Electronic Supplementary Material (ESI) for Organic Chemistry Frontiers.

Supporting Information

Palladium-Catalyzed Cross-Electrophile Coupling Reaction involving Sulfur Dioxide for the Direct Synthesis of Diverse Functionalized Sulfones

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General information and Materials

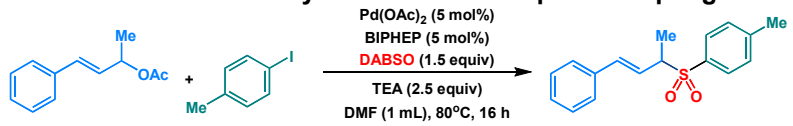
Unless otherwise noted, all reactions or reagents were obtained from commercial suppliers and used as received. Unless otherwise noted, all strict water-free and oxygen-free conditions were carried in an argon atmosphere glovebox (Vigor, SGI800-750TS-F). The substrates and reagents for catalytic reactions were degassed and stored in the glovebox, unless otherwise noted. All work-up and purification procedures were carried out with reagent-grade solvents in air.

Thin Layer Chromatography analyses were performed on silica gel coated glass plates (0.25 mm) with fluorescence indicator UV254. For detection of spots, irradiation of UV light at 254 nm or staining reagent using phosphomolybdic acid solution was used. Flash column chromatography was conducted with silica gel 60 (particle size 230–400 mesh, Huanghai) at room temperature and under elevated pressure.

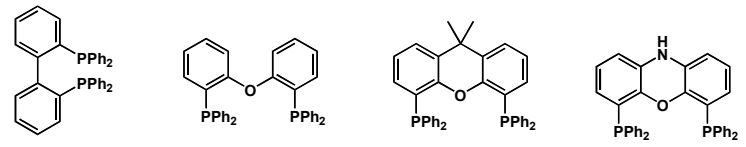
Gas Chromatography (GC) analysis was conducted on a Shimadzu GC-2030 instrument equipped with a Rtx-5 column (30 m $\times$ 0.25 mm) with dodecane as an internal standard. GC-MS analysis was conducted on Agilent 5977B GC/MSD instrument equipped with a HP-5MS UI column (30 m $\times$ 0.25 mm). ^{1}H NMR, ^{13}C NMR and ^{19}F NMR spectra were recorded at 400 MHz, 101 MHz and 376 MHz, respectively in $CDCl_3$ (or DMSO-d_6) at room temperature. ^{1}H NMR was reported as follows: chemical shift, multiplicity (s = singlet, d = doublet, t = triplet, q = quadruplet, m = multiplet), coupling constant (*J* values) in Hz and integration.

Optimization Table

Table S1: Optimization of the Pd-Catalyzed Cross-Electrophile Coupling Reaction



1, 0.2 mmol **2,** 1.2 equiv **3**



BIPHEP(L1), 83% yield **L2,** 79% yield **L3,** 73% yield **L4,** 66% yield

L5, 52% yield **L6,** trace **L7,** trace **L8,** 11% yield

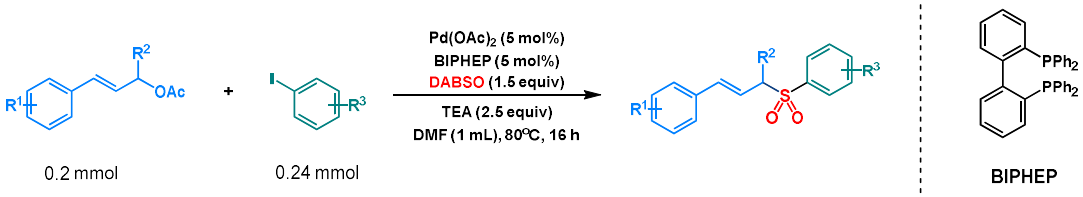
Entry	Deviation from std. conditions	Yield of **3a**[a]
1	none	83% (81%)[b]
2	$Pd(TFA)_2$ instead of $Pd(OAc)_2$	77%
3	$Pd(acac)_2$ instead of $Pd(OAc)_2$	70%
4	$Pd_2(dba)_3$ instead of $Pd(OAc)_2$	65%
5	**L2** instead of **L1**	79%
6	**L3** instead of **L1**	73%
7	**L4** instead of **L1**	66%
8	**L5** instead of **L1**	52%
9	**L6** instead of **L1**	trace
10	**L7** instead of **L1**	trace
11	**L8** instead of **L1**	11%
12	DIPEA instead of TEA	45%
13	DBU instead of TEA	nd
14	DMAP instead of TEA	nd
15	$Na_2S_2O_5$ instead of DABSO	nd
16	$K_2S_2O_5$ instead of DABSO	nd
17	$Na_2S_2O_8$ instead of DABSO	nd
18	$K_2S_2O_8$ instead of DABSO	nd
19	SOgen instead of DABSO	trace
20	Without $Pd(OAc)_2$/**L1**	nd

[a]Yields determined by GC analysis using n-dodecane as the internal standard; [b] Isolated yield in the parenthesis.

The initial study started with the attempts on the introduction of SO_2 into allylic acetate and aryl iodide (Table S1). (E)-4-phenylbut-3-en-2-yl **1**, 1-iodo-4-methylbenzene **2** and DABSO were employed as the substrates to evaluate this Pd-catalyzed multicomponent cross-electrophile coupling reaction. After evaluation of a range of reaction parameters, we found that a combination of $Pd(OAc)_2$ (5 mol%), BIPHEP (5 mol%), and TEA (2.5 equiv) in DMF (1 mL) at 80 °C provided the best results, giving rise to **3** in 81% isolated yield (Table S1, entry 1). When $Pd(OAc)_2$ was replaced by other palladium sources such as $Pd(TFA)_2$, $Pd(acac)_2$ and $Pd_2(dba)_3$, the efficiency of the reaction decreased slightly (entries 2-4). A comparison of entries 5−11 reveals that the characteristic of the ligand played an important role, with bidentate phosphine ligand (**L1**) providing the best interplay between electronic and steric effects. It was found that the type of the base has a significant impact on the reaction (entries 12-14). Switching the TEA to DIPEA caused a precipitously decrease in the yield, moreover, no desired product was detected when other bases such as DBU and DMAP were used. Various inorganic SO_2 surrogates such as $Na_2S_2O_5$, $K_2S_2O_5$, $Na_2S_2O_8$ or $K_2S_2O_8$ were tested, however, no reaction was observed (entries 15-18). Finally, a control experiment demonstrated that the catalyst and ligand were essential to this transformation (entry 19).

General Procedures

General procedure 1：Synthesis of allylic-aryl sulfones (compounds 3-51)



0.2 mmol　　0.24 mmol　　BIPHEP

In an argon fulfilled glovebox, allylic acetate (0.2 mmol, 1 equiv), aryl iodide (0.24 mmol, 1.2 equiv), $Pd(OAc)_2$ (2.2 mg, 0.01 mmol, 0.05 equiv), BIPHEP (5.2 mg, 0.01 mmol, 0.05 equiv), DABSO (72.1 mg, 1.5 equiv), and TEA (0.5 mmol, 2.5 equiv) were added as this order into an oven-dried 4 mL vial with a magnetic stirring bar, followed by addition of DMF (1.0 mL). The vial was sealed and removed out of the glovebox, then heated to 80 °C using heating mantle with 600-700 rpm stirring speed. After 16 h, the vial was cooled to room temperature. The mixture was passed through a short silica gel pad with EtOAc. The filtrate was washed by H_2O (3×5 mL), dried over anhydrous Na_2SO_4, then concentrated and the residue was purified by flash column chromatography to give the desired products **3-51**.

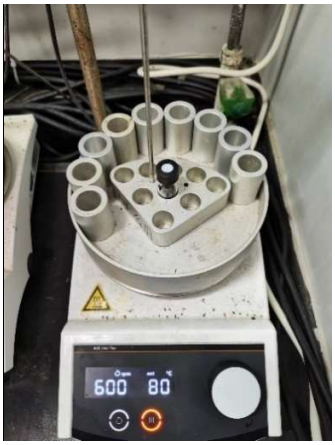
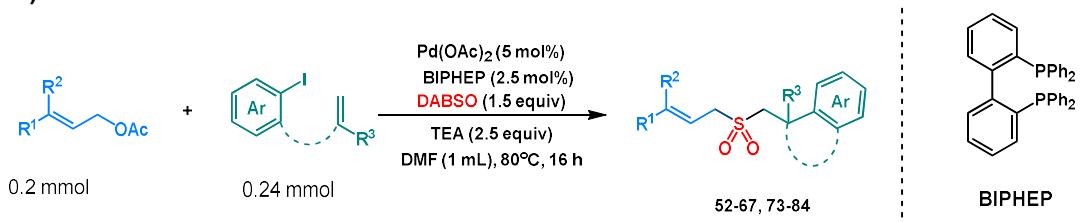


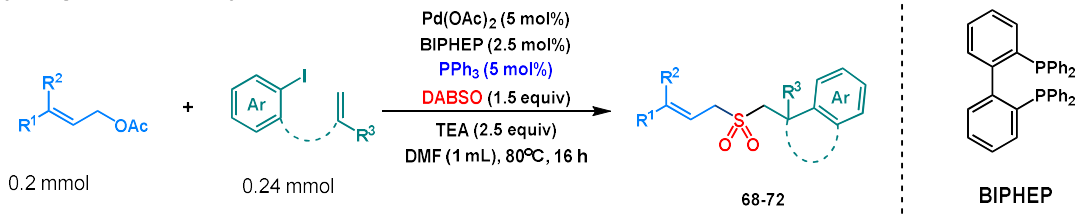
Figure S1 | The heat source used in this study.

General procedure 2：Synthesis of sulfone-containing heterocycles (compounds 52-67, 73-84)



In an argon fulfilled glovebox, allylic acetate (0.2 mmol, 1 equiv), alkene-tethered aryl halide (0.24 mmol, 1.2 equiv), $Pd(OAc)_2$ (2.2 mg, 0.01 mmol, 0.05 equiv), BIPHEP (2.6 mg, 0.005 mmol, 0.025 equiv), DABSO (72.1 mg, 1.5 equiv), and TEA (0.5 mmol, 2.5 equiv) were added as this order into an oven-dried 4 mL vial with a magnetic stirring bar, followed by addition of DMF (1.0 mL). The vial was sealed and removed out of the glovebox, then heated to 80 °C using heating mantle with 600-700 rpm stirring speed. After 16 h, the vial was cooled to room temperature. The mixture was passed through a short silica gel pad with EtOAc. The filtrate was washed by H_2O (3×5 mL), dried over anhydrous Na_2SO_4, then concentrated and the residue was purified by flash column chromatography to give the desired products **52-67**, **73-84**.

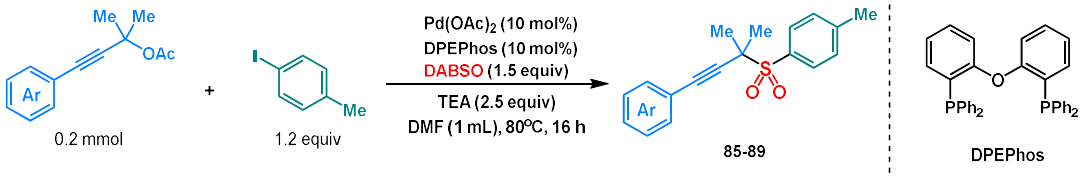
General procedure 3： Synthesis of sulfone-containing hetero- and carbocyclic scaffolds (compounds 68-72)



In an argon fulfilled glovebox, allylic acetate (0.2 mmol, 1 equiv), alkene-tethered aryl halide (0.24 mmol, 1.2 equiv), $Pd(OAc)_2$ (2.2 mg, 0.01 mmol, 0.05 equiv), BIPHEP (2.6 mg, 0.005 mmol, 0.025 equiv), PPh_3 (2.6 mg, 0.01 mmol, 0.05 equiv) DABSO (72.1 mg, 1.5 equiv), and TEA (0.5 mmol, 2.5 equiv) were added as this order into an oven-dried 4 mL vial with a magnetic stirring bar,

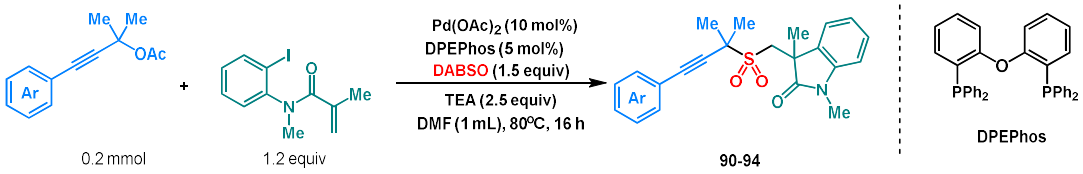
followed by addition of DMF (1.0 mL). The vial was sealed and removed out of the glovebox, then heated to 80 °C using heating mantle with 600-700 rpm stirring speed. After 16 h, the vial was cooled to room temperature. The mixture was passed through a short silica gel pad with EtOAc. The filtrate was washed by H_2O (3×5 mL), dried over anhydrous Na_2SO_4, then concentrated and the residue was purified by flash column chromatography to give the desired products **68-72**.

General procedure 4： Synthesis of propargyl-aryl sulfones (compounds 85-89)



In an argon fulfilled glovebox, propargyl acetate (0.2 mmol, 1 equiv), 4-Iodotoluene (0.24 mmol, 1.2 equiv), $Pd(OAc)_2$ (4.5 mg, 0.02 mmol, 0.1 equiv), DPEPhos (10.8 mg, 0.02 mmol, 0.1 equiv), DABSO (72.1 mg, 1.5 equiv), and TEA (0.5 mmol, 2.5 equiv) were added as this order into an oven-dried 4 mL vial with a magnetic stirring bar, followed by addition of DMF (1.0 mL). The vial was sealed and removed out of the glovebox, then heated to 80 °C using heating mantle with 600-700 rpm stirring speed. After 16 h, the vial was cooled to room temperature. The mixture was passed through a short silica gel pad with EtOAc. The filtrate was washed by H_2O (3×5 mL), dried over anhydrous Na_2SO_4, then concentrated and the residue was purified by flash column chromatography to give the desired products **85-89**.

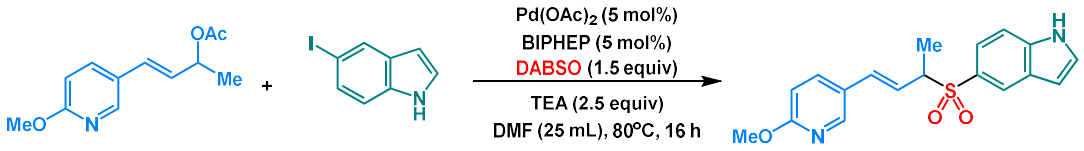
General procedure 5： Synthesis of propargyl-alkyl sulfones (compounds 90-94)



In an argon fulfilled glovebox, propargyl acetate (0.2 mmol, 1 equiv), *N*-(2-iodophenyl)-*N*-methylmethacrylamide (0.24 mmol, 1.2 equiv), $Pd(OAc)_2$ (4.5 mg, 0.02 mmol, 0.1 equiv), DPEPhos (5.4 mg, 0.01 mmol, 0.05 equiv), DABSO (72.1 mg, 1.5 equiv), and TEA (0.5 mmol, 2.5 equiv) were added as this order into an oven-dried 4 mL vial with a magnetic stirring bar, followed by addition of DMF (1.0 mL). The vial was sealed and removed out of the glovebox, then heated to 80 °C using heating mantle with 600-700 rpm stirring speed. After 16 h, the vial was cooled to room temperature. The mixture was passed through a short silica gel pad with EtOAc. The filtrate was washed by H_2O (3×5 mL), dried over anhydrous Na_2SO_4, then concentrated and the residue was purified by flash column chromatography to give the desired products **90-94**.

The procedure for the gram scale reactions:

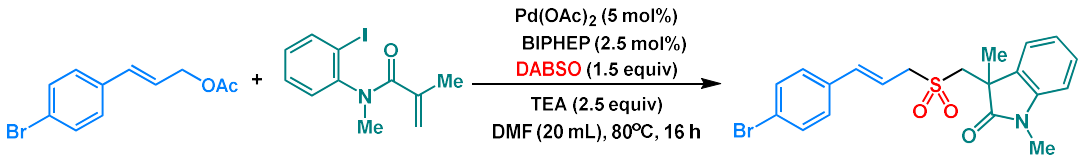
1) Synthesis of compound 43



95, 5 mmol, 1.1 g **50**, 1.2 equiv **43**, 83 % yield

In an argon fulfilled glovebox, (E)-4-(6-methoxypyridin-3-yl)but-3-en-2-yl acetate **95** (1.1 g, 5.0 mmol), 5-iodo-1H-indole **50** (6.0 mmol, 1.2 equiv), $Pd(OAc)_2$ (56.0 mg, 0.25 mmol, 0.05 equiv), BIPHEP (130.6 mg, 0.25 mmol, 0.05 equiv), DABSO (7.5 mmol, 1.5 equiv) and TEA (12.5 mmol, 2.5 equiv) were added as this order into an oven-dried 100 mL seal-tube with a magnetic stirring bar, followed by addition of DMF (25 mL). The tube was sealed and removed out of the glovebox, then heated to 80 °C using oil bath with 600 rpm stirring speed. After 16 h, the seal-tube was cooled to room temperature. The mixture was passed through a short silica gel pad with EtOAc. The filtrate was washed by H_2O (3×50 mL), dried over anhydrous Na_2SO_4, then concentrated and the residue was purified by flash column chromatography using petroleum/ethyl acetate (1:1) as eluent to give the desired product **43** as a white solid (1.421 g, 83% yield).

2) Synthesis of compound 97

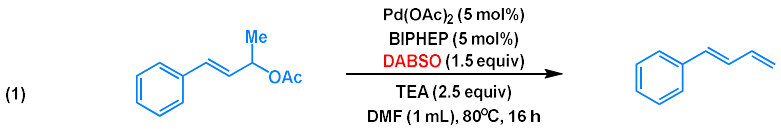


96, 3.9 mmol, 1 g **83**, 1.2 equiv **97**, 80% yield

In an argon fulfilled glovebox, (E)-3-(4-bromophenyl)allyl acetate **96** (1.0 g, 3.9 mmol), *N*-(2-iodophenyl)-*N*-methylmethacrylamide **83** (4.7 mmol, 1.2 equiv), $Pd(OAc)_2$ (43.8 mg, 0.195 mmol, 0.05 equiv), BIPHEP (50.9 mg, 0.025 equiv), DABSO (5.85 mmol, 1.5 equiv) and TEA (9.75 mmol, 2.5 equiv) were added as this order into an oven-dried 100 mL seal-tube with a magnetic stirring bar, followed by addition of DMF (20 mL). The tube was sealed and removed out of the glovebox, then heated to 80 °C using oil bath with 600 rpm stirring speed. After 16 h, the seal-tube was cooled to room temperature. The mixture was passed through a short silica gel pad with EtOAc. The filtrate was washed by H_2O (3×50 mL), dried over anhydrous Na_2SO_4, then concentrated and the residue was purified by flash column chromatography using petroleum/ethyl acetate (2:1) as eluent to give the desired product **97** as a white solid (1.355 g, 80% yield).

Figure S2 | The heat source used in the gram scale reaction.

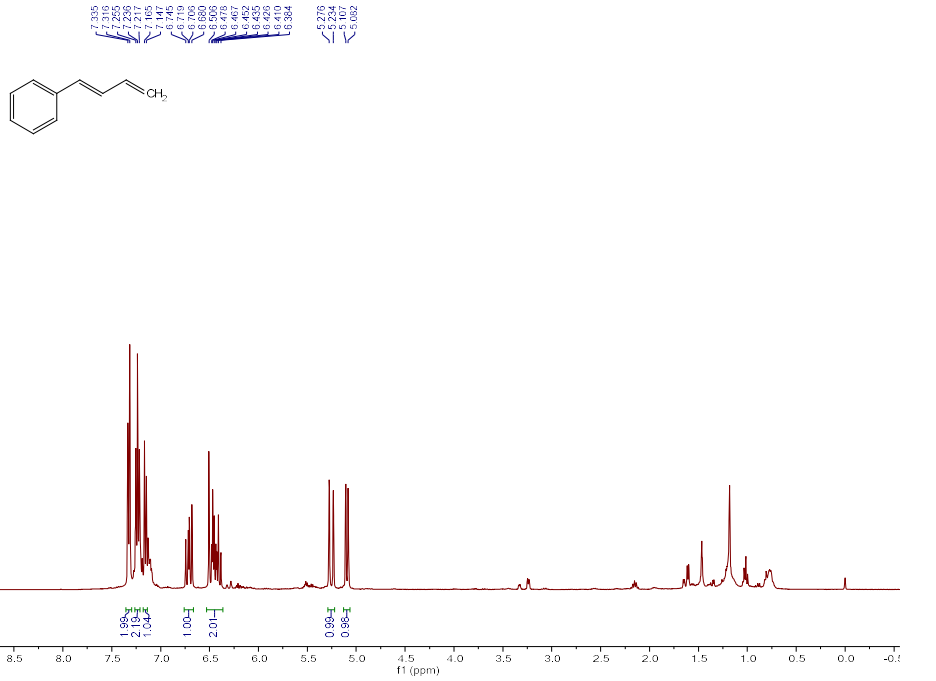
Mechanistic Experiments

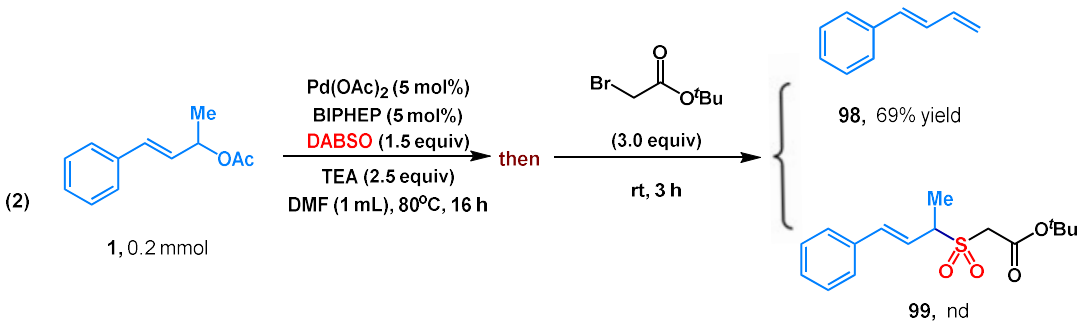


In an argon fulfilled glovebox, (*E*)-4-phenylbut-3-en-2-yl acetate **1** (0.2 mmol, 1 equiv), $Pd(OAc)_2$ (2.2 mg, 0.01 mmol, 0.05 equiv), BIPHEP (5.2 mg, 0.01 mmol, 0.05 equiv), DABSO (72.1 mg, 1.5 equiv), and TEA (0.5 mmol, 2.5 equiv) were added as this order into an oven-dried 4 mL vial with a magnetic stirring bar, followed by addition of DMF (1.0 mL). The vial was sealed and removed out of the glovebox, then heated to 80 °C using heating mantle with 600 rpm stirring speed. After 16 h, the vial was cooled to room temperature. The mixture was passed through a short silica gel pad with EtOAc. The filtrate was washed by H_2O (3×5 mL), dried over anhydrous Na_2SO_4, then concentrated and the residue was purified by flash column chromatography using petroleum/ethyl acetate (100:1) as eluent to give the compound **98** as a colorless oil (18.2 mg, 70% yield).

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.33 (d, *J* = 7.6 Hz, 2H), 7.24 (t, *J* = 7.6 Hz, 2H), 7.16 (d, *J* = 7.2 Hz, 1H), 6.71 (dd, *J* = 15.6, 10.4 Hz, 1H), 6.51 – 6.38 (m, 2H), 5.25 (d, *J* = 16.8 Hz, 1H), 5.09 (d, *J* = 10.0 Hz, 1H).

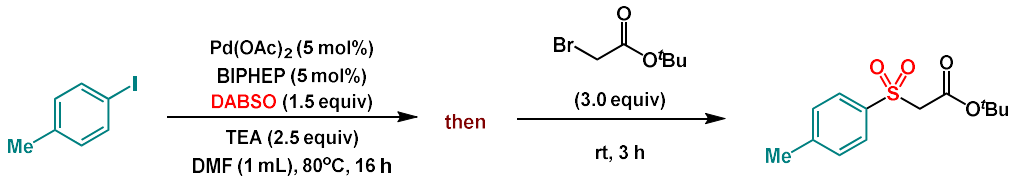
^{1}H NMR spectrum (400 MHz, $CDCl_3$) of compound **98**





In an argon fulfilled glovebox, (*E*)-4-phenylbut-3-en-2-yl acetate **1** (0.2 mmol, 1 equiv), $Pd(OAc)_2$ (2.2 mg, 0.01 mmol, 0.05 equiv), BIPHEP (5.2 mg, 0.01 mmol, 0.05 equiv), DABSO (72.1 mg, 1.5 equiv), and TEA (0.5 mmol, 2.5 equiv) were added as this order into an oven-dried 4 mL vial with a magnetic stirring bar, followed by addition of DMF (1.0 mL). The vial was sealed and removed out of the glovebox, then heated to 80 °C using heating mantle with 600 rpm stirring speed. After 16 h, the resulting mixture was cooled to room temperature before adding *t*-butylbromoacetate (0.6 mmol, 3 equiv). The reaction was left to stir at room temperature for an additional 3 hours. The mixture was passed through a short silica gel pad with EtOAc. The filtrate was washed by H_2O (3×5 mL), dried over anhydrous Na_2SO_4, then concentrated and the residue was purified by flash column chromatography using petroleum/ethyl acetate (100:1) as eluent to give the compound **98** as a colorless oil (18.0 mg, 69% yield). *No sulfone product **99** was detected in the reaction.*

(3)



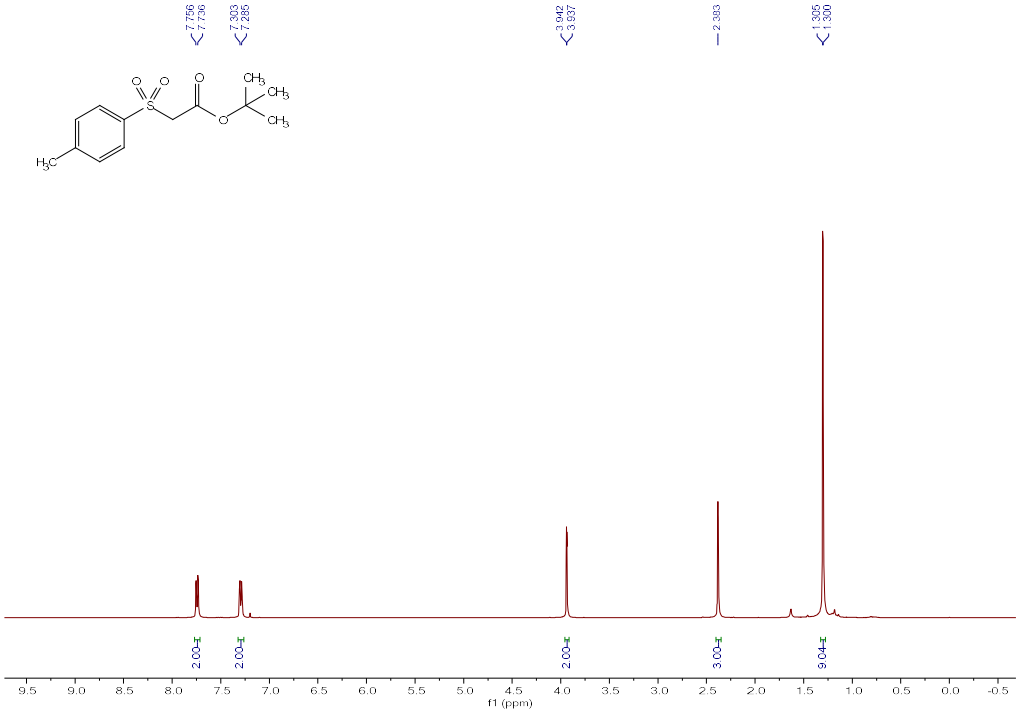
2, 0.2 mmol

100, 71% yield

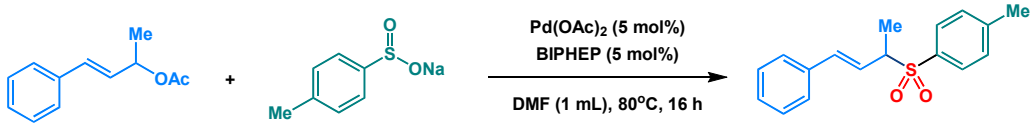
In an argon fulfilled glovebox, 1-iodo-4-methylbenzene **2** (0.2 mmol, 1 equiv), $Pd(OAc)_2$ (2.2 mg, 0.01 mmol, 0.05 equiv), BIPHEP (5.2 mg, 0.01 mmol, 0.05 equiv), DABSO (72.1 mg, 1.5 equiv), and TEA (0.5 mmol, 2.5 equiv) were added as this order into an oven-dried 4 mL vial with a magnetic stirring bar, followed by addition of DMF (1.0 mL). The vial was sealed and removed out of the glovebox, then heated to 80 °C using heating mantle with 600 rpm stirring speed. After 16 h, the resulting mixture was cooled to room temperature before adding *t*-butylbromoacetate (0.6 mmol, 3 equiv). The reaction was left to stir at room temperature for an additional 3 hours. The mixture was passed through a short silica gel pad with EtOAc. The filtrate was washed by H_2O (3×5 mL), dried over anhydrous Na_2SO_4, then concentrated and the residue was purified by flash column chromatography using petroleum/ethyl acetate (3:1) as eluent to give the compound **100** as a colorless oil (38.4 mg, 71% yield).

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.75 (d, *J* = 8.0 Hz, 2H), 7.29 (d, *J* = 7.2 Hz, 2H), 3.94 (d, *J* = 2.0 Hz, 2H), 2.38 (s, 3H), 1.30 (d, *J* = 2.0 Hz, 9H).

^{1}H NMR spectrum (400 MHz, $CDCl_3$) of compound **100**



(4)



1, 0.2 mmol **101,** 1.2 equiv **3,** 79% yield

In an argon fulfilled glovebox, (*E*)-4-phenylbut-3-en-2-yl acetate **1** (0.2 mmol, 1 equiv), sodium 4-methylbenzenesulfinate **101** (0.24 mmol, 1.2 equiv), $Pd(OAc)_2$ (2.2 mg, 0.01 mmol, 0.05 equiv) and BIPHEP (5.2 mg, 0.01 mmol, 0.05 equiv) were added as this order into an oven-dried 4 mL vial with a magnetic stirring bar, followed by addition of DMF (1.0 mL). The vial was sealed and removed out of the glovebox, then heated to 80 °C using heating mantle with 600 rpm stirring speed. After 16 h, the vial was cooled to room temperature. The mixture was passed through a short silica gel pad with EtOAc. The filtrate was washed by H_2O (3×5 mL), dried over anhydrous Na_2SO_4, then concentrated and the residue was purified by flash column chromatography using petroleum/ethyl acetate (10:1) as eluent to give the compound **3** as a white solid (45.2 mg, 79% yield).

(5)

1, 0.2 mmol **101,** 1.2 equiv **3,** nd

In an argon fulfilled glovebox, (*E*)-4-phenylbut-3-en-2-yl acetate **1** (0.2 mmol, 1 equiv), sodium 4-methylbenzenesulfinate **101** (0.24 mmol, 1.2 equiv) were added as this order into an oven-dried 4 mL vial with a magnetic stirring bar, followed by addition of DMF (1.0 mL). The vial was sealed and removed out of the glovebox, then heated to 80 °C using heating mantle with 600 rpm stirring speed. After 16 h, the vial was cooled to room temperature. The mixture was passed through a short silica gel pad with EtOAc. The filtrate was analyzed by GC-MS and GC, *no desired product **3** was found in this reaction.*

Computational Details

Computational Methods

All the calculations were performed with Gaussian 16 package. [1] Geometries were optimized in gas phase by using unrestricted MN15[2] and a mixed basis set of SDD[3] for Pd, P, and I, and 6-31G(d,p) [4] basis set for all other atoms at temperature of 353K. Optimized geometries were verified by frequency computations as minima (zero imaginary frequencies) or transition state (a single imaginary frequency) at the same level of theory. The transition states (TSs) were also confirmed by viewing normal mode vibrational vector. Solvent effect was included by single-point energy calculation using SMD model with toluene as the solvent and MN15 method with def2-TZVP basis set for Pd, P, and I, and 6-311++G(d,p) basis set for other atoms. [5] All relative Gibbs free energies

and electronic energies were reported in kcal/mol.

References

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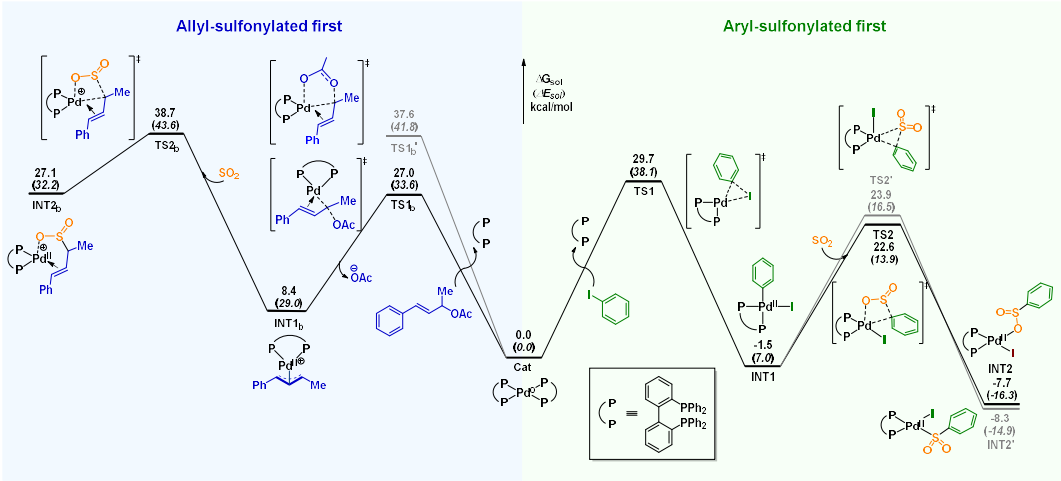

Figure S3. The DFT studies of allyl-sulfonylated first (left) and aryl-sulfonylated first (right) by Pd Catalyst. Relative free energies (electronic energies) are in kcal/mol at 353 K and 1 atm.

Table S2. Listed are the zero-point vibrational energy correction (cZPE), enthalpy correction (cH), Gibbs free energy correction (cG) and imaginary frequencies (IF) determined in the gas-phase

geometries at 353 K and 1 atm. Single-point solvent (n,n-dimethylformamide) corrected SCF Done energies (E) are also presented. All energies values are given in Hartree.

Geometry	$cZPE_{353,gas}$	$cH_{353,gas}$	$cG_{353,gas}$	$E_{0,sol}$	IF
OAc	0.048552	0.055367	0.014662	-228.438375	-
P_ligand	0.529418	0.575252	0.440302	-2069.826232	-
cinnamyl_acetate	0.233719	0.253874	0.178953	-615.592189	-
PhI	0.090533	0.099638	0.051465	-528.398678	-
Cat	1.063503	1.156625	0.927562	-4267.483608	-
TS1	0.621046	0.678283	0.521788	-2725.991718	-74.097
INT1	0.623492	0.680962	0.524061	-2726.043839	-
TS1b'	0.763845	0.831466	0.655557	-2813.179026	-261.574
TS1b	0.763502	0.831650	0.651337	-2813.191669	-186.482
INT1b	0.713894	0.774965	0.613442	-2584.759652	-
TS2	0.632852	0.694305	0.531265	-3274.448915	-151.888
TS2'	0.632966	0.694646	0.529537	-3274.44501	-189.083
INT2	0.634734	0.696091	0.533014	-3274.498901	-
INT2'	0.634528	0.696424	0.529761	-3274.496594	-
TS2b	0.722756	0.788044	0.617842	-3133.152113	-192.048
INT2b	0.724559	0.790054	0.619237	-3133.17199	-
INT3	0.585692	0.642227	0.488362	-2722.974221	-
INT4	0.098213	0.109668	0.057060	-779.962497	-
INT5	0.813791	0.887141	0.698512	-3364.73786	-
TS3	0.812869	0.885969	0.693672	-3364.713385	-133.088
TS3'	0.812745	0.885504	0.698118	-3364.705912	-87.564
INT6	0.815686	0.888194	0.699510	-3364.743961	-
Prd	0.283005	0.308014	0.221082	-1167.110803	-

Table S3. Cartesian coordinates (in Å) of related structures which were calculated at the M N15/6-31G(d,p)+SDD(Pd) level of theory

OAc anion

O	0.688921	1.166683	-0.000133
C	0.218674	0.002120	0.000264
O	0.805885	-1.106535	-0.000130
C	-1.346311	-0.057585	0.000058
H	-1.737640	0.469460	0.880274
H	-1.737522	0.470828	-0.879385
H	-1.717465	-1.088682	-0.000717

P_ligand

C	0.278575	-0.695422	-1.413044
C	1.268597	-1.068543	-0.481871
C	1.762668	-2.375651	-0.499014
C	1.280965	-3.306710	-1.422746
C	0.306305	-2.936394	-2.346755
C	-0.186946	-1.631594	-2.341587
C	-0.278669	0.692487	-1.414238
C	-1.268492	1.067340	-0.483552
C	-1.762336	2.374502	-0.502795
C	-1.280685	3.303904	-1.428219
C	-0.306305	2.931842	-2.351826
C	0.186777	1.626989	-2.344500
H	2.530167	-2.671414	0.211851
H	1.674789	-4.320021	-1.419712

H	-0.076162	-3.658158	-3.063507
H	-0.969590	-1.334981	-3.037298
H	-2.529619	2.671592	0.207754
H	-1.674320	4.317291	-1.426812
H	0.076098	3.652315	-3.069909
H	0.969242	1.329067	-3.039850
P	1.852576	0.240562	0.715382
P	-1.852564	-0.239664	0.715946
C	2.883469	1.255575	-0.450928
C	2.831380	2.647745	-0.336543
C	3.628926	0.679463	-1.487744
C	3.510317	3.458090	-1.248104
H	2.225946	3.091158	0.451216
C	4.308902	1.486957	-2.399079
H	3.658523	-0.404983	-1.584652
C	4.246350	2.877890	-2.281298
H	3.455687	4.539855	-1.157973
H	4.882470	1.033559	-3.203555
H	4.769322	3.507330	-2.996816
C	3.100022	-0.703539	1.709160
C	4.484859	-0.573665	1.570775
C	2.589682	-1.573487	2.684851
C	5.345819	-1.303898	2.394091
H	4.893436	0.100437	0.822112
C	3.448603	-2.314140	3.493320
H	1.509967	-1.664773	2.800809
C	4.831844	-2.177570	3.350994
H	6.421261	-1.191476	2.281755
H	3.040765	-2.989981	4.240567
H	5.504235	-2.747102	3.987209
C	-3.099619	0.706418	1.708331
C	-2.588899	1.578266	2.682124
C	-4.484510	0.576426	1.570594
C	-3.447509	2.320581	3.489398
H	-1.509140	1.669701	2.797547
C	-5.345154	1.308348	2.392738
H	-4.893373	-0.099082	0.823354
C	-4.830805	2.183839	3.347777
H	-3.039386	2.997863	4.235182
H	-6.420641	1.195815	2.280941
H	-5.502950	2.754674	3.983084
C	-2.883925	-1.256322	-0.448541
C	-2.831958	-2.648326	-0.332058
C	-3.629639	-0.681709	-1.486004
C	-3.511221	-3.459982	-1.242205
H	-2.226366	-3.090607	0.456215
C	-4.309948	-1.490517	-2.395930
H	-3.659180	0.402590	-1.584543
C	-4.247483	-2.881275	-2.276075
H	-3.456672	-4.541614	-1.150451
H	-4.883707	-1.038279	-3.200921
H	-4.770708	-3.511746	-2.990500

cinnamyl_acetate

C	-0.303325	0.504088	0.062352
C	0.708076	-0.034850	-0.629436
H	-0.142755	0.970346	1.035199
H	0.477100	-0.511274	-1.584852
C	-1.710413	0.545341	-0.449430
H	-1.805158	-0.046146	-1.367480
C	2.128350	-0.075879	-0.242005
C	3.010247	-0.867730	-0.992162
C	2.643304	0.644530	0.848219
C	4.360848	-0.953708	-0.659307
H	2.623423	-1.424429	-1.843745
C	3.991021	0.559528	1.182776
H	1.985809	1.285056	1.430783
C	4.856087	-0.241148	0.432091
H	5.025510	-1.575743	-1.252889
H	4.371833	1.125156	2.029154
H	5.908787	-0.302766	0.694261
C	-2.198243	1.968589	-0.696699
H	-1.572898	2.453776	-1.451479
H	-3.232093	1.950857	-1.051390
H	-2.142057	2.550503	0.229161
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C	-3.723935	-0.552799	0.152257
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PhI

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Cat

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H	6.011066	2.679916	2.234897
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H	6.010533	-2.680316	-2.235313
H	5.819869	-0.357026	-1.387010
P	1.678882	1.236298	-1.274339
P	1.678888	-1.236241	1.274351
C	2.514981	0.420344	-2.723053
C	1.880790	-0.682225	-3.298029
C	3.757819	0.830833	-3.220747
C	2.479417	-1.378246	-4.350211
H	0.921168	-1.000700	-2.896403
C	4.348577	0.151786	-4.284864
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C	-1.880788	0.680035	-3.298559
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C	-1.989578	-3.699405	-2.759281
C	0.170469	-3.267129	-1.779402
C	-4.063518	0.718322	-0.217886

C	-3.272665	3.009126	-0.248406
C	0.170475	3.266964	1.779554
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C	-1.881066	-0.680144	3.298411
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C	-5.104811	-1.112640	1.070611
C	-4.282727	-3.368805	1.138216
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C	-2.479438	1.375335	-4.351204
H	-0.921177	0.998795	-2.897139
C	-4.348548	-0.154718	-4.284841
H	-4.289719	-1.653280	-2.739688
C	-1.501960	-4.885513	-3.305576
H	-3.025215	-3.416924	-2.929709
C	0.666765	-4.448075	-2.335897
H	0.810131	-2.611517	-1.189040
C	-5.104869	1.112461	-1.070669
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H	-2.566429	3.764923	0.088953
C	0.666775	4.447880	2.336110
H	0.810187	2.611226	1.189377
C	-1.502167	4.885686	3.305151
H	-3.025532	3.417304	2.928900
C	-2.479813	-1.375445	4.351009
H	-0.921499	-0.999025	2.896978
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C	-5.210926	-2.415017	1.550231
H	-5.819797	-0.356018	1.387108
H	-4.350863	-4.395009	1.491965
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H	-1.981638	-2.246680	4.769704
H	-5.315507	0.478583	4.662860
H	-6.010572	-2.678721	2.236962
H	-4.183186	1.492434	-5.667525
H	0.208495	-6.179394	-3.536683
H	-6.010672	2.678491	-2.237048
H	0.208413	6.179337	3.536653
H	-4.183604	-1.492448	5.667285

TS1

C	1.574976	2.465946	-0.514520
C	2.047247	1.260866	-1.072460
C	2.379693	1.224486	-2.435070
C	2.293806	2.362180	-3.232732
C	1.875433	3.569117	-2.672785
C	1.526725	3.610131	-1.326842
C	1.097702	2.641668	0.897811
C	-0.173262	2.217187	1.343014
C	-0.572553	2.511049	2.652035
C	0.271036	3.195845	3.525347
C	1.528174	3.612218	3.091386
C	1.922012	3.349405	1.781381
H	2.702770	0.284150	-2.875894
H	2.553700	2.303524	-4.286378
H	1.802731	4.466386	-3.281199
H	1.164734	4.535617	-0.884229
H	-1.555801	2.198188	2.993419
H	-0.058675	3.406700	4.539334
H	2.198001	4.140539	3.764369
H	2.899174	3.671337	1.427846
P	2.001400	-0.339198	-0.138779
P	-1.218829	1.148720	0.244926
C	2.678132	0.061319	1.538947
C	1.869725	-0.188913	2.650790
C	3.948293	0.620137	1.713362
C	2.324335	0.132405	3.931247
H	0.880297	-0.622583	2.495790
C	4.403562	0.935273	2.992125
H	4.578638	0.818412	0.849037
C	3.589469	0.694184	4.101605
H	1.689184	-0.054856	4.793089
H	5.390991	1.370183	3.124497
H	3.943623	0.943691	5.098608
C	3.332752	-1.390223	-0.882121
C	4.558930	-0.896135	-1.345578
C	3.086752	-2.767067	-0.922402
C	5.526374	-1.770991	-1.838329

H	4.747980	0.175797	-1.345450
C	4.060058	-3.643064	-1.405729
H	2.123552	-3.137915	-0.569318
C	5.279402	-3.145283	-1.864638
H	6.473007	-1.380229	-2.202467
H	3.862110	-4.711319	-1.429377
H	6.035513	-3.825161	-2.248441
C	-2.857125	1.016534	1.081105
C	-2.938897	0.139391	2.173755
C	-4.027272	1.586646	0.571376
C	-4.169705	-0.150137	2.758044
H	-2.031832	-0.346181	2.534537
C	-5.262986	1.282005	1.148307
H	-3.978576	2.251363	-0.287218
C	-5.337450	0.417363	2.239907
H	-4.219965	-0.835815	3.599629
H	-6.169467	1.720873	0.739310
H	-6.301252	0.178321	2.681379
C	-1.511335	2.219133	-1.227580
C	-1.350972	1.655014	-2.495612
C	-1.830073	3.576853	-1.097462
C	-1.507211	2.450381	-3.633504
H	-1.086393	0.599668	-2.575486
C	-1.985959	4.367598	-2.234432
H	-1.938303	4.009053	-0.102901
C	-1.821205	3.802994	-3.502927
H	-1.375019	2.012740	-4.619602
H	-2.230461	5.422088	-2.134390
H	-1.937257	4.421644	-4.389325
Pd	-0.269059	-1.061294	-0.255292
I	-1.412499	-3.346234	1.052401
C	-1.908446	-2.194221	-0.869027
C	-1.158497	-2.573098	-2.005627
C	-3.193191	-1.618054	-1.000531
C	-1.652235	-2.220995	-3.280313
H	-0.275394	-3.198255	-1.907057
C	-3.649189	-1.296350	-2.266735
H	-3.780655	-1.389557	-0.114342
C	-2.875940	-1.583234	-3.411318
H	-1.079101	-2.496656	-4.162496
H	-4.614484	-0.807037	-2.373640
H	-3.259315	-1.335033	-4.397306

INT1

C	1.120050	2.809337	-0.131800
C	1.847621	1.774617	-0.750672
C	2.530542	2.036788	-1.943715
C	2.485772	3.298017	-2.536357
C	1.769360	4.324891	-1.926367
C	1.109291	4.078265	-0.725035
C	0.407029	2.662468	1.177634
C	-0.789142	1.943183	1.375153
C	-1.370464	1.921005	2.648895
C	-0.777467	2.574936	3.726458
C	0.405468	3.286167	3.537630
C	0.972406	3.339763	2.268301
H	3.103983	1.245948	-2.418070
H	3.017732	3.474893	-3.467264
H	1.725741	5.312502	-2.377393
H	0.545625	4.870161	-0.236170
H	-2.304449	1.390226	2.803175
H	-1.246066	2.531804	4.705741
H	0.882426	3.798914	4.368234
H	1.896586	3.889088	2.103846
P	1.829832	0.061404	-0.029896
P	-1.540495	0.908502	0.023796
C	2.468141	0.346454	1.674184
C	1.810225	-0.258359	2.748435
C	3.535539	1.222910	1.906424
C	2.219134	0.017959	4.054773
H	0.979763	-0.935616	2.550591
C	3.948338	1.486862	3.211045
H	4.023827	1.711575	1.063765
C	3.285395	0.887451	4.285192
H	1.703294	-0.446999	4.890417
H	4.778551	2.164867	3.391150
H	3.601870	1.099964	5.303123
C	3.159590	-0.794753	-0.978582
C	4.457384	-0.963145	-0.496819
C	2.813441	-1.299149	-2.239375
C	5.408787	-1.623756	-1.278383
H	4.725354	-0.601928	0.492068
C	3.767597	-1.939988	-3.024107
H	1.783487	-1.209567	-2.585961
C	5.068570	-2.104925	-2.541101
H	6.415437	-1.764674	-0.894131
H	3.491183	-2.333183	-3.998391
H	5.810835	-2.619653	-3.145289
C	-3.326996	0.713526	0.462887
C	-3.650098	-0.186687	1.487619

C	-4.354133	1.329174	-0.256545
C	-4.980015	-0.449807	1.802512
H	-2.852823	-0.716428	2.005466
C	-5.687742	1.060937	0.059101
H	-4.126129	1.998768	-1.079763
C	-6.003070	0.175055	1.086781
H	-5.214808	-1.164977	2.585851
H	-6.479174	1.539935	-0.511077
H	-7.041909	-0.040863	1.321300
C	-1.534041	2.008706	-1.452725
C	-0.994019	1.545964	-2.654090
C	-2.039845	3.312347	-1.367038
C	-0.964908	2.383701	-3.771473
H	-0.581659	0.536827	-2.697975
C	-2.023263	4.140841	-2.486405
H	-2.434699	3.674016	-0.418103
C	-1.484006	3.675280	-3.688785
H	-0.534987	2.026363	-4.703090
H	-2.420002	5.150410	-2.420408
H	-1.463595	4.324248	-4.560292
Pd	-0.316903	-1.111774	-0.140409
I	0.935269	-3.438719	0.114146
C	-2.054281	-2.122408	-0.359719
C	-2.873460	-1.805738	-1.452708
C	-2.521164	-3.061900	0.570818
C	-4.138232	-2.384490	-1.596472
H	-2.543134	-1.070941	-2.188967
C	-3.786451	-3.636970	0.430184
H	-1.893588	-3.347351	1.411768
C	-4.603424	-3.296066	-0.649033
H	-4.761137	-2.112004	-2.445880
H	-4.130815	-4.360032	1.166922
H	-5.589307	-3.741947	-0.754932

TS1b'

C	-0.520020	2.294632	1.674027
C	-1.207198	1.101906	1.988120
C	-1.322252	0.715371	3.327873
C	-0.743724	1.467494	4.349898
C	-0.057785	2.640478	4.043998
C	0.027444	3.053834	2.717080
C	-0.398222	2.867229	0.290776
C	0.468728	2.377778	-0.709516
C	0.516669	3.014958	-1.953990
C	-0.274655	4.132244	-2.218628
C	-1.116927	4.634310	-1.228102
C	-1.166227	4.007111	0.014520
H	-1.875552	-0.184249	3.580760
H	-0.840295	1.138555	5.381292
H	0.400950	3.235036	4.829283
H	0.554070	3.970821	2.462040
H	1.181184	2.629819	-2.723451
H	-0.224759	4.609723	-3.193615
H	-1.739488	5.503668	-1.421515
H	-1.833526	4.377737	0.789714
P	-1.828748	0.024343	0.604576
P	1.445297	0.831362	-0.415211
C	-2.978010	1.167669	-0.268859
C	-2.752032	1.442301	-1.618597
C	-3.988571	1.843232	0.426381
C	-3.551642	2.375550	-2.281047
H	-1.925718	0.952177	-2.131158
C	-4.781931	2.778697	-0.235720
H	-4.139976	1.640764	1.486323
C	-4.564223	3.042040	-1.591342
H	-3.369617	2.588640	-3.331476
H	-5.566697	3.303743	0.302811
H	-5.182740	3.773001	-2.106056
C	-2.873386	-1.281363	1.384701
C	-4.224374	-1.452736	1.075744
C	-2.230047	-2.227520	2.198700
C	-4.929337	-2.541175	1.596638
H	-4.722211	-0.749331	0.413846
C	-2.940174	-3.298103	2.737154
H	-1.160530	-2.123854	2.388468
C	-4.295782	-3.457177	2.434818
H	-5.977935	-2.671217	1.342425
H	-2.433796	-4.017606	3.375415
H	-4.849582	-4.299282	2.841134
C	2.714638	0.743816	-1.751815
C	2.299175	0.189592	-2.972468
C	4.060827	1.060980	-1.550497
C	3.231543	-0.026500	-3.987151
H	1.257279	-0.107270	-3.105375
C	4.991258	0.824622	-2.565021
H	4.393381	1.456883	-0.594917
C	4.578917	0.282958	-3.782599
H	2.906711	-0.458266	-4.930056
H	6.039738	1.058656	-2.398901
H	5.306408	0.094521	-4.567990

C	2.367163	1.228158	1.128068
C	2.378684	0.291734	2.162422
C	2.995416	2.468816	1.296635
C	3.024861	0.590129	3.363683
H	1.868088	-0.659085	2.019026
C	3.639550	2.764843	2.496355
H	2.958832	3.204106	0.493099
C	3.652025	1.824501	3.530871
H	3.033825	-0.143196	4.165968
H	4.125609	3.728099	2.628703
H	4.151215	2.058168	4.467877
Pd	0.043377	-1.060022	-0.414493
O	-0.681162	-1.075633	-3.112602
C	-1.890518	-1.353359	-2.955944
O	-2.372215	-2.058127	-2.002134
C	-2.906016	-0.859801	-3.982262
H	-3.846193	-0.594465	-3.492416
H	-2.507008	-0.004834	-4.534223
H	-3.110968	-1.670001	-4.690660
C	-0.999407	-3.515718	-1.409571
C	0.012444	-3.236063	-0.466979
C	1.283346	-2.678390	-0.852519
H	-0.164310	-3.577302	0.553174
H	1.480695	-2.612937	-1.926645
C	2.488688	-2.718063	0.004621
C	3.702933	-2.224276	-0.505388
C	2.470265	-3.174859	1.334861
C	4.835418	-2.131069	0.299472
H	3.742408	-1.886954	-1.540356
C	3.610348	-3.101670	2.132815
H	1.550664	-3.576497	1.755231
C	4.796165	-2.565080	1.626296
H	5.751984	-1.718871	-0.116457
H	3.570897	-3.460391	3.158915
H	5.680315	-2.496281	2.254271
C	-2.150982	-4.386572	-1.013345
H	-2.604058	-4.003613	-0.091855
H	-2.913159	-4.422642	-1.790191
H	-1.776191	-5.399310	-0.813650
H	-0.704833	-3.476091	-2.455750

TS1b

C	1.840887	-2.511468	-0.291980
C	2.219359	-1.590684	0.707297
C	2.562796	-2.056655	1.980987
C	2.522771	-3.417949	2.280369
C	2.159390	-4.333834	1.295089
C	1.842427	-3.877458	0.017746
C	1.476959	-2.119397	-1.693955
C	0.229841	-1.568549	-2.054399
C	-0.021078	-1.244535	-3.392208
C	0.947209	-1.455648	-4.372964
C	2.175031	-2.016746	-4.026064
C	2.424206	-2.356967	-2.698238
H	2.859646	-1.347134	2.748993
H	2.782817	-3.758013	3.279130
H	2.123513	-5.397035	1.515803
H	1.552858	-4.581224	-0.759328
H	-0.982180	-0.816043	-3.665151
H	0.736344	-1.187833	-5.404740
H	2.937262	-2.186676	-4.781565
H	3.382056	-2.786393	-2.412673
P	2.077016	0.228646	0.384910
P	-1.006797	-1.126260	-0.748745
C	3.086565	0.528519	-1.119464
C	2.516537	1.268427	-2.159495
C	4.365331	-0.023219	-1.265659
C	3.228583	1.459796	-3.345478
H	1.508612	1.668372	-2.040346
C	5.075544	0.174768	-2.448138
H	4.788642	-0.621901	-0.459555
C	4.504741	0.914684	-3.487719
H	2.782006	2.026941	-4.157351
H	6.068182	-0.252417	-2.563866
H	5.056736	1.062302	-4.412256
C	2.935008	1.078409	1.780561
C	4.183631	1.692233	1.662050
C	2.215415	1.200177	2.979715
C	4.709240	2.418152	2.734316
H	4.738624	1.624544	0.730117
C	2.750780	1.906415	4.053970
H	1.220283	0.756212	3.048138
C	3.999100	2.522709	3.928983
H	5.675118	2.905170	2.630756
H	2.188306	1.993958	4.979611
H	4.410410	3.090724	4.758921
C	-2.574068	-0.720292	-1.626121
C	-2.690273	0.590090	-2.108424
C	-3.668176	-1.587967	-1.693945
C	-3.896065	1.041944	-2.641455

H	-1.868542	1.299967	-2.009893
C	-4.873299	-1.136242	-2.236640
H	-3.593551	-2.597899	-1.298643
C	-4.990187	0.175117	-2.704000
H	-3.959315	2.081311	-2.950120
H	-5.727362	-1.807401	-2.279796
H	-5.939362	0.523917	-3.102901
C	-1.304660	-2.693993	0.160322
C	-1.365753	-2.649562	1.554910
C	-1.430630	-3.915753	-0.512229
C	-1.548751	-3.829338	2.278872
H	-1.267111	-1.691273	2.063969
C	-1.612240	-5.091616	0.213399
H	-1.365588	-3.940697	-1.599721
C	-1.666952	-5.047550	1.609736
H	-1.599440	-3.791340	3.363903
H	-1.707354	-6.041535	-0.306282
H	-1.805223	-5.966068	2.174347
Pd	-0.222446	0.798172	0.412300
C	-0.161720	3.228246	0.388114
C	-0.944689	2.607858	1.383260
C	-2.025987	1.772576	0.973597
H	-0.670162	2.747966	2.429079
H	-2.509475	2.048044	0.033172
C	-2.785352	0.891443	1.882964
C	-2.348973	0.591219	3.186735
C	-3.936092	0.243855	1.399102
C	-3.030654	-0.337276	3.971061
H	-1.457511	1.076995	3.580168
C	-4.604477	-0.697990	2.177895
H	-4.287555	0.476349	0.394612
C	-4.154659	-0.996192	3.466365
H	-2.679688	-0.553173	4.977464
H	-5.482634	-1.198289	1.777375
H	-4.679138	-1.728429	4.074442
C	1.113197	3.951577	0.693499
H	1.938593	3.558147	0.086672
H	0.968248	5.003780	0.434928
H	1.388576	3.866710	1.750551
O	-1.362948	5.029691	-0.170228
C	-2.123071	4.712762	-1.135742
O	-2.185973	3.591022	-1.707045
C	-3.079636	5.802789	-1.623609
H	-2.718056	6.794106	-1.343443
H	-3.212002	5.730371	-2.706081
H	-4.057732	5.645320	-1.155545
H	-0.449885	3.070862	-0.650950

INT1b

C	1.281307	-1.792422	1.709180
C	1.798401	-0.483166	1.683375
C	2.088938	0.174478	2.883474
C	1.852567	-0.446774	4.109329
C	1.339859	-1.742228	4.142805
C	1.074868	-2.409970	2.948877
C	1.001062	-2.595682	0.476184
C	-0.114552	-2.397047	-0.362945
C	-0.308161	-3.241301	-1.461885
C	0.600247	-4.258605	-1.753195
C	1.707867	-4.456049	-0.931514
C	1.888926	-3.639172	0.182177
H	2.507014	1.176735	2.864881
H	2.080207	0.078708	5.032309
H	1.153622	-2.235747	5.092309
H	0.679034	-3.422762	2.962364
H	-1.181402	-3.114949	-2.094453
H	0.431331	-4.899955	-2.613431
H	2.420850	-5.246561	-1.146849
H	2.744816	-3.786221	0.836923
P	2.003508	0.380055	0.061611
P	-1.242502	-0.946675	-0.088121
C	3.134222	-0.677238	-0.916492
C	2.772298	-1.019333	-2.222370
C	4.292969	-1.211416	-0.339308
C	3.572035	-1.897264	-2.955879
H	1.850682	-0.616783	-2.644306
C	5.092001	-2.082577	-1.077181
H	4.553044	-0.957904	0.687789
C	4.728610	-2.426815	-2.382579
H	3.289199	-2.172770	-3.967789
H	5.992749	-2.498617	-0.634908
H	5.349449	-3.112498	-2.952305
C	2.864093	1.960790	0.442689
C	4.183334	2.217928	0.066888
C	2.098608	2.972256	1.045037
C	4.732385	3.484860	0.285412
H	4.776394	1.442467	-0.411589
C	2.655707	4.226989	1.280536
H	1.060254	2.769063	1.318055
C	3.973928	4.485696	0.890982

H	5.755522	3.686527	-0.018440
H	2.063744	5.004904	1.754566
H	4.406150	5.467681	1.060022
C	-2.750826	-1.255937	-1.102615
C	-2.636151	-1.132002	-2.496098
C	-4.000381	-1.514434	-0.535471
C	-3.751855	-1.293279	-3.314403
H	-1.663651	-0.903620	-2.935602
C	-5.121862	-1.660366	-1.357086
H	-4.109146	-1.582603	0.543145
C	-5.000490	-1.555949	-2.741752
H	-3.651609	-1.206542	-4.392649
H	-6.091914	-1.855401	-0.908649
H	-5.874372	-1.674196	-3.375925
C	-1.743056	-1.050713	1.672108
C	-1.585656	0.064344	2.498022
C	-2.215050	-2.260885	2.196453
C	-1.905179	-0.029539	3.853721
H	-1.198198	0.992160	2.077820
C	-2.541123	-2.347470	3.548140
H	-2.311297	-3.131216	1.548168
C	-2.383370	-1.231801	4.375464
H	-1.775933	0.832864	4.501519
H	-2.910629	-3.283052	3.958293
H	-2.632090	-1.302748	5.430676
Pd	-0.093062	0.979252	-0.878630
C	0.529422	2.487535	-2.400218
C	-0.608297	2.929715	-1.712708
C	-1.764955	2.094803	-1.673870
H	-0.513748	3.776295	-1.030824
H	-2.001868	1.527569	-2.576926
C	-2.895994	2.320053	-0.751679
C	-2.726560	2.980453	0.478301
C	-4.166591	1.829318	-1.083914
C	-3.802361	3.154976	1.342617
H	-1.738229	3.339411	0.767103
C	-5.243073	1.999890	-0.214676
H	-4.303923	1.299069	-2.025106
C	-5.066115	2.665700	0.997856
H	-3.658195	3.668807	2.289088
H	-6.219802	1.609524	-0.487479
H	-5.904853	2.801002	1.674592
C	1.834729	3.224145	-2.446159
H	2.677081	2.524854	-2.482719
H	1.878535	3.835489	-3.355862
H	1.968552	3.879419	-1.580185
H	0.368031	1.758351	-3.202763

TS2

C	-0.594409	2.861181	1.017699
C	-1.366210	1.732918	1.362038
C	-1.769444	1.551054	2.689308
C	-1.431306	2.480522	3.671651
C	-0.697078	3.614753	3.331102
C	-0.291284	3.800418	2.011849
C	-0.071625	3.122620	-0.357749
C	0.903580	2.310882	-0.968153
C	1.362949	2.633414	-2.249280
C	0.857708	3.739531	-2.932320
C	-0.100331	4.550525	-2.328612
C	-0.546344	4.245915	-1.044507
H	-2.353041	0.676714	2.959262
H	-1.747405	2.315467	4.697687
H	-0.430061	4.346747	4.088325
H	0.306842	4.666184	1.736420
H	2.121538	2.017630	-2.722728
H	1.221154	3.967022	-3.930669
H	-0.500143	5.414958	-2.851434
H	-1.301520	4.863544	-0.563200
P	-1.789773	0.433191	0.107201
P	1.563362	0.823770	-0.068221
C	-2.339620	1.369827	-1.373412
C	-1.824201	1.068431	-2.634420
C	-3.264877	2.410434	-1.216508
C	-2.242716	1.807095	-3.743294
H	-1.102682	0.258956	-2.737481
C	-3.691247	3.133053	-2.328121
H	-3.639193	2.655833	-0.223147
C	-3.177657	2.830801	-3.591968
H	-1.838508	1.577255	-4.725141
H	-4.415617	3.934182	-2.208605
H	-3.505545	3.397986	-4.459138
C	-3.282285	-0.437420	0.764291
C	-4.552312	-0.224806	0.224135
C	-3.101178	-1.377482	1.787693
C	-5.645379	-0.933564	0.726566
H	-4.696096	0.464980	-0.601248
C	-4.199229	-2.072515	2.288920
H	-2.099977	-1.574147	2.170615
C	-5.472762	-1.851813	1.760479

H	-6.630418	-0.771694	0.297407
H	-4.052844	-2.802213	3.080285
H	-6.325594	-2.404720	2.145123
C	2.991218	0.330176	-1.125128
C	2.702799	-0.461728	-2.243654
C	4.305344	0.736399	-0.877264
C	3.723713	-0.823940	-3.122731
H	1.680134	-0.806548	-2.409307
C	5.325696	0.354590	-1.748937
H	4.536952	1.329990	0.002921
C	5.035751	-0.417736	-2.874974
H	3.494686	-1.441071	-3.987253
H	6.348226	0.662899	-1.547879
H	5.832616	-0.709089	-3.554095
C	2.198477	1.587783	1.482758
C	1.825569	1.040148	2.713477
C	2.934790	2.779471	1.428245
C	2.221848	1.676943	3.892641
H	1.210123	0.139071	2.744980
C	3.329993	3.404489	2.608967
H	3.173675	3.225363	0.463264
C	2.973379	2.850489	3.841899
H	1.928494	1.255650	4.850273
H	3.905250	4.325733	2.568835
H	3.276382	3.342076	4.762857
Pd	0.019121	-1.015434	-0.009614
I	-1.590276	-2.632859	-1.463803
C	1.596139	-2.587255	0.485307
C	2.720997	-2.010979	1.118194
C	1.811066	-3.428909	-0.625720
C	4.004382	-2.220334	0.634515
H	2.554742	-1.448487	2.035898
C	3.099608	-3.639219	-1.115851
H	0.962993	-3.921425	-1.094594
C	4.191146	-3.030432	-0.492738
H	4.860290	-1.767931	1.129170
H	3.254446	-4.280937	-1.979694
H	5.194802	-3.195159	-0.877903
O	1.075675	-3.878784	2.830837
S	0.244434	-3.067158	1.923505
O	0.041529	-1.655920	2.459770

TS2'

C	1.246037	2.793692	-0.616959
C	1.827322	1.633009	-1.173783
C	2.335921	1.677470	-2.475742
C	2.256967	2.840117	-3.241957
C	1.679256	3.986081	-2.701747
C	1.196386	3.958052	-1.395666
C	0.728272	2.910008	0.786413
C	-0.423970	2.260647	1.273829
C	-0.836063	2.468421	2.593751
C	-0.120355	3.314578	3.439642
C	1.012115	3.971504	2.962628
C	1.421203	3.773471	1.645948
H	2.814915	0.799470	-2.896581
H	2.655565	2.846084	-4.252658
H	1.608347	4.898595	-3.287149
H	0.743864	4.846165	-0.960088
H	-1.724757	1.963178	2.962697
H	-0.452145	3.460230	4.463880
H	1.580828	4.631198	3.612102
H	2.313986	4.267383	1.269112
P	1.846690	0.047901	-0.198985
P	-1.361134	1.097529	0.184041
C	2.635953	0.633970	1.364233
C	2.049686	0.459514	2.616730
C	3.834959	1.349452	1.237504
C	2.669577	0.998683	3.746389
H	1.120064	-0.096945	2.704171
C	4.453835	1.875905	2.368685
H	4.277179	1.493891	0.252234
C	3.867878	1.700838	3.625243
H	2.208022	0.867157	4.721131
H	5.388209	2.421977	2.270192
H	4.347472	2.114304	4.508761
C	3.081604	-1.083382	-0.980639
C	2.847463	-1.575006	-2.272754
C	4.181757	-1.546946	-0.255085
C	3.729232	-2.486433	-2.847500
H	1.965506	-1.260697	-2.829325
C	5.056297	-2.470690	-0.831266
H	4.345284	-1.210836	0.764381
C	4.837935	-2.934847	-2.126301
H	3.537138	-2.860108	-3.849155
H	5.901946	-2.835725	-0.255315
H	5.517785	-3.657857	-2.568401
C	-2.961779	0.788138	1.043525
C	-2.963378	-0.228225	2.008619
C	-4.139929	1.483857	0.756303

C	-4.137524	-0.525292	2.700612
H	-2.051063	-0.799322	2.195872
C	-5.313789	1.171432	1.442758
H	-4.151274	2.250385	-0.013335
C	-5.312547	0.172677	2.417379
H	-4.133779	-1.316557	3.445168
H	-6.230311	1.708195	1.212612
H	-6.229116	-0.067087	2.949977
C	-1.686716	2.159387	-1.291051
C	-1.321509	1.709636	-2.563362
C	-2.180405	3.459602	-1.122619
C	-1.476809	2.550503	-3.667029
H	-0.891353	0.714445	-2.685790
C	-2.342464	4.292879	-2.228298
H	-2.411016	3.824264	-0.122281
C	-1.991318	3.836695	-3.501128
H	-1.183660	2.200249	-4.652801
H	-2.730120	5.299500	-2.095987
H	-2.109488	4.489522	-4.361992
Pd	-0.279293	-0.958264	-0.302085
I	0.579311	-2.787976	1.829844
C	-2.146106	-1.976740	-0.868091
C	-3.080102	-1.216324	-1.585859
C	-2.573751	-2.988959	0.003837
C	-4.442255	-1.394433	-1.352330
H	-2.739029	-0.499159	-2.328012
C	-3.937376	-3.171459	0.220469
H	-1.836830	-3.606848	0.511186
C	-4.867167	-2.359768	-0.436562
H	-5.168458	-0.787296	-1.886218
H	-4.274539	-3.943557	0.906883
H	-5.929770	-2.496244	-0.251628
O	-0.269577	-3.884707	-1.966867
S	-0.393662	-2.436982	-2.016382
O	-0.616201	-1.819681	-3.328856

INT2

C	1.341877	-2.147473	-1.729967
C	-0.006279	-1.750188	-1.811265
C	-0.612271	-1.611113	-3.064244
C	0.105541	-1.856892	-4.234490
C	1.435990	-2.263347	-4.159644
C	2.039774	-2.416248	-2.913690
C	2.055292	-2.353074	-0.432135
C	2.383850	-1.309560	0.457100
C	3.053855	-1.620117	1.646057
C	3.385204	-2.936489	1.966566
C	3.070857	-3.966994	1.084171
C	2.423141	-3.666197	-0.111067
H	-1.654256	-1.311796	-3.128629
H	-0.380458	-1.737348	-5.198851
H	2.004732	-2.457558	-5.064825
H	3.081493	-2.719989	-2.840250
H	3.326977	-0.824953	2.332307
H	3.897410	-3.148346	2.901131
H	3.325397	-4.996326	1.321052
H	2.158897	-4.458923	-0.807572
P	-0.967092	-1.395195	-0.264154
P	1.881963	0.452520	0.087678
C	-0.774185	-2.941957	0.708038
C	-0.431276	-2.874418	2.059972
C	-0.886754	-4.182221	0.066746
C	-0.203471	-4.053893	2.771556
H	-0.344256	-1.902233	2.542422
C	-0.670960	-5.356304	0.785109
H	-1.121885	-4.222069	-0.996377
C	-0.325015	-5.290275	2.137231
H	0.070309	-4.002882	3.821627
H	-0.762648	-6.319445	0.290241
H	-0.147933	-6.205858	2.695485
C	-2.709771	-1.280213	-0.846174
C	-3.603759	-2.345616	-0.740513
C	-3.125092	-0.061034	-1.398981
C	-4.914310	-2.197794	-1.199546
H	-3.292162	-3.279266	-0.281085
C	-4.428758	0.073560	-1.869720
H	-2.437710	0.787393	-1.438015
C	-5.324525	-0.993908	-1.769015
H	-5.613547	-3.023963	-1.104283
H	-4.746523	1.021208	-2.294096
H	-6.345291	-0.880910	-2.124349
C	2.914154	1.445669	1.243582
C	2.529442	1.481703	2.589479
C	4.027373	2.169846	0.814938
C	3.287104	2.202204	3.510709
H	1.620964	0.969004	2.904932
C	4.777760	2.896671	1.739626
H	4.290532	2.192069	-0.238397
C	4.414891	2.907153	3.086355
H	2.983002	2.229089	4.553255

H	5.640836	3.464377	1.402632
H	5.000107	3.477654	3.802724
C	2.512812	0.668478	-1.623789
C	1.667526	1.149073	-2.624649
C	3.815968	0.263755	-1.931836
C	2.130514	1.228006	-3.937411
H	0.656870	1.452901	-2.360039
C	4.282032	0.363278	-3.242709
H	4.457298	-0.138111	-1.148173
C	3.436766	0.842240	-4.245138
H	1.470509	1.590962	-4.720855
H	5.298162	0.060666	-3.481383
H	3.795882	0.911915	-5.268733
Pd	-0.375236	0.602115	0.760893
I	-2.536688	0.420162	2.317342
O	1.306851	3.178791	-0.503231
S	0.250429	3.605133	0.477227
O	-0.048694	2.481305	1.527151
C	-1.255926	3.533286	-0.513360
C	-1.153837	3.620105	-1.901787
C	-2.498136	3.465946	0.119816
C	-2.319075	3.625872	-2.672501
H	-0.165204	3.685340	-2.349825
C	-3.657108	3.470105	-0.655865
H	-2.545606	3.378321	1.202302
C	-3.566989	3.559437	-2.048531
H	-2.254924	3.696867	-3.755459
H	-4.628492	3.397304	-0.173804
H	-4.473715	3.579864	-2.649319

INT2'

C	-2.391553	-1.577266	1.391333
C	-1.024710	-1.867277	1.568546
C	-0.537352	-2.134064	2.852731
C	-1.388549	-2.112479	3.957384
C	-2.745314	-1.845767	3.784251
C	-3.238595	-1.594600	2.505903
C	-2.990303	-1.284042	0.052199
C	-2.746001	-0.093729	-0.661386
C	-3.335498	0.087561	-1.917552
C	-4.155104	-0.894959	-2.472065
C	-4.415283	-2.064741	-1.761382
C	-3.844465	-2.244459	-0.503595
H	0.516167	-2.361329	2.990812
H	-0.989881	-2.314114	4.947868
H	-3.417261	-1.828692	4.637861
H	-4.292535	-1.370900	2.357010
H	-3.152836	1.005701	-2.468279
H	-4.594562	-0.737517	-3.453151
H	-5.054413	-2.835901	-2.182423
H	-4.024876	-3.159328	0.056363
P	0.138156	-1.803014	0.123438
P	-1.591869	1.196783	0.012510
C	-0.610100	-2.944877	-1.104271
C	-0.711069	-2.539704	-2.437326
C	-1.144030	-4.173745	-0.695686
C	-1.344241	-3.370828	-3.363639
H	-0.296160	-1.578488	-2.737548
C	-1.765897	-5.003675	-1.626293
H	-1.091938	-4.463392	0.353396
C	-1.867834	-4.599169	-2.959910
H	-1.428441	-3.054946	-4.399703
H	-2.177987	-5.958805	-1.311678
H	-2.359205	-5.243475	-3.684310
C	1.689800	-2.568493	0.760297
C	1.999593	-3.917895	0.587740
C	2.583981	-1.727106	1.435922
C	3.197874	-4.424156	1.097282
H	1.324978	-4.570221	0.040115
C	3.771645	-2.237031	1.952366
H	2.365759	-0.662735	1.529017
C	4.080163	-3.588872	1.781335
H	3.442756	-5.472627	0.950759
H	4.461957	-1.568351	2.460113
H	5.013553	-3.987270	2.169962
C	-1.902212	2.686230	-1.023887
C	-1.268980	2.745423	-2.271909
C	-2.717206	3.737791	-0.599885
C	-1.473781	3.845292	-3.102818
H	-0.589771	1.947799	-2.577650
C	-2.914308	4.837551	-1.434010
H	-3.176370	3.713065	0.384108
C	-2.298945	4.889609	-2.685268
H	-0.966771	3.893872	-4.061794
H	-3.540993	5.659848	-1.099672
H	-2.448736	5.752906	-3.328046
C	-2.231099	1.514552	1.701889
C	-1.346720	1.532008	2.780856
C	-3.607662	1.658183	1.913245
C	-1.840148	1.692913	4.075751

H	-0.282051	1.417469	2.589769
C	-4.095712	1.833067	3.207080
H	-4.292230	1.613859	1.066839
C	-3.210942	1.845688	4.287854
H	-1.153809	1.700119	4.917980
H	-5.163293	1.950401	3.372862
H	-3.592042	1.974025	5.297593
Pd	0.614972	0.478292	-0.398190
I	2.601866	-0.285637	-2.013073
S	1.355831	2.645787	-0.199308
O	1.694922	3.389409	-1.422165
O	0.477493	3.298441	0.804247
C	2.894258	2.336663	0.671120
C	4.098987	2.373344	-0.027887
C	2.840393	2.006002	2.025184
C	5.275140	2.048644	0.646768
H	4.091071	2.643164	-1.079821
C	4.021940	1.673566	2.689342
H	1.884017	2.031959	2.541904
C	5.235190	1.688004	1.996409
H	6.224222	2.071230	0.118517
H	3.998976	1.418058	3.745851
H	6.156063	1.431056	2.513931

TS2b

C	0.374631	2.924350	0.986671
C	-0.586276	2.077566	1.570012
C	-0.770026	2.070188	2.956545
C	0.014902	2.882995	3.773681
C	0.972874	3.720752	3.204536
C	1.135110	3.751122	1.820214
C	0.554873	3.028469	-0.494891
C	1.109627	2.015484	-1.303781
C	1.219380	2.221039	-2.683304
C	0.769237	3.403200	-3.270701
C	0.220927	4.407706	-2.476609
C	0.131899	4.219741	-1.099369
H	-1.532378	1.437156	3.400917
H	-0.132841	2.868640	4.849528
H	1.586392	4.358405	3.834442
H	1.875245	4.406299	1.367120
H	1.668492	1.458303	-3.311439
H	0.859545	3.537442	-4.344661
H	-0.130362	5.333640	-2.922265
H	-0.298038	4.992894	-0.466780
P	-1.553825	0.963512	0.476487
P	1.616757	0.380317	-0.572414
C	-2.442780	2.028887	-0.709992
C	-2.424757	1.706045	-2.069030
C	-3.075666	3.192060	-0.254285
C	-3.039969	2.563539	-2.982207
H	-1.931788	0.793473	-2.398752
C	-3.693933	4.038304	-1.172025
H	-3.069764	3.436599	0.807050
C	-3.669495	3.725509	-2.534401
H	-3.027801	2.323254	-4.041302
H	-4.190588	4.940931	-0.827953
H	-4.147365	4.390497	-3.248331
C	-2.752654	0.047136	1.512907
C	-4.126185	0.105883	1.265862
C	-2.241404	-0.861319	2.453797
C	-4.989874	-0.730747	1.978272
H	-4.516448	0.787272	0.513847
C	-3.110300	-1.681359	3.171426
H	-1.163775	-0.921365	2.616342
C	-4.485731	-1.616076	2.931577
H	-6.057186	-0.691006	1.782588
H	-2.716004	-2.375635	3.908244
H	-5.162872	-2.262918	3.481560
C	2.749232	-0.375000	-1.814659
C	2.179410	-0.942189	-2.963938
C	4.131862	-0.442206	-1.621645
C	2.985420	-1.566756	-3.913814
H	1.097971	-0.901443	-3.104103
C	4.936151	-1.073077	-2.573120
H	4.580327	-0.035868	-0.719789
C	4.366759	-1.635645	-3.715409
H	2.537270	-2.003669	-4.801491
H	6.009272	-1.130009	-2.415323
H	4.996102	-2.129830	-4.449793
C	2.624843	0.836684	0.887188
C	2.341262	0.278734	2.132683
C	3.634837	1.799349	0.751671
C	3.081044	0.671293	3.249598
H	1.544170	-0.456601	2.222713
C	4.375345	2.181994	1.867443
H	3.826677	2.254175	-0.219564
C	4.096550	1.617890	3.116253
H	2.862692	0.233808	4.219910
H	5.163103	2.923158	1.766621

H	4.672937	1.920923	3.985925
Pd	-0.368495	-0.857098	-0.408242
C	-1.512572	-4.041005	-1.513147
C	-0.495272	-3.819934	-0.581099
C	0.581522	-2.894865	-0.635670
H	-0.591099	-4.390054	0.348297
H	1.019215	-2.728139	-1.621919
C	1.531577	-2.929955	0.511492
C	2.918999	-2.912800	0.304421
C	1.051624	-3.025200	1.831408
C	3.798747	-2.960715	1.386007
H	3.303596	-2.888282	-0.712983
C	1.932023	-3.100035	2.909172
H	-0.025304	-3.035042	2.005692
C	3.311247	-3.054721	2.690949
H	4.870441	-2.947545	1.206046
H	1.542845	-3.186370	3.920512
H	3.999841	-3.105073	3.529432
C	-2.305924	-5.320699	-1.533483
H	-2.355799	-5.771107	-0.536048
H	-3.324872	-5.137057	-1.889968
H	-1.839200	-6.046554	-2.207686
H	-1.458886	-3.482205	-2.451418
S	-2.959890	-2.632183	-0.514047
O	-4.209039	-2.890595	-1.226252
O	-2.220126	-1.431507	-1.113209

INT2b

C	-0.270285	2.914734	0.965627
C	-1.026394	1.882277	1.551811
C	-1.207791	1.844827	2.938932
C	-0.622488	2.815291	3.751643
C	0.133830	3.836562	3.178665
C	0.292933	3.890448	1.794552
C	-0.105292	3.041916	-0.513888
C	0.640821	2.142101	-1.299961
C	0.721839	2.339939	-2.682379
C	0.058681	3.405101	-3.292035
C	-0.677321	4.299977	-2.518913
C	-0.742350	4.121339	-1.138852
H	-1.816401	1.065241	3.386936
H	-0.769334	2.776963	4.826986
H	0.591129	4.596948	3.805154
H	0.876327	4.686225	1.337732
H	1.311307	1.665606	-3.295335
H	0.129532	3.535902	-4.367825
H	-1.194338	5.134356	-2.983456
H	-1.318708	4.807324	-0.522469
P	-1.767518	0.588750	0.475937
P	1.450693	0.654978	-0.526280
C	-2.825010	1.456089	-0.730250
C	-2.747614	1.143526	-2.089009
C	-3.659108	2.482357	-0.269262
C	-3.508912	1.879193	-2.997830
H	-2.108808	0.327565	-2.418928
C	-4.423450	3.203246	-1.184061
H	-3.698502	2.720906	0.792823
C	-4.340998	2.904935	-2.547016
H	-3.455641	1.646161	-4.057199
H	-5.078266	3.996980	-0.836448
H	-4.933555	3.472168	-3.259306
C	-2.754744	-0.522142	1.541775
C	-4.123125	-0.694255	1.330985
C	-2.070813	-1.317515	2.473782
C	-4.813992	-1.654354	2.074324
H	-4.639370	-0.101871	0.579858
C	-2.769273	-2.263960	3.219435
H	-0.993832	-1.192308	2.606582
C	-4.142061	-2.431958	3.017122
H	-5.877256	-1.798010	1.907854
H	-2.245670	-2.875500	3.948794
H	-4.685258	-3.178573	3.588867
C	2.675788	0.097624	-1.783738
C	2.190954	-0.627621	-2.882002
C	4.045654	0.344002	-1.663967
C	3.071476	-1.109124	-3.849533
H	1.119849	-0.820231	-2.972364
C	4.924985	-0.136798	-2.636431
H	4.435617	0.873559	-0.799919
C	4.442187	-0.865252	-3.723977
H	2.690537	-1.671958	-4.696778
H	5.990133	0.051298	-2.536716
H	5.130555	-1.243004	-4.474382
C	2.362010	1.327728	0.912848
C	2.159660	0.787762	2.182654
C	3.184486	2.450310	0.742486
C	2.806353	1.349560	3.284684
H	1.484811	-0.056655	2.304716
C	3.833075	3.003718	1.843731
H	3.298381	2.896922	-0.244473

C	3.645176	2.450607	3.113945
H	2.648298	0.930590	4.274582
H	4.476377	3.869374	1.714713
H	4.148354	2.886570	3.972430
Pd	-0.275695	-0.951492	-0.382725
C	-0.899720	-3.961697	-1.082795
C	0.109594	-3.377816	-0.162871
C	1.315398	-2.822779	-0.500118
H	-0.108789	-3.539068	0.897982
H	1.592980	-2.796316	-1.554905
C	2.414968	-2.579844	0.461895
C	3.709906	-2.394463	-0.039603
C	2.226502	-2.587581	1.854576
C	4.786836	-2.189638	0.823215
H	3.869041	-2.414103	-1.116716
C	3.303063	-2.401323	2.715422
H	1.229558	-2.728104	2.270939
C	4.587059	-2.191568	2.202701
H	5.782226	-2.040749	0.413536
H	3.142548	-2.413265	3.790265
H	5.425036	-2.040882	2.876992
C	-1.050271	-5.473130	-0.930944
H	-1.223197	-5.745620	0.116797
H	-1.912115	-5.802321	-1.519587
H	-0.156588	-5.997568	-1.278971
H	-0.737804	-3.657822	-2.125816
S	-2.498017	-3.172159	-0.604897
O	-3.497679	-3.648980	-1.581050
O	-2.026056	-1.705214	-1.051247

INT3

C	0.521195	2.468566	-1.217992
C	1.402943	1.388891	-1.427302
C	1.908099	1.162180	-2.712252
C	1.533961	1.968998	-3.786302
C	0.661590	3.035706	-3.582981
C	0.178635	3.287670	-2.301565
C	-0.045055	2.832525	0.118551
C	-1.011729	2.064966	0.795789
C	-1.498157	2.504658	2.031730
C	-1.028765	3.684576	2.607506
C	-0.077026	4.450783	1.938972
C	0.395606	4.028516	0.698856
H	2.606451	0.348360	-2.880037
H	1.933554	1.765096	-4.775922
H	0.361687	3.670975	-4.411740
H	-0.504255	4.115564	-2.124385
H	-2.251161	1.920962	2.552409
H	-1.413267	4.002173	3.572741
H	0.298339	5.371076	2.377858
H	1.146241	4.611105	0.169559
P	1.787975	0.213801	-0.035606
P	-1.613329	0.461276	0.077801
C	2.338241	1.327194	1.317070
C	1.815723	1.184678	2.603029
C	3.248528	2.351496	1.028310
C	2.200509	2.081615	3.601151
H	1.130424	0.365024	2.806181
C	3.643104	3.232288	2.033309
H	3.635421	2.459862	0.015340
C	3.112165	3.099495	3.318724
H	1.790546	1.980007	4.602260
H	4.355520	4.023082	1.813763
H	3.412464	3.790716	4.102062
C	3.271159	-0.726541	-0.593819
C	4.523292	-0.555262	0.000918
C	3.104031	-1.687106	-1.601795
C	5.612402	-1.309385	-0.441303
H	4.647752	0.151491	0.816141
C	4.196320	-2.427220	-2.049906
H	2.110589	-1.871348	-2.007902
C	5.453793	-2.235057	-1.472351
H	6.583809	-1.173582	0.026131
H	4.059371	-3.168430	-2.832111
H	6.303863	-2.819238	-1.814661
C	-3.078656	0.053545	1.114947
C	-2.831814	-0.569140	2.345699
C	-4.385859	0.333694	0.720029
C	-3.892659	-0.888109	3.188001
H	-1.808715	-0.826172	2.622351
C	-5.448716	-0.003531	1.561848
H	-4.581686	0.788059	-0.247178
C	-5.203838	-0.607065	2.793822
H	-3.699026	-1.376721	4.138603
H	-6.468471	0.201002	1.247520
H	-6.033708	-0.870679	3.443893
C	-2.189776	0.949494	-1.596308
C	-1.804844	0.190323	-2.703790
C	-2.930537	2.125822	-1.766683
C	-2.162127	0.612908	-3.985610

H	-1.227004	-0.720367	-2.552181
C	-3.296798	2.534981	-3.047237
H	-3.197171	2.727543	-0.898398
C	-2.906772	1.780042	-4.156502
H	-1.857359	0.027874	-4.848772
H	-3.875557	3.444969	-3.181200
H	-3.184100	2.104753	-5.155984
Pd	-0.045161	-1.253449	0.138511
O	1.239317	-2.823516	0.287333
C	2.042883	-2.732696	1.302619
O	2.064605	-1.785782	2.101324
C	3.045509	-3.863587	1.391635
H	3.447758	-3.933081	2.403204
H	2.593407	-4.808273	1.083892
H	3.863581	-3.633730	0.697360
I	-1.955704	-3.038616	-0.288441

INT4

S	-1.755546	-0.000019	-0.345357
O	-2.134423	1.278493	0.363173
O	-2.134376	-1.278480	0.363363
C	0.066328	-0.000004	-0.112393
C	0.762341	1.207216	-0.058039
C	0.762362	-1.207216	-0.058109
C	2.155327	1.209610	0.035747
H	0.176806	2.125038	-0.064879
C	2.155346	-1.209595	0.035655
H	0.176826	-2.125037	-0.064995
C	2.855224	0.000014	0.077320
H	2.701010	2.151548	0.086314
H	2.701041	-2.151529	0.086144
H	3.941886	0.000024	0.149749

INT5

S	-2.273577	2.368559	1.771369
O	-1.327827	1.767585	0.711628
C	-3.670295	2.805839	0.704763
C	-4.967207	2.476873	1.090319
C	-3.426180	3.495728	-0.483405
C	-6.036967	2.826064	0.261521
H	-5.105157	1.934105	2.023009
C	-4.496819	3.845771	-1.305169
H	-2.398513	3.723982	-0.761800
C	-5.802165	3.509132	-0.933049
H	-7.053942	2.567235	0.547070
H	-4.318623	4.380105	-2.236376
H	-6.635938	3.781882	-1.575125
C	2.163132	0.024107	-2.370795
C	2.873564	-0.069085	-1.158481
C	4.072697	-0.789531	-1.119227
C	4.559762	-1.438029	-2.253610
C	3.856811	-1.355380	-3.453298
C	2.678762	-0.614825	-3.506281
C	0.917871	0.837428	-2.552394
C	-0.353238	0.485031	-2.052773
C	-1.448960	1.307998	-2.326710
C	-1.302684	2.463206	-3.093265
C	-0.050824	2.816198	-3.592204
C	1.044911	1.999615	-3.326565
H	4.640586	-0.843407	-0.195449
H	5.490080	-1.996969	-2.196916
H	4.222855	-1.858452	-4.344206
H	2.119140	-0.538219	-4.435801
H	-2.425562	1.060920	-1.920929
H	-2.173034	3.085727	-3.286695
H	0.075490	3.719860	-4.182318
H	2.033034	2.266185	-3.695987
P	2.206134	0.786154	0.353007
P	-0.542461	-0.969169	-0.910945
C	2.319117	2.549186	-0.168412
C	1.198829	3.370835	-0.025245
C	3.470773	3.017238	-0.816175
C	1.238743	4.672216	-0.534999
H	0.290918	2.966412	0.426554
C	3.503185	4.317180	-1.315335
H	4.327365	2.355283	-0.942249
C	2.382775	5.143242	-1.177236
H	0.364053	5.310682	-0.438577
H	4.394130	4.684161	-1.818317
H	2.405230	6.153830	-1.577476
C	3.531706	0.506122	1.605953
C	4.333043	1.527270	2.117778
C	3.653891	-0.794074	2.121618
C	5.242683	1.252826	3.143904
H	4.235521	2.538623	1.730687
C	4.581012	-1.071797	3.122423
H	2.997102	-1.578679	1.740535
C	5.371839	-0.041969	3.642788
H	5.851846	2.055698	3.550392
H	4.674399	-2.082304	3.511400

H	6.082561	-0.251077	4.437662
C	-2.323756	-1.469912	-0.920127
C	-3.235903	-0.642783	-0.248843
C	-2.763366	-2.678492	-1.469213
C	-4.583307	-0.992728	-0.184115
H	-2.876441	0.261493	0.237240
C	-4.111824	-3.032371	-1.384951
H	-2.062271	-3.360441	-1.940563
C	-5.025414	-2.187658	-0.755639
H	-5.276026	-0.327329	0.324823
H	-4.443010	-3.977158	-1.808641
H	-6.075000	-2.465474	-0.699583
C	0.314550	-2.320117	-1.831754
C	1.331356	-3.054608	-1.220681
C	-0.020055	-2.574635	-3.168224
C	2.005838	-4.046165	-1.935714
H	1.608302	-2.819138	-0.194168
C	0.645677	-3.571376	-3.878923
H	-0.798711	-1.981947	-3.647073
C	1.659176	-4.308317	-3.261039
H	2.807496	-4.605373	-1.460414
H	0.380492	-3.768654	-4.914295
H	2.183828	-5.081163	-3.816845
Pd	0.187417	-0.194579	1.230460
C	0.264980	0.355348	3.381873
C	0.017573	-1.021114	3.234973
C	-1.135537	-1.388975	2.487752
H	0.776021	-1.755335	3.513699
H	-1.983869	-0.697409	2.529113
C	-1.431767	-2.782274	2.095538
C	-0.415604	-3.702196	1.790745
C	-2.766178	-3.199225	1.994971
C	-0.724392	-4.997002	1.385208
H	0.623041	-3.376711	1.843959
C	-3.077156	-4.499340	1.598496
H	-3.558157	-2.485634	2.210620
C	-2.059326	-5.401060	1.288336
H	0.074830	-5.690165	1.133907
H	-4.118542	-4.799318	1.513435
H	-2.301079	-6.410549	0.966244
C	1.440938	0.935028	4.111132
H	1.786104	1.855648	3.628412
H	1.135850	1.201975	5.131129
H	2.284345	0.241046	4.173895
H	-0.618437	0.993486	3.310819
O	-2.862041	1.288025	2.650091

TS3

S	-3.935454	-2.194038	0.912537
O	-4.339285	-3.545581	1.402072
C	-5.470695	-1.386199	0.435638
C	-5.561518	0.006647	0.437407
C	-6.530613	-2.172565	-0.015010
C	-6.729692	0.616730	-0.020773
H	-4.731939	0.594187	0.826848
C	-7.697861	-1.557073	-0.466195
H	-6.426743	-3.254112	0.020635
C	-7.795191	-0.163566	-0.475024
H	-6.813471	1.700930	-0.016709
H	-8.534610	-2.162047	-0.807054
H	-8.704332	0.314717	-0.831150
C	3.693592	0.676390	0.223801
C	3.326293	-0.234468	-0.789004
C	3.856945	-0.089010	-2.075428
C	4.737348	0.950345	-2.373258
C	5.114496	1.846446	-1.374848
C	4.607055	1.692092	-0.086782
C	3.199227	0.599208	1.638778
C	1.918547	1.025605	2.046701
C	1.550810	0.922924	3.392671
C	2.433036	0.398125	4.336169
C	3.706840	-0.008339	3.943143
C	4.084680	0.110002	2.607353
H	3.572684	-0.792476	-2.854099
H	5.130528	1.051748	-3.381160
H	5.799765	2.660554	-1.593916
H	4.889268	2.387829	0.700164
H	0.561464	1.249698	3.702381
H	2.124474	0.315161	5.374646
H	4.403479	-0.418212	4.669270
H	5.073004	-0.212266	2.286749
P	1.995578	-1.484970	-0.475372
P	0.678859	1.574693	0.787678
C	2.530012	-2.405763	1.021337
C	1.601691	-2.591748	2.049780
C	3.845499	-2.863307	1.169939
C	1.986250	-3.245116	3.222673
H	0.588421	-2.204187	1.935481
C	4.224192	-3.521274	2.338295
H	4.571865	-2.681097	0.378278

C	3.293463	-3.710919	3.363855
H	1.265124	-3.383510	4.023172
H	5.244149	-3.878209	2.454400
H	3.591482	-4.219069	4.277146
C	2.056380	-2.681625	-1.881770
C	2.675357	-3.932170	-1.811931
C	1.368903	-2.315657	-3.049062
C	2.614261	-4.803683	-2.902044
H	3.188798	-4.237861	-0.904544
C	1.324932	-3.179146	-4.141568
H	0.854787	-1.353100	-3.079468
C	1.946272	-4.428274	-4.066600
H	3.088157	-5.779324	-2.836543
H	0.793503	-2.886234	-5.043026
H	1.899742	-5.110257	-4.911211
C	-0.739842	2.287519	1.722759
C	-1.683889	1.378385	2.220431
C	-0.975113	3.661699	1.827551
C	-2.864158	1.834415	2.806190
H	-1.543823	0.302570	2.106231
C	-2.156234	4.117339	2.418353
H	-0.257997	4.372945	1.425344
C	-3.100954	3.208898	2.901033
H	-3.589930	1.097838	3.140693
H	-2.342805	5.185829	2.489569
H	-4.025331	3.572375	3.342405
C	1.489889	2.970205	-0.087657
C	1.388124	3.028886	-1.479339
C	2.231677	3.933634	0.606836
C	2.031516	4.051510	-2.179005
H	0.809570	2.270228	-2.005037
C	2.874024	4.952106	-0.094902
H	2.317148	3.868918	1.691218
C	2.776275	5.007693	-1.488514
H	1.948209	4.096957	-3.261677
H	3.452899	5.699605	0.441285
H	3.280814	5.800932	-2.034130
Pd	-0.058379	-0.306659	-0.460134
C	-1.732859	-2.078550	-0.422317
C	-1.882843	-1.065854	-1.393503
C	-2.046783	0.276166	-0.937556
H	-1.865234	-1.335262	-2.449305
H	-2.525751	0.390211	0.037083
C	-2.056249	1.466455	-1.805840
C	-1.563207	1.442877	-3.123097
C	-2.481285	2.694309	-1.270047
C	-1.480649	2.614391	-3.872251
H	-1.219748	0.501645	-3.550199
C	-2.381546	3.867053	-2.015389
H	-2.875092	2.717531	-0.253966
C	-1.877827	3.834217	-3.317667
H	-1.097725	2.578145	-4.889294
H	-2.701912	4.809447	-1.578453
H	-1.802843	4.749325	-3.898855
C	-1.435665	-3.510848	-0.739239
H	-0.465676	-3.803258	-0.316324
H	-2.200649	-4.146153	-0.274928
H	-1.411435	-3.691461	-1.818834
H	-1.684151	-1.767589	0.625119
O	-3.354399	-1.238330	1.931965

TS3'

S	-2.237527	-2.924814	-0.629801
O	-1.251351	-1.907405	-1.201072
C	-3.795032	-2.023677	-0.722594
C	-4.174686	-1.227250	0.356522
C	-4.577313	-2.106208	-1.872639
C	-5.350747	-0.478887	0.274050
H	-3.547174	-1.186900	1.248371
C	-5.744246	-1.347098	-1.954172
H	-4.258222	-2.774303	-2.669633
C	-6.128211	-0.532417	-0.883730
H	-5.658818	0.141246	1.112893
H	-6.363383	-1.394741	-2.846986
H	-7.041879	0.052830	-0.949913
C	0.734892	3.028825	-0.256367
C	0.078637	2.545492	0.894754
C	0.378439	3.105749	2.140693
C	1.319446	4.128325	2.260557
C	1.955695	4.622962	1.123756
C	1.648189	4.082494	-0.122341
C	0.469874	2.505633	-1.635395
C	0.891697	1.238104	-2.087282
C	0.571122	0.826324	-3.384923
C	-0.146955	1.659263	-4.241620
C	-0.536071	2.927403	-3.812782
C	-0.219024	3.343532	-2.522361
H	-0.132542	2.744955	3.029280
H	1.541795	4.543623	3.240004
H	2.688099	5.421583	1.203812

H	2.144219	4.450036	-1.017893
H	0.884165	-0.156433	-3.726900
H	-0.393790	1.316923	-5.242882
H	-1.094678	3.585537	-4.472676
H	-0.540689	4.319302	-2.165005
P	-1.105999	1.119347	0.735273
P	1.793134	0.092321	-0.940906
C	-2.315546	1.768026	-0.493948
C	-2.640745	0.982052	-1.601879
C	-2.838850	3.061086	-0.361058
C	-3.519077	1.486002	-2.564576
H	-2.197166	-0.008190	-1.705282
C	-3.711172	3.558565	-1.327182
H	-2.548342	3.676402	0.490504
C	-4.052984	2.766964	-2.427892
H	-3.780032	0.870707	-3.421604
H	-4.120237	4.560674	-1.226068
H	-4.733683	3.155694	-3.181378
C	-2.005008	1.064558	2.353004
C	-3.335099	1.463584	2.512114
C	-1.327439	0.493264	3.441144
C	-3.980371	1.282652	3.738381
H	-3.875868	1.890441	1.671666
C	-1.965193	0.332495	4.670034
H	-0.293179	0.171406	3.306184
C	-3.299477	0.720732	4.817574
H	-5.019388	1.583340	3.847265
H	-1.427223	-0.104955	5.507108
H	-3.805159	0.581799	5.769266
C	2.564289	-1.200085	-2.010090
C	1.741022	-2.267329	-2.401674
C	3.927070	-1.217599	-2.321529
C	2.286570	-3.340115	-3.106984
H	0.683572	-2.264726	-2.125865
C	4.467797	-2.301038	-3.017439
H	4.575433	-0.410276	-1.992652
C	3.650901	-3.362209	-3.408627
H	1.644751	-4.164754	-3.405040
H	5.530405	-2.317302	-3.245911
H	4.076550	-4.207343	-3.943479
C	3.186026	1.136644	-0.341325
C	3.458985	1.176052	1.025542
C	3.926595	1.928996	-1.228652
C	4.480177	1.996745	1.508746
H	2.860442	0.568834	1.701533
C	4.943806	2.748989	-0.744536
H	3.689343	1.912230	-2.292043
C	5.219654	2.782904	0.625901
H	4.691338	2.020268	2.574838
H	5.517909	3.364948	-1.431963
H	6.011724	3.425377	1.002200
Pd	0.207818	-0.912301	0.514775
C	-1.037258	-3.509345	1.688109
C	0.049681	-2.682335	1.921078
C	1.222035	-2.644980	1.075458
H	0.018946	-2.084415	2.834500
H	1.217366	-3.349452	0.237827
C	2.570918	-2.334327	1.600468
C	2.783969	-1.776666	2.874711
C	3.694191	-2.589961	0.794220
C	4.068150	-1.452989	3.307843
H	1.937128	-1.586502	3.530864
C	4.974733	-2.243841	1.218574
H	3.548944	-3.056534	-0.178827
C	5.169588	-1.668909	2.476310
H	4.209315	-1.024886	4.297539
H	5.823288	-2.433087	0.565509
H	6.169184	-1.404370	2.810340
C	-2.207207	-3.556605	2.622880
H	-2.329272	-2.598735	3.142281
H	-3.135160	-3.794486	2.096428
H	-2.044021	-4.336963	3.378528
H	-0.920634	-4.337496	0.991378
O	-2.427173	-4.114689	-1.508854

INT6

S	-4.496611	0.785092	2.107351
O	-5.243313	-0.025831	3.070482
C	-5.273588	0.578066	0.518637
C	-5.090161	1.559669	-0.457166
C	-6.033100	-0.565868	0.277117
C	-5.675572	1.379877	-1.710020
H	-4.498851	2.441846	-0.221730
C	-6.622532	-0.731187	-0.977198
H	-6.165494	-1.292127	1.074681
C	-6.442056	0.238439	-1.965957
H	-5.545063	2.135301	-2.480246
H	-7.227590	-1.610942	-1.179825
H	-6.906837	0.108587	-2.940173
C	2.876600	-1.550807	-1.409515

C	1.524830	-1.797130	-1.729714
C	1.130651	-1.833770	-3.071673
C	2.049379	-1.612814	-4.096807
C	3.387391	-1.377249	-3.787880
C	3.791559	-1.370512	-2.455012
C	3.424375	-1.533212	-0.010847
C	3.279465	-0.454203	0.887962
C	3.859041	-0.537108	2.159202
C	4.572357	-1.668808	2.552756
C	4.732095	-2.730347	1.664042
C	4.171755	-2.648610	0.391332
H	0.091723	-2.036190	-3.318254
H	1.718532	-1.634514	-5.131736
H	4.114405	-1.203116	-4.576336
H	4.833227	-1.188104	-2.200428
H	3.746018	0.294955	2.850338
H	5.007248	-1.713550	3.547779
H	5.285141	-3.618454	1.957515
H	4.280581	-3.474140	-0.308786
P	0.266528	-1.906252	-0.372602
P	2.184298	0.978940	0.455640
C	0.888178	-3.280627	0.681585
C	1.025760	-3.047777	2.052574
C	1.303631	-4.499372	0.131511
C	1.577156	-4.032603	2.874442
H	0.725868	-2.079394	2.454562
C	1.849429	-5.483252	0.954192
H	1.212847	-4.662566	-0.942006
C	1.988085	-5.247251	2.325032
H	1.695647	-3.846505	3.938439
H	2.173038	-6.429663	0.528778
H	2.421154	-6.012433	2.964091
C	-1.299254	-2.511448	-1.143483
C	-1.875308	-3.750460	-0.855492
C	-2.033232	-1.566867	-1.878807
C	-3.180539	-4.028817	-1.274547
H	-1.324872	-4.486256	-0.274623
C	-3.330661	-1.844535	-2.297694
H	-1.589907	-0.588205	-2.070960
C	-3.912062	-3.077430	-1.983512
H	-3.628500	-4.988424	-1.030010
H	-3.900694	-1.090063	-2.834415
H	-4.936001	-3.285833	-2.283259
C	2.559702	2.276545	1.719526
C	1.763209	2.271782	2.873490
C	3.540074	3.260734	1.565587
C	1.957703	3.226815	3.870251
H	0.975890	1.522088	2.964387
C	3.723549	4.226186	2.557766
H	4.148006	3.288362	0.665297
C	2.938176	4.208408	3.710465
H	1.334184	3.215962	4.760155
H	4.480543	4.995040	2.426827
H	3.082384	4.963424	4.478710
C	2.888474	1.598397	-1.129382
C	1.997911	1.939718	-2.150473
C	4.269650	1.677865	-1.348508
C	2.488077	2.366617	-3.386281
H	0.924930	1.863786	-1.973441
C	4.756275	2.106992	-2.582072
H	4.958078	1.375065	-0.559592
C	3.863638	2.449188	-3.602013
H	1.788651	2.636180	-4.173570
H	5.828263	2.166790	-2.752375
H	4.244096	2.779086	-4.565456
Pd	-0.107446	0.293160	0.475262
C	-2.846007	0.043961	1.884955
C	-2.174796	0.681782	0.699723
C	-1.463866	1.900699	0.804037
H	-2.640841	0.405398	-0.246926
H	-1.349386	2.353024	1.790966
C	-1.203126	2.805360	-0.340515
C	-1.725111	2.585681	-1.629380
C	-0.355560	3.915292	-0.156822
C	-1.387698	3.425569	-2.692481
H	-2.409226	1.756066	-1.801963
C	-0.020884	4.750835	-1.217424
H	0.058859	4.095226	0.834868
C	-0.529590	4.508537	-2.497516
H	-1.805797	3.234143	-3.678363
H	0.643310	5.594501	-1.047068
H	-0.267828	5.160577	-3.326510
C	-2.978347	-1.471518	1.784743
H	-1.976253	-1.915390	1.804504
H	-3.573993	-1.871385	2.609366
H	-3.445758	-1.752456	0.831431
H	-2.348897	0.341974	2.819488
O	-4.313646	2.218155	2.326295

Prd

C	1.079511	-0.497771	-0.662669	H	-0.446341	-1.224813	-2.842064
C	1.992889	0.474050	-0.531186	H	-2.042414	-1.022014	-2.090670
H	1.344421	-1.548181	-0.544309	H	-0.912459	-2.242382	-1.460846
H	1.665512	1.506947	-0.664852	S	-1.207348	-0.284310	0.677221
C	-0.368097	-0.225307	-0.937226	O	-0.676974	0.810954	1.481446
H	-0.512482	0.808797	-1.276042	O	-1.149760	-1.669067	1.141458
C	3.424055	0.302380	-0.238595	C	-2.901601	0.096105	0.306770
C	4.285374	1.395722	-0.412403	C	-3.280468	1.433837	0.192640
C	3.967431	-0.912685	0.210143	C	-3.811738	-0.946735	0.135419
C	5.651971	1.279499	-0.166002	C	-4.606970	1.731131	-0.115579
H	3.871302	2.344709	-0.747883	H	-2.545969	2.215214	0.369382
C	5.331393	-1.030304	0.456406	C	-5.136668	-0.636742	-0.169022
H	3.314212	-1.763460	0.386548	H	-3.471988	-1.971692	0.257752
C	6.180228	0.063661	0.266554	C	-5.529105	0.697556	-0.297573
H	6.302558	2.138139	-0.308973	H	-4.924457	2.766171	-0.204015
H	5.734964	-1.976321	0.807500	H	-5.863362	-1.433335	-0.300552
H	7.244614	-0.031019	0.463759	H	-6.562990	0.934246	-0.534090
C	-0.988819	-1.238920	-1.892580				

X-Ray Crystal Structures

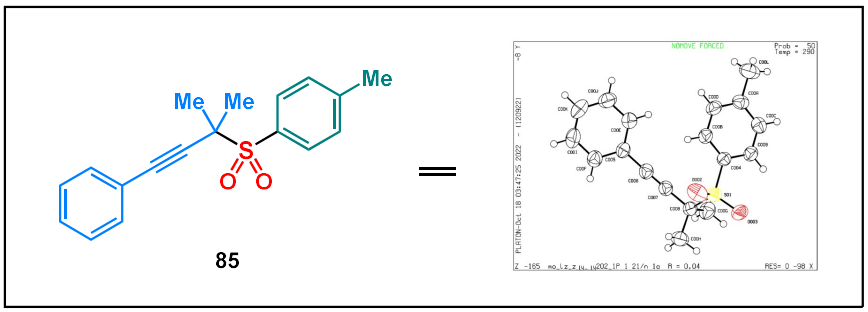
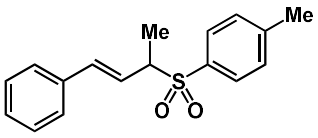


Table S4 Crystal data and structure refinement for compound **85**

Identification code	**85**
Empirical formula	$C_{18}H_{18}O_2S$
Formula weight	298.38
Temperature/K	290.0
Crystal system	monoclinic
Space group	$P2_1/n$
a/Å	11.7968(3)
b/Å	7.4154(2)
c/Å	18.6524(5)
α/°	90
β/°	104.9740(10)
γ/°	90
Volume/Å^3	1576.27(7)
Z	4
ρ_{calc}g/cm^3	1.257
μ/mm^{-1}	0.207
F(000)	632.0
Crystal size/mm^3	0.3 × 0.3 × 0.2
Radiation	MoKα (λ = 0.71073)
2Θ range for data collection/°	4.522 to 55.07
Index ranges	-13 ≤ h ≤ 15, -9 ≤ k ≤ 9, -24 ≤ l ≤ 24
Reflections collected	36614
Independent reflections	3618 [R_{int} = 0.0655, R_{sigma} = 0.0359]
Data/restraints/parameters	3618/0/193
Goodness-of-fit on F^2	1.029
Final R indexes [I>=2σ (I)]	R_1 = 0.0395, wR_2 = 0.0996
Final R indexes [all data]	R_1 = 0.0549, wR_2 = 0.1095
Largest diff. peak/hole / e Å^{-3}	0.18/-0.34

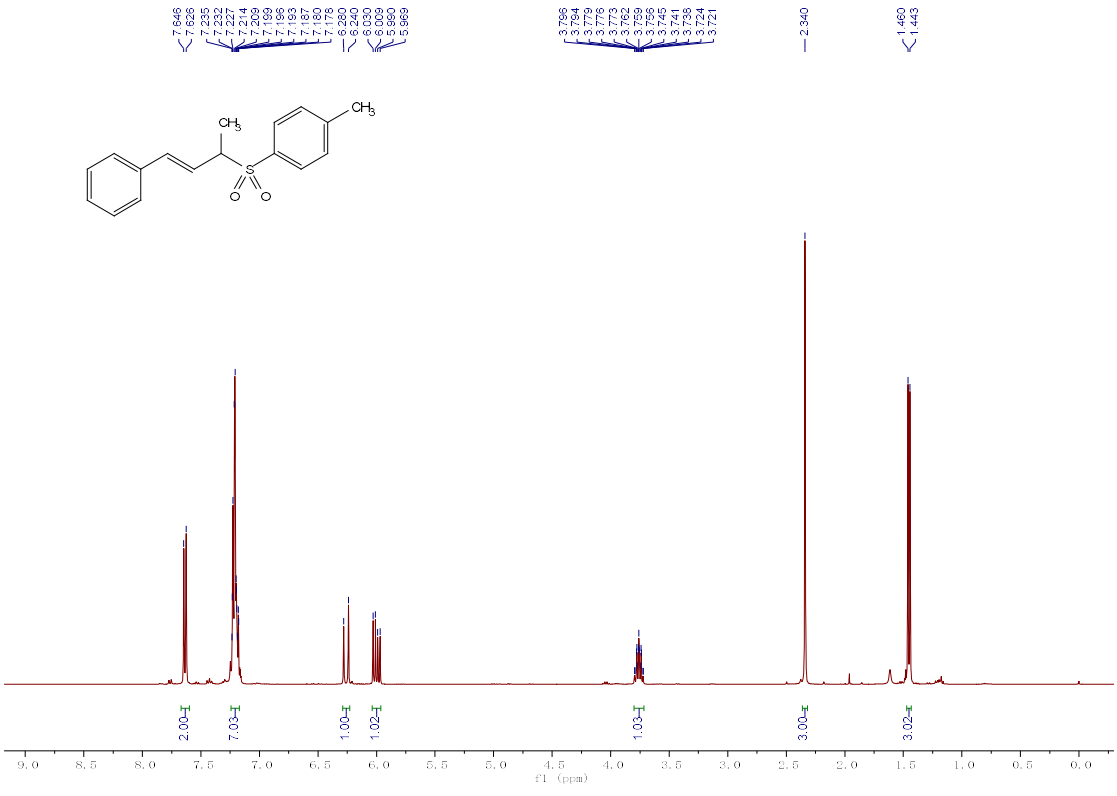
Characterization data of products

(*E*)-1-methyl-4-((4-phenylbut-3-en-2-yl)sulfonyl)benzene (3).

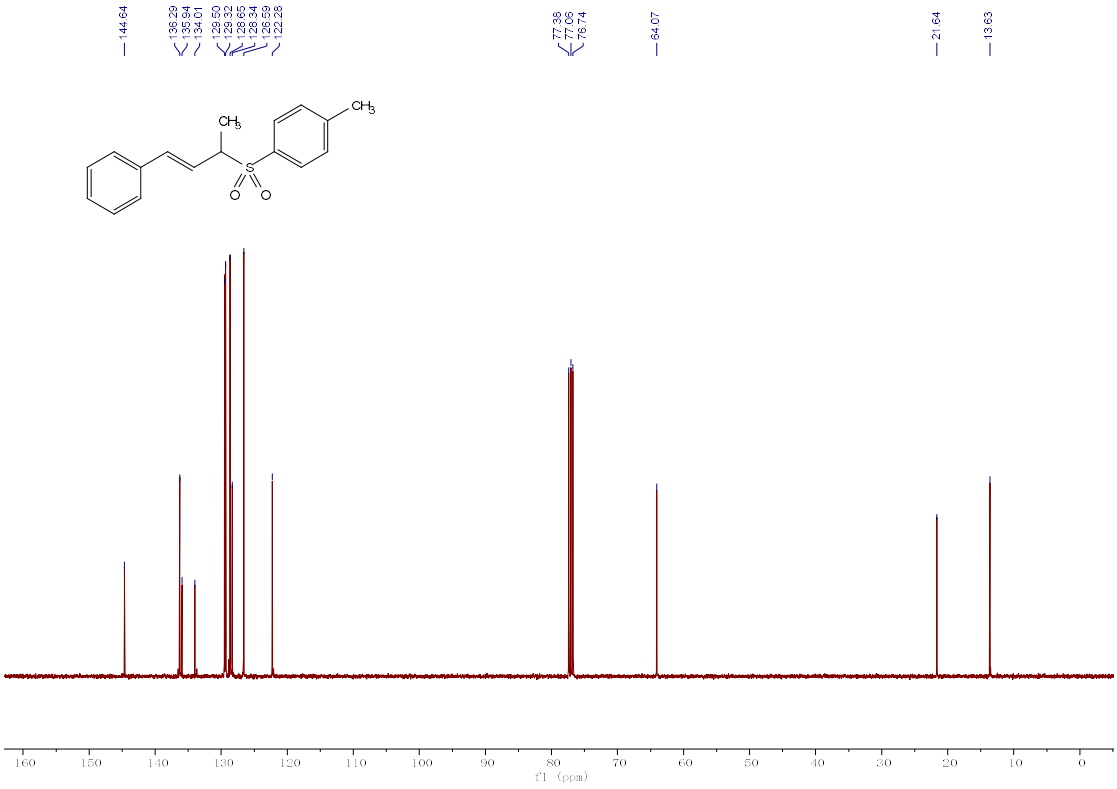


The product (46.4 mg, 81% yield) as white solid was purified with silica gel chromatography (petroleum ether/ethyl acetate = 10/1). **^{1}H NMR (400 MHz, $CDCl_3$)** δ 7.64 (d, *J* = 8.0 Hz, 2H), 7.24-7.18 (m, 7H), 6.26 (d, *J* = 16.0 Hz, 1H), 6.00 (dd, *J* = 16.0 Hz, 8.4 Hz, 1H), 3.80-3.72 (m, 1H), 2.34 (s, 3H), 1.45 (d, *J* = 6.8 Hz, 3H); **^{13}C NMR (101 MHz, $CDCl_3$)** δ 144.6, 136.3, 135.9, 134.0, 129.5, 129.3, 128.7, 128.3, 126.6, 122.3, 64.1, 21.6, 13.6; **HRMS** Calculated for $C_{17}H_{18}O_2S$ ($M+Na^+$): 309.0920; Found: 309.0917.

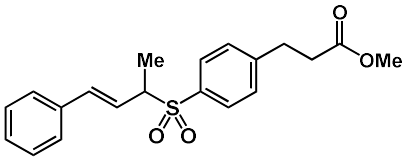
^{1}H NMR spectrum (400 MHz, $CDCl_3$) of compound **3**



^{13}C NMR spectrum (101 MHz, $CDCl_3$) of compound **3**

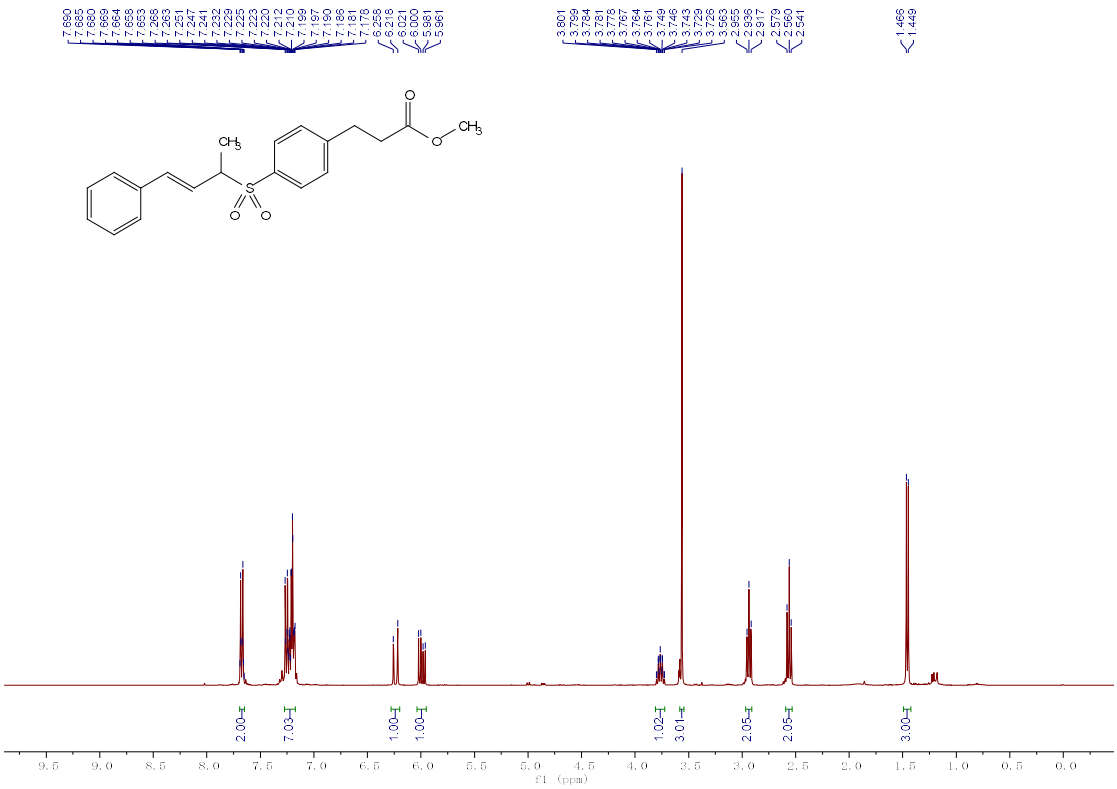


methyl (*E*)-3-(4-((4-phenylbut-3-en-2-yl)sulfonyl)phenyl)propanoate (4).

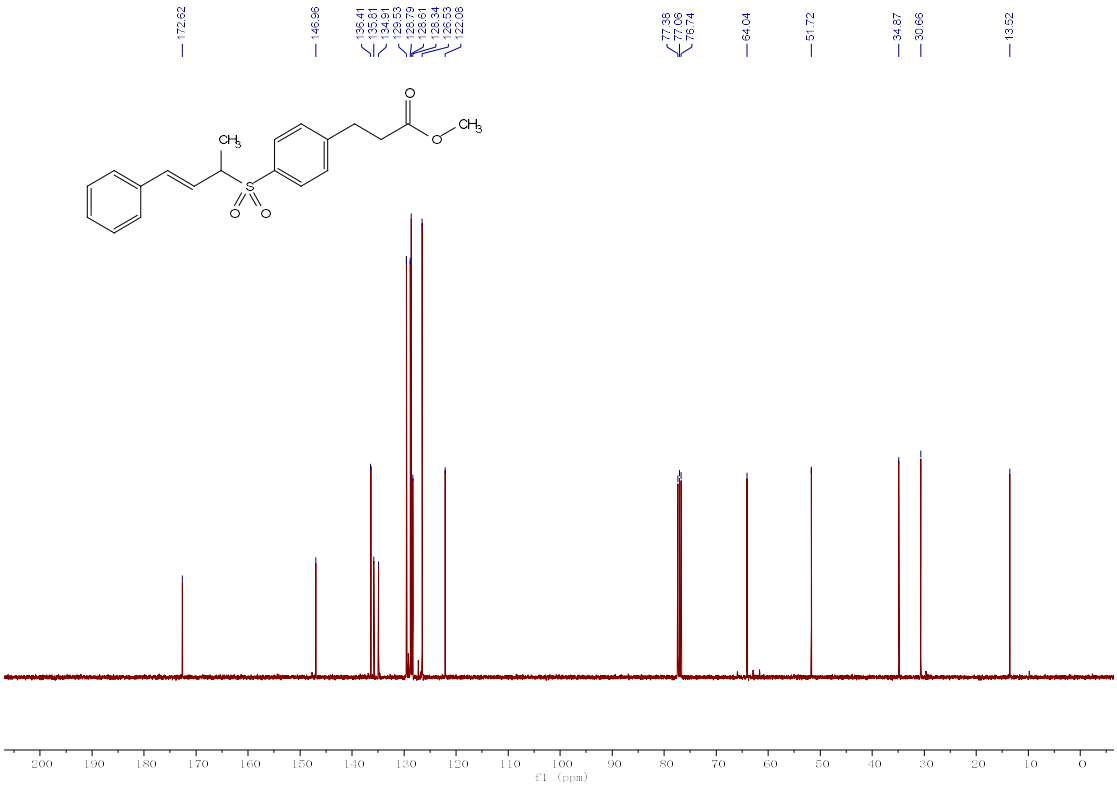


The product (58.1 mg, 81% yield) as yellow solid was purified with silica gel chromatography (petroleum ether/ethyl acetate = 3/1). **^{1}H NMR (400 MHz, $CDCl_3$)** δ 7.69-7.65 (m, 2H), 7.27-7.18 (m, 7H), 6.24 (d, *J* = 16.0 Hz, 1H), 5.99 (dd, *J* = 16.0 Hz, 8.4 Hz, 1H), 3.80-3.73 (m, 1H), 3.56 (s, 3H), 2.94 (t, *J* = 7.6 Hz, 2H), 2.56 (t, *J* = 7.6 Hz, 2H), 1.46 (d, *J* = 6.8 Hz, 3H); **^{13}C NMR (101 MHz, $CDCl_3$)** δ 172.6, 147.0, 136.4, 135.8, 134.9, 129.5, 128.8, 128.6, 128.3, 126.5, 122.1, 64.0, 51.7, 34.9, 30.7, 13.5; **HRMS** Calculated for $C_{20}H_{22}O_4S$ ($M+Na^+$): 381.1131; Found: 381.1130.

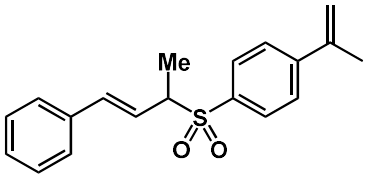
^{1}H NMR spectrum (400 MHz, $CDCl_3$) of compound **4**



^{13}C NMR spectrum (101 MHz, $CDCl_3$) of compound **4**

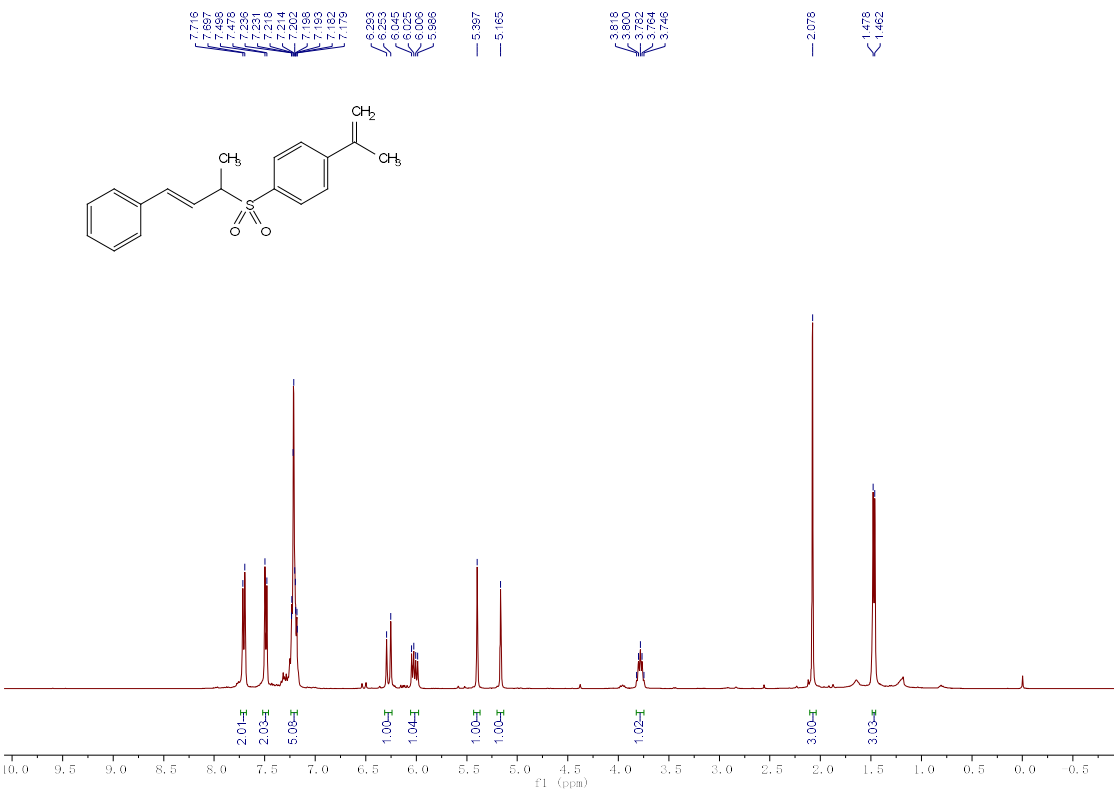


(*E*)-1-((4-phenylbut-3-en-2-yl)sulfonyl)-4-(prop-1-en-2-yl)benzene (5)

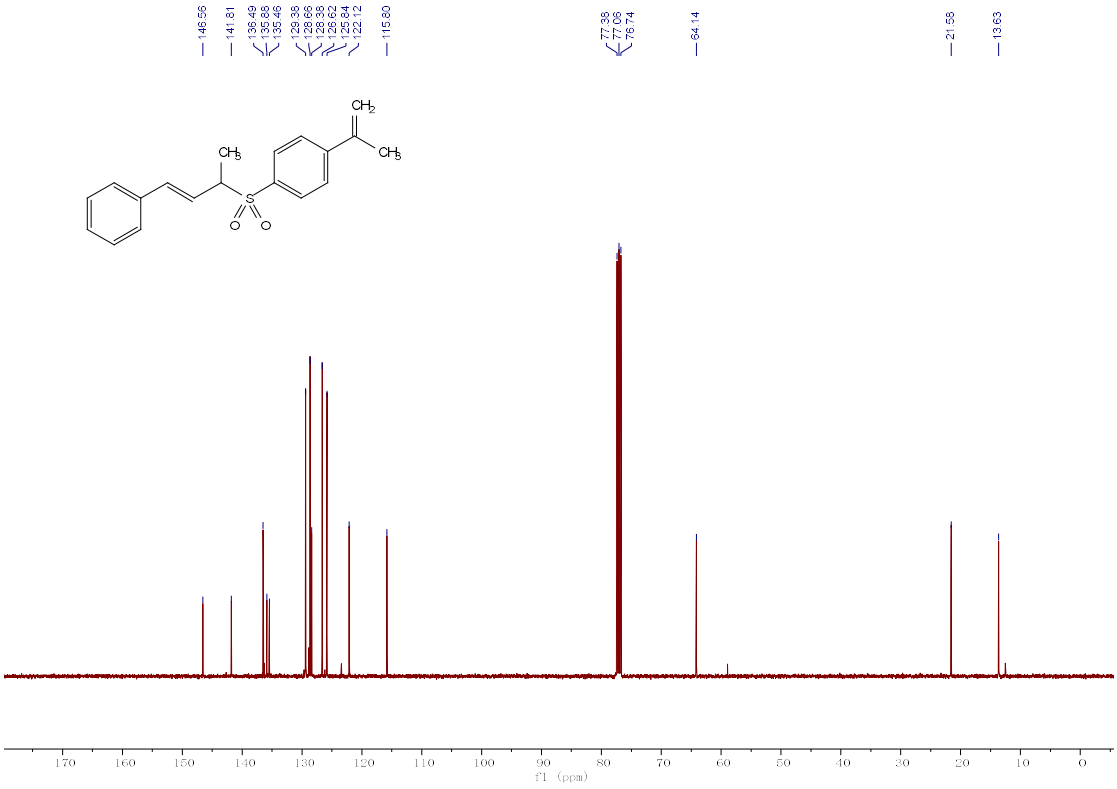


The product (51.9 mg, 83% yield) as light yellow oil was purified with silica gel chromatography (petroleum ether/ethyl acetate = 10/1). **^{1}H NMR (400 MHz, $CDCl_3$)** δ 7.71 (d, *J* = 7.6 Hz, 2H), 7.49 (d, *J* = 8.0 Hz, 2H), 7.24-7.18 (m, 5H), 6.27 (d, *J* = 16.0 Hz, 1H), 6.02 (dd, *J* = 15.6 Hz, 8.0 Hz, 1H), 5.40 (s, 1H), 5.16 (s, 1H), 3.82-3.75 (m, 1H), 2.08 (s, 3H), 1.47 (d, *J* = 6.4 Hz, 3H); **^{13}C NMR (101 MHz, $CDCl_3$)** δ 146.6, 141.8, 136.5, 135.9, 135.5, 129.4, 128.7, 128.4, 126.6, 125.8, 122.1, 115.8, 64.1, 21.6, 13.6; **HRMS** Calculated for $C_{19}H_{20}O_2S$ ($M+Na^+$): 335.1076; Found: 335.1076.

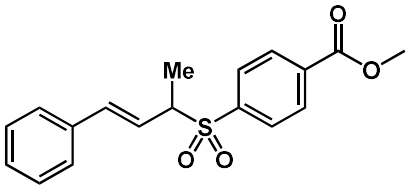
^{1}H NMR spectrum (400 MHz, $CDCl_3$) of compound **5**



^{13}C NMR spectrum (101 MHz, $CDCl_3$) of compound **5**

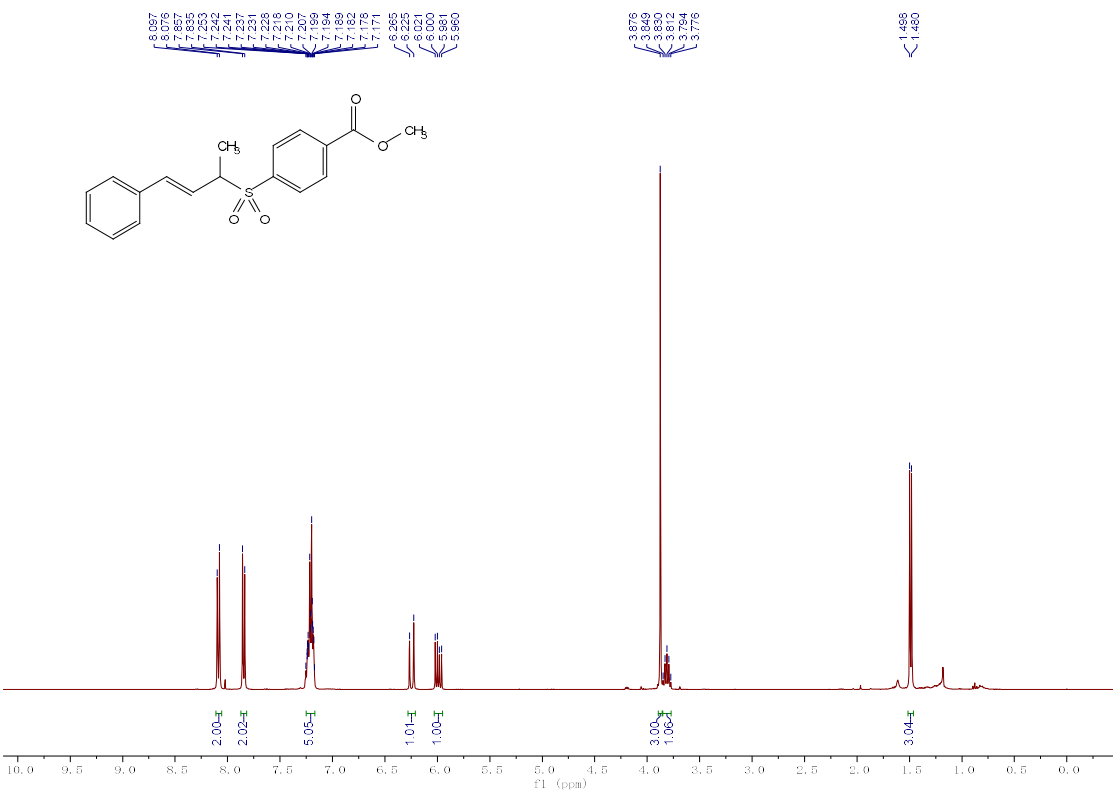


methyl (*E*)-4-((4-phenylbut-3-en-2-yl)sulfonyl)benzoate (6).

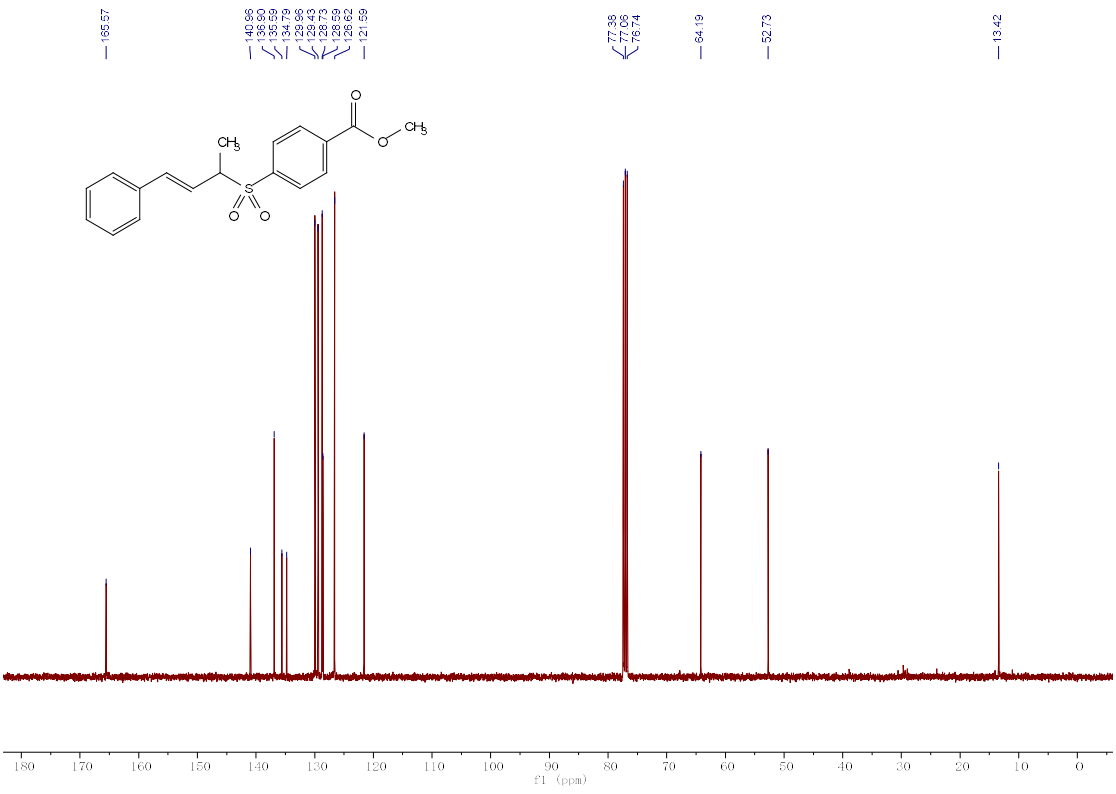


The product (37.0 mg, 56% yield) as white solid was purified with silica gel chromatography (petroleum ether/ethyl acetate = 5/1). **^{1}H NMR (400 MHz, $CDCl_3$)** δ 8.09 (d, *J* = 8.4 Hz, 2H), 7.85 (d, *J* = 8.8 Hz, 2H), 7.25-7.17 (m, 5H), 6.24 (d, *J* = 16.0 Hz, 1H), 5.99 (dd, *J* = 16.0 Hz, 8.4 Hz, 1H), 3.88 (s, 3H), 3.85-3.78 (m, 1H), 1.49 (d, *J* = 7.2 Hz, 3H); **^{13}C NMR (101 MHz, $CDCl_3$)** δ 165.6, 141.0, 136.9, 135.6, 134.8, 130.0, 129.4, 128.7, 128.6, 126.6, 121.6, 64.2, 52.7, 13.4; **HRMS** Calculated for $C_{18}H_{18}O_4S$ ($M+Na^+$): 353.0818; Found: 353.0817.

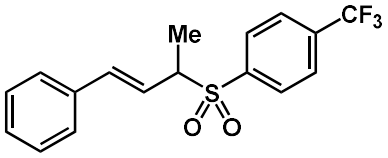
^{1}H NMR spectrum (400 MHz, $CDCl_3$) of compound **6**



^{13}C NMR spectrum (101 MHz, $CDCl_3$) of compound **6**

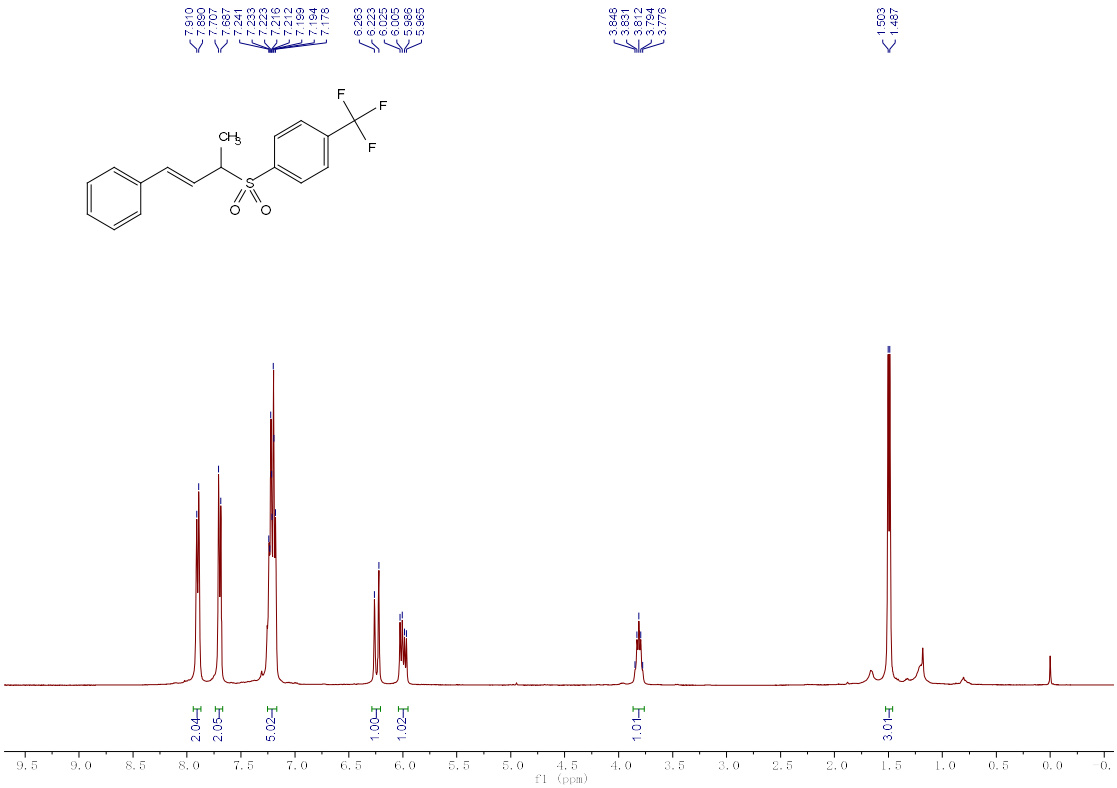


(*E*)-1-((4-phenylbut-3-en-2-yl)sulfonyl)-4-(trifluoromethyl)benzene (7).



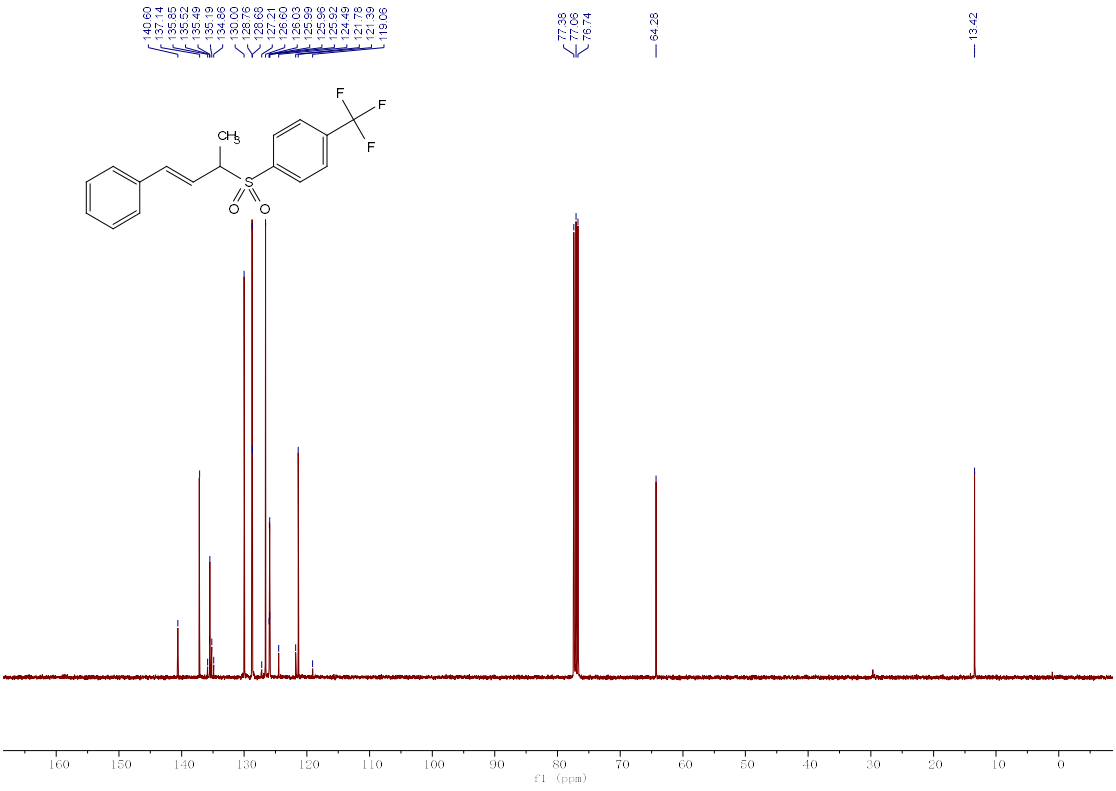
The product (53.1 mg, 78% yield) as light yellow solid was purified with silica gel chromatography (petroleum ether/ethyl acetate = 10/1). **^{1}H NMR (400 MHz, $CDCl_3$)** δ 7.90 (d, *J* = 8.0 Hz, 2H), 7.70 (d, *J* = 8.0 Hz, 2H), 7.24-7.18 (m, 5H), 6.24 (d, *J* = 16.0 Hz, 1H), 6.00 (dd, *J* = 16.0 Hz, 8.0 Hz, 1H), 3.85-3.78 (m, 1H), 1.50 (d, *J* = 6.4 Hz, 3H); **^{19}F NMR (376 MHz, $CDCl_3$)** δ -63.18 (s, 1F); **^{13}C NMR (101 MHz, $CDCl_3$)** δ 140.6, 137.1, 135.5, 135.4 (q, *J* = 33.3 Hz), 130.0, 128.8, 128.7, 126.6, 126.0 (q, *J* = 4.0 Hz), 123.1 (q, *J* = 273.7 Hz), 121.4, 64.3, 13.4; **HRMS** Calculated for $C_{17}H_{15}F_3O_2S$ (M+Na^+): 363.0637; Found: 363.0637.

^{1}H NMR spectrum (400 MHz, $CDCl_3$) of compound **7**

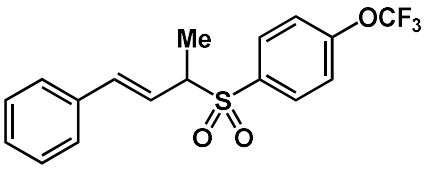


^{19}F NMR spectrum (376 MHz, $CDCl_3$) of compound **7**

^{13}C NMR spectrum (101 MHz, $CDCl_3$) of compound **7**

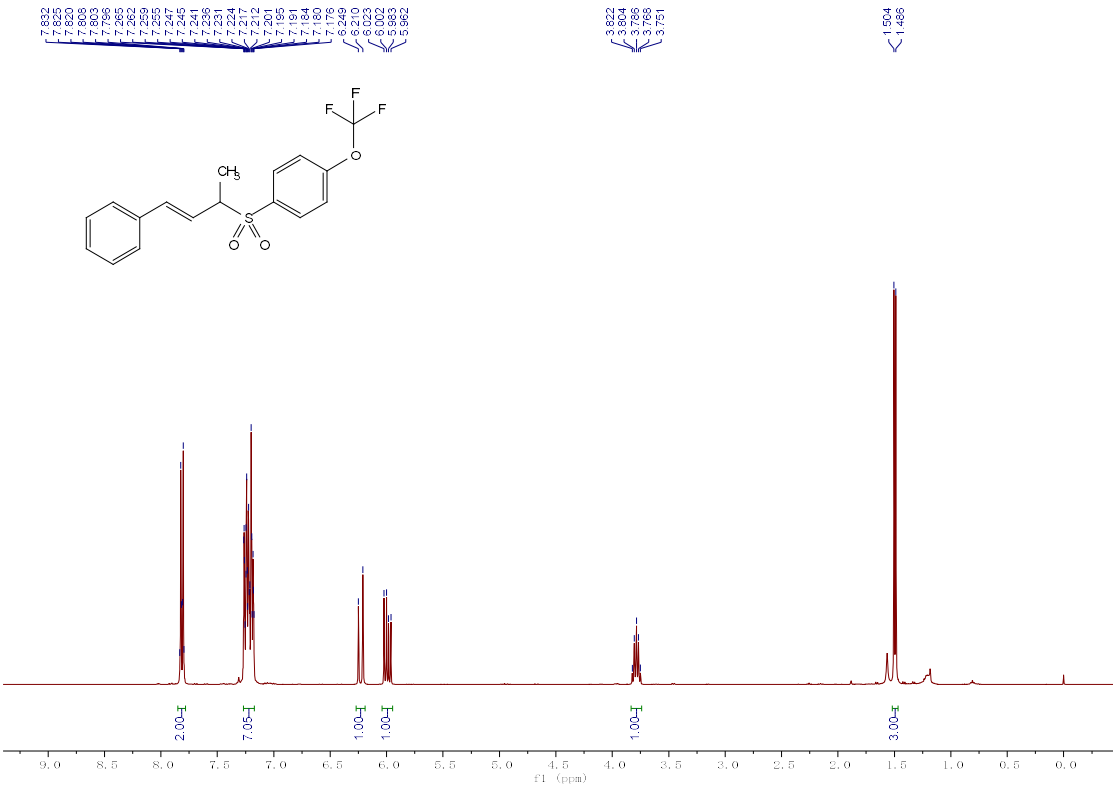


(*E*)-1-((4-phenylbut-3-en-2-yl)sulfonyl)-4-(trifluoromethoxy)benzene (8).

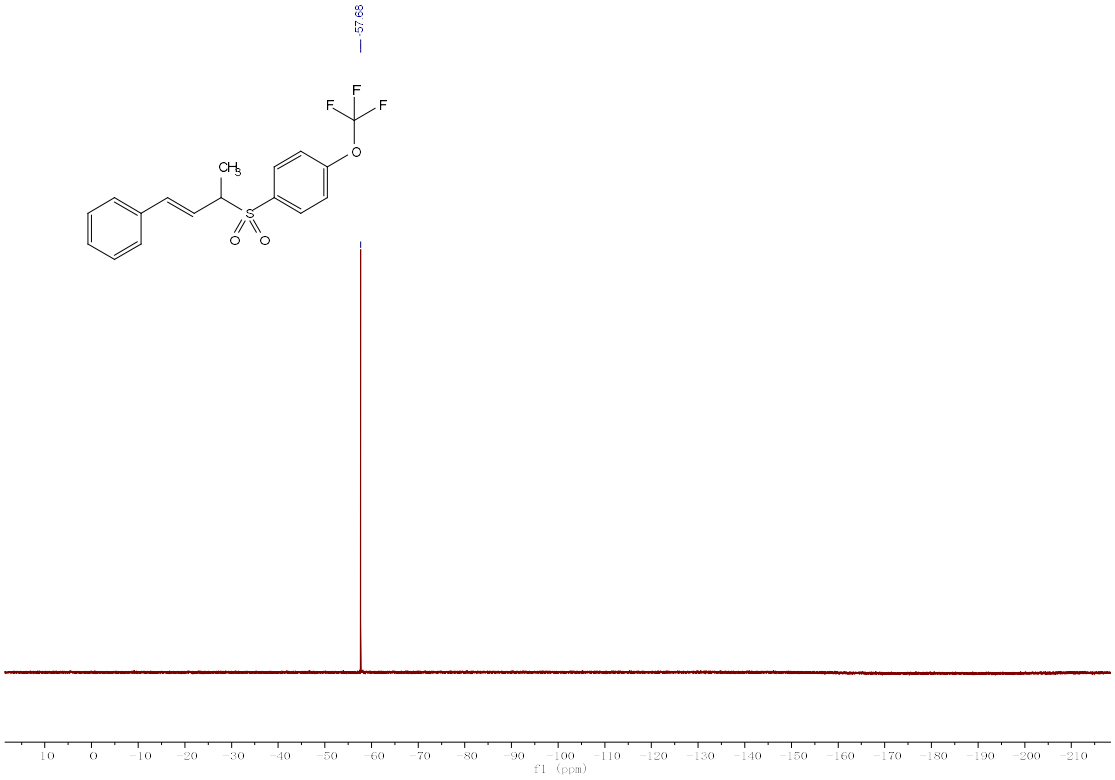


The product (53.5 mg, 75% yield) as white solid was purified with silica gel chromatography (petroleum ether/ethyl acetate = 10/1). **^{1}H NMR (400 MHz, $CDCl_3$)** δ 7.83-7.80 (m, 2H), 7.27-7.18 (m, 7H), 6.23 (d, *J* = 15.6 Hz, 1H), 5.99 (dd, *J* = 16.0 Hz, 8.4 Hz, 1H), 3.82-3.75 (m, 1H), 1.49 (d, *J* = 7.2 Hz, 3H); **^{19}F NMR (376 MHz, $CDCl_3$)** δ -57.68 (s, 1F); **^{13}C NMR (101 MHz, $CDCl_3$)** δ 153.0, 137.0, 135.6, 135.2, 131.6, 128.8, 128.6, 126.6, 121.7, 120.6, 120.2 (q, *J* = 260.6 Hz), 64.4, 13.4; **HRMS** Calculated for $C_{17}H_{15}F_3O_3S$ ($M+Na^+$): 379.0586; Found: 379.0585.

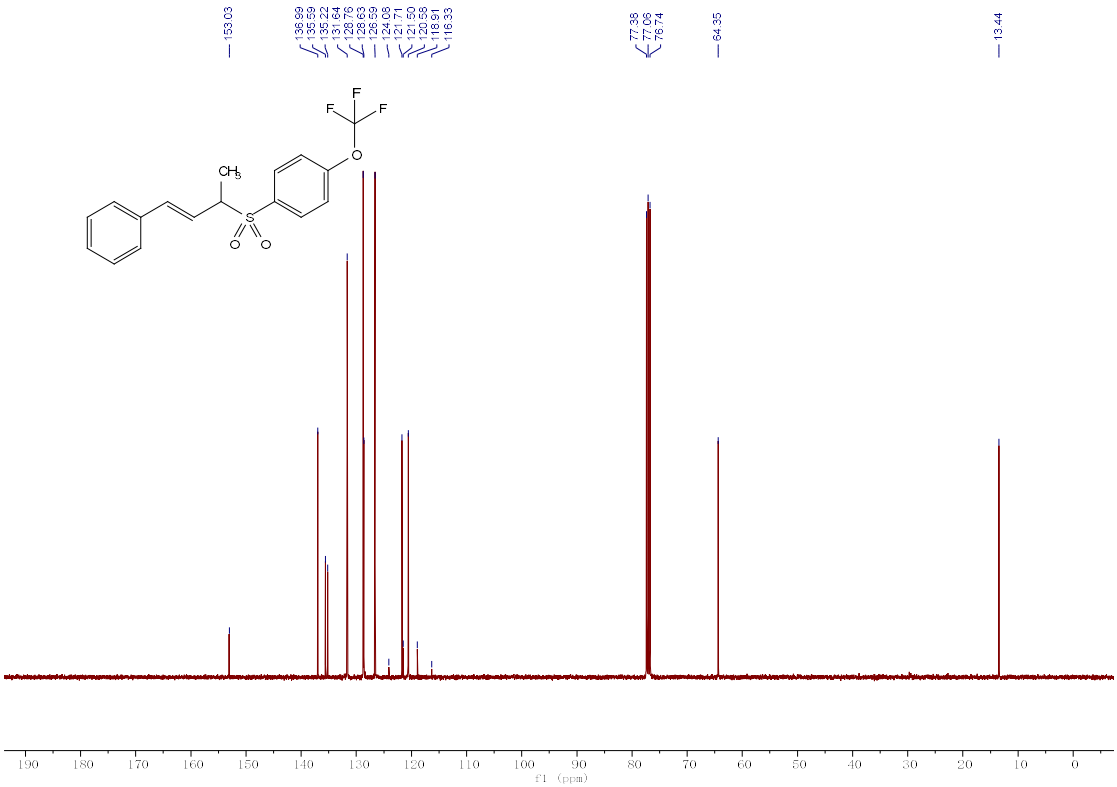
^{1}H NMR spectrum (400 MHz, $CDCl_3$) of compound **8**



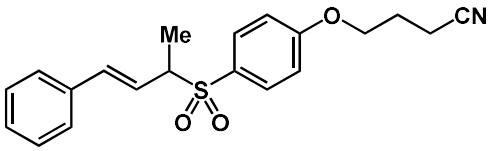
^{19}F NMR spectrum (376 MHz, $CDCl_3$) of compound **8**



^{13}C NMR spectrum (101 MHz, $CDCl_3$) of compound **8**

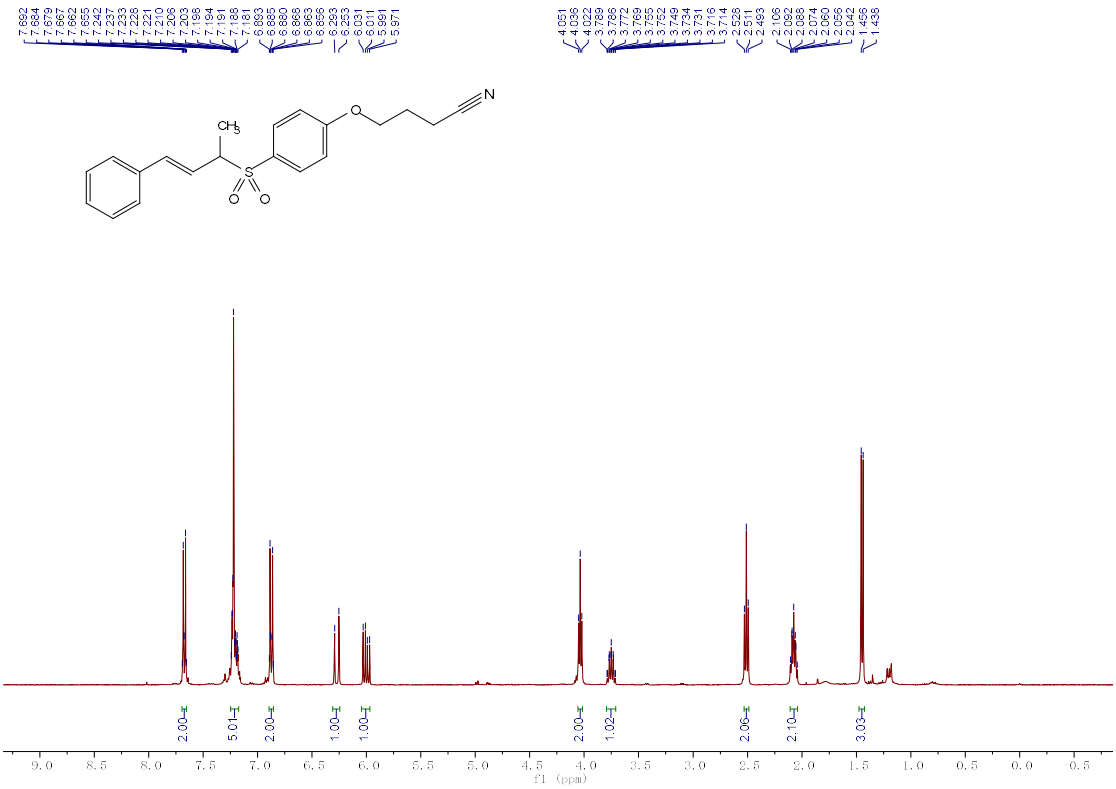


(*E*)-4-(4-((4-phenylbut-3-en-2-yl)sulfonyl)phenoxy)butanenitrile (9).

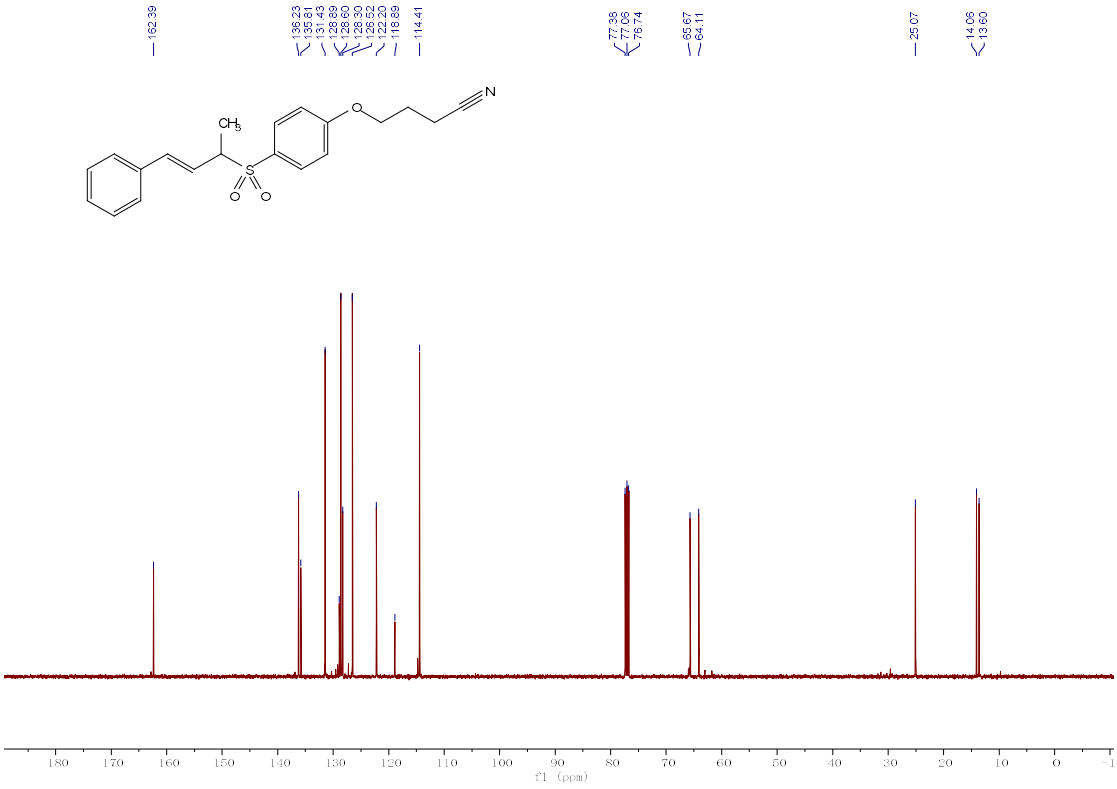


The product (60.4 mg, 85% yield) as yellow oil was purified with silica gel chromatography (petroleum ether/ethyl acetate = 2/1). **^{1}H NMR (400 MHz, $CDCl_3$)** δ 7.69-7.66 (m, 2H), 7.24-7.18 (m, 5H), 6.89-6.86 (m, 2H), 6.27 (d, *J* = 16.0 Hz, 1H), 6.00 (dd, *J* = 16.0 Hz, 8.0 Hz, 1H), 4.04 (t, *J* = 6.0 Hz, 2H), 3.79-3.71 (m, 1H), 2.51 (t, *J* = 6.8 Hz, 2H), 2.11-2.04 (m, 2H), 1.45 (d, *J* = 7.2 Hz, 3H); **^{13}C NMR (101 MHz, $CDCl_3$)** δ 162.4, 136.2, 135.8, 131.4, 128.9, 128.6, 128.3, 126.5, 122.2, 118.9, 114.4, 65.7, 64.1, 25.1, 14.1, 13.6; **HRMS** Calculated for $C_{20}H_{21}NO_3S$ ($M+Na^+$): 378.1134; Found: 378.1132.

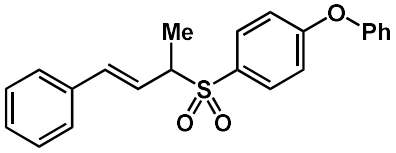
^{1}H NMR spectrum (400 MHz, $CDCl_3$) of compound **9**



^{13}C NMR spectrum (101 MHz, $CDCl_3$) of compound **9**

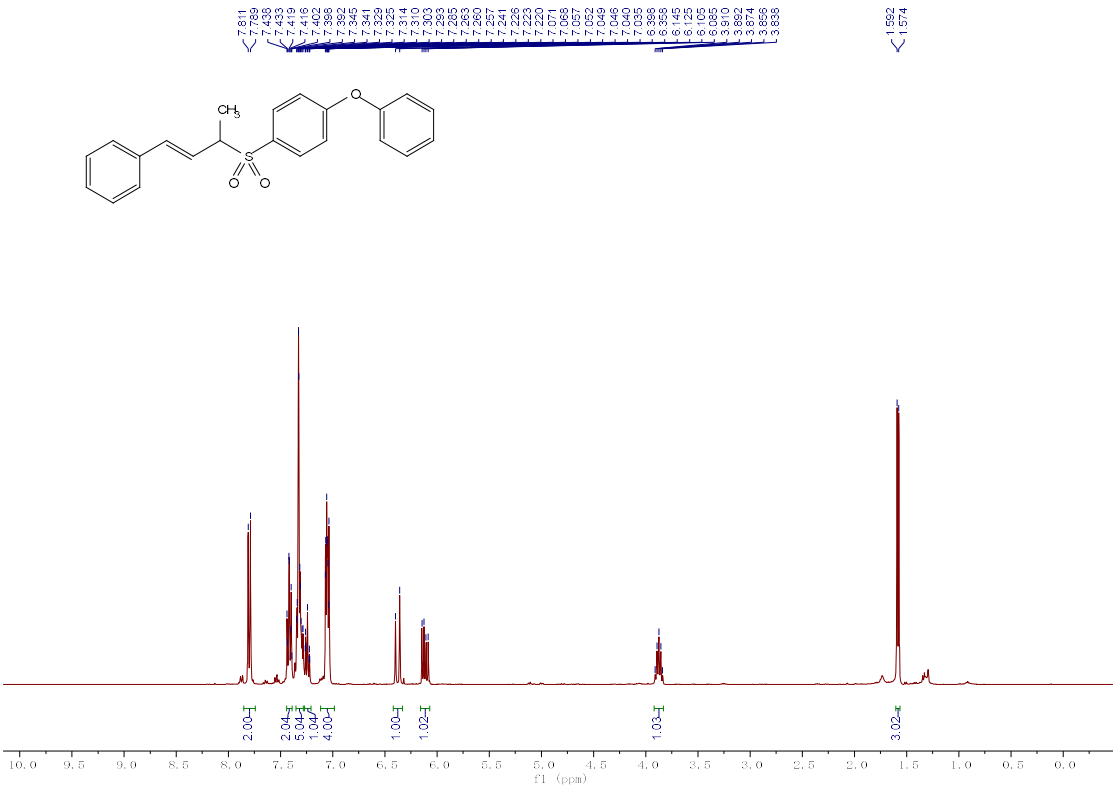


(*E*)-1-phenoxy-4-((4-phenylbut-3-en-2-yl)sulfonyl)benzene (10).

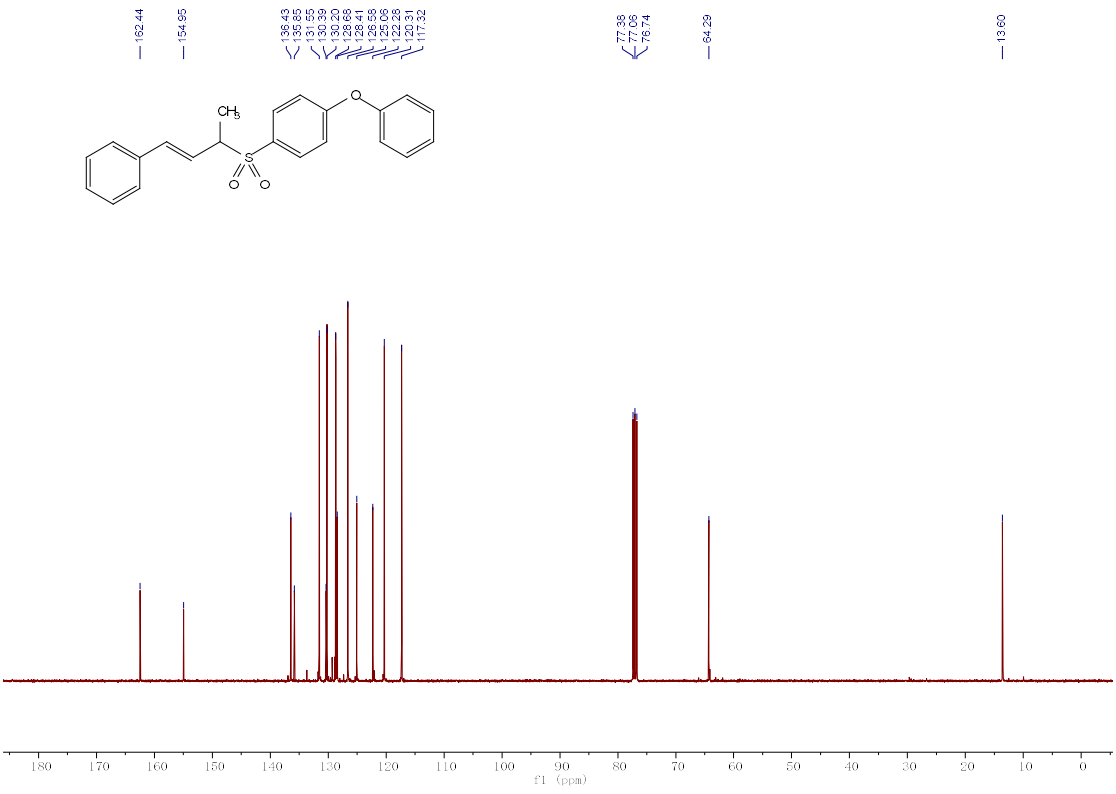


The product (64.9 mg, 89% yield) as white solid was purified with silica gel chromatography (petroleum ether/ethyl acetate = 10/1). **^{1}H NMR (400 MHz, $CDCl_3$)** δ 7.80 (d, *J* = 8.8 Hz, 2H), 7.44-7.39 (m, 2H), 7.35-7.29 (m, 5H), 7.26-7.22 (m, 1H), 7.07-7.04 (m, 4H), 6.38 (d, *J* = 16.0 Hz, 1H), 6.11 (dd, *J* = 16.0 Hz, 8.0 Hz, 1H), 3.91-3.84 (m, 1H), 1.58 (d, *J* = 7.2 Hz, 3H); **^{13}C NMR (101 MHz, $CDCl_3$)** δ 162.4, 155.0, 136.4, 135.9, 131.6, 130.4, 130.2, 128.7, 128.4, 126.6, 125.1, 122.3, 120.3, 117.3, 64.3, 13.6; **HRMS** Calculated for $C_{22}H_{20}O_3S$ ($M+Na^+$): 387.1025; Found: 387.1025.

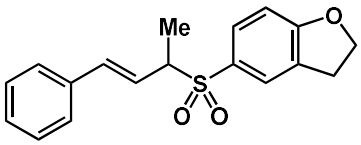
^{1}H NMR spectrum (400 MHz, $CDCl_3$) of compound **10**



^{13}C NMR spectrum (101 MHz, $CDCl_3$) of compound **10**

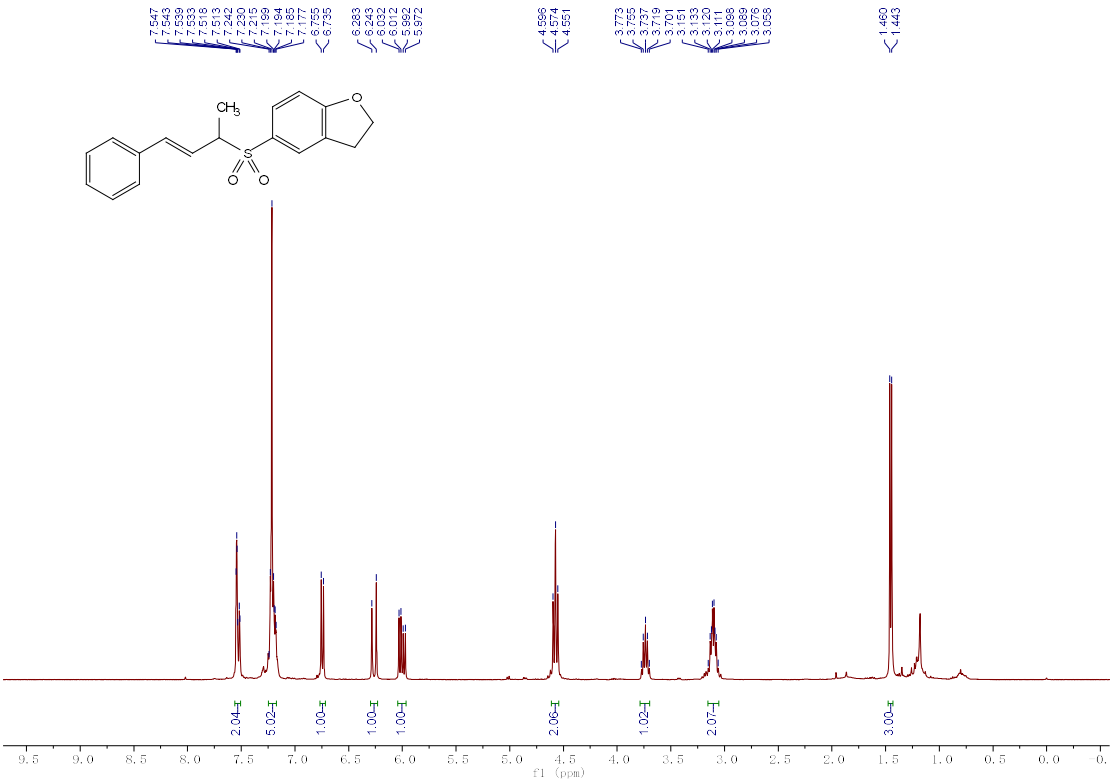


(*E*)-5-((4-phenylbut-3-en-2-yl)sulfonyl)-2,3-dihydrobenzofuran (11).

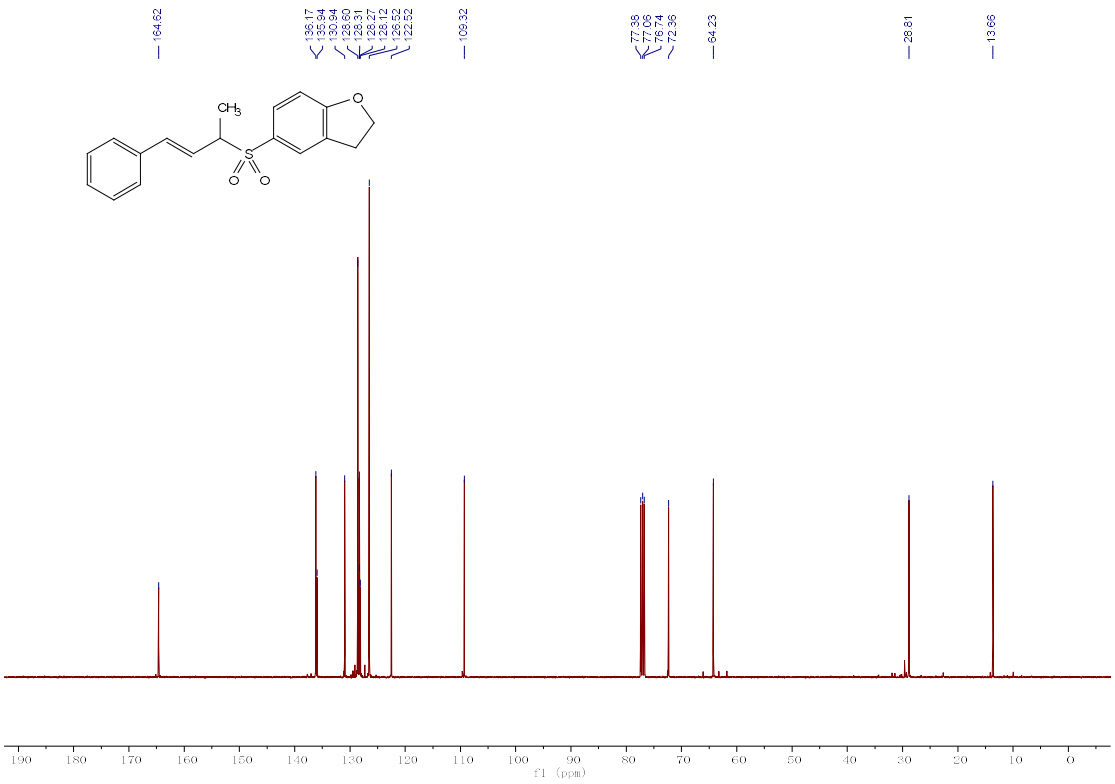


The product (52.8 mg, 84% yield) as yellow oil was purified with silica gel chromatography (petroleum ether/ethyl acetate = 10/1). **^{1}H NMR (400 MHz, $CDCl_3$)** δ 7.55-7.51 (m, 2H), 7.24-7.18 (m, 5H), 6.75 (d, *J* = 8.0 Hz, 1H), 6.26 (d, *J* = 16.0 Hz, 1H), 6.00 (dd, *J* = 16.0 Hz, 8.0 Hz, 1H), 4.57 (t, *J* = 8.8 Hz, 2H), 3.77-3.70 (m, 1H), 3.15-3.06 (m, 2H), 1.45 (d, *J* = 6.8 Hz, 3H); **^{13}C NMR (101 MHz, $CDCl_3$)** δ 164.6, 136.2, 135.9, 130.9, 128.6, 128.31, 128.27, 128.1, 126.5, 122.5, 109.3, 72.4, 64.2, 28.8, 13.7; **HRMS** Calculated for $C_{18}H_{18}O_3S$ ($M+Na^+$): 337.0869; Found: 337.0869.

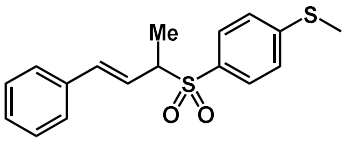
^{1}H NMR spectrum (400 MHz, $CDCl_3$) of compound **11**



^{13}C NMR spectrum (101 MHz, $CDCl_3$) of compound **11**

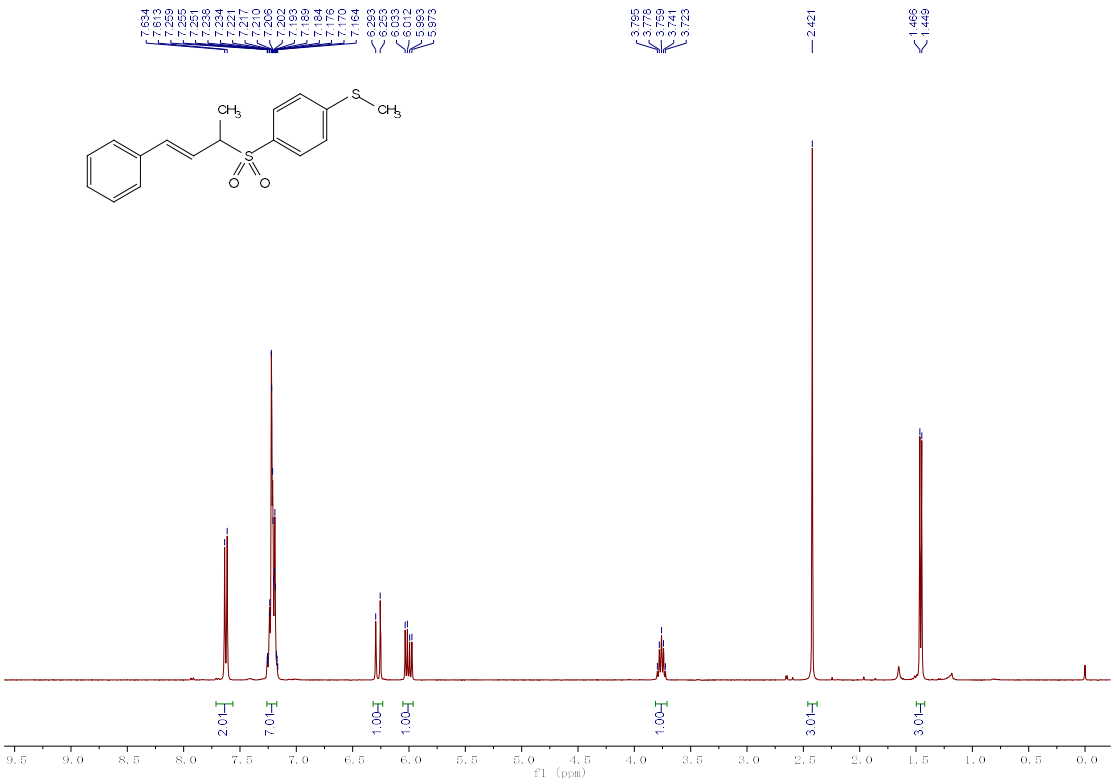


(*E*)-methyl(4-((4-phenylbut-3-en-2-yl)sulfonyl)phenyl)sulfane (12).

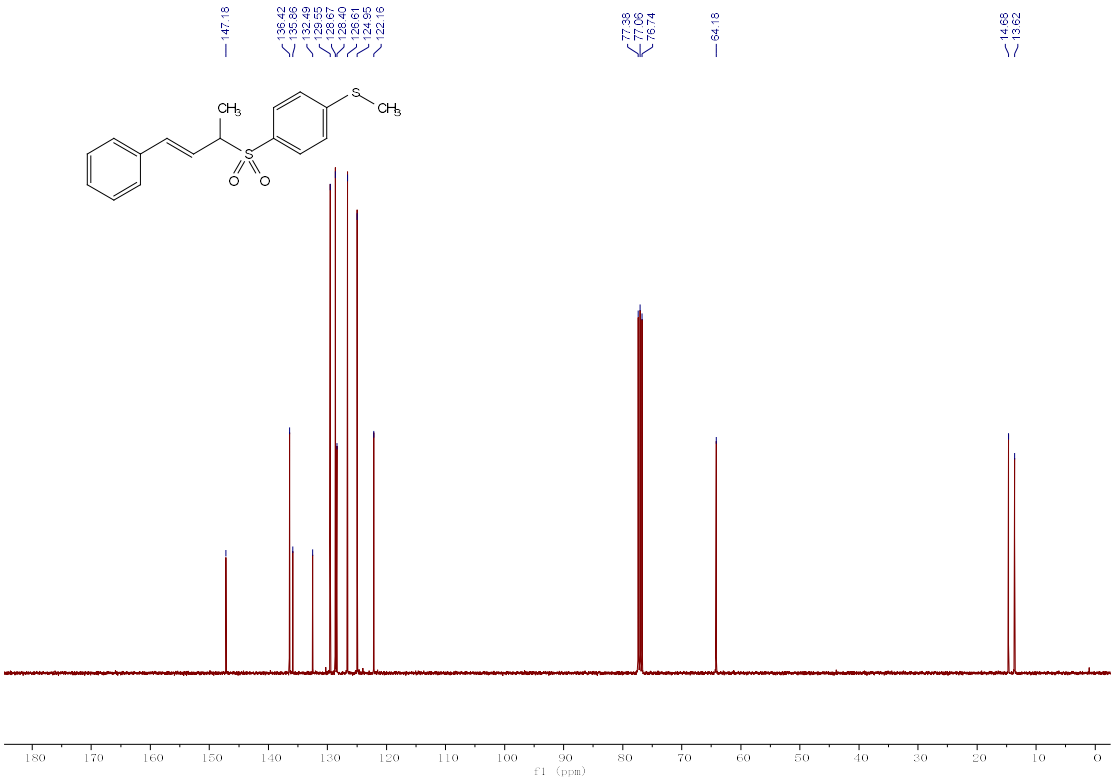


The product (52.2 mg, 82% yield) as white solid was purified with silica gel chromatography (petroleum ether/ethyl acetate = 5/1). **^{1}H NMR (400 MHz, $CDCl_3$)** δ 7.62 (d, *J* = 8.4 Hz, 2H), 7.26-7.16 (m, 7H), 6.27 (d, *J* = 16.0 Hz, 1H), 6.00 (dd, *J* = 16.0 Hz, 8.4 Hz, 1H), 3.80-3.72 (m, 1H), 2.42 (s, 3H), 1.46 (d, *J* = 6.8 Hz, 3H); **^{13}C NMR (101 MHz, $CDCl_3$)** δ 147.2, 136.4, 135.9, 132.5, 129.6, 128.7, 128.4, 126.6, 125.0, 122.2, 64.2, 14.7, 13.6; **HRMS** Calculated for $C_{17}H_{18}O_2S_2$ ($M+Na^+$): 341.0640; Found: 341.0640.

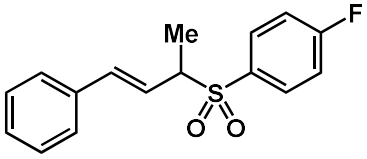
^{1}H NMR spectrum (400 MHz, $CDCl_3$) of compound **12**



^{13}C NMR spectrum (101 MHz, $CDCl_3$) of compound **12**

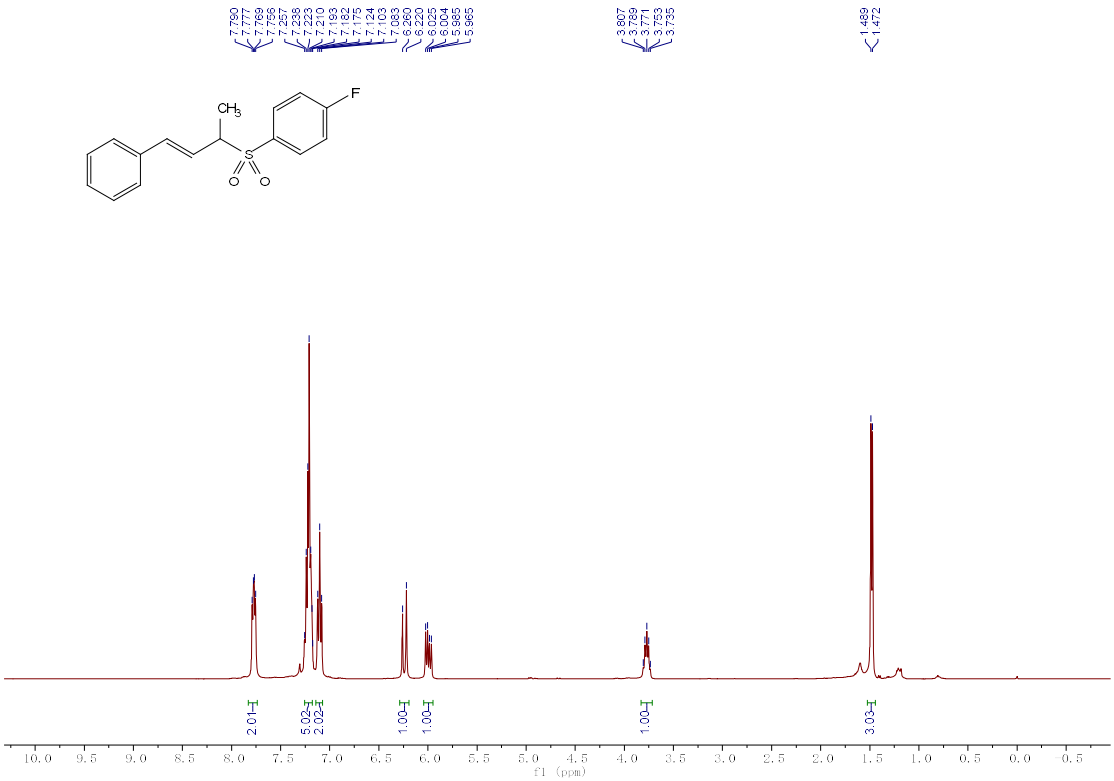


(*E*)-1-fluoro-4-((4-phenylbut-3-en-2-yl)sulfonyl)benzene (13).

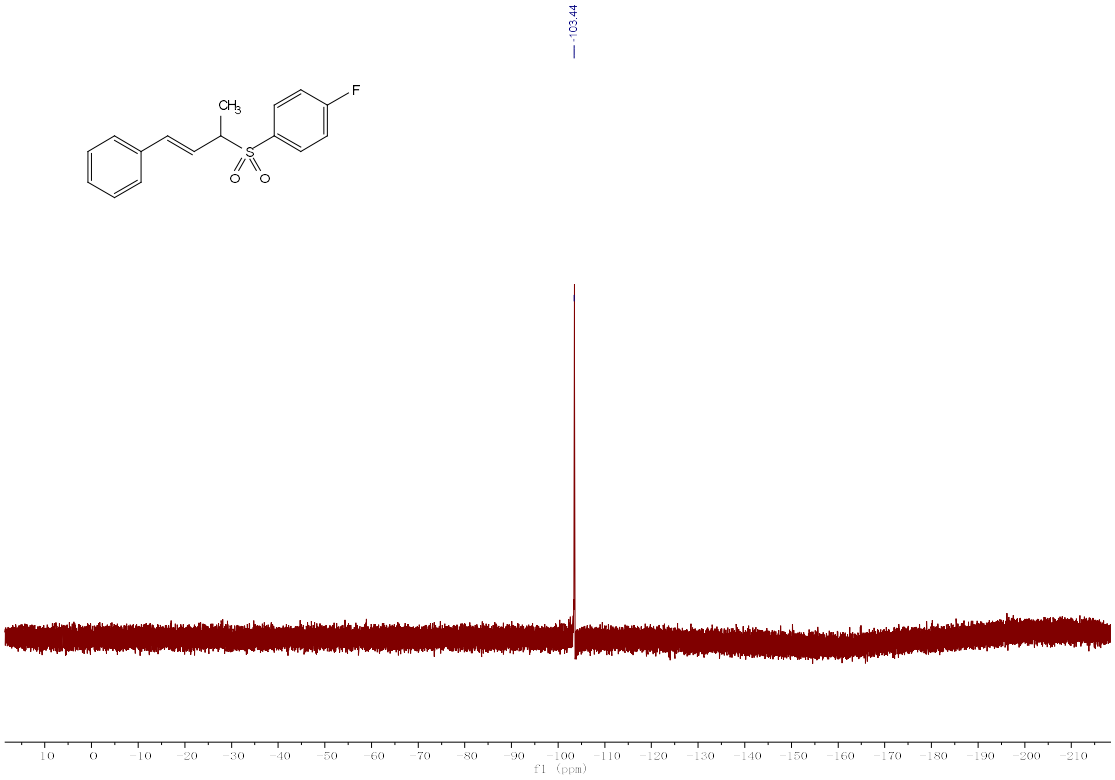


The product (42.4 mg, 73% yield) as white solid was purified with silica gel chromatography (petroleum ether/ethyl acetate = 10/1). **^{1}H NMR (400 MHz, $CDCl_3$)** δ 7.77 (dd, *J* = 8.4 Hz, 5.2 Hz, 2H), 7.26-7.18 (m, 5H), 7.10 (t, *J* = 8.4 Hz, 2H), 6.24 (d, *J* = 16.0 Hz, 1H), 5.99 (dd, *J* = 16.0 Hz, 8.4 Hz, 1H), 3.81-3.74 (m, 1H), 1.48 (d, *J* = 6.8 Hz, 3H); **^{19}F NMR (376 MHz, $CDCl_3$)** δ -103.44 (s, 1F); **^{13}C NMR (101 MHz, $CDCl_3$)** δ 165.9 (d, *J* = 257.6 Hz), 136.7, 135.7, 133.0 (d, *J* = 4.0 Hz), 132.2 (d, *J* = 10.1 Hz), 128.7, 128.5, 126.6, 121.9, 116.2 (d, *J* = 22.2 Hz), 64.3, 13.5; **HRMS** Calculated for $C_{16}H_{15}FO_2S$ ($M+Na^+$): 313.0669; Found: 313.0666.

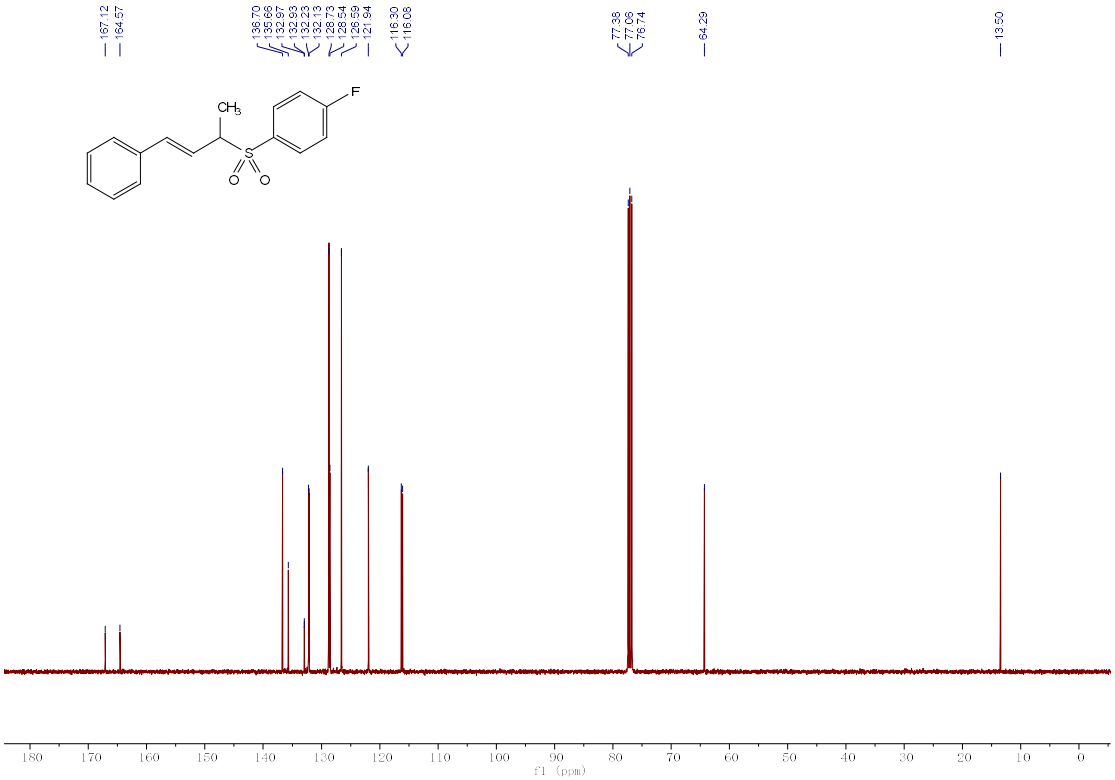
^{1}H NMR spectrum (400 MHz, $CDCl_3$) of compound **13**



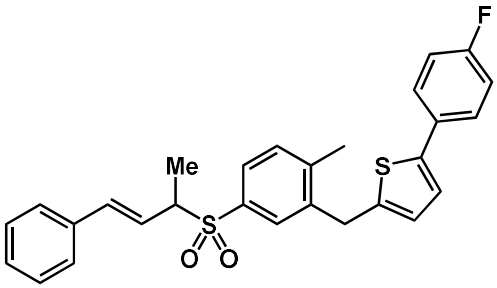
^{19}F NMR spectrum (376 MHz, $CDCl_3$) of compound **13**



^{13}C NMR spectrum (101 MHz, $CDCl_3$) of compound **13**

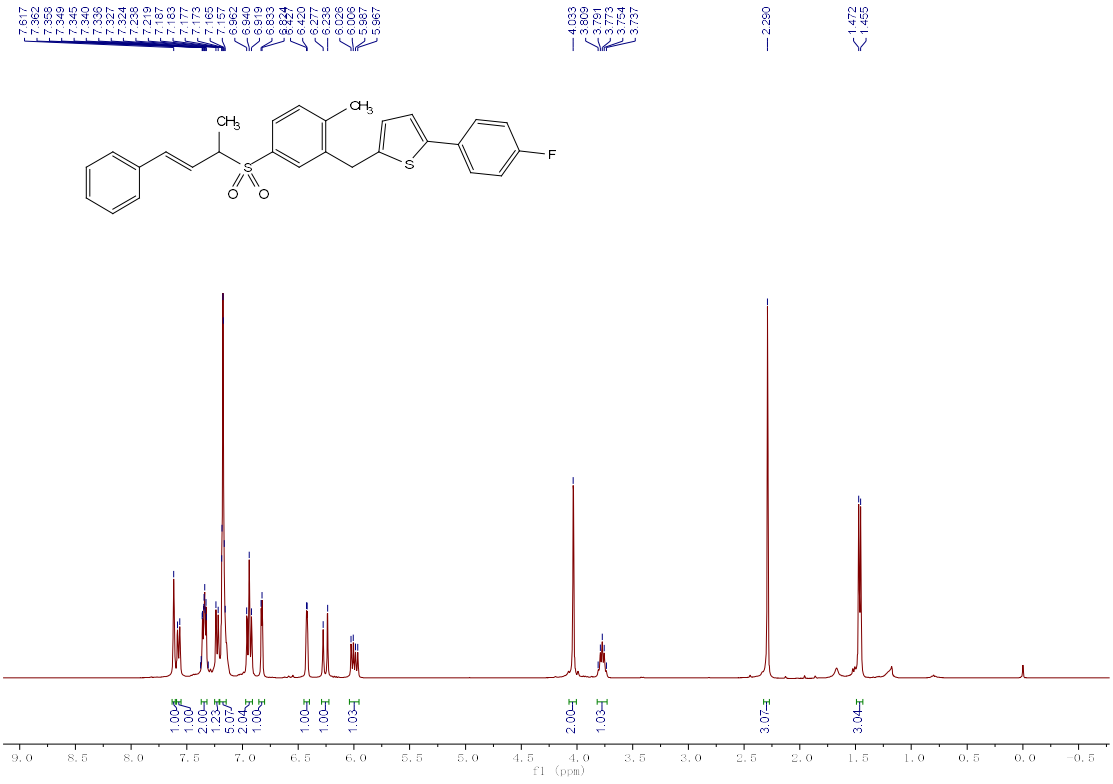


(*E*)-2-(4-fluorophenyl)-5-(2-methyl-5-((4-phenylbut-3-en-2-yl)sulfonyl)benzyl)thiophene (14).

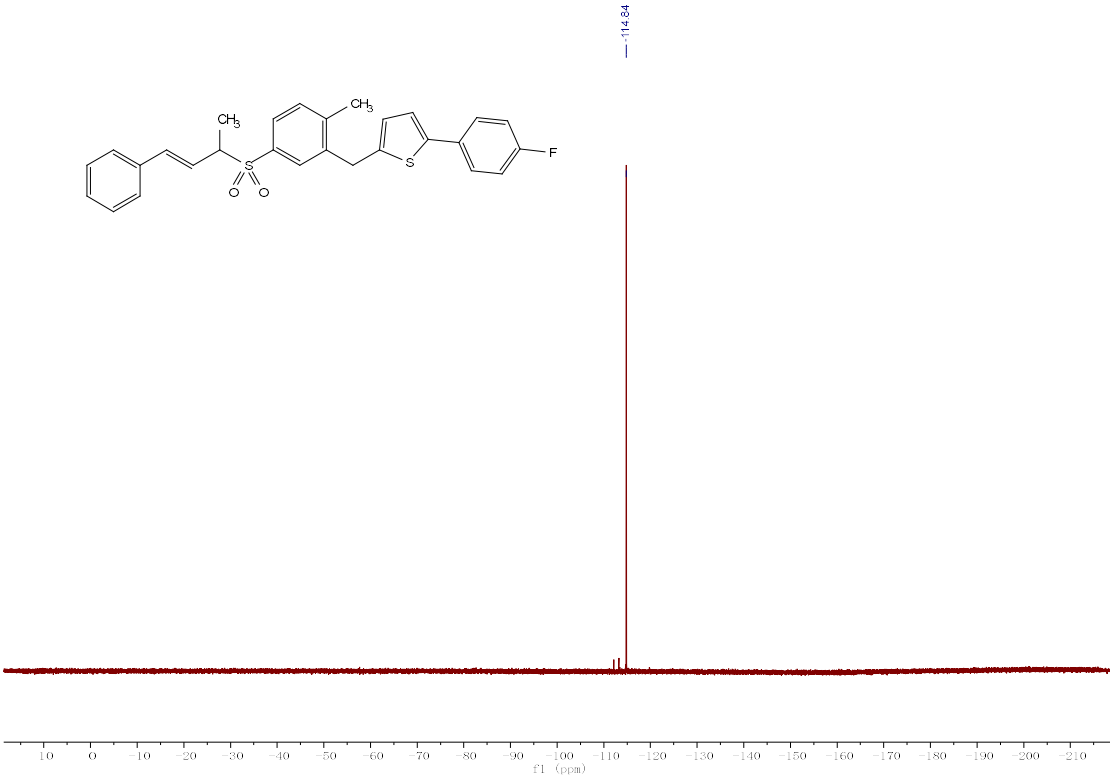


The product (63.9 mg, 67% yield) as light yellow solid was purified with silica gel chromatography (petroleum ether/ethyl acetate = 5/1). **^{1}H NMR (400 MHz, $CDCl_3$)** δ 7.62 (s, 1H), 7.57 (d, *J* = 7.6 Hz, 1H), 7.38 – 7.31 (m, 2H), 7.23 (d, *J* = 7.6 Hz, 1H), 7.19 – 7.16 (m, 5H), 6.94 (t, *J* = 8.4 Hz, 2H), 6.83 (d, *J* = 3.6 Hz, 1H), 6.42 (d, *J* = 2.8 Hz, 1H), 6.26 (d, *J* = 15.6 Hz, 1H), 6.00 (dd, *J* = 15.6, 8.0 Hz, 1H), 4.03 (s, 2H), 3.81 – 3.74 (m, 1H), 2.29 (s, 3H), 1.46 (d, *J* = 6.8 Hz, 3H); **^{19}F NMR (376 MHz, $CDCl_3$)** δ -114.84 (s, 1F); **^{13}C NMR (101 MHz, $CDCl_3$)** δ 162.1 (d, *J* = 247.5 Hz), 143.3, 141.9, 141.4, 139.2, 136.3, 135.9, 134.7, 131.0, 130.6 (d, *J* = 3.0 Hz), 130.1, 128.6, 128.3, 127.8, 127.2 (d, *J* = 8.1 Hz), 126.6, 126.3, 122.8, 122.3, 115.8 (d, *J* = 22.2 Hz), 64.2, 33.9, 19.8, 13.6; **HRMS** Calculated for $C_{28}H_{25}FO_2S_2$ ($M+Na^+$): 499.1172; Found: 499.1173.

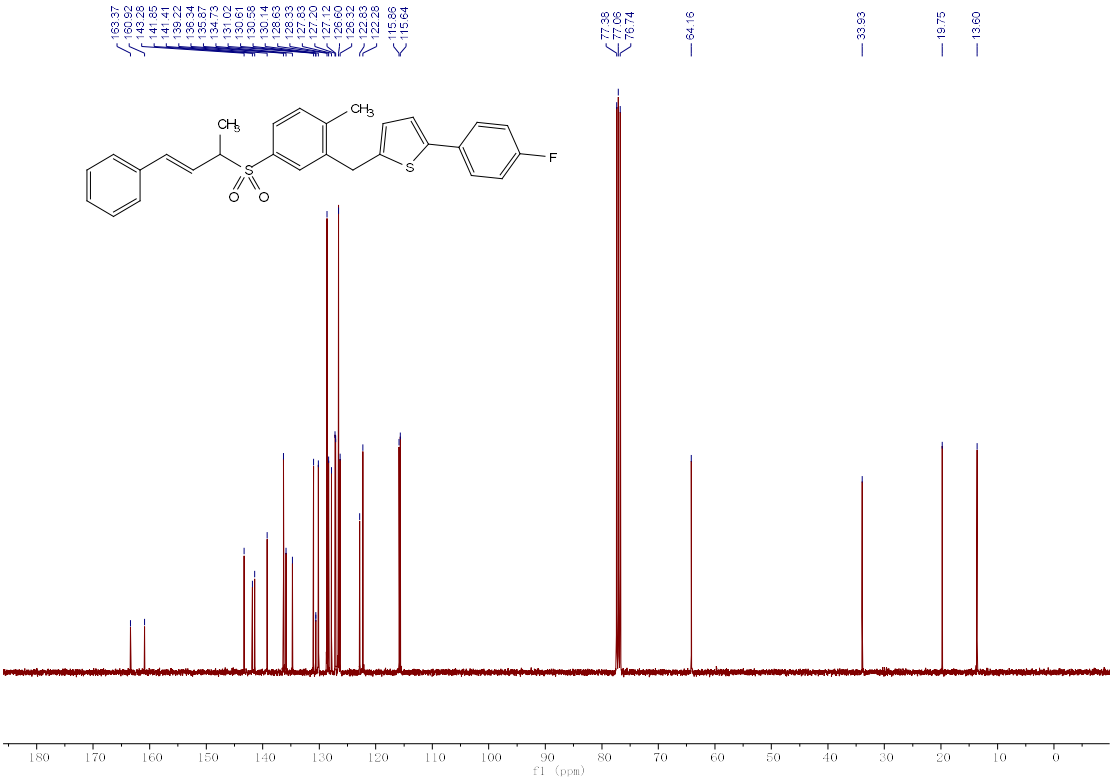
^{1}H NMR spectrum (400 MHz, $CDCl_3$) of compound **14**



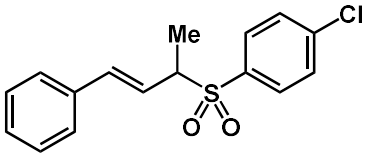
^{19}F NMR spectrum (376 MHz, $CDCl_3$) of compound **14**



^{13}C NMR spectrum (101 MHz, $CDCl_3$) of compound **14**

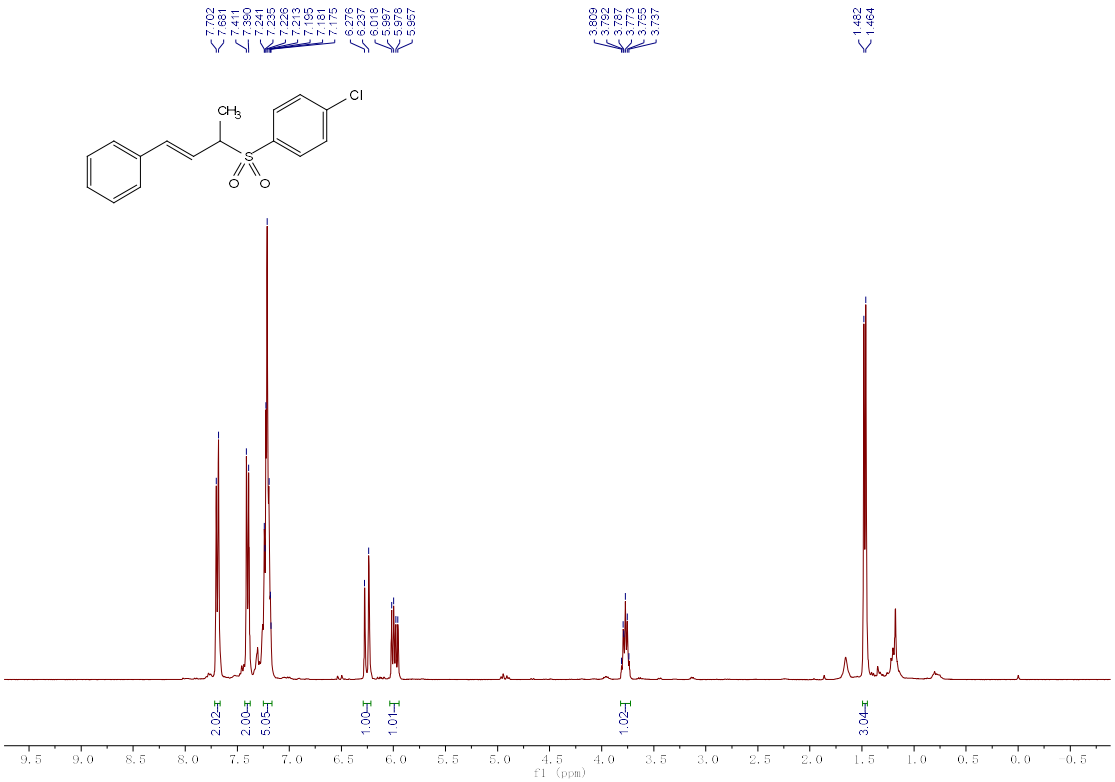


(*E*)-1-chloro-4-((4-phenylbut-3-en-2-yl)sulfonyl)benzene (15).

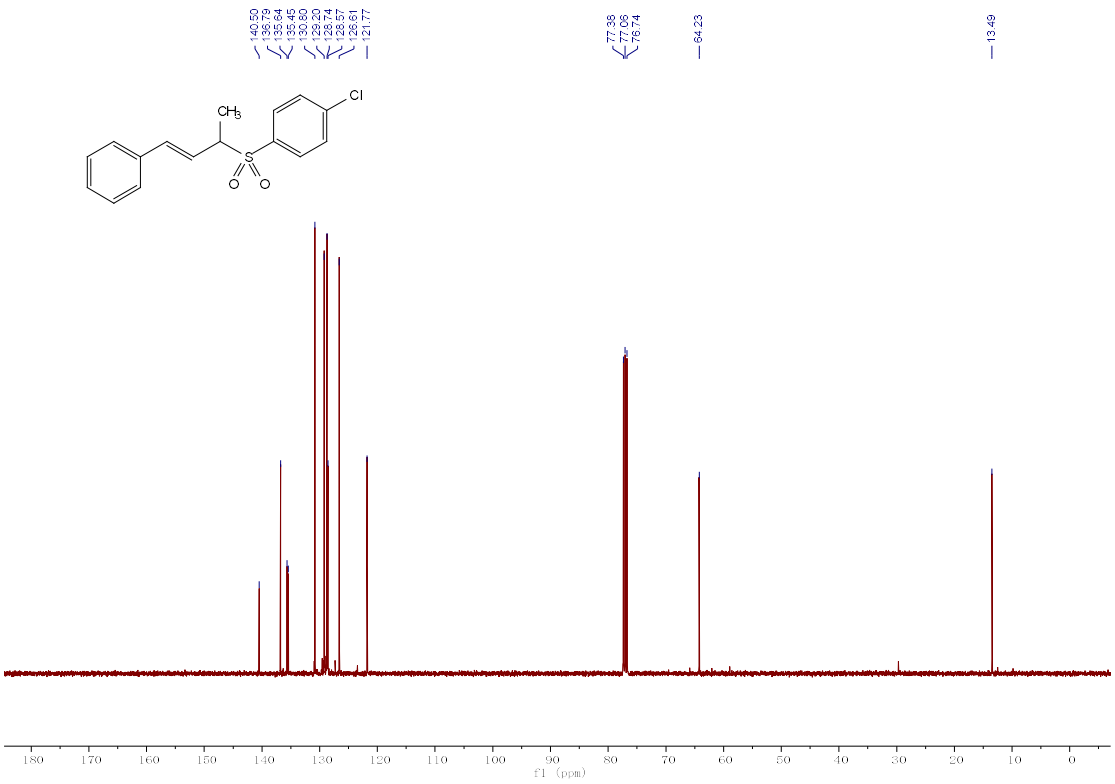


The product (44.2 mg, 72% yield) as yellow oil was purified with silica gel chromatography (petroleum ether/ethyl acetate = 10/1). **^{1}H NMR (400 MHz, $CDCl_3$)** δ 7.69 (d, *J* = 8.4 Hz, 2H), 7.40 (d, *J* = 8.4 Hz, 2H), 7.24 – 7.18 (m, 5H), 6.26 (d, *J* = 15.6 Hz, 1H), 5.99 (dd, *J* = 16.0, 8.4 Hz, 1H), 3.81 – 3.74 (m, 1H), 1.47 (d, *J* = 7.2 Hz, 3H); **^{13}C NMR (101 MHz, $CDCl_3$)** δ 140.5, 136.8, 135.6, 135.5, 130.8, 129.2, 128.7, 128.6, 126.6, 121.8, 64.2, 13.5; **HRMS** Calculated for $C_{16}H_{15}ClO_2S$ ($M+Na^+$): 329.0373; Found: 329.0374.

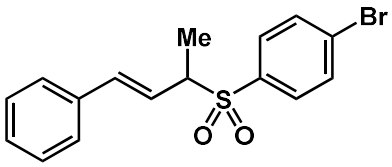
^{1}H NMR spectrum (400 MHz, $CDCl_3$) of compound **15**



^{13}C NMR spectrum (101 MHz, $CDCl_3$) of compound **15**

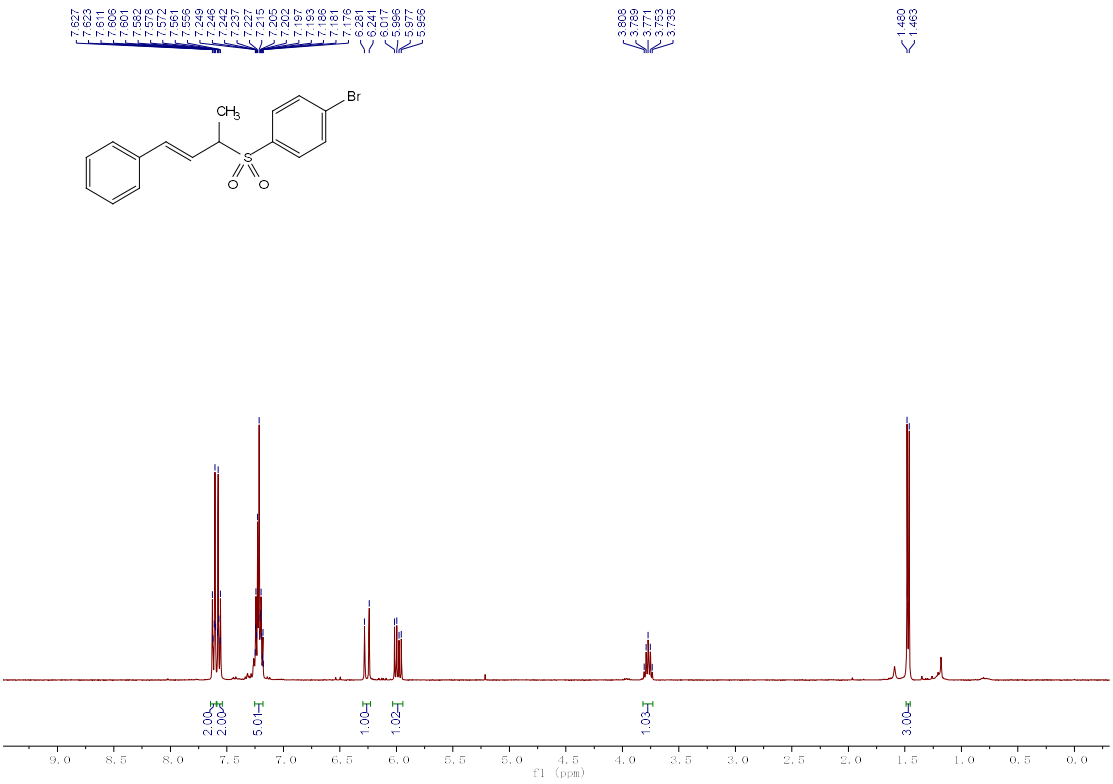


(*E*)-1-bromo-4-((4-phenylbut-3-en-2-yl)sulfonyl)benzene (16).

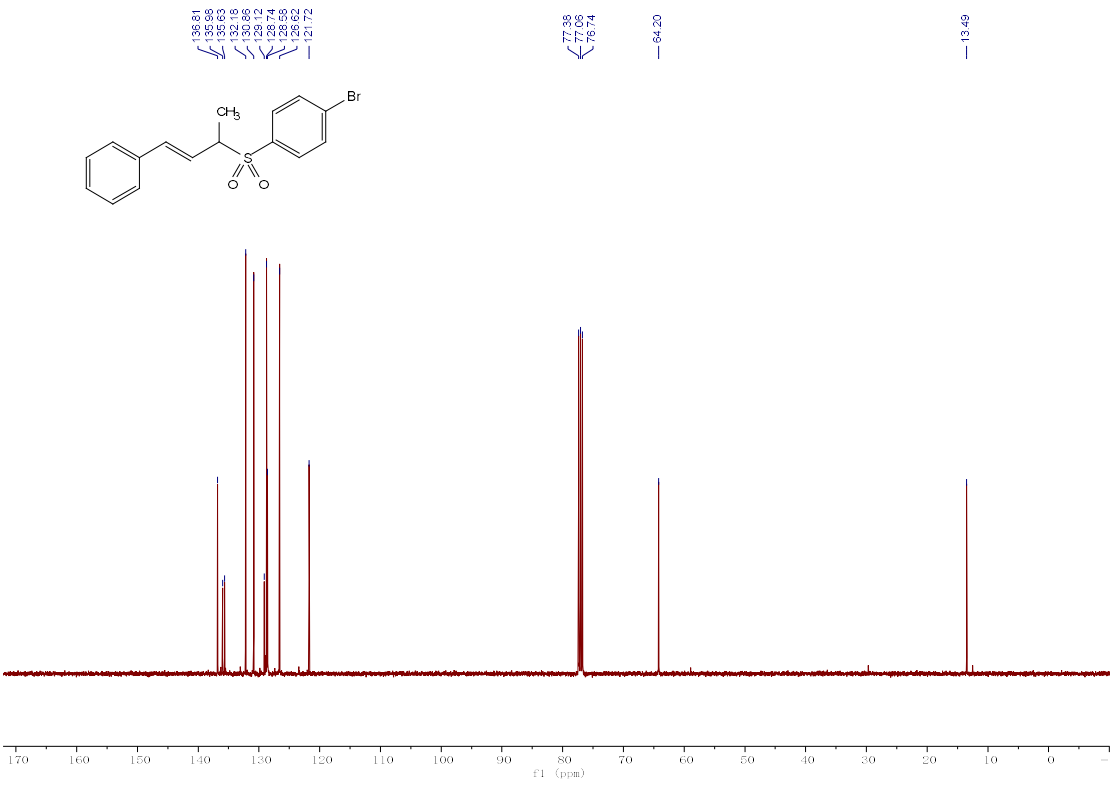


The product (45.7 mg, 65% yield) as light yellow solid was purified with silica gel chromatography (petroleum ether/ethyl acetate = 10/1). **^{1}H NMR (400 MHz, $CDCl_3$)** δ 7.63-7.60 (m, 2H), 7.58-7.56 (m, 2H), 7.25-7.18 (m, 5H), 6.26 (d, *J* = 16.0 Hz, 1H), 5.99 (dd, *J* = 16.0 Hz, 8.4 Hz, 1H), 3.81-3.74 (m, 1H), 1.47 (d, *J* = 6.8 Hz, 3H); **^{13}C NMR (101 MHz, $CDCl_3$)** δ 136.8, 136.0, 135.6, 132.2, 130.9, 129.1, 128.7, 128.6, 126.6, 121.7, 64.2, 13.5; **HRMS** Calculated for $C_{16}H_{15}BrO_2S$ ($M+Na^+$): 372.9868; Found: 372.9870.

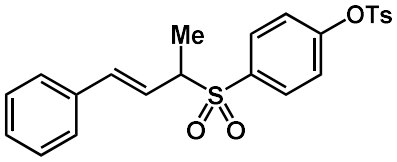
^{1}H NMR spectrum (400 MHz, $CDCl_3$) of compound **16**



^{13}C NMR spectrum (101 MHz, $CDCl_3$) of compound **16**

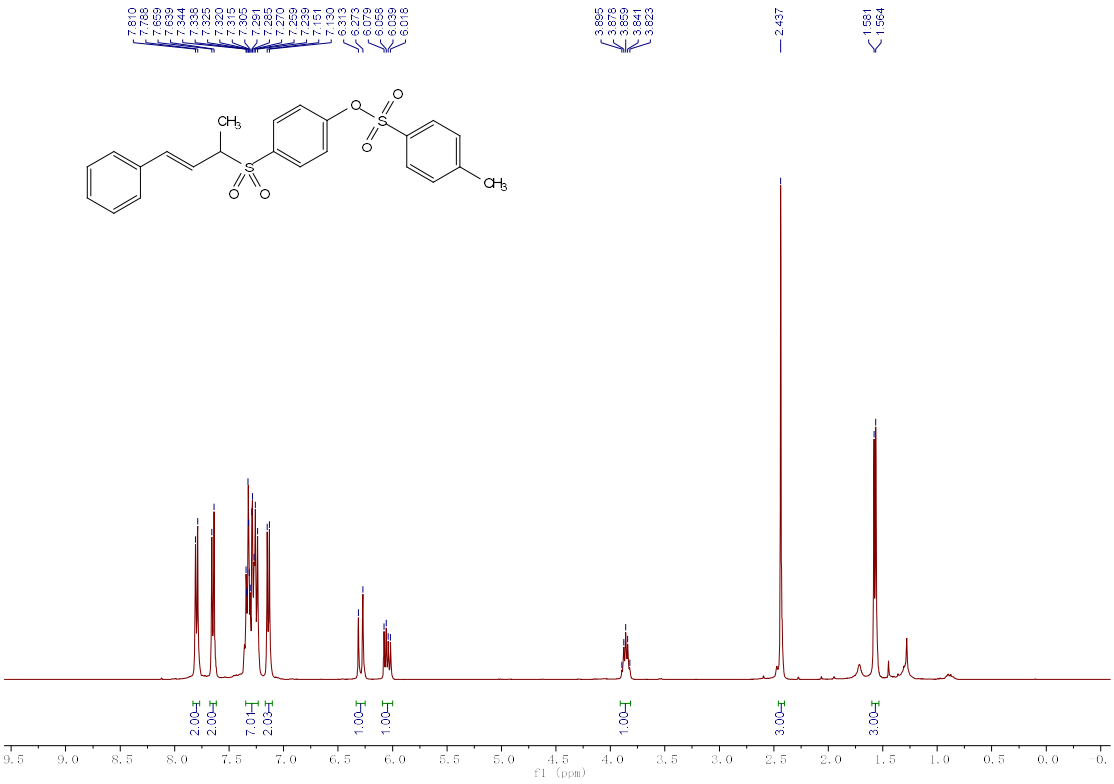


(*E*)-4-((4-phenylbut-3-en-2-yl)sulfonyl)phenyl 4-methylbenzenesulfonate (17).

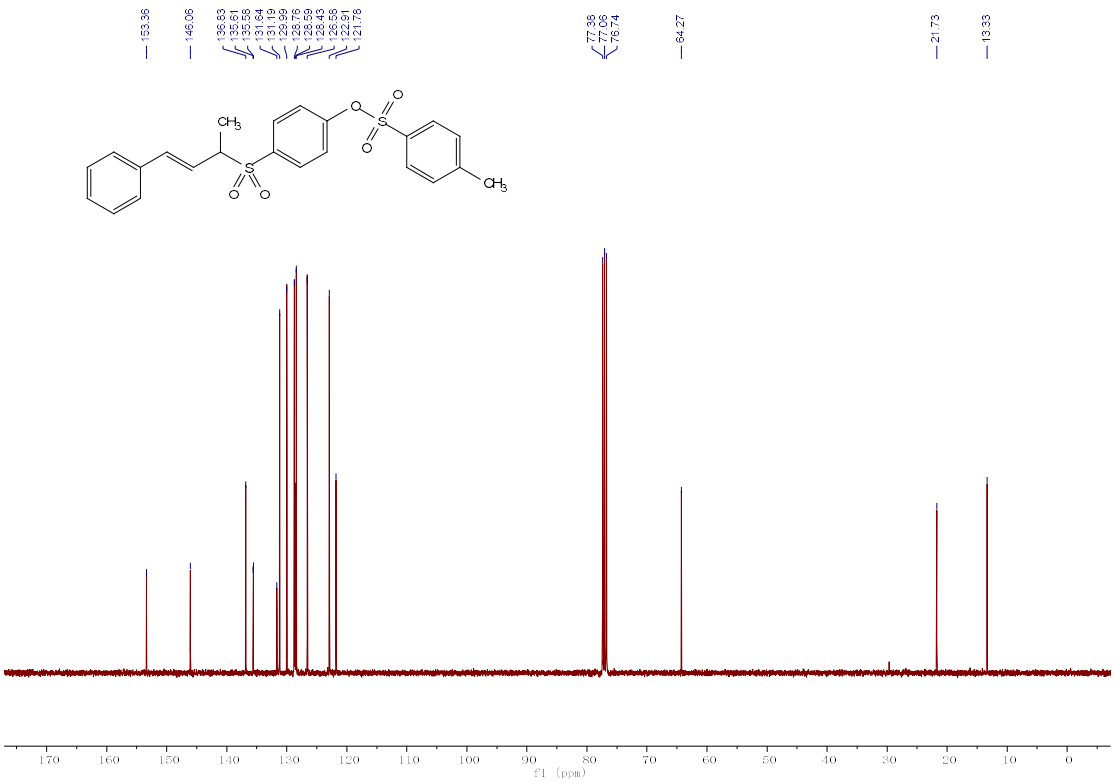


The product (56.6 mg, 64% yield) as light yellow solid was purified with silica gel chromatography (petroleum ether/ethyl acetate = 5/1). **^{1}H NMR (400 MHz, $CDCl_3$)** δ 7.80 (d, *J* = 8.8 Hz, 2H), 7.65 (d, *J* = 8.0 Hz, 2H), 7.34-7.24 (m, 7H), 7.14 (d, *J* = 8.4 Hz, 2H), 6.29 (d, *J* = 16.0 Hz, 1H), 6.05 (dd, *J* = 16.0 Hz, 8.4 Hz, 1H), 3.90-3.82 (m, 1H), 2.44 (s, 3H), 1.57 (d, *J* = 6.8 Hz, 3H); **^{13}C NMR (101 MHz, $CDCl_3$)** δ 153.4, 146.1, 136.8, 135.61, 135.58, 131.6, 131.2, 130.0, 128.8, 128.6, 128.4, 126.6, 122.9, 121.8, 64.3, 21.7, 13.3; **HRMS** Calculated for $C_{23}H_{22}O_5S_2$ ($M+Na^+$): 465.0801; Found: 465.0802.

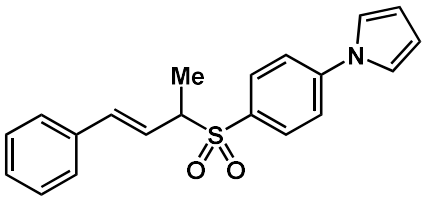
^{1}H NMR spectrum (400 MHz, $CDCl_3$) of compound **17**



^{13}C NMR spectrum (101 MHz, $CDCl_3$) of compound **17**

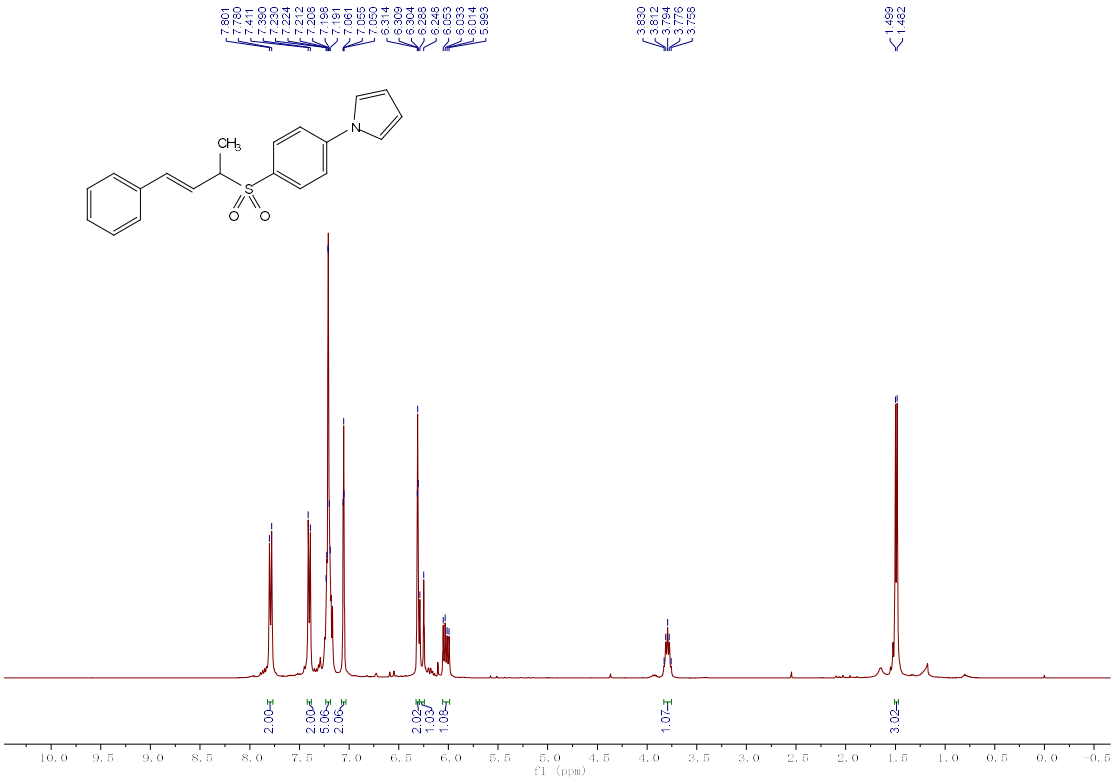


(*E*)-1-(4-((4-phenylbut-3-en-2-yl)sulfonyl)phenyl)-1*H*-pyrrole (18).

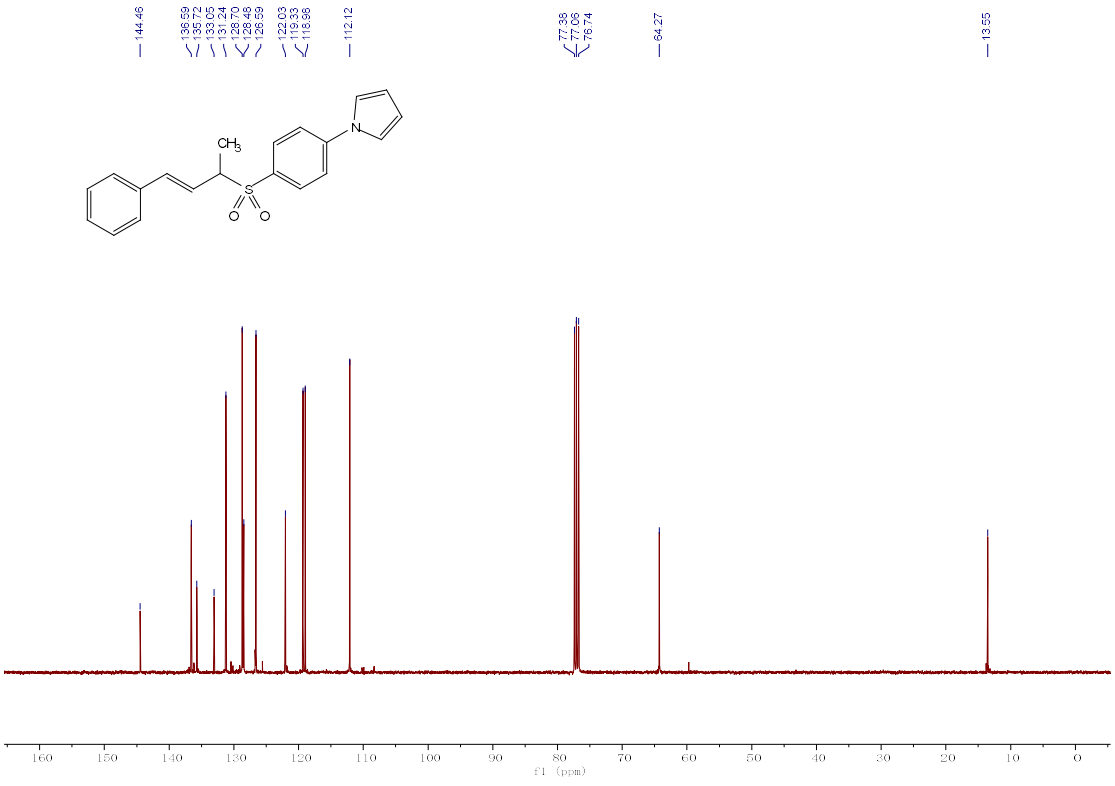


The product (58.0 mg, 86% yield) as white solid was purified with silica gel chromatography (petroleum ether/ethyl acetate = 5/1). **^{1}H NMR (400 MHz, $CDCl_3$)** δ 7.79 (d, *J* = 8.4 Hz, 2H), 7.40 (d, *J* = 8.4 Hz, 2H), 7.23-7.19 (m, 5H), 7.06-7.05 (m, 2H), 6.31-6.30 (m, 2H), 6.27 (d, *J* = 16.0 Hz, 1H), 6.02 (dd, *J* = 15.6 Hz, 8.0 Hz, 1H), 3.83-3.76 (m, 1H), 1.49 (d, *J* = 6.8 Hz, 3H); **^{13}C NMR (101 MHz, $CDCl_3$)** δ 144.5, 136.6, 135.7, 133.1, 131.2, 128.7, 128.5, 126.6, 122.0, 119.3, 119.0, 112.1, 64.3, 13.6; **HRMS** Calculated for $C_{20}H_{19}NO_2S$ ($M+H^+$): 338.1209; Found: 338.1209.

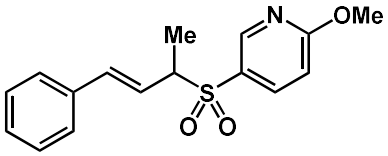
^{1}H NMR spectrum (400 MHz, $CDCl_3$) of compound **18**



^{13}C NMR spectrum (101 MHz, $CDCl_3$) of compound **18**

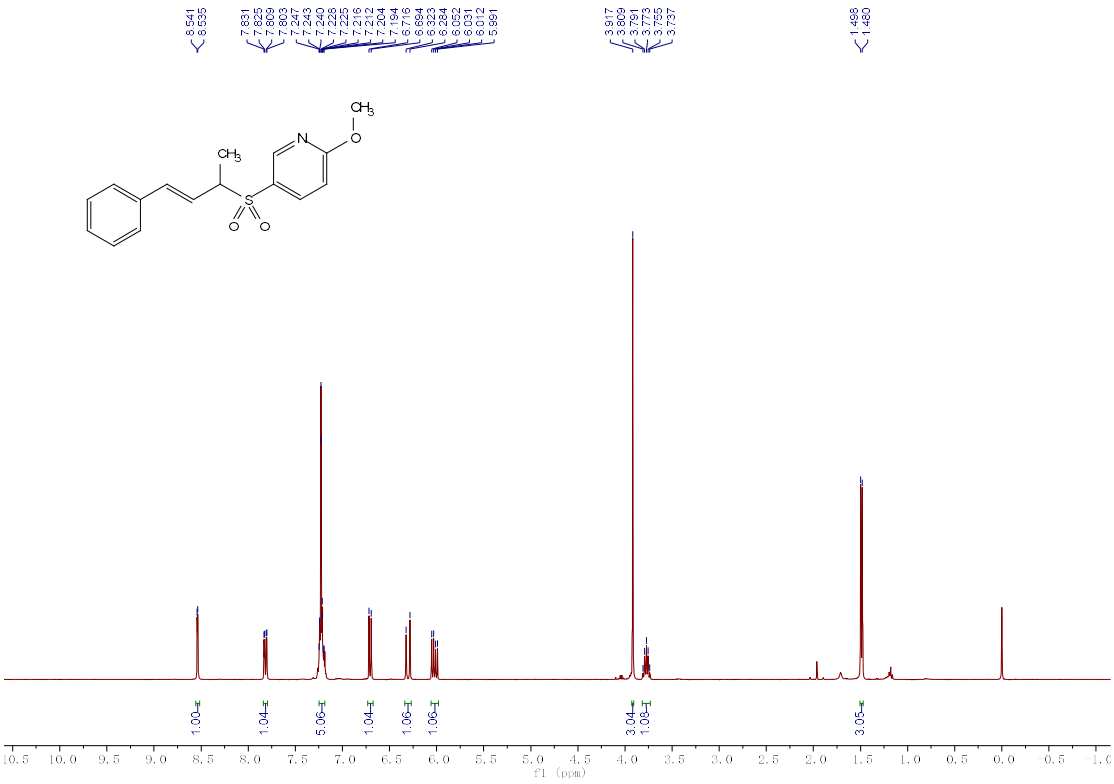


(*E*)-2-methoxy-5-((4-phenylbut-3-en-2-yl)sulfonyl)pyridine (19).

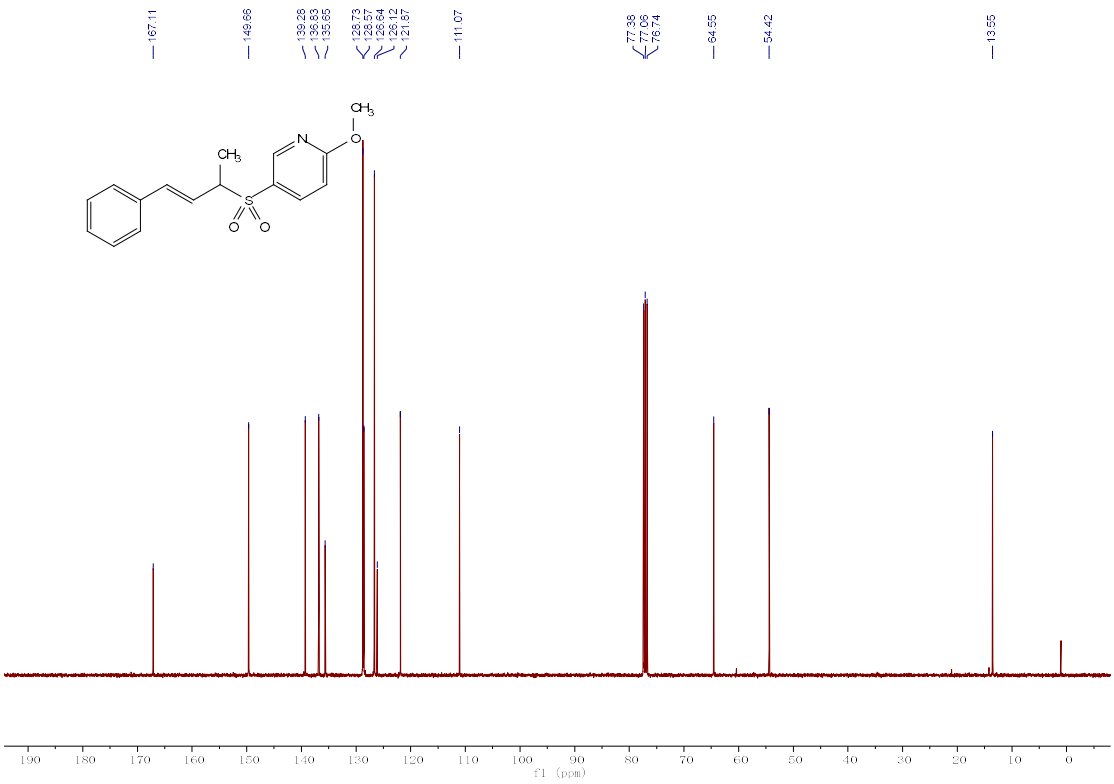


The product (51.0 mg, 84% yield) as white solid was purified with silica gel chromatography (petroleum ether/ethyl acetate = 5/1). **^{1}H NMR (400 MHz, Chloroform-*d*)** δ 8.54 (d, *J* = 2.4 Hz, 1H), 7.82 (dd, *J* = 8.8 Hz, 2.4 Hz, 1H), 7.25-7.19 (m, 5H), 6.71 (d, *J* = 8.8 Hz, 1H), 6.30 (d, *J* = 15.6 Hz, 1H), 6.02 (dd, *J* = 16.0 Hz, 8.4 Hz, 1H), 3.92 (s, 3H), 3.81-3.74 (m, 1H), 1.49 (d, *J* = 7.2 Hz, 3H); **^{13}C NMR (101 MHz, $CDCl_3$)** δ 167.1, 149.7, 139.3, 136.8, 135.7, 128.7, 128.6, 126.6, 126.1, 121.9, 111.1, 64.6, 54.4, 13.6; **HRMS** Calculated for $C_{16}H_{17}NO_3S$ ($M+H^+$): 304.1002; Found: 304.1000.

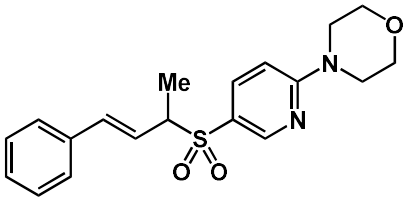
^{1}H NMR spectrum (400 MHz, $CDCl_3$) of compound **19**



^{13}C NMR spectrum (101 MHz, $CDCl_3$) of compound **19**

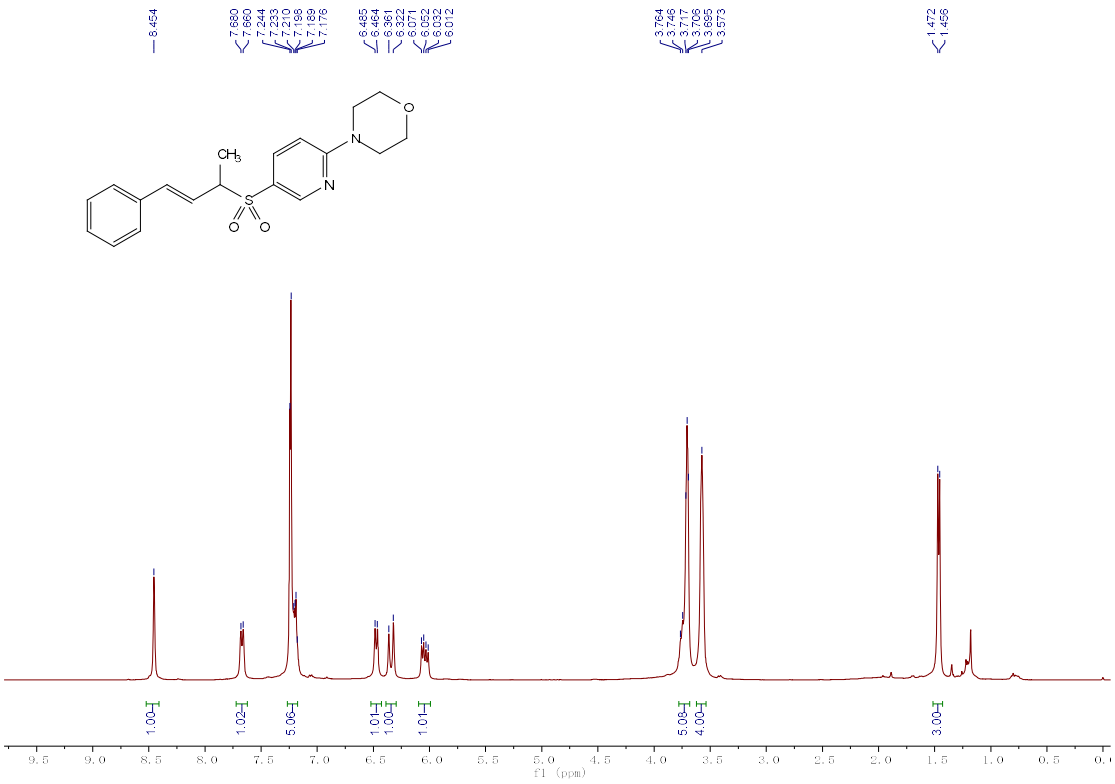


(*E*)-4-(5-((4-phenylbut-3-en-2-yl)sulfonyl)pyridin-2-yl)morpholine (20).

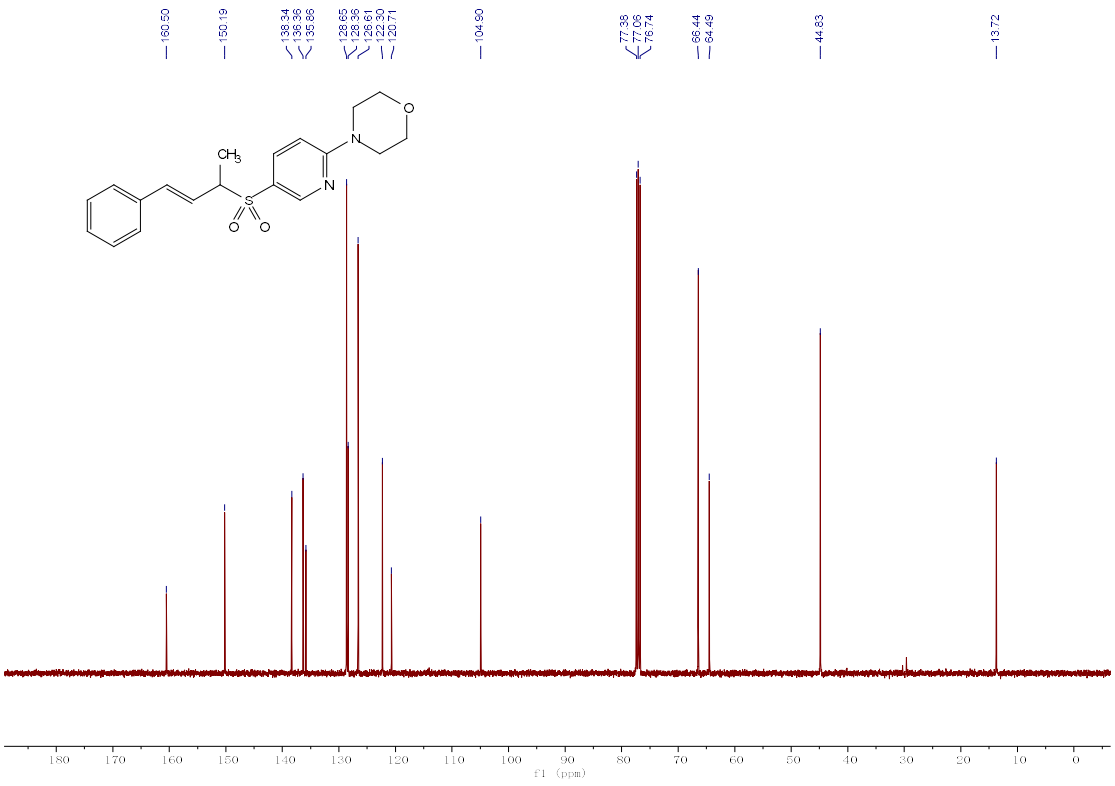


The product (66.0 mg, 92% yield) as yellow solid was purified with silica gel chromatography (petroleum ether/ethyl acetate = 3/1). **^{1}H NMR (400 MHz, $CDCl_3$)** δ 8.45 (s, 1H), 7.67 (d, *J* = 8.0 Hz, 1H), 7.24-7.18 (m, 5H), 6.47 (d, *J* = 8.4 Hz, 1H), 6.34 (d, *J* = 15.6 Hz, 1H), 6.04 (dd, *J* = 15.6 Hz, 7.6 Hz, 1H), 3.76-3.70 (m, 5H), 3.57 (s, 4H), 1.46 (d, *J* = 6.4 Hz, 3H); **^{13}C NMR (101 MHz, $CDCl_3$)** δ 160.5, 150.2, 138.3, 136.4, 135.9, 128.7, 128.4, 126.6, 122.3, 120.7, 104.9, 66.4, 64.5, 44.8, 13.7; **HRMS** Calculated for $C_{19}H_{22}N_2O_3S$ (M+ H^+): 359.1424; Found: 359.1425.

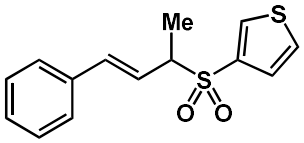
^{1}H NMR spectrum (400 MHz, $CDCl_3$) of compound **20**



^{13}C NMR spectrum (101 MHz, $CDCl_3$) of compound **20**

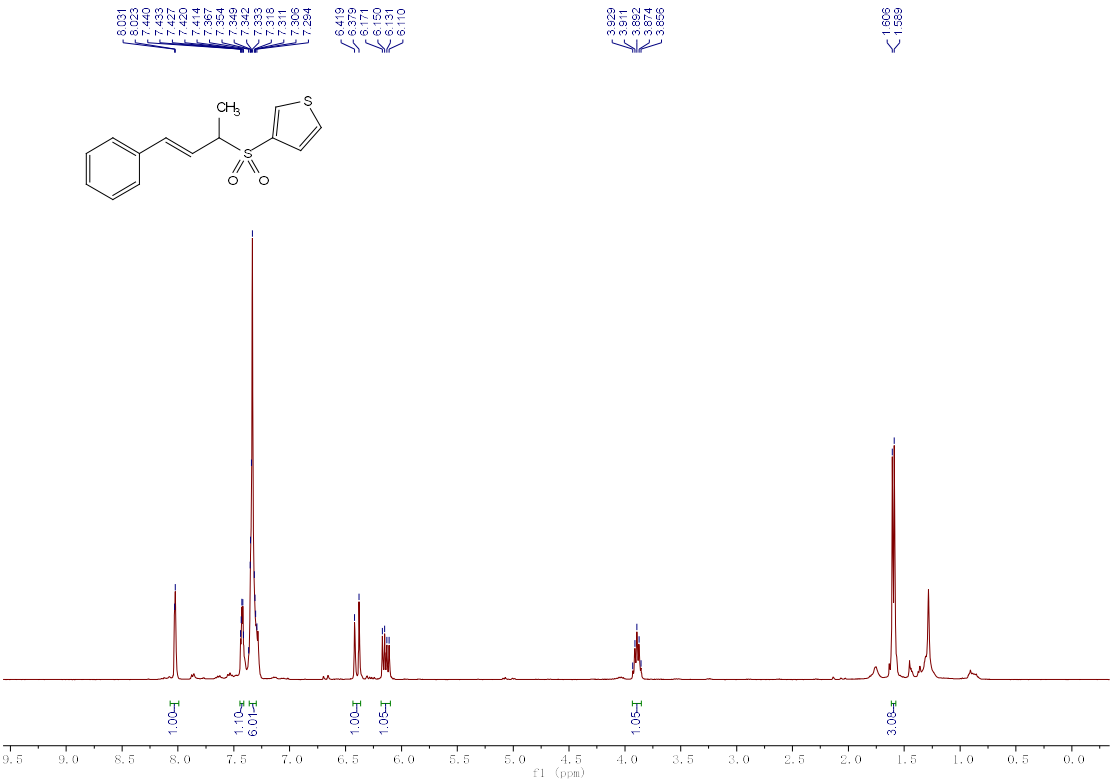


(*E*)-3-((4-phenylbut-3-en-2-yl)sulfonyl)thiophene (21).

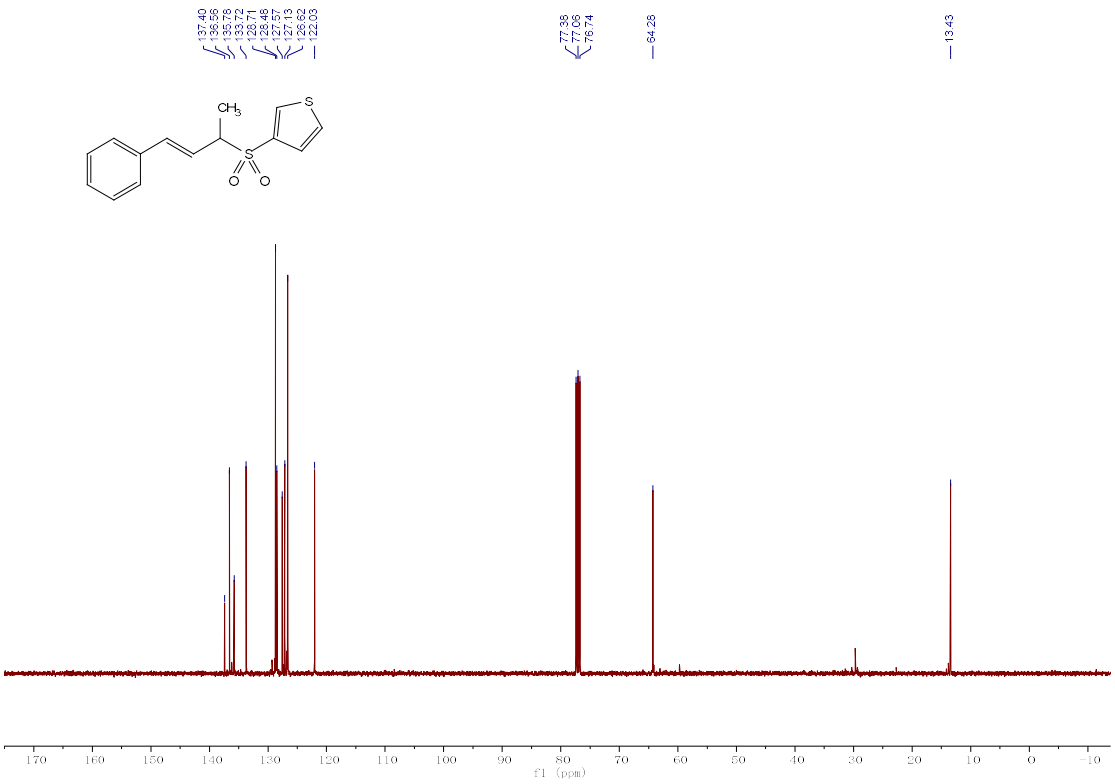


The product (34.0 mg, 61% yield) as yellow oil was purified with silica gel chromatography (petroleum ether/ethyl acetate = 5/1). **^{1}H NMR (400 MHz, $CDCl_3$)** δ 8.03-8.02 (m, 1H), 7.44-7.41 (m, 1H), 7.37-7.29 (m, 6H), 6.40 (d, *J* = 16.0 Hz, 1H), 6.14 (dd, *J* = 16.0 Hz, 8.4 Hz, 1H), 3.93-3.86 (m, 1H), 1.60 (d, *J* = 6.8 Hz, 3H); **^{13}C NMR (101 MHz, $CDCl_3$)** δ 137.4, 136.6, 135.8, 133.7, 128.7, 128.5, 127.6, 127.1, 126.6, 122.0, 64.3, 13.4; **HRMS** Calculated for $C_{14}H_{14}O_2S_2$ ($M+Na^+$): 301.0327; Found: 301.0334.

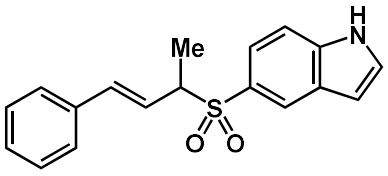
^{1}H NMR spectrum (400 MHz, $CDCl_3$) of compound **21**



^{13}C NMR spectrum (101 MHz, $CDCl_3$) of compound **21**

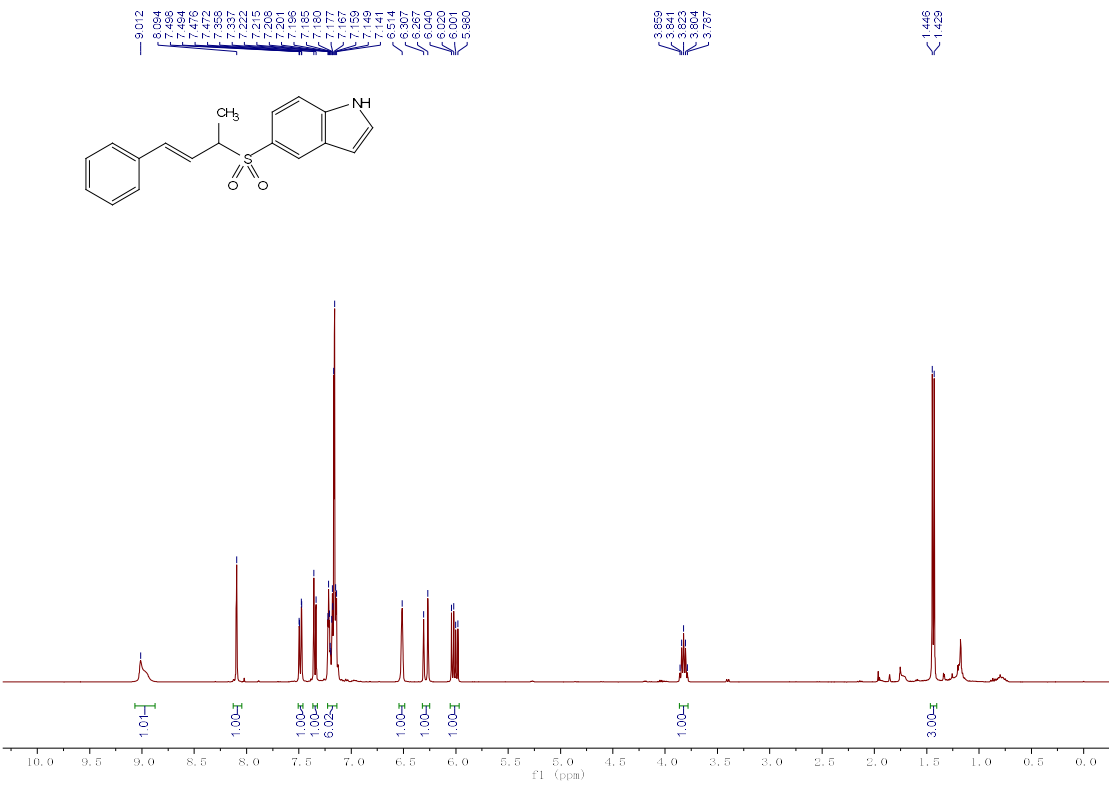


(*E*)-5-((4-phenylbut-3-en-2-yl)sulfonyl)-1*H*-indole (22).

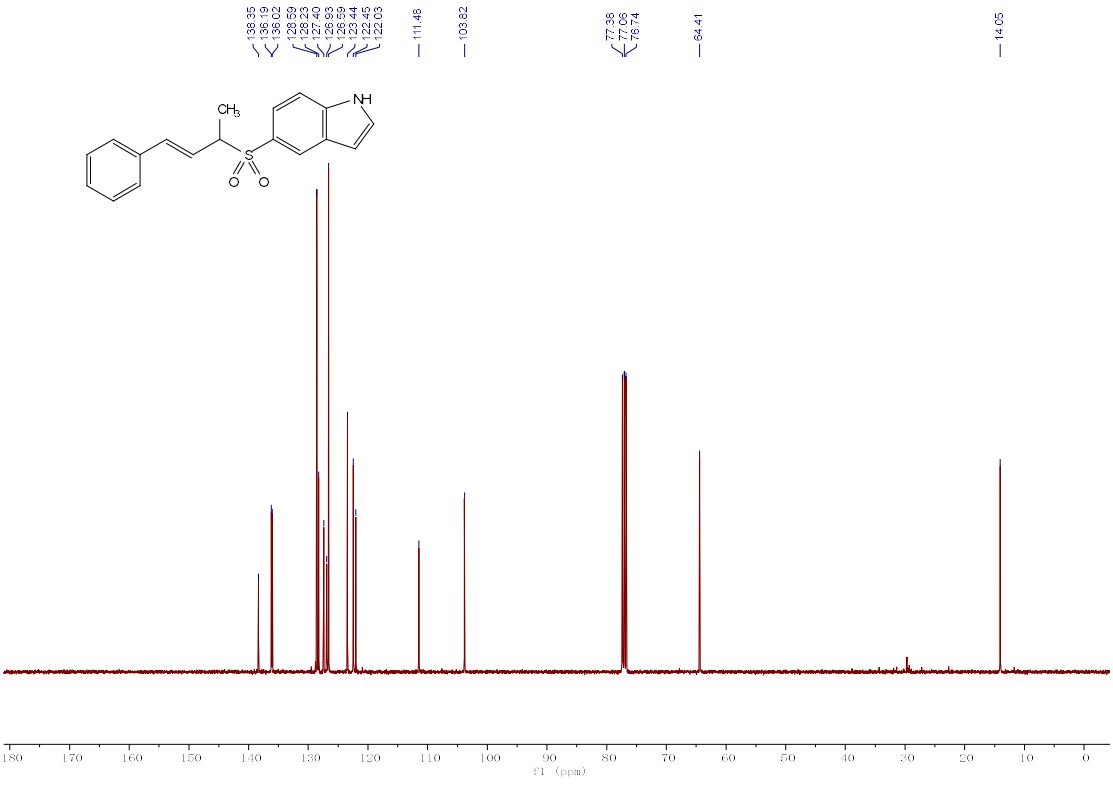


The product (52.9 mg, 85% yield) as white solid was purified with silica gel chromatography (petroleum ether/ethyl acetate = 2/1). **^{1}H NMR (400 MHz, $CDCl_3$)** δ 9.01 (s, 1H), 7.49 (dd, *J* = 8.8 Hz, 1.6 Hz, 1H), 7.35 (d, *J* = 8.4 Hz, 1H), 7.22-7.14 (m, 6H), 6.51 (s, 1H), 6.29 (d, *J* = 16.0 Hz, 1H), 6.01 (dd, *J* = 15.6 Hz, 8.0 Hz, 1H), 3.86-3.79 (m, 1H), 1.44 (d, *J* = 6.8 Hz, 3H); **^{13}C NMR (101 MHz, $CDCl_3$)** δ 138.4, 136.2, 136.0, 128.6, 128.2, 127.4, 126.9, 126.6, 123.4, 122.5, 122.0, 111.5, 103.8, 64.4, 14.1; **HRMS** Calculated for $C_{18}H_{17}NO_2S$ ($M+Na^+$): 334.0872; Found: 334.0872.

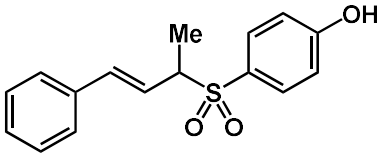
^{1}H NMR spectrum (400 MHz, $CDCl_3$) of compound **21**



^{13}C NMR spectrum (101 MHz, $CDCl_3$) of compound **21**

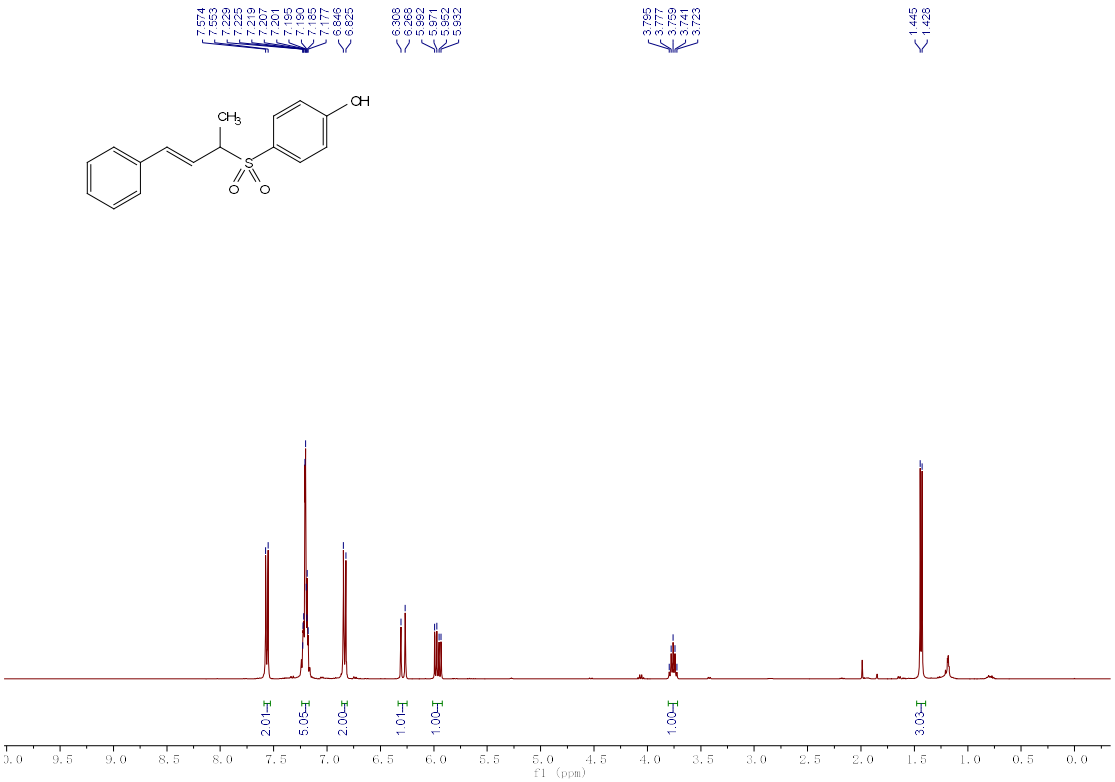


(*E*)-4-((4-phenylbut-3-en-2-yl)sulfonyl)phenol (23).

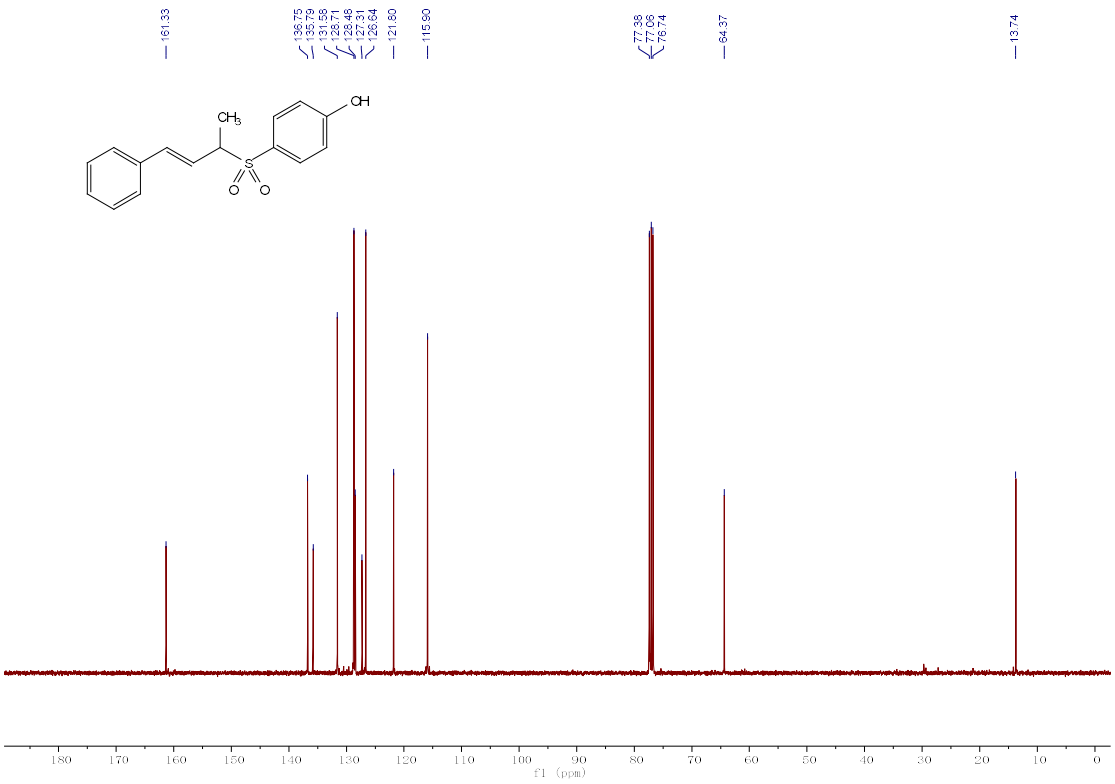


The product (51.9 mg, 90% yield) as white solid was purified with silica gel chromatography (petroleum ether/ethyl acetate = 2/1). **^{1}H NMR (400 MHz, $CDCl_3$)** δ 7.56 (d, *J* = 8.4 Hz, 2H), 7.23-7.18 (m, 5H), 6.84 (d, *J* = 8.4 Hz, 2H), 6.29 (d, *J* = 16.0 Hz, 1H), 5.96 (dd, *J* = 16.0 Hz, 8.4 Hz, 1H), 3.80-3.72 (m, 1H), 1.44 (d, *J* = 6.8 Hz, 3H); **^{13}C NMR (101 MHz, $CDCl_3$)** δ 161.3, 136.8, 135.8, 131.6, 128.7, 128.5, 127.3, 126.6, 121.8, 115.9, 64.4, 13.7; **HRMS** Calculated for $C_{16}H_{16}O_3S$ ($M+Na^+$): 311.0712; Found: 311.0711.

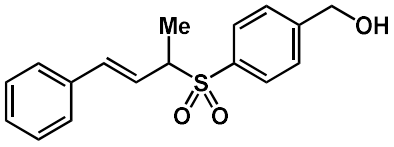
^{1}H NMR spectrum (400 MHz, $CDCl_3$) of compound **23**



^{13}C NMR spectrum (101 MHz, $CDCl_3$) of compound **23**

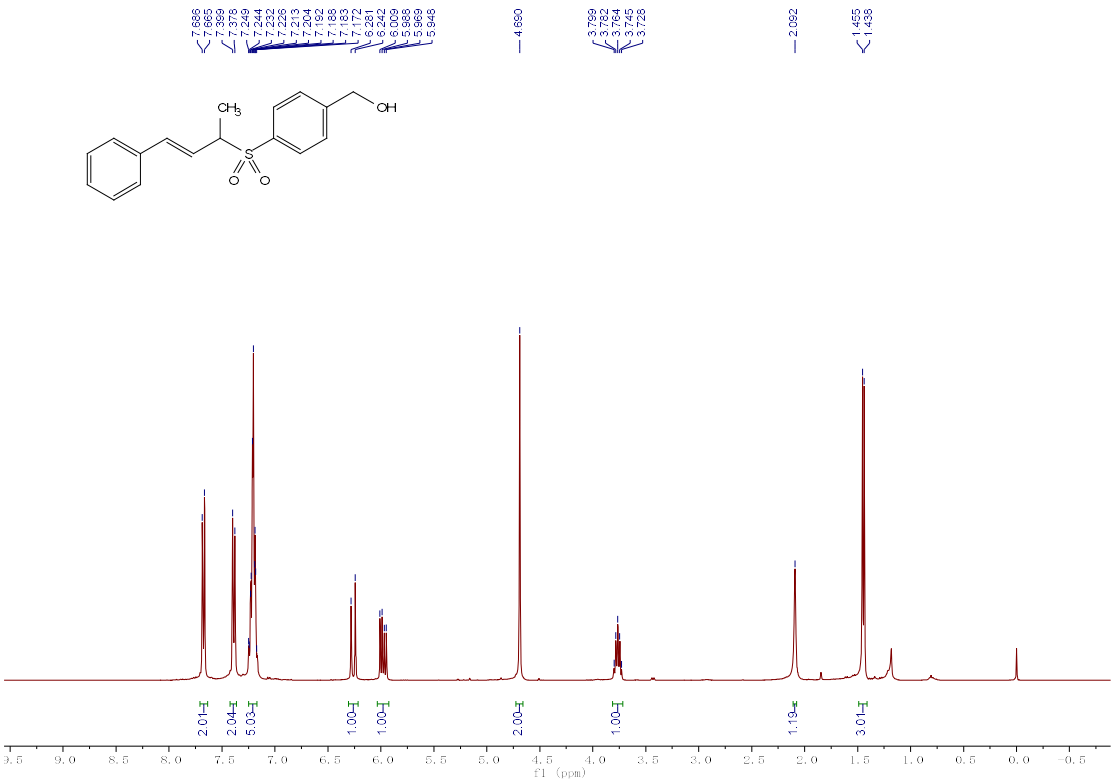


(*E*)-(4-((4-phenylbut-3-en-2-yl)sulfonyl)phenyl)methanol (24).

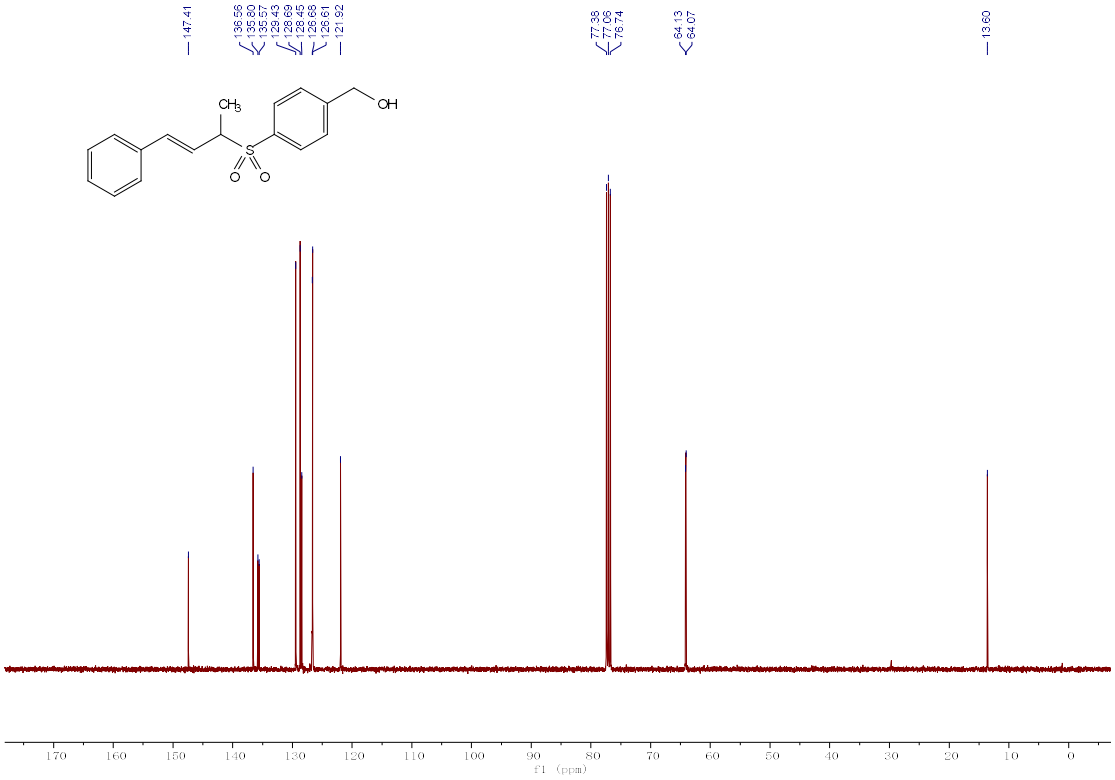


The product (44.2 mg, 73% yield) as white solid was purified with silica gel chromatography (petroleum ether/ethyl acetate = 2/1). **^{1}H NMR (400 MHz, $CDCl_3$)** δ 7.68 (d, *J* = 8.4 Hz, 2H), 7.39 (d, *J* = 8.4 Hz, 2H), 7.25-7.17 (m, 5H), 6.26 (d, *J* = 15.6 Hz, 1H), 5.98 (dd, *J* = 16.0 Hz, 8.4 Hz, 1H), 4.69 (s, 2H), 3.80-3.73 (m, 1H), 2.09 (s, 1H), 1.45 (d, *J* = 6.8 Hz, 3H); **^{13}C NMR (101 MHz, $CDCl_3$)** δ 147.4, 136.6, 135.8, 135.6, 129.4, 128.7, 128.5, 126.7, 126.6, 121.9, 64.1, 64.1, 13.6; **HRMS** Calculated for $C_{17}H_{18}O_3S$ ($M+Na^+$): 325.0869; Found: 325.0868.

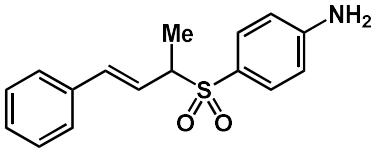
^{1}H NMR spectrum (400 MHz, $CDCl_3$) of compound **24**



^{13}C NMR spectrum (101 MHz, $CDCl_3$) of compound **24**

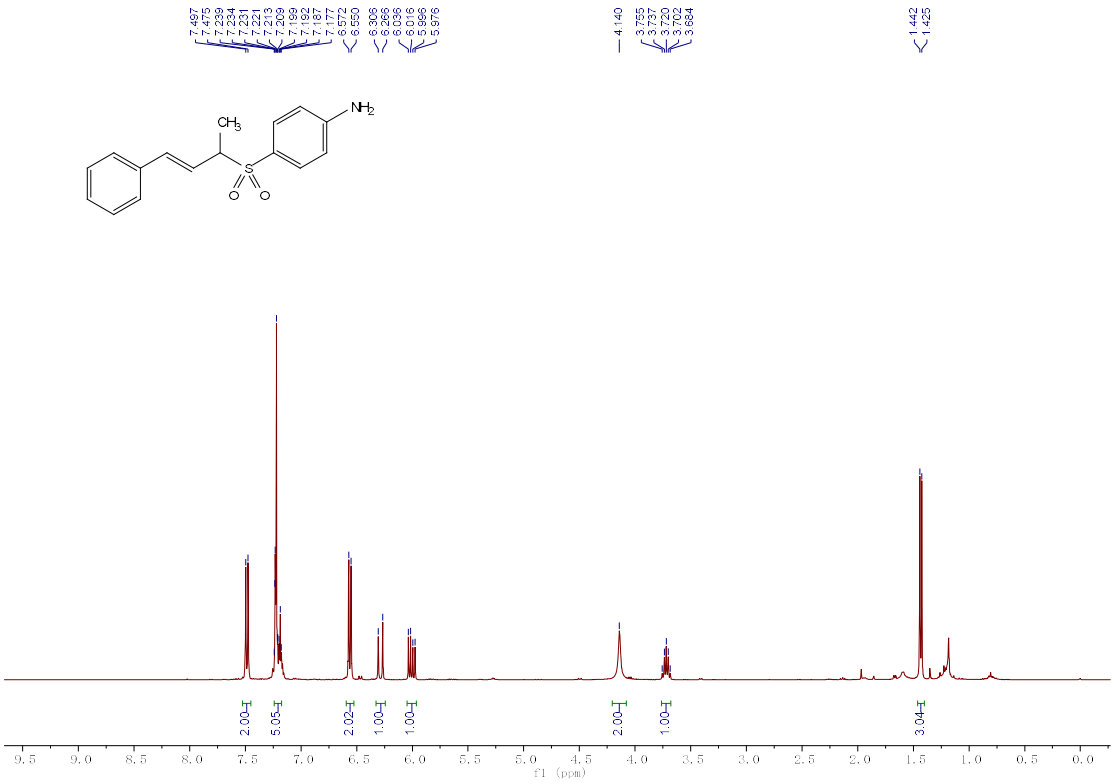


(*E*)-4-((4-phenylbut-3-en-2-yl)sulfonyl)aniline (25).

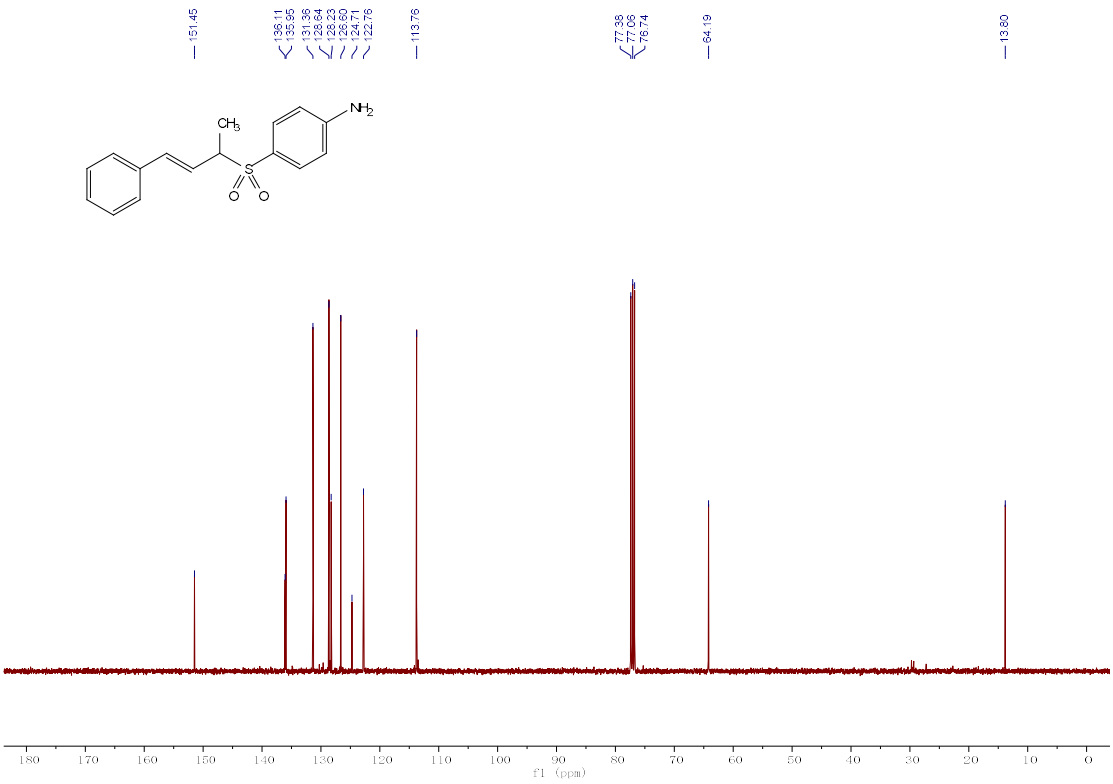


The product (35.1 mg, 61% yield) as white solid was purified with silica gel chromatography (petroleum ether/ethyl acetate = 2/1). **^{1}H NMR (400 MHz, $CDCl_3$)** δ 7.49 (d, *J* = 8.8 Hz, 2H), 7.24-7.18 (m, 5H), 6.56 (d, *J* = 8.8 Hz, 2H), 6.29 (d, *J* = 16.0 Hz, 1H), 6.01 (dd, *J* = 16.0 Hz, 8.0 Hz, 1H), 4.14 (s, 2H), 3.76-3.68 (m, 1H), 1.43 (d, *J* = 6.8 Hz, 3H); **^{13}C NMR (101 MHz, $CDCl_3$)** δ 151.5, 136.1, 136.0, 131.4, 128.6, 128.2, 126.6, 124.7, 122.8, 113.8, 64.2, 13.8; **HRMS** Calculated for $C_{16}H_{17}NO_2S$ ($M+Na^+$): 310.0872; Found: 310.0869.

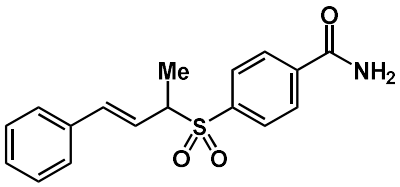
^{1}H NMR spectrum (400 MHz, $CDCl_3$) of compound **25**



^{13}C NMR spectrum (101 MHz, $CDCl_3$) of compound **25**

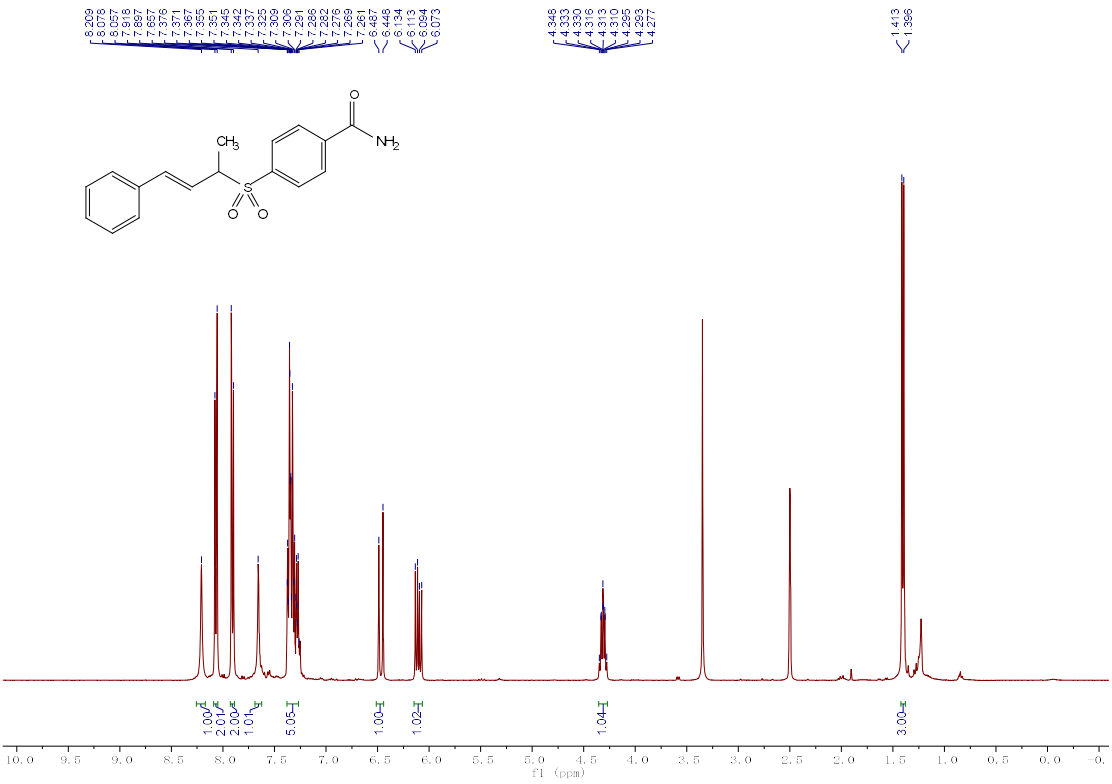


(*E*)-4-((4-phenylbut-3-en-2-yl)sulfonyl)benzamide (26).

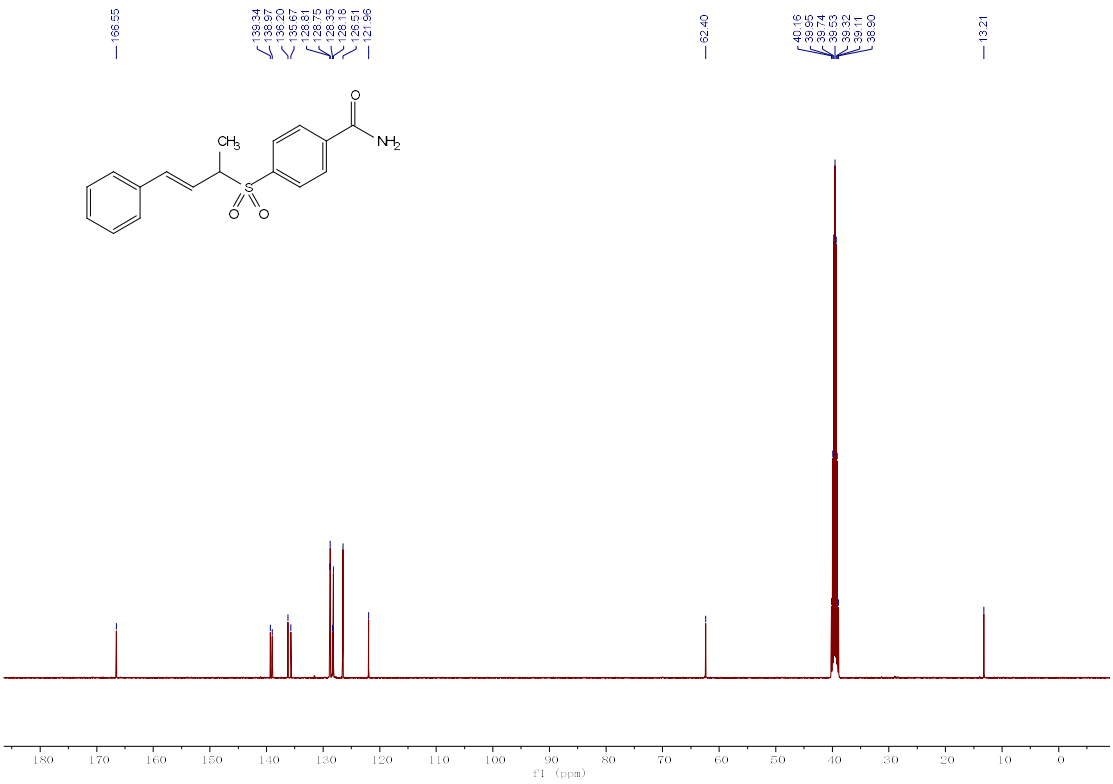


The product (40.4 mg, 64% yield) as white solid was purified with silica gel chromatography (petroleum ether/ethyl acetate = 1/4). **^{1}H NMR (400 MHz, DMSO-d_6)** δ 8.21 (s, 1H), 8.07 (d, J = 8.4 Hz, 2H), 7.91 (d, J = 8.4 Hz, 2H), 7.66 (s, 1H), 7.38-7.26 (m, 5H), 6.47 (d, J = 15.6 Hz, 1H), 6.10 (dd, J = 16.0 Hz, 8.4 Hz, 1H), 4.35-4.28 (m, 1H), 1.40 (d, J = 6.8 Hz, 3H); **^{13}C NMR (101 MHz, DMSO-d_6)** δ 166.6, 139.3, 139.0, 136.2, 135.7, 128.81, 128.75, 128.4, 128.2, 126.5, 122.0, 62.4, 13.2; **HRMS** Calculated for $C_{17}H_{17}NO_3S$ ($M+H^+$): 316.1002; Found: 316.1003.

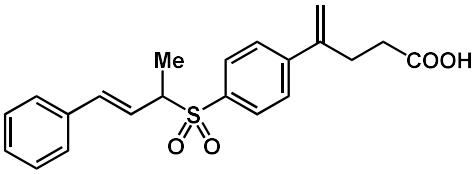
^{1}H NMR spectrum (400 MHz, DMSO-d_6) of compound **26**



^{13}C NMR spectrum (101 MHz, DMSO-d_6) of compound **26**

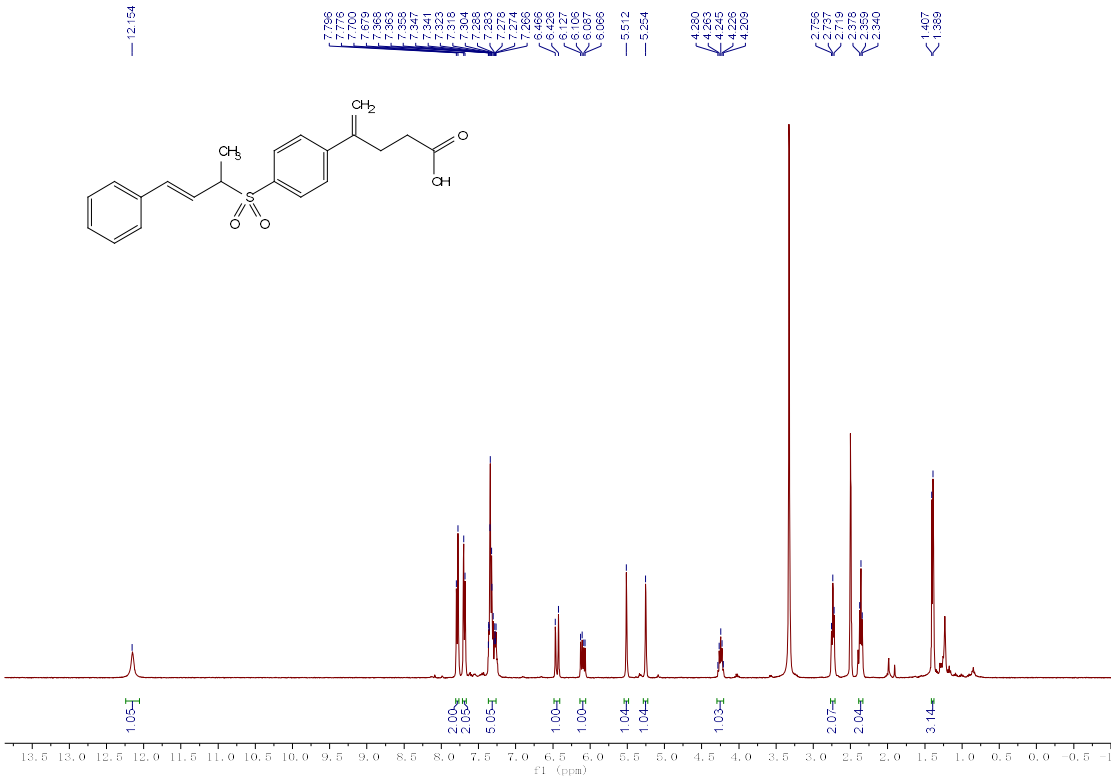


(*E*)-4-(4-((4-phenylbut-3-en-2-yl)sulfonyl)phenyl)pent-4-enoic acid (27).

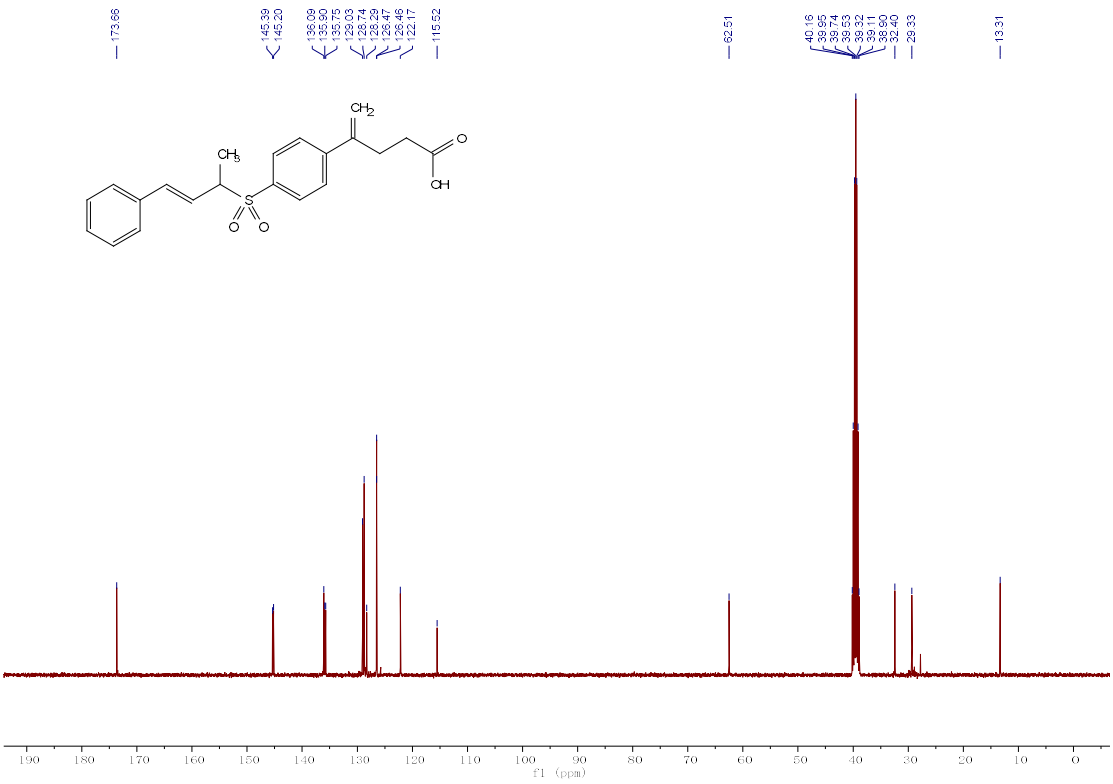


The product (51.9 mg, 70% yield) as yellow solid was purified with silica gel chromatography (petroleum ether/ethyl acetate = 1/1). **^{1}H NMR (400 MHz, DMSO-d_6)** δ 12.15 (s, 1H), 7.79 (d, J = 8.0 Hz, 2H), 7.69 (d, J = 8.4 Hz, 2H), 7.37 – 7.27 (m, 5H), 6.45 (d, J = 16.0 Hz, 1H), 6.10 (dd, J = 16.0, 8.4 Hz, 1H), 5.51 (s, 1H), 5.25 (s, 1H), 4.28 – 4.21 (m, 1H), 2.74 (t, J = 7.6 Hz, 2H), 2.36 (t, J = 7.6 Hz, 2H), 1.40 (d, J = 7.2 Hz, 3H); **^{13}C NMR (101 MHz, DMSO-d_6)** δ 173.7, 145.4, 145.2, 136.1, 135.9, 135.8, 129.0, 128.7, 128.3, 126.47, 126.46, 122.2, 115.5, 62.5, 32.4, 29.3, 13.3; **HRMS** Calculated for $C_{21}H_{22}O_4S$ ($M+Na^+$): 393.1131; Found: 393.1130.

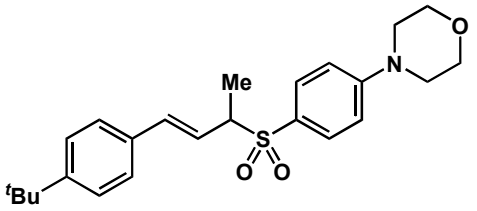
^{1}H NMR spectrum (400 MHz, DMSO-d_6) of compound **27**



^{13}C NMR spectrum (101 MHz, DMSO-d_6) of compound **27**

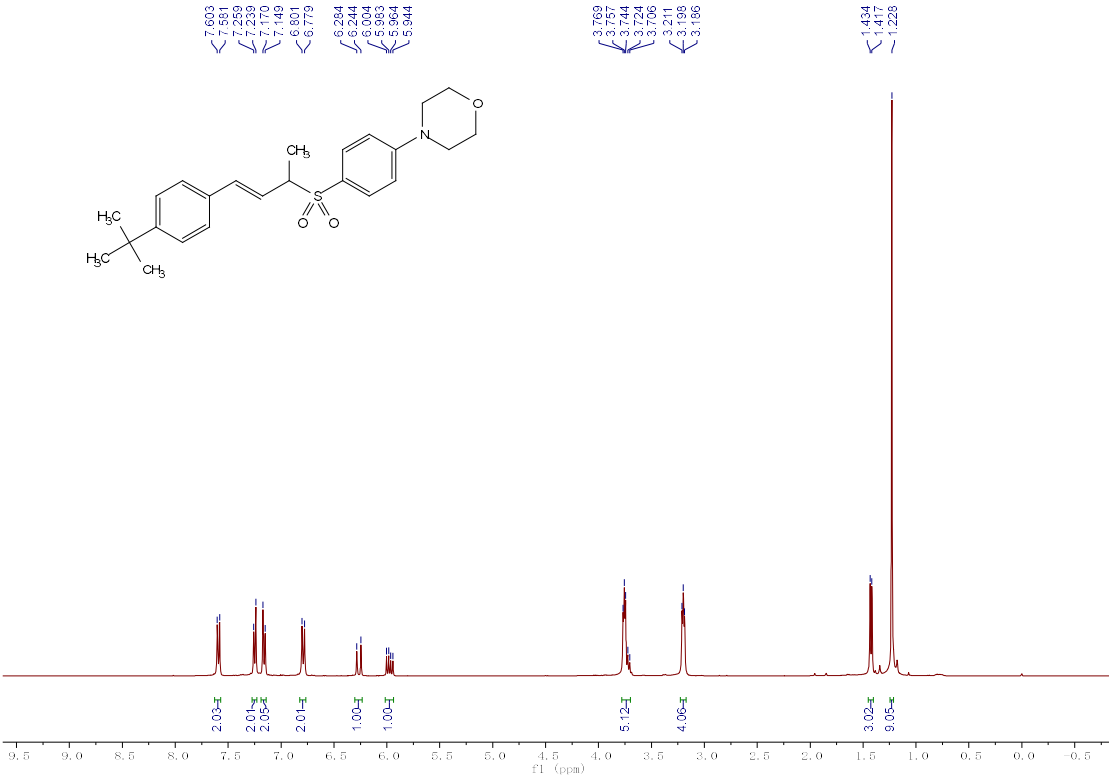


(*E*)-4-(4-((4-(4-(*tert*-butyl)phenyl)but-3-en-2-yl)sulfonyl)phenyl)morpholine (28).

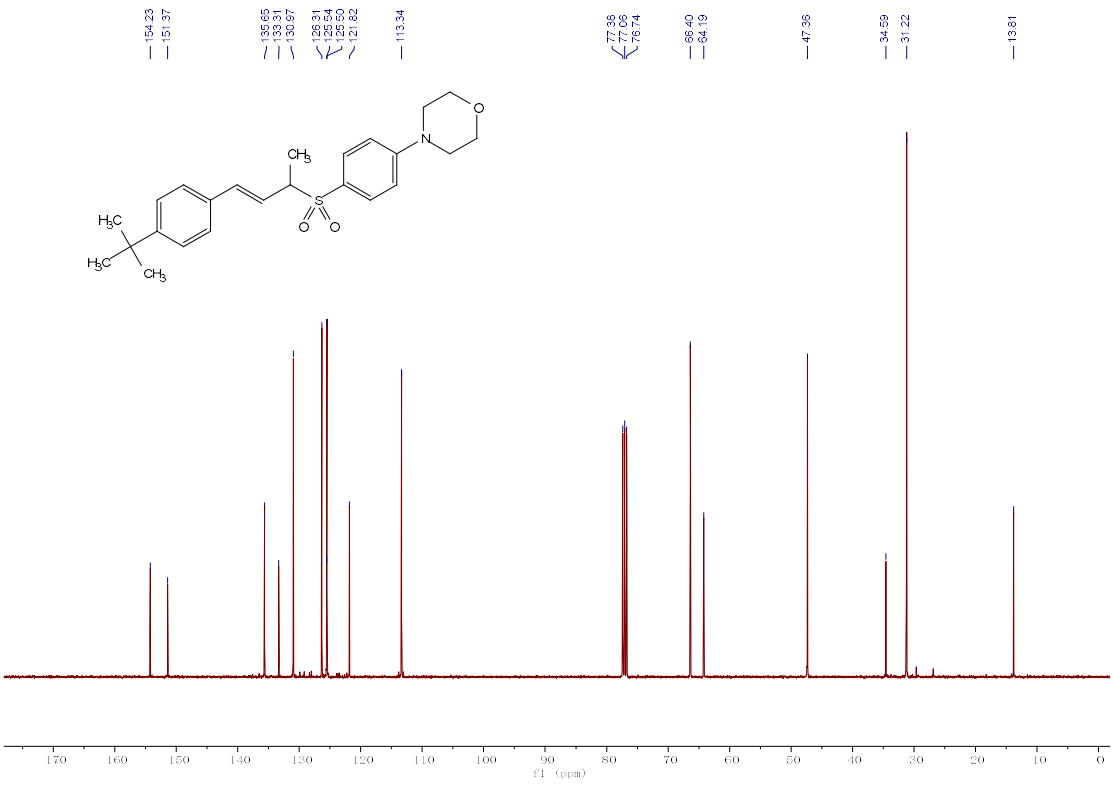


The product (71.1 mg, 86% yield) as yellow solid was purified with silica gel chromatography (petroleum ether/ethyl acetate = 10/1). **^{1}H NMR (400 MHz, Chloroform-*d*)** δ 7.59 (d, *J* = 8.8 Hz, 2H), 7.25 (d, *J* = 8.0 Hz, 2H), 7.16 (d, *J* = 8.4 Hz, 2H), 6.79 (d, *J* = 8.8 Hz, 2H), 6.26 (d, *J* = 16.0 Hz, 1H), 5.97 (dd, *J* = 16.0 Hz, 8.4 Hz, 1H), 3.77-3.71 (m, 5H), 3.21-3.19 (m, 4H), 1.43 (d, *J* = 6.8 Hz, 3H), 1.23 (s, 9H); **^{13}C NMR (101 MHz, $CDCl_3$)** δ 154.2, 151.4, 135.7, 133.3, 131.0, 126.3, 125.54, 125.50, 121.8, 113.3, 66.4, 64.2, 47.4, 34.6, 31.2, 13.8; **HRMS** Calculated for $C_{24}H_{31}NO_3S$ ($M+H^+$): 414.2097; Found: 414.2098.

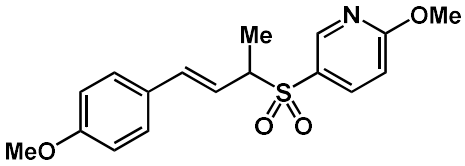
^{1}H NMR spectrum (400 MHz, $CDCl_3$) of compound **28**



^{13}C NMR spectrum (101 MHz, $CDCl_3$) of compound **28**

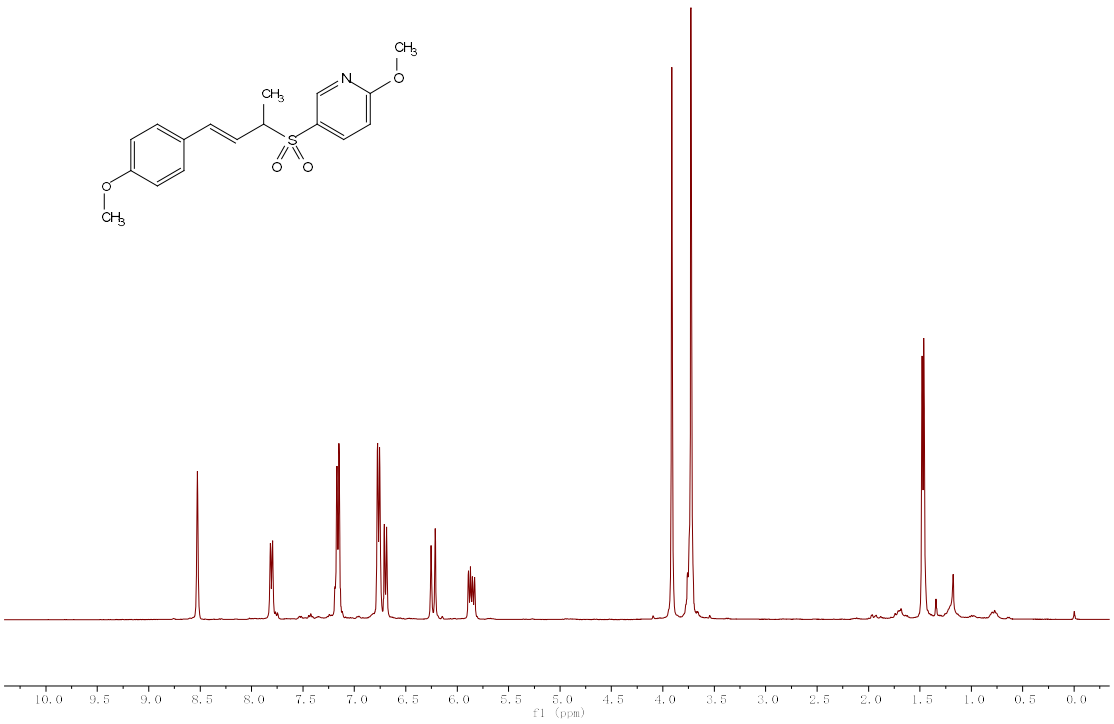


(*E*)-5-methoxy-2-((4-(4-methoxyphenyl)but-3-en-2-yl)sulfonyl)pyridine (29).

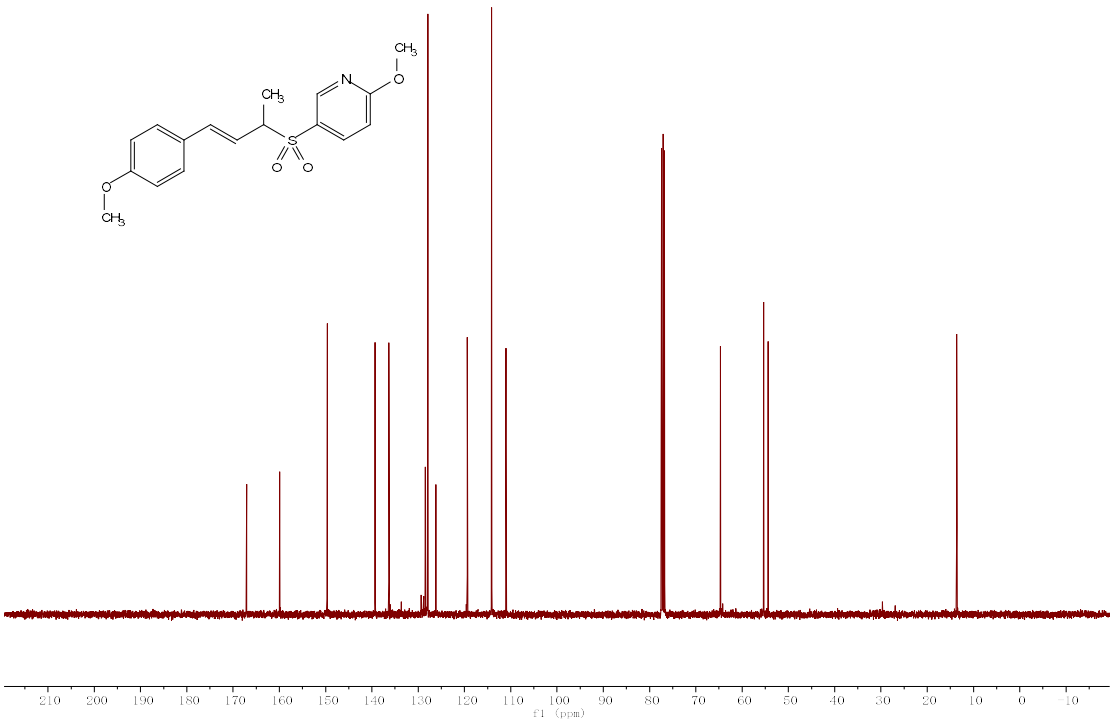


The product (55.3 mg, 83% yield) as brown solid was purified with silica gel chromatography (petroleum ether/ethyl acetate = 5/1). **^{1}H NMR (400 MHz, $CDCl_3$)** δ 8.53 (s, 1H), 7.81 (d, *J* = 8.8 Hz, 1H), 7.16 (d, *J* = 8.0 Hz, 2H), 6.76 (d, *J* = 7.6 Hz, 2H), 6.70 (d, *J* = 8.4 Hz, 1H), 6.23 (d, *J* = 15.6 Hz, 1H), 5.86 (dd, *J* = 15.6 Hz, 8.0 Hz, 1H), 3.91 (s, 3H), 3.73 (s, 3H), 1.47 (d, *J* = 6.4 Hz, 3H); **^{13}C NMR (101 MHz, $CDCl_3$)** δ 167.1, 159.9, 149.6, 139.3, 136.3, 128.4, 127.9, 126.2, 119.4, 114.1, 111.0, 64.6, 55.3, 54.4, 13.6; **HRMS** Calculated for $C_{17}H_{19}NO_4S$ ($M+H^+$): 334.1108; Found: 334.1107.

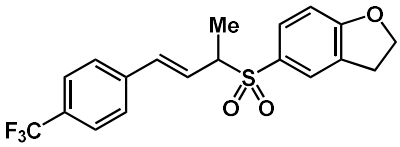
^{1}H NMR spectrum (400 MHz, $CDCl_3$) of compound **29**



^{13}C NMR spectrum (101 MHz, $CDCl_3$) of compound **29**

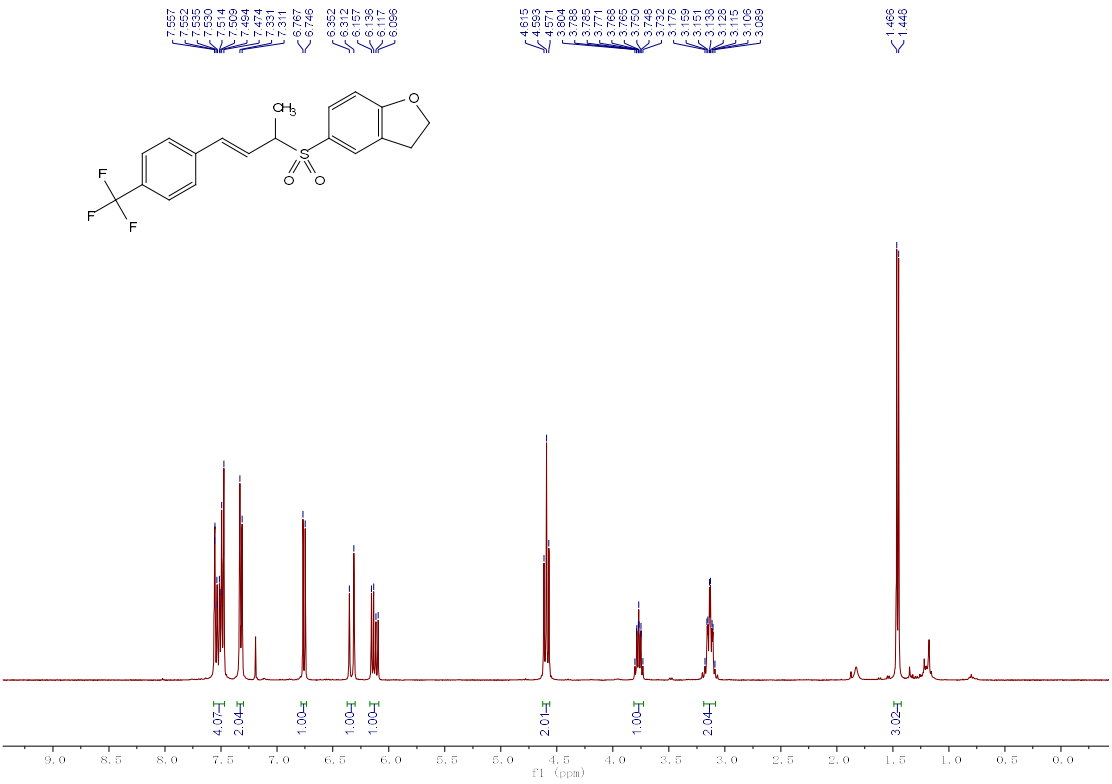


(E)-5-((4-(4-(trifluoromethyl)phenyl)but-3-en-2-yl)sulfonyl)-2,3-dihydrobenzofuran (30).

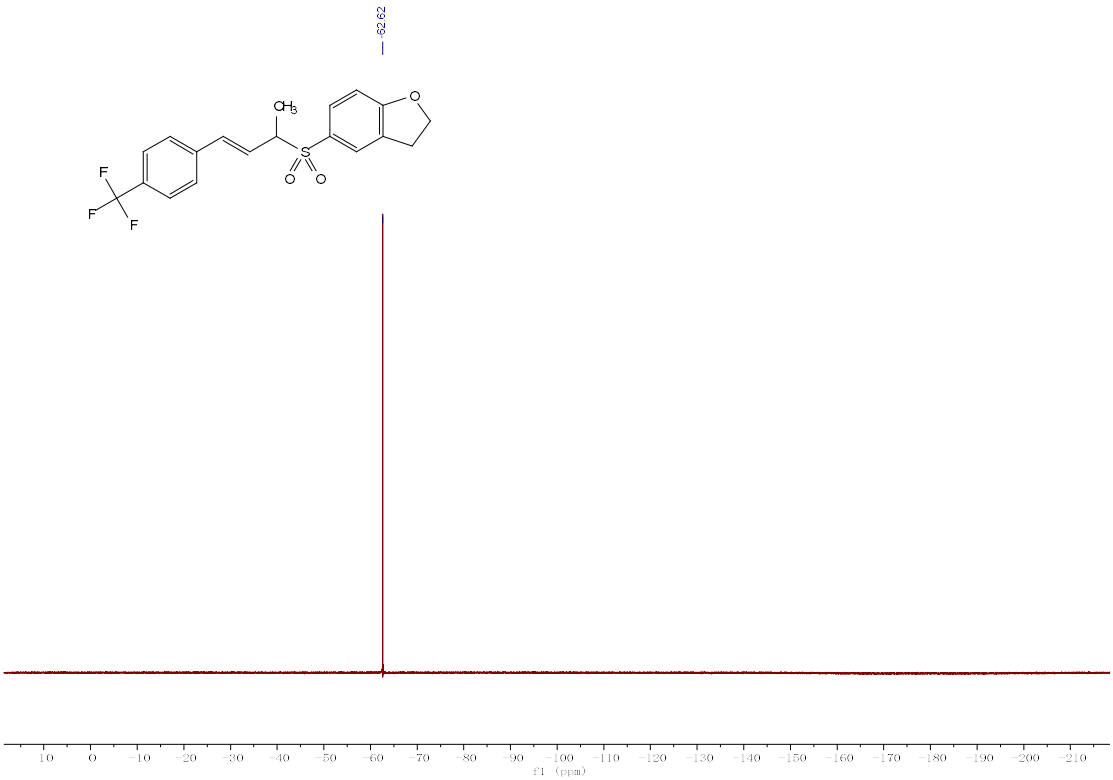


The product (52.0 mg, 68% yield) as yellow oil was purified with silica gel chromatography (petroleum ether/ethyl acetate = 10/1). **^{1}H NMR (400 MHz, $CDCl_3$)** δ 7.56-7.47 (m, 4H), 7.32 (d, *J* = 8.0 Hz, 2H), 6.76 (d, *J* = 8.4 Hz, 1H), 6.33 (d, *J* = 16.0 Hz, 1H), 6.13 (dd, *J* = 16.0 Hz, 8.4 Hz, 1H), 4.59 (t, *J* = 8.8 Hz, 2H), 3.80-3.73 (m, 1H), 3.18-3.09 (m, 2H), 1.46 (d, *J* = 7.2 Hz, 3H); **^{19}F NMR (376 MHz, $CDCl_3$)** δ -62.62 (s, 1F); **^{13}C NMR (101 MHz, $CDCl_3$)** δ 164.8, 139.4, 134.8, 131.0, 130.0 (q, *J* = 32.3 Hz), 128.3, 128.3, 126.7, 126.4, 125.6 (q, *J* = 4.0 Hz), 125.3, 124.0 (q, *J* = 272.7 Hz), 109.5, 72.4, 64.1, 28.9, 13.7; **HRMS** Calculated for $C_{19}H_{17}F_3O_3S$ ($M+Na^+$): 405.0743; Found: 405.0742.

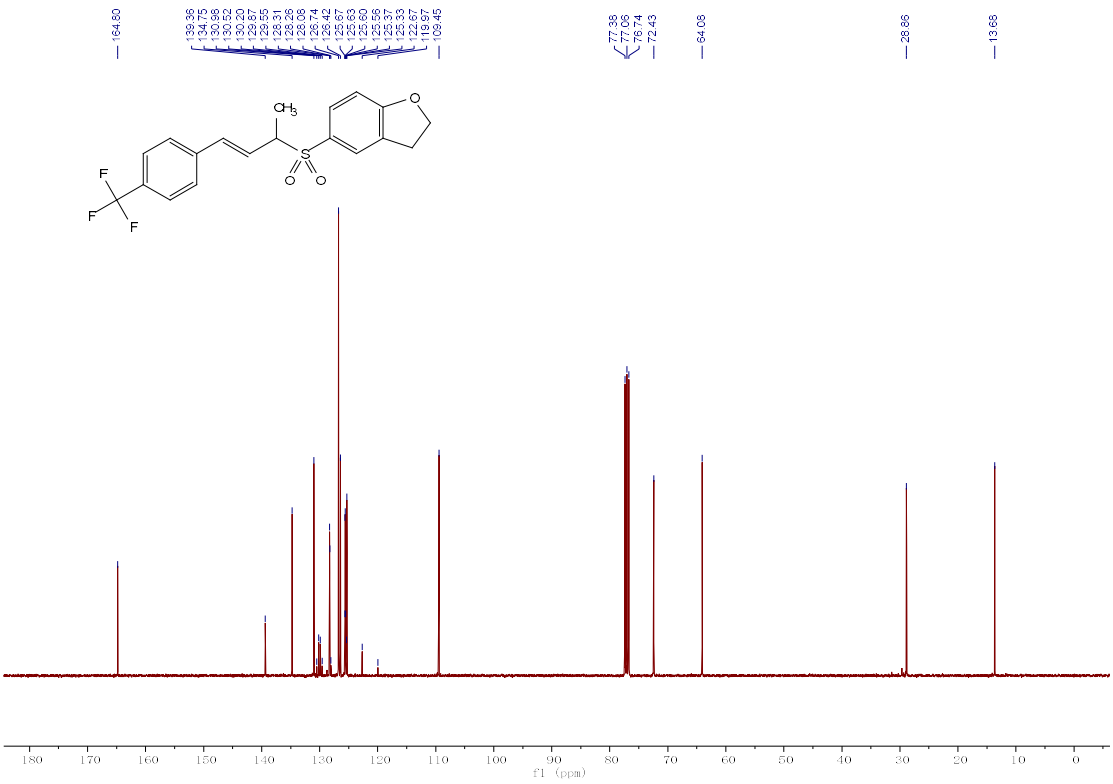
^{1}H NMR spectrum (400 MHz, $CDCl_3$) of compound **30**



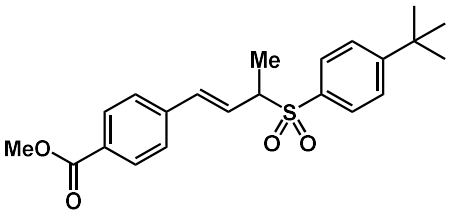
^{19}F NMR spectrum (376 MHz, $CDCl_3$) of compound **30**



^{13}C NMR spectrum (101 MHz, $CDCl_3$) of compound **30**

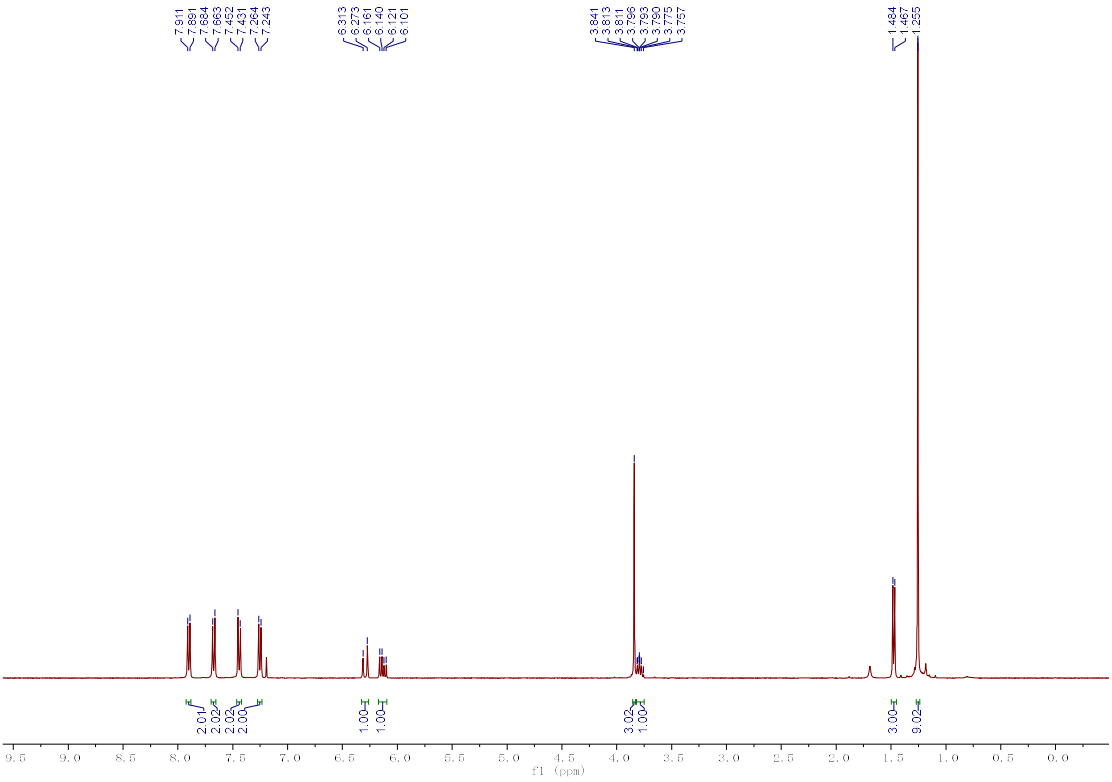


methyl (*E*)-4-(3-((4-(*tert*-butyl)phenyl)sulfonyl)but-1-en-1-yl)benzoate (31).

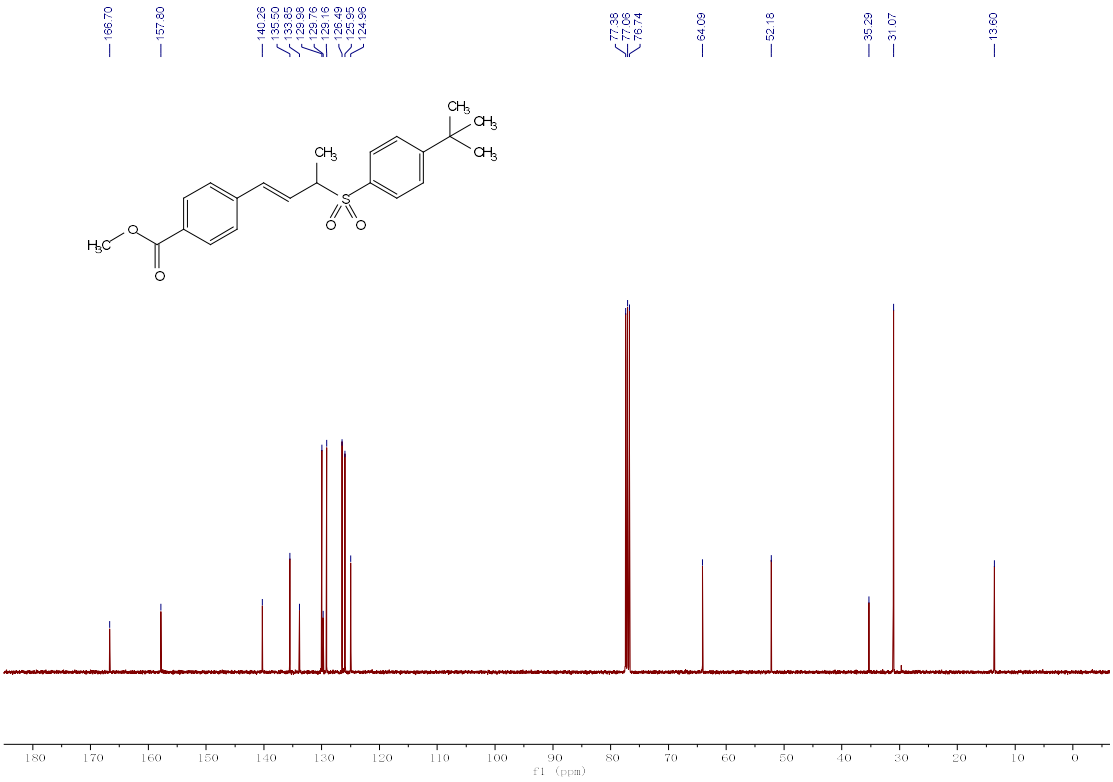


The product (52.6 mg, 68% yield) as white solid was purified with silica gel chromatography (petroleum ether/ethyl acetate = 5/1). **^{1}H NMR (400 MHz, $CDCl_3$)** δ 7.90 (d, *J* = 8.0 Hz, 2H), 7.67 (d, *J* = 8.4 Hz, 2H), 7.44 (d, *J* = 8.4 Hz, 2H), 7.25 (d, *J* = 8.4 Hz, 2H), 6.29 (d, *J* = 16.0 Hz, 1H), 6.13 (dd, *J* = 16.0 Hz, 8.4 Hz, 1H), 3.84 (s, 3H), 3.81-3.76 (m, 1H), 1.48 (d, *J* = 6.8 Hz, 3H), 1.25 (s, 9H); **^{13}C NMR (101 MHz, $CDCl_3$)** δ 166.7, 157.8, 140.3, 135.5, 133.9, 130.0, 129.8, 129.2, 126.5, 126.0, 125.0, 64.1, 52.2, 35.3, 31.1, 13.6; **HRMS** Calculated for $C_{22}H_{26}O_4S$ ($M+Na^+$): 409.1444; Found: 409.1443.

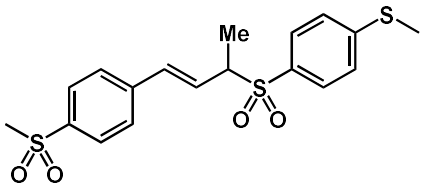
^{1}H NMR spectrum (400 MHz, $CDCl_3$) of compound **31**



^{13}C NMR spectrum (101 MHz, $CDCl_3$) of compound **31**

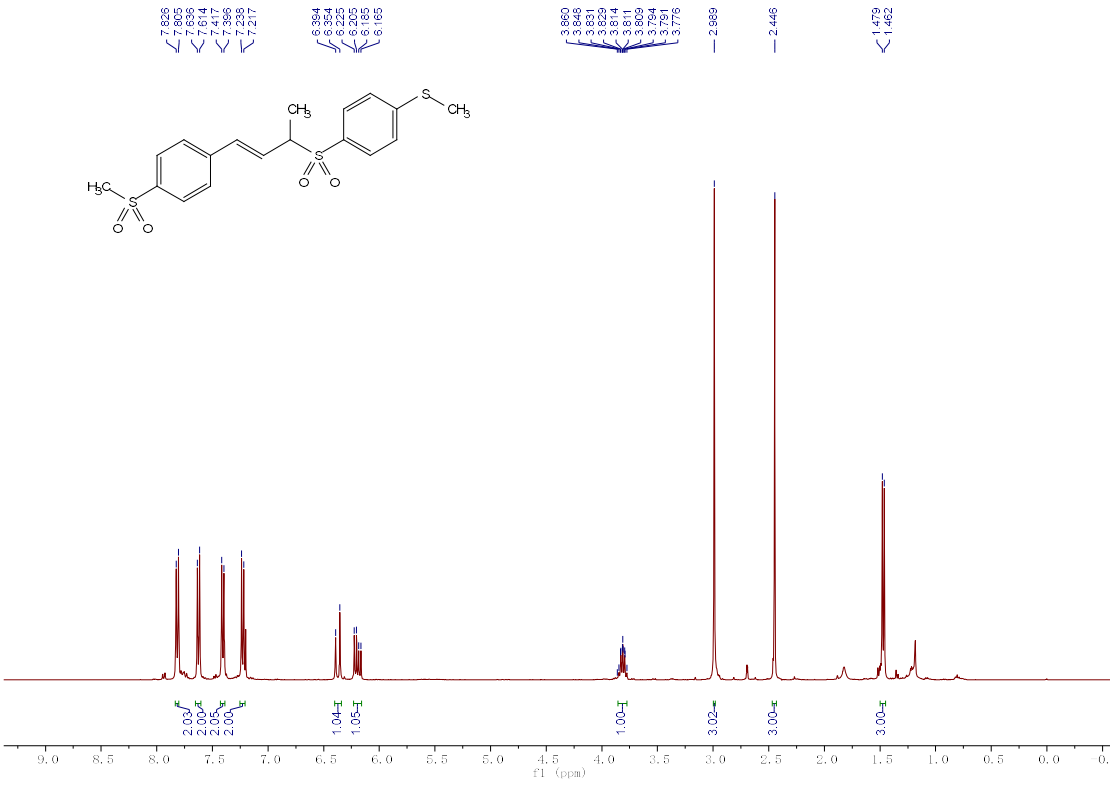


(*E*)-methyl(4-((4-(4-(methylsulfonyl)phenyl)but-3-en-2-yl)sulfonyl)phenyl)sulfane (32).

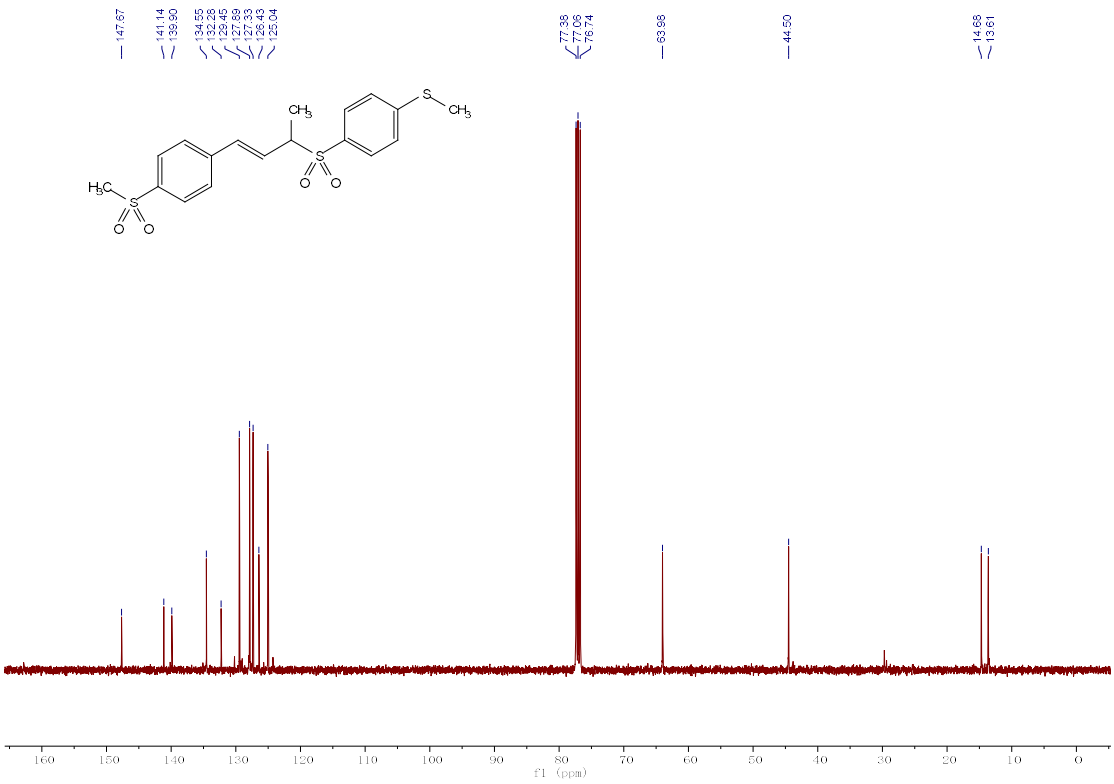


The product (57.9 mg, 73% yield) as yellow solid was purified with silica gel chromatography (petroleum ether/ethyl acetate = 2/1). **^{1}H NMR (400 MHz, $CDCl_3$)** δ 7.82 (d, *J* = 8.4 Hz, 2H), 7.63 (d, *J* = 8.8 Hz, 2H), 7.41 (d, *J* = 8.4 Hz, 2H), 7.23 (d, *J* = 8.4 Hz, 2H), 6.37 (d, *J* = 16.0 Hz, 1H), 6.19 (dd, *J* = 16.0 Hz, 8.0 Hz, 1H), 3.86-3.78 (m, 1H), 2.99 (s, 3H), 2.45 (s, 3H), 1.47 (d, *J* = 6.8 Hz, 3H); **^{13}C NMR (101 MHz, $CDCl_3$)** δ 147.7, 141.1, 139.9, 134.6, 132.3, 129.5, 127.9, 127.3, 126.4, 125.0, 64.0, 44.5, 14.7, 13.6; **HRMS** Calculated for $C_{18}H_{20}O_4S_3$ ($M+Na^+$): 419.0416; Found: 419.0416.

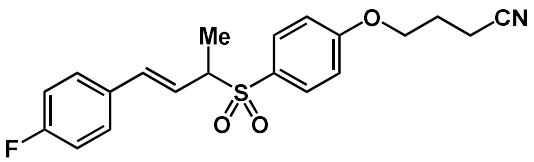
^{1}H NMR spectrum (400 MHz, $CDCl_3$) of compound **32**



^{13}C NMR spectrum (101 MHz, $CDCl_3$) of compound **32**

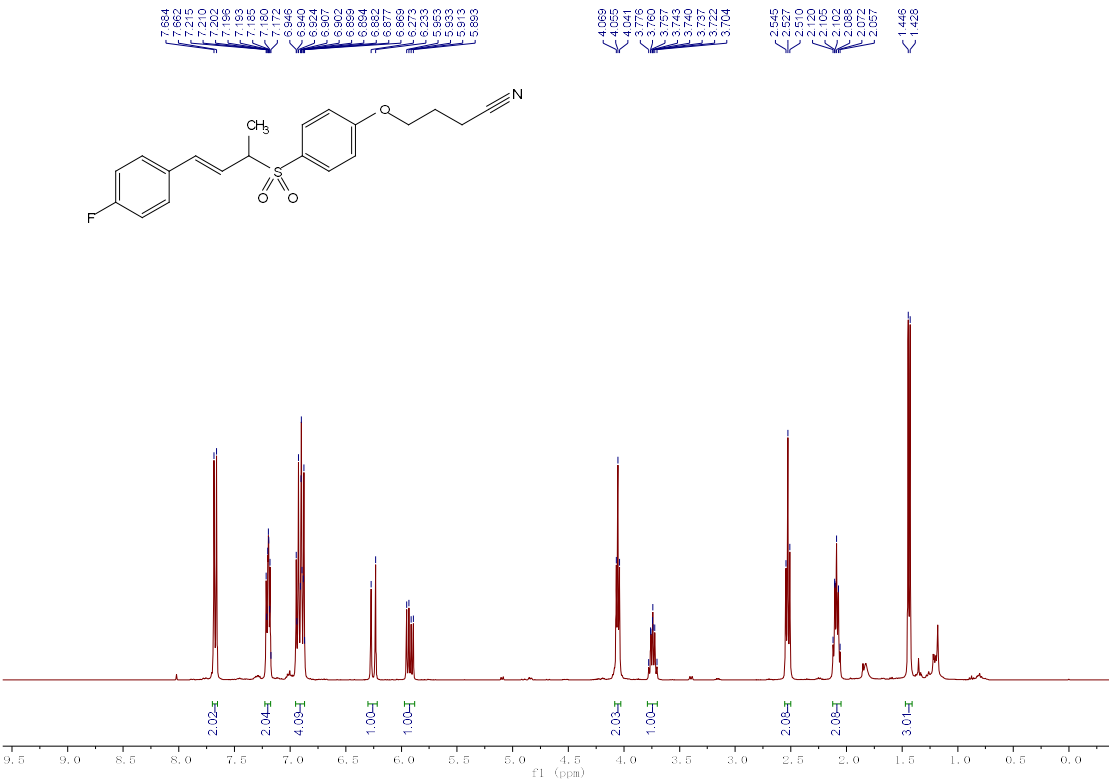


(*E*)-4-(4-((4-(4-fluorophenyl)but-3-en-2-yl)sulfonyl)phenoxy)butanenitrile (33).

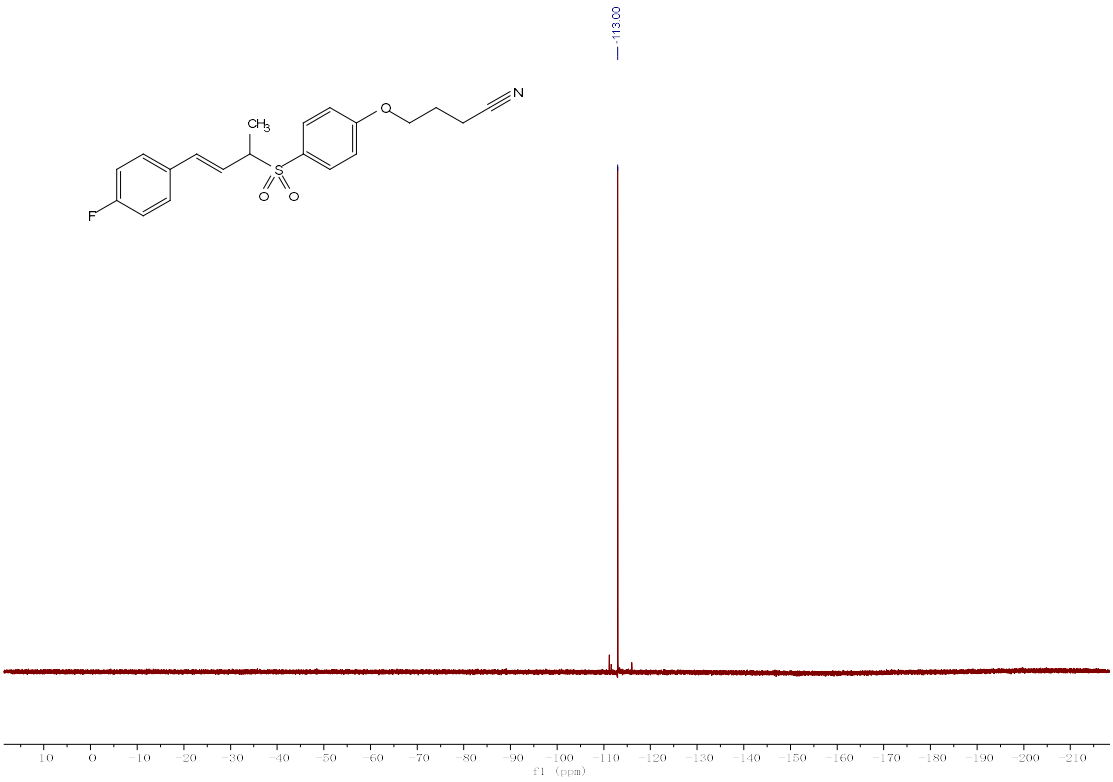


The product (54.5 mg, 73% yield) as yellow oil was purified with silica gel chromatography (petroleum ether/ethyl acetate = 3/1). **^{1}H NMR (400 MHz, $CDCl_3$)** δ 7.67 (d, *J* = 8.8 Hz, 2H), 7.22-7.17 (m, 2H), 6.95-6.87 (m, 4H), 6.25 (d, *J* = 16.0 Hz, 1H), 5.92 (dd, *J* = 16.0 Hz, 8.0 Hz, 1H), 4.05 (t, *J* = 5.6 Hz, 2H), 3.78-3.70 (m, 1H), 2.53 (t, *J* = 7.2 Hz, 2H), 2.12-2.06 (m, 2H), 1.44 (d, *J* = 7.2 Hz, 3H); **^{19}F NMR (376 MHz, $CDCl_3$)** δ -113.00 (s, 1F); **^{13}C NMR (101 MHz, $CDCl_3$)** δ 162.7 (d, *J* = 249.5 Hz), 162.5, 135.1, 132.1 (d, *J* = 3.0 Hz), 131.5, 129.0, 128.2 (d, *J* = 8.1 Hz), 121.9 (d, *J* = 2.0 Hz), 118.9, 115.6 (d, *J* = 22.2 Hz), 114.5, 65.7, 64.1, 25.1, 14.1, 13.7; **HRMS** Calculated for $C_{20}H_{20}FNO_3S$ ($M+Na^+$): 396.1040; Found: 396.1040.

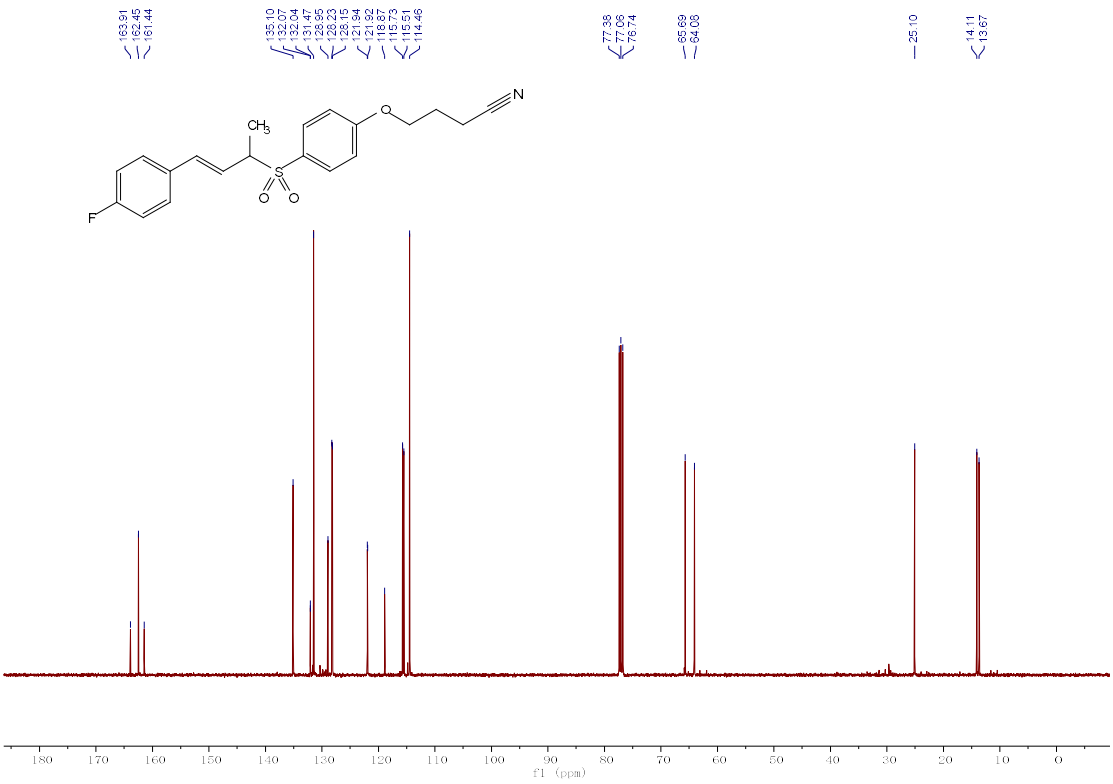
^{1}H NMR spectrum (400 MHz, $CDCl_3$) of compound **33**



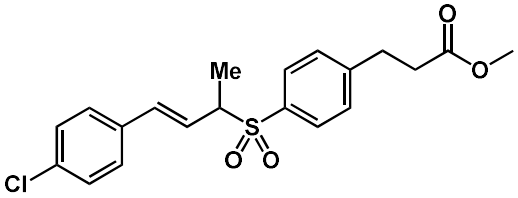
^{19}F NMR spectrum (376 MHz, $CDCl_3$) of compound **33**



^{13}C NMR spectrum (101 MHz, $CDCl_3$) of compound **33**

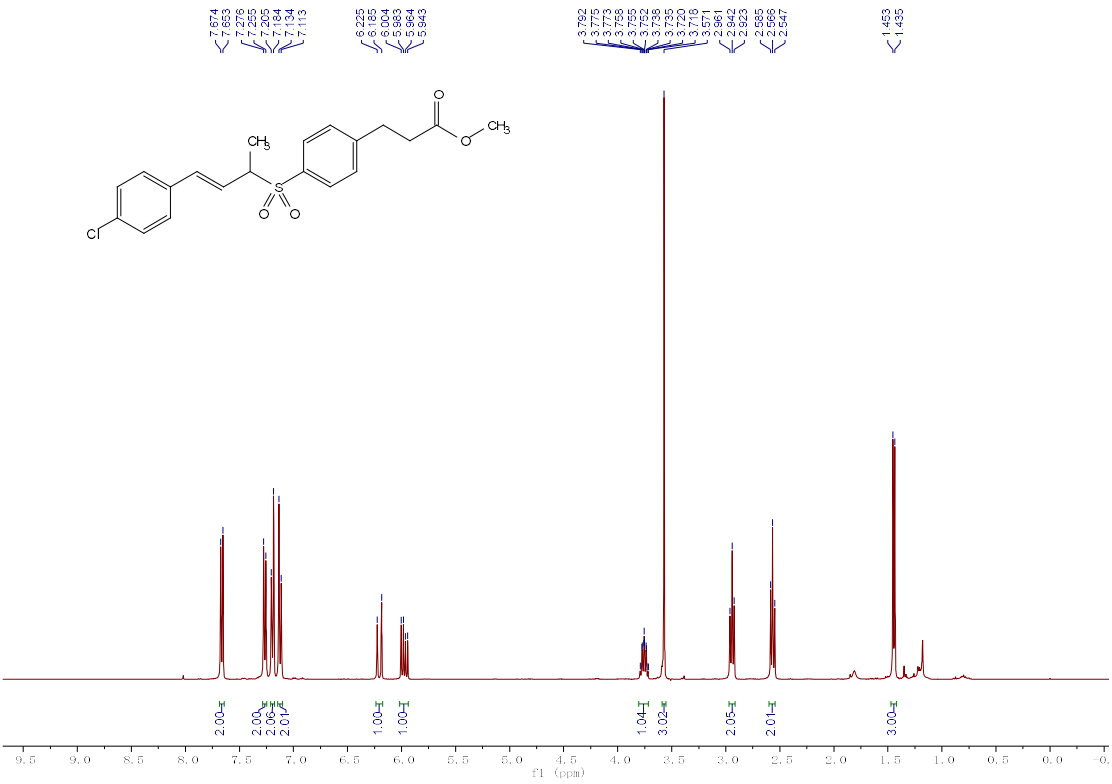


methyl (*E*)-3-(4-((4-(4-chlorophenyl)but-3-en-2-yl)sulfonyl)phenyl)propanoate (34).

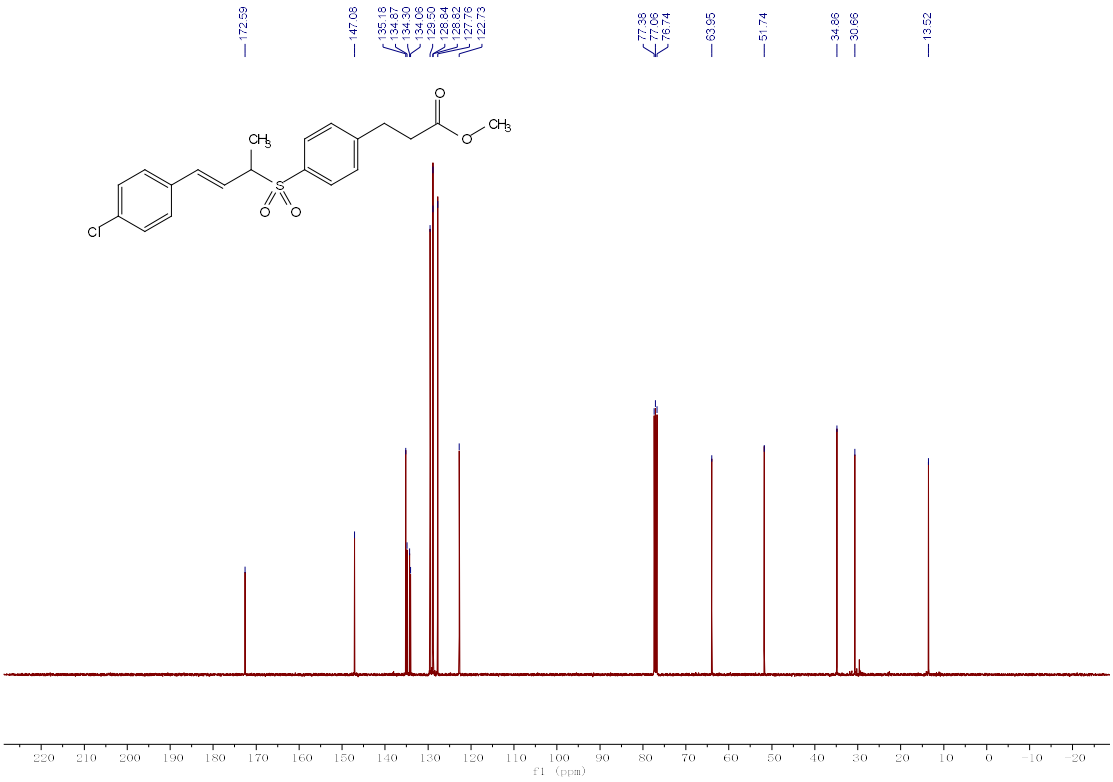


The product (58.8 mg, 75% yield) as brown oil was purified with silica gel chromatography (petroleum ether/ethyl acetate = 3/1). **^{1}H NMR (400 MHz, $CDCl_3$)** δ 7.66 (d, *J* = 8.4 Hz, 2H), 7.27 (d, *J* = 8.4 Hz, 2H), 7.19 (d, *J* = 8.4 Hz, 2H), 7.12 (d, *J* = 8.4 Hz, 2H), 6.21 (d, *J* = 16.0 Hz, 1H), 5.97 (dd, *J* = 16.0 Hz, 8.4 Hz, 1H), 3.79-3.72 (m, 1H), 3.57 (s, 3H), 2.94 (t, *J* = 7.6 Hz, 2H), 2.57 (t, *J* = 7.6 Hz, 2H), 1.44 (d, *J* = 7.2 Hz, 3H); **^{13}C NMR (101 MHz, $CDCl_3$)** δ 172.6, 147.1, 135.2, 134.9, 134.3, 134.1, 129.5, 128.84, 128.82, 127.8, 122.7, 64.0, 51.7, 34.9, 30.7, 13.5; **HRMS** Calculated for $C_{20}H_{21}ClO_4S$ ($M+Na^+$): 415.0741; Found: 415.0742.

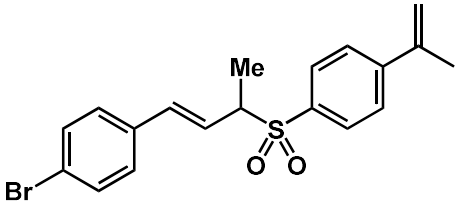
^{1}H NMR spectrum (400 MHz, $CDCl_3$) of compound **34**



^{13}C NMR spectrum (101 MHz, $CDCl_3$) of compound **34**

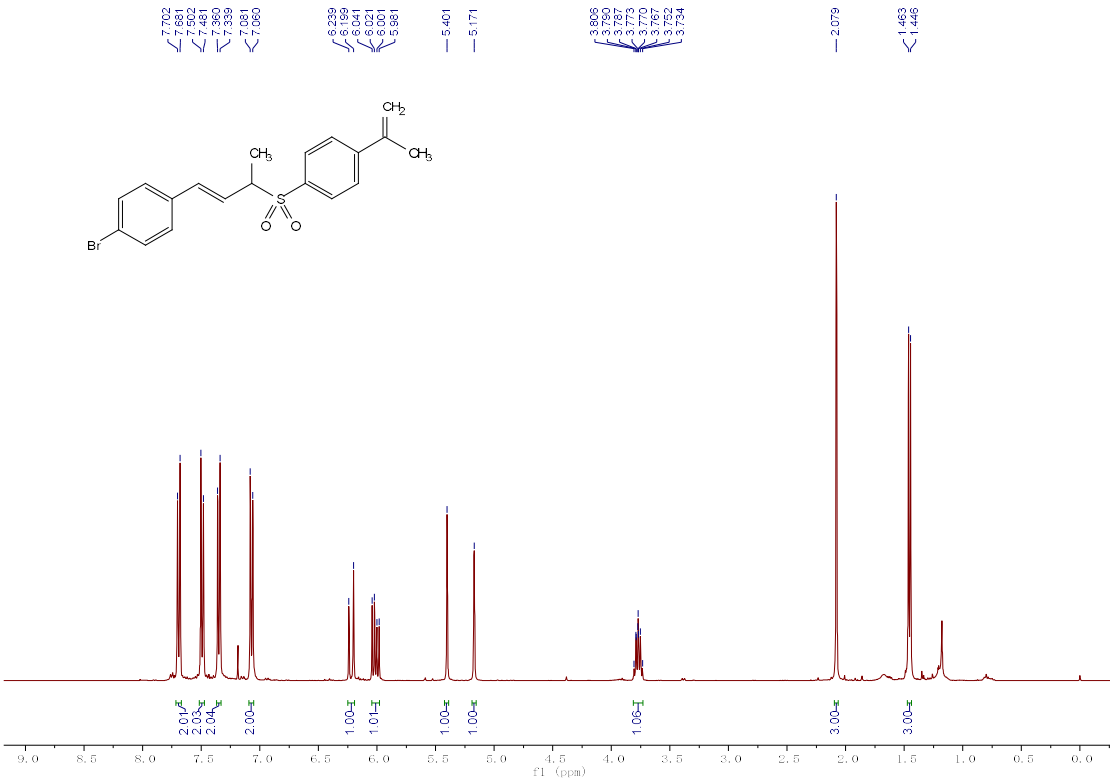


(*E*)-1-bromo-4-(3-((4-(prop-1-en-2-yl)phenyl)sulfonyl)but-1-en-1-yl)benzene (35).

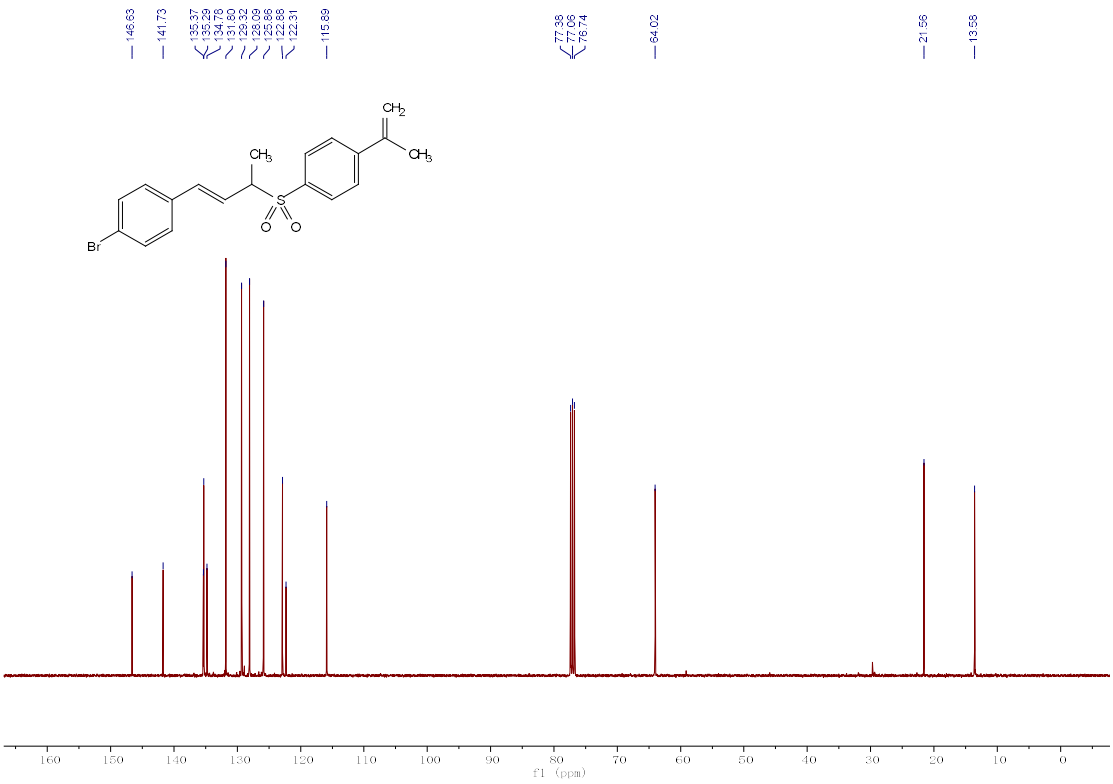


The product (50.9 mg, 65% yield) as yellow solid was purified with silica gel chromatography (petroleum ether/ethyl acetate = 10/1). **^{1}H NMR (400 MHz, $CDCl_3$)** δ 7.69 (d, *J* = 8.4 Hz, 2H), 7.49 (d, *J* = 8.4 Hz, 2H), 7.35 (d, *J* = 8.4 Hz, 2H), 7.07 (d, *J* = 8.4 Hz, 2H), 6.22 (d, *J* = 16.0 Hz, 1H), 6.01 (dd, *J* = 16.0 Hz, 8.0 Hz, 1H), 5.40 (s, 1H), 5.17 (s, 1H), 3.81-3.73 (m, 1H), 2.08 (s, 3H), 1.45 (d, *J* = 6.8 Hz, 3H); **^{13}C NMR (101 MHz, $CDCl_3$)** δ 146.63, 141.73, 135.37, 135.29, 134.78, 131.80, 129.32, 128.09, 125.86, 122.88, 122.31, 115.89, 64.02, 21.56, 13.58; **HRMS** Calculated for $C_{19}H_{19}BrO_2S$ ($M+Na^+$): 413.0181; Found: 413.0183.

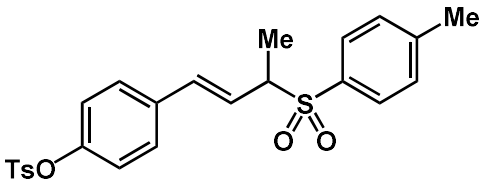
^{1}H NMR spectrum (400 MHz, $CDCl_3$) of compound **35**



^{13}C NMR spectrum (101 MHz, $CDCl_3$) of compound **35**

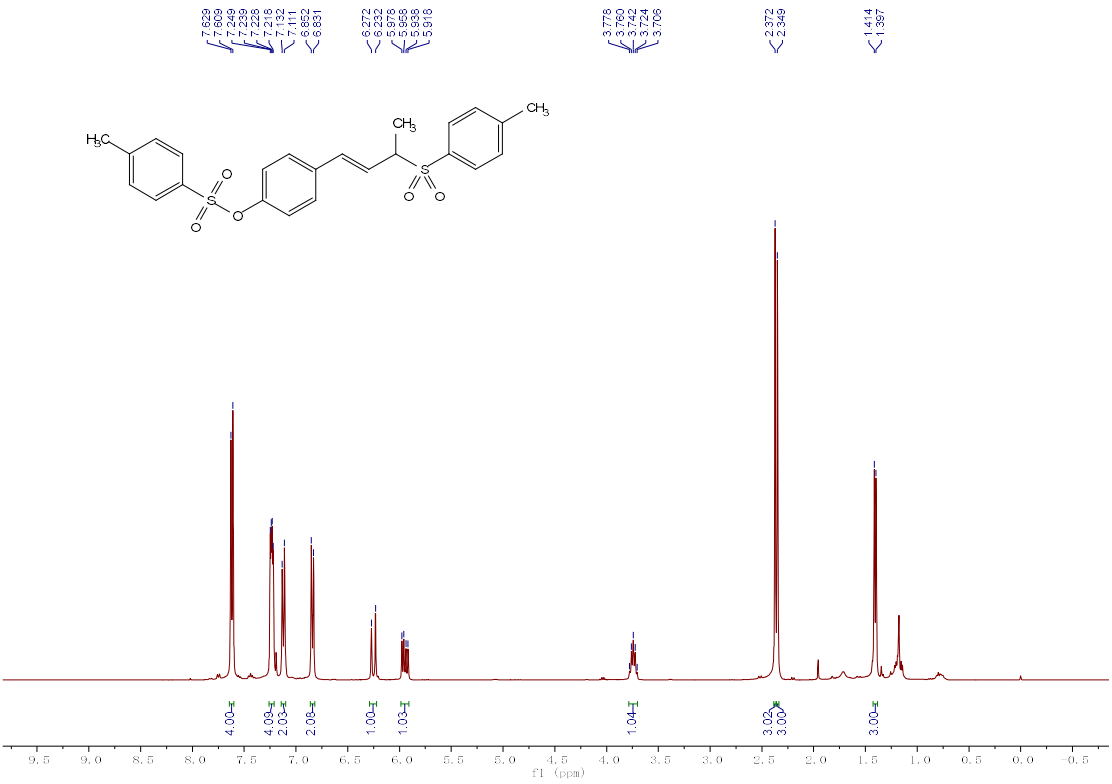


(*E*)-4-(3-tosylbut-1-en-1-yl)phenyl 4-methylbenzenesulfonate (36).

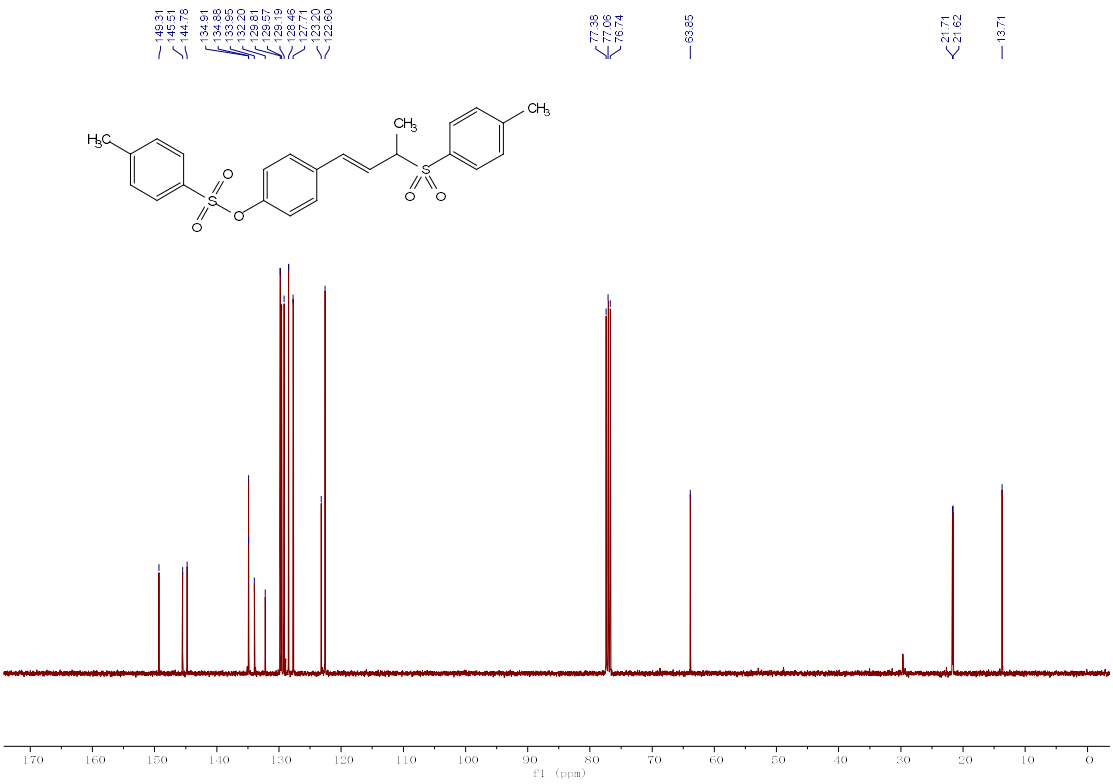


The product (65.8 mg, 72% yield) as yellow solid was purified with silica gel chromatography (petroleum ether/ethyl acetate = 5/1). **^{1}H NMR (400 MHz, $CDCl_3$)** δ 7.62 (d, *J* = 8.0 Hz, 4H), 7.25-7.22 (m, 4H), 7.12 (d, *J* = 8.4 Hz, 2H), 6.84 (d, *J* = 8.4 Hz, 2H), 6.25 (d, *J* = 16.0 Hz, 1H), 5.95 (dd, *J* = 16.0 Hz, 8.0 Hz, 1H), 3.78-3.71 (m, 1H), 2.37 (s, 3H), 2.35 (s, 3H), 1.41 (d, *J* = 6.8 Hz, 3H); **^{13}C NMR (101 MHz, $CDCl_3$)** δ 149.3, 145.5, 144.8, 134.91, 134.88, 134.0, 132.2, 129.8, 129.6, 129.2, 128.5, 127.7, 123.2, 122.6, 63.9, 21.7, 21.6, 13.7; **HRMS** Calculated for $C_{24}H_{24}O_5S_2$ ($M+Na^+$): 479.0957; Found: 479.0959.

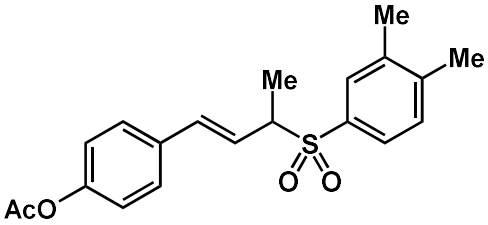
^{1}H NMR spectrum (400 MHz, $CDCl_3$) of compound **36**



^{13}C NMR spectrum (101 MHz, $CDCl_3$) of compound **36**

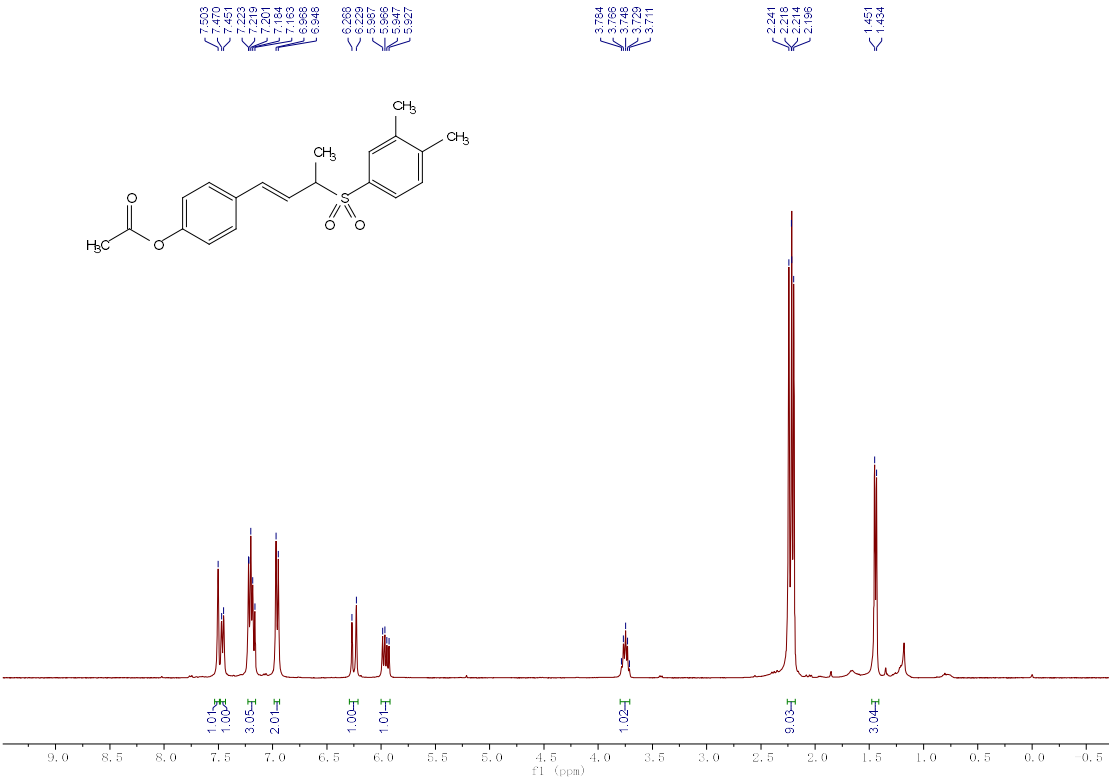


(*E*)-4-(3-((3,4-dimethylphenyl)sulfonyl)but-1-en-1-yl)phenyl acetate (37).

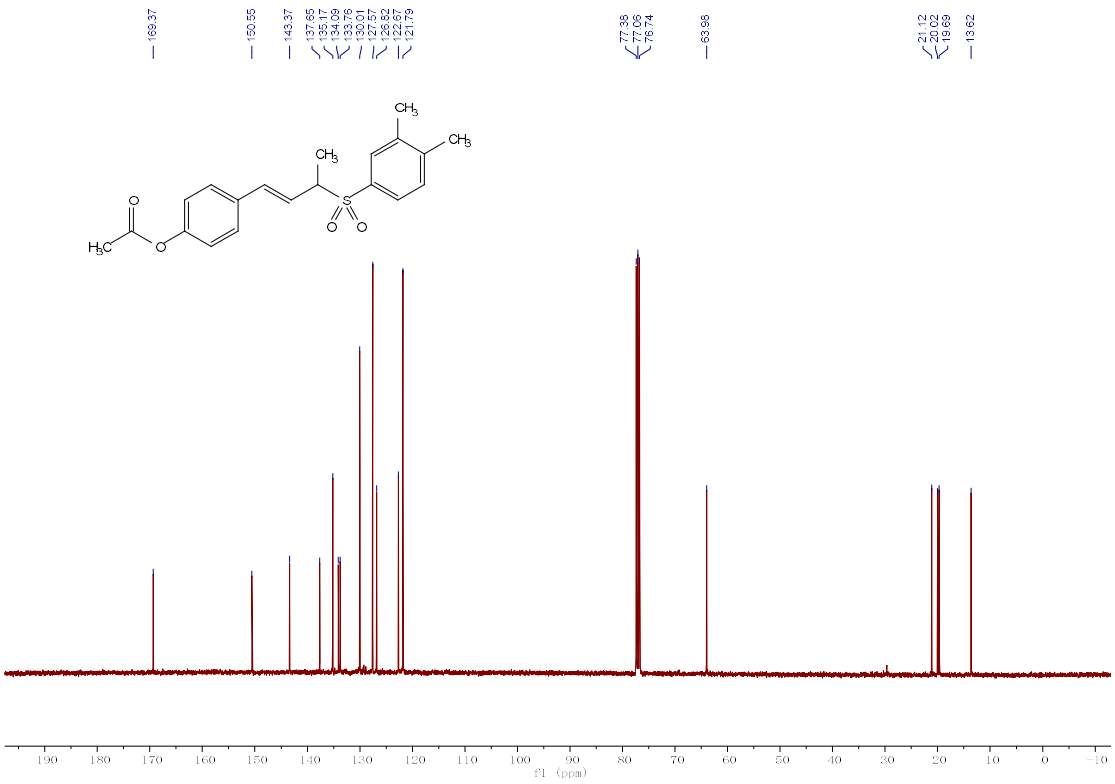


The product (44.5 mg, 62% yield) as brown solid was purified with silica gel chromatography (petroleum ether/ethyl acetate = 5/1). **^{1}H NMR (400 MHz, $CDCl_3$)** δ 7.50 (s, 1H), 7.46 (d, *J* = 7.6 Hz, 1H), 7.22-7.16 (m, 3H), 6.96 (d, *J* = 8.0 Hz, 2H), 6.25 (d, *J* = 15.6 Hz, 1H), 5.96 (dd, *J* = 16.0 Hz, 8.4 Hz, 1H), 3.78-3.71 (m, 1H), 2.24-2.20 (m, 9H), 1.44 (d, *J* = 6.8 Hz, 3H); **^{13}C NMR (101 MHz, $CDCl_3$)** δ 169.4, 150.6, 143.4, 137.7, 135.2, 134.1, 133.8, 130.0, 127.6, 126.8, 122.7, 121.8, 64.0, 21.1, 20.0, 19.7, 13.6; **HRMS** Calculated for $C_{20}H_{22}O_4S$ ($M+Na^+$): 381.1131; Found: 381.1129.

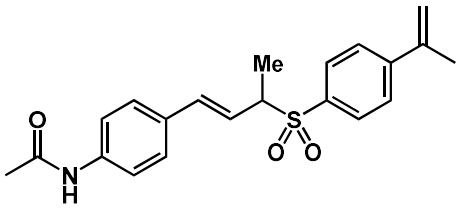
^{1}H NMR spectrum (400 MHz, $CDCl_3$) of compound **37**



^{13}C NMR spectrum (101 MHz, $CDCl_3$) of compound **37**

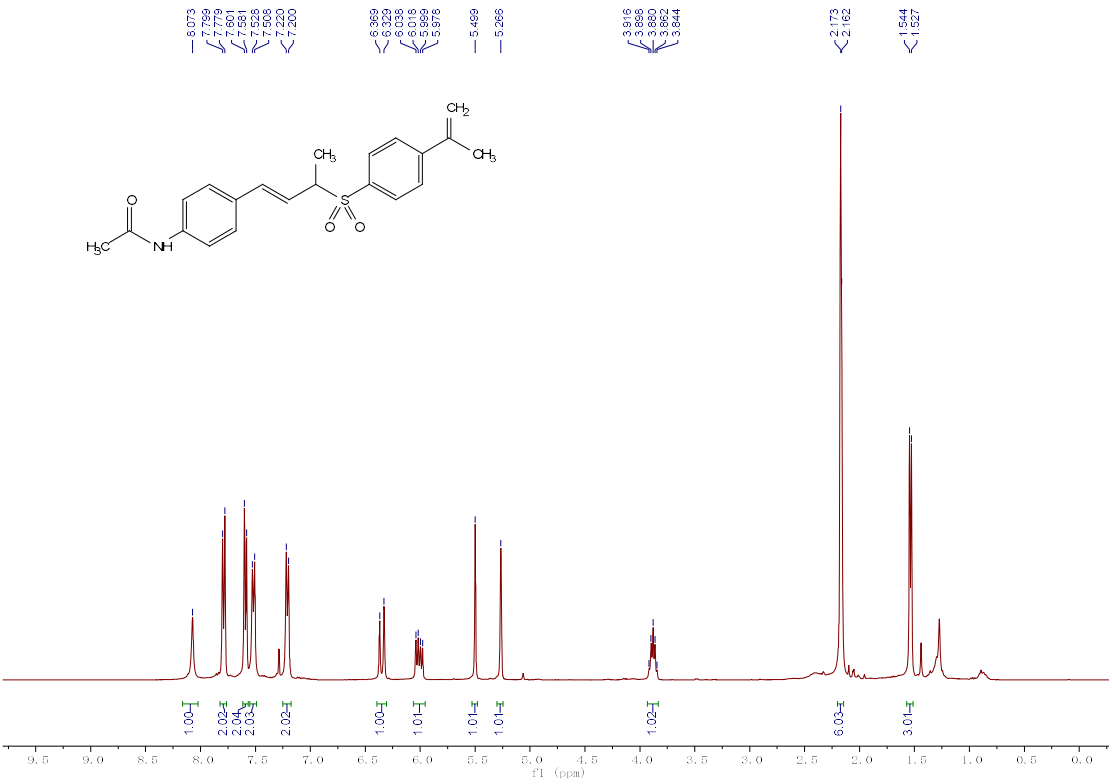


(*E*)-*N*-(4-(3-((4-(prop-1-en-2-yl)phenyl)sulfonyl)but-1-en-1-yl)phenyl)acetamide (38).

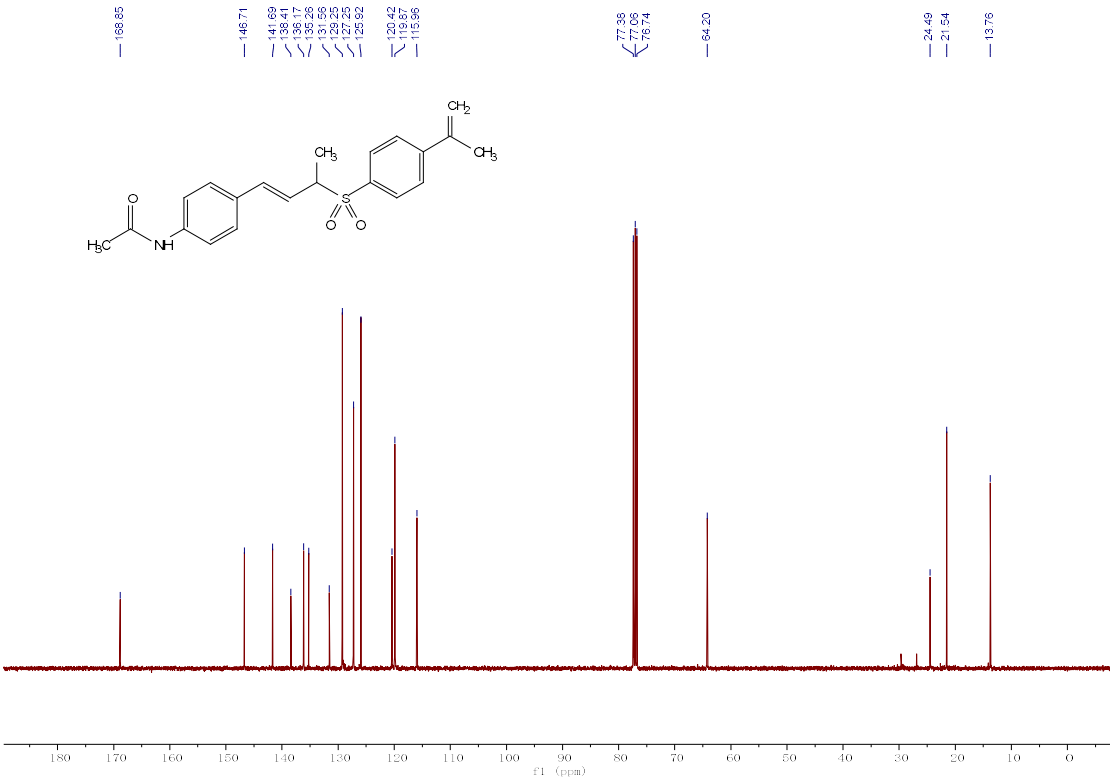


The product (52.5 mg, 71% yield) as brown solid was purified with silica gel chromatography (petroleum ether/ethyl acetate = 2/1). **^{1}H NMR (400 MHz, $CDCl_3$)** δ 8.07 (s, 1H), 7.79 (d, *J* = 8.0 Hz, 2H), 7.59 (d, *J* = 8.0 Hz, 2H), 7.52 (d, *J* = 8.0 Hz, 2H), 7.21 (d, *J* = 8.0 Hz, 2H), 6.35 (d, *J* = 16.0 Hz, 1H), 6.01 (dd, *J* = 15.6 Hz, 8.0 Hz, 1H), 5.50 (s, 1H), 5.27 (s, 1H), 3.92-3.84 (m, 1H), 2.17-2.16 (m, 6H), 1.54 (d, *J* = 6.8 Hz, 3H); **^{13}C NMR (101 MHz, $CDCl_3$)** δ 168.9, 146.7, 141.7, 138.4, 136.2, 135.3, 131.6, 129.3, 127.3, 125.9, 120.4, 119.9, 116.0, 64.2, 24.5, 21.5, 13.8; **HRMS** Calculated for $C_{21}H_{23}NO_3S$ ($M+Na^+$): 392.1291; Found: 392.1290.

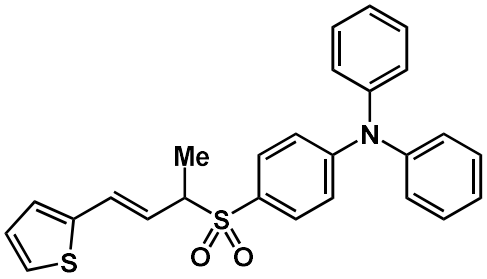
^{1}H NMR spectrum (400 MHz, $CDCl_3$) of compound **38**



^{13}C NMR spectrum (101 MHz, $CDCl_3$) of compound **38**

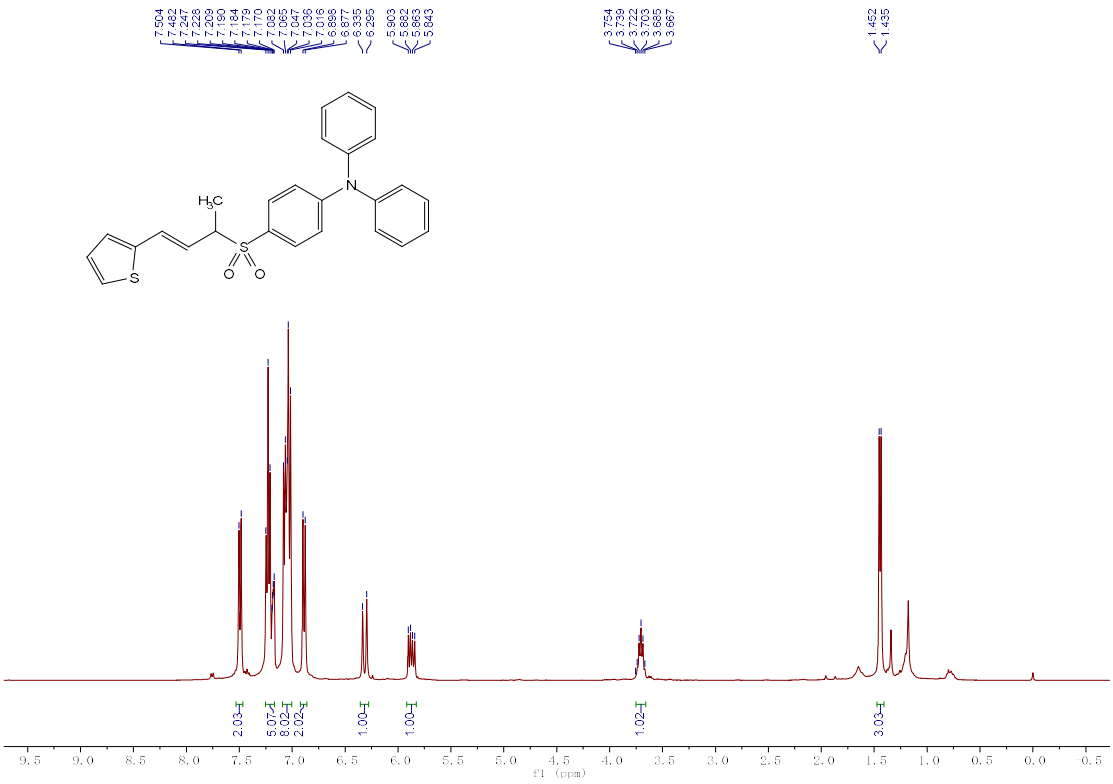


(*E*)-*N*,*N*-diphenyl-4-((4-(thiophen-2-yl)but-3-en-2-yl)sulfonyl)aniline (39).

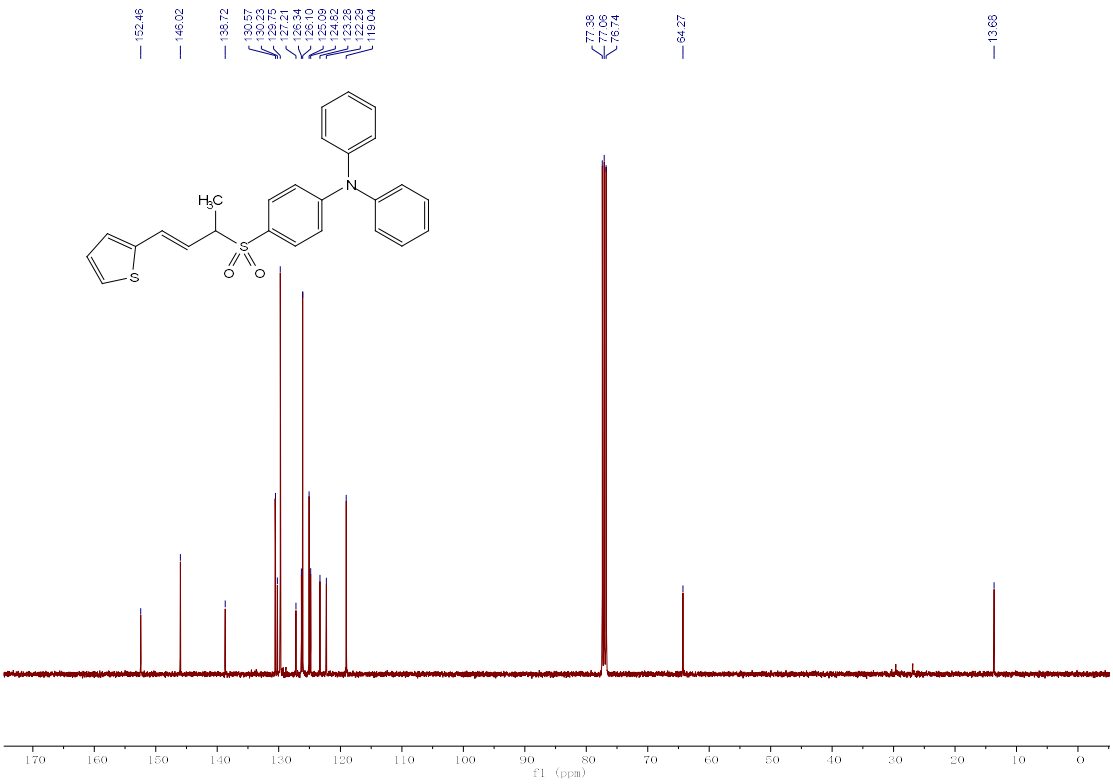


The product (70.4 mg, 79% yield) as yellow oil was purified with silica gel chromatography (petroleum ether/ethyl acetate = 5/1). **^{1}H NMR (400 MHz, $CDCl_3$)** δ 7.49 (d, *J* = 8.8 Hz, 2H), 7.25-7.17 (m, 5H), 7.08-7.02 (m, 8H), 6.89 (d, *J* = 8.4 Hz, 2H), 6.31 (d, *J* = 16.0 Hz, 1H), 5.87 (dd, *J* = 16.0 Hz, 8.4 Hz, 1H), 3.75-3.67 (m, 1H), 1.44 (d, *J* = 6.8 Hz, 3H); **^{13}C NMR (101 MHz, $CDCl_3$)** δ 152.5, 146.0, 138.7, 130.6, 130.2, 129.8, 127.2, 126.3, 126.1, 125.1, 124.8, 123.3, 122.3, 119.0, 64.3, 13.7; **HRMS** Calculated for $C_{26}H_{23}NO_2S_2$ ($M+Na^+$): 468.1062; Found: 468.1064.

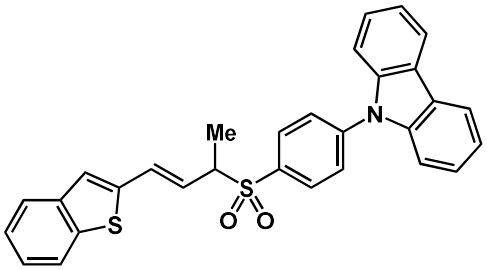
^{1}H NMR spectrum (400 MHz, $CDCl_3$) of compound **39**



^{13}C NMR spectrum (101 MHz, $CDCl_3$) of compound **39**

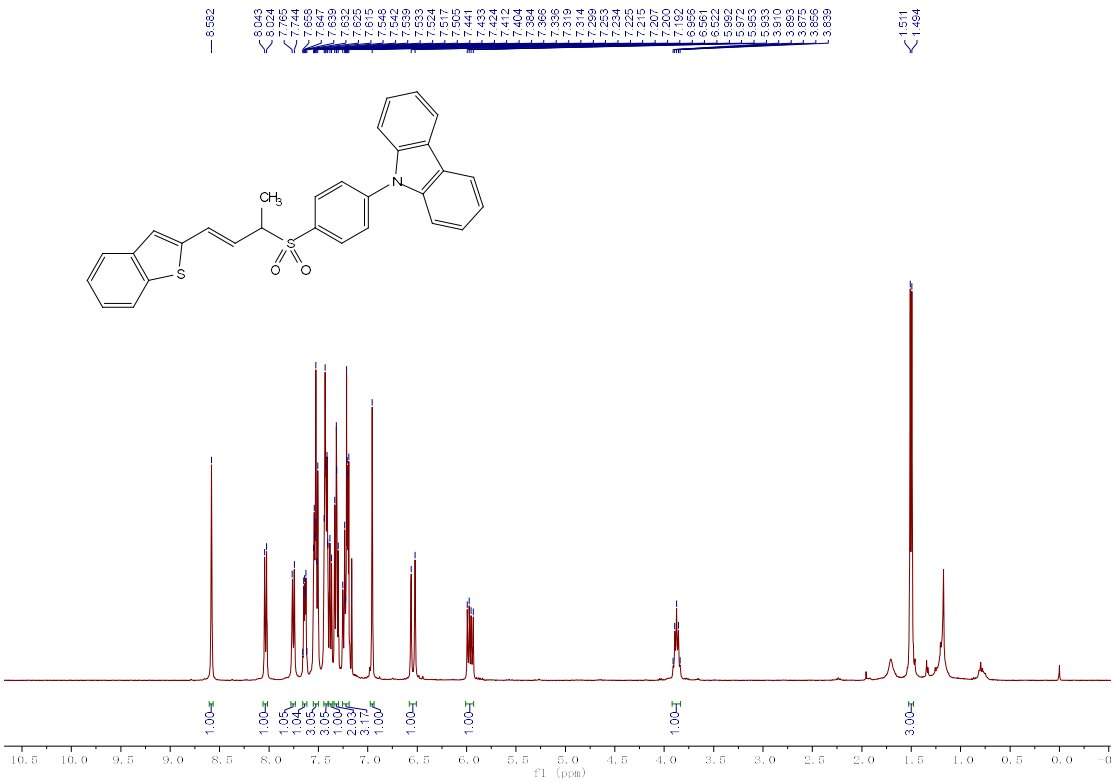


(*E*)-9-(4-((4-(benzo[*b*]thiophen-2-yl)but-3-en-2-yl)sulfonyl)phenyl)-9*H*-carbazole (40).

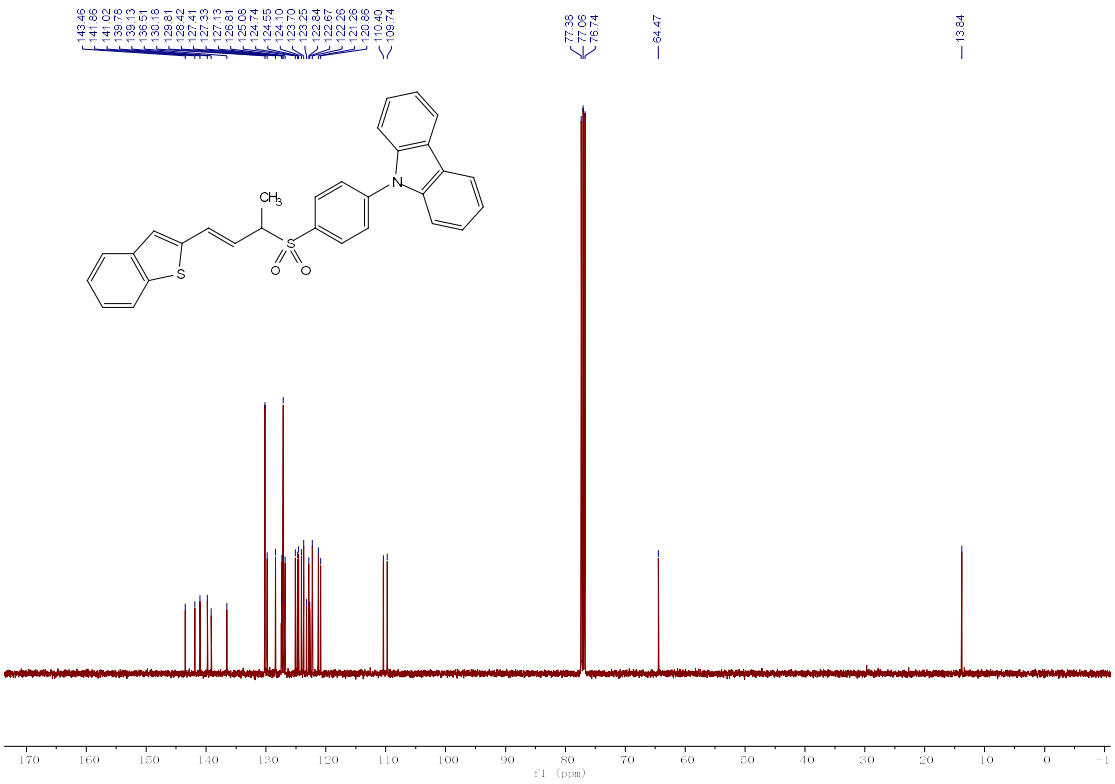


The product (64.2 mg, 65% yield) as brown oil was purified with silica gel chromatography (petroleum ether/ethyl acetate = 5/1). **^{1}H NMR (400 MHz, $CDCl_3$)** δ 8.58 (s, 1H), 8.03 (d, *J* = 7.6 Hz, 1H), 7.75 (d, *J* = 8.4 Hz, 1H), 7.66-7.62 (m, 1H), 7.55-7.51 (m, 3H), 7.44-7.40 (m, 3H), 7.38 (d, *J* = 7.2 Hz, 1H), 7.34-7.30 (m, 2H), 7.25-7.19 (m, 3H), 6.96 (s, 1H), 6.54 (d, *J* = 15.6 Hz, 1H), 5.96 (dd, *J* = 15.6 Hz, 8.0 Hz, 1H), 3.91-3.84 (m, 1H), 1.50 (d, *J* = 6.8 Hz, 3H); **^{13}C NMR (101 MHz, $CDCl_3$)** δ 143.5, 141.9, 141.0, 139.8, 139.1, 136.5, 130.2, 129.8, 128.4, 127.4, 127.3, 127.1, 126.8, 125.1, 124.7, 124.6, 124.1, 123.7, 123.3, 122.8, 122.67, 122.3, 121.3, 120.9, 110.4, 109.7, 64.5, 13.8; **HRMS** Calculated for $C_{30}H_{23}NO_2S_2$ ($M+Na^+$): 516.1062; Found: 516.1064.

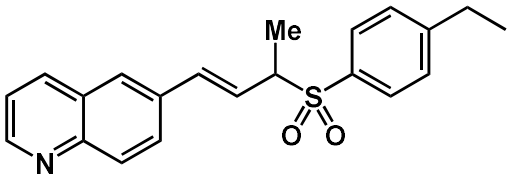
^{1}H NMR spectrum (400 MHz, $CDCl_3$) of compound **40**



^{13}C NMR spectrum (101 MHz, $CDCl_3$) of compound **40**

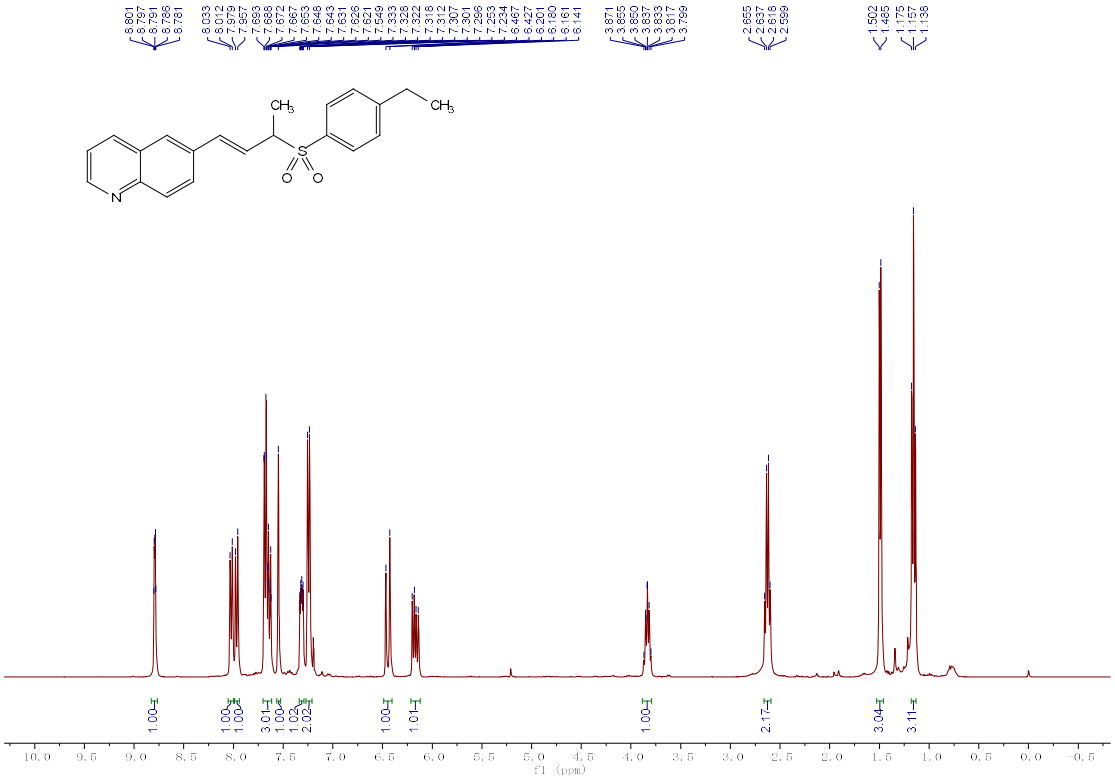


(*E*)-6-(3-((4-ethylphenyl)sulfonyl)but-1-en-1-yl)quinoline (41).

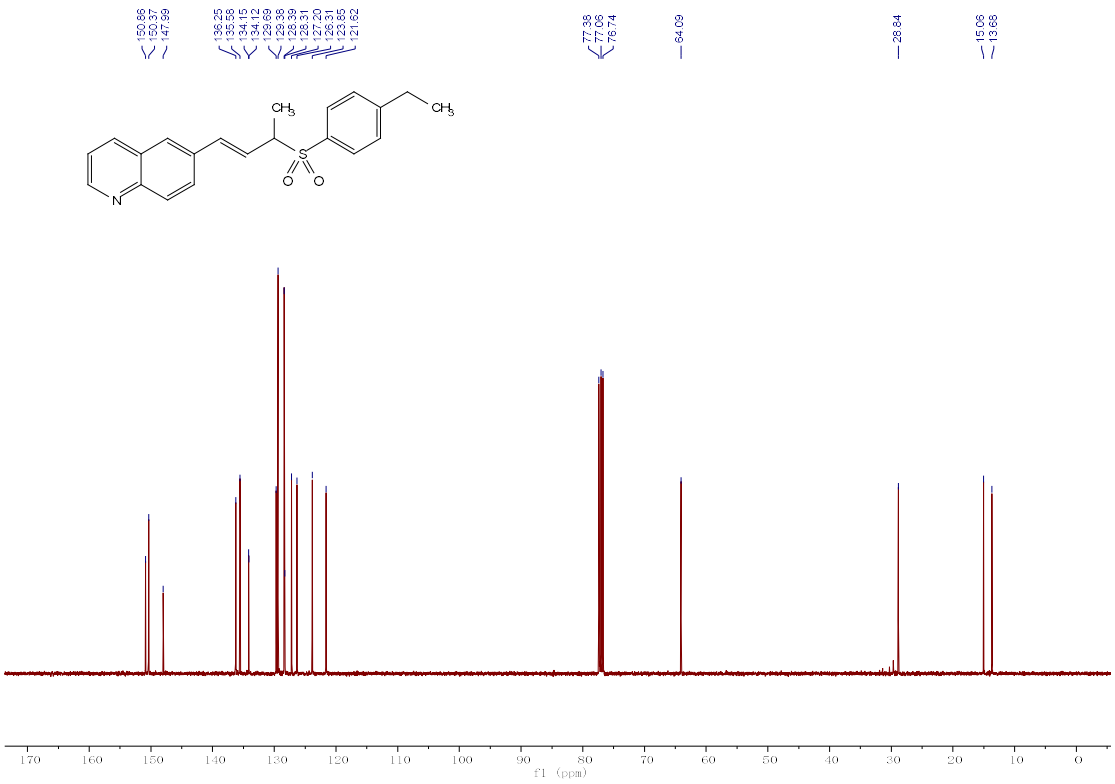


The product (49.2 mg, 70% yield) as yellow solid was purified with silica gel chromatography (petroleum ether/ethyl acetate = 5/1). **^{1}H NMR (400 MHz, $CDCl_3$)** δ 8.80-8.78 (m, 1H), 8.02 (d, *J* = 8.4 Hz, 1H), 7.97 (d, *J* = 8.8 Hz, 1H), 7.69-7.62 (m, 3H), 7.55 (s, 1H), 7.33-7.30 (m, 1H), 7.24 (d, *J* = 7.6 Hz, 2H), 6.45 (d, *J* = 16.0 Hz, 1H), 6.17 (dd, *J* = 16.0 Hz, 8.4 Hz, 1H), 3.87-3.80 (m, 1H), 2.63 (q, *J* = 7.2 Hz, 2H), 1.49 (d, *J* = 6.8 Hz, 3H), 1.16 (t, *J* = 7.2 Hz, 3H); **^{13}C NMR (101 MHz, $CDCl_3$)** δ 150.9, 150.4, 148.0, 136.3, 135.6, 134.15, 134.12, 129.7, 129.4, 128.4, 128.3, 127.2, 126.3, 123.9, 121.6, 64.1, 28.8, 15.1, 13.7; **HRMS** Calculated for $C_{17}H_{19}NO_4S$ ($M+H^+$): 352.1366; Found: 352.1368.

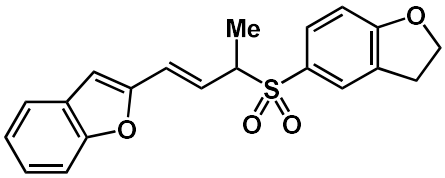
^{1}H NMR spectrum (400 MHz, $CDCl_3$) of compound **41**



^{13}C NMR spectrum (101 MHz, $CDCl_3$) of compound **41**

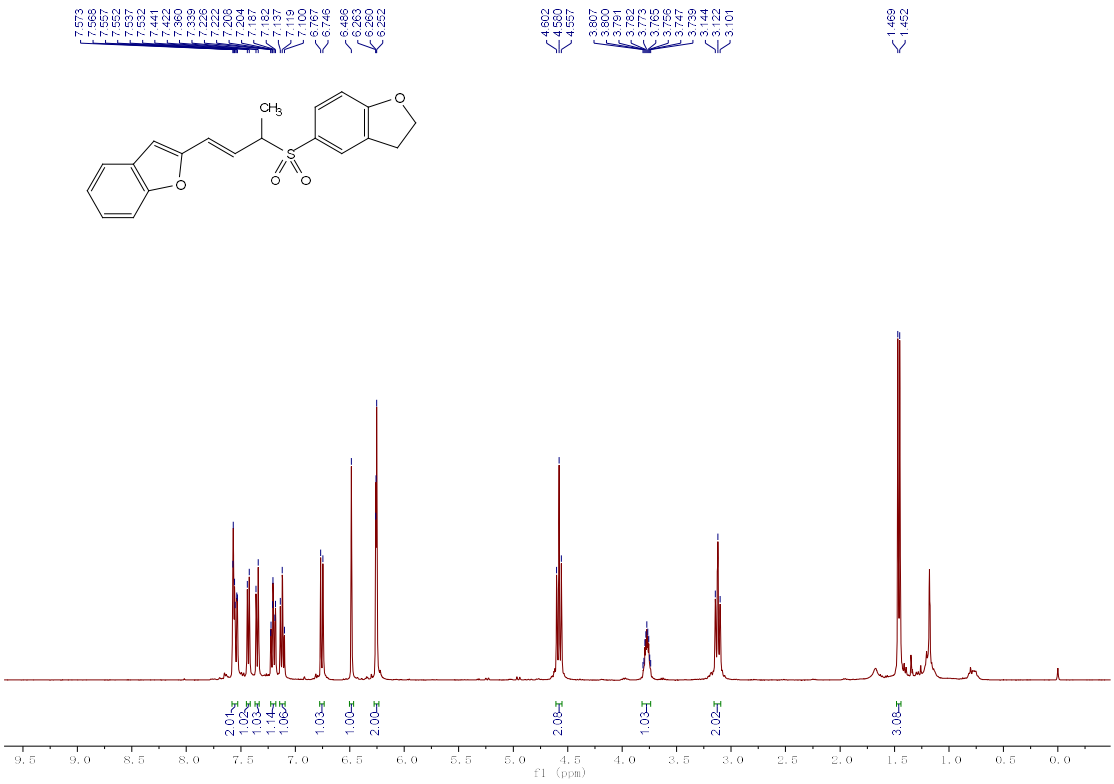


(*E*)-2-(3-((2,3-dihydrobenzofuran-5-yl)sulfonyl)but-1-en-1-yl)benzofuran (42).

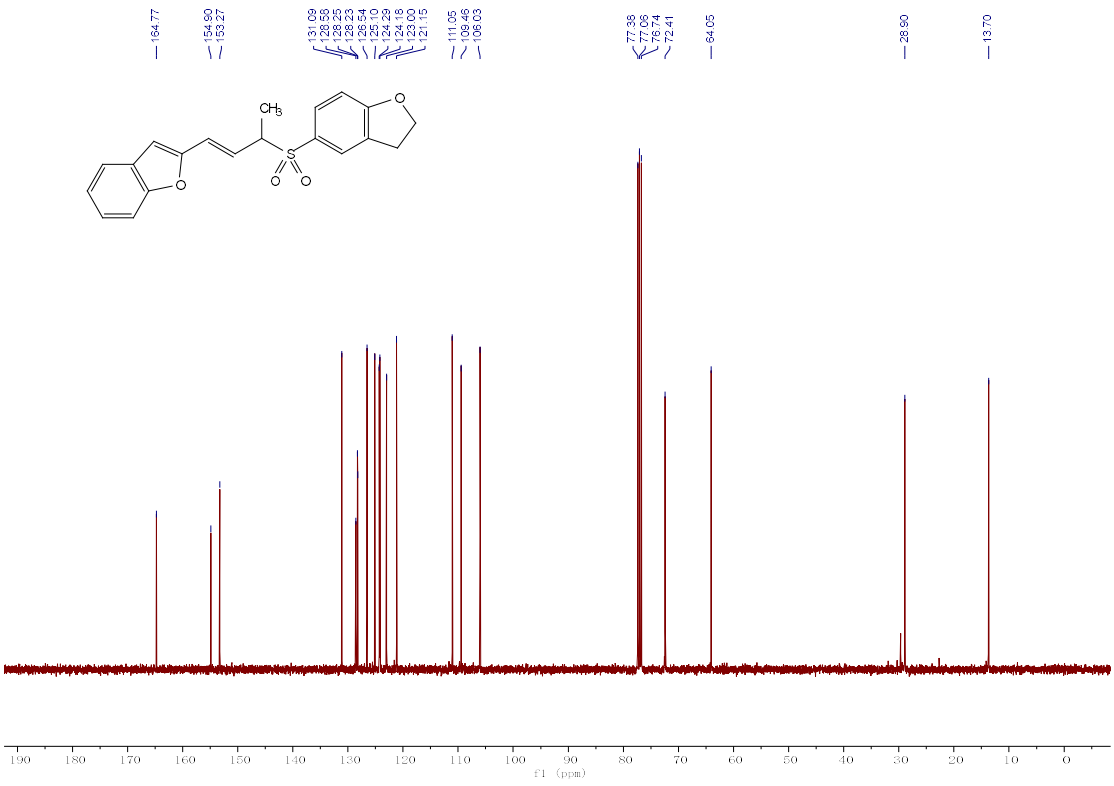


The product (36.9 mg, 52% yield) as yellow solid was purified with silica gel chromatography (petroleum ether/ethyl acetate = 5/1). **^{1}H NMR (400 MHz, $CDCl_3$)** δ 7.57 – 7.53 (m, 2H), 7.43 (d, *J* = 7.6 Hz, 1H), 7.35 (d, *J* = 8.4 Hz, 1H), 7.23 – 7.18 (m, 1H), 7.12 (t, *J* = 7.2 Hz, 1H), 6.76 (d, *J* = 8.4 Hz, 1H), 6.49 (s, 1H), 6.26 – 6.25 (m, 2H), 4.58 (t, *J* = 8.8 Hz, 2H), 3.81 – 3.74 (m, 1H), 3.12 (t, *J* = 8.8 Hz, 2H), 1.46 (d, *J* = 6.8 Hz, 3H); **^{13}C NMR (101 MHz, $CDCl_3$)** δ 164.8, 154.9, 153.3, 131.1, 128.6, 128.3, 128.2, 126.5, 125.1, 124.3, 124.2, 123.0, 121.2, 111.1, 109.5, 106.0, 72.4, 64.1, 28.9, 13.7; **HRMS** Calculated for $C_{20}H_{18}O_4S$ ($M+Na^+$): 377.0818; Found: 377.0817.

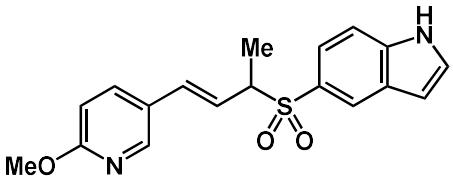
^{1}H NMR spectrum (400 MHz, $CDCl_3$) of compound **42**



^{13}C NMR spectrum (101 MHz, $CDCl_3$) of compound **42**

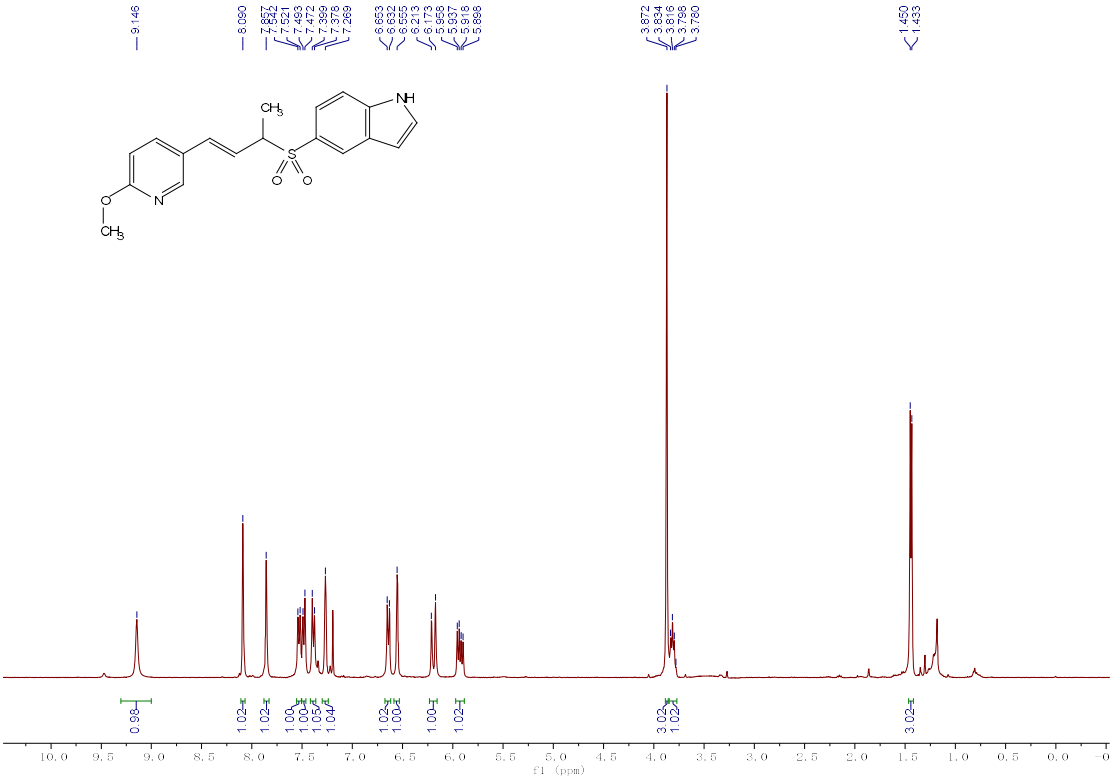


(*E*)-5-((4-(6-methoxypyridin-3-yl)but-3-en-2-yl)sulfonyl)-1*H*-indole (43).

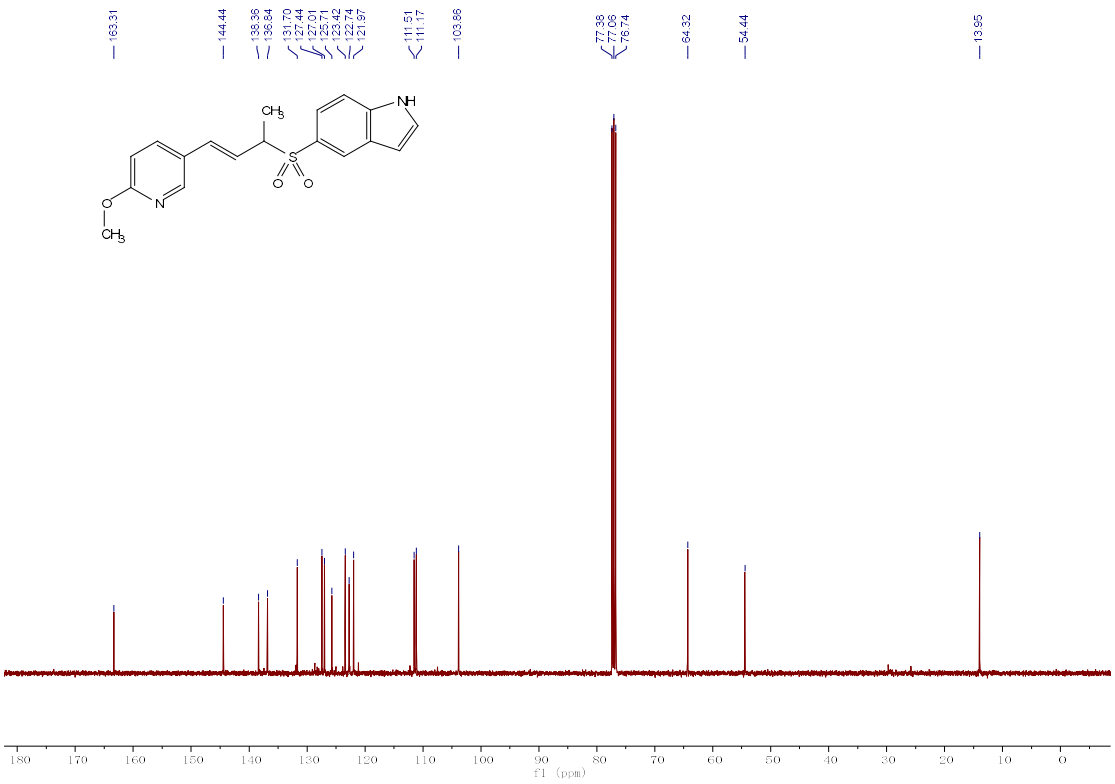


The product (62.3 mg, 91% yield) as white solid was purified with silica gel chromatography (petroleum ether/ethyl acetate = 1/1). **^{1}H NMR (400 MHz, $CDCl_3$)** δ 9.15 (s, 1H), 8.09 (s, 1H), 7.86 (s, 1H), 7.53 (d, *J* = 8.4 Hz, 1H), 7.48 (d, *J* = 8.4 Hz, 1H), 7.39 (d, *J* = 8.4 Hz, 1H), 7.27 (s, 1H), 6.64 (d, *J* = 8.4 Hz, 1H), 6.55 (s, 1H), 6.19 (d, *J* = 16.0 Hz, 1H), 5.93 (dd, *J* = 16.0 Hz, 8.4 Hz, 1H), 3.87 (s, 3H), 3.83-3.78 (m, 1H), 1.44 (d, *J* = 6.8 Hz, 3H); **^{13}C NMR (101 MHz, $CDCl_3$)** δ 163.3, 144.4, 138.4, 136.8, 131.7, 127.4, 127.0, 125.7, 123.4, 122.7, 122.0, 111.5, 111.2, 103.9, 64.3, 54.4, 14.0; **HRMS** Calculated for $C_{18}H_{18}N_2O_3S$ ($M+H^+$): 343.1111; Found: 343.1112.

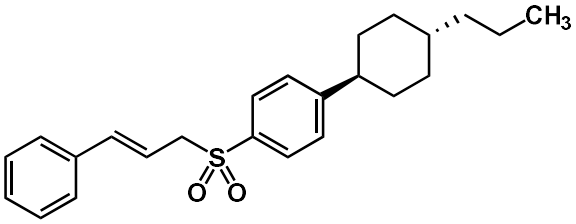
^{1}H NMR spectrum (400 MHz, $CDCl_3$) of compound **43**



^{13}C NMR spectrum (101 MHz, $CDCl_3$) of compound **43**

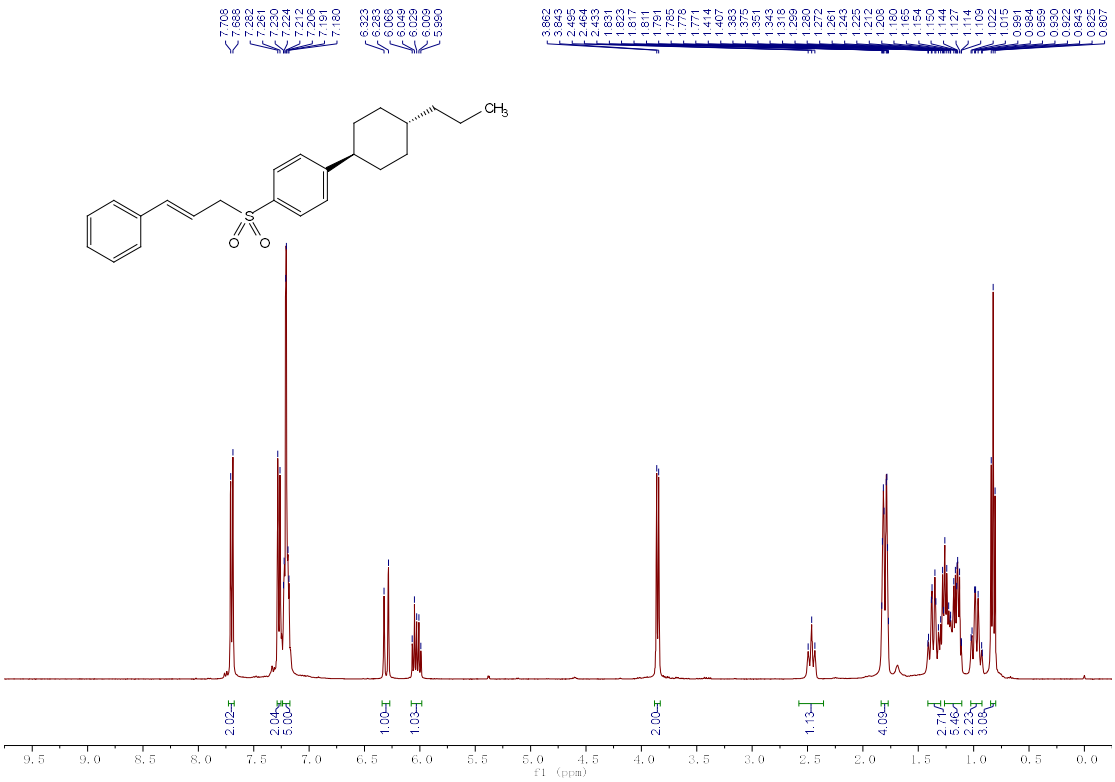


1-(cinnamylsulfonyl)-4-((1*s*,4*r*)-4-propylcyclohexyl)benzene (44).

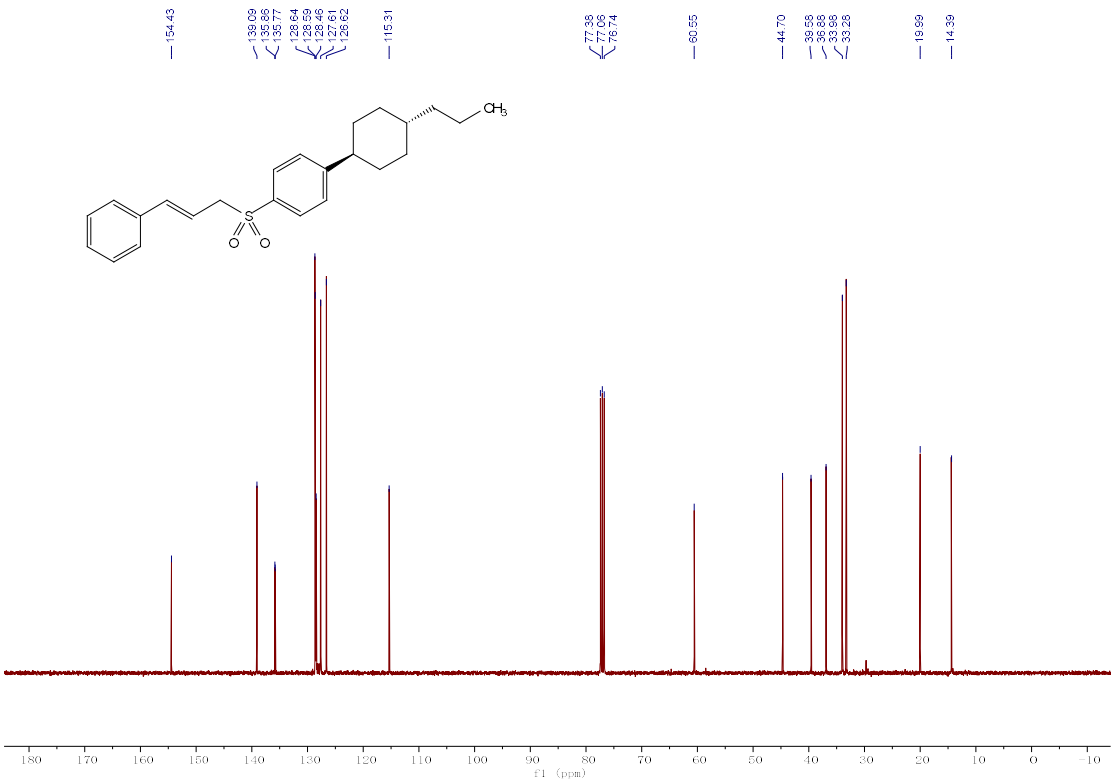


The product (55.9 mg, 73% yield) as yellow solid was purified with silica gel chromatography (petroleum ether/ethyl acetate = 10/1). **^{1}H NMR (400 MHz, $CDCl_3$)** δ 7.70 (d, *J* = 8.0 Hz, 2H), 7.27 (d, *J* = 8.4 Hz, 2H), 7.23-7.18 (m, 5H), 6.30 (d, *J* = 16.0 Hz, 1H), 6.07-5.99 (m, 1H), 3.85 (d, *J* = 7.6 Hz, 2H), 2.46 (t, *J* = 12.4 Hz, 1H), 1.83-1.77 (m, 4H), 1.41-1.32 (m, 2H), 1.30-1.11 (m, 5H), 1.02-0.92 (m, 2H), 0.82 (t, *J* = 7.2 Hz, 3H); **^{13}C NMR (101 MHz, $CDCl_3$)** δ 154.4, 139.1, 135.9, 135.8, 128.64, 128.59, 128.5, 127.6, 126.6, 115.3, 60.6, 44.7, 39.6, 36.9, 34.0, 33.3, 20.0, 14.4; **HRMS** Calculated for $C_{24}H_{30}O_2S$ ($M+Na^+$): 405.1859; Found: 405.1858.

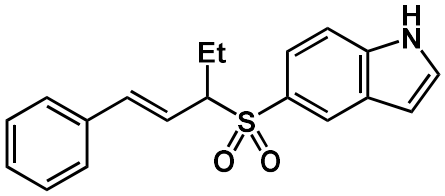
^{1}H NMR spectrum (400 MHz, $CDCl_3$) of compound **44**



^{13}C NMR spectrum (101 MHz, $CDCl_3$) of compound **44**

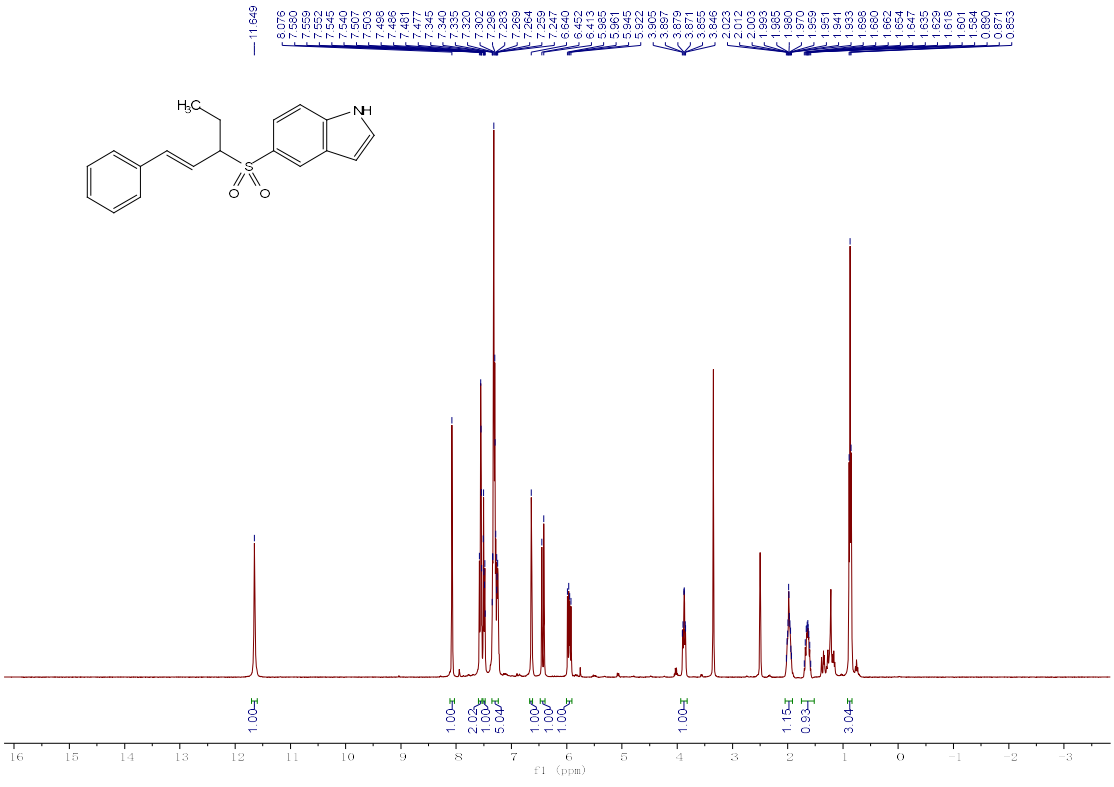


(*E*)-5-((1-phenylpent-1-en-3-yl)sulfonyl)-1*H*-indole (45).

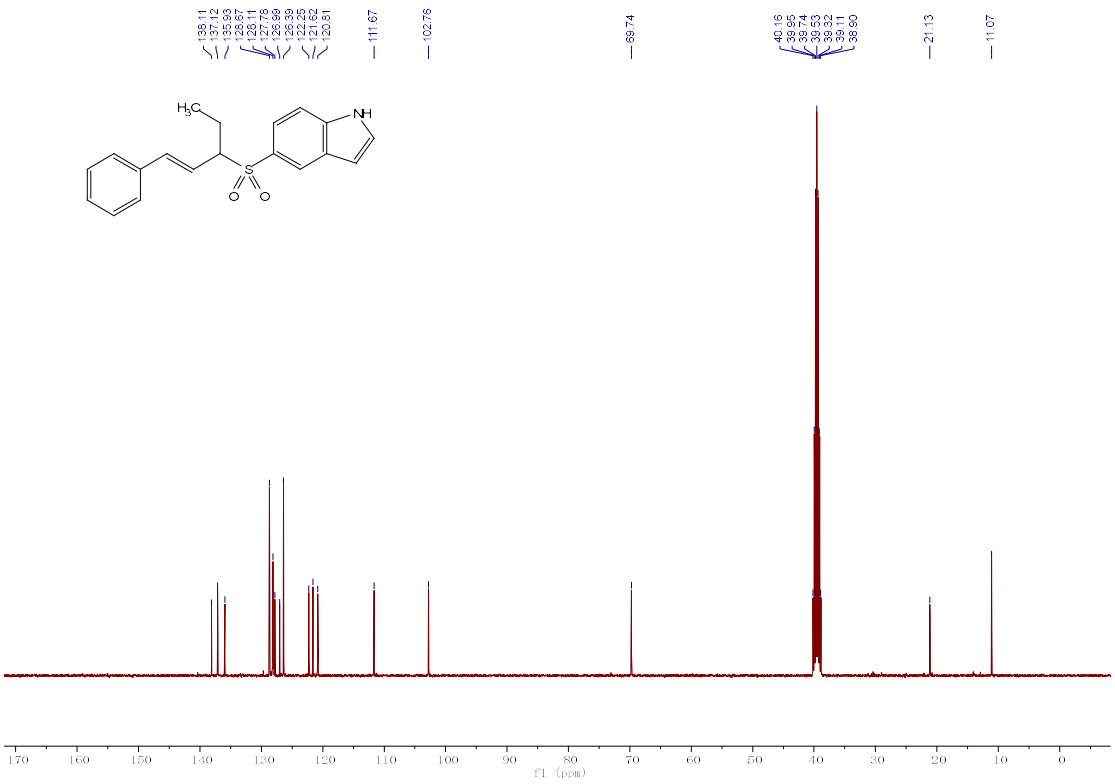


The product (52.7 mg, 81% yield) as light yellow solid was purified with silica gel chromatography (petroleum ether/ethyl acetate = 2/1). **^{1}H NMR (400 MHz, DMSO-d_6)** δ 11.65 (s, 1H), 8.08 (s, 1H), 7.58-7.54 (m, 2H), 7.51-7.48 (m, 1H), 7.35-7.25 (m, 5H), 6.64 (s, 1H), 6.43 (d, *J* = 15.6 Hz, 1H), 5.95 (dd, *J* = 16.0 Hz, 9.6 Hz, 1H), 3.91-3.85 (m, 1H), 2.02-1.93 (m, 1H), 1.70-1.58 (m, 1H), 0.87 (t, *J* = 7.6 Hz, 3H); **^{13}C NMR (101 MHz, DMSO-d_6)** δ 138.1, 137.1, 135.9, 128.7, 128.1, 127.8, 127.0, 126.4, 122.3, 121.6, 120.8, 111.7, 102.8, 69.7, 21.1, 11.1; **HRMS** Calculated for $C_{19}H_{19}NO_2S$ (M+Na$^+$): 348.1029; Found: 348.1028.

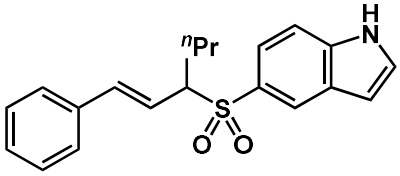
^{1}H NMR spectrum (400 MHz, DMSO-d_6) of compound **45**



^{13}C NMR spectrum (101 MHz, DMSO-d_6) of compound **45**

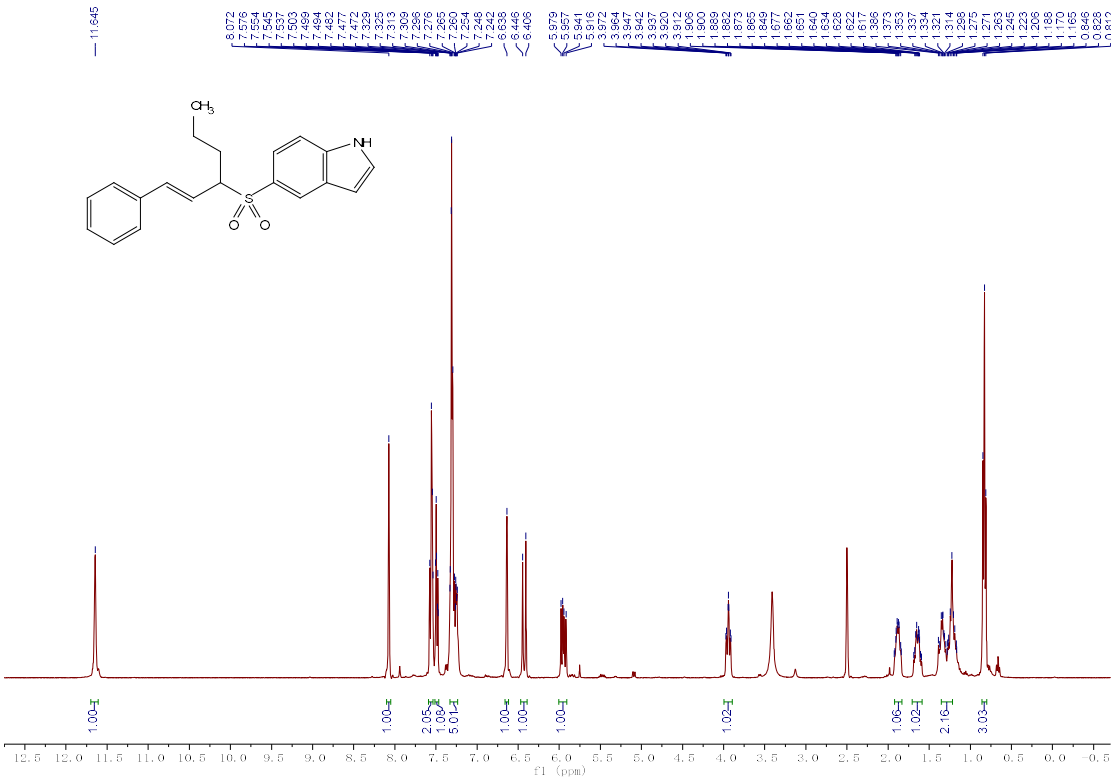


(*E*)-5-((1-phenylhex-1-en-3-yl)sulfonyl)-1*H*-indole (46).

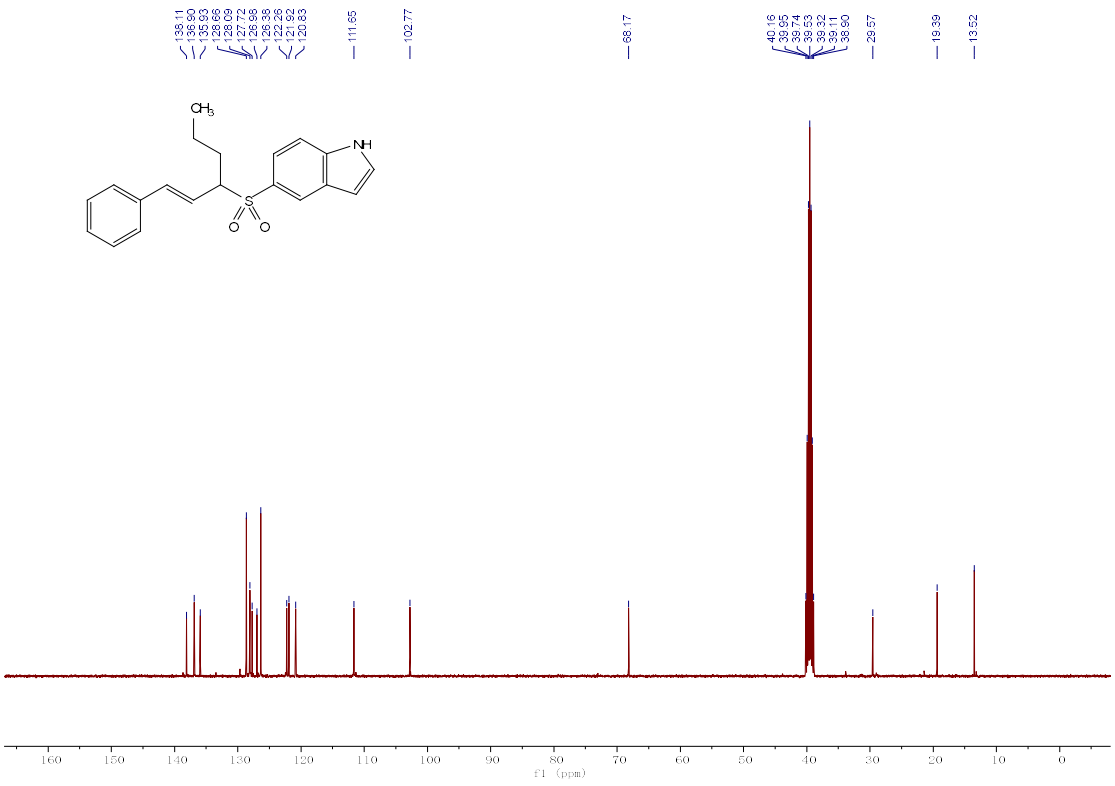


The product (50.2 mg, 74% yield) as pink solid was purified with silica gel chromatography (petroleum ether/ethyl acetate = 2/1). **^{1}H NMR (400 MHz, DMSO-d_6)** δ 11.65 (s, 1H), 8.07 (s, 1H), 7.58-7.54 (m, 2H), 7.50-7.47 (m, 1H), 7.33-7.24 (m, 5H), 6.64 (s, 1H), 6.43 (d, J = 16.0 Hz, 1H), 5.95 (dd, J = 15.2 Hz, 8.8 Hz, 1H), 3.97-3.91 (m, 1H), 1.92-1.84 (m, 1H), 1.69-1.59 (m, 1H), 1.39-1.17 (m, 2H), 0.83 (t, J = 7.2 Hz, 3H); **^{13}C NMR (101 MHz, DMSO-d_6)** δ 138.1, 136.9, 135.9, 128.7, 128.1, 127.7, 127.0, 126.4, 122.3, 121.9, 120.8, 111.7, 102.8, 68.2, 29.6, 19.4, 13.5; **HRMS** Calculated for $C_{20}H_{21}NO_2S$ ($M+Na^+$): 362.1185; Found: 362.1185.

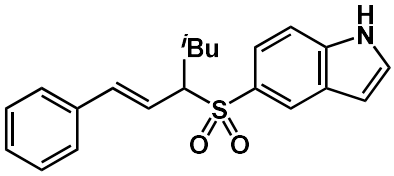
^{1}H NMR spectrum (400 MHz, DMSO-d_6) of compound **46**



^{13}C NMR spectrum (101 MHz, DMSO-d_6) of compound **46**

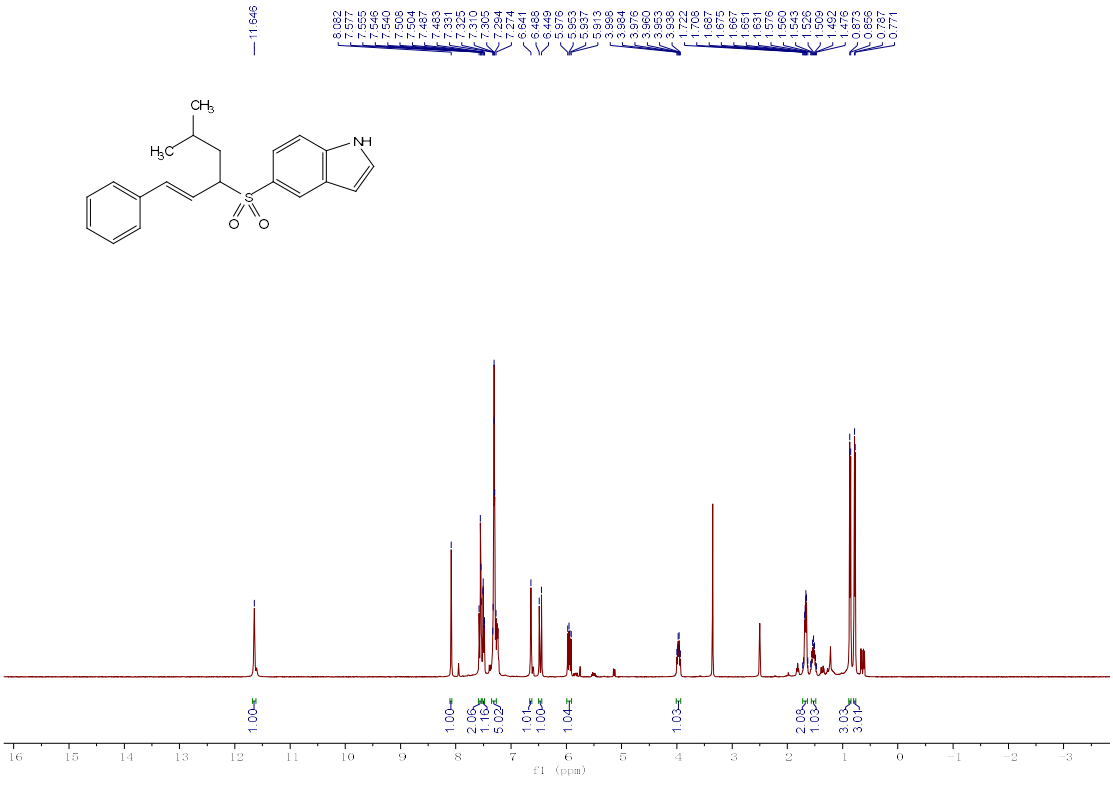


(*E*)-5-((5-methyl-1-phenylhex-1-en-3-yl)sulfonyl)-1*H*-indole (47).

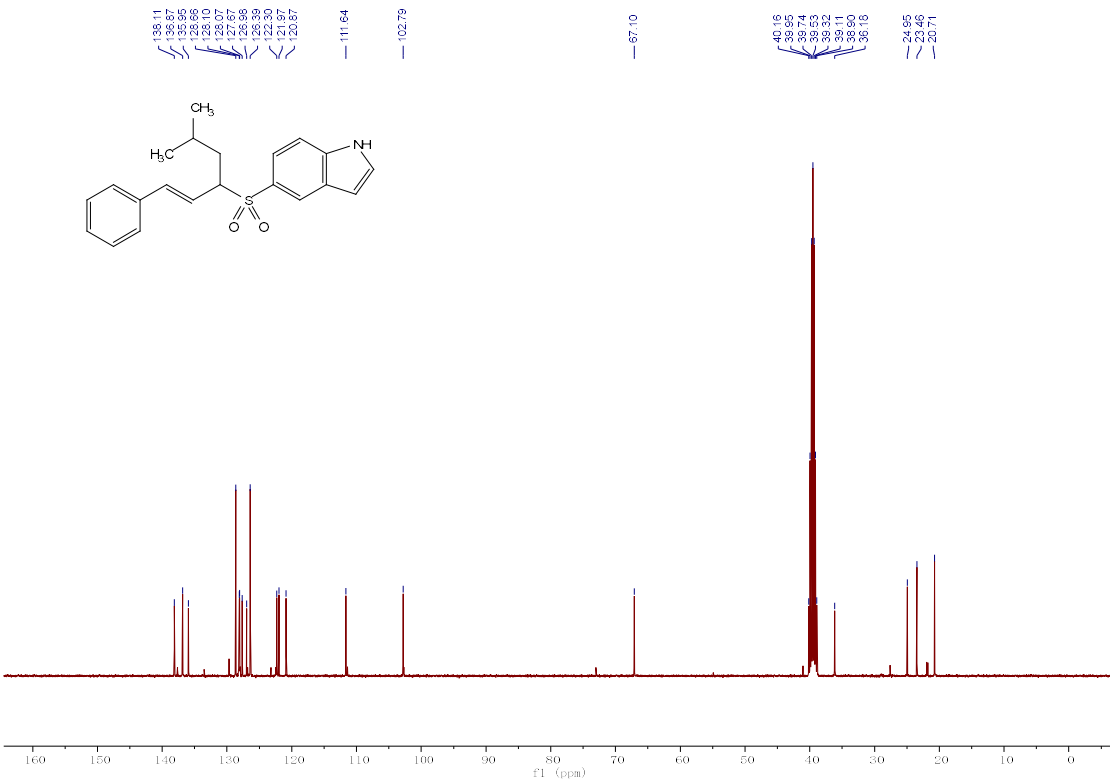


The product (55.1 mg, 78% yield) as pink solid was purified with silica gel chromatography (petroleum ether/ethyl acetate = 2/1). **^{1}H NMR (400 MHz, DMSO-d_6)** δ 11.65 (s, 1H), 8.08 (s, 1H), 7.58-7.54 (m, 2H), 7.51-7.48 (m, 1H), 7.33-7.27 (m, 5H), 6.64 (s, 1H), 6.47 (d, *J* = 15.6 Hz, 1H), 5.94 (dd, *J* = 15.6 Hz, 9.2 Hz, 1H), 4.00-3.94 (m, 1H), 1.72-1.63 (m, 2H), 1.58-1.48 (m, 1H), 0.86 (d, *J* = 6.8 Hz, 3H), 0.78 (d, *J* = 6.4 Hz, 3H); **^{13}C NMR (101 MHz, DMSO-d_6)** δ 138.1, 136.9, 136.0, 128.7, 128.10, 128.07, 127.7, 127.0, 126.4, 122.3, 122.0, 120.9, 111.6, 102.8, 67.1, 36.2, 25.0, 23.5, 20.7; **HRMS** Calculated for $C_{21}H_{23}NO_2S$ (M+Na$^+$): 376.1342; Found: 376.1342.

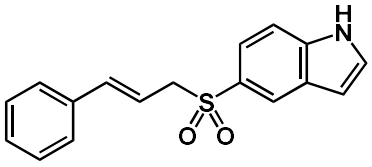
^{1}H NMR spectrum (400 MHz, DMSO-d_6) of compound **47**



^{13}C NMR spectrum (101 MHz, DMSO-d_6) of compound **47**

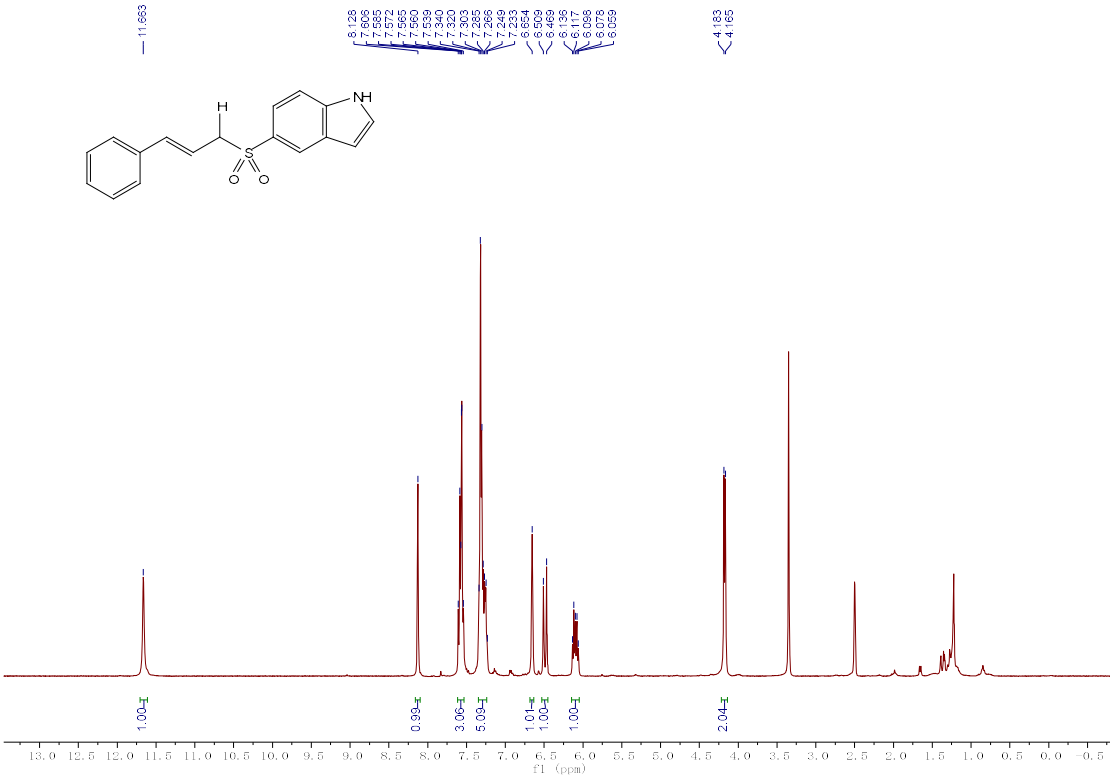


5-(cinnamylsulfonyl)-1*H*-indole (51).

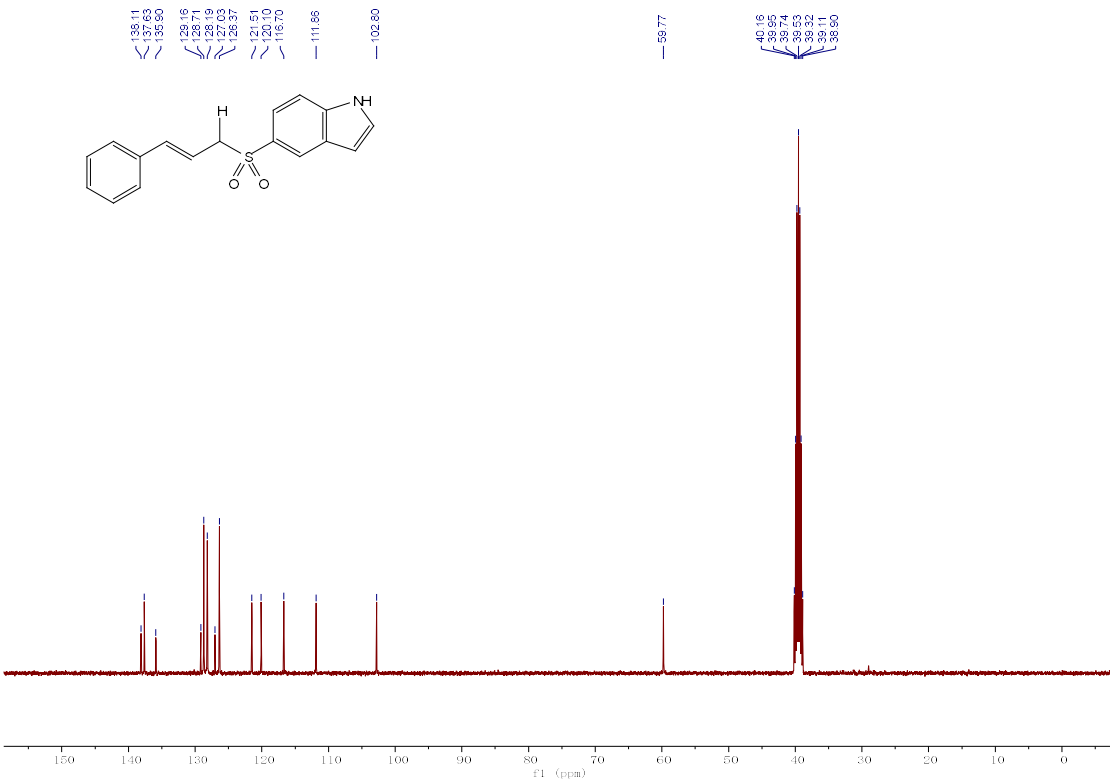


The product (42.8 mg, 72% yield) as white solid was purified with silica gel chromatography (petroleum ether/ethyl acetate = 2/1). **^{1}H NMR (400 MHz, DMSO-d_6)** δ 11.66 (s, 1H), 8.13 (s, 1H), 7.61-7.54 (m, 3H), 7.34-7.23 (m, 5H), 6.65 (s, 1H), 6.49 (d, J = 16.0 Hz, 1H), 6.14-6.06 (m, 1H), 4.17 (d, J = 7.2 Hz, 2H); **^{13}C NMR (101 MHz, DMSO-d_6)** δ 138.1, 137.6, 135.9, 129.2, 128.7, 128.2, 127.0, 126.4, 121.5, 120.1, 116.7, 111.9, 102.8, 59.8; **HRMS** Calculated for $C_{17}H_{15}NO_2S$ ($M+Na^+$): 320.0716; Found: 320.0715.

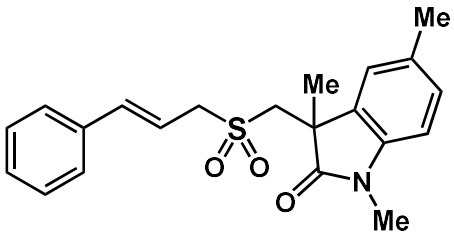
^{1}H NMR spectrum (400 MHz, DMSO-d_6) of compound **51**



^{13}C NMR spectrum (101 MHz, DMSO-d_6) of compound **51**

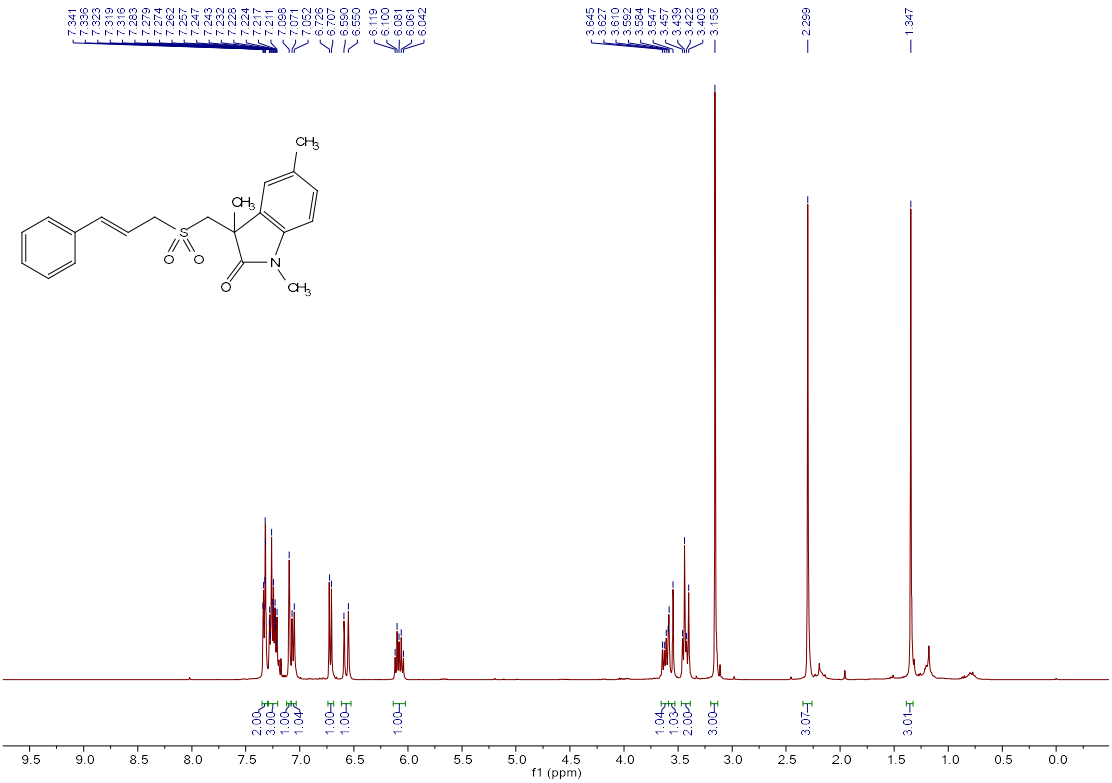


3-((cinnamylsulfonyl)methyl)-1,3,5-trimethylindolin-2-one (52).

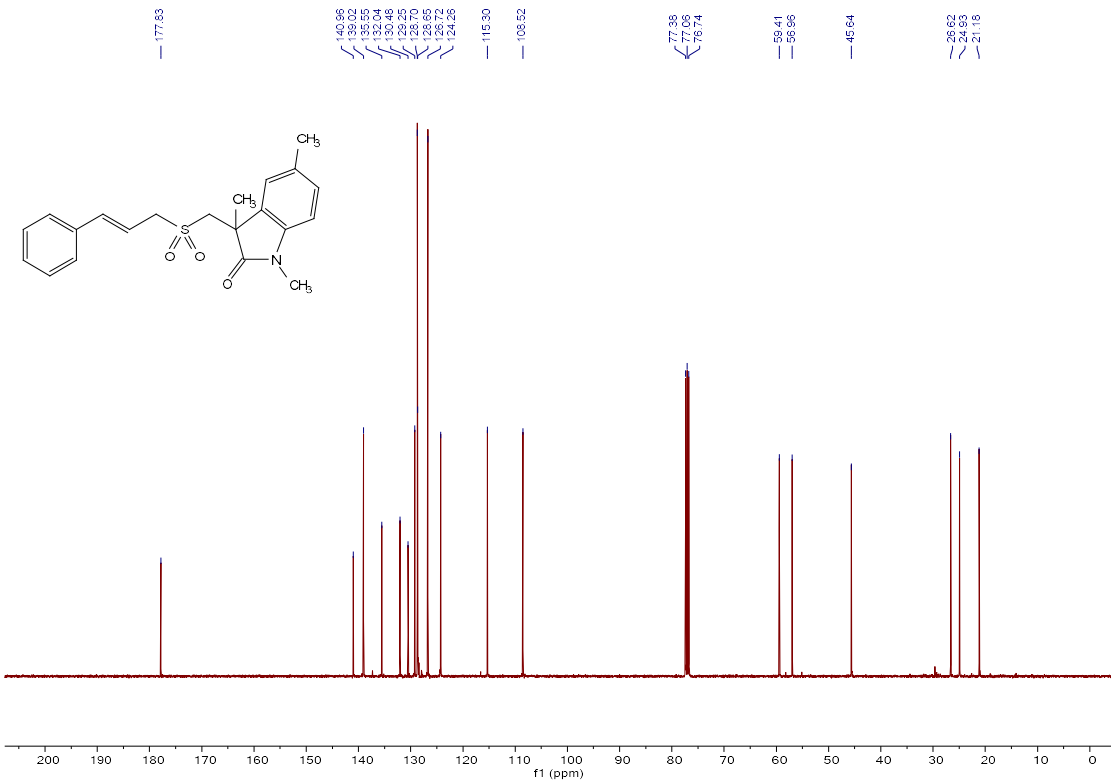


The product (62.8 mg, 85% yield) as white solid was purified with silica gel chromatography (petroleum ether/ethyl acetate = 2/1). **^{1}H NMR (400 MHz, $CDCl_3$)** δ 7.34-7.32 (m, 2H), 7.28-7.21 (m, 3H), 7.10 (s, 1H), 7.06 (d, *J* = 7.6 Hz, 1H), 6.72 (d, *J* = 7.6 Hz, 1H), 6.57 (d, *J* = 16.0 Hz, 1H), 6.12-6.04 (m, 1H), 3.62 (dd, *J* = 14.0 Hz, 7.2 Hz, 1H), 3.57 (d, *J* = 14.8 Hz, 1H), 3.46-3.40 (m, 2H), 3.16 (s, 3H), 2.30 (s, 3H), 1.35 (s, 3H); **^{13}C NMR (101 MHz, $CDCl_3$)** δ 177.8, 141.0, 139.0, 135.6, 132.0, 130.5, 129.3, 128.70, 128.65, 126.7, 124.3, 115.3, 108.5, 59.4, 57.0, 45.6, 26.6, 24.9, 21.2; **HRMS** Calculated for $C_{21}H_{23}NO_3S$ ($M+H^+$): 370.1471; Found: 370.1472.

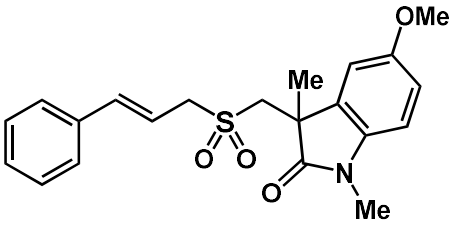
^{1}H NMR spectrum (400 MHz, $CDCl_3$) of compound **52**



^{13}C NMR spectrum (101 MHz, $CDCl_3$) of compound **52**

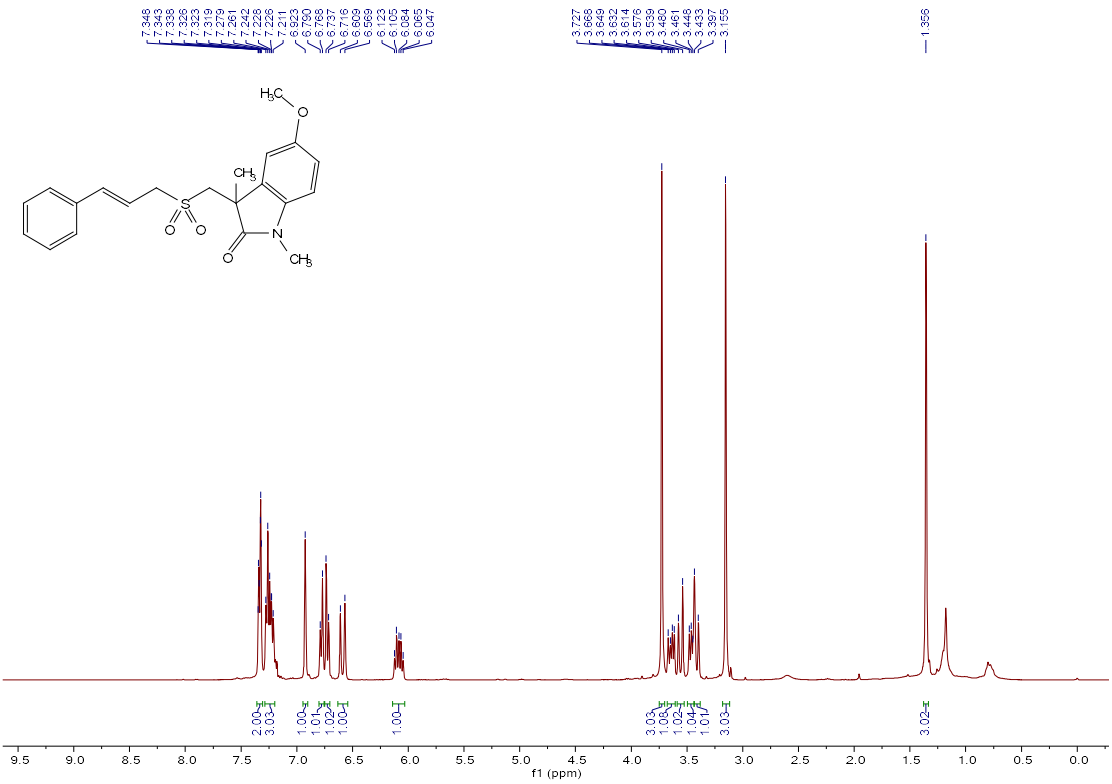


3-((cinnamylsulfonyl)methyl)-5-methoxy-1,3-dimethylindolin-2-one (53).

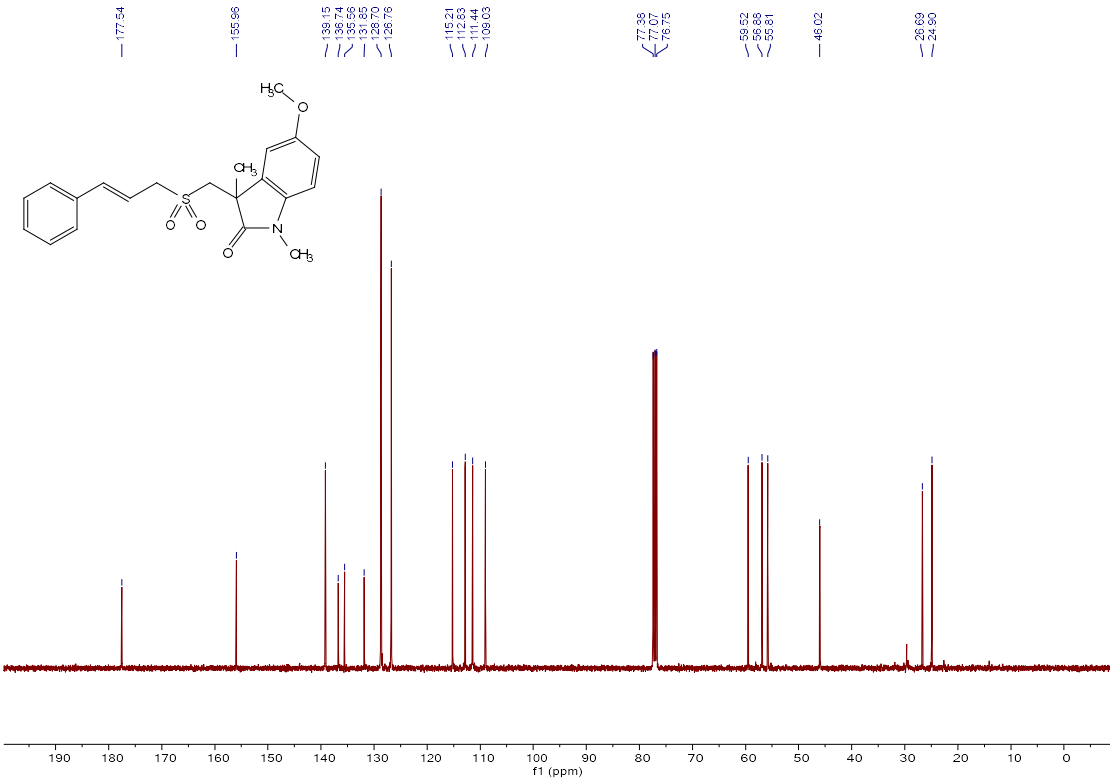


The product (68.6 mg, 89% yield) as light yellow solid was purified with silica gel chromatography (petroleum ether/ethyl acetate = 2/1). **^{1}H NMR (400 MHz, $CDCl_3$)** δ 7.35-7.32 (m, 2H), 7.28-7.21 (m, 3H), 6.92 (s, 1H), 6.78 (d, *J* = 8.8 Hz, 1H), 6.73 (d, *J* = 8.4 Hz, 1H), 6.59 (d, *J* = 16.0 Hz, 1H), 6.12-6.05 (m, 1H), 3.73 (s, 3H), 3.64 (dd, *J* = 14.4 Hz, 7.2 Hz, 1H), 3.56 (d, *J* = 14.8 Hz, 1H), 3.45 (dd, *J* = 15.2 Hz, 7.6 Hz, 1H), 3.42 (d, *J* = 14.8 Hz, 1H), 3.16 (s, 3H), 1.36 (s, 3H).**^{13}C NMR (101 MHz, $CDCl_3$)** δ 177.5, 156.0, 139.2, 136.7, 135.6, 131.9, 128.7, 126.8, 115.2, 112.8, 111.4, 109.0, 59.5, 56.9, 55.8, 46.0, 26.7, 24.9; **HRMS** Calculated for $C_{21}H_{23}NO_4S$ ($M+H^+$): 386.1421; Found: 386.1422.

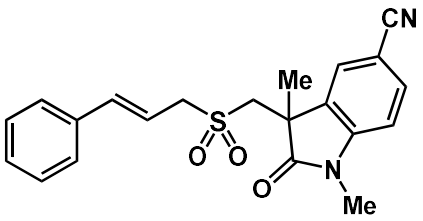
^{1}H NMR spectrum (400 MHz, $CDCl_3$) of compound **53**



^{13}C NMR spectrum (101 MHz, $CDCl_3$) of compound **53**

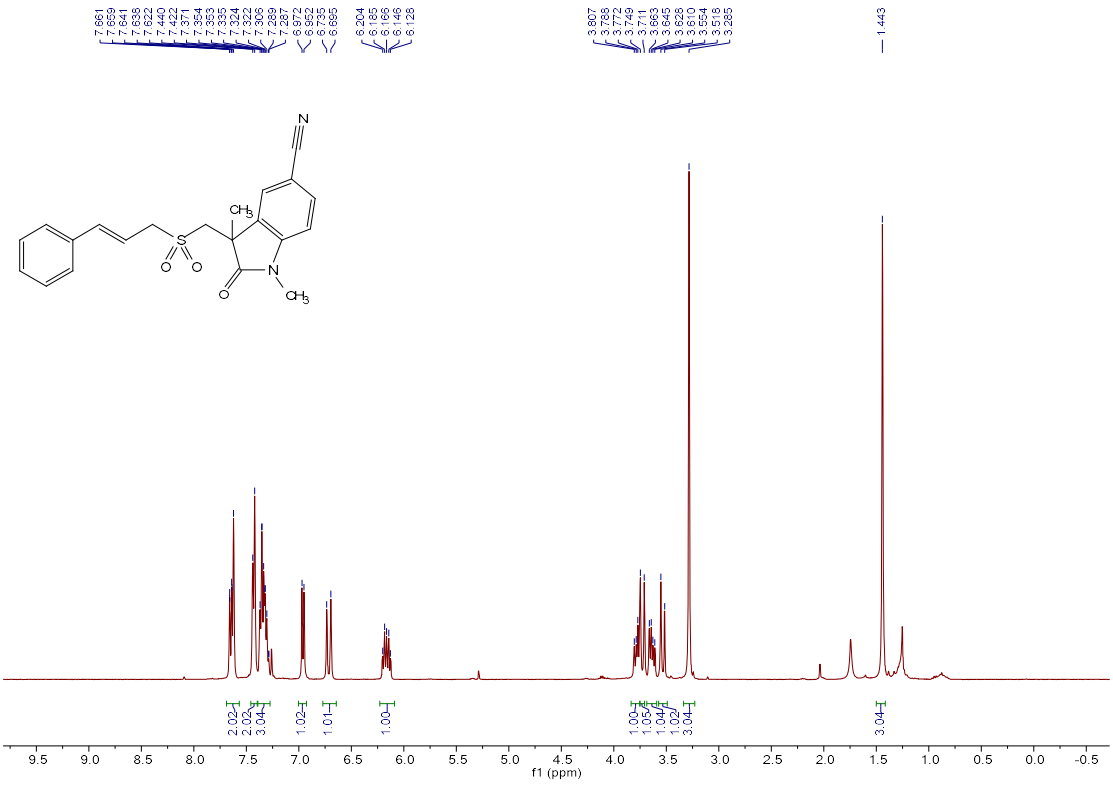


3-((cinnamylsulfonyl)methyl)-1,3-dimethyl-2-oxoindoline-5-carbonitrile (54).

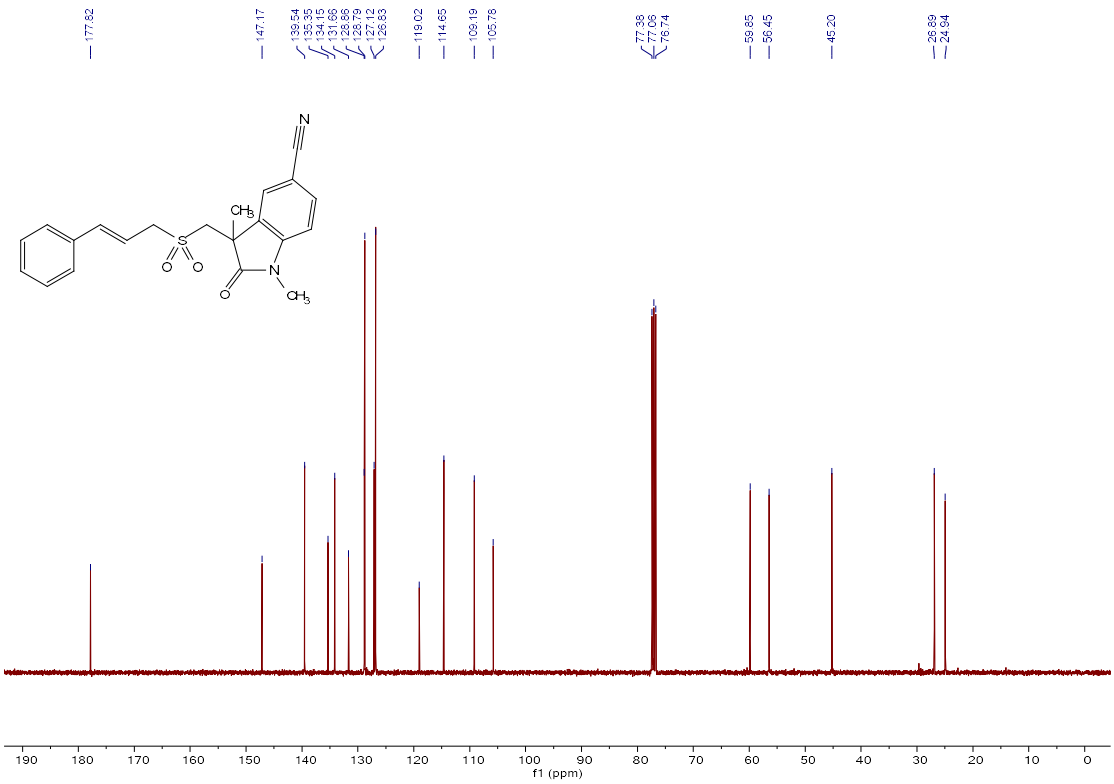


The product (48.7 mg, 64% yield) as white solid was purified with silica gel chromatography (petroleum ether/ethyl acetate = 1/1). **^{1}H NMR (400 MHz, $CDCl_3$)** δ 7.66-7.62 (m, 2H), 7.43 (d, *J* = 7.2 Hz, 2H), 7.37-7.29 (m, 3H), 6.96 (d, *J* = 8.0 Hz, 1H), 6.72 (d, *J* = 16.0 Hz, 1H), 6.20-6.13 (m, 1H), 3.78 (dd, *J* = 14.0 Hz, 7.6 Hz, 1H), 3.73 (d, *J* = 15.2 Hz, 1H), 3.64 (dd, *J* = 14.1 Hz, 7.3 Hz, 1H), 3.54 (d, *J* = 14.4 Hz, 1H), 3.28 (s, 3H), 1.44 (s, 3H); **^{13}C NMR (101 MHz, $CDCl_3$)** δ 177.8, 147.2, 139.5, 135.4, 134.2, 131.7, 128.9, 128.8, 127.1, 126.8, 119.0, 114.7, 109.2, 105.8, 59.9, 56.5, 45.2, 26.9, 24.9; **HRMS** Calculated for $C_{21}H_{20}N_2O_3S$ ($M+H^+$): 381.1267; Found: 381.1267.

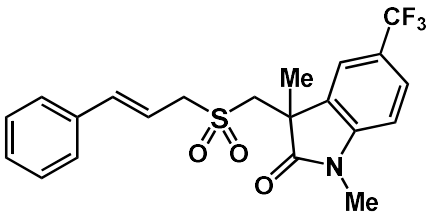
^{1}H NMR spectrum (400 MHz, $CDCl_3$) of compound **54**



^{13}C NMR spectrum (101 MHz, $CDCl_3$) of compound **54**

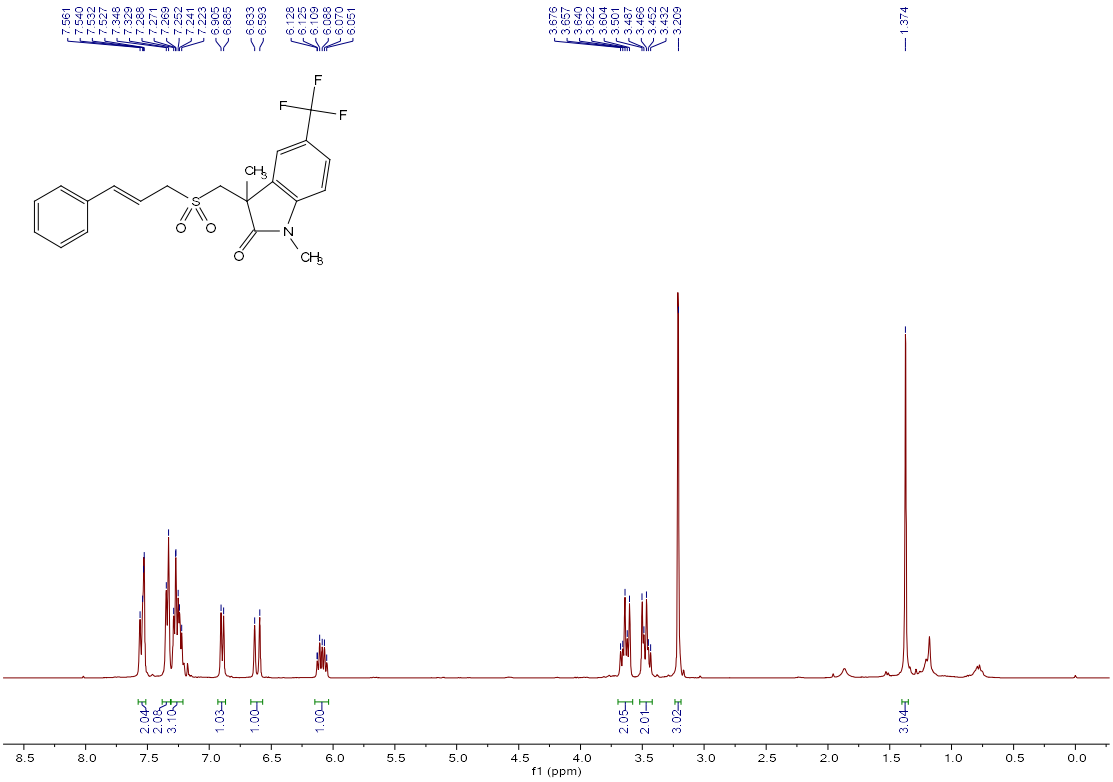


3-((cinnamylsulfonyl)methyl)-1,3-dimethyl-5-(trifluoromethyl)indolin-2-one (55).

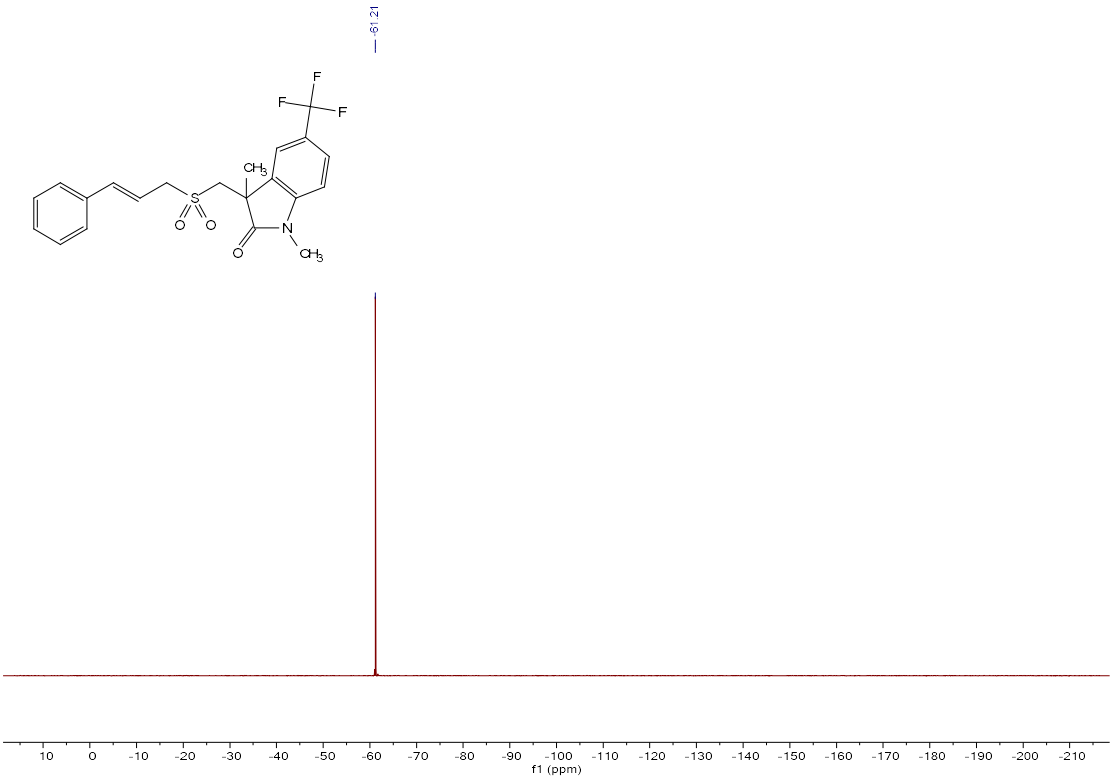


The product (67.8 mg, 80% yield) as white solid was purified with silica gel chromatography (petroleum ether/ethyl acetate = 2/1). **^{1}H NMR (400 MHz, $CDCl_3$)** δ 7.56-7.53 (m, 2H), 7.34 (d, *J* = 7.6 Hz, 2H), 7.29-7.22 (m, 3H), 6.90 (d, *J* = 8.0 Hz, 1H), 6.61 (d, *J* = 16.0 Hz, 1H), 6.13-6.05 (m, 1H), 3.68-3.60 (m, 2H), 3.50-3.43 (m, 2H), 3.21 (s, 3H), 1.37 (s, 3H); **^{19}F NMR (376 MHz, $CDCl_3$)** δ -61.2 (s, 3F); **^{13}C NMR (101 MHz, $CDCl_3$)** δ 178.0, 146.4, 139.3, 135.4, 131.1, 128.81, 128.77, 126.8-126.7 (m, 2C), 124.8 (q, *J* = 33.3 Hz), 124.3 (q, *J* = 272.7 Hz), 120.7 (q, *J* = 4.0 Hz), 115.0, 108.6, 60.0, 56.6, 45.5, 26.9, 24.9; **HRMS** Calculated for $C_{21}H_{20}F_3NO_3S$ ($M+H^+$): 424.1189; Found: 424.1190.

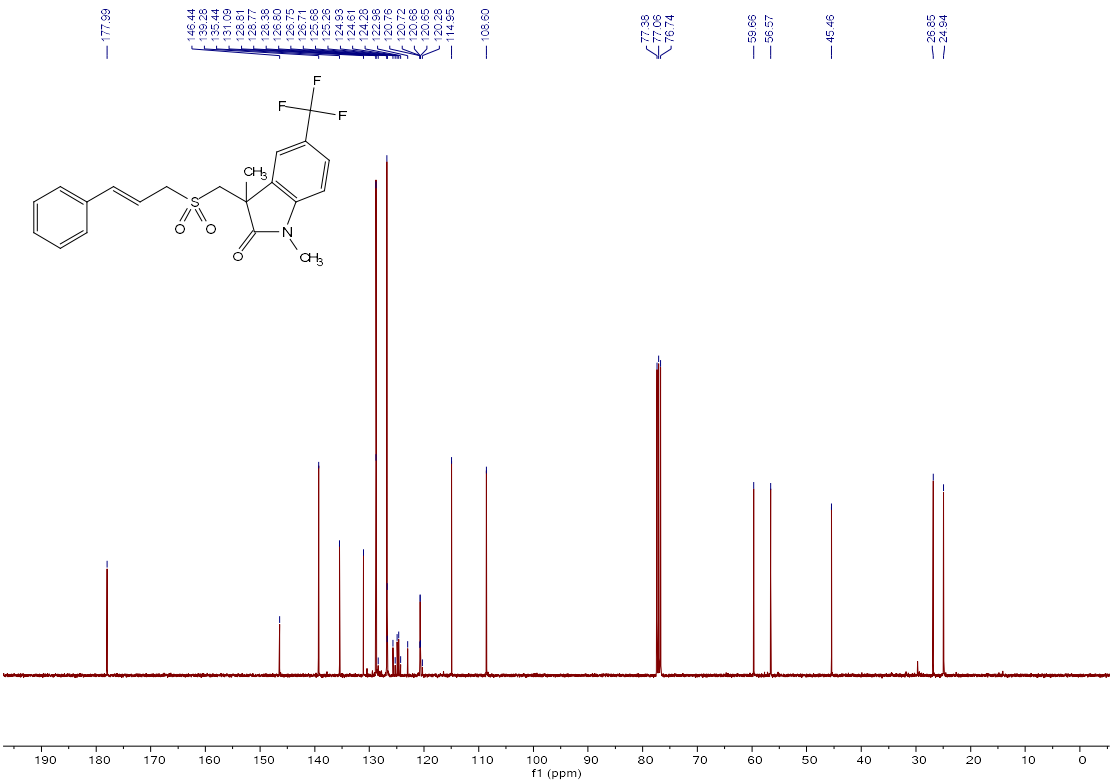
^{1}H NMR spectrum (400 MHz, $CDCl_3$) of compound **55**



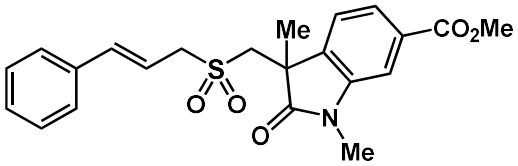
^{19}F NMR spectrum (376 MHz, $CDCl_3$) of compound **55**



^{13}C NMR spectrum (101 MHz, $CDCl_3$) of compound **55**

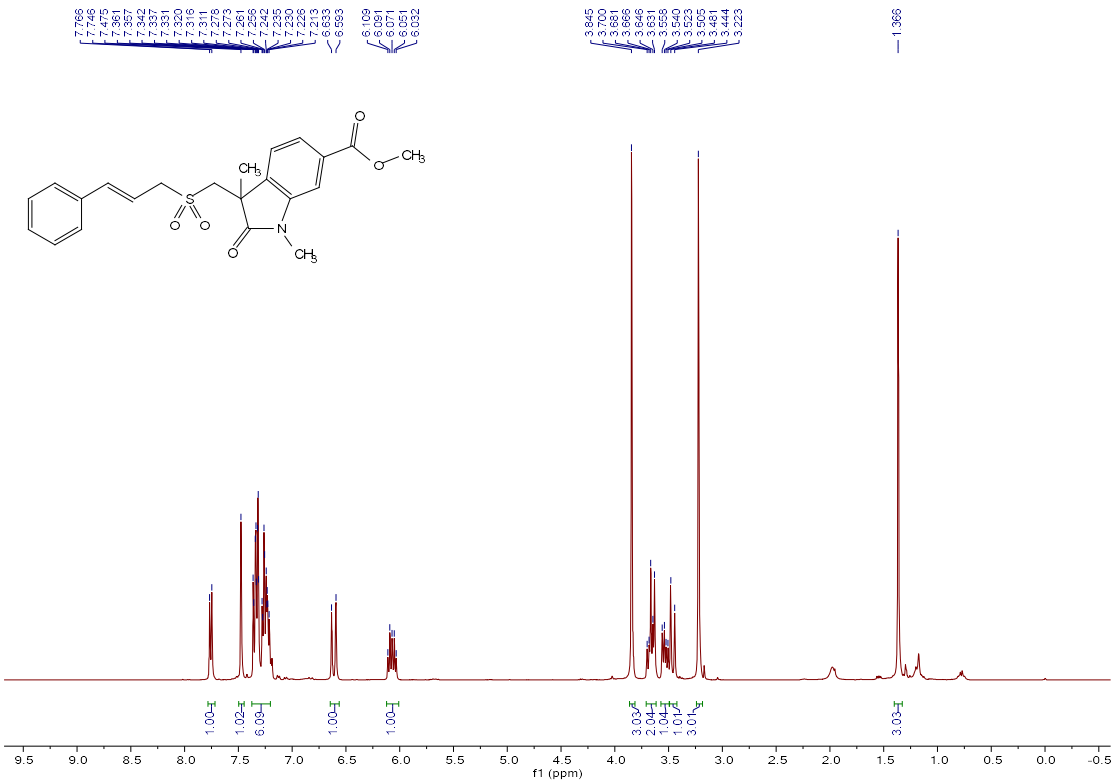


Methyl 3-((cinnamylsulfonyl)methyl)-1,3-dimethyl-2-oxoindoline-6-carboxylate (56).

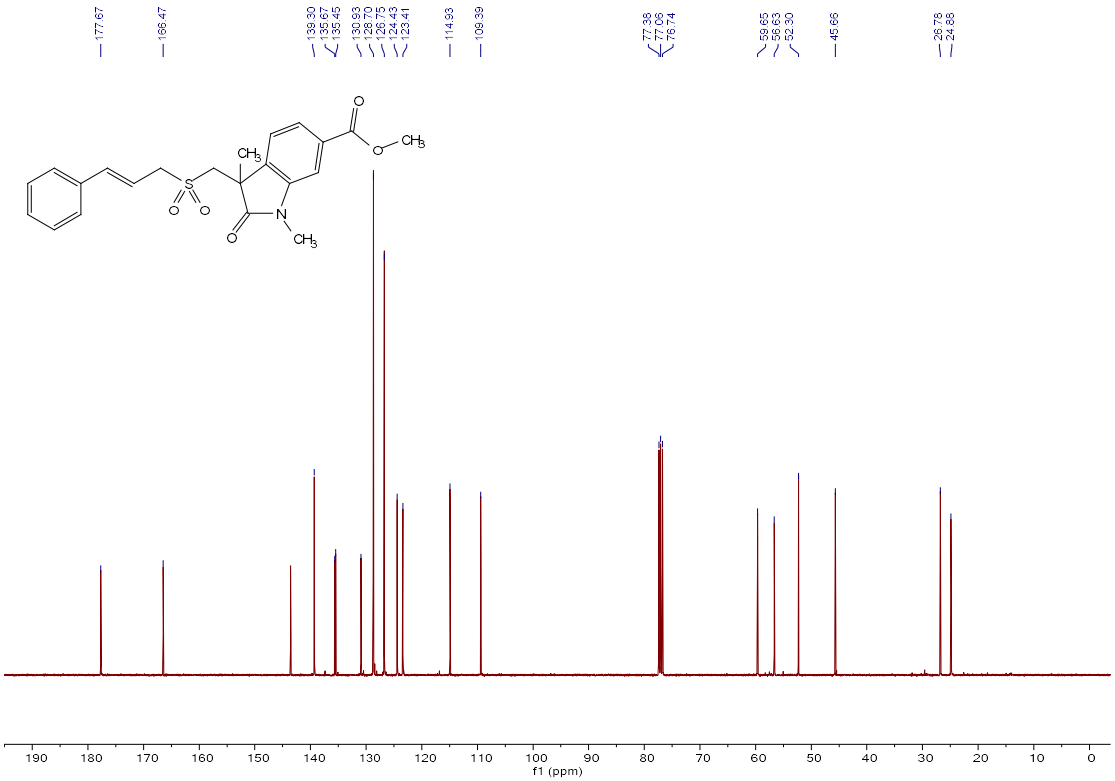


The product (70.3 mg, 85% yield) as light yellow solid was purified with silica gel chromatography (petroleum ether/ethyl acetate = 1/1). **^{1}H NMR (400 MHz, $CDCl_3$)** δ 7.76 (d, J = 8.0 Hz, 1H), 7.48 (s, 1H), 7.36-7.21 (m, 6H), 6.61 (d, J = 16.0 Hz, 1H), 6.11-6.03 (m, 1H), 3.85 (s, 3H), 3.70-3.63 (m, 2H), 3.53 (dd, J = 14.0 Hz, 7.2 Hz, 1H), 3.46 (d, J = 14.8 Hz, 1H), 3.22 (s, 3H), 1.37 (s, 3H); **^{13}C NMR (101 MHz, $CDCl_3$)** δ 177.7, 166.5, 139.3, 135.7, 135.5, 130.9, 128.7, 126.8, 124.4, 123.4, 114.9, 109.4, 59.7, 56.6, 52.3, 45.7, 26.8, 24.9; **HRMS** Calculated for $C_{22}H_{23}NO_5S$ ($M+H^+$): 414.1370; Found: 414.1371.

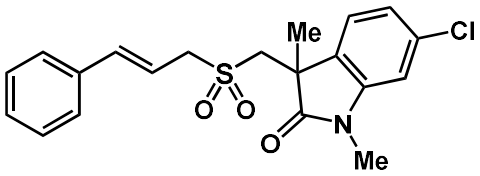
^{1}H NMR spectrum (400 MHz, $CDCl_3$) of compound **56**



^{13}C NMR spectrum (101 MHz, $CDCl_3$) of compound **56**

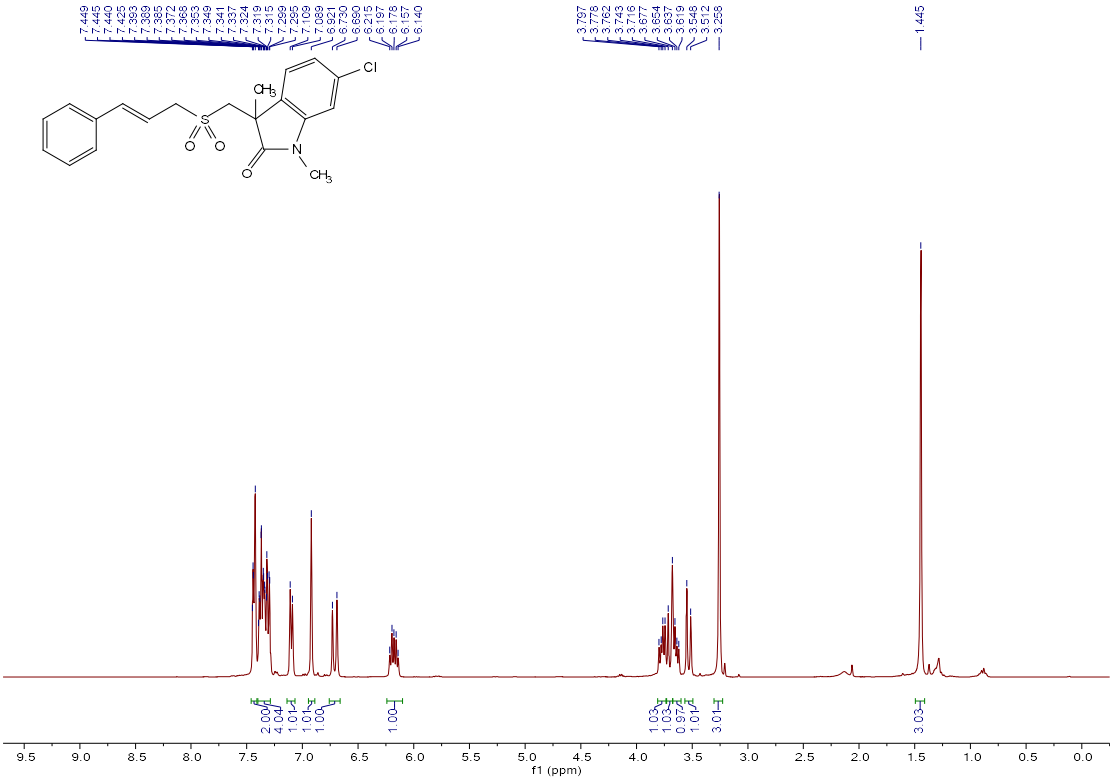


6-chloro-3-((cinnamylsulfonyl)methyl)-1,3-dimethylindolin-2-one (57).

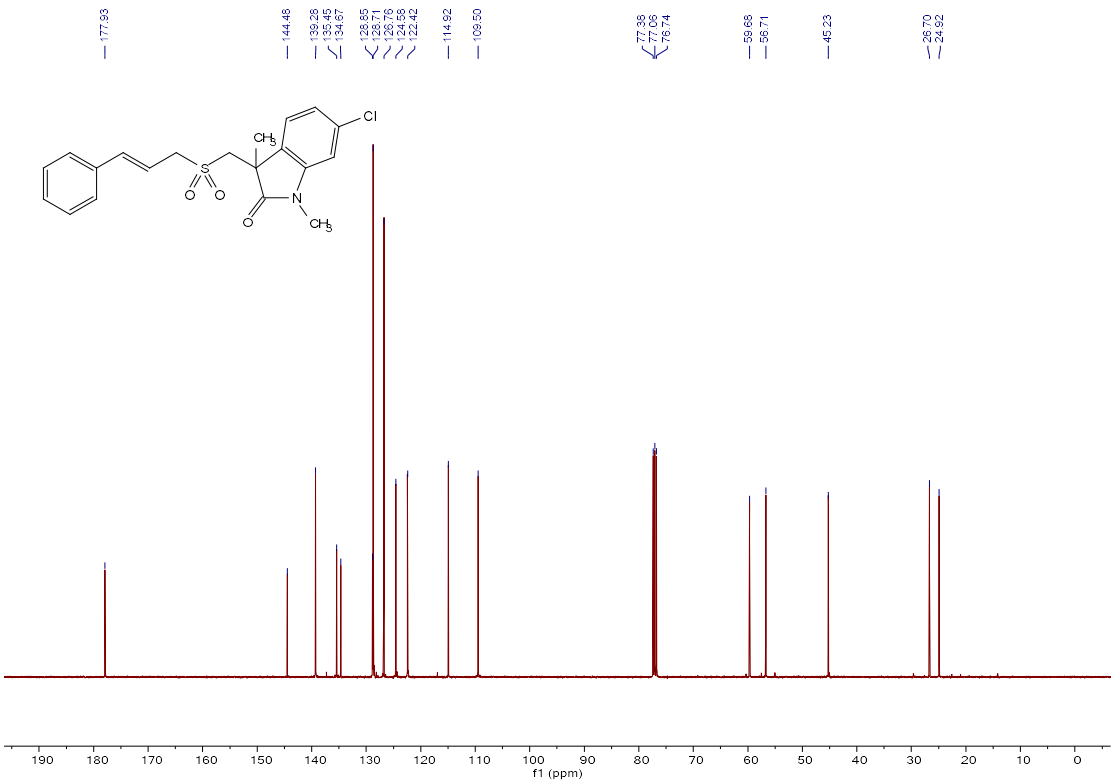


The product (71.0 mg, 91% yield) as light yellow solid was purified with silica gel chromatography (petroleum ether/ethyl acetate = 2/1). **^{1}H NMR (400 MHz, $CDCl_3$)** δ 7.45-7.43 (m, 2H), 7.39-7.30 (m, 4H), 7.10 (d, *J* = 8.0 Hz, 1H), 6.92 (s, 1H), 6.71 (d, *J* = 16.0 Hz, 1H), 6.22-6.14 (m, 1H), 3.77 (dd, *J* = 14.0 Hz, 7.6 Hz, 1H), 3.70 (d, *J* = 15.6 Hz, 1H), 3.65 (dd, *J* = 14.0 Hz, 7.2 Hz, 1H), 3.53 (d, *J* = 14.4 Hz, 1H), 3.26 (s, 3H), 1.44 (s, 3H); **^{13}C NMR (101 MHz, $CDCl_3$)** δ 177.9, 144.5, 139.3, 135.5, 134.7, 128.9, 128.7, 126.8, 124.6, 122.4, 114.9, 109.5, 59.7, 56.7, 45.2, 26.7, 24.9; **HRMS** Calculated for $C_{20}H_{20}ClNO_3S$ ($M+H^+$): 390.0925; Found: 390.0924.

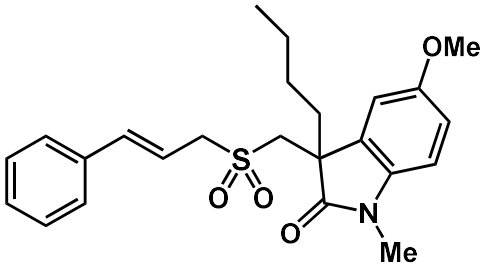
^{1}H NMR spectrum (400 MHz, $CDCl_3$) of compound **57**



^{13}C NMR spectrum (101 MHz, $CDCl_3$) of compound **57**

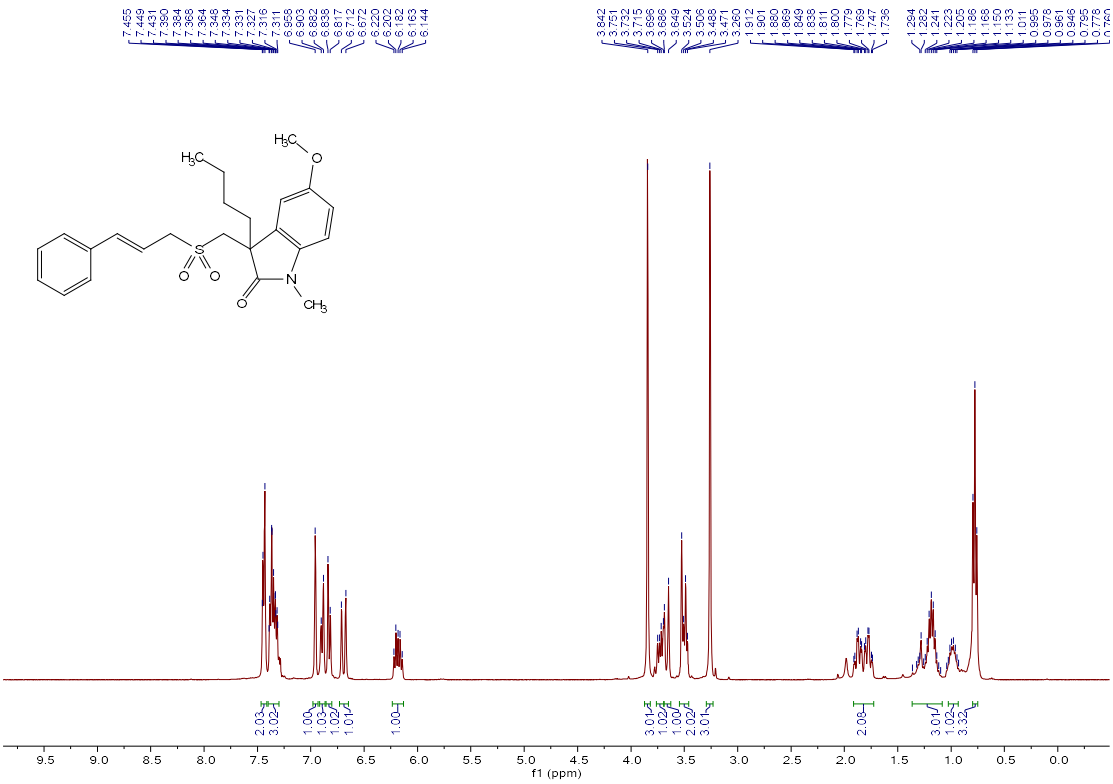


3-butyl-3-((cinnamylsulfonyl)methyl)-5-methoxy-1-methylindolin-2-one (58).

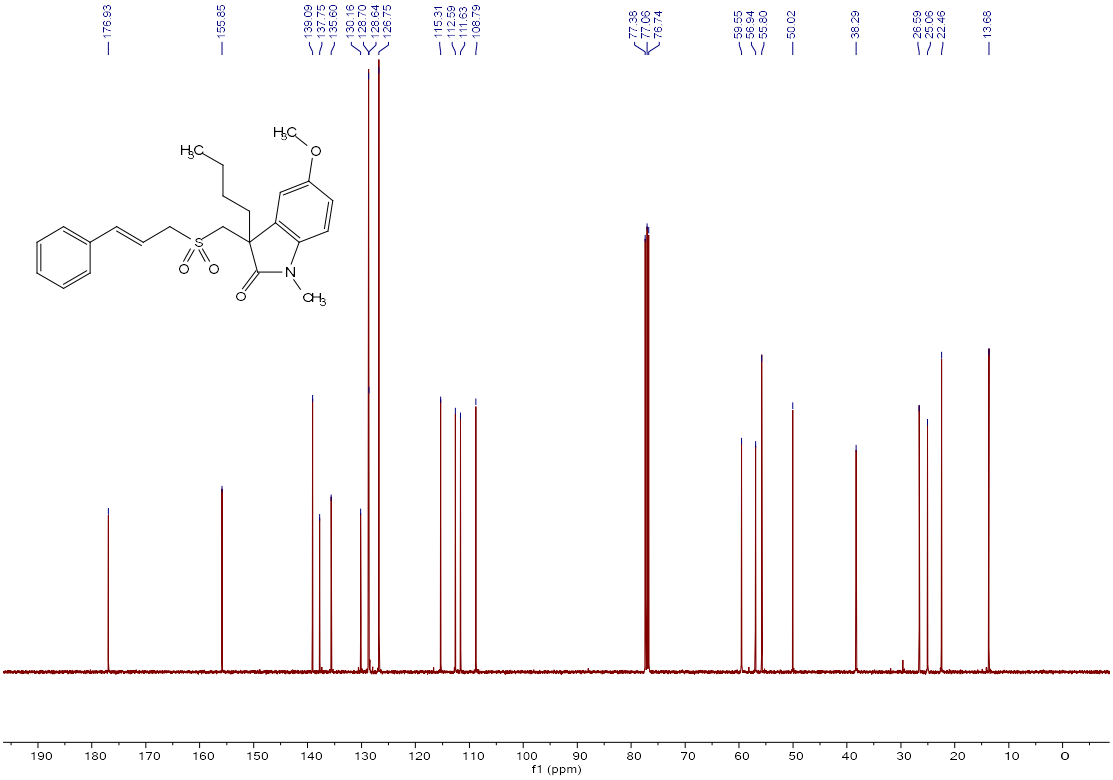


The product (70.1 mg, 82% yield) as brown solid was purified with silica gel chromatography (petroleum ether/ethyl acetate = 2/1). **^{1}H NMR (400 MHz, $CDCl_3$)** δ 7.46-7.43 (m, 2H), 7.39-7.31 (m, 3H), 6.96 (s, 1H), 6.89 (d, *J* = 8.4 Hz, 1H), 6.83 (d, *J* = 8.4 Hz, 1H), 6.69 (d, *J* = 16.8 Hz, 1H), 6.22-6.14 (m, 1H), 3.84 (s, 3H), 3.72 (dd, *J* = 14.4 Hz, 7.6 Hz, 1H), 3.67 (d, *J* = 14.8 Hz, 1H), 3.52-3.47 (m, 2H), 3.26 (s, 3H), 1.91-1.74 (m, 2H), 1.36-1.10 (m, 3H), 1.04-0.93 (m, 1H), 0.78 (t, *J* = 6.8 Hz, 3H); **^{13}C NMR (101 MHz, $CDCl_3$)** δ 176.9, 155.9, 139.1, 137.8, 135.6, 130.2, 128.7, 128.6, 126.8, 115.3, 112.6, 111.6, 108.8, 59.6, 56.9, 55.8, 50.0, 38.3, 26.6, 25.1, 22.5, 13.7; **HRMS** Calculated for $C_{24}H_{29}NO_4S$ ($M+H^+$): 428.1890; Found: 428.1897.

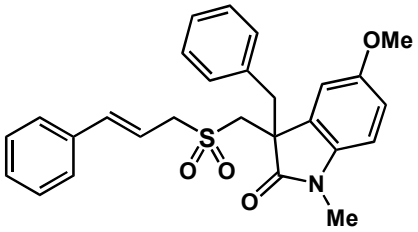
^{1}H NMR spectrum (400 MHz, $CDCl_3$) of compound **58**



^{13}C NMR spectrum (101 MHz, $CDCl_3$) of compound **58**

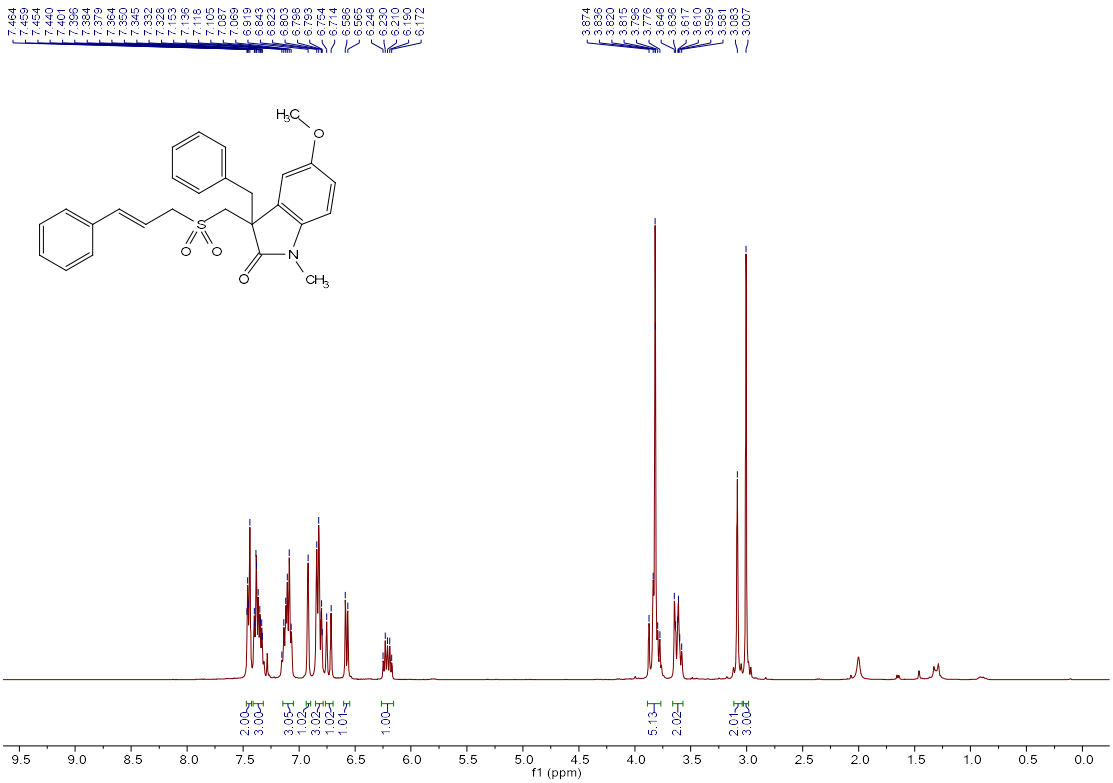


3-benzyl-3-((cinnamylsulfonyl)methyl)-5-methoxy-1-methylindolin-2-one (59).

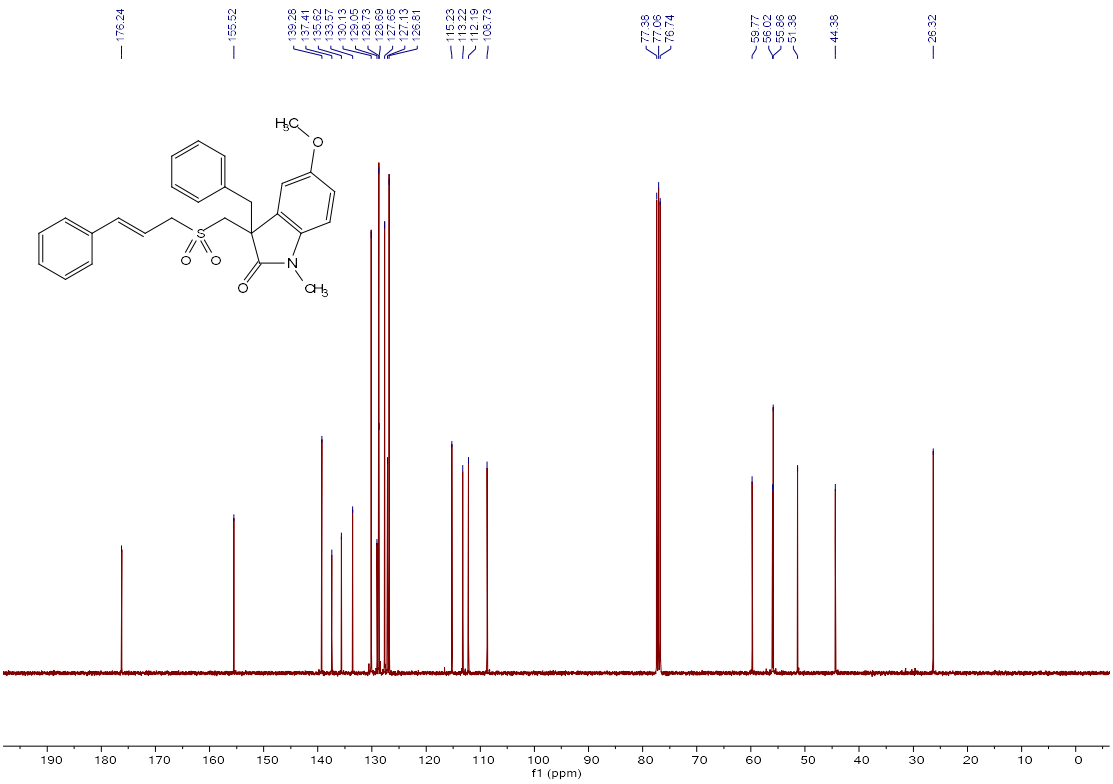


The product (73.9 mg, 80% yield) as brown solid was purified with silica gel chromatography (petroleum ether/ethyl acetate = 2/1). **^{1}H NMR (400 MHz, $CDCl_3$)** δ 7.46-7.44 (m, 2H), 7.40-7.33 (m, 3H), 7.15-7.07 (m, 3H), 6.92 (s, 1H), 6.84-6.79 (m, 3H), 6.73 (d, *J* = 16.0 Hz, 1H), 6.58 (d, *J* = 8.4 Hz, 1H), 6.25-6.17 (m, 1H), 3.87-3.78 (m, 5H), 3.65-3.58 (m, 2H), 3.08 (s, 2H), 3.01 (s, 3H); **^{13}C NMR (101 MHz, $CDCl_3$)** δ 176.2, 155.5, 139.3, 137.4, 135.6, 133.6, 130.1, 129.1, 128.73, 128.69, 127.7, 127.1, 126.8, 115.2, 113.2, 112.2, 108.7, 59.8, 56.0, 55.9, 51.4, 44.4, 26.3; **HRMS** Calculated for $C_{27}H_{27}NO_4S$ ($M+H^+$): 462.1734; Found: 462.1736.

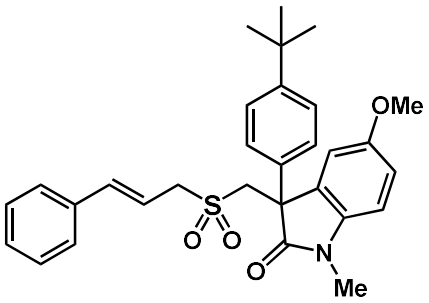
^{1}H NMR spectrum (400 MHz, $CDCl_3$) of compound **59**



^{13}C NMR spectrum (101 MHz, $CDCl_3$) of compound **59**

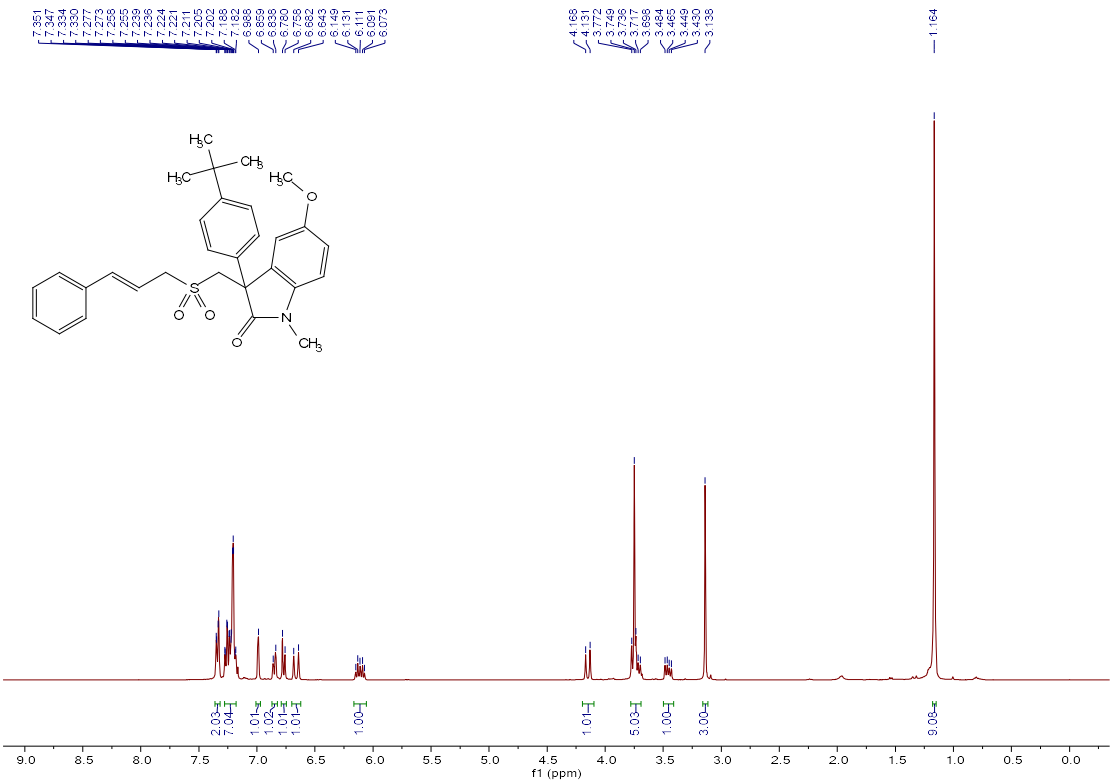


3-(4-(*tert*-butyl)phenyl)-3-((cinnamylsulfonyl)methyl)-5-methoxy-1-methylindolin-2-one (60).

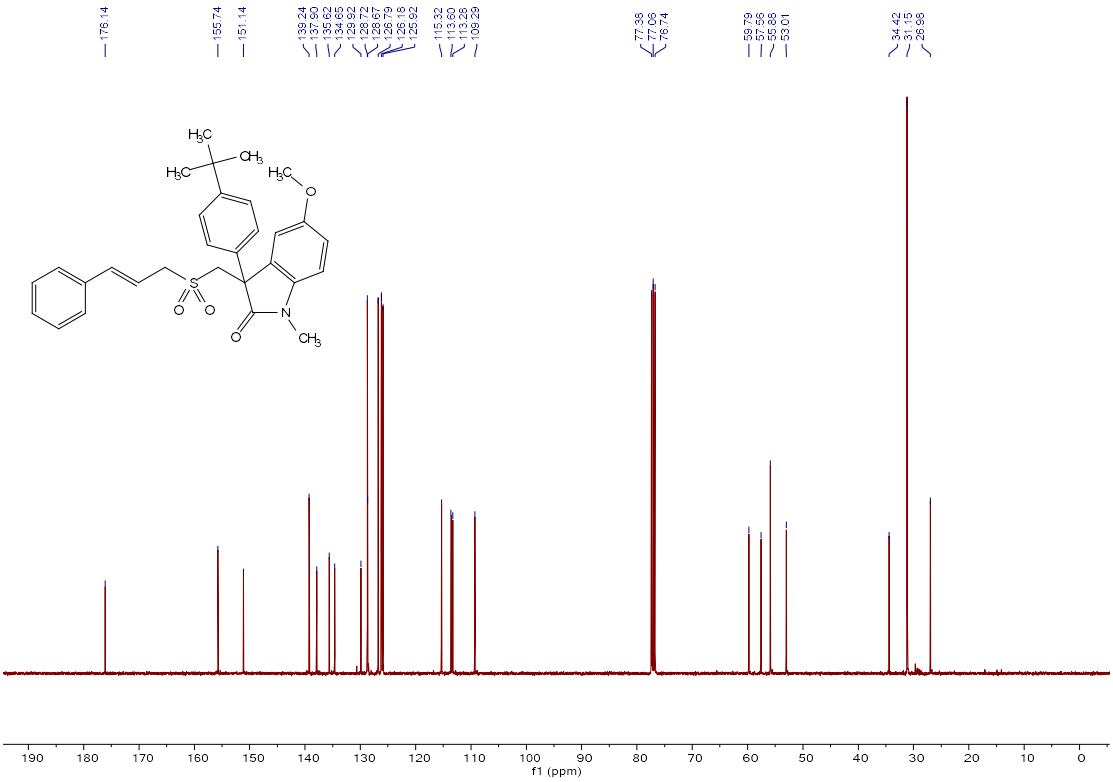


The product (78.6 mg, 78% yield) as light yellow solid was purified with silica gel chromatography (petroleum ether/ethyl acetate = 2/1). **^{1}H NMR (400 MHz, $CDCl_3$)** δ 7.35-7.33 (m, 2H), 7.28-7.18 (m, 7H), 6.99 (s, 1H), 6.85 (d, *J* = 8.4 Hz, 1H), 6.77 (d, *J* = 8.8 Hz, 1H), 6.66 (d, *J* = 15.6 Hz, 1H), 6.15-6.07 (m, 1H), 4.15 (d, *J* = 14.8 Hz, 1H), 3.77-3.70 (m, 5H), 3.46 (dd, *J* = 14.0 Hz, 7.6 Hz, 1H), 3.14 (s, 3H), 1.16 (s, 9H); **^{13}C NMR (101 MHz, $CDCl_3$)** δ 176.1, 155.7, 151.1, 139.2, 137.9, 135.6, 134.7, 129.9, 128.72, 128.67, 126.8, 126.2, 125.9, 115.3, 113.6, 113.3, 109.3, 59.8, 57.6, 55.9, 53.0, 34.4, 31.2, 27.0; **HRMS** Calculated for $C_{30}H_{33}NO_4S$ ($M+H^+$): 504.2203; Found: 504.2206.

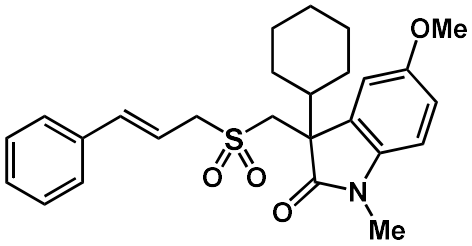
^{1}H NMR spectrum (400 MHz, $CDCl_3$) of compound **60**



^{13}C NMR spectrum (101 MHz, $CDCl_3$) of compound **60**

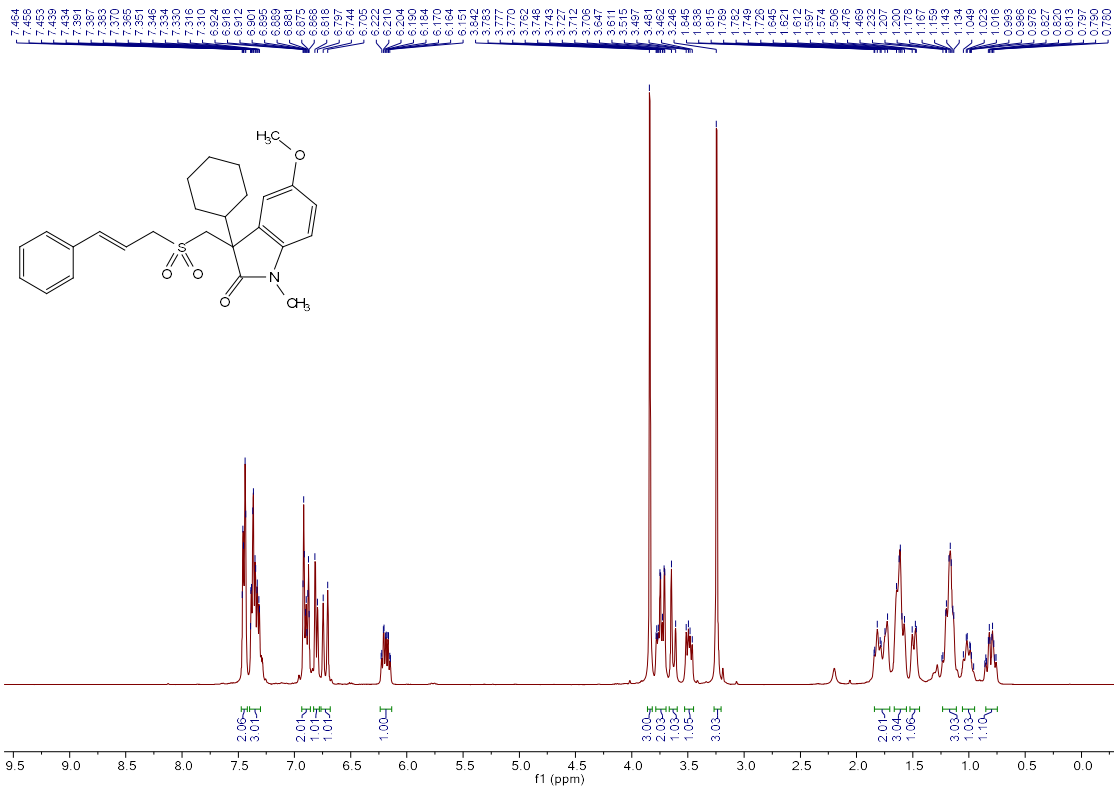


3-((cinnamylsulfonyl)methyl)-3-cyclohexyl-5-methoxy-1-methylindolin-2-one (61).

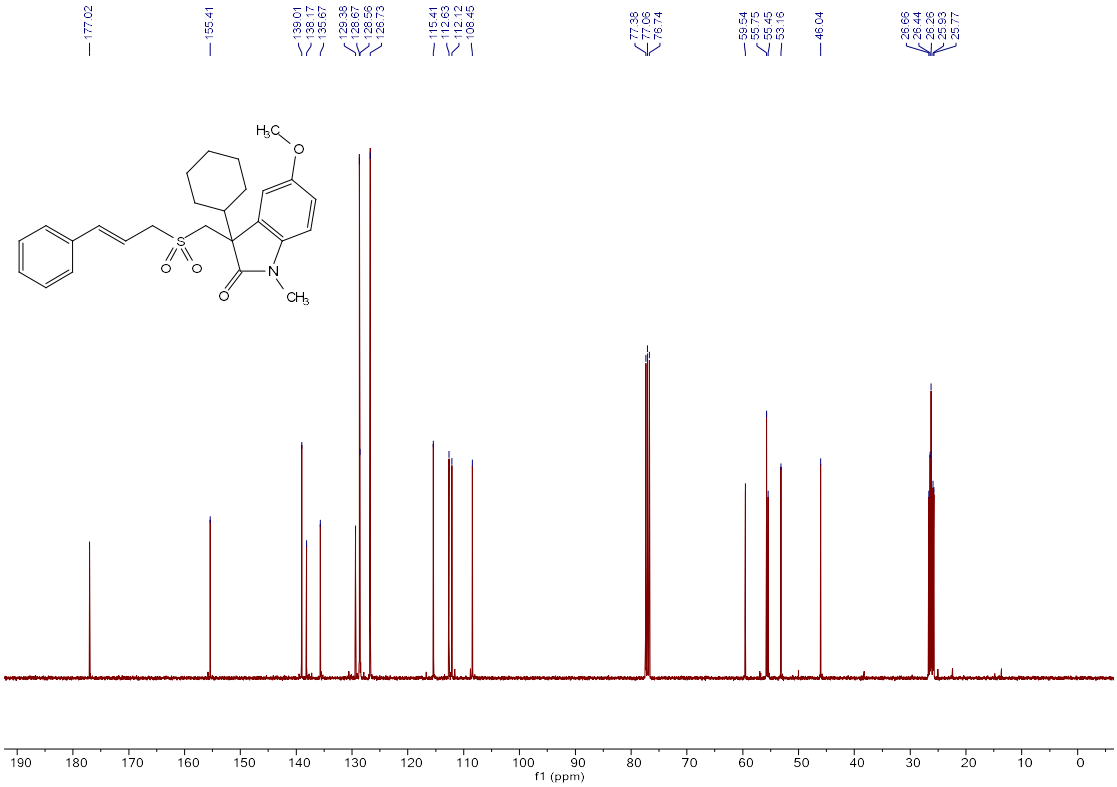


The product (76.2 mg, 84% yield) as light yellow solid was purified with silica gel chromatography (petroleum ether/ethyl acetate = 2/1). **^{1}H NMR (400 MHz, $CDCl_3$)** δ 7.46-7.43 (m, 2H), 7.39-7.31 (m, 3H), 6.92-6.87 (m, 2H), 6.81 (d, *J* = 8.4 Hz, 1H), 6.72 (d, *J* = 15.6 Hz, 1H), 6.23-6.15 (m, 1H), 3.84 (s, 3H), 3.78-3.71 (m, 2H), 3.63 (d, *J* = 14.4 Hz, 1H), 3.49 (dd, *J* = 13.6 Hz, 7.2 Hz, 1H), 3.25 (s, 3H), 1.85-1.73 (m, 2H), 1.65-1.57 (m, 3H), 1.51-1.47 (m, 1H), 1.24-1.13 (m, 3H), 1.05-0.96 (m, 1H), 0.86-0.76 (m, 1H); **^{13}C NMR (101 MHz, $CDCl_3$)** δ 177.0, 155.4, 139.0, 138.2, 135.7, 129.4, 128.7, 128.6, 126.7, 115.4, 112.6, 112.1, 108.5, 59.5, 55.8, 55.5, 53.2, 46.0, 26.7, 26.4, 26.3(m, 2C), 25.9, 25.8; **HRMS** Calculated for $C_{26}H_{31}NO_4S$ ($M+H^+$): 454.2047; Found: 454.2049.

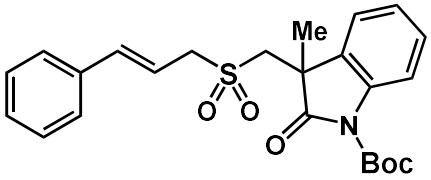
^{1}H NMR spectrum (400 MHz, $CDCl_3$) of compound **61**



^{13}C NMR spectrum (101 MHz, $CDCl_3$) of compound **61**

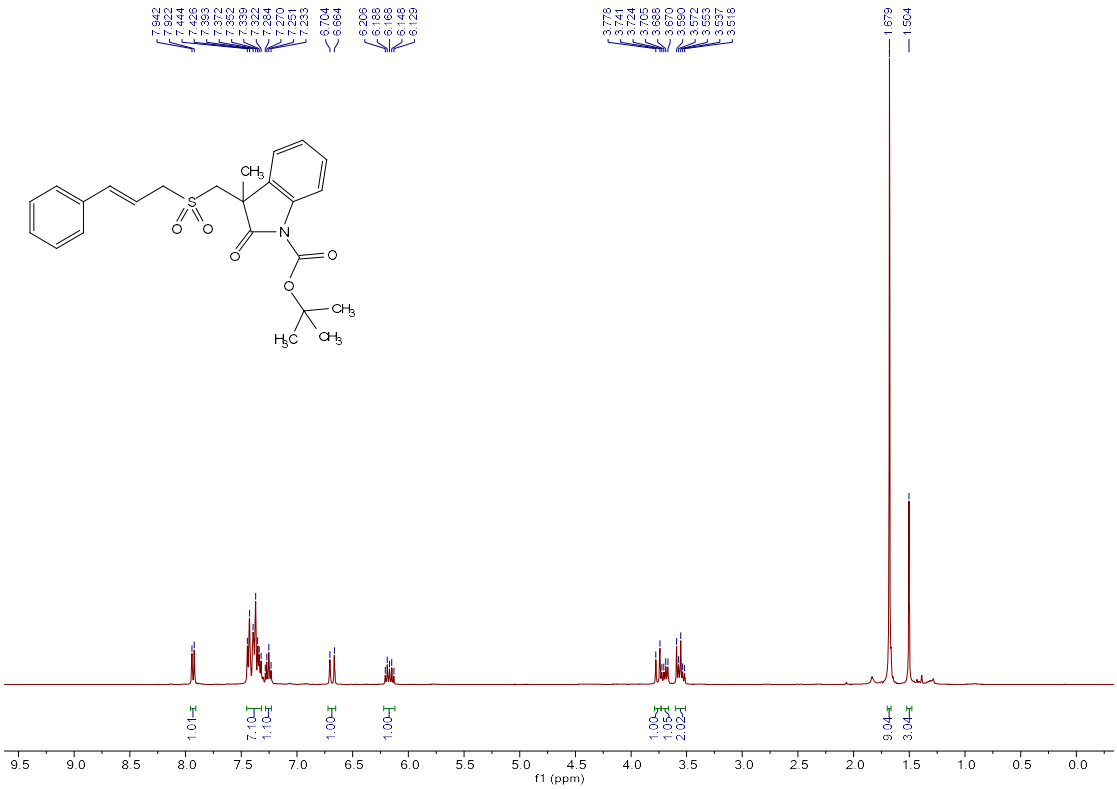


***tert*-butyl 3-((cinnamylsulfonyl)methyl)-3-methyl-2-oxoindoline-1-carboxylate (62).**

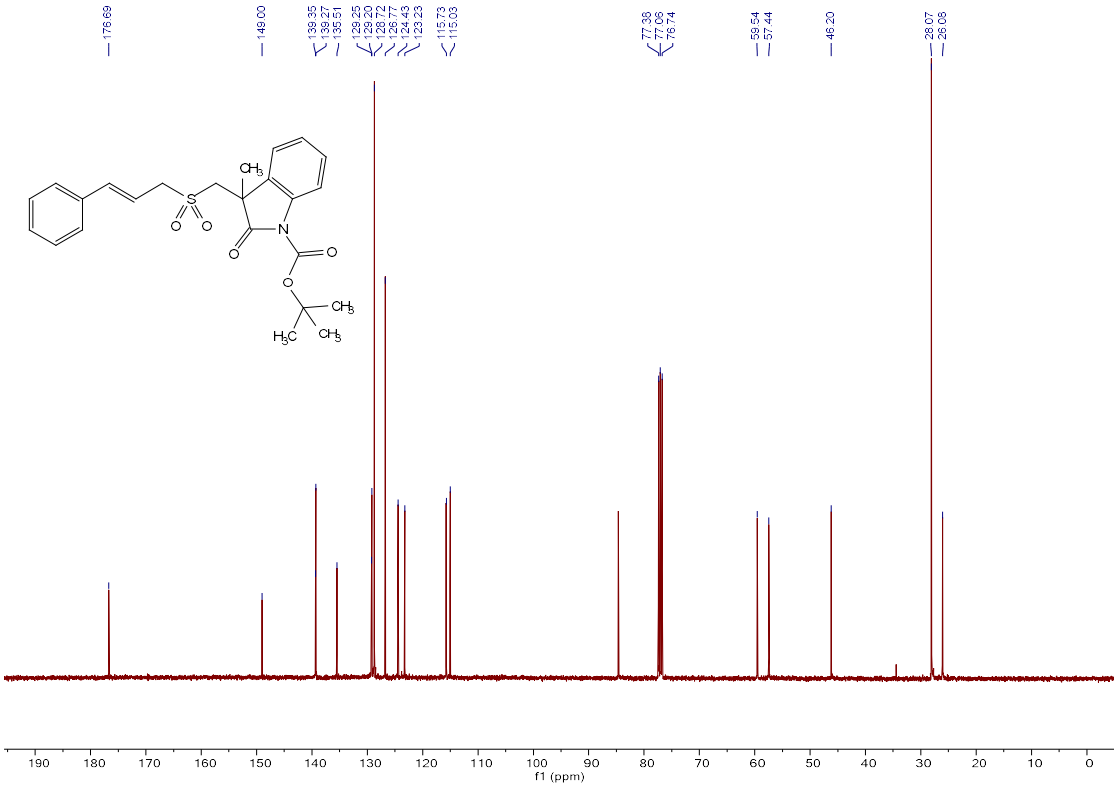


The product (63.6 mg, 72% yield) as yellow solid was purified with silica gel chromatography (petroleum ether/ethyl acetate = 2/1). **^{1}H NMR (400 MHz, $CDCl_3$)** δ 7.93 (d, *J* = 8.0 Hz, 1H), 7.44-7.32 (m, 7H), 7.28-7.23 (m, 1H), 6.68 (d, *J* = 16.0 Hz, 1H), 6.21-6.13 (m, 1H), 3.76 (d, *J* = 14.8 Hz, 1H), 3.70 (dd, *J* = 14.4 Hz, 7.6 Hz, 1H), 3.59-3.52 (m, 2H), 1.68 (s, 9H), 1.50 (s, 3H); **^{13}C NMR (101 MHz, $CDCl_3$)** δ 176.7, 149.0, 139.4, 139.3, 135.5, 129.3, 129.2, 128.7, 126.8, 124.4, 123.2, 115.7, 115.0, 59.5, 57.4, 46.2, 28.1, 26.1; **HRMS** Calculated for $C_{24}H_{27}NO_5S$ ($M+Na^+$): 464.1502; Found: 464.1504.

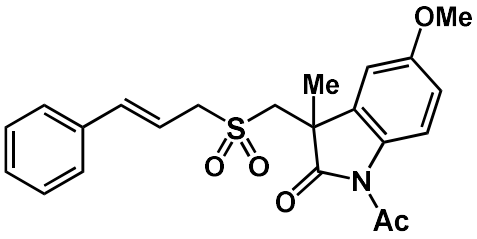
^{1}H NMR spectrum (400 MHz, $CDCl_3$) of compound **62**



^{13}C NMR spectrum (101 MHz, $CDCl_3$) of compound **62**

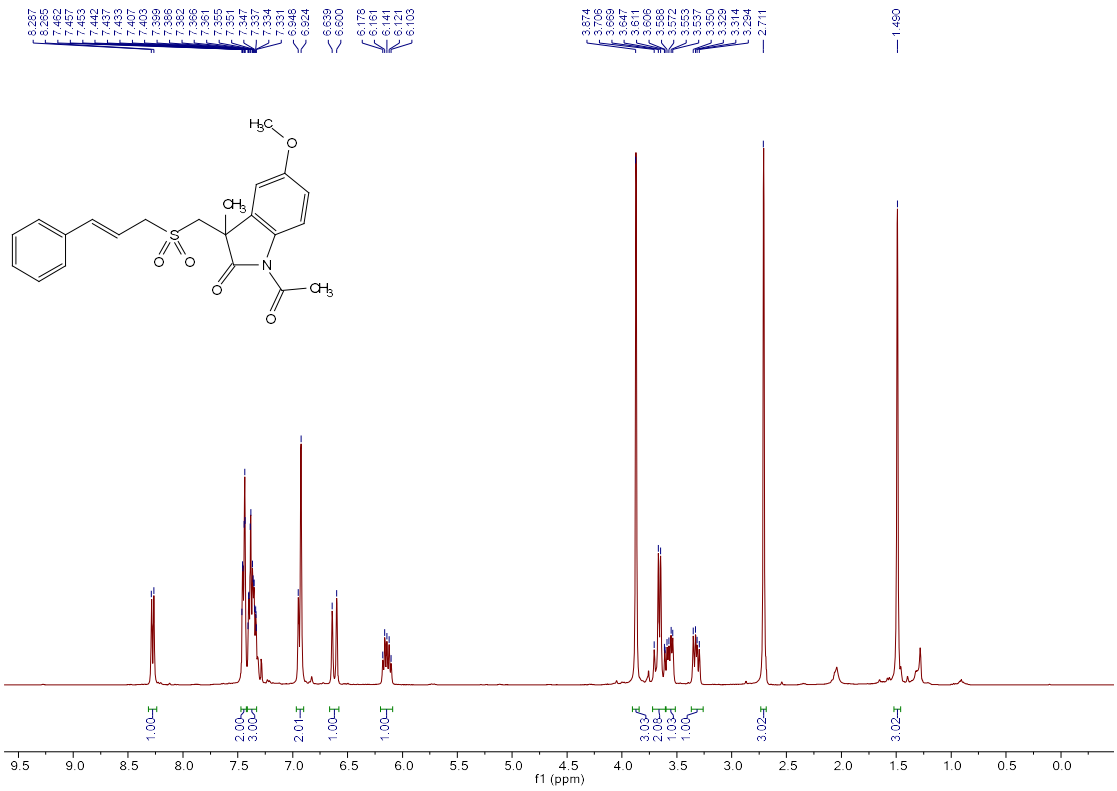


1-acetyl-3-((cinnamylsulfonyl)methyl)-5-methoxy-3-methylindolin-2-one (63).

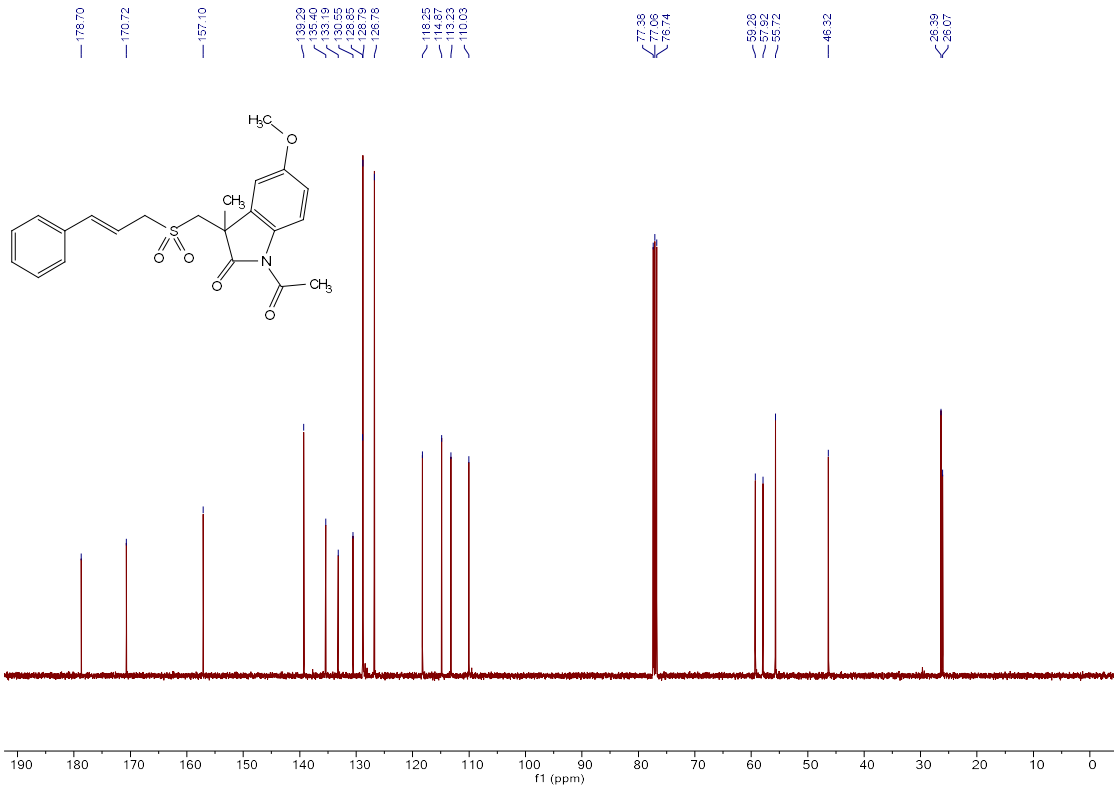


The product (52.9 mg, 64% yield) as yellow oil was purified with silica gel chromatography (petroleum ether/ethyl acetate = 2/1). **^{1}H NMR (400 MHz, $CDCl_3$)** δ 8.28 (d, *J* = 8.8 Hz, 1H), 7.46-7.43 (m, 2H), 7.41-7.33 (m, 3H), 6.95-6.92 (m, 2H), 6.62 (d, *J* = 15.6 Hz, 1H), 6.18-6.10 (m, 1H), 3.87 (s, 3H), 3.71-3.61 (m, 2H), 3.56 (dd, *J* = 14.0 Hz, 6.4 Hz, 1H), 3.32 (dd, *J* = 14.4 Hz, 8.4 Hz, 1H), 2.71 (s, 3H), 1.49 (s, 3H); **^{13}C NMR (101 MHz, $CDCl_3$)** δ 178.7, 170.7, 157.1, 139.3, 135.4, 133.2, 130.6, 128.9, 128.8, 126.8, 118.3, 114.9, 113.2, 110.0, 59.3, 57.9, 55.7, 46.3, 26.4, 26.1; **HRMS** Calculated for $C_{22}H_{23}NO_5S$ ($M+H^+$): 414.1370; Found: 414.1371.

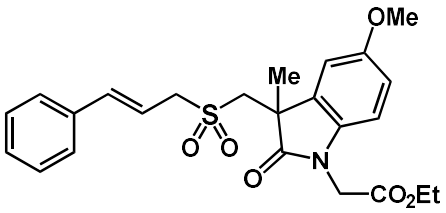
^{1}H NMR spectrum (400 MHz, $CDCl_3$) of compound **63**



^{13}C NMR spectrum (101 MHz, $CDCl_3$) of compound **63**

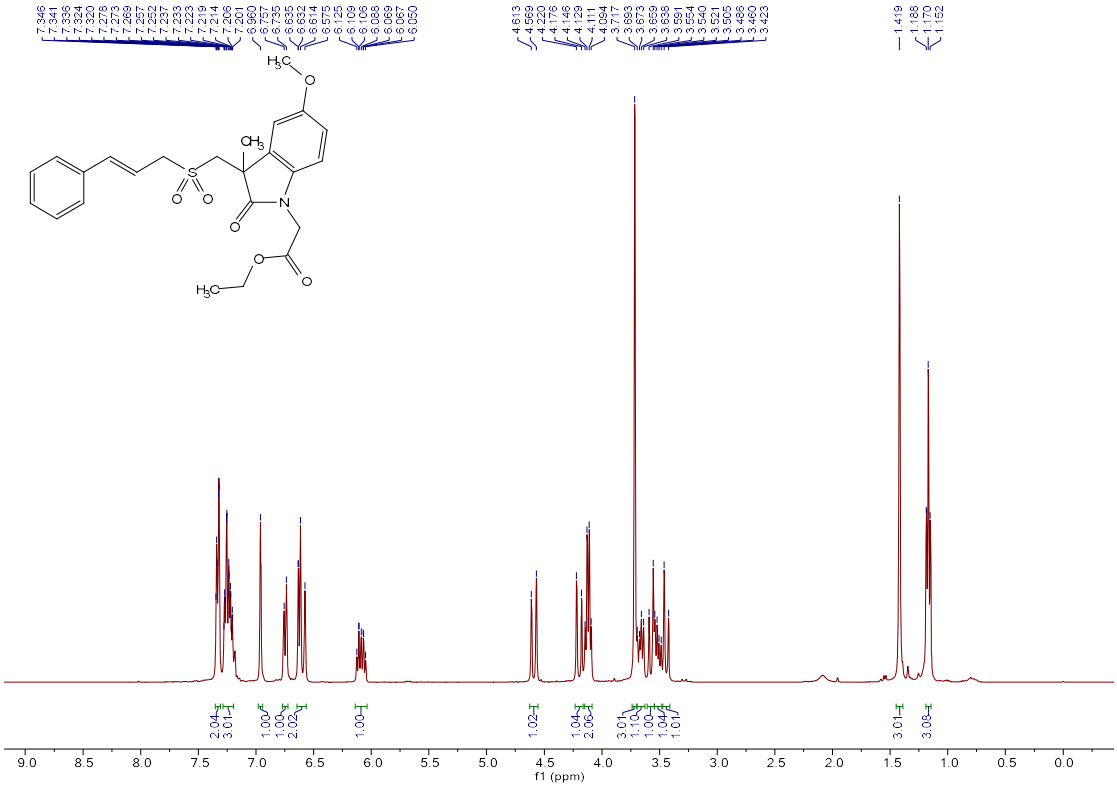


ethyl 2-(3-((cinnamylsulfonyl)methyl)-5-methoxy-3-methyl-2-oxoindolin-1-yl) acetate (64).

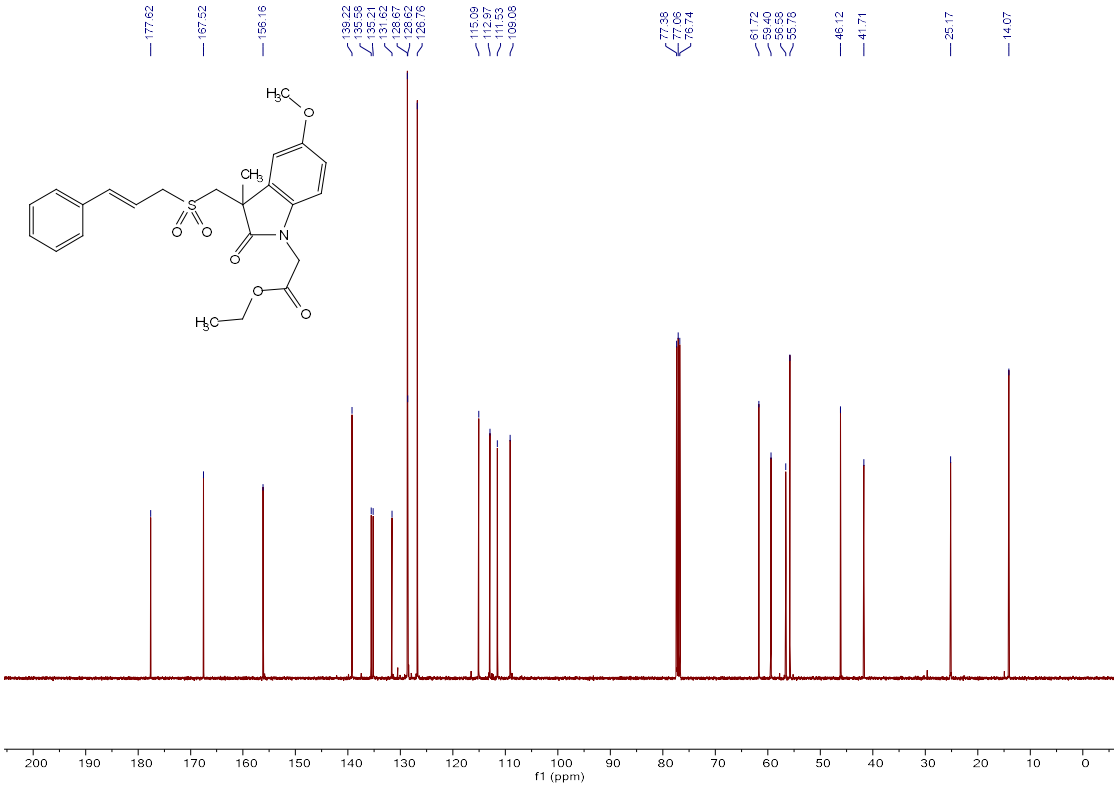


The product (75.0 mg, 82% yield) as yellow solid was purified with silica gel chromatography (petroleum ether/ethyl acetate = 2/1). **^{1}H NMR (400 MHz, $CDCl_3$)** δ 7.34-7.32 (m, 2H), 7.28-7.20 (m, 3H), 6.96 (s, 1H), 6.75 (d, *J* = 8.8 Hz, 1H), 6.64-6.58 (m, 2H), 6.13-6.05 (m, 1H), 4.59 (d, *J* = 17.6 Hz, 1H), 4.20 (d, *J* = 17.6 Hz, 1H), 4.12 (q, *J* = 6.8 Hz, 2H), 3.72 (s, 3H), 3.67 (dd, *J* = 14.0 Hz, 8.4 Hz, 1H), 3.57 (d, *J* = 14.8 Hz, 1H), 3.51 (dd, *J* = 14.0 Hz, 7.6 Hz, 1H), 3.44 (d, *J* = 14.8 Hz, 1H), 1.42 (s, 3H), 1.17 (t, *J* = 7.2 Hz, 3H); **^{13}C NMR (101 MHz, $CDCl_3$)** δ 177.6, 167.5, 156.2, 139.2, 135.6, 135.2, 131.6, 128.7, 128.6, 126.8, 115.1, 113.0, 111.5, 109.1, 61.7, 59.4, 56.6, 55.8, 46.1, 41.7, 25.2, 14.1; **HRMS** Calculated for $C_{24}H_{27}NO_6S$ ($M+H^+$): 458.1632; Found: 458.1635.

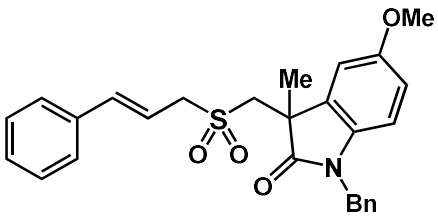
^{1}H NMR spectrum (400 MHz, $CDCl_3$) of compound **64**



^{13}C NMR spectrum (101 MHz, $CDCl_3$) of compound **64**

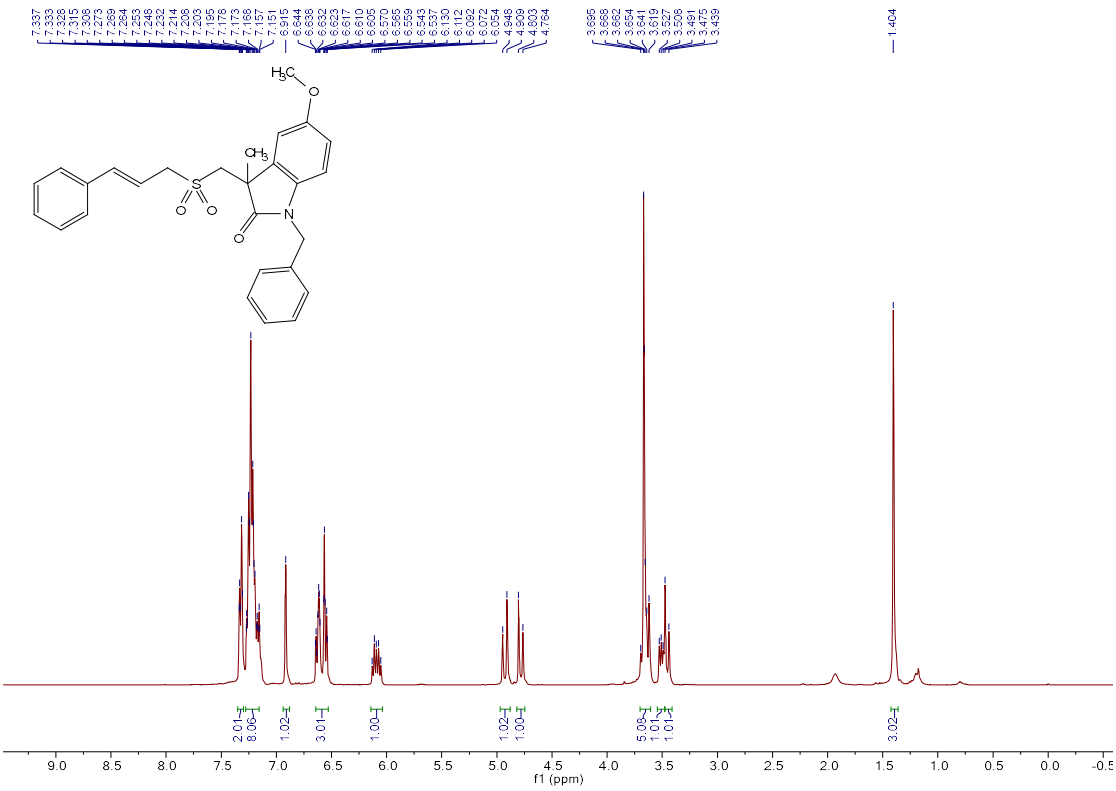


1-benzyl-3-((cinnamylsulfonyl)methyl)-5-methoxy-3-methylindolin-2-one (**65**).

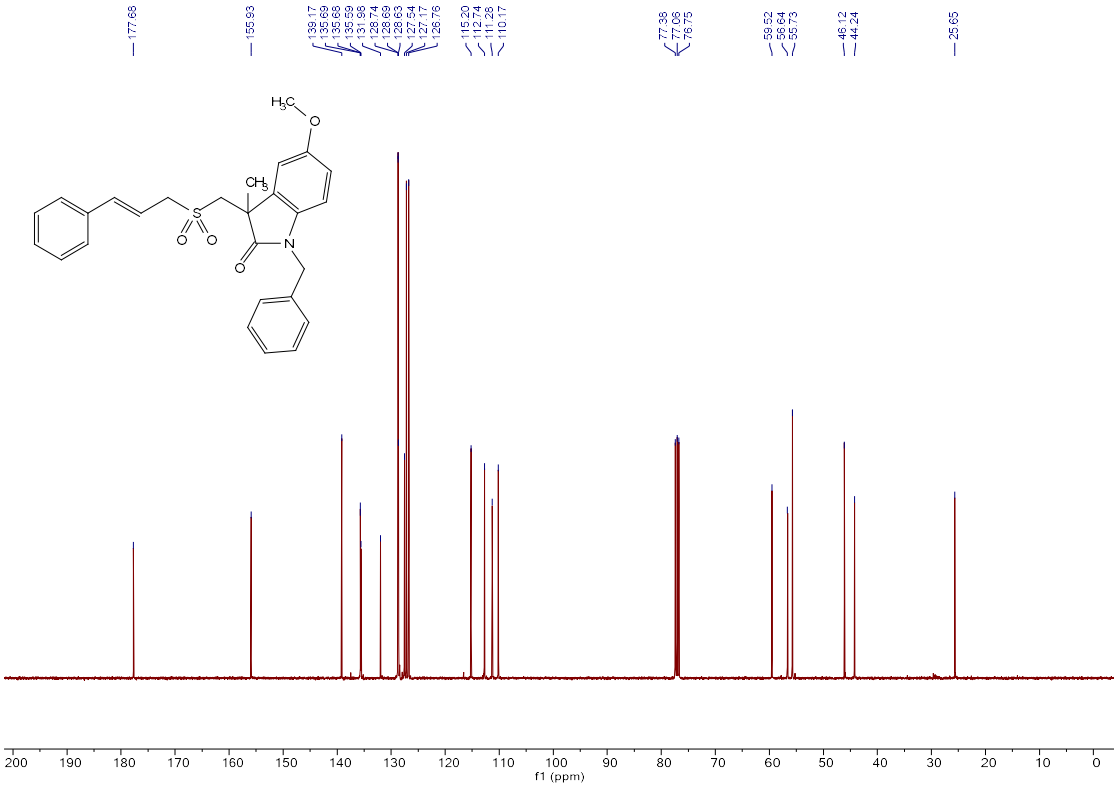


The product (83.1 mg, 90% yield) as yellow oil was purified with silica gel chromatography (petroleum ether/ethyl acetate = 2/1). **^{1}H NMR (400 MHz, $CDCl_3$)** δ 7.34-7.31 (m, 2H), 7.27-7.15 (m, 8H), 6.91 (s, 1H), 6.64-6.54 (m, 3H), 6.13-6.05 (m, 1H), 4.93 (d, *J* = 15.6 Hz, 1H), 4.78 (d, *J* = 15.6 Hz, 1H), 3.70-3.62 (m, 5H), 3.50 (dd, *J* = 14.4 Hz, 7.6 Hz, 1H), 3.46 (d, *J* = 14.4 Hz, 1H), 1.40 (s, 3H); **^{13}C NMR (101 MHz, $CDCl_3$)** δ 177.7, 155.9, 139.2, 135.69, 135.68, 135.6, 132.0, 128.74, 128.69, 128.6, 127.5, 127.2, 126.8, 115.2, 112.7, 111.3, 110.2, 59.5, 56.6, 55.7, 46.1, 44.2, 25.7; **HRMS** Calculated for $C_{27}H_{27}NO_4S$ ($M+H^+$): 462.1734; Found: 462.1736.

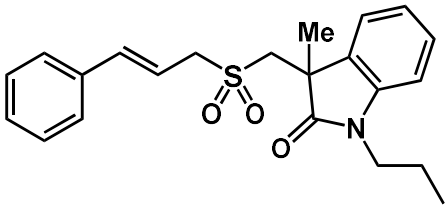
^{1}H NMR spectrum (400 MHz, $CDCl_3$) of compound **65**



^{13}C NMR spectrum (101 MHz, $CDCl_3$) of compound **65**

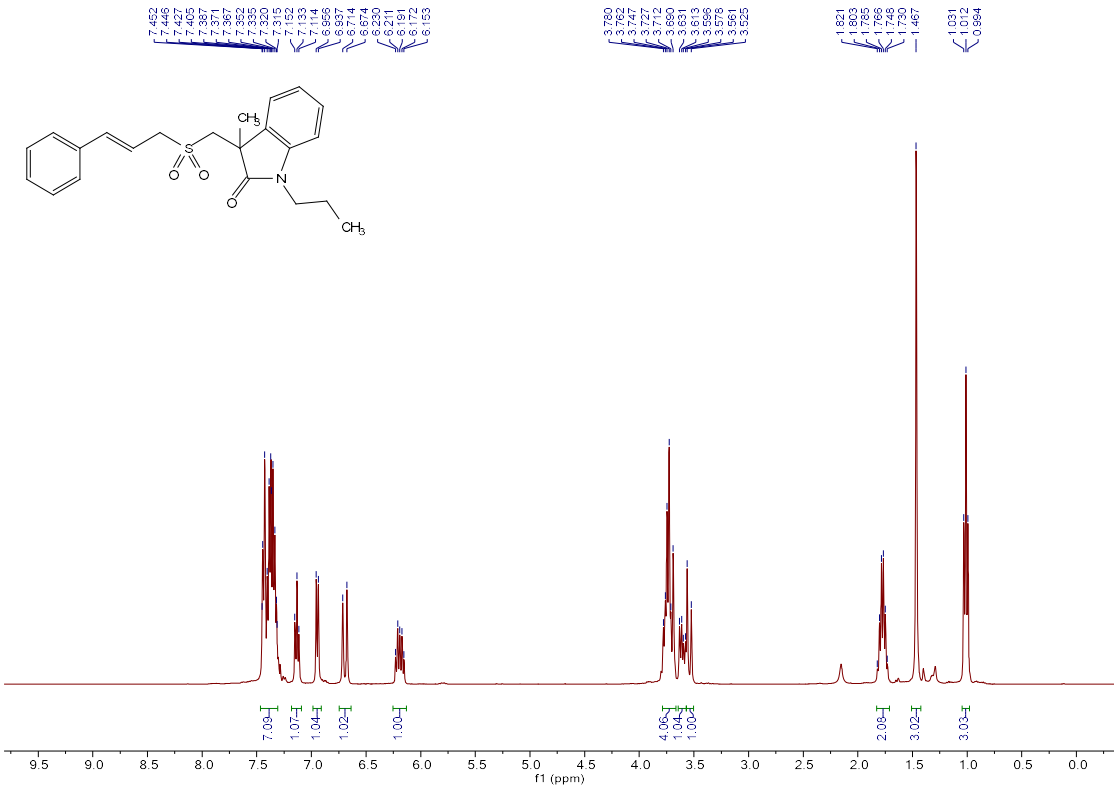


3-((cinnamylsulfonyl)methyl)-3-methyl-1-propylindolin-2-one (66).

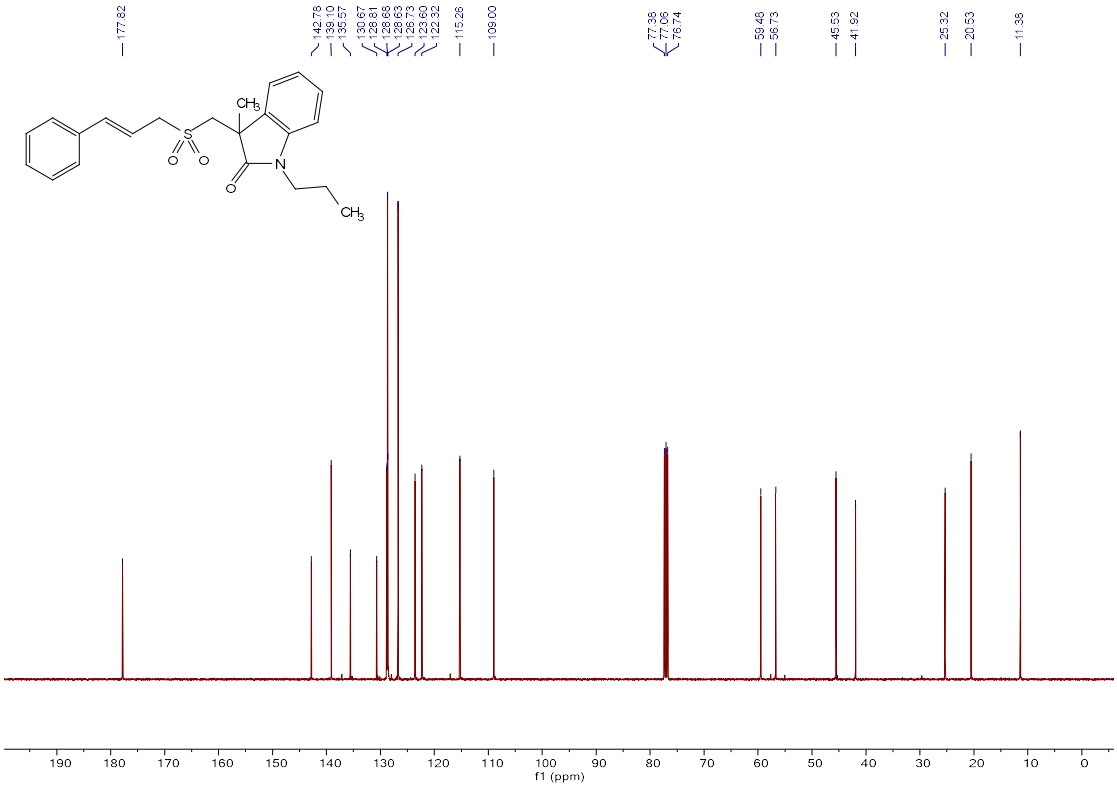


The product (61.4 mg, 80% yield) as yellow solid was purified with silica gel chromatography (petroleum ether/ethyl acetate = 2/1). **^{1}H NMR (400 MHz, $CDCl_3$)** δ 7.45-7.32 (m, 7H), 7.13 (t, *J* = 7.6 Hz, 1H), 6.95 (d, *J* = 7.6 Hz, 1H), 6.69 (d, *J* = 16.0 Hz, 1H), 6.23-6.15 (m, 1H), 3.78-3.69 (m, 4H), 3.60 (dd, *J* = 14.0 Hz, 7.2 Hz, 1H), 3.54 (d, *J* = 14.4 Hz, 1H), 1.82-1.73 (m, 2H), 1.47 (s, 3H), 1.01 (t, *J* = 7.6 Hz, 3H); **^{13}C NMR (101 MHz, $CDCl_3$)** δ 177.8, 142.8, 139.1, 135.6, 130.7, 128.8, 128.7, 128.6, 126.7, 123.6, 122.3, 115.3, 109.0, 59.5, 56.7, 45.5, 41.9, 25.3, 20.5, 11.4; **HRMS** Calculated for $C_{22}H_{25}NO_3S$ ($M+H^+$): 384.1628; Found: 384.1628.

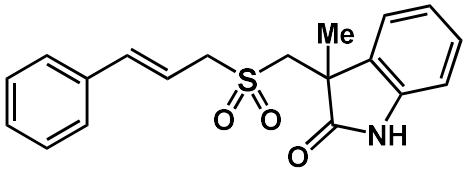
^{1}H NMR spectrum (400 MHz, $CDCl_3$) of compound **66**



^{13}C NMR spectrum (101 MHz, $CDCl_3$) of compound **66**

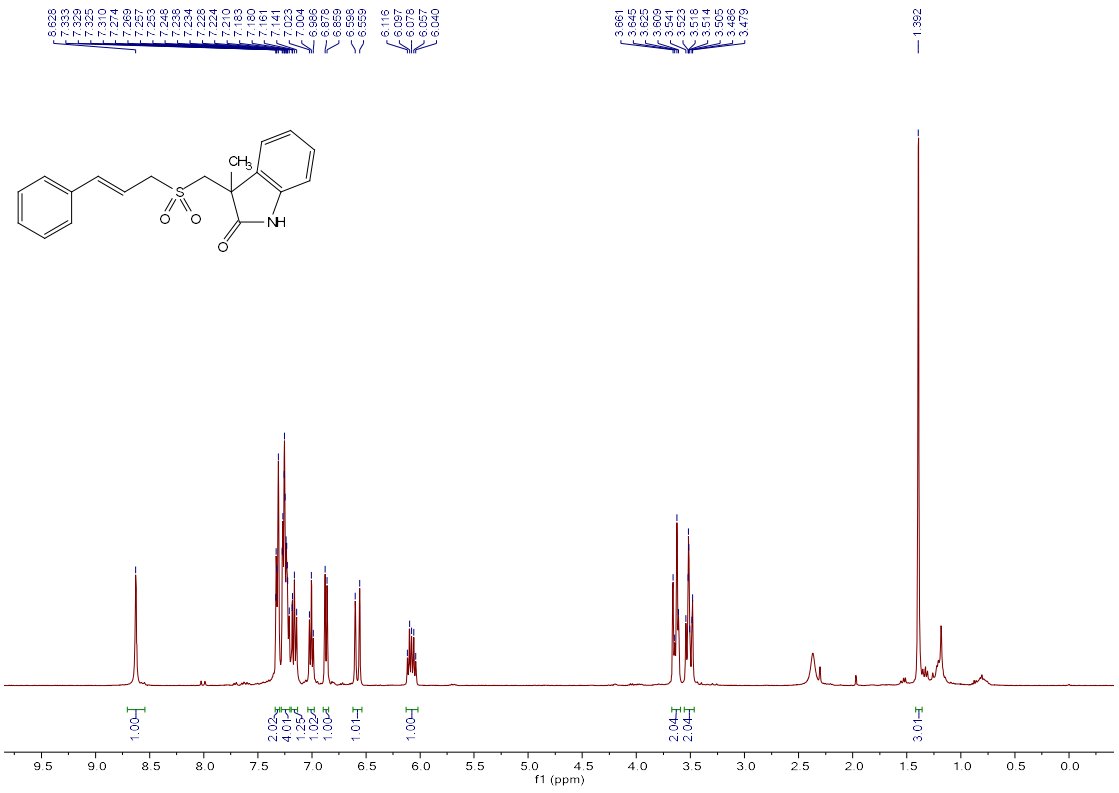


3-((cinnamylsulfonyl)methyl)-3-methylindolin-2-one (67).

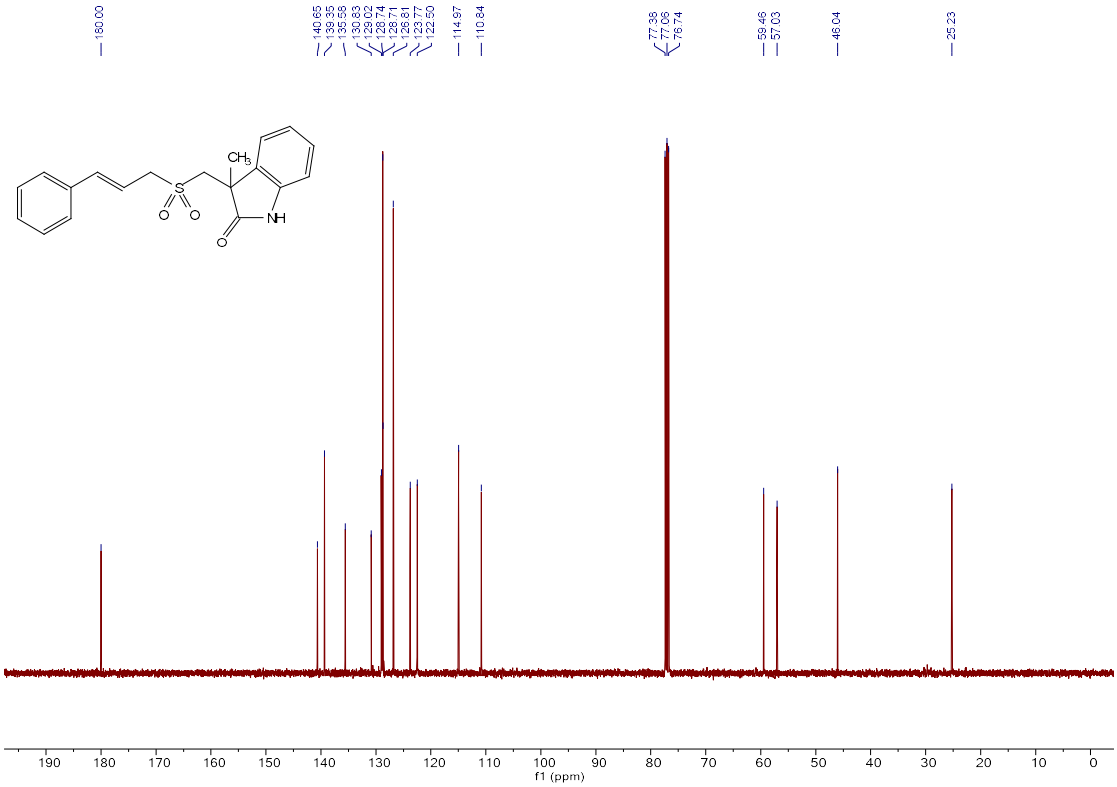


The product (28.7 mg, 42% yield) as yellow solid was purified with silica gel chromatography (petroleum ether/ethyl acetate = 2/1). **^{1}H NMR (400 MHz, $CDCl_3$)** δ 8.63 (s, 1H), 7.33-7.31 (m, 2H), 7.27-7.21 (m, 4H), 7.18-7.14 (m, 1H), 7.00 (t, *J* = 7.6 Hz, 1H), 6.87 (d, *J* = 7.6 Hz, 1H), 6.58 (d, *J* = 15.6 Hz, 1H), 6.12-6.04 (m, 1H), 3.66-3.61 (m, 2H), 3.54-3.48 (m, 2H), 1.39 (s, 3H); **^{13}C NMR (101 MHz, $CDCl_3$)** δ 180.0, 140.7, 139.4, 135.6, 130.8, 129.0, 128.74, 128.71, 126.8, 123.8, 122.5, 115.0, 110.8, 59.5, 57.0, 46.0, 25.2; **HRMS** Calculated for $C_{19}H_{19}NO_3S$ ($M+H^+$): 342.1158; Found: 342.1158.

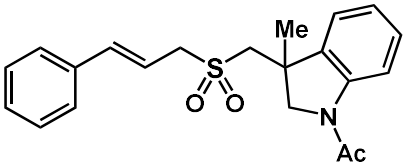
^{1}H NMR spectrum (400 MHz, $CDCl_3$) of compound **67**



^{13}C NMR spectrum (101 MHz, $CDCl_3$) of compound **67**

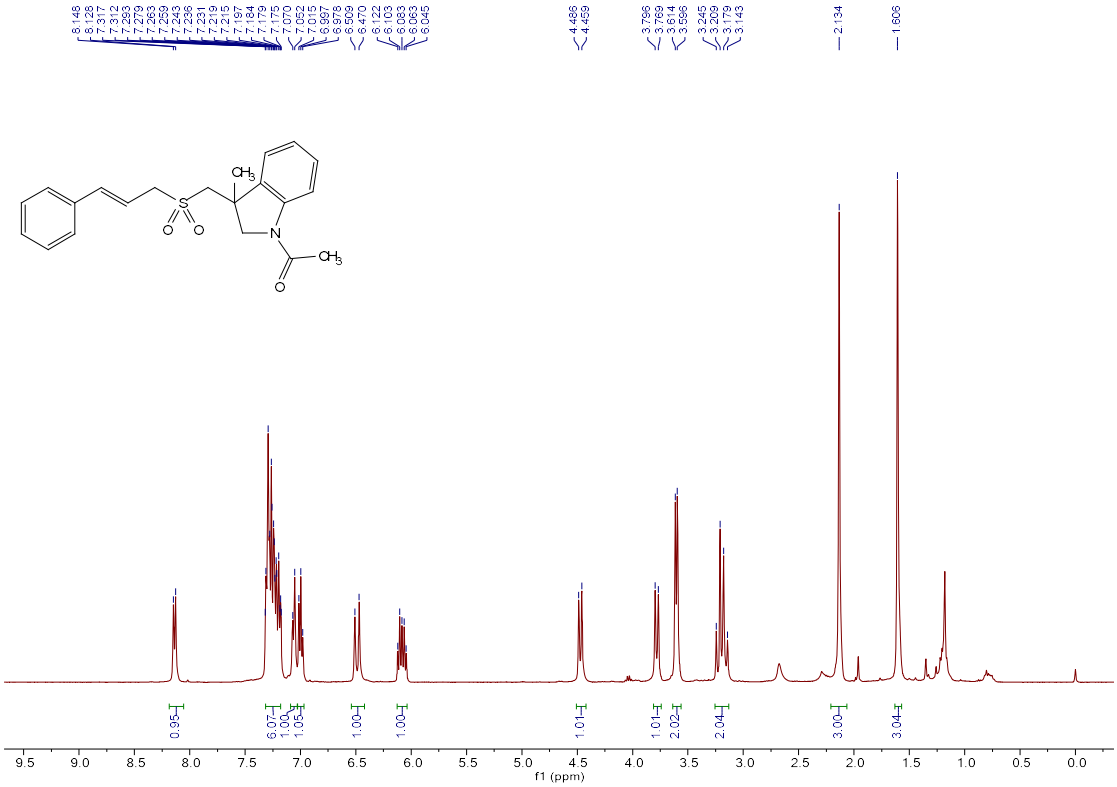


1-(3-((cinnamylsulfonyl)methyl)-3-methylindolin-1-yl)ethan-1-one (68).

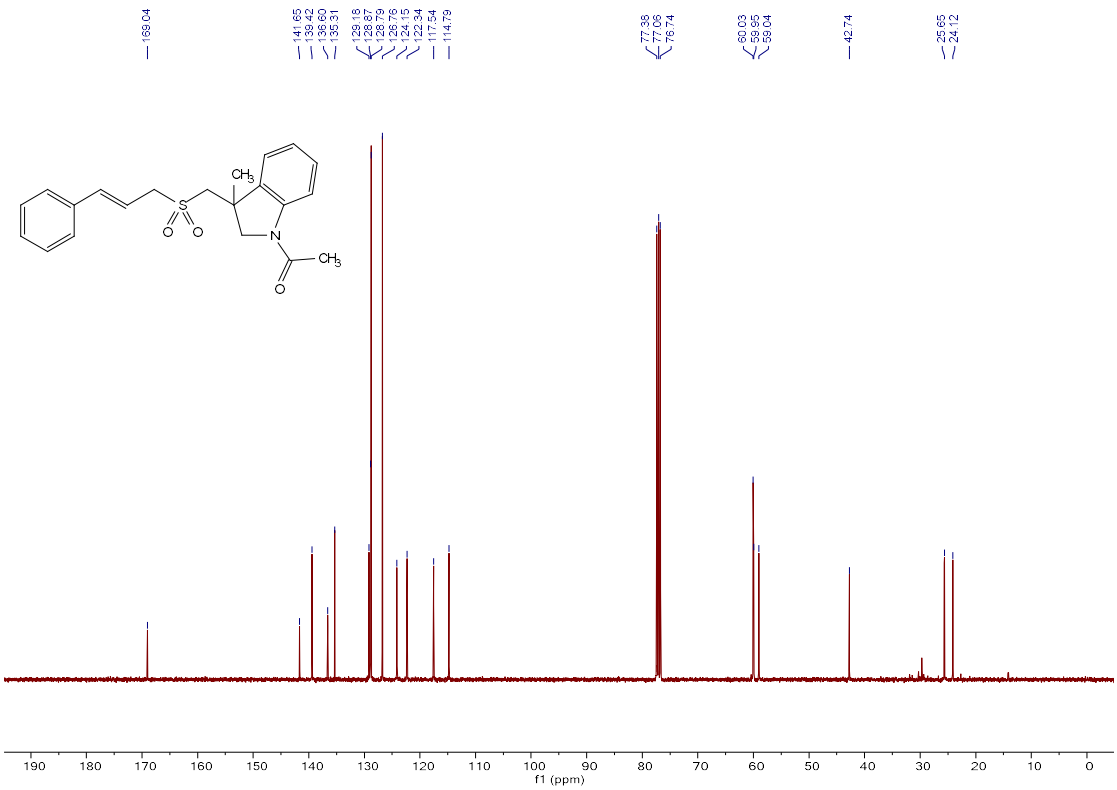


The product (50.3 mg, 68% yield) as yellow oil was purified with silica gel chromatography (petroleum ether/ethyl acetate = 5/1). **^{1}H NMR (400 MHz, $CDCl_3$)** δ 8.14 (d, *J* = 8.0 Hz, 1H), 7.32-7.18 (m, 6H), 7.06 (d, *J* = 7.2 Hz, 1H), 7.00 (t, *J* = 7.2 Hz, 1H), 6.49 (d, *J* = 15.6 Hz, 1H), 6.12-6.05 (m, 1H), 4.47 (d, *J* = 10.8 Hz, 1H), 3.78 (d, *J* = 10.8 Hz, 1H), 3.60 (d, *J* = 7.2 Hz, 2H), 3.19 (dd, *J* = 26.4 Hz, 14.4 Hz, 2H), 2.13 (s, 3H), 1.61 (s, 3H); **^{13}C NMR (101 MHz, $CDCl_3$)** δ 169.0, 141.7, 139.4, 136.6, 135.3, 129.2, 128.9, 128.8, 126.8, 124.2, 122.3, 117.5, 114.8, 60.03, 59.95, 59.0, 42.7, 25.7, 24.1; **HRMS** Calculated for $C_{21}H_{23}NO_3S$ ($M+H^+$): 370.1471; Found: 370.1470.

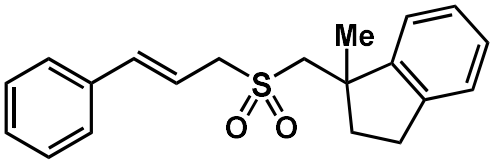
^{1}H NMR spectrum (400 MHz, $CDCl_3$) of compound **68**



^{13}C NMR spectrum (101 MHz, $CDCl_3$) of compound **68**

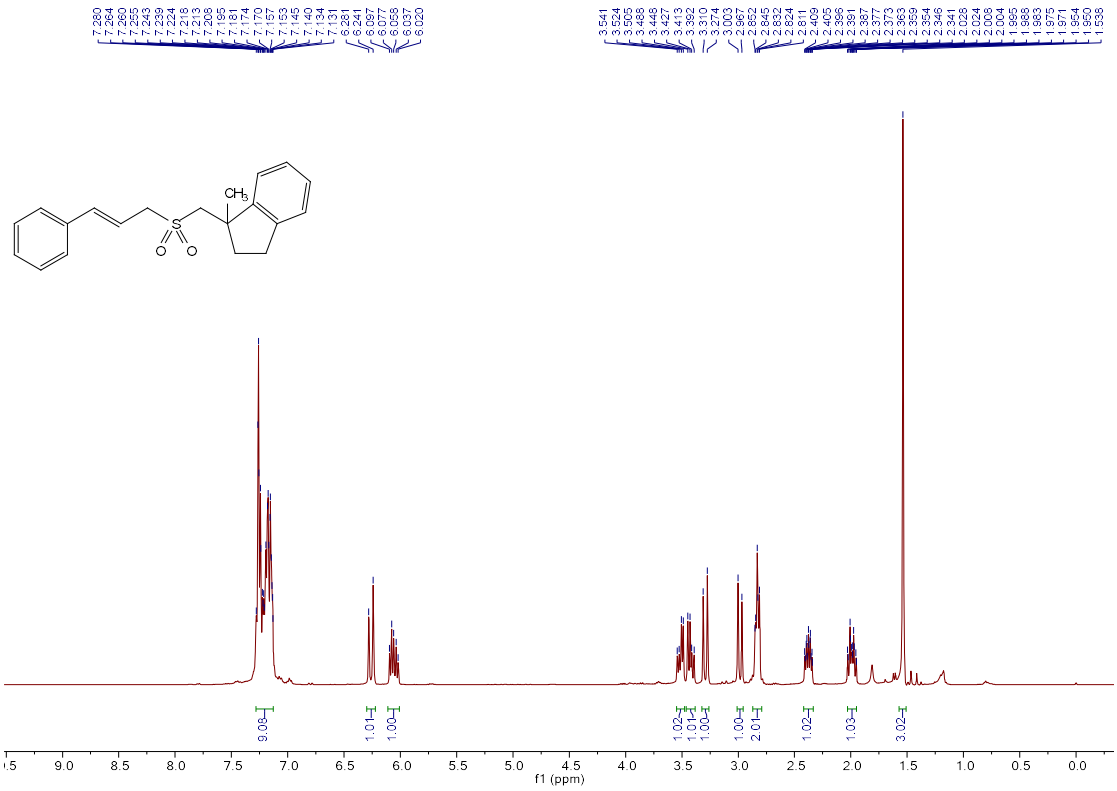


1-((cinnamylsulfonyl)methyl)-1-methyl-2,3-dihydro-1*H*-indene (69).

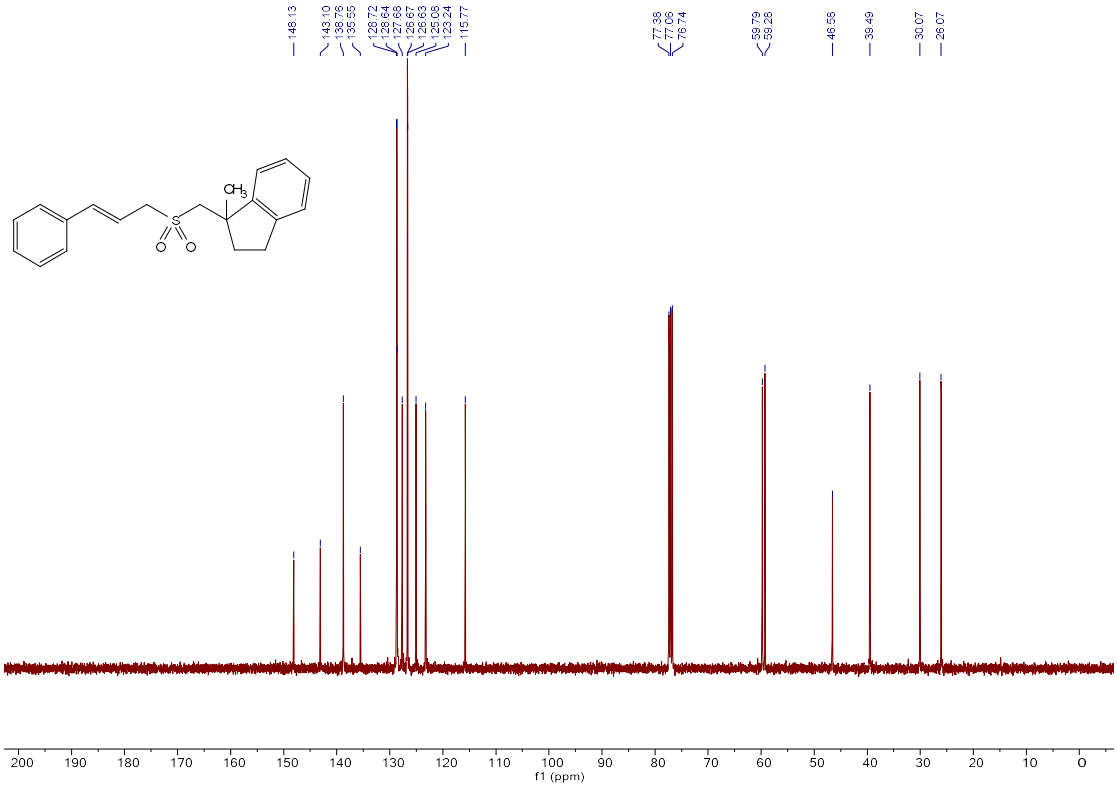


The product (58.8 mg, 90% yield) as yellow oil was purified with silica gel chromatography (petroleum ether/ethyl acetate = 5/1). **^{1}H NMR (400 MHz, $CDCl_3$)** δ 7.28-7.13 (m, 9H), 6.26 (d, *J* = 16.0 Hz, 1H), 6.10-6.02 (m, 1H), 3.51 (dd, *J* = 14.4 Hz, 6.8 Hz, 1H), 3.42 (dd, *J* = 14.0 Hz, 8.4 Hz, 1H), 3.29 (d, *J* = 14.4 Hz, 1H), 2.98 (d, *J* = 14.4 Hz, 1H), 2.85-2.81 (m, 2H), 2.41-2.34 (m, 1H), 2.03-1.95 (m, 1H), 1.54 (s, 3H); **^{13}C NMR (101 MHz, $CDCl_3$)** δ 148.1, 143.1, 138.8, 135.6, 128.7, 128.6, 127.7, 126.67, 126.63, 125.1, 123.2, 115.8, 59.8, 59.3, 46.6, 39.5, 30.1, 26.1; **HRMS** Calculated for $C_{20}H_{22}O_2S$ ($M+Na^+$): 349.1233; Found: 349.1238.

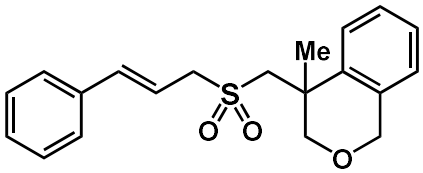
^{1}H NMR spectrum (400 MHz, $CDCl_3$) of compound **69**



^{13}C NMR spectrum (101 MHz, $CDCl_3$) of compound **69**

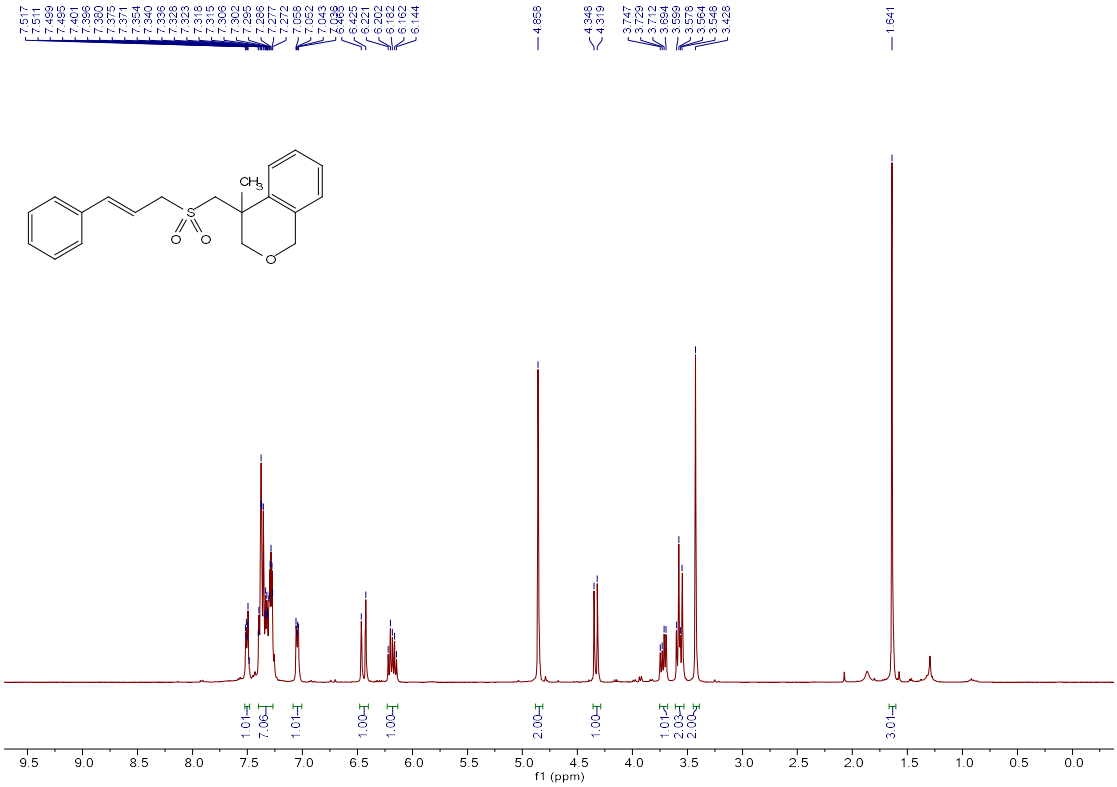


4-((cinnamylsulfonyl)methyl)-4-methylisochromane (70).

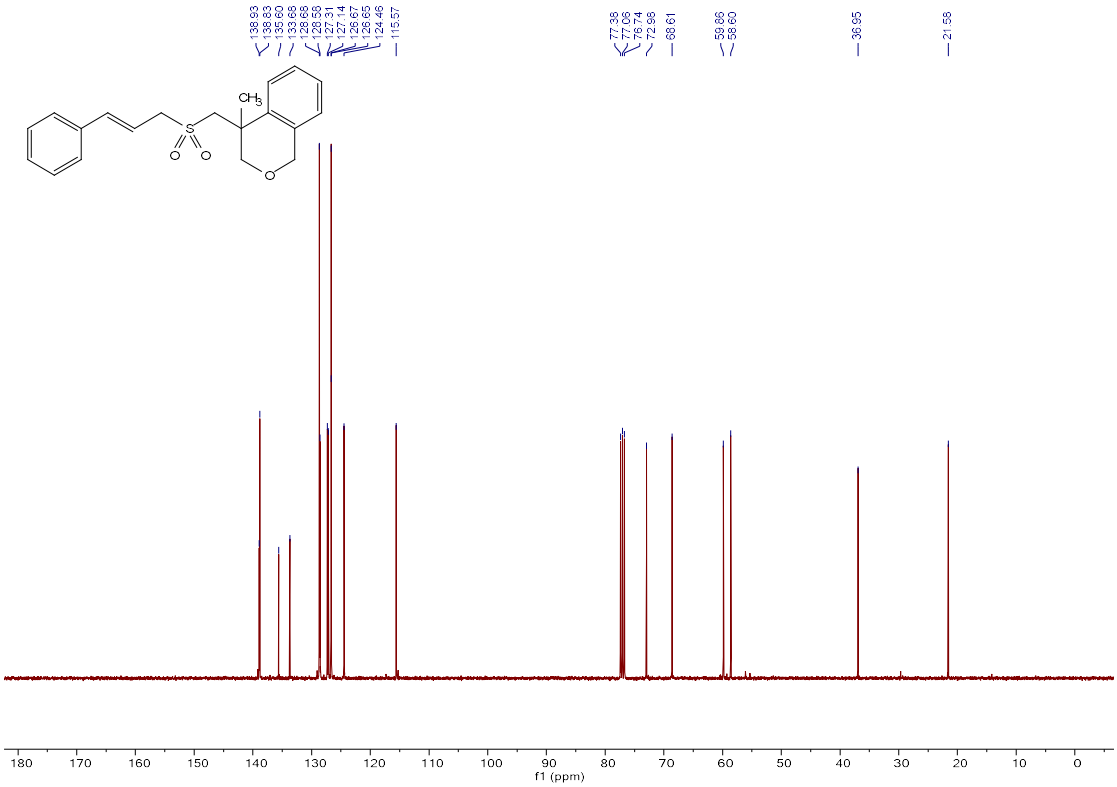


The product (56.2 mg, 82% yield) as brown oil was purified with silica gel chromatography (petroleum ether/ethyl acetate = 5/1). **^{1}H NMR (400 MHz, $CDCl_3$)** δ 7.52-7.48 (m, 1H), 7.40-7.27 (m, 7H), 7.06-7.04 (m, 1H), 6.45 (d, J = 16.0 Hz, 1H), 6.22-6.14 (m, 1H), 4.86 (s, 2H), 4.33 (d, J = 11.6 Hz, 1H), 3.72 (dd, J = 14.0 Hz, 7.2 Hz, 1H), 3.60-3.55 (m, 2H), 3.43 (s, 2H), 1.64 (s, 3H); **^{13}C NMR (101 MHz, $CDCl_3$)** δ 138.9, 138.8, 135.6, 133.7, 128.7, 128.6, 127.3, 127.1, 126.67, 126.65, 124.5, 115.6, 73.0, 68.6, 59.9, 58.6, 37.0, 21.6; **HRMS** Calculated for $C_{20}H_{22}O_3S$ ($M+H^+$): 343.1362; Found: 343.1363.

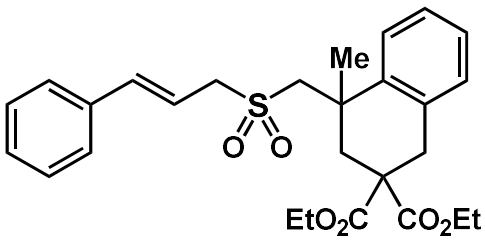
^{1}H NMR spectrum (400 MHz, $CDCl_3$) of compound **70**



^{13}C NMR spectrum (101 MHz, $CDCl_3$) of compound **70**

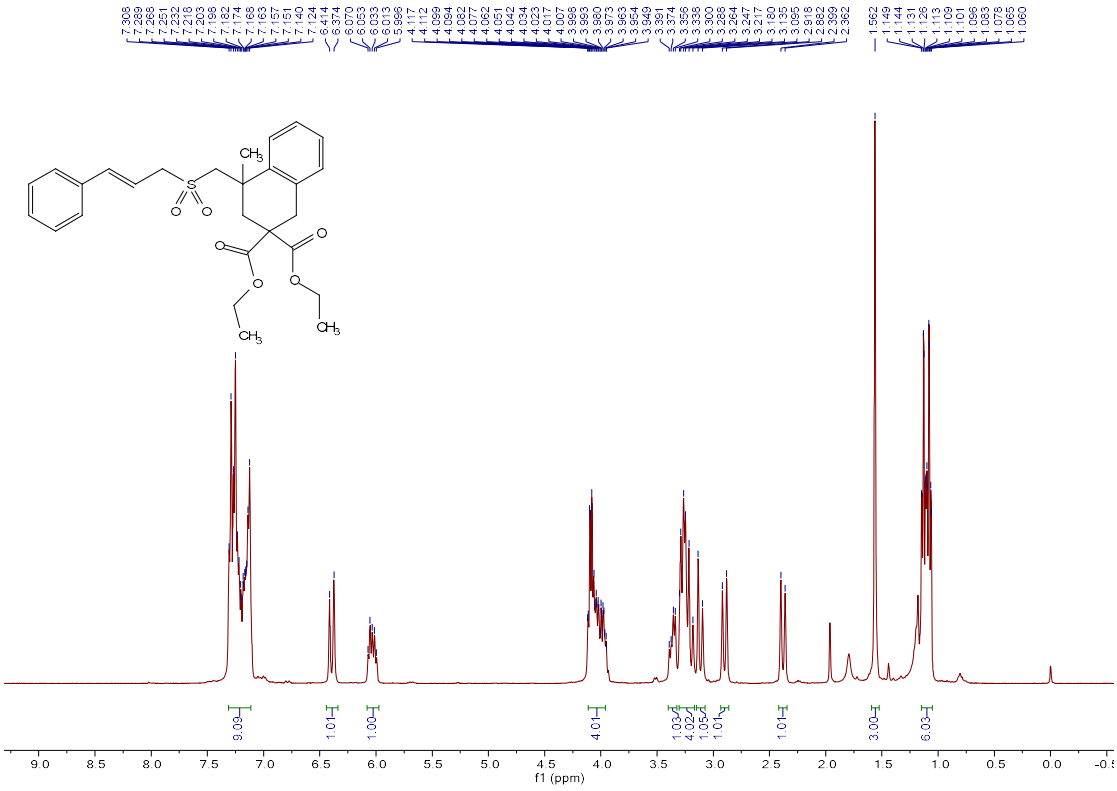


Diethyl 4-((cinnamylsulfonyl)methyl)-4-methyl-3,4-dihydronaphthalene-2,2(1*H*)-dicarboxylate (71).

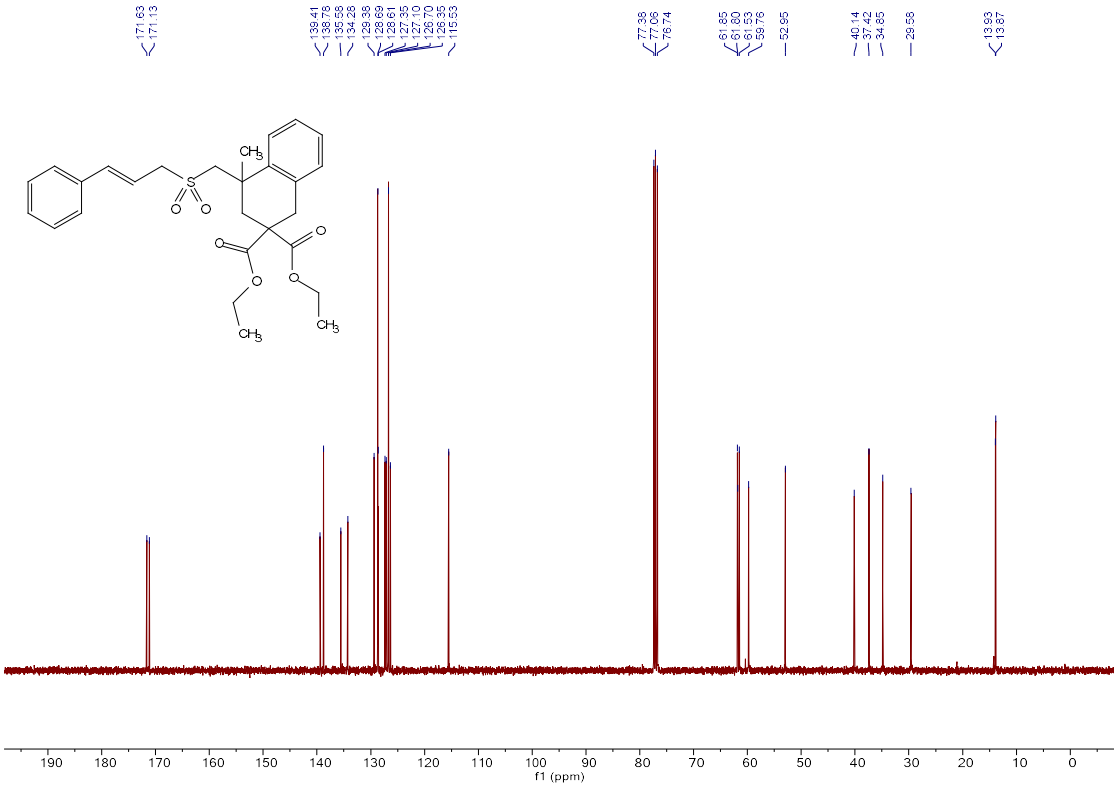


The product (69.8 mg, 72% yield) as white oil was purified with silica gel chromatography (petroleum ether/ethyl acetate = 5/1). **^{1}H NMR (400 MHz, $CDCl_3$)** δ 7.31-7.12 (m, 9H), 6.39 (d, *J* = 16.0 Hz, 1H), 6.07-6.00 (m, 1H), 4.12-3.95 (m, 4H), 3.39-3.34 (m, 1H), 3.30-3.18 (m, 4H), 3.11 (d, *J* = 16.0 Hz, 1H), 2.90 (d, *J* = 14.4 Hz, 1H), 2.38 (d, *J* = 14.8 Hz, 1H), 1.56 (s, 3H), 1.15-1.06 (m, 6H); **^{13}C NMR (101 MHz, $CDCl_3$)** δ 171.6, 171.1, 139.4, 138.8, 135.6, 134.3, 129.4, 128.7, 128.6, 127.4, 127.1, 126.7, 126.4, 115.5, 61.9, 61.8, 61.5, 59.8, 53.0, 40.1, 37.4, 34.9, 29.6, 13.9, 13.9; **HRMS** Calculated for $C_{27}H_{32}O_6S$ ($M+H^+$): 485.1992; Found: 485.2000.

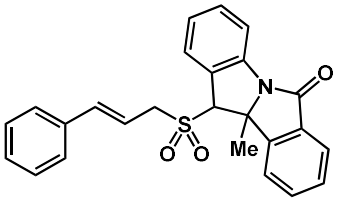
^{1}H NMR spectrum (400 MHz, $CDCl_3$) of compound **71**



^{13}C NMR spectrum (101 MHz, $CDCl_3$) of compound **71**

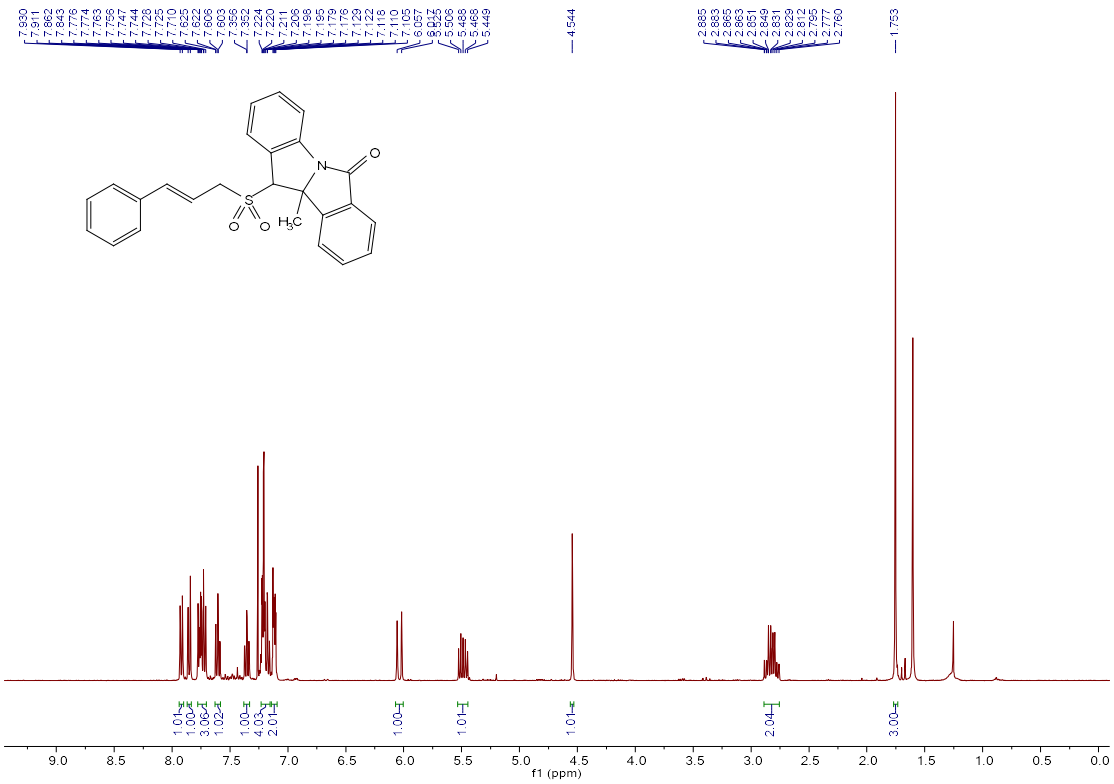


11-(cinnamylsulfonyl)-10b-methyl-10b,11-dihydro-6*H*-isoindolo[2,1-*a*]indol-6-one (72).

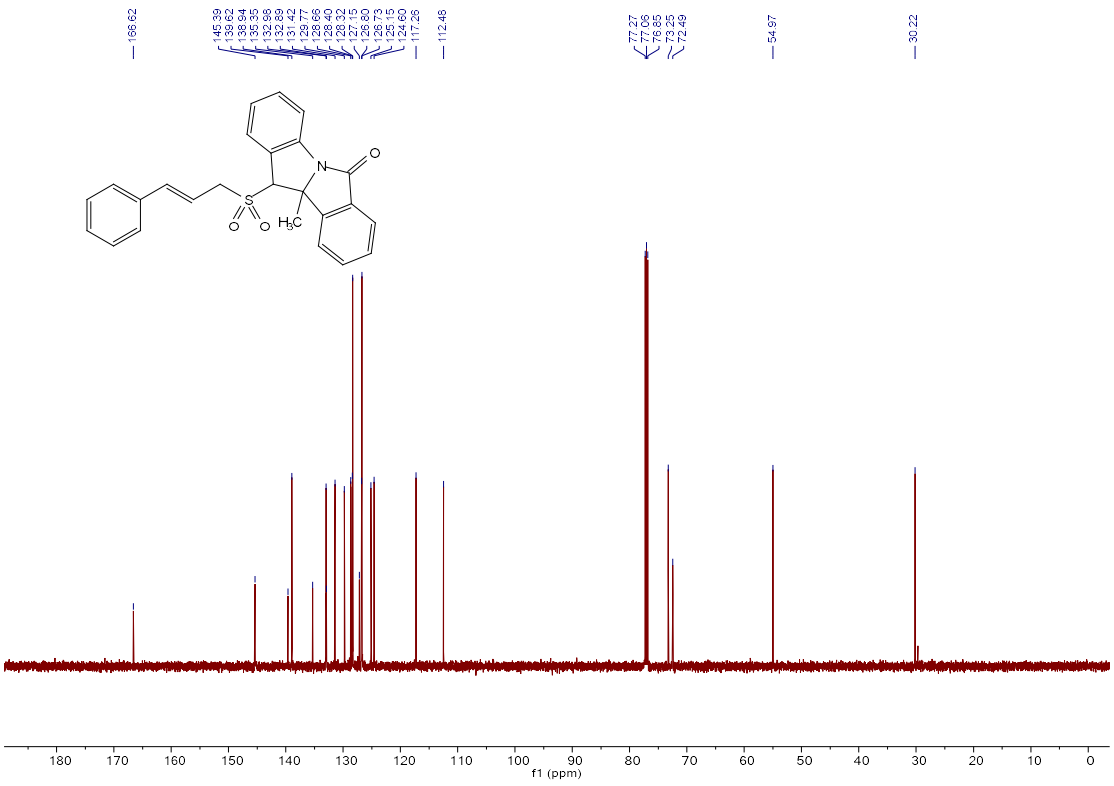


The product (33.2 mg, 40% yield) as white solid was purified with silica gel chromatography (petroleum ether/ethyl acetate = 1/1). **^{1}H NMR (400 MHz, $CDCl_3$)** δ 7.92 (d, *J* = 7.6 Hz, 1H), 7.85 (d, *J* = 7.6 Hz, 1H), 7.78-7.71 (m, 3H), 7.63-7.59 (m, 1H), 7.38-7.33 (m, 1H), 7.24-7.16 (m, 4H), 7.14-7.11 (m, 2H), 6.04 (d, *J* = 16.0 Hz, 1H), 5.53-5.45 (m, 1H), 4.54 (s, 1H), 2.89-2.76 (m, 2H), 1.75 (s, 3H); **^{13}C NMR (151 MHz, $CDCl_3$)** δ 166.6, 145.4, 139.6, 138.9, 135.4, 133.0, 132.9, 131.4, 129.8, 128.7, 128.4, 128.3, 127.2, 126.8, 126.7, 125.2, 124.6, 117.3, 112.5, 73.3, 72.5, 55.0, 30.2; **HRMS** Calculated for $C_{25}H_{21}NO_3S$ ($M+Na^+$): 438.1134; Found: 438.1136.

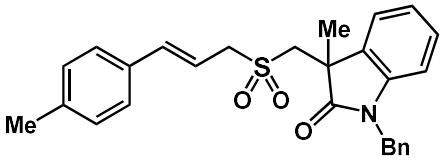
^{1}H NMR spectrum (400 MHz, $CDCl_3$) of compound **72**



^{13}C NMR spectrum (151 MHz, $CDCl_3$) of compound **72**

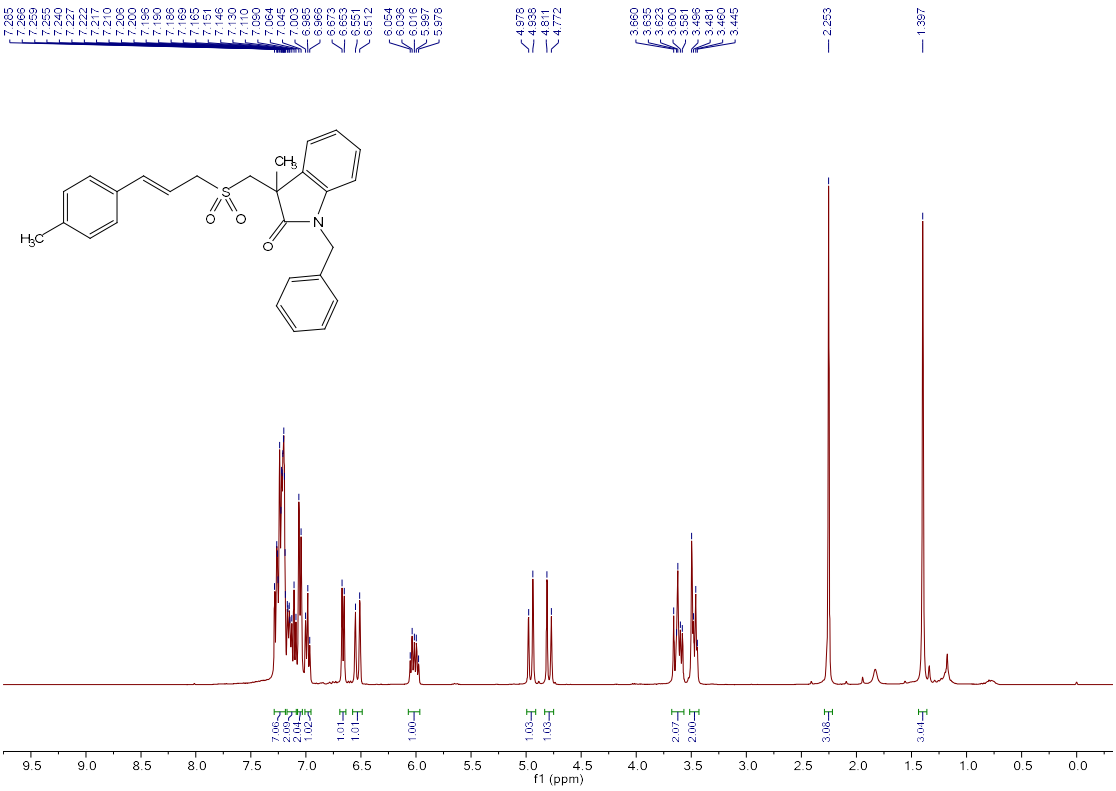


(*E*)-1-benzyl-3-methyl-3-(((3-(*p*-tolyl)allyl)sulfonyl)methyl)indolin-2-one (73).

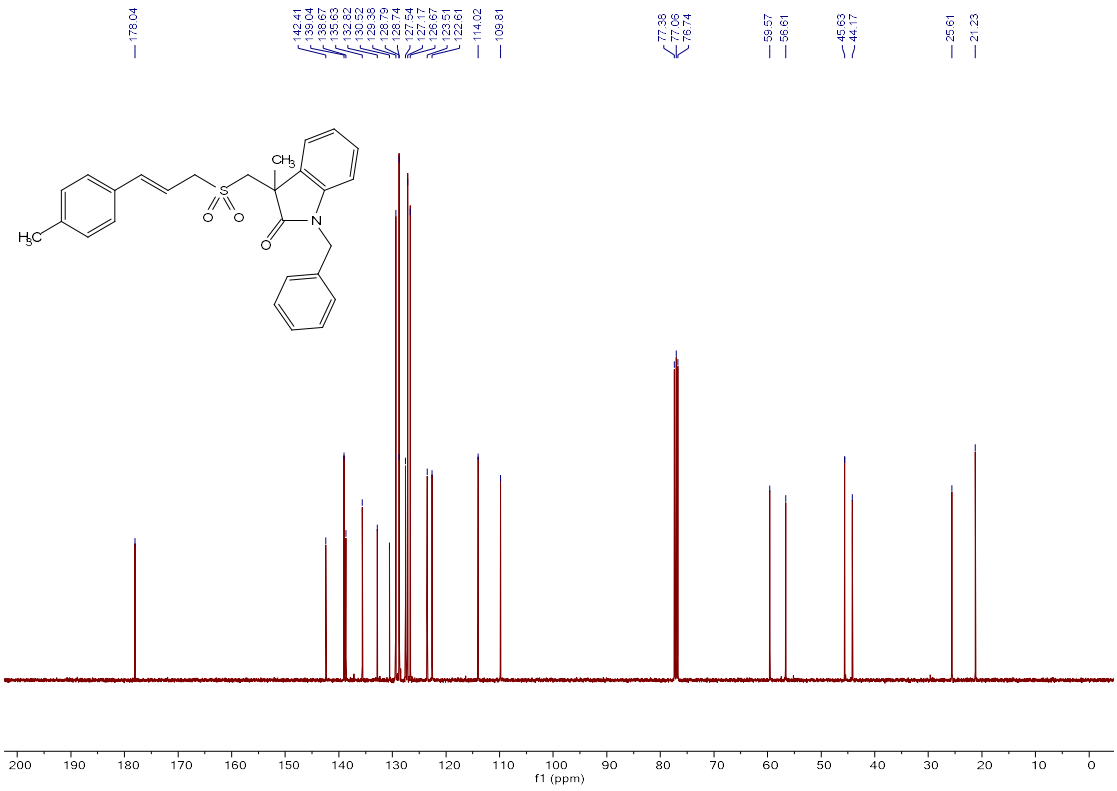


The product (74.0 mg, 83% yield) as brown solid was purified with silica gel chromatography (petroleum ether/ethyl acetate = 2/1). **^{1}H NMR (400 MHz, $CDCl_3$)** δ 7.29-7.19 (m, 7H), 7.17-7.09 (m, 2H), 7.06-7.05 (m, 2H), 6.98 (t, *J* = 7.2 Hz, 1H), 6.66 (d, *J* = 8.0 Hz, 1H), 6.53 (d, *J* = 15.6 Hz, 1H), 6.05-5.98 (m, 1H), 4.96 (d, *J* = 16.0 Hz, 1H), 4.79 (d, *J* = 15.6 Hz, 1H), 3.66-3.58 (m, 2H), 3.50-3.45 (m, 2H), 2.25 (s, 3H), 1.40 (s, 3H); **^{13}C NMR (101 MHz, $CDCl_3$)** δ 178.0, 142.4, 139.0, 138.7, 135.6, 132.8, 130.5, 129.4, 128.8, 128.7, 127.5, 127.2, 126.7, 123.5, 122.6, 114.0, 109.8, 59.6, 56.6, 45.6, 44.2, 25.6, 21.2; **HRMS** Calculated for $C_{27}H_{27}NO_3S$ ($M+H^+$): 446.1784; Found: 446.1787.

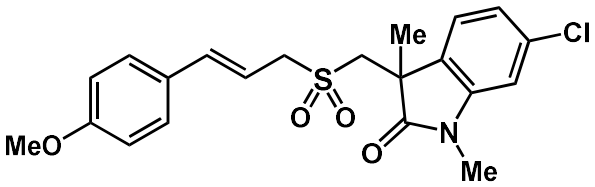
^{1}H NMR spectrum (400 MHz, $CDCl_3$) of compound **73**



^{13}C NMR spectrum (101 MHz, $CDCl_3$) of compound **73**

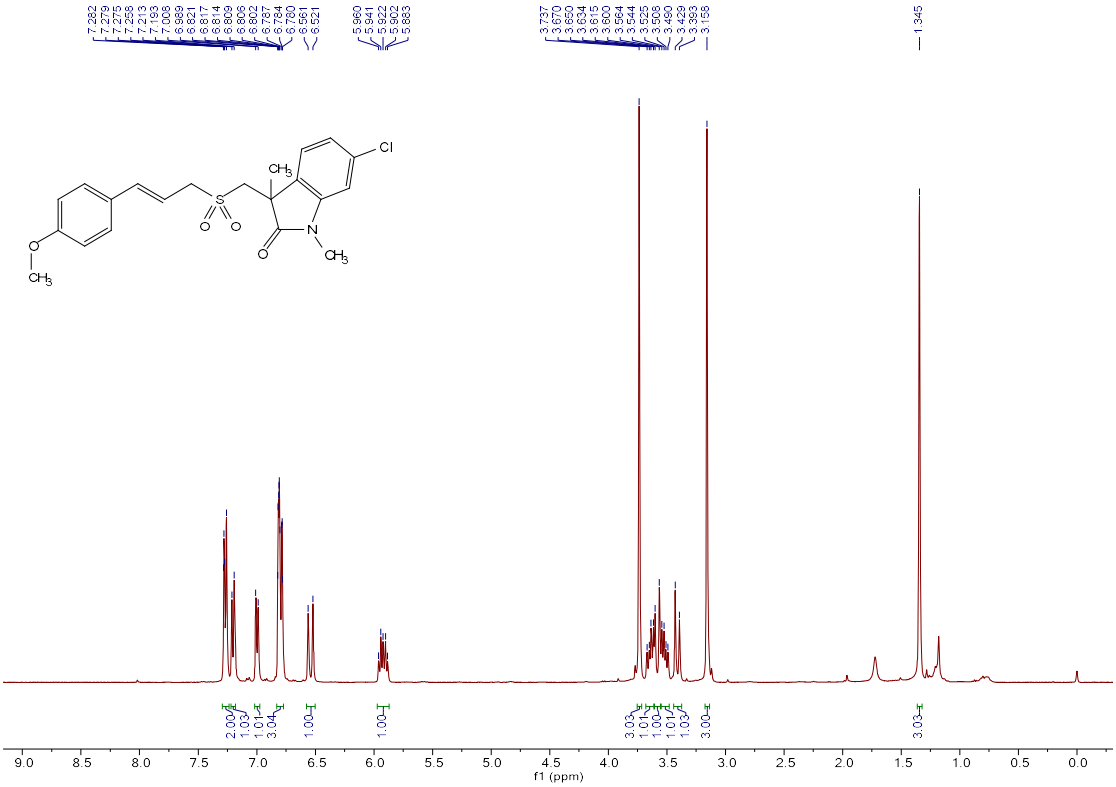


(*E*)-6-chloro-3-(((3-(4-methoxyphenyl)allyl)sulfonyl)methyl)-1,3-dimethylindolin-2-one (74).

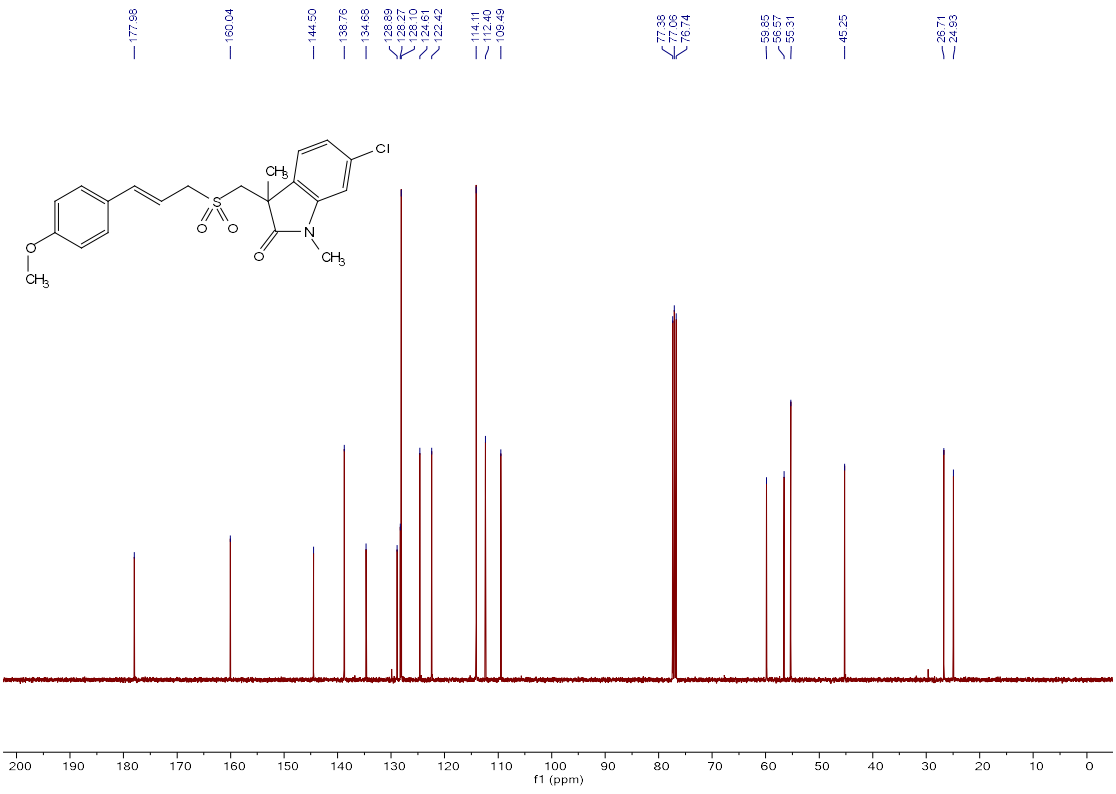


The product (63.0 mg, 75% yield) as white solid was purified with silica gel chromatography (petroleum ether/ethyl acetate = 2/1). **^{1}H NMR (400 MHz, Chloroform-*d*)** δ 7.28-7.26 (m, 2H), 7.20 (d, *J* = 8.0 Hz, 1H), 7.00 (d, *J* = 7.6 Hz, 1H), 6.82-6.78 (m, 3H), 6.54 (d, *J* = 16.0 Hz, 1H), 5.96-5.88 (m, 1H), 3.74 (s, 3H), 3.64 (dd, *J* = 14.4 Hz, 7.6 Hz, 1H), 3.58 (d, *J* = 14.4 Hz, 1H), 3.52 (dd, *J* = 14.4 Hz, 7.6 Hz, 1H), 3.41 (d, *J* = 14.4 Hz, 1H), 3.16 (s, 3H), 1.34 (s, 3H); **^{13}C NMR (101 MHz, $CDCl_3$)** δ 178.0, 160.0, 144.5, 138.8, 134.7, 128.9, 128.3, 128.1, 124.6, 122.4, 114.1, 112.4, 109.5, 59.9, 56.6, 55.3, 45.3, 26.7, 24.9; **HRMS** Calculated for $C_{21}H_{22}ClNO_4S$ ($M+Na^+$): 442.0850; Found: 442.0852.

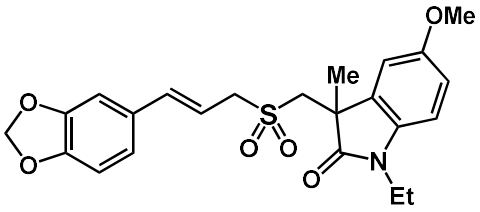
^{1}H NMR spectrum (400 MHz, $CDCl_3$) of compound **74**



^{13}C NMR spectrum (101 MHz, $CDCl_3$) of compound **74**

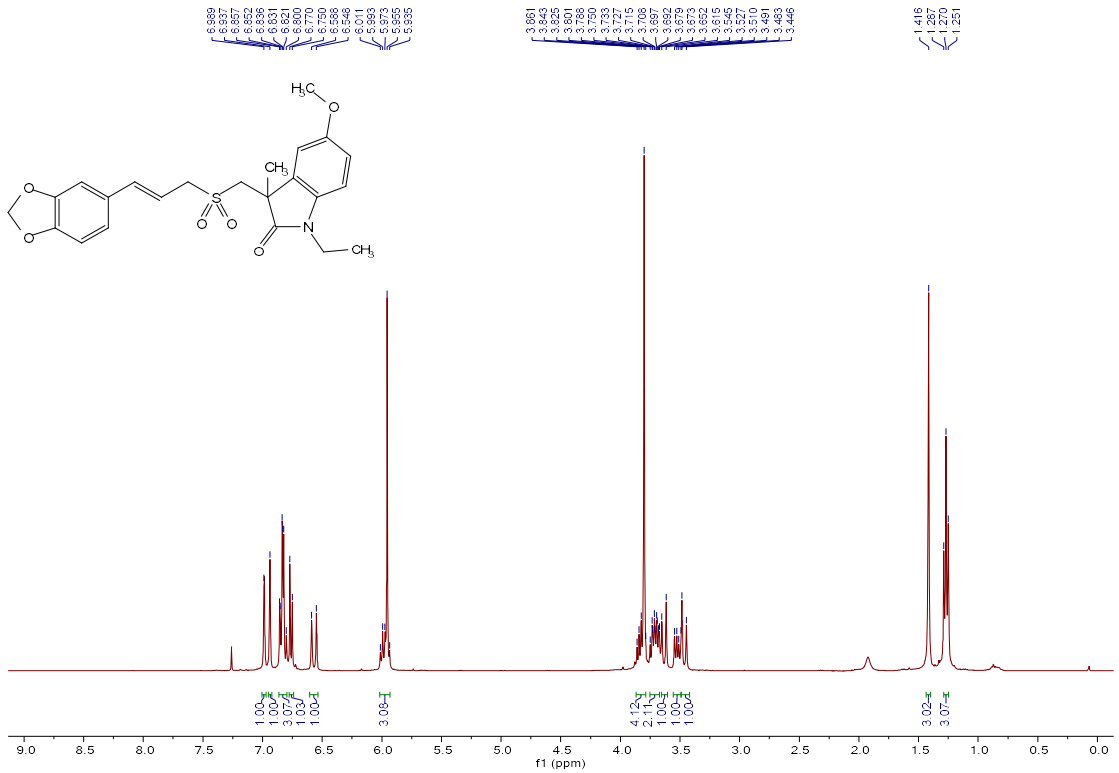


(*E*)-3-(((3-(benzo[*d*][1,3]dioxol-5-yl)allyl)sulfonyl)methyl)-1-ethyl-5-methoxy-3methylindolin-2-one (75).

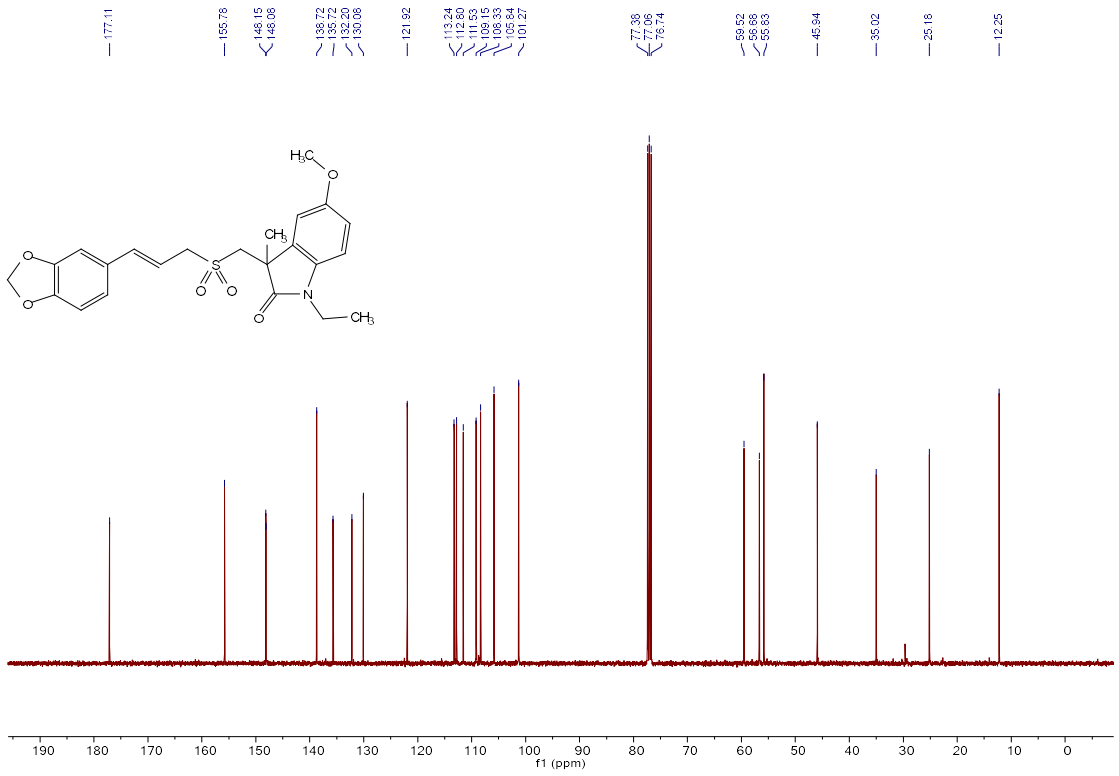


The product (67.4 mg, 76% yield) as yellow solid was purified with silica gel chromatography (petroleum ether/ethyl acetate = 2/1). **^{1}H NMR (400 MHz, $CDCl_3$)** δ 6.99 (s, 1H), 6.94 (s, 1H), 6.86-6.80 (m, 3H), 6.76 (d, *J* = 8.0 Hz, 1H), 6.57 (d, *J* = 16.0 Hz, 1H), 6.01-5.94 (m, 3H), 3.86-3.79 (m, 4H), 3.75-3.67 (m, 2H), 3.63 (d, *J* = 14.8 Hz, 1H), 3.52 (dd, *J* = 14.0 Hz, 7.2 Hz, 1H), 3.46 (d, *J* = 14.8 Hz, 1H), 1.42 (s, 3H), 1.27 (t, *J* = 7.6 Hz, 3H); **^{13}C NMR (101 MHz, $CDCl_3$)** δ 177.1, 155.8, 148.2, 148.1, 138.7, 135.7, 132.2, 130.1, 121.9, 113.2, 112.8, 111.5, 109.2, 108.3, 105.8, 101.3, 59.5, 56.7, 55.8, 45.9, 35.0, 25.2, 12.3; **HRMS** Calculated for $C_{23}H_{25}NO_6S$ ($M+H^+$): 444.1475; Found: 444.1477.

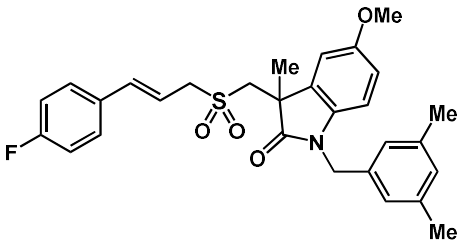
^{1}H NMR spectrum (400 MHz, $CDCl_3$) of compound **75**



^{13}C NMR spectrum (101 MHz, $CDCl_3$) of compound **75**

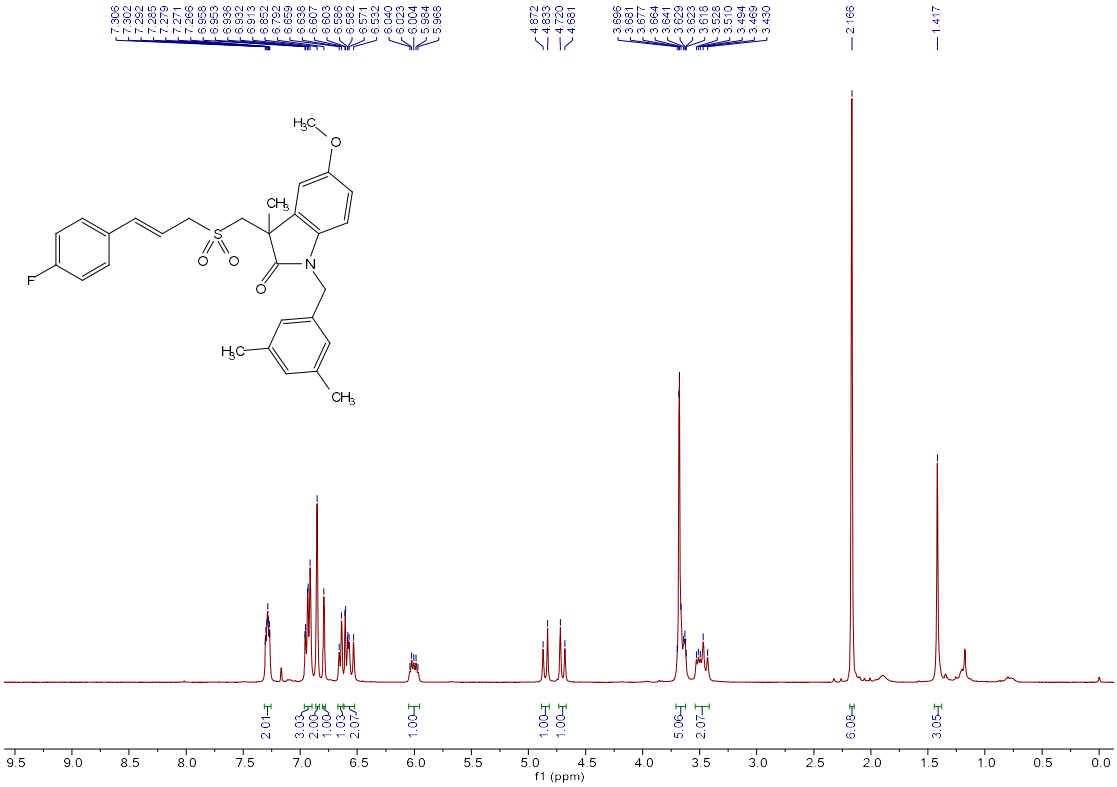


(*E*)-1-(3,5-dimethylbenzyl)-3-(((3-(4-fluorophenyl)allyl)sulfonyl)methyl)-5-methoxy-3-methylindolin-2-one (76).

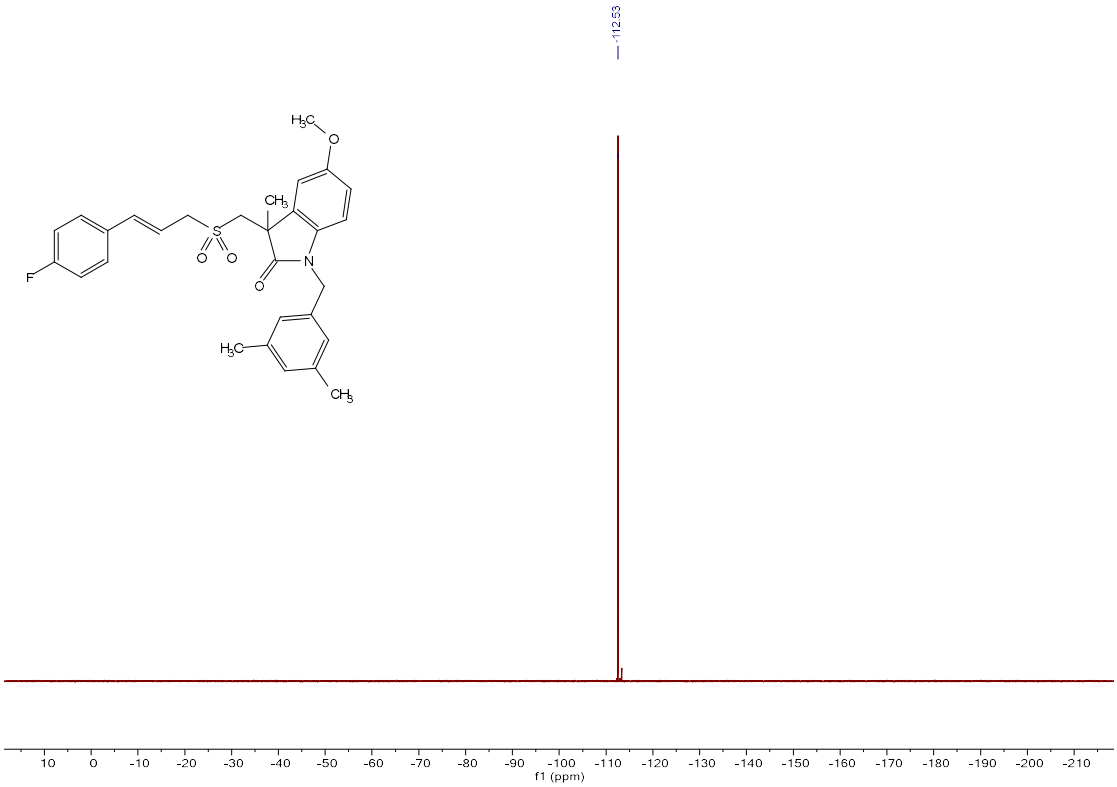


The product (73.1 mg, 72% yield) as brown solid was purified with silica gel chromatography (petroleum ether/ethyl acetate = 2/1).**^{1}H NMR (400 MHz, $CDCl_3$)** δ 7.31-7.27 (m, 2H), 6.96-6.91 (m, 3H), 6.85 (s, 2H), 6.79 (s, 1H), 6.65 (d, *J* = 8.4 Hz, 1H), 6.61-6.53 (m, 2H), 6.04-5.97 (m, 1H), 4.85 (d, *J* = 15.6 Hz, 1H), 4.70 (d, *J* = 15.6 Hz, 1H), 3.70-3.62 (m, 5H), 3.53-3.43 (m, 2H), 2.17 (s, 6H), 1.42 (s, 3H); **^{19}F NMR (376 MHz, $CDCl_3$)** δ -112.53 (s, 1F); **^{13}C NMR (101 MHz, $CDCl_3$)** δ 177.7, 164.1, 161.6, 156.0, 138.3, 138.0, 135.8, 135.6, 132.0, 131.9 (d, *J* = 3.0 Hz), 129.2, 128.4 (d, *J* = 8.1 Hz), 125.0, 115.8, 115.6, 114.9 (d, *J* = 2.0 Hz), 112.8, 111.2, 110.2, 59.4, 56.8, 55.7, 46.2, 44.2, 25.7, 21.3; **HRMS** Calculated for $C_{29}H_{30}FNO_4S$ ($M+H^+$): 508.1952; Found: 508.1956.

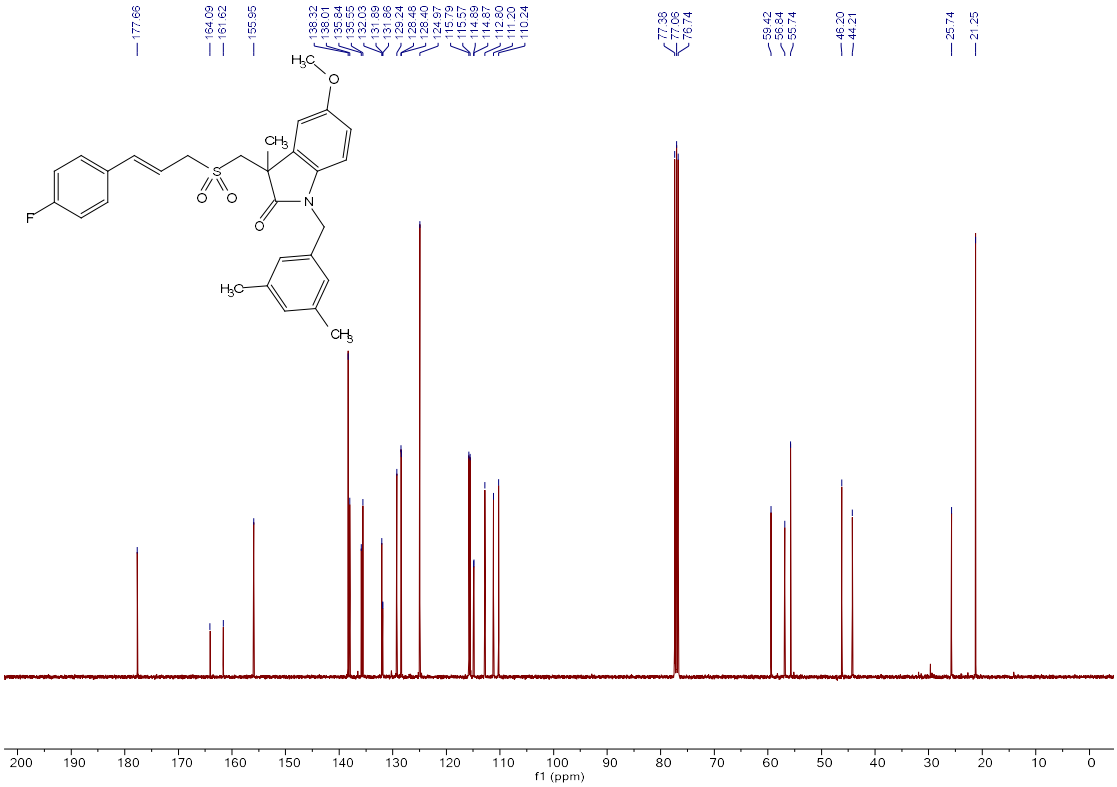
^{1}H NMR spectrum (400 MHz, $CDCl_3$) of compound **76**



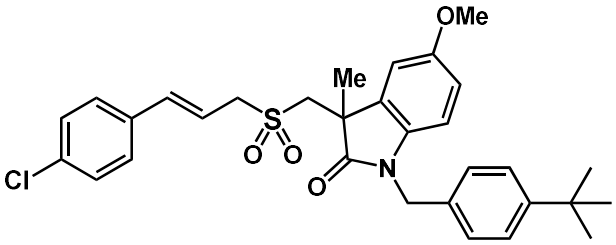
^{19}F NMR spectrum (376 MHz, $CDCl_3$) of compound **76**



^{13}C NMR spectrum (101 MHz, $CDCl_3$) of compound **76**

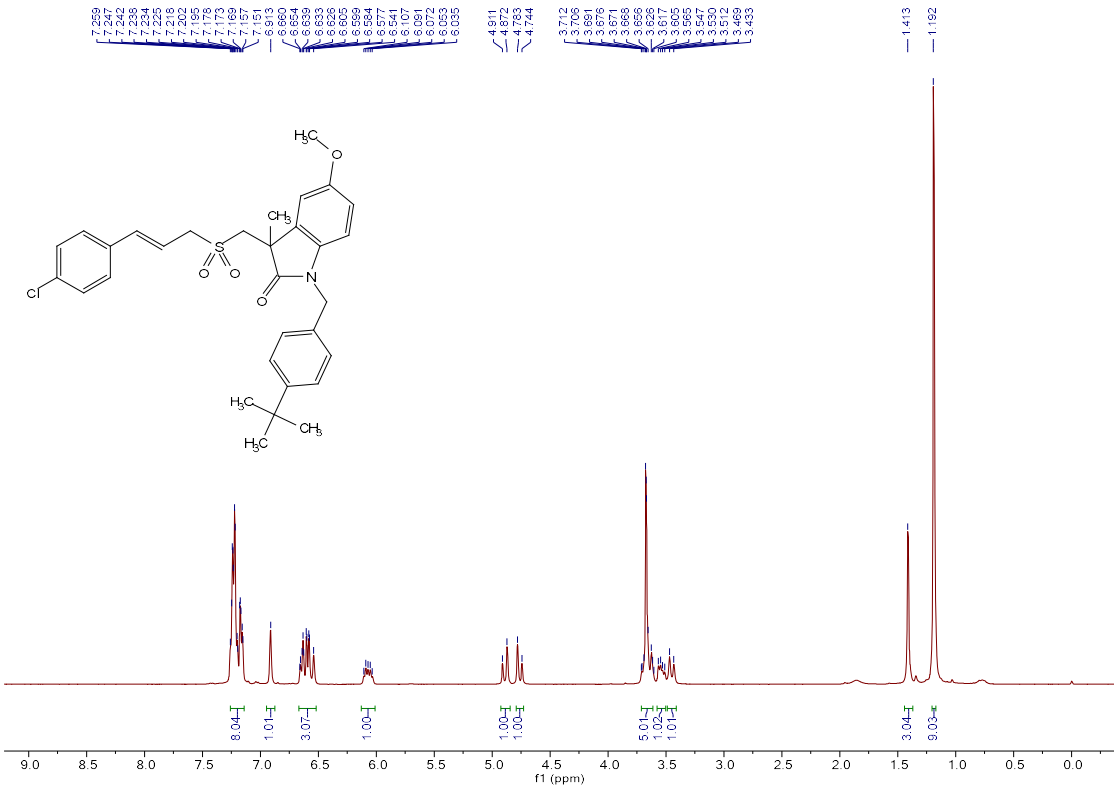


(*E*)-1-(4-(*tert*-butyl)benzyl)-3-(((3-(4-chlorophenyl)allyl)sulfonyl)methyl)-5-methoxy-3-methylindolin-2-one (77).

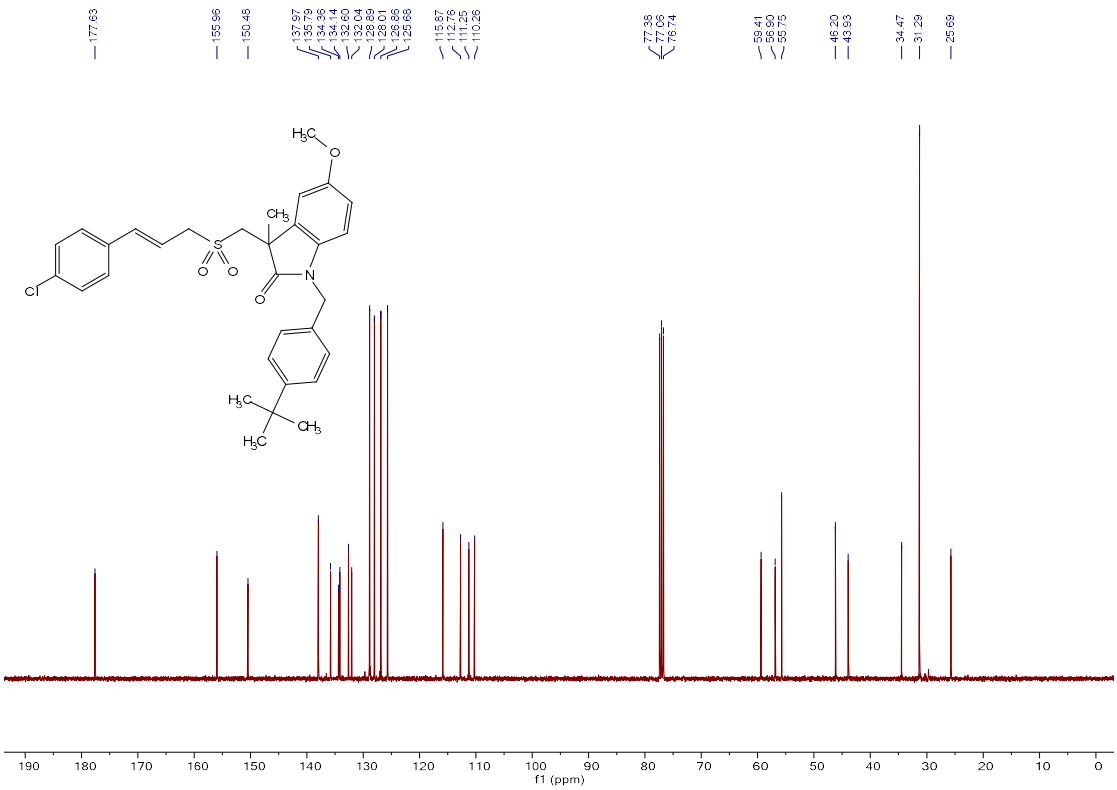


The product (82.8 mg, 75% yield) as yellow solid was purified with silica gel chromatography (petroleum ether/ethyl acetate = 2/1).**^{1}H NMR (400 MHz, CDCl3)** δ 7.26-7.15 (m, 8H), 6.91 (s, 1H), 6.66-6.54 (m, 3H), 6.11-6.04 (m, 1H), 4.89 (d, *J* = 15.6 Hz, 1H), 4.76 (d, *J* = 15.6 Hz, 1H), 3.71-3.61 (m, 5H), 3.57-3.51 (m, 1H), 3.45 (d, *J* = 14.4 Hz, 1H), 1.41 (s, 3H), 1.19 (s, 9H); **^{13}C NMR (101 MHz, $CDCl_3$)** δ 177.6, 156.0, 150.5, 138.0, 135.8, 134.4, 134.1, 132.6, 132.0, 128.9, 128.0, 126.9, 125.7, 115.9, 112.8, 111.3, 110.3, 59.4, 56.9, 55.8, 46.2, 43.9, 34.5, 31.3, 25.7; **HRMS** Calculated for $C_{31}H_{34}ClNO_4S$ ($M+H^+$): 552.1970; Found: 552.1975.

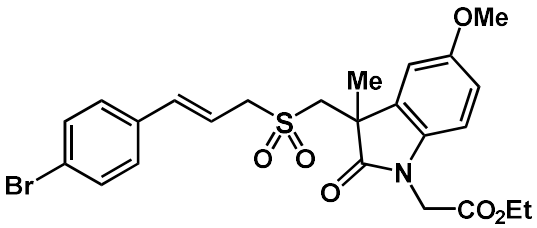
^{1}H NMR spectrum (400 MHz, $CDCl_3$) of compound **77**



^{13}C NMR spectrum (101 MHz, $CDCl_3$) of compound **77**

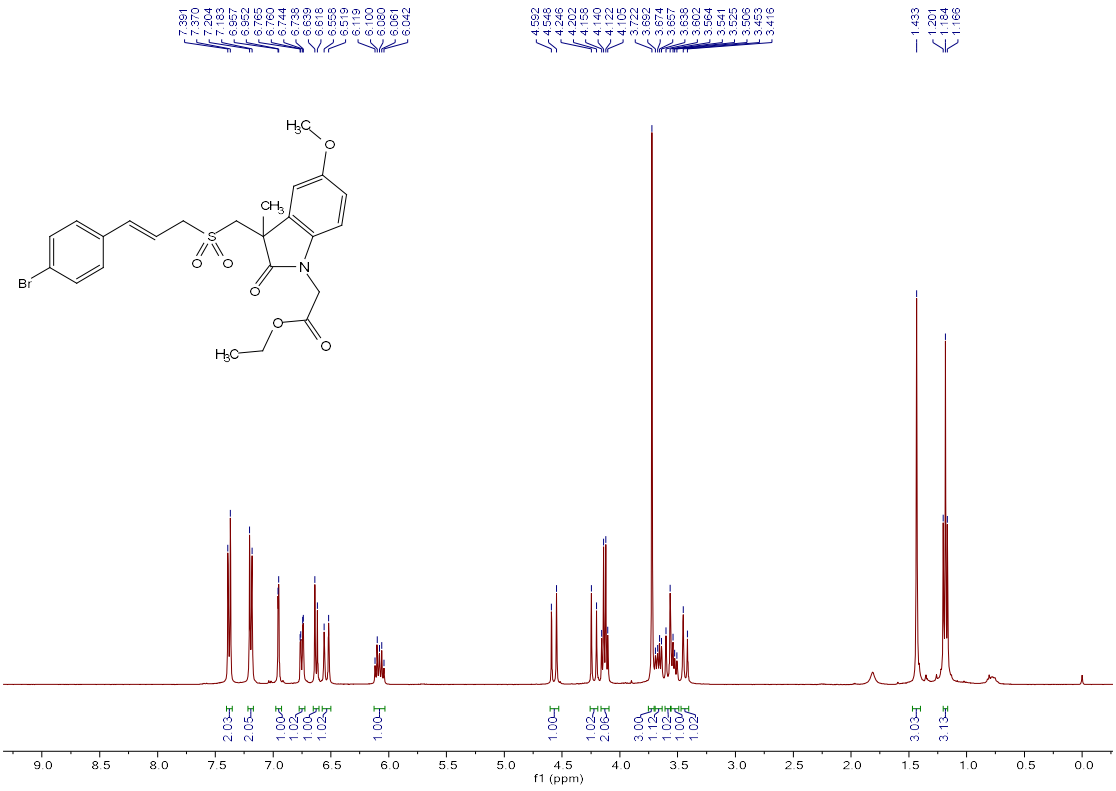


(*E*)-2-(3-(((3-(4-bromophenyl)allyl)sulfonyl)methyl)-5-methoxy-3-methyl-2-oxoindolin-1-yl)acetate (78).

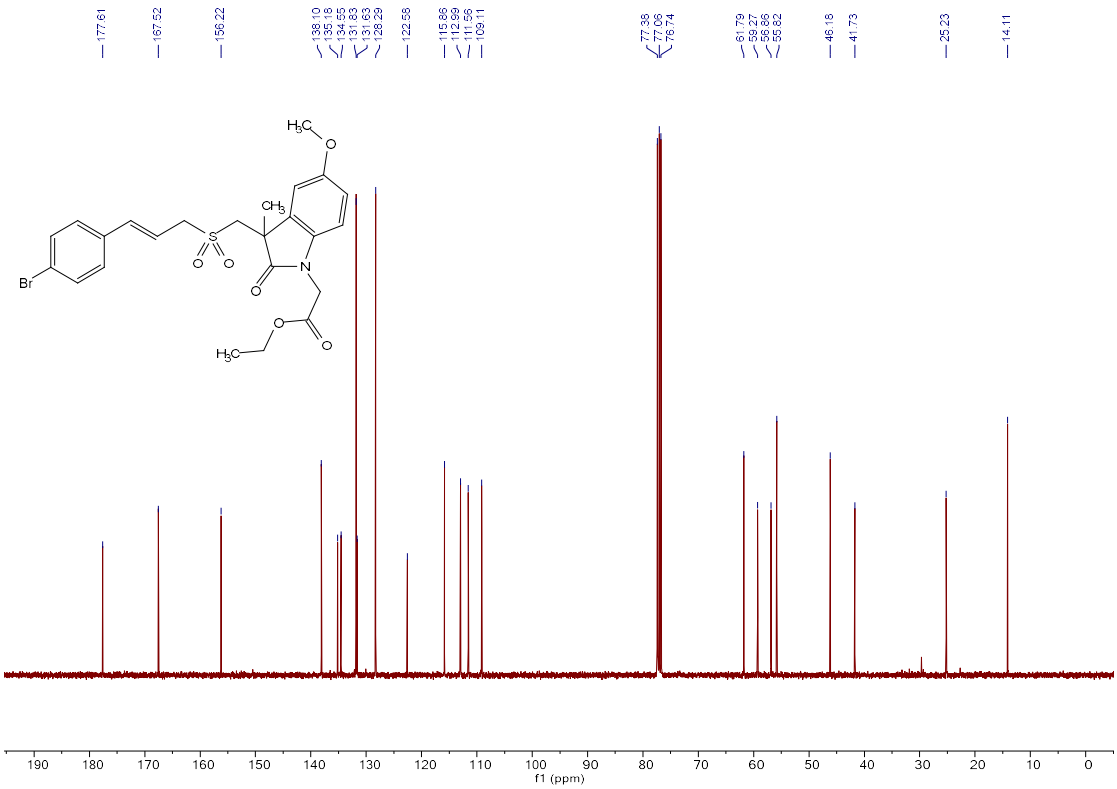


The product (75.1 mg, 70% yield) as yellow solid was purified with silica gel chromatography (petroleum ether/ethyl acetate = 2/1). **^{1}H NMR (400 MHz, $CDCl_3$)** δ 7.38 (d, *J* = 8.4 Hz, 2H), 7.19 (d, *J* = 8.4 Hz, 2H), 6.95 (d, *J* = 2.0 Hz, 1H), 6.75 (dd, *J* = 8.4 Hz, 2.0 Hz, 1H), 6.63 (d, *J* = 8.4 Hz, 1H), 6.54 (d, *J* = 15.6 Hz, 1H), 6.12-6.04 (m, 1H), 4.57 (d, *J* = 17.6 Hz, 1H), 4.22 (d, *J* = 17.6 Hz, 1H), 4.13 (q, *J* = 7.2 Hz, 2H), 3.72 (s, 3H), 3.67 (dd, *J* = 14.0 Hz, 7.6 Hz, 1H), 3.58 (d, *J* = 15.2 Hz, 1H), 3.53 (dd, *J* = 14.0 Hz, 7.6 Hz, 1H), 3.43 (d, *J* = 14.8 Hz, 1H), 1.43 (s, 3H), 1.18 (t, *J* = 7.2 Hz, 3H); **^{13}C NMR (101 MHz, $CDCl_3$)** δ 177.6, 167.5, 156.2, 138.1, 135.2, 134.6, 131.8, 131.6, 128.3, 122.6, 115.9, 113.0, 111.6, 109.1, 61.8, 59.3, 56.9, 55.8, 46.2, 41.7, 25.2, 14.1; **HRMS** Calculated for $C_{24}H_{26}BrNO_6S$ ($M+H^+$): 536.0737; Found: 536.0743.

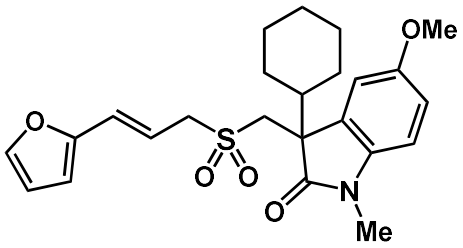
^{1}H NMR spectrum (400 MHz, $CDCl_3$) of compound **78**



^{13}C NMR spectrum (101 MHz, $CDCl_3$) of compound **78**

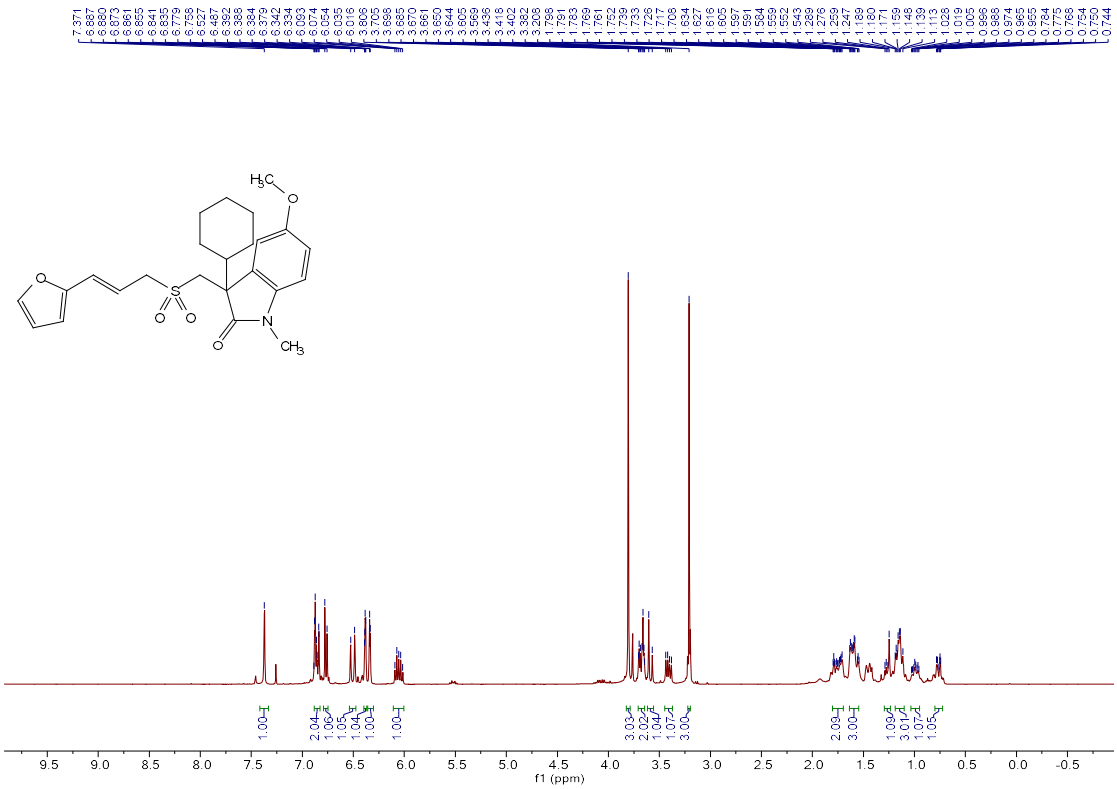


(*E*)-3-cyclohexyl-3-(((3-(furan-2-yl)allyl)sulfonyl)methyl)-5-methoxy-1-methylindolin-2-one (79).

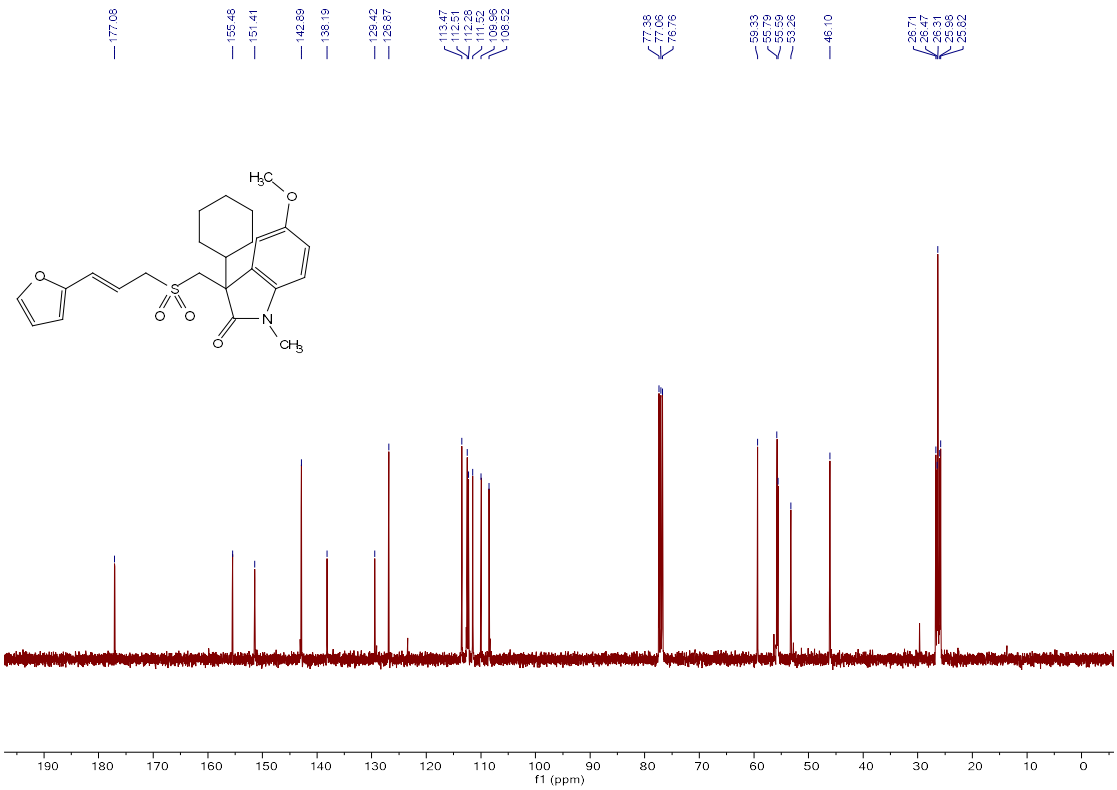


The product (48.8 mg, 55% yield) as brown oil was purified with silica gel chromatography (petroleum ether/ethyl acetate = 2/1). **^{1}H NMR (400 MHz, $CDCl_3$)** δ 7.37 (s, 1H), 6.89-6.84 (m, 2H), 6.77 (d, *J* = 8.4 Hz, 1H), 6.51 (d, *J* = 16.0 Hz, 1H), 6.39-6.38 (m, 1H), 6.34 (d, *J* = 3.2 Hz, 1H), 6.09-6.02 (m, 1H), 3.81 (s, 3H), 3.71-3.64 (m, 2H), 3.59 (d, *J* = 14.4 Hz, 1H), 3.41 (dd, *J* = 14.4, 7.2 Hz, 1H), 3.21 (s, 3H), 1.80-1.71 (m, 2H), 1.63-1.54 (m, 3H), 1.29-1.25 (m, 1H), 1.19-1.11 (m, 3H), 1.03-0.96 (m, 1H), 0.78-0.74 (m, 1H); **^{13}C NMR (101 MHz, $CDCl_3$)** δ 177.1, 155.5, 151.4, 142.9, 138.2, 129.4, 126.9, 113.5, 112.5, 112.3, 111.5, 110.0, 108.5, 59.3, 55.8, 55.6, 53.3, 46.1, 26.7, 26.5, 26.3, 26.0, 25.8; **HRMS** Calculated for $C_{24}H_{29}NO_5S$ ($M+H^+$): 444.1839; Found: 444.1841.

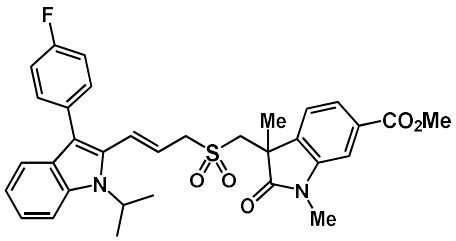
^{1}H NMR spectrum (400 MHz, $CDCl_3$) of compound **79**



^{13}C NMR spectrum (101 MHz, $CDCl_3$) of compound **79**

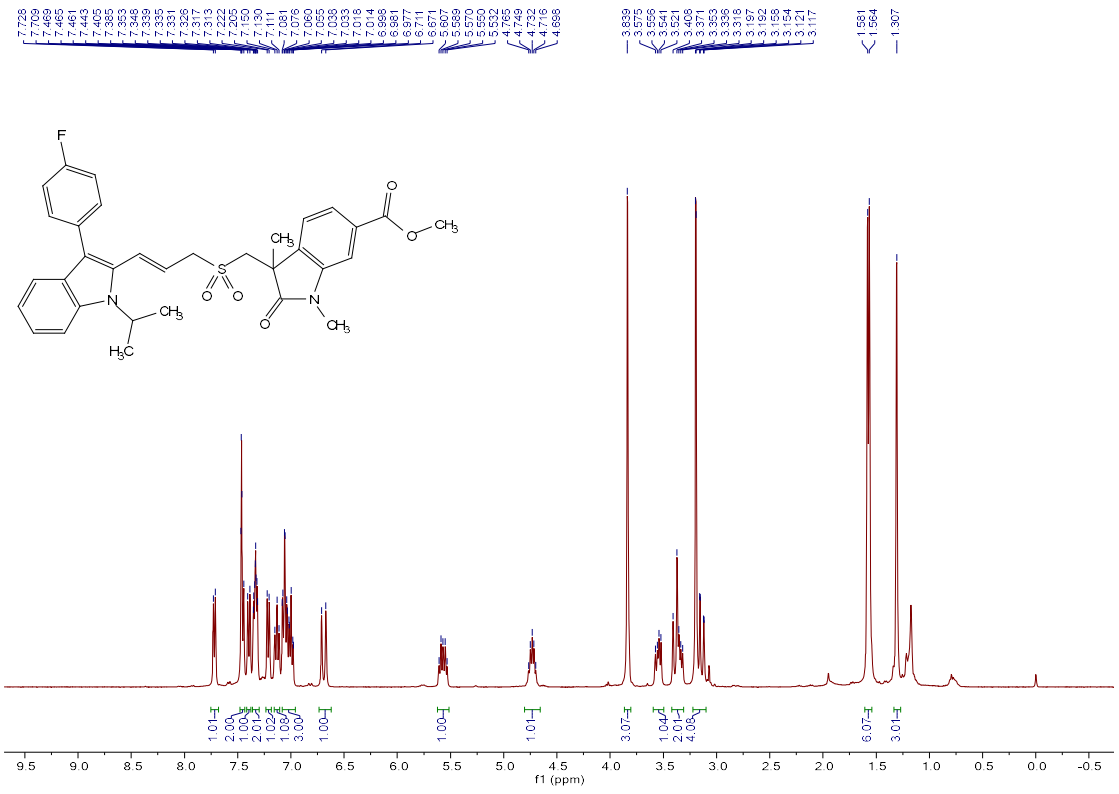


methyl (*E*)-3-(((3-(3-(4-fluorophenyl)-1-isopropyl-1*H*-indol-2-yl)allyl)sulfonyl)methyl)-1,3-dimethyl-2-oxoindoline-6-carboxylate (80).

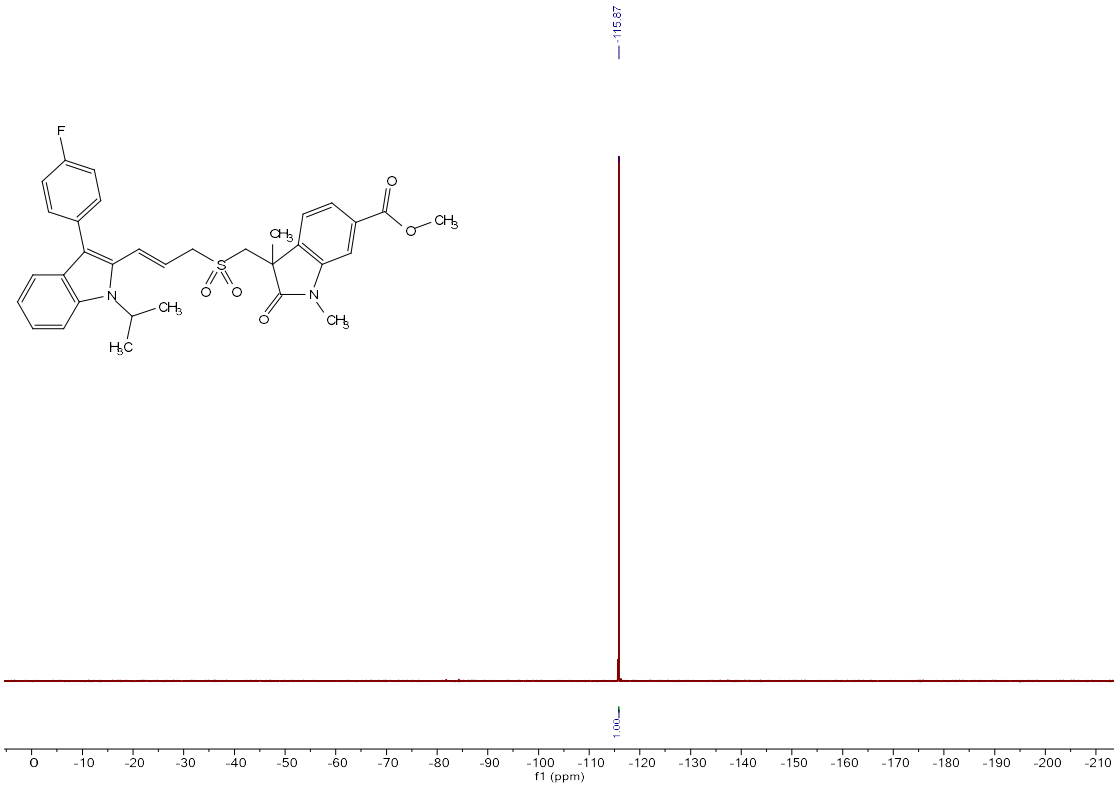


The product (83.6 mg, 71% yield) as brown solid was purified with silica gel chromatography (petroleum ether/ethyl acetate = 1/1). **^{1}H NMR (400 MHz, $CDCl_3$)** δ 7.72 (d, *J* = 7.6 Hz, 1H), 7.47-7.44 (m, 2H), 7.39 (d, *J* = 8.0 Hz, 1H), 7.35-7.31 (m, 2H), 7.21 (d, *J* = 6.8 Hz, 1H), 7.13 (t, *J* = 8.0 Hz, 1H), 7.08-6.98 (m, 3H), 6.69 (d, *J* = 16.0 Hz, 1H), 5.61-5.53 (m, 1H), 4.77-4.70 (m, 1H), 3.84 (s, 3H), 3.55 (dd, *J* = 13.6 Hz, 7.6 Hz, 1H), 3.41-3.32 (m, 2H), 3.20-3.12 (m, 4H), 1.57 (d, *J* = 6.8 Hz, 6H), 1.31 (s, 3H); **^{19}F NMR (376 MHz, $CDCl_3$)** δ -115.87 (s, 1F); **^{13}C NMR (101 MHz, $CDCl_3$)** δ 177.5, 166.5, 161.57 (d, *J* = 246.4 Hz), 143.6, 135.5, 135.3, 132.3 (d, *J* = 8.1 Hz), 132.1, 131.2 (d, *J* = 3.0 Hz), 131.0, 129.3, 128.3, 124.5, 123.2, 122.5, 120.8, 119.9, 119.8, 116.1, 115.6 (d, *J* = 21.2 Hz), 111.8, 109.5, 59.6, 57.1, 52.3, 48.0, 45.6, 26.8, 24.8, 21.8; **HRMS** Calculated for $C_{33}H_{33}FN_2O_5S$ ($M+H^+$): 589.2167; Found: 589.2173.

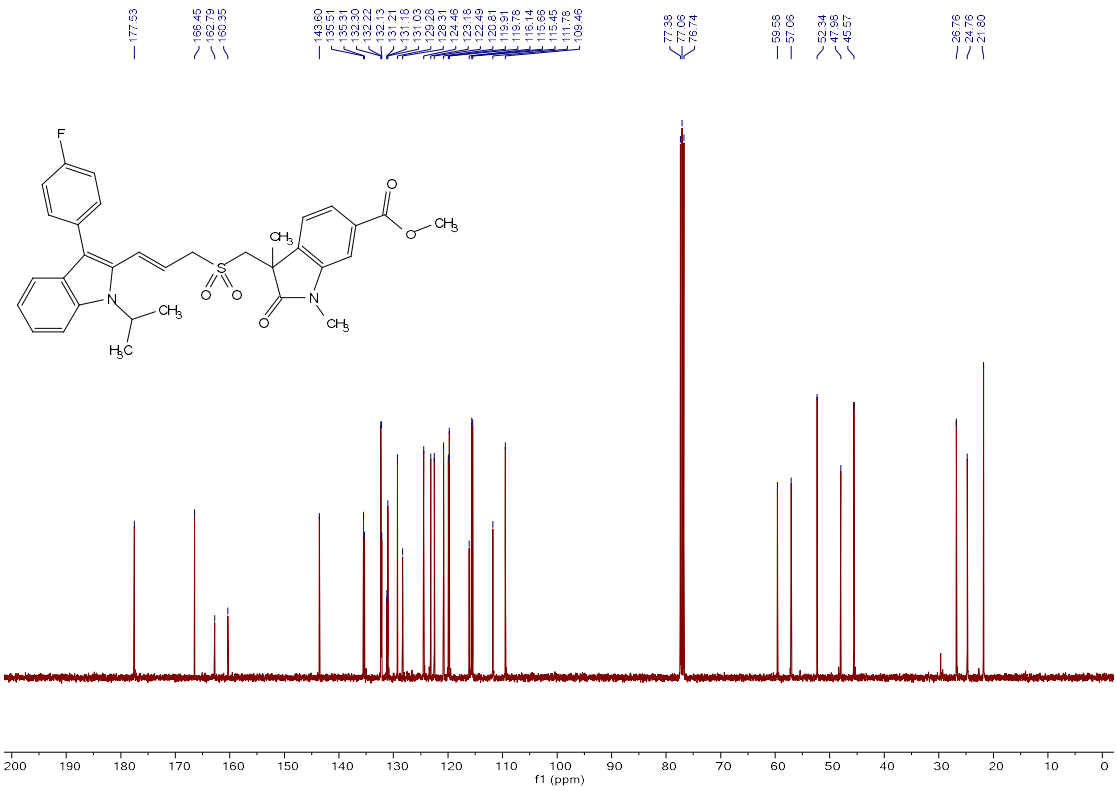
^{1}H NMR spectrum (400 MHz, $CDCl_3$) of compound **80**



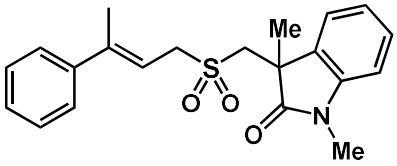
^{19}F NMR spectrum (376 MHz, $CDCl_3$) of compound **80**



^{13}C NMR spectrum (101 MHz, $CDCl_3$) of compound **80**

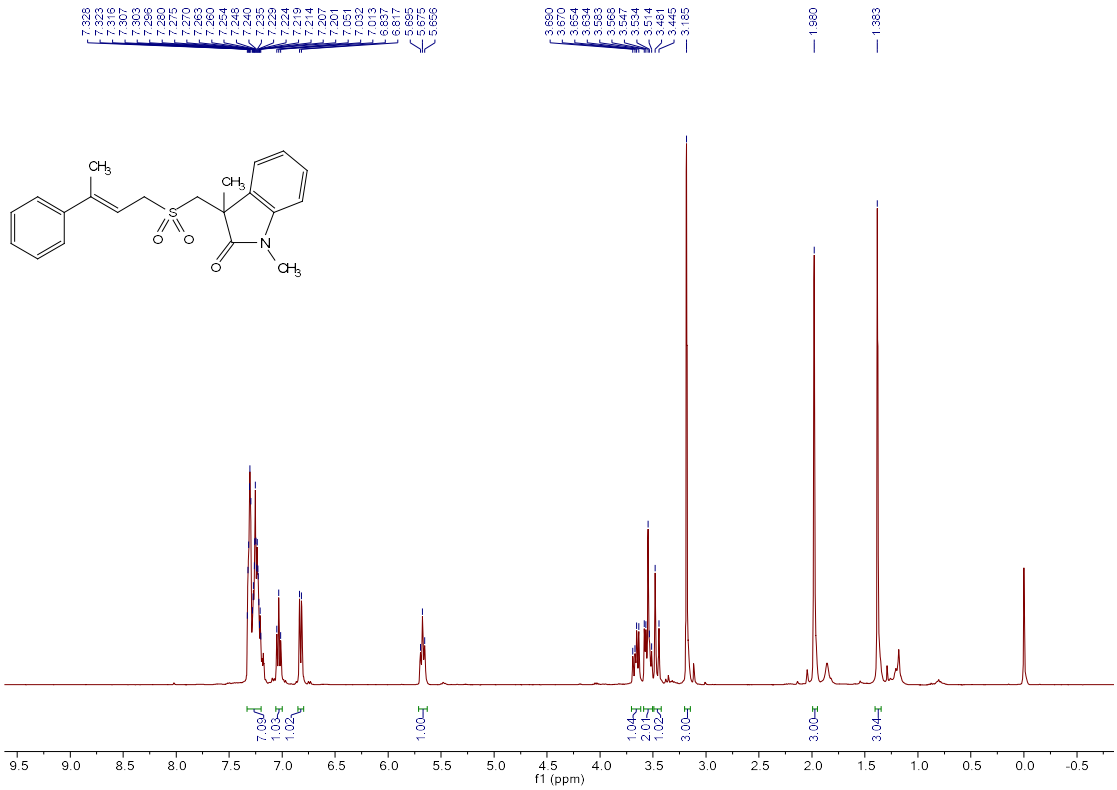


(*E*)-1,3-dimethyl-3-(((3-phenylbut-2-en-1-yl)sulfonyl)methyl)indolin-2-one (81).

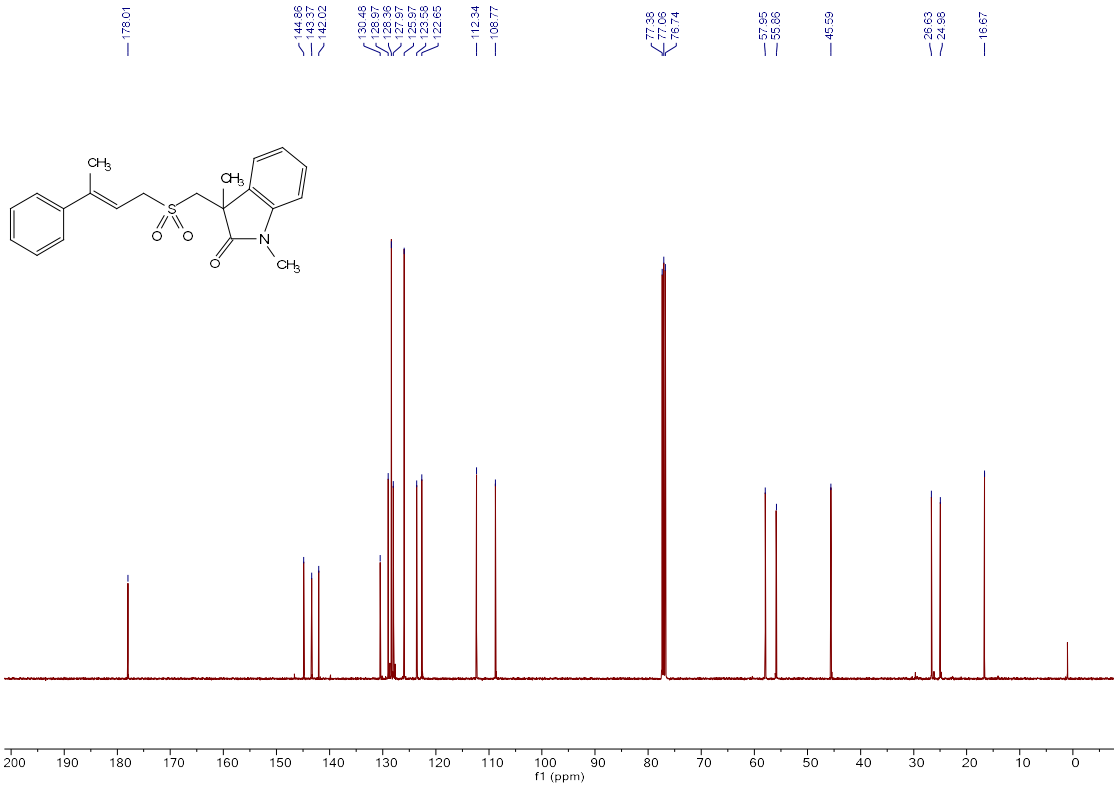


The product (44.3 mg, 60% yield) as brown solid was purified with silica gel chromatography (petroleum ether/ethyl acetate = 2/1). **^{1}H NMR (400 MHz, $CDCl_3$)** δ 7.33-7.20 (m, 7H), 7.03 (t, *J* = 7.6 Hz, 1H), 6.83 (d, *J* = 8.0 Hz, 1H), 5.68 (t, *J* = 8.0 Hz, 1H), 3.66 (dd, *J* = 14.4 Hz, 8.0 Hz, 1H), 3.58-3.51 (m, 2H), 3.46 (d, *J* = 14.4 Hz, 1H), 3.18 (s, 3H), 1.98 (s, 3H), 1.38 (s, 3H); **^{13}C NMR (101 MHz, $CDCl_3$)** δ 178.0, 144.9, 143.4, 142.0, 130.5, 129.0, 128.4, 128.0, 126.0, 123.6, 122.7, 112.3, 108.8, 58.0, 55.9, 45.6, 26.6, 25.0, 16.7; **HRMS** Calculated for $C_{21}H_{23}NO_3S$ ($M+H^+$): 370.1471; Found: 370.1472.

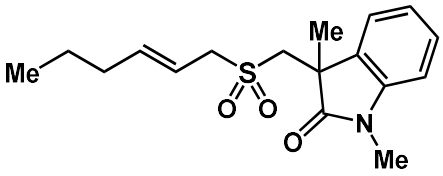
^{1}H NMR spectrum (400 MHz, $CDCl_3$) of compound **81**



^{13}C NMR spectrum (101 MHz, $CDCl_3$) of compound **81**

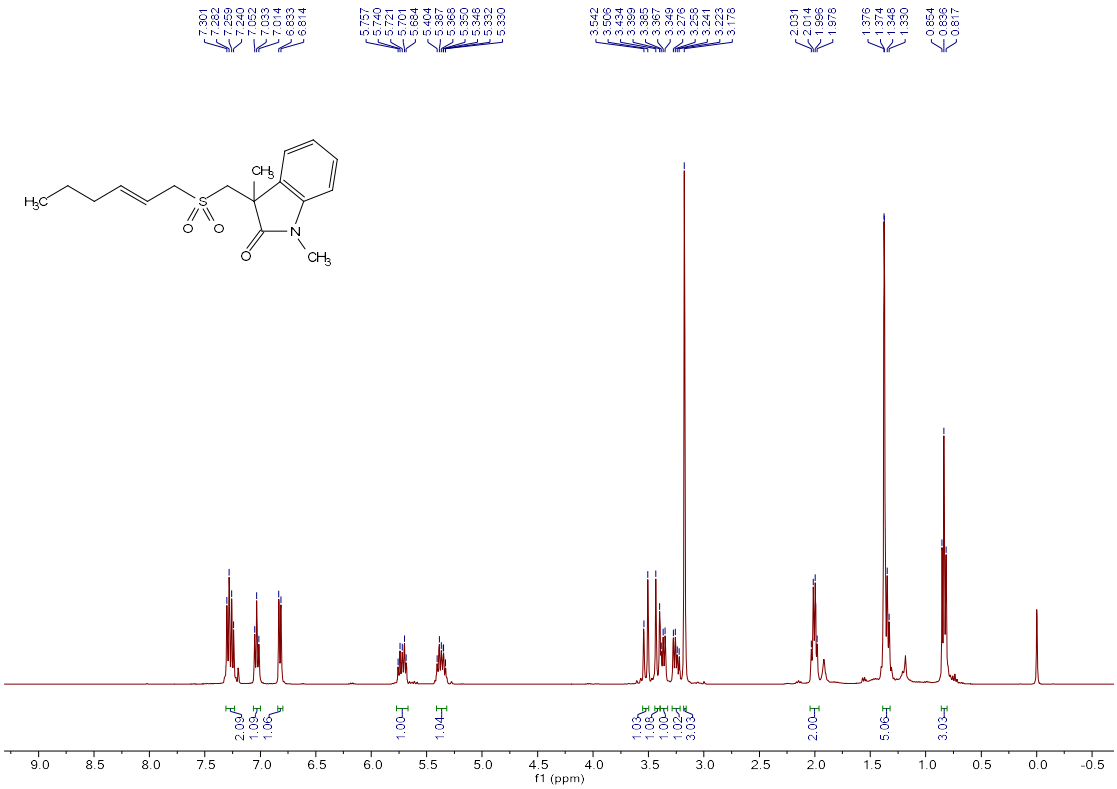


(*E*)-3-((hex-2-en-1-ylsulfonyl)methyl)-1,3-dimethylindolin-2-one (82).

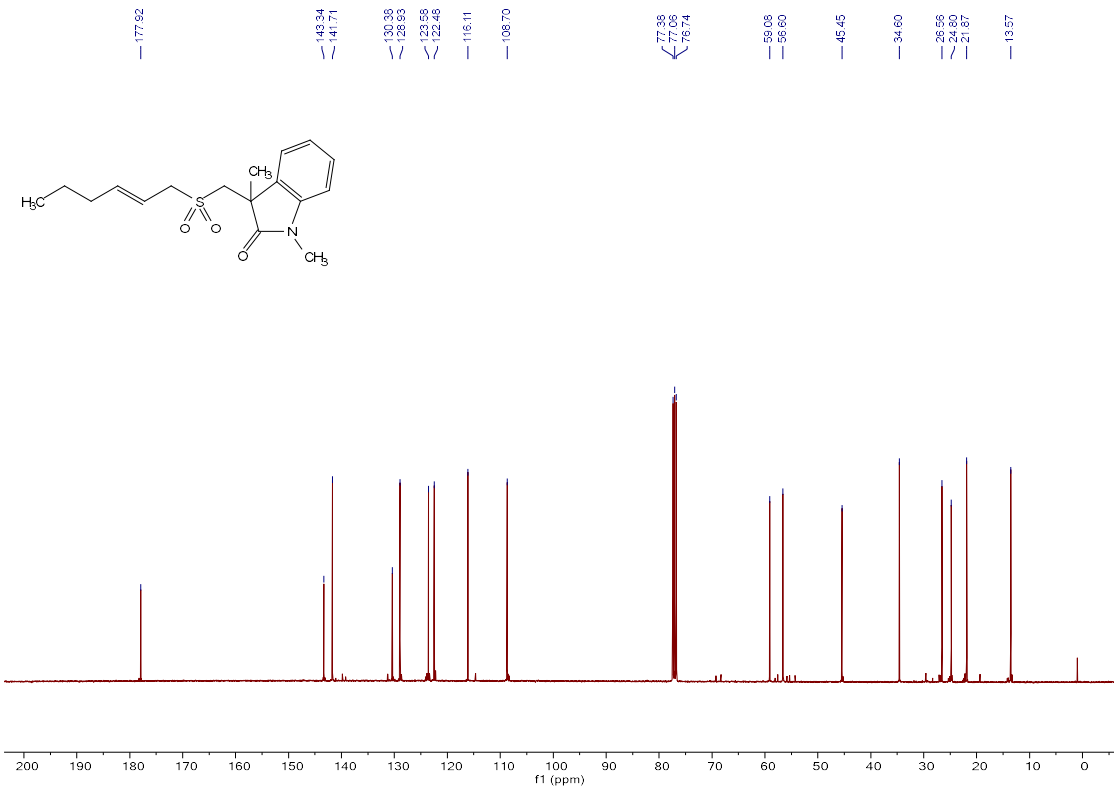


The product (54.6 mg, 85% yield) as brown oil was purified with silica gel chromatography (petroleum ether/ethyl acetate = 5/1). **^{1}H NMR (400 MHz, $CDCl_3$)** δ 7.30-7.24 (m, 2H), 7.03 (t, *J* = 7.6 Hz, 1H), 6.82 (d, *J* = 7.6 Hz, 1H), 5.76-5.68 (m, 1H), 5.40-5.33 (m, 1H), 3.52 (d, *J* = 14.4 Hz, 1H), 3.42 (d, *J* = 14.0 Hz, 1H), 3.38 (dd, *J* = 14.4 Hz, 7.2 Hz, 1H), 3.25 (dd, *J* = 14.0 Hz, 7.2 Hz, 1H), 3.18 (s, 3H), 2.00 (q, *J* = 7.2 Hz, 2H), 1.38-1.33 (m, 5H), 0.84 (t, *J* = 7.2 Hz, 3H); **^{13}C NMR (101 MHz, $CDCl_3$)** δ 177.9, 143.3, 141.7, 130.4, 128.9, 123.6, 122.5, 116.1, 108.7, 59.1, 56.6, 45.5, 34.6, 26.6, 24.8, 21.9, 13.6; **HRMS** Calculated for $C_{17}H_{23}NO_3S$ ($M+H^+$): 322.1471; Found: 322.1471.

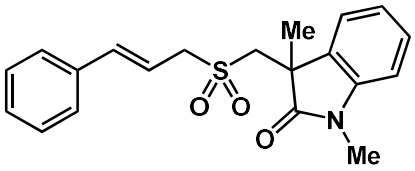
^{1}H NMR spectrum (400 MHz, $CDCl_3$) of compound **82**



^{13}C NMR spectrum (101 MHz, $CDCl_3$) of compound **82**

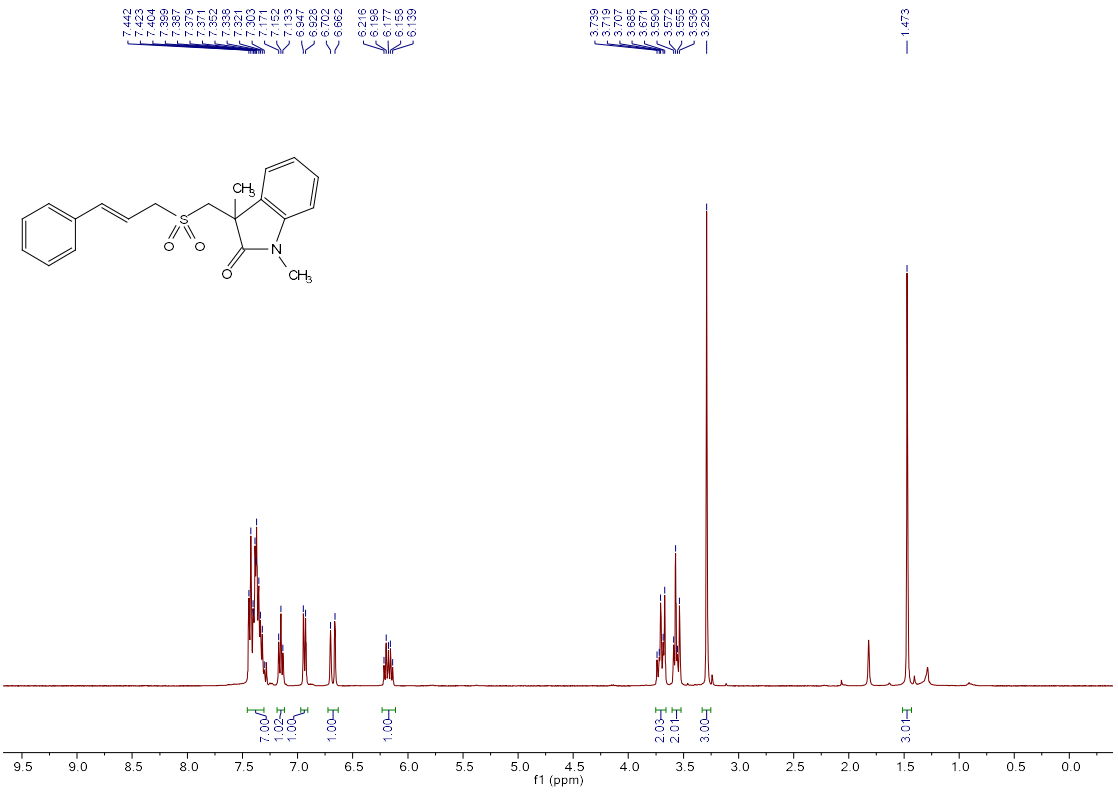


3-((cinnamylsulfonyl)methyl)-1,3-dimethylindolin-2-one (84).

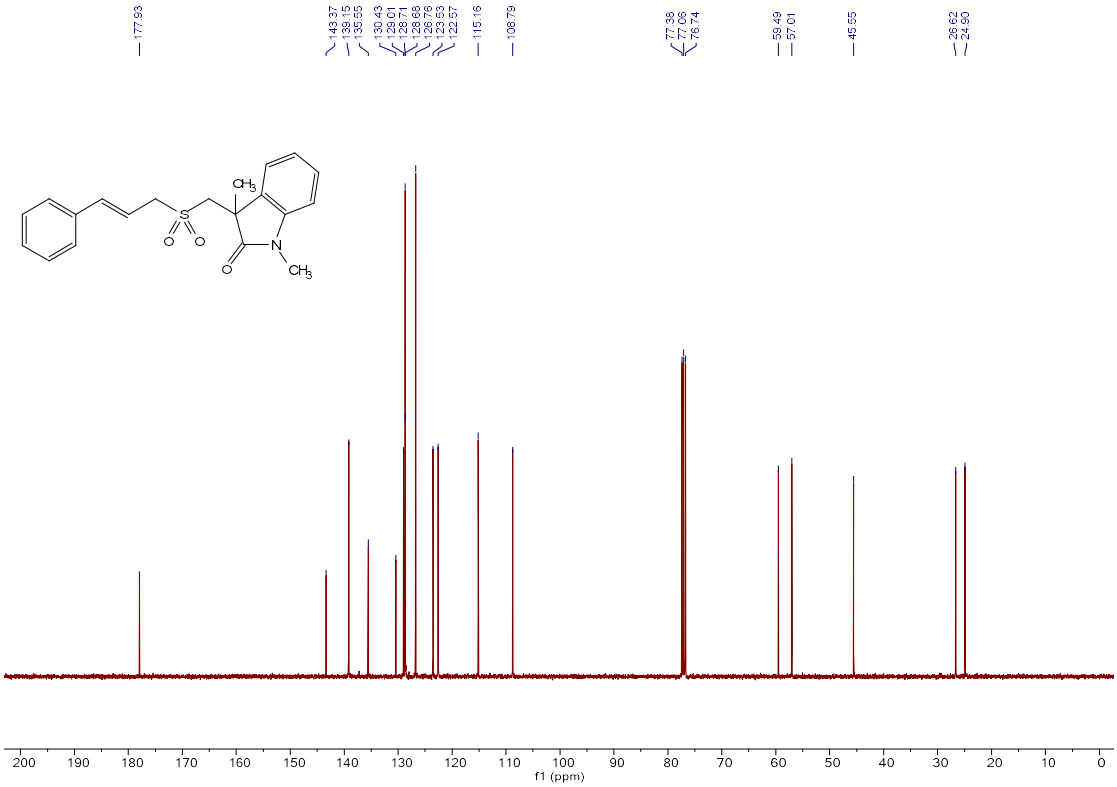


The product (66.1 mg, 93% yield) as white solid was purified with silica gel chromatography (petroleum ether/ethyl acetate = 2/1). **^{1}H NMR (400 MHz, $CDCl_3$)** δ 7.44-7.30 (m, 7H), 7.15 (t, *J* = 7.6 Hz, 1H), 6.94 (d, *J* = 7.6 Hz, 1H), 6.68 (d, *J* = 16.0 Hz, 1H), 6.22-6.14 (m, 1H), 3.74-3.67 (m, 2H), 3.59-3.54 (m, 2H), 3.29 (s, 3H), 1.47 (s, 3H); **^{13}C NMR (101 MHz, $CDCl_3$)** δ 177.9, 143.4, 139.2, 135.6, 130.4, 129.0, 128.71, 128.68, 126.8, 123.5, 122.6, 115.2, 108.8, 59.5, 57.0, 45.6, 26.6, 24.9; **HRMS** Calculated for $C_{20}H_{21}NO_3S$ ($M+H^+$): 356.1315; Found: 356.1316.

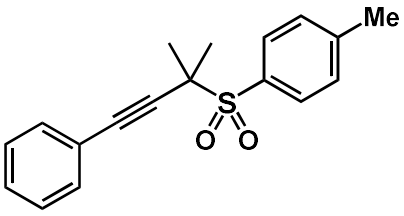
^{1}H NMR spectrum (400 MHz, $CDCl_3$) of compound **84**



^{13}C NMR spectrum (101 MHz, $CDCl_3$) of compound **84**

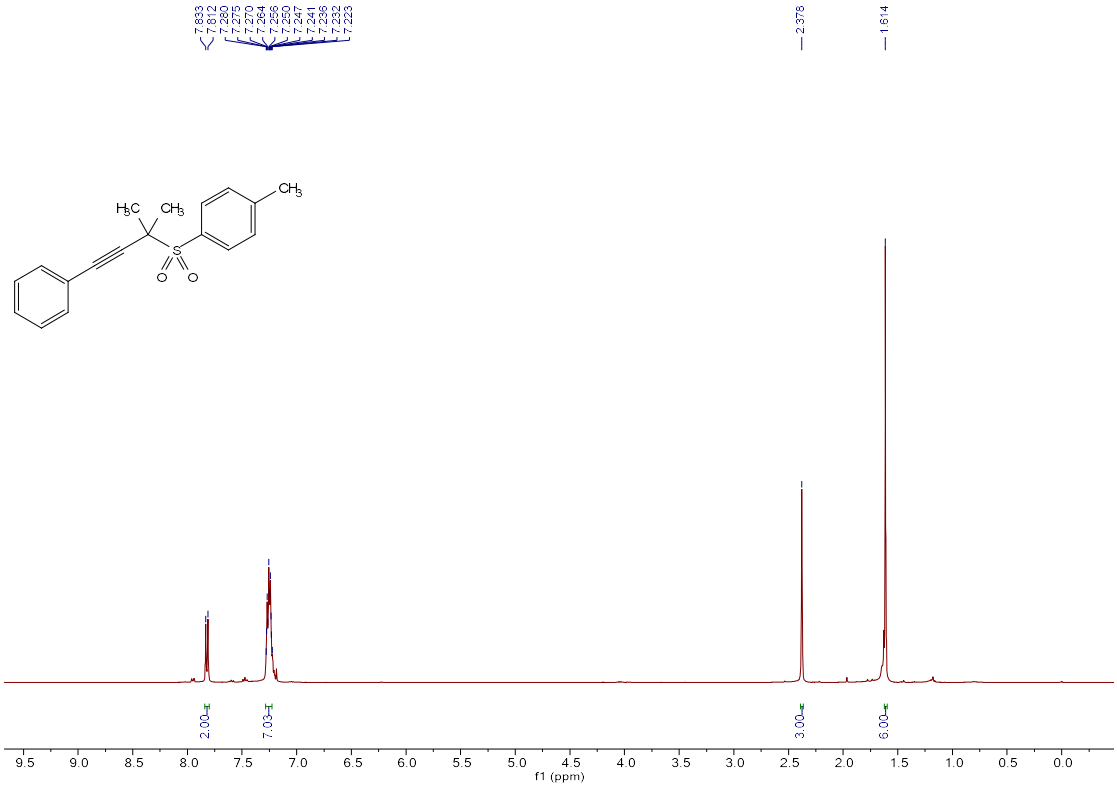


1-methyl-4-((2-methyl-4-phenylbut-3-yn-2-yl)sulfonyl)benzene (85).

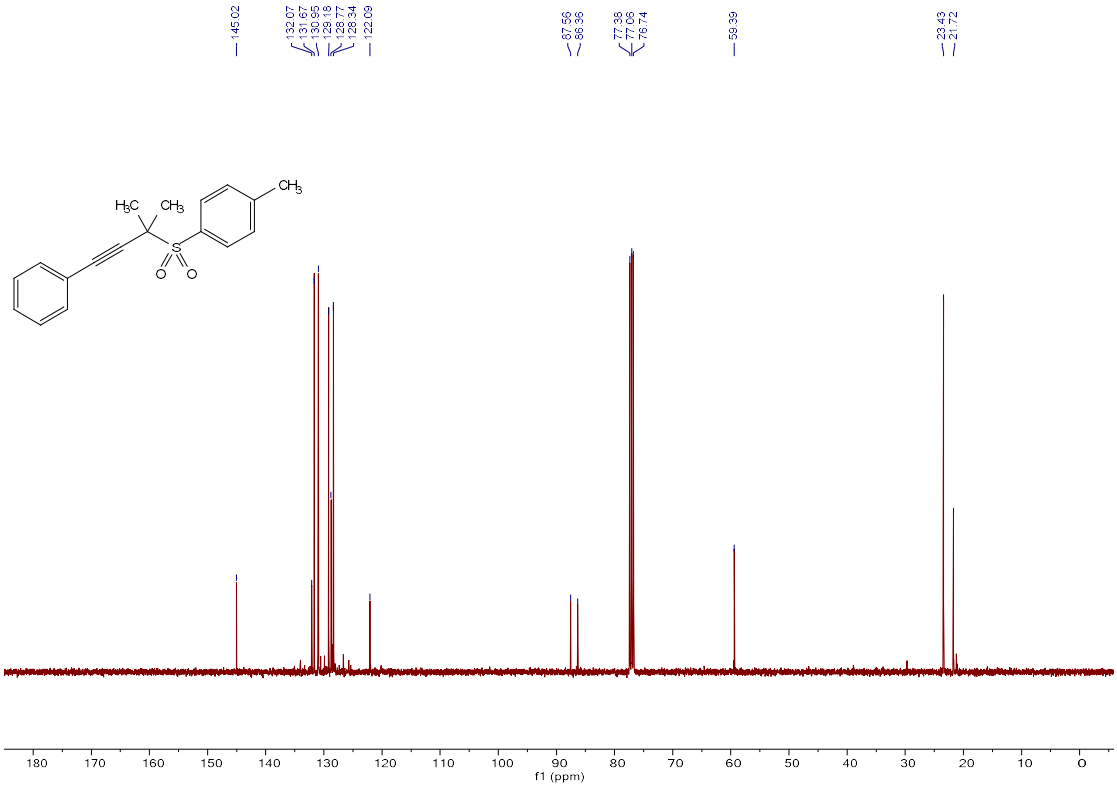


The product (46.0 mg, 77% yield) as yellow solid was purified with silica gel chromatography (petroleum ether/ethyl acetate = 5/1). **^{1}H NMR (400 MHz, $CDCl_3$)** δ 7.82 (d, J = 8.4 Hz, 2H), 7.28-7.22 (m, 7H), 2.38 (s, 3H), 1.61 (s, 6H); **^{13}C NMR (101 MHz, $CDCl_3$)** δ 145.0, 132.1, 131.7, 131.0, 129.2, 128.8, 128.3, 122.1, 87.6, 86.4, 59.4, 23.4, 21.7; **HRMS** Calculated for $C_{18}H_{18}O_2S$ ($M+Na^+$): 321.0920; Found: 321.0920.

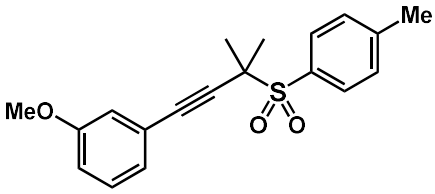
^{1}H NMR spectrum (400 MHz, $CDCl_3$) of compound **85**



^{13}C NMR spectrum (101 MHz, $CDCl_3$) of compound **85**

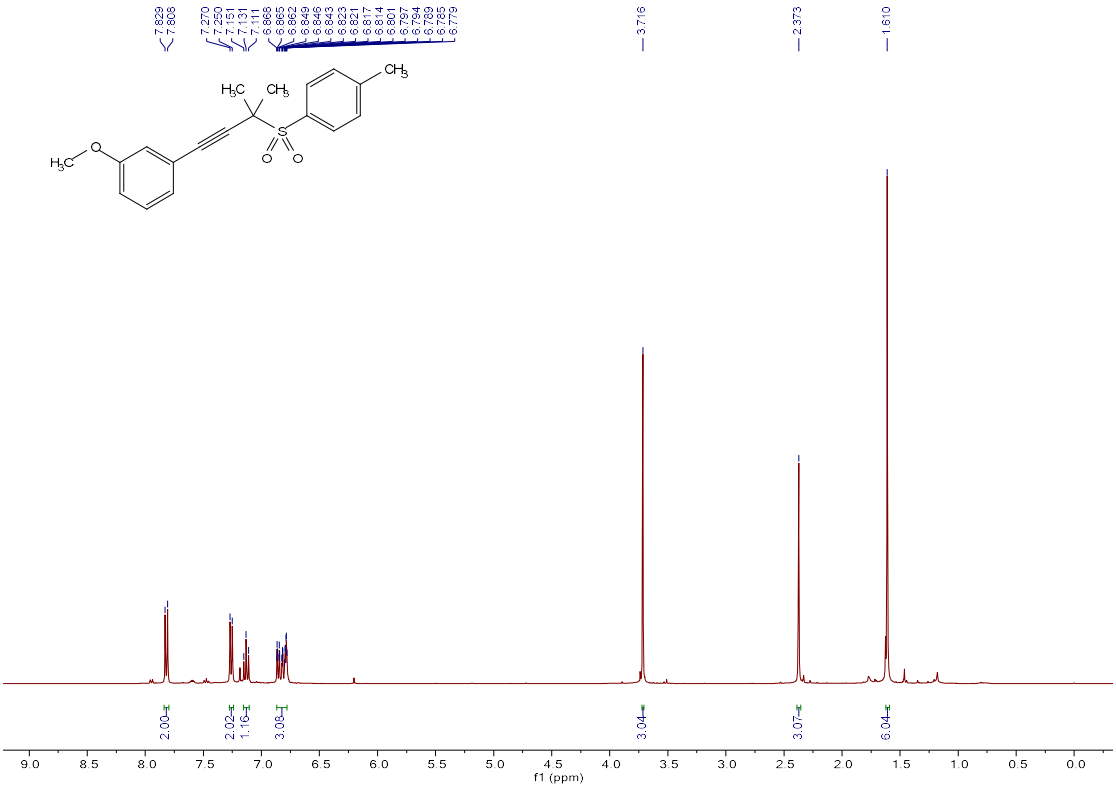


1-methoxy-3-(3-methyl-3-tosylbut-1-yn-1-yl)benzene (86).

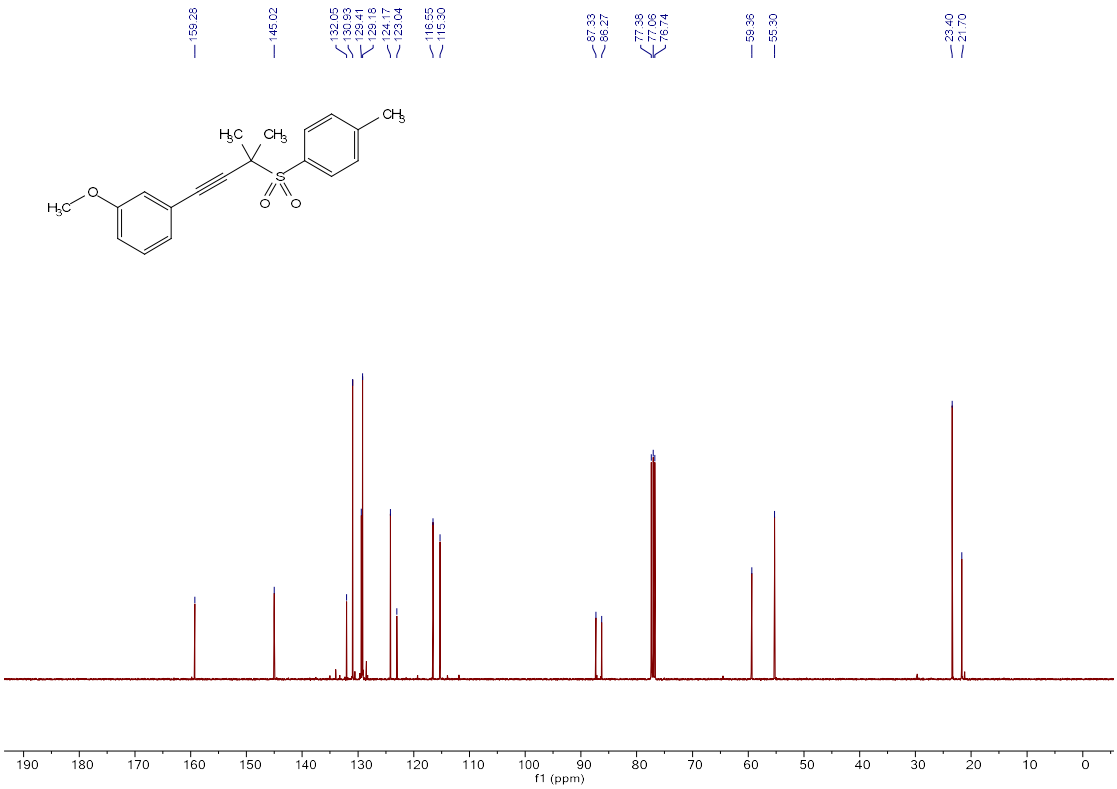


The product (47.9 mg, 73% yield) as brown solid was purified with silica gel chromatography (petroleum ether/ethyl acetate = 5/1). **^{1}H NMR (400 MHz, $CDCl_3$)** δ 7.82 (d, *J* = 8.4 Hz, 2H), 7.26 (d, *J* = 8.0 Hz, 2H), 7.13 (t, *J* = 8.0 Hz, 1H), 6.87-6.78 (m, 3H), 3.72 (s, 3H), 2.37 (s, 3H), 1.61 (s, 6H); **^{13}C NMR (101 MHz, $CDCl_3$)** δ 159.3, 145.0, 132.1, 130.9, 129.4, 129.2, 124.2, 123.0, 116.6, 115.3, 87.3, 86.3, 59.4, 55.3, 23.4, 21.7; **HRMS** Calculated for $C_{19}H_{20}O_3S$ ($M+Na^+$): 351.1025; Found: 351.1030.

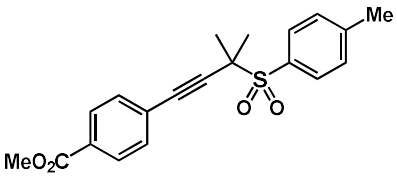
^{1}H NMR spectrum (400 MHz, $CDCl_3$) of compound **86**



^{13}C NMR spectrum (101 MHz, $CDCl_3$) of compound **86**

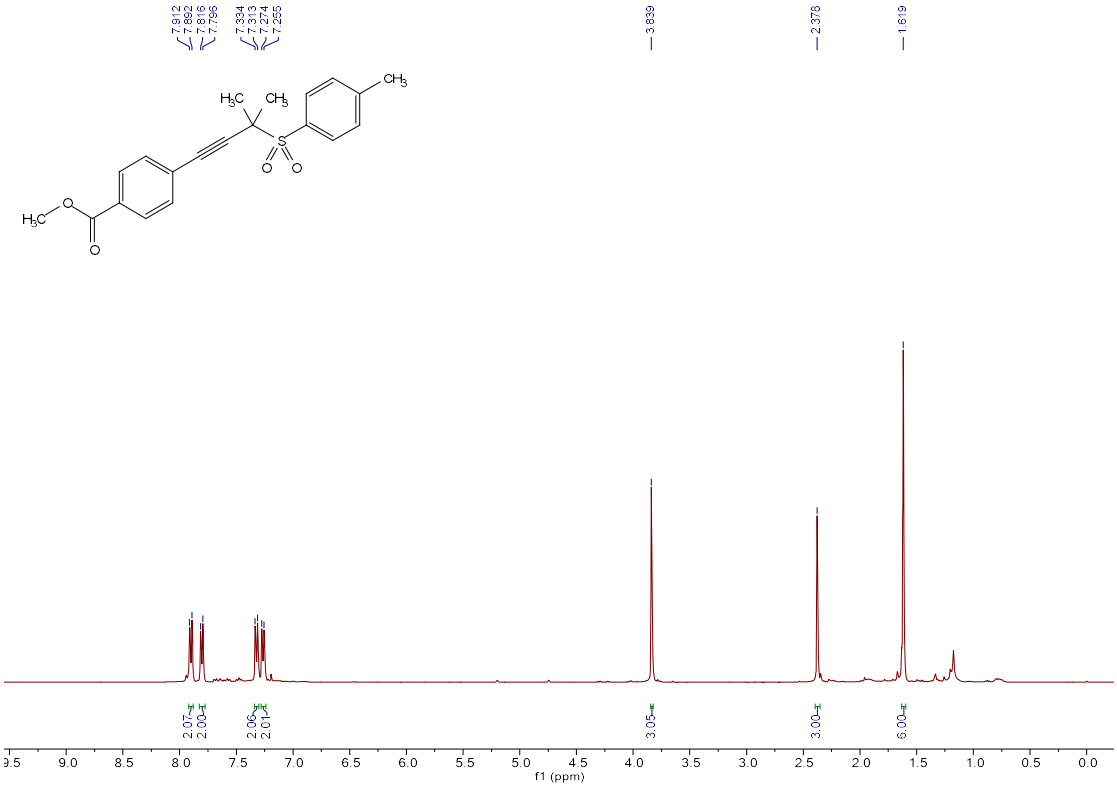


methyl 4-(3-methyl-3-tosylbut-1-yn-1-yl)benzoate (87).

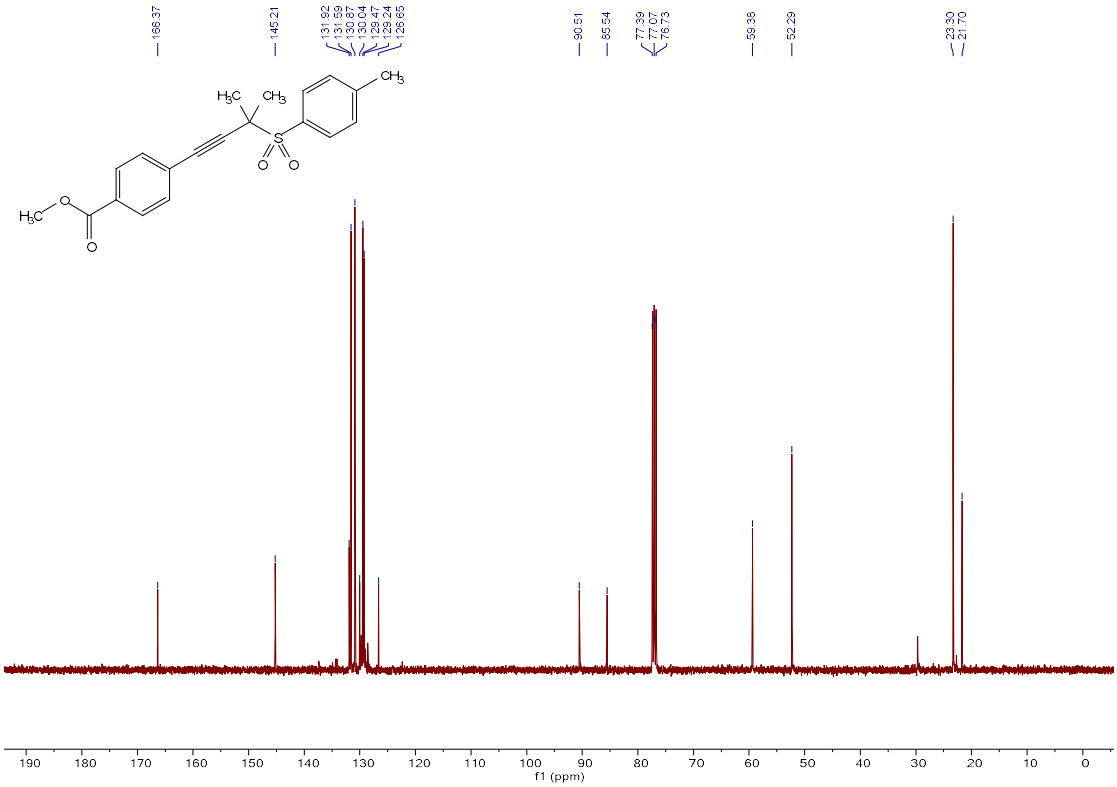


The product (52.0 mg, 73% yield) as brown solid was purified with silica gel chromatography (petroleum ether/ethyl acetate = 2/1). **^{1}H NMR (400 MHz, $CDCl_3$)** δ 7.90 (d, *J* = 8.0 Hz, 2H), 7.81 (d, *J* = 8.0 Hz, 2H), 7.32 (d, *J* = 8.4 Hz, 2H), 7.26 (d, *J* = 7.6 Hz, 2H), 3.84 (s, 3H), 2.38 (s, 3H), 1.62 (s, 6H); **^{13}C NMR (101 MHz, $CDCl_3$)** δ 166.4, 145.2, 131.9, 131.6, 130.9, 130.0, 129.5, 129.2, 126.7, 90.5, 85.5, 59.4, 52.3, 23.3, 21.7; **HRMS** Calculated for $C_{20}H_{20}O_4S$ ($M+Na^+$): 379.0975; Found: 379.0974.

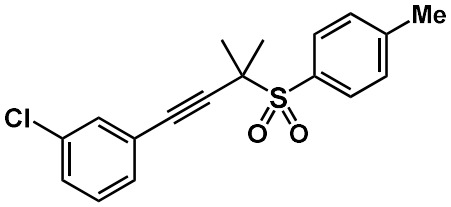
^{1}H NMR spectrum (400 MHz, $CDCl_3$) of compound **87**



^{13}C NMR spectrum (101 MHz, $CDCl_3$) of compound **87**

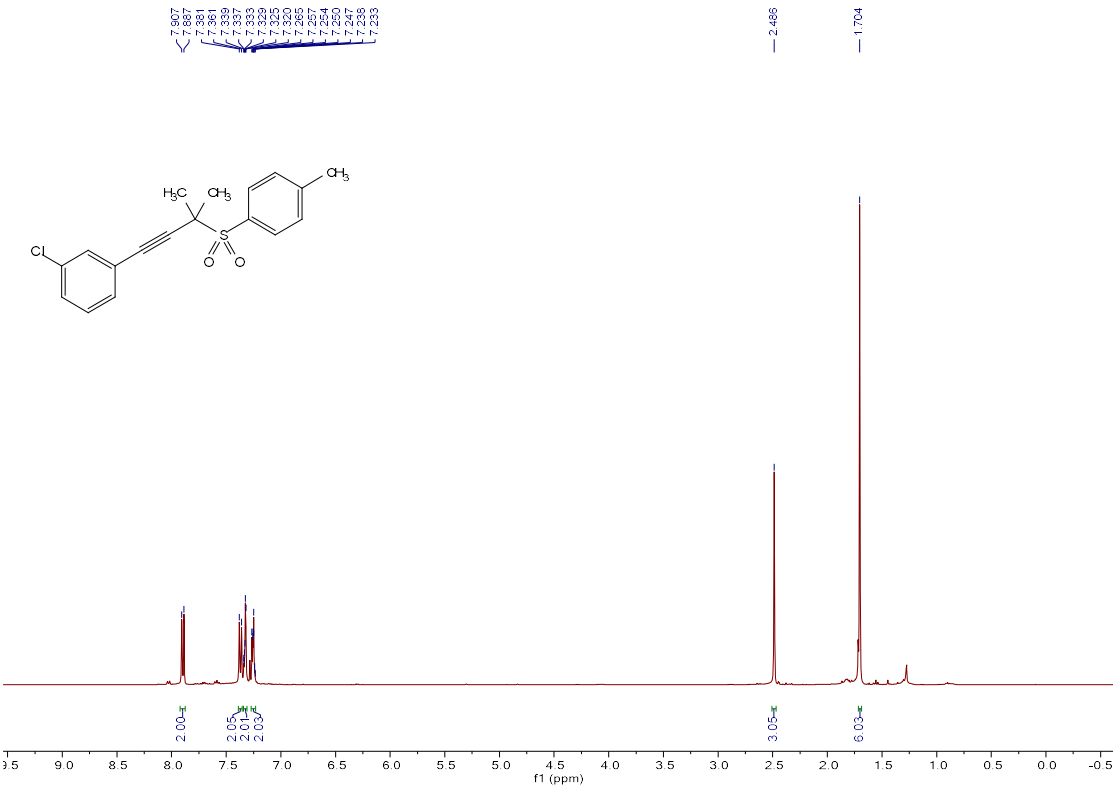


1-chloro-3-(3-methyl-3-tosylbut-1-yn-1-yl)benzene (88).

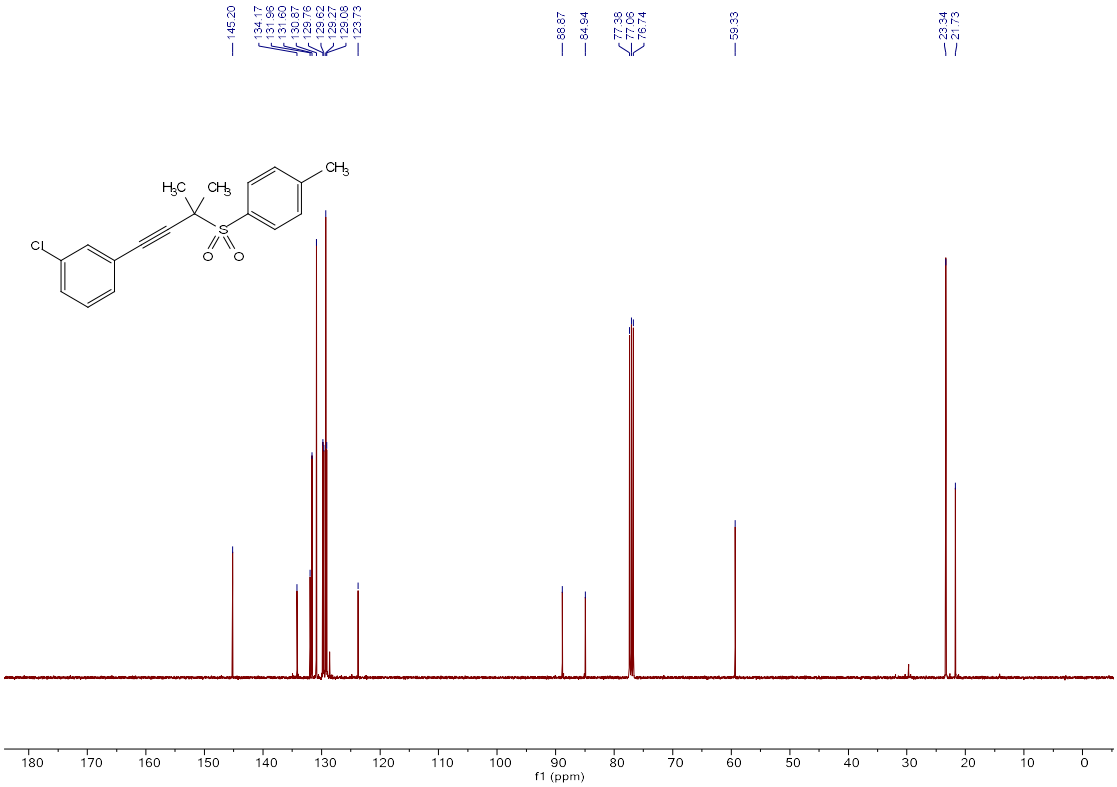


The product (49.3 mg, 74% yield) as brown solid was purified with silica gel chromatography (petroleum ether/ethyl acetate = 5/1). **^{1}H NMR (400 MHz, $CDCl_3$)** δ 7.90 (d, *J* = 8.0 Hz, 2H), 7.37 (d, *J* = 8.0 Hz, 2H), 7.34-7.32 (m, 2H), 7.27-7.23 (m, 2H), 2.49 (s, 3H), 1.70 (s, 6H); **^{13}C NMR (101 MHz, $CDCl_3$)** δ 145.2, 134.2, 132.0, 131.6, 130.9, 129.8, 129.6, 129.3, 129.1, 123.7, 88.9, 84.9, 59.3, 23.3, 21.7; **HRMS** Calculated for $C_{18}H_{17}ClO_2S$ ($M+Na^+$): 355.0530; Found: 355.0530.

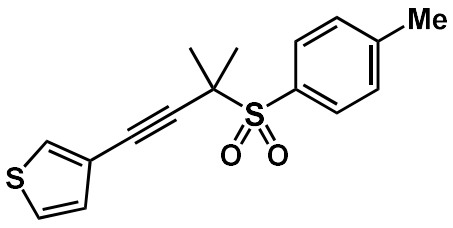
^{1}H NMR spectrum (400 MHz, $CDCl_3$) of compound **88**



^{13}C NMR spectrum (101 MHz, $CDCl_3$) of compound **88**

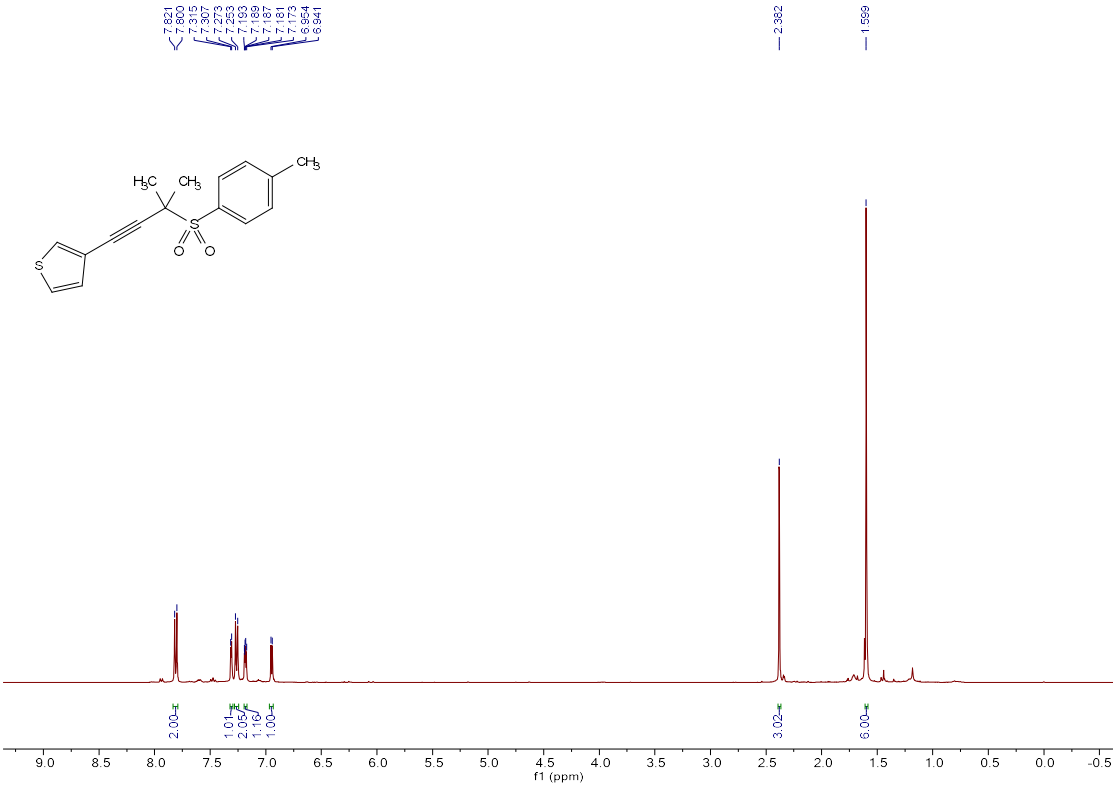


3-(3-methyl-3-tosylbut-1-yn-1-yl)thiophene (89).

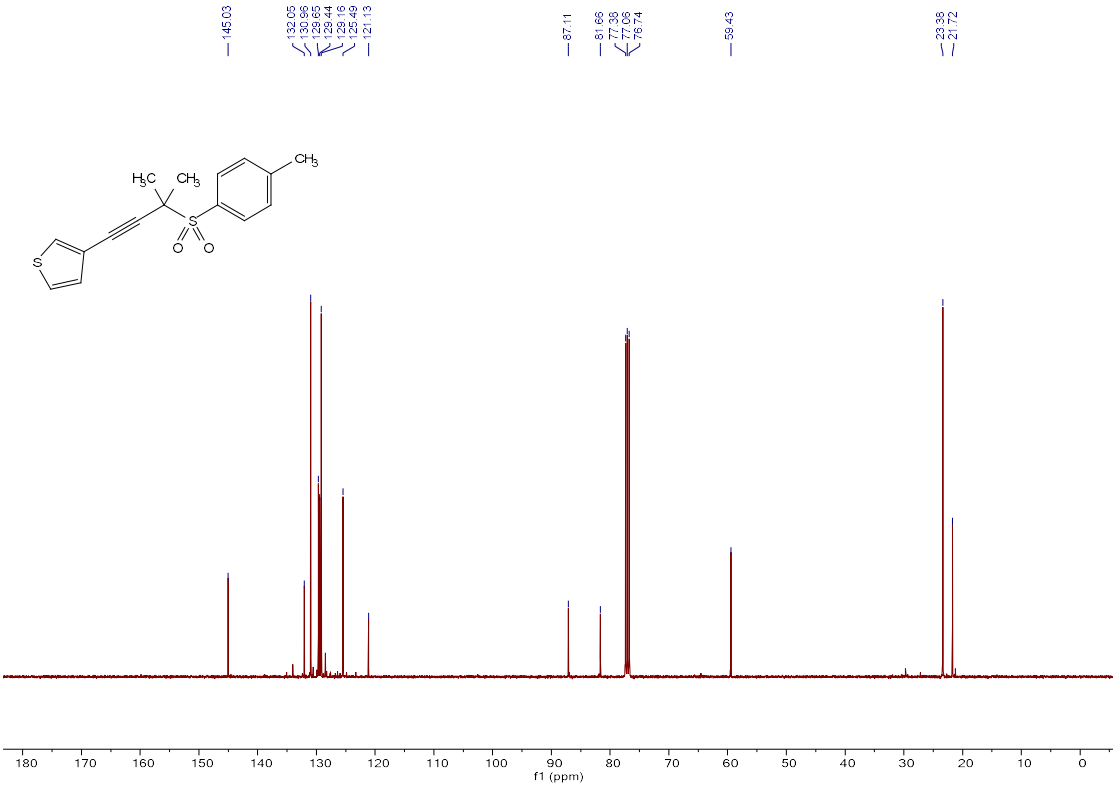


The product (38.4 mg, 63% yield) as brown solid was purified with silica gel chromatography (petroleum ether/ethyl acetate = 5/1). **^{1}H NMR (400 MHz, $CDCl_3$)** δ 7.81 (d, *J* = 8.4 Hz, 2H), 7.31 (d, *J* = 3.2 Hz, 1H), 7.26 (d, *J* = 8.0 Hz, 2H), 7.19-7.17 (m, 1H), 6.95 (d, *J* = 5.2 Hz, 1H), 2.38 (s, 3H), 1.60 (s, 6H); **^{13}C NMR (101 MHz, $CDCl_3$)** δ 145.0, 132.1, 131.0, 129.7, 129.4, 129.2, 125.5, 121.1, 87.1, 81.7, 59.4, 23.4, 21.7; **HRMS** Calculated for $C_{16}H_{16}O_2S_2$ ($M+Na^+$): 327.0484; Found: 327.0479.

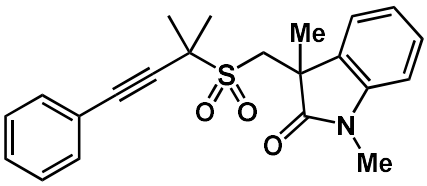
^{1}H NMR spectrum (400 MHz, $CDCl_3$) of compound **89**



^{13}C NMR spectrum (101 MHz, $CDCl_3$) of compound **89**

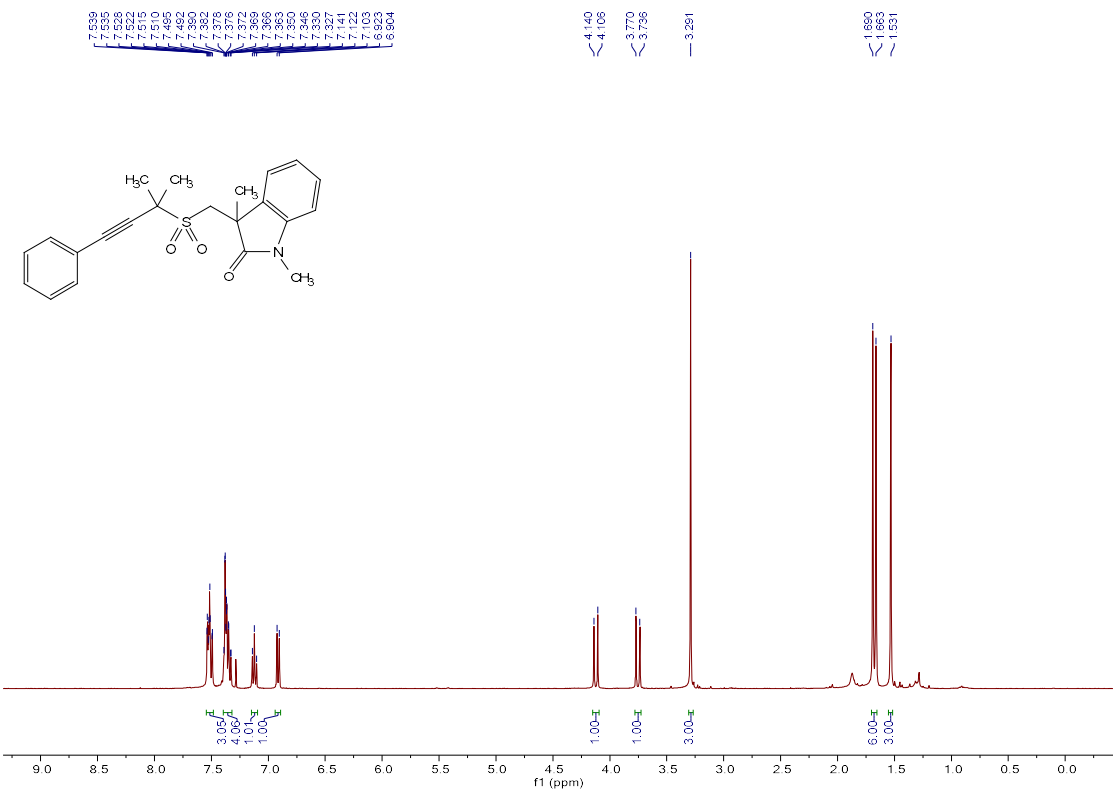


1,3-dimethyl-3-(((2-methyl-4-phenylbut-3-yn-2-yl)sulfonyl)methyl)indolin-2-one (90).

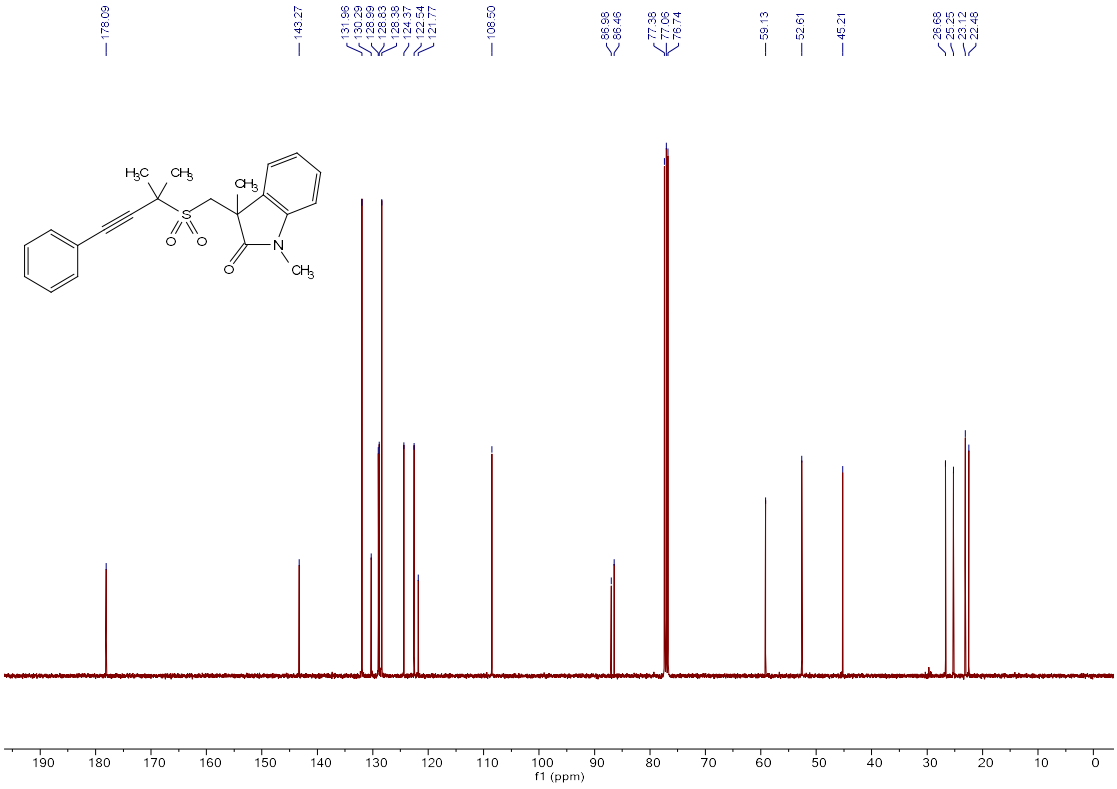


The product (45.8 mg, 60% yield) as yellow oil was purified with silica gel chromatography (petroleum ether/ethyl acetate = 2/1). **^{1}H NMR (400 MHz, $CDCl_3$)** δ 7.54-7.49 (m, 3H), 7.39-7.33 (m, 4H), 7.12 (t, *J* = 7.6 Hz, 1H), 6.91 (d, *J* = 7.6 Hz, 1H), 4.12 (d, *J* = 13.6 Hz, 1H), 3.75 (d, *J* = 13.6 Hz, 1H), 3.29 (s, 3H), 1.68 (d, *J* = 10.8 Hz, 6H), 1.53 (s, 3H); **^{13}C NMR (101 MHz, $CDCl_3$)** δ 178.1, 143.3, 132.0, 130.3, 129.0, 128.8, 128.4, 124.4, 122.5, 121.8, 108.5, 87.0, 86.5, 59.1, 52.6, 45.2, 26.7, 25.3, 23.1, 22.5; **HRMS** Calculated for $C_{22}H_{23}NO_3S$ ($M+Na^+$): 404.1291; Found: 404.1295.

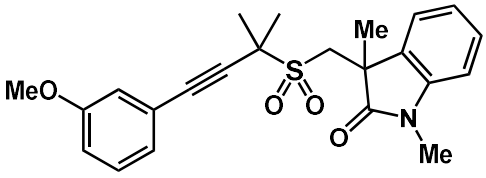
^{1}H NMR spectrum (400 MHz, $CDCl_3$) of compound **90**



^{13}C NMR spectrum (101 MHz, $CDCl_3$) of compound **90**

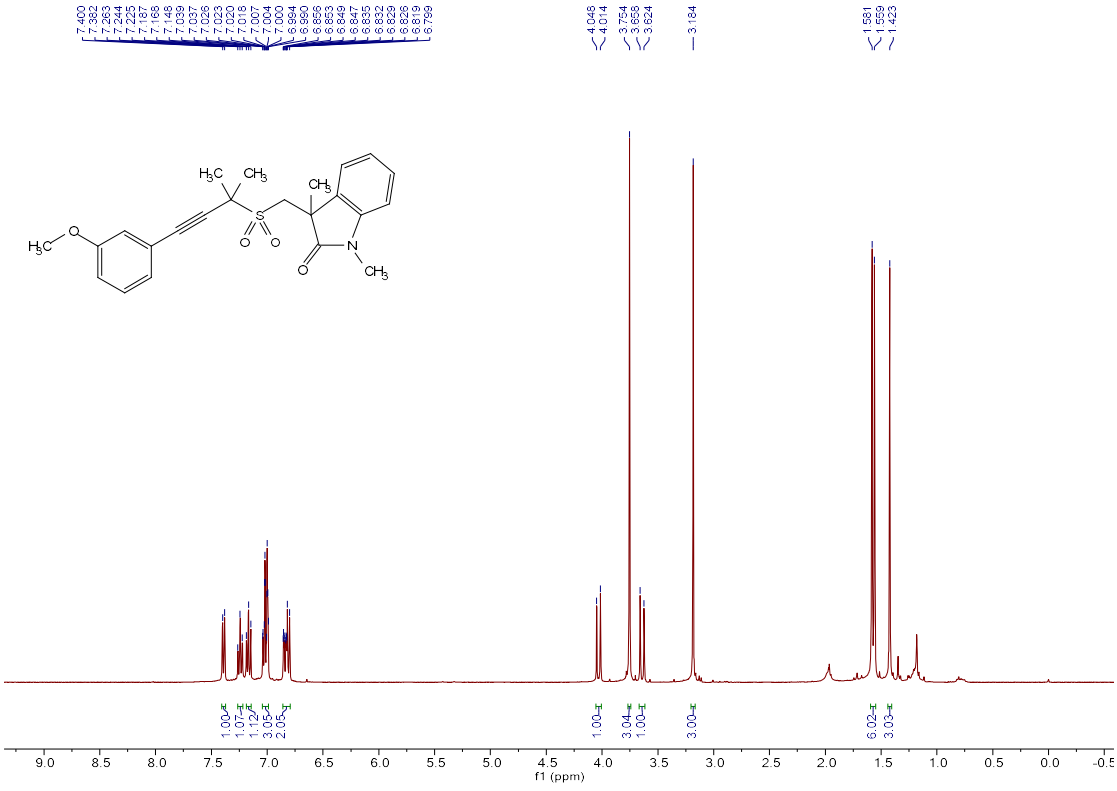


3-(((4-(3-methoxyphenyl)-2-methylbut-3-yn-2-yl)sulfonyl)methyl)-1,3-dimethylindolin-2-one (91).

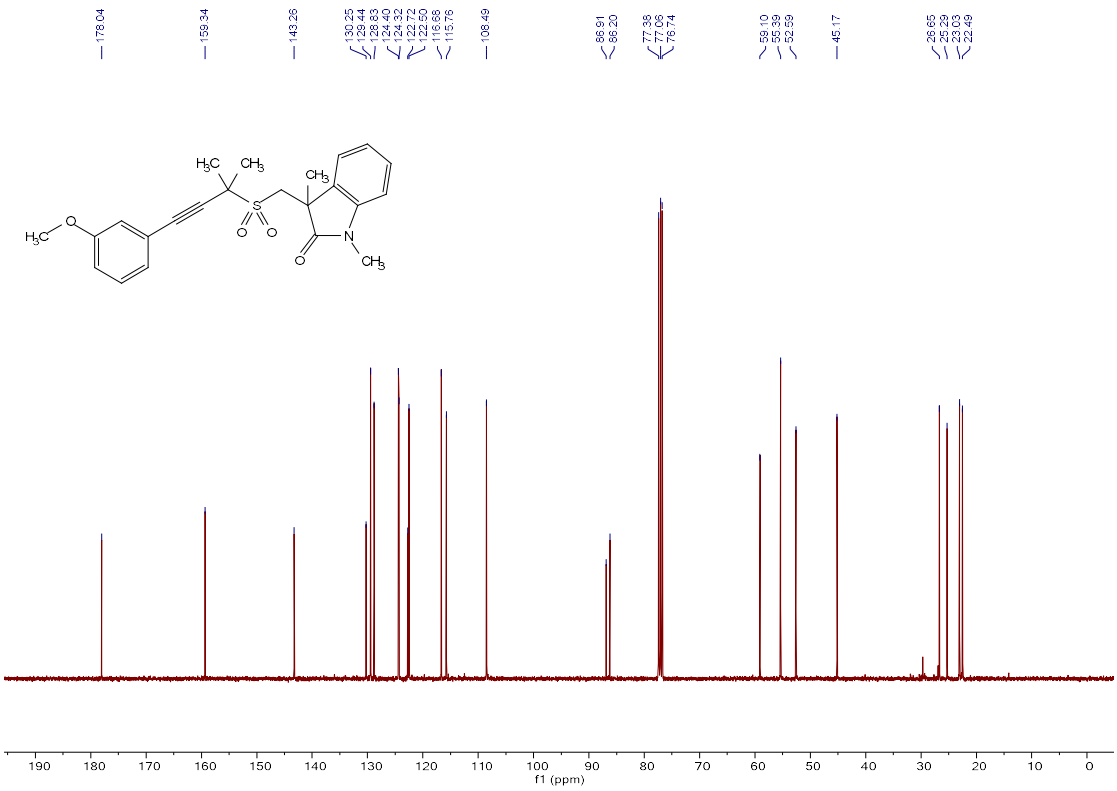


The product (51.0 mg, 62% yield) as brown solid was purified with silica gel chromatography (petroleum ether/ethyl acetate = 2/1). **^{1}H NMR (400 MHz, $CDCl_3$)** δ 7.39 (d, *J* = 7.2 Hz, 1H), 7.24 (t, *J* = 7.6 Hz, 1H), 7.17 (t, *J* = 7.6 Hz, 1H), 7.04-6.99 (m, 3H), 6.86-6.80 (m, 2H), 4.03 (d, *J* = 13.6 Hz, 1H), 3.75 (s, 3H), 3.64 (d, *J* = 13.6 Hz, 1H), 3.18 (s, 3H), 1.57 (d, *J* = 8.8 Hz, 6H), 1.42 (s, 3H); **^{13}C NMR (101 MHz, $CDCl_3$)** δ 178.0, 159.3, 143.3, 130.3, 129.4, 128.8, 124.4, 124.3, 122.7, 122.5, 116.7, 115.8, 108.5, 86.9, 86.2, 59.1, 55.4, 52.6, 45.2, 26.7, 25.3, 23.0, 22.5; **HRMS** Calculated for $C_{23}H_{25}NO_4S$ ($M+Na^+$): 434.1397; Found: 434.1399.

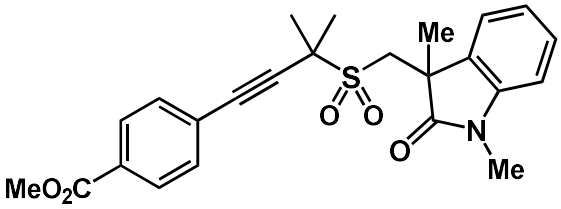
^{1}H NMR spectrum (400 MHz, $CDCl_3$) of compound **91**



^{13}C NMR spectrum (101 MHz, $CDCl_3$) of compound **91**

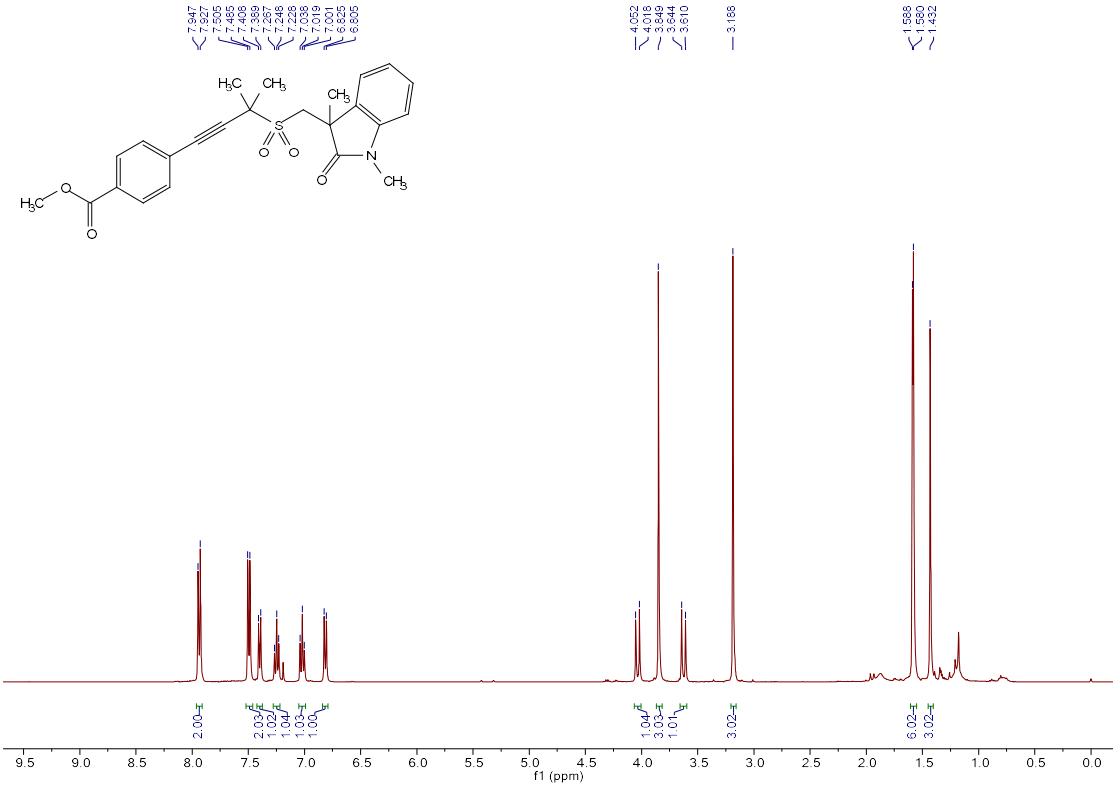


methyl 4-(3-(((1,3-dimethyl-2-oxoindolin-3-yl)methyl)sulfonyl)-3-methylbut-1-yn-1-yl)benzoate (92).

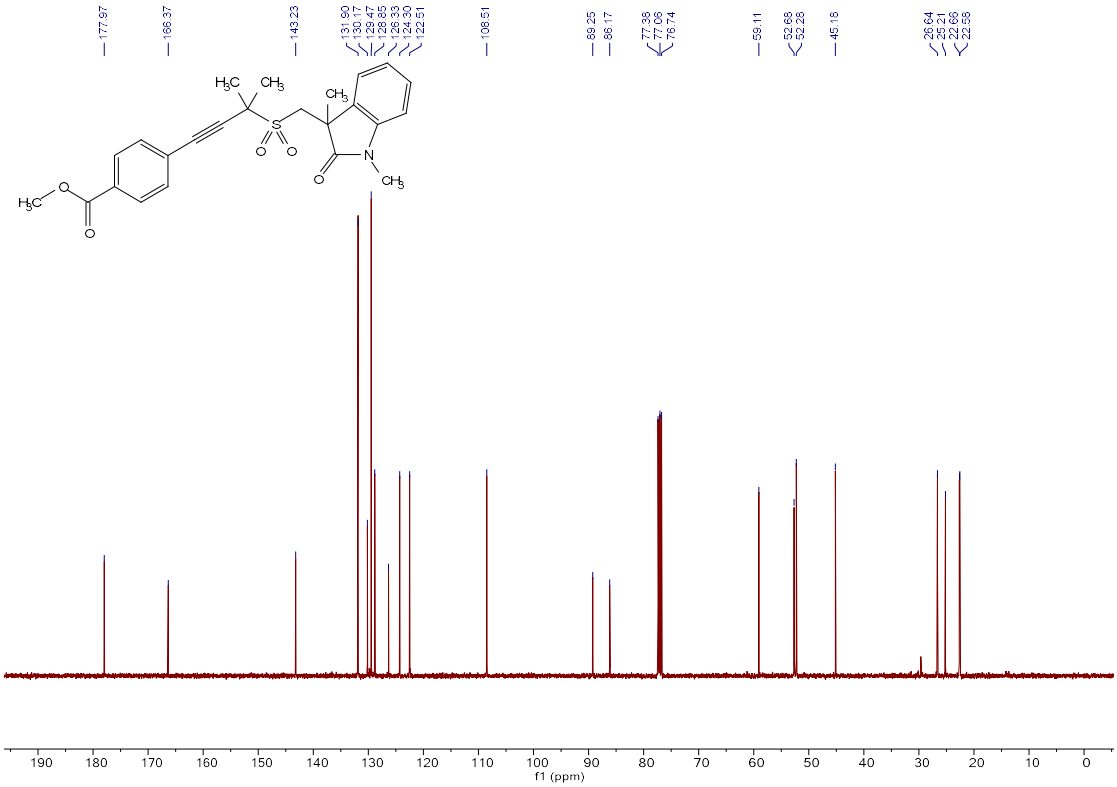


The product (52.7 mg, 60% yield) as yellow solid was purified with silica gel chromatography (petroleum ether/ethyl acetate = 1/1). **^{1}H NMR (400 MHz, $CDCl_3$)** δ 7.94 (d, *J* = 8.0 Hz, 2H), 7.49 (d, *J* = 8.0 Hz, 2H), 7.40 (d, *J* = 7.6 Hz, 1H), 7.25 (t, *J* = 7.6 Hz, 1H), 7.02 (t, *J* = 7.6 Hz, 1H), 6.82 (d, *J* = 8.0 Hz, 1H), 4.04 (d, *J* = 13.6 Hz, 1H), 3.85 (s, 3H), 3.63 (d, *J* = 13.6 Hz, 1H), 3.19 (s, 3H), 1.58 (d, *J* = 3.2 Hz, 6H), 1.43 (s, 3H); **^{13}C NMR (101 MHz, $CDCl_3$)** δ 178.0, 166.4, 143.2, 131.9, 130.2, 129.5, 128.9, 126.3, 124.3, 122.5, 108.5, 89.3, 86.2, 59.1, 52.7, 52.3, 45.2, 26.6, 25.2, 22.7, 22.6; **HRMS** Calculated for $C_{24}H_{25}NO_5S$ ($M+Na^+$): 462.1346; Found: 462.1349.

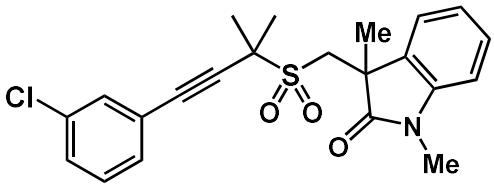
^{1}H NMR spectrum (400 MHz, $CDCl_3$) of compound **92**



^{13}C NMR spectrum (101 MHz, $CDCl_3$) of compound **92**

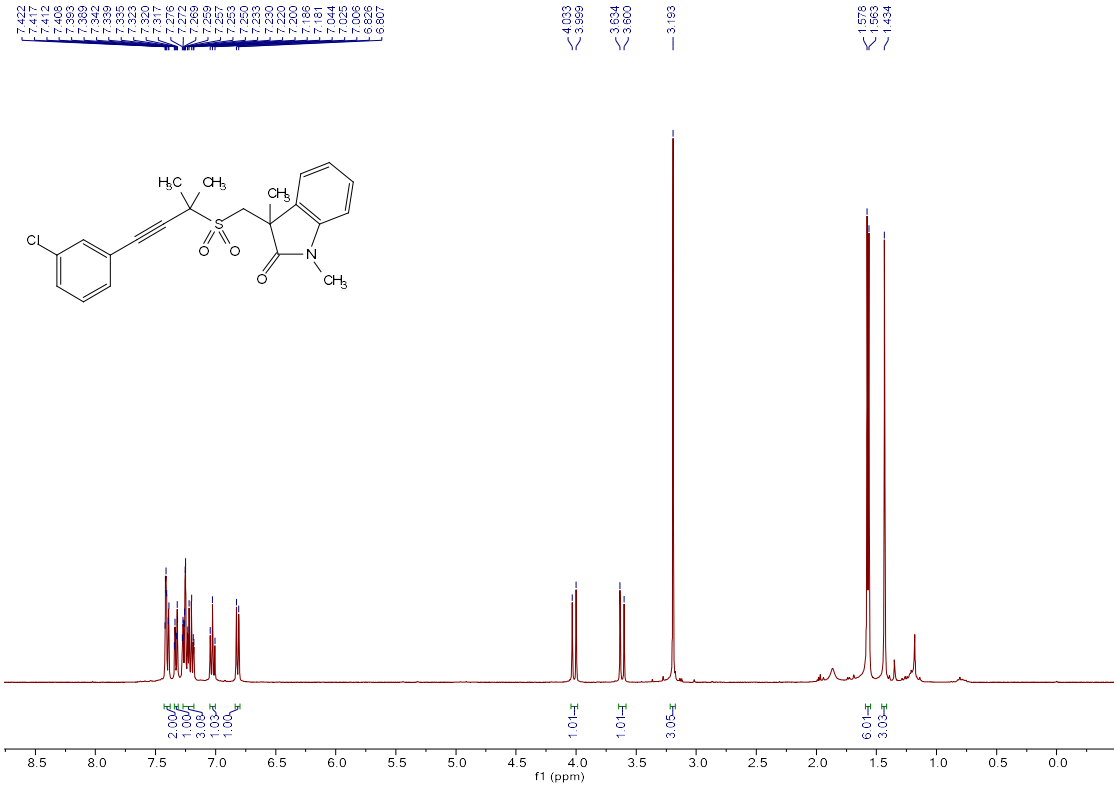


3-(((4-(3-chlorophenyl)-2-methylbut-3-yn-2-yl)sulfonyl)methyl)-1,3-dimethylindolin-2-one (93).

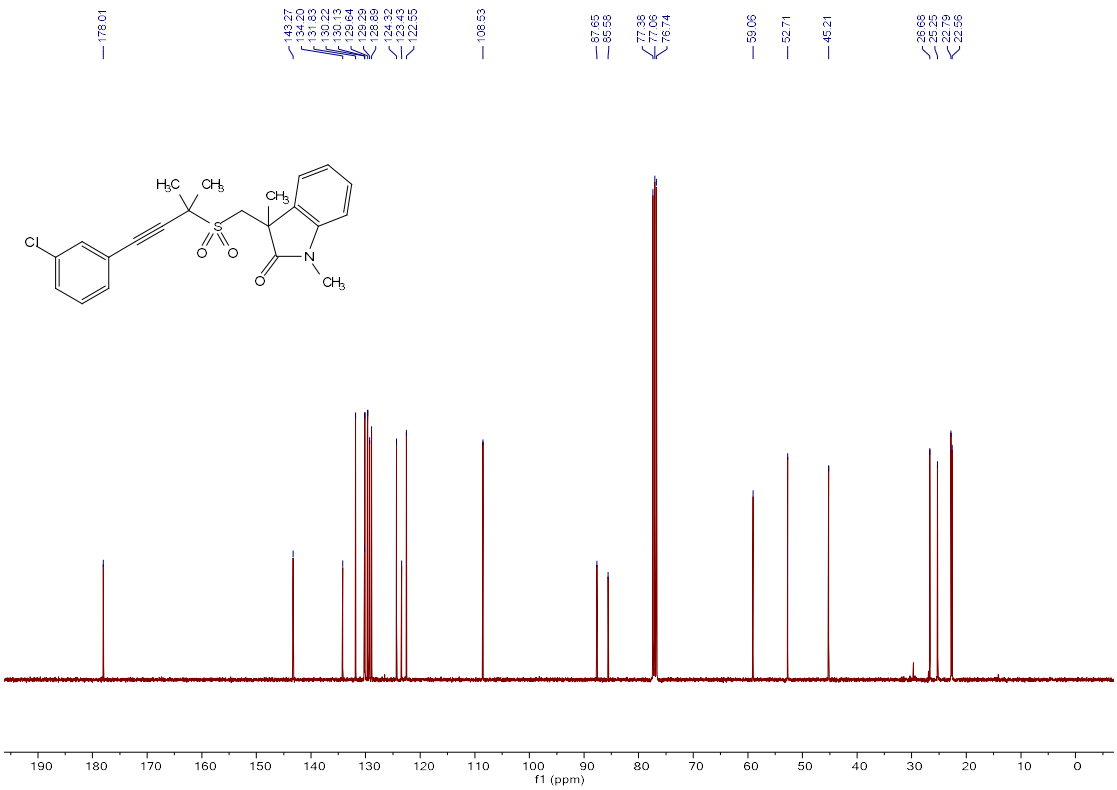


The product (52.4 mg, 63% yield) as brown solid was purified with silica gel chromatography (petroleum ether/ethyl acetate = 2/1). **^{1}H NMR (400 MHz, $CDCl_3$)** δ 7.42 – 7.39 (m, 2H), 7.34 – 7.32 (m, 1H), 7.28 – 7.18 (m, 3H), 7.03 (t, *J* = 7.6 Hz, 1H), 6.82 (d, *J* = 7.6 Hz, 1H), 4.02 (d, *J* = 13.6 Hz, 1H), 3.62 (d, *J* = 13.6 Hz, 1H), 3.19 (s, 3H), 1.57 (d, *J* = 6.0 Hz, 6H), 1.43 (s, 3H); **^{13}C NMR (101 MHz, $CDCl_3$)** δ 178.0, 143.3, 134.2, 131.8, 130.2, 130.1, 129.6, 129.3, 128.9, 124.3, 123.4, 122.6, 108.5, 87.7, 85.6, 59.1, 52.7, 45.2, 26.7, 25.3, 22.8, 22.6; **HRMS** Calculated for $C_{22}H_{22}ClNO_3S$ ($M+Na^+$): 438.0901; Found: 438.0909.

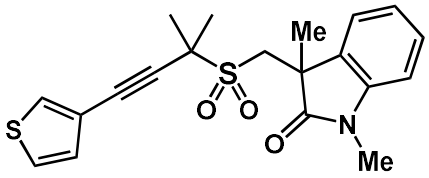
^{1}H NMR spectrum (400 MHz, $CDCl_3$) of compound **93**



^{13}C NMR spectrum (101 MHz, $CDCl_3$) of compound **93**

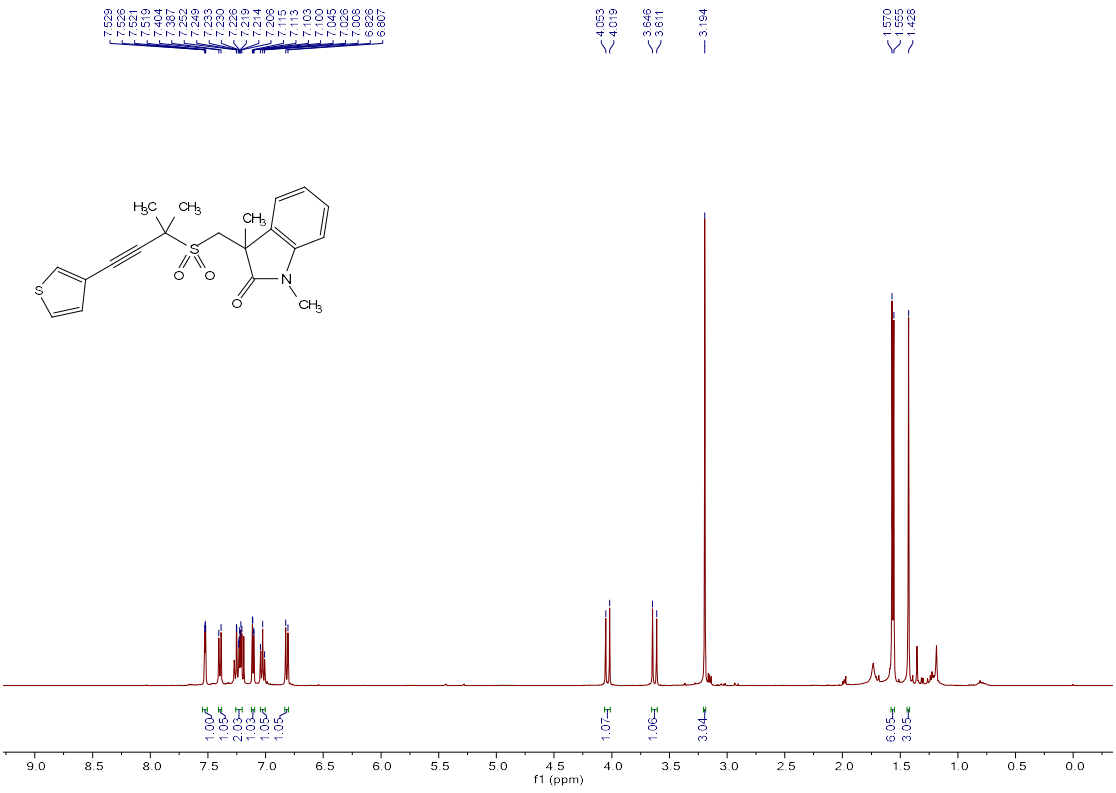


1,3-dimethyl-3-(((2-methyl-4-(thiophen-3-yl)but-3-yn-2-yl)sulfonyl)methyl)indolin-2-one (94).

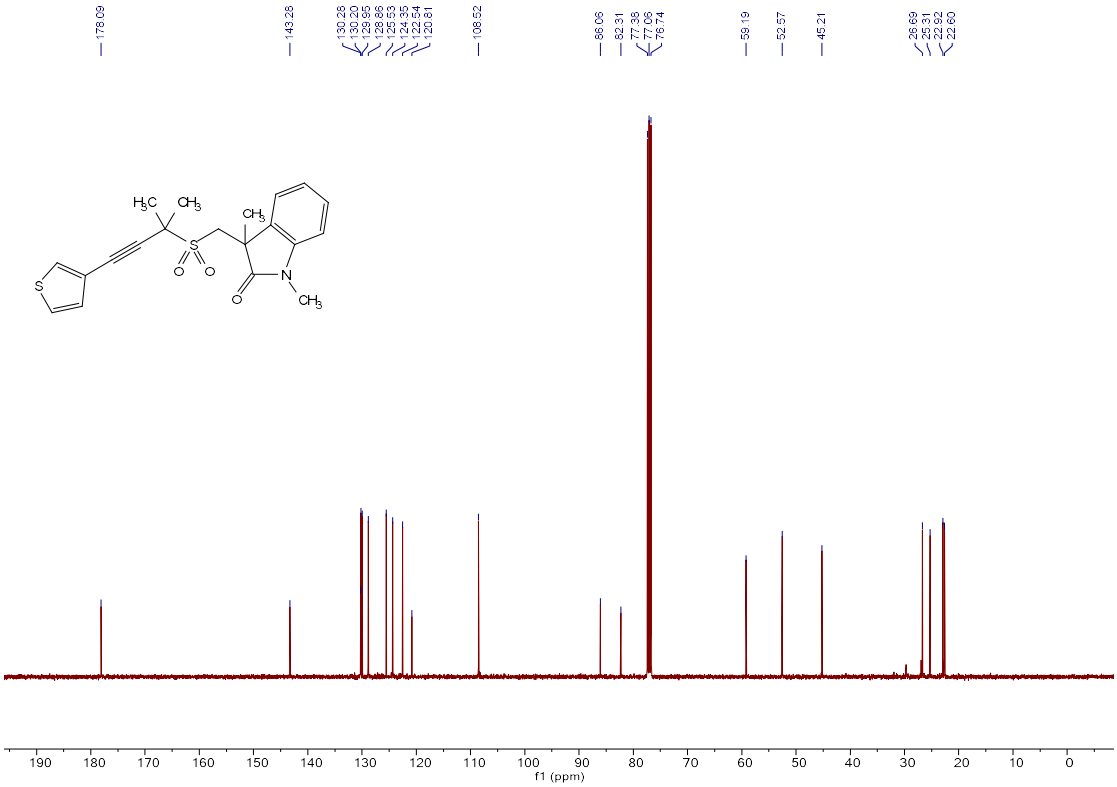


The product (42.6 mg, 55% yield) as brown oil was purified with silica gel chromatography (petroleum ether/ethyl acetate = 2/1). **^{1}H NMR (400 MHz, $CDCl_3$)** δ 7.52 (dd, *J* = 3.2 Hz, 1.2 Hz, 1H), 7.40 (d, *J* = 6.8 Hz, 1H), 7.25-7.21 (m, 2H), 7.11 (dd, *J* = 4.8 Hz, 0.8 Hz, 1H), 7.03 (t, *J* = 7.6 Hz, 1H), 6.82 (d, *J* = 7.6 Hz, 1H), 4.04 (d, *J* = 13.6 Hz, 1H), 3.63 (d, *J* = 14.0 Hz, 1H), 3.19 (s, 3H), 1.56 (d, *J* = 6.0 Hz, 6H), 1.43 (s, 3H); **^{13}C NMR (101 MHz, $CDCl_3$)** δ 178.1, 143.3, 130.3, 130.2, 130.0, 128.9, 125.5, 124.4, 122.5, 120.8, 108.5, 86.1, 82.3, 59.2, 52.6, 45.2, 26.7, 25.3, 22.9, 22.6; **HRMS** Calculated for $C_{20}H_{21}NO_3S_2$ ($M+Na^+$): 410.0855; Found: 410.0855.

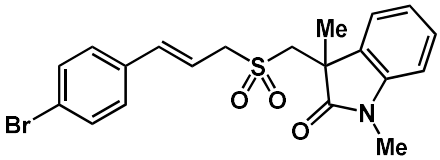
^{1}H NMR spectrum (400 MHz, $CDCl_3$) of compound **94**



^{13}C NMR spectrum (101 MHz, $CDCl_3$) of compound **94**

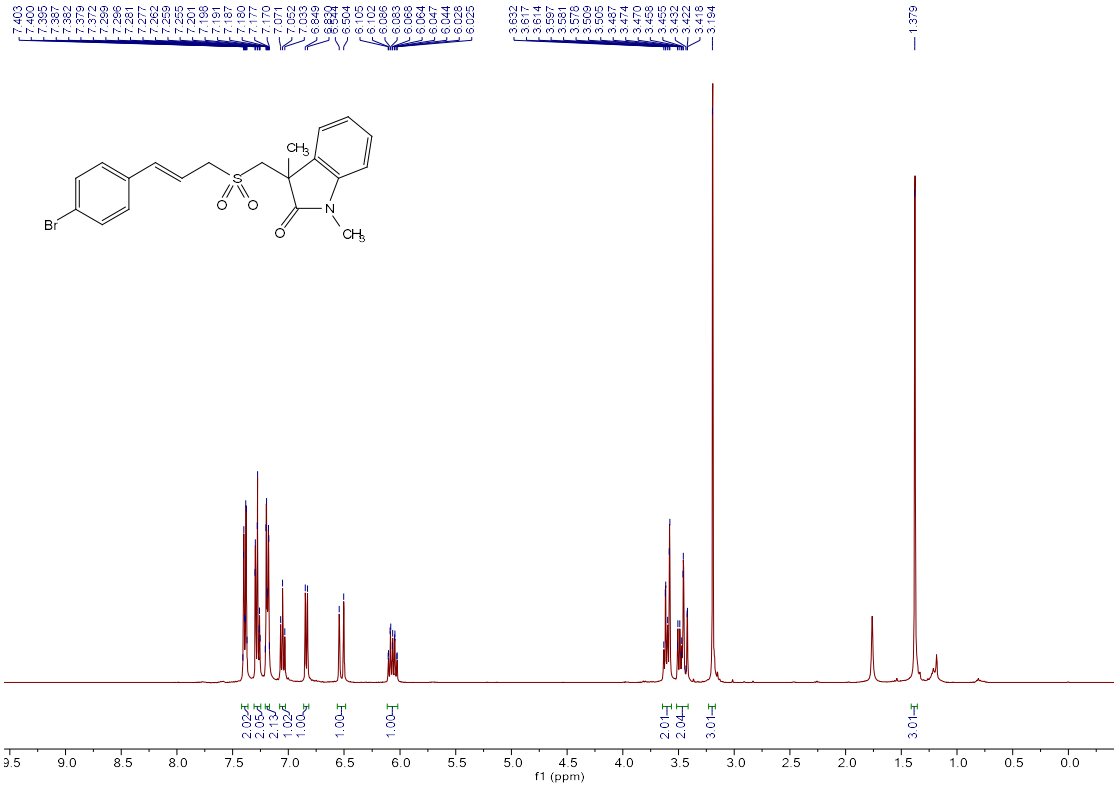


(*E*)-3-(((3-(4-bromophenyl)allyl)sulfonyl)methyl)-1,3-dimethylindolin-2-one (97).



The product (1.4 g, 80% yield) as light yellow solid was purified with silica gel chromatography (petroleum ether/ethyl acetate = 2/1). **^{1}H NMR (400 MHz, $CDCl_3$)** δ 7.41 – 7.37 (m, 2H), 7.30 – 7.26 (m, 2H), 7.21 – 7.17 (m, 2H), 7.05 (t, *J* = 7.6 Hz, 1H), 6.84 (d, *J* = 7.6 Hz, 1H), 6.52 (d, *J* = 16.0 Hz, 1H), 6.11 – 6.03 (m, 1H), 3.63 – 3.58 (m, 2H), 3.51 – 3.42 (m, 2H), 3.19 (s, 3H), 1.38 (s, 3H); **^{13}C NMR (101 MHz, $CDCl_3$)** δ 177.9, 143.4, 138.0, 134.5, 131.9, 130.4, 129.1, 128.3, 123.5, 122.7, 115.9, 108.8, 59.4, 57.3, 45.6, 26.7, 25.0; **HRMS** Calculated for $C_{20}H_{20}BrNO_3S$ ($M+Na^+$): 456.0239; Found: 456.0246.

^{1}H NMR spectrum (400 MHz, $CDCl_3$) of compound **97**



^{13}C NMR spectrum (101 MHz, $CDCl_3$) of compound **97**