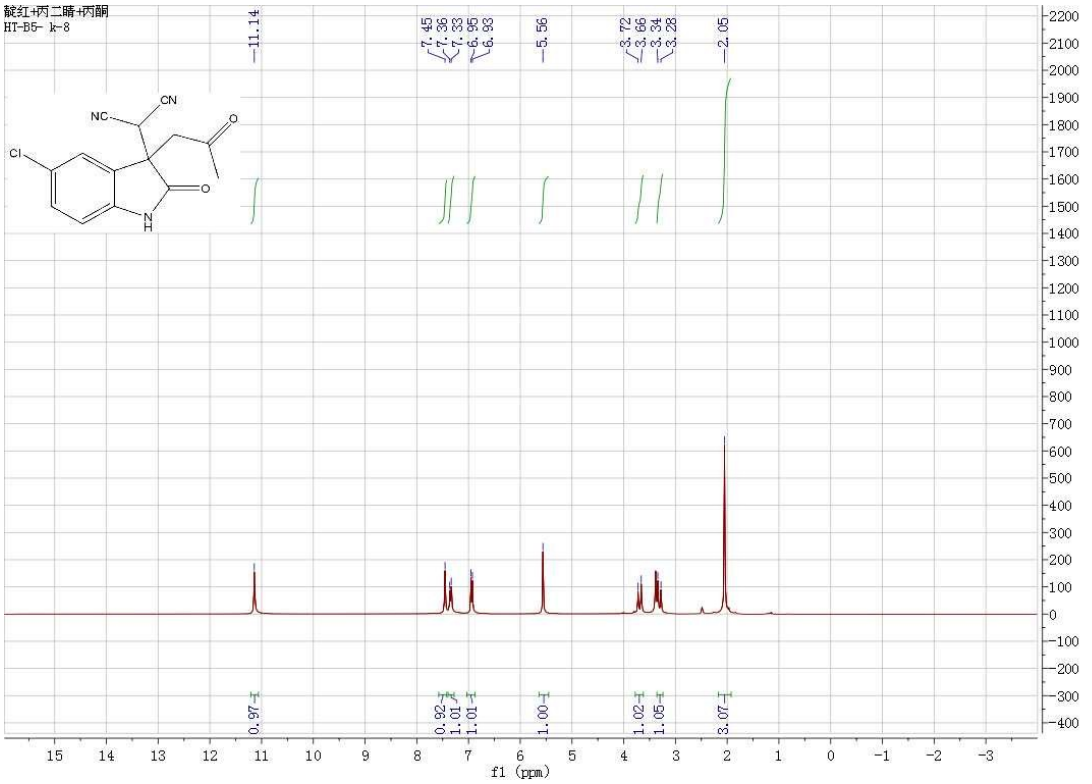
111.74
111.41
111.32
48.99
45.99
30.26
30.06
f1 (ppm)

4f


靛红+丙二睛+丙酮
HT-B5- k-8
11.14
7.45
7.36
7.33
6.95
6.93
5.56
3.72
3.66
3.34
3.28
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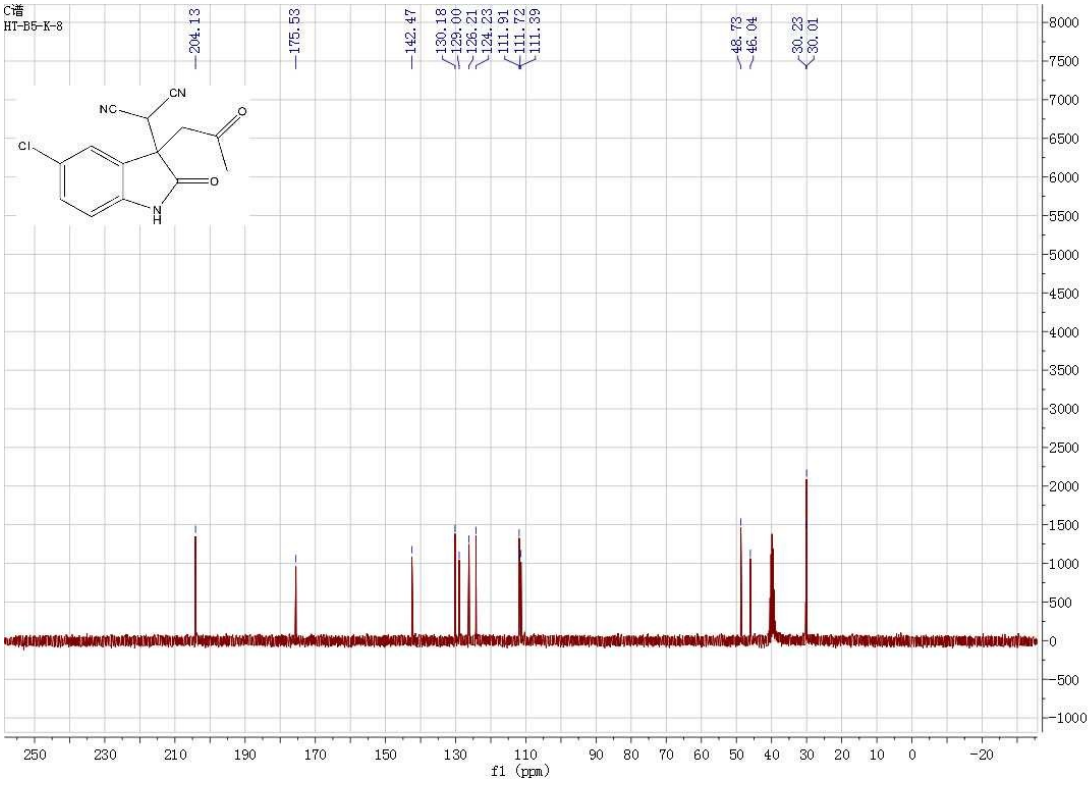
0.97
0.92
1.01
1.01
1.00
1.02
1.05
3.07
f1 (ppm)


C谱
HT-B5-K-8
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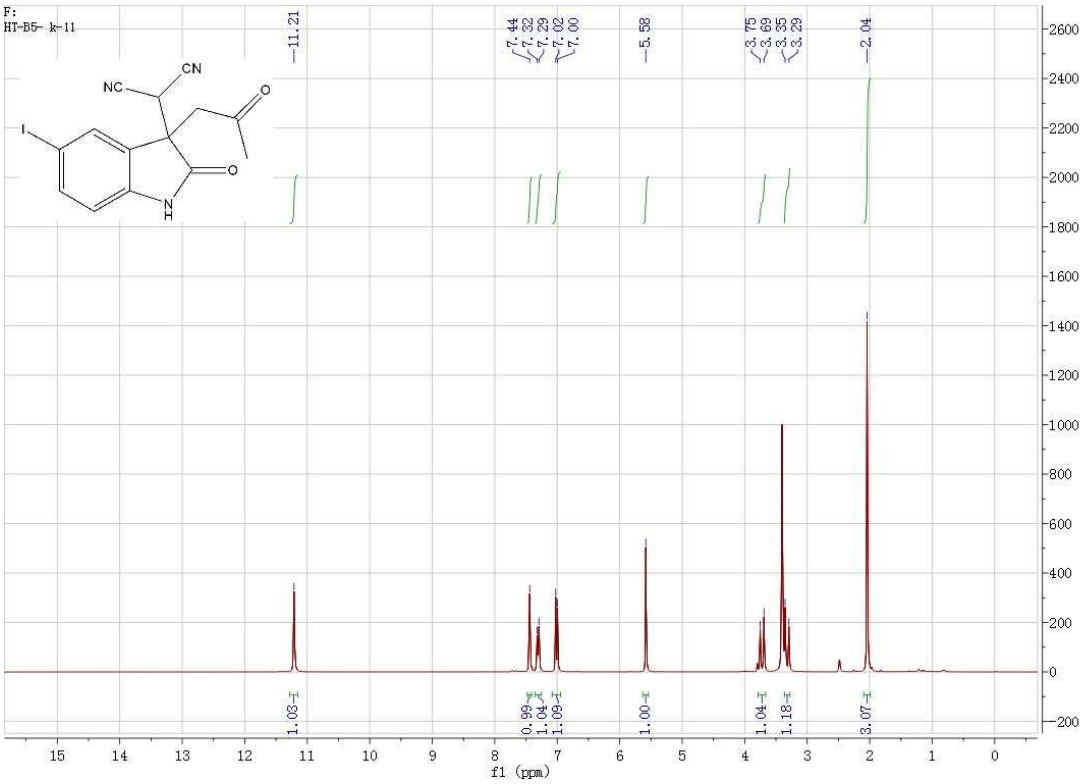
175.53
142.47
130.18
129.00
126.21
124.23
111.91
111.72
111.39
48.73
46.04
30.23
30.01
f1 (ppm)

4g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7.00
5.58
3.75
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1.03
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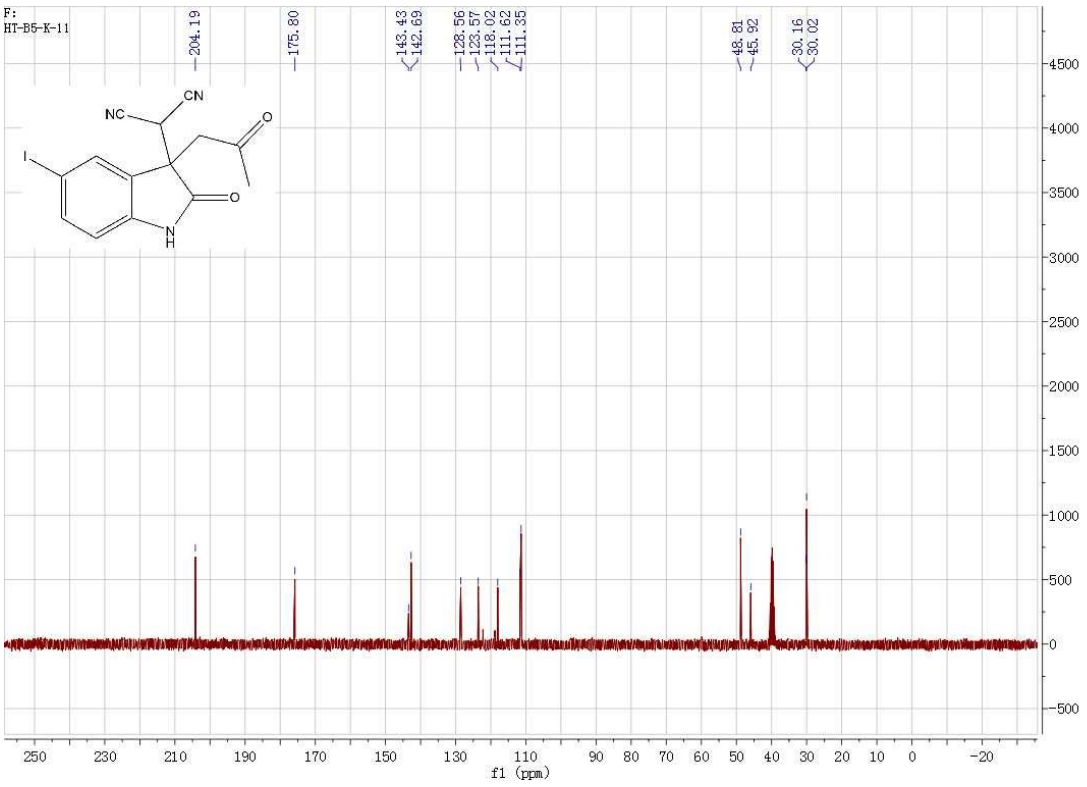
1.04
1.09
1.00
1.04
1.18
3.07
f1 (ppm)


F:
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143.43
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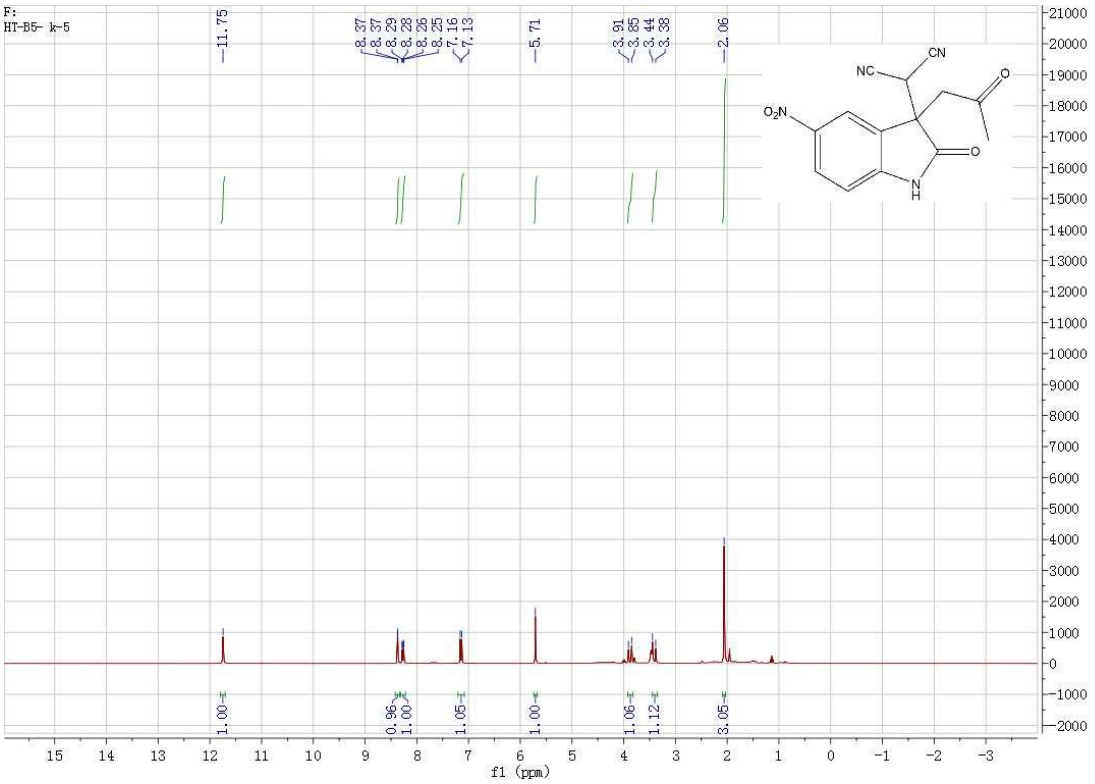
45.92
30.16
30.02
f1 (ppm)

4h


F:
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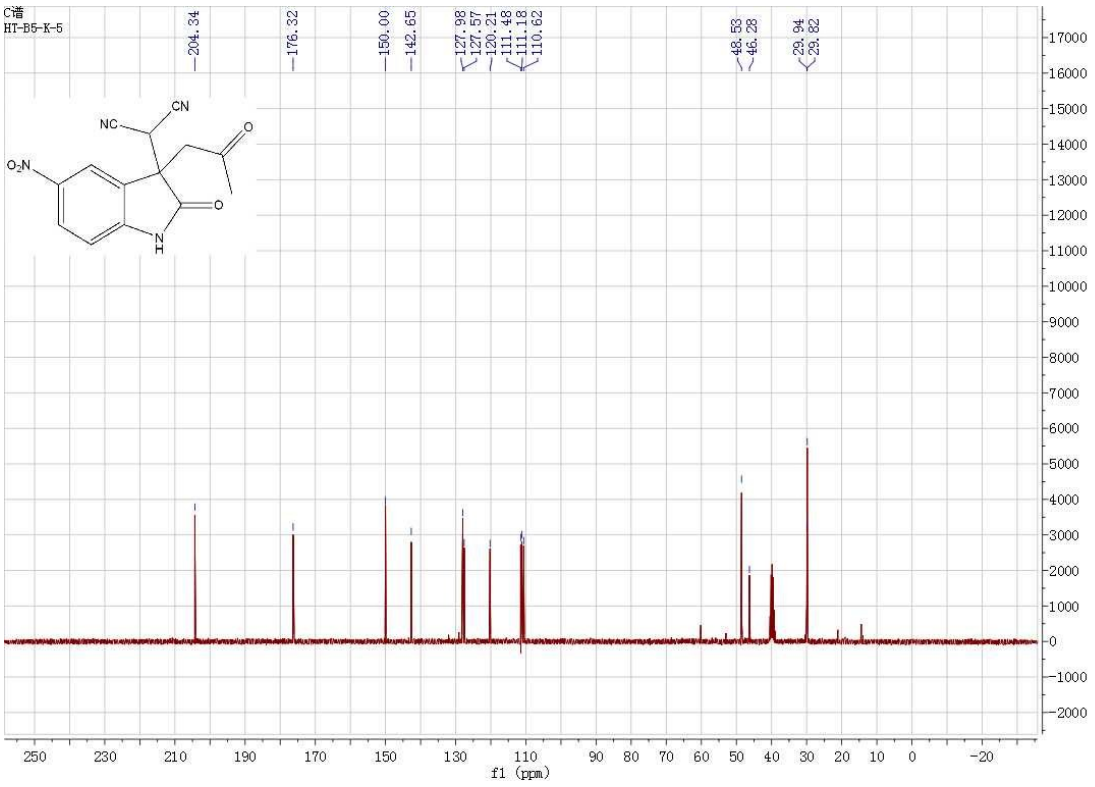
8.37
8.37
8.29
8.28
8.26
8.25
7.16
7.13
5.71
3.91
3.85
3.44
3.38
2.06
1.00
0.96
1.00
1.05
1.00
1.06
1.12
3.05
f1 (ppm)


C谱
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142.65
127.98
127.57
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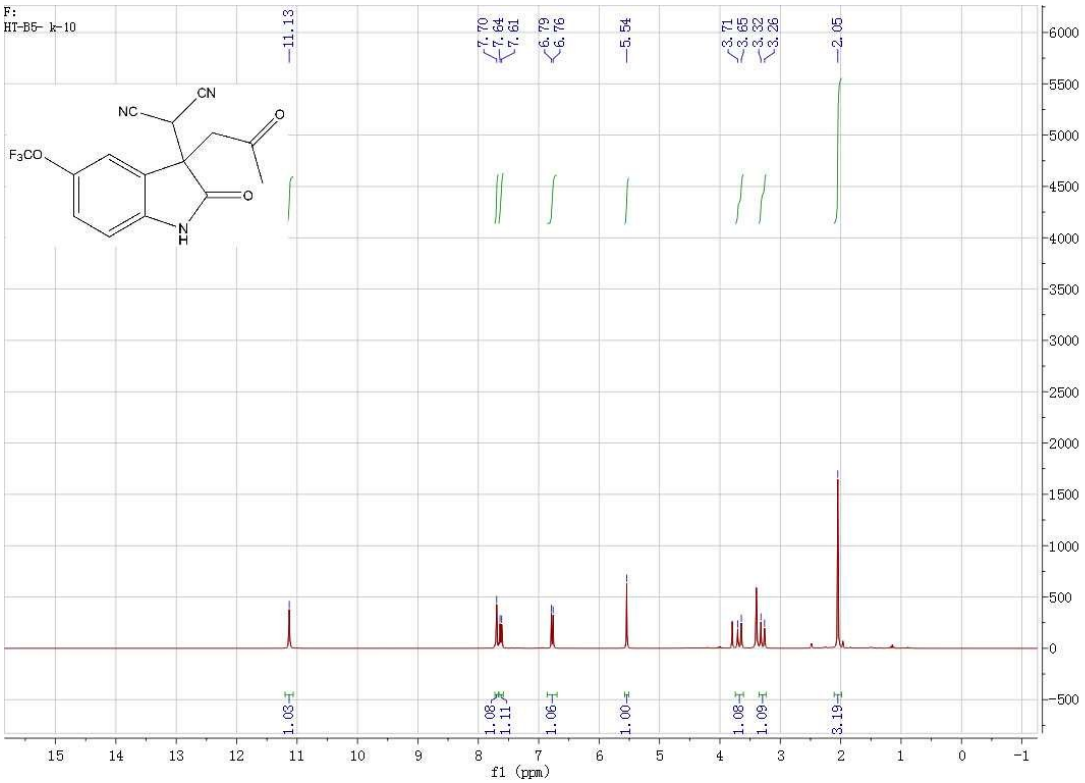
111.48
111.18
110.62
48.53
46.28
29.94
29.82
f1 (ppm)

4i


F:
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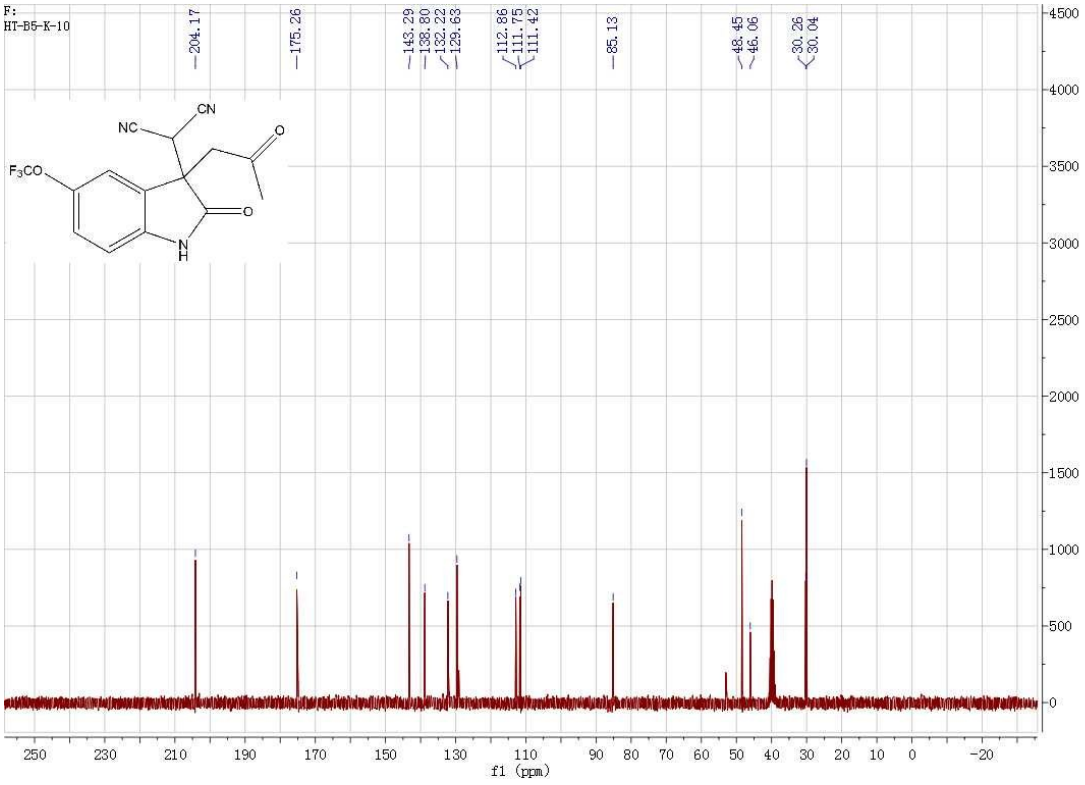
7.70
7.64
7.61
6.79
6.76
5.54
3.71
3.65
3.32
3.26
2.05
NC
CN
O
F3CO
O
N
H
1.03
1.08
1.11
1.06
1.00
1.08
1.09
3.19
f1 (ppm)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46.06
30.26
30.04
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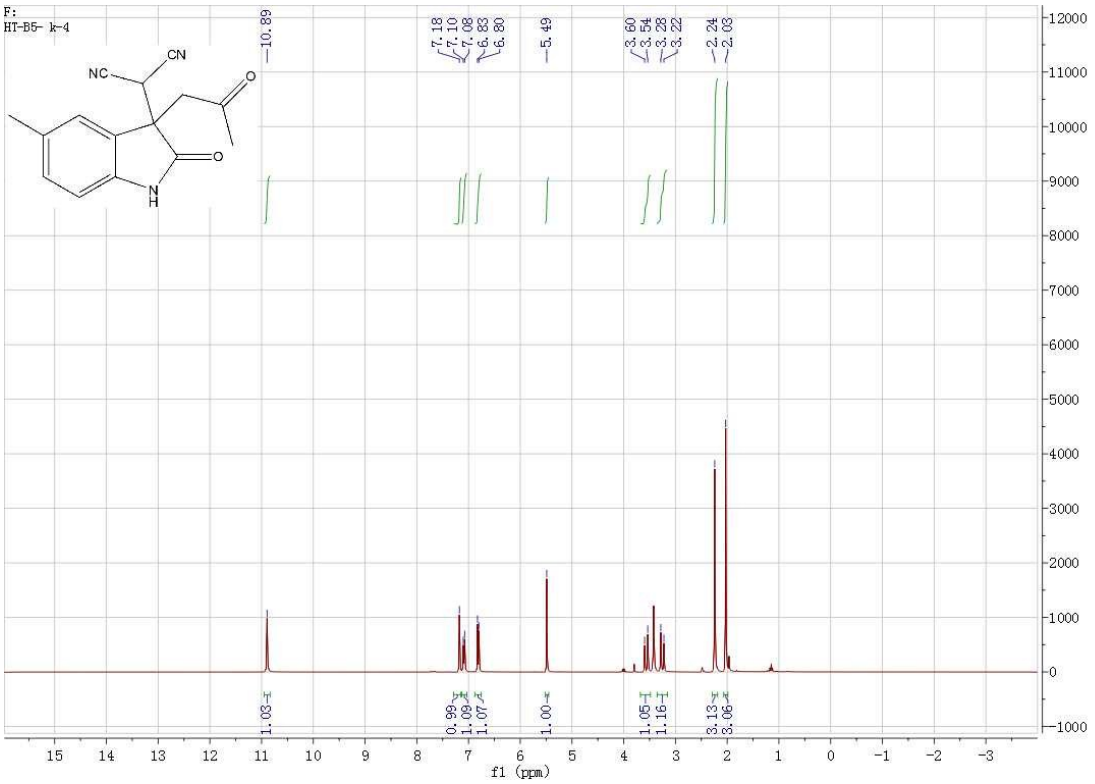
CN
O
F3CO
O
N
H
f1 (ppm)

4j


F:
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6.80
5.49
3.60
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3.28
3.22
2.24
2.03
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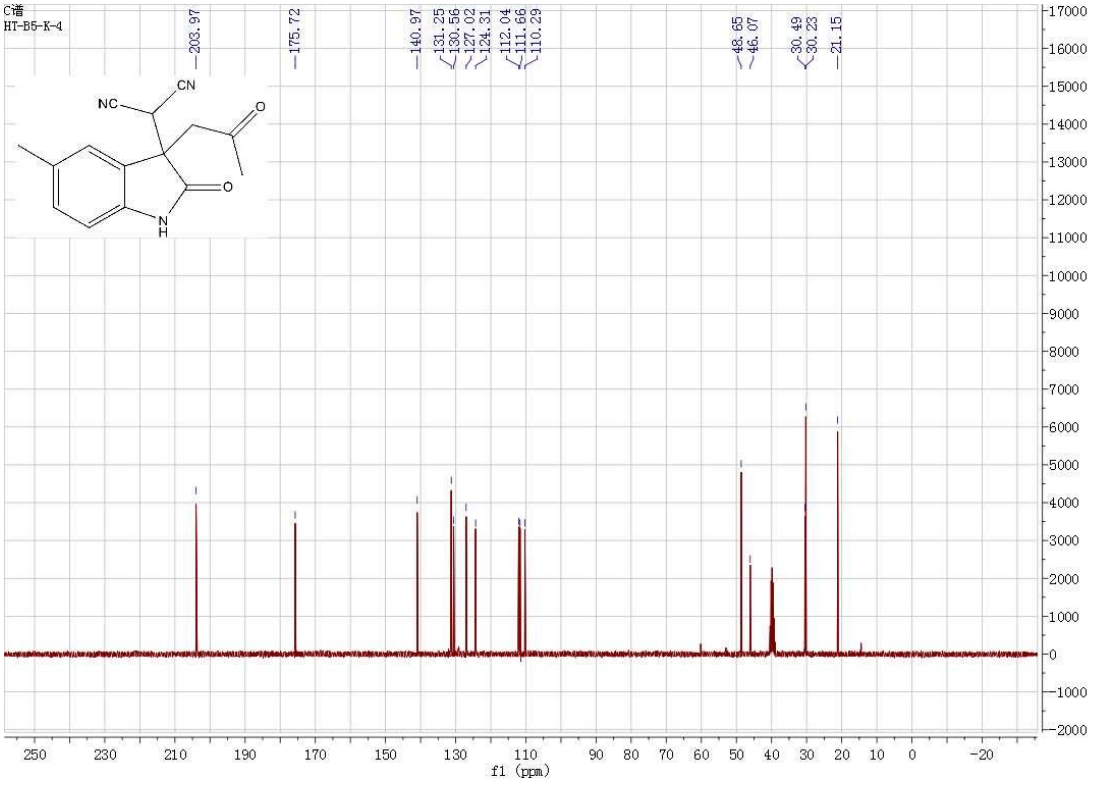
0.99
1.09
1.07
1.00
1.05
1.16
3.13
3.06
f1 (ppm)


C谱
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140.97
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124.31
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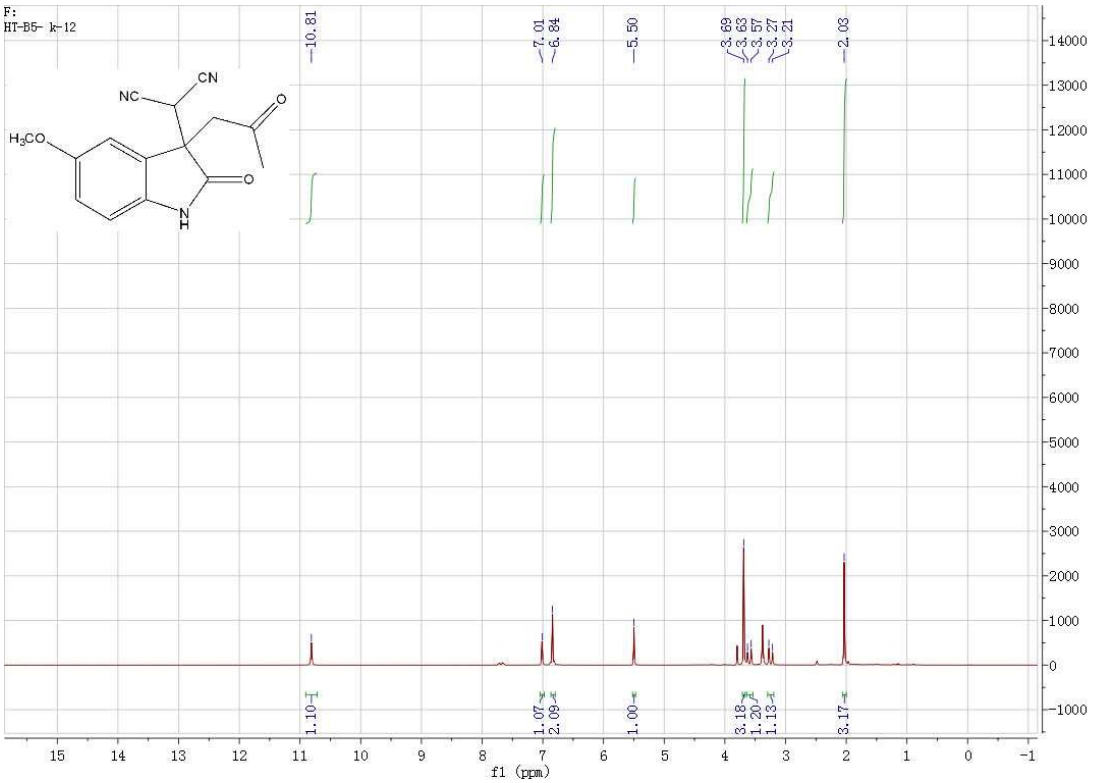
30.49
30.23
21.15
f1 (ppm)

4k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2.03
NC
CN
O
H3CO
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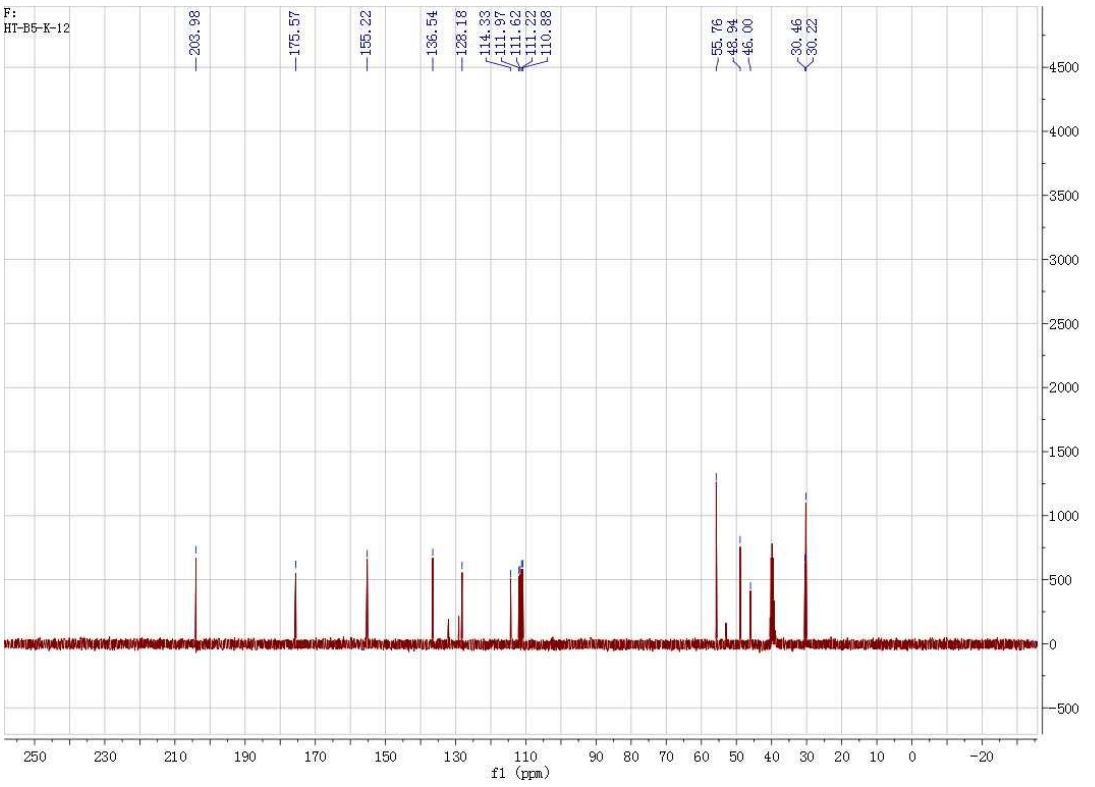
N
H
1.10
1.07
2.09
1.00
3.18
1.20
1.13
3.17
f1 (ppm)


F:
HT-B5-K-12
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136.54
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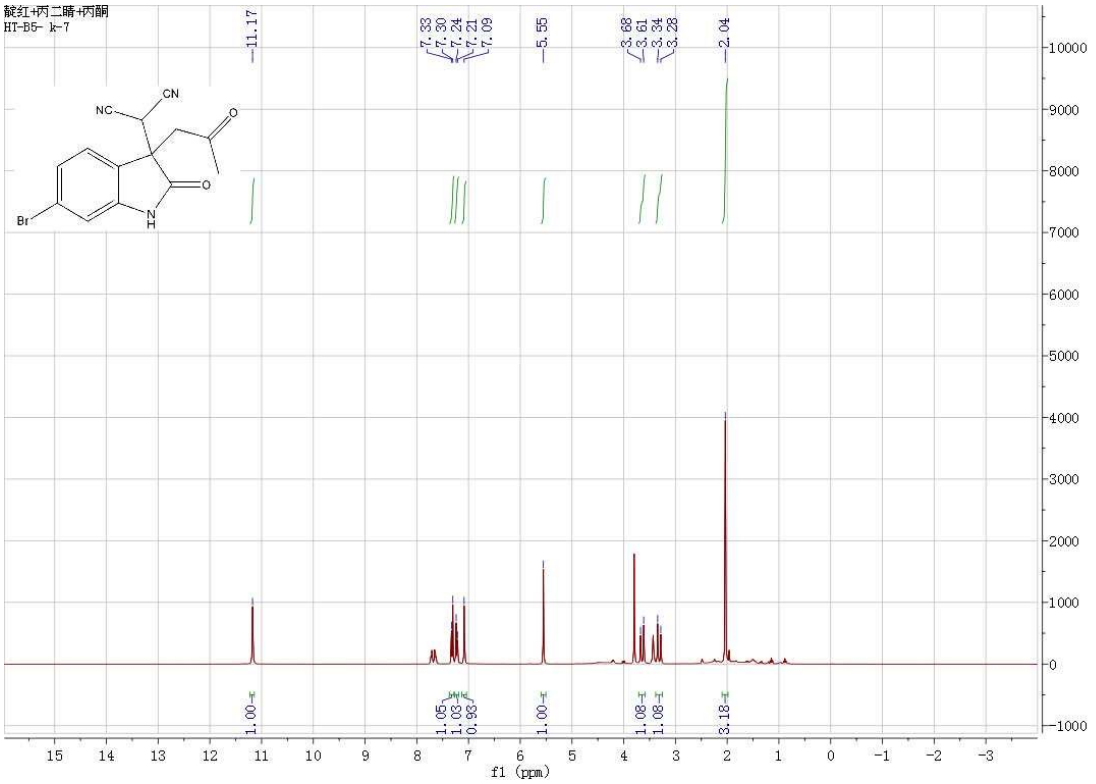
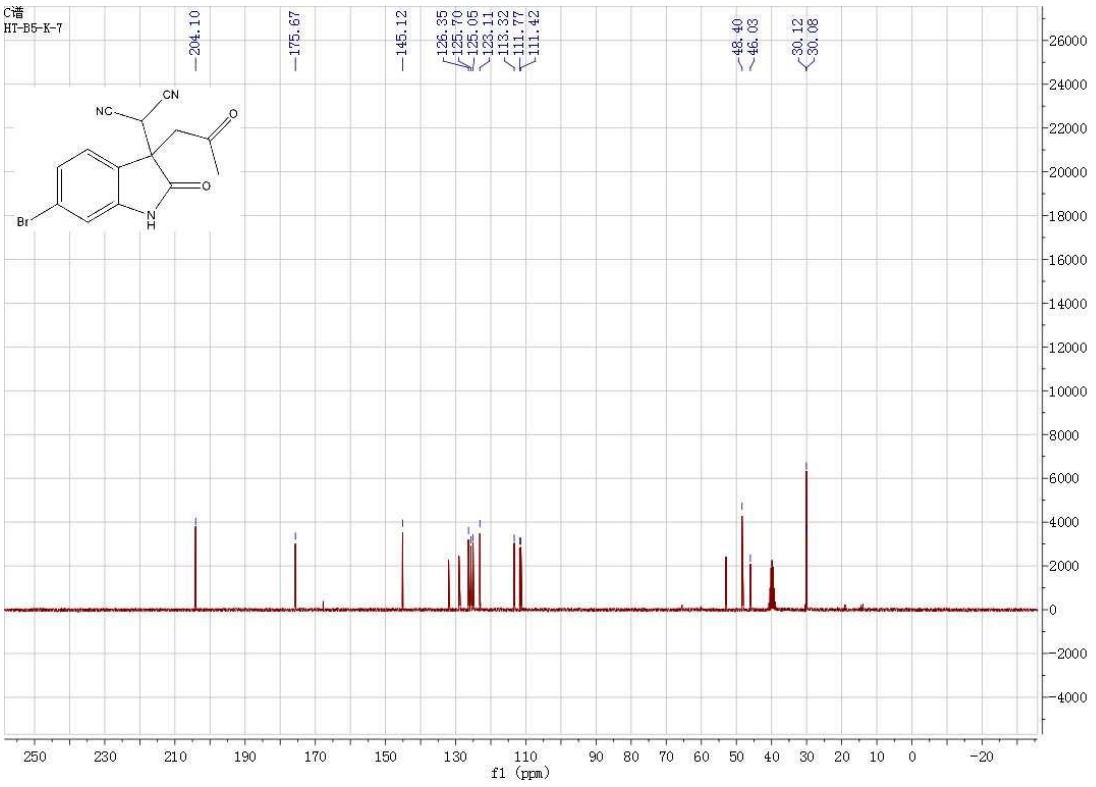
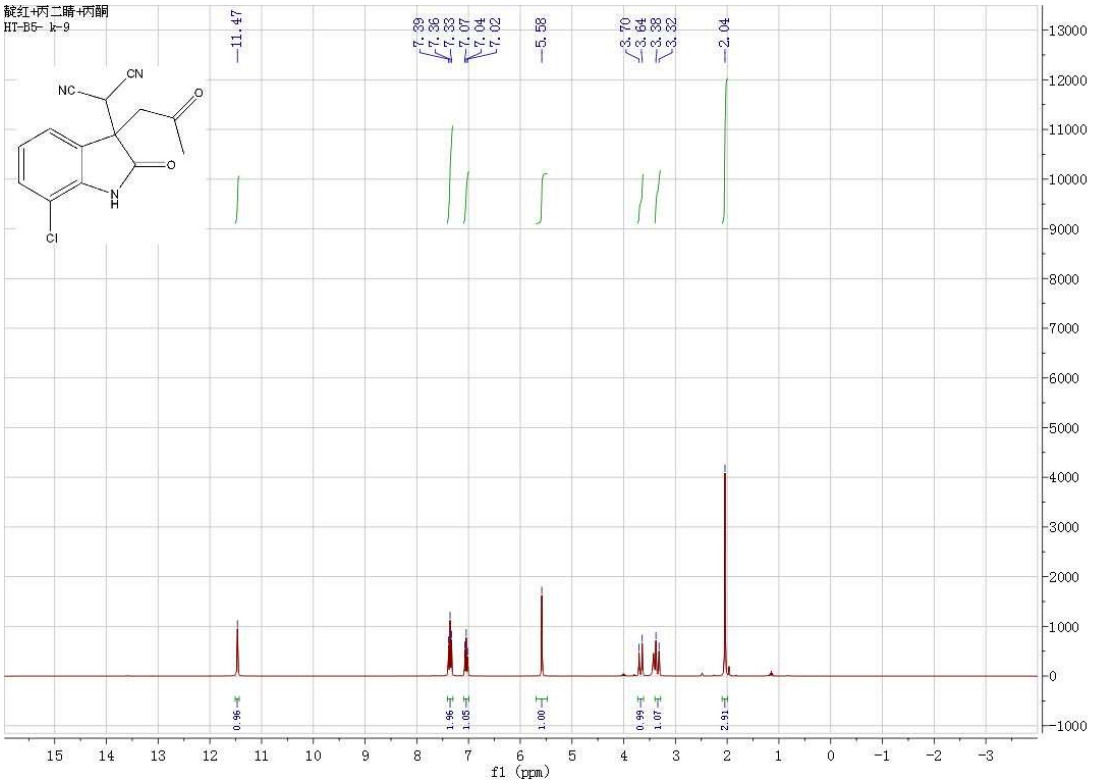
114.33
111.97
111.62
111.22
110.88
55.76
43.94
46.00
30.46
30.22
f1 (ppm)

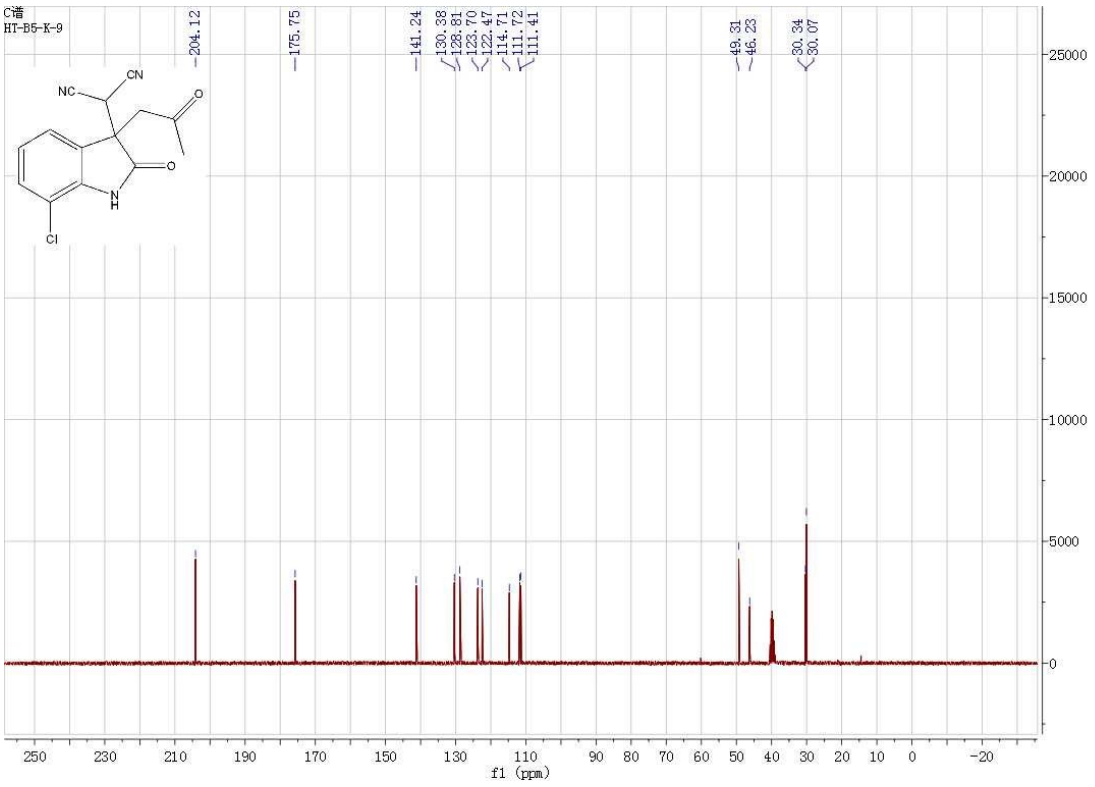
4l


靛红+丙二腈+丙酮
HT-B5- k-7
11.17
7.33
7.30
7.24
7.21
7.09
5.55
3.68
3.61
3.34
3.28
2.04
1.00
1.05
1.03
0.93
1.00
1.08
1.08
3.18
f1 (ppm)

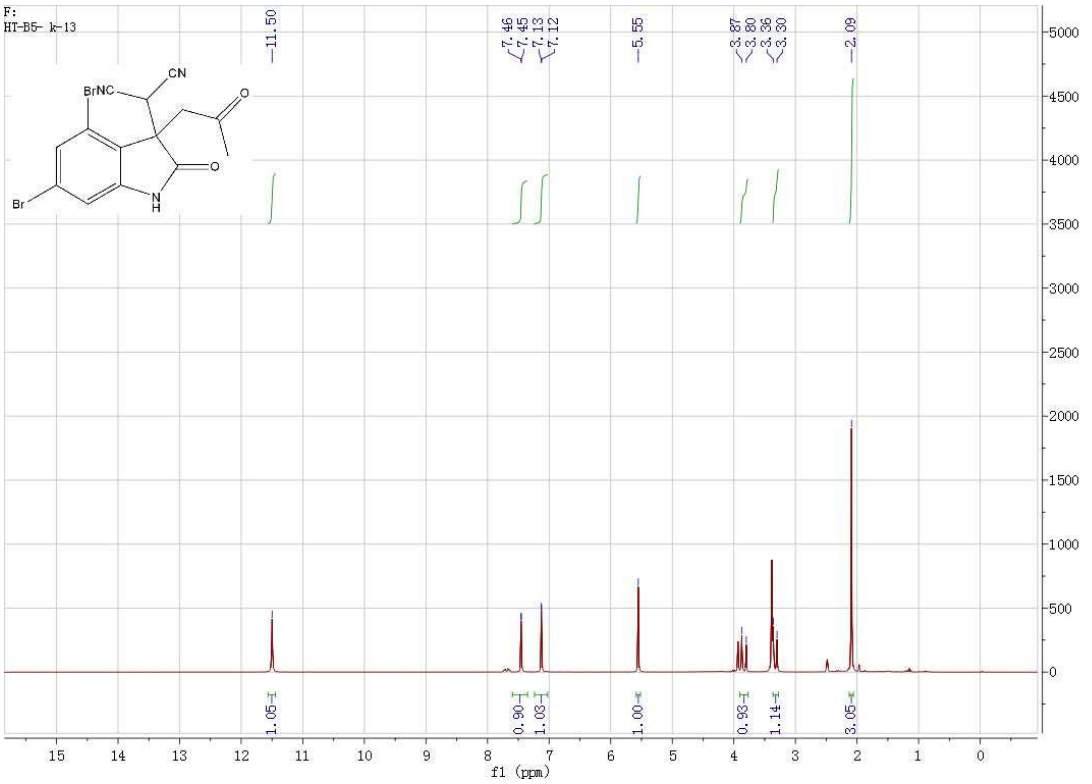

C谱
HT-B5-K-7
204.10
175.67
145.12
126.35
125.70
125.05
123.11
113.32
111.77
111.42
48.40
46.03
30.12
30.08
f1 (ppm)

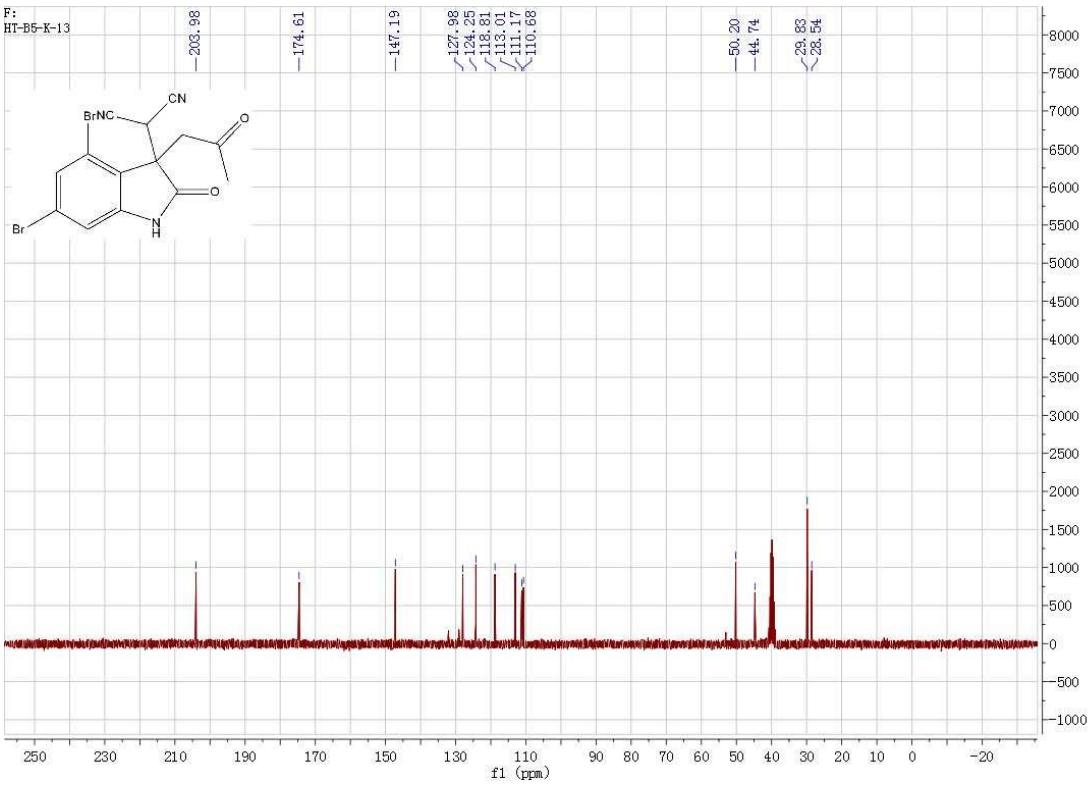
4m


靛红+丙二腈+丙酮
HT-B5- k-9
11.47
7.39
7.36
7.33
7.07
7.04
7.02
5.58
3.70
3.64
3.38
3.32
2.04
0.96
1.96
1.05
1.00
0.99
1.07
2.91
f1 (ppm)

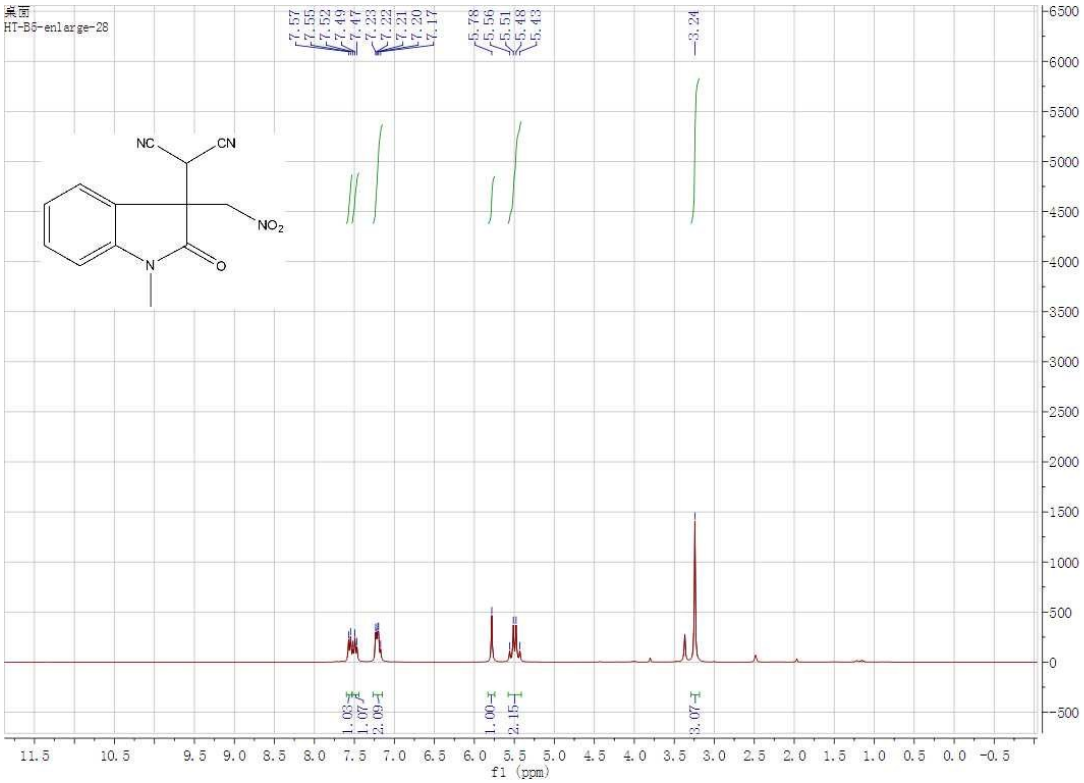

C谱
HT-B5-K-9
204.12
175.75
141.24
130.38
128.81
123.70
122.47
114.71
111.72
111.41
49.31
46.23
30.34
30.07
f1 (ppm)

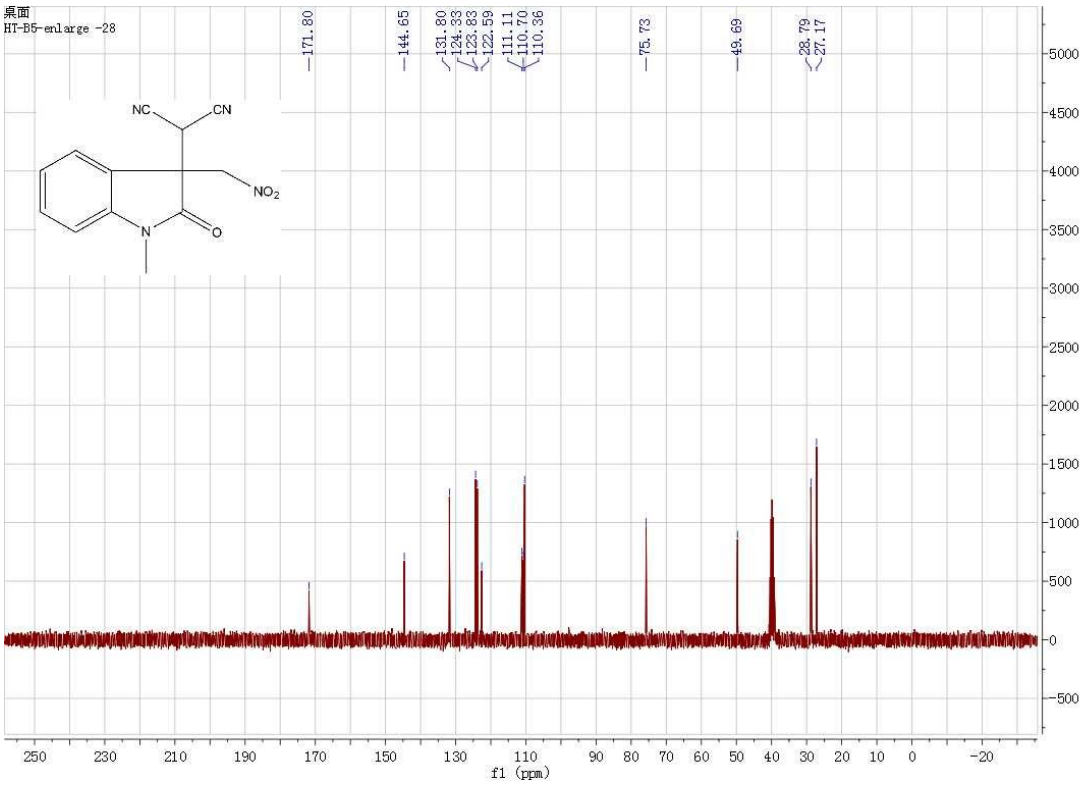
4n

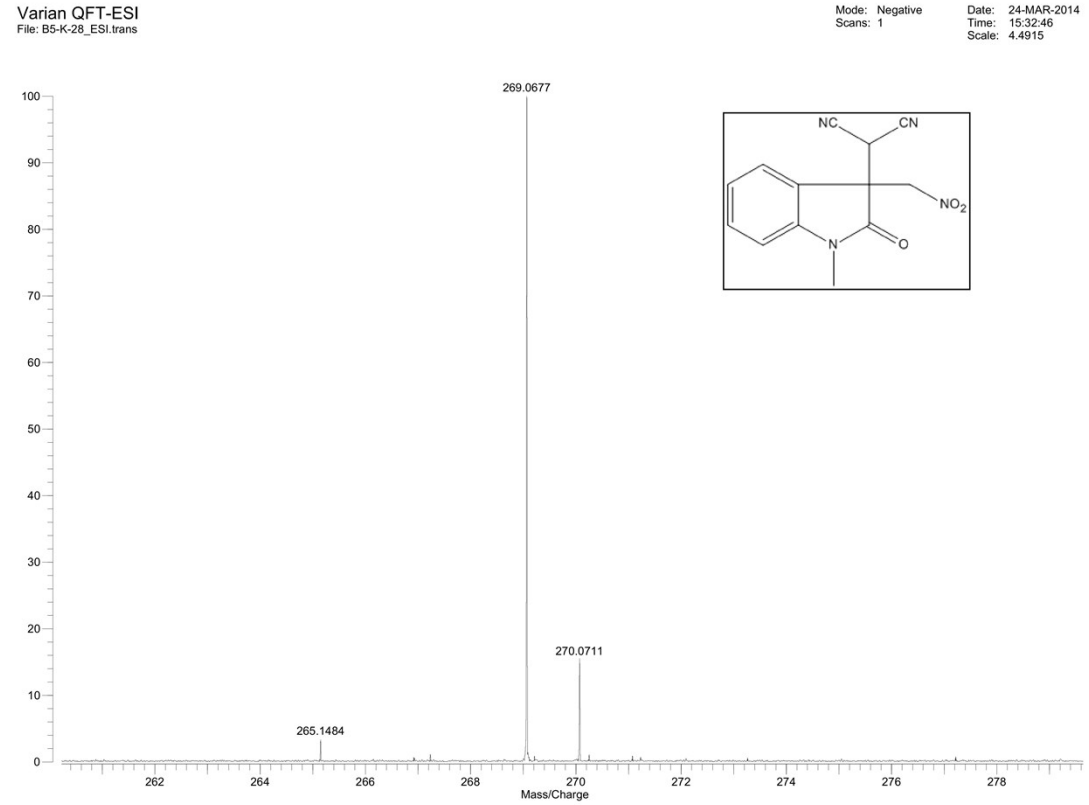

F:
HT-B5- k-13
11.50
7.46
7.45
7.13
7.12
5.55
3.87
3.80
3.36
3.30
2.09
BrNC
CN
O
O
Br
N
H
1.05
0.90
1.03
1.00
0.93
1.14
3.05
f1 (ppm)

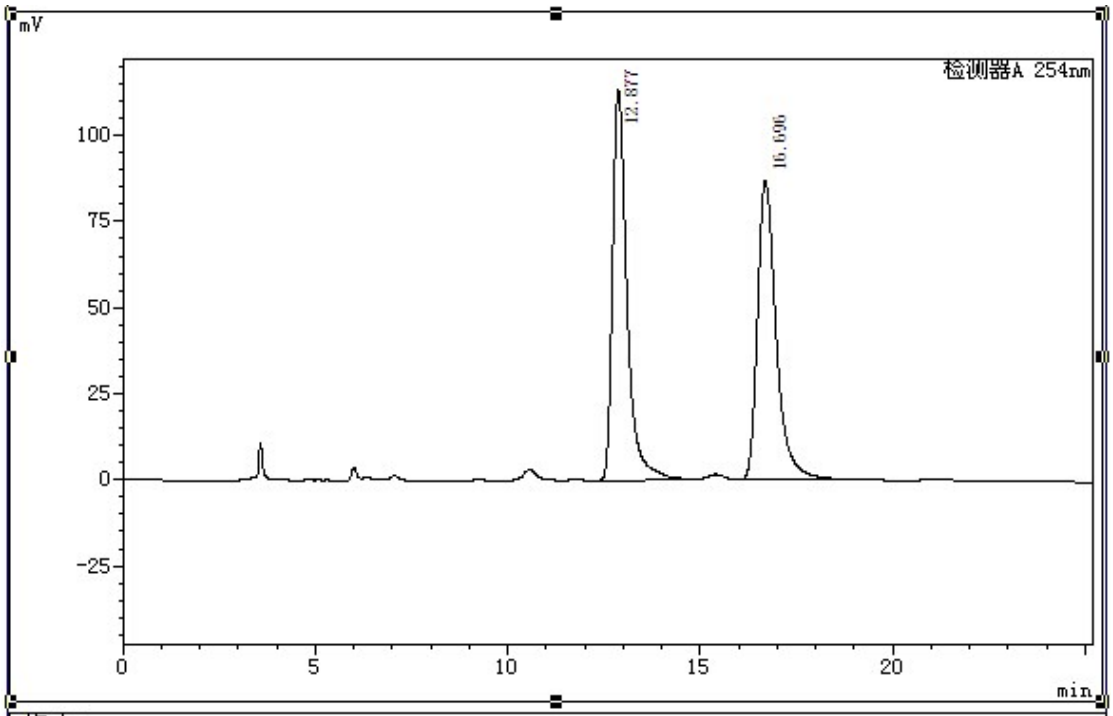

F:
HT-B5-K-13
203.98
174.61
147.19
127.98
124.25
118.81
113.01
111.17
110.68
50.20
44.74
29.83
28.54
BrNC
CN
O
O
Br
N
H
f1 (ppm)

6a


桌面
HT-B5-enlarge-28
NC
CN
NO2
N
O
7.57
7.55
7.52
7.49
7.47
7.23
7.22
7.21
7.20
7.17
5.78
5.56
5.51
5.48
5.43
3.24
1.03
1.07
2.09
1.00
2.15
3.07
f1 (ppm)


桌面
HT-B5-enlarge -28
NC
CN
NO2
N
O
171.80
144.65
131.80
124.33
123.83
122.59
111.11
110.70
110.36
75.73
49.69
28.79
27.17
f1 (ppm)



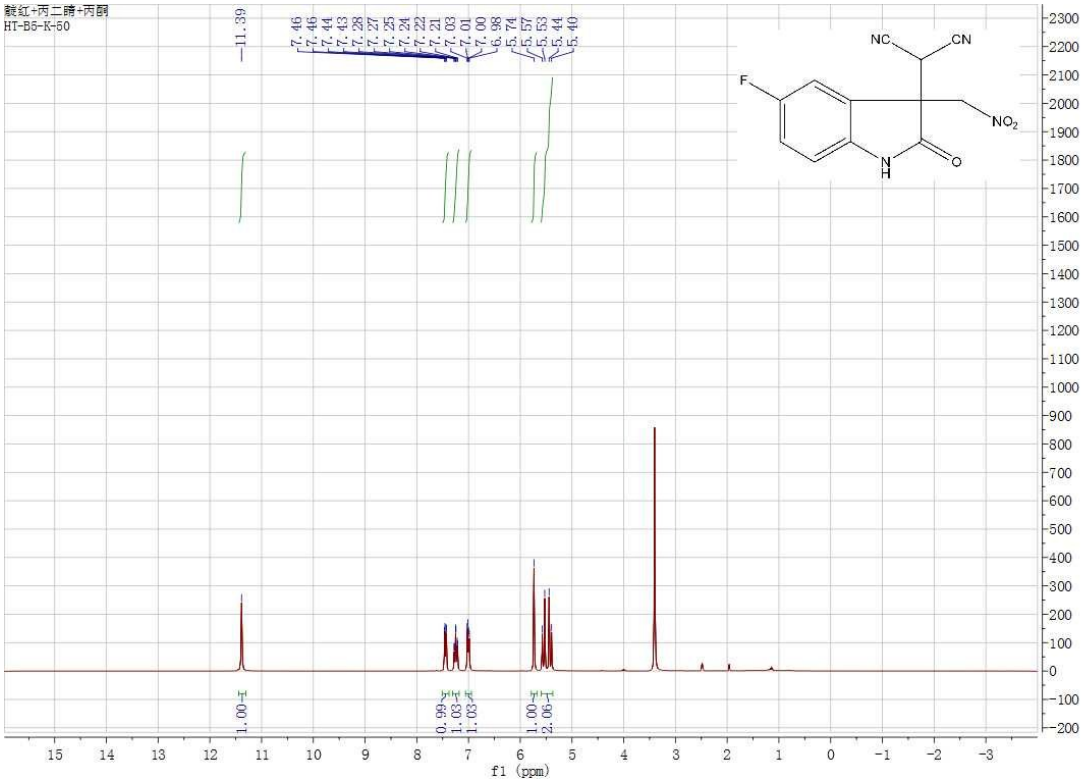


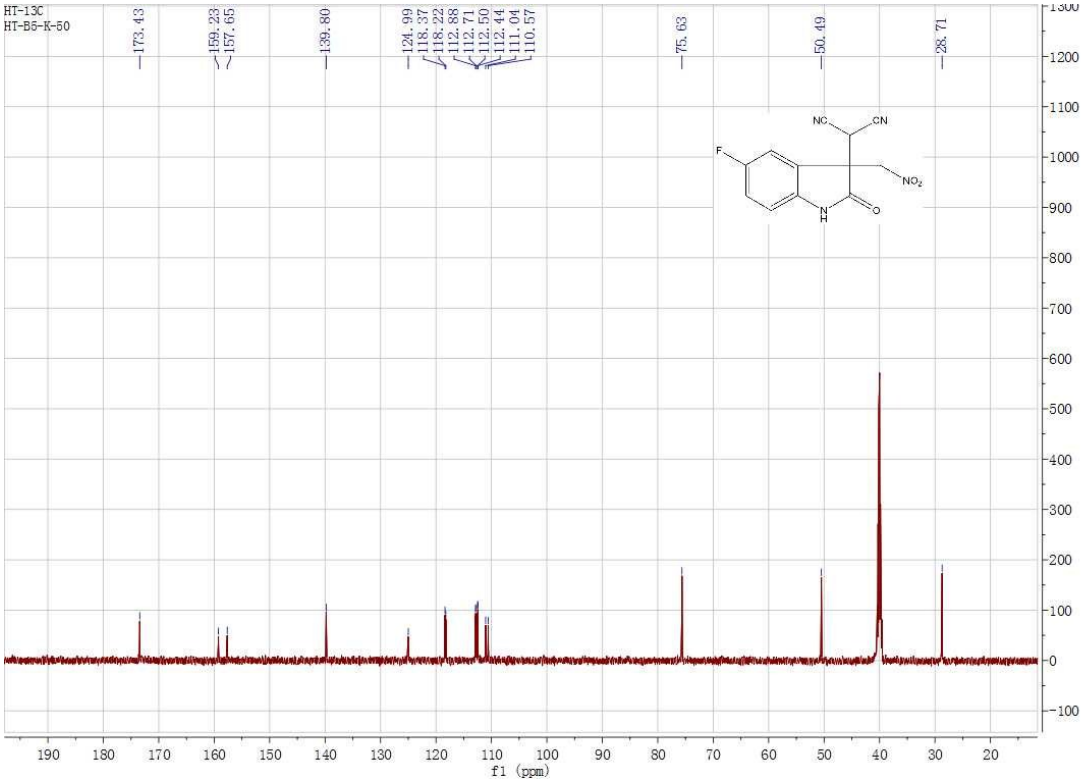
<峰表>

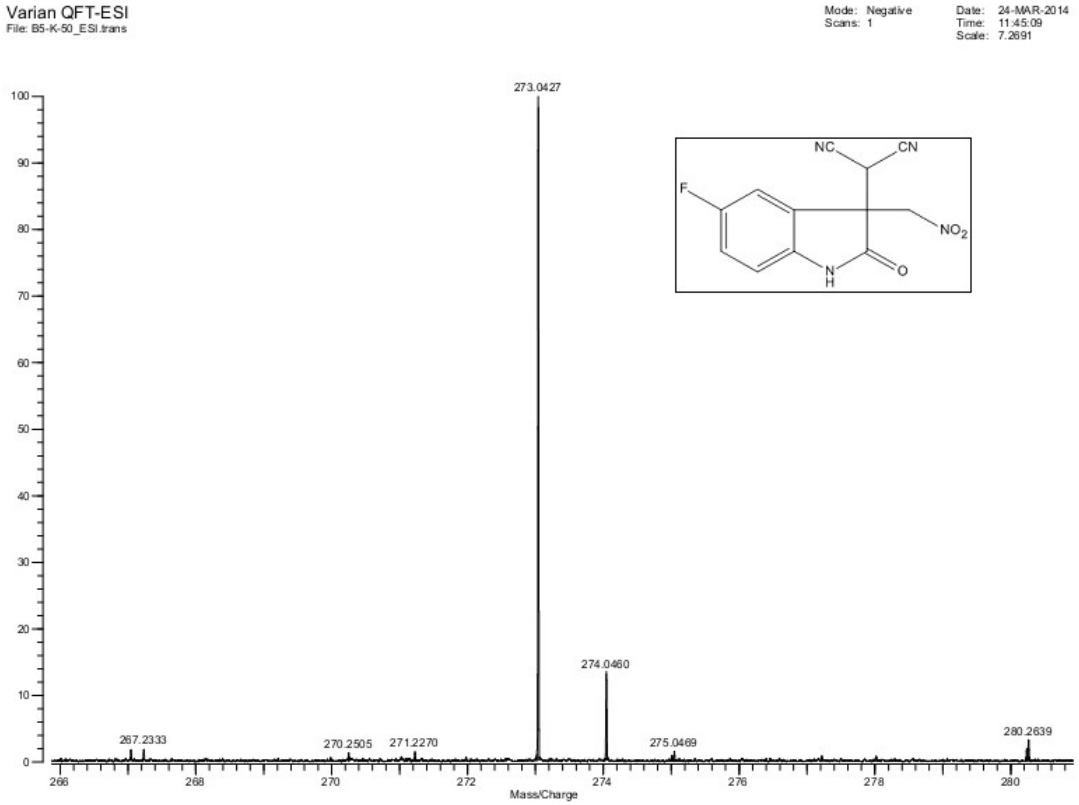
检测器A 254nm

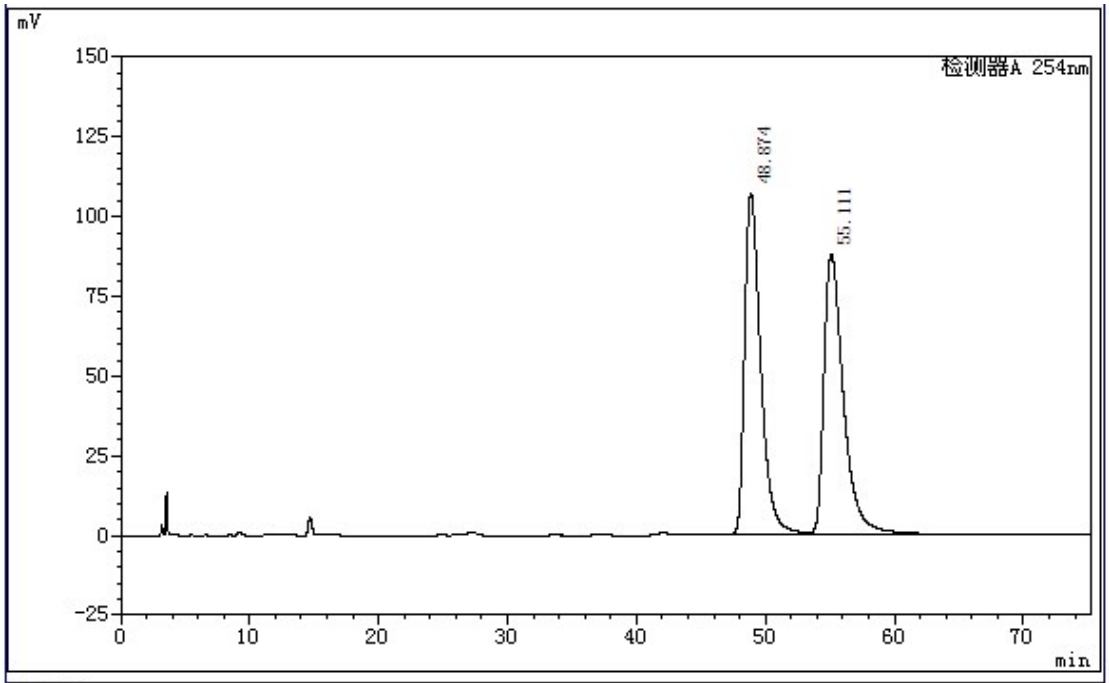
峰号	保留时间	面积	高度	浓度	浓度单位	标记	化合物名
1	12.877	2946519	113571	50.319			
2	16.696	2909107	86813	49.681			

6b


11.39
7.46
7.44
7.43
7.28
7.27
7.25
7.24
7.22
7.21
7.03
7.01
7.00
6.98
5.74
5.57
5.53
5.44
5.40
1.00
0.99
1.03
1.03
1.00
2.06
NC
CN
F
NO2
N
H
O
f1 (ppm)


HT-13C
HT-B5-K-50
173.43
159.23
157.65
139.80
124.99
118.37
118.22
112.88
112.71
112.50
112.44
111.04
110.57
75.63
50.49
28.71
NC
CN
F
NO2
N
H
O
f1 (ppm)

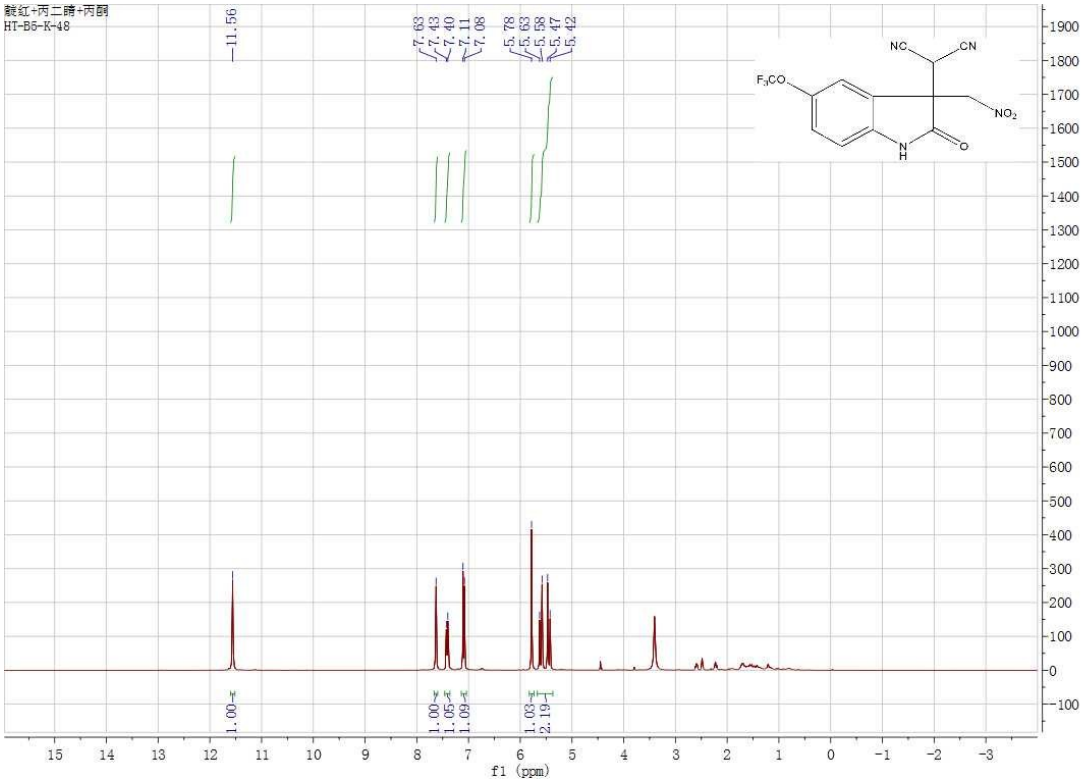


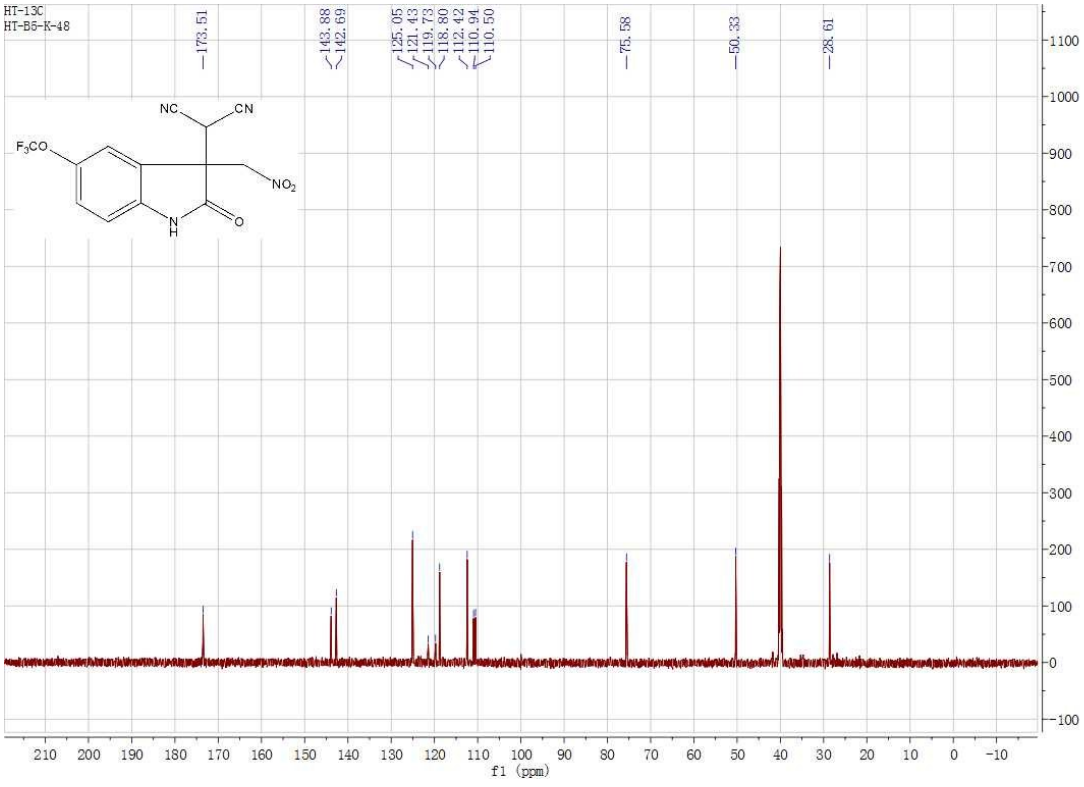


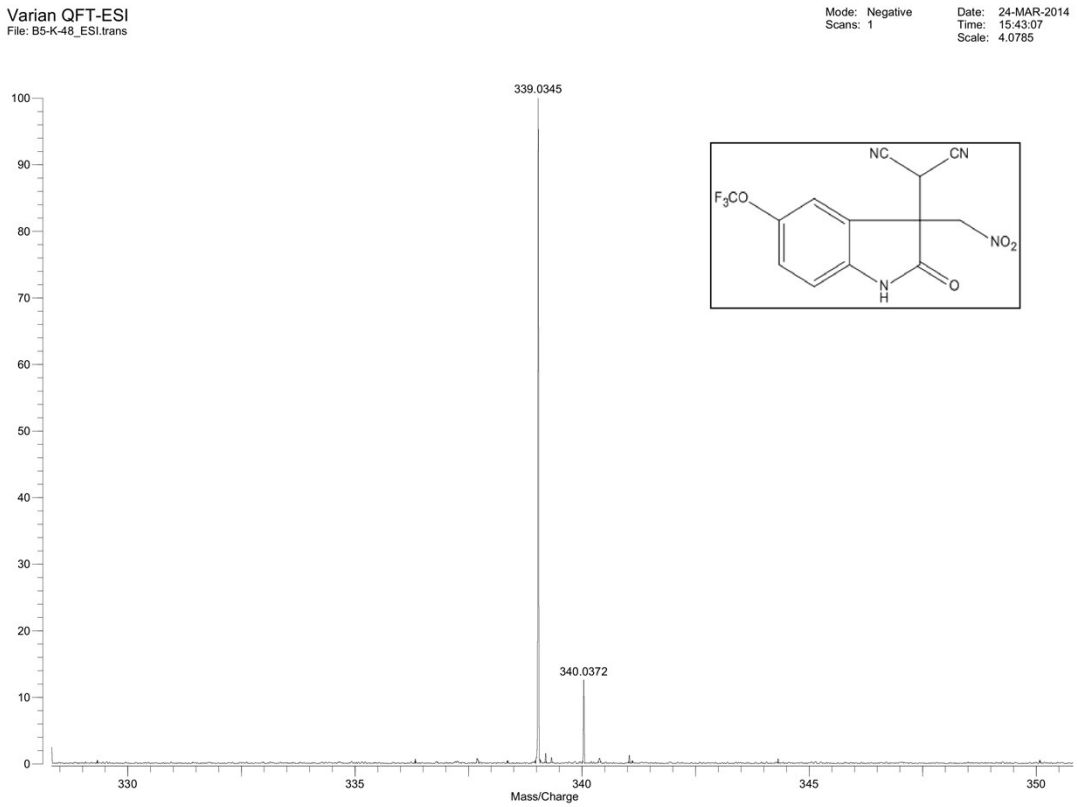
<峰表>
检测器A 254nm

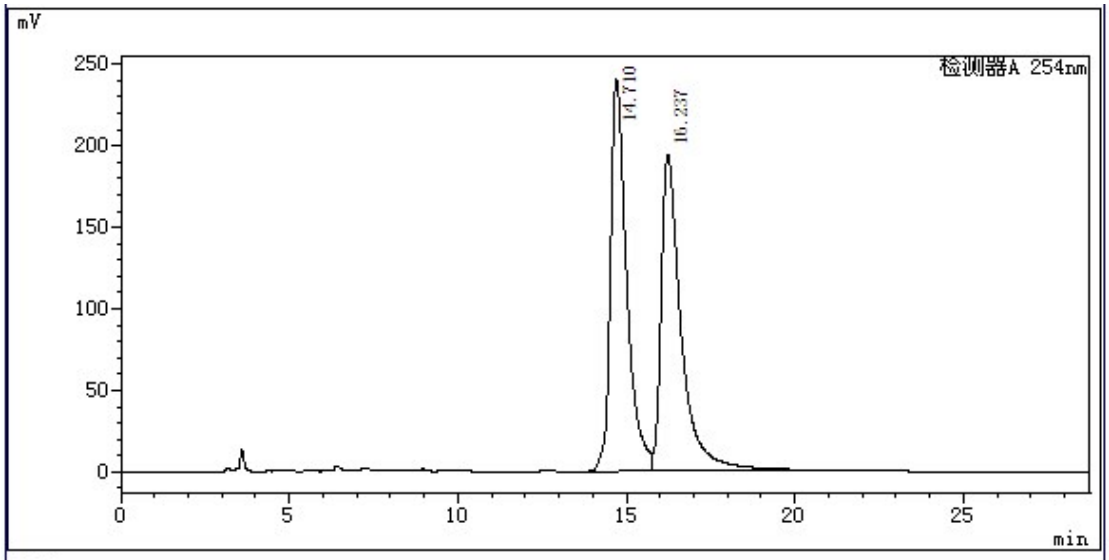
峰号	保留时间	面积	高度	浓度	浓度单位	标记	化合物名
1	48.874	9297974	107180	50.132			
2	55.111	9248883	88035	49.868		SV	

6c


11.56
7.63
7.43
7.40
7.11
7.08
5.78
5.63
5.58
5.47
5.42
NC
CN
F3CO
NO2
N
H
O
f1 (ppm)


HT-13C
HT-B5-K-48
173.51
143.88
142.69
125.05
121.43
119.73
118.80
112.42
110.94
110.50
75.58
50.33
28.61
NC
CN
F3CO
NO2
N
H
O
f1 (ppm)



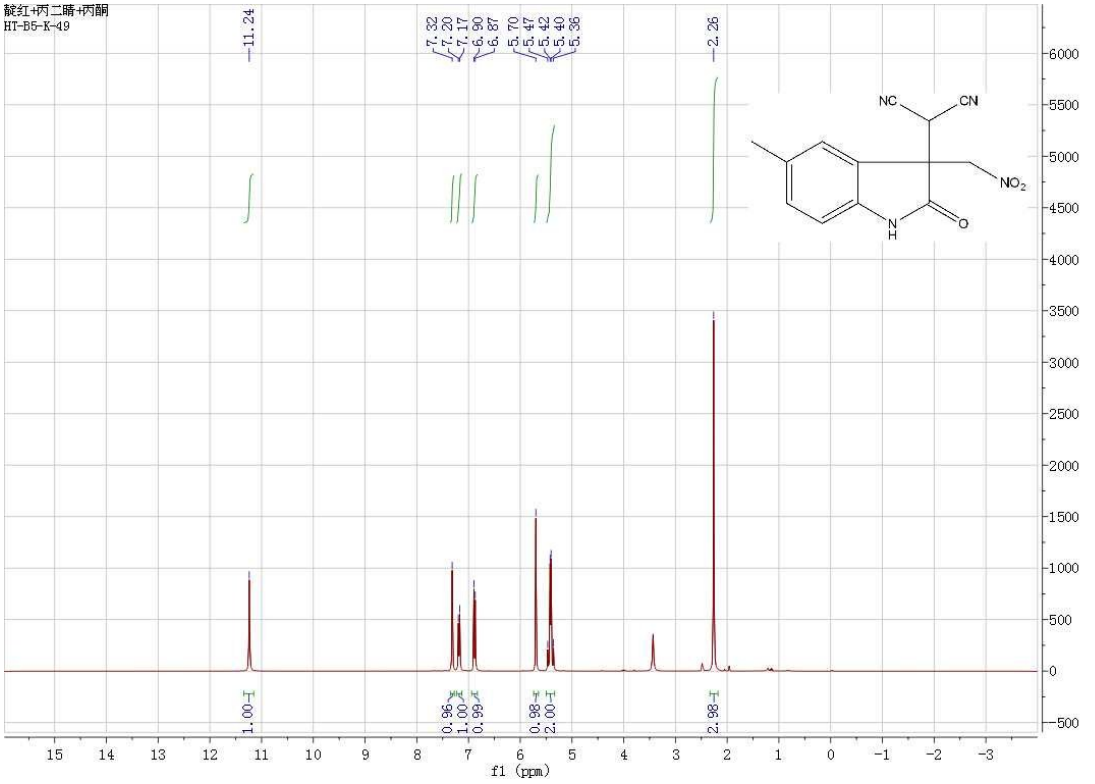


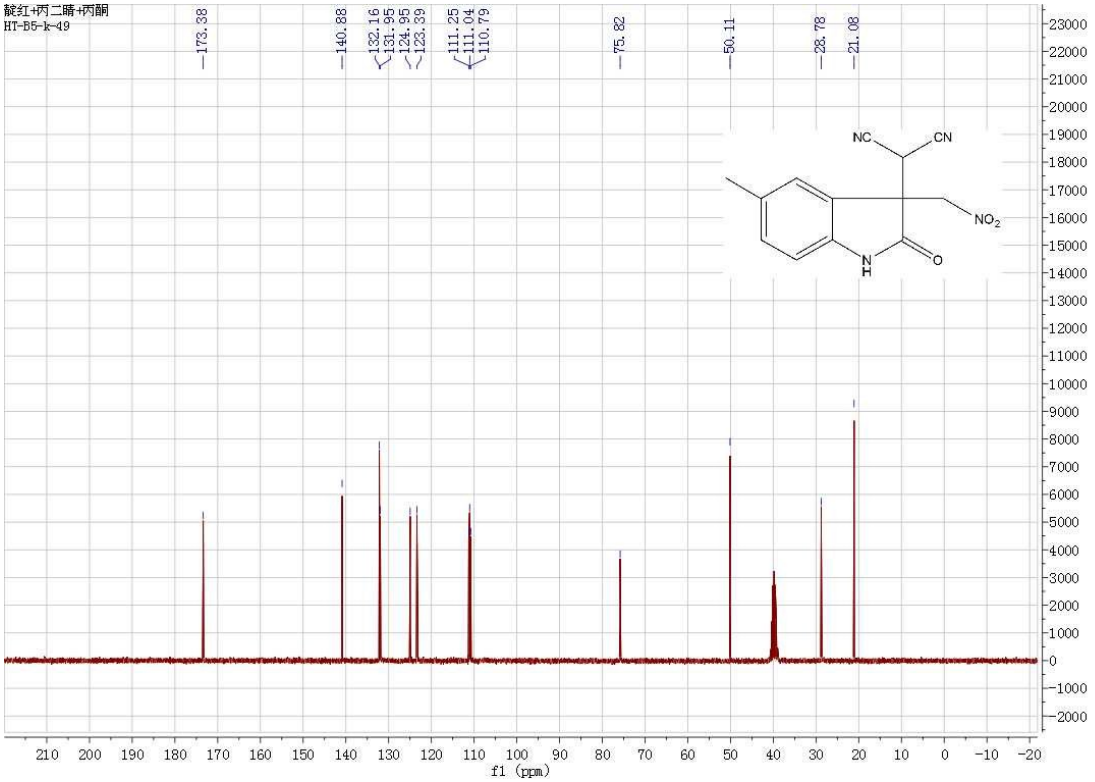
<峰表>

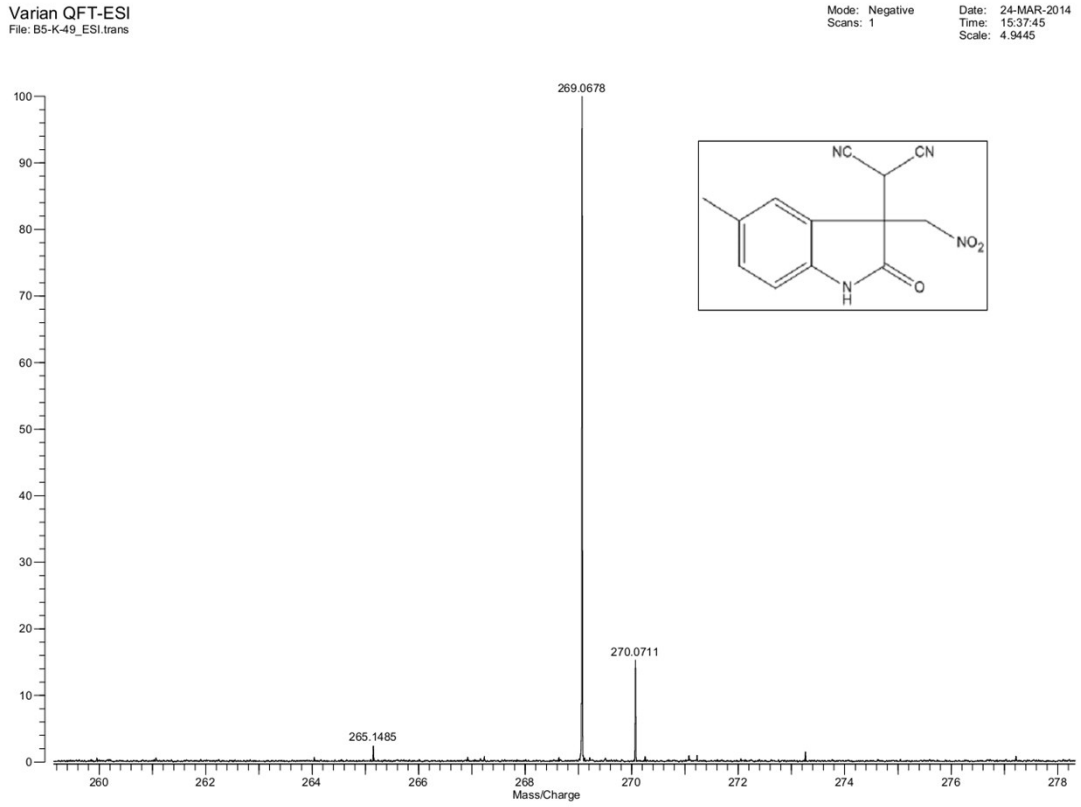
检测器A 254nm

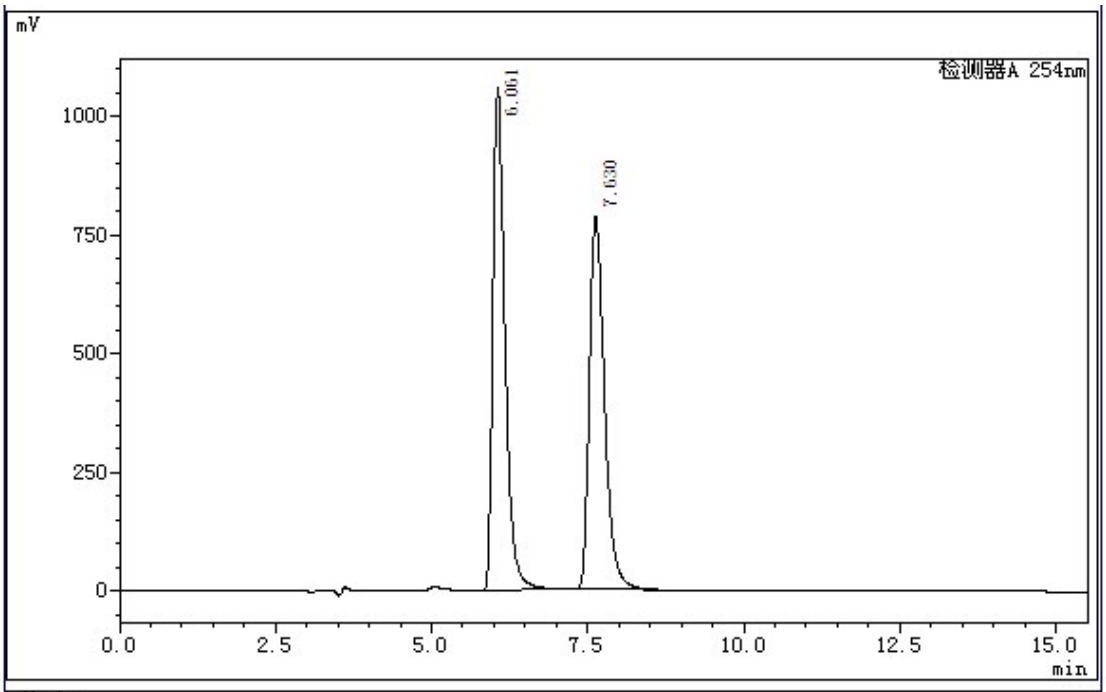
峰号	保留时间	面积	高度	浓度	浓度单位	标记	化合物名
1	14.710	8069258	240723	49.774			
2	16.237	8142433	193626	50.226		V	

6d


靛红+丙二腈+丙酮
HT-B5-K-49
11.24
7.32
7.20
7.17
6.90
6.87
5.70
5.47
5.42
5.40
5.36
2.26
NC
CN
NO2
N
H
O
1.00
0.96
1.00
0.99
0.98
2.00
2.98
f1 (ppm)


靛红+丙二腈+丙酮
HT-B5-k-49
173.38
140.88
132.16
131.95
124.95
123.39
111.25
111.04
110.79
75.82
50.11
28.78
21.08
NC
CN
NO2
N
H
O
f1 (ppm)



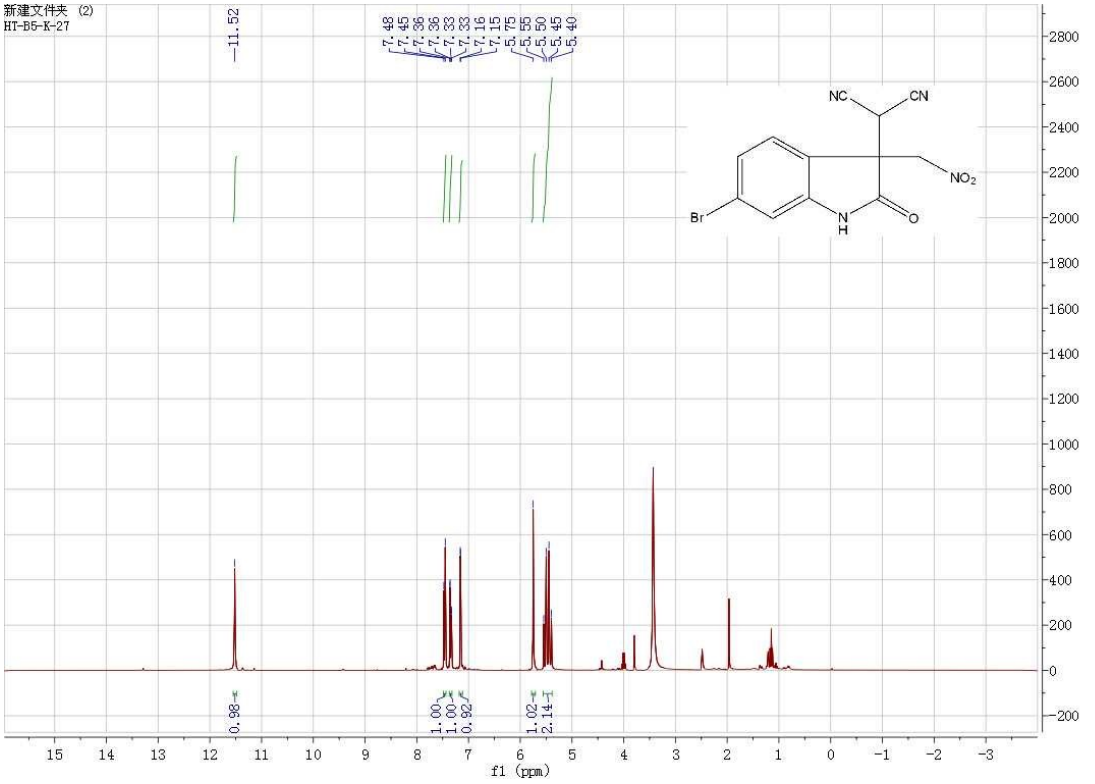


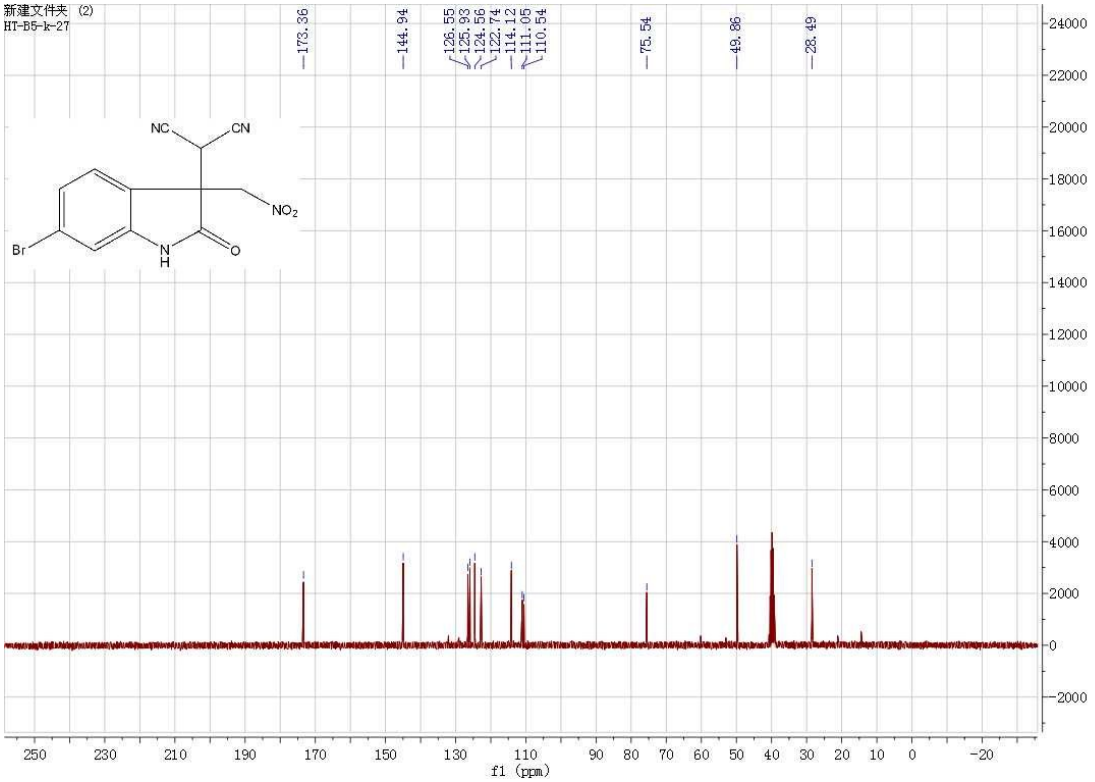
<峰表>

检测器A 254nm

峰号	保留时间	面积	高度	浓度	浓度单位	标记	化合物名
1	6.061	14362973	1056548	51.872			
2	7.630	13326056	786422	48.128			

6e

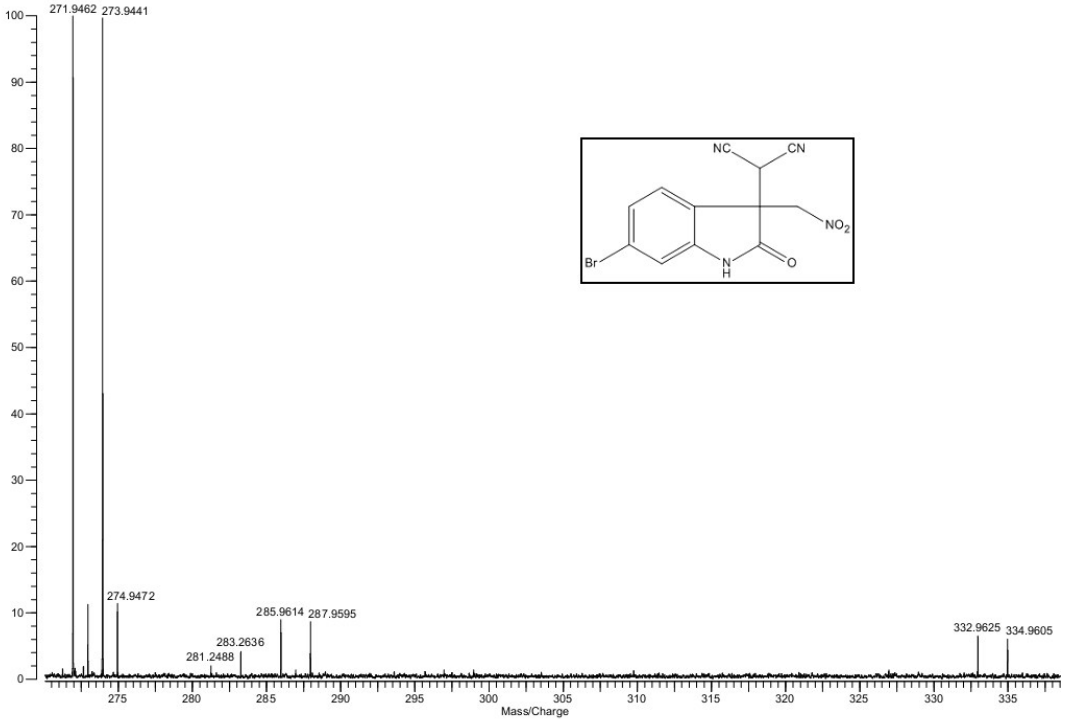

新建文件夹 (2)
HT-B5-K-27
11.52
7.48
7.45
7.36
7.36
7.33
7.33
7.16
7.15
5.75
5.55
5.50
5.45
5.40
NC
CN
NO2
Br
N
H
O
0.98
1.00
1.00
0.92
1.02
2.14
f1 (ppm)

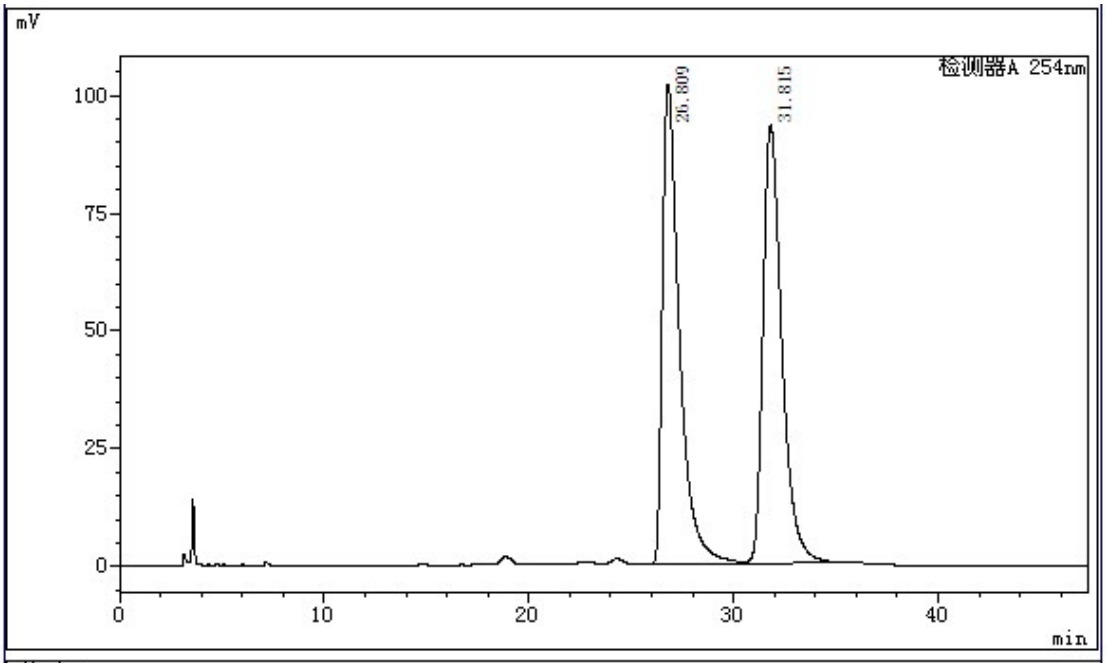

新建文件夹 (2)
HT-B5-k-27
173.36
144.94
126.55
125.93
124.56
122.74
114.12
111.05
110.54
75.54
49.86
28.49
NC
CN
NO2
Br
N
H
O
f1 (ppm)

Varian QFT-ESI
File: 6-Br+NO2_ESI.trans

Mode: Negative
Scans: 1

Date: 22-MAR-2015
Time: 14:50:48
Scale: 11.6726

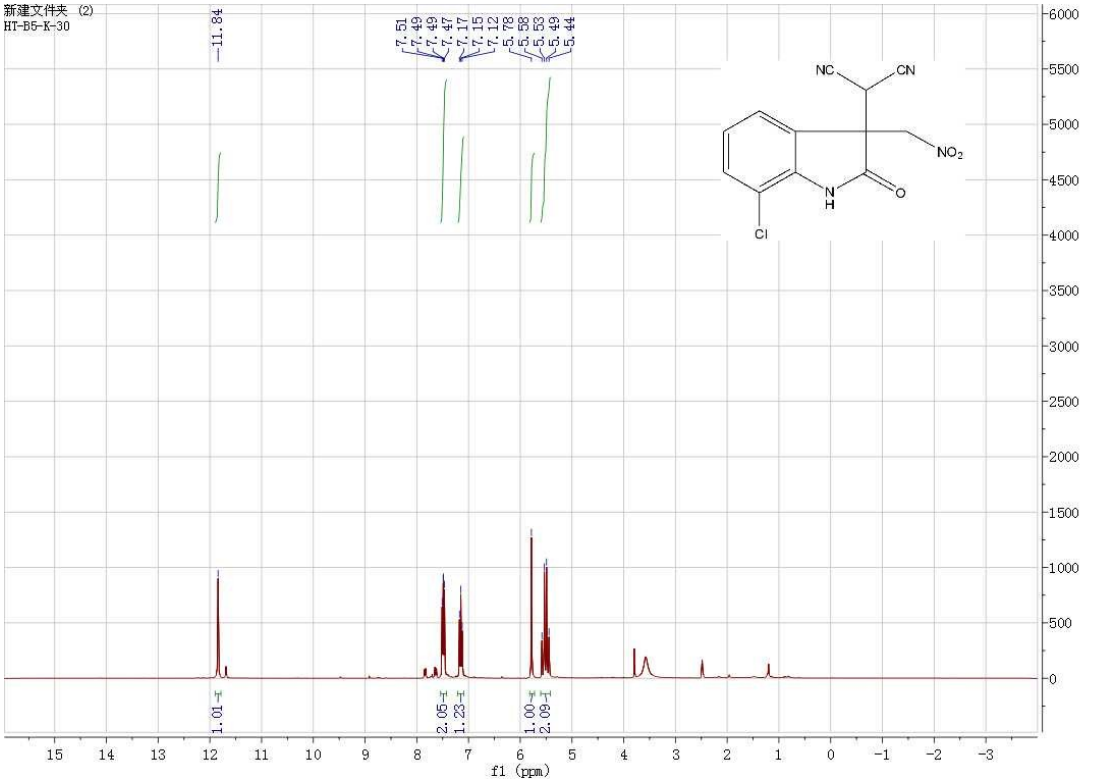


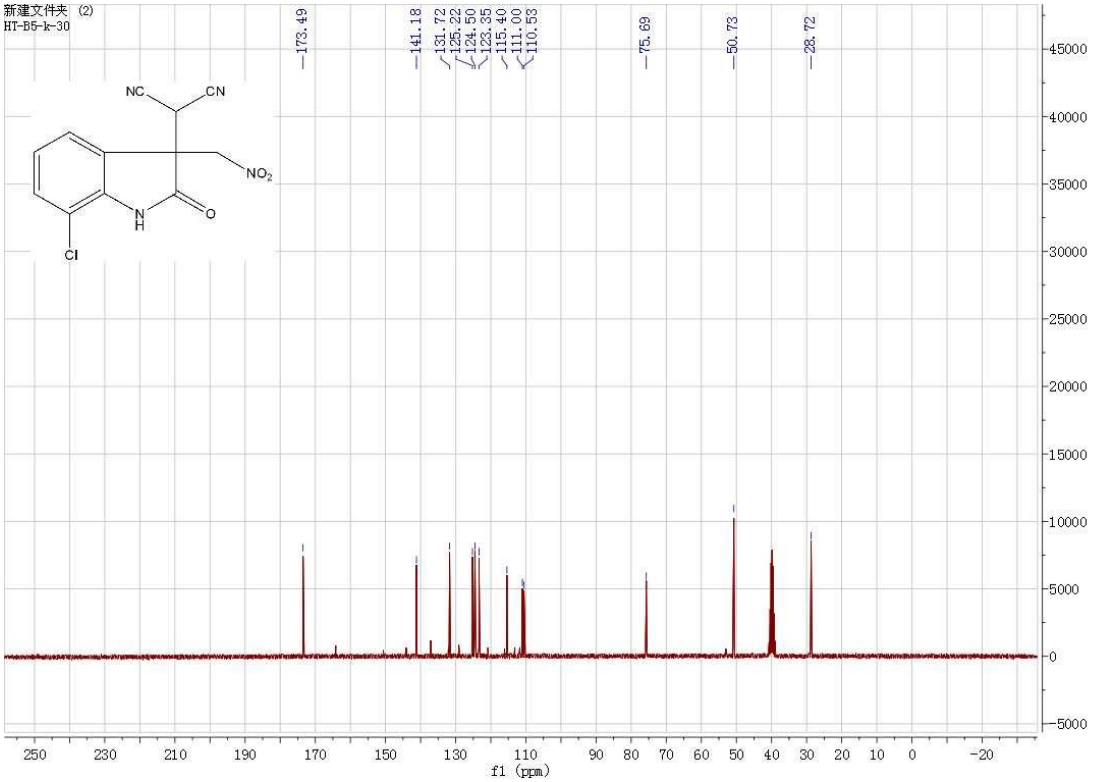


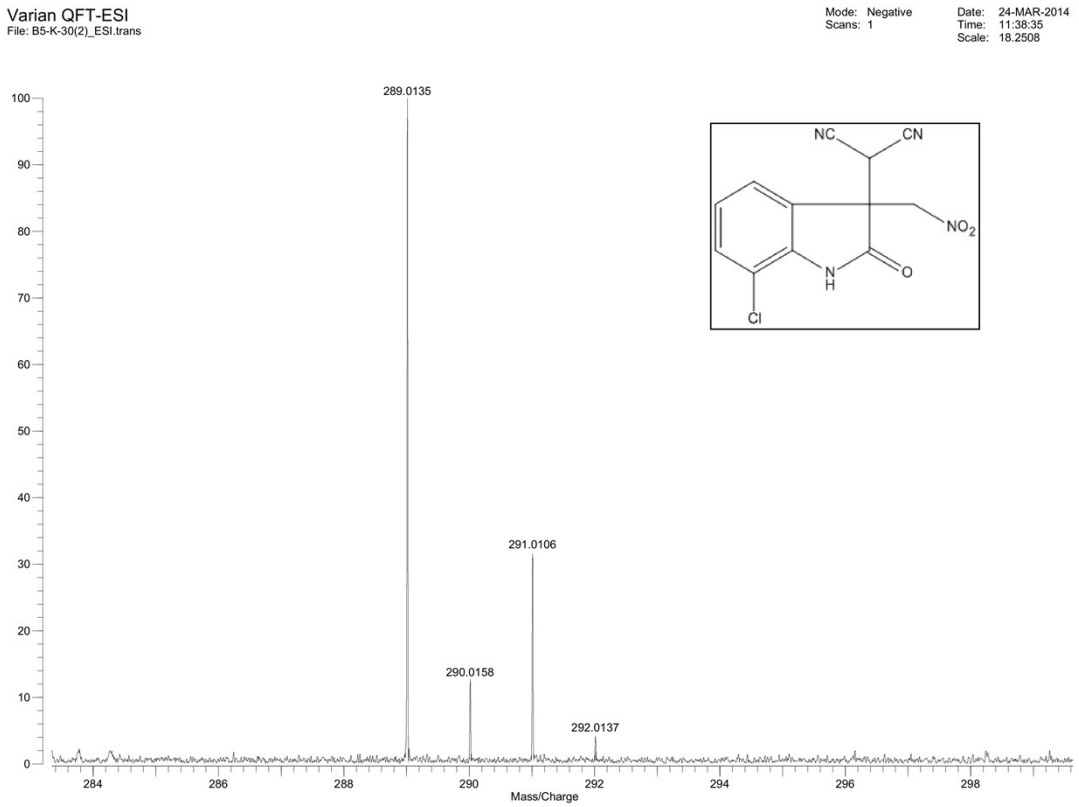
<峰表>
检测器A 254nm

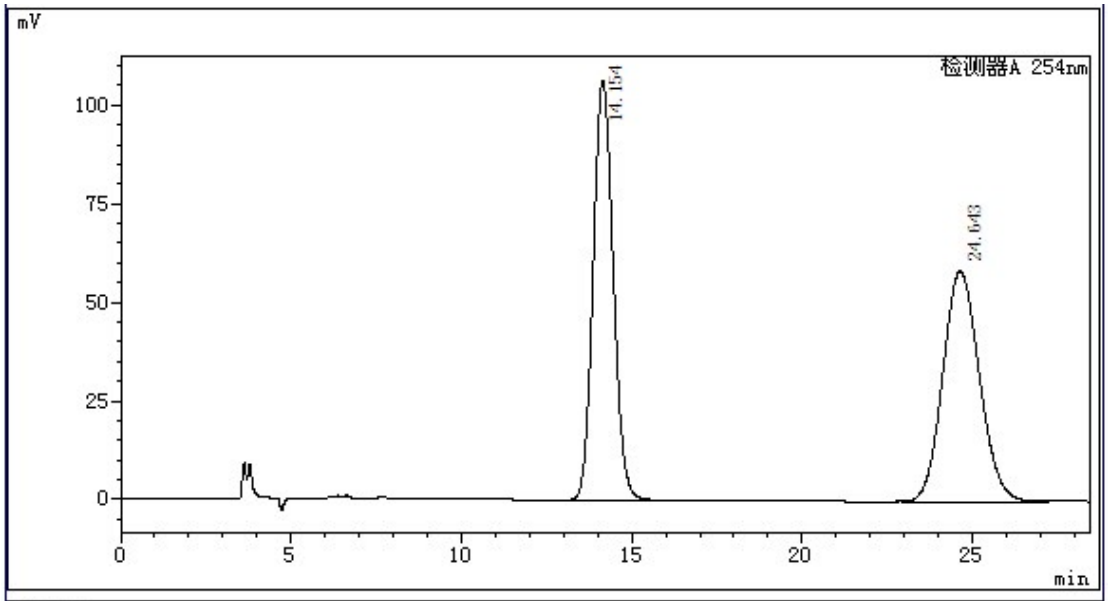
峰号	保留时间	面积	高度	浓度	浓度单位	标记	化合物名
1	26.809	5896937	101970	49.653			
2	31.815	5979364	93013	50.347		V	

6f


新建文件夹 (2)
HT-B5-K-30
11.84
7.51
7.49
7.49
7.47
7.17
7.15
7.12
5.58
5.53
5.49
5.44
NC
CN
NO2
N
H
O
Cl
1.01
2.05
1.23
1.00
2.09
f1 (ppm)


新建文件夹 (2)
HT-B5-k-30
173.49
141.18
131.72
126.22
124.50
123.35
115.40
111.00
110.53
75.69
50.73
28.72
NC
CN
NO2
N
H
O
Cl
f1 (ppm)



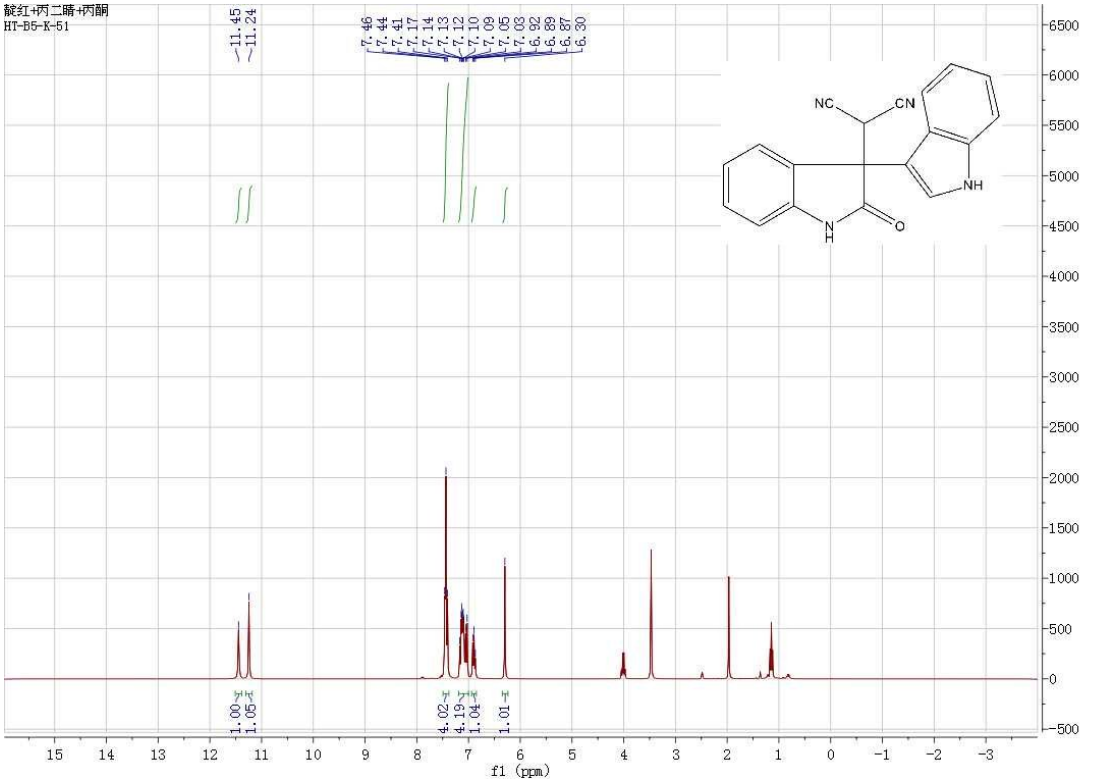


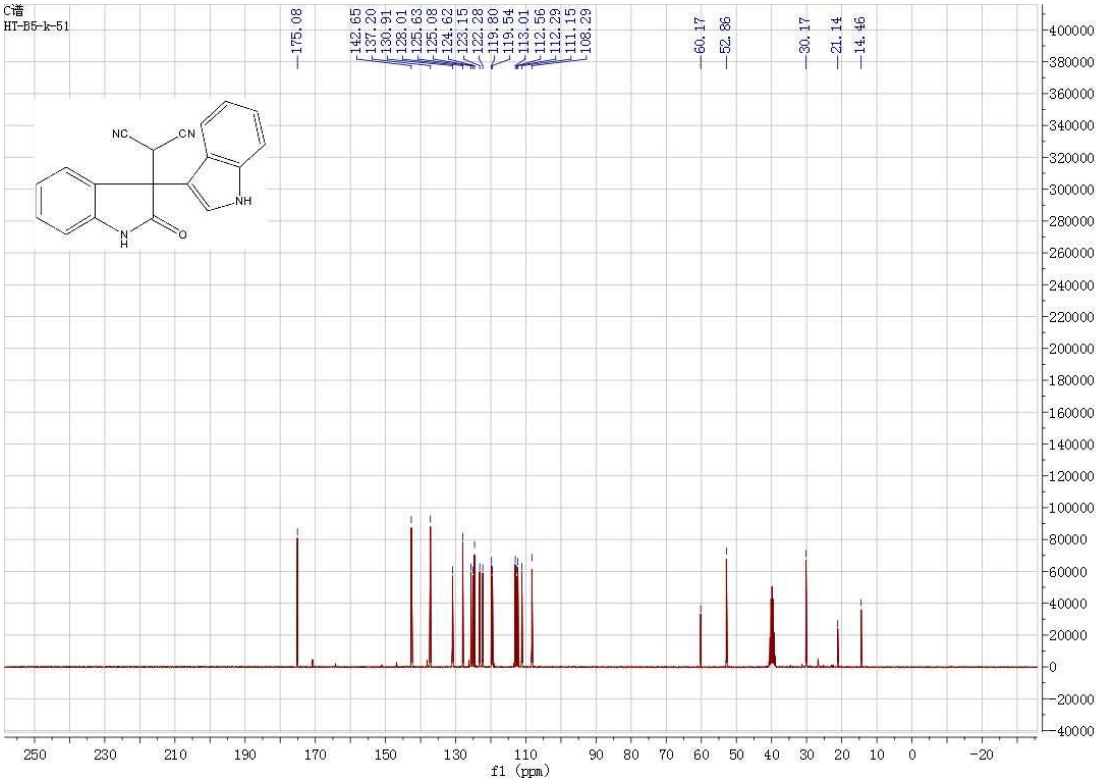
<峰表>

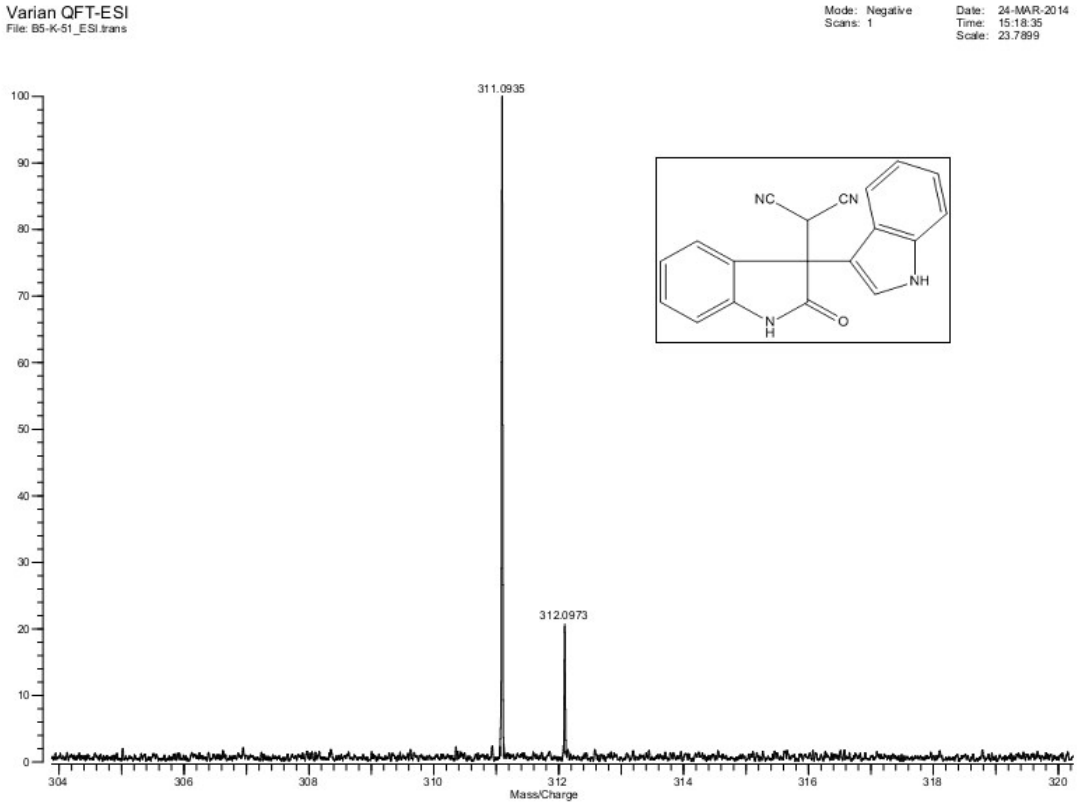
检测器A 254nm

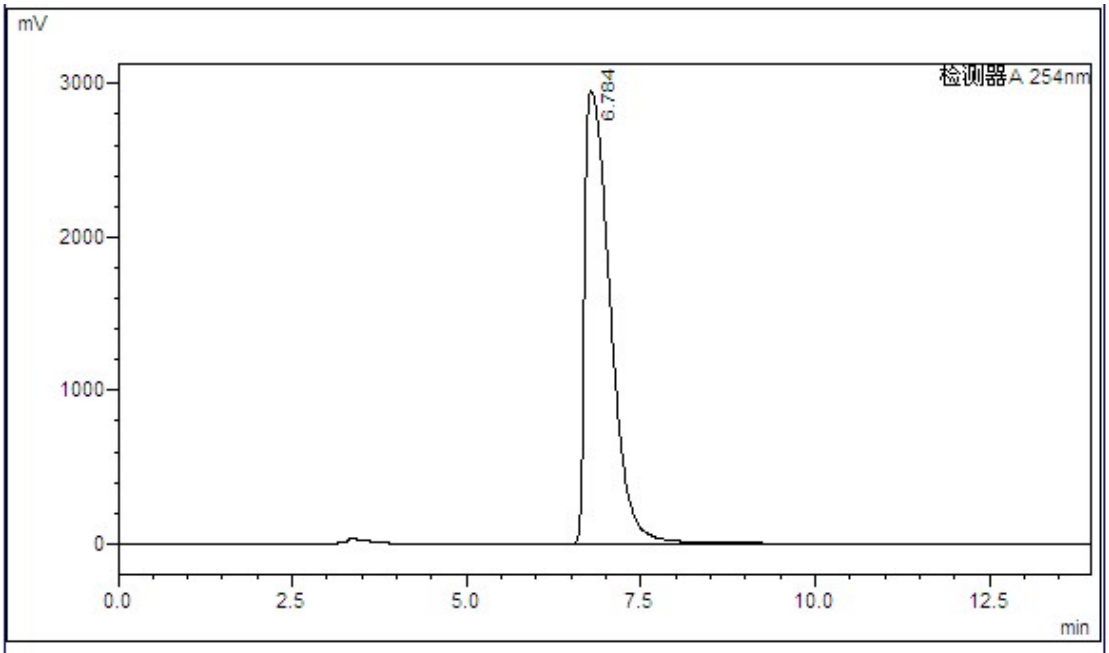
峰号	保留时间	面积	高度	浓度	浓度单位	标记	化合物名
1	14.154	4348130	106309	49.903			
2	24.643	4365045	58507	50.097		V	

8a


靛红+丙二腈+丙酮
HT-B5-K-51
11.45
11.24
7.46
7.44
7.41
7.17
7.14
7.13
7.12
7.10
7.09
7.05
7.03
6.92
6.89
6.87
6.30
NC
CN
NH
N
H
O
1.00
1.05
4.02
4.19
1.04
1.01
f1 (ppm)


C谱
HT-B5-k-51
175.08
142.65
137.20
130.91
128.01
125.63
125.08
124.62
123.15
122.28
119.80
119.54
113.01
112.56
112.29
111.15
108.29
60.17
52.86
30.17
21.14
14.46
NC
CN
NH
N
H
O
f1 (ppm)



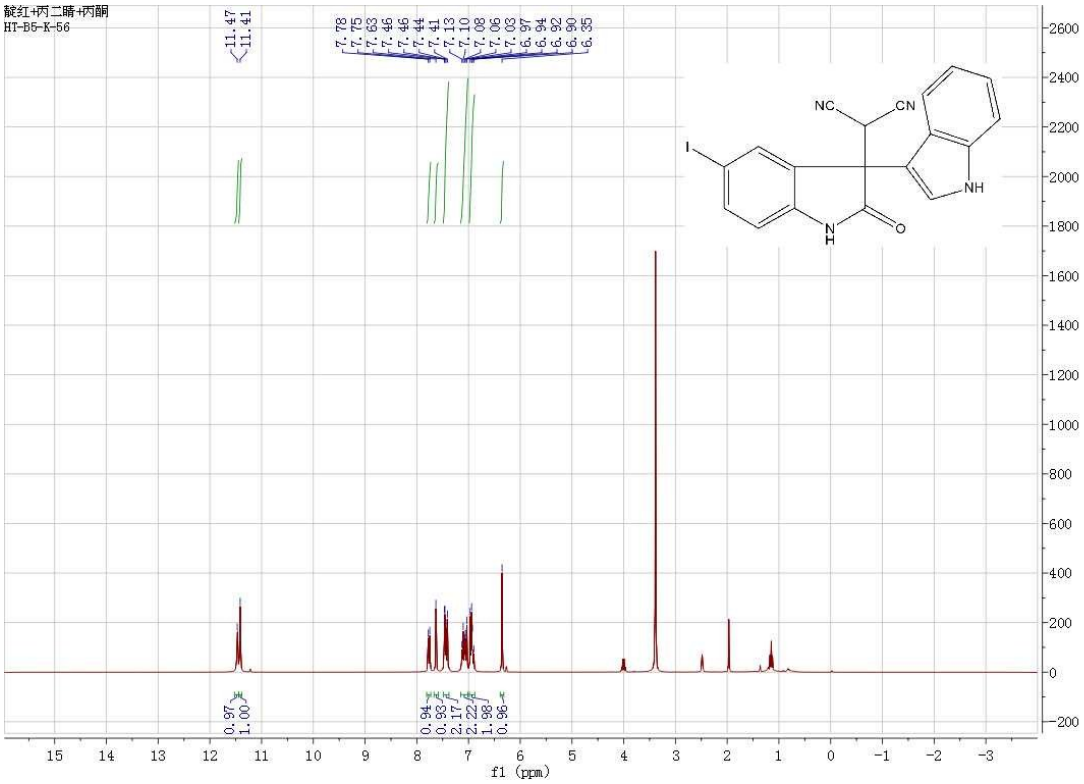


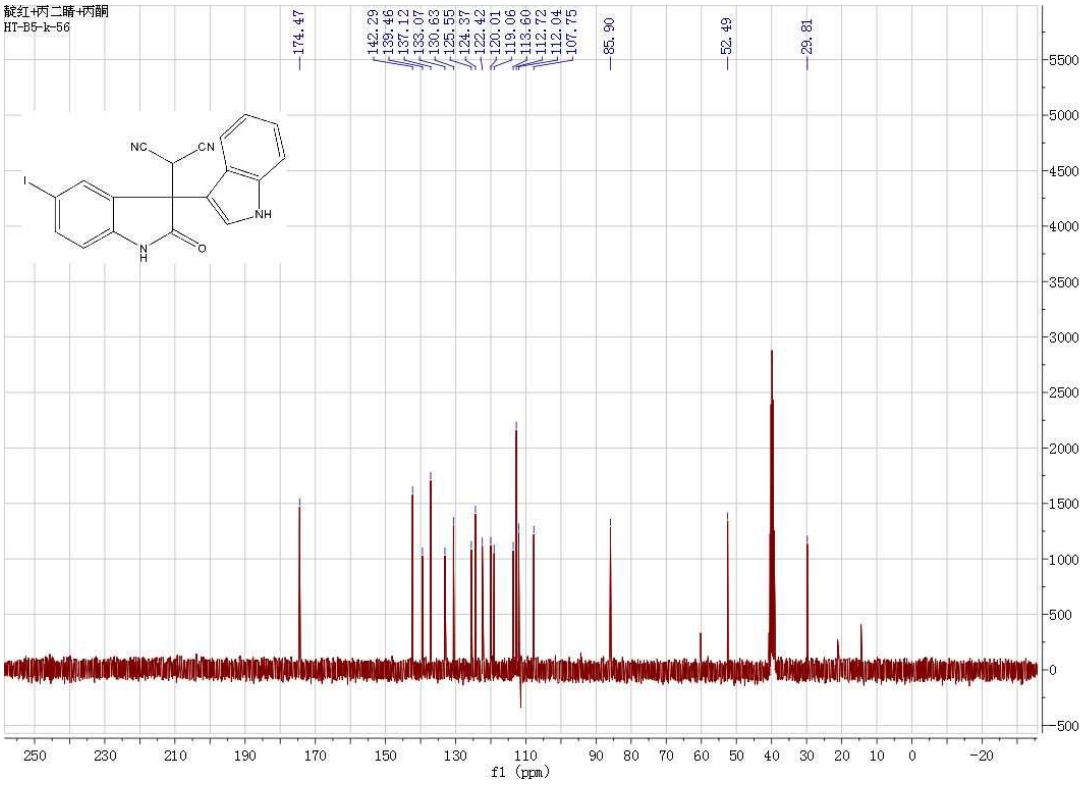
<Peak Table>

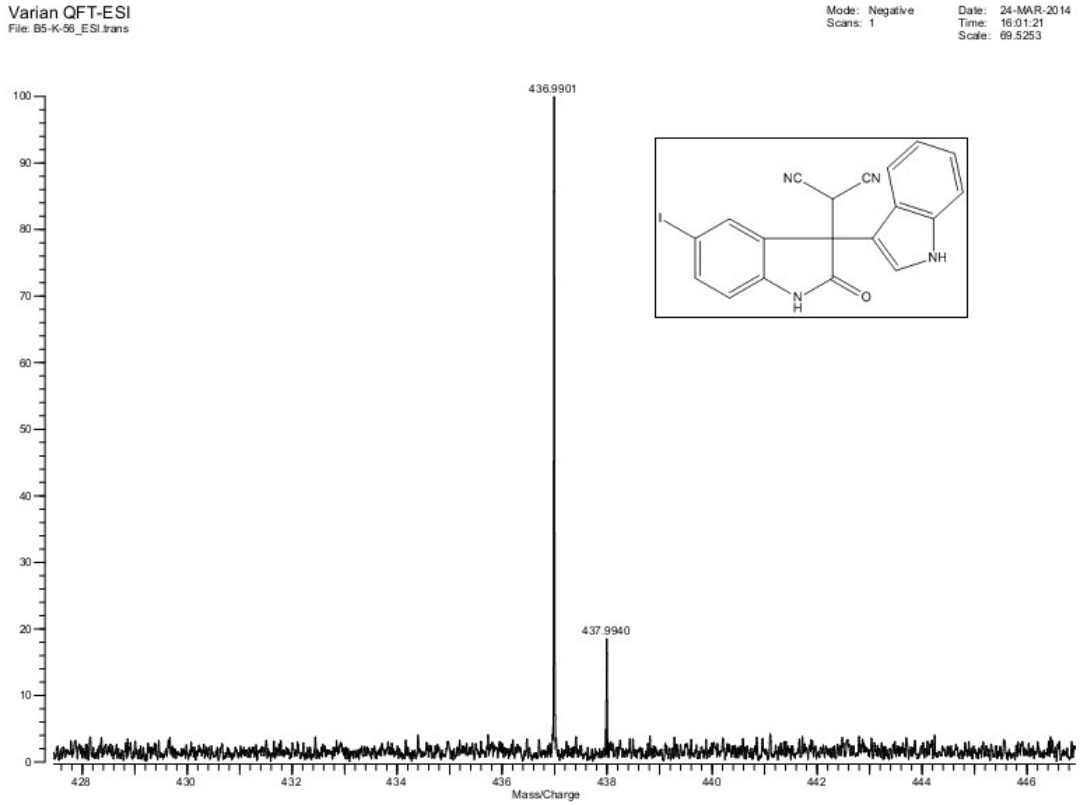
检测器A 254nm

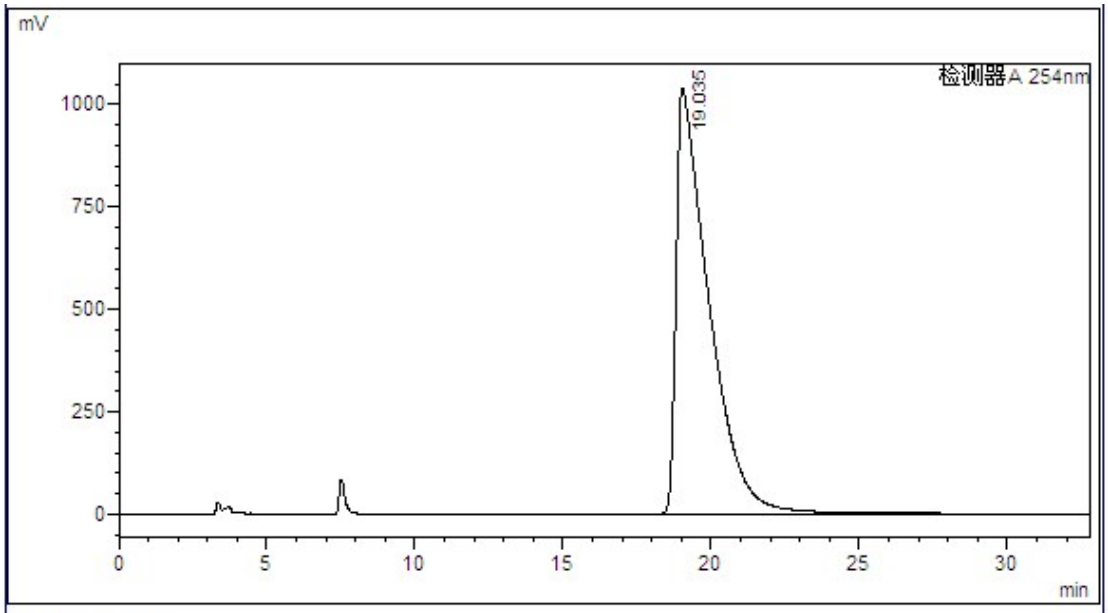
Peak#	Ret. Time	Area	Height	Conc.	Unit	Mark	Name
1	6.784	75072110	2954915	100.000		S	
总计		75072110	2954915				

8b


靛红+丙二睛+丙酮
HT-B5-K-56
11.47
11.41
7.78
7.75
7.63
7.46
7.45
7.44
7.41
7.13
7.10
7.08
7.06
7.03
6.97
6.94
6.92
6.90
6.35
NC
CN
I
NH
N
H
O
0.97
1.00
0.94
0.93
2.17
2.22
1.98
0.96
f1 (ppm)


靛红+丙二睛+丙酮
HT-B5-k-56
174.47
142.29
139.46
137.12
133.07
130.63
125.55
124.37
122.42
120.01
119.06
113.60
112.72
112.04
107.75
85.90
52.49
29.81
NC
CN
I
NH
N
H
O
f1 (ppm)



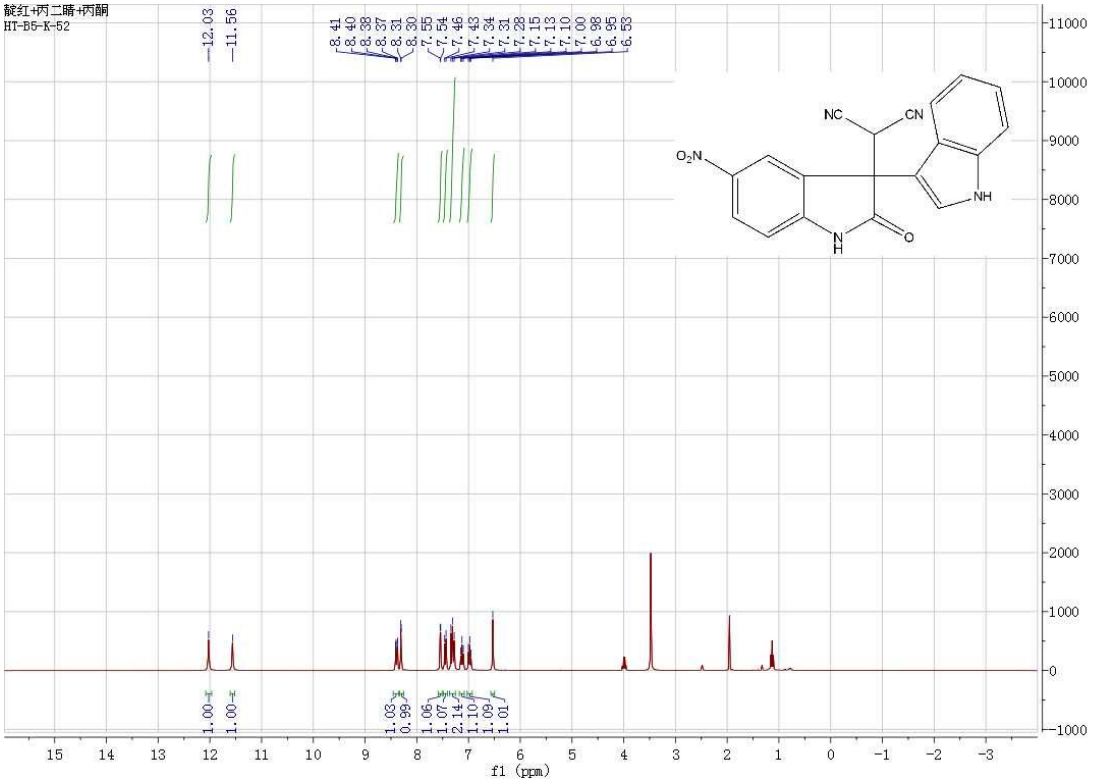


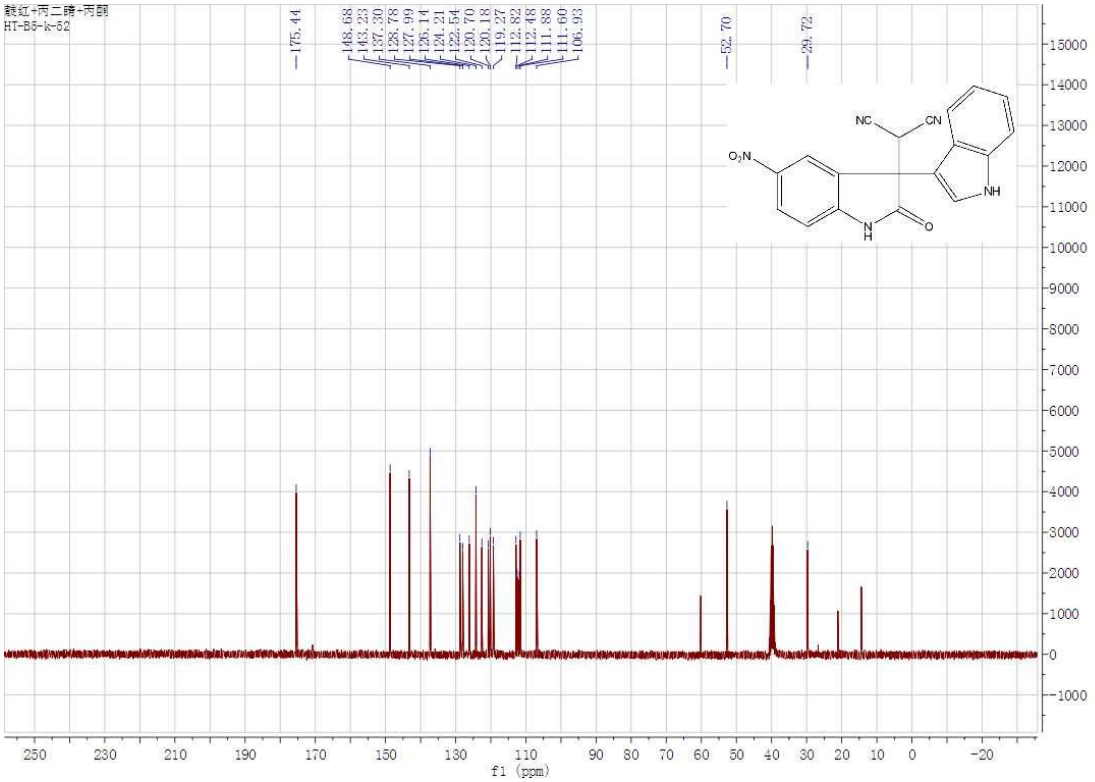
<Peak Table>

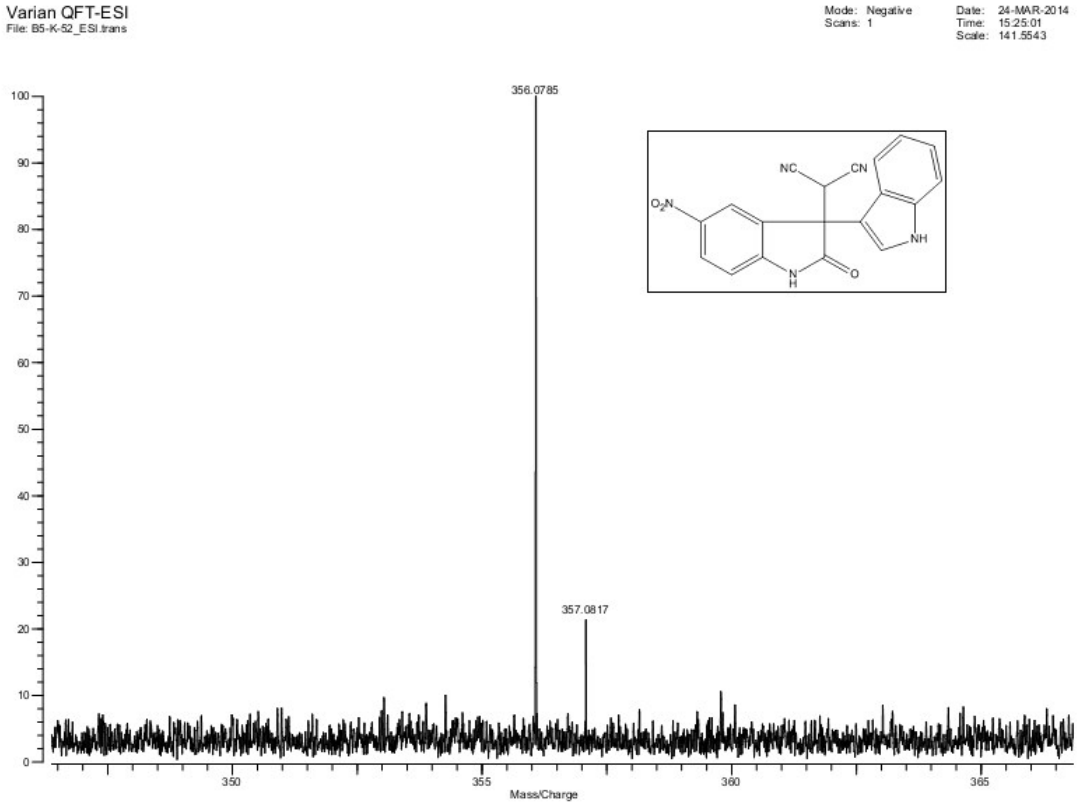
检测器A 254nm

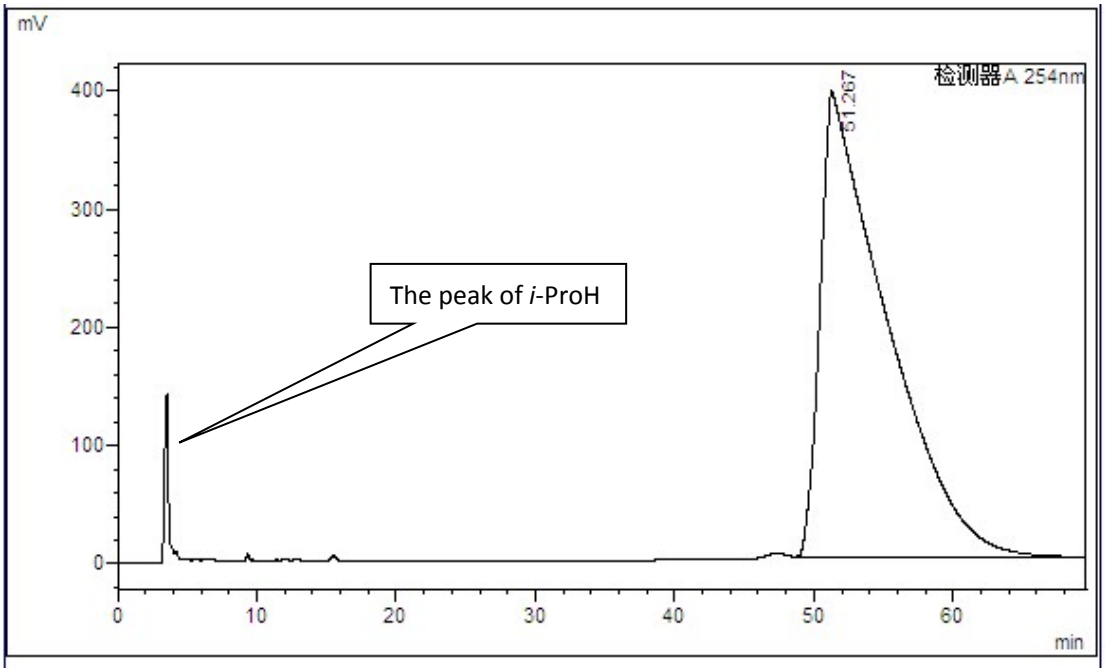
Peak#	Ret. Time	Area	Height	Conc.	Unit	Mark	Name
1	19.035	79926726	1037207	100.000		S	
总计		79926726	1037207				

8c


靛红+丙二腈+丙酮
HT-B5-K-52
12.03
11.56
8.41
8.40
8.38
8.37
8.31
8.30
7.55
7.54
7.46
7.43
7.34
7.31
7.28
7.15
7.13
7.10
7.00
6.98
6.95
6.53
NC
CN
O2N
NH
N
H
O
1.00
1.00
1.03
0.99
1.06
1.07
2.14
1.10
1.09
1.01
f1 (ppm)


靛红+丙二腈+丙酮
HT-B5-k-52
175.44
148.68
143.23
137.30
128.78
127.99
126.14
124.21
122.54
120.70
120.18
119.27
112.82
112.48
111.88
111.66
106.93
52.70
29.72
NC
CN
O2N
NH
N
H
O
f1 (ppm)



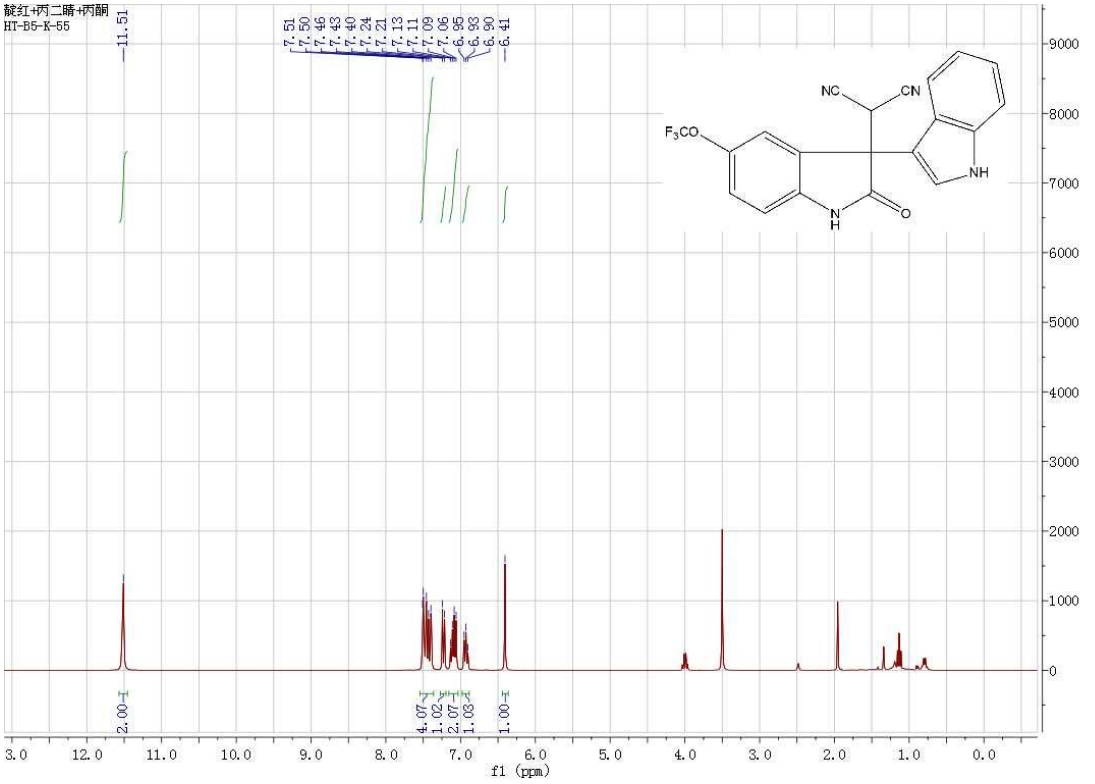


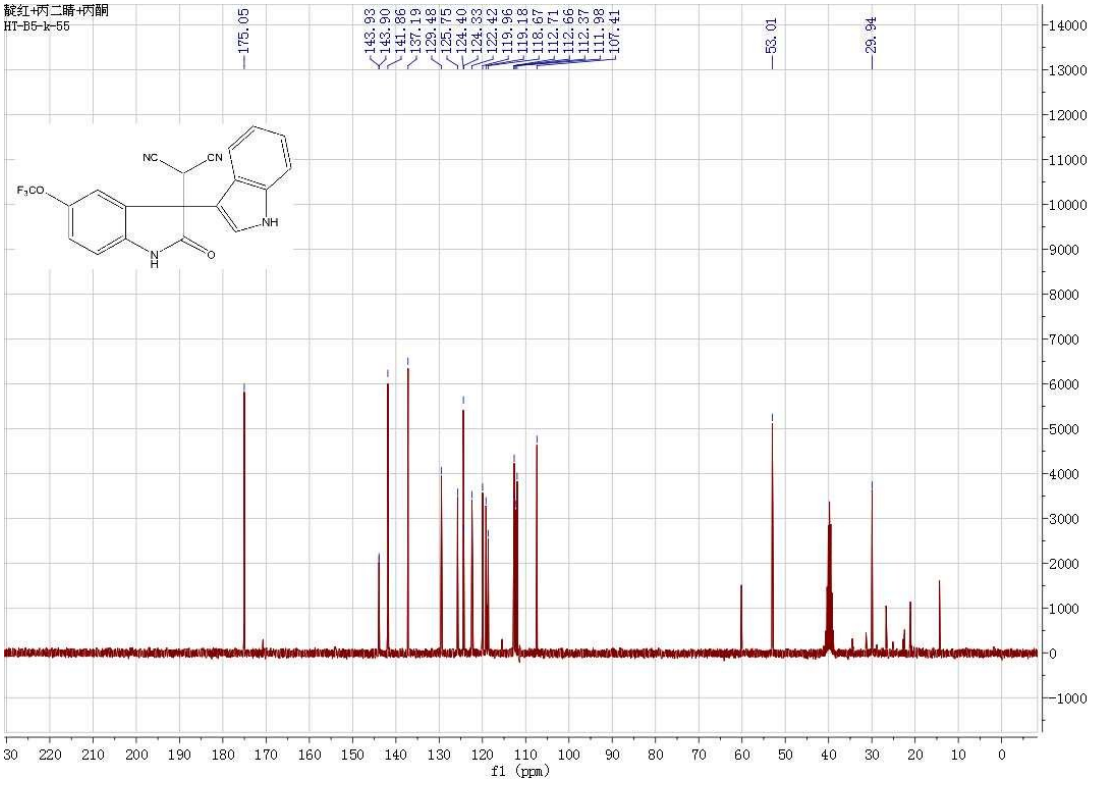
<Peak Table>

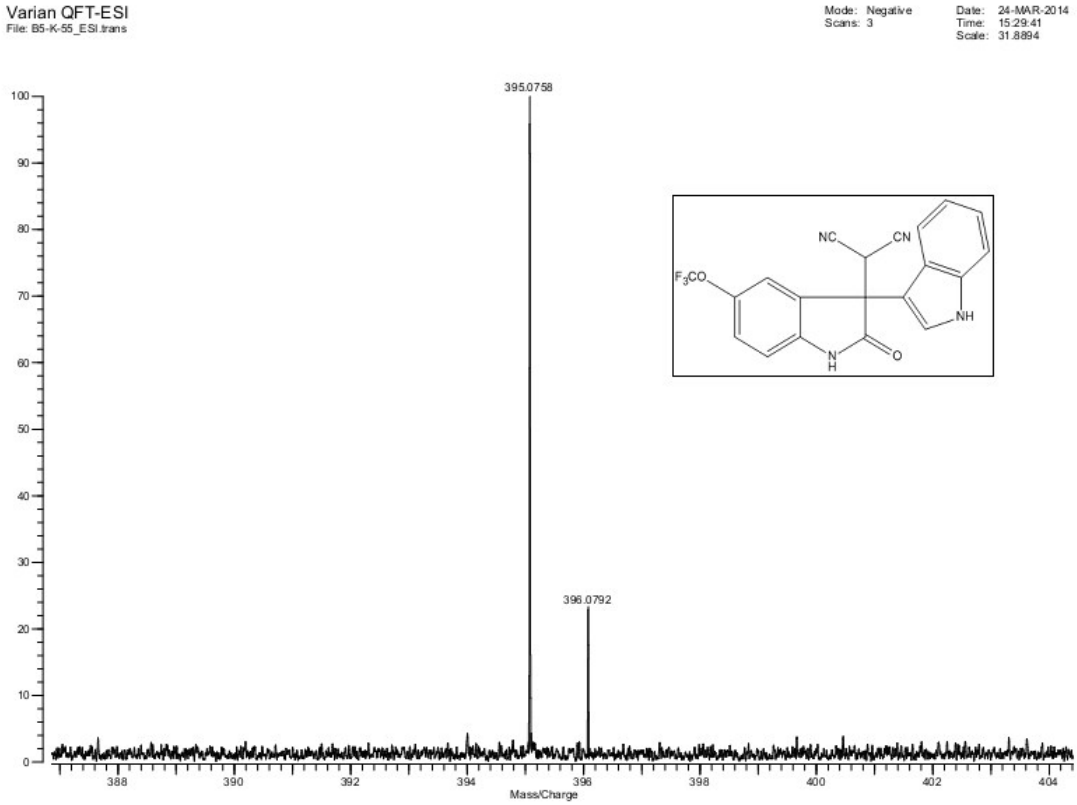
检测器A 254nm

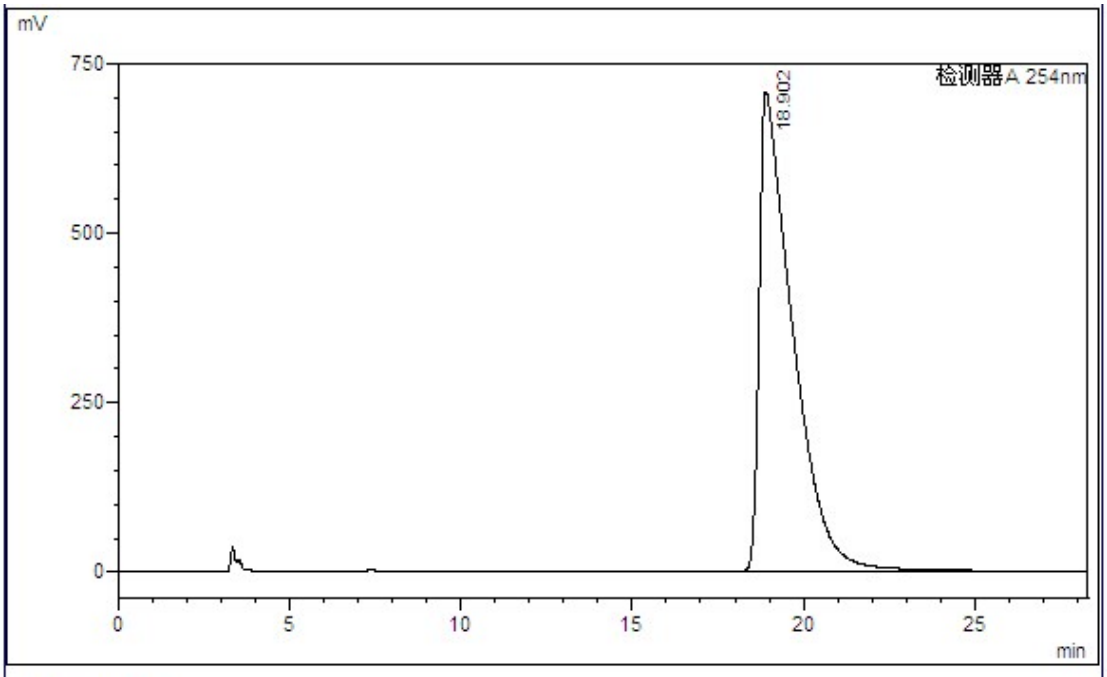
Peak#	Ret. Time	Area	Height	Conc.	Unit	Mark	Name
1	51.267	130218331	393928	100.000		S	
总计		130218331	393928				

8d


旋红+丙二腈+丙酮
HT-B5-K-55
11.51
7.51
7.50
7.46
7.43
7.40
7.24
7.21
7.13
7.11
7.09
7.06
6.95
6.93
6.90
6.41
NC
CN
F3CO
NH
N
H
O
2.00
4.07
1.02
2.07
1.03
1.00
f1 (ppm)


旋红+丙二腈+丙酮
HT-B5-k-55
175.05
143.93
143.90
141.86
137.19
129.48
125.75
124.40
124.33
122.42
119.96
119.18
118.67
112.71
112.66
112.37
111.98
107.41
53.01
29.94
NC
CN
F3CO
NH
N
H
O
f1 (ppm)



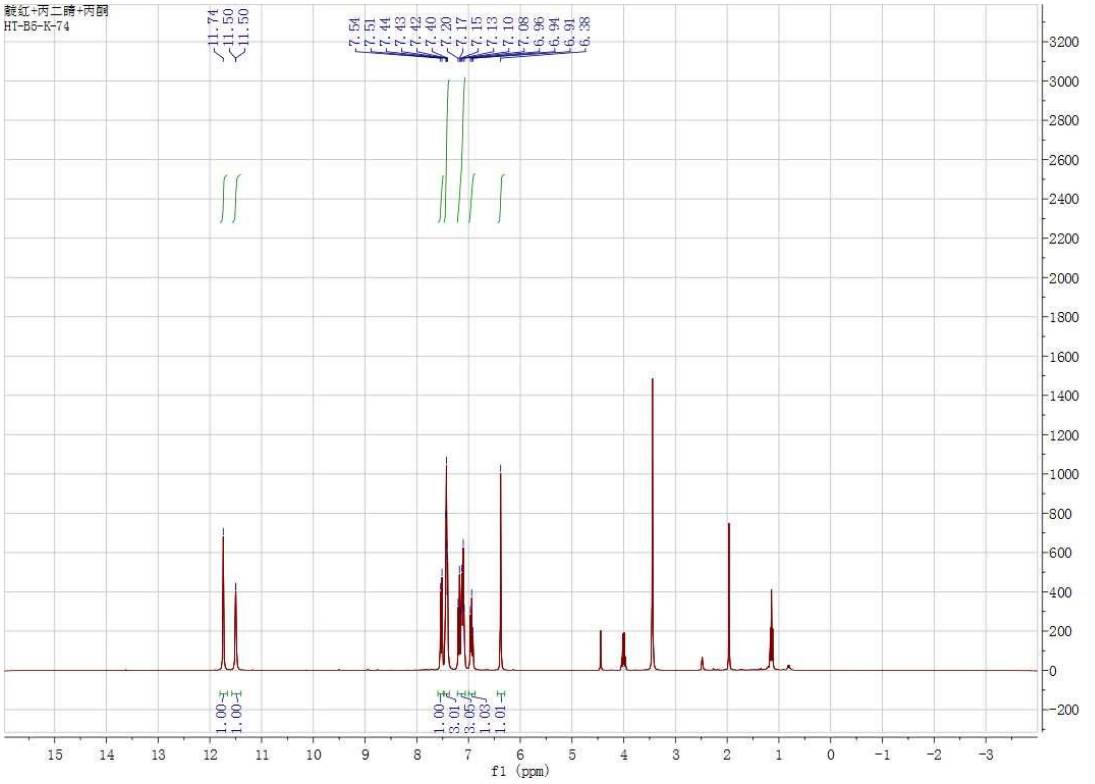


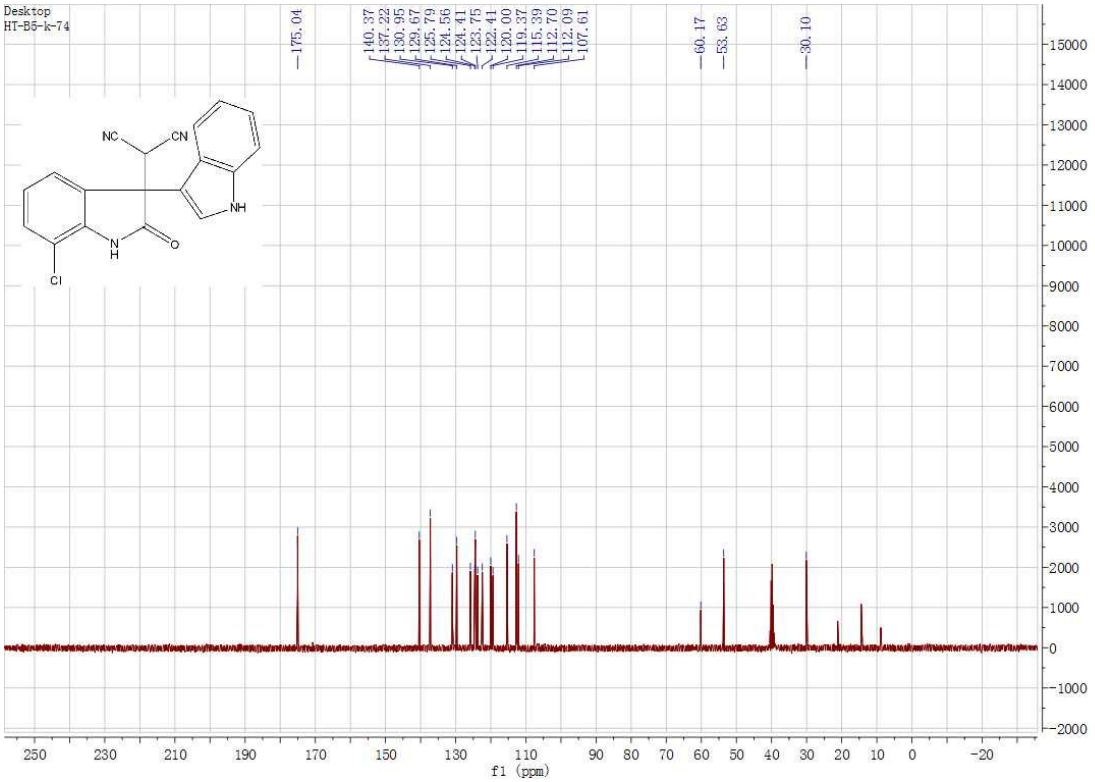
<Peak Table>

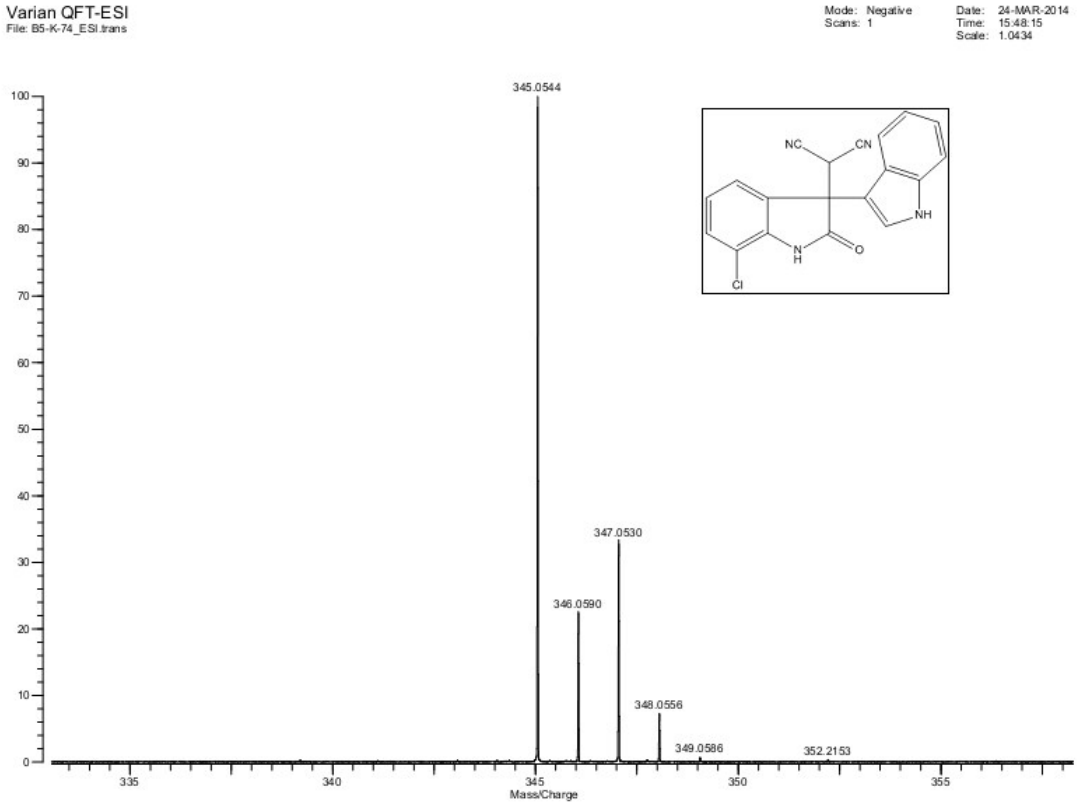
检测器A 254nm

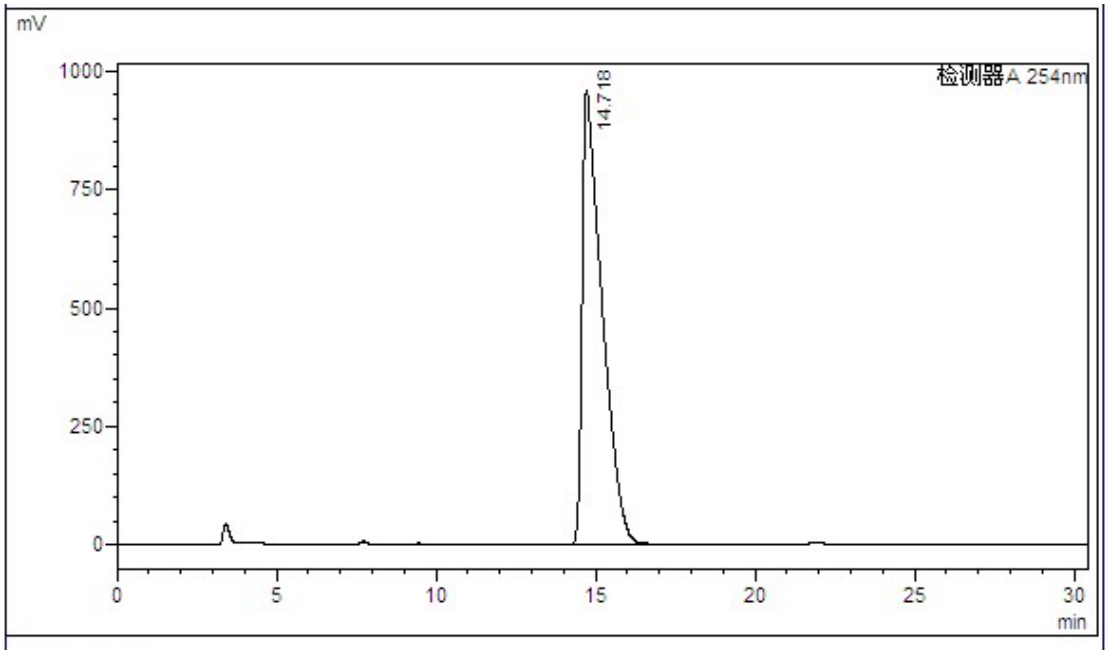
Peak#	Ret. Time	Area	Height	Conc.	Unit	Mark	Name
1	18.902	48159609	707701	100.000			
总计		48159609	707701				

8e


11.74
11.50
11.50
7.54
7.51
7.44
7.43
7.42
7.40
7.20
7.17
7.15
7.13
7.10
7.08
6.96
6.94
6.91
6.38
1.00
1.00
1.00
3.01
3.05
1.03
1.01
f1 (ppm)


Desktop
HT-B5-k-74
175.04
140.37
137.22
130.95
129.67
125.79
124.56
124.41
123.75
122.41
120.00
119.37
115.39
112.70
112.09
107.61
60.17
53.63
30.10
NC
CN
NH
N
H
O
Cl
f1 (ppm)



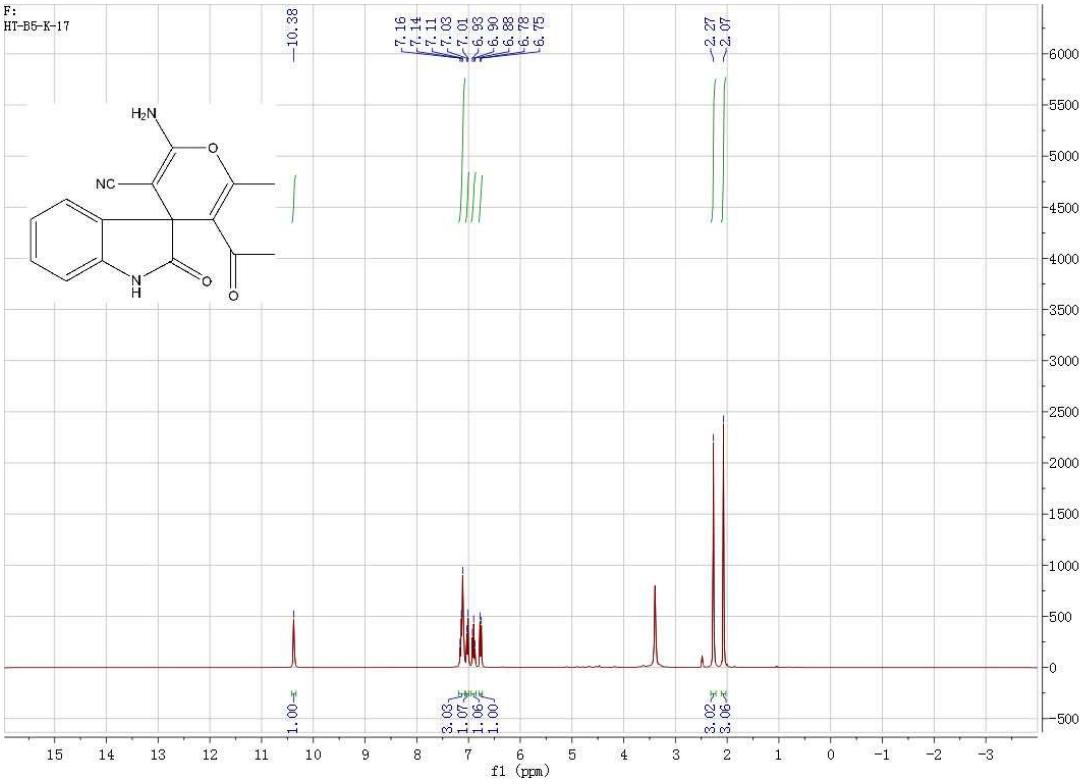


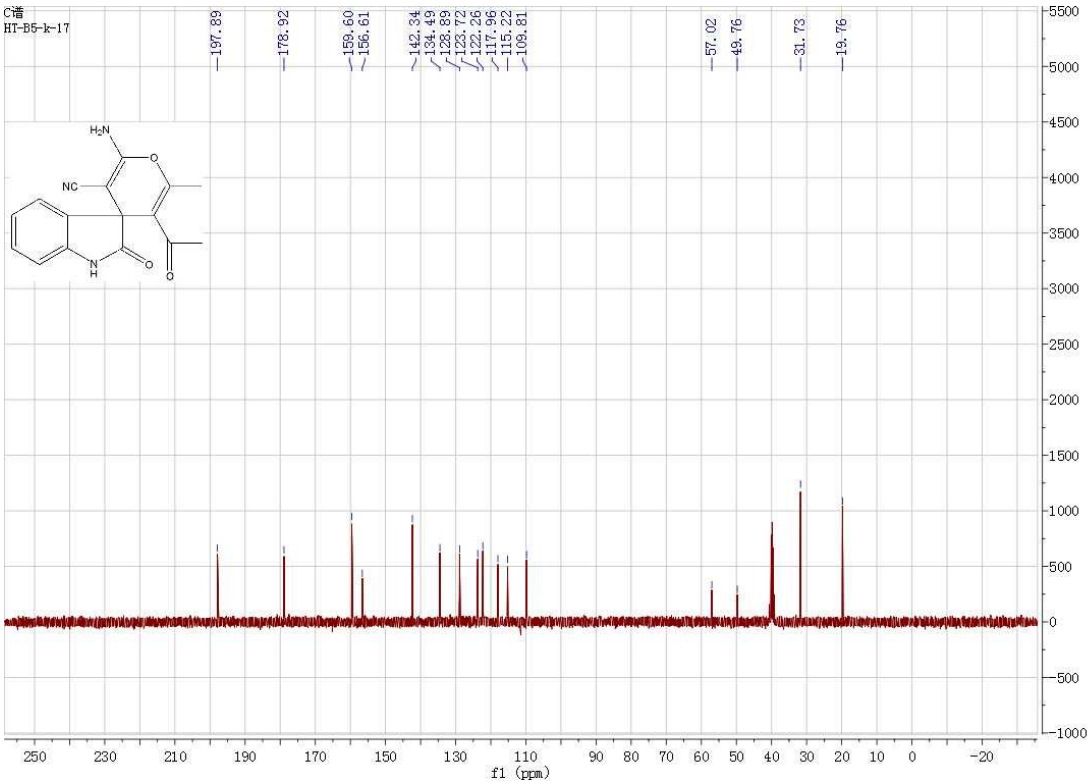
<Peak Table>

检测器A 254nm

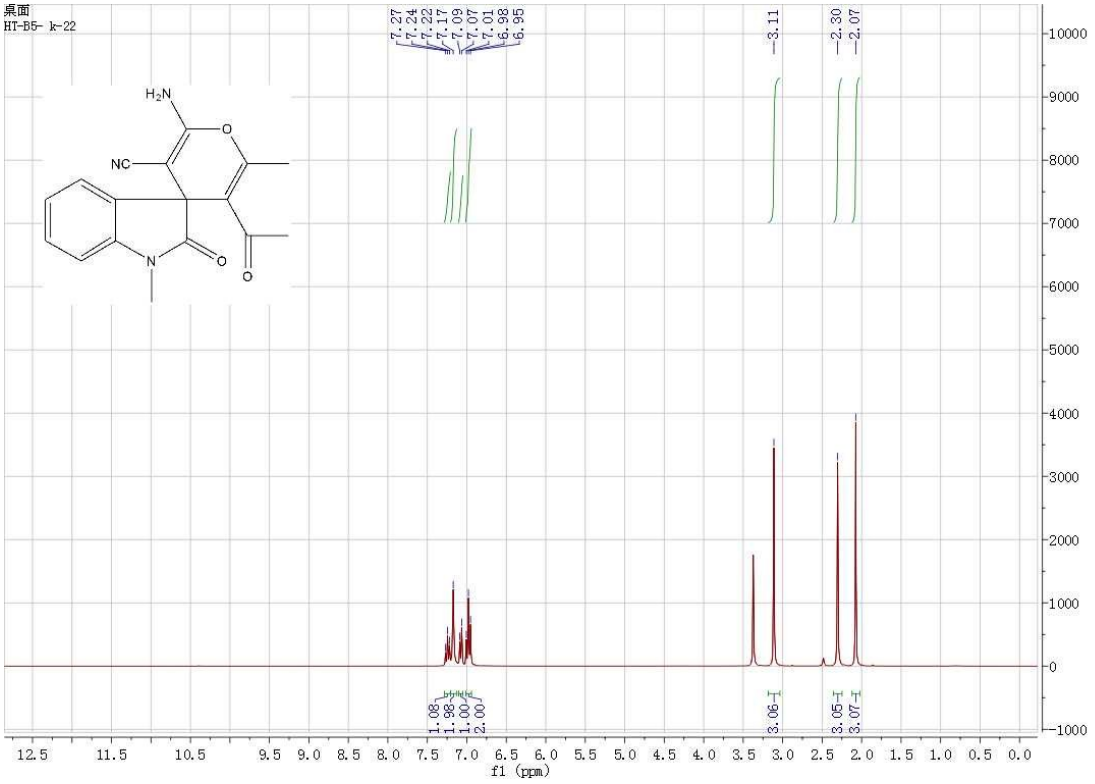
Peak#	Ret. Time	Area	Height	Conc.	Unit	Mark	Name
1	14.718	41676932	959960	100.000		S	
总计		41676932	959960				

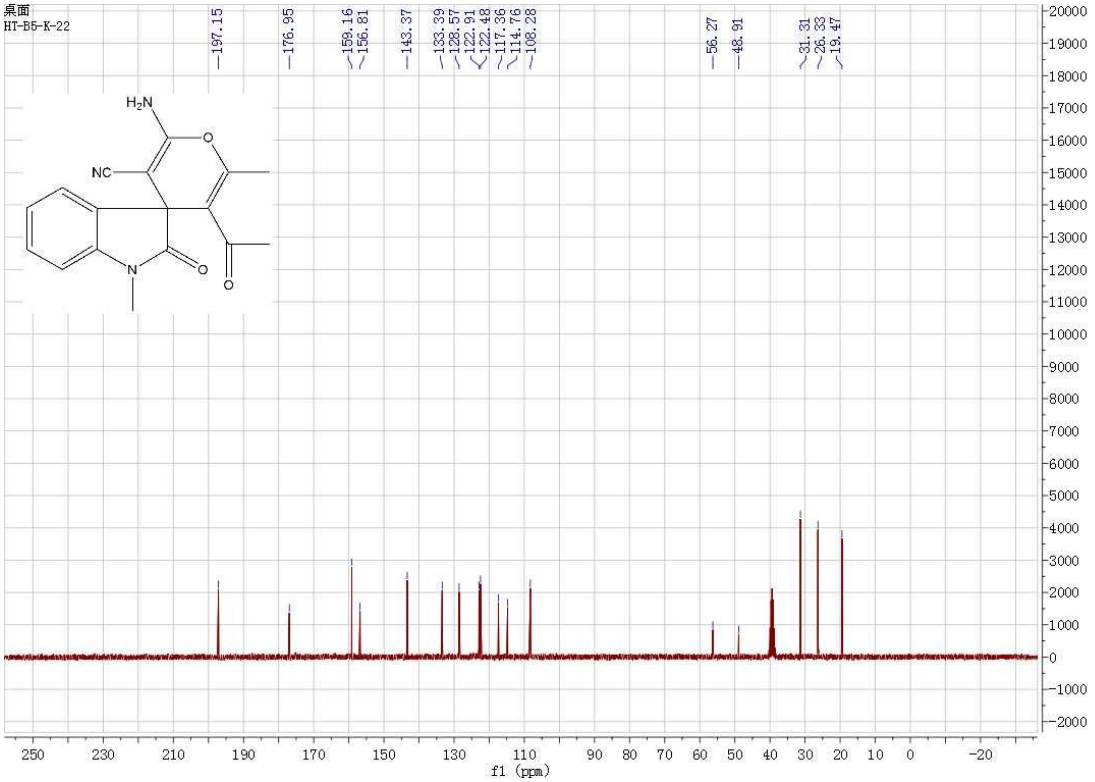
11a


F:
HT-B5-K-17
10.38
7.16
7.14
7.11
7.03
7.01
6.93
6.90
6.88
6.78
6.75
2.27
2.07
1.00
3.03
1.07
1.06
1.00
3.02
3.06
f1 (ppm)

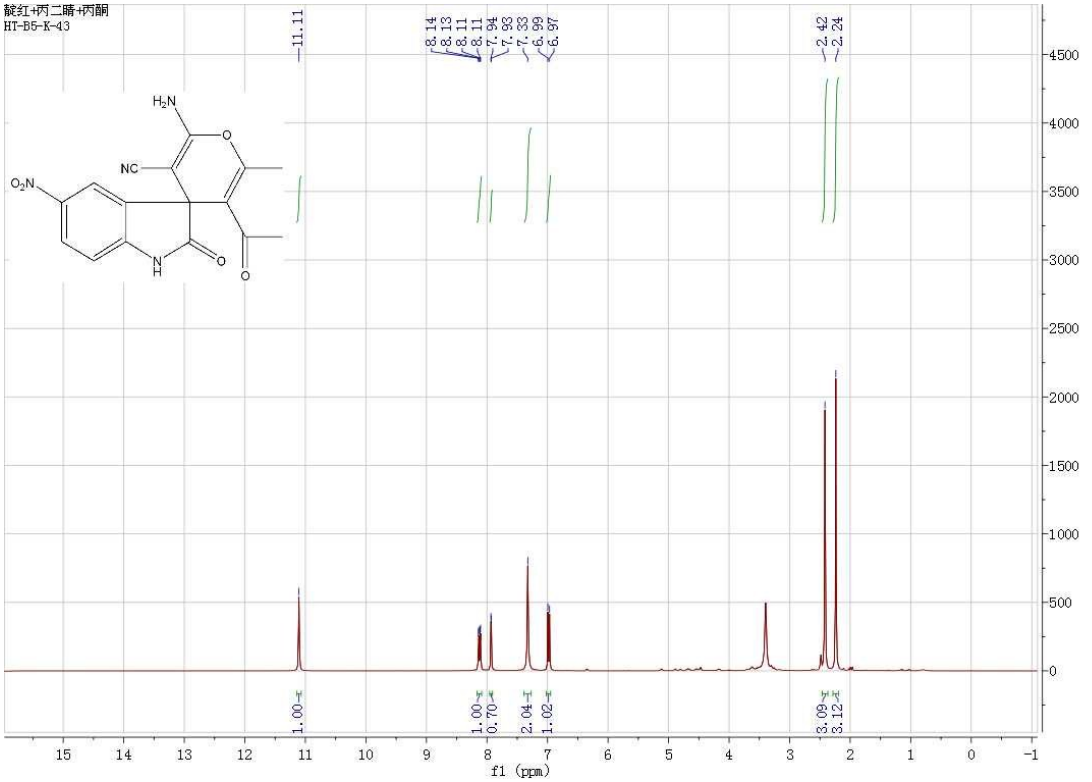

C谱
HT-B5-k-17
197.89
178.92
159.60
156.61
142.34
134.49
128.89
123.72
122.26
117.96
115.22
109.81
57.02
49.76
31.73
19.76
f1 (ppm)

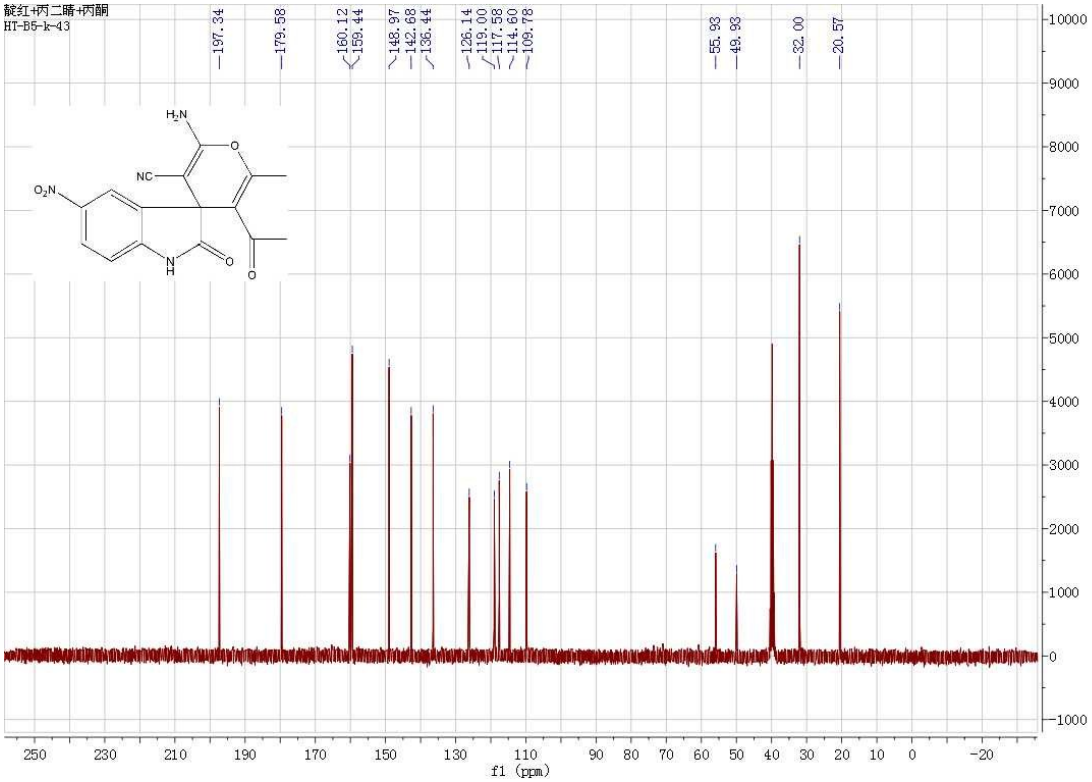
11b


桌面
HT-B5- k-22
7.27
7.24
7.22
7.17
7.09
7.07
7.01
6.98
6.95
3.11
2.30
2.07
1.08
1.98
1.00
2.00
3.06
3.05
3.07
f1 (ppm)

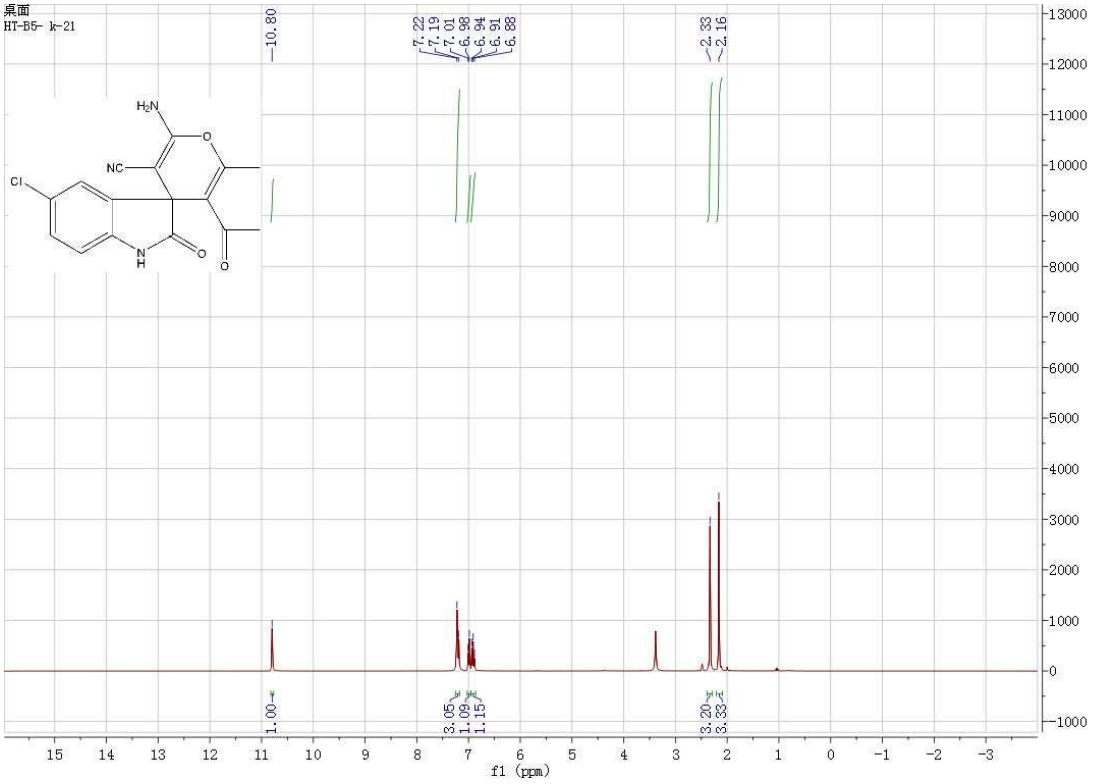

桌面
HT-B5-K-22
197.15
176.95
159.16
156.81
143.37
133.39
128.57
122.91
122.48
117.36
114.76
108.28
56.27
48.91
31.31
26.33
19.47
f1 (ppm)

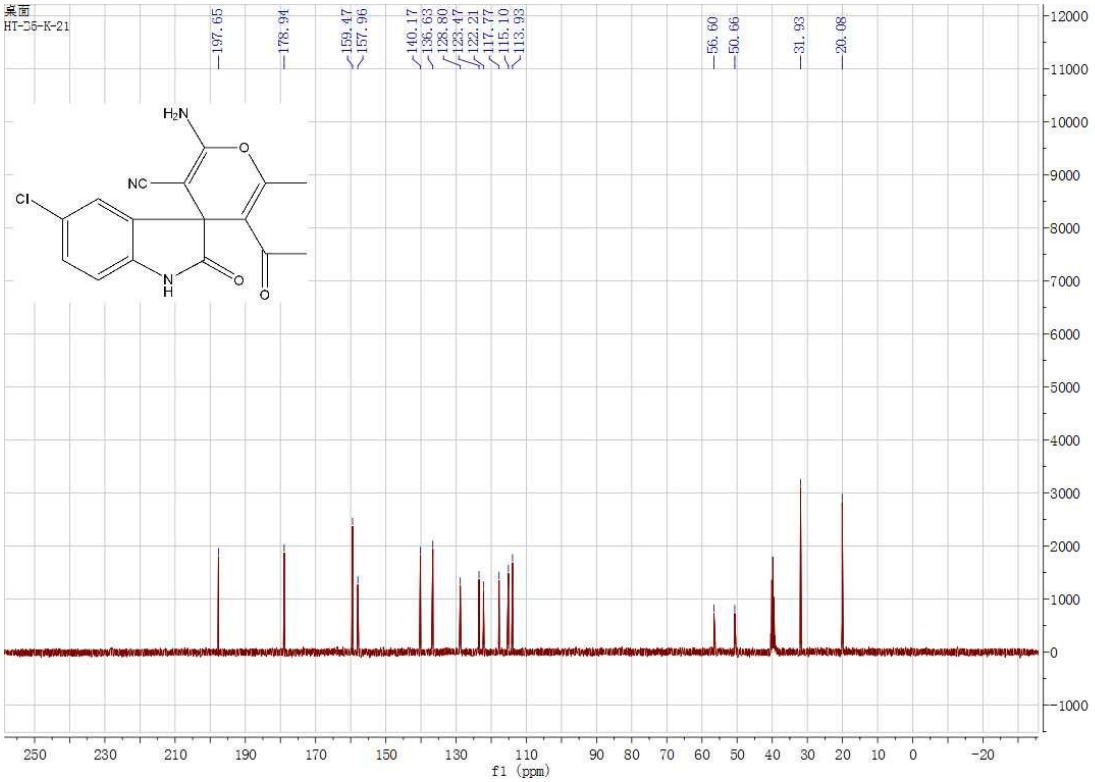
11c


靛红+丙二腈+丙酮
HT-B5-K-43
11.11
8.14
8.13
8.11
8.11
7.94
7.93
7.33
6.99
6.97
2.42
2.24
1.00
1.00
0.70
2.04
1.02
3.09
3.12
f1 (ppm)

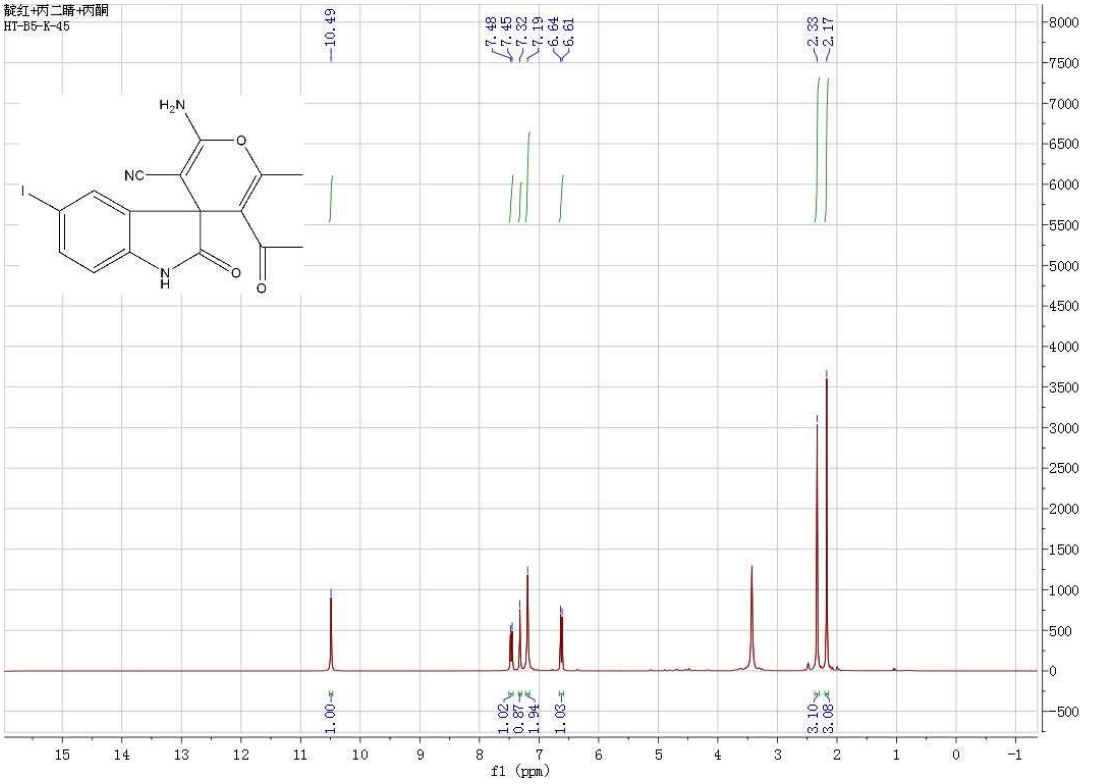

靛红+丙二腈+丙酮
HT-B5-k-43
197.34
179.58
160.12
159.44
148.97
142.68
136.44
126.14
119.00
117.58
114.60
109.78
55.93
49.93
32.00
20.57
f1 (ppm)

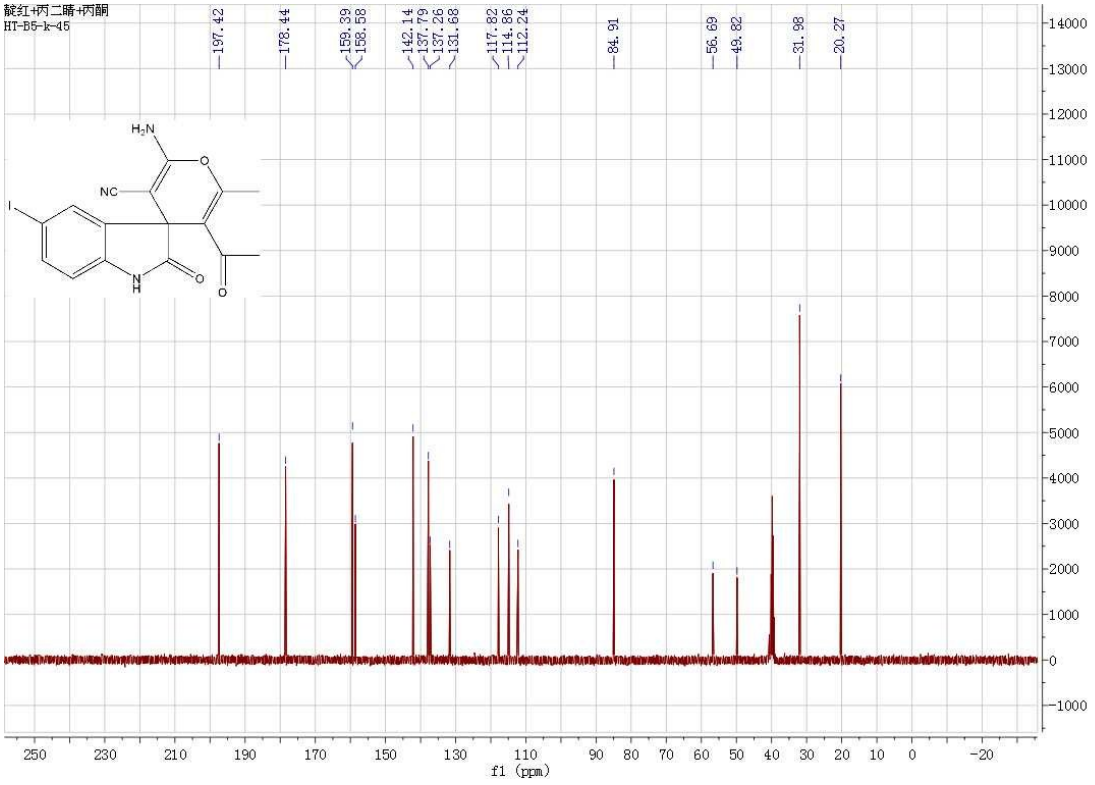
11d


桌面
HT-B5- k-21
10.80
7.22
7.19
7.01
6.98
6.94
6.91
6.88
2.33
2.16
1.00
3.05
1.09
1.15
3.20
3.33
f1 (ppm)

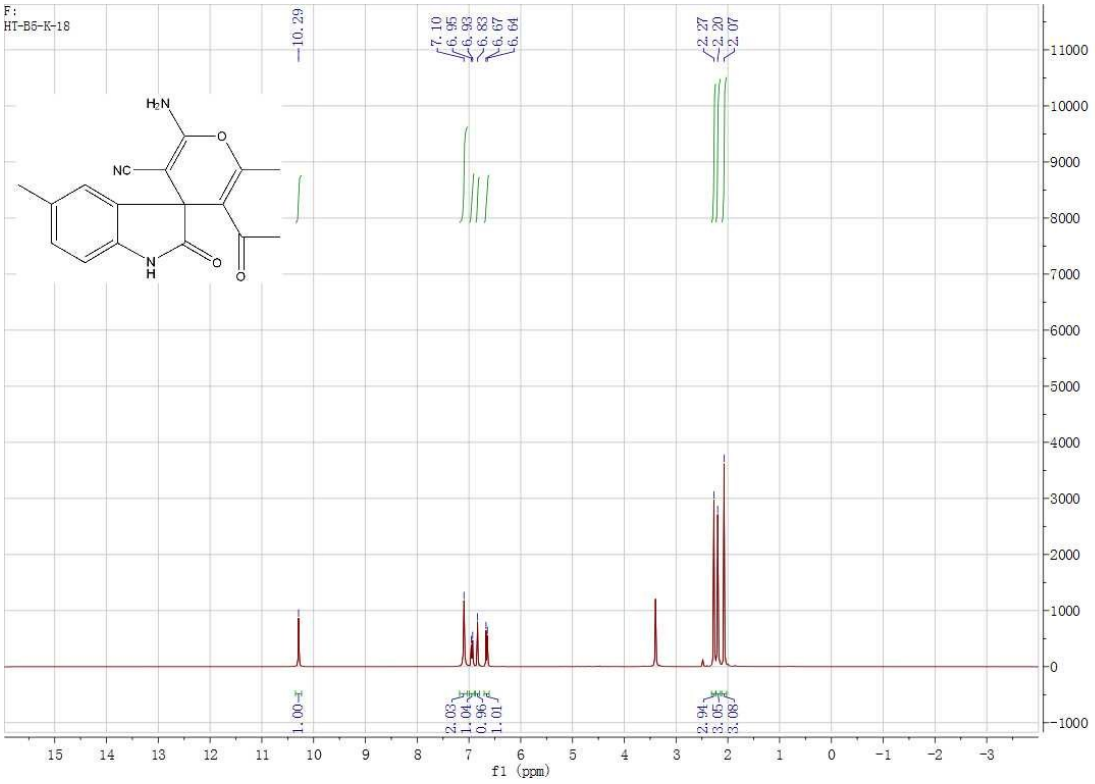

桌面
HT-C6-K-21
197.65
178.94
159.47
157.96
140.17
136.63
128.80
123.47
122.21
117.77
115.10
113.93
56.60
50.66
31.93
20.08
f1 (ppm)

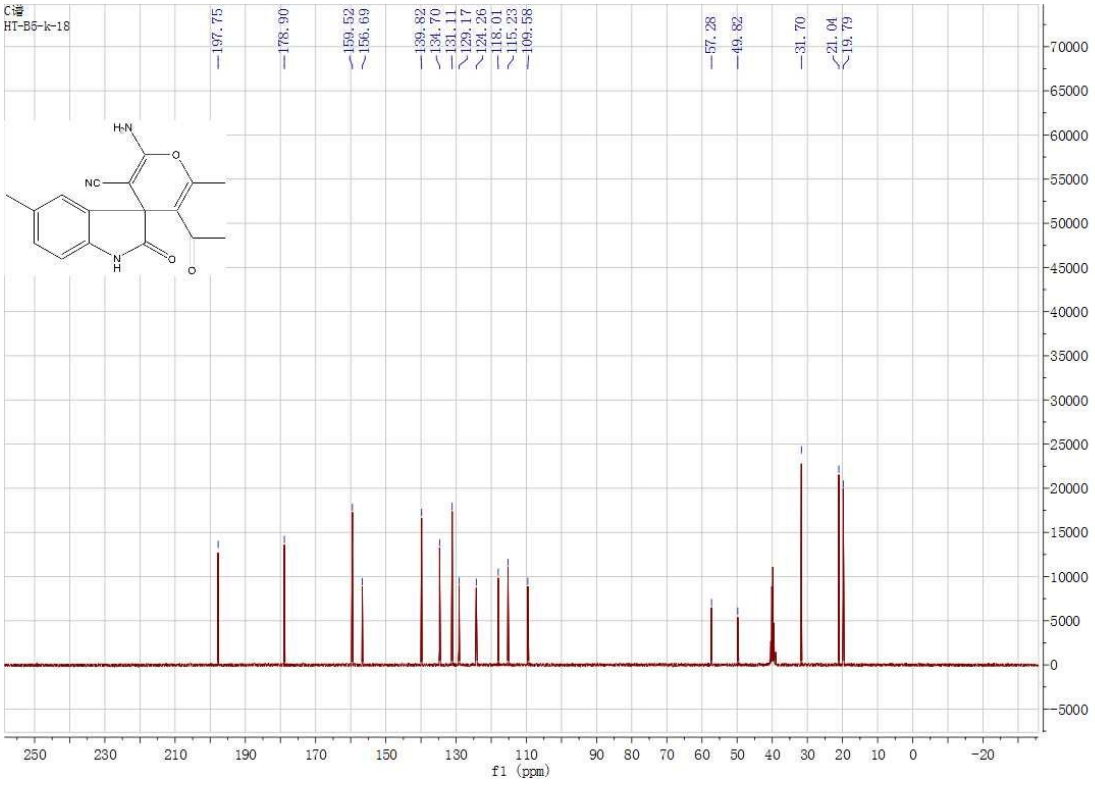
11e


靛红+丙二腈+丙酮
HT-B5-K-45
10.49
7.48
7.45
7.32
7.19
6.64
6.61
2.33
2.17
1.00
1.02
0.87
1.94
1.03
3.10
3.08
f1 (ppm)

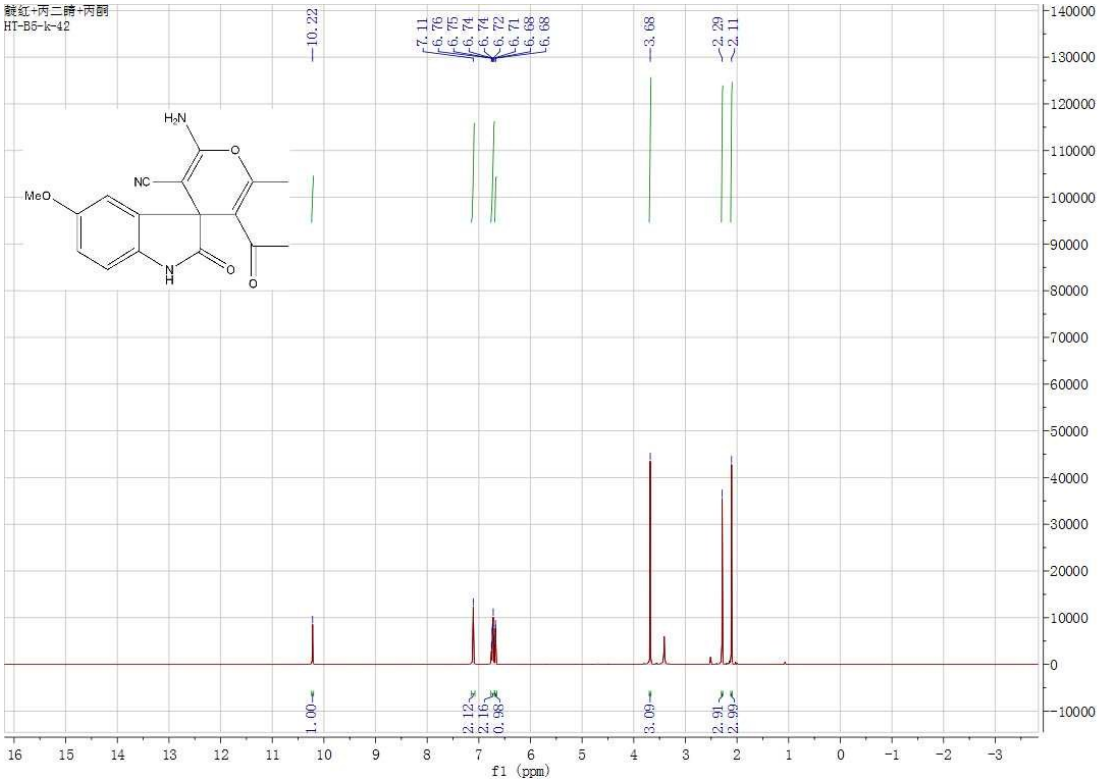

靛红+丙二腈+丙酮
HT-B5-k-45
197.42
178.44
159.39
158.58
142.14
137.79
137.26
131.68
117.82
114.86
112.24
84.91
56.69
49.82
31.98
20.27
f1 (ppm)

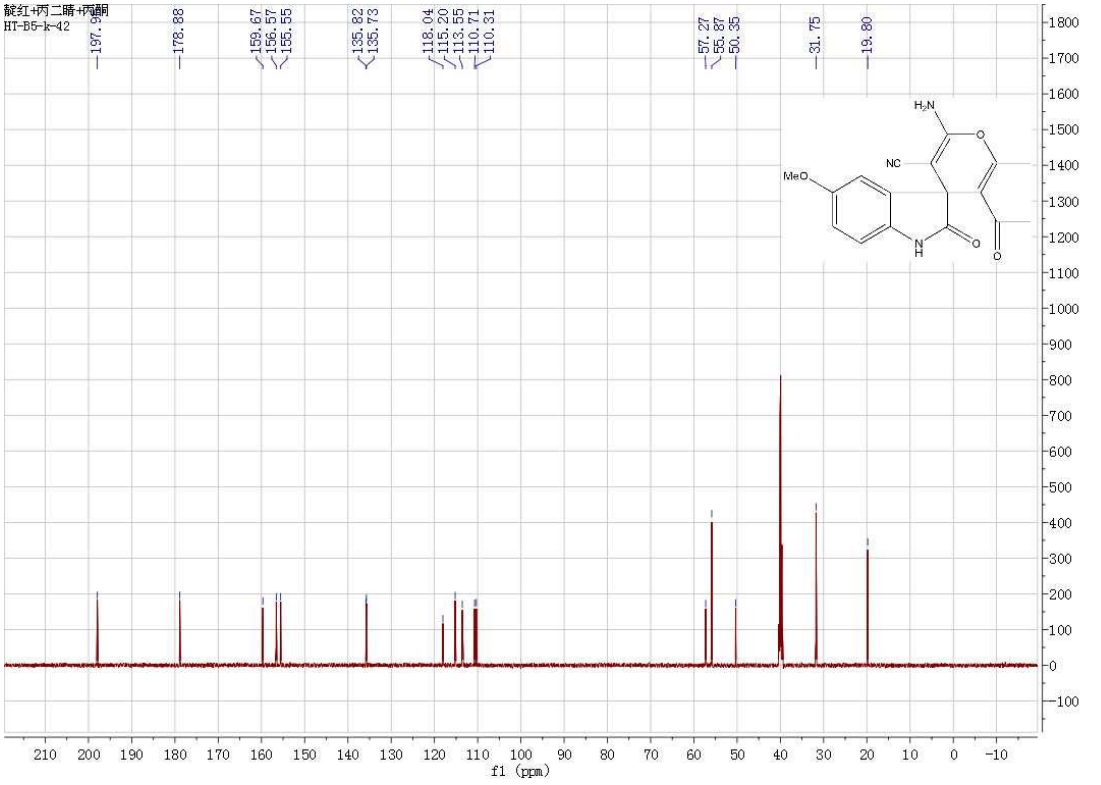
11f


F:
HT-B5-K-18
10.29
7.10
6.95
6.93
6.83
6.67
6.64
2.27
2.20
2.07
1.00
2.03
1.04
0.96
1.01
2.94
3.05
3.08
f1 (ppm)

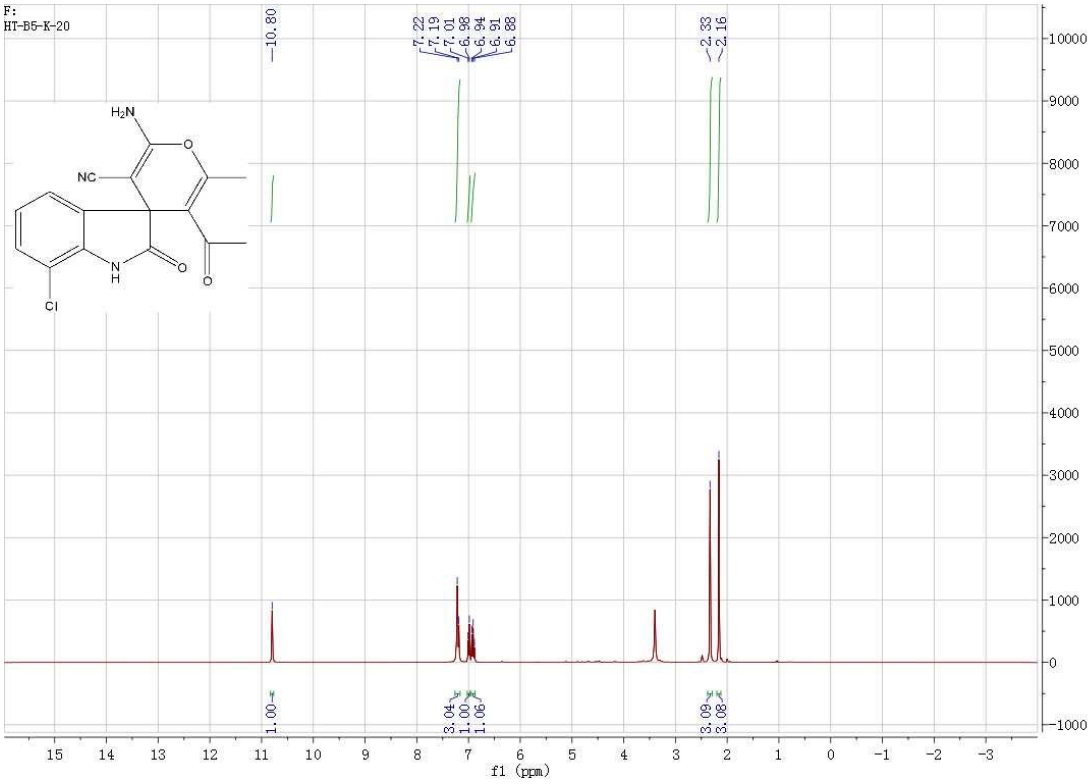

C:
HT-B5-k-18
197.75
178.90
159.52
156.69
139.82
134.70
131.11
129.17
124.26
118.01
115.23
109.58
57.28
49.82
31.70
21.04
19.79
f1 (ppm)

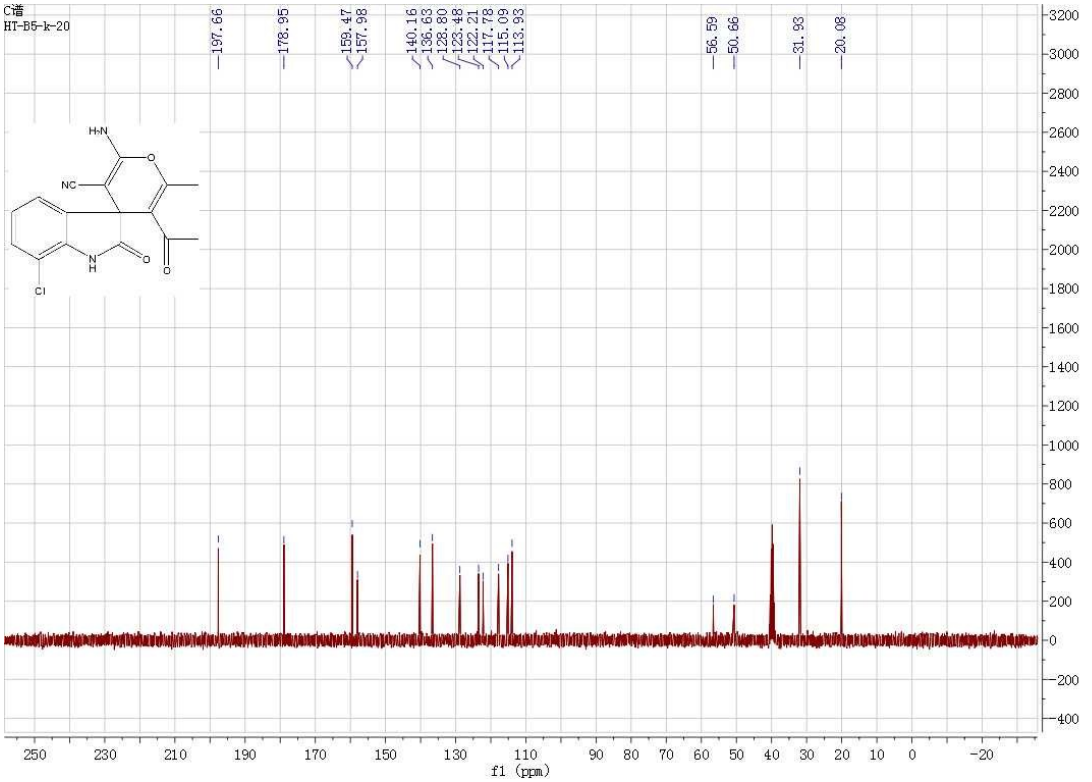
11g


靛红+丙二腈+丙酮
HT-B5-k-42
10.22
7.11
6.76
6.75
6.74
6.74
6.72
6.71
6.68
6.68
3.68
2.29
2.11
1.00
2.12
2.16
0.98
3.09
2.91
2.99
f1 (ppm)

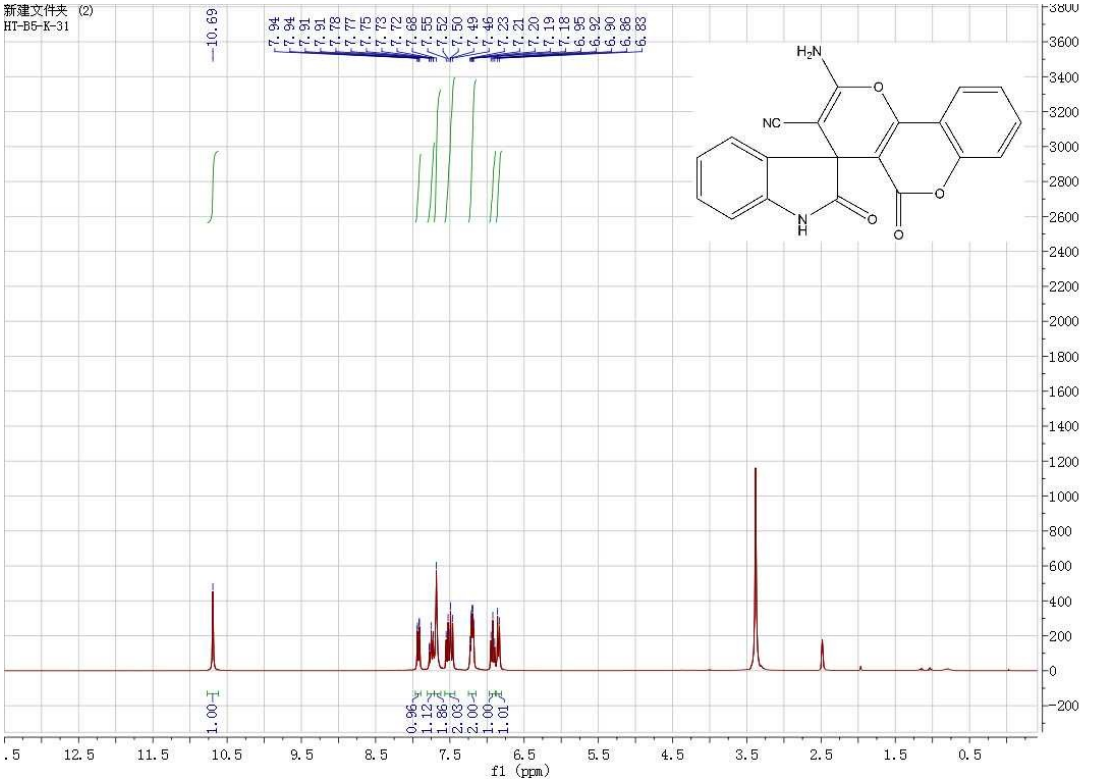

靛红+丙二腈+丙酮
HT-B5-k-42
197.99
178.88
159.67
156.57
155.55
135.82
135.73
118.04
115.20
113.55
110.71
110.31
57.27
55.87
50.35
31.75
19.80
f1 (ppm)

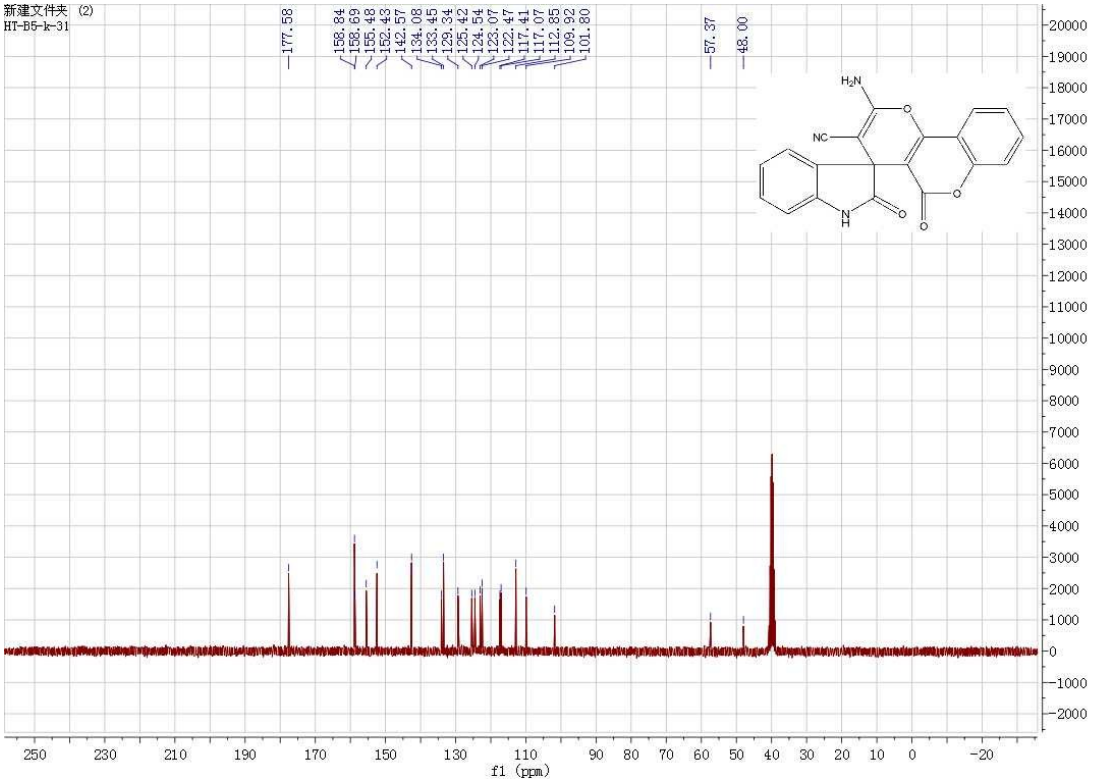
11h


F:
HT-B5-K-20
10.80
7.22
7.19
7.01
6.98
6.94
6.91
6.88
2.33
2.16
1.00
3.04
1.00
1.06
3.09
3.08
f1 (ppm)

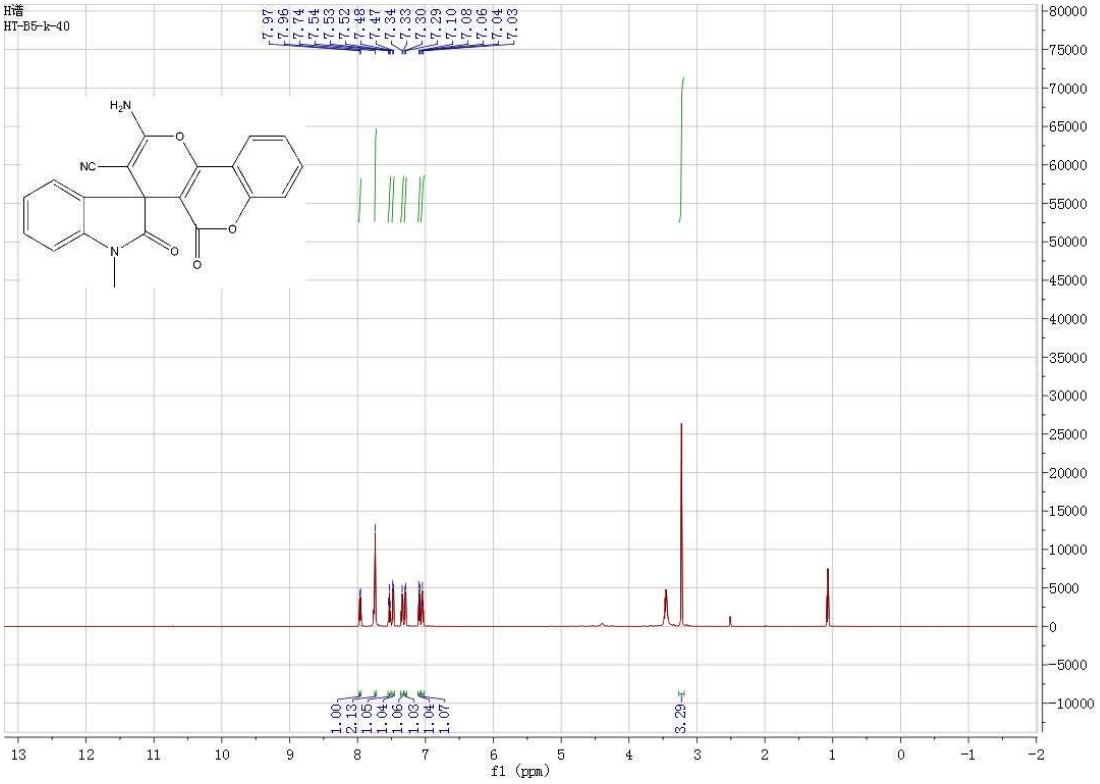

C谱
HT-B5-k-20
197.66
178.95
159.47
157.98
140.16
136.63
128.80
123.48
122.21
117.78
115.09
113.93
56.59
50.66
31.93
20.08
f1 (ppm)

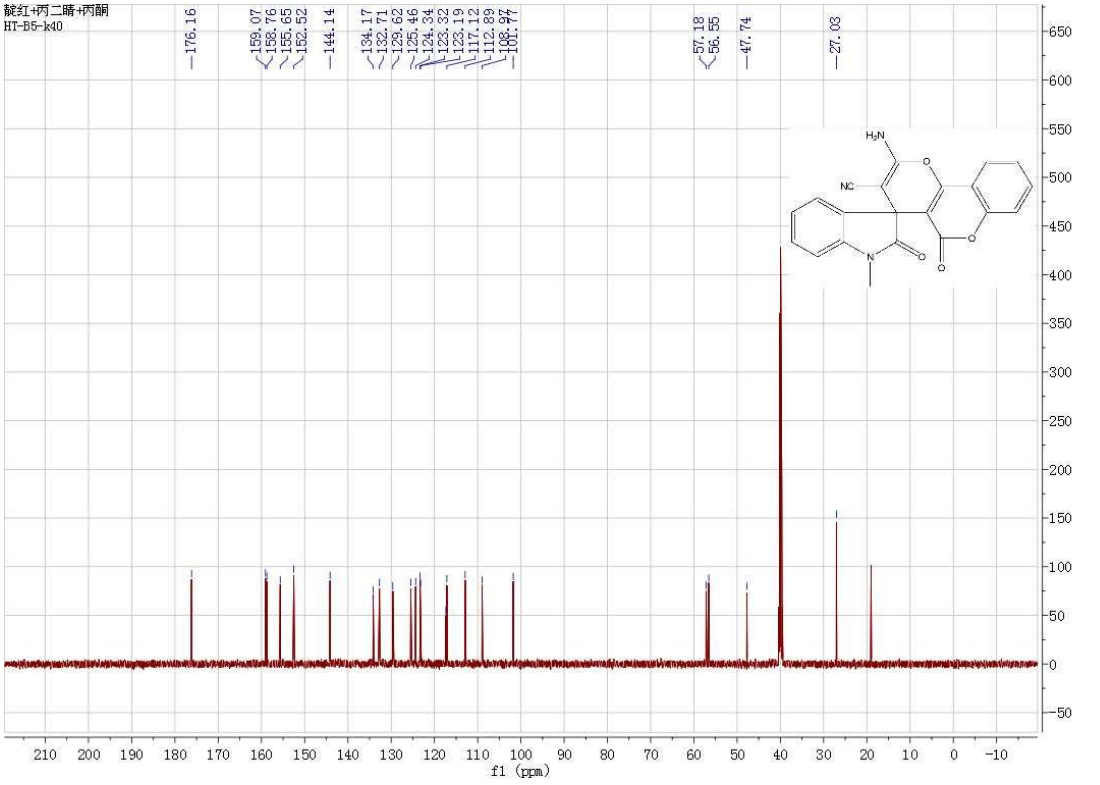
13a


新建文件夹 (2)
HT-B5-K-31
10.69
7.94
7.94
7.91
7.91
7.78
7.77
7.75
7.73
7.72
7.68
7.55
7.52
7.50
7.49
7.46
7.23
7.21
7.20
7.19
7.18
6.95
6.92
6.90
6.86
6.83
1.00
0.96
1.12
1.86
2.03
2.00
1.00
1.01
f1 (ppm)

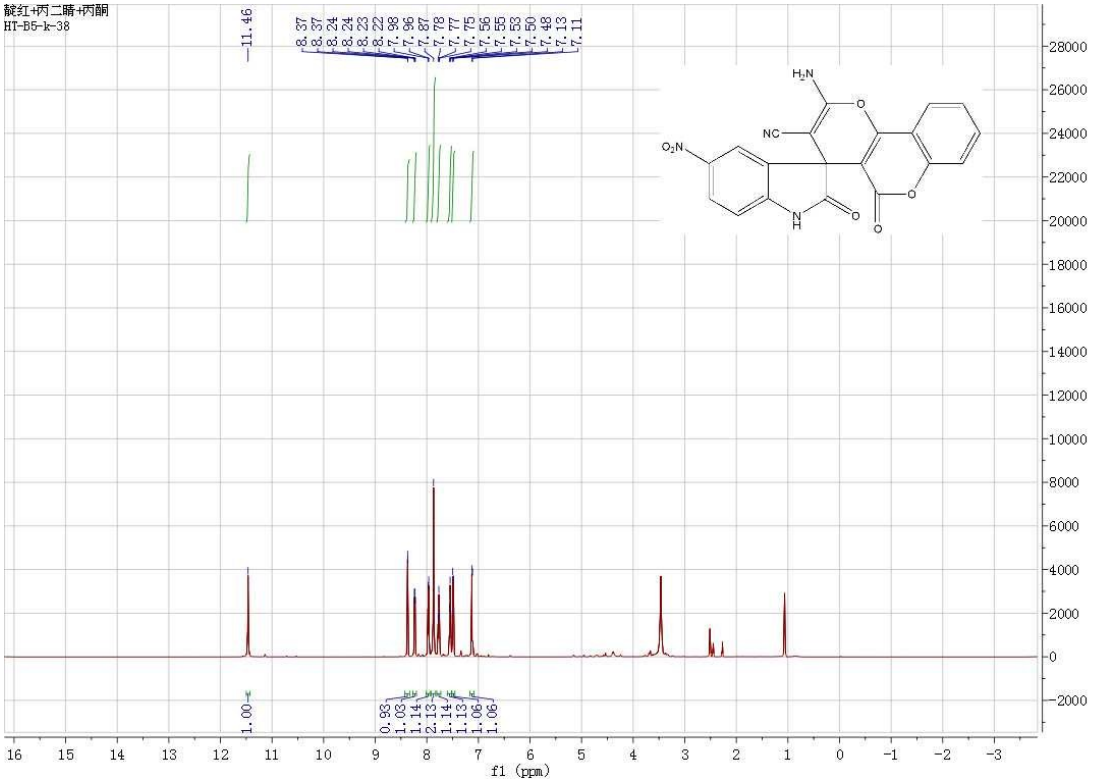

新建文件夹 (2)
HT-B5-k-31
177.58
158.84
158.69
155.48
152.43
142.57
134.08
133.45
129.34
125.42
124.54
123.07
122.47
117.41
117.07
112.85
109.92
101.80
57.37
48.00
f1 (ppm)

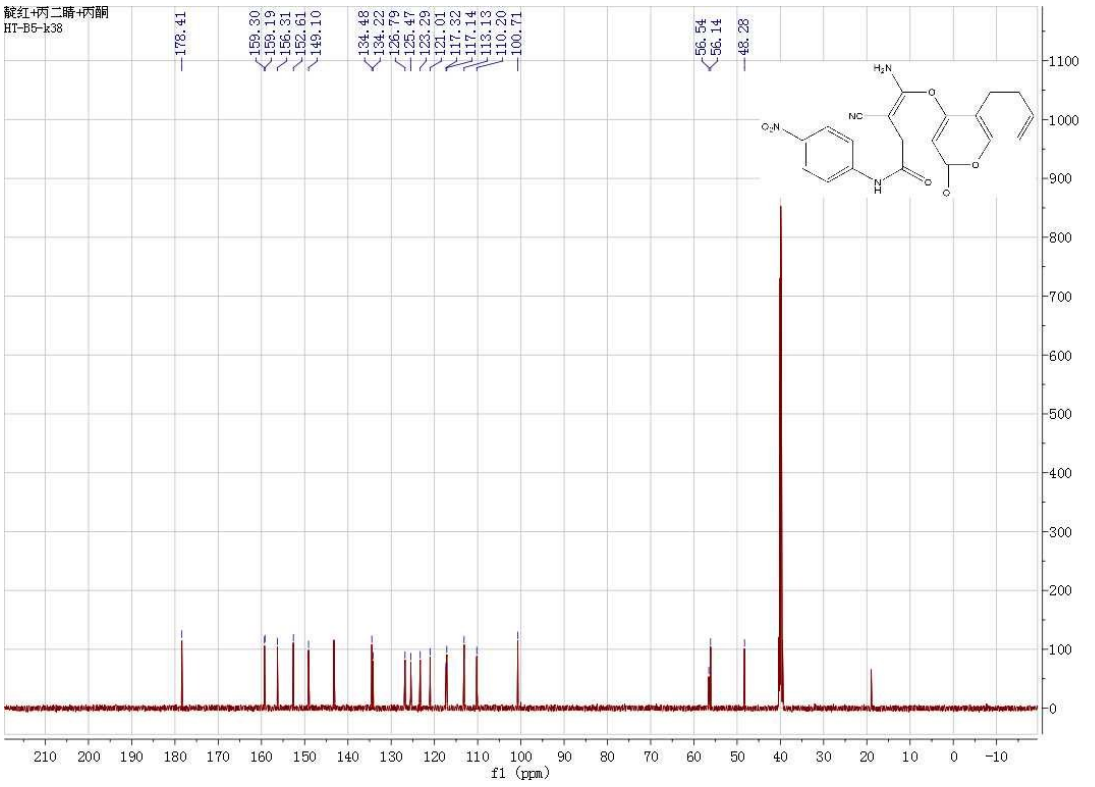
13b


H谱
HT-B5-k-40
7.97
7.96
7.74
7.54
7.53
7.52
7.48
7.47
7.34
7.33
7.30
7.29
7.10
7.08
7.06
7.04
7.03
1.00
2.13
1.05
1.04
1.06
1.03
1.04
1.07
3.29
f1 (ppm)

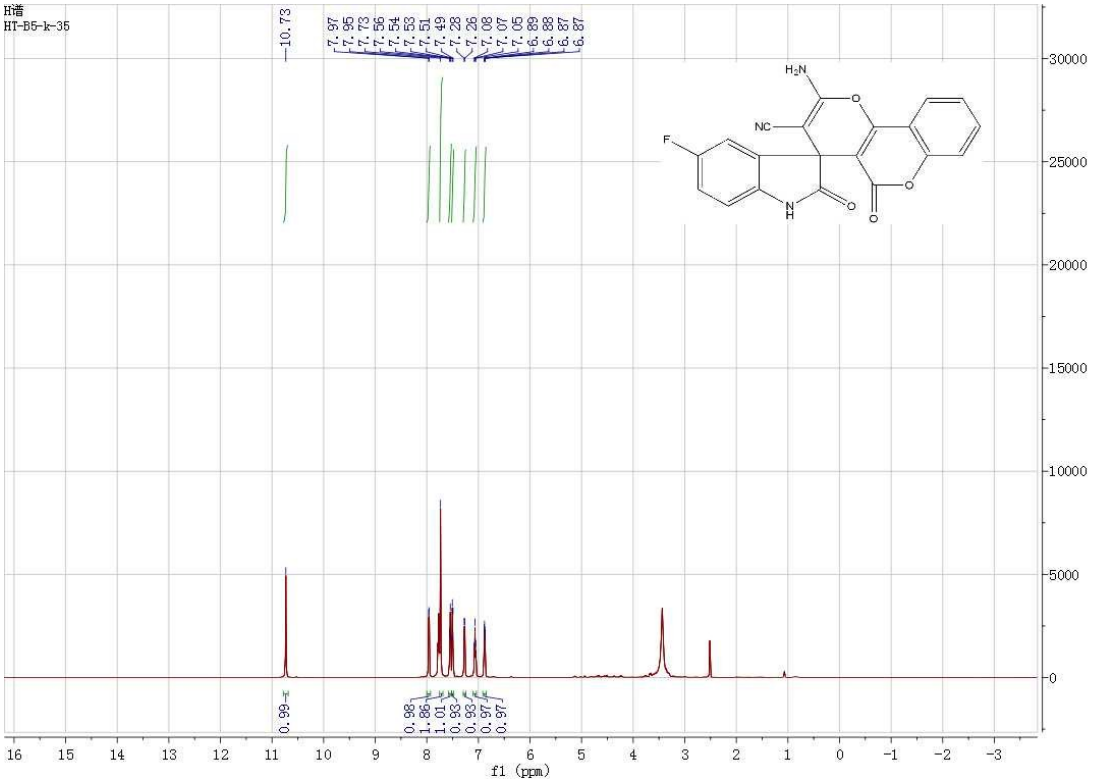

靛红+丙二睛+丙酮
HT-B5-k40
176.16
159.07
158.76
155.65
152.52
144.14
134.17
132.71
129.62
125.46
124.34
123.32
123.19
117.12
112.89
108.97
107.77
57.18
56.55
47.74
27.03
f1 (ppm)

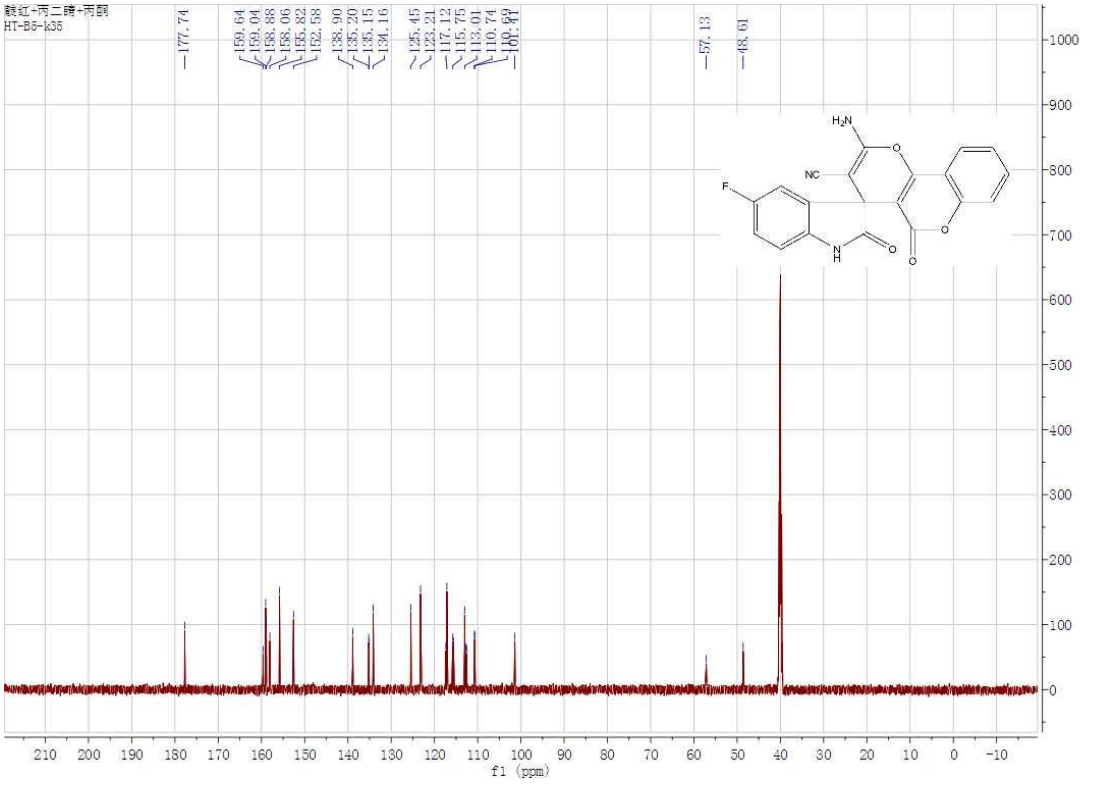
13c


靛红+丙二腈+丙酮
HT-B5-k-38
11.46
8.37
8.37
8.24
8.24
8.23
8.22
7.98
7.96
7.87
7.78
7.77
7.75
7.56
7.55
7.53
7.50
7.48
7.13
7.11
1.00
0.93
1.03
1.14
2.13
1.14
1.13
1.06
1.06
f1 (ppm)

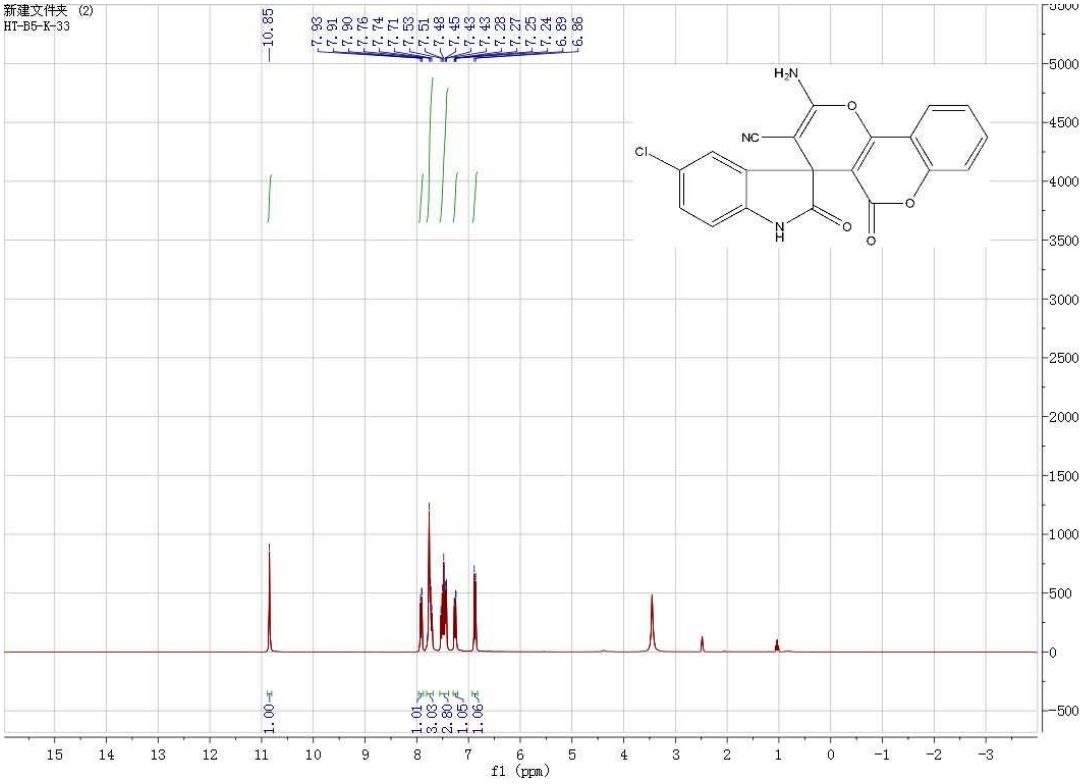

靛红+丙二腈+丙酮
HT-B5-k38
178.41
159.30
159.19
156.31
152.61
149.10
134.48
134.22
126.79
125.47
123.29
121.01
117.32
117.14
113.13
110.20
100.71
56.54
56.14
48.28
f1 (ppm)

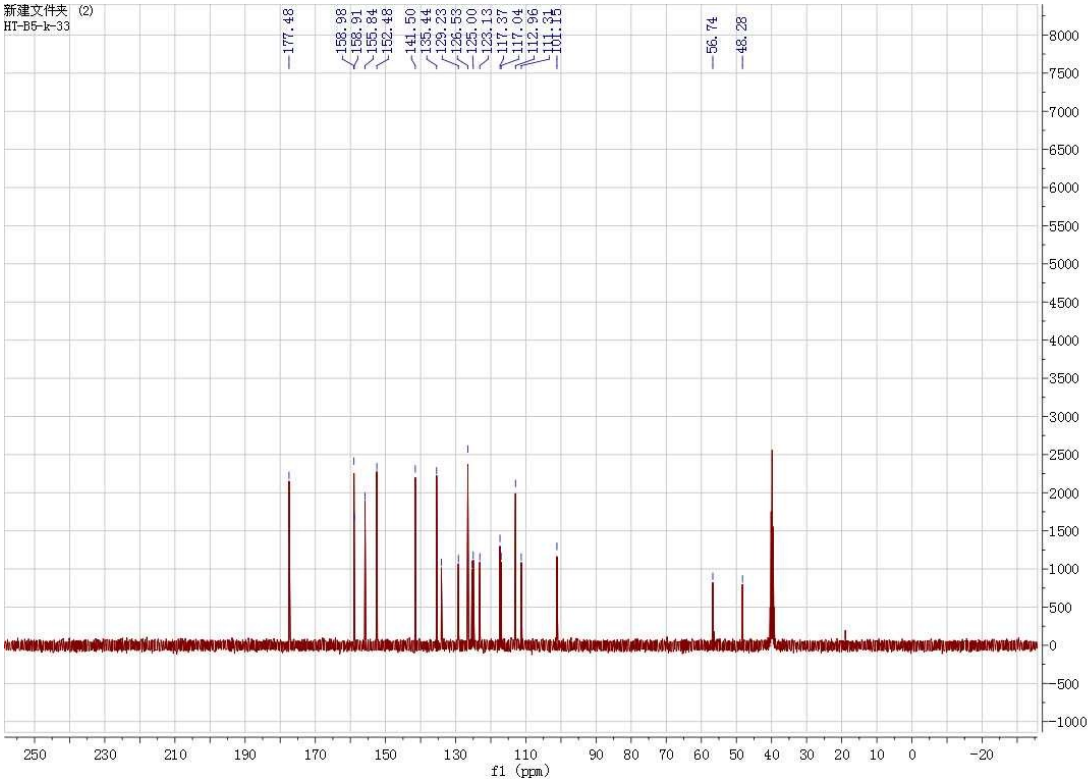
13d


H谱
HT-B5-k-35
10.73
7.97
7.95
7.73
7.56
7.54
7.53
7.51
7.49
7.28
7.26
7.08
7.07
7.05
6.89
6.88
6.87
6.87
0.99
0.98
1.86
1.01
0.93
0.93
0.97
0.97
f1 (ppm)

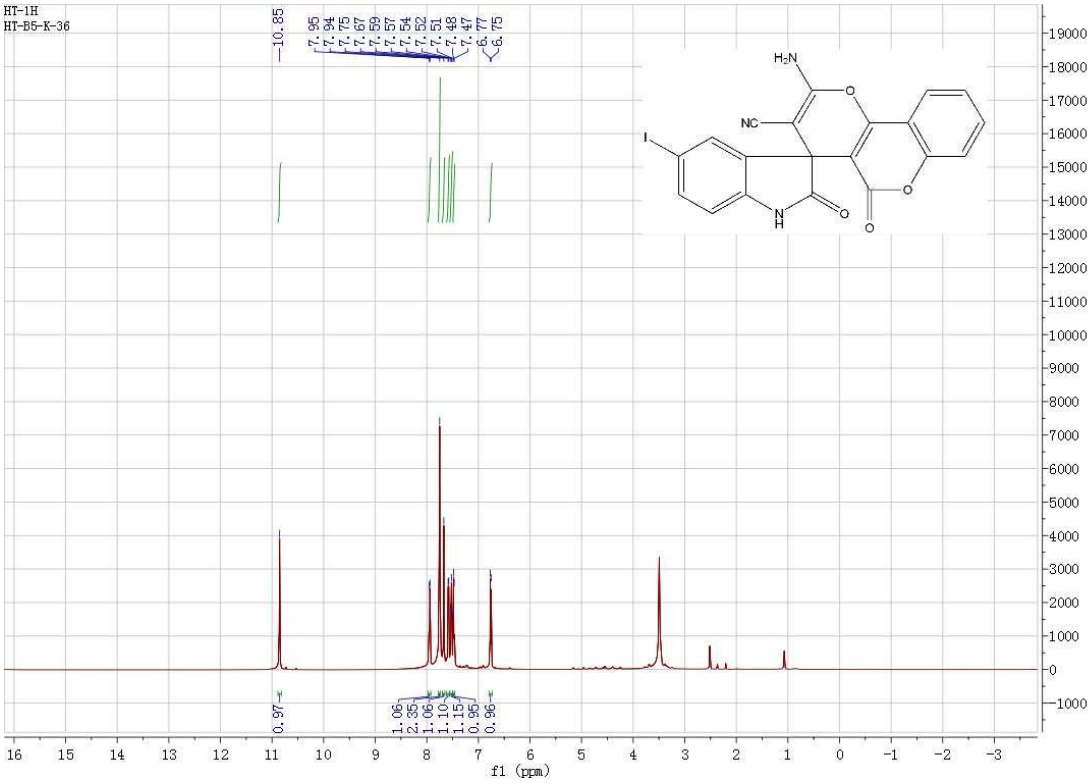

碳虹+丙二腈+丙酮
HT-B5-k35
177.74
159.64
159.04
158.88
158.06
155.82
152.58
138.90
135.20
135.15
134.16
125.45
123.21
117.12
115.75
113.01
110.74
110.63
107.47
57.13
48.61
f1 (ppm)

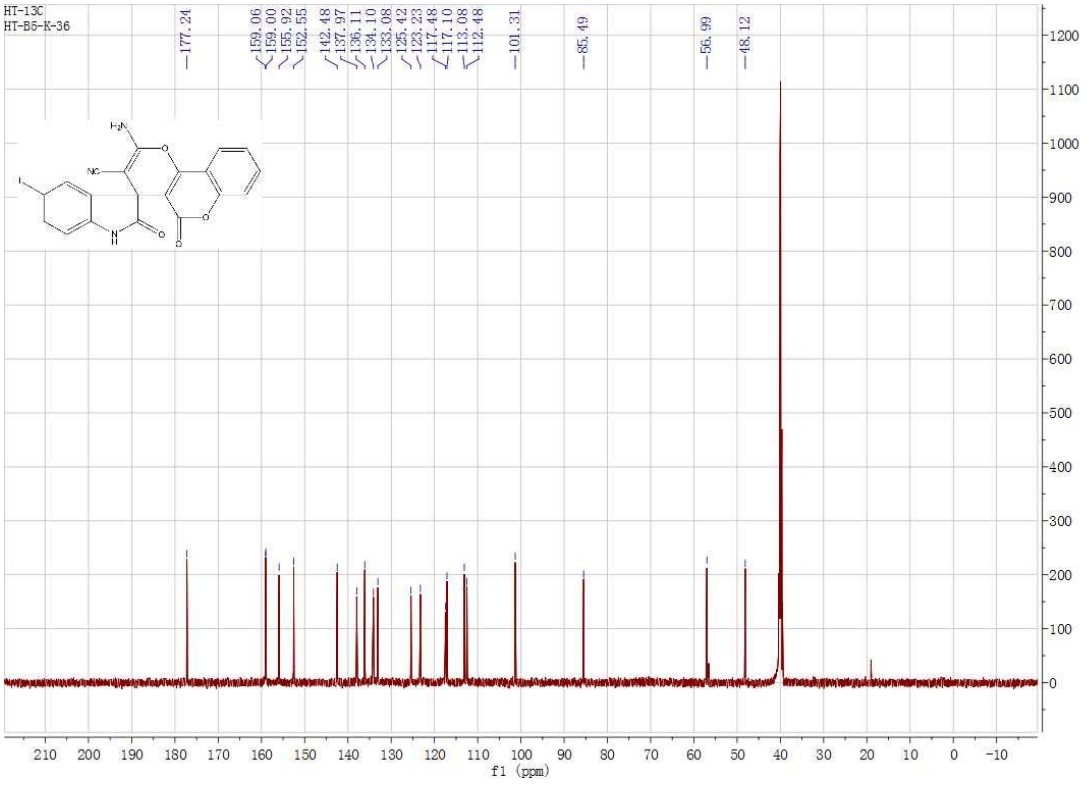
13e


新建文件夹 (2)
HT-B5-K-33
10.85
7.93
7.91
7.90
7.76
7.74
7.71
7.53
7.51
7.48
7.45
7.43
7.28
7.27
7.25
7.24
6.89
6.86
H2N
NC
Cl
O
N
H
1.00
1.01
3.03
2.80
1.05
1.06
f1 (ppm)

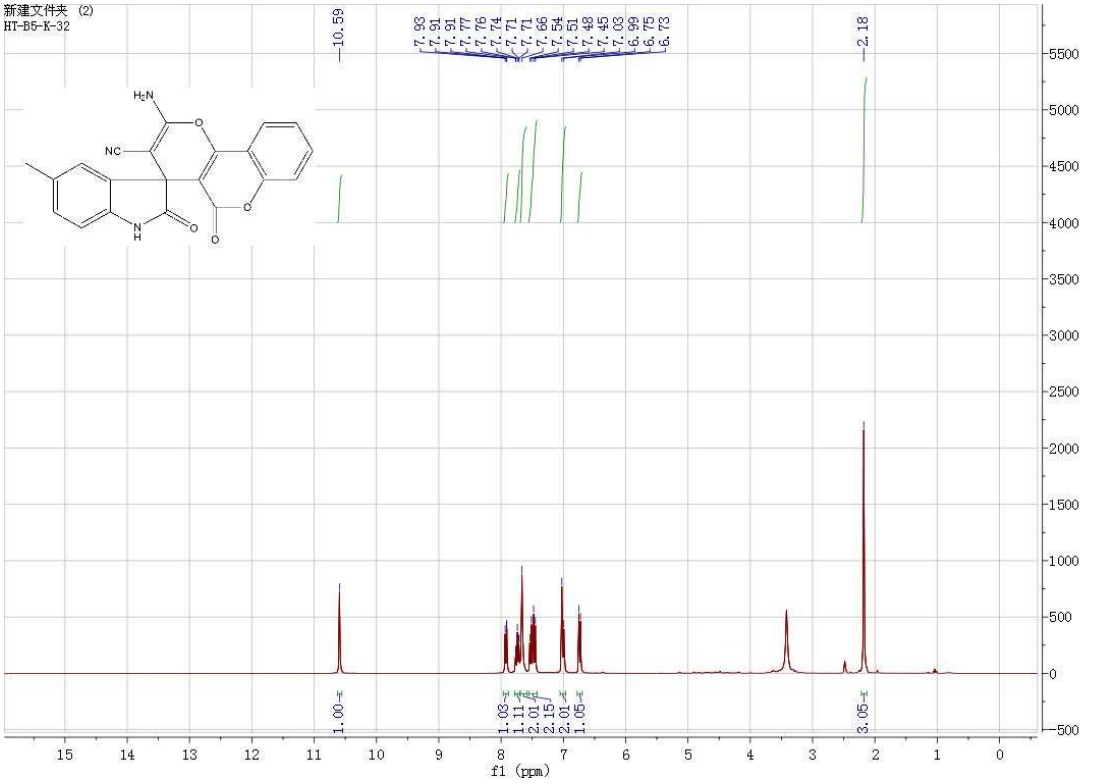

新建文件夹 (2)
HT-B5-k-33
177.48
158.98
158.91
155.84
152.48
141.50
135.44
129.23
126.53
125.00
123.13
117.37
117.04
112.96
112.71
101.45
56.74
48.28
f1 (ppm)

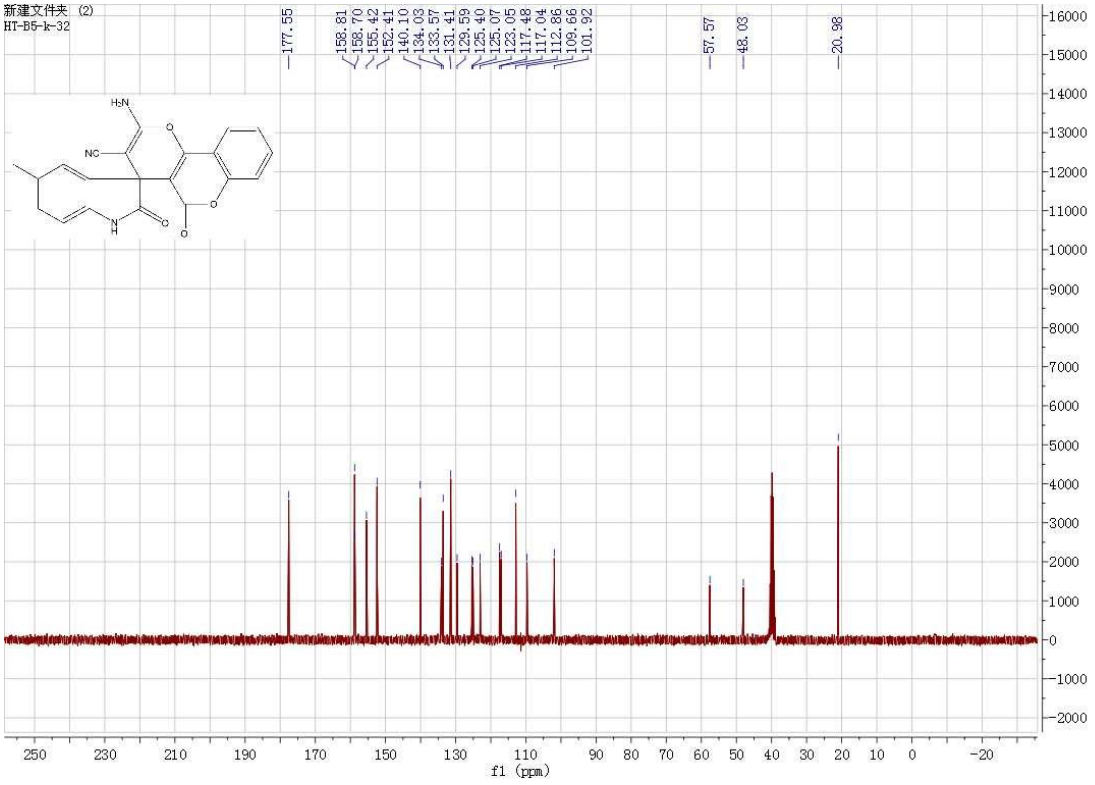
13f


HT-1H
HT-B5-K-36
10.85
7.95
7.94
7.75
7.67
7.59
7.57
7.54
7.52
7.51
7.48
7.47
6.77
6.75
0.97
1.06
2.35
1.06
1.10
1.15
0.95
0.96
f1 (ppm)

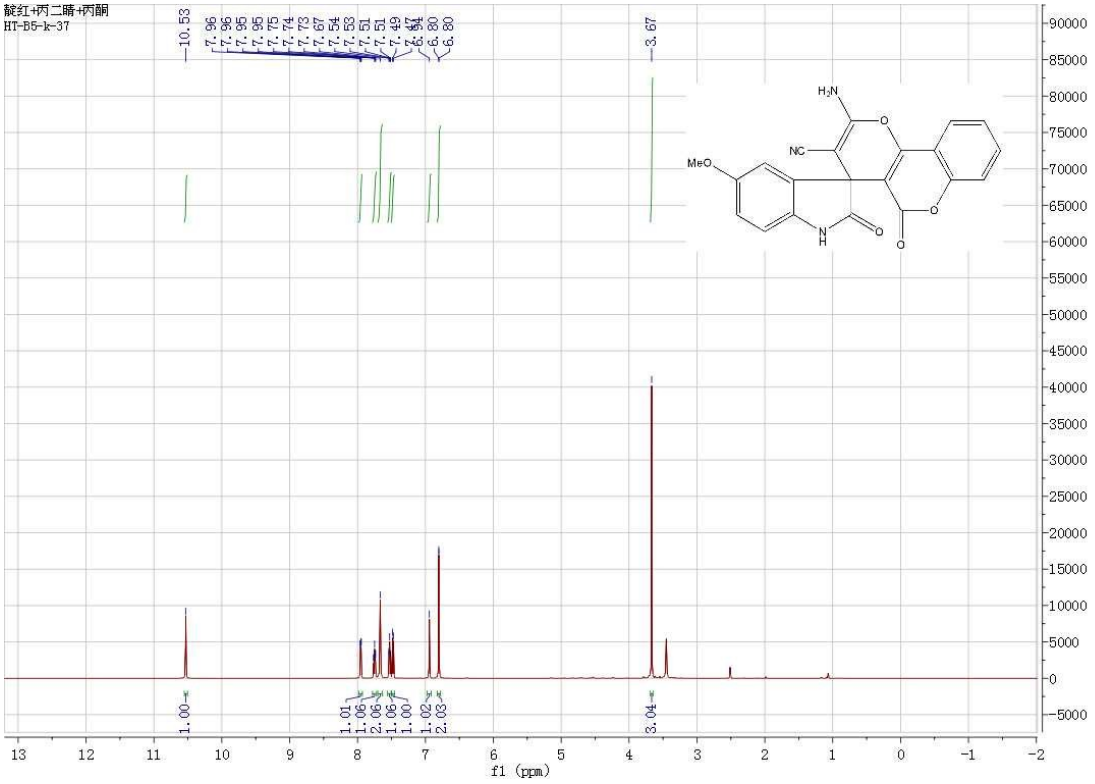

HT-13C
HT-B5-K-36
177.24
159.06
159.00
155.92
152.55
142.48
137.97
136.11
134.10
133.08
125.42
123.23
117.48
117.10
113.08
112.48
101.31
85.49
56.99
48.12
f1 (ppm)

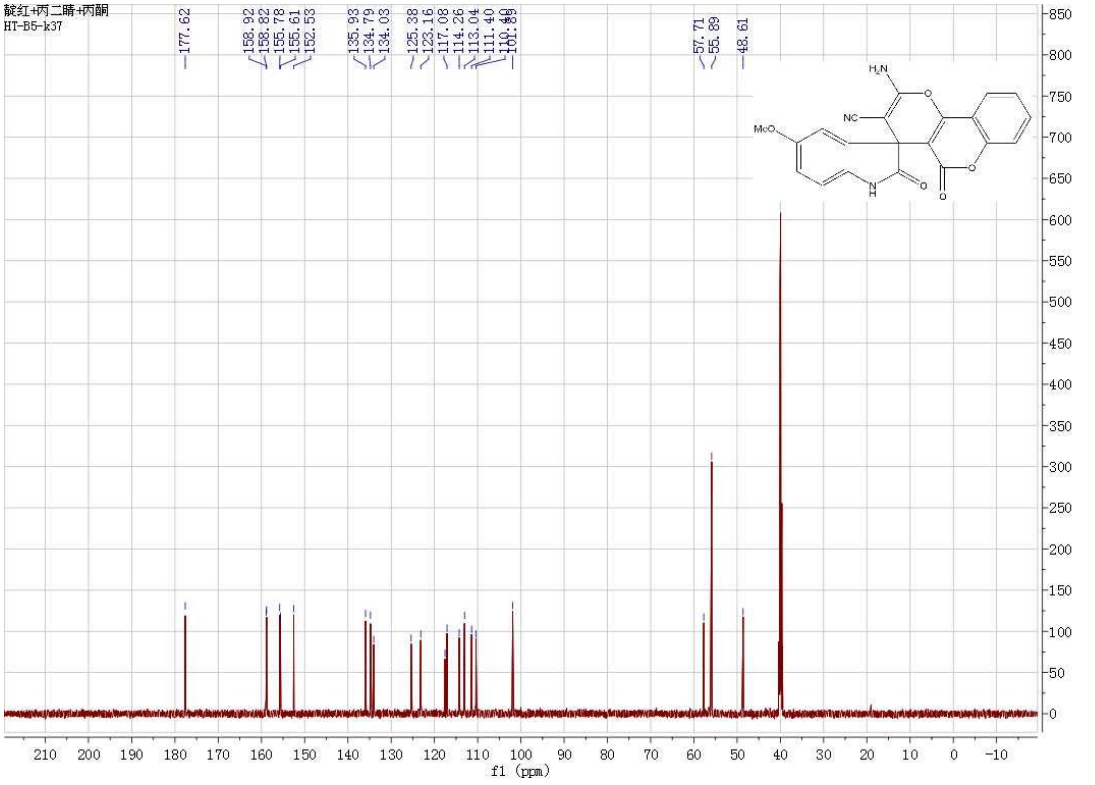
13g


新建文件夹 (2)
HT-B5-K-32
10.59
7.93
7.91
7.91
7.77
7.76
7.74
7.71
7.71
7.66
7.54
7.51
7.48
7.45
7.03
6.99
6.75
6.73
2.18
1.00
1.03
1.11
2.01
2.15
2.01
1.05
3.05
f1 (ppm)

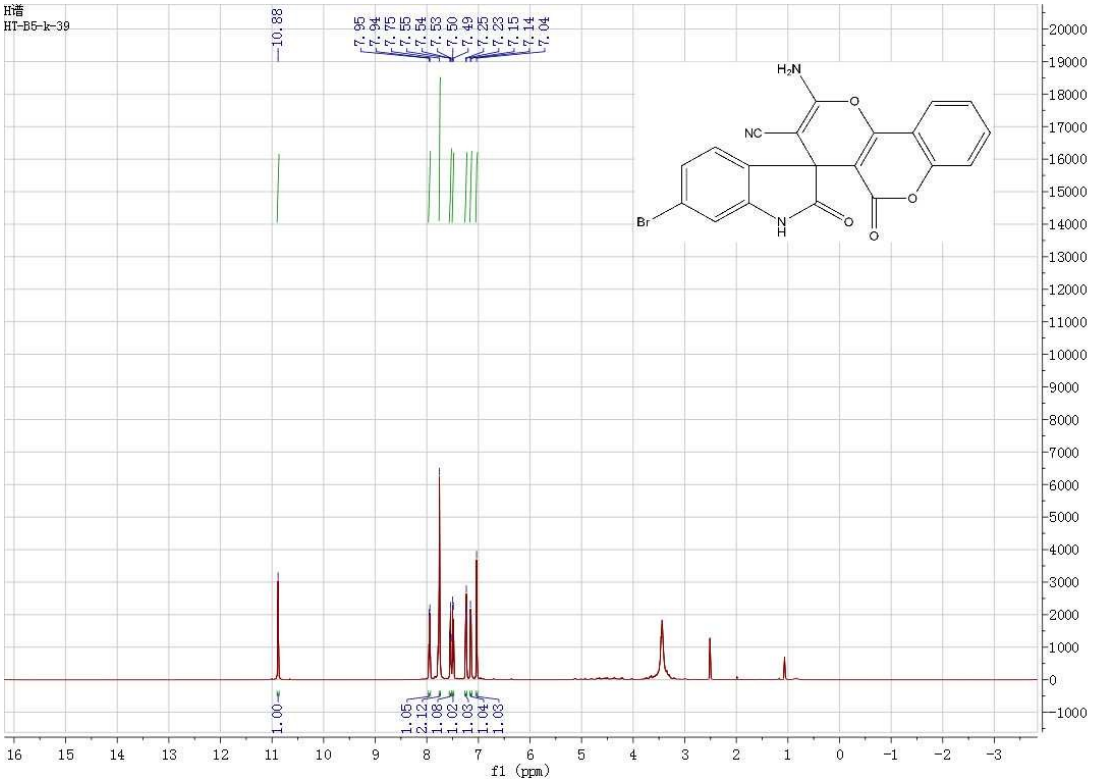

新建文件夹 (2)
HT-B5-k-32
177.55
158.81
158.70
155.42
152.41
140.10
134.03
133.57
131.41
129.59
125.40
125.07
123.05
117.48
117.04
112.86
109.66
101.92
57.57
48.03
20.98
f1 (ppm)

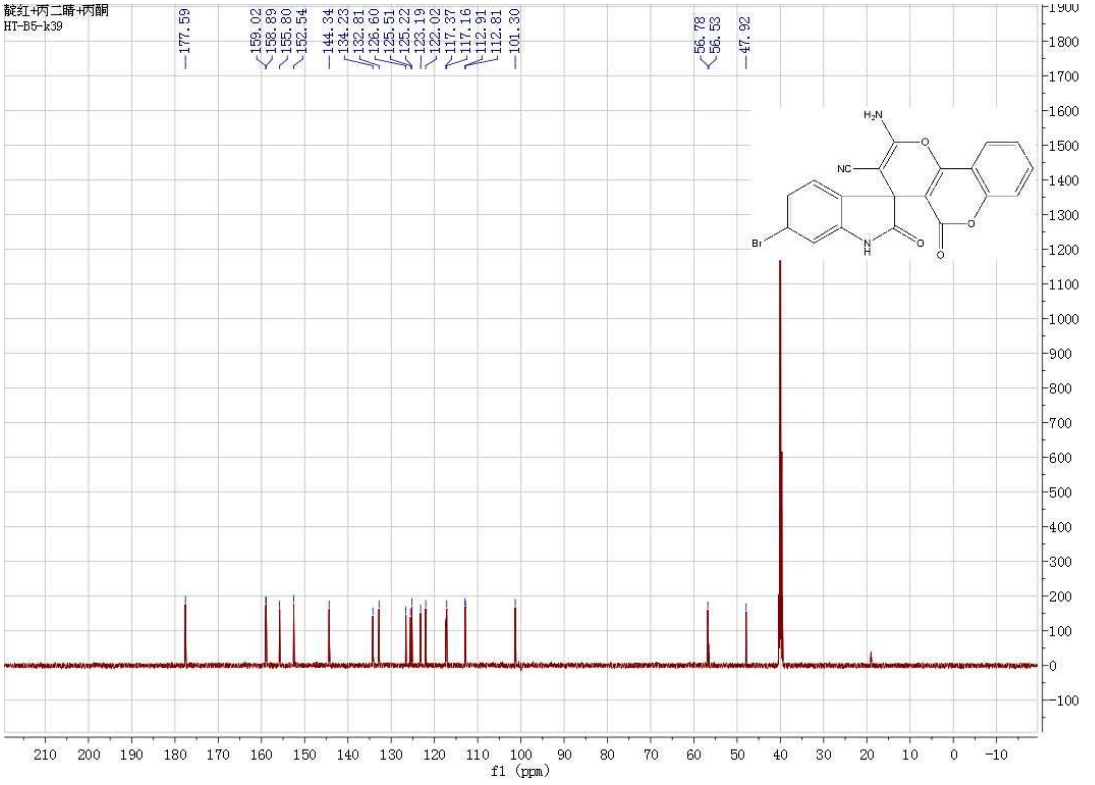
13h


靛红+丙二腈+丙酮
HT-B5-k-37
10.53
7.96
7.96
7.95
7.95
7.75
7.74
7.73
7.67
7.54
7.53
7.51
7.51
7.49
6.80
6.80
3.67
1.00
1.01
1.06
2.06
1.06
1.00
1.02
2.03
3.04
f1 (ppm)

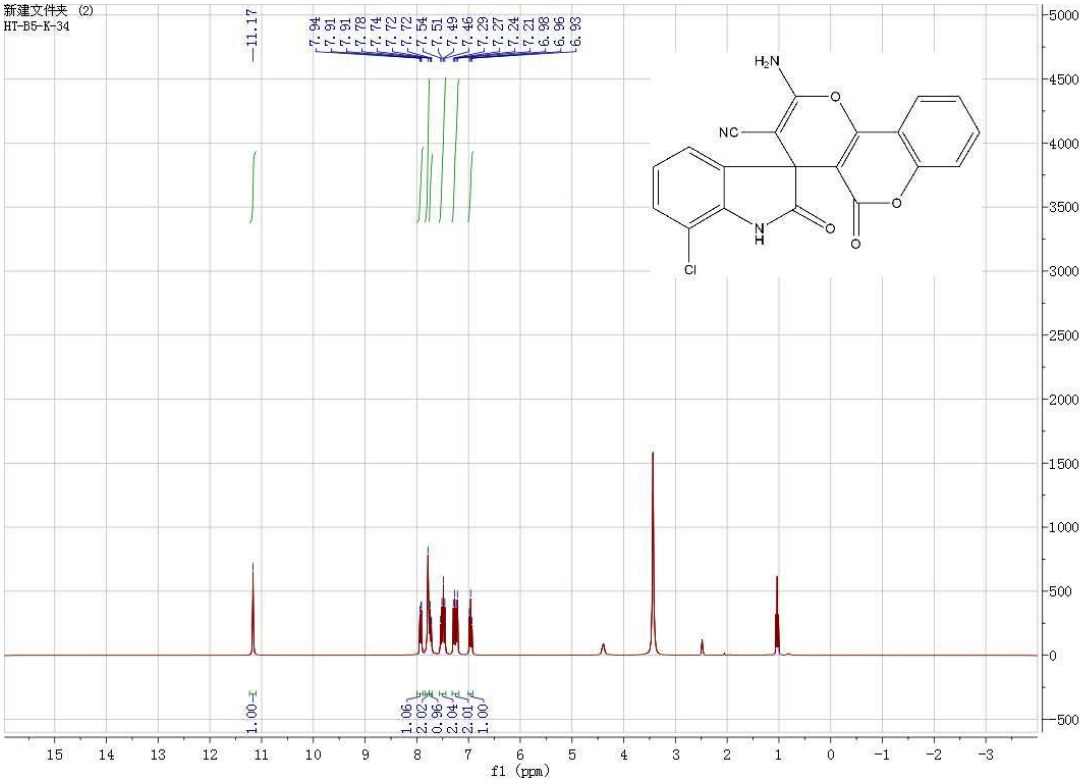

靛红+丙二腈+丙酮
HT-B5-k37
177.62
158.92
158.82
155.78
155.61
152.53
135.93
134.79
134.03
125.38
123.16
117.08
114.26
113.04
111.40
101.89
57.71
55.89
48.61
f1 (ppm)

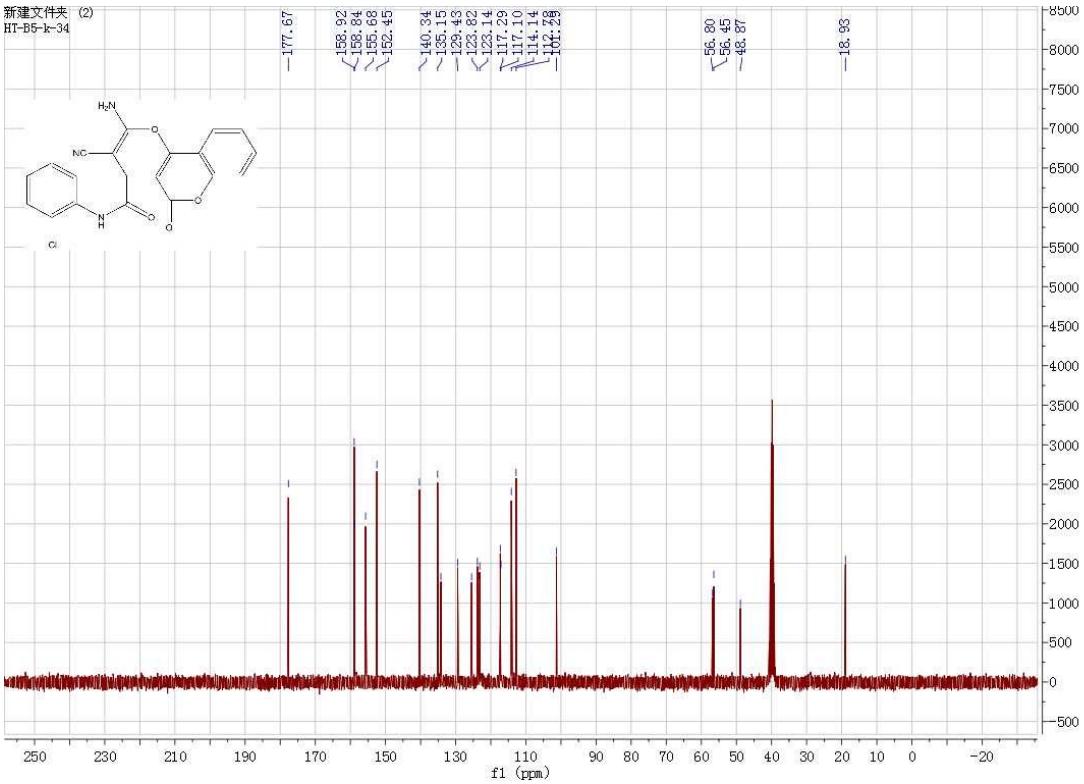
13i


H谱
HT-B5-k-39
10.88
7.95
7.94
7.75
7.55
7.54
7.53
7.50
7.49
7.25
7.23
7.15
7.14
7.04
1.00
1.05
2.12
1.08
1.02
1.03
1.04
1.03
f1 (ppm)

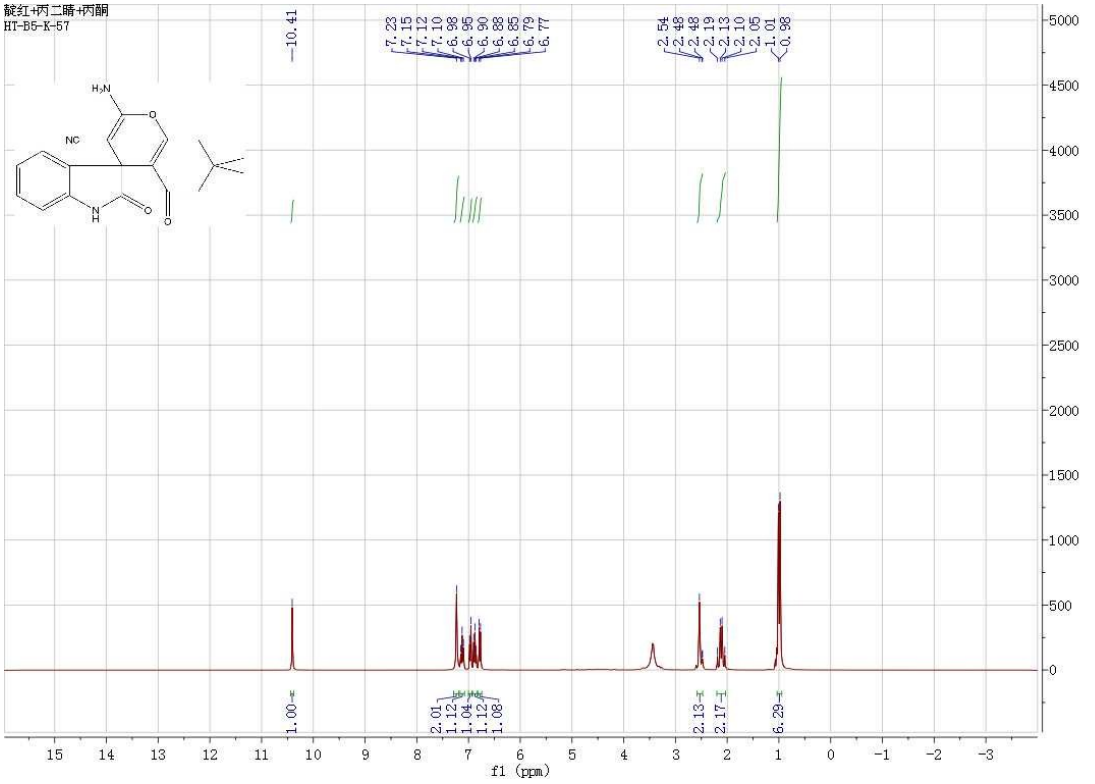

靛红+丙二腈+丙酮
HT-B5-k39
177.59
159.02
158.89
155.80
152.54
144.34
134.23
132.81
126.60
125.51
125.22
123.19
122.02
117.37
117.16
112.91
112.81
101.30
56.78
56.53
47.92
f1 (ppm)

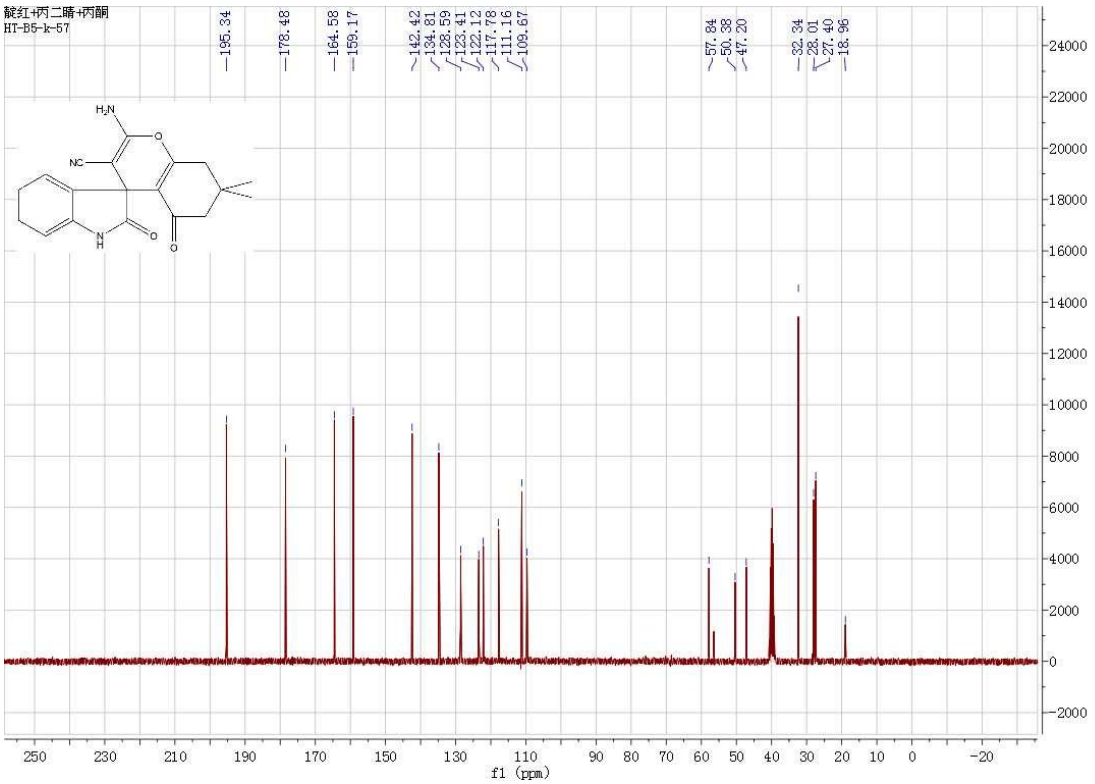
13j


新建文件夹 (2)
HT-B5-K-34
11.17
7.94
7.91
7.91
7.78
7.74
7.72
7.72
7.54
7.51
7.49
7.46
7.29
7.27
7.24
7.21
6.98
6.96
6.93
1.00
1.06
2.02
0.96
2.04
2.01
1.00
f1 (ppm)

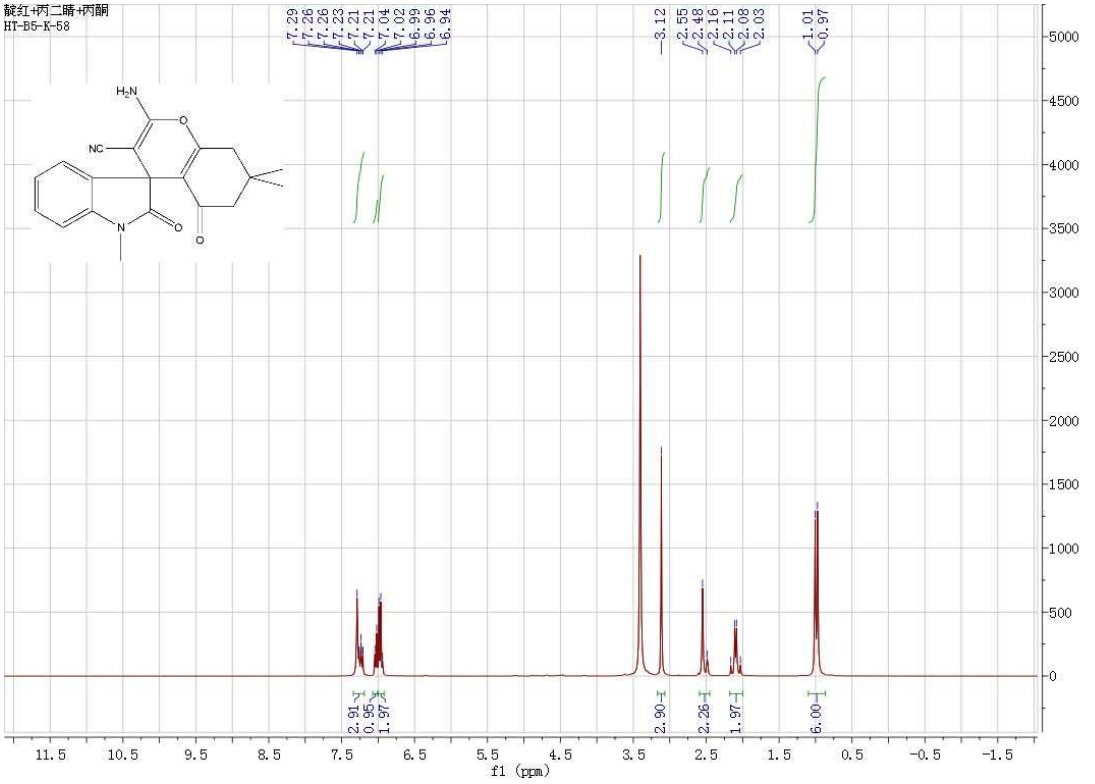

新建文件夹 (2)
HT-B5-k-34
177.67
158.92
158.84
155.68
152.45
140.34
136.15
129.43
123.82
123.14
117.29
117.10
114.14
112.78
107.28
56.80
56.45
48.87
18.93
f1 (ppm)

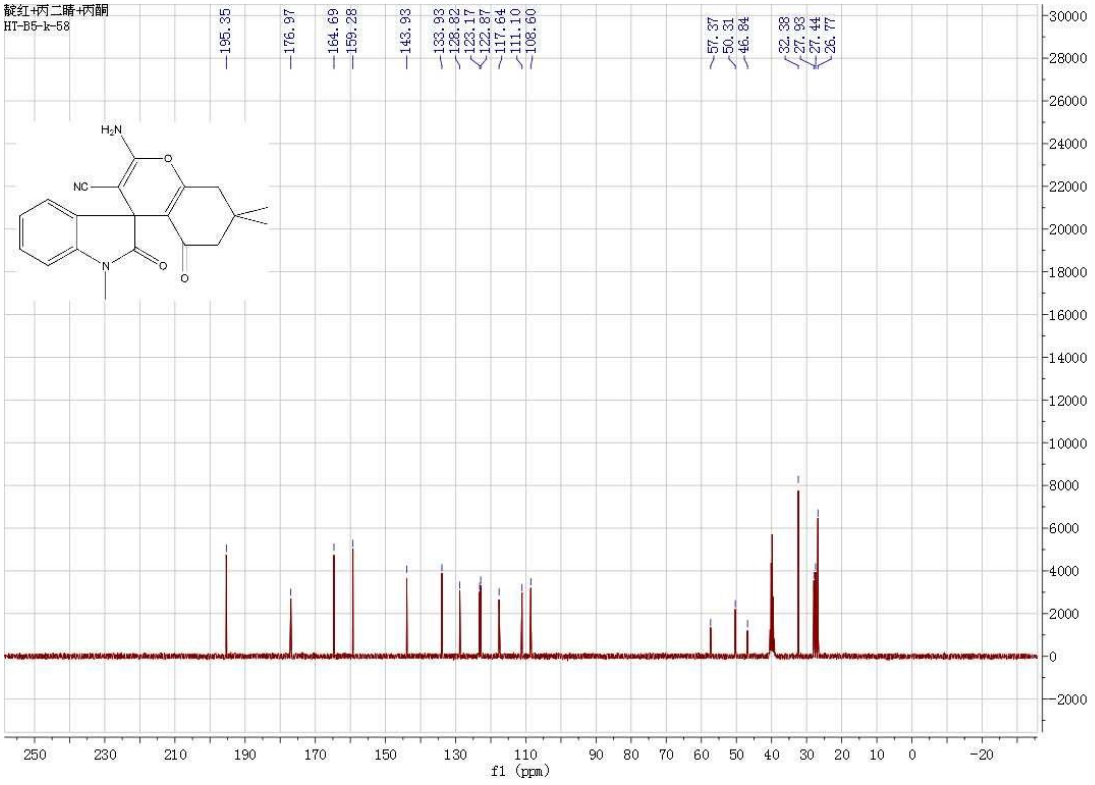
15a


靛红+丙二腈+丙酮
HT-B5-K-57
10.41
7.23
7.15
7.12
7.10
6.98
6.95
6.90
6.88
6.85
6.79
6.77
2.54
2.48
2.19
2.13
2.10
2.05
1.01
0.98
1.00
2.01
1.12
1.04
1.12
1.08
2.13
2.17
6.29
f1 (ppm)

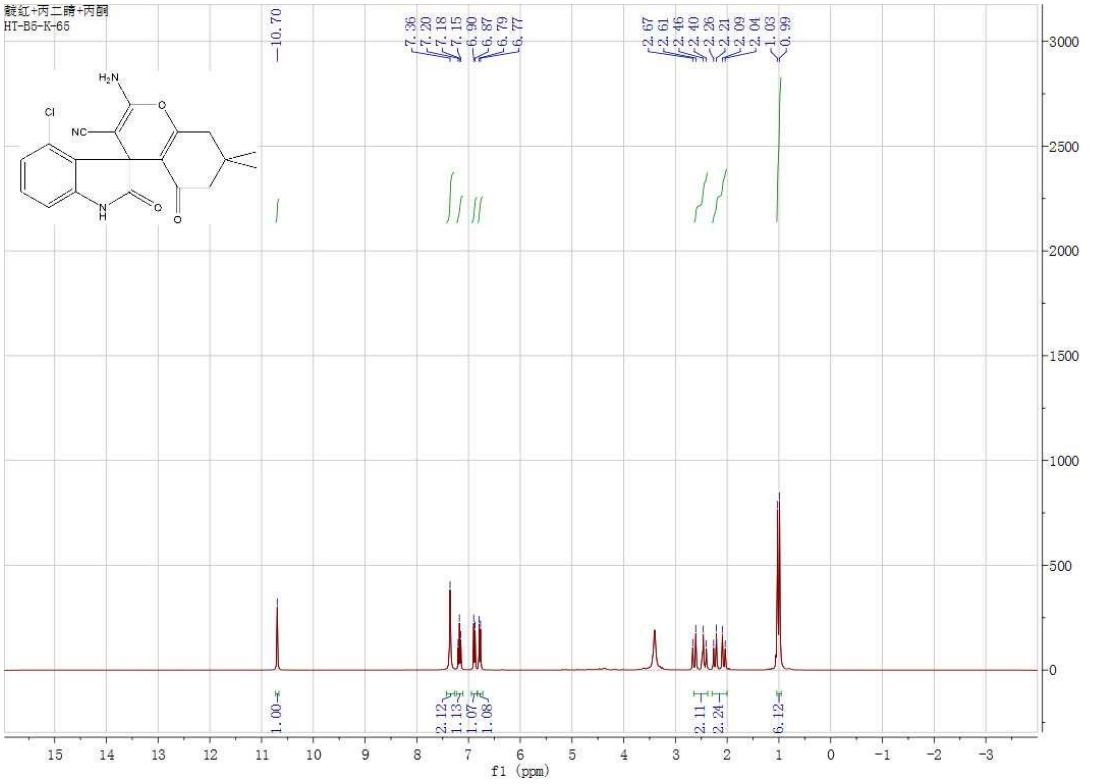

靛红+丙二腈+丙酮
HT-B5-k-57
195.34
178.48
164.58
159.17
142.42
134.81
128.59
123.41
122.12
117.78
111.16
109.67
57.84
50.38
47.20
32.34
28.01
27.40
18.96
f1 (ppm)

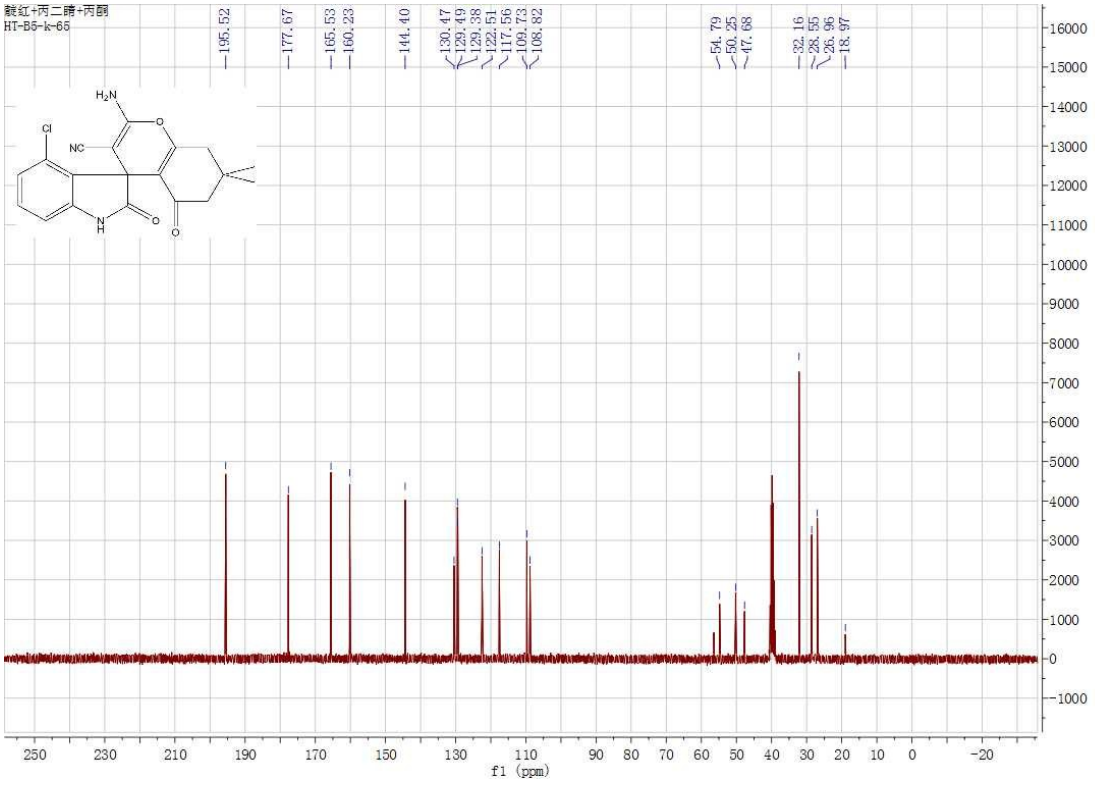
15b


靛红+丙二腈+丙酮
HT-B5-K-58
7.29
7.26
7.26
7.23
7.21
7.21
7.04
7.02
6.99
6.96
6.94
3.12
2.55
2.48
2.16
2.11
2.08
2.03
1.01
0.97
2.91
0.95
1.97
2.90
2.26
1.97
6.00
f1 (ppm)

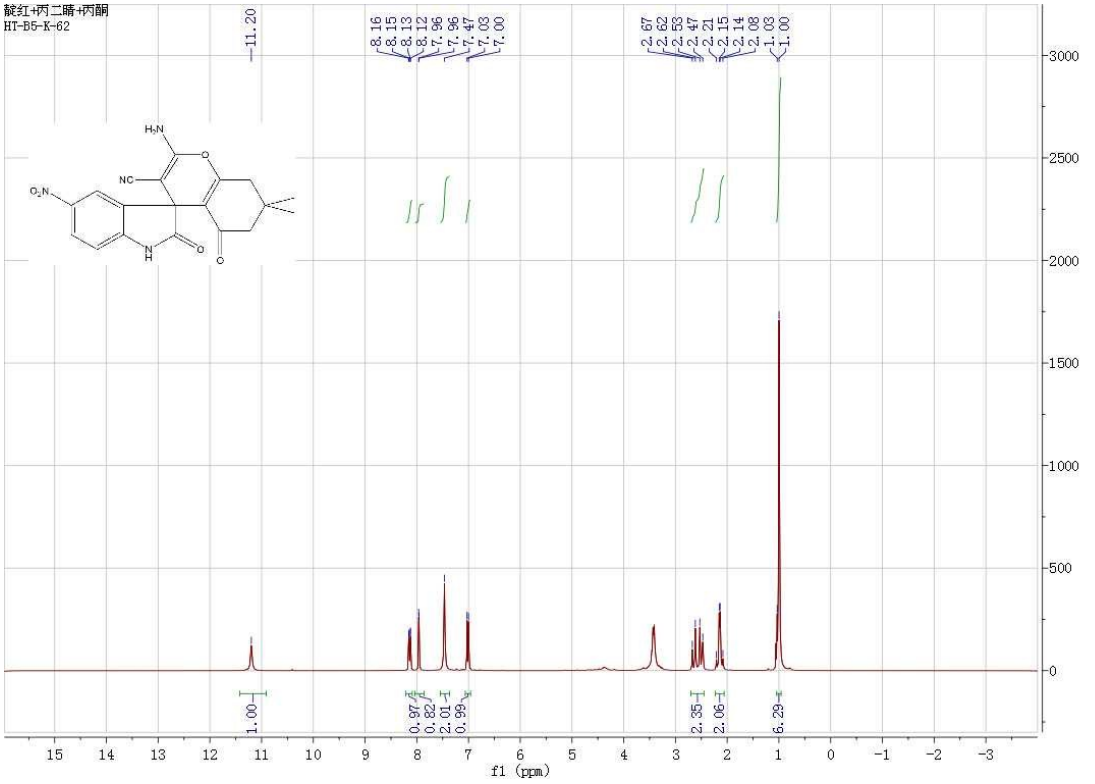

靛红+丙二腈+丙酮
HT-B5-k-58
195.35
176.97
164.69
159.28
143.93
133.93
128.82
123.17
122.87
117.64
111.10
108.60
57.37
50.31
46.84
32.38
27.93
27.44
26.77
f1 (ppm)

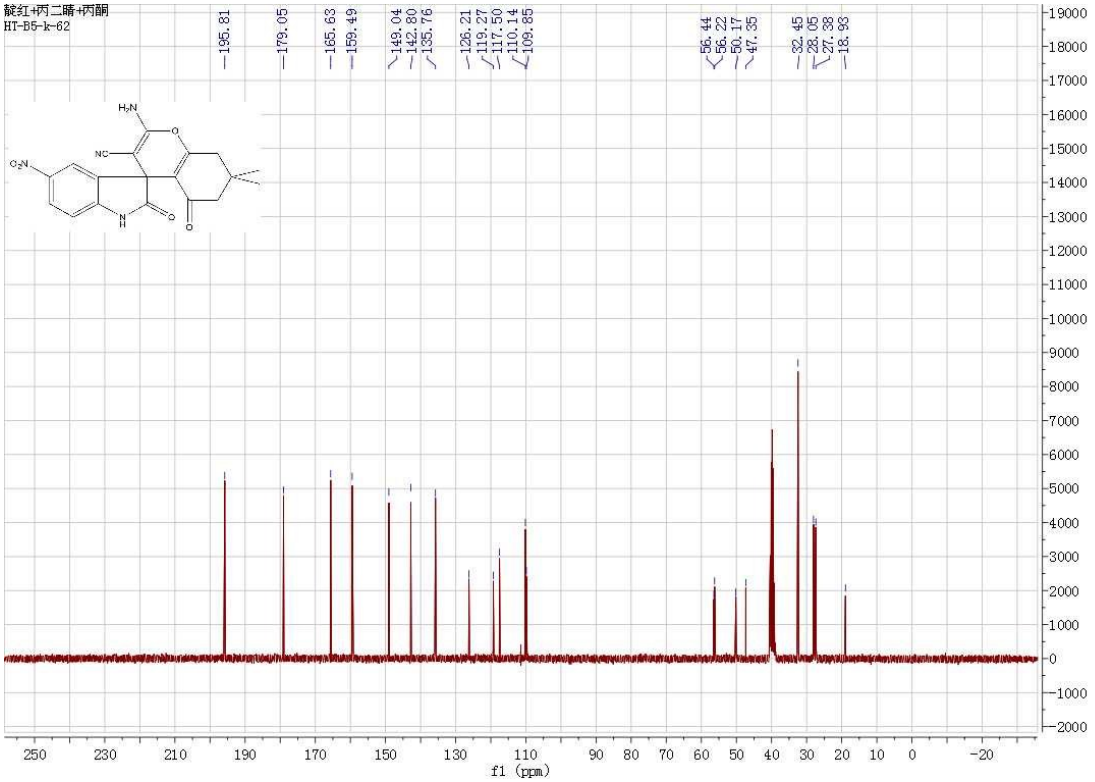
15c


靛红+丙二腈+丙酮
HT-B5-K-65
10.70
7.36
7.20
7.18
7.15
6.90
6.87
6.79
6.77
2.67
2.61
2.46
2.40
2.26
2.21
2.09
2.04
1.03
0.99
1.00
2.12
1.13
1.07
1.08
2.11
2.24
6.12
f1 (ppm)

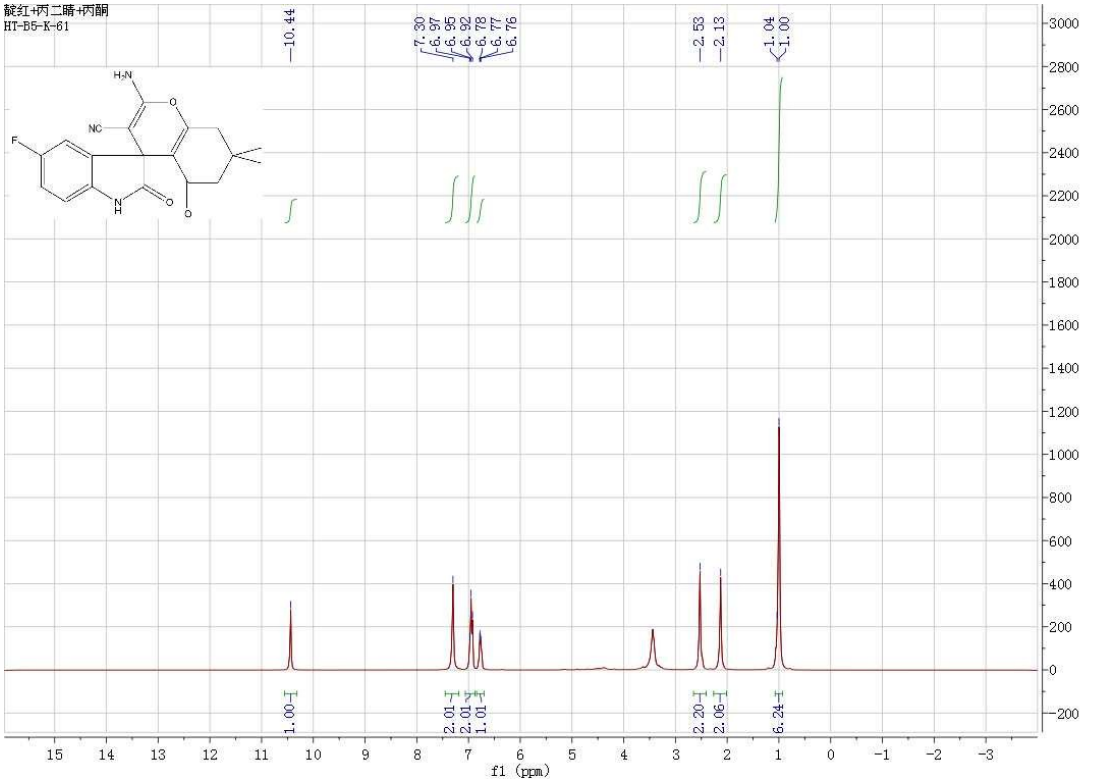

靛红+丙二腈+丙酮
HT-B5-k-65
195.52
177.67
165.53
160.23
144.40
130.47
129.49
129.38
122.51
117.56
109.73
108.82
54.79
50.25
47.68
32.16
28.55
26.96
18.97
f1 (ppm)

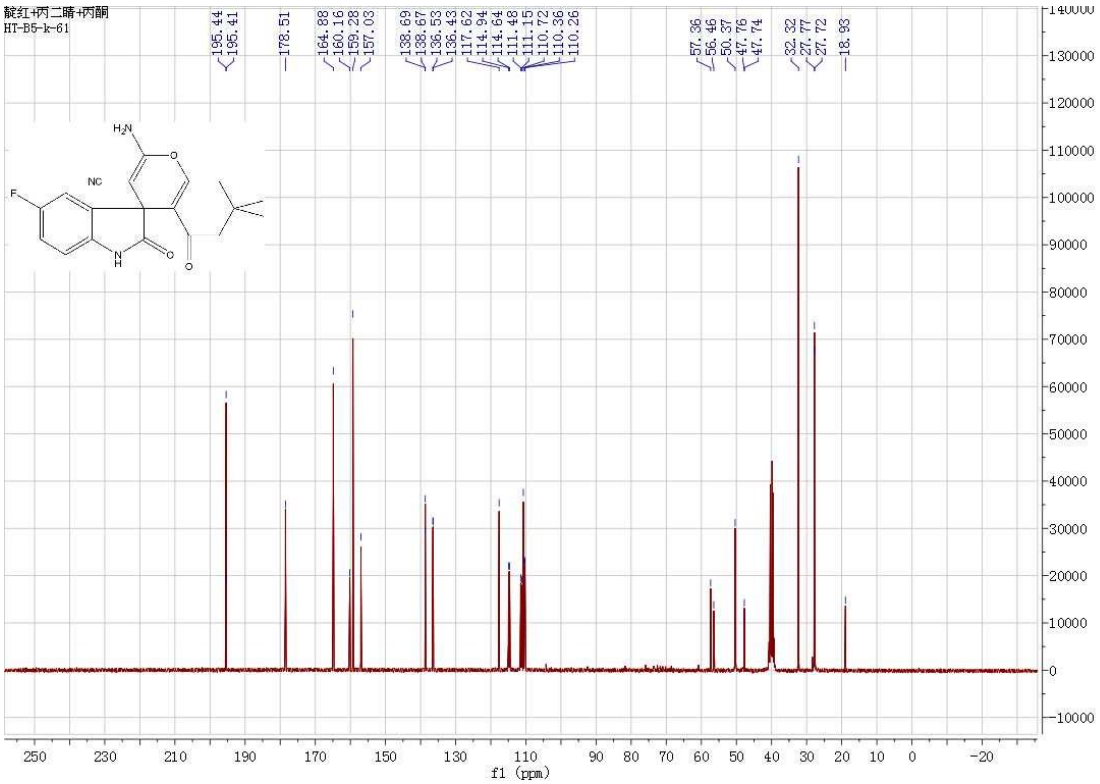
15d


靛红+丙二腈+丙酮
HT-B5-K-62
11.20
8.16
8.15
8.13
8.12
7.96
7.96
7.47
7.03
7.00
2.67
2.62
2.53
2.47
2.21
2.15
2.14
2.08
1.03
1.00
1.00
0.97
0.82
2.01
0.99
2.35
2.06
6.29
f1 (ppm)

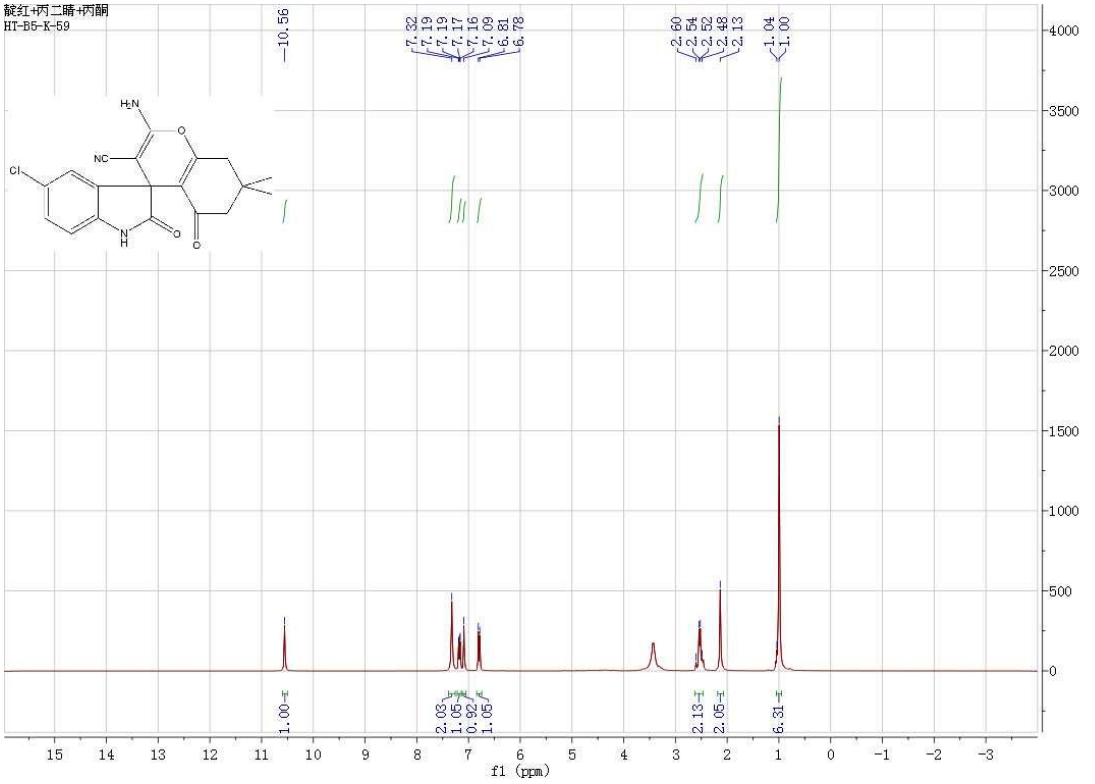

靛红+丙二腈+丙酮
HT-B5-k-62
195.81
179.05
165.63
159.49
149.04
142.80
135.76
126.21
119.27
117.50
110.14
109.85
56.44
56.22
50.17
47.35
32.45
28.05
27.38
18.93
f1 (ppm)

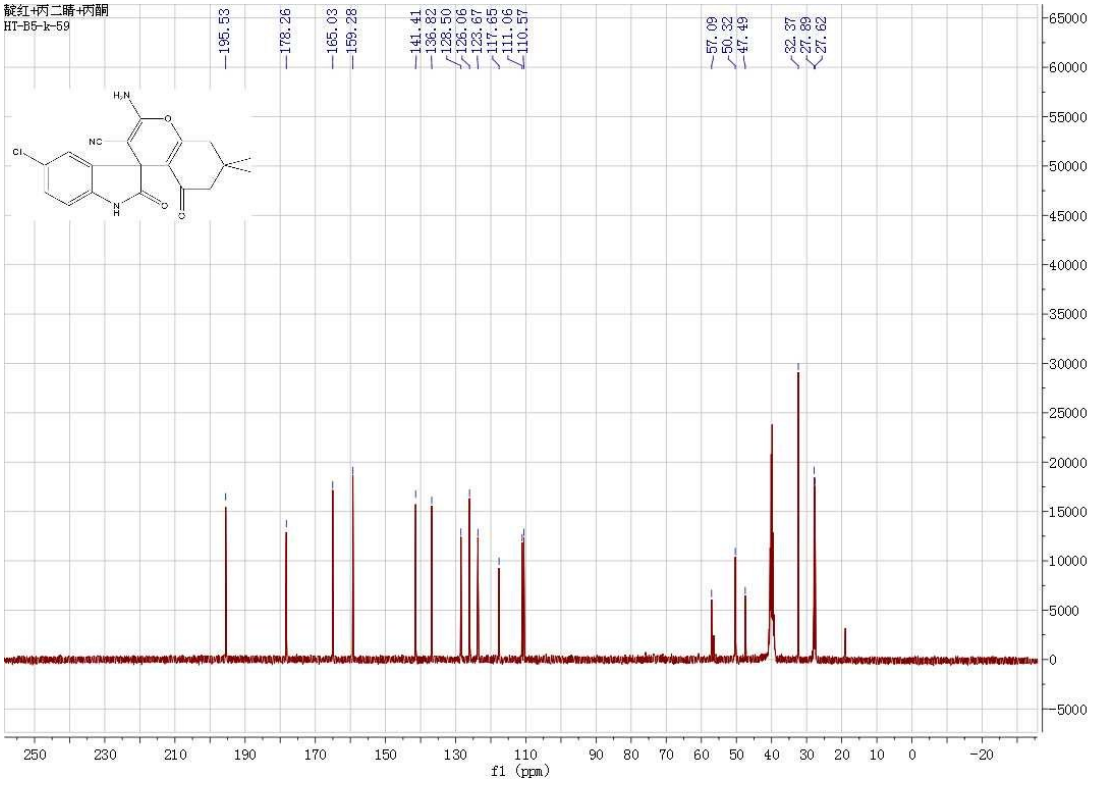
15e


靛红+丙二腈+丙酮
HT-B5-K-61
10.44
7.30
6.97
6.95
6.92
6.78
6.77
6.76
2.53
2.13
1.04
1.00
1.00
2.01
2.01
1.01
2.20
2.06
6.24
f1 (ppm)

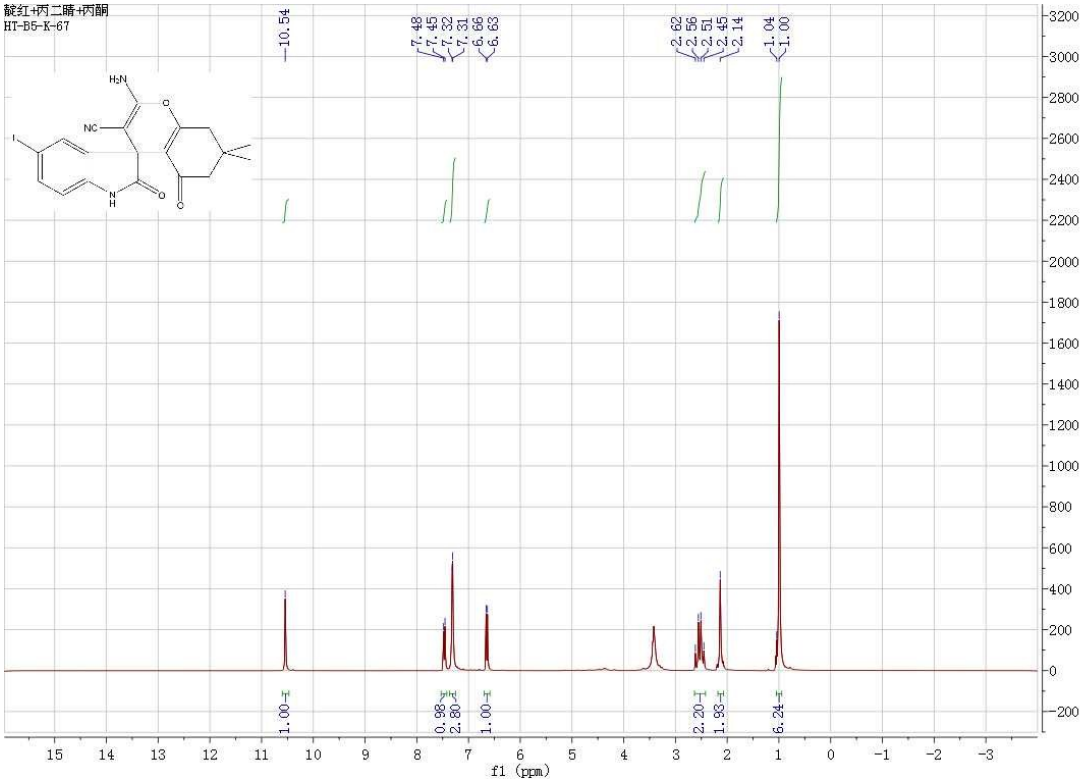

靛红+丙二腈+丙酮
HT-B5-k-61
196.44
196.41
178.51
164.88
160.16
159.28
157.03
138.69
138.67
136.53
136.43
117.62
114.94
114.64
111.48
111.15
110.72
110.36
110.26
57.36
56.46
50.37
47.76
47.74
32.32
27.77
27.72
18.93
f1 (ppm)

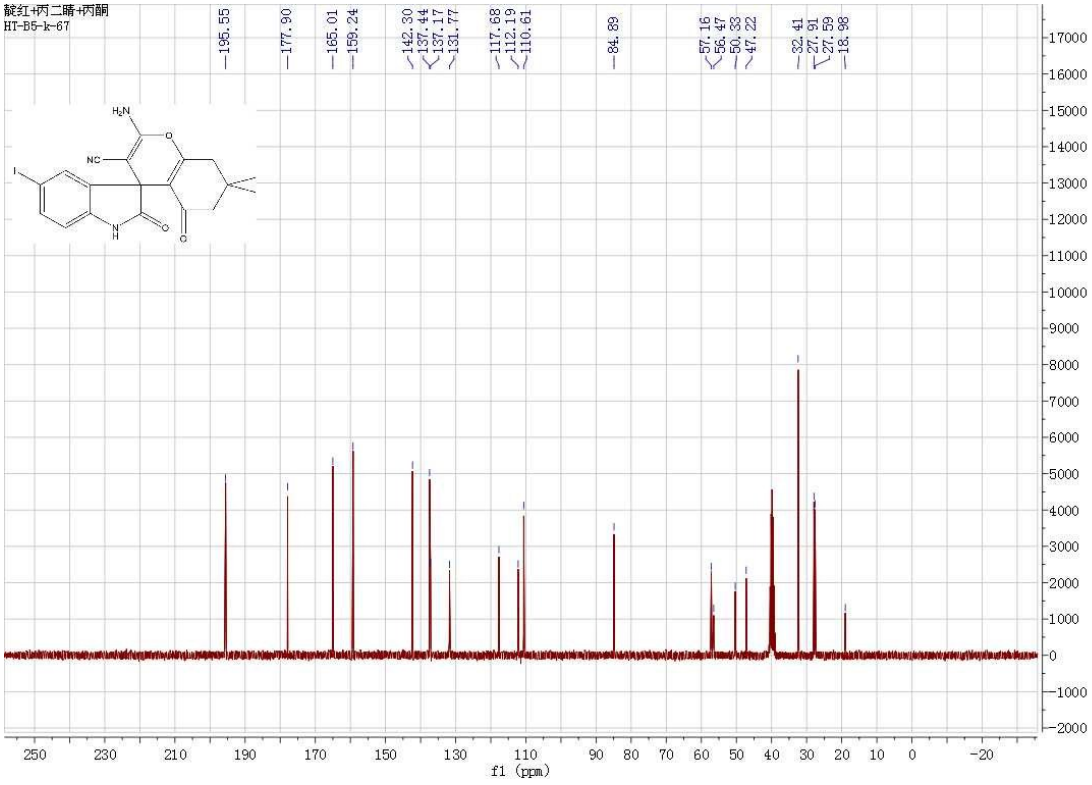
15f


靛红+丙二腈+丙酮
HT-B5-K-59
10.56
7.32
7.19
7.19
7.17
7.16
7.09
6.81
6.78
2.60
2.54
2.52
2.48
2.13
1.04
1.00
f1 (ppm)

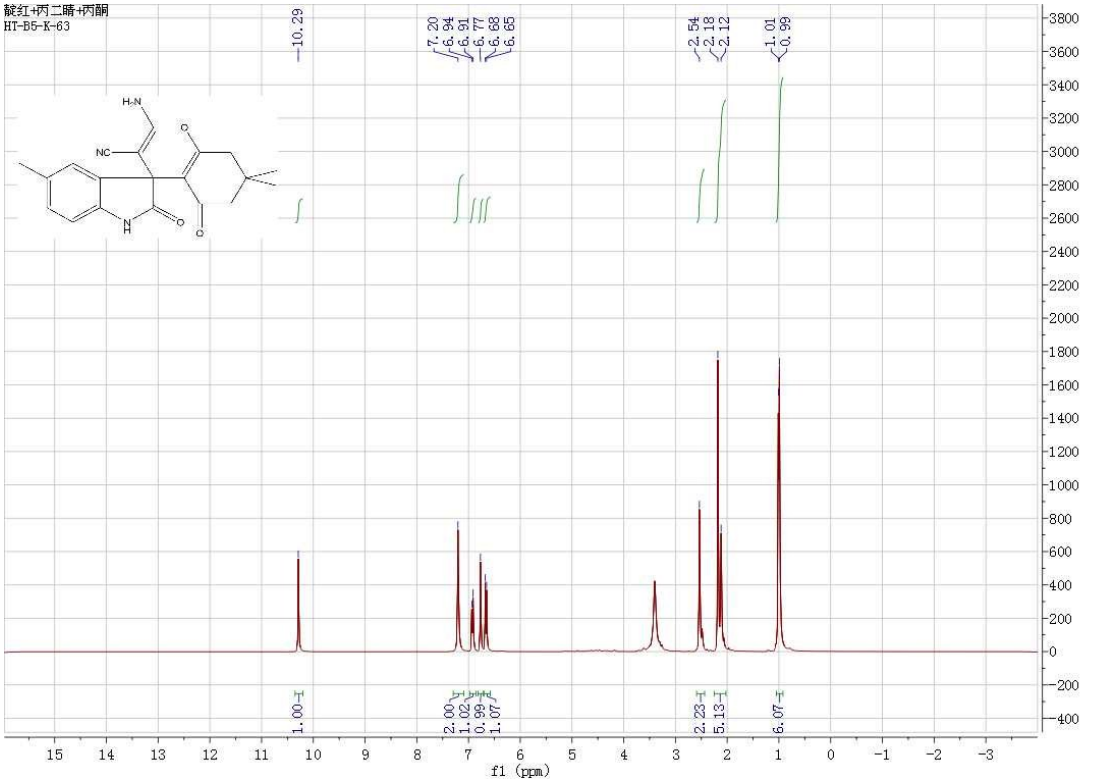

靛红+丙二腈+丙酮
HT-B5-k-59
195.53
178.26
165.03
159.28
141.41
136.82
128.50
126.06
123.67
117.65
111.06
110.57
57.09
50.32
47.49
32.37
27.89
27.62
f1 (ppm)

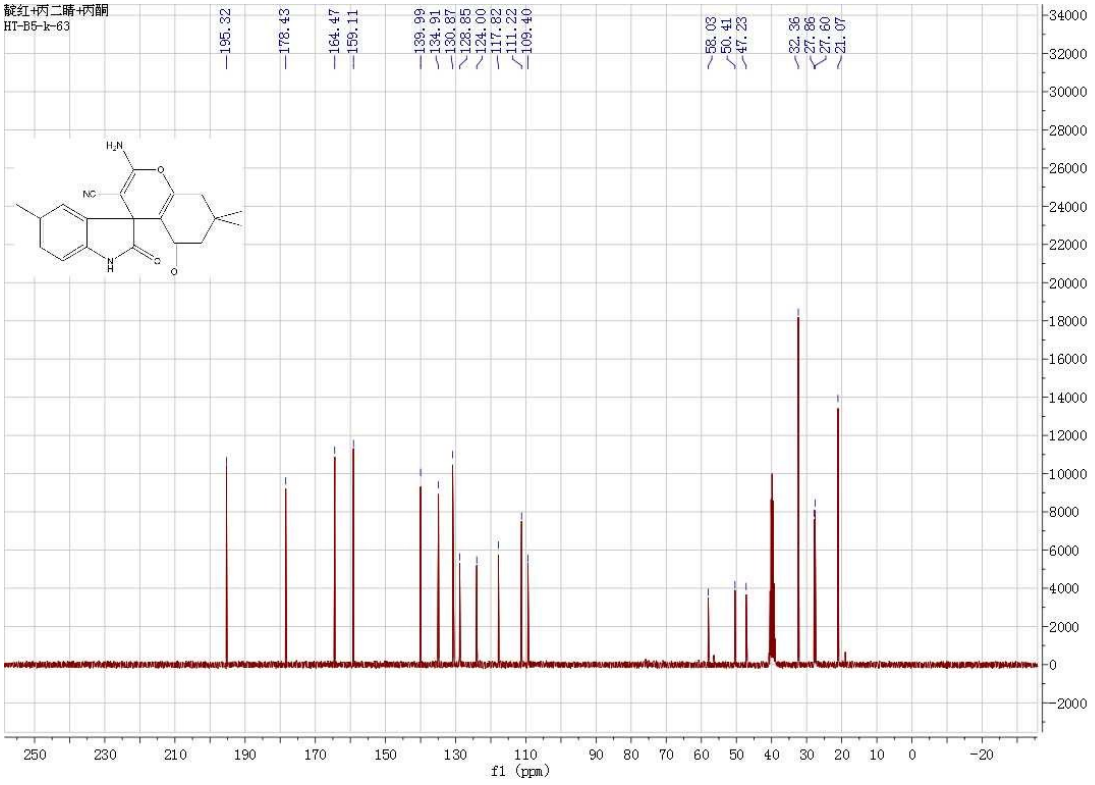
15g


靛红+丙二腈+丙酮
HT-B5-K-67
10.54
7.48
7.45
7.32
7.31
6.66
6.63
2.62
2.56
2.51
2.45
2.14
1.04
1.00
f1 (ppm)

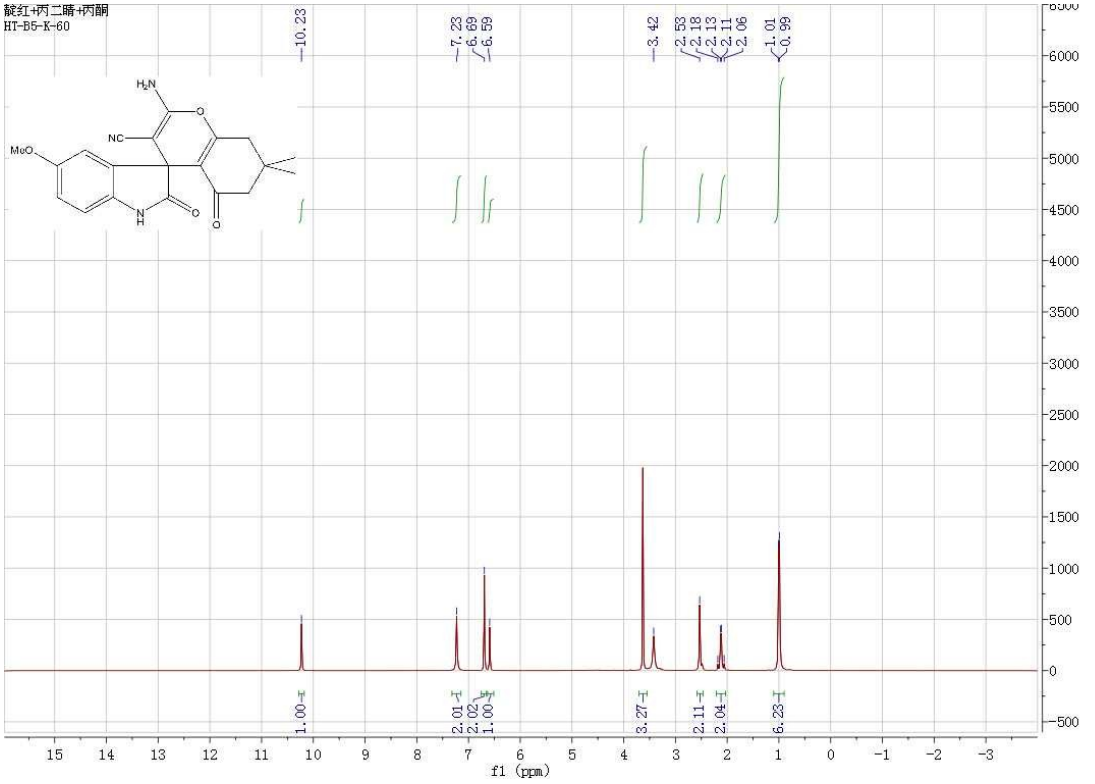

靛红+丙二腈+丙酮
HT-B5-k-67
195.55
177.90
165.01
159.24
142.30
137.44
137.17
131.77
117.68
112.19
110.61
84.89
57.16
56.47
50.33
47.22
32.41
27.91
27.59
18.98
f1 (ppm)

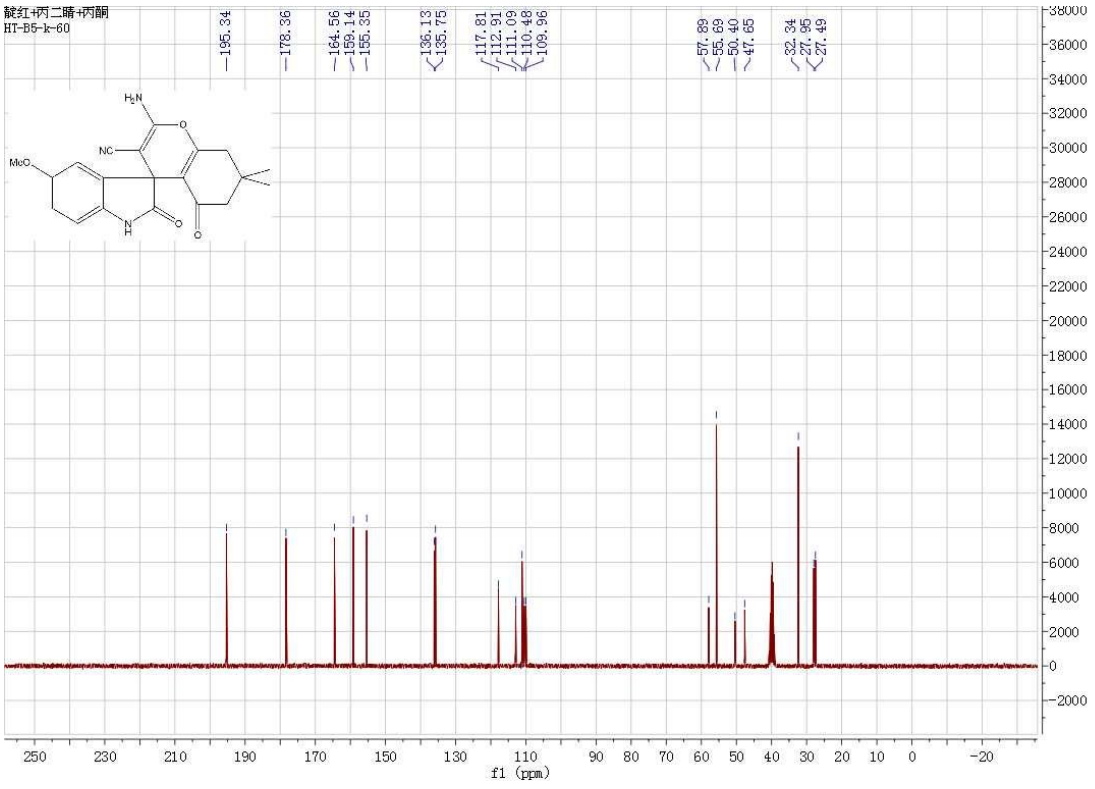
15h


靛红+丙二腈+丙酮
HT-B5-K-63
10.29
7.20
6.94
6.91
6.77
6.68
6.65
2.54
2.18
2.12
1.01
0.99
1.00
2.00
1.02
0.99
1.07
2.23
5.13
6.07
f1 (ppm)

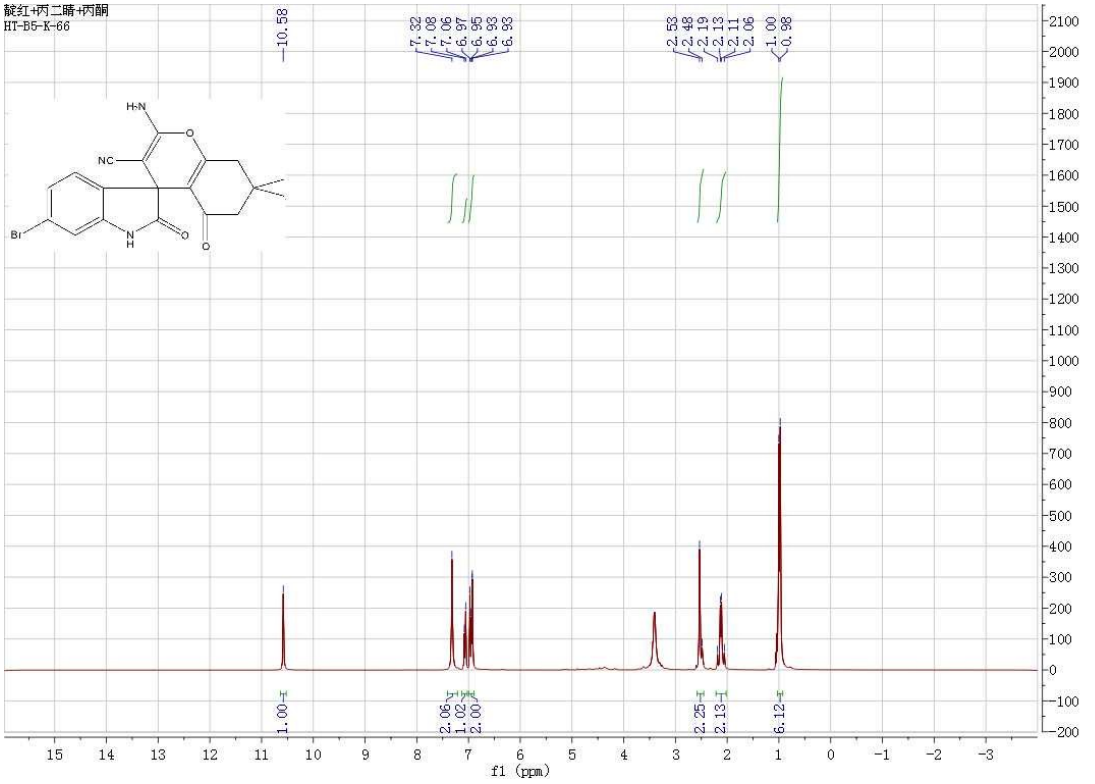

靛红+丙二腈+丙酮
HT-B5-k-63
195.32
178.43
164.47
159.11
139.99
134.91
130.87
128.85
124.00
117.82
111.22
109.40
58.03
50.41
47.23
32.36
27.86
27.60
21.07
f1 (ppm)

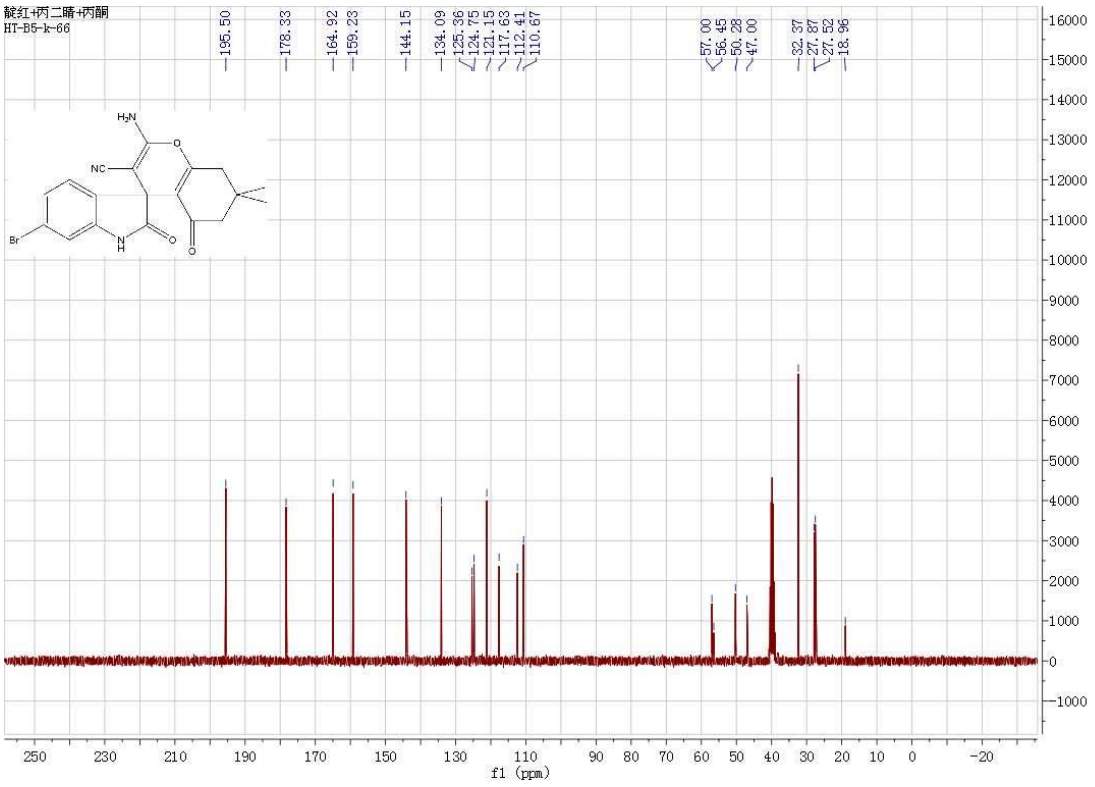
15i


靛红+丙二腈+丙酮
HT-B5-K-60
10.23
7.23
6.69
6.59
3.42
2.53
2.18
2.13
2.11
2.06
1.01
0.99
1.00
2.01
2.02
1.00
3.27
2.11
2.04
6.23
f1 (ppm)

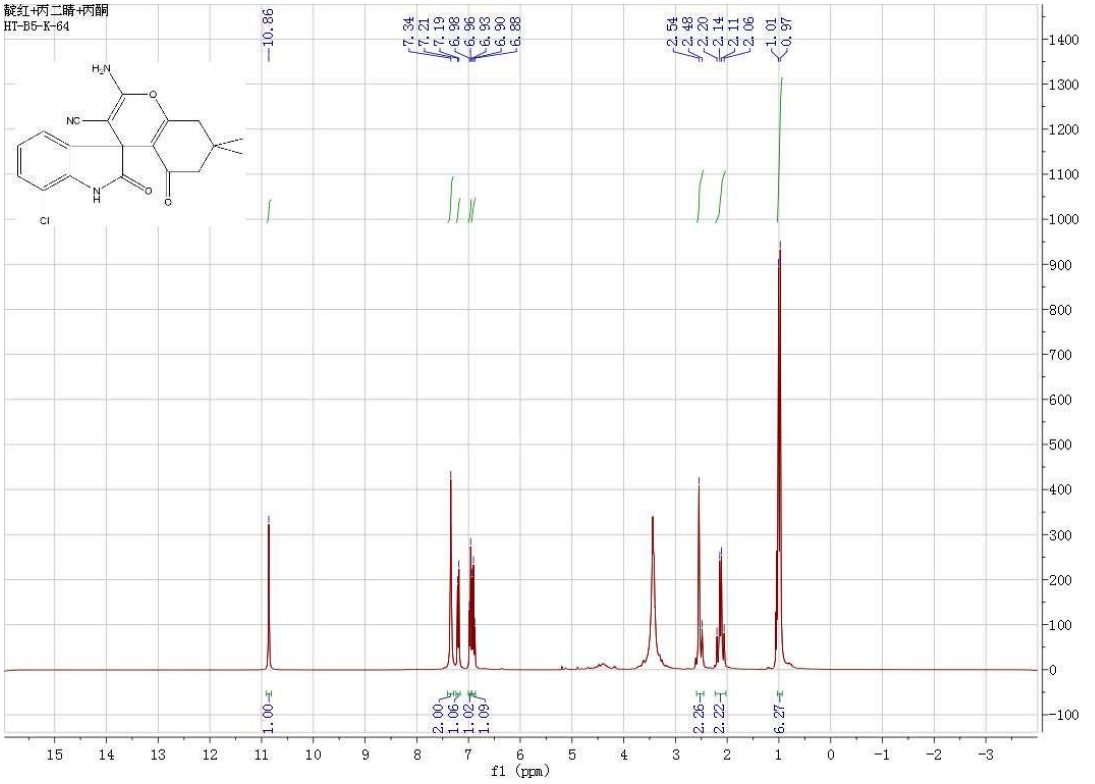

靛红+丙二腈+丙酮
HT-B5-k-60
195.34
178.36
164.56
159.14
155.35
136.13
135.75
117.81
112.91
111.09
110.48
109.96
57.89
55.69
50.40
47.65
32.34
27.95
27.49
f1 (ppm)

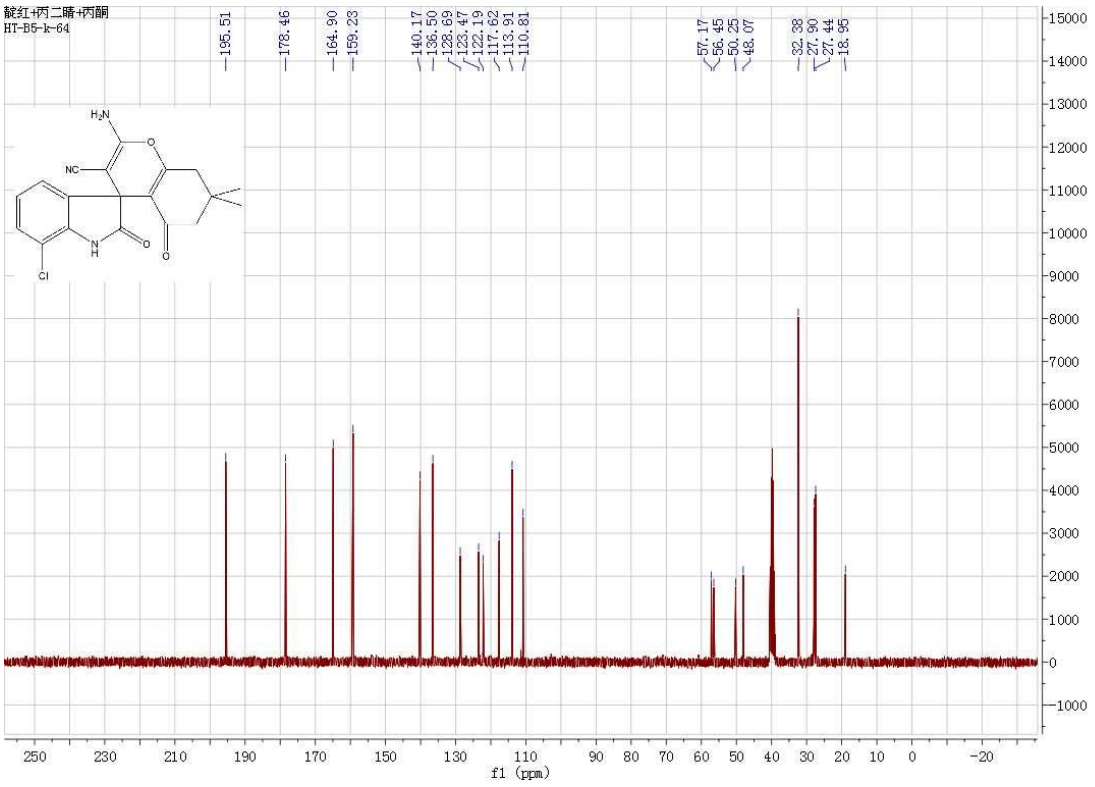
15j


靛红+丙二腈+丙酮
HT-B5-K-66
10.58
7.32
7.08
7.06
6.97
6.95
6.93
6.93
2.53
2.48
2.19
2.13
2.11
2.06
1.00
0.98
1.00
2.06
1.02
2.00
2.25
2.13
6.12
f1 (ppm)

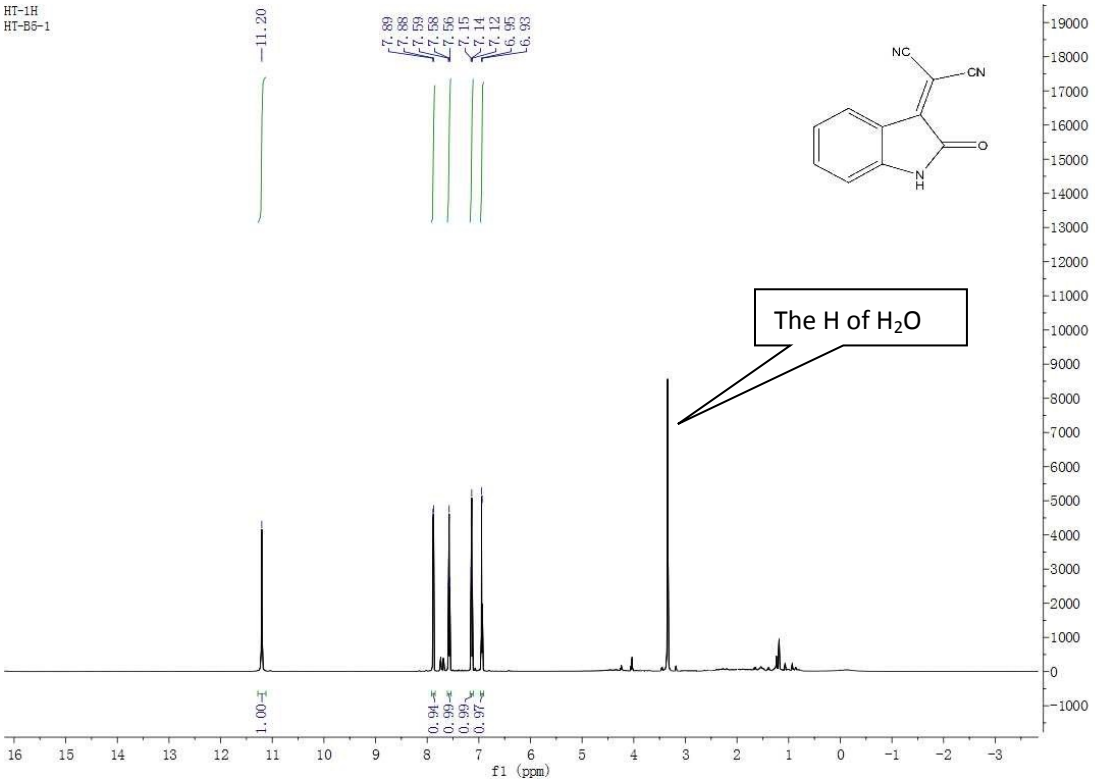

靛红+丙二腈+丙酮
HT-B5-k-66
195.50
178.33
164.92
159.23
144.15
134.09
125.36
124.75
121.15
117.63
112.41
110.67
57.00
56.45
50.28
47.00
32.37
27.87
27.52
18.96
f1 (ppm)

15k


靛红+丙二腈+丙酮
HT-B5-K-64
10.86
7.34
7.21
7.19
6.98
6.96
6.93
6.90
6.88
2.54
2.48
2.20
2.14
2.11
2.06
1.01
0.97
1.00
2.00
1.06
1.02
1.09
2.26
2.22
6.27
f1 (ppm)


靛红+丙二腈+丙酮
HT-B5-k-64
195.51
178.46
164.90
159.23
140.17
136.50
128.69
123.47
122.19
117.82
113.91
110.81
57.17
56.45
50.25
48.07
32.38
27.90
27.44
18.95
f1 (ppm)

16



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