Dynamic Kinetic Resolution via Dual-Function Catalysis of Modified Cinchona Alkaloids: Asymmetric Synthesis of α-Hydroxy Carboxylic Acids

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Supporting Information

General Information. ^{1}H and ^{13}C NMR were recorded on Varian instruments (400 MHz and 100 MHz, respectively) and internally referenced to a tetramethylsilane signal. Data for ^{1}H NMR are reported as chemical shift (ppm), multiplicity (s = singlet, d = doublet, t = triplet, q = quartet, m = multiplet), coupling constant (Hz), integration. Data for ^{13}C NMR are reported as chemical shift form tetramethylsilane with the solvent as the internal standard). Infrared spectra were recorded on a Perkin Elmer FT-IR Spectrometer and reported in frequency of absorption. Low-resolution mass spectra for all the new compounds done by either 20 eV, CH_4/CI or NH_3/CI were recorded on a Hewlett-Packard 5989A GC/MS, and exact mass spectra on a VG 7070 high resolution mass spectrometer. Specific rotations were measured on a Jasco Digital Polarometer.

Liquid chromatography was performed on EM Science silica gel 60 (SiO_2, 230-400 mesh). Thin layer chromatography was performed on EM Science 0.25 mm silica gel 60 F_{254} plates. Gas chromatography (GC) analysis was performed on a Hewlett – Packard 6890 series instrument using the columns indicated. High performance liquid chromatography (HPLC) analysis was performed on a Hewlett–Packard 1100 series instrument using the columns indicated.

Mandelic acid, 4-chloromandelic acid, 4-bromomandelic acid, 4-trifluoromethyl mandelic acid, 2-hydroxycaproic acid and 2-hydroxy-3-methylbutyric acid were purchased from Aldrich (Milwaukee) and used without further purification. Phenyllactic acid and 3,4-difluoromandelic acid were purchased from Lancaster. Diphosgene and 2-chloromandelic acid were purchased from Alfa Aesar. 4-Isopropylmandelic acid, 1-napthaleneglycolic acid, 4-fluoromandelic acid and 2-methylmandelic acid were prepared from corresponding benzaldehyde according to a literature procedure.[1] 2-Hydroxy-4-phenylbutyric acid was prepared from benzaldehyde and pyruvic acid according to literature procedure.[2,3,4] All reactions were conducted in flame-dried glassware under N_2 atmosphere. 4 Å molecular sieves were flame-dried under reduced pressure (0.2 mmHg) immediately prior to use. Diethyl ether and tetrahydrofuran (THF) were distilled from sodium ketyl benzophenone immediately prior to use. Ethanol, allyl alcohol and *n*-propanol were freshly distilled from calcium hydride.

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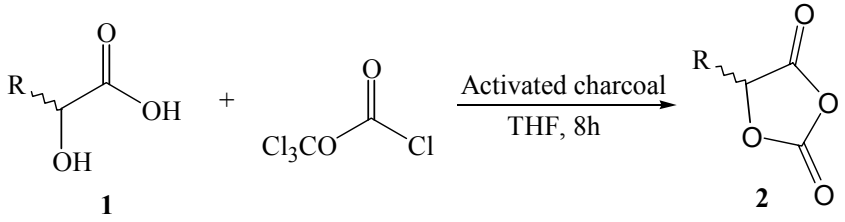
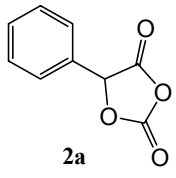
[1] Compere, E. L. *J. Org. Chem.* **1968**, *33*, 2565.
[2] Stecher, E. D.; Ryder, H. F. *J. Am. Chem. Soc.* **1952**, *74*, 4392.
[3] Clawson, P.; Lunn, P. M.; Whiting, D. A. *J. Chem. Soc. Perkin trans I* **1990**, 159.
[4] Nikaido, T.; Takase, I. *Jpn. Kokai Tokkyo Koho* **1991**.

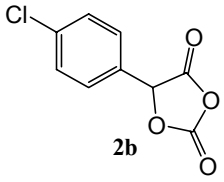
General Procedure for Preparations of 5-Substituted 1,3-Dioxolane-2,4-Diones



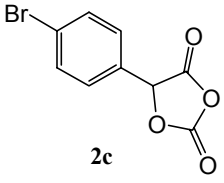
To a solution of α-hydroxy acid (10.0 mmol) in anhydrous THF (10 mL), diphosgene (12.0 mmol, 1.5 mL) was added in one portion via a syringe. The resulting mixture was treated with activated charcoal (~30 mg). The reaction mixture was stirred for 8 hours at room temperature. The mixture was filtered through celite, the filtrate was concentrated and the resulting residue was subjected to vacuum (~0.2 mmHg) for 1-2 h to give the desired 5-Substituted 1,3-Dioxolane-2, 4-Diones in 90-100 % yield.



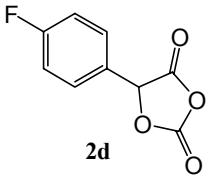
This product was obtained as a white solid in quantitative yield from the corresponding racemic hydroxy acid. ^{1}H NMR (400 MHz, $CDCl_3$) δ 6.02 (s, 1H), 7.40-7.46 (m, 5H); ^{13}C NMR (100MHz, $CDCl_3$) δ 80.40, 126.11, 129.22, 129.53, 130.78, 147.96, 165.28; IR ($CHCl_3$) ν 3096, 1900, 1817, 1495, 1245, 1067 cm^{-1}.



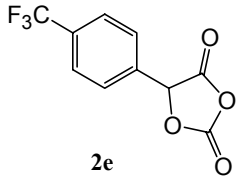
This product was obtained as a white solid in quantitative yield from the corresponding racemic hydroxy acid. ^{1}H NMR (400 MHz, $CDCl_3$) δ 6.01 (s, 1H), 7.37-7.40 (m, 2H), 7.45-7.48 (m, 2H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 79.60, 127.38, 127.56, 129.77, 137.02, 147.80, 164.94 cm^{-1}; IR ($CHCl_3$) ν 3048, 2989, 1899, 1816, 1485, 1270, 1241, 1171, 1042 cm^{-1}; HRMS (DEI) exact mass calcd for ($C_9H_5O_4Cl^+$) requires m/z 211.9876, found m/z 211.9881.



This product was obtained as a white solid in quantitative yield from the corresponding racemic hydroxy acid. ^{1}H NMR (400 MHz, $CDCl_3$) δ 6.00 (s, 1H), 7.29-7.32 (m, 2H), 7.60-7.63 (m, 2H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 79.98, 125.42, 127.77, 127.90, 128.35, 132.96, 148.14, 165.28; IR ($CHCl_3$) ν 3053, 2987, 1900, 1816, 1491, 1265, 1243, 1073 cm^{-1}; HRMS (DEI) exact mass calcd for ($C_9H_5O_4Br^+$) requires m/z 255.9371, found m/z 255.9382.

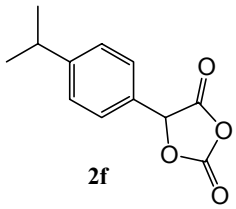


This product was obtained as a white solid in quantitative yield from the corresponding racemic hydroxy acid. ^{1}H NMR (400 MHz, $CDCl_3$) δ 6.01 (s, 1H), 7.15-7.22 (m, 2H), 7.42-7.46 (m, 2H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 79.75, 116.81 (d, J = 23 Hz), 125.05, 128.32 (d, J = 8 Hz), 147.69, 163.92 (d, J = 236 Hz), 165.24; IR ($CHCl_3$) ν 3056, 1899, 1812, 1514, 1265, 1235 cm^{-1}; HRMS (DEI) exact mass calcd for ($C_9H_5O_4F^+$) requires m/z 196.0172, found m/z 196.0167.



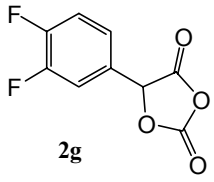
2e

This product was obtained as a white solid in quantitative yield from the corresponding racemic hydroxy acid. ^{1}H NMR (400 MHz, $CDCl_3$) δ 6.10 (s, 1H), 6.62 (d, 2H, *J* = 8.0 Hz); ^{13}C NMR (100 MHz, $CDCl_3$) δ 79.19, 123.39 (q, *J* = 271 Hz), 126.16, 126.55 (q, *J* = 3.8 Hz), 132.82, 132.91 (q, *J* = 33.4 Hz), 147.40, 164.52; IR ($CHCl_3$) ν 3057, 1902, 1816, 1329, 1265, 1069 cm^{-1}; HRMS (DEI) exact mass calcd for ($C_{10}H_5O_4F_3^+$) requires m/z 246.0140, found m/z 246.0147.



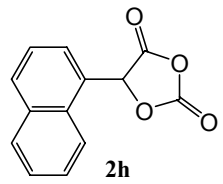
2f

This product was obtained as a white solid in quantitative yield from the corresponding racemic hydroxy acid. 1H NMR (400 MHz, $CDCl_3$) δ 1.26 (d, 6H, *J* = 6.4 Hz), 2.90-3.01 (m, 1H), 5.98 (s, 1H), 7.33-7.35 (m, 4H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 23.73, 33.99, 80.60, 126.39, 126.56, 127.65, 152.04, 165.49; IR ($CHCl_3$) ν 3040, 2964, 1897, 1812, 1265, 1066 cm^{-1}; HRMS (CI) exact mass calcd for ($C_{12}H_{12}O_4^+$) requires m/z 220.0736, found m/z 220.0734.



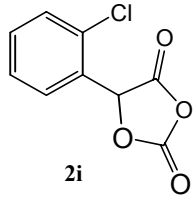
2g

This product was obtained as a pale yellow solid in quantitative yield from the corresponding racemic hydroxy acid. ^{1}H NMR (400 MHz, $CDCl_3$) δ 5.99 (s, 1H), 7.22–7.35 (m, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 78.79, 115.59 (d, *J* = 19.8 Hz), 118.75 (d, *J* = 17.5 Hz), 122.40 (dd, *J* = 7.6, 4.6 Hz), 125.83 (dd, *J* = 5.4, 4.5 Hz), 147.32, 150.88 (dd, *J* = 250, 12.2 Hz), 157.79 (dd, *J* = 250, 9.8 Hz), 164.55; IR ($CHCl_3$) ν 3053, 2987, 1897, 1815, 1518, 1421, 1265 cm^{-1}.



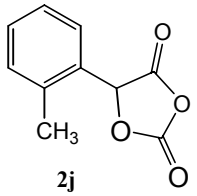
2h

This product was obtained as a white solid in quantitative yield from the corresponding racemic hydroxy acid. ^{1}H NMR (400 MHz, $CDCl_3$) δ 6.76 (s, 1H), 7.51-7.70 (m, 4H), 7.92-8.02 (m, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 78.88, 122.37, 124.89, 125.08, 126.92, 127.89, 129.26, 130.31, 131.82, 133.97, 148.07, 165.16; IR ($CHCl_3$) ν 3053, 1896, 1816, 1265, 1078 cm^{-1}; HRMS (DEI) exact mass calcd for ($C_{13}H_8O_4^+$) requires m/z 228.0422, found m/z 228.0414.



2i

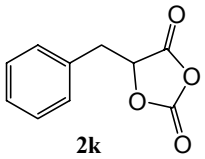
This product was obtained as a white solid in quantitative yield from the corresponding racemic hydroxy acid. ^{1}H NMR (400 MHz, $CDCl_3$) δ 6.18 (s, 1H), 7.38-7.54 (m, 5H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 79.63, 127.20, 127.78, 130.91, 130.97, 132.77, 134.13, 147.91, 164.65; IR ($CHCl_3$) ν 3054, 2986, 1899, 1816, 1298, 1264, 1068, 1031 cm-1; HRMS (DEI) exact mass calcd for ($C_9H_5O_4Cl^+$) requires m/z 211.9876, found m/z 211.9879.



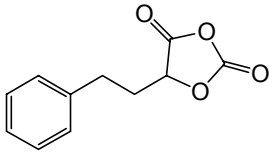
2j

This product was obtained as a white solid in 95% yield from the corresponding racemic hydroxy acid. ^{1}H NMR (400 MHz, $CDCl_3$) δ 2.47 (s, 3H), 6.22 (s, 1H),7.25-7.34 (m, 3H), 7.37-7.43 (m, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 19.14, 79.28, 126.60, 126.94, 127.67, 131.00, 131.66, 136.99, 148.17, 165.46; IR ($CHCl_3$) ν 3054, 2986,

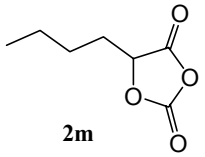
1896, 1813, 1464, 1421, 1263, 1069, 1024 cm^{-1}.


2k

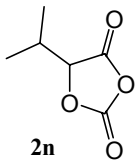
This product was obtained as a white solid in quantitative yield from corresponding racemic hydroxy acid. ^1H NMR (400 MHz, $CDCl_3$) δ 3.23-3.41 (m, 2H), 5.31 (t, 1H, *J* = 4.8 Hz), 7.22-7.36 (m, 5H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 36.41, 79.86, 128.40, 129.15, 129.65, 131.48, 147.76, 166.28; IR ($CHCl_3$) ν 3056, 2987, 1888, 1808, 1455, 1340, 1266, 1078 cm^{-1}; HRMS (EI) exact mass calcd for ($C_{10}H_8O_4^+$) requires m/z 192.0422, found m/z 192.0419.


2l

This product was obtained as a white solid in quantitative yield from corresponding racemic hydroxy acid. ^1H NMR (400 MHz, $CDCl_3$) δ 2.22-2.42 (m, 2H), 2.78-2.94 (m, 2H), 4.97 (dd, 1H, *J* = 8.0, 5.0 Hz), 7.18-7.36 (m, 5H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 30.11, 32.35, 78.40, 127.02, 128.51, 128.91, 138.08, 148.11, 167.04; IR ($CHCl_3$) 3054, 2986, 1892, 1812, 1496, 1330, 1239, 1066 cm^{-1}; HRMS exact mass calcd for ($C_{11}H_{11}O_4^+$) requires m/z 207.0657, found m/z 207.0655.

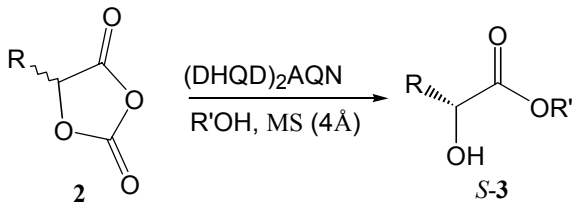

2m

This product was obtained as a colorless liquid in 92% yield from corresponding racemic hydroxy acid. ^1H NMR (400 MHz, $CDCl_3$) δ 0.95 (t, 3H, *J* = 7.2 Hz), 1.36-1.58 (m, 4H), 1.90-2.12 (m, 2H), 5.06 (dd, 1H, J = 7.6, 4.8 Hz); ^{13}C NMR (100 MHz, $CDCl_3$) δ 13.58, 21.88, 25.95, 30.46, 79.72, 148.25, 167.14; IR ($CHCl_3$) ν 2936, 2856, 1895, 1265, 1067 cm^{-1}; HRMS (DEI) exact mass calcd for ($C_7H_{11}O_4^+$) requires m/z 159.0657, found m/z 159.0652.


2n

This product was obtained as a colorless liquid in 90% yield from corresponding racemic hydroxy acid. ^1H NMR (400 MHz, $CDCl_3$) δ 1.09 (d, 3H, *J* = 7.2 Hz), 1.16 (d, 3H, *J* = 7.2 Hz), 2.32-2.42 (m, 1H), 4.90 (d, 1H, *J* = 4.0 Hz); ^{13}C NMR (100 MHz, $CDCl_3$) δ 15.97, 17.41, 30.58, 84.01, 148.40, 166.39; IR ($CHCl_3$) ν 2974, 1889, 1817, 1468, 1253, 1028 cm^{-1}; HRMS (CH_4/CI) exact mass calcd for ($C_6H_9O_4^+$) requires m/z 145.0501, found m/z 145.0500.

General Procedure for Modified Cinchona Alkaloid-Catalyzed Dynamic Kinetic Resolution of 5-Aryl-1,3-Dioxolane-2,4-Diones.

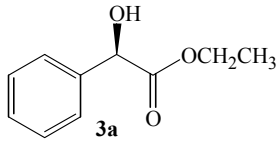


2 *S*-**3**

A mixture of 5-aryl-1,3-dioxolane-2,4-diones (1.0 mmol) and 4 Å molecular sieves (100 mg) in anhydrous diethyl ether (50 mL) was stirred at room temperature for 15 minutes, then cooled to the temperature indicated in Table 2, afterwhich the modified cinchona alkaloid (0.1 mmol), $(DHQD)_2AQN$, was added to the mixture. The resulting mixture was stirred for another 5 minutes and then ethanol (1.5 eq.) was added dropwise over 10 minutes via a syringe. The resulting reaction mixture was stirred at that temperature for 8-24 hours. HCl (1 N, 5.0 mL) was added to the mixture dropwise. The resulting mixture was allowed to warm to room temperature. The organic phase was collected, washed with aqueous HCl (1 N, 2 x 5.0 mL) and the aqueous phase was extract with ether (2 x 5.0 mL).[5] The combined organic phase was washed with brine, dried (Na_2SO_4) and concentrated. The residue was subjected to column chromatography to give the final product.

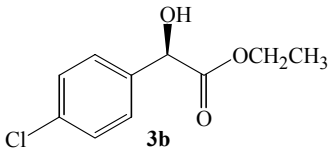
Determination of Absolute Configurations of α-Hydroxy Acids 1, α-Hydroxy Esters 3

The absolute configuration of **3a, 3b, 3k, 3m** and **1k-1n** were determined by comparing their optical rotation value with the literature value. The absolute configuration of **3c, 3d, 3e, 3f, 3g, 3h, 3i, 3j, 3l** and **3m** were assigned by analogy.



3a

(*R*)-Ethyl-mandelate (3a):
This product was obtained as a white solid in 71% yield after purification by silica gel chromatography (hexanes:ethyl acetate = 4:1) and 95% ee as determined by HPLC analysis [Daicel chiralpak OD, Hexanes:IPA, 20:1, 1.0 mL/min, λ 220 nm, t (major) = 17.18 min, t (minor) = 9.23 min]. $[\alpha]_D^{25}$ -123° (c = 1.0, $CHCl_3$); (Literature,[6] $[\alpha]_D^{25}$ -125.4° (c = 1.0, $CHCl_3$)); ^{1}H NMR (400 MHz, $CDCl_3$) δ 1.22 (t, 3H, *J* = 7.3 Hz), 3.55 (d, 1H, J = 4.8 Hz), 4.10-4.30 (m, 2H), 5.15 (d, 1H, *J* = 4.8 Hz), 7.29-7.44 (m, 5H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 13.96, 62.16, 72.82, 126.47, 128.33, 128.50, 138.38, 173.62; IR ($CHCl_3$) ν 3515, 3065, 2985, 1740, 1453, 1250, 1066 cm^{-1}.

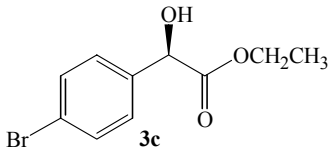


3b

(*R*)-Ethyl-4-chloromandelate (3b):
This product was obtained as a colorless oil in 70 % yield after purification by silica gel chromatography (hexanes:ethyl acetate = 4:1) and 96% ee as determined by HPLC analysis [Daicel chiralpak OD, Hexanes:IPA, 20:1, 1.0 mL/min, λ 220 nm, t (major) = 10.54 min, t (minor) = 8.94 min]. $[\alpha]_D^{25}$ -91.3° (c = 1.2, $CHCl_3$). (Literature,[7] $[\alpha]_D^{25}$ - 14.7° (c = 1, $CHCl_3$), for 8% ee); ^{1}H NMR (400 MHz, $CDCl_3$) δ 1.23 (t, 3H, *J* = 7.2 Hz), 4.16-4.28 (m, 2H), 5.14 (s, 1H), 7.32-7.40 (m, 4H); ^{13}C NMR

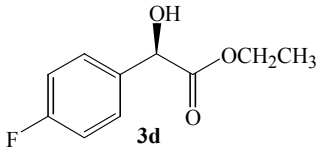
[5] Following a procedure described previously (see references **6a-d** of the text), we have recovered the catalyst quantitatively from the mixture resulting from a dynamic kinetic resolution of **2a**.
[6] Naoshima, Y.; Maeda, J.; Munakata, Y.; Nishiyama, T.; Kamezawa, M.; Tachibana, H. *J. Chem. Soc., Chem. Commun.* **1990**, 965.
[7] Carpentier, J.-F.; Mortreux, A. *Tetrahedron: Asymmetry* **1997**, *8*, 1083.

(100 MHz, $CDCl_3$) δ 13.99, 62.48, 72.14, 127.86, 128.70, 134.25, 136.83, 173.29; IR ($CHCl_3$) ν 3518, 3055, 2986, 1730, 1493, 1421, 1266, 1184, 1092 cm^{-1}.



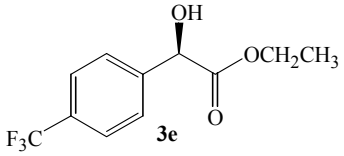
3c

(*R*)-Ethyl-4-bromomandelate (3c):
This product was obtained as a colorless oil in 80% yield after purification by silica gel chromatography (hexanes:ethyl acetate = 4:1) and 96% ee as determined by HPLC analysis [Daicel chiralpak OD, Hexanes:IPA, 20:1, 1.0 mL/min, λ 220 nm, t (major) = 11.52 min, t (minor) = 9.89 min]. $[\alpha]_D^{25}$ -77.8° (c = 1.4, $CHCl_3$); ^1H NMR (400 MHz, $CDCl_3$) δ 1.22 (t, 3H, *J* = 8.0 Hz), 3.61 (s, 2H), 4.14-4.28 (m, 2H), 5.11 (s, 1H), 7.29-7.34 (m, 2H), 7.45-7.49 (m, 2H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 13.96, 62.43, 72.17, 122.36, 128.16, 131.60, 137.33, 173.15; IR ($CHCl_3$) ν 3514, 3054, 2985, 1732, 1487, 1267, 1073 cm^{-1}.



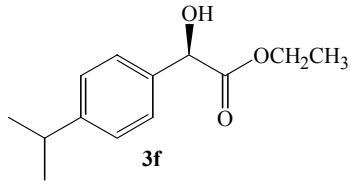
3d

(*R*)-Ethyl-4-fluoromandelate (3d):
This product was obtained as a yellow oil in 65% yield after purification by silica gel chromatography (hexanes:ethyl acetate = 2:1) and 95% ee as determined by HPLC analysis [Daicel chiralpak OD, Hexanes:IPA, 20:1, 1.0 mL/min, λ 220 nm, t (major) = 11.04 min, t (minor) = 8.83 min]. $[\alpha]_D^{25}$ -102.3° (c = 1.1, $CHCl_3$); ^1H NMR (400 MHz, $CDCl_3$) δ 1.22 (t, 3H, *J* = 7.6 Hz), 3.58 (d, 1H, *J* = 5.2 Hz), 4.15-4.26 (m, 2H), 5.14 (d, 1H, *J* = 5.6 Hz), 7.02-7.07 (m, 2H), 7.38-7.42 (m, 2H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 13.96, 62.33, 72.14, 115.43 (d, *J* = 22 Hz), 128.24 (d, *J* = 8.3 Hz), 134.60 (d, *J* = 3 Hz), 162.68 (d, *J* = 245 Hz), 173.48; IR ($CHCl_3$) ν 3509, 3055, 2985, 1731, 1604, 1509, 1265, 1082 cm^{-1}.



3e

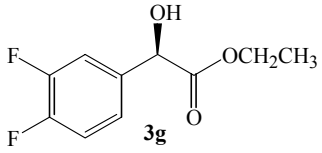
(*R*)-Ethyl-4-trifluoromethylmandelate (3e):
This product was obtained as a yellow solid in 85% yield after purification by silica gel chromatography (hexanes:ethyl acetate = 8:1) and 93% ee as determined by HPLC analysis [Daicel chiralpak OD, Hexanes:IPA, 50:1, 1.0 mL/min, λ 220 nm, t (major) = 15.90 min, t (minor) = 13.66 min]. $[\alpha]_D^{25}$ -53.7° (c = 1.0, $CHCl_3$); ^1H NMR (400 MHz, $CDCl_3$) δ 1.24 (t, 3H, *J* = 7.2 Hz), 3.61 (d, 1H, *J* = 4.8 Hz), 4.15-4.32 (m, 2H), 5.26 (d, 1H, *J* = 4.8 Hz), 7.58 (d, 2H, *J* = 8.8 Hz), 7.63 (d, 2H, *J* = 8.0 Hz); ^{13}C NMR (100 MHz, $CDCl_3$) δ 13.99, 62.67, 72.23, 123.97 (q, *J* = 271 Hz), 125.44 (q, *J* = 3.8 Hz), 126.82, 130.52 (q, *J* = 31.9 Hz), 142.14, 172.96; IR ($CHCl_3$) ν 3517, 3053, 2987, 1725, 1422, 1329, 1266, 1194, 1066 cm^{-1}; HRMS exact mass calcd for ($C_{11}H_{12}O_3F_3^+$) requires m/z 249.0739, found m/z 249.0733.



3f

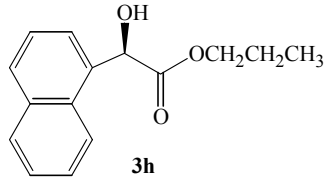
(*R*)-Ethyl-4-isopropylmandelate (3f):
This product was obtained as a yellow oil in 66% yield after purification by silica gel chromatography (hexanes:ethyl acetate = 4:1) and 91% ee as determined by HPLC analysis [Daicel chiralpak OD, Hexanes:IPA, 20:1, 1.0 mL/min, λ 220 nm, t (major) = 10.58 min, t (minor) = 8.18 min].

$[\alpha]_D^{25}$ -56.0° (c = 1.2, $CHCl_3$); ^1H NMR (400 MHz, $CDCl_3$) δ 1.24 (d, *J* = 7.2 Hz, 6H), 2.92-2.98 (m, 1H), 3.39 (d, *J* = 4.4 Hz, 1H), 4.12-4.26 (m, 2H), 5.13 (s, 1H), 7.24 (d, *J* = 7.6 Hz, 2H), 7.33 (d, *J* = 7.8 Hz, 2H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 14.03, 23.90, 33.82, 62.12, 72.73, 126.47, 126.66, 135.80, 149.12, 173.79; IR ($CHCl_3$) ν 3516, 3053, 2969, 1724, 1604, 1512, 1421, 1266 cm^{-1}.



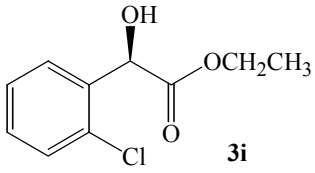
3g

(*R*)-Ethyl-3,4-difluoromandelate (3g):
This product was obtained as a yellow oil in 65% yield after purification by silica gel chromatography (hexanes:ethyl acetate = 4:1) and 94% ee as determined by HPLC analysis [Daicel chiralpak, OD, Hexanes:IPA, 20:1, 1.0 mL/min, λ 220 nm, t (major) = 10.88 min, t (minor) = 9.29 min]. $[\alpha]_D^{25}$ -73.1° (c = 1.0, $CHCl_3$); ^1H NMR (400 MHz, $CDCl_3$) δ 1.25 (t, 3H, *J* = 7.2 Hz), 4.18-4.32 (m, 2H), 5.12 (s, 1H), 7.12-7.32(m, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 13.98, 62.67, 71.64, 115.58 (d, *J* = 18 Hz), 117.28 (d, *J* = 18 Hz), 122.55 (dd, *J* = 3.8, 6.9Hz), 135.19 (dd, *J* = 3.8, 5.3 Hz), 150.19 (dd, *J* = 247.5, 3.8 Hz), 150.32 (dd, *J* = 247.5, 3.8 Hz), 172.99; IR ($CHCl_3$) ν 3509, 3054, 2985, 1735, 1612, 1514, 1437, 1276, 1139, 1019 cm^{-1}; HRMS exact mass calcd for ($C_{10}H_{10}O_3F_2^+$) requires m/z 216.0598, found m/z 216.0603.



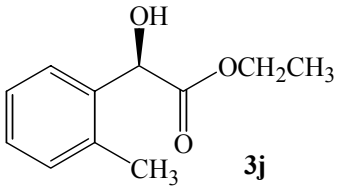
3h

(*R*)-1-Napthaleneglycolic acid, *n*-propyl ester (3h):
This product was obtained as a yellow oil in 74% yield after purification by silica gel chromatography (hexanes:ethyl acetate = 4:1) and 91% ee as determined by HPLC analysis [Daicel chiralpak AS, Hexanes:IPA, 20:1, 1.0 mL/min, λ 280 nm, t (major) = 19.86 min, t (minor) = 14.84 min]. $[\alpha]_D^{25}$ -97.8° (c = 1.1, $CHCl_3$); ^1H NMR (400 MHz, $CDCl_3$) δ 0.68 (t, 3H, *J* = 7.6 Hz), 1.45-1.55 (m, 2H), 4.05-4.18 (m, 2H), 5.82 (s, 1H), 7.41-7.56 (m, 4H), 7.82-7.90 (m, 2H), 8.17 (d, 1H, *J* = 8.8 Hz); ^{13}C NMR (100 MHz, $CDCl_3$) δ 9.96, 21.70, 67.76, 71.23, 123.75, 125.17, 125.60, 125.80, 126.42, 128.73, 129.30, 131.02, 133.97, 134.18, 174.28; IR ($CHCl_3$) ν 3511, 3052, 2971, 1738, 1512, 1421, 1257, 1165, 1096 cm^{-1}; HRMS exact mass calcd for ($C_{15}H_{16}O_3^+$) requires m/z 244.1099, found m/z 244.1103.



3i

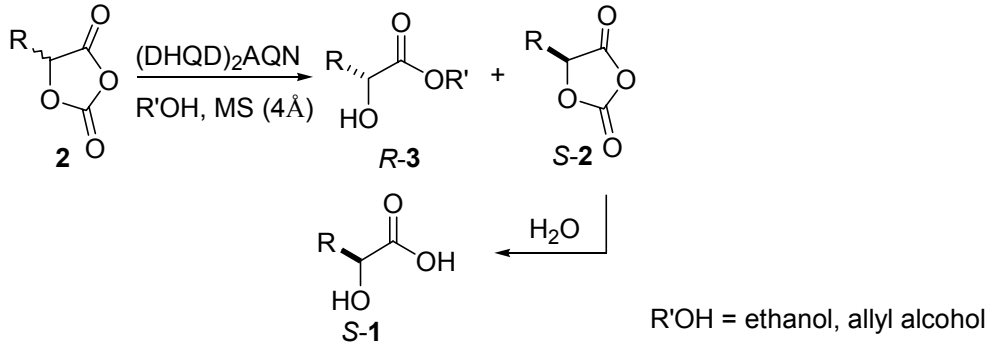
(*R*)-Ethyl-2-chloromandelate (3i):
This product was obtained as a yellow oil in 66% yield after purification by silica gel chromatography (hexanes:ethyl acetate = 5:1) and 62% ee as determined by HPLC analysis [Daicel chiralpak OD, Hexanes:IPA, 20:1, 1.0 mL/min, λ 220 nm, t (major) =11.95, t (minor) = 9.56 min]. $[\alpha]_D^{25}$ -45.0° (c = 4.0, $CHCl_3$); ^1H NMR (400 MHz, $CDCl_3$) δ 1.20 (t, 3H, *J* = 7.6 Hz), 3.78 (br, 1H), 4.14-4.29 (m, 2H), 7.22-7.40 (m, 4H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 13.86, 62.28, 70.26, 127.00, 128.64, 129.57, 129.77, 133.41, 136.08, 173.08; IR ($CHCl_3$) ν 3508, 2984, 1731, 1476, 1252, 1086 cm^{-1}.



3j

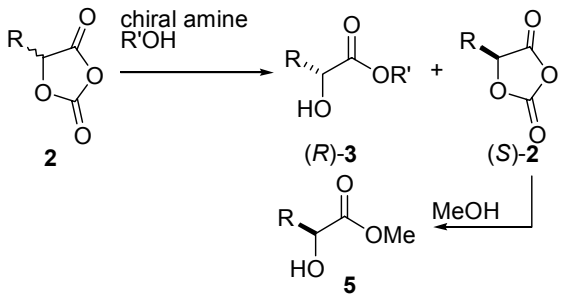
(*R*)-Ethyl-2-methylmandelate (3j):
This product was obtained as a yellow oil in 61% yield after purification by silica gel chromatography (hexanes:ethyl acetate = 3:1) and 60% ee as determined by HPLC analysis [Daicel chiralpak OD, Hexanes:IPA, 20:1, 1.0 mL/min, λ 220 nm, t (major) =13.51, t (minor) = 10.71 min]. $[\alpha]_D^{25}$ –57.4° (c = 2.8, $CHCl_3$); ^{1}H NMR (400 MHz, $CDCl_3$) δ 1.21 (t, 3H , *J* = 7.2 Hz), 2.43 (s, 3H), 3.52 (d, 1H, *J* = 4.8 Hz), 4.09-4.29 (m, 2H), 5.35 (d, 1H, *J* = 4.8 Hz), 7.04-7.32 (m, 4H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 13.97, 19.23, 62.10, 70.29, 126.20, 126.65, 128.33, 130.72, 131.72, 135.99, 174.11; IR ($CHCl_3$) ν 3522, 3054, 2984, 1733, 1464, 1373, 1285, 1068, 1048 cm^{-1}.

General Procedure for Cinchona Alkaloid-Catalyzed Kinetic Resolution of 5-Alkyl 1,3-Dioxolane-2,4-Diones



A mixture of 5-alkyl-1,3-dioxolane-2,4-dione (1.0 mmol) and 4 Å molecular sieves (100 mg) in anhydrous diethyl ether (50 mL) was stirred at room temperature for 15 minutes, then cooled to –78 °C afterwhich the modified cinchona alkaloid $(DHQD)_2AQN$ (0.1mmol) was added to the mixture. The resulting mixture was stirred for another 5 minutes and then ethanol or allyl alcohol (1.0 eq.) was added dropwise over 10 minutes via a syringe. The resulting mixture was stirred at that temperature for 8-36 hrs. When the ee of both ester **3** and unreacted starting material **2** were found to be close to or above 90%, aqueous HCl (1N, 5.0 mL) was added dropwise to the reaction mixture. The resulting mixture was allowed to warm to room temperature. The organic phase was collected, washed with aqueous HCl (1N, 2 x 3.0 mL) and concentrated. The residue was dissolved in H_2O/THF (v/v: 1/4, 5.0 mL) and the resulting solution was stirred at room temperature overnight and diluted with ether (20 mL). The resulting mixture was extracted with aqueous Na_2CO_3 (1N, 2 x 5.0 mL). The organic phase was washed with brine and dried over Na_2SO_4, and concentrated to give α-hydroxy ester **3** in NMR-pure form and in yields indicated in Table 3. The aqueous phases were combined and then acidified to pH = 1 by conc. HCl, then extracted with ethyl acetate (3 x 5.0 mL). The organic phase was dried over Na_2SO_4 and concentrated to give α-hydroxy acid **1** in NMR-pure form and in yields indicated in Table 3.

Determination of the Enantiomeric Excesses of 2k-2n and 3k-3n in Reaction Mixture.



Dioxolanediones (**2**) are found to be unstable toward conditions for GC and HPLC analysis. The ee of the **2** in the reaction mixture was determined by converting the unreacted **2** into methyl ester **5** and subsequently GC or HPLC analysis of the resulting mixture of ester **3** and **5** as following: A small aliquot (50 μL) of the reaction mixture was added to dry methanol (200 μL). The resulting mixture was stirred at room temperature for 10min, and then was allowed to pass through a plug of silica gel with ether as the eluent. The resulting solution of esters **3** and **5** was concentrated and then subjected to GC or HPLC analysis.

GC condition for **2k** and **3k**: HP chiral 20% Permethylated B-Cyclodextrin, 100 °C, 20 min, 0.5 °C/min ramp, 130 °C (10 min).

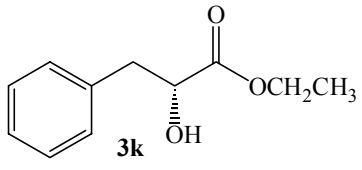
HPLC condition for **2l** and **3l**: Chiralpak OD, Hexanes:IPA, 20:1, 1 mL/min, λ 220 nm.

GC condition for **2m** and **3m**: Gamma cyclodextrin Trifluoroacetyl, 60°, 2 min, 1°/min ramp, 90° (10 min).

GC condition for **2n** and **3n**: Gamma cyclodextrin Trifluoroacetyl, 80°.

Determination of Enantiomeric Excesses of Isolated Optically Active α-Hydroxy Acid 1

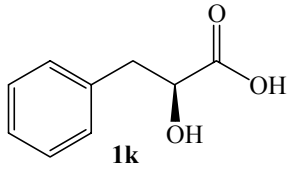
Optically pure α-hydroxy acid **1** (5.0 mg) isolated following the perocedure described on page 7 was dissolved in EtOH or MeOH (1.0 mL), and then treated with sulfuric acid (1 drop). The mixture was stirred for 8 hrs and diluted with water (2.0 mL). After extracting with ether (2 x 2.0 mL), the combined organic phase was washed with saturated sodium bicarbonate and brine. The solvent was removed to give the α-hydroxy ester. This ester was subject to HPLC or GC analysis to give the enantiomeric excesses of the isolated optically active α-hydroxy acid.



3k

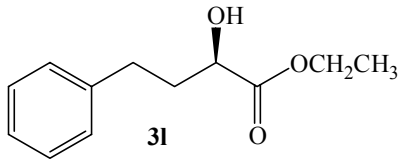
(*R*)-Ethyl-2-hydroxy-3-phenylpropinate (3k):
This product was obtained as yellow oil in 47% yield and 96% ee as determined by HPLC analysis [Daicel chiralpak AS, Hexanes:IPA, 50:1, 0.5 mL/min, λ 220nm, t (major) = 32.45 min, t (minor) = 29.13 min]. $[\alpha]_D^{25}$ +14.5° (c = 1.0,

$CHCl_3$); (Literature,[8] $[\alpha]_D^{25}$ +22.2° (c = 3.85, $CHCl_3$)); ^{1}H NMR (400 MHz, $CDCl_3$) δ 1.28 (t, 3H, *J* = 7.2 Hz), 2.79 (s, 1H), 2.94-3.16 (m, 2H), 4.43 (s, 1H), 7.20-7.32 (m, 5H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 14.13, 40.50, 61.68, 71.16, 126.82, 128.33, 129.48, 136.33, 174.14; IR ($CHCl_3$) ν 3526, 3065, 2983, 1745, 1496, 1368, 1214, 1098 cm^{-1}.



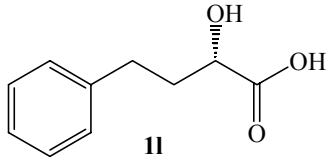
1k

(*S*)-2-hydroxy-3-phenylpropinic acid (1k):
This product was obtained as white solid in 39% yield and 95% ee as determined by GC analysis of the methyl ester derived from **1k** following the procedure described above [HP Chiral 20% Permethylated B-Cyclodextrin, 100 °C, 20 min, 0.5 °C/min to 130 °C, t (major) = 60.72 min, t (minor) = 58.90 min]. $[\alpha]_D^{25}$ -17.9° (c = 1, H_2O). (Literature,[9] $[\alpha]_D$ =-20.0° (c = 1, H_2O)) .



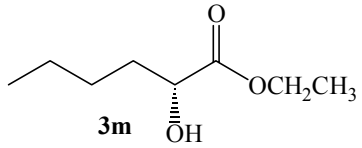
3l

(*R*)-2-hydroxy-4-phenylbutyric acid ethyl ester (3l):
This product was obtained as yellow oil in 46% yield and 93% ee as determined by HPLC analysis [Daicel chiralpak OD, Hexanes:IPA, 20:1, 1.0 mL/min, λ 220 nm, t (major) = 15.03 min, t (minor) = 9.45 min]. $[\alpha]_D^{25}$ -14.5° (c = 1.3, $CHCl_3$); ^{1}H NMR (400 MHz, $CDCl_3$) δ 1.27 (t, 3H, *J* = 7.2 Hz), 1.86-2.24 (m, 2H), 2.66-2.86 (m, 2H), 4.12-4.24 (m, 3H), 7.18-7.32 (m, 5H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 14.11, 30.93, 35.86, 61.72, 69.64, 125.95, 128.41, 128.49, 141.06, 175.19; IR ($CHCl_3$) ν 3520, 3053, 2983, 1743, 1454, 1252, 1101 cm^{-1}.



1l

(*S*)-2-hydroxy-4-phenylbutanoic acid (1l):
This product was obtained as white solid in 40% yield and 85% ee as determined by HPLC analysis of the ethyl ester derived from **1l** following the procedure described above [Daicel chiralpak OD, Hexanes:IPA, 20:1, 1 mL/min, λ 220 nm, t (major) = 8.94 min, t (minor) = 13.90 min]. $[\alpha]_D^{25}$ + 6.8° (c = 1.0, EtOH); (Literature,[10] $[\alpha]_D^{25}$ + 7.6° (c = 1.0, EtOH), for 91% ee).

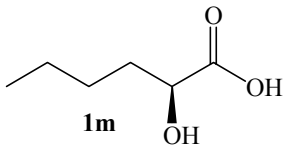


3m

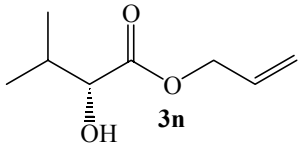
(*R*)-Ethyl-2-hydroxy-hexanoate (3m):
This product was obtained as yellow oil in 46% yield and 92% ee as determined by GC with chiral support [Gamma cyclodextrin Trifluoroacetyl, 60°, 2 min, 1°/min to 90°, t (major) = 24.10 min, t (minor) = 25.00]. $[\alpha]_D^{25}$ 5.5° (c = 5.0, EtOH); (Literature,[11] $[\alpha]_D^{25}$ 6.6°, (c=7.1, EtOH)); ^{1}H NMR (400 MHz, $CDCl_3$) δ 0.91 (t, 3H, *J* = 7.2 Hz), 1.30 (t, 3H, *J* = 7.2 Hz), 1.33-1.50 (m, 4H), 1.59-1.69 (m, 1H), 1.74-1.84 (m, 1H), 4.17 (dd, 1H, *J* = 7.2, 4.4 Hz), 4.21-4.29 (m, 2H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 13.84, 14.12, 22.34,

[8] Uang, B-J; Chang, J-W; Jang, D-P. *PCT Int. Appl*. **2001.**
[9] Urban, F. J.; Moore, B. S. *J. Heterocyclic Chem.* **1992**, *29*, 431.
[10] Kalaritis, P.; Regenye, W. R.; Partridge, J. J.; Coffen, D. L. *J. Org. Chem*. **1990**, *55*, 812.
[11] Larcheveque, M., Petit, Y. *Bull. Soc. Chim. Fr*. **1989**, 130.

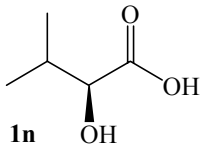
26.79, 34.02, 61.50, 70.37, 175.39; IR ($CHCl_3$) ν 3535, 3054, 2959, 1728, 1422, 1260 cm^{-1}.



(*S*)-2-hydroxyhexanic acid (1m).
This product was obtained as white solid in 36% yield and 95% ee as determined by GC analysis of the methyl ester derived from **1m** following the procedure described above [Gamma cyclodextrin Trifluoroacetyl, 60°, 2 min, 1°/min to 90°, t (major) = 19.65 min, t (minor) = 19.07 min]. $[\alpha]_D^{25}$ 6.4° (c=5.0, $CHCl_3$); (Literature,[6] $[\alpha]_D^{25}$ +4.8° (c = 6.3, $CHCl_3$) for 79% ee).



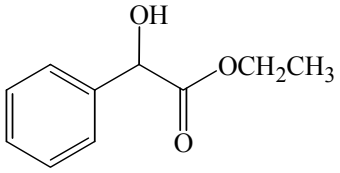
(*R*)-allyl-2-hydroxy-3-methylbutanoate (3n):
This product was obtained as a yellow oil in 48% yield and 90% ee as determined by GC on a chiral support [Gamma cyclodextrin Trifluoroacetyl 80 °C, t (major) = 18.68 min, t (minor) = 17.82 min]. $[\alpha]_D^{25}$ - 1.0° (c = 1.5, $CHCl_3$); ^1H NMR (400 MHz, $CDCl_3$) δ 0.88 (d, 3H, *J* = 7.0), 1.03 (d, 3H, *J* = 7.0 Hz), 2.02-2.10 (m, 1H), 3.28 (s, 1H, br), 4.08 (d, 1H, *J* = 4.0 Hz), 4.64-4.76 (m, 2H), 5.24-5.40 (m, 2H), 5.86-6.04 (m, 2H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 15.89, 18.69, 32.07, 66.02, 74.99, 131.35, 137.10, 174.59; IR ($CHCl_3$) ν 3536, 3054, 2969, 1733, 1467, 1266, 1030 cm^{-1}; HRMS exact mass calcd for ($C_8H_{15}O_3^+$) requires m/z 159.1021, found m/z 159.1026.



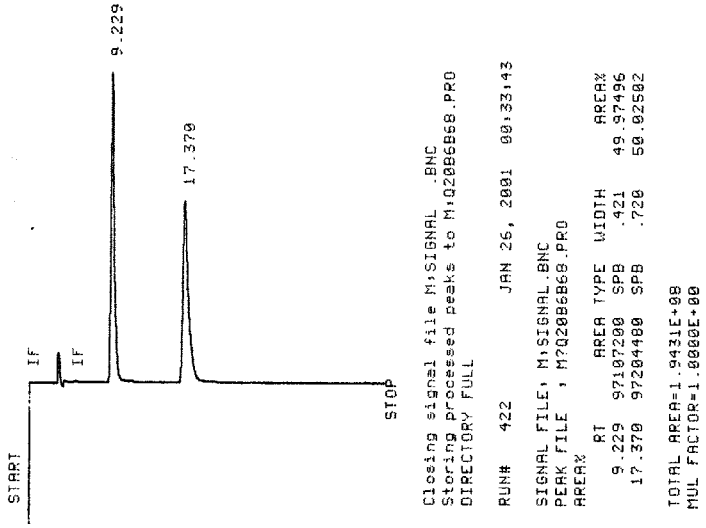
(*S*)-2-Hydroxy-3-methylbutanoic acid (1n):
This product was obtained as a yellow solid in 32% yield and 93% ee as determined by GC analysis of the methyl ester ester derived from **1n** following the procedure described above[Gamma cyclodextrin Trifluoroacetyl, 40 °C 20 min, 0.5°/min to 60 °C, t (major) = 41.01 min, t (minor) = 43.27 min]. $[\alpha]_D^{25}$ +16.5° (c = 0.8, $CHCl_3$); (Literature,[12] $[\alpha]_D^{25}$ +17.5° (c = 1, $CHCl_3$)).

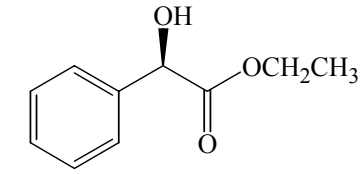
[12] Shin, I.; Lee, M.; Lee, J.; Jung, M.; Lee, W.; Yoon, J. *J. Org. Chem*. **2000**, *65*, 7667.

HPLC Condition: Chiralpak OD, Hexanes:IPA, 20:1, 1.0 mL/min, λ 220 nm.

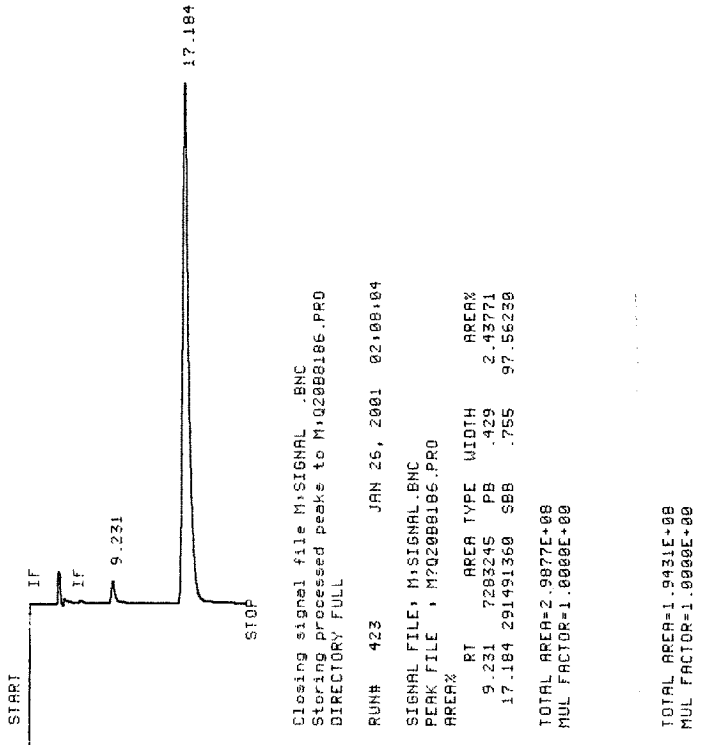


Racemic **3a**

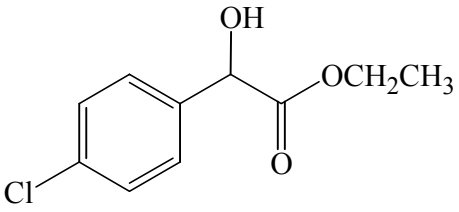




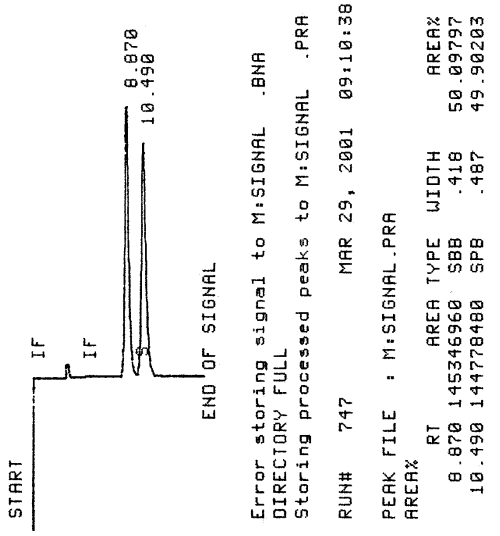
Isolated optically active **3a**

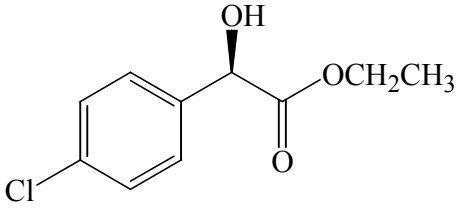


HPLC Conditions: Chiralpak OD, Hexanes:IPA, 20:1, 1.0 mL/min, λ 220 nm

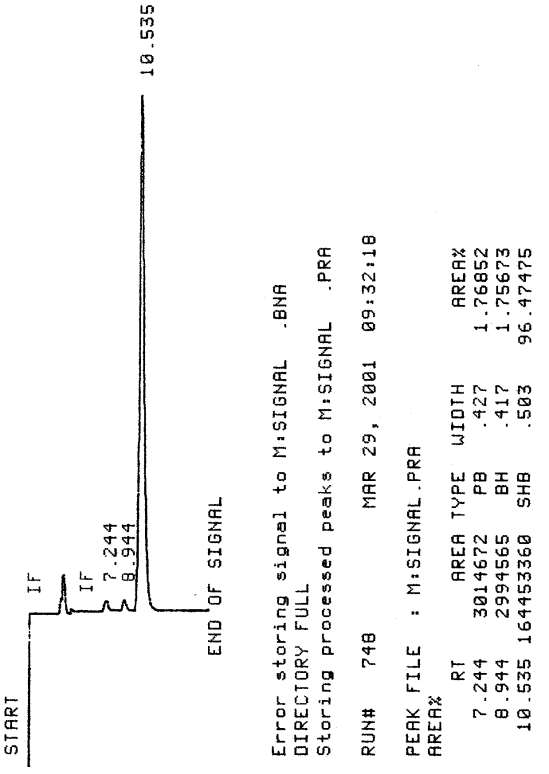


Racemic **3b**

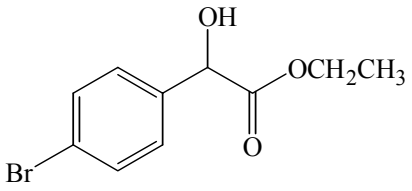




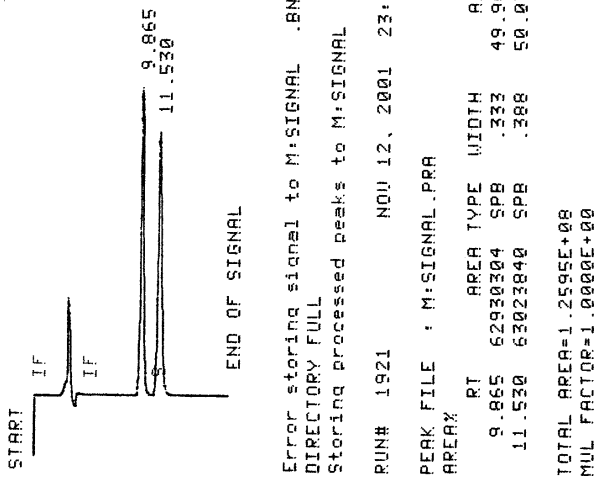
Isolated optically active **3b**

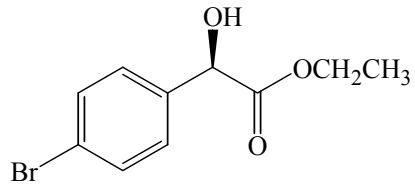


HPLC Condition: Chiralpak OD, Hexanes:IPA, 20:1, 1.0 mL/min, λ 220 nm.

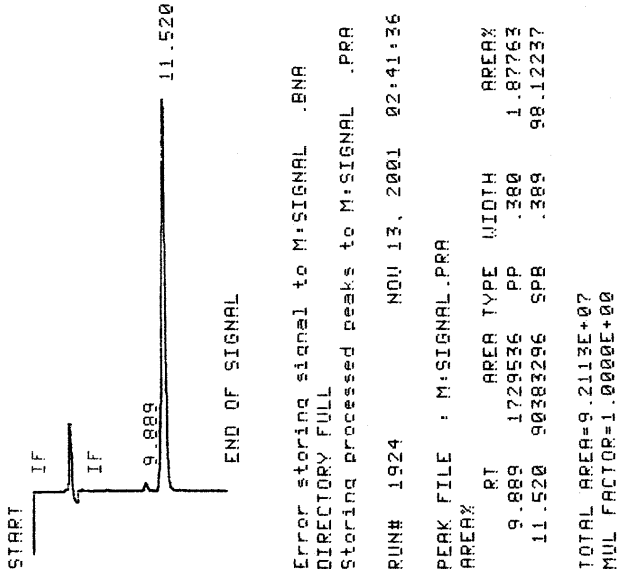


Racemic **3c**

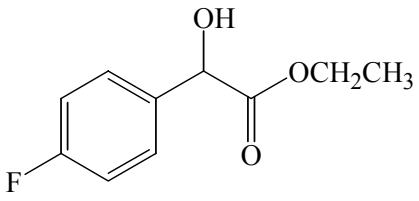




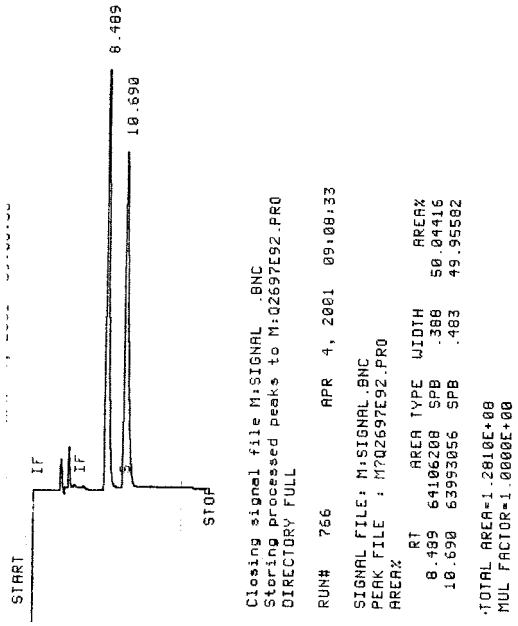
Isolated optically active **3c**

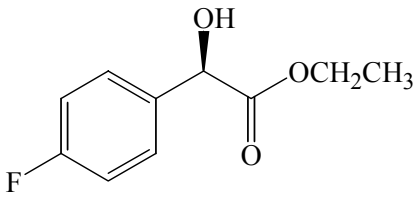


HPLC Condition: Chiralpak OD, Hexanes:IPA, 20:1, 1.0 mL/min, λ 220 nm

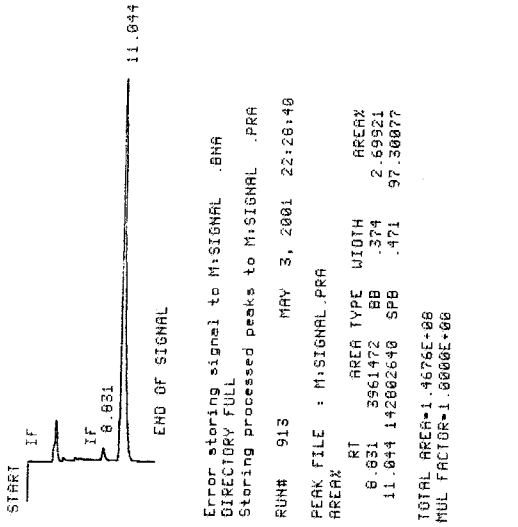


Racemic **3d**

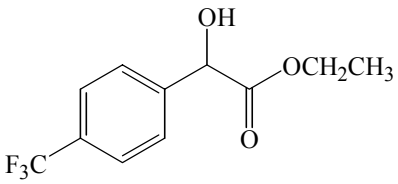




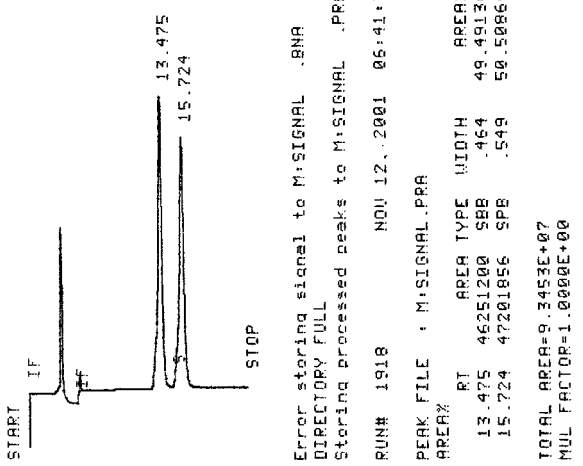
Isolated optically active **3d**

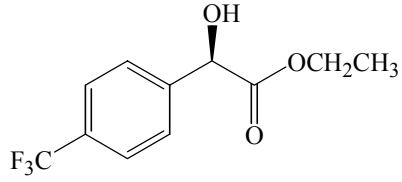


HPLC Conditions: Chiralpak OD, Hexanes:IPA, 50:1, 1.0 mL/min, λ 220 nm.

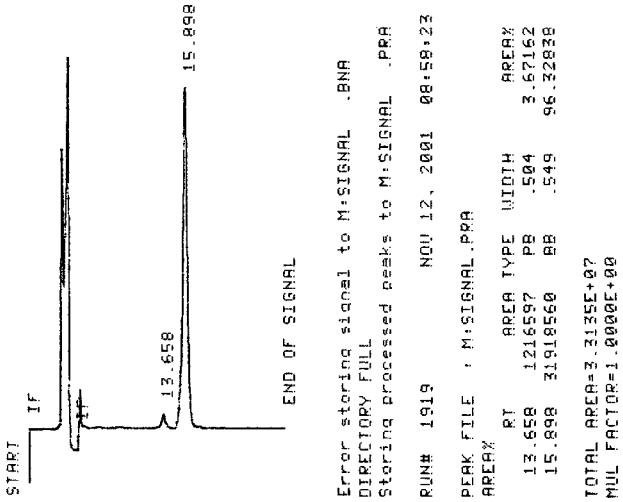


Racemic **3e**

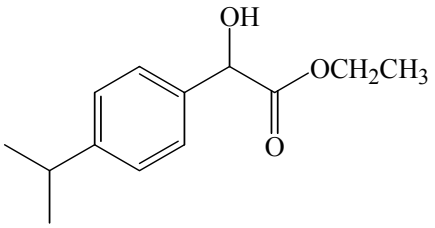




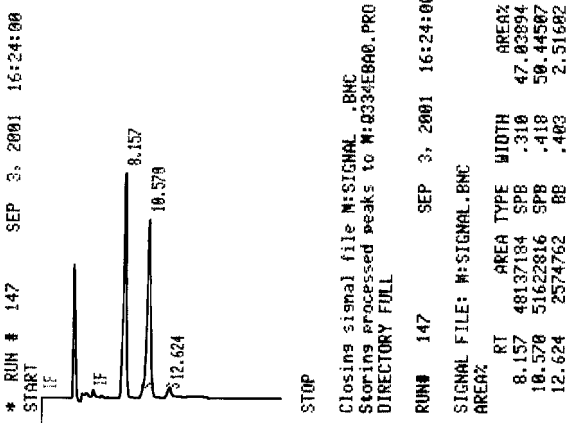
Isolated optically active **3e**

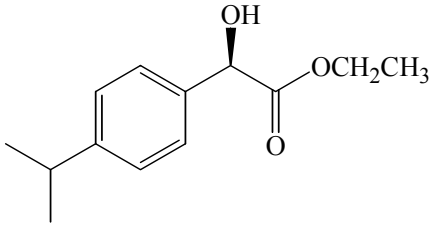


HPLC Conditions: Chiralpak OD, Hexanes:IPA, 20:1, 1.0 mL/min, λ 220 nm.

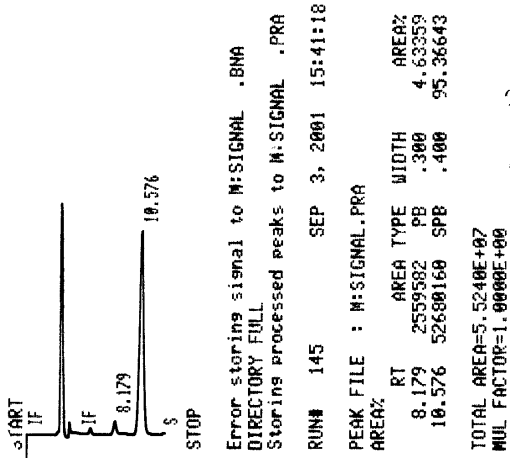


Racemic **3f**

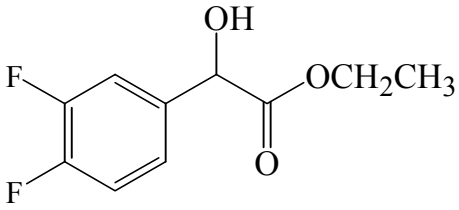




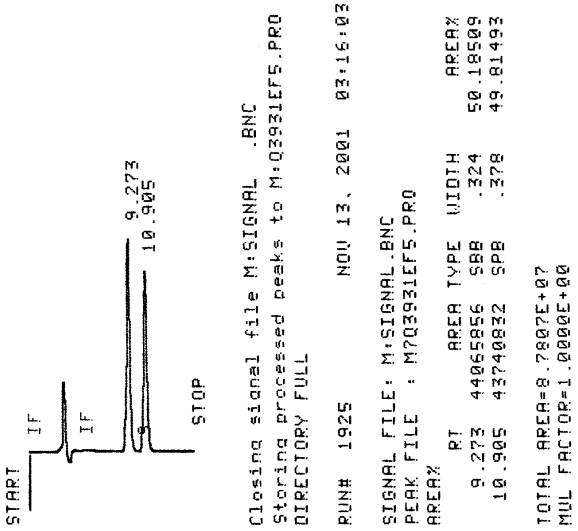
Isolated optically active **3f**

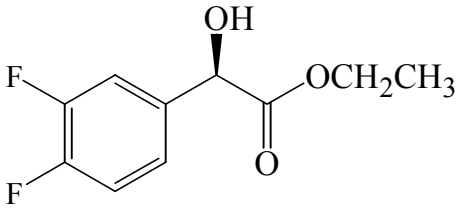


HPLC Conditions: Chiralpak OD, Hexanes:IPA, 20:1, 1.0 mL/min, λ 220 nm.

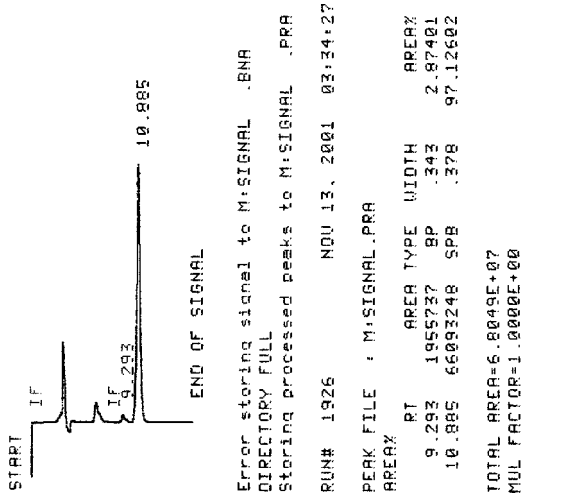


Racemic **3g**

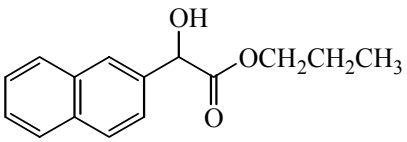




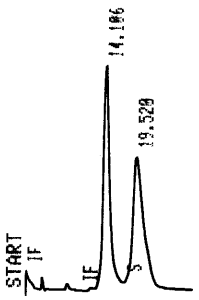
Isolated optically active **3g**



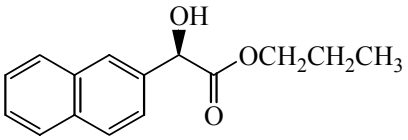
HPLC Conditions: Chiralpak AS, Hexanes:IPA, 19:1, 1.0 mL/min, λ 280 nm.



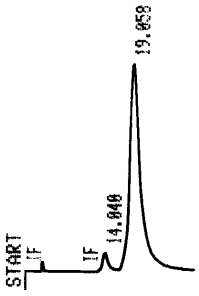
Racemic **3h**




```
END OF SIGNAL

Error storing signal to M:SIGNAL  .BNA
DIRECTORY FULL
Storing processed peaks to M:SIGNAL  .PRA

RUN#  454        NOV 17, 2001  16:47:16

PEAK FILE  : M:SIGNAL.PRA
AREA%:
      RT      AREA TYPE  WIDTH     AREA%
  14.106  83697088  SBB  1.235   49.73501
  19.520  94588992   BB  2.158   50.26501

TOTAL AREA=1.6829E+08
MUL FACTOR=1.0000E+00
```

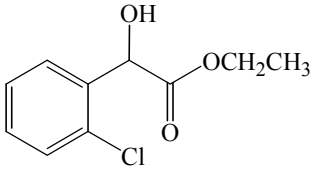


Isolated optically active **3h**

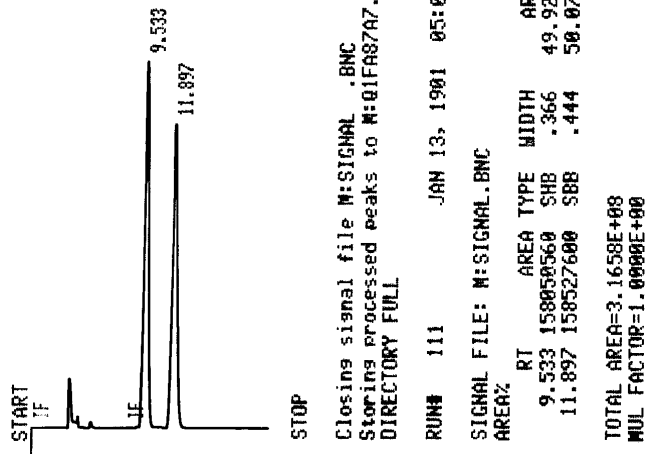


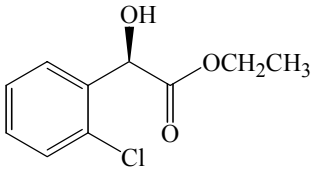

```
STOP

Closing signal file M:SIGNAL  .BNC
Storing processed peaks to M:03992C98.PRO
DIRECTORY FULL

RUN#  455        NOV 17, 2001  17:27:52

SIGNAL FILE: M:SIGNAL.BNC
AREA%:
      RT      AREA TYPE  WIDTH     AREA%
  14.040   6647658   BP  1.169   4.62698
  19.058 137024000   PB  2.161  95.37302

TOTAL AREA=1.4367E+08
MUL FACTOR=1.0000E+00
```

HPLC Condition: Chiralpak OD, Hexanes:IPA, 20:1, 1.0 mL/min, λ 220 nm.

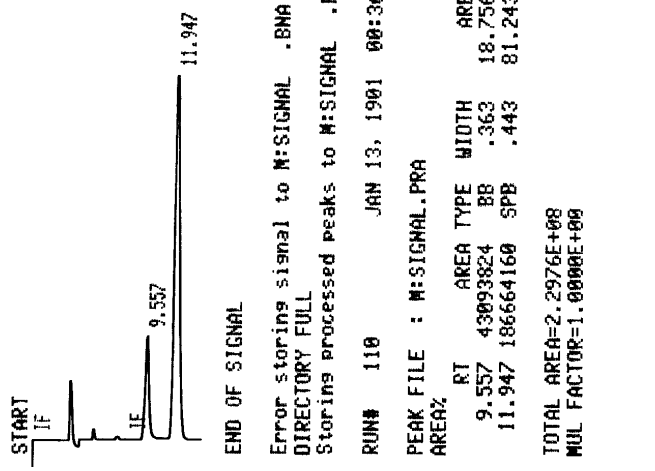


Racemic **3i**

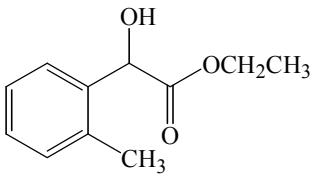




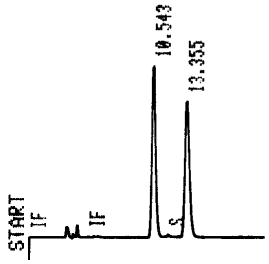
Isolated optically active **3i**



HPLC Condition: Chiralpak OD, Hexanes:IPA, 19:1, 1.0 mL/min, λ 220 nm.



Racemic **3j**




```
END OF SIGNAL

Error storing signal to M:SIGNAL  .BNA
DIRECTORY FULL
Storing processed peaks to M:SIGNAL  .PRA

RUN#  146        JAN 21, 1901  01:15:35

PEAK FILE  : M:SIGNAL.PRA
AREA%
      RT      AREA TYPE  WIDTH     AREA%
  10.543 138862080 SPB   .342    49.32344
  13.355 142671520 SPB   .444    50.67658

TOTAL AREA=2.8153E+08
MUL FACTOR=1.0000E+00
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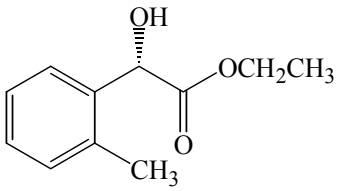
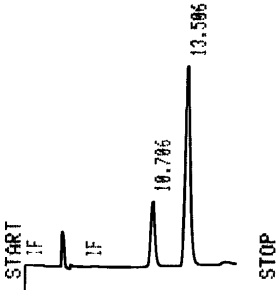


Isolated optically active **3j**

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Closing signal file M:SIGNAL  .BNC
Storing processed peaks to M:Q2057210.PRO
DIRECTORY FULL

RUN#  149        JAN 21, 1901  11:48:45

SIGNAL FILE: M:SIGNAL.BNC
AREA%
      RT      AREA TYPE  WIDTH     AREA%
  10.706  28254512 SBB   .370    20.54654
  13.506 109260160 SBB   .468    79.45347

TOTAL AREA=1.3751E+08
MUL FACTOR=1.0000E+00
```
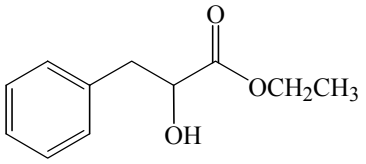
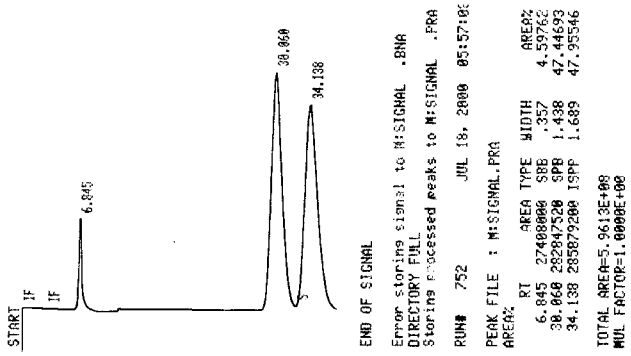
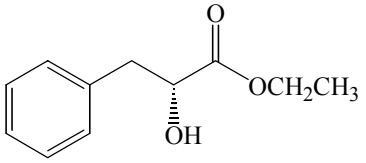

HPLC Condition: Chiralpak AS, Hexanes:IPA, 50:1, 0.5 mL/min, λ 220 nm.

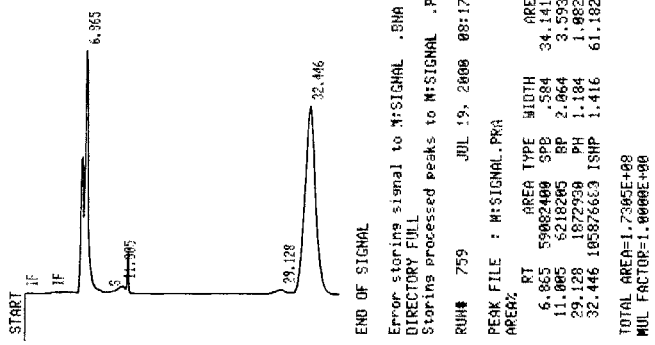


Racemic **3k**

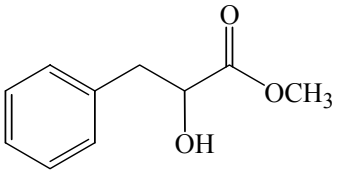




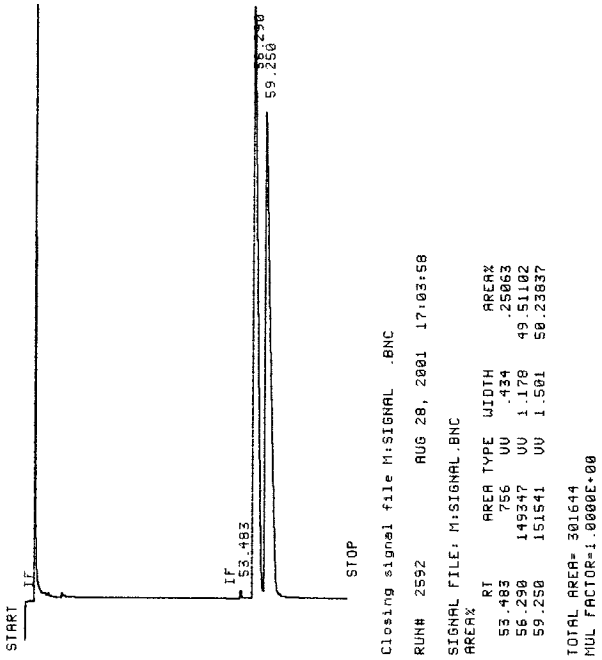
Isolated optically active **3k**

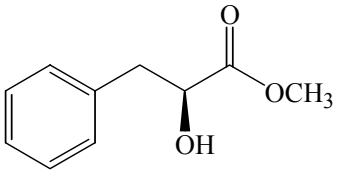


GC Conditions: HP chiral 20% Permethylated B-Cyclodextrin, 100 °C, 20 min, 0.5 °C/min ramp, 130 °C (10 min).

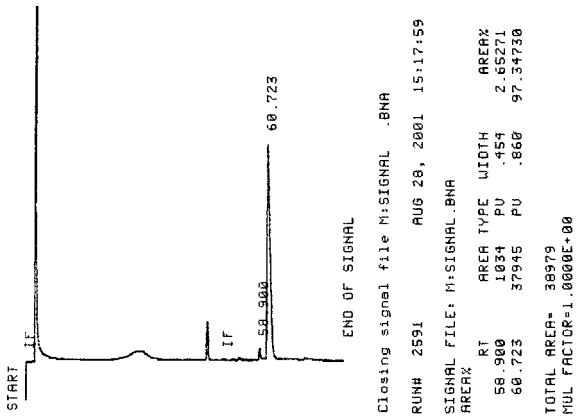


Derived from racemic acid **1k**

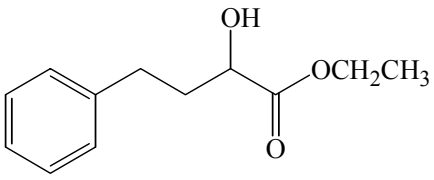




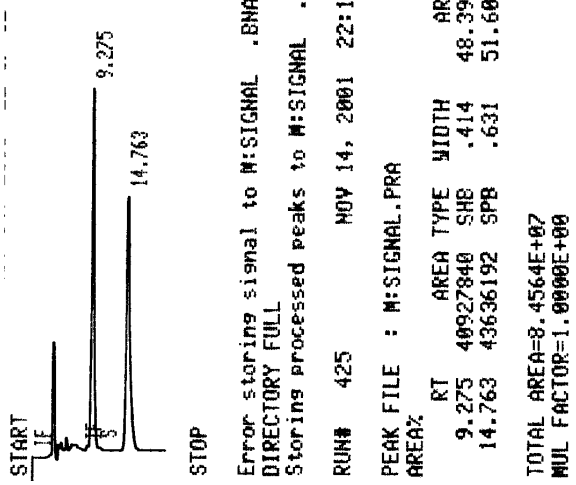
Derived from optically active acid 1**k**

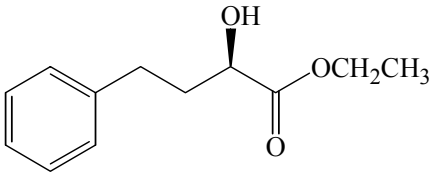


HPLC Conditions: Chiralpak OD, Hexanes:IPA, 20:1, 1 mL/min, λ 220 nm.

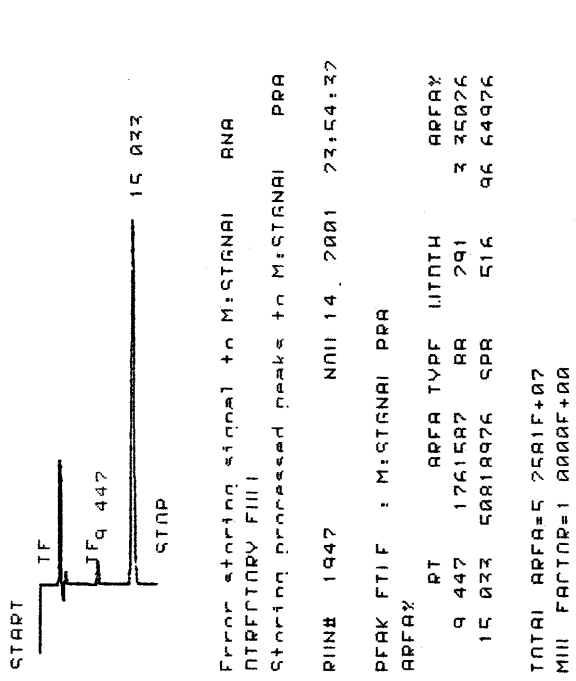


Racemic **3l**

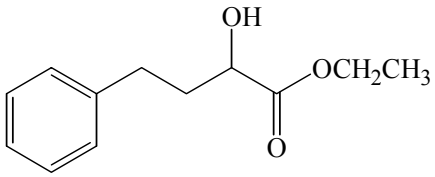




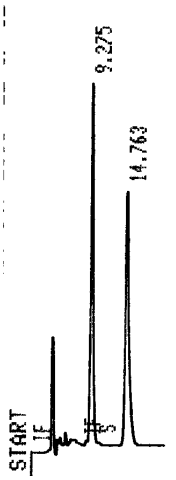
Isolated optically active **3l**



HPLC Conditions: Chiralpak OD, Hexanes:IPA, 20:1, 1 mL/min, λ 220 nm.



Derived form racemic acid **1l**



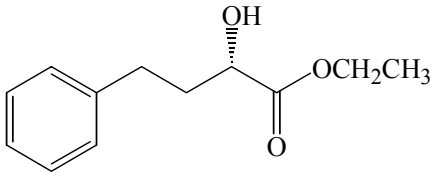
Error storing signal to M:SIGNAL .BNA
DIRECTORY FULL
Storing processed peaks to M:SIGNAL .PRA

RUN# 425 NOV 14, 2001 22:17:52

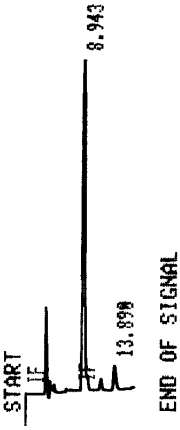
PEAK FILE : M:SIGNAL.PRA
AREA%

RT	AREA	TYPE	WIDTH	AREA%
9.275	40927840	SHB	.414	48.39864
14.763	43636192	SPB	.631	51.60134

TOTAL AREA=8.4564E+07
MUL FACTOR=1.0000E+00



Derived from isolated optically pure acid **1l**



END OF SIGNAL

Error storing signal to M:SIGNAL .BNA
DIRECTORY FULL
Storing processed peaks to M:SIGNAL .PRA

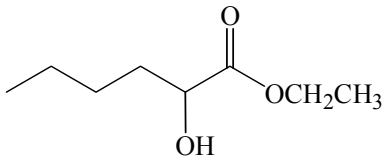
RUN# 439 NOV 16, 2001 16:13:50

PEAK FILE : M:SIGNAL.PRA
AREA%

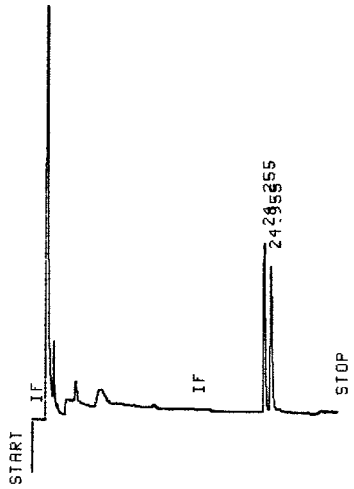
RT	AREA	TYPE	WIDTH	AREA%
8.943	65052224	BB	.359	91.75994
13.890	5841696	PB	.443	8.24005

TOTAL AREA=7.0894E+07
MUL FACTOR=1.0000E+00

GC Conditions: Gamma cyclodextrin Trifluoroacetyl, 60°, 2 min, 1°/min ramp, 90° (10 min).



Racemic **3m**



Closing signal file M:SIGNAL .BNC

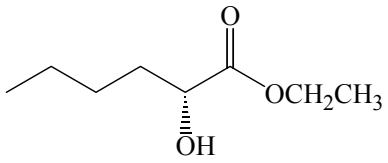
RUN# 2747 JAN 21, 2002 17:14:00

SIGNAL FILE: M:SIGNAL.BNC

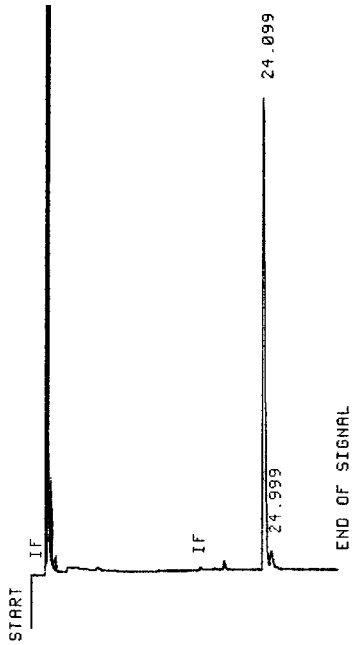
AREA%	RT	AREA TYPE	WIDTH	AREA%
	24.255	5711 PU	.197	49.76472
	24.955	5765 VV	.232	50.23526

TOTAL AREA= 11476

MUL FACTOR=1.0000E+00



Isolated optically active **3m**



Closing signal file M:SIGNAL .BNA

RUN# 2745 JAN 21, 2002 15:40:11

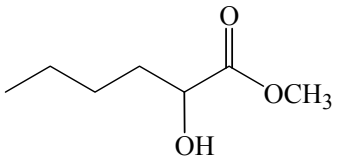
SIGNAL FILE: M:SIGNAL.BNA

AREA%	RT	AREA TYPE	WIDTH	AREA%
	24.099	23270 PU	.287	95.78890
	24.999	1023 VV	.316	4.21109

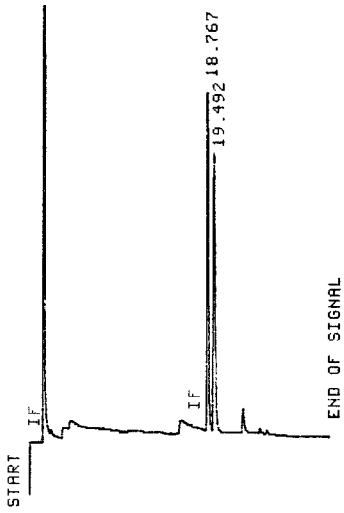
TOTAL AREA= 24293

MUL FACTOR=1.0000E+00

GC Conditions: Gamma cyclodextrin Trifluoroacetyl, 60°, 2 min, 1°/min ramp, 90° (10 min).



Derived from racemic acid **1m**



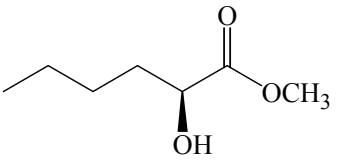
Closing signal file M:SIGNAL .BNA

RUN# 2744 JAN 21, 2002 12:00:18

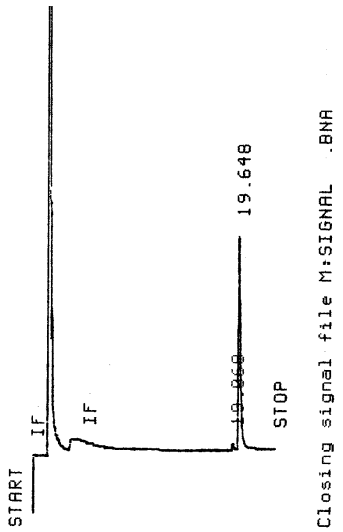
SIGNAL FILE: M:SIGNAL.BNA
AREA%

RT	AREA TYPE	WIDTH	AREA%
18.767	11250 PB	.191	49.99112
19.492	11254 PB	.235	50.00888

TOTAL AREA= 22504
MUL FACTOR=1.0000E+00



Derived from optically active acid **1m**



Closing signal file M:SIGNAL .BNA

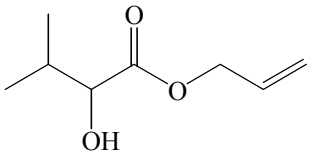
RUN# 2743 JAN 20, 2002 16:31:31

SIGNAL FILE: M:SIGNAL.BNA
AREA%

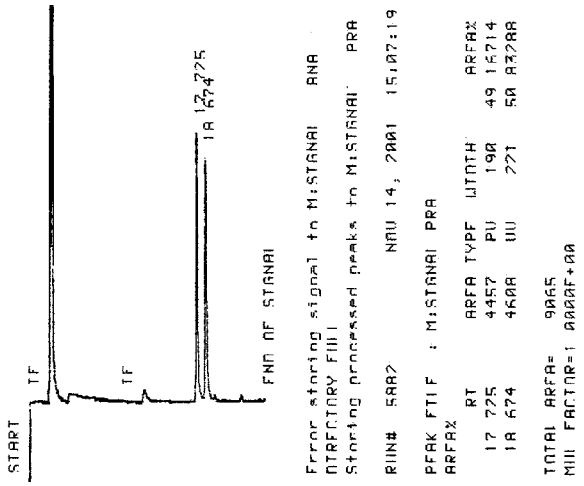
RT	AREA TYPE	WIDTH	AREA%
19.068	190 PP	.167	2.52157
19.648	7345 PB	.217	97.47843

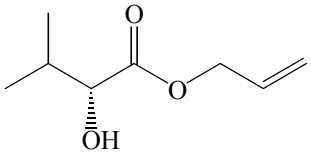
TOTAL AREA= 7535
MUL FACTOR=1.0000E+00

GC Conditions: γ-TA, 80°C

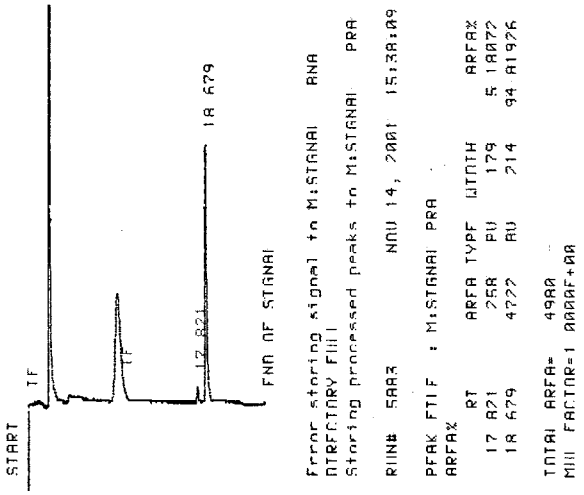


Racemic **3n**

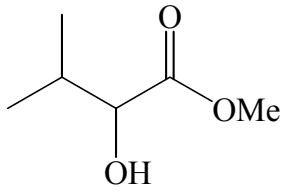




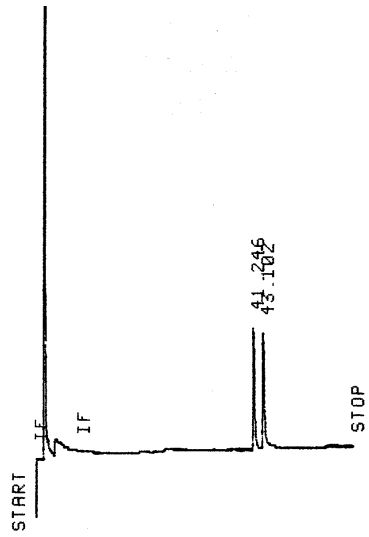
Isolated optically active **3n**



GC Conditions: Gamma cyclodextrin Trifluoroacetyl, 40 °C, 20 min, 0.5°/min ramp, 60 °C (10 min).



Derived from racemic acid **1n**



Closing signal file M:SIGNAL .BNA

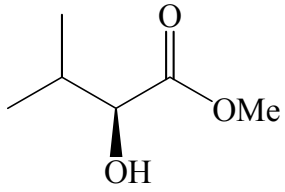
RUN# 2700 NOV 22, 2001 19:58:40

SIGNAL FILE: M:SIGNAL.BNA

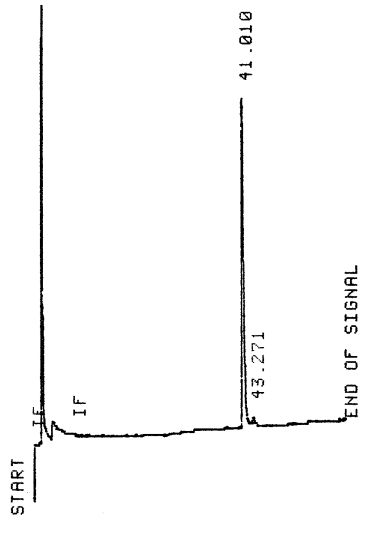
AREA% RT	AREA	TYPE	WIDTH	AREA%
41.246	3375	PP	.354	49.42882
43.102	3453	PU	.386	50.57117

TOTAL AREA= 6828

MUL FACTOR=1.0000E+00



Derived from optically active acid **1n**



Closing signal file M:SIGNAL .BNA

RUN# 2701 NOV 22, 2001 22:13:31

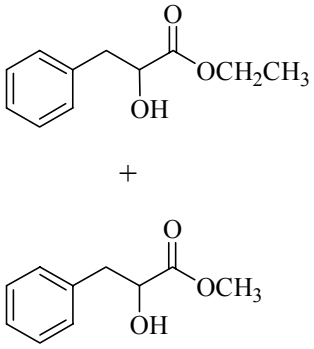
SIGNAL FILE: M:SIGNAL.BNA

AREA% RT	AREA	TYPE	WIDTH	AREA%
41.010	12268	PU	.464	96.85011
43.271	399	VB	.475	3.14992

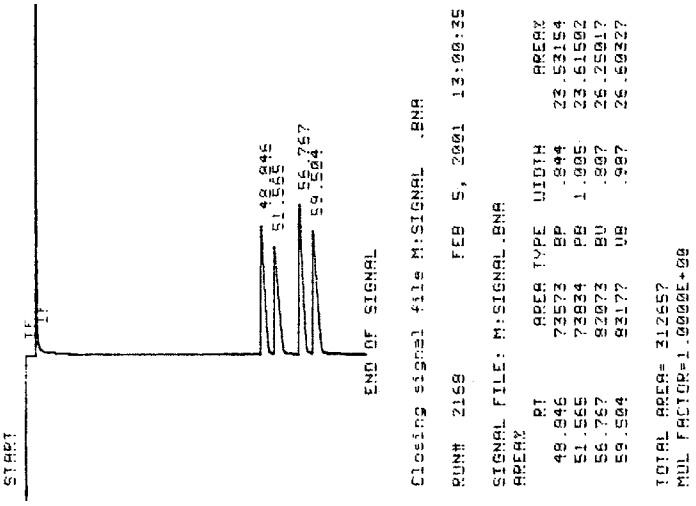
TOTAL AREA= 12667

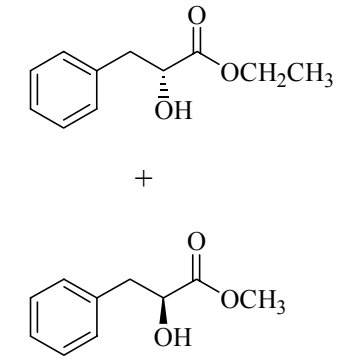
MUL FACTOR=1.0000E+00

GC Conditions: HP chiral 20% Permethylated B-Cyclodextrin, 100 °C, 20 min, 0.5 °C/min ramp, 130 °C (10 min).

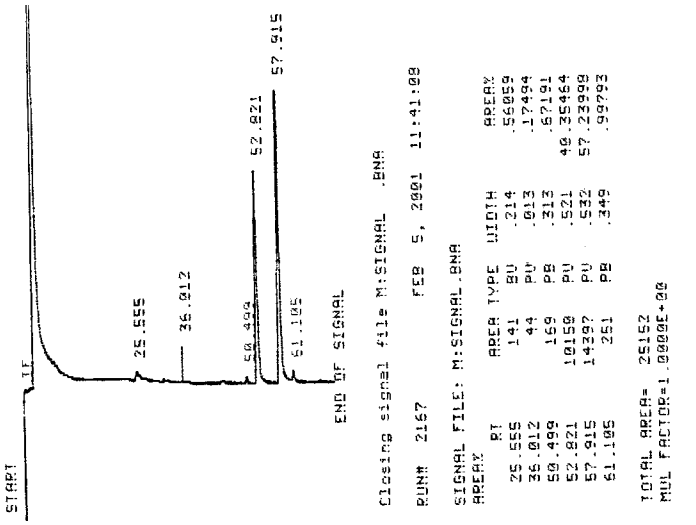


Racemic **3k** and **5k**

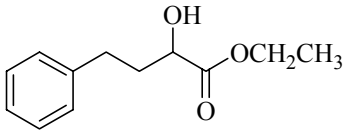




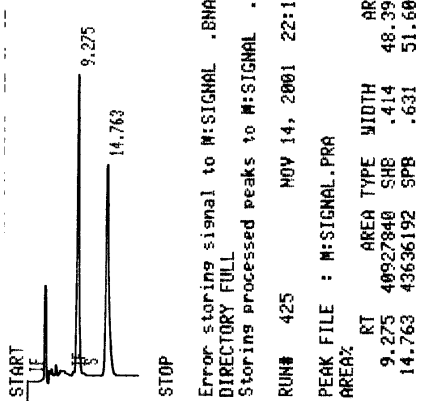
Optically active **3k** and **5k** derived from reaction mixture

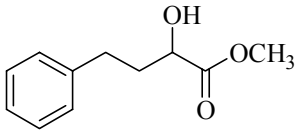


HPLC Conditions: Chiralpak OD, Hexanes:IPA, 20:1, 1 mL/min, λ 220 nm.

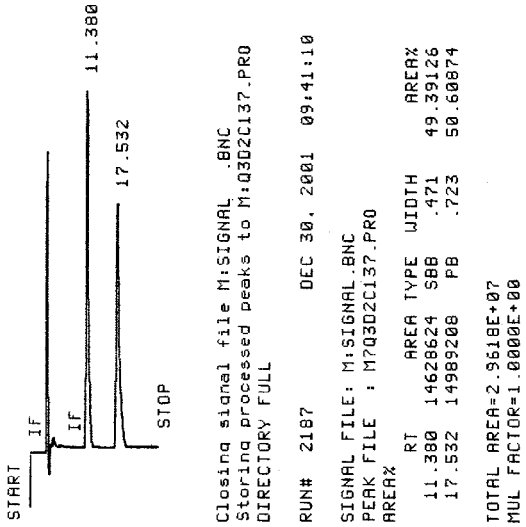


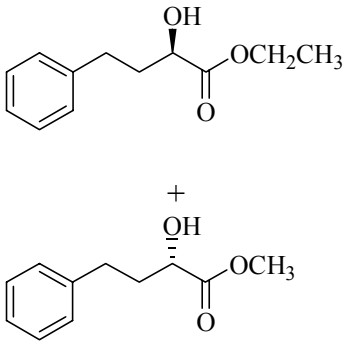
Racemic **3l**





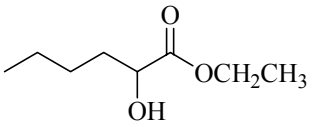
Racemic **5l**



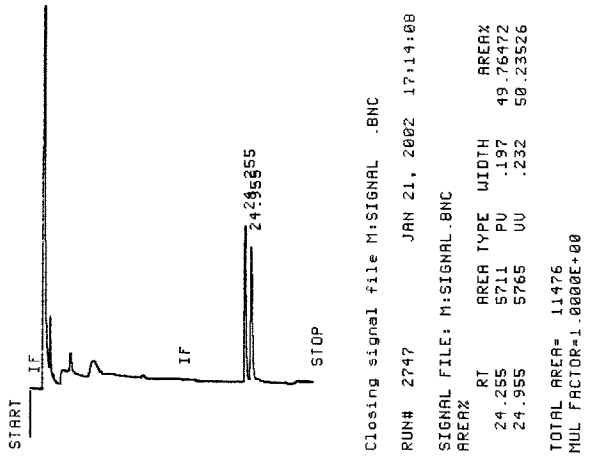


Optically active **3l** and **1l** derived from reaction mixture

GC Conditions: Gamma cyclodextrin Trifluoroacetyl, 60°, 2 min, 1°/min ramp, 80° (10 min).



Racemic **3m**



Closing signal file M:SIGNAL .BNC

RUN# 2747 JAN 21, 2002 17:14:08

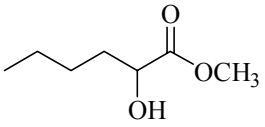
SIGNAL FILE: M:SIGNAL.BNC

AREA%

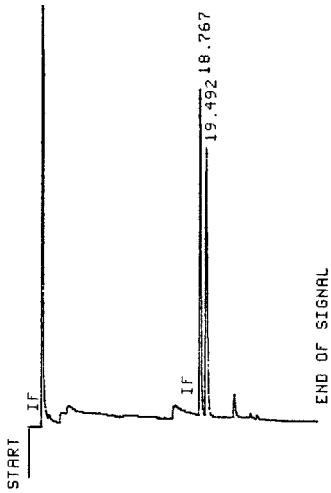
	RT	AREA TYPE	WIDTH	AREA%
	24.255	PU	.197	49.76472
	24.955	VV	.232	50.23526

TOTAL AREA= 11476

MUL FACTOR=1.0000E+00



Racemic **5m**



Closing signal file M:SIGNAL .BNA

RUN# 2744 JAN 21, 2002 12:00:18

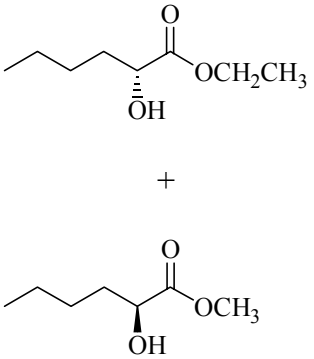
SIGNAL FILE: M:SIGNAL.BNA

AREA%

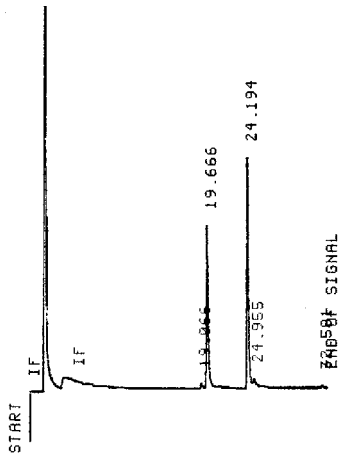
	RT	AREA TYPE	WIDTH	AREA%
	18.767	PB	.191	49.99112
	19.492	PB	.235	50.00888

TOTAL AREA= 22504

MUL FACTOR=1.0000E+00



Optically active **3m** and **5m** derived from reaction mixture



Closing signal file M:SIGNAL .BNA

RUN# 2742 JAN 20, 2002 10:44:37

SIGNAL FILE: M:SIGNAL.BNA

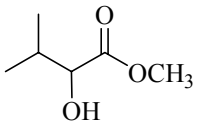
AREA%

	RT	AREA TYPE	WIDTH	AREA%
	19.066	PB	.138	.80321
	19.666	BV	.208	39.68779
	24.194	PV	.210	57.17709
	24.955	VB	.240	1.95621
	32.581	PB	.139	.37570

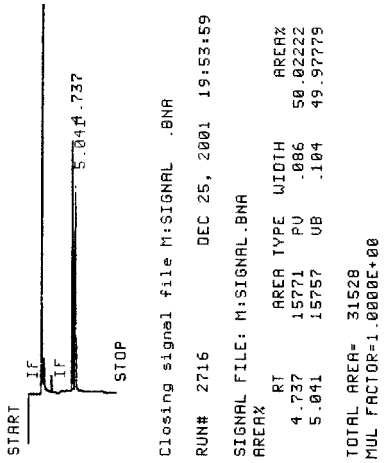
TOTAL AREA= 15438

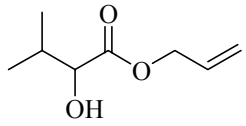
MUL FACTOR=1.0000E+00

GC Conditions: Gamma cyclodextrin Trifluoroacetyl, 80°C

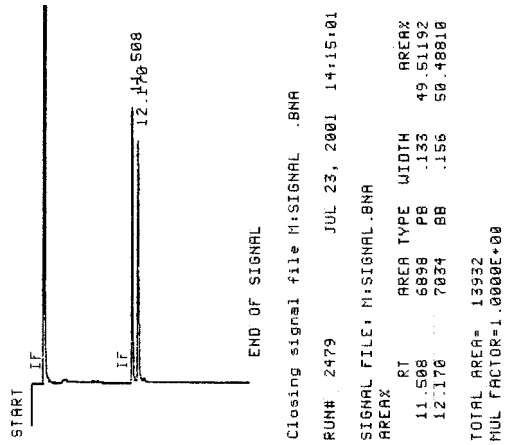


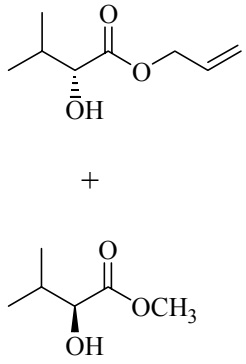
Racemic **5n**





Racemic **3n**





Optically active **3n** and **5n** derived from reaction mixture