Supporting Information

Photoinduced decarboxylative radical cascade alkylation/cyclization of benzimidazole derivatives with aliphatic carboxylic acid via ligand-to-iron charge transfer.

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I. General Information

^{1}H NMR spectra were recorded at 400 MHz using TMS as internal standard, ^{13}C NMR spectra were recorded at 100 MHz using TMS as internal standard. All chemical shifts were reported as δ values (ppm) relative to TMS and observed coupling constants (*J*) are given in Hertz (Hz). All NMR solvents used in this study are $CDCl_3$. GC-Mass spectra were recorded on Agilent GC-MS (8890-7250). High-resolution mass spectra were obtained with a Bruker Impact II UHR-QTOF.by ESI on a TOF mass analyzer. The UV-Vis measurements were carried out using a UV-Vis spectrophotometer (ULN 2209003, MAPADA P6). The thin layer chromatography (TLC) was performed using glass plates covered with SiO_2. Spots were visualized by UV light irradiation or by staining of the TLC plate with iodine. Unless otherwise indicated, all reactions were carried out under air atmosphere at room temperature with magnetic stirring. All reagents were purchased from commercial source and without prior purification. Column chromatography was performed on silica gel (200-300 mesh) and the elution was performed with *n*-hexane/ethyl acetate.

The Material of the Irradiation Vessel

Manufacturer: Shenzhen Kelo Light Co., Ltd.

Irradiation wavelength: 400 nm

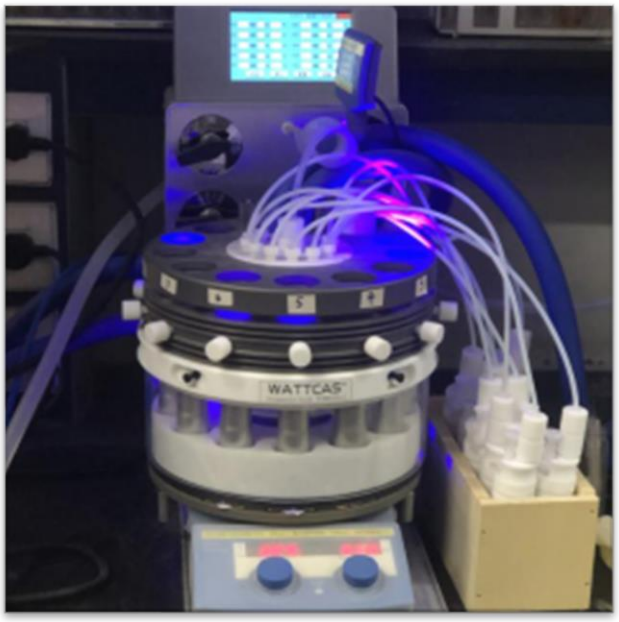
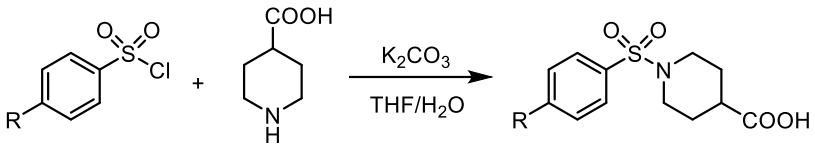


Figure S1. light setup

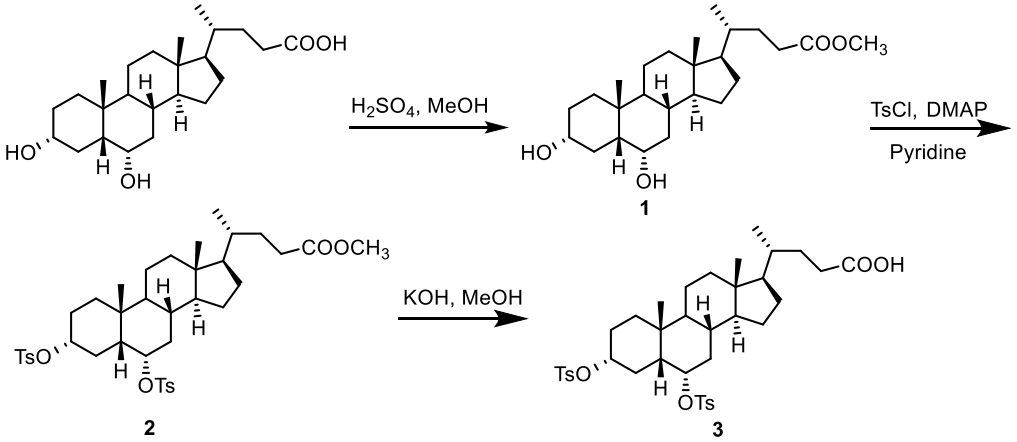
II. Preparation of substrate

General procedure for the synthesis of N-sulfoylpiperidinic acid derivatives[1]



Piperidine 4-carboxylic acid (646 mg, 5.00 mmol, 1.0 eq) was stirred with potassium carbonate (970 mg, 7.0 mmol, 1.4 eq) in water (5 mL) at room temperature until a clear solution was obtained. Solution of benzene sulfonyl chloride (6.5 mmol, 1.3 equiv) in THF (5 mL) was added with the aid of a dropping funnel within 15 min. After stirring for 15 min, the cooling bath was removed and the reaction mixture was stirred for 24 h. After that, the reaction mixture was diluted with EtOAc (20 mL) and 2 N HCl (20 mL). Then, poured into an extraction funnel, the organic phase was washed with brine (1 x 20 mL), dried over Na_2SO_4 and concentrated under reduced pressure. Dry the residues in high vacuo to obtain the corresponding product.

General procedure for the synthesis of hyodeoxycholic acid derivative. [2]

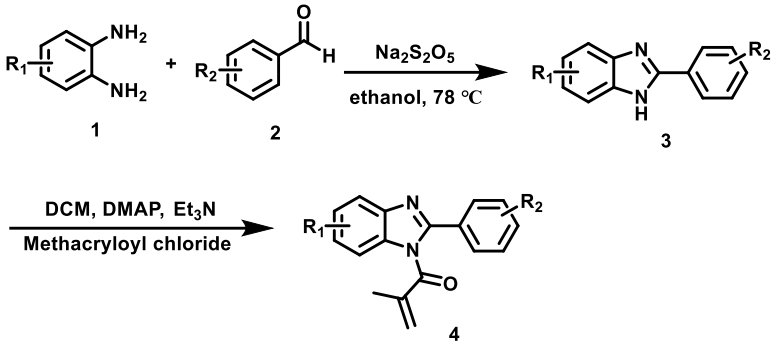


Hyodeoxycholic acid (20.0g, 51mmol, 1 equiv.) was added into methanol (100 mL) and stirred at room temperature for 5 min. After all dissolved, sulfuric acid (2.5 mL) was slowly added into the reaction solution and the reaction was carried out for 18 hours at room temperature under nitrogen atmosphere. The mixture was concentrated to obtain yellow oil, which was extracted by ethyl acetate. After that, saturated $NaHCO_3$ solution was added to adjust the pH to neutral and washed combined organic layers with brine. The organic phase was concentrated to obtain **1** (20.7g,99%).

1 (10.2g, 25 mmol, 1 equiv.), TsCl (14.1g, 75 mmol, 3 equiv.), DMAP (0.305 g, 2.5 mmol, 0.1 equiv.) were dissolved in pyridine (50 mL). The mixture was placed in an ice bath and stirred for 48 hours under nitrogen atmosphere. Subsequently, 250 mL 10 % HCl was added to the solution and then the white solid was precipitated, filtered under reduced pressure. The filter cake was washed with 5% HCl to neutral, and dried to obtain **2** (17.85 g, 99%).

2 (7.1g, 10 mmol, 1 equiv.), KOH (0.729g, 13 mmol, 1.3 equiv.) was dissolved in MeOH (50 mL). The mixture was stirred for 16 h at room temperature. Concentrated under reduced pressure The mixture was purified by silica gel column to obtain **3** (6.8g, 98%).

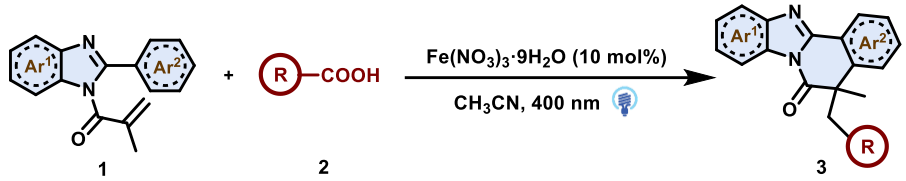
General procedure for the synthesis of N-sulfoylpiperidinic acid derivatives[3,4]



Add o-phenylenediamine (**1**) (10 mmol, 1.0 equiv.), $Na_2S_2O_5$ (15 mmol, 1.5 equiv.), and ethanol (30 mL) to a 100 mL round-bottomed flask. Then introduce benzaldehyde (**2**) (10 mmol, 1.0 equiv.) into the reaction mixture, and heat it to 78 ℃ under reflux conditions. Upon completion of the reaction, cool the reaction mixture to room temperature and pour it into ice water, leading to the formation of yellow solid precipitates. Filter the precipitate and wash it with an appropriate amount of water to obtain the crude product of 2-arylbenzimidazole (**3**). This crude product can be utilized directly for subsequent reactions without requiring further purification. If solid precipitation does not occur upon stirring in the ice water bath, extract the reaction mixture with ethyl acetate three times. Combine the organic layers, dry them with anhydrous sodium sulfate, filter, and concentrate the solution under reduced pressure. Purify the crude product by silica gel column chromatography using petroleum ether/ethyl acetate (5:1) as the eluent.

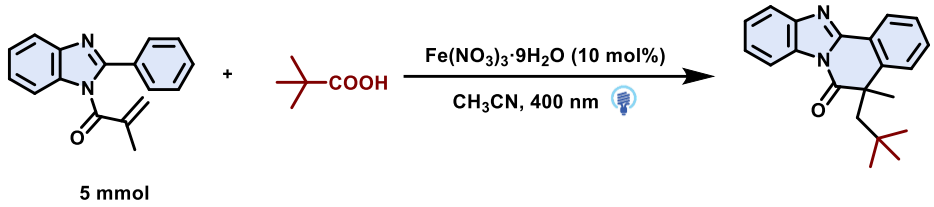
The 100 mL round-bottom flask was cooled to 0℃, and a solution containing crude product (**3)** (5 mmol, 1.0 equiv.), DMAP (2.0 mmol, 0.4 equiv.), and Et_3N (10 mmol, 2.0 equiv.) in DCM (30 mL) was prepared. Subsequently, methyl acrylyl chloride (10 mmol, 2.0 equiv.) was added dropwise with stirring to the reaction mixture. Once the addition was complete, the reaction mixture was allowed to warm to room temperature and stirred while monitoring the progress via TLC analysis. Following completion of the reaction, the mixture was subjected to extraction thrice with dichloromethane and saturated NH4Cl solution. The combined organic layer was then dried over Na2SO4, concentrated under reduced pressure, and purified via silica gel column chromatography, yielding the corresponding white solid product (**4**).

III. General procedure for decarboxylative cascade cyclization.



Procedure : To a dried 8 mL vial was added **1** (0.3 mmol), acid (**2**) (0.6 mmol), $Fe(NO_3)_3{\cdot}9H_2O$ (10 mol %), in 3 mL CH_3CN under air atmosphere. The resulting solution was stirred under 400 nm LED light for 10 h (25 ℃). After that, the reaction mixture was diluted with DCM. Then, poured into an extraction funnel, the organic phase was dried over Na_2SO_4 and concentrated under reduced pressure. Purification by flash column chromatography with PE/EA as an eluent gave the product.

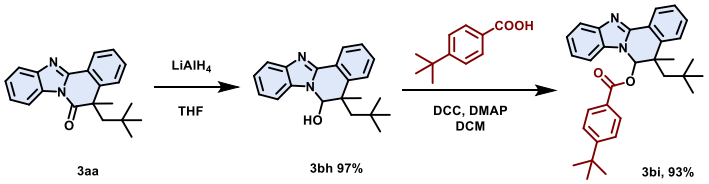
IV. Gram-scale synthesis.



Procedure : In a dry 100 mL round-bottom flask was added 2-methyl-1-(2-phenyl-1H-benzo[d]imidazol-1-yl) prop-2-en-1-one (5 mmol), pivalic acid (10 mmol), $Fe(NO_3)_3{\cdot}9H_2O$(10 mol%) in 20 mL CH_3CN under air atmosphere. The resulting solution was stirred for 12 h at room temperature under 400 nm LED lights. On completion, the resulting solution was diluted with H_2O (50 mL) and DCM (30 mL). Then, poured into an extraction funnel, the organic phase was dried over Na_2SO_4 and concentrated under reduced pressure. Purification by flash column chromatography with PE/EA (20/1) as eluent gave the target compound as white solid (2.229 g, 70% yield). (Figure S2)

Figure S2. gram scale synthesis

V. Late-stage modification.

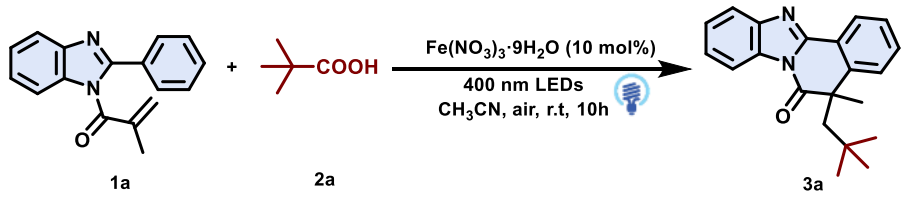


Procedure: In a dry 100 mL round-bottom flask was added **3aa** (1mmol), $LiAlH_4$ (2 mmol) in 10 mL THF under air atmosphere. The resulting solution was stirred for 45 min at 0℃. On completion, the resulting solution was diluted with H_2O (20 mL) and EA (20 mL). Then, poured into an extraction funnel, the organic phase was dried over Na_2SO_4 and concentrated under reduced pressure to give the **3bh** as white solid (310.8 mg, 97% yield).

3bh (310.8 mg, 0.97 mmol), 4-tert-butylbenzoic acid (178.2 mg, 1 mmol), DCC (412.2 mg, 2 mmol,), DMAP (12 mg, 0.1mmol) was dissolved in DCM (15 mL). The mixture was stirred for 5 h at room temperature. Concentrated under reduced pressure The mixture was purified by silica gel column to obtain **3bi** (433.6 mg, 93%).

VI. Optimization of the reaction conditions

Table S1. Iron salts and additive screening

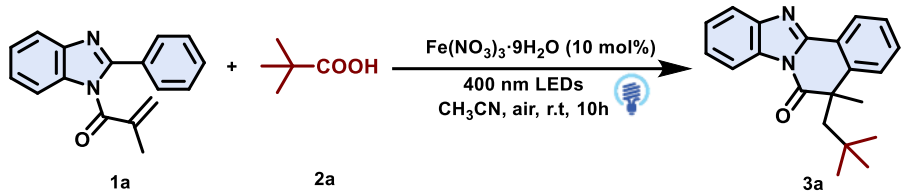


1a 2a 3a

Entry	Deviation from standard conditions[a]	Yield[b] (%)
1	None	84
2	$Fe(acac)_3$ as PC	62
3	$Fe(SO_4)_3$ as PC	25
4	$Fe(OTf)_3$ as PC	33
5	20 mol % of $Fe(NO_3)_3{\cdot}9H_2O$	83
6	*t*-BuOK (20 mol %) as additive	80
7	K_2CO_3 (20 mol %) as additive	75
8	Et_3N (20 mol %) as additive	29
9	100 mol % of *t*- BuONa	72

[a] Conditions: 1a (0.4 mmol), 2a (0.2 mmol.), $Fe(NO_3)_3 \cdot 9H_2O$ (10 mol%), additive (20 mol %), CH_3CN (2 mL), room temperature, air atmosphere, 400 nm LEDs, 10 h. b Determined by 1HNMR spectroscopy using 1,3,5-trimethoxybenzene as internal standard.

Table S2. Other parameter screening

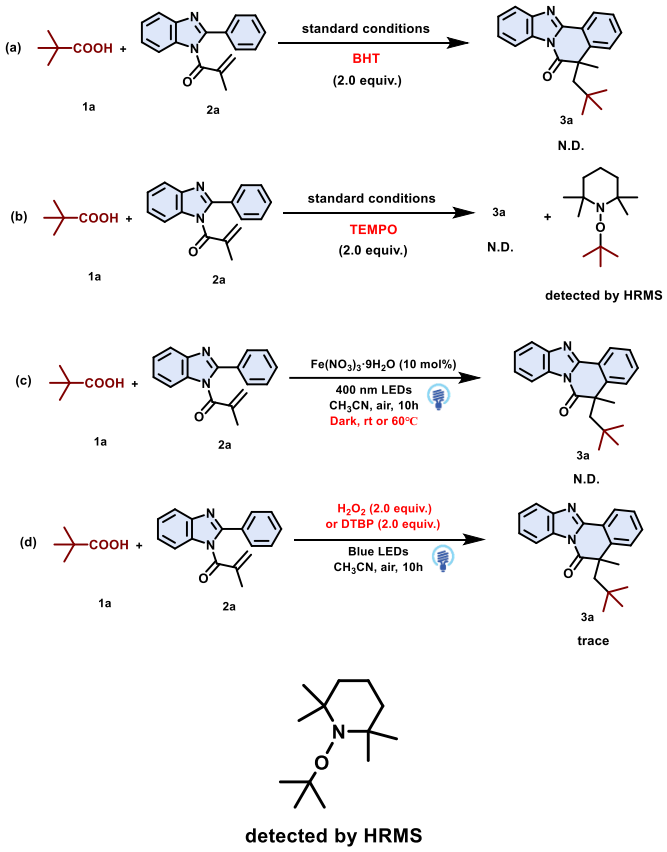


1a 2a 3a

Entry	Deviation from standard conditions[a]	Yield[b] (%)
1	None	84
2	DCE as solvent	42
3	DMF as solvent	36
4	EtOAc as solvent	31
5	370 nm light instend of 100W Blue LEDs	32
6	435 nm light instend of 100W Blue LEDs	52
7	475 nm light instend of 100W Blue LEDs	24
8	Dark conditions	n.d.
9	No $Fe(NO_3)_3{\cdot}9H_2O$	n.d.
10	Nitrogen atmosphere	trace

[a] Conditions: 1a (0.4 mmol), 2a (0.2 mmol.), $Fe(NO_3)_3 \cdot 9H_2O$ (10 mol%), additive (20 mol %), CH_3CN (2 mL), room temperature, air atmosphere, 400 nm LEDs, 10 h. b Determined by 1HNMR spectroscopy using 1,3,5-trimethoxybenzene as internal standard. n.d. No detected.

VII. Control experiments



The reaction was completely inhibited by free radical inhibitors, and the radical adducts was detected by HRMS ($[M+H]^+$=214.2144)

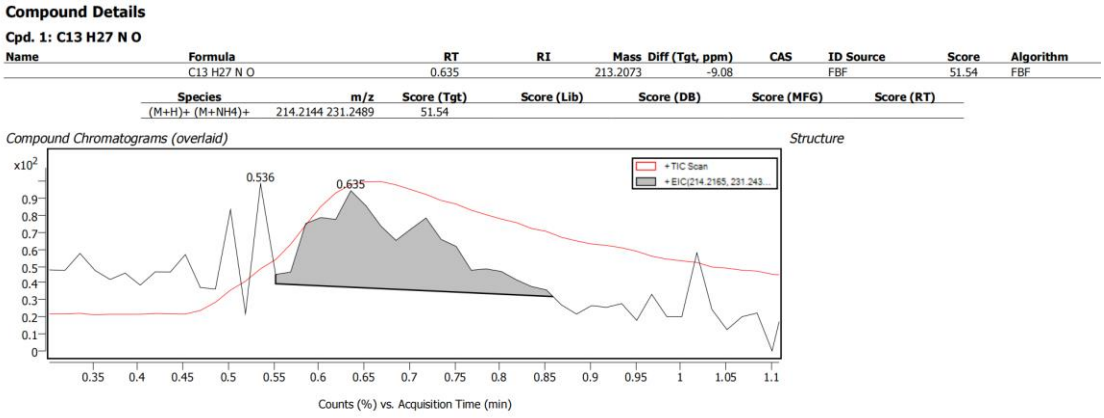


Figure S3. HRMS data of TEMPO adduct

VIII. KI-starch test for the detection of hydrogen peroxide (H_2O_2) in the reaction[5]

It was anticipated that H_2O_2 may be one of the reasonable by-products of the photo-induced decaboxylative cascade reaction, which was confirmed by KI/starch test.

After the irradiation of light on reaction mixture, the aqueous solution of starch-potassium iodide was added and the solution turns dark blue, which confirms the formation of H_2O_2. (Figure S4)

Solution A: KI (0.05M), starch (4 mg/mL), and glacial acetic acid (0.5 M) in 2 mL H_2O

Solution B: Reaction mixture after irradiation.

Solution C: Add 100uL solution B to solution A.

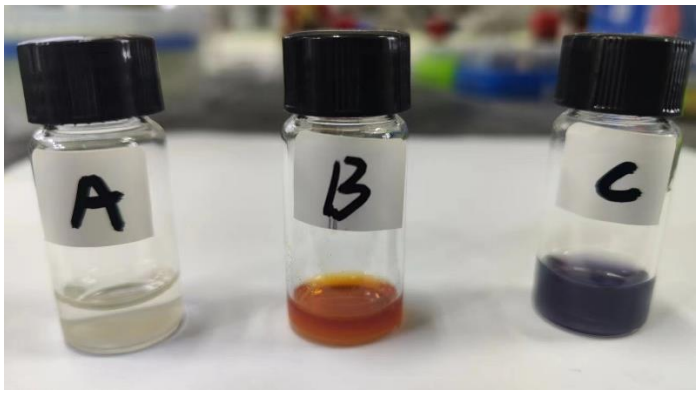


Figure S4 KI-starch test

IX. UV-visible absorption Spectra[6]

UV-Vis experiments were performed to analyse the ligand-to-metal-charge-transfer (LMCT) process between Iron salt and alkyl carboxylic acids.

Preparation of a stock solution (solution A): In a glass vial equipped with a teflon-coated stirring bar and a septum, $Fe(NO_3)_3{\cdot}9H_2O$ (0.03 mmol) were dissolved in MeCN (3 mL). Dilute 66 µL of the above solution to 6 mL to obtain solution A.

Preparation of a stock solution (solution B): In a glass vial equipped with a teflon-coated stirring bar and a septum, $Fe(NO_3)_3{\cdot}9H_2O$ (0.03 mmol) and Pivalic acid (0.3 mmol) were dissolved in MeCN (3 mL). Dilute 200 µL of the above solution to 6 mL to obtain solution B.

UV-Visible absorption spectra of solution A

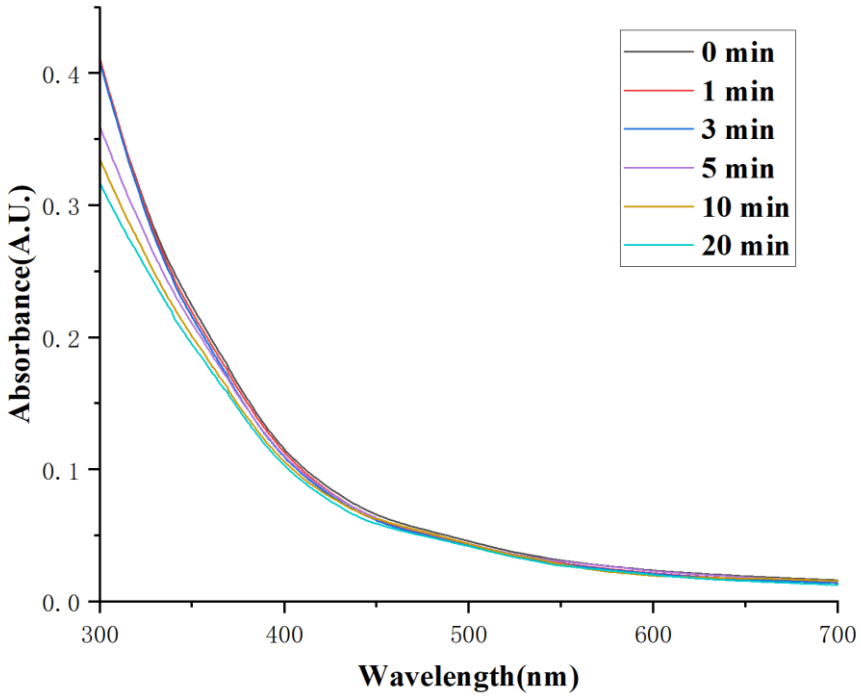


Figure S4 UV-Visible spectra of a solution of $Fe(NO_3)_3{\cdot}9H_2O$ without acid after irradiation with 400 nm LED light.

As shown in Figure S4, there is little change in absorbance as the irradiation time increases without the addition of acid.

UV-Visible absorption spectra of solution B

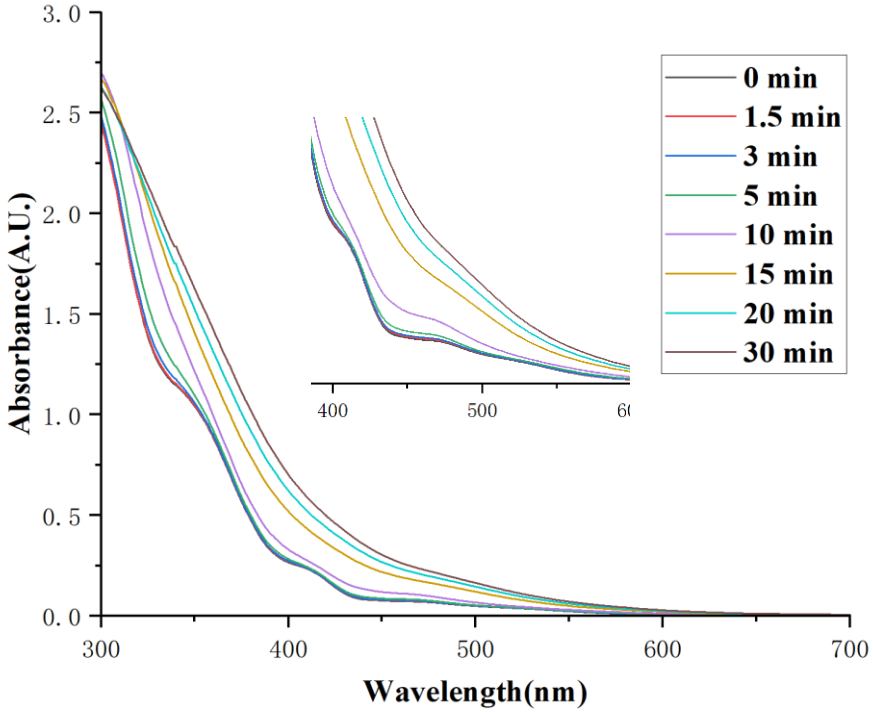
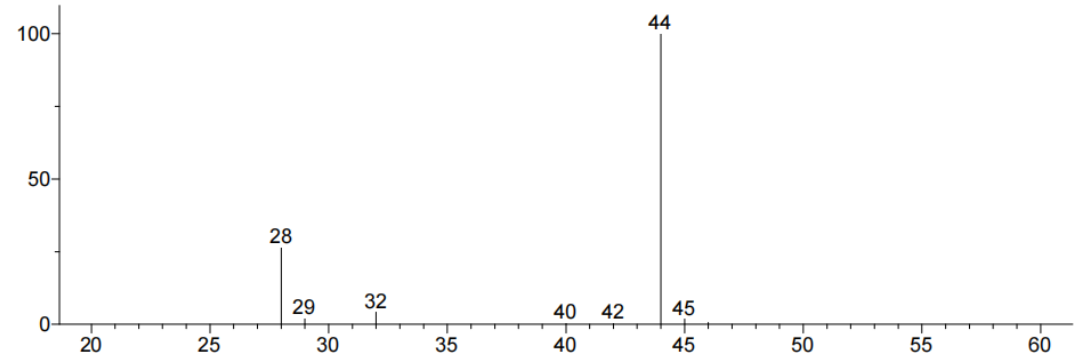


Figure S4 UV-Visible spectra of a solution of $Fe(NO_3)_3{\cdot}9H_2O$ with pivalic acid after irradiation with 400 nm LED light.

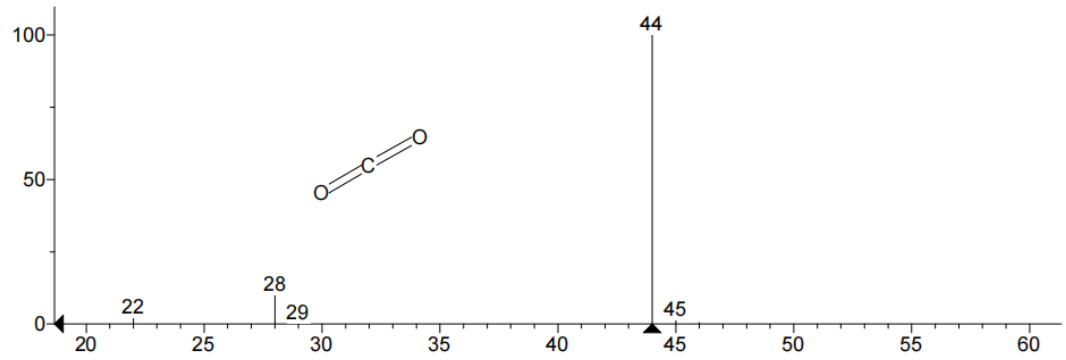
When the 400 nm LED was switched-on, the absorbance of Fe^{II} (λ_{absorb}≈400-600 nm) gradually increases, which demostrated that in the presence of carboxylic acid, the Fe^{III} was reduced to Fe^{II} after gradually increasing the illumination time. Concurrently, Fe^{II} is gradually oxidized to Fe^{III} in the presence of oxygen, which accounts for the relatively slow increase in absorbance.

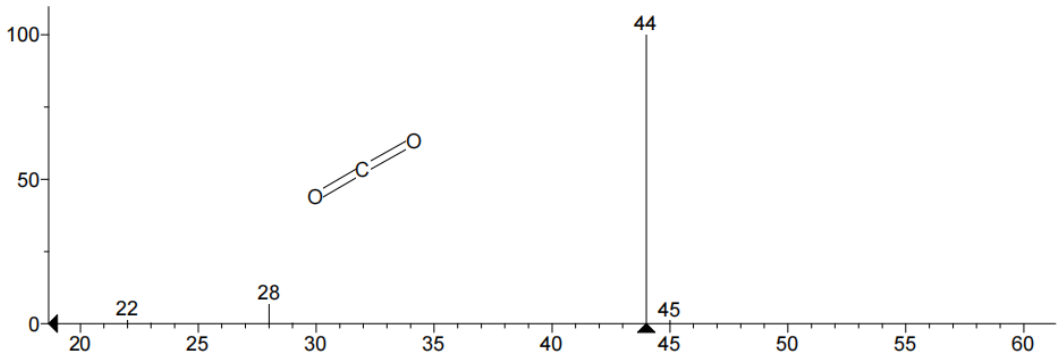
X. GC-MS experiment.

Unknown: +EI Scan (rt: 1.56-1.57 min, 3 scans) Frag=70.0V wjy-CO2_2.D Subtract
Compound in Library Factor = 139

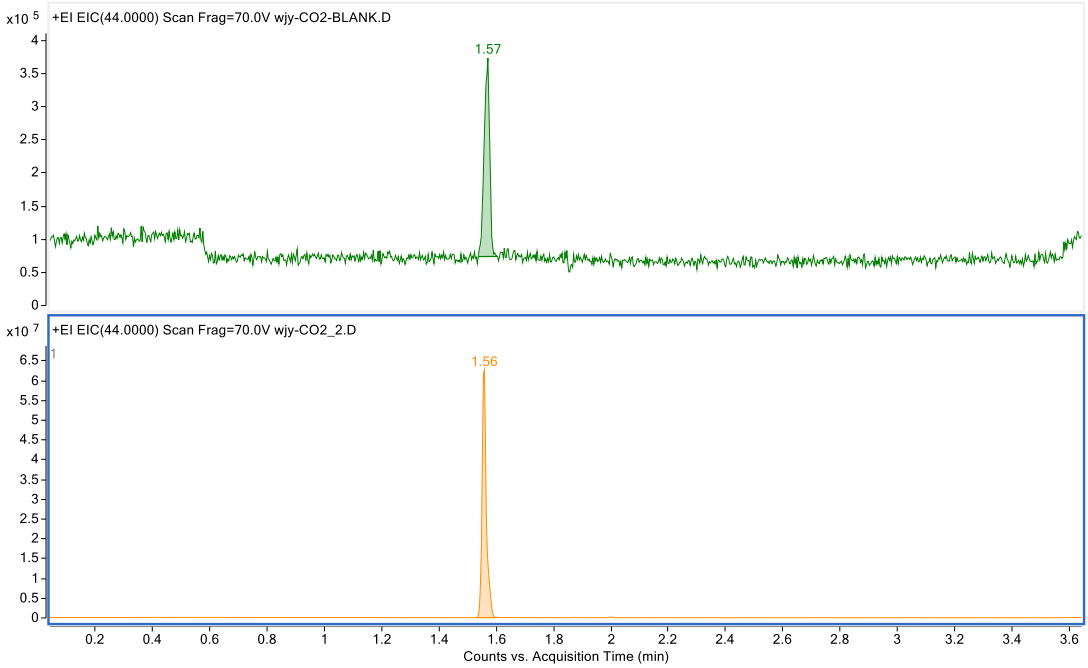


Hit 1 : Carbon dioxide
CO2; MF: 879; RMF: 895; Prob 81.4%; CAS: 124-38-9; Lib: mainlib; ID: 17540.





The substance identified by gas chromatography-mass spectrometry analysis at RT=1.56-1.57 is carbon dioxide (CO_2).



	RT	Area
pre-reaction	1.57	401396
after the reaction	1.56	65188545

Preparation of a stock solution: In a glass vial equipped with a teflon-coated stirring bar and a septum, 2-methyl-1-(2-phenyl-1H-benzo[d]imidazol-1-yl)prop-2-en-1-one (0.3 mmol, 1.0 equiv.) $Fe(NO_3)_3{\cdot}9H_2O$ (0.03 mmol, 10 mol%) and Pivalic acid (3 mmol, 10.0 equiv.) were dissolved in MeCN (3 mL).

Reference:

1 P. H. Huy and C. Mbouhom, *Chem. Sci.*, 2019, **10**, 7399–7406.

2 M. D. Hill, M.-J. Blanco, F. G. Salituro, Z. Bai, J. T. Beckley, M. A. Ackley, J. Dai, J. J. Doherty, B. L. Harrison, E. C. Hoffmann, T. M. Kazdoba, D. Lanzetta, M. Lewis, M. C. Quirk and A. J. Robichaud, *J. Med. Chem.*, 2022, **65**, 9063–9075.

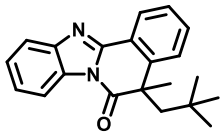
3 D. R. Stuart, E. Villemure and K. Fagnou, *J. Am. Chem. Soc.*, 2007, **129**, 12072–12073.

4 A. Kamal, M. Kashi Reddy, T. B. Shaik, Rajender, Y. V. V. Srikanth, V. Santhosh Reddy, G. Bharath Kumar and S. V. Kalivendi, *European Journal of Medicinal Chemistry*, 2012, **50**, 9–17.

5 S. Singh, N. Dagar and S. R. Roy, *Chem. Commun.*, 2022, **58**, 3831–3834.

6 Y. Zhang, J. Qian, M. Wang, Y. Huang and P. Hu, *Org. Lett.*, 2022, **24**, 5972–5976.

XI. Characterization Data for the products



3aa

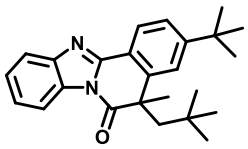
5-methyl-5-neopentylbenzo [4,5] imidazo[2,1-a] isoquinolin-6(5H)-one

Purification by flash column chromatography (eluent: PE/EA = 20/1) gave the title compound as white solid (78.3 mg, 82% yield).

^{1}H NMR (400 MHz, Chloroform-*d*) δ 8.52 (d, *J* = 8.8 Hz, 1H), 8.42 (d, *J* = 7.2 Hz, 1H), 7.85 (dd, *J* = 7.7, 1.5 Hz, 1H), 7.59 – 7.41 (m, 5H), 2.66 (d, *J* = 14.3 Hz, 1H), 2.19 (d, *J* = 14.3 Hz, 1H), 1.73 (s, 3H), 0.56 (s, 9H).

^{13}C NMR (101 MHz, Chloroform-*d*) δ 173.40, 149.76, 144.08, 142.00, 131.45, 131.13, 127.60, 127.53, 125.92, 125.85, 125.51, 122.44, 119.72, 115.79, 55.33, 47.68, 33.03, 32.01, 30.78.

(Known compound: Chem Asian J. 2023, e202300028 (3 of 5)).



3ab

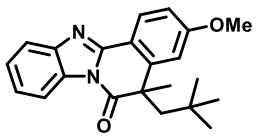
3-(tert-butyl)-5-methyl-5-neopentylbenzo [4,5] imidazo[2,1-a] isoquinolin-6(5H)-one

Purification by flash column chromatography (eluent: PE/EA = 20/1) gave the title compound as white solid (94.4 mg, 84% yield).

^{1}H NMR (400 MHz, Chloroform-*d*) δ 8.46 – 8.38 (m, 2H), 7.86 – 7.81 (m, 1H), 7.57 – 7.50 (m, 2H), 7.49 – 7.40 (m, 2H), 2.68 (d, *J* = 14.4 Hz, 1H), 2.20 (d, *J* = 14.4 Hz, 1H), 1.73 (s, 3H), 1.40 (s, 9H), 0.55 (s, 9H).

^{13}C NMR (101 MHz, Chloroform-*d*) δ 173.79, 154.55, 149.90, 144.05, 141.37, 131.37, 125.80, 125.72, 125.30, 124.97, 124.52, 119.62, 119.54, 115.75, 55.08, 47.82, 35.22, 33.27, 31.98, 31.09, 30.83.

HRMS: $C_{25}H_{31}N_2O$ [M+H] $^+$; calculated: 375.2436, found: 375.2433.



3ac

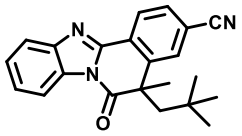
3-methoxy-5-methyl-5-neopentylbenzo[4,5]imidazo[2,1-a]isoquinolin-6(5H)-one

Purification by flash column chromatography (eluent: PE/EA = 20/1) gave the title compound as white solid (84.7 mg, 81% yield).

^{1}H NMR (400 MHz, Chloroform-*d*) δ 8.45 (dd, *J* = 8.7, 1.7 Hz, 1H), 8.38 (d, *J* = 7.7 Hz, 1H), 7.80 (d, *J* = 7.7 Hz, 1H), 7.42 (dt, *J* = 15.3, 7.5 Hz, 2H), 7.09 – 6.97 (m, 2H), 3.93 (s, 3H), 2.64 (d, *J* = 14.6 Hz, 1H), 2.14 (d, *J* = 13.6 Hz, 1H), 1.72 (s, 3H), 0.59 (s, 9H).

^{13}C NMR (101 MHz, Chloroform-*d*) δ 173.44, 162.08, 149.93, 144.16, 144.06, 131.33, 127.83, 125.77, 125.04, 119.30, 115.65, 115.41, 113.57, 113.13, 55.56, 55.41, 47.79, 33.24, 32.07, 30.83.

(Known compound: Chem. Commun, 2019, 55, 2861-2864).



3ad

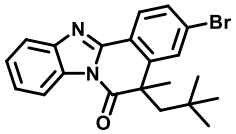
5-methyl-5-neopentyl-6-oxo-5,6-dihydrobenzo[4,5]imidazo[2,1-a]isoquinoline-3-carbonitrile

Purification by flash column chromatography (eluent: PE/EA = 10/1) gave the title compound as white solid (79.3 mg, 77% yield).

^{1}H NMR (400 MHz, Chloroform-*d*) δ 8.62 (d, *J* = 8.1 Hz, 1H), 8.46 – 8.37 (m, 1H), 7.91 – 7.81 (m, 2H), 7.75 (d, *J* = 8.1 Hz, 1H), 7.55 – 7.47 (m, 2H), 2.70 (d, *J* = 14.5 Hz, 1H), 2.16 (d, *J* = 14.5 Hz, 1H), 1.75 (s, 3H), 0.56 (s, 9H).

^{13}C NMR (101 MHz, Chloroform-*d*) δ 171.98, 147.66, 143.95, 142.87, 131.69, 131.38, 130.71, 126.63, 126.41, 126.35, 120.30, 118.09, 115.95, 114.46, 55.38, 47.66, 32.88, 32.08, 30.83.

(Known compound: Chem. Commun, 2019, 55, 2861-2864).



3ae

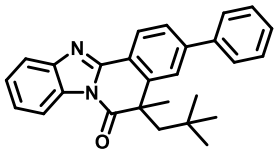
3-bromo-5-methyl-5-neopentylbenzo[4,5]imidazo[2,1-a]isoquinolin-6(5H)-one

Purification by flash column chromatography (eluent: PE/EA = 20/1) gave the title compound as white solid (95.4 mg, 80% yield).

^{1}H NMR (400 MHz, Chloroform-*d*) δ 8.45 – 8.36 (m, 2H), 7.86 (d, *J* = 6.8 Hz, 1H), 7.71 – 7.61 (m, 2H), 7.50 – 7.44 (m, 2H), 2.67 (d, *J* = 14.6 Hz, 1H), 2.15 (d, *J* = 14.6 Hz, 1H), 1.73 (s, 3H), 0.59 (s, 9H).

^{13}C NMR (101 MHz, Chloroform-*d*) δ 172.57, 148.83, 143.86, 143.53, 131.18, 130.77, 127.50, 126.19, 126.08, 125.95, 121.16, 119.71, 115.84, 55.32, 47.69, 32.98, 32.09, 30.84.

(Known compound: Synlett, 2023, 34, 143-148).



3af

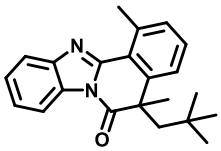
5-methyl-5-neopentyl-3-phenylbenzo[4,5]imidazo[2,1-a]isoquinolin-6(5H)-one

Purification by flash column chromatography (eluent: PE/EA = 20/1) gave the title compound as white solid (94.7 mg, 80% yield).

^{1}H NMR (400 MHz, Chloroform-*d*) δ 8.61 (d, *J* = 8.6 Hz, 1H), 8.43 (dd, *J* = 7.7, 1.6 Hz, 1H), 7.91 – 7.86 (m, 1H), 7.75 – 7.72 (m, 2H), 7.69 – 7.66 (m, 2H), 7.54 (dd, *J* = 8.3, 6.6 Hz, 2H), 7.50 – 7.44 (m, 3H), 2.72 (d, *J* = 14.4 Hz, 1H), 2.28 (d, *J* = 14.4 Hz, 1H), 1.79 (s, 3H), 0.62 (s, 9H).

^{13}C NMR (101 MHz, Chloroform-*d*) δ 173.46, 149.60, 144.11, 142.40, 140.07, 131.38, 129.08, 128.33, 127.21, 126.76, 126.54, 126.29, 126.02, 125.64, 121.06, 119.62, 115.83, 55.30, 47.87, 33.21, 32.10, 30.91.

HRMS: $C_{27}H_{27}N_2O$ $[M+H]^+$; calculated: 395.2123, found: 395.2125.



3ag

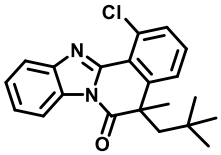
1,5-dimethyl-5-neopentylbenzo[4,5]imidazo[2,1-a]isoquinolin-6(5H)-one

Purification by flash column chromatography (eluent: PE/EA = 20/1) gave the title compound as white solid (80.8 mg, 81% yield).

^{1}H NMR (400 MHz, Chloroform-*d*) δ 8.49 – 8.43 (m, 1H), 7.91 – 7.85 (m, 1H), 7.48 – 7.44 (m, 2H), 7.43 – 7.40 (m, 2H), 3.10 (s, 3H), 2.65 (d, *J* = 14.4 Hz, 1H), 2.18 (d, *J* = 14.4 Hz, 1H), 1.74 (s, 3H), 0.56 (s, 9H).

^{13}C NMR (101 MHz, Chloroform-*d*) δ 173.69, 150.03, 144.18, 143.09, 139.69, 130.88, 130.60, 129.84, 125.61, 125.59, 125.55, 121.09, 120.02, 115.91, 55.77, 47.52, 33.63, 32.06, 30.80, 24.82.

HRMS: $C_{22}H_{25}NO$ $[M+H]^+$; calculated: 333.1967, found: 333.1966.



3ah

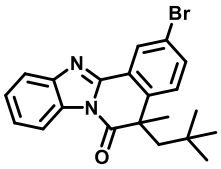
1-chloro-5-methyl-5-neopentylbenzo[4,5]imidazo[2,1-a]isoquinolin-6(5H)-one

Purification by flash column chromatography (eluent: PE/EA = 20/1) gave the title compound as white solid (80.5 mg, 76% yield).

^{1}H NMR (400 MHz, Chloroform-*d*) δ 8.50 – 8.39 (m, 1H), 8.01 – 7.91 (m, 1H), 7.63 – 7.37 (m, 5H), 2.67 (d, *J* = 14.4 Hz, 1H), 2.17 (d, *J* = 14.4 Hz, 1H), 1.75 (s, 3H), 0.57 (s, 9H).

^{13}C NMR (101 MHz, Chloroform-*d*) δ 172.57, 147.11, 144.94, 143.97, 133.44, 131.17, 130.60, 130.30, 126.44, 126.26, 125.88, 120.70, 115.84, 55.90, 47.84, 33.49, 32.05, 30.78.

HRMS: $C_{21}H_{22}ClN_2O$ $[M+H]^+$; calculated: 353.1421, found: 353.1418.



3ai

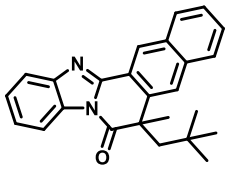
2-bromo-5-methyl-5-neopentylbenzo[4,5]imidazo[2,1-a]isoquinolin-6(5H)-one

Purification by flash column chromatography (eluent: PE/EA = 20/1) gave the title compound as white solid (94.1 mg, 79% yield).

^{1}H NMR (400 MHz, Chloroform-*d*) δ 8.67 (d, *J* = 2.2 Hz, 1H), 8.43 – 8.36 (m, 1H), 7.88 – 7.82 (m, 1H), 7.65 (dd, *J* = 8.5, 2.2 Hz, 1H), 7.51 – 7.43 (m, 2H), 7.40 (d, *J* = 8.5 Hz, 1H), 2.65 (d, *J* = 14.4 Hz, 1H), 2.14 (d, *J* = 14.4 Hz, 1H), 1.70 (s, 3H), 0.57 (s, 9H).

^{13}C NMR (101 MHz, Chloroform-*d*) δ 172.80, 148.28, 143.84, 140.78, 134.11, 131.37, 129.33, 128.52, 126.14, 125.99, 124.22, 121.66, 119.93, 115.84, 55.13, 47.58, 32.98, 32.06, 30.89.

HRMS: $C_{21}H_{22}BrN_2O$ $[M+H]^+$; calculated: 397.0916, found: 397.0912.



3aj

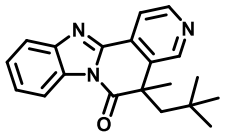
7-methyl-7-neopentylbenzo[g]benzo[4,5]imidazo[2,1-a]isoquinolin-6(7H)-one

Purification by flash column chromatography (eluent: PE/EA = 20/1) gave the title compound as white solid (88.4 mg, 80% yield).

^{1}H NMR (400 MHz, Chloroform-*d*) δ 8.69 (d, *J* = 8.6 Hz, 1H), 8.63 (d, *J* = 8.5 Hz, 1H), 8.47 – 8.42 (m, 1H), 8.01 – 7.88 (m, 3H), 7.66 – 7.57 (m, 2H), 7.53 – 7.45 (m, 2H), 3.10 (d, *J* = 14.7 Hz, 1H), 2.89 (d, *J* = 14.7 Hz, 1H), 2.14 (s, 3H), 0.43 (s, 9H).

^{13}C NMR (101 MHz, Chloroform-*d*) δ 174.85, 150.27, 144.29, 138.39, 135.99, 131.60, 131.25, 130.25, 129.76, 127.01, 126.91, 126.37, 126.11, 125.66, 122.69, 121.04, 119.75, 115.84, 53.43, 50.14, 32.30, 30.88, 30.15.

HRMS: $C_{25}H_{25}N_2O$ [M+H] $^+$; calculated: 369.1967, found: 369.1963.



3ak

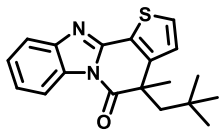
5-methyl-5-neopentylbenzo[4,5]imidazo[2,1-a][2,6]naphthyridin-6(5H)-one

Purification by flash column chromatography (eluent: PE/EA = 10/1) gave the title compound as yellow oil (70.0 mg, 72% yield).

^{1}H NMR (400 MHz, Chloroform-*d*) δ 8.87 (s, 1H), 8.71 (d, *J* = 5.2 Hz, 1H), 8.41 (dd, *J* = 6.0, 3.3 Hz, 1H), 8.28 (d, *J* = 5.2 Hz, 1H), 7.89 (dd, *J* = 6.0, 3.2 Hz, 1H), 7.50 (dd, *J* = 6.1, 3.2 Hz, 2H), 2.70 (d, *J* = 14.5 Hz, 1H), 2.27 (d, *J* = 14.5 Hz, 1H), 1.78 (s, 3H), 0.56 (s, 9H).

^{13}C NMR (101 MHz, Chloroform-*d*) δ 172.28, 149.83, 148.19, 147.25, 143.88, 136.00, 131.43, 129.20, 126.72, 126.34, 120.44, 118.25, 115.97, 54.93, 46.42, 32.55, 32.04, 30.86.

HRMS: $C_{20}H_{22}N_3O$ [M+H] $^+$; calculated: 320.1763, found: 320.1760.



3al

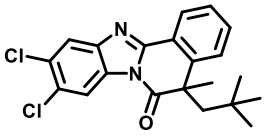
4-methyl-4-neopentylbenzo[4,5]imidazo[1,2-a]thieno[2,3-c]pyridin-5(4H)-one

Purification by flash column chromatography (eluent: PE/EA = 20/1) gave the title compound as yellow oil (74.0 mg, 76% yield).

^{1}H NMR (400 MHz, Chloroform-*d*) δ 8.39 – 8.33 (m, 1H), 7.82 – 7.76 (m, 1H), 7.59 (dd, *J* = 5.0, 0.8 Hz, 1H), 7.46 – 7.40 (m, 2H), 7.13 (dd, *J* = 5.0, 0.9 Hz, 1H), 2.61 (d, *J* = 14.5 Hz, 1H), 2.07 (d, *J* = 14.3 Hz, 1H), 1.66 (s, 3H), 0.62 (s, 9H).

^{13}C NMR (101 MHz, Chloroform-*d*) δ 173.98, 148.38, 146.64, 143.82, 130.81, 130.30, 126.87, 125.85, 125.51, 122.93, 119.55, 115.29, 55.03, 47.90, 31.96, 31.92, 30.58.

HRMS: $C_{19}H_{20}N_2OSNa$ [M+Na] $^+$; calculated: 347.1194, found: 347.1192.



3am

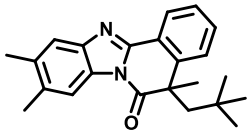
9,10-dichloro-5-methyl-5-neopentylbenzo[4,5]imidazo[2,1-a]isoquinolin-6(5H)-one

Purification by flash column chromatography (eluent: PE/EA = 20/1) gave the title compound as white solid (75.8 mg, 74% yield).

^{1}H NMR (400 MHz, Chloroform-*d*) δ 8.54 (s, 1H), 8.47 (d, *J* = 7.9 Hz, 1H), 7.91 (s, 1H), 7.61 – 7.50 (m, 3H), 2.64 (d, *J* = 14.4 Hz, 1H), 2.20 (d, *J* = 14.4 Hz, 1H), 1.73 (s, 3H), 0.55 (s, 9H).

^{13}C NMR (101 MHz, Chloroform-*d*) δ 173.22, 151.34, 143.45, 142.14, 131.81, 130.37, 129.98, 129.37, 127.85, 127.68, 126.15, 121.72, 120.88, 117.16, 55.39, 47.75, 33.02, 32.06, 30.79.

HRMS: $C_{21}H_{21}Cl_2N_2O$ [M+H] $^{+}$; calculated: 387.1031, found: 387.1028.



3an

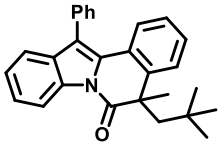
5,9,10-trimethyl-5-neopentylbenzo[4,5]imidazo[2,1-a]isoquinolin-6(5H)-one

Purification by flash column chromatography (eluent: PE/EA = 20/1) gave the title compound as white solid (81.1 mg, 78% yield).

^{1}H NMR (400 MHz, Chloroform-*d*) δ 8.48 (d, *J* = 7.7 Hz, 1H), 8.19 (s, 1H), 7.61 (s, 1H), 7.54 – 7.51 (m, 2H), 7.47 (ddd, *J* = 8.3, 5.3, 3.2 Hz, 1H), 2.64 (d, *J* = 14.4 Hz, 1H), 2.45 (s, 3H), 2.43 (s, 3H), 2.17 (d, *J* = 14.4 Hz, 1H), 1.72 (s, 3H), 0.55 (s, 10H).

^{13}C NMR (101 MHz, Chloroform-*d*) δ 173.39, 149.02, 142.40, 141.73, 134.88, 134.86, 130.84, 129.72, 127.55, 127.53, 125.70, 122.58, 119.89, 116.09, 55.30, 47.55, 33.01, 32.02, 30.79, 20.56, 20.49.

HRMS: $C_{23}H_{27}N_2O$ [M+H] $^{+}$; calculated: 347.2123, found: 347.2120.



3ao

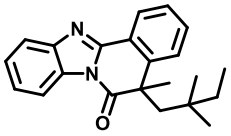
5-methyl-5-neopentyl-12-phenylindolo[2,1-a]isoquinolin-6(5H)-one

Purification by flash column chromatography (eluent: PE/EA = 20/1) gave the title compound as white solid (98.0 mg, 83% yield).

^{1}H NMR (400 MHz, Chloroform-*d*) δ 8.76 (d, *J* = 8.5 Hz, 1H), 7.62 – 7.53 (m, 5H), 7.51 – 7.43 (m, 3H), 7.36 – 7.26 (m, 3H), 7.07 – 7.00 (m, 1H), 2.67 (d, *J* = 14.3 Hz, 1H), 2.14 (d, *J* = 14.3 Hz, 1H), 1.78 (s, 3H), 0.65 (s, 9H).

^{13}C NMR (101 MHz, Chloroform-*d*) δ 173.76, 139.32, 134.33, 134.22, 132.43, 130.34, 129.73, 129.28, 128.09, 127.84, 127.73, 126.46, 125.80, 125.17, 124.90, 124.56, 120.15, 119.35, 116.98, 55.87, 46.90, 32.98, 32.06, 31.65, 30.85, 29.77, 22.72, 14.20.

HRMS: $C_{28}H_{28}NO$ [M+H] $^{+}$; calculated: 394.2171, found: 394.2164.



3ap

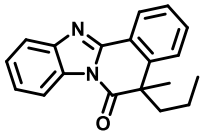
5-(2,2-dimethylbutyl)-5-methylbenzo[4,5]imidazo[2,1-a]isoquinolin-6(5H)-one

Purification by flash column chromatography (eluent: PE/EA = 20/1) gave the title compound as white solid (80.7 mg, 81% yield).

^{1}H NMR (400 MHz, Chloroform-*d*) δ 8.52 (d, *J* = 7.8 Hz, 1H), 8.42 (d, *J* = 6.8 Hz, 1H), 7.86 (d, *J* = 6.5 Hz, 1H), 7.58 – 7.42 (m, 5H), 2.63 (d, *J* = 14.4 Hz, 1H), 2.18 (d, *J* = 14.4 Hz, 1H), 1.73 (s, 3H), 0.96 (dhept, *J* = 28.1, 7.1 Hz, 2H), 0.71 (t, *J* = 7.5 Hz, 3H), 0.50 (s, 3H), 0.39 (s, 3H).

^{13}C NMR (101 MHz, Chloroform-*d*) δ 173.52, 149.79, 144.04, 142.16, 131.44, 131.12, 127.60, 127.54, 125.89, 125.87, 125.52, 122.33, 119.70, 115.80, 53.14, 47.50, 36.56, 34.45, 33.25, 27.57, 26.91, 8.25.

(Known compound: J. Org. Chem. 2021, 86, 9055–9066).



3aq

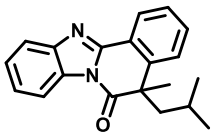
5-methyl-5-propylbenzo[4,5]imidazo[2,1-a]isoquinolin-6(5H)-one

Purification by flash column chromatography (eluent: PE/EA = 20/1) gave the title compound as white solid (54.4 mg, 62% yield).

^{1}H NMR (400 MHz, Chloroform-*d*) δ 8.50 (dd, *J* = 8.1, 1.5 Hz, 1H), 8.43 – 8.36 (m, 1H), 7.88 – 7.81 (m, 1H), 7.63 – 7.56 (m, 1H), 7.54 – 7.43 (m, 4H), 2.41 (ddd, *J* = 13.4, 11.7, 4.8 Hz, 1H), 1.98 (ddd, *J* = 13.4, 12.1, 4.4 Hz, 1H), 1.76 (s, 3H), 1.05 – 0.95 (m, 1H), 0.88 (dddd, *J* = 15.7, 8.5, 5.6, 1.6 Hz, 1H), 0.76 (t, *J* = 7.1 Hz, 3H).

^{13}C NMR (101 MHz, Chloroform-*d*) δ 173.40, 149.92, 144.11, 141.93, 131.81, 131.33, 127.59, 126.03, 125.83, 125.81, 125.48, 123.05, 119.76, 115.68, 49.50, 45.56, 28.62, 18.49, 13.97.

(Known compound: Chem. Commun, 2019, 55, 2861-2864).



3ar

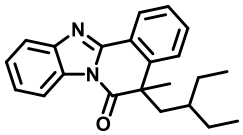
5-isobutyl-5-methylbenzo[4,5]imidazo[2,1-a]isoquinolin-6(5H)-one

Purification by flash column chromatography (eluent: PE/EA = 20/1) gave the title compound as white solid (71.2 mg, 78% yield).

^{1}H NMR (400 MHz, Chloroform-*d*) δ 8.52 (d, *J* = 8.0 Hz, 1H), 8.41 (dd, *J* = 7.4, 1.8 Hz, 1H), 7.85 (dd, *J* = 6.6, 2.4 Hz, 1H), 7.61 – 7.54 (m, 1H), 7.52 – 7.41 (m, 4H), 2.47 (dd, *J* = 14.0, 8.3 Hz, 1H), 2.09 (dd, *J* = 14.1, 5.2 Hz, 1H), 1.70 (s, 3H), 1.39 – 1.29 (m, 1H), 0.64 (d, *J* = 6.7 Hz, 3H), 0.59 (d, *J* = 6.7 Hz, 3H).

^{13}C NMR (101 MHz, Chloroform-*d*) δ 173.49, 149.80, 144.10, 141.84, 131.60, 131.43, 127.56, 126.60, 125.95, 125.83, 125.50, 122.76, 119.75, 115.76, 50.62, 48.60, 31.31, 25.64, 23.84, 22.43.

(Known compound: J. Org. Chem. 2021, 86, 9055–9066).



3as

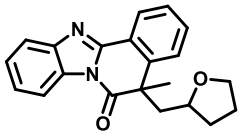
5-(2-ethylbutyl)-5-methylbenzo[4,5]imidazo[2,1-a]isoquinolin-6(5H)-one

Purification by flash column chromatography (eluent: PE/EA = 20/1) gave the title compound as white solid (75.8 mg, 76% yield).

^{1}H NMR (400 MHz, Chloroform-*d*) δ 8.51 (d, *J* = 7.8 Hz, 1H), 8.39 (d, *J* = 7.2 Hz, 1H), 7.85 (d, *J* = 7.2 Hz, 1H), 7.59 (t, *J* = 7.6 Hz, 1H), 7.54 – 7.42 (m, 4H), 2.43 (dd, *J* = 14.3, 6.5 Hz, 1H), 2.03 (d, *J* = 14.5 Hz, 1H), 1.75 (s, 3H), 0.95 (dt, *J* = 20.6, 8.3 Hz, 6H), 0.58 (dt, *J* = 13.9, 7.3 Hz, 6H).

^{13}C NMR (101 MHz, Chloroform-*d*) δ 173.51, 149.91, 144.00, 141.90, 131.60, 131.37, 127.61, 126.67, 125.86, 125.54, 122.81, 119.72, 115.69, 48.65, 46.33, 37.29, 29.98, 25.82, 25.25, 10.35, 9.98.

(Known compound: Chem. Commun, 2019, 55, 2861-2864).



3at

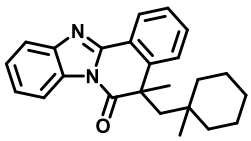
5-methyl-5-((tetrahydrofuran-2-yl)methyl)benzo[4,5]imidazo[2,1-a]isoquinolin-6(5H)-one

Purification by flash column chromatography (eluent: PE/EA = 20/1) gave the title compound as white solid (53.8 mg, 54% yield), d:r = 1:1.

^{1}H NMR (400 MHz, Chloroform-*d*) δ 8.50 (d, *J* = 7.8 Hz, 1H), 8.39 (dd, *J* = 7.7, 1.7 Hz, 1H), 7.85 (dd, *J* = 7.8, 1.7 Hz, 1H), 7.63 – 7.54 (m, 2H), 7.52 – 7.43 (m, 3H), 3.47 (td, *J* = 7.7, 6.1 Hz, 2H), 3.37 (td, *J* = 8.1, 5.9 Hz, 1H), 2.61 (dd, *J* = 13.9, 7.2 Hz, 1H), 2.48 (dd, *J* = 13.8, 5.5 Hz, 1H), 1.78 (s, 3H), 1.72 – 1.62 (m, 1H), 1.61 – 1.46 (m, 2H), 1.42 – 1.22 (m, 2H).

^{13}C NMR (101 MHz, Chloroform-*d*) δ 173.16, 149.90, 143.99, 141.69, 131.74, 131.35, 127.66, 126.54, 125.93, 125.91, 125.57, 122.51, 119.76, 115.69, 67.22, 47.69, 47.64, 31.20, 29.68, 25.65.

(Known compound: Chem. Commun, 2019, 55, 2861-2864).



3au

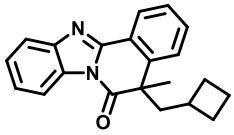
5-methyl-5-((1-methylcyclohexyl)methyl)benzo[4,5]imidazo[2,1-a]isoquinolin-6(5H)-one

Purification by flash column chromatography (eluent: PE/EA = 20/1) gave the title compound as white solid (88.2 mg, 82% yield).

^{1}H NMR (400 MHz, Chloroform-*d*) δ 8.51 (d, *J* = 7.8 Hz, 1H), 8.41 (d, *J* = 6.9 Hz, 1H), 7.86 (d, *J* = 8.9 Hz, 1H), 7.55 (d, *J* = 3.3 Hz, 2H), 7.52 – 7.43 (m, 3H), 2.62 (d, *J* = 14.4 Hz, 1H), 2.23 (d, *J* = 14.5 Hz, 1H), 1.73 (s, 3H), 1.38 – 1.29 (m, 2H), 1.26 – 1.06 (m, 5H), 1.04 – 0.95 (m, 1H), 0.88 – 0.76 (m, 2H), 0.42 (s, 3H).

^{13}C NMR (101 MHz, Chloroform-*d*) δ 173.58, 149.80, 144.03, 142.28, 131.44, 131.08, 127.59, 125.86, 125.51, 122.19, 119.68, 115.82, 55.39, 47.33, 39.22, 39.14, 34.51, 33.31, 26.00, 23.98, 21.79, 21.69.

(Known compound: J. Org. Chem. 2021, 86, 12851–12861).



3av

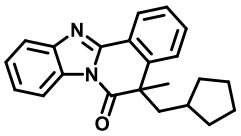
5-(cyclobutylmethyl)-5-methylbenzo[4,5]imidazo[2,1-a]isoquinolin-6(5H)-one

Purification by flash column chromatography (eluent: PE/EA = 20/1) gave the title compound as colorless oil (68.3 mg, 72% yield).

^{1}H NMR (400 MHz, Chloroform-*d*) δ 8.51 (d, *J* = 7.8 Hz, 1H), 8.39 (d, *J* = 7.2 Hz, 1H), 7.85 (d, *J* = 7.2 Hz, 1H), 7.59 (t, *J* = 7.7 Hz, 1H), 7.52 – 7.43 (m, 4H), 2.54 – 2.45 (m, 1H), 2.16 – 2.06 (m, 1H), 1.89 – 1.82 (m, 1H), 1.77 (s, 3H), 1.54 – 1.44 (m, 5H), 1.37 – 1.28 (m, 1H).

^{13}C NMR (101 MHz, Chloroform-*d*) δ 173.34, 149.92, 143.85, 141.85, 131.67, 131.32, 127.66, 126.49, 125.88, 125.81, 125.58, 122.78, 119.70, 115.69, 51.36, 48.60, 32.87, 28.93, 28.53, 27.92, 18.63.

(Known compound: Chem. Commun, 2019, 55, 2861-2864).



3aw

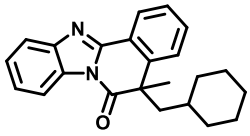
5-(cyclopentylmethyl)-5-methylbenzo[4,5]imidazo[2,1-a]isoquinolin-6(5H)-one

Purification by flash column chromatography (eluent: PE/EA = 20/1) gave the title compound as white solid (74.3 mg, 75% yield).

^{1}H NMR (400 MHz, Chloroform-*d*) δ 8.52 (d, *J* = 7.6 Hz, 1H), 8.41 (d, *J* = 6.7 Hz, 1H), 7.86 (d, *J* = 8.0 Hz, 1H), 7.60 (t, *J* = 7.5 Hz, 1H), 7.55 – 7.41 (m, 4H), 2.55 (dd, *J* = 13.7, 7.3 Hz, 1H), 2.21 (dd, *J* = 13.8, 5.4 Hz, 1H), 1.75 (s, 3H), 1.47 – 1.36 (m, 2H), 1.33 – 1.14 (m, 5H), 1.03 – 0.92 (m, 1H), 0.88 – 0.76 (m, 1H).

^{13}C NMR (101 MHz, Chloroform-*d*) δ 173.56, 149.91, 143.99, 142.12, 131.63, 131.41, 127.62, 126.60, 125.96, 125.86, 125.53, 122.79, 119.75, 115.79, 49.22, 49.15, 37.48, 33.59, 32.46, 30.03, 24.88, 24.61.

(Known compound: Chem. Commun, 2019, 55, 2861-2864).



3ax

5-(cyclohexylmethyl)-5-methylbenzo[4,5]imidazo[2,1-a]isoquinolin-6(5H)-one

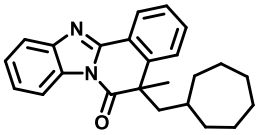
Purification by flash column chromatography (eluent: PE/EA = 20/1) gave the title compound as white solid (81.6 mg, 79% yield).

^{1}H NMR (400 MHz, Chloroform-*d*) δ 8.52 (d, *J* = 7.9 Hz, 1H), 8.43 – 8.37 (m, 1H), 7.88 – 7.82 (m, 1H), 7.63 – 7.56 (m, 1H), 7.53 – 7.42 (m, 4H), 2.50 (dd, *J* = 14.2, 7.9 Hz, 1H), 2.08 (dd, *J* = 14.1, 5.0

Hz, 1H), 1.69 (s, 3H), 1.51 – 1.39 (m, 3H), 1.31 – 1.18 (m, 2H), 1.05 – 0.91 (m, 3H), 0.88 – 0.76 (m, 3H).

^{13}C NMR (101 MHz, Chloroform-*d*) δ 173.49, 149.84, 144.09, 141.92, 131.59, 131.47, 127.54, 126.57, 125.97, 125.80, 125.47, 122.62, 119.72, 115.78, 48.90, 48.36, 34.93, 34.26, 32.96, 31.66, 25.96, 25.91.

(Known compound: Chem. Commun, 2019, 55, 2861-2864).



3ay

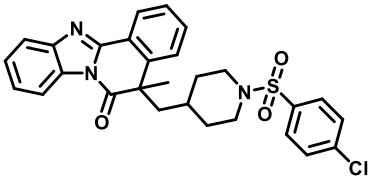
5-(cycloheptylmethyl)-5-methylbenzo[4,5]imidazo[2,1-a]isoquinolin-6(5H)-one

Purification by flash column chromatography (eluent: PE/EA = 20/1) gave the title compound as white solid (74.2 mg, 69% yield).

^{1}H NMR (400 MHz, Chloroform-*d*) δ 8.52 (d, *J* = 7.8 Hz, 1H), 8.40 (d, *J* = 7.0 Hz, 1H), 7.86 (d, *J* = 7.3 Hz, 1H), 7.60 (t, *J* = 7.7 Hz, 1H), 7.54 – 7.34 (m, 4H), 2.53 (dd, *J* = 14.2, 7.7 Hz, 1H), 2.07 (dd, *J* = 14.2, 4.4 Hz, 1H), 1.71 (s, 3H), 1.27 (dt, *J* = 33.4, 12.8 Hz, 10H), 1.01 (dt, *J* = 25.7, 8.7 Hz, 3H).

^{13}C NMR (101 MHz, Chloroform-*d*) δ 173.59, 149.86, 143.98, 141.85, 131.64, 131.39, 127.58, 126.61, 125.92, 125.84, 125.52, 122.70, 119.70, 115.74, 49.93, 48.65, 36.39, 35.60, 33.86, 30.98, 28.42, 28.29, 25.60, 25.49.

(Known compound: Adv. Synth. Catal, 2022, 364, 2080–2085).



3az

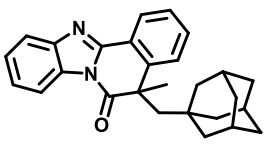
5-((1-((4-chlorophenyl)sulfonyl)piperidin-4-yl)methyl)-5-methylbenzo[4,5]imidazo[2,1-a]isoquinolin-6(5H)-one

Purification by flash column chromatography (eluent: PE/EA = 10/1) gave the title compound as white solid (87.4 mg, 56% yield).

^{1}H NMR (400 MHz, Chloroform-*d*) δ 8.47 (d, *J* = 7.8 Hz, 1H), 8.36 (d, *J* = 7.4 Hz, 1H), 7.83 (d, *J* = 7.4 Hz, 1H), 7.62 – 7.50 (m, 4H), 7.50 – 7.44 (m, 3H), 7.40 (d, *J* = 8.3 Hz, 2H), 3.49 (d, *J* = 11.5 Hz, 2H), 2.58 – 2.49 (m, 1H), 2.13 – 2.06 (m, 1H), 1.91 – 1.79 (m, 2H), 1.68 (s, 3H), 1.36 – 1.28 (m, 2H), 1.20 – 1.09 (m, 2H), 0.97 – 0.86 (m, 1H).

^{13}C NMR (101 MHz, Chloroform-*d*) δ 172.93, 149.50, 144.02, 141.26, 139.19, 134.29, 131.87, 131.26, 129.68, 129.27, 128.93, 127.93, 126.45, 126.11, 125.74, 122.47, 119.82, 115.79, 48.33, 47.54, 46.02, 45.98, 45.82, 40.65, 32.67, 32.19, 31.60, 31.57.

HRMS: $C_{28}H_{27}ClN_3O_3S$ $[M+H]^+$; calculated: 520.1462, found: 520.1459.



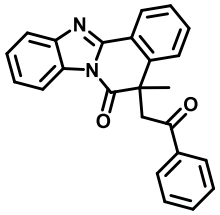
3ba

5-(((3r,5r,7r)-adamantan-1-yl)methyl)-5-methylbenzo[4,5]imidazo[2,1-a]isoquinolin-6(5H)-one

Purification by flash column chromatography (eluent: PE/EA = 30/1) gave the title compound as white solid (97.5 mg, 82% yield).

^{1}H NMR (400 MHz, Chloroform-*d*) δ 8.52 (d, *J* = 7.6 Hz, 1H), 8.42 (d, *J* = 6.8 Hz, 1H), 7.87 (d, *J* = 7.9 Hz, 1H), 7.57 – 7.42 (m, 5H), 2.53 (d, *J* = 14.5 Hz, 1H), 2.09 (d, *J* = 14.6 Hz, 1H), 1.69 (s, 3H), 1.68 – 1.63 (m, 3H), 1.46 (d, *J* = 12.1 Hz, 3H), 1.35 – 1.29 (m, 3H), 1.14 (q, *J* = 12.2 Hz, 6H).

^{13}C NMR (101 MHz, Chloroform-*d*) δ 173.40, 149.77, 144.04, 142.35, 131.48, 131.08, 127.57, 127.53, 125.90, 125.83, 125.47, 122.05, 119.68, 115.87, 56.24, 46.87, 43.48, 36.46, 34.19, 33.68, 28.43. (Known compound: Chem. Commun, 2019, 55, 2861-2864).



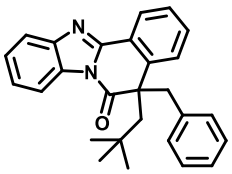
3bb

5-methyl-5-(2-oxo-2-phenylethyl)benzo[4,5]imidazo[2,1-a]isoquinolin-6(5H)-one

Purification by flash column chromatography (eluent: PE/EA = 10/1) gave the title compound as white solid (89.0 mg, 81% yield).

^{1}H NMR (400 MHz, Chloroform-*d*) δ 8.65 – 8.56 (m, 1H), 8.40 – 8.31 (m, 1H), 7.96 – 7.83 (m, 3H), 7.60 – 7.54 (m, 1H), 7.51 – 7.41 (m, 6H), 7.39 – 7.33 (m, 1H), 4.33 (d, *J* = 18.2 Hz, 1H), 4.18 (d, *J* = 18.2 Hz, 1H), 1.75 (s, 3H).

^{13}C NMR (101 MHz, Chloroform-*d*) δ 196.13, 173.32, 150.09, 143.82, 142.02, 135.68, 133.70, 131.75, 128.69, 128.10, 127.66, 126.53, 125.74, 125.46, 124.43, 119.72, 115.68, 49.37, 46.21, 30.23. (Known compound: Org. Lett, 2021, 23, 2976−2980).



3bc

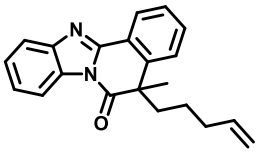
5-benzyl-5-neopentylbenzo[4,5]imidazo[2,1-a]isoquinolin-6(5H)-one

Purification by flash column chromatography (eluent: PE/EA = 20/1) gave the title compound as white solid (89.9 mg, 76% yield).

^{1}H NMR (400 MHz, Chloroform-*d*) δ 8.46 – 8.38 (m, 1H), 8.32 (dd, *J* = 7.9, 1.4 Hz, 1H), 7.76 – 7.69 (m, 2H), 7.66 – 7.60 (m, 1H), 7.51 – 7.45 (m, 1H), 7.44 – 7.37 (m, 2H), 6.86 (t, *J* = 7.3 Hz, 1H), 6.79 (t, *J* = 7.4 Hz, 2H), 6.57 – 6.50 (m, 2H), 3.63 (d, *J* = 12.7 Hz, 1H), 3.24 (d, *J* = 12.7 Hz, 1H), 2.87 (d, *J* = 14.4 Hz, 1H), 2.41 (d, *J* = 14.4 Hz, 1H), 0.64 (s, 9H).

^{13}C NMR (101 MHz, Chloroform-*d*) δ 172.36, 149.39, 143.61, 139.54, 134.24, 130.95, 130.76, 129.19, 128.17, 127.74, 127.71, 126.98, 125.79, 125.73, 125.40, 124.08, 119.51, 115.62, 54.31, 53.38, 52.48, 32.16, 31.32.

HRMS: $C_{27}H_{27}N_2O$ $[M+H]^+$; calculated: 395.2123, found: 395.2125.



3bd

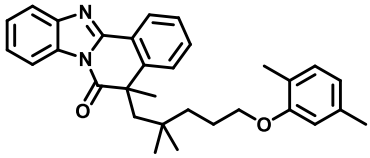
5-methyl-5-(pent-4-en-1-yl)benzo[4,5]imidazo[2,1-a]isoquinolin-6(5H)-one

Purification by flash column chromatography (eluent: PE/EA = 40/1) gave the title compound as white solid (59.8 mg, 63% yield).

^{1}H NMR (400 MHz, Chloroform-*d*) δ 8.49 (d, *J* = 7.8 Hz, 1H), 8.38 (d, *J* = 7.6 Hz, 1H), 7.83 (d, *J* = 7.1 Hz, 1H), 7.57 (t, *J* = 6.8 Hz, 1H), 7.53 – 7.39 (m, 4H), 5.66 – 5.50 (m, 1H), 4.95 – 4.79 (m, 2H), 2.41 (td, *J* = 12.9, 4.5 Hz, 1H), 2.10 – 1.85 (m, 3H), 1.73 (s, 3H), 1.14 – 1.00 (m, 1H), 0.97 – 0.85 (m, 1H).

^{13}C NMR (101 MHz, Chloroform-*d*) δ 173.27, 149.85, 144.02, 141.74, 137.61, 131.92, 131.28, 127.69, 126.03, 125.87, 125.54, 122.97, 119.76, 115.71, 115.13, 49.37, 42.43, 33.45, 28.91, 24.28.

(Known compound: J. Org. Chem. 2021, 86, 9055–9066).



3be

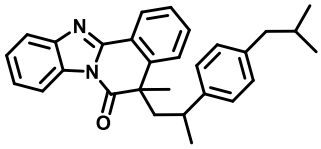
5-(5-(2,5-dimethylphenoxy)-2,2-dimethylpentyl)-5-methylbenzo[4,5]imidazo[2,1-a]isoquinolin-6(5H)-one

Purification by flash column chromatography (eluent: PE/EA = 20/1) gave the title compound as white solid (57.4 mg, 41% yield).

^{1}H NMR (400 MHz, Chloroform-*d*) δ 8.55 (d, *J* = 7.7 Hz, 1H), 8.44 (d, *J* = 7.5 Hz, 1H), 7.88 (d, *J* = 7.4 Hz, 1H), 7.56 (d, *J* = 4.0 Hz, 2H), 7.53 – 7.41 (m, 3H), 7.03 (d, *J* = 7.4 Hz, 1H), 6.69 (d, *J* = 7.5 Hz, 1H), 6.55 (s, 1H), 3.77 – 3.64 (m, 2H), 2.72 (d, *J* = 14.5 Hz, 1H), 2.35 (s, 3H), 2.24 (d, *J* = 14.7 Hz, 1H), 2.19 (s, 3H), 1.77 (s, 3H), 1.75 – 1.63 (m, 2H), 1.17 – 1.01 (m, 2H), 0.59 (s, 3H), 0.51 (s, 3H).

^{13}C NMR (101 MHz, Chloroform-*d*) δ 173.45, 156.98, 149.74, 144.10, 142.02, 136.38, 131.43, 131.21, 130.28, 127.71, 127.49, 125.97, 125.93, 125.60, 123.52, 122.44, 120.65, 119.79, 115.78, 111.97, 68.28, 53.35, 47.52, 40.41, 34.32, 33.11, 28.30, 27.52, 24.06, 21.47, 15.88.

HRMS: $C_{31}H_{35}N_2O_2$ $[M+H]^+$; calculated: 467.2699, found: 467.2693.



3bf

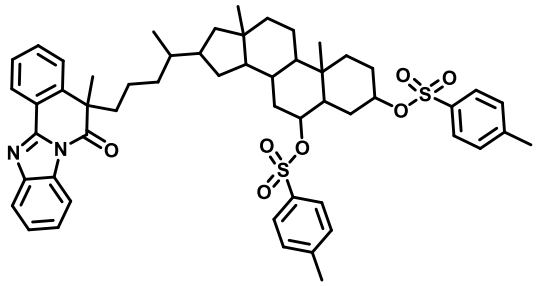
5-(2-(4-isobutylphenyl)propyl)-5-methylbenzo[4,5]imidazo[2,1-a]isoquinolin-6(5H)-one

Purification by flash column chromatography (eluent: PE/EA = 20/1) gave the title compound as white solid (43.1 mg, 34% yield).

^{1}H NMR (400 MHz, Chloroform-*d*) δ 8.45 (d, *J* = 7.0 Hz, 1H), 8.36 (d, *J* = 7.8 Hz, 1H), 7.87 (d, *J* = 7.2 Hz, 1H), 7.51 – 7.32 (m, 5H), 6.80 (d, *J* = 7.6 Hz, 2H), 6.67 (d, *J* = 7.7 Hz, 2H), 2.89 – 2.79 (m, 1H), 2.54 – 2.44 (m, 2H), 2.34 (d, *J* = 7.2 Hz, 2H), 1.82 – 1.75 (m, 1H), 1.71 (s, 3H), 1.00 (d, *J* = 6.4 Hz, 3H), 0.90 (d, *J* = 5.9 Hz, 6H).

^{13}C NMR (101 MHz, Chloroform-*d*) δ 173.45, 149.89, 144.06, 143.23, 141.30, 139.19, 131.41, 131.32, 129.09, 128.93, 127.31, 126.67, 126.61, 126.23, 125.92, 125.75, 125.52, 122.60, 119.76, 115.81, 50.22, 48.76, 44.93, 37.17, 31.27, 30.11, 22.63, 22.45.

HRMS: $C_{29}H_{31}N_2O$ [M+H] $^+$; calculated: 423.2436, found: 423.2433.



3bg

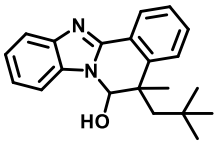
10,13-dimethyl-16-(5-(5-methyl-6-oxo-5,6-dihydrobenzo[4,5]imidazo[2,1-a]isoquinolin-5-yl)pentan-2-yl)hexadecahydro-1H-cyclopenta[a]phenanthrene-3,6-diyl bis(4-methylbenzenesulfonate)

Purification by flash column chromatography (eluent: PE/EA = 10/1) gave the title compound as white solid (148.8 mg, 54% yield).

^{1}H NMR (400 MHz, Chloroform-*d*) δ 8.49 (d, *J* = 7.4 Hz, 1H), 8.39 (d, *J* = 9.1 Hz, 1H), 7.88 – 7.70 (m, 5H), 7.60 (t, *J* = 7.6 Hz, 1H), 7.54 – 7.42 (m, 4H), 7.41 – 7.31 (m, 4H), 4.85 – 4.71 (m, 1H), 4.38 – 4.22 (m, 1H), 2.47 (d, *J* = 3.2 Hz, 6H), 1.73 (s, 3H), 1.70 – 1.55 (m, 4H), 1.54 – 1.29 (m, 7H), 1.31 – 1.19 (m, 10H), 1.16 – 1.01 (m, 4H), 1.02 – 0.79 (m, 9H), 0.77 (s, 3H), 0.68 – 0.46 (m, 4H).

^{13}C NMR (101 MHz, Chloroform-*d*) δ 173.45, 149.98, 144.69, 144.04, 141.90, 134.49, 131.91, 131.33, 130.30, 129.84, 129.81, 129.07, 127.66, 127.60, 127.53, 126.68, 126.03, 125.89, 125.54, 123.06, 122.94, 119.73, 115.74, 81.81, 56.05, 55.89, 55.66, 49.52, 46.30, 43.33, 43.13, 42.70, 39.47, 39.39, 36.11, 35.68, 35.59, 35.26, 35.18, 34.78, 32.07, 29.72, 29.12, 27.95, 27.33, 26.44, 23.84, 22.85, 21.70, 21.68, 20.46, 18.26, 18.21, 11.89.

HRMS: $C_{54}H_{65}N_2O_7S_2$ [M+H] $^+$; calculated: 917.4233, found: 917.4243.



3bh

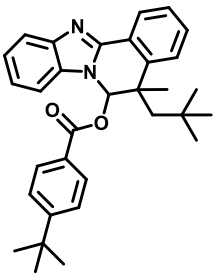
5-methyl-5-neopentyl-5,6-dihydrobenzo[4,5]imidazo[2,1-a]isoquinolin-6-ol

Purification by flash column chromatography (eluent: PE/EA = 10/1) gave the title compound as white solid (310.8mg, 97% yield).

^{1}H NMR (400 MHz, Chloroform-*d*) δ 8.10 (dd, *J* = 7.7, 1.4 Hz, 1H), 7.71 – 7.66 (m, 1H), 7.52 (dd, *J* = 7.9, 1.2 Hz, 1H), 7.43 – 7.38 (m, 2H), 7.28 – 7.20 (m, 3H), 5.69 (s, 1H), 1.85 (s, 3H), 1.41 (s, 2H), 0.69 (s, 9H).

^{13}C NMR (101 MHz, Chloroform-*d*) δ 147.42, 143.66, 139.83, 133.79, 130.55, 127.73, 127.59, 125.88, 125.00, 123.10, 122.93, 119.65, 109.17, 81.63, 52.13, 45.01, 32.50, 31.31, 21.86.

HRMS: $C_{21}H_{25}N_2O$ [M+H] $^+$; calculated: 321.1982, found: 321.1983.



3bi

5-methyl-5-neopentyl-5,6-dihydrobenzo[4,5]imidazo[2,1-a]isoquinolin-6-yl 4-(tert-butyl)benzoate

Purification by flash column chromatography (eluent: PE/EA = 10/1) gave the title compound as white solid (433.6mg, 93% yield).

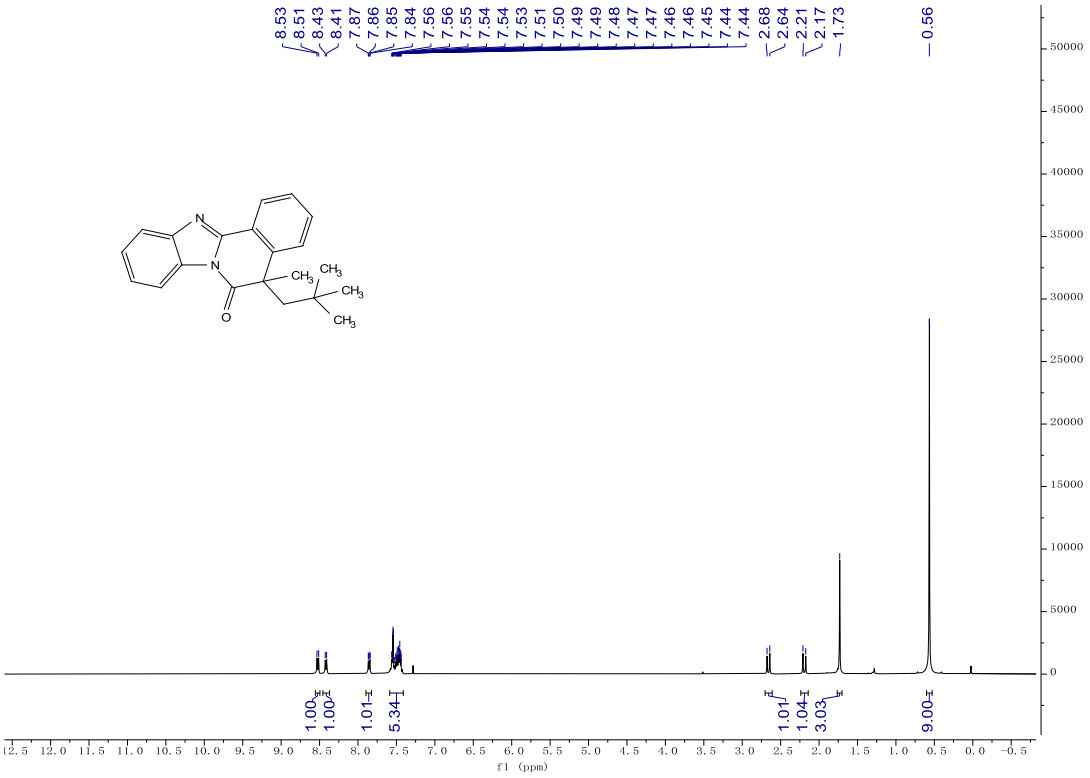
^{1}H NMR (400 MHz, Chloroform-*d*) δ 8.41 (d, *J* = 7.2 Hz, 1H), 7.89 – 7.81 (m, 1H), 7.79 – 7.74 (m, 1H), 7.71 (d, *J* = 8.6 Hz, 2H), 7.58 – 7.49 (m, 3H), 7.44 (s, 1H), 7.37 – 7.31 (m, 4H), 1.80 (s, 3H), 1.63 – 1.53 (m, 2H), 1.26 (s, 9H), 0.84 (s, 9H).

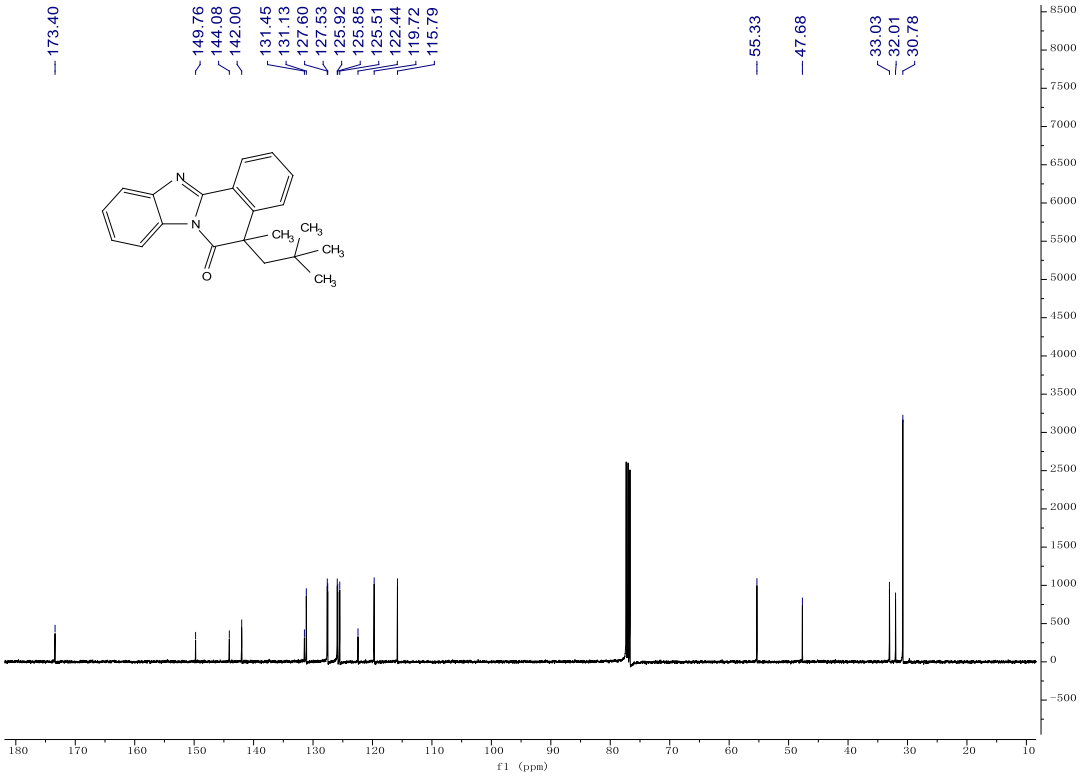
^{13}C NMR (101 MHz, Chloroform-*d*) δ 165.72, 157.51, 148.24, 141.11, 133.70, 130.80, 129.79, 127.66, 126.28, 126.04, 125.81, 125.44, 123.62, 123.34, 119.64, 110.57, 52.70, 43.90, 35.10, 32.75, 31.49, 30.98, 21.15.

HRMS: $C_{32}H_{37}N_2O_2$ $[M+H]^+$; calculated: 481.2855, found: 481.2854.

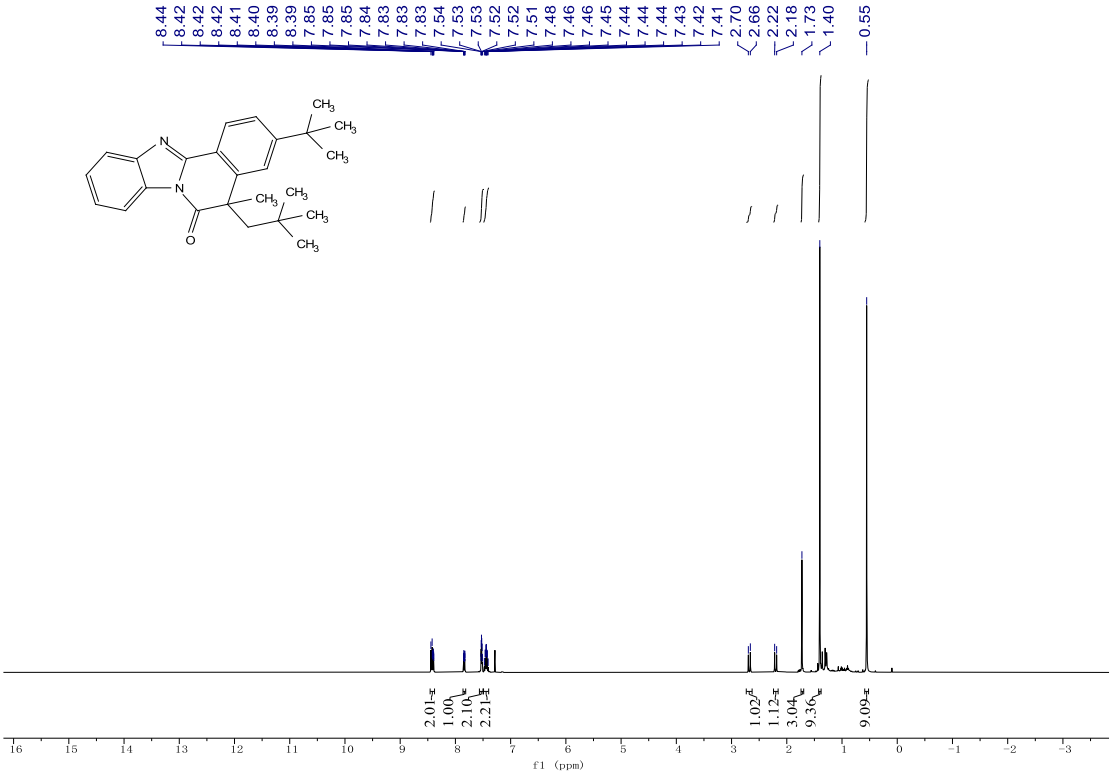
XII. Copied of NMR spectra

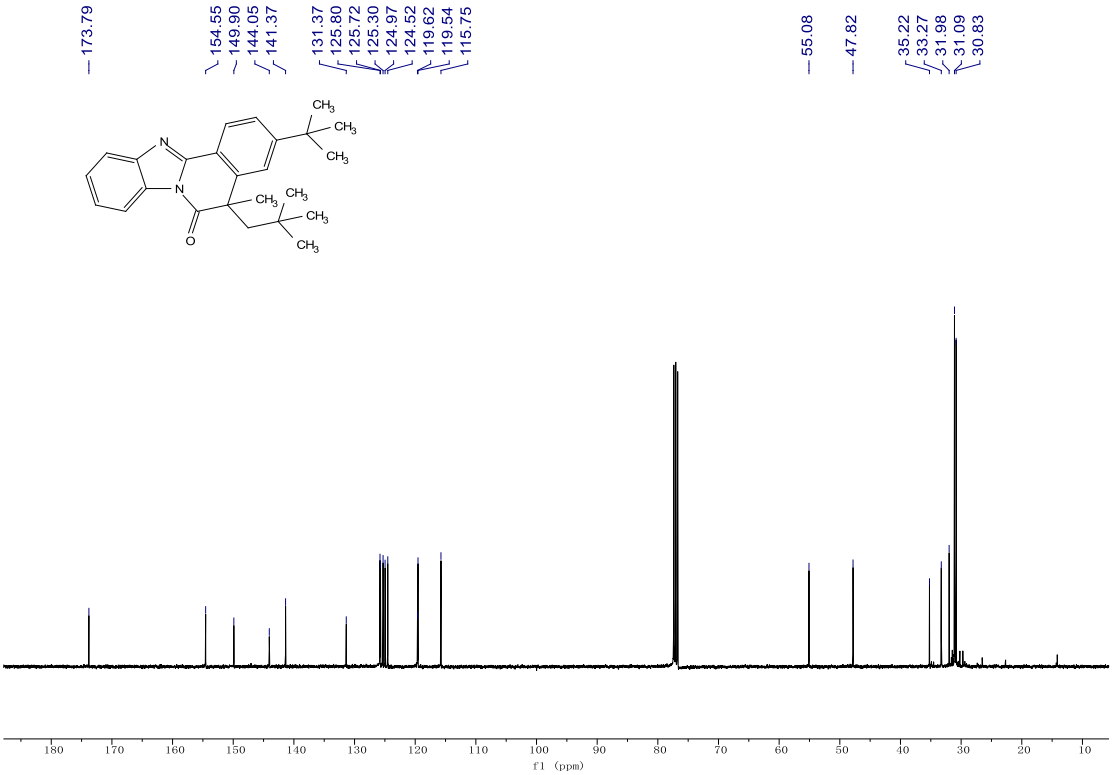
^{1}H and ^{13}C NMR spectra of 3aa



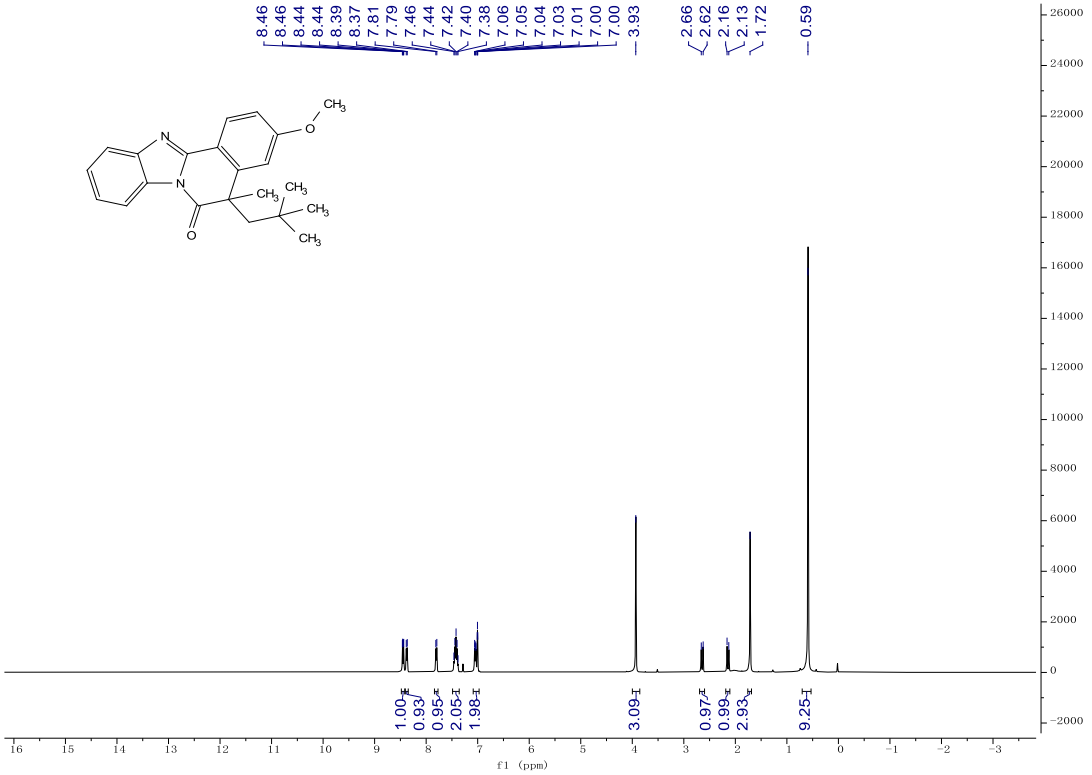


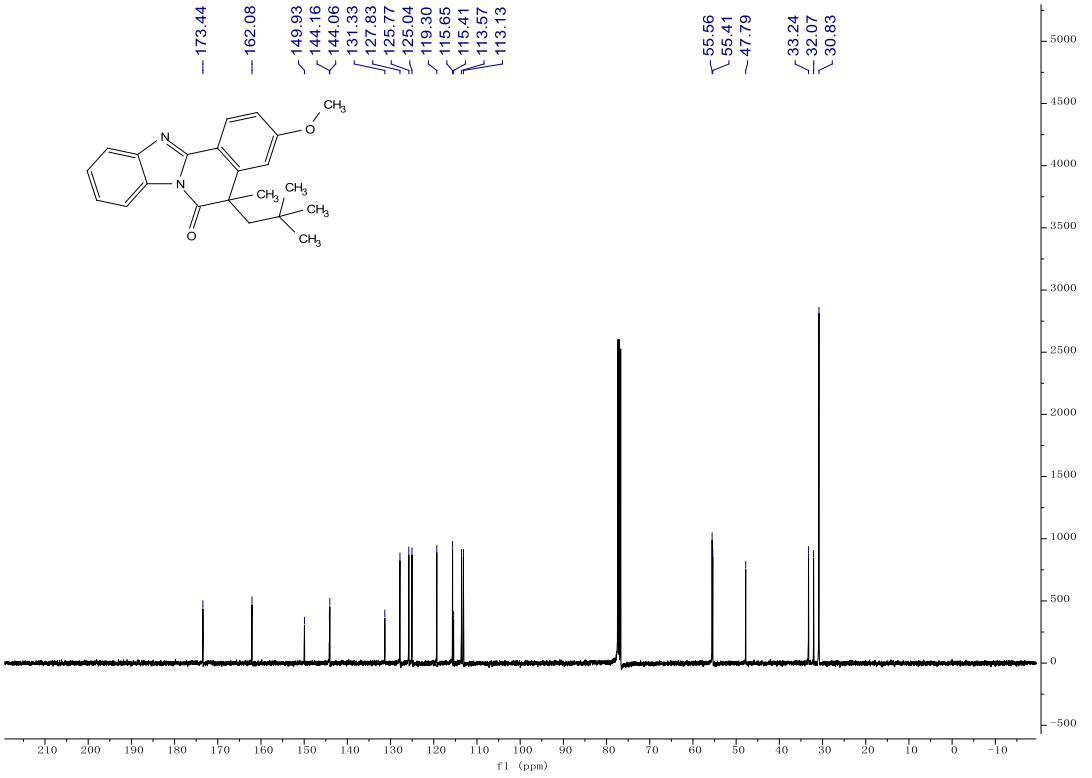
^{1}H and ^{13}C NMR spectra of 3ab



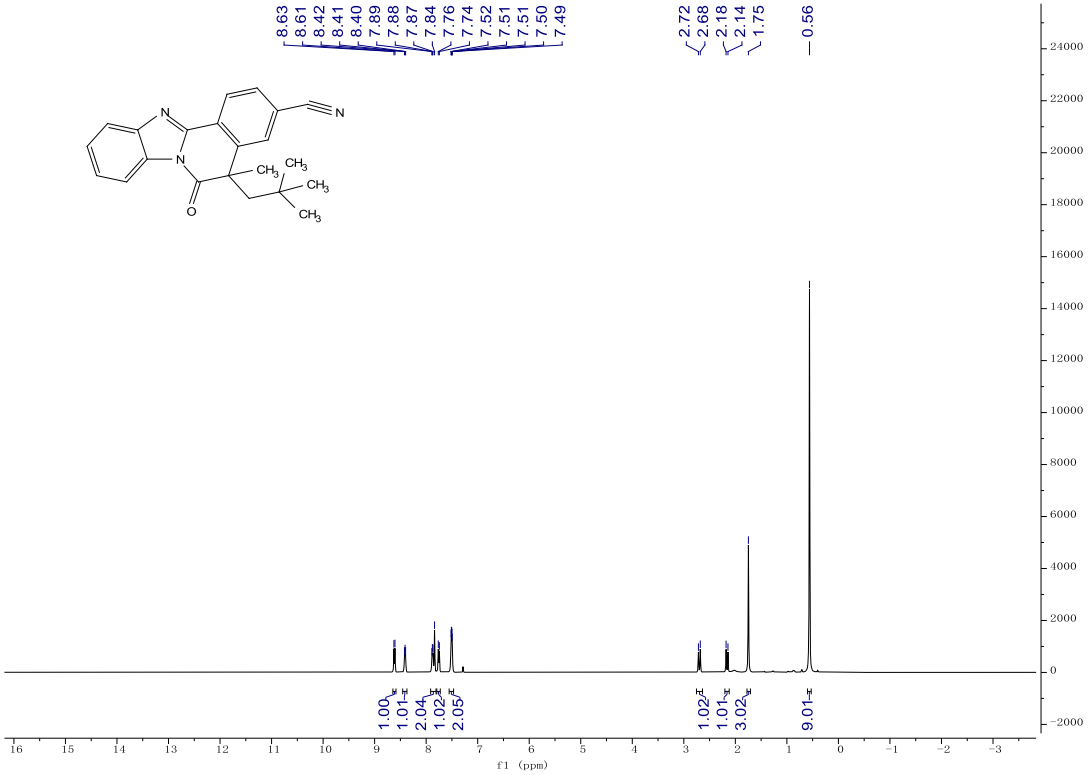


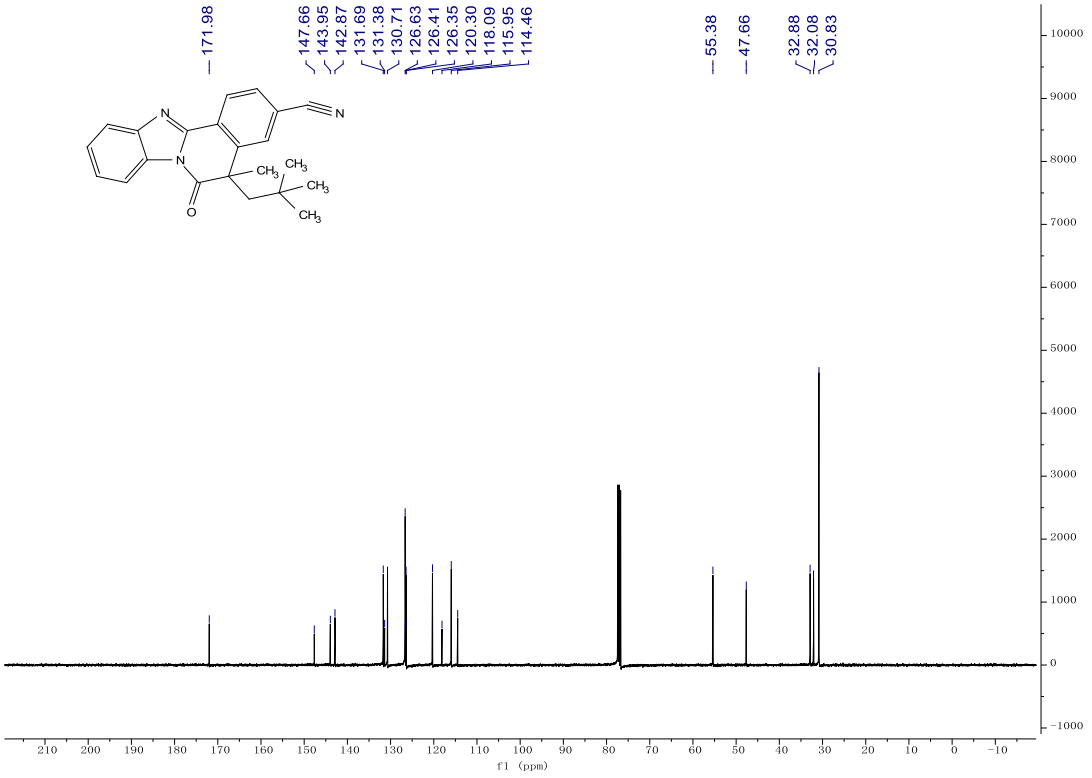
^{1}H and ^{13}C NMR spectra of 3ac



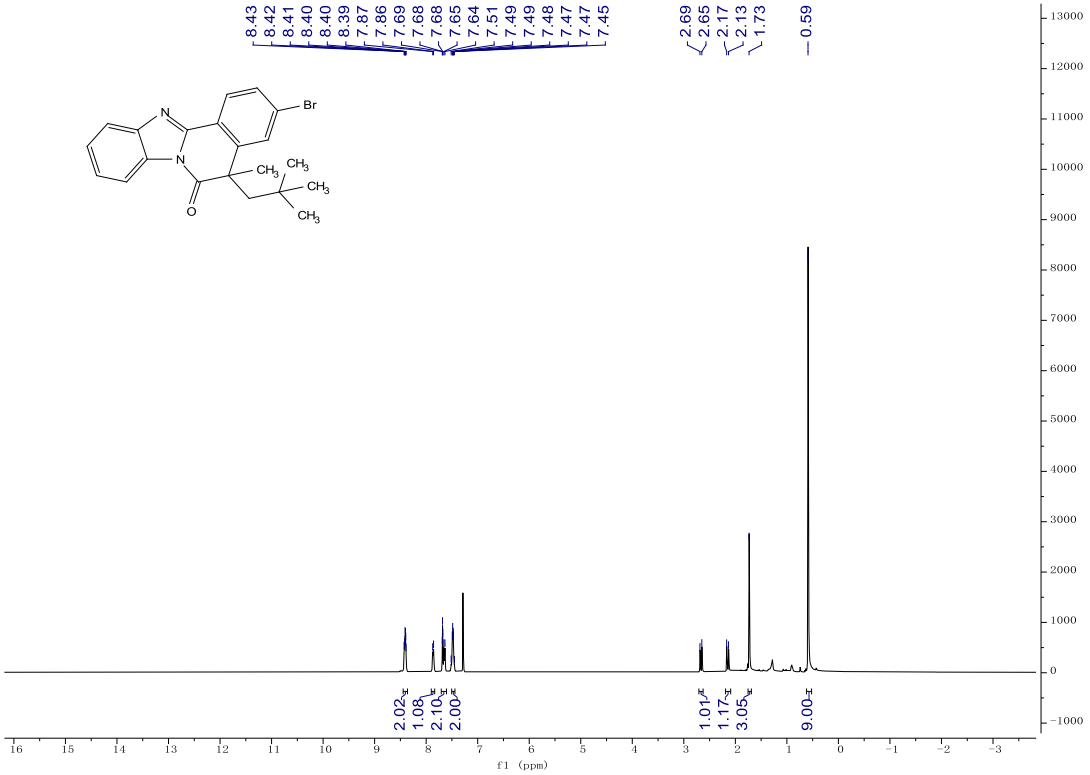


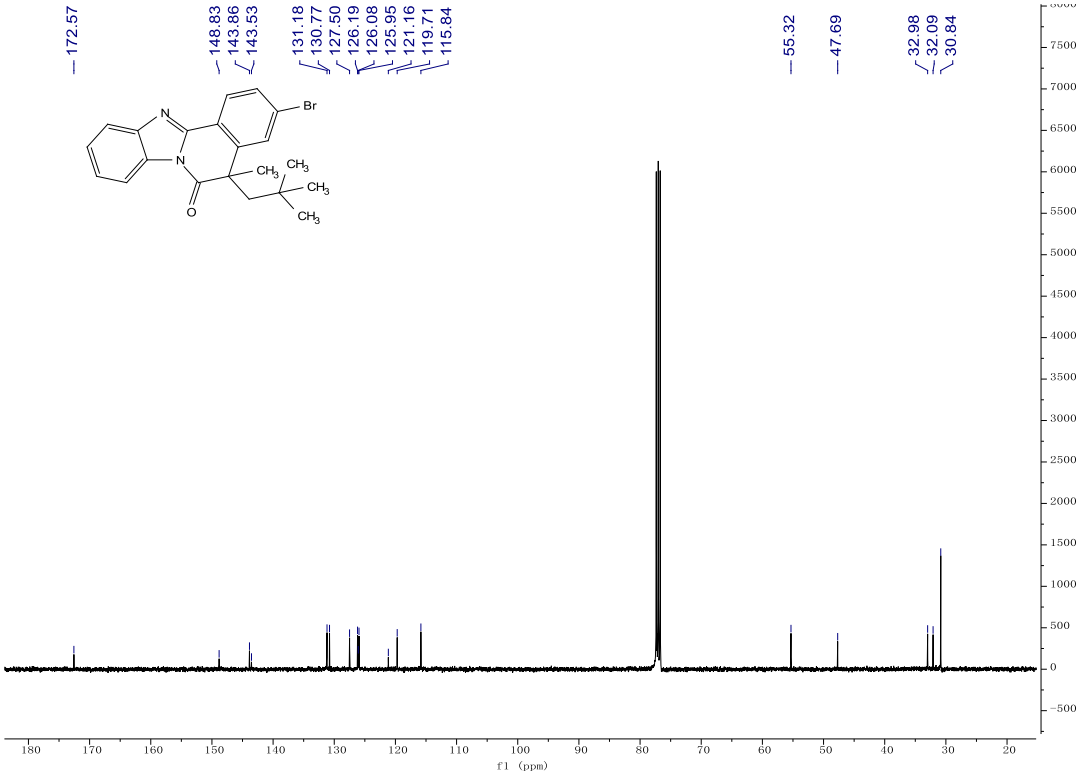
^{1}H and ^{13}C NMR spectra of 3ad



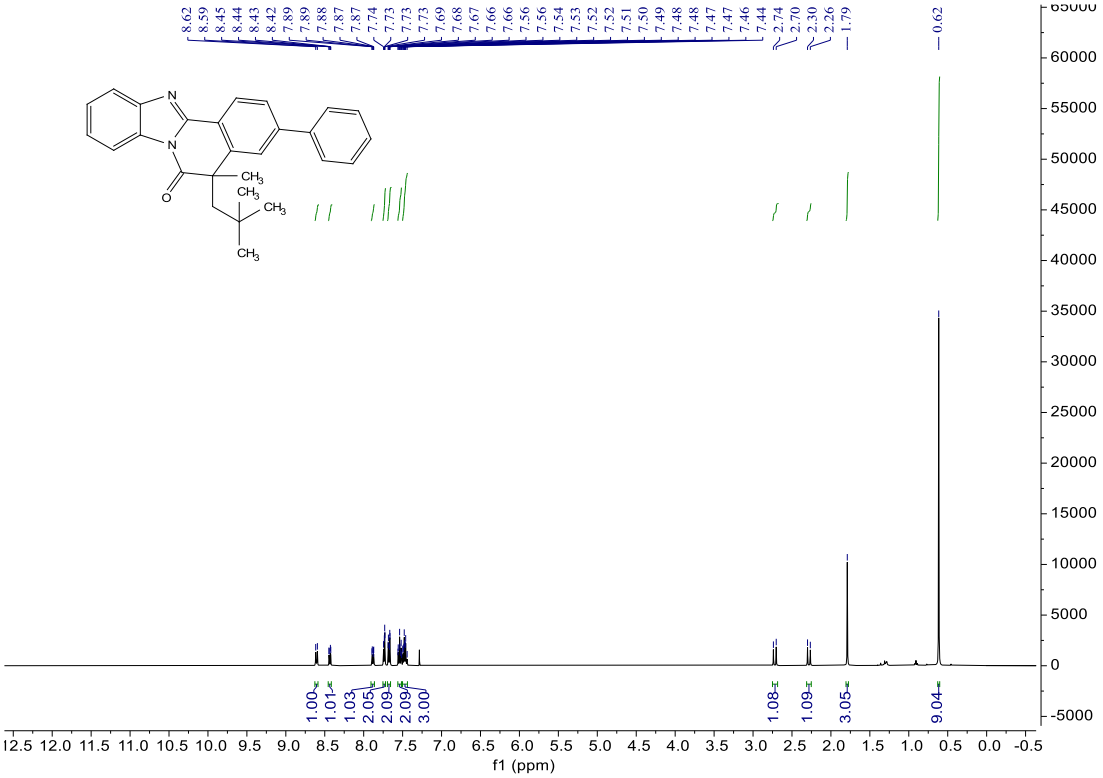


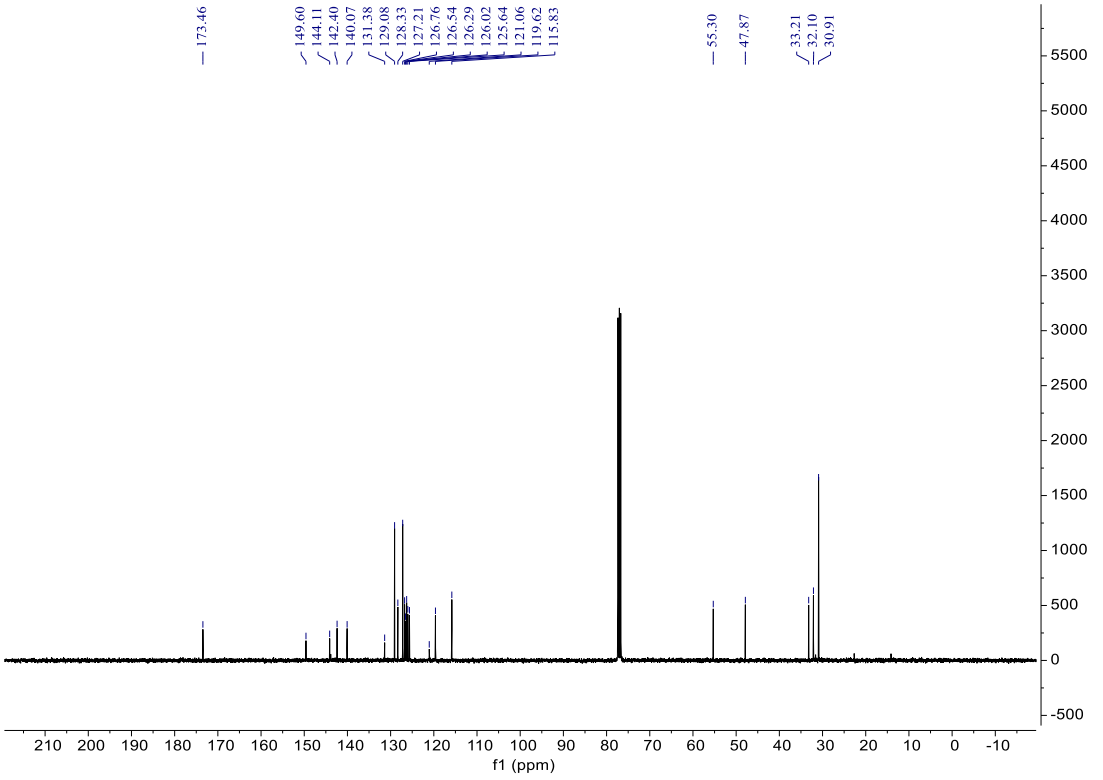
^{1}H and ^{13}C NMR spectra of 3ae



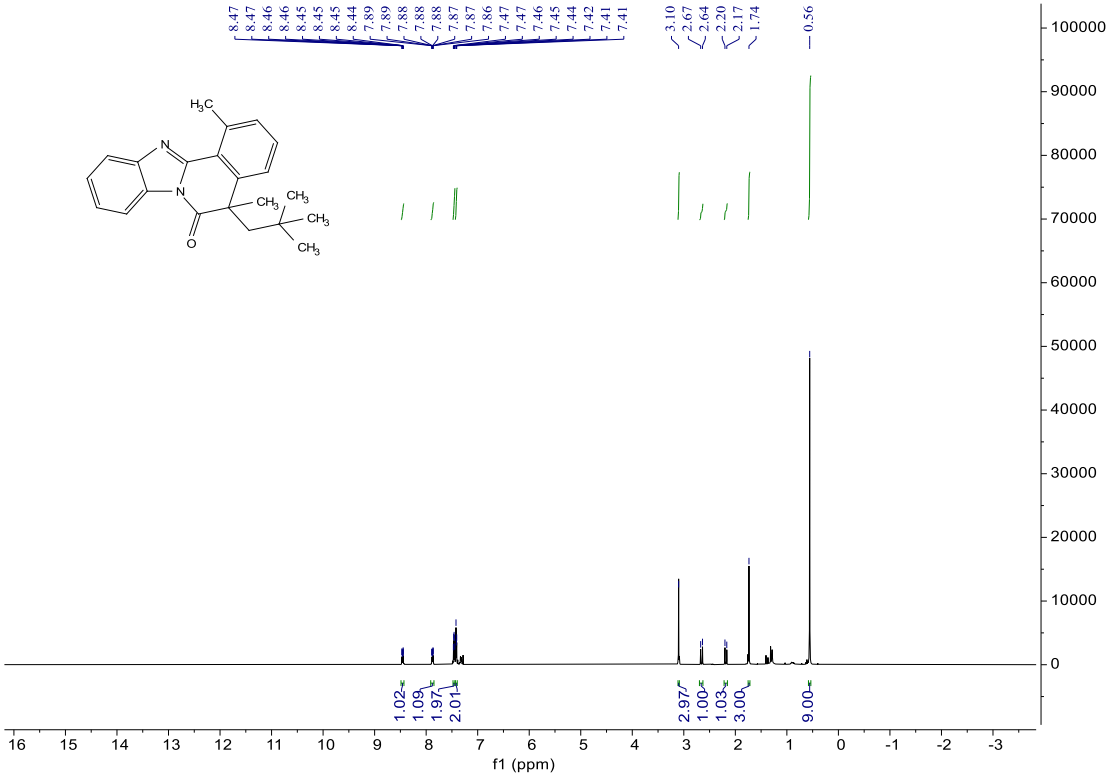


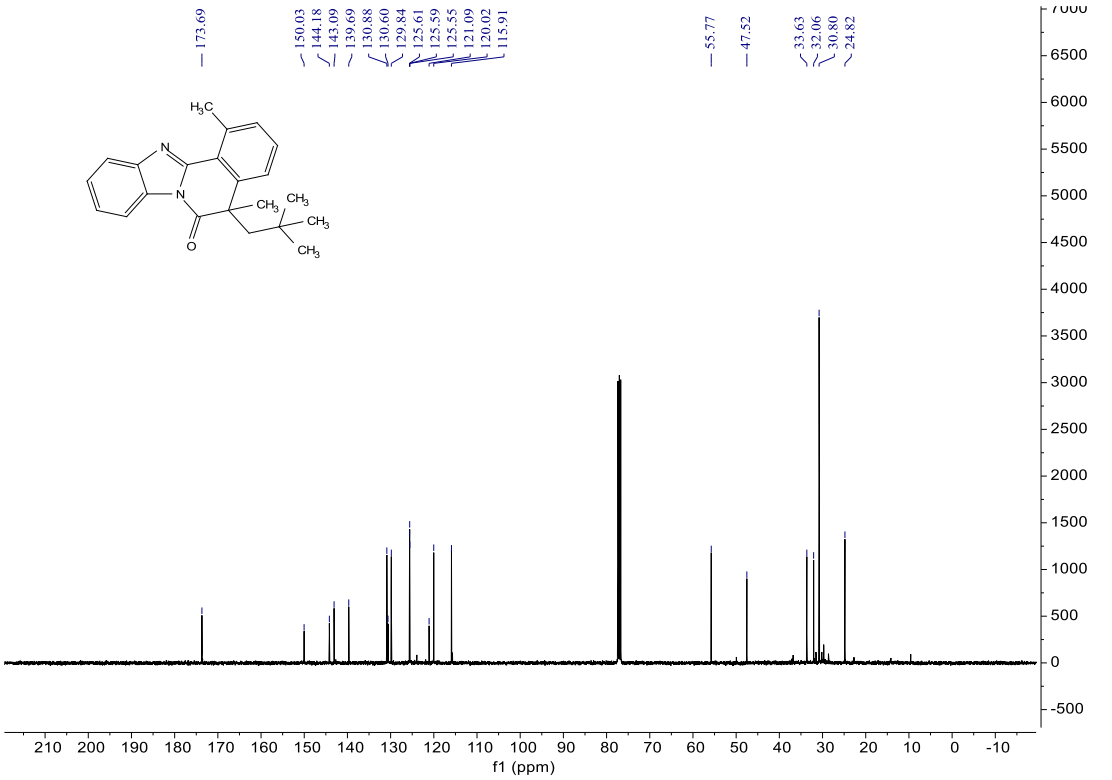
^{1}H and ^{13}C NMR spectra of 3af



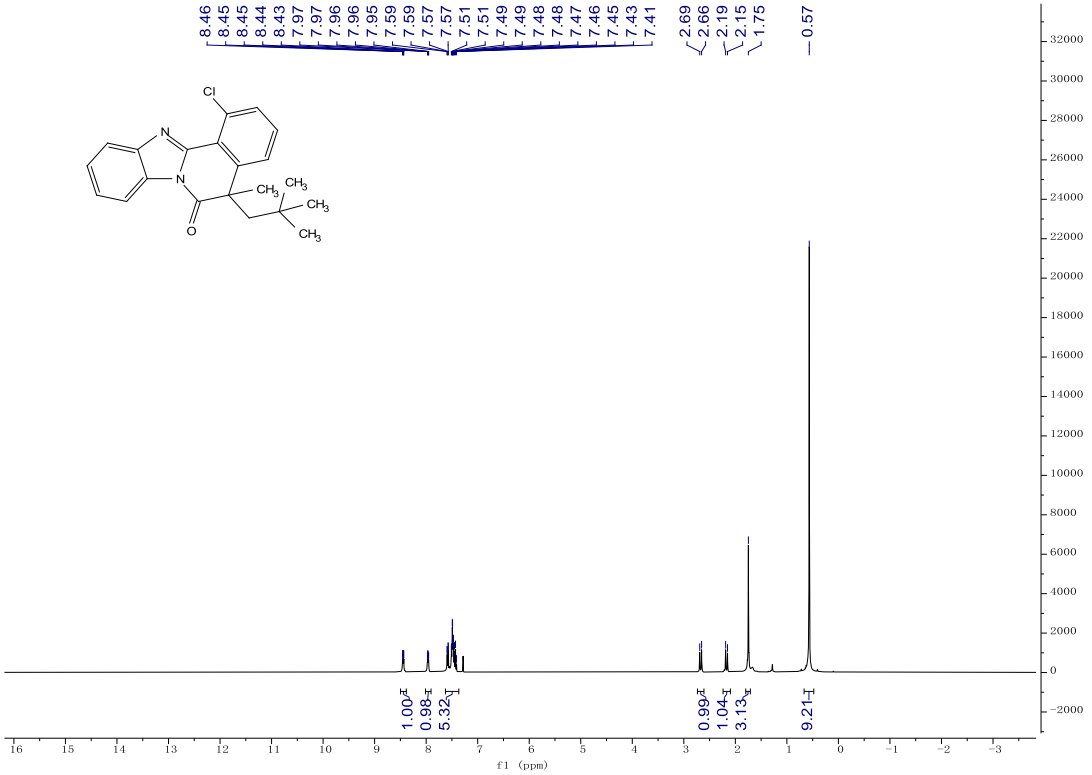


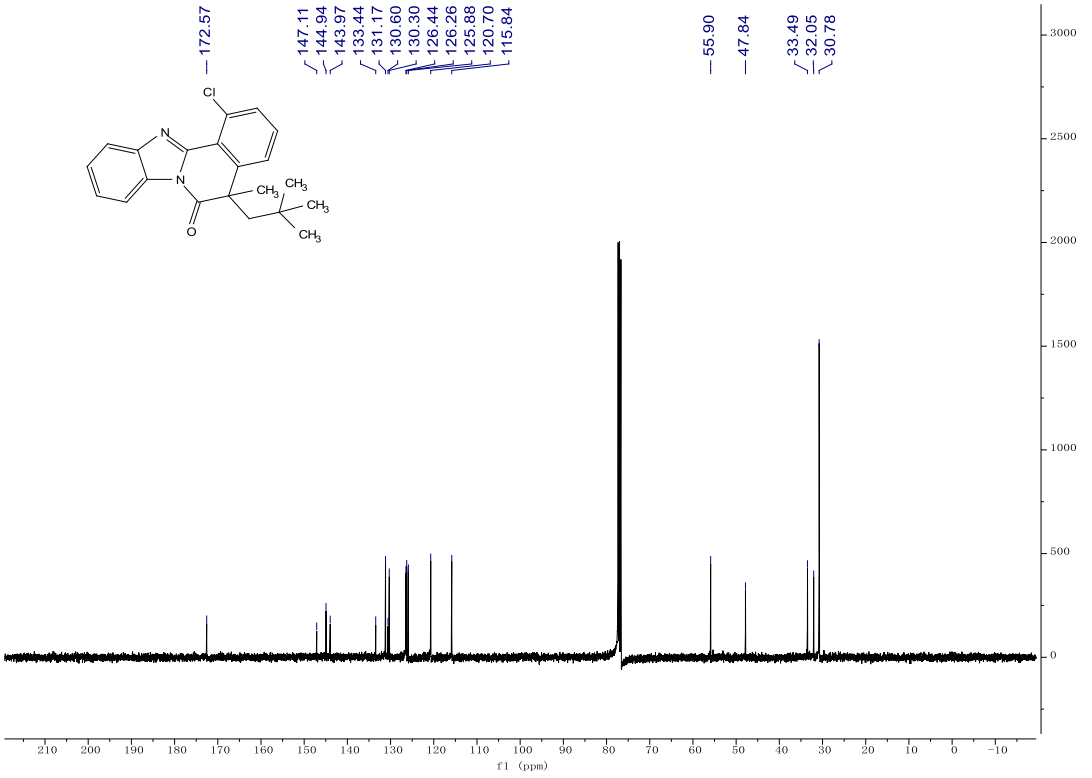
^{1}H and ^{13}C NMR spectra of 3ag



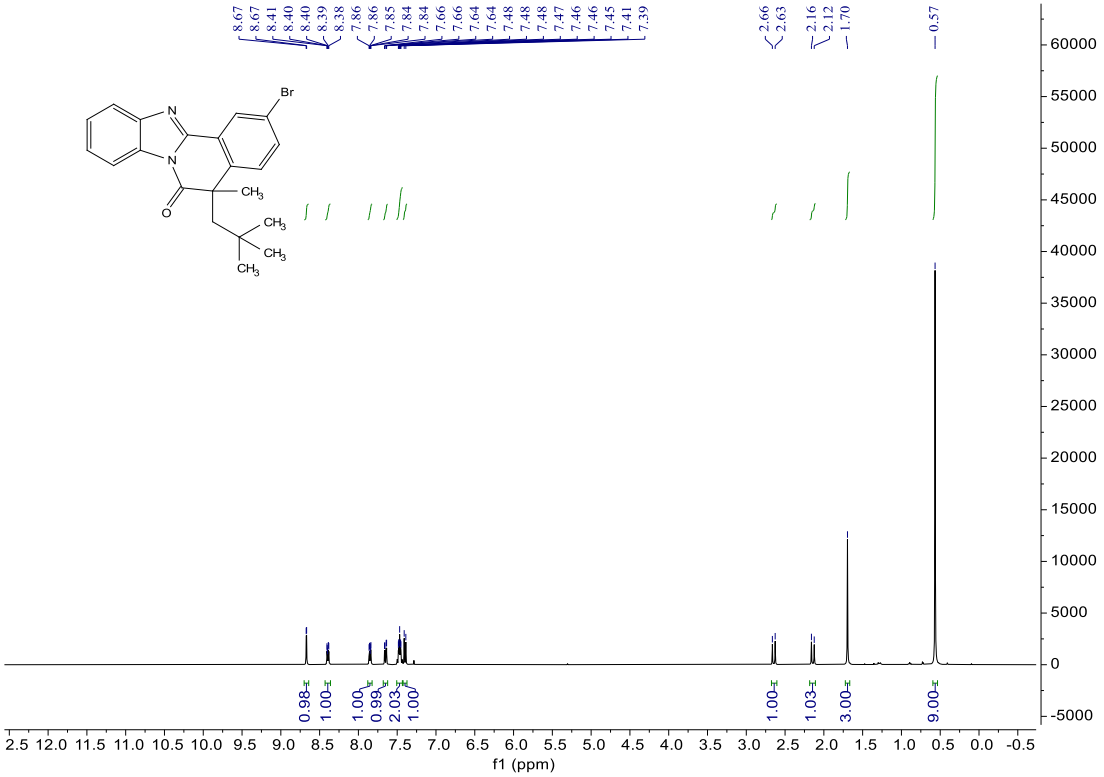


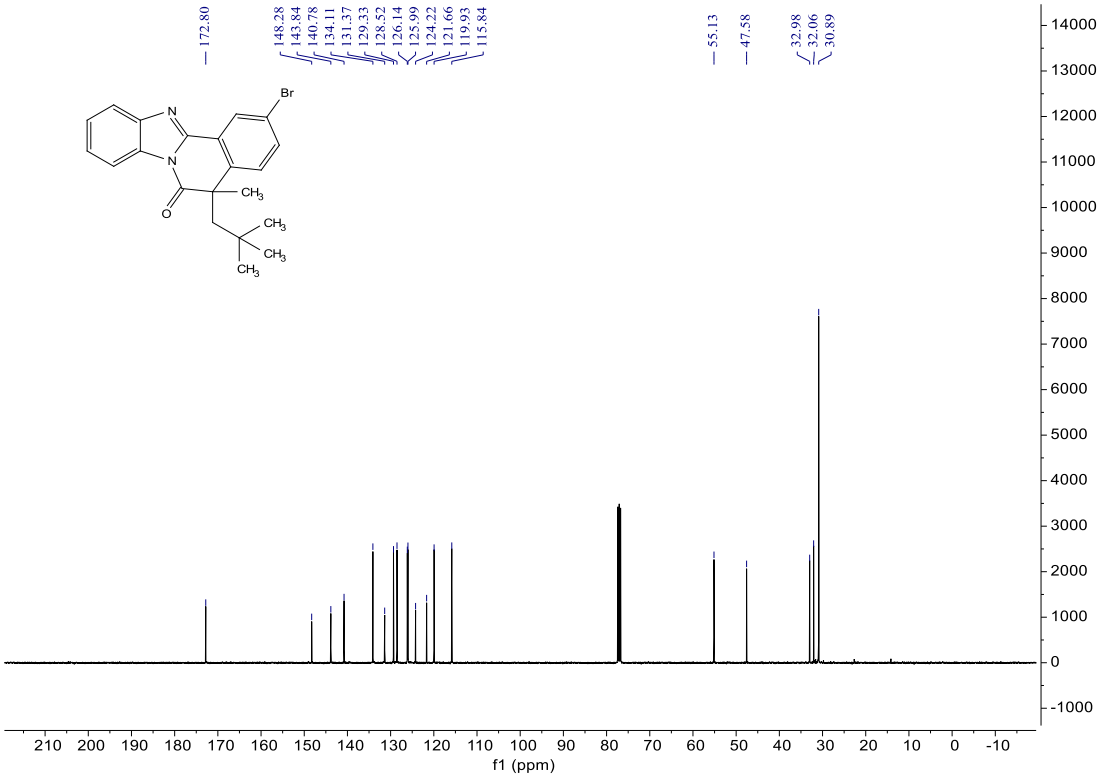
^{1}H and ^{13}C NMR spectra of 3ah



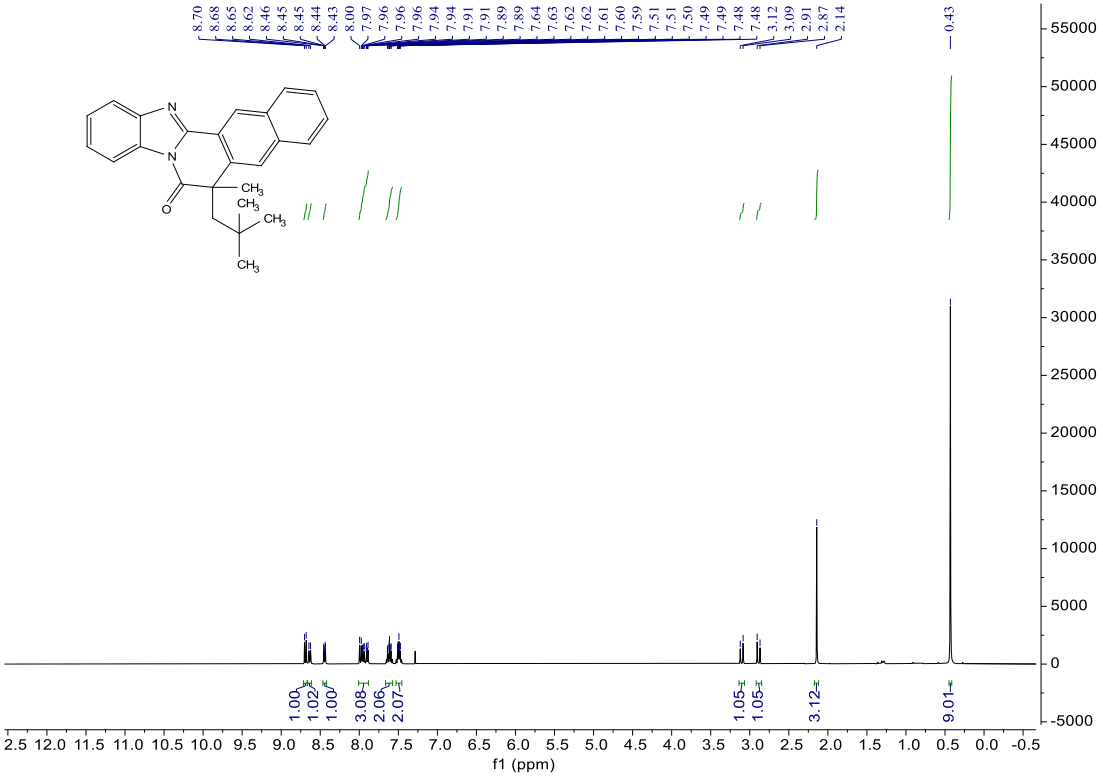


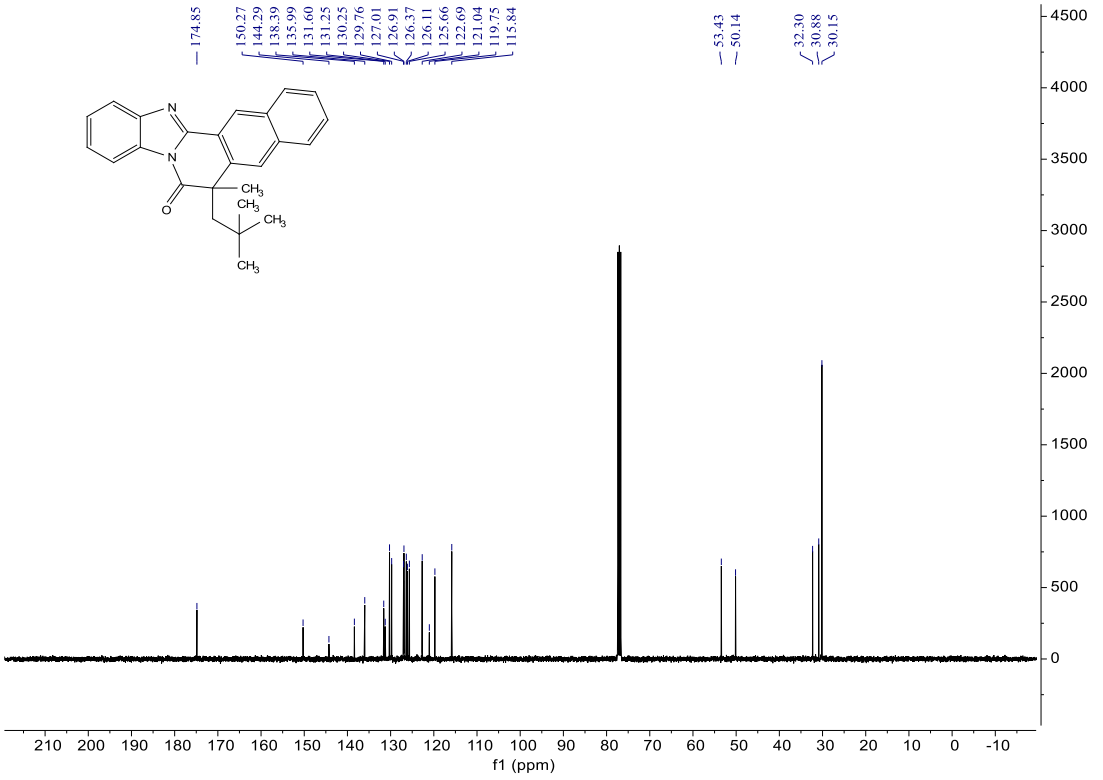
^{1}H and ^{13}C NMR spectra of 3ai



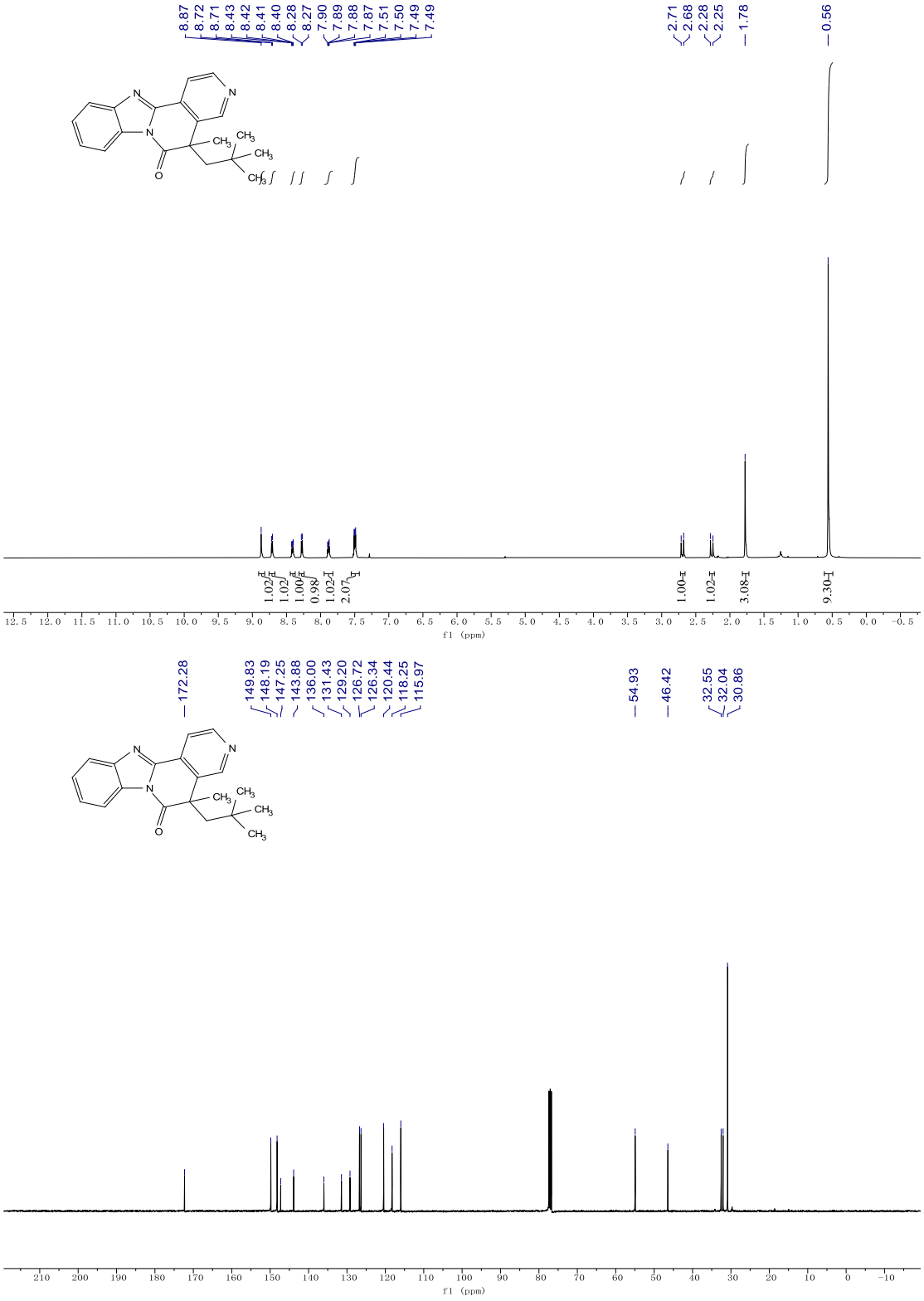


^{1}H and ^{13}C NMR spectra of 3aj

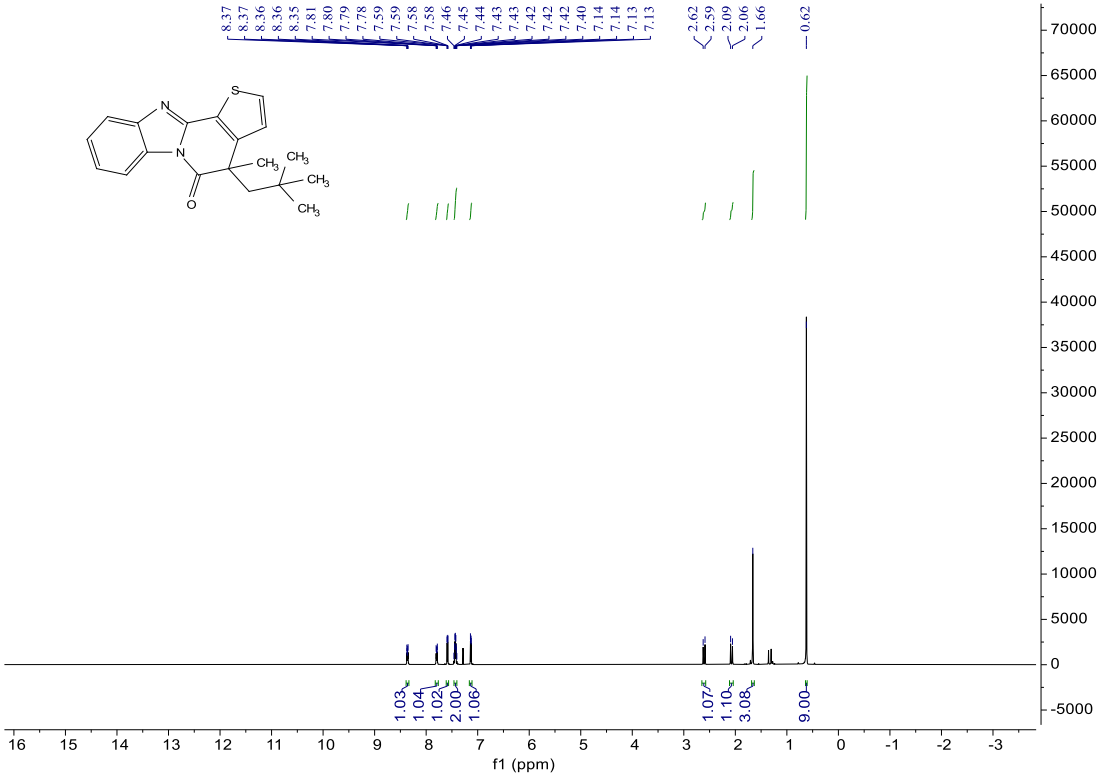


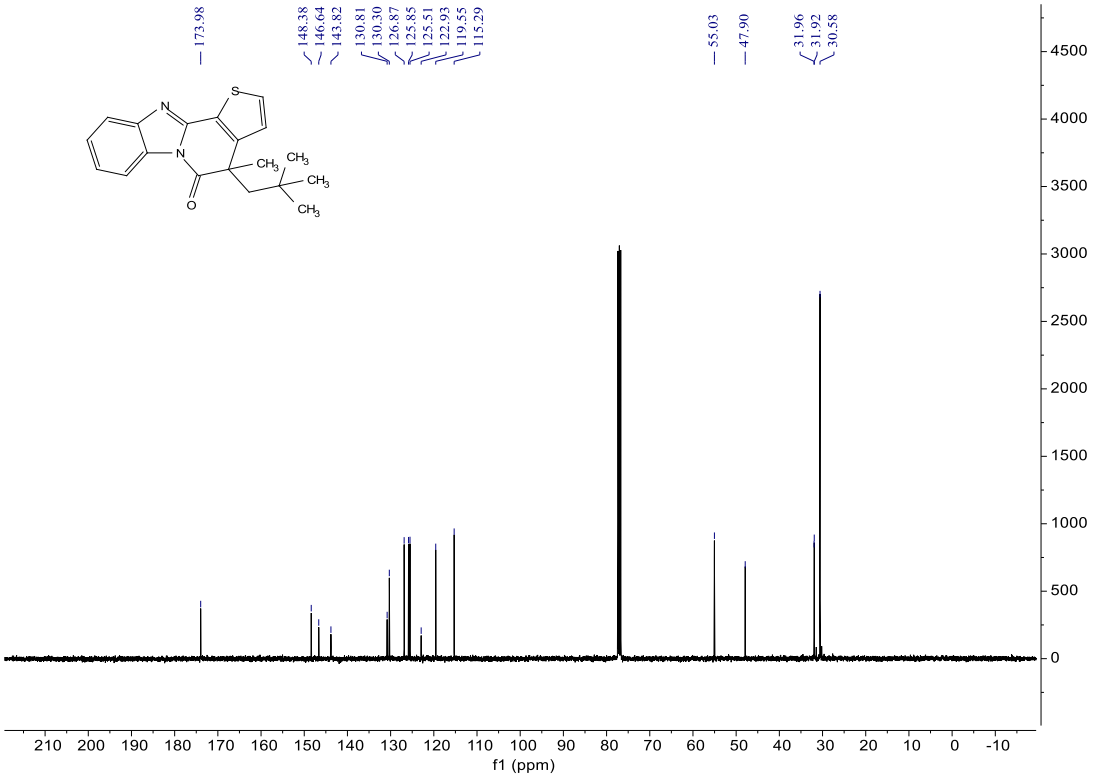


^{1}H and ^{13}C NMR spectra of 3ak

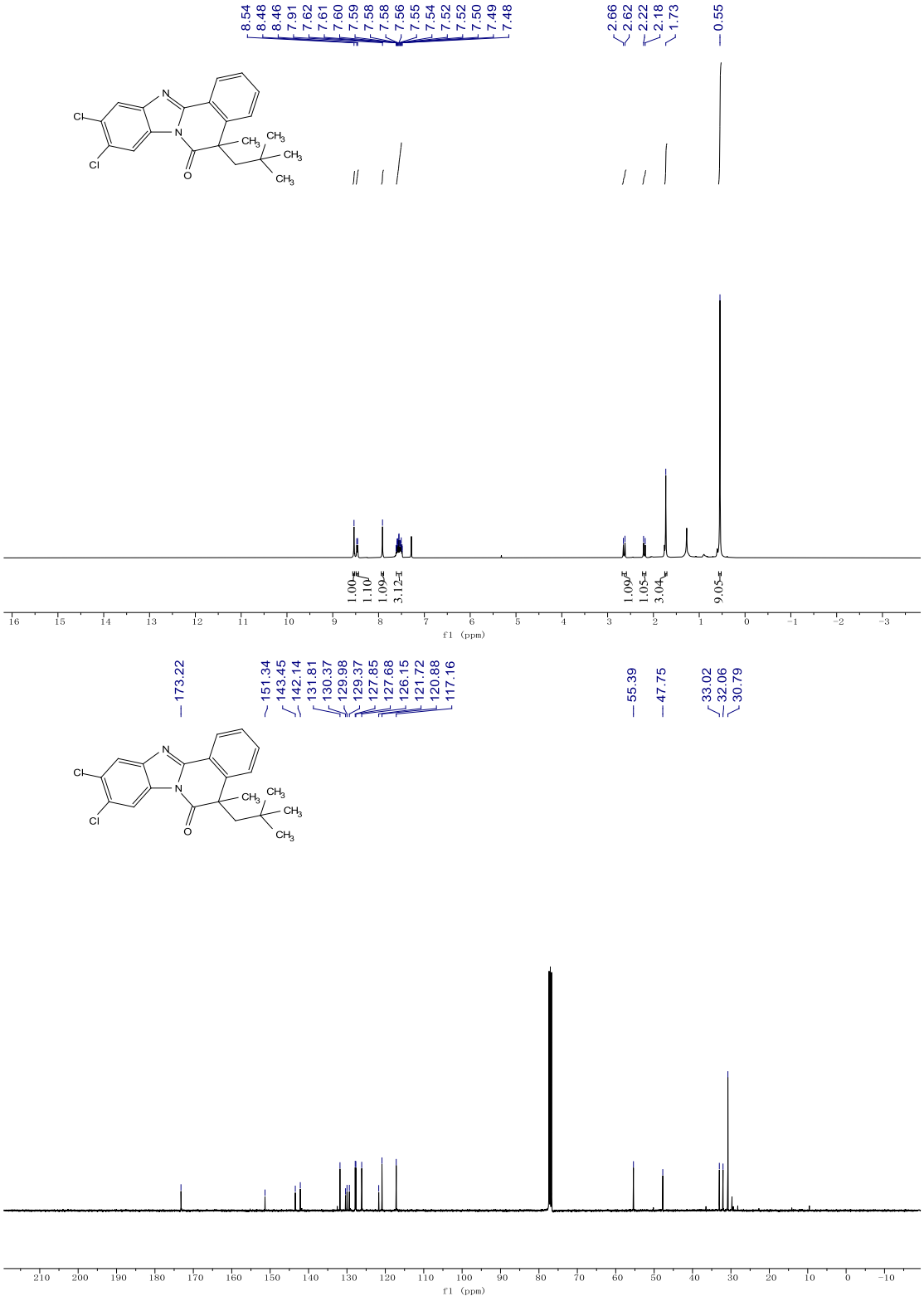


^{1}H and ^{13}C NMR spectra of 3al

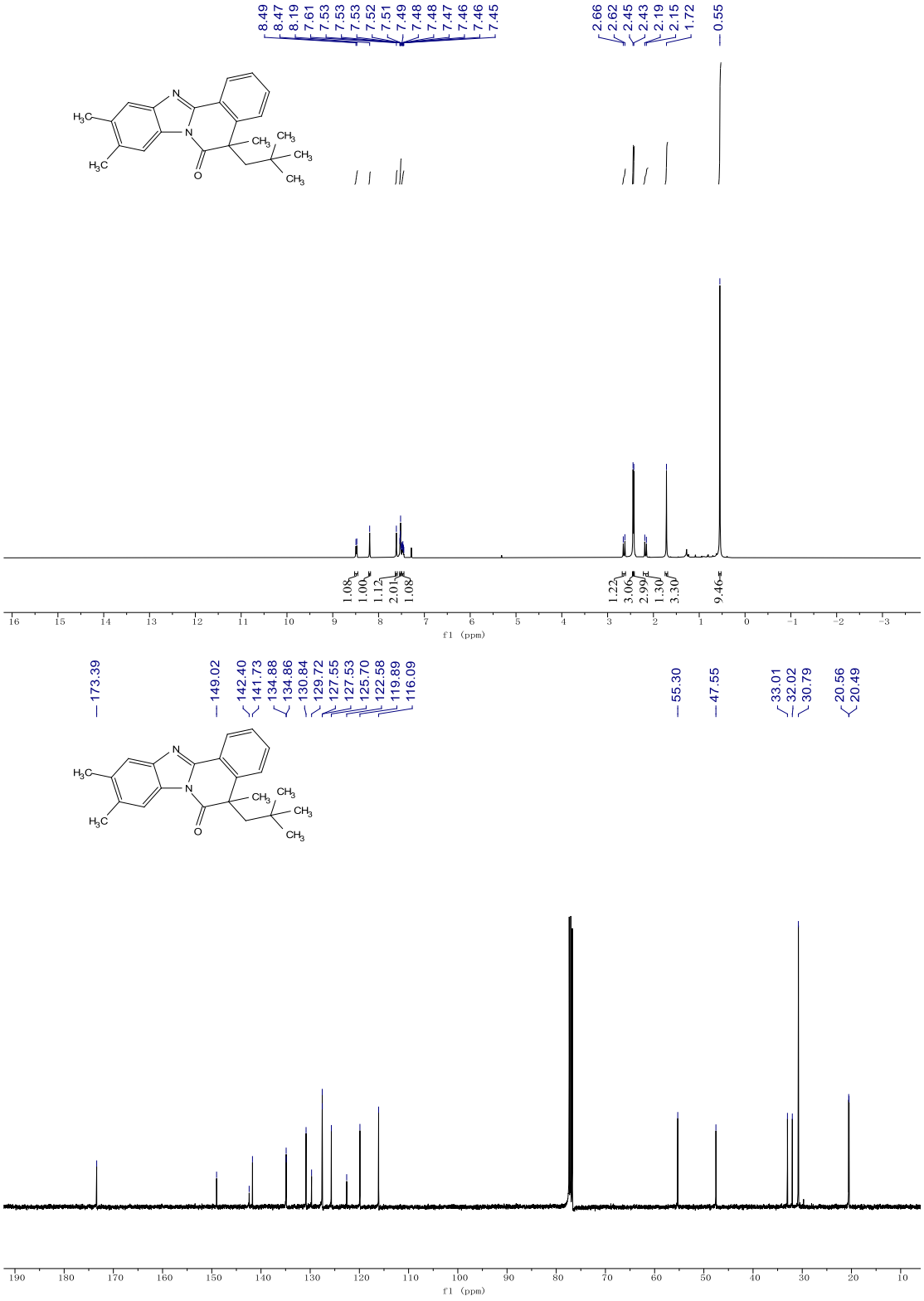




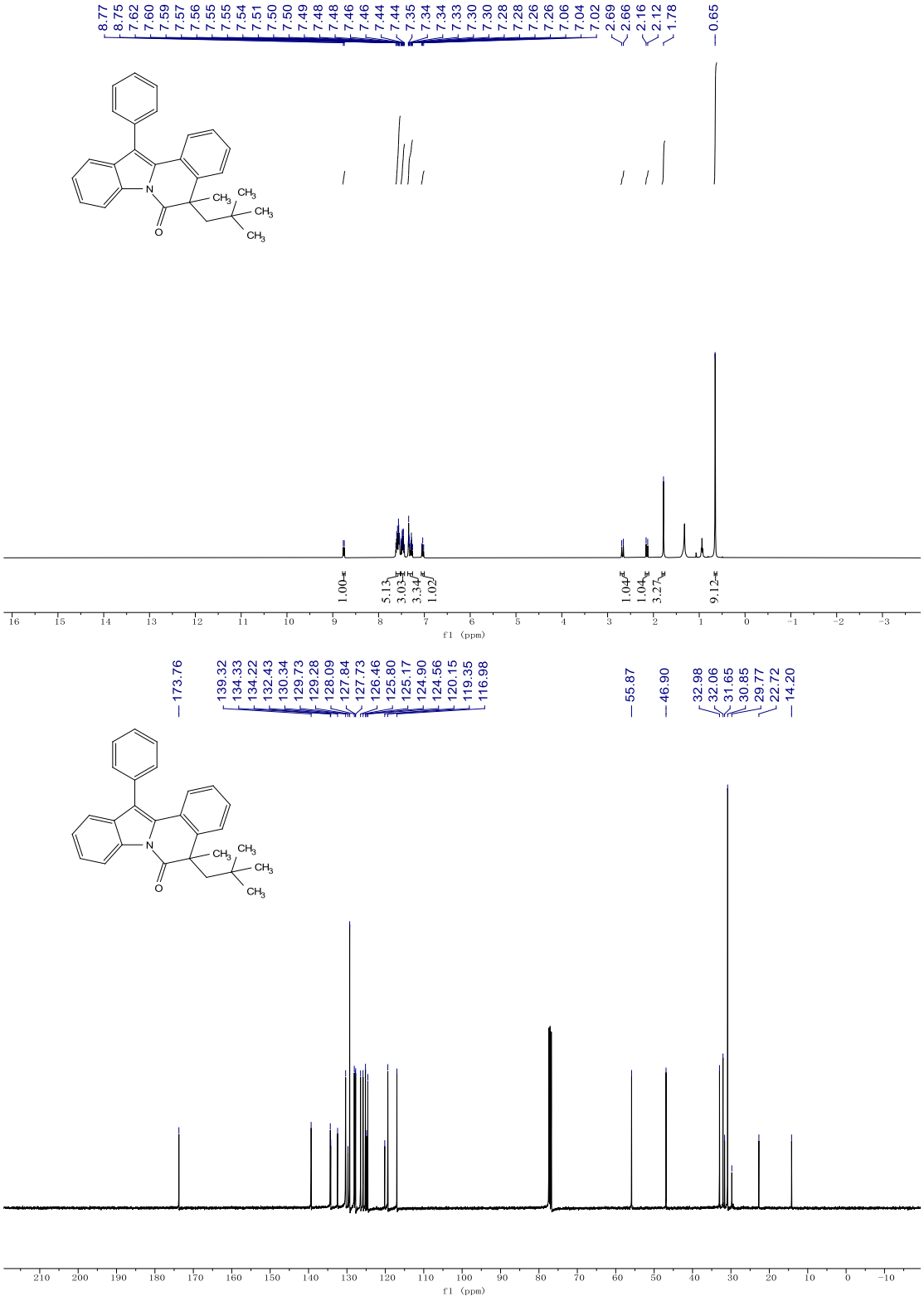
^{1}H and ^{13}C NMR spectra of 3am



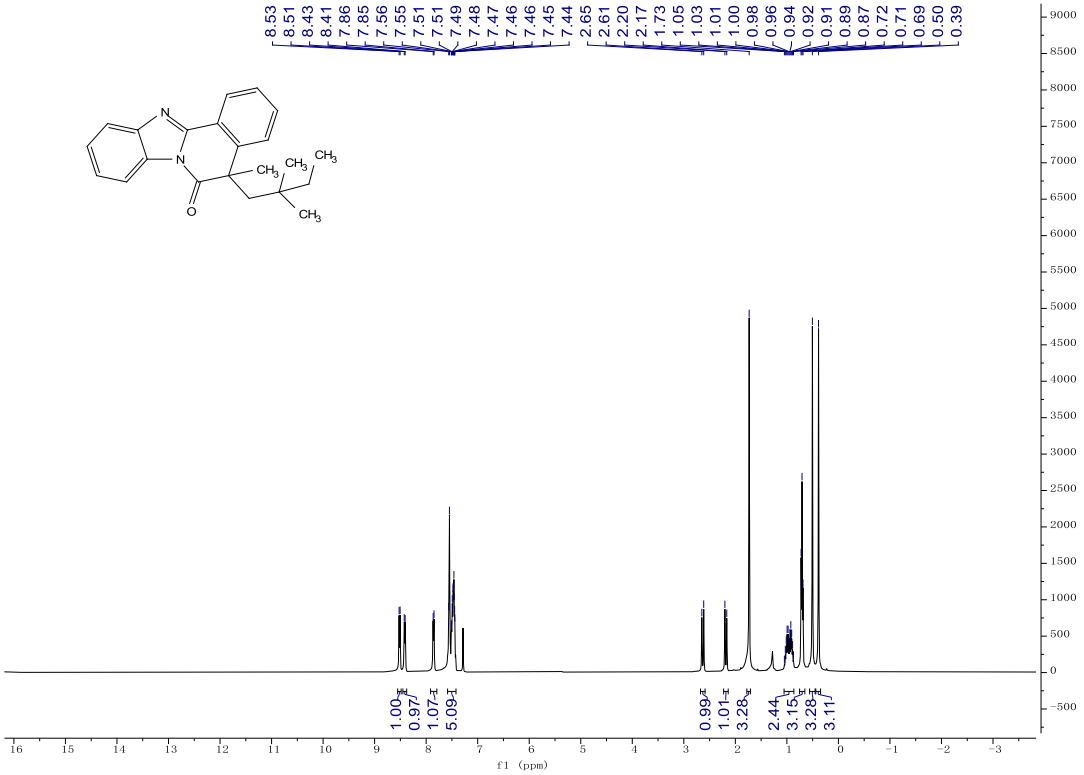
^{1}H and ^{13}C NMR spectra of 3an

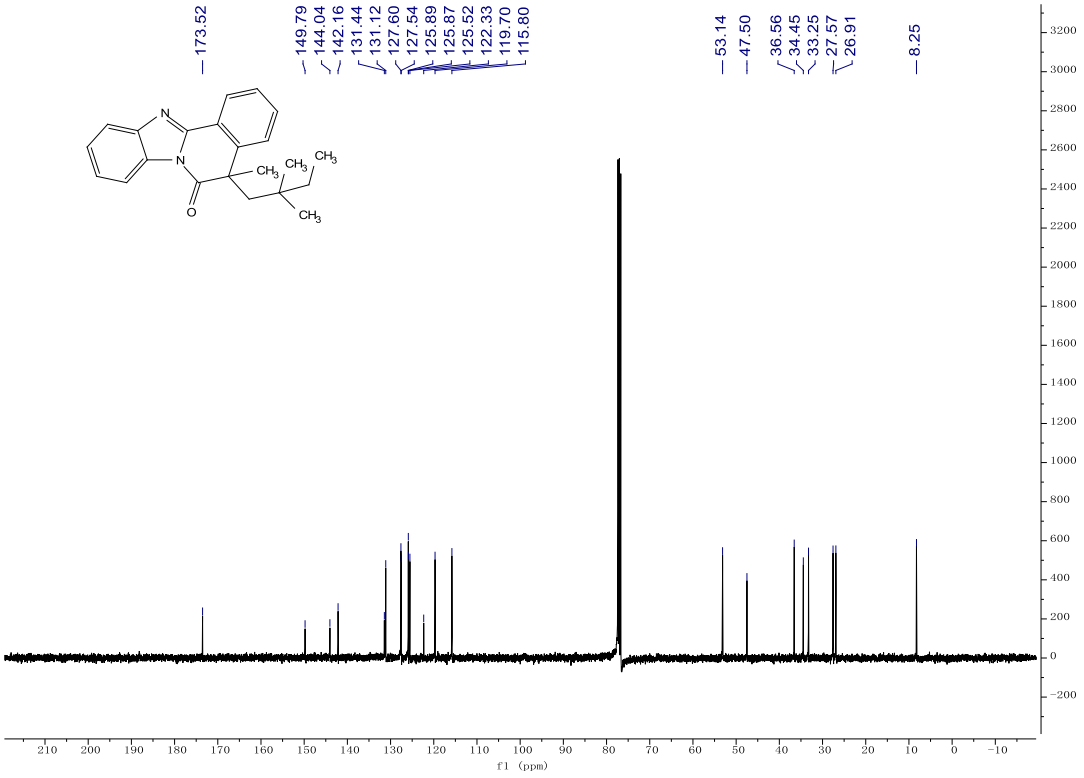


^{1}H and ^{13}C NMR spectra of 3ao

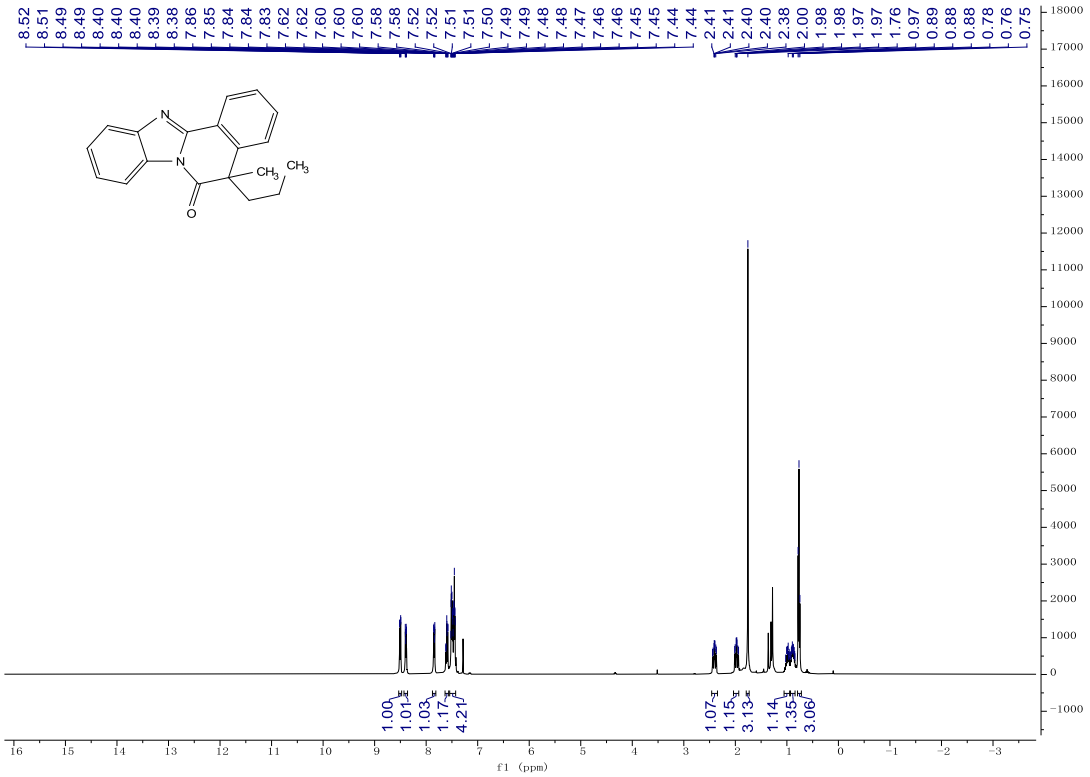


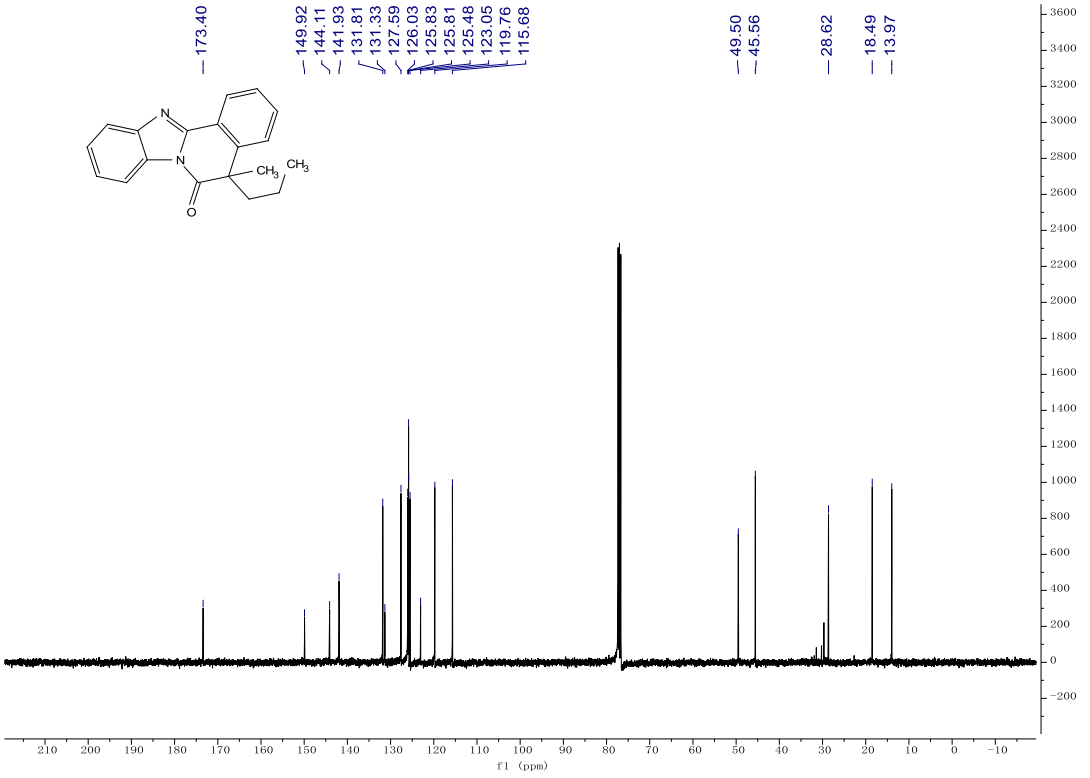
^{1}H and ^{13}C NMR spectra of 3ap



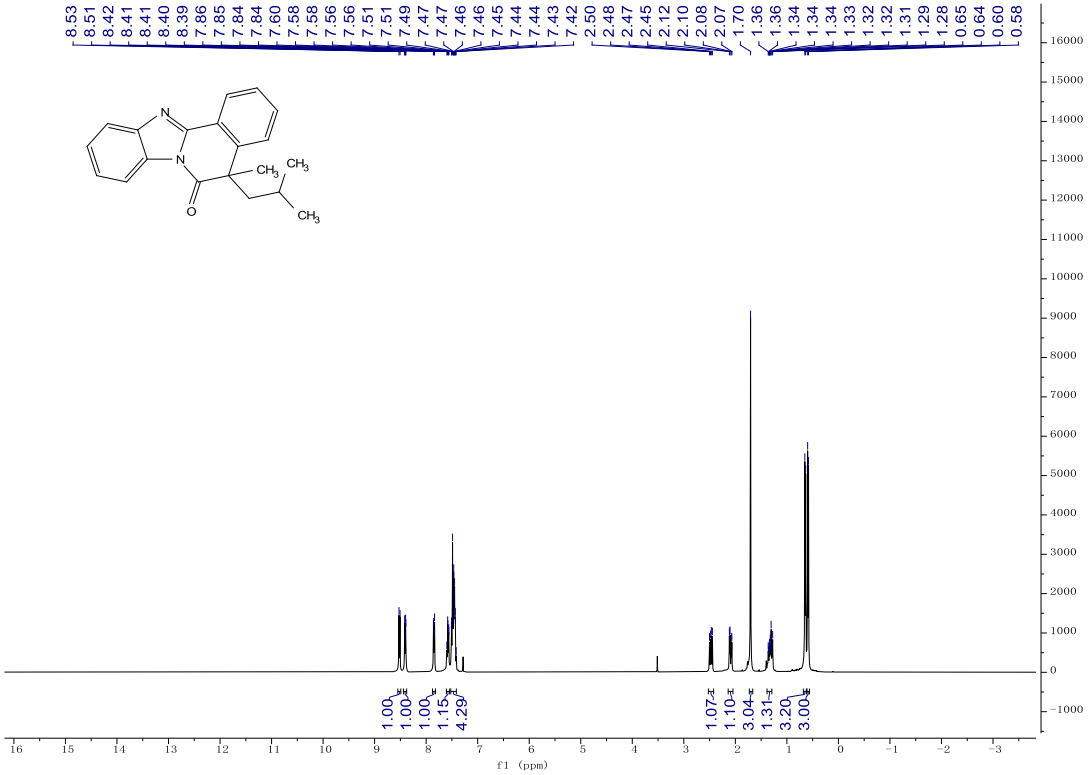


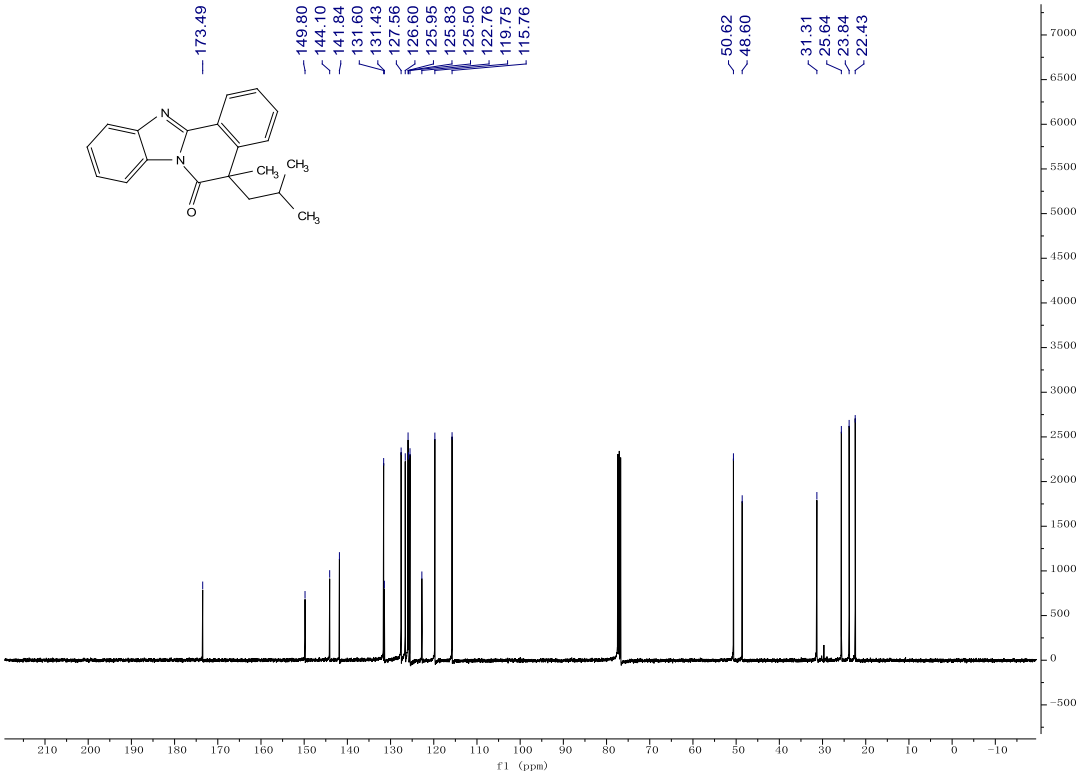
^{1}H and ^{13}C NMR spectra of 3aq



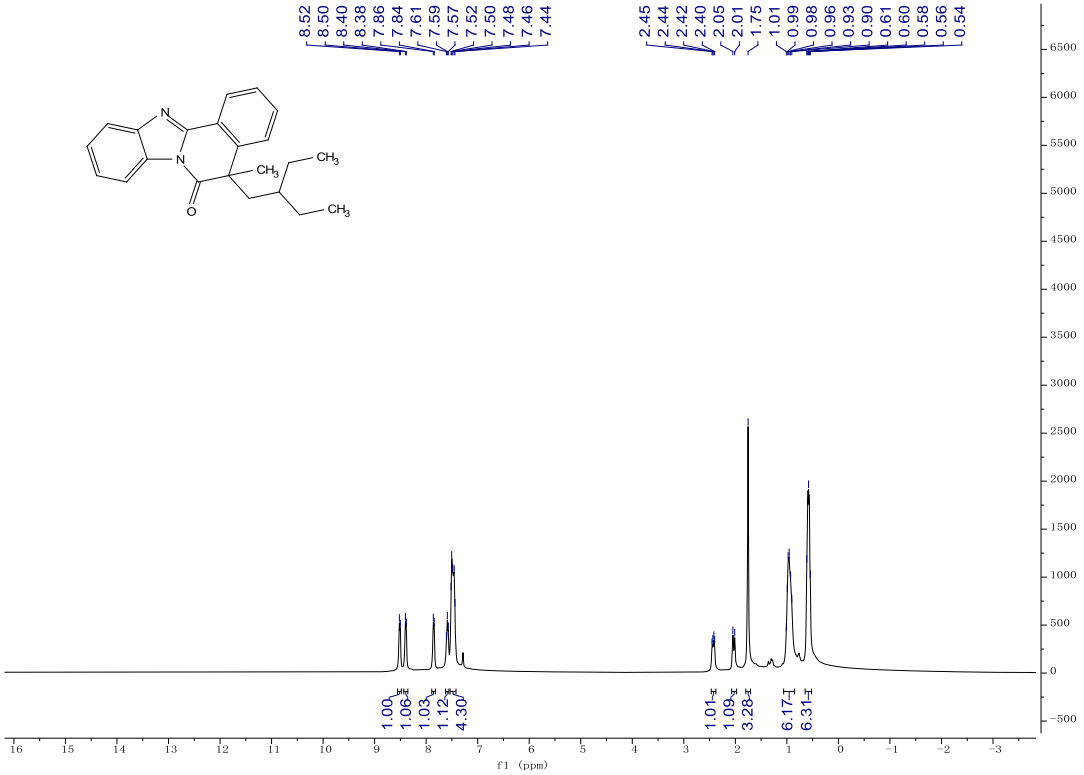


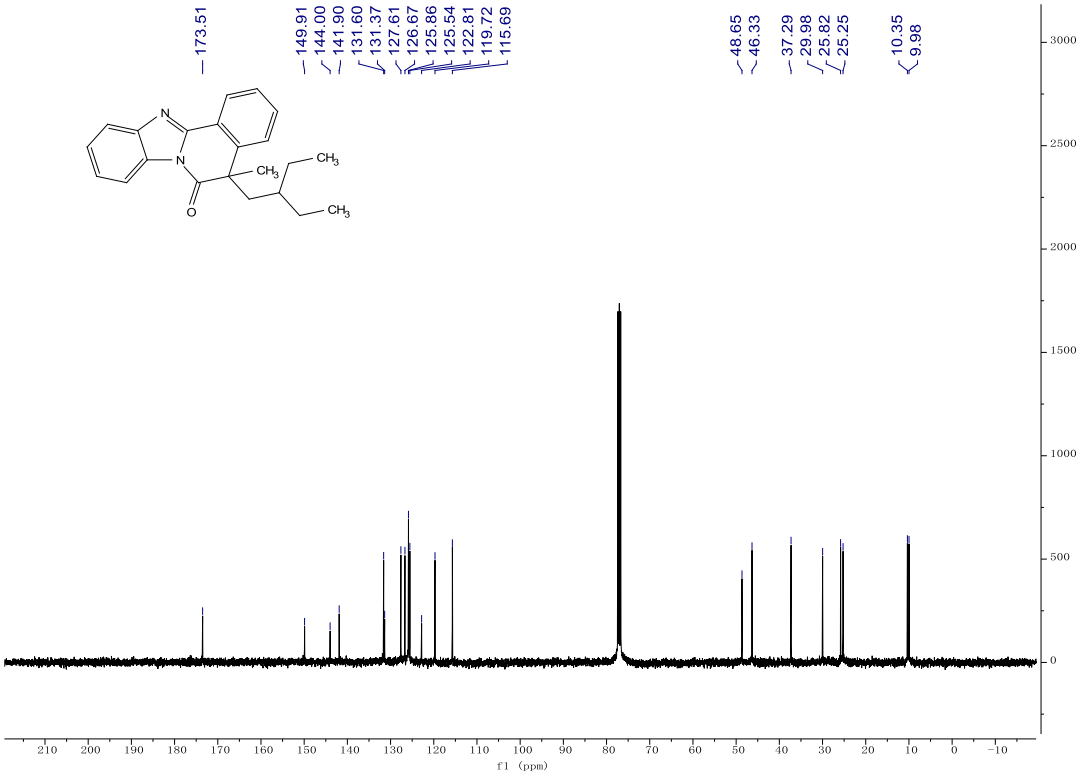
^{1}H and ^{13}C NMR spectra of 3ar



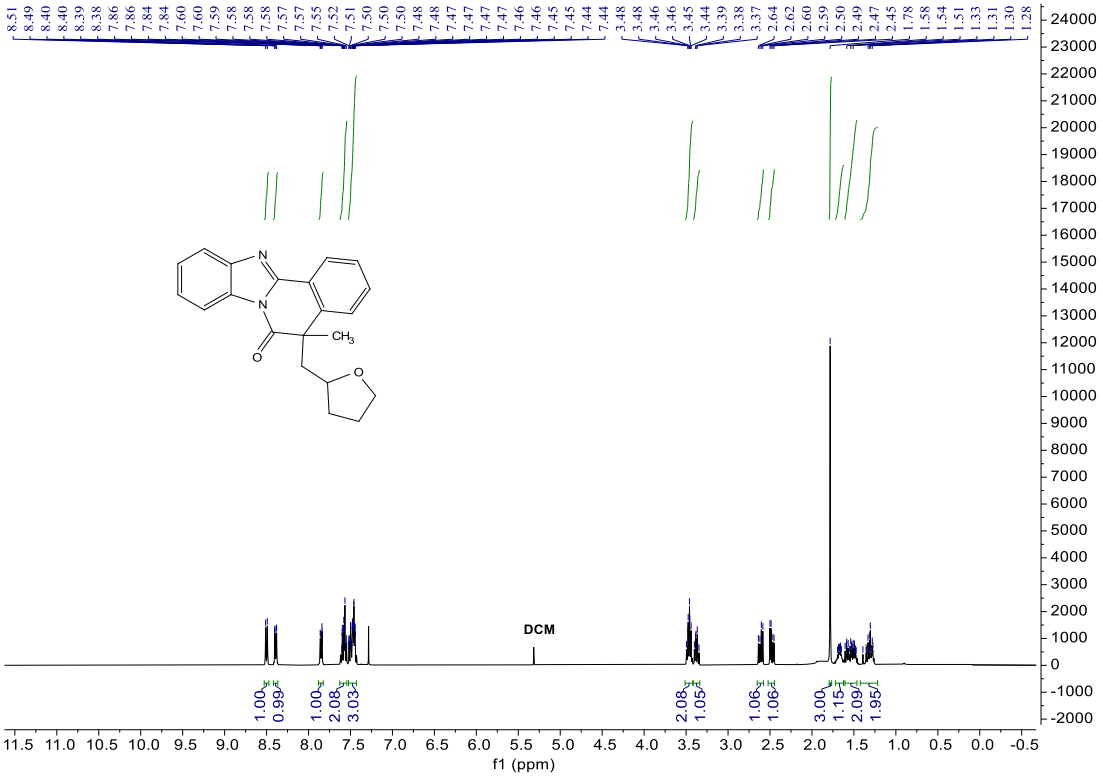


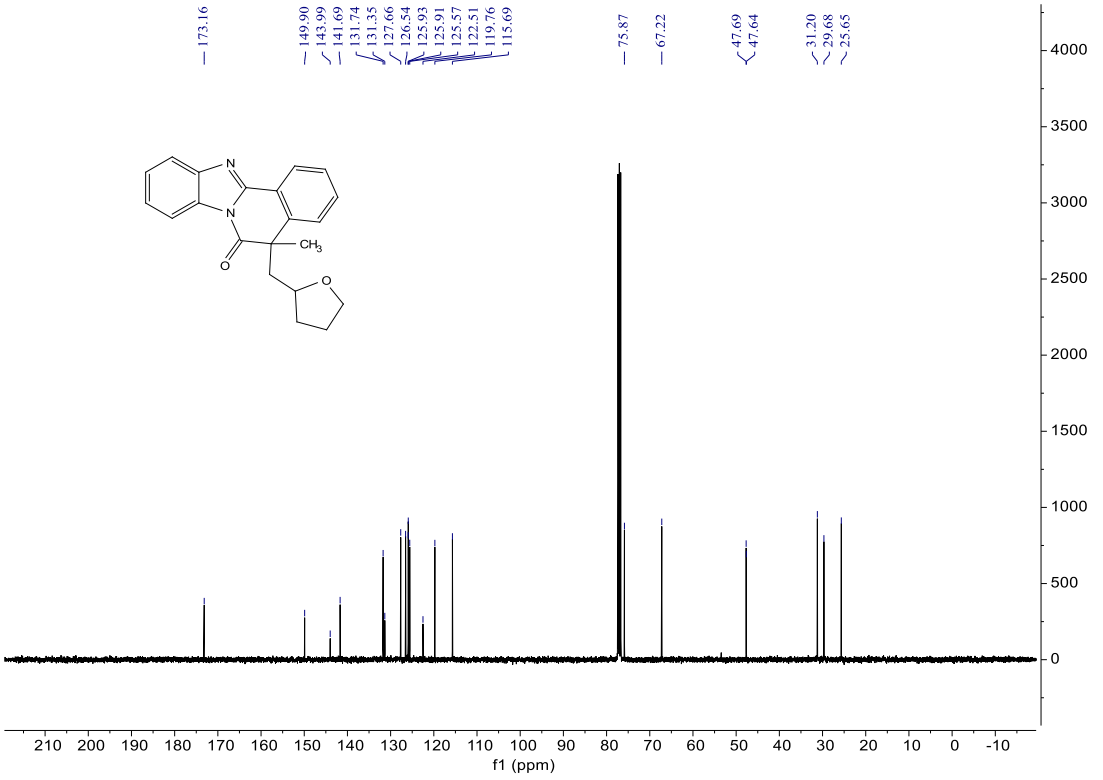
^{1}H and ^{13}C NMR spectra of 3as



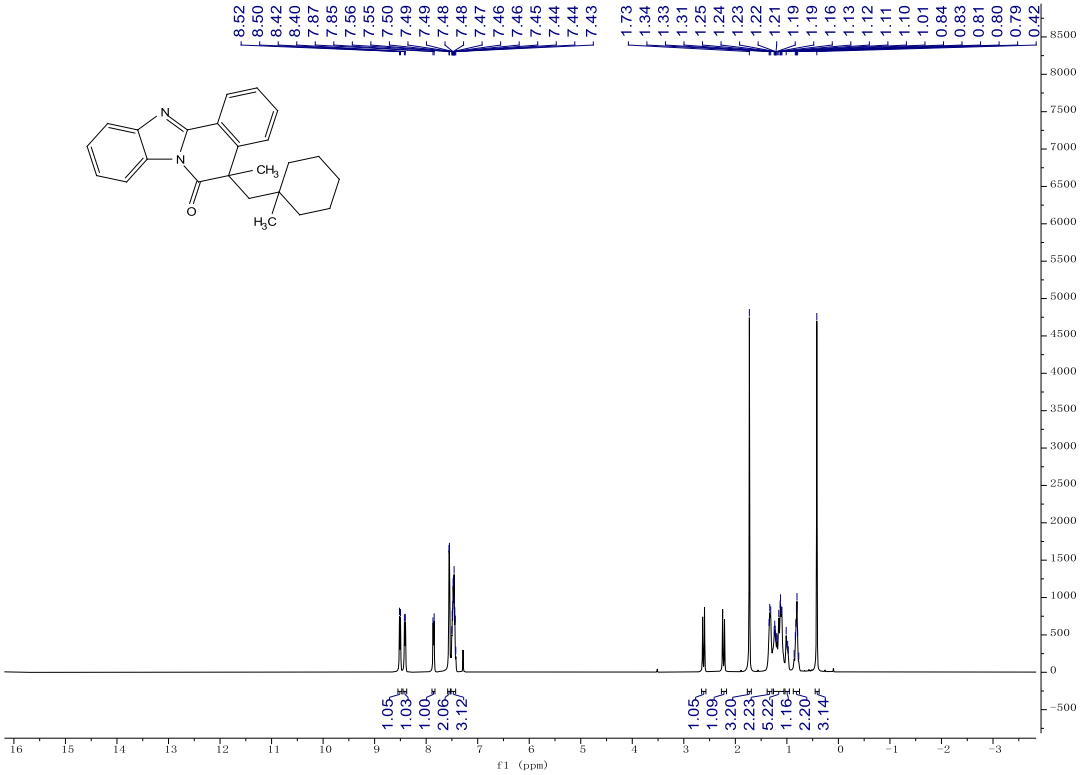


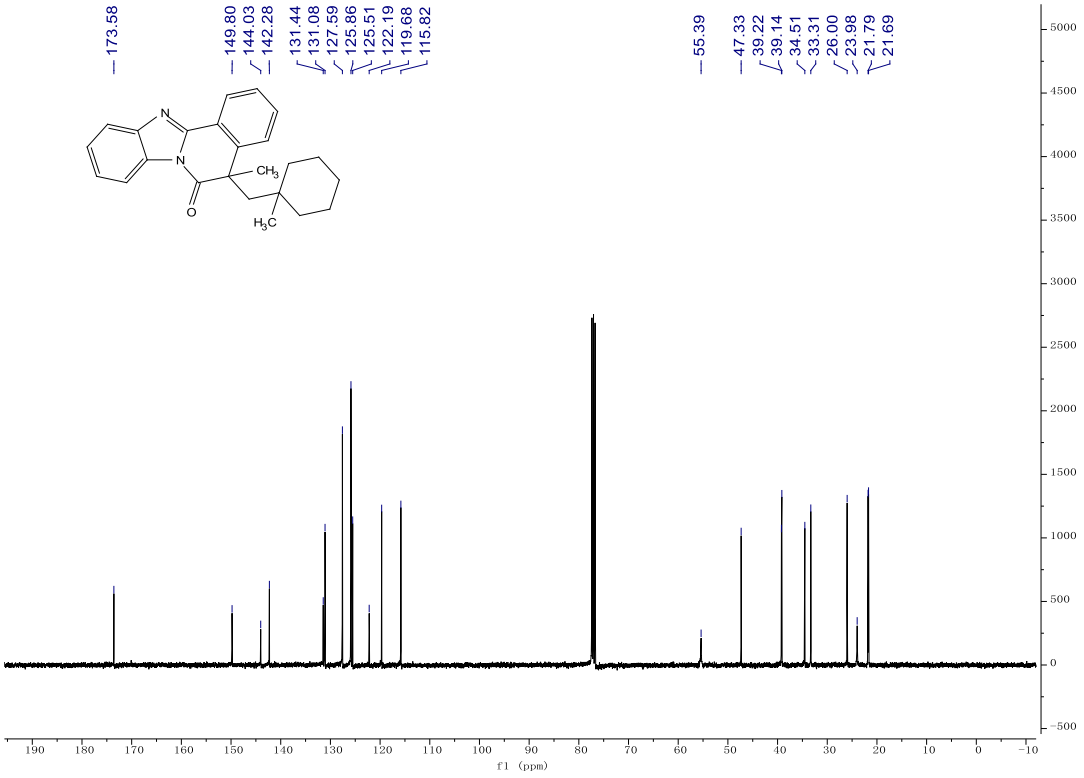
^{1}H and ^{13}C NMR spectra of 3at



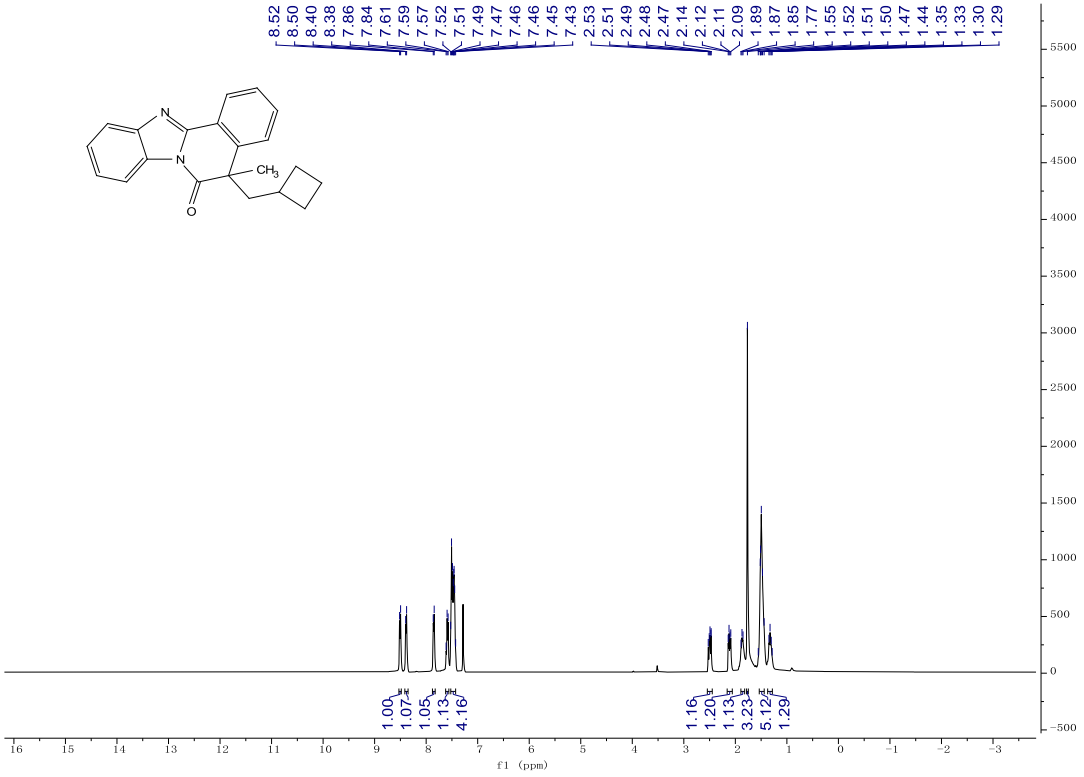


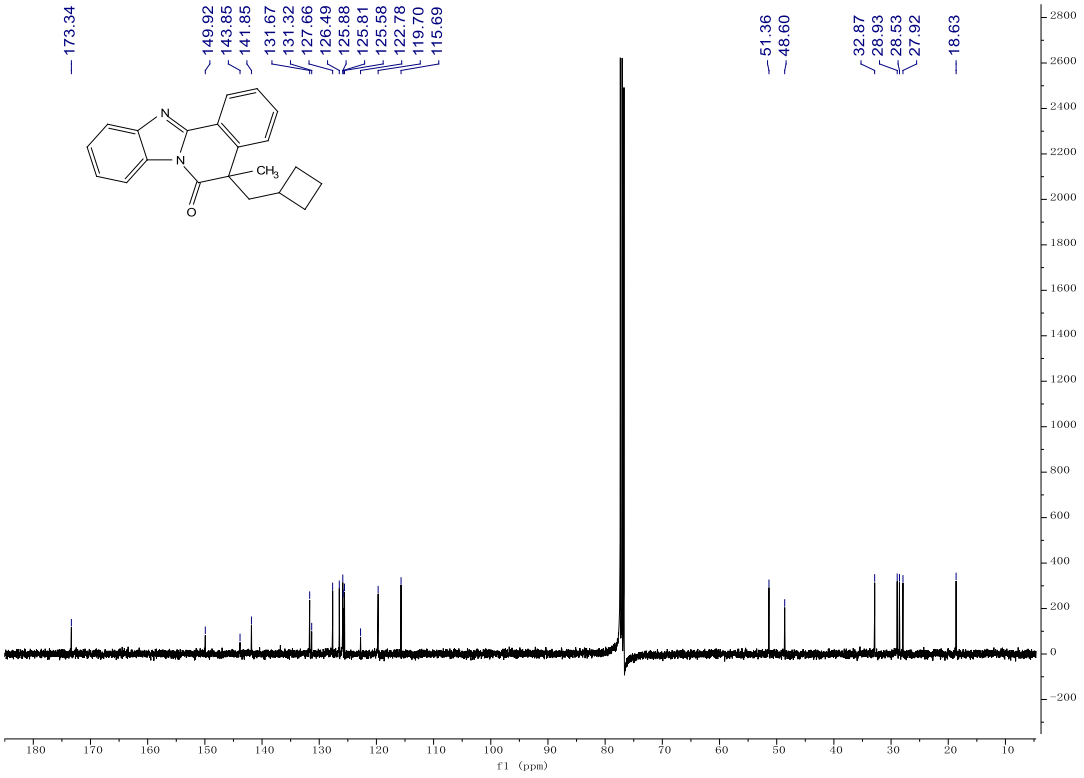
^{1}H and ^{13}C NMR spectra of 3au



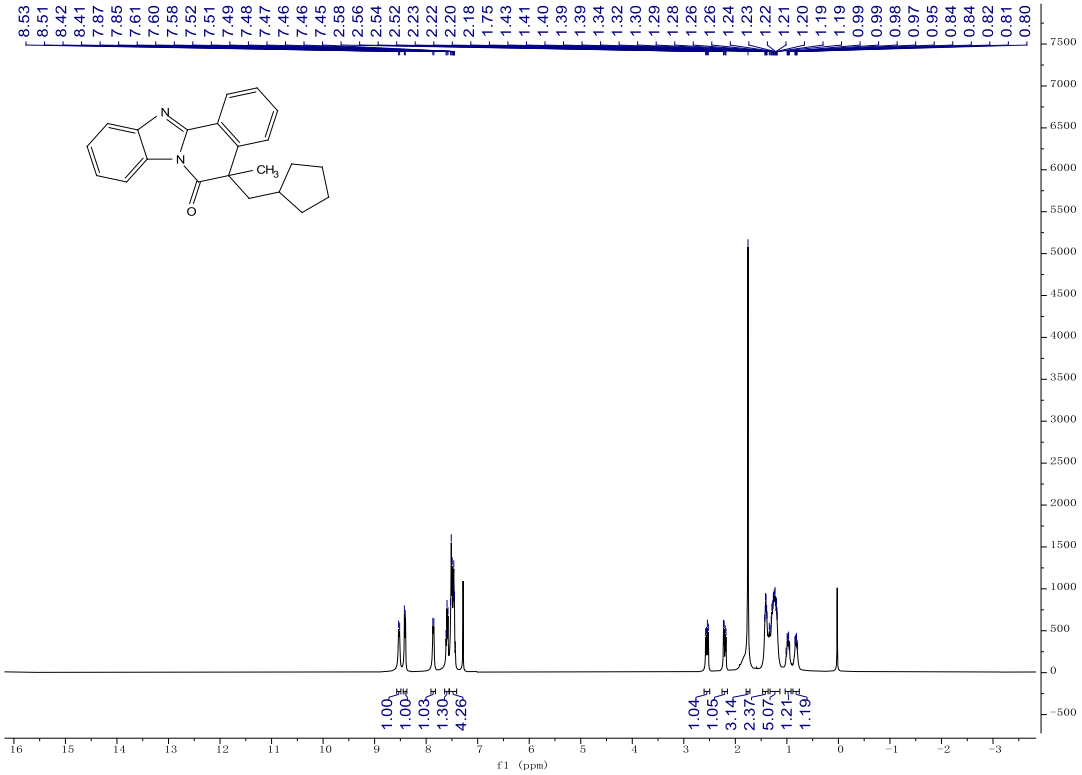


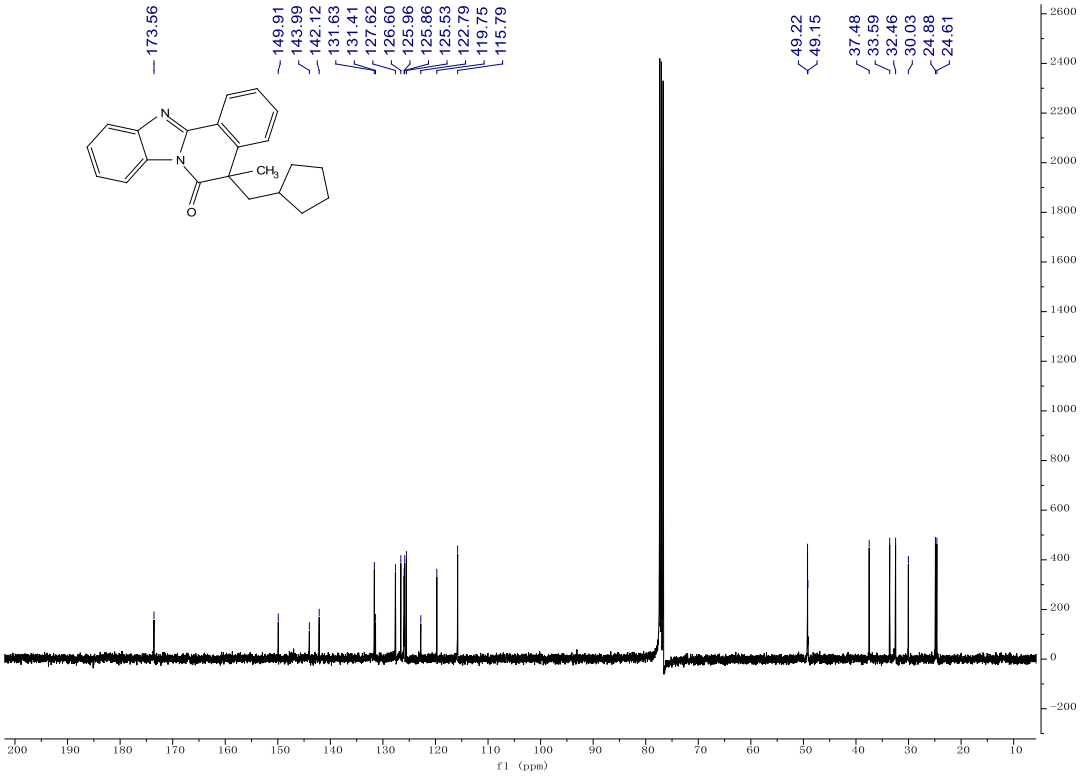
^{1}H and ^{13}C NMR spectra of 3av



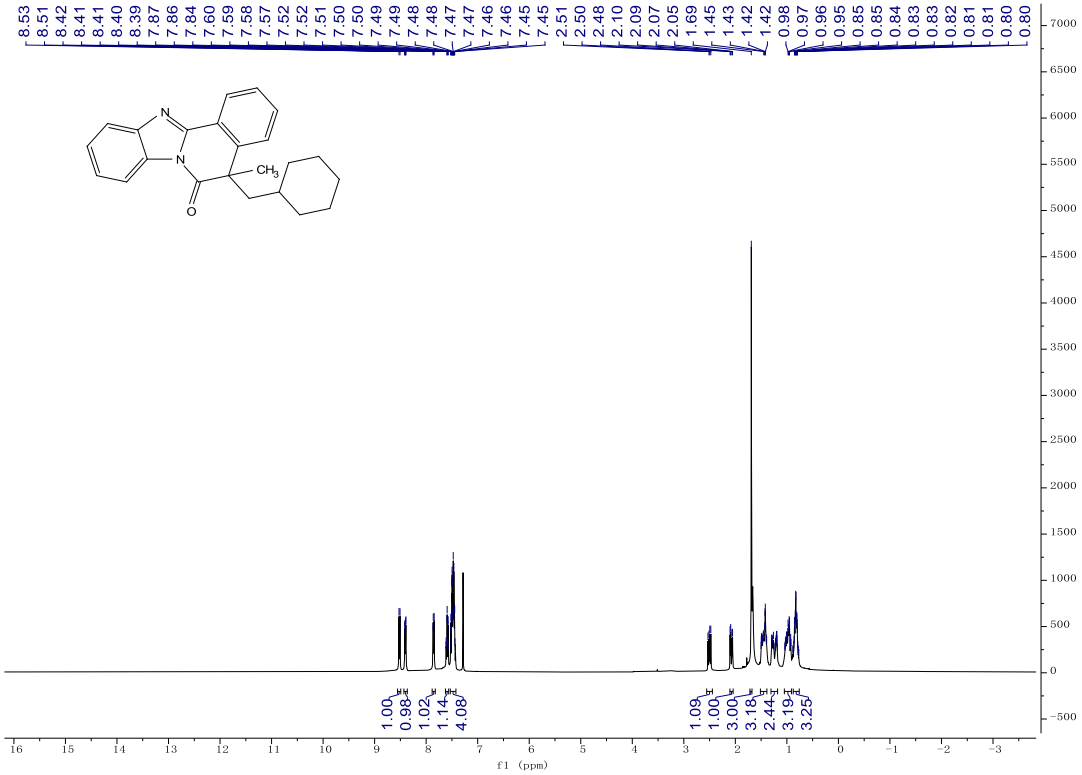


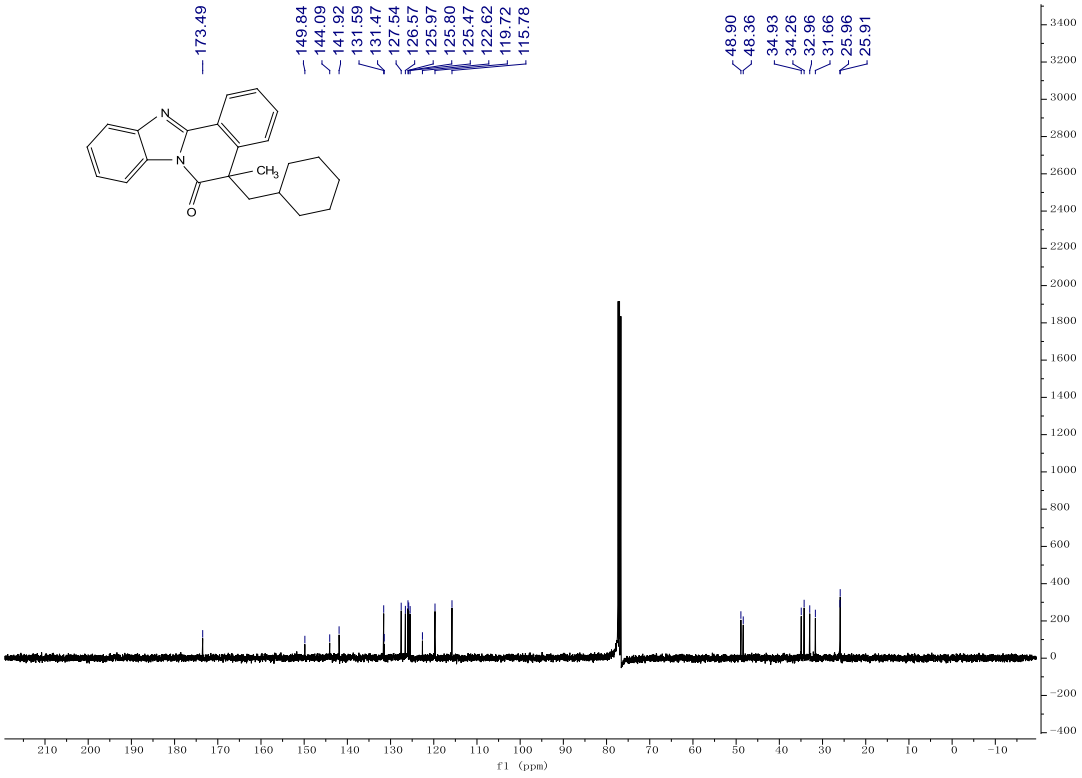
^{1}H and ^{13}C NMR spectra of 3aw



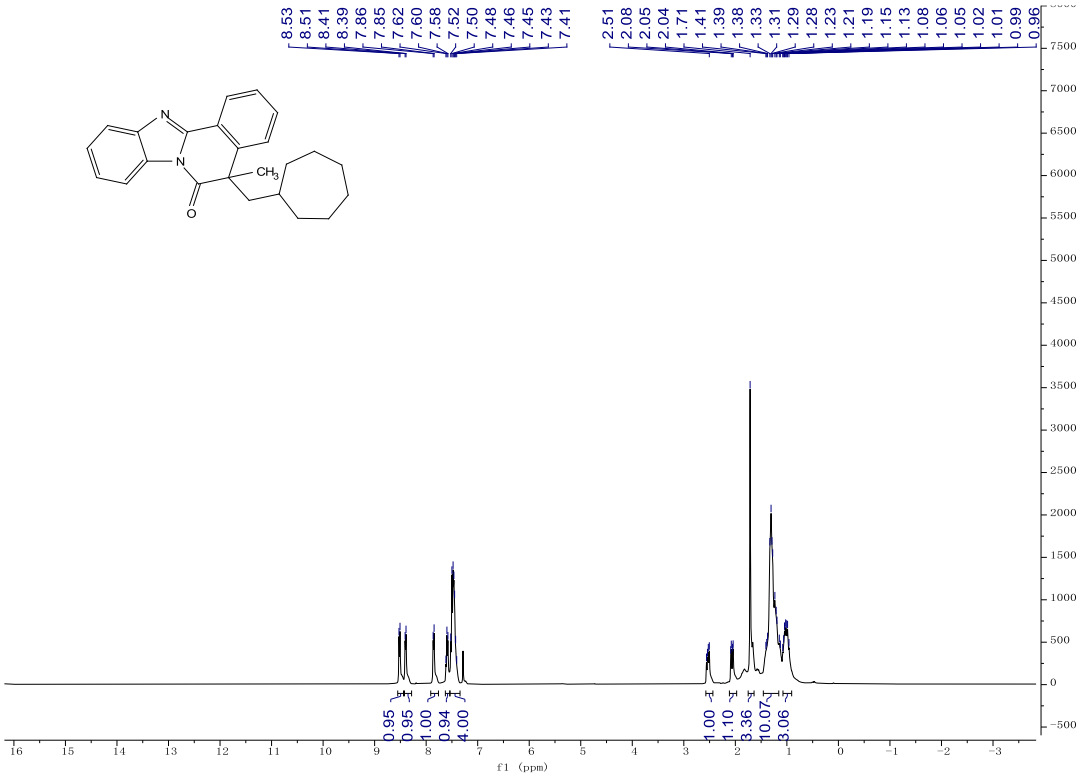


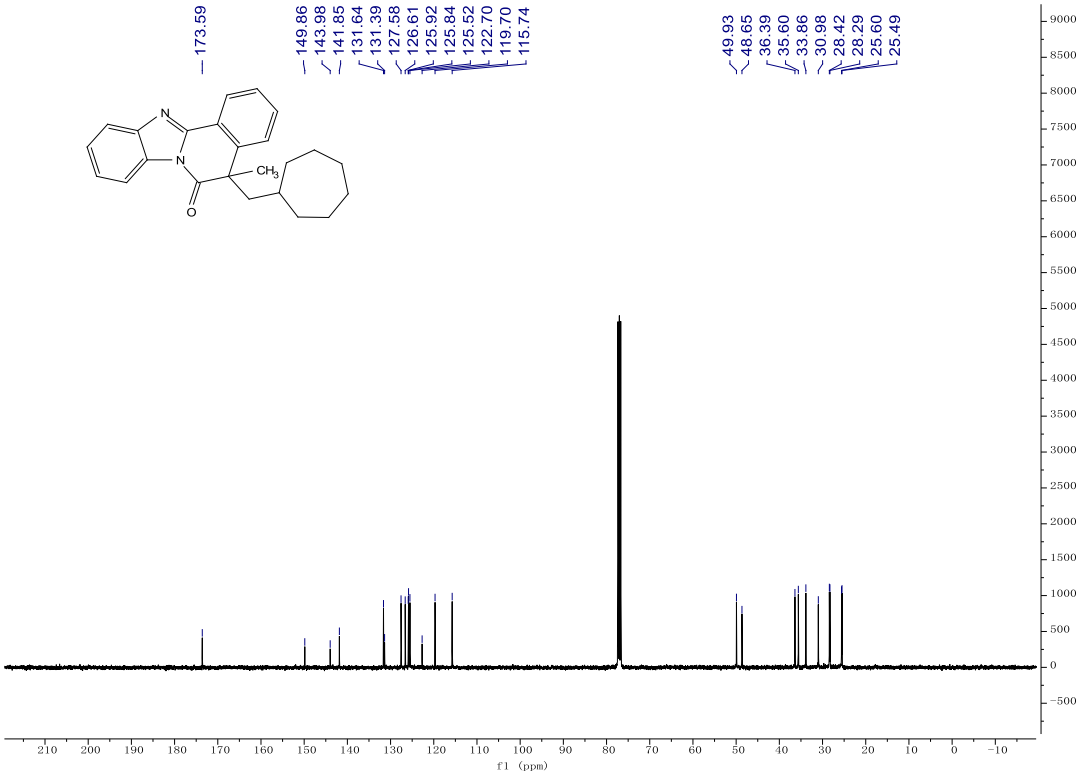
^{1}H and ^{13}C NMR spectra of 3ax



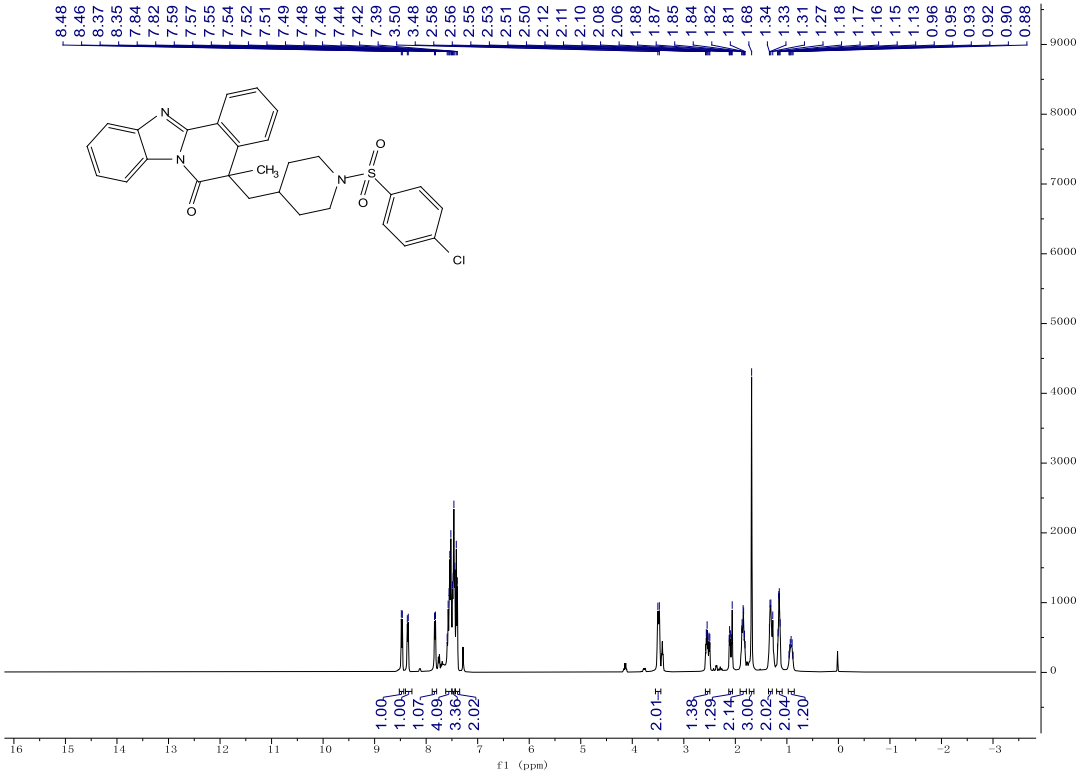


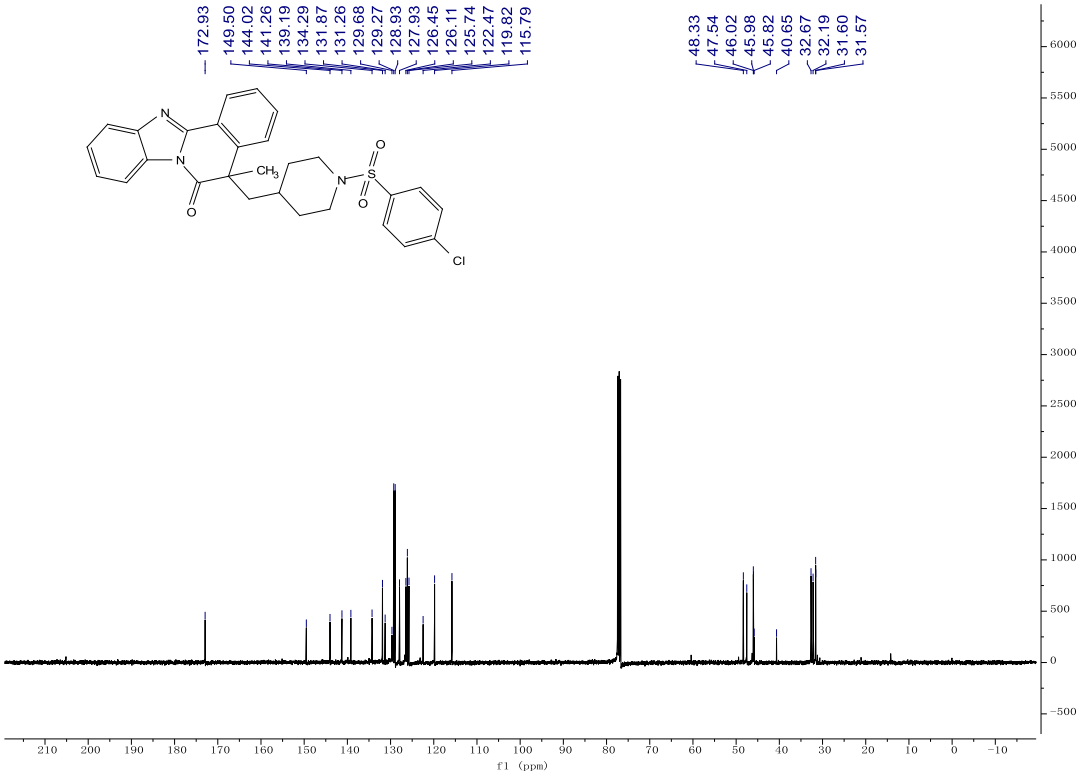
^{1}H and ^{13}C NMR spectra of 3ay



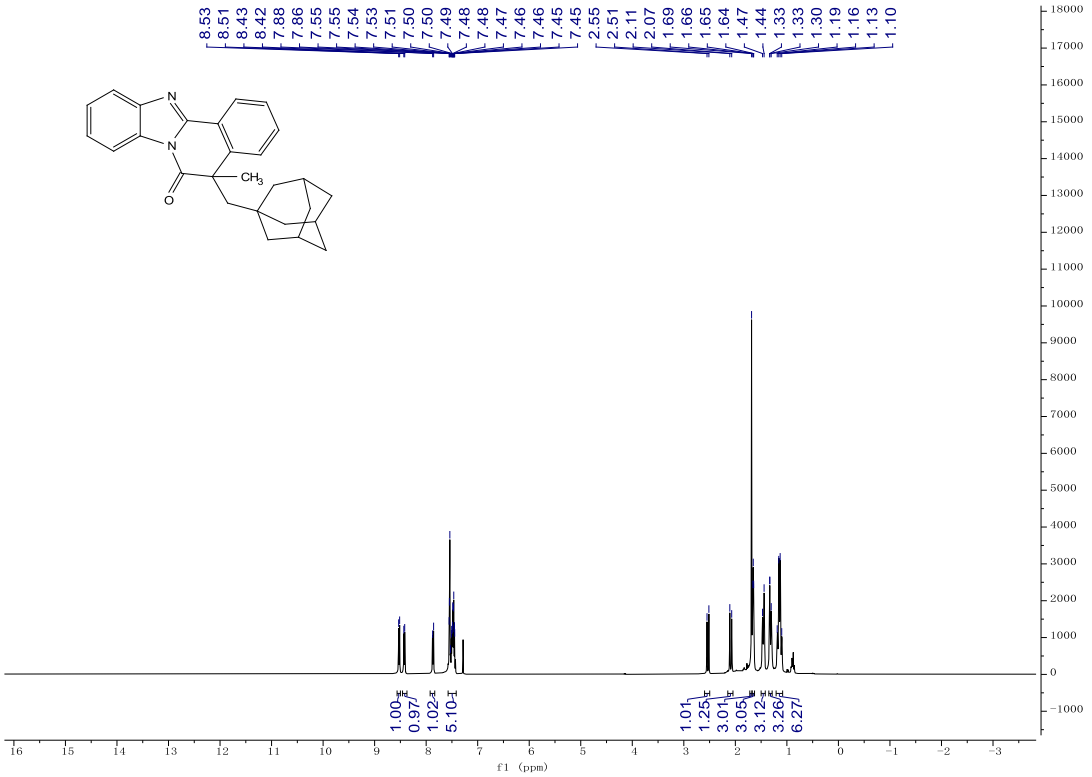


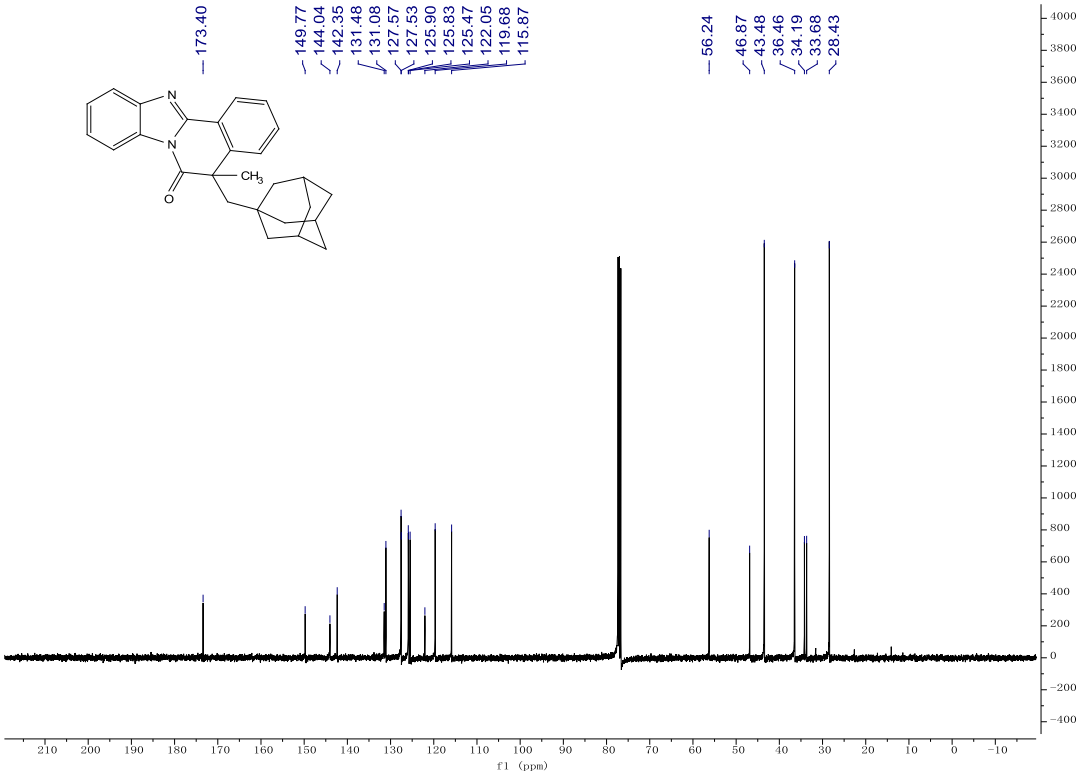
^{1}H and ^{13}C NMR spectra of 3az



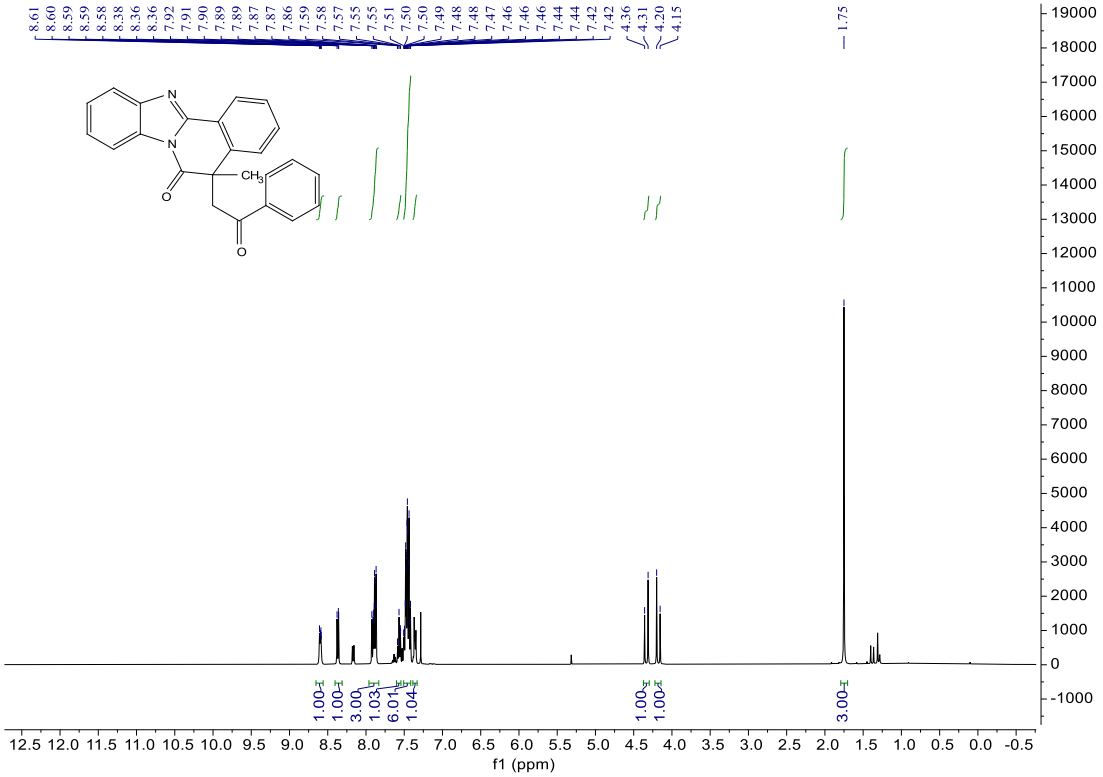


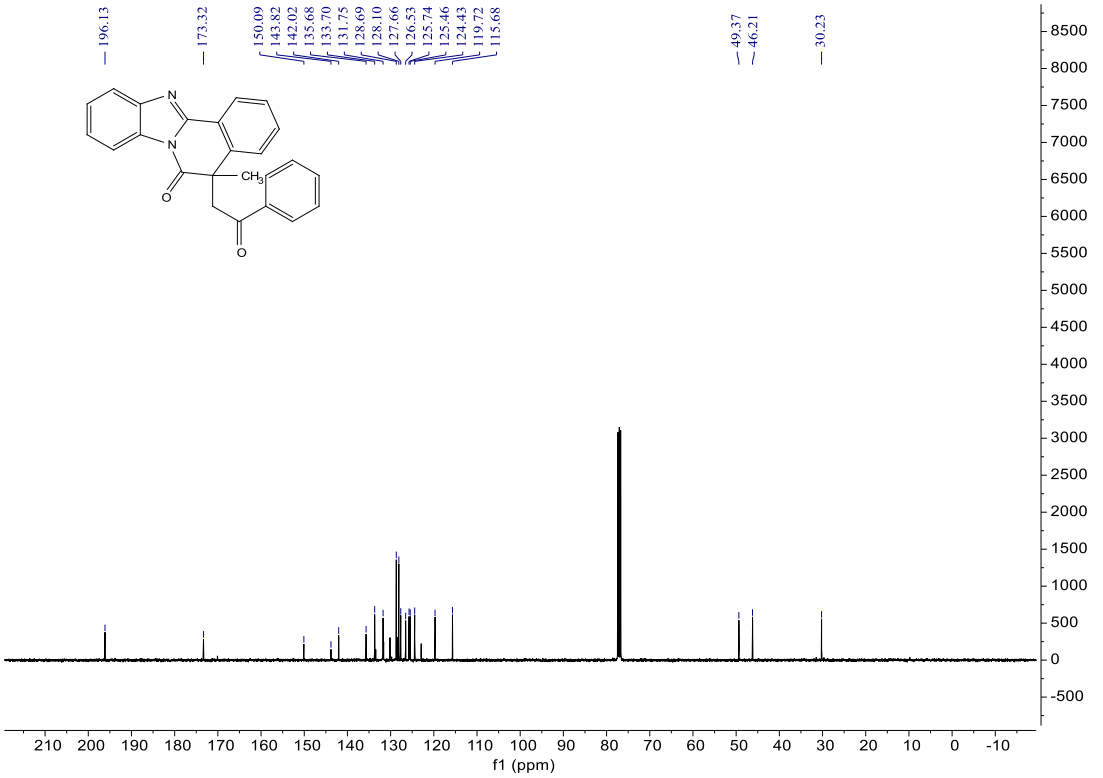
^{1}H and ^{13}C NMR spectra of 3ba



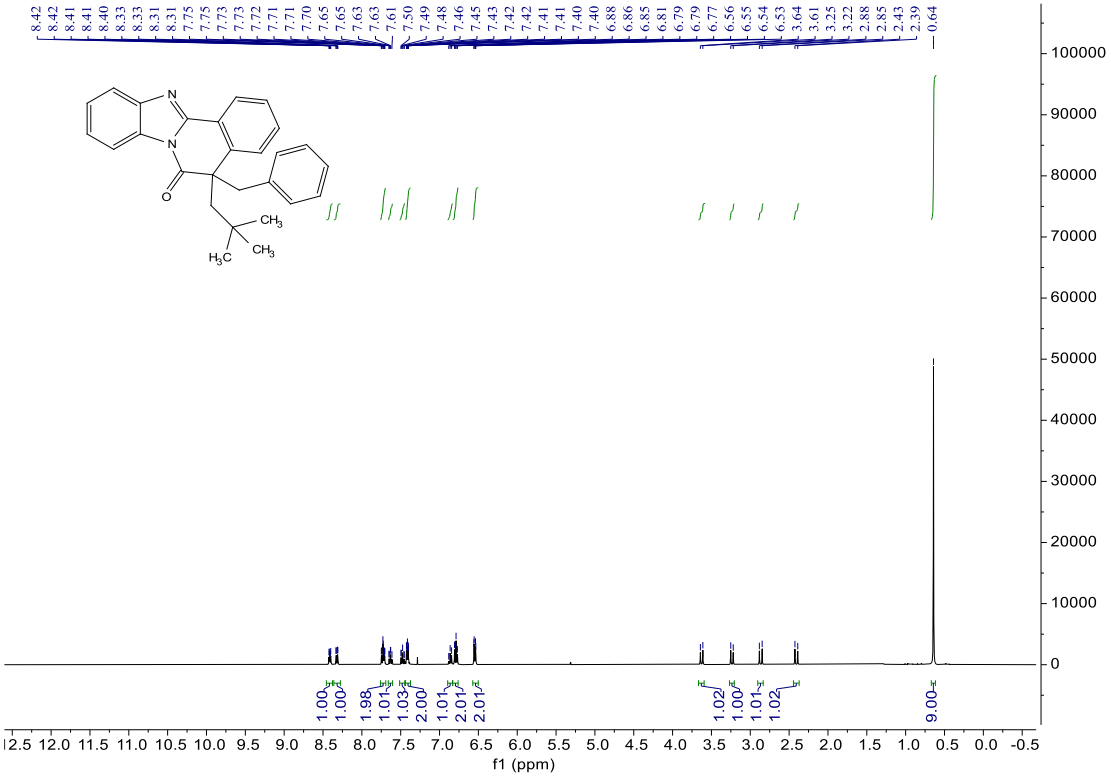


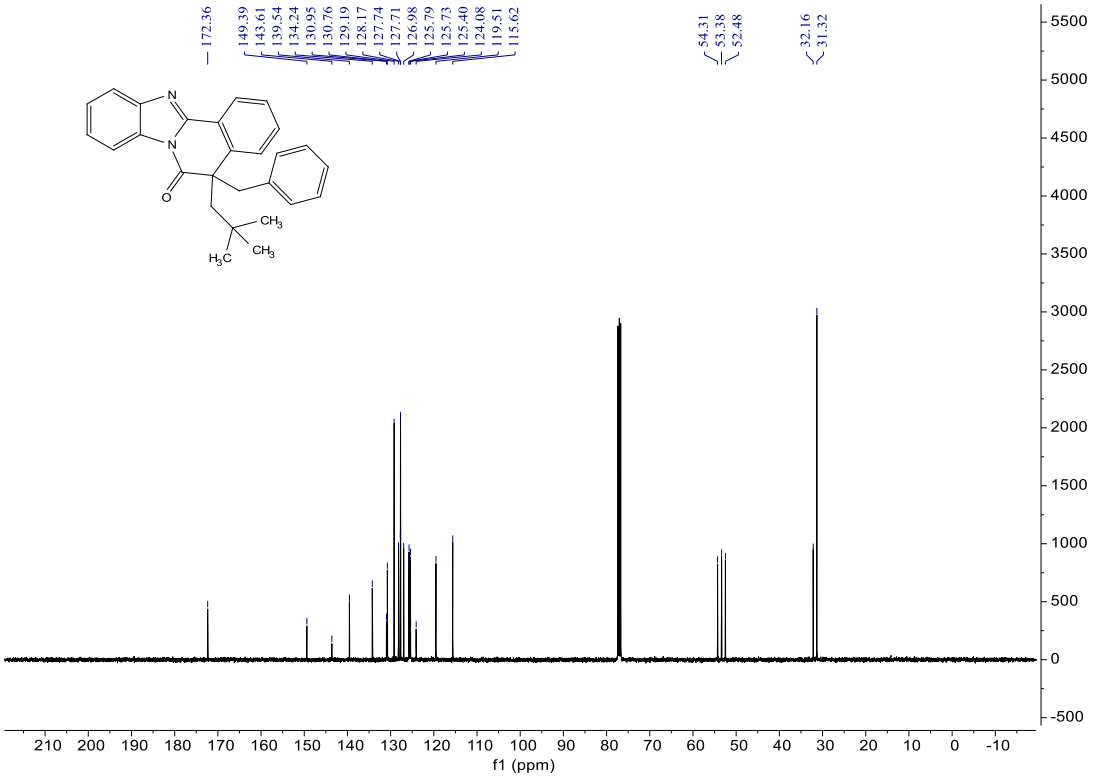
^{1}H and ^{13}C NMR spectra of 3bb



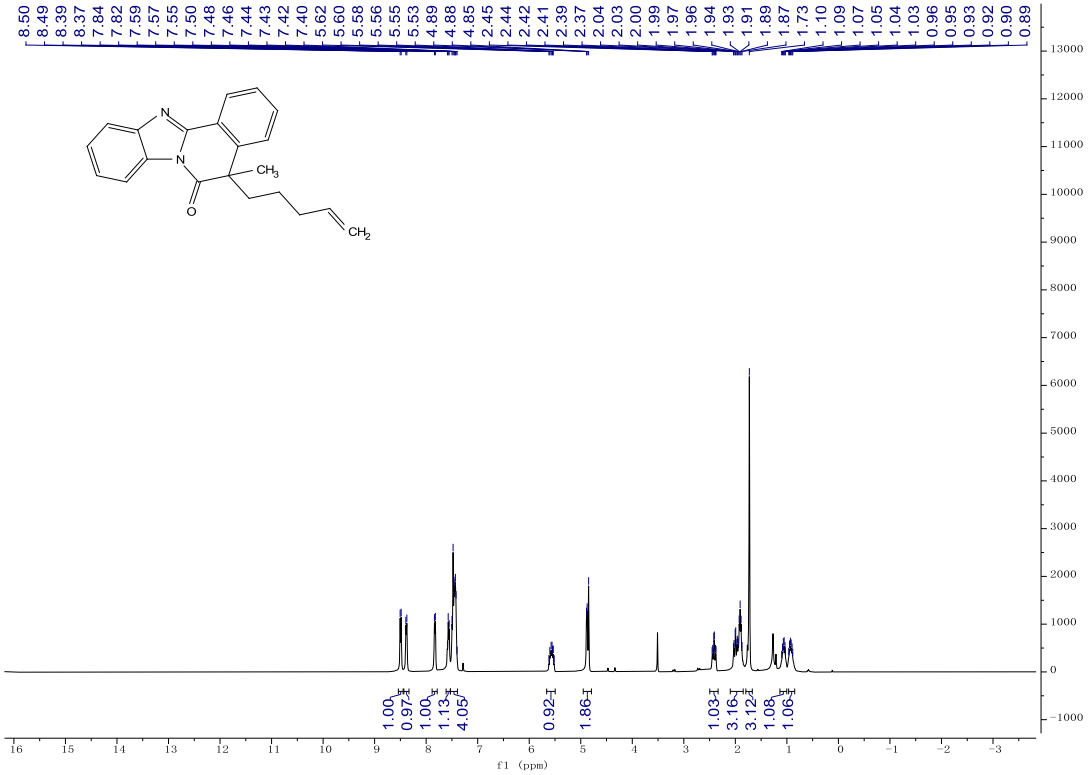


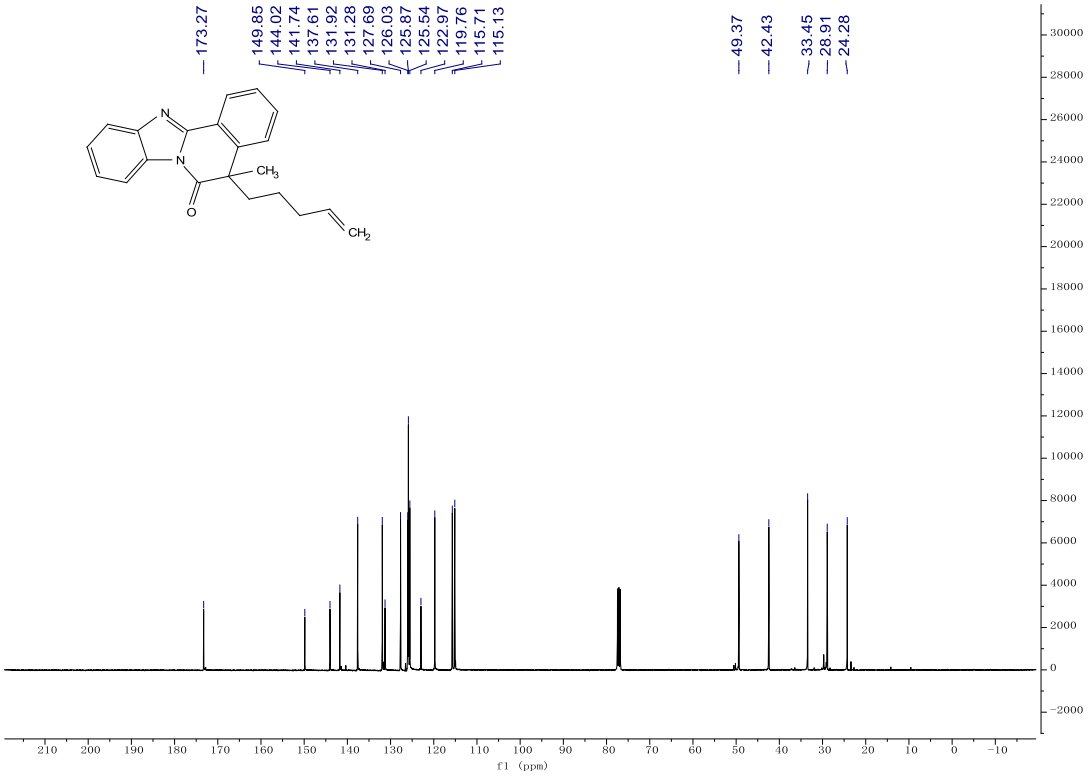
^{1}H and ^{13}C NMR spectra of 3bc



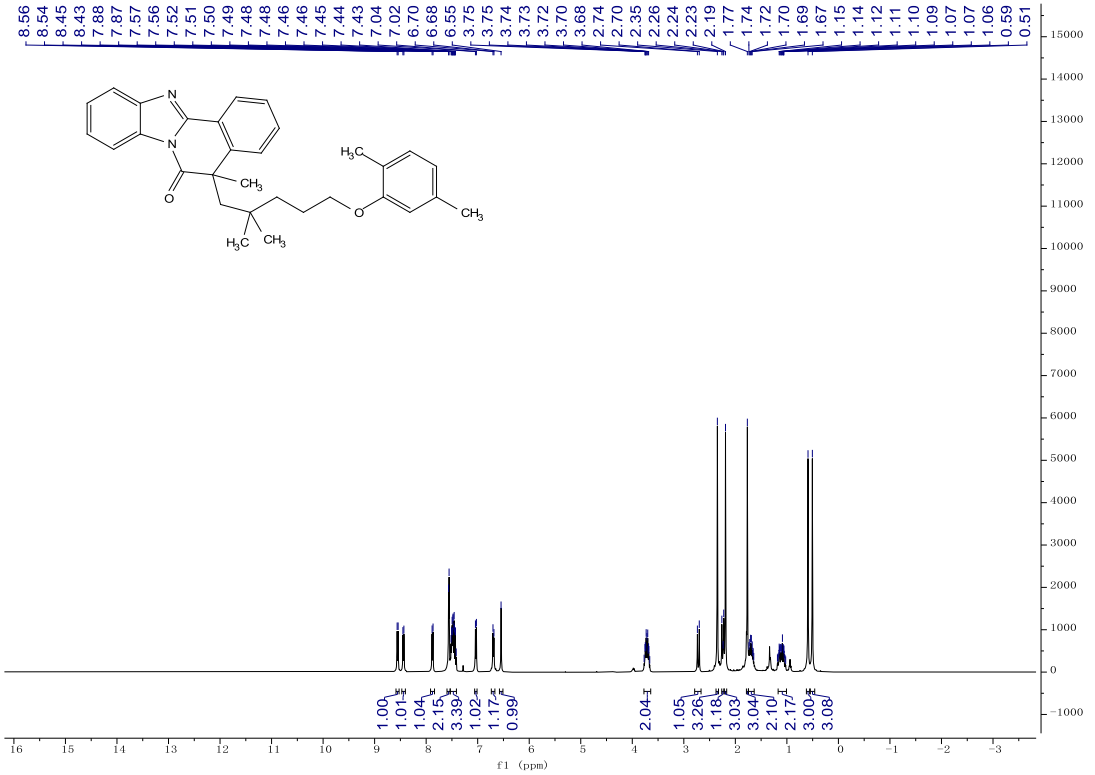


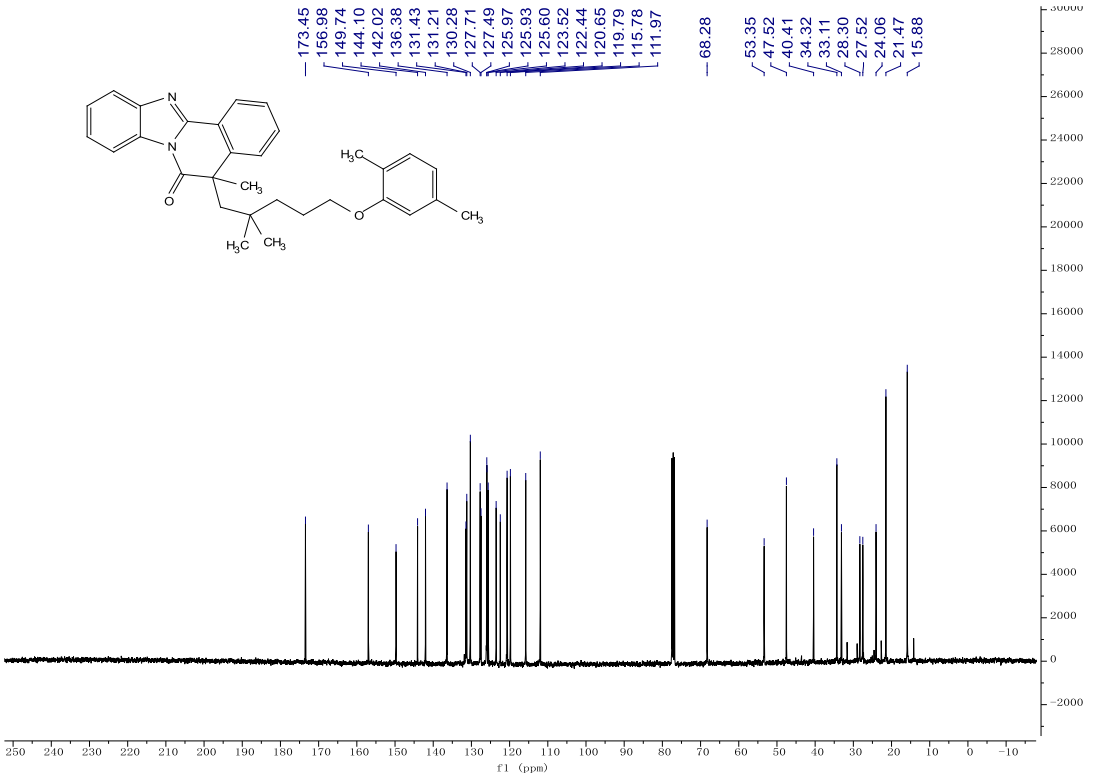
^{1}H and ^{13}C NMR spectra of 3bd



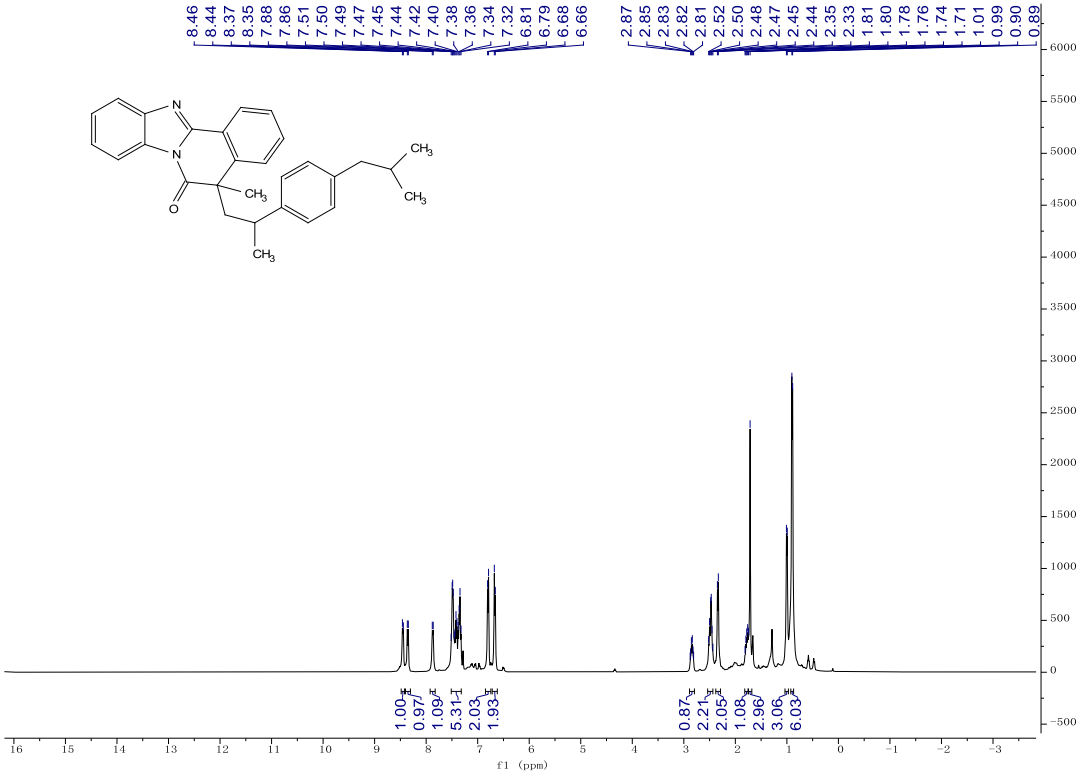


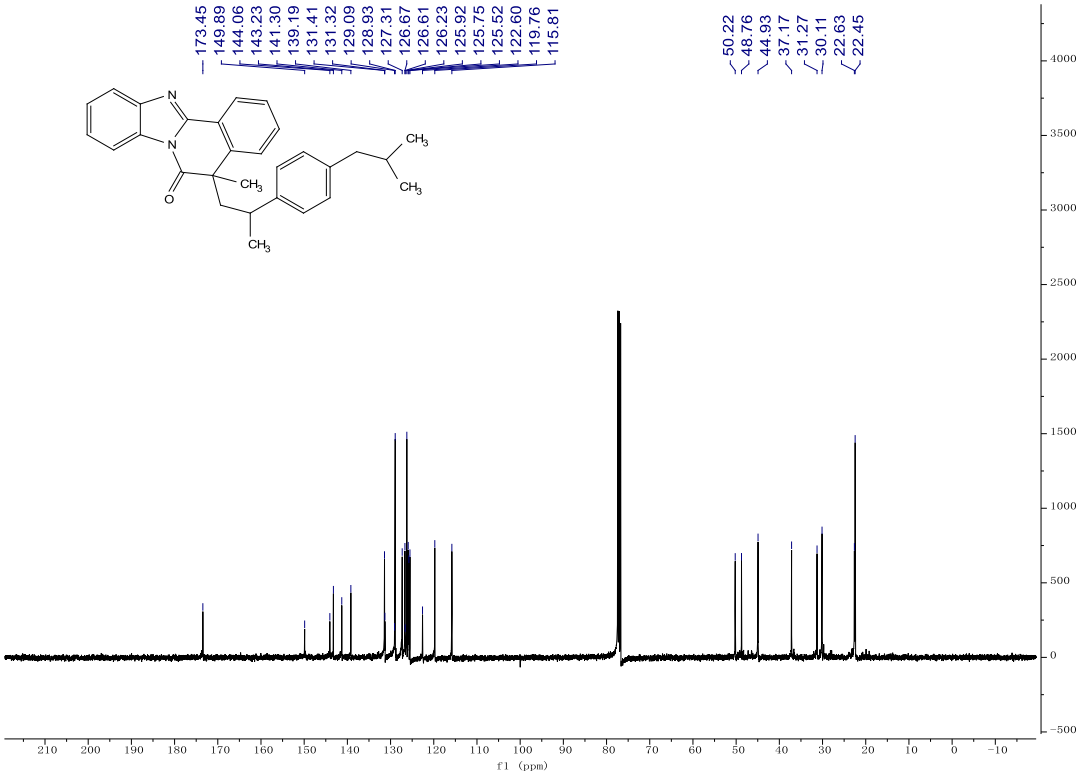
^{1}H and ^{13}C NMR spectra of 3be



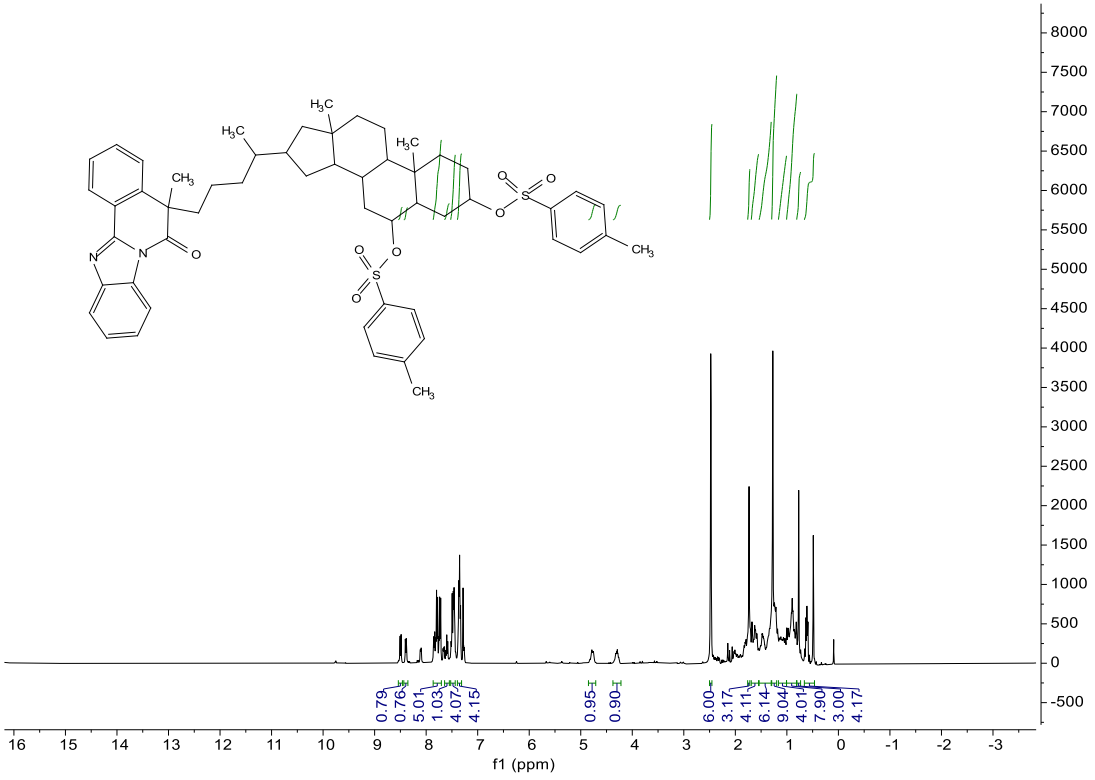


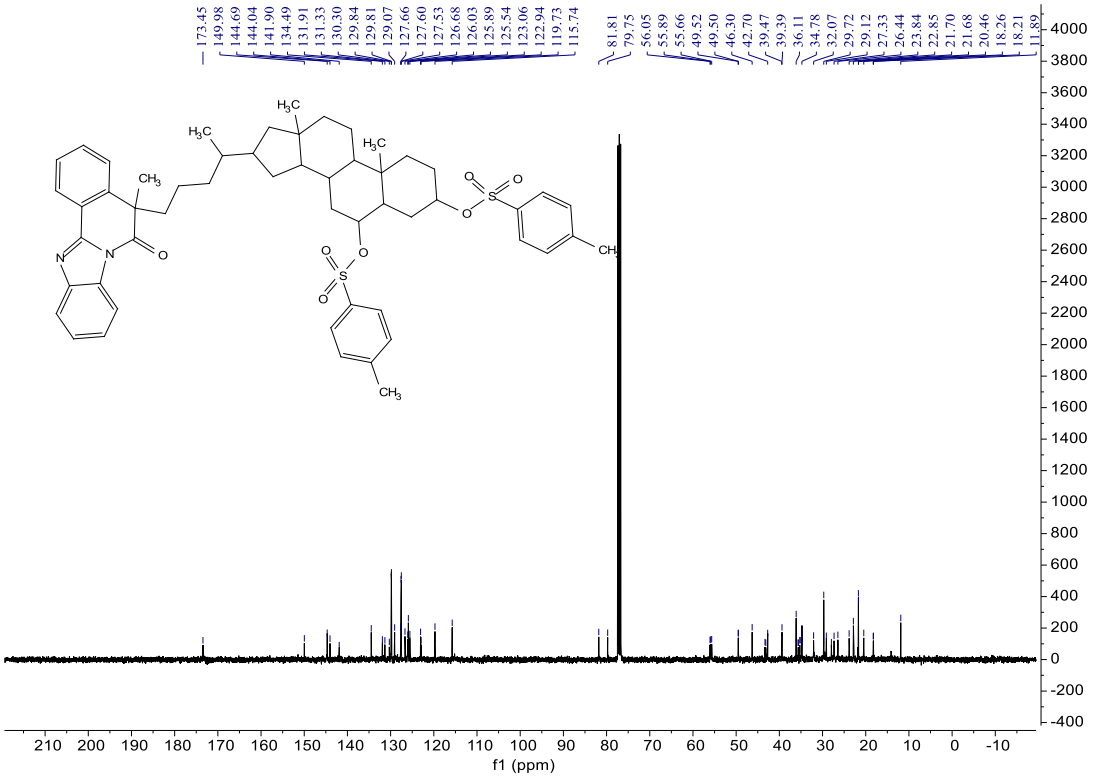
^{1}H and ^{13}C NMR spectra of 3bf



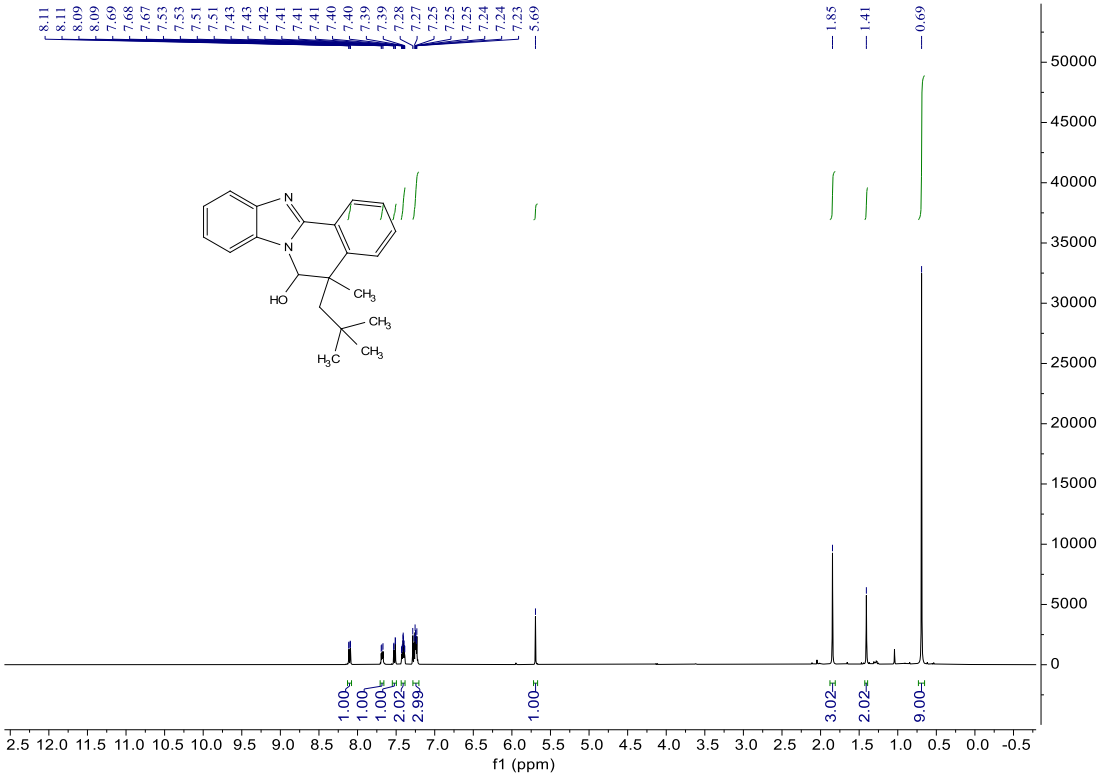


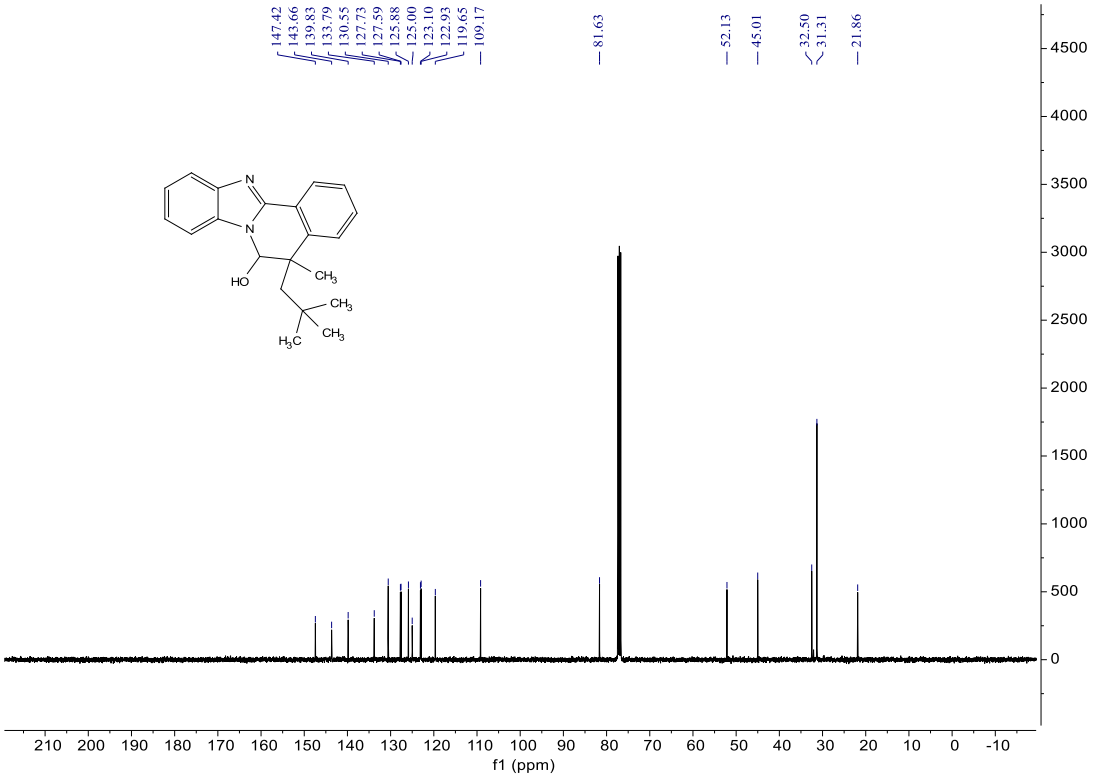
^{1}H and ^{13}C NMR spectra of 3bg





^{1}H and ^{13}C NMR spectra of 3bh





^{1}H and ^{13}C NMR spectra of 3bi