Electronic Supplementary Material (ESI) for Chemical Science


# Supporting Information

## Asymmetric Catalytic Epoxidation of α,β-Unsaturated Carbonyl Compounds with Hydrogen Peroxide: Additive-Free and Wide Substrate Scope †

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**Contents:**

## 1. General information

Reactions were carried out using commercial available reagents. THF, $CH_2Cl_2$, toluene, ether, $CH_3CN$, $C_2H_5OH$, DMF, $H_2O$, *n*-hexane were directly use without any pretreatment. Enantiomeric excesses (*ee*) were determined by HPLC analysis using the corresponding commercial chiral column as stated in the experimental procedures at 23 °C with UV detector at 210 nm or 254 nm. Optical rotations were reported as follows: $[\alpha]^T_D$ (c g/100 mL, in $CH_2Cl_2$ or $CHCl_3$). $^1$H NMR spectra was recorded on commercial instruments (400 MHz or 600MHz). Chemical shifts was reported in ppm from tetramethylsilane with the solvent resonance as the internal standard ($CDCl_3$, δ = 7.26). Spectra was reported as follows: chemical shift (δ ppm), multiplicity (s = singlet, d = doublet, t = triplet, q = quartet, m = multiplet ), coupling constants (Hz), integration and assignment. $^{13}$C NMR spectra was collected on commercial instruments (100 MHz or 150 Hz) with complete proton decoupling. Chemical shifts were reported in ppm from the tetramethylsilane with the solvent resonance as internal standard ($CDCl_3$, δ =77.0). HRMS was recorded on a commercial apparatus (ESI Source) and $^{78.9183}$Br was chosen as a reference to calculate the exact mass.

The corresponding racemic products were obtained by using racemic *N,N'*-dioxide **L3**–$Sc(OTf)_3$ as the catalyst.

## 2. General procedure for chiral *N,N'*-dioxide preparation

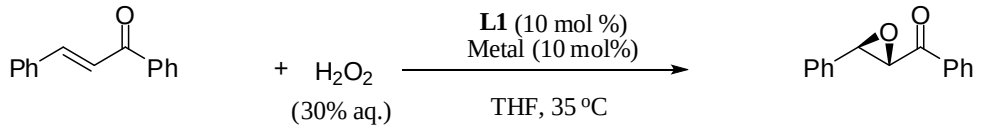
The *N,N'*-dioxide ligands **L1**–**L18** were synthesized by the same procedure in the literature[1].

## 3. Typical procedure for enantioselective epoxidation reaction

Chalcon **1a** (20.8 mg, 0.1 mmol), $Sc(OTf)_3$ (2.5 mg, 0.005 mmol) and **L3** (3.3 mg, 0.005 mmol) were weighted into a dry reaction tube, followed by THF (0.5 mL). The mixture was stirred at 35 °C for 30 min, and then hydrogen peroxide (28.2 μL, 0.3 mmol, 30% w/w in $H_2O$) was added under stirring. The reaction mixture was stirred at 35 °C for 8 h. The residue was purified by flash chromatography on silica gel to afford the desired product.

## 4. Extra optimization of reaction conditions

A) Screen of metals in the epoxidation of chalcone



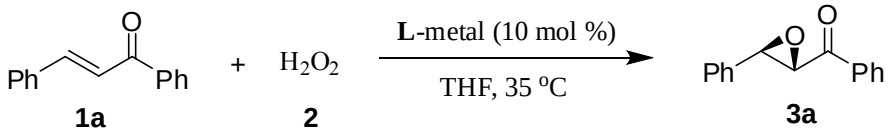

**1a** **2** **3a**

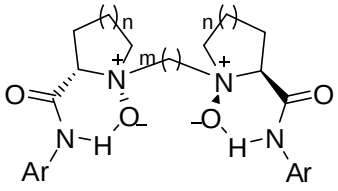
| Entry[a] | Ligand | Metal | Time (h) | Yield (%)[b] | ee (%)[c] |
|---|---|---|---|---|---|
| 1 | **L1** | $Yb(OTf)_3$ | 24 | trace | 13 (2*R*,3*S*) [2] |
| 2 | **L1** | $Sm(OTf)_3$ | 24 | trace | 6 (2*R*,3*S*) |
| 3 | **L1** | $Zn(OTf)_2$ | 24 | n.r.[d] | - |
| 4 | **L1** | $Cu(OTf)_2$ | 24 | n.r. | - |
| 5 | **L1** | $Ni(ClO_4)_2$ $6H_2O$ | 24 | n.r. | - |

| | | | | | |
|---|---|---|---|---|---|
| 6 | **L1** | $Fe(ClO_4)_2$ $6H_2O$ | 24 | 9 | 0 |
| 7 | **L1** | $ScCl_3{\cdot}6H_2O$ | 24 | 11 | 79 (2*S*,3*R*) |
| 8 | **L1** | $Sc(acac)_3$ | 24 | trace | 80 (2*S*,3*R*) |
| 9 | **L1** | $Sc(OTf)_3$ | 24 | 65 | 83 (2*S*,3*R*) |

[a] Unless otherwise noted, all reactions were performed with **L1** (10 mol%), $Sc(OTf)_3$ (10 mol%), **1a** (0.1 mmol) and $H_2O_2$ (0.3 mmol) in THF (0.5 mL) at 35 °C. [b] Yield of isolated product. [c] Determined by HPLC analysis. [d] n.r. = no reaction

B) Screen of *N,N'*-dioxides in the epoxidation of chalcone



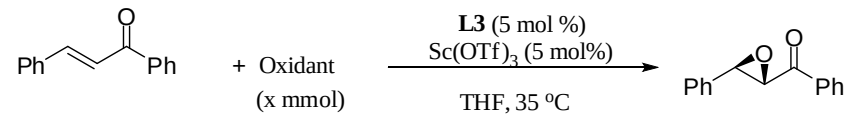
**L6**: Ar = $CH_2Ph$, n = 2, m=3
**L7**: Ar = $(CH_2)_2Ph$, n = 2, m=3
**L8**: Ar = $(CH_2)_3Ph$, n = 2, m=3

**L9**: Ar = $CH(Ph)_2$, n = 2, m=3
**L10**: Ar = 4-*i*-$PrC_6H_4$, n = 2, m=3
**L11**: Ar = 2,6-t-$Bu_2C_6H_3$, n = 2, m=3
**L12**: Ar =adam, n = 2, m=3
**L13:** Ar = 2-$CH_3OC_6H_4$, n = 2, m=3
**L14**: Ar = 4-$FC_6H_4$, n = 2, m=3
**L15**: Ar = 3-$ClC_6H_4$, n = 2, m=3
**L16**: Ar = 4-$BrC_6H_4$, n = 2, m=3
**L17**: Ar = 2,6-*i*-$Pr_2C_6H_3$, n = 2, m=2
**L18**: Ar = $CH(Ph)_2$, n = 2, m=5

| Entry[a] | Ligand | Metal | Time (h) | Yield (%)[b] | ee (%)[c] |
|---|---|---|---|---|---|
| 1 | **L6** | $Sc(OTf)_3$ | 24 | 49 | 83 |
| 2 | **L7** | $Sc(OTf)_3$ | 24 | 50 | 89 |
| 3 | **L8** | $Sc(OTf)_3$ | 24 | 16 | 87 |
| 4 | **L9** | $Sc(OTf)_3$ | 24 | 69 | 88 |
| 5 | **L10** | $Sc(OTf)_3$ | 24 | 59 | 89 |
| 6 | **L11** | $Sc(OTf)_3$ | 24 | 58 | 88 |
| 7 | **L12** | $Sc(OTf)_3$ | 24 | 70 | 80 |
| 8 | **L13** | $Sc(OTf)_3$ | 24 | 55 | 79 |
| 9 | **L14** | $Sc(OTf)_3$ | 24 | 66 | 98 |
| 10 | **L15** | $Sc(OTf)_3$ | 24 | 22 | 83 |
| 11 | **L16** | $Sc(OTf)_3$ | 24 | 50 | 86 |
| 12 | **L17** | $Sc(OTf)_3$ | 24 | 38 | 75 |
| 13 | **L18** | $Sc(OTf)_3$ | 24 | 8 | 0 |

[a] Unless otherwise noted, all reactions were performed with ligand (10 mol%), $Sc(OTf)_3$ (10 mol%), **1a** (0.1 mmol) and $H_2O_2$ (0.3 mmol) in THF (0.5 mL) at 35 °C. [b] Yield of isolated product. [c] Determined by HPLC analysis.

C) Optimization of the oxidant in the epoxidation reaction

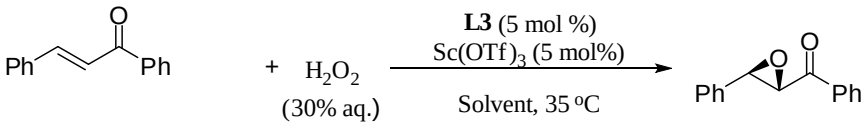



**1a** **2** **3a**

| Entry[a] | Oxidant | x (mmol) | Time (h) | Yield (%)[b] | ee (%)[c] |
|---|---|---|---|---|---|
| 1 | m-CPBA | 0.3 | 48 | 60 | 80 |
| 2 | NaClO | 0.3 | 72 | trace | 0 |
| 3 | TBHP (70% in water) | 0.3 | 48 | 50 | 97 |
| 4 | $H_2O_2$ (30% in water) | 0.3 | 8 | 99 | 98 |
| 5 | $H_2O_2$ (30% in water) | 0.12 | 8 | 82 | 95 |
| 6 | $H_2O_2$ (30% in water) | 0.2 | 8 | 83 | 94 |

[a] Unless otherwise noted, all reactions were performed with **L3** (5 mol %), $Sc(OTf)_3$ (5 mol %), **1a** (0.1 mmol ), **2** in THF (0.5 mL) at 35 °C for 8–72 h. [b] Yield of isolated product. [c] Determined by HPLC analysis.

D) Survey of solvent effents

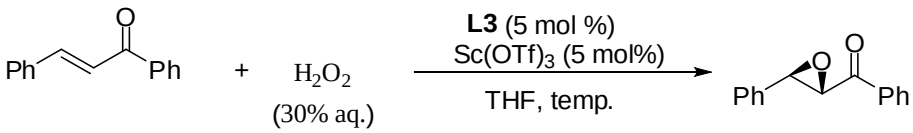



**1a** **2** **3a**

| Entry[a] | Solvent | Time (h) | Yield (%)[b] | ee (%)[c] |
|---|---|---|---|---|
| 1 | THF | 8 | 99 | 98 |
| 2 | $CH_3CN$ | 8 | 81 | 95 |
| 3 | $C_2H_5OH$ | 8 | 57 | 98 |
| 4 | $CH_2Cl_2$ | 8 | 43 | 98 |
| 5 | toluene | 8 | 41 | 98 |
| 6 | $Et_2O$ | 8 | trace | - |
| 7 | DMF | 8 | trace | - |
| 8 | $H_2O$ | 8 | trace | - |
| 9 | n-hexane | 8 | trace | - |

[a] Unless otherwise noted, all reactions were performed with **L3** (5 mol%), $Sc(OTf)_3$ (5 mol%), **1a** (0.1 mmol) and $H_2O_2$ (0.3 mmol) in solvent (0.5 mL) at 35 °C. [b] Yield of isolated product. [c] Determined by HPLC analysis.

E) Survey of temperature effents

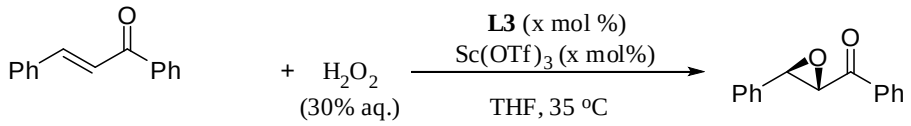



**1a** **2** **3a**

| Entry[a] | Temp. (°C) | Time (h) | Yield (%)[b] | ee (%)[c] |
|---|---|---|---|---|
| 1 | −20 | 8 | 13 | 98 |
| 2 | 0 | 8 | 44 | 98 |
| 3 | 20 | 8 | 54 | 98 |
| 4 | 35 | 8 | 99 | 98 |
| 5 | 45 | 4 | 99 | 98 |
| 6 | 60 | 4 | 99 | 93 |

[a] Unless otherwise noted, all reactions were performed with **L3** (5 mol%), $Sc(OTf)_3$ (5 mol%), **1a** (0.1 mmol) and $H_2O_2$ (0.3 mmol) in THF (0.5 mL). [b] Yield of isolated product. [c] Determined by HPLC analysis.

F) Optimization of catalyst loading

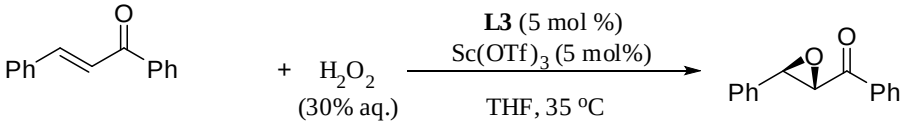



**1a** **2** **3a**

| Entry[a] | x (mol%) | Time (h) | Yield (%)[b] | ee (%)[c] |
|---|---|---|---|---|
| 1 | 10 | 8 | 99 | 98 |
| 2 | 5 | 8 | 99 | 98 |
| 3 | 2 | 8 | 50 | 97 |
| 4 | 1 | 8 | 38 | 96 |
| 5 | 0.5 | 8 | 10 | 96 |

[a] Unless otherwise noted, all reactions were performed with **L3**, $Sc(OTf)_3$ (1:1), **1a** (0.1 mmol) and $H_2O_2$ (0.3 mmol) in THF (0.5 mL) at 35 °C. [b] Yield of isolated product. [c] Determined by HPLC analysis.

## 5. The experment of water-tolerance.




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

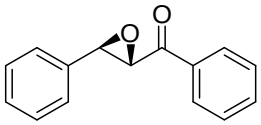
| Entry[a] | Volume of water (μL) | Time (h) | Yield (%)[b] | ee (%)[c] |
|---|---|---|---|---|
| 1 | 0 | 8 | 99 | 98 |
| 2 | 28.2 | 8 | 98 | 97 |
| 3 | 56.4 | 8 | 99 | 98 |
| 4 | 112.8 | 8 | 99 | 98 |
| 5 | 141.1 | 8 | 99 | 98 |
| 6 | 225.6 | 8 | 99 | 98 |
| 7 | 282.0 | 8 | 99 | 98 |

| | | | | |
|---|---|---|---|---|
| 8 | 1410.0 | 8 | 99 | 98 |
| 9 | 2820.0 | 8 | 99 | 97 |
| 10 | 5000.0 | 8 | 41 | 97 |
| 11 | 10000.0 | 8 | 4 | 97 |

[a] Unless otherwise noted, all reactions were performed with ligand (5 mol%), $Sc(OTf)_3$ (5 mol%), **1a** (0.1 mmol) and $H_2O_2$ (0.3 mmol) in THF (0.5 mL) at 35 °C. [b] Yield of isolated product. [c] Determined by HPLC analysis.

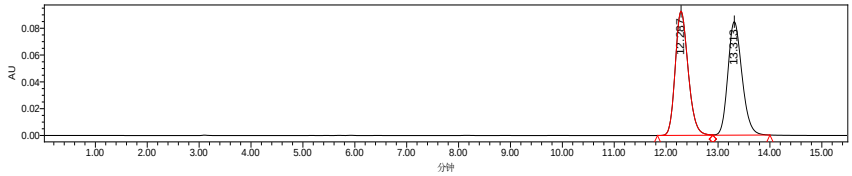
## 6. The ananlytical and spectral characterization data of the products 3

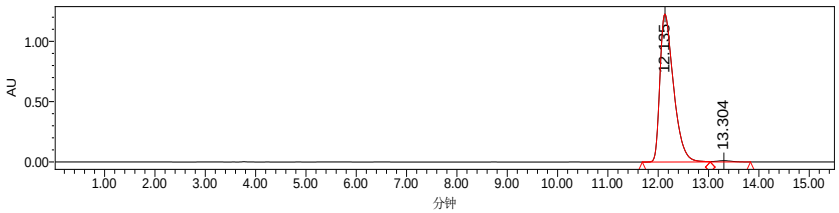
**phenyl(3-phenyloxiran-2-yl)methanone(3a):**



White solid in 99% yield after 8 hours, by silica gel chromatography (petroleum ether: EtOAc = 20:1). HPLC (Chiralcel OD-H, hexane/ *i*-PrOH = 95/5), flow rate 1.0 mL/min, λ= 254 nm, $t_r$(major)= 12.13 min, $t_r$(minor)= 13.30 min, 98% *ee*. $^1$H NMR (400 MHz, $CDCl_3$) δ = 8.02 (d, *J* = 7.7, 2H), 7.63 (t, *J* = 7.2, 1H), 7.50 (t, *J* = 7.6, 2H), 7.40 (d, *J* = 4.5, 5H), 4.31 (s, 1H), 4.09 (s, 1H).

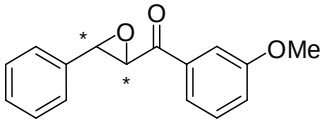
$[\alpha]^{11}_D$ = +220.9 (c = 4.28, in $CH_2Cl_2$ 98% *ee*). The literature data[2] was $[\alpha]^{rt}_{578}$ = -72.2 (c = 0.69, in $CH_2Cl_2$, 34% *ee*).




| | Retention Time | Area | %Area |
|---|---|---|---|
| 1 | 12.135 | 22948226 | 99.04 |
| 2 | 13.304 | 221835 | 0.96 |

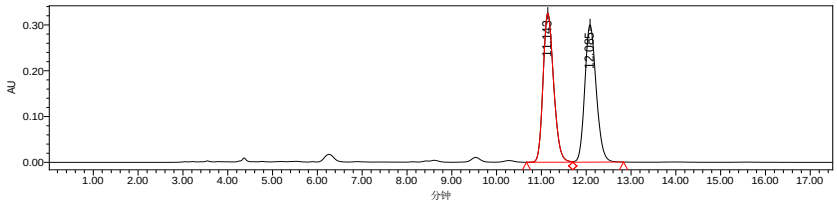
**(3-methoxyphenyl)(3-phenyloxiran-2-yl)methanone(3b)**

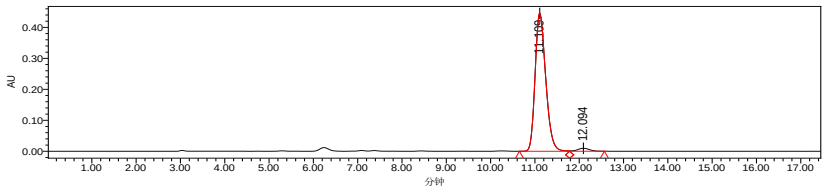


White solid in 83% yield after 74 hours, by silica gel chromatography (petroleum ether: EtOAc = 20:1). HPLC (Chiralcel OD-H, hexane/ *i*-PrOH = 90/10), flow rate 1.0 mL/min, λ = 254 nm, $t_r$(major)= 11.11 min, $t_r$(minor)= 12.09 min, 95% *ee*.

$^1$H NMR (600 MHz, $CDCl_3$) δ = 7.58 (d, *J* = 7.7, 1H), 7.53 (d, *J* = 2.1, 1H), 7.39 (ddd, *J* = 8.5, 7.9, 5.6, 6H), 7.17 (dd, *J* = 8.2, 2.5, 1H), 4.29 (d, *J* = 1.8, 1H), 4.08 (d, *J* = 1.7, 1H), 3.86 (s, 3H).

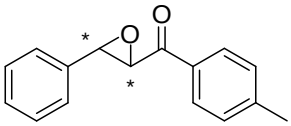
$[\alpha]^{13}_D$ = +76.3 (c = 1.10, in $CH_2Cl_2$).




| | Retention Time | Area | %Area |
|---|---|---|---|
| 1 | 11.109 | 7392003 | 97.63 |
| 2 | 12.094 | 179385 | 2.37 |

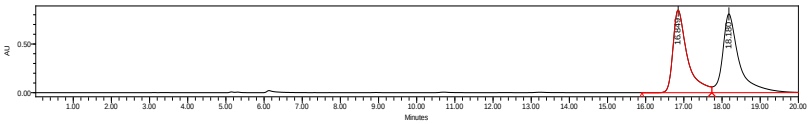
**(3-phenyloxiran-2-yl)(p-tolyl)methanone (3c)**

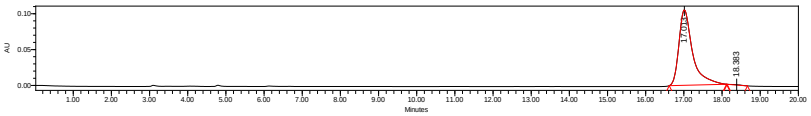


White solid in 82% yield after 24 hours, by silica gel chromatography (petroleum ether: EtOAc = 20:1). HPLC (Chiralcel IA, hexane/ *i*-PrOH = 95/5), flow rate 1.0 mL/min, λ = 254 nm, $t_r$(major)= 17.01 min, $t_r$(minor)= 18.40 min, 99% *ee*.

$^1$H NMR (400 MHz, $CDCl_3$) δ = 7.92 (d, *J* = 8.2, 2H), 7.39 (m, *J* = 5.0, 5H), 7.34–7.23 (d, 2H), 4.28 (d, *J* = 1.9, 1H), 4.07 (d, *J* = 1.8, 1H), 2.43 (s, 3H).

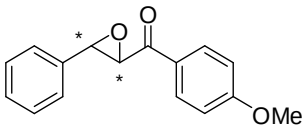
$[\alpha]^{21}_D$ = +160.0 (c = 1.00, in $CHCl_3$).




| | Retention Time | Area | %Area |
|---|---|---|---|
| 1 | 17.013 | 2658691 | 99.87 |
| 2 | 18.400 | 3591 | 0.13 |

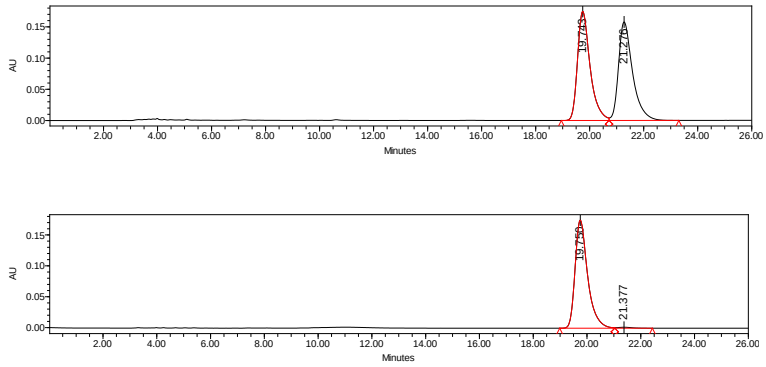
**(4-methoxyphenyl)(3-phenyloxiran-2-yl)methanone (3d)**



White solid in 95% yield after 42 hours, by silica gel chromatography (petroleum ether: EtOAc = 10:1). HPLC (Chiralcel IC, hexane/ *i*-PrOH = 70/30), flow rate 1.0 mL/min, λ= 254 nm, $t_r$(major)= 19.75 min, $t_r$(minor)= 21.38 min, 98% *ee*.

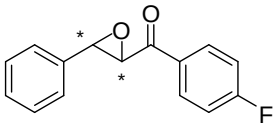
$^1$H NMR(400 MHz, $CDCl_3$) δ = 8.02 (d, *J* = 8.8, 2H), 7.52–7.30 (m, 5H), 6.95 (d, *J* = 8.8, 2H), 4.25 (d, *J* = 1.6, 1H), 4.07 (d, *J* = 1.3, 1H), 3.88 (s, 3H).

$[\alpha]^{26}_D$ = +581.6 (c = 1.68 ,in $CHCl_3$).




| | Retention Time | Area | %Area |
|---|---|---|---|
| 1 | 19.750 | 5674228 | 99.02 |
| 2 | 21.377 | 56341 | 0.98 |

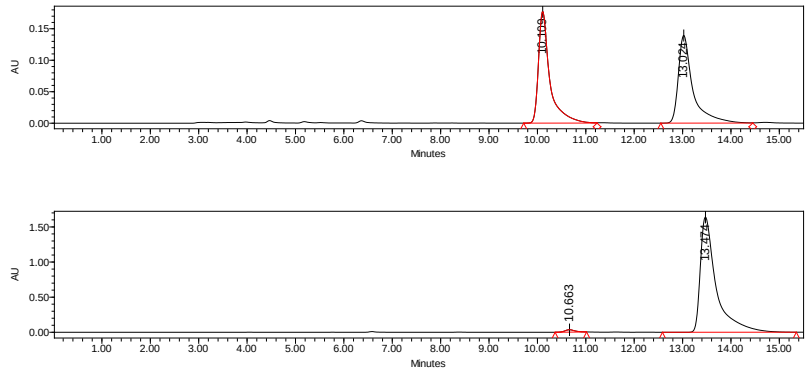
**(4-fluorophenyl)(3-phenyloxiran-2-yl)methanone (3e)**



White solid in 99% yield after 36 hours, by silica gel chromatography (petroleum ether: EtOAc = 20:1). HPLC (Chiralcel IA, hexane/ *i*-PrOH = 90/10), flow rate 1.0 mL/min, λ = 254 nm, $t_r$(minor) = 10.66 min, $t_r$(major) = 13.47 min, 97% *ee*.

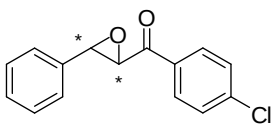
$^1$H NMR(400 MHz, $CDCl_3$) δ = 8.06 (dd, *J* = 8.4, 5.6, 2H), 7.48–7.31 (m, 5H), 7.16 (t, *J* = 8.5, 2H), 4.24 (s, 1H), 4.07 (s, 1H).

$[\alpha]^{13}_D$ = +47.9 (c = 0.48, in $CH_2Cl_2$).




| | Retention Time | Area | %Area |
|---|---|---|---|
| 1 | 10.663 | 651341 | 1.71 |
| 2 | 13.474 | 37469423 | 98.29 |

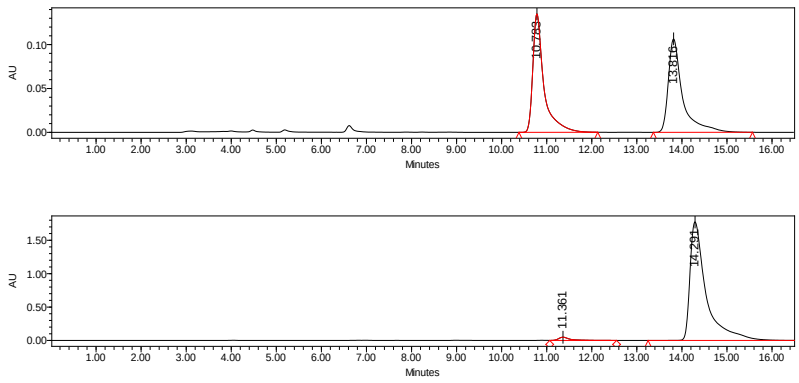
**(4-chlorophenyl)(3-phenyloxiran-2-yl)methanone (3f)**



White solid in 90% yield after 24 hours, by silica gel chromatography (petroleum ether: EtOAc = 20:1). HPLC (Chiralcel IA, hexane/ *i*-PrOH = 90/10), flow rate 1.0 mL/min, λ = 254 nm, $t_r$(minor)= 11.36 min, $t_r$(major)= 14.29 min, 96% *ee*.

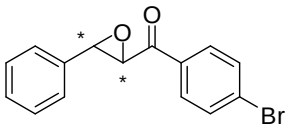
$^1$H NMR (400 MHz, $CDCl_3$) δ = 7.96 (d, *J* = 8.5, 2H), 7.46 (d, *J* = 8.5, 2H), 7.43–7.29 (m, 5H), 4.23 (d, *J* = 1.5, 1H), 4.07 (s, 1H).

$[\alpha]^{27}_D$ = +35.9 (c = 7.82, in $CHCl_3$).




| | Retention Time | Area | %Area |
|---|---|---|---|
| 1 | 11.361 | 903452 | 2.00 |
| 2 | 14.291 | 44259892 | 98.00 |

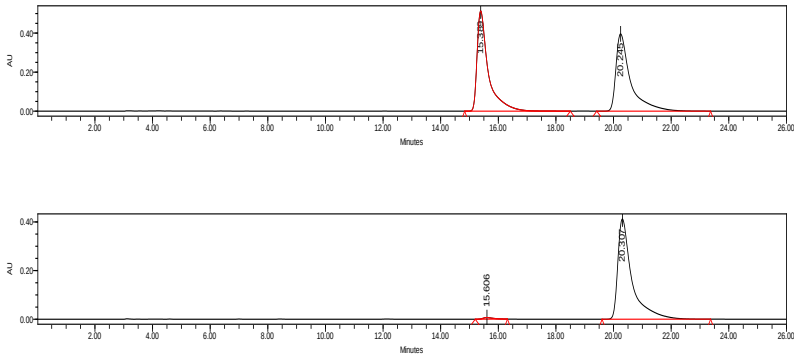
**(4-bromophenyl)(3-phenyloxiran-2-yl)methanone (3g)**



White solid in 99% yield after 8 hours, by silica gel chromatography (petroleum ether: EtOAc = 20:1). HPLC (Chiralcel IA, hexane/ *i*-PrOH = 95/5), flow rate 1.0 mL/min, λ = 254 nm, $t_r$(minor)= 15.61 min, $t_r$(major)= 20.31 min, 97% *ee*.

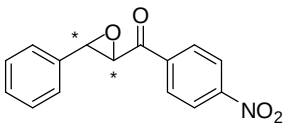
$^1$H NMR (400 MHz, $CDCl_3$) δ = 7.92–7.82 (m, 2H), 7.68–7.55 (m, 2H), 7.45–7.30 (m, 5H), 4.23 (d, *J* = 1.9, 1H), 4.07 (d, *J* = 1.8, 1H).

$[\alpha]^{21}_D$ = +66.1 (c = 4.16, in $CHCl_3$).




| | Retention Time | Area | %Area |
|---|---|---|---|
| 1 | 15.606 | 201726 | 1.41 |
| 2 | 20.307 | 14087751 | 98.59 |

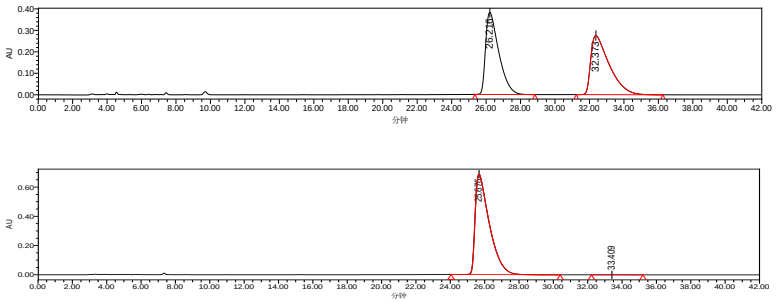
**(4-nitrophenyl)(3-phenyloxiran-2-yl)methanone (3h)**



White solid in 87% yield after 42 hours, by silica gel chromatography (petroleum ether: EtOAc = 5:1). HPLC (Chiralcel OD-H, hexane/ *i*-PrOH = 70/30), flow rate 1.0 mL/min, λ = 254 nm, $t_r$(major)= 25.68 min, $t_r$(minor)= 33.41 min, 99% *ee*.

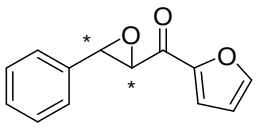
$^1$H NMR (400 MHz, $CDCl_3$) δ = 8.40–8.31 (m, 2H), 8.24–8.12 (m, 2H), 7.48–7.32 (m, 5H), 4.26 (d, *J* = 1.8, 1H), 4.11 (d, *J* = 1.8, 1H).

$[\alpha]^{25}_{D}$ = +170.0 (c = 1.50, in $CHCl_3$).




| | Retention Time | Area | %Area |
|---|---|---|---|
| 1 | 25.676 | 39339892 | 99.90 |
| 2 | 33.409 | 40779 | 0.10 |

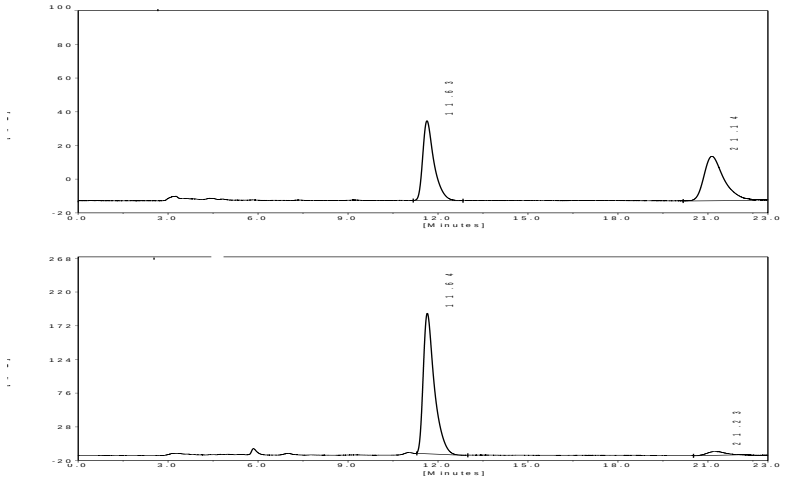
**furan-2-yl(3-phenyloxiran-2-yl)methanone (3i)**



White solid in 80% yield after 48 hours, by silica gel chromatography (petroleum ether: EtOAc = 20:1). HPLC (Chiralcel AS-H, hexane/ *i*-PrOH= 80/20), flow rate 1.0 mL/min, λ = 254 nm, $t_r$(major)= 11.64 min, $t_r$(minor)= 21.23 min, *ee*= 92%.

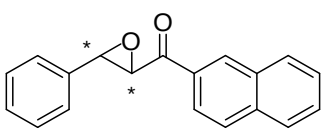
$^1$H NMR (600 MHz, $CDCl_3$) δ = 7.67 (d, *J* = 0.9, 1H), 7.46 (d, *J* = 3.6, 1H), 7.37 (ddd, *J* = 19.0, 6.9, 3.9, 5H), 6.60 (dd, *J* = 3.6, 1.6, 1H), 4.14 (d, *J* = 1.7, 2H).

$[\alpha]^{26}_{D}$ = +183.2 (c = 3.46, in $CHCl_3$).




| | Retention Time | Area | %Area |
|---|---|---|---|
| 1 | 11.64 | 5112.59 | 96.1496 |
| 2 | 21.23 | 5.08 | 3.8504 |

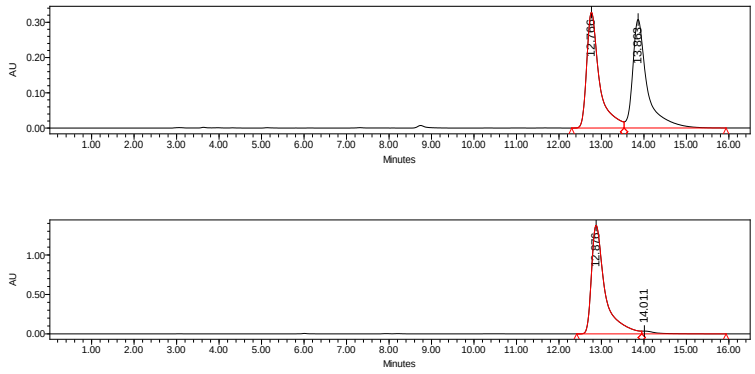
**naphthalen-2-yl(3-phenyloxiran-2-yl)methanone (3j)**



White solid in 70% yield after 36 hours, by silica gel chromatography (petroleum ether: EtOAc = 10:1). HPLC (Chiralcel OD-H, hexane/ *i*-PrOH= 90/10), flow rate 1.0 mL/min, λ= 254 nm, $t_r$(major)= 12.88 min, $t_r$(minor)= 14.01 min, 95% *ee*.

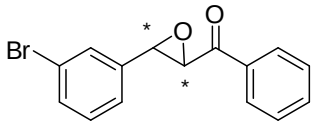
$^1$H NMR (600 MHz, $CDCl_3$) δ = 8.03 (d, *J* = 7.6, 2H), 7.88 (dt, *J* = 9.1, 6.1, 4H), 7.63 (t, *J* = 7.4, 1H), 7.55–7.47 (m, 4H), 7.43 (d, *J* = 8.7, 1H), 4.41 (d, *J* = 1.4, 1H), 4.25 (s, 1H).

$[\alpha]^{25}_{D}$ = +102.0 (c = 1.0, in $CH_2Cl_3$).




| | Retention Time | Area | %Area |
|---|---|---|---|
| 1 | 12.876 | 30567762 | 97.51 |
| 2 | 14.011 | 779931 | 2.49 |

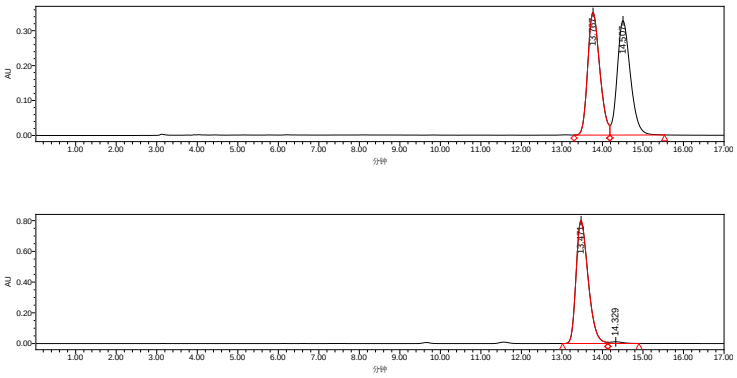
**(3-(3-bromophenyl)oxiran-2-yl)(phenyl)methanone (3k)**




White solid in 99% yield after 24 hours, by silica gel chromatography (petroleum ether: EtOAc = 20:1). HPLC (Chiralcel OD-H, hexane/ *i*-PrOH= 95/5), flow rate 1.0 mL/min, λ = 254 nm, $t_r$(major)= 13.47 min, $t_r$(minor)= 14.33 min, 97% *ee*.

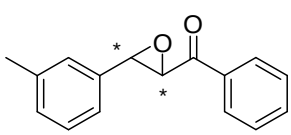
$^1$H NMR (400 MHz, $CDCl_3$) δ = 8.01 (d, *J* = 7.8, 2H), 7.63 (d, *J* = 7.3, 1H), 7.51 (t, *J* = 7.5, 4H), 7.36 – 7.22 (m, 2H), 4.26 (s, 1H), 4.06 (s, 1H).

$[\alpha]^{13}_{D}$ = +175.2 (c = 2.30, in $CH_2Cl_2$).




| | Retention Time | Area | %Area |
|---|---|---|---|
| 1 | 13.471 | 16523650 | 98.56 |
| 2 | 14.329 | 242138 | 1.44 |

**phenyl(3-m-tolyloxiran-2-yl)methanone (3l)**

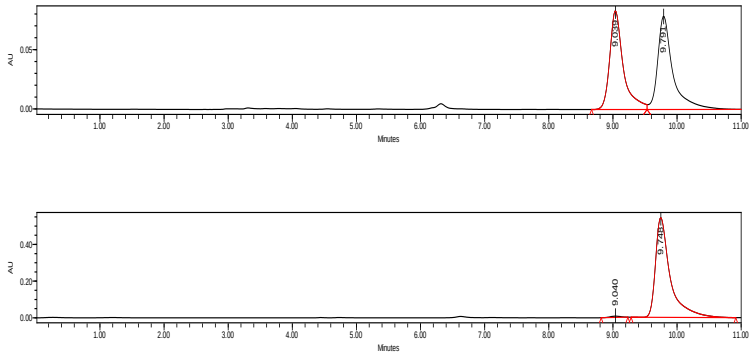



White solid in 99% yield after 24 hours, by silica gel chromatography (petroleum ether: EtOAc = 20:1). HPLC (Chiralcel IA, hexane/ *i*-PrOH= 90/10), flow rate 1.0 mL/min, λ= 254 nm, $t_r$(minor)= 9.04 min, $t_r$(major)= 9.75 min, 96% *ee*.

$^1$H NMR (600 MHz, $CDCl_3$) δ = 8.01 (d, *J* = 7.4, 2H), 7.62 (d, *J* = 7.4, 1H), 7.49 (t, *J* = 7.8, 2H), 7.29 (d, *J* = 7.8, 1H), 7.19 (d, *J* = 12.3, 3H), 4.30 (d, *J* = 1.8, 1H), 4.05 (d, *J* = 1.6, 1H), 2.38 (s,

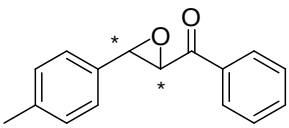
3H).

$[\alpha]^{13}_{D}$ = +162.8 (c = 1.80, in $CH_2Cl_2$).




| | Retention Time | Area | %Area |
|---|---|---|---|
| 1 | 9.040 | 173386 | 1.92 |
| 2 | 9.748 | 8869613 | 98.08 |

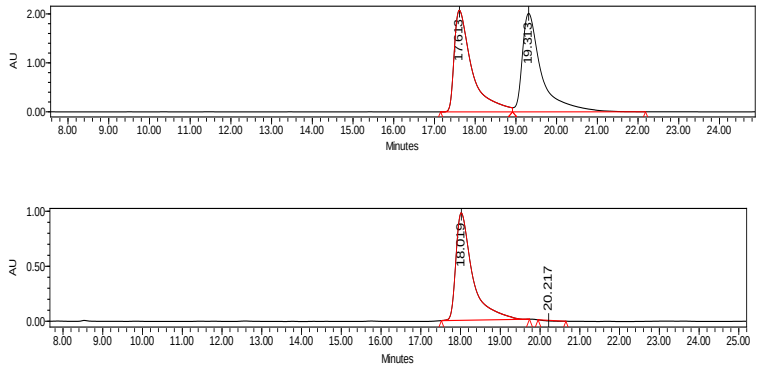
**phenyl(3-p-tolyloxiran-2-yl)methanone (3m)**



White solid in 84% yield after 24 hours, by silica gel chromatography (petroleum ether: EtOAc = 20:1). HPLC(Chiralcel IA, hexane/ *i*-PrOH= 95/5), flow rate 1.0 mL/min, λ = 254 nm, $t_r$(major)= 18.02 min, $t_r$(minor)= 20.22 min, 99% *ee*.

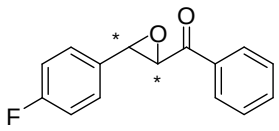
$^1$H NMR (400 MHz, $CDCl_3$) δ = 7.92 (d, *J* = 8.2, 2H), 7.47 – 7.32 (m, 5H), 7.32 – 7.26 (d, 2H), 4.28 (d, *J* = 1.9, 1H), 4.07 (d, *J* = 1.8, 1H), 2.43 (s, 3H).

$[\alpha]^{21}_{D}$ = +226.5 (c = 0.34, in $CHCl_3$).




| | Retention Time | Area | %Area |
|---|---|---|---|
| 1 | 18.019 | 28424749 | 99.54 |
| 2 | 20.217 | 132563 | 0.46 |

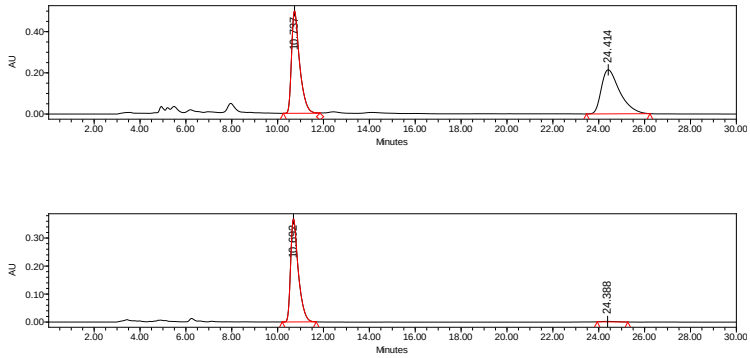
**(3-(4-fluorophenyl)oxiran-2-yl)(phenyl)methanone (3n)**



White solid in 95% yield after 20 hours, by silica gel chromatography (petroleum ether: EtOAc = 20:1). HPLC (Chiralcel AS-H, hexane/ *i*-PrOH= 80/20), flow rate 1.0 mL/min, λ= 254 nm, $t_r$(major)= 10.69 min, $t_r$(minor)= 24.39 min, 98% *ee*.

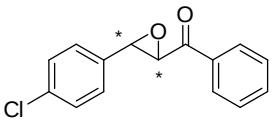
$^1$H NMR (600 MHz, $CDCl_3$) δ = 8.01 (d, *J* = 7.9, 2H), 7.63 (t, *J* = 7.4, 1H), 7.50 (t, *J* = 7.8, 2H),

7.35 (dd, *J* = 8.6, 5.3, 2H), 7.10 (t, *J* = 8.6, 2H), 4.26 (d, *J* = 1.7, 1H), 4.07 (d, *J* = 1.3, 1H).
$[\alpha]^{27}_{D}$ = +567.0 (c = 2.24, in $CHCl_3$).



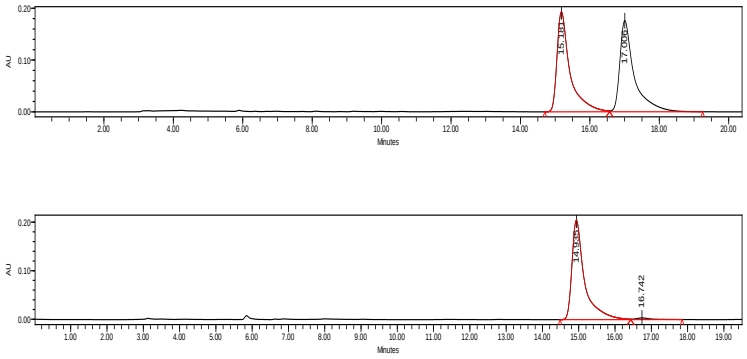

| | Retention Time | Area | %Area |
|---|---|---|---|
| 1 | 10.692 | 8526186 | 99.13 |
| 2 | 24.388 | 74936 | 0.87 |

**(3-(4-chlorophenyl)oxiran-2-yl)(phenyl)methanone (3o)**



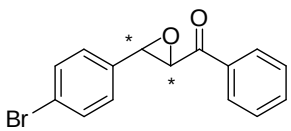
White solid in 96% yield after 20 hours, by silica gel chromatography (petroleum ether: EtOAc = 20:1). HPLC(Chiralcel IA, hexane/ *i*-PrOH= 95/5), flow rate 1.0 mL/min, λ= 254 nm, $t_r$(major)= 14.94 min, $t_r$(minor)= 16.74 min, 96% *ee*.

$^1$H NMR (600 MHz, $CDCl_3$) δ = 8.00 (dd, *J* = 8.2, 1.0, 2H), 7.63 (d, *J* = 7.5, 1H), 7.50 (t, *J* = 7.8, 2H), 7.42 – 7.36 (m, 2H), 7.34 – 7.29 (m, 2H), 4.26 (d, *J* = 1.8, 1H), 4.06 (d, *J* = 1.7, 1H).
$[\alpha]^{27}_{D}$ = +628.2 (c = 3.90, in $CHCl_3$).




| | Retention Time | Area | %Area |
|---|---|---|---|
| 1 | 14.935 | 4965721 | 98.17 |
| 2 | 16.742 | 92594 | 1.83 |

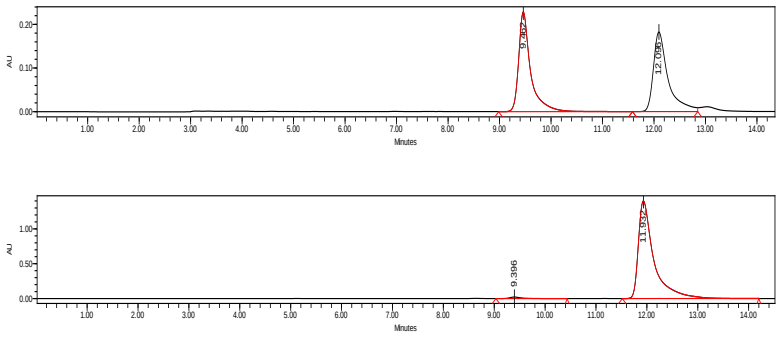
**(3-(4-bromophenyl)oxiran-2-yl)(phenyl)methanone (3p)**



White solid in 99% yield after 24 hours, by silica gel chromatography (petroleum ether: EtOAc = 20:1). HPLC (Chiralcel IA, hexane/ *i*-PrOH= 90/10), flow rate 1.0 mL/min, λ= 254 nm, $t_r$(minor)= 9.40 min, $t_r$(major)= 11.93 min, 98% *ee*.

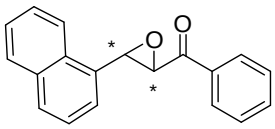
$^1$H NMR (400 MHz, $CDCl_3$) δ = 8.08–7.93 (m, 2H), 7.63 (td, *J* = 7.3, 1.1, 1H), 7.56–7.47 (m, 3H),

7.39–7.21 (m, 3H), 4.26 (dd, *J* = 6.5, 1.8, 1H), 4.06 (dd, *J* = 5.0, 1.6, 1H).
$[\alpha]^{21}_{D}$ =+205.9 (c = 6.44, in $CHCl_3$).



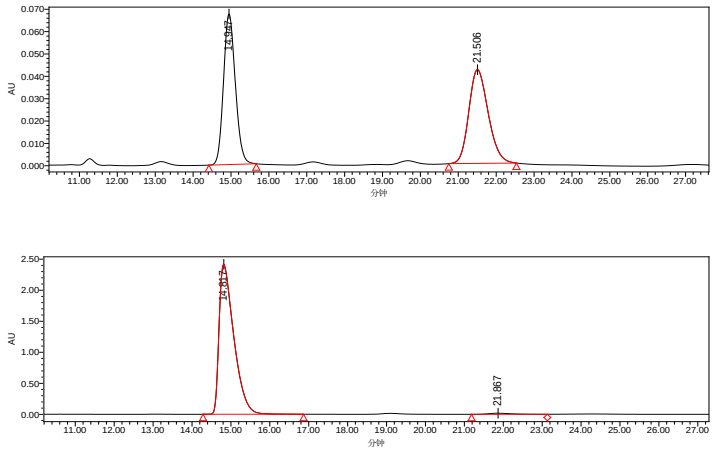

| | Retention Time | Area | %Area |
|---|---|---|---|
| 1 | 9.396 | 367178 | 1.23 |
| 2 | 11.932 | 29526729 | 98.77 |

**(3-(naphthalen-1-yl)oxiran-2-yl)(phenyl)methanone (3q)**



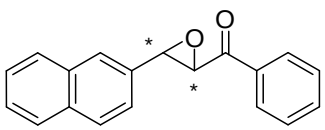
White solid in 99% yield after 36 hours, by silica gel chromatography (petroleum ether: EtOAc = 10:1). HPLC(Chiralcel OD-H, hexane/ *i*-PrOH= 95/5), flow rate 1.0 mL/min, λ= 254 nm, $t_r$(major)= 14.82 min, $t_r$(minor)= 21.87 min, 98% *ee*.

$^1$H NMR (400 MHz, $CDCl_3$) δ = 8.10 – 8.04 (m, 2H), 8.01 – 7.97 (m, 1H), 7.92 (dd, *J* = 7.2, 2.1, 1H), 7.87 (d, *J* = 8.2, 1H), 7.66 – 7.60 (m, 2H), 7.55 – 7.46 (m, 5H), 4.73 (d, *J* = 1.8, 1H), 4.31 (d, *J* = 2.0, 1H).
$[\alpha]^{25}_{D}$ = –86.5 (c = 0.54, in $CHCl_3$).




| | Retention Time | Area | %Area |
|---|---|---|---|
| 1 | 14.817 | 63414023 | 98.90 |
| 2 | 21.867 | 707126 | 1.10 |

**(3-(naphthalen-2-yl)oxiran-2-yl)(phenyl)methanone (3r)**

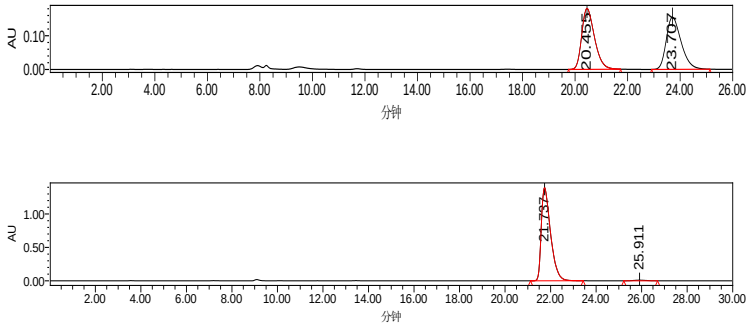


White solid in 99% yield after 36 hours, by silica gel chromatography (petroleum ether: EtOAc = 10:1). HPLC (Chiralcel AS-H, hexane/ *i*-PrOH= 95/5), flow rate 1.0 mL/min, λ=

254 nm, $t_r$(major)= 21.74 min, $t_r$(minor)= 25.91 min, 98% *ee*.

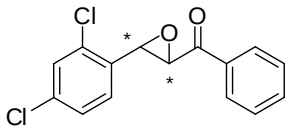
$^1$H NMR (600 MHz, $CDCl_3$) δ = 8.03 (d, *J* = 7.6, 2H), 7.88 (dt, *J* = 9.1, 6.1, 4H), 7.63 (t, *J* = 7.4, 1H), 7.55–7.47 (m, 4H), 7.43 (d, *J* = 8.7, 1H), 4.41 (d, *J* = 1.4, 1H), 4.25 (s, 1H).

$[\alpha]^{14}_D$ = +161.2 (c = 1.16, in $CH_2Cl_2$).




| | Retention Time | Area | %Area |
|---|---|---|---|
| 1 | 21.737 | 39343909 | 99.13 |
| 2 | 25.911 | 346058 | 0.87 |

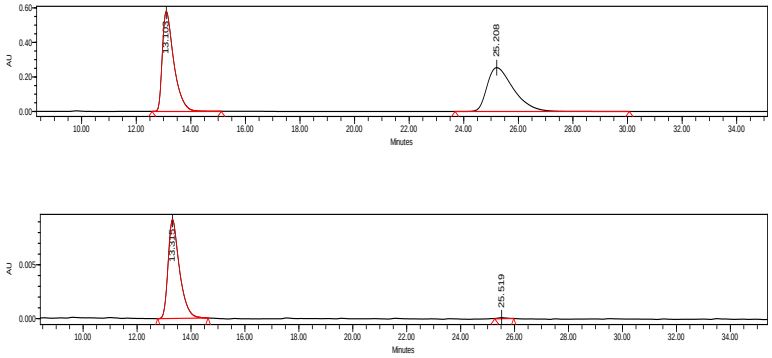
**(3-(2,4-dichlorophenyl)oxiran-2-yl)(phenyl)methanone (3s)**




White solid in 83% yield after 24 hours, by silica gel chromatography (petroleum ether: EtOAc = 20:1). HPLC (Chiralcel OD-H, hexane/ *i*-PrOH= 95/5), flow rate 1.0 mL/min, λ= 254 nm, $t_r$(major)= 13.32 min, $t_r$(minor)= 25.52 min, 98% *ee*.

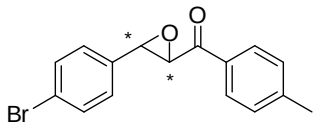
$^1$H NMR (400 MHz, $CDCl_3$) δ = 8.04 (d, *J* = 7.9, 2H), 7.65 (t, *J* = 7.4, 1H), 7.52 (t, *J* = 7.7, 2H), 7.43 (s, 1H), 7.33 (q, *J* = 8.4, 2H), 4.37 (s, 1H), 4.15 (s, 1H).

$[\alpha]^{14}_D$ = +31.1 (c = 4.70, in $CH_2Cl_2$).




| | Retention Time | Area | %Area |
|---|---|---|---|
| 1 | 13.315 | 269354 | 99.18 |
| 2 | 25.519 | 2222 | 0.82 |

**(3-(4-bromophenyl)oxiran-2-yl)(p-tolyl)methanone (3t)**



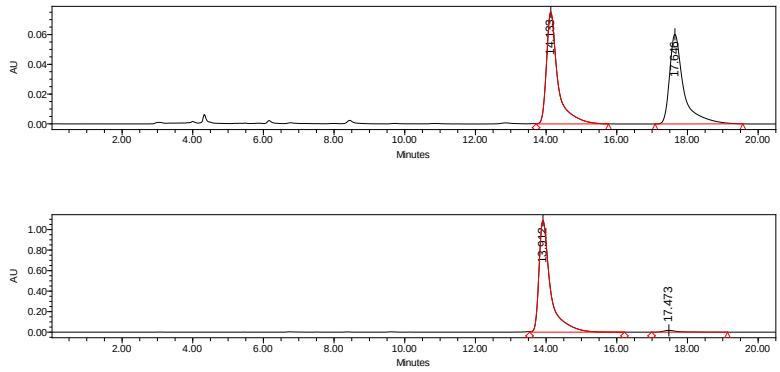

White solid in 88% yield after 42 hours, by silica gel chromatography (petroleum ether: EtOAc = 10:1). HPLC (Chiralcel IA, hexane/ *i*-PrOH= 90/10), flow rate 1.0 mL/min, λ= 254 nm, $t_r$(major)= 13.91 min, $t_r$(minor)= 17.47 min, 96% *ee*.

$^1$H NMR (400 MHz, $CDCl_3$) δ = 7.90 (d, *J* = 8.1, 2H), 7.53 (d, *J* = 8.3, 2H), 7.31 – 7.23 (m, 4H), 4.22 (s, 1H), 4.04 (s, 1H), 2.43 (s, 3H).

$^{13}$C NMR (101 MHz, $CDCl_3$) δ = 192.21, 145.24, 134.74, 132.96, 131.97, 129.63, 128.49, 127.42, 123.03, 60.81, 58.66, 21.81.

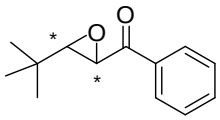
HRMS (ESI-TOF) calcd for $C_{16}H_{13}BrO_2$([M]+$Na^+$)= 338.9997, Found 339.0000.

$[\alpha]^{26}_D$ =+602.2 (c = 4.08, in $CHCl_3$).




| | Retention Time | Area | %Area |
|---|---|---|---|
| 1 | 13.912 | 24643824 | 98.08 |
| 2 | 17.473 | 482234 | 1.92 |

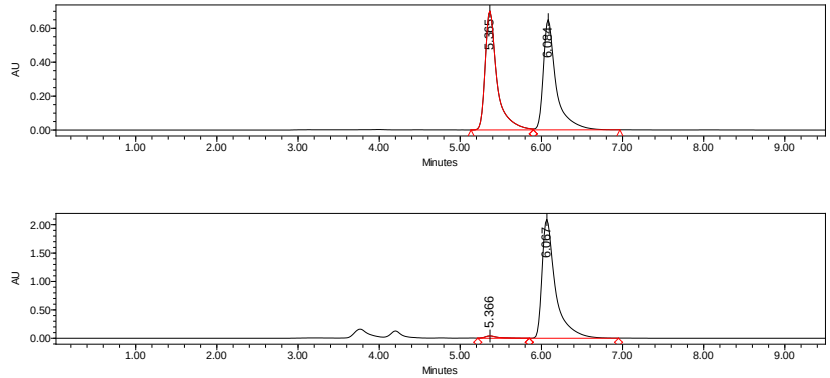
**(3-tert-butyloxiran-2-yl)(phenyl)methanone (3u)**



White solid in 99% yield after 24 hours, by silica gel chromatography (petroleum ether: EtOAc = 20:1). HPLC(Chiralcel IA, hexane/ *i*-PrOH= 90/10), flow rate 1.0 mL/min, λ= 254 nm, $t_r$(minor)= 5.37 min, $t_r$(major)= 6.07 min, 96% *ee*.

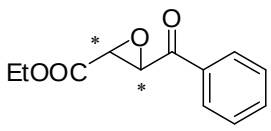
$^1$H NMR (600 MHz, $CDCl_3$) δ= 8.01 (d, *J* = 7.3, 2H), 7.62 (t, *J* = 7.4, 1H), 7.51 (t, *J* = 7.8, 2H), 4.12 (d, *J* = 2.1, 1H), 2.96 (d, *J* = 2.1, 1H), 1.04 (s, 9H).

$[\alpha]^{26}_D$ = –69.4 (c = 3.46, in $CHCl_3$).




| | Retention Time | Area | %Area |
|---|---|---|---|
| 1 | 5.366 | 455910 | 1.86 |
| 2 | 6.067 | 24100327 | 98.14 |

**ethyl 3-benzoyloxirane-2-carboxylate (3v)**

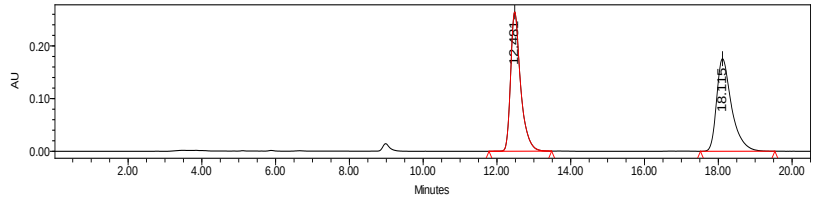


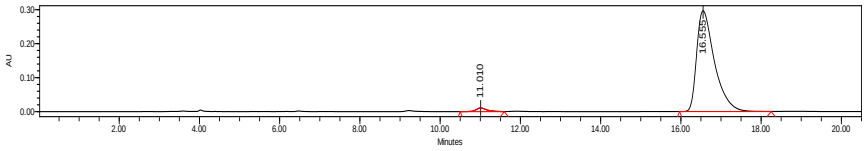

White solid in 82% yield after 48 hours, by silica gel chromatography

(petroleum ether: EtOAc = 5:1). HPLC (Chiralcel IC, hexane/ *i*-PrOH = 70/30), flow rate 1.0 mL/min, λ= 254 nm, $t_r$(minor)= 12.37 min, $t_r$(major)= 18.06 min, 96% *ee*.

$^1$H NMR (400 MHz, $CDCl_3$) δ = 8.03 (d, *J* = 7.7, 2H), 7.60 (dt, *J* = 53.9, 7.4, 3H), 4.48 (s, 1H), 4.31 (td, *J* = 11.4, 6.9, 2H), 3.70 (s, 1H), 1.35 (t, *J* = 7.1, 3H).

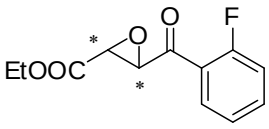
$[\alpha]^{17}_D$ = +82.7 (c = 7.22, in $CHCl_3$).




| | Retention Time | Area | %Area |
|---|---|---|---|
| 1 | 11.010 | 198837 | 2.13 |
| 2 | 16.555 | 9137686 | 97.87 |

**ethyl 3-(2-fluorobenzoyl)oxirane-2-carboxylate (3w)**



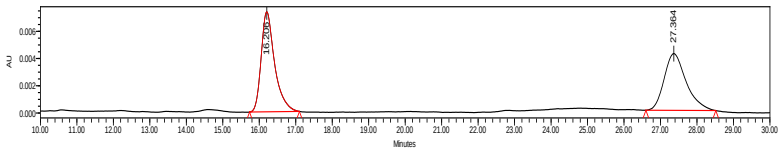

White solid in 87% yield after 60 hours, by silica gel chromatography (petroleum ether: EtOAc = 5:1). HPLC (Chiralcel IC, hexane/ *i*-PrOH= 70/30), flow rate 1.0 mL/min, λ= 254 nm, $t_r$(major)= 16.47 min, $t_r$(minor)= 27.88 min, 93% *ee*.

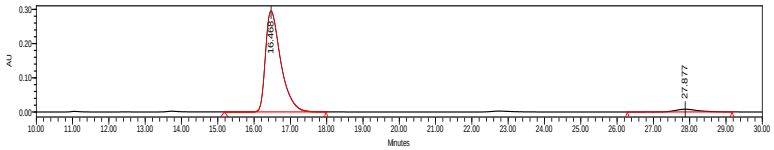
$^1$H NMR (400 MHz, $CDCl_3$) δ = 7.91 (t, *J* = 7.4, 1H), 7.64 (d, *J* = 6.3, 1H), 7.31 (t, *J* = 7.5, 1H), 7.25 – 7.13 (m, 1H), 4.49 – 4.42 (m, 1H), 4.32 (dd, *J* = 14.0, 6.9, 2H), 3.65 (s, 1H), 1.35 (t, *J* = 7.1, 3H).

$^{13}$C NMR (101 MHz, $CDCl_3$) δ = 190.56, 167.03, 136.24, 136.15, 130.77, 125.02, 123.62, 62.28, 57.85, 57.74, 53.38, 14.09.

HRMS (ESI-TOF) calcd for $C_{12}H_{11}FO_4$ ([M]+$Na^+$) = 261.0539, Found 261.0540.

$[\alpha]^{17}_D$ = +82.9 (c = 3.86, in $CHCl_3$).

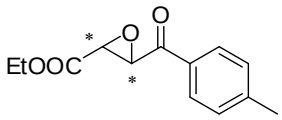



| | Retention Time | Area | %Area |
|---|---|---|---|
| 1 | 16.468 | 8596160 | 96.14 |

| | | | |
|---|---|---|---|
| 2 | 27.877 | 345172 | 3.86 |

**ethyl 3-(4-methylbenzoyl)oxirane-2-carboxylate (3x)**



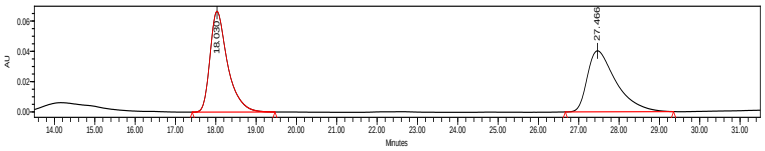

White solid in 91% yield after 60 hours, by silica gel chromatography (petroleum ether: EtOAc = 5:1). HPLC (Chiralcel IC, hexane/ *i*-PrOH= 70/30), flow rate 1.0 mL/min, λ = 254 nm, $t_r$(major)= 17.74 min, $t_r$(minor)= 27.36 min, 86% *ee*.

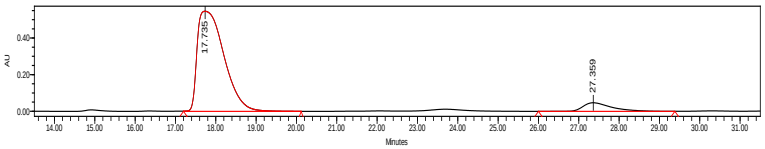
$^1$H NMR (400 MHz, $CDCl_3$) δ = 8.00 – 7.89 (m, 2H), 7.36 – 7.28 (m, 2H), 4.50 – 4.38 (m, 1H), 4.36 – 4.24 (m, 2H), 3.75 – 3.63 (m, 1H), 2.47 – 2.41 (m, 3H), 1.39 – 1.31 (m, 3H).

$^{13}$C NMR (101 MHz, $CDCl_3$) δ = 191.31, 167.34, 145.68, 132.61, 129.71, 128.70, 62.33, 55.10, 53.08, 21.87, 14.11.

HRMS (ESI-TOF) calcd for $C_{13}H_{14}O_4$ ([M]+$Na^+$) = 257.0790, Found 257.0801.

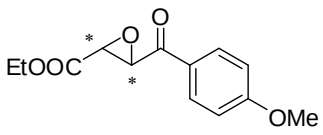
$[\alpha]^{17}_D$ = +81.0 (c = 4.58, in $CHCl_3$).




| | Retention Time | Area | %Area |
|---|---|---|---|
| 1 | 17.735 | 25162799 | 92.25 |
| 2 | 27.359 | 2137817 | 7.75 |

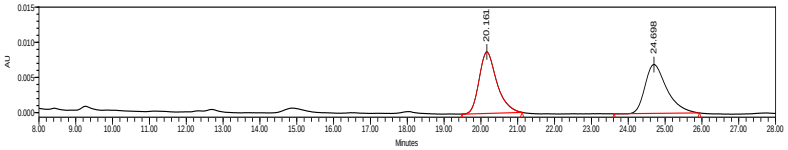
**ethyl 3-(4-methoxybenzoyl)oxirane-2-carboxylate (3y)**

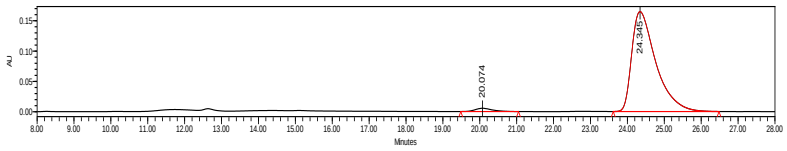



White solid in 88% yield after 60 hours, by silica gel chromatography (petroleum ether: EtOAc = 5:1). HPLC (Chiralcel IC, hexane/ *i*-PrOH= 70/30), flow rate 1.0 mL/min, λ= 254 nm, $t_r$(minor)= 20.07 min, $t_r$(major) = 24.35 min, 96% *ee*.

$^1$H NMR (400 MHz, $CDCl_3$) δ = 8.03 (d, *J* = 8.8, 2H), 6.99 (d, *J* = 8.8, 2H), 4.42 (s, 1H), 4.31 (td, *J* = 12.0, 7.0, 2H), 3.90 (s, 3H), 3.70 (s, 1H), 1.34 (t, *J* = 7.1, 3H).

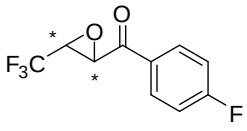
$[\alpha]^{17}_D$ = +77.5 (c = 4.14, in $CHCl_3$).






| | Retention Time | Area | %Area |
|---|---|---|---|
| 1 | 20.074 | 174490 | 2.29 |
| 2 | 24.345 | 7460230 | 97.71 |

**(4-fluorophenyl)(3-(trifluoromethyl)oxiran-2-yl)methanone (3z)**



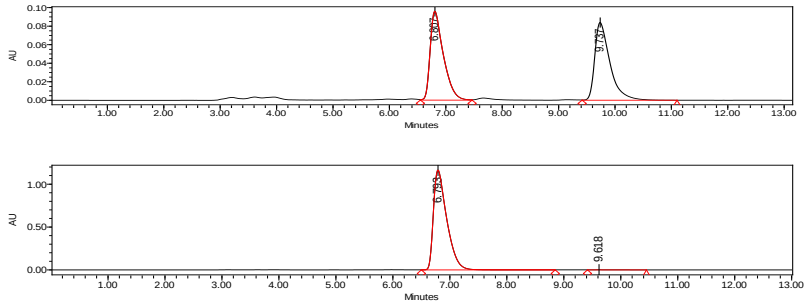
White solid in 99% yield after 30 hours, by silica gel chromatography (petroleum ether: EtOAc = 20:1). HPLC (Chiralcel AS-H, hexane/ *i*-PrOH= 90/10), flow rate 1.0 mL/min, λ= 254 nm, $t_r$(major)= 6.79 min, $t_r$(minor) = 9.62 min, 99% *ee*.

$^1$H NMR (400 MHz, $CDCl_3$) δ = 8.15–7.98 (m, 2H), 7.27–7.20 (m, 2H), 4.48–4.36 (m, 1H), 3.80–3.63 (m, 1H).

$^{13}$C NMR (101 MHz, $CDCl_3$) δ = 188.96, 167.97, 165.41, 131.47, 131.37, 120.32, 116.63, 116.41, 52.21, 52.19.

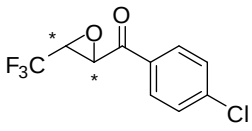
HRMS (ESI-TOF) calcd for $C_{10}H_6F_4O_2$([M]+$Na^+$) = 257.0202, Found 257.0208.

$[\alpha]^{20}_D$ = +134.7 (c = 3.34, in $CHCl_3$).




| | Retention Time | Area | %Area |
|---|---|---|---|
| 1 | 6.793 | 18834223 | 99.90 |
| 2 | 9.618 | 19368 | 0.10 |

**(4-chlorophenyl)(3-(trifluoromethyl)oxiran-2-yl)methanone (3aa)**



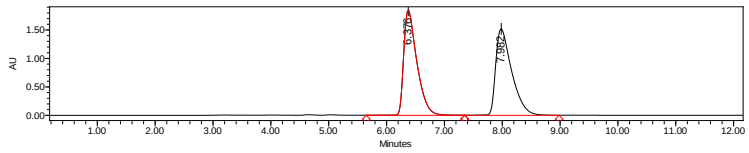
White solid in 91% yield after 30 hours, by silica gel chromatography (petroleum ether: EtOAc = 20:1). HPLC (Chiralcel AS-H, hexane/ *i*-PrOH= 90/10), flow rate 1.0 mL/min, λ= 254 nm, $t_r$(major)= 6.38 min, $t_r$(minor)= 8.01 min, 99% *ee*.

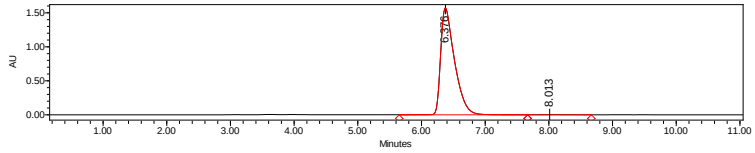
$^1$H NMR (400 MHz, $CDCl_3$) δ= 7.97 (d, *J* = 8.6, 2H), 7.52 (d, *J* = 8.6, 2H), 4.41 (s, 1H), 3.74 (qd, *J* = 4.6, 1.5, 1H).

$^{13}$C NMR (101 MHz, $CDCl_3$) δ= 189.45, 141.54, 132.98, 129.92, 129.57, 123.03, 120.29, 52.22, 52.20.

HRMS (ESI-TOF) calcd for $C_{10}H_6ClF_3O_2$ ([M]+$Na^+$)= 272.9906, Found 272.9903.

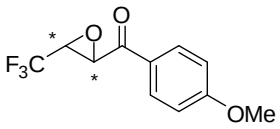
$[\alpha]^{20}_D$ = +83.8 (c = 3.82, in $CHCl_3$).




| | Retention Time | Area | %Area |
|---|---|---|---|
| 1 | 6.376 | 23672385 | 99.80 |
| 2 | 8.013 | 47230 | 0.20 |

**(4-methoxyphenyl)(3-(trifluoromethyl)oxiran-2-yl)methanone (3ab)**



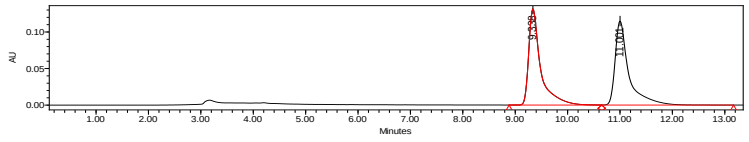
White solid in 99% yield after 30 hours, by silica gel chromatography (petroleum ether: EtOAc = 20:1). HPLC (Chiralcel IA, hexane/ *i*-PrOH= 95/5), flow rate 1.0 mL/min, λ= 254 nm, $t_r$(minor)= 9.33 min, $t_r$(major)= 10.95 min, 97% *ee*.

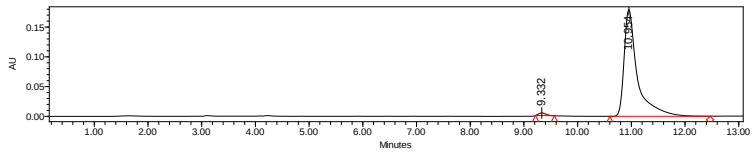
$^1$H NMR (400 MHz, $CDCl_3$) δ= 8.02 (d, *J* = 8.6, 2H), 7.01 (d, *J* = 8.6, 2H), 4.43 (s, 1H), 3.91 (s, 3H), 3.74 (m, 1H).

$^{13}$C NMR (101 MHz, $CDCl_3$) δ = 188.59, 164.85, 131.51, 131.03, 127.88, 123.23, 120.48, 114.40, 114.11, 55.68, 51.98.

HRMS (ESI-TOF) calcd for $C_{11}H_9F_3O_3$ ([M]+$Na^+$) =269.0401, Found 269.0407.

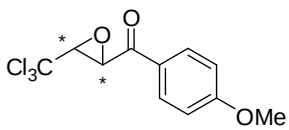
$[\alpha]^{20}_D$ = +117.0 (c = 3.43, in $CHCl_3$).




| | Retention Time | Area | %Area |
|---|---|---|---|
| 1 | 9.332 | 41602 | 1.34 |
| 2 | 10.954 | 3072308 | 98.66 |

**(4-methoxyphenyl)(3-(trichloromethyl)oxiran-2-yl)methanone (3ac)**



White solid in 99% yield after 30 hours, by silica gel chromatography (petroleum ether: EtOAc = 20:1). HPLC (Chiralcel IA, hexane/ *i*-PrOH= 95/5), flow rate 1.0 mL/min, λ= 254 nm, $t_r$(minor)= 13.45 min, $t_r$(major)=17.17 min, *ee*= 99%.

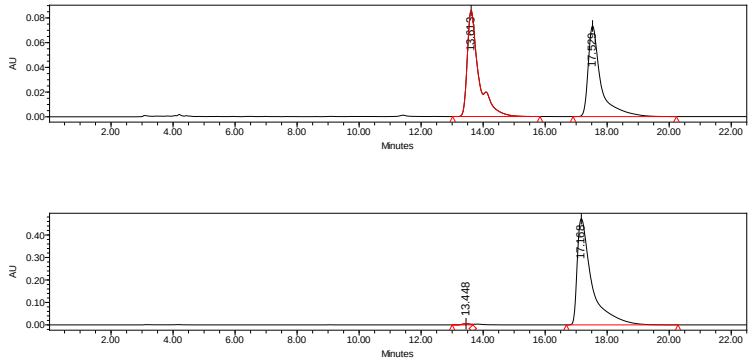
$^1$H NMR (600 MHz, $CDCl_3$) δ = 8.03 (d, *J* = 8.9, 2H), 7.01 (d, *J* = 8.8, 2H), 4.60 (d, *J* = 1.3, 1H),

4.04 (d, *J* = 1.3, 1H), 3.91 (s, 3H).

$^{13}$C NMR (151 MHz, $CDCl_3$) δ = 188.81, 164.74, 130.96, 127.92, 114.36, 95.04, 66.09, 56.39, 55.65, 29.69.

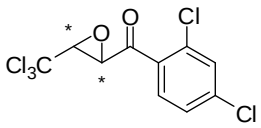
HRMS (ESI-TOF) calcd for $C_{11}H_9Cl_3O_3$ ([M]+$Na^+$) = 316.9515, Found 316.9512.

$[\alpha]^{20}_D$ = –26.3 (c = 3.84, in $CHCl_3$).




| | Retention Time | Area | %Area |
|---|---|---|---|
| 1 | 13.448 | 93861 | 0.60 |
| 2 | 17.168 | 15529452 | 99.40 |

**(2,4-dichlorophenyl)(3-(trichloromethyl)oxiran-2-yl)methanone (3ad)**



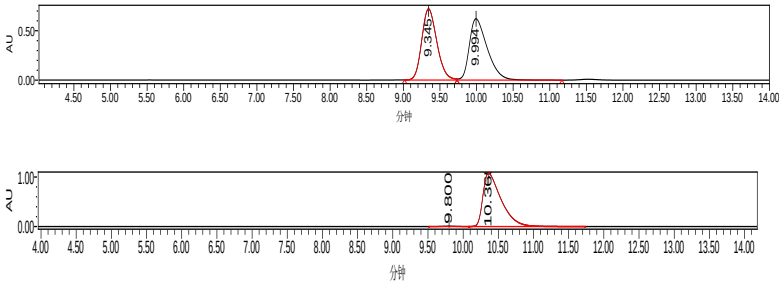
White solid in 99% yield after 30 hours, by silica gel chromatography (petroleum ether: EtOAc = 20:1). HPLC (Chiralcel OD-H, hexane/ *i*-PrOH= 95/5), flow rate 1.0 mL/min, λ= 254 nm, $t_r$(minor)= 9.80 min, $t_r$(major)=10.37 min, 99% *ee*.

$^1$H NMR (600 MHz, $CDCl_3$) δ = 8.12 (d, *J* = 1.9, 1H), 7.87 (dd, *J* = 8.4, 1.9, 1H), 7.64 (d, *J* = 8.4, 1H), 4.54 (d, *J* = 1.4, 1H), 4.05 (d, *J* = 1.4, 1H).

$^{13}$C NMR (151 MHz, $CDCl_3$) δ = 188.95, 139.57, 134.09, 131.29, 130.45, 127.44, 94.56, 66.09, 56.49.

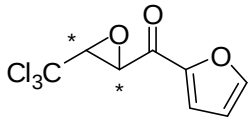
HRMS (ESI-TOF) calcd for $C_{10}H_5Cl_5O_2$ ([M]+$Na^+$) = 356.8600, Found 356.8588.

$[\alpha]^{20}_D$ = –70.1 (c = 2.85, in $CHCl_3$).




| | Retention Time | Area | %Area |
|---|---|---|---|
| 1 | 9.800 | 101136 | 0.52 |
| 2 | 10.365 | 19384418 | 99.48 |

**furan-2-yl(3-(trichloromethyl)oxiran-2-yl)methanone (3ae)**



White solid in 99% yield after 30 hours, by silica gel chromatography

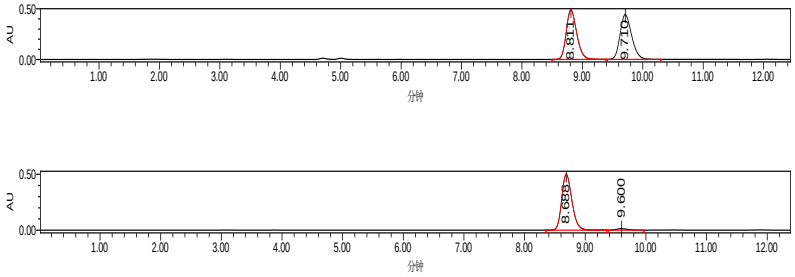
(petroleum ether: EtOAc = 20:1). HPLC (Chiralcel OD-H, hexane/ *i*-PrOH= 95/5), flow rate 1.0 mL/min, λ= 254 nm, $t_r$(major)= 8.69 min, $t_r$(minor)=9.60 min, 95% *ee*.

$^1$H NMR (400 MHz, $CDCl_3$) δ = 7.75 (s, 1H), 7.49 (d, *J* = 3.4, 1H), 6.66 (d, *J* = 1.7, 1H), 4.51 (s, 1H), 4.13 (s, 1H).

$^{13}$C NMR (101 MHz, $CDCl_3$) δ = 179.72, 148.53, 120.41, 113.22, 94.44, 66.00, 55.35, 41.55.

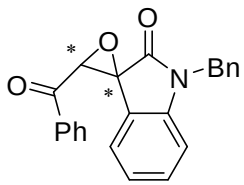
HRMS(ESI-TOF) calcd for $C_8H_5Cl_3O_3$ ([M]+$Na^+$) = 276.9202, Found 276.9208.

$[\alpha]^{20}_D$ =+33.3 (c = 2.73, in $CHCl_3$).




| | Retention Time | Area | %Area |
|---|---|---|---|
| 1 | 8.688 | 5853738 | 97.38 |
| 2 | 9.600 | 157650 | 2.62 |

**3'-benzoyl-1-benzylspiro[indoline-3,2'-oxiran]-2-one (3af)**



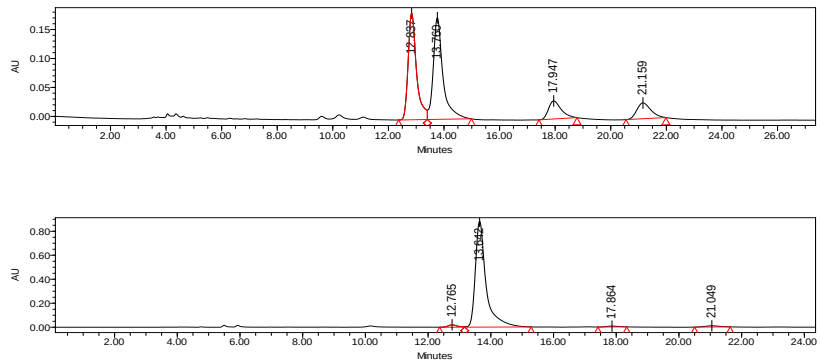

Yellow solid in 94% yield after 74 hours, by silica gel chromatography (petroleum ether: EtOAc = 4:1). HPLC (Chiralcel IA, hexane/ *i*-PrOH= 90/10), flow rate 1.0 mL/min, λ = 254 nm, $t_r$(minor)= 12.77 min, $t_r$(major)=13.64 min, 96% *ee*.

$^1$H NMR (600 MHz, $CDCl_3$) δ = 7.94 (d, *J* = 7.9, 2H), 7.60 (s, 1H), 7.46 (t, *J* = 7.7, 2H), 7.34 (s, 4H), 7.30 (d, *J* = 5.4, 1H), 7.21 (d, *J* = 7.8, 1H), 7.12 (d, *J* = 7.6, 1H), 6.92 (d, *J* = 7.6, 1H), 6.79 (d, *J* = 7.9, 1H), 5.05 (s, 1H), 5.01 (s, 2H).

$^{13}$C NMR (151 MHz, $CDCl_3$) δ = 207.09, 190.67, 170.39, 144.49, 135.06, 135.03, 134.51, 130.99, 129.03, 128.96, 128.82, 128.34, 127.98, 127.41, 127.32, 124.42, 123.28, 119.23, 110.03, 63.98, 60.94, 50.78, 44.47, 30.92.

HRMS (ESI-TOF) calcd for $C_{23}H_{17}NO_3$ ([M]+$Na^+$) = 379.1186, Found 379.1095.

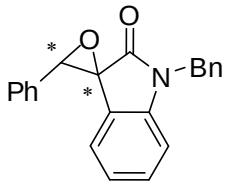
$[\alpha]^{26}_D$ = +422.4 (c = 5.80, in $CHCl_3$).




| | Retention Time | Area | %Area |
|---|---|---|---|
| 1 | 12.765 | 397426 | 2.16 |

| | | | |
|---|---|---|---|
| 2 | 13.642 | 20932692 | 96.04 |
| 3 | 17.864 | 0.83 | 0.75 |
| 4 | 21.049 | 1.44 | 1.06 |

**1-benzyl-3'-phenylspiro[indoline-3,2'-oxiran]-2-one (3ag)**



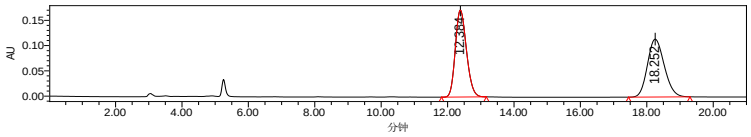
White solid in 95% yield after 36 hours, by silica gel chromatography (petroleum ether: EtOAc = 10:1). HPLC (Chiralcel IA, hexane/ *i*-PrOH = 90/10), flow rate 1.0 mL/min, λ= 254 nm, $t_r$(minor) =12.31 min, $t_r$(major)=17.97 min, 99% *ee*.

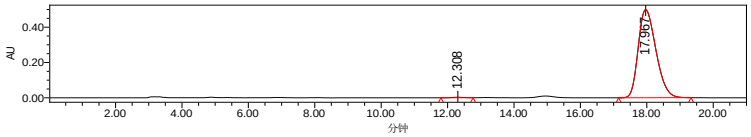
$^1$H NMR (600 MHz, $CDCl_3$) δ = 7.47 (d, *J* = 7.3, 2H), 7.41 (t, *J* = 7.3, 2H), 7.37 (d, *J* = 7.2, 1H), 7.36 – 7.32 (m, 4H), 7.30 – 7.26 (m, 1H), 7.14 (t, *J* = 7.8, 1H), 6.76 (d, *J* = 7.9, 1H), 6.72 (t, *J* = 7.6, 1H), 6.46 (d, *J* = 7.5, 1H), 4.98 (q, *J* = 15.6, 2H), 4.89 (s, 1H).

$^{13}$C NMR (151 MHz, $CDCl_3$) δ = 171.89, 144.44, 135.34, 133.15, 130.10, 128.90, 128.73, 128.48, 127.86, 127.45, 126.79, 123.75, 122.52, 120.96, 109.68, 65.25, 61.56, 44.36

HRMS (ESI-TOF) calcd for $C_{22}H_{16}NO_2$ ([M]+$Na^+$) =350.1112, Found 350.1154.

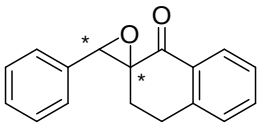
$[\alpha]^{19}_D$ = +205.33 (c = 2.44, in $CHCl_3$).




| | Retention Time | Area | %Area |
|---|---|---|---|
| 1 | 12.308 | 69274 | 0.37 |
| 2 | 17.967 | 18443233 | 99.63 |

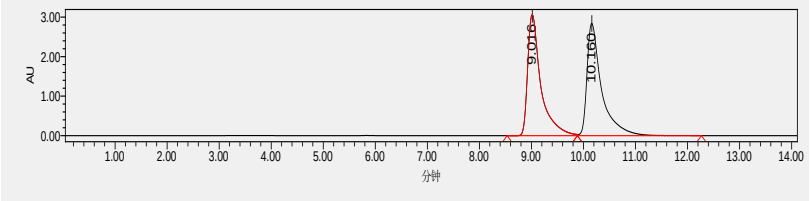
**3'-phenyl-3,4-dihydro-1H-spiro[naphthalene-2,2'-oxiran]-1-one (3ah)**

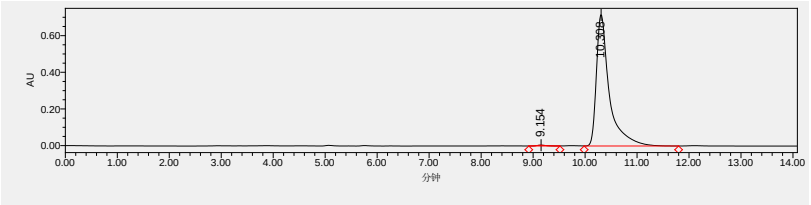


White solid in 82% yield after 30 hours, by silica gel chromatography (petroleum ether: EtOAc = 10:1). HPLC (Chiralcel IA, hexane/ *i*-PrOH= 90/10), flow rate 1.0 mL/min, λ= 254 nm, $t_r$(minor)= 9.15 min, $t_r$(major)=10.31 min, 99% *ee*.

$^1$H NMR (400 MHz, $CDCl_3$) δ = 8.12 (d, *J* = 7.8, 1H), 7.52 (t, *J* = 7.2, 1H), 7.48 – 7.28 (m, 6H), 7.22 (d, *J* = 7.6, 1H), 4.36 (s, 1H), 2.83 (dd, *J* = 8.3, 4.0, 2H), 2.45 (dt, *J* = 13.5, 8.6, 1H), 1.85 (dt, *J* = 13.5, 4.1, 1H).

$[\alpha]^{28}_D$ = +186.7 (c = 3.54, in $CHCl_3$).






| | Retention Time | Area | %Area |
|---|---|---|---|
| 1 | 9.154 | 63143 | 0.51 |
| 2 | 10.308 | 12400776 | 99.49 |

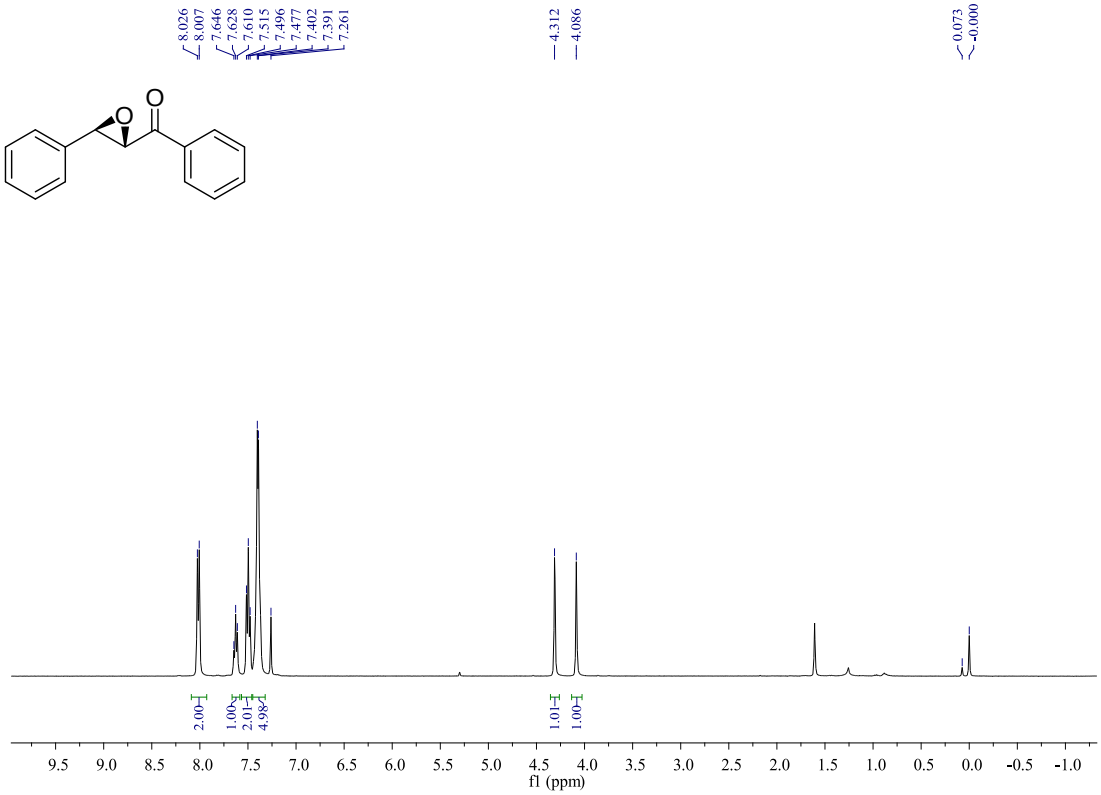
## 7. References

1 Wen, Y. H., Huang, X., Huang, J. L., Xiong, Y., Qin, B. & Feng, X. M. Asymmetric cyanosilylation of aldehydes catalyzed by novel organocatalysts. *Synlett.* 2005, 2445.

2 (a) B. Marsman, H. Wynberg, J. Org. Chem. 1979, **44**, 2312; (b) E. J. Corey, F. Y. Zhang, *Org. Lett.* 1999, **1**, 1287; (c) C. Palumbo, G. Mazzeo, A. Mazziotta, A. Gambacorta, M. A. Loreto, A. Migliorini, S. Superchi, D. Tofani, T. Gasperi, *Org. Lett*. 2011, **13**, 6248.

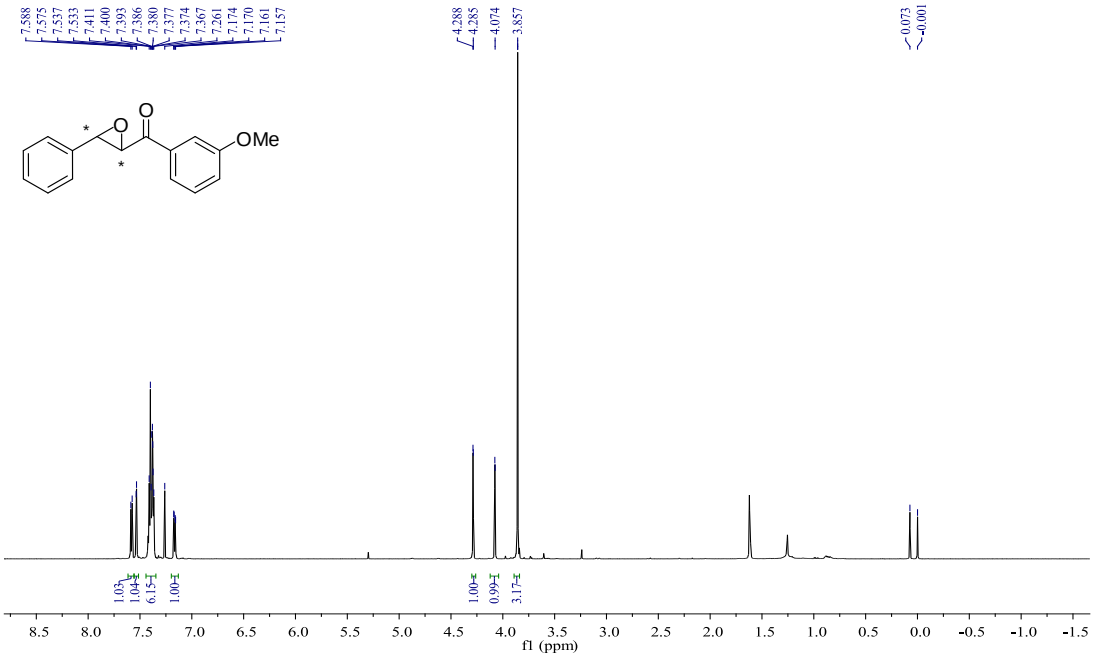
## 8. Copy of $^{1}$H NMR and $^{13}$C NMR spectra for products

**phenyl(3-phenyloxiran-2-yl)methanone(3a)**



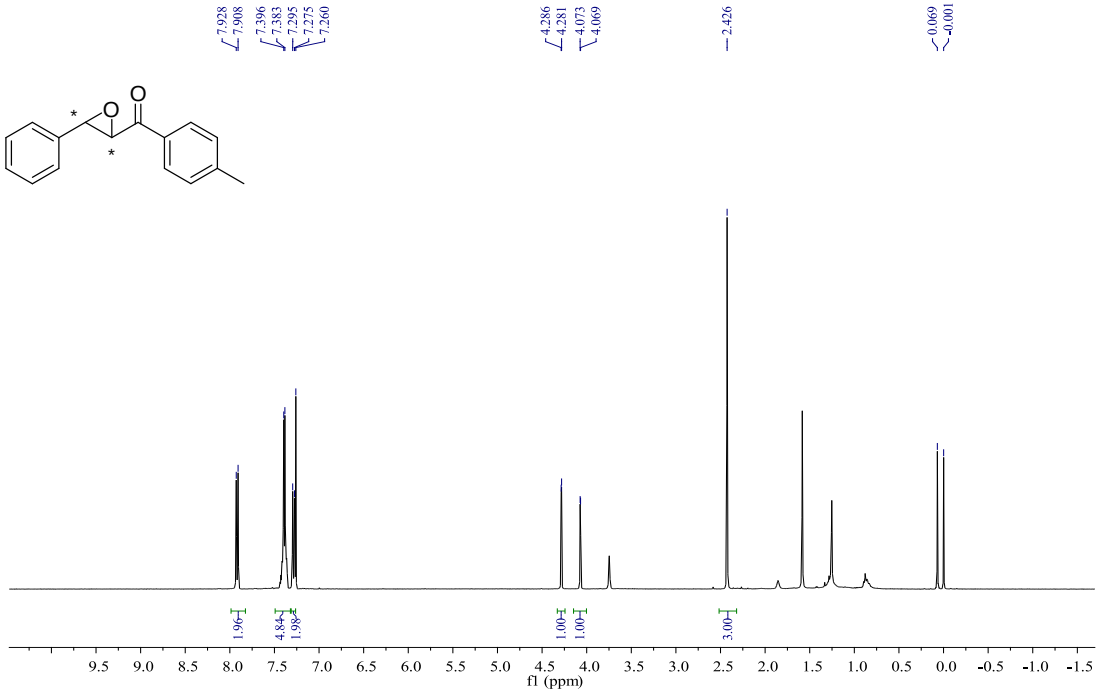

$^{1}$H NMR (400 MHz, $CDCl_3$) δ = 8.02 (d, *J* = 7.7, 2H), 7.63 (t, *J* = 7.2, 1H), 7.50 (t, *J* = 7.6, 2H), 7.40 (d, *J* = 4.5, 5H), 4.31 (s, 1H), 4.09 (s, 1H).

**(3-methoxyphenyl)(3-phenyloxiran-2-yl)methanone(3b)**



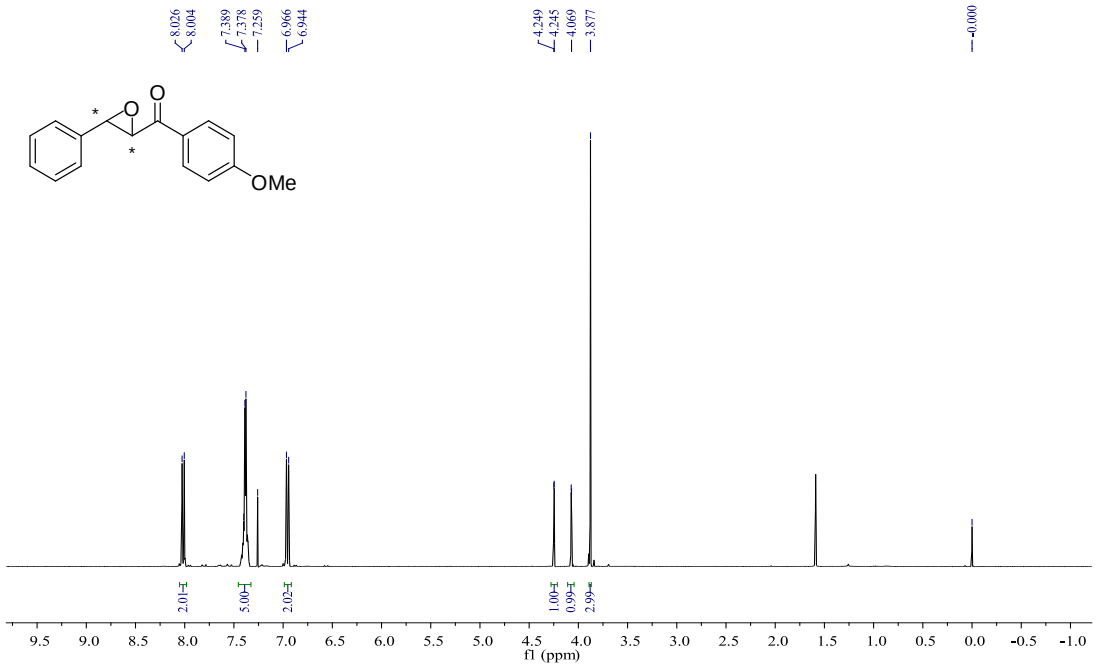

$^1$H NMR (600 MHz, $CDCl_3$) δ = 7.58 (d, *J* = 7.7, 1H), 7.53 (d, *J* = 2.1, 1H), 7.39 (ddd, *J* = 8.5, 7.9, 5.6, 6H), 7.17 (dd, *J* = 8.2, 2.5, 1H), 4.29 (d, *J* = 1.8, 1H), 4.08 (d, *J* = 1.7, 1H), 3.86 (s, 3H).

**(3-phenyloxiran-2-yl)(p-tolyl)methanone (3c)**



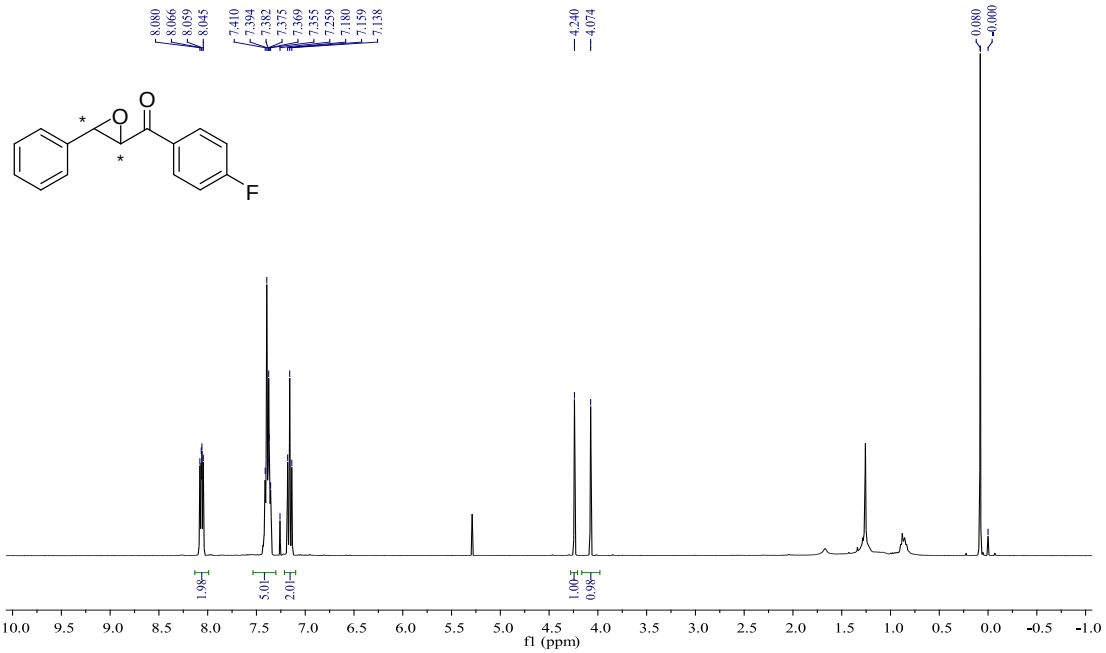

$^1$H NMR (400 MHz, $CDCl_3$) δ = 7.92 (d, *J* = 8.2, 2H), 7.39 (m, *J* = 5.0, 5H), 7.34 – 7.23 (d, 2H), 4.28 (d, *J* = 1.9, 1H), 4.07 (d, *J* = 1.8, 1H), 2.43 (s, 3H).

**(4-methoxyphenyl)(3-phenyloxiran-2-yl)methanone (3d)**



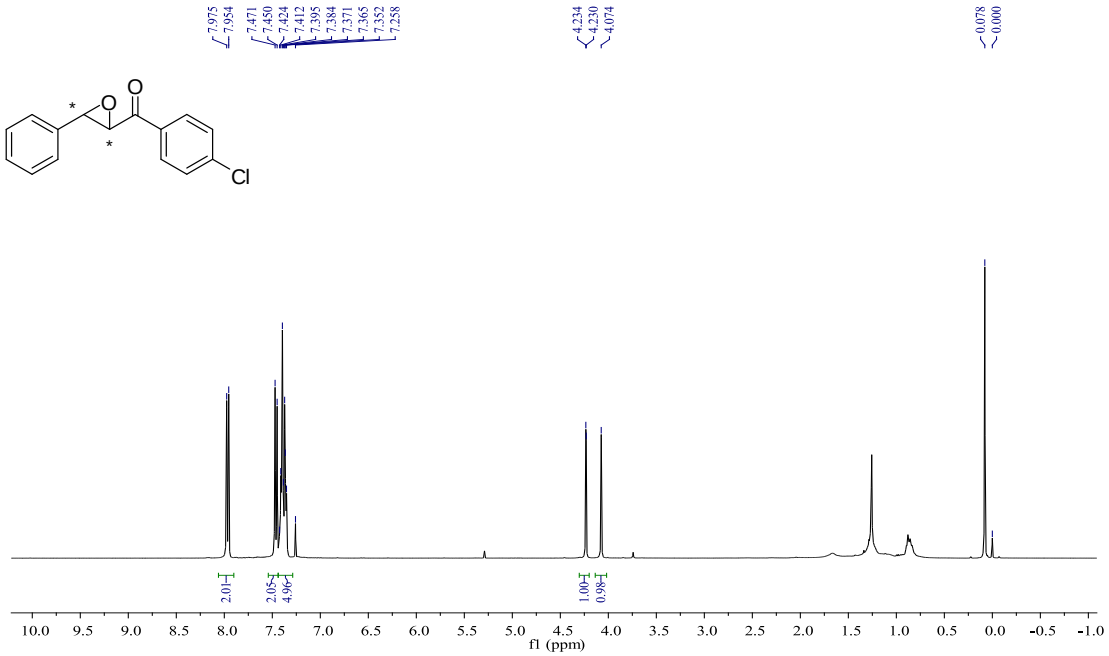

$^1$H NMR (400 MHz, $CDCl_3$) δ = 8.02 (d, *J* = 8.8, 2H), 7.46 – 7.34 (m, 5H), 6.95 (d, *J* = 8.8, 2H), 4.25 (d, *J* = 1.6, 1H), 4.07 (d, *J* = 1.3, 1H), 3.88 (s, 3H).

**(4-fluorophenyl)(3-phenyloxiran-2-yl)methanone (3e)**



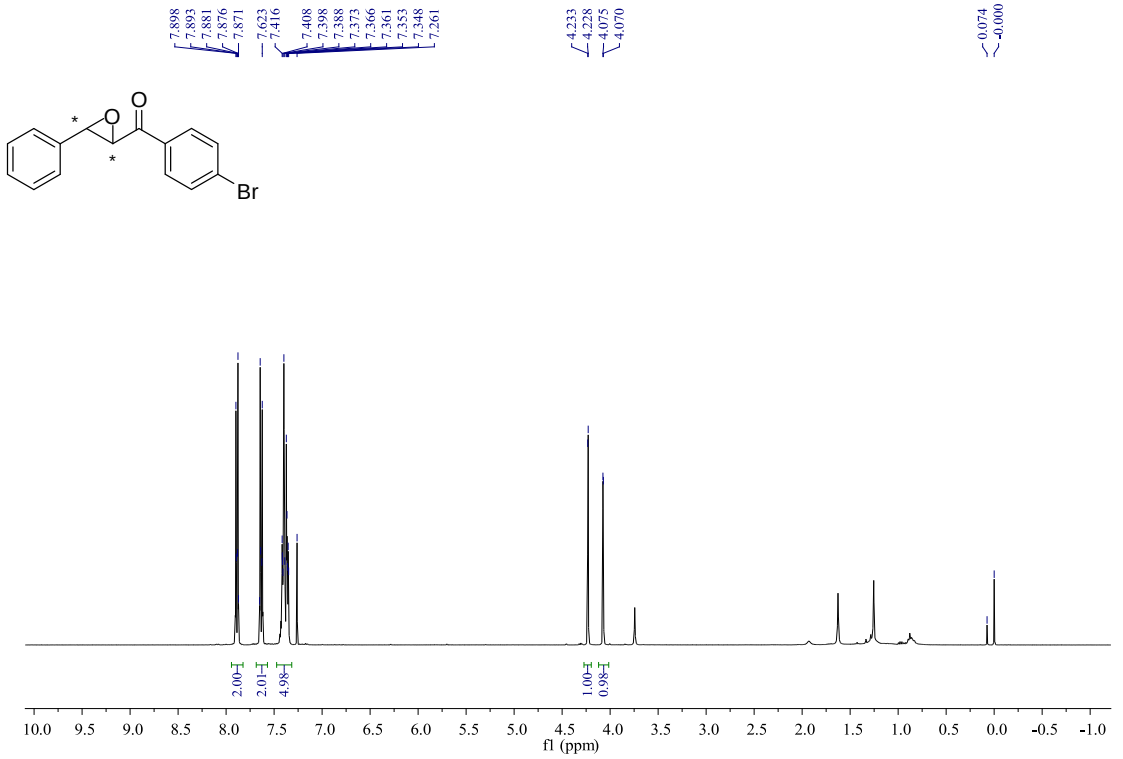

$^1$H NMR (400 MHz, $CDCl_3$) δ = 8.06 (dd, *J* = 8.4, 5.6, 2H), 7.38 (dt, *J* = 7.9, 6.0, 5H), 7.16 (t, *J* = 8.5, 2H), 4.24 (s, 1H), 4.07 (s, 1H).

**(4-chlorophenyl)(3-phenyloxiran-2-yl)methanone (3f)**



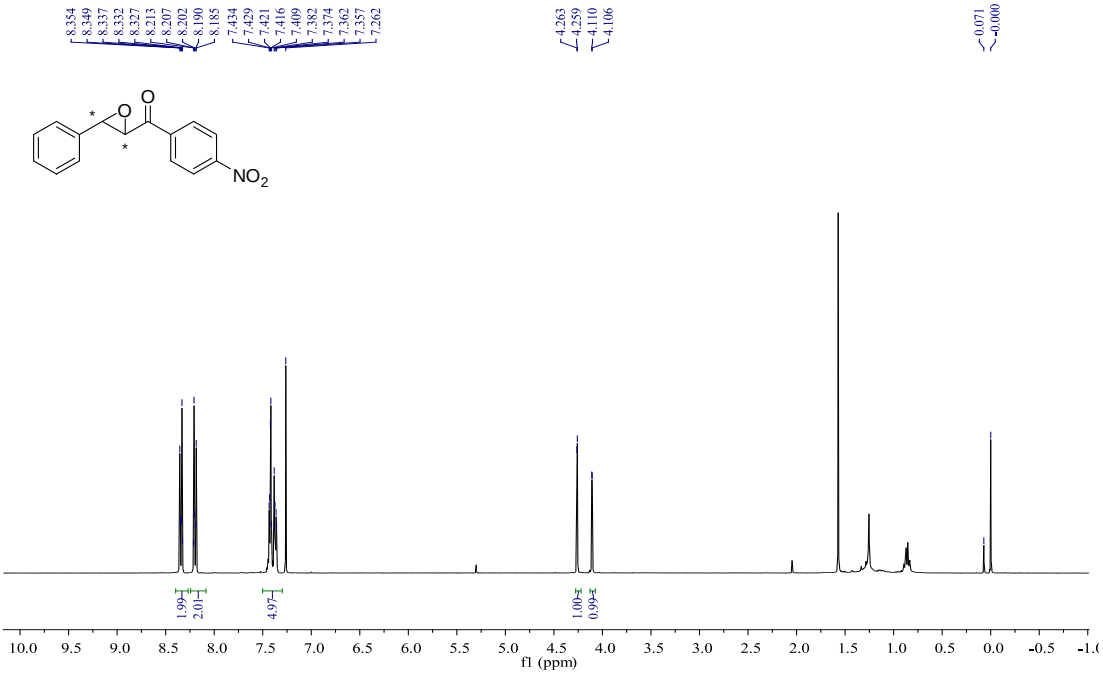

$^1$H NMR (400 MHz, $CDCl_3$) δ = 7.96 (d, *J* = 8.5, 2H), 7.46 (d, *J* = 8.5, 2H), 7.43 – 7.29 (m, 5H), 4.23 (d, *J* = 1.5, 1H), 4.07 (s, 1H).

**(4-bromophenyl)(3-phenyloxiran-2-yl)methanone (3g)**



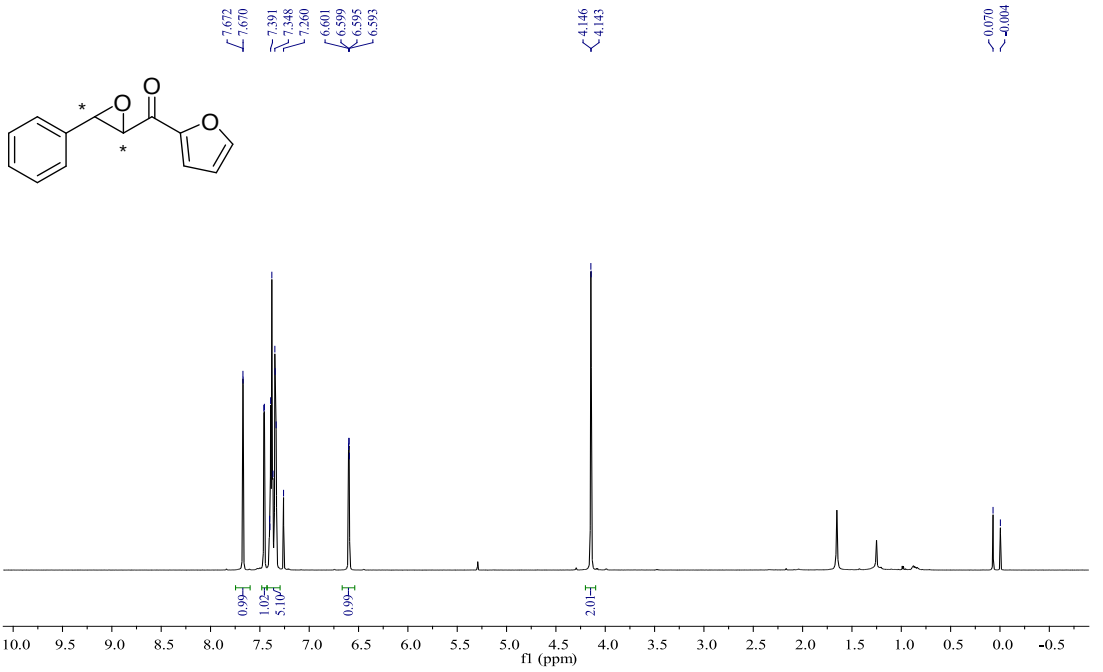

$^1$H NMR (400 MHz, $CDCl_3$) δ = 7.92 – 7.82 (m, 2H), 7.68 – 7.55 (m, 2H), 7.45 – 7.30 (m, 5H), 4.23 (d, *J* = 1.9, 1H), 4.07 (d, *J* = 1.8, 1H).

**(4-nitrophenyl)(3-phenyloxiran-2-yl)methanone (3h)**



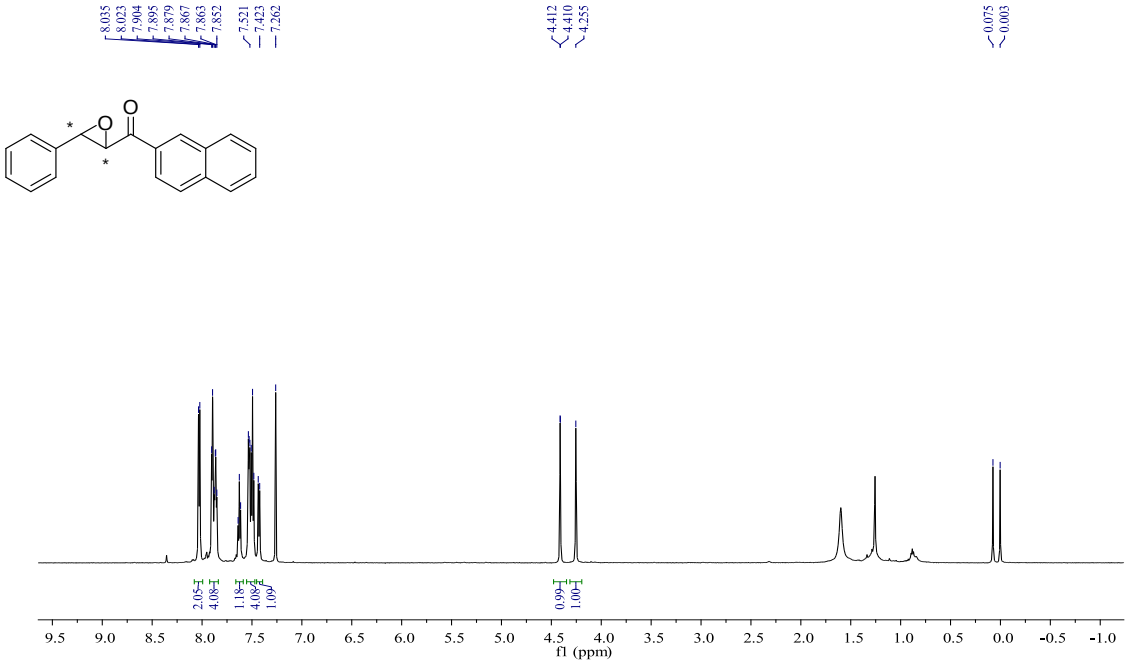

$^1$H NMR (400 MHz, $CDCl_3$) δ = 8.40 – 8.31 (m, 2H), 8.24 – 8.12 (m, 2H), 7.48 – 7.32 (m, 5H), 4.26 (d, *J* = 1.8, 1H), 4.11 (d, *J* = 1.8, 1H).

**furan-2-yl(3-phenyloxiran-2-yl)methanone (3i)**



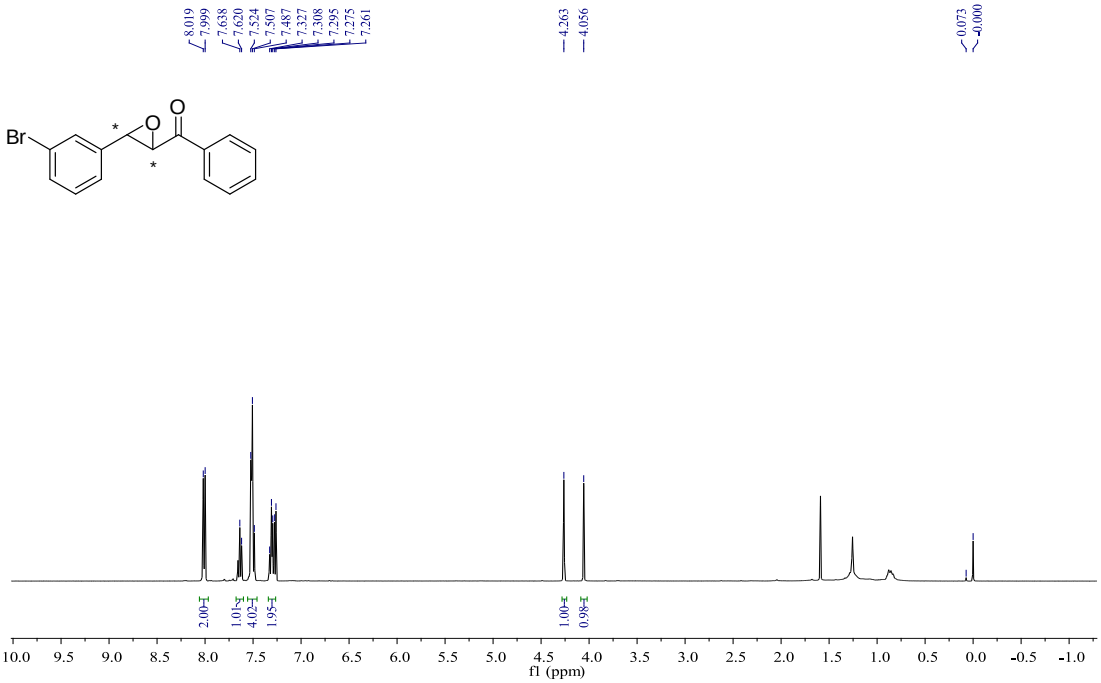

$^1$H NMR (600 MHz, $CDCl_3$) δ = 7.67 (d, *J* = 0.9, 1H), 7.46 (d, *J* = 3.6, 1H), 7.37 (ddd, *J* = 19.0, 6.9, 3.9, 5H), 6.60 (dd, *J* = 3.6, 1.6, 1H), 4.14 (d, *J* = 1.7, 2H).

**naphthalen-2-yl(3-phenyloxiran-2-yl)methanone (3j)**



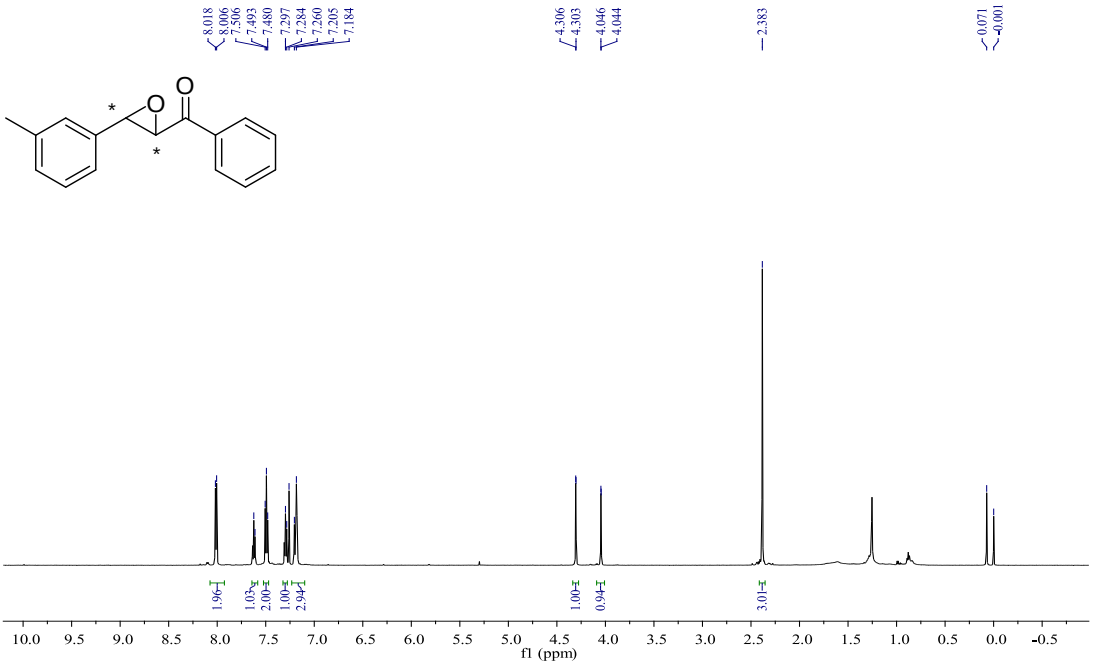

$^1$H NMR (600 MHz, $CDCl_3$) δ = 8.03 (d, *J* = 7.6, 2H), 7.88 (dt, *J* = 9.1, 6.1, 4H), 7.63 (t, *J* = 7.4, 1H), 7.55 – 7.47 (m, 4H), 7.43 (d, *J* = 8.7, 1H), 4.41 (d, *J* = 1.4, 1H), 4.25 (s, 1H).

**(3-(3-bromophenyl)oxiran-2-yl)(phenyl)methanone (3k)**



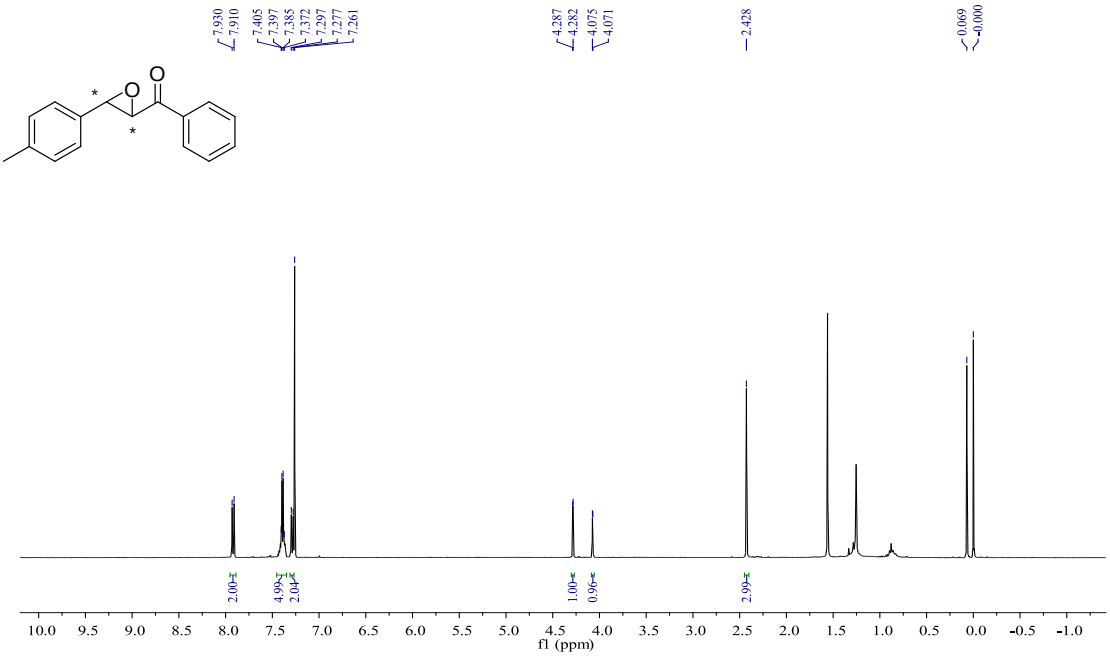

$^1$H NMR (400 MHz, $CDCl_3$) δ = 8.01 (d, *J* = 7.8, 2H), 7.63 (d, *J* = 7.3, 1H), 7.51 (t, *J* = 7.5, 4H), 7.36 – 7.22 (m, 2H), 4.26 (s, 1H), 4.06 (s, 1H).

**phenyl(3-m-tolyloxiran-2-yl)methanone (3l)**



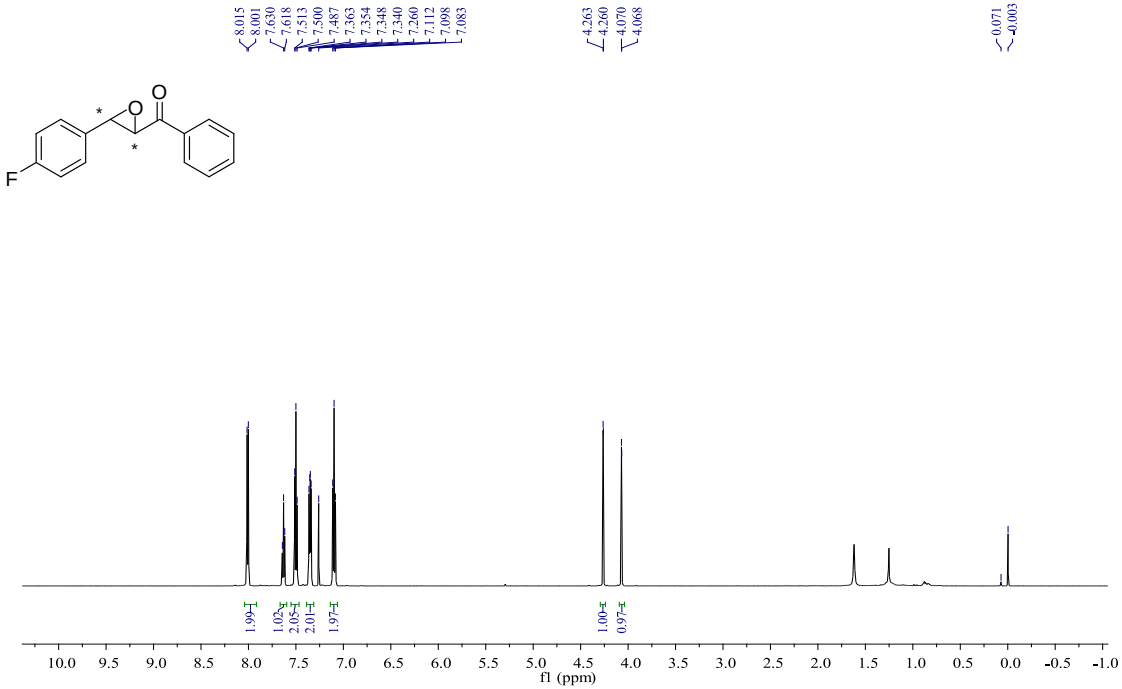

$^1$H NMR (600 MHz, $CDCl_3$) δ = 8.01 (d, *J* = 7.4, 2H), 7.62 (d, *J* = 7.4, 1H), 7.49 (t, *J* = 7.8, 2H), 7.29 (d, *J* = 7.8, 1H), 7.19 (d, *J* = 12.3, 3H), 4.30 (d, *J* = 1.8, 1H), 4.05 (d, *J* = 1.6, 1H), 2.38 (s, 3H).

**phenyl(3-p-tolyloxiran-2-yl)methanone (3m)**



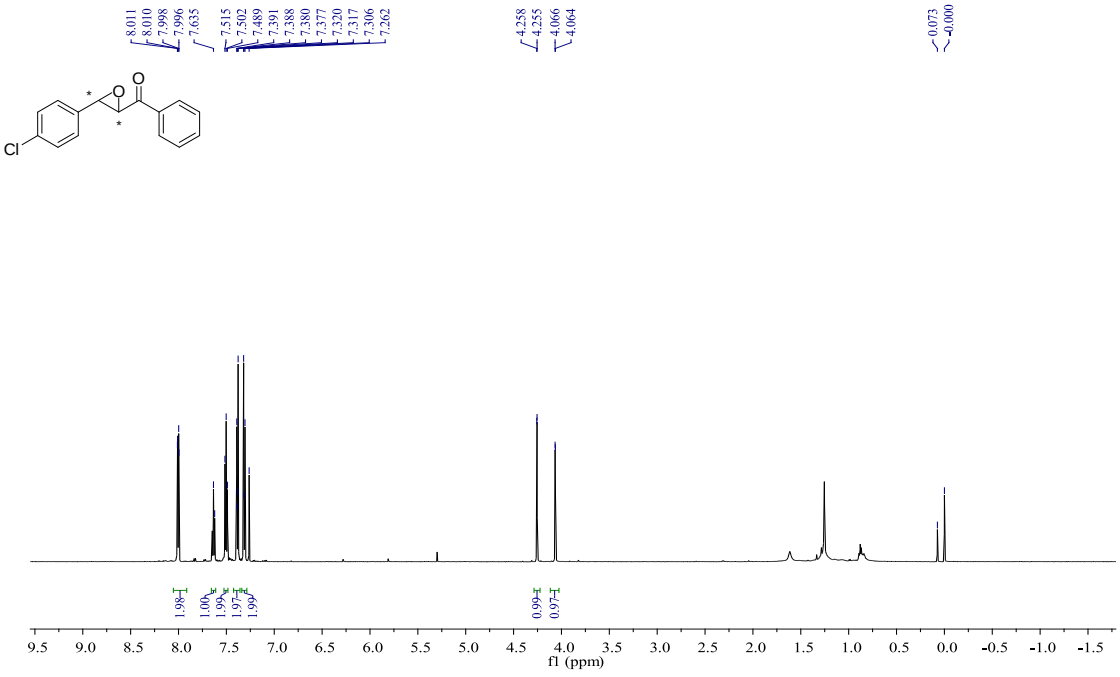

$^1$H NMR (400 MHz, $CDCl_3$) δ = 7.92 (d, *J* = 8.2, 2H), 7.47 – 7.32 (m, 5H), 7.32 – 7.26 (d, 2H), 4.28 (d, *J* = 1.9, 1H), 4.07 (d, *J* = 1.8, 1H), 2.43 (s, 3H).

**(3-(4-fluorophenyl)oxiran-2-yl)(phenyl)methanone (3n)**



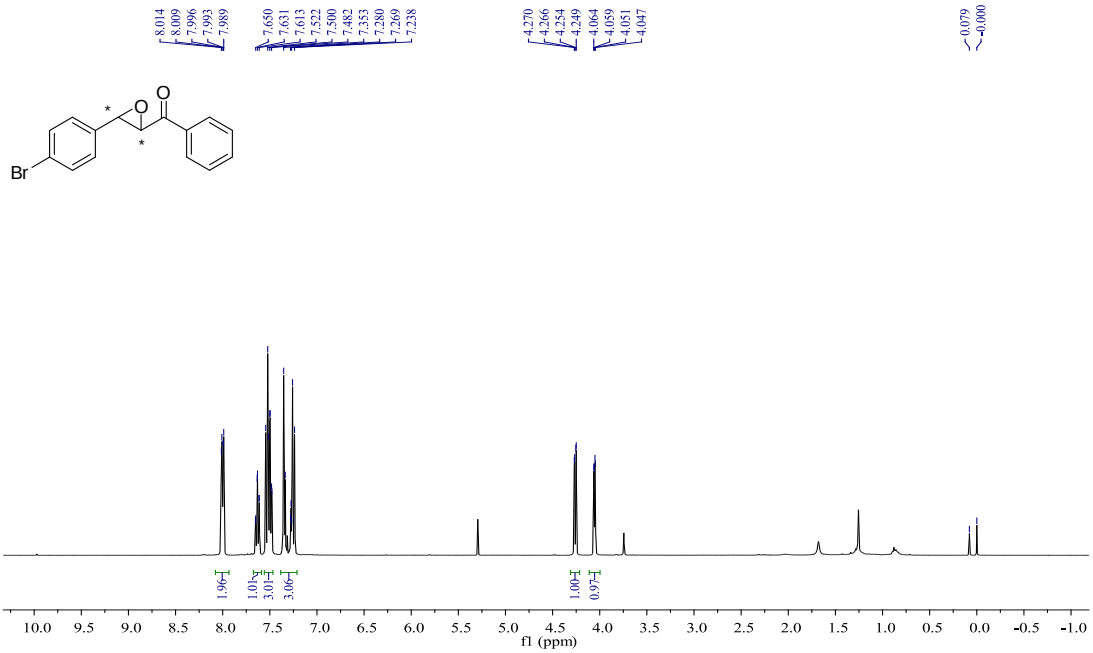

$^1$H NMR (600 MHz, $CDCl_3$) δ = 8.01 (d, *J* = 7.9, 2H), 7.63 (t, *J* = 7.4, 1H), 7.50 (t, *J* = 7.8, 2H), 7.35 (dd, *J* = 8.6, 5.3, 2H), 7.10 (t, *J* = 8.6, 2H), 4.26 (d, *J* = 1.7, 1H), 4.07 (d, *J* = 1.3, 1H).

**(3-(4-chlorophenyl)oxiran-2-yl)(phenyl)methanone (3o)**



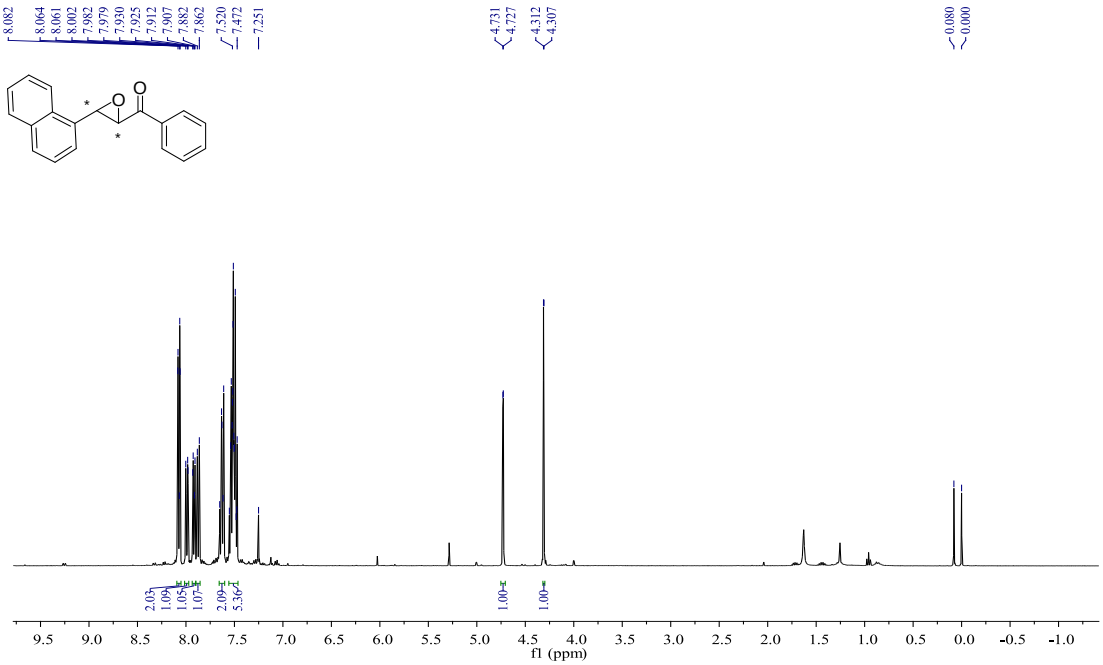

$^1$H NMR (600 MHz, $CDCl_3$) δ = 8.00 (dd, *J* = 8.2, 1.0, 2H), 7.63 (d, *J* = 7.5, 1H), 7.50 (t, *J* = 7.8, 2H), 7.42 – 7.36 (m, 2H), 7.34 – 7.29 (m, 2H), 4.26 (d, *J* = 1.8, 1H), 4.06 (d, *J* = 1.7, 1H).

**(3-(4-bromophenyl)oxiran-2-yl)(phenyl)methanone (3p)**



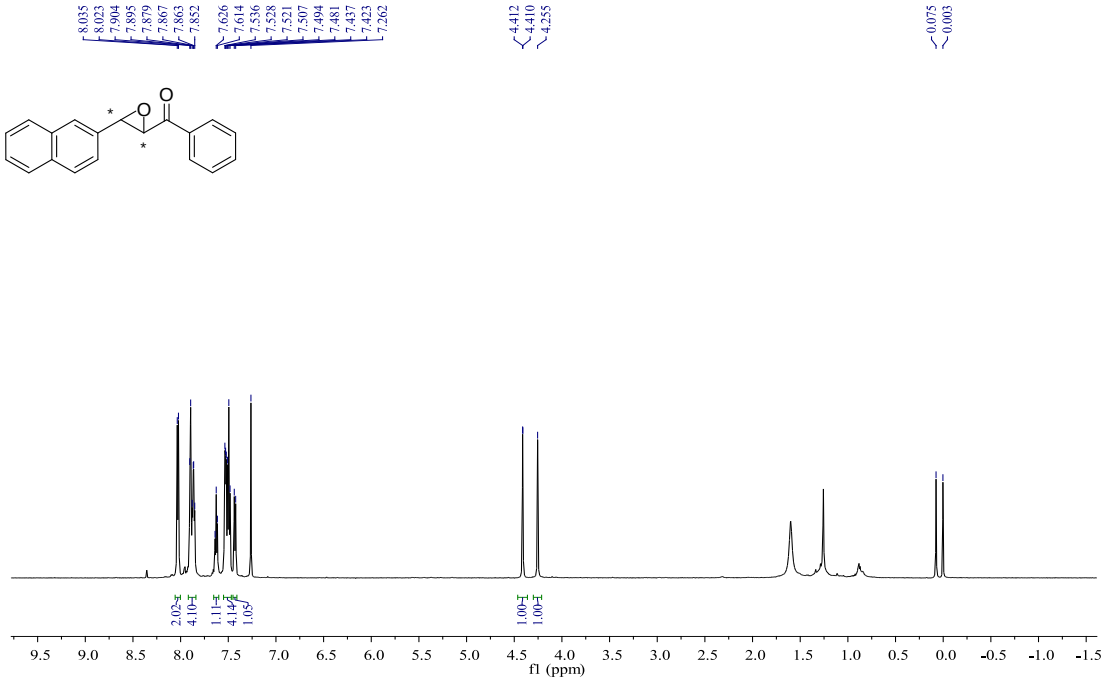

$^1$H NMR (400 MHz, $CDCl_3$) δ = 8.08 – 7.93 (m, 2H), 7.63 (td, *J* = 7.3, 1.1, 1H), 7.56 – 7.47 (m, 3H), 7.39 – 7.21 (m, 3H), 4.26 (dd, *J* = 6.5, 1.8, 1H), 4.06 (dd, *J* = 5.0, 1.6, 1H).

**(3-(naphthalen-1-yl)oxiran-2-yl)(phenyl)methanone (3q)**



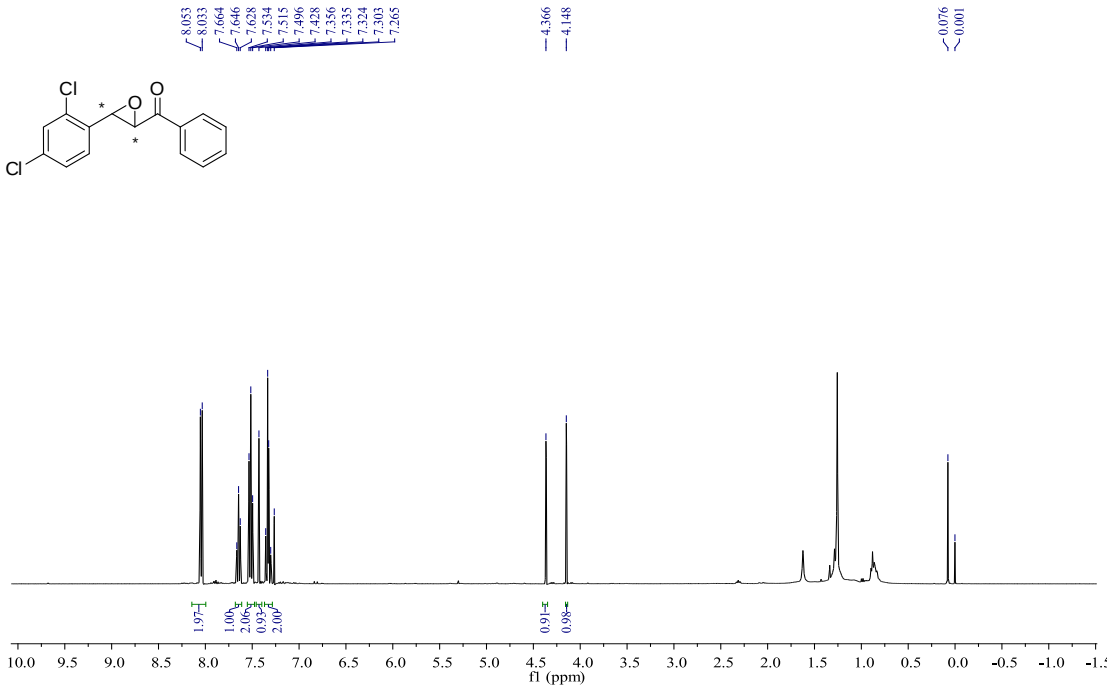

$^1$H NMR (400 MHz, $CDCl_3$) δ = 8.10 – 8.04 (m, 2H), 8.01 – 7.97 (m, 1H), 7.92 (dd, *J* = 7.2, 2.1, 1H), 7.87 (d, *J* = 8.2, 1H), 7.66 – 7.60 (m, 2H), 7.55 – 7.46 (m, 5H), 4.73 (d, *J* = 1.8, 1H), 4.31 (d, *J* = 2.0, 1H).

**(3-(naphthalen-2-yl)oxiran-2-yl)(phenyl)methanone (3r)**



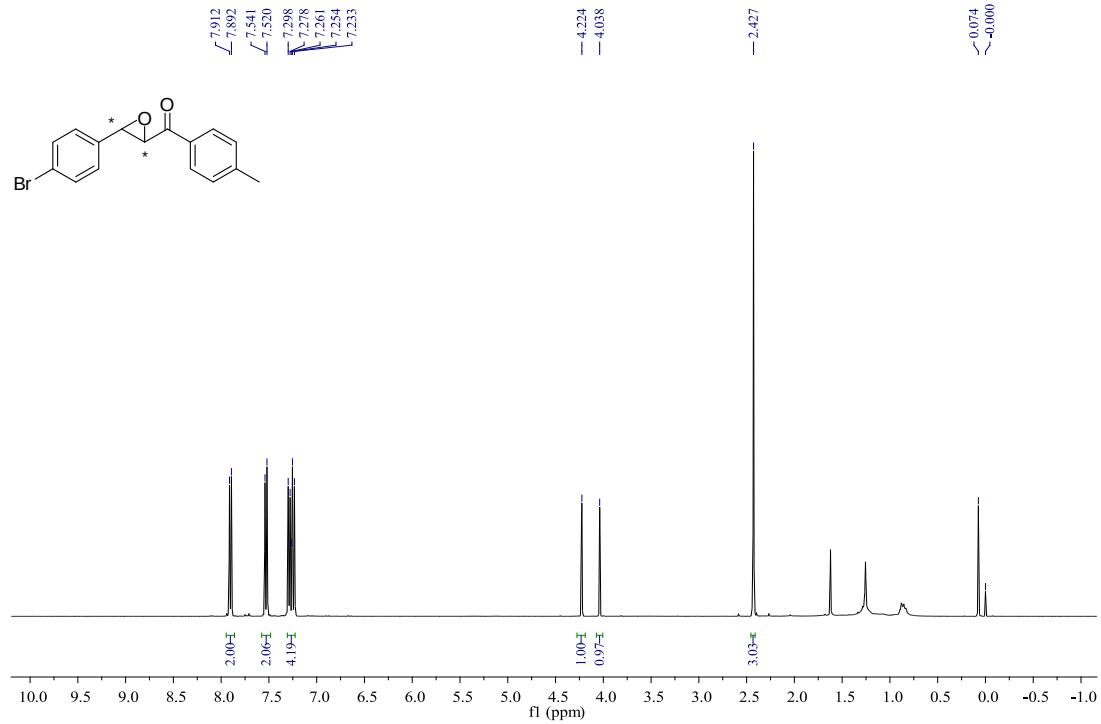

$^1$H NMR (600 MHz, $CDCl_3$) δ = 8.03 (d, *J* = 7.6, 2H), 7.88 (dt, *J* = 9.1, 6.1, 4H), 7.63 (t, *J* = 7.4, 1H), 7.55 – 7.47 (m, 4H), 7.43 (d, *J* = 8.7, 1H), 4.41 (d, *J* = 1.4, 1H), 4.25 (s, 1H).

**(3-(2,4-dichlorophenyl)oxiran-2-yl)(phenyl)methanone (3s)**

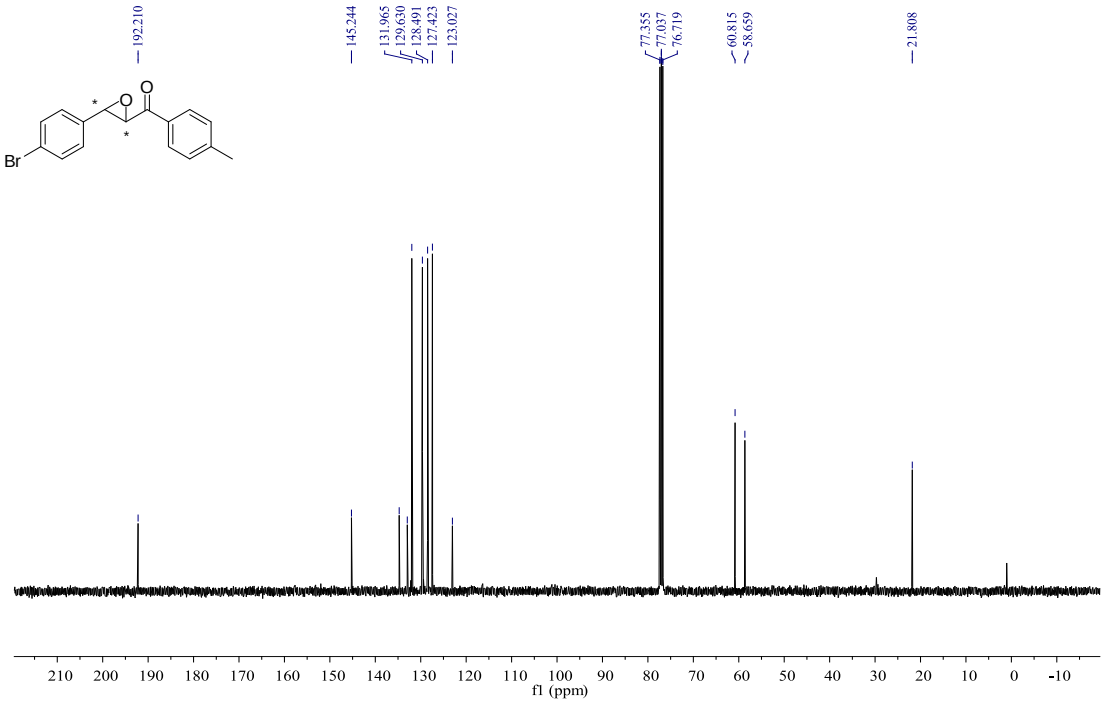



$^1$H NMR (400 MHz, $CDCl_3$) δ = 8.04 (d, *J* = 7.9, 2H), 7.65 (t, *J* = 7.4, 1H), 7.52 (t, *J* = 7.7, 2H), 7.43 (s, 1H), 7.33 (q, *J* = 8.4, 2H), 4.37 (s, 1H), 4.15 (s, 1H).

**(3-(4-bromophenyl)oxiran-2-yl)(p-tolyl)methanone (3t)**

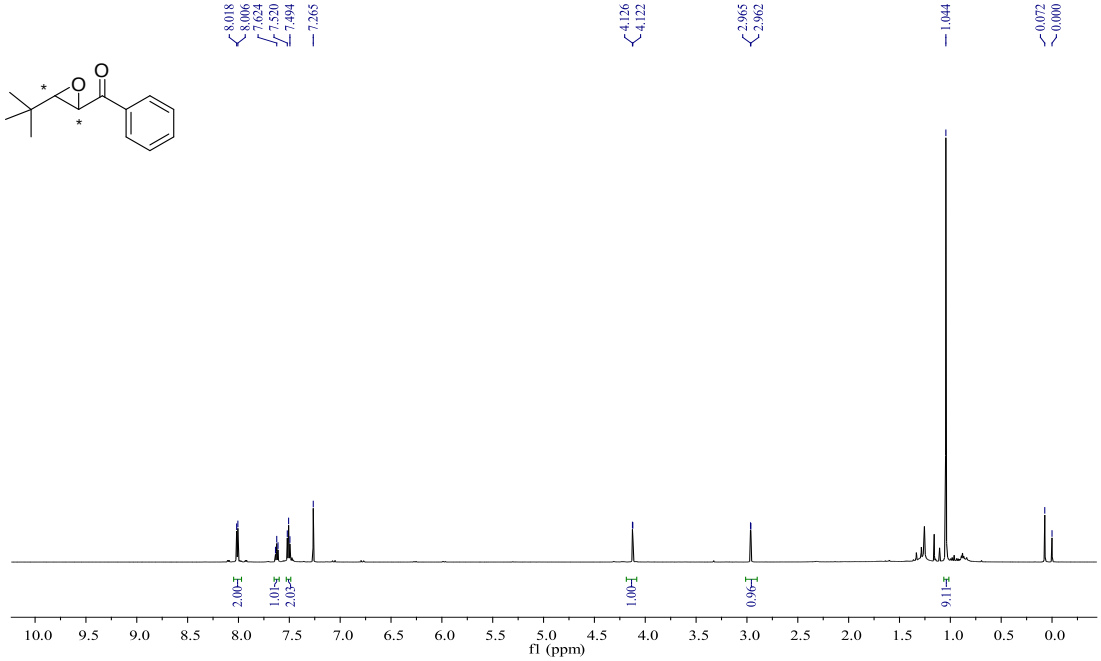



$^{1}$H NMR (400 MHz, $CDCl_3$) δ = 7.90 (d, *J* = 8.1, 2H), 7.53 (d, *J* = 8.3, 2H), 7.31 – 7.23 (m, 4H), 4.22 (s, 1H), 4.04 (s, 1H), 2.43 (s, 3H).



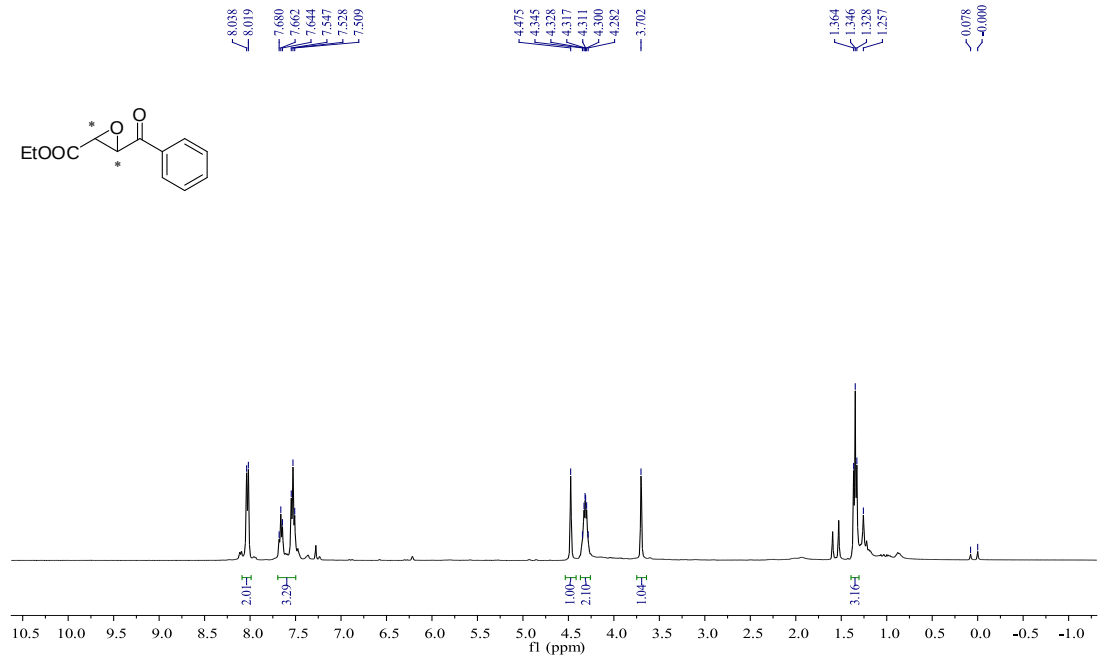

$^{13}$C NMR (101 MHz, $CDCl_3$) δ = 192.21, 145.24, 134.74, 132.96, 131.97, 129.63, 128.49, 127.42, 123.03, 60.81, 58.66, 21.81.

**(3-tert-butyloxiran-2-yl)(phenyl)methanone (3u)**



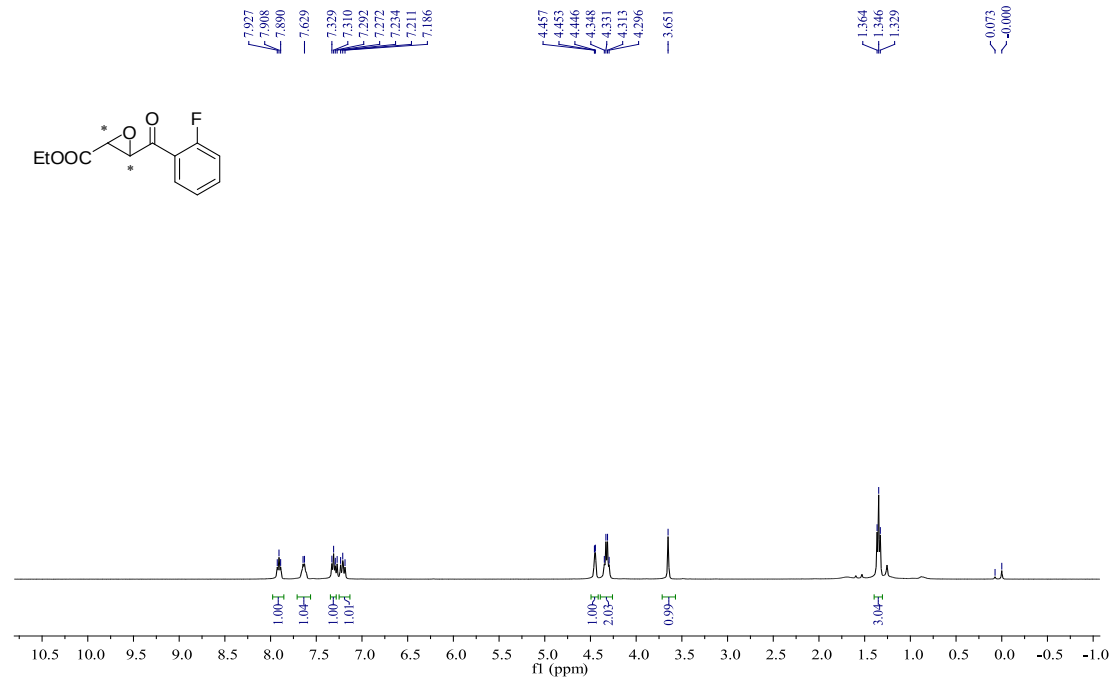
$^1$H NMR (600 MHz, $CDCl_3$) δ = 8.01 (d, *J* = 7.3, 2H), 7.62 (t, *J* = 7.4, 1H), 7.51 (t, *J* = 7.8, 2H), 4.12 (d, *J* = 2.1, 1H), 2.96 (d, *J* = 2.1, 1H), 1.04 (s, 9H).

**ethyl 3-benzoyloxirane-2-carboxylate (3v)**

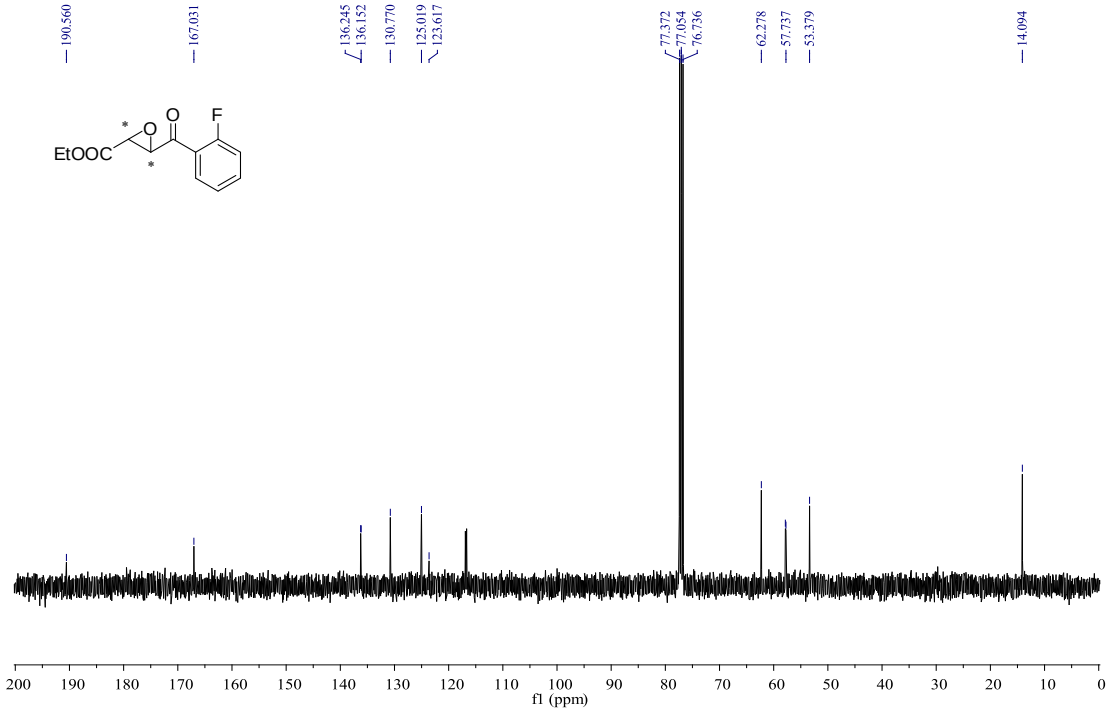


$^1$H NMR (400 MHz, $CDCl_3$) δ = 8.03 (d, *J* = 7.7, 2H), 7.60 (dt, *J* = 53.9, 7.4, 3H), 4.48 (s, 1H), 4.31 (td, *J* = 11.4, 6.9, 2H), 3.70 (s, 1H), 1.35 (t, *J* = 7.1, 3H).

**ethyl 3-(2-fluorobenzoyl)oxirane-2-carboxylate (3w)**

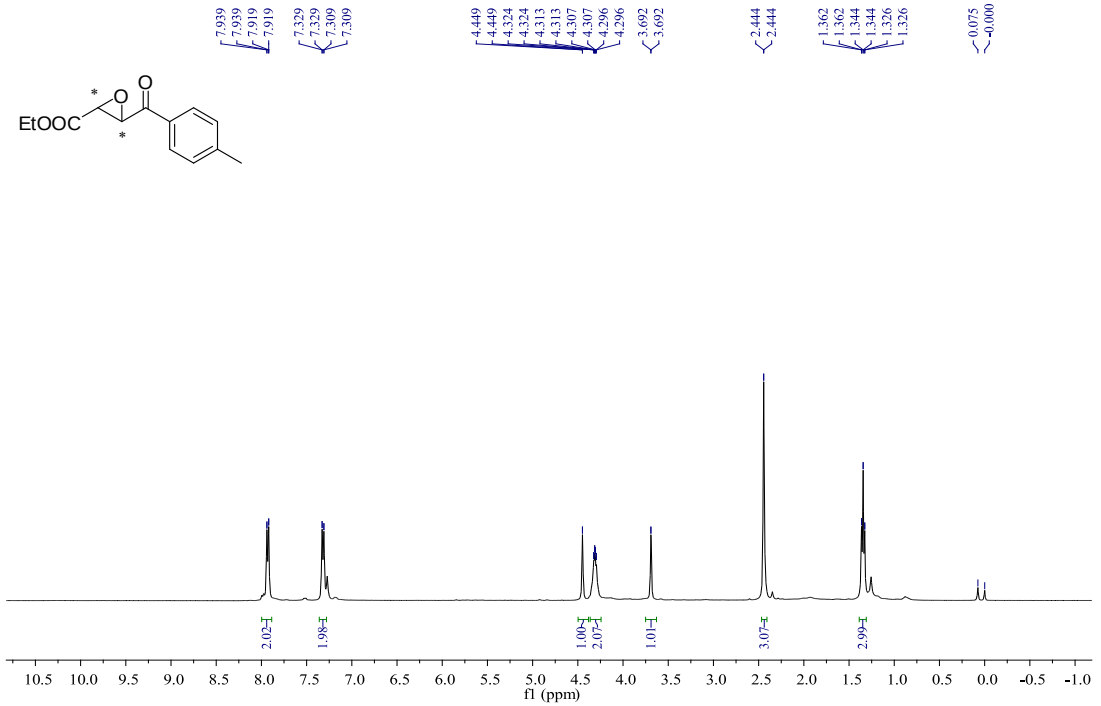



$^{1}$H NMR (400 MHz, $CDCl_3$) δ = 7.91 (t, *J* = 7.4, 1H), 7.64 (d, *J* = 6.3, 1H), 7.31 (t, *J* = 7.5, 1H), 7.25 – 7.13 (m, 1H), 4.49 – 4.42 (m, 1H), 4.32 (dd, *J* = 14.0, 6.9, 2H), 3.65 (s, 1H), 1.35 (t, *J* = 7.1, 3H).

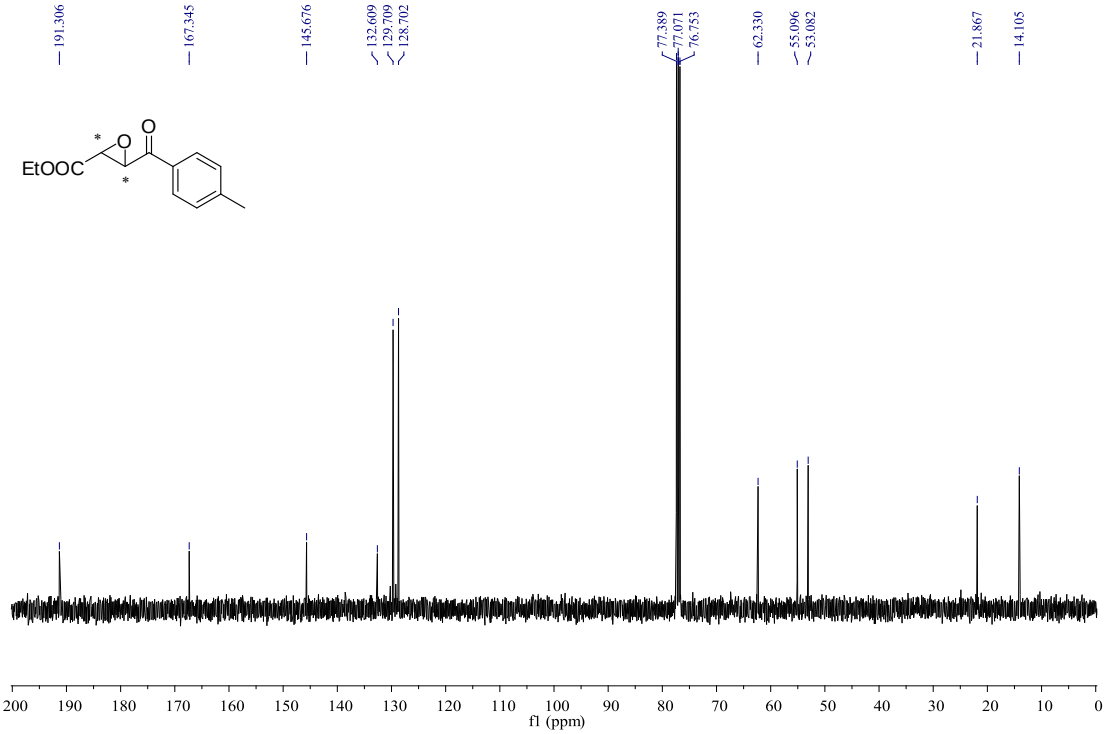



$^{13}$C NMR (101 MHz, $CDCl_3$) δ = 190.56, 167.03, 136.24, 136.15, 130.77, 125.02, 123.62, 62.28, 57.85, 57.74, 53.38, 14.09.

**ethyl 3-(4-methylbenzoyl)oxirane-2-carboxylate (3x)**

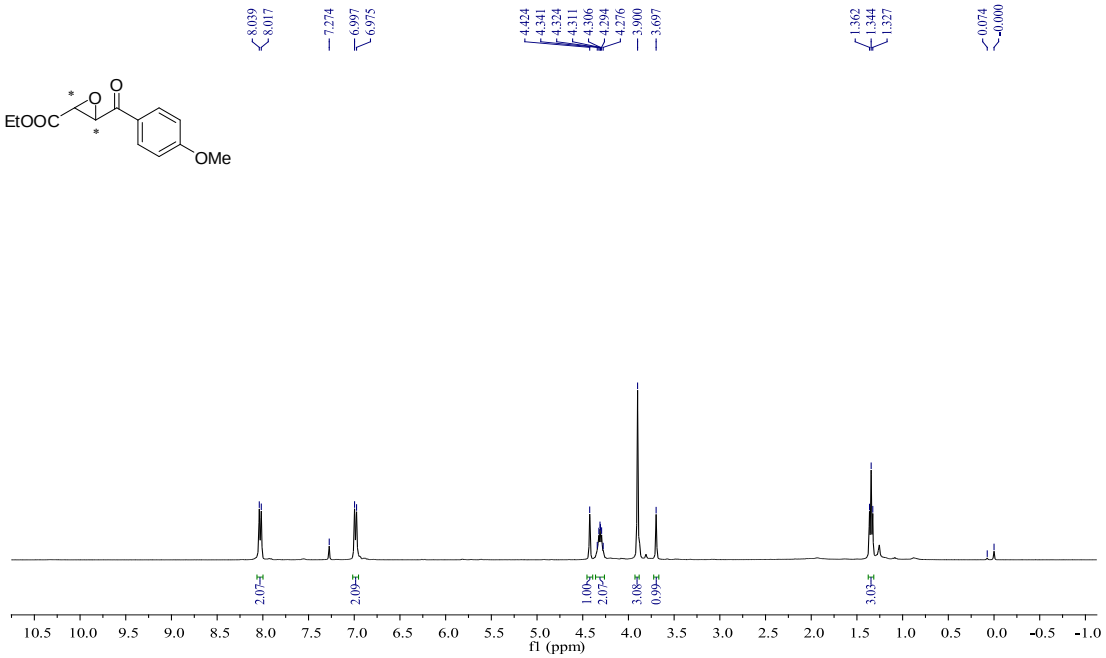



$^{1}$H NMR (400 MHz, $CDCl_3$) δ = 8.00 – 7.89 (m, 2H), 7.36 – 7.28 (m, 2H), 4.50 – 4.38 (m, 1H), 4.36 – 4.24 (m, 2H), 3.75 – 3.63 (m, 1H), 2.47 – 2.41 (m, 3H), 1.39 – 1.31 (m, 3H).



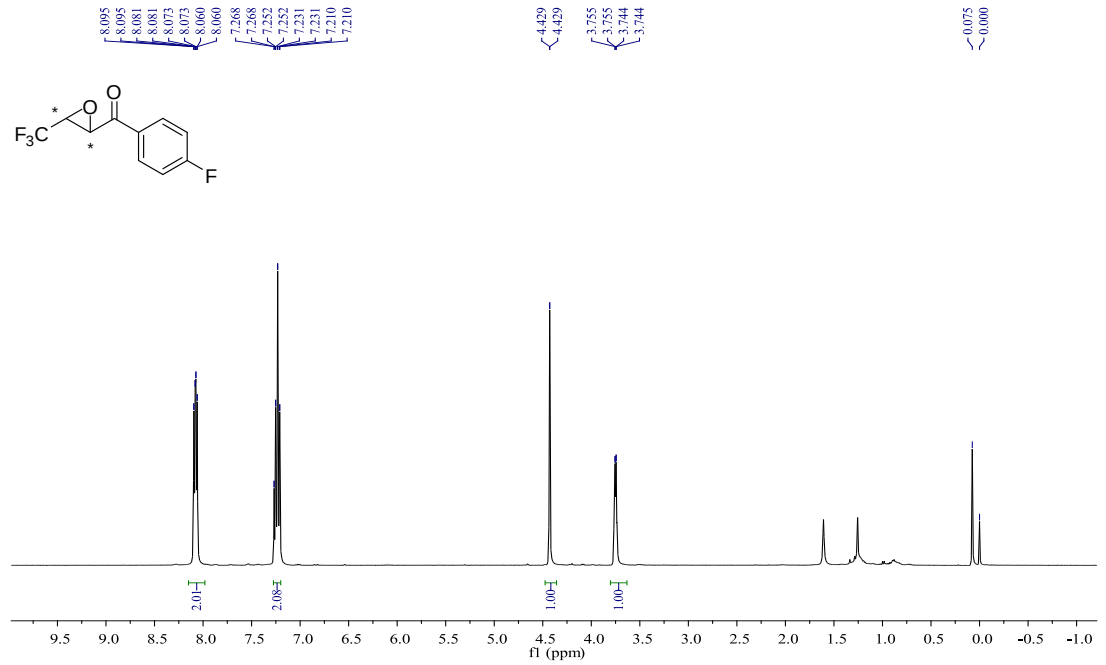

$^{13}$C NMR (101 MHz, $CDCl_3$) δ = 191.31, 167.34, 145.68, 132.61, 129.71, 128.70, 62.33, 55.10, 53.08, 21.87, 14.11.

**ethyl 3-(4-methoxybenzoyl)oxirane-2-carboxylate (3y)**

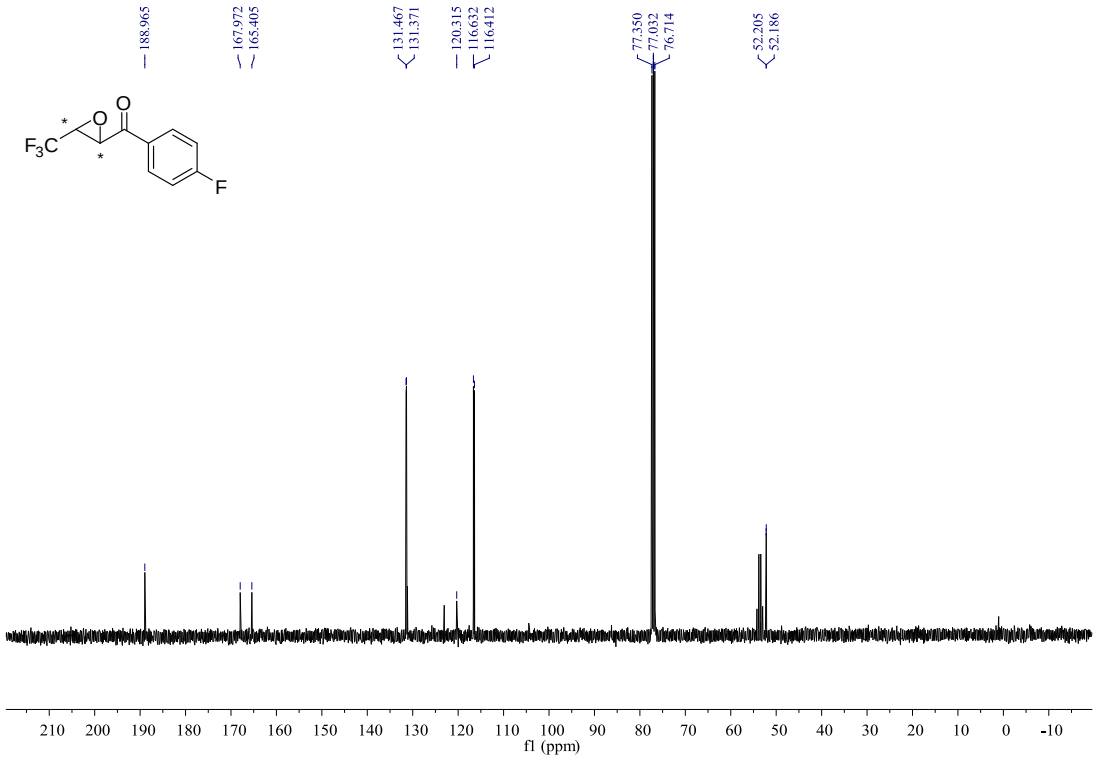



$^1$H NMR (400 MHz, $CDCl_3$) δ = 8.03 (d, *J* = 8.8, 2H), 6.99 (d, *J* = 8.8, 2H), 4.42 (s, 1H), 4.31 (td, *J* = 12.0, 7.0, 2H), 3.90 (s, 3H), 3.70 (s, 1H), 1.34 (t, *J* = 7.1, 3H).

**(4-fluorophenyl)(3-(trifluoromethyl)oxiran-2-yl)methanone (3z)**

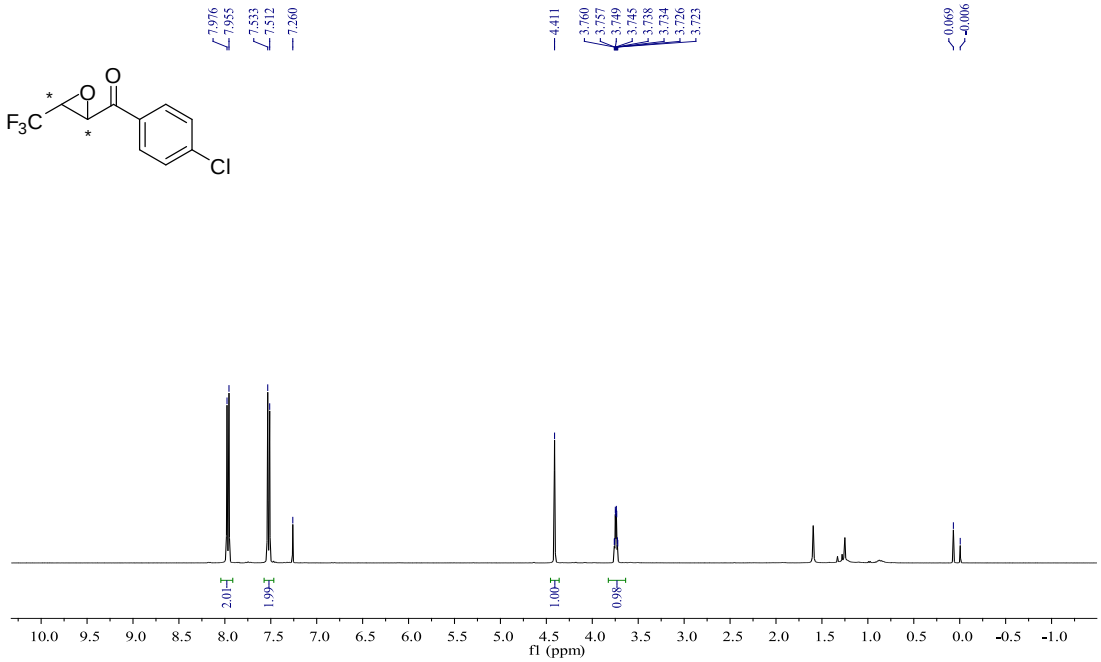



$^1$H NMR (400 MHz, $CDCl_3$) δ = 8.15 – 7.98 (m, 2H), 7.27 – 7.20 (m, 2H), 4.48 – 4.36 (m, 1H), 3.80 – 3.63 (m, 1H).

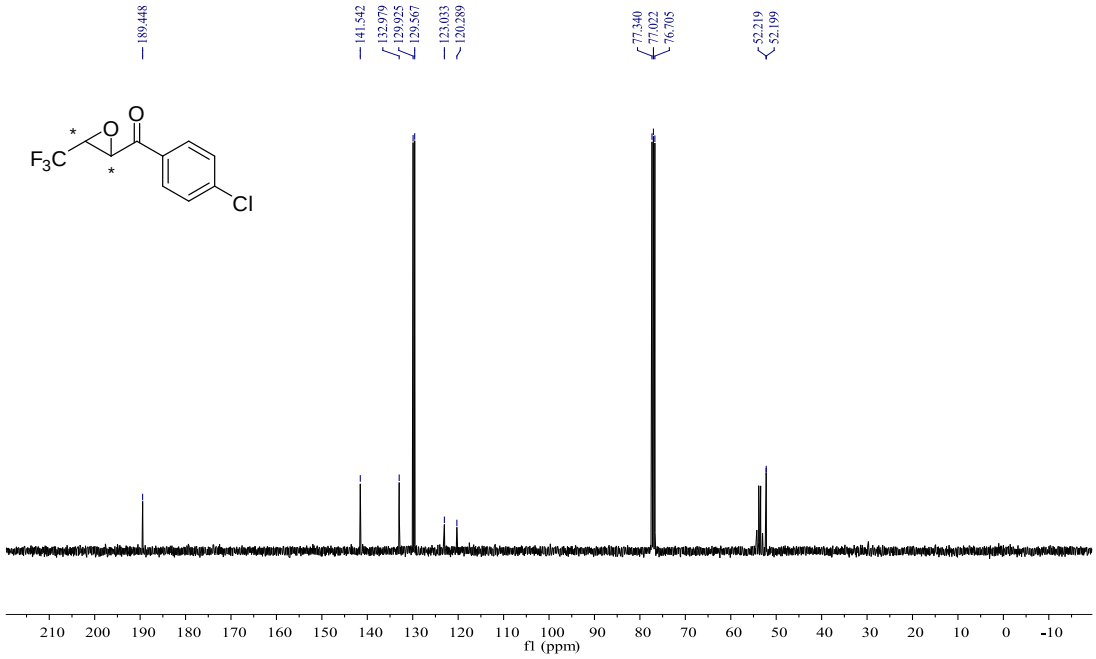



$^{13}$C NMR (101 MHz, $CDCl_3$) δ = 188.96, 167.97, 165.41, 131.47, 131.37, 120.32, 116.63, 116.41, 52.21, 52.19.

**(4-chlorophenyl)(3-(trifluoromethyl)oxiran-2-yl)methanone (3aa)**

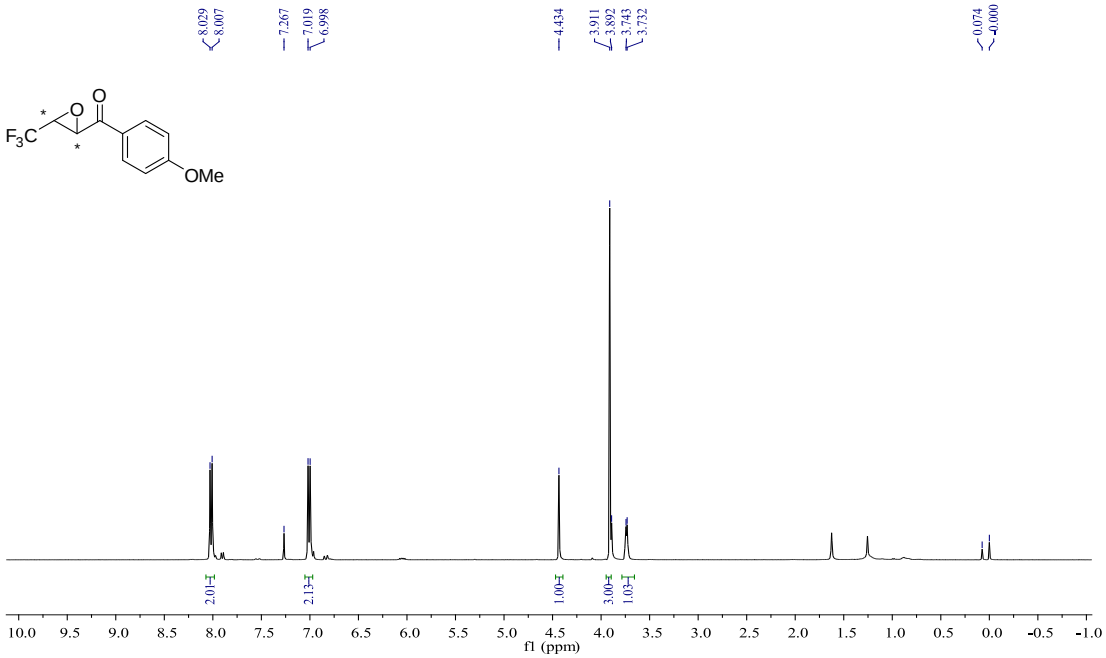



$^{1}$H NMR (400 MHz, $CDCl_3$) δ = 7.97 (d, *J* = 8.6, 2H), 7.52 (d, *J* = 8.6, 2H), 4.41 (s, 1H), 3.74 (qd, *J* = 4.6, 1.5, 1H).

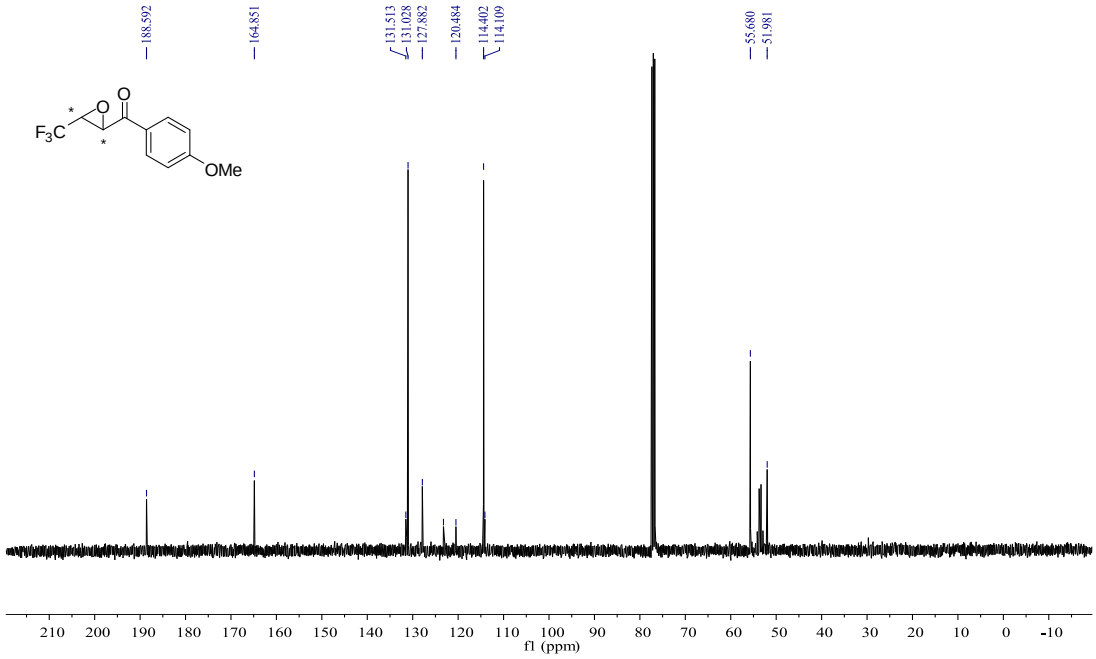



$^{13}$C NMR (101 MHz, $CDCl_3$) δ = 189.45, 141.54, 132.98, 129.92, 129.57, 123.03, 120.29, 52.22, 52.20.

**(4-methoxyphenyl)(3-(trifluoromethyl)oxiran-2-yl)methanone (3ab)**

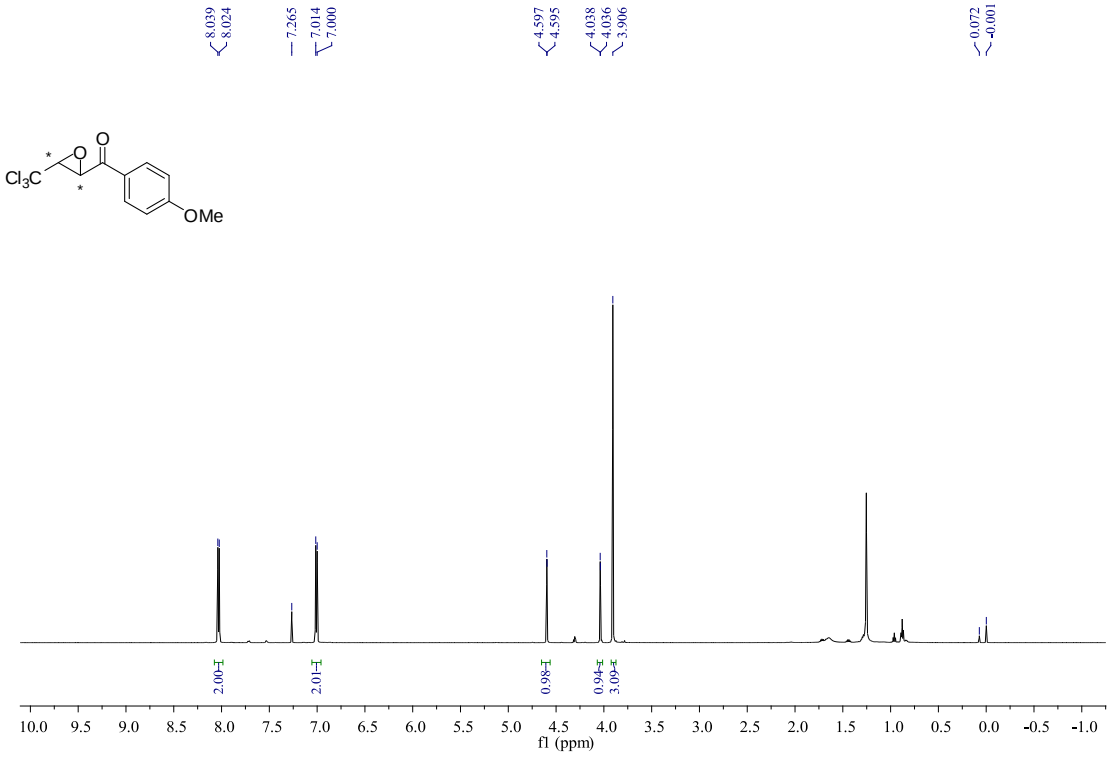



$^{1}$H NMR (400 MHz, $CDCl_3$) δ = 8.02 (d, *J* = 8.6, 2H), 7.01 (d, *J* = 8.6, 2H), 4.43 (s, 1H), 3.91 (s, 3H), 3.74 (m, 1H).

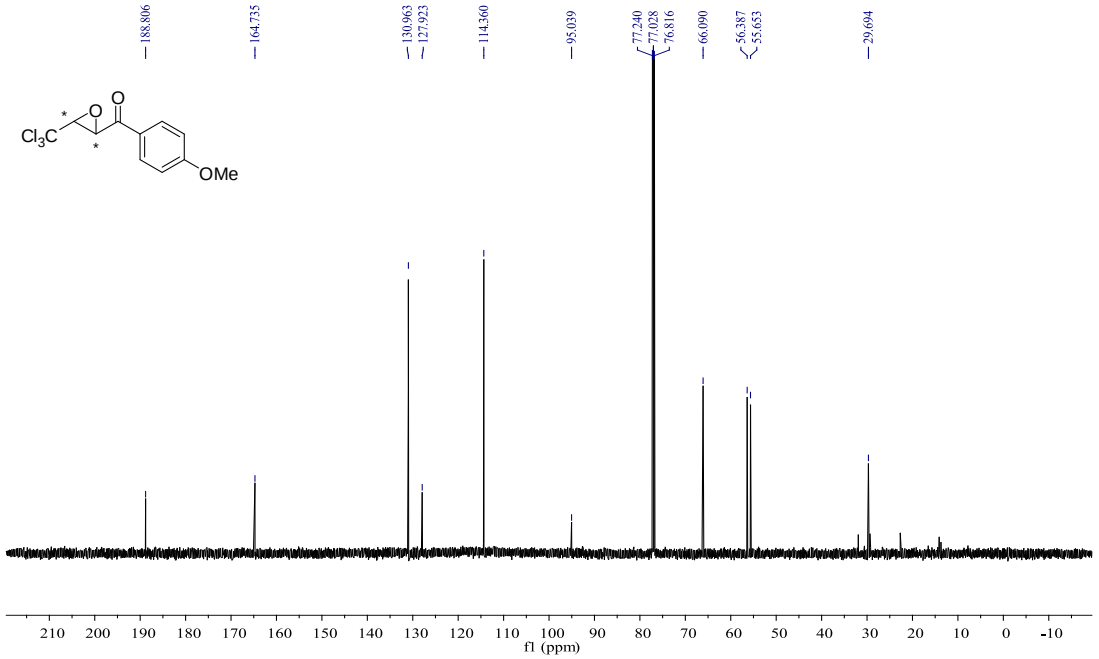



$^{13}$C NMR (101 MHz, $CDCl_3$) δ = 188.59, 164.85, 131.51, 131.03, 127.88, 123.23, 120.48, 114.40, 114.11, 55.68, 51.98.

**(4-methoxyphenyl)(3-(trichloromethyl)oxiran-2-yl)methanone (3ac)**

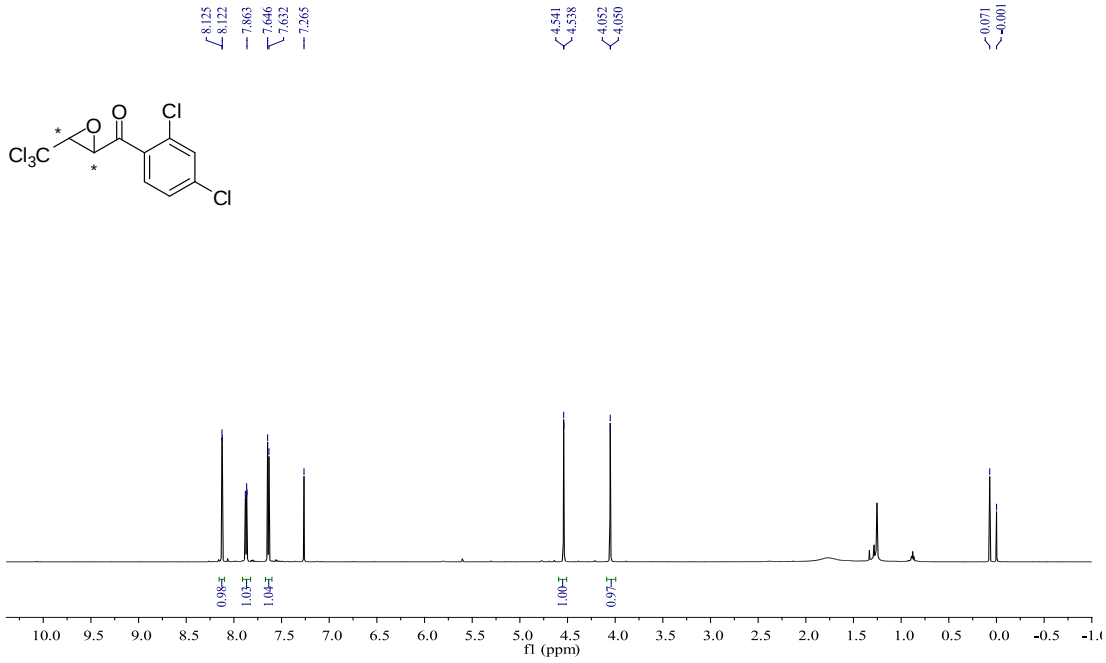



$^{1}$H NMR (600 MHz, $CDCl_3$) δ = 8.03 (d, *J* = 8.9, 2H), 7.01 (d, *J* = 8.8, 2H), 4.60 (d, *J* = 1.3, 1H), 4.04 (d, *J* = 1.3, 1H), 3.91 (s, 3H).

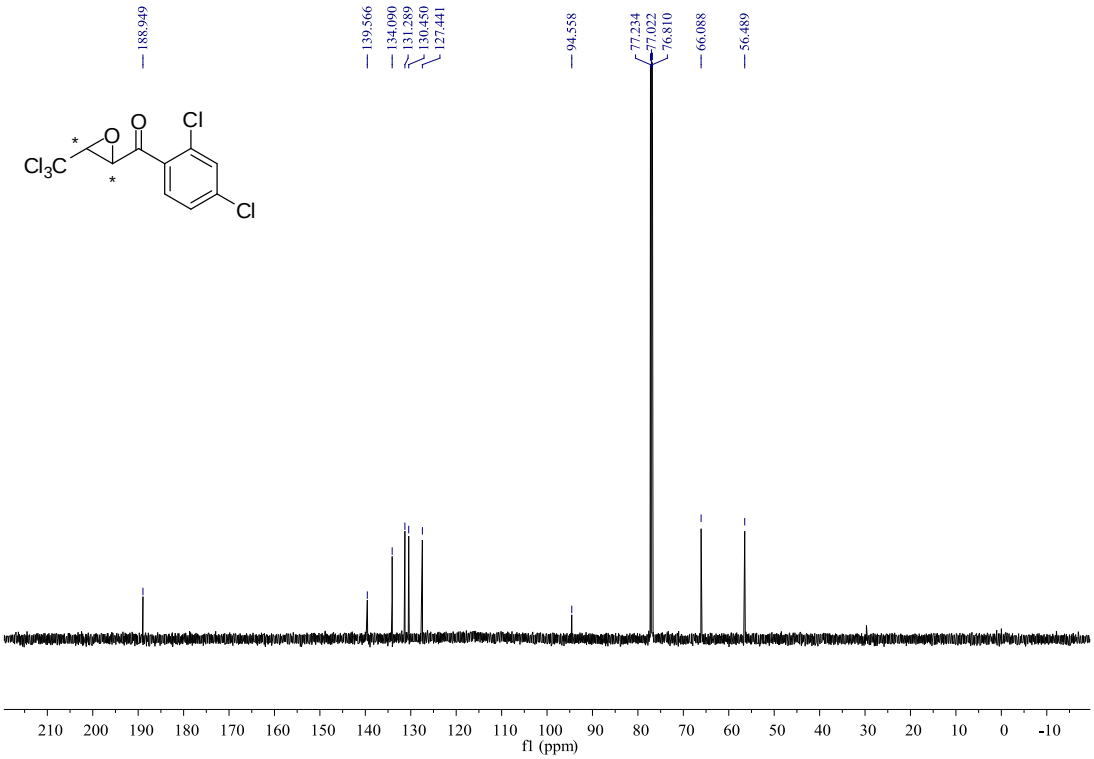



$^{13}$C NMR (151 MHz, $CDCl_3$) δ = 188.81, 164.74, 130.96, 127.92, 114.36, 95.04, 66.09, 56.39, 55.65, 29.69.

**(2,4-dichlorophenyl)(3-(trichloromethyl)oxiran-2-yl)methanone (3ad)**

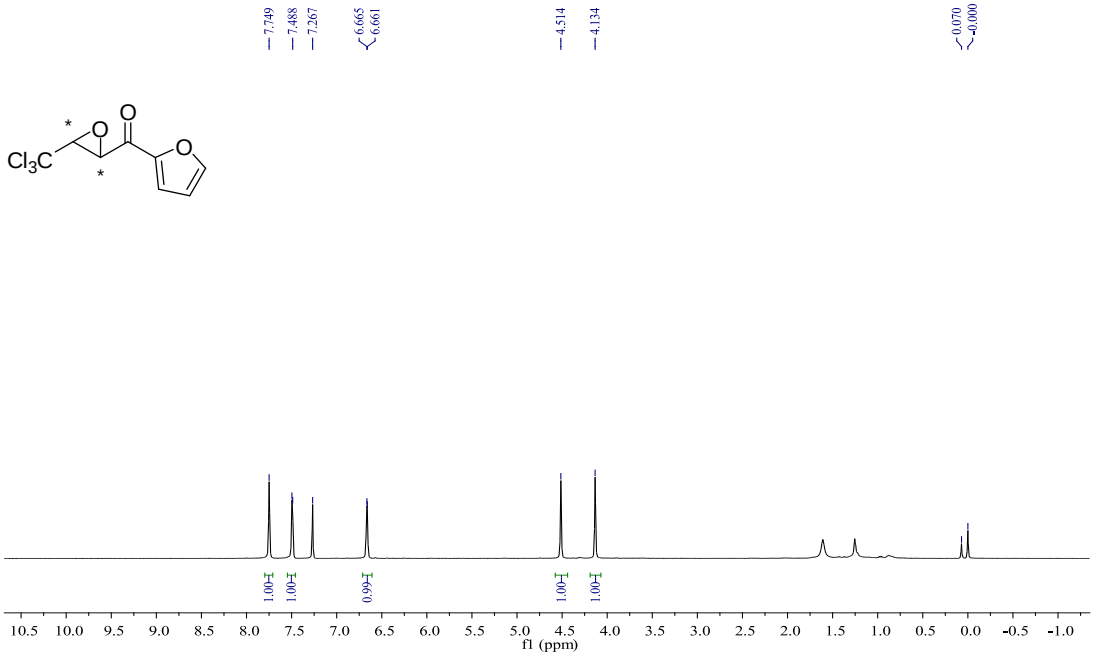



$^{1}$H NMR (600 MHz, $CDCl_3$) δ = 8.12 (d, *J* = 1.9, 1H), 7.87 (dd, *J* = 8.4, 1.9, 1H), 7.64 (d, *J* = 8.4, 1H), 4.54 (d, *J* = 1.4, 1H), 4.05 (d, *J* = 1.4, 1H).

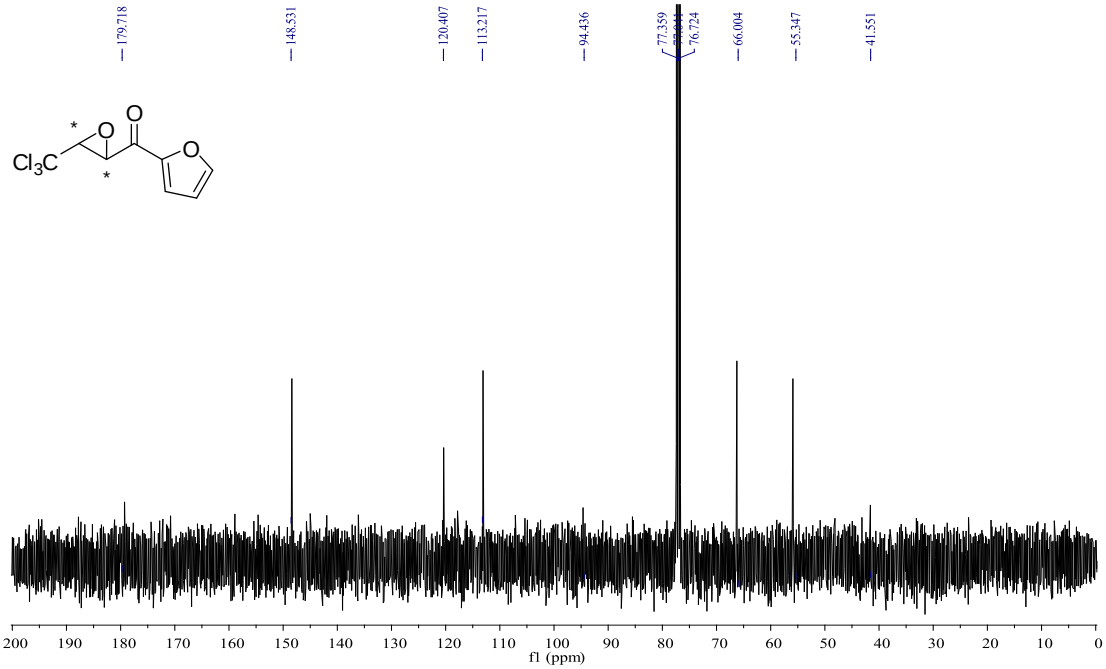



$^{13}$C NMR (151 MHz, $CDCl_3$) δ = 188.95, 139.57, 134.09, 131.29, 130.45, 127.44, 94.56, 66.09, 56.49.

**furan-2-yl(3-(trichloromethyl)oxiran-2-yl)methanone (3ae)**

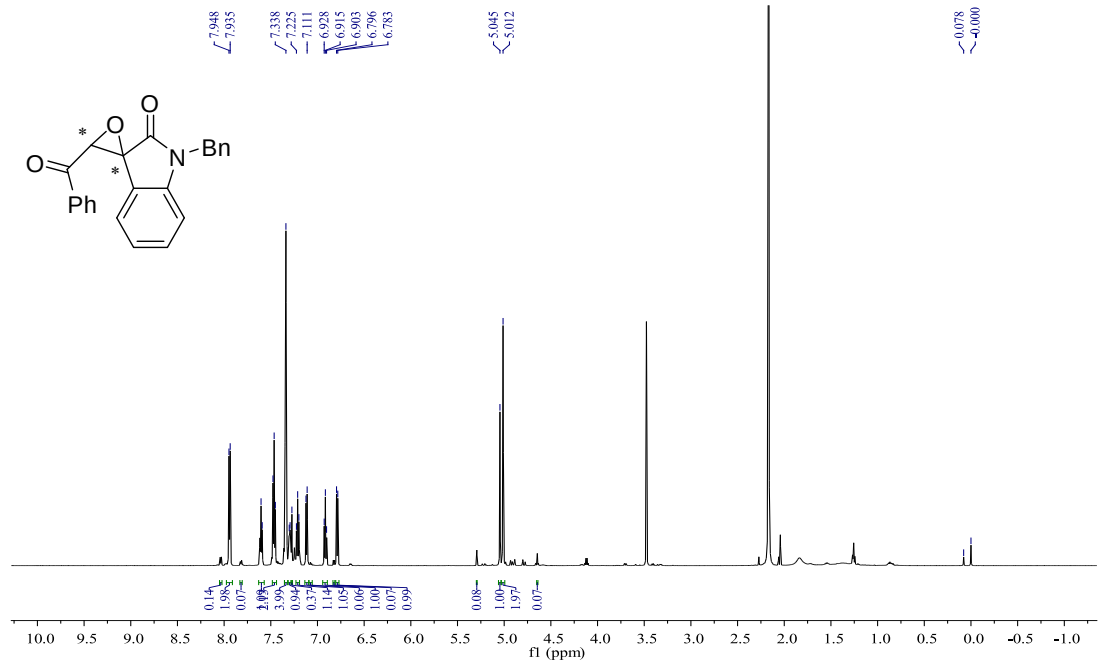



$^{1}$H NMR (400 MHz, $CDCl_3$) δ = 7.75 (s, 1H), 7.49 (d, *J* = 3.4, 1H), 6.66 (d, *J* = 1.7, 1H), 4.51 (s, 1H), 4.13 (s, 1H).

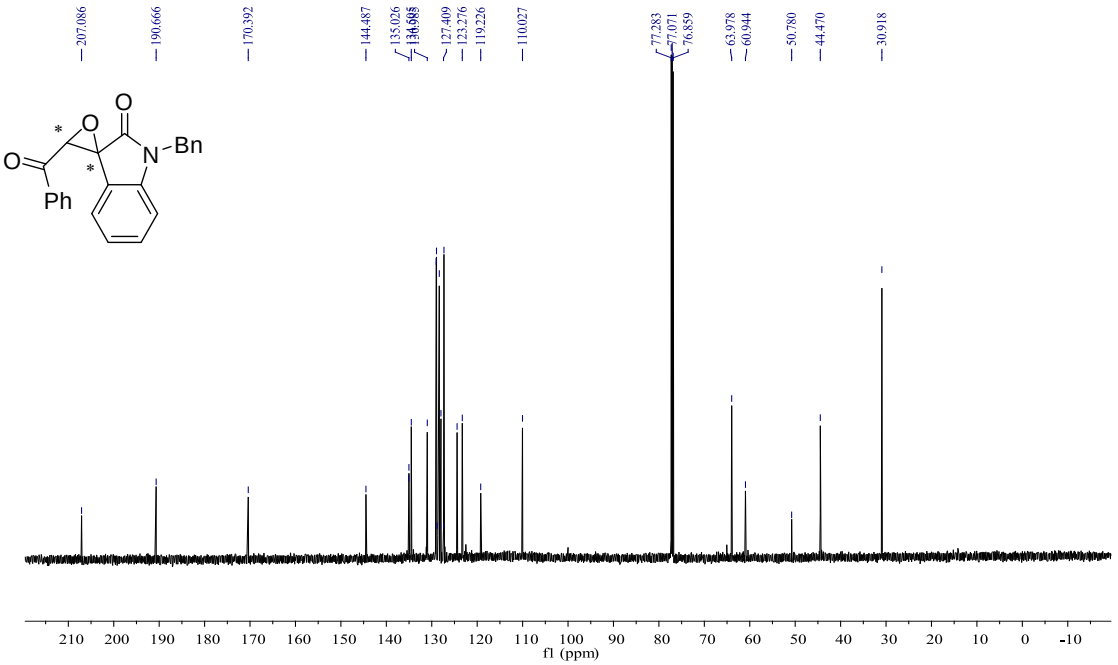



$^{13}$C NMR (101 MHz, $CDCl_3$) δ = 179.72, 148.53, 120.41, 113.22, 94.44, 66.00, 55.35, 41.55.

**3'-benzoyl-1-benzylspiro[indoline-3,2'-oxiran]-2-one (3af)**

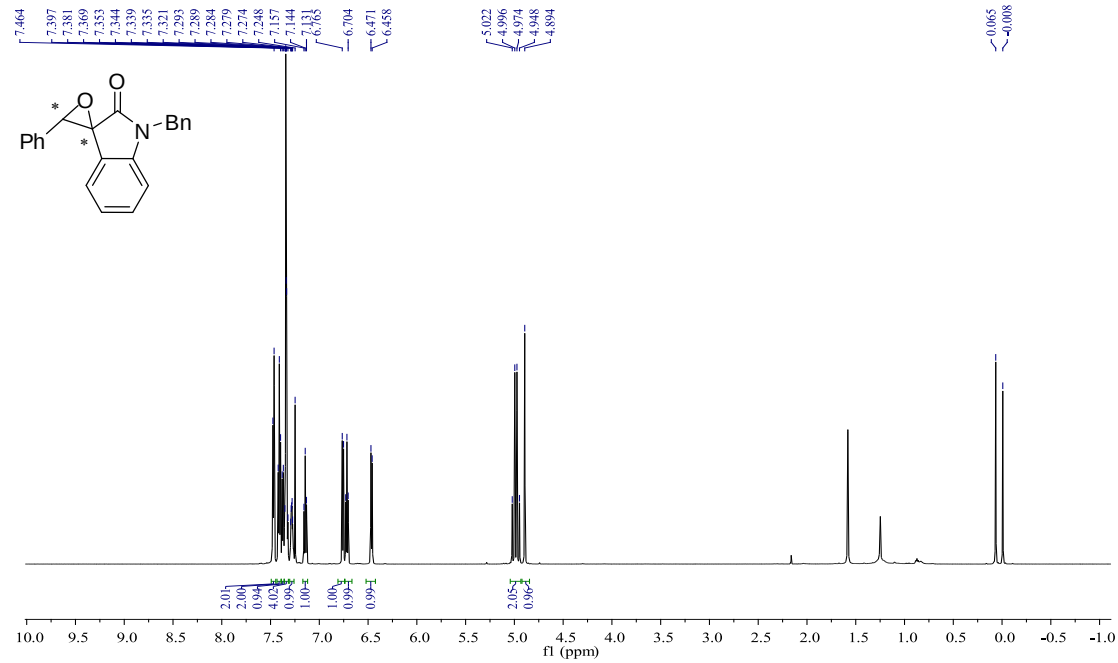



$^{1}$H NMR (600 MHz, $CDCl_3$) δ = 7.94 (d, *J* = 7.9, 2H), 7.60 (s, 1H), 7.46 (t, *J* = 7.7, 2H), 7.34 (s, 4H), 7.30 (d, *J* = 5.4, 1H), 7.21 (d, *J* = 7.8, 1H), 7.12 (d, *J* = 7.6, 1H), 6.92 (d, *J* = 7.6, 1H), 6.79 (d, *J* = 7.9, 1H), 5.05 (s, 1H), 5.01 (s, 2H).

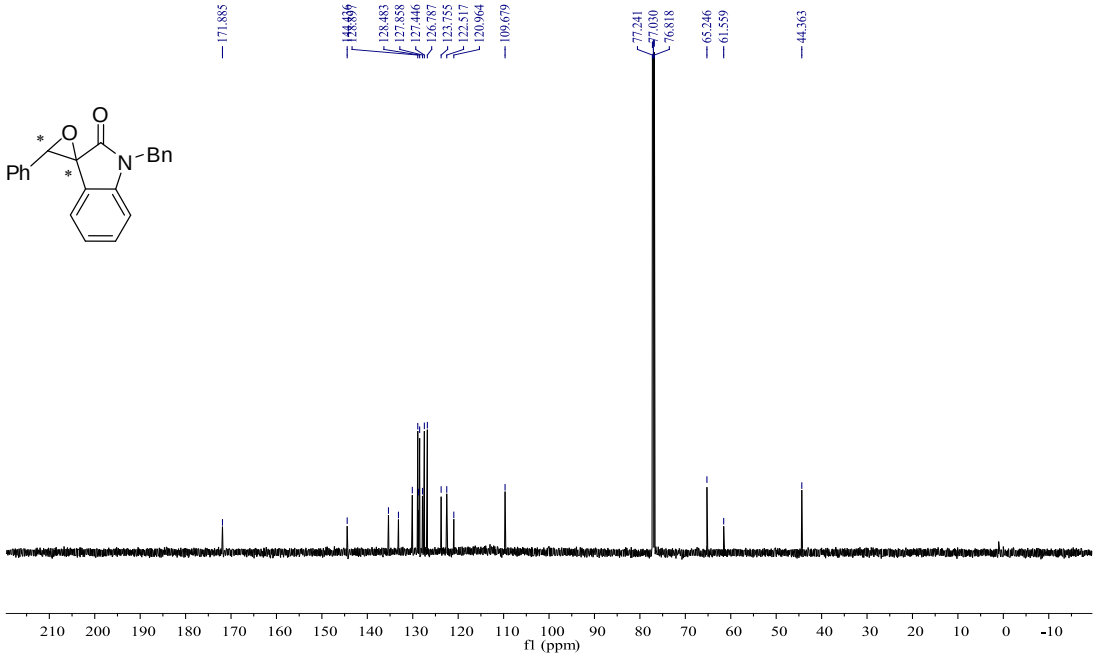



$^{13}$C NMR (151 MHz, $CDCl_3$) δ = 207.09, 190.67, 170.39, 144.49, 135.06, 135.03, 134.51, 130.99, 129.03, 128.96, 128.82, 128.34, 127.98, 127.41, 127.32, 124.42, 123.28, 119.23, 110.03, 63.98, 60.94, 50.78, 44.47, 30.92.

**1-benzyl-3'-phenylspiro[indoline-3,2'-oxiran]-2-one (3ag)**

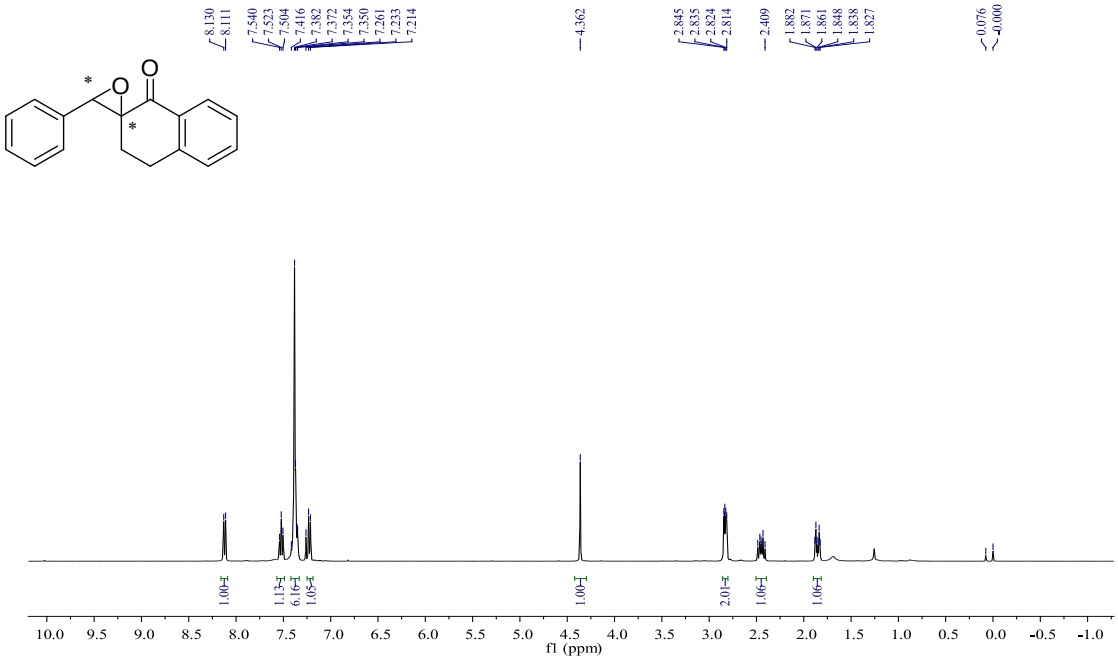



$^{1}$H NMR (600 MHz, $CDCl_3$) δ = 7.47 (d, *J* = 7.3, 2H), 7.41 (t, *J* = 7.3, 2H), 7.37 (d, *J* = 7.2, 1H), 7.36 – 7.32 (m, 4H), 7.30 – 7.26 (m, 1H), 7.14 (t, *J* = 7.8, 1H), 6.76 (d, *J* = 7.9, 1H), 6.72 (t, *J* = 7.6, 1H), 6.46 (d, *J* = 7.5, 1H), 4.98 (q, *J* = 15.6, 2H), 4.89 (s, 1H).




$^{13}$C NMR (151 MHz, $CDCl_3$) δ = 171.89, 144.44, 135.34, 133.15, 130.10, 128.90, 128.73, 128.48, 127.86, 127.45, 126.79, 123.75, 122.52, 120.96, 109.68, 65.25, 61.56, 44.36.

**3'-phenyl-3,4-dihydro-1H-spiro[naphthalene-2,2'-oxiran]-1-one (3ah)**




$^{1}$H NMR (400 MHz, $CDCl_3$) δ = 8.12 (d, *J* = 7.8, 1H), 7.52 (t, *J* = 7.2, 1H), 7.48 – 7.28 (m, 6H), 7.22 (d, *J* = 7.6, 1H), 4.36 (s, 1H), 2.83 (dd, *J* = 8.3, 4.0, 2H), 2.45 (dt, *J* = 13.5, 8.6, 1H), 1.85 (dt, *J* = 13.5, 4.1, 1H).