Catalytic Asymmetric [3 + 2] Cycloaddition of Aromatic Aldehydes with Oxiranes by C–C Bond Cleavage of Epoxides: Highly Efficient Synthesis of Chiral 1,3-Dioxolanes

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Contents:
1. General remarks………………………………………………………………………………..S1
2. Typical procedure for catalytic asymmetric [3+2] cycloaddition of aryl oxiranyl diketones and aldehydes………………………………………………………………………S2
3. Scope of oxiranes………………………………………………………………………………S2
4. Scale-up version of the reaction………………………………………………………………S2
5. X-ray structure of 3h………………………………………………………………………..S2
6. Characterization of the oxiranes…………………………………………………………S2-S4
7. Characterization of the products…………………………………………………………S4-S17
8. References……………………………………………………………………………………S17
9. Copy of 1H NMR and 13C NMR spectra for products and substrates…………S18-50
10. Copy of CD spectras for products………………………………………………………..S51-S58

1. General remarks

1H NMR spectra were recorded on commercial instruments (400 MHz). Chemical shifts were reported in ppm from tetramethylsilane with the solvent resonance as the internal standard (CDCl3, δ = 7.26; DMSO, δ = 2.49). Spectra were reported as follows: chemical shift (δ ppm), multiplicity (s = singlet, d = doublet, t = triplet, q = quartet, m = multiplet), coupling constants (Hz), integration and assignment.

13C NMR spectra were collected on commercial instruments (100 MHz) with complete proton decoupling. Chemical shifts are reported in ppm from the tetramethylsilane with the solvent resonance as internal standard (CDCl3, δ = 77.0; DMSO, δ = 39.6). Melting points (m.p.) were measured on electrothermal digital melting point apparatus and were uncorrected. Enantiomeric excesses (ee) were determined by HPLC analysis using the corresponding commercial chiral column as stated in the experimental procedures at 23 °C. Optical rotations were reported as follows: [α]D (c g/100 mL, in ethyl acetate). HRMS was recorded on a commercial apparatus (ESI Source). All catalytic reactions were run in dried glassware using standard techniques. CH2Cl2, DCE, DCB (1,2-dichlorobenzene) was
distilled over CaH₂. Toluene and THF were freshly distilled from sodium metal prior to use. All liquid aldehydes and ketones were freshly distilled prior to use and solid aldehydes were used after recrystallization.

2. Typical procedure for catalytic asymmetric [3+2] cycloaddition of oxiranes and aldehydes

\[ N,N'-\text{dioxide} \, L_2 \, (6.5 \text{ mg}, \, 0.01 \text{ mmol}), \, \text{Gd(OTf)}_3 \, (6.0 \text{ mg}, \, 0.01 \text{ mmol}), \, \text{LiNTf}_2 \, (15 \text{ mol\%}) \text{ and } 4 \, \text{Å MS (20.0 mg) were stirred in 0.5 mL 1,2-dichlorobenzene at 35 °C under N2 atmosphere for 0.5 h, then benzaldehyde (15.0 µL, 0.15 mmol) was added. After the temperature decreased to 0 °C, (3-phenyloxirane-2,2-diyl)bis(phenylmethanone) 1a (32.8 mg, 0.1 mmol) was added. The mixture was stirred at 0 °C for 72 h. The reaction mixture was purified by flash chromatography (petroleum ether: ethyl acetate = 20:1) on silica gel to afford the desired product. (When 2-furaldehyde, 3-furaldehyde or 1,3-dihydroisobenzofuran-5-carbaldehyde was employed, 1.2 eq. aldehyde was added.)} \]

3. The scope of oxiranes

4. Scale-up version of the reaction

5. X-ray structure of 3h

6. Characterization of the aryl oxiranyl diketones.
(3-(3-chlorophenyl)oxirane-2,2-diyl)bis(phenylmethanone): white solid; $^1$H NMR (400 MHz, CDCl$_3$) $\delta$ 8.20 – 8.13 (m, 2H), 7.97 – 7.91 (m, 2H), 7.63 – 7.58 (m, 1H), 7.54 – 7.46 (m, 3H), 7.42 – 7.43 (m, 3H), 7.25 – 7.16 (m, 3H), 4.66 (s, 1H) ppm; $^{13}$C NMR (101 MHz, CDCl$_3$) $\delta$ = 191.69, 190.69, 134.58, 134.54, 134.44, 134.40, 134.09, 130.11, 129.77, 129.65, 129.16, 128.87, 128.68, 126.64, 124.48, 73.81, 61.80 ppm; EI-HRMS: Calcd for C$_{22}$H$_{15}$ClO$_3$ [M+H]$^+$ 363.0788, Found 363.0789.

(3-(3-bromophenyl)oxirane-2,2-diyl)bis(phenylmethanone): white solid; 1H NMR (400 MHz, DMSO) $\delta$ 8.07 (d, $J$ = 7.2 Hz, 2H), 7.89 (d, $J$ = 7.3 Hz, 2H), 7.76 – 7.69 (m, 1H), 7.66 – 7.57 (m, 3H), 7.56 – 7.43 (m, 4H), 7.40 – 7.32 (m, 1H), 7.30 – 7.22 (m, 1H), 5.07 (s, 1H) ppm; 13C NMR (101 MHz, DMSO) $\delta$ = 191.65, 190.62, 135.16, 134.78, 134.72, 134.12, 133.73, 131.74, 130.51, 129.41, 129.13, 129.08, 129.05, 128.95, 125.39, 121.55, 73.19, 60.94 ppm.

(3-(m-tolyl)oxirane-2,2-diyl)bis(phenylmethanone): white solid; 1H NMR (400 MHz, CDCl$_3$) $\delta$ 8.21 – 8.15 (m, 2H), 7.99 – 7.93 (m, 2H), 7.64 – 7.55 (m, 1H), 7.51 – 7.44 (m, 3H), 7.41 – 7.32 (m, 1H), 7.18 – 7.11 (m, 3H), 7.07 – 7.01 (m, 1H), 4.65 (s, 1H), 2.27 (s, 3H) ppm; 13C NMR (101 MHz, CDCl$_3$) $\delta$ = 192.13, 191.16, 138.17, 134.82, 134.44, 134.23, 134.16, 132.23, 130.14, 129.73, 129.72, 128.79, 128.54, 128.33, 127.00, 123.46, 73.98, 62.81, 21.34 ppm; EI-HRMS: Calcd for C$_{23}$H$_{18}$O$_3$ [M+Na]$^+$ 365.1154, Found 365.1152.

(3-(p-tolyl)oxirane-2,2-diyl)bis(phenylmethanone): white solid; 1H NMR (400 MHz, CDCl$_3$) $\delta$ 8.21 – 8.15 (m, 2H), 7.99 – 7.93 (m, 2H), 7.62 – 7.56 (m, 1H), 7.51 – 7.45 (m, 3H), 7.36 (t, $J$ = 7.7 Hz, 2H), 7.23 (d, $J$ = 8.1 Hz, 2H), 7.07 (d, $J$ = 8.0 Hz, 2H), 4.66 (s, 1H), 2.26 (s, 3H) ppm; 13C NMR (101 MHz, CDCl$_3$) $\delta$ = 192.15, 191.21, 138.83, 134.79, 134.42, 134.25, 134.17, 130.13, 129.76, 129.28, 129.18, 128.78, 128.56, 126.30, 74.07, 62.84, 21.21 ppm; EI-HRMS: Calcd for C$_{23}$H$_{18}$O$_3$ [M+H]$^+$ 343.1334, Found 343.1332.

(3-(3-phenoxyphenyl)oxirane-2,2-diyl)bis(phenylmethanone): white solid; 1H NMR (400 MHz, DMSO) $\delta$ 8.10 - 8.03 (m, 2H), 7.92 – 7.85 (m, 2H), 7.75 – 7.69 (m, 1H), 7.67 – 7.56(m, 3H), 7.52 - 7.45 (m, 2H), 7.40 – 7.30 (m, 3H), 7.20 – 7.12 (m, 2H), 6.96 – 6.87 (m, 2H), 6.84 – 6.75 (m, 2H), 5.02 (s, 1H) ppm; $^{13}$C NMR (101 MHz, DMSO) $\delta$ = 191.90, 190.58, 156.45, 156.22, 134.70, 134.68, 134.66, 134.04, 133.75, 130.25, 130.01, 129.44, 129.21, 129.00, 128.85, 123.57, 121.61, 119.39, 118.38, 115.98, 73.16, 61.40 ppm; EI-HRMS: Calcd for C$_{28}$H$_{20}$O$_4$ [M+H]$^+$ 421.1440, Found 421.1436.

(3-phenyloxirane-2,2-diyl)bis(p-tolylmethanone): white solid; 1H NMR (400 MHz, DMSO) $\delta$ 8.01 – 7.93 (m, 2H), 7.80 – 7.73 (m, 2H), 7.40 (d, $J$ = 8.1 Hz, 2H), 7.36 – 7.24 (m, 7H), 4.96 (s, 1H), 2.38 (s, 3H), 2.30 (s, 3H); $^{13}$C NMR (101 MHz, DMSO) $\delta$ = 191.21, 190.19, 145.62, 145.51, 132.56, 131.73, 131.31, 129.60, 129.44, 129.27, 128.79, 128.28, 126.26, 73.53, 61.66, 21.29, 21.20 ppm; EI-HRMS: Calcd for C$_{24}$H$_{20}$O$_3$ [M+H]$^+$ 357.1491, Found 357.1488.
(3-(furan-3-yl)oxirane-2,2-diyl)bis(phenylmethanone): white solid; $^1$H NMR (400 MHz, DMSO) $\delta$ 8.10 – 8.02 (m, 2H), 8.00 – 7.90 (m, 2H), 7.84 (s, 1H), 7.74 – 7.49 (m, 7H), 6.30 – 6.09 (m, 1H), 4.91 (s, 1H) ppm; $^{13}$C NMR (101 MHz, DMSO) $\delta$ = 191.86, 191.43, 144.13, 143.18, 134.70, 134.18, 133.79, 129.37, 129.23, 129.03, 128.95, 118.52, 108.44, 72.58, 56.37 ppm; EI-HRMS: Calcd for C$_{20}$H$_{14}$O$_4$ [M+H]$^+$ 319.0970, Found 319.0966.

(3-(thiophen-3-yl)oxirane-2,2-diyl)bis(phenylmethanone): white solid; $^1$H NMR (400 MHz, CDCl$_3$) $\delta$ 8.20 – 8.13 (m, 2H), 8.02 – 7.94 (m, 2H), 7.62 – 7.56 (m, 1H), 7.54 – 7.44 (m, 3H), 7.41 – 7.34 (m, 2H), 7.33 – 7.28 (m, 1H), 7.21 – 7.16 (m, 1H), 7.01 – 6.96 (m, 1H), 4.75 (s, 1H) ppm; $^{13}$C NMR (101 MHz, CDCl$_3$) $\delta$ = 191.95, 191.47, 134.66, 134.50, 134.28, 134.22, 133.90, 130.11, 129.71, 128.81, 128.61, 126.56, 125.75, 124.27, 73.73, 59.72 ppm; EI-HRMS: Calcd for C$_{20}$H$_{14}$O$_3$S [M+H]$^+$ 335.0742, Found 335.0737.

7. Characterization of the products

(2,5-diphenyl-1,3-dioxolane-4,4-diyl)bis(phenylmethanone) 3a:

Viscous oil in 92% yield (petroleum ether : EtOAc = 20: 1); $[\alpha]_{D}^{26} = -119.52$ (c 0.84, CH$_2$Cl$_2$); the ee was determined by HPLC analysis using a chiral ASH column (iPrOH/hexane = 2/98, 1.0 mL/min, 254 nm), $t_r$ (minor) = 9.22 min, $t_r$ (major) = 10.35 min, 90% ee; $^1$H NMR (400 MHz, CDCl$_3$) $\delta$ 8.11 – 8.02 (m, 2H), 7.76 – 7.66 (m, 4H), 7.52 – 7.46 (m, 4H), 7.43 – 7.35 (m, 5H), 7.19 – 7.09 (m, 5H), 6.59 (s, 1H), 6.06 (s, 1H) ppm.

(5-phenyl-2-(m-tolyl)-1,3-dioxolane-4,4-diyl)bis(phenylmethanone) 3b:

Viscous oil in 97% yield (petroleum ether : EtOAc = 20: 1); $[\alpha]_{D}^{26} = -101.16$ (c 0.60, CH$_2$Cl$_2$); the ee was determined by HPLC analysis using a chiral ID column (iPrOH/hexane = 10/90, 1.0 mL/min, 254 nm), $t_r$ (minor) = 8.19 min, $t_r$ (major) = 8.75 min, 89% ee; $^1$H NMR (400 MHz, CDCl$_3$) $\delta$ 8.08 (d, $J = 7.6$ Hz, 2H), 7.72 (d, $J = 7.6$ Hz, 2H), 7.56 – 7.51 (m, 2H), 7.51 – 7.47(m, 1H), 7.43 – 7.35 (m, 6H), 7.31 – 7.27 (m, 1H), 7.21 – 7.08 (m, 5H), 6.58 (s, 1H), 6.02 (s, 1H), 2.44 (s, 3H) ppm; $^{13}$C NMR (101 MHz, CDCl$_3$) $\delta$ 196.37, 194.27, 138.27, 135.61, 134.81, 134.57, 134.22, 133.46, 132.96, 130.70, 130.28, 129.96, 128.49, 128.44, 128.22, 127.94, 127.88, 127.72, 127.49, 124.28, 104.40, 94.89, 82.64, 21.52 ppm; EI-HRMS: Calcd for C$_{30}$H$_{24}$O$_4$ [M+Na]$^+$ 471.1572, Found 471.1571.
(2-(3-methoxyphenyl)-5-phenyl-1,3-dioxolane-4,4-diyl)bis(phenylmethanone) 3c: Viscous oil in 90% yield (petroleum ether : EtOAc = 10: 1); \([\alpha]^{26}_D = -77.30 \) (c 0.89, CH2Cl2); the ee was determined by HPLC analysis using a chiral IE column (iPrOH/hexane = 10/90, 1.0 mL/min, 254 nm), \(t_r \) (minor) = 8.19 min, \(t_r \) (major) =8.75 min, 88% ee; \(^1\)H NMR (400 MHz, CDCl3) \(\delta \) 8.08 (d, \(J = 7.6 \) Hz, 2H), 7.72 (d, \(J = 7.6 \) Hz, 2H), 7.56 – 7.51 (m, 2H), 7.51 – 7.47 (m, 1H), 7.43 – 7.35 (m, 6H), 7.32 – 7.28 (m, 1H), 7.20 – 7.12 (m, 5H), 6.58 (s, 1H), 6.02 (s, 1H), 2.44 (s, 3H) ppm; \(^13\)C NMR (101 MHz, CDCl3) \(\delta \) 196.37, 194.27, 138.27, 136.51, 135.61, 134.81, 134.47, 134.17, 133.53, 133.00, 130.26, 129.99, 129.44, 128.22, 127.94, 127.88, 127.72, 127.49, 124.28, 104.40, 94.89, 82.64, 21.52 ppm; EI-HRMS: Calcd for C30H24O5 \([\text{M}+\text{Na}]^+ \) 487.1521, Found 487.1520.

(2-(3-phenoxyphenyl)-5-phenyl-1,3-dioxolane-4,4-diyl)bis(phenylmethanone) 3d: Viscous oil in 96% yield (petroleum ether : EtOAc = 10: 1); \([\alpha]^{26}_D = -70.68 \) (c 1.01, CH2Cl2); the ee was determined by HPLC analysis using a chiral IE column (iPrOH/hexane = 10/90, 1.0 mL/min, 254 nm), \(t_r \) (minor) = 9.30min, \(t_r \) (major) =10.09 min, 83% ee; \(^1\)H NMR (400 MHz, CDCl3) \(\delta \) 8.07 (d, \(J = 7.6 \) Hz, 2H), 7.68 (d, \(J = 7.6 \) Hz, 2H), 7.54 – 7.41 (m, 5H), 7.40 – 7.34 (m, 6H), 7.21 – 7.04 (m, 9H), 6.58 (s, 1H), 6.03 (s, 1H) ppm; \(^13\)C NMR (101 MHz, CDCl3) \(\delta \) 196.10, 194.06, 157.58, 156.89, 136.98, 135.52, 134.47, 134.17, 133.53, 133.00, 130.26, 129.99, 129.44, 128.22, 127.94, 127.88, 127.72, 127.49, 124.28, 104.40, 94.89, 82.64, 21.52 ppm; EI-HRMS: Calcd for C35H26O5 \([\text{M}+\text{Na}]^+ \) 549.1678, Found 549.1677.
(5-phenyl-2-(p-tolyl)-1,3-dioxolane-4,4-diyl)bis(phenylmethanone) 3e: Viscous oil in 95% yield (petroleum ether : EtOAc = 20: 1); $[\alpha]_{D}^{26} = -103.62$ (c 0.41, CH$_2$Cl$_2$); the ee was determined by HPLC analysis using a chiral IB column ($i$PrOH/hexane = 10/90, 1.0 mL/min, 254 nm), $t_r$ (minor) = 5.54 min, $t_r$ (major) = 6.72 min, 86% ee; $^1$H NMR (400 MHz, CDCl$_3$) $\delta$ 8.07 (d, $J = 8.0$ Hz, 2H), 7.76 – 7.67 (m, 2H), 7.66 – 7.58 (m, 2H), 7.52 – 7.46 (m, 1H), 7.44 – 7.33 (m, 5H), 7.33 – 7.27 (m, 2H), 7.22 – 7.07 (m, 5H), 6.58 (s, 1H), 6.03 (s, 1H), 2.43 (s, 3H) ppm; $^{13}$C NMR (101 MHz, CDCl$_3$) $\delta$ 196.35, 194.30, 139.93, 135.62, 134.63, 134.24, 133.45, 132.95, 132.05, 130.28, 129.91, 129.20, 128.48, 128.20, 127.93, 127.74, 127.50, 127.19, 104.38, 94.89, 82.60, 21.45 ppm; EI-HRMS: Calcd for C$_{30}$H$_{24}$O$_4$ [M+Na]$^+$ 471.1572, Found 471.1572.

(2-(3-chlorophenyl)-5-phenyl-1,3-dioxolane-4,4-diyl)bis(phenylmethanone) 3f: Viscous oil in 96% yield (petroleum ether : EtOAc = 20: 1); $[\alpha]_{D}^{26} = -95.90$ (c 0.95, CH$_2$Cl$_2$); the ee was determined by HPLC analysis using a chiral ID column ($i$PrOH/hexane = 10/90, 1.0 mL/min, 254 nm), $t_r$ (minor) = 7.49 min, $t_r$ (major) = 7.93 min, 88% ee; $^1$H NMR (400 MHz, CDCl$_3$) $\delta$ 8.06 (d, $J = 7.6$Hz, 2H), 7.76 (s, 1H), 7.66 – 7.59 (m, 3H), 7.53 – 7.36 (m, 8H), 7.20 – 7.10 (m, 5H), 6.58 (s, 1H), 6.03 (s, 1H) ppm; $^{13}$C NMR (101 MHz, CDCl$_3$) $\delta$ 195.96, 194.04, 137.01, 135.43, 134.54, 134.19, 134.15, 133.63, 133.07, 130.25, 130.08, 129.89, 129.75, 128.57, 128.42, 128.04, 127.81, 127.53, 127.39, 125.47, 103.30, 94.74, 82.86 ppm; EI-HRMS: Calcd for C$_{29}$H$_{21}$Cl$_3$O$_4$ [M+Na]$^+$ 491.1026, Found 491.1025.
(2-(3-bromophenyl)-5-phenyl-1,3-dioxolane-4,4-diyl)bis(phenylmethanone) 3g:
Viscous oil in 99% yield (petroleum ether : EtOAc = 20:1); [α]_{D}^{26} = -93.47 (c 0.81, CH₂Cl₂); the ee was determined by HPLC analysis using a chiral ID column (iPrOH/hexane = 10/90, 1.0 mL/min, 254 nm), t₁ (minor) = 7.88 min, t₁ (major) = 8.35 min, 87% ee; ¹H NMR (400 MHz, CDCl₃) δ 8.06 (d, J = 8.4 Hz, 2H), 7.91 (s, 1H), 7.77 – 7.69(m, 4H), 7.53 – 7.48 (m, 1H), 7.42 – 7.33 (m, 6H), 7.21 – 7.10 (m, 5H), 6.58 (s, 1H), 6.02 (s, 1H) ppm; 13C NMR (101 MHz, CDCl₃) δ 195.98, 194.02, 137.20, 135.44, 134.17, 134.13, 133.65, 133.08, 133.04, 130.30, 130.26, 130.17, 129.76, 128.58, 128.43, 128.05, 127.83, 127.52, 125.97, 122.61, 103.24, 94.73, 82.86 ppm; EI-HRMS: Calcd for C_{29}H_{21}O_{4}Br Na⁺ 535.0521, Found 535.0518.

(2-(naphthalen-1-yl)-5-phenyl-1,3-dioxolane-4,4-diyl)bis(phenylmethanone) 3h:
White solid in 97% yield (petroleum ether : EtOAc = 20:1); [α]_{D}^{18} = -143.82 (c 0.94, CH₂Cl₂); the ee was determined by HPLC analysis using a chiral IC column (iPrOH/hexane = 10/90, 1.0 mL/min, 254 nm), t₁ (minor) = 8.32 min, t₁ (major) = 9.52 min, 77% ee; ¹H NMR (400 MHz, CDCl₃) δ 8.19 (d, J = 7.2 Hz, 1H), 8.16 – 8.08 (m, 2H), 7.98 (d, J = 8.4 Hz, 1H), 7.94 – 7.86(m, 2H), 7.80 – 7.72 (m, 2H), 7.63 – 7.58 (m, 1H), 7.58 – 7.49 (m, 2H), 7.48 – 7.35 (m, 6H), 7.19 – 7.07 (m, 5H), 6.72 (s, 1H), 6.66 (s, 1H) ppm.
(2-(naphthalen-2-yl)-5-phenyl-1,3-dioxolane-4,4-diyl)bis(phenylmethanone) 3i: White solid in 95% yield (petroleum ether : EtOAc = 20: 1); [α]_D^26 = -94.19 (0.77, CH₂Cl₂); the ee was determined by HPLC analysis using a chiral IE column (iPrOH/hexane = 10/90, 1.0 mL/min, 254 nm), t_r (minor) = 10.74 min, t_r (major) = 14.14 min, 87% ee; ^1H NMR (400 MHz, CDCl₃) δ 8.17 (s, 1H), 8.12 (d, J = 8.0 Hz, 2H), 8.01 – 7.97 (m, 1H), 7.95 – 7.86 (m, 3H), 7.74 (d, J = 8.0 Hz, 2H), 7.59 – 7.53 (m, 2H), 7.51 – 7.44 (m, 3H), 7.42 – 7.36 (m, 3H), 7.19 – 7.12 (m, 5H), 6.67 (s, 1H), 6.24 (s, 1H) ppm; ^13C NMR (101 MHz, CDCl₃) δ = 196.32, 194.23, 135.63, 134.57, 134.26, 134.15, 133.54, 133.00, 132.92, 132.36, 130.31, 129.92, 128.55, 128.49, 128.48, 128.31, 128.00, 127.89, 127.79, 127.56, 127.14, 126.93, 126.50, 124.23, 104.48, 94.99, 82.84 ppm; EI-HRMS: Calcd for C₃₃H₂₄O₄ [M+Na]^+ 507.1572, Found 507.1575.

(2-(furan-3-yl)-5-phenyl-1,3-dioxolane-4,4-diyl)bis(phenylmethanone) 3j: Viscous oil in 95% yield (petroleum ether : EtOAc = 10: 1); [α]_D^26 = -140.47 (c 0.77, CH₂Cl₂); the ee was determined by HPLC analysis using a chiral IE column (iPrOH/hexane = 10/90, 1.0 mL/min, 254 nm), t_r (minor) = 9.59 min, t_r (major) = 10.28 min, 89% ee; ^1H NMR (400 MHz, DMSO) δ 8.08 (s, 1H), 7.91 (d, J = 7.4 Hz, 2H), 7.84 (s, 1H), 7.73 (d, J = 7.4 Hz, 2H), 7.63 – 7.58 (m, 1H), 7.57 – 7.52 (m, 1H), 7.50 – 7.44 (m, 2H), 7.40 – 7.34 (m, 4H), 7.23 – 7.13 (m, 3H), 6.88 (d, J = 0.9 Hz, 1H), 6.43 (s, 1H), 6.16 (s, 1H) ppm; ^13C NMR (101 MHz, CDCl₃) δ = 196.23, 194.09, 143.72, 142.34, 135.55, 134.37, 134.09, 133.52, 133.06, 130.26, 129.86, 128.50, 128.27, 127.96, 127.80,
127.38, 121.24, 109.02, 99.35, 94.71, 82.50 ppm; EI-HRMS: Calcd for C_{27}H_{20}O_{5} [M+Na]^+ 447.1208, Found 447.1208.

(5-phenyl-2-(thiophen-3-yl)-1,3-dioxolane-4,4-diyl)bis(phenylmethanone) 3k: Viscous oil in 96% yield (petroleum ether : EtOAc = 20: 1); [α]^{26}_D = -99.19 (c 0.87, CH_{2}Cl_{2}); the ee was determined by HPLC analysis using a chiral ID column (iPrOH/hexane = 10/90, 1.0 mL/min, 254 nm), t_r (minor) = 10.17 min, t_r (major) = 10.84 min, 82% ee; \(^1\)H NMR (400 MHz, CDCl_3) δ 8.06 (d, \(J = 8.4\) Hz, 2H), 7.73 (d, \(J = 8.0\) Hz, 2H), 7.68 (s, 1H), 7.52 – 7.47 (m, 1H), 7.46 – 7.34 (m, 7H), 7.23 – 7.18 (m, 2H), 7.17 – 7.09 (m, 3H), 6.55 (s, 1H), 6.14 (s, 1H) ppm; \(^{13}\)C NMR (101 MHz, CDCl_3) δ 196.29, 194.14, 136.71, 135.53, 134.42, 134.15, 133.51, 133.03, 130.27, 129.89, 128.50, 128.27, 127.96, 127.79, 127.43, 126.54, 126.29, 125.48, 101.12, 94.79, 82.60 ppm; EI-HRMS: Calcd for C_{27}H_{20}O_{5}S [M+Na]^+ 463.0980, Found 463.0976.

(2-(4-chlorophenyl)-5-(m-tolyl)-1,3-dioxolane-4,4-diyl)bis(phenylmethanone) 3l: Viscous oil in 98% yield (petroleum ether : EtOAc = 20: 1); [α]^{26}_D = -86.78 (c 0.90, CH_{2}Cl_{2}); the ee was determined by HPLC analysis using a chiral IE column (iPrOH/hexane = 10/90, 1.0 mL/min, 254 nm), t_r (minor) = 7.54 min, t_r (major) = 8.39 min, 83% ee; \(^1\)H NMR (400 MHz, CDCl_3) δ 8.06 (d, \(J = 8.0\) Hz, 2H), 7.70 (d, \(J = 8.0\) Hz, 2H), 7.63 (d, \(J = 8.0\) Hz, 2H), 7.52 – 7.45 (m, 3H), 7.41 – 7.34 (m, 3H), 7.23 – 7.12 (m, 4H), 7.03 (t, \(J = 7.6\) Hz, 1H), 6.95 – 6.88 (m, 1H), 6.53 (s, 1H), 6.03 (s, 1H), 2.17 (s, 3H) ppm; \(^{13}\)C NMR (101 MHz, CDCl_3) δ 195.99, 194.09, 137.61, 135.86, 135.60, 134.25, 134.07, 133.68, 133.60, 132.95, 130.25, 129.73, 129.15,
(2-(4-bromophenyl)-5-(m-tolyl)-1,3-dioxolane-4,4-diyl)bis(phenyl methanone) 3m: Viscous oil in 96% yield (petroleum ether : EtOAc = 20: 1); [α]26\(^{D}\) = -74.85 (c 1.05, CH\(_2\)Cl\(_2\)); the ee was determined by HPLC analysis using a chiral IE column (iPrOH/hexane = 10/90, 1.0 mL/min, 254 nm), \(t_r\) (minor) = 8.02 min, \(t_r\) (major) = 9.04 min, 83% ee; \(^1\)H NMR (400 MHz, CDCl\(_3\)) \(\delta\) 8.09 – 8.01 (m, 2H), 7.67 – 7.59 (m, 6H), 7.52 – 7.46 (m, 1H), 7.41 – 7.34 (m, 3H), 7.21 – 7.13 (m, 4H), 7.07 – 6.99 (m, 1H), 6.95 – 6.89 (m, 1H), 6.51 (s, 1H), 6.01 (s, 1H), 2.16 (s, 3H) ppm; \(^{13}\)C NMR (101 MHz, CDCl\(_3\)) \(\delta\) 195.97, 194.07, 137.61, 135.59, 134.24, 134.18, 134.05, 133.61, 132.96, 131.74, 130.24, 129.72, 129.15, 128.97, 128.55, 128.30, 127.96, 127.73, 124.63, 124.15, 103.54, 94.66, 82.96, 21.27 ppm; EI-HRMS: Calcd for C\(_{30}\)H\(_{23}\)\(^{79}\)BrO\(_4\) [M+Na]\(^+\) 549.0677, Found 549.0676.

(2-(3-methoxyphenyl)-5-(m-tolyl)-1,3-dioxolane-4,4-diyl)bis(phenyl methanone) 3n: Viscous oil in 93% yield (petroleum ether : EtOAc = 10: 1); [α]22\(^{D}\) = -100.21 (c 0.93, CH\(_2\)Cl\(_2\)); the ee was determined by HPLC analysis using a chiral IE column (iPrOH/hexane = 10/90, 1.0 mL/min, 254 nm), \(t_r\) (minor) = 9.32 min, \(t_r\) (major) = 10.64 min, 86% ee; \(^1\)H NMR (400 MHz, CDCl\(_3\)) \(\delta\) 8.08 (d, \(J\) = 8.0 Hz, 2H), 7.72 (d, \(J\) = 8.4 Hz, 2H), 7.52 – 7.47 (m, 1H), 7.43 – 7.35 (m, 4H), 7.34 – 7.29 (m, 2H), 7.23 – 7.15 (m, 4H), 7.07 – 6.99 (m, 2H), 6.95 – 6.88 (m, 1H), 6.55 (s, 1H), 6.02 (s, 1H), 3.87 (s, 3H), 2.17 (s, 3H) ppm; \(^{13}\)C NMR (101 MHz, CDCl\(_3\)) \(\delta\) 196.25, 194.20, 159.73, 137.51, 136.49, 135.74, 134.36, 134.26, 133.47, 132.90, 132.90, 129.90, 129.64,
129.00, 128.50, 128.28, 127.89, 127.70, 124.61, 119.56, 115.60, 112.63, 104.09, 94.83, 82.76, 55.38, 21.27 ppm; EI-HRMS: Calcd for C\textsubscript{31}H\textsubscript{26}O\textsubscript{5} [M+Na]\textsuperscript{+} 501.1678, Found 501.1684.

(2-phenyl-5-(m-tolyl)-1,3-dioxolane-4,4-diyl)bis(phenylmethanone) 3o:
Viscous oil in 98% yield (petroleum ether : EtOAc = 20: 1); \([\alpha]\textsuperscript{26}\textsubscript{D} = -117.43 (c 0.61, CH\textsubscript{2}Cl\textsubscript{2}); the ee was determined by HPLC analysis using a chiral IE column (iPrOH/hexane = 10/90, 1.0 mL/min, 254 nm), \(t\) (minor) = 7.89 min, \(t\) (major) = 8.78 min, 84% ee; \(^1\)H NMR (400 MHz, CDCl\textsubscript{3}) \(\delta 7.98 (d, J = 8.0 \text{ Hz}, 2\text{H}), 7.68 – 7.58 (m, 4\text{H}), 7.42 – 7.36 (m, 4\text{H}), 7.32 – 7.24 (m, 3\text{H}), 7.16 – 7.05 (m, 4\text{H}), 6.94 (t, J = 7.6 \text{ Hz}, 1\text{H}), 6.86 – 6.79 (m, 1\text{H}), 6.46 (s, 1\text{H}), 5.96 (s, 1\text{H}), 2.07 (s, 3\text{H}) \text{ppm}; \(^{13}\)C NMR (101 MHz, CDCl\textsubscript{3}) \(\delta 196.32, 194.27, 137.54, 135.71, 135.04, 134.34, 134.27, 133.49, 132.92, 130.29, 129.93, 129.91, 129.02, 128.54, 128.51, 128.27, 127.90, 127.69, 127.25, 124.60, 104.27, 94.80, 82.81, 21.29 ppm; EI-HRMS: Calcd for C\textsubscript{30}H\textsubscript{24}O\textsubscript{4} [M+Na]\textsuperscript{+} 471.1572, Found 471.1572.

(2-phenyl-5-(p-tolyl)-1,3-dioxolane-4,4-diyl)bis(phenylmethanone) 3p:
Viscous oil in 92% yield (petroleum ether : EtOAc = 20: 1); \([\alpha]\textsuperscript{26}\textsubscript{D} = -88.39 (c 0.62, CH\textsubscript{2}Cl\textsubscript{2}); the ee was determined by HPLC analysis using a chiral IE column (iPrOH/hexane = 10/90, 1.0 mL/min, 254 nm), \(t\) (minor) = 10.36 min, \(t\) (major) = 11.52 min, 82% ee; \(^1\)H NMR (400 MHz, CDCl\textsubscript{3}) \(\delta 8.09 – 8.02 (m, 2\text{H}), 7.76 – 7.68 (m, 4\text{H}), 7.52 – 7.45 (m, 4\text{H}), 7.42 – 7.34 (m, 3\text{H}), 7.32 – 7.27 (m, 2\text{H}), 7.20 – 7.13 (m, 2\text{H}), 6.99 – 6.89 (m, 2\text{H}), 6.56 (s, 1\text{H}), 6.05 (s, 1\text{H}), 2.20 (s, 3\text{H}) \text{ppm};
$^{13}$C NMR (101 MHz, CDCl$_3$) $\delta$ = 196.49, 194.29, 137.95, 135.54, 135.06, 134.23, 133.46, 132.91, 131.42, 130.27, 129.95, 129.86, 128.68, 128.50, 128.48, 127.71, 127.38, 127.17, 104.14, 94.82, 82.75, 21.14 ppm; EI-HRMS: Calcd for C$_{30}$H$_{24}$O$_4$ [M+Na]$^+$ 471.1572, Found 471.1572.

(5-(benzo[d][1,3]dioxol-5-yl)-2-phenyl-1,3-dioxolane-4,4-diyl)bis(phenylmethanone) 3q: Viscous oil in 94% yield (petroleum ether : EtOAc = 10: 1); $[\alpha]^2_{D}$ = -94.48 (c 0.86, CH$_2$Cl$_2$); the ee was determined by HPLC analysis using a chiral ID column (iPrOH/hexane = 10/90, 1.0 mL/min, 254 nm), $t_r$ (minor) = 16.00 min, $t_r$ (major) =17.44 min, 86% ee; $^1$H NMR (400 MHz, CDCl$_3$) $\delta$ 8.06 (d, $J$ = 8.0 Hz, 2H), 7.78 – 7.69 (m, 4.9 Hz, 4H), 7.52 – 7.45 (m, 4H), 7.44 – 7.34 (m, 3H), 7.24 – 7.17 (m, 2H), 6.95 – 6.85 (m, 2H), 6.59 (d, $J$ = 8.0 Hz, 1H), 6.50 (s, 1H), 6.03 (s, 1H), 5.86 – 5.77 (m, 2H) ppm; $^{13}$C NMR (101 MHz, CDCl$_3$) $\delta$ = 196.14, 194.19, 147.46, 147.36, 135.57, 134.99, 134.22, 133.53, 133.03, 130.26, 129.91, 129.88, 128.53, 128.51, 128.25, 127.83, 127.14, 121.41, 108.13, 108.83, 104.09, 100.96, 94.74, 82.65 ppm; EI-HRMS: Calcd for C$_{30}$H$_{22}$O$_6$ [M+Na]$^+$ 501.1314, Found 501.1310.

(5-(2-fluorophenyl)-2-(3-methoxyphenyl)-1,3-dioxolane-4,4-diyl)bis(phenylmethanone) 3r: Viscous oil in 93% yield (petroleum ether : EtOAc = 10: 1); $[\alpha]^2_{D}$ = -110.47 (c 0.90, CH$_2$Cl$_2$); the ee was determined by HPLC analysis using a chiral ID column (iPrOH/hexane = 10/90, 1.0 mL/min, 254 nm), $t_r$ (minor) = 13.07 min, $t_r$ (major) =18.46 min, 84% ee; $^1$H NMR (400 MHz, CDCl$_3$) $\delta$ 8.08 (d, $J$ = 8.4 Hz, 2H), 7.73 (d, $J$ = 8.4 Hz, 2H), 7.53 – 7.48 (m, 1H), 7.45 – 7.36 (m, 4H), 7.31 – 7.27 (m, 2H), 7.23 – 7.16 (m, 3H), 7.16...
(5-(3-fluorophenyl)-2-(3-methoxyphenyl)-1,3-dioxolane-4,4-diyl)bis(phenylmethanone) 3s: Viscous oil in 93% yield (petroleum ether : EtOAc = 10: 1); [α] kinky = -79.87 (c 0.92, CH2Cl2); the ee was determined by HPLC analysis using a chiral IE column (tPrOH/hexane = 10/90, 1.0 mL/min, 254 nm), tR (major) = 10.24 min, 83% ee; 1H NMR (400 MHz, CDCl3) δ 8.08 (d, J = 7.6 Hz, 2H), 7.73 (d, J = 7.6 Hz, 2H), 7.54 – 7.48 (m, 1H), 7.44 – 7.36 (m, 4H), 7.31 – 7.26 (m, 2H), 7.24 – 7.16 (m, 3H), 7.15 – 7.09 (m, 2H), 7.05 – 7.01 (m, 1H), 6.85 – 6.76 (m, 1H), 6.56 (s, 1H), 6.02 (s, 1H), 3.86 (s, 3H) ppm; 13C NMR (101 MHz, CDCl3) δ = 195.99, 193.98, 163.61, 161.16, 159.77, 137.21, 137.13, 136.14, 135.49, 134.03, 133.60, 133.21, 130.28, 129.86, 129.71, 129.61, 129.53, 128.55, 127.89, 123.27, 119.38, 115.61, 115.26, 115.04, 114.58, 114.35, 112.58, 104.19, 94.93, 81.93, 55.38 ppm; EI-HRMS: Calcd for C30H23FO5 [M+Na]+ 505.1427, Found 505.1428.

(5-(4-fluorophenyl)-2-(3-methoxyphenyl)-1,3-dioxolane-4,4-diyl)bis(phenylmethanone) 3t: Viscous oil in 99% yield (petroleum ether : EtOAc = 10: 1); [α] biz = -109.94 (c 0.98, CH2Cl2); the ee was determined by HPLC analysis using a chiral
IE column (iPrOH/hexane = 10/90, 1.0 mL/min, 254 nm), \( t_r \) (minor) = 9.09 min, \( t_r \) (major) =9.84 min, 85% ee; \(^1\)H NMR (400 MHz, CDCl\(_3\)) \( \delta \) 8.07 (d, \( J = 7.6 \) Hz, 2H), 7.73 (d, \( J = 8.4 \) Hz, 2H), 753 – 7.48 (m, 1H), 7.44 – 7.35 (m, 6H), 7.32 – 7.28 (m, 2H), 7.23 – 7.17 (m, 2H), 7.05 – 7.00 (m, 1H), 6.87 – 6.79 (m, 2H), 6.56 (s, 1H), 6.03 (s, 1H), 3.86 (s, 3H) ppm; \(^{13}\)C NMR (101 MHz, CDCl\(_3\)) \( \delta \) 196.13, 194.12, 163.75, 161.29, 159.75, 136.29, 135.47, 134.09, 133.61, 133.21, 130.39, 130.36, 130.27, 129.85, 129.70, 129.22, 128.55, 127.91, 119.39, 115.49, 115.05, 114.84, 112.65, 104.08, 94.83, 82.09, 55.39 ppm; EI-HRMS: Calcd for C\(_{30}\)H\(_{23}\)FO\(_5\) [M+Na]+ 505.1427, Found 505.1431.

(5-(4-chlorophenyl)-2-(3-methoxyphenyl)-1,3-dioxolane-4,4-diyl)bis(phenylmethanone) 3u: Viscous oil in 93% yield (petroleum ether : EtOAc = 10: 1); \([\alpha]_{26}^{20} = -70.39 \) (c 0.93, CH\(_2\)Cl\(_2\)); the ee was determined by HPLC analysis using a chiral IE column (iPrOH/hexane = 10/90, 1.0 mL/min, 254 nm), \( t_r \) (minor) = 9.40 min, \( t_r \) (major) = 10.21 min, 80% ee; \(^1\)H NMR (400 MHz, CDCl\(_3\)) \( \delta \) 8.06 (d, \( J = 8.0 \) Hz, 2H), 7.72 (d, \( J = 7.6 \) Hz, 2H), 7.52 – 7.47 (m, 1H), 7.45 – 7.30 (m, 7H), 7.28 (s, 1H), 7.23 – 7.17 (m, 2H), 7.11 (d, \( J = 8.4 \) Hz, 2H), 7.04 – 6.99 (m, 1H), 6.53 (s, 1H), 6.01 (s, 1H), 3.85 (s, 3H) ppm; \(^{13}\)C NMR (101 MHz, CDCl\(_3\)) \( \delta \) = 195.25, 191.34, 159.74, 136.17, 135.42, 134.09, 133.99, 133.64, 133.27, 133.14, 130.29, 129.90, 129.72, 128.78, 128.47, 127.93, 119.35, 115.48, 112.64, 104.14, 94.90, 82.01, 55.40 ppm; EI-HRMS: Calcd for C\(_{30}\)H\(_{23}\)ClO\(_5\) [M+Na]+ 521.1132, Found 521.1129.

(5-(furan-2-yl)-2-phenyl-1,3-dioxolane-4,4-diyl)bis(phenylmethanone) 3v: Viscous oil in 97% yield (petroleum ether : EtOAc = 10: 1); \([\alpha]_{26}^{20} = -101.94 \) (c 0.82, CH\(_2\)Cl\(_2\)); the ee was determined by HPLC analysis using a chiral IC column (iPrOH/hexane = 10/90, 1.0 mL/min, 254 nm), \( t_r \) (minor) = 9.24 min, \( t_r \) (major) = 13.44 min, 86% ee; \(^1\)H NMR (400 MHz, DMSO) \( \delta \) 7.94 (d, \( J = 7.2 \) Hz, 2H), 7.78 – 7.72 (m, 4H), 7.62 – 7.54 (m, 2H), 7.53 – 7.49 (m, 3H), 7.48 – 7.43 (m, 3H), 7.39 – 7.34 ppm; EI-HRMS: Calcd for C\(_{30}\)H\(_{23}\)ClO\(_5\) [M+Na]+ 521.1132, Found 521.1129.
(m, 2H), 6.60 (s, 1H), 6.57 (d, J = 3.2 Hz, 1H), 6.30 – 6.24 (m, 1H), 6.03 (s, 1H) ppm; $^{13}$C NMR (101 MHz, DMSO) δ 194.32, 192.46, 147.46, 143.98, 134.77, 134.16, 134.11, 133.58, 133.43, 130.16, 129.56, 129.11, 128.85, 128.46, 128.22, 127.44, 111.87, 110.57, 103.71, 93.20, 75.74 ppm; EI-HRMS: Calcd for C$_{27}$H$_{20}$O$_{5}$ [M+Na]$^+$ 447.1208, Found 447.1209.

(5-(furan-3-yl)-2-phenyl-1,3-dioxolane-4,4-diyl)bis(phenylmethanone)

3w: Viscous oil in 96% yield (petroleum ether : EtOAc = 10: 1); [α]$^{26}_{D} = -132.14$ (c 0.87, CH$_2$Cl$_2$); the ee was determined by HPLC analysis using a chiral IE 90/10 column (iPrOH/hexane = 10/90, 1.0 mL/min, 254 nm), $t_r$ (minor) = 8.86 min, $t_r$ (major) = 9.44 min, 90% ee; $^1$H NMR (400 MHz, DMSO) δ 7.94 (d, J = 8.0 Hz, 2H), 7.78 (d, J = 8.0 Hz, 2H), 7.74 (s, 1H), 7.72 – 7.68 (m, 2H), 7.62 – 7.54 (m, 2H), 7.54 – 7.45 (m, 6H), 7.40 – 7.31 (m, 2H), 6.50 (s, 1H), 6.27 (s, 1H), 6.08 (s, 1H) ppm; $^{13}$C NMR (101 MHz, DMSO) δ = 195.72, 193.35, 143.73, 141.71, 134.58, 134.51, 133.94, 133.62, 133.53, 130.03, 129.55, 129.33, 128.82, 128.50, 128.25, 127.18, 120.06, 109.47, 103.61, 93.65, 75.93 ppm; EI-HRMS: Calcd for C$_{27}$H$_{20}$O$_{5}$ [M+Na]$^+$ 447.1208, Found 447.1211.

(2-phenyl-5-(thiophen-2-yl)-1,3-dioxolane-4,4-diyl)bis(phenylmethanone)

e) 3x: Viscous oil in 97% yield (petroleum ether : EtOAc = 20: 1); [α]$^{26}_{D} = -155.39$ (c 0.74, CH$_2$Cl$_2$); the ee was determined by HPLC analysis using a chiral IE 90/10 column (iPrOH/hexane = 10/90, 1.0 mL/min, 254 nm), $t_r$ (minor) = 10.52 min, $t_r$ (major) = 11.03 min, 91% ee; $^1$H NMR (400 MHz, DMSO) δ 7.95 (d, J = 8.0 Hz, 2H), 7.77 – 7.70 (m, 4H), 7.63 – 7.57 (m, 1H), 7.56 – 7.50 (m, 4H), 7.50 – 7.44 (m, 2H), 7.40 – 7.36 (m, 1H), 7.36 – 7.30 (m, 2H), 7.09 – 7.04 (m, 1H), 6.89 – 6.84 (m, 1H), 6.82 (s, 1H), 6.10 (s, 1H) ppm; $^{13}$C NMR (101 MHz, DMSO) δ = 195.01, 193.03, 143.73, 141.71, 134.58, 134.51, 133.74, 133.62, 133.53, 130.03, 129.55, 129.33, 128.82, 128.50, 128.25, 127.18, 120.06, 109.47, 103.61, 93.65, 75.93 ppm; EI-HRMS: Calcd for C$_{27}$H$_{20}$O$_{5}$ [M+Na]$^+$ 447.1208, Found 447.1211.
(2-phenyl-5-(thiophen-3-yl)-1,3-dioxolane-4,4-diyl)bis(phenylmethanone) 3y: Viscous oil in 97% yield (petroleum ether : EtOAc = 20: 1); $[\alpha]_{D}^{26} = -130.83$ (c 0.92, CH$_2$Cl$_2$); the ee was determined by HPLC analysis using a chiral IE 90/10 column ($i$PrOH/hexane = 10/90, 1.0 mL/min, 254 nm), $t_r$ (minor) = 10.03 min, $t_r$ (major) = 10.75 min, 90% ee; $^{1}H$ NMR (400 MHz, CDCl$_3$) $\delta$ 8.08 (d, $J$ = 7.6 Hz, 2H), 7.75 (d, $J$ = 8.2 Hz, 2H), 7.73 – 7.69 (m, 2H), 7.51 – 7.46 (m, 4H), 7.42 – 7.35(m, 3H), 7.29 – 7.26 (m, 1H), 7.23 – 7.18 (m, 2H), 7.11 – 7.07 (m, 1H), 7.04 – 6.99 (m 1H), 6.64 (s, 1H), 6.03 (s, 1H) ppm; $^{13}C$ NMR (101 MHz, CDCl$_3$) $\delta$ = 196.13, 194.14, 135.79, 135.42, 135.01, 134.13, 133.59, 133.03, 130.27, 129.93, 129.73, 128.52, 127.85, 127.15, 126.93, 125.73, 123.90, 104.31, 94.49, 79.95 ppm; EI-HRMS: Calcd for C$_{27}$H$_{20}$O$_4$S [M+Na]$^+$ 463.0980, Found 463.0973.

(2,5-diphenyl-1,3-dioxolane-4,4-diyl)bis(p-tolylmethanone) 3z: Viscous oil in 99% yield (petroleum ether : EtOAc = 20: 1); $[\alpha]_{D}^{26} = -89.82$ (c 0.90, CH$_2$Cl$_2$); the ee was determined by HPLC analysis using a chiral ID column ($i$PrOH/hexane = 10/90, 1.0 mL/min, 254 nm), $t_r$ (minor) = 10.92 min, $t_r$ (major) = 11.51 min, 87% ee; $^{1}H$ NMR (400 MHz, CDCl$_3$) $\delta$ 7.98 (d, $J$ = 8.4 Hz, 2H), 7.79 – 7.73 (m, 2H), 7.63 (d, $J$ = 8.4 Hz, 2H), 7.52 – 7.47 (m, 3H), 7.45 – 7.40 (m, 2H), 7.18 – 7.09 (m, 5H), 6.96 (d, $J$ = 8.4 Hz, 2H), 6.59 (s, 1H), 6.04 (s, 1H), 2.34 (s, 3H), 2.29 (s, 3H) ppm; $^{13}C$ NMR (101 MHz, CDCl$_3$) $\delta$ = 195.49, 193.94, 144.45, 143.88, 135.18, 134.82, 133.92, 131.74, 130.43, 130.04, 129.84, 129.20, 128.51, 128.48, 128.19, 127.90, 127.63, 127.19, 104.05, 94.94, 82.56, 21.70, 21.65 ppm; EI-HRMS: Calcd for C$_{31}$H$_{26}$O$_4$ [M+Na]$^+$ 485.1729, Found 485.1731.
8. Reference
9. Copy of $^1$H NMR and $^{13}$C NMR spectra for products and substrates
Current data parameters

FT - Acquisition Parameters
SOLVENT: DMSO
DS: 11763
NS: 100000
TE: 14.2
DG: undefined
FF: 234-1 Hz
AD: 10.017Hz
TM: 246.2

--------------- CHANNEL 1 --------------
ROE: 18
PD: 18.5 Hz
SPG: undefined NG:

E2 - Processing Parameters
DS: 18
M1: 8
M2: 0
PG: 20 Hz
PP: 5.5 Hz
NF: 10.13 Hz
NH: 3.5 Hz

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Current data parameters

FS - Acquisition Parameters
Daten: 2012-02-21 19:02:17
Proton: 39.50
Solvent: CD3OD
S = 16
pH = undefined
MW: 312.2
AUC: unknown
TE: 90°

FS - Processing Parameters
Z = 64
V = 0.75
FWHM: 0.50 Hz
PFT: Wyckoff
Phase: normal
Max: 41.14
Min: 20.04
10. Copy of CD spectras for products
Circular Dichroism (mdeg)

Wavelength (nm)

Circular Dichroism (mdeg)

Wavelength (nm)

Circular Dichroism (mdeg)

Wavelength (nm)