Enantioselective Total Synthesis of Natural Isoflavans: Asymmetric Transfer Hydrogenation/Deoxygenation of Isoflavanones with Dynamic Kinetic Resolution

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Supporting Information

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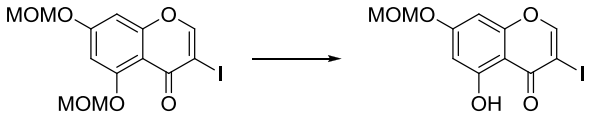
1. General information

THF and CH_2Cl_2 were dried and purified by passage through a MB-SPS-800 device using molecular sieves. Et_3N was freshly distilled over CaH_2. All other commercially available reagents were used as received. Reactions were performed under argon atmosphere. Thin layer chromatography (TLC) was performed on Merck silica gel 60 F_{254} 0.2 mm precoated plates. Product spots were visualized by UV light at 254 nm and subsequently developed using anisaldehyde solution as appropriate. Flash column chromatography was carried out using silica gel (Merck, particle size 40-63 microns). Melting points were measured on a Wagner & Munz PolyTherm A and are uncorrected. Infrared spectra were recorded on a THERMONICOLET Avatar 360 instrument using ATR. NMR spectra were recorded on a Bruker AC 300 P (300 MHz ^{1}H, 75 MHz ^{13}C, 282 MHz ^{19}F), on a Bruker DRX 500 P (500 MHz ^{1}H, 125 MHz ^{13}C) or on a Bruker AC 600-P (600 MHz ^{1}H, 151 MHz ^{13}C) spectrometer. Chemical shifts (δ) are quoted in parts per million (ppm) downfield of tetramethylsilane, using residual proton-containing solvent as internal standard ($CDCl_3$ at 7.27 ppm or $(CD_3)_2CO$ at 2.05 ppm). Abbreviations used in the description of resonances are: s (singlet), d (doublet), t (triplet), q (quartet), br (broad). Coupling constants (*J*) are quoted to the nearest 0.1 Hz. Mass spectra were recorded with an Agilent 5973N detector coupled with an Agilent 6890N GC (GC-MS, 70 eV) or else with a Bruker Esquire-LC (direct injection as a methanolic NH_4OAc solution, ESI). HRMS spectra were recorded on a Bruker Daltonic "Impact II" (ESI-TOF). Optical rotations were measured on a Perkin Elmer 341 LC polarimeter. Elemental analysis was performed on a Hekatech EA 3000. Microwave synthesis was carried out in a microwave synthesizer (CEM Discover, 300 W). Enantiomeric excesses were determined by chiral HPLC on a Hewlett Packard LC 1090 with photodiode array detector (DAD) using chiral column Chiralpak IA (DAICEL, 250 mm, inner diameter 4.6 mm, particle size 5 microns and 3 microns respectively), Chiralpak AD (DAICEL, 250 mm, inner diameter 4.6 mm, particle size 10 micron) or Lux Amylose 1 (Phenomenex, 250 mm, inner diameter 4.6 mm, particle size 5 microns). All measurements were carried out at ambient temperature and with a flow rate of 0.5 to 1.0 mL/min. CD spectra were measured on a JASCO J-810 spectropolarimeter. Unless stated otherwise, racemic samples were prepared according to the procedures described for the enantiomerically pure series.

2. Synthesis of (*S*)-equol (1)

Chromone **7a**



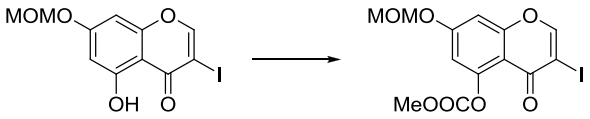
7 **7a**

Chromone **7** (549.4 mg, 1.40 mmol) was dissolved in a mixture of THF (26.5 mL) and MeOH (26.5 mL) and 1 N HCl (2.65 mL) was added. The mixture was stirred for 19 h at rt and was then

quenched with saturated aqueous NaCl solution and extracted three times with EtOAc. The combined organic layers were dried over $MgSO_4$. The solvents were removed under reduced pressure, and the residue was submitted to flash chromatography (isohexane/ethyl acetate 3:2) to afford chromone **7a** (464.6 mg, 1.33 mmol, 95%) as a white solid.

M.p. 124 - 127 °C. ^{1}H NMR (300 MHz, $CDCl_3$): δ = 12.17 (s, 1 H), 8.16 (s, 1 H), 6.59 (d, *J* = 2.3 Hz, 1 H), 6.55 (d, *J* = 2.1 Hz, 1 H), 5.23 (s, 2 H), 3.50 (s, 3 H) ppm. ^{13}C NMR (75 MHz, $CDCl_3$): δ = 177.55 (C), 163.35 (C), 161.65 (C), 158.13 (CH), 157.59 (C), 105.20 (C), 100.60 (CH), 94.45 (CH), 94.26 (CH_2), 83.68 (C), 56.50 (CH_3) ppm. IR (ATR): ν = 3111, 3053, 2995, 2965, 2937, 2833, 2057, 2030, 1877, 1734, 1717, 1699, 1641, 1594, 1563, 1510, 1478, 1448, 1433, 1399, 1355, 1302, 1264, 1218, 1203, 1138, 1068, 1047, 1015, 921, 840, 797, 765, 692, 664 cm^{-1}. ESI-MS: m/z = 349.1 $[M+NH_4]^+$. Anal. calcd for $C_{11}H_9IO_5$: C, 37.95; H, 2.61; found: C, 38.04; H, 2.29.

Chromone **8**

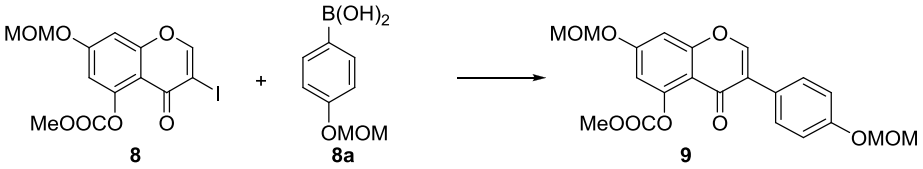


7a **8**

Chromone **7a** (310.0 mg, 890.6 μmol) was dissolved in THF (10.0 mL) and Et_3N (0.22 mL) was added. At 0 °C ClCOOMe (0.13 mL, 1.7 mmol) was added dropwise, and the solution was stirred for 45 min at rt. The reaction was quenched with saturated aqueous NH_4Cl solution and extracted three times with EtOAc. The combined organic layers were dried over $MgSO_4$. The solvents were removed under reduced pressure, and the residue was submitted to flash chromatography (isohexane/ethyl acetate 3:2) to afford chromone **8** (339.9 mg, 836.9 μmol, 94%) as a white solid.

M.p. 142 - 145 °C. ^{1}H NMR (300 MHz, $CDCl_3$): δ = 8.17 (s, 1 H), 7.02 (d, *J* = 2.5 Hz, 1 H), 6.85 (d, *J* = 2.3 Hz, 1 H), 5.26 (s, 2 H), 3.99 (s, 3 H), 3.50 (s, 3 H) ppm. ^{13}C NMR (75 MHz, $CDCl_3$): δ = 171.05 (C), 161.21 (C), 158.44 (C), 156.53 (CH), 153.46 (C), 150.47 (C), 110.36 (C), 109.96 (CH), 101.73 (CH), 94.57 (CH_2), 88.03 (C), 56.63 (CH_3), 55.92 (CH_3) ppm. IR (ATR): ν = 3114, 3074, 3005, 2958, 2823, 2192, 1914, 1843, 1752, 1699, 1684, 1630, 1596, 1555, 1486, 1472, 1457, 1437, 1372, 1358, 1258, 1204, 1184, 1158, 1140, 1092, 1063, 1000, 987, 937, 921, 878, 846, 831, 790, 764, 729, 679 cm^{-1}. ESI-MS: m/z = 407.2 $[M+H]^+$. Anal. calcd for $C_{13}H_{11}IO_7$: C, 38.45; H, 2.73; found: C, 38.71; H, 2.59.

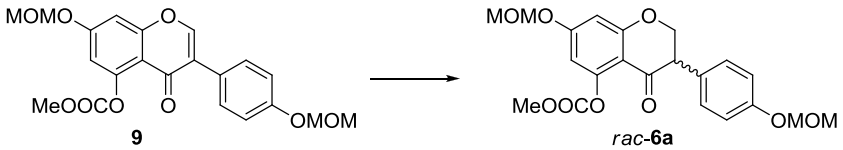
Isoflavone **9**



Chromone **8** (300.6 mg, 740.2 μmol), boronic acid **8a** (223.0 mg, 1.2 mmol), and K_2CO_3 (266.6 mg, 1.9 mmol) were suspended in dioxane (3.7 mL) and water (1.6 mL), and the mixture was heated to 50 °C until the solution became clear. The mixture was degassed at ambient temperature for 10 min, and PCy_3 (10.50 mg, 37.4 μmol) and $Pd_2(dba)_3$ (17.17 mg, 18.8 μmol) were added. The solution was stirred for 60 min at 50 °C. The reaction was quenched with saturated aqueous NH_4Cl solution and extracted three times with EtOAc. The combined organic layers were dried over $MgSO_4$. The solvents were removed under reduced pressure, and the residue was submitted to flash chromatography (isohexane/ethyl acetate 2:1) to afford isoflavone **9** (247.9 mg, 595.4 μmol, 80%) as a white solid.

M.p. 115 - 119 °C. ^{1}H NMR (300 MHz, $CDCl_3$): δ = 7.84 (s, 1 H), 7.44 (m, 2 H), 7.09 (m, 2 H), 7.02 (d, *J* = 2.3Hz, 1 H), 6.82 (d, *J* = 2.3 Hz, 1 H), 5.27 (s, 2 H), 5.21 (s, 2 H), 3.95 (s, 3 H), 3.51 (s, 3 H), 3.49 (s, 3 H) ppm. ^{13}C NMR (75 MHz, $CDCl_3$): δ = 174.70 (C), 160.77 (C), 158.58 (C), 157.26 (C), 153.55 (C), 151.28 (CH), 150.94 (C), 130.33 (CH), 125.70 (C), 124.90 (C), 116.20 (CH), 112.73 (C), 109.36 (CH), 101.86 (CH), 94.50 (CH_2), 94.32 (CH_2), 56.53 (CH_3), 55.96 (CH_3), 55.77 (CH_3) ppm. IR (ATR): ν = 3078, 2995, 2955, 2929, 2896, 2826, 2138, 2056, 2030, 2009, 1942, 1919, 1890, 1868, 1843, 1828, 1763, 1734, 1717, 1699, 1684, 1627, 1606, 1561, 1511, 1473, 1457, 1435, 1281, 1241, 1195, 1143, 1099, 1075, 1053, 996, 925, 871, 834, 801, 760, 729, 693, 667, 363 cm^{-1}. ESI-MS: m/z = 417.3 $[M+NH_4]^+$. Anal. calcd for $C_{21}H_{20}O_9$: C, 60.58; H, 4.84; found: C, 60.64; H, 5.18.

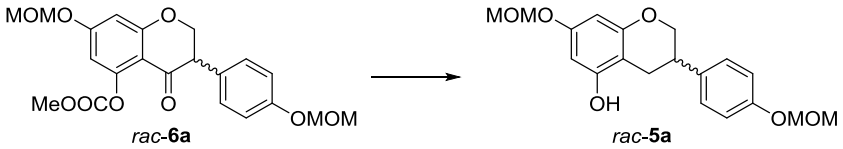
Isoflavanone *rac*-**6a**



Isoflavone **9** (551.2 mg, 1.32 mmol) was dissolved in THF (10.0 mL) and cooled to −78°C. L-selectride solution (1.56 mL, 1.0 M in THF, 1.56 mmol) was added, and the mixture was stirred for 60 min. The reaction was quenched with a small portion of MeOH and poured into NH_4Cl solution. The mixture was extracted three times with EtOAc. The combined organic layers were dried over $MgSO_4$. The solvents were removed in vacuo, and the residue was purified by flash chromatography (isohexane/ethyl acetate 2:1) to afford racemic isoflavanone *rac*-**6a** (500.3 mg, 1.20 mmol, 90%) as a colorless oil.

^{1}H NMR (300 MHz, $CDCl_3$): δ = 7.17 (m, 2 H), 7.01 (m, 2 H), 6.58 (d, *J* = 2.2 Hz, 1 H), 6.48 (d, *J* = 2.5 Hz, 1 H), 5.20 (s, 2 H), 5.16 (s, 2 H), 4.61 (m), 3.91 (s, 3 H), 3.86 (dd, *J* = 7.9 Hz, 6.0 Hz, 1 H), 3.49 (s, 3 H), 3.47 (s, 3 H) ppm. ^{13}C NMR (75 MHz, $CDCl_3$): δ = 189.68 (C), 163.87 (C), 162.86 (C), 156.75 (C), 153.39 (C), 152.13 (C), 129.67 (CH), 128.06 (C), 116.59 (CH), 108.91 (C), 105.63 (CH), 101.96 (CH), 94.32 (CH_2), 94.24 (CH_2), 71.37 (CH_2), 56.54 (CH_3), 55.96 (CH_3), 55.63 (CH_3), 51.60 (CH) ppm. IR (ATR): ν = 2956, 2902, 2850, 2826, 2057, 2030, 1844, 1765, 1735, 1717, 1681, 1652, 1612, 1562, 1540, 1511, 1437, 1385, 1342, 1246, 1197, 1143, 1110, 1076, 1052, 995, 919, 835, 793, 764, 648 cm^{-1}. ESI-MS: m/z = 419.3 $[M+H]^+$. HRMS (ESI): m/z calcd for $[M+H]^+$: 419.1347; found: 419.1343.

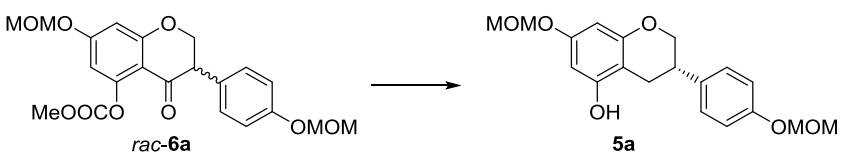
Isoflavan *rac*-**5a**



Isoflavanone **6a** (59.6 mg, 142.5 μmol) was dissolved in THF (0.86 mL). Separately, mortared $NaBH_4$ (33.1 mg, 87.5 μmol) was dissolved in H_2O (0.35 mL) and both solutions were combined and stirred at rt for 20 min. The reaction was quenched with saturated aqueous NH_4Cl solution, and the mixture was extracted three times with EtOAc. The combined organic layers were dried over $MgSO_4$. The solvents were removed in vacuo, and the residue was purified by flash chromatography (isohexane/ethyl acetate 3:2) to afford isoflavan *rac*-**5a** (39.9 mg, 115.2 μmol, 81%) as a yellow solid.

M.p. 70 - 74 °C. ^{1}H NMR (600 MHz, $CDCl_3$): δ = 7.19 (m, 2 H), 7.03 (m, 2 H), 6.23 (d, *J* = 2.3 Hz, 1 H), 6.16 (d, *J*= 2.3 Hz, 1 H), 5.18 (s, 2 H), 5.12 (s, 2 H), 4.87 (s, 1 H), 4.30 (ddd, *J* = 10.5 Hz, 3.4 Hz, 1.9 Hz, 1 H), 3.95 (dd, *J* = 10.5 Hz, 10.5 Hz, 1 H), 3.49 (s, 3 H), 3.48 (s, 3 H), 3.16 (m, 1 H), 2.97 (ddd, *J* = 16.0 Hz, 5.5 Hz, 1.9 Hz, 1 H), 2.70 (dd, *J* = 15.8 Hz, 10.9 Hz, 1 H) ppm. ^{13}C NMR (151 MHz, $CDCl_3$): δ = 156.69 (C), 156.24 (C), 155.92 (C), 154.48 (C), 134.69 (C), 128.38 (CH), 116.55 (CH), 103.35 (C), 97.02 (CH), 96.17 (CH), 94.47 (2 ∗ CH_2), 70.78 (CH_2), 55.98 (CH_3), 55.97 (CH_3), 37.41 (CH), 26.34 (CH_2) ppm. IR (ATR): ν = 3385, 2932, 2901, 2846, 2823, 1735, 1698, 1622, 1593, 1557, 1540, 1511, 1435, 1231, 1135, 1095, 1072, 994, 919, 822, 712 cm^{-1}. ESI-MS: m/z = 347.3 $[M+H]^+$. Anal. calcd for $C_{19}H_{22}O_6$: C, 65.88; H, 6.40; found: C, 65.54; H, 6.75.

ATH of isoflavanone *rac*-**6a**



Preparation of the catalyst solution:

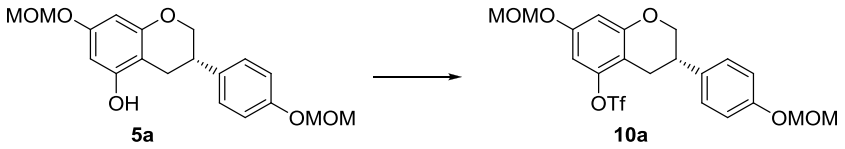
[Ru(*p*-cymene)Cl_2]$_2$ (21.61 mg, 35.3 μmol) and (*S*,*S*)-TsDPEN (25.98 mg, 70.9 μmol) were dissolved in EtOAc (2.35 mL) and stirred for 20 min. Separately, Et_3N (1.8 mL) and HCOOH (0.5 mL) were mixed at 0 °C. The lower layer of this biphasic Et_3N / HCOOH mixture (approximately 2.8:1 {v/v}, 0.96 mL) was added to the catalyst solution, and the mixture stirred for further 10 min. The freshly prepared solution was used for ATH.

ATH:

Isoflavanone *rac*-**6a** (104.9 mg, 250.7 μmol) was dissolved in EtOAc (0.3 mL), and freshly prepared catalyst solution (0.22 mL, 2.37 μmol) was added. After adding a mixture of Et_3N and HCOOH (0.06 mL, 2.8:1 {v / v}), the reaction mixture was stirred at 40°C for 5 h. EtOAc (1.0 mL) was added, and the solution was further stirred at 40°C for 2 h. The reaction was quenched with saturated aqueous NH_4Cl solution, and the mixture was extracted three times with EtOAc. The combined organic layers were dried over $MgSO_4$. The solvents were removed in vacuo, and the residue was purified by flash chromatography (isohexane/ethyl acetate 3:1) to afford isoflavane **5a** (77.9 mg, 224.9 μmol, 90%, 99% *ee*) as a yellow solid.

$[\alpha]_D^{25}$ = −12.1 (*c* 0.63, $CHCl_3$). Further analytical data were in agreement with the data listed above for isoflavan *rac*-**5a**.

Treatment with Tf_2O – isoflavan **10a**

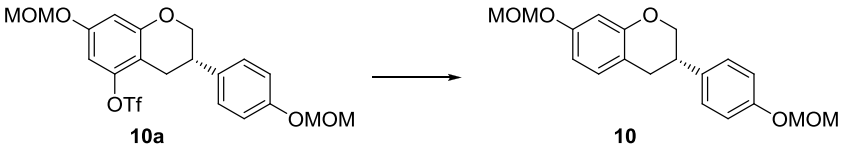


Isoflavan **5a** (88.1 mg, 254.3 μmol) was dissolved in CH_2Cl_2 (2.8 mL) and cooled to −40°C. Et_3N (165.0 μL) and Tf_2O (50.0 μL, 297.2 μmol) were added, and the reaction mixture was stirred for 40 min. The reaction mixture was quenched with saturated aqueous NH_4Cl solution, and the aqueous phase was extracted three times with CH_2Cl_2. The combined organic layers were dried over $MgSO_4$, the solvents were removed in vacuo, and the residue was purified by flash chromatography (isohexane/ethyl acetate 3:1) to afford isoflavan **10a** (116.8 mg, 244.1 μmol, 96%, 99% *ee*) as a yellow oil.

$[\alpha]_D^{25}$ = −12.5 (*c* 0.53, $CHCl_3$). ^{1}H NMR (300 MHz, $CDCl_3$): δ = 7.17 (m, 2 H), 7.05 (m, 2 H), 6.63 (d, *J* = 2.3 Hz, 1 H), 6.60 (d, *J* = 2.3 Hz, 1 H), 5.19 (s, 2 H), 5.15 (s, 2 H), 4.34 (ddd, *J* = 10.8 Hz, 3.4 Hz, 2.1 Hz, 1 H), 4.01 (t-like, *J* = 10.5 Hz, 1 H), 3.49 (s, 3 H), 3.48 (s, 3 H), 3.16 (m, 1 H), 3.07 (ddd, *J* = 16.2 Hz, 5.1 Hz, 1.9 Hz, 1 H), 2.85 (dd, *J* = 16.1 Hz, 10.9 Hz, 1 H) ppm. ^{13}C NMR (75 MHz, $CDCl_3$): δ = 156.60 (C), 156.48 (C), 156.20 (C), 148.20 (C), 133.47 (C), 128.34 (CH), 118.56 (C, q, *J* = 320.2 Hz), 116.69 (CH), 109.51 (C), 104.13 (CH), 102.58 (CH), 94.63 (CH_2), 94.43 (CH_2), 70.94 (CH_2),

56.17 (CH_3), 56.00 (CH_3), 36.81 (CH), 26.80 (CH_2) ppm. ^{19}F NMR (282 MHz, $CDCl_3$): δ = −73.56 ppm. IR (ATR): ν = 2955, 2903, 2846, 2823, 2056, 2030, 2007, 1629, 1578, 1559, 1540, 1512, 1495, 1419, 1314, 1281, 1208, 1134, 1079, 1041, 1000, 972, 920, 816, 762, 662 cm^{-1}. ESI-MS: m/z = 4996.3 $[M+H]^+$. Anal. calcd for $C_{20}H_{21}F_3O_8S$: C, 50.21; H, 4.42, S, 6.7;0 found: C, 49.83; H, 4.60, S, 6.71.

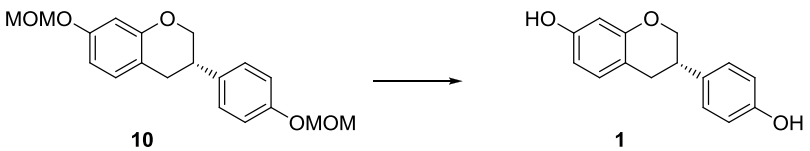
Deoxygenation – isoflavan **10**



Isoflavan **10a** (103.5 mg, 216.3 μmol), $Pd(OAc)_2$ (2.5 mg, 11.1 μmol), and dppf (6.29 mg, 11.4 μmol) were dissolved in THF (1.35 mL). Et_3N (235.0 μL) and HCOOH (70.0 μL) were added, and the mixture was stirred for 60 min at 60 °C in a closed round bottom flask. The reaction was quenched with saturated aqueous NH_4Cl solution, and the mixture was extracted three times with EtOAc. The combined organic layers were dried over $MgSO_4$. The solvents were removed in vacuo, and the residue was purified by flash chromatography (isohexane/ethyl acetate 3:1) to afford isoflavan **10** (68.2 mg, 206.4 μmol, 96%, 99% *ee*) as a yellow oil.

$[\alpha]_D^{25}$ = −12.7 (*c* 0.78, $CHCl_3$). ^{1}H NMR (500 MHz, $CDCl_3$): δ = 7.18 (m, 2 H), 7.04 (m, 2 H), 7.00 (d, *J* = 7.9 Hz, 1 H), 6.60 (m, 2 H, 6-H), 5.18 (s, 2 H), 5.15 (s, 2 H), 4.32 (ddd, *J* = 10.6 Hz, 3.5 Hz, 1.6 Hz, 1 H), 3.98 (dd, *J* = 10.6 Hz, 1 H), 3.49 (s, 3 H), 3.49 (s, 3 H), 3.19 (ddt-like, *J* = 10.0 Hz, 10.0 Hz, 6.7 Hz, 3.5 Hz, 1 H), 2.96 (m, 2 H) ppm. ^{13}C NMR (126 MHz, $CDCl_3$): δ = 156.59 (C), 156.21 (C), 154.89 (C), 134.63 (C), 130.15 (CH), 128.33 (CH), 116.53 (CH), 115.51 (C), 108.97 (CH), 104.29 (CH), 94.51 (CH_2), 94.44 (CH_2), 71.02 (CH_2), 55.98 (CH_3), 55.94 (CH_3), 37.85 (CH), 31.86 (CH_2) ppm. IR (ATR): ν = 2952, 2929, 2898, 2846, 2823, 2783, 1619, 1584, 1558, 1541, 1507, 1472, 1441, 1317, 1257, 1236, 1201, 1148, 1114, 1073, 993, 920, 830, 796, 727, 651, 617 cm^{-1}. ESI-MS: m/z = 331.2 $[M+H]^+$. Anal. calcd for $C_{19}H_{22}O_5$: C, 69.07; H, 6.71; found: C, 69.29; H, 6.73.

(*S*)-Equol (**1**)



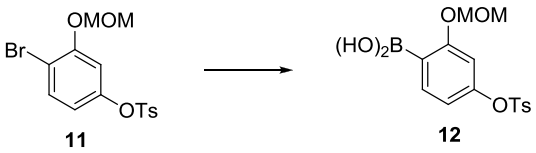
Isoflavan **10** (58.7 mg, 177.7 μmol) was dissolved in THF (2.4 mL) and MeOH (2.4 mL) and a 1:1 mixture of water and 37% HCl (0.91 mL) were added. The mixture was stirred for 20 min at 60 °C and poured into NaCl solution. The mixture was extracted three times with EtOAc. The combined organic layers were dried over $MgSO_4$. The solvents were removed in vacuo, and the residue was purified by

flash chromatography (isohexane/ethyl acetate 2:1) to afford isoflavan **1** (39.5 mg, 163.0 μmol, 92%, 99% *ee*) as an off-white solid.

$[\alpha]_D^{25}$ = –20.4 (*c* 0.55, EtOH). M.p. 185 - 187 °C. ^{1}H NMR (300 MHz, DMSO-d6): δ =9.27 (s, 1 H), 9.15 (s, 1 H), 7.10 (m, 2 H), 6.86 (d, *J* = 8.3 Hz,1 H), 6.70 (m, 2 H), 6.28 (dd, *J* = 8.2 Hz, 2.4 Hz, 1 H), 6.18 (d, *J* = 2.5 Hz, 1 H), 4.14 (ddd, *J* = 10.6 Hz, 3.6 Hz, 1.9 Hz, 1 H), 3.89 (t-like, *J* = 10.4 Hz, 1 H), 3.00 (m, 1 H), 2.80 (m, 2 H) ppm. ^{13}C NMR (75 MHz, DMSO-d6): δ =156.47 (C), 156.12 (C), 154.49 (C), 131.64 (C), 130.06 (CH), 128.31 (CH), 115.22 (CH), 112.55 (C), 107.94 (CH), 102.45 (CH), 70.23 (CH_2), 37.13 (CH), 31.28 (CH_2) ppm. IR (ATR): ν = 3330, 3018, 2924, 2899, 2846, 1880, 1734, 1696, 1597, 1557, 1541, 1511, 1451, 1392, 1365, 1274, 1240,1226, 1149, 1117, 1061, 1020, 938, 891, 847, 825, 794, 768, 735, 621 cm^{-1}. ESI-MS: m/z = 240.8 $[M–H]^-$.

3. Synthesis of manuifolin K (2)

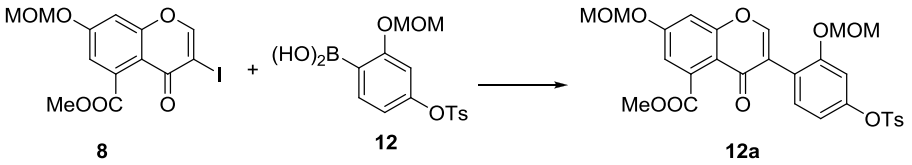
Boronic acid **12**



Aryl bromide **11** (720.8 mg 1.86 mmol) and B(O*i*Pr)$_3$ (0.6 mL, 2.60 mmol) were added to THF (9.6 mL). The solution was cooled to – 78 °C, and BuLi (1.6 M, 1.75 mL, 2.80 mmol) was added dropwise over 15 min. The mixture was stirred for 60 min at – 78 °C and additional 3 h at rt. The reaction mixture was poured into 1 N HCl, and the mixture was extracted three times with EtOAc. The combined organic layers were dried over $MgSO_4$ and the solvents were removed in vacuo. Boronic acid **12** was obtained as a yellow solid (712.5 mg, quantitative, crude).

M.p. 84 - 89 °C. ^{1}H NMR (300 MHz, $CDCl_3$): δ = 7.76 (d, *J* = 8.2 Hz, 1 H), 7.73 (m, 2 H), 7.33 (s, 2 H), 6.82 (d, *J* = 1.9 Hz, 1 H), 6.68 (dd, *J* = 8.2 Hz, 2.2 Hz, 1 H), 5.63 (s, 2 H), 5.18 (s, 2 H), 3.45 (s, 3 H), 2.46 (s, 3 H) ppm. ^{13}C NMR (75 MHz, $CDCl_3$): δ = 162.86 (C), 152.72 (C), 145.43 (C), 137.62 (CH), 132.26 (C), 129.75 (CH), 128.56 (CH), 115.83 (CH), 108.33 (CH), 94.83 (CH_2), 56.50 (CH_2), 21.71 (CH_3), (C-B-Signal only observed in HMBC-experiment due to quadrupole interactions) ppm. IR (ATR): ν = 3523, 3356, 3078, 2959, 2938, 2826, 1633, 1599, 1580, 1486, 1455, 1433, 1379, 1360, 1330, 1236, 1208, 1190, 1158, 1136, 1089, 1054, 1017, 981, 933, 864, 833, 767, 746, 701, 651, 629 cm^{-1}. Data from mass spectroscopy were not obtained.

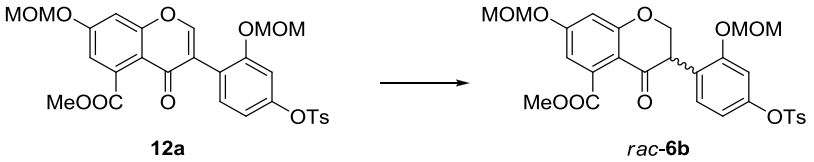
Isoflavone **12a**



Chromone **8** (412.0 mg, 1.01 mmol), boronic acid **12** (690.6 mg, approximately 1.80 mmol) and K_2CO_3 (365.6 mg, 2.65 mmol) were dissolved at 50 °C in a mixture of water (1.5 mL) and dioxane (3.5 mL). $Pd_2(dba)_3$ (23.3 mg, 25.44 µmol) and PCy_3 (14.4 mg, 51.35 µmol) were added, and the mixture was stirred for 30 min at 50 °C. The reaction was quenched with saturated aqueous NH_4Cl solution, and the mixture was extracted three times with EtOAc. The combined organic layers were dried over $MgSO_4$. The solvents were removed in vacuo, and the residue was purified by flash chromatography (isohexane/ethyl acetate 1:1) to afford isoflavone **12a** (501.8 mg, 0.86 mmol, 84%) as a yellow solid.

M.p. 44 - 48 °C. ^{1}H NMR (300 MHz, $CDCl_3$): δ = 7.79 (m, 3 H, 7.35 (m, 2 H), 7.20 (d, *J* = 8.3 Hz, 1 H), 7.03 (d, *J* = 2.3 Hz, 1 H), 6.84 (d, *J* = 2.3 Hz, 1 H), 6.82 (d, *J* = 2.3 Hz, 1 H), 6.70 (dd, *J* = 8.4 Hz, 2.4 Hz, 1 H), 5.26 (s, 2 H), 4.99 (s, 2 H), 3.91 (s, 3 H), 3.50 (s, 3 H), 3.36 (s, 3 H), 2.47 (s, 3 H) ppm. ^{13}C NMR (75 MHz, $CDCl_3$): δ = 173.88 (C), 160.82 (C), 158.56 (C), 156.02 (C), 153.46 (C), 152.84 (CH), 150.80 (C), 150.33 (C), 145.31 (C), 132.57 (C), 132.09 (CH), 129.77 (CH), 128.60 (CH), 122.45 (C), 120.30 (C), 115.33 (CH), 112.65 (C), 109.74 (CH), 109.37 (CH), 101.98 (CH), 95.03 (CH_2), 94.49 (CH_2), 56.52 (CH_3), 56.15 (CH_3), 55.65 (CH_3), 21.71 (CH_3) ppm. IR (ATR): ν = 3201, 3098, 2957, 2826, 2136, 2056, 2030, 2000, 1767, 1717, 1699, 1621, 1598, 1563, 1541, 1493, 1437, 1372, 1290, 1251, 1190, 1178, 1139, 1114, 1075, 1044, 992, 935, 856, 807, 778, 717, 692, 662 cm^{-1}. ESI-MS: m/z = 587.3 $[M+H]^+$. HRMS (ESI): m/z calcd for $[M+Na]^+$: 609.1037; found: 609.1038.

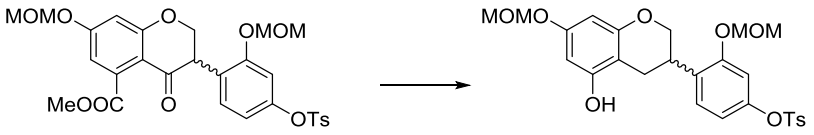
Isoflavanone *rac*-**6b**



Isoflavone **12a** (758.2 mg, 1.29 mmol) was dissolved in THF (10.0 mL) and cooled to −78°C. L-selectride (1.0 M in THF, 1.57 mL, 1.57 mmol) was added dropwise, and the solution was stirred for 60 min at −78°C. The reaction was quenched with saturated aqueous NH_4Cl solution, and the mixture was extracted three times with EtOAc. The combined organic layers were dried over $MgSO_4$. The solvents were removed in vacuo, and the residue was purified by flash chromatography (isohexane/ethyl acetate 6:5) to afford isoflavanone *rac*-**6b** (704.2 mg, 1.20 mmol, 93% as a yellow solid.

M.p. 35 - 38 °C. ^{1}H NMR (300 MHz, $CDCl_3$): δ = 7.76 (m, 2 H), 7.34 (m, 2 H), 7.00 (d, *J* = 8.5 Hz, 1 H), 6.81 (d, *J* = 2.3 Hz, 1 H), 6.62 (dd, *J* = 8.4 Hz, 2.4 Hz, 1 H), 6.59 (d, *J* = 2.5 Hz, 1 H), 6.49 (d, *J* = 2.5 Hz, 1 H), 5.21 (s, 2 H), 5.02 (d, *J* = 11.3 Hz, 1 H), 5.00 (d, *J* = 11.3 Hz, 1 H), 4.61 (t-like, *J* = 11.2 Hz, 1 H), 4.46 (dd, *J* = 11.0 Hz, 5.5 Hz, 1 H), 4.19 (dd, *J* = 11.3 Hz, 5.3 Hz, 1 H), 3.89 (s, 3 H), 3.49 (s, 3 H), 3.37 (s, 3 H), 2.46 (s, 3 H) ppm. ^{13}C NMR (75 MHz, $CDCl_3$): δ = 189.08 (C), 164.20 (C), 162.82 (C), 155.86 (C), 153.39 (C), 152.11 (C), 149.84 (C), 145.30 (C), 132.55 (C), 130.93 (CH), 129.76 (CH), 128.57 (CH), 122.89 (C), 115.55 (CH), 109.43 (CH), 109.31 (C), 105.68 (CH), 102.13 (CH), 94.83 (CH_2), 94.27 (CH_2), 70.29 (CH_3), 56.55 (CH_3), 56.22 (CH_3), 55.57 (CH_3), 48.53 (CH), 21.71 (CH_3) ppm. IR (ATR): ν = 3217, 2958, 2826, 2056, 2030, 1844, 1766, 1735, 1717, 1685, 1652, 1618, 1569, 1541, 1495, 1436, 1373, 1247, 1191, 1178, 1143, 1110, 1089, 1051, 922, 857, 814, 771, 715, 661 cm^{-1}. ESI-MS: m/z = 589.3 $[M+H]^+$. HRMS (ESI): m/z calcd for $[M+Na]^+$: 611.1194; found: 611.1202.

Isoflavan *rac*-**5b**



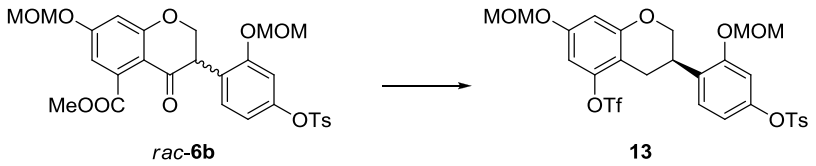
rac-**6b** *rac*-**5b**

Isoflavanone *rac*-**6b** (61.4 mg, 104.3 μmol) was dissolved in THF (0.5 mL). Separately, mortared $NaBH_4$ (16.7 mg, 441.4 μmol) was dissolved in water (0.2 mL). Both solutions were unified, and the reaction mixture was stirred for 30 min at rt. The reaction was quenched with saturated aqueous NH_4Cl solution, and the mixture was extracted three times with EtOAc. The combined organic layers were dried over $MgSO_4$. The solvents were removed in vacuo, and the residue was purified by flash chromatography (isohexane/ethyl acetate 6:5) to afford isoflavan *rac*-**5b** (27.4 mg, 53.3 μmol, 51% as a yellow solid.

M.p. 35 - 39 °C. ^{1}H NMR (300 MHz, $CDCl_3$): δ = 7.75 (m, 2 H), 7.34 (m, 2 H), 7.06 (d, *J* = 8.5 Hz, 1 H), 6.76 (d, *J* = 2.3 Hz, 1 H), 6.64 (dd, *J* = 8.4 Hz, 2.4 Hz, 1 H), 6.22 (d, *J* = 2.3 Hz, 1 H), 6.15 (d, *J* = 2.3 Hz, 1 H), 5.11 (s, 2 H), 5.08 (s, 2 H), 4.78 (s, 1 H), 4.27 (ddd, *J* = 10.4 Hz, 3.2 Hz, 1.9 Hz, 1 H), 4.00 (t-like, *J* = 10.0 Hz, 1 H), 3.58 (m, 1 H), 3.47 (s, 3 H), 3.41 (s, 3 H), 2.91 (ddd, *J* = 15.9 Hz, 5.6 Hz, 1.7 Hz, 1 H), 2.70 (dd, *J* = 15.9 Hz, 10.4 Hz, 1 H), 2.47 (s, 3 H) ppm. ^{13}C NMR (75 MHz, $CDCl_3$): δ = 156.71 (C), 155.94 (C), 155.42 (C), 154.43 (C), 148.95 (C), 145.29 (C), 132.54 (C), 129.73 (CH), 129.03 (C), 128.56 (CH), 127.71 (CH), 115.44 (CH), 108.80 (CH), 103.26 (C), 97.06 (CH), 96.21 (CH), 94.50 (CH_2), 94.46 (CH_2), 69.39 (CH_2), 56.18 (CH_3), 55.97 (CH_3), 31.42 (CH), 24.82 (CH_2), 21.71 (CH_3) ppm. IR (ATR): ν = 3461, 2952, 2924, 2846, 1622, 1594, 1561, 1494, 1457, 1435, 1399,

1369, 1245, 1210, 1191, 1176, 1136, 1091, 1073, 1022, 989, 938, 859, 812, 715, 663 cm^{-1}. ESI-MS: m/z = 517.4 $[M+H]^+$. HRMS (ESI): m/z calcd for $[2M+Na]^+$: 1055.2800; found: 1055.2799.

ATH of isoflavanone *rac*-**6b**



Preparation of the catalyst solution:

$[Ru(p\text{-cymene})Cl_2]_2$ (21.61 mg, 35.3 μmol) and (*R*,*R*)-TsDPEN (25.98 mg, 70.9 μmol) were dissolved in EtOAc (2.35 mL) and stirred for 20 min. Separately, Et_3N (1.8 mL) and HCOOH (0.5 mL) were mixed at 0 °C. The lower layer of this biphasic Et_3N / HCOOH mixture (approximately 2.8:1 (v/v), 0.96 mL) was added to the catalyst solution, and the mixture stirred for further 10 min. The freshly prepared solution was used for ATH.

ATH:

Racemic isoflavanone **6b** (414.4 mg, 704.4 μmol) was dissolved in EtOAc (0.88 mL), and freshly prepared catalyst solution (1.65 mL, 35.3 μmol) was added. The reaction mixture was stirred at 40°C for 15 h. The reaction was quenched with saturated aqueous NH_4Cl solution, and the mixture was extracted three times with EtOAc. The combined organic layers were dried over $MgSO_4$. The solvents were removed in vacuo, and the residue was purified by flash chromatography (isohexane/ethyl acetate 6:5).

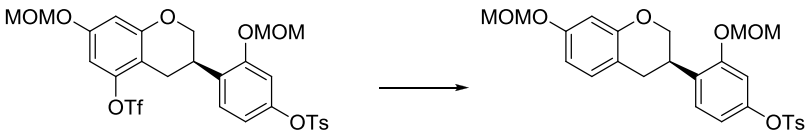
Treatment with Tf_2O:

The residue was dissolved in CH_2Cl_2 (7.7 mL) and cooled to – 40 °C. Et_3N (0.46 mL) and Tf_2O (0.24mL, 832.1 μmol) were added, and the mixture was stirred for 40 min. The reaction was quenched with saturated aqueous NH_4Cl solution, and the mixture was extracted three times with EtOAc. The combined organic layers were dried over $MgSO_4$. The solvents were removed in vacuo, and the residue was purified by flash chromatography (isohexane/ethyl acetate 5:2) to afford isoflavan **13** (383.6 mg, 591.4 μmol, 84% over two steps, 99% *ee*) as a white solid.

$[\alpha]_D^{25}$ = +9.7 (*c* 0.75, $CDCl_3$). M.p. 76 - 80 °C. ^{1}H NMR (300 MHz, $CDCl_3$): δ = 7.76 (m, 2 H), 7.35 (m, 2 H), 7.02 (d, *J* = 8.5 Hz, 1 H), 6.78 (d, *J* = 2.5 Hz, 1 H), 6.66 (dd, *J* = 8.4 Hz, 2.4 Hz, 1 H), 6.62 (d, *J* = 2.5 Hz, 1 H), 6.59 (d, *J* = 2.5 Hz, 1 H), 5.14 (s, 2 H), 5.09 (s, 2 H), 4.33 (ddd, *J* = 10.6 Hz, 3.4 Hz, 1.9 Hz, 1 H), 4.08 (t-like, *J* = 10.0 Hz, 1 H), 3.55 (m, 1 H), 3.48 (s, 3 H), 3.41 (s, 3 H), 3.03 (ddd, *J* = 16.3 Hz, 5.3 Hz, 1.6 Hz, 1 H), 2.86 (dd, *J* = 16.2 Hz, 10.4 Hz, 1 H), 2.47 (s, 3 H) ppm. ^{13}C NMR (75 MHz, $CDCl_3$): δ = 156.63 (C), 156.20 (C), 155.43 (C), 149.23 (C), 148.22 (C), 145.34 (C), 132.50

(C), 129.75 (CH), 128.56 (CH), 127.82 (C), 127.61 (CH), 118.54 (q, *J* = 320.2 Hz, C), 115.53 (CH), 109.44 (C), 108.90 (CH), 104.20 (CH), 102.64 (CH), 94.62 (CH_2), 94.48 (CH_2), 69.49 (CH_2), 56.21 (CH_3), 56.17 (CH_3), 31.12 (CH), 25.24 (CH_2), 21.70 (CH_3) ppm. ^{19}F NMR (282 MHz, $CDCl_3$): δ = −74.20 ppm. IR (ATR): ν = 3088, 2969, 2938, 2899, 2866, 2819, 2053, 2030, 2007, 1970, 1632, 1576, 1543, 1495, 1472, 1457, 1419, 1372, 1328, 1278, 1245, 1217, 1135, 1080, 1043, 997, 970, 944, 895, 866, 829, 813, 789, 167, 721, 664, 644 cm^{-1}. ESI-MS: m/z = 666.4 $[M+NH_4]^+$. Anal. calcd for $C_{27}H_{27}F_3O_{11}S$: C, 50.00; H, 4.20, S, 9.89; found: C, 50.38; H, 4.10, S, 9.59.

Isoflavan **13a**

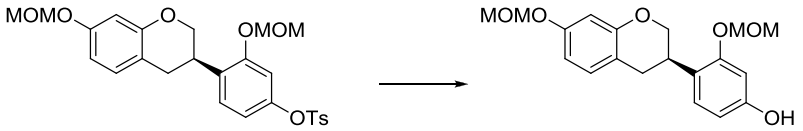


13 **13a**

Isoflavan **13** (677.4 mg, 1.04 mmol), $Pd(OAc)_2$ (11.84 mg, 52.74 μmol), and dppf (29.06 mg, 52.42 μmol) were dissolved in THF (6.50 mL). Et_3N (1.15 mL) and HCOOH (0.35 mL) were added, and the mixture was stirred for 60 min at 60 °C in a closed round bottom flask. The reaction was quenched with saturated aqueous NH_4Cl solution, and the mixture was extracted three times with EtOAc. The combined organic layers were dried over $MgSO_4$. The solvents were removed in vacuo, and the residue was purified by flash chromatography (isohexane/ethyl acetate 5:2) to afford isoflavan **13a** (513.2 mg, 1.03 mmol, 98%, 99% *ee*) as a white solid.

$[\alpha]_D^{25}$ = −4.3 (*c* 0.97, $CDCl_3$). M.p. 92 - 95 °C. ^{1}H NMR (300 MHz, $CDCl_3$): δ = 7.76 (m, 2 H), 7.34 (m, 2 H), 7.04 (d, *J* = 8.5 Hz, 1 H), 6.99 (d, *J* = 8.5 Hz, 1 H), 6.75 (d, *J* = 2.5 Hz, 1 H), 6.65 (dd, *J* = 8.4 Hz, 2.4 Hz, 1 H), 6.60 (m, 2 H), 5.15 (s, 2 H), 5.08 (s, 2 H), 4.30 (ddd, *J* = 10.4 Hz, 3.3 Hz, 1.6 Hz, 1 H), 4.01 (t-like, *J* = 10.1 Hz, 1 H), 3.61 (m, 1 H), 3.48 (s, 3 H), 3.41 (s, 3 H), 2.94 (m, 2 H), 2.47 (s, 3 H) ppm. ^{13}C NMR (126 MHz, $CDCl_3$): δ =156.61 (C), 155.40 (C), 154.90 (C), 148.90 (C), 145.28 (C), 132.55 (C), 130.13 (CH), 129.72 (CH), 128.96 (C), 128.54 (CH), 127.60 (CH), 115.43 (CH), 115.40 (C), 109.03 (CH), 108.76 (CH), 104.33 (CH), 94.50 (CH_2), 94.46 (CH_2), 69.63 (CH_2), 56.16 (CH_3), 55.93 (CH_3), 31.81 (CH), 30.28 (CH_2), 21.71 (CH_3) ppm. IR (ATR): ν = 2955, 2927, 2850, 2823, 1734, 1698, 1624, 1589, 1492, 1454, 1398, 1370, 1310, 1261, 1244, 1206, 1188, 1177, 1150, 1128, 1105, 1072, 1019, 980, 936, 876, 858, 813, 802, 786, 731, 706, 660, 618 cm^{-1}. ESI-MS: m/z = 518.5 $[M+NH_4]^+$. Anal. calcd for $C_{26}H_{28}O_8S$: C, 62.39; H, 5.64; S, 6.41; found: C, 62.52; H, 5.96; S, 6.11.

Isoflavan **14**



13a **14**

Isoflavan **13a** (333.4 mg, 666.1 μmol) was dissolved in *i*PrOH (20 mL) and water (2 mL). KOH (182.0 mg, 3.2 mmol) was added, and the mixture was stirred for 4 h at 80 °C. The reaction was quenched with saturated aqueous NH_4Cl solution, and the mixture was extracted three times with EtOAc. The combined organic layers were dried over $MgSO_4$. The solvents were removed in vacuo, and the residue was purified by flash chromatography (isohexane/ethyl acetate 2:1) to afford isoflavan **14** (192.9 mg, 556.9 μmol, 86%, 99% *ee*) as a colorless residue.

$[\alpha]_D^{25}$ = –4.2 (*c* 0.95, $CDCl_3$). ^{1}H NMR (300 MHz, $CDCl_3$): δ =7.00 (m, 2 H), 6.69 (d, *J* = 2.5 Hz, 1 H), 6.60 (m, 2 H), 6.47 (dd, *J* = 8.3 Hz, 2.5 Hz, 1 H), 5.20 (s, 2 H), 5.15 (s, 2 H), 4.70 (s, 1 H), 4.32 (ddd, *J* = 10.4 Hz, 3.4 Hz, 2.1 Hz, 1 H), 4.00 (t-like, *J* = 10.2 Hz, 1 H), 3.59 (m, 1 H), 3.49 (s, 3 H), 3.48 (s, 3 H), 3.00 (dd, *J* = 15.9 Hz, 10.8 Hz, 1 H), 2.88 (ddd, *J* = 15.7 Hz, 5.5 Hz, 1.9 Hz, 1 H) ppm. ^{13}C NMR (75 MHz, $CDCl_3$): δ = 156.55 (C), 155.98 (C), 155.36 (C), 155.02 (C), 130.17 (CH), 127.85 (CH), 122.16 (C), 115.97 (C), 108.89 (CH), 108.42 (CH), 104.35 (CH), 102.19 (CH), 94.55 (CH_2), 94.43 (CH_2), 70.17 (CH_2), 56.15 (CH_3), 55.93 (CH_3), 31.62 (CH), 30.56 (CH_2) ppm. IR (ATR): ν = 3380, 2932, 2900, 2846, 2823, 1697, 1616, 1586, 1557, 1542, 1319, 1276, 1259, 1210, 1148, 1112, 1071, 996, 950, 920, 840, 800, 728, 628 cm^{-1}. ESI-MS: m/z = 347.2 $[M+H]^+$. Anal. calcd for $C_{19}H_{22}O_6$: C, 65.88; H, 6.40; found: C, 65.55; H, 6.42.

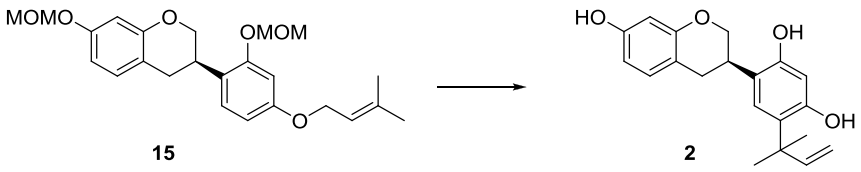
Prenylation – isoflavan **15**

14 **15**

Phenol **14** (124.1 mg, 358.3 μmol), PPh_3 (121.2 mg, 462.1 μmol) and 3-methyl-2-buten-1-ol (0.06 mL, 590.7 μmol) were dissolved in THF (4.7 mL). DIAD (0.12 mL, 611.2 μmol) was added at 0 °C, and the mixture was stirred for 90 min at rt. The reaction was quenched with saturated aqueous NH_4Cl solution, and the mixture was extracted three times with EtOAc. The combined organic layers were dried over $MgSO_4$. The solvents were removed in vacuo, and the residue was purified by flash chromatography (isohexane/ethyl acetate 9:2) to afford isoflavan **15** (131.4 mg, 317.0 μmol, 88%, 99% *ee*) as a white solid.

$[\alpha]_D^{25}$ = – 3.9 (*c* 0.54, $CDCl_3$). M.p. 29 - 32 °C. ^{1}H NMR (300 MHz, $CDCl_3$): δ = 7.01 (m, 2 H), 6.77 (d, *J* = 2.3 Hz, 1 H), 6.60 (m, 2 H), 6.55 (dd, *J* = 8.5 Hz, 2.5 Hz, 1 H), 5.49 (m, 1 H), 5.20 (s, 2 H), 5.15 (s, 2 H), 4.50 (d, *J* = 6.8 Hz, 2 H), 4.33 (ddd, *J* = 10.2 Hz, 3.4 Hz, 1.9 Hz, 1 H), 4.01 (t-like, *J* = 10.3 Hz, 1 H), 3.60 (m, 1 H), 3.49 (s, 3 H), 3.48 (s, 3 H), 3.01 (dd, *J* = 15.7 Hz, 11.0 Hz, 1 H), 2.89 (ddd, *J* = 15.7 Hz, 5.3 Hz, 1.6 Hz, 1 H), 1.81 (s, 3 H), 1.75 (s, 3 H) ppm. ^{13}C NMR (75 MHz, $CDCl_3$): δ = 158.78 (C), 156.53 (C), 155.88 (C), 155.04 (C), 138.29 (C), 130.16 (CH), 127.51 (CH), 122.06 (C), 119.56 (CH), 116.02 (C), 108.85 (CH), 106.99 (CH), 104.33 (CH), 102.09 (CH), 94.55 (CH_2), 94.46 (CH_2), 70.21 (CH_2), 64.80 (CH_2), 56.14 (CH_3), 55.91 (CH_3), 31.64 (CH), 30.57 (CH_2), 25.82 (CH_3), 18.17 (CH_3) ppm. IR (ATR): ν = 2985, 2962, 2936, 2894, 2850, 1612, 1584, 1556, 1542, 1503, 1444, 1407, 1380, 1304, 1288, 1276, 1255, 1212, 1149, 1127, 1114, 1068, 1008, 914, 852, 804, 783, 745, 722, 645, 629, 606 cm^{-1}. ESI-MS: m/z = 432.3 $[M+NH_4]^+$. Anal. calcd for $C_{24}H_{30}O_6$: C, 69.54; H, 7.30; found: C, 69.90; H, 7.37.

Preparation of manuifolin K (**2**)



Isoflavan **15** (97.8 mg, 235.6 μmol), NaOAc (19.7 mg, 240.1 μmol) and Ac_2O (2.9 mL) were put in a microwave tube. The mixture was irradiated at 180 °C for 120 min at 300 W. The mixture was poured in saturated $NaHCO_3$ solution using a small amount of EtOAc and stirred for 30 min. Saturated NaCl solution was added, and the mixture was extracted three times with EtOAc. The combined organic layers were dried over $MgSO_4$ and the solvents were removed in vacuo.

The crude residue was dissolved in MeOH (2.9 mL) and water (2.3 mL). NaOH (485.6 mg, 12.14 mmol) was added, and the mixture was stirred for 60 min under water bath cooling at rt. The reaction was quenched with saturated aqueous NH_4Cl solution. 2 N HCl (6 mL) was added, and the mixture was extracted three times with EtOAc. The combined organic layers were dried over $MgSO_4$, and the solvents were removed in vacuo.

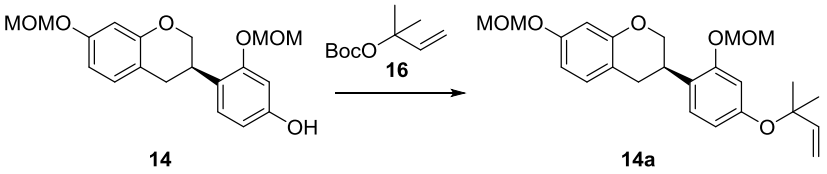
The crude residue was dissolved in MeOH (1.45 mL) and THF (1.45 mL). A 1:1 mixture (0.29 mL) of water and 37% HCl was added, and the solution was stirred for 30 min at 60 °C. The reaction was quenched with saturated aqueous NH_4Cl solution, and the mixture was extracted three times with EtOAc. The combined organic layers were dried over $MgSO_4$. The solvents were removed in vacuo, and the residue was purified by flash chromatography (isohexane/ethyl acetate 3:2) to afford isoflavan **2** (54.9 mg, 168.2 μmol, 71% over three steps, 99% *ee*) as a yellow solid.

$[\alpha]_D^{25}$ = – 22.7 (*c* 0.16, MeOH). M.p. 175 - 177 °C. ^{1}H NMR (300 MHz, $CDCl_3$): δ = 6.96 (m, 2 H), 6.39 (m, 2 H), 6.30 (s, 1 H), 6.17 (dd, *J* = 17.8 Hz, 10.4 Hz, 1 H), 5.85 (s, 1 H), 5.36 (dd, *J* = 17.8 Hz,

0.8 Hz, 1 H), 5.31 (dd, *J* = 10.6 Hz, 0.8 Hz, 1 H), 4.79 (s, 1 H), 4.64 (s, 1 H), 4.35 (ddd, *J* = 10.4 Hz, 3.4 Hz, 1.9 Hz, 1 H), 4.09 (t-like, *J* = 10.2Hz, 1 H), 3.50 (m, 1 H), 3.04 (dd, *J* = 15.7 Hz, 10.4 Hz, 1 H), 2.91 (ddd, *J* = 15.7 Hz, 5.3 Hz, 1.5 Hz, 1 H), 1.38 (s, 3 H), 1.37 (s, 3 H) ppm. ^{1}H NMR (300 MHz, acetone-d6): δ = 8.17 (s, 1 H), 8.04 (s, 1 H), 7.79 (s, 1 H), 6.98 (s, 1 H), 6.89 (d, *J* = 8.1 Hz, 1 H), 6.45 (s, 1 H), 6.36 (dd, *J* = 8.1 Hz, 2.5 Hz, 1 H), 6.27 (d, *J* = 2.5 Hz, 1 H), 6.25 (dd, *J* = 17.6 Hz, 10.8 Hz, 1 H), 4.98 (dd, *J* = 17.4 Hz, 1.3 Hz, 1 H), 4.93 (dd, *J* = 10.4 Hz, 1.8 Hz, 1 H), 4.21 (ddd, *J* = 10.2 Hz, 3.4 Hz, 2.1 Hz, 1 H), 3.98 (t-like, *J* = 10.2 Hz, 1 H), 3.44 (m, 1 H), 2.98 (dd, *J* = 15.5 Hz, 11.1 Hz, 1 H), 2.77 (ddd, *J* = 15.7 Hz, 5.3 Hz, 1.7 Hz, 1 H), 1.42 (s, 6 H) ppm. ^{13}C NMR (75 MHz, acetone-d6): δ = 157.45 (C), 156.12 (C), 155.52 (C), 154.77 (C), 149.22 (CH), 130.95 (CH), 126.79 (CH), 125.93 (C), 118.75 (C), 114.42 (C), 110.22 (CH_2), 108.65 (CH), 104.77 (CH), 103.60 (CH), 70.59 (CH_2), 40.70 (C), 33.00 (CH), 31.13 (CH_2), 27.50 (CH_3), 27.42 (CH_3) ppm. IR (ATR): ν = 3382 (m), 3028 (w), 2960 (w), 2906 (w), 2869 (w), 2192 (w), 1729 (w), 1621 (m), 1597 (m), 1557 (m), 1540 (m), 1502 (m), 1458 (m), 1426 (m), 1356 (m), 1274 (m), 1223 (s), 1147 (s), 1113 (s), 1050 (m), 1016 (s), 934 (m), 903 (m), 868 (m), 825 (s), 786 (m), 734 (m), 715 (m), 696 (m), 618 (m) cm^{-1}. ESI-MS: m/z = 327.2 $[M+NH_4]^+$.

4. Synthesis of isoflavan 3

Tsuji-Trost allylation of phenol **14**



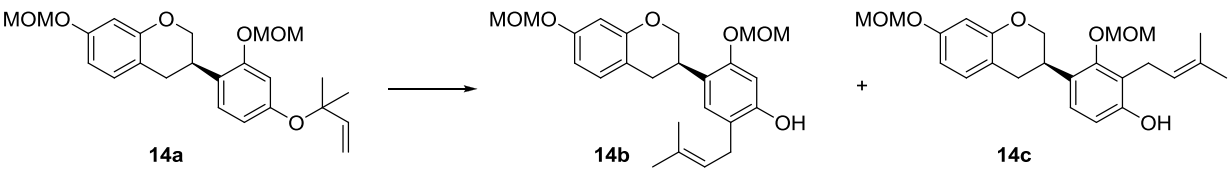
14 **14a**

Isoflavan **14** (121.6 mg, 351.3 μmol), carbonate **16** (203.8 mg, 1.1 mmol), and $Pd(PPh_3)_4$ (20.9 mg, 18.1 μmol) were dissolved in THF (3.5 mL), and the mixture was stirred for 20 min at rt. The solution was rinsed over a pad of silica gel with CH_2Cl_2. The solvent was removed in vacuo, and the residue was purified by flash chromatography (isohexane/ethyl acetate 2:1) to afford isoflavan **14a** (138.5 mg, 334.1 μmol, 95%, 99% *ee*) as a colorless oil.

$[\alpha]_D^{25}$ = – 1.1 (*c* 0.70, $CDCl_3$). ^{1}H NMR (300 MHz, $CDCl_3$): δ = 6.98 (m, 2 H), 6.81 (d, *J* = 2.3 Hz, 1 H), 6.61 (m, 3 H), 6.14 (dd, *J* = 17.6 Hz, 10.8 Hz, 1 H), 5.17 (m, 6 H), 4.34 (ddd, *J* = 10.2 Hz, 3.4 Hz, 2.0 Hz, 1 H), 4.00 (t-like, *J* = 10.3 Hz, 1 H), 3.59 (m, 1 H), 3.48 (s, 3 H), 3.47 (s, 3 H), 3.00 (dd, *J* = 15.5 Hz, 10.6 Hz, 1 H), 2.88 (ddd, 15.9 Hz, 5.3 Hz, 1.9 Hz, 1 H), 1.47 (s, 6 H) ppm. ^{13}C NMR (75 MHz, $CDCl_3$): δ = 156.54 (C), 155.94 (C), 155.27 (C), 155.04 (C), 144.44 (CH), 130.17 (CH), 126.76 (CH), 123.25 (C), 116.06 (C), 114.00 (CH), 113.39 (CH_2), 108.84 (CH), 107.86 (CH), 104.34 (CH), 94.56 (CH_2), 94.51 (CH_2), 79.54 (C), 70.20 (CH_2), 56.08 (CH_3), 55.91 (CH_3), 31.72 (CH), 30.57

(CH_2), 27.01 (CH_3) ppm. IR (ATR): ν = 3082 (w), 2976 (w), 2931 (w), 2895 (w), 2845 (w), 2823 (w), 2780 (w), 1625 (w), 1609 (w), 1580 (w), 1558 (w), 1541 (w), 1500 (m), 1466 (w), 1454 (w), 1422 (w), 1316 (w), 1258 (m), 1211 (m), 1149 (s), 1112 (s), 1072 (s), 1000 (s), 967 (s), 920 (s), 845 (m), 780 (m), 724 (m), 691 (m), 644 (m) cm^{-1}. ESI-MS: m/z = 431.9 $[M+NH_4]^+$. Anal. calcd for $C_{24}H_{30}O_6$: C, 69.54; H, 7.30; found: C, 69.42; H, 7.43.

Claisen rearrangement – isoflavans **14b** and **14c**



Isoflavan **14a** (136.6 mg, 329.6 μmol) and $Eu(fod)_3$ (35.0 mg, 33.7 μmol) was dissolved in $CHCl_3$ (2.3 mL) in a microwave tube. The mixture was irradiated at 110 °C for 15 min at 300 W. The solvent was removed in vacuo, and the residue was purified by flash chromatography (isohexane/ethyl acetate 3:1) to afford isoflavan **14c** (36.8 mg, 88.8 μmol, 27%, 99% *ee*) as a white solid and isoflavan **14b** (94.4 mg, 227.7 μmol, 69%, 99% *ee*) as a colorless oil. Both substances **14b** and **14c** were separated once by means of column chromatography for analytical purposes. Elsewise, the mixture of both **14b** and **14c** was used for further synthesis.

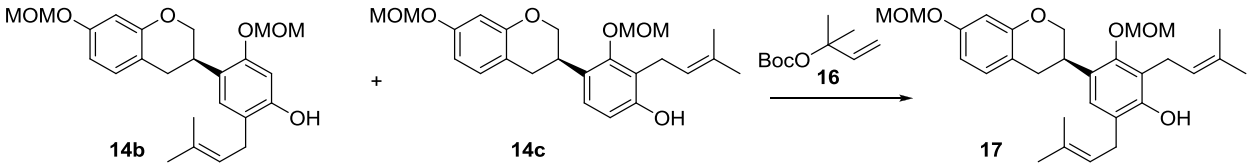
Isoflavan **14c**:

$[\alpha]_D^{25}$ = +13.8 (*c* 0.41, $CDCl_3$). M.p. 67 - 71 °C. ^{1}H NMR (500 MHz, $CDCl_3$): δ = 7.00 (d, *J* = 8.8 Hz, 1 H), 6.90 (d, *J* = 8.5 Hz, 1 H), 6.67 (d, *J* = 8.5 Hz, 1 H), 6.60 (m, 2 H), 5.34 (s, 1 H), 5.24 (m, 1 H), 5.16 (s, 2 H), 4.95 (s, 2 H), 4.30 (m, 1 H), 3.92 (t-like, *j* = 10.5 Hz, 1 H), 3.60 (m, 1 H), 3.56 (s, 3 H), 3.49 (s, 3 H), 3.45 (d, *J* = 6.6 Hz, 2 H), 2.91 (m, 2 H), 1.84 (s, 3 H), 1.77 (d, *J* = 1.3 Hz, 3 H) ppm. ^{13}C NMR (126 MHz, $CDCl_3$): δ = 156.53 (C), 155.00 (C), 154.77 (C), 154.57 (C), 135.35 (C), 130.14 (CH), 126.84 (C), 125.32 (CH), 121.62 (CH), 120.77 (C), 116.01 (C), 112.66 (CH), 108.86 (CH), 104.36 (CH), 100.60 (CH_2), 94.55 (CH_2), 70.64 (CH_2), 57.62 (CH_3), 55.94 (CH_3), 31.83 (CH_2), 31.40 (CH), 25.76 (CH_3), 24.13 (CH_2), 17.97 (CH_3) ppm. IR (ATR): ν = 3471 (w), 2913 (w), 2846 (w), 1619 (w), 1585 (w), 1542 (w), 1501 (m), 1436 (m), 1375(w), 1323 (w), 1281 (m), 1258 (m), 1210 (w), 1150 (s), 1111 (m), 1075 (m), 1006 (s), 985 (s), 958 (s), 920 (s), 875 (m), 845 (m), 806 (m), 780 (w), 726 (w), 705 (w), 624 (w) cm^{-1}. ESI-MS: m/z = 415.3 $[M+H]^+$. HRMS (ESI): m/z calcd for $[M+Na]^+$: 437.1935; found: 437.1938.

Isoflavan **14b**:

$[\alpha]_D^{25}$ = –7.7 (*c* 0.78, $CDCl_3$). ^{1}H NMR (300 MHz, $CDCl_3$): δ = 7.00 (m, 1 H), 6.83 (s, 1 H), 6.67 (s, 1 H), 6.60 (m, 2 H), 5.29 (m, 1 H), 5.17 (br. s., 1 H), 5.16 (s, 2 H), 5.16 (s, 2 H), 4.32 (m, *J* = 10.4 Hz, 3.6 Hz, 2.1 Hz, 1 H), 4.01 (t-like, *J* = 10.3 Hz, 1 H), 3.58 (m, 1 H), 3.49 (s, 3 H), 3.47 (s, 3 H), 3.29 (d, *J* = 7.2 Hz, 2 H), 3.01 (dd, *J* = 15.6 Hz, 11.0 Hz, 1 H), 2.87 (ddd, *J* = 15.7 Hz, 5.1 Hz, 1.7 Hz, 1 H), 1.77 (s, 3 H), 1.76 (s, 11 H) ppm. ^{13}C NMR (75 MHz, $CDCl_3$): δ = 156.52 (C), 155.03 (C), 154.30 (C), 153.79 (C), 134.76 (C), 130.15 (CH), 128.28 (CH), 121.91 (CH), 121.80 (C), 119.78 (C), 116.08 (C), 108.84 (CH), 104.33 (CH), 102.72 (CH), 94.55 (CH_2), 70.24 (CH_2), 56.06 (CH_3), 55.90 (CH_3), 31.71 (CH), 30.64 (CH_2), 29.33 (CH_2), 25.75 (CH_3), 17.83 (CH_3) ppm. IR (ATR): ν = 3402 (w), 2949 (w), 2911 (w), 2846 (w), 2820 (w), 1620 (m), 1585 (m), 1557 (w), 1542 (w), 1501 (m), 1425 (w), 1290 (w), 1258 (w), 1211 (m), 1148 (s), 1109 (m), 1054 (m), 994 (s), 922 (m), 846 (m), 798 (m), 727 (m) cm^{-1}. ESI-MS: m/z = 431.8 $[M+NH_4]^+$. HRMS (ESI): m/z calcd for $[M+Na]^+$: 437.1935; found: 437.1932.

Synthesis of isoflavan **17**



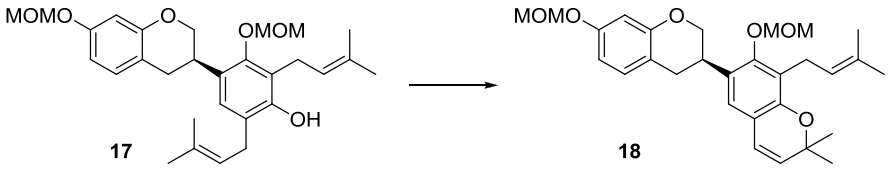
Carbonate **16** (171.7 mg, 921.9 μmol), a mixture of phenols **14b** and **14c** (128.2 mg, 309.5 μmol) and $Pd(PPh_3)_4$ (17.8 mg, 15.4 μmol) were dissolved in THF (2.9 mL), and the mixture was stirred for 20 min at rt. The solution was rinsed over a pad of silica with CH_2Cl_2. The solvents were removed in vacuo, and the residue was purified by flash chromatography (isohexane/ethyl acetate 4:1).

The residue and $Eu(fod)_3$ (31.7 mg, 30.6 μmol) were dissolved in $CHCl_3$ (2.1 mL) in a microwave tube. The mixture was irradiated at 110 °C for 40 min at 300 W. The solvents were removed in vacuo, and the residue was purified by flash chromatography (isohexane/ethyl acetate 5:1) to afford isoflavan **17** (118.9 mg, 246.4 μmol, 80% over two steps, 99% *ee*) as a colorless oil.

$[\alpha]_D^{25}$ = +0.4 (*c* 0.48, $CDCl_3$). ^{1}H NMR (500 MHz, $CDCl_3$): δ = 7.00 (m, 1 H), 6.74 (s, 1 H), 6.60 (m, 2 H), 5.48 (s, 1 H), 5.29 (m, 1 H), 5.24 (m, 1 H), 5.16 (s, 2 H), 4.93 (s, 2 H), 4.30 (ddd, *J* = 10.4 Hz, 3.5 Hz, = 1.6 Hz, 1 H), 3.92 (t-like, *J* = 10.6 Hz, 1 H), 3.59 (m, 1 H), 3.55 (s, 3 H), 3.49 (s, 3 H), 3.44 (d, *J* = 6.6 Hz, 2 H), 3.29 (d, *J* = 6.9 Hz, 2 H), 2.90 (m, 2 H), 1.83 (s, 3 H), 1.76 (s, 6 H), 1.74 (s, 3 H) ppm. ^{13}C NMR (75 MHz, $CDCl_3$): δ = 156.50 (C), 155.03 (C), 152.72 (C), 152.67 (C), 134.74 (C), 134.19 (C), 130.12 (CH), 126.20 (C), 125.43 (CH), 124.10 (C), 121.99 (CH), 121.89 (CH), 120.72 (C), 116.13 (C), 108.81 (CH), 104.35 (CH), 100.59 (CH_2), 94.56 (CH_2), 70.71 (CH_2), 57.55 (CH_3), 55.93 (CH_3), 31.89 (CH_2), 31.30 (CH), 29.26 (CH_2), 25.76 (CH_3), 24.26 (CH_2), 17.98 (CH_3), 17.84

(CH_3) ppm. IR (ATR): ν = 3456 (w), 2959 (w), 2913 (w), 1622 (w), 1585 (w), 1542 (w), 1502 (m), 1472 (m), 1439(w), 1398 (m), 1376 (w), 1319 (w), 1258 (m), 1210 (s), 1150 (s), 1125 (m), 1072 (s), 1030 (s), 1007 (s), 970 (s), 923 (s), 846 (m), 796 (m), 731 (m), 648 (m) cm^{-1}. ESI-MS: m/z = 500.5 $[M+NH_4]^+$. HRMS (ESI): m/z calcd for $[M+Na]^+$: 505.2561; found: 505.2564.

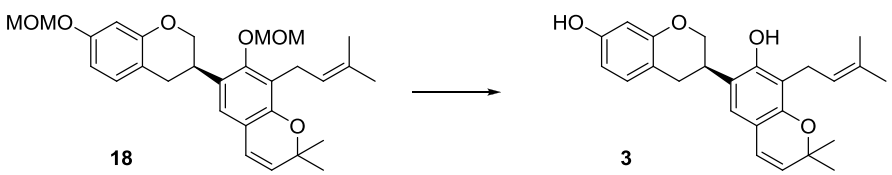
Oxidative cyclization with DDQ – isoflavan **18**



Isoflavan **17** (109.5 mg, 226.9 μmol) and DDQ (100.1 mg, 445.4 μmol) were dissolved in benzene (6.0 mL), and the mixture was stirred for 60 min at rt. Afterwards, the solution was directly submitted to flash chromatography (isohexane/ethyl acetate 3:1) to afford isoflavan **18** (40.9 mg, 85.1 μmol, 38%, 99% *ee*) as a colorless oil.

$[\alpha]_D^{25}$ = –17.6 (*c* 0.67, $CDCl_3$). ^{1}H NMR (300 MHz, $CDCl_3$): δ = 6.99 (m, 1 H), 6.58 (m, 3 H), 6.25 (d, *J* = 9.8 Hz, 1 H), 5.56 (d, *J* = 9.8 Hz, 1 H), 5.21 (m, 1 H), 5.15 (s, 2 H), 4.95 (s, 2 H), 4.32 (m, 1 H), 3.90 (t, *J* = 10.6 Hz, 1 H), 3.61 (m, 1 H), 3.55 (s, 3 H), 3.49 (s, 3 H), 3.33 (d, *J* = 6.8 Hz, 2 H), 2.90 (m, 2 H), 1.79 (s, 3 H), 1.70 (m, 3 H), 1.42 (s, 3 H), 1.41 (s, 3 H) ppm. ^{13}C NMR (75 MHz, $CDCl_3$): δ = 156.49 (C), 155.03 (C), 154.64 (C), 150.72 (C), 131.08 (C), 130.14 (CH), 129.69 (CH), 126.50 (C), 122.95 (CH), 122.93 (C), 122.02 (CH), 117.99 (C), 116.14 (C), 108.78 (C), 104.34 (CH), 100.48 (CH_2), 94.56 (CH_2), 76.14 (C), 70.73 (CH_2), 57.53 (CH_3), 55.95 (CH_3), 31.87 (CH_2), 31.19 (CH), 28.06 (CH_3), 28.02 (CH_3), 25.74 (CH_3), 23.65 (CH_2), 18.02 (CH_3) ppm. IR (ATR): ν = 2965 (w), 2926 (w), 1732 (w), 1621 (m), 1584 (m), 1584 (m), 1542 (m), 1501 (m), 1458 (m), 1440 (m), 1374 (w), 1320 (w), 1261 (m), 1209 (m), 1151 (s), 1123 (s), 1064 (s), 1030 (s), 1006 (s), 961 (s), 923 (s), 880 (m), 848 (m), 796 (w), 754 (w), 698 (w), 647 (w) cm^{-1}. ESI-MS: m/z = 498.4 $[M+NH_4]^+$. HRMS (ESI): m/z calcd for $[M+Na]^+$: 503.2404; found: 503.2401.

Synthesis of compound **3**



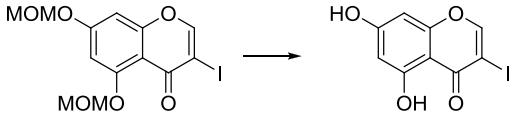
Isoflavan **18** (35.7mg, 74.3 μmol) was dissolved in a 1:1 mixture (2.0 mL) of MeOH and THF. Water (0.35 mL) and 37 % HCl (0.35 mL) were added, and the solution was stirred at 60 °C for 30 min in a closed round bottom flask. The reaction was quenched with saturated aqueous NH_4Cl solution, and the

mixture was extracted three times with EtOAc. The combined organic layers were dried over $MgSO_4$. The solvents were removed in vacuo, and the residue was purified by flash chromatography (isohexane/ethyl acetate 3:1) to afford isoflavan **3** (18.8 mg, 47.9 μmol, 64%, 99% *ee*) as an off-white amorphous solid. Compound **3** is not stable.

$[\alpha]_D^{25}$ = +7.7 (*c* 0.61, $CDCl_3$). ^{1}H NMR (300 MHz, $CDCl_3$): δ = 6.94 (d, *J* = 8.1 Hz, 1 H), 6.61 (s, 1 H), 6.37 (m, 2 H), 6.24 (d, *J* = 9.8 Hz, 1 H), 5.57 (s, 1 H), 5.48 (d, *J* = 9.6 Hz, 1 H), 5.24 (m, 1 H), 4.33 (ddd, *J* = 10.4 Hz, 3.4 Hz, 1.9 Hz, 1 H), 3.99 (t-like, *J* = 10.2 Hz, 1 H), 3.51 (m, 1 H), 3.44 (d, *J* = 7.0 Hz, 2 H), 2.97 (m, 1 H), 2.87 (ddd, *J* = 15.9 Hz, 5.7 Hz, 1.9 Hz, 1 H), 1.85 (s, 3 H), 1.78 (d, *J* = 1.1 Hz, 3 H), 1.41 (s, 6 H) ppm. ^{13}C NMR (75 MHz, $CDCl_3$): δ = 155.23 (C), 154.76 (C), 153.64 (C), 149.73 (C), 135.66 (C), 130.38 (CH), 127.79 (CH), 122.61 (CH), 122.45 (CH), 121.57 (CH), 119.71 (C), 114.89 (C), 114.38 (C), 114.22 (C), 107.75 (CH), 103.19 (CH), 76.25 (C), 70.11 (CH_2), 31.71 (CH), 30.41 (CH_2), 27.98 (CH_3), 27.96 (CH_3), 25.82 (CH_3), 22.36 (CH_2), 17.89 (CH_3) ppm. IR (ATR): ν = 3378 (w), 3035 (w), 2971 (w), 2923 (w), 2850 (w), 1698 (w), 1613 (m), 1596 (m), 1570 (w), 1540 (w), 1508 (m), 1469 (m), 1374 (w), 1322 (w), 1211 (m), 1151 (s), 1114 (s), 1028 (s), 972 (m), 942 (m), 909 (m), 880 (m), 843 (m), 796 (m), 737 (m), 674 (m) cm^{-1}. ESI-MS: m/z = 392.2 $[M+NH_4]^+$.

5. Synthesis of eryzerin D (4)

Chromone **19**



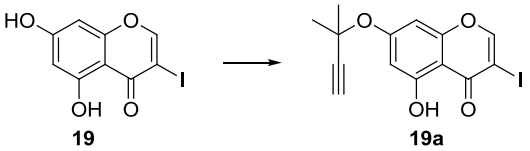
7 **19**

Chromone **7** (1.427 g, 4.31 mmol) was dissolved in a 1:1 mixture of THF and MeOH (72 mL). Water (13.6 mL) and 37% HCl (13.6 mL) were added, and the solution was stirred for 30 min at 60 °C in a closed vessel. The reaction mixture was cooled to rt and poured into saturated NaCl solution. The aqueous layer was extracted three times with EtOAc. The combined organic layers were dried over $MgSO_4$. The solvents were removed in vacuo, and the residue was purified by flash chromatography (isohexane/ethyl acetate 2:1) to afford chromone **19** (1.089 g, 3.58 mmol, 83%) as a yellow solid.

M.p. 227 - 234 °C. ^{1}H NMR (300 MHz, acetone-d_6): δ = 12.35 (s, 1 H), 9.85 (br. s., 1 H), 8.52 (s, 1 H), 6.44 (d, *J* = 2.3 Hz, 1 H), 6.34 (d, *J* = 2.3 Hz, 1 H) ppm. ^{13}C NMR (75 MHz, acetone-d_6): δ = 178.40 (C), 165.31 (C), 162.86 (C), 160.10 (CH), 158.93 (C), 104.48 (C), 100.27 (CH), 94.74 (CH), 83.38 (C) ppm. IR (ATR): ν = 3346 (m), 3117 (w), 3058 (w), 3043 (w), 1882 (w), 1736 (w), 1700 (w), 1659 (m), 1642 (m), 1602 (m), 1563 (w), 1492 (m), 1458 (m), 1414 (w), 1369 (m), 1310 (m), 1263 (m), 1190 (m), 1166 (m), 1079 (m), 1043 (m), 945 (w), 849 (m), 822 (s), 792 (m), 776 (m), 686 (m),

641 (m), 627 (m) cm^{-1}. ESI-MS: m/z = 305.0 $[M+H]^+$. Anal. calcd for $C_9H_5IO_4$: C, 35.55; H, 1.66; found: C, 35.42; H, 1.57.

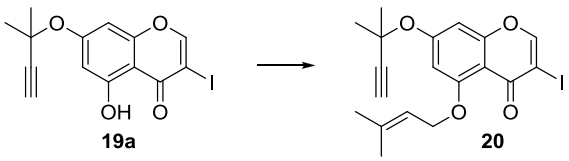
Propargylation



Phenol **19** (1.677g, 5.52 mmol), CuI (97.5 mg, 0.51 mmol), K_2CO_3 (2.231g, 16.14 mmol) and KI (2.73g, 16.45 mmol) were suspended in acetone (17.8 mL). 3-Chloro-3-methylbutyne (1.20 g, 11.70 mmol) was added, and the mixture was stirred for 60 min at 60 °C. The reaction was quenched with saturated aqueous NH_4Cl solution and 2 N HCl (8 mL). The mixture was extracted three times with EtOAc. The combined organic layers were dried over $MgSO_4$. The solvents were removed in vacuo, and the residue was purified by flash chromatography (isohexane/ethyl acetate 9:1) to afford chromone **19a** (1.673 g, 4.52 mmol, 82%) as a yellow solid.

M.p. 143 - 148 °C. ^{1}H NMR (600 MHz, $CDCl_3$): δ = 12.12 (s, 1 H), 8.15 (s, 1 H), 6.80 (d, *J* = 2.3 Hz, 1 H), 6.76 (d, *J* = 2.3 Hz, 1 H), 2.70 (s, 1 H), 1.74 (s, 6 H) ppm. ^{13}C NMR (151 MHz, $CDCl_3$): δ = 177.57 (C), 162.35 (C), 161.15 (C), 158.10 (CH), 157.13 (C), 105.07 (C), 103.10 (CH), 97.23 (CH), 84.45 (C), 83.61 (C), 75.48 (CH), 72.96 (C), 29.52 (CH_3) ppm. IR (ATR): ν = 3227 (m), 3098 (w), 2993 (w), 2932 (w), 2107 (w), 2056 (w), 2030 (w), 2009 (w), 1975 (w), 1771 (w), 1735 (w), 1717 (w), 1699 (w), 1643 (m), 1595 (m), 1555 (w), 1543 (w), 1489 (m), 1451 (w), 1430 (w), 1398 (w), 1387 (w), 1346 (w), 1296 (m), 1228 (w), 1211 (w), 1177 (m), 1130 (s), 1077 (s), 1045 (m), 992 (m), 950 (m), 901 (m), 881 (m), 839 (s), 790, 743 (s), 678 (m), 617 (m) cm^{-1}. ESI-MS: m/z = 371.1 $[M+H]^+$. Anal. calcd for $C_{14}H_{11}IO_4$: C, 45.43; H, 3.00; found: C, 45.39; H, 2.86.

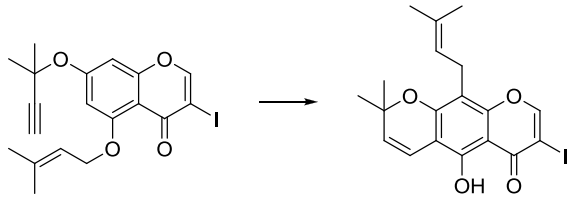
Prenylation



Chromone **19a** (1.898 g, 5.13 mmol), PPh_3 (1.936 g, 7.38 mmol) and 3-methyl-2-buten-1-ol (0.76 mL, 7.48 mmol) were dissolved in THF (73 mL). DIAD (1.38 mL, 6.63 mmol) was added at 0 °C over 15 min. The reaction mixture was stirred for 16 h at rt. The solvents were removed in vacuo, and the residue was purified by flash chromatography (isohexane/ethyl acetate 5:1) to afford chromone **20** (1.789 g, 4.08 mmol, 80%) as a yellow solid.

M.p. 85 - 92 °C. ^{1}H NMR (600 MHz, $CDCl_3$): δ = 8.05 (s, 1 H), 6.91 (d, *J* = 2.3 Hz, 1 H), 6.59 (m, 1 H), 5.58 (m, 1 H), 4.60 (d, *J* = 6.4 Hz, 2 H), 2.68 (s, 1 H), 1.77 (m, 3 H), 1.72 (s, 9 H) ppm. ^{13}C NMR (75 MHz, $CDCl_3$): δ = 171.20 (C), 160.40 (C), 159.82 (C), 158.94 (C), 155.35 (CH), 137.81 (C), 119.20 (CH), 108.20 (C), 101.01 (CH), 98.20 (CH), 89.63 (C), 84.68 (C), 75.29 (CH), 72.74 (C), 66.45 (CH_2), 29.49 (CH_3), 25.76 (CH_3), 18.38 (CH_3) ppm. IR (ATR): ν = 3230 (w), 2985 (w), 2976 (w), 2933 (w), 2899 (w), 2856 (w), 2106 (w), 2056 (w), 2030 (w), 2009 (w), 1916 (w), 1843 (w), 1733 (w), 1716 (w), 1699 (w), 1684 (w), 1641 (m), 1619 (m), 1560 (m), 1555 (m), 1509 (m), 1476 (m), 1454 (m), 1421 (m), 1351 (m), 1271 (s), 1231 (m), 1214 (m), 1188 (m), 1158 (m), 1129 (s), 1065 (s), 1014 (m), 946 (m), 881 (m), 849 (m), 824 (m), 809 (m), 780 (m), 740 (m), 689 (m), 662 (m), 641 (m), 606 (m) cm^{-1}. ESI-MS: m/z = 439.2 $[M+H]^+$. HRMS (ESI): m/z calcd for $[M+Na]^+$: 461.0220; found: 461.0222.

Chromone **21**

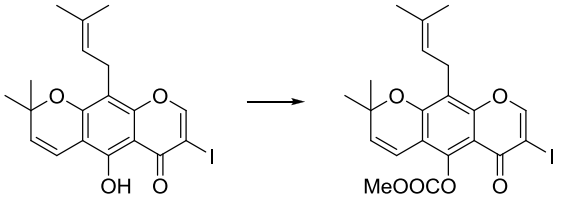


Chromone **20** (1.338 g, 3.05 mmol) and $Eu(fod)_3$ (163.7 mg, 157.8 μmol) were dissolved in chlorobenzene (7.0 mL). The solution was allocated to five microwave tubes. Cs_2CO_3 (21.9 mg, 67.2 μmol) was added to each tube, and the mixtures were irradiated at 140 °C for 10 min. The reaction was quenched with saturated aqueous NH_4Cl solution, and the mixture was extracted two times with EtOAc. The combined organic layers were dried over $MgSO_4$. The solvents were removed in vacuo, and the residue was purified by flash chromatography (isohexane/ethyl acetate 25:1) to afford chromone **21** (640.7 mg, 1.46 mmol, 48%) as a yellow solid.

M.p. 86 - 92 °C. ^{1}H NMR (300 MHz, $CDCl_3$): δ = 12.44 (s, 1 H), 8.18 (s, 1 H), 6.72 (d, *J* = 10.0 Hz, 1 H), 5.64 (d, *J* = 10.0 Hz, 1 H), 5.13 (m, 1 H), 3.36 (d, *J* = 7.4 Hz, 2 H), 1.79 (s, 3 H), 1.68 (d, *J* = 0.9 Hz, 3 H), 1.47 (s, 6 H) ppm. ^{13}C NMR (126 MHz, $CDCl_3$): δ = 177.84 (C), 157.76 (CH), 157.24 (C154.43 (C), 153.87 (C), 131.92 (C), 128.36 (CH), 121.56 (CH), 115.67 (CH), 107.71 (C), 105.85 (C), 104.36 (C), 83.40 (C), 78.09 (C), 28.26 (CH_3), 25.72 (CH_3), 21.33 (CH_2), 17.85 (CH_3) ppm. IR (ATR): ν = 3111 (w), 3060 (w), 2970 (w), 2915 (w), 2846 (w), 2031 (w), 2007 (w), 1975 (w), 1874 (w), 1739 (w), 1643 (m), 1598 (m), 1580 (m), 1547 (m), 1529 (m), 1453 (m), 1424 (s), 1403 (m), 1356 (m), 1304 (m), 1284 (m), 1248 (m), 1204 (m), 1170 (m), 1141 (m), 1117 (m), 1094 (s), 1075 (s), 1021

(m), 977 (m), 959 (m), 942 (m), 886 (m), 809 (s), 763 (m), 716 (m), 664 (m), 633 (m) cm^{-1}. ESI-MS: m/z = 439.3 $[M+H]^+$. Anal. calcd for $C1_9H_{19}IO_4$: C, 52.07; H, 4.37; found: C, 52.35; H, 4.33.

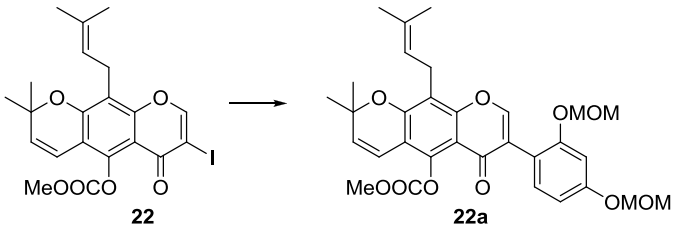
Chromone **22**



Chromone **21** (639.9 mg, 1.46 mmol) was dissolved in THF (18.5 mL). Et_3N (0.57 mL) and ClCOOMe (0.32 mL, 4.14 mmol) was added at 0 °C. Afterwards, the mixture was stirred for 60 min at rt. The reaction was quenched with saturated aqueous NH_4Cl solution, and the mixture was extracted three times with EtOAc. The combined organic layers were dried over $MgSO_4$. The solvents were removed in vacuo, and the residue was purified by flash chromatography (isohexane/ethyl acetate 4:1) to afford chromone **22** (621.6 mg, 1.25 mmol, 86%) as a white solid.

M.p. 138 - 145 °C. ^{1}H NMR (500 MHz, $CDCl_3$): δ = 8.18 (s, 1 H), 6.58 (d, *J* = 10.1 Hz, 1 H), 5.80 (d, *J* = 10.4 Hz, 1 H), 5.14 (m, 1 H), 3.98 (s, 3 H), 3.44 (d, *J* = 7.3 Hz, 2 H), 1.81 (s, 3 H), 1.69 (s, 3 H), 1.48 (s, 6 H) ppm. ^{13}C NMR (126 MHz, $CDCl_3$): δ = 171.59 (C), 156.15 (CH), 155.46 (C), 155.18 (C), 153.42 (C), 142.29 (C), 132.61 (C), 132.37 (CH), 120.67 (CH), 115.37 (C), 115.09 (CH), 113.00 (C), 109.49 (C), 87.85 (C), 78.17 (C), 55.91 (CH_3), 28.36 (CH_3), 25.71 (CH_3), 21.91 (CH_2), 17.92 (CH_3) ppm. IR (ATR): ν = 3088 (w), 2970 (w), 2915 (w), 2846 (w), 2138 (w), 2079 (w), 2056 (m), 2030 (m), 2010 (w), 1867 (w), 1843 (w), 1757 (m), 1698 (w), 1641 (m), 1606 (m), 1576 (w), 1489 (w), 1454 (m), 1424 (m), 1359 (w), 1300 (w), 1248 (s), 1215 (s), 1169 (m), 1141 (m), 1102 (m), 1076 (m), 1040 (m), 1016 (m), 965 (m), 942 (m), 892 (m), 870 (m), 842 (m), 805 (m), 764 (s), 725 (m), 663 (m) cm^{-1}. ESI-MS: m/z = 497.2 $[M+H]^+$. Anal. calcd for $C_{21}H_{21}IO_6$: C, 50.82; H, 4.26; found: C, 52.65; H, 4.32.

Isoflavone **22a**



Preparation of 2,4-bis(methoxymethoxy)phenylboronic acid:

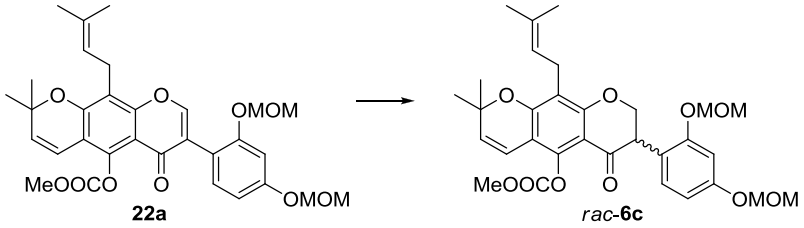
1-Bromo-2,4-bis(methoxymethoxy)benzene (630.9 mg, 2.28 mmol) and $B(O\textit{i}Pr)_3$ (0.74 mL, 3.21 mmol) were suspended in THF (11.5 mL). BuLi (2.2 mL, 1.6 M in THF, 3.52 mmol) was added at – 78 °C over 15 min. The reaction was stirred for 70 min at – 78 °C and an additional 100 min at rt. The reaction was quenched with 1 N HCl, and the mixture was extracted three times with EtOAc. The combined organic layers were washed with saturated $NaHCO_3$ solution and saturated NaCl solution respectively. The combined organic layers were dried over $MgSO_4$, and the solvents were removed in vacuo. The crude product (621.6 mg, 1.25 mmol) was directly used for further transformation.

Suzuki coupling:

Above-mentioned boronic acid (621.6 mg, 1.25 mmol) and chromone **22** (621.6mg, 1.25 mmol) were dissolved in dioxane (4.6 mL) at 50 °C. Water (2.0 mL), mortared K_2CO_3 (452.2 mg, 3.27 mmol), PCy_3 (18.0 mg, 64.2 μmol), and $Pd_2(dba)_3$ (28.6 mg, 31.2 μmol) were added to the solution, and the mixture was stirred for 40 min at 50 °C in a closed vessel. The reaction was quenched with saturated aqueous NH_4Cl solution, and the mixture was extracted three times with EtOAc. The combined organic layers were dried over $MgSO_4$. The solvents were removed in vacuo, and the residue was purified by flash chromatography (isohexane/ethyl acetate 11:5) to afford isoflavone **22a** (539.2 mg, 951.7 μmol, 76%) as a white solid.

M.p. 42 - 45 °C. ^{1}H NMR (600 MHz, $CDCl_3$): δ = 7.81 (s, 1 H), 7.18 (d, *J* = 8.4 Hz, 1 H), 6.90 (d, *J* = 2.4 Hz, 1 H), 6.75 (dd, *J* = 8.4 Hz, *J* = 2.4 Hz, 1 H), 6.60 (d, *J* = 10.1 Hz, 1 H), 5.78 (d, *J* = 10.1 Hz, 1 H), 5.22 (m, 1 H), 5.18 (s, 2 H), 5.12 (s, 2 H), 3.90 (s, 3 H), 3.49 (m, 5 H), 3.45 (s, 3 H), 1.83 (d, *J* = 0.9 Hz, 3 H), 1.71 (d, *J* = 0.9 Hz, 3 H), 1.48 (s, 6 H) ppm. ^{13}C NMR (151 MHz, $CDCl_3$): δ = 174.96 (C), 158.52 (C), 156.41 (C), 155.67 (C), 154.60 (C), 153.42 (C), 152.12 (CH), 142.74 (C), 132.25 (C), 132.10 (CH), 131.91 (CH), 122.77 (C), 121.14 (CH), 115.37 (CH), 115.36 (C), 112.39 (C), 111.69 (C), 108.97 (CH), 104.24 (CH), 95.07 (CH_2), 94.44 (CH_2), 77.75 (C), 56.19 (CH_3), 56.18 (CH_3), 55.60 (CH_3), 28.27 (CH_3), 25.74 (CH_3), 21.89 (CH_2), 17.94 (CH_3) ppm. IR (ATR): ν = 2963 (w), 2922 (w), 2850 (w), 2823 (w), 2137 (w), 2056 (w), 2030 (w), 2009 (w), 1844 (w), 1766 (m), 1735 (w), 1698 (w), 1643 (m), 1605 (s), 1578 (m), 1541 (w), 1504 (m), 1459 (m), 1434 (m), 1373 (m), 1304 (m), 1238 (s), 1209 (s), 1150 (s), 1121 (s), 1079 (s), 1121 (s), 1079 (s), 998 (s), 922 (m), 889 (m), 842 (m), 783 (m), 756 (m), 697 (m), 652 (m) cm^{-1}. ESI-MS: m/z = 567.3 $[M+H]^+$. Anal. calcd for $C_{31}H_{34}O_{10}$: C, 65.71; H, 6.05; found: C, 65.55; H, 6.27.

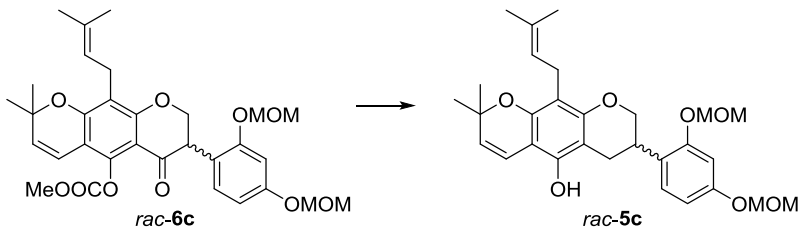
Isoflavanone *rac*-**6c**



Isoflavone **22a** (536.9 mg, 947.6 μmol) was dissolved in THF (8.6 mL) and cooled to – 78 °C. L-selectride solution (1.36 mL, 1.0 M, 1.36 mmol) was added, and the mixture was stirred for 60 min. The reaction was quenched with a small portion of MeOH at – 78 °C, and the mixture was poured into saturated NH_4Cl solution. The mixture was extracted three times with EtOAc, and the combined organic layers were dried over $MgSO_4$. The solvents were removed in vacuo, and the residue was purified by flash chromatography (Et_2O/pentane 1:1) to afford isoflavanone *rac*-**6c** (466.6 mg, 820.6 μmol, 87%) as a yellow oil.

^{1}H NMR (600 MHz, $CDCl_3$): δ = 7.00 (d, *J* = 8.3 Hz, 1 H), 6.86 (d, *J* = 2.3 Hz, 1 H), 6.68 (dd, *J* = 8.3 Hz, *J* = 2.3 Hz, 1 H), 6.48 (d, *J* = 10.2 Hz, 1 H), 5.65 (d, *J* = 10.2 Hz, 1 H), 5.19 (m, 1 H), 5.15 (m, 3 H), 5.11 (m, 1 H), 4.61 (m, 1 H), 4.50 (dd, *J* = 10.7 Hz, *J* = 5.5 Hz, 1 H), 4.19 (dd, *J* = 11.9 Hz, *J* = 5.5 Hz, 1 H), 3.88 (s, 3 H), 3.47 (s, 3 H), 3.45 (s, 3 H), 3.30 (m, 2 H), 1.78 (s, 3 H), 1.70 (d, *J* = 0.8 Hz, 3 H), 1.47 (s, 3 H), 1.46 (s, 3 H) ppm. ^{13}C NMR (151 MHz, $CDCl_3$): δ = 190.42 (C), 161.09 (C), 157.93 (C), 156.74 (C), 156.20 (C), 153.36 (C), 144.26 (C), 131.67 (C), 131.06 (CH), 129.76 (CH), 121.71 (CH), 117.69 (C), 115.29 (C), 115.25 (C), 109.17 (C), 109.10 (CH), 108.24 (C), 103.88 (CH), 94.75 (CH_2), 94.46 (CH_2), 77.84 (C), 70.48 (CH_2), 56.20 (CH_3), 56.02 (CH_3), 55.51 (CH_3), 48.61 (CH), 28.45 (CH_3), 28.38 (CH_3), 25.76 (CH_3), 21.80 (CH_2), 17.86 (CH_3) ppm. IR (ATR): ν = 3213 (w), 2972 (w), 2922 (w), 2136 (w), 2056 (w), 2030 (w), 2009 (w), 1844 (w), 1767 (m), 1735 (m), 1716 (m), 1681 (m), 1651 (w), 1574 (m), 1505 (m), 1473 (m), 1436 (m), 1397 (m), 1343 (w), 1245 (s), 1183 (s), 1149 (s), 1120 (s), 1078 (m), 997 (s), 924 (m), 893 (m), 842 (m), 813 (m), 763 (m), 711 (w), 689 (w) cm^{-1}. ESI-MS: m/z = 569.4 $[M+H]^+$. HRMS (ESI): m/z calcd for $[M+Na]^+$: 591.2206; found: 591.2214.

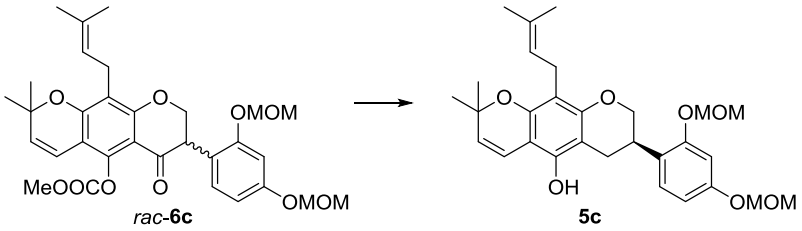
Synthesis of *rac*-**5c**



Isoflavanone *rac*-**6c** (50.1 mg, 88.1 μmol) was dissolved in THF (0.53 mL). Separately, $NaBH_4$ (20.3 mg, 536.6 μmol) was dissolved in water (0.21 mL). Both solutions were merged and stirred for 35 min at rt. The reaction was quenched with saturated aqueous NH_4Cl solution, and the mixture was extracted three times with EtOAc. The combined organic layers were dried over $MgSO_4$. The solvents were removed in vacuo, and the residue was purified by flash chromatography (Et_2O/pentane 5:6) to afford isoflavan *rac*-**5c** (23.1 mg, 46.5 μmol, 53%) as a brown resin.

^{1}H NMR (600 MHz, $CDCl_3$): δ = 7.05 (d, *J* = 8.3 Hz, 1 H), 6.86 (d, *J* = 2.3 Hz, 1 H), 6.70 (dd, *J* = 8.5 Hz, *J* = 2.4 Hz, 1 H), 6.53 (d, *J* = 9.8 Hz, 1 H), 5.50 (d, *J* = 9.8 Hz, 1 H), 5.23 (m, 1 H), 5.21 (s, 2 H), 5.17 (s, 2 H), 4.61 (s, 1 H), 4.34 (m, 1 H), 4.02 (t-like, *J* = 10.2 Hz, 1 H), 3.60 (m, 1 H), 3.50 (s, 6 H), 3.26 (m, 2 H), 2.83 (ddd, *J* = 15.1 Hz, 5.6 Hz, 1.9 Hz, 1 H), 2.70 (dd, *J* = 15.2 Hz, 11.1 Hz, 1 H), 1.79 (s, 3 H), 1.68 (s, 3 H), 1.42 (s, 3 H), 1.41 (s, 3 H) ppm. ^{13}C NMR (151 MHz, $CDCl_3$): δ = 157.07 (C), 155.83 (C), 152.96 (C), 149.89 (C), 147.14 (C), 130.26 (C), 127.77 (CH), 126.95 (CH), 123.80 (C), 123.52 (CH), 116.37 (CH), 109.94 (C), 108.94 (CH), 103.53 (CH), 102.68 (C), 101.28 (C), 94.53 (CH_2), 75.47 (C), 69.51 (CH_2), 56.24 (CH_3), 56.06 (CH_3), 31.39 (CH), 27.62 (CH_3), 27.52 (CH_3), 25.85 (CH_3), 25.67 (CH_2), 21.70 (CH_2), 17.82 (CH_3) ppm. IR (ATR): ν = 3438 (w), 2965 (w), 2918 (w), 1612 (m), 1597 (m), 1542 (m), 1505 (m), 1456 (m), 1435 (m), 1398 (m), 1376 (m), 1325 (m), 1252 (m), 1214 (m), 1151 (s), 1130 (s), 1076 (s), 992 (s), 922 (m), 845 (m), 808 (m), 729 (m), 664 (m) cm^{-1}. ESI-MS: m/z = 497.5 $[M+H]^+$. HRMS (ESI): m/z calcd for $[M+Na]^+$: 519.2359; found: 519.2337.

ATH of isoflavanone *rac*-**6c**



Preparation of the catalyst solution:

$[Ru(p\text{-cymene})Cl_2]_2$ (21.61 mg, 35.3 μmol) and (*R*,*R*)-TsDPEN (25.98 mg, 70.9 μmol) were dissolved in EtOAc (2.35 mL) and stirred for 20 min. Separately, Et_3N (1.8 mL) and HCOOH (0.5 mL) were mixed at 0 °C. The lower layer of this biphasic Et_3N / HCOOH mixture (approximately 2.8:1 (v/v), 0.96 mL) was added to the catalyst solution, and the mixture stirred for further 10 min. The freshly prepared solution was used for ATH.

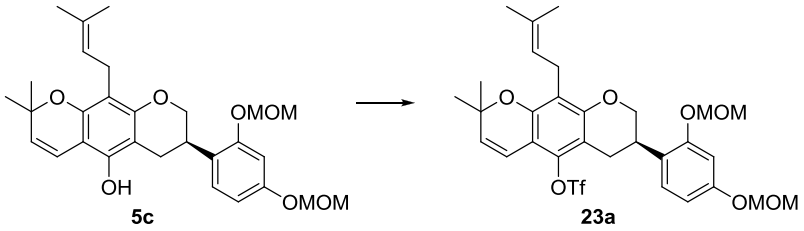
ATH:

Isoflavanone *rac*-**6c** (461.8 mg, 812.2 μmol) was dissolved in EtOAc (1.0 mL), and the above-mentioned catalyst solution (1.9 mL, 40.5 μmol) was added. The mixture was stirred at 45 °C for 16 h. The reaction was quenched with saturated aqueous NH_4Cl solution, and the mixture was extracted three times with EtOAc. The combined organic layers were dried over $MgSO_4$. The solvents were removed in vacuo, and the residue was purified by flash chromatography (Et_2O/pentane 1:1) to afford isoflavan **5c** (161.5 mg, 325.2 μmol, 40%, 98% *ee*) as a brown resin and isoflavanone (*S*)-**6c** (149.0 mg, 262.0 μmol, 32%, 17% *ee*) as a yellow oil.

Isoflavan (*R*)-**5c**:
The analytical data obtained match the aforementioned data.
$[\alpha]_D^{25}$ = +55.4 (*c* 0.37, $CDCl_3$).

Isoflavanone (*S*)-**6c**:
The analytical data obtained match the aforementioned data.
$[\alpha]_D^{25}$ = n.d. (close to zero)

Isoflavan **23a**

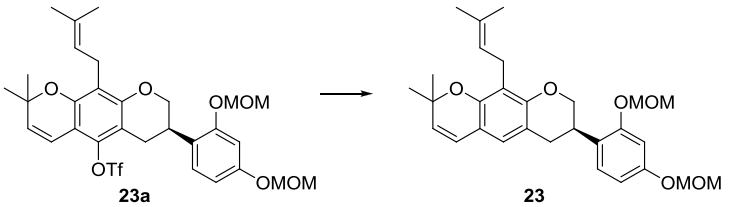


Isoflavan **5c** (160.5 mg, 3223.2 μmol) was dissolved in CH_2Cl_2 (3.8 mL). Et_3N (225 μl) and Tf_2O (70 μl, 416.1 μmol) were added at − 40 °C, and the solution was stirred for 40 min. The reaction was quenched with saturated aqueous NH_4Cl solution, and the mixture was extracted three times with EtOAc. The combined organic layers were dried over $MgSO_4$. The solvents were removed in vacuo, and the residue was purified by flash chromatography (pentane/Et_2O 5:1) to afford isoflavan **23a** (175.4 mg, 279.0 μmol, 86%, *ee* n.d.) as a colorless resin.

$[\alpha]_D^{25}$ = +25.0 (*c* 0.18, $CDCl_3$). ^{1}H NMR (300 MHz, $CDCl_3$): δ = 7.03 (d, *J* = 8.5 Hz, 1 H), 6.86 (d, J = 2.5 Hz, 1 H), 6.70 (dd, *J* = 8.5 Hz, 2.5 Hz, 1 H), 6.48 (d, *J* = 10.0 Hz, 1 H), 5.65 (d, *J* = 9.8 Hz, 1 H), 5.21 (m, 3 H), 5.17 (s, 2 H), 4.39 (ddd, *J* = 10.4 Hz, 3.21 Hz, 1.51 Hz, 1 H), 4.10 (t-like, *J* = 10.2 Hz, 1 H), 3.51 (m, 7 H), 3.30 (d, *J* = 7.4 Hz, 2 H), 2.98 (m, 2 H), 1.79 (s, 3 H), 1.69 (d, *J* = 0.6 Hz, 3 H), 1.44 (s, 3 H), 1.42 (s, 3 H) ppm. ^{13}C NMR (75 MHz, $CDCl_3$): δ = 157.24 (C), 155.88 (C), 153.05 (C), 150.12 (C), 140.92 (C), 131.45 (C), 129.92 (CH), 127.73 (CH), 122.78 (C), 121.97 (CH), 118.54 (q, *J* = 320.8 Hz, C), 117.53 (C), 116.22 (CH), 108.88 (CH), 108.64 (C), 108.58 (C), 103.48 (CH), 94.53

(CH_2), 94.48 (CH_2), 76.09 (C), 69.86 (CH_2), 56.20 (CH_3), 56.08 (CH_3), 31.17 (CH), 27.64 (CH_3), 27.31 (CH_3), 26.19 (CH_2), 25.81 (CH_3), 22.14 (CH_2), 17.87 (CH_3) ppm. ^{19}F-NMR (282 MHz, $CDCl_3$): δ = – 74.0 ppm. IR (ATR): ν = 2965 (w), 2920 (w), 2823 (w), 1613 (m), 1585 (m), 1505 (m), 1405 (m), 1327 (m), 1242 (m), 1208 (s), 1135 (s), 1078 (m), 1003 (s), 952 (s), 924 (m), 900 (m), 831 (s), 795 (m), 763 (m), 733 (m), 689 (m), 665 (m) cm^{-1}. ESI-MS: m/z = 646.4 $[M+NH_4]^+$. HRMS (ESI): m/z calcd for $[M+Na]^+$: 651.1852; found: 651.1852.

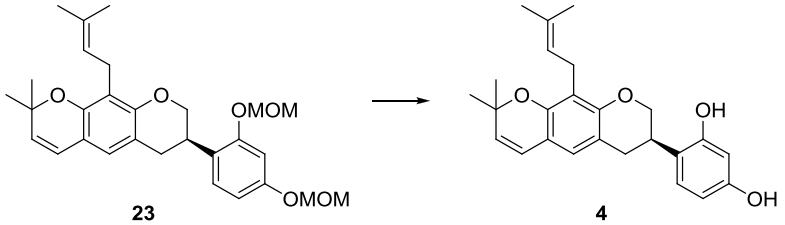
Isoflavan **23**



Isoflavan **23a** (174.8 mg, 278.1 μmol) was dissolved in a mixture of THF (1.7 mL), Et_3N (0.3 mL) and HCOOH (90 μl). $Pd(OAc)_2$ (3.16 mg, 14.1 μmol) and dppf (8.06 mg, 14.5 μmol) were added, and the solution was stirred for 60 min at 60 °C in a closed round bottom flask. The reaction was quenched with saturated aqueous NH_4Cl solution, and the mixture was extracted three times with EtOAc. The combined organic layers were dried over $MgSO_4$. The solvents were removed in vacuo, and the residue was purified by flash chromatography (pentane/Et_2O 5:1) to afford isoflavan **23** (122.9 mg, 255.7 μmol, 92%, 98% *ee*) as a colorless resin.

$[\alpha]_D^{25}$ = +49.0 (*c* 0.25, $CDCl_3$). ^{1}H NMR (300 MHz, $CDCl_3$): δ = 7.04 (d, *J* = 8. 3Hz, 1 H), 6.85 (d, *J* = 2.5 Hz, 1 H), 6.70 (dd, *J* = 8.5 Hz, 2.5 Hz, 1 H), 6.56 (s, 1 H), 6.24 (d, *J* = 9.8 Hz, 1 H), 5.48 (d, *J* = 9.8 Hz, 1 H), 5.26 (m, 1 H), 5.21 (s, 2 H), 5.16 (s, 2 H), 4.36 (dd, *J* = 10.2 Hz, 3.4Hz, 1.9Hz, 1 H), 4.02 (t-like, *J* = 10.2 Hz, 1 H), 3.60 (m, 1 H), 3.49 (s, 6 H), 3.31 (d, *J* = 7.4 Hz, 2 H), 2.96 (dd, *J* = 15.7 Hz, 11.0 Hz, 1 H), 2.84 (ddd, *J* = 15.7 Hz, 5.5 Hz, 1.5 Hz, 1 H), 1.80 (s, 3 H), 1.68 (s, 3 H), 1.41 (s, 6 H) ppm. ^{13}C NMR (75 MHz, $CDCl_3$): δ = 156.96 (C), 155.83 (C), 152.61 (C), 149.64 (C), 130.64 (C), 128.10 (CH), 127.69 (CH), 124.21 (CH), 124.01 (C), 122.95 (CH), 122.33 (CH), 116.85 (C), 114.44 (C), 113.94 (C), 108.87 (CH), 103.49 (CH), 94.56 (CH_2), 94.52 (CH_2), 75.70 (C), 70.05 (CH_2), 56.21 (CH_3), 56.06 (CH_3), 31.70 (CH), 31.15 (CH_2), 27.90 (CH_3), 27.84 (CH_3), 25.84 (CH_3), 22.10 (CH_2), 17.87 (CH_3) ppm. IR (ATR): ν = 3038 (w), 2969 (w), 2921 (w), 2846 (w), 2823 (w), 1611 (m), 1582 (m), 1542 (m), 1505 (m), 1472 (m), 1390 (m), 1360 (m), 1322 (m), 1261 (m), 1213 (m), 1151 (s), 1126 (s), 1076 (s), 1000 (s), 922 (m), 489 (m), 801 (m), 730 (m), 665 (m) cm^{-1}. ESI-MS: m/z = 498.4 $[M+NH_4]^+$. HRMS (ESI): m/z calcd for $[M+Na]^+$: 503.2410; found: 503.2411.

Eryzerin D (**4**)

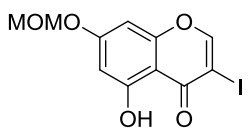


23 **4**

Isoflavan **23** (62.9 mg, 130.9 μmol) was dissolved in THF (1.75 mL) and MeOH (1.75 mL). Water (0.35 mL) and 37% HCl (0.35 mL) were added, and the mixture was stirred for 40 min at 60 °C in a closed vessel. The reaction was quenched with saturated aqueous NaCl solution, and the mixture was extracted three times with EtOAc. The combined organic layers were dried over $MgSO_4$. The solvents were removed in vacuo, and the residue was purified by flash chromatography (pentane/Et_2O 1:1) to afford crude isoflavan **4**. The resin was further purified by means of semi-preparative HPLC to afford the pure product **4** (18.6 mg, 47.4 μmol, 36%, 98% *ee*) as a slightly brown resin. Eryzerin D (**4**) is not stable and decomposes especially during column chromatography.

$[\alpha]_D^{25}$ = +36.1 (*c* 0.23, MeOH). ^{1}H NMR (300 MHz, $CDCl_3$): δ = 6.95 (d, *J* = 8.3 Hz, 1 H), 6.57 (s, 1 H), 6.38 (dd, *J* = 8.3 Hz, 2.5 Hz, 1 H), 6.28 (d, *J* = 2.5 Hz, 1 H), 6.24 (d *J* = 9.8 Hz, 1 H), 5.49 (d, *J* = 9.8 Hz, 1 H), 5.25 (m, 1 H), 5.06 (s, 1 H), 4.91 (s, 1 H), 4.36 (ddd, *J* = 10.6 Hz, 3.6 Hz, 1.9 Hz, 1 H), 4.03 (t-like, *J* = 10.2 Hz, 1 H), 3.47 (m, 1 H), 3.32 (d, *J* = 7.4 Hz, 2 H), 2.96 (dd, *J* = 15.9 Hz, 10.2 Hz, 1 H), 2.86 (ddd, *J* = 15.7 Hz, 5.6 Hz, 1.2 Hz, 1 H), 1.79 (s, 3 H), 1.67 (s, 3 H), 1.42 (s, 6 H) ppm. ^{13}C NMR (151 MHz, $CDCl_3$): δ = 155.07 (C), 154.39 (C), 152.63 (C), 149.67 (C), 130.81 (C), 128.45 (CH), 128.23 (CH), 124.27 (CH), 122.96 (CH), 122.39 (CH), 120.34 (C), 116.98 (C), 114.61 (C), 113.94 (C), 107.98 (CH), 103.14 (CH), 75.82 (C), 69.91 (CH_2), 31.71 (CH), 30.92 (CH_2), 27.91 (CH_3), 27.86 (CH_3), 25.87 (CH_3), 22.15 (CH_2), 17.92 (CH_3) ppm. IR (ATR): ν = 3362 (m), 3035 (w), 2922 (m), 1612 (m), 1527 (m), 1452 (m), 1376 (m), 1301 (m), 1260 (m), 1209 (m), 1164 (m), 1126 (s), 1097 (s), 1033 (m), 973 (m), 903 (m), 837 (m), 798 (m), 729 (m), 688 (m), 664 (m), 628 (m) cm^{-1}. CD-spectra: Δε = 298 (0), 277 (+ 0.77), 245 (+ 0.02), 231 (+ 1.74) . ESI-MS: m/z = 391.2 $[M–H]^–$.

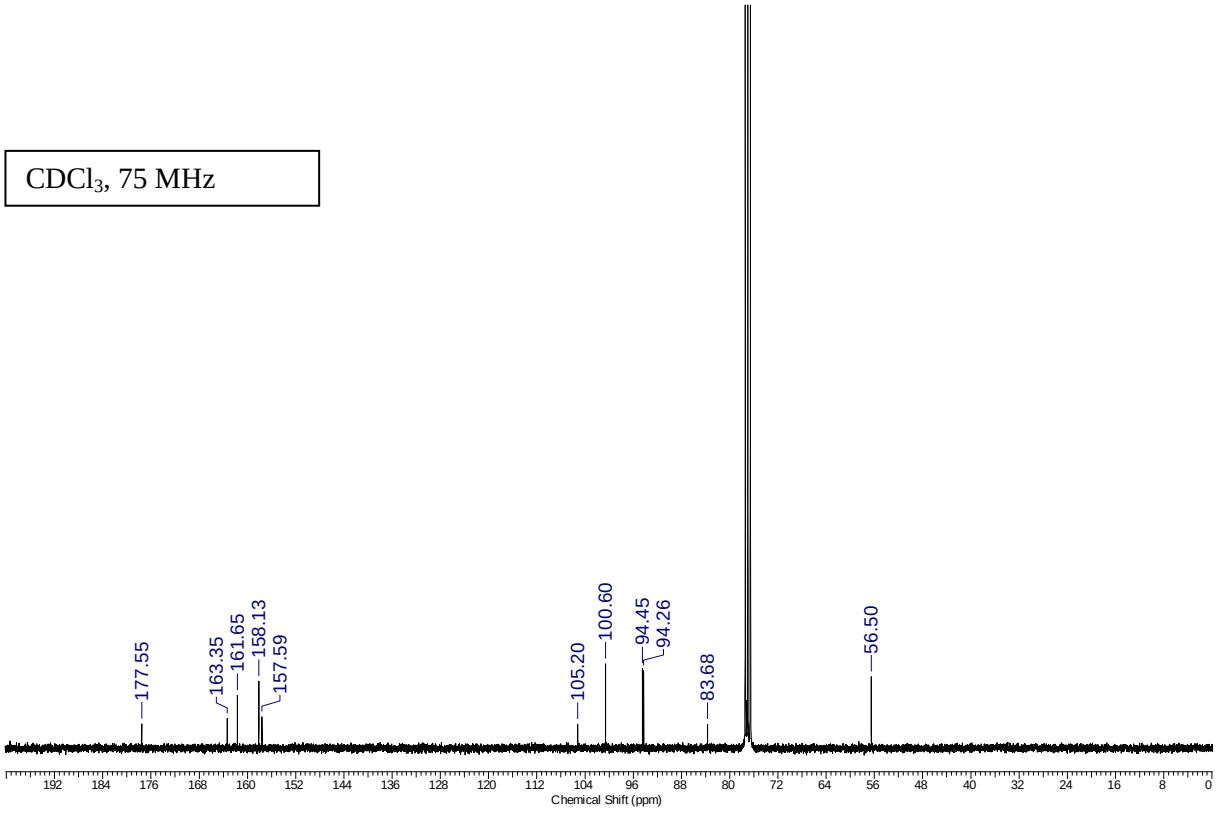
6. Spectra and HPCL traces

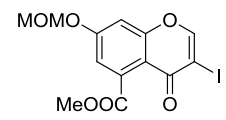


7a

$CDCl_3$, 300 MHz

$CDCl_3$, 75 MHz

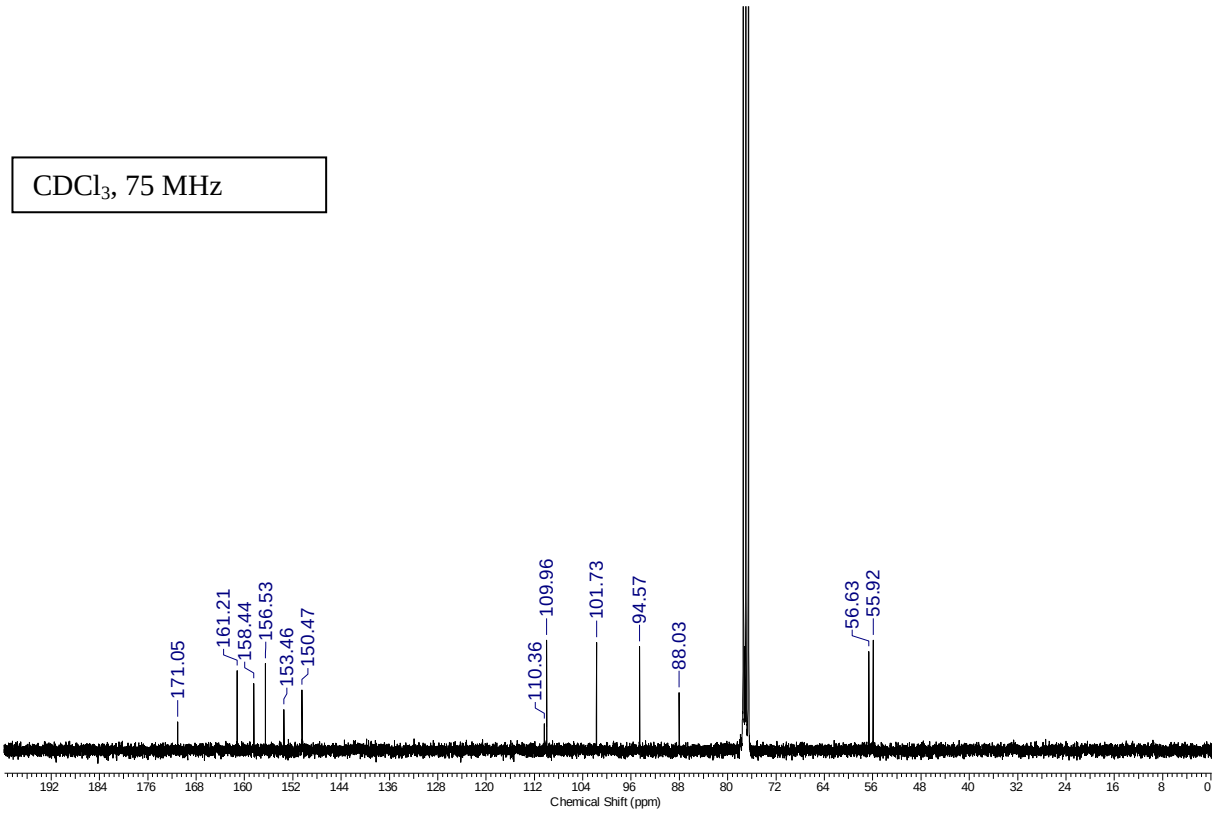


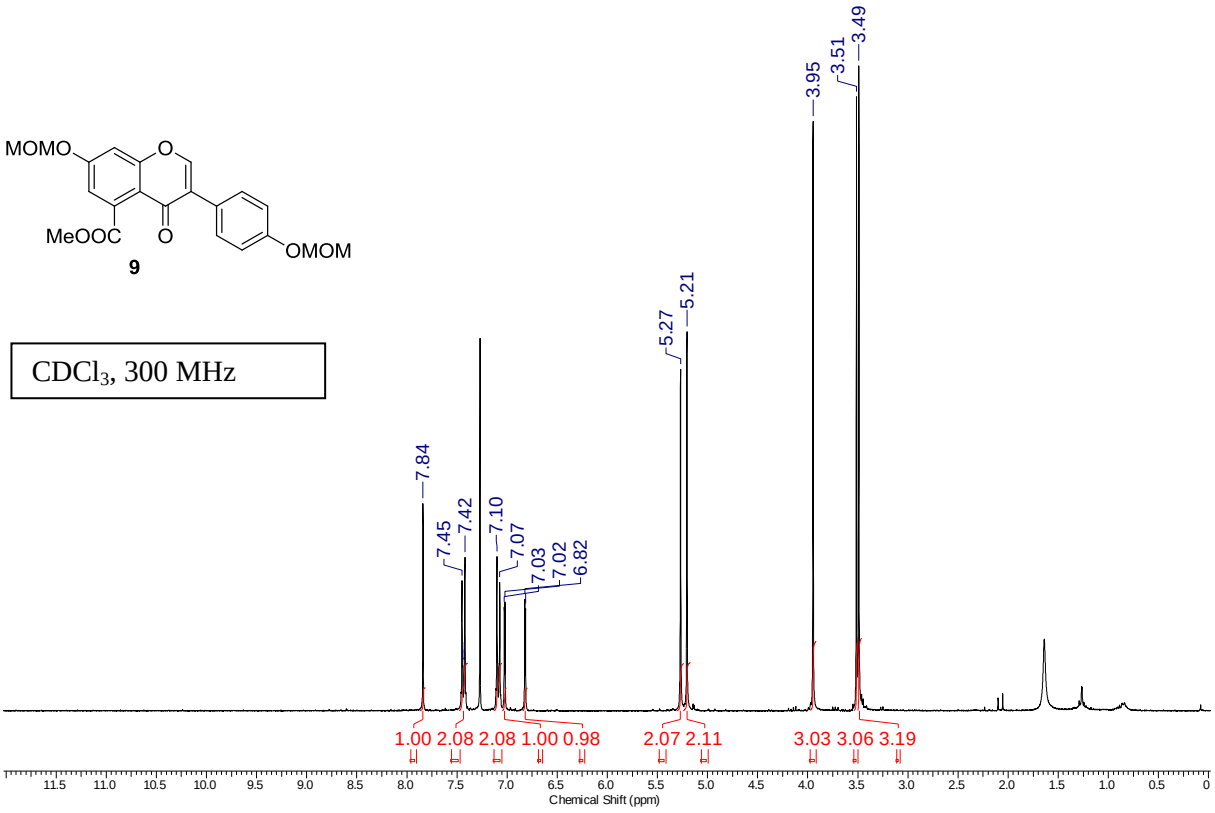


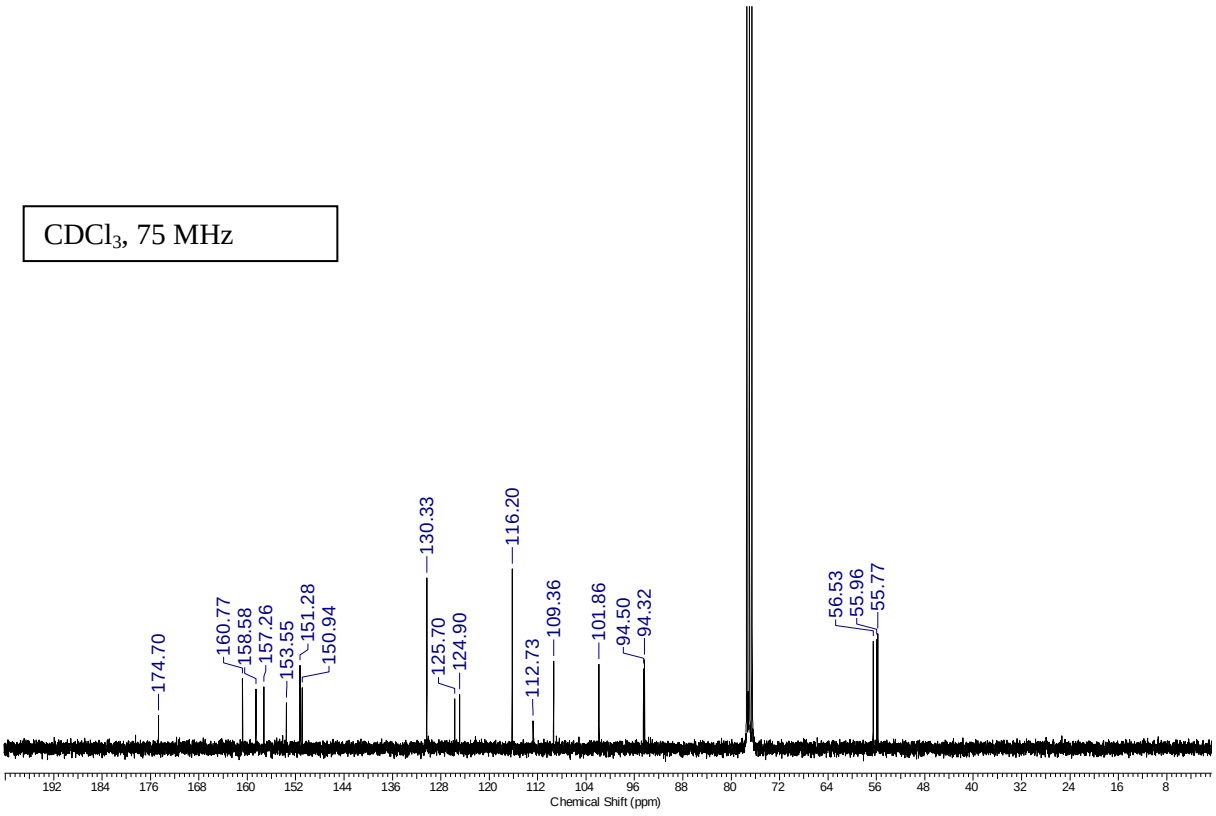
8

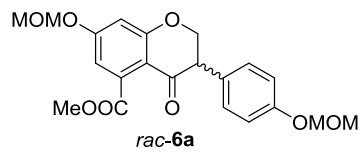
$CDCl_3$, 300 MHz

$CDCl_3$, 75 MHz




MOMO
O
MeOOC
O
OMOM
9
CDCl3, 300 MHz
7.84
7.45
7.42
7.10
7.07
7.03
7.02
6.82
5.27
5.21
3.95
3.51
3.49
1.00 2.08 2.08 1.00 0.98
2.07 2.11
3.03 3.06 3.19
Chemical Shift (ppm)

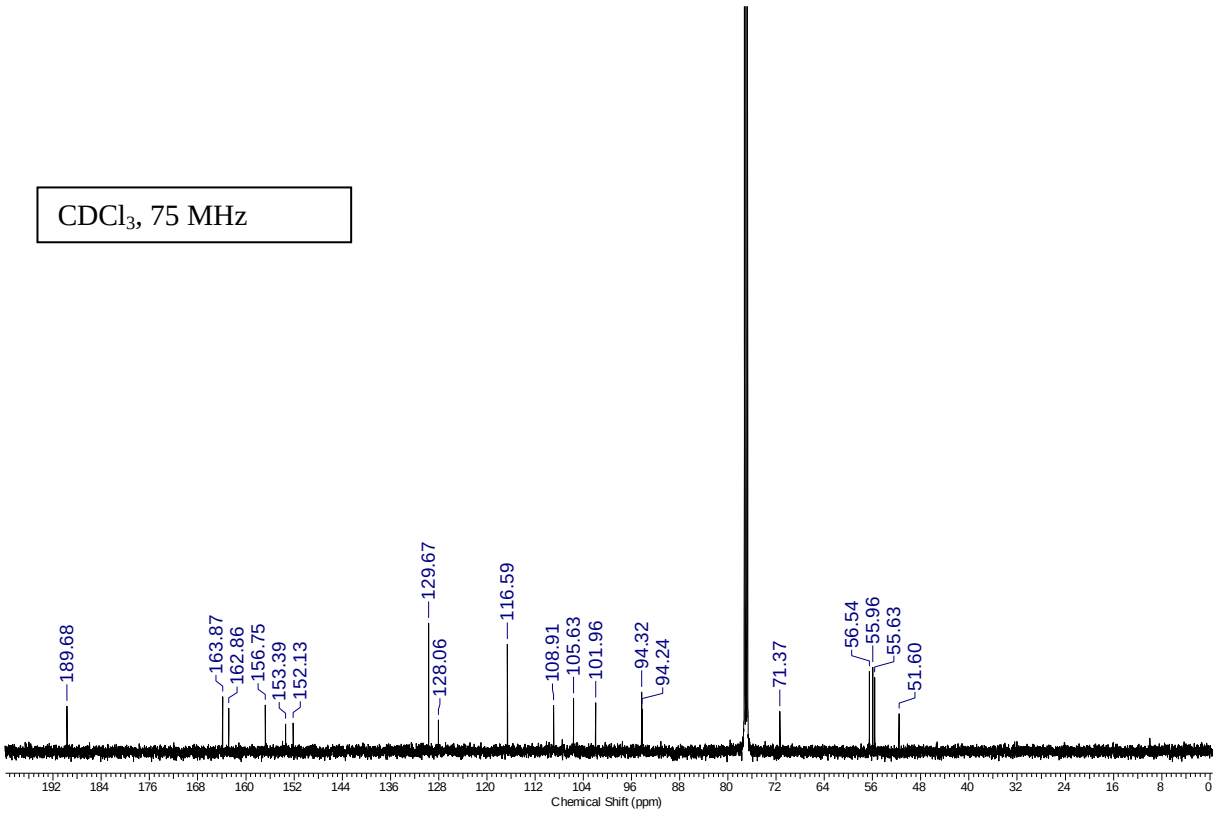

CDCl3, 75 MHz
174.70
160.77
158.58
157.26
153.55
151.28
150.94
130.33
125.70
124.90
116.20
112.73
109.36
101.86
94.50
94.32
56.53
55.96
55.77
Chemical Shift (ppm)

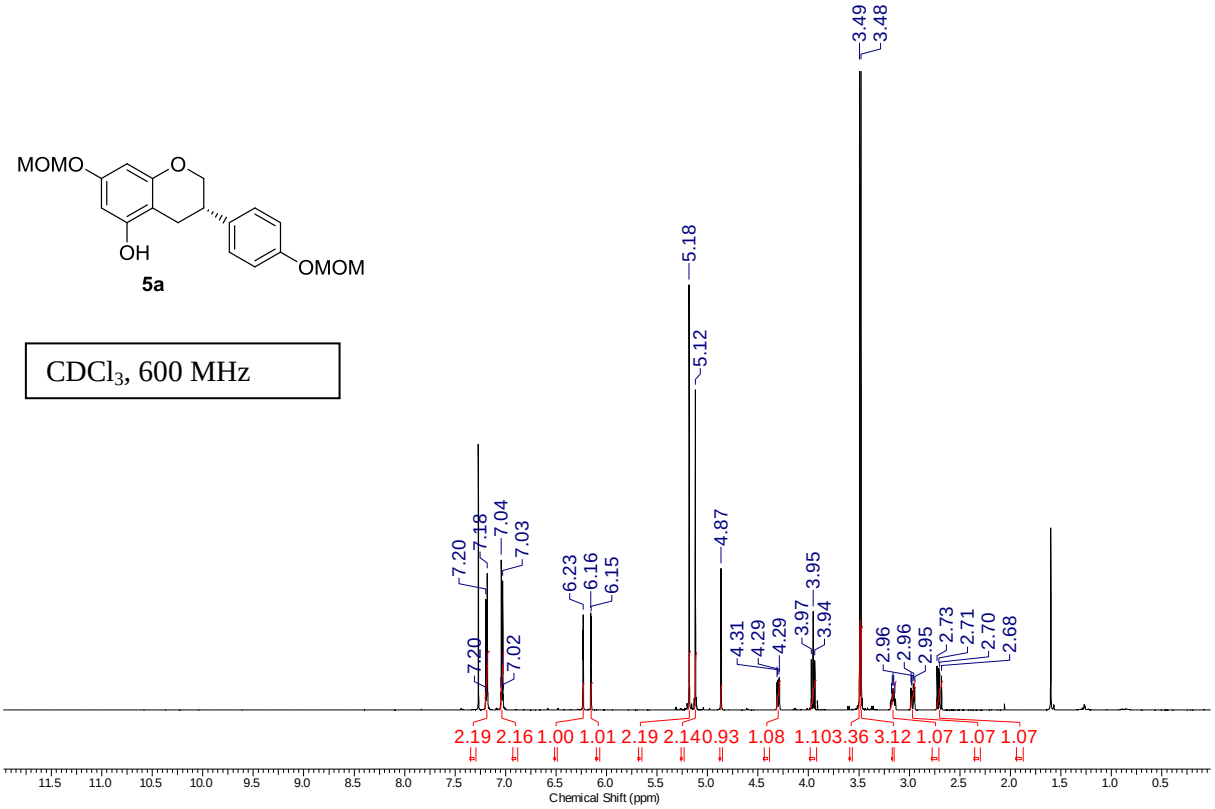


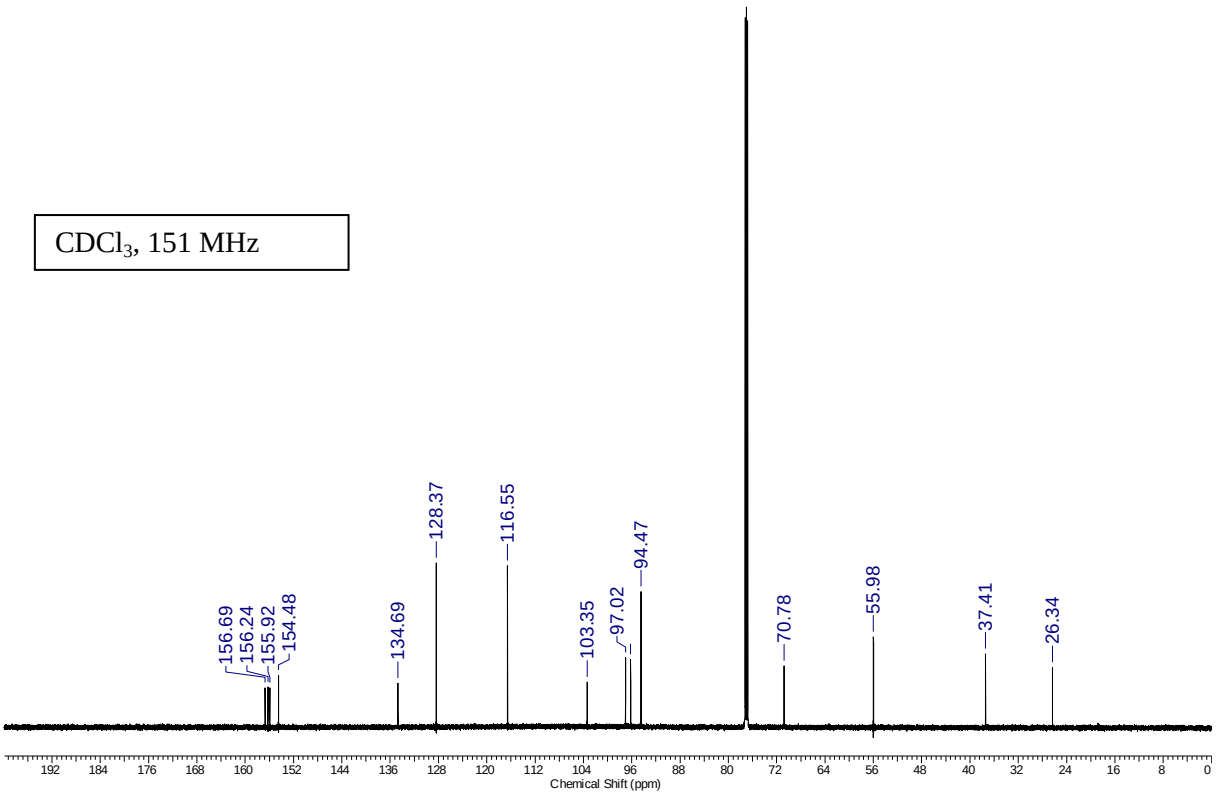
rac-**6a**

$CDCl_3$, 300 MHz

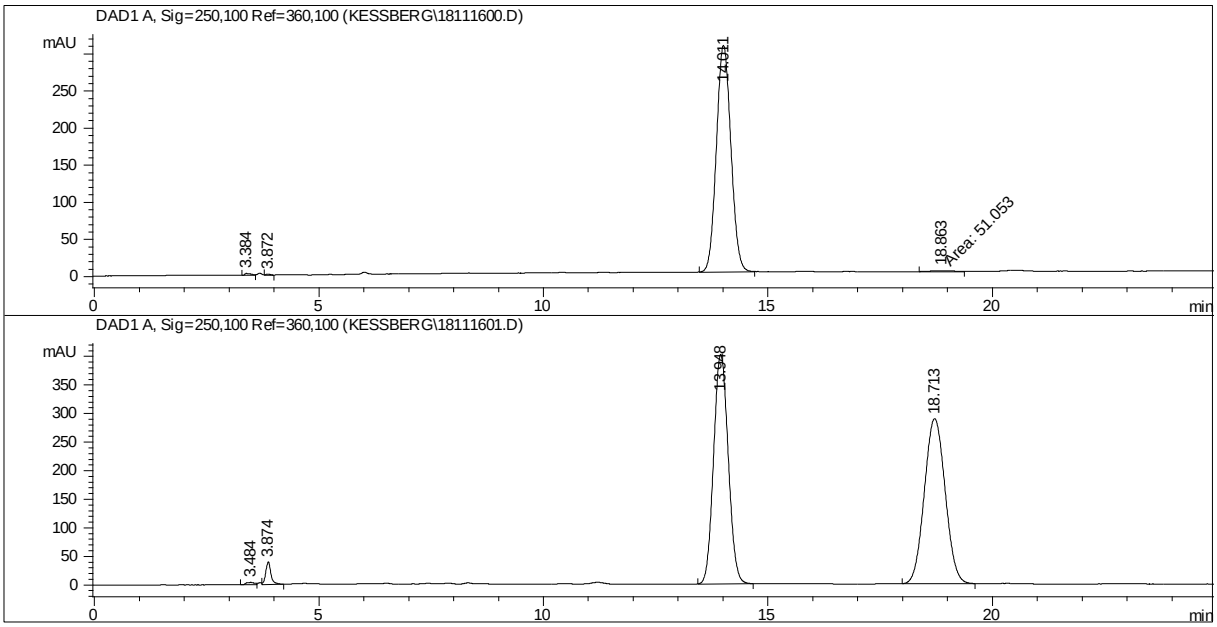
$CDCl_3$, 75 MHz



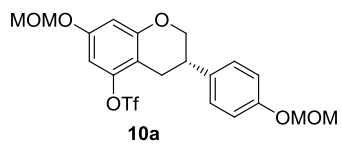

MOMO
O
OH
OMOM
5a
CDCl3, 600 MHz
3.49
3.48
5.18
5.12
4.87
7.20
7.18
7.04
7.03
6.23
6.16
6.15
3.95
3.97
3.94
4.31
4.29
4.29
2.96
2.96
2.95
2.73
2.71
2.70
2.68
7.20
7.02
2.19 2.16 1.00 1.01 2.19 2.14 0.93 1.08 1.10 3.36 3.12 1.07 1.07 1.07
Chemical Shift (ppm)


CDCl3, 151 MHz
156.69
156.24
155.92
154.48
134.69
128.37
116.55
103.35
97.02
94.47
70.78
55.98
37.41
26.34
Chemical Shift (ppm)

HPLC trace of racemic **5a** (bottom) and (*S*)-**5a** (top, 99% ee).



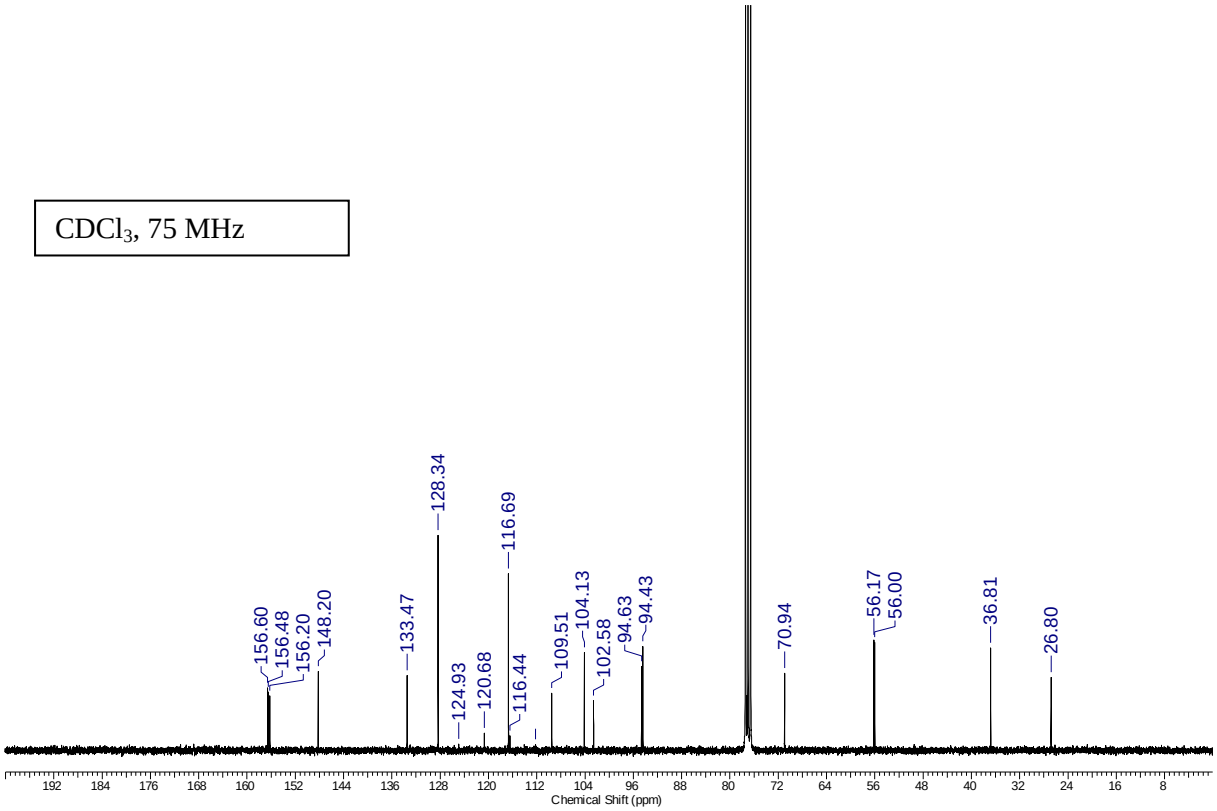
Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	3.384	PV	0.1270	23.14852	2.43323	0.3333
2	3.872	VP	0.0951	8.82991	1.30290	0.1271
3	14.011	BB	0.3544	6862.03955	305.11459	98.8045
4	18.863	MM T	0.6025	51.05299	1.41214	0.7351
Totals :				6945.07097	310.26286	



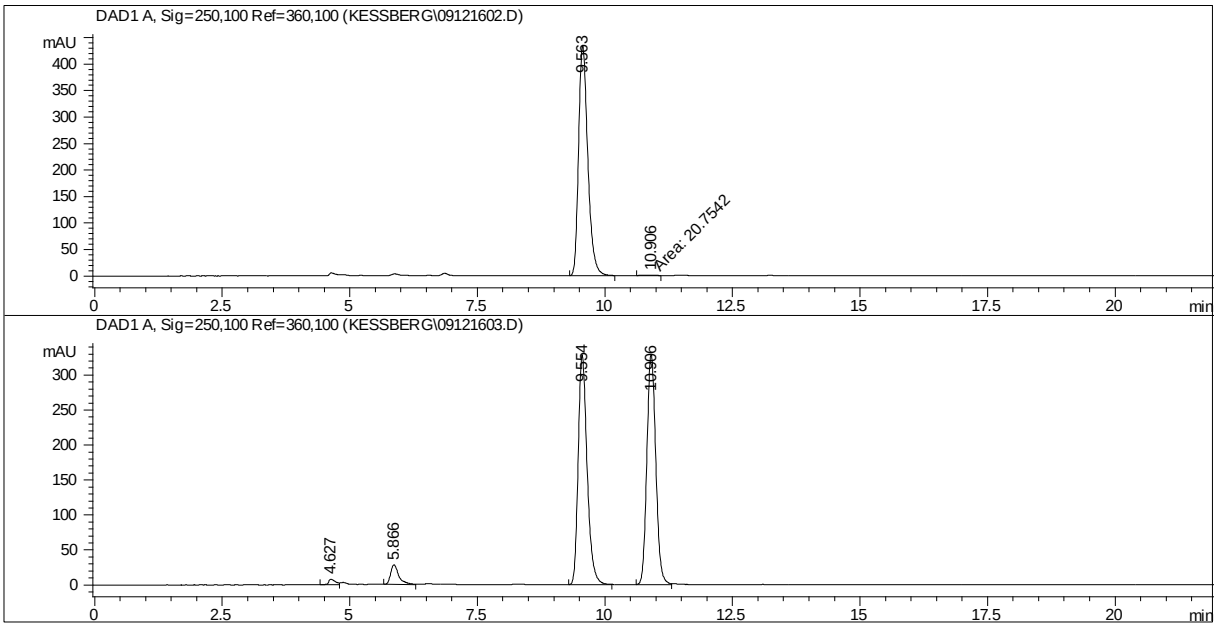
10a

$CDCl_3$, 300 MHz

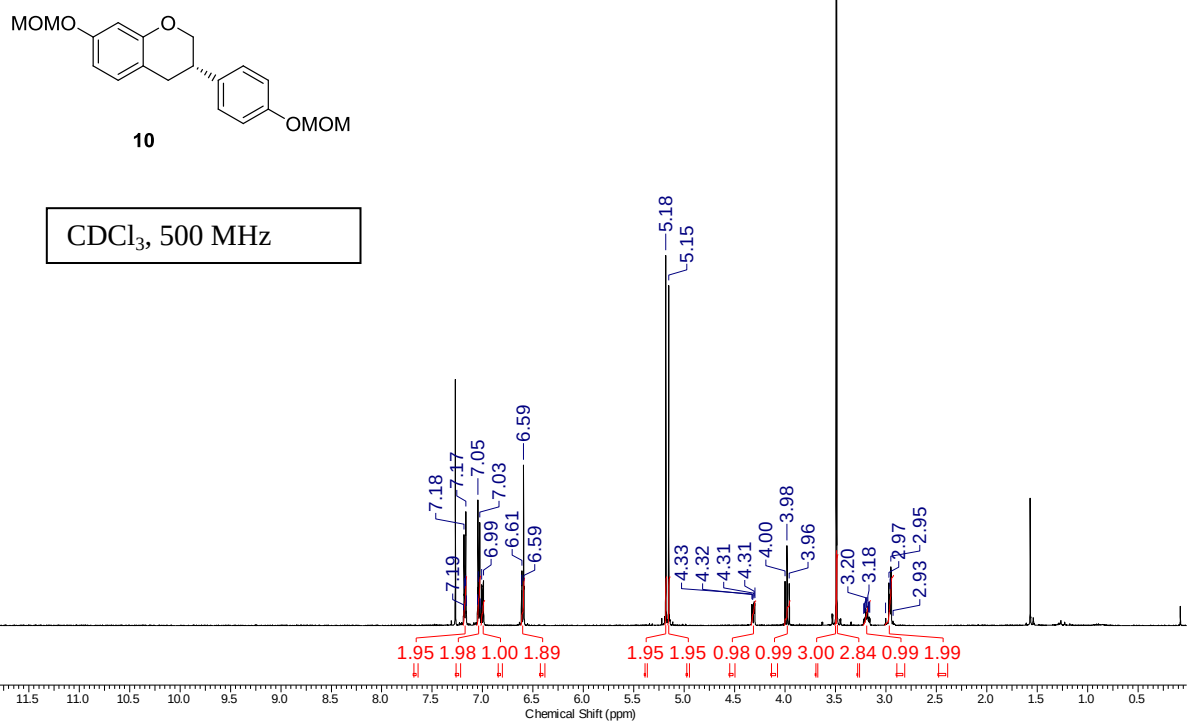
$CDCl_3$, 75 MHz

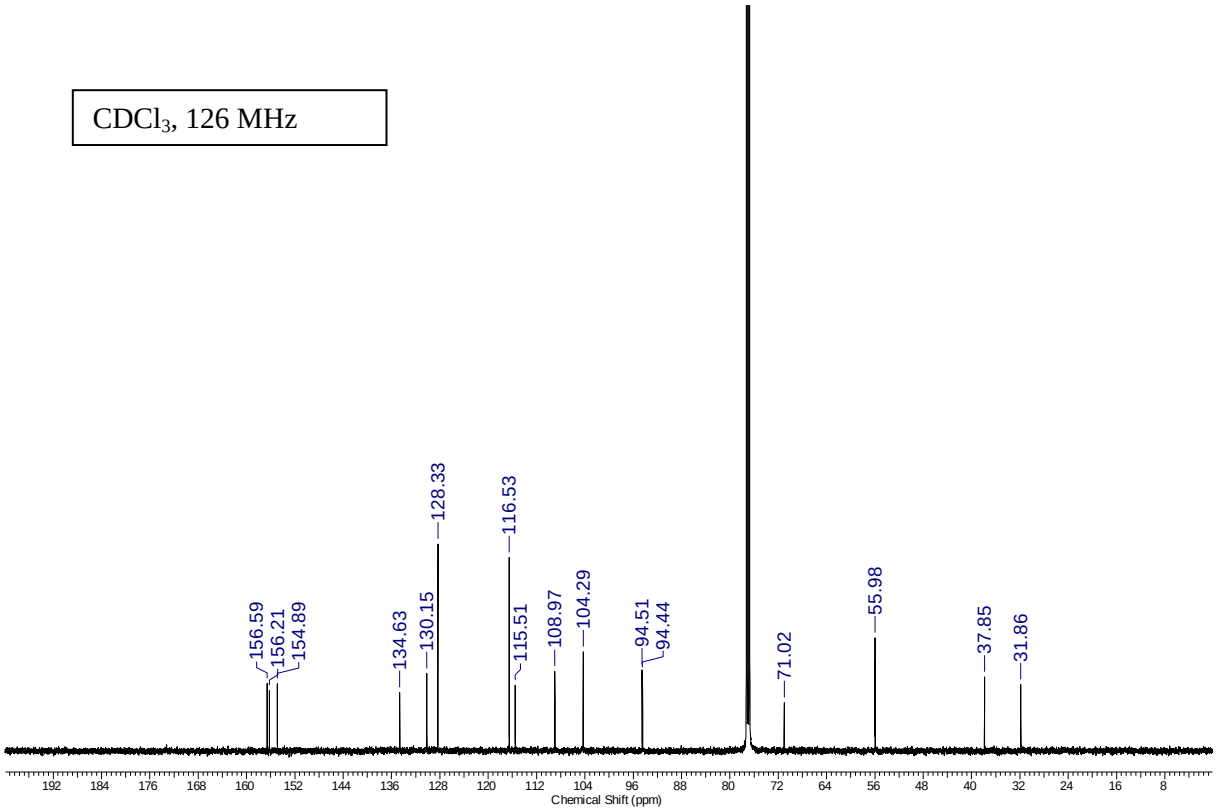


HPLC trace of racemic **10a** (bottom) and (*S*)-**10a** (top, 99% ee).

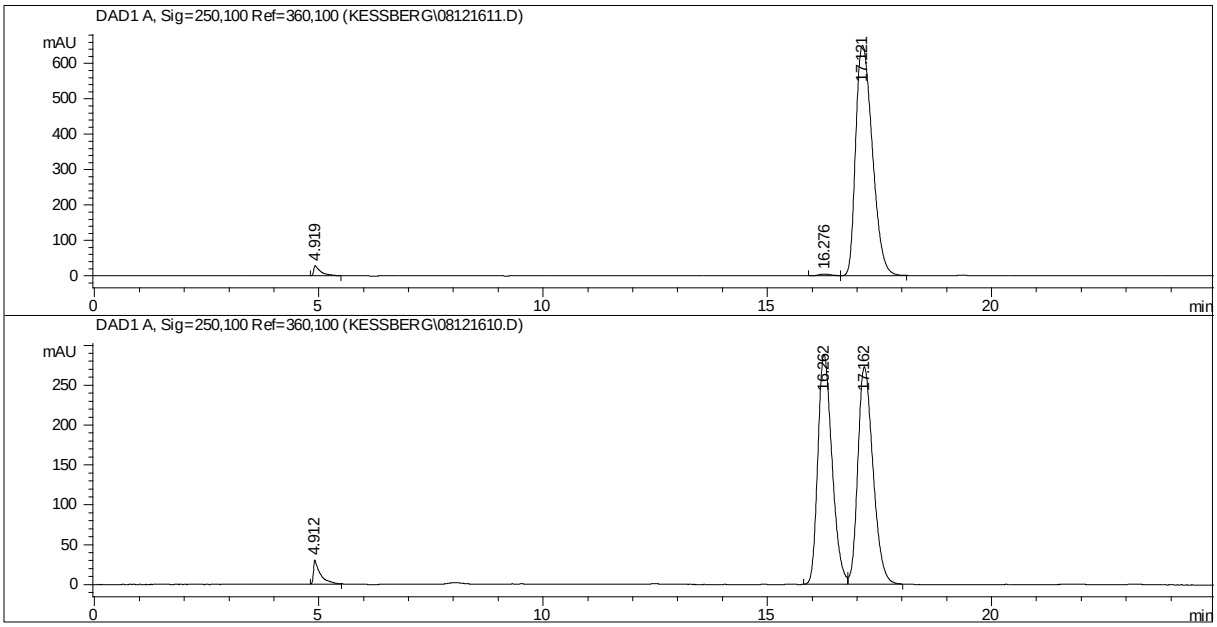


Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	9.563	BB	0.1944	5454.07666	434.75156	99.6209
2	10.906	MM T	0.3412	20.75419	1.01384	0.3791
Totals :				5474.83085	435.76539	

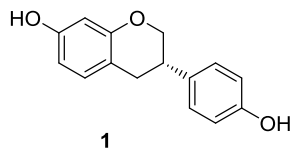

MOMO
O
OMOM
10
CDCl3, 500 MHz
3.49
3.49
5.18
5.15
7.18
7.17
7.05
7.03
6.59
6.99
6.61
6.59
7.19
4.33
4.32
4.31
4.31
4.00
3.98
3.96
3.20
3.18
2.97
2.95
2.93
1.95 1.98 1.00 1.89
1.95 1.95 0.98 0.99 3.00 2.84 0.99 1.99
Chemical Shift (ppm)


CDCl3, 126 MHz
156.59
156.21
154.89
134.63
130.15
128.33
116.53
115.51
108.97
104.29
94.51
94.44
71.02
55.98
37.85
31.86
Chemical Shift (ppm)

HPLC trace of racemic **10** (bottom) and (*S*)-**10** (top, 99% ee).



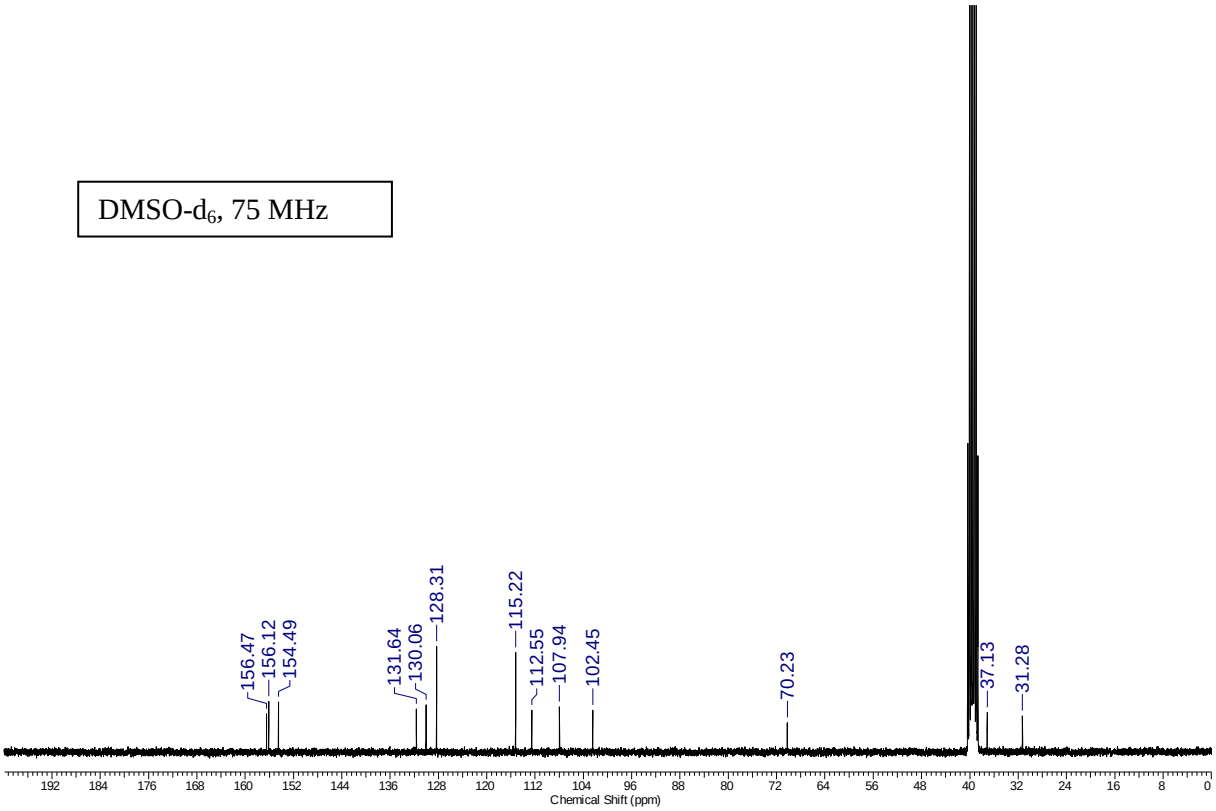
Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	4.919	BB	0.1405	308.78705	28.94362	1.8021
2	16.276	PV	0.2764	88.68208	4.61164	0.5175
3	17.121	VB	0.4082	1.67378e4	650.56274	97.6804
Totals :				1.71353e4	684.11800	



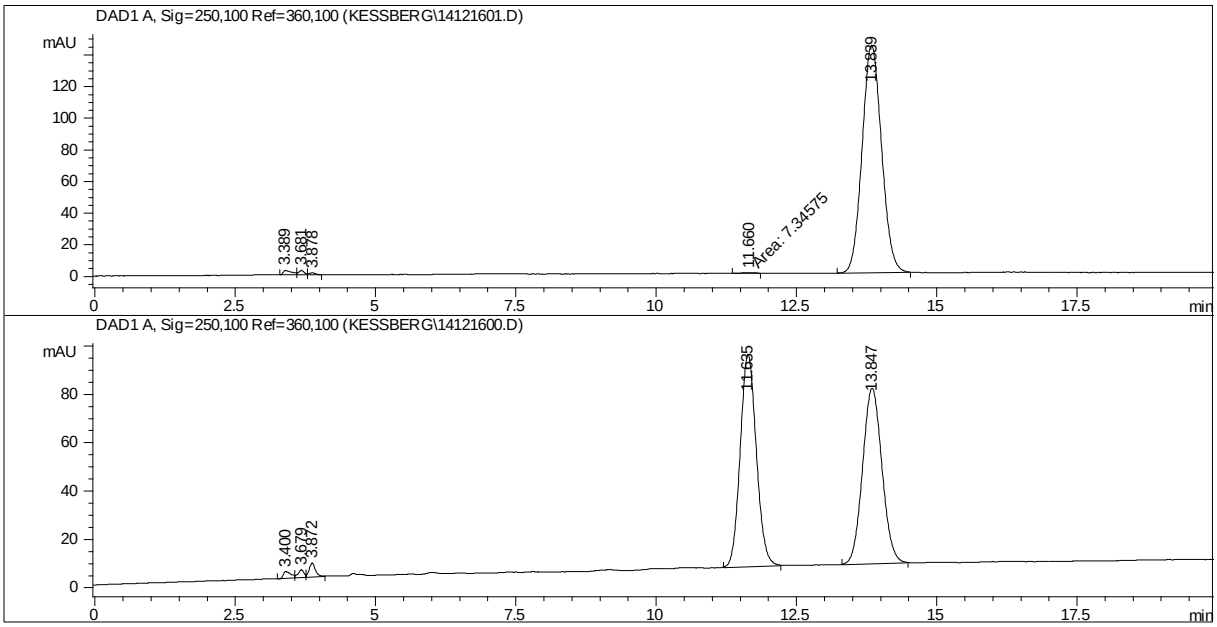
1

DMSO-d_6, 300 MHz

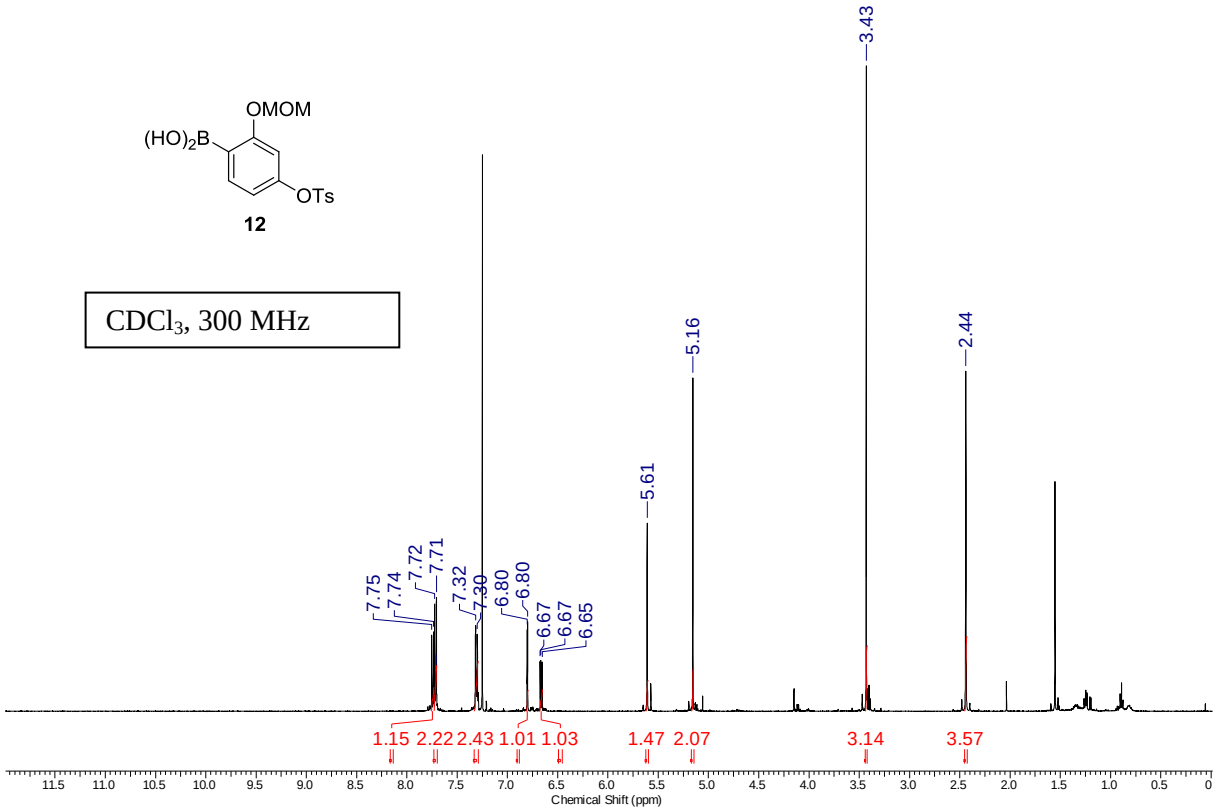
DMSO-d_6, 75 MHz

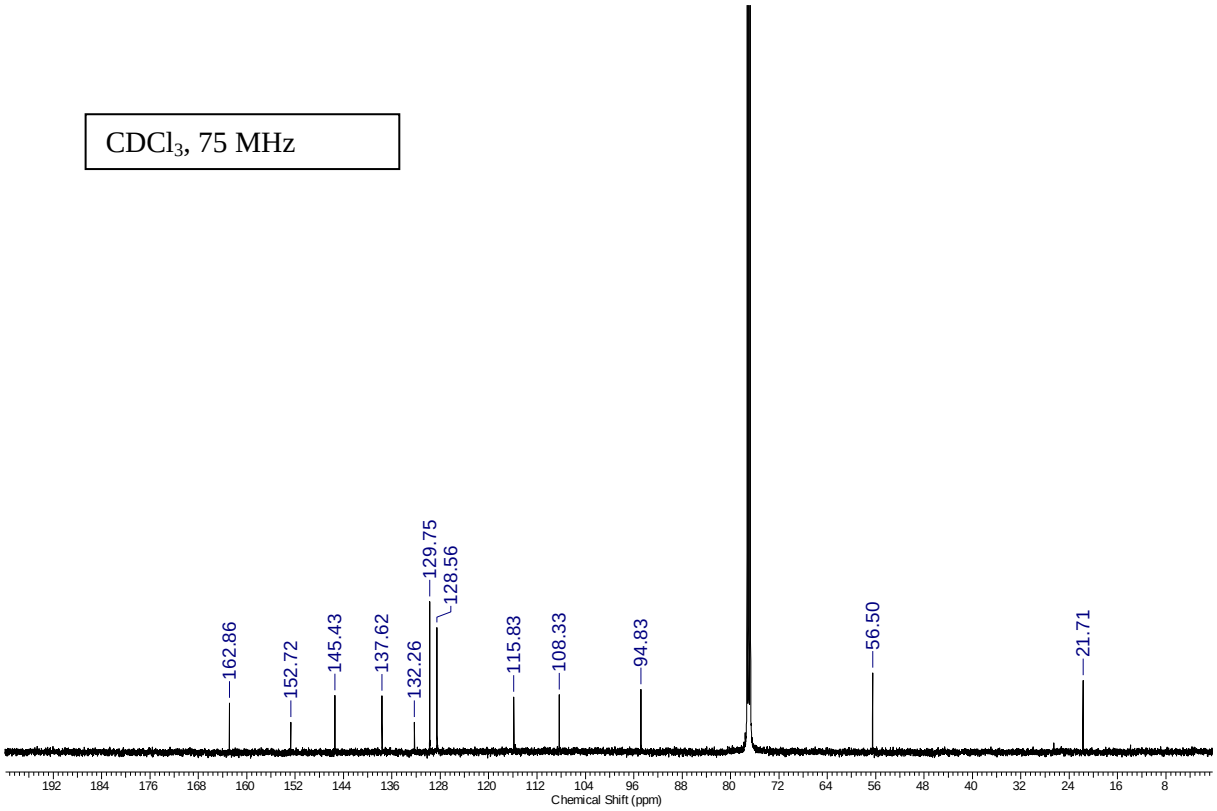


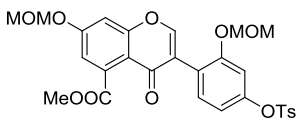
HPLC trace of racemic **1** (bottom) and (*S*)-**1** (top, 99% ee).



Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	3.389	BV	0.1413	28.45775	2.64934	0.8039
2	3.681	VV	0.1033	18.89930	2.71065	0.5339
3	3.878	VB	0.1056	9.03314	1.20362	0.2552
4	11.660	MM T	0.3024	7.34575	4.03336e-1	0.2075
5	13.839	BB	0.3801	3476.09180	143.75949	98.1995
Totals :				3539.82773	150.72644	


OMOM
(HO)2B
OTs
12
CDCl3, 300 MHz
3.43
5.16
2.44
5.61
7.75
7.74
7.72
7.71
7.32
7.30
6.80
6.80
6.67
6.67
6.65
1.15 2.22 2.43 1.01 1.03
1.47 2.07
3.14
3.57
Chemical Shift (ppm)

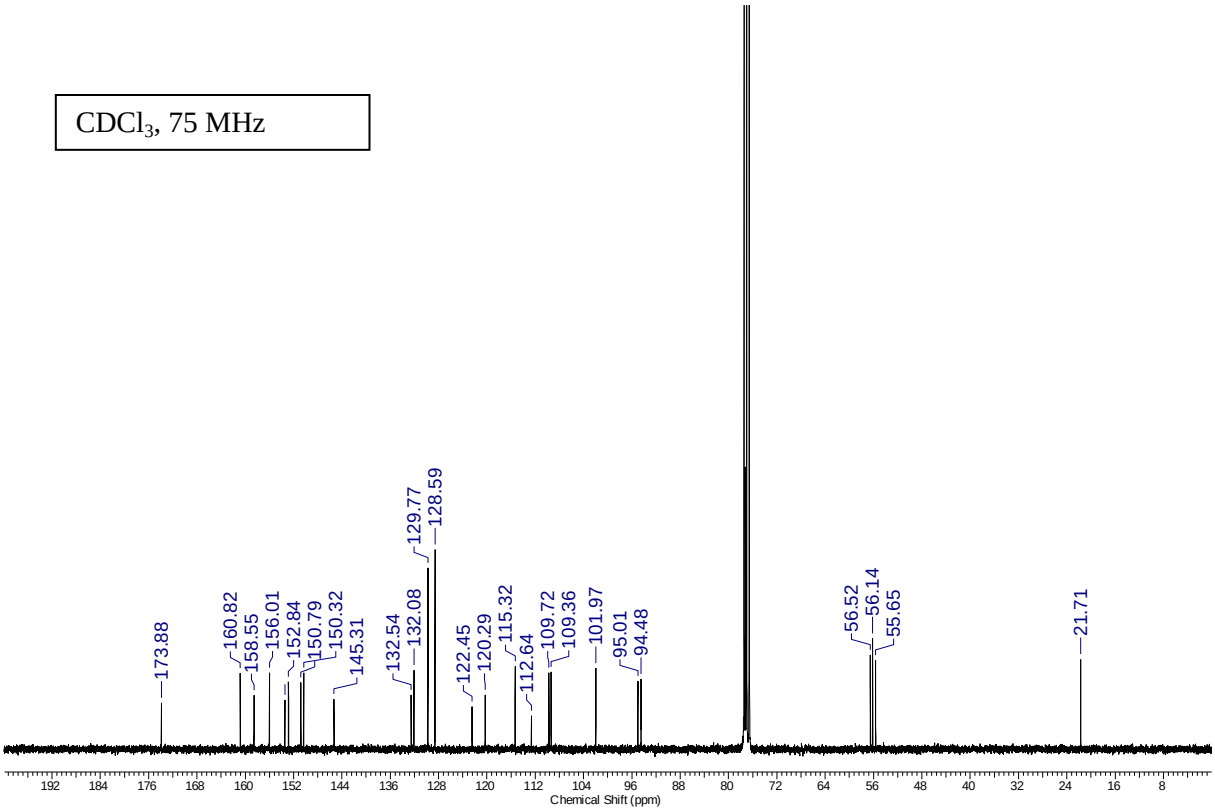

CDCl3, 75 MHz
129.75
128.56
162.86
152.72
145.43
137.62
132.26
115.83
108.33
94.83
56.50
21.71
Chemical Shift (ppm)

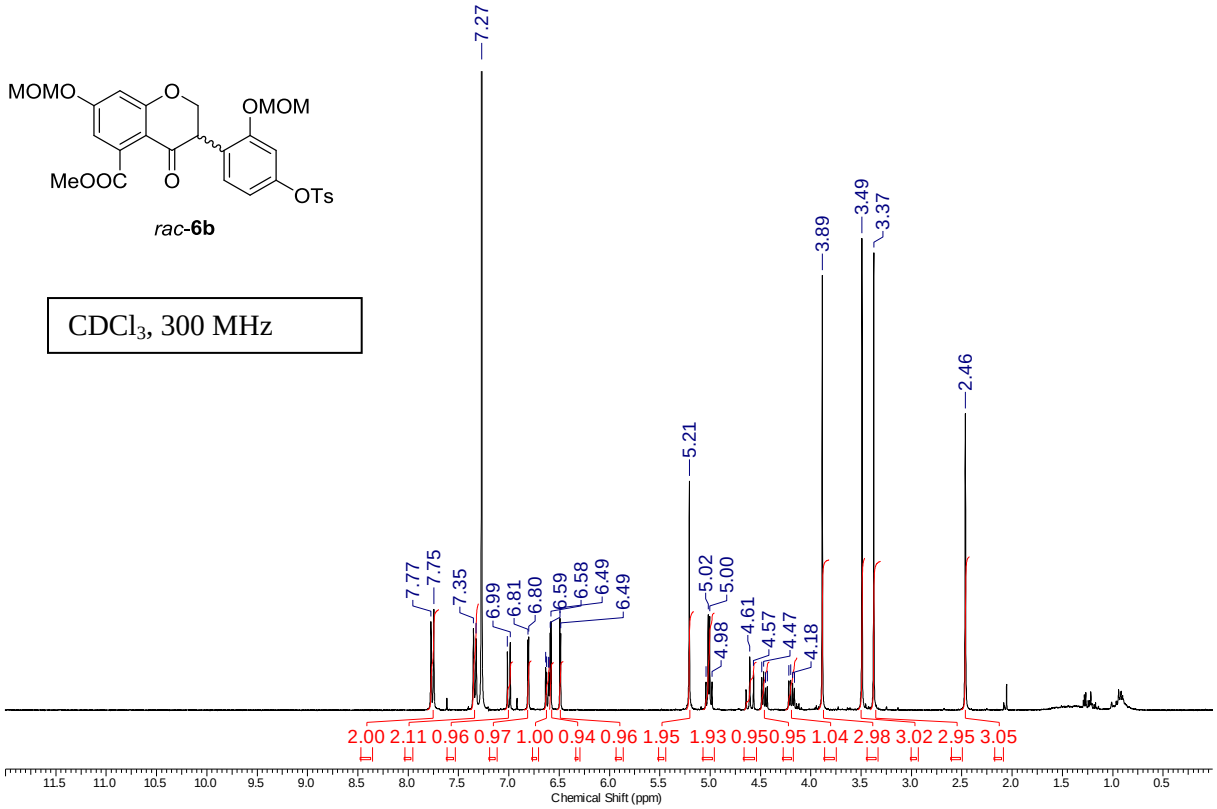


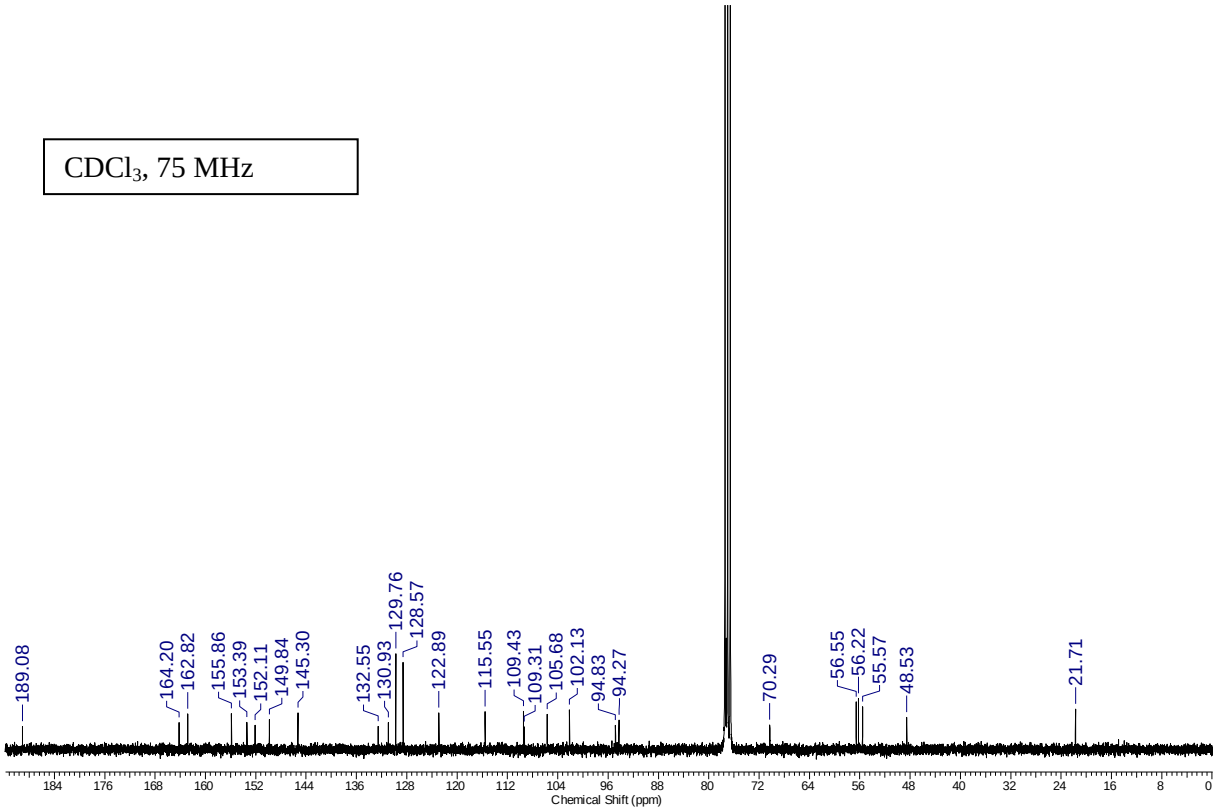
12a

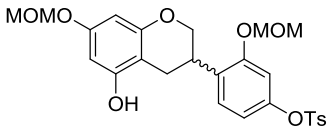
$CDCl_3$, 300 MHz

$CDCl_3$, 75 MHz




MOMO
O
OMOM
MeOOC
O
OTs
rac-6b
CDCl3, 300 MHz
7.27
3.89
3.49
3.37
2.46
5.21
7.77
7.75
7.35
6.99
6.81
6.80
6.59
6.58
6.49
6.49
5.02
5.00
4.98
4.61
4.57
4.47
4.18
2.00 2.11 0.96 0.97 1.00 0.94 0.96 1.95 1.93 0.95 0.95 1.04 2.98 3.02 2.95 3.05
Chemical Shift (ppm)

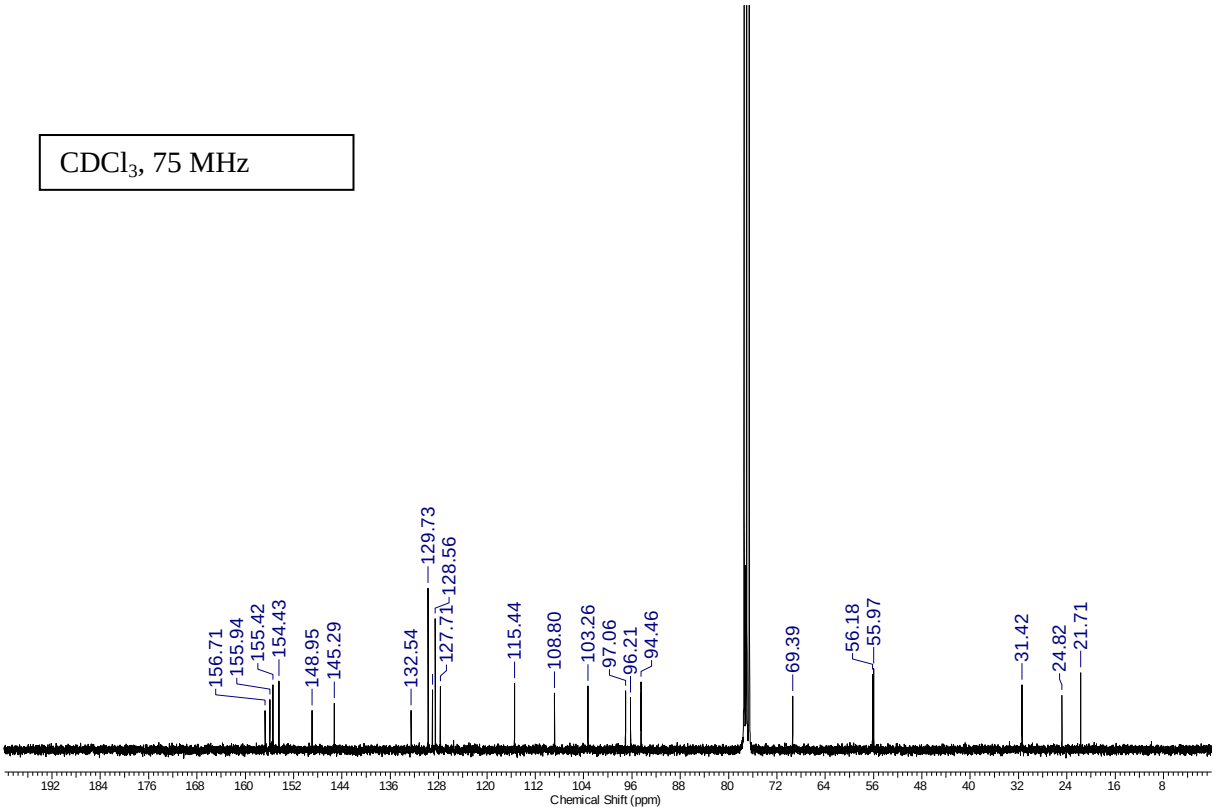

CDCl3, 75 MHz
189.08
164.20
162.82
155.86
153.39
152.11
149.84
145.30
132.55
130.93
129.76
128.57
122.89
115.55
109.43
109.31
105.68
102.13
94.83
94.27
70.29
56.55
56.22
55.57
48.53
21.71
Chemical Shift (ppm)

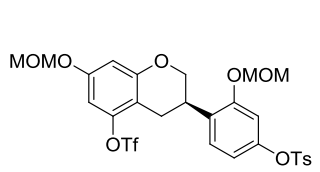


rac-**5b**

$CDCl_3$, 300 MHz

$CDCl_3$, 75 MHz

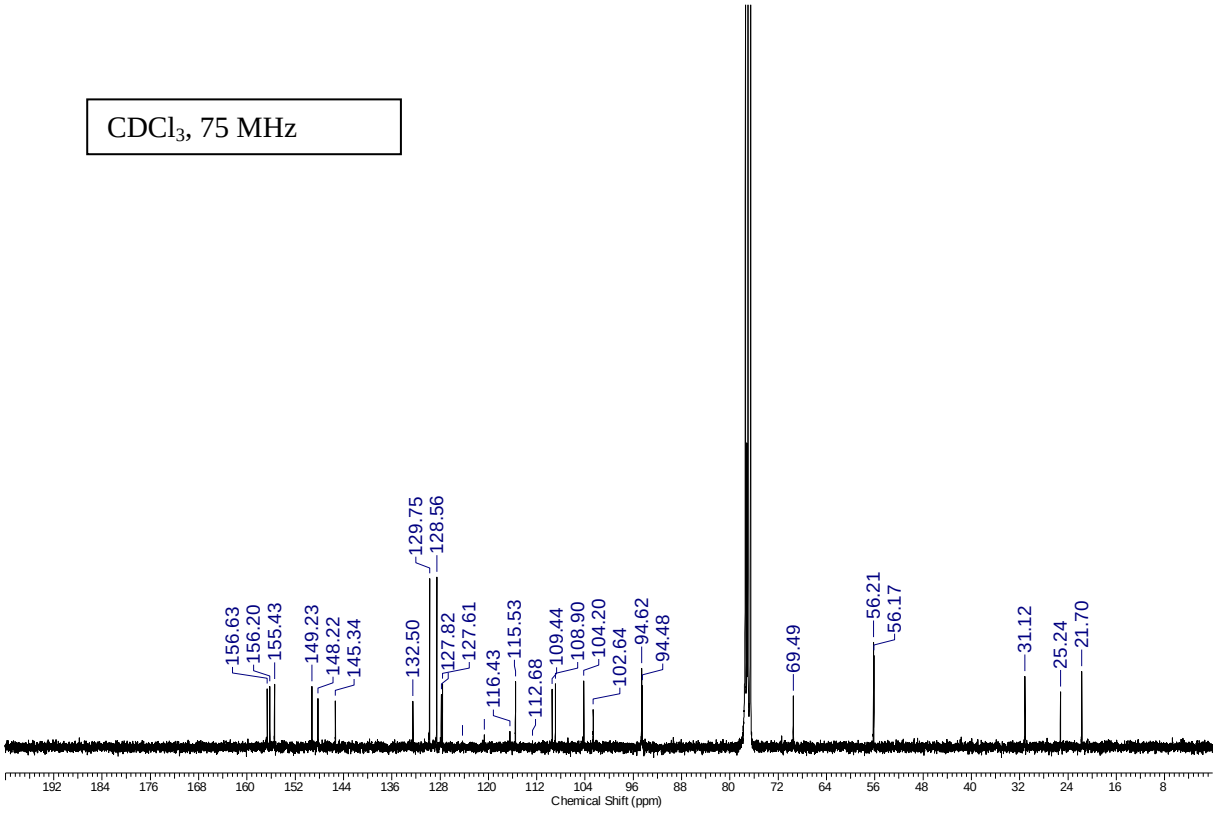




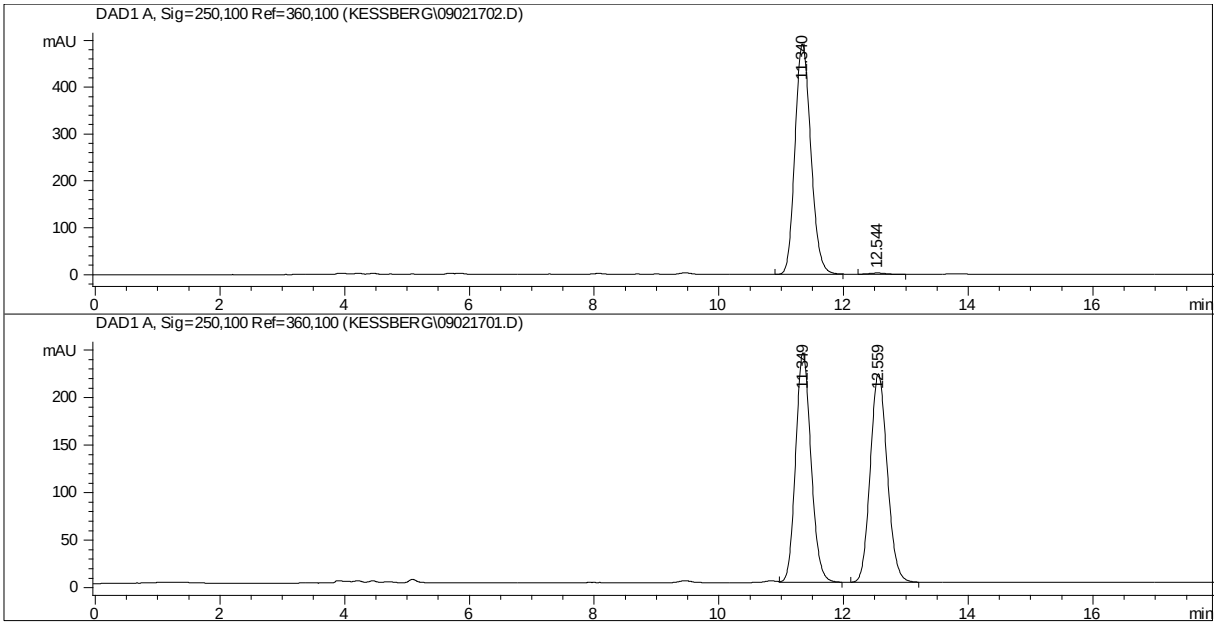
13

$CDCl_3$, 300 MHz

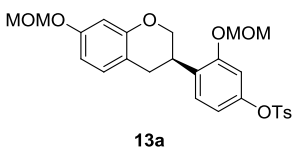
$CDCl_3$, 75 MHz



HPLC trace of racemic **13** (bottom) and (*R*)-**13** (top, 99% ee).



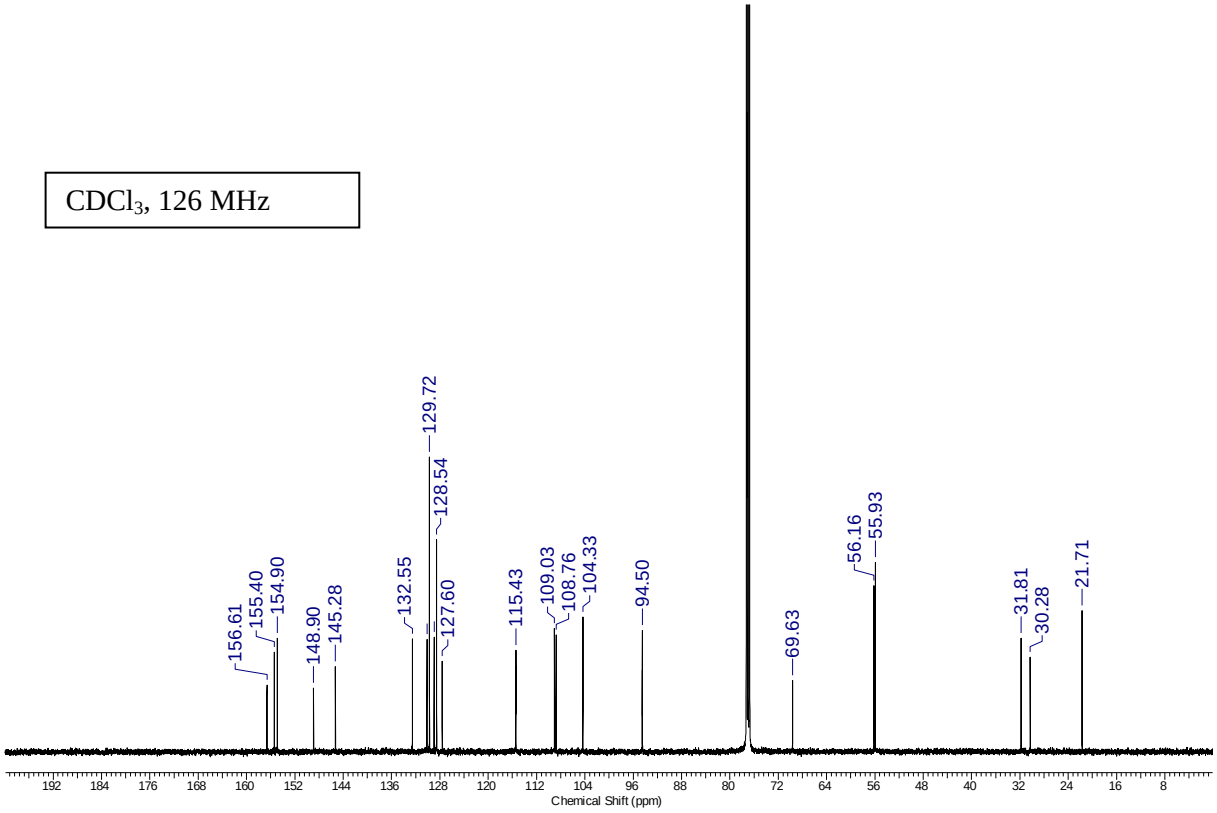
Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	11.340	PB	0.2784	8693.46094	491.38745	99.4786
2	12.544	BP	0.2284	45.56372	2.65305	0.5214
Totals :				8739.02466	494.04050	



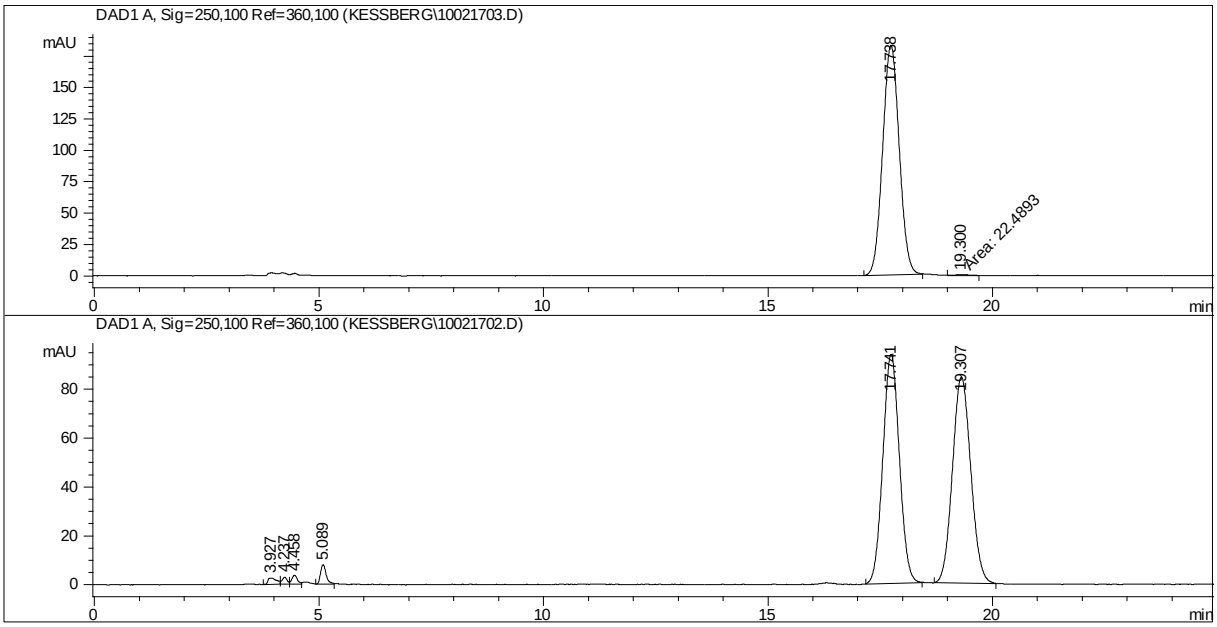
13a

$CDCl_3$, 300 MHz

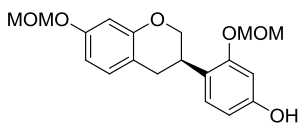
$CDCl_3$, 126 MHz



HPLC trace of racemic **13a** (bottom) and (*R*)-**13a** (top, 99% ee).



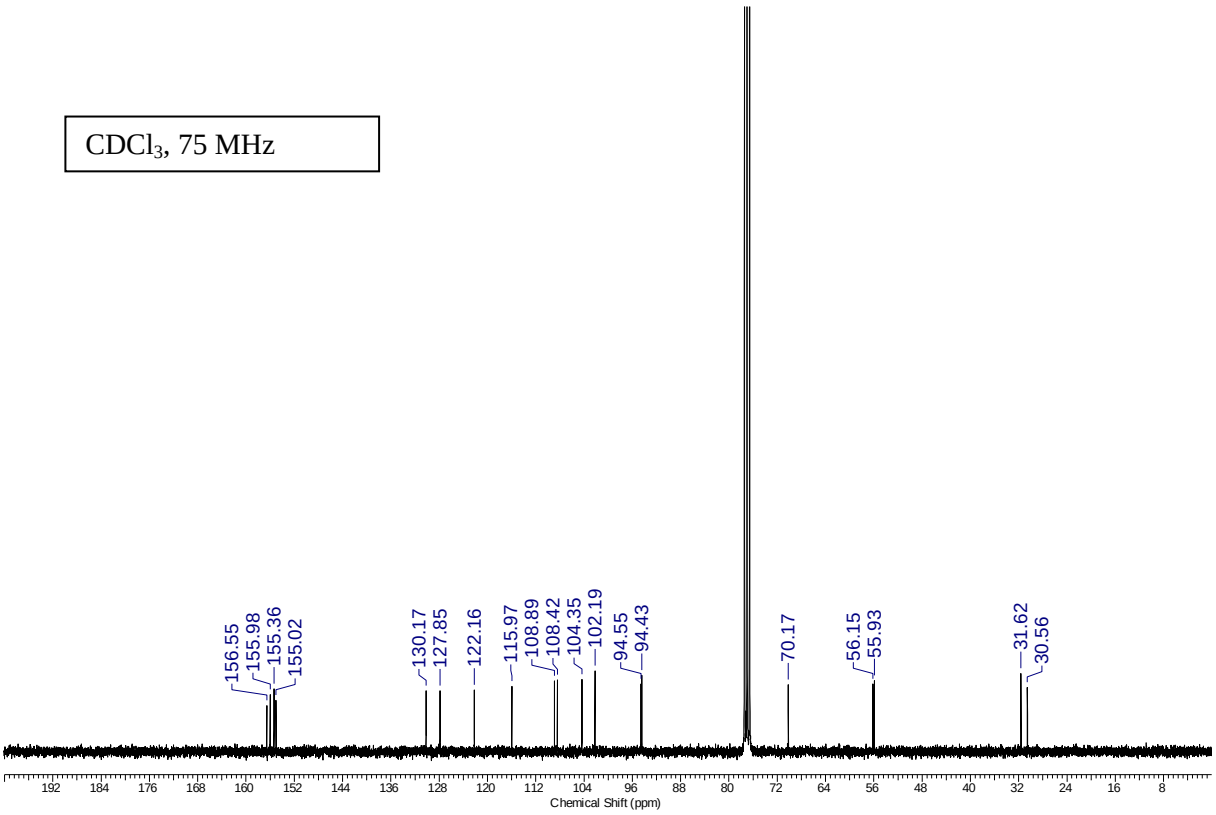
Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	17.738	BB	0.3959	4699.22559	182.83292	99.5237
2	19.300	MM T	0.3996	22.48929	8.58096e-1	0.4763
Totals :				4721.71488	183.69101	



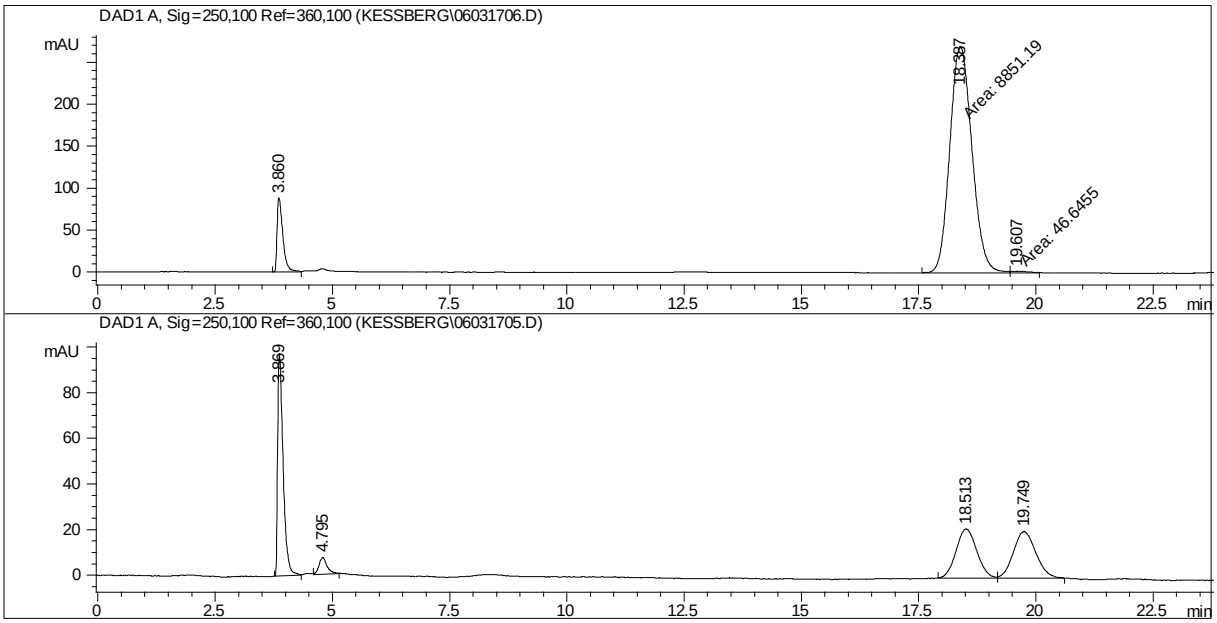
14

$CDCl_3$, 300 MHz

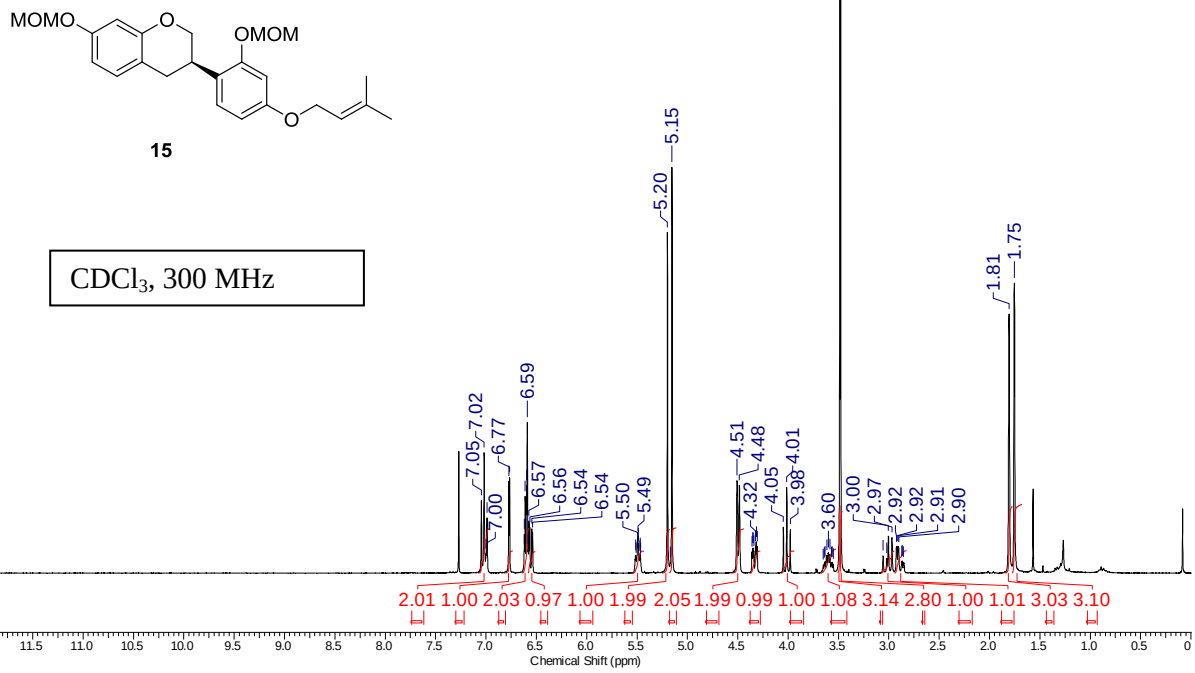
$CDCl_3$, 75 MHz

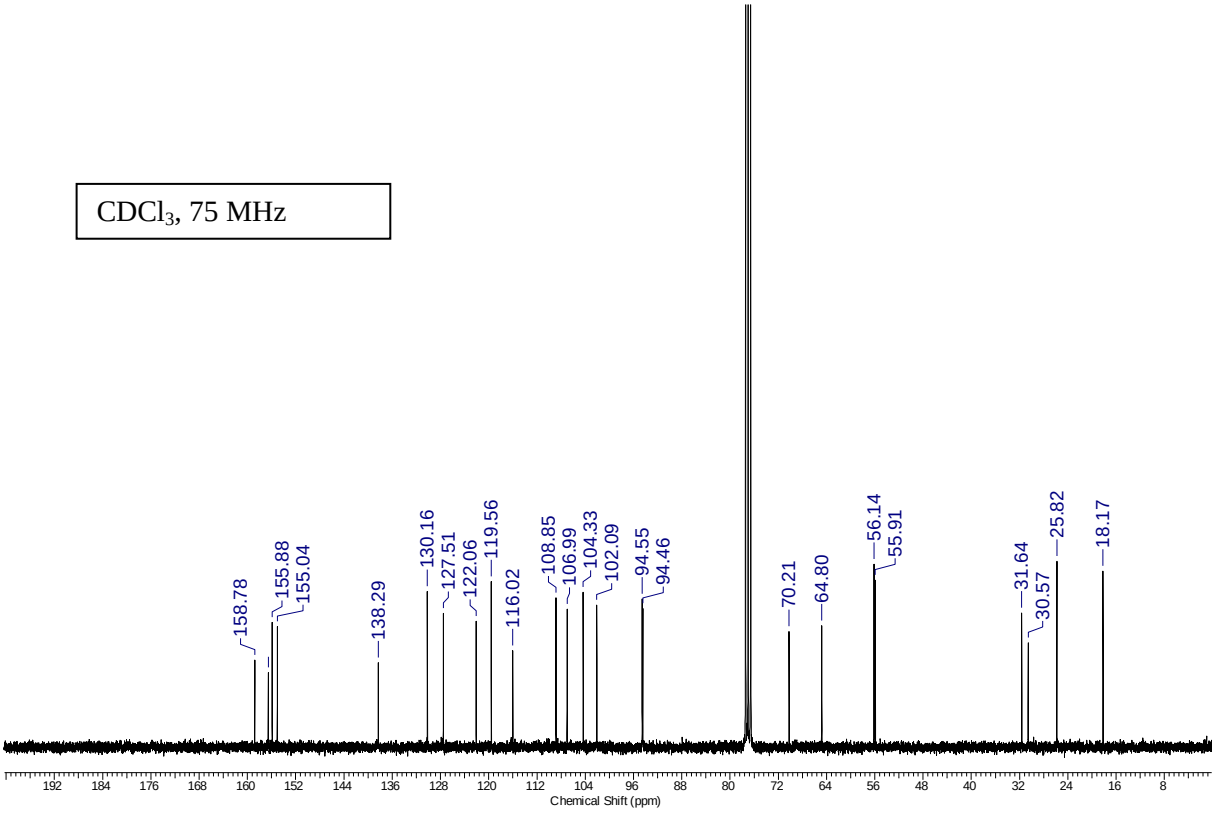


HPLC trace of racemic **14** (bottom) and (*R*)-**14** (top, 99% ee).

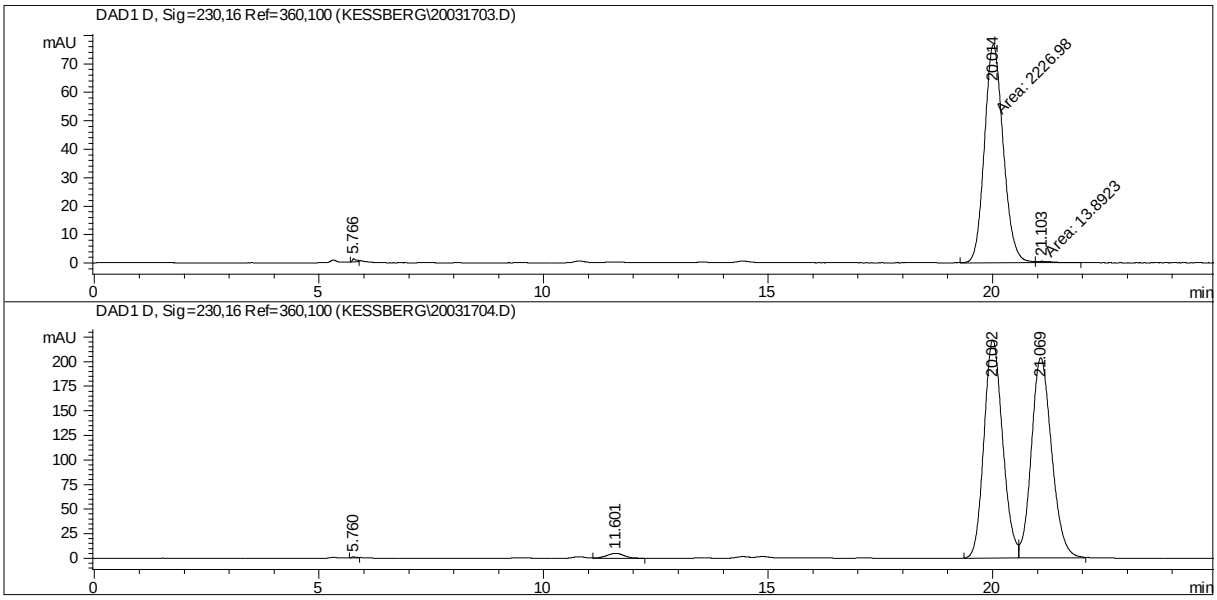


Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	3.860	BB	0.1291	746.13293	87.85747	7.7368
2	18.387	MF T	0.5468	8851.19141	269.80188	91.7795
3	19.607	FM T	0.3976	46.64545	1.95529	0.4837
Totals :				9643.96980	359.61464	

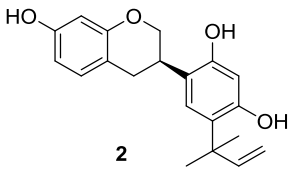

MOMO
O
OMOM
O
15
CDCl3, 300 MHz
3.49
3.48
5.15
5.20
1.81
1.75
6.59
7.02
7.05
6.77
7.00
6.57
6.56
6.54
6.54
5.50
5.49
4.51
4.48
4.01
4.32
4.05
3.98
3.60
3.00
2.97
2.92
2.92
2.91
2.90
2.01 1.00 2.03 0.97 1.00 1.99 2.05 1.99 0.99 1.00 1.08 3.14 2.80 1.00 1.01 3.03 3.10
Chemical Shift (ppm)


CDCl3, 75 MHz
158.78
155.88
155.04
138.29
130.16
127.51
122.06
119.56
116.02
108.85
106.99
104.33
102.09
94.55
94.46
70.21
64.80
56.14
55.91
31.64
30.57
25.82
18.17
Chemical Shift (ppm)

HPLC trace of racemic **15** (bottom) and (*R*)-**15** (top, 99% ee).



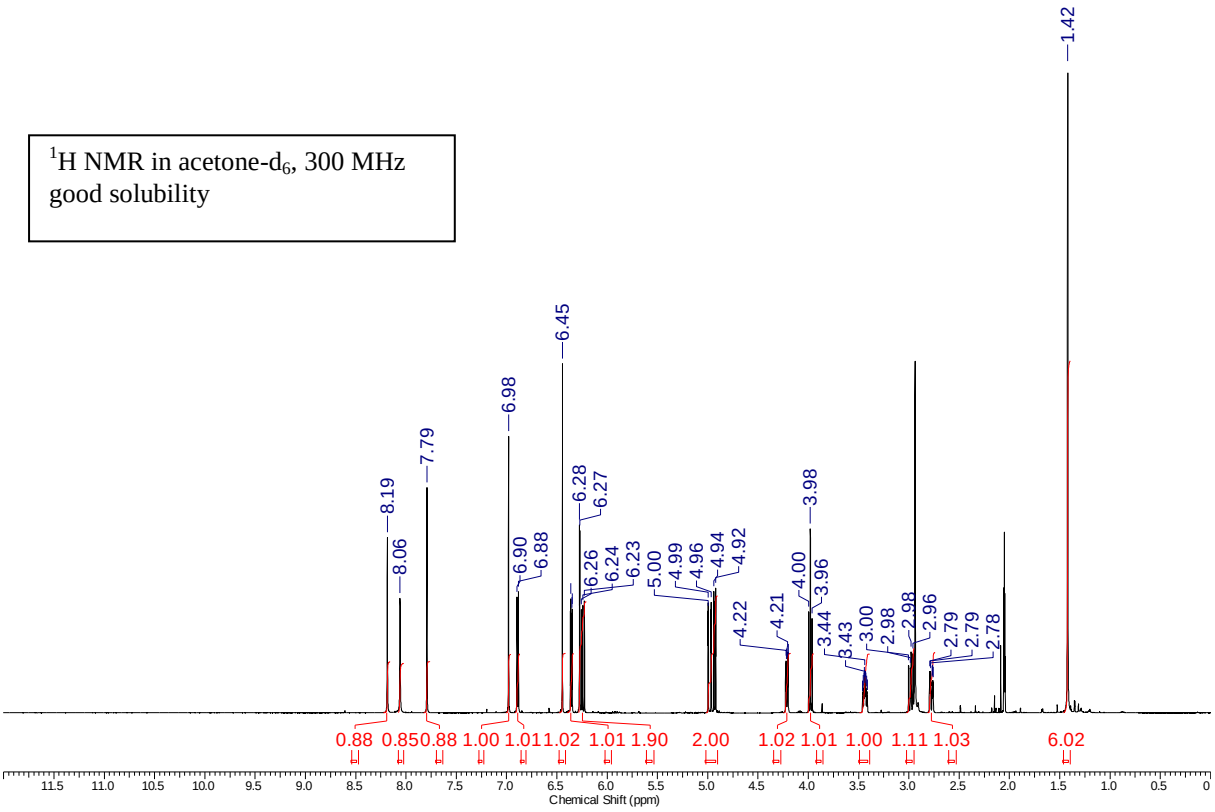
Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	5.766	PB	0.0854	6.83830	1.08655	0.3042
2	20.014	MF	T 0.4842	2226.97534	76.65750	99.0777
3	21.103	FM	T 0.4482	13.89234	5.16640e-1	0.6181
Totals :				2247.70598	78.26069	

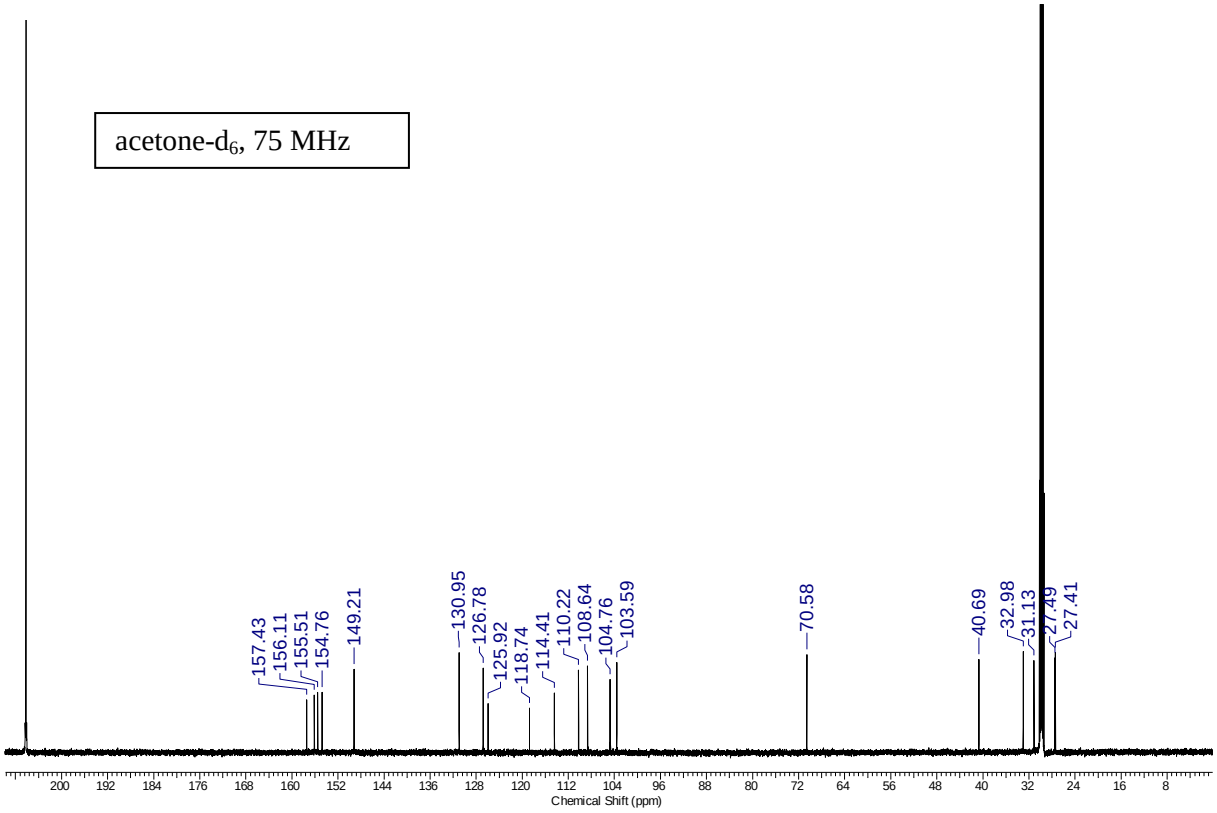


2

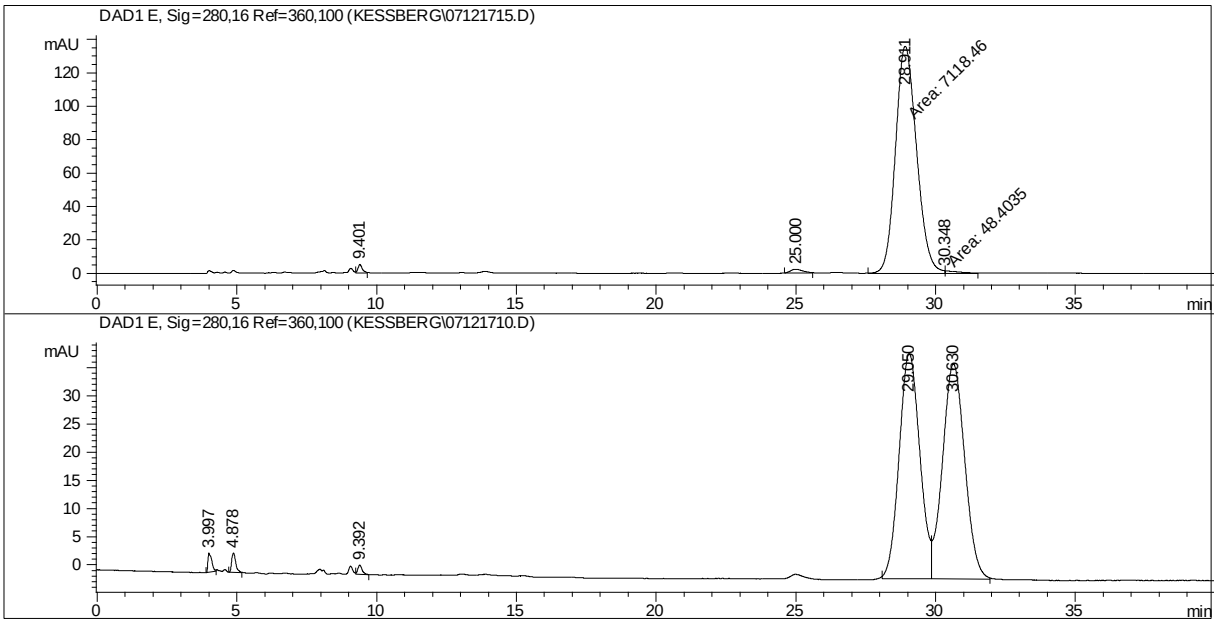
^{1}H NMR in $CDCl_3$, 300 MHz
poor solubility

^{1}H NMR in acetone-d_6, 300 MHz
good solubility

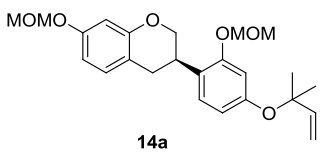



acetone-d6, 75 MHz
157.43
156.11
155.51
154.76
149.21
130.95
126.78
125.92
118.74
114.41
110.22
108.64
104.76
103.59
70.58
40.69
32.98
31.13
27.49
27.41
200 192 184 176 168 160 152 144 136 128 120 112 104 96 88 80 72 64 56 48 40 32 24 16 8
Chemical Shift (ppm)

HPLC trace of racemic **2** (bottom) and (*R*)-**2** (top, 99% ee).



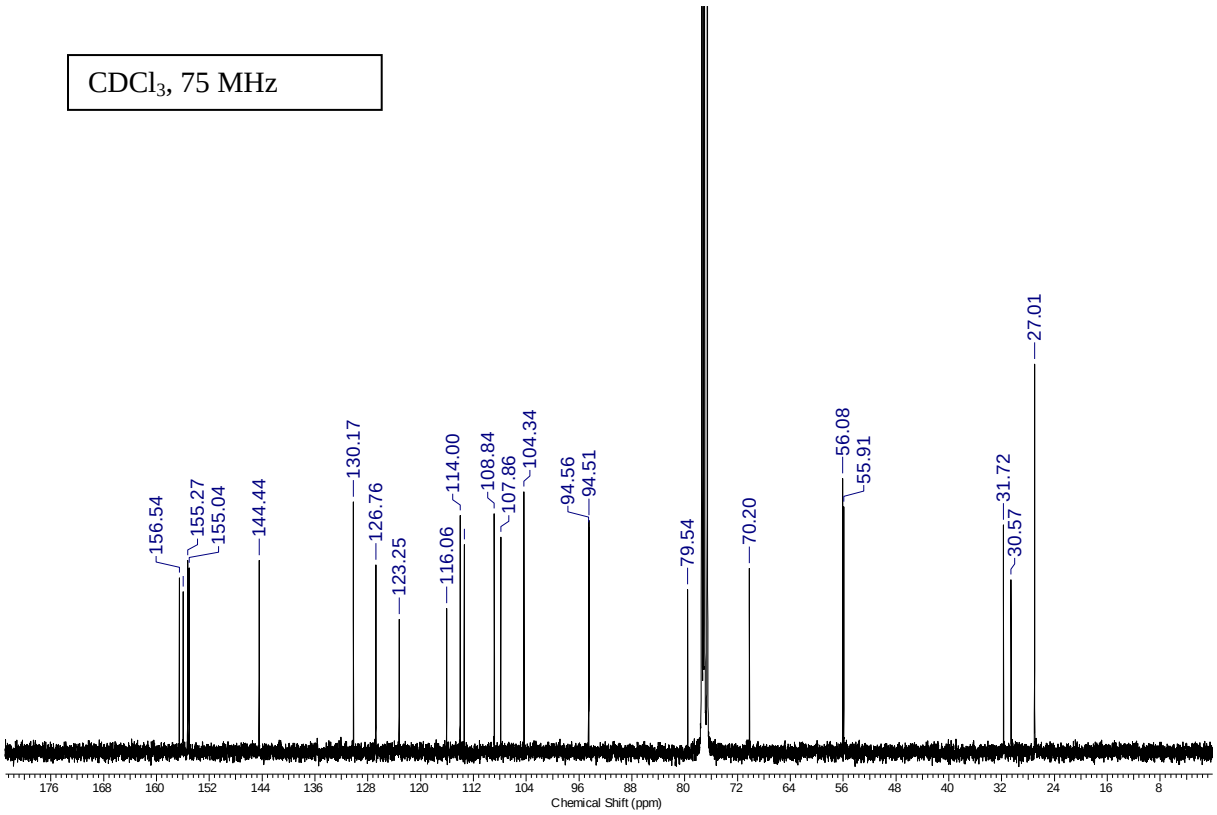
Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	9.401	VB	0.1579	52.17762	4.91345	0.7160
2	25.000	BB	0.3877	68.55892	2.26128	0.9408
3	28.911	MF T	0.8739	7118.45654	135.76443	97.6791
4	30.348	FM T	0.5536	48.40351	1.45711	0.6642
Totals :				7287.59660	144.39627	



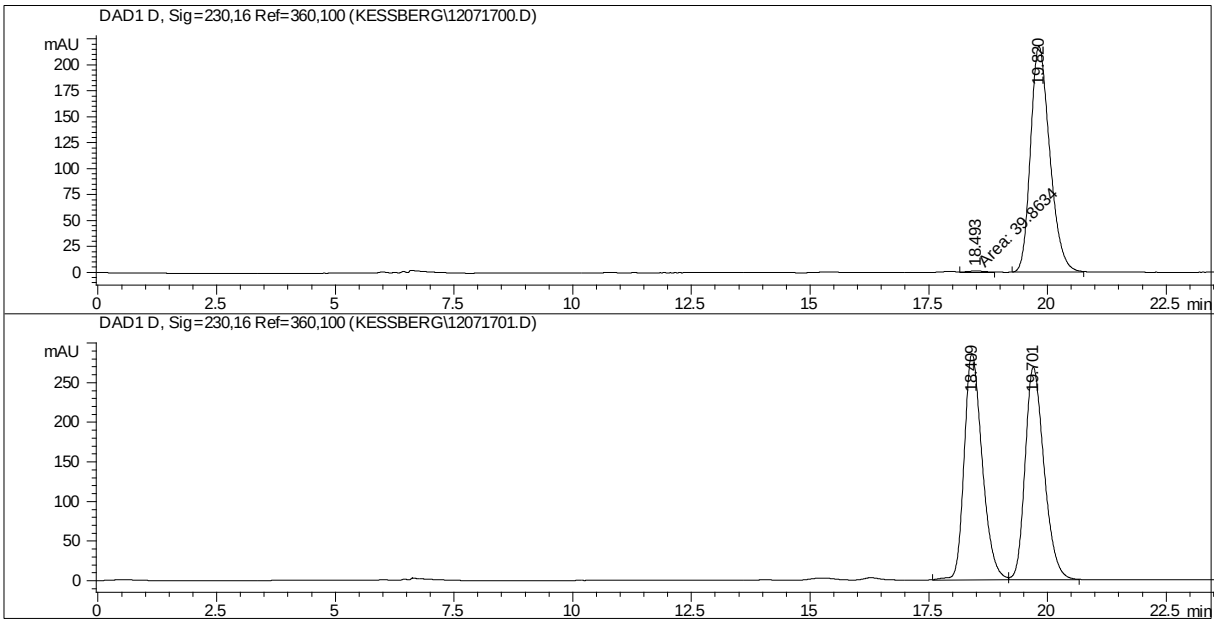
14a

$CDCl_3$, 300 MHz

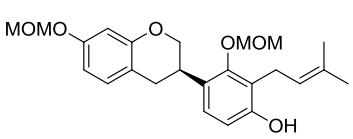
$CDCl_3$, 75 MHz



HPLC trace of racemic **14a** (bottom) and (*R*)-**14a** (top, 99% ee).



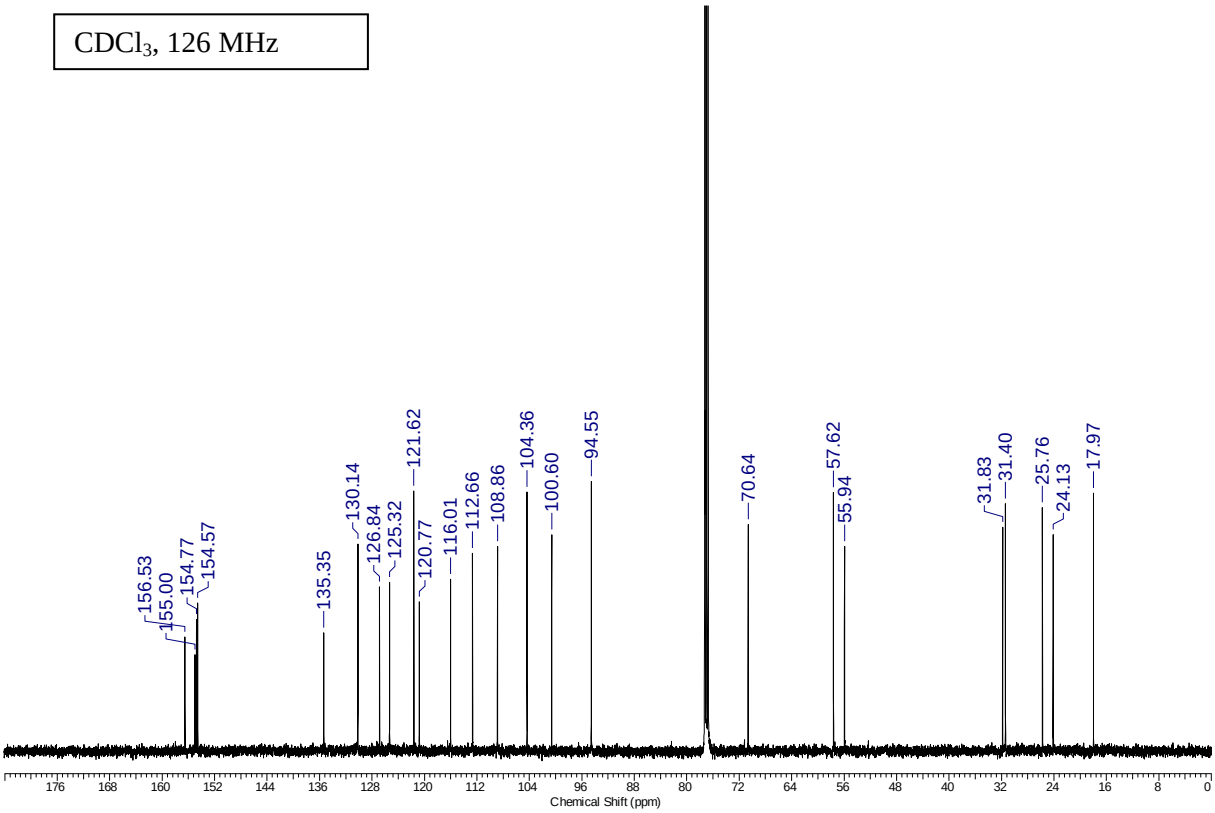
Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	18.493	MM T	0.4408	39.86337	1.40683	0.6468
2	19.820	BB	0.4324	6123.16992	217.54582	99.3532
Totals :				6163.03329	218.95265	



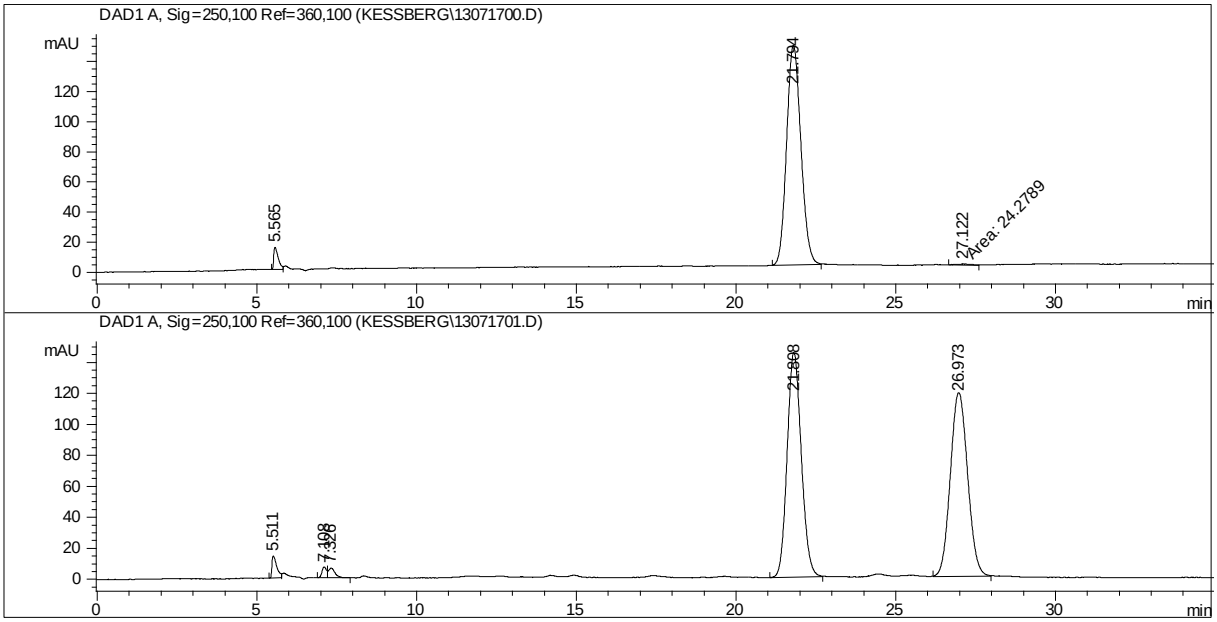
14c

$CDCl_3$, 500 MHz

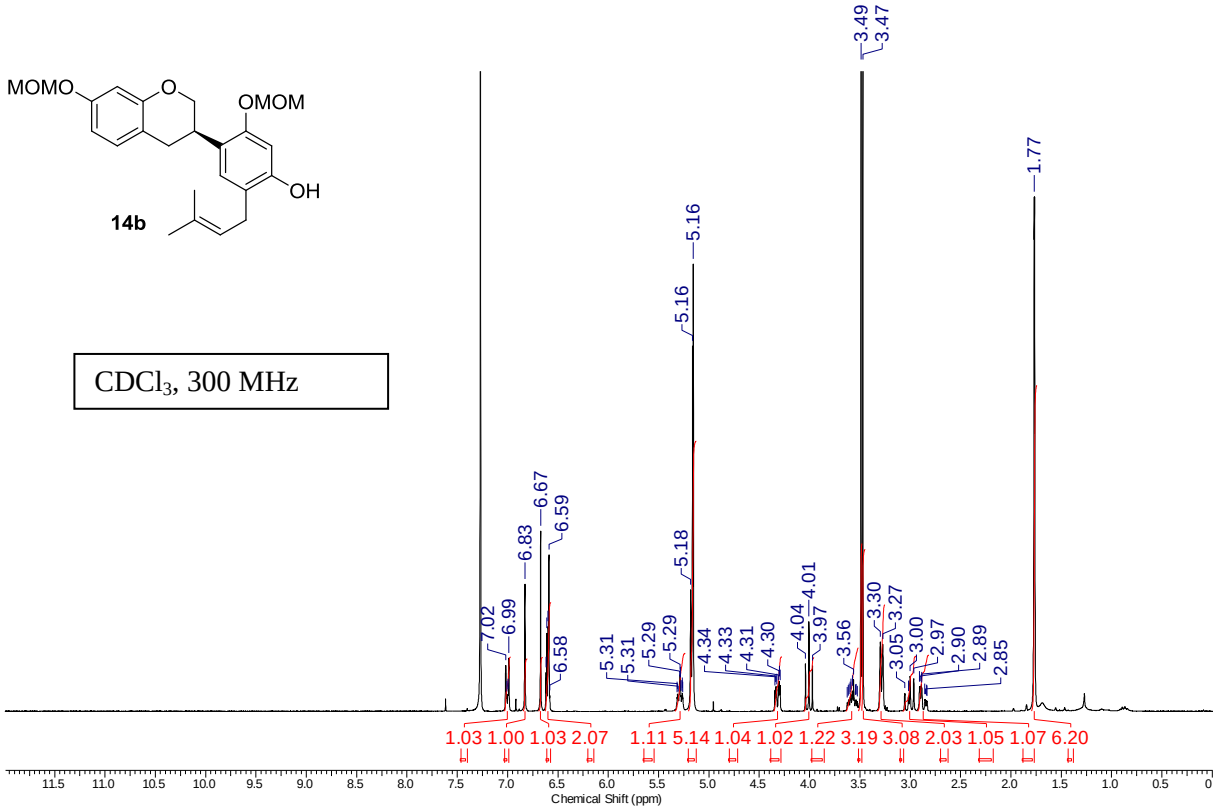
$CDCl_3$, 126 MHz

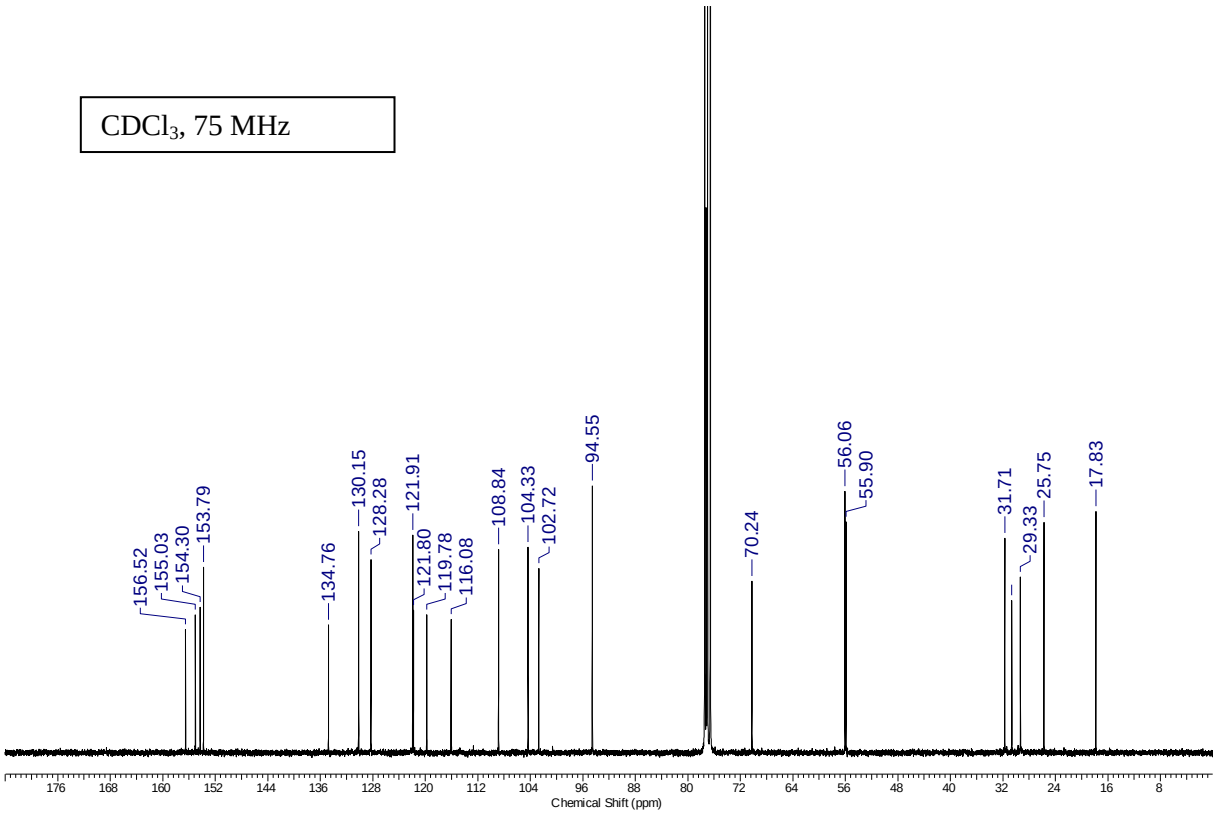


HPLC trace of racemic **14c** (bottom) and (*R*)-**14c** (top, 99% ee).

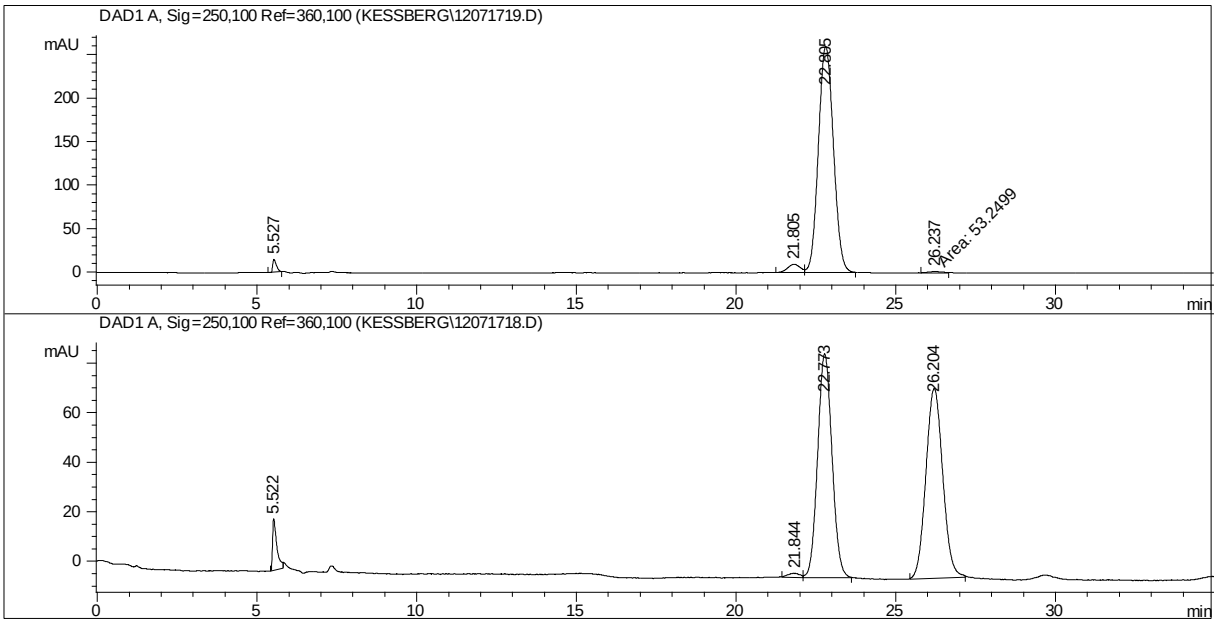


Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	5.565	BV	0.1499	143.23648	14.67602	3.0517
2	21.794	BB	0.4772	4526.15918	145.39931	96.4310
3	27.122	MM T	0.5936	24.27892	6.81711e-1	0.5173
Totals :				4693.67458	160.75703	

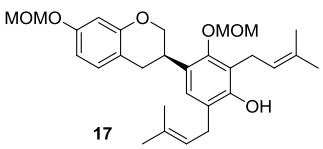

MOMO
O
OMOM
OH
14b
CDCl3, 300 MHz
3.49
3.47
1.77
5.16
5.16
6.67
6.83
6.59
5.18
4.01
7.02
6.99
6.58
5.31
5.31
5.29
5.29
4.34
4.33
4.31
4.30
4.04
3.97
3.56
3.30
3.27
3.05
3.00
2.97
2.90
2.89
2.85
1.03 1.00 1.03 2.07 1.11 5.14 1.04 1.02 1.22 3.19 3.08 2.03 1.05 1.07 6.20
Chemical Shift (ppm)


CDCl3, 75 MHz
156.52
155.03
154.30
153.79
134.76
130.15
128.28
121.91
121.80
119.78
116.08
108.84
104.33
102.72
94.55
70.24
56.06
55.90
31.71
29.33
25.75
17.83
Chemical Shift (ppm)

HPLC trace of racemic **14b** (bottom) and (*R*)-**14b** (top, 99% ee).



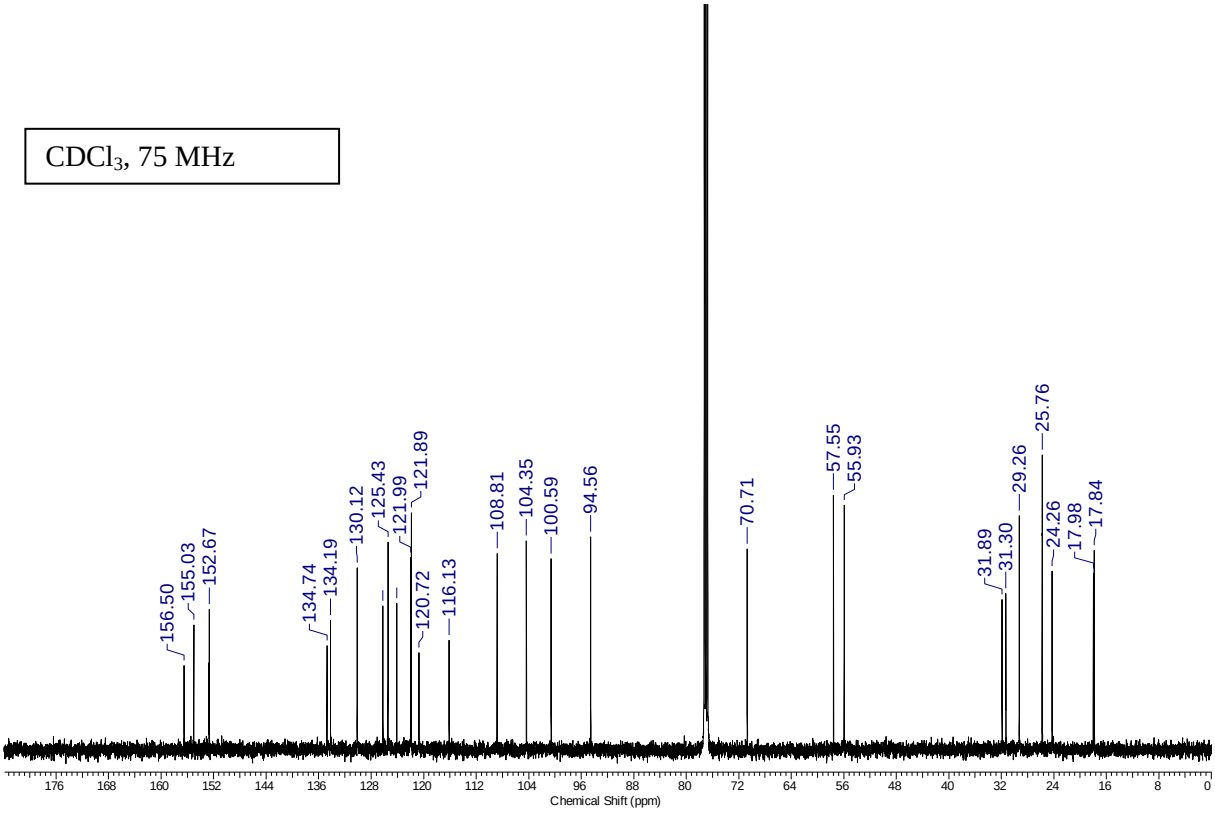
Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	5.527	PB	0.1227	111.51190	14.34839	1.2467
2	21.805	BV	0.3531	264.50159	9.49106	2.9571
3	22.805	VB	0.5103	8515.25098	259.85995	95.2008
4	26.237	MM T	0.5385	53.24990	1.64808	0.5953
Totals :				8944.51437	285.34748	



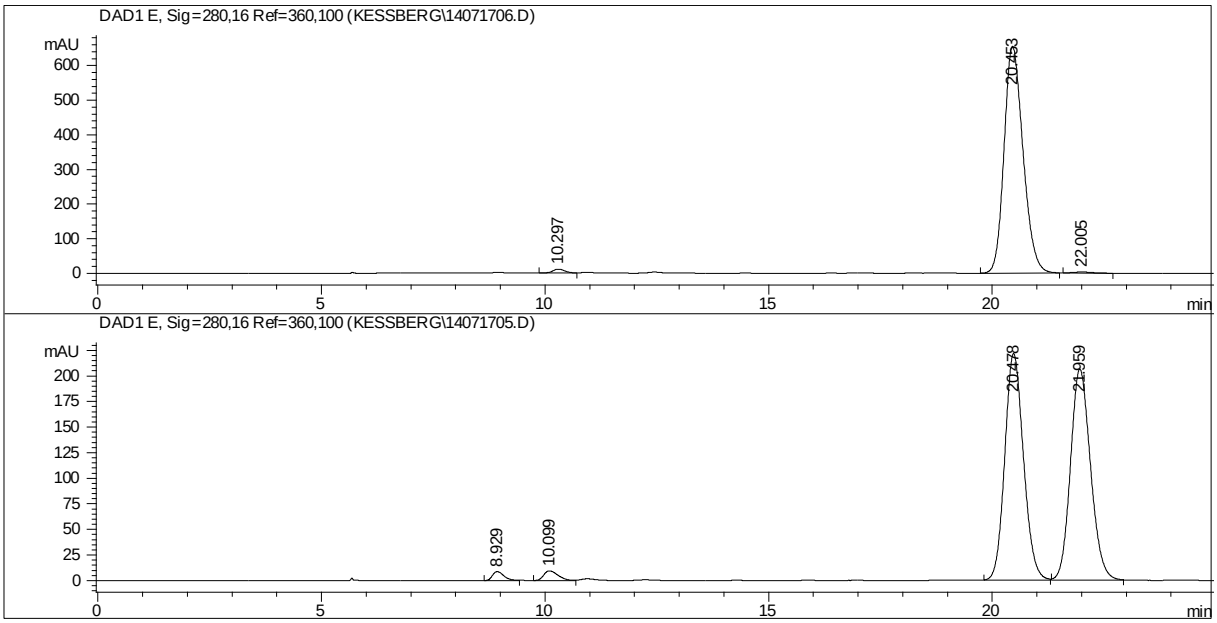
17

$CDCl_3$, 500 MHz

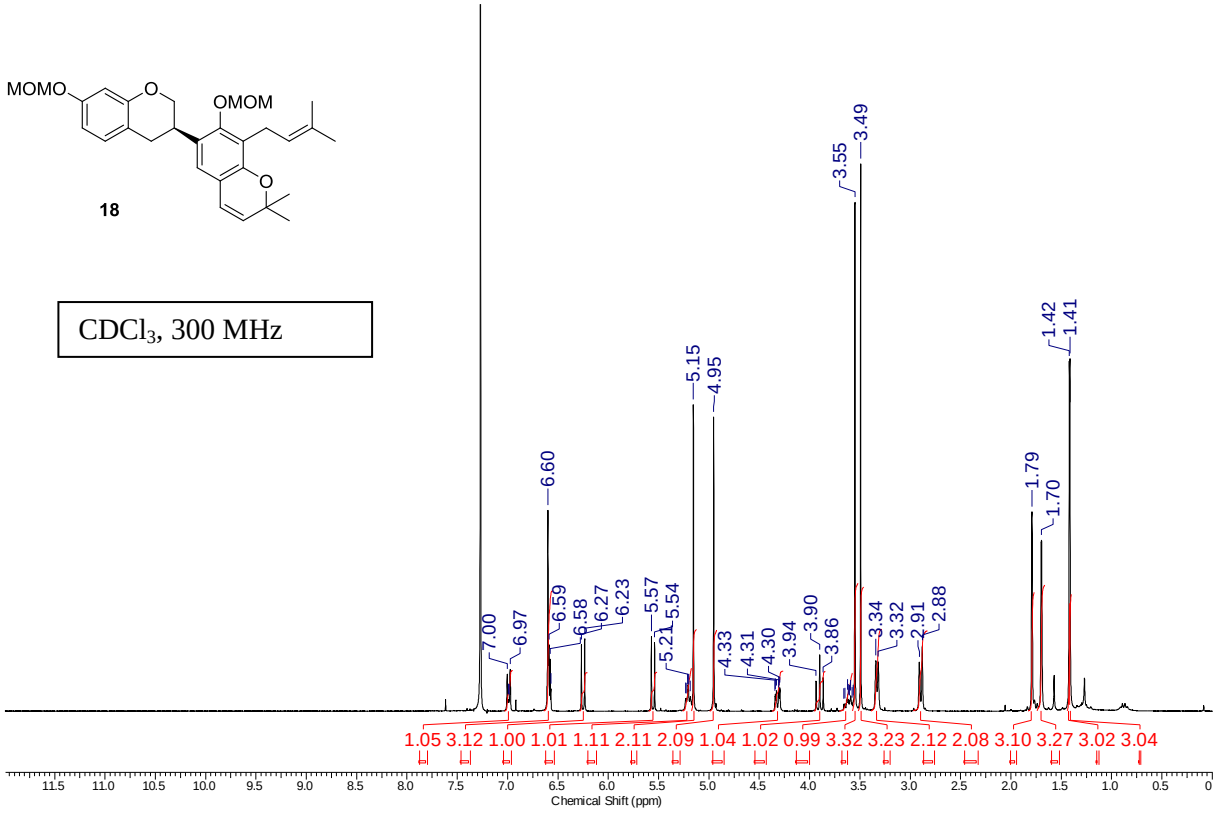
$CDCl_3$, 75 MHz

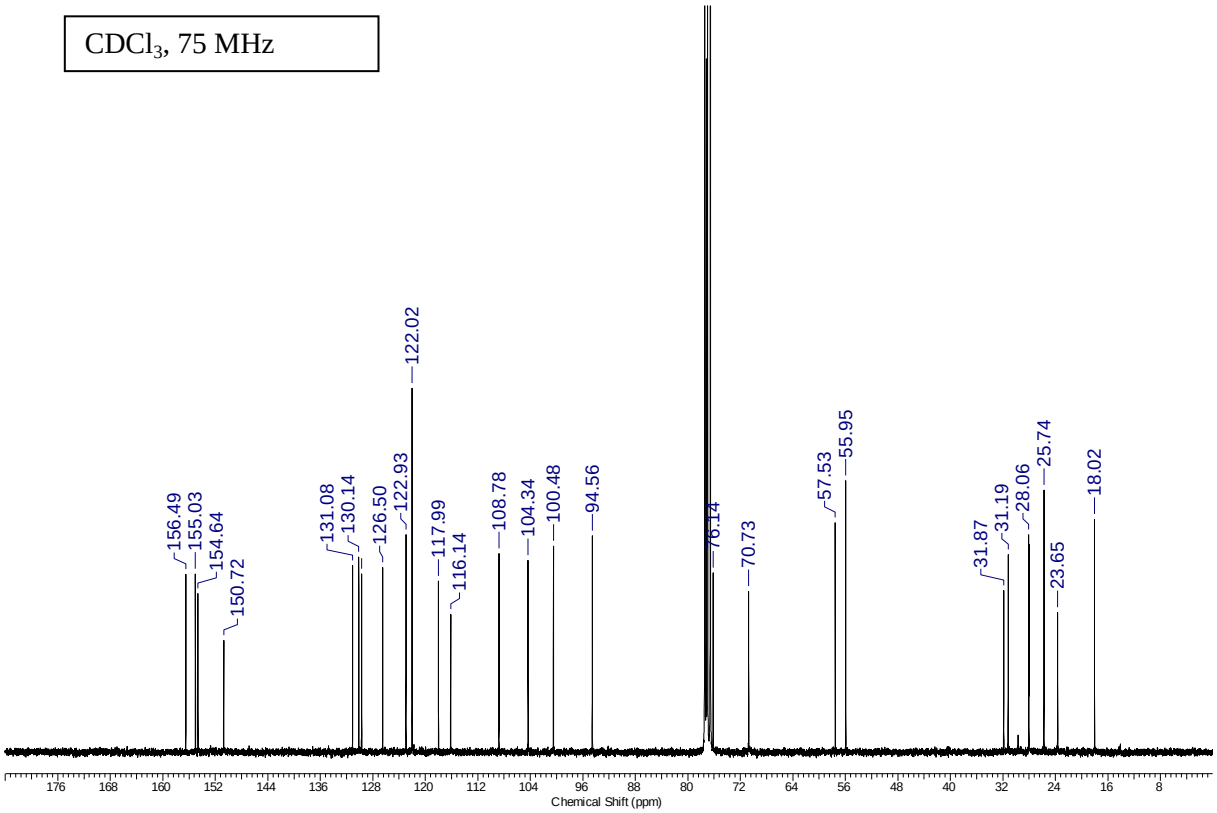


HPLC trace of racemic **17** (bottom) and (*R*)-**17** (top, 99% ee).

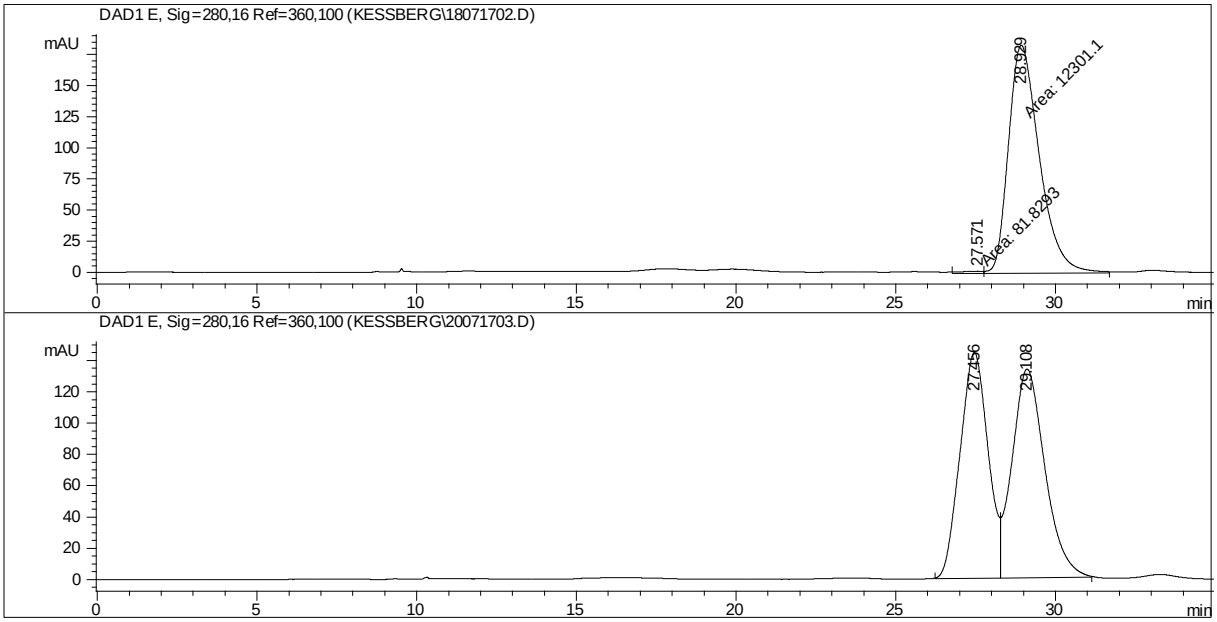


Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	10.297	BV	0.3022	217.84346	11.33493	1.1124
2	20.453	BB	0.4576	1.92876e4	654.97406	98.4939
3	22.005	BP	0.3918	77.08681	2.84768	0.3937
Totals :				1.95825e4	669.15667	

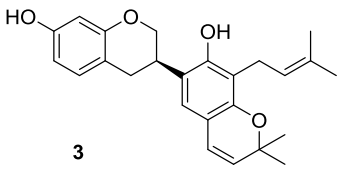

MOMO
O
OMOM
O
18
CDCl3, 300 MHz
7.00
6.97
6.60
6.59
6.58
6.27
6.23
5.57
5.54
5.21
5.15
4.95
4.33
4.31
4.30
3.94
3.90
3.86
3.55
3.49
3.34
3.32
2.91
2.88
1.79
1.70
1.42
1.41
1.05 3.12 1.00 1.01 1.11 2.11 2.09 1.04 1.02 0.99 3.32 3.23 2.12 2.08 3.10 3.27 3.02 3.04
Chemical Shift (ppm)


CDCl3, 75 MHz
156.49
155.03
154.64
150.72
131.08
130.14
126.50
122.93
122.02
117.99
116.14
108.78
104.34
100.48
94.56
76.14
70.73
57.53
55.95
31.87
31.19
28.06
25.74
23.65
18.02
Chemical Shift (ppm)

HPLC trace of racemic **18** (bottom) and (*R*)-**18** (top, 99% ee).



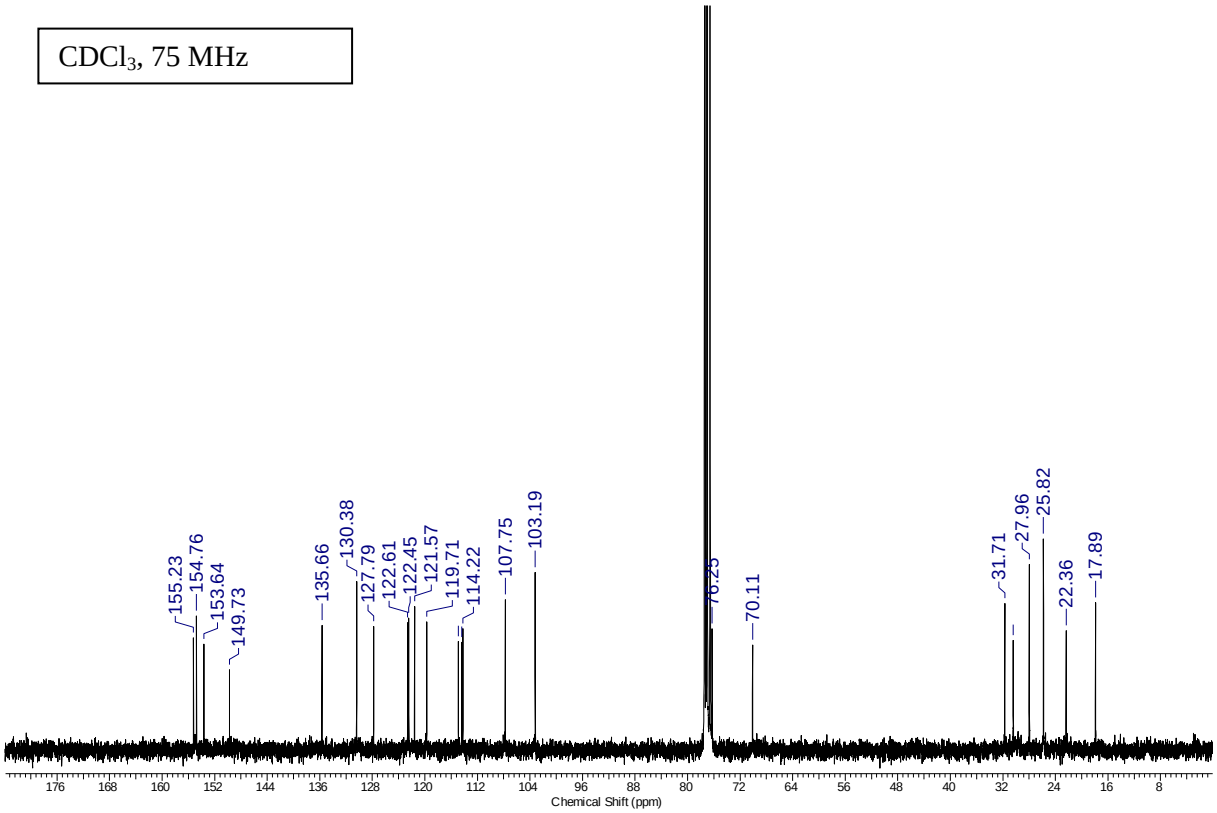
Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	27.571	MF	T 0.8294	81.82935	1.64428	0.6608
2	28.929	FM	T 1.1197	1.23011e4	183.10583	99.3392
Totals :				1.23829e4	184.75011	



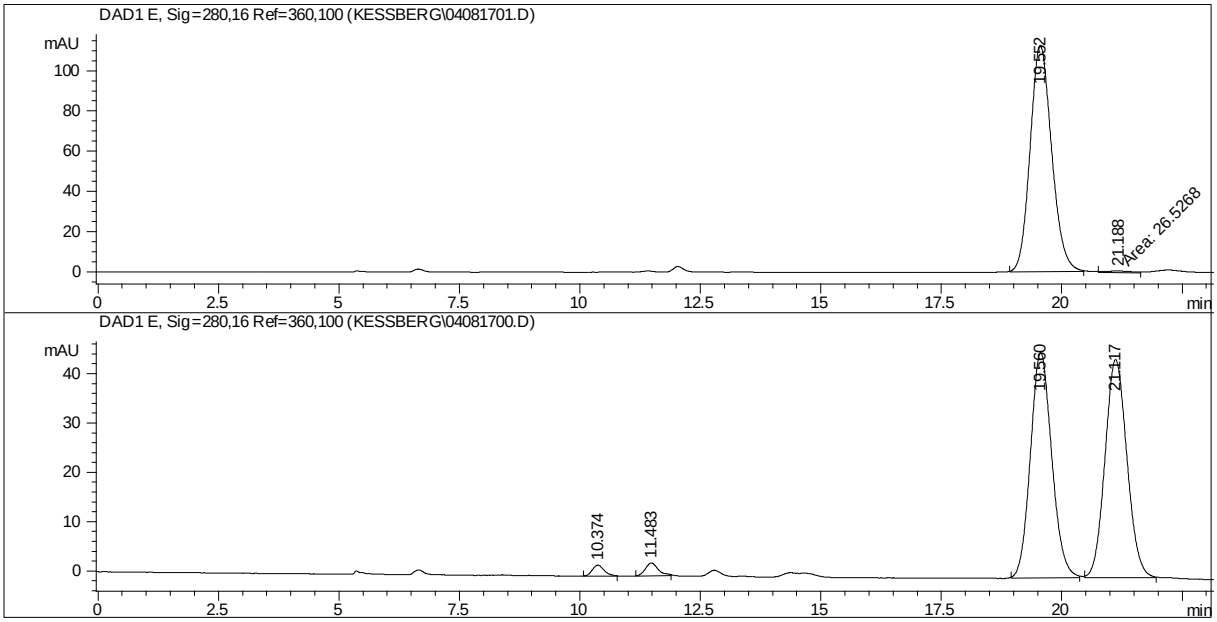
3

$CDCl_3$, 300 MHz

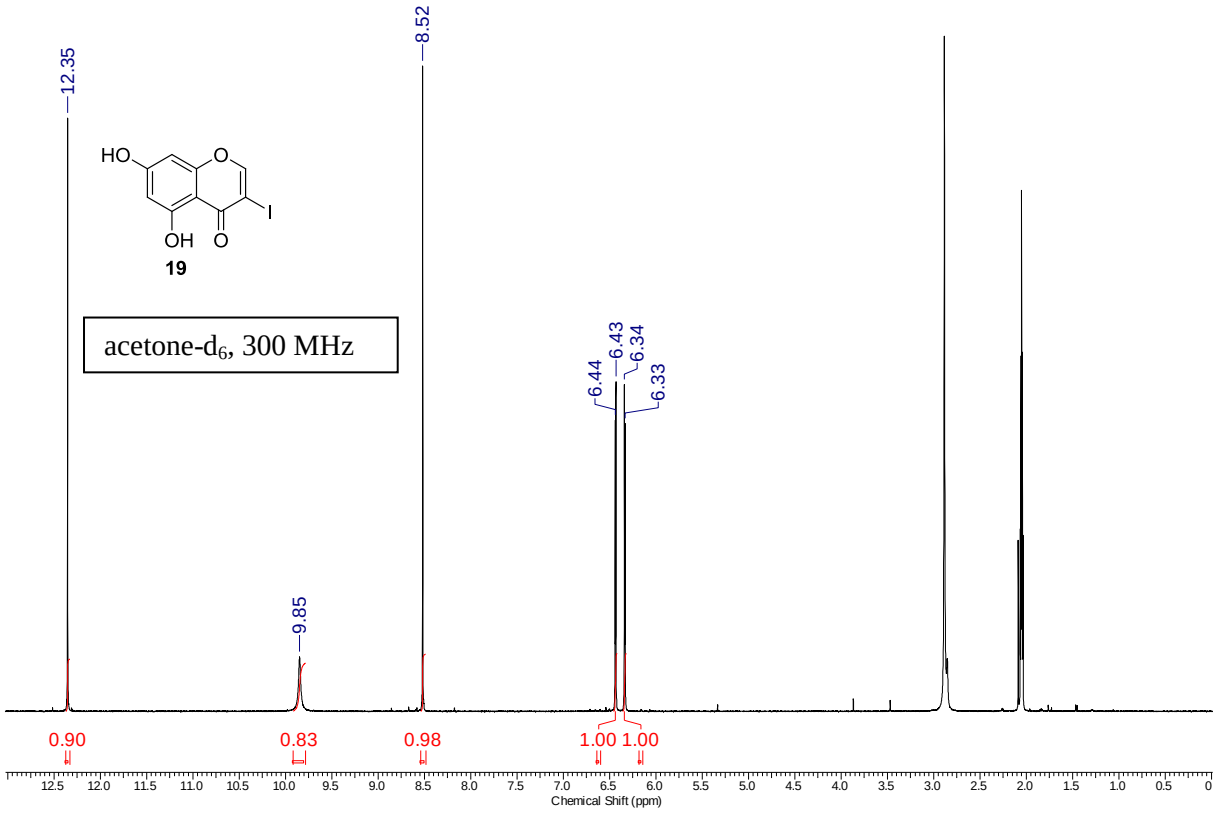
$CDCl_3$, 75 MHz

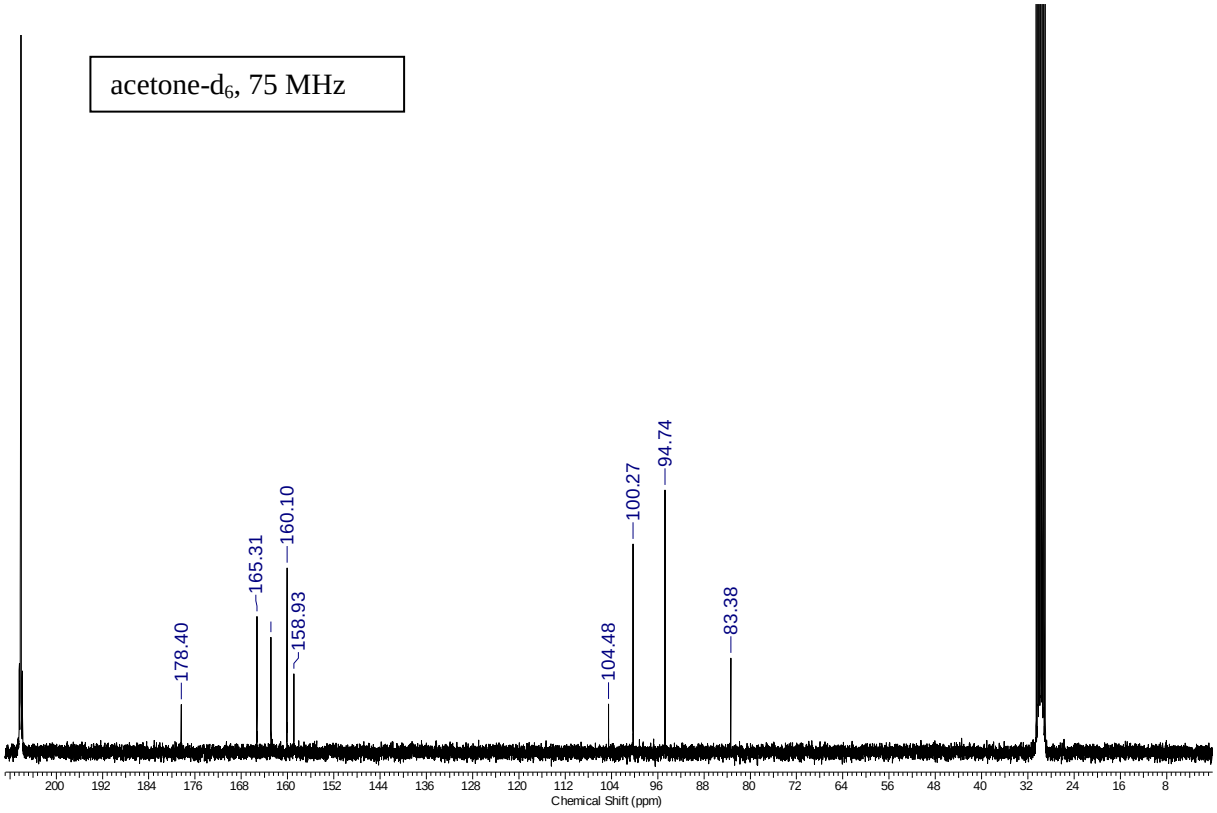


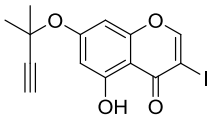
HPLC trace of racemic **3** (bottom) and (*R*)-**3** (top, 99% ee).



Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	19.552	BB	0.4780	3493.01758	112.57558	99.2463
2	21.188	MM T	0.6098	26.52677	7.24957e-1	0.7537
Totals :				3519.54434	113.30054	


12.35
8.52
HO
O
I
OH
O
19
acetone-d6, 300 MHz
6.44
6.43
6.34
6.33
9.85
0.90
0.83
0.98
1.00
1.00
Chemical Shift (ppm)

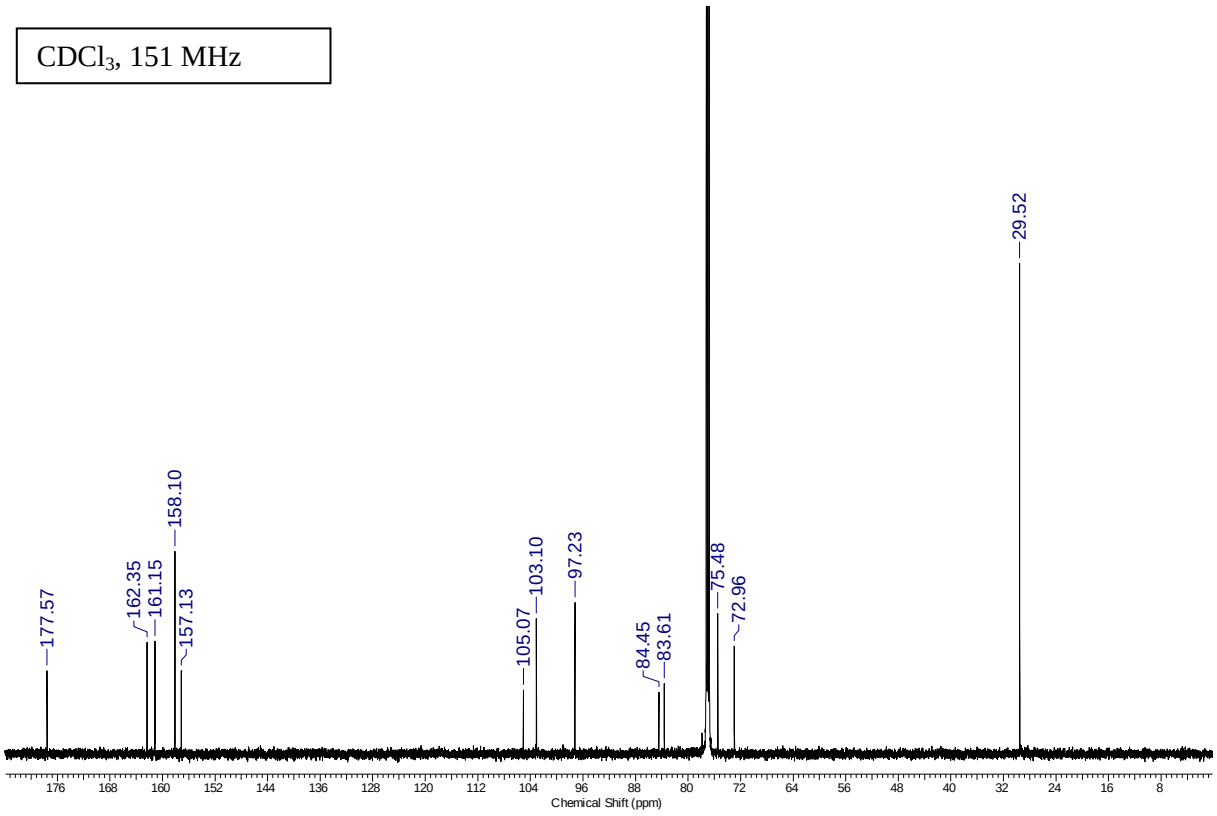

acetone-d6, 75 MHz
178.40
165.31
160.10
158.93
104.48
100.27
94.74
83.38
Chemical Shift (ppm)

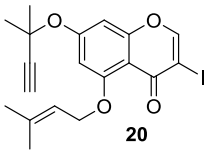


19a

$CDCl_3$, 600 MHz

$CDCl_3$, 151 MHz

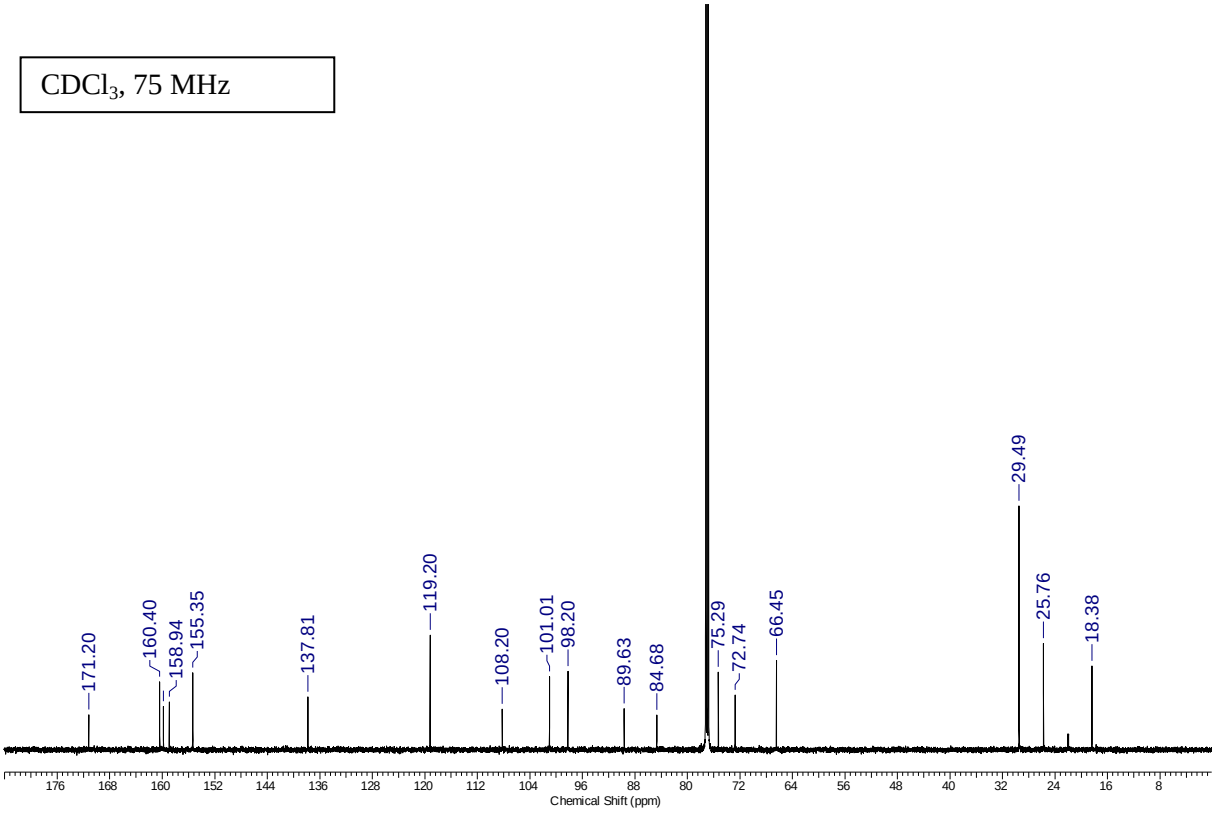


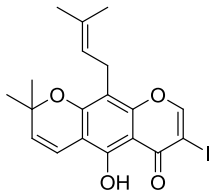


20

$CDCl_3$, 600 MHz

$CDCl_3$, 75 MHz

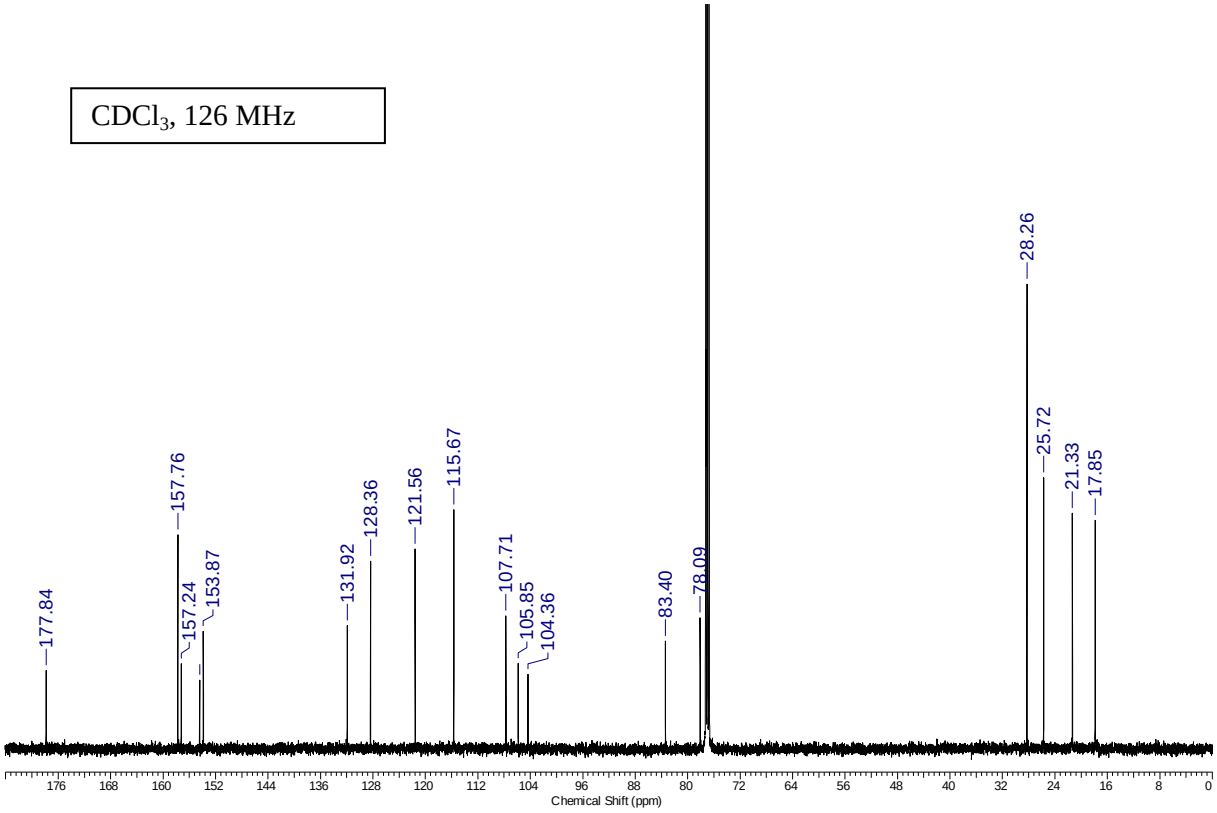


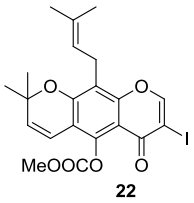


21

$CDCl_3$, 300 MHz

$CDCl_3$, 126 MHz

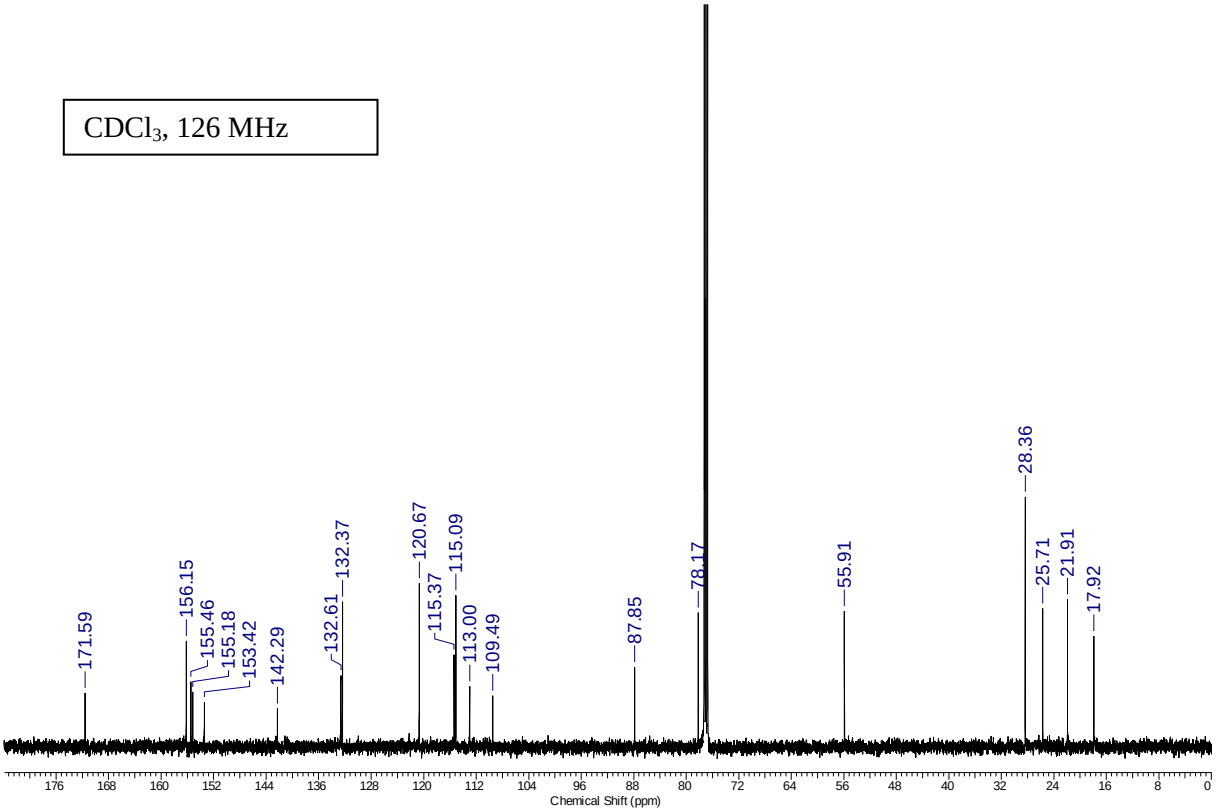


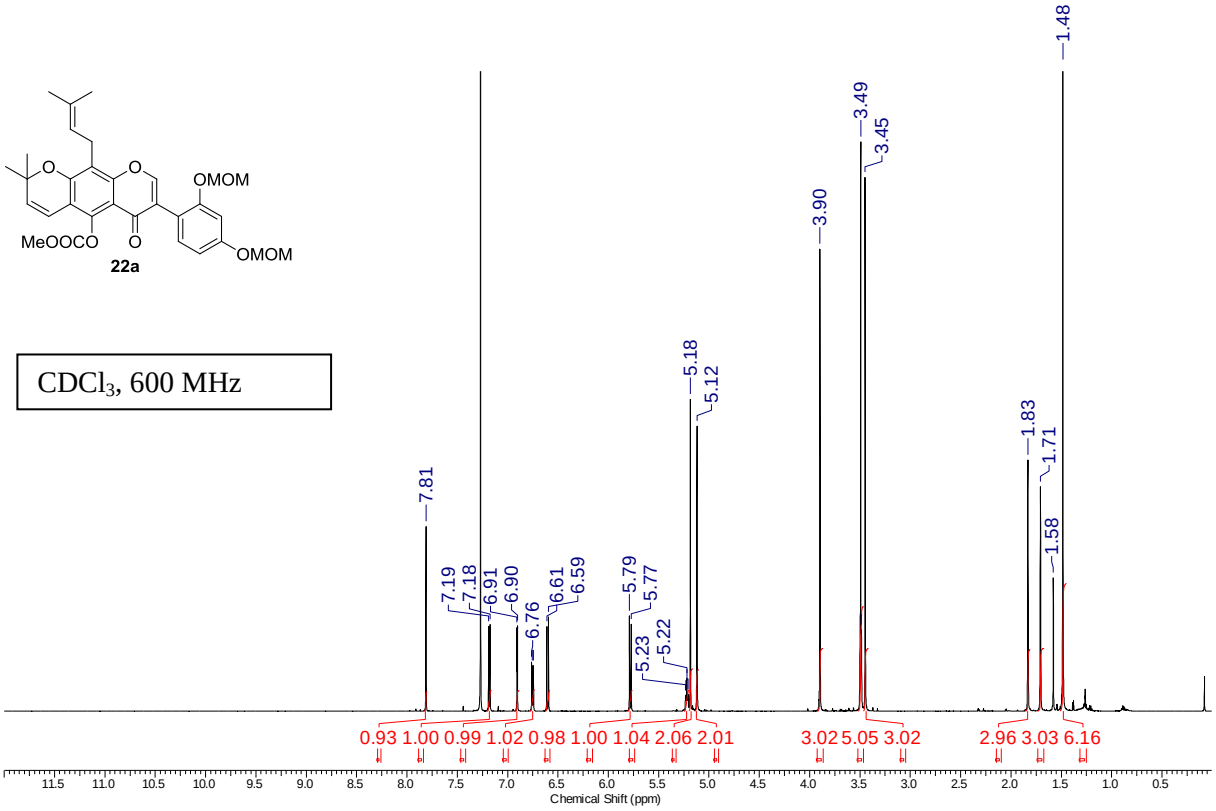


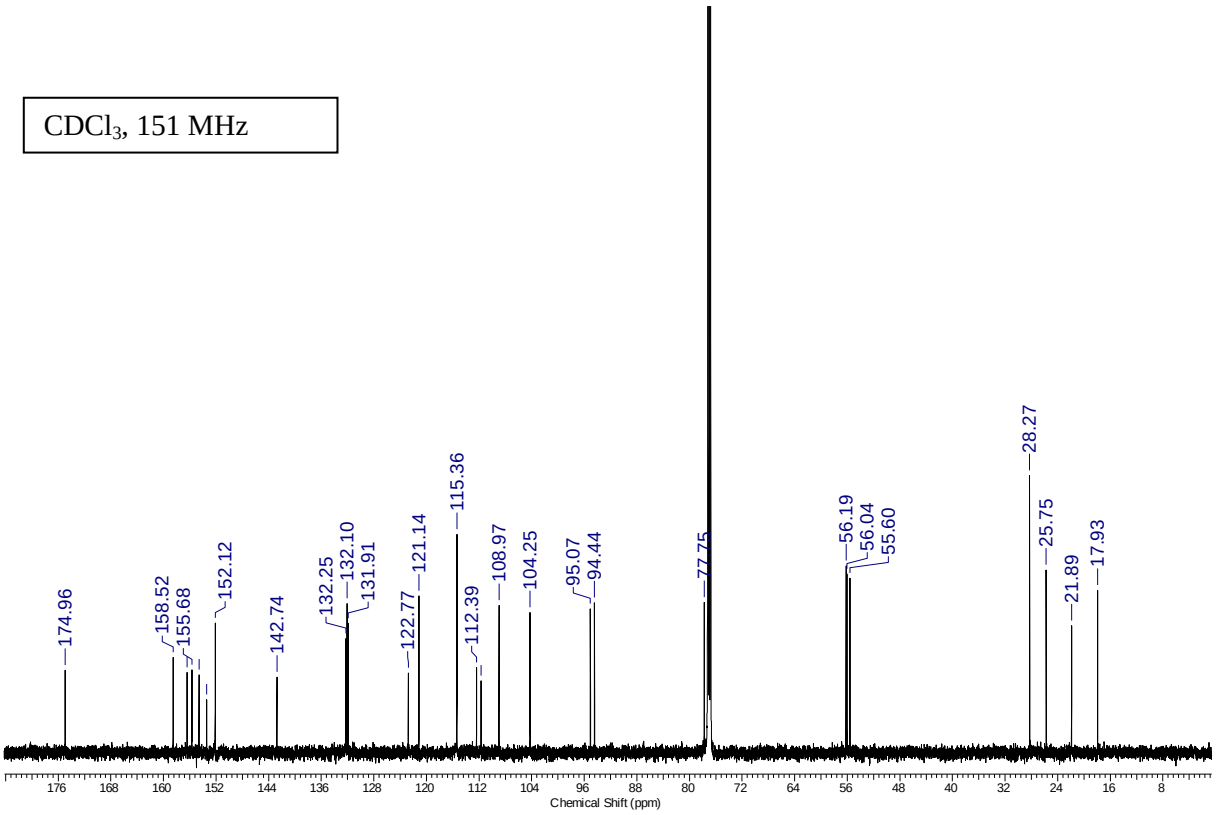
22

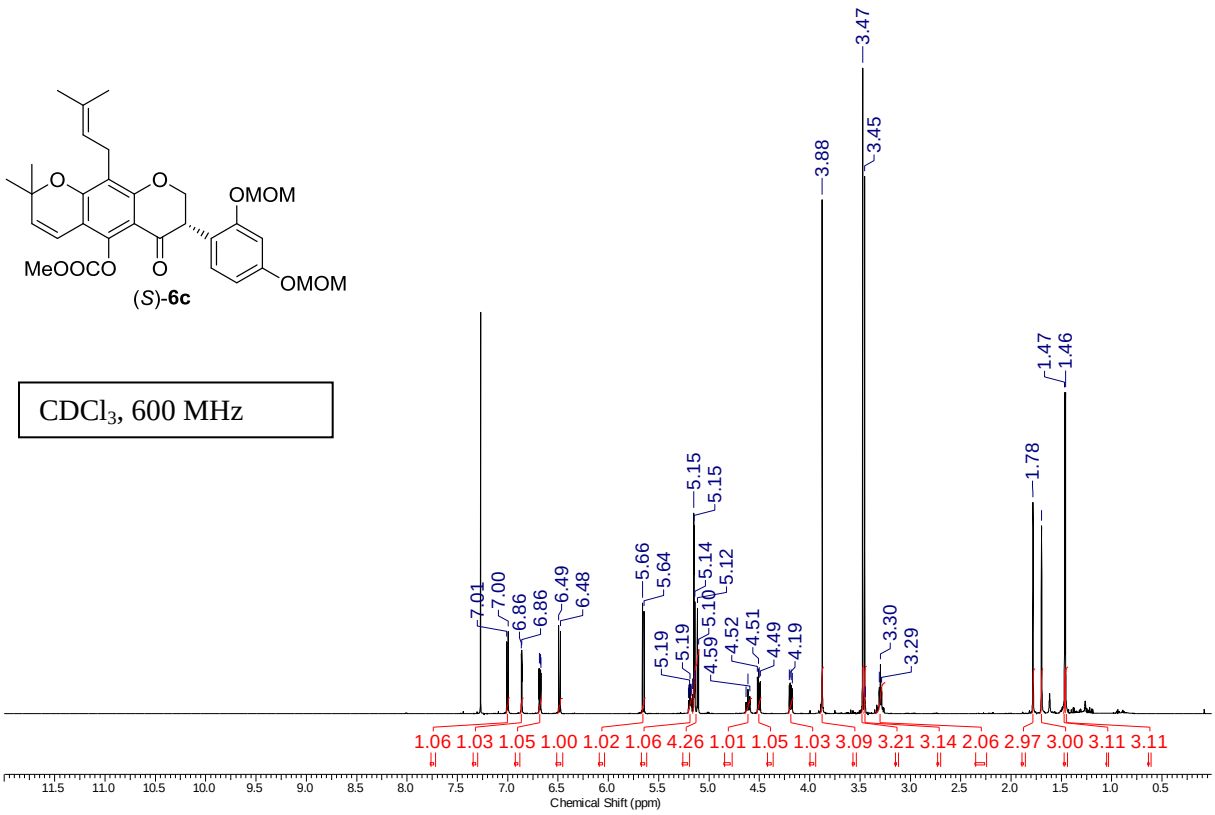
$CDCl_3$, 500 MHz

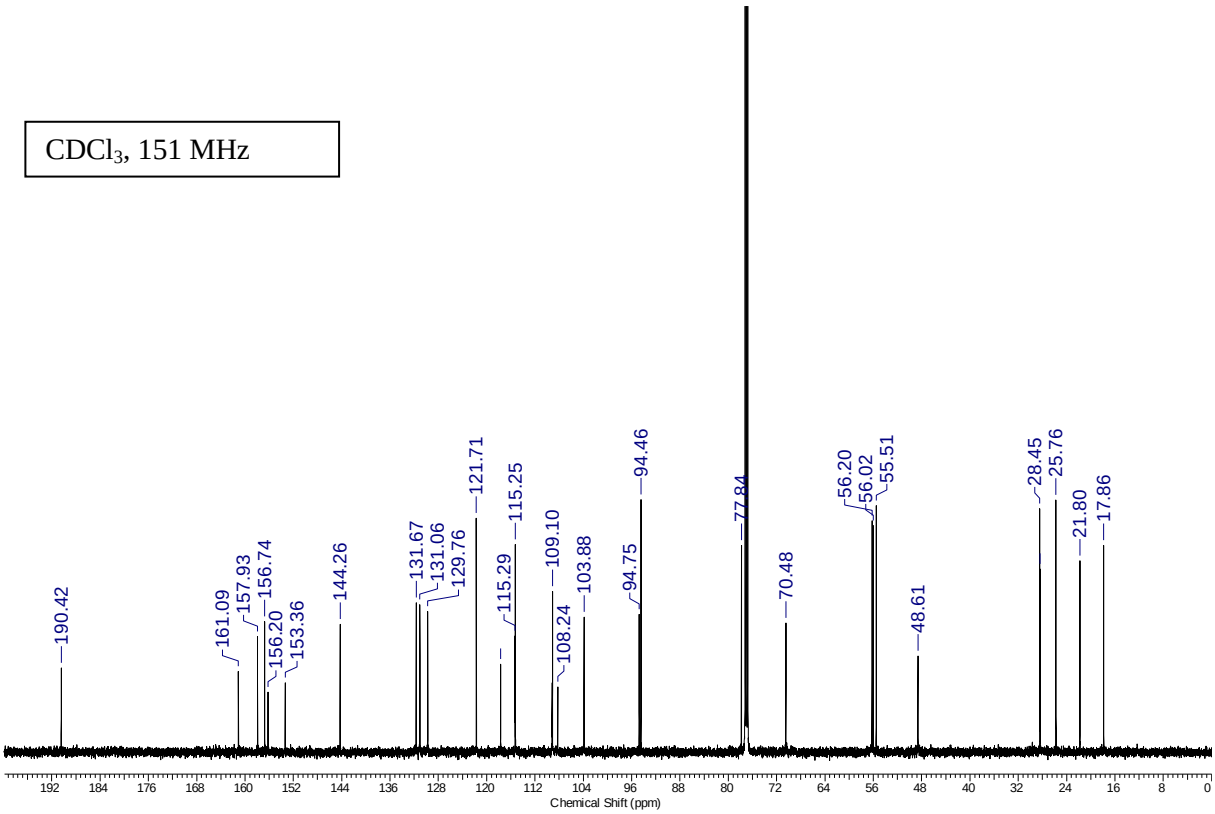
$CDCl_3$, 126 MHz



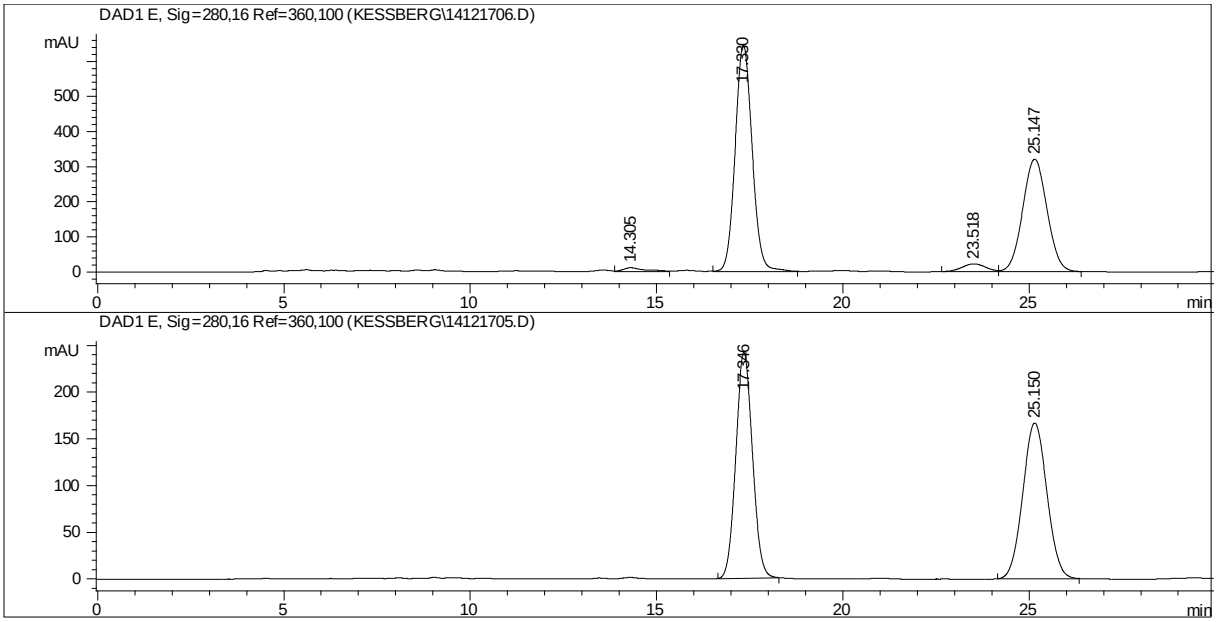

OMOM
MeOOCO
O
OMOM
22a
CDCl3, 600 MHz
7.81
7.19
7.18
6.91
6.90
6.76
6.61
6.59
5.79
5.77
5.23
5.22
5.18
5.12
3.90
3.49
3.45
1.83
1.71
1.58
1.48
0.93 1.00 0.99 1.02 0.98 1.00 1.04 2.06 2.01
3.02 5.05 3.02
2.96 3.03 6.16
Chemical Shift (ppm)


CDCl3, 151 MHz
174.96
158.52
155.68
152.12
142.74
132.25
132.10
131.91
122.77
121.14
115.36
112.39
108.97
104.25
95.07
94.44
77.75
56.19
56.04
55.60
28.27
25.75
21.89
17.93
Chemical Shift (ppm)

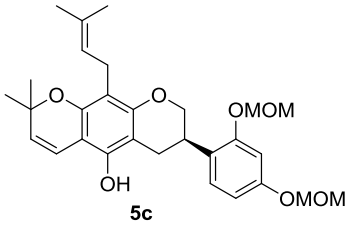

OMOM
MeOOCO
O
OMOM
(S)-6c
CDCl3, 600 MHz
7.01
7.00
6.86
6.86
6.49
6.48
5.66
5.64
5.15
5.15
5.14
5.12
5.10
5.19
5.19
4.59
4.52
4.51
4.49
4.19
3.88
3.47
3.45
3.30
3.29
1.78
1.47
1.46
1.06 1.03 1.05 1.00 1.02 1.06 4.26 1.01 1.05 1.03 3.09 3.21 3.14 2.06 2.97 3.00 3.11 3.11
Chemical Shift (ppm)


CDCl3, 151 MHz
190.42
161.09
157.93
156.74
156.20
153.36
144.26
131.67
131.06
129.76
121.71
115.29
115.25
109.10
108.24
103.88
94.75
94.46
77.84
70.48
56.20
56.02
55.51
48.61
28.45
25.76
21.80
17.86
Chemical Shift (ppm)

HPLC trace of racemic **6c** (bottom) and (*S*)-**6c** (top, 17% ee).



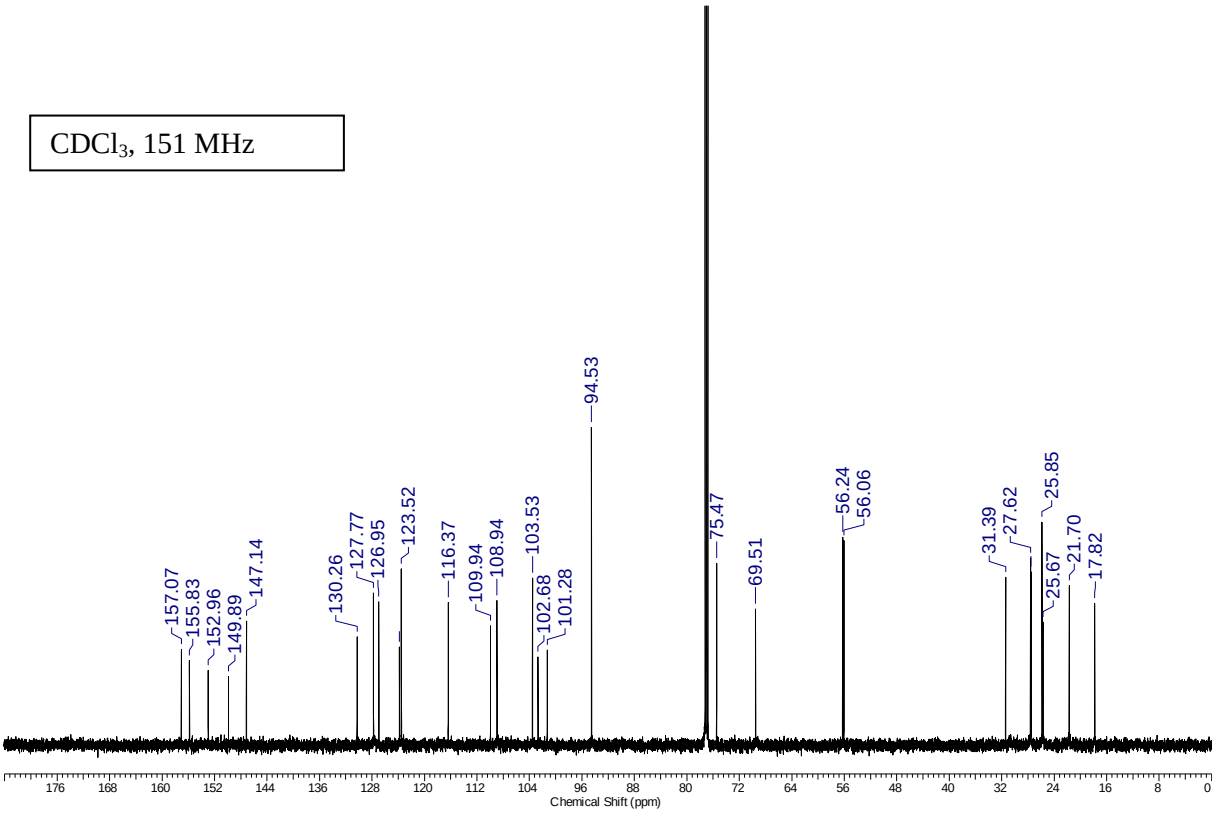
Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	14.305	VB	0.5563	422.87811	10.58074	1.1619
2	17.330	BB	0.4953	2.04213e4	645.15869	56.1120
3	23.518	BV	0.6814	995.08429	22.34986	2.7342
4	25.147	VB	0.7058	1.45546e4	320.52261	39.9919
Totals :				3.63939e4	998.61191	



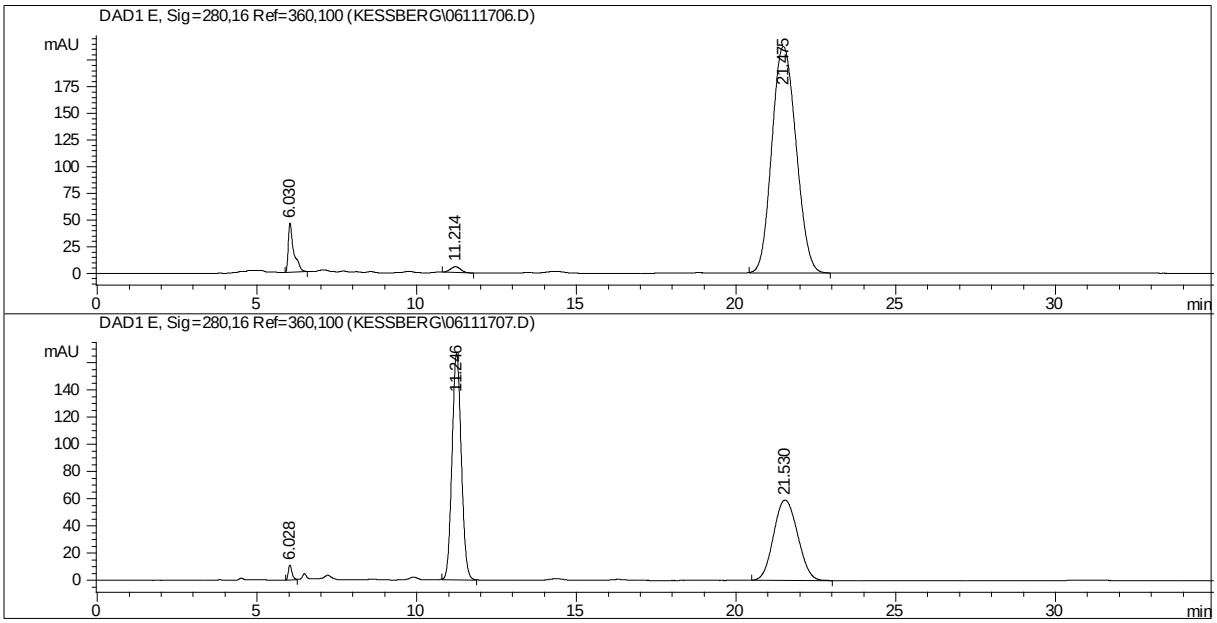
5c

$CDCl_3$, 600 MHz

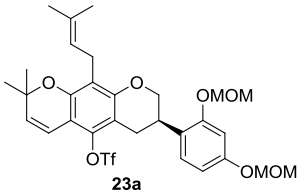
$CDCl_3$, 151 MHz



HPLC trace of racemic **5c** (bottom) and (*R*)-**5c** (top, 98% ee).



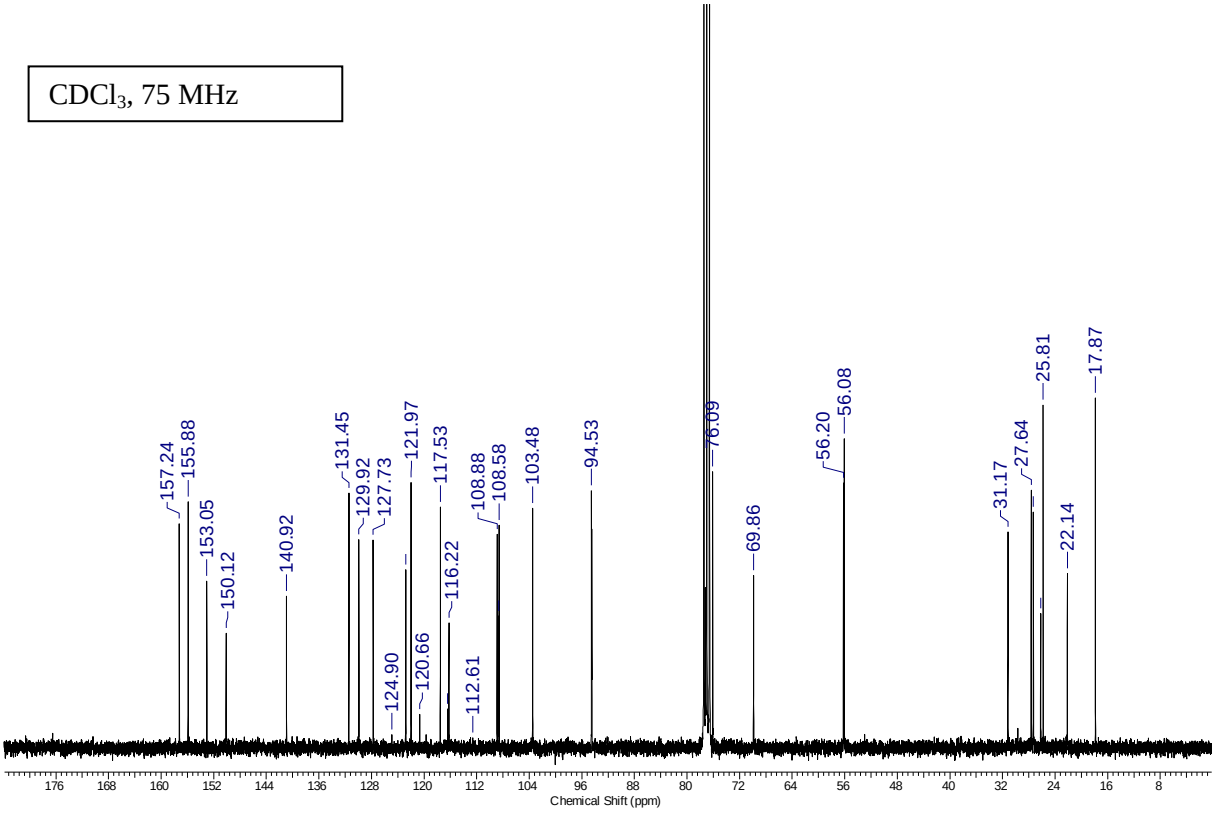
Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	6.030	PB	0.1691	548.85950	46.03070	4.6337
2	11.214	BP	0.3440	122.19493	5.48325	1.0316
3	21.475	BB	0.8337	1.11738e4	212.41016	94.3346
Totals :				1.18449e4	263.92411	



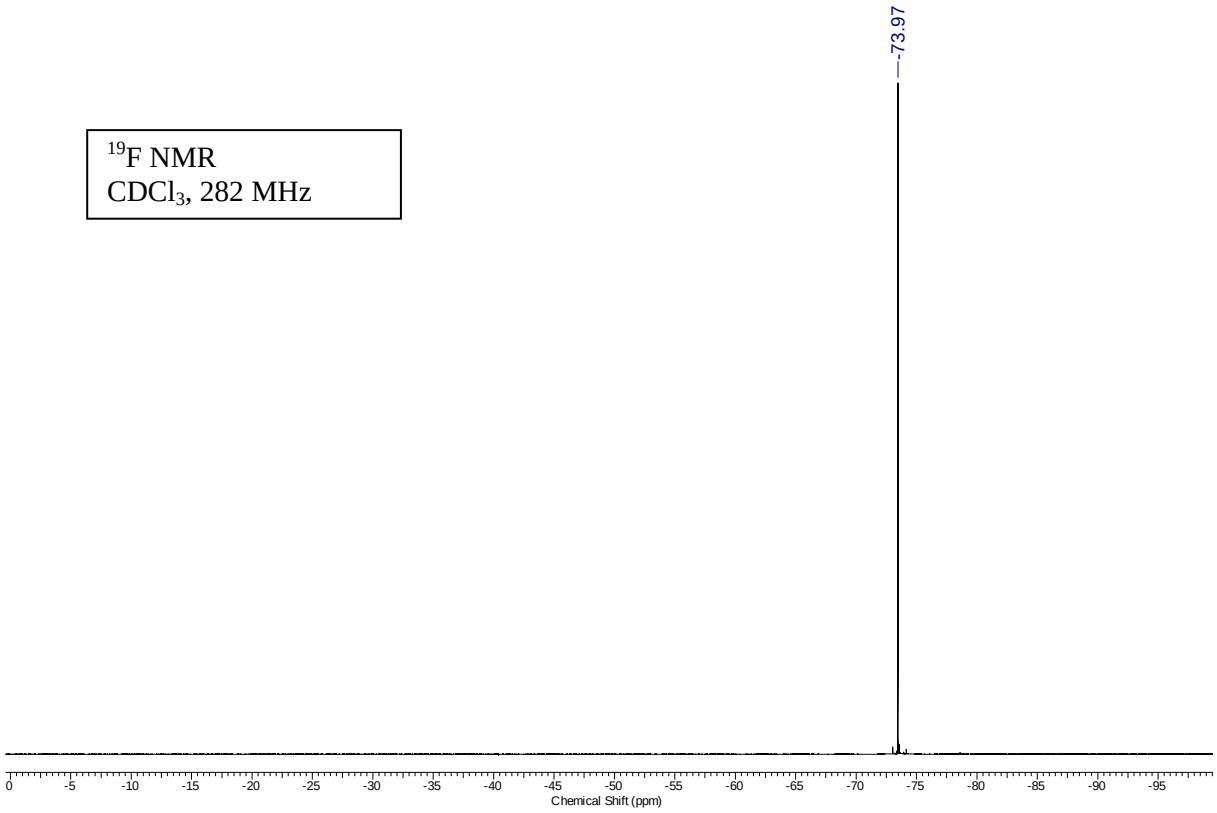
23a

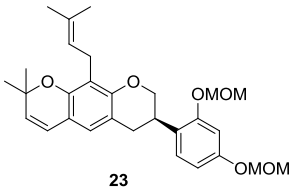
$CDCl_3$, 300 MHz

$CDCl_3$, 75 MHz



^{19}F NMR
$CDCl_3$, 282 MHz

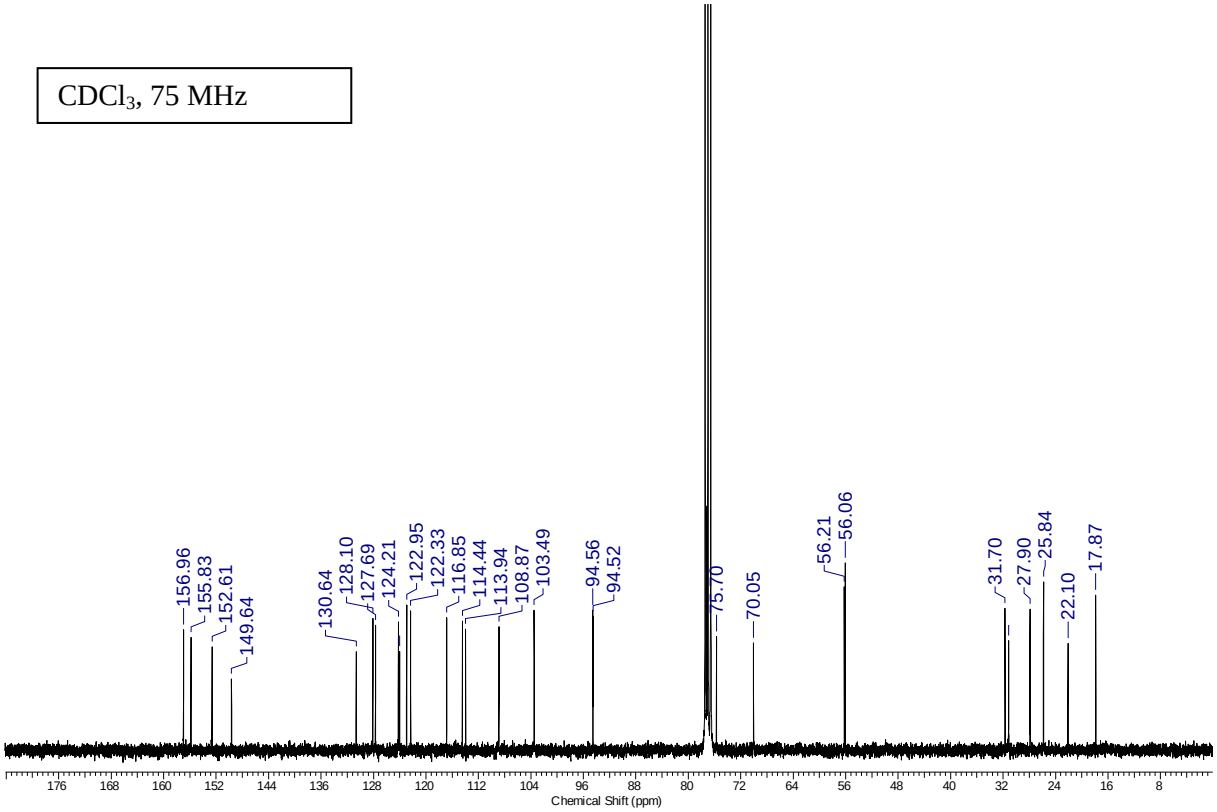




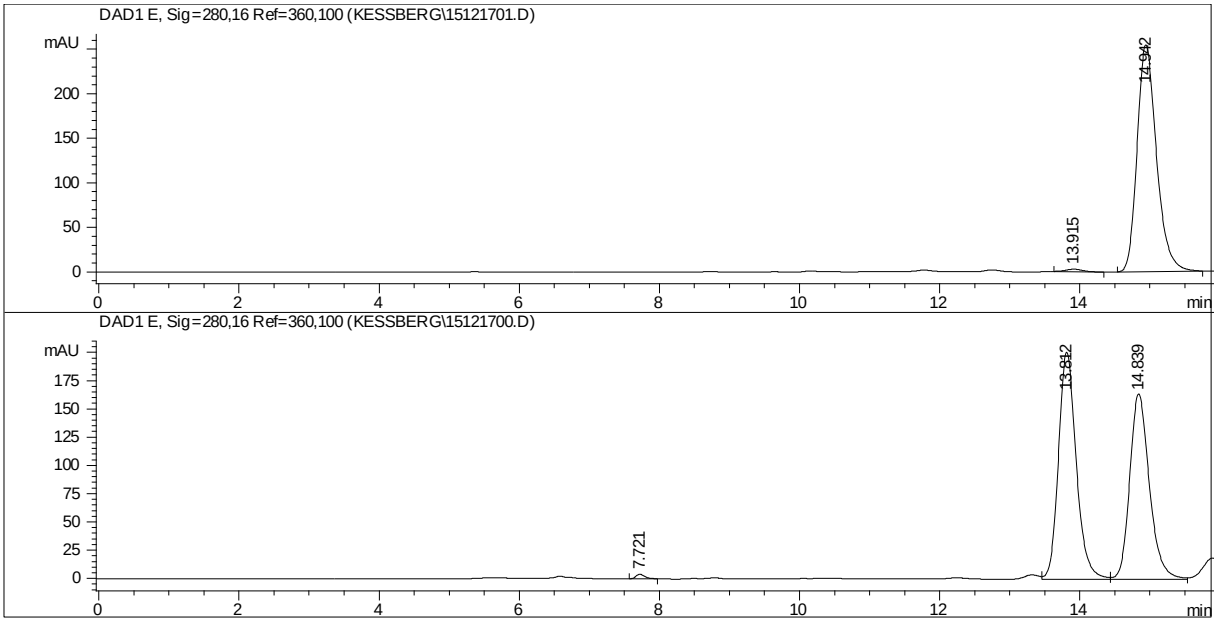
23

$CDCl_3$, 300 MHz

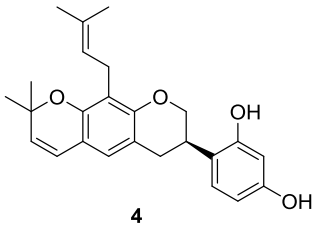
$CDCl_3$, 75 MHz



HPLC trace of racemic **23** (bottom) and (*R*)-**23** (top, 98% ee).



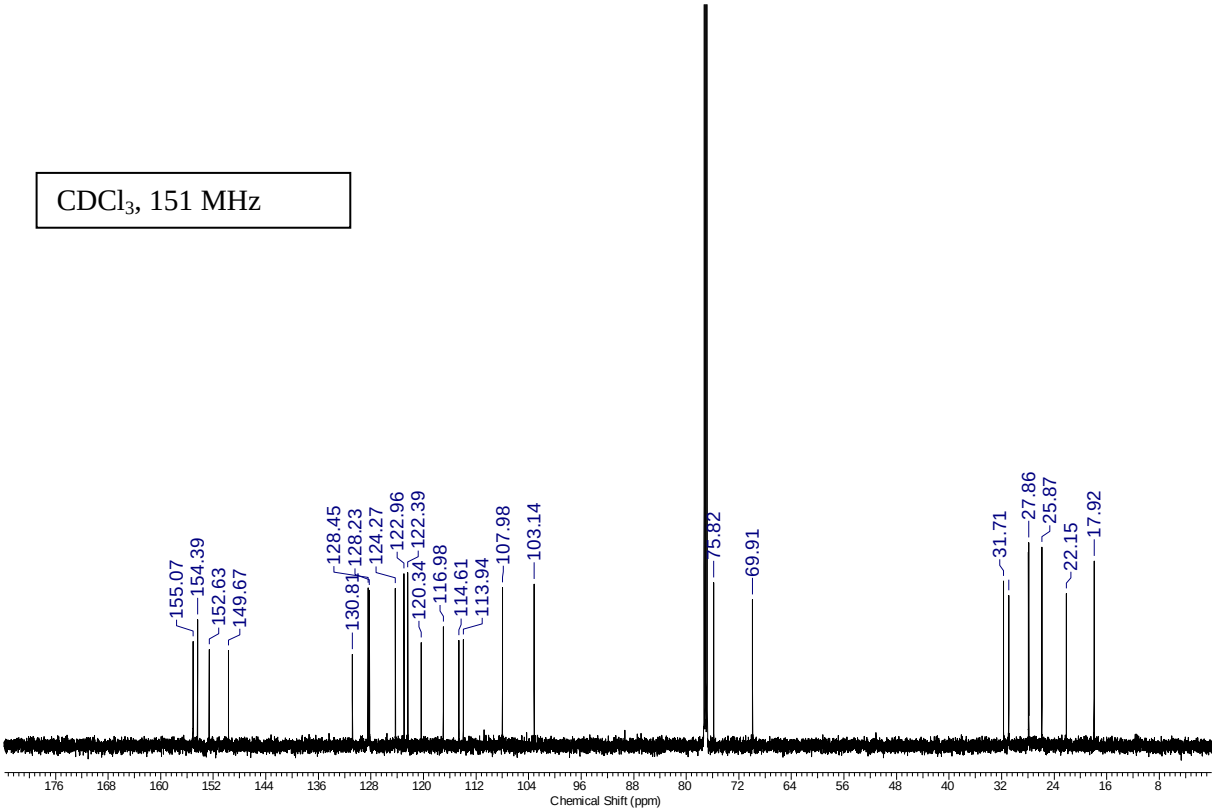
Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	13.915	BP	0.2570	49.75921	2.91659	1.0056
2	14.942	BB	0.2944	4898.51172	254.62425	98.9944
Totals :				4948.27093	257.54084	



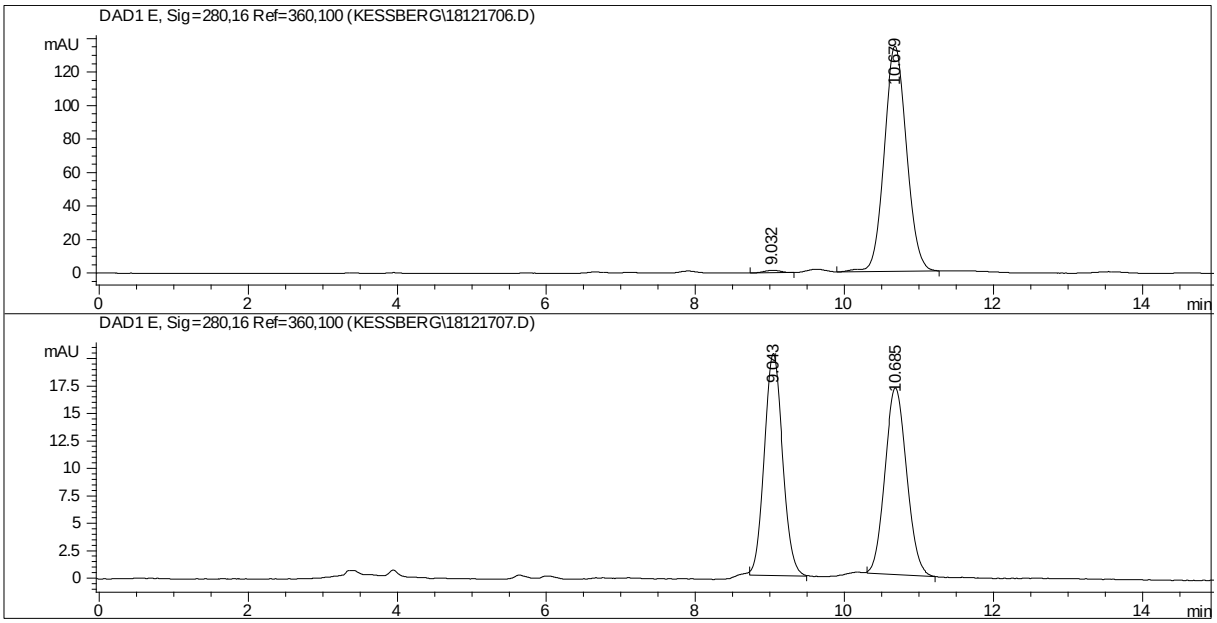
4

$CDCl_3$, 300 MHz

$CDCl_3$, 151 MHz



HPLC trace of racemic **4** (bottom) and (*R*)-**4** (top, 98% ee).



Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	9.032	PP	0.2513	23.85667	1.51817	0.8450
2	10.679	VB	0.3228	2799.30664	134.48871	99.1550
Totals :				2823.16331	136.00688	