Supporting Information

Electrochemically-mediated C-H functionalization of allenes and 1,3-carbonyl compounds to construct tetrasubstituted furans

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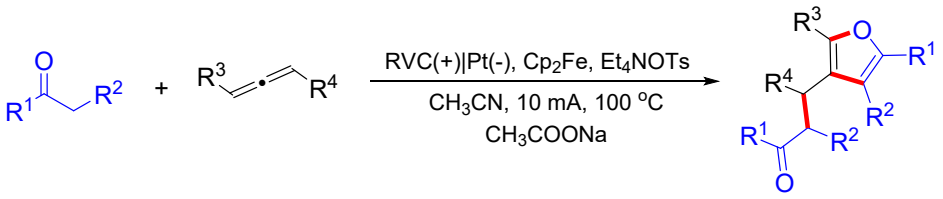
1. General Information

Without special instructions, all reagents and solvents were commercially available and were not further purified. Column chromatography was carried out using silica gel (300-400 mesh). NMR spectroscopy was performed on Bruker AV-400 or Bruker AV-600 instruments. Chemical shifts for ^{1}H NMR spectra are reported as δ in units of parts per million (ppm) downfield from TMS (δ 0.00) and relative to the signal of chloroform-d (δ 7.26, singlet). The abbreviations used to explain the multiplicities were as follows: s, singlet; d, doublet; t, triplet; m, multiplet; brs, broad singlet and J, coupling constant in Hz. ^{13}C NMR spectra are reported as δ in units of parts per million (ppm) downfield from TMS (δ 0.00) and relative to the signal of chloroform-d (δ 77.00, triplet). The HRMS spectrum was measured by micromass QTOF2 Quadrupole/Time of Flight Tandem mass spectrometer with electron spray ionization. Cyclic voltammograms were recorded on a CHI 660E potentiostat.

2. Procedures for the Electrolysis



A 10 ml three-necked round-bottomed flask was charged with 1,3-carbonyl compounds (0.3 mmol, 1.0 equiv.), allenes (0.45 mmol, 1.5 equiv.), Cp_2Fe (0.03 mmol, 10 mol %), CH_3COONa (0.3 mmol, 1.0 equiv.), Et_4NOTs (0.6 mmol, 2.0 equiv.). The flask was equipped with a reticulated vitreous carbon RVC (100 PPI, 1 cm x 1 cm x 1.2 cm) anode and a platinum plate (1 cm x 1 cm) cathode. CH_3CN (6 mL) was added under air atmosphere. Electrolysis was carried out at 100 °C (oil bath temperature), which using a constant current of 10 mA until the substrate was completely consumed (monitored by TLC, about 2 hours). After the reaction was completed, the solvent was concentrated under reduced pressure. Purification with silica gel column chromatography using ethyl acetate/petroleum ether to afford the desired products. The pictures of reaction set-up were shown in **Figure S1**.

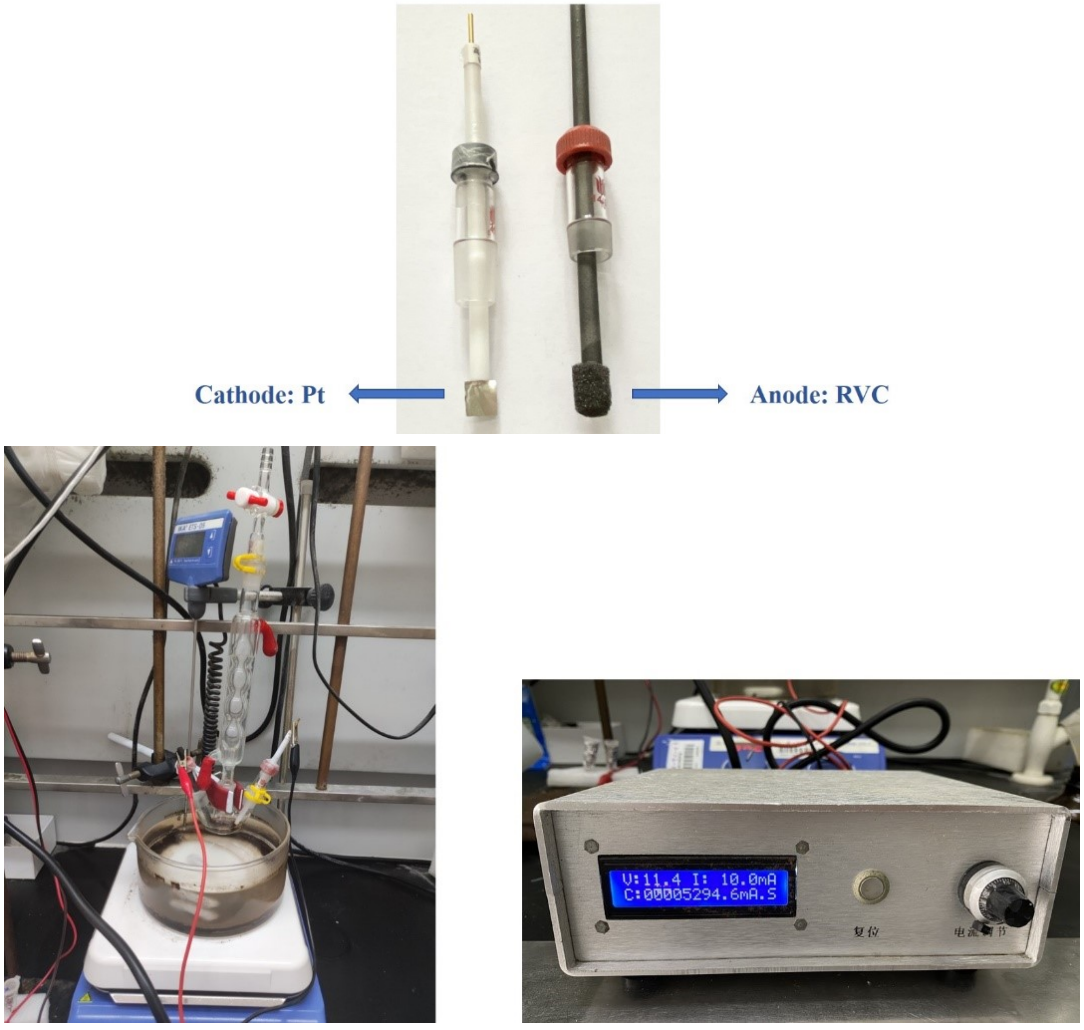
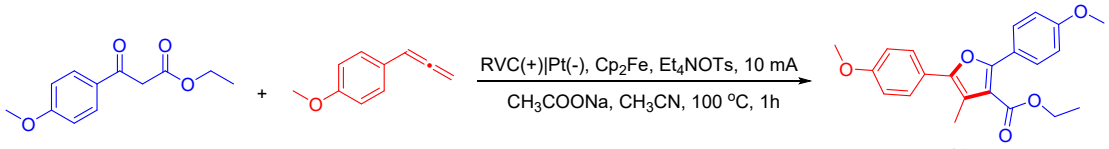


Figure S1. Electrolysis setup. (undivided cell)

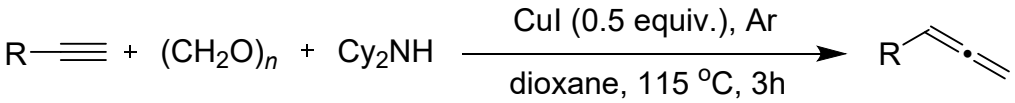
Procedure for the synthesis intermediate 10:

A 10 ml three-necked round-bottomed flask was charged with ethyl (4-methoxybenzoyl)acetate **1a** (0.3 mmol, 1.0 equiv.), (4-methoxyphenyl)allene **2a** (0.45 mmol, 1.5 equiv.), Cp_2Fe (0.03 mmol, 10 mol %), CH_3COONa (0.3 mmol, 1.0 equiv.), Et_4NOTs (0.6 mmol, 2.0 equiv.). The flask was equipped with a reticulated vitreous carbon RVC (100 PPI, 1 cm x 1 cm x 1.2 cm) anode and a platinum plate (1 cm x 1 cm) cathode. CH_3CN (6 mL) was added under air atmosphere. Electrolysis was carried out at 100 °C (oil bath temperature), which using a constant current of 10 mA until the generated intermediate **10** no longer increases (monitored by TLC, about 1 hour). The solvent was concentrated under reduced pressure. Purification with silica gel column chromatography using ethyl acetate/petroleum ether to afford the intermediate **10**.

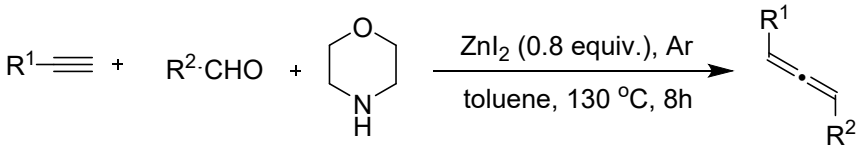


1a + **2a** → **10** 63% yield

3. Procedure for the Synthesis Allenes



The terminal allenes were prepared according to literature procedure [1]. Solid paraformaldehyde (125 mmol, 2.5 equiv.) and cuprous iodide (25 mmol, 0.5 equiv.) were weighed and added to a 500 mL round-bottomed flask. Argon was filled, and the gas was pumped to remove the air from the flask. The terminal alkynes (50 mmol, 1.0 equiv.) and dicyclohexylamine (90 mmol, 1.8 equiv.) were then measured and added to the round-bottomed flask. The solvent 1, 4-dioxane (120 mL) was added and the solid was fully dissolved. Reaction mixture was stirred at 115 °C (oil bath temperature) for 3h and cooled to room temperature. Subsequently, 50 mL of water and 50 mL of diethyl ether were added for extraction. The aqueous phase was extracted three times with 50 mL of diethyl ether, and the organic phase was collected. The collected organic phase was extracted with 50 mL saturated NaCl solution once and dried with anhydrous Na_2SO_4. The filtered solution was concentrated under reduced pressure to obtain an oily liquid. Finally, the concentrate was purified by silica gel column chromatography using petroleum ether as eluent to afford the terminal allenes.



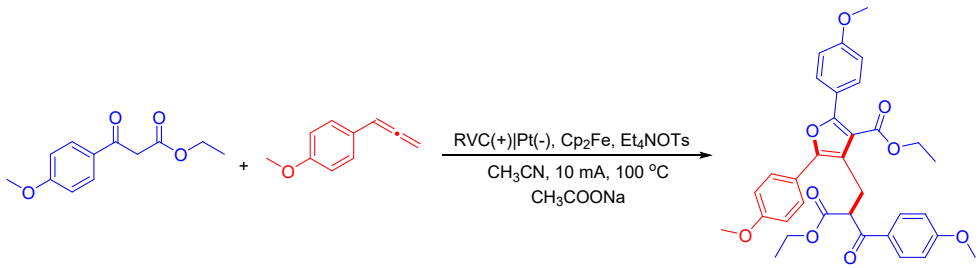
The 1,3-disubstituted allenes were prepared according to literature procedure [2]. Solid zinc iodide (40 mmol, 0.8 equiv.) was weighed and added to a 500 mL round-bottomed flask. Argon was filled, and the gas was pumped to remove the air from the flask. The terminal alkynes (50 mmol, 1.0 equiv.), aldehydes (90 mmol, 1.8 equiv.) and morpholine (70 mmol, 1.4 equiv.) were then measured and added to the round-bottomed flask. The solvent toluene (120 mL) was added and the solid was fully dissolved. Reaction mixture was stirred at 130°C (oil bath temperature) for 8h and cooled to room temperature. Subsequently, 50 mL of water and 50 mL of diethyl ether were added for extraction. The aqueous phase was extracted three times with 50 mL of diethyl ether, and the organic phase was collected. The collected organic phase was extracted with 50 mL saturated NaCl solution once and dried with anhydrous Na_2SO_4. The filtered solution was concentrated under reduced pressure to obtain an oily liquid. Ultimately, the concentrate was purified by silica gel column chromatography using petroleum ether as eluent to afford the 1,3-disubstituted allenes.

References:

1 J.-Q. Kuang and S.-M. Ma, *J. Org. Chem.*, 2009, **74**, 1763.
2 J.-Q. Kuang and S.-M. Ma, *J. Am. Chem. Soc.*, 2010, **132**, 1786.

4. Additional Optimization of Reaction Conditions

Table S1. Optimization of the reaction conditions[a]

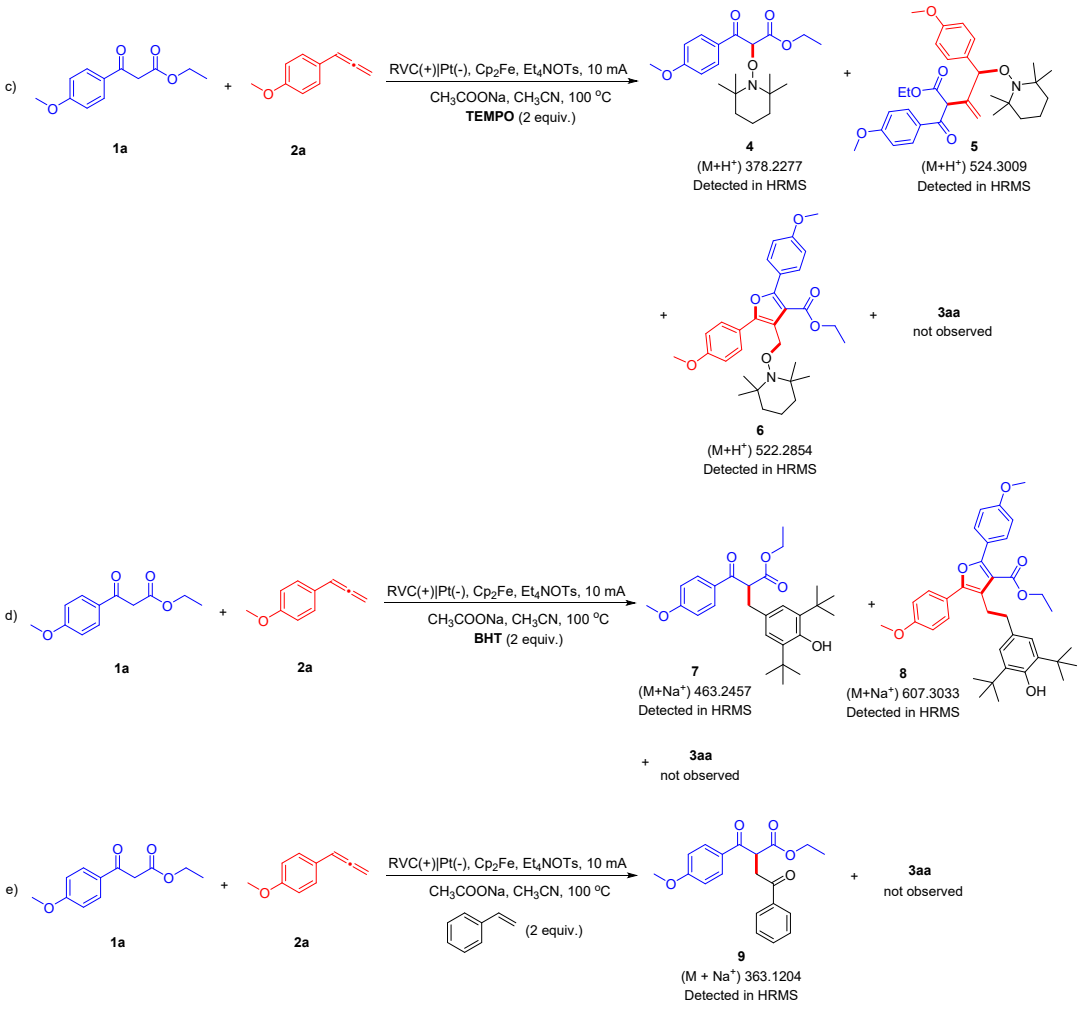


1a **2a** **3aa**

Entry	Variation from standard conditions	Yield[b] (%)
1	5 mA	56
2	15 mA	52
3	nBu$_4$NBF$_4$ as electrolyte	80
4	nBu$_4$NPF$_6$ as electrolyte	81
5	Et$_4$NPF$_6$ as electrolyte	73
6	Na_2CO_3 as base	33
7	Cs_2CO_3 as base	trace
8	NaOEt as base	16
9	DBU as base	23
10	RVC (+) | RVC (-)	55
11	Pt (+) | RVC (-)	trace
12	Pt (+) | Pt (-)	trace
13	C (+) | Pt (-)	44
14	RVC (+) | Ag (-)	56
15	RVC (+) | Ni (-)	62
16	RVC (+) | Pb (-)	47
17	**1a** : **2a** = 1.5 : 1	41
18	**1a** : **2a** = 1 : 1	46
19	**1a** : **2a** = 1 : 2	59

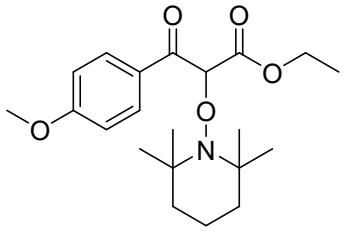
[a] Reaction conditions: reticulated vitreous carbon (RVC) anode (100 PPI, 1 cm × 1 cm × 1.2 cm), Pt plate cathode (1 cm × 1 cm), undivided cell,**1a** (0.3 mmol, 1.0 equiv.), **2a** (0.45 mmol, 1.5 equiv.), catalyst (10 mol %), base (1.0 equiv.), electrolyte (2.0 equiv.), CH_3CN (6 mL), under air atmosphere, 10 mA, 100 °C, 2 h (2.5 F mol^{-1}). [b] Isolated yield.

5. Control Experiments



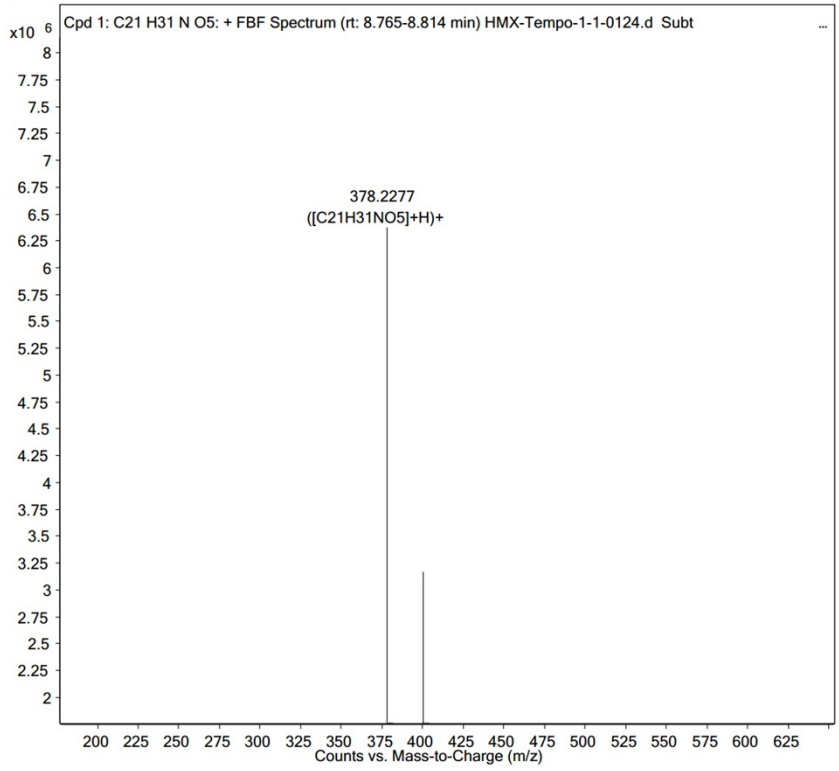
Scheme S1. Control experiments.

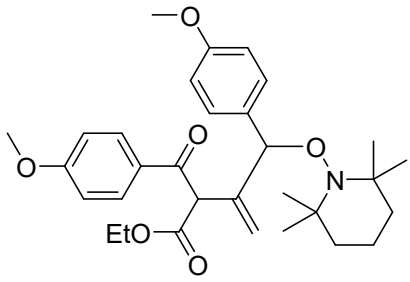
6. The HRMS Spectra of Compounds 4-9



Compound **4**：**HRMS**(m/z) [ESI]: calculated for $C_{21}H_{32}NO_5^+[M+H]^+$: 378.2275, found 378.2277.

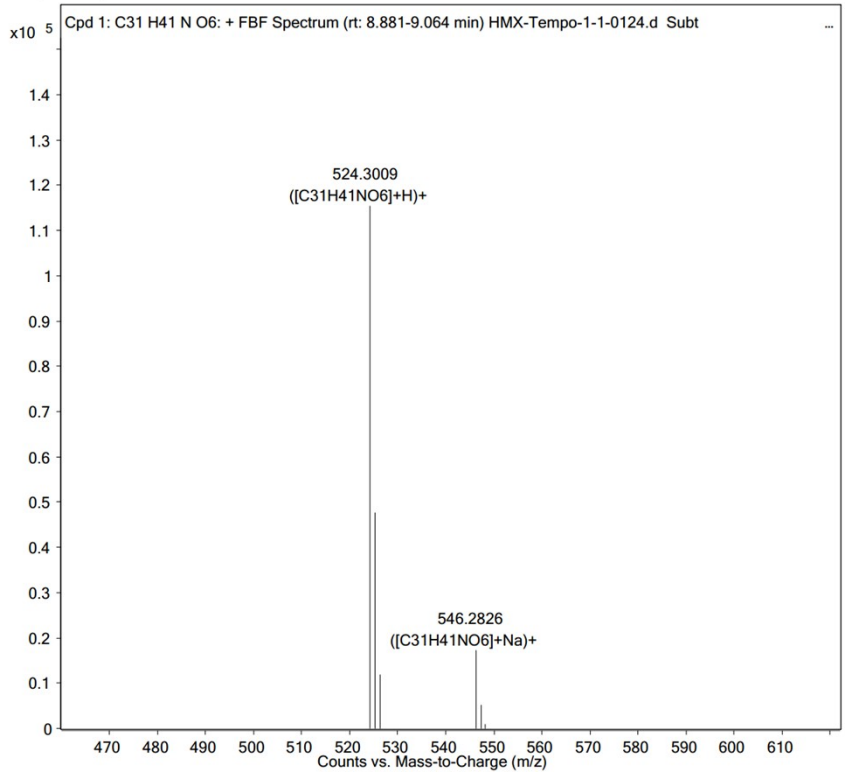
Sample Name	HMX-Tempo-1-0124	**Position**	P1D1	**Instrument Name**	Instrument 1
User Name		**Inj Vol**	0.2	**InjPosition**	
Sample Type	Sample	**IRM Calibration Status**	Success	**Data Filename**	HMX-Tempo-1-1-0124.d
ACQ Method	10-100% jiachun Zheng.m	**Comment**		**Acquired Time**	1/24/2021 7:14:38 PM

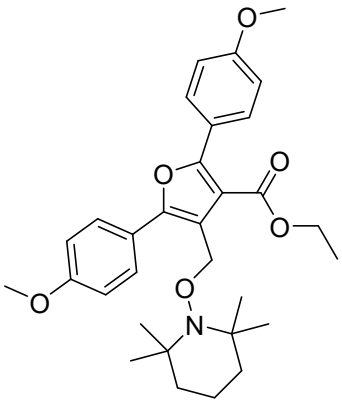




Compound **5**: **HRMS**(m/z) [ESI]: calculated for $C_{31}H_{42}NO_6^+[M+H]^+$: 524.3007, found 524.3009.

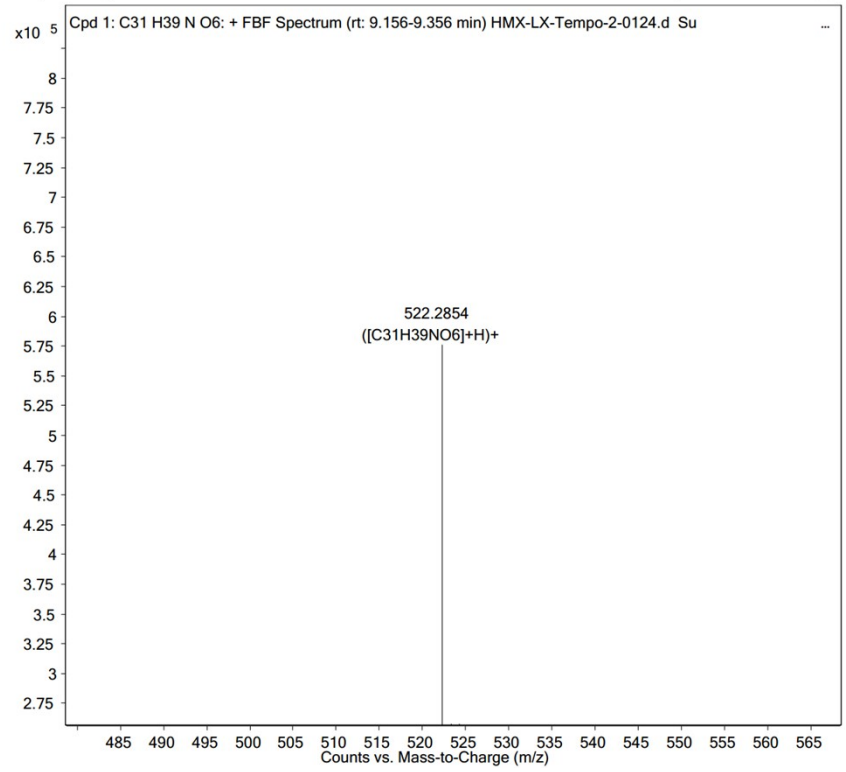
Sample Name	HMX-Tempo-1-0124	**Position**	P1D1	**Instrument Name**	Instrument 1
User Name		**Inj Vol**	0.2	**InjPosition**	
Sample Type	Sample	**IRM Calibration Status**	Success	**Data Filename**	HMX-Tempo-1-1-0124.d
ACQ Method	10-100% jiachun Zheng.m	**Comment**		**Acquired Time**	1/24/2021 7:14:38 PM

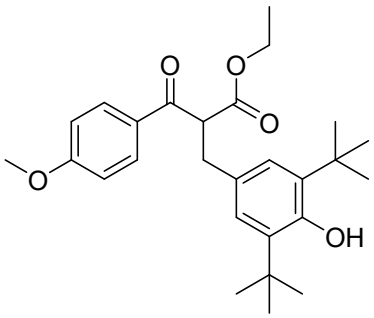




Compound **6**：**HRMS**(m/z) [ESI]: calculated for $C_{31}H_{40}NO_6^+[M+H]^+$: 522.2850, found 522.2854.

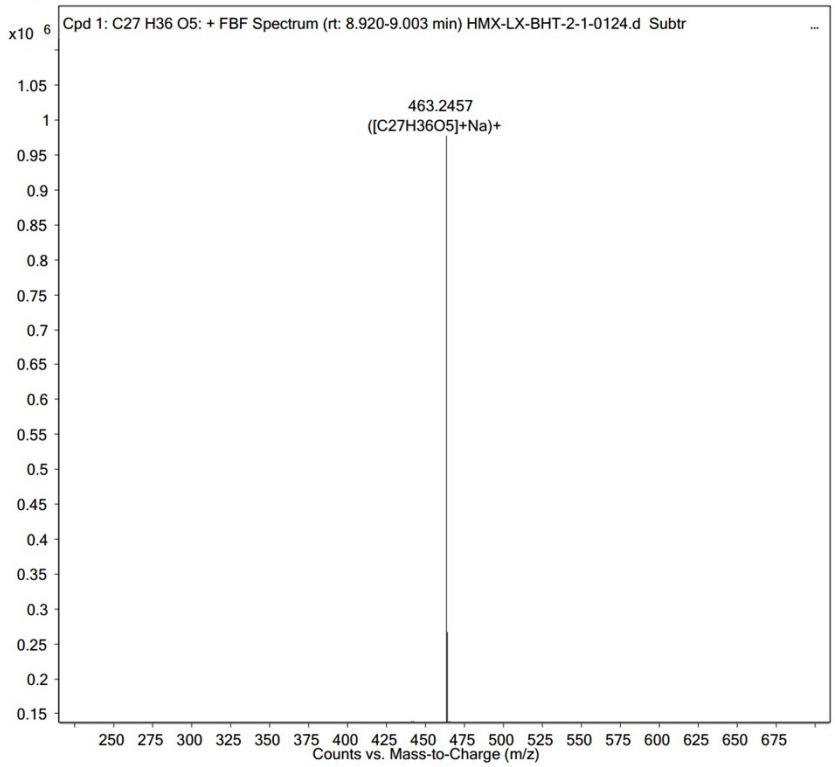
Sample Name	HMX-LX-Tempo-2-0124	**Position**	P1-B1	**Instrument Name**	Instrument 1
User Name		**Inj Vol**	0.2	**InjPosition**	
Sample Type	Sample	**IRM Calibration Status**	Success	**Data Filename**	HMX-LX-Tempo-2-0124.d
ACQ Method	10-100% jiachun Zheng.m	**Comment**		**Acquired Time**	1/24/2021 9:18:12 PM

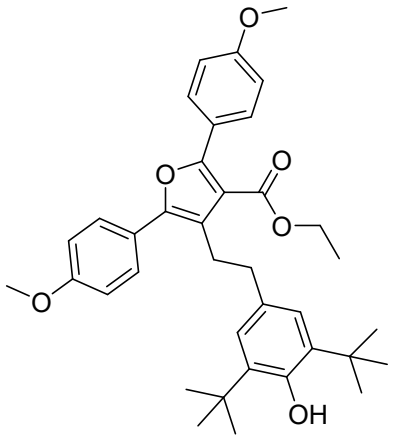




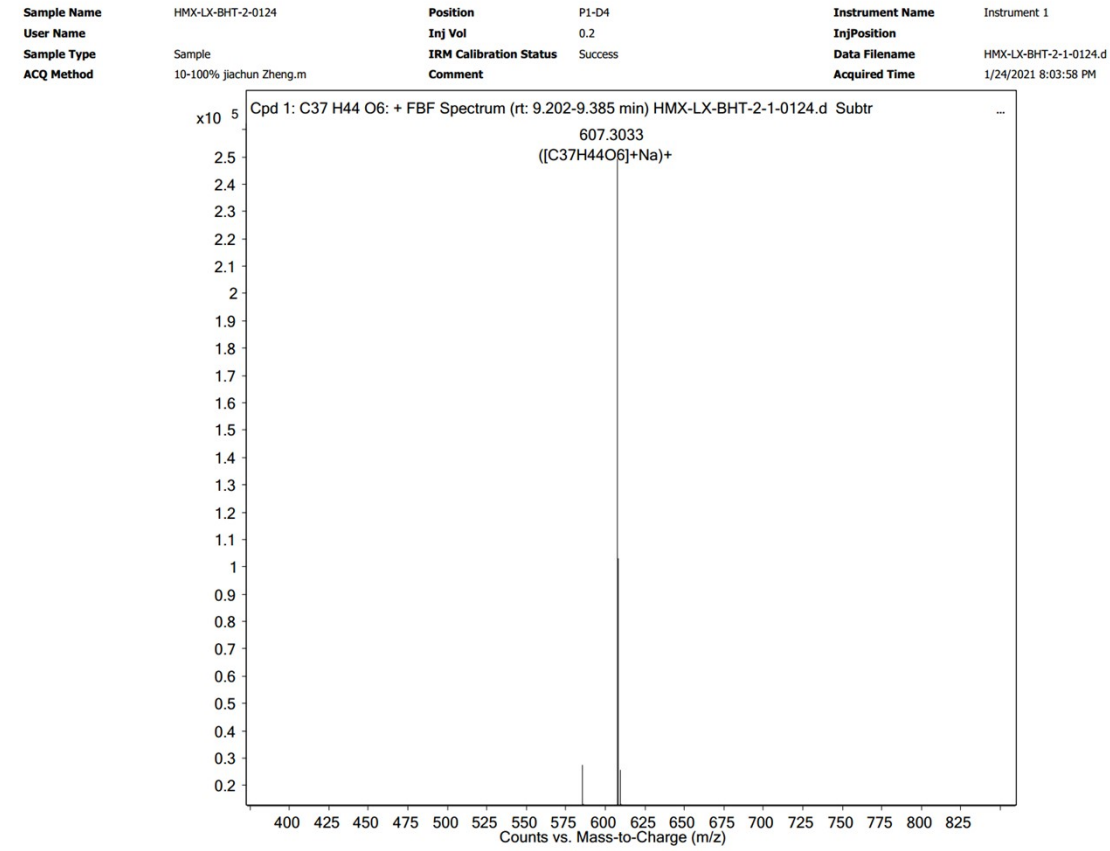
Compound **7**：**HRMS**(m/z) [ESI]: calculated for $C_{27}H_{36}O_5$+Na^+ $[M+Na]^+$: 463.2455, found 463.2457.

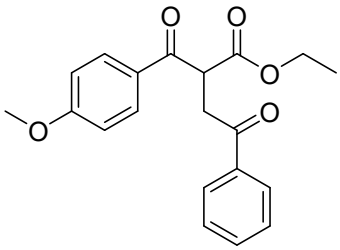
Sample Name	HMX-LX-BHT-2-0124	**Position**	P1-D4	**Instrument Name**	Instrument 1
User Name		**Inj Vol**	0.2	**InjPosition**	
Sample Type	Sample	**IRM Calibration Status**	Success	**Data Filename**	HMX-LX-BHT-2-1-0124.d
ACQ Method	10-100% jiachun Zheng.m	**Comment**		**Acquired Time**	1/24/2021 8:03:58 PM





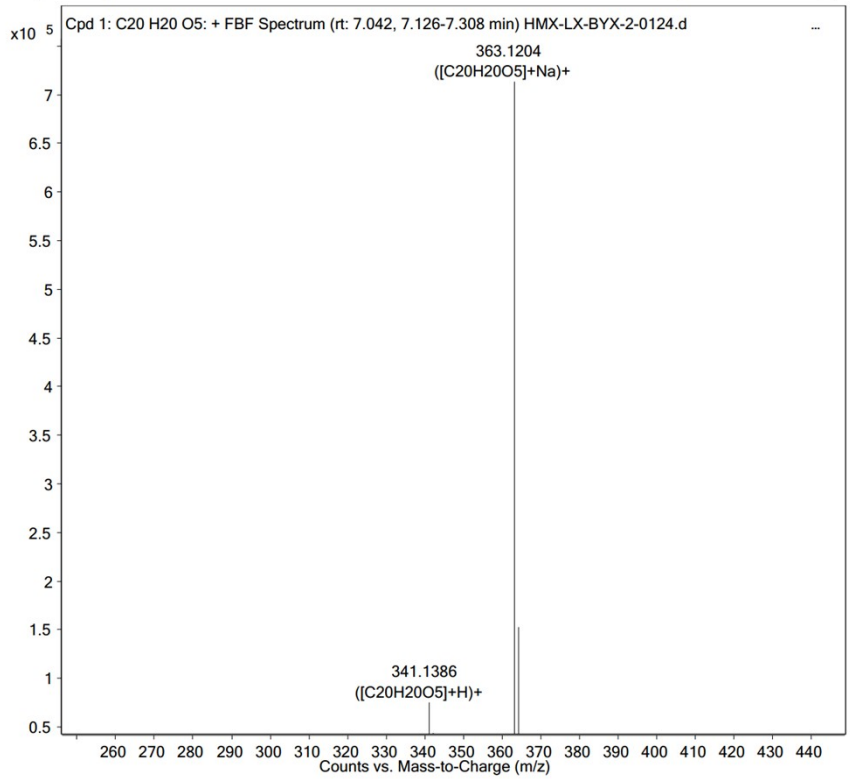
Compound **8**：**HRMS**(m/z) [ESI]: calculated for $C_{37}H_{44}O_6$+Na^+ $[M+Na]^+$: 607.3030, found 607.3033.





Compound **9**：**HRMS**(m/z) [ESI]: calculated for $C_{20}H_{20}O_5$+Na^+ $[M+Na]^+$: 363.1203, found 363.1204.

Sample Name	HMX-LX-BYX-2-0124	**Position**	P1-D5	**Instrument Name**	Instrument 1
User Name		**Inj Vol**	0.2	**InjPosition**	
Sample Type	Sample	**IRM Calibration Status**	Success	**Data Filename**	HMX-LX-BYX-2-0124.d
ACQ Method	10-100% jiachun Zheng.m	**Comment**		**Acquired Time**	1/24/2021 9:37:57 PM



7. Cyclic Voltammetry Studies

The cyclic voltammograms were recorded in an electrolyte solution of Et_4NOTs (0.1 M) in CH_3CN using a glassy carbon disk working electrode (diameter, 3 mm), a Pt wire auxiliary electrode and a Ag/AgCl reference electrode. The scan rate was 100 mV/s.

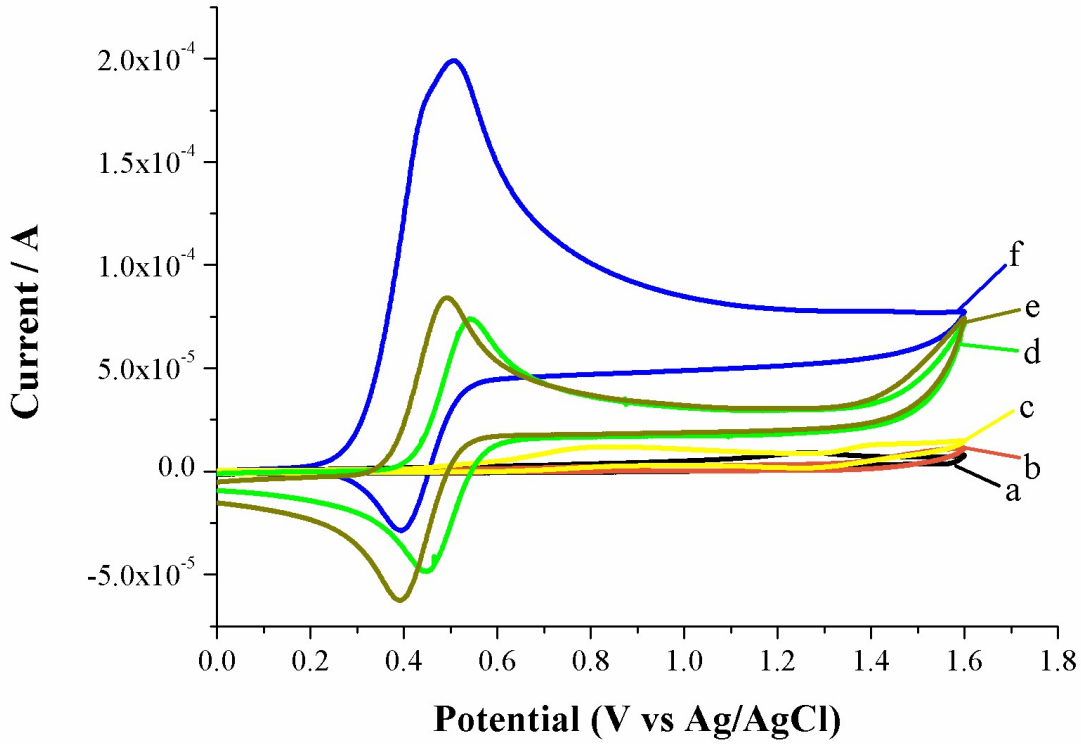


Figure S2-1. Cyclic voltammograms. (a) background; (b) **1a** (12 mM); (c) **1a** (12 mM) + CH_3COONa (12 mM); (d) Cp_2Fe; (e) Cp_2Fe + **1a** (12 mM); (f) Cp_2Fe + **1a** (12 mM) + CH_3COONa (12 mM).

We measured the cyclic voltammogram of the substrate**1a**, from which the oxidation potential of **1a** was 1.44V vs. Ag/AgCl (Figure S2-1, Curve b). The cyclic voltammogram in the presence of both **1a** and CH_3COONa was also studied (Figure S2-1, Curve c). At this point, substrate **1a**deproton into the form of a carbon anion intermediate under the influence of CH_3COONa.Therefore, this curve shows that the oxidation potential of the conjugate base of **1a**is 0.84 V vs. Ag/AgCl. According to the cyclic voltammogram of Cp_2Fe (Figure S2-1, Curve d), its oxidation potential is 0.54 V vs. Ag/AgCl. It can be seen from the above results that the oxidation potential of Cp_2Fe is closer to that of the conjugate base of **1a**, so ferrocene is easier to oxidize the conjugate base of **1a**. Moreover, the curve of Cp_2Fe and **1a**(Figure S2-1, curve e) had almost no change in current compared to the curve of Cp_2Fe (Figure S2-1, curve d).However, the current of Cp_2Fe, **1a** and CH_3COONa (Figure S2-1, curve f) showed a significant increase, indicating that electron transfer was performed. In summary, Cp_2Fe and **1a** are difficult to react directly under electrochemical conditions, but Cp_2Fe catalyzed the conjugate base of **1a** to promote the reaction. Adding another substrate **2a** under the same conditions (Figure S2-2), the change of curve was similar and the same conclusion could be obtained.

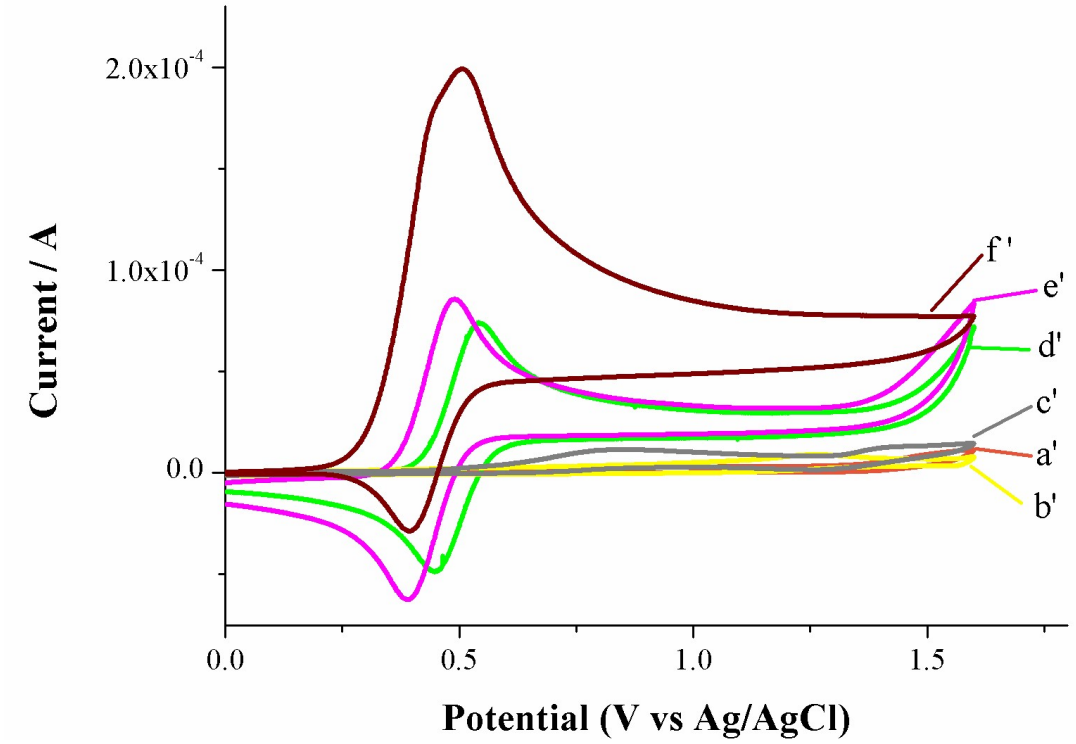


Figure S2-2. Cyclic voltammograms. (a') **1a** (12 mM); (b') **2a** (12 mM); (c') **1a** (12 mM) + **2a** (12 mM); (d') Cp_2Fe; (e') Cp_2Fe + **1a** (12 mM) + **2a** (12 mM); (f') Cp_2Fe + **1a** (12 mM) + **2a** (12 mM) + CH_3COONa (12 mM).

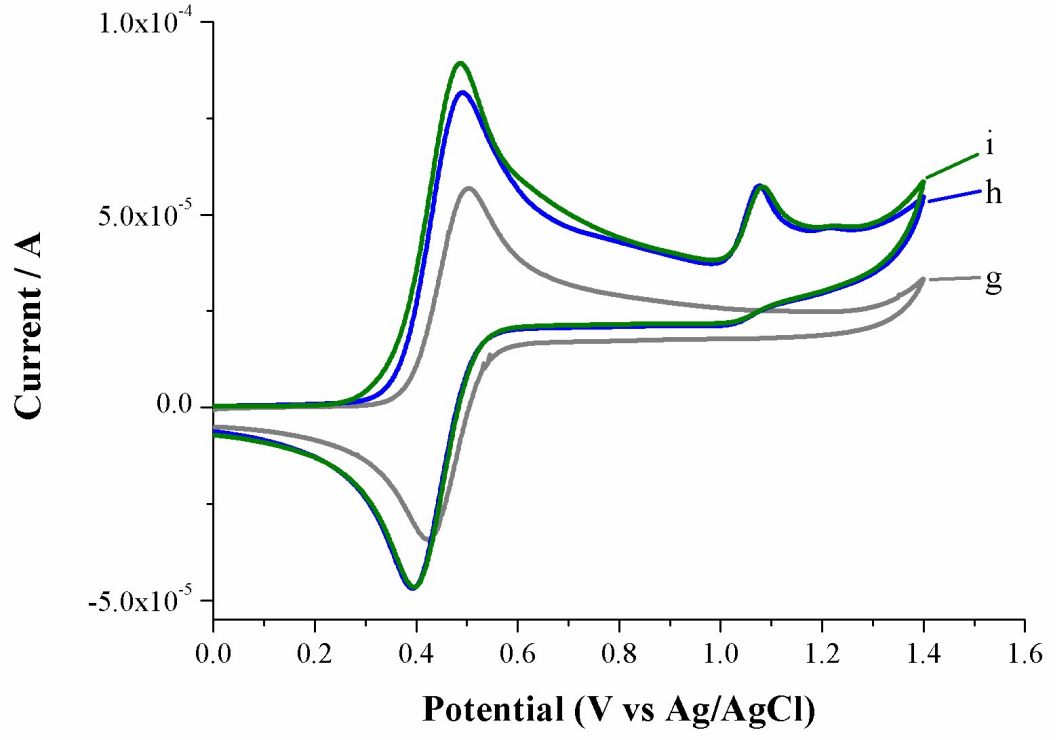


Figure S2-3. Cyclic voltammograms. (g) Cp_2Fe + CH_3COONa (12 mM); (h) Cp_2Fe + **10** (12 mM) + CH_3COONa (12 mM); (i) Cp_2Fe + **10** (12 mM) + **1a** (12 mM) + CH_3COONa (12 mM).

We studied the cyclic voltammogram of reaction intermediate **10** (Figure S2-3). Compared with the cyclic voltammogram without adding any reaction substrate or intermediate (Figure S2-3, Curve g), the curve with adding intermediate **10** (Figure S2-3, Curve h) has an additional oxidation peak, whose oxidation potential is 1.08V vs. Ag/AgCl. The results show that there is an oxidation process of the intermediate **10** under the electrochemical conditions. We also measured the cyclic voltammogram (Figure S2-3, Curve i) in the presence of both the intermediate **10** and the substrate **1a**, and it showed no significant change compared with the curve in the presence of **10**. The above experimental results indicate that in the further reaction between intermediate **10** and substrate **1a**, only **10** is oxidized, while **1a** participates in the next reaction in the form of its conjugate base.

8. X-ray Crystallography Data

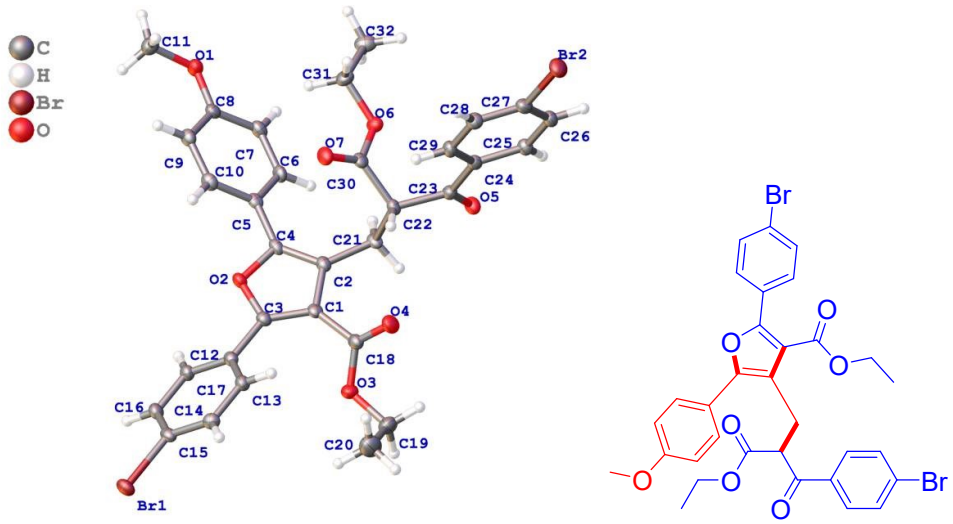


Figure S3. X-ray Structure of **3ga**, CCDC number: 2036760.

Crystal structure determination of 3ga

Crystal Data for $C_{32}H_{28}Br_2O_7$ (M =684.36 g/mol): triclinic, space group P-1 (no. 2), a = 5.5321(2) Å, b = 12.1112(4) Å, c = 21.5318(6) Å, α = 84.490(3)°, β = 89.273(3)°, γ = 81.405(3)°, V = 1419.84(8) Å^3, Z = 2, T = 100.00(10) K, μ(Cu Kα) = 4.032 mm^{-1}, *Dcalc* = 1.601 g/cm^3, 9433 reflections measured (4.122° ≤ 2Θ ≤ 147.484°), 5536 unique (R_{int} = 0.0351, R_{sigma} = 0.0466) which were used in all calculations. The final R_1 was 0.0421 (I >2σ(I)) and wR_2 was 0.1231 (all data).

Table S2 Crystal data and structure refinement for **3ga**.

Empirical formula	$C_{32}H_{28}Br_2O_7$
Formula weight	684.36
Temperature/K	100.00(10)
Crystal system	triclinic
Space group	P-1
a/Å	5.5321(2)
b/Å	12.1112(4)
c/Å	21.5318(6)
α/°	84.490(3)
β/°	89.273(3)
γ/°	81.405(3)
Volume/Å^3	1419.84(8)
Z	2
ρ_{calc}g/cm^3	1.601
μ/mm^{-1}	4.032
F(000)	692.0
Crystal size/mm^3	0.12 × 0.1 × 0.08
Radiation	Cu Kα (λ = 1.54184)
2Θ range for data collection/°	4.122 to 147.484
Index ranges	-6 ≤ h ≤ 4, -15 ≤ k ≤ 14, -26 ≤ l ≤ 26
Reflections collected	9433
Independent reflections	5536 [R_{int} = 0.0351, R_{sigma} = 0.0466]
Data/restraints/parameters	5536/0/373
Goodness-of-fit on F^2	1.060
Final R indexes [I>=2σ (I)]	R_1 = 0.0421, wR_2 = 0.1173
Final R indexes [all data]	R_1 = 0.0507, wR_2 = 0.1231
Largest diff. peak/hole / e Å^{-3}	0.55/-1.25

Table S3 Fractional Atomic Coordinates ($\times 10^4$) and Equivalent Isotropic Displacement Parameters ($Å^2 \times 10^3$) for **3ga**. U_{eq} is defined as 1/3 of of the trace of the orthogonalised U_{IJ} tensor.

Atom	*x*	*y*	*z*	U(eq)
Br1	-4315.7(7)	11547.1(3)	9144.7(2)	22.75(12)
Br2	2892.3(8)	1622.1(3)	4755.7(2)	28.17(13)
O1	11780(5)	3123(2)	9694.2(12)	25.7(6)
O2	4694(5)	7321(2)	8477.3(11)	18.8(5)
O3	2625(5)	9468(2)	6846.2(12)	26.6(6)
O4	2563(6)	7833(2)	6436.9(13)	29.7(6)
O5	9043(5)	5486(2)	5913.1(12)	21.9(5)
O6	8466(5)	3779(2)	7217.5(12)	20.3(5)
O7	4698(5)	4283(2)	7602.9(12)	24.2(6)
C1	4045(7)	7805(3)	7465.0(16)	18.2(7)
C2	6025(7)	6882(3)	7527.2(16)	18.0(7)
C3	3306(7)	8034(3)	8050.9(16)	18.0(7)
C4	6354(6)	6612(3)	8154.4(16)	17.7(7)
C5	7792(7)	5723(3)	8554.1(16)	17.3(7)
C6	10173(7)	5252(3)	8407.5(17)	20.0(7)
C7	11443(7)	4385(3)	8792.6(17)	21.5(8)
C8	10364(7)	3967(3)	9338.2(17)	20.3(7)
C9	7986(7)	4422(3)	9490.9(17)	20.5(7)
C10	6762(7)	5292(3)	9100.6(17)	20.1(7)
C11	10665(8)	2624(3)	10232.7(18)	26.1(8)
C12	1458(7)	8865(3)	8311.9(16)	17.7(7)
C13	-821(7)	9203(3)	8021.6(17)	20.6(7)
C14	-2548(7)	9998(3)	8265.8(17)	19.4(7)
C15	-1987(7)	10450(3)	8805.4(17)	19.5(7)
C16	238(7)	10120(3)	9102.6(17)	20.6(7)
C17	1948(7)	9322(3)	8857.5(16)	19.9(7)
C18	2981(7)	8343(3)	6862.4(17)	20.1(7)
C19	1586(9)	10081(4)	6270.8(19)	33.4(10)
C20	-1153(10)	10361(4)	6323(2)	42.8(12)
C21	7416(7)	6368(3)	6993.8(16)	17.4(7)
C22	6170(7)	5437(3)	6749.1(16)	17.7(7)
C23	7300(7)	5086(3)	6129.8(16)	18.9(7)
C24	6199(7)	4248(3)	5810.9(16)	18.1(7)
C25	7259(7)	3880(3)	5260.2(16)	19.1(7)
C26	6305(7)	3098(3)	4945.4(17)	22.1(8)
C27	4257(7)	2688(3)	5187.1(17)	22.8(8)

Table S3 Fractional Atomic Coordinates ($\times 10^4$) and Equivalent Isotropic Displacement Parameters ($Å^2 \times 10^3$) for **3ga**. U_{eq} is defined as 1/3 of of the trace of the orthogonalised U_{IJ} tensor.

Atom	***x***	***y***	***z***	**U(eq)**
C28	3115(7)	3034(3)	5726.0(17)	21.8(8)
C29	4099(7)	3815(3)	6037.4(17)	20.9(8)
C30	6298(7)	4448(3)	7235.6(16)	17.9(7)
C31	8765(8)	2799(3)	7675.3(18)	24.2(8)
C32	11295(7)	2176(3)	7592(2)	27.0(8)

Table S4 Anisotropic Displacement Parameters ($Å^2 \times 10^3$) for **3ga**. The Anisotropic displacement factor exponent takes the form: $-2\pi^2[h^2a^{*2}U_{11}+2hka^*b^*U_{12}+\ldots]$.

Atom	U_{11}	U_{22}	U_{33}	U_{23}	U_{13}	U_{12}
Br1	19.6(2)	20.5(2)	28.8(2)	-8.79(15)	4.59(15)	-0.95(15)
Br2	36.2(3)	25.6(2)	25.7(2)	-8.89(16)	0.36(17)	-10.24(18)
O1	28.8(15)	25.4(14)	20.2(13)	-1.2(11)	3.7(11)	3.7(12)
O2	19.8(13)	17.9(12)	18.5(12)	-5.5(10)	3.0(10)	0.0(10)
O3	39.5(17)	16.5(13)	22.7(13)	-1.3(10)	1.0(12)	-1.4(12)
O4	41.4(17)	25.6(15)	22.1(14)	-7.7(11)	-4.0(12)	-1.1(13)
O5	22.5(14)	22.1(13)	22.7(13)	-5.0(10)	6.5(10)	-7.2(11)
O6	19.5(13)	19.1(13)	21.8(13)	0.3(10)	4.0(10)	-3.0(10)
O7	25.1(14)	24.2(14)	24.3(13)	-3.4(11)	10.2(11)	-7.6(11)
C1	22.2(18)	14.3(16)	19.5(17)	-4.0(13)	1.6(14)	-5.6(14)
C2	17.9(17)	17.7(17)	19.8(17)	-4.8(13)	2.8(13)	-5.8(14)
C3	18.8(17)	16.2(17)	19.9(17)	-3.9(13)	0.9(13)	-4.2(14)
C4	16.0(17)	18.2(17)	21.1(17)	-8.5(14)	5.3(13)	-5.8(14)
C5	16.7(17)	17.2(17)	20.5(17)	-7.0(13)	1.2(13)	-7.0(14)
C6	18.8(18)	22.5(18)	19.2(17)	-4.5(14)	7.3(14)	-3.6(15)
C7	17.9(18)	24.5(19)	22.8(18)	-8.3(15)	1.2(14)	-1.4(15)
C8	25.5(19)	16.2(17)	19.3(17)	-5.7(14)	0.4(14)	-0.6(15)
C9	19.0(18)	22.2(18)	21.6(18)	-4.6(14)	5.6(14)	-5.9(15)
C10	13.7(17)	23.3(18)	24.4(18)	-6.3(15)	3.2(13)	-4.5(14)
C11	29(2)	26(2)	23.1(19)	0.4(15)	-1.0(15)	-5.7(17)
C12	19.4(18)	16.2(17)	18.2(17)	-3.0(13)	4.3(13)	-4.2(14)
C13	25.4(19)	18.4(17)	18.1(17)	-3.8(14)	3.5(14)	-2.8(15)
C14	14.6(17)	20.3(18)	23.5(18)	-1.8(14)	0.4(13)	-3.8(14)
C15	21.3(18)	14.9(16)	23.2(18)	-4.1(14)	5.5(14)	-4.7(14)
C16	25.2(19)	19.2(18)	18.3(17)	-5.6(14)	2.2(14)	-4.1(15)
C17	21.5(18)	19.6(17)	18.1(17)	-2.6(14)	3.8(14)	-1.6(15)
C18	21.2(18)	17.8(17)	21.7(18)	-3.3(14)	5.7(14)	-3.5(14)
C19	48(3)	25(2)	24(2)	2.9(16)	-0.8(18)	1.0(19)
C20	50(3)	41(3)	34(2)	-3(2)	-9(2)	5(2)
C20	50(3)	41(3)	34(2)	-3(2)	-9(2)	5(2)
C21	17.1(17)	14.9(16)	22.1(17)	-5.8(13)	4.4(13)	-6.9(14)
C22	18.0(17)	19.2(17)	17.2(16)	-6.9(14)	1.6(13)	-3.8(14)
C23	20.9(18)	16.5(17)	18.2(17)	-0.8(13)	2.9(14)	-0.4(14)
C24	19.0(17)	17.5(17)	17.4(17)	-2.1(13)	-0.7(13)	-0.3(14)
C25	16.2(17)	21.0(18)	20.0(17)	-3.5(14)	1.5(13)	-2.3(14)
C26	25.6(19)	20.9(18)	19.2(17)	-4.7(14)	1.6(14)	0.3(15)
C27	27(2)	18.1(18)	22.9(18)	-3.9(14)	-2.9(15)	-1.2(15)

Table S4 Anisotropic Displacement Parameters ($Å^2 \times 10^3$) for **3ga**. The Anisotropic displacement factor exponent takes the form: $-2\pi^2[h^2a^{*2}U_{11}+2hka^*b^*U_{12}+\ldots]$.

Atom	U_{11}	U_{22}	U_{33}	U_{23}	U_{13}	U_{12}
C28	22.0(19)	20.8(18)	23.5(18)	-2.0(14)	0.6(14)	-5.8(15)
C29	21.9(19)	22.1(18)	18.0(17)	-3.2(14)	4.0(14)	-0.8(15)
C30	19.6(18)	16.5(17)	19.7(17)	-6.7(13)	0.0(14)	-6.5(14)
C31	28(2)	18.5(18)	25.3(19)	2.8(15)	2.1(15)	-5.2(16)
C32	22(2)	21.8(19)	38(2)	0.6(16)	-2.9(16)	-6.7(16)

Table S5 Bond Lengths for **3ga.**

Atom	Atom	Length/Å	Atom	Atom	Length/Å
Br1	C15	1.900(4)	C6	C7	1.382(5)
Br2	C27	1.907(4)	C7	C8	1.397(5)
O1	C8	1.368(4)	C8	C9	1.396(5)
O1	C11	1.431(5)	C9	C10	1.380(5)
O2	C3	1.359(4)	C12	C13	1.402(5)
O2	C4	1.388(4)	C12	C17	1.392(5)
O3	C18	1.344(4)	C13	C14	1.388(5)
O3	C19	1.459(5)	C14	C15	1.388(5)
O4	C18	1.196(5)	C15	C16	1.381(5)
O5	C23	1.212(5)	C16	C17	1.386(5)
O6	C30	1.346(4)	C19	C20	1.507(7)
O6	C31	1.459(4)	C21	C22	1.543(5)
O7	C30	1.205(4)	C22	C23	1.535(5)
C1	C2	1.441(5)	C22	C30	1.507(5)
C1	C3	1.362(5)	C23	C24	1.483(5)
C1	C18	1.482(5)	C24	C25	1.398(5)
C2	C4	1.366(5)	C24	C29	1.408(5)
C2	C21	1.507(5)	C25	C26	1.385(5)
C3	C12	1.469(5)	C26	C27	1.380(6)
C4	C5	1.455(5)	C27	C28	1.385(5)
C5	C6	1.400(5)	C28	C29	1.388(5)
C5	C10	1.392(5)	C31	C32	1.505(5)

Table S6 Bond Angles for **3ga**.

Atom	Atom	Atom	Angle/°	Atom	Atom	Atom	Angle/°
C8	O1	C11	117.2(3)	C14	C15	Br1	119.6(3)
C3	O2	C4	107.8(3)	C16	C15	Br1	119.0(3)
C18	O3	C19	116.2(3)	C16	C15	C14	121.4(3)
C30	O6	C31	115.1(3)	C15	C16	C17	119.4(3)
C2	C1	C18	124.6(3)	C16	C17	C12	120.7(4)
C3	C1	C2	107.5(3)	O3	C18	C1	111.8(3)
C3	C1	C18	127.8(3)	O4	C18	O3	124.4(3)
C1	C2	C21	125.3(3)	O4	C18	C1	123.7(3)
C4	C2	C1	105.7(3)	O3	C19	C20	110.7(4)
C4	C2	C21	129.0(3)	C2	C21	C22	112.0(3)
O2	C3	C1	109.5(3)	C23	C22	C21	111.4(3)
O2	C3	C12	115.4(3)	C30	C22	C21	110.1(3)
C1	C3	C12	135.2(3)	C30	C22	C23	111.3(3)
O2	C4	C5	113.7(3)	O5	C23	C22	120.3(3)
C2	C4	O2	109.5(3)	O5	C23	C24	121.5(3)
C2	C4	C5	136.4(3)	C24	C23	C22	118.1(3)
C6	C5	C4	123.0(3)	C25	C24	C23	119.1(3)
C10	C5	C4	119.4(3)	C25	C24	C29	118.3(3)
C10	C5	C6	117.7(3)	C29	C24	C23	122.5(3)
C7	C6	C5	120.9(3)	C26	C25	C24	121.4(4)
C6	C7	C8	120.2(3)	C27	C26	C25	118.3(3)
O1	C8	C7	115.9(3)	C26	C27	Br2	119.0(3)
O1	C8	C9	124.4(3)	C26	C27	C28	122.7(4)
C9	C8	C7	119.7(3)	C28	C27	Br2	118.3(3)
C10	C9	C8	118.9(3)	C27	C28	C29	118.3(4)
C9	C10	C5	122.5(3)	C28	C29	C24	121.0(3)
C13	C12	C3	120.9(3)	O6	C30	C22	111.1(3)
C17	C12	C3	120.1(3)	O7	C30	O6	124.0(3)
C17	C12	C13	119.0(3)	O7	C30	C22	124.9(3)
C14	C13	C12	120.7(3)	O6	C31	C32	107.2(3)
C15	C14	C13	118.9(3)				

Table S7 Torsion Angles for **3ga.**

A	B	C	D	Angle/°	A	B	C	D	Angle/°
Br1	C15	C16	C17	-179.9(3)	C10	C5	C6	C7	0.2(5)
Br2	C27	C28	C29	-179.6(3)	C11	O1	C8	C7	-175.7(3)
O1	C8	C9	C10	178.4(3)	C11	O1	C8	C9	4.9(5)
O2	C3	C12	C13	-144.4(3)	C12	C13	C14	C15	-0.3(5)
O2	C3	C12	C17	35.1(5)	C13	C12	C17	C16	-1.6(5)
O2	C4	C5	C6	-150.2(3)	C13	C14	C15	Br1	179.6(3)
O2	C4	C5	C10	31.5(5)	C13	C14	C15	C16	-0.3(6)
O5	C23	C24	C25	2.6(5)	C14	C15	C16	C17	0.0(6)
O5	C23	C24	C29	-176.7(3)	C15	C16	C17	C12	1.0(6)
C1	C2	C4	O2	-0.3(4)	C17	C12	C13	C14	1.3(5)
C1	C2	C4	C5	172.1(4)	C18	O3	C19	C20	94.6(4)
C1	C2	C21	C22	-87.2(4)	C18	C1	C2	C4	-177.2(3)
C1	C3	C12	C13	37.4(6)	C18	C1	C2	C21	3.9(6)
C1	C3	C12	C17	-143.0(4)	C18	C1	C3	O2	177.3(3)
C2	C1	C3	O2	0.3(4)	C18	C1	C3	C12	-4.4(7)
C2	C1	C3	C12	178.5(4)	C19	O3	C18	O4	2.0(6)
C2	C1	C18	O3	-135.6(4)	C19	O3	C18	C1	179.9(3)
C2	C1	C18	O4	42.3(6)	C21	C2	C4	O2	178.6(3)
C2	C4	C5	C6	37.6(7)	C21	C2	C4	C5	-9.0(7)
C2	C4	C5	C10	-140.6(4)	C21	C22	C23	O5	4.0(5)
C2	C21	C22	C23	168.7(3)	C21	C22	C23	C24	-176.1(3)
C2	C21	C22	C30	-67.3(4)	C21	C22	C30	O6	-82.7(3)
C3	O2	C4	C2	0.4(4)	C21	C22	C30	O7	95.8(4)
C3	O2	C4	C5	-173.8(3)	C22	C23	C24	C25	-177.3(3)
C3	C1	C2	C4	0.0(4)	C22	C23	C24	C29	3.5(5)
C3	C1	C2	C21	-179.0(3)	C23	C22	C30	O6	41.3(4)
C3	C1	C18	O3	47.8(5)	C23	C22	C30	O7	-140.1(4)
C3	C1	C18	O4	-134.3(4)	C23	C24	C25	C26	179.9(3)
C3	C12	C13	C14	-179.2(3)	C23	C24	C29	C28	179.8(3)
C3	C12	C17	C16	178.8(3)	C24	C25	C26	C27	0.3(5)
C4	O2	C3	C1	-0.4(4)	C25	C24	C29	C28	0.6(5)
C4	O2	C3	C12	-179.1(3)	C25	C26	C27	Br2	179.3(3)
C4	C2	C21	C22	94.1(5)	C25	C26	C27	C28	0.6(6)
C4	C5	C6	C7	-178.0(3)	C26	C27	C28	C29	-0.8(6)
C4	C5	C10	C9	177.7(3)	C27	C28	C29	C24	0.2(6)
C5	C6	C7	C8	-0.2(6)	C29	C24	C25	C26	-0.9(5)
C6	C5	C10	C9	-0.7(5)	C30	O6	C31	C32	-178.8(3)
C6	C7	C8	O1	-178.9(3)	C30	C22	C23	O5	-119.3(4)

Table S7 Torsion Angles for **3ga.**

A	B	C	D	Angle/°	A	B	C	D	Angle/°
C6	C7	C8	C9	0.5(6)	C30	C22	C23	C24	60.6(4)
C7	C8	C9	C10	-0.9(6)	C31	O6	C30	O7	1.1(5)
C8	C9	C10	C5	1.0(6)	C31	O6	C30	C22	179.7(3)

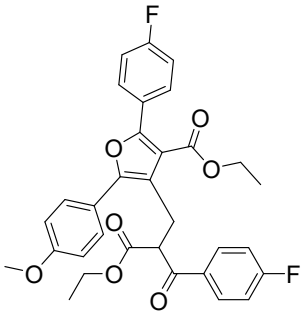
Table S8 Hydrogen Atom Coordinates (Å×10^4) and Isotropic Displacement Parameters (Å^2×10^3) for **3ga.**

Atom	*x*	*y*	*z*	U(eq)
H6	10910.45	5525.22	8045.96	24
H7	13022.5	4079.5	8688.24	26
H9	7239.06	4144.63	9849.87	25
H10	5187.61	5601.21	9206.96	24
H11A	9254.8	2324.39	10107.61	39
H11B	10178.48	3181.81	10515.89	39
H11C	11814.68	2030.77	10435.69	39
H13	-1179.31	8892.14	7661.49	25
H14	-4056.21	10224.37	8071.35	23
H16	585.8	10431.43	9463.63	25
H17	3438.32	9088.62	9059.65	24
H19A	1989.6	9628.71	5925.23	40
H19B	2287.78	10767.41	6186.78	40
H20A	-1795.76	10789.49	5947.73	64
H20B	-1551.97	10791.13	6672.21	64
H20C	-1854.3	9679.67	6383.33	64
H21A	9060.32	6055.69	7131.32	21
H21B	7538.67	6948.4	6656.55	21
H22	4442.7	5735.98	6673.33	21
H25	8633.8	4167.05	5101.86	23
H26	7026.18	2855.42	4580.31	27
H28	1723.99	2750.03	5875.44	26
H29	3360.71	4055.29	6400.98	25
H31A	7548.76	2322.56	7608.96	29
H31B	8573.54	3029.87	8094.41	29
H32A	11496.24	1993.8	7168.04	40
H32B	11518.04	1497.58	7868.08	40
H32C	12483.09	2637.87	7685.51	40

9. Study on Antitumor Activity

MTT assay. The 180 μL cell suspensions (4500-5000 cells/mL) was seeded in 96-well plates and incubated for 24 h. All compounds and 5-FU were dissolved in the Phosphate Buffered Saline (PBS) with 1% DMSO to give various concentrations (2.5, 5, 10, 20, and 40 μM, respectively) to 96-well plates and control wells contained supplemented media with 1% DMSO. Continue incubating for 48 h at 37 ^{o}C in 5% CO_2 atmosphere and then the MTT solution (10 μL, 5 mg/mL) was added into each well and the cultures were incubated further for 4-6 h. After removal of the supernatant, DMSO (100 μL) was added to dissolve the formazan crystals. The absorbance was read by enzyme labeling instrument with 570/630 nm double wavelength measurement. The cytotoxicity was estimated based on the percentage cell survival in a dose dependent manner relative to the negative control. The final IC_{50} (a drug concentration killing 50% cells) values were calculated by the Bliss method. All the tests were repeated in at least three independent experiments.

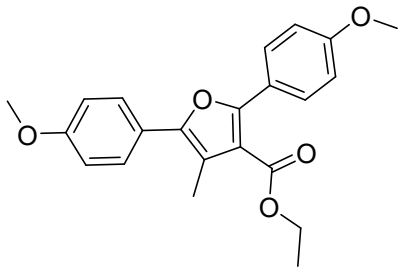
Table S9 The IC_{50} (μM) values of tested compounds on four tumor cell lines and one normal liver cell line.



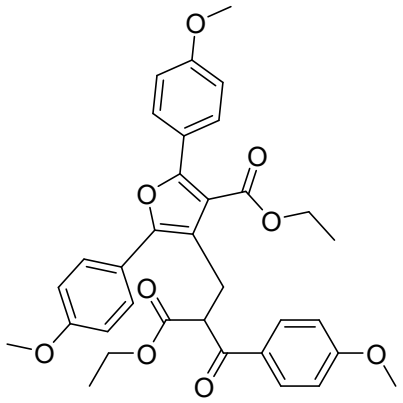
3ea

Compounds	T-24	MGC-803	HeLa	HePG-2	WI-38
3aa	38.1 ± 1.2	>40	32.0 ± 1.3	>40	>40
3ba	30.7 ± 0.9	38.5 ± 2.0	29.3 ± 0.9	>40	>40
3da	>40	>40	>40	>40	>40
3ea	**6.3 ± 0.7**	**12.6± 0.9**	**7.4 ± 0.5**	**20.2 ± 1.3**	**33.6 ± 0.4**
3fa	27.1 ± 1.0	35.6 ± 1.6	30.9 ± 1.2	>40±	>40
3ga	25.8 ± 1.5	30.6 ± 1.4	31.6 ± 0.8	>40	>40
3ha	22.5 ± 0.4	30.5 ± 0.7	27.2 ± 1.6	35.8 ± 0.9	>40
3ia	28.9 ± 0.8	35.4 ± 0.9	33.0 ± 0.5	>40	>40
3ja	20.4 ± 1.1	31.6 ± 1.2	22.1 ± 1.0	36.2 ± 1.5	38.9 ± 0.7
3ka	32.5 ± 0.7	>40	34.3 ± 0.9	>40	>40
3ma	30.4 ± 1.3	>40	33.1 ± 0.5	>40	>40
3na	37.5 ± 1.5	>40	30.8 ± 1.3	>40	>40
3oa	33.4 ± 0.8	39.6 ± 0.9	29.5 ± 2.1	>40	>40
3pa	>40	>40	36.2 ± 1.8	>40	>40
3qa	>40	>40	35.3 ± 0.8	>40	>40
3ra	30.1 ± 0.5	38.1 ± 1.0	29.6 ± 1.4	37.6 ± 1.6	>40
3sa	>40	>40	37.2 ± 0.9	>40	>40
3ta	28.0 ± 0.8	31.9 ± 0.8	25.4 ± 1.2	>40	>40
3ab	30.5 ± 0.9	>40	>40	>40	>40
3ad	27.3 ± 1.1	35.1 ± 1.4	30.7 ± 0.6	38.5 ± 0.5	>40
3ae	34.6 ± 0.4	38.9 ± 1.1	33.1 ± 1.2	>40	>40
3af	>40	>40	>40	>40	>40
3ag	38.6 ± 0.7	>40	35.1 ± 0.9	>40	>40
3ah	29.1	36.9 ± 0.9	25.4 ± 1.5	>40	>40
3ai	>40	>40	>40	>40	>40
3aj	33.1 ± 1.2	>40	35.7 ± 0.7	>40	>40
5-FU	30.5 ± 0.9	38.7 ± 0.8	>40	＞40	＞40

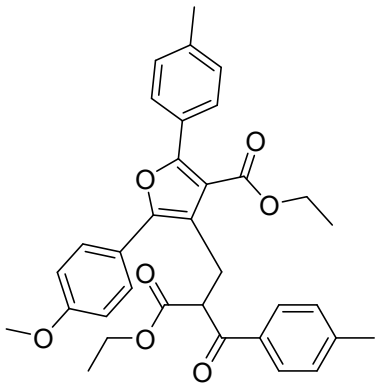
10. Characterization Data for the Electrolysis Products



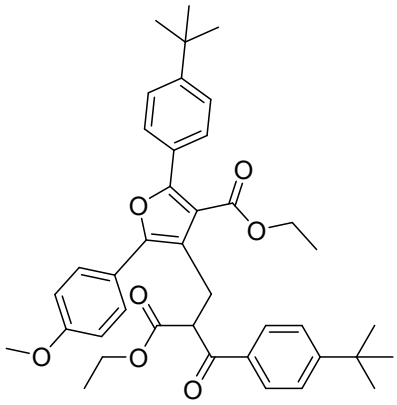
ethyl 2,5-bis(4-methoxyphenyl)-4-methylfuran-3-carboxylate (10). yellow liquid (69.2 mg, 63%). **^{1}H NMR** (600 MHz, Chloroform-*d*) δ 7.79 (d, *J* = 8.9 Hz, 2H), 7.58 (d, *J* = 8.8 Hz, 2H), 6.96 (dd, *J* = 17.5, 8.8 Hz, 4H), 4.32 (q, *J* = 7.1 Hz, 2H), 3.85 (d, *J* = 2.6 Hz, 6H), 2.39 (s, 3H), 1.32 (t, *J* = 7.1 Hz, 3H). **^{13}C NMR** (150 MHz, Chloroform-*d*) δ 164.84, 160.06, 158.97, 155.46, 148.48, 129.84, 127.81, 123.61, 123.05, 116.56, 114.97, 114.00, 113.38, 60.31, 55.31,55.30, 14.16, 11.06. IR (KBr) ν: 3061, 2925, 1721, 1604, 1253, 1030 cm^{-1}. **HRMS** (m/z) [ESI]: calculated for $C_{22}H_{23}O_5^+$ $[M+H]^+$: 367.1540, found 367.1542.



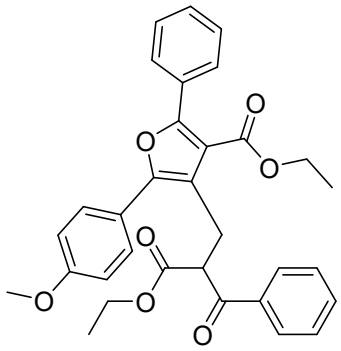
ethyl 4-(3-ethoxy-2-(4-methoxybenzoyl)-3-oxopropyl)-2,5-bis(4-methoxyphenyl)furan-3-carboxylate (3aa). yellow liquid (73.9 mg, 84%). **^{1}H NMR** (600 MHz, Chloroform-*d*) δ 7.87 (d, *J* = 6.0 Hz, 2H), 7.72 (d, *J* = 12.0 Hz, 2H), 7.55 (d, *J* = 6.0 Hz, 2H), 6.93 (d, *J* = 6.0 Hz, 4H), 6.85 (d, *J* = 6.0 Hz, 2H), 4.84-4.81 (m, 1H), 4.31-4.25 (m, 2H), 4.00-3.95 (m, 1H), 3.88-3.85 (m, 1H), 3.84 (s, 3H), 3.83 (s, 3H), 3.82 (s, 3H), 3.64 (dd, *J* = 18.0, 12.0 Hz, 1H), 3.52 (dd, *J* = 18.0, 12.0 Hz, 1H), 1.24 (t, *J* = 6.0 Hz, 3H), 0.98 (t, *J* = 6.0 Hz, 3H). **^{13}C NMR** (150 MHz, Chloroform-*d*) δ 193.52, 169.77, 164.41, 163.65, 160.18, 159.32, 156.51, 149.77, 130.91, 130.07, 129.33, 128.39, 122.87, 122.78, 117.17, 113.95, 113.83, 113.62, 113.27, 61.17, 60.47, 55.38, 55.26, 55.23, 53.78, 24.13, 13.98, 13.72. IR (KBr) ν: 3080, 2938, 1708, 1600, 1254, 1028 cm^{-1}. **HRMS** (m/z) [ESI]: calculated for $C_{34}H_{35}O_9^+$ $[M+H]^+$: 587.2276, found 587.2277.



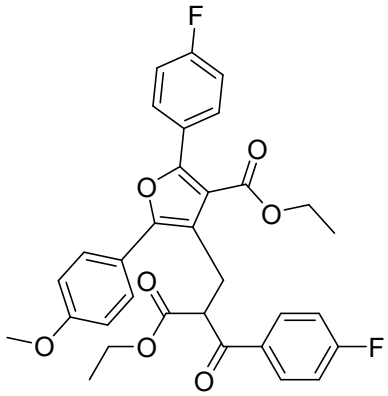
ethyl 4-(3-ethoxy-2-(4-methylbenzoyl)-3-oxopropyl)-5-(4-methoxyphenyl)-2-(*p*-tolyl)furan-3-carboxylate (3ba). yellow solid (68.1 mg, 82%). mp: 100-103 °C. **^{1}H NMR** (600 MHz, Chloroform-*d*) δ 7.80 (d, *J* = 6.0 Hz, 2H), 7.65 (d, *J* = 6.0 Hz, 2H), 7.58 (d, *J* = 6.0 Hz, 2H), 7.23 -7.18 (m, 4H), 6.95 (d, *J* = 12.0 Hz, 2H), 4.88 (t, *J* = 6.0 Hz, 1H), 4.32-4.26 (m, 2H), 4.00-3.95 (m, 1H), 3.88-3.84 (m, 1H), 3.83 (s, 3H), 3.65 (dd, *J* = 14.5, 6.0 Hz, 1H), 3.55 (dd, *J* = 14.5, 6.0 Hz, 1H), 2.40 (s, 3H), 2.37 (s, 3H), 1.25 (t, *J* = 6.0 Hz, 3H), 0.99 (t, *J* = 6.0 Hz, 3H). **^{13}C NMR** (150 MHz, Chloroform-*d*) δ 194.68, 169.65, 164.34, 159.34, 156.43, 149.99, 144.17, 139.09, 133.80, 129.13, 128.62, 128.54, 128.40, 128.35, 127.30, 122.80, 117.14, 114.42, 113.94, 61.16, 60.48, 55.19, 53.85, 24.00, 21.54, 21.34, 13.92, 13.68. IR (KBr) ν: 3046, 2981, 1710, 1508, 1228, 1037 cm^{-1}. **HRMS** (m/z) [ESI]: calculated for $C_{34}H_{35}O_7^+$ $[M+H]^+$: 555.2377, found 555.2384.



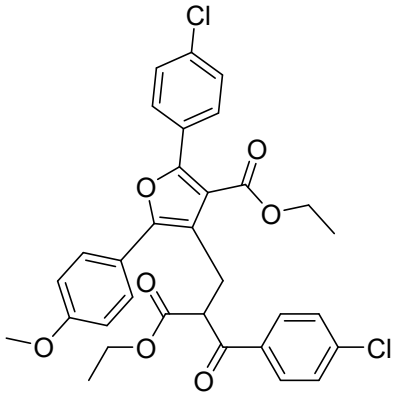
ethyl 4-(2-(4-(*tert*-butyl)benzoyl)-3-ethoxy-3-oxopropyl)-2-(4-(*tert*-butyl)phenyl)-5-(4-methoxyphenyl)furan-3-carboxylate (3ca). yellow liquid (67.0 mg, 70%). **^{1}H NMR** (600 MHz, Chloroform-*d*) δ 7.81 (d, *J* = 12.0 Hz, 2H), 7.69 (d, *J* = 12.0 Hz, 2H), 7.56 (d, *J* = 12.0 Hz, 2H), 7.43-7.38 (m, 4H), 6.95-6.93 (m, 2H), 4.87 (t, *J* = 6.0 Hz, 1H), 4.34-4.25 (m, 2H), 4.01-3.96 (m, 1H), 3.90-3.86 (m, 1H), 3.84 (s, 3H), 3.64 (dd, *J* = 14.5, 8.0 Hz, 1H), 3.54 (dd, *J* = 14.5, 7.0 Hz, 1H), 1.35 (s, 9H), 1.29 (s, 9H), 1.25 (t, *J* = 7.1 Hz, 3H), 1.00 (t, *J* = 7.1 Hz, 3H). **^{13}C NMR** (150 MHz, Chloroform-*d*) δ 194.81, 169.72, 164.42, 159.38, 157.06, 156.45, 152.25, 150.07, 133.78, 128.51, 128.40, 128.25, 127.32, 125.44, 124.85, 122.89, 117.14, 114.57, 114.01, 61.22, 60.56, 55.28, 53.82, 35.06, 34.75, 31.19, 30.97, 24.14, 14.00, 13.77. IR (KBr) ν: 3061, 2903, 1732, 1508, 1253, 1038 cm^{-1}. **HRMS** (m/z) [ESI]: calculated for $C_{40}H_{47}O_7^+$ $[M+H]^+$: 639.3316, found 639.3317.



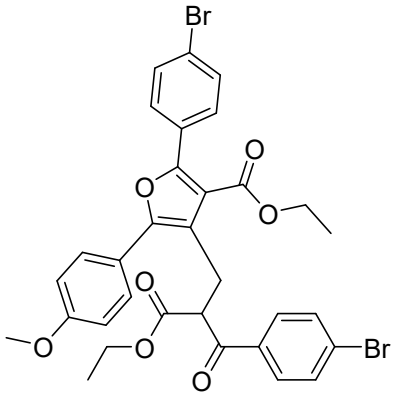
ethyl 4-(2-benzoyl-3-ethoxy-3-oxopropyl)-5-(4-methoxyphenyl)-2-phenylfuran-3-carboxylate (3da). yellow solid (63.9 mg, 81%). mp: 64-67 °C. **^{1}H NMR** (600 MHz, Chloroform-*d*) δ 7.88 (d, *J* = 6.0 Hz, 2H), 7.73 (d, *J* = 12.0 Hz, 2H), 7.57 (d, *J* = 6.0 Hz, 2H), 7.52 (t, *J* = 6.0 Hz, 1H), 7.42-7.37 (m, 5H), 6.95 (d, *J* = 6.0 Hz, 2H), 4.90 (t, *J* = 6.0 Hz, 1H), 4.31-4.25 (m, 2H), 4.00-3.95 (m, 1H), 3.88-3.85 (m, 1H), 3.84 (s, 3H), 3.64 (dd, *J* = 12.0, 6.0 Hz, 1H), 3.55 (dd, *J* = 12.0, 6.0 Hz, 1H), 1.23 (t, *J* = 6.0 Hz, 3H), 0.98 (t, *J* = 6.0 Hz, 3H). **^{13}C NMR** (150 MHz, Chloroform-*d*) δ 195.20, 169.56, 164.35, 159.48, 156.17, 150.40, 136.34, 133.33, 130.18, 129.05, 128.55, 128.54, 128.50, 128.44, 127.89, 122.75, 117.20, 114.96, 114.04, 61.29, 60.63, 55.29, 53.97, 24.00, 13.93, 13.72. IR (KBr) ν: 3064, 2926, 1734, 1509, 1255, 1027 cm^{-1}. **HRMS** (m/z) [ESI]: calculated for $C_{32}H_{30}O_7$+Na^+ $[M+Na]^+$: 549.1884, found 549.1884.



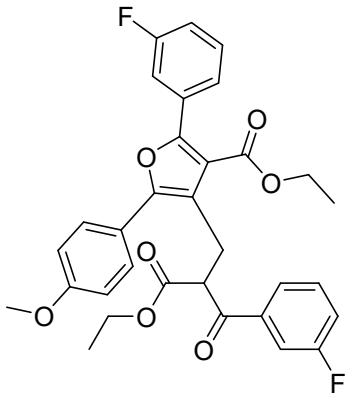
ethyl 4-(3-ethoxy-2-(4-fluorobenzoyl)-3-oxopropyl)-2-(4-fluorophenyl)-5-(4-methoxyphenyl)furan-3-carboxylate (3ea). yellow solid (63.3 mg, 75%). mp: 49-52 °C. **^{1}H NMR** (400 MHz, Chloroform-*d*) δ 7.93-7.90 (m, 2H), 7.76-7.72 (m, 2H), 7.55 (d, *J* = 8.0 Hz, 2H), 7.12-7.04 (m, 4H), 6.94 (d, *J* = 8.0 Hz, 2H), 4.84 (t, *J* = 8.0 Hz, 1H), 4.30-4.24 (m, 2H), 4.01-3.94 (m, 1H), 3.88-3.84 (m, 1H), 3.83 (s, 3H), 3.64 (dd, *J* = 16.0, 8.0 Hz, 1H), 3.54 (dd, *J* = 16.0, 8.0 Hz, 1H), 1.23 (t, *J* = 8.0 Hz, 3H), 0.98 (t, *J* = 8.0 Hz, 3H). **^{13}C NMR** (100 MHz, Chloroform-*d*) δ 193.44, 169.34, 167.08, 164.42 (d, *J* = 24.0 Hz), 164.13, 161.82, 159.55, 152.91 (d, *J* = 494.0 Hz), 132.68 (d, *J* = 3.0 Hz), 131.20 (d, *J* = 10.0 Hz), 130.59 (d, *J* = 8.0 Hz), 128.43, 126.31 (d, *J* = 3.0 Hz), 122.51, 117.08, 115.61 (d, *J* = 22.0 Hz), 114.97 (d, *J* = 21.0 Hz), 114.71, 114.04, 61.35, 60.65, 55.22, 54.02, 23.93, 13.90, 13.67. **^{19}F NMR** (565 MHz, Chloroform-*d*) δ -104.45, -111.25. IR (KBr) ν: 3080, 2925, 1732, 1599, 1234, 1033 cm^{-1}. **HRMS** (m/z) [ESI]: calculated for $C_{32}H_{29}F_2O_7^+$ $[M+H]^+$: 563.1876, found 563.1875.



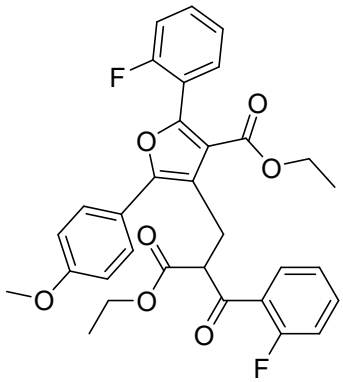
ethyl 4-(2-(4-chlorobenzoyl)-3-ethoxy-3-oxopropyl)-2-(4-chlorophenyl)-5-(4-methoxyphenyl)furan-3-carboxylate (3fa). yellow solid (68.6 mg, 77%). mp: 96-100 °C. **^{1}H NMR** (600 MHz, Chloroform-*d*) δ 7.81 (d, *J* = 12.0 Hz, 2H), 7.69 (d, *J* = 12.0 Hz, 2H), 7.54 (d, *J* = 12.0 Hz, 2H), 7.39-7.35 (m, 4H), 6.94 (d, *J* = 6.0 Hz, 2H), 4.82 (t, *J* = 6.0 Hz, 1H), 4.31-4.26 (m, 2H), 4.00-3.95 (m, 1H), 3.87-3.85 (m, 1H), 3.83 (s, 3H), 3.63 (dd, *J* = 14.5, 6.0 Hz, 1H), 3.54 (dd, *J* = 14.5, 6.0 Hz, 1H), 1.24 (t, *J* = 6.0 Hz, 3H), 0.98 (t, *J* = 6.0 Hz, 3H). **^{13}C NMR** (150 MHz, Chloroform-*d*) δ 193.84, 169.23, 164.04, 159.59, 154.94, 150.66, 139.83, 135.01, 134.52, 129.87, 129.78, 128.79, 128.47, 128.43, 128.13, 122.38, 117.16, 115.16, 114.04, 61.41, 60.75, 55.24, 54.04, 23.86, 13.93, 13.68. IR (KBr) ν: 3077, 2980, 1720, 1506, 1229, 1035 cm^{-1}. **HRMS** (m/z) [ESI]: calculated for $C_{32}H_{29}Cl_2O_7^+$ $[M+H]^+$: 595.1285, found 595.1283.



ethyl 4-(2-(4-bromobenzoyl)-3-ethoxy-3-oxopropyl)-2-(4-bromophenyl)-5-(4-methoxyphenyl)furan-3-carboxylate (3ga). yellow solid (75.9 mg, 74%). mp: 61-64 °C. **^{1}H NMR** (400 MHz, Chloroform-*d*) δ 7.72 (d, *J* = 8.0 Hz, 2H), 7.62 (d, *J* = 8.0 Hz, 2H), 7.53-7.51 (m, 6H), 6.94 (d, *J* = 8.0 Hz, 2H), 4.81 (t, *J* = 8.0 Hz, 1H), 4.32-4.25 (m, 2H), 4.02-3.94 (m, 1H), 3.89-3.86 (m, 1H), 3.84 (s, 3H), 3.62 (dd, *J* = 14.5, 8.0 Hz, 1H), 3.54 (dd, *J* = 14.5, 8.0 Hz, 1H), 1.25 (t, *J* = 8.0 Hz, 3H), 0.98 (t, *J* = 8.0 Hz, 3H). **^{13}C NMR** (100 MHz, Chloroform-*d*) δ 194.08, 169.20, 164.04, 159.62, 154.93, 150.72, 134.96, 131.79, 131.10, 130.00, 129.96, 128.92, 128.64, 128.44, 123.37, 122.38, 117.20, 115.25, 114.07, 61.43, 60.77, 55.26, 54.01, 23.86, 13.95, 13.70. IR (KBr) ν: 3077, 2929, 1720, 1507, 1229, 1035 cm^{-1}. **HRMS** (m/z) [ESI]: calculated for $C_{32}H_{29}{}^{79}Br_2O_7^+$ $[M+H]^+$: 705.0094, found 705.0105; calculated for $C_{32}H_{29}{}^{81}Br_2O_7^+$ $[M+H]^+$: 707.0074, found 707.0069.

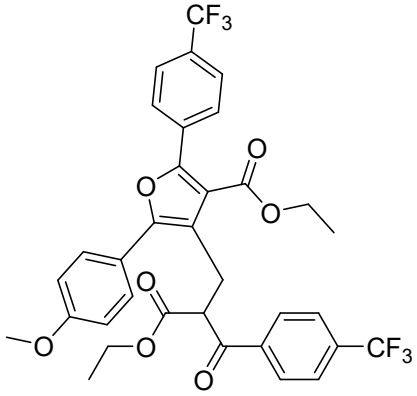


ethyl 4-(3-ethoxy-2-(3-fluorobenzoyl)-3-oxopropyl)-2-(3-fluorophenyl)-5-(4-methoxyphenyl)furan-3-carboxylate (3ha). yellow liquid (59.1 mg, 70%). **^{1}H NMR** (600 MHz, Chloroform-*d*) δ 7.71-7.68 (m, 1H), 7.56 (d, *J* = 6.0 Hz, 2H), 7.54-7.52 (m, 1H), 7.47-7.43 (m, 1H), 7.41-7.37 (m, 1H), 7.21 (t, *J* = 7.9 Hz, 1H), 7.16-7.11 (m, 2H), 7.05-7.02 (m, 1H), 6.94 (d, *J* = 6.0 Hz, 2H), 4.91 (t, *J* = 7.7 Hz, 1H), 4.25- 4.20 (m, 2H), 4.02-3.93 (m, 2H), 3.84 (s, 3H), 3.64-3.57 (m, 2H), 1.16 (t, *J* = 6.0 Hz, 3H), 1.03 (t, *J* = 6.0 Hz, 3H). **^{13}C NMR** (150 MHz, Chloroform-*d*) δ 193.89 (d, *J* = 3.1 Hz), 169.48, 163.80, 162.08, 160.49 (d, *J* = 30.0 Hz), 159.49, 158.92, 150.79 (d, *J* = 136.5 Hz), 134.54 (d, *J* = 9.0 Hz), 130.91 (d, *J* = 7.5 Hz), 130.82 (d, *J* = 3.0 Hz), 130.71 (d, *J* = 1.5 Hz), 128.30, 125.51 (d, *J* = 12.0 Hz), 124.32 (d, *J* = 3.0 Hz), 123.66 (d, *J* = 3.0 Hz), 122.64, 119.06 (d, *J* = 15.0 Hz), 117.59, 116.80, 116.45 (d, *J* = 24.0 Hz), 115.64 (d, *J* = 22.5 Hz), 114.04, 61.19, 60.47, 57.04, 57.00, 55.27, 23.55, 13.73. **^{19}F NMR** (565 MHz, Chloroform-*d*) δ -110.52, -111.83. IR (KBr) ν: 3077, 2983, 1738, 1508, 1253, 1031 cm^{-1}. **HRMS** (m/z) [ESI]: calculated for $C_{32}H_{29}F_2O_7^+$ $[M+H]^+$: 563.1876, found 563.1883.

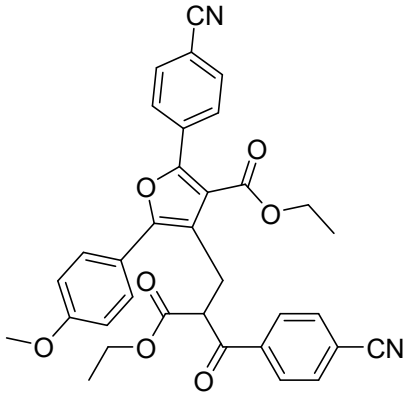


ethyl 4-(3-ethoxy-2-(2-fluorobenzoyl)-3-oxopropyl)-2-(2-fluorophenyl)-5-(4-methoxyphenyl)furan-3-carboxylate (3ia). yellow liquid (53.9 mg, 64%). **^{1}H NMR** (600 MHz, Chloroform-*d*) δ 7.65 (d, *J* = 6.0 Hz, 1H), 7.56-7.53 (m, 4H), 7.49 (d, *J* = 6.0 Hz, 1H), 7.39-7.35 (m, 2H), 7.24-7.21 (m, 1H), 7.10-7.07 (m, 1H), 6.96 (d, *J* = 12.0 Hz, 2H), 4.84 (t, *J* = 6.0 Hz, 1H), 4.34-4.29 (m, 2H), 4.01-3.96 (m, 1H), 3.90- 3.86 (m, 1H), 3.85 (s, 3H), 3.63 (dd, *J* = 18.0, 6.0 Hz, 1H), 3.55 (dd, *J* = 18.0, 6.0 Hz, 1H), 1.26 (t, *J* = 6.0 Hz, 3H), 0.99 (t, *J* = 6.0 Hz, 3H). **^{13}C NMR** (150 MHz, Chloroform-*d*) δ 193.92, 169.18, 164.07, 163.27 (d, *J* = 67.5 Hz), 161.63 (d, *J* = 64.5 Hz), 159.67, 154.37, 150.83, 138.32 (d, *J* = 6.0 Hz), 131.94 (d, *J* = 7.5 Hz), 130.17 (d, *J* = 7.5 Hz), 129.46 (d, *J* = 7.5 Hz), 128.48, 124.24 (d, *J* = 3.0 Hz), 124.12 (d, *J* = 3.0 Hz), 122.37, 120.41 (d, *J* = 22.5 Hz), 117.23, 115.92 (d, *J* = 21.0 Hz), 115.58 (d, *J* = 15.0 Hz), 115.34 (d, *J* = 9.0 Hz), 115.16, 114.11, 61.46, 60.87,

55.29, 54.08, 23.88, 13.87, 13.71. **^{19}F NMR** (565 MHz, Chloroform-*d*) δ -111.61, -113.28. IR (KBr) ν: 3077, 2983, 1716, 1508, 1251, 1043 cm^{-1}. **HRMS** (m/z) [ESI]: calculated for $C_{32}H_{28}F_2O_7$+Na^+ $[M+Na]^+$: 585.1695, found 585.1701.

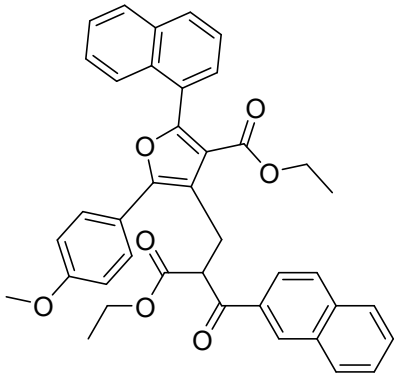


ethyl 4-(3-ethoxy-3-oxo-2-(4-(trifluoromethyl)benzoyl)propyl)-5-(4-methoxyphenyl)-2-(4-(trifluoromethyl)phenyl)furan-3-carboxylate (3ja). yellow solid (59.6 mg, 60%). mp: 51-53 °C. **^{1}H NMR** (600 MHz, Chloroform-*d*) δ 7.97 (d, *J* = 6.0 Hz, 2H), 7.85 (d, *J* = 12.0 Hz, 2H), 7.67-7.65 (m, 4H), 7.55 (d, *J* = 6.0 Hz, 2H), 6.96 (d, *J* = 12.0 Hz, 2H), 4.88 (t, *J* = 7.5 Hz, 1H), 4.33-4.28 (m, 2H), 4.01-3.96 (m, 1H), 3.89- 3.86 (m, 1H), 3.85 (s, 3H), 3.65 (dd, *J* = 14.6, 6.0 Hz, 1H), 3.59 (dd, *J* = 14.6, 6.0 Hz, 1H), 1.25 (t, *J* = 6.0 Hz, 3H), 0.99 (t, *J* = 6.0 Hz, 3H). **^{13}C NMR** (150 MHz, Chloroform-*d*) δ 194.22, 169.04, 163.96, 159.81, 154.22, 151.35, 138.90, 134.53 (d, *J* = 31.5 Hz), 133.30, 130.67 (d, *J* = 33.0 Hz), 128.74 (d, *J* = 13.5 Hz), 128.52, 125.58 (d, *J* = 3.0 Hz), 124.88 (d, *J* = 3.0 Hz), 124.33, 123.02, 122.52, 122.21, 117.26, 116.20, 114.16, 61.60, 60.97, 55.29, 54.30, 23.79, 13.93, 13.69. **^{19}F NMR** (565 MHz, Chloroform-*d*) δ -62.75, -63.18. IR (KBr) ν: 3077, 2985, 1735, 1504, 1254, 1068 cm^{-1}. **HRMS** (m/z) [ESI]: calculated for $C_{34}H_{28}F_6O_7$$^+$$Na^+$ $[M+Na]^+$: 685.1631, found 685.1636.

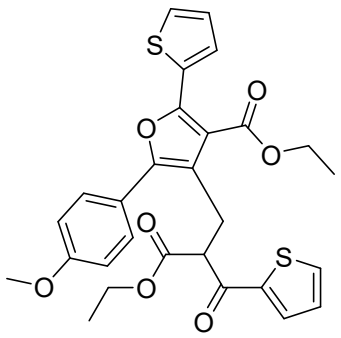


ethyl 4-(2-(4-cyanobenzoyl)-3-ethoxy-3-oxopropyl)-2-(4-cyanophenyl)-5-(4-methoxyphenyl)furan-3-carboxylate (3ka). yellow solid (50.2 mg, 58%). mp: 61-64 °C. **^{1}H NMR** (600 MHz, Chloroform-*d*) δ 7.94 (d, *J* = 12.0 Hz, 2H), 7.87 (d, *J* = 12.0 Hz, 2H), 7.70-7.68 (m, 4H), 7.54 (d, *J* = 6.0 Hz, 2H), 6.96 (d, *J* = 12.0 Hz, 2H), 4.82 (t, *J* = 6.0 Hz, 1H), 4.34-4.30 (m, 2H), 3.99-3.94 (m, 1H), 3.85 (s, 3H), 3.85-3.82 (m, 1H), 3.63 (dd, *J* = 14.6, 6.0 Hz, 1H), 3.57 (dd, *J* = 14.6, 6.0 Hz, 1H), 1.26 (t, *J* = 6.0 Hz, 3H), 0.96 (t, *J* = 6.0 Hz, 3H). **^{13}C NMR** (150 MHz, Chloroform-*d*) δ 193.67, 168.74, 163.80, 159.95, 153.24, 151.80, 139.07, 133.95, 132.38, 131.75, 128.82, 128.69, 128.55, 121.95, 118.56, 117.71, 117.48, 116.94, 116.58, 114.21, 112.23, 61.72, 61.16, 55.34, 54.37, 23.65, 13.94, 13.68. IR (KBr) ν: 3074,

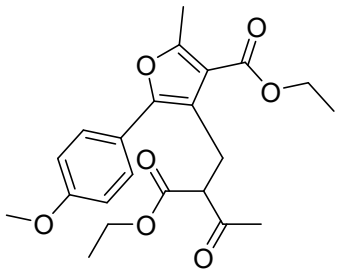
2982, 2228, 1716, 1603, 1254, 1025 cm^{-1}. **HRMS** (m/z) [ESI]: calculated for $C_{34}H_{28}N_2O_7$+Na^+ $[M+Na]^+$: 599.1789, found 599.1797.



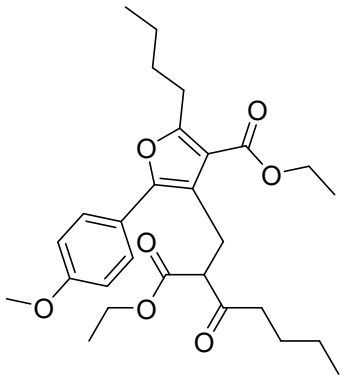
ethyl 4-(2-(2-naphthoyl)-3-ethoxy-3-oxopropyl)-5-(4-methoxyphenyl)-2-(naphthalen-1-yl)furan-3-carboxylate (3la). yellow liquid (63.9 mg, 68%). **^{1}H NMR** (600 MHz, Chloroform-*d*) δ 8.41 (s, 1H), 8.13 (s, 1H), 7.94-7.89 (m, 2H), 7.85-7.81 (m, 5H), 7.73-7.71 (m, 1H), 7.60-7.56 (m, 3H), 7.53-7.50 (m, 3H), 6.94 (d, *J* = 12.0 Hz, 2H), 5.10 (t, *J* = 7.5 Hz, 1H), 4.35-4.29 (m, 2H), 4.05-3.99 (m, 1H), 3.95-3.89 (m, 1H), 3.83 (s, 3H), 3.72 (dd, *J* = 14.5, 7.9 Hz, 1H), 3.65 (dd, *J* = 14.4, 7.3 Hz, 1H), 1.23 (t, *J* = 7.1 Hz, 3H), 1.02 (t, *J* = 7.1 Hz, 3H). **^{13}C NMR** (150 MHz, Chloroform-*d*) δ 195.38, 169.76, 164.43, 159.52, 156.17, 150.68, 135.63, 133.76, 133.33, 132.70, 132.32, 130.66, 129.71, 128.65, 128.52, 128.38, 128.24, 127.70, 127.64, 127.48, 127.30, 126.78, 126.72, 126.32, 125.86, 124.05, 122.72, 117.47, 115.28, 114.06, 61.36, 60.70, 55.29, 53.97, 24.24, 14.04, 13.82. IR (KBr) ν: 3068, 2925, 1734, 1571, 1250, 1090 cm^{-1}. **HRMS** (m/z) [ESI]: calculated for $C_{40}H_{34}O_7$+Na^+ $[M+Na]^+$: 649.2197, found 649.2197.



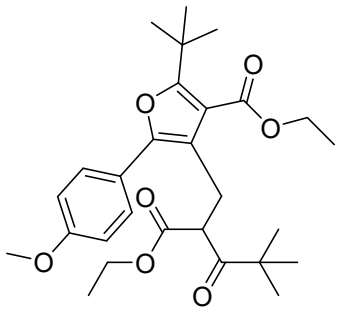
ethyl 4-(3-ethoxy-3-oxo-2-(thiophene-2-carbonyl)propyl)-5-(4-methoxyphenyl)-2-(thiophen-2-yl)furan-3-carboxylate (3ma). red liquid (58.2 mg, 72%). **^{1}H NMR** (400 MHz, Chloroform-*d*) δ 7.87 (d, *J* = 4.0 Hz, 1H), 7.67-7.56 (m, 4H), 7.41 (d, *J* = 4.0 Hz, 1H), 7.11-7.03 (m, 2H), 6.95 (d, *J* = 8.0 Hz, 2H), 4.66 (t, *J* = 8.0 Hz, 1H), 4.42-4.35 (m, 2H), 4.04-3.96 (m, 1H), 3.92-3.86 (m, 1H), 3.84 (s, 3H), 3.67 (dd, *J* = 14.4, 8.0 Hz, 1H), 3.55 (dd, *J* = 14.5, 8.0 Hz, 1H), 1.34 (t, *J* = 8.0 Hz, 3H), 1.01 (t, *J* = 8.0 Hz, 3H). **^{13}C NMR** (100 MHz, Chloroform-*d*) δ 187.40, 169.13, 163.88, 159.57, 151.71, 149.85, 143.45, 134.76, 132.96, 131.70, 128.62, 128.54, 128.12, 127.79, 127.10, 122.38, 117.02, 114.04, 113.33, 61.42, 60.73, 55.30, 55.25, 24.06, 14.14, 13.72. IR (KBr) ν: 3103, 2980, 1735, 1506, 1250, 1027 cm^{-1}. **HRMS** (m/z) [ESI]: calculated for $C_{28}H_{27}O_7S_2^+$ $[M+H]^+$: 539.1193, found 539.1201.



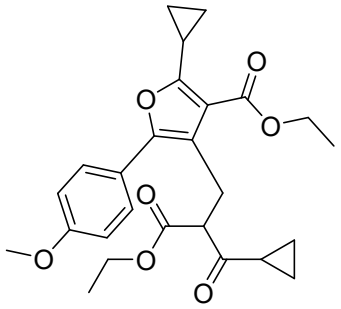
ethyl 4-(2-(ethoxycarbonyl)-3-oxobutyl)-5-(4-methoxyphenyl)-2-methylfuran-3-carboxylate (3na). yellow liquid (48.3 mg, 80%). **^{1}H NMR** (400 MHz, Chloroform-*d*) δ 7.49 (d, *J* = 8.0 Hz, 2H), 6.92 (d, *J* = 8.0 Hz, 2H), 4.29 (q, *J* = 8.0 Hz, 2H), 4.04-3.93 (m, 2H), 3.88-3.82 (m, 1H), 3.80 (s, 3H), 3.35 (d, *J* = 8.0 Hz, 2H), 2.56 (s, 3H), 2.10 (s, 3H), 1.34 (t, *J* = 6.0 Hz, 3H), 1.03 (t, *J* = 6.0 Hz, 3H). **^{13}C NMR** (100 MHz, Chloroform-*d*) δ 202.79, 169.41, 164.32, 159.23, 158.78, 149.04, 128.28, 122.90, 115.82, 113.92, 113.83, 61.10, 60.03, 59.51, 55.18, 28.91, 22.96, 14.57, 14.18, 13.71. IR (KBr) ν: 3057, 2984, 1714, 1508, 1253, 1027 cm^{-1}. **HRMS** (m/z) [ESI]: calculated for $C_{22}H_{26}O_7$+Na^+ $[M+Na]^+$: 425.1571, found 425.1577.



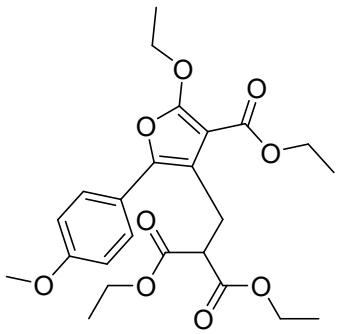
ethyl 2-butyl-4-(2-(ethoxycarbonyl)-3-oxoheptyl)-5-(4-methoxyphenyl)furan-3-carboxylate (3oa). yellow liquid (51.8 mg, 71%). **^{1}H NMR** (400 MHz, Chloroform-*d*) δ 7.49 (d, *J* = 8.9 Hz, 2H), 6.91 (d, *J* = 8.9 Hz, 2H), 4.28 (q, *J* = 7.1 Hz, 2H), 4.03-3.95 (m, 2H), 3.89-3.82 (m, 1H), 3.79 (s, 3H), 3.35 (d, *J* = 8.0 Hz, 2H), 2.98-2.94 (m, 2H), 2.45-2.27 (m, 2H), 1.69-1.61 (m, 2H), 1.45-1.31 (m, 7H), 1.21-1.12 (m, 2H), 1.03 (t, *J* = 7.1 Hz, 3H), 0.90 (t, *J* = 7.4 Hz, 3H), 0.80 (t, *J* = 7.3 Hz, 3H). **^{13}C NMR** (100 MHz, Chloroform-*d*) δ 205.11, 169.44, 164.22, 162.69, 159.14, 148.91, 128.12, 122.97, 115.70, 113.86, 113.39, 60.94, 59.94, 58.40, 55.10, 41.95, 30.15, 27.96, 25.25, 23.06, 22.27, 21.89, 14.10, 13.70, 13.65, 13.61. IR (KBr) ν: 3068, 2951, 1713, 1508, 1252, 1030 cm^{-1}. **HRMS** (m/z) [ESI]: calculated for $C_{28}H_{39}O_7^+$ $[M+H]^+$: 487.2690, found 487.2685.



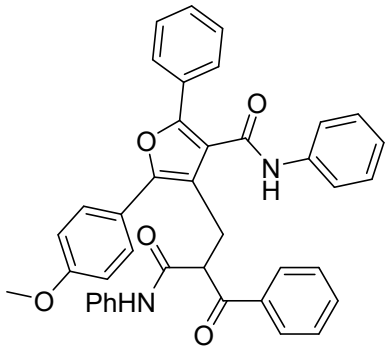
ethyl 2-(*tert*-butyl)-4-(2-(ethoxycarbonyl)-4,4-dimethyl-3-oxopentyl)-5-(4-methoxyphenyl)furan-3-carboxylate (3pa). yellow liquid (54.0 mg, 74%). **^{1}H NMR** (400 MHz, Chloroform-*d*) δ 7.52 (d, *J* = 8.0 Hz, 2H), 6.92 (d, *J* = 8.0 Hz, 2H), 4.38-4.29 (m, 2H), 4.26 (t, *J* = 7.5 Hz, 1H), 4.04-3.90 (m, 2H), 3.79 (s, 3H), 3.34-3.32 (m, 2H), 1.39-1.35 (m, 12H), 1.09 (t, *J* = 8.0 Hz, 3H), 0.95 (s, 9H). **^{13}C NMR** (100 MHz, Chloroform-*d*) δ 209.70, 169.10, 164.97, 164.23, 159.00, 147.06, 127.65, 123.12, 116.18, 114.21, 113.88, 61.00, 60.54, 55.06, 51.93, 45.03, 34.39, 28.45, 25.71, 24.64, 14.01, 13.74. IR (KBr) ν: 3077, 2975, 1712, 1508, 1252, 1034 cm^{-1}. **HRMS** (m/z) [ESI]: calculated for $C_{28}H_{39}O_7^+$ $[M+H]^+$: 487.2690, found 487.2688.



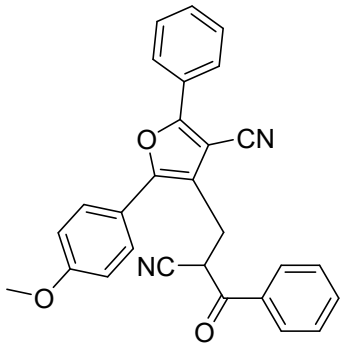
ethyl 4-(2-(cyclopropanecarbonyl)-3-ethoxy-3-oxopropyl)-2-cyclopropyl-5-(4-methoxyphenyl)furan-3-carboxylate (3qa). yellow solid (53.1 mg, 78%). mp: 82-86 °C. **^{1}H NMR** (400 MHz, Chloroform-*d*) δ 7.42 (d, *J* = 8.8 Hz, 2H), 6.87 (d, *J* = 8.8 Hz, 2H), 4.29 (q, *J* = 7.1 Hz, 2H), 4.11 (t, *J* = 8.0 Hz, 1H), 4.04-3.96 (m, 1H), 3.87-3.79 (m, 1H), 3.75 (s, 3H), 3.37 (d, *J* = 8.0 Hz, 2H), 2.79-2.72 (m, 1H), 1.97- 1.91 (m, 1H), 1.32 (t, *J* = 4.0 Hz, 3H), 1.05-0.98 (m, 7H), 0.94-0.88 (m, 2H), 0.79-0.70 (m, 2H). **^{13}C NMR** (100 MHz, Chloroform-*d*) δ 204.92, 169.39, 164.50, 162.49, 158.98, 147.59, 127.99, 122.90, 115.92, 113.72, 113.42, 60.82, 59.86, 59.50, 55.02, 22.99, 19.71, 14.07, 13.66, 11.54, 11.34, 9.41, 8.48, 8.39. IR (KBr) ν: 3055, 2983, 1737, 1513, 1255, 1042 cm^{-1}. **HRMS** (m/z) [ESI]: calculated for $C_{26}H_{30}O_7$+Na^+ $[M+Na]^+$: 477.1884, found 477.1883.



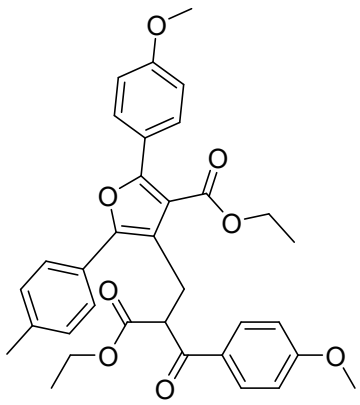
diethyl 2-((5-ethoxy-4-(ethoxycarbonyl)-2-(4-methoxyphenyl)furan-3-yl)methyl)malonate (3ra). yellow solid (52.0 mg, 75%). mp: 40-42 °C. **^{1}H NMR** (400 MHz, Chloroform-*d*) δ 7.43 (d, *J* = 8.7 Hz, 2H), 6.88 (d, *J* = 8.7 Hz, 2H), 4.41 (q, *J* = 8.0 Hz, 2H), 4.23 (q, *J* = 8.0 Hz, 2H), 4.06-3.97 (m, 2H), 3.95-3.87 (m, 3H), 3.76 (s, 3H), 3.37 (d, *J* = 8.0 Hz, 2H), 1.42 (t, *J* = 4.0 Hz, 3H), 1.28 (t, *J* = 8.0 Hz, 3H), 1.06 (t, *J* = 8.0 Hz, 6H). **^{13}C NMR** (100 MHz, Chloroform-*d*) δ 168.86, 163.29, 161.77, 158.83, 140.88, 127.79, 122.46, 115.84, 113.80, 92.47, 67.26, 60.96, 59.56, 55.05, 51.54, 23.96, 14.75, 14.05, 13.67. IR (KBr) ν: 3045, 2984, 1733, 1597, 1254, 1030 cm^{-1}. **HRMS** (m/z) [ESI]: calculated for $C_{24}H_{30}O_9$+Na^+ $[M+Na]^+$: 485.1782, found 485.1789.



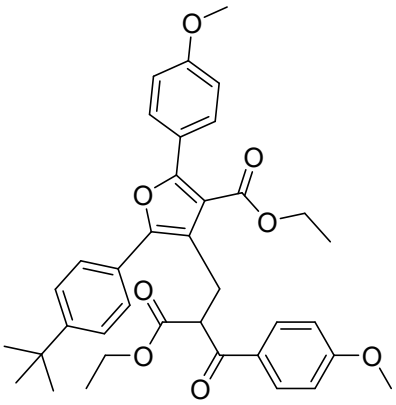
4-(2-benzoyl-3-oxo-3-(phenylamino)propyl)-5-(4-methoxyphenyl)-*N*,2-diphenylfuran-3-carboxamide (3sa). red solid (53.1 mg, 57%). mp: 165-167 °C. **^{1}H NMR** (400 MHz, Chloroform-*d*) δ 9.15 (s, 1H), 8.19 (s, 1H), 7.98 (d, *J* = 4.0 Hz, 2H), 7.70 (d, *J* = 8.0 Hz, 2H), 7.61-7.52 (m, 5H), 7.43-7.34 (m, 9H), 7.19 (q, *J* = 8.0 Hz, 3H), 7.01 (t, *J* = 8.0 Hz, 1H), 6.91 (d, *J* = 8.0 Hz, 2H), 5.09 (dd, *J* = 9.0, 7.1 Hz, 1H), 3.81 (s, 3H), 3.70 (dd, *J* = 14.8, 8.0 Hz, 1H), 3.41 (dd, *J* = 14.8, 8.0 Hz, 1H). **^{13}C NMR** (100 MHz, Chloroform-*d*) δ 197.01, 166.92, 164.15, 159.59, 150.98, 150.33, 137.58, 137.51, 136.03, 133.73, 129.15, 129.12, 128.88, 128.87, 128.71, 128.67, 128.57, 126.55, 124.95, 124.13, 122.42, 120.10, 119.67, 116.44, 114.08, 55.21, 55.03, 25.30. IR (KBr) ν: 3287, 3058, 2929, 1653, 1504, 1252, 1028 cm^{-1}. **HRMS** (m/z) [ESI]: calculated for $C_{40}H_{33}N_2O_5^+$ $[M+H]^+$: 621.2384, found 621.2392.



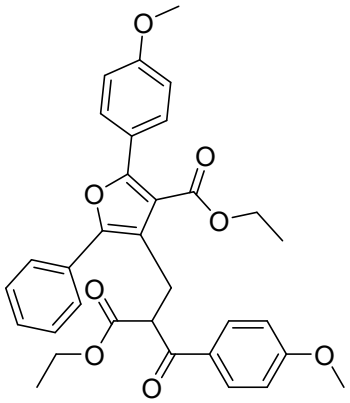
4-(2-cyano-3-oxo-3-phenylpropyl)-5-(4-methoxyphenyl)-2-phenylfuran-3-carbonitrile (3ta). red solid (31.1 mg, 48%). mp: 56-59 °C. **^{1}H NMR** (600 MHz, Chloroform-*d*) δ 8.04-8.01 (m, 4H), 7.68-7.64 (m, 3H), 7.55-7.50 (m, 4H), 7.46 (t, *J* = 6.0 Hz, 1H), 7.03 (d, *J* = 6.0 Hz, 2H), 4.94 (dd, *J* = 12.0, 6.0 Hz, 1H), 3.88 (s, 3H), 3.51 (dd, *J* = 15.0, 10.3 Hz, 1H), 3.40 (dd, *J* = 15.0, 6.1 Hz, 1H). **^{13}C NMR** (150 MHz, Chloroform-*d*) δ 189.44, 160.45, 158.51, 151.61, 134.91, 133.62, 130.37, 129.24, 129.14, 129.00, 128.55, 127.68, 125.34, 120.97, 116.27, 115.81, 114.88, 114.56, 93.85, 55.41, 38.64, 24.84. IR (KBr) ν: 3064, 2926, 2227, 1757, 1598, 1260, 1026 cm^{-1}. **HRMS** (m/z) [ESI]: calculated for $C_{28}H_{21}N_2O_3^+$ $[M+H]^+$: 433.1547, found 433.1547.



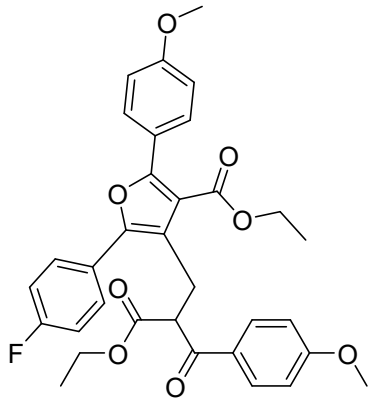
ethyl 4-(3-ethoxy-2-(4-methoxybenzoyl)-3-oxopropyl)-2-(4-methoxyphenyl)-5-(*p*-tolyl)furan-3-carboxylate (3ab). yellow liquid (69.3 mg, 81%). **^{1}H NMR** (600 MHz, Chloroform-*d*) δ 7.88 (d, *J* = 12.0 Hz, 2H), 7.73 (d, *J* = 12.0 Hz, 2H), 7.52 (d, *J* = 6.0 Hz, 2H), 7.21 (d, *J* = 6.0 Hz, 2H), 6.94 (d, *J* = 12.0 Hz, 2H), 6.86 (d, *J* = 6.0 Hz, 2H), 4.83-4.81 (m, 1H), 4.31-4.25 (m, 2H), 3.98-3.93 (m, 1H), 3.85 (s, 3H), 3.82 (s, 3H), 3.81-3.79 (m, 1H), 3.67 (dd, *J* = 14.5, 6.0 Hz, 1H), 3.55 (dd, *J* = 14.5, 6.0 Hz, 1H), 2.37 (s, 3H), 1.24 (t, *J* = 6.0 Hz, 3H), 0.97 (t, *J* = 6.0 Hz, 3H). **^{13}C NMR** (150 MHz, Chloroform-*d*) δ 193.41, 169.73, 164.37, 163.63, 160.20, 156.68, 149.84, 137.87, 130.89, 130.07, 129.29, 129.21, 127.37, 126.80, 122.72, 117.86, 113.89, 113.60, 113.27, 61.16, 60.48, 55.37, 55.24, 53.83, 24.06, 21.22, 13.96, 13.66. IR (KBr) ν: 3065, 2974, 1735, 1601, 1257, 1030 cm^{-1}. **HRMS** (m/z) [ESI]: calculated for $C_{34}H_{35}O_8^+$ $[M+H]^+$: 571.2326, found 527.2331.



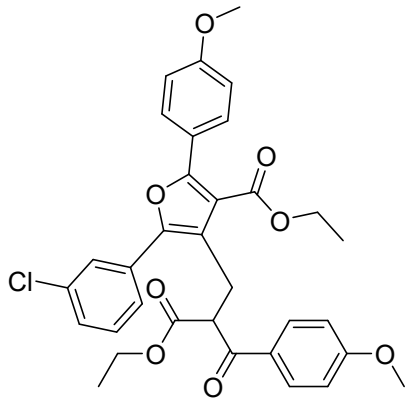
ethyl 5-(4-(*tert*-butyl)phenyl)-4-(3-ethoxy-2-(4-methoxybenzoyl)-3-oxopropyl)-2-(4-methoxyphenyl)furan-3-carboxylate (3ac). yellow liquid (66.1 mg, 72%). **^{1}H NMR** (600 MHz, Chloroform-*d*) δ 7.91 (d, *J* = 6.0 Hz, 2H), 7.74 (d, *J* = 12.0 Hz, 2H), 7.58 (d, *J* = 12.0 Hz, 2H), 7.43 (d, *J* = 12.0 Hz, 2H), 6.94 (d, *J* = 12.0 Hz, 2H), 6.87 (d, *J* = 6.0 Hz, 2H), 4.83 (dd, *J* = 8.4, 6.4 Hz, 1H), 4.30-4.24 (m, 2H), 3.96-3.90 (m, 1H), 3.86 (s, 3H), 3.83 (s, 3H), 3.78-3.73 (m, 1H), 3.70 (dd, *J* = 14.6, 8.7 Hz, 1H), 3.54 (dd, *J* = 14.5, 6.3 Hz, 1H), 1.34 (s, 9H), 1.23 (t, *J* = 7.1 Hz, 3H), 0.92 (t, *J* = 7.1 Hz, 3H). **^{13}C NMR** (150 MHz, Chloroform-*d*) δ 193.42, 169.74, 164.40, 163.67, 160.23, 156.80, 151.01, 149.86, 130.94, 130.12, 129.33, 127.42, 126.69, 125.49, 122.78, 118.00, 113.91, 113.66, 113.30, 61.14, 60.49, 55.40, 55.28, 54.07, 34.62, 31.19, 24.08, 14.00, 13.67. IR (KBr) ν: 3079, 2923, 1706, 1601, 1256, 1031 cm^{-1}. **HRMS** (m/z) [ESI]: calculated for $C_{37}H_{40}O_8$+Na^+ $[M+Na]^+$: 635.2615, found 635.2622.



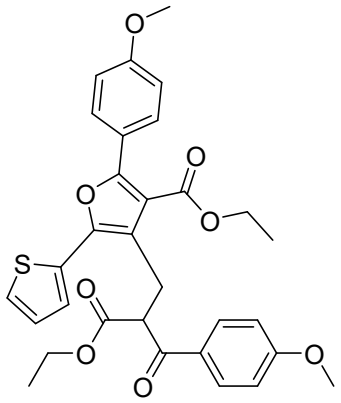
ethyl 4-(3-ethoxy-2-(4-methoxybenzoyl)-3-oxopropyl)-2-(4-methoxyphenyl)-5-phenylfuran-3-carboxylate (3ad). yellow liquid (65.1 mg, 78%). **^{1}H NMR** (600 MHz, Chloroform-*d*) δ 7.89 (d, *J* = 12.0 Hz, 2H), 7.75 (d, *J* = 6.0 Hz, 2H), 7.65-7.64 (m, 2H), 7.41 (t, *J* = 6.0 Hz, 2H), 7.32 (t, *J* = 6.0 Hz, 1H), 6.95 (d, *J* = 6.0 Hz, 2H), 6.86 (d, *J* = 12.0 Hz, 2H), 4.85-4.82 (m, 1H), 4.31-4.25 (m, 2H), 3.98-3.92 (m, 1H), 3.85 (s, 3H), 3.81 (s, 3H), 3.81-3.76 (m, 1H), 3.70 (dd, *J* = 14.5, 6.0 Hz, 1H), 3.57 (dd, *J* = 14.5, 6.0 Hz, 1H), 1.24 (t, *J* = 6.0 Hz, 3H), 0.95 (t, *J* = 6.0 Hz, 3H). **^{13}C NMR** (150 MHz, Chloroform-*d*) δ 193.33, 169.68, 164.31, 163.65, 160.27, 156.96, 149.61, 130.89, 130.20, 130.11, 129.26, 128.52, 127.94, 126.87, 122.63, 118.50, 113.95, 113.63, 113.29, 61.15, 60.51, 55.37, 55.24, 53.86, 24.03, 13.96, 13.66. IR (KBr) ν: 3068, 2980, 1732, 1601, 1257, 1028 cm^{-1}. **HRMS** (m/z) [ESI]: calculated for $C_{33}H_{32}O_8$+Na^+ $[M+Na]^+$: 579.1989, found 579.1996.



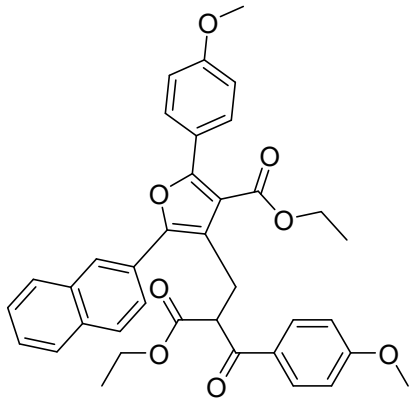
ethyl 4-(3-ethoxy-2-(4-methoxybenzoyl)-3-oxopropyl)-5-(4-fluorophenyl)-2-(4-methoxyphenyl)furan-3-carboxylate (3ae). yellow liquid (63.7 mg, 74%). **^{1}H NMR** (400 MHz, Chloroform-*d*) δ 7.88 (d, *J* = 8.9 Hz, 2H), 7.72 (d, *J* = 8.9 Hz, 2H), 7.63-7.60 (m, 2H), 7.10 (t, *J* = 8.0 Hz, 2H), 6.94 (d, *J* = 8.0 Hz, 2H), 6.86 (d, *J* = 8.0 Hz, 2H), 4.86 (t, *J* = 8.0 Hz, 1H), 4.32-4.24 (m, 2H), 4.02-3.94 (m, 1H), 3.89- 3.86 (m, 1H), 3.84 (s, 3H), 3.82 (s, 3H), 3.63 (dd, *J* = 16.0, 8.0 Hz, 1H), 3.52 (dd, *J* = 16.0, 8.0 Hz, 1H), 1.24 (t, *J* = 8.0 Hz, 3H), 0.99 (t, *J* = 8.0 Hz, 3H). **^{13}C NMR** (100 MHz, Chloroform-*d*) δ 193.35, 169.65, 164.24, 163.71, 163.56, 161.09, 160.33, 157.00, 148.82, 130.90, 130.11, 129.24, 128.86 (d, *J* = 8.0 Hz), 126.41 (d, *J* = 3.0 Hz), 122.52, 118.27, 115.55 (d, *J* = 21.0 Hz), 113.86, 113.48 (d, *J* = 33.0 Hz), 61.19, 60.55, 55.38, 55.24, 53.62, 24.08, 13.95, 13.71. **^{19}F NMR** (376 MHz, Chloroform-*d*) δ -112.92. IR (KBr) ν: 3080, 2980, 1735, 1600, 1257, 1030 cm^{-1}. **HRMS** (m/z) [ESI]: calculated for $C_{33}H_{30}FO_8$+Na^+ $[M+Na]^+$: 597.1895, found 597.1905.



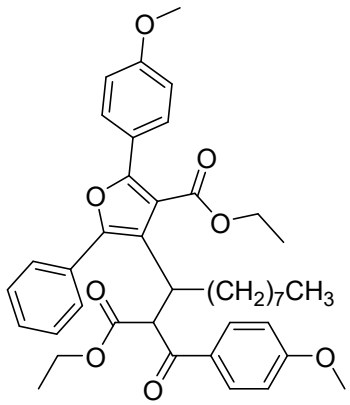
ethyl 5-(3-chlorophenyl)-4-(3-ethoxy-2-(4-methoxybenzoyl)-3-oxopropyl)-2-(4-methoxyphenyl)furan-3-carboxylate (3af). yellow solid (51.4 mg, 58%). mp: 41-44 °C. **^{1}H NMR** (600 MHz, Chloroform-*d*) δ 7.87 (d, *J* = 6.0 Hz, 2H), 7.72 (d, *J* = 6.0 Hz, 2H), 7.57-7.56 (m, 2H), 7.34 (t, *J* = 6.0 Hz, 1H), 7.29 (d, *J* = 7.9 Hz, 1H), 6.95 (d, *J* = 12.0 Hz, 2H), 6.86 (d, *J* = 12.0 Hz, 2H), 4.81 (t, *J* = 6.0 Hz, 1H), 4.31-4.25 (m, 2H), 4.02-3.96 (m, 1H), 3.89-3.87 (m, 1H), 3.86 (s, 3H), 3.84 (s, 3H), 3.65 (dd, *J* = 14.5, 6.0 Hz, 1H), 3.54 (dd, *J* = 14.5, 6.0 Hz, 1H), 1.24 (t, *J* = 6.0 Hz, 3H), 0.99 (t, *J* = 6.0 Hz, 3H). **^{13}C NMR** (150 MHz, Chloroform-*d*) δ 193.30, 169.67, 164.17, 163.75, 160.48, 157.45, 148.13, 134.49, 131.90, 130.96, 130.23, 129.86, 129.21, 127.96, 126.82, 124.87, 122.39, 119.67, 114.07, 113.69, 113.39, 61.32, 60.68, 55.46, 55.34, 53.79, 24.07, 14.00, 13.75. IR (KBr) ν: 3065, 2926, 1735, 1601, 1258, 1030 cm^{-1}. **HRMS** (m/z) [ESI]: calculated for $C_{33}H_{32}ClO_8^+$ $[M+H]^+$: 591.1780, found 591.1779.



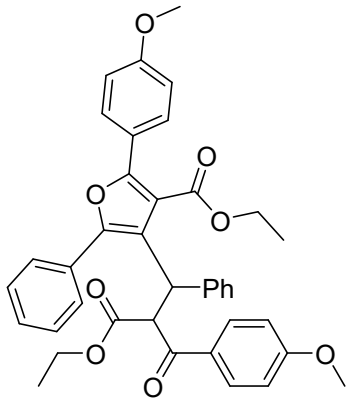
ethyl 4-(3-ethoxy-2-(4-methoxybenzoyl)-3-oxopropyl)-2-(4-methoxyphenyl)-5-(thiophen-2-yl)furan-3-carboxylate (3ag). yellow liquid (53.2 mg, 63%). **^{1}H NMR** (400 MHz, Chloroform-*d*) δ 7.91 (d, *J* = 8.0 Hz, 2H), 7.73 (d, *J* = 8.0 Hz, 2H), 7.43 (dd, *J* = 3.7, 1.0 Hz, 1H), 7.30 (dd, *J* = 5.1, 1.0 Hz, 1H), 7.07 (dd, *J* = 5.0, 3.7 Hz, 1H), 6.94 (d, *J* = 8.9 Hz, 2H), 6.87 (d, *J* = 8.9 Hz, 2H), 4.90-4.86 (m, 1H), 4.32- 4.24 (m, 2H), 4.07-3.93 (m, 2H), 3.84 (s, 3H), 3.81 (s, 3H), 3.68 (dd, *J* = 16.0, 8.0 Hz, 1H), 3.55 (dd, *J* = 16.0, 8.0 Hz, 1H), 1.25 (t, *J* = 8.0 Hz, 3H), 1.03 (t, *J* = 8.0 Hz, 3H). **^{13}C NMR** (100 MHz, Chloroform-*d*) δ 193.29, 169.67, 163.99, 163.66, 160.33, 156.57, 145.27, 131.66, 130.87, 130.09, 129.25, 127.44, 125.26, 124.77, 122.29, 118.20, 114.06, 113.62, 113.29, 61.23, 60.55, 55.34, 55.21, 53.35, 24.27, 13.92, 13.72. IR (KBr) ν: 3080, 2980, 1710, 1601, 1258, 1029 cm^{-1}. **HRMS** (m/z) [ESI]: calculated for $C_{31}H_{31}O_8S^+$ $[M+H]^+$: 563.1734, found 563.1738.



ethyl 4-(3-ethoxy-2-(4-methoxybenzoyl)-3-oxopropyl)-2-(4-methoxyphenyl)-5-(naphthalen-2-yl)furan-3-carboxylate (3ah). yellow liquid (65.5 mg, 72%). **^{1}H NMR** (600 MHz, Chloroform-*d*) δ 8.10 (s, 1H), 7.88-7.86 (m, 4H), 7.84-7.77 (m, 4H), 7.51-7.47 (m, 2H), 6.98 (d, *J* = 8.8 Hz, 2H), 6.81 (d, *J* = 8.9 Hz, 2H), 4.86 (t, *J* = 6.0 Hz, 1H), 4.36-4.29 (m, 2H), 3.97-3.92 (m, 1H), 3.86 (s, 3H), 3.84-3.80 (m, 2H), 3.78 (s, 3H), 3.71-3.67 (m, 1H), 1.28 (t, *J* = 6.0 Hz, 3H), 0.91 (t, *J* = 6.0 Hz, 3H). **^{13}C NMR** (150 MHz, Chloroform-*d*) δ 193.35, 169.72, 164.28, 163.59, 160.29, 157.06, 149.59, 133.10, 132.62, 130.85, 130.12, 129.17, 128.30, 128.15, 127.54, 127.52, 126.32, 125.91, 124.43, 122.60, 119.02, 114.14, 113.56, 113.31, 61.16, 60.55, 55.31, 55.23, 53.96, 24.15, 13.96, 13.58. IR (KBr) ν: 3058, 2980, 1731, 1600, 1257, 1030 cm^{-1}. **HRMS** (m/z) [ESI]: calculated for $C_{37}H_{35}O_8^+$ $[M+H]^+$: 607.2326, found 607.2322.



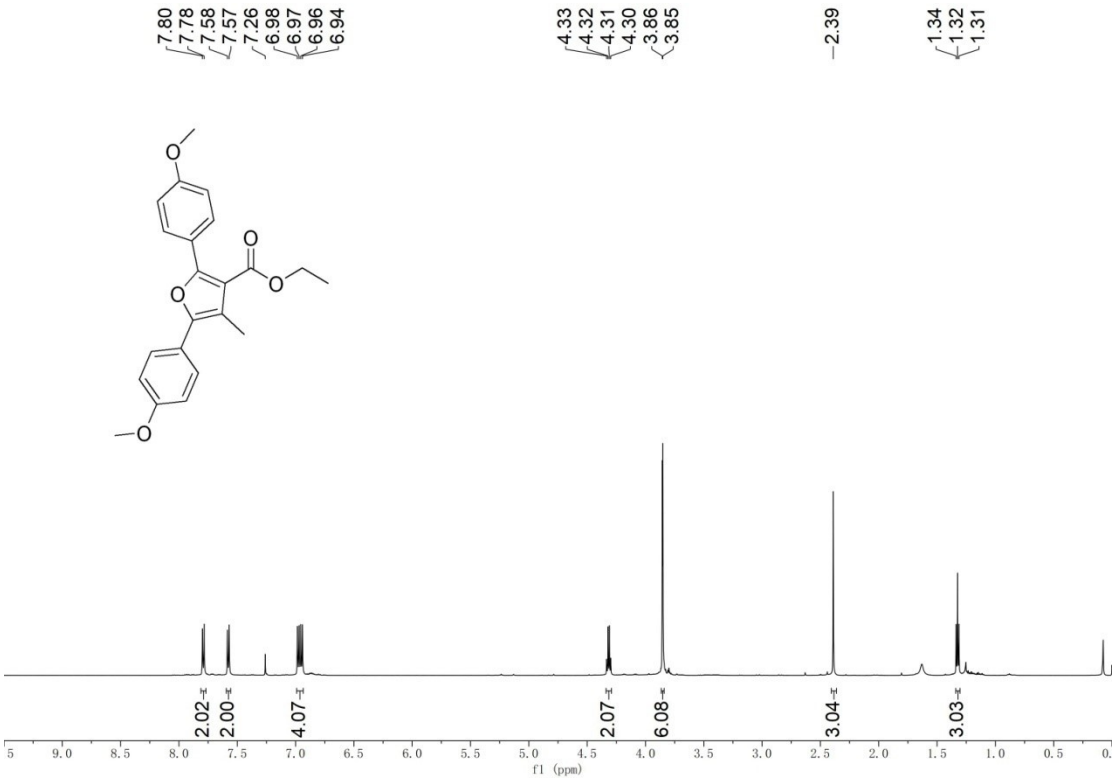
ethyl 4-(1-ethoxy-2-(4-methoxybenzoyl)-1-oxoundecan-3-yl)-2-(4-methoxyphenyl)-5-phenylfuran-3-carboxylate (3ai). yellow liquid (61.1 mg, 61%). **^{1}H NMR** (600 MHz, Chloroform-*d*) δ 7.94 (d, *J* = 6.0 Hz, 2H), 7.84 (s, 2H), 7.47 (t, *J* = 7.6 Hz, 2H), 7.41 (d, *J* = 12.0 Hz, 2H), 7.37 (t, *J* = 6.0 Hz, 1H), 6.86 (d, *J* = 12.0 Hz, 2H), 6.82 (d, *J* = 12.0 Hz, 2H), 4.27-4.22 (m, 1H), 4.18-4.12 (m, 4H), 3.89-3.84 (m, 1H), 3.82 (s, 3H), 3.79 (s, 3H), 1.92-1.87 (m, 1H), 1.66-1.61 (m, 1H), 1.23-1.17 (m, 9H), 1.14-1.04 (m, 9H), 0.83 (t, *J* = 7.3 Hz, 3H). **^{13}C NMR** (150 MHz, Chloroform-*d*) δ 193.86, 169.34, 165.54, 163.40, 159.98, 156.24, 150.92, 131.26, 130.65, 130.12, 129.57, 128.44, 128.07, 127.94, 122.98, 120.74, 113.92, 113.32, 113.20, 61.18, 60.67, 57.04, 55.34, 55.26, 36.16, 32.09, 31.75, 29.36, 29.34, 29.17, 27.43, 22.58, 14.06, 14.05, 13.80. IR (KBr) ν: 3053, 2921, 1741, 1602, 1257, 1033 cm^{-1}. **HRMS** (m/z) [ESI]: calculated for $C_{41}H_{49}O_8^+$ $[M+H]^+$: 669.3422, found 669.3419.

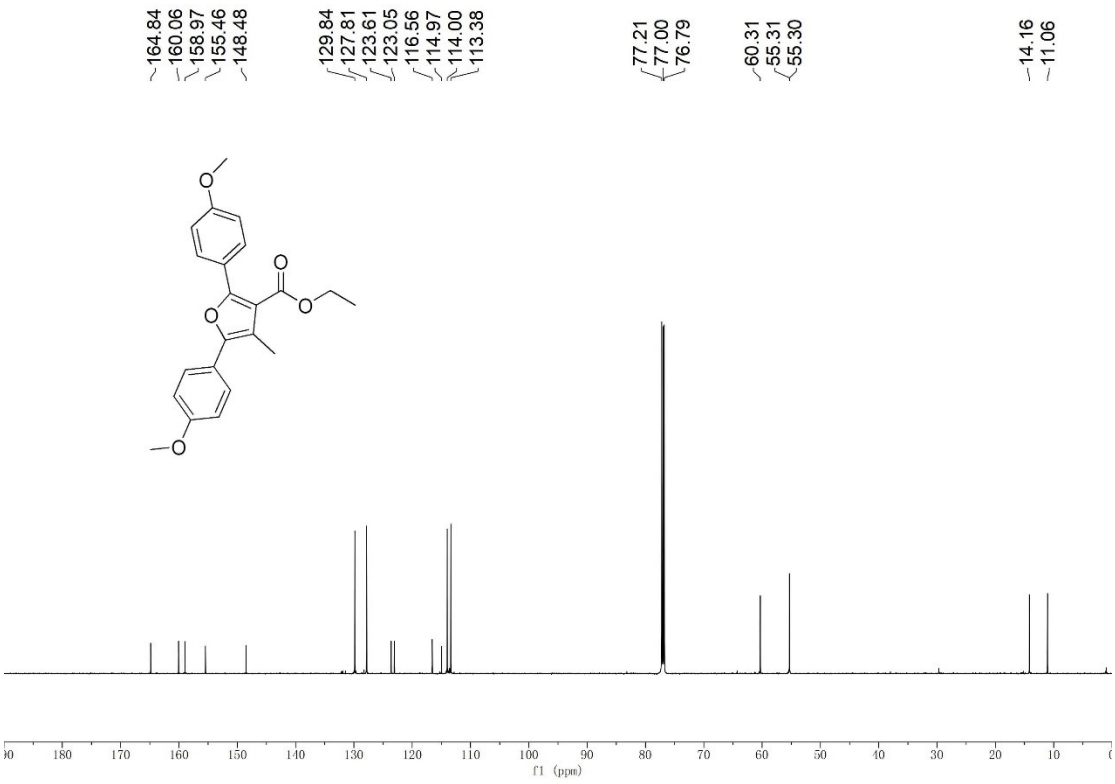


ethyl 4-(3-ethoxy-2-(4-methoxybenzoyl)-3-oxo-1-phenylpropyl)-2-(4-methoxyphenyl)-5-phenylfuran-3-carboxylate (3aj). yellow solid (43.6 mg, 46%). mp: 58-61 °C. **^{1}H NMR** (600 MHz, Chloroform-*d*) δ 8.03 (d, *J* = 6.0 Hz, 2H), 7.80 (d, *J* = 6.0 Hz, 2H), 7.46 (t, *J* = 6.0 Hz, 2H), 7.42-7.39 (m, 3H), 7.34 (d, *J* = 6.0 Hz, 2H), 7.23 (t, *J* = 6.0 Hz, 2H), 7.15 (t, *J* = 6.0 Hz, 1H), 6.84 (t, *J* = 8.6 Hz, 4H), 6.09 (d, *J* = 12.0 Hz, 1H), 5.57 (d, *J* = 12.0 Hz, 1H), 4.12-4.07 (m, 1H), 4.05-4.02 (m, 1H), 4.02-3.98 (m, 2H), 3.81 (s, 3H), 3.80 (s, 3H), 1.04 (t, *J* = 6.0 Hz, 3H), 1.00 (t, *J* = 6.0 Hz, 3H). **^{13}C NMR** (150 MHz, Chloroform-*d*) δ 192.71, 168.66, 165.49, 163.64, 159.97, 155.48, 149.84, 141.18, 131.52, 130.55, 129.71, 129.29, 128.56, 128.46, 128.26, 128.11, 128.04, 126.47, 122.74, 121.86, 113.92, 113.44, 113.28, 61.31, 60.70, 55.89, 55.41, 55.25, 40.73, 13.80, 13.69. IR (KBr) ν: 3065, 2932, 1710, 1601, 1258, 1030 cm^{-1}. **HRMS** (m/z) [ESI]: calculated for $C_{39}H_{37}O_8^+$ $[M+H]^+$: 633.2483, found 633.2479.

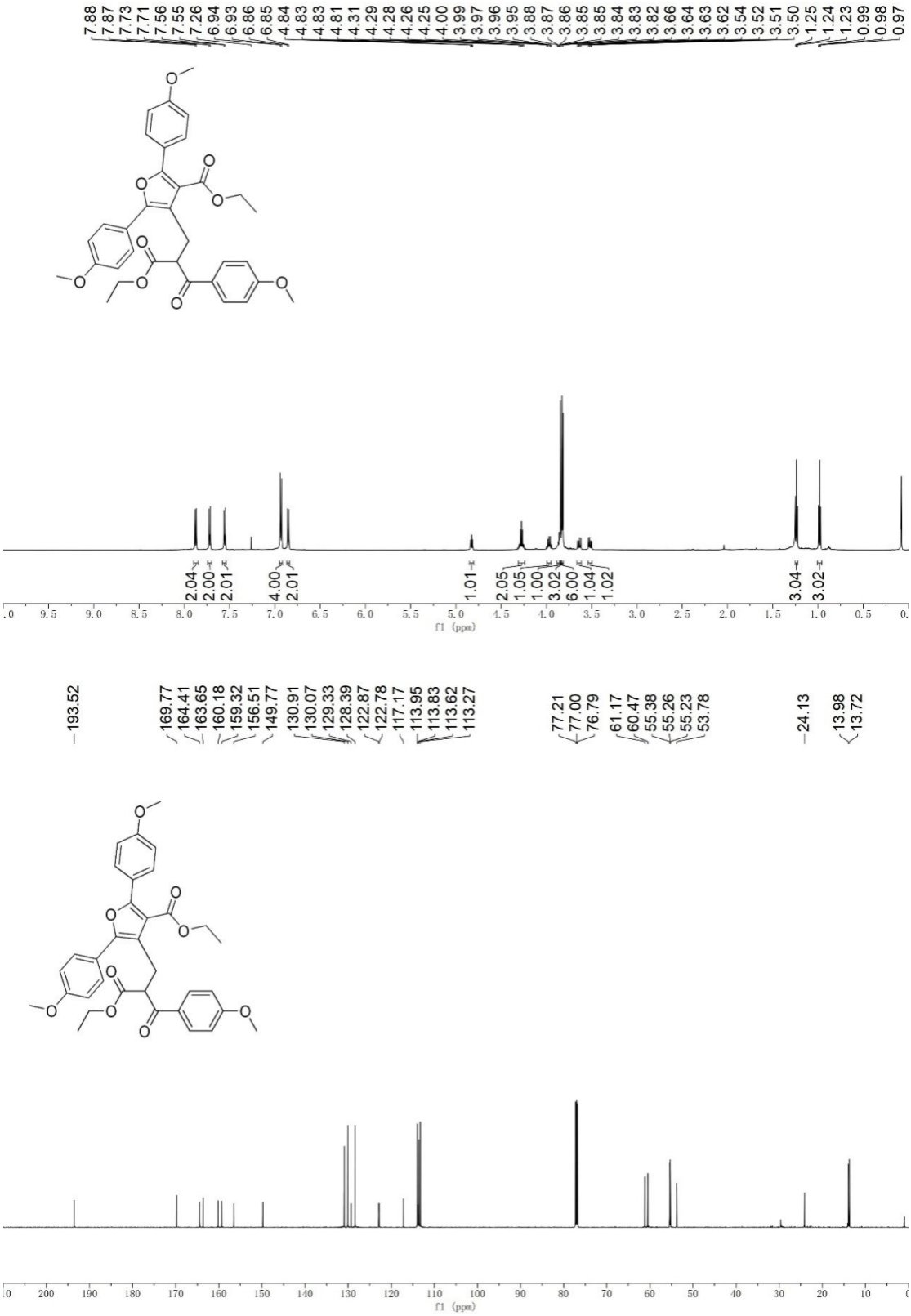
11. Copies of ^{1}H NMR and ^{13}C NMR for the Products

ethyl 2,5-bis(4-methoxyphenyl)-4-methylfuran-3-carboxylate (10)

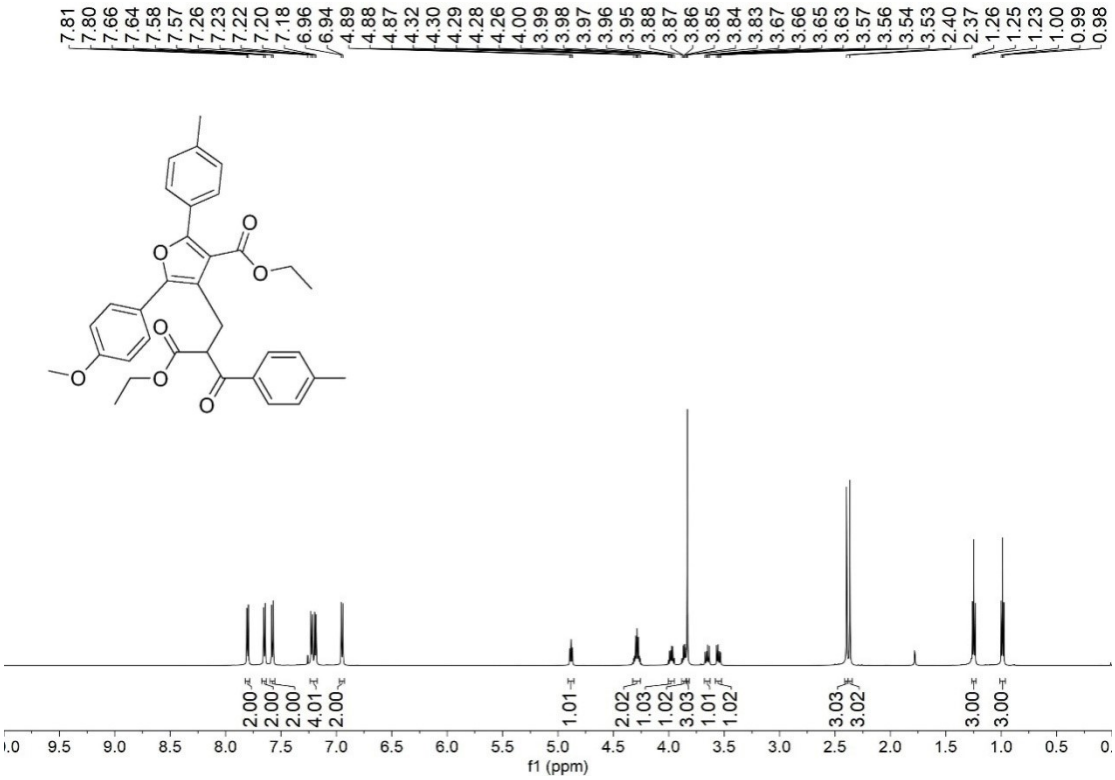


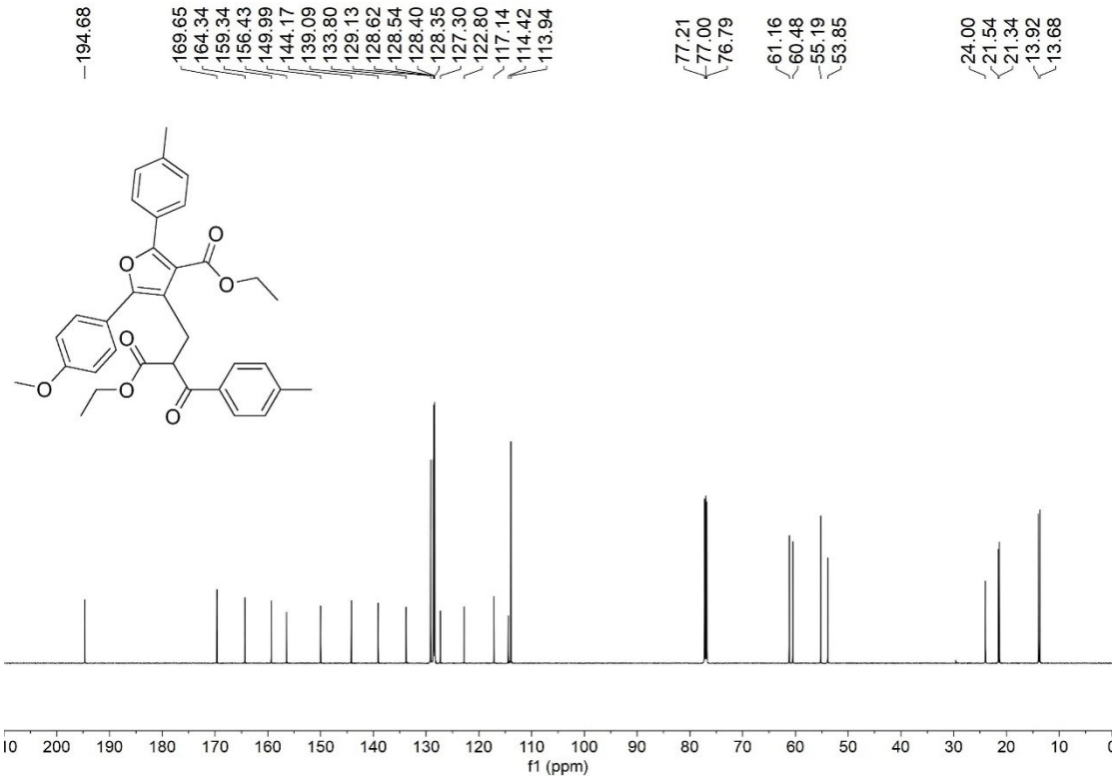


Ethyl4-(3-ethoxy-2-(4-methoxybenzoyl)-3-oxopropyl)-2,5-bis(4-methoxyphenyl)furan-3-carboxylate (3aa)

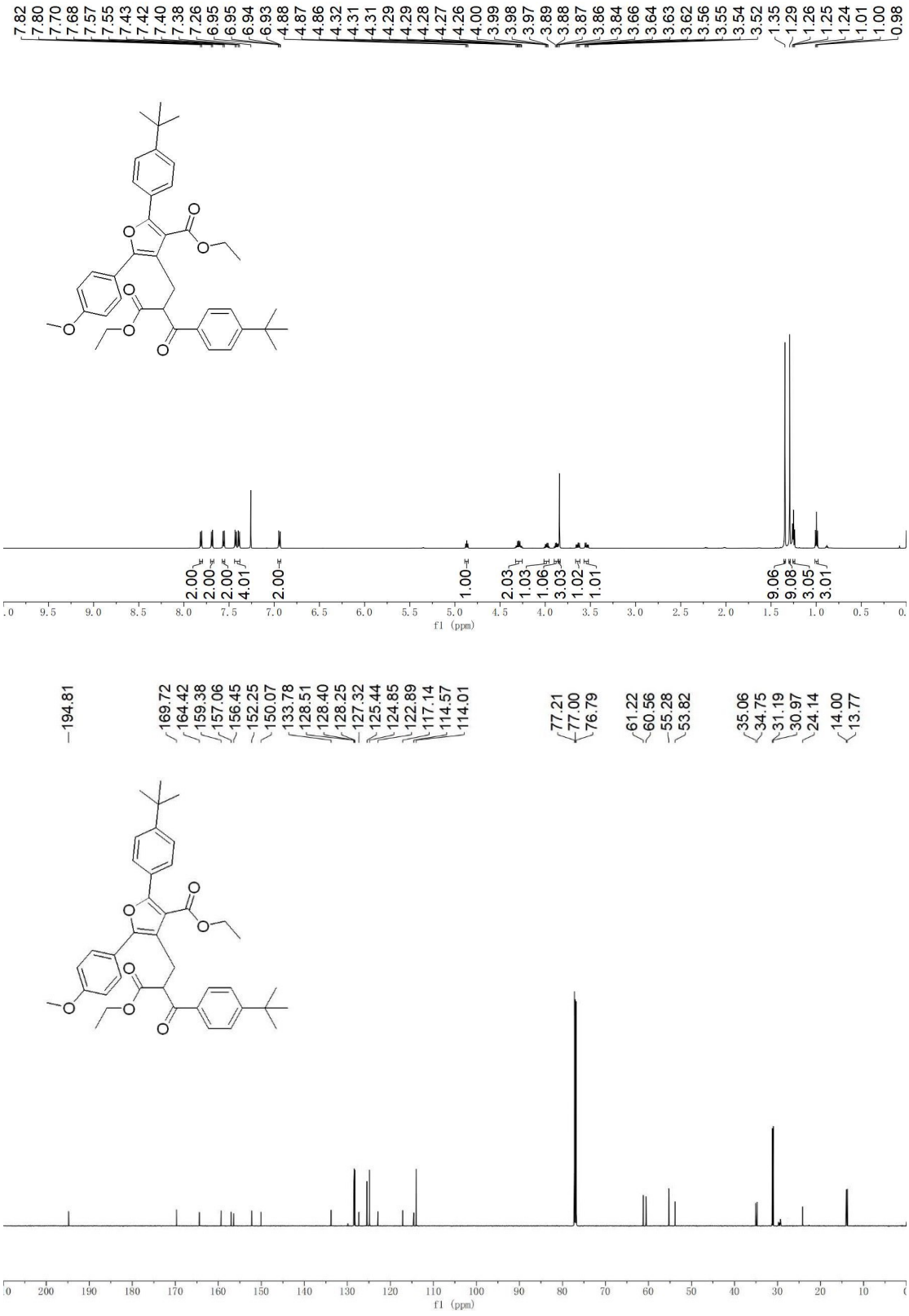


ethyl 4-(3-ethoxy-2-(4-methylbenzoyl)-3-oxopropyl)-5-(4-methoxyphenyl)-2-(*p*-tolyl)furan-3-carboxylate (3ba)

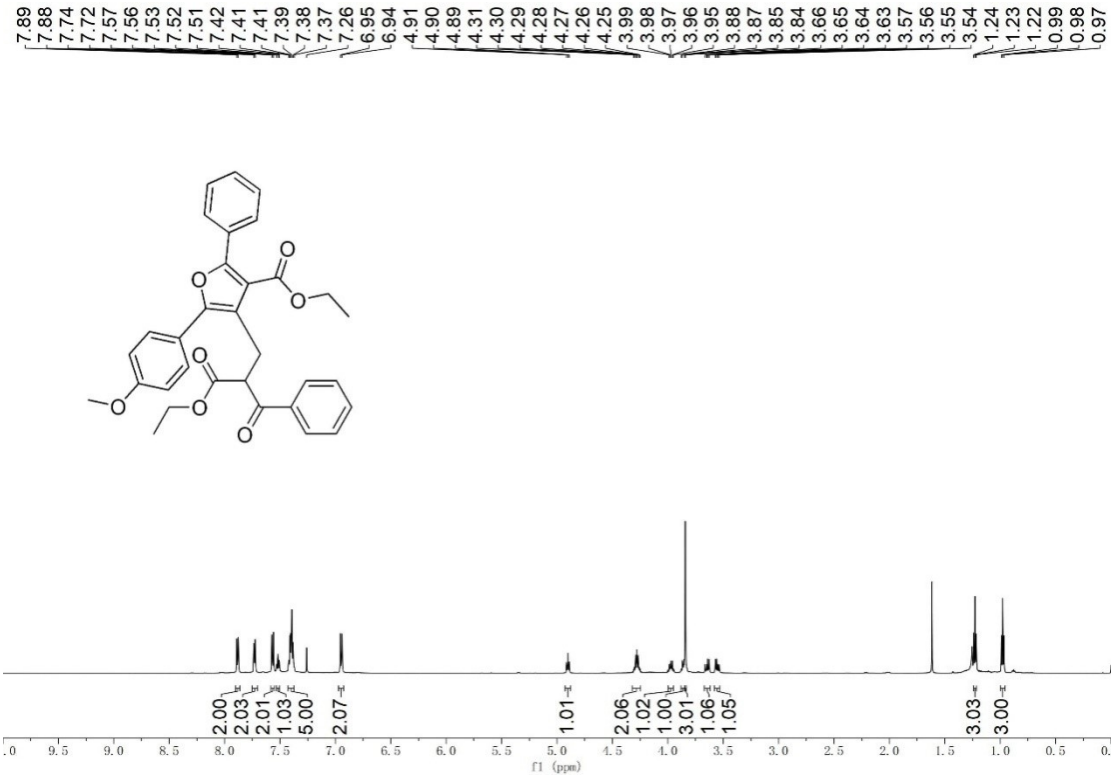




ethyl 4-(2-(4-(*tert*-butyl)benzoyl)-3-ethoxy-3-oxopropyl)-2-(4-(*tert*-butyl)phenyl)-5-(4-methoxyphenyl)furan-3-carboxylate (3ca)



ethyl 4-(2-benzoyl-3-ethoxy-3-oxopropyl)-5-(4-methoxyphenyl)-2-phenylfuran-3-carboxylate (3da)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0.97
2.00
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1.03
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1.00
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1.06
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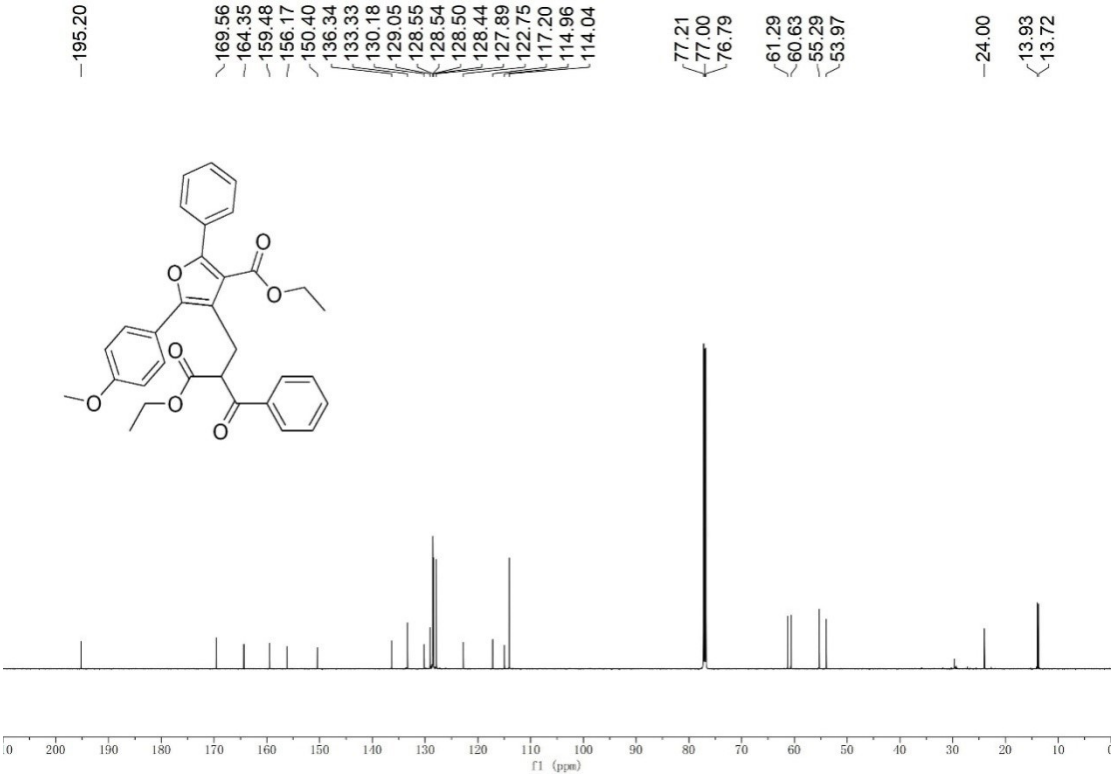
3.00
f1 (ppm)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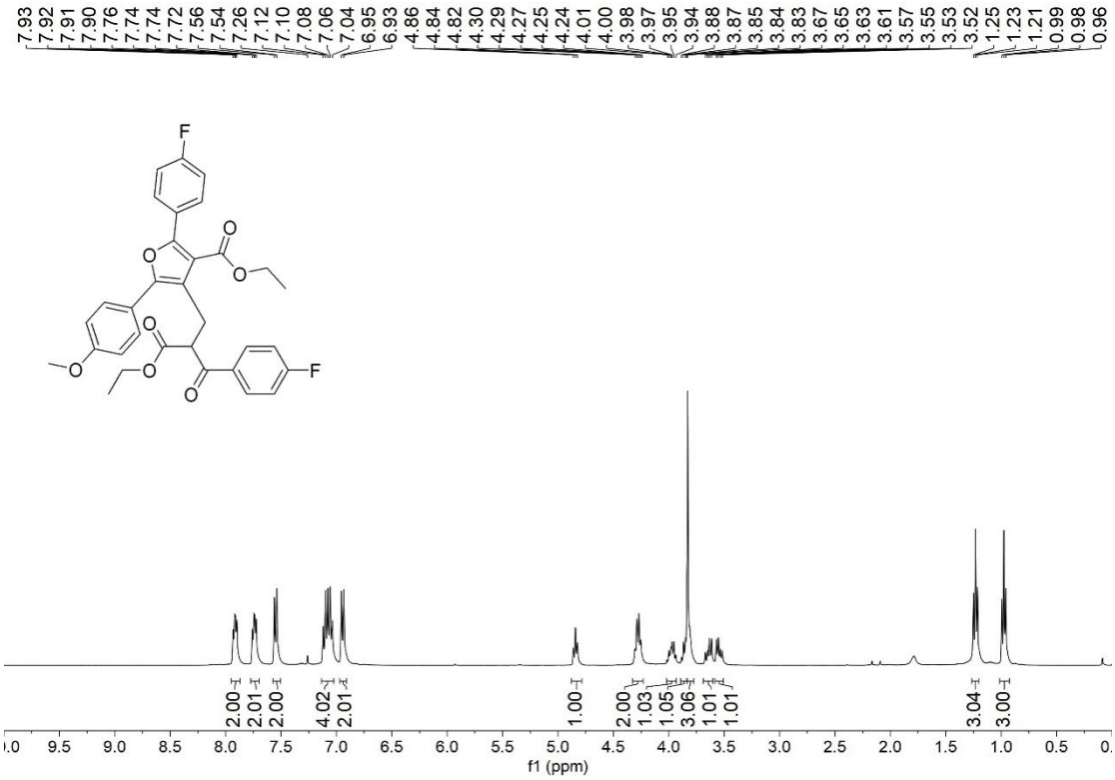
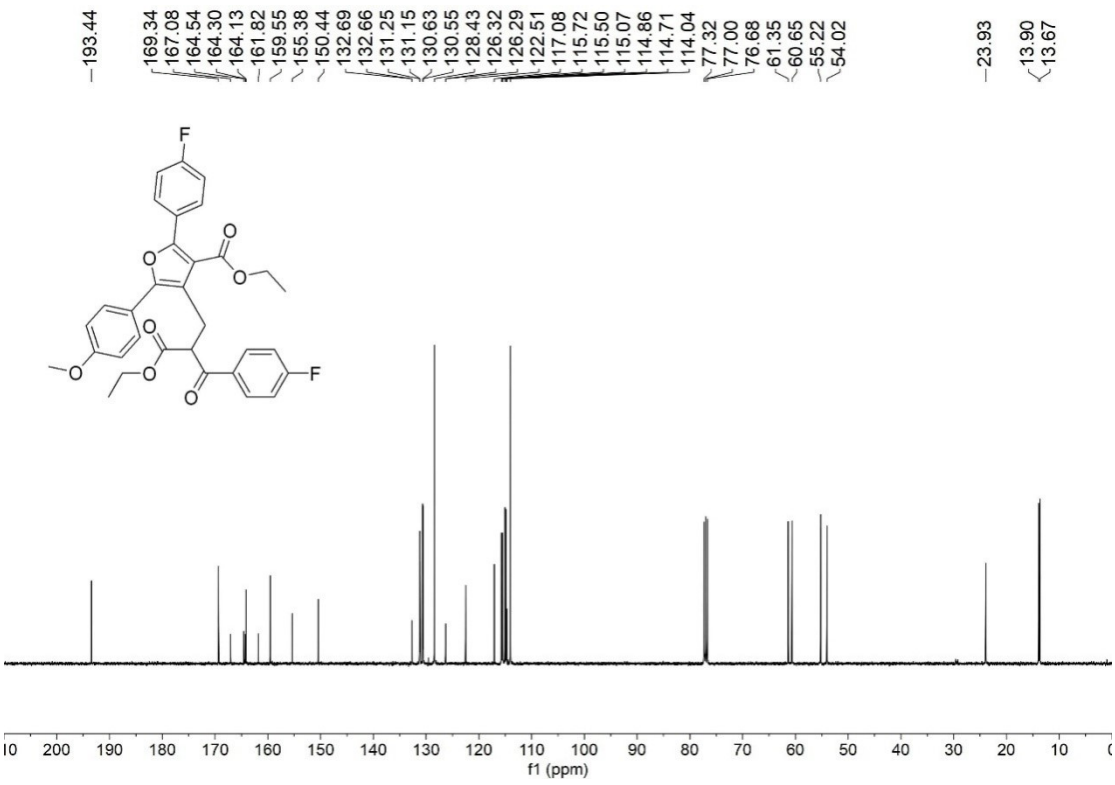
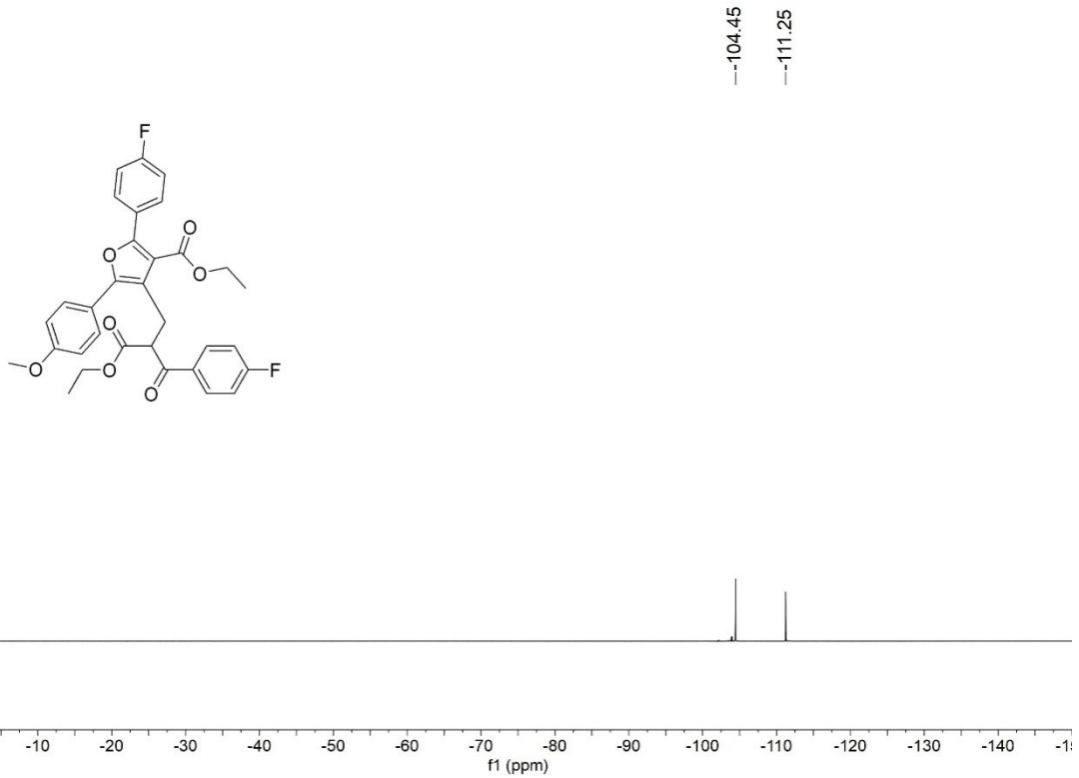
114.04
77.21
77.00
76.79
61.29
60.63
55.29
53.97
24.00
13.93
13.72
f1 (ppm)

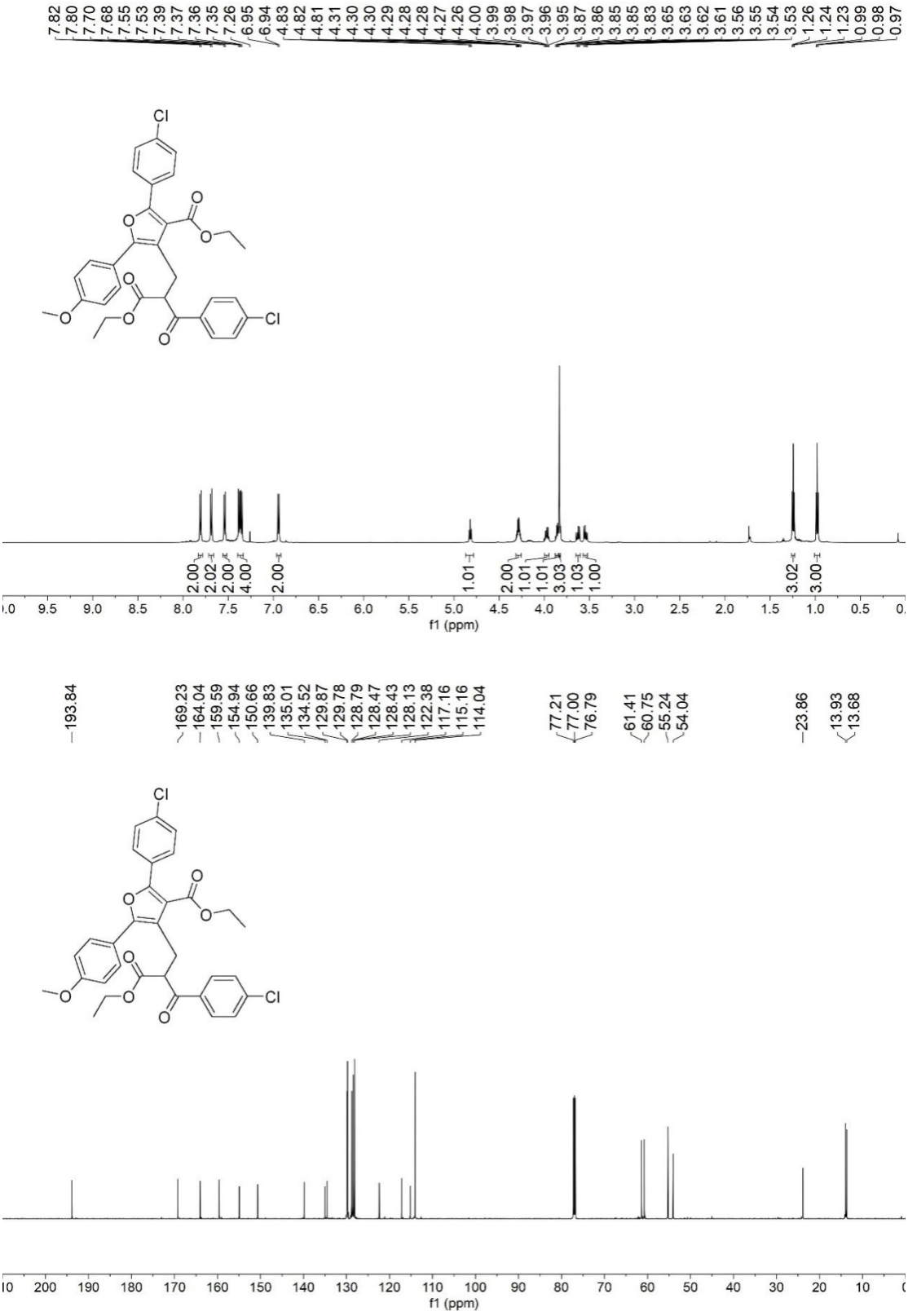
Ethyl 4-(3-ethoxy-2-(4-fluorobenzoyl)-3-oxopropyl)-2-(4-fluorophenyl)-5-(4-methoxyphenyl)furan-3-carboxylate (3ea)



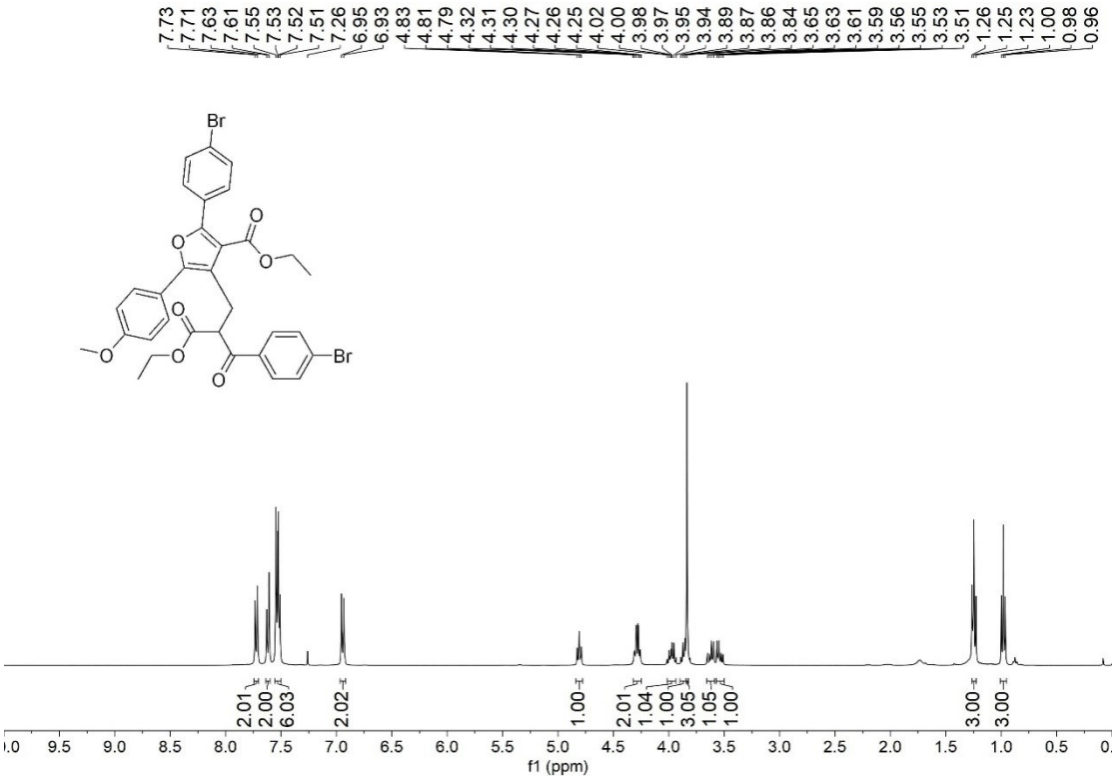


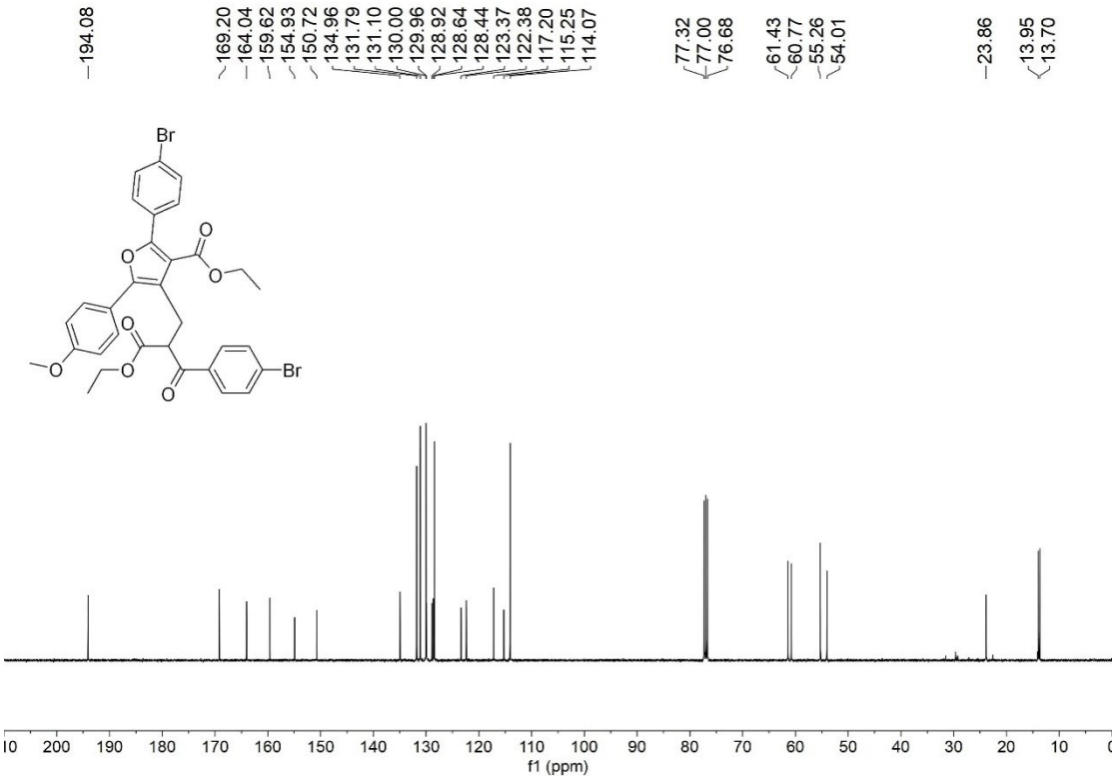

-104.45
-111.25
F
O
O
O
O
O
O
F
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
-110
-120
-130
-140
f1 (ppm)

ethyl 4-(2-(4-chlorobenzoyl)-3-ethoxy-3-oxopropyl)-2-(4-chlorophenyl)-5-(4-methoxyphenyl)furan-3-carboxylate (3fa)

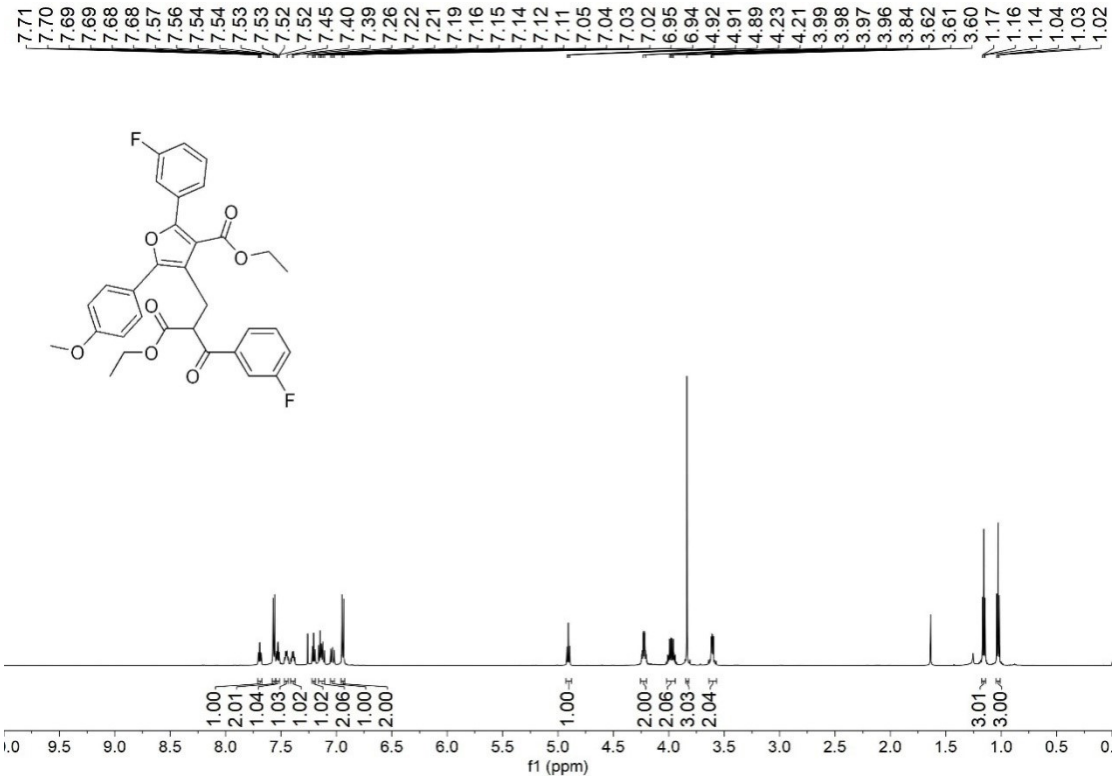


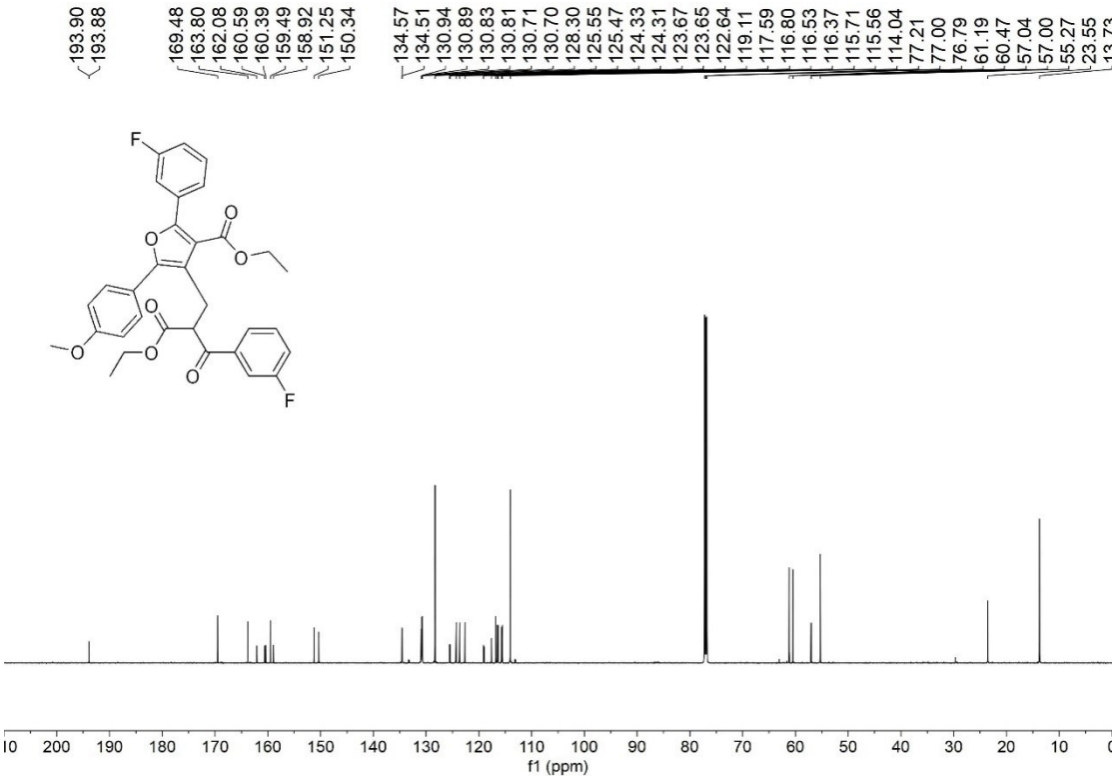
ethyl 4-(2-(4-bromobenzoyl)-3-ethoxy-3-oxopropyl)-2-(4-bromophenyl)-5-(4-methoxyphenyl)furan-3-carboxylate (3ga)

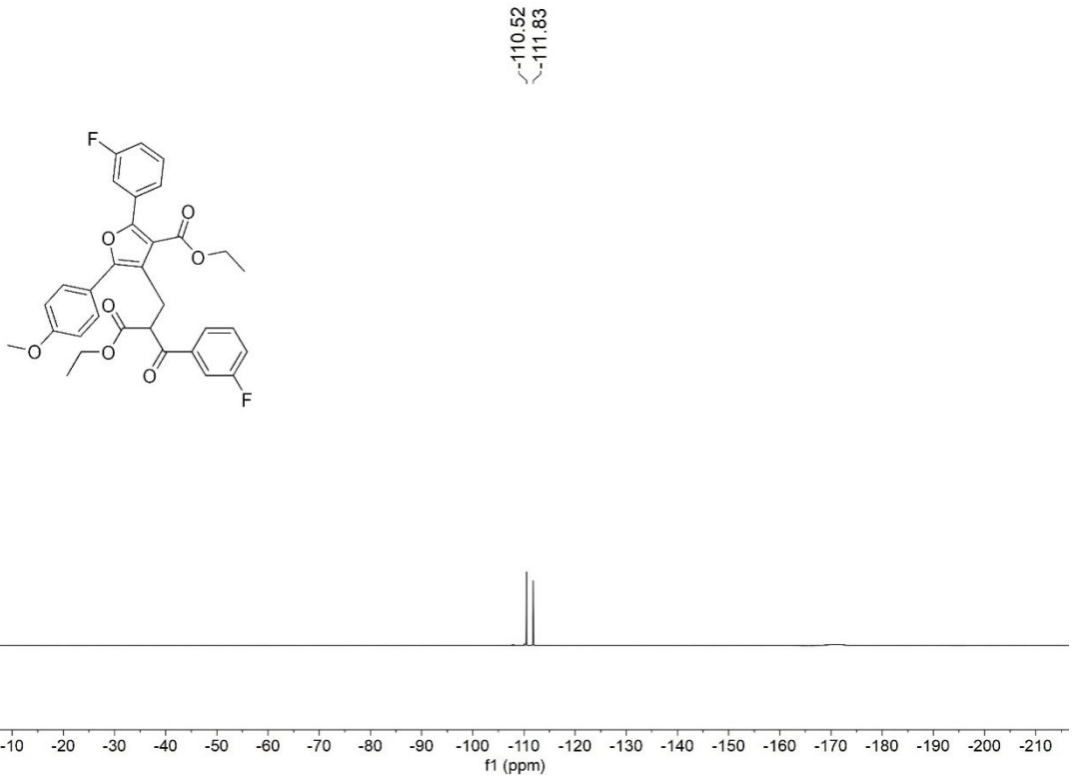




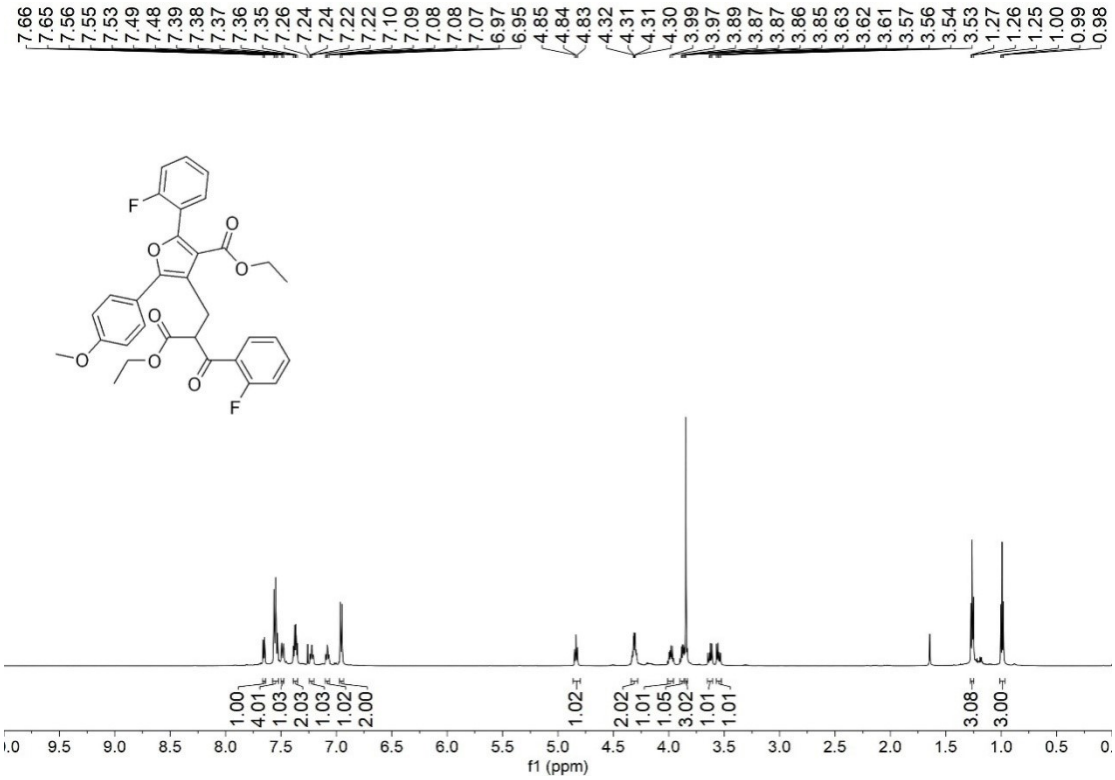
ethyl 4-(3-ethoxy-2-(3-fluorobenzoyl)-3-oxopropyl)-2-(3-fluorophenyl)-5-(4-methoxyphenyl)furan-3-carboxylate (3ha)

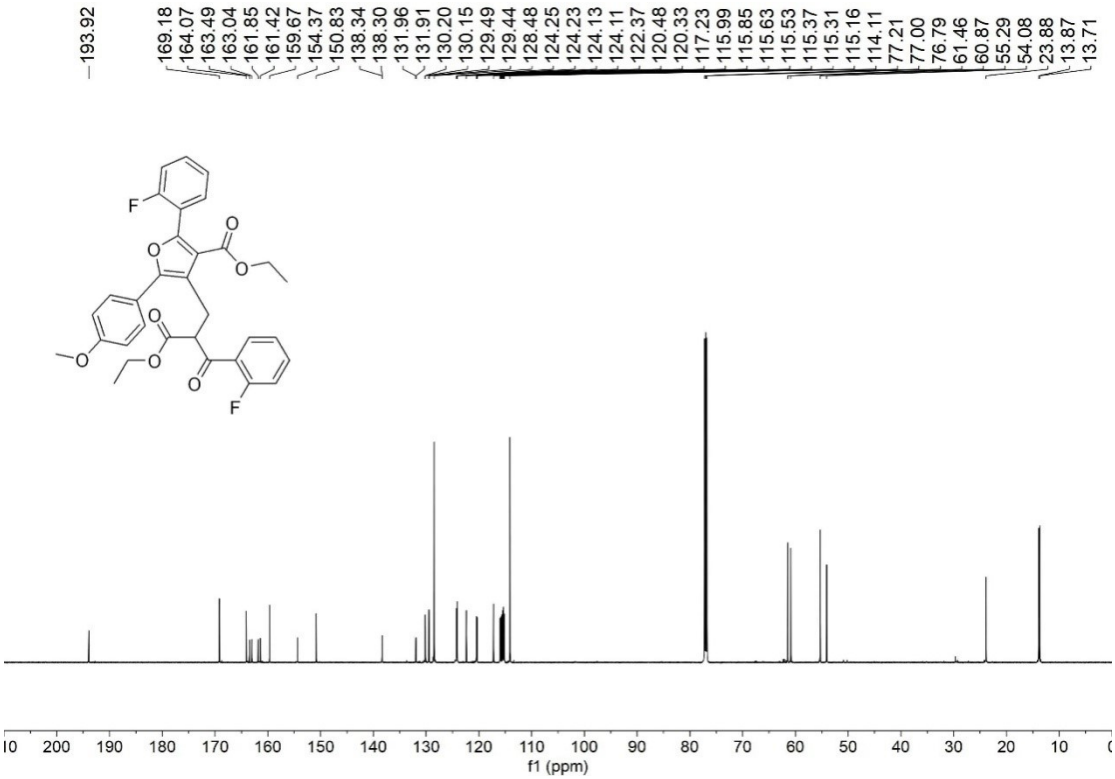


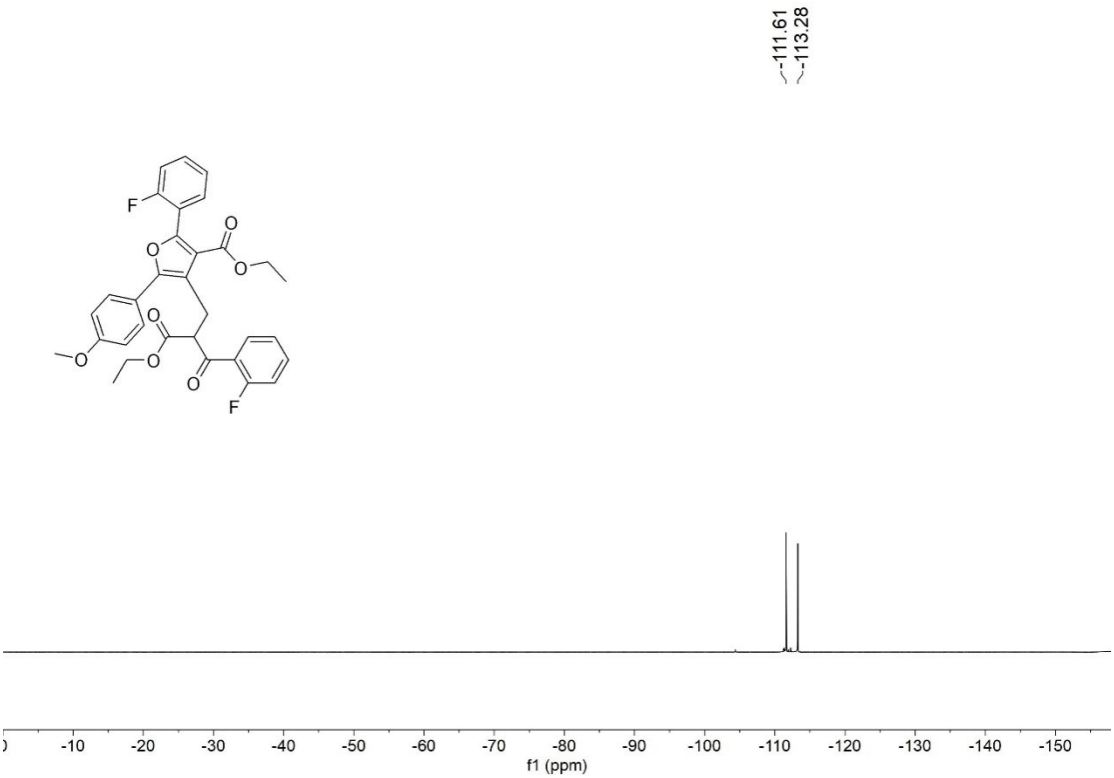



-110.52
-111.83
F
O
O
O
O
O
O
F
-10 -20 -30 -40 -50 -60 -70 -80 -90 -100 -110 -120 -130 -140 -150 -160 -170 -180 -190 -200 -210
f1 (ppm)

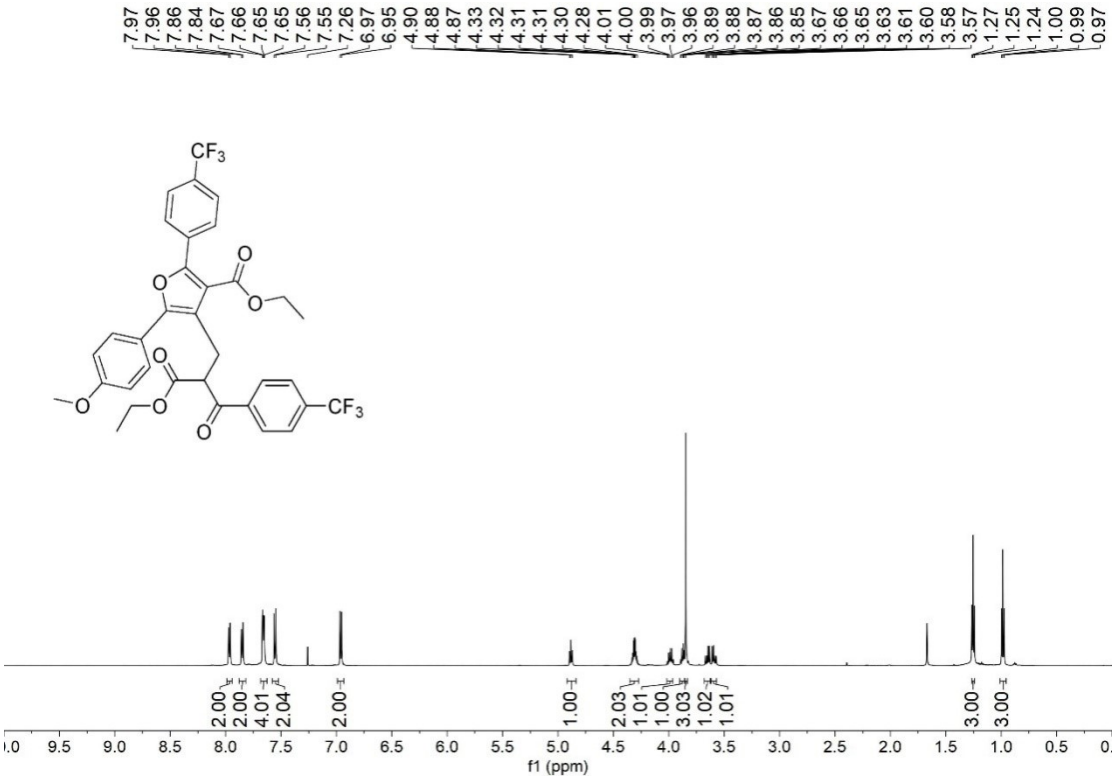
ethyl 4-(3-ethoxy-2-(2-fluorobenzoyl)-3-oxopropyl)-2-(2-fluorophenyl)-5-(4-methoxyphenyl)furan-3-carboxylate (3ia)

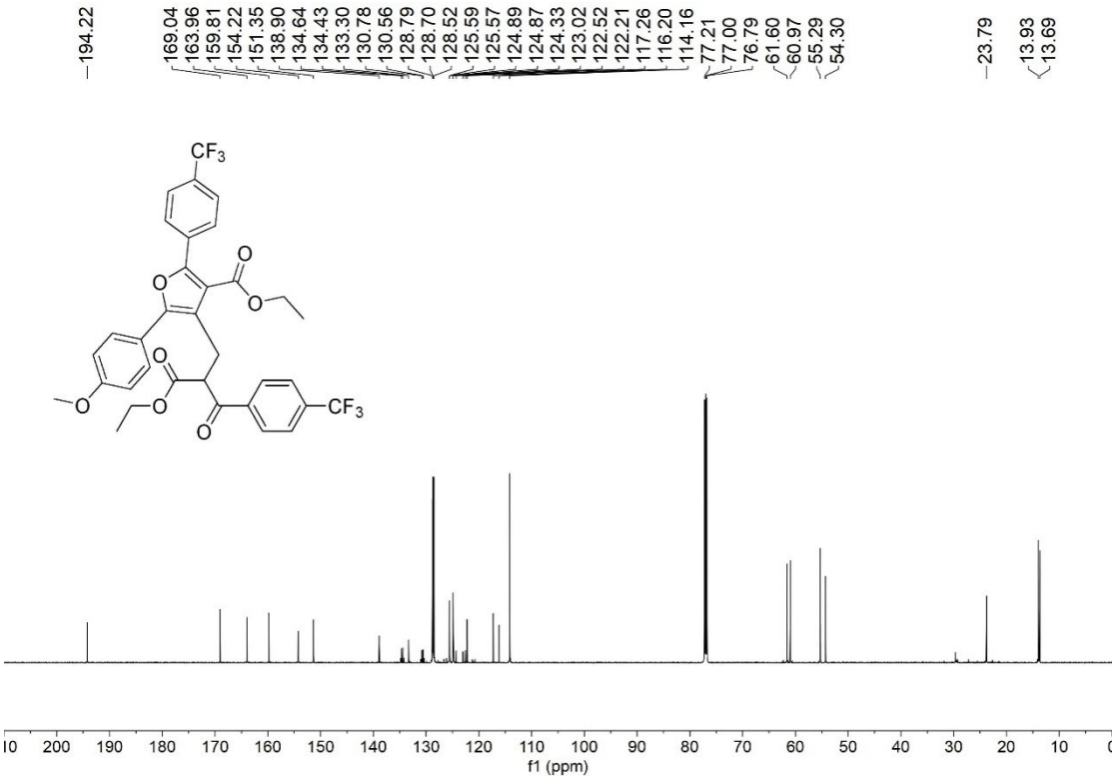


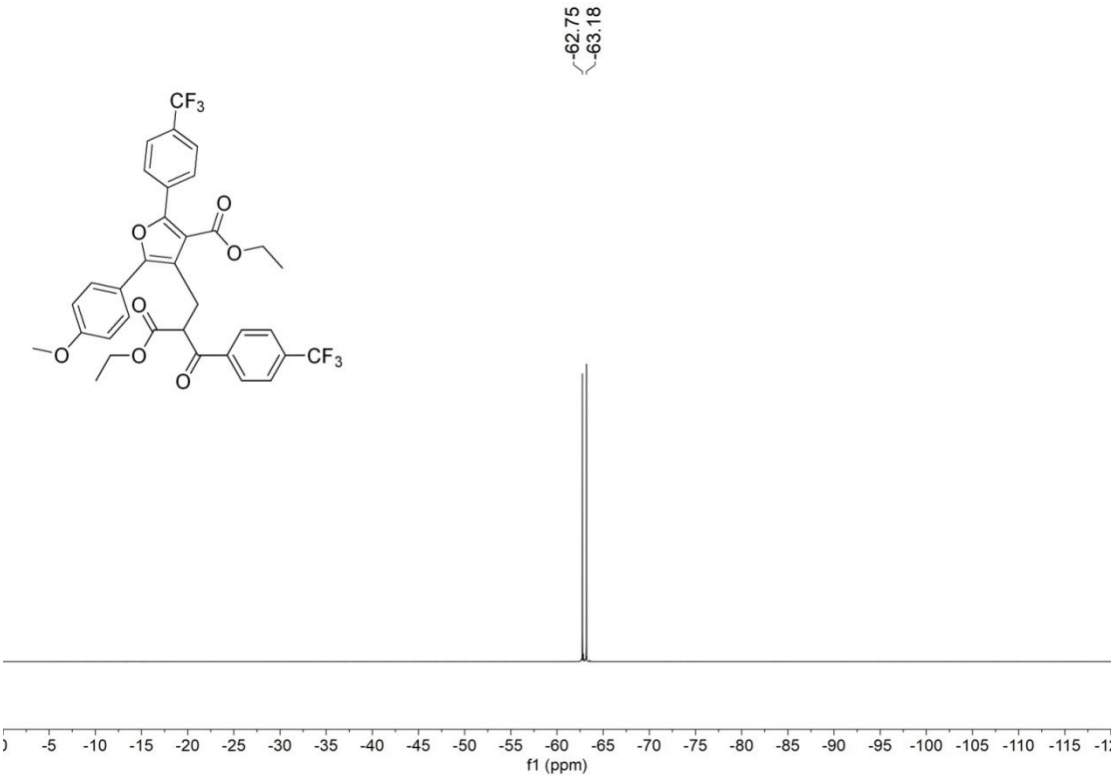



-111.61
-113.28
F
O
O
O
O
O
O
F
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
-110
-120
-130
-140
-150
f1 (ppm)

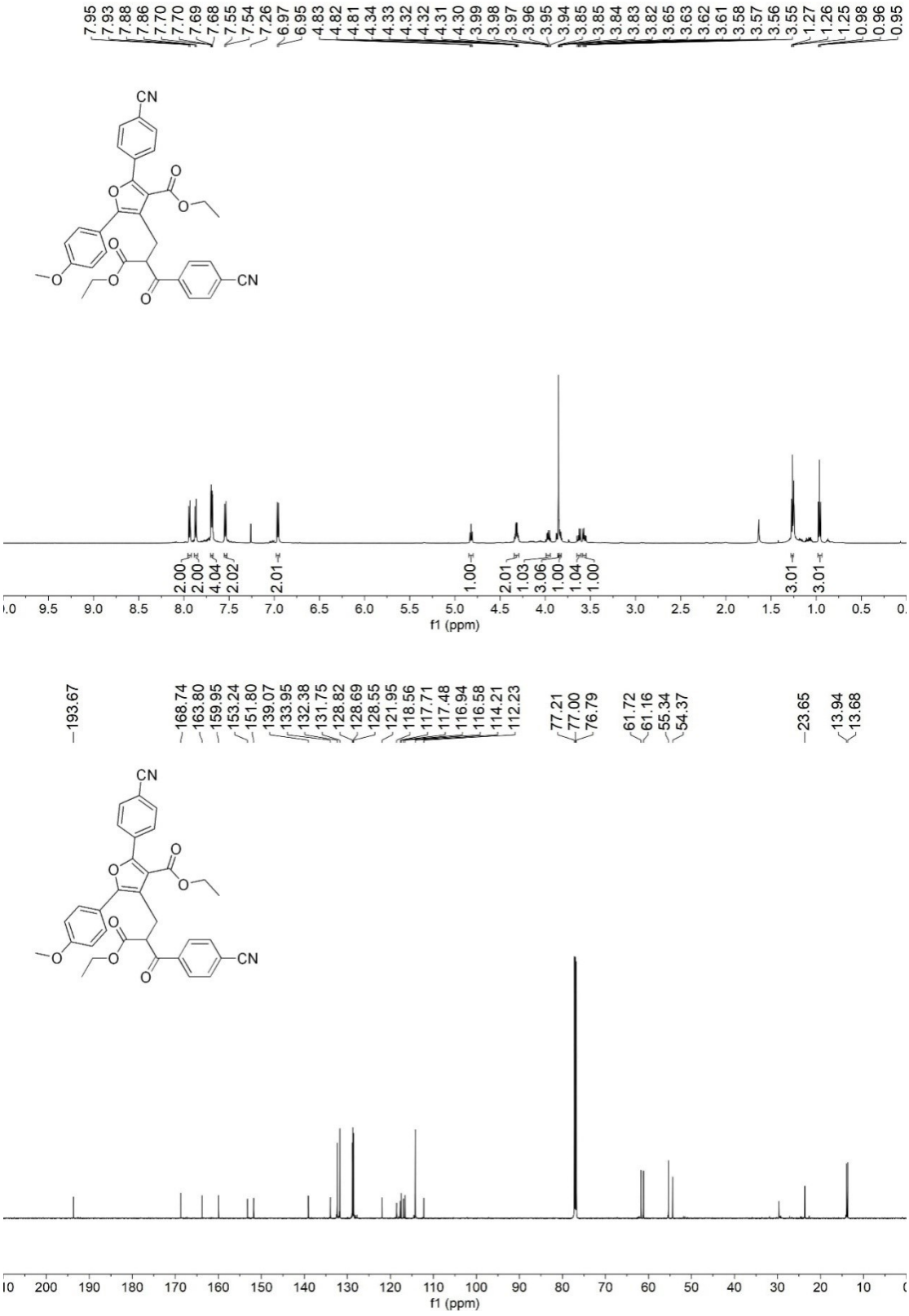
ethyl 4-(3-ethoxy-3-oxo-2-(4-(trifluoromethyl)benzoyl)propyl)-5-(4-methoxyphenyl)-2-(4-(trifluoromethyl)phenyl)furan-3-carboxylate (3ja)





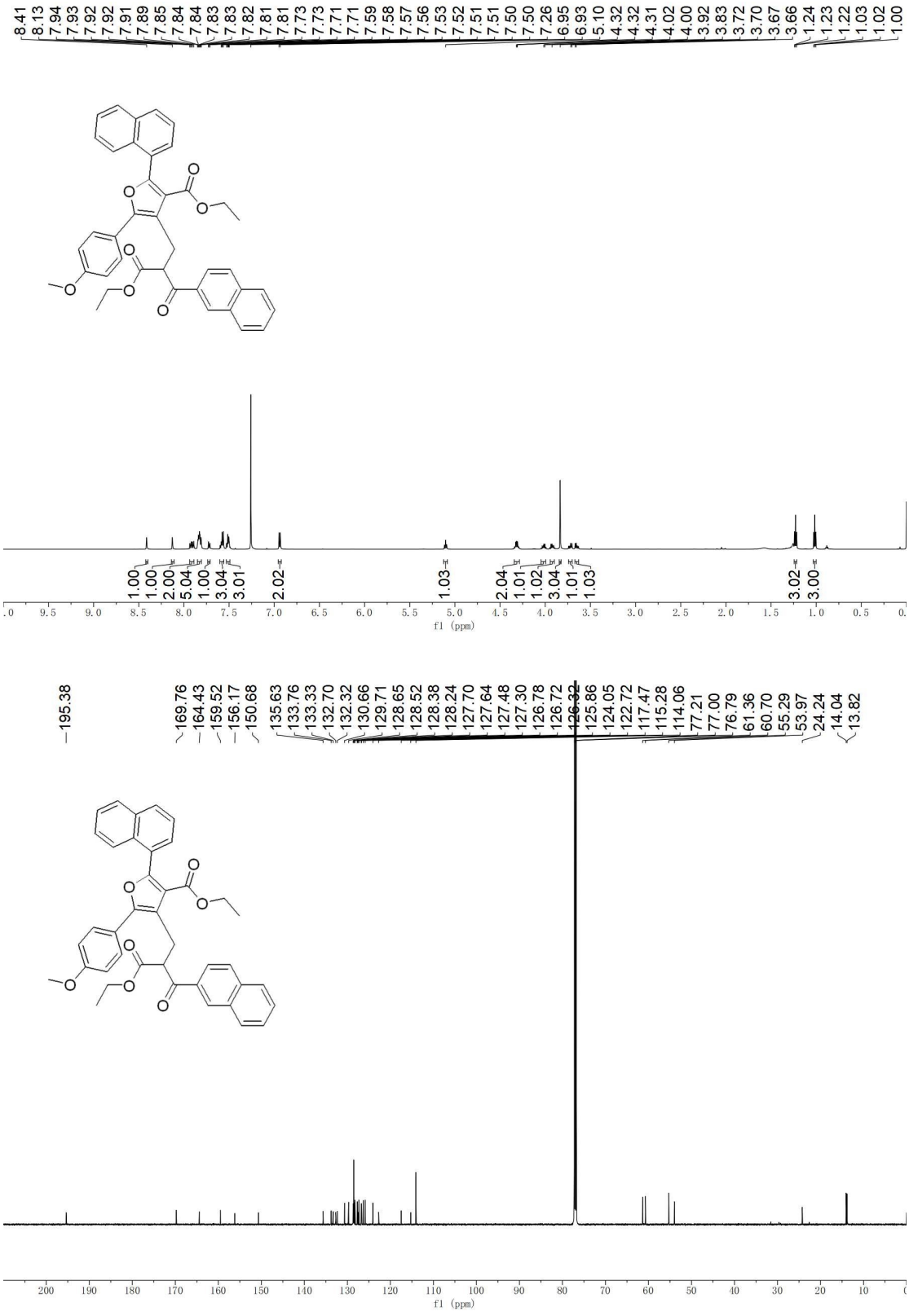

-62.75
-63.18
CF3
O
O
O
O
O
O
CF3
-5 -10 -15 -20 -25 -30 -35 -40 -45 -50 -55 -60 -65 -70 -75 -80 -85 -90 -95 -100 -105 -110 -115
f1 (ppm)

ethyl 4-(2-(4-cyanobenzoyl)-3-ethoxy-3-oxopropyl)-2-(4-cyanophenyl)-5-(4-methoxyphenyl)furan-3-carboxylate (3ka)

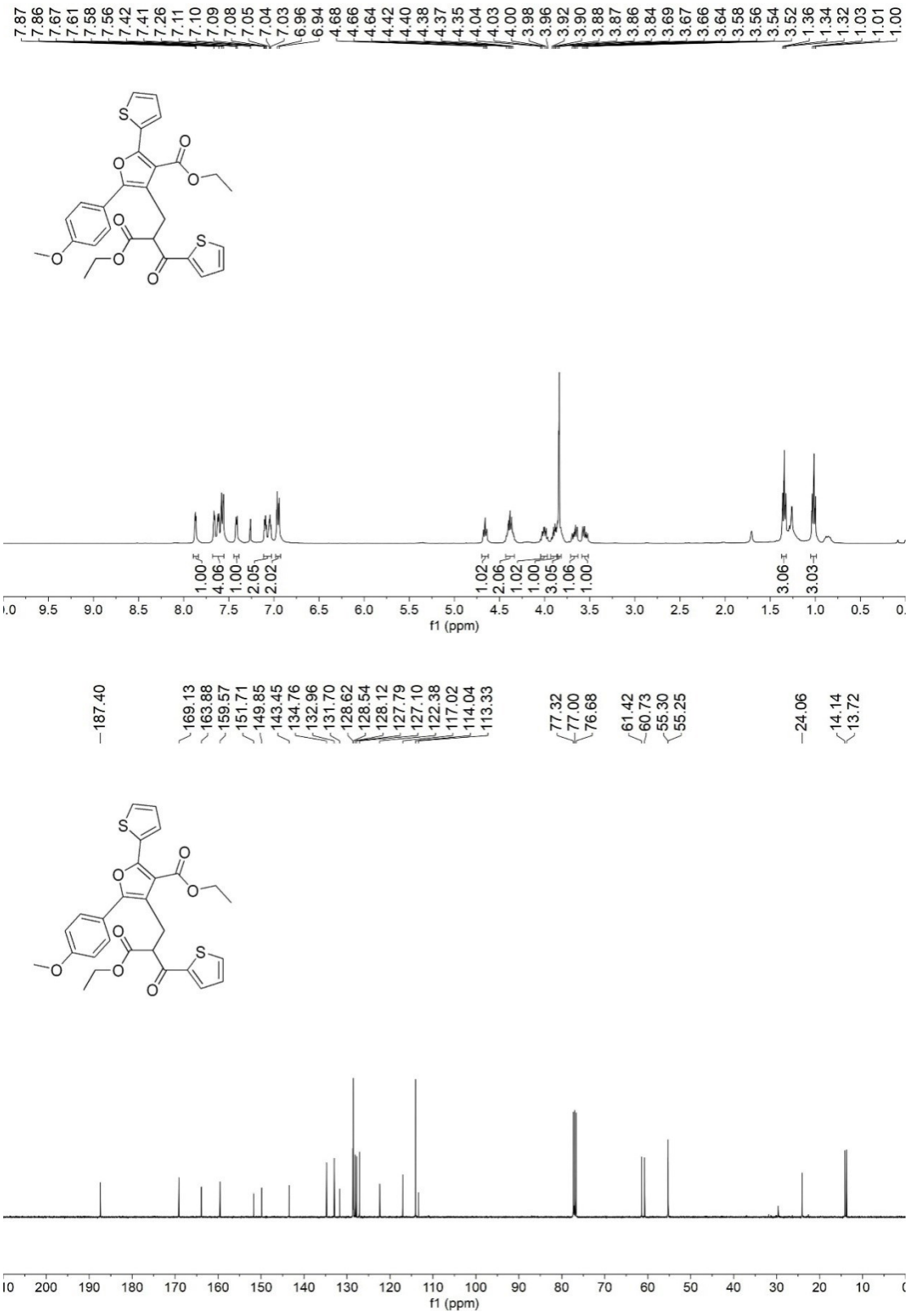


ethyl 4-(2-(2-naphthoyl)-3-ethoxy-3-oxopropyl)-5-(4-methoxyphenyl)-2-(naphthalen-1-

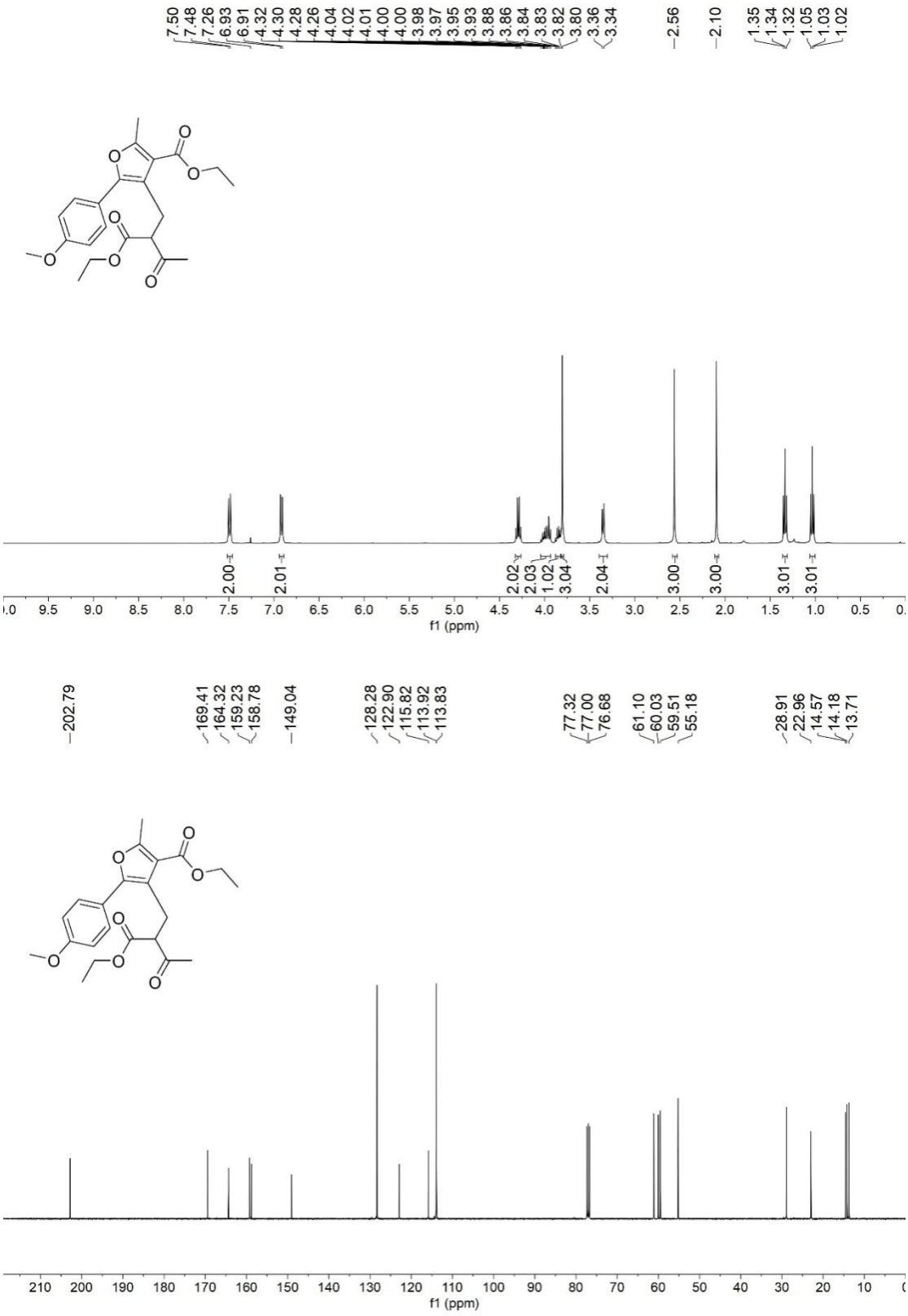
yl)furan-3-carboxylate (3la)



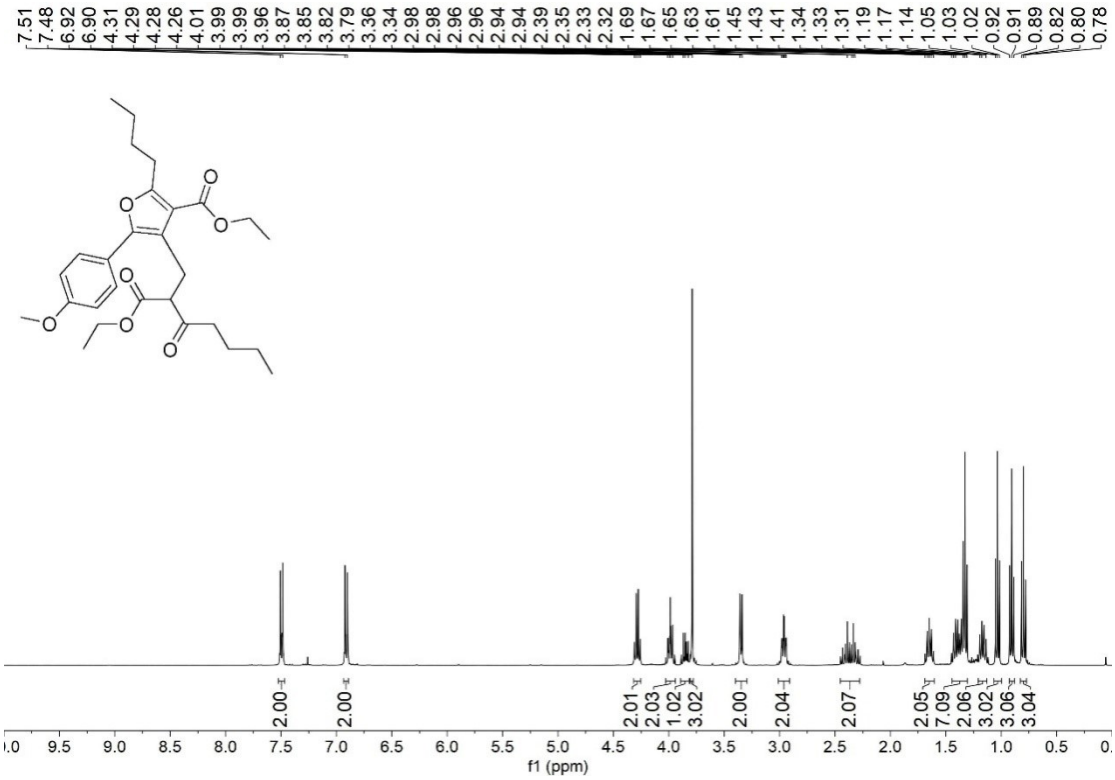
ethyl 4-(3-ethoxy-3-oxo-2-(thiophene-2-carbonyl)propyl)-5-(4-methoxyphenyl)-2-(thiophen-2-yl)furan-3-carboxylate (3ma)

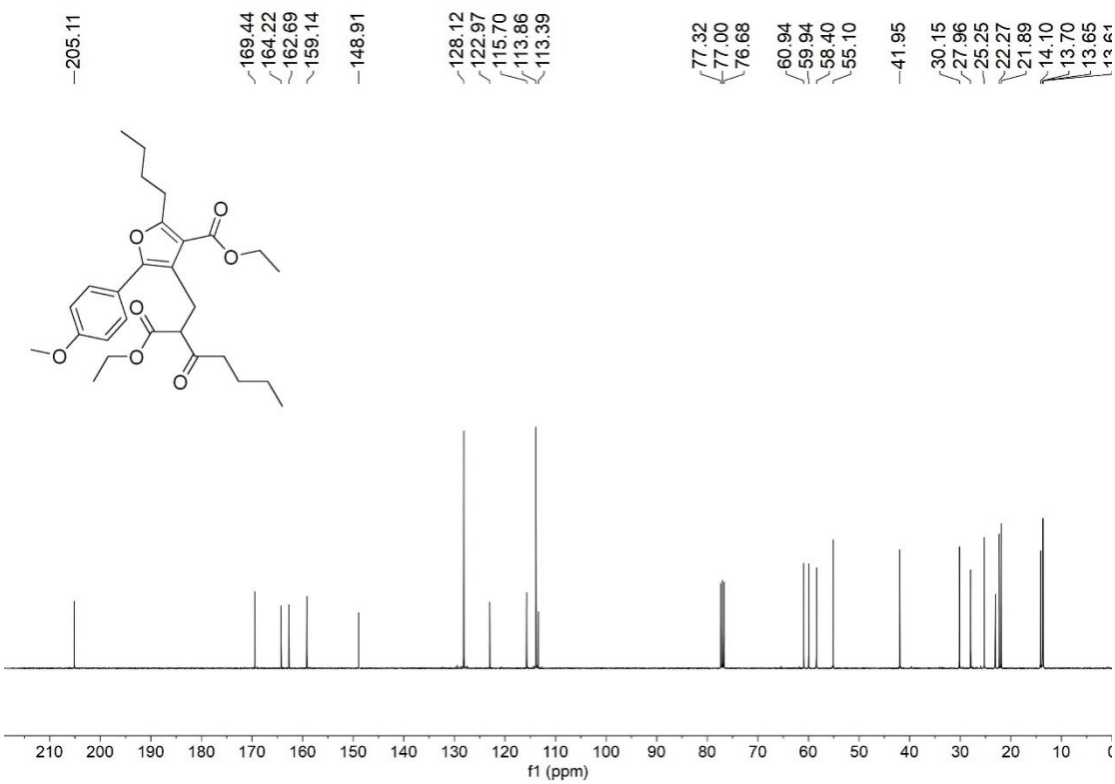


Ethyl4-(2-(ethoxycarbonyl)-3-oxobutyl)-5-(4-methoxyphenyl)-2-methylfuran-3-carboxylate (3na)

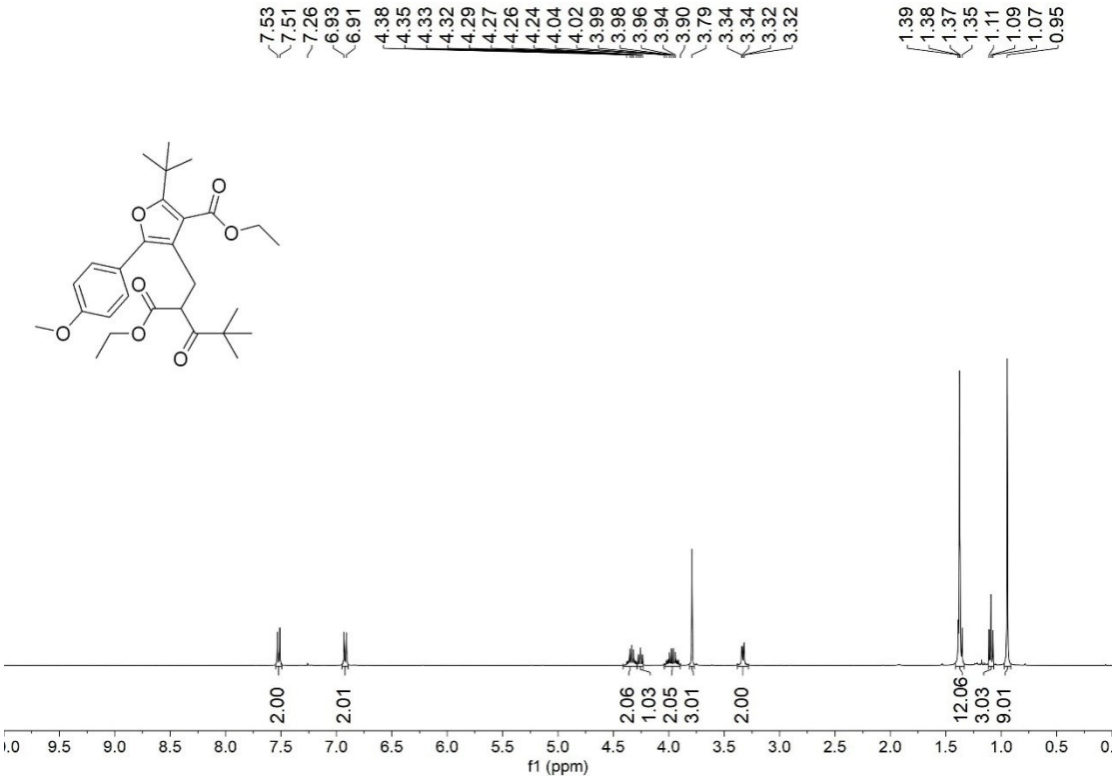


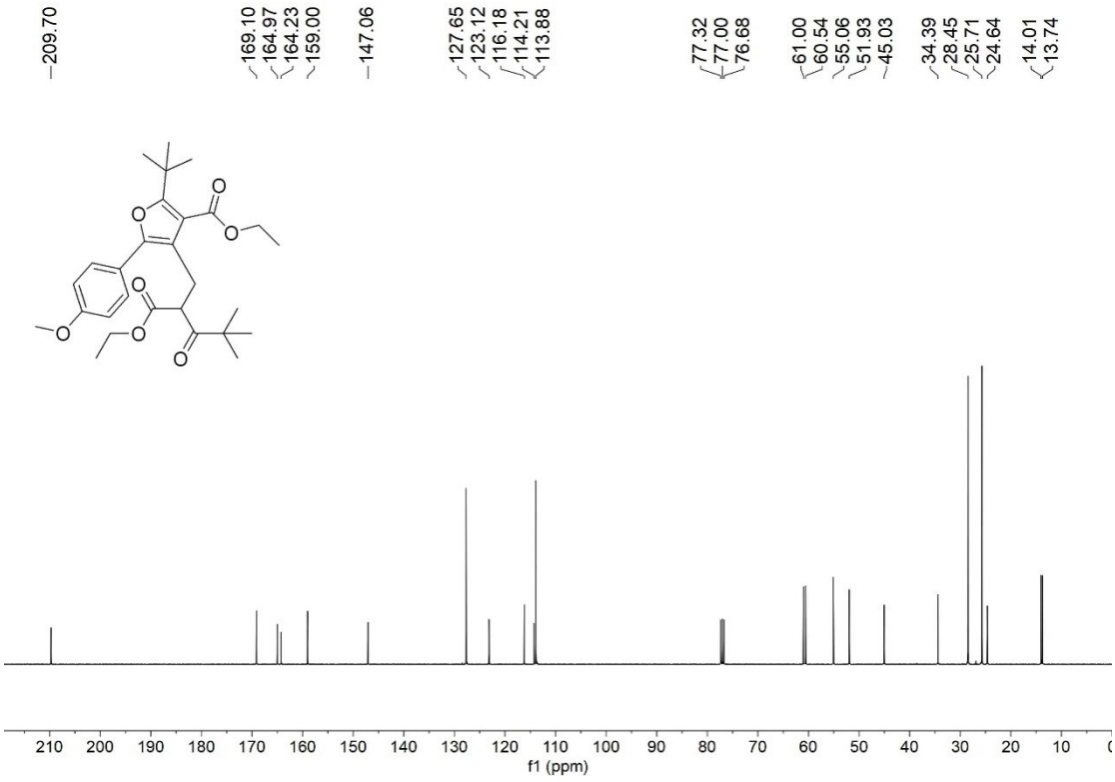
ethyl 2-butyl-4-(2-(ethoxycarbonyl)-3-oxoheptyl)-5-(4-methoxyphenyl)furan-3-carboxylate (3oa)



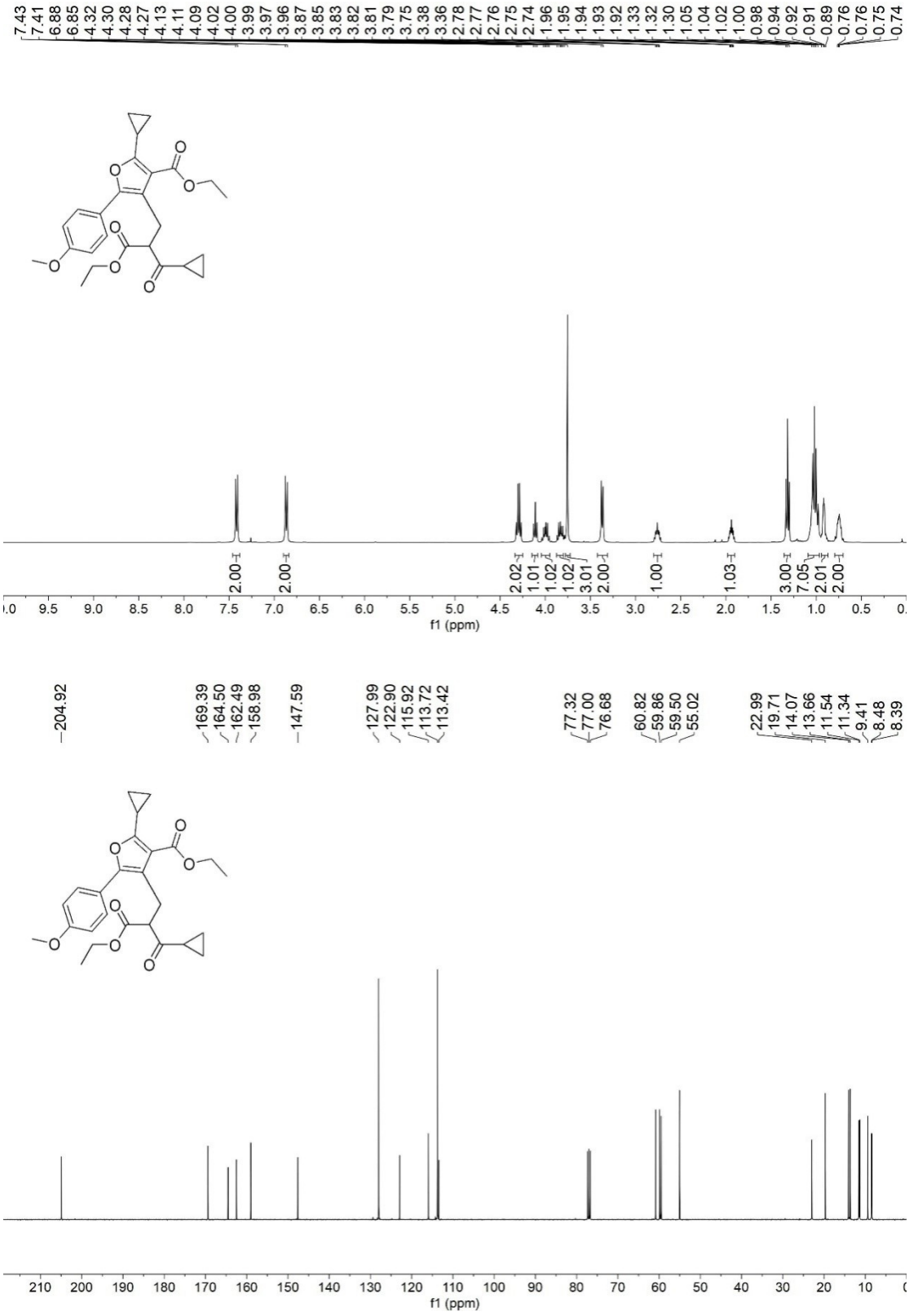


ethyl 2-(*tert*-butyl)-4-(2-(ethoxycarbonyl)-4,4-dimethyl-3-oxopentyl)-5-(4-methoxyphenyl)furan-3-carboxylate (3pa)

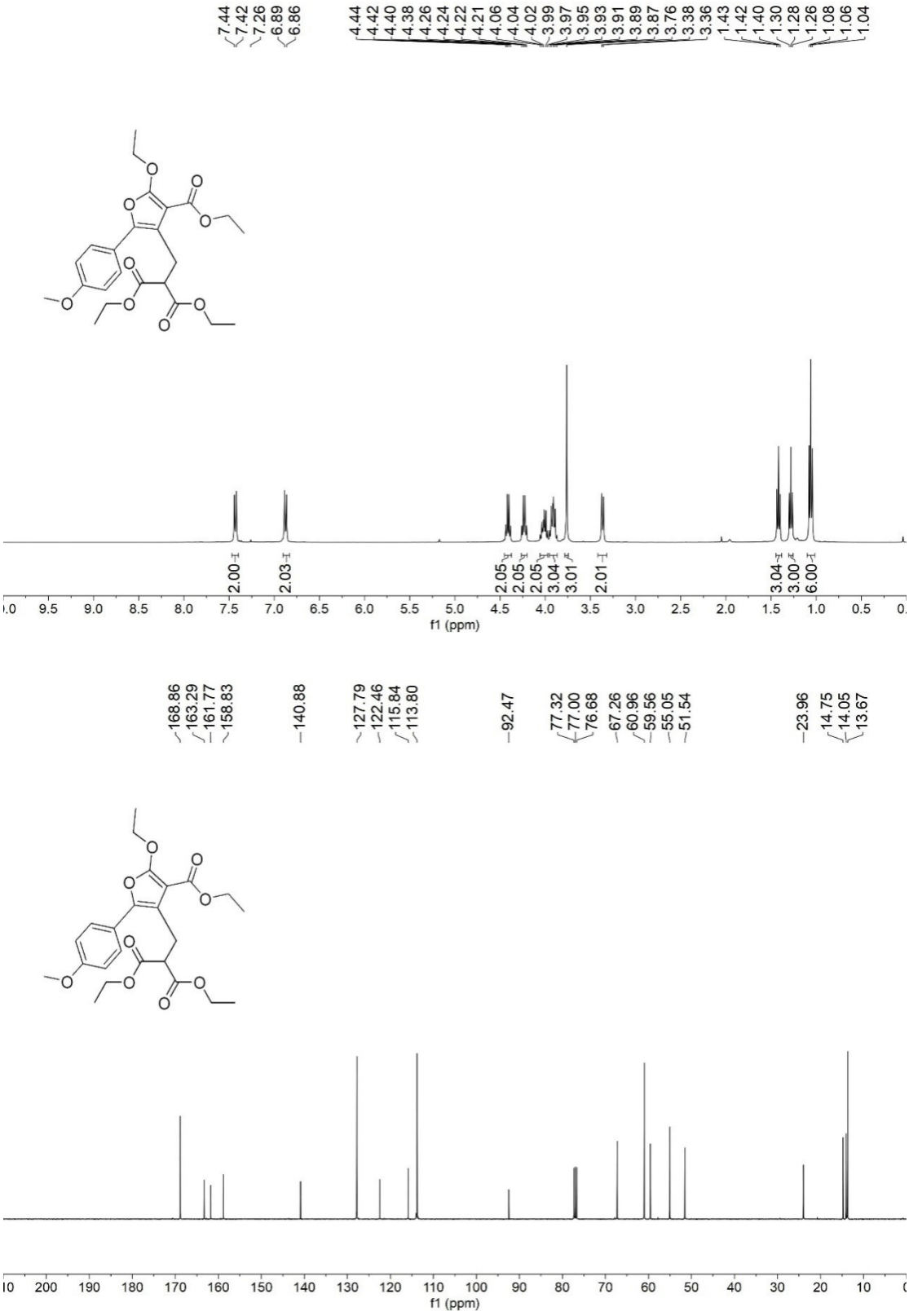




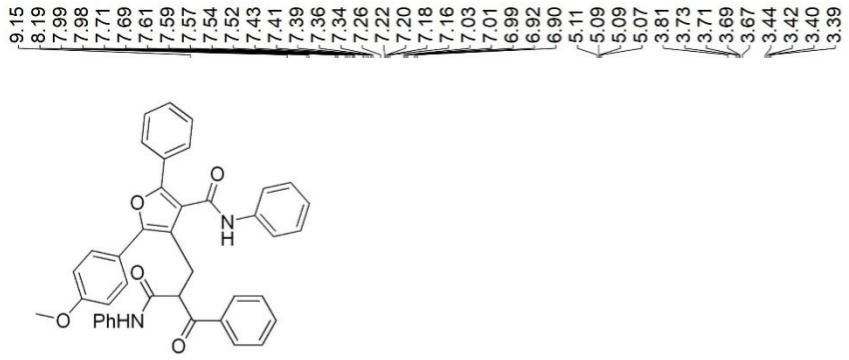
ethyl 4-(2-(cyclopropanecarbonyl)-3-ethoxy-3-oxopropyl)-2-cyclopropyl-5-(4-methoxyphenyl)furan-3-carboxylate (3qa)

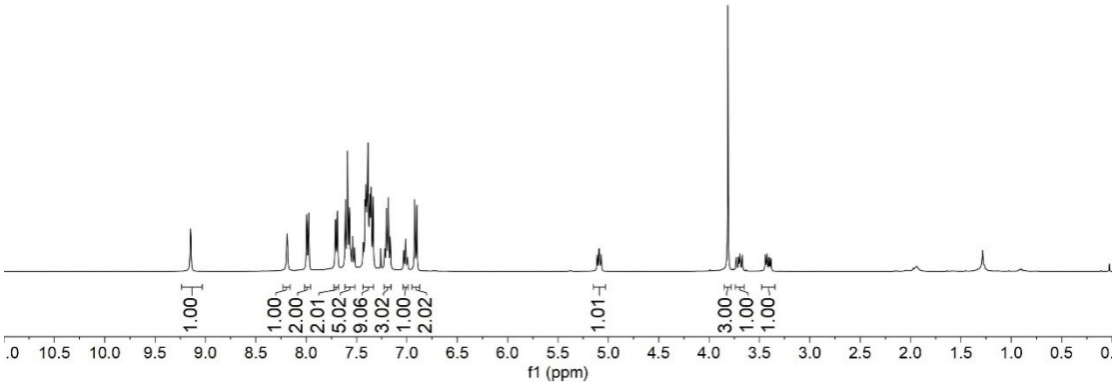


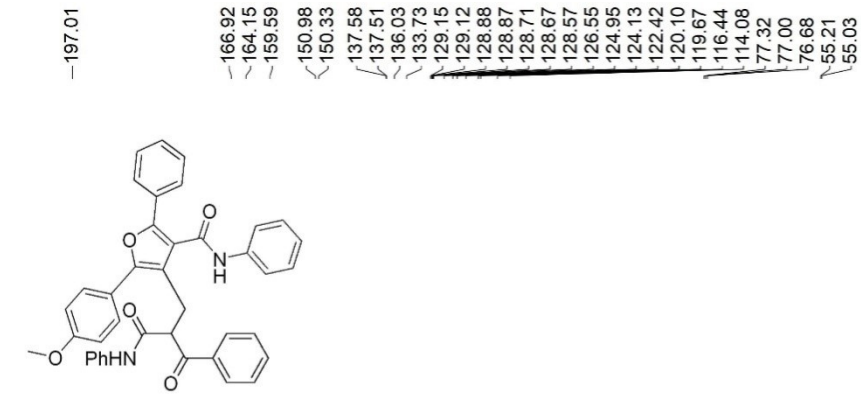
diethyl 2-((5-ethoxy-4-(ethoxycarbonyl)-2-(4-methoxyphenyl)furan-3-yl)methyl)malonate (3ra)

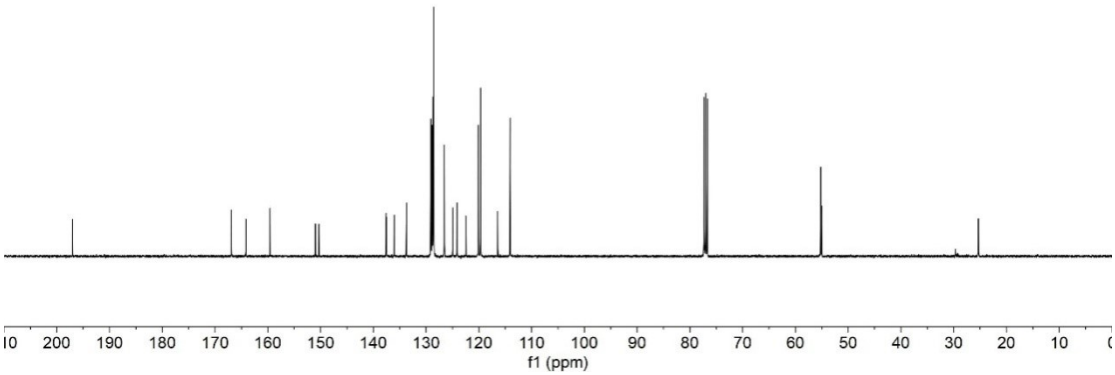


4-(2-benzoyl-3-oxo-3-(phenylamino)propyl)-5-(4-methoxyphenyl)-*N*,2-diphenylfuran-3-carboxamide (3sa)

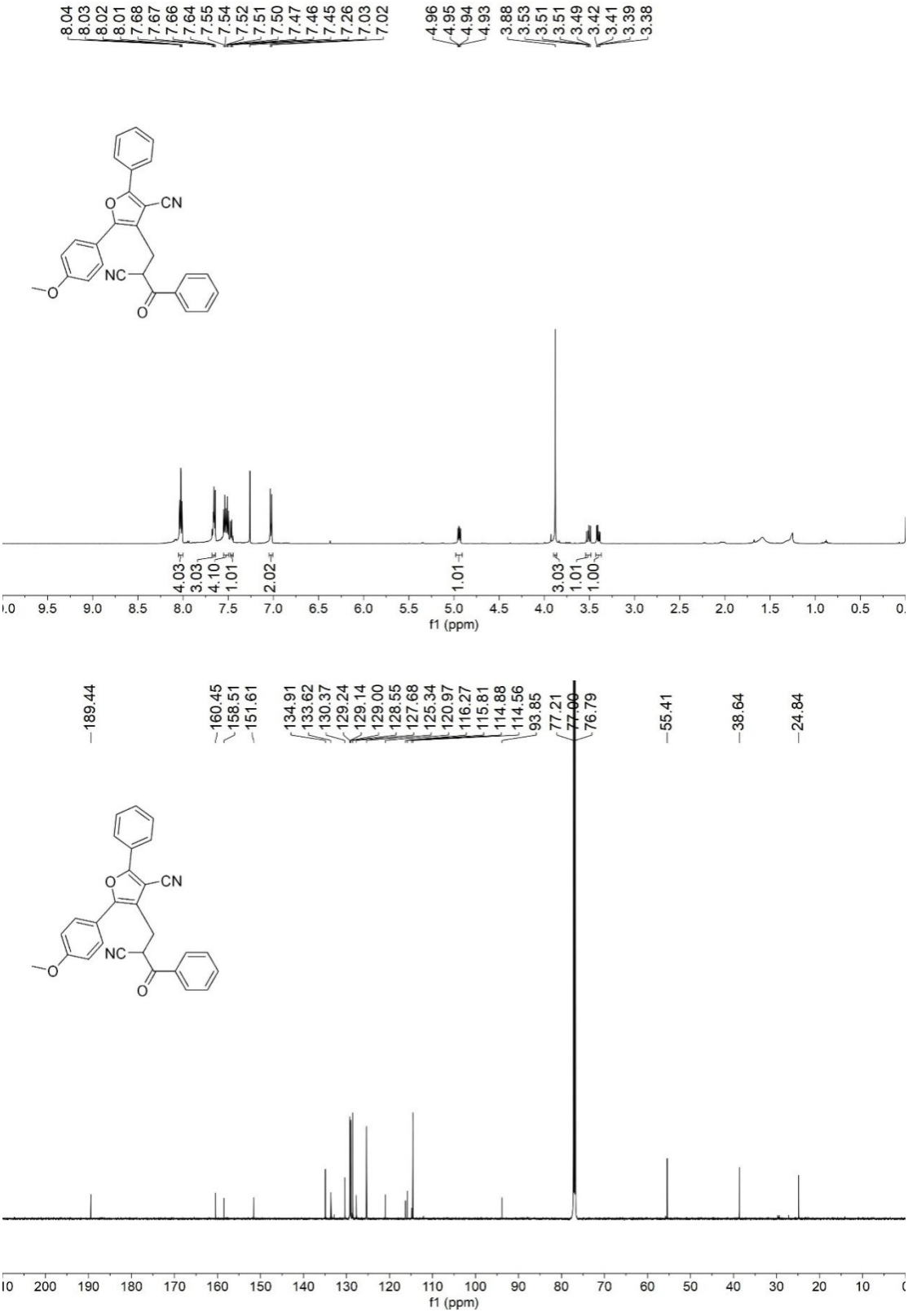




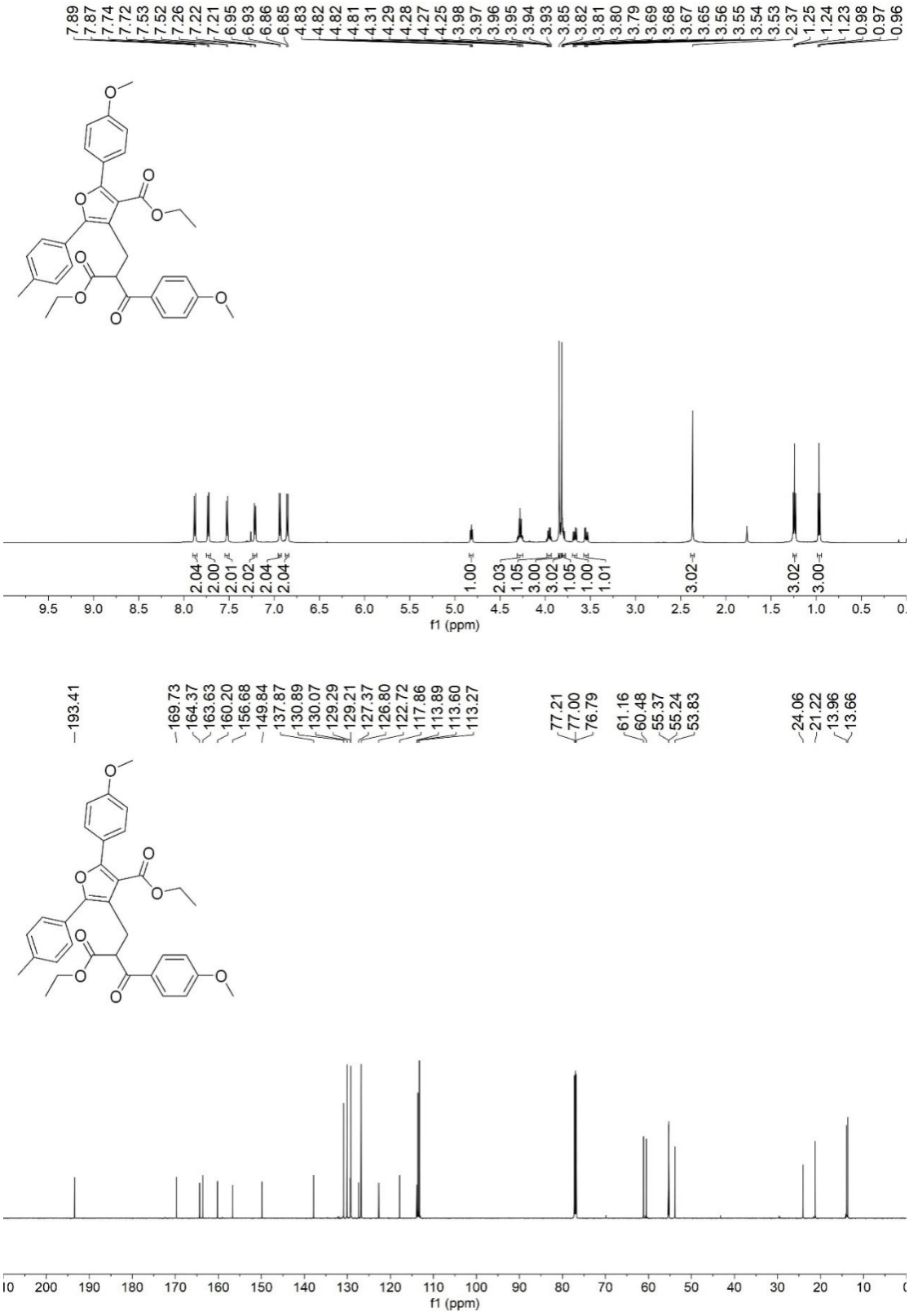




4-(2-cyano-3-oxo-3-phenylpropyl)-5-(4-methoxyphenyl)-2-phenylfuran-3-carbonitrile (3ta)

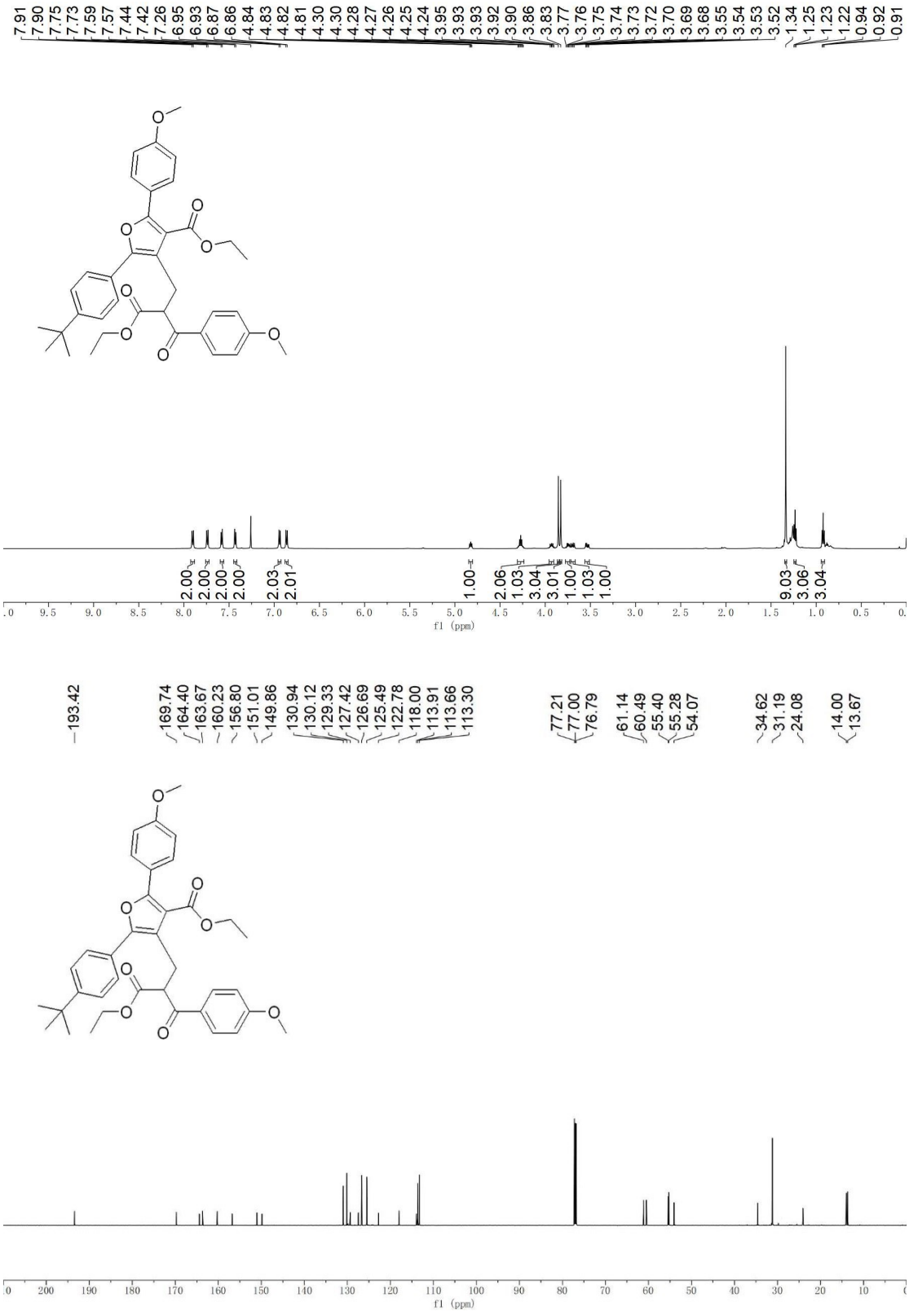


ethyl 4-(3-ethoxy-2-(4-methoxybenzoyl)-3-oxopropyl)-2-(4-methoxyphenyl)-5-(*p*-tolyl)furan-3-carboxylate (3ab)

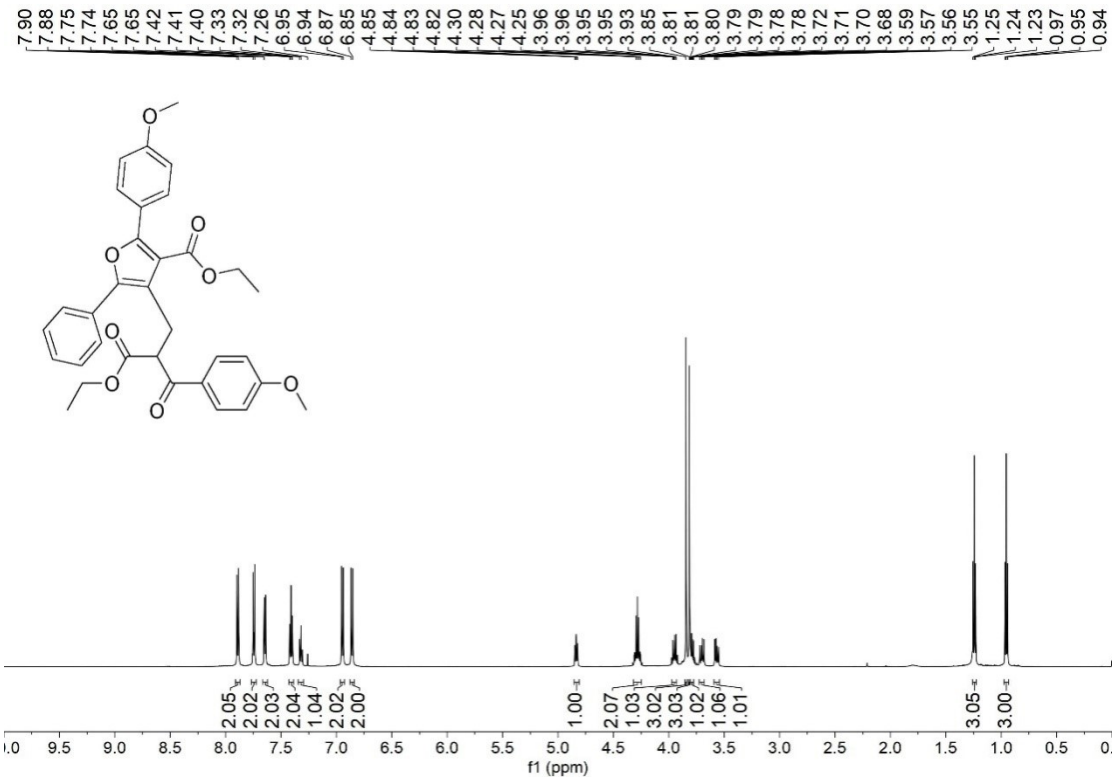


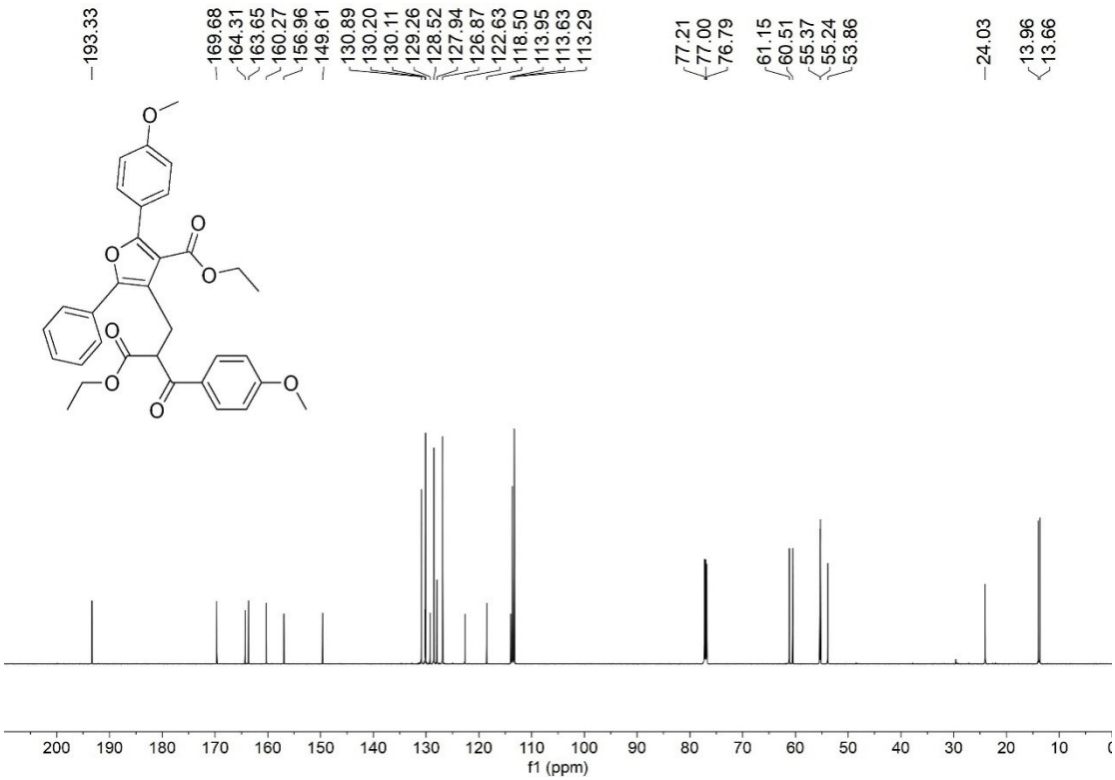
ethyl 5-(4-(*tert*-butyl)phenyl)-4-(3-ethoxy-2-(4-methoxybenzoyl)-3-oxopropyl)-2-(4-

methoxyphenyl)furan-3-carboxylate (3ac)

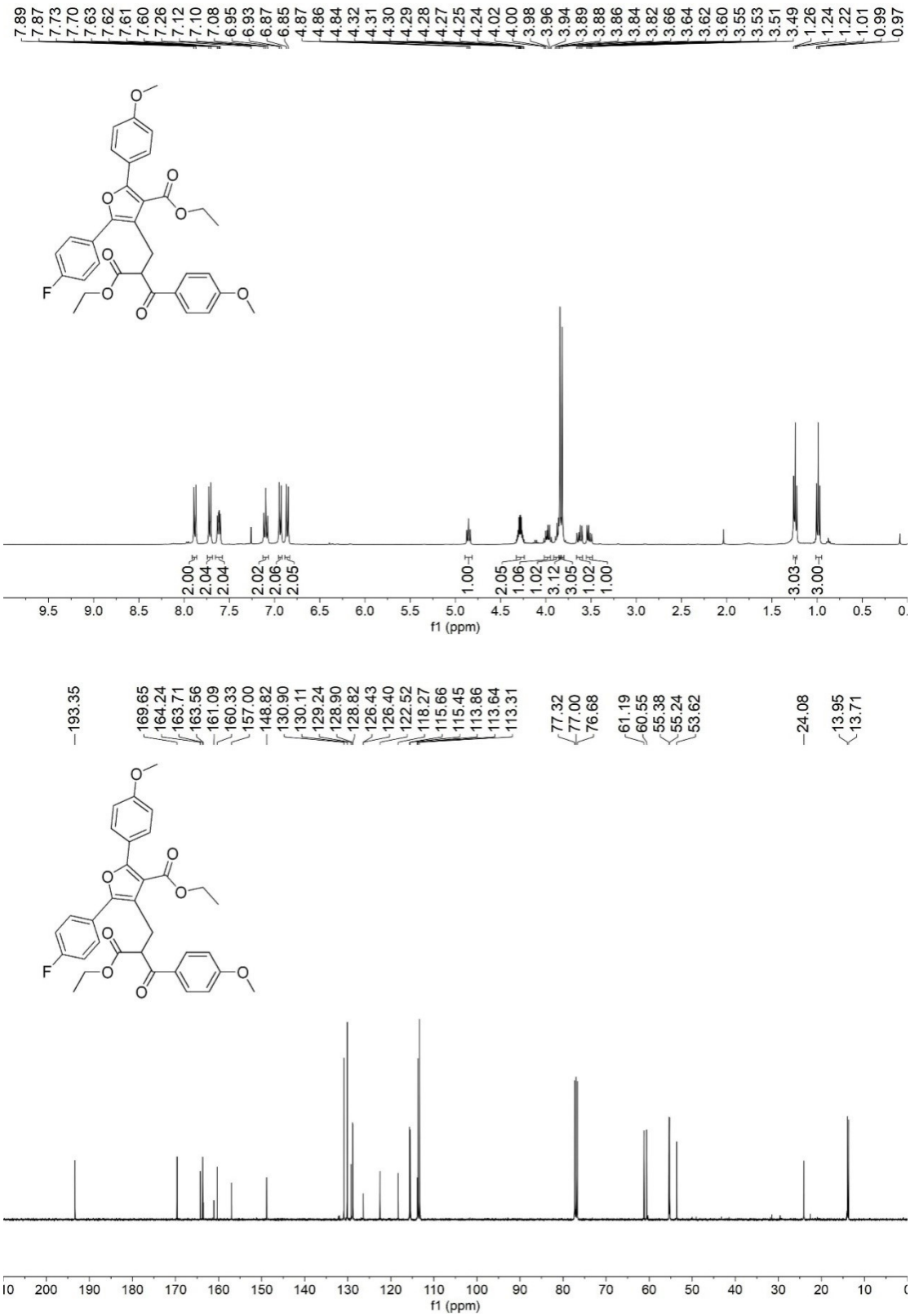


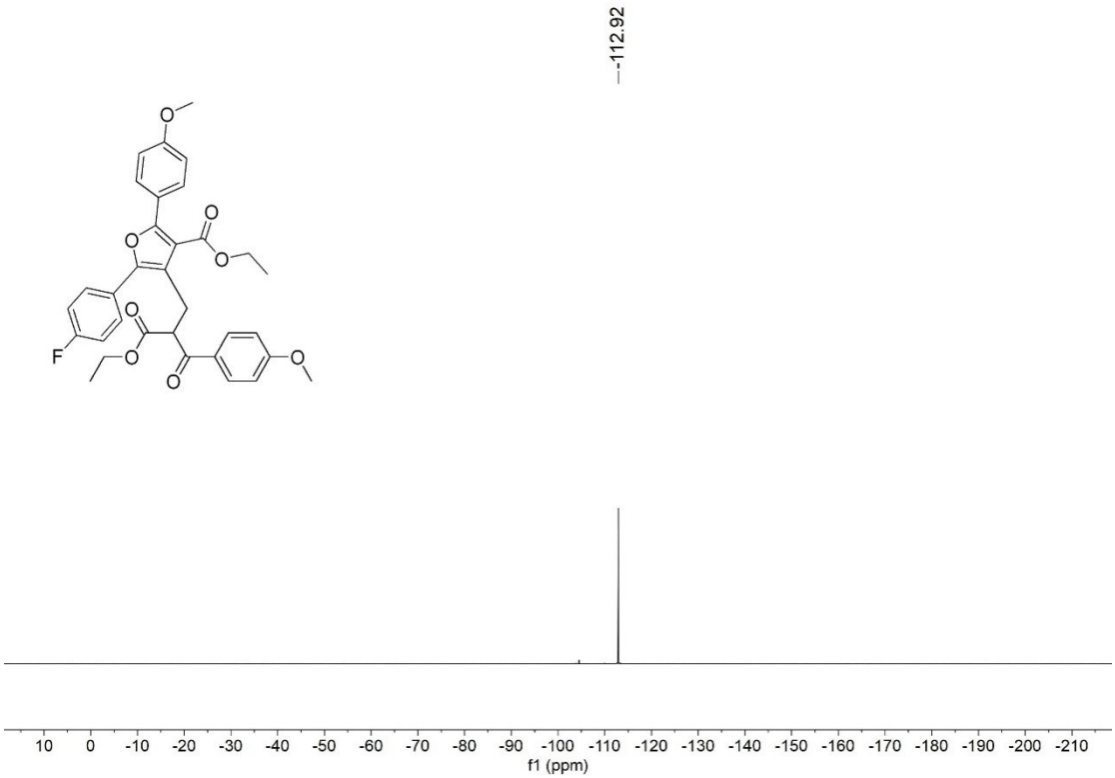
ethyl 4-(3-ethoxy-2-(4-methoxybenzoyl)-3-oxopropyl)-2-(4-methoxyphenyl)-5-phenylfuran-3-carboxylate (3ad)


7.90
7.88
7.75
7.74
7.65
7.65
7.42
7.41
7.40
7.33
7.32
7.26
6.95
6.94
6.87
6.85
4.85
4.84
4.83
4.82
4.30
4.28
4.27
4.25
3.96
3.96
3.95
3.95
3.93
3.85
3.81
3.81
3.80
3.79
3.79
3.78
3.78
3.72
3.71
3.70
3.68
3.59
3.57
3.56
3.55
1.25
1.24
1.23
0.97
0.95
0.94
2.05
2.02
2.03
2.04
1.04
2.02
2.00
1.00
2.07
1.03
3.02
3.03
1.02
1.06
1.01
3.05
3.00
f1 (ppm)

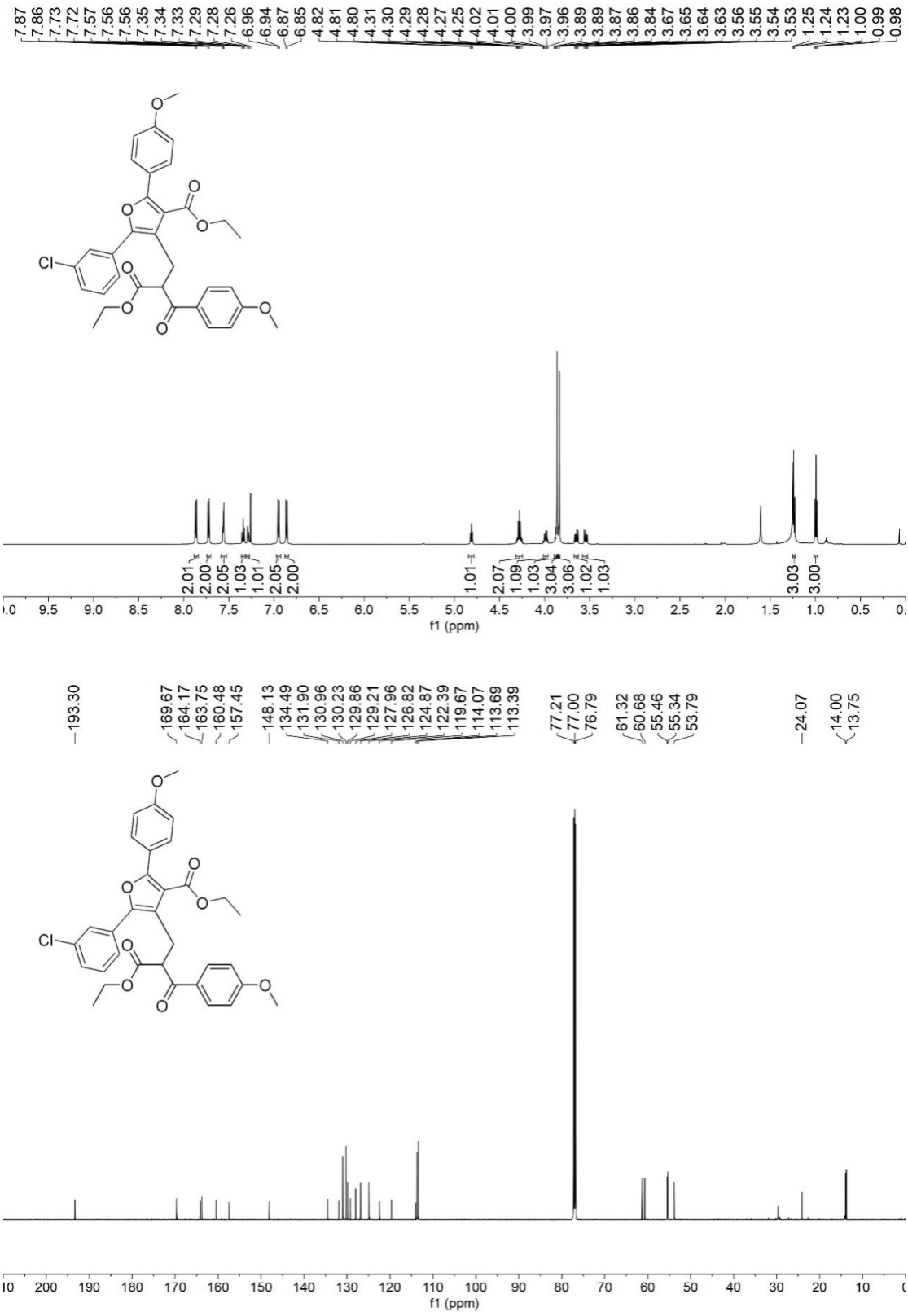

193.33
169.68
164.31
163.65
160.27
156.96
149.61
130.89
130.20
130.11
129.26
128.52
127.94
126.87
122.63
118.50
113.95
113.63
113.29
77.21
77.00
76.79
61.15
60.51
55.37
55.24
53.86
24.03
13.96
13.66
f1 (ppm)

ethyl 4-(3-ethoxy-2-(4-methoxybenzoyl)-3-oxopropyl)-5-(4-fluorophenyl)-2-(4-methoxyphenyl)furan-3-carboxylate (3ae)



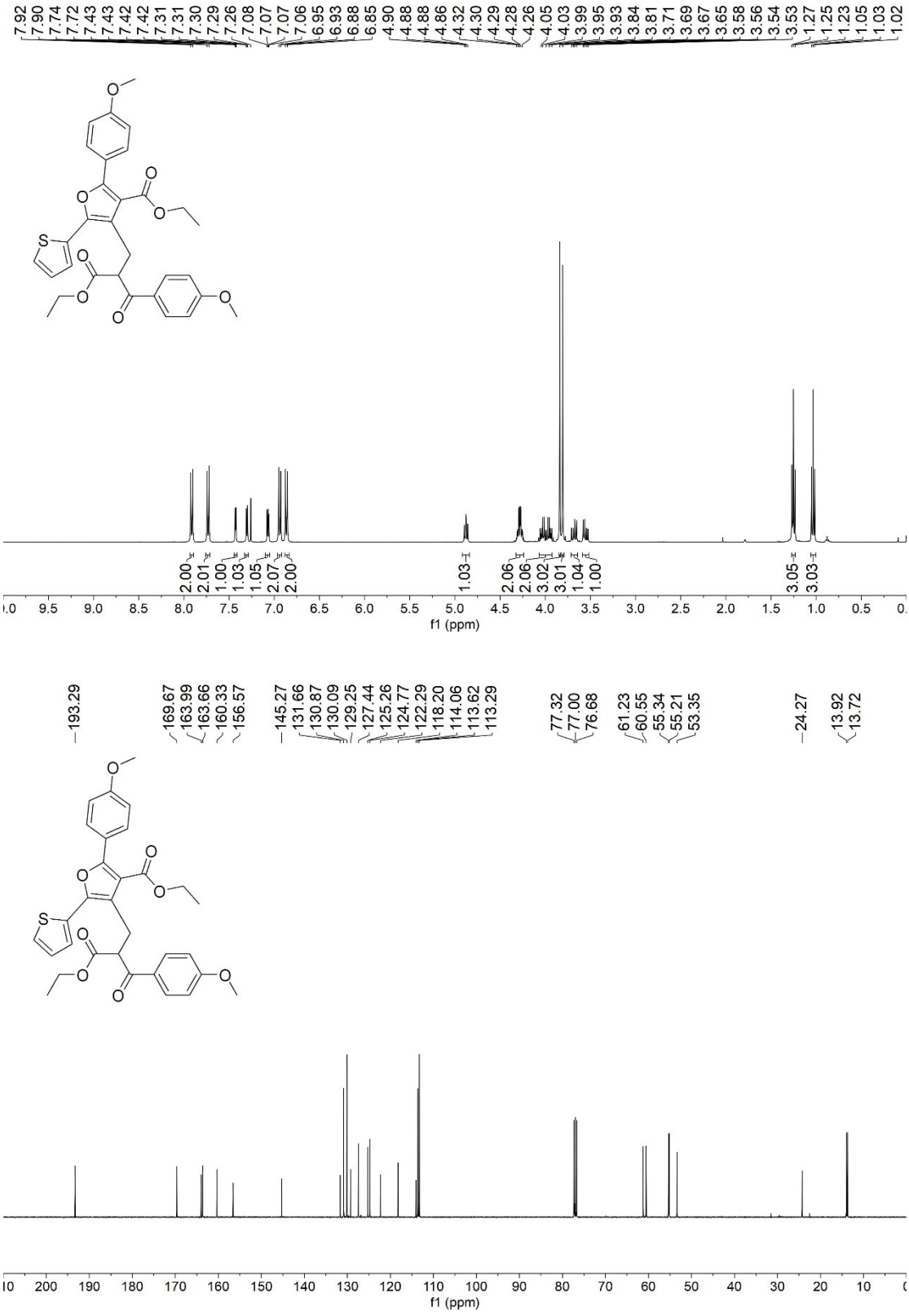

-112.92
10 0 -10 -20 -30 -40 -50 -60 -70 -80 -90 -100 -110 -120 -130 -140 -150 -160 -170 -180 -190 -200 -210
f1 (ppm)

ethyl 5-(3-chlorophenyl)-4-(3-ethoxy-2-(4-methoxybenzoyl)-3-oxopropyl)-2-(4-methoxyphenyl)furan-3-carboxylate (3af)

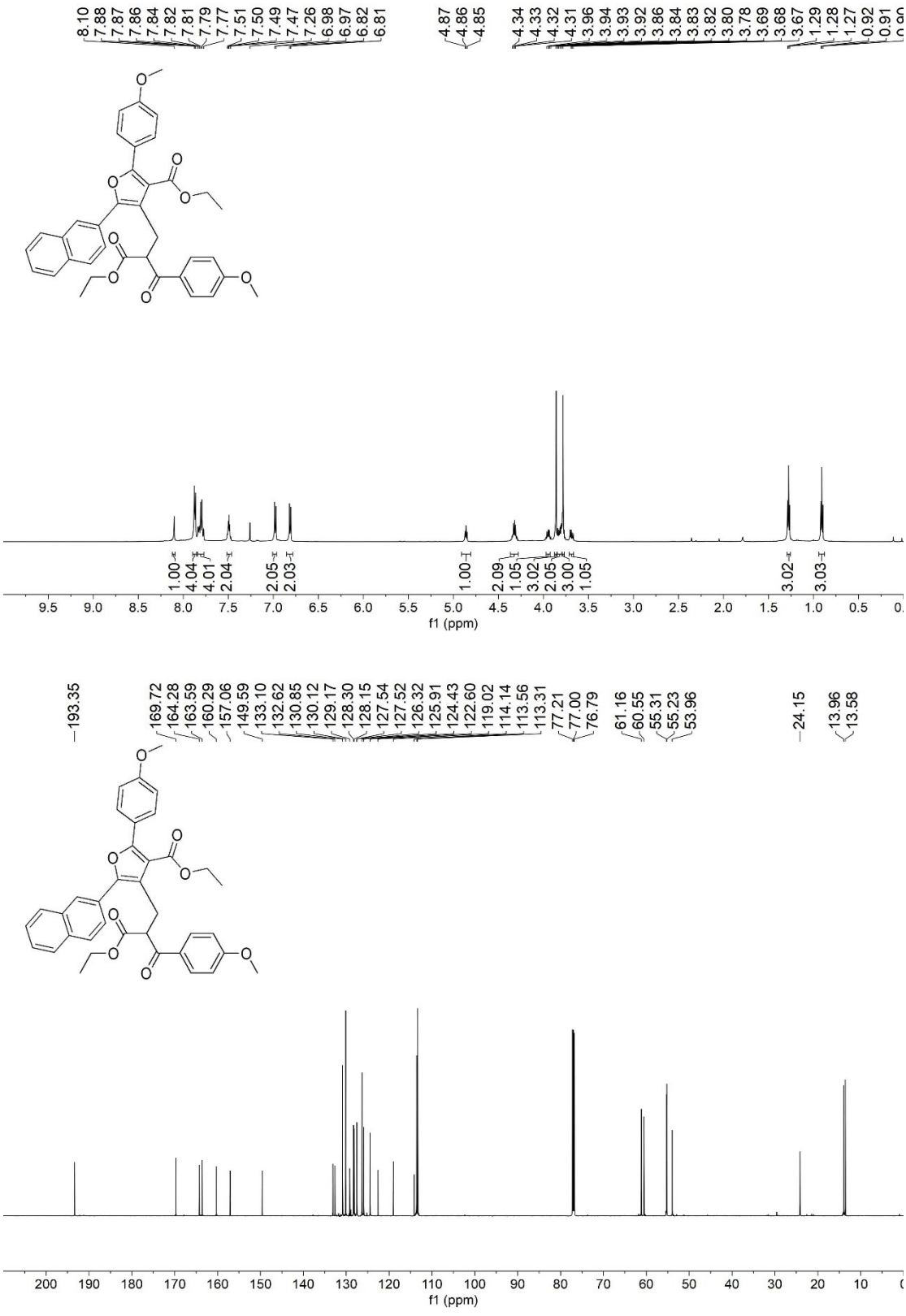


ethyl 4-(3-ethoxy-2-(4-methoxybenzoyl)-3-oxopropyl)-2-(4-methoxyphenyl)-5-(thiophen-2-

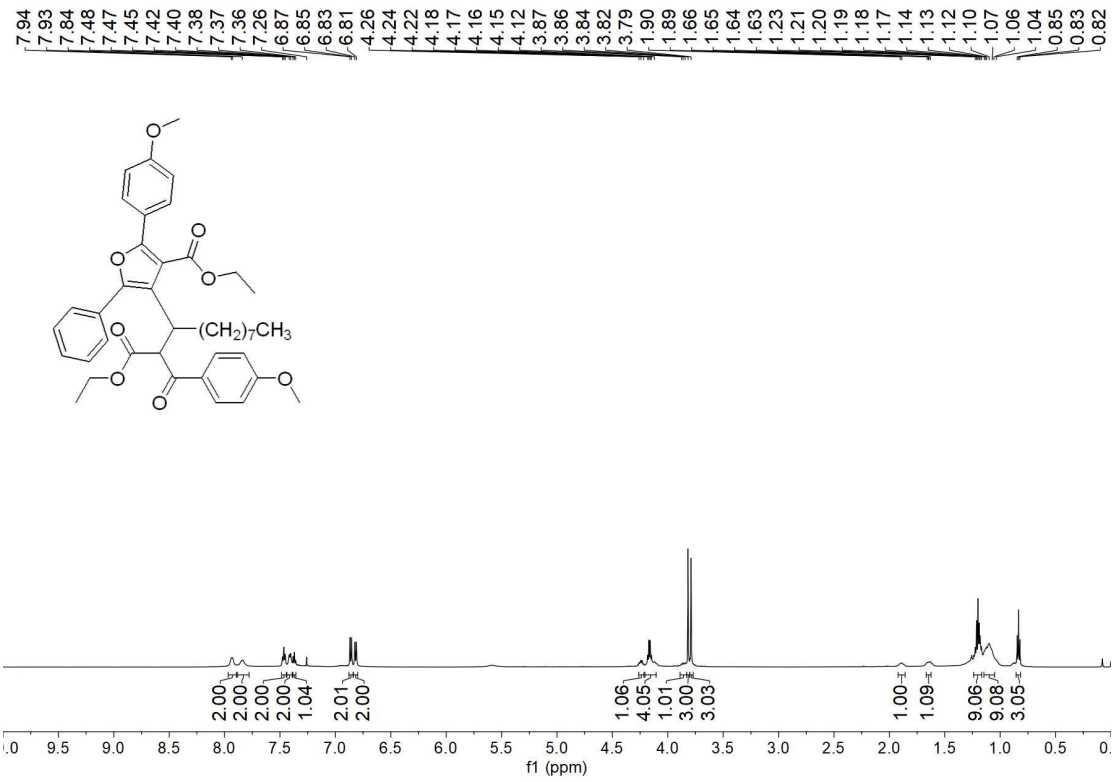
yl)furan-3-carboxylate (3ag)

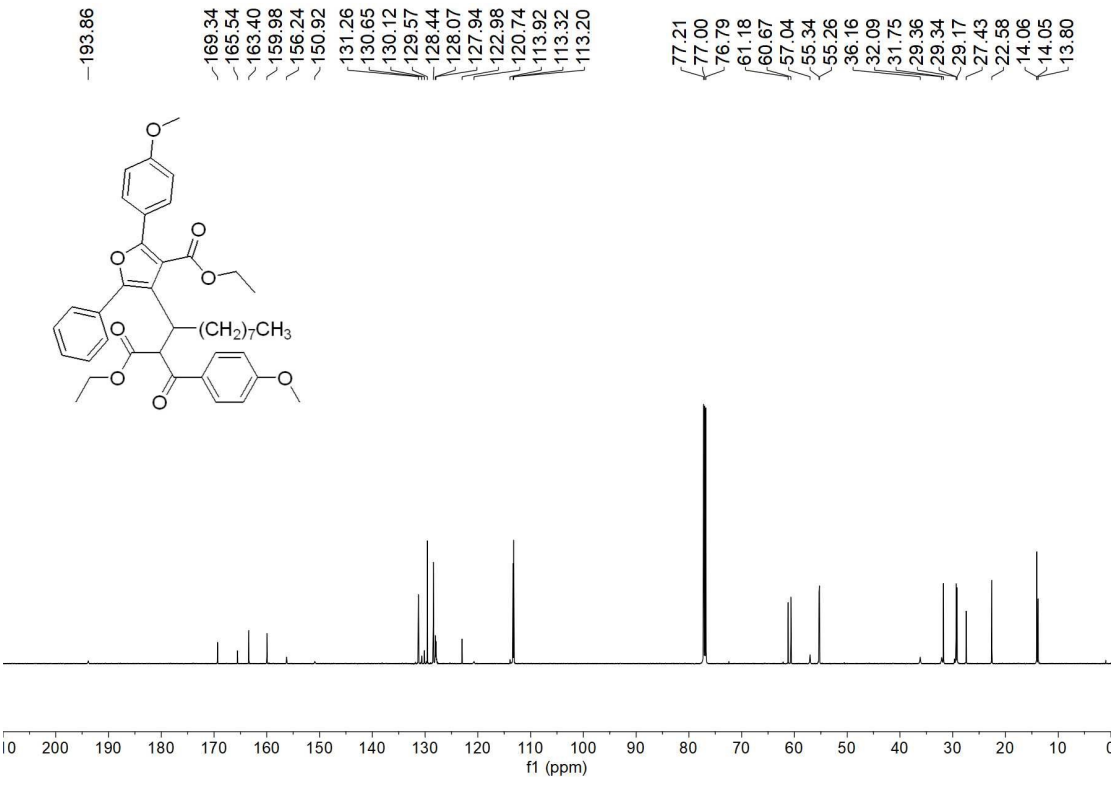


ethyl 4-(3-ethoxy-2-(4-methoxybenzoyl)-3-oxopropyl)-2-(4-methoxyphenyl)-5-(naphthalen-2-yl)furan-3-carboxylate (3ah)



ethyl 4-(1-ethoxy-2-(4-methoxybenzoyl)-1-oxoundecan-3-yl)-2-(4-methoxyphenyl)-5-phenylfuran-3-carboxylate (3ai)


7.94 7.93 7.84 7.48 7.47 7.45 7.42 7.40 7.38 7.37 7.36 7.26 6.87 6.85 6.83 6.81 4.26 4.24 4.22 4.18 4.17 4.16 4.15 4.12 3.87 3.86 3.84 3.82 3.79 1.90 1.89 1.66 1.65 1.64 1.63 1.23 1.21 1.20 1.19 1.18 1.17 1.14 1.13 1.12 1.10 1.07 1.06 1.04 0.85 0.83 0.82
(CH2)7CH3
2.00 2.00 2.00 2.00 1.04 2.01 2.00 1.06 4.05 1.01 3.00 3.03 1.00 1.09 9.06 9.08 3.05
f1 (ppm)


193.86 169.34 165.54 163.40 159.98 156.24 150.92 131.26 130.65 130.12 129.57 128.44 128.07 127.94 122.98 120.74 113.92 113.32 113.20 77.21 77.00 76.79 61.18 60.67 57.04 55.34 55.26 36.16 32.09 31.75 29.36 29.34 29.17 27.43 22.58 14.06 14.05 13.80
(CH2)7CH3
f1 (ppm)

ethyl 4-(3-ethoxy-2-(4-methoxybenzoyl)-3-oxo-1-phenylpropyl)-2-(4-methoxyphenyl)-5-phenylfuran-3-carboxylate (3aj)