Catalytic Asymmetric Reaction with Water: Enantioselective Synthesis of α-Hydroxyesters by Copper-carbenoid O–H Insertion Reaction

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General. All reactions and manipulations were performed using standard Schlenk techniques. All solvents were purified and dried using standard procedures. CuCl and CuPF₆(MeCN)₄ were prepared according to the literature procedures.¹ The other copper salts were purchased and used without further purification. Ligands ¹ ² ³ ⁴ ⁵ ⁶ ⁷ ⁸ ⁹

were prepared by literature methods. All the 2-diazophenylacetates were prepared according to the literature procedure. Melting points were measured on a RY–I apparatus and uncorrected. NMR spectra were recorded on a Bruker or Varian spectrometer at 400 or 300 (1H NMR), 100 or 75 (13C NMR) MHz. Chemical shifts (δ values) were reported in ppm down field from internal Me4Si (1H and 13C NMR). Optical rotations were determined using a Perkin Elmer 341 MC polarimeter. HRMS were recorded on VG ZAB-HS mass spectrometer with EI resource. HPLC analyses were performed on a Hewlett Packard Model HP 1100 Series chromatography. SFC analyses were performed on Mettler-Toledo Model Analytix SFC.

1. Typical Procedure for Cu-catalyzed Asymmetric Insertion of Carbenoid into Water

The CuSO4 (2.4 mg, 0.015 mmol, 5 mol%), (S,R,S,S)-1a (9.1 mg, 0.018 mmol, 6 mol%) and NaBARF (16.9 mg, 0.018 mmol, 6 mol%) were introduced into an oven-dried Schlenk tube in argon-filled glovebox. After CHCl3 (3 mL) was injected into the Schlenk tube, the solution was stirred at room temperature under the argon atmosphere for 4 h. Then the Schlenk tube was heated to 40 °C, H2O (27 mg, 1.5 mmol) and diazoesters (0.3 mmol) were injected. The resulting mixture was stirred at 40 °C for 15 min and the product was purified by flash chromatography (ethyl acetate/petroleum ether = 1:5). The analytical data for α-hydroxyesters are listed below.

2. Analytical Data for Insertion Products

(R)-(−)-Methyl 2-hydroxy-2-phenylacetate (3a).11 Colorless oil; 91% yield; 1H NMR (400 MHz, CDCl3): δ 7.43–7.33 (m, 5H), 5.18 (d, J = 4.8 Hz, 1H), 3.76 (s, 3H), 3.46 (d, J = 5.2 Hz, 1H); 90% ee [SFC condition:

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Chiralcel OD-H column, sc CO$_2$/i-PrOH = 80:20, flow rate = 2.0 mL/min, wavelength = 220 nm, pressure = 100 bar, $t_R = 2.35$ min for (S)-enantiomer, $t_R = 2.87$ min for (R)-enantiomer; $[\alpha]_D^{25} = -122$ ($c$ 1.00, EtOH) [lit: $[\alpha]_D^{20} = -130$ ($c$ 1.03, EtOH) for (R)].

$\textbf{(R)-(–)-Ethyl 2-hydroxy-2-phenylacetate (3b).}$\textsuperscript{13} Colorless oil; 91\% yield; $^1$H NMR (400 MHz, CDCl$_3$): $\delta$ 7.43–7.30 (m, 5H), 5.15 (d, $J = 5.6$ Hz, 1H), 4.31–4.13 (m, 2H), 3.47 (d, $J = 5.6$ Hz, 1H), 1.23 (t, $J = 7.2$ Hz, 3H); 88\% ee [SFC condition: Chiralcel OD-H column, sc CO$_2$/i-PrOH = 94:6, flow rate = 2.0 mL/min, wavelength = 220 nm, pressure = 100 bar, $t_R = 4.15$ min for (S)-enantiomer, $t_R = 5.71$ min for (R)-enantiomer]; $[\alpha]_D^{25} = -104$ ($c$ 1.00, CHCl$_3$) [lit: $[\alpha]_D^{25} = -126$ ($c$ 2.01, CHCl$_3$) for (R)].

$\textbf{(R)-(–)-Isopropyl 2-hydroxy-2-phenylacetate (3c).}$\textsuperscript{13} Colorless oil; 81\% yield; $^1$H NMR (300 MHz, CDCl$_3$): $\delta$ 7.44–7.31 (m, 5H), 5.13–5.03 (m, 1H), 3.48 (d, $J = 6.0$ Hz, 1H), 1.28 (d, $J = 6.0$ Hz, 3H), 1.11 (d, $J = 6.0$ Hz, 3H); 86\% ee [SFC condition: Chiralcel OD-H column, sc CO$_2$/i-PrOH = 94:6, flow rate = 2.0 mL/min, wavelength = 220 nm, pressure = 100 bar, $t_R = 4.71$ min for (R)-enantiomer]; $[\alpha]_D^{25} = -96.1$ ($c$ 1.15, CHCl$_3$) [lit: $[\alpha]_D^{25} = -98.9$ ($c$ 1.00, CHCl$_3$) for (R)].

$\textbf{(R)-(–)-Methyl 2-hydroxy-2-\text{p}-tolylacetate (3d).}$\textsuperscript{13} Colorless oil; 83\% yield; $^1$H NMR (400 MHz, CDCl$_3$): $\delta$ 7.29 (d, $J = 8.0$ Hz, 2H), 7.17 (d, $J = 8.0$ Hz, 2H), 5.14 (d, $J = 5.2$ Hz, 1H), 3.75 (s, 3H), 3.40 (brs, 1H), 2.35 (s, 3H); 92\% ee [SFC condition: Chiralcel OD-H column, sc CO$_2$/i-PrOH = 90:10, flow rate = 2.0 mL/min, wavelength = 220 nm, pressure = 100 bar, $t_R = 3.41$ min for (S)-enantiomer, $t_R = 3.89$ min for (R)-enantiomer]; $[\alpha]_D^{25} = -108$ ($c$ 0.90, EtOH).

$\textbf{(–)-Mehtyl 2-hydroxy-2-(4-biphenyl)acetate (3e).}$ White solid; 87\% yield; mp = 103–104 °C; $^1$H NMR (300 MHz, CDCl$_3$): $\delta$ 7.50–7.24 (m, 9H), 5.13 (s, 1H), 3.66 (s, 3H), 3.53 (d, $J = 1.5$ Hz, 1H); $^{13}$C NMR (75


MHz, CDCl₃): δ 174.1, 141.5, 140.6, 137.3, 128.8, 127.5, 127.4, 127.1, 72.8, 53.0; HRMS (EI) Calcd for C₁₅H₁₄O₃: 242.0943; Found: 242.0969; 92% ee [SFC condition: Chiralcel OD-H column, sc CO₂/i-PrOH = 94:6, flow rate = 2.0 mL/min, wavelength = 220 nm, pressure = 100 bar, tᵣ = 18.69 min for minor isomer, tᵣ = 20.47 min for major isomer]; [α]₂⁵ = -135 (c 1.80, CHCl₃).

(–)-Methyl 2-(4-fluorophenyl)-2-hydroxyacetate (3f).¹⁶ Colorless oil; 90% yield; ¹H NMR (300 MHz, CDCl₃): δ 7.32 (dd, J = 5.4 and 8.4 Hz, 2H), 6.97 (t, J = 8.7 Hz, 2H), 5.09 (s, 1H), 3.68 (s, 3H), 3.47 (brs, 1H); 92% ee [SFC condition: Chiralpak AD-H column, sc CO₂/i-PrOH = 90:10, flow rate = 2.0 mL/min, wavelength = 220 nm, pressure = 100 bar, tᵣ = 3.61 min for minor isomer, tᵣ = 3.90 min for major isomer]; [α]₂⁵ = -89.4 (c 0.70, acetone).

(R)-(–)-Methyl 2-(4-chlorophenyl)-2-hydroxyacetate (3g).¹⁶ Colorless oil; 83% yield; ¹H NMR (300 MHz, CDCl₃): δ 7.39–7.32 (m, 4H), 5.16 (d, J = 5.4 Hz, 1H), 3.77 (s, 3H), 3.45 (d, J = 5.4 Hz, 1H); 92% ee [SFC condition: Chiralcel OD-H column, sc CO₂/i-PrOH = 94:6, flow rate = 2.0 mL/min, wavelength = 220 nm, pressure = 100 bar, tᵣ = 5.80 min for (S)-enantiomer, tᵣ = 6.26 min for (R)-enantiomer]; [α]₂⁵ = -61.4 (c 0.35, acetone).

(R)-(–)-Methyl 2-(4-bromophenyl)-2-hydroxyacetate (3h).¹⁶ Colorless oil; 86% yield; ¹H NMR (300 MHz, CDCl₃): δ 7.50 (d, J = 8.4 Hz, 2H), 7.31 (d, J = 8.4 Hz, 2H), 5.14 (s, 1H), 3.77 (s, 3H), 3.48 (brs, 1H); 91% ee [SFC condition: Chiralcel OD-H column, sc CO₂/i-PrOH = 94:6, flow rate = 2.0 mL/min, wavelength = 220 nm, pressure = 100 bar, tᵣ = 7.07 min for (S)-enantiomer, tᵣ = 7.65 min for (R)-enantiomer]; [α]₂⁵ = -71.2 (c 0.70, acetone).

(–)-Methyl 2-hydroxy-2-m-toly lacetate (3i). Colorless oil; 87% yield; ¹H NMR (300 MHz, CDCl₃): δ 7.19–7.04 (m, 4H), 5.04 (d, J = 5.7 Hz, 1H), 3.66 (s, 3H), 3.45 (d, J = 5.7 Hz, 1H), 2.27 (s, 3H); ¹³C NMR (75 MHz, CDCl₃): δ 174.2, 138.4, 138.3, 129.3, 128.5, 127.2, 123.8, 73.0, 52.9, 21.4; HRMS (EI) Calcd for C₁₀H₁₂O₃: 180.0786; Found: 180.0789; 92% ee [SFC condition: Chiralcel OD-H

column, sc CO$_2$/i-PrOH = 94:6, flow rate = 2.0 mL/min, wavelength = 220 nm, pressure = 100 bar, $t_R$ = 4.68 min for minor isomer, $t_R$ = 5.78 min for major isomer; $[\alpha]_D^{25} = -112$ (c 0.35, EtOH).

(R)-(−)-Methyl 2-hydroxy-2-(3-methoxyphenyl)acetate (3j). Colorless oil; 89% yield; $^1$H NMR (300 MHz, CDCl$_3$): $\delta$ 7.23–7.18 (m, 1H), 6.94–6.89 (m, 2H), 6.81–6.78 (m, 1H), 5.08 (s, 1H), 3.73 (s, 3H), 3.69 (s, 3H), 3.41 (d, $J$ = 3.9 Hz, 1H); 91% ee [SFC condition: Chiralcel OD-H column, sc CO$_2$/i-PrOH = 90:10, flow rate = 2.0 mL/min, wavelength = 220 nm, pressure = 100 bar, $t_R$ = 4.42 min for (S)-enantiomer, $t_R$ = 5.11 min for (R)-enantiomer; $[\alpha]_D^{25} = -97.3$ (c 0.75, EtOH).

(−)-Methyl 2-(3-fluorophenyl)-2-hydroxyacetate (3k). Colorless oil; 85% yield; $^1$H NMR (300 MHz, CDCl$_3$): $\delta$ 7.25–7.05 (m, 3H), 6.96–6.90 (m, 1H), 5.09 (d, $J$ = 3.3 Hz, 1H), 3.69 (s, 3H), 3.59 (d, $J$ = 4.5 Hz, 1H); $^{13}$C NMR (75 MHz, CDCl$_3$): $\delta$ 173.6, 164.5, 161.3, 140.7, 140.6, 130.1, 130.0, 122.2, 115.5, 115.2, 113.8, 113.5, 72.3, 53.1; HRMS (EI) Calcd for C$_9$H$_9$FO$_3$: 184.0536; Found: 184.0534; 89% ee [SFC condition: Chiralcel OD-H column, sc CO$_2$/i-PrOH = 95:5, flow rate = 2.0 mL/min, wavelength = 220 nm, pressure = 100 bar, $t_R$ = 4.64 min for major isomer]; $[\alpha]_D^{25} = -117$ (c 0.70, CHCl$_3$).

(R)-(−)-Methyl 2-(3-chlorophenyl)-2-hydroxyacetate (3l). Colorless oil; 88% yield; $^1$H NMR (400 MHz, CDCl$_3$): $\delta$ 7.43–7.31 (m, 4H), 5.15 (s, 1H), 3.78 (s, 3H), 3.51 (brs, 1H); 88% ee [SFC condition: Chiralcel OD-H column, sc CO$_2$/i-PrOH = 90:10, flow rate = 2.0 mL/min, wavelength = 220 nm, pressure = 100 bar, $t_R$ = 3.93 min for (S)-enantiomer, $t_R$ = 4.20 min for (R)-enantiomer; $[\alpha]_D^{25} = -111$ (c 1.80, CHCl$_3$).

(−)-Methyl 2-(3-bromophenyl)-2-hydroxyacetate (m). Colorless oil; 92% yield; $^1$H NMR (300 MHz, CDCl$_3$): $\delta$ 7.61–7.26 (m, 4H), 5.16 (d, $J$ = 5.4 Hz, 1H), 3.80 (s, 3H), 3.52 (d, $J$ = 5.4 Hz, 1H); 88% ee [SFC condition: Chiralcel OD-H column, sc CO$_2$/i-PrOH = 94:6, flow rate = 2.0 mL/min,

wavelength = 220 nm, pressure = 100 bar, \( t_R = 5.42 \text{ min for major isomer, } t_R = 5.94 \text{ min for minor isomer} \); \([\alpha]_D^{26} = -100 (c \ 0.90, \text{EtOH})\).

\((R)-(\cdash)-\text{Methyl 2-(3,4-dichlorophenyl)-2-hydroxyacetate (3n).}\)

Colorless oil; 91% yield; \(^1\text{H NMR (300 MHz, CDCl}_3\): \( \delta 7.46 \ (d, J = 2.1 \text{ Hz, } 1\text{H}), 7.34 \ (d, J = 8.1 \text{ Hz, } 1\text{H}), 7.21\text{--}7.17 \ (m, 1\text{H}), 5.06 \ (d, J = 5.1 \text{ Hz, } 1\text{H}), 3.69 \ (s, 3\text{H}), 3.65 \ (d, J = 3.0 \text{ Hz, } 1\text{H}); ^{13}\text{C NMR (75 MHz, CDCl}_3\): \( \delta 173.2, 138.3, 132.8, 132.6, 130.5, 128.6, 125.9, 71.7, 53.3; \text{HRMS (EI) Calcd for } \text{C}_9\text{H}_8\text{Cl}_2\text{O}_3: 233.9850; \text{Found: 233.9851; 94\% ee [SFC condition: Chiralpak AD-H column, sc CO}_2/i\text{-PrOH = 90:10, flow rate = 2.0 mL/min, wavelength = 220 nm, pressure = 100 bar, } t_R = 6.86 \text{ min for (S)-enantiomer, } t_R = 7.57 \text{ min for (R)-enantiomer}; [\alpha]_D^{25} = -123 (c \ 0.65, \text{CHCl}_3). \text{The absolute configuration was determined by comparing the specific rotation of corresponding acid with the literature data. See next section for details.}\

\((-\cdash)-\text{Methyl 2-hydroxy-2-o-tolylacetate (3o).}\) Colorless oil; 81% yield; \(^1\text{H NMR (300 MHz, CDCl}_3\): \( \delta 7.29\text{--}7.14 \ (m, 4\text{H}), 5.36 \ (d, J = 5.1 \text{ Hz, } 1\text{H}), 3.72 \ (s, 3\text{H}), 3.53 \ (d, J = 5.1 \text{ Hz, } 1\text{H}), 2.41 \ (s, 3\text{H}); ^{13}\text{C NMR (75 MHz, CDCl}_3\): \( \delta 174.6, 136.6, 136.4, 130.8, 128.5, 126.9, 126.3, 70.5, 52.8, 19.2; \text{HRMS (EI) Calcd for } \text{C}_{10}\text{H}_{12}\text{O}_3: 180.0786; \text{Found: 180.0782; 89\% ee [SFC condition: Chiralcel OJ-H column, sc CO}_2/i\text{-PrOH = 90:10, flow rate = 2.0 mL/min, wavelength = 220 nm, pressure = 100 bar, } t_R = 3.34 \text{ min for major isomer, } t_R = 3.74 \text{ min for minor isomer]; [\alpha]_D^{25} = -87.0 (c \ 0.40, \text{EtOH).}\

\((R)-(\cdash)-\text{Methyl 2-hydroxy-2-(2-methoxyphenyl)acetate (3p).}^{13}\) Colorless oil; 71% yield; \(^1\text{H NMR (300 MHz, CDCl}_3\): \( \delta 7.35\text{--}7.28 \ (m, 2\text{H}), 7.00\text{--}6.90 \ (m, 2\text{H}), 5.29 \ (d, J = 7.2 \text{ Hz, } 1\text{H}), 3.85 \ (s, 3\text{H}), 3.74 \ (s, 3\text{H}), 3.53 \ (d, J = 6.9 \text{ Hz, } 1\text{H}); 50\% ee [SFC condition: Chiralcel OD-H column, sc CO}_2/i\text{-PrOH = 90:10, flow rate = 2.0 mL/min, wavelength = 220 nm, pressure = 100 bar, } t_R = 4.48 \text{ min for (S)-enantiomer, } t_R = 4.88 \text{ min for (R)-enantiomer]; [\alpha]_D^{25} = -70.7 (c \ 0.40, \text{EtOH).}\

\((R)-(\cdash)-\text{Methyl 2-(2-chlorophenyl)-2-hydroxyacetate (3q).}^{17}\) Colorless oil; 90% yield; \(^1\text{H NMR (300 MHz, CDCl}_3\): \( \delta 7.41\text{--}7.38 \ (m, 2\text{H}), 7.30\text{--}7.26 \ (m, 2\text{H}), 5.57 \ (d, J = 5.1 \text{ Hz, } 1\text{H}), 3.77 \ (s, 3\text{H}), 3.57 \ (d, J = 4.8 \text{ Hz, } 1\text{H}); 36\% ee [SFC condition: Chiralcel OJ-H column, sc CO}_2/i\text{-PrOH = 94:6, flow rate = 2.0
mL/min, wavelength = 220 nm, pressure = 100 bar, \( t_R = 5.43 \) min for (R)-enantiomer, \( t_R = 6.12 \) min for (S)-enantiomer; [\( \alpha \)]\( _D \) = \(-84.6 \) (c 0.92, CHCl\(_3\)).

\( (R)-(-)-\)Methyl 2-hydroxy-2-naphthalen-2-ylacetate (3r). \(^{19}\) White solid; 76% yield; \(^1\)H NMR (300 MHz, CDCl\(_3\)): \( \delta \) 7.90–7.82 (m, 4H), 7.53–7.48 (m, 3H), 5.35 (d, \( J = 5.4 \) Hz, 1H), 3.76 (s, 3H), 3.55 (d, \( J = 5.7 \) Hz, 1H); 90% ee [SFC condition: Chiralcel OD-H column, sc CO\(_2\)/i-PrOH = 90:10, flow rate = 2.0 mL/min, wavelength = 220 nm, pressure = 100 bar, \( t_R = 9.76 \) min for (S)-enantiomer, \( t_R = 10.60 \) min for (R)-enantiomer]; [\( \alpha \)]\( _D \) = \(-144 \) (c 1.00, CHCl\(_3\)).

\( (\rightarrow)-\)Methyl 2-hydroxy-2-thiophene-3-ylacetate (3s). Colorless oil; 70% yield; \(^1\)H NMR (300 MHz, CDCl\(_3\)): \( \delta \) 7.22–7.15 (m, 2H), 7.00 (d, \( J = 4.8 \) Hz, 1H), 5.17 (d, \( J = 5.7 \) Hz, 1H), 3.87 (d, \( J = 6.0 \) Hz, 1H), 3.62 (s, 3H); \(^{13}\)C NMR (75 MHz, CDCl\(_3\)): \( \delta \) 173.5, 139.3, 126.3, 125.9, 122.7, 69.5, 52.8; HRMS (EI) Calcd for C\(_7\)H\(_8\)O\(_3\)S: 172.0194; Found: 172.0194; 90% ee [SFC condition: Chiralcel OD-H column, sc CO\(_2\)/i-PrOH = 90:10, flow rate = 2.0 mL/min, wavelength = 220 nm, pressure = 100 bar, \( t_R = 3.79 \) min for minor isomer, \( t_R = 4.21 \) min for major isomer]; [\( \alpha \)]\( _D \) = \(-108 \) (c 0.65, CHCl\(_3\)).

\( (R)-(\rightarrow)-\)Benzyl 2-hydroxypropionate (3t). \(^{20}\) Colorless oil; 78% yield; \(^1\)H NMR (300 MHz, CDCl\(_3\)): \( \delta \) 7.40–7.33 (m, 5H), 5.21 (s, 2H), 4.36–4.28 (m, 1H), 2.85 (d, \( J = 5.1 \) Hz, 1H), 1.43 (d, \( J = 6.9 \) Hz, 3H); 78% ee [HPLC condition: Chiralcel OD-H column, n-Hex/i-PrOH = 96:4, flow rate = 1.0 mL/min, wavelength = 220 nm, \( t_R = 20.95 \) min for (S)-enantiomer, \( t_R = 21.86 \) min for (R)-enantiomer]; [\( \alpha \)]\( _D \) = \(+13.2 \) (c 0.72, MeOH).

3. Typical Procedure for Hydrolysis of Methyl 2-Hydroxyphenylacetate

A solution of methyl 2-hydroxyphenylacetate (170 mg, 1.02 mmol) in EtOH (3 mL) was added to an aqueous solution of NaOH (4 mL, 1.25 M) at 0 °C. After being stirred for 2 h, the reaction mixture was acidified by 3 M hydrochloric acid and extracted with EtOAc (10 mL X


3). The organic layer was washed with brine, dried over anhydrous sodium sulfate, and concentrated in vacuum to give mandelic acid (4a) (154 mg, quant.) as a white solid which was recrystallized from DCE to give a optically pure (R)-mandelic acid in 74% yield. The analytical data for 2-hydroxyphenylacetic acids are listed below.

4. Analytical Data for Mandelic Acids

(R)-(−)-Mandelic acid (4a).\(^{21}\) White solid; 74% yield; mp = 132–133 °C; \(^1\)H NMR (300 MHz, Acetone-d\(_6\)): \(\delta\) 7.52–7.27 (m, 7H), 5.22 (s, 1H); \([\alpha]_D^{25} = -157\) (c 2.00, EtOH).

(R)-(−)-2-(3,4-Dichlorophenyl)-2-hydroxyacetic acid (4n).\(^{22}\) White solid; 65% yield; mp = 117–118 °C; \(^1\)H NMR (300 MHz, Acetone-d\(_6\)): \(\delta\) 7.72–7.49 (m, 5H), 5.29 (s, 1H); \([\alpha]_D^{25} = -115\) (c 0.50, H\(_2\)O).


5. NMR Spectra for New Compounds

Methyl 2-hydroxy-2-biphenylacetate (3e)
Methyl 2-hydroxy-2-\text{m}-tolylacetate (3i)
Methyl 2-(3-fluorophenyl)-2-hydroxyacetate (3k)
Methyl 2-(3,4-dichlorophenyl)-2-hydroxyacetate (3n)
Methyl 2-hydroxy-2-\(\alpha\)-tolylacetate (3o)
Methyl 2-hydroxy-2-thiophene-3-ylacetate (3s)
6. HPLC and SFC Charts for O–H Insertion Products

Methyl 2-hydroxy-2-phenylacetate (3a)

![HPLC chart for (rac)-Methyl 2-hydroxy-2-phenylacetate](image1)

![HPLC chart for (R)-Methyl 2-hydroxy-2-phenylacetate](image2)

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2 4.708 BB 0.1191 643.32587 92.8141 ?

Uncalib. totals : 693.13395 100.0000
Methyl 2-hydroxy-2-\textit{p}\text{-}tolylacetate (3d)

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\includegraphics[width=\textwidth]{methyl_2-hydroxy_2p-tolylacetate.png}
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Mehtyl 2-hydroxy-2-biphenylacetate (3e)

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1 18.693 BV 0.6932 1212.89990 3.9385 ?
2 20.470 VB 0.8907 2.95829e4 96.0615 ?

Uncalib. totals : 3.07958e4 100.0000
Methyl 2-(4-fluorophenyl)-2-hydroxyacetate (3f)

Peak RetTime Type Width Area Area Name
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1 3.611 BV 0.0907 473.03259 3.9603 ?
2 3.905 VB 0.0974 1.14712e4 96.0397 ?

Uncalib. totals : 1.19443e4 100.0000
Methyl 2-(4-chlorophenyl)-2-hydroxyacetate (3g)

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Methyl 2-(4-bromophenyl)-2-hydroxyacetate (3h)

![Chemical Structure](image)

### Chromatogram Data

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<th>Area %</th>
<th>Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>7.068</td>
<td>BV</td>
<td>0.2304</td>
<td>657.94080</td>
<td>4.7047</td>
<td>?</td>
</tr>
<tr>
<td>2</td>
<td>7.649</td>
<td>VB</td>
<td>0.2495</td>
<td>1.33267e4</td>
<td>95.2953</td>
<td>?</td>
</tr>
</tbody>
</table>

Uncalib. totals: 1.39846e4 100.0000
**Methyl 2-hydroxy-2-m-tolylacetate (3i)**

![Chemical structure](image)

### Chromatogram Data

<table>
<thead>
<tr>
<th>Peak</th>
<th>RetTime (min)</th>
<th>Type</th>
<th>Width (min)</th>
<th>Area</th>
<th>Area %</th>
<th>Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>4.676</td>
<td>BB</td>
<td>0.2146</td>
<td>281.81863</td>
<td>4.0539 %</td>
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<tr>
<td>2</td>
<td>5.782</td>
<td>BB</td>
<td>0.2438</td>
<td>6669.95361</td>
<td>95.9461 %</td>
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</tbody>
</table>

**Uncalib. totals:** 6951.77225 100.0000
Methyl 2-hydroxy-2-(3-methoxyphenyl)acetate (3j)

Peak RetTime Type Width Area  Area Name
# [min] [min] mAU *s %

1 4.422 BB 0.1739 2121.41138 4.7026 ?
2 5.110 BB 0.2540 4.29896e4 95.2974 ?

Uncalib. totals : 4.51110e4 100.0000
Methyl 2-(3-fluorophenyl)-2-hydroxyacetate (3k)

Peak RetTime Type Width Area Area Name
#  [min]   [min]   mA  *s  %
---|------|------|-----|-----|-----|
1  4.153 BV  0.1940  467.53360  5.7116 ?
2  4.640 VB  0.2124  7718.12891  94.2884 ?

Uncalib. totals :  8185.66251 100.0000
(--)-Methyl 2-(3-chlorophenyl)-2-hydroxyacetate (3l)
Methyl 2-(3-bromophenyl)-2-hydroxyacetate (3m)

![Chemical Structure](image)

### Peaks

<table>
<thead>
<tr>
<th>Peak</th>
<th>RetTime [min]</th>
<th>Type</th>
<th>Width [min]</th>
<th>Area [mAU]</th>
<th>Area [%]</th>
<th>Name</th>
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</thead>
<tbody>
<tr>
<td>1</td>
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<td>0.1819</td>
<td>2.58546e4</td>
<td>94.1936</td>
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<td>2</td>
<td>5.940</td>
<td>VB</td>
<td>0.1838</td>
<td>1593.75732</td>
<td>5.8064</td>
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</tbody>
</table>

Uncalib. totals: 2.74483e4 100.0000
Methyl 2-(3,4-dichlorophenyl)-2-hydroxyacetate (3n)

Peak RetTime Type Width Area Area Name
# [min] [min] mAU % %
1 6.860 BB 0.1795 975.15881 3.1712 ?
2 7.575 BB 0.1937 2.97758e4 96.8288 ?

Uncalib. totals : 3.07509e4 100.0000
Methyl 2-hydroxy-2-o-tolylacetate (3o)

Peak RetTime Type Width Area Area Name
# [min] [min] mAU *s %

1 3.341 BB 0.1015 1.12703e4 94.5132 ?
2 3.738 BB 0.1080 654.27826 5.4868 ?

Uncalib. totals : 1.19246e4 100.0000
Methyl 2-hydroxy-2-(2-methoxyphenyl)acetate (3p)

Peak RetTime Type Width Area Area Name
# [min] [min] mAU *s %
-----|--------|-------|-------|--------|
1 4.480 BV 0.1441 5507.33936 25.1827 ?
2 4.884 VB 0.1600 1.63622e4 74.8173 ?

Uncalib. totals: 2.18695e4 100.0000
Methyl 2-(2-chlorophenyl)-2-hydroxyacetate (3q)

Uncalibrated Peaks:

<table>
<thead>
<tr>
<th>#</th>
<th>RetTime</th>
<th>Type</th>
<th>Width</th>
<th>Area</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>5.433</td>
<td>BB</td>
<td>0.1427</td>
<td>1.34908e4</td>
<td>67.8944</td>
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<tr>
<td>2</td>
<td>6.122</td>
<td>BB</td>
<td>0.1517</td>
<td>6382.38525</td>
<td>32.1156</td>
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</tbody>
</table>

Uncalib. totals: 1.98732e4 100.0000
Methyl 2-hydroxy-2-naphthalen-2-ylacetate (3r)

Peak RetTime Type Width Area Area Name
# [min] [min] mAU *s %
1 9.757 BB 0.2542 1125.72778 4.8067 ?
2 10.602 BB 0.2820 2.22943e4 95.1933 ?

Uncalib. totals : 2.34200e4 100.0000
Methyl 2-hydroxy-2-thiophene-3-ylacetate (3s)

Peak RetTime  Type  Width  Area  Area %
#  [min]   [min]  mAU  *s    %
---  ------  ------  -----  ----  ----
1   3.795   BB     0.1443 514.14624 5.0422 ?
2   4.214   BB     0.1610 9682.80273 94.9578 ?

Uncalib. totals :  1.01969e4  100.0000
Benzyl 2-hydroxypropionate (3t)

Peak RetTime Type Width Area Height Area
# [min] [min] mAU *s [mAU] %
--- | ------- | ------ | -------- | --------- | ------ | ------ | ------- | -------- | 
1 20.951 BV 0.3742 2010.90552 84.34593 10.9802  
2 21.861 VB 0.5926 1.63030e4 448.93365 89.0198  
Totals: 1.83139e4 533.27959