An Enantioselective Brønsted Acid Catalyzed Enamine Mannich Reaction

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SUPPLEMENTARY INFORMATION

General experimental

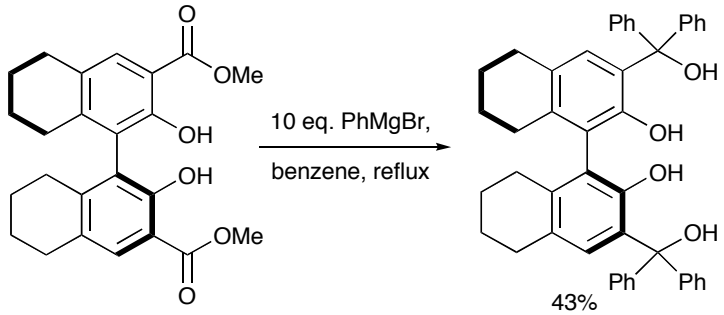
Melting points were recorded on a Gallenkamp melting point apparatus and are uncorrected. Optical rotations were recorded on a Perkin-Elmer 241 Polarimeter and $[\alpha]_D^{25}$ are given in 10^{-1} deg ml / g, concentrations are given in g / 100 ml. IR spectra were recorded on a Perkin-Elmer Spectrum 1 FTIR with an ATR sampling accessory as neat films or compressed solids; only selected absorbances are quoted. HRMS was recorded on Finnigan MAT 900XLT or a Finnigan MAT 95XP at the EPSRC National Mass Spectrometry Service. ^{1}H NMR spectra were recorded at 400 MHz on a Brucker DRX 400 spectrometer at 300 K (unless otherwise stated) against an internal deuterium lock and are reported (δ_H ± 0.01) / ppm (number of protons, multiplicity, coupling constant (J ±0.1) / Hz, assignment). ^{13}C NMR spectra were recorded on the same instrument at 100 MHz with broadband proton decoupling and are quoted (δ_C ± 0.1) / ppm (assignment).

Flash column chromatography was performed on 9385 silica gel unless otherwise stated. Chiral HPLC analysis was performed on a Hewlett-Packard

Series 1090 liquid chromatograph and retention times (r.t.) are given from the solvent front. THF was distilled from calcium hydride, lithium aluminium hydride with triphenylmethane indicator. All other reagents and solvents were used as provided without purification.

N-Boc imines **7** were prepared by the method reported by Jacobsen.[1] Imines **13a** and **13b** were prepared using the method reported by Dixon.[2] Catalysts **9** and **10** were obtained from Aldrich whilst catalysts **11a**, **b**, **c** and **f** were prepared according to the procedures reported by Schaus.[3] Catalyst **11d** was kindly donated by Isabella Villaneuva. Enamines were made using the procedure by Stork.[4]

Preparation of catalyst 11e – (S)-3,3'-Bis-(hydroxy-diphenyl-methyl)-5,6,7,8,5',6',7',8'-octahydro-1,1'-binaphthalenyl-2,2'-diol

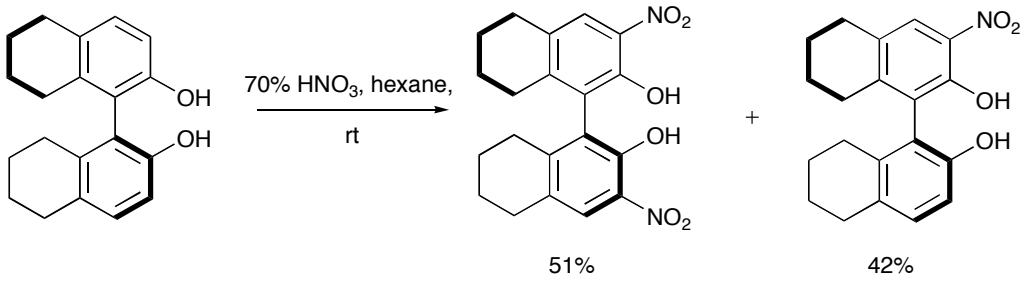


A solution of **11f** (20 mg, 0.053 mmol) in benzene (5 mL) under N_2, was treated with phenyl magnesium bromide (3.0 M solution in diethyl ether, 0.18 mL, 0.53 mmol) and refluxed for 14 hours. The reaction mixture was quenched with 1 M $HCl_{(aq)}$, extracted with dichloromethane (10 mL) and dried over Na_2SO_4. The solvent was removed *in vacuo*, and the resulting solid was purified by flash column chromatography eluting with 40-60 petroleum ether / acetone (50 / 1 to neat acetone). This produced **11e** as a white solid (14.5 mg, 0.023 mmol, 43%).

Mpt 126 ^{o}C (decomposes); $[\alpha]_D^{25}$ -49.4 (c = 0.78, $CHCl_3$); IR (film) / cm^{-1} υ_{max} = 3501 (s, O-H), 3358 (br, O-H), 1492 (Ar), 1447 (Ar); ^{1}H NMR (400 MHz; $CDCl_3$): δ_H 7.33-7.22 (20H, m, Ph), 6.24 (2H, s, 2 x $CH_2CC\mathbf{H}C$), 5.94 (2H, s, 2 x $CH_2CCCO\mathbf{H}$), 4.57 (2H, s, 2 x $Ph_2CO\mathbf{H}$), 2.51 (4H, m, 2 x $C\mathbf{H}_2CCCCOH$), 2.19

(4H, m, 2 x C**H**$_2$CCCOH), 1.65 (8H, m, 2 x CH$_2$C**H**$_2$C**H**$_2$CH$_2$); ^{13}C NMR (100 MHz; $CDCl_3$): δ_c 149.4 (CH$_2$CC**C**OH, Ar), 146.2 (Ph$_{ipso}$, Ar), 145.7 (Ph$_{ipso}$, Ar), 136.8 (CH$_2$C**C**COH, Ar), 131.0 (CH$_2$C**C**HCCOH, Ar), 129.8 (CH$_2$**C**CH, Ar), 129.0 (CH$_2$CCH**C**, Ar), 127.8 (Ph$_{meta}$, Ar), 127.8 (Ph$_{meta}$, Ar), 127.8 (Ph$_{ortho}$, Ar), 127.7 (Ph$_{ortho}$, Ar), 127.3 (Ph$_{para}$, Ar), 127.3 (Ph$_{para}$, Ar), 120.9 (CH$_2$C**C**COH, Ar), 82.5 (Ph$_2$**C**OH), 29.3 (**C**H$_2$CCH), 26.9 (**C**H$_2$CCCOH), 22.9 (**C**H$_2$), 22.9 (**C**H$_2$); m/z (ESI-Na$^+$) 681.3001; $C_{46}H_{42}O_4Na^+$ requires 681.2975.

Preparation of catalyst 11g – (S)-3,3'-dinitro-5,6,7,8,5',6',7',8'-octahydro-1,1-binaphthalenyl-2,2'-diol



A stirred solution of (*S*)-H$_8$-BINOL **11a** (50 mg, 0.17 mmol) in hexane (12 mL) at room temperature was treated with 70% nitric acid (0.2 mL). The resulting yellow reaction mixture was stirred for 20 seconds, quenched by the addition of saturated $NaHCO_3$ (10 mL) and extracted with ethyl acetate (2 x 10 mL). The combined organic layers were then washed with water (10 mL) and brine (10 mL) and dried over $MgSO_4$. The solvent was removed *in vacuo* and the resulting yellow solid was purified by flash column chromatography eluting with hexane / acetone (20 / 1 to neat acetone) to yield di-nitro **11g** (33.3 mg, 0.09 mmol, 51%) as a pale yellow solid and mono nitrated **18** (24.2 mg, 0.07 mmol, 42%) as a pale yellow solid.

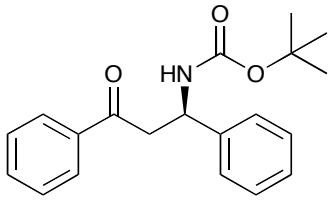
11g : Mpt 197 - 199 ^{o}C; $[\alpha]_D^{25}$ +14.7 (*c* 1.19, $CHCl_3$); IR (film) / cm^{-1} υ_{max} = 3337 (br, O-H), 1529 (NO_2), 1324 (NO_2) ; ^{1}H NMR (400 MHz; $CDCl_3$): δ_H 10.62 (2H, s, O**H**), 7.93 (2H, s, C**H**CNO$_2$), 2.83 (4H, dd, *J* 12.0, 6.0, 2 x CHCC**H**$_2$), 2.45 (2H, dt, *J* 18.4, 6.0, 2 x HOCCCC**H**$_A$H$_B$), 2.20 (2H, dt, *J* 18.4, 6.0, 2 x HOCCCCH$_A$**H**$_B$),

1.83-1.65 (8H, m, 2 x $CCH_2C\mathbf{H}_2C\mathbf{H}_2$); ^{13}C NMR (100 MHz; $CDCl_3$): δ_c 150.0 (HO**C**, Ar), 148.0 (HOCC**C**CH_2, Ar), 131.9 (NO_2**C**, Ar), 130.2 (NO_2CCH**C**, Ar), 124.9 (HOC**C**CCH_2, Ar), 124.6 (NO_2C**C**H, Ar), 29.1 (CHC**C**H_2), 27.9 (HOCCC**C**H_2), 22.3 (**C**H_2), 22.2 (**C**H_2); Elemental analyses: C, 62.72%; H, 5.22%; N, 6.79%; $C_{20}H_{20}N_2O_6$ requires C, 62.49%; H, 5.24%; N, 7.29%.

General procedure for the addition of 1,3-dicarbonyls to N-acyl imines

To a solution of imine **7** or **13** (0.125 mmol, 1 eq) and catalyst **11a** (0.025 mmol, 0.2 eq) in toluene (0.5 mL) at –30 ^oC was added enamine **6** (0.375 mmol, 3 eq). After two days the reaction was quenched by the addition of 2N HCl (0.5 mL). The organic layer was extracted with ethyl acetate (3 x 2 mL), washed with brine (1 mL) and dried over sodium sulphate. The solvent was removed *in vacuo* and the residue was purified by flash column chromatography eluting with toluene / acetone (200 / 1 to 20 / 1). This method was used to prepare:

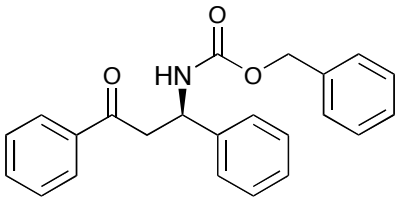
3-Oxo-1,3-diphenylpropyl-carbamic acid tert-butyl ester 8a



36 mg, 0.11 mmol, 88% from benzaldehyde *N*-(*tert*-butoxycarbonyl)imine **7a** and enamine **6a** as a white solid. Analytical Chiral HPLC (Daicel CHIRALCEL AD, 25 cm x 0.46 cm dia., 254nm), hexane / *i*-PrOH (9 / 1, 0.8 ml / min), retention times 18.12 (4829.38 mAu s), 21.62 min (24639.15 mAu s) gives 67% ee; Mpt 123 - 124 ^oC; $[\alpha]_D^{25}$ -3.63 (*c* 1.02, $CHCl_3$); IR (film) / cm^{-1} υ_{max} = 3355 (br, N-H), 1685 (C=O), 1598 (Ar), 1581 (Ar) ; ^1H NMR (400 MHz; $CDCl_3$): δ_H 7.90 (2H, dd, *J* 7.3, 1.2, 2 x COCC**H**), 7.55 (1H, tt, *J* 7.3, 1.2, COCCHCHC**H**), 7.42 (2H, t, *J* 7.3, 2 x COCHC**H**CH), 7.36-7.29 (4H, m, Ar), 7.23 (1H, tt, *J* 7.2, 1.4, NHCHCCHCHC**H**), 5.59 (1H, s, br, N**H**), 5.30 (1H, dd, *J* 8.7, 6.0, NHC**H**), 3.65 (1H, d, br, *J* 16.7, $NHCHC\mathbf{H}_AH_B$), 3.44 (1H, dd, *J* 16.7, 6.2, $NHCHCH_A\mathbf{H}_B$), 1.41 (9H, s, $OC(C\mathbf{H}_3)_3$);

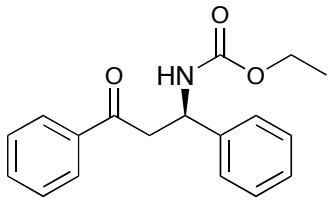
^{13}C NMR (100 MHz; $CDCl_3$): δ_c 198.2 (**C**OC_6H_5), 159.0 (**C**O$O(CH_3)_3$), 141.7 (NHCH**C**, Ar), 136.8 (CO**C**CH, Ar), 133.3 (COCCHCH**C**H, Ar), 128.5 (**C**H, Ar), 128.5 (**C**H, Ar), 128.0 (NHCHCCH**C**H, Ar), 127.2 (NHCHCCHCH**C**H, Ar), 126.2 (NHCHC**C**H, Ar), 79.6 (COO**C**$(CH_3)_3$), 51.7 (NH**C**H), 44.3 (NHCH**C**H_2), 28.3 (COOC(**C**$H_3)_3$); m/z (ESI-H^+) 326.1752; $C_{20}H_{24}NO_3^+$ requires 326.1751.

3-Oxo-1,3-diphenylpropyl-carbamic acid benzyl ester 14a



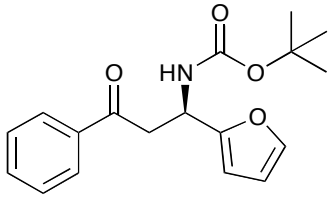
25 mg, 0.07 mmol, 55% from benzaldehyde *N*-(benzyloxycarbonyl)imine **13a** and enamine **6a** as a white solid. Analytical Chiral HPLC (Daicel CHIRALCEL AD, 25 cm x 0.46 cm dia., 254nm), hexane / *i*-PrOH (9 / 1, 0.8 ml / min), retention times 35.40 (1573.7 mAu s), 42.84 min (4922.4 mAu s) gives 52% ee; Mpt 101 – 102 ^oC; $[\alpha]_D^{25}$ -2.72 (*c* 0.63, $CHCl_3$); IR (film) / cm^{-1} υ_{max} = 3334 (br, N-H), 1687 (C=O), 1597 (Ar), 1581 (Ar); ^{1}H NMR (400 MHz; $CDCl_3$): δ_H 7.89 (2H, d, *J* 7.4, 2 x COCC**H**), 7.55 (1H, tt, *J* 7.4, 1.1, COCCHCHC**H**), 7.43 (2H, t, *J* 7.4, 2 x COCHC**H**CH), 7.36–7.26 (9H, m, Ar), 7.23 (1H, tt, *J* 6.9, 1.5, NHCHCCHCHC**H**), 5.84 (1H, s, br, N**H**), 5.33 (1H, dd, *J* 13.9, 6.0, NHC**H**), 5.12 (1H, d, *J* 12.3, COOC$\mathbf{H}_A$$H_B$$C_6H_5$), 5.08 (1H, d, *J* 12.3, COO$CH_A$$\mathbf{H}_B$$C_6H_5$), 3.70 (1H, d, br, *J* 16.8, NHCHC$\mathbf{H}_A$$H_B$), 3.46 (1H, dd, *J* 16.8, 6.0, NHCH$CH_A$$\mathbf{H}_B$); ^{13}C NMR (100 MHz; $CDCl_3$): δ_c 197.9 (**C**OC_6H_5), 155.7 (**C**OO$CH_2C_6H_5$), 141.3 (NHCH**C**, Ar), 136.7 (CO**C**CH, Ar), 136.4 (COOCH_2**C**),133.4 (**C**H, Ar), 128.6 (**C**H, Ar), 128.4 (**C**H, Ar), 128.0 (**C**H, Ar), 127.4 (**C**H, Ar), 126.3 (NHCHC**C**H, Ar), 66.8 (COO**C**$H_2C_6H_5$), 51.8 (NH**C**H), 43.9 (NHCH**C**H_2); m/z (ESI-H^+) 360.1597; $C_{23}H_{22}NO_3^+$ requires 360.1594.

3-Oxo-1,3-diphenylpropyl-carbamic acid ethyl ester 14b



23 mg, 0.08 mmol, 62% from benzaldehyde *N*-(ethoxycarbonyl)imine **13b** and enamine **6a** as a white solid. Analytical Chiral HPLC (Daicel CHIRALCEL OJ, 25 cm x 0.46 cm dia., 254nm), hexane / *i*-PrOH (98 / 2, 0.8 ml / min), retention times 33.86 (23346 mAu s), 54.64 min (8111.8 mAu s) gives 48% ee; Mpt 64 - 65 ^{o}C; $[\alpha]_D^{25}$ -3.72 (*c* 1.35, $CHCl_3$); IR (film) / cm^{-1} υ_{max} = 3327 (br, N-H), 1684 (C=O), 1597 (Ar), 1581 (Ar) ; ^{1}H NMR (400 MHz; $CDCl_3$): δ_H 7.89 (2H, dd, *J* 8.0, 1.3, 2 x COCC**H**), 7.55 (1H, tt, *J* 8.0, 1.3, COCCHCHC**H**), 7.43 (2H, t, *J* 8.0, 2 x COCHC**H**CH), 7.34 (2H, ddd, *J* 7.0, 6.3, 1.6, 2 x NHCHCCHC**H**), 7.30 (2H, dd, *J* 6.3, 1.6, 2 x NHCHCC**H**CH), 7.23 (1H, tt, *J* 7.0, 1.6, NHCHCCHCHC**H**), 5.73 (1H, s, br, N**H**), 5.30 (1H, dd, *J* 8.0, 6.0, NHC**H**), 4.10 (2H, q, *J* 7.1, COOC**H**$_2$), 3.68 (1H, d, br, *J* 16.8, NHCHC**H**$_A$H$_B$), 3.45 (1H, dd, *J* 16.8, 6.1, NHCHCH$_A$**H**$_B$), 1.21 (3H, t, *J* 7.1, CH_2C**H**$_3$); ^{13}C NMR (100 MHz; $CDCl_3$): δ_c 197.9 (**C**OC_6H_5), 156.0 (**C**OOCH_2CH_3), 141.5 (NHCH**C**, Ar), 136.9 (CO**C**CH, Ar), 133.4 (COCCHCH**C**H), 128.7 (**C**H, Ar), 128.6 (**C**H, Ar), 128.1 (NHCHCCH**C**H, Ar), 127.4 (NHCHCCHCH**C**H, Ar), 126.4 (NHCHC**C**H, Ar), 61.0 (COO**C**H$_2$), 51.7 (NH**C**H), 44.1 (NHCH**C**H$_2$), 14.5 (COOCH$_2$**C**H$_3$); m/z (ESI-H$^+$) 298.1440; $C_{18}H_{20}NO_3^+$ requires 298.1438.

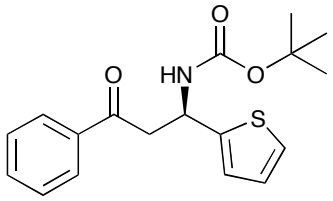
1-Furan-2-yl-3-oxo-3-phenylpropylcarbamic acid tert-butyl ester 8ab



29 mg, 0.09 mmol, 72% from 2-furanaldehyde *N*-(*tert*-butoxycarbonyl)imine **7b** and enamine **6a** as a white solid. Analytical Chiral HPLC (Daicel CHIRALCEL OG, 25 cm x 0.46 cm dia., 254nm), hexane / *i*-PrOH (95 / 5, 0.8 ml / min),

retention times 16.05 (4086.8 mAu s), 20.53 min (26789 mAu s) gives 73 % ee; Mpt 126 - 128 °C; $[\alpha]_D^{25}$ -1.33 (*c* 0.30, $CHCl_3$); IR (film) / cm^{-1} υ_{max} = 3353 (br, N-H), 1687 (C=O), 1597 (Ar), 1581 (Ar) ; ^1H NMR (400 MHz; $CDCl_3$): δ_H 7.92 (2H, d, *J* 7.2, 2 x COCC**H**), 7.56 (1H, tt, *J* 7.3, 1.2, COCCHCHC**H**), 7.45 (2H, t, *J* 7.3, 2 x COCHC**H**CH), 7.28 (1H, d, *J* 1.8, NHCHCOC**H**), 6.28 (1H, dd, *J* 3.2, 1.8, NHCHCOCHC**H**), 6.20 (1H, d, *J* 3.2, NHCHCOCHCHC**H**), 5.55 (1H, s, br, N**H**), 5.33 (1H, dt, *J* 8.6, 5.9, NHC**H**), 3.68 (1H, d, br, *J* 16.8, NHCHC$\mathbf{H}_A$$H_B$), 3.45 (1H, dd, *J* 16.8, 5.9, NHCHC$H_A$$\mathbf{H}_B$), 1.44 (9H, s, OC(C$\mathbf{H}_3$)$_3$); ^{13}C NMR (100 MHz; $CDCl_3$): δ_c 197.7 (**C**OC_6H_5), 155.1 (NHCH**C**O), 154.0 (**C**OO$(CH_3)_3$), 141.6 (NHCHCO**C**H), 136.7 (CO**C**CH, Ar), 133.4 (COCCHCH**C**H, Ar), 128.6 (**C**H, Ar), 128.1 (**C**H, Ar), 110.4 (NHCHCOCH**C**H), 106.1 (NHCHC**C**H), 79.8 (COO**C**$(CH_3)_3$), 45.8 (NH**C**H), 41.7 (NHCH**C**H_2), 28.3 (COOC(**C**$H_3)_3$); m/z (ESI-H^+) 316.1541; $C_{18}H_{22}NO_4^+$ requires 316.1543.

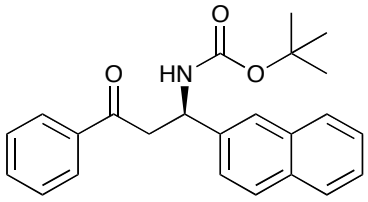
3-Oxo-3-phenyl-1-thiophen-2-ylpropylcarbamic acid tert-butyl ester 8ac



26 mg, 0.08 mmol, 64% from thiophene 2-carboxaldehyde *N*-(*tert*-butoxycarbonyl)imine **7c** and enamine **6a** as a white solid. Analytical Chiral HPLC (Daicel CHIRALCEL OD, 25 cm x 0.46 cm dia., 254nm), hexane / *i*-PrOH (9 / 1, 0.8 ml / min), retention times 11.47 (2040.1 mAu s), 13.95 min (13400 mAu s) gives 74% ee; Mpt 86 - 87 °C; $[\alpha]_D^{25}$ +6.67 (*c* 0.30, $CHCl_3$); IR (film) / cm^{-1} υ_{max} = 3353 (br, N-H), 1687 (C=O), 1597 (Ar), 1581 (Ar); ^1H NMR (400 MHz; $CDCl_3$): δ_H 7.92 (2H, d, *J* 7.2, 2 x COCC**H**), 7.56 (1H, tt, *J* 7.4, 1.2, COCCHCHC**H**), 7.45 (2H, t, *J* 7.4, 2 x COCHC**H**CH), 7.15 (1H, dd, *J* 5.0, 1.2, NHCHCSC**H**), 6.94 (1H, d, *J* 3.5, NHCHCSCHCHC**H**), 6.89 (1H, dd, *J* 5.0, 3.5, NHCHCSCHC**H**), 5.69 (1H, s, br, N**H**), 5.52 (1H, dt, *J* 8.4, 5.9, NHC**H**), 3.72 (1H, d, br, *J* 17.0, NHCHC$\mathbf{H}_A$$H_B$), 3.50 (1H, dd, *J* 17.0, 5.9, NHCHC$H_A$$\mathbf{H}_B$), 1.44 (9H, s,

OC(C**H**$_3$)$_3$); ^{13}C NMR (100 MHz; $CDCl_3$): δ_c 197.7 (**C**OC_6H_5), 155.0 (**C**OO$(CH_3)_3$), 145.8 (NHCH**C**S), 136.7 (CO**C**CH, Ar), 133.4 (COCCHCH**C**H, Ar), 128.6 (**C**H, Ar), 128.0 (**C**H, Ar), 126.7 (NHCHCSCH**C**H), 124.2 (**C**H), 124.1 (**C**H), 79.8 (COO**C**$(CH_3)_3$), 47.5 (NH**C**H), 44.4 (NHCH**C**H_2), 28.3 (COOC(**C**$H_3)_3$); m/z (ESI-Na^+) 354.1141; $C_{18}H_{21}NO_3NaS^+$ requires 354.1140. Elemental analyses: C, 65.09%; H, 6.37; N, 4.23%; $C_{18}H_{21}NO_3S$ requires C, 65.23%; H, 6.39%; N, 4.23%.

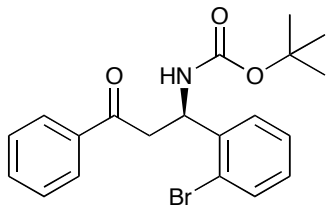
1-Naphthalen-2-yl-3-oxo-3-phenylpropylcarbamic acid tert-butyl ester 8ad



28 mg, 0.08 mmol, 64% from 2-naphthaldehyde *N*-(*tert*-butoxycarbonyl)imine **7d** and enamine **6a** as a white solid. Analytical Chiral HPLC (Daicel CHIRALCEL OD, 25 cm x 0.46 cm dia., 254nm), hexane / *i*-PrOH (9 / 1, 0.8 ml / min), retention times 16.23 (1186.31 mAu s), 17.81 min (14154.09 mAu s) gives 84% ee; Mpt 118 - 120 ^{o}C; $[\alpha]_D^{25}$ -3.05 (*c* 0.59, $CHCl_3$); IR (film) / cm^{-1} υ_{max} = 3359 (br, N-H), 1687 (C=O), 1598 (Ar), 1493 (Ar) ; ^{1}H NMR (400 MHz; $CDCl_3$): δ_H 7.92 (2H, d, *J* 7.2, 2 x COCC**H**), 7.81-7.78 (4H, m, Ar), 7.54 (1H, tt, *J* 7.3, 1.2, COCCHCHC**H**), 7.49-7.41 (5H, m, Ar), 5.66 (1H, s, br, N**H**), 5.41 (1H, dt, *J* 7.0, 6.1, NHC**H**), 3.75 (1H, d, br, *J* 16.7, NHCHC$\mathbf{H}_A$$H_B$), 3.54 (1H, dd, *J* 16.7, 6.1, NHCHC$H_A$$\mathbf{H}_B$), 1.42 (9H, s, OC(C$\mathbf{H}_3)_3$); ^{13}C NMR (100 MHz; $CDCl_3$): δ_c 198.0 (**C**OC_6H_5), 155.2 (**C**OO$(CH_3)_3$), 139.2 (NHCH**C**, Ar), 136.7 (CO**C**CH, Ar), 133.4 (COCCHCH**C**H, Ar), 133.3 (NHCHCCH**C**, Ar), 132.7 (NHCHCCHCH**C**, Ar), 128.7 (COC**C**H, Ar), 128.4 (NHCHC**C**HCH, Ar), 128.1 (COCCH**C**H, Ar), 128.0 (NHCHCCHCHC**C**H, Ar), 127.6 (NHCHCCHC**C**H, Ar), 126.1 (NHCHCCH**C**H, Ar), 125.8 (NHCHC**C**H, Ar), 125.1 (NHCHCCHCCH**C**H, Ar), 124.6 (NHCHCCHCHCCH**C**H, Ar), 79.7 (COO**C**$(CH_3)_3$), 51.6 (NH**C**H), 44.3

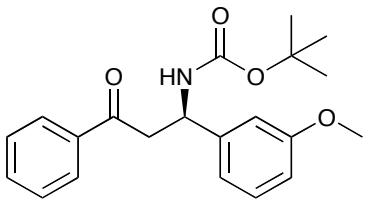
(NHCH**C**H_2), 28.4 (COOC(**C**H_3)$_3$); m/z (ESI-H^+) 376.1904; $C_{24}H_{26}NO_3^+$ requires 376.1907.

1-(2-Bromo-phenyl)-3-oxo-3-phenyl-propyl]-carbamic acid tert-butyl ester 8ae



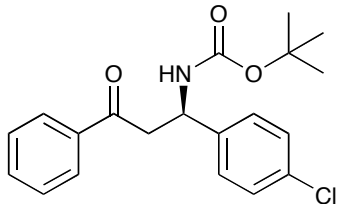
44 mg, 0.11 mmol, 86% from 2-Bromo-benzaldehyde *N*-(*tert*-butoxycarbonyl)imine **7e** and enamine **6a** as a white solid. Analytical Chiral HPLC (Daicel CHIRALCEL OD, 25 cm x 0.46 cm dia., 254nm), hexane / *i*-PrOH (95 / 5, 0.8 ml / min), retention times 11.74 (1637.12 mAu s), 14.47 min (8550.77 mAu s) gives 68% ee; Mp 124-125 ^oC; $[\alpha]_D^{25}$ -3.75 (*c* 1.20, $CHCl_3$); IR (film) / cm^{-1} υ_{max} = 3363 (br, N-H), 1687 (C=O), 1597(Ar), 1492 (Ar) ; ^1H NMR (400 MHz; $CDCl_3$): δ_H 7.90 (1H, d, *J* 7.5, COCC**H**CHCH, Ar), 7.54 (1H, t, *J* 7.5, COCCHCHC**H**), 7.51 (1H, d, *J* 7.8, BrCCC**H**), 7.48 (1H, dd, *J* 7.9, 1.4, BrCC**H**), 7.42 (2H, t, *J* 7.5, COCCHC**H**CH), 7.26 (1H, m, BrCCHCHC**H**), 7.07 (1H, t, *J* 7.8, BrCCHC**H**), 6.03 (1H, s, br, N**H**), 5.51 (1H, dd, J 13.0, 6.1, C**H**NH), 3.64 (1H, d, br NHCHC**H**$_A$H$_B$), 3.45 (1H, d, J 13.6, NHCHCH$_A$**H**$_B$), 1.40 (9H, s, br, C(C**H**$_3$)$_3$); ^{13}C NMR (100 MHz; $CDCl_3$): δ_c 198.5 (**C**OC_6H_5), 154.9 (**C**OOC$(CH_3)_3$), 140.6 (NHCH**C**, Ar), 136.6 (CO**C**CH), 133.4 (COCCHCH**C**H, Ar), 133.0 (NHCHCC**C**H, Ar) 128.8 (NHCHC**C**H, Ar), 128.6 (COC**C**H, Ar), 128.6 (NHCHCCHCH**C**H, Ar), 128.2 (COCCH**C**H, Ar), 127.6 (NHCHCCH**C**H, Ar), 122.5 (Br**C**), 79.7 (**C**$(CH_3)_3$), 51.4 (NH**C**H), 42.0 (NHCH**C**H_2), 28.3 (C(**C**H_3)$_3$); m/z (ESI-H^+) 404.0856; $C_{20}H_{23}BrNO_3^+$ requires 404.0856. Elemental analyses: C, 59.00%; H, 5.66%; N, 3.21%; Br, 19.60%; $C_{20}H_{22}NO_3Br$ requires C, 59.42%; H, 5.48%; N, 3.46%; Br, 19.76%.

1-(3-Methoxyphenyl)-3-oxo-3-phenylpropylcarbamic acid tert-butyl ester 8af



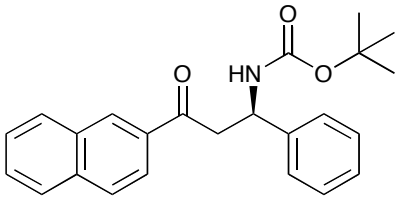
32 mg, 0.09 mmol, 72% from 3-methoxybenzaldehyde *N*-(*tert*-butoxycarbonyl)imine **7f** and enamine **6a** as a white solid. Analytical Chiral HPLC (Daicel CHIRALCEL AD, 25 cm x 0.46 cm dia., 254nm), hexane / *i*-PrOH (9 / 1, 0.8 ml / min), retention times 55.72 (38950.3 mAu s), 93.22 min (6654.86 mAu s) gives 71% ee; Mpt 78 - 80 ^{o}C; $[\alpha]_D^{25}$ -2.13 (*c* 1.22, $CHCl_3$); IR (film) / cm^{-1} υ_{max} = 3364 (br, N-H), 1685 (C=O), 1598 (Ar), 1489 (Ar) ; ^{1}H NMR (400 MHz; $CDCl_3$): δ_H 7.91 (2H, d, *J* 7.1, 2 x COCC**H**), 7.55 (1H, tt, *J* 7.4, 1.2, COCCHCHC**H**), 7.43 (2H, t, *J* 7.4, 2 x COCHC**H**CH), 7.22 (1H, t, *J* 7.9, NHCHCCHC**H**), 6.91 (1H, dd, *J* 7.9, 0.6, NHCHCC**H**CHCH), 6.89 (1H, t, *J* 2.1, NHCHCCHC**H**CH), 6.77 (1H, ddd, *J* 7.9, 2.1, 0.6, NHCHCCHCHC**H**), 5.54 (1H, s, br, N**H**), 5.22 (1H, dt, *J* 9.1, 6.0, NHC**H**), 3.77, (3H, s, OC$\mathbf{H}_3$), 3.63 (1H, d, br, *J* 16.6, NHCHC$\mathbf{H}_A$H$_B$), 3.42 (1H, dd, *J* 16.6, 6.0, NHCHCH$_A$$\mathbf{H}_B$), 1.41 (9H, s, OC(C$\mathbf{H}_3$)$_3$); ^{13}C NMR (100 MHz; $CDCl_3$): δ_c 198.0 (**C**OC_6H_5), 159.8 (CH_3O**C**, Ar), 155.2 (**C**OO$(CH_3)_3$), 143.5 (NHCH**C**, Ar), 136.8 (CO**C**CH, Ar), 133.3 (COCCHCH**C**H, Ar), 129.6 (NHCHCCH**C**H, Ar), 128.5 (COC**C**H, Ar), 128.1 (COCCH**C**H, Ar), 118.5 (CH_3OCCHCH**C**H, Ar), 112.6 (NHCHC**C**HCOCH_3, Ar), 112.3 (NHCHCCHCH**C**H), 79.6 (COO**C**$(CH_3)_3$), 55.2 (O**C**H_3), 51.4 (NH**C**H), 44.3 (NHCH**C**H_2), 28.3 (COOC(**C**H_3)$_3$); m/z (ESI-H^+) 356.1859; $C_{21}H_{25}NO_4^+$ requires 356.1856. Elemental analyses: C, 70.83%; H, 7.09%; N, 3.94%; $C_{21}H_{25}NO_4$ requires C, 73.96%; H, 7.09%; N, 3.94%.

1-(4-Chlorophenyl)-3-oxo-3-phenylpropylcarbamic acid tert-butyl ester 8ag[5]



31 mg, 0.09 mmol, 73% from 4-chlorobenzaldehyde *N*-(*tert*-butoxycarbonyl)imine **7g** and enamine **6a** as a white solid. Analytical Chiral HPLC (Daicel CHIRALCEL AD, 25 cm x 0.46 cm dia., 254nm), hexane / *i*-PrOH (9 / 1, 0.8 ml / min), retention times 18.61 (69.318 mAu s), 20.23 min (344.12 mAu s) gives 73% ee; Mpt 113-115 °C; $[\alpha]_D^{25}$ -4.2 ° (*c* 0.60, $CHCl_3$); δ_H 7.87 (2H, dd, *J* 7.4, 1.4, 2 x COCC**H**), 7.56 (1H, tt, *J* 7.4, 1.2, COCCHCHC**H**), 7.43 (2H, t, *J* 7.4, 2 x COCHC**H**CH), 7.28 (4H, s, NHCHC$_6$**H**$_4$), 5.60 (1H, s, br, N**H**), 5.21 (1H, dd, *J* 13.0, 5.9, NHC**H**), 3.64 (1H, d, br, *J* 16.9, NHCHC**H**$_A$H$_B$), 3.40 (1H, dd, *J* 16.9, 5.9, NHCHCH$_A$**H**$_B$), 1.41 (9H, s, OC(C**H**$_3$)$_3$). Elemental analyses: C, 66.41%; H, 6.19%; N, 3.72%; Cl, 9.80%; $C_{20}H_{22}NO_3Cl$ requires C, 66.78%; H, 6.16%; N, 3.89%; Cl, 9.85%.

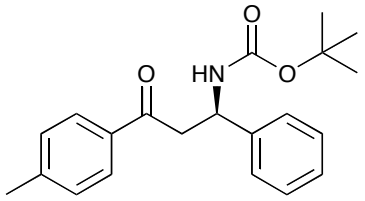
3-Naphthalen-2-yl-3-oxo-1-phenylpropyl carbamic acid tert-butyl ester 8ba



41 mg, 0.11 mmol, 88% from benzaldehyde *N*-(*tert*-butoxycarbonyl)imine **7a** and enamine **6b** as a white solid. Analytical Chiral HPLC (Daicel CHIRALCEL OD, 25 cm x 0.46 cm dia., 254nm), hexane / *i*-PrOH (95 / 5, 0.8 ml / min), retention times 25.35 (3111.5 mAu s), 30.12 min (17015.8 mAu s) gives 69% ee; Mpt 118 – 120 °C; $[\alpha]_D^{25}$ -14.97 (*c* 0.74, $CHCl_3$); IR (film) / cm^{-1} υ_{max} = 3359 (br, N-H), 1683 (C=O), 1597 (Ar), 1494 (Ar) ; ^{1}H NMR (400 MHz; $CDCl_3$): δ_H 7.92 (2H, d, *J* 7.2, 2 x COCC**H**), 7.81-7.78 (4H, m, Ar), 7.54 (1H, tt, *J* 7.3, 1.2, COCCHCHC**H**), 7.49-7.41 (5H, m, Ar), 5.66 (1H, s, br, N**H**), 5.41 (1H, dt, *J* 7.0, 6.1, NHC**H**), 3.75 (1H, d, br, *J* 16.7, NHCHC**H**$_A$H$_B$), 3.54 (1H, dd, *J* 16.7, 6.1, NHCHCH$_A$**H**$_B$), 1.42 (9H, s, OC(C**H**$_3$)$_3$); ^{13}C NMR (100 MHz; $CDCl_3$): δ_c 198.0 (**C**OC$_6$H$_5$), 155.2 (**C**OO(CH$_3$)$_3$), 141.8 (NHCH**C**, Ar), 135.7 (CO**C**CH, Ar), 134.1 (COCCH**C**, Ar), 132.4 (COCCHC**C**, Ar), 130.0 (COC**C**HC, Ar), 129.6 (COCCHC**C**H, Ar), 128.6 (NHCHCCH**C**H, Ar), 128.6 (**C**H, Ar), 128.5 (**C**H, Ar), 127.7 (COCCHCHC**C**H, Ar), 127.3 (NHCHCCHCH**C**H), 126.8 (COCCHCCH**C**H, Ar), 126.4 (NHCHC**C**H, Ar),

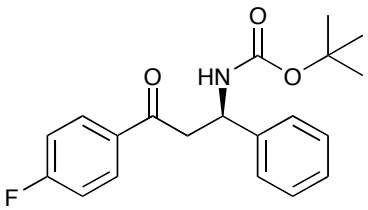
123.7 (COC**C**HCH, Ar), 79.6 (COO**C**$(CH_3)_3$), 51.6 (NH**C**H), 44.3 (NHCH**C**H_2), 28.4 (COOC(**C**$H_3)_3$); m/z (ESI-H^+) 376.1906; $C_{24}H_{26}NO_3^+$ requires 376.1907.

3-(4-Methylphenyl)-3-oxo-3-phenylpropylcarbamic acid tert-butyl ester 8ca



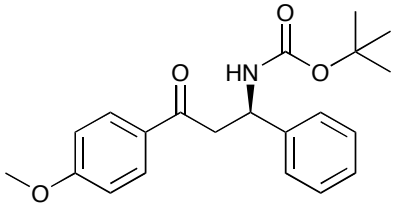
41 mg, 0.12 mmol, 98% from 4-methylbenzaldehyde *N*-(*tert*-butoxycarbonyl)imine **7a** and enamine **6c** as a white solid. Analytical Chiral HPLC (Daicel CHIRALCEL AD, 25 cm x 0.46 cm dia., 254nm), hexane / *i*-PrOH (95 / 5, 0.8 ml / min), retention times 35.91 (4651.93 mAu s), 40.77 min (23993.6 mAu s) gives 68% ee; Mpt 82 - 84 ^oC; $[\alpha]_D^{25}$ -5.07 (*c* 1.42, $CHCl_3$); IR (film) / cm^{-1} υ_{max} = 3356 (br, N-H), 1683 (C=O), 1606 (Ar), 1493 (Ar); ^1H NMR (400 MHz; $CDCl_3$): δ_H 7.79 (2H, d, *J* 8.2, 2 x COCC**H**CH), 7.35-7.28 (4H, m, $Ph_{ortho+meta}$), 7.24-7.19 (3H, m, Ar), 5.59 (1H, s, br, N**H**), 5.23 (1H, dd, *J* 12.6, 5.9, NHC**H**), 3.60 (1H, d, br, *J* 16.5, NHCHC$\mathbf{H}_A H_B$), 3.40 (1H, dd, *J* 16.5, 5.9, NHCH$CH_A\mathbf{H}_B$), 2.39 (3H, s, COCCHCHCC$\mathbf{H}_3$), 1.41 (9H, s, OC(C$\mathbf{H}_3)_3$); ^{13}C NMR (100 MHz; $CDCl_3$): δ_c 197.5 (**C**OC_6H_5), 155.2 (**C**O$O(CH_3)_3$), 144.2 (COCCHCH**C**(CH_3), Ar), 141.9 (NHCH**C**, Ar), 134.3 (CO**C**CH, Ar), 129.3 (COC**C**H, Ar), 128.5 (COCCH**C**H, Ar), 128.2 (NHCHCCH**C**H, Ar), 127.2 (NHCHCCHCH**C**H, Ar), 126.3 (NHCHC**C**HCH, Ar), 79.6 (COO**C**$(CH_3)_3$), 51.8 (NH**C**H), 44.1 (NHCH**C**H_2), 28.3 (COOC(**C**$H_3)_3$), 21.6 (COCCHCHC**C**H_3); m/z (ESI-Na^+) 362.1732; $C_{21}H_{25}NO_3Na^+$ requires 362.1732.

3-(4-Fluorophenyl)-3-oxo-1-phenylpropylcarbamic acid tert-butyl ester 8da



39 mg, 0.11 mmol, 92% from 4-fluorobenzaldehyde *N*-(*tert*-butoxycarbonyl)imine **7a** and enamine **6d** as a white solid. Analytical Chiral HPLC (Daicel CHIRALCEL OD, 25 cm x 0.46 cm dia., 254nm), hexane / *i*-PrOH (9 / 1, 0.8 ml / min), retention times 13.16 (1087.76 mAu s), 14.20 min (10378.99 mAu s) gives 81% ee; Mpt 89 - 90 °C; $[\alpha]_D^{25}$ +1.00 (*c* 0.50, $CHCl_3$); IR (film) / cm^{-1} υ_{max} = 3358 (br, N-H), 1687 (C=O), 1598 (Ar), 1506 (Ar), 1496 (Ar); ^1H NMR (400 MHz; $CDCl_3$): δ_H 7.92 (2H, dd, *J* 8.9, 5.4, 2 x COCC**H**), 7.54-7.28 (4H, m, $Ph_{ortho+para}$), 7.23 (1H, t, *J* 6.3, NHCHCCHCHC**H**), 7.10 (2H, t, *J* 8.9, 2 x COCCHC**H**CF), 5.49 (1H, s, br, N**H**), 5.23 (1H, dd, *J* 13.1, 6.2, NHC**H**), 3.64 (1H, d, br, *J* 16.4, NHCHC$\mathbf{H}_A$$H_B$), 3.40 (1H, dd, *J* 16.4, 6.2, NHCH$CH_A$$\mathbf{H}_B$), 1.41 (9H, s, OC(C$\mathbf{H}_3$)$_3$); ^{13}C NMR (100 MHz; $CDCl_3$): δ_c 198.2 (**C**OC_6H_5), 165.9 (d, *J* 255.4, **C**F, Ar), 155.2 (**C**O$O(CH_3)_3$), 141.5 (NHCH**C**, Ar), 133.2 (d, *J* 2.9, CO**C**CHCHCF, Ar), 130.8 (d, *J* 9.4, COC**C**HCHCF), Ar), 128.6 (**C**H, Ar), 127.4 (NHCHCCHCH**C**H, Ar), 126.3 (**C**H, Ar), 115.7 (d, J 21.8, COCCH**C**HCF, Ar), 79.7 (COO**C**$(CH_3)_3$), 51.6 (NH**C**H), 44.3 (NHCH**C**H_2), 28.3 (COOC(**C**H_3)$_3$); m/z (ESI-Na^+) 366.1485; $C_{20}H_{22}NO_3FNa^+$ requires 366.1481.

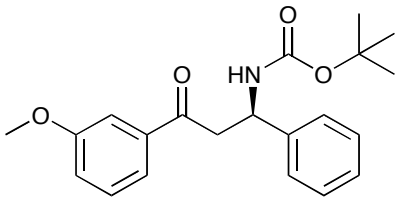
3-(4-Methoxyphenyl)-3-oxo-3-phenylpropylcarbamic acid tert-butyl ester 8ea



19 mg, 0.05 mmol, 45% from benzaldehyde *N*-(*tert*-butoxycarbonyl)imine **7a** and enamine **6f** as a white solid. Analytical Chiral HPLC (Daicel CHIRALCEL AD, 25 cm x 0.46 cm dia., 254nm), hexane / *i*-PrOH (95 / 5, 0.8 ml / min), retention times 59.40 (2209.03 mAu s), 69.22 min (13905.8 mAu s) gives 72% ee; Mpt 92 – 94 °C; $[\alpha]_D^{25}$ -8.21 (*c* 0.56, $CHCl_3$); IR (film) / cm^{-1} υ_{max} = 3402 (br, N-H), 1682 (C=O), 1596 (Ar), 1508 (Ar); ^1H NMR (400 MHz; $CDCl_3$): δ_H 7.89 (2H, d, *J* 8.8, 2

x COCC**H**CH), 7.35-7.27 (4H, m, Ar), 7.22 (1H, tt, *J* 7.0, 1.8, NHCHCCHCHC**H**), 6.89 (2H, d, *J* 8.8, 2 x $CH_3OCC\mathbf{H}CH$), 5.63 (1H, s, br, N**H**), 5.21 (1H, d, br, *J* 6.0, NHC**H**), 3.85 (3H, s, $OC\mathbf{H}_3$), 3.58 (1H, d, br, *J* 16.3, $NHCHC\mathbf{H}_AH_B$), 3.36 (1H, dd, *J* 16.3, 6.0, $NHCHCH_A\mathbf{H}_B$), 1.41 (9H, s, $OC(C\mathbf{H}_3)_3$); ^{13}C NMR (100 MHz; $CDCl_3$): δ_c 196.6 ($\mathbf{C}OC_6H_5$), 163.7 ($CH_3O\mathbf{C}$, Ar), 155.2 ($\mathbf{C}OO(CH_3)_3$), 141.9 (NHCH**C**, Ar), 130.4 (COC**C**H, Ar), 129.9 (CO**C**CH, Ar), 128.5 (NHCHCCH**C**H, Ar), 127.2 (NHCHCCHCH**C**H, Ar), 126.3 (NHCHC**C**HCH, Ar), 113.8 ($CH_3OC\mathbf{C}H$), 79.5 ($COO\mathbf{C}(CH_3)_3$), 55.5 ($\mathbf{C}H_3O$), 51.6 (NH**C**H), 43.9 ($NHCH\mathbf{C}H_2$), 28.4 ($COOC(\mathbf{C}H_3)_3$); m/z (ESI-H^+) 356.1859; $C_{21}H_{26}NO_4^+$ requires 356.1856.

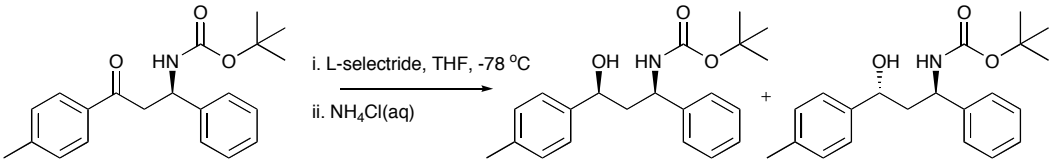
3-(3-Methoxyphenyl)-3-oxo-3-phenylpropylcarbamic acid tert-butyl ester 8fa



26 mg, 0.07 mmol, 54% from benzaldehyde *N*-(*tert*-butoxycarbonyl)imine **7a** and enamine **6e** as a white solid. Analytical Chiral HPLC (Daicel CHIRALCEL AD, 25 cm x 0.46 cm dia., 254nm), hexane / *i*-PrOH (95 / 5, 0.8 ml / min), retention times 41.38 (3249.06 mAu s), 50.95 min (13081.5 mAu s) gives 60% ee; Mpt 82 – 83 °C; $[\alpha]_D^{25}$ -2.00 (*c* 0.45, $CHCl_3$); IR (film) / cm^{-1} υ_{max} = 3362 (br, N-H), 1677 (C=O), 1596 (Ar), 1522 (Ar); ^{1}H NMR (400 MHz; $CDCl_3$): δ_H 7.48 (1H, d, *J* 7.7, $CH_3OCCHCC\mathbf{H}$), 7.41 (1H, dd, *J* 2.8, 2.8, $CH_3OCC\mathbf{H}C$), 7.36-7.29 (5H, m, Ar), 7.22 (1H, tt, *J* 6.9, 1.6, NHCHCCHCHC**H**), 7.09 (1H, ddd, *J* 8.2, 2.6, 0.6, $CH_3OCC\mathbf{H}CH$), 5.51 (1H, s, br, N**H**), 5.24 (1H, d, br, *J* 6.2, NHC**H**), 3.83 (3H, s, $OC\mathbf{H}_3$), 3.63 (1H, d, br, *J* 16.6, $NHCHC\mathbf{H}_AH_B$), 3.42 (1H, dd, *J* 16.6, 6.2, $NHCHCH_A\mathbf{H}_B$), 1.41 (9H, s, $OC(C\mathbf{H}_3)_3$); ^{13}C NMR (100 MHz; $CDCl_3$): δ_c 197.8, ($\mathbf{C}OC_6H_5$), 159.9 ($CH_3O\mathbf{C}$, Ar), 155.2 ($\mathbf{C}OO(CH_3)_3$), 141.8 (NHCH**C**, Ar), 138.1 (CO**C**CH, Ar), 129.6 (COCCH**C**H, Ar), 128.6 (NHCHCCH**C**H, Ar), 127.3 (NHCHCCHCH**C**H, Ar), 126.3 (NHCHC**C**HCH, Ar), 120.8 (COC**C**HCH, Ar), 120.0 (COCCHCH**C**H), 112.2 ($COC\mathbf{C}HCOCH_3$), 79.6 ($COO\mathbf{C}(CH_3)_3$), 55.4 ($\mathbf{C}H_3O$),

51.5 (NH**C**H), 44.4 (NHCH**C**H_2), 28.3 (COOC(**C**H_3)$_3$); m/z (ESI-Na^+) 378.1678; $C_{21}H_{25}NO_4Na^+$ requires 378.1681.

(3-Hydroxy-1-phenyl-3-*p*-tolyl-propyl)-carbamic acid *tert*-butyl ester *15*



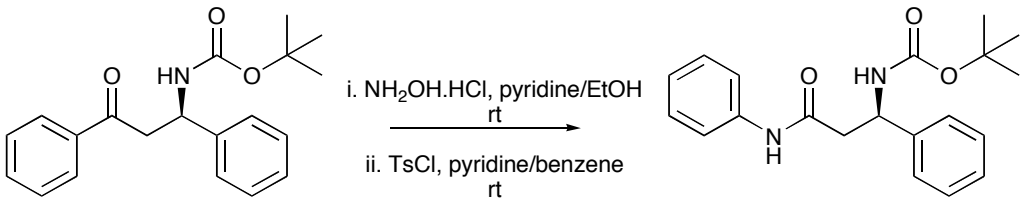
To a solution of **8ca** (25.4 mg, 0.075 mmol) in THF (2.0 mL) under argon, L-selectride (0.1 mL, 0.1 mmol, 1 M in THF) was added dropwise at –78 °C. The resulting orange coloured solution was allowed to stir at –78 °C until the reaction was observed to have gone to completion by TLC. The reaction was then quenched by the addition of saturated NH_4Cl solution (1.5 mL) and allowed to warm to room temperature. The mixture was extracted with ethyl acetate (3 x 4 mL) and the combined organics were washed with brine (5 mL) and dried over $MgSO_4$. The solvent was removed *in vacuo* and the residue was purified by flash column chromatography eluting with 40-60 pet. ether / ether (20 / 1 to 1 / 2) to yield the major diastereomer **15-maj** as an oil (20.1 mg, 0.06 mmol, 79%) and the minor diastereomer **15-min** as a white crystalline solid (2.9 mg, 0.009 mmol, 11%).

Major diastereomer **15-maj**: Analytical Chiral HPLC (Daicel CHIRALCEL OD, 25 cm x 0.46 cm dia., 254nm), hexane / *i*-PrOH (9 / 1, 0.8 ml / min), retention times 14.26 (2967.35 mAu s), 25.77 min (549.37 mAu s) gives 68% ee; $[\alpha]_D^{25}$ -1.86 (*c* 0.81, $CHCl_3$); IR (film) / cm^{-1} υ_{max} = 3353 (br, N-H, OH), 1691 (C=O); ^{1}H NMR (400 MHz; $CDCl_3$): δ_H 7.33 (2H, tt, *J* 7.3, 1.5 Ph_{meta}), 7.31-7.23 (3H, m, $Ph_{ortho+para}$), 7.20 (2H, d, *J* 8.0, 2 x OHCHCC**H**), 7.13 (2H, d, *J* 8.0, 2 x OHCHCCHC**H**), 5.14 (1H, s, br, N**H**), 4.79 (1H, s, br NHC**H**), 4.61 (1H, dd, *J* 8.8, 4.1, OHC**H**), 2.32 (3H, s, CHCHCC**H**$_3$), 2.26 (1H, dd, *J* 18.6, 8.8, NHCHC**H**$_A$H$_B$),

2.04 (1H, s, br, NHCHC**H**$_A$H$_B$), 2.04 (1H, s, br, O**H**), 1.40 (9H, s, OC(C**H**$_3$)$_3$); ^{13}C NMR (100 MHz; $CDCl_3$): δ_c 155.4 (**C**OO(CH$_3$)$_3$), 142.9 (NHCH**C**, Ar), 141.4 (OHCH**C**), 137.4 (CH$_3$**C**CH, Ar), 129.2 (CH$_3$C**C**H), 128.6 (NHCHCCH**C**H, Ar), 127.3 (NHCHCCHCH**C**H, Ar), 126.4 (NHCHC**C**HCH, Ar), 125.7 (HOCHC**C**H), 79.6 (COO**C**(CH$_3$)$_3$), 72.3 (OH**C**H), 53.5 (NH**C**H), 46.1 (NHCH**C**H$_2$), 28.3 (COOC(**C**H$_3$)$_3$), 21.0 (**C**H$_3$CCH); m/z (ESI-Na$^+$) 364.1891; $C_{21}H_{27}NO_3Na^+$ requires 364.1883.

Minor diastereomer **15-min**: Mpt 119-120 ^{o}C $[\alpha]_D^{25}$ -0.21 (*c* 0.14, $CHCl_3$); IR (film) / cm^{-1} υ_{max} = 3282 (N-H, OH), 1669 (C=O); ^{1}H NMR (400 MHz; $CDCl_3$): δ_H 7.35 (2H, t, *J* 7.6, Ph$_{meta}$), 7.33-7.26 (3H, m, Ph$_{ortho+para}$), 7.24 (2H, d, *J* 8.0, 2 x OHCHCC**H**), 7.14 (2H, d, *J* 8.0, 2 x OHCHCCHC**H**), 5.40 (1H, d, br, *J* 6.9 N**H**), 5.02 (1H, s, br NHC**H**), 4.71 (1H, dd, *J* 10.2, 2.7, OHC**H**), 3.90 (1H, s, br, O**H**), 2.34 (3H, s, CHCHCC**H**$_3$), 2.15 (1H, ddd, *J* 14.0, 10.2, 3.6 NHCHC**H**$_A$H$_B$), 2.04 (1H, ddd, *J* 14.0, 10.0, 2.7, NHCHC**H**$_A$H$_B$), 1.48 (9H, s, OC(C**H**$_3$)$_3$); ^{13}C NMR (100 MHz; $CDCl_3$): δ_c 156.5 (**C**OO(CH$_3$)$_3$), 142.0 (NHCH**C**, Ar), 141.1 (OHCH**C**), 137.0 (CH$_3$**C**CH, Ar), 129.1 (CH$_3$C**C**H), 128.7 (NHCHCCH**C**H, Ar), 127.4 (NHCHCCHCH**C**H, Ar), 126.4 (NHCHC**C**HCH, Ar), 125.7 (HOCHC**C**H), 80.0 (COO**C**(CH$_3$)$_3$), 70.7 (OH**C**H), 52.1 (NH**C**H), 46.4 (NHCH**C**H$_2$), 28.3 (COOC(**C**H$_3$)$_3$), 21.0 (**C**H$_3$CCH); Elemental analyses: C, 73.91%; H, 7.92%; N, 4.09%; $C_{21}H_{27}NO_3$ requires C, 73.87%; H, 7.97%; N, 4.10%.

(1-Phenyl-2-phenylcarbamoyl-ethyl)-carbamic acid *tert*-butyl ester 16

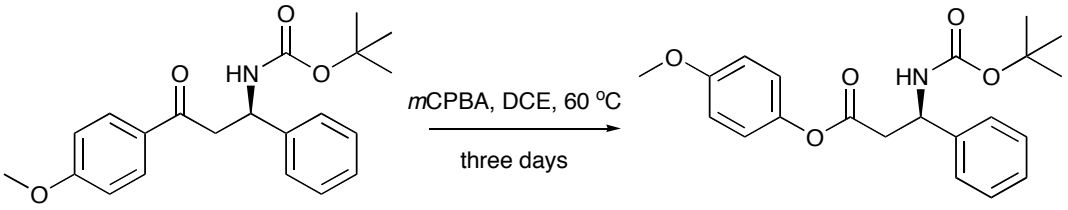


To a solution of **8a** (22 mg, 0.068 mmol) in pyridine (0.5 mL) and ethanol (0.3 mL) was added hydroxylamine hydrochloride (6 mg, 0.87 mmol). The reaction mixture was allowed to stir at room temperature overnight and was then cooled

to 0 ^{o}C, diluted with water (1 mL) and extracted with ethyl acetate (3 x 5 mL). The combined organics were then washed successively with 1N HCl (5 mL), saturated aqueous $NaHCO_3$ (5 mL) and brine (5 mL) and dried over $MgSO_4$. The solvent was removed *in vacuo* and the resulting residue (23 mg) was redissolved in pyridine (0.3 mL) and benzene (0.5 mL). Tosylchloride (13 mg, 0.068 mmol) was added and the reaction mixture was allowed to stir at room temperature overnight. The reaction was then diluted with water (1 mL) and extracted with ethyl acetate (3 x 5 mL). The combined organic extract was washed successively with 1N HCl (5 mL), saturated aqueous $NaHCO_3$ (5 mL) and brine (5 mL) and then dried over $MgSO_4$. The solvent was removed under reduced pressure and the resulting residue was purified by flash column chromatography eluting with toluene / acetone (200 / 1 to 10 /1) to yield **16** as a white solid (19 mg, 0.056 mmol, 82%).

Analytical Chiral HPLC (Daicel CHIRALCEL OD, 25 cm x 0.46 cm dia., 254nm), hexane / *i*-PrOH (95 / 5, 0.8 ml / min), retention times 9.50 (1043.08 mAu s), 13.35 min (5776.91 mAu s) gives 67% ee; Mpt 96 ^{o}C; $[\alpha]_D^{25}$ -14.00 (*c* 0.10, $CHCl_3$); IR (film) / cm^{-1} υ_{max} = 3323 (br, N-H), 1686 (C=O); ^{1}H NMR (400 MHz; $CDCl_3$): δ_H 7.58 (2H, s, br, NHCC**H**CH), 7.39-7.35 (3H, m, Ar), 7.32-7.31 (4H, m, Ar), 7.25-7.21 (1H, m, Ar), 5.47 (1H, s, br, N**H**), 4.96 (1H, s, br NHC**H**), 3.51 (1H, s, br, NHCHC$\mathbf{H}_A$H$_B$), 3.46 (1H, d, br, *J* 7.0, NHCHCH$_A$$\mathbf{H}_B$), 1.36 (9H, s, OC(C$\mathbf{H}_3$)$_3$); ^{13}C NMR (100 MHz; $CDCl_3$): δ_c 157.2 (NH**C**OCH$_2$), 155.1 (**C**OO(CH$_3$)$_3$), 142.4 (NHCH**C**, Ar), 135.0 (NH**C**CHCH, Ar), 129.5 (NHCCH**C**HCH, Ar), 128.6 (NHCHCCH**C**H, Ar), 128.6 (NHCCHCH**C**H, Ar), 127.4 (NHCHCCHCH**C**H, Ar), 126.4 (NHC**C**H, Ar), 126.0 (NHCHC**C**HCH, Ar), 79.4 (COO**C**(CH$_3$)$_3$), 53.2 (NH**C**H), 33.4 (NHCH**C**H$_2$), 28.3 (COOC(**C**H$_3$)$_3$); m/z (ESI-H$^+$) 341.1860; $C_{20}H_{25}NO_3^+$ requires 341.1860.

3-*tert*-Butoxycarbonylamino-3-phenyl-propionic acid 4-methoxy-phenyl ester 17

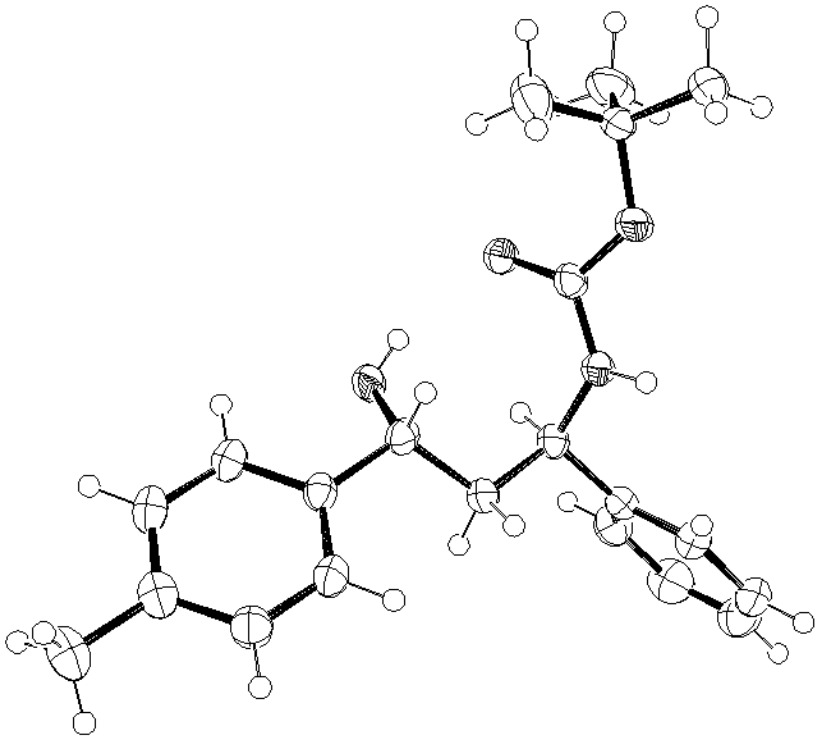


To a solution of **8fa** (30 mg, 0.085 mmol) in dichoroethane (2.5 mL) was added *m*CPBA (95.3 mg, 0.55 mmol). The reaction mixture was heated at 60 °C until the reaction was seen to have gone to completion by TLC (3 days). The mixture was allowed to cool to room temperature and ethyl actetate was added (1 mL), the reaction was then quenched by the addition of saturated aqueous $Na_2S_2O_3$ (2 mL). The resulting mixture was extracted with ethyl acetate (3 x 5 mL), the combined organics were washed with saturated aqueous $NaHCO_3$ (10 mL), brine (10 mL) and dried over Na_2SO_4. The solvent was removed *in vacuo* and the resulting residue was purified by flash column chromatography eluting with toluene / acetone (200 /1 to 20 /1) to yield **17** as a white solid (25 mg, 0.068 mmol, 80%).

Analytical Chiral HPLC (Daicel CHIRALCEL AD, 25 cm x 0.46 cm dia., 254nm), hexane / *i*-PrOH (9 / 1, 0.8 ml / min), retention times 31.65 (1410.06 mAu s), 34.31 min (7854.78 mAu s) gives 70% ee; Mpt 122-124 °C $[\alpha]_D^{25}$ -2.00 (*c* 0.45, $CHCl_3$); IR (film) / cm^{-1} υ_{max} = 3356 (br, N-H, OH), 1754 ($C{=}O_{ester}$), 1691 ($C{=}O_{carbamate}$); ^1H NMR (400 MHz; $CDCl_3$): δ_H 7.39-7.35 (4H, m, $Ph_{meta+ortho}$), 7.34-7.28 (1H, m, Ph_{para}), 6.84 (4H, s, $C_6\mathbf{H}_4OCH_3$), 5.42 (1H, s, br, N**H**), 5.21 (1H, s, br NHC**H**), 3.77 (3H, s, C$\mathbf{H}_3$O) 3.11 (1H, dd, *J* 12.1, 6.0, NHCHC$\mathbf{H}_A$H$_B$), 3.02 (1H, dd, *J* 12.1, 6.2, NHCHCH$_A\mathbf{H}_B$), 1.43 (9H, s, OC(C$\mathbf{H}_3)_3$); ^{13}C NMR (100 MHz; $CDCl_3$): δ_c 169.8 (**C**O$OC_6H_4OCH_3$), 157.3 (**C**OCH_3, Ar), 155.0 (**C**O$O(CH_3)_3$), 143.8 ($CH_3OCCHCH$**C**, Ar), 140.8 (NHCH**C**, Ar), 130.9 (NHCHCCH**C**H, Ar), 127.9 (NHCHCCHCH**C**H, Ar), 126.3 (NHCHC**C**HCH, Ar), 122.2 (CH_3OCCH**C**H),

114.4 (CH_3O**C**CHCH), 79.9 (COO**C**$(CH_3)_3$), 55.6 (**C**H_3O), 51.7 (NH**C**H), 41.2 (NHCH**C**H_2), 28.3 (COOC(**C**$H_3)_3$); m/z (ESI-Na^+) 394.1643; $C_{21}H_{25}NO_5Na^+$ requires 394.1630.

X-ray of 15-min:



[1] Wenzel, A. G.; Jacobsen, E. N. *J. Am. Chem. Soc.* **2002**, *124,* 12964.

[2] Tillman, A. L; Ye, J.; Dixon, D. J. *Chem. Commun.*, **2006**, *11*, 1191.

[3] McDougal, N. T.; Trevellini, W. L.; Rodgen, S. A.; Kliman, L. T.; Scahus, S. E. *Adv. Synth. Catal.* **2004**, *346*, 1231.

[4] Stork, G.; Brizzolara, A; Landesman, H.; Szmuszkovic, J.; Terrel, R. *J. Am. Chem. Soc.* **1963**, *85,* 207.

[5] Josephsohn, N. S.; Snapper, M. L.; Hoveyda, A. H *J. Am. Chem. Soc.* **2004**, *126,* 3734. *R*-enantiomer $[\alpha]_D^{20}$ =-4.8 ^{o} (>99% ee, *c* 1.35, $CHCl_3$).

An Enantioselective Brønsted Acid Catalyzed Enamine Mannich Reaction

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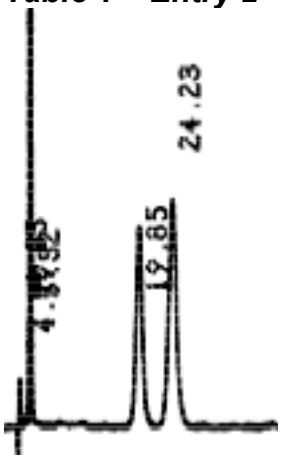
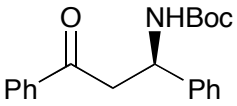
HPLC DATA

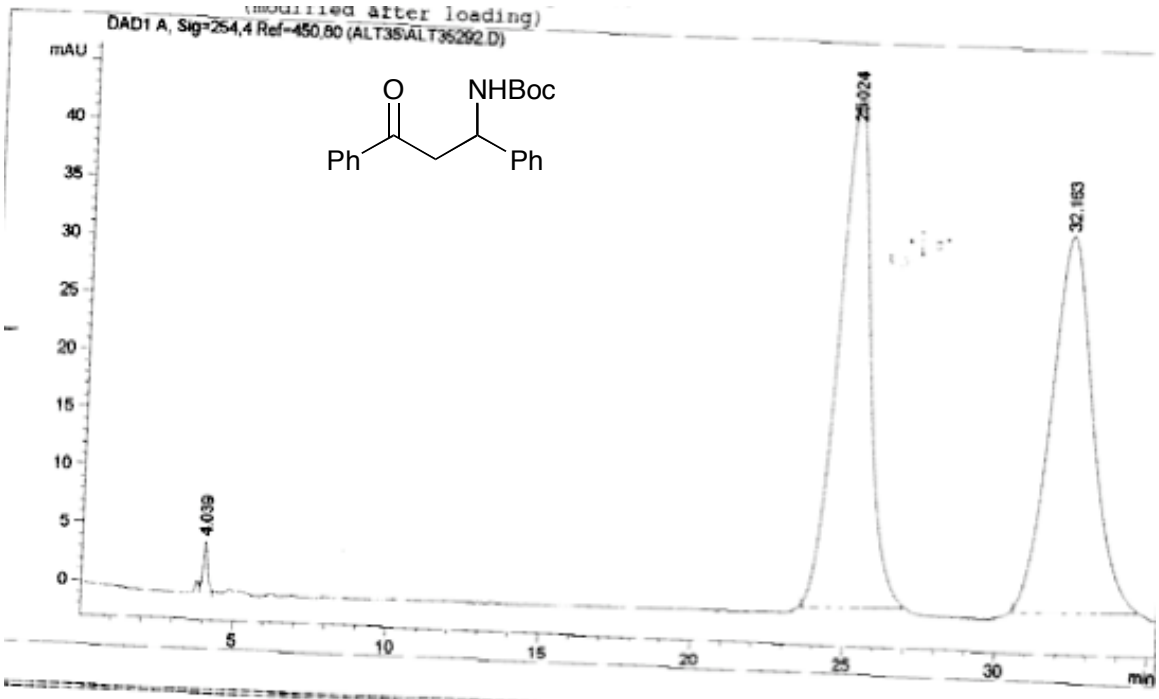
Table 1 – Entry 2





PEAK#	AREA%	RT	AREA BC
1	2.492	4.05	22705 01
2	0.308	4.77	2803 02
3	28.099	5.32	256036 03
4	28.845	19.85	262838 01
5	40.257	24.23	366826 01

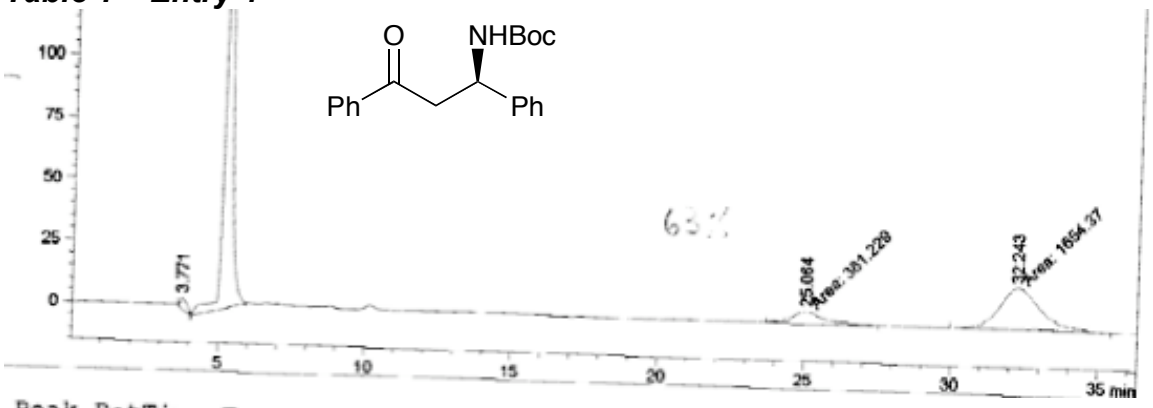
Table 1 – Entry 3



Area Percent Report

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	4.039	VB	0.1515	44.85767	4.37979	0.7017
2	25.024	BB	0.8632	3228.49951	43.95926	50.5026
3	32.163	BB	1.1462	3119.38110	32.47700	48.7957

Table 1 – Entry 4



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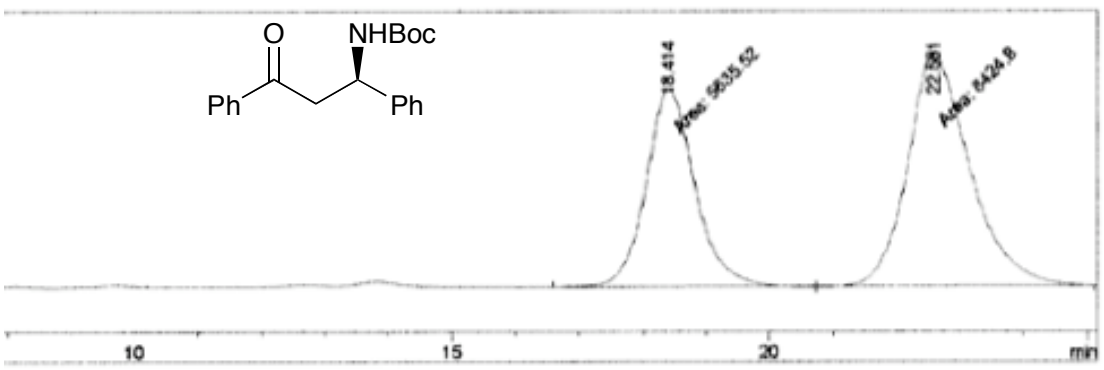
1	3.771	BP	0.2199	71.50804	4.36503	1.2947
2	5.181	VB	0.2415	3416.22900	205.98764	61.8509
3	25.064	MM	1.3534	381.22864	4.69469	6.9021
4	32.243	MM	1.6479	1654.36621	16.73165	29.9523

Table 1 – Entry 5



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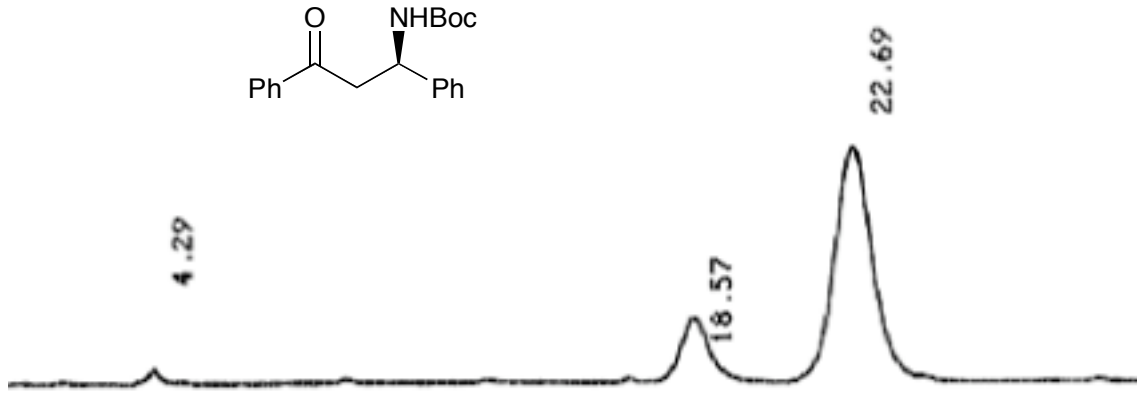
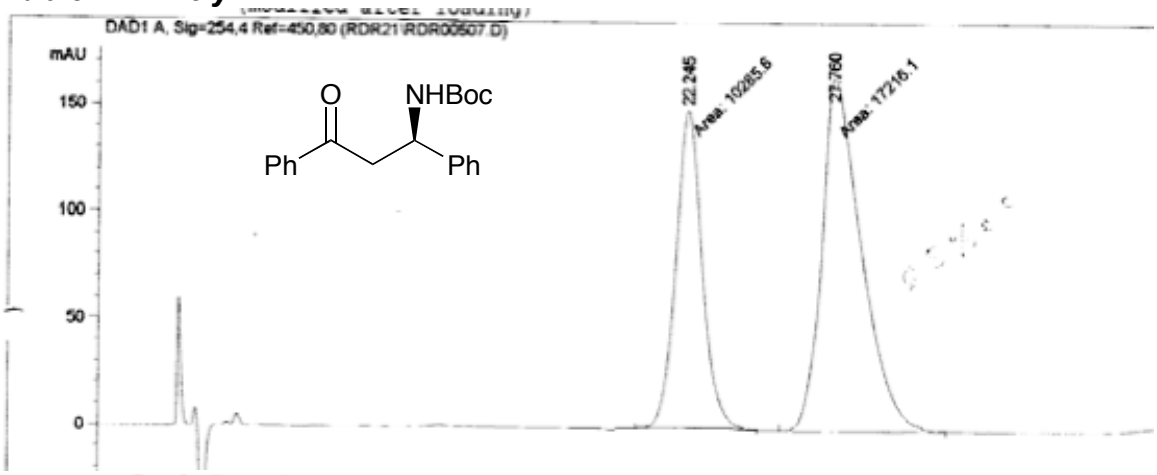
1	18.414	MF	0.8940	5635.52295	105.06309	40.0810
2	22.581	FM	1.1397	8424.79590	123.19863	59.9190

Table 1- Entry 6



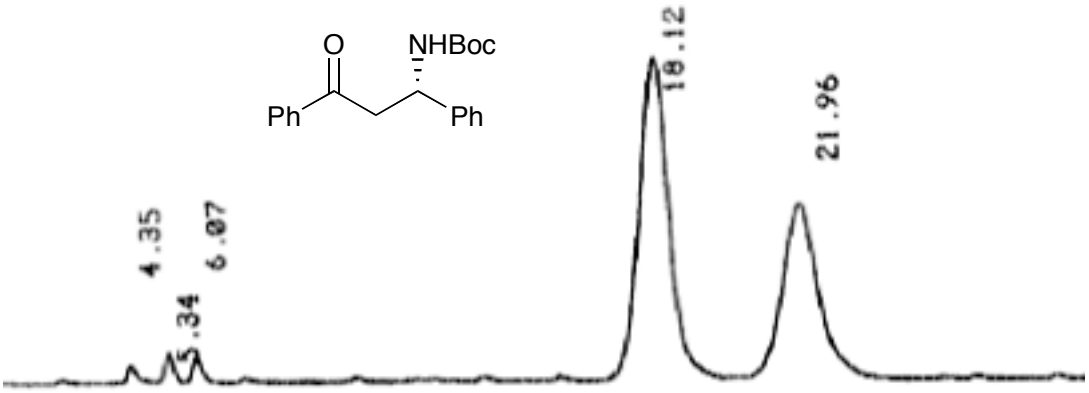
PEAK#	AREA%	RT	AREA BC
1	1.376	4.29	6229 01
2	17.355	18.57	78568 01
3	81.269	22.69	367914 01

Table 1 – Entry 7



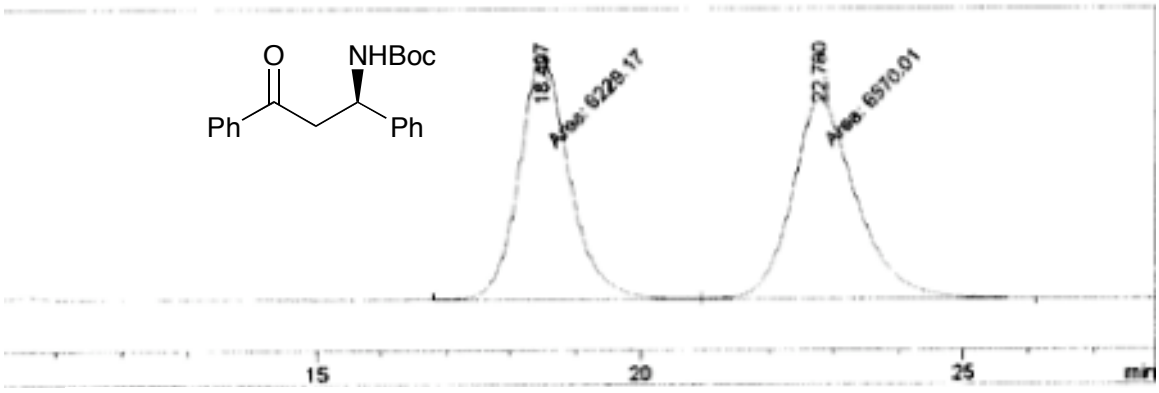
Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	22.245	MM	1.1561	1.02856e4	148.28154	37.3998
2	27.760	MM	1.7367	1.72161e4	165.21649	62.6002

Table 1 – Entry 8



PEAK#	AREA%	RT	AREA BC
1	0.655	4.35	4328 01
2	1.468	5.34	9698 01
3	1.195	6.07	7896 01
4	58.292	18.12	385102 01
5	38.39	21.96	253618 01

Table 1 – Entry 9



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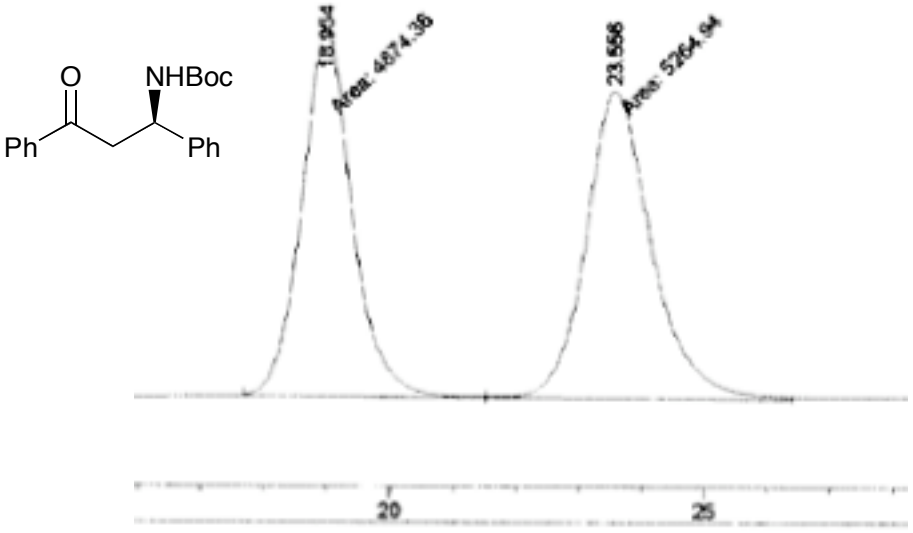
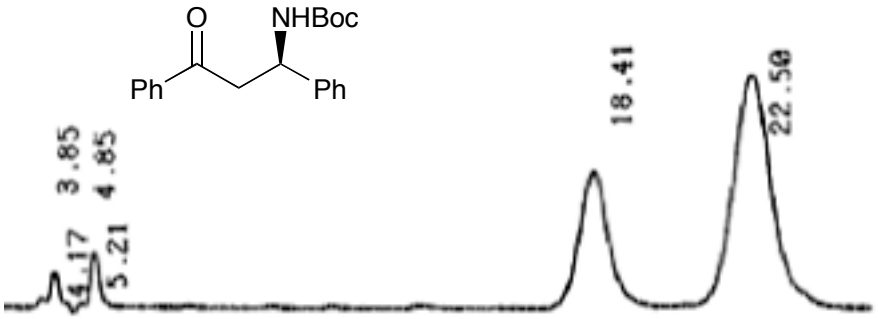
2	22.780	FM	1.1574	6570.00928	94.61230	51.3315

Table 1 – Entry 10



Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	18.954	MF	0.9326	4874.35693	87.11170	48.0739
2	23.556	FM	1.2117	5264.93994	72.41717	51.9261

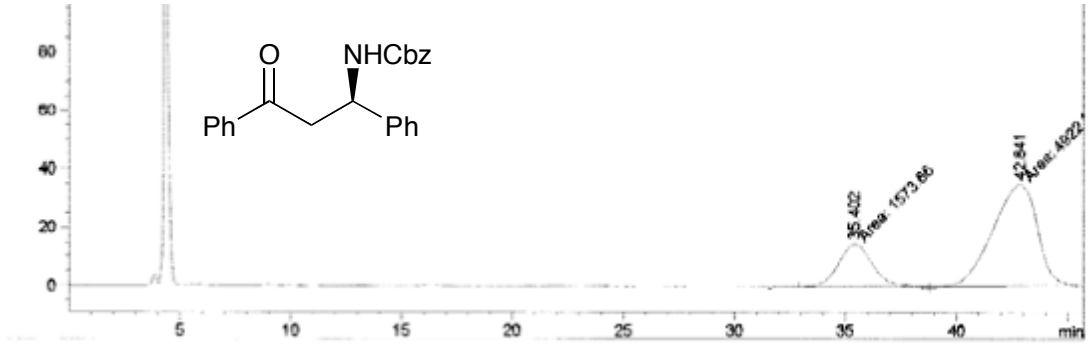
Table 1 – Entry 11



PEAK#	AREA%	RT	AREA BC
1	0.569	3.85	3215 02
2	2.65	4.17	14966 02
3	0.413	4.85	2335 02
4	3.832	5.21	21643 03
5	29.649	18.41	167440 01
6	62.886	22.5	355147 01

Table 2 – Entry 1

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	35.627	MF	1.8620	1.61061e4	144.16652	50.0591
2	45.609	FM	3.5025	1.60681e4	76.46009	49.9409



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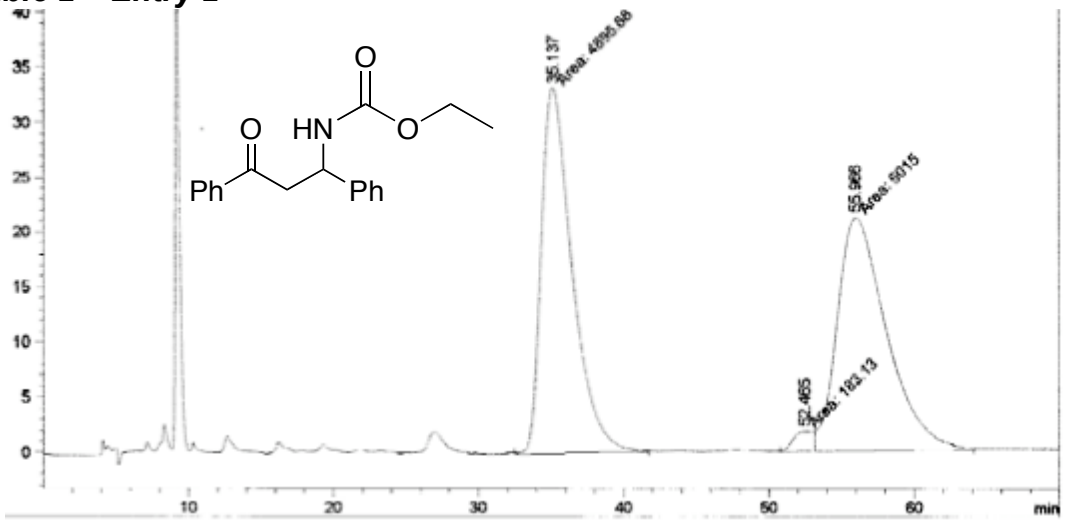
1	35.402	MF	1.7825	1573.66052	14.71424	24.2250
2	42.841	FM	2.3415	4922.36768	35.03757	75.7750

Table 2 – Entry 2



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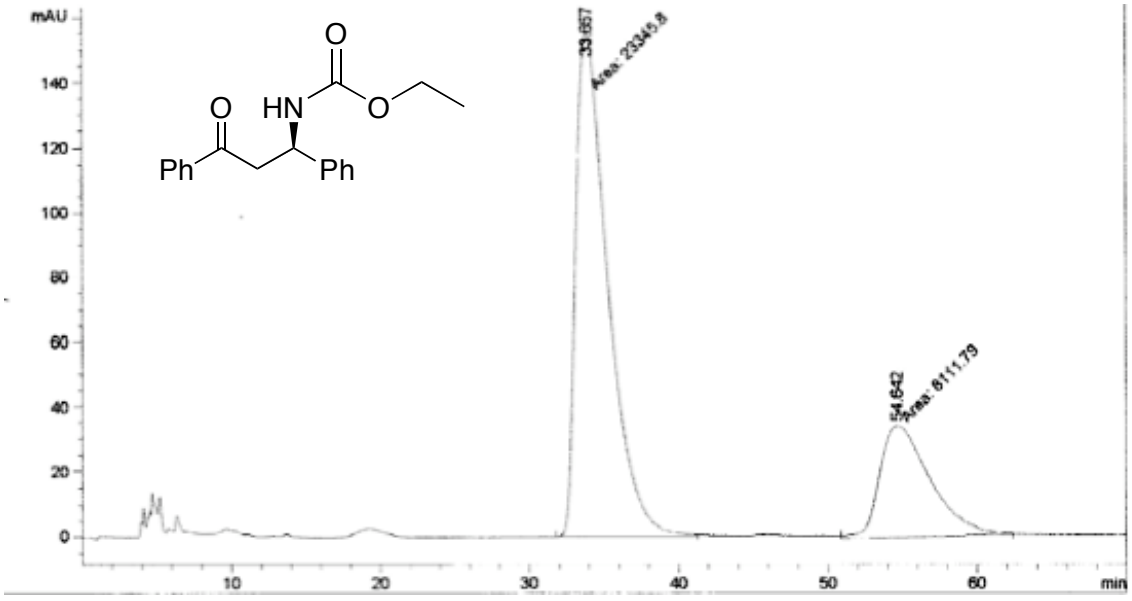
2	52.465	MF	1.6100	183.12985	1.89578	1.8143
3	55.966	FM	3.9296	5015.00000	21.27045	49.6839



Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
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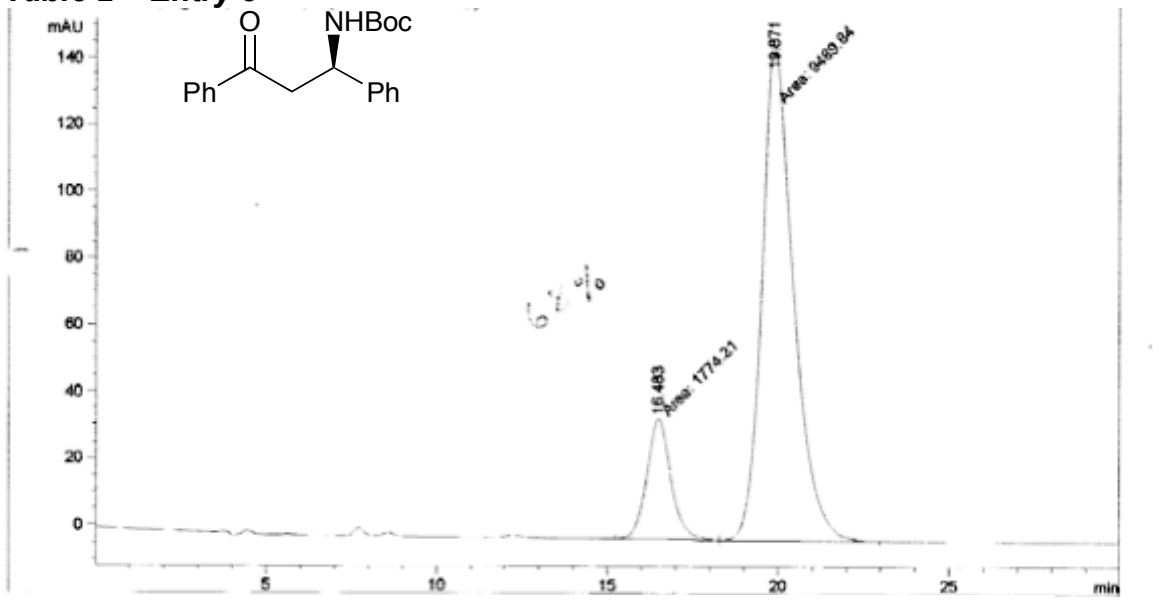
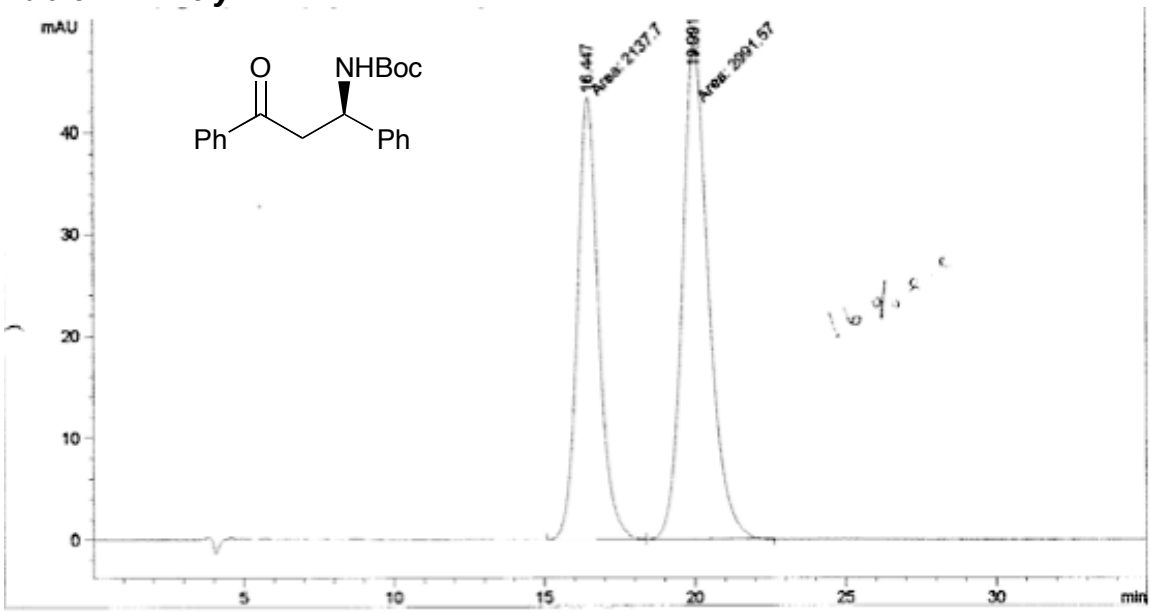
Table 2 – Entry 3



Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	16.483	MF	0.8216	1774.21350	35.99164	15.7511
2	19.871	FM	1.0668	9489.84082	148.25484	84.2489

Table 2 – Entry 4



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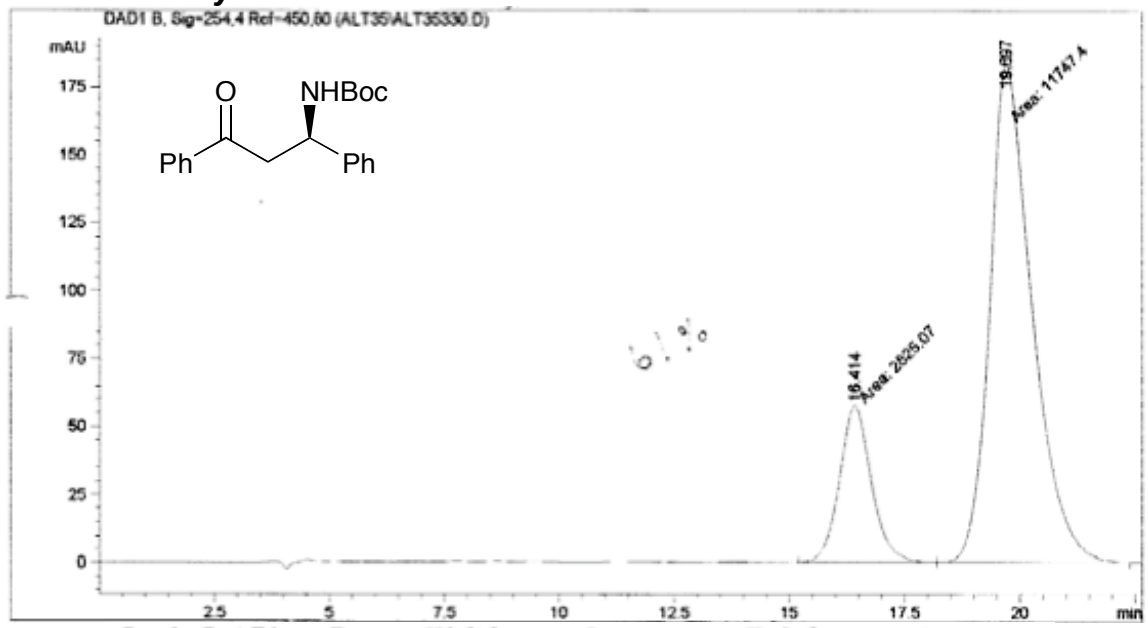
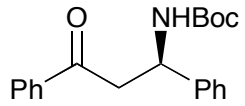
1	16.447	MF	0.8192	2137.69531	43.49226	41.6764
2	19.991	FM	1.0214	2991.57251	48.81657	58.3236

Table 2 – Entry 5



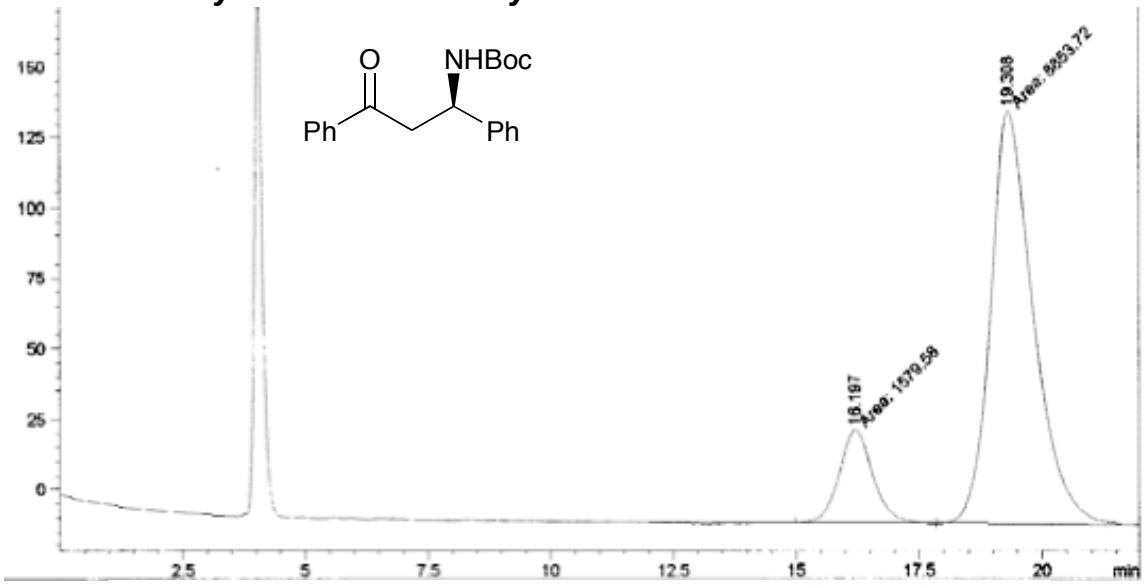
Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	16.414	MF	0.8153	2825.06665	57.75155	19.3863
2	19.697	FM	1.0655	1.17474e4	183.75905	80.6137

Table 2 – Entry 6



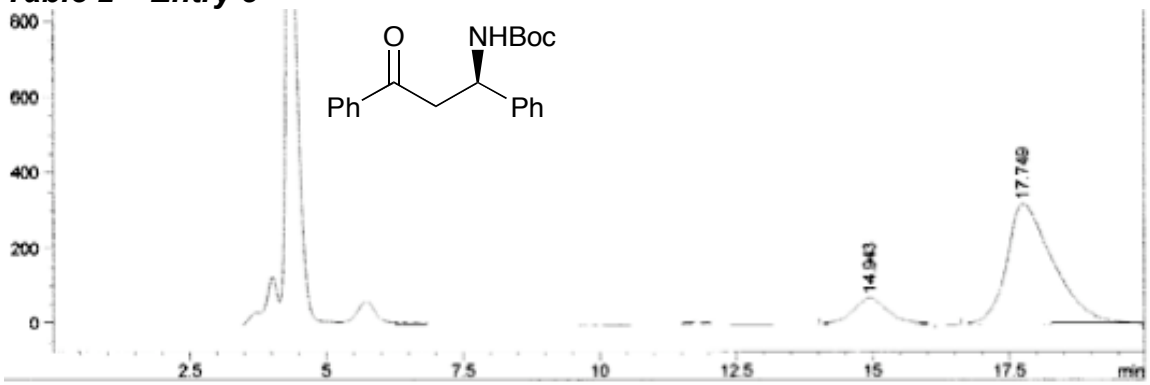
PEAK#	AREA%	RT	AREA BC
1	0.307	4.3	4886 01
2	4.948	5.45	78796 01
3	15.845	18.31	252313 01
4	78.9	21.99	1256390 01

Table 2 – Entry 7 & Table 3 – Entry 1



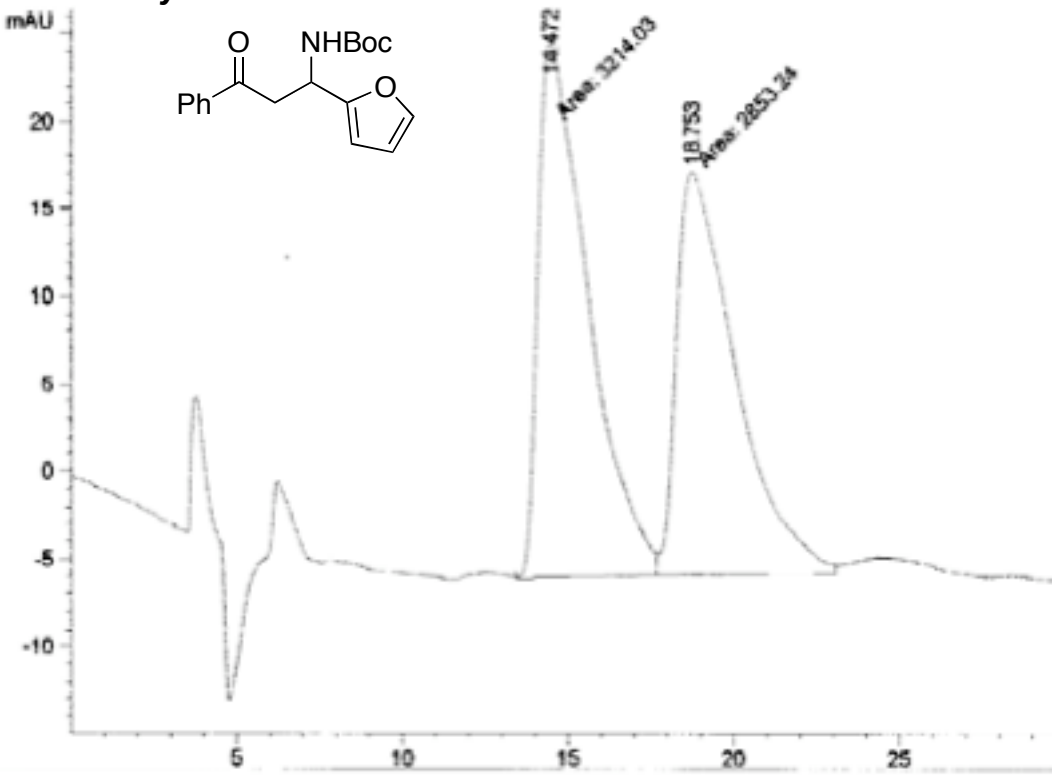
Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	16.197	MM	0.7982	1579.57739	32.98352	15.1398
2	19.308	MM	1.0062	8853.71680	146.65512	84.8602

Table 2 – Entry 8

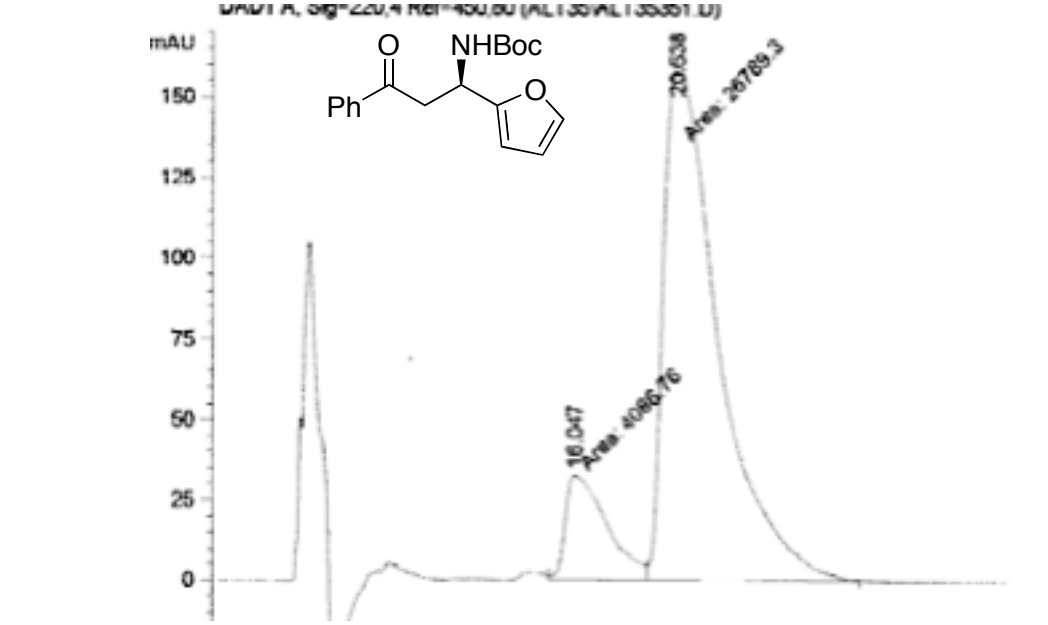


Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	14.943	BB	0.5788	3096.21875	69.73298	13.9715
2	17.749	BB	0.7897	1.90647e4	319.14929	86.0285

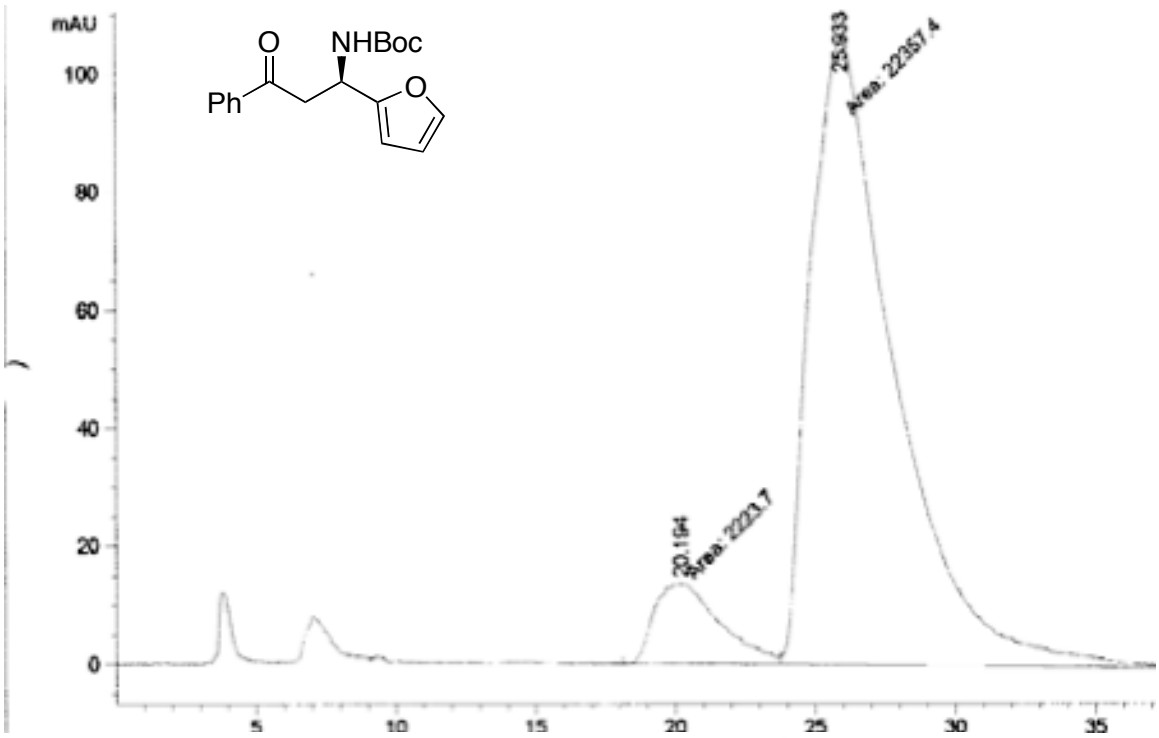
Table 3 – Entry 2



Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	14.472	MF	1.7533	3214.02808	30.55290	52.9732
2	18.753	FM	2.0592	2853.23828	23.09336	47.0268

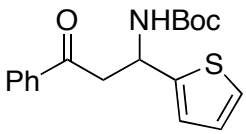


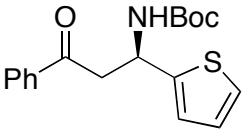
Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	16.047	MF	2.1052	4086.75977	32.35486	13.2360
2	20.538	FM	2.7973	2.67893e4	159.61227	86.7640



Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	20.194	MF	2.6996	2223.69629	13.72857	9.0464
2	25.933	FM	3.5324	2.23574e4	105.48651	90.9536

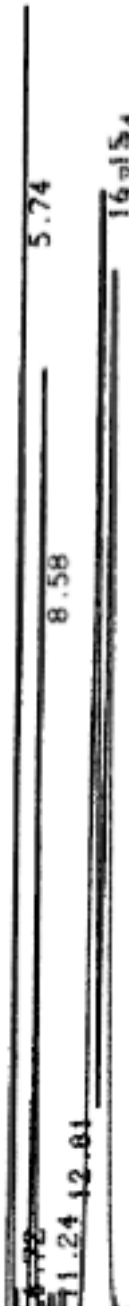
Table 3 – Entry 3

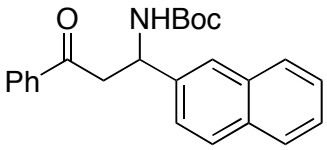


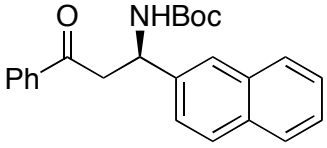


PEAK#	AREA%	RT	AREA BC
1	19.094	5.72	365381 01
2	0.219	8.36	4189 01
3	10.661	11.47	204009 01
4	70.026	13.95	1340030 01

Table 3 – Entry 4



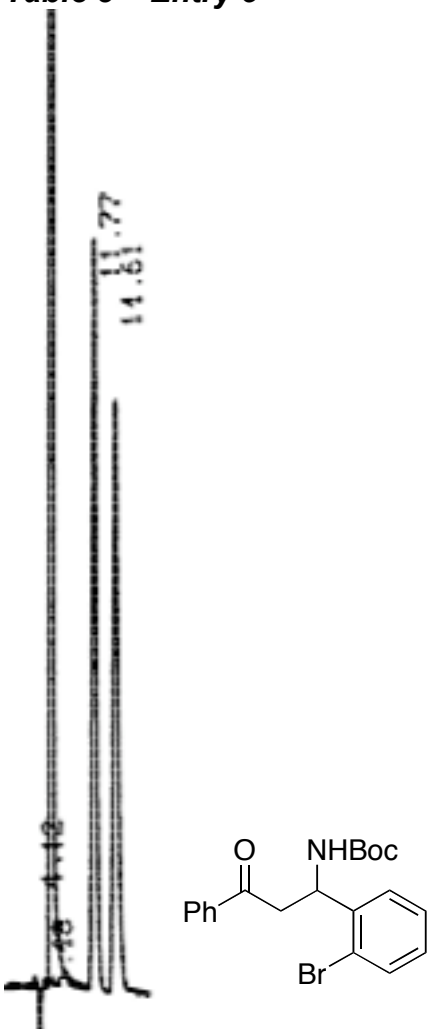


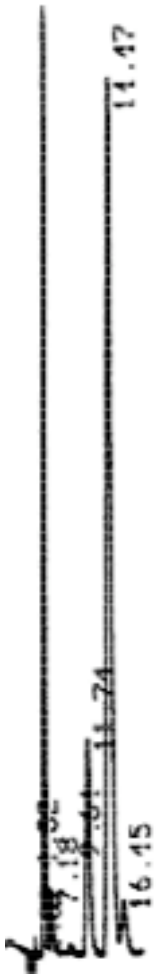


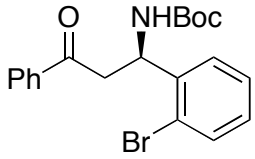
PEAK#	AREA%	RT	AREA BC
1	16.2	5.74	626828 01
2	0.277	6.72	10734 01
3	14.075	8.58	544595 01
4	0.344	11.24	13327 01
5	0.406	12.81	15711 01
6	32.664	16.15	1263871 02
7	36.034	17.74	1394295 03

#	AREA%	RT	AREA BC
1	1.21	3.46	27446 02
2	1.863	4.45	42251 02
3	1.54	5.35	34922 02
4	25.537	5.73	579202 02
5	1.565	6.57	35498 03
6	0.476	8.63	10806 01
7	0.171	10.5	3886 01
8	5.231	16.23	118631 02
9	62.406	17.81	1415409 03

Table 3 – Entry 5



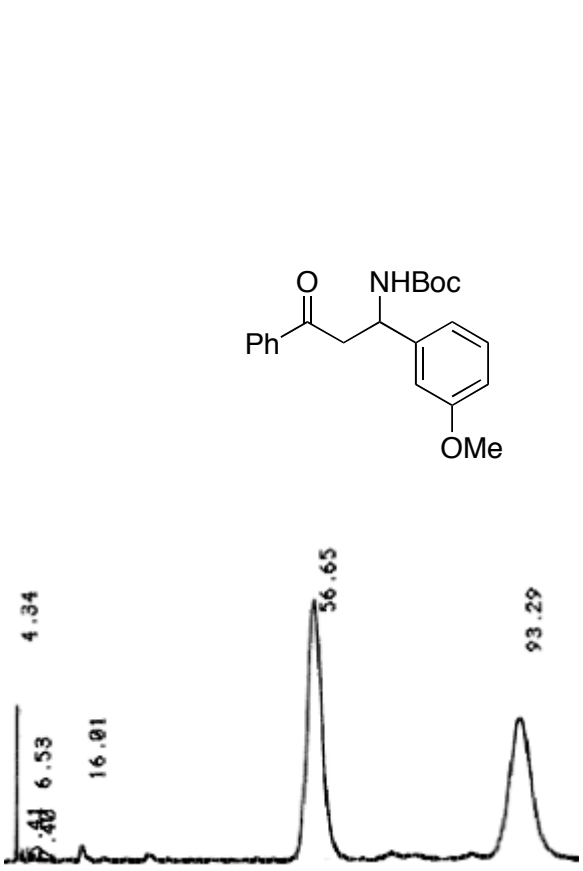


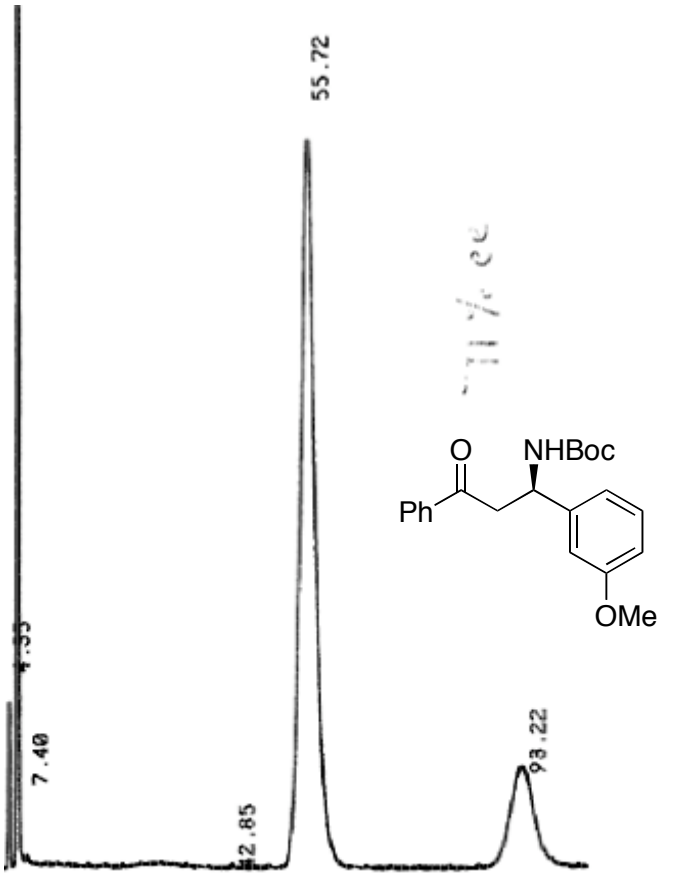


PEAK#	AREA%	RT	AREA BC
1	0.081	4.12	3925 01
2	0.047	5.48	2182 02
3	71.135	6.01	3472309 03
4	12.773	11.77	595813 01
5	12.661	14.61	590631 01

PEAK#	AREA%	RT	AREA BC
1	1.211	4.32	18114 02
2	0.557	4.89	8319 03
3	24.511	6.15	367100 01
4	1.374	7.18	20585 01
5	0.461	9.64	6909 01
6	10.931	11.74	163712 01
7	57.093	14.47	855077 02
8	3.86	16.15	57811 03

Table 3 – Entry 6

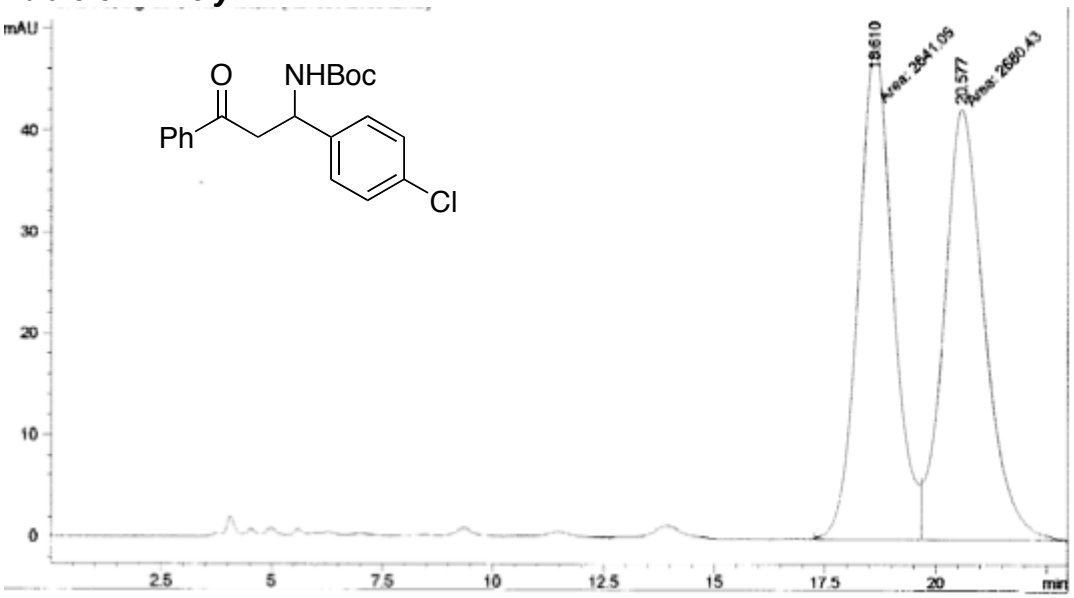




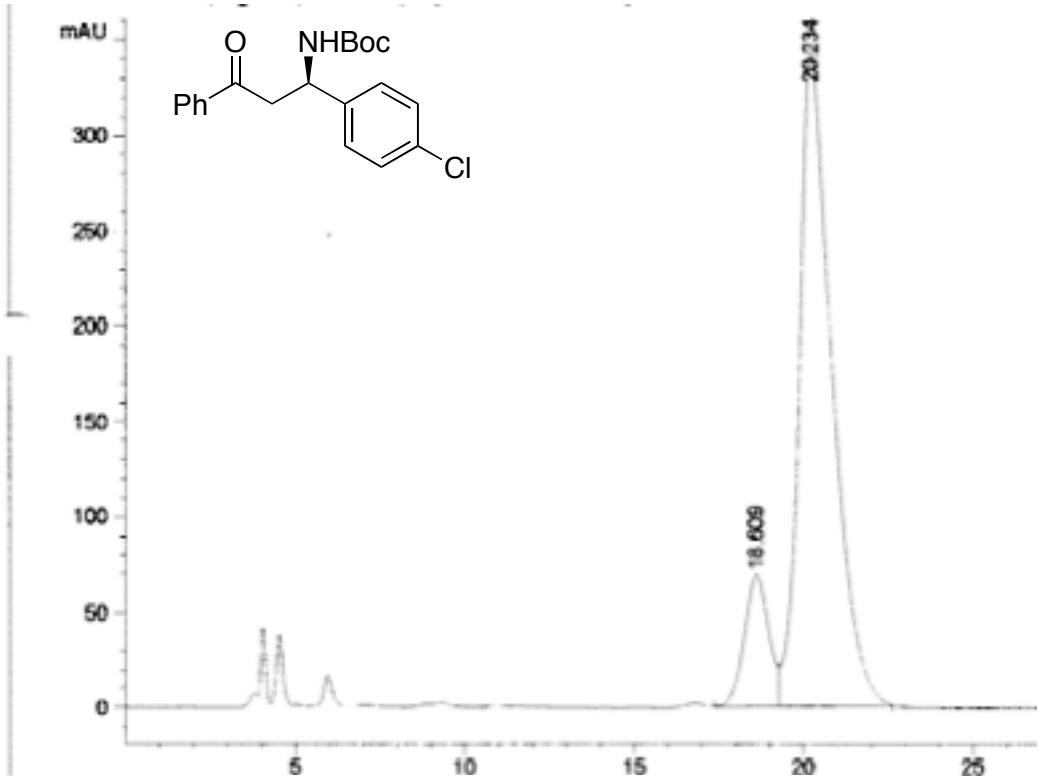
PEAK#	AREA%	RT	AREA BC
1	2.699	4.34	69852 01
2	0.205	5.41	5308 01
3	0.075	6.53	1939 01
4	0.111	7.4	2876 01
5	0.686	16.01	17755 01
6	54.75	56.65	1417032 01
7	41.474	93.29	1073434 01

PEAK#	AREA%	RT	AREA BC
1	1.361	4.35	78121 01
2	19.062	5.75	1093815 01
3	0.061	7.4	3482 01
4	0.037	42.85	2117 01
5	67.881	55.72	3895026 01
6	11.598	93.22	665486 01

Table 3 – Entry 7

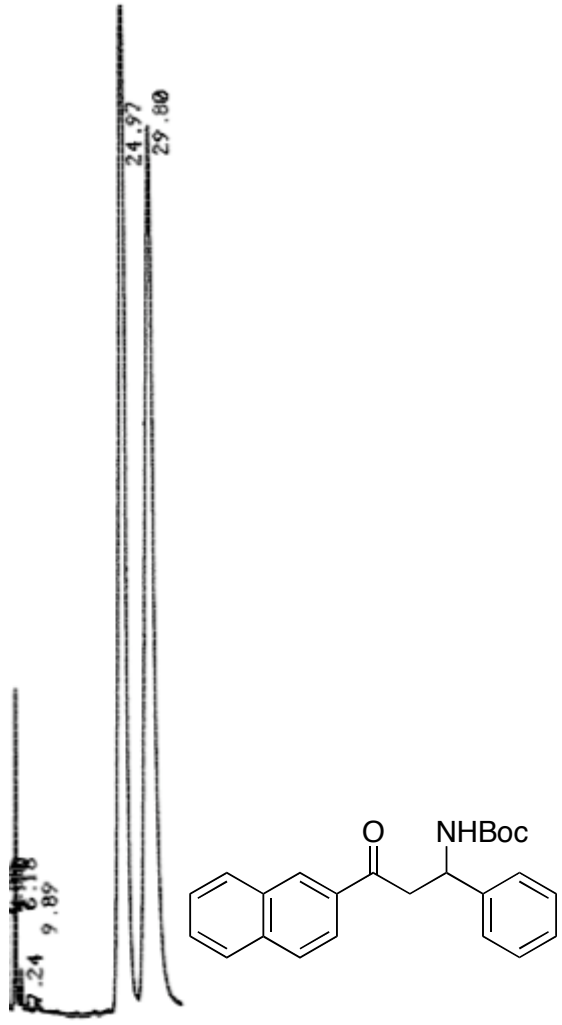


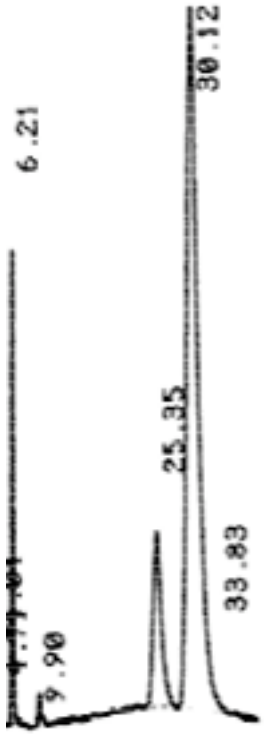
Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	18.610	MF	0.9065	2641.05225	48.55785	49.6300
2	20.577	FM	1.0553	2680.43335	42.33384	50.3700

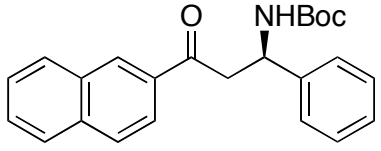


Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	18.609	VV	0.6093	3506.03467	69.31760	13.2122
2	20.234	VB	0.8608	2.30304e4	344.11658	86.7878

Table 3 – Entry 8



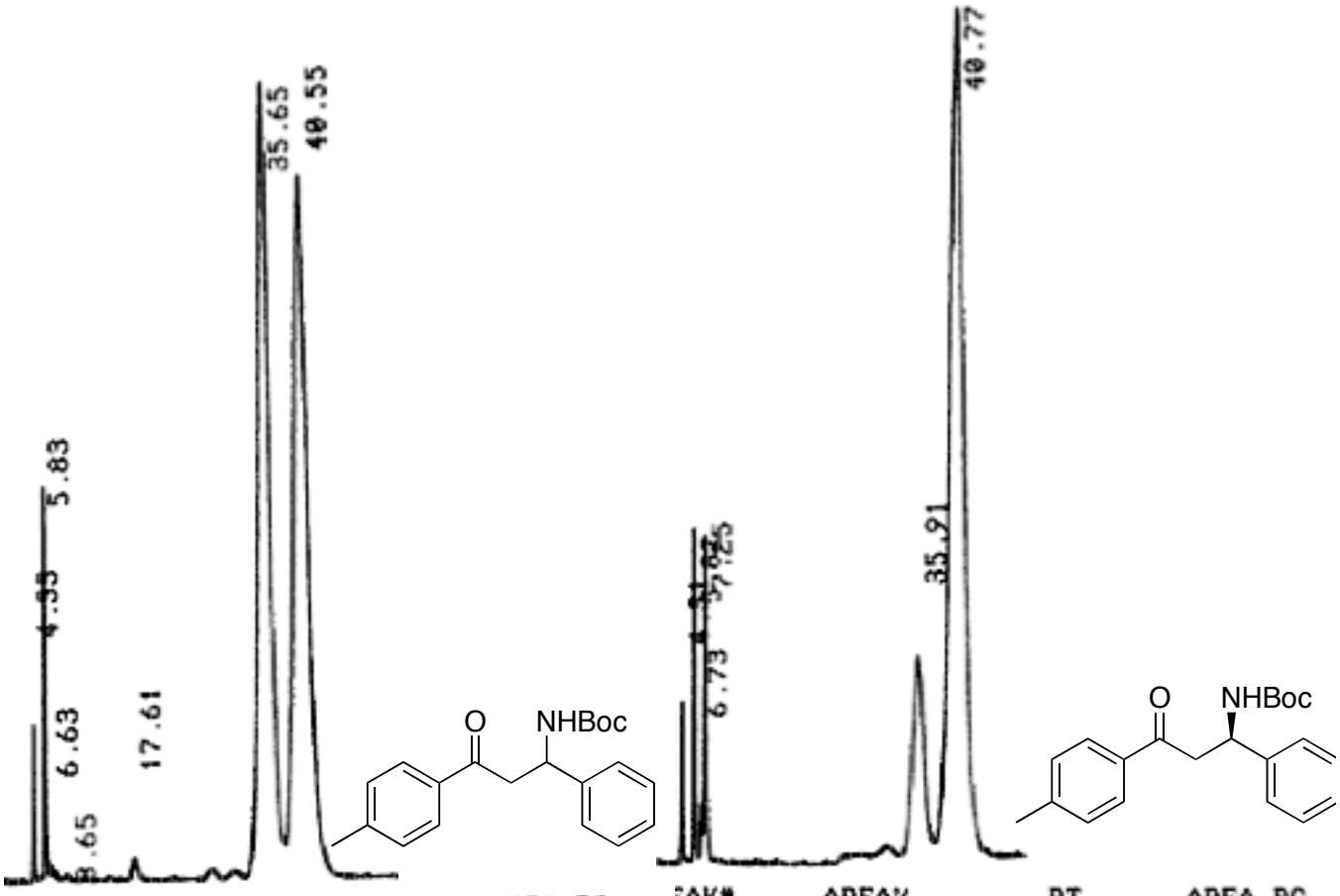




PEAK#	AREA%	RT	AREA BC
1	0.124	4.03	7477 01
2	0.699	4.7	42180 01
3	2.915	6.18	175910 02
4	0.388	7.24	23395 03
5	0.071	9.89	4292 01
6	47.487	24.97	2865599 02
7	48.316	29.8	2915649 03

PEAK#	AREA%	RT	AREA BC
1	0.145	4.04	3245 01
2	0.757	4.71	16942 01
3	8.374	6.21	187495 01
4	0.649	9.9	14521 01
5	13.898	25.35	311153 01
6	76.	30.12	1701579 02
7	0.177	33.83	3974 03

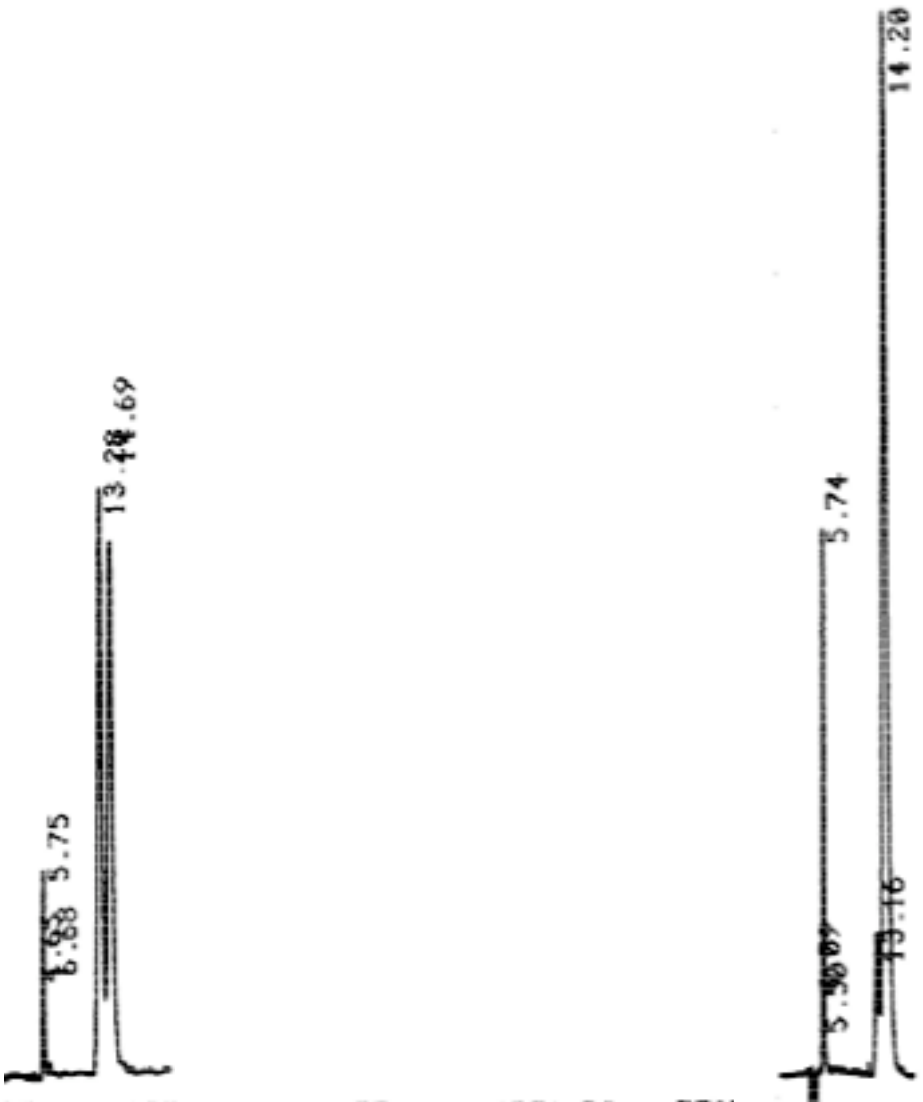
Table 3 – Entry 9



PEAK#	AREA%	RT	AREA	BC
1	1.318	4.33	54344	01
2	3.563	5.83	146927	01
3	0.077	6.63	3192	01
4	0.075	8.65	3105	01
5	0.633	17.61	26122	01
6	46.936	35.65	1935775	02
7	47.397	40.55	1954783	03

PEAK#	AREA%	RT	AREA	BC
1	1.732	4.31	55850	01
2	3.997	5.82	128860	02
3	0.72	6.73	23206	02
4	4.693	7.25	151277	03
5	14.43	35.91	465193	02
6	74.428	40.77	2399355	03

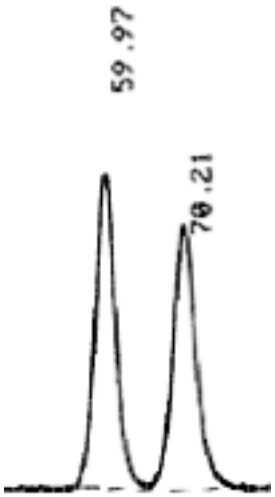
Table 3 – Entry 10

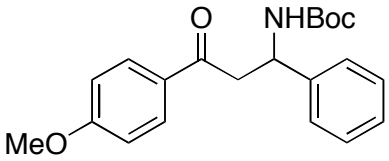


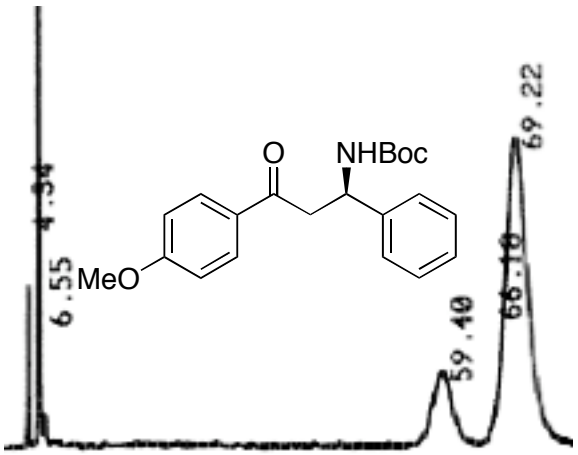
PEAK#	AREA%	RT	AREA BC
1	0.15	4.65	1730 01
2	6.509	5.75	75190 01
3	0.432	6.68	4992 01
4	45.707	13.28	528001 02
5	47.202	14.69	545279 03

PEAK#	AREA%	RT	AREA BC
1	4.093	4.09	62635 02
2	5.618	5.5	85960 02
3	15.351	5.74	234894 03
4	7.109	13.16	108776 02
5	67.829	14.2	1037899 03

Table 3 – Entry 11



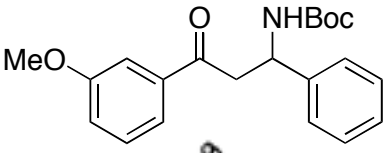


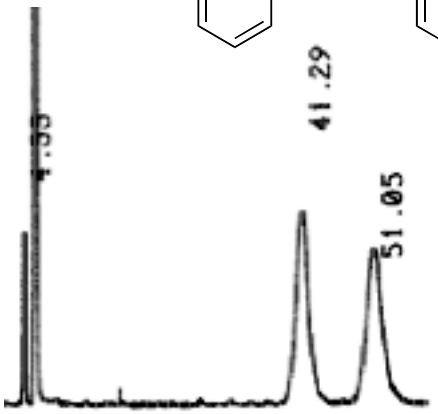


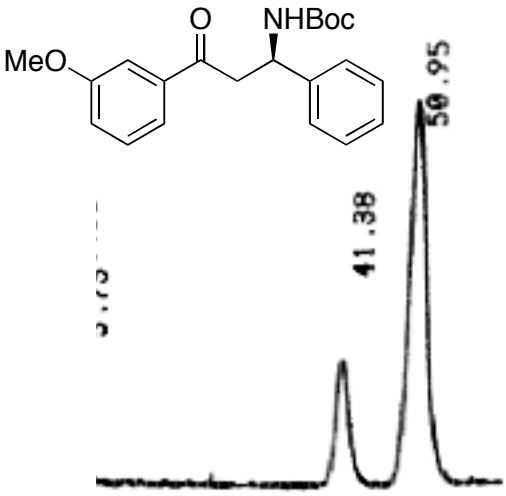
PEAK#	AREA%	RT	AREA BC
1	2.102	4.33	58146 01
2	10.442	5.75	288887 01
3	45.119	59.97	1248205 01
4	42.337	70.21	1171247 01

PEAK#	AREA%	RT	AREA BC
1	2.8	4.34	54795 01
2	14.514	5.74	284017 01
3	0.333	6.55	6526 01
4	11.289	59.4	220903 01
5	0.382	66.18	7479 02
6	70.681	69.22	1383103 03

Table 3 – Entry 12



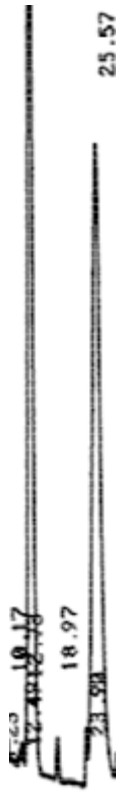


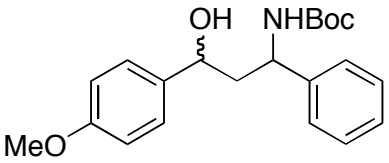


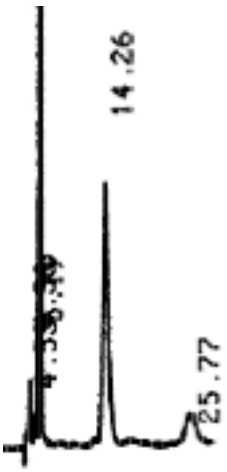
PEAK#	AREA%	RT	AREA BC
1	3.626	4.33	59380 01
2	33.947	5.73	555850 01
3	31.741	41.29	519723 01
4	30.686	51.05	502457 01

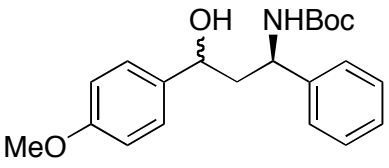
PEAK#	AREA%	RT	AREA B
1	2.257	4.33	55073 0
2	30.826	5.73	752294 0
3	13.314	41.38	324906 0
4	53.603	50.95	1308152 0

Scheme 2 : 15-Major





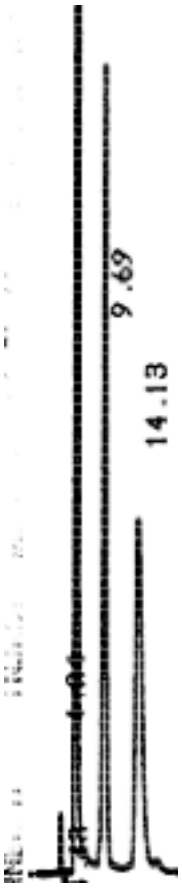


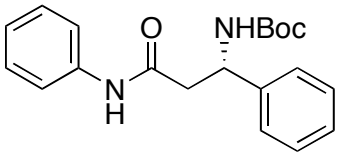


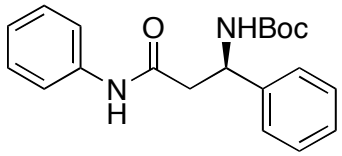
PEAK#	AREA%	RT	AREA BC
1	0.751	0.97	32065 01
2	43.754	14.2	1867439 03
3	0.83	18.97	35426 01
4	0.808	23.9	34505 02
5	44.603	25.57	1903646 02

PEAK#	AREA%	RT	AREA BC
1	1.695	4.36	12966 02
2	4.343	4.53	33224 02
3	2.171	5.19	16608 02
4	45.826	5.75	350598 03
5	38.785	14.26	296735 01
6	7.181	25.77	54937 01

Scheme 2 : 16



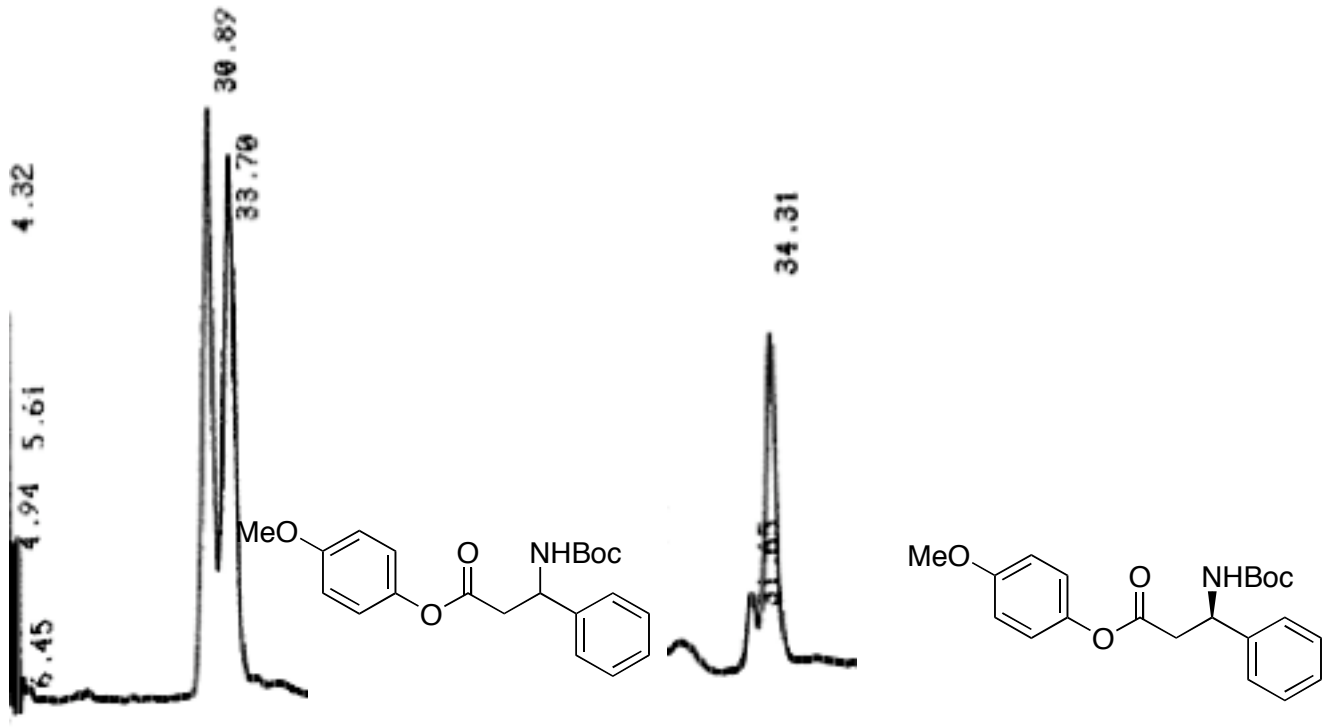




PEAK#	AREA%	RT	AREA	BC
1	0.976	4.04	36790	02
2	0.159	4.43	5988	03
3	70.504	5.87	2657165	01
4	13.984	9.69	527018	01
5	11.575	14.13	436224	01

1	4.013	4.02	28070	02
2	0.927	4.37	6667	03
3	0.263	5.57	1892	01
4	14.199	9.5	[illegible]	[illegible]
5	80.299	13.35	[illegible]	[illegible]

Scheme 2 – 17



				PEAK#	AREA%	RT	AREA BC
1	6.649	4.32	[illegible]	1	4.291	4.14	47581 01
2	2.693	4.94	73253 02	2	1.262	4.9	13991 02
3	1.732	5.61	[illegible]	3	9.623	5.61	106714 03
4	0.064	6.45	2800 01	4	0.639	12.01	7086 01
5	43.592	30.89	[illegible]	5	0.64	16.61	7092 01
6	45.23	33.7	[illegible]	6	12.715	31.65	141006 02
				7	70.831	34.31	785478 03

An Enantioselective Brønsted Acid Catalyzed Enamine Mannich Reaction

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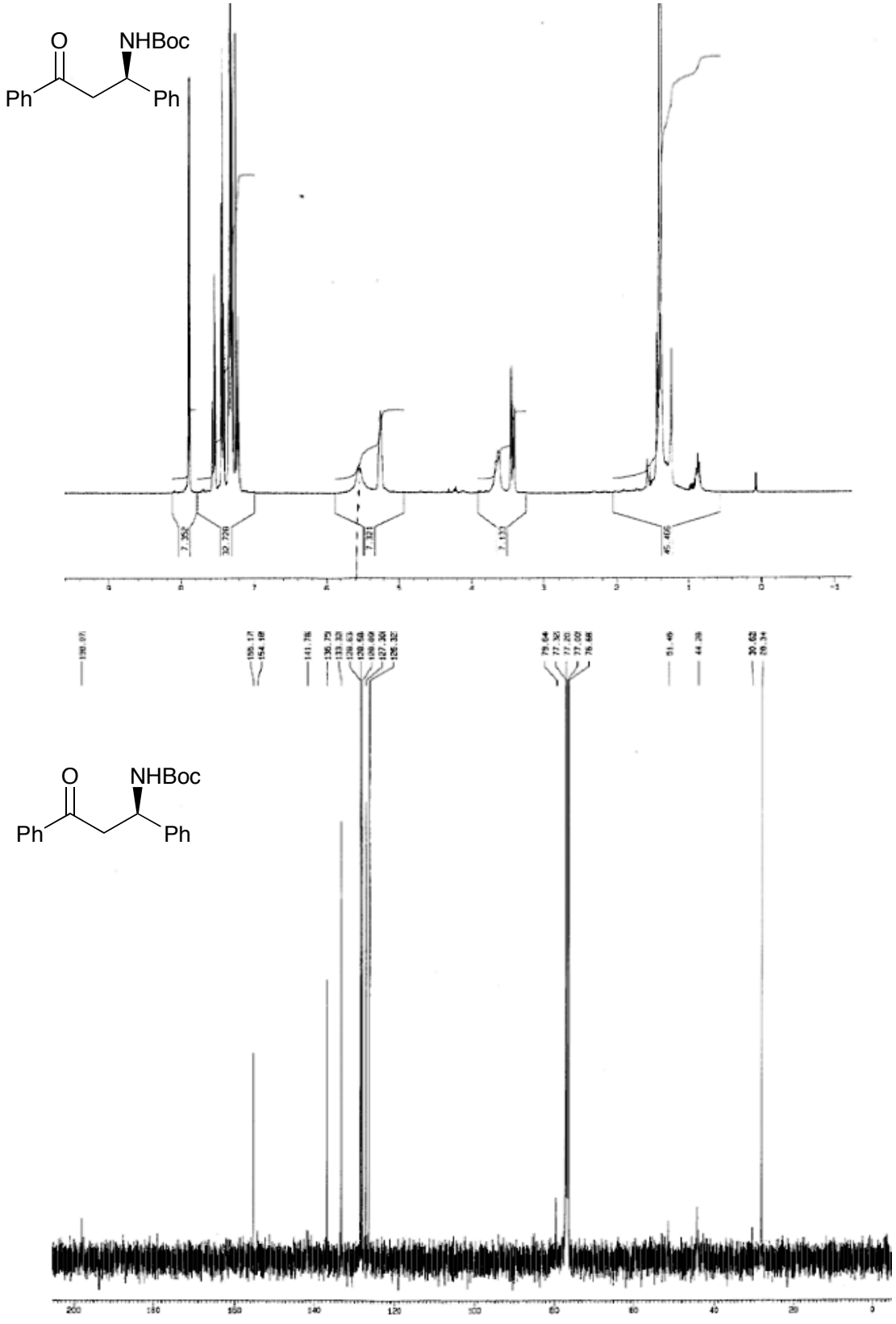
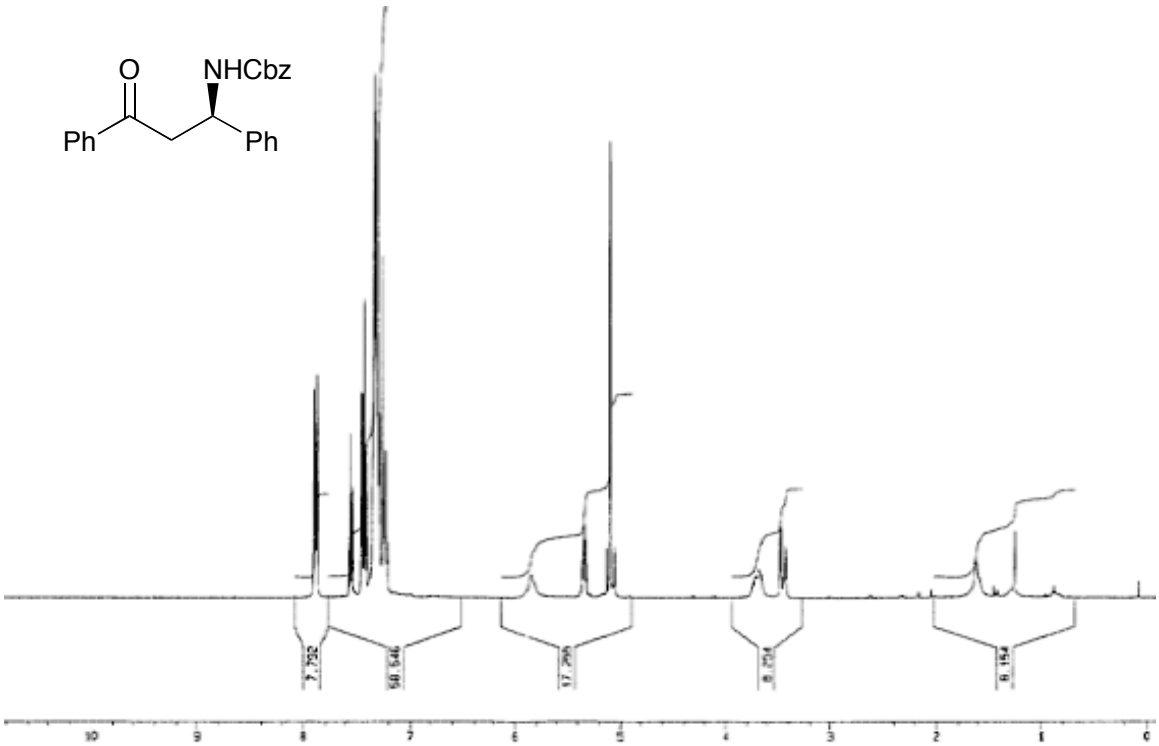
NMR DATA

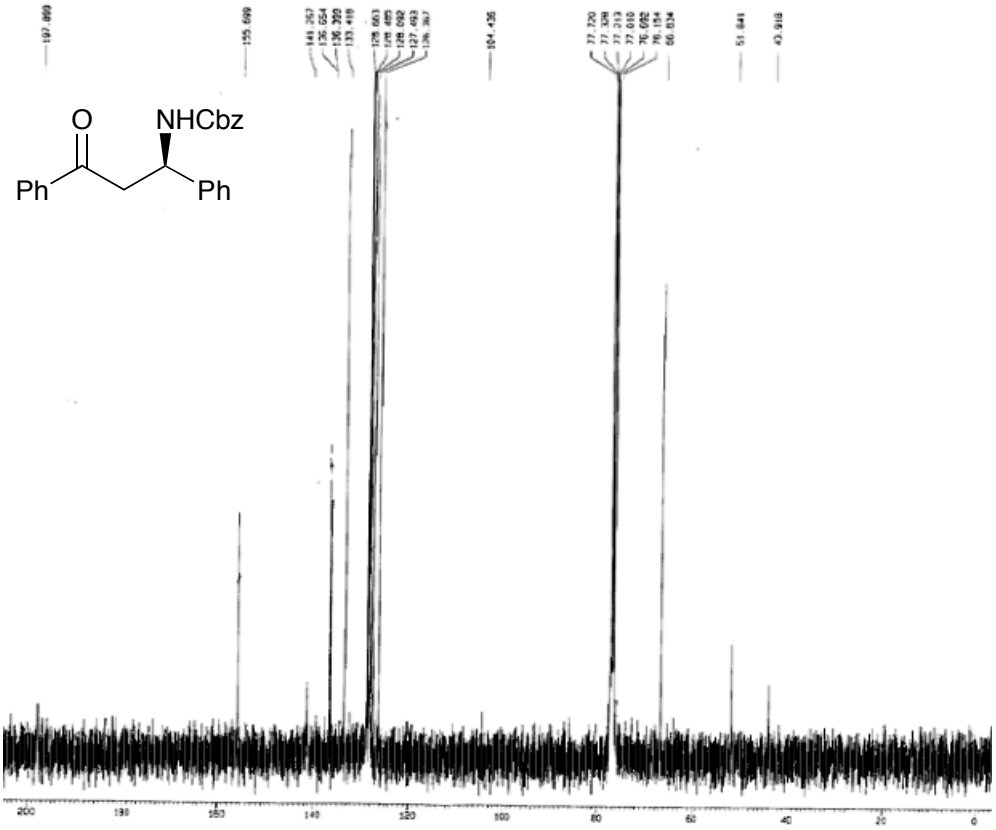
3-oxo-1,3-diphenylpropyl-carbamic acid tert-butyl ester 8a



NMR 2

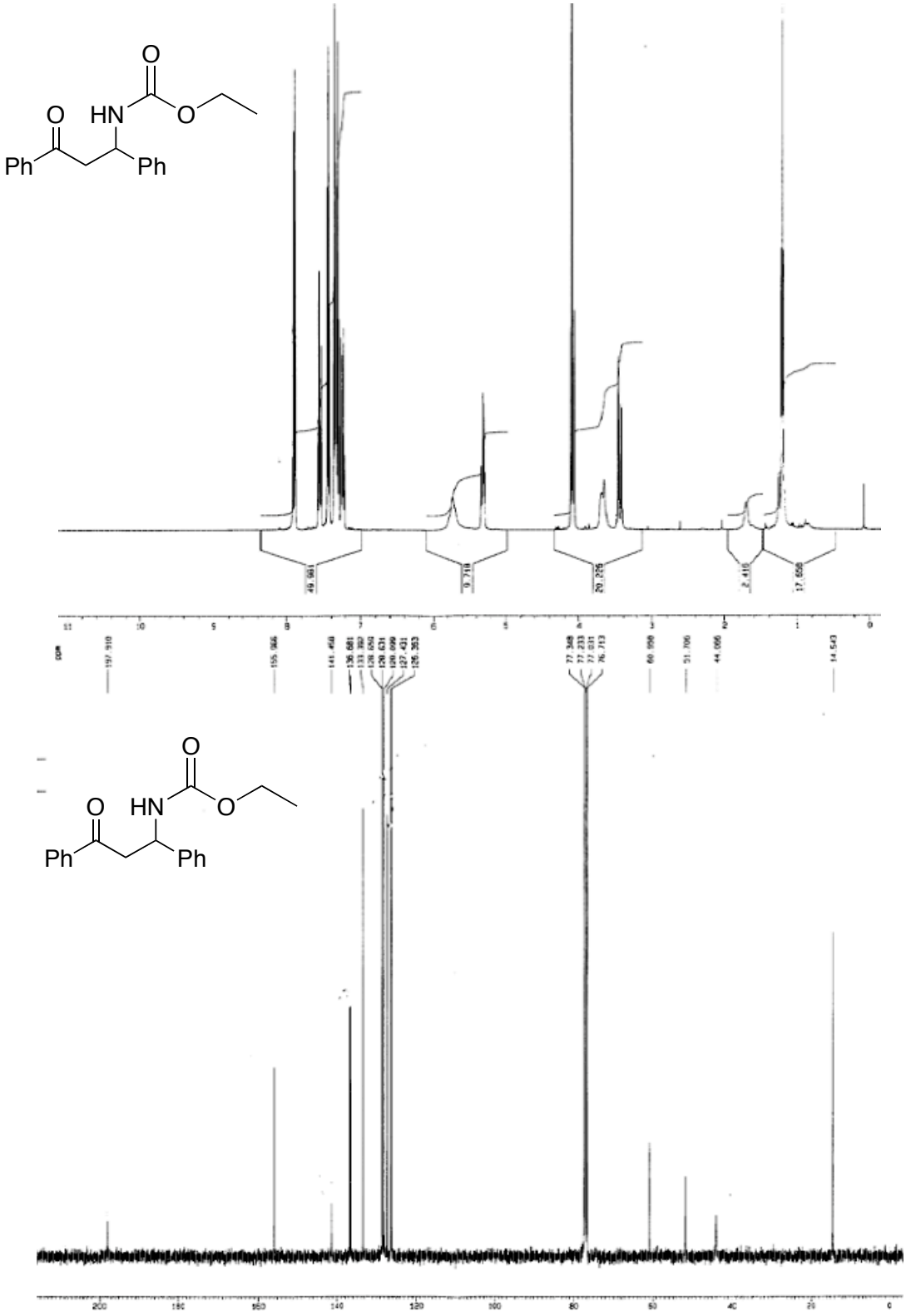
3-oxo-1,3-diphenylpropyl-carbamic acid benzyl ester 14a





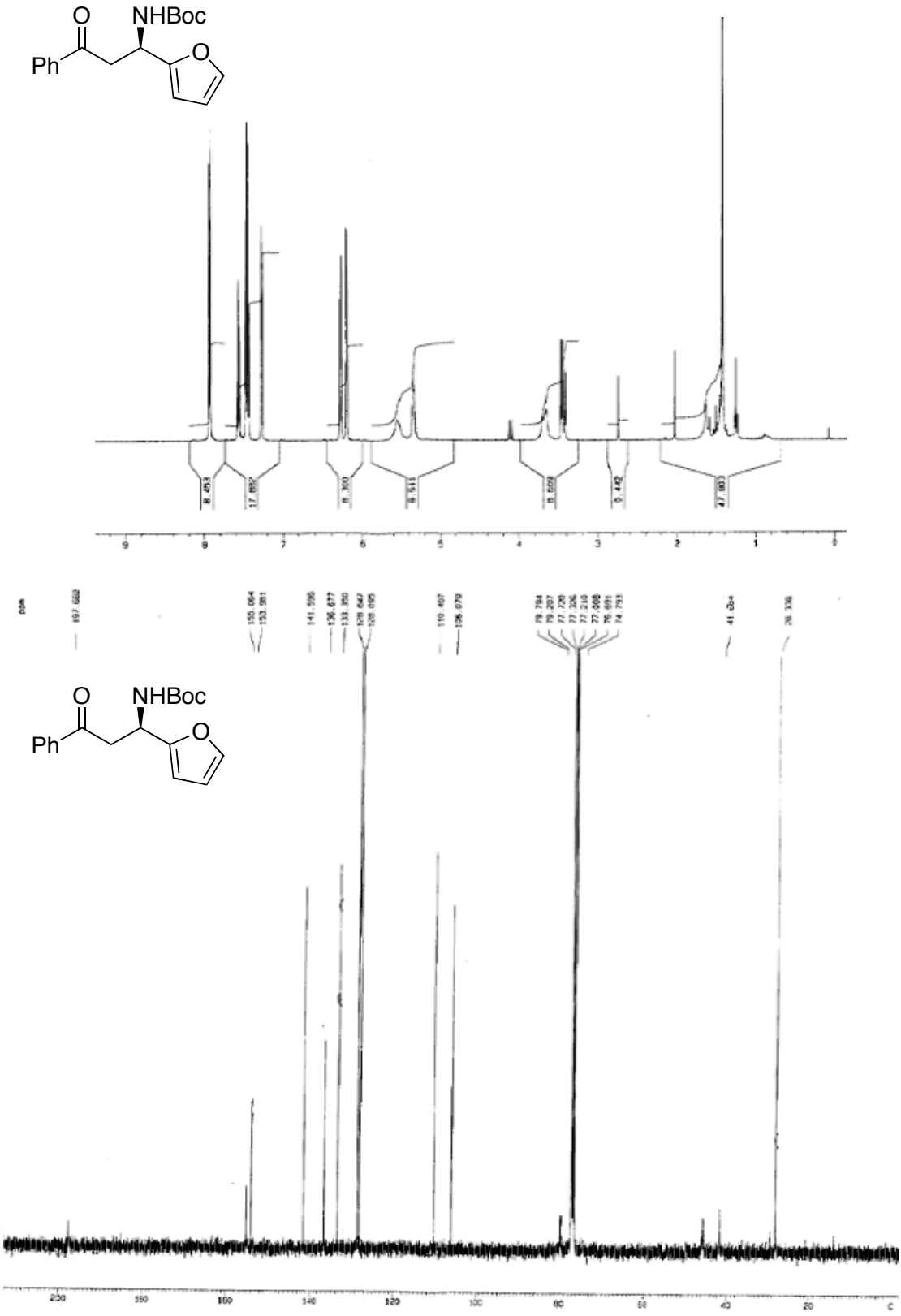
NMR 3

3-oxo-1,3-diphenylpropyl-carbamic acid ethyl ester 14b



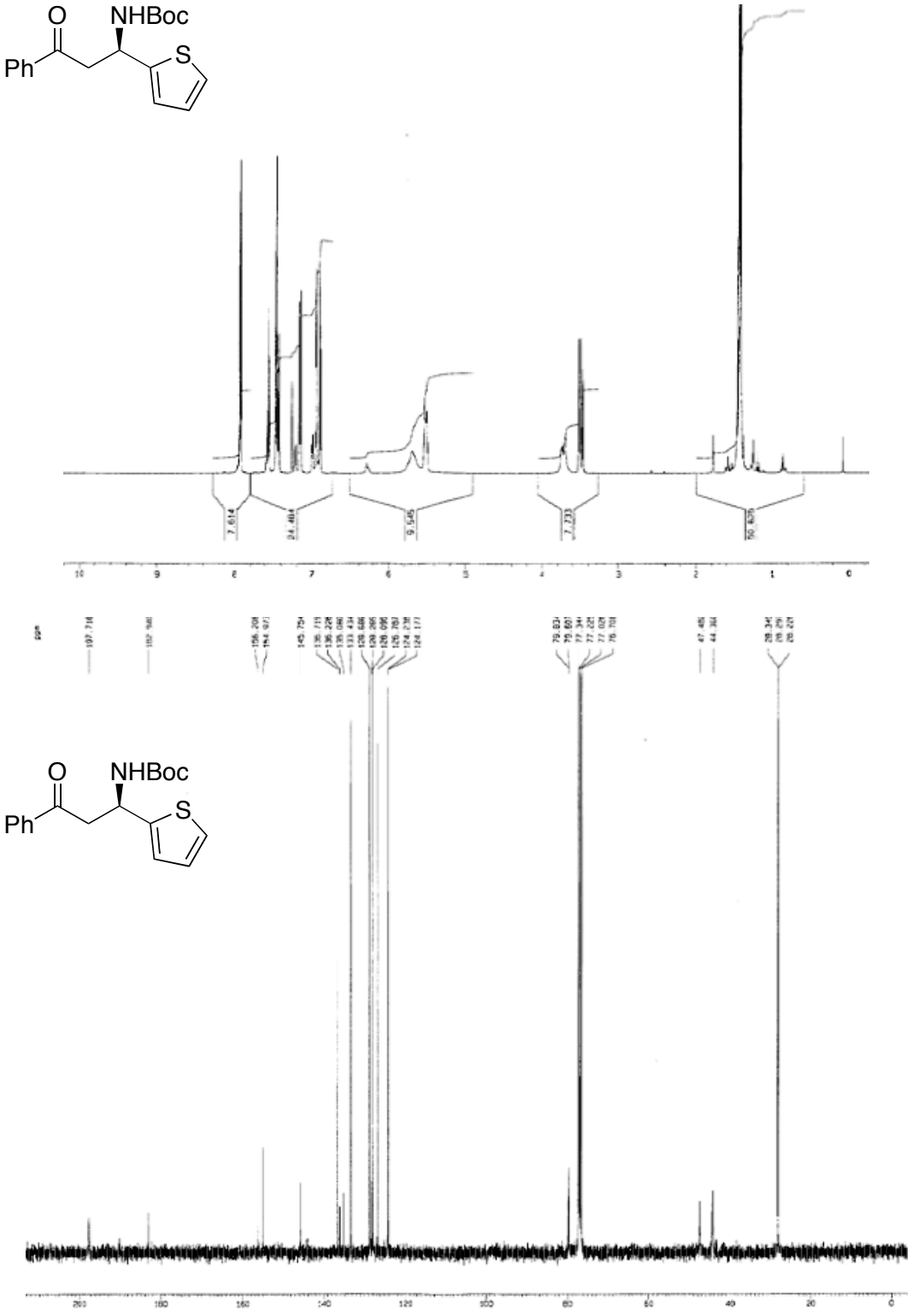
NMR 4

1-Furan-2-y-3-oxo-3-phenylpropylcarbamic acid tert-butyl ester 8ab

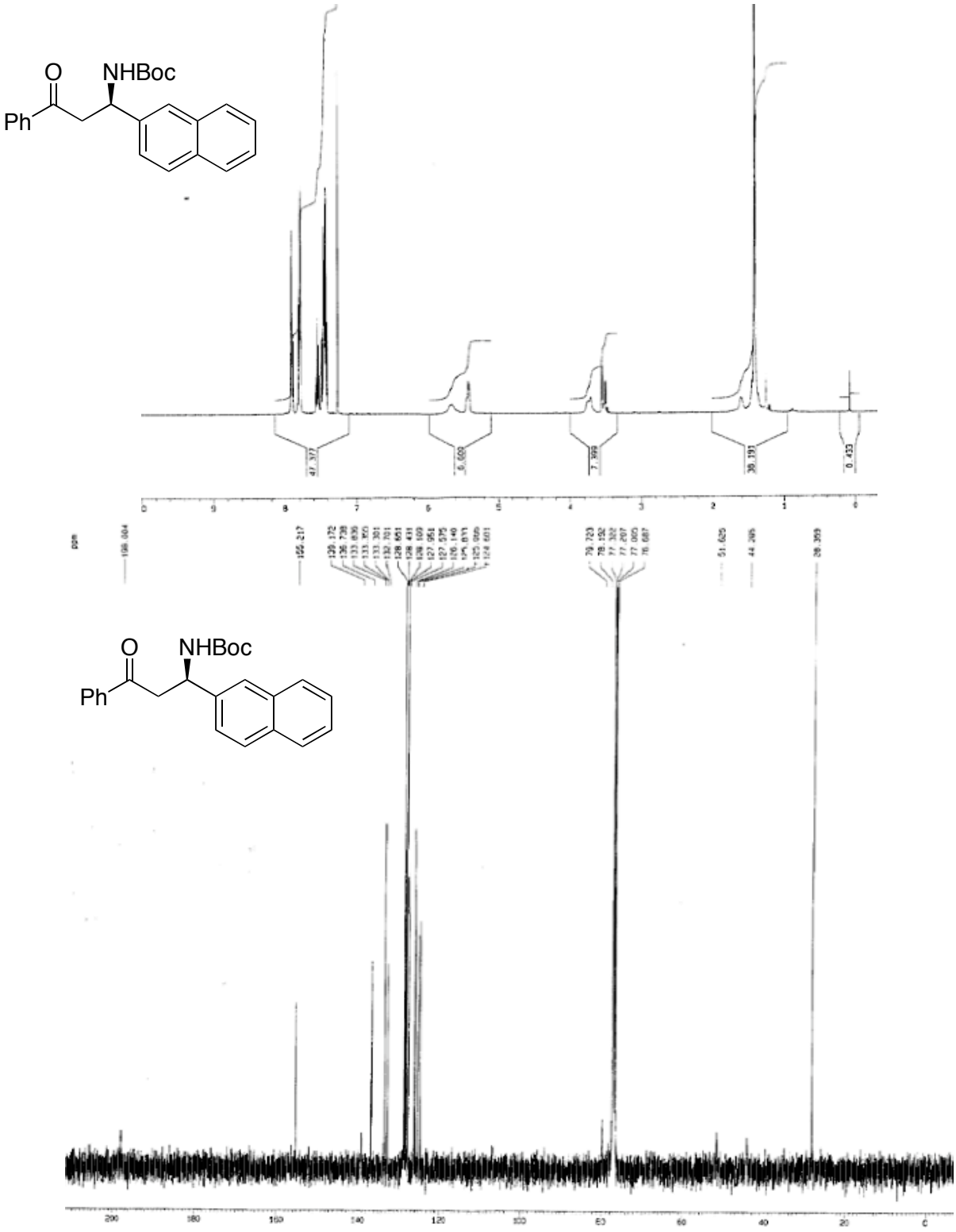


NMR 5

3-oxo-3-phenyl-1-thiophen-2-ylpropylcarbamic acid tert-butyl ester 8ac

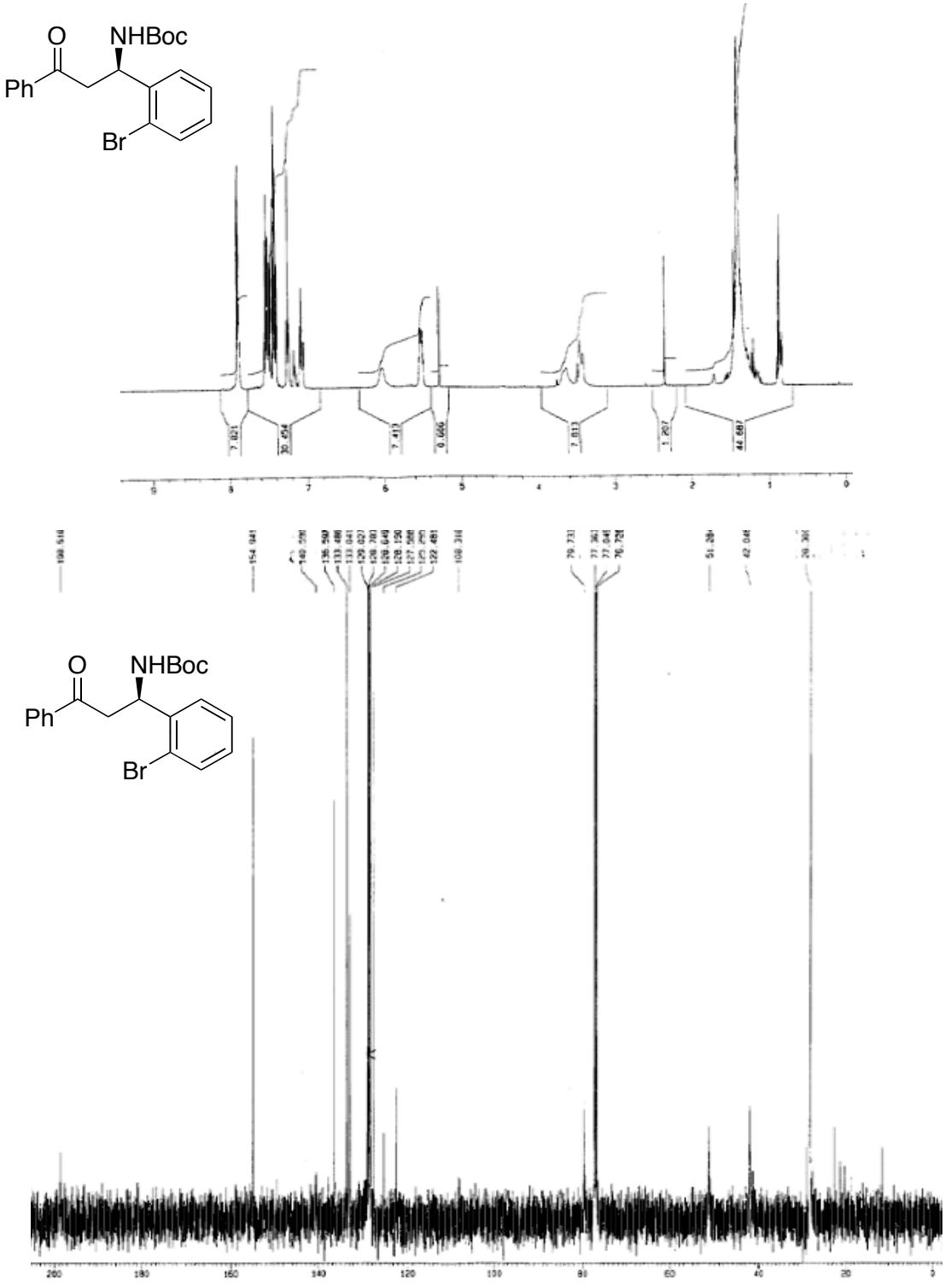


1-Naphthalen-2-yl-3-oxo-3-phenylpropylcarbamic acid tert-butyl ester 8ad

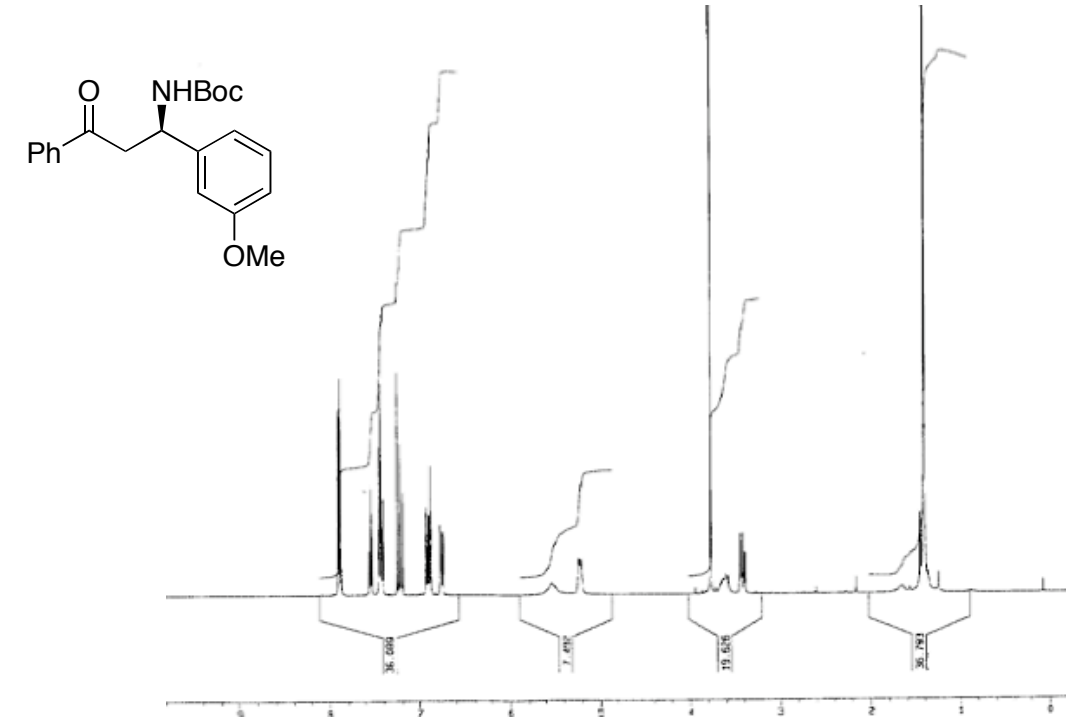


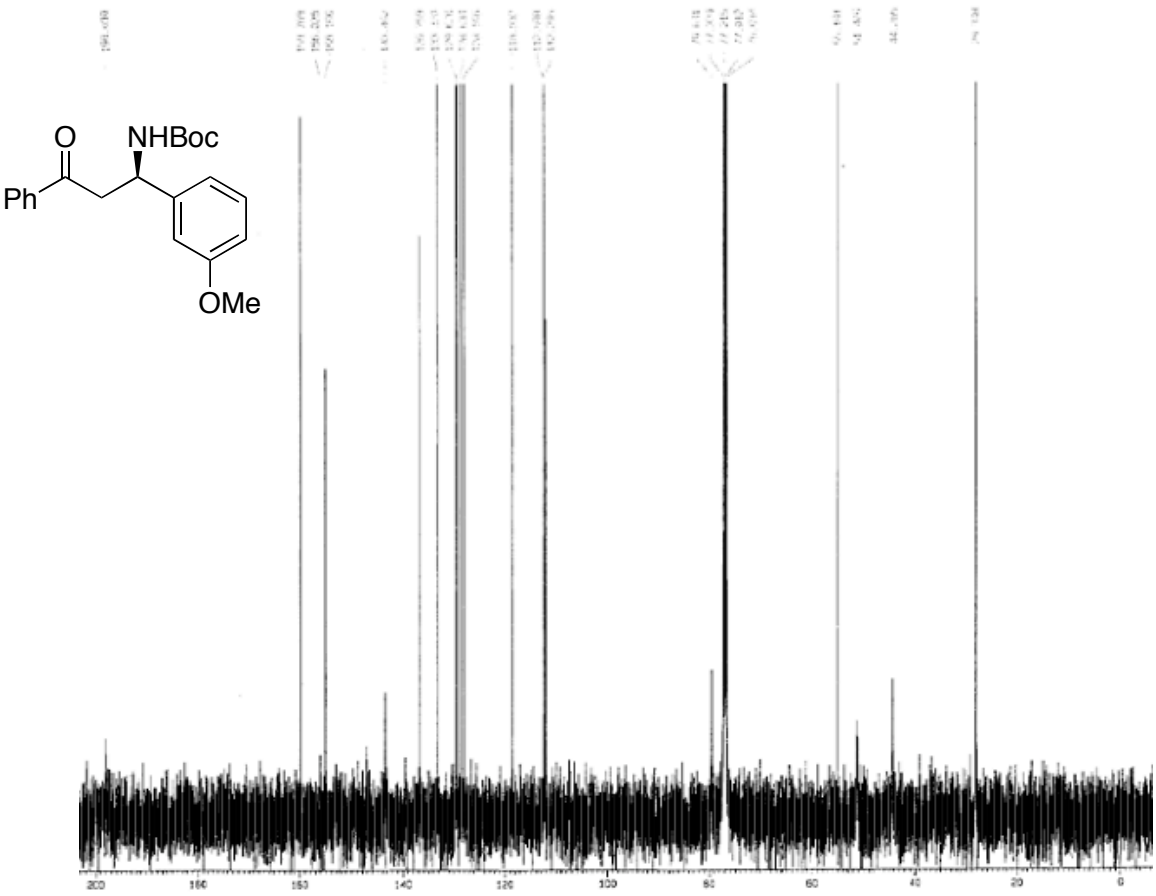
NMR 7

1-(2-Bromo-phenyl)-3-oxo-3-phenyl-propyl]-carbamic acid tert-butyl ester 8ae

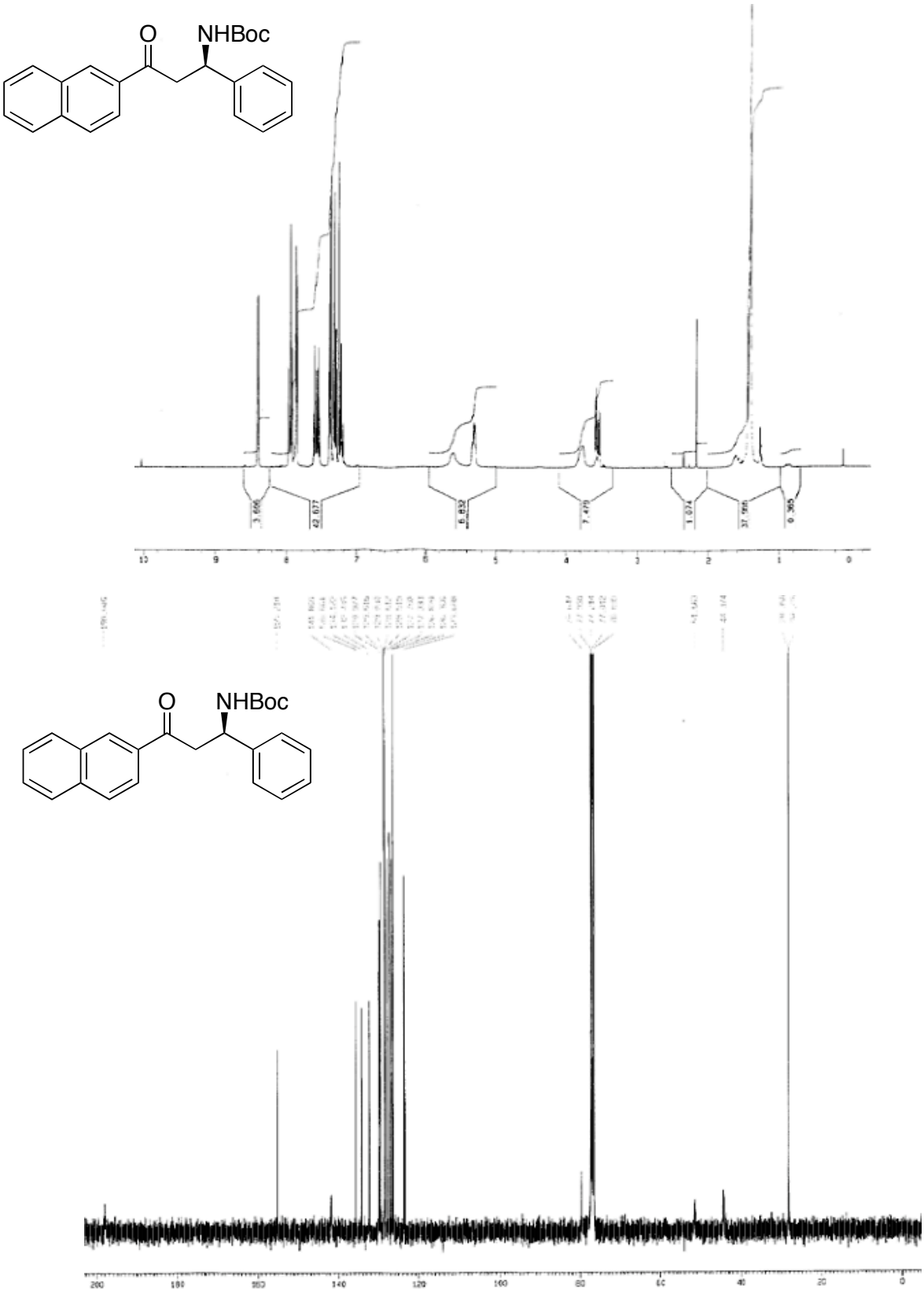


1-(3-Methoxyphenyl)-3-oxo-3-phenylpropylcarbamic acid tert-butyl ester 8af

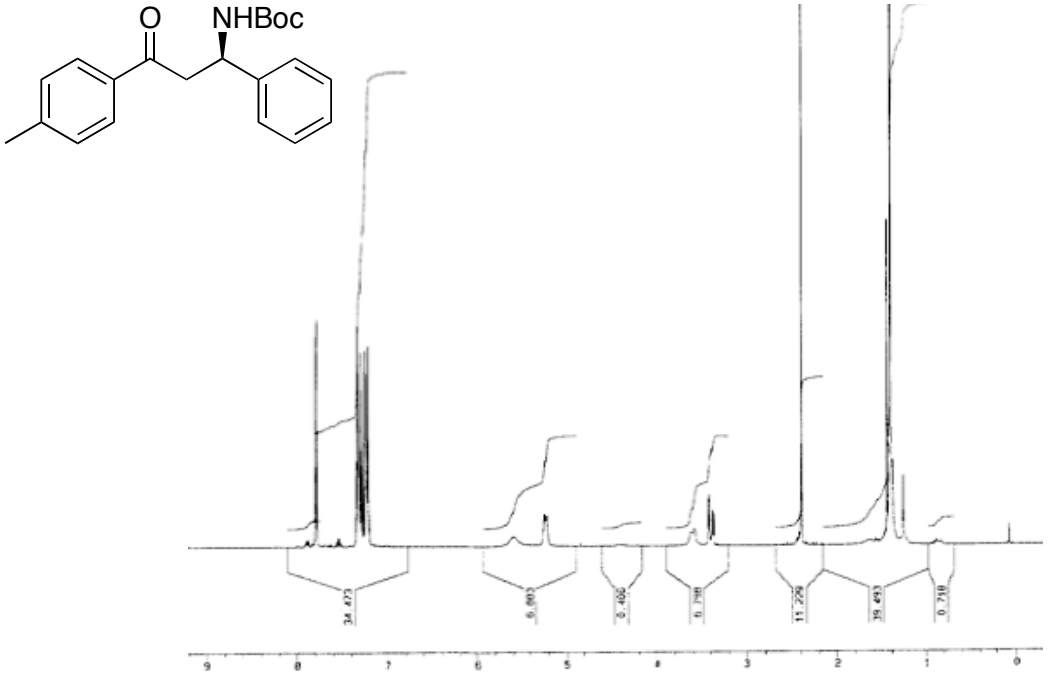


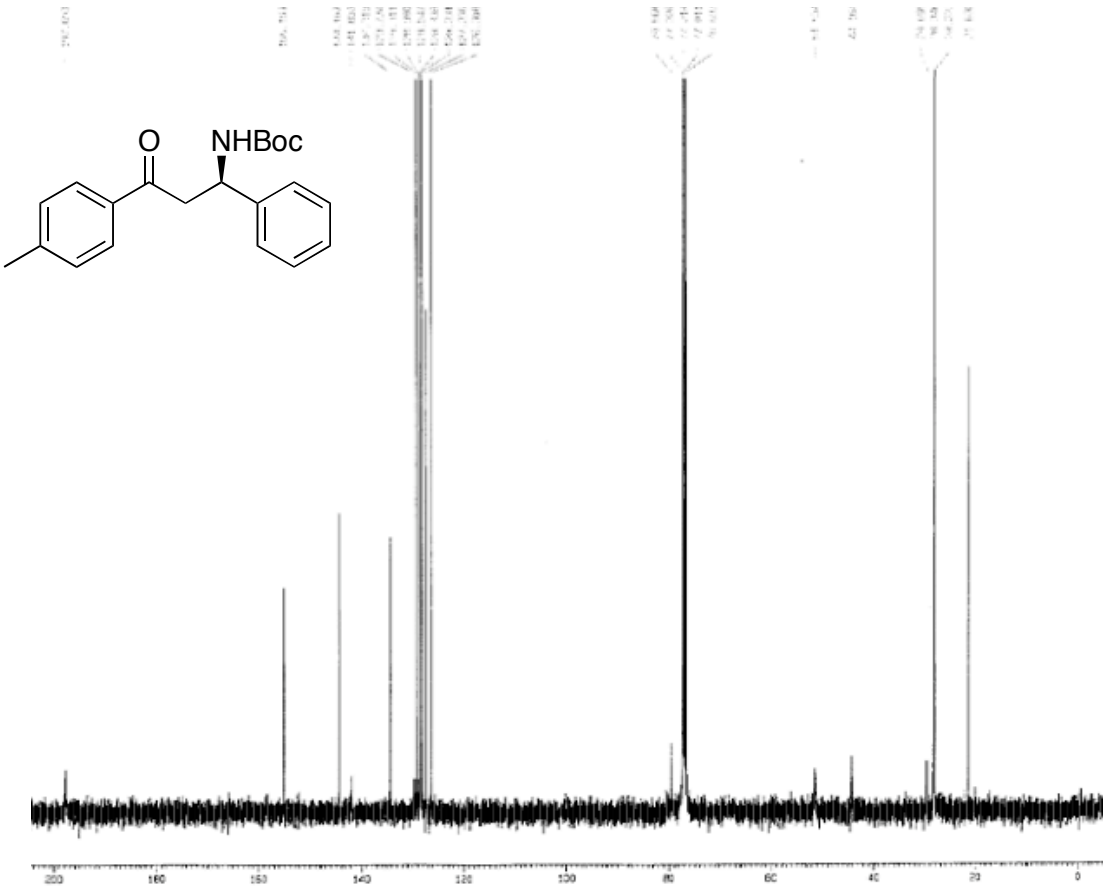


3-Naphthalen-2-yl-3-oxo-1-phenylpropyl carbamic acid tert-butyl ester 8ba

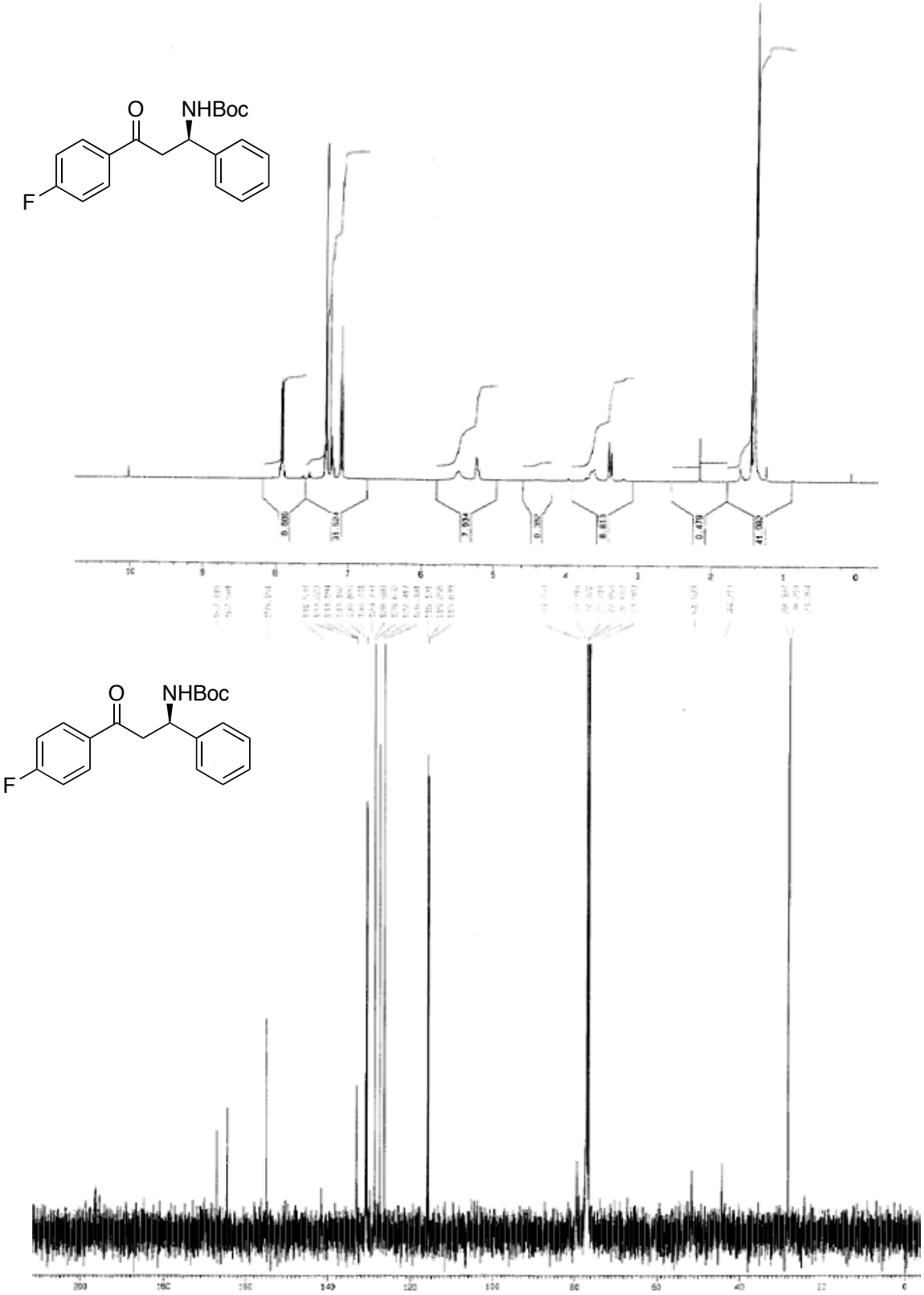


3-(4-Methylphenyl)-3-oxo-3-phenylpropylcarbamic acid tert-butyl ester 8ca



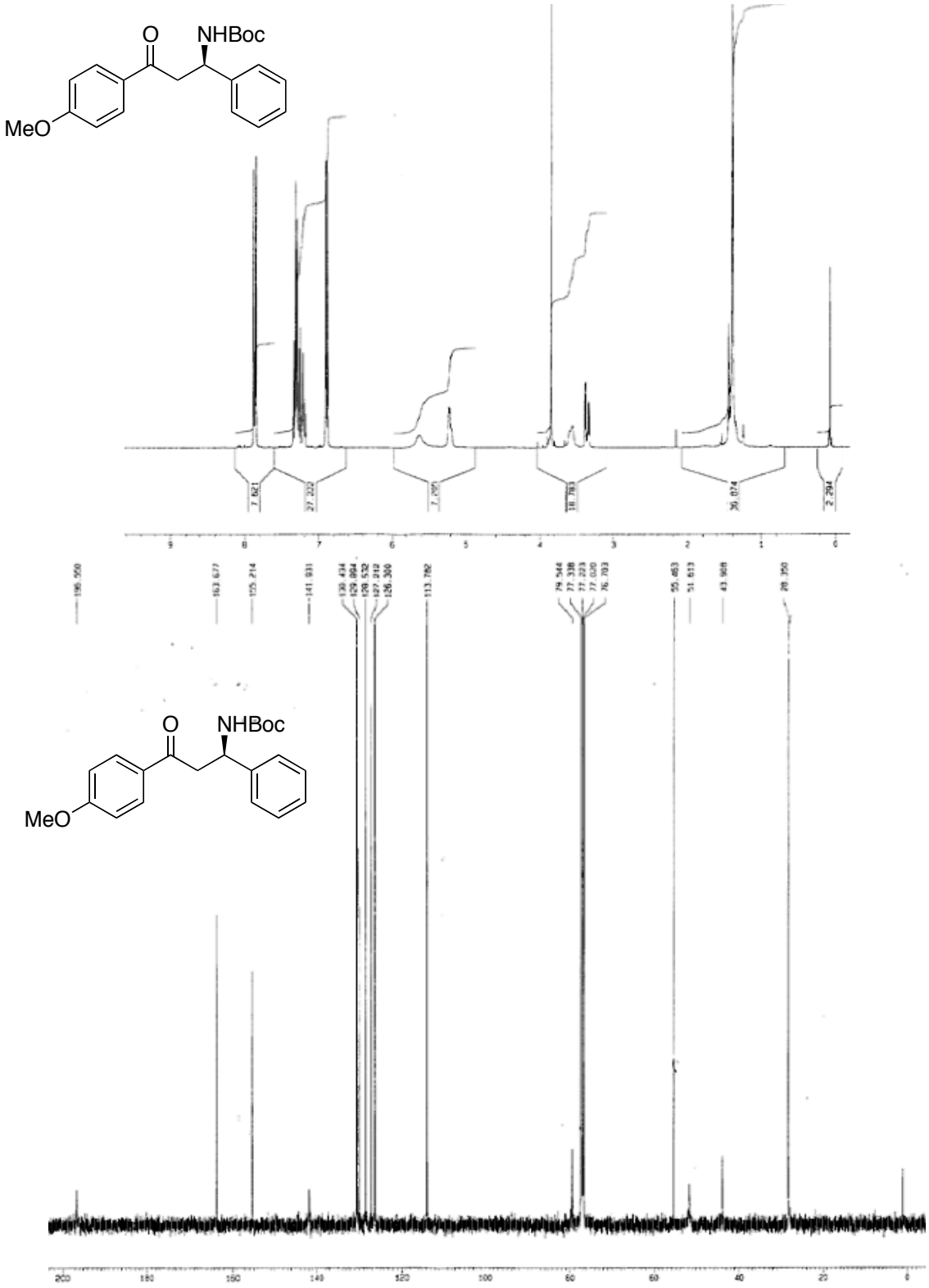


3-(4-Fluorophenyl)-3-oxo-1-phenylpropylcarbamic acid tert-butyl ester 8da

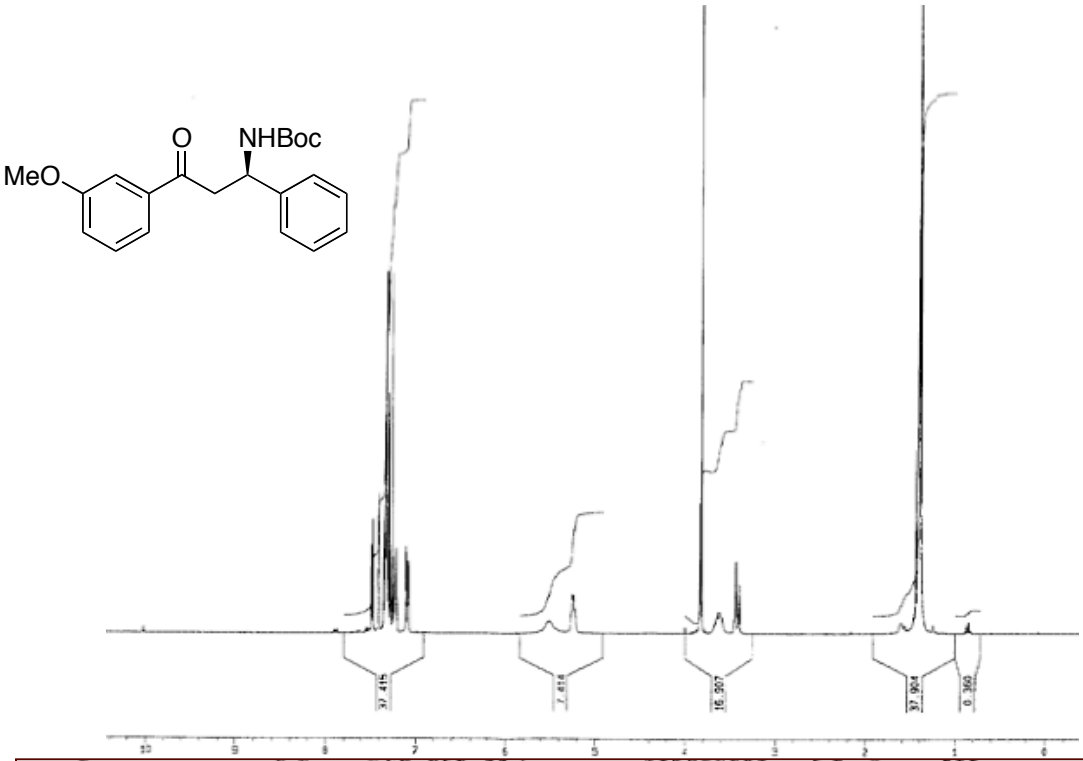


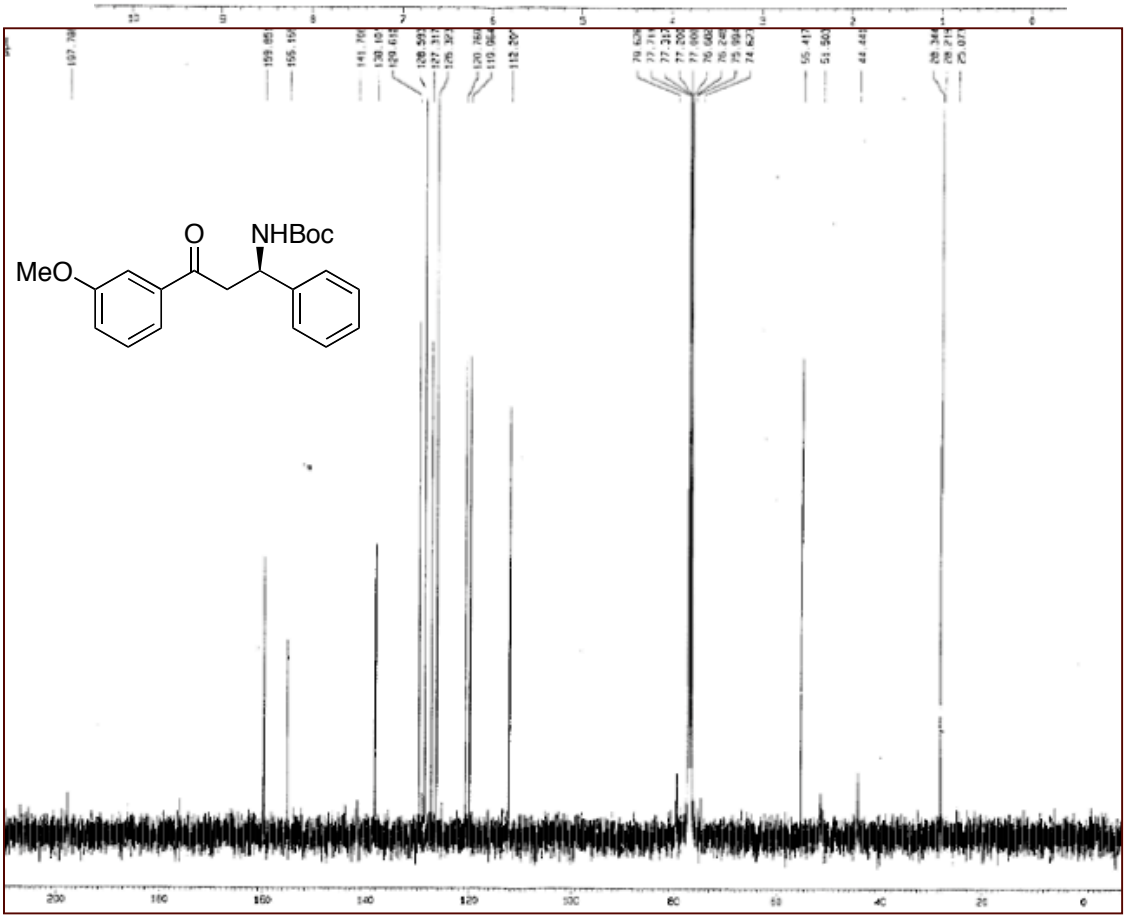
NMR 12

3-(4-Methoxyphenyl)-3-oxo-3-phenylpropylcarbamic acid tert-butyl ester 8ea

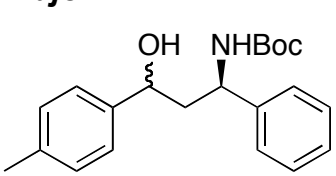


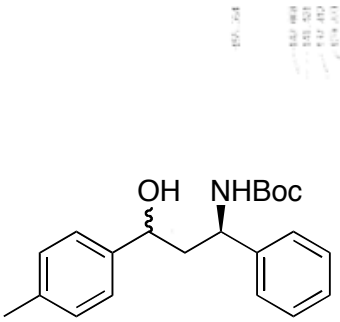
3-(3-Methoxyphenyl)-3-oxo-3-phenylpropylcarbamic acid tert-butyl ester 8fa



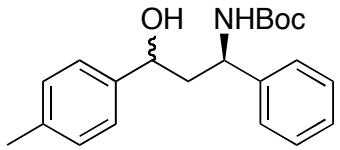


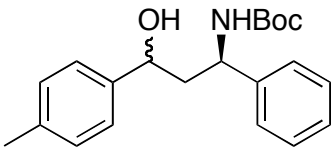
15 - Major



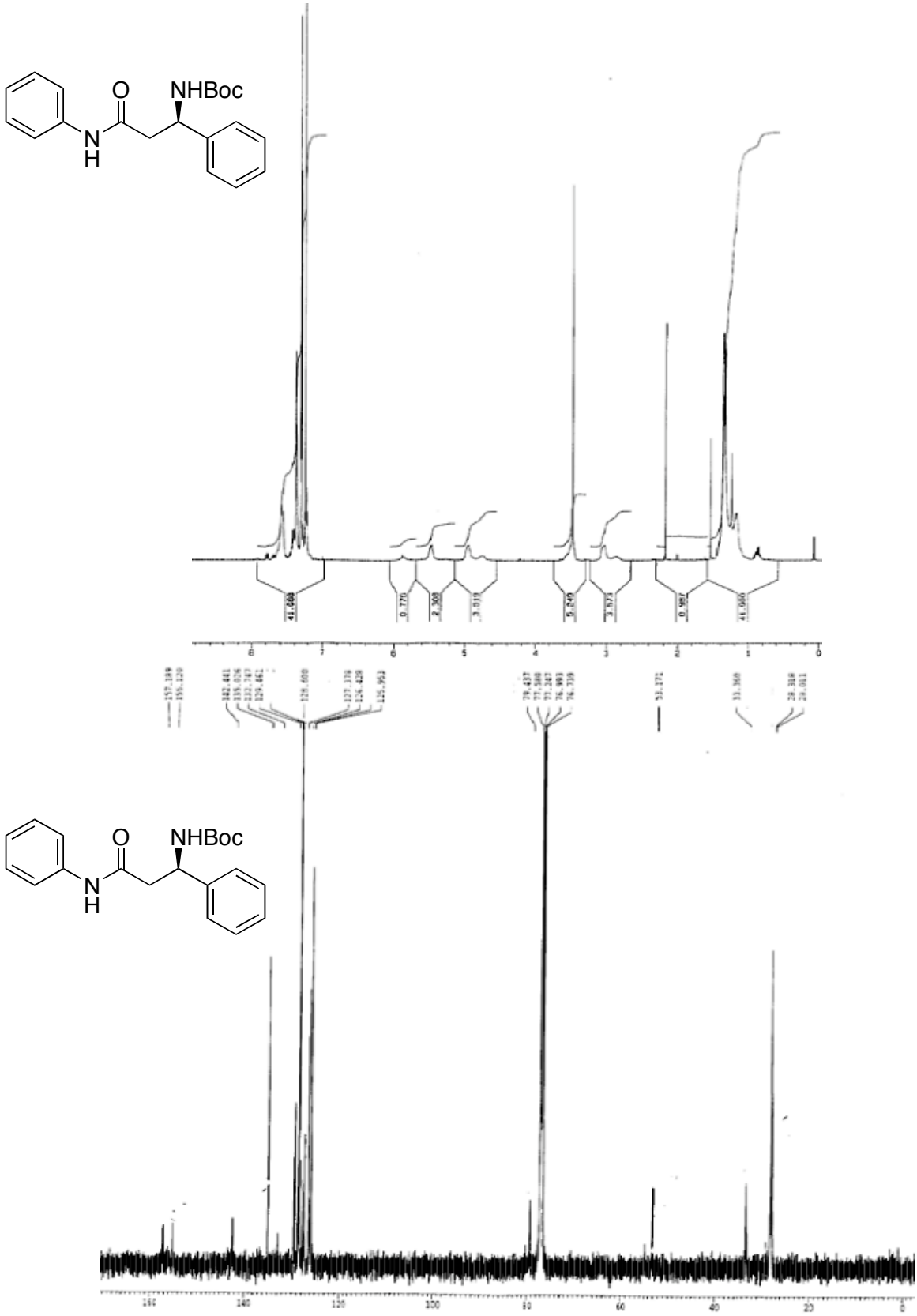


15 - Minor



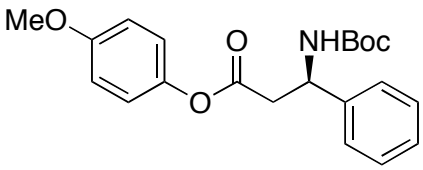


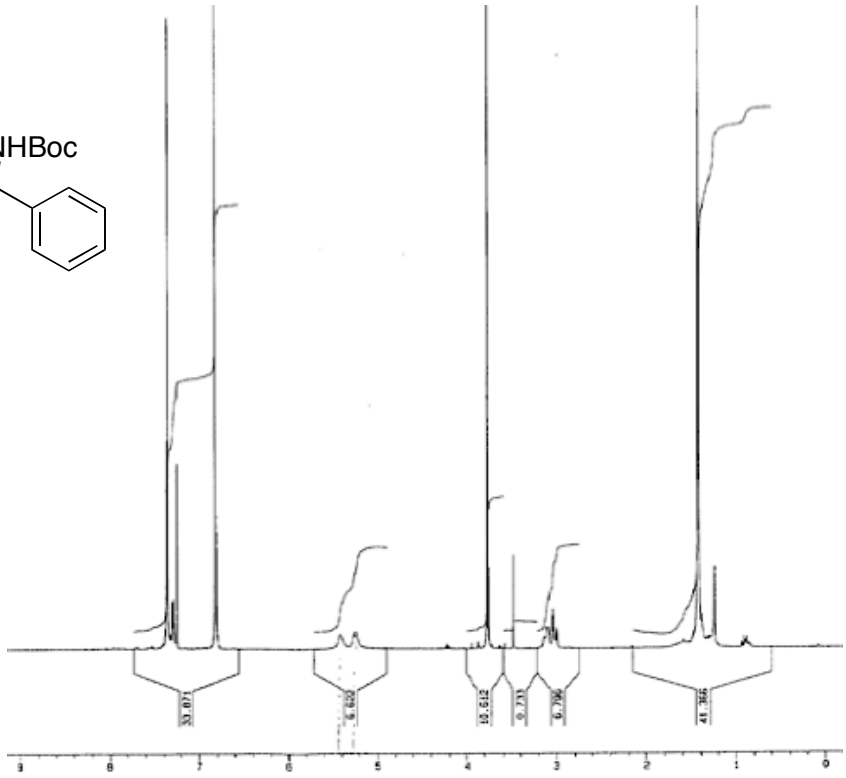
16

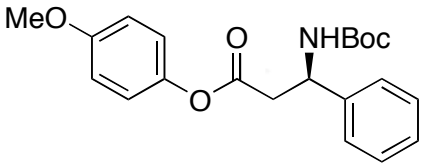


NMR 17

17







NMR 18