Electronic Supplementary Information

Naphtho[2,3-b]furan-4,9-diones synthesis via palladium-catalyzed reverse hydrogenolysis

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General information:

All reagents were obtained from commercial suppliers unless otherwise stated. DMA were distilled from magnesium sulfate under vacuum. The Pd/C was first washed with acetone and then was dried under reduced pressure at 80 ^{o}C before used. All corresponding glassware was oven dried (120 ^{o}C) and cooled under a stream of Argon gas. Flash chromatography was performed using silica gel (300-400 mesh) with solvents distilled prior to use. Visualization was achieved under a UV lamp (254 nm and 365nm).^{1}H-NMR (400MHz) and ^{13}C-NMR (100 MHz) spectra were obtained on a Bruker DRX-400 NMR as solutions indicated. Chemical shifts are reported in parts per million and coupling constants are in hertz. The chemical structures of products were confirmed by GC-MS (Agilent Technologies, GC7683B, MS5973) and ^{1}H-NMR (400 MHz) and ^{13}C-NMR (100 MHz).

General procedure for synthesis of substrates:

General Procedure A

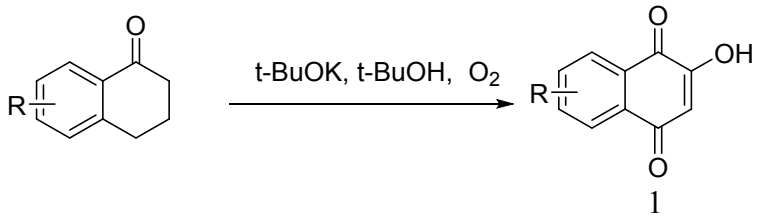
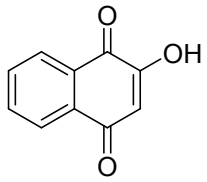


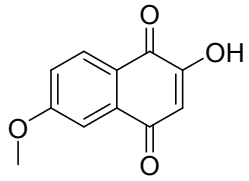
Fig S1. General Procedure A [1]

The reaction flask was first degassed and then sealed with a O_2 balloon. All the reactants and solvent was added under a O_2 atmosphere. Add a solution of potassium t-butoxide in t-butanol (1 M, 40 ml) to a solution of a-tetralone (185 mCi, 5 mmol) t-butanol (10ml) . The mixture was stirred under an oxygen atmosphere. After 2 h TLC of an aliquot quenched with 2 N HCl showed complete absence of a-tetralone. The reaction mixture was acidified with 2 N HCl (10 ml) and extracted with $CHCl_3$(20 ml). The combined organicsolution was extracted with a saturated solution of $NaHCO_3$(10 ml).Acidification of the $NaHCO_3$ extract with 6N HCl yielded a yellow solid, which was filtered and dried. Recrystallization from ethyl acetate–petroleum ether (19:1) gave 0.4 g (46%) of bright yellow solid of 1 with a purity of 99%.



1a 2-hydroxy-1,4-naphthoquinone

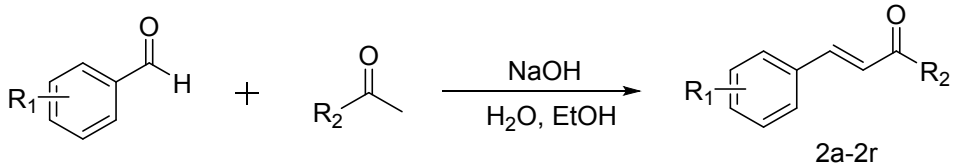
Yellow solid, yield: 70%. ^{1}H-NMR (400 MHz, Chloroform-d) ^{1}H-NMR (400 MHz, $CDCl_3$) δ 8.12 (d, J = 7.6 Hz, 2H), 7.80 (t, J = 7.5 Hz, 1H), 7.72 (t, J = 7.5 Hz, 1H), 7.37 (s, 1H), 6.37 (s, 1H). HR-MS: m/z calcd for $C_{10}H_6O_3$: 174.0317; found: 174.0318.

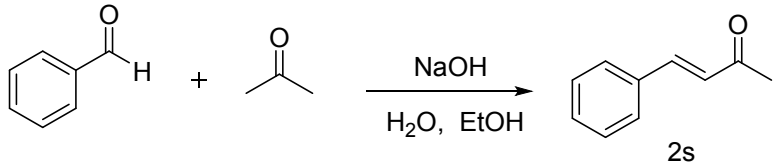


1b 6-methoxy-2-hydroxy-1,4-naphthoquinone

Yellow solid, yield: 72%. ^{1}H-NMR (400 MHz, $CDCl_3$) δ 8.06 (d, J = 8.6 Hz, 1H), 7.57 (d, J = 2.4 Hz, 1H), 7.46 (s, 1H), 7.16 (dd, J = 8.6, 2.4 Hz, 1H), 6.31 (s, 1H), 3.97 (s, 3H). HR-MS: m/z calcd for $C_{11}H_8O_4$: 204.0423; found: 204.0424.

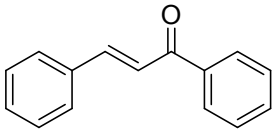
General Procedure B





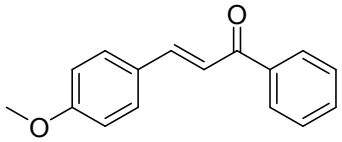
(1) To a solution of benzaldehyde(15mmol, 1.59g) in 10ml ethyl alcohol, added acetophenone (10mmol, 1.2g) in 5 ml H_2O, Stirred for 10min, then dropwise added NaOH(30mmol, 1.2g) in 5ml H_2O. Stirred for another 2h at room temperature after TLC showed complete absence of acetophenone. A yellow solid was separated out. Filtrated to get raw product. Recrystallization from ethyl acetate–petroleum ether (30:1) gave 1.64 g (79%) of bright yellow needles of 2a-2r and 2t-2w with a radiochemical purity of 99%.

(2) A solution of aldehyde (33 mmol) in acetone (10 mL) and water (1 mL) was placed in a water bath. The reaction mixture was stirred and 10% solution of NaOH (1 mL) was added slowly. The reaction mixture was then stirred for 6 h at room temperature and acidied with 1 M HCl to pH=2. The product was extracted with ethyl acetate (3×40 mL). The organic layer was washed with brine, dried over anhydrous $MgSO_4$. After evaporation of solvent in vacuo pure ketone 2s was obtained.



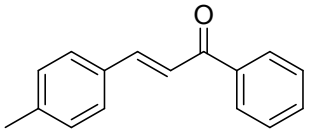
2a 1,3-Diphenyl-propenone

Light yellow solid, yield: 79%. ^{1}H-NMR (400 MHz, Chloroform-d) δ 8.03 (d, J = 7.3 Hz, 2H), 7.82 (d, J = 15.7 Hz, 1H), 7.65 (dd, J = 6.5, 2.8 Hz, 2H), 7.62 – 7.53 (m, 2H), 7.51 (t, J = 5.5 Hz, 2H), 7.46 – 7.38 (m, 3H). HR-MS: m/z calcd for $C_{15}H_{12}O$: 208.0888; found: 208.0888. These characterization data are matched with those previously reported [2].



2b 3-(4-Methoxy-phenyl)-1-phenyl-propenone

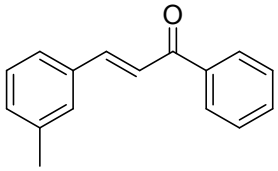
Yellow solid, yield: 76%. ^{1}H-NMR (400 MHz, Chloroform-d) δ 8.02 (d, J = 7.7 Hz, 2H), 7.78 (d, J = 15.7 Hz, 1H), 7.57 – 7.47 (m, 4H), 7.43 (d, J = 5.1 Hz, 2H), 7.29 (t, J = 7.8 Hz, 1H), 7.20 (d, J = 7.4 Hz, 1H), 2.37 (s, 3H). HR-MS: m/z calcd for $C_{16}H_{14}O_2$: 238.0994; found: 238.0996. These characterization data are matched with those previously reported [2].



2c 1-phenyl-3-*p*-tolyl-propenone

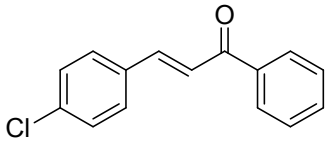
Yellow solid, yield: 71%. ^{1}H-NMR (400 MHz, Chloroform-d) δ 8.01 (d, J = 7.4 Hz, 2H), 7.79 (d, J = 15.7 Hz, 1H), 7.51 (dq, J = 15.5, 8.0, 6.9 Hz, 6H), 7.20 (d, J = 7.9 Hz, 2H), 2.37 (s, 3H). HR-

MS: m/z calcd for $C_{16}H_{14}O$: 222.1045; found: 222.1044. These characterization data are matched with those previously reported [2].



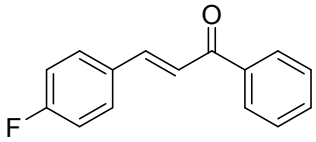
2d 1-phenyl-3-*m*-tolyl-propenone

Yellow solid, yield: 69%. ^{1}H-NMR (400 MHz, Chloroform-d) δ 8.02 (d, J = 7.3 Hz, 2H), 7.79 (d, J = 15.7 Hz, 1H), 7.58 (t, J = 7.3 Hz, 1H), 7.54 – 7.47 (m, 3H), 7.44 (d, J = 6.4 Hz, 2H), 7.30 (t, J = 7.9 Hz, 1H), 7.23 (t, J = 7.2 Hz, 1H), 2.39 (s, 3H). HR-MS: m/z calcd for $C_{16}H_{14}O$: 222.1045; found: 222.1045.



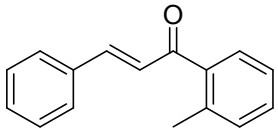
2e 3- (4-Chlorophenyl)-1-phenyl-propenone

Yellow solid, yield: 57%. ^{1}H-NMR (400 MHz, Chloroform-d) δ 7.99 (d, J = 7.6 Hz, 2H), 7.71 (d, J = 15.7 Hz, 1H), 7.58 – 7.43 (m, 6H), 7.33 (d, J = 8.3 Hz, 2H). HR-MS: m/z calcd for $C_{16}H_{11}ClO$: 242.0498; found: 242. 0497. These characterization data are matched with those previously reported [2].



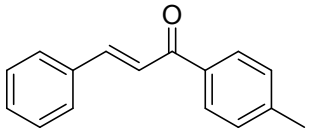
2f 3- (4-Fluorophenyl)-1-phenyl-propenone

Yellow solid, yield: 50%. ^{1}H-NMR (400 MHz, Chloroform-d) δ 8.02 (d, J = 7.5 Hz, 2H), 7.76 (d, J = 15.7 Hz, 1H), 7.58 (dq, J = 14.2, 7.3, 6.5 Hz, 3H), 7.51 – 7.42 (m, 3H), 7.07 (t, J = 8.5 Hz, 2H). HR-MS: m/z calcd for $C_{16}H_{11}ClO$: 226.0794; found: 226.0794. These characterization data are matched with those previously reported [3].



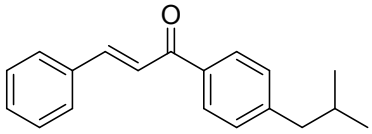
2g 3-phenyl-1-*o*-tolyl-propenone

Yellow solid, yield: 71%. ^{1}H-NMR (400 MHz, Chloroform-d) δ 7.54 – 7.45 (m, 3H), 7.45 (d, J = 12.4 Hz, 1H), 7.34 (t, J = 4.5 Hz, 4H), 7.27 – 7.20 (m, 2H), 7.12 (d, J = 16.1 Hz, 1H), 2.43 (s, 3H). HR-MS: m/z calcd for $C_{16}H_{14}O$: 222.1045; found: 222.1044. These characterization data are matched with those previously reported [4].



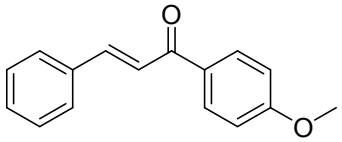
2h 3-phenyl-1-*p*-tolyl-propenone

Yellow solid, yield: 79%. ^{1}H-NMR (400 MHz, Chloroform-d) δ 7.95 (d, J = 8.0 Hz, 2H), 7.81 (d, J = 15.7 Hz, 1H), 7.68 – 7.62 (m, 2H), 7.55 (d, J = 15.7 Hz, 1H), 7.45 – 7.39 (m, 3H), 7.31 (d, J = 7.9 Hz, 2H), 2.44 (s, 3H). HR-MS: m/z calcd for $C_{16}H_{14}O$: 222.1045; found: 222.1045. These characterization data are matched with those previously reported [2].



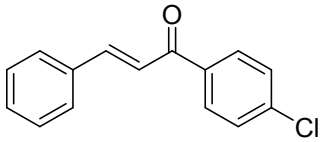
2i 1-(4-isobutyl-phenyl)-3 phenyl –propenone

Yellow solid, yield: 77%. ^{1}H-NMR (400 MHz, Chloroform-d) δ 7.96 (d, J = 8.0 Hz, 2H), 7.81 (d, J = 15.7 Hz, 1H), 7.67 – 7.61 (m, 2H), 7.55 (d, J = 15.7 Hz, 1H), 7.40 (d, J = 4.5 Hz, 43H), 7.27 (d, J = 8.0 Hz, 2H), 2.55 (d, J = 7.2 Hz, 2H), 1.91 (m, J = 13.5, 6.7 Hz, 1H), 0.92 (d, J = 6.6 Hz, 6H). HR-MS: m/z calcd for $C_{19}H_{20}O$: 264.1514; found: 264.1513.



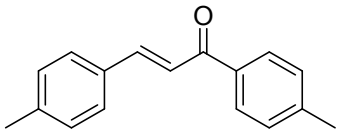
2j 1-(4-Methoxy-phenyl)-3-phenyl-propenone

Yellow solid, yield: 77%. ^{1}H-NMR (400 MHz, Chloroform-d) δ 8.05 (d, J = 8.9 Hz, 2H), 7.81 (d, J = 15.7 Hz, 1H), 7.64 (dd, J = 6.5, 2.8 Hz, 2H), 7.55 (d, J = 15.7 Hz, 1H), 7.41 (dd, J = 5.1, 1.8 Hz, 3H), 6.98 (d, J = 8.9 Hz, 2H), 3.87 (s, 3H). HR-MS: m/z calcd for $C_{16}H_{14}O_2$: 238.0994; found: 238.0992 These characterization data are matched with those previously reported [2].



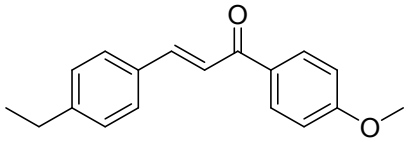
2k 1- (4-Chlorophenyl)-3-phenyl-propenone

Yellow solid, yield: 57%. ^{1}H-NMR (400 MHz, Chloroform-d) δ 7.98 – 7.93 (d, 2H), 7.81 (d, J = 15.7 Hz, 1H), 7.65 – 7.60 (m, 2H), 7.52 – 7.43 (m, 3H), 7.42 (q, J = 3.4 Hz, 3H). HR-MS: m/z calcd for $C_{16}H_{11}ClO$: 242.0498; found: 242. 0497. These characterization data are matched with those previously reported [2].



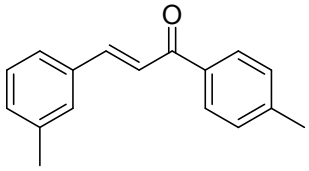
2l 1,3-Di-*p*-tolyl-propenone

Yellow solid, yield: 67%. ^{1}H-NMR (400 MHz, Chloroform-d) δ 7.95 (d, J = 8.2 Hz, 2H), 7.80 (d, J = 15.7 Hz, 1H), 7.56 – 7.47 (m, 3H), 7.29 (d, J = 8.0 Hz, 2H), 7.21 (d, J = 7.9 Hz, 2H), 2.42 (s, 3H), 2.38 (s, 3H). HR-MS: m/z calcd for $C_{17}H_{16}O$: 236.1201; found: 236.1201. These characterization data are matched with those previously reported [5].



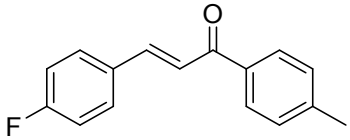
2m 3-(4-Ethyl-phenyl)-1-(4-methoxy-phenyl)- propenone

Yellow solid, yield: 79%. ^{1}H-NMR (400 MHz, Chloroform-d) δ 8.04 (d, J = 8.8 Hz, 2H), 7.80 (d, J = 15.6 Hz, 1H), 7.57 (d, J = 8.0 Hz, 2H), 7.51 (d, J = 15.6 Hz, 1H), 7.25 (d, J = 7.9 Hz, 2H), 6.98 (d, J = 8.8 Hz, 2H), 3.89 (s, 3H), 2.69 (q, J = 7.6 Hz, 2H), 1.26 (t, J = 7.6 Hz, 3H). HR-MS: m/z calcd for $C_{18}H_{18}O_2$: 266.1307; found: 266.1309.



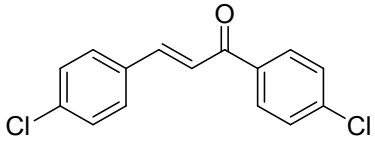
2n 3-m-Tolyl-1-*p*-tolyl-propenone

Yellow solid, yield: 78%. ^{1}H-NMR (400 MHz, Chloroform-d) δ 7.96 (d, J = 8.1 Hz, 2H), 7.79 (d, J = 15.7 Hz, 1H), 7.53 (d, J = 15.7 Hz, 1H), 7.45 (d, J = 5.6 Hz, 2H), 7.30 (d, J = 7.5 Hz, 3H), 7.22 (d, J = 7.5 Hz, 1H), 2.43 (s, 3H), 2.39 (s, 3H). HR-MS: m/z calcd for $C_{17}H_{16}O$: 236.1201; found: 236.1201. These characterization data are matched with those previously reported [4].



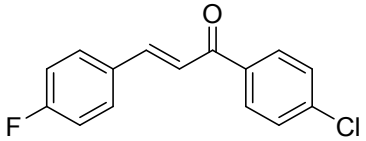
2o 3-(4-Fluoro-phenyl)-1-*p*-tolyl-propenone

Yellow solid, yield: 66%. ^{1}H-NMR (400 MHz, Chloroform-d) δ 7.93 (d, J = 8.1 Hz, 2H), 7.75 (d, J = 15.7 Hz, 1H), 7.61 (dd, J = 8.5, 5.5 Hz, 2H), 7.45 (d, J = 15.7 Hz, 1H), 7.28 (d, J = 8.0 Hz, 2H), 7.08 (t, J = 8.6 Hz, 2H), 2.41 (s, 3H). HR-MS: m/z calcd for $C_{16}H_{13}FO$: 240.0950; found: 240.0948. These characterization data are matched with those previously reported [4].



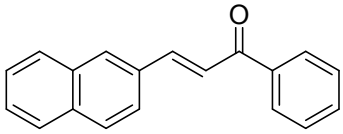
2p 1,3-Bis-(4-chloro-phenyl)-propenone

Yellow solid, yield: 50%. ^{1}H-NMR (400 MHz, Chloroform-d) δ 7.95 (d, J = 8.5 Hz, 2H), 7.75 (d, J = 15.7 Hz, 1H), 7.56 (d, J = 8.4 Hz, 2H), 7.49 – 7.41 (m, 3H), 7.38 (d, J = 8.4 Hz, 2H). HR-MS: m/z calcd for $C_{15}H_{10}Cl_2O$: 276.0109; found: 276.0111. These characterization data are matched with those previously reported [6].



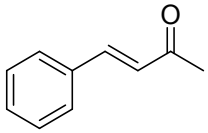
2q 1-(4-Chloro-phenyl)-3-(4-fluoro-phenyl)-propenone

Yellow solid, yield: 59%. ^{1}H-NMR (400 MHz, Chloroform-d) δ 7.94 (d, J = 8.2 Hz, 2H), 7.76 (d, J = 15.6 Hz, 1H), 7.66 – 7.56 (m, 2H), 7.45 (d, J = 8.2 Hz, 2H), 7.40 (d, J = 15.8 Hz, 1H), 7.09 (t, J = 8.2 Hz, 2H). HR-MS: m/z calcd for $C_{15}H_{10}ClFO$: 260.0404; found: 260.0402.



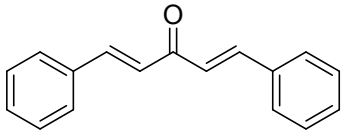
2r 3-Naphthalen-2- phenyl-propenone

Yellow solid, yield: 77%. ^{1}H-NMR (400 MHz, Chloroform-d) δ 8.64 (d, J = 15.4 Hz, 1H), 8.20 (d, J = 8.2 Hz, 1H), 8.05 (d, J = 7.4 Hz, 2H), 7.84 (q, J = 7.0, 6.4 Hz, 3H), 7.62 – 7.50 (m, 3H), 7.50 – 7.40 (m, 4H). HR-MS: m/z calcd for $C_{19}H_{14}O$: 258.1045; found: 258.1045. These characterization data are matched with those previously reported [3].



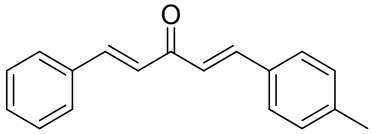
2s 4- phenyl-but-3-en-2-one

White solid, yield: 49% .^{1}H-NMR (400 MHz, Chloroform-d) δ 7.55 – 7.51 (m, 2H), 7.48 (s, 1H), 7.40 – 7.35 (m, 3H), 6.70 (d, J = 16.3 Hz, 1H), 2.36 (s, 3H). HR-MS: m/z calcd for $C_{10}H_{10}O$: 146.0732; found: 146.0732.



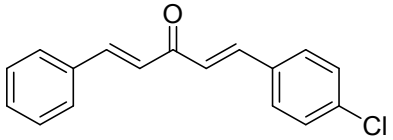
2t 1,5-Diphenyl-penta-1,4-dien-3-one

Yellow solid, yield: 77%. ^{1}H-NMR (400 MHz, Chloroform-d) δ 7.74 (d, J = 16.0 Hz,2H), 7.59 (dd, J = 6.2, 2.5 Hz,4H), 7.43 – 7.35 (m,6H), 7.08 (d, J = 16.0 Hz, 2H). HR-MS: m/z calcd for $C_{17}H_{14}O$: 234.1045; found: 234.1045.



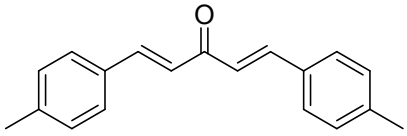
2u 1-phenyl-5-*p*-tolyl-penta-1,4-dien-3-one

Yellow solid, yield: 67%. ^{1}H-NMR (400 MHz, Chloroform-d) δ 7.75 (d, J = 3.2 Hz, 1H), 7.71 (d, J = 3.1 Hz, 1H), 7.65 – 7.60 (m, 2H), 7.52 (d, J = 7.9 Hz, 2H), 7.41 (d, J = 3.8 Hz, 3H), 7.22 (d, J = 7.8 Hz, 2H), 7.07 (t, J = 16.1 Hz, 2H), 2.39 (s, 3H). HR-MS: m/z calcd for $C_{18}H_{16}O$: 248.1201; found: 248.1199.



2v 1-(4-Chloro-phenyl)-5-phenyl-penta-1,4-dien-3-one

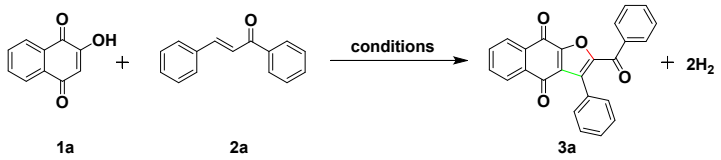
Yellow solid, yield: 50%. ^{1}H-NMR (400 MHz, Chloroform-d) δ 7.74 (d, J = 16.0 Hz, 1H), 7.68 (d, J = 15.9 Hz, 1H), 7.61 (dd, J = 6.5, 2.9 Hz, 2H), 7.54 (d, J = 8.5 Hz, 2H), 7.44 – 7.40 (m, 3H), 7.38 (d, J = 8.5 Hz, 2H), 7.08 (d, J = 2.9 Hz, 1H), 7.04 (d, J = 2.9 Hz, 1H). HR-MS: m/z calcd for $C_{17}H_{13}ClO$: 268.0655; found: 268.0657.



2w 1,5-Di-*p*-tolyl-penta-1,4-dien-3-one

Yellow solid, yield: 71%. ^{1}H-NMR (400 MHz, Chloroform-d) δ 7.72 (d, J = 15.9 Hz, 2H), 7.52 (d, J = 8.0 Hz, 4H), 7.22 (d, J = 7.8 Hz, 4H), 7.04 (d, J = 15.9 Hz, 2H), 2.39 (s, 6H). HR-MS: m/z calcd for $C_{19}H_{18}O$: 262.1358; found: 262.1356.

Reaction optimization for the synthesis of naphtho[2,3-b]furan-4,9-diones. [a]

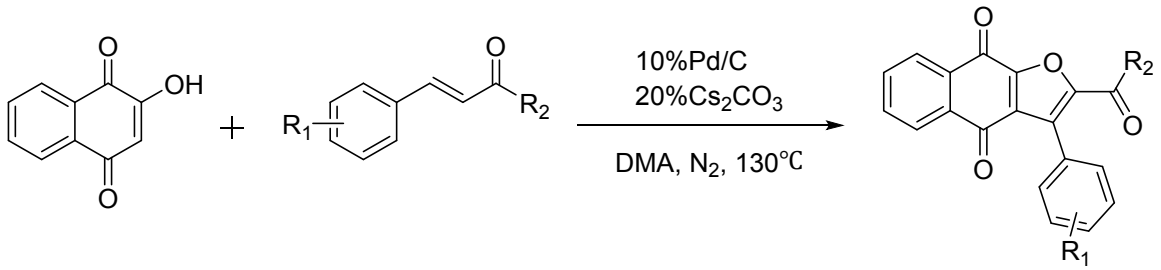


1a 2a 3a

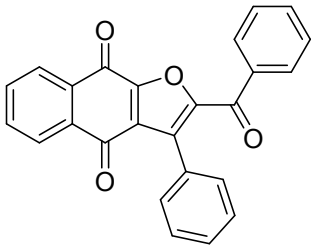
Entry	1a:2a(equiv)	conditions	Yield.(%) [b]
1	1:2	1ml DMA/10mol%Pd/50% Cs_2CO_3/120°C/ N_2	70
2	1:2	1ml DMF/10mol%Pd/50% Cs_2CO_3/120 °C/ N_2	47
3	1:2	1ml DMI/10mol%Pd/50% Cs_2CO_3/120°C/ N_2	47
4	1:2	1ml NMP/10mol%Pd/50% Cs_2CO_3/120 °C/ N_2	0
5	1:2	1ml DMSO/10mol%Pd/50% Cs_2CO_3/120 °C/ N_2	45
6	1:2	0.5ml DMA/10mol%Pd/50%Cs_2CO_3/120 °C/N_2	57
7	1:2	1.5ml DMA/10mol%Pd/50%Cs_2CO_3/120°C/N_2	56
8	1:2	1ml DMA/10mol%Pd/50% Na_2CO_3/120 °C/ N_2	57
9	1:2	1ml DMA/10mol%Pd/50% K_2CO_3/120 °C/ N_2	69
10	1:2	1ml DMA/10mol%Pd/50% NaOH/120 °C/ N_2	0
11	1:2	1ml DMA/10mol%Pd/50% CH_3ONa/120 °C/ N_2	0
12	1:2	1ml DMA/10mol%Pd/50% TsOH/120 °C/ N_2	0
13	1:2	1ml DMA/10mol%Pd/50% CH_3COOH/120 °C/ N_2	0
14	1:2	1ml DMA/10mol%Pd/120 °C/ N_2	0
15	1:2	1ml DMA/10mol%Pd/10% Cs_2CO_3/120 °C/ N_2	63
16	1:2	1ml DMA/10mol%Pd/20% Cs_2CO_3/120 °C/ N_2	83
17	1:2	1ml DMA/10mol%Pd/25% Cs_2CO_3/120 °C/ N_2	79
18	1:2	1ml DMA/10mol%Pd/20% Cs_2CO_3/110 °C/ N_2	63
19	**1:2**	**1ml DMA/10mol%Pd/20% Cs_2CO_3/130 °C/ N_2**	**84**
20	1:2	1ml DMA/10mol%Pd/20% Cs_2CO_3/140 °C/ N_2	59
21	1:2	1ml DMA/5mol%Pd/20% Cs_2CO_3/130 °C/ N_2	62
22	1:2	1ml DMA/15mol%Pd/20% Cs_2CO_3/130 °C/ N_2	81
23	1:2	1ml DMA/0mol%Pd/20% Cs_2CO_3/130 °C/ N_2	0
24	1:2	1ml DMA/10mol%Pd/20% Cs_2CO_3/130 °C/air	37
25	1:2	1ml DMA/10mol%Pd/20% Cs_2CO_3/130 °C/O_2	57
26	1:2	1ml DMA/10mol%Pd/20% Cs_2CO_3/130 °C/H_2	0
27	2:1	1ml DMA/10mol%Pd/20% Cs_2CO_3/130 °C/ N_2	80
28	1:1	1ml DMA/10mol%Pd/20% Cs_2CO_3/130 °C/ N_2	67
29	1:1.5	1ml DMA/10mol%Pd/20% Cs_2CO_3/130 °C/ N_2	79

[a] Reaction conditions: 0.2mmol substrates. [b] Isolated yields

General procedure for synthesis of naphtho[2,3-b]furan-4,9-diones compounds

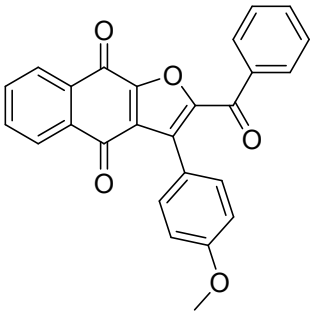


2-hydroxide-1,4-naphthoquinone(0.2 mmol), 1,3-Diphenyl- propenone (0.4mmol), Pd/C (21.2 mg, 0.02mmol Pd), Cs_2CO_3 (13.03 mg, 0.04mmol), and DMA (1 ml) were added to a two-necks reaction flask loaded with a stir bar. The reaction flask was first degassed under the oil pump, and then sealed with a N_2 balloon. The reaction was heated in an oil bath to 130℃ with vigorous stirring for an appropriate time, detected by GC and TLC. After the 2-hydroxide-1,4-naphthoquinone was completely disappeared, the solvent was evaporated under reduced pressure. The residue was purified by a silica gel column chromatography (ethylacetate/ petroleum ether=1:100) given a pure product of light yellow solid.



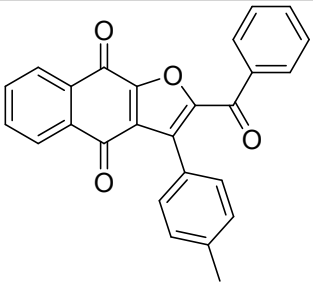
3a 2-Benzoyl-3-phenyl-4,9-dihydronaphtho[2,3-b]furane-4,9-dione

Yellow solid, yield: 83%. ^{1}H-NMR (400 MHz, Chloroform-d) δ 8.23 (d, J = 7.5 Hz, 1H), 8.01 (dd, J = 14.3, 7.6 Hz, 3H), 7.75 (dd, J = 6.6, 3.9 Hz, 3H), 7.69 (t, J = 7.3 Hz, 1H), 7.61 (t, J = 7.4 Hz, 1H), 7.47 (t, J = 7.7 Hz, 2H), 7.37 (q, J = 5.4 Hz, 3H). ^{13}C-NMR (101 MHz, Chloroform-d) δ 190.71 , 179.63 , 173.15 , 156.76 , 150.56 , 136.61 , 134.37 , 134.14 , 133.97 , 132.81 , 132.46 , 130.80 (d, J = 4.4 Hz), 129.53 , 129.07 , 128.97 , 127.47 , 127.09 , 126.95 , 118.81 . HR-MS: m/z calcd for $C_{25}H_{14}O_4$:378.0892; found:378.0892.



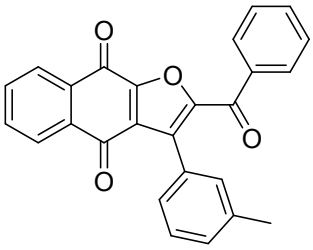
3b 2-Benzoyl-3-(4-methoxylphenyl)-4,9–dihydronaphtho[2,3-b]furane-4,9-dione

Yellow solid, yield: 80%.^{1}H-NMR (400 MHz, Chloroform-d) δ 8.27 – 8.21 (m, 1H), 8.05 – 7.99 (m, 1H), 7.99 – 7.94 (m, 2H), 7.79 – 7.66 (m, 4H), 7.61 (t, J = 7.4 Hz, 1H), 7.46 (t, J = 7.7 Hz, 2H), 6.88 (d, J = 8.9 Hz, 2H), 3.81 (s, 3H). ^{13}C-NMR (101 MHz, Chloroform-d) δ 191.33 , 180.12 , 173.35 , 161.95 , 157.58 , 150.41 , 137.08 , 134.60 , 134.41 , 134.15 , 133.16 , 132.87 , 131.38 , 129.85 , 129.26 , 129.09 , 127.38 , 127.23 , 120.41 , 117.62, 114.89, 55.75. HR-MS: m/z calcd for $C_{26}H_{16}O_5$:408.0998; found:408.0997.



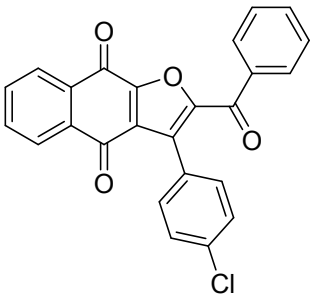
3c 2-Benzoyl-3-(4-methylphenyl)-4,9–dihydronaphtho[2,3-b]furane-4,9-dione

Yellow solid, yield: 71%. ^{1}H-NMR (400 MHz, Chloroform-d) δ 8.25 (d, J = 7.6 Hz, 1H), 8.04 (d, J = 7.4 Hz, 1H), 7.98 (d, J = 7.4 Hz, 2H), 7.74 (dt, J = 15.8, 7.5 Hz, 2H), 7.66 (t, J = 8.5 Hz, 2H), 7.61 (t, J = 7.4 Hz, 1H), 7.46 (t, J = 7.7 Hz, 2H), 7.18 (d, J = 8.0 Hz, 2H), 2.34 (s, 2H). ^{13}C-NMR (101 MHz, Chloroform-d) δ 190.87 , 179.72 , 173.11 , 157.17 , 150.33 , 141.37 , 136.67 , 134.29 , 134.10 , 133.89 , 132.83 , 132.52 , 130.92 , 129.79 , 129.52 , 128.93 , 127.07 , 126.92 (d, J = 2.1 Hz), 124.72 , 118.15 , 21.51 . HR-MS: m/z calcd for $C_{26}H_{16}O_4$: 392,1049; found:392,1047.



3d 2-Benzoyl-3-(3-methylphenyl)-4,9–dihydronaphtho[2,3-b]furane-4,9-dione

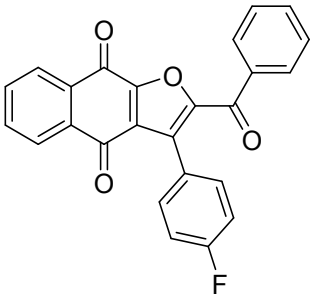
Yellow solid, yield: 79%. ^{1}H-NMR (400 MHz, Chloroform-d) δ 8.25 (d, J = 7.6 Hz, 1H), 8.04 (d, J = 7.4 Hz, 1H), 7.98 (d, J = 7.7 Hz, 2H), 7.74 (dt, J = 22.5, 7.4 Hz, 2H), 7.65 – 7.57 (m, 2H), 7.48 (q, J = 8.3, 7.7 Hz, 3H), 7.27 – 7.18 (m, 2H), 2.33 (s, 3H). ^{13}C-NMR (101 MHz, Chloroform-d) δ 190.77 , 179.67 , 173.19 , 157.02 , 150.49 , 138.94 , 136.66 , 134.30 , 134.12 , 133.95 , 132.84 , 132.49 , 131.64 , 130.85 , 129.51 , 128.94 , 127.41 (d, J = 7.8 Hz), 127.10 , 126.96 , 124.22 , 118.69 , 21.38 . HR-MS: m/z calcd for $C_{26}H_{16}O_4$: 392,1049; found:392,1048.



3e 2-Benzoyl-3-(4-chlorophenyl)-4,9-dihydronaphtho[2,3-b]furane-4,9-dione

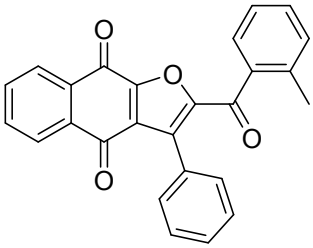
Yellow solid, yield: 61%. ^{1}H-NMR (400 MHz, Chloroform-d) δ 8.27 – 8.23 (m, 1H), 8.06 – 8.02 (m, 1H), 7.96 (d, J = 7.3 Hz, 2H), 7.78 (td, J = 7.5, 1.3 Hz, 1H), 7.72 (t, J = 8.0 Hz, 3H), 7.63 (t, J = 7.4 Hz, 1H), 7.48 (t, J = 7.7 Hz, 2H), 7.36 (d, J = 8.7 Hz, 2H). ^{13}C-NMR (101 MHz, Chloroform-d) δ 190.86 , 179.85 , 173.50 , 155.98 , 150.97 , 137.38 , 136.80 , 134.87 , 134.55 , 134.41 , 133.12 , 132.74 , 131.09 ,

129.80 (d, J = 5.7 Hz), 129.37 , 128.50 , 127.50 , 127.35 , 126.28 , 119.47 . HR-MS: m/z calcd for $C_{25}H_{13}ClO_4$: 412.0502; found:412.0502.



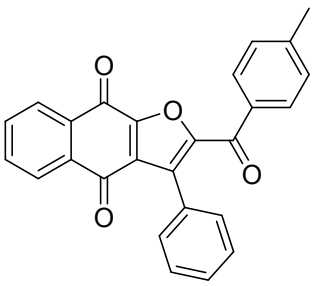
3f 2-Benzoyl-3-(4-fluorophenyl)-4,9-dihydronaphtho[2,3-b]furane-4,9-dione

Yellow solid, yield:71 %. ^{1}H-NMR (400 MHz, Chloroform-d) δ 8.21 (d, J = 7.5 Hz, 1H), 8.01 (d, J = 7.4 Hz, 1H), 7.97 (d, J = 7.7 Hz, 2H), 7.75 (dt, J = 10.2, 5.7 Hz, 3H), 7.69 (t, J = 7.4 Hz, 1H), 7.61 (t, J = 7.4 Hz, 1H), 7.47 (t, J = 7.6 Hz, 2H), 7.06 (t, J = 8.5 Hz, 2H). ^{13}C-NMR (101 MHz, Chloroform-d) δ 190.58 , 179.53 , 173.10 , 165.27 , 162.75 , 155.93 , 150.50 , 136.58 , 134.45 , 134.17 , 134.01 , 132.78 , 132.38 , 130.77 , 129.50 , 129.23 (d, J = 8.7 Hz), 129.00 , 126.94 , 123.98 – 123.64 (m), 118.56 , 116.50 , 116.28 .. HR-MS: m/z calcd for $C_{25}H_{13}FO_4$: 396.0798; found:396.0800.



3g 2-(2-methylphenyl)-3-phenyl-4,9-dihydronaphtho[2,3-b]furane-4,9-dione

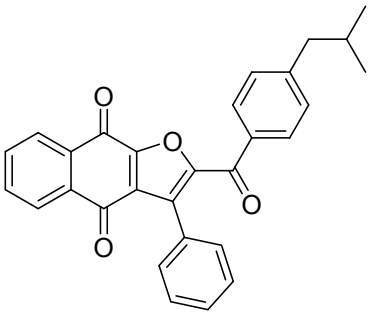
Yellow solid, yield: 59%. ^{1}H-NMR (400 MHz, Chloroform-d) δ 8.26 – 8.22 (m, 1H), 8.05 – 8.00 (m, 1H), 7.85 – 7.79 (m, 2H), 7.75 (td, J = 7.5, 1.3 Hz, 1H), 7.70 (td, J = 7.5, 1.3 Hz, 1H), 7.53 (d, J = 7.7 Hz, 1H), 7.41 (dt, J = 5.7, 2.7 Hz, 5H), 7.13 (t, J = 7.1 Hz, 1H), 2.84 (s, 3H). ^{13}C-NMR (101 MHz, Chloroform-d) δ 192.44 , 179.68 , 173.21 , 156.56 , 150.45 , 140.91 , 136.14 , 134.06 , 133.90 , 132.96 , 132.83 , 132.45 (d, J = 3.7 Hz), 131.54 , 130.77 , 130.61 , 129.06 , 127.61 , 127.07 , 126.95 , 125.78 , 120.78 , 21.82 . HR-MS: m/z calcd for $C_{26}H_{16}O_4$: 392,1049; found:392,1051.



3h 2-(4-methylphenyl)-3-phenyl-4,9-dihydronaphtho[2,3-b]furane-4,9-dione

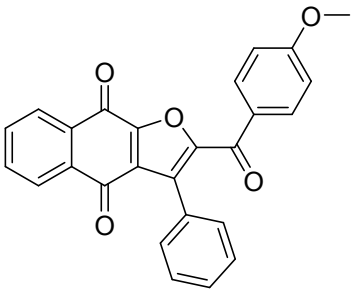
White solid, yield: 71%. ^{1}H-NMR (400 MHz, Chloroform-d) δ 8.25 (dd, J = 7.6, 1.1 Hz, 1H), 8.05 (dd, J = 7.5, 1.1 Hz, 1H), 7.88 (d, J = 8.2 Hz, 2H), 7.77 (ddd, J = 7.8, 6.0, 1.7 Hz, 3H), 7.71 (td, J = 7.5, 1.3 Hz, 1H), 7.42 – 7.34 (m, 3H), 7.27 (s, 1H), 7.26 (d, J = 2.4 Hz, 1H), 2.41 (s, 2H). ^{13}C-NMR (101 MHz, Chloroform-d) δ 190.64 , 180.03 , 173.53 , 156.93 , 150.85 , 145.89 , 134.52 , 134.45 , 134.28 , 133.18 ,

132.83 , 131.17 , 131.03 , 130.04 (d, J = 5.2 Hz), 129.39 , 127.87 , 127.45 , 127.26 (d, J = 5.9 Hz), 119.35 , 22.22 . HR-MS: m/z calcd for $C_{26}H_{16}O_4$: 392.1049; found:392.1049.



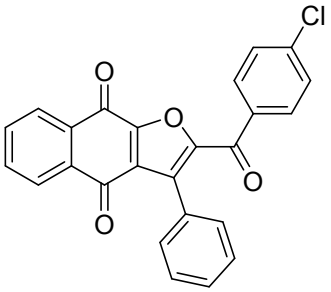
3i 2-(4-isopropylphenyl))-3-phenyl-4,9-dihydronaphtho[2,3-b]furane-4,9-dione

Yellow solid, yield: 69%.^{1}H-NMR (400 MHz, Chloroform-d) δ 8.27 – 8.22 (m, 1H), 8.07 – 8.02 (m, 1H), 7.89 (d, J = 8.2 Hz, 1H), 7.76 (ddd, J = 8.8, 4.1, 2.2 Hz, 3H), 7.71 (td, J = 7.5, 1.3 Hz, 1H), 7.41 – 7.34 (m, 3H), 7.23 (d, J = 8.2 Hz, 2H), 2.52 (d, J = 7.2 Hz, 2H), 1.90 (m, J = 13.5, 6.8 Hz, 1H), 0.90 (d, J = 6.6 Hz, 6H). ^{13}C-NMR (101 MHz, Chloroform-d) δ 190.34 , 179.65 , 173.19 , 156.58 , 150.54 , 149.18 , 134.43 , 134.09 , 133.94 , 132.88 , 132.49 , 130.86 , 130.67 , 129.72 , 129.56 , 129.03 , 127.57 , 127.10 , 126.94 , 119.07 , 45.56 , 30.05 , 22.40 . HR-MS: m/z calcd for $C_{29}H_{22}O_4$: 434.1518; found: 434.1520.



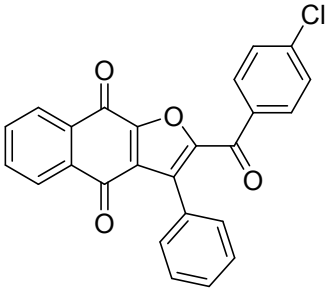
3j 2-(4-methoxylphenyl)-3-phenyl-4,9-dihydronaphtho[2,3-b]furane-4,9-dione

Yellow solid, yield: 80%. ^{1}H-NMR (400 MHz, Chloroform-d) δ 8.25 (dd, J = 7.5, 1.1 Hz, 1H), 8.05 (dd, J = 7.5, 1.1 Hz, 1H), 7.96 (d, J = 8.8 Hz, 2H), 7.80 – 7.74 (m, 3H), 7.71 (td, J = 7.5, 1.4 Hz, 1H), 7.42 – 7.34 (m, 3H), 6.93 (d, J = 9.0 Hz, 2H), 3.85 (s, 3H). ^{13}C-NMR (101 MHz, Chloroform-d) δ 189.06 , 179.71 , 173.19 , 164.60 , 156.42 , 150.54 , 134.10 , 133.94 , 132.88 , 132.49 , 132.01 , 130.79 , 130.65 , 129.75 , 129.05 , 127.58 , 127.09 , 126.90 (d, J = 6.9 Hz), 119.07 , 114.28 , 55.57 . HR-MS: m/z calcd for $C_{26}H_{16}O_5$: 408.0998; found: 408.0999.



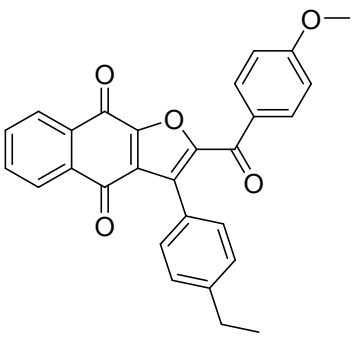
3k 2-(4-chlorophenyl)-3-phenyl-4,9-dihydronaphtho[2,3-b]furane-4,9-dione

Yellow solid, yield: 68%.^{1}H-NMR (400 MHz, Chloroform-d) δ 8.25 (d, J = 6.8 Hz, 1H), 8.04 (d, J = 6.9 Hz, 1H), 7.92 (d, J = 8.1 Hz, 2H), 7.80 – 7.68 (m, 4H), 7.48 – 7.35 (m, 5H). ^{13}C-NMR (101 MHz, Chloroform-d) δ 189.48 , 179.69 , 173.13 , 156.97 , 150.62 , 140.97 , 135.01 , 134.25 , 134.05 , 132.75 , 132.43 , 130.95 , 130.83 , 130.68 , 129.38 , 129.14 , 127.33 , 127.13 , 127.00 (d, J = 6.5 Hz), 118.28 . HR-MS: m/z calcd for $C_{25}H_{13}ClO_4$: 412.0502; found:412.0502.



3l 2-(4-methylphenyl)-3-(4-methylphenyl)-4,9-dihydronaphtho[2,3-b]furane-4,9-dione

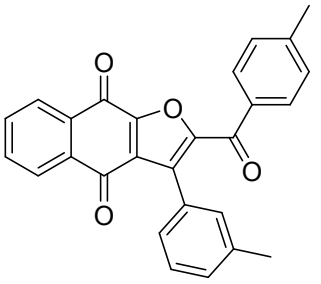
Yellow solid, yield: 71%. ^{1}H-NMR (400 MHz, Chloroform-d) δ 8.27 – 8.22 (m, 1H), 8.07 – 8.02 (m, 1H), 7.87 (d, J = 8.1 Hz, 2H), 7.80 – 7.67 (m, 2H), 7.65 (d, J = 8.2 Hz, 2H), 7.27 (s, 1H), 7.25 (s, 1H), 7.17 (d, J = 8.1 Hz, 1H), 2.40 (s, 2H), 2.34 (s, 2H). ^{13}C-NMR (101 MHz, Chloroform-d) δ 190.46 , 179.77 , 173.13 , 156.98 , 150.28 , 145.46 , 141.26 , 134.26 , 134.07 , 133.86 , 132.86 , 132.54 , 130.93 , 129.77 , 129.69 (d, J = 2.3 Hz), 127.08 , 126.89 (d, J = 6.2 Hz), 124.78 , 118.36 , 21.88 , 21.51 . HR-MS: m/z calcd for $C_{27}H_{18}O_4$: 406.1205; found: 406.1205.



3m 2-(4-ethylphenyl)-3-(4-methoxylphenyl)-4,9-dihydronaphtho[2,3-b]furane-4,9-dione

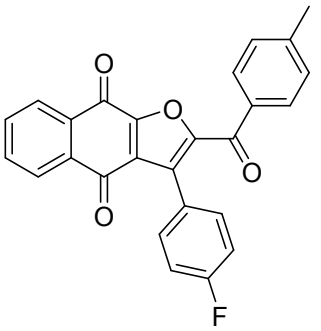
Yellow solid, yield: 69%. ^{1}H-NMR (400 MHz, Chloroform-d) δ 8.27 – 8.22 (m, 1H), 8.07 – 8.02 (m, 1H), 7.96 (d, J = 8.8 Hz, 2H), 7.74 (dt, J = 14.9, 7.5, 1.3 Hz, 2H), 7.69 (d, J = 8.3 Hz, 2H), 7.20 (d, J = 8.3 Hz, 2H), 6.93 (d, J = 8.9 Hz, 2H), 3.85 (s, 3H), 2.64 (q, J = 7.6 Hz, 2H), 1.21 (t, J = 7.6 Hz, 3H). ^{13}C-NMR (101 MHz, Chloroform-d) δ 189.24 , 179.80 , 173.12 , 164.53 , 156.82 , 150.29 , 147.40 ,

134.05 , 133.85 , 132.88 , 132.55 , 132.00 , 130.88 , 129.84 , 128.58 , 127.05 , 126.91 , 125.01 , 118.42 , 114.24 , 55.55 , 28.78 , 15.12 . HR-MS: m/z calcd for $C_{28}H_{20}O_5$: 436.1311; found: 436.1313.



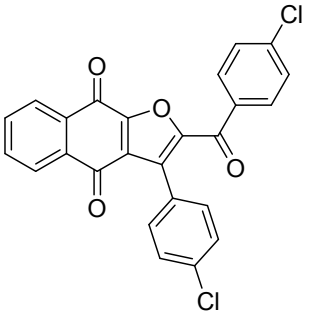
3n 2-(4-methylphenyl)-3-(3-methylphenyl)-4,9-dihydronaphtho[2,3-b]furane-4,9-dione

Yellow solid, yield: 74%. ^{1}H-NMR (400 MHz, Chloroform-d) δ 8.24 (dd, J = 7.6, 1.4 Hz, 1H), 8.06 – 8.02 (m, 1H), 7.88 (d, J = 8.2 Hz, 2H), 7.73 (dtd, J = 22.1, 7.4, 1.3 Hz, 2H), 7.63 (s, 1H), 7.49 (d, J = 7.3 Hz, 1H), 7.27 (s, 1H), 7.25 (s, 1H), 7.23 – 7.16 (m, 2H), 2.40 (s, 3H), 2.33 (s, 3H). ^{13}C-NMR (101 MHz, Chloroform-d) δ 190.35 , 179.70 , 173.19 , 156.82 , 150.44 , 145.45 , 138.90 , 134.26 , 134.08 , 133.91 , 132.86 , 132.51 , 131.56 , 130.86 , 129.68 (d, J = 3.9 Hz), 128.92 , 127.41 (d, J = 5.8 Hz), 127.09 , 126.93 , 124.17 , 118.91 , 21.88 , 21.39 . HR-MS: m/z calcd for $C_{27}H_{18}O_4$: 406.1205; found: 406.1205.



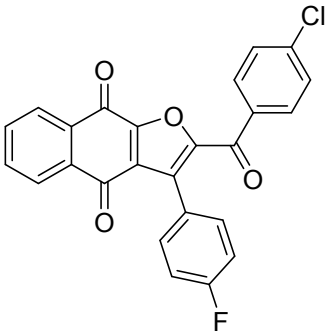
3o 2-(4-methylphenyl)-3-(4-fluorophenyl)-4,9-dihydronaphtho[2,3-b]furane-4,9-dione

Yellow solid, yield: 70%. ^{1}H-NMR (400 MHz, Chloroform-d) δ 8.23 (d, J = 7.3 Hz, 1H), 8.04 (d, J = 7.4 Hz, 1H), 7.87 (d, J = 8.1 Hz, 2H), 7.80 – 7.73 (m, 3H), 7.71 (t, J = 7.1 Hz, 1H), 7.27 (d, J = 7.9 Hz, 2H), 7.07 (t, J = 8.6 Hz, 2H), 2.41 (s, 3H). ^{13}C-NMR (101 MHz, Chloroform-d) δ 190.10 , 179.56 , 173.12 , 165.24 , 162.72 , 155.75 , 150.49 , 145.62 , 134.16 (d, J = 10.6 Hz), 133.95 , 132.85 , 132.44 , 130.79 , 129.69 (d, J = 9.0 Hz), 129.17 (d, J = 8.7 Hz), 127.11 , 126.93 , 123.91 (d, J = 2.5 Hz), 118.80 , 116.46 , 116.24 , 21.84 . HR-MS: m/z calcd for $C_{26}H_{15}FO_4$: 410.0954; found: 410.0954.



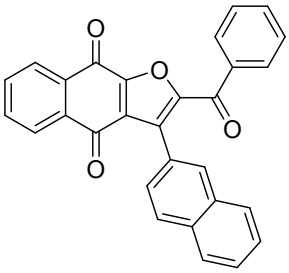
3p 2-(4-chlorophenyl)-3-(4-chlorophenyl)-4,9-dihydronaphtho[2,3-b]furane-4,9-dione

Yellow solid, yield: 52%.^{1}H-NMR (400 MHz, Chloroform-d) δ 8.26 (d, J = 7.5 Hz, 1H), 8.05 (d, J = 7.6 Hz, 1H), 7.90 (d, J = 8.5 Hz, 2H), 7.82 – 7.72 (m, 2H), 7.70 (d, J = 8.6 Hz, 2H), 7.44 (s, 2H), 7.38 (d, J = 8.6 Hz, 2H). HR-MS: m/z calcd for $C_{25}H_{12}Cl_2O_4$: 446.0113; found: 446.0116.



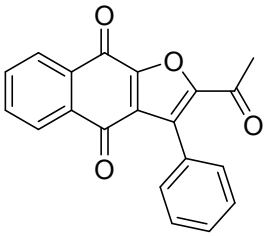
3q 2-(4-chlorophenyl)-3-(4-fluorophenyl)-4,9-dihydronaphtho[2,3-b]furane-4,9-dione

Yellow solid, yield: 63%. ^{1}H-NMR (400 MHz, Chloroform-d) δ 8.27 – 8.22 (m, 1H), 8.06 – 8.02 (m, 1H), 7.90 (d, J = 8.6 Hz, 2H), 7.81 – 7.70 (m, 4H), 7.44 (d, J = 8.6 Hz, 2H), 7.10 (t, J = 8.6 Hz, 2H). ^{13}C-NMR (101 MHz, Chloroform-d) δ 189.70 , 179.95 , 173.44 , 165.74 , 156.51 , 150.92 , 141.42 , 135.36 , 134.62 , 134.44 , 133.08 , 132.73 , 131.12 , 130.96 (d, J = 3.3 Hz), 129.75 , 129.66 , 129.57 , 127.50 , 127.38 , 118.41 , 116.94 , 116.72 . HR-MS: m/z calcd for $C_{25}H_{12}ClFO_4$: 430.0408; found: 430.0408.



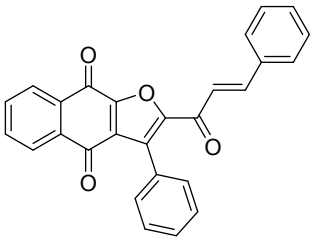
3r 2-(2-Naphthylcarbonyl)-3-phenyl-4,9-dihydronaphtho[2,3-b]-furane-4,9-dione

Yellow solid, yield: 74%. ^{1}H-NMR (400 MHz, Chloroform-d) δ 8.28 – 8.25 (m, 1H), 8.14 (d, J = 7.9 Hz, 1H), 8.10 (dd, J = 7.4, 1.2 Hz, 1H), 7.88 (q, J = 8.1, 7.4 Hz, 4H), 7.75 (dtd, J = 16.6, 7.4, 1.3 Hz, 2H), 7.69 – 7.65 (m, 1H), 7.54 (dq, J = 13.1, 6.9, 6.1 Hz, 2H), 7.47 (t, J = 7.4 Hz, 1H), 7.42 – 7.37 (m, 1H), 7.32 (t, J = 7.8 Hz, 2H). ^{13}C-NMR (101 MHz, Chloroform-d) δ 189.46 , 179.49 , 173.38 , 158.74 , 151.54 , 136.63 , 134.08 (d, J = 2.9 Hz), 133.87 , 133.54 , 132.98 , 132.29 , 131.67 , 131.01 , 130.01 , 129.82 , 129.33 , 128.58 (d, J = 3.3 Hz), 127.65 , 127.19 , 126.91 , 126.58 , 125.04 , 124.86 , 124.71 , 121.79 . HR-MS: m/z calcd for $C_{29}H_{16}O_4$: 428.1049; found: 428.1049.



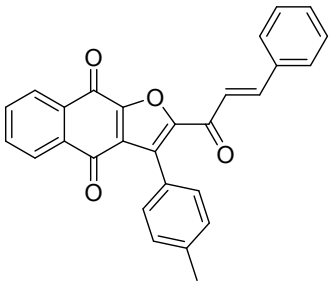
3s 2-Acetyl-3-phenyl-4,9-dihydronaphtho[2,3-b]furane-4,9-dione

Yellow solid, yield: 43%.^{1}H-NMR (400 MHz, Chloroform-d) δ 8.27 – 8.22 (m, 1H), 8.21 – 8.16 (m, 1H), 7.87 – 7.82 (m, 2H), 7.81 – 7.77 (m, 2H), 7.48 (dd, J = 5.2, 1.7 Hz, 3H), 2.72 (s, 3H). ^{13}C-NMR (101 MHz, Chloroform-d) δ 197.53 , 180.29 , 173.22 , 156.79 , 150.57 , 134.24 , 134.11 , 132.99 , 132.23 , 131.06 , 129.14 , 129.00 , 127.60 (d, J = 3.9 Hz), 127.22 , 126.94 , 121.41 , 32.07 . HR-MS: m/z calcd for $C_{20}H_{12}O_4$: 316.0736; found: 316.0738.



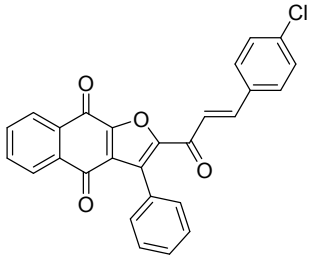
3t 2-Phenyl-acryloyl-3-phenyl-4,9-dihydronaphtho[2,3-b]furane-4,9-dione

Yellow solid, yield: 69%.^{1}H-NMR (500 MHz, Chloroform-d) δ 8.27 – 8.22 (m,1H), 8.16 – 8.11 (m, 1H), 7.85 (dd, J = 6.5, 2.8 Hz, 2H), 7.81 – 7.71 (m, 2H), 7.58 – 7.48 (m, 3H), 7.46 – 7.41 (m, 3H), 7.38 (t, J = 7.8 Hz, 3H), 7.16 (d, J = 16.1 Hz, 1H). ^{13}C-NMR (126 MHz, Chloroform-d) δ 190.37 , 180.46 , 173.86 , 157.69 , 151.32 , 147.45 , 134.76 , 134.66 (d, J = 4.0 Hz), 133.60 , 133.02 , 131.78 , 131.51 , 130.88 , 129.69 , 129.57 (d, J = 9.9 Hz), 129.43 , 128.19 , 128.06 – 127.66 (m), 127.55 , 120.22 . HR-MS: m/z calcd for $C_{27}H_{16}O_4$: 404.1049; found: 404.1050.



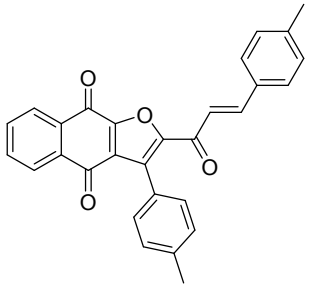
3u 2-(3-Phenyl-acryloy)-3-p-toly-naphtho[2,3-b]furan-4,9-dione

Yellow solid, yield: 63%. ^{1}H-NMR (400 MHz, Chloroform-d) δ 8.25 (d, J = 6.2 Hz, 1H), 8.13 (d, J = 6.4 Hz, 1H), 7.85 (s, 2H), 7.76 – 7.67 (m, 2H), 7.52 (t, J = 13.1 Hz, 2H), 7.46 – 7.32 (m, 4H), 7.24 (d, J = 8.2 Hz, 1H), 7.19 – 7.05 (m, 2H), 2.35 (s, 3H). HR-MS: m/z calcd for $C_{28}H_{18}O_4$: 418.1205; found: 418.1204.



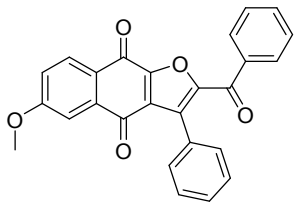
3v 2-[3-(4-Chloro-phenyl)-acryloyl]-3-phenyl-naphtho[2,3-b]furan-4,9-dione

Yellow solid, yield: 47%.^{1}H-NMR (400 MHz, Chloroform-d) δ 8.25 (d, J = 7.1 Hz, 1H), 8.14 (d, J = 7.0 Hz, 1H), 7.86 – 7.72 (m, 4H), 7.58 – 7.51 (m, 2H), 7.50 – 7.41 (m, 3H), 7.41 – 7.31 (m, 3H), 7.14 (t, J = 16.7 Hz, 1H). ^{13}C-NMR (126 MHz, Chloroform-d) δ 190.09 , 180.19 , 173.59 , 157.42 , 151.05 , 147.16 , 145.97 , 134.42 (d, J = 14.2 Hz), 133.33 , 132.75 , 131.50 , 131.24 , 130.51 , 129.37 (d, J = 10.5 Hz), 129.25 , 129.14 , 128.42 , 127.59 , 127.28 , 121.86 , 119.93 . HR-MS: m/z calcd for $C_{27}H_{15}ClO_4$: 438.0659; found: 438.0660.



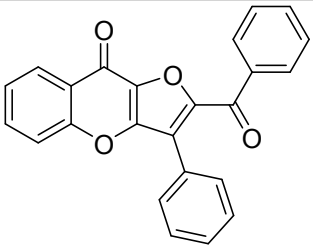
3w 3-*p*-Tolyl-2-(3-*p*-tolyl-acryloy)-naphtho[2,3-b]furan-4,9-dione

Yellow solid, yield: 59%. ^{1}H-NMR (400 MHz, Chloroform-d) δ 8.25 (dd, J = 7.1, 1.8 Hz, 1H), 8.13 (dd, J = 7.4, 1.4 Hz, 1H), 7.80 – 7.71 (m, 4H), 7.49 (d, J = 16.1 Hz, 1H), 7.40 (d, J = 8.1 Hz, 2H), 7.23 (d, J = 8.1 Hz, 2H), 7.17 (d, J = 8.0 Hz, 2H), 7.10 (d, J = 16.1 Hz, 1H), 2.36 (d, J = 7.8 Hz, 6H). ^{13}C-NMR (101 MHz, Chloroform-d) δ 190.04 , 179.91 , 173.21 , 157.32 , 150.44 , 147.02 , 141.85 , 141.42 , 134.07 , 133.93 , 132.98 , 132.44 , 131.34 , 130.39 , 129.75 (d, J = 5.3 Hz), 128.84 , 127.16 (d, J = 1.7 Hz), 126.89 , 126.39 , 124.80 , 118.99 , 21.57 (d, J = 3.4 Hz). HR-MS: m/z calcd for $C_{29}H_{20}O_4$: 432.1362; found: 432.1362.



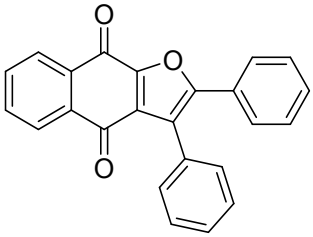
3x 6-methoxy-2-Benzoyl-3-phenyl-4,9-dihydronaphtho[2,3-b]furane-4,9-dione

Yellow solid, yield: 81%.^{1}H-NMR (400 MHz, Chloroform-d) δ 8.17 (d, J = 8.6 Hz, 1H), 7.99 – 7.95 (m, 2H), 7.76 – 7.72 (m, 2H), 7.62 – 7.57 (m, 1H), 7.49 – 7.43 (m, 3H), 7.41 – 7.32 (m, 3H), 7.18 (dd, J = 8.6, 2.7 Hz, 1H). ^{13}C-NMR (101 MHz, Chloroform-d) δ 190.80 , 179.62 , 172.64 , 164.30 , 156.38 , 150.98 , 136.69 , 135.09 , 134.31 , 130.63 , 130.42 , 129.50 , 129.39 , 128.99 (d, J = 9.2 Hz), 127.56 , 126.90 , 125.68 , 119.82 , 118.70 , 111.34 , 55.95 . HR-MS: m/z calcd for $C_{26}H_{16}O_5$:408.0998; found:408.0997.



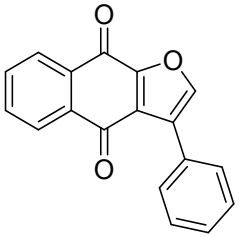
3y 2-Benzoyl-3-phenyl-1,4-dioxa-cyclopenta[b]naphthalen-9-one

White solid, yield: 49%. ^{1}H-NMR (400 MHz, Chloroform-d) δ 8.03 (s, 1H), 7.97 (s, 2H), 7.73 (s, 2H), 7.58 (s, 2H), 7.45 (t, 4H), 7.38 (s, 3H). ^{13}C-NMR (101 MHz, Chloroform-d) δ 190.52 , 156.49 , 156.25 , 154.08 , 153.00 , 136.82 , 134.17 , 131.35 , 129.90 , 129.71 , 128.96 , 128.78 , 128.09 , 126.55 , 124.75 , 121.14 , 118.29 , 117.52 , 112.27 , 111.66 . HR-MS: m/z calcd for $C_{24}H_{14}O_4$: 366.0892; found: 366.0890.



3z 2,3-Diphenyl-naphtho[2,3-b]furan-4,9-dione

^{1}H-NMR (400 MHz, DMSO-d6) δ 8.19 (dd, J = 6.8, 2.2 Hz, 1H), 8.05 (dd, J = 6.9, 2.2 Hz, 1H), 7.92 (ddd, J = 6.7, 4.2, 1.9 Hz, 2H), 7.71 – 7.24 (m, 10H). ^{13}C-NMR (101 MHz, DMSO-d6) δ 180.58, 173.35, 154.68, 151.40, 134.63, 133.63, 132.48, 130.52, 130.46, 130.42, 129.55, 129.45, 129.05, 128.98, 128.63, 127.21, 126.90, 126.59, 121.82. HR-MS: m/z calcd for $C_{24}H_{14}O_3$: 350.0943; found: 350.0944. Mp:212-213℃



3α 3-phenyl-naphtho[2,3-b]furan-4,9-dione

^{1}H-NMR (400 MHz, DMSO-d_6) δ 8.16 – 8.10 (m, 2H), 8.01 (d, J = 7.3 Hz, 2H), 7.93 – 7.87 (m, 2H), 7.74 (s, 1H), 7.55 (dt, J = 15.0, 7.0 Hz, 3H). ^{13}C-NMR (126 MHz, Chloroform-d) δ 180.70 , 172.93 , 160.21 , 133.88 , 133.52 , 132.96 , 132.73 , 132.30 , 130.17 , 128.99 , 128.18 , 126.84 , 126.79 , 125.43 , 102.82 . HR-MS: m/z calcd for $C_{24}H_{14}O_3$: 274.0630; found: 274.0631. Mp: 238-240℃

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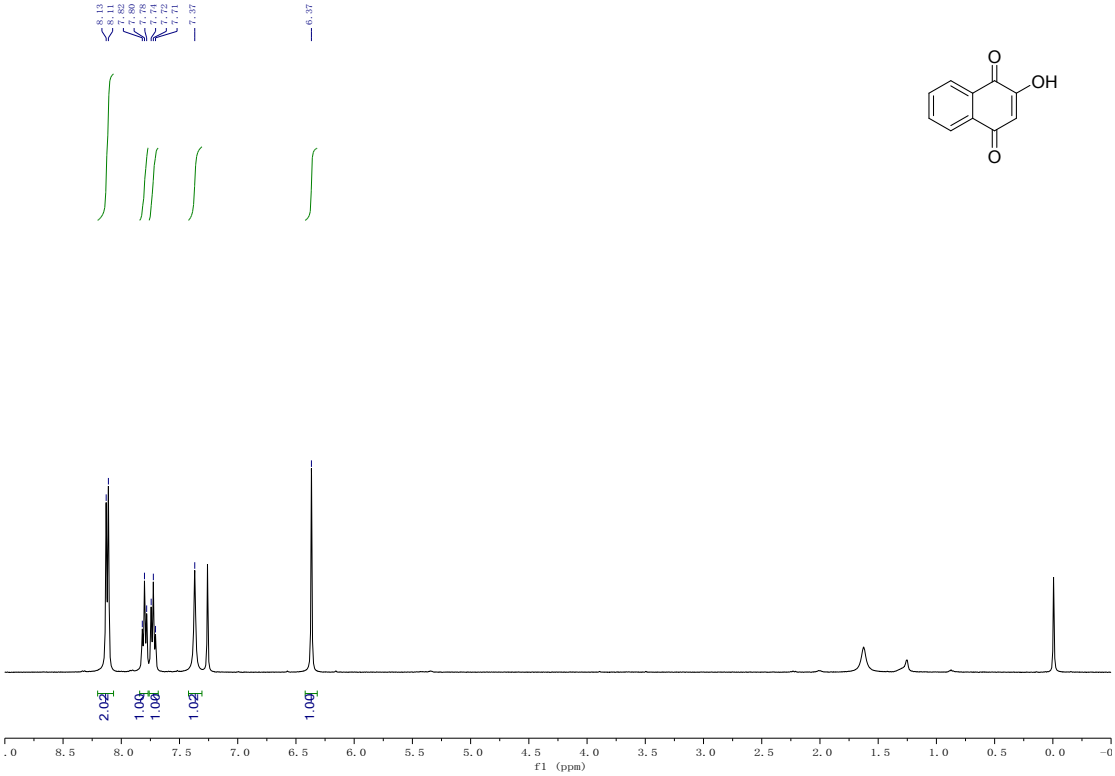
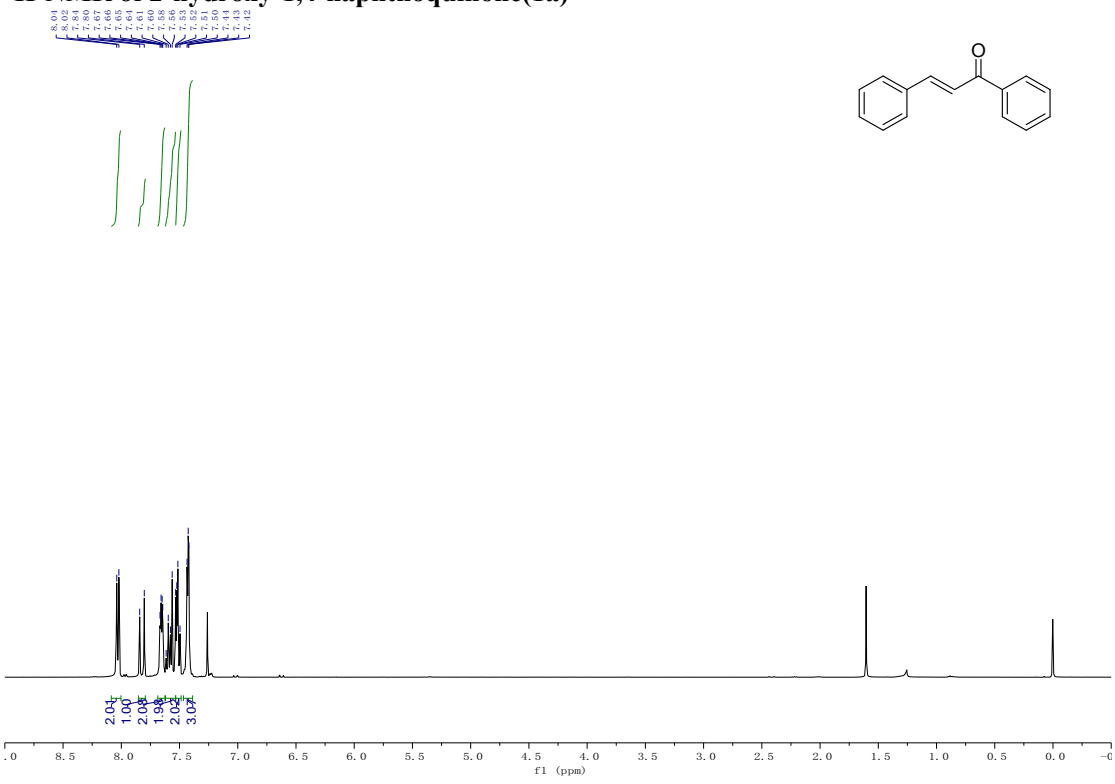
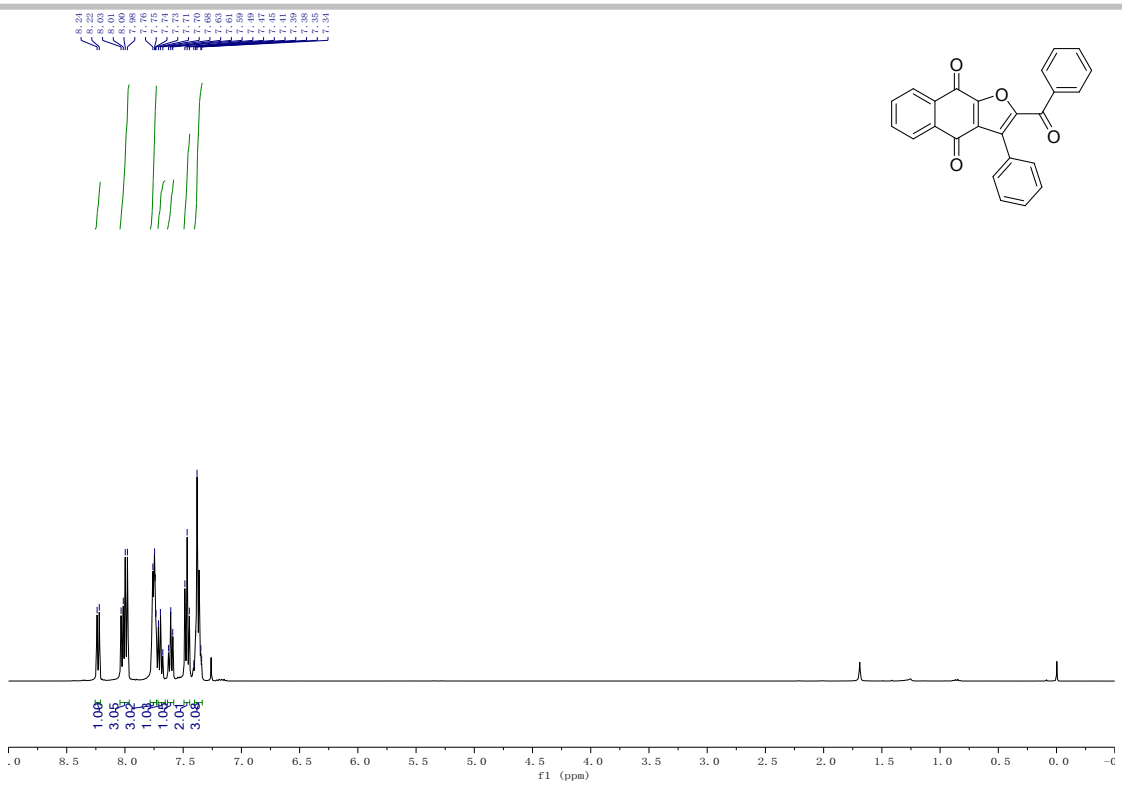
NMR spectra



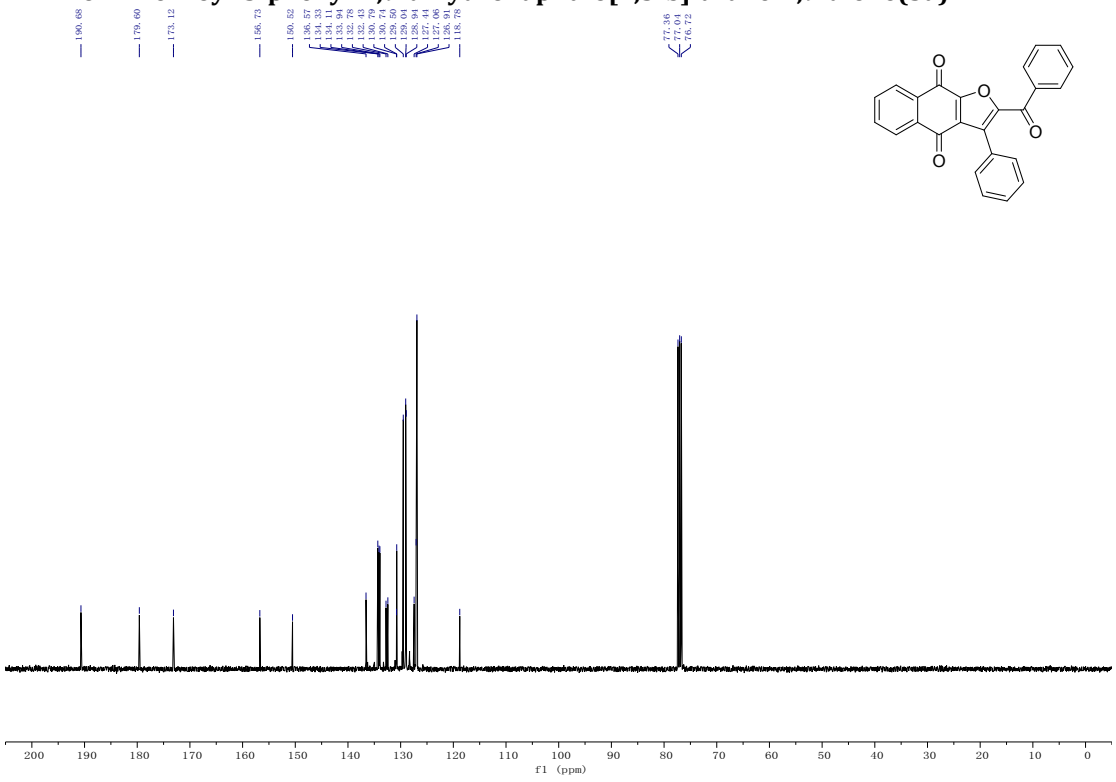
[1]H-NMR of 2-hydroxy-1,4-naphthoquinone(1a)



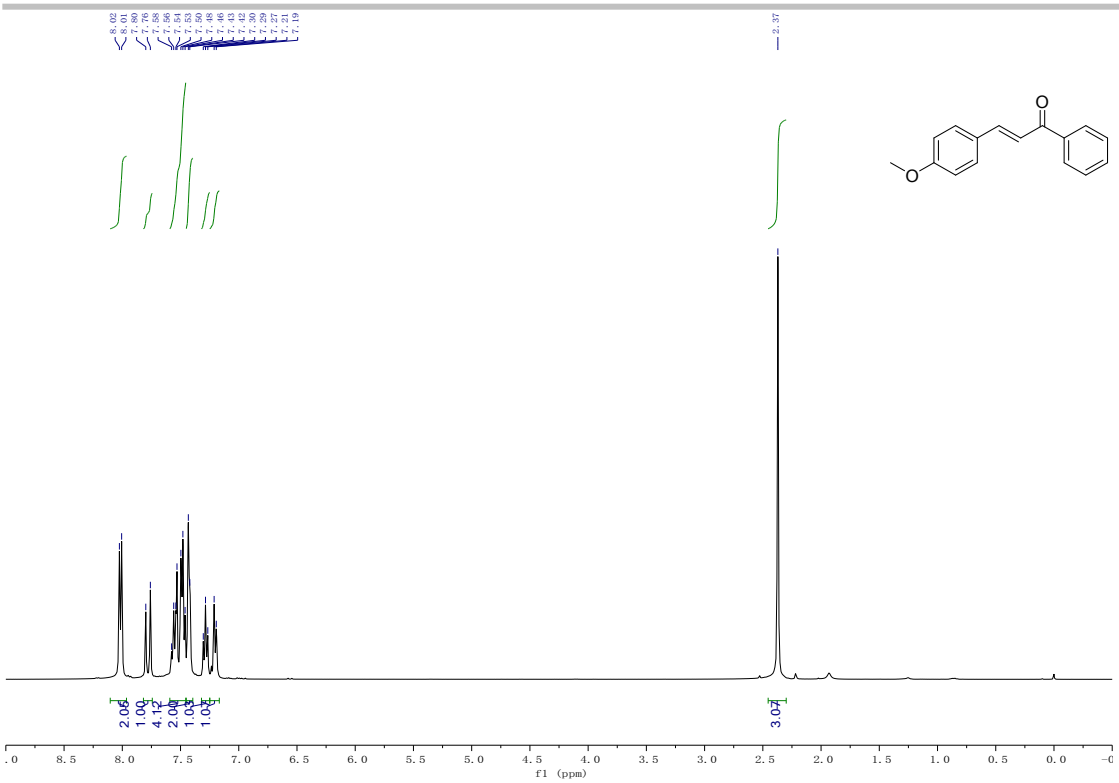
[1]H-NMR of 1,3-Diphenyl-propenone (2a)



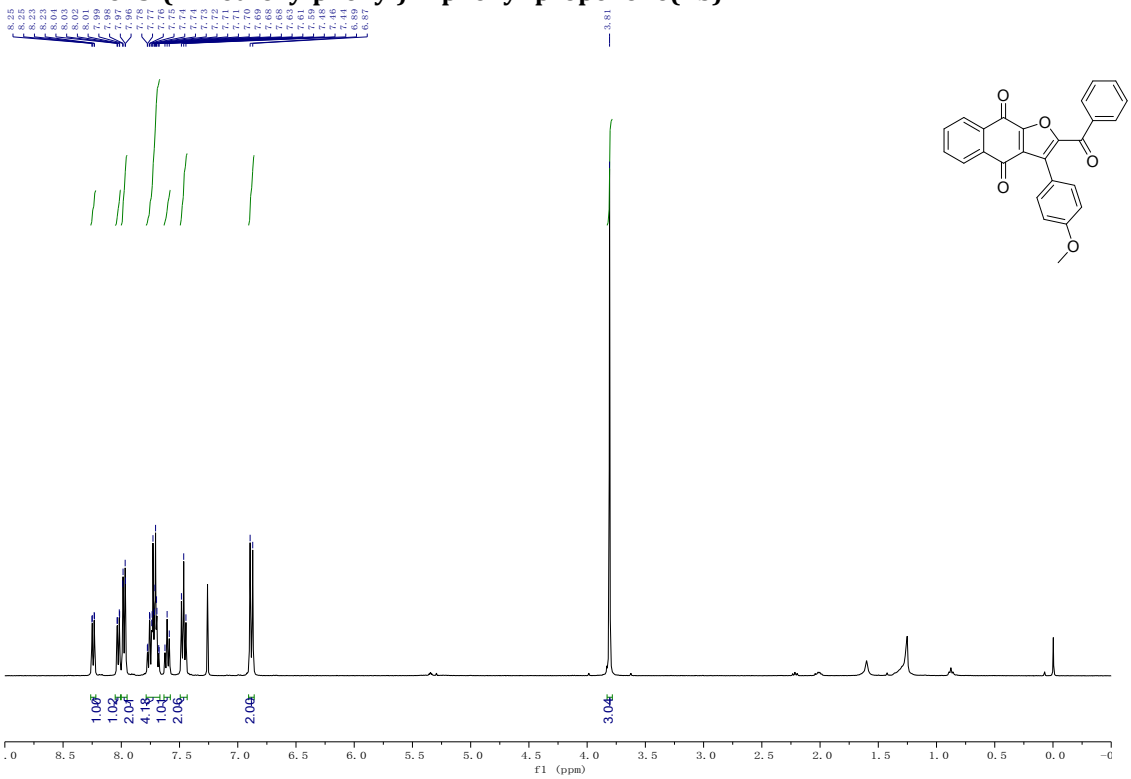
^{1}H-NMR of 2-Benzoyl-3-phenyl-4,9-dihydronaphtho[2,3-b]furane-4,9-dione(3a)



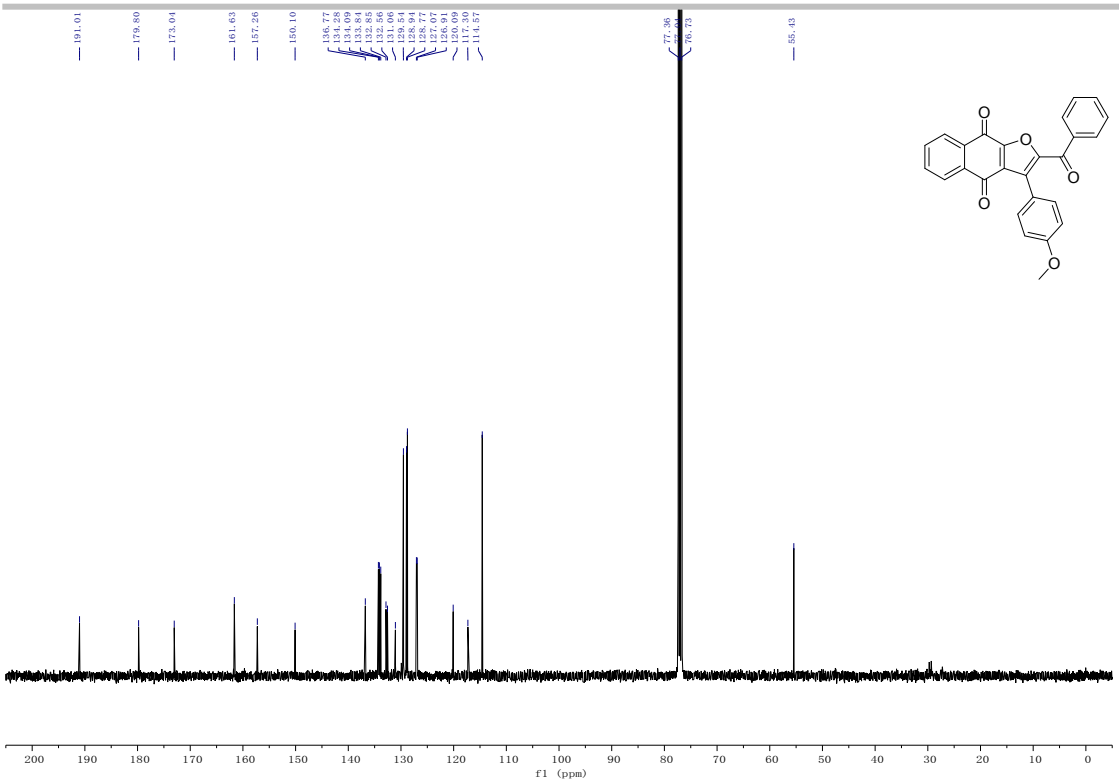
^{13}C-NMR of 2-Benzoyl-3-phenyl-4,9-dihydronaphtho[2,3-b]furane-4,9-dione(3a)



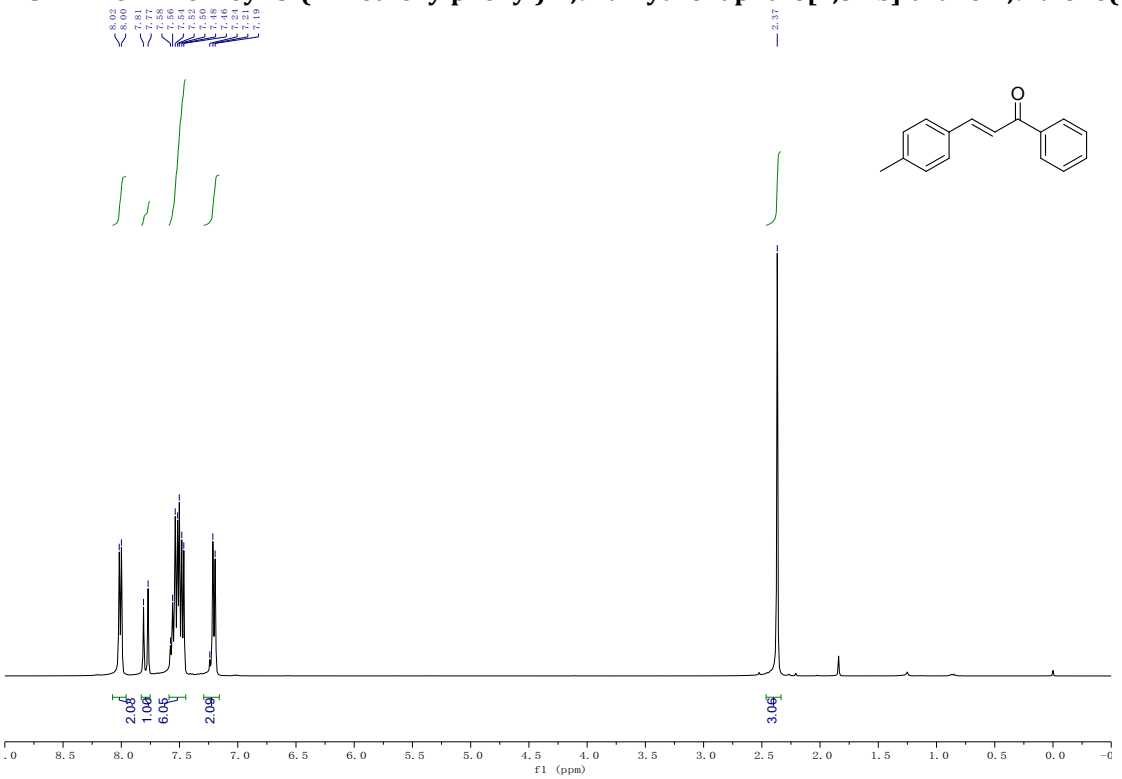
^{1}H-NMR of 3-(4-Methoxy-phenyl)-1-phenyl-propenone(2b)



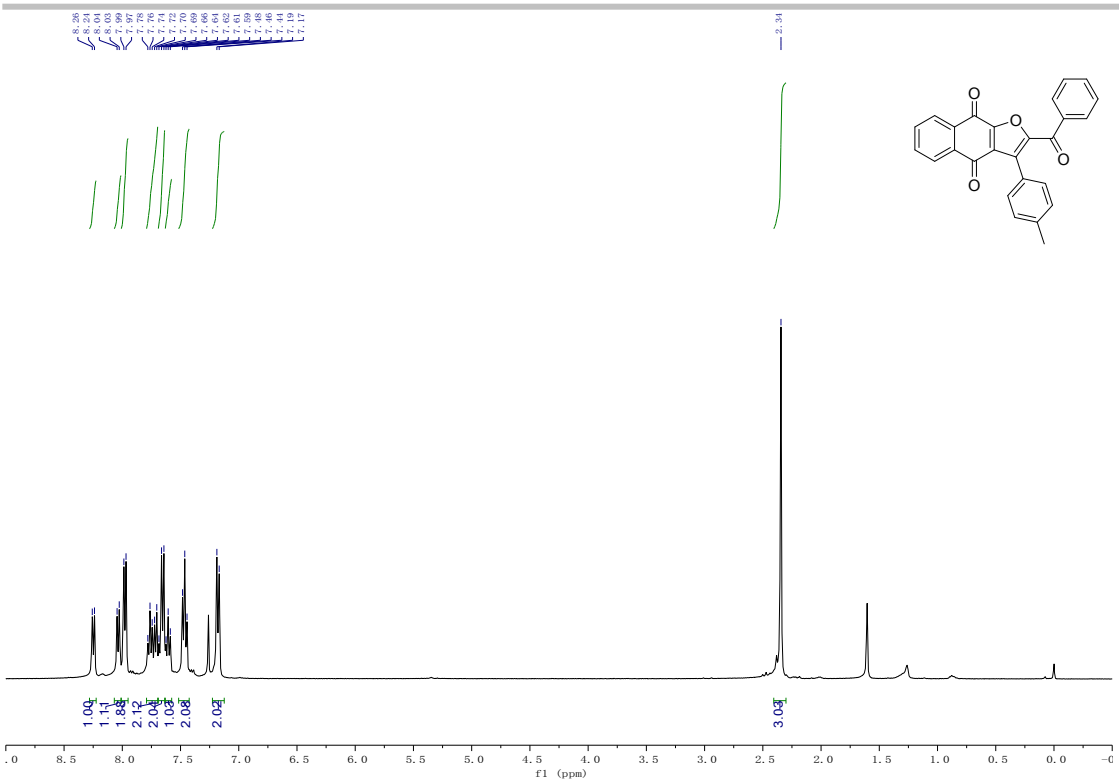
^{1}H-NMR of 2-Benzoyl-3-(4-methoxylphenyl)-4,9–dihydronaphtho[2,3 - b]furane-4,9-dione(3b)



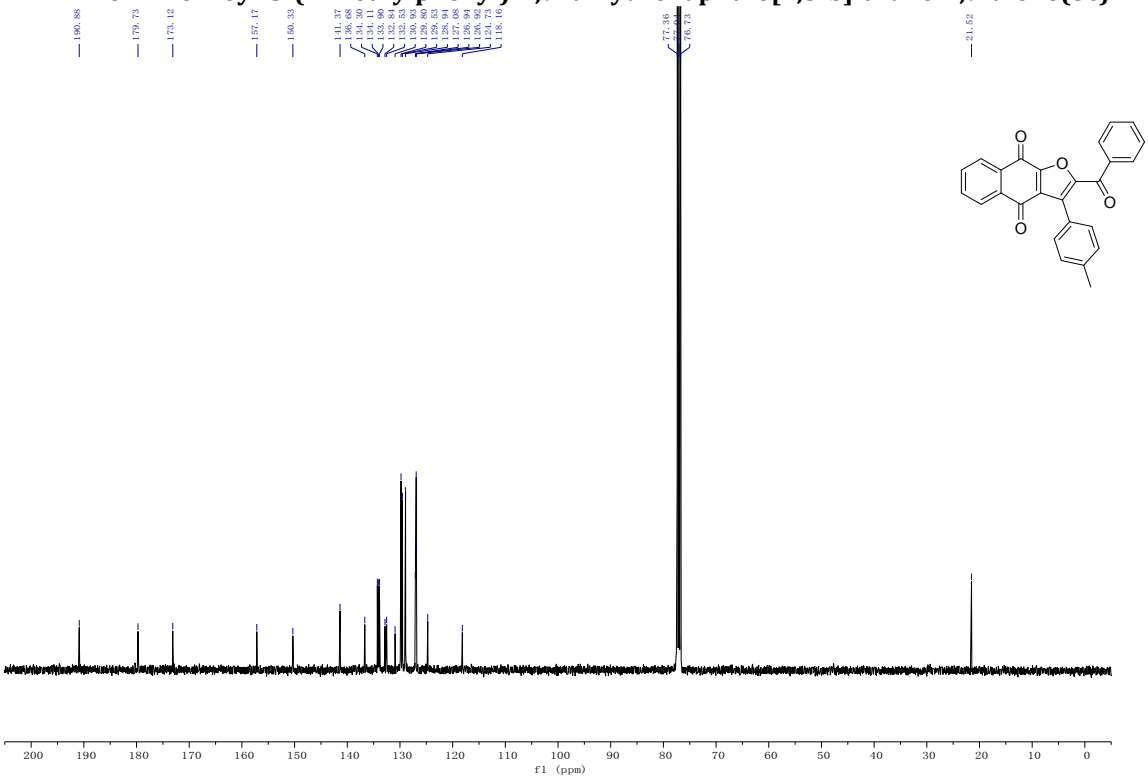
^{13}C-NMR of 2-Benzoyl-3-(4-methoxylphenyl)-4,9–dihydronaphtho[2,3 - b]furane-4,9-dione(3b)



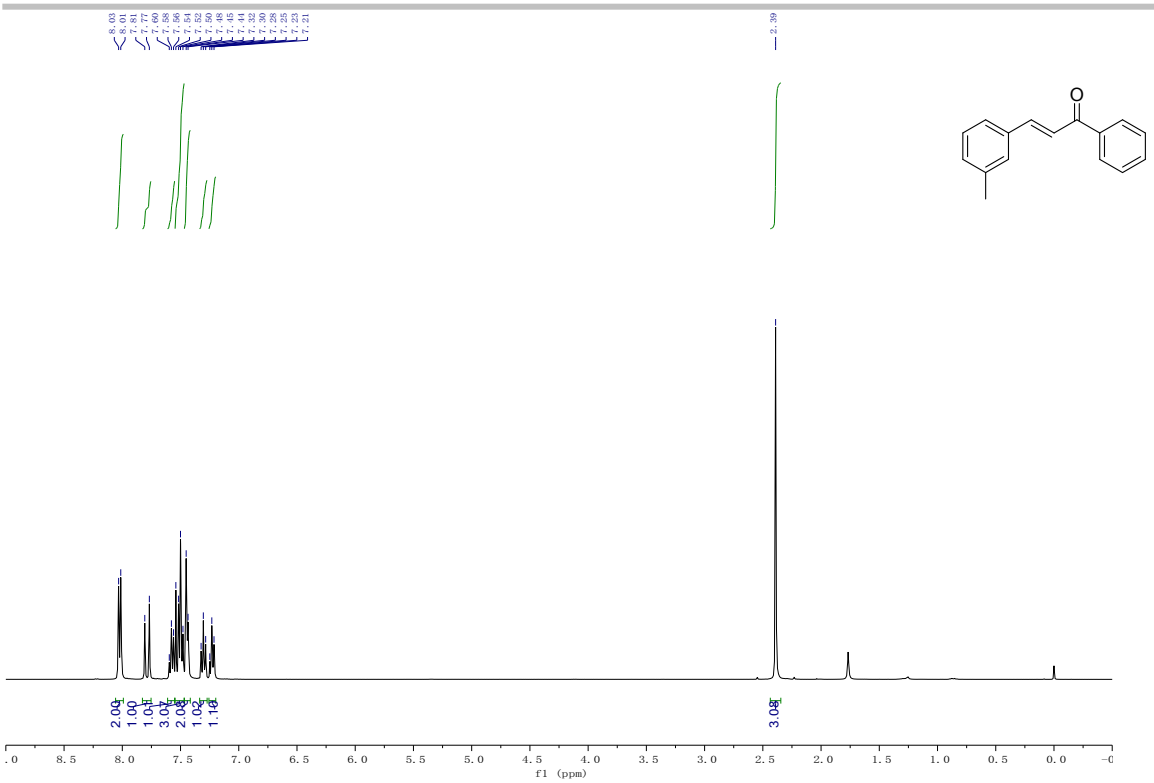
^{1}H-NMR of 1-phenyl-3-p-tolyl-propenone(2c)



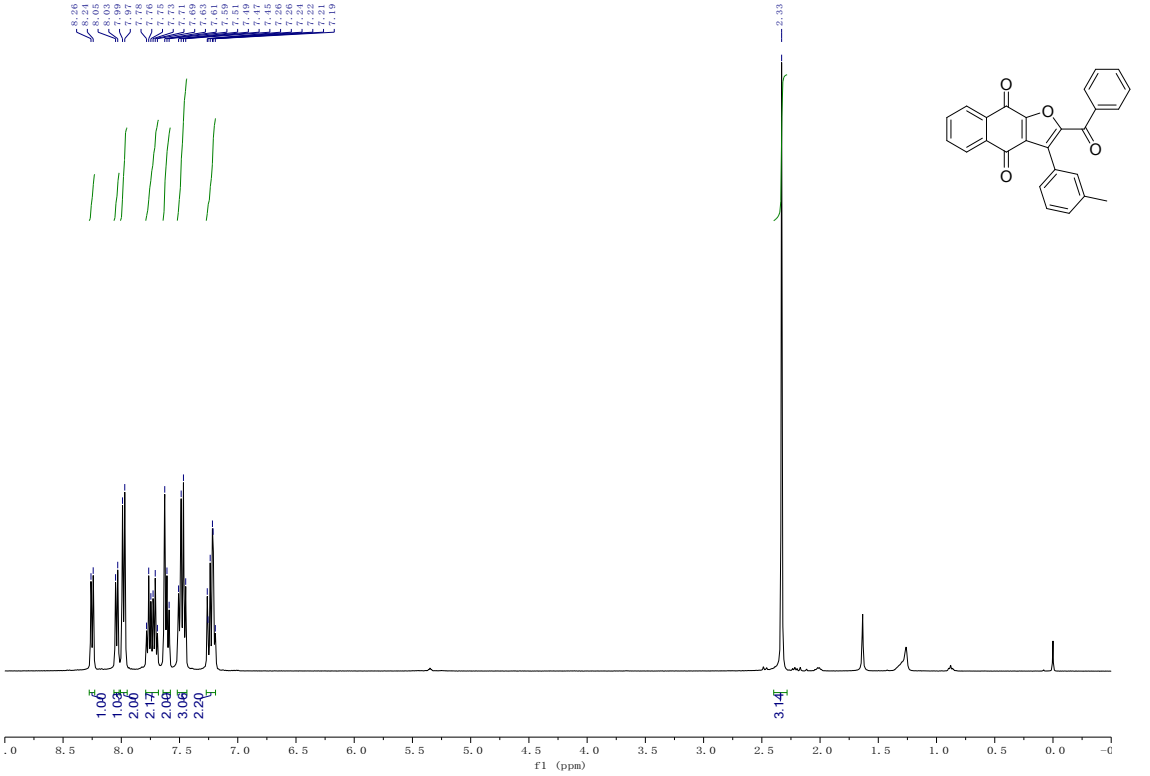
^{1}H-NMR of 2-Benzoyl-3-(4-methylphenyl)-4,9–dihydronaphtho[2,3-b]furane-4,9-dione(3c)



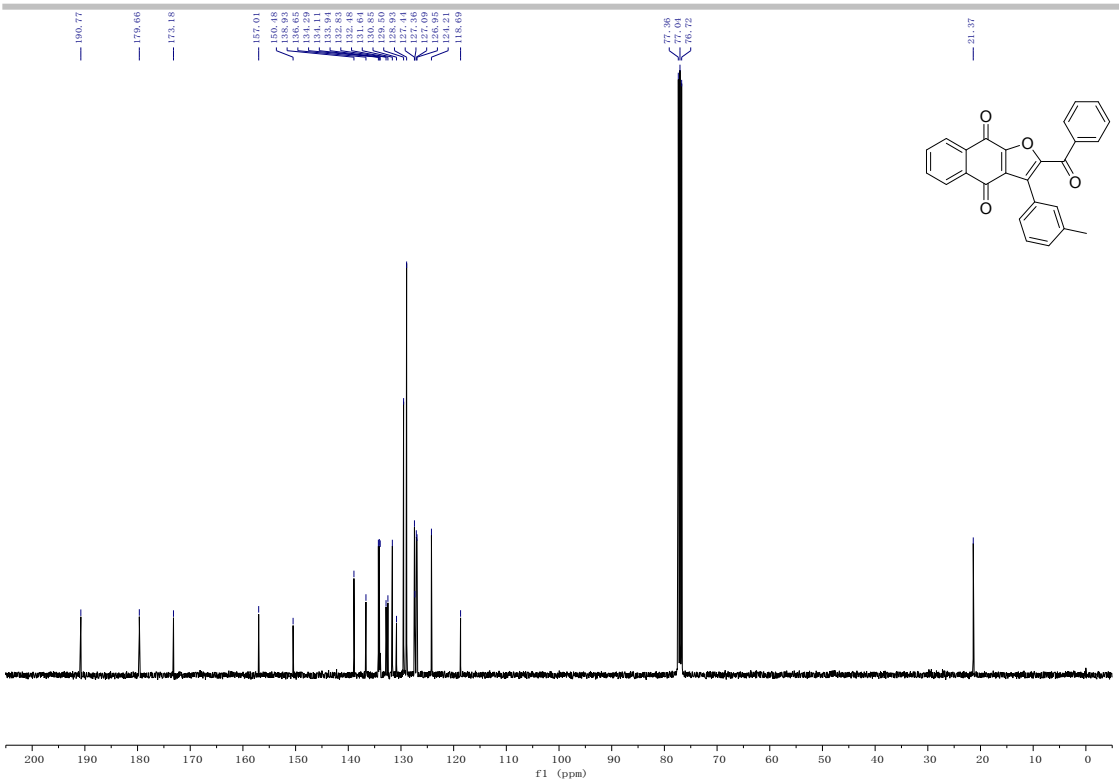
^{13}C-NMR of 2-Benzoyl-3-(4-methylphenyl)-4,9–dihydronaphtho[2,3-b]furane-4,9-dione(3c)



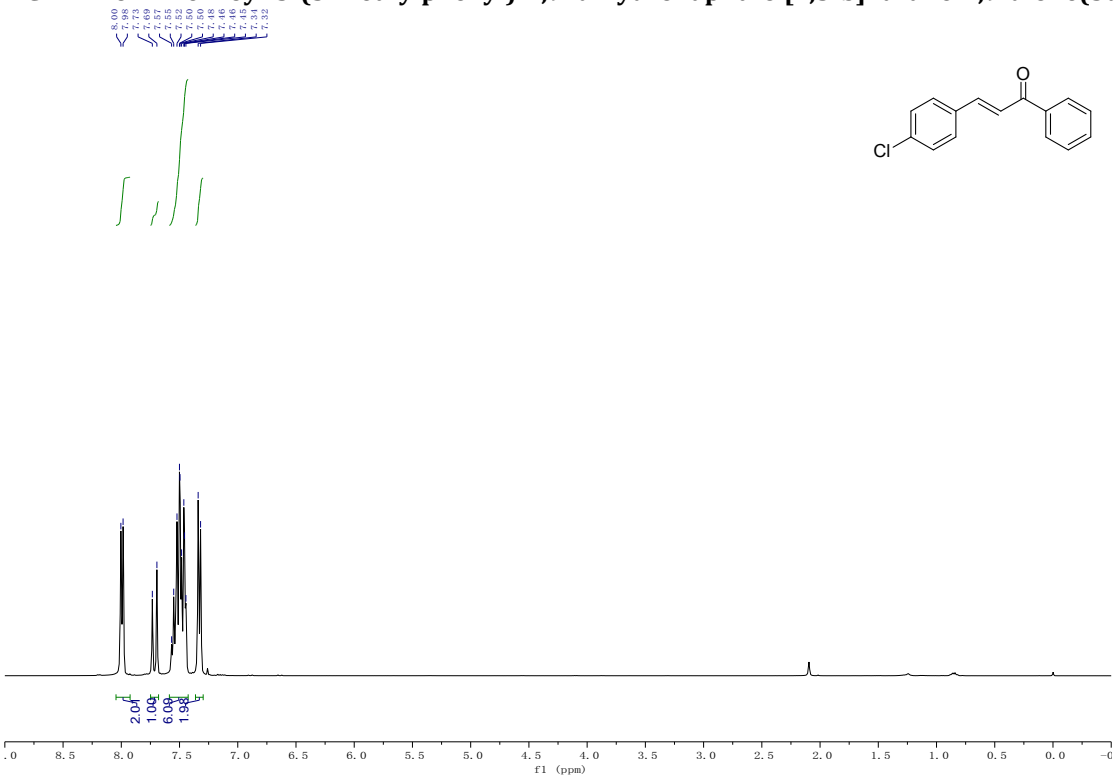
^{1}H-NMR of 1-phenyl-3-m-tolyl-propenone（2d）



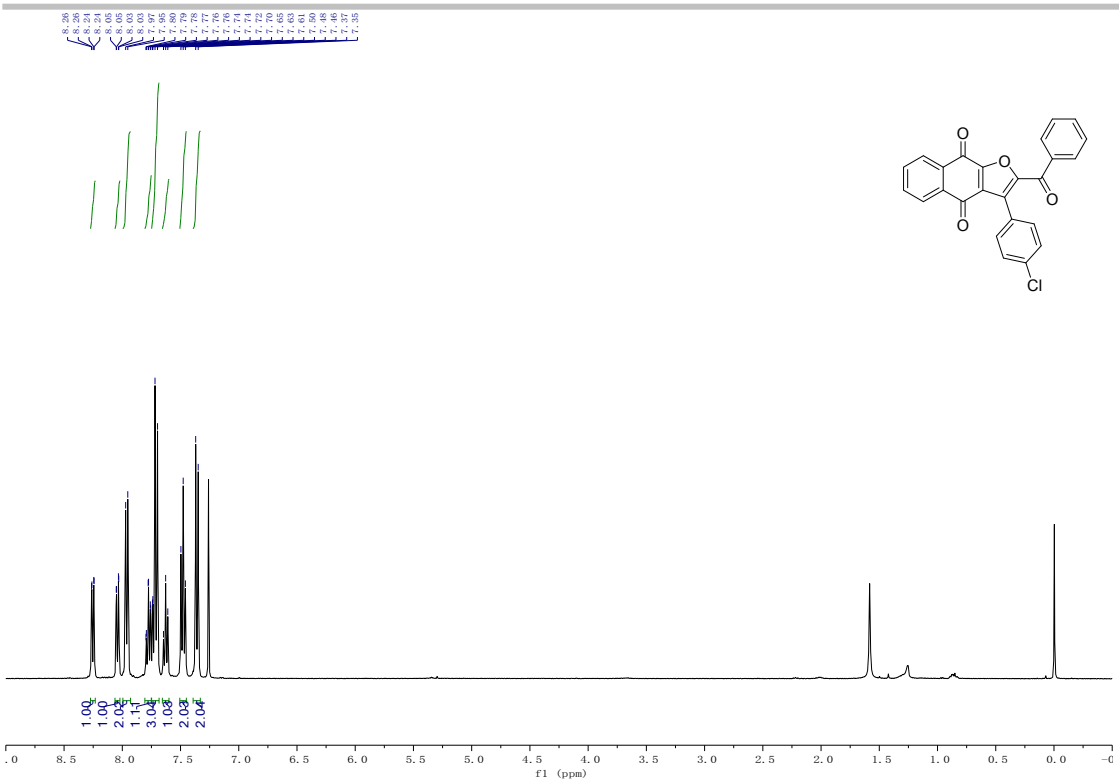
^{1}H-NMR of 2-Benzoyl-3-(3-methylphenyl)-4,9–dihydronaphtho [2,3-b] furane-4,9-dione(3d)



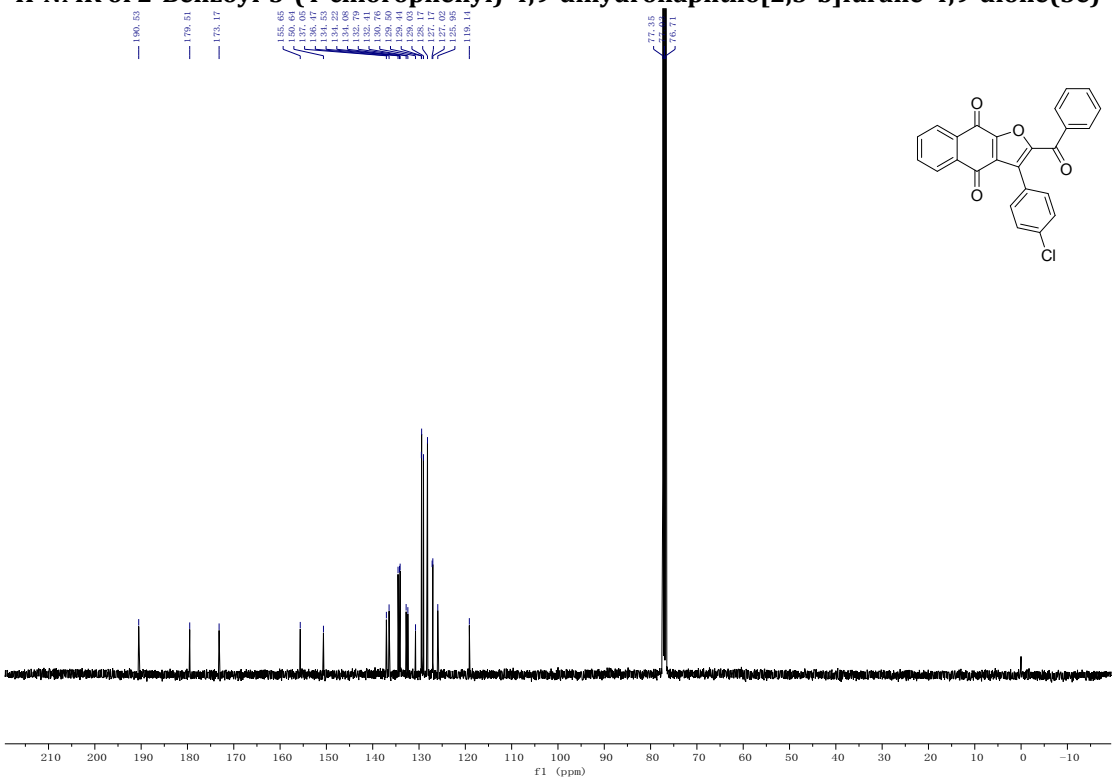
^{13}C-NMR of 2-Benzoyl-3-(3-methylphenyl)-4,9–dihydronaphtho [2,3-b] furane-4,9-dione(3d)



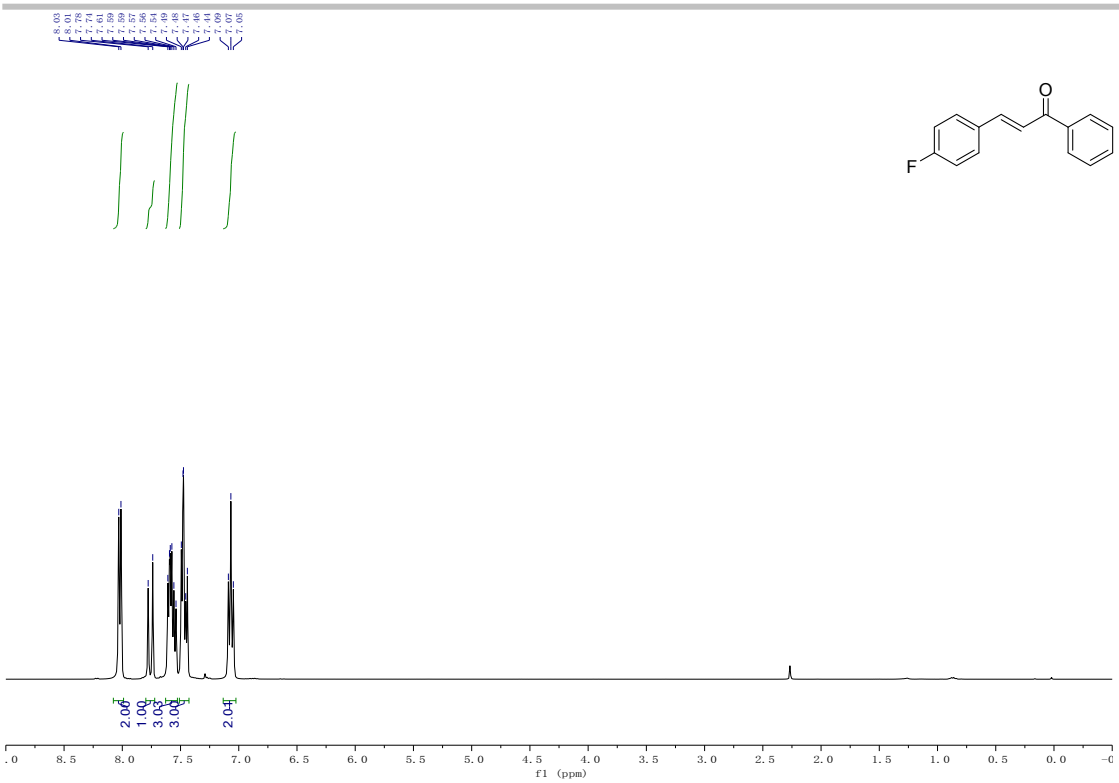
^{1}H-NMR of 3- (4-Chlorophenyl)-1-phenyl-propenone(2e)



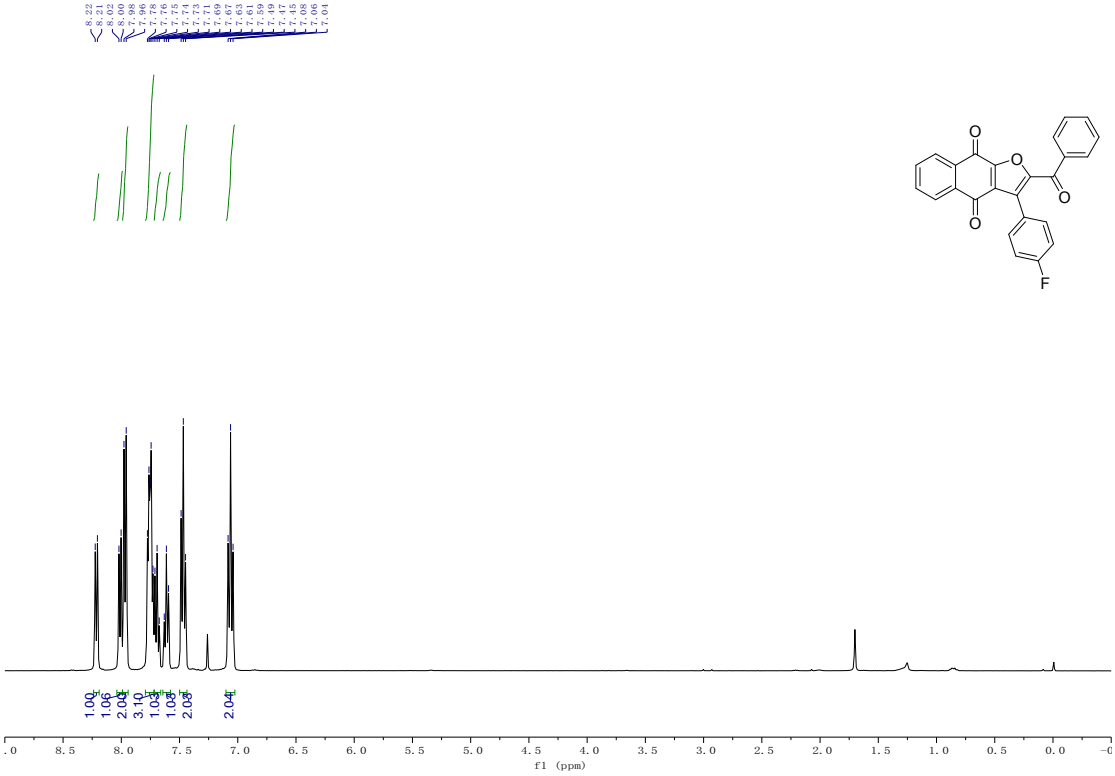
^{1}H-NMR of 2-Benzoyl-3-(4-chlorophenyl)-4,9-dihydronaphtho[2,3-b]furane-4,9-dione(3e)



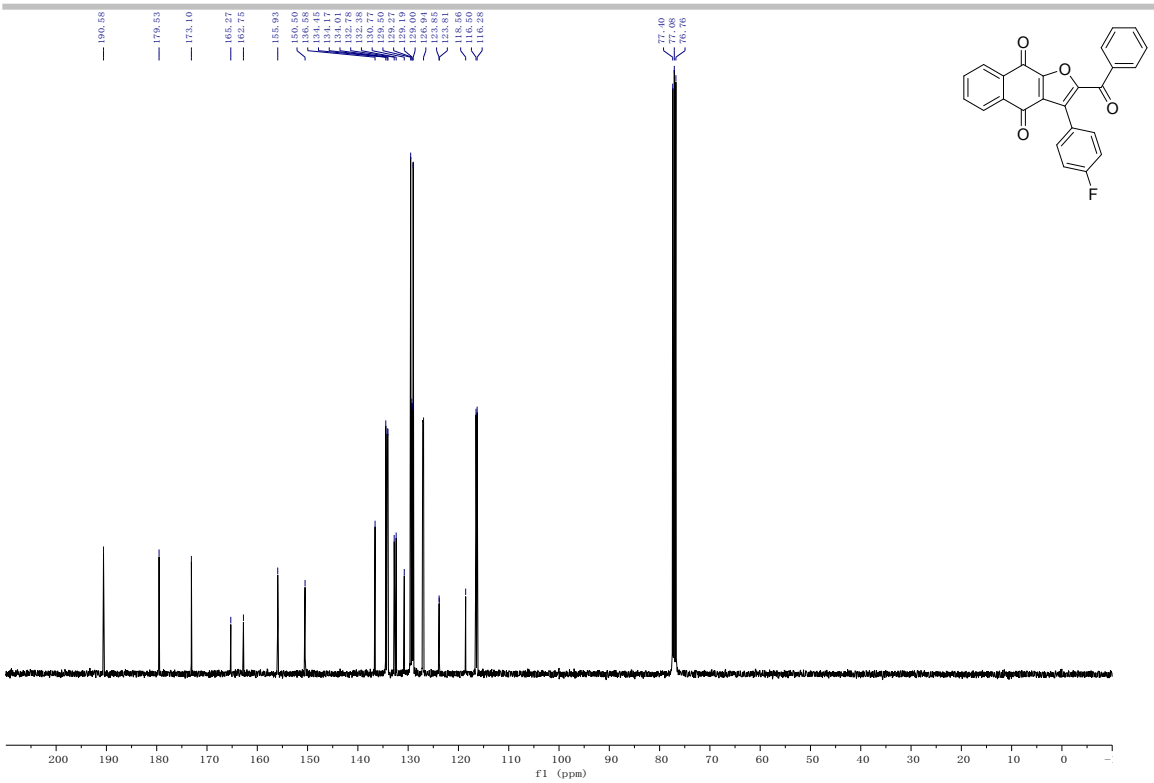
^{13}C-NMR of 2-Benzoyl-3-(4-chlorophenyl)-4,9-dihydronaphtho[2,3-b]furane-4,9-dione(3e)



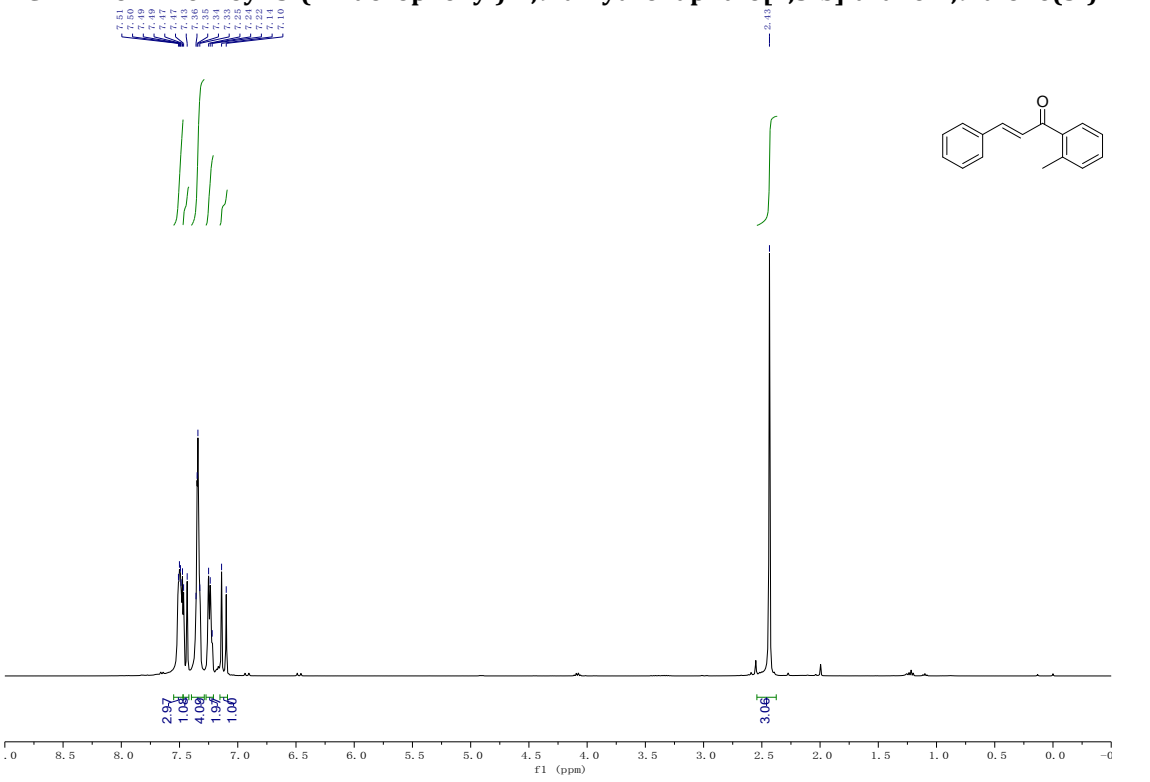
^{1}H-NMR of 3- (4-Fluorophenyl)-1-phenyl-propenone（2f）



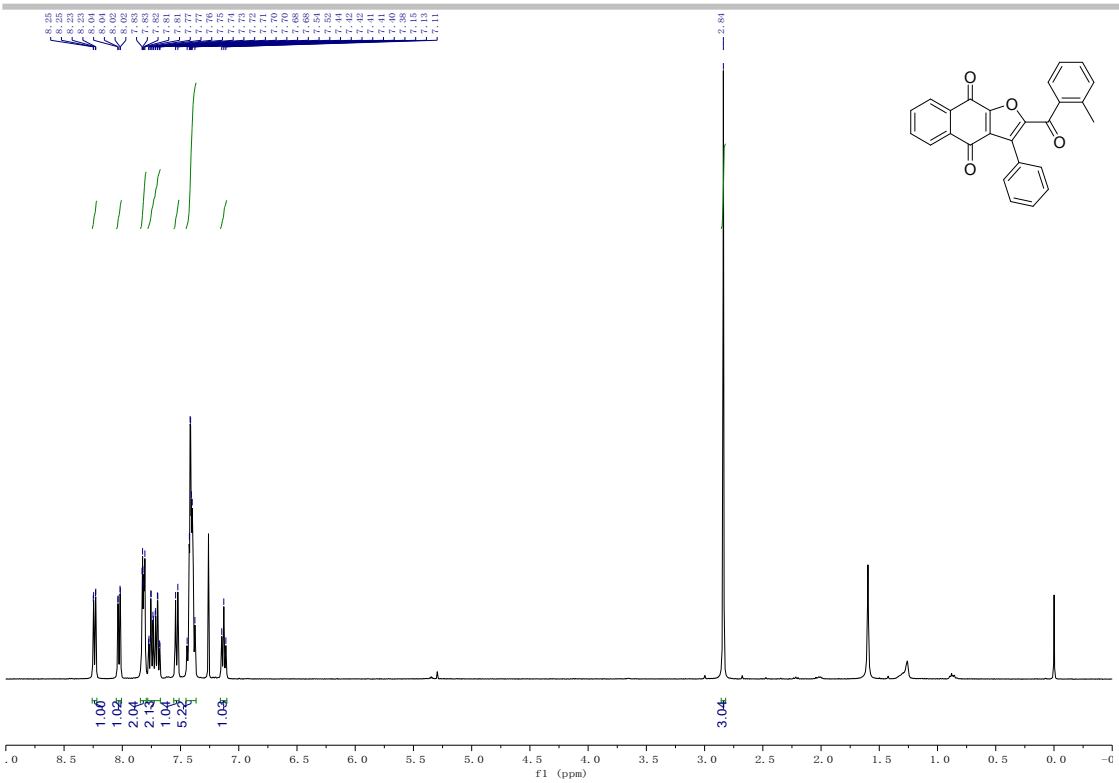
^{1}H-NMR of 2-Benzoyl-3-(4-fluorophenyl)-4,9-dihydronaphtho[2,3-b]furane-4,9-dione(3f)



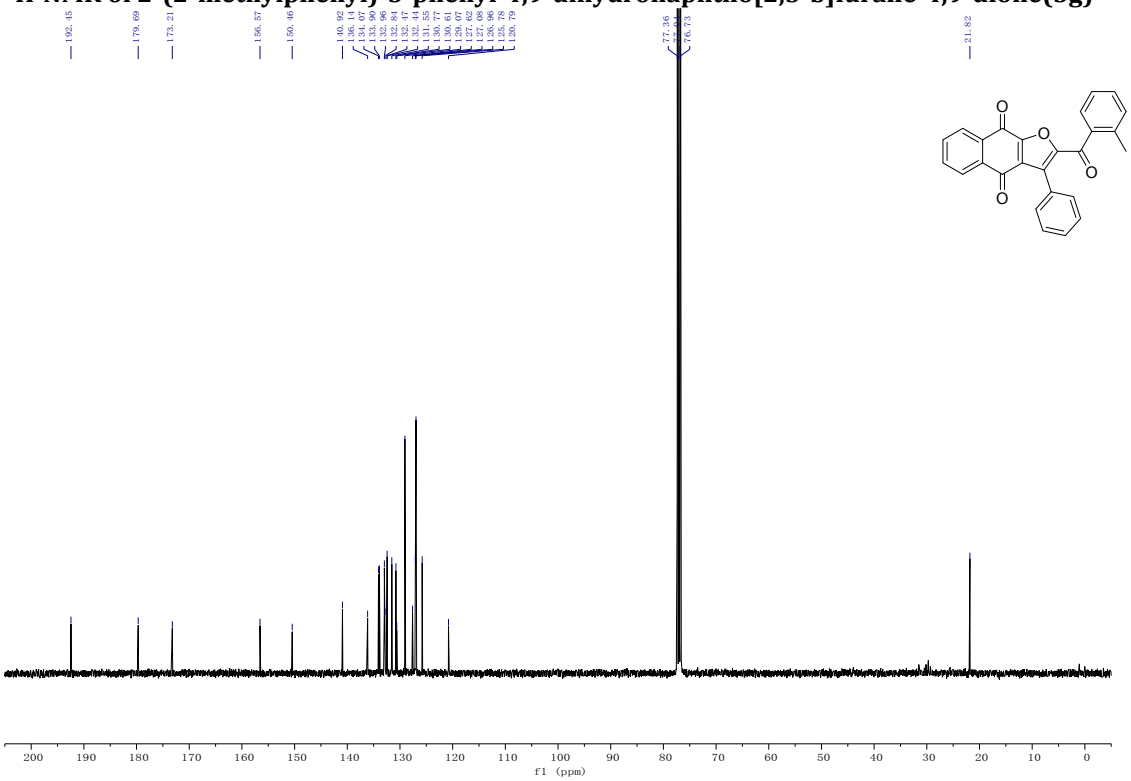
^{13}C-NMR of 2-Benzoyl-3-(4-fluorophenyl)-4,9-dihydronaphtho[2,3-b]furane-4,9-dione(3f)



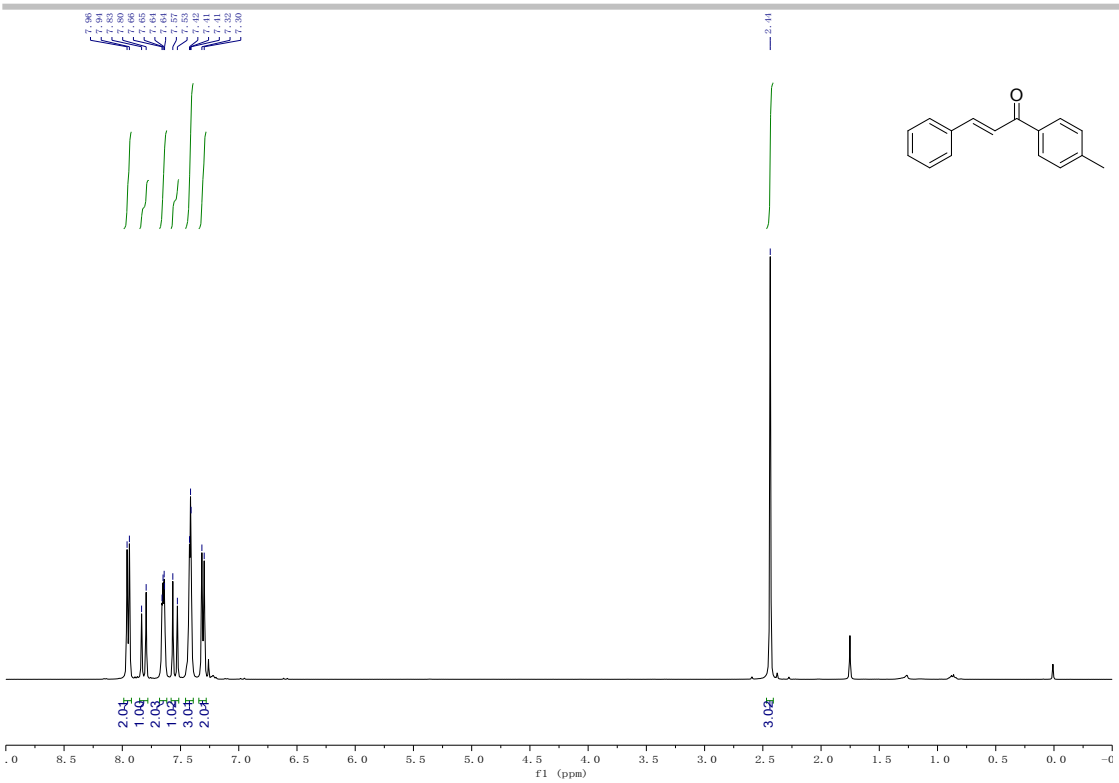
^{1}H-NMR of 3-phenyl-1-o-tolyl-propenone(2g)



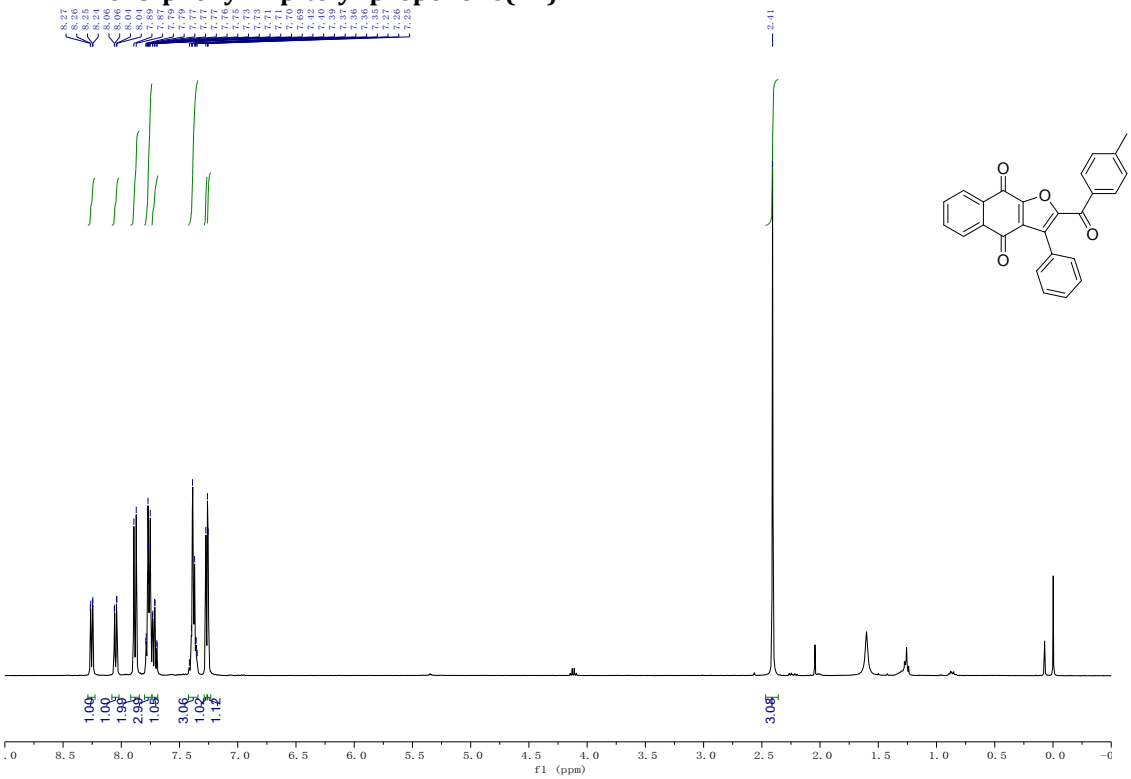
^{1}H-NMR of 2-(2-methylphenyl)-3-phenyl-4,9-dihydronaphtho[2,3-b]furane-4,9-dione(3g)



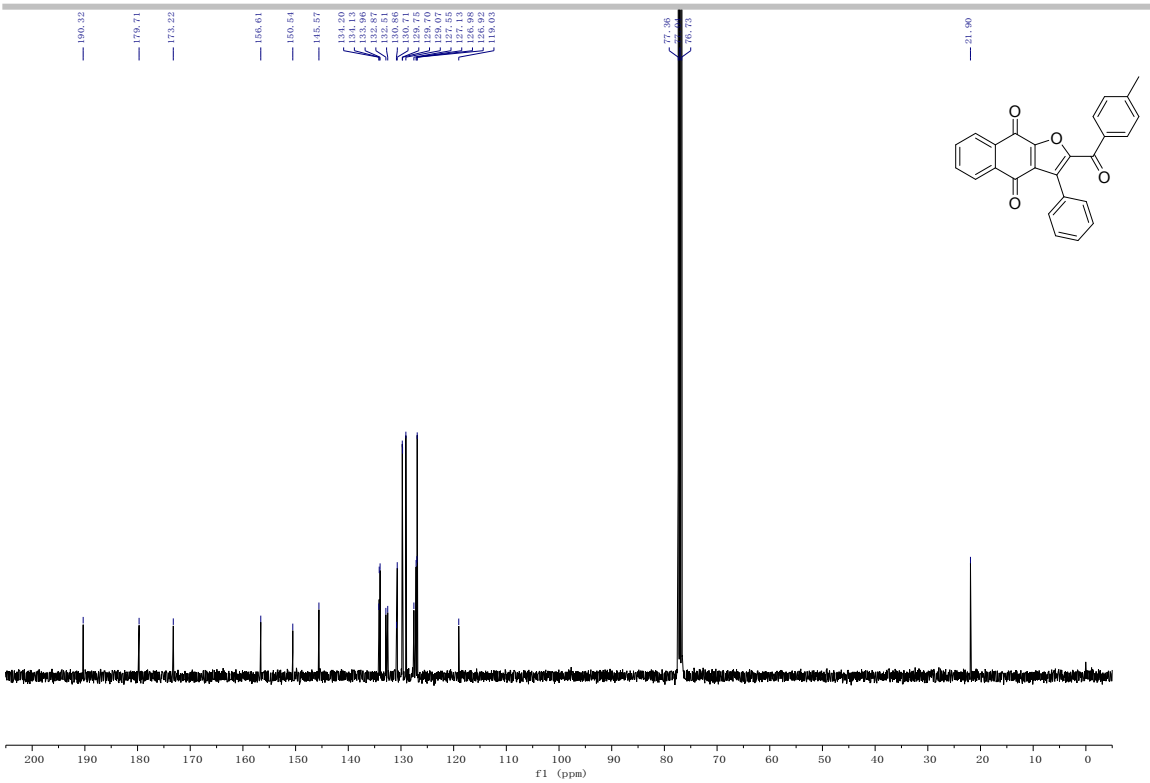
^{13}C-NMR of 2-(2-methylphenyl)-3-phenyl-4,9-dihydronaphtho[2,3-b]furane-4,9-dione(3g)



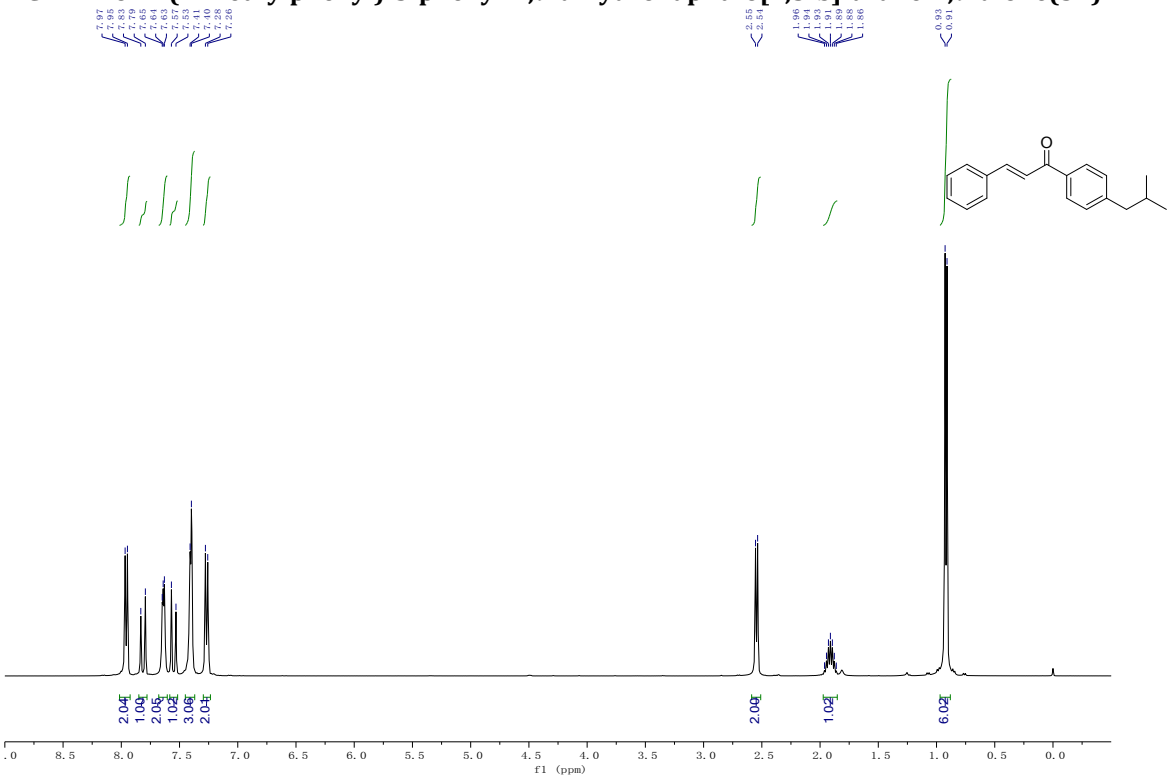
^{1}H-NMR of 3-phenyl-1-p-tolyl-propenone(2h)



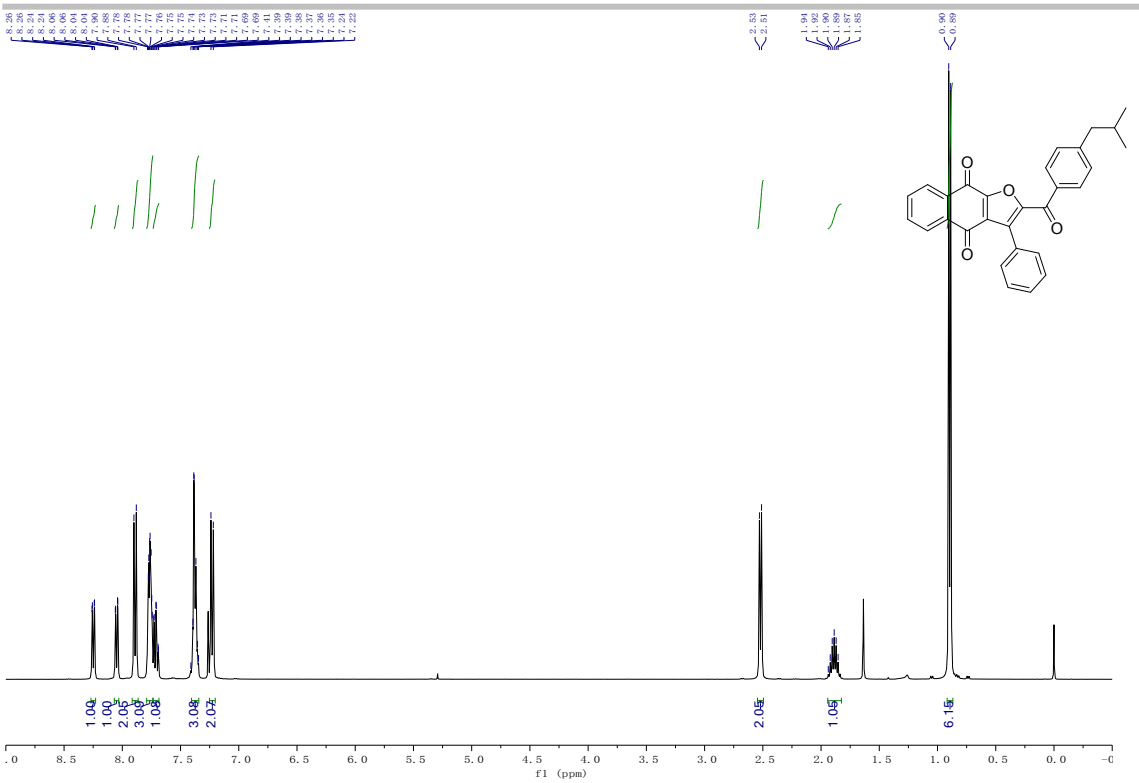
^{1}H-NMR of 2-(4-methylphenyl)-3-phenyl-4,9-dihydronaphtho[2,3-b]furane-4,9-dione(3h)



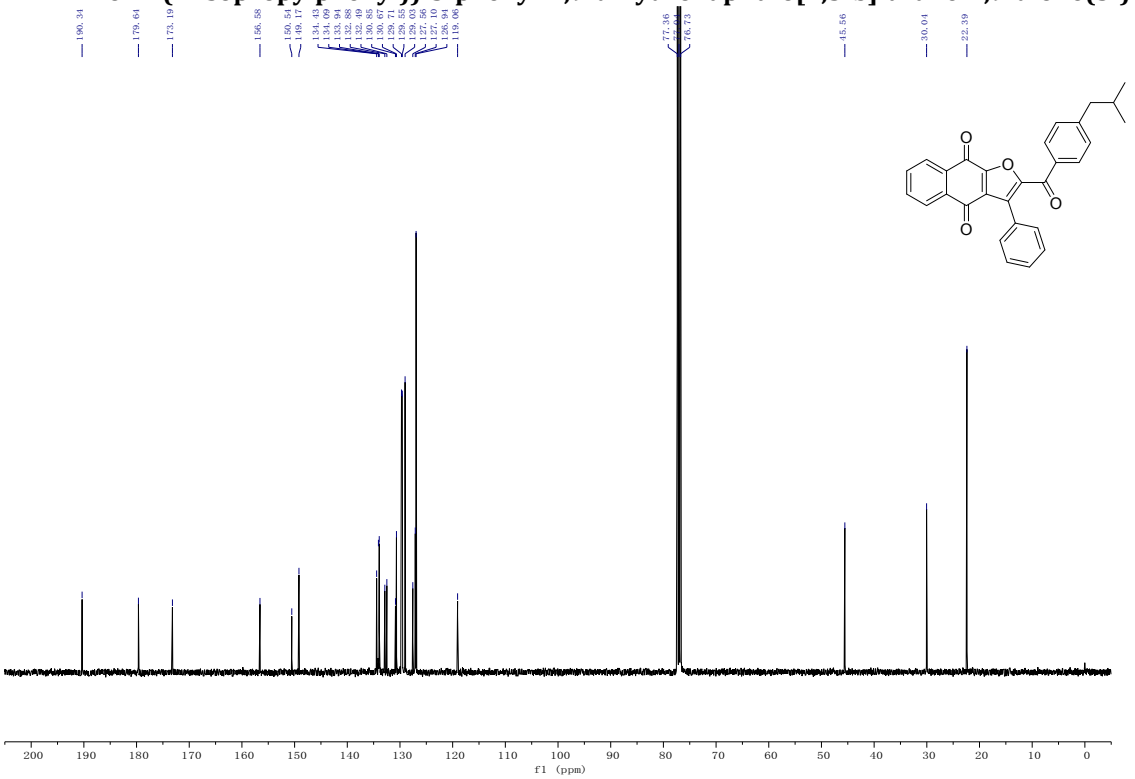
^{13}C-NMR of 2-(4-methylphenyl)-3-phenyl-4,9-dihydronaphtho[2,3-b]furane-4,9-dione(3h)



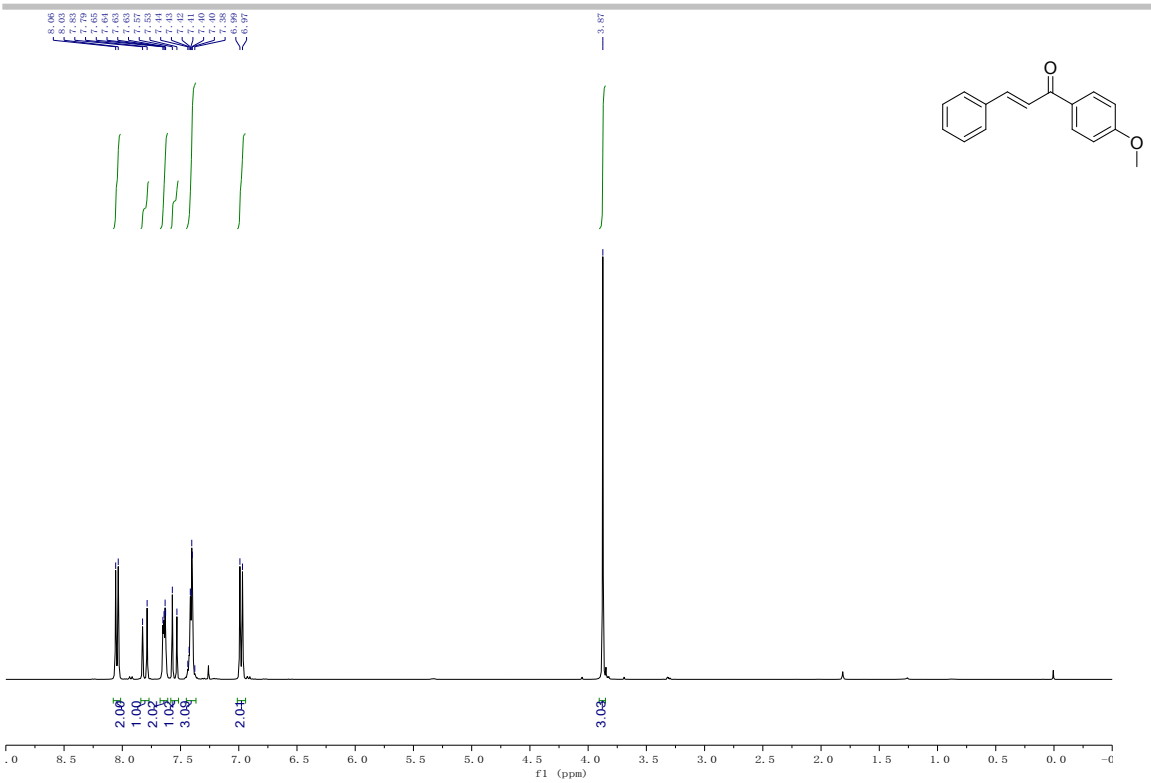
^{1}H-NMR of 1-(4-isobutyl-phenyl)-3 phenyl –propenone(2i)



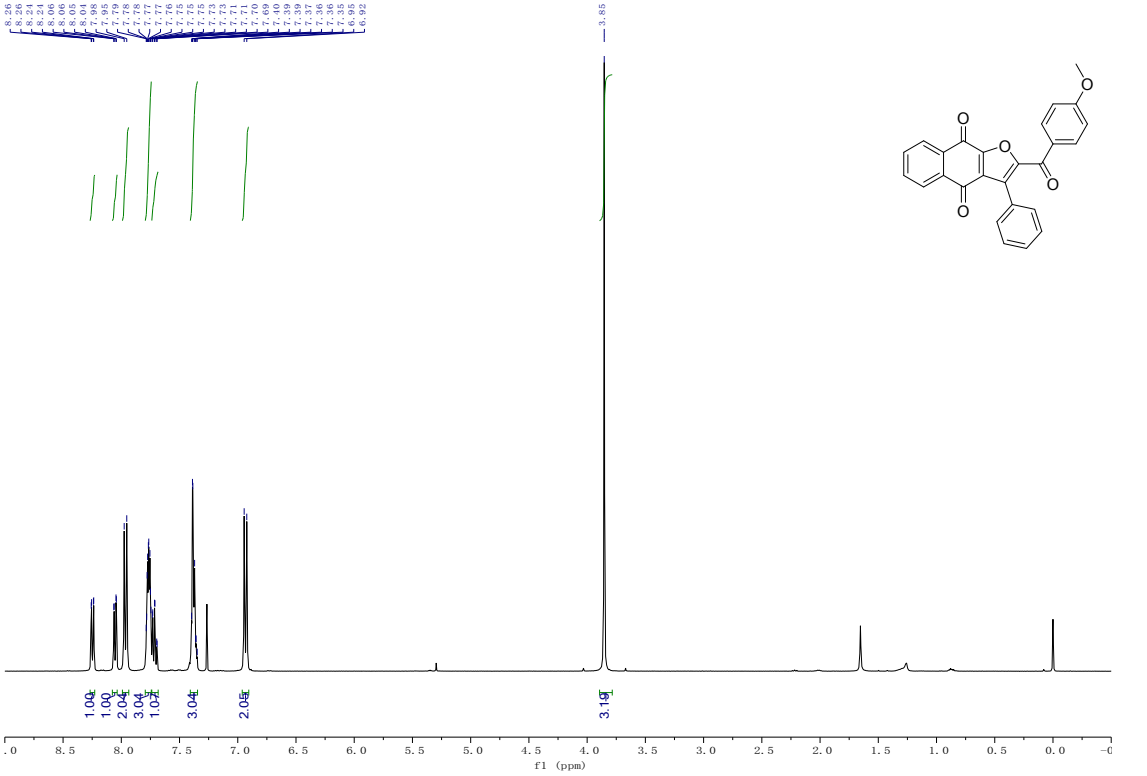
^{1}H-NMR of 2-(4-isopropylphenyl))-3-phenyl-4,9-dihydronaphtho[2,3-b]furane-4,9-dione(3i)



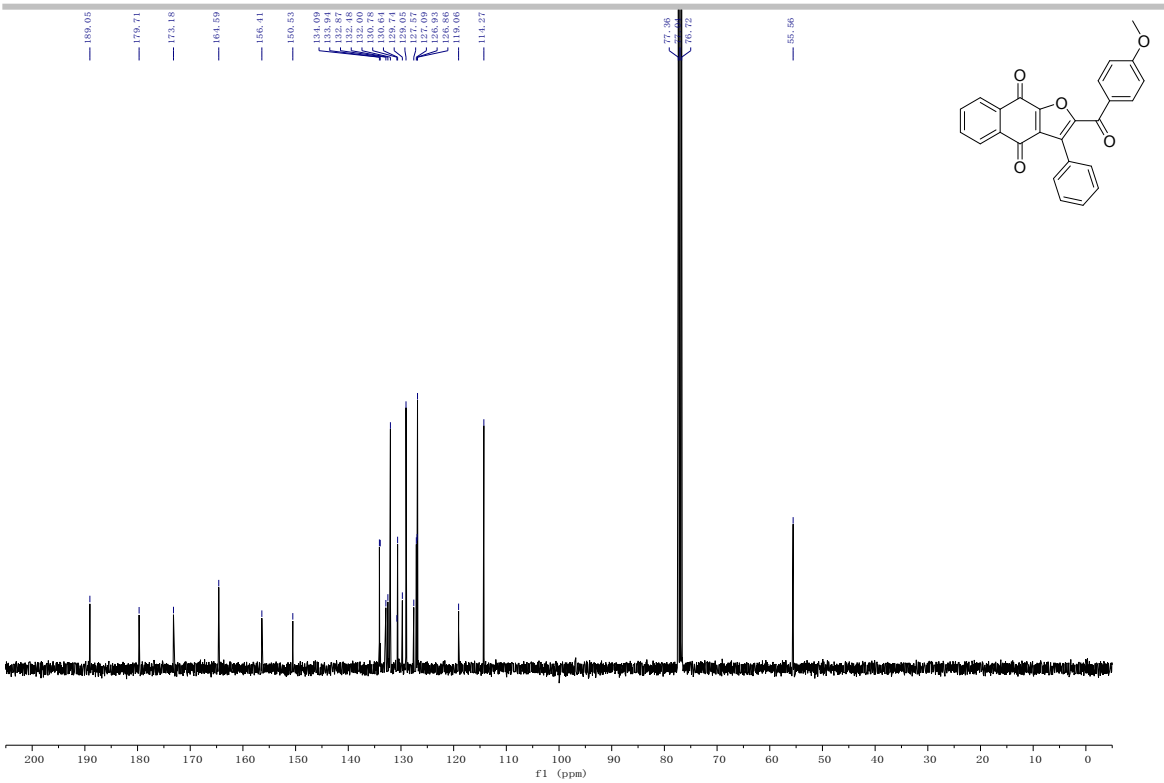
^{13}C-NMR of 2-(4-isopropylphenyl))-3-phenyl-4,9-dihydronaphtho[2,3-b]furane-4,9-dione(3i)



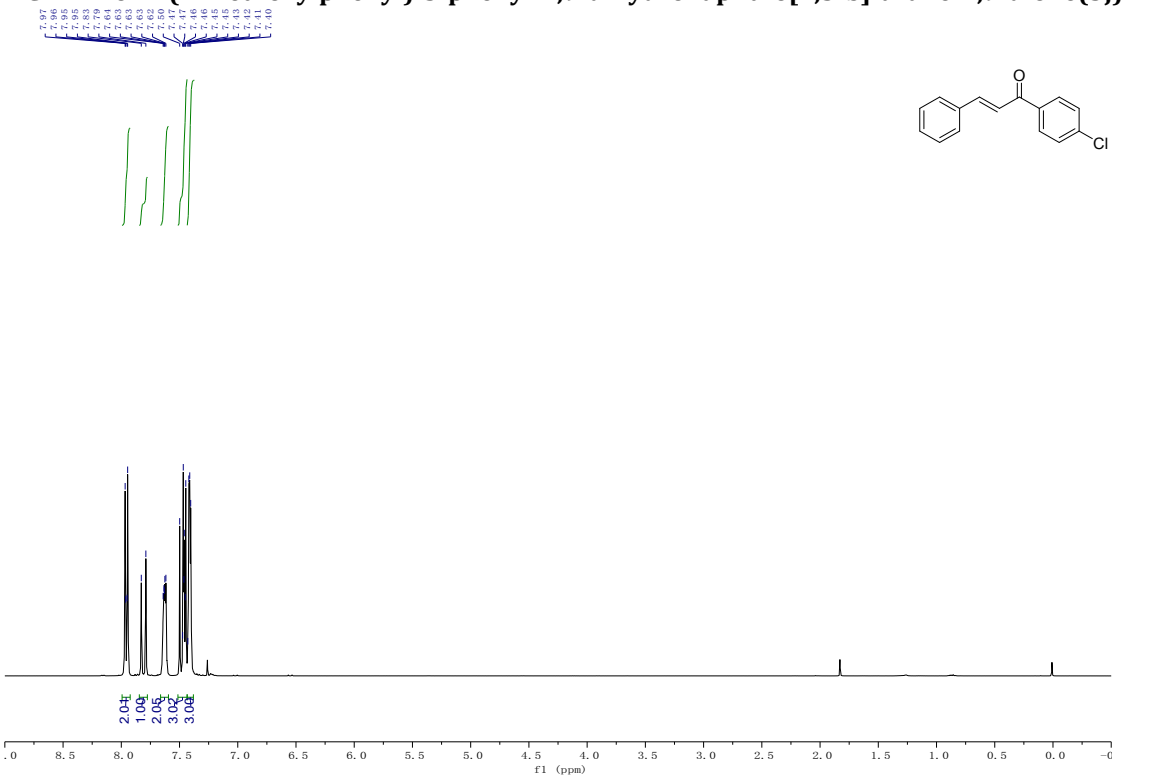
^{1}H-NMR of 1-(4-Methoxy-phenyl)-3-phenyl-propenone（2j）



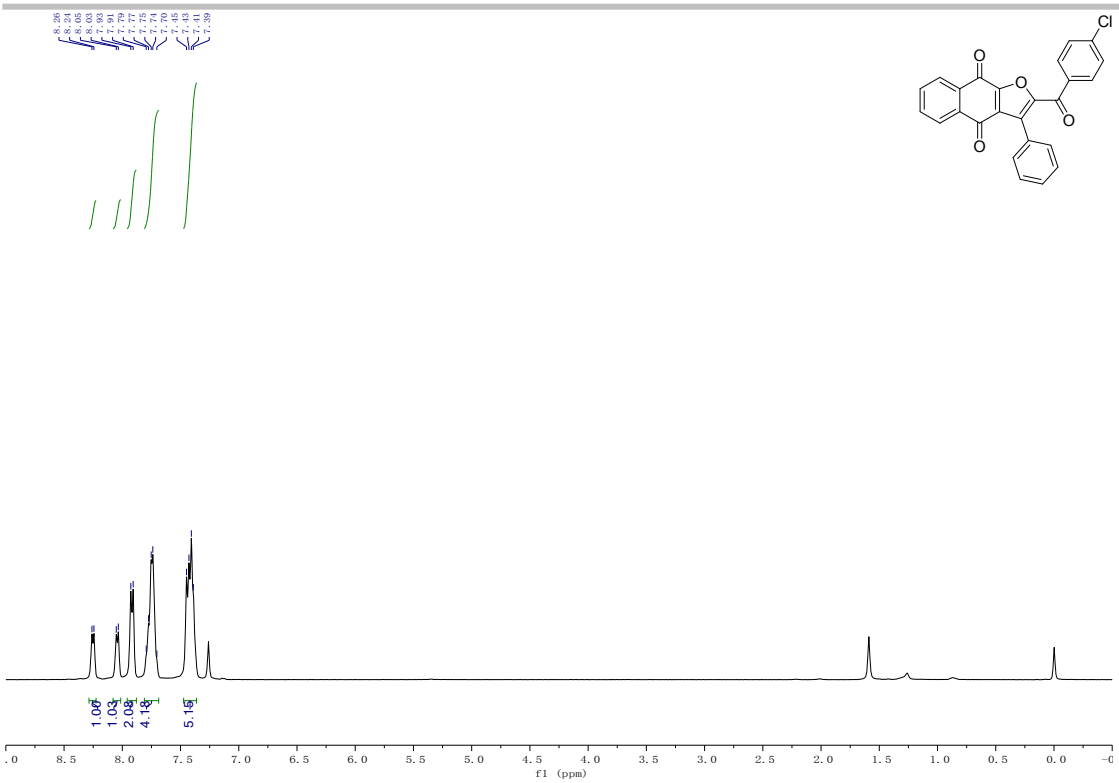
^{1}H-NMR of 2-(4-methoxylphenyl)-3-phenyl-4,9-dihydronaphtho[2,3-b]furane-4,9-dione(3j)



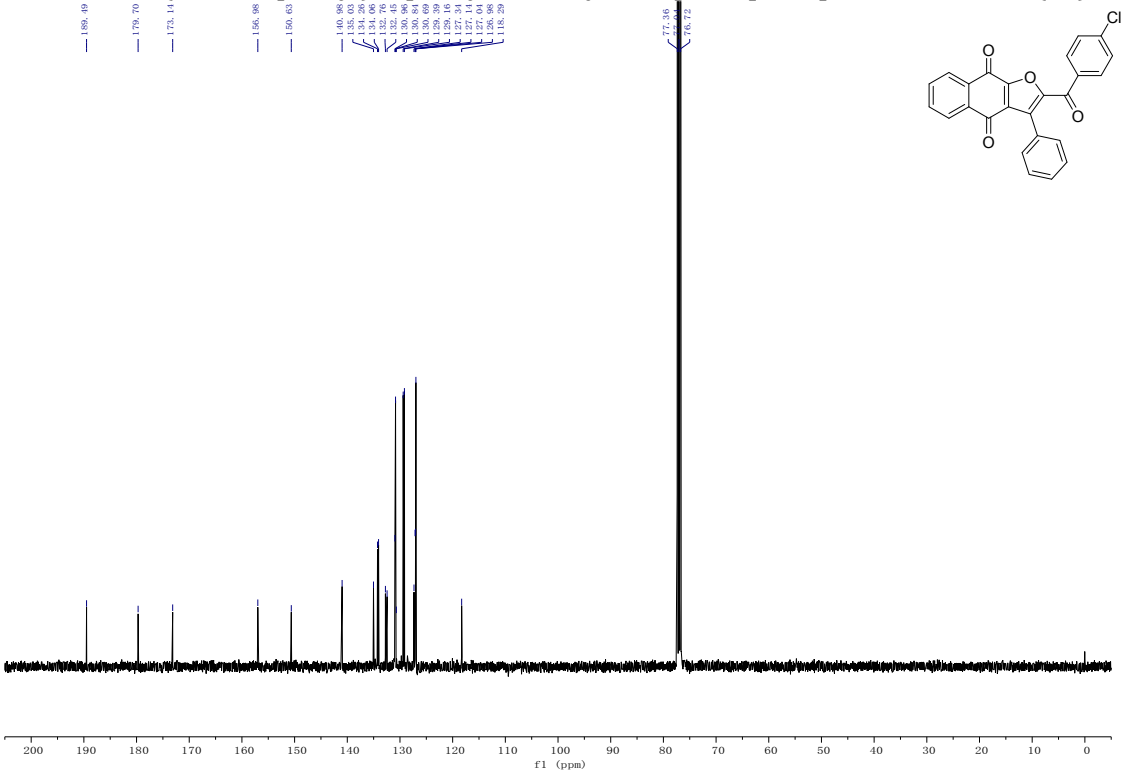
^{13}C-NMR of 2-(4-methoxylphenyl)-3-phenyl-4,9-dihydronaphtho[2,3-b]furane-4,9-dione(3j)



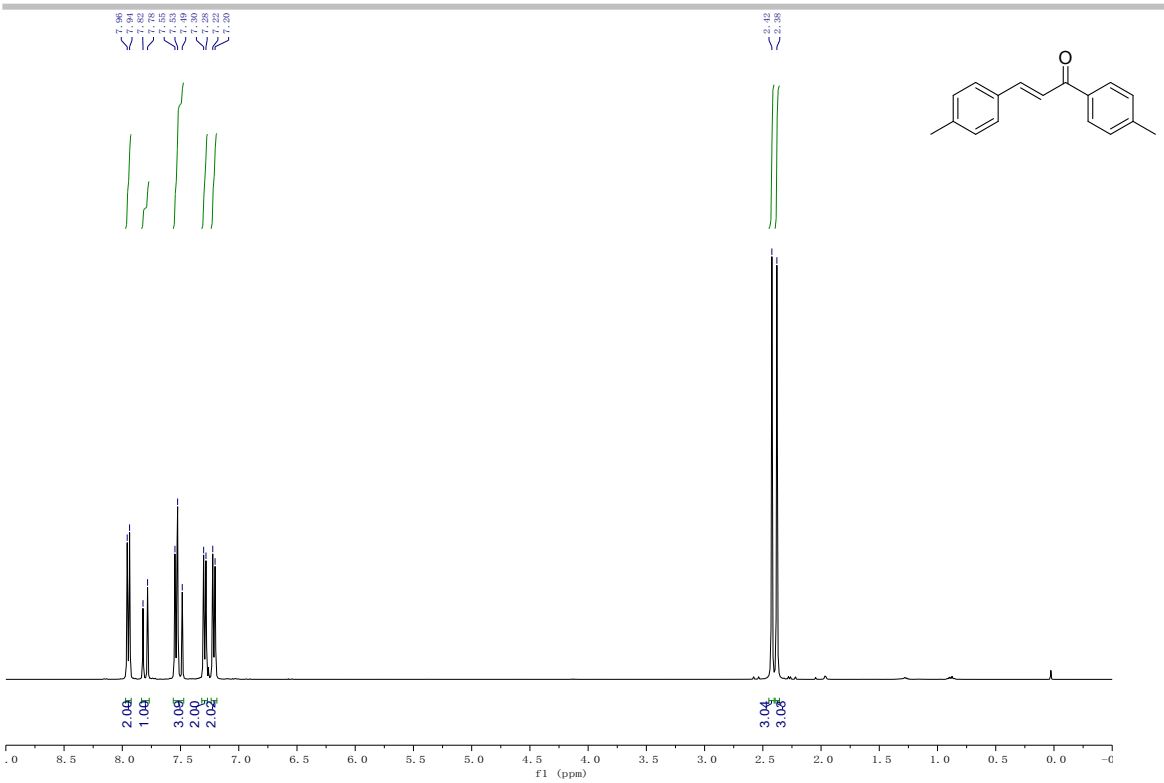
^{1}H-NMR of 1- (4-Chlorophenyl)-3-phenyl-propenone（2k）



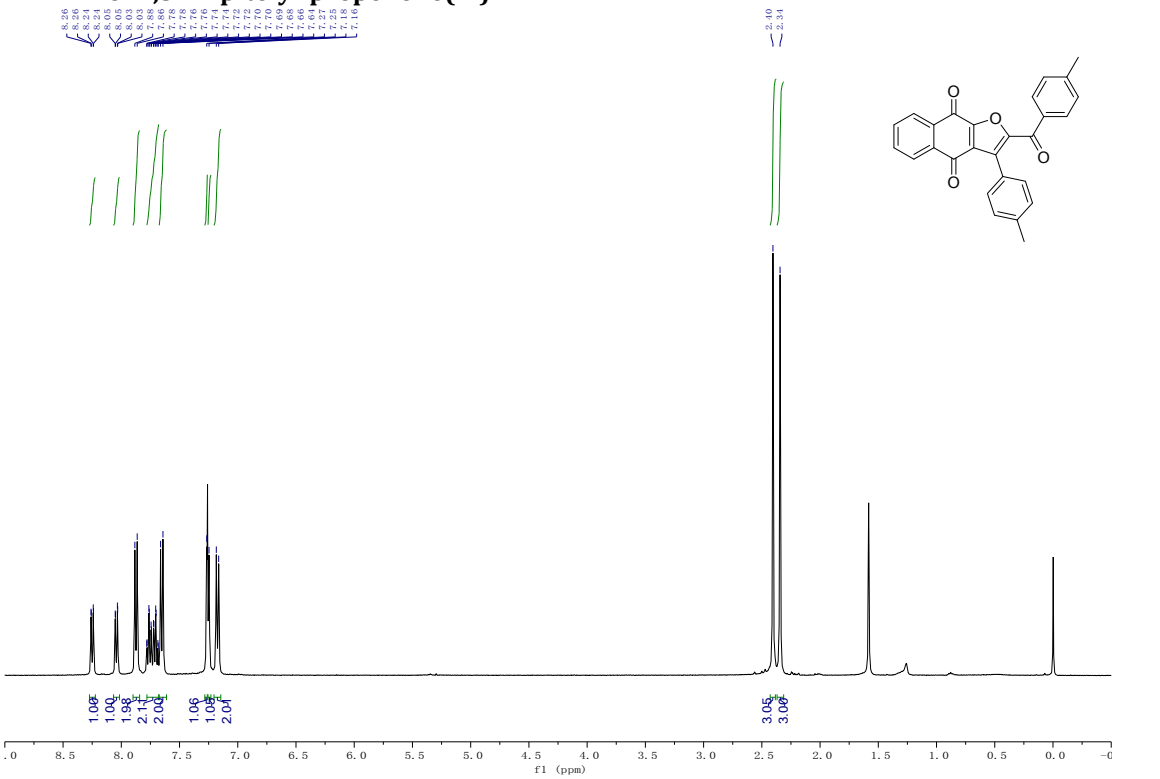
^{1}H-NMR of 2-(4-chlorophenyl)-3-phenyl-4,9-dihydronaphtho[2,3-b]furane-4,9-dione(3k)



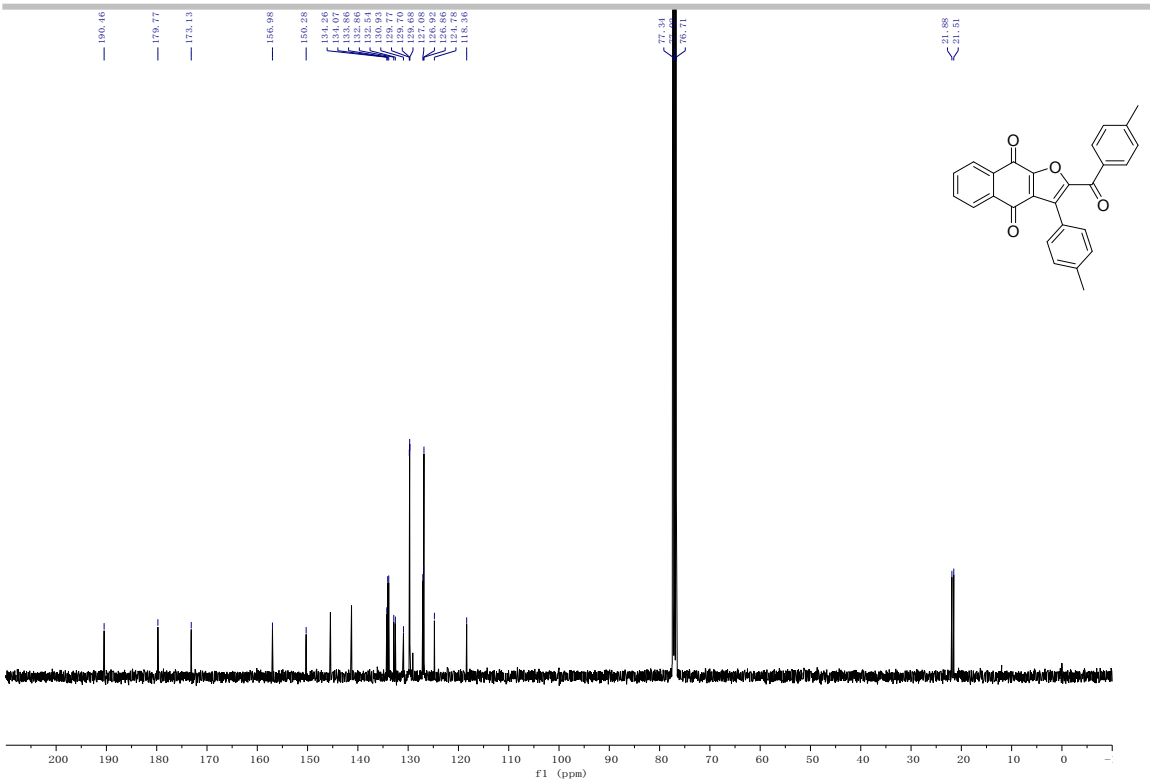
^{13}C-NMR of 2-(4-chlorophenyl)-3-phenyl-4,9-dihydronaphtho[2,3-b]furane-4,9-dione(3k)



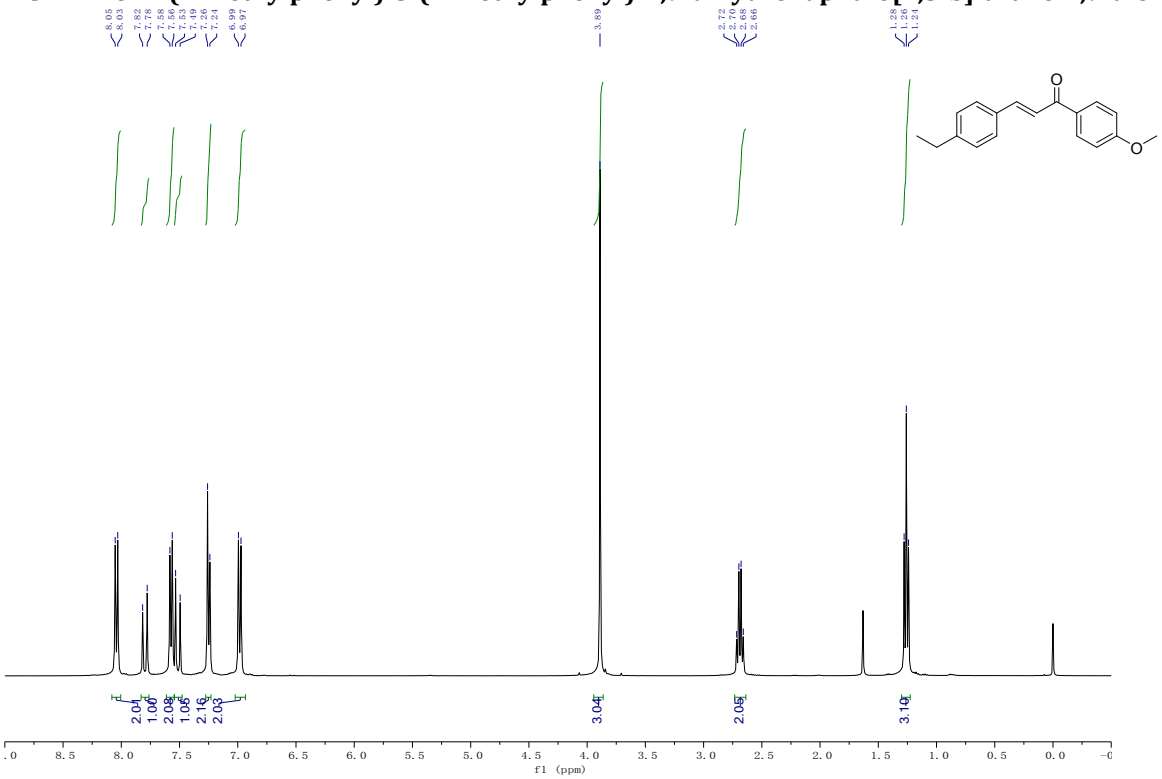
^{1}H-NMR of 1,3-Di-p-tolyl-propenone(2l)



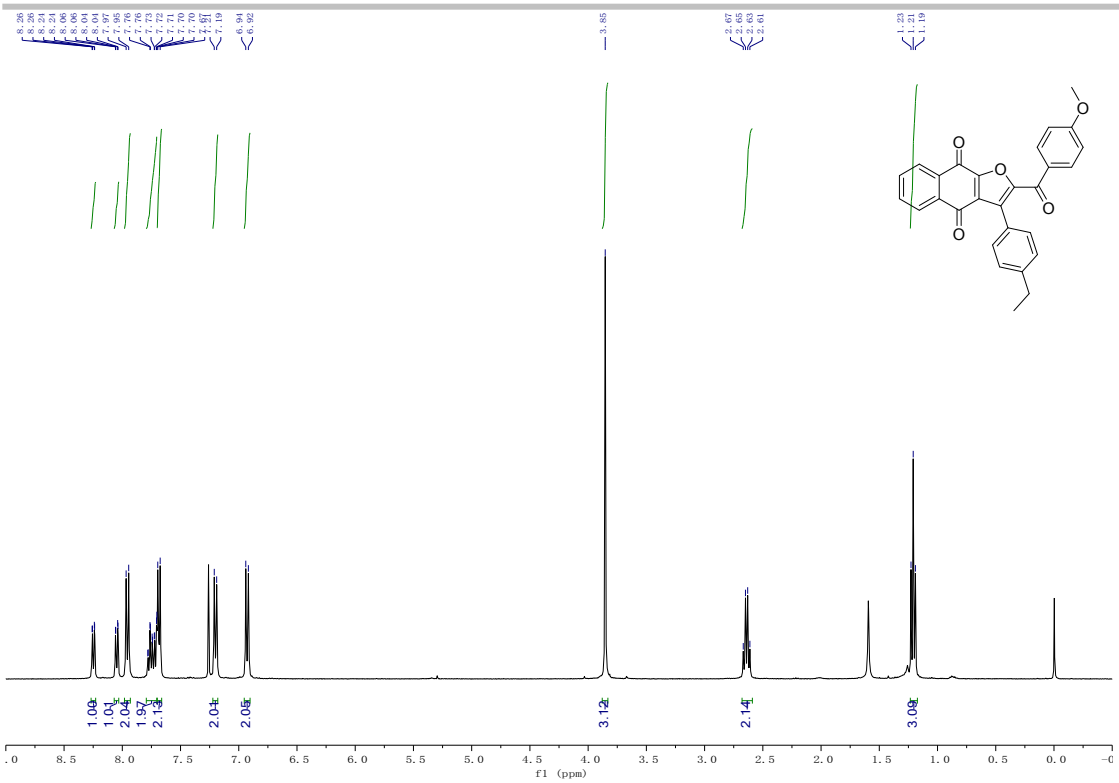
^{1}H-NMR of 2-(4-methylphenyl)-3-(4-methylphenyl)-4,9-dihydronaphtho[2,3-b]furane-4,9-dione(3l)



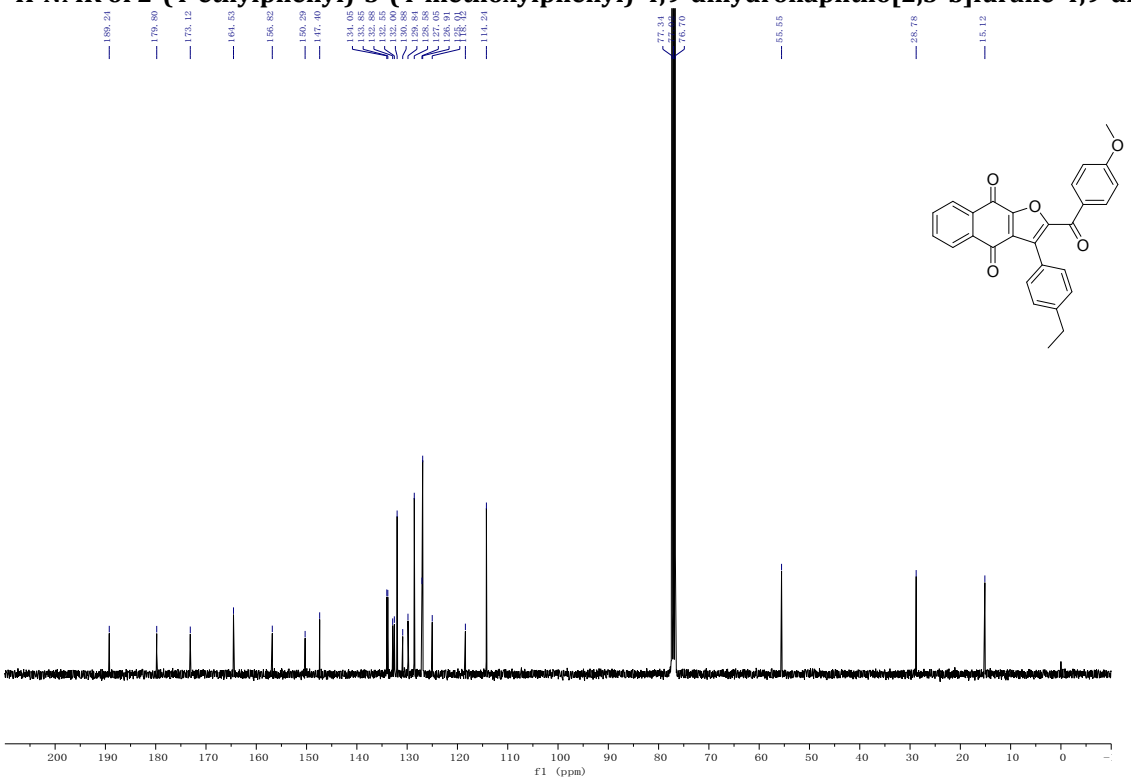
^{13}C-NMR of 2-(4-methylphenyl)-3-(4-methylphenyl)-4,9-dihydronaphtho[2,3-b]furane-4,9-dione(3l)



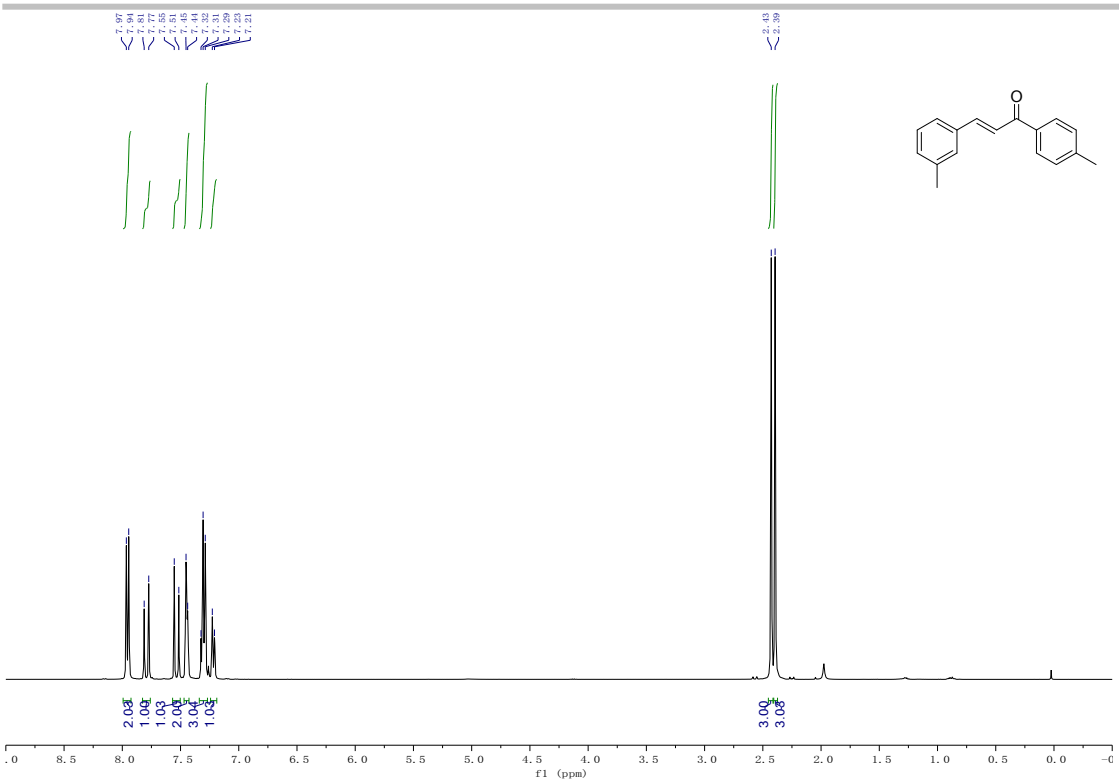
^{1}H-NMR of 3-(4-Ethyl-phenyl)-1-(4-methoxy-phenyl)- propenone(2m)



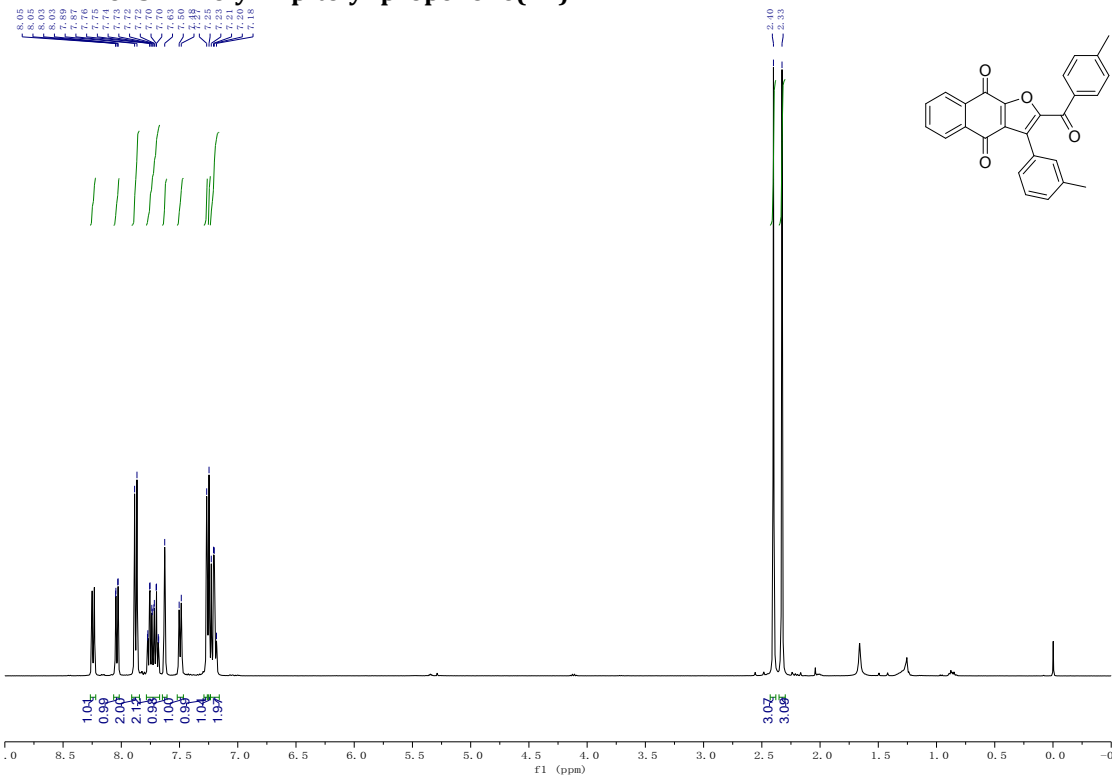
^{1}H-NMR of 2-(4-ethylphenyl)-3-(4-methoxylphenyl)-4,9-dihydronaphtho[2,3-b]furane-4,9-dione(3m)



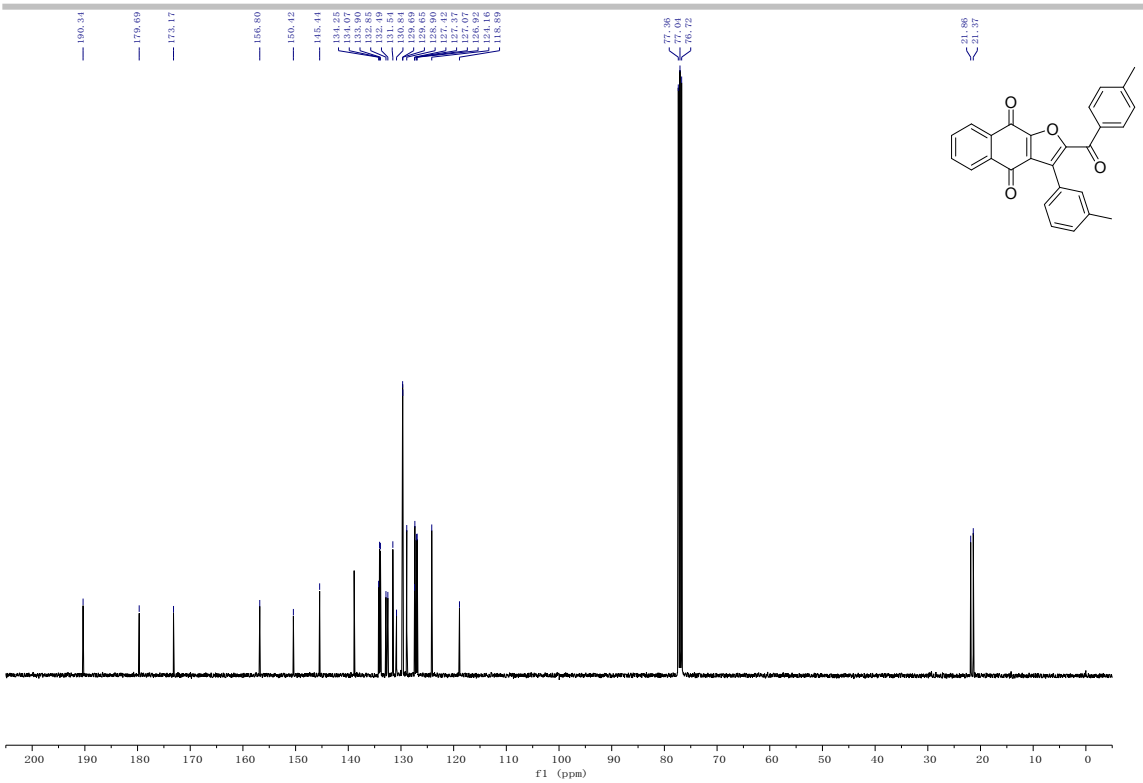
^{13}C-NMR of 2-(4-ethylphenyl)-3-(4-methoxylphenyl)-4,9-dihydronaphtho[2,3-b]furane-4,9-dione(3m)



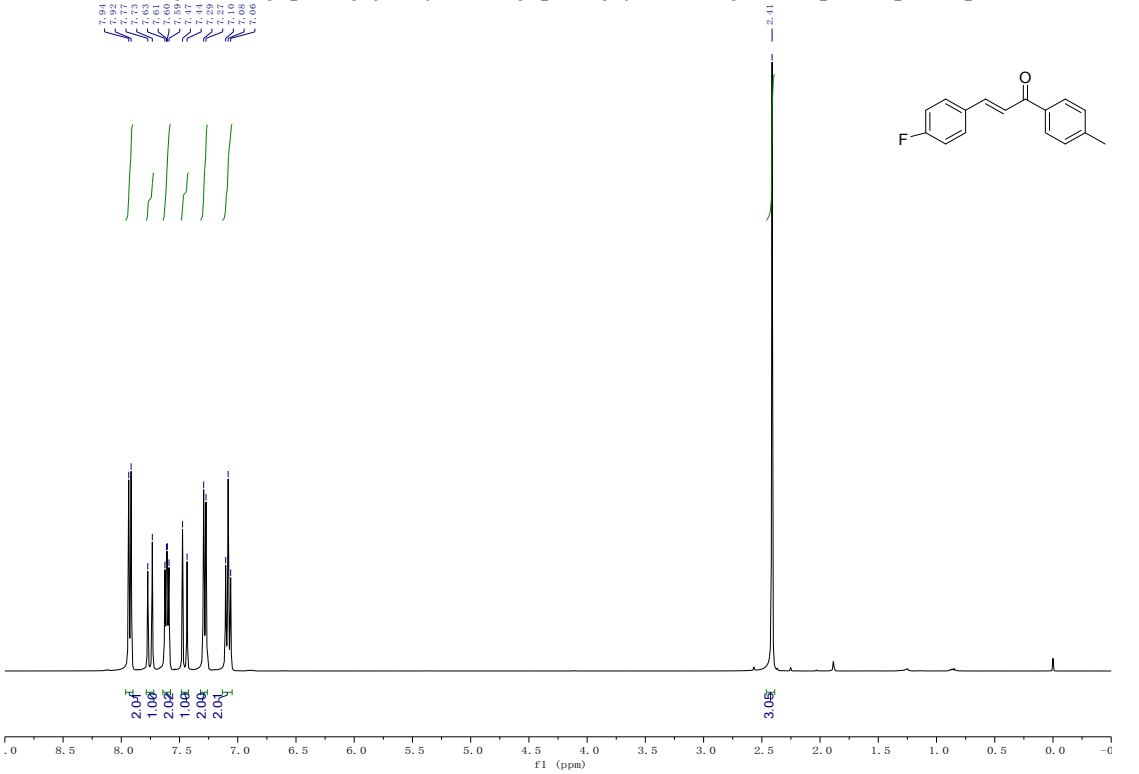
^{1}H-NMR of 3-m-Tolyl-1-p-tolyl-propenone(2n)



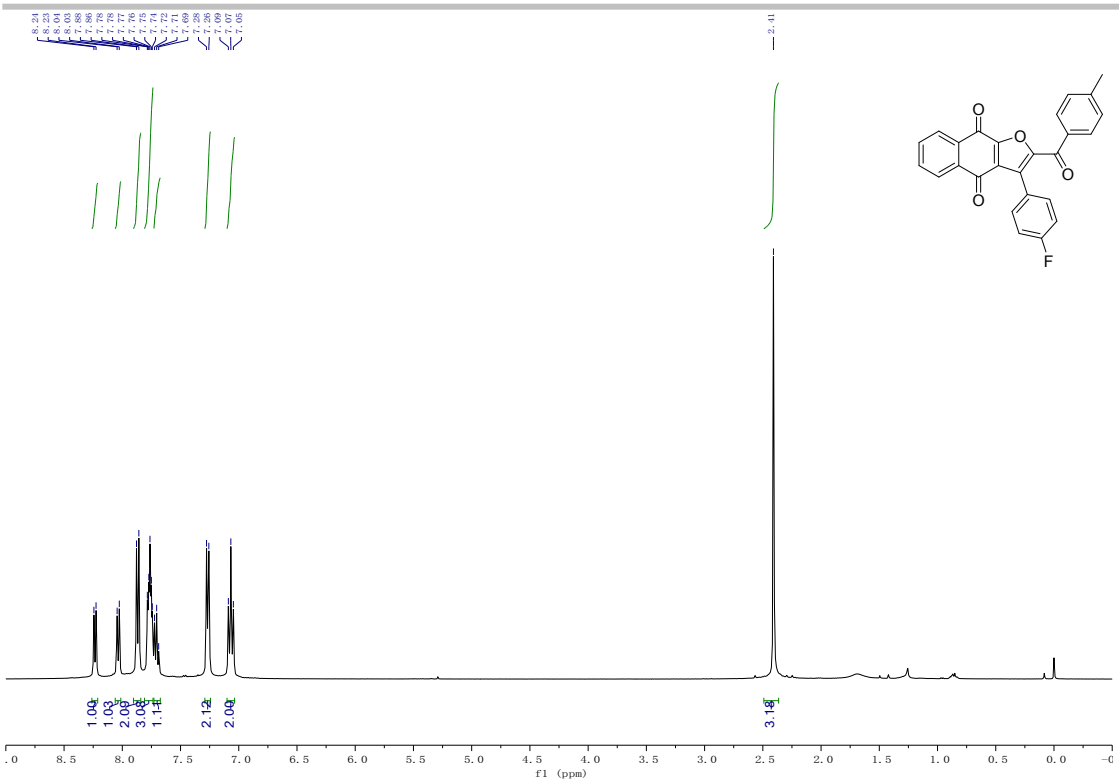
^{1}H-NMR of 2-(4-methylphenyl)-3-(3-methylphenyl)-4,9-dihydronaphtho[2,3-b]furane-4,9-dione(3n)



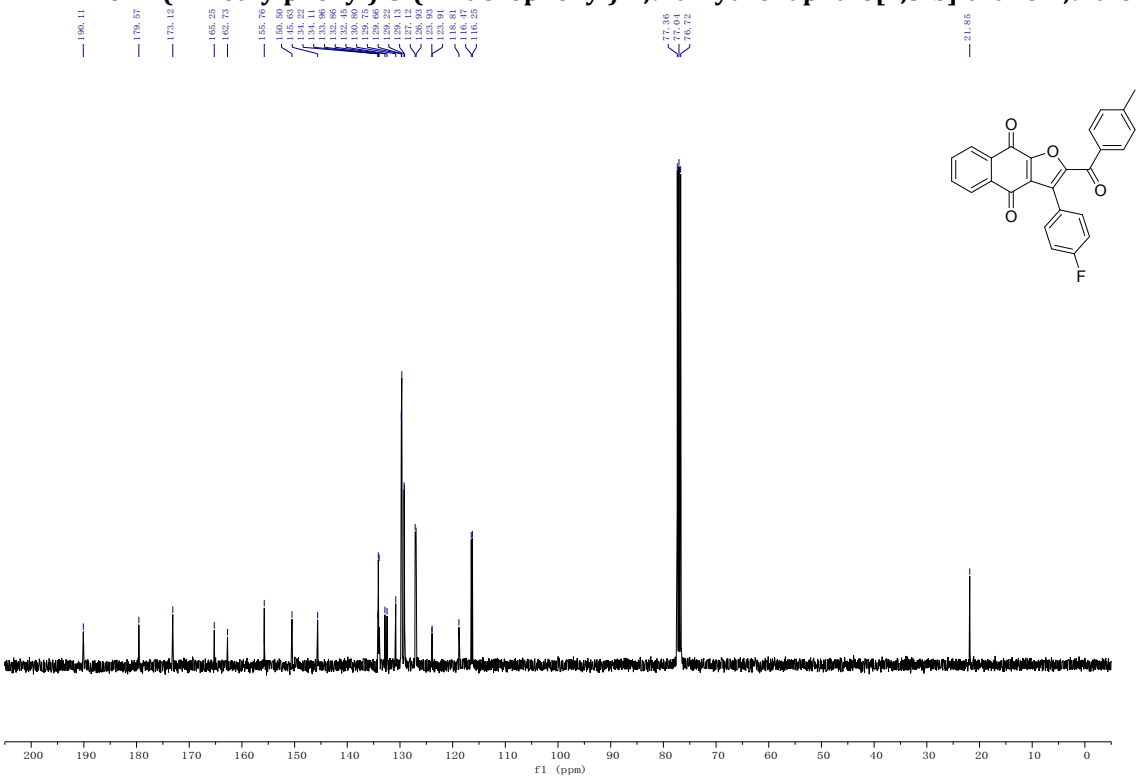
^{13}C-NMR of 2-(4-methylphenyl)-3-(3-methylphenyl)-4,9-dihydronaphtho[2,3-b]furane-4,9-dione(3n)



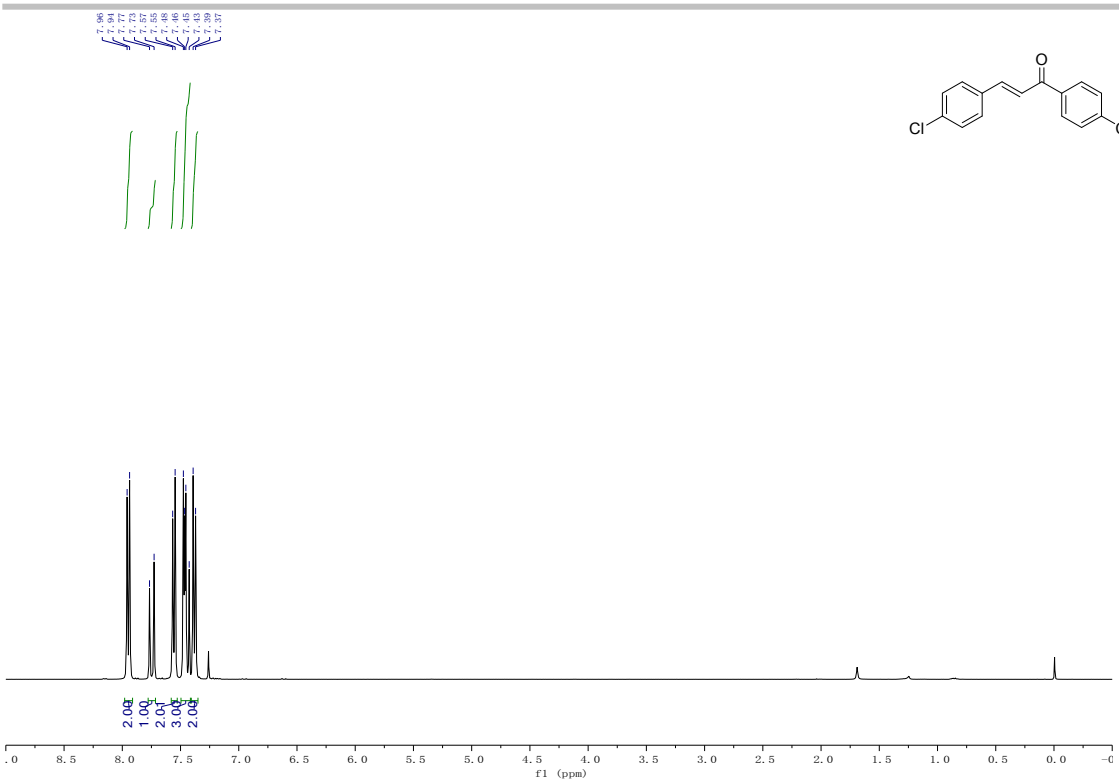
^{1}H-NMR of 3-(4-Fluoro-phenyl)-1-p-tolyl-propenone(2o)



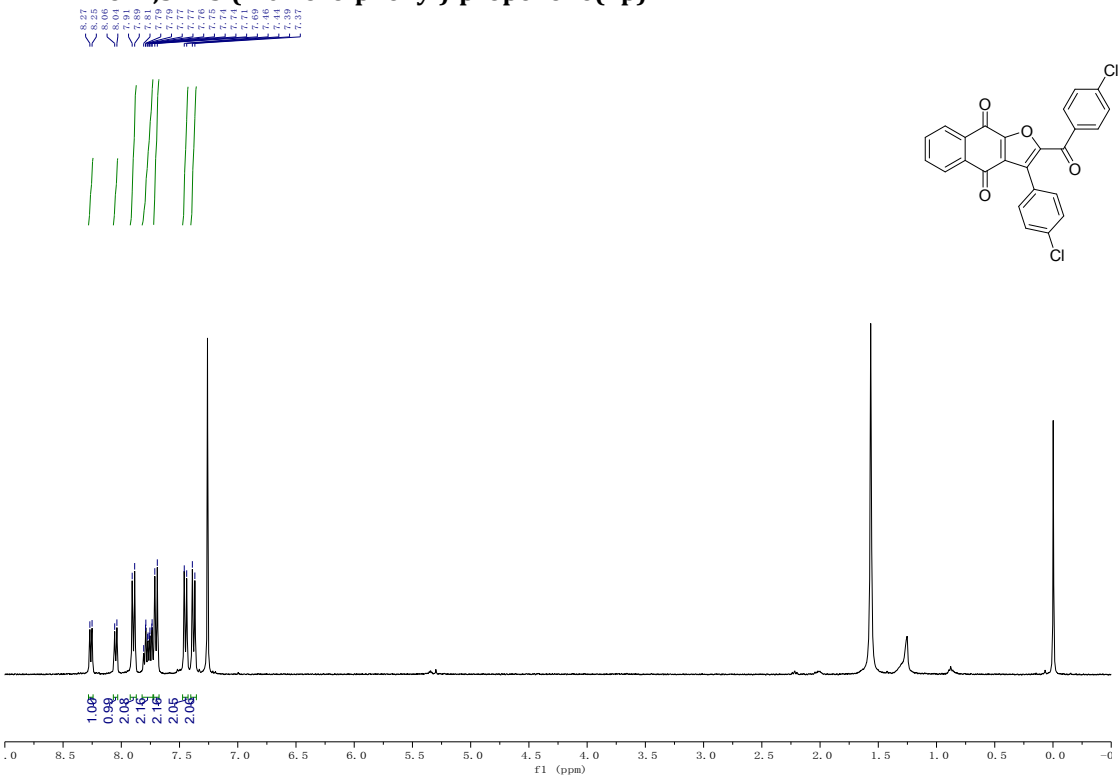
^{1}H-NMR of 2-(4-methylphenyl)-3-(4-fluorophenyl)-4,9-dihydronaphtho[2,3-b]furane-4,9-dione(3o)



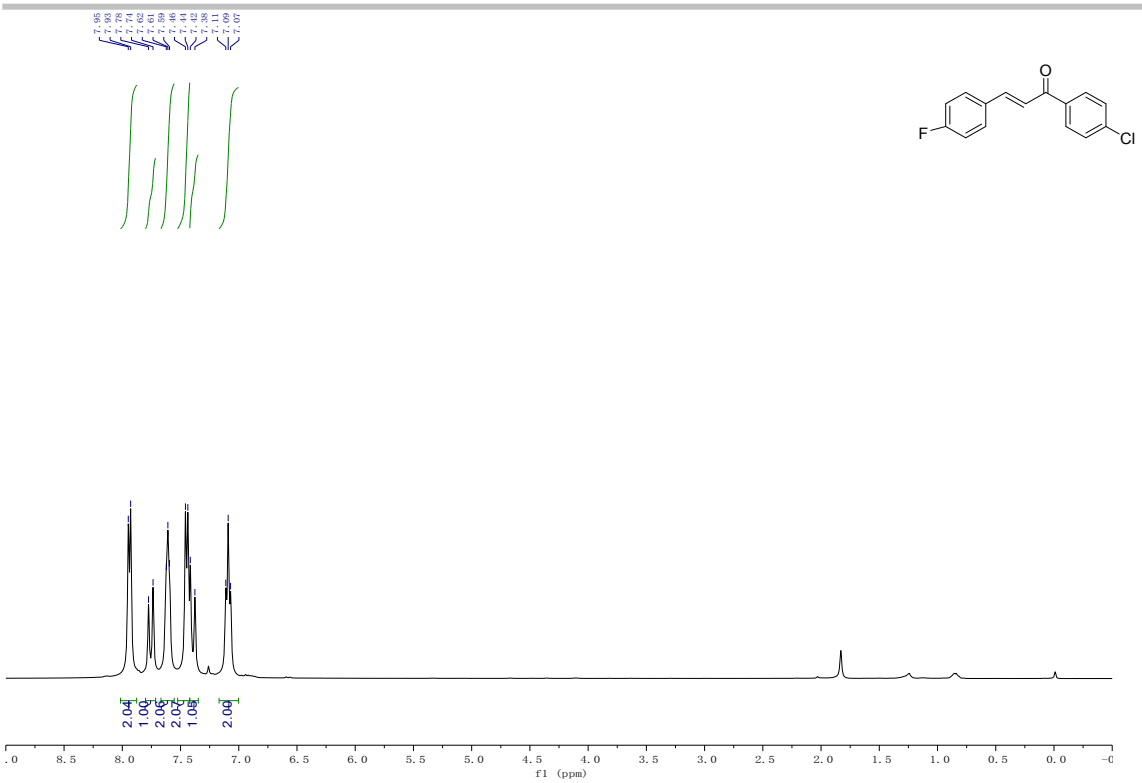
^{13}C-NMR of 2-(4-methylphenyl)-3-(4-fluorophenyl)-4,9-dihydronaphtho[2,3-b]furane-4,9-dione(3o)



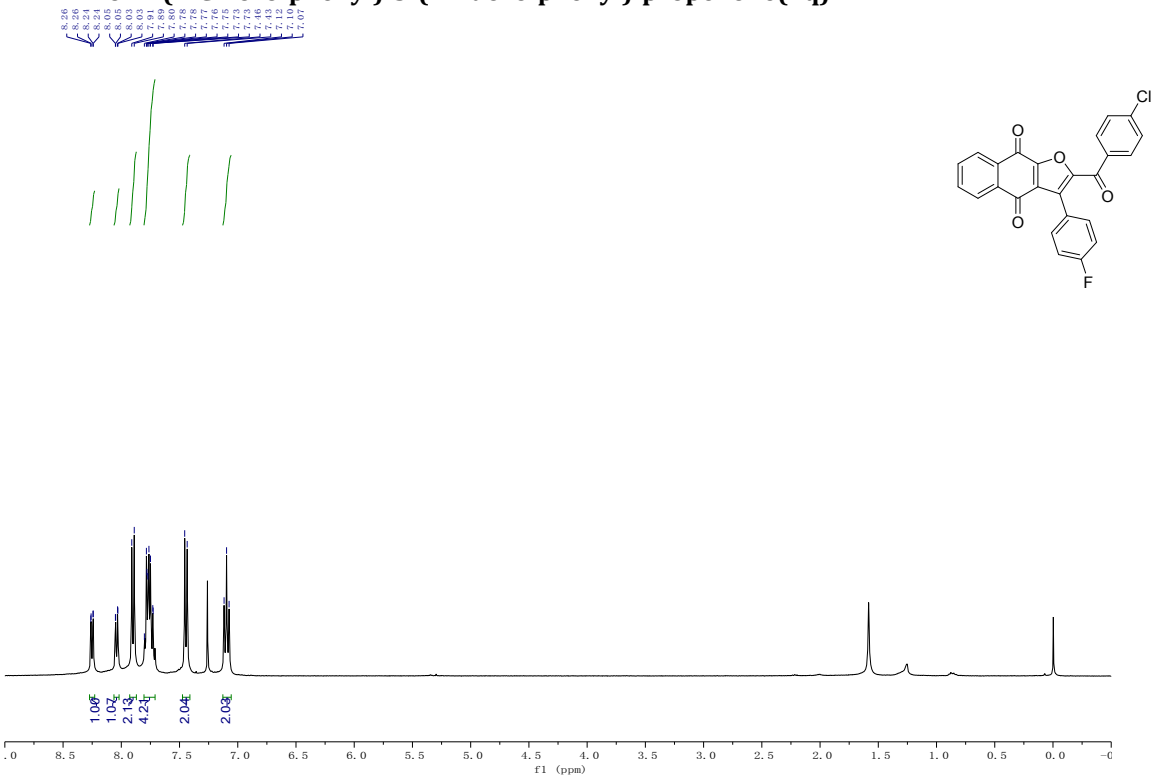
^{1}H-NMR of 1,3-Bis-(4-chloro-phenyl)-propenone(2p)



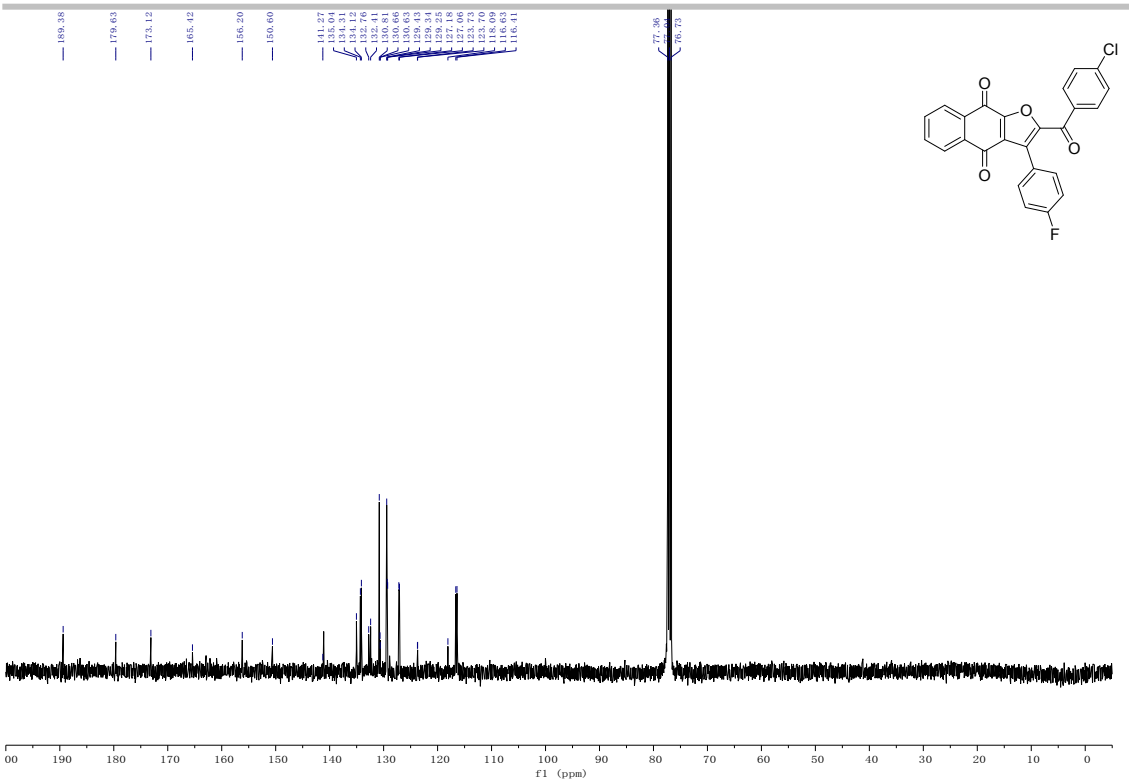
^{1}H-NMR of 2-(4-chlorophenyl)-3-(4-chlorophenyl)-4,9-dihydronaphtho[2,3-b]furane-4,9-dione(3p)



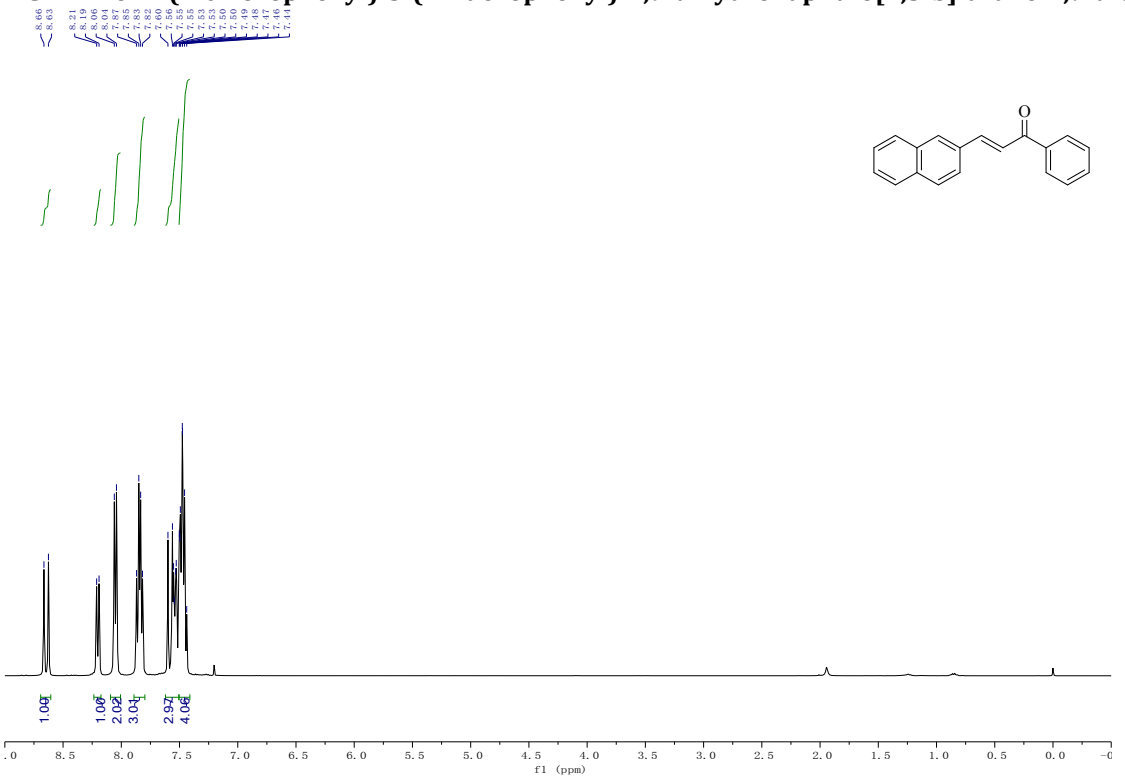
^{1}H-NMR of 1-(4-Chloro-phenyl)-3-(4-fluoro-phenyl)-propenone(2q)



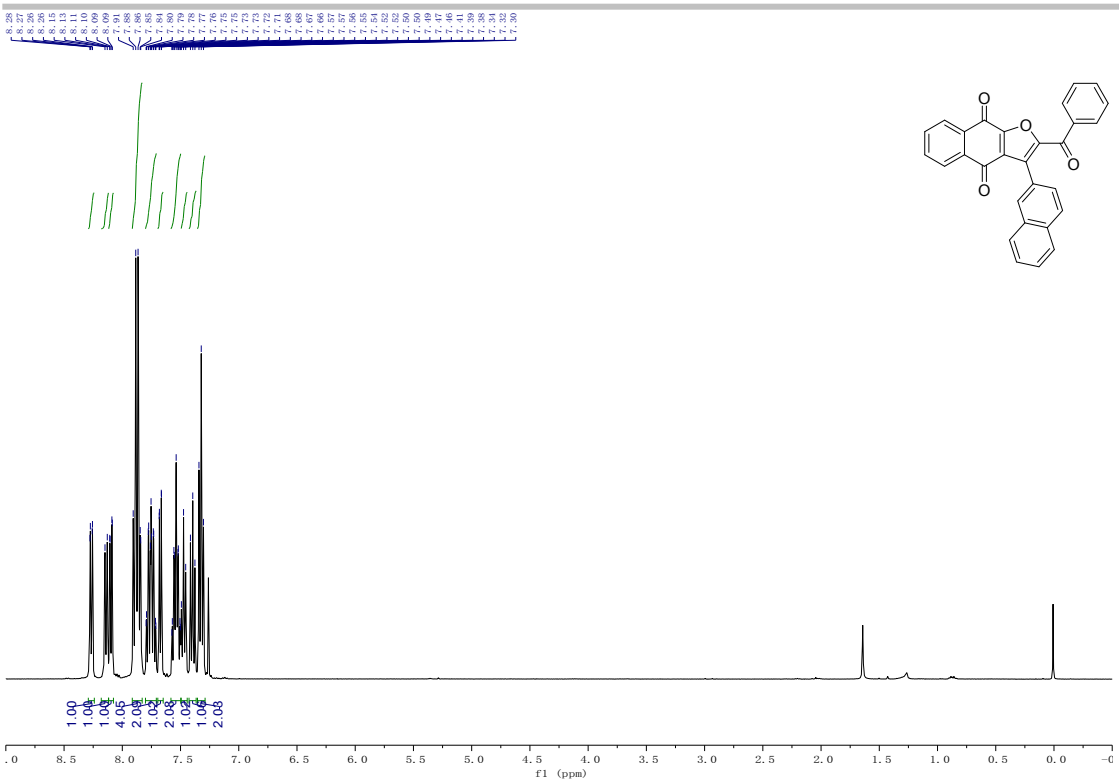
^{1}H-NMR of 2-(4-chlorophenyl)-3-(4-fluorophenyl)-4,9-dihydronaphtho[2,3-b]furane-4,9-dione(3q)



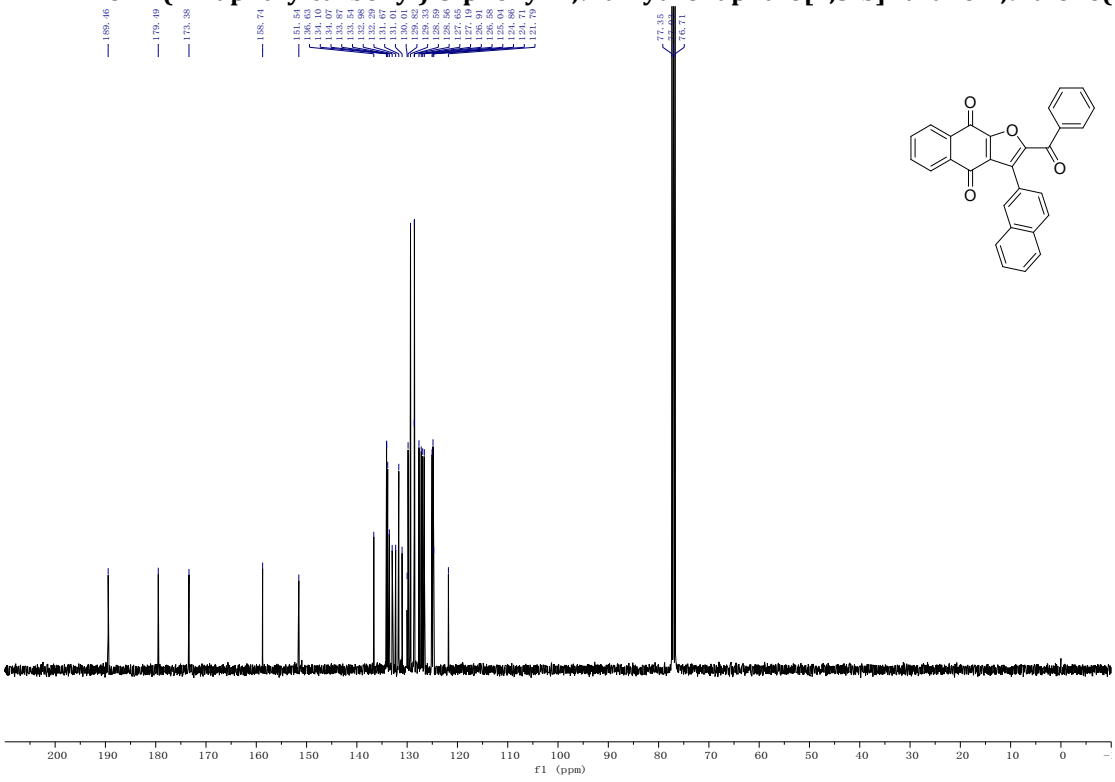
^{13}C-NMR of 2-(4-chlorophenyl)-3-(4-fluorophenyl)-4,9-dihydronaphtho[2,3-b]furane-4,9-dione(3q)



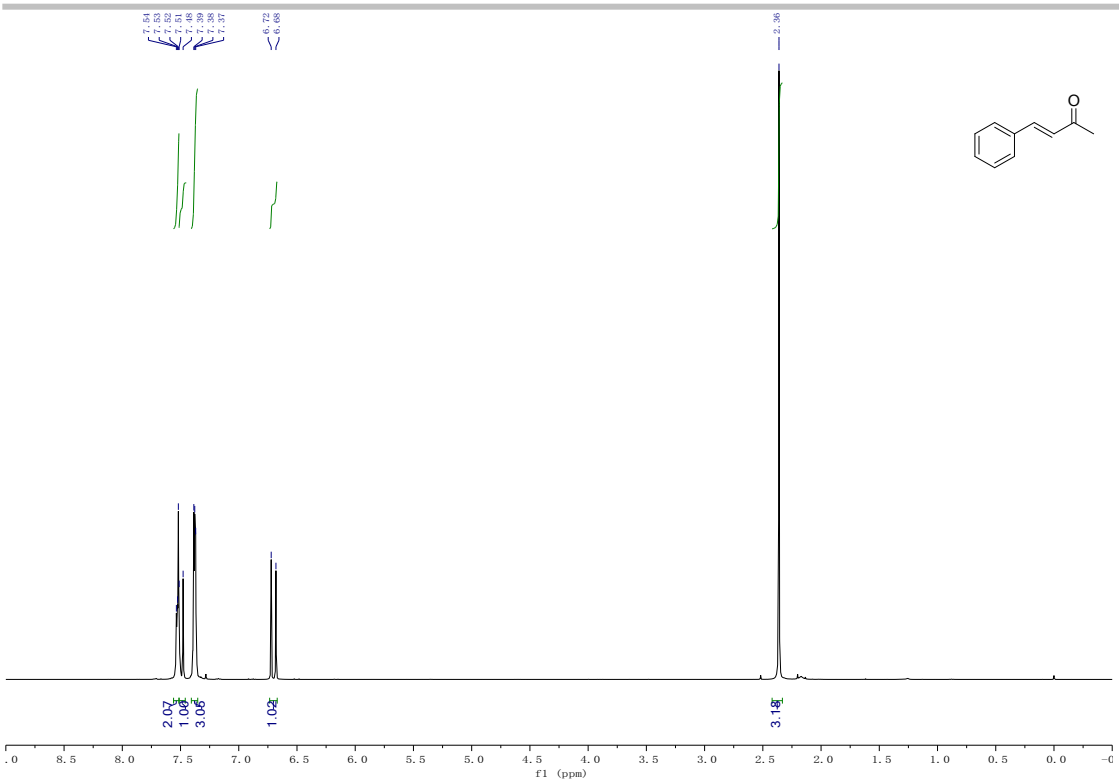
^{1}H-NMR of 3-Naphthalen-2- phenyl-propenone(2r)



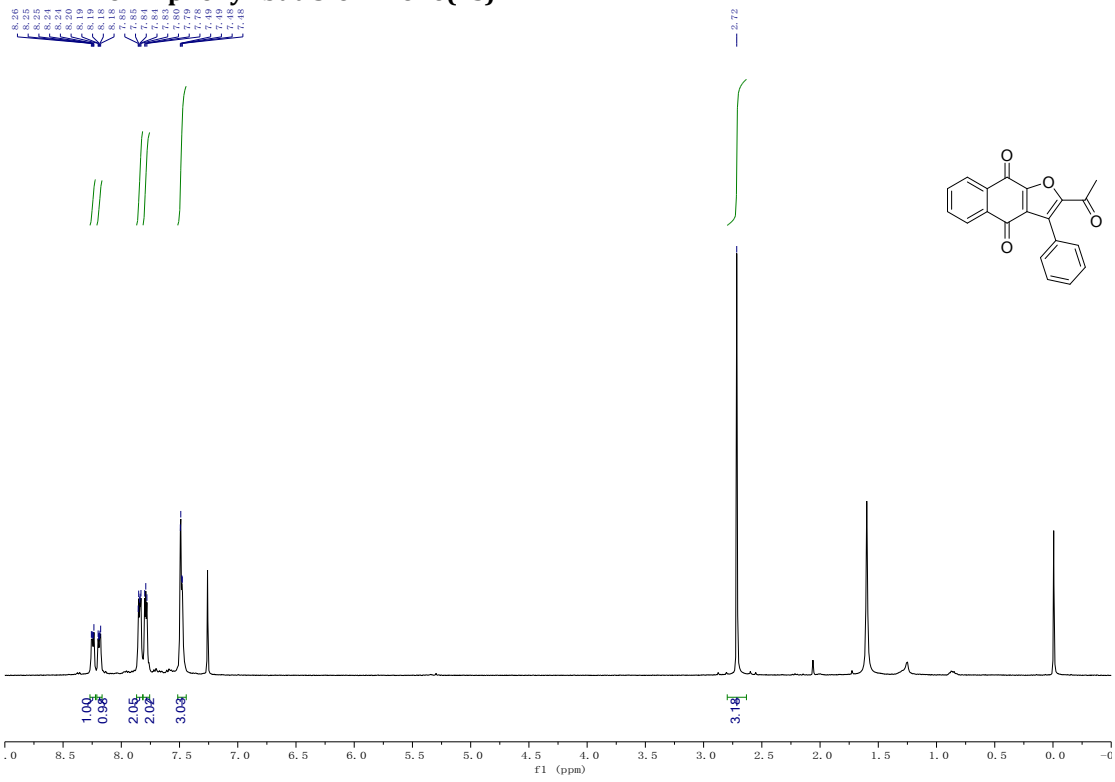
^{1}H-NMR of 2-(2-Naphthylcarbonyl)-3-phenyl-4,9-dihydronaphtho[2,3-b]-furane-4,9-dione(3r)



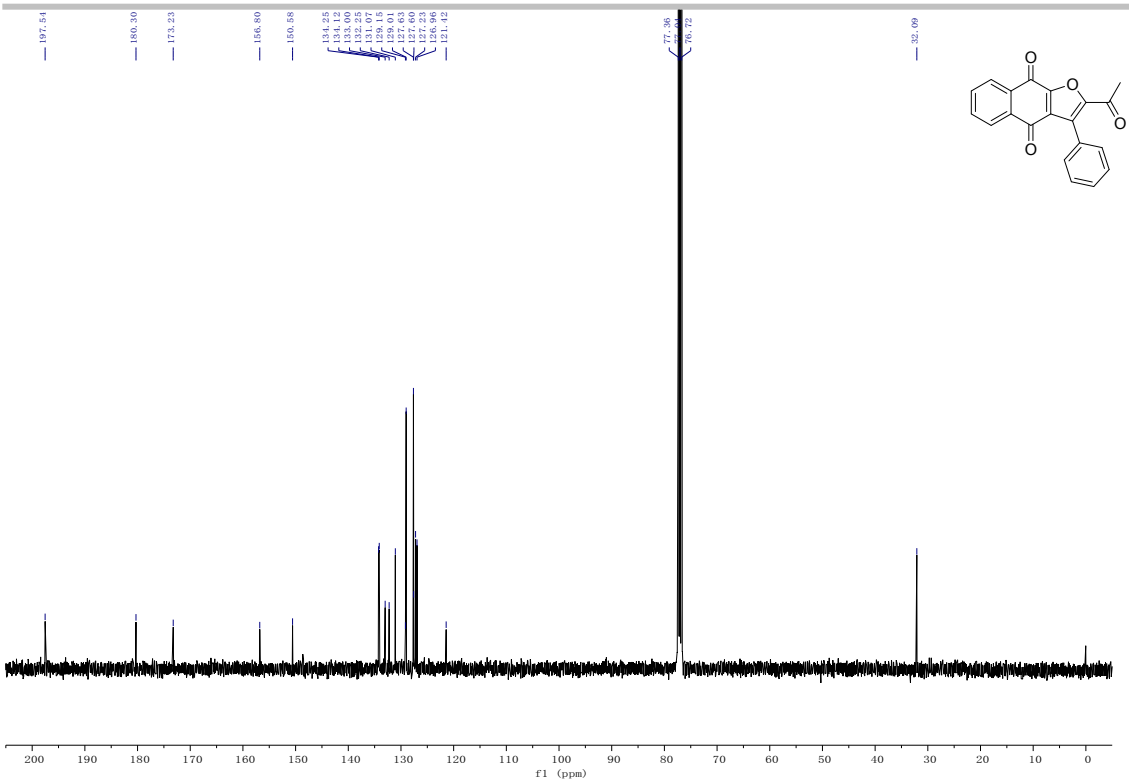
^{13}C-NMR of 2-(2-Naphthylcarbonyl)-3-phenyl-4,9-dihydronaphtho[2,3-b]-furane-4,9-dione(3r)



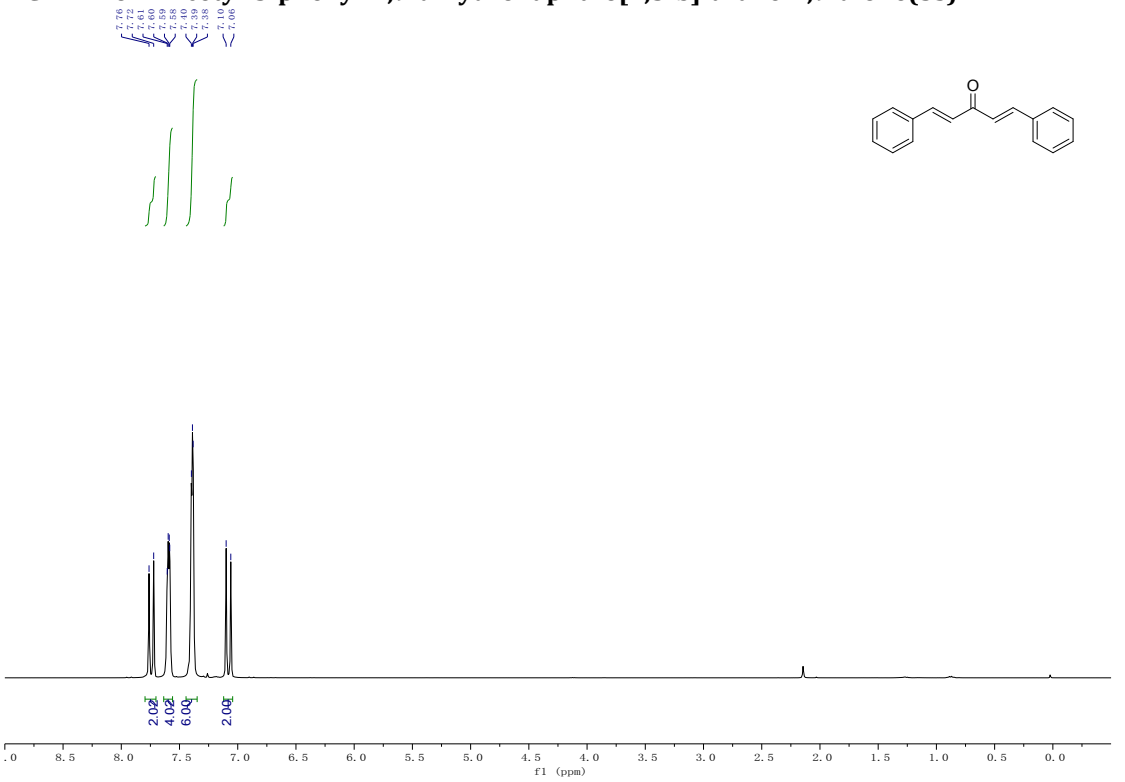
^{1}H-NMR of 4- phenyl-but-3-en-2-one(2s)



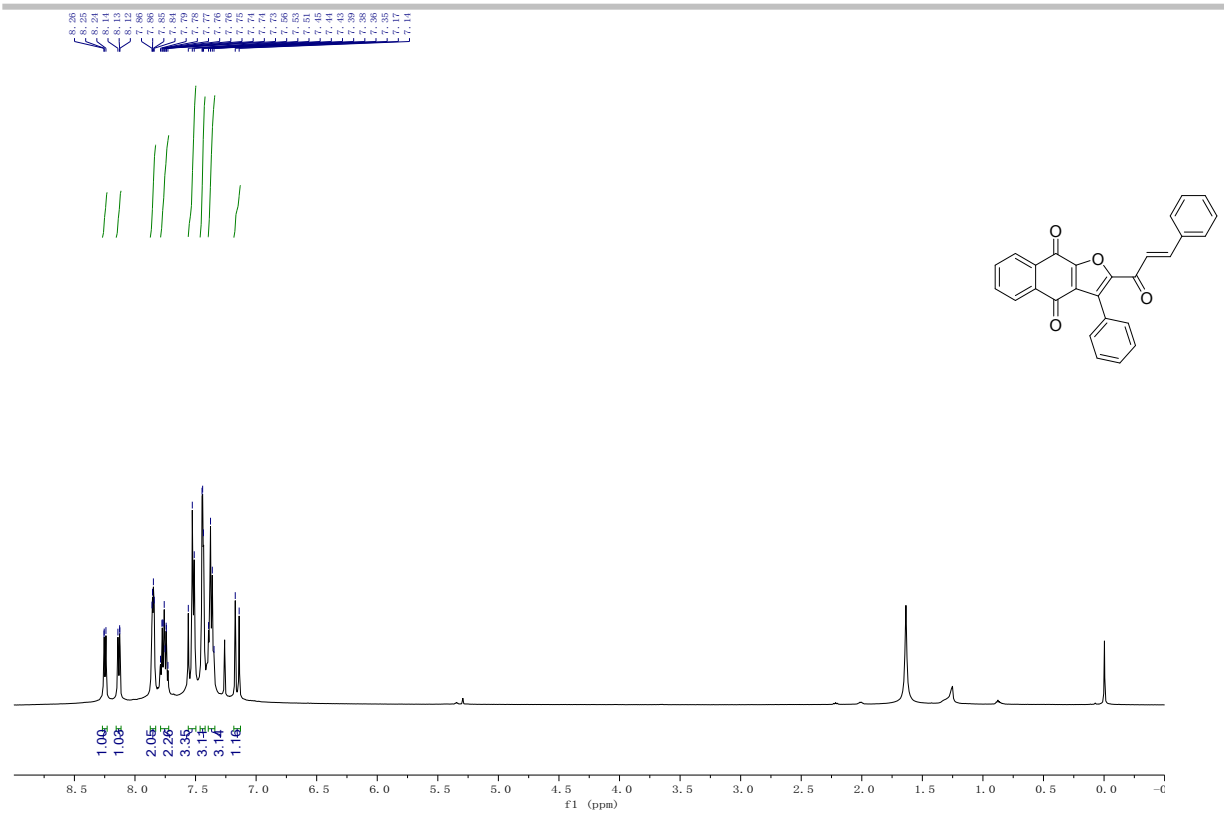
^{1}H-NMR of 2-Acetyl-3-phenyl-4,9-dihydronaphtho[2,3-b]furane-4,9-dione(3s)



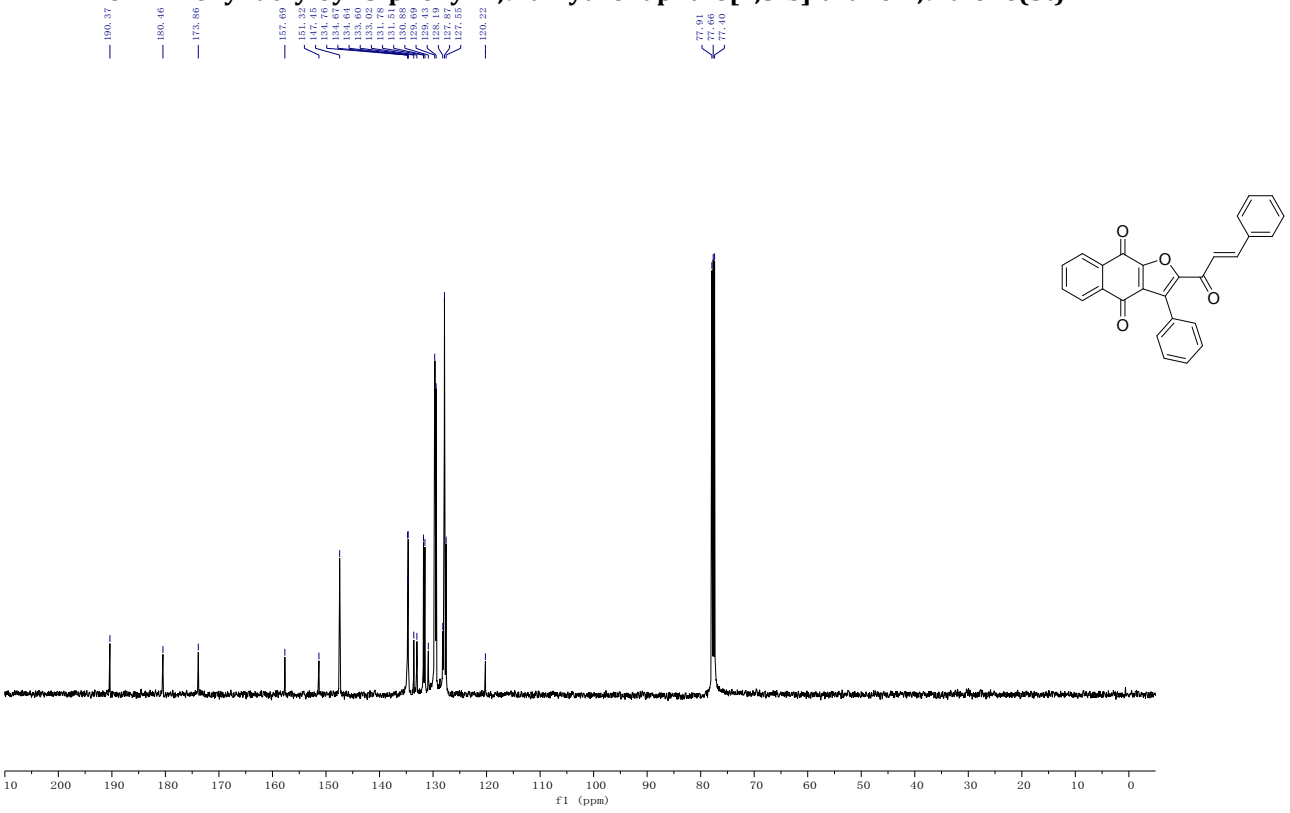
^{13}C-NMR of 2-Acetyl-3-phenyl-4,9-dihydronaphtho[2,3-b]furane-4,9-dione(3s)



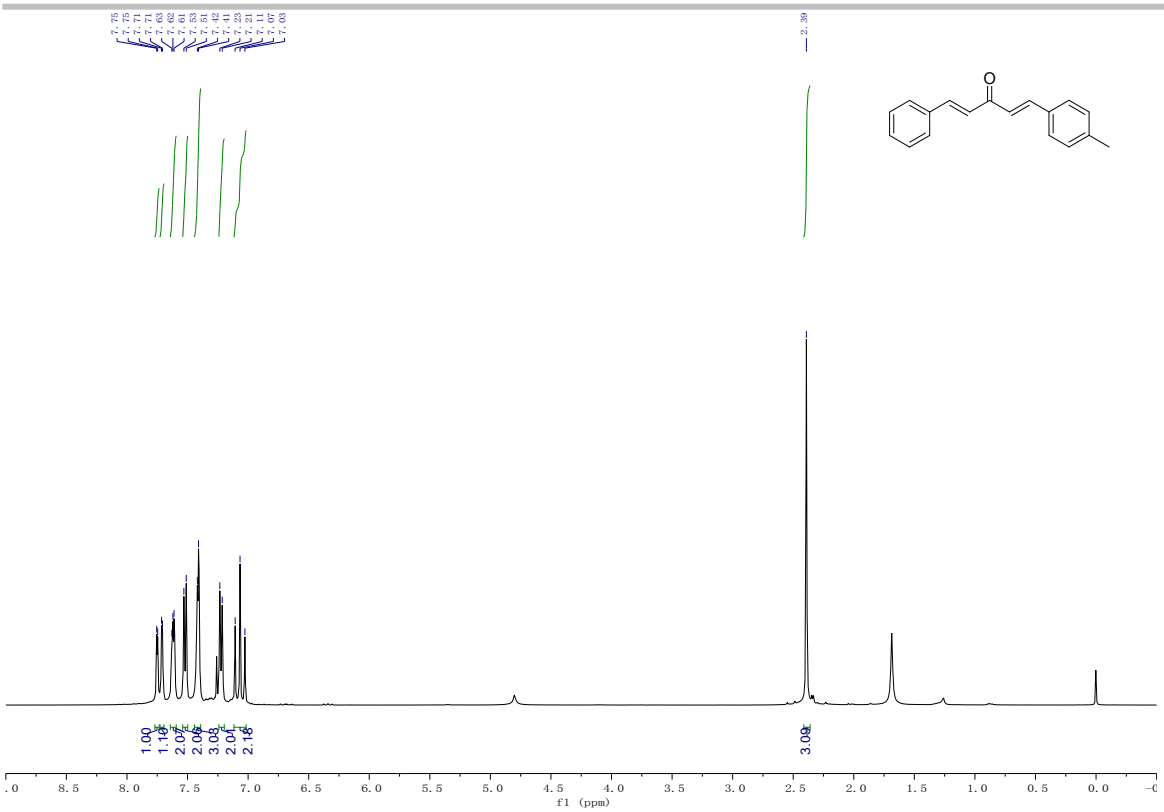
^{1}H-NMR of 1,5-Diphenyl-penta-1,4-dien-3-one(2t)



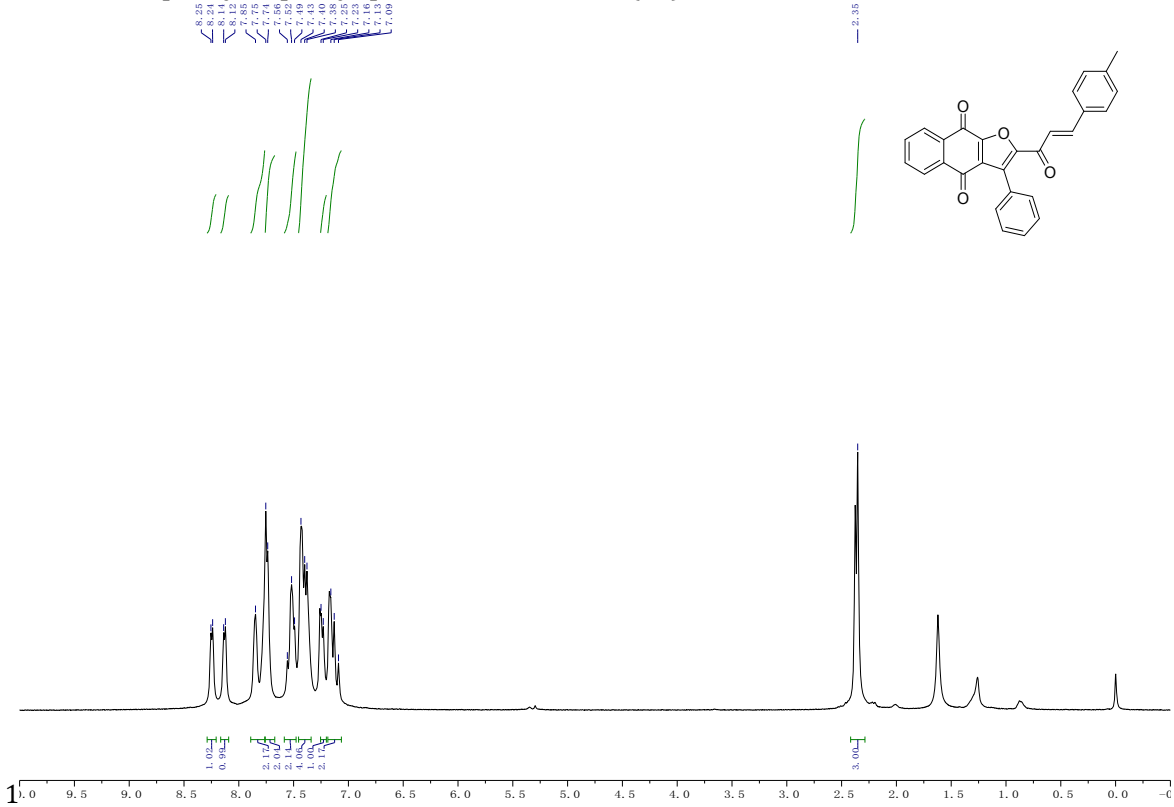
^{1}H-NMR of 2-Phenyl-acryloyl-3-phenyl-4,9-dihydronaphtho[2,3-b]furane-4,9-dione(3t)



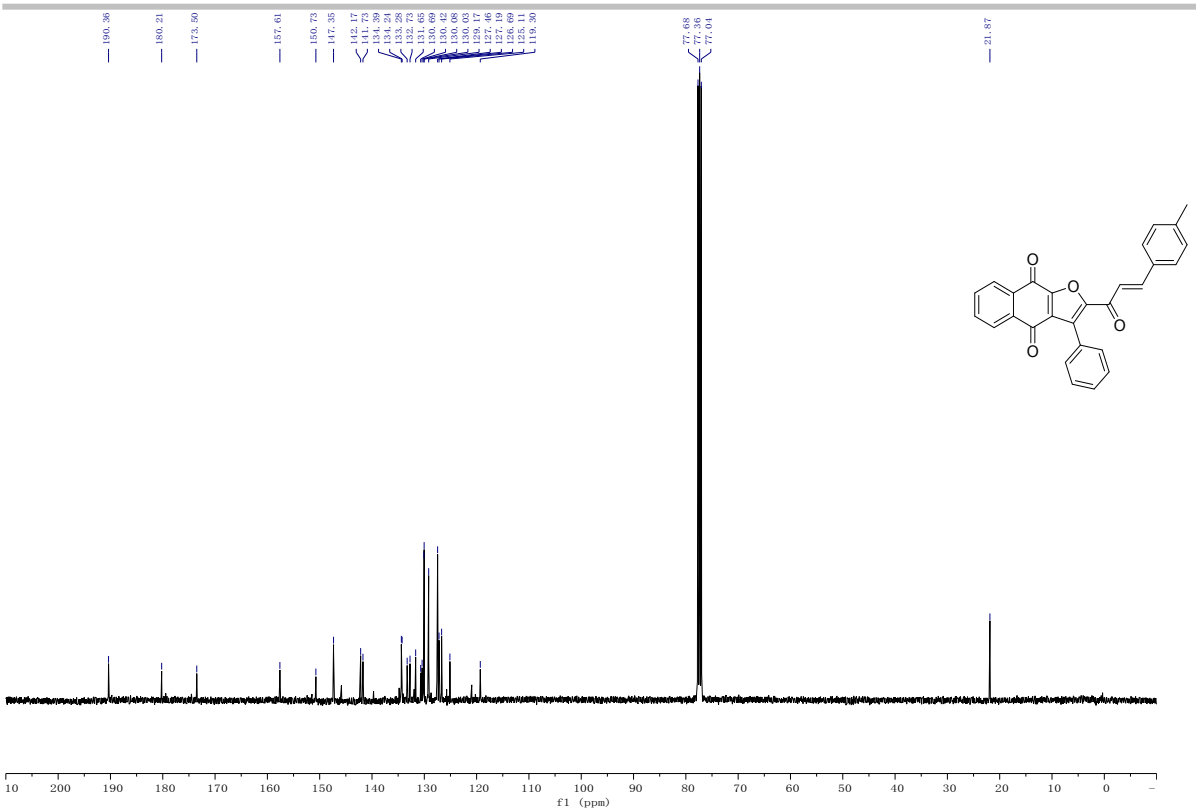
^{13}C-NMR of 2-Phenyl-acryloyl-3-phenyl-4,9-dihydronaphtho[2,3-b]furane-4,9-dione(3t)



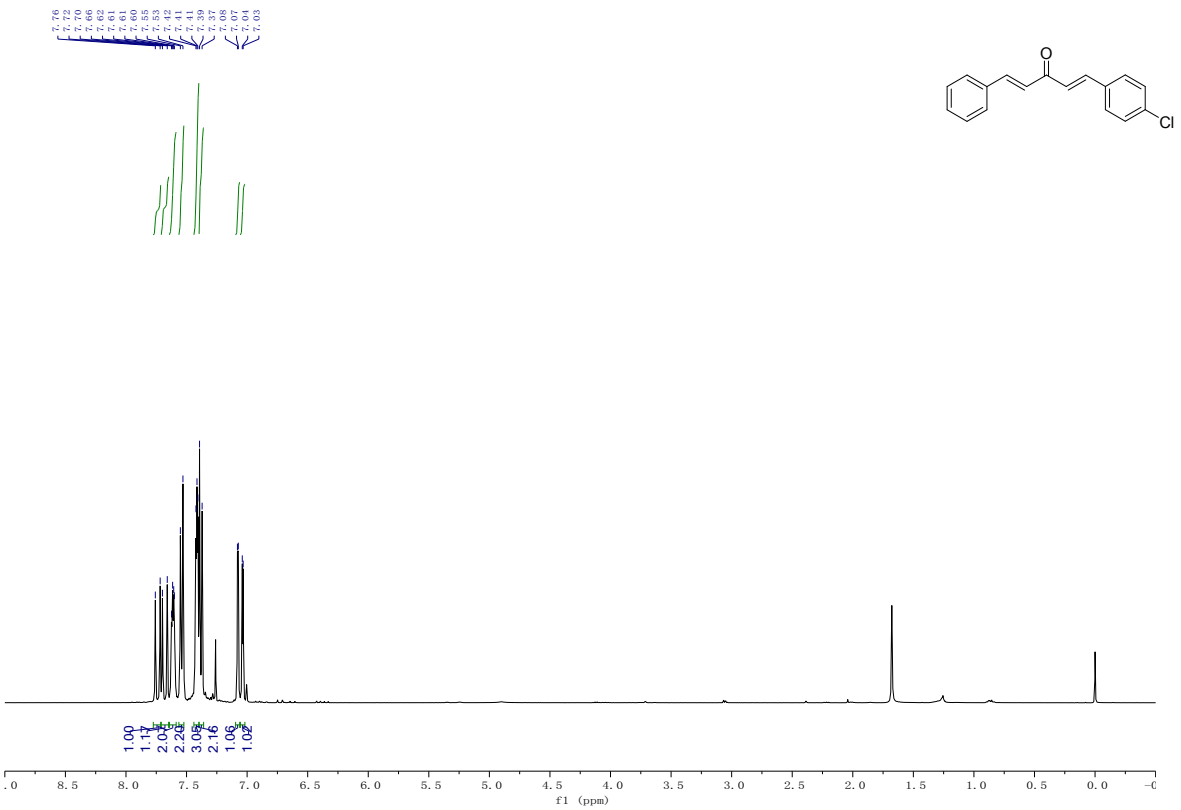
^{1}H-NMR of 1-phenyl-5-p-tolyl-penta-1,4-dien-3-one(2u)



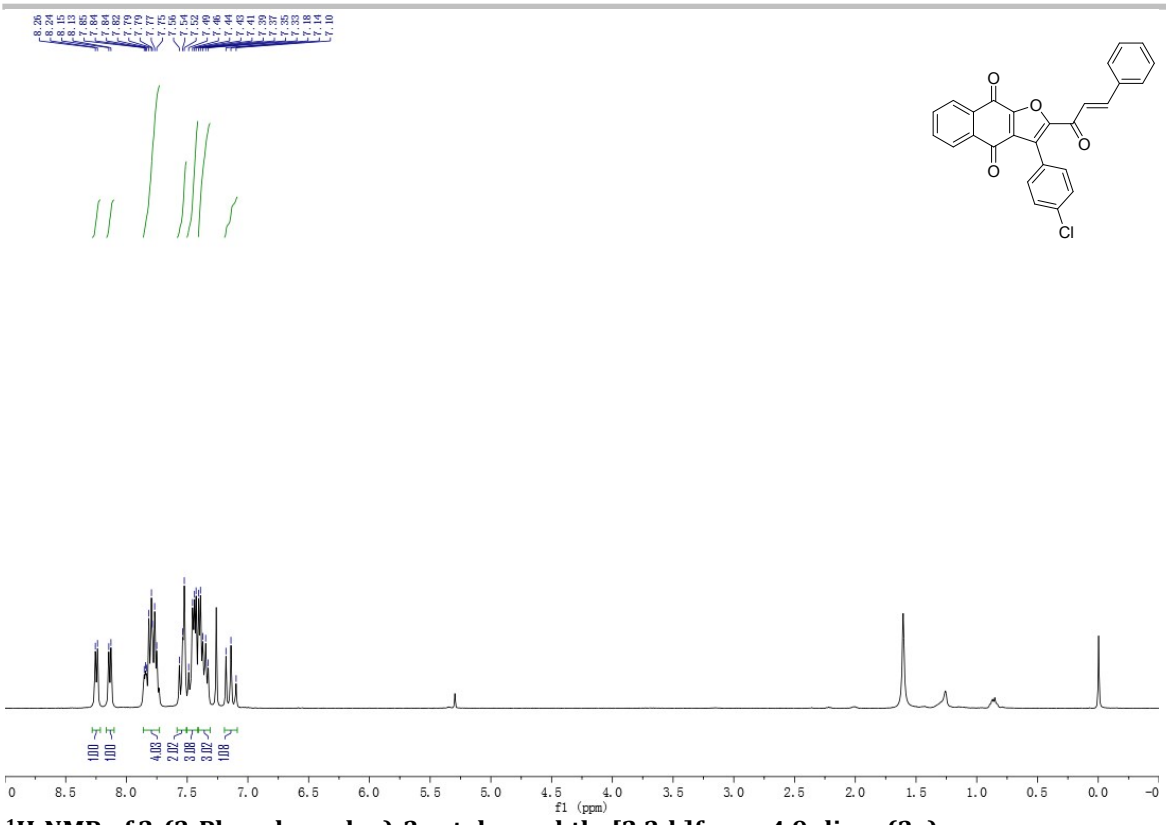
^{1}H-NMR of 2-Phenyl-acryloyl-3-phenyl-4,9-dihydronaphtho[2,3-b]furane-4,9-dione(3u)



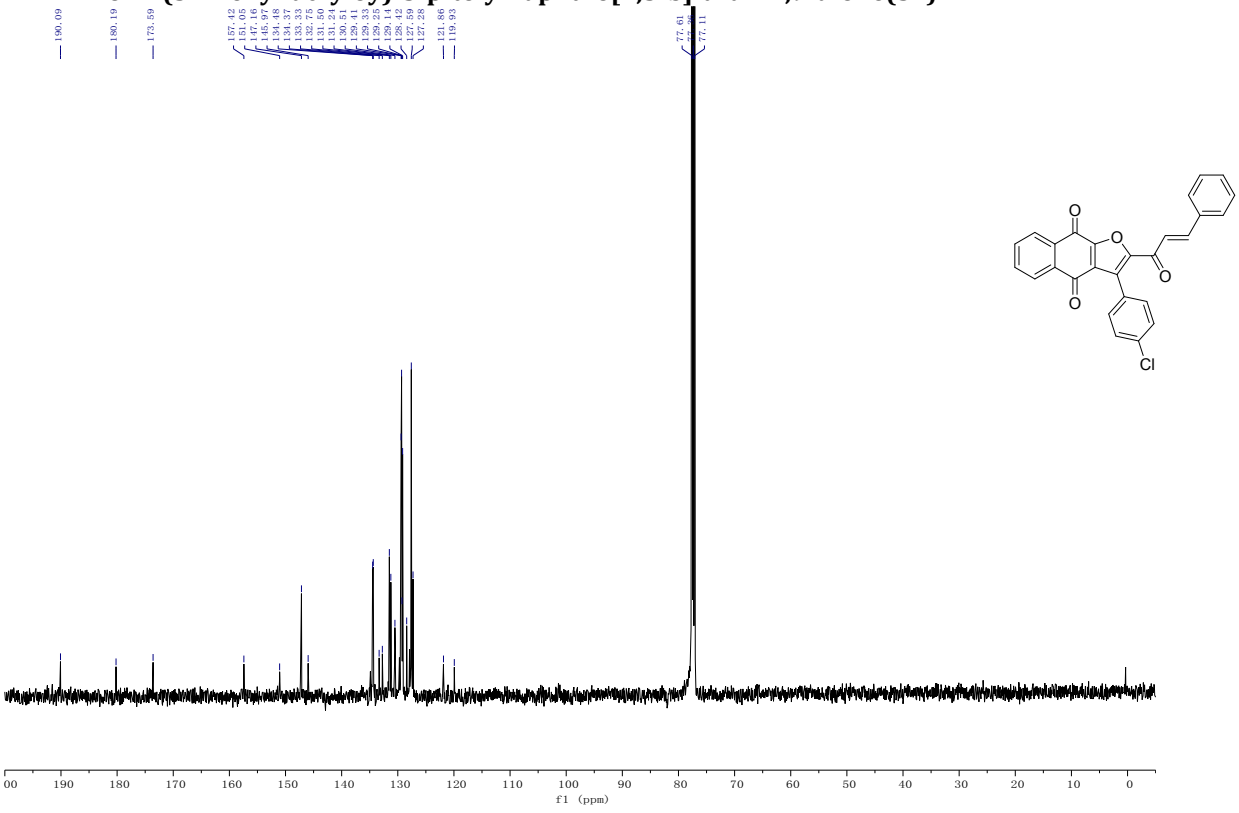
^{13}C-NMR of 2-Phenyl-acryloyl-3-phenyl-4,9-dihydronaphtho[2,3-b]furane-4,9-dione(3u)



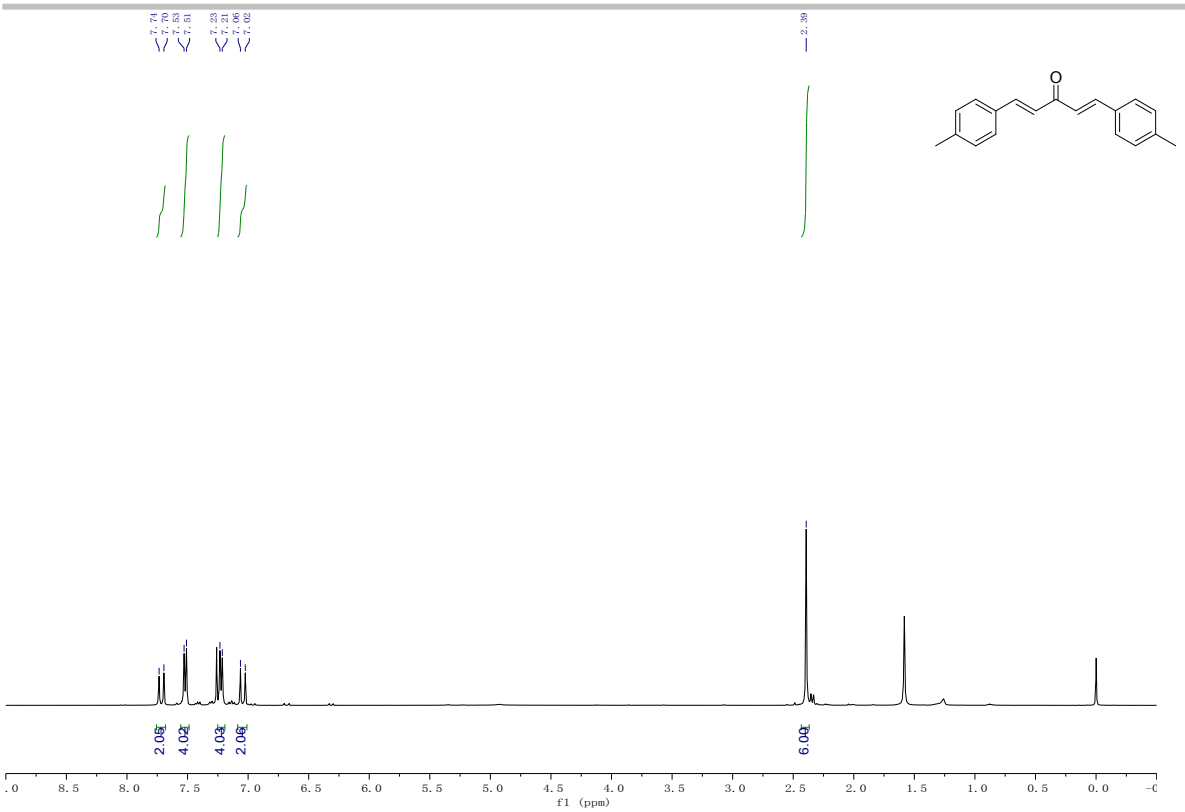
^{1}H-NMR of 1-(4-Chloro-phenyl)-5-phenyl-penta-1,4-dien-3-one(2v)



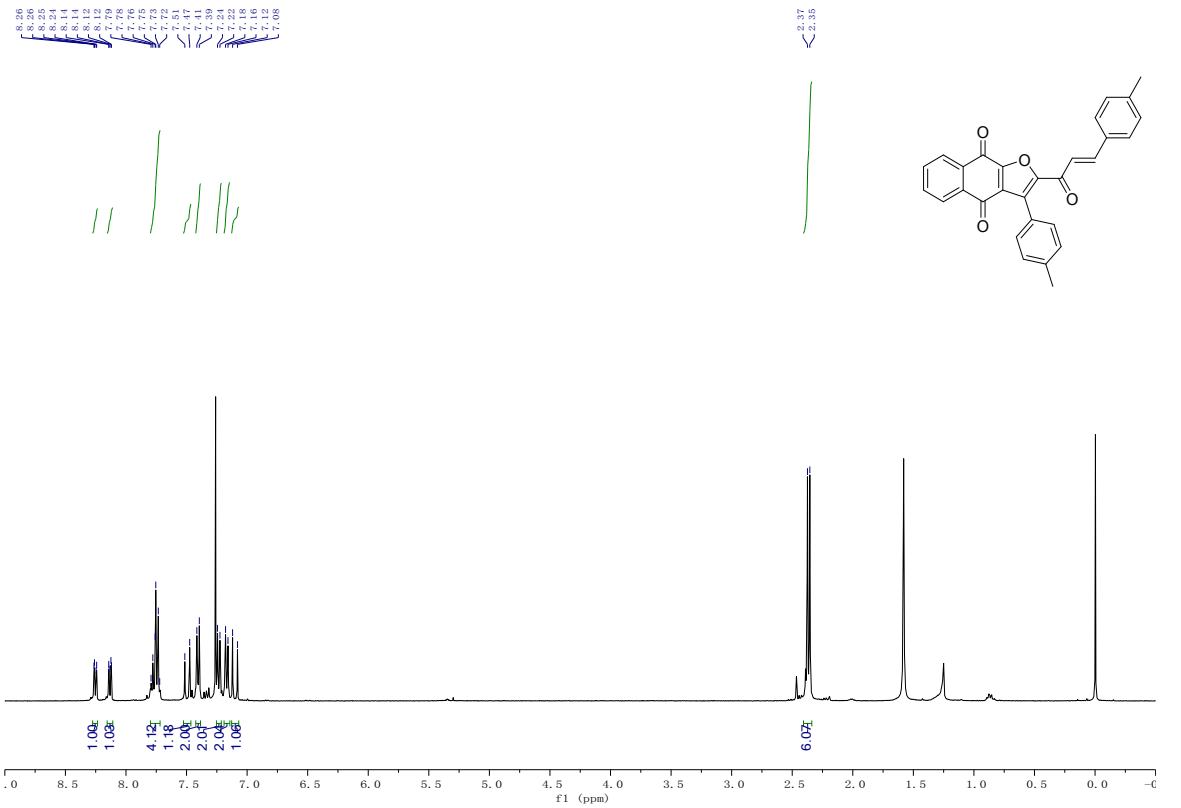
^{1}H-NMR of 2-(3-Phenyl-acryloy)-3-p-toly-naphtho[2,3-b]furan-4,9-dione(3v)



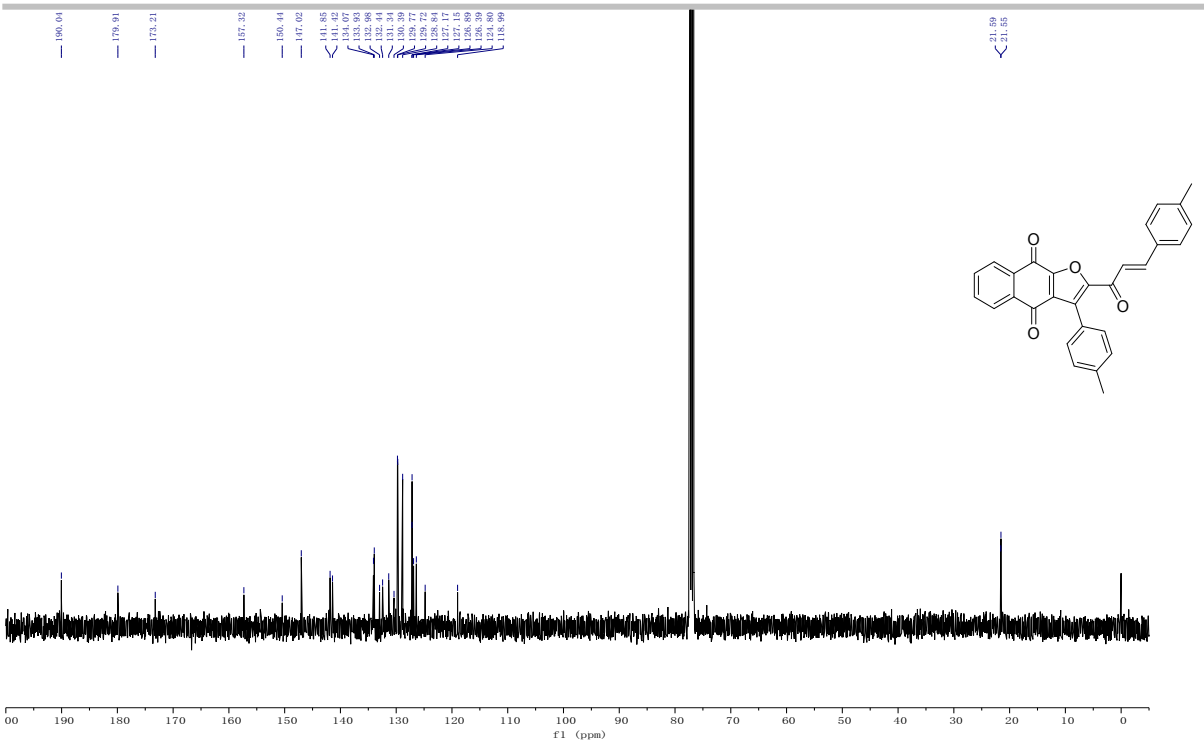
^{13}C-NMR of 2-(3-Phenyl-acryloy)-3-p-toly-naphtho[2,3-b]furan-4,9-dione(3v)



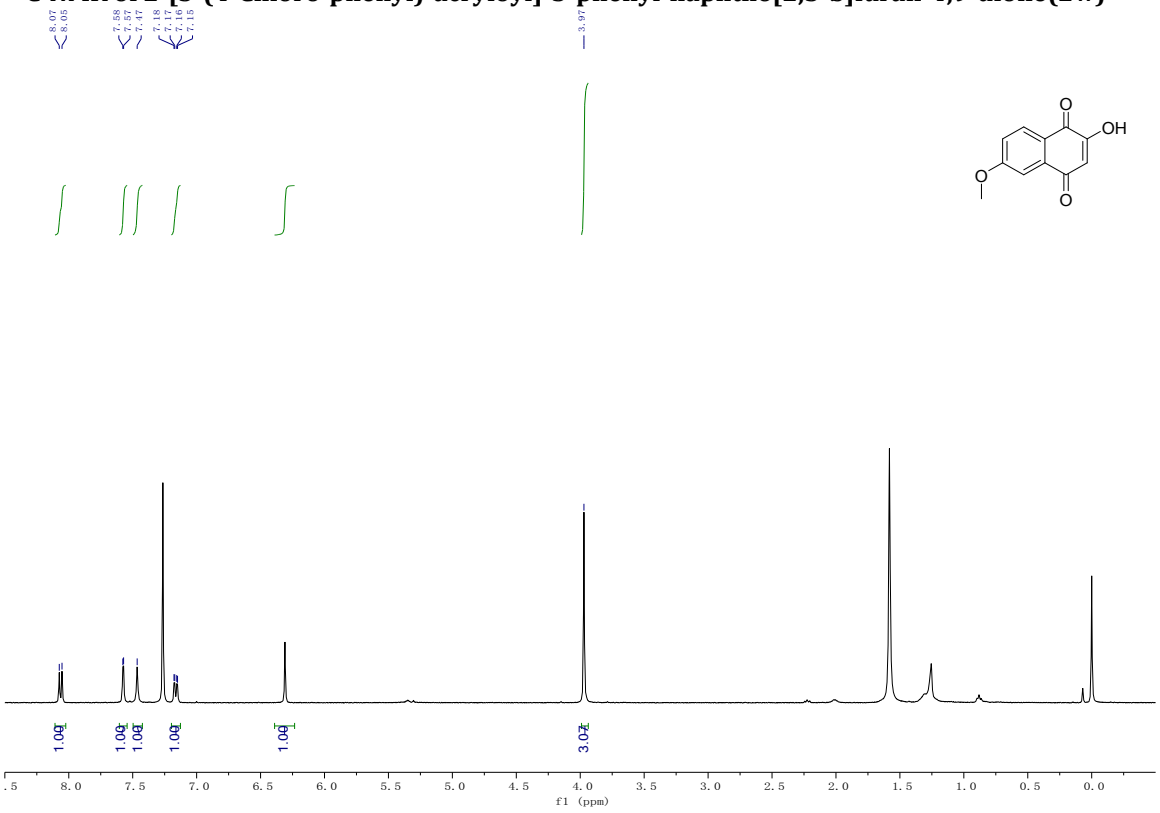
^{1}H-NMR of 1,5-Di-p-tolyl-penta-1,4-dien-3-one(2w)



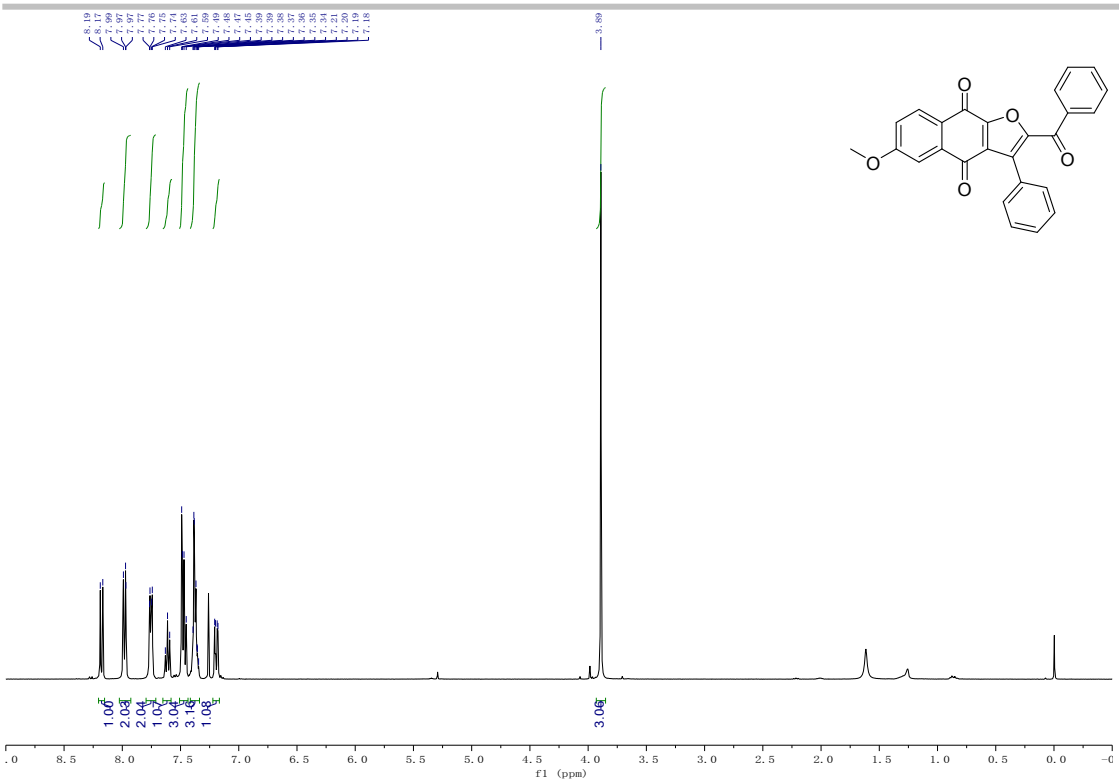
^{1}H-NMR of 2-[3-(4-Chloro-phenyl)-acryloyl]-3-phenyl-naphtho[2,3-b]furan-4,9-dione(2w)



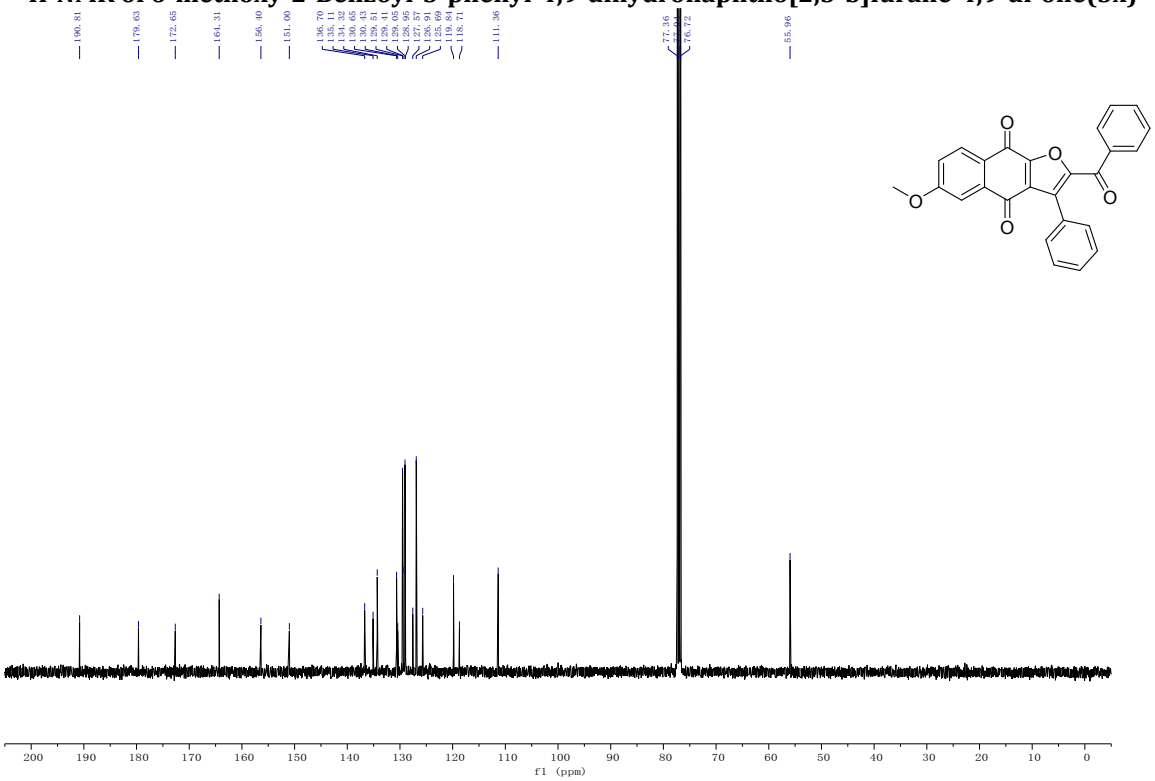
^{13}C-NMR of 2-[3-(4-Chloro-phenyl)-acryloyl]-3-phenyl-naphtho[2,3-b]furan-4,9-dione(2w)



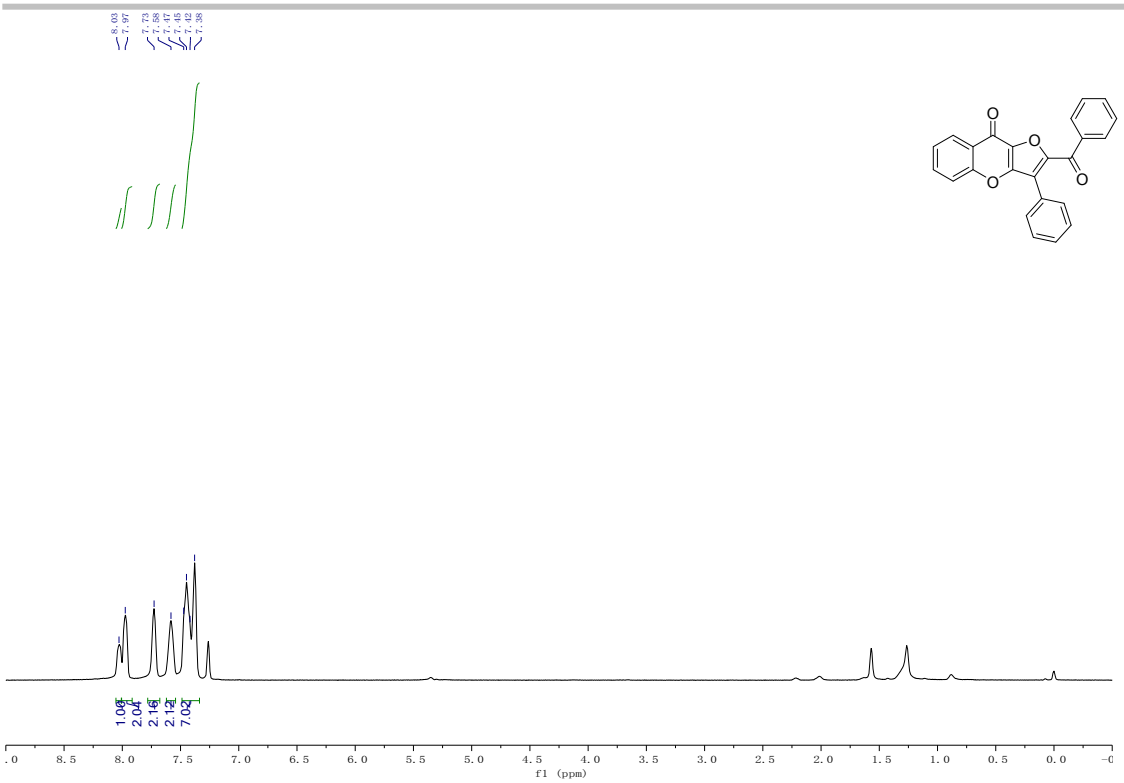
^{1}H-NMR of 6-methoxy-2-hydroxy-1,4-naphthoquinone(1b)



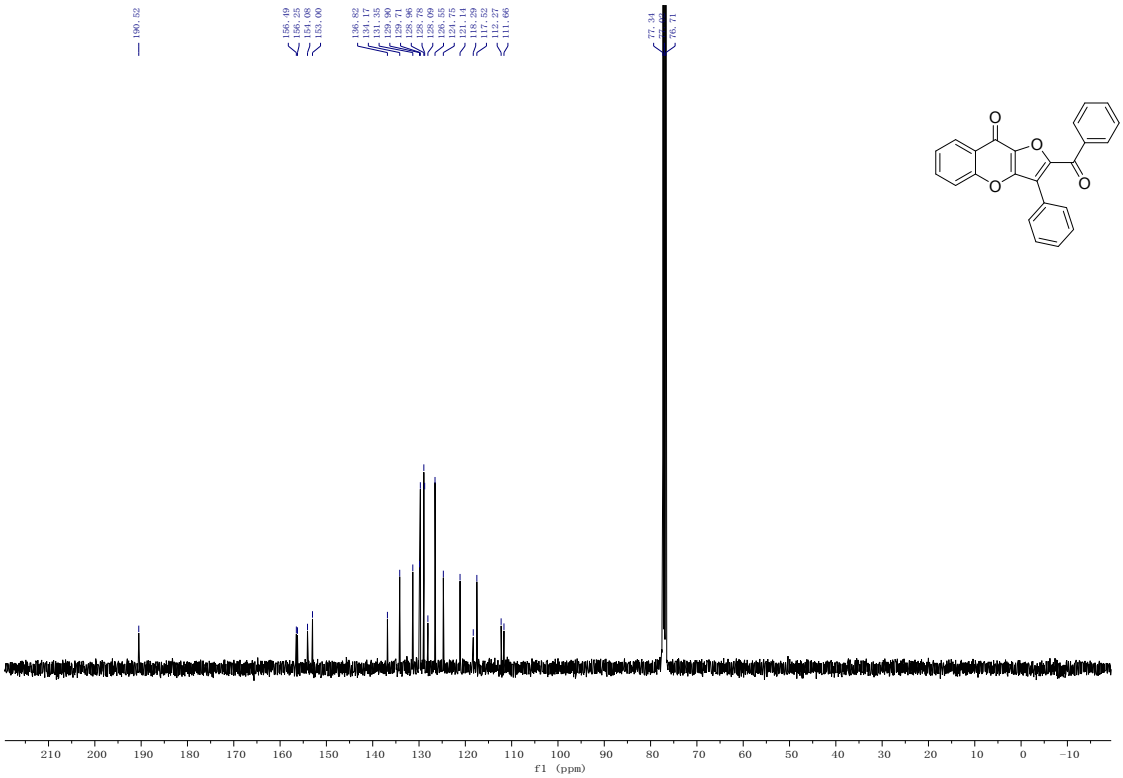
^{1}H-NMR of 6-methoxy-2-Benzoyl-3-phenyl-4,9-dihydronaphtho[2,3-b]furane-4,9-di-one(3x)



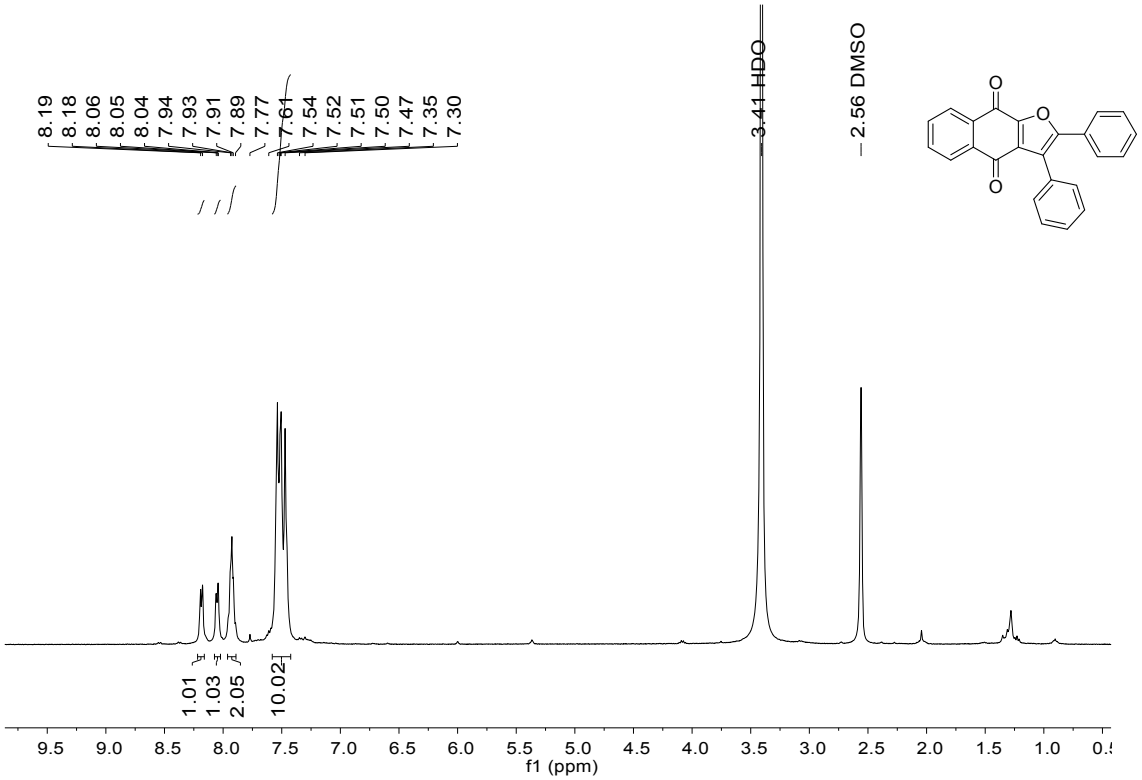
^{13}C-NMR of 6-methoxy-2-Benzoyl-3-phenyl-4,9-dihydronaphtho[2,3-b]furane-4,9-di-one(3x)



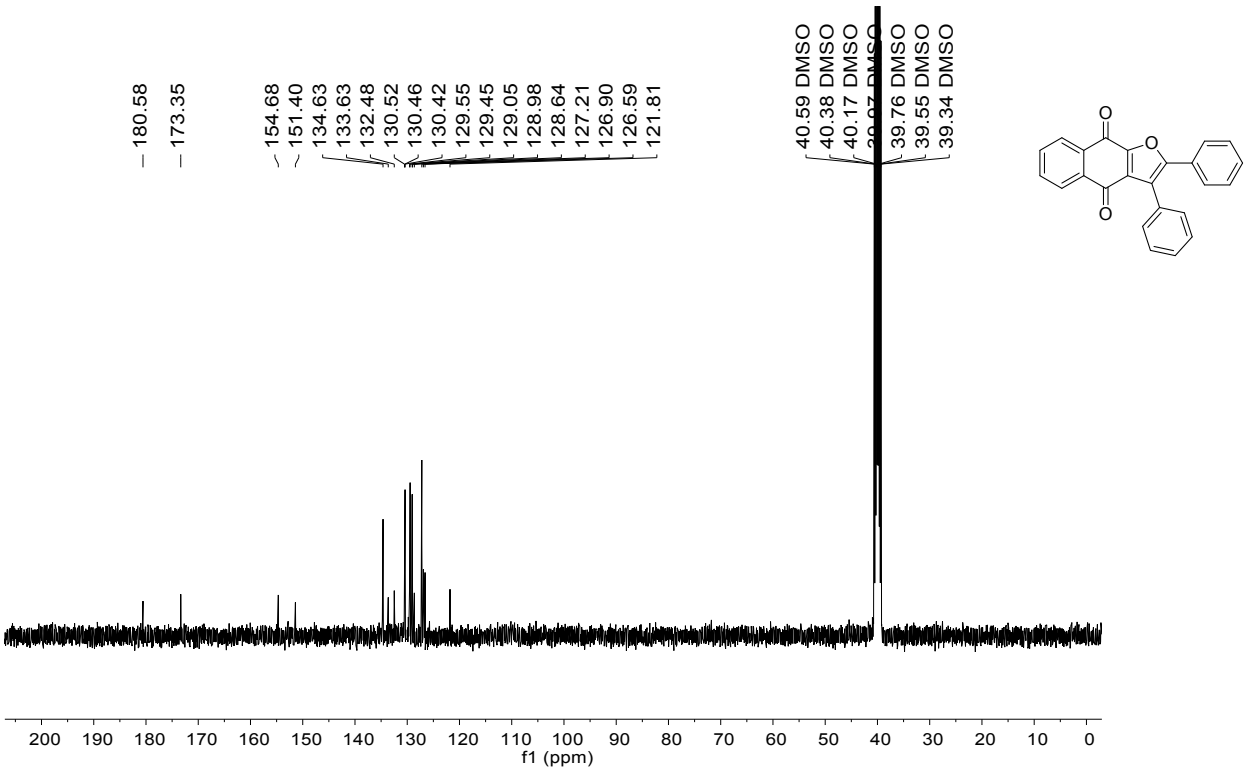
^{1}H-NMR of 2-Benzoyl-3-phenyl-1,4-dioxa-cyclopenta[b]naphthalen-9-one(3y)



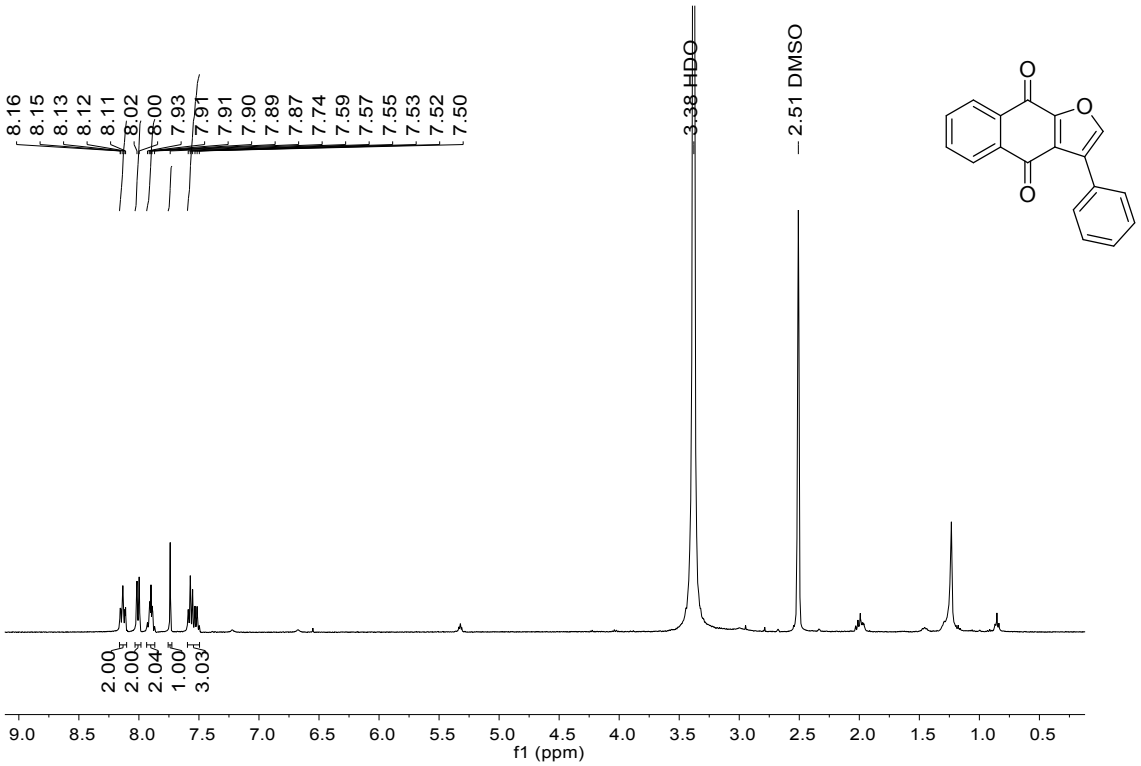
^{13}C-NMR of 2-Benzoyl-3-phenyl-1,4-dioxa-cyclopenta[b]naphthalen-9-one(3y)



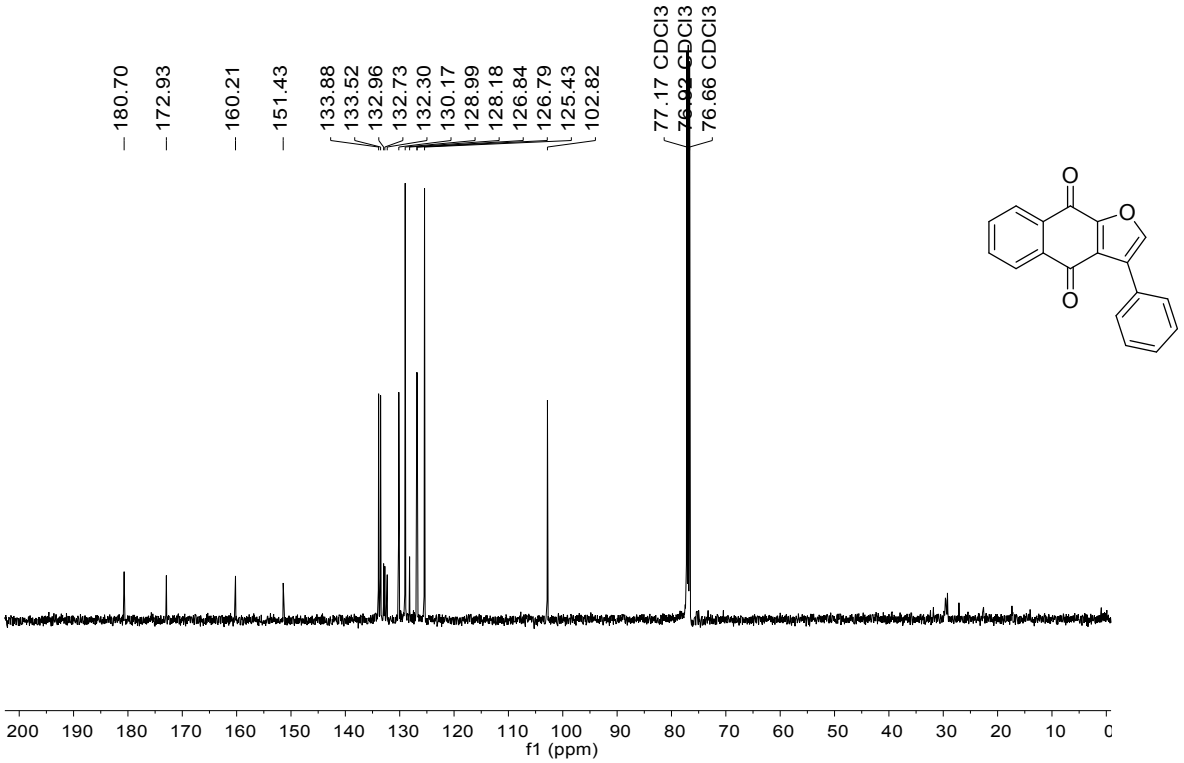
^{1}H-NMR of 2,3-Diphenyl-naphtho[2,3-b]furan-4,9-dione (3z)



^{13}C-NMR of 2,3-Diphenyl-naphtho[2,3-b]furan-4,9-dione (3z)



^{1}H-NMR of 3-phenyl-naphtho[2,3-b]furan-4,9-dione (3α)



^{13}C-NMR of 3-phenyl-naphtho[2,3-b]furan-4,9-dione (3α)