Supporting Information

Silver-Mediated Radical Process of β-Keto Sulfones for Synthesis of 2,3-Diacyl Furan

Jian Fan,*[a+] Yanhong Zu,[a+] Zhimin Zheng,[b] Lulu Song,[a] Yating, Wang,[a]

Zhou Zhou,[a] Yujun Liu*[a] and Shuwen Xu*[a]

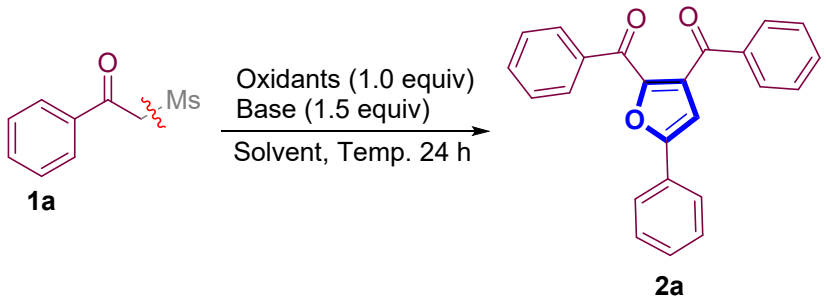
[a] Anhui Academy of Science and Technology, Hefei 230088, China.
[b] University of Science and Technology of China, Hefei 230026, China

* Corresponding author. Tel.: +86 0551 65149890; Fax: +86 0551 65145209. E-mail address: jianF@ahnu.edu.cn

1. General information:

All commercial materials were used as received unless otherwise noted. Commercial reagents were purchased from Alfa Aesar, TCI, Energy Chemical, and used without further purification. ^{1}H NMR spectra were recorded at 300 MHz, 400 MHz or 500 MHz NMR spectrometers using TMS as an internal standard, ^{13}C NMR spectra were recorded at 100 MHz or 125 MHz NMR spectrometers using TMS as an internal standard and were fully decoupled by broad band proton decoupling. The multiplicities are reported as follows: singlet (s), doublet (d), doublet of doublets (dd), multiplet (m), triplet (t) and broad resonances (br). Melting points were measured on a hot-stage microscope (XT4-A) and are uncorrected. High resolution mass spectra (HRMS) were obtained on an APEXM Fourier transform mass spectrometry (APCI).

2. Table S1 Optimization of reaction conditions



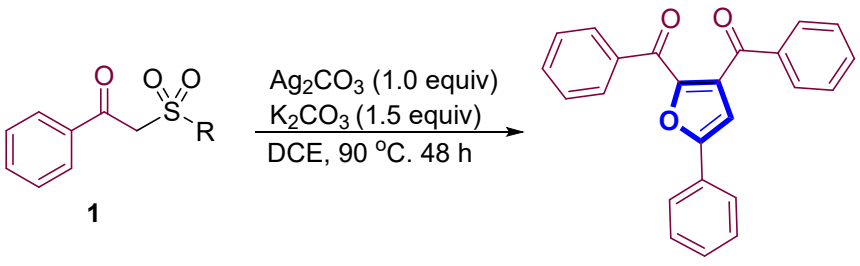
1a **2a**

Entry[a]	Oxidants	Base	Solvent	Temp. (°C)	Yield[b] (%)
1	Ag_2CO_3	K_2CO_3	DCE	90	80
2	AgOAc	K_2CO_3	DCE	90	65
3	AgOTf	K_2CO_3	DCE	90	71
4	$FeCl_3$	K_2CO_3	DCE	90	trace
5	$Fe(OAc)_3$	K_2CO_3	DCE	90	trace
6	$Cu(OAc)_2$	K_2CO_3	DCE	90	trace
7	CuBr	K_2CO_3	DCE	90	trace
8	MnO_4	K_2CO_3	DCE	90	nr
9	$K_2S_2O_8$	K_2CO_3	DCE	90	nr
10	TBHP	K_2CO_3	DCE	90	nr
11	DTBP	K_2CO_3	DCE	90	nr

12	BQ	K_2CO_3	DCE	90	nr
13	BPO	K_2CO_3	DCE	90	nr
14[c]	Ag_2CO_3	K_2CO_3	DCE	90	81
15[d]	Ag_2CO_3	K_2CO_3	DCE	90	68
16	Ag_2CO_3	Na_2CO_3	DCE	90	nr
17	Ag_2CO_3	Cs_2CO_3	DCE	90	nr
18	Ag_2CO_3	KOAc	DCE	90	55
19	Ag_2CO_3	$KHCO_3$	DCE	90	58
20[e]	Ag_2CO_3	K_2CO_3	DCE	90	82
21[f]	Ag_2CO_3	K_2CO_3	DCE	90	76
22	Ag_2CO_3	K_2CO_3	DCM	90	46
23	Ag_2CO_3	K_2CO_3	$CHCl_3$	90	20
24	Ag_2CO_3	K_2CO_3	toluene	90	58
25	Ag_2CO_3	K_2CO_3	THF	90	trace
26	Ag_2CO_3	K_2CO_3	DME	90	nr
27	Ag_2CO_3	K_2CO_3	1,4-dioxane	90	trace
28	Ag_2CO_3	K_2CO_3	DMSO	90	0
29	Ag_2CO_3	K_2CO_3	DMF	90	0
30	Ag_2CO_3	K_2CO_3	HFIP	90	0
31	Ag_2CO_3	K_2CO_3	DCE	80	71
32	Ag_2CO_3	K_2CO_3	DCE	70	57
33	Ag_2CO_3	K_2CO_3	DCE	100	79

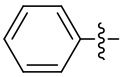
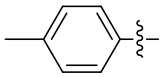
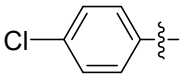
[a] Reaction conditions: **1a** (59.4 mg, 0.3 mmol), Oxidants (1.0 equiv), Base (1.5 eqiuv), Solvent (2 mL), 24 h, air. [b] Isolated yield by flash column chromatography based on **1a**. [c] With 1.2 equiv. of Ag_2CO_3. [d] With 0.8 equiv. of Ag_2CO_3.[e] With 2.0 equiv. of K_2CO_3. [f] With 1.2 equiv. of K_2CO_3.

Screening of Different Sulfonyl Leaving Groups



1 **2a**

R	Yield of **2a**

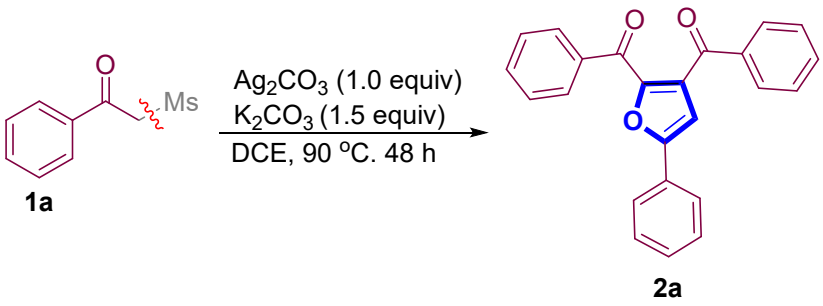
	80
	77
	79
	78

3. General procedure for synthesis of 2,3-diacylfurans

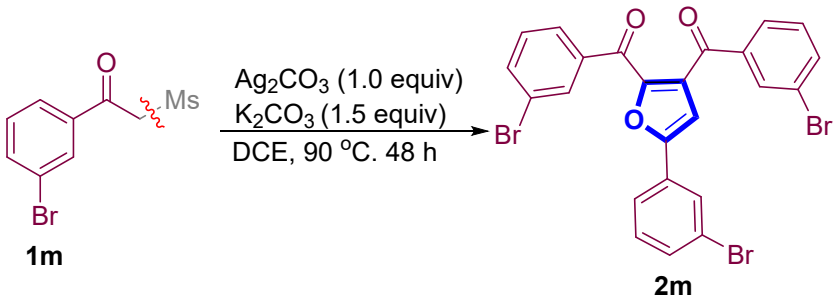
A mixture of *β*-Keto sulfone substrates (**1**, 0.3 mmol), Ag_2CO_3 (0.3 mmol), K_2CO_3 (0.45 mmol) and DCE (2.0 mL) was added to a 15 mL sealed tube. The tube was stirred at 90 °C (oil bath) for 24 h. Then, the reaction mixture was cooled to room temperature. The mixture was filtered through Celite®, and the filter cake was rinsed with EtOAc. The combined organic was removed in vacuo. Then the mixture was subjected to column chromatography on silica gel to give the desired product.

4. Gram-scale reaction and derivatization

Gram-scale preparation 2a and 2m

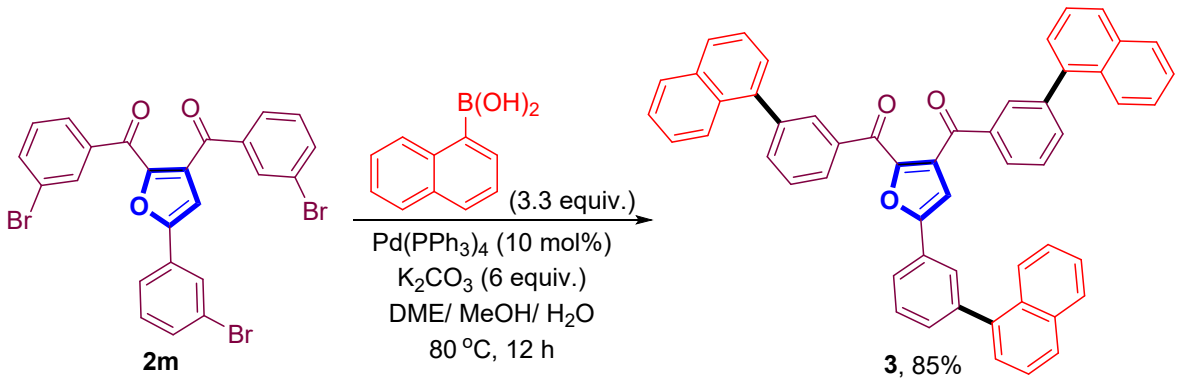


A 75 mL Schlenk tube was charged with 2-(methylsulfonyl)-1-phenylethan-1-one **1a** (10 mmol), Ag_2CO_3 (10 mmol), K_2CO_3 (15 mmol) and DCE (30 mL). The reaction mixture was stirred for 48 hours at 90 °C (oil bath). After that it was filtered through a short pad of Celite® and washed with ethyl acetate. The solvent was then evaporated under reduced pressure and the crude was purified by column chromatography on silica gel to afford the pure product **2a**.



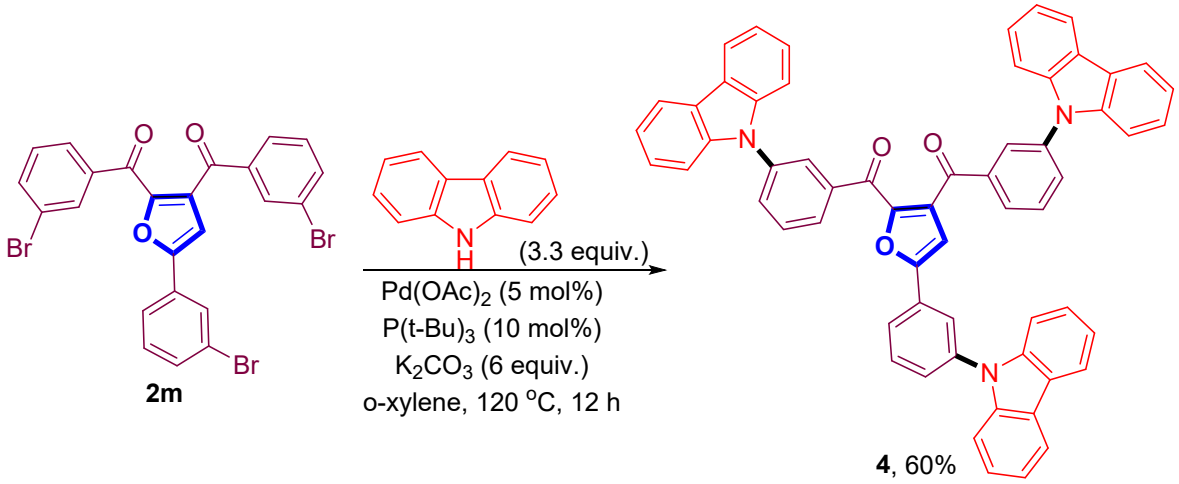
A 75 mL Schlenk tube was charged with 2 1-(3-bromophenyl)-2-(methylsulfonyl)ethan-1-one **1m** (10 mmol), Ag_2CO_3 (10 mmol), K_2CO_3 (15 mmol) and DCE (30 mL). The reaction mixture was stirred for 48 hours at 90 °C (oil bath). After that it was filtered through a short pad of Celite® and washed with ethyl acetate. The solvent was then evaporated under reduced pressure and the crude was purified by column chromatography on silica gel to afford the pure product **2m**.

Derivatization of product 2m



A Schlenk tube was charged with a solution of **2m** (0.1 mmol) and $Pd(PPh_3)_4$ (0.01 mmol,) in DME (2 mL). A solution of K_2CO_3 (1.2 mmol) in H_2O (0.5 mL) and a solution of the naphthalen-1-ylboronic acid (0.33 mmol) in MeOH (1 mL) were sequentially added. The reaction mixture was stirred at 80 °C overnight (oil bath). After cooling to room temperature, the reaction mixture was quenched with H_2O (5 mL) and extracted with CH_2Cl_2 (3×5 mL). The combined organic layers were dried over Na_2SO_4, filtered, concentrated, and the residue was chromatographed on silica gel (petroleum ether:diethyl

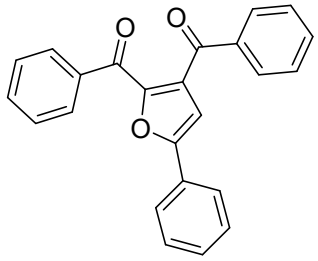
ether 5:1) to yield in **3** (85% yield)



2m (0.2 mmol), $Pd(OAc)_2$ (5 mol%), $P(t\text{-}Bu)_3$ (10 mol%), K_2CO_3 (1.2 mmol) and 9H-carbazole (0.66 mmol) were dissolved in o-xylene (2 ml) under Ar atmosphere, then the mixture was stirred at 120 °C for 12 hour. The solvent was removed in vacuo and the residue was chromatographed on silica gel (petroleum ether:diethyl ether 5:1) to yield in **4** (60% yield)

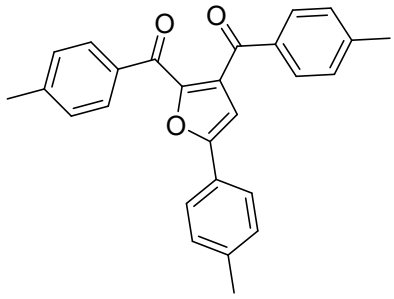
Analytic Data of Products

(5-phenylfuran-2,3-diyl)bis(phenylmethanone) (**2a**)



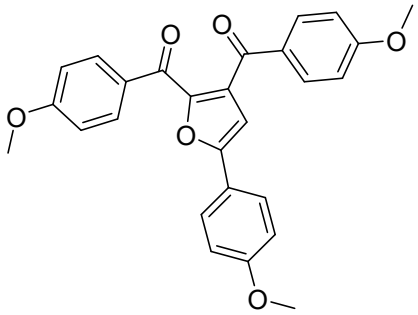
Yellow solid; m.p. 50-51 °C. (28.2 mg, 80% yield); ^1H NMR (500 MHz, $CDCl_3$) δ 7.99-7.97 (m, 2H), 7.86-7.84 (m, 2H), 7.57-52 (m, 2H), 7.82-7.80 (m, 2H), 7.50-7.38 (m, 7H), 7.03 (s, 1H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 191.7, 182.1, 157.4, 149.4, 137.4, 137.1, 135.0, 134.0, 133.4, 130.2, 130.1, 129.7, 129.5, 129.1, 129.0, 128.8, 125.5, 108.5; HRMS (ESI) calculated for $C_{24}H_{17}O_3$ ($M+H^+$): 353.1172, found: 353.1169.

(5-(p-tolyl)furan-2,3-diyl)bis(p-tolylmethanone) (**2b**)



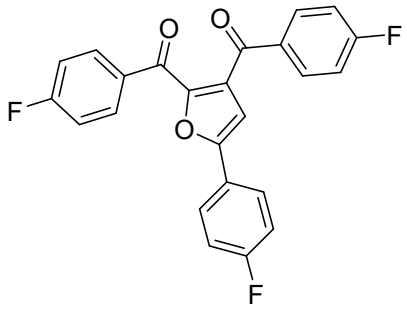
Yellow solid; m.p. 68-69 °C. (28.8 mg, 73% yield); ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.93 (d, *J* = 8.0 Hz, 2H), 7.77 (d, *J* = 8.0 Hz, 2H), 7.69 (d, *J* = 8.0 Hz, 2H), 7.29-7.24 (m, 4H), 7.20 (d, *J* = 8.0 Hz, 2H), 6.94 (s, 1H), 2.42-2.41 (m, 6H), 2.38 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) *δ* 191.1, 181.2, 157.0, 148.9, 144.5, 143.8, 139.9, 134.7, 134.5, 134.2, 129.9, 129.8, 129.5, 129.3, 129.1, 126.2, 125.1, 107.5, 21.8, 21.7, 21.5; HRMS (ESI) calculated for $C_{27}H_{23}O_3$ ($M+H^+$): 395.1641, found: 395.1637.

(5-(4-methoxyphenyl)furan-2,3-diyl)bis((4-methoxyphenyl)methanone) (**2c**)



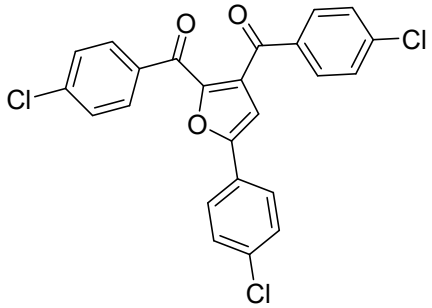
White solid; m.p. 44-46 °C. (23.6 mg, 76% yield); ^{1}H NMR (500 MHz, $CDCl_3$) δ 8.06-8.04 (m, 2H), 7.87-7.85 (m, 2H), 7.75-7.73 (m, 2H), 7.01-6.99 (m, 2H), 6.95-6.93 (m, 2H), 6.88-6.87 (m, 2H), 6.86 (s, 1H), 3.88 (s, 3H), 3.87 (s, 3H), 3.84 (s, 3H); ^{13}C NMR (125 MHz, $CDCl_3$) *δ* 190.5, 180.4, 164.3, 163.8, 161.1, 157.2, 148.9, 135.2, 132.4, 132.1, 130.5, 130.0, 127.0, 122.2, 114.9, 114.2, 114.1, 107.1, 55.9, 55.8; HRMS (ESI) calculated for $C_{27}H_{23}O_6$ ($M+H^+$): 443.1489, found: 443.1484.

（5-(4-fluorophenyl)furan-2,3-diyl)bis((4-fluorophenyl)methanone) (**2d**)



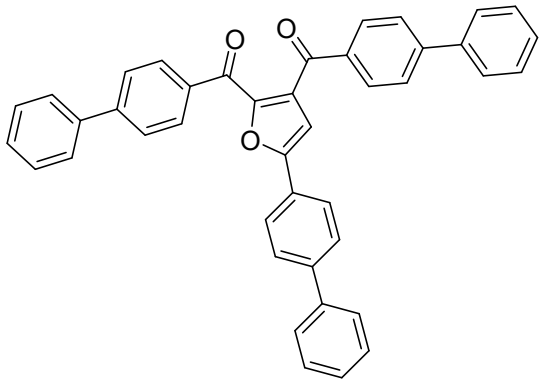
Yellow solid; m.p. 98-99 °C. (27.6 mg, 68% yield); ^{1}H NMR (500 MHz, $CDCl_3$) δ 8.06-8.03 (m, 2H), 7.90-7.88 (m, 2H), 7.80-7.77 (m, 2H), 7.21-7.13 (m, 4H), 7.11-7.07 (m, 2H), 6.96 (s, 1H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 189.9, 180.3, 166.5 ($J_{F\text{-}C}$ = 254.0 Hz), 166.1 ($J_{F\text{-}C}$ = 254.0 Hz), 164.0 ($J_{F\text{-}C}$ = 249.7 Hz), 156.7, 149.1, 135.0, 133.7 ($J_{F\text{-}C}$ = 2.5 Hz), 133.2 ($J_{F\text{-}C}$ = 2.3 Hz), 132.7 ($J_{F\text{-}C}$ = 9.3 Hz), 132.3 ($J_{F\text{-}C}$ = 9.5 Hz), 127.5 ($J_{F\text{-}C}$ = 8.5 Hz), 125.3 ($J_{F\text{-}C}$ = 3.5 Hz), 116.9 ($J_{F\text{-}C}$ = 22.1 Hz), 116.3 ($J_{F\text{-}C}$ = 22.0 Hz), 116.2 ($J_{F\text{-}C}$ = 21.7 Hz), 108.2; HRMS (ESI) calculated for $C_{24}H_{14}F_3O_3$ ($M+H^+$): 407.0889, found: 407.0885.

(5-(4-chlorophenyl)furan-2,3-diyl)bis((4-chlorophenyl)methanone) (**2e**)



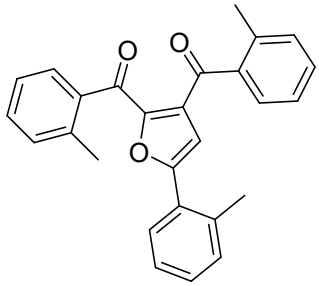
Yellow solid; m.p. 52-53 °C. (31.8 mg, 70% yield); ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.95 (d, J = 8.5 Hz, 2H), 7.80 (d, J = 8.5 Hz, 2H), 7.72 (d, J = 8.5 Hz, 2H), 7.48-7.45 (m, 4H), 7.40 (d, J = 8.5 Hz, 2H), 7.01 (s, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 189.7, 180.1, 156.2, 148.8, 140.3, 139.8, 136.0, 135.2, 134.7, 134.5, 131.0, 130.6, 129.6, 129.0, 128.9, 127.0, 126.3, 108.5; HRMS (ESI) calculated for $C_{24}H_{14}Cl_3O_3$ ($M+H^+$): 455.0003, found: 454.9998.

(5-([1,1'-biphenyl]-4-yl)furan-2,3-diyl)bis([1,1'-biphenyl]-4-ylmethanone) (**2f**)



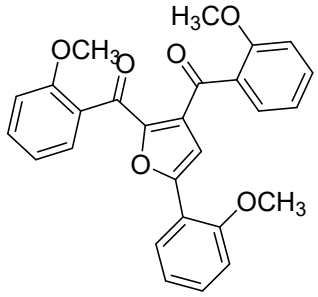
Yellow solid; m.p. 92-93 °C. (43.5 mg, 75% yield); ^{1}H NMR (500 MHz, $CDCl_3$) δ 8.11 (d, *J* = 8.4 Hz, 2H), 7.96-7.91 (m, 4H), 7.74 (d, *J* = 8.4 Hz, 2H), 7.69 (d, *J* = 8.4 Hz, 2H), 7.66-7.63 (m, 5H), 7.62-7.59 (m, 3H), 7.50-7.44 (m, 7H), 7.42-7.39 (m, 2H), 7.11 (s, 1H); ^{13}C NMR (125 MHz, $CDCl_3$) *δ* 191.3, 181.6, 157.3, 149.6, 146.6, 146.1, 142.9, 140.4, 140.2, 136.1, 135.8, 135.2, 130.7, 130.3, 129.4, 129.3, 128.7, 128.3, 128.2, 128.0, 127.7, 127.6, 127.5, 127.4, 126.0, 108.7; HRMS (ESI) calculated for $C_{42}H_{29}O_3$ ($M+H^+$): 581.2111, found: 581.2106.

(5-(o-tolyl)furan-2,3-diyl)bis(o-tolylmethanone) (**2g**)



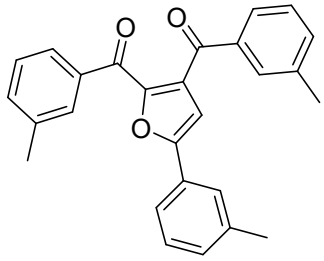
Yellow solid; m.p. 55-56 °C. (26.4 mg, 67% yield); ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.81-7.79 (m, 1H), 7.43 (d, *J* = 7.2 Hz, 1H), 7.37 (d, *J* = 7.5 Hz, 1H), 7.32-7.24 (m, 5H), 7.13 (t, *J* = 7.0 Hz, 3H), 7.05 (d, *J* = 7.6 Hz, 1H), 6.97 (s, 1H), 2.56 (s, 3H), 2.40 (s, 3H), 2.19 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) *δ* 192.5, 184.9, 156.8, 149.2, 139.8, 137.9, 137.3, 137.1, 135.9, 134.8, 132.0, 131.9, 131.6, 131.2, 131.1, 131.06, 129.5, 129.2, 128.1, 128.05, 126.4, 125.3, 125.27, 111.5, 22.0, 21.4, 19.9; HRMS (ESI) calculated for $C_{27}H_{23}O_3$ ($M+H^+$): 395.1641, found: 395.1638.

(5-(2-methoxyphenyl)furan-2,3-diyl)bis((2-methoxyphenyl)methanone) (**2h**)



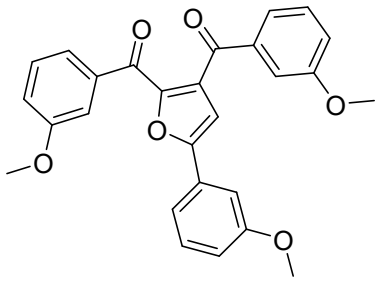
Yellow solid; m.p. 77-78 °C. (27.4 mg, 62% yield); ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.94-7.92 (m, 1H), 7.45-7.43 (m, 1H), 7.38-7.33 (m, 3H), 7.32 (s, 1H), 7.28-7.26 (m, 1H), 7.05-6.99 (m, 2H), 6.85-6.82 (m, 2H), 6.78-6.74 (m, 2H), 3.96 (s, 3H), 3.68 (s, 3H), 3.66 (s, 3H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 190.5, 183.0, 158.9, 158.1, 157.0, 153.0, 148.7, 135.7, 133.9, 133.0, 131.6, 130.6, 130.5, 128.43, 128.4, 127.4, 121.6, 120.7, 120.6, 118.4, 113.3, 111.8, 111.5, 111.4, 55.9, 55.8; HRMS (ESI) calculated for $C_{27}H_{23}O_6$ ($M+H^+$): 443.1989, found: 443.1986.

(5-(m-tolyl)furan-2,3-diyl)bis(m-tolylmethanone) (**2i**)



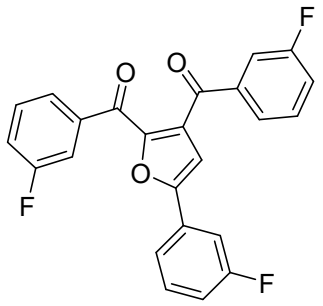
Yellow solid; m.p. 76-77 °C. (28.4 mg, 72% yield); ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.74-7.71 (m, 1H), 7.66-7.55 (m, 5H), 7.39-7.23 (m, 7H), 2.43 (s, 3H), 2.33 (s, 6H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 191.5, 182.2, 157.1, 149.0, 138.8, 138.2, 138.1, 137.2, 137.0, 134.6, 134.2, 133.5, 130.5, 130.0, 129.5, 129.0, 128.7, 128.3, 128.2, 126.7, 126.6, 125.7, 122.3, 107.9, 21.5, 21.3; HRMS (ESI) calculated for $C_{27}H_{23}O_3$ ($M+H^+$): 395.1641, found: 395.1637.

(5-(3-methoxyphenyl)furan-2,3-diyl)bis((3-methoxyphenyl)methanone) (**2j**)



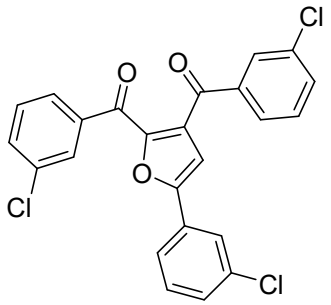
Yellow solid; m.p. 95-96 °C. (30.5 mg, 69% yield); ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.59-7.57 (m, 1H), 7.40-7.39 (m, 3H), 7.37-7.36 (m, 1H), 7.35-7.32 (m, 3H), 7.29-7.25 (m, 1H), 7.10-7.06 (m, 2H), 7.02 (s, 1H), 6.98-6.96 (m, 1H), 3.88 (s, 3H), 3.81 (s, 3H), 3.80 (s, 3H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 191.4, 182.0, 160.4, 160.1, 159.9, 157.2, 149.4, 138.8, 138.4, 135.0, 130.6, 130.3, 129.9, 129.8, 122.8, 122.7, 120.8, 120.4, 118.1, 115.9, 113.7, 113.0, 110.8, 108.7, 55.8, 55.75; HRMS (ESI) calculated for $C_{27}H_{23}O_6$ ($M+H^+$): 443.1489, found: 443.1486.

（5-(3-fluorophenyl)furan-2,3-diyl)bis((3-fluorophenyl)methanone) (**2k**)



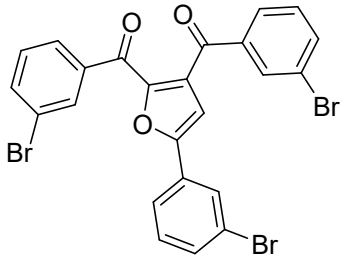
Yellow solid; m.p. 58-59 °C. (26.4 mg, 65% yield); ^{1}H NMR (300 MHz, $CDCl_3$) δ 7.83 (d, J = 7.6 Hz, 1H), 7.70-7.37 (m, 8H), 7.33-7.27 (m, 2H), 7.18-7.13 (m, 1H), 7.05 (s, 1H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 189.5, 180.0, 163.1 (J_{F-C} = 245.9 Hz), 162.8 (J_{F-C} = 247.0 Hz), 162.6 (J_{F-C} = 246.7 Hz), 156.1 (J_{F-C} = 1.5 Hz), 148.9, 138.8 (J_{F-C} = 6.4 Hz), 138.2 (J_{F-C} = 6.6 Hz), 134.5, 131.0 (J_{F-C} = 8.3 Hz), 130.3 (J_{F-C} = 14.1 Hz), 130.34, 125.4 (J_{F-C} = 3.0 Hz), 125.1 (J_{F-C} = 3.0 Hz), 120.9, 120.89, 120.7, 120.5, 120.2, 117.0 (J_{F-C} = 21.2 Hz), 116.4 (J_{F-C} = 22.9 Hz), 115.7 (J_{F-C} = 22.6 Hz), 112.1 (J_{F-C} = 23.7 Hz), 108.9; HRMS (ESI) calculated for $C_{24}H_{14}F_3O_3$ ($M+H^+$): 407.0889, found: 407.0886.

(5-(3-chlorophenyl)furan-2,3-diyl)bis((3-chlorophenyl)methanone) (**2l**)



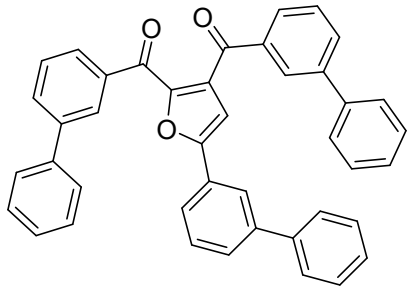
Yellow solid; m.p. 59-60 °C. (35.4 mg, 78% yield); ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.92-7.91 (m, 1H), 7.86-7.84 (m, 1H), 7.79-7.76 (m, 2H), 7.70-7.68 (m, 2H), 7.57-7.54 (m, 2H), 7.47-7.40 (m, 3H), 7.38-7.34 (m, 1H), 7.06 (s, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 189.4, 180.1, 156.0, 148.9, 138.4, 137.9, 135.4, 135.1, 134.9, 134.4, 133.6, 133.1, 130.6, 130.1, 130.02, 130.0, 129.9, 129.6, 129.0, 127.6, 127.3, 125.2, 123.2, 108.9; HRMS (ESI) calculated for $C_{24}H_{14}Cl_3O_3$ ($M+H^+$): 455.0003, found: 455.0002.

(5-(3-bromophenyl)furan-2,3-diyl)bis((3-bromophenyl)methanone) (**2m**)



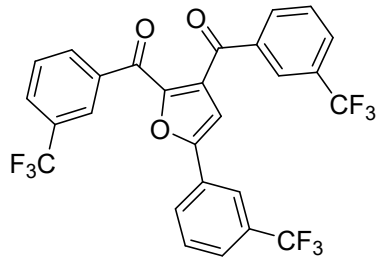
Yellow solid; m.p. 102-103 °C. (46.9 mg, 80% yield); ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.06-8.05 (m, 1H), 7.96-7.95 (m, 1H), 7.91-7.90 (m, 1H), 7.86 (d, J = 7.8 Hz, 1H), 7.75 – 7.68 (m, 4H), 7.58 (d, J = 8.0 Hz, 1H), 7.40- 7.29 (m, 3H), 7.06 (s, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 189.4, 180.1, 155.9, 148.9，138.6, 138.1, 136.5, 136.0, 134.3, 133.0, 132.5, 131.9, 130.8, 130.3, 130.2, 130.17, 128.1, 128.0, 127.7, 123.7, 123.4, 123.1, 122.9, 108.9; HRMS (ESI) calculated for $C_{24}H_{14}Br_3O_3$ ($M+H^+$): 586.8487, found: 586.8482.

(5-([1,1'-biphenyl]-3-yl)furan-2,3-diyl)bis([1,1'-biphenyl]-3-ylmethanone) (**2n**)



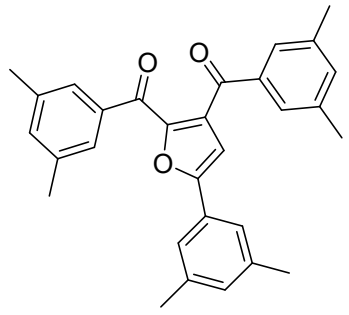
Yellow solid; m.p. 82-83 °C. (41.2 mg, 71% yield); ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.15-8.14 (m, 1H), 8.07-8.06 (m, 1H), 8.01-8.00 (m, 1H), 7.90-7.87 (m, 1H), 7.84-7.82 (m, 1H), 7.78-7.70 (m, 3H), 7.67-7.60 (m, 3H), 7.58-7.33 (m, 16H), 7.16 (s, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 191.1, 182.0, 157.2, 149.2, 142.3, 141.6, 141.4, 140.3, 139.9, 137.7, 137.5, 134.6, 132.2, 131.6, 129.6, 129.2, 129.1, 129.0, 128.9, 128.7, 128.3, 127.8, 127.2, 127.0, 124.1, 123.9, 108.5; HRMS (ESI) calculated for $C_{42}H_{29}O_3$ ($M+H^+$): 581.2111, found: 581.2108.

(5-(3-(trifluoromethyl)phenyl)furan-2,3-diyl)bis((3-(trifluoromethyl)phenyl)methanone) (**2o**)



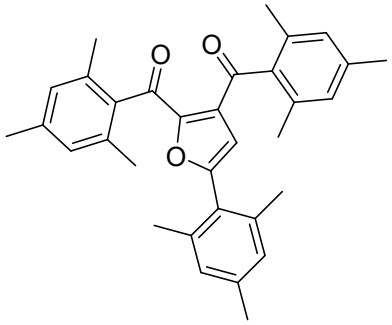
White solid; m.p. 78-79 °C. (40.0 mg, 72% yield); ^{1}H NMR (500 MHz, $CDCl_3$) δ 8.35 (s, 1H), 8.14 (d, J = 7.9 Hz, 1H), 8.10 (s, 1H), 8.07 (s, 1H), 8.03 (d, J = 7.9 Hz, 1H), 7.99 (d, J = 7.8 Hz, 1H), 7.87-7.82 (m, 2H), 7.72 (d, J = 7.8 Hz, 1H), 7.67-7.62 (m, 2H), 7.58 (t, J = 7.8 Hz, 1H), 7.17 (s, 1H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 189.2, 179.9, 156.1, 148.9, 137.3, 136.7, 134.4, 132.7, 132.4, 132.3, 132.2, 131.9, 131.8, 131.6, 131.58, 131.4, 131.3, 131.1, 131.06, 130.9, 130.2 (J_{F-C} = 3.2 Hz), 130.0, 129.8 (J_{F-C} = 3.1 Hz), 129.44, 129.4, 129.1, 128.2, 126.9, 126.8, 126.7, 126.63, 126.6, 125.9 (J_{F-C} = 3.6 Hz), 124.7, 124.6, 124.58, 122.5, 122.47, 122.4, 122.0 (J_{F-C} = 4.0 Hz), 120.4, 120.3, 120.2. (The ^{13}C NMR spectrum was very complex due to C-F coupling. All signals observed were shown); ^{19}F NMR (376 Mz, $CDCl_3$): δ -62.9, -63.0, -63.1; HRMS (ESI) calculated for $C_{27}H_{14}F_9O_3$ ($M+H^+$): 557.0793, found: 557.0790.

(5-(3,5-dimethylphenyl)furan-2,3-diyl)bis((3,5-dimethylphenyl)methanone) (**2p**)



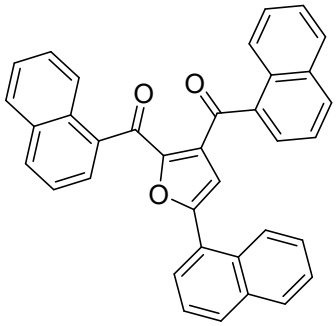
White solid; m.p. 64-65 °C. (25.3 mg, 58% yield); ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.47 (s, 2H), 7.41 (s, 2H), 7.30 (s, 2H), 7.13 (s, 2H), 7.06 (s, 1H), 7.98 (s, 1H), 2.39 (s, 6H), 2.28-2.27 (m, 12H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 191.8, 182.7, 157.3, 149.0, 138.7, 138.1, 138.0, 137.5, 137.4, 135.0, 134.7, 134.2, 131.5, 128.7, 127.2, 127.0, 123.0, 107.8, 21.4, 21.1; HRMS (ESI) calculated for $C_{30}H_{29}O_3$ ($M+H^+$): 437.2111, found: 437.2107.

(5-mesitylfuran-2,3-diyl)bis(mesitylmethanone) (**2q**)



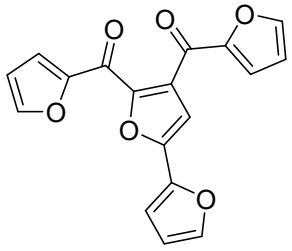
Yellow oil; (25.3 mg, 53% yield); ^{1}H NMR (400 MHz, $CDCl_3$) δ 6.88 (s, 2H), 6.84 (s, 2H), 6.76 (s, 2H), 6.67 (s, 1H), 2.28-2.26 (12H), 2.24 (s, 3H), 2.12 (s, 6H), 2.06 (s, 6H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 195.5, 188.3, 155.4, 150.6, 139.8, 139.3, 139.0, 138.1, 137.5, 136.1, 135.2, 134.5, 133.4, 129.1, 128.6, 128.3, 125.8, 113.6, 21.2, 20.6, 20.1, 19.2; HRMS (ESI) calculated for $C_{33}H_{35}O_3$ ($M+H^+$): 479.2580, found: 479.2574.

(5-(naphthalen-1-yl)furan-2,3-diyl)bis(naphthalen-1-ylmethanone) (**2r**)



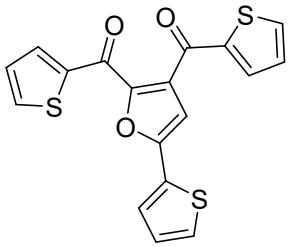
Yellow solid; m.p. 75-76 °C. (32.1 mg, 64% yield); ^{1}H NMR (500 MHz, $CDCl_3$) δ 8.54 (d, J = 8.4 Hz, 1H), 8.44-8.46 (m, 1H), 8.01-7.99 (m, 2H), 7.97-7.93 (m, 2H), 7.67-7.63 (m, 2H), 7.61-7.53 (m, 4H), 7.48-7.43 (m, 4H), 7.37-7.36 (m, 2H), 7.35 (s, 2H), 7.14-7.07 (m, 2H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 192.3, 184.6, 157.5, 151.2, 135.8, 135.7, 135.5, 134.4, 133.7, 133.6, 133.5, 132.5, 131.2, 131.1, 130.5, 130.2, 130.1, 129.3, 129.1, 128.5, 128.1, 127.9, 126.8, 126.7, 126.4, 125.7, 125.4, 124.5, 124.2, 113.1; HRMS (ESI) calculated for $C_{36}H_{23}O_3$ ($M+H^+$): 503.1641, found: 503.1637.

[2,2'-bifuran]-4,5-diylbis(furan-2-ylmethanone) (**2s**)



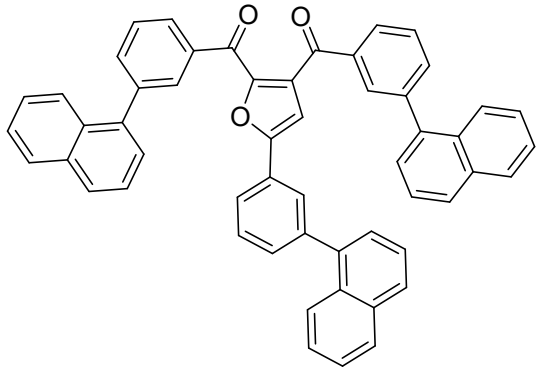
Yellow solid; m.p. 72-73 °C. (13.8 mg, 43% yield); ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.67 (s, 1H), 7.62-7.57 (m, 3H), 7.19 (d, *J* = 3.3 Hz, 1H), 6.94 (s, 1H), 6.90 (d, *J* = 3.2 Hz, 1H), 6.62-6.53 (m, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) *δ* 190.2, 185.1, 177.3, 168.1, 152.5, 150.8, 148.6, 147.7, 147.6, 147.5, 144.5, 144.1, 132.4, 120.7, 119.9, 112.7, 109.4, 107.8; HRMS (ESI) calculated for $C_{18}H_{11}O_6$ ($M+H^+$): 323.0550, found: 323.0547.

(5-(thiophen-2-yl)furan-2,3-diyl)bis(thiophen-2-ylmethanone) (**2t**)



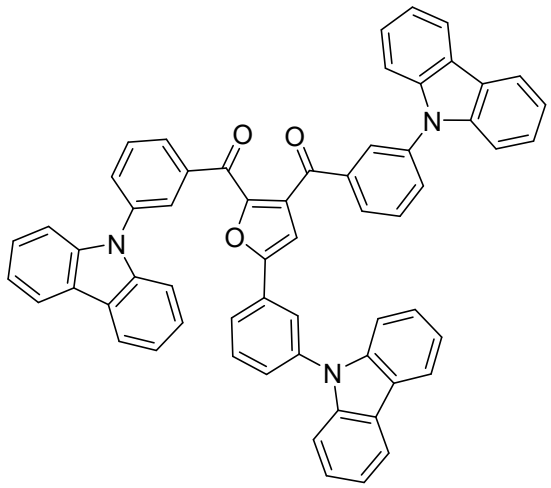
Yellow solid; m.p. 65-66 °C. (16.7 mg, 45% yield); ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.25-8.24 (m, 1H), 7.75-7.71 (m, 2H), 7.60-7.59 (m, 1H), 7.55-7.54 (m, 1H), 7.46-7.45 (m, 1H), 7.24-7.22 (m, 1H), 7.17-7.15 (m, 1H), 7.11-7.09 (m, 1H), 6.86 (s, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) *δ* 182.6, 172.0, 152.3, 147.2, 143.7, 141.7, 135.3, 134.9, 134.8, 134.4, 134.2, 131.3, 128.4, 128.3, 127.6, 126.2, 107.7; HRMS (ESI) calculated for $C_{18}H_{11}O_3S_3$ ($M+H^+$): 370.9864, found: 370.9861.

(5-(3-(naphthalen-1-yl)phenyl)furan-2,3-diyl)bis((3-(naphthalen-1-yl)phenyl)methanone) (**3**)



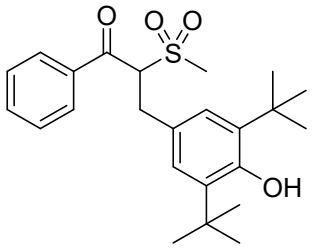
White solid; m.p. 92-93. (62mg, 85% yield); ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.14-8.13 (m, 1H), 8.06-8.05 (m, 1H), 8.01-8.00 (m, 1H), 7.95-7.92 (m, 2H), 7.90-7.89 (m, 2H), 7.87-7.80 (m, 6H), 7.78-7.75 (m, 1H), 7.69-7.65 (m, 3H), 7.58-7.51 (m, 6H), 7.67-7.41 (m, 4H), 7.38-7.28 (m, 5H), 7.15-7.11 (m, 1H), 7.08 (s, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 191.1, 181.9, 157.2, 149.2, 141.7, 141.1, 141.05, 139.2, 138.9, 138.8, 137.1, 137.0, 135.2, 134.7, 134.5, 133.8, 133.7, 133.67, 131.5, 131.4, 131.3, 131.29, 131.2, 131.1, 129.1, 128.8, 128.78, 128.6, 128.4, 128.36, 128.3, 128.2, 128.1, 128.05, 127.7, 127.1, 127.0, 126.98, 126.6, 126.4, 126.3, 126.32, 126.0, 125.9, 125.9, 125.7, 125.6, 125.5, 125.4, 125.3, 124.1, 121.6, 120.5, 108.6; HRMS (ESI) calculated for $C_{54}H_{35}O_3$ ($M+H^+$): 731.2580, found: 731.2576.

(5-(3-(9H-carbazol-9-yl)phenyl)furan-2,3-diyl)bis((3-(9H-carbazol-9-yl)phenyl)methanone) (**4**)



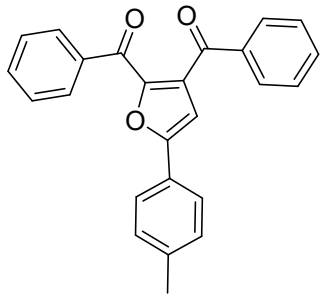
Yellow solid; m.p. 108-109 ^{o}C. (101.6mg, 60% yield); ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.34 (s, 1H), 8.20-8.17 (m, 1H), 8.15 (s, 1H), 8.13-8.09 (m, 4H), 8.06-8.02 (m, 3H), 7.92 (s, 1H), 7.83-7.80 (m, 1H), 7.76-7.68 (m, 4H), 7.58-7.56 (m, 2H), 7.39-7.38 (m, 6H), 7.31-7.24 (m, 8H), 7.22 (s, 1H), 7.16-7.13 (m, 3H), 7.07 (s, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 190.0, 180.4, 156.7, 149.2, 140.6, 140.57, 138.8, 138.4, 138.3, 138.2, 138.0, 134.8, 132.3, 132.0, 131.0, 130.4, 130.3, 128.7, 128.5, 128.2, 127.7, 126.21, 126.2, 126.1, 124.0, 123.7, 123.6, 123.61, 123.58, 123.5, 120.52, 120.5, 120.4, 120.3, 109.6, 109.56, 109.5, 109.4; HRMS (ESI) calculated for $C_{60}H_{34}N_3O_3$ ($M+H^+$): 844.2594, found: 844.2591.

3-(3,5-di-tert-butyl-4-hydroxyphenyl)-2-(methylsulfonyl)-1-phenylpropan-1-one (**C**)



White soild; m.p. 83-84 ^{o}C. (74.8 mg, 90% yield); ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.69 (d, *J* = 8.0 Hz, 2H), 7.51 (t, *J* = 7.3 Hz, 1H), 7.35 (t, *J* = 7.6 Hz, 2H), 6.85 (s, 2H), 5.07-5.06 (m, 0.5H), 5.04 (s, 1H), 3.53-3.41 (m, 2H), 3.10 (s, 3H), 1.26 (s, 18H); ^{13}C NMR (100 MHz, $CDCl_3$) *δ* 194.8, 152.9, 137.0, 136.4, 134.0, 128.7, 128.6, 128.5, 125.6, 125.3, 70.6, 37.9, 35.6, 34.3, 30.0. HRMS (ESI) calculated for $C_{24}H_{33}O_4S$ ($M+H^+$): 471.2094, found: 471.2090.

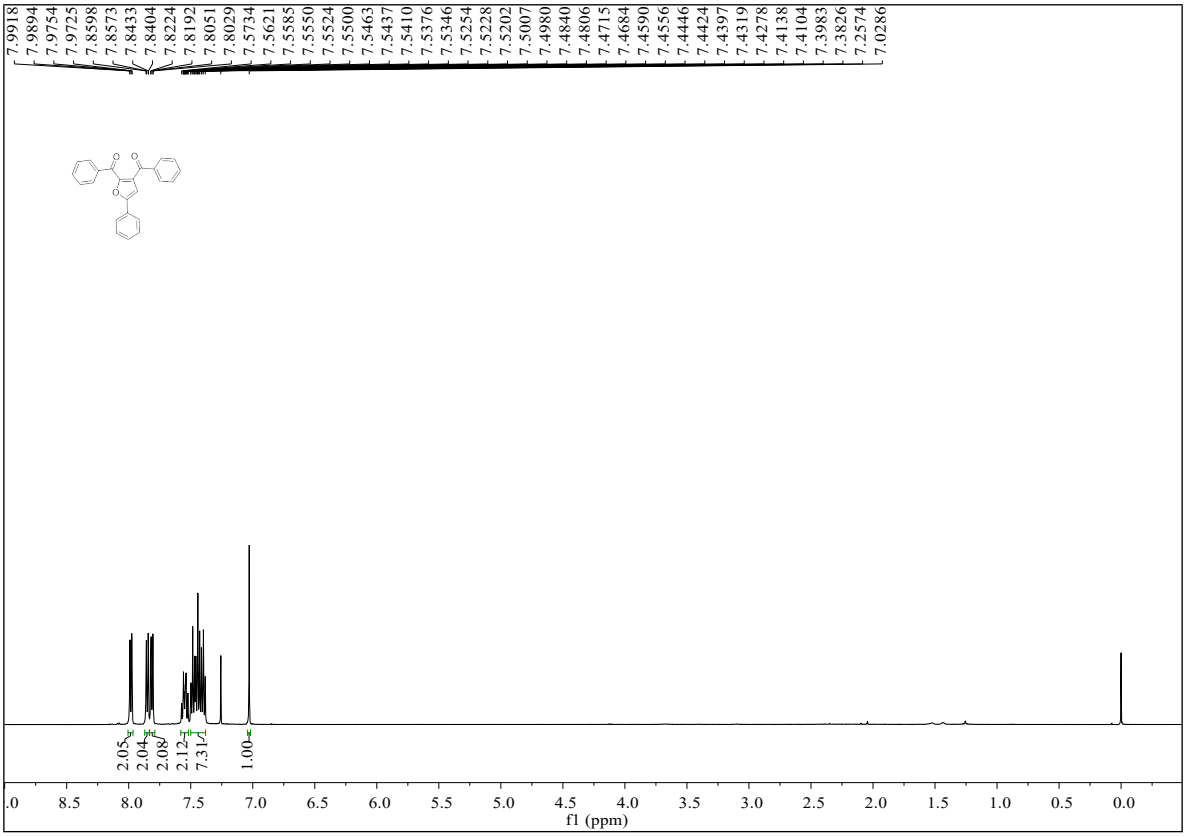
(5-(p-tolyl)furan-2,3-diyl)bis(phenylmethanone) (**5**)

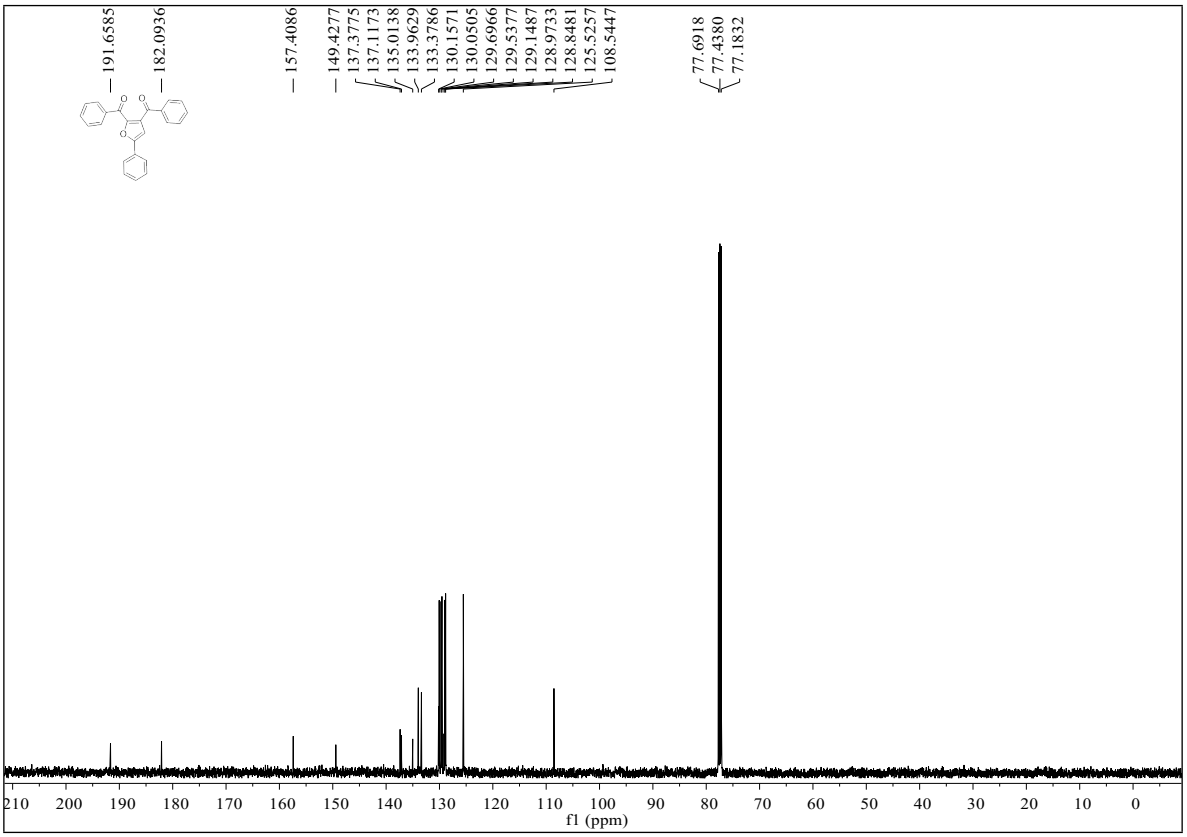


White solid; (64.4 mg, 88% yield) ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.98 (d, *J* = 8.0 Hz, 1H), 7.92 (d, *J* = 8.0 Hz, 1H), 7.87-7.84 (m, 2H), 7.81 (d, J = 7.9 Hz, 1H), 7.70 (d, *J* = 8.0 Hz, 1H), 7.56-7.38 (m, 6H), 7.30-7.24 (m, 2H), 7.02 (s, 0.5H), 6.98 (s, 0.5H), 2.42 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) *δ* 191.4, 181.6, 181.3, 157.4, 156.7, 148.7, 143.9, 140.1, 137.0, 136.8, 134.8, 134.0, 133.5, 132.9, 129.8, 129.6, 129.3, 129.2, 129.1, 128.5, 128.4, 125.1, 108.1, 107.6, 21.7, 21.5. HRMS (ESI) calculated for $C_{25}H_{19}O_3$ ($M+H^+$): 367.1328, found: 367.1323.

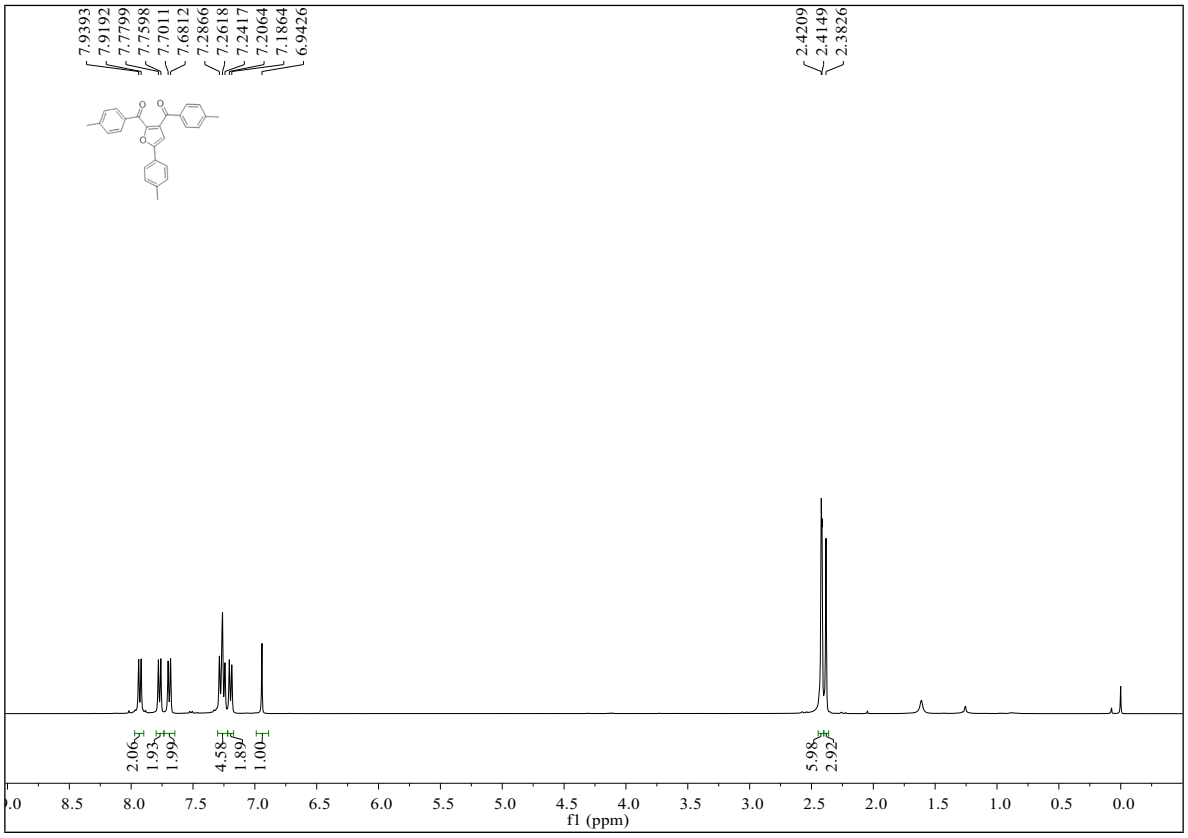
Copies of ^{1}H and ^{13}C Spectra

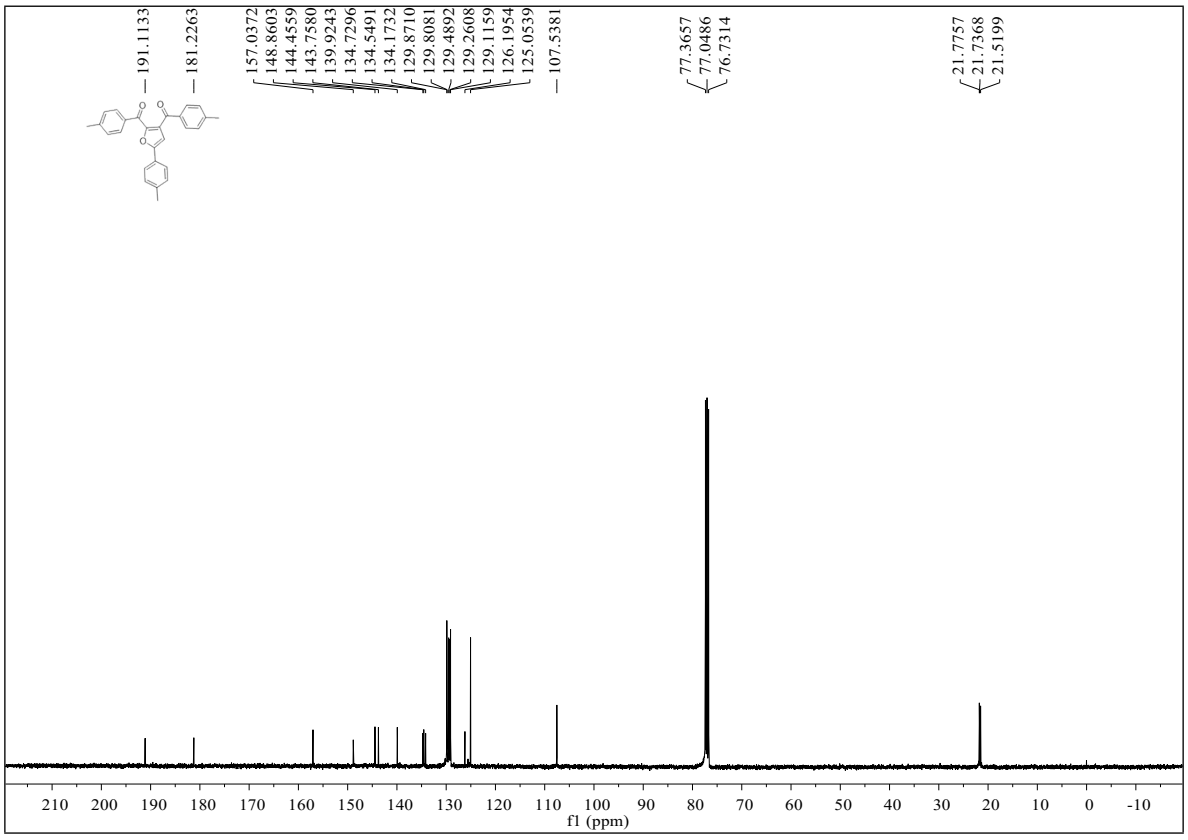
(5-phenylfuran-2,3-diyl)bis(phenylmethanone) (**2a**)



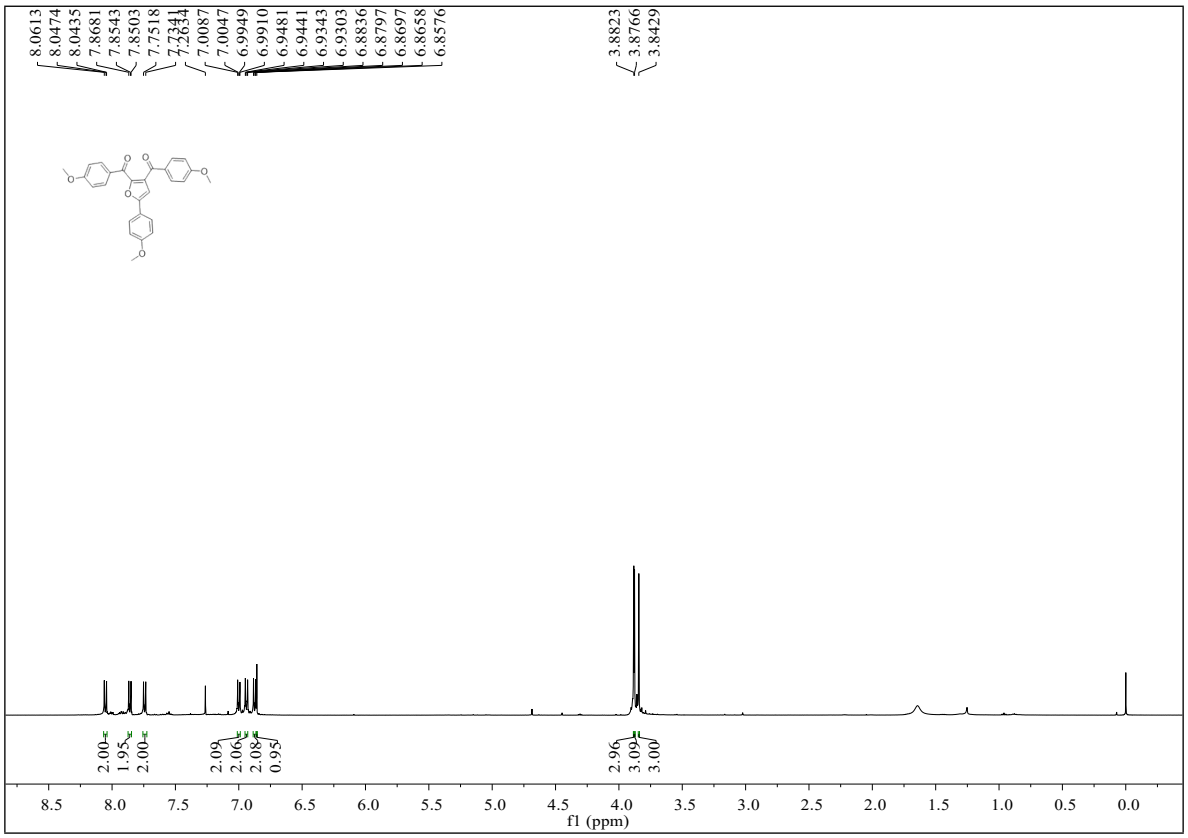


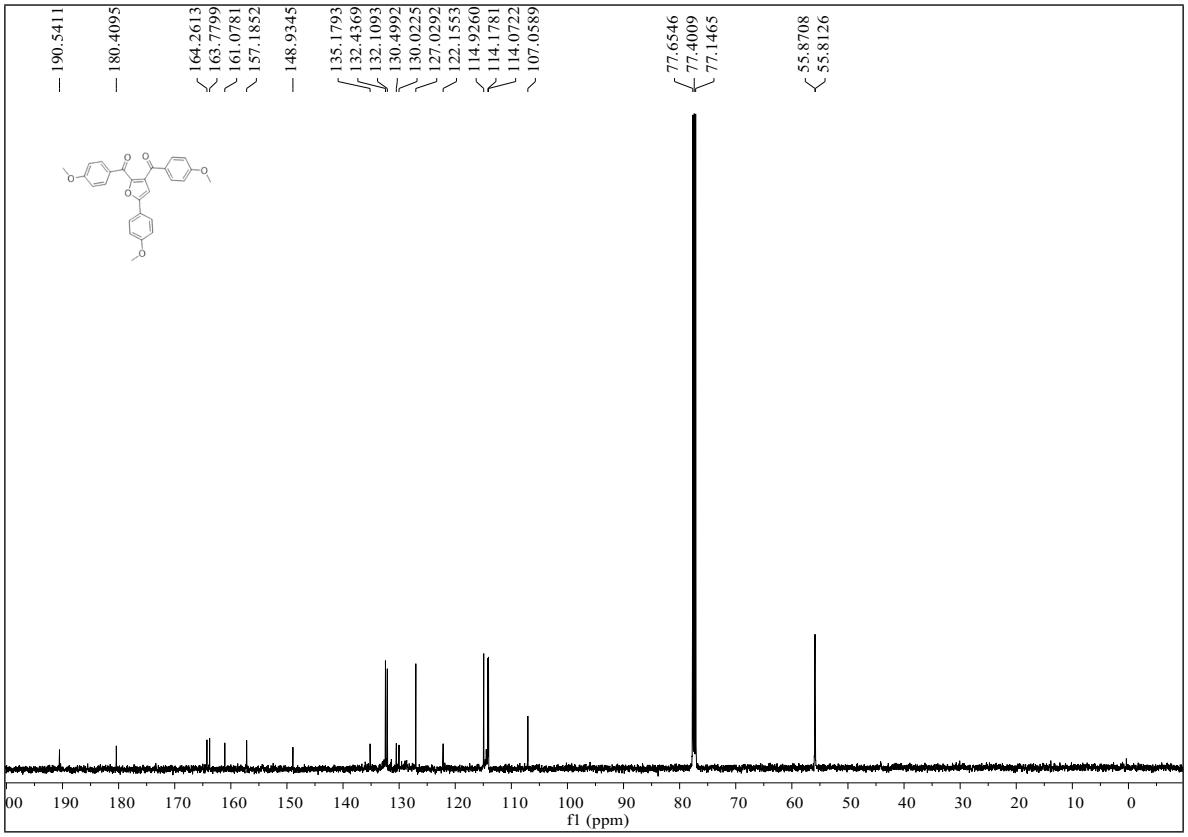
(5-(p-tolyl)furan-2,3-diyl)bis(p-tolylmethanone) (**2b**)



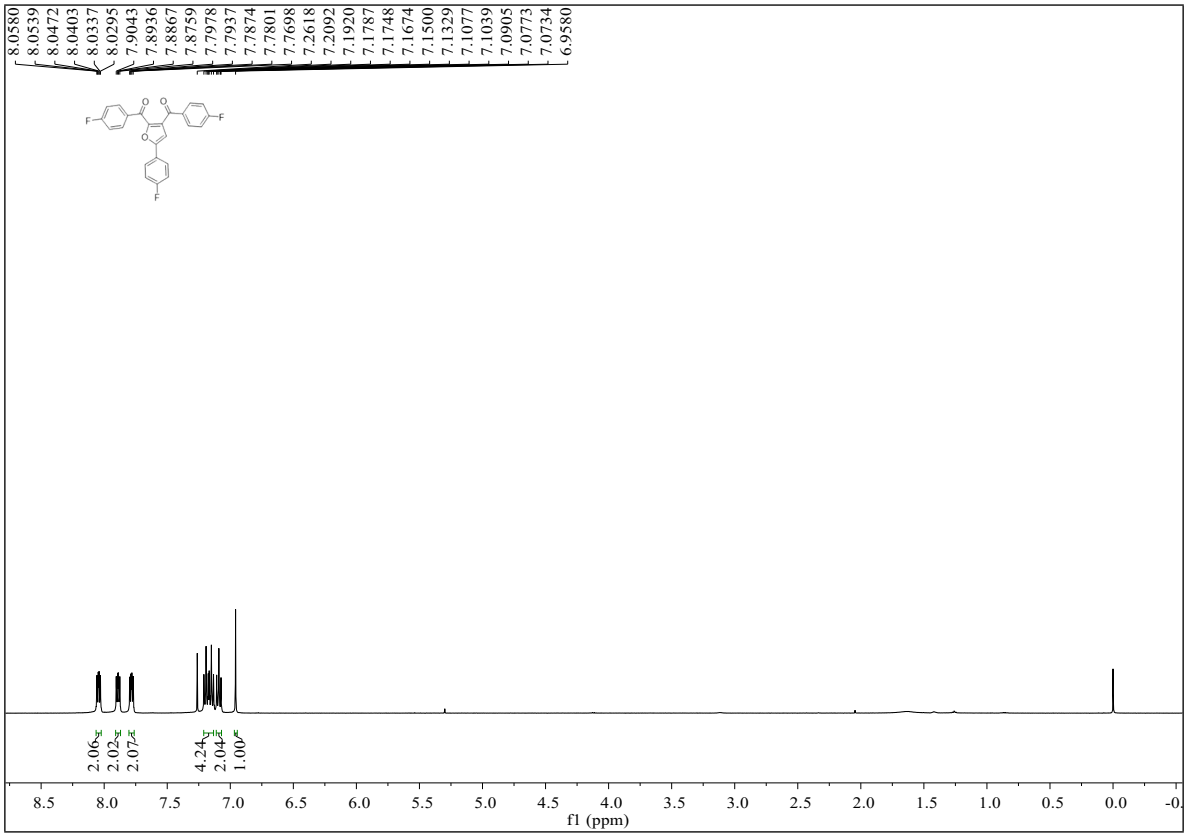


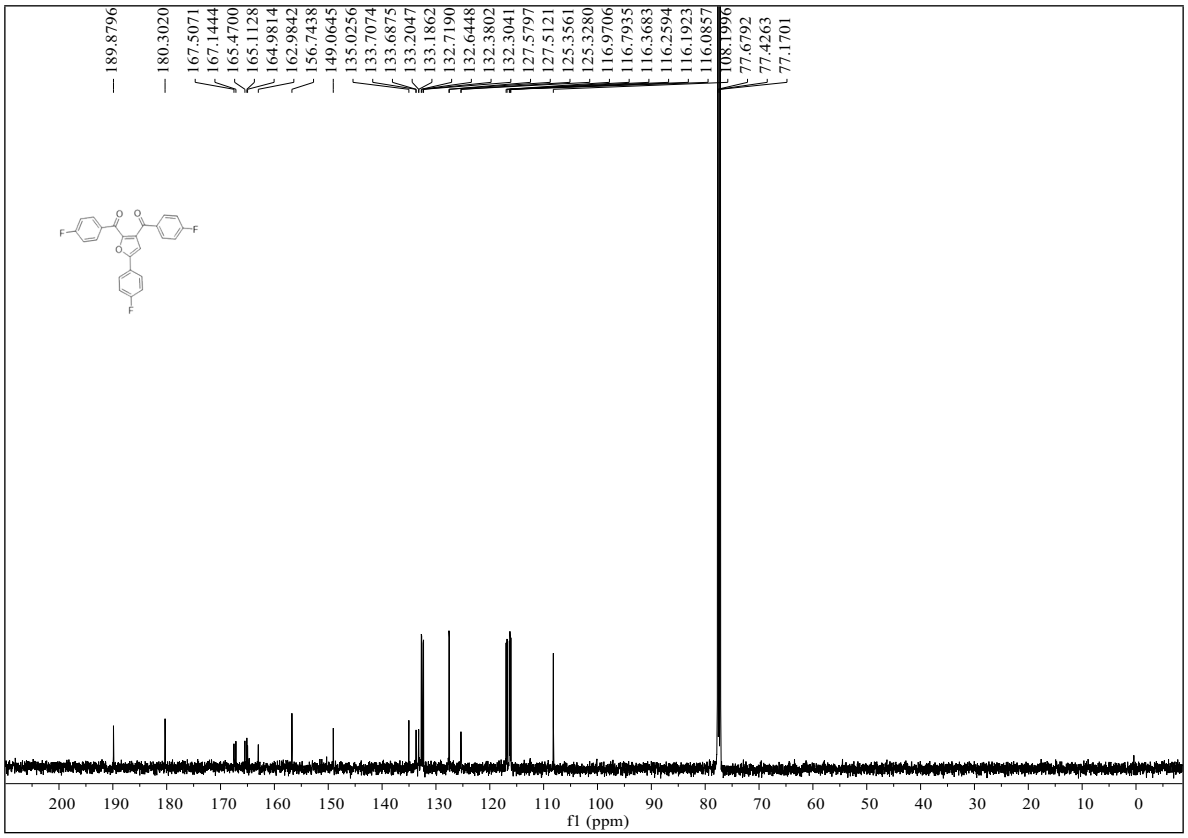
(5-(4-methoxyphenyl)furan-2,3-diyl)bis((4-methoxyphenyl)methanone) (**2c**)



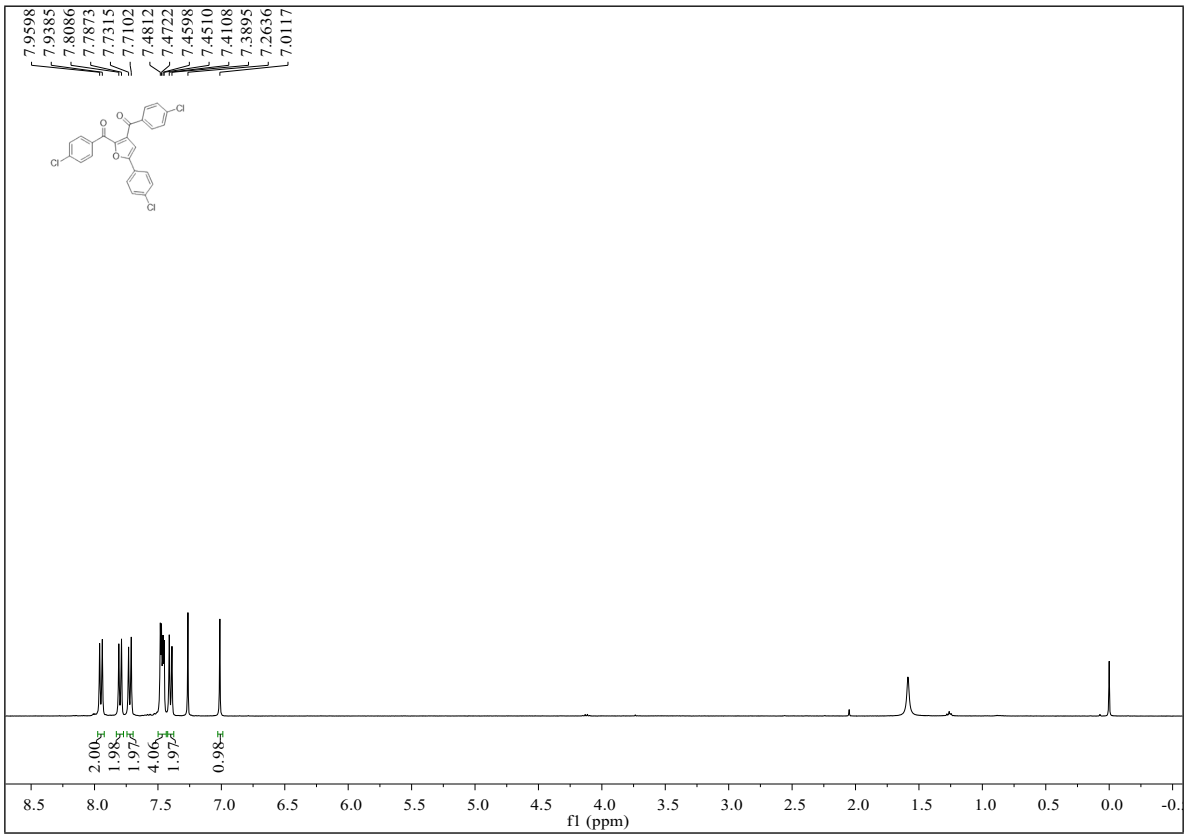


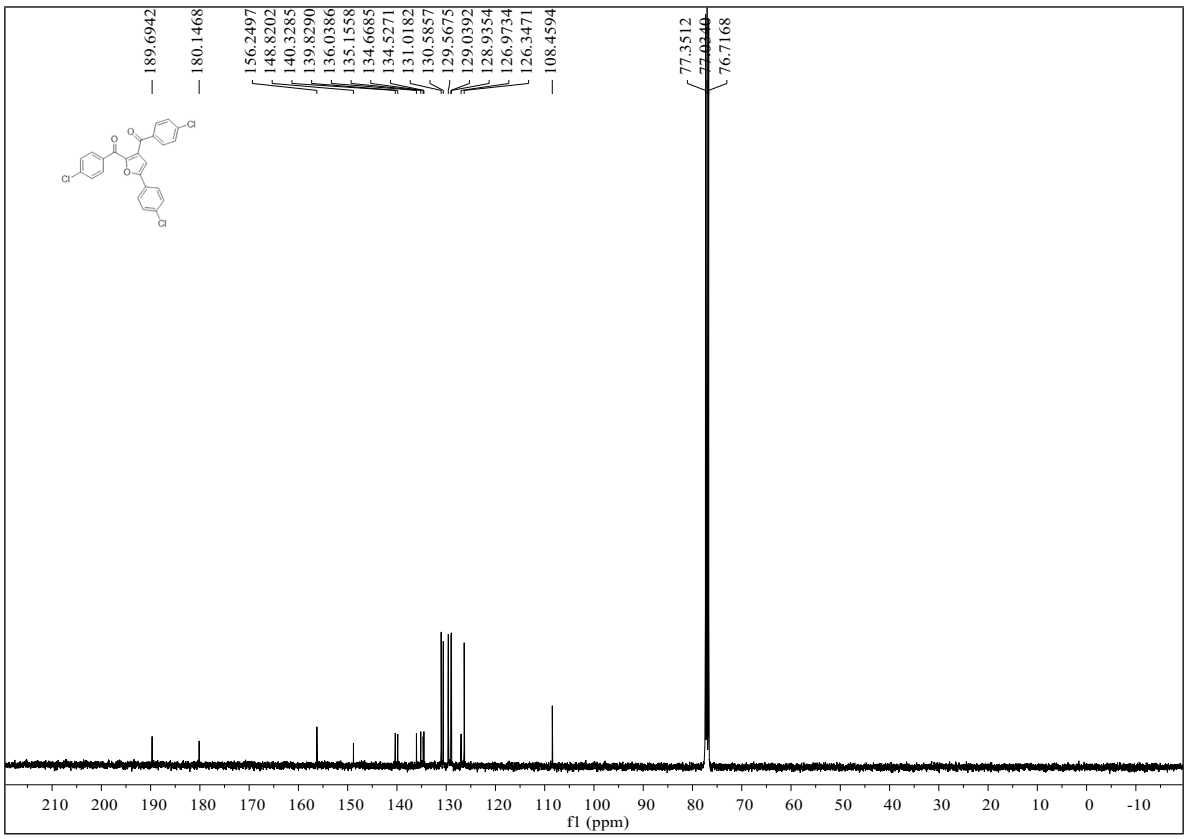
(5-(4-fluorophenyl)furan-2,3-diyl)bis((4-fluorophenyl)methanone) (**2d**)



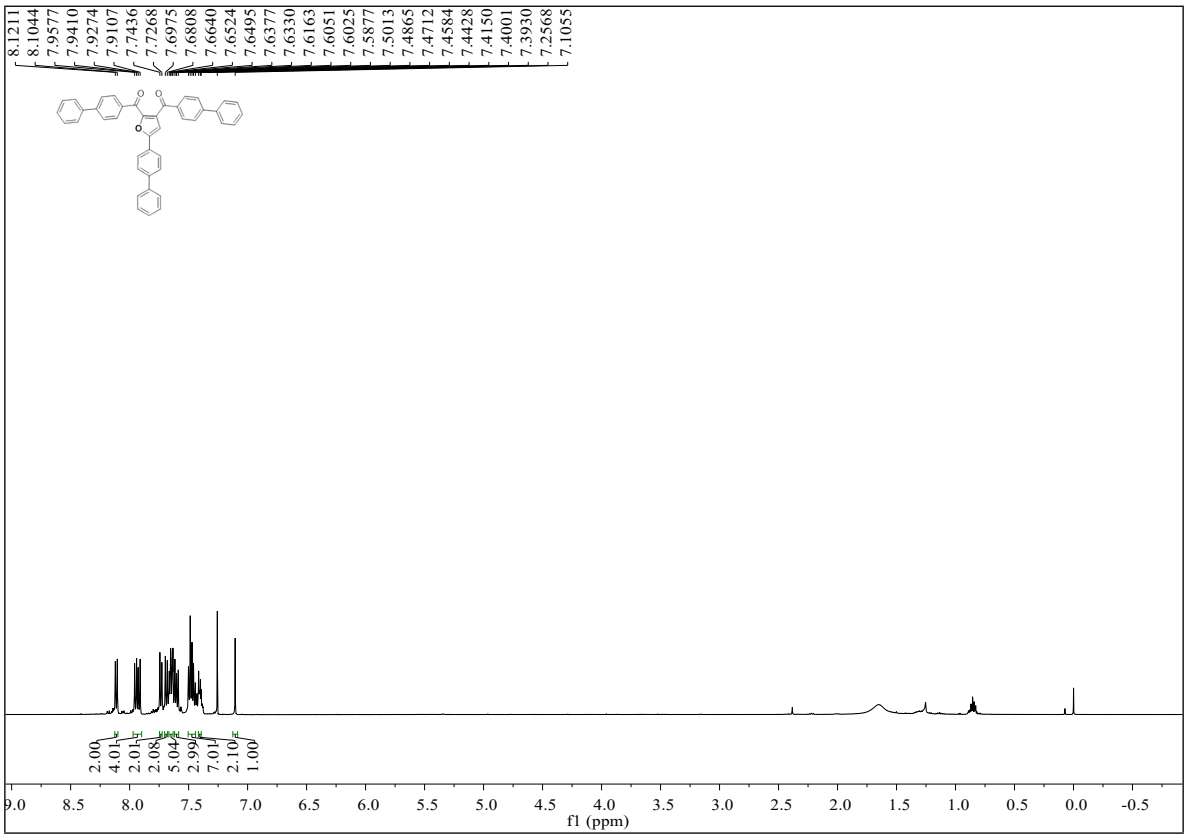


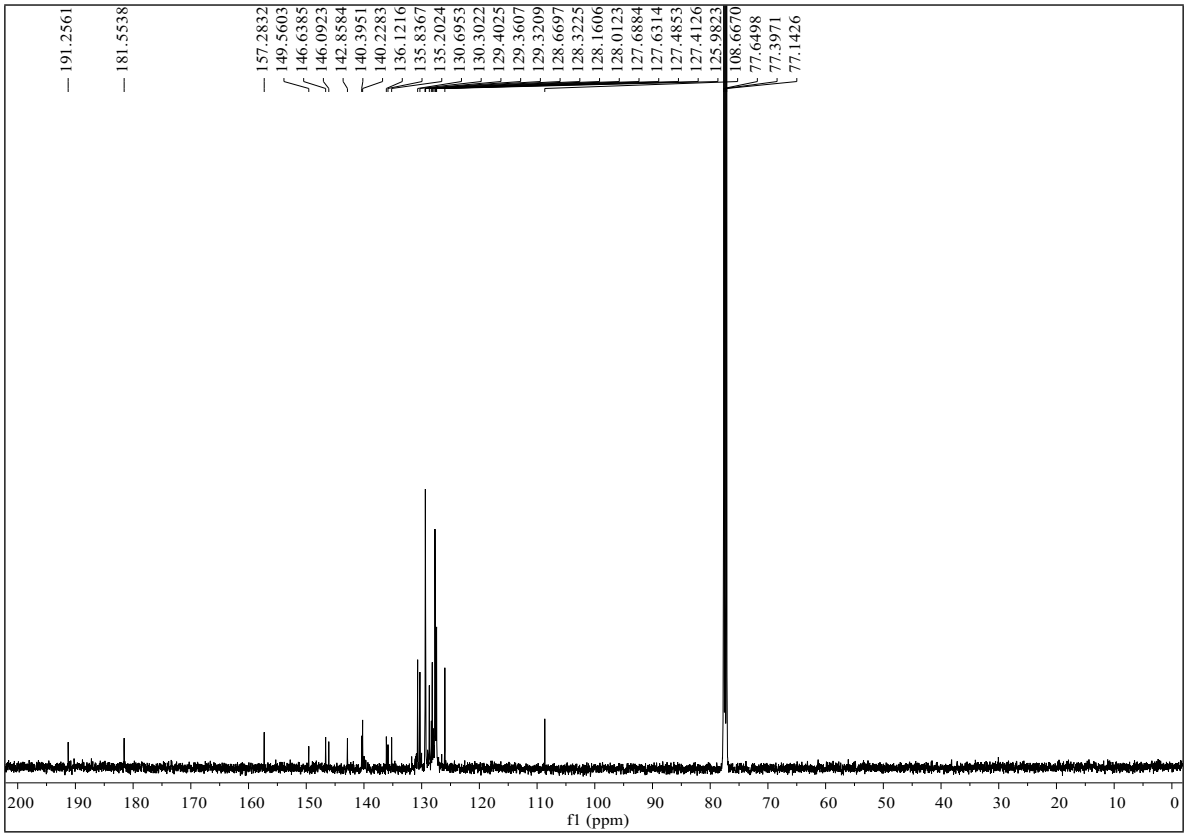
(5-(4-chlorophenyl)furan-2,3-diyl)bis((4-chlorophenyl)methanone) (**2e**)



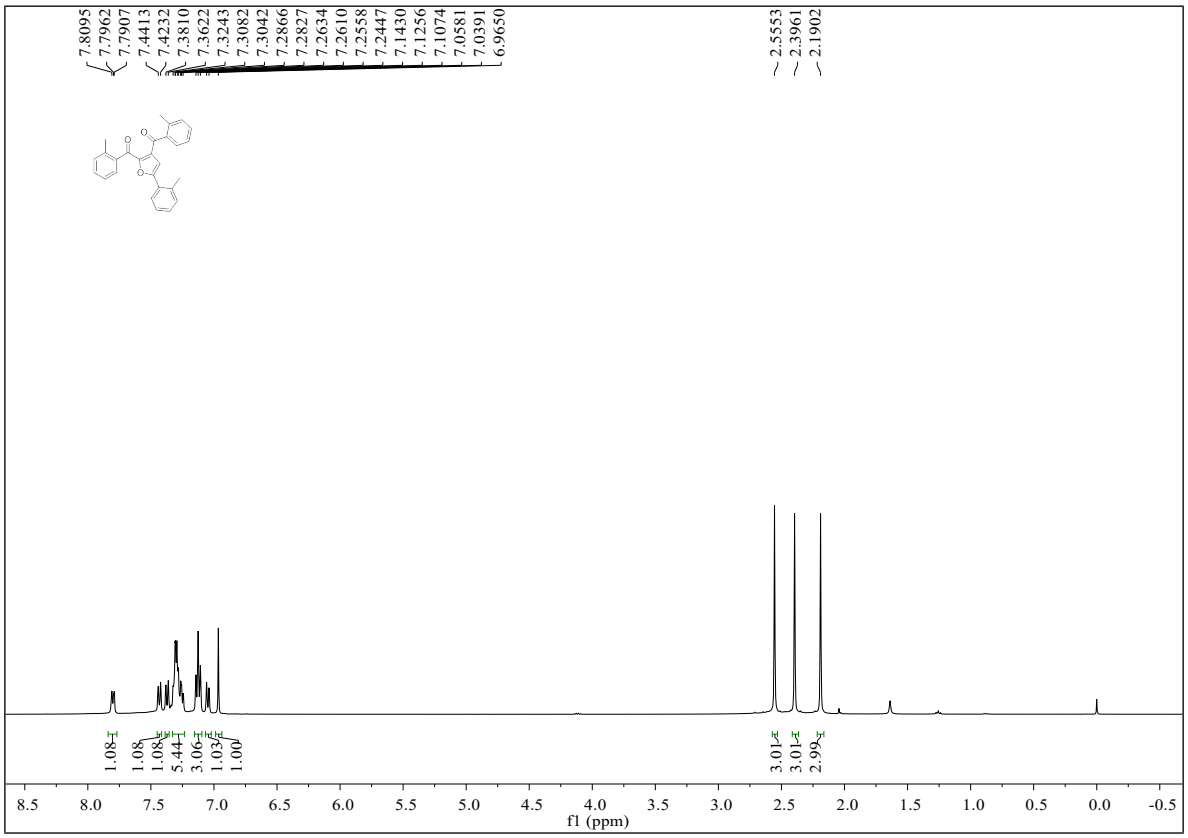


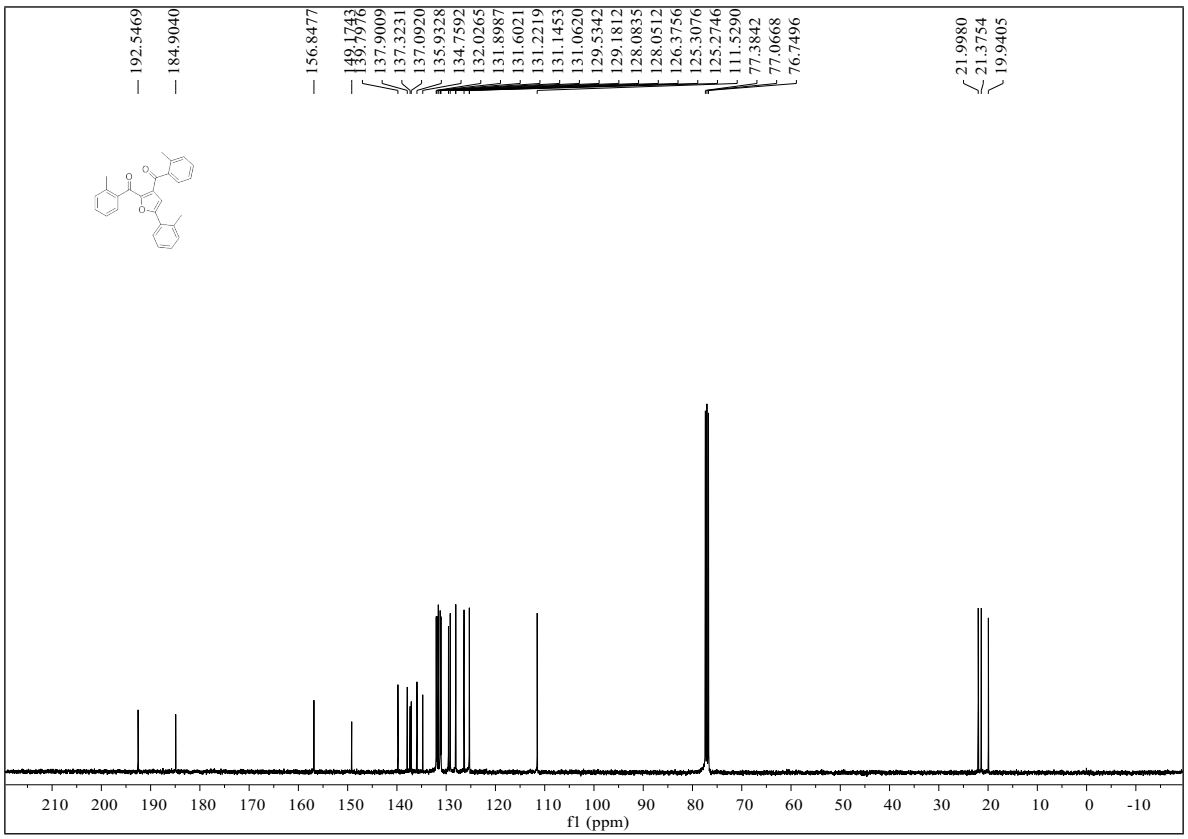
(5-([1,1'-biphenyl]-4-yl)furan-2,3-diyl)bis([1,1'-biphenyl]-4-ylmethanone) (**2f**)



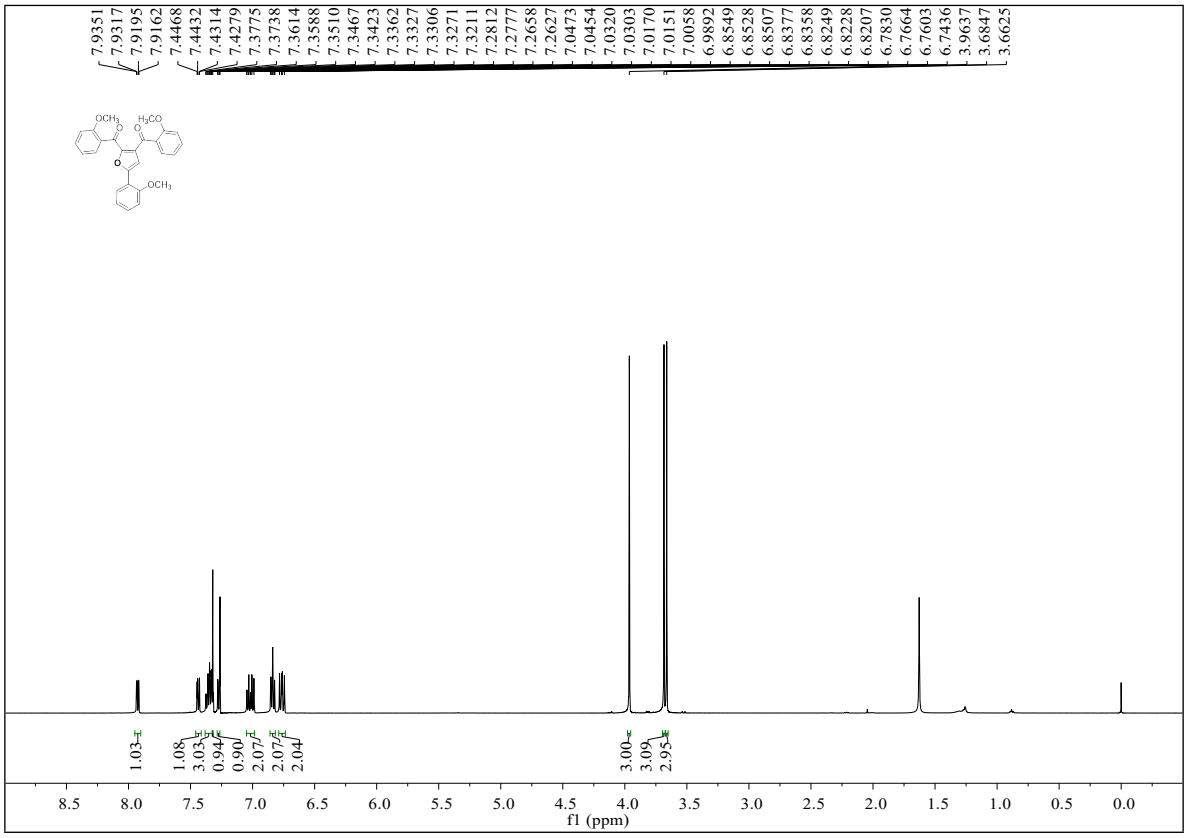


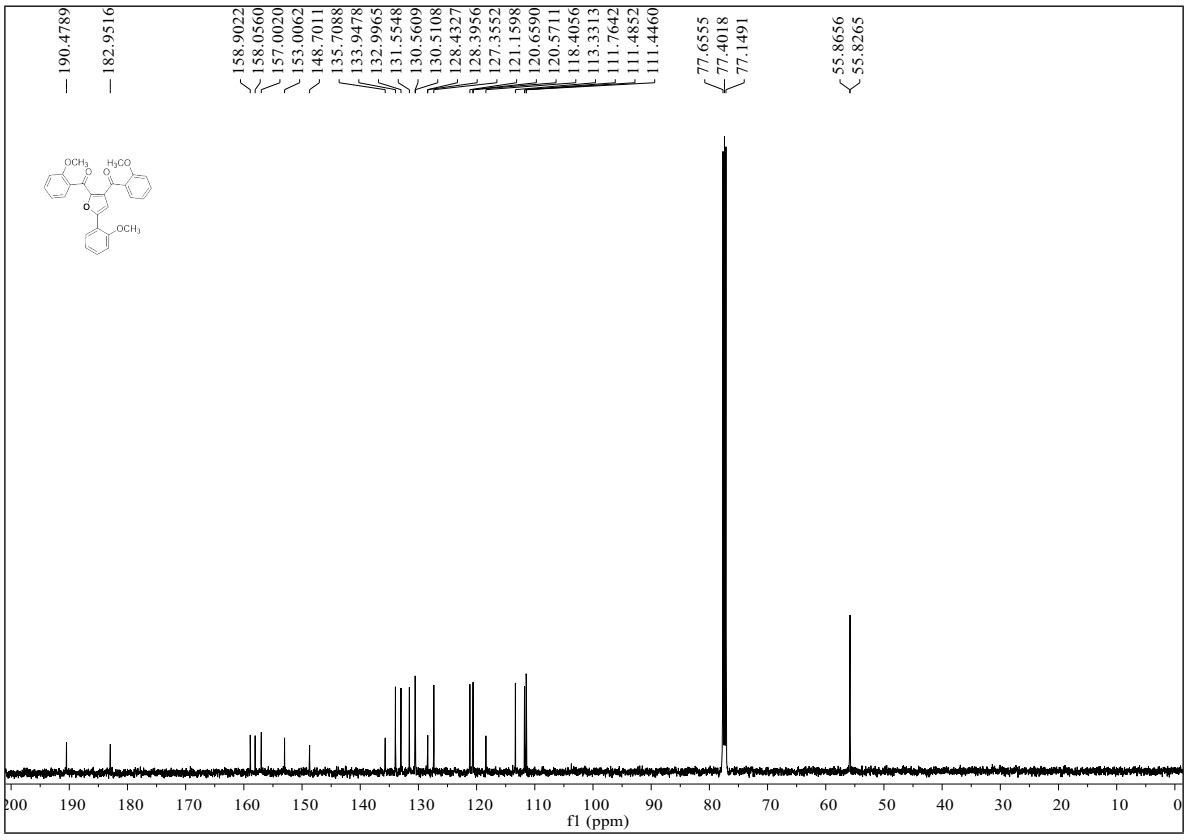
(5-(o-tolyl)furan-2,3-diyl)bis(o-tolylmethanone) (**2g**)



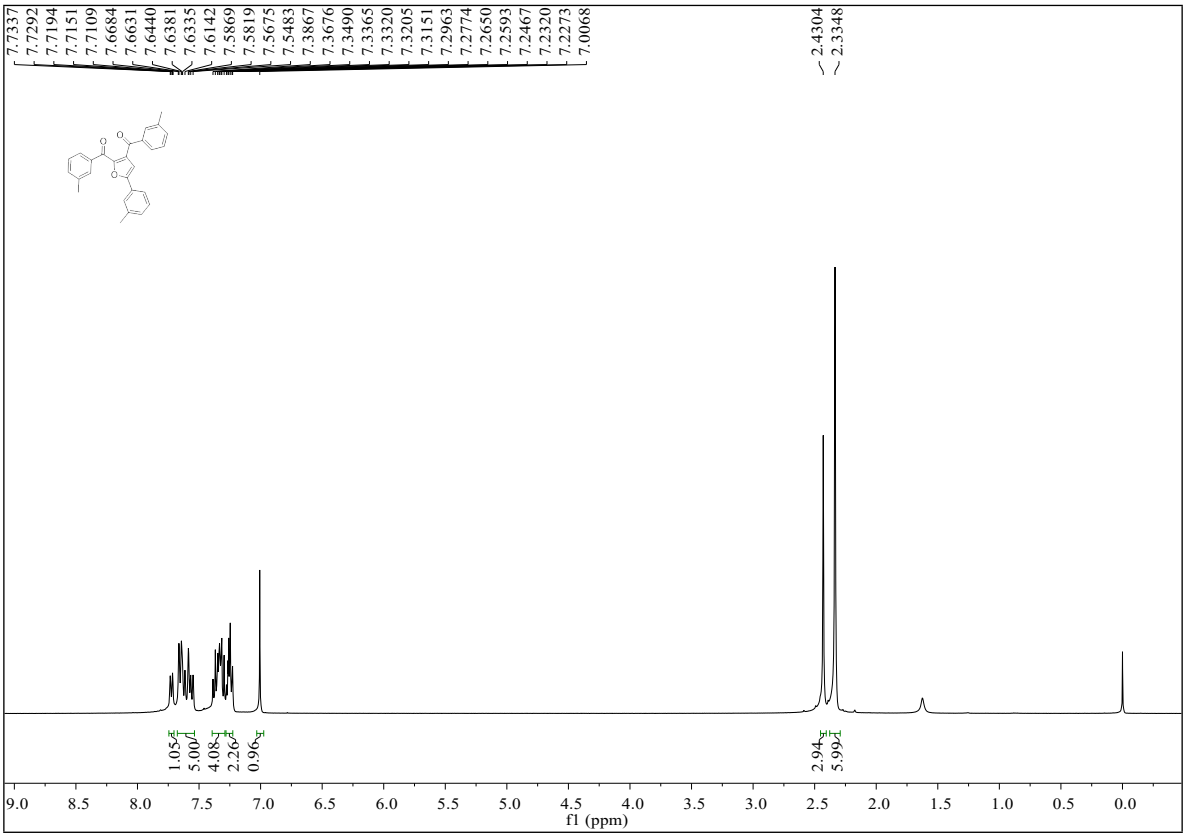


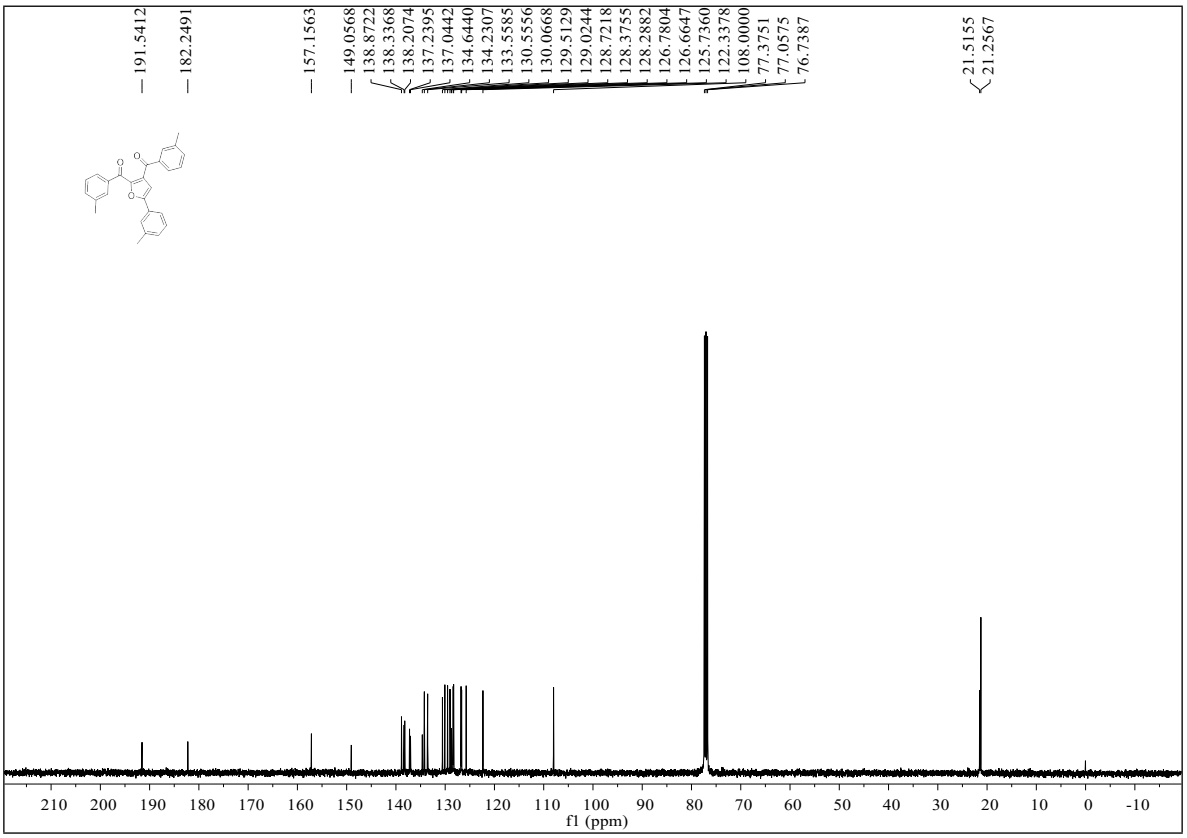
(5-(2-methoxyphenyl)furan-2,3-diyl)bis((2-methoxyphenyl)methanone) (**2h**)



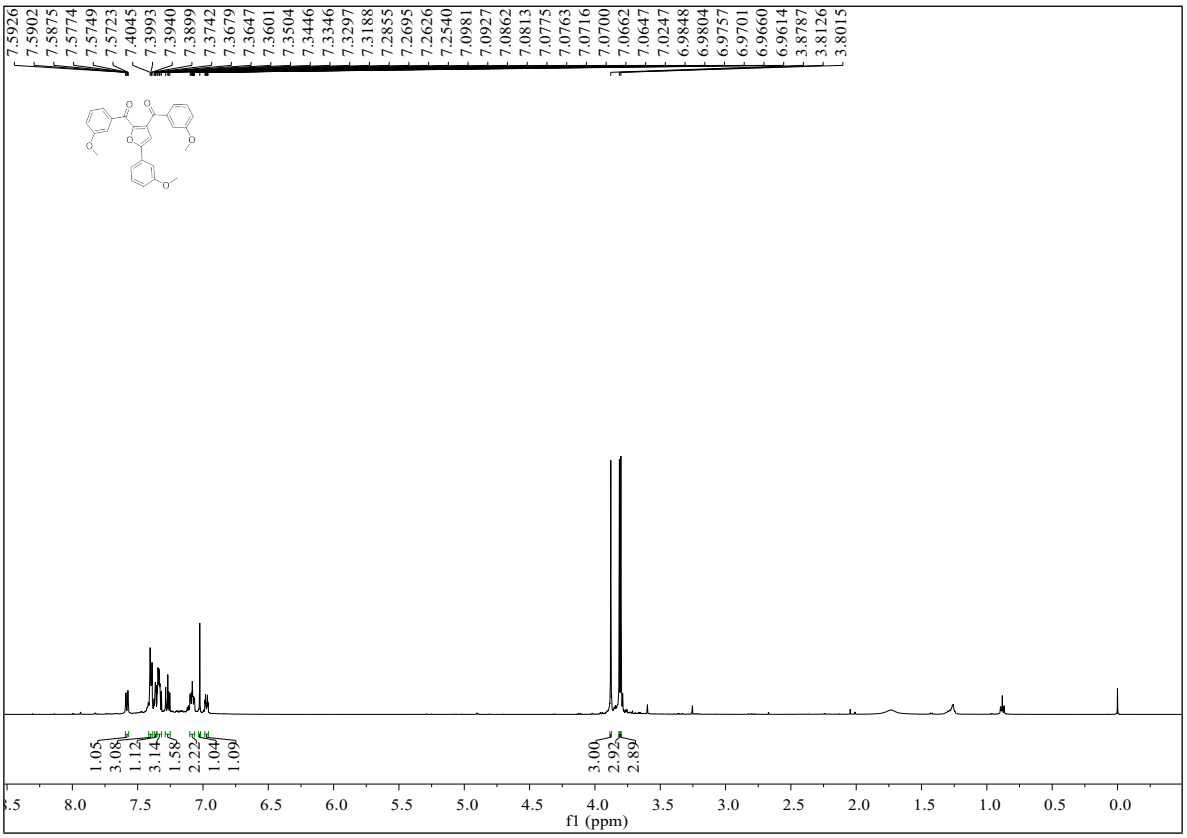


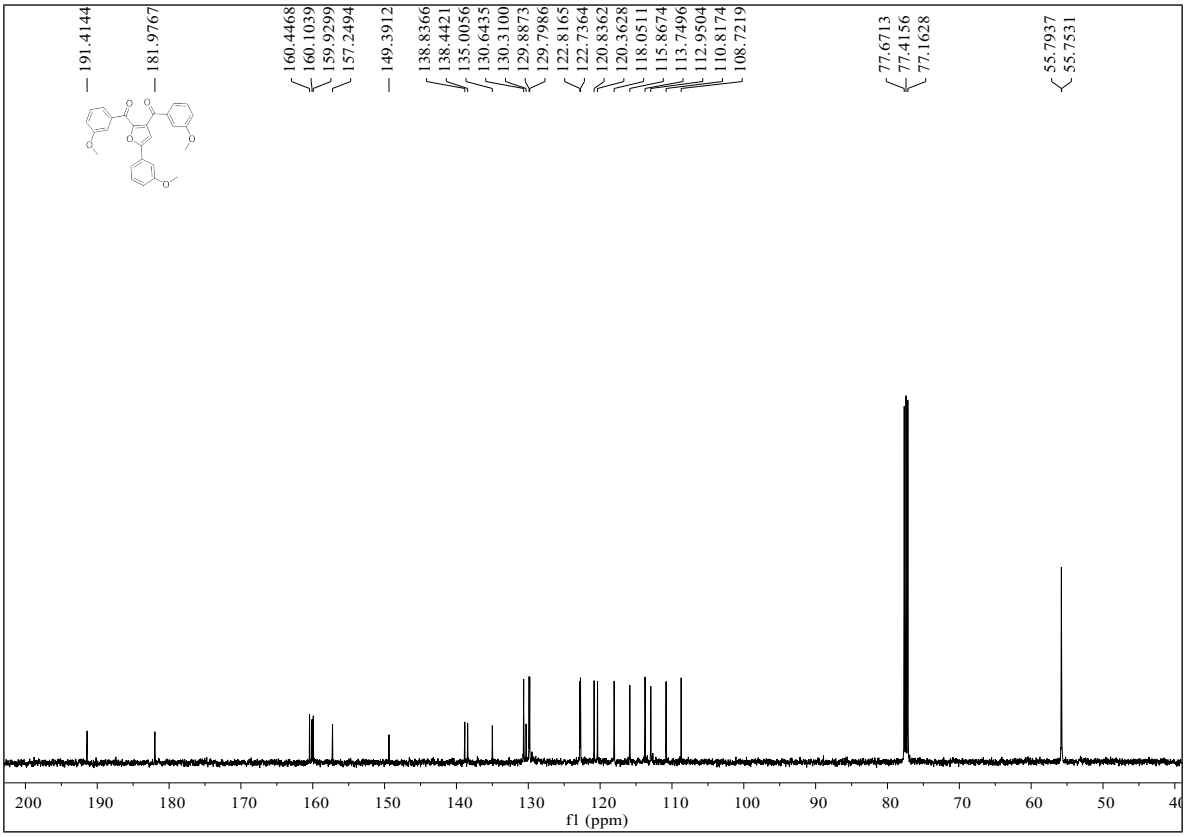
(5-(m-tolyl)furan-2,3-diyl)bis(m-tolylmethanone) (**2i**)



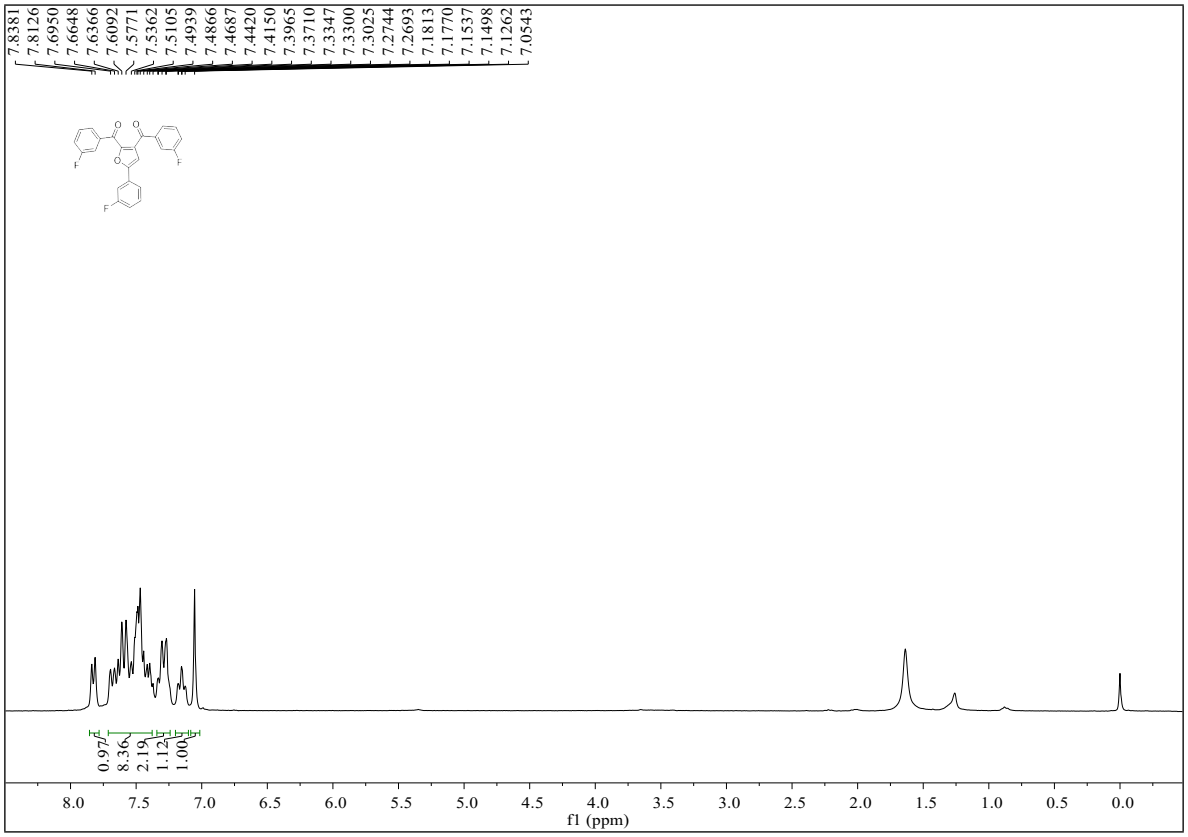


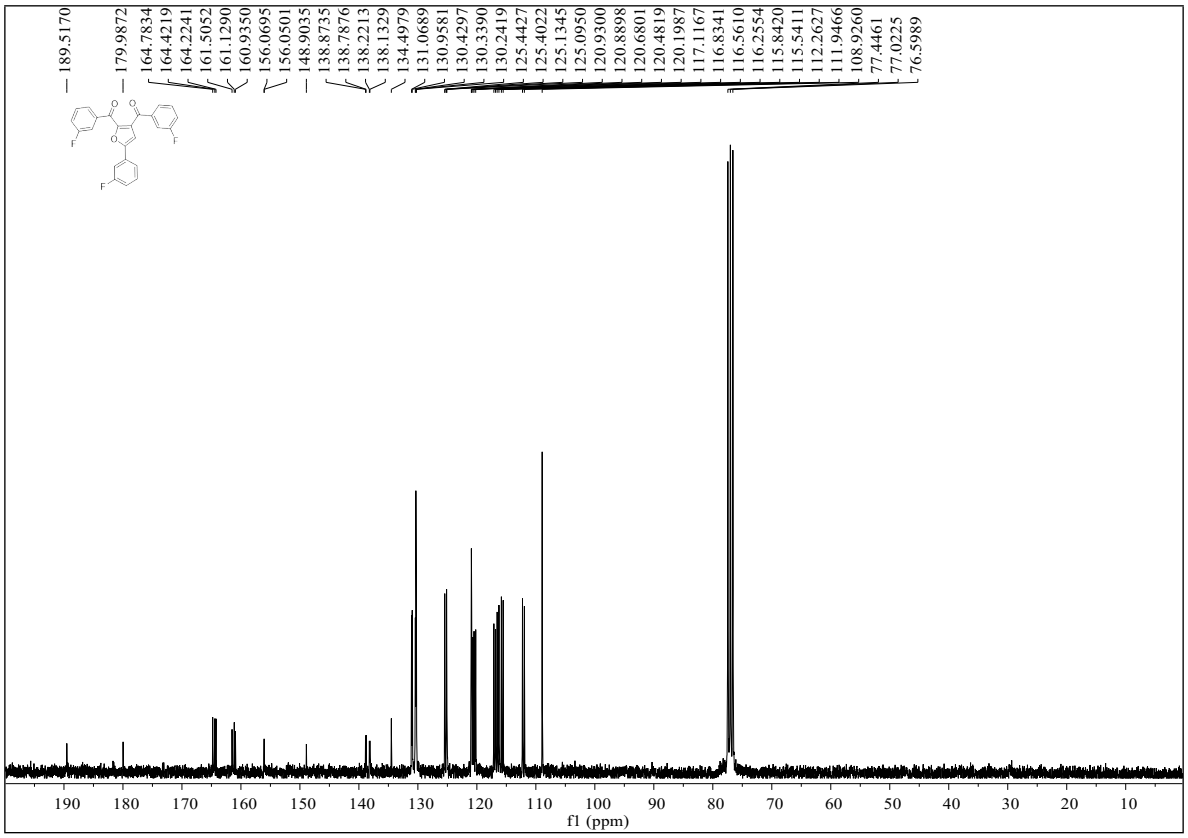
(5-(3-methoxyphenyl)furan-2,3-diyl)bis((3-methoxyphenyl)methanone) (**2j**)



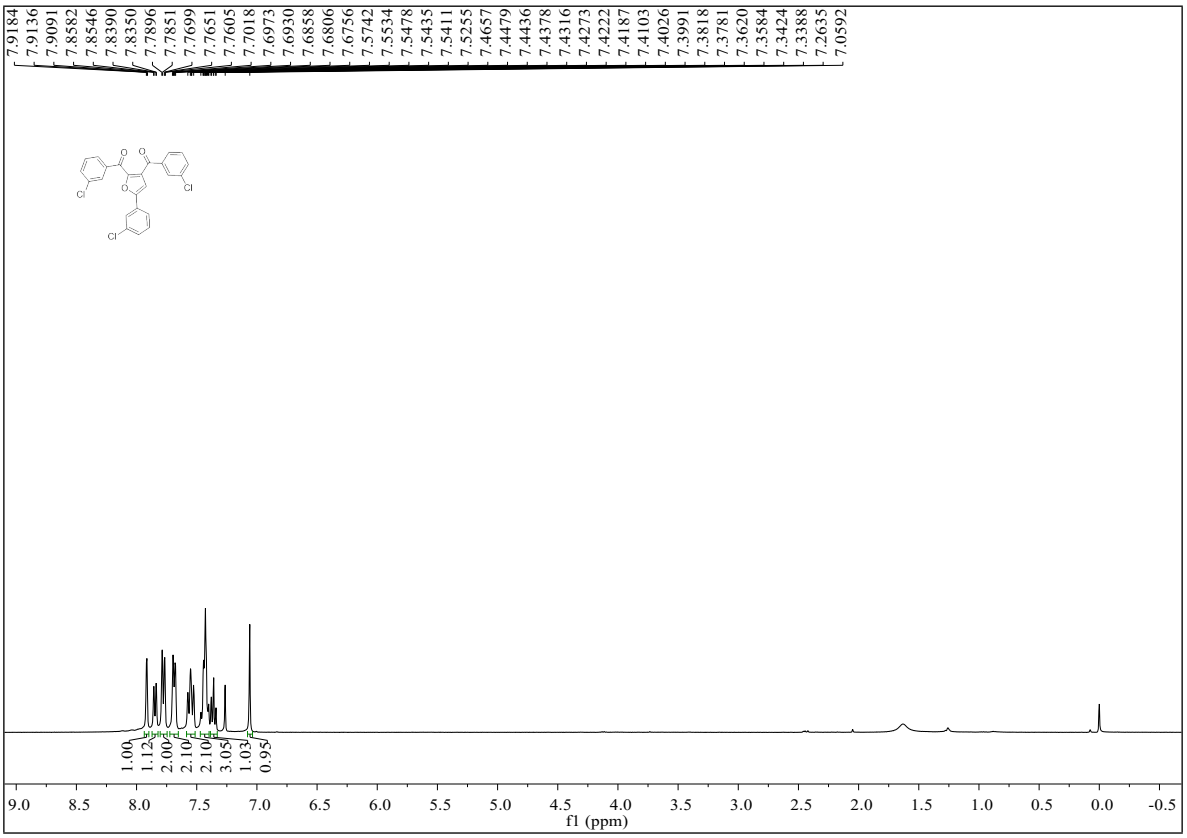


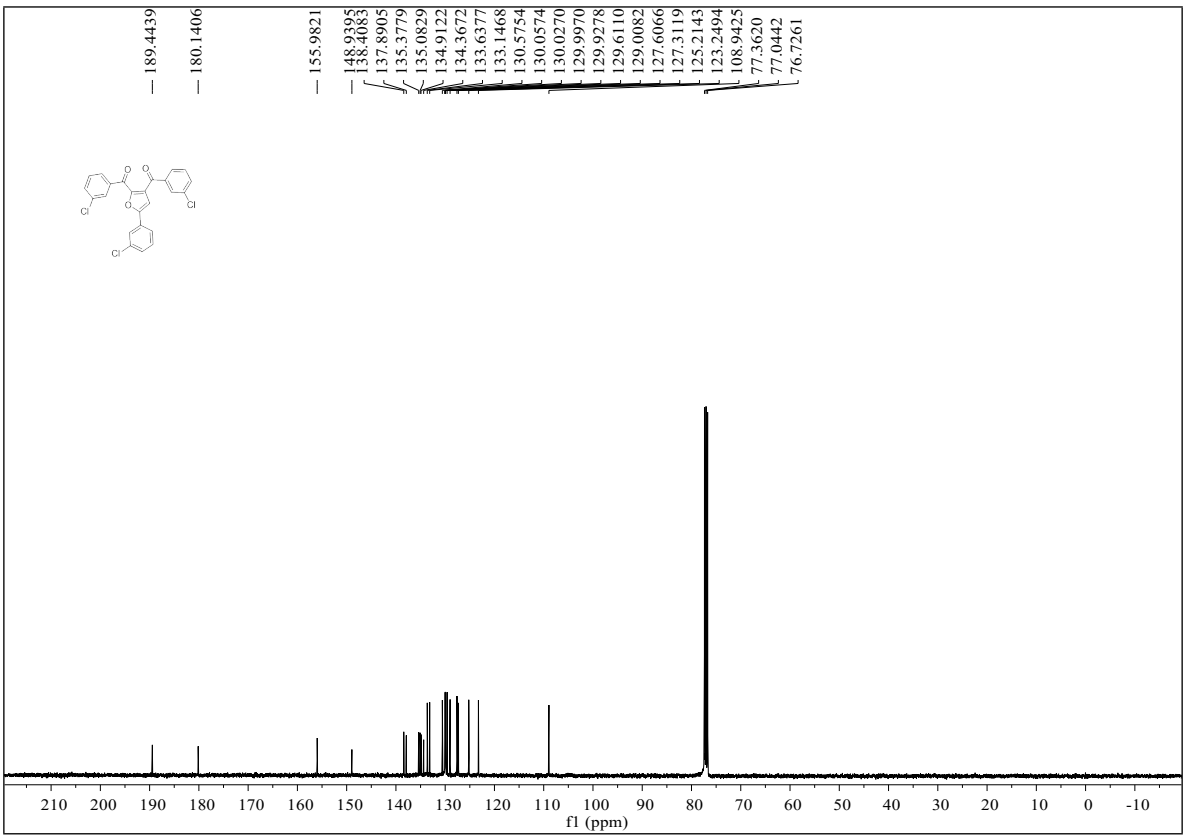
(5-(3-fluorophenyl)furan-2,3-diyl)bis((3-fluorophenyl)methanone) (**2k**)



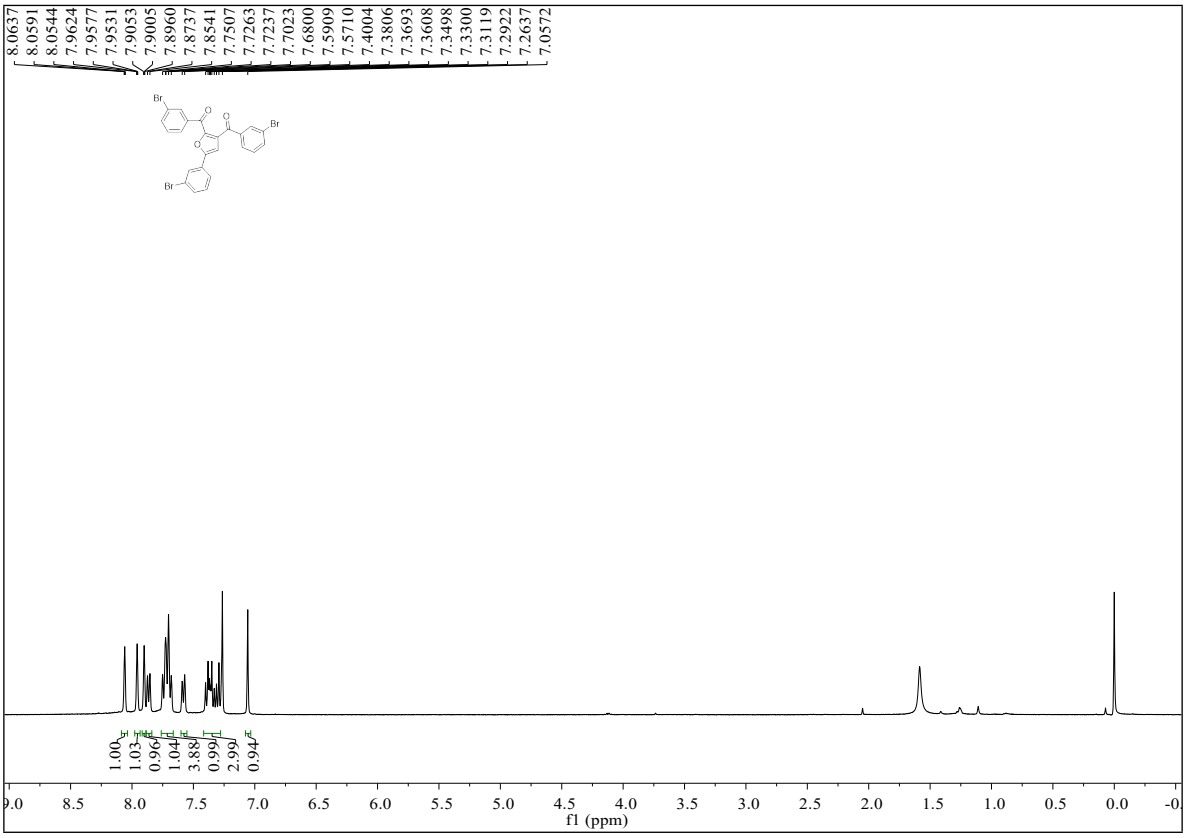


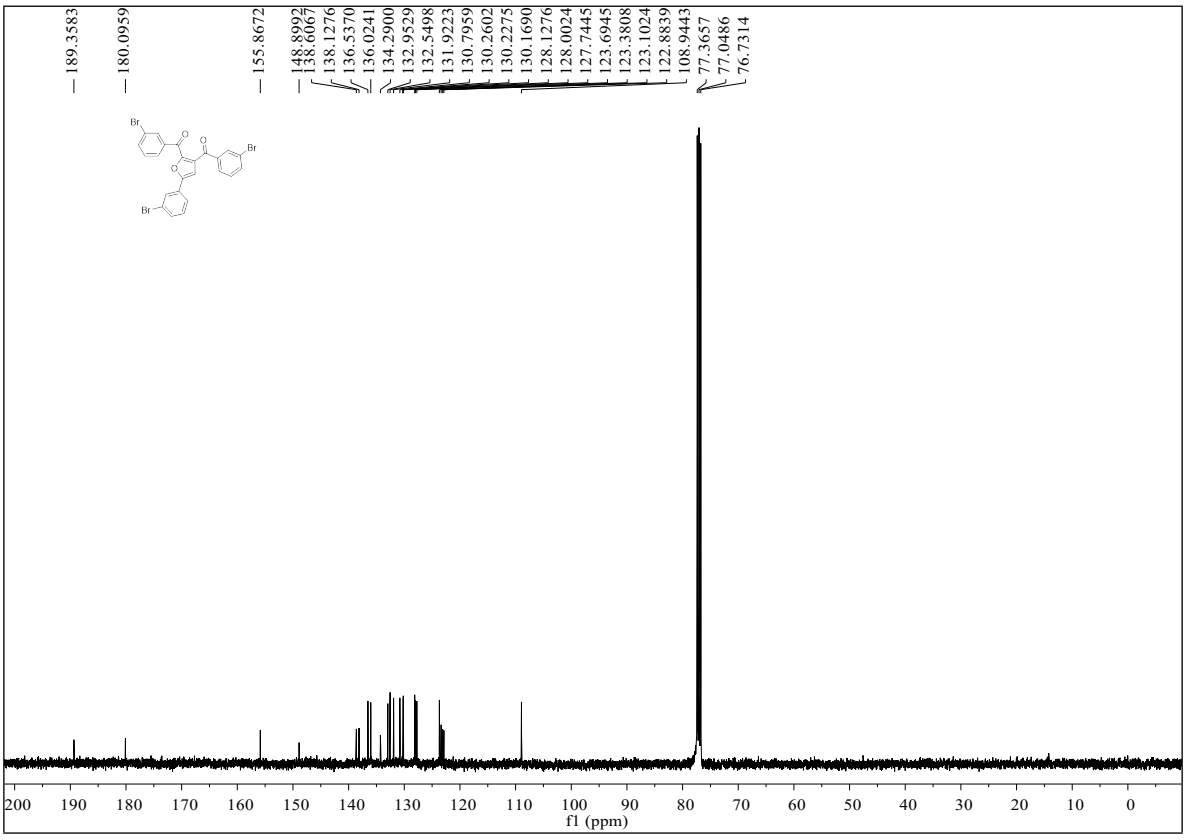
(5-(3-chlorophenyl)furan-2,3-diyl)bis((3-chlorophenyl)methanone) (**2l**)



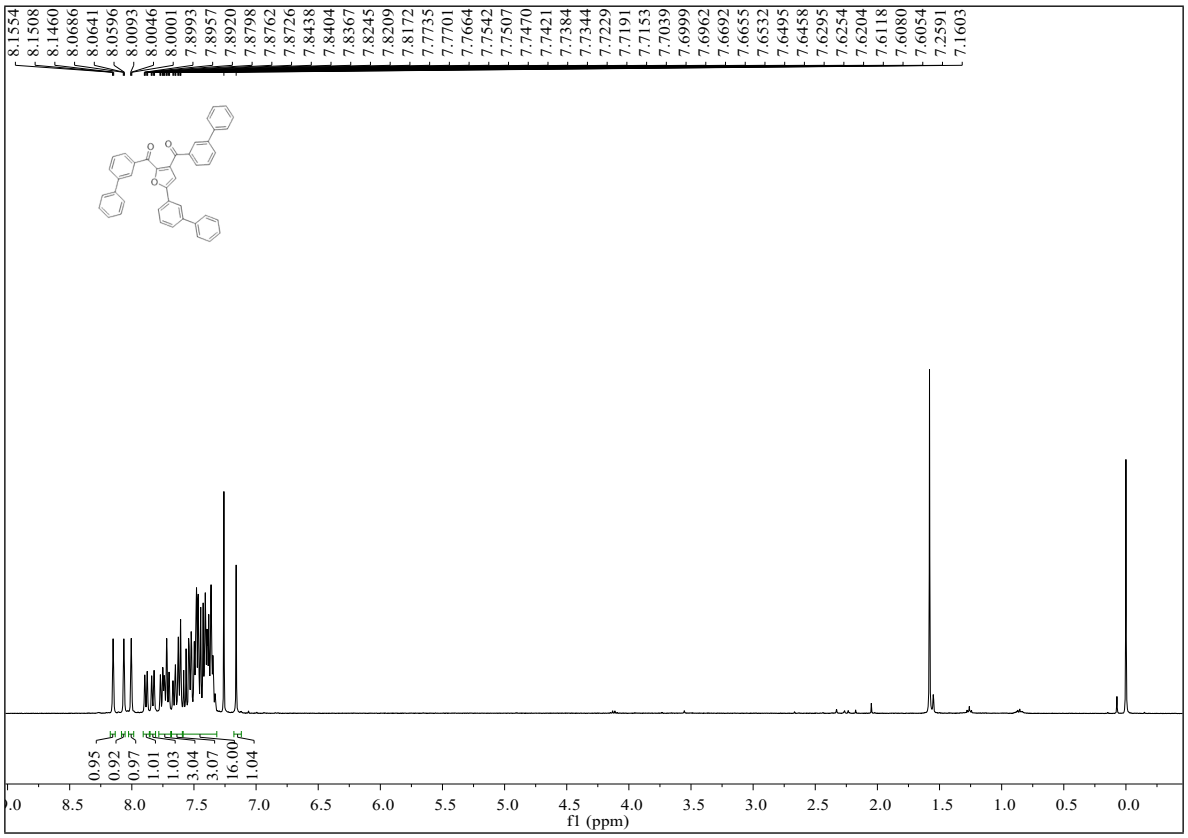


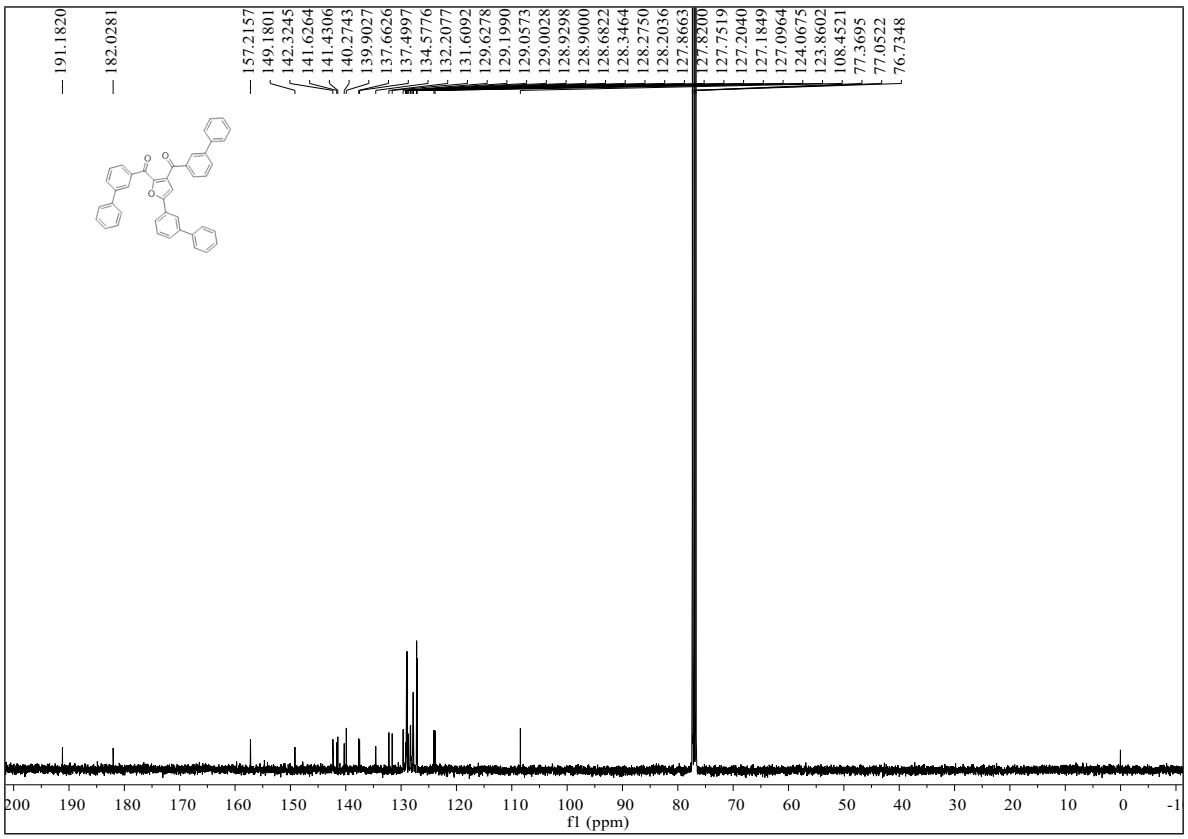
(5-(3-bromophenyl)furan-2,3-diyl)bis((3-bromophenyl)methanone) (**2m**)





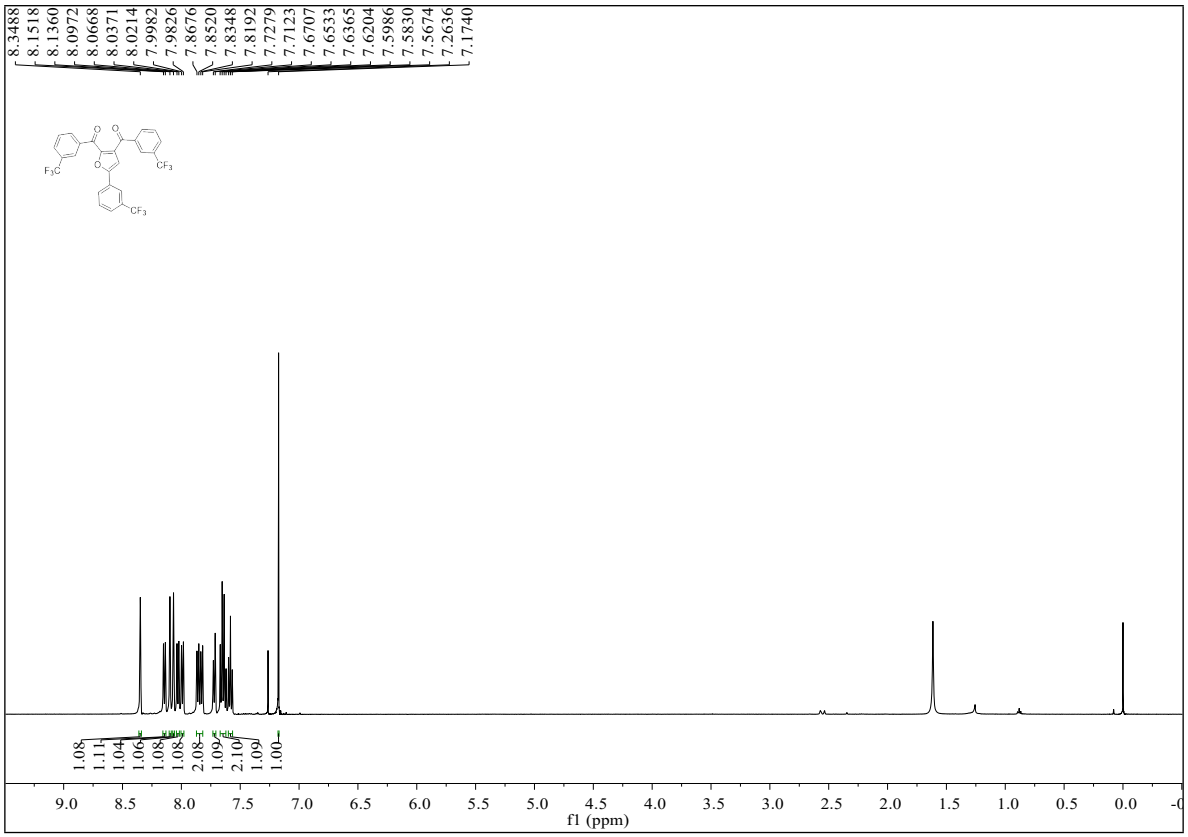
(5-([1,1'-biphenyl]-3-yl)furan-2,3-diyl)bis([1,1'-biphenyl]-3-ylmethanone) (**2n**)

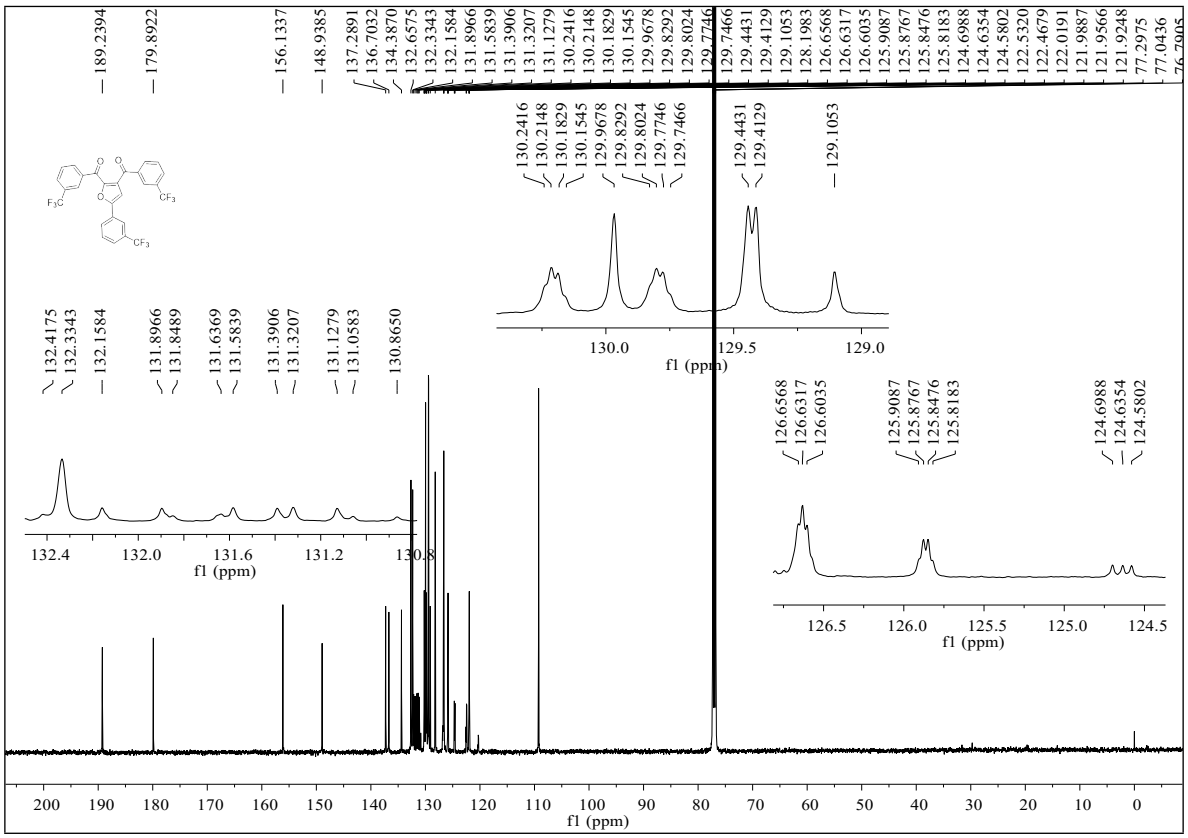


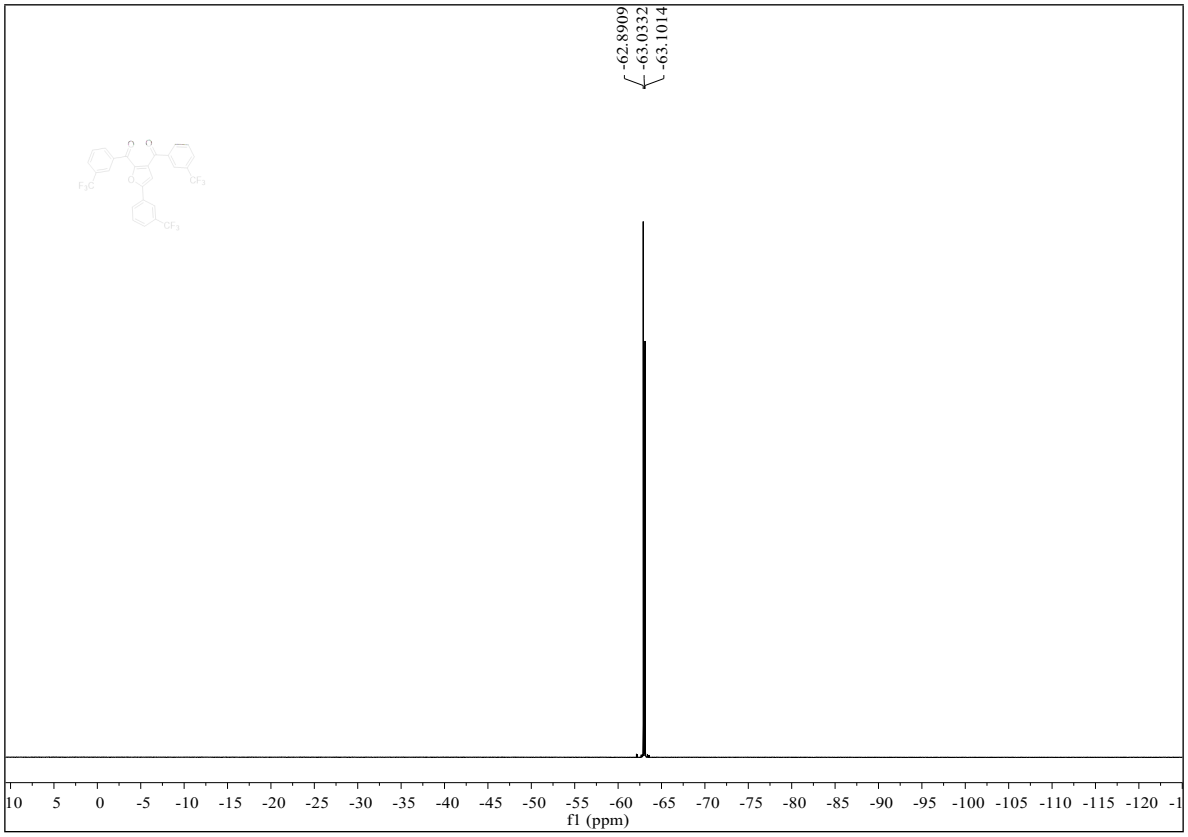


(5-(3-(trifluoromethyl)phenyl)furan-2,3-diyl)bis((3-(trifluoromethyl)phenyl)methanone)

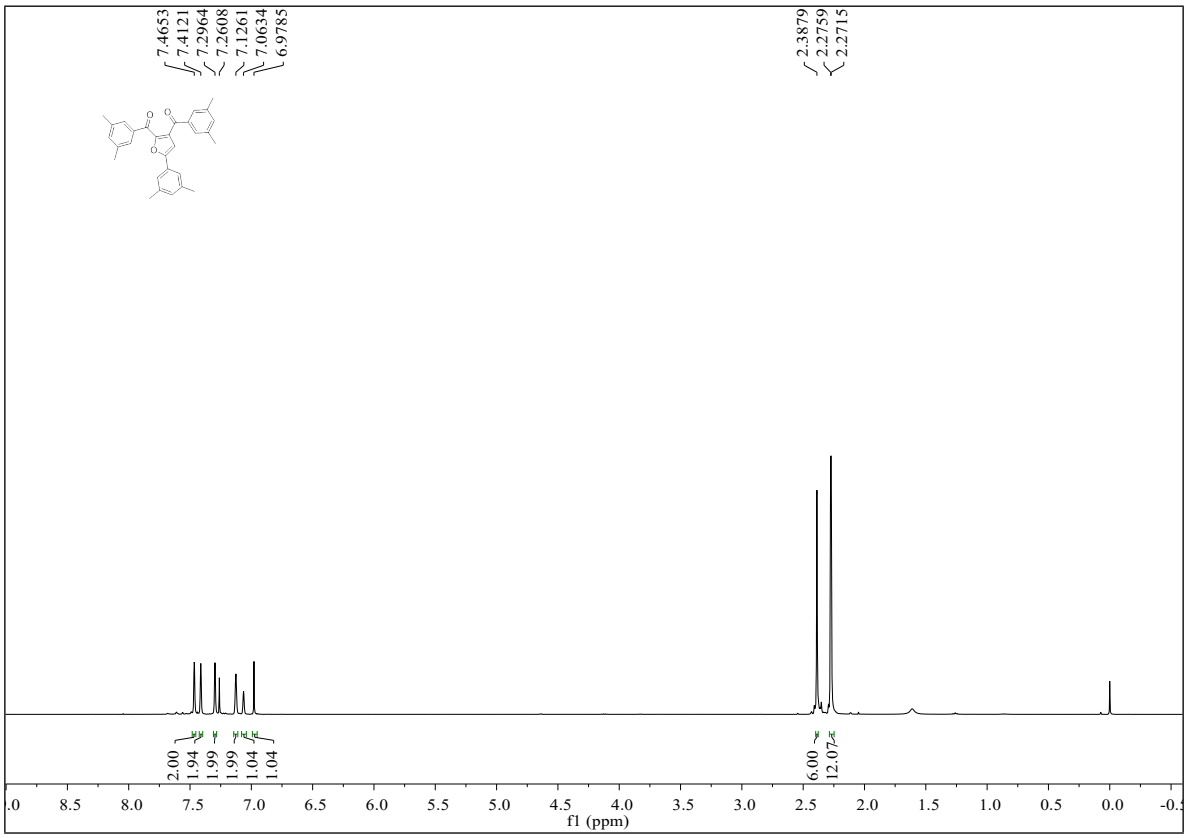
(**2o**)

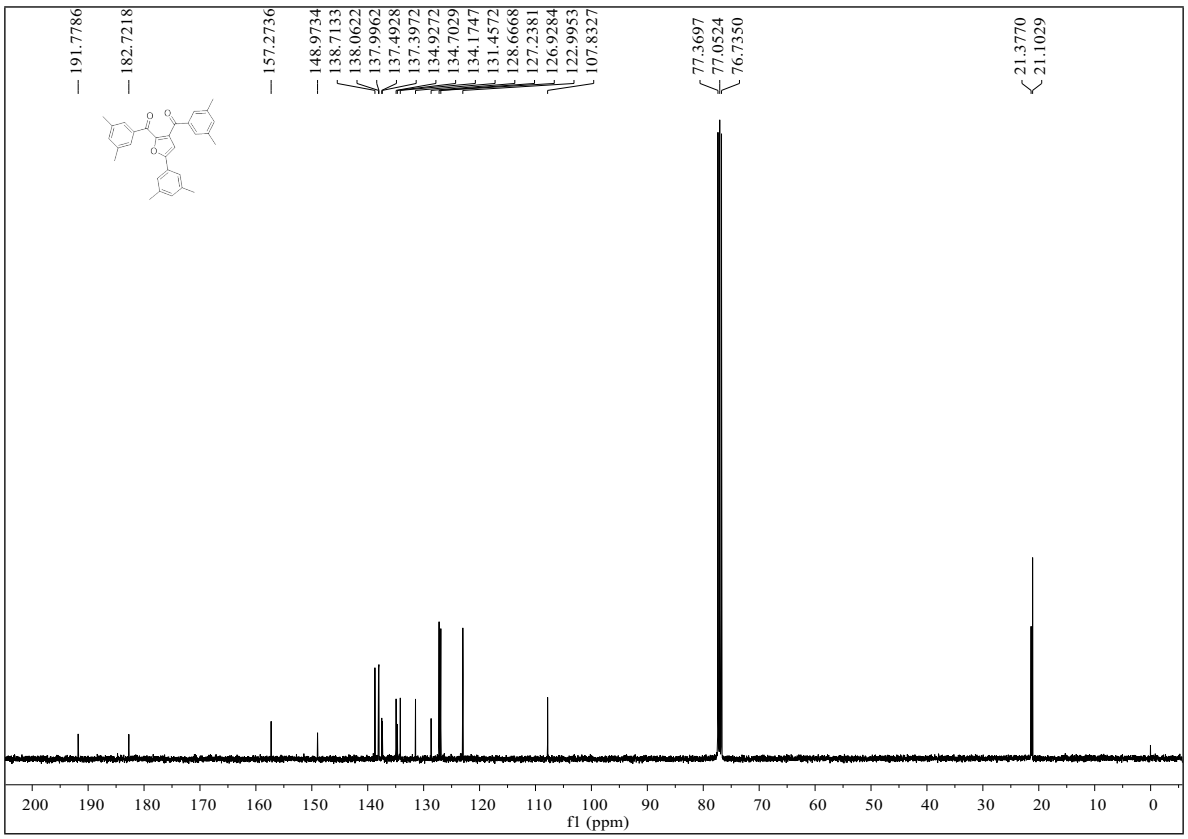




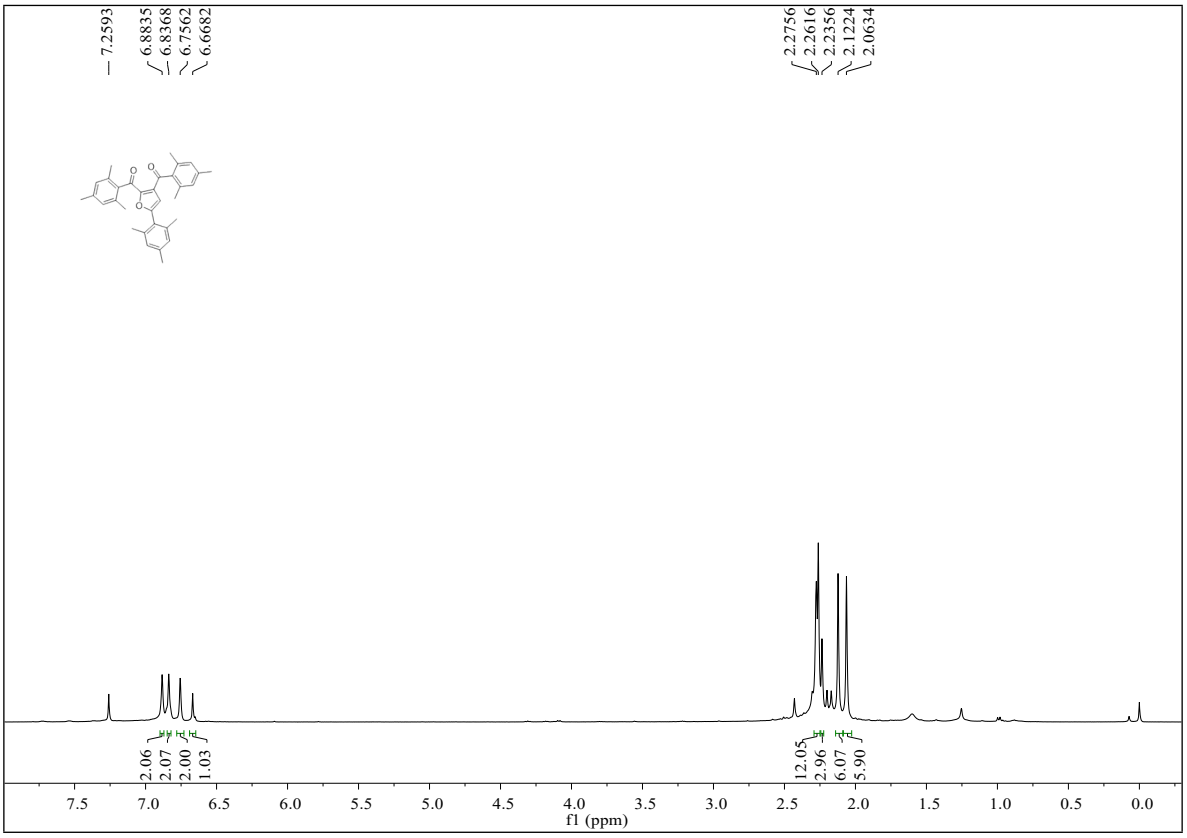

-62.8909
-63.0332
-63.1014
10 5 0 -5 -10 -15 -20 -25 -30 -35 -40 -45 -50 -55 -60 -65 -70 -75 -80 -85 -90 -95 -100 -105 -110 -115 -120 -1
f1 (ppm)

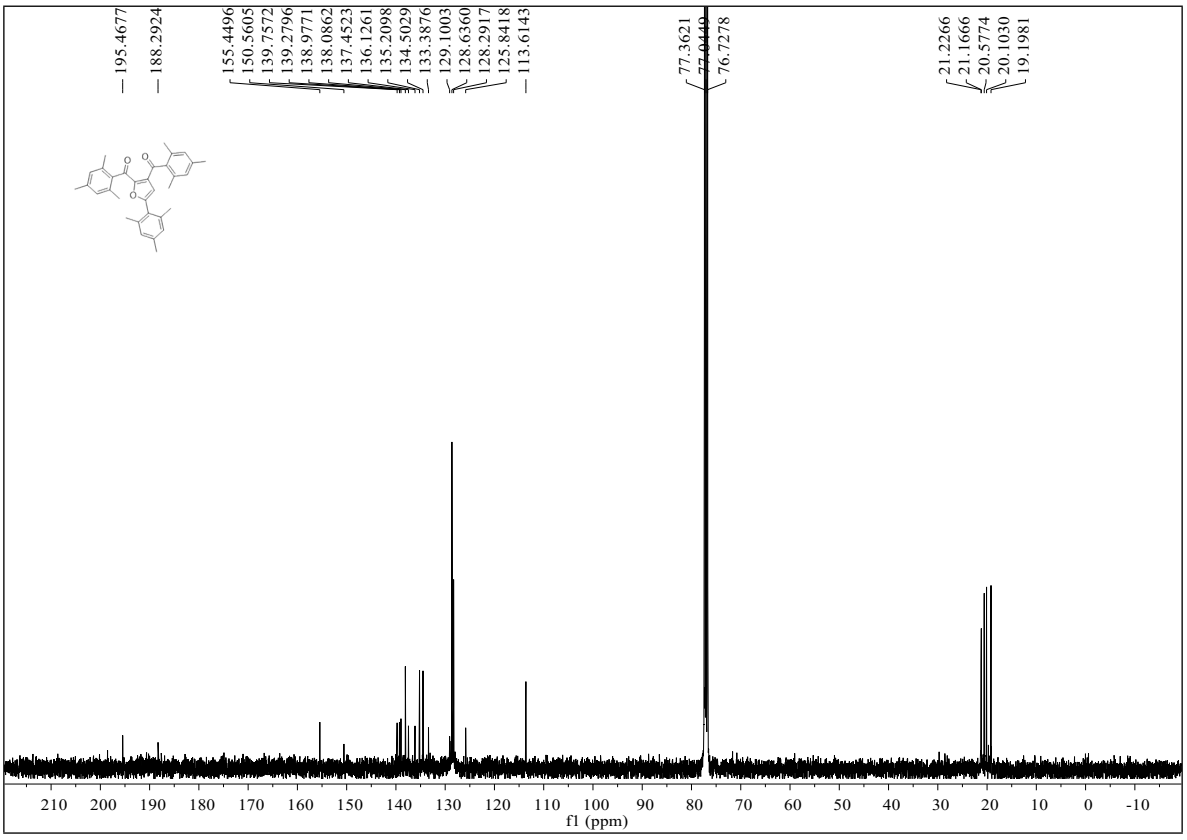
(5-(3,5-dimethylphenyl)furan-2,3-diyl)bis((3,5-dimethylphenyl)methanone) (**2p**)



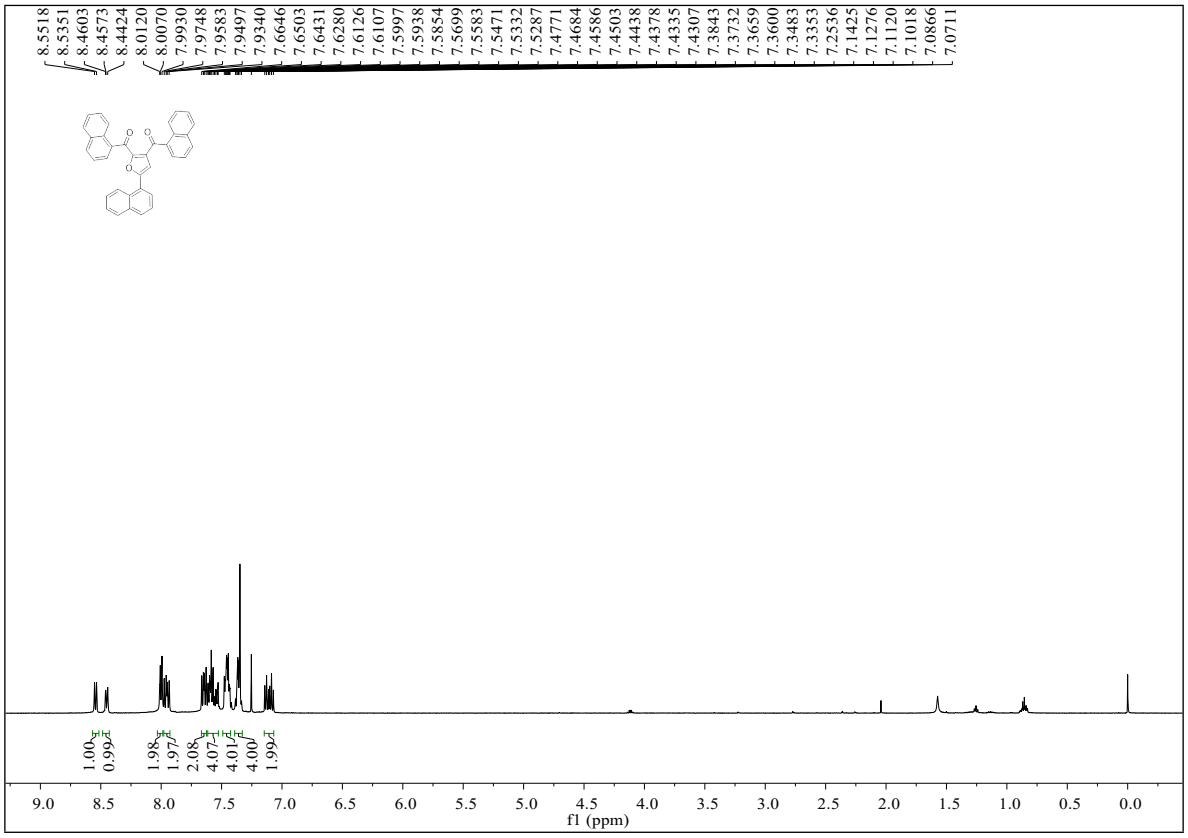


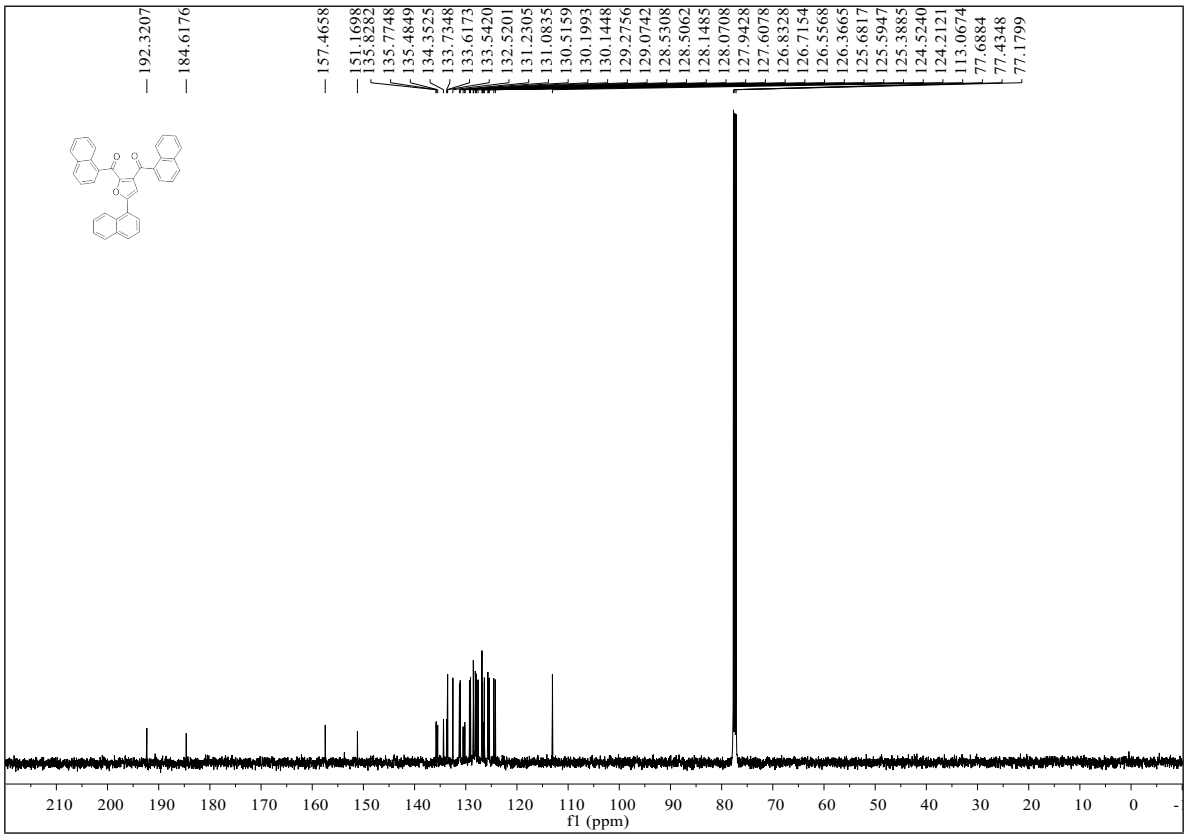
(5-mesitylfuran-2,3-diyl)bis(mesitylmethanone) (**2q**)



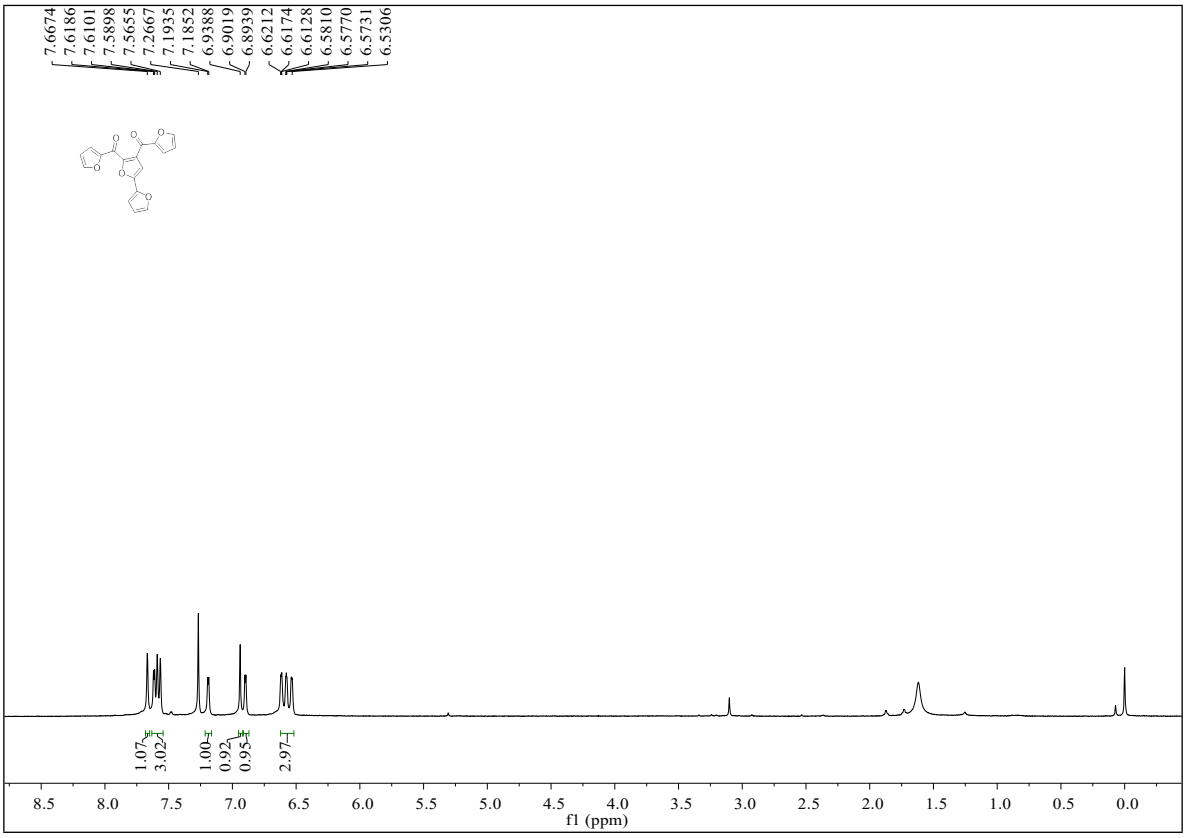


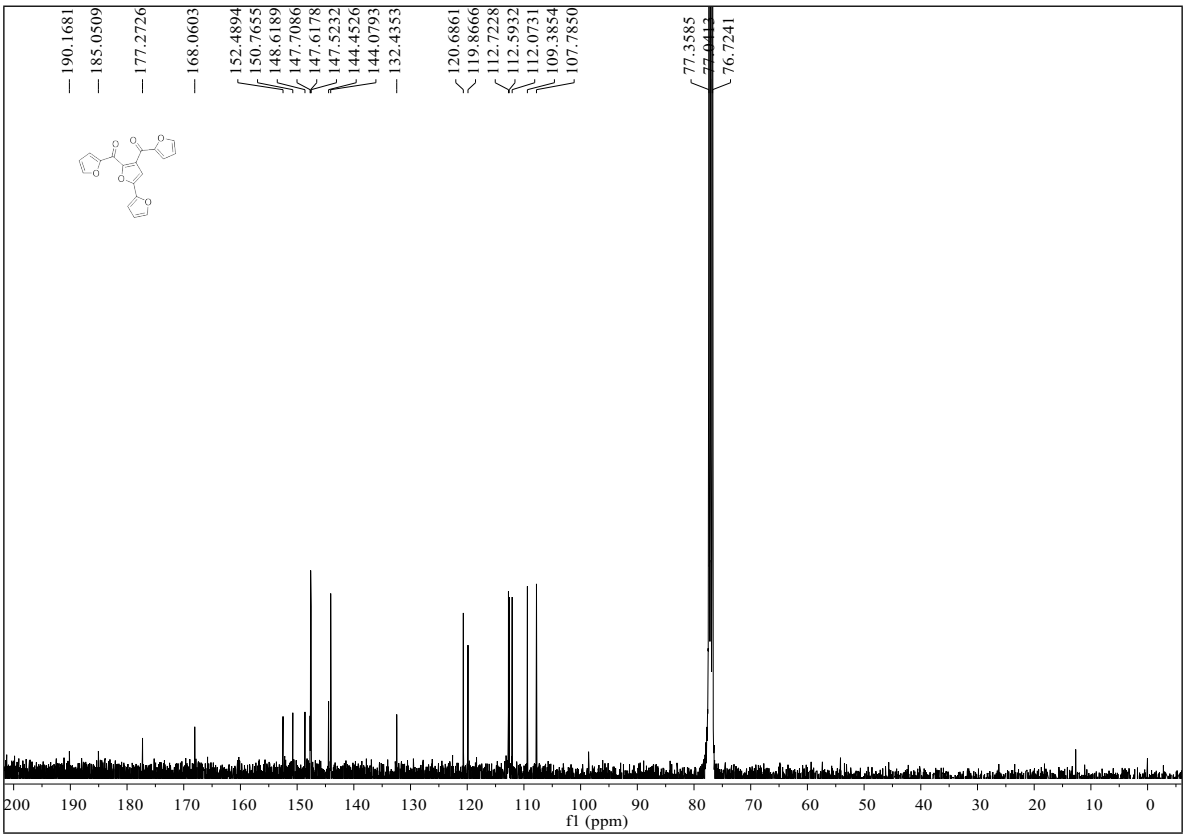
(5-(naphthalen-1-yl)furan-2,3-diyl)bis(naphthalen-1-ylmethanone) (**2r**)



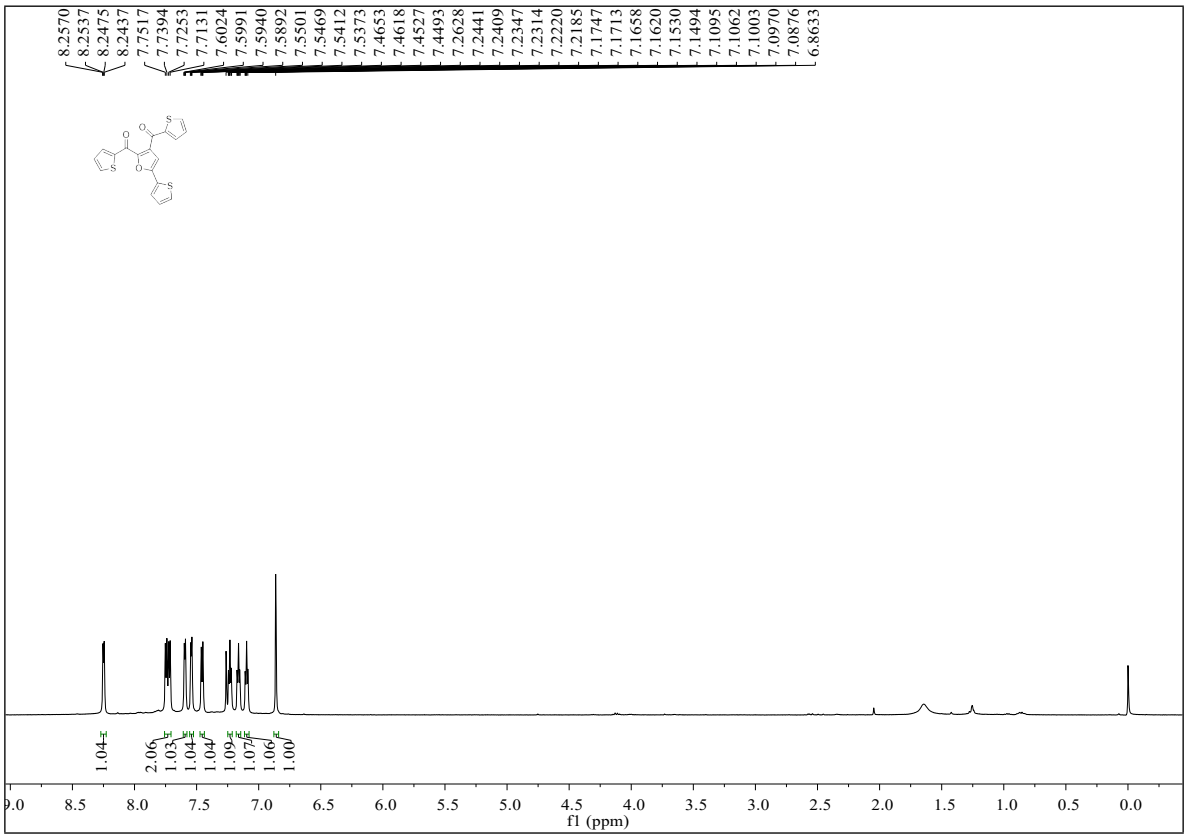


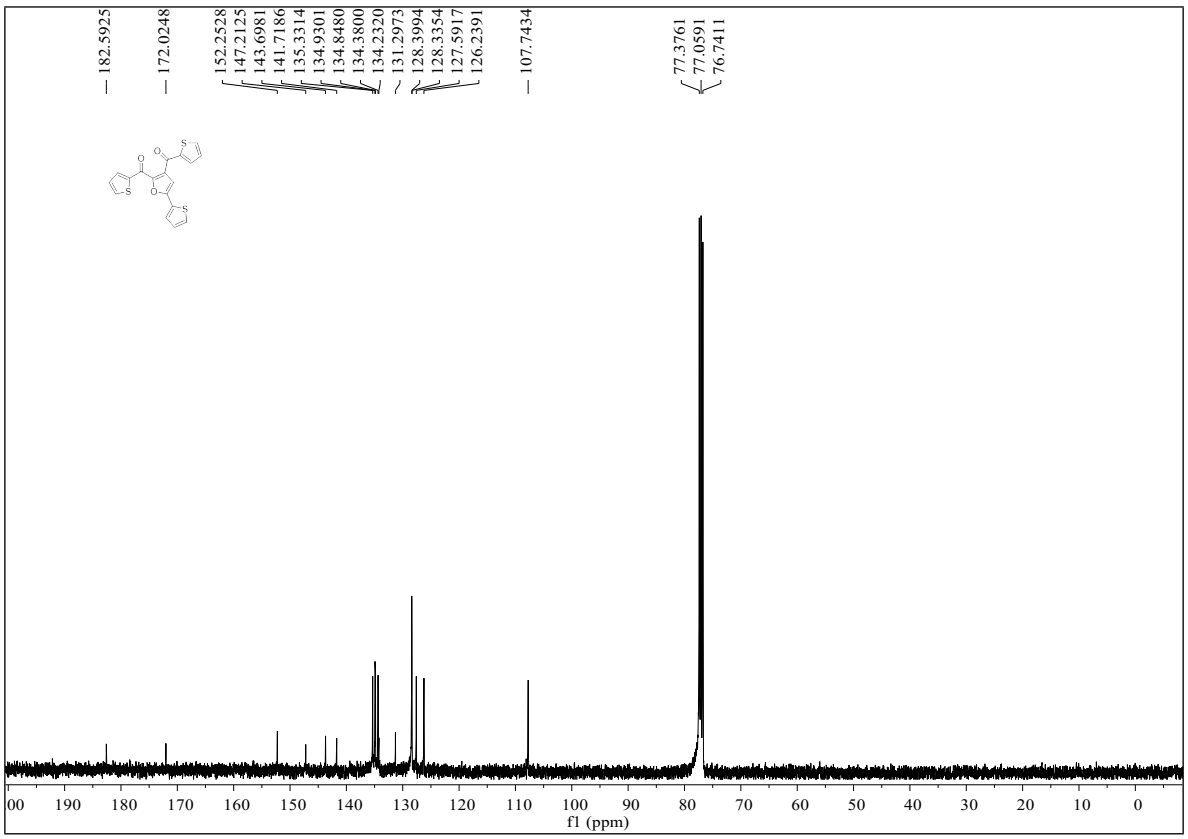
[2,2'-bifuran]-4,5-diylbis(furan-2-ylmethanone) (**2s**)



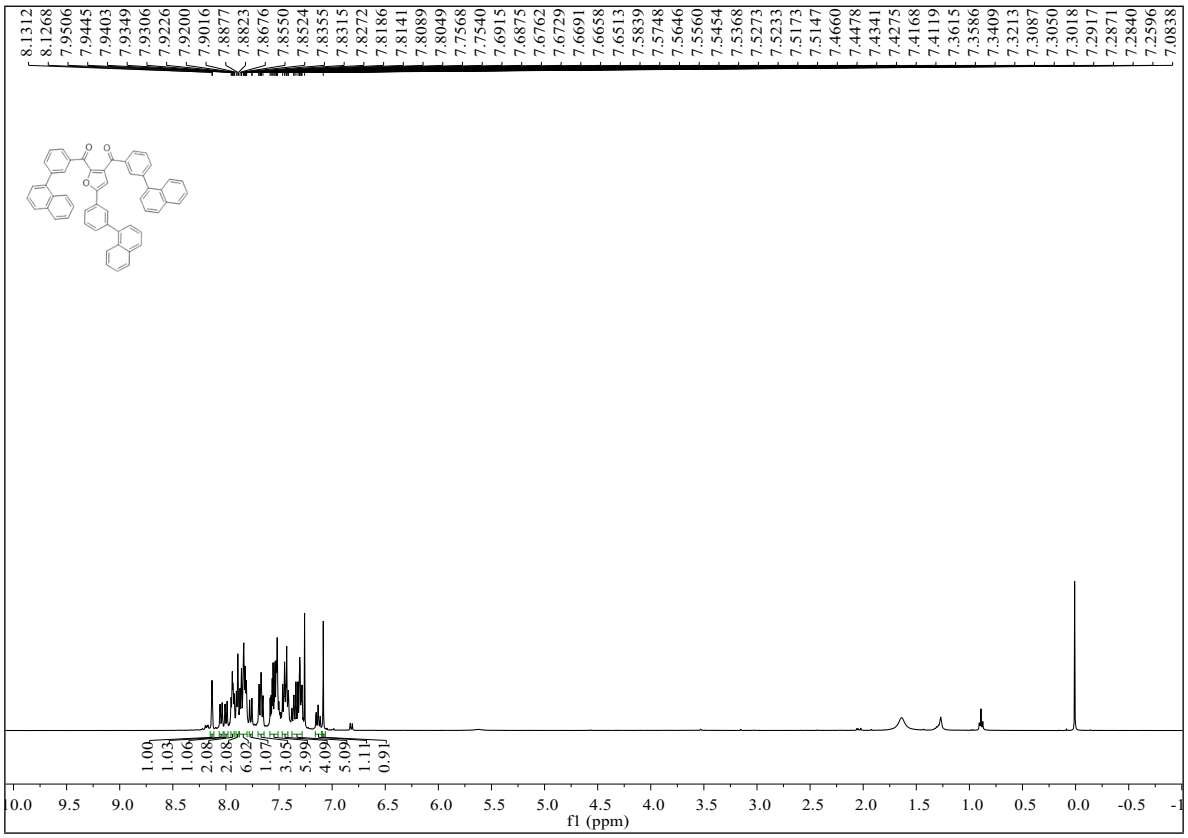


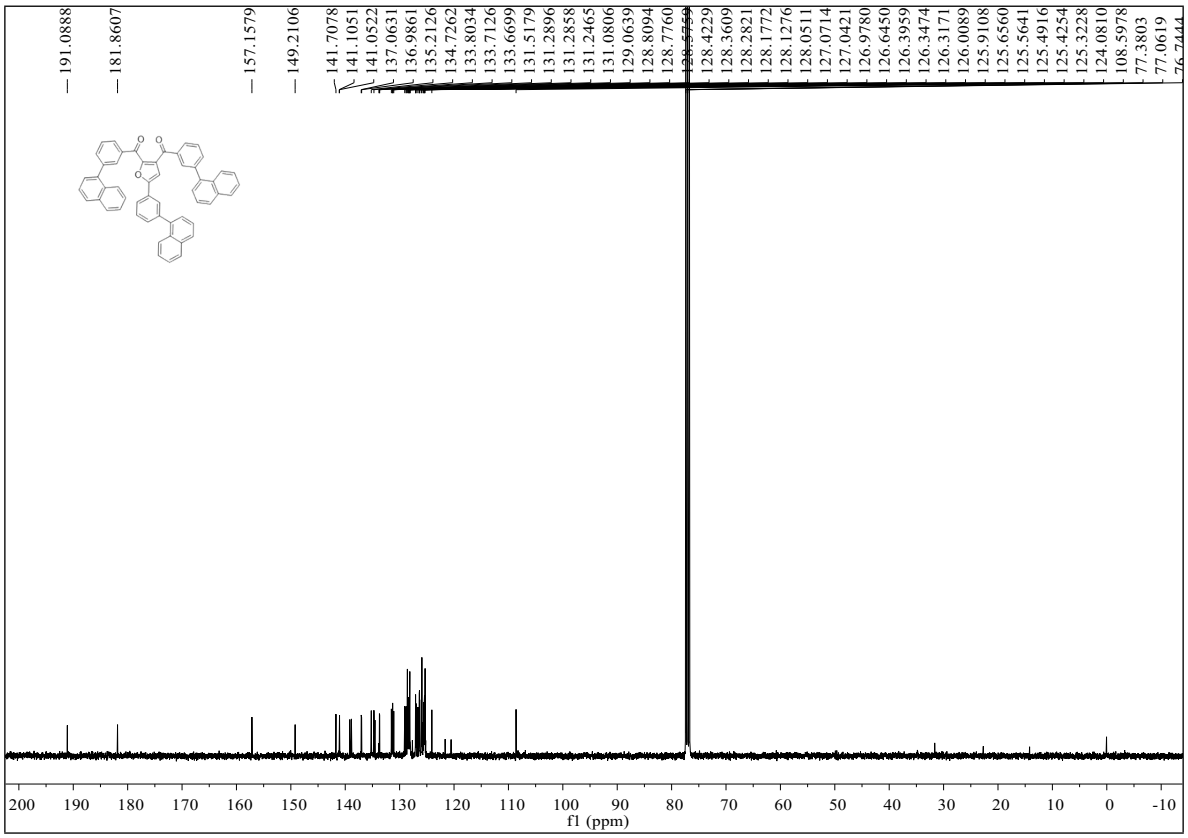
(5-(thiophen-2-yl)furan-2,3-diyl)bis(thiophen-2-ylmethanone) (**2t**)





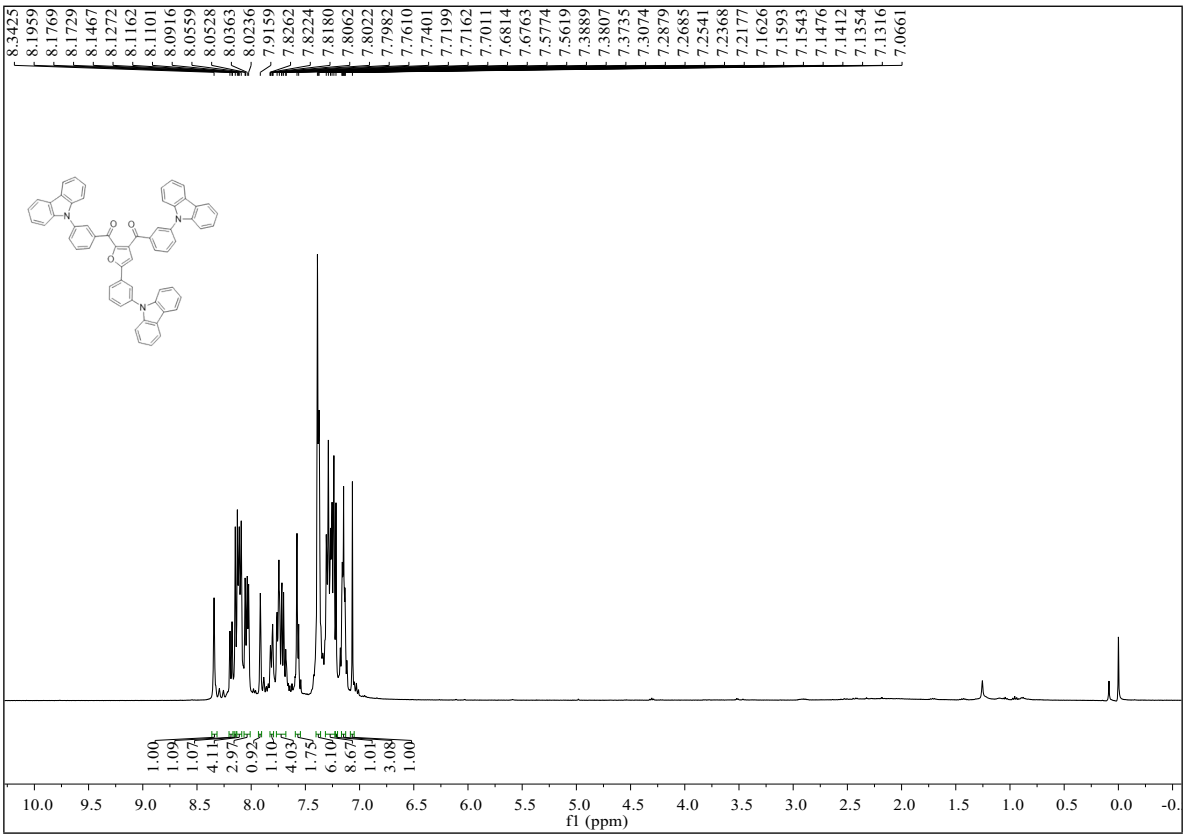
(5-(3-(naphthalen-1-yl)phenyl)furan-2,3-diyl)bis((3-(naphthalen-1-yl)phenyl)methanone) (**3**)

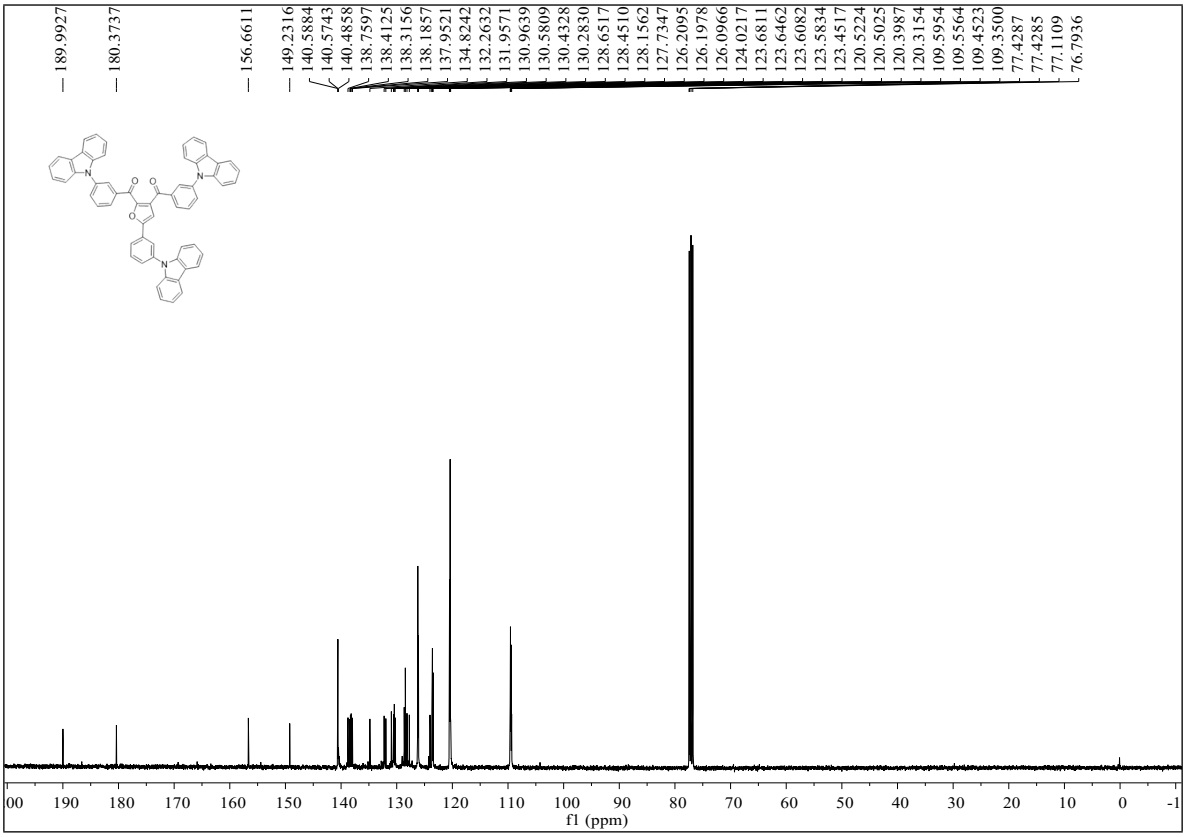




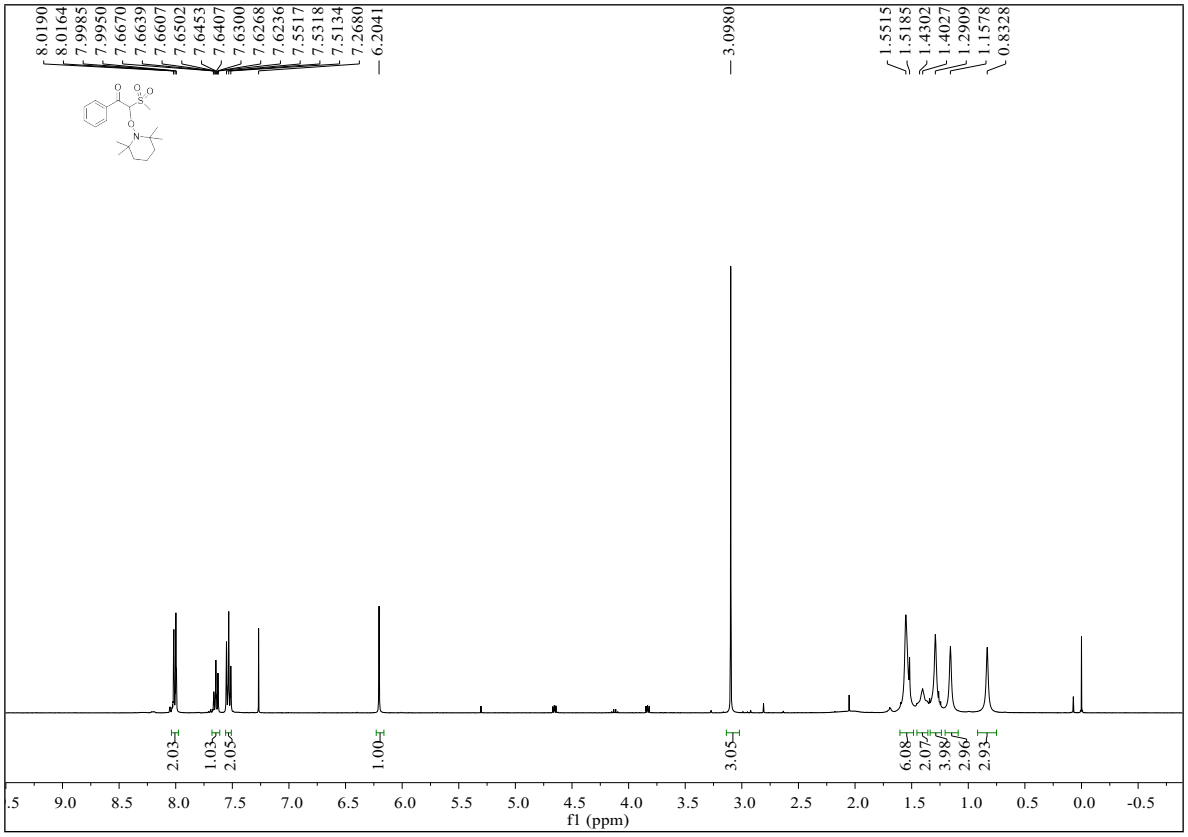
(5-(3-(9H-carbazol-9-yl)phenyl)furan-2,3-diyl)bis((3-(9H-carbazol-9-yl)phenyl)methanone)

(**4**)

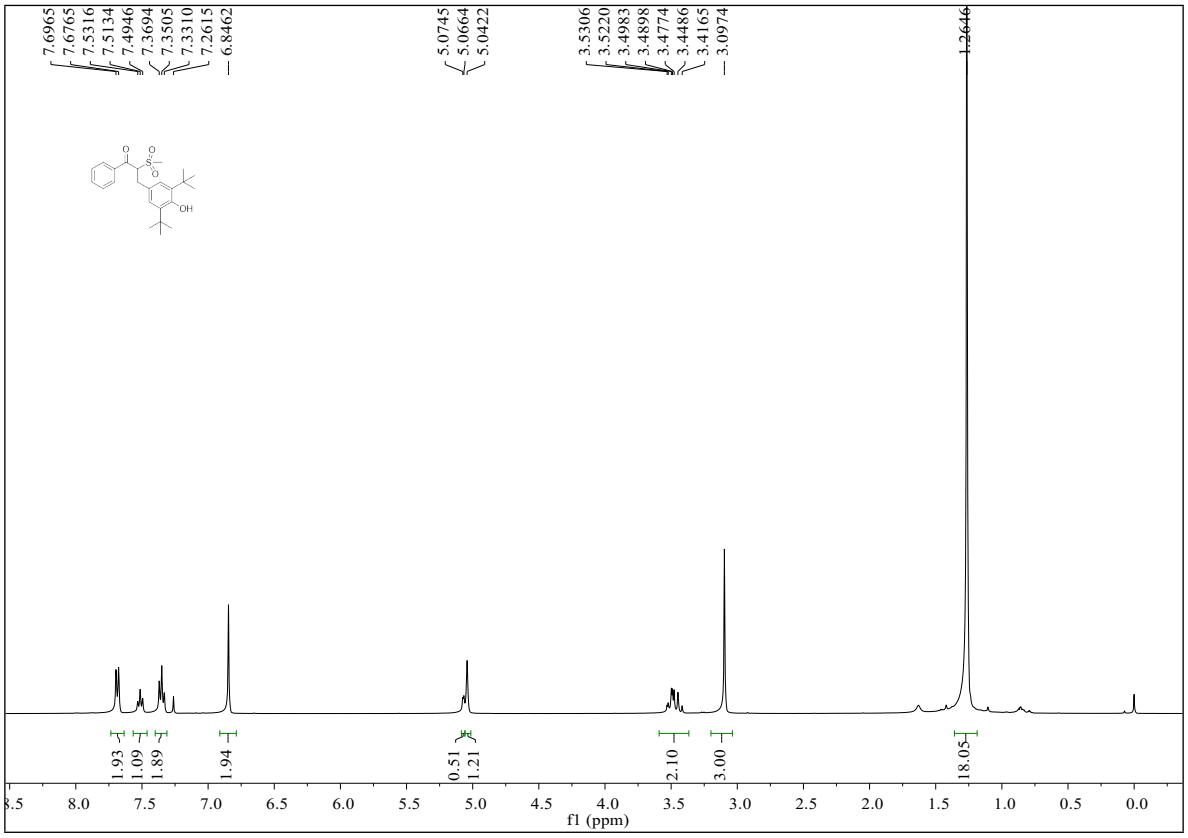


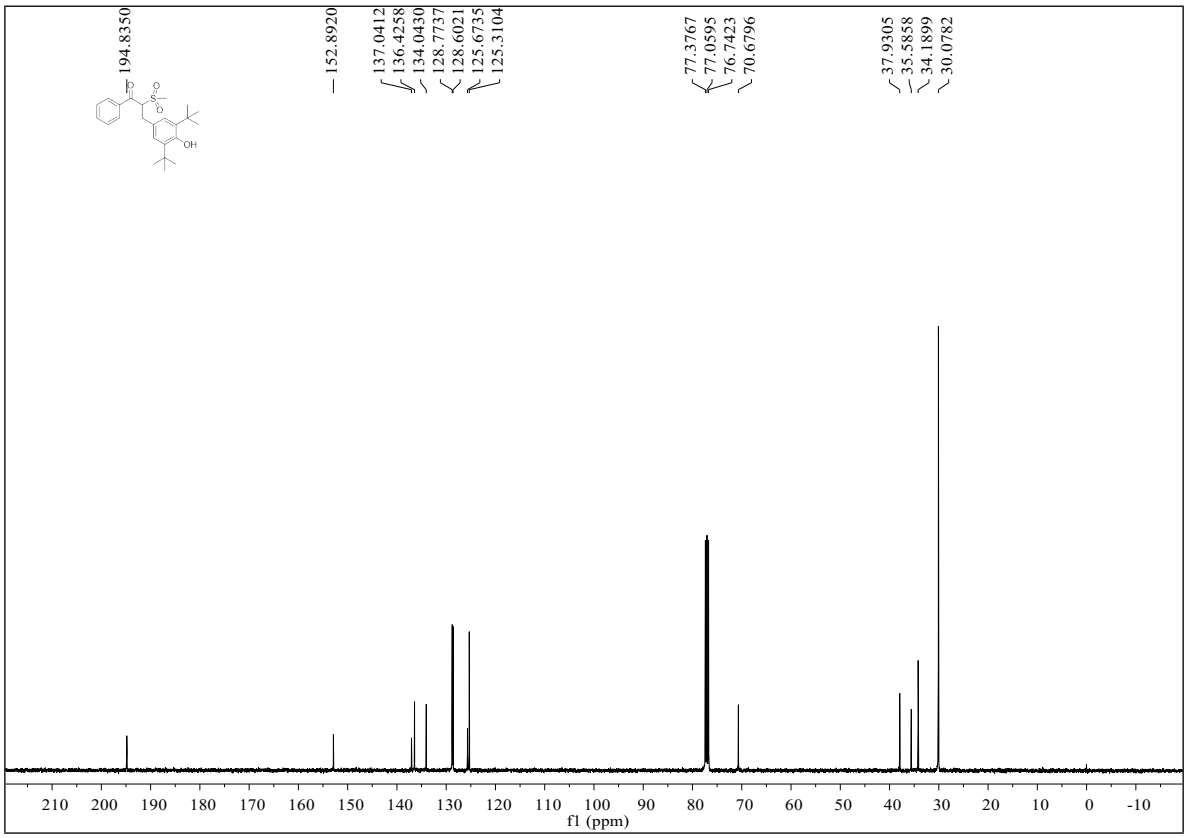


2-(methylsulfonyl)-1-phenyl-2-((2,2,6,6-tetramethylpiperidin-1-yl)oxy)ethan-1-one (**A**)

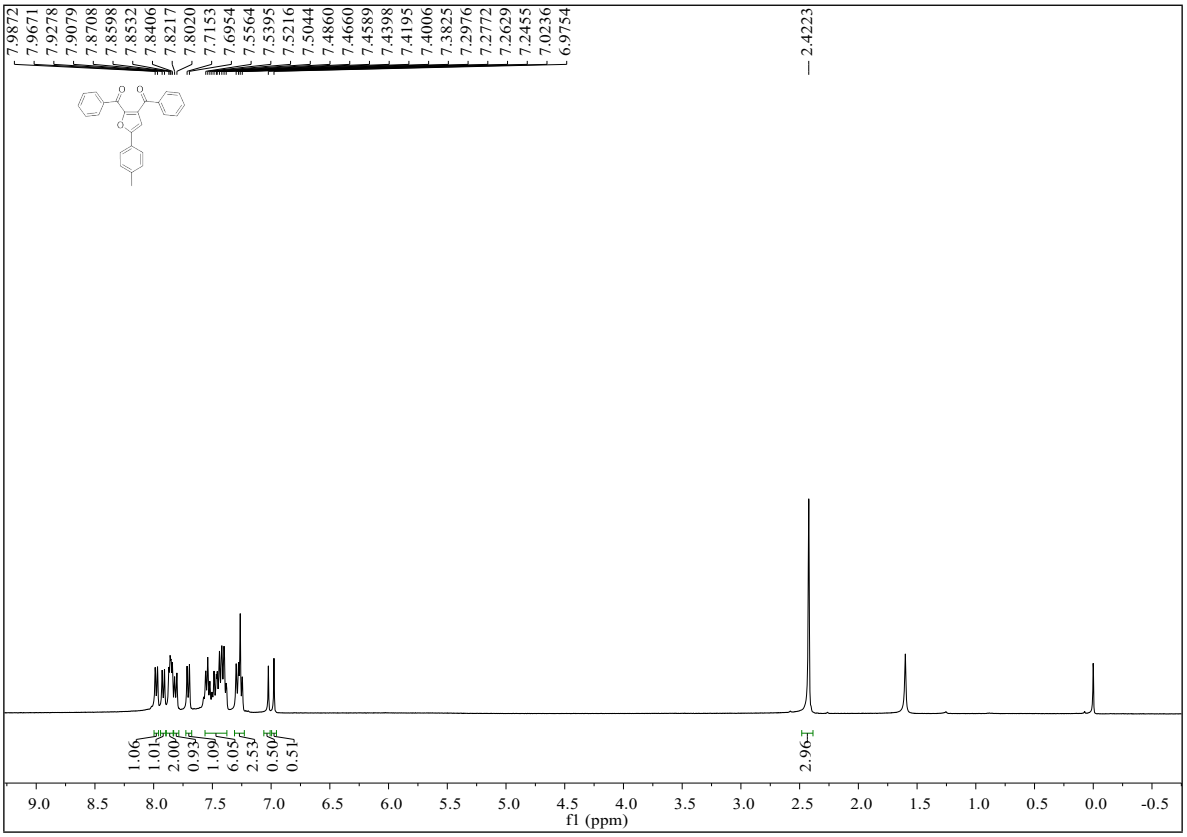

8.0190
8.0164
7.9985
7.9950
7.6670
7.6639
7.6607
7.6502
7.6453
7.6407
7.6300
7.6268
7.6236
7.5517
7.5318
7.5134
7.2680
6.2041
3.0980
1.5515
1.5185
1.4302
1.4027
1.2909
1.1578
0.8328
2.03
1.03
2.05
1.00
3.05
6.08
2.07
3.98
2.96
2.93
f1 (ppm)

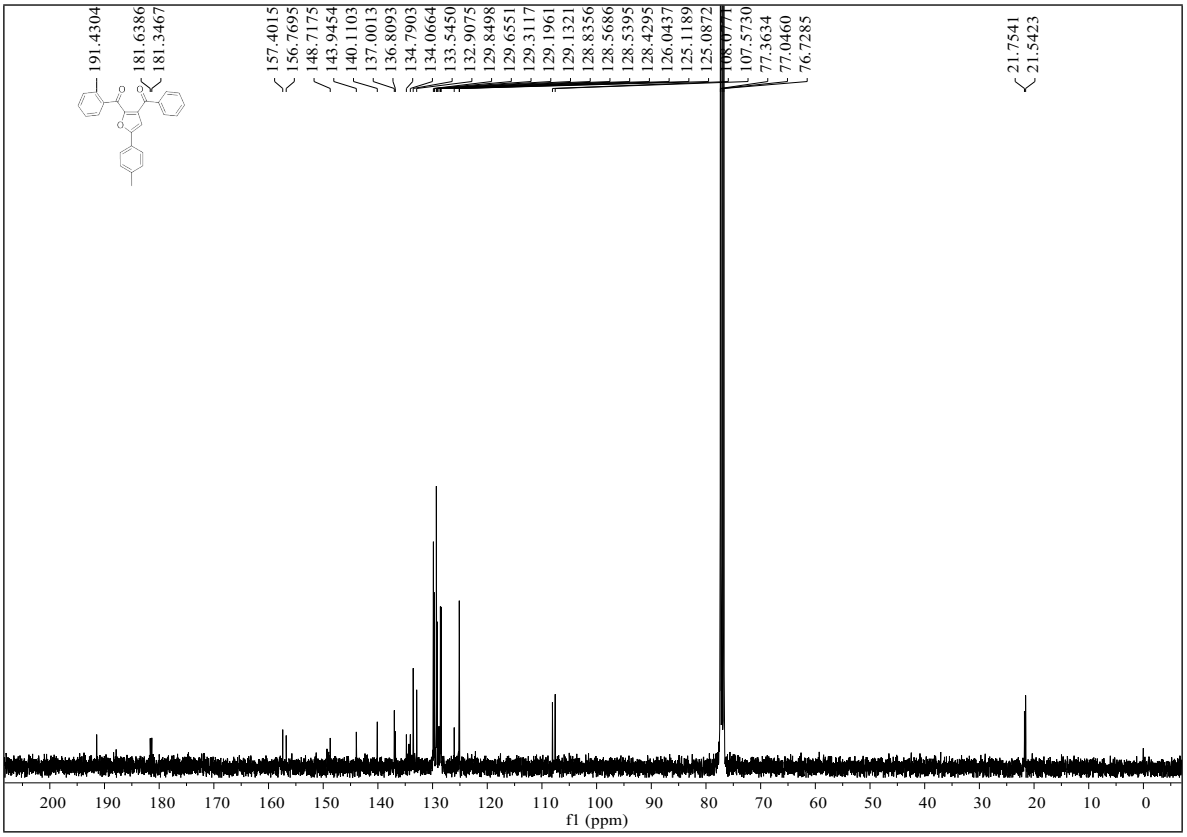
3-(3,5-di-tert-butyl-4-hydroxyphenyl)-2-(methylsulfonyl)-1-phenylpropan-1-one (**C**)



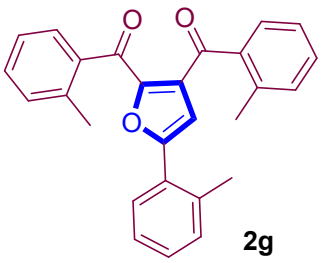


(5-(p-tolyl)furan-2,3-diyl)bis(phenylmethanone) (**5**)



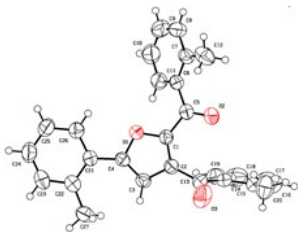


X-ray single crystal data of 2g



2g

≡



X-ray structure of **2g**
(CCDC 2292188)

Empirical formula	$C_{27}H_{22}O_3$
Temperature	300 K
Wavelength	0.71073 Å
Unit cell dimensions	a = 10.9241 (10) Å alpha = 90° . b = 18.1857 (18) Å beta = 115.93°. c = 11.7611 (13) Å gamma =90°
Volume	2101.3(4) Å^3
Z	4
Calculated density	1.247 g/cm^3
Absorption coefficient	0.080 mm^{-1}
F(000)	832.0
Crystal size	0.28 × 0.26 × 0.23 mm^3
Theta range for data collection	6.106^o to 54.982^o
Reflections collected / unique	63696
Data / restraints / parameters	4809/0/274
Goodness-of-fit on F 2	1.017
Final R indices [I>2sigma(I)]	R_1 = 0.0539, wR_2 = 0.1039
R indices (all data)	R_1 = 0.1124, wR_2 = 0.1286