Electronic Supplementary Material (ESI) for Organic & Biomolecular Chemistry

Chiral Picolylamines for Michael and Aldol Reactions: Probing Substrate Boundaries

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General information:

Reactions were performed in 2.0 mL screw cap vials. Liquid reagents were transferred with glass syringes. Routine monitoring of reactions were performed by thin-layer chromatography (TLC) using precoated plates of silica gel 60 F_{254} and visualized under ultraviolet irradiation (254 nm) or ceric ammonium molybdate stain. Column chromatography separations were performed with silica gel 60 (0.040-0.063 mm). Petroleum ether with a boiling point range of 60-80 °C was used. Organic extracts were dried over anhydrous sodium sulfate.

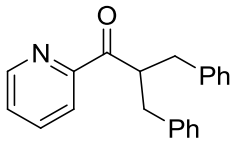
Instrumentation:

NMR spectra were recorded on a JEOL ECX 400 spectrometer, operating at 400 MHz (^{1}H) and 100 MHz (^{13}C) respectively. Chemical shifts (δ) were reported in parts per million (ppm) downfield from tetramethylsilane (TMS = 0) or relative to $CHCl_3$ (7.26 ppm) for ^{1}H NMR. Multiplicities are abbreviated as: (s = singlet, d = doublet, t = triplet, q = quartet, br = broad, m = multiplet). Coupling constants are expressed in Hz. FT-IR spectra were obtained on Nicolet Avatar 370 thermonicolet spectrometer. MS data was measured on a Bruker Daltonics HCT Ultra. HRMS were recorded on a Brukar micrOTOF instrument with an ionization potential of 70 eV with ESI positive mode. All chiral HPLC analysis was performed on a CHIRALCEL OD-H or CHIRALCEL AS-H column with HPLC grade *n*-heptane and *i*-propanol as the eluents.

Catalyst Synthesis Details:

PicAm-1 Catalyst Synthesis

The below experimental descriptions represent a significant optimization of our first reported synthesis of PicAm-**1**, as found in *Org. Biomol. Chem.* **2010**, *8*, 4085-4089. The most critical improvement has been an optimization of the resolution of rac-PicAm-**1**. The procedures shown here should be used instead of the earlier reported ones..



Precursor ketone synthesis: 2-benzyl-3-phenyl-1-(pyridin-2-yl)propan-1-one.

To a 150 mL two neck round bottom flask was added NaH (4.0 equiv, 1.2 g, 48.0 mmol) in anhydrous toluene (40 mL), followed by the addition of 18-C-6 (0.1 equiv, 0.32 g, 1.2 mmol), and 2-acetyl pyridine (1.0 equiv, 1.35 mL, 12.0 mmol). This was stirred for 20 min and then benzyl bromide (2.5 equiv, 3.6 mL, 30 mmol) was added dropwise over 2-3 min. The reaction mixture was stirred at 50 ^{o}C for 5-6 h under an inert atmosphere. The reaction can be monitored by TLC or GC, but TLC is sufficient. The faint yellow reaction mixture was quenched by adding saturated NH_4Cl (50 mL) at 25 ^{o}C. The reaction mixture was extracted with ethyl acetate. The combined organic layers were dried over sodium sulfate, filtered, and concentrated under low and high vacuum providing a yellow oil. Flash chromatography of the crude product, EtOAc/hexane (1:19), gave the desired ketone (2.65 g, 74% yield) as a white solid.

TLC: R_f = 0.32 in EtOAc/hexane (1:9)

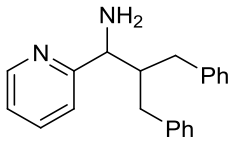
GC: Shimadzu GC-2010 instrument with a Rtx-5 amine column (Restec, 30m x 0.25mm); T_{inj} = 300 °C and T_{det} = 300 °C were always constant; 80 °C (hold 3 min), 250 °C (10 °C/min, then hold 10 min), 280 °C (20 °C/min, then hold for 3 min)

2-acetyl pyridine (starting material): retention time = 8.2 min

ketone product: retention time = 28.3 min.

^{1}H NMR (400 MHz, $CDCl_3$) (ppm): 2.77 (dd, *J* = 6.4 Hz, 13.7 Hz, 2H), 3.17 (dd, *J* = 7.7 Hz, 13.7 Hz, 2H), 4.81-4.88, (m, 1H), 7.08-7.41 (m, 10H), 7.69-7.73 (m 2H) 7.92 (d, *J* = 7.79 Hz, 1H), 8.62 (d, *J* = 4.12 Hz, 1H).

^{13}C NMR (100 MHz, $CDCl_3$) (ppm): 37.2, 47.9, 122.3, 125.9, 126.8, 128.1, 129.1, 136.6, 139.8, 148.8, 153.0, 203.5.



rac-PicAm-**1**

Synthesis of racemic PicAm-1: 2-benzyl-3-phenyl-1-(pyridin-2-yl)propan-1-amine.
A mixture of hydroxylammonium chloride (3.0 equiv, 9.67 g, 139.2 mmol) and Et_3N (3.0 equiv, 19.4 mL, 139.2 mmol) in EtOH (154 mL) were stirred at room temperature for 30 min. The above described ketone (1.0 equiv, 14.0 g, 46.4 mmol) was then added. After heating under reflux for 72 h, the reaction was monitor by TLC, approximately 95% of the starting ketone was consumed. The solvent was removed by rotary evaporation and the residue was extracted with EtOAc (150 mL x 3). The combined organic layers were washed with brine, dried over Na_2SO_4, and concentrated to give the crude oxime as a brown oil. Without further purification, the crude oxime (1.0 equiv, 13.5 g, 42.7 mmol) was added to EtOH (143 mL) with NH_4OAc (1.3 equiv, 4.92 g, 64.0 mmol) and NH_4OH (154.6 mL, 25% v/v in H_2O). This solution was heated at reflux and zinc powder (5.0 equiv, 14.78 g, 213.0 mmol) was added portion wise over 2 h every 15 min. After refluxing for an additional 24 h, the reaction mixture was cooled to room temperature. The EtOH was removed by rotary evaporation and EtOAc was added. This heterogenous mixture was Buchner funnel filtered with celite and the undissolved material was further treated with small portions of EtOAc to remove any remaining amine. The filtrate was treated with 1.0 N NaOH, the EtOAc was removed, and the basic aqueous was further extracted with EtOAc. The organic phases were combined, washed with brine, dried over Na_2SO_4, filtered, and concentrated. After column chromatography, first with EtOAc/pet ether (1:4), and then with 100 % EtOAc, and removal of the solvent, a pure viscous oil of racemic PicAm-**1** (8.5 g, 60% yield) was obtained.

HPLC: Chiralcel OD-H, *i*-PrOH/heptane 5/95, flow rate = 1 mL/min, λ = 254 nm): t= 10.2 min [(R)-PicAm-**1**)], t= 13.5 min [(S)-PicAm-**1**)].
^{1}H NMR (400 MHz, $CDCl_3$) (ppm): 1.75 (br s, 2H), 2.46-2.54 (m, 2H), 2.58-2.66 (m, 2H), 2.70-2.78 (m, 1H), 4.00 (d, *J* = 3.9 Hz, 1H), 7.05-7.29 (m, 12H), 7.55-7.61 (m, 1H), 8.52-8.54 (m, 1H);
^{13}C NMR (100 MHz, $CDCl_3$) (ppm): 34.5, 36.8, 49.2, 56.69, 121.71, 125.73, 125.83, 125.94, 128.31, 128.45, 129.18, 129.24, 136.16, 141.14, 144.17, 148.7, 163.9.

Resolution of Racemic PicAm-1
Racemic PicAm-**1** was analyzed by HPLC (Chiralcel OD-H, *i*-PrOH/heptane 5/95, flow rate = 1 mL/min, λ = 254 nm): t= 10.2 min [(R)-PicAm-1)], t= 13.5 min [(S)-PicAm-1)], *i*-PrOH: Roth Art.-Nr. 7343.1, n-heptane: Roth.-Nr. 7337.1. Before beginning the resolution, the enantiomeric ratio was shown to be 50.1:49.9.

THF/CH_3CN (72 mL, 1:5) was added to racemic free amine PicAm-**1** (1.0 equiv, 8.05 g, 26.6 mmol) and the flask (250 mL) was heated to 75 °C. The mixture was stirred and natural tartaric acid, (*R*,*R*)-L-tartaric acid, (0.50 equiv, 1.99 g, 13.26 mmol) was added. The mixture was refluxed until the tartaric acid was fully dissolved, approximately 5 min.

The mixture was then cooled down to room temperature and the solvent was evaporated. The ensuing salt was high vacuum dried producing an off-white solid. This high vacuum drying step may be important because it possibly removes trace amounts of solvent that may have been trapped in the isolated racemic free amine of PicAm-**1**, which is a rather viscous oil.

The obtained salt was again dissolved in a mixture of THF/CH_3CN (72 mL, 1:5) and the temperature was gently raised to reflux (75 ^oC). After another 15-20 min at gentle reflux, the salt fully dissolved and a transparent, slightly yellow, solution was observed. Oil bath heating was discontinued, and with the round bottom flask remained in the oil bath with continuous stirring, the solution cooled down to room temperature over approximately 45 min. Note, usually within minutes of discontinuation of heating, white solids start to crystallize out of solution. After stirring for an additional 3 h at room temperature the white precipitate was Buchner funnel filtered under vacuum and the resulting solid salt was air dried for several hours providing a white solid (5.7 g). The ratio of the two enantiomers for this material was 43:57 (HPLC).

The solid white salt (5.7 g) was dissolved in 25 mL of an EtOH (Sigma-Aldrich, cat. # 32205)/H_2O (distilled water) [95:5 v/v] mixture. The solution was heated to 75 ^oC, and became homogeneous after approximately 10-15 min of stirring. Heating of the oil bath was discontinued, the round bottom flask remained in the oil bath, and under continuous stirring, the solution cooled down to room temperature over approximately 45 min. Note, at this stage, crystallization did not occur until the solution was close to room temperature. After stirring for an additional 3 h at room temperature the white precipitate was Buchner funnel filtered under vacuum and the resulting solid salt was air dried for several hours providing a white solid (3.7 g). The ratio of the two enantiomers was 30:70 (HPLC).

The above noted white salt (3.7 g) was again dissolved in EtOH/H_2O (15 mL in total, 95:5), and after stirring at 75 ^oC (gentle reflux) for approximately 10 min., the solution became transparent and was colorless. The heater was turned off and once the solution was allowed to come to room temperature and then stirred for approximately 3 h at room temperature providing a white precipitate, which was Buchner funnel filtered under vacuum and air dried for several hours providing a white solid (2.5 g). The ratio of the two enantiomers was 11:89 (HPLC).

The above white salt (2.5 g) was dissolved in EtOH/H_2O (20 mL in total, 95:5) by stirring at 75 ^oC under reflux and the solution became homogenous after 10 min. Note: for the prior recrystallization 15 mL of the solvent were used, but here we use 20 mL. The heater was turned off and once the solution was at room temperature, it stirred for approximately 3 h providing a white precipitate, which was Buchner funnel filtered under vacuum and air dried for several hours providing a white solid (1.5 g). The ratio of the two enantiomers was 2:98 (HPLC).

The above white salt (1.5 g) was dissolved in 15 mL of EtOH/H_2O (95:5) by stirring at 75 ^oC under reflux, the solution became homogenous after 10 min. The heater was turned off

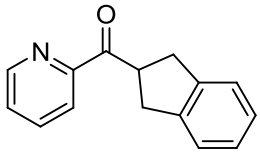
and after reaching room temperature (over 45 min), the stirring was continued for approximately 3 h. The precipitate was filtered, and air dried for several hours, providing a white solid salt (1.0 g). The ratio of the two enantiomers was 0.24:99.75 (HPLC).

After these five resolutions (one with THF/CH_3CN and four with EtOH/H_2O), high vacuum drying furnished the (*S*)-PicAm-**1** salt as a white powder (~10% weight recovery from the beginning racemic PicAm-**1** (8.05 g) and L-tartaric acid (1.99 g)). Thus, 1.0 g of ≥99% *ee* (*S*)-PicAm-**1** was isolated, which represent an ~20% yield for the (*S*) enantiomer, when using natural tartaric acid: (*R*,*R*)-L-tartaric acid.

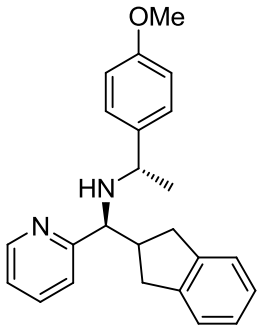
(S)-PicAm-1 Salt Preparation (Catalyst for Reactions).
Before use in reactions, the above salt (1.0 g) was first converted to the free amine by addition to EtOAc (75 mL) and NaOH (75 mL, 0.5 M). Further extraction (EtOAc, 30 mL x 2) of the basic aqueous layer, followed by combination of the organic extracts, drying (Na_2SO_4), filtration, concentration (rotary evaporator), and high vacuum drying until a constant weight was achieved, provided the free amine (S)-PicAm-**1** (MW = 302.41) as a viscous clear oil (760 mg, 2.51 mmol, 19% yield from racemic material), this was dissolved in MeOH (30 mL) and 2,4-dinitrobenzenesulfonic acid (Sigma-Aldrich Cat # 556971, MW = 248.17, 1.00 equiv, 622.9 mg, 2.51 mmol) was added to form the 1:1 salt with (S)-PicAm-**1**. Important Note: 2,4-dinitrobenzenesulfonic acid is sold and described by Sigma-Aldrich as an unspecified hydrate, it is therefore clear that less than 1.0 equiv of the acid has been added for salt formation. Regardless, this is the procedure that should be used for salt formation. Further note that addition of more than 1.0 equiv of the acid is detrimental to the diastereoselectivity (product epimerization) of the aldol products in particular.

For clarity regarding the absolute stereochemistry of the catalyst described above, in the supporting information of our *Org. Biomol. Chem.* **2010**, *8*, 4085-4089 paper, we demonstrated that when one uses unnatural (*S*,*S*)-D-tartaric acid, for the resolution, the (*R*)-PicAm-**1** enantiomer, as judged by X-ray analysis of the salt (see Supp Info of *Org. Biomol. Chem.* **2010**, *8*, 4085-4089), is obtained. Further note that the crystals used for the X-ray crystallographic analysis were that of a 1:1 (*S*,*S*)-D-tartaric acid/(*R*)-PicAm-**1** salt. This was accomplished by taking the >99% ee PicAm-**1** from the resolution, splitting this salt (which has an undefined stoichiometry) in EtOAc/NaOH (0.5 M), isolating the free amine, and then adding 1.0 equiv of (*S*,*S*)-D-tartaric acid. This 1:1 defined salt was used for crystal growth. As a consequence, the absolute configuration of the catalyst resolved here (see above) with L-tartaric acid provides the (*S*)-PicAm-**1** catalyst. It should be further noted that for our first publication (*Org. Biomol. Chem.* **2010**, *8*, 4085-4089) we mostly used the (*S*)-PicAm-**1** catalyst.

Procedure for Synthesis of PicAm-2

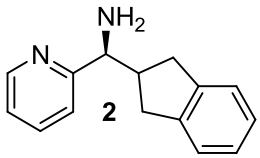


Precursor ketone synthesis: 2,3-dihydro-1H-inden-2-yl)(pyridin-2-yl)methanone. To a 100 mL round bottom flask was added NaH (3.00 equiv, 0.72 g, 30 mmol) in anhydrous toluene (30 mL), followed by the addition of 18-C-6 (0.10 equiv, 0.264 gm, 1 mmol), acetyl pyridine (1.00 equiv, 1.12 g, 10 mmol). After strirring for 15 min, α,α-dibromoxylene (1.50 equiv, 3.96 g, 15 mmol) was added over 5 min. The reaction mixture was stirred at 45 ^{o}C, and after 12 h the reaction was complete (GC and TLC). The reaction mixture was quenched with H_2O and extracted with EtOAc (3×20 mL). The combined organic layers were dried (anhydrous sodium sulfate), filtered, and concentrated under low vacuum, providing a yellow oil (crude product). The crude product was submitted to flash chromatography (EtOAc/hexane, 1:9) to give the desired precursor ketone **2** (51% yield, 1.12 g) as a yellow oil.



Imine formation and reduction: (S)-N-((S)-(2,3-dihydro-1H-inden-2-yl)(pyridin-2-yl)methyl)-1-(4-methoxyphenyl)ethanamine. To a glass vessel was added the above synthesized ketone (1.00 equiv, 1.12 g, 5.0 mmol), OMe-α-MBA (1.2 equiv, 0.89 mL, 6 mmol) and Ti(O*i*Pr)$_4$ (2.00 equiv, 2.98 mL, 10 mmol). The reaction mixture was stirred neat at 60 ^{o}C for 24 h under nitrogen. To this reaction mixture was added Pd/C (5 mol %) and isopropyl acetate (0.5 M), and this solution was pressurized with hydrogen (10 bars, 145 psi) at 60 ^{o}C. Conversion of the imine to the secondary amine product was evident after 36 h (GC analysis). The reaction was transferred to an Erlenmeyer flask with the aid of EtOAc (~70 mL) and then NaOH (~50 mL, 1.0 N) was added. It is important to rigorously stir this solution for about 1 h before filtration through a bed of celite (subsequently wash celite with EtOAc). Phase separation, and further extraction with EtOAc, followed by drying (Na_2SO_4) of the combined organic layers, filtration, and concentratation under low and then high vacuum provided the crude product. GC analysis showed the crude product to have a 63:37 diastereomeric ratio. Slow chromatography eluting with 3% EtOAc/petroleum ether gave the major secondary amine product in 20% yield with a dr of 99.6: 0.4 by GC analysis (Shimadzu GC-2010 instrument with a

Rtx-5 amine column was used for reaction progress and diastereomeric excess measurements for this amine. Rtx-5 amine column (Restec, 30 m x 0.25 mm); T_{inj}= 300 °C and T_{det}= 300 °C, and carrier gas He @ 24 psi were always constant).



2

PicAm-2 from secondary amine: (S)-(2,3-dihydro-1H-inden-2-yl)(pyridin-2-yl)methanamine (2). To a round bottom flask (10 mL) was added the above synthesized secondary amine (1.00 equiv, 570 mg, 1.6 mmol) and anhydrous 1,2-dichloromethane (0.5 M), followed by NaI (0.50 equiv, 120 mg, 0.8 mmol) and boron trichloride (2.50 equiv, 360 uL, 4.0 mmol). The reaction mixture was stirred at room temperature. [Note: this procedure is a modification of one reported earlier, here we added NaI and were successful with the reaction, without NaI the reaction provided very poor yields and more by-products. For the original method description, see: S. D. Boggs, J. D. Cobb, K. S. Gudmundsson, L. A. Jones, R. T. Matsuoka, A. Millar, D. E. Patterson, V. Samano, M. D. Trone, S. Xie, X.-M. Zhou, *Org. Process Res. Dev.* **2007**, *11*, 539 – 545.] The progress of the reaction was monitored by GC analysis and full conversion of starting material into product was observed within 21 h. Aqueous NaOH (1.0 N) was added and separatory funnel separation and further extraction with 1,2-dichloromethane (3 x 15 mL), followed by drying (Na_2SO_4) of the combined organic extracts and concentration, low and then high vacuum, gave the crude product. Flash chromatography, eluting with 30% EtOAc in petroleum ether and then with 10% MeOH in CH_2Cl_2 gave the desired primary free amine, PicAm-**2**, as a brown oil 98% yield (350 mg) in >99% *ee* (see below for ee determination).

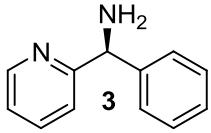
^{1}H NMR (400 MHz, $CDCl_3$) (ppm): 2.11 (bs, 2H), 2.66-2.68 (m, 2H), 2.85-2.99 (m, 2H), 3.12-3.18 (m, 1H), 4.01 (d, *J* = 7.6 Hz, 1H), 7.09-7.14 (m, 3H), 7.19-7.22 (m, 2H), 7.28 (d, *J* = 7.8 Hz, 1H), 7.65-7.70 (m, 1H), 8.59 (d, *J* = 4.2 Hz, 1H).

^{13}C NMR (100 MHz, $CDCl_3$) (ppm): 36.3, 36.4, 46.6, 60.8, 124.3, 124.5, 126.2, 126.3, 136.8, 142.5, 142.6, 149.3, 161.9; FT-IR: (KBr) ν_{max}: 1168, 1542, 2851, 2859, 3356, 3382 cm^{-1}; MS (EI), *m/z* (relative intensity): 225 $[M+H]^+$; HRMS (ESI-TOF) calculated for $C_{15}H_{17}N_2$ $[M+H]^+$ is 225.1386; found: 225.1392.

Ee determination for PicAm-2:

In a pressure vessel (glass) was added anhydrous CH_2Cl_2 (2.0 mL). Note: for reasons that are not currently clear, it appears to be important to perform this reaction in a sealed vessel. Add PicAm-**2** (1.0 equiv, 1.0 mmol), triethylamine (7.0 equiv, 7.0 mmol) and trifluoroacetic anhydride (4.0 equiv). Stir in the sealed vessel for 15 h at room temperature. Work-up: add saturated aqueous Na_2CO_3 and more CH_2Cl_2 and stir for 30 min. Extract with CH_2Cl_2 (2×30 mL) and dry with the combined organic layers with anhydrous Na_2SO_4. Concentrate the extracts and purify the crude reaction product using silica gel chromatography (EtOAc and petroleum ether). The *ee* of the diamine was found to be >99% and determined using chiral HPLC (Chiralcel AS-H, *i*-propanol/heptane 5/95, flow rate = 0.4 mL/min, λ = 210 nm):[1] t_{major} = 24.5 min, t_{minor} = 27.5 min.

PicAm-3 Synthesis (previously reported, see citations within the manuscript)



(*S*)-phenyl(pyridin-2-yl)methanamine (PicAm-3). The product was obtained as brown oil in enantiopure form with >99% *ee*. The *ee* was determined by Chiral HPLC (Chiralcel OD-H, *i*-propanol/heptane 2/98, flow rate = 0.5 mL/min, λ = 210 nm): t_{major} = 55.6 min, t_{minor} = 60.9 min; $[a]_D^{22}$ +63.6 (*c* 1.9, $CHCl_3$). The previously reported optical rotation was $[a]_D^{20}$ +67.1 (*c* 1.9, $CHCl_3$) which was determined to be the (S) enantiomer, see: G. Alvaro, G. Martelli, D. Savoia, *J. Chem. Soc. Perkin Trans. 1*. **1998**, *4*, 775-784.
^{1}H NMR (400 MHz, $CDCl_3$) (ppm): 2.17 (bs, 2H), 5.20 (s, 1H), 7.07-7.11 (m, 1H), 7.19-7.31 (m, 4H), 7.39-7.41 (m, 2H), 7.53-7.58 (m, 1H), 8.55 (d, *J* = 4.3 Hz, 1H).

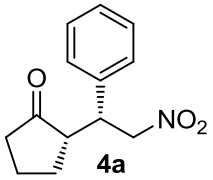
Michael Section (carbonyl additions to unsaturated nitrocompounds)

General Procedure for synthesizing the racemic Michael adducts with cyclopentanone.
To a mixture of nitroolefin (1.00 equiv) and 2-picolylamine (20 mol %) in the presence of 2,4-dinitrobenzenesulfonic acid hydrate (10 mol %) in chloroform (0.5 M) was added cyclopentanone (20.0 equiv). The reaction was stirred at room temperature and monitored by TLC. At maximum conversion the reaction was quenched with 1.0 N HCl, extracted with dichloromethane and the combined organics dried under reduced pressure. The crude product was purified by column chromatography on silica gel (Pet Ether/EtOAc, 95:5, with slowly increasing polarity as needed).

General procedure for synthesis of racemic Michael adducts (aldehydes).
To a mixture of the nitroolefin (1.00 equiv) and aldehyde (20.0 equiv) in chloroform (0.5 M) was added glycine (15 mol %) and dimethylaminopyridine (15 mol %). The reaction was stirred at room temperature and monitored by TLC. At maximum conversion the reaction mixture was filtered, and the solution was concentrated reduced pressure and subsequently purify by column chromatography.

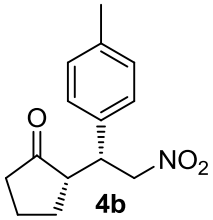
General procedure for enantioselective Michael reactions.
To a mixture of the nitroolefin (1.00 equiv), PicAm catalyst (free amine, 10 mol% unless otherwise stated) in the presence of dodecylbenzenesulfonic acid sodium salt (10 mol%), and 2,4-dinitrobenzene sulfonic acid hydrate (2.5 mol%) in chloroform (2.0 M) was added the ketone or aldehyde (5.00 equiv). The reactions were performed at room temperature and monitored by HPLC and/or TLC. At the indicated reaction time (Tables in manuscript text) the reaction was concentrated (low vacuum, then short exposure to high vacuum) and the resulting crude Michael product was purified by column chromatography. For all products, the yield, dr, and ee are given below. Note: PicAm-**3** overlaps with β-nitrostyrene in the HPLC. We tried working up the crude reaction material with dilute HCl to remove the catalyst, but in our hands this was not completely

successful and thus we did not use an acid work-up. For the new Michael compounds identified here, **4b-d**, we assumed that the same stereochemical trend prevails as found in **4a**.



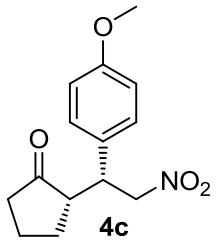
4a

(*S*)-2-((*R*)-2-nitro-1-phenylethyl)cyclopentanone (4a). White solid, 76% isolated yield, *syn/anti* = 81/19, 87 % *ee* (*syn*).
The *ee* was determined by two different methods:
Method A: [Reported method (REF)] The *ee* was determined by chiral HPLC (Chiralcel AS-H, *i*-propanol/hexane 25/75, flow rate = 1.0 mL/min, λ = 210 nm): t_{major} = 16.7 min, t_{minor} = 10.7 min
Method B: The *ee* was determined by chiral HPLC (Chiralcel OD-H, *i*-propanol/heptane 5/95, flow rate = 1.0 mL/min, λ = 210 nm): t_{major} = 24.1 min, t_{minor} = 31.7 min.
R_f = 0.37 EtOAc/pet ether (1:4).
^{1}H NMR (400 MHz, $CDCl_3$) (ppm) (major diastereomer): 1.43-1.54 (m, 2H), 1.61-1.76 (m, 1H), 1.82-1.96 (m, 2H), 2.06-2.18 (m, 1H), 2.31-2.43 (m, 2H), 3.66-3.73 (m, 1H), 4.73 (dd, *J* = 10.0, 12.9 Hz, 1H), 5.35 (dd, *J* = 5.6, 12.9 Hz, 1H), 7.15-7.20 (m, 2H), 7.24-7.34 (m, 3H).
Y. Xiong, Y. Wen, F. Wang, B. Gao, X. Liu, X. Huang, X. Fenga, *Adv. Synth. Catal*. **2007**, *349*, 2156-2166.



4b

(*S*)-2-((*R*)-2-nitro-1-p-tolylethyl)cyclopentanone (4b). Yellow oil, 92% isolated yield, *syn/anti* = 76/24, 88 % *ee* (*syn*), >99 % *ee* (*anti*). The *ee* was determined by chiral HPLC (Chiralcel OD-H, *i*-propanol/heptane 15/85, flow rate = 1.0 mL/min, λ = 190 nm): t_{minor} (*anti*) = 9.2 min, t_{major} (*syn*) = 9.7 min, t_{minor} (*syn*) = 11.4 min, t_{major} (*anti*) = 15.4 min, R_f = 0.41 EtOAc/pet ether (1:4).
^{1}H NMR (400 MHz, $CDCl_3$) (ppm) (major diastereomer): 1.42-1.53 (m, 1H), 1.58-1.77 (m, 2H), 1.83-1.93 (m, 2H), 2.07-2.16 (m, 1H), 2.31 (s, 3H), 2.30-2.40 (m, 1H), 3.63-3.69 (m, 1H), 4.70 (dd, *J* = 10.0, 12.8 Hz, 1H), 5.31 (dd, *J* = 12.8, 5.6 Hz, 1H), 7.03-7.07 (m, 2H), 7.10-7.12 (m, 2H).
V. G. Saraswathy, S. Sankararaman, *J. Org. Chem*. **1995**, *60*, 5024-5028.

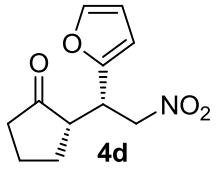


4c

(*S*)-2-((*R*)-1-(4-methoxyphenyl)-2-nitroethyl)cyclopentanone (4c). Yellowish solid, 85% isolated yield, *syn/anti* = 88/12, 77 % *ee* (*syn*). The *ee* was determined by chiral HPLC (Chiralcel OD-H, *i*-propanol/heptane 20/80, flow rate = 1.0 mL/min, λ = 190 nm): t_{major} = 15.0 min, t_{minor} = 16.6 min, R_f = 0.29 EtOAc/pet ether (1:4).

^{1}H NMR (400 MHz, $CDCl_3$) (ppm) (major diastereomer): 1.44-1.54 (m, 1H), 1.64-1.76 (m, 1H), 1.85-1.96 (m, 2H), 2.07-2.16 (m, 1H), 2.31-2.39 (m, 2H), 3.63-3.69 (m, 1H), 3.78 (s, 3H), 4.68 (dd, *J* = 10.0, 12.6 Hz, 1H), 5.29 (dd, *J* = 5.6, 12.6), 6.84 (d, *J* = 8.7 Hz, 2H), 7.08 (d, *J* = 8.7 Hz, 2H).

M. C. Moorjani, g. K. Trivedi, *Ind. J. Chem*. **1978**, *16B*, 405.



4d

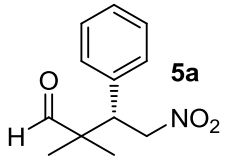
(S)-2-((S)-1-(furan-2-yl)-2-nitroethyl)cyclopentanone (4d). Dark yellow oil, 89% yield, *syn/anti* = 57/43, 81 % *ee* (*syn*). The *ee* was determined by chiral HPLC (Chiralcel AS-H, *i*-propanol/heptane 10/90, flow rate = 0.5 mL/min, λ = 230 nm): t_{minor} =37.6 min, t_{major} = 67.5 min, R_f = 0.30 EtOAc/pet ether (1:4).

^{1}H NMR (400 MHz, $CDCl_3$) (ppm) (major diastereomer): 1.51-1.61 (m, 1H), 1.67-1.78 (m, 1H), 1.89-1.95 (m, 1H), 2.00-2.14 (m, 2H), 2.29-2.43 (m, 1H), 3.95-4.02 (m, 1H), 4.78 (dd, *J* = 9.2, 12.9 Hz, 1H), 5.06 (dd, *J* = 6.2, 12.9 Hz, 1H), 6.13 (d, 3.24 Hz, 1H), 6.28-6.29 (m, 1H), 7.33 (s, 1H).

^{13}C NMR (100MHz. $CDCl_3$) (ppm) (major diastereomer): 20.2, 27.0, 37.7, 38.3, 49.5, 75.9, 108.8, 110.4, 142.4, 150.6, 217.9.

FT-IR: (KBr) ν_{max}: 3122, 2968, 2882, 1729, 1378, 1150, 1013, 917, 817, 742, 599 cm^{-1}.

MS (EI), *m/z* (relative intensity): 246 $[M+Na]^+$; HRMS (ESI-TOF) calculated for $C_{11}H_{13}NO_4$ $[M+Na]^+$ 246.0742; found: 246.0739.

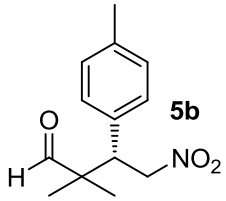


5a

(*S*)-2,2-dimethyl-4-nitro-3-phenylbutanal (5a). Clear oil, 58% isolated yield, 78 % *ee*. The *ee* was determined by chiral HPLC (Chiralcel OD-H, *i*-propanol/heptane 8/92, flow rate = 1 mL/min, λ = 210 nm), t_{minor} = 21.1 min, t_{major} = 33.7 min, R_f = 0.38 EtOAc/pet ether (1:4).

^{1}H NMR (400 MHz, $CDCl_3$) (ppm): 1.00 (s, 3H), 1.13 (s, 3H), 3.78 (dd, *J* = 4.2, 11.3 Hz, 1H), 4.69 (dd, *J* = 4.2, 13.1 Hz, 1H), 4.86 (dd, *J* = 11.3, 13.1 Hz, 1H), 7.16-7.21 (m, 2H), 7.27-7.35 (m, 3H), 9.52 (s, 1H).

REF: S. H. McCooey, S. J. Connon, *Org. Lett.* **2007**, *9*, 599-602.

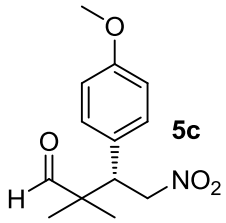


5b

(*S*)-2,2-dimethyl-4-nitro-3-p-tolylbutanal (5b). Yellow oil, 53% isolated yield, 80 % *ee*. The *ee* was determined by chiral HPLC (Chiralcel OD-H, *i*-propanol/heptane 20/80, flow rate = 1 mL/min, λ = 215 nm), t_{minor} = 12.0 min, t_{major} = 16.7 min, R_f = 0.39 EtOAc/pet ether (1:4).

^{1}H NMR (400 MHz, $CDCl_3$) (ppm): 1.00 (s, 3H), 1.12 (s, 3H), 2.32 (s, 3H), 3.74 (dd, *J* = 4.2, 11.3 Hz, 1H), 4.66 (dd, *J* = 4.2, 13.3 Hz, 1H), 4.83 (dd, *J* = 11.3, 13.3 Hz, 1H), 7.07, (d, *J* = 8.1 Hz, 2H), 7.13 (d, *J* = 8.0 Hz, 2H), 9.52 (s, 1H).

W. Wang, J. Wang, H. Li, *Angew. Chem. Int. Ed*. **2005**, *44*, 1369-1371.

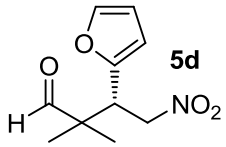


5c

(*S*)-3-(4-methoxyphenyl)-2,2-dimethyl-4-nitrobutanal (5c). Colourless solid, 59% isolated yield, 90 % *ee*. The *ee* was determined by chiral HPLC (Chiralcel OD-H, *i*-propanol/heptane 10/90, flow rate = 1 mL/min, λ = 210 nm), t_{minor} = 13.3 min, t_{major} = 18.2 min, R_f = 0.33 EtOAc/ pet ether (1:4).

^{1}H NMR (400 MHz, $CDCl_3$) (ppm): 0.99 (s, 3H), 1.11 (s, 3H), 3.78 (s, 3H), 3.73 (dd, *J* = 4.2, 11.5 Hz, 1H), 4.66 (dd, *J* = 4.3, 12.9 Hz, 1H), 4.80 (dd, *J* = 11.5, 12.8 Hz, 1H), 6.85 (d, *J* = 8.8 Hz, 2H), 7.11 (d, *J* = 8.7 Hz, 2H), 9.51 (s, 1H).

X.-J. Zhang, S.-P. Liu, X.-M. Li, M. Yan, A. S. C. Chan, *Chem. Commun*. **2009**, *7*, 833-835.



(*S*)-3-(furan-2-yl)-2,2-dimethyl-4-nitrobutanal (5d). Yellow oil, 70% isolated yield, 90 % *ee*. The *ee* was determined by chiral HPLC (Chiralcel OD-H, *i*-propanol/heptane 25/75, flow rate = 0.8 mL/min, λ = 190 nm), t_{minor} = 12.3 min, t_{major} = 18.1 min, R_f = 0.34 EtOAc/pet ether (1:4).
^{1}H NMR (400 MHz, $CDCl_3$) (ppm): 1.05 (s, 3H), 1.18 (s, 3H), 3.92 (dd, *J* = 3.9, 11.1 Hz, 1H), 4.59 (dd, *J* = 4.0, 12.9 Hz, 1H), 4.76 (dd, *J* = 11.1, 12.9 Hz, 1H), 6.22 (d, *J* = 3.24 Hz, 1H), 6.31-6.32 (m, 1H), 7.37 (d, *J* = 1.75 Hz, 1H), 9.52 (s, 1H).
S. H. McCooey, S. J. Connon, *Org. Lett.* **2007**, *9*, 599-602.

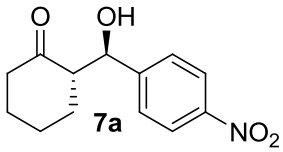
Aldol Section (carbonyl additions to aromatic aldehydes)

General Procedure for Racemic Aldol product

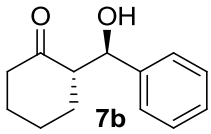
To a solution of water/methanol (4 mL, 1:1), picolylamine (0.4 mmol), and ketone (6.5 mmol), was added the aldedyde (2 mmol). Depending on the substrate, the reaction was stirred at room temperature for a 12-24 h period. The reaction was monitored by TLC, and in most instances the starting material was fully consumed. The reactions were quenched by the addition of saturated aqueous NH_4Cl (20-25 mL) and the resulting mixture was extracted 3x with ethyl acetate (25 mL). The combined organic layers were dried over anhydrous sodium sulfate, evaporated, and filtered to obtain the crude aldol product. Column chromatography on silica gel using 5-10% ethyl acetate-hexane provided the pure aldol products.

General Procedure for Enantioselctive Aldol Reaction

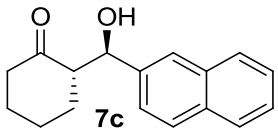
The (*S*)-PicAm-**1**/2,4-dinitrobenzenesulfonic acid 1:1 salt (MW = 550.58) was added (0.035 mmol, 7.0 mol%) to a mixture of the aldehyde (0.5 mmol, 1.0 equiv) and ketone (1.65 mmol, 3.3 equiv) in distilled water (1.0 mL), and the reaction mixture was stirred at 45 ^{o}C for the specified reaction time period. Note, all aldol products reported here were obtained by using 7 mol% of the catalyst and 3.3 equiv of the ketone donor, and extended reactions can lead to epimerization of the product. Work-up involved simply adding EtOAc and extracting with this solvent. The organic layers were collected and concentrated (no drying agent was used), and the ^{1}H NMR and HPLC of the crude product were recorded. The crude sample was then purified by chromatography (petroleum ether/EtOAc) for yield and ee assessment. Relative and absolute configurations of the products were determined by comparison with the known ^{1}H NMR data and chiral HPLC traces. For new aldol compound identified here, **9c**, we assumed that the same stereochemical trend prevails.



(S)-2-((R)-hydroxy(4-nitrophenyl)methyl)cyclohexanone (7a).
The reaction media was brine.
Reaction time: 16 h; The crude product was purified by flash column chromatography (EtOAc/pet ether = 10:90); yield: 92%; The *ee* was determined by chiral HPLC (Chiralcel OD-H, *i*-PrOH/heptane 5/95, flow rate = 1 mL/min, λ = 210 nm): t_{major} =24.2 min, t_{minor} = 36.5 min, *ee* = 99%, *dr* = 22:1 *(anti/syn*). R_f = 0.29, 40% EtOAc/pet ether.
H NMR (400 MHz, $CDCl_3$) (ppm) (major diastereomer): 1.36-1.44 (m, 1H), 1.55-1.72 (m, 3H), 1.80-1.88 (m, 1H), 2.09-2.16 (m, 1H), 2.33-2.41 (m, 1H), 2.47-2.52 (m, 1H), 2.56-2.64 (m, 1H), 4.12 (s, 1H), 4.91 (d, *J* = 8.4 Hz, 1H), 7.52 (d, *J* = 8.6 Hz, 2H), 8.21 (d, *J* = 8.6 Hz, 2H).
N. Mase, Y. Nakai, N. Ohara, H. Yoda, K. Takabe, F. Tanaka, C. F. Barbas III, *J. Am. Chem. Soc.* **2006**, *128*, 734-735.
T. Miura, K. Imai, M. Ina, N. Tada, N. Imai, A. Itoh, *Org. Lett.* **2010**, *12*, 1620-1623.

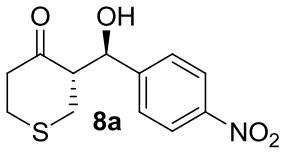


(S)-2-((R)-hydroxy(phenyl)methyl)cyclohexanone (7b).
Reaction time: 9 h; The crude product was purified by flash column chromatography (EtOAc/pet ether = 7:93); yield: 50%; The *ee* was determined by chiral HPLC (Chiralcel OD-H, *i*-PrOH/heptane 5/95, flow rate = 0.5 mL/min, λ = 210 nm): t_{major} =23.2 min, t_{minor} = 39.0 min, *ee* = 96%, *dr* = 6:1 (*anti/syn*), R_f = 0.27, 20% EtOAc/pet ether.
^{1}H NMR (400 MHz, $CDCl_3$) (ppm) (major diastereomer): 1.47-1.60 (m, 3H), 1.64-1.70 (m, 1H), 1.74-1.80 (m, 1H), 2.05-2.12 (m, 1H), 2.32-2.40 (m, 1H), 2.46-2.50 (m, 1H), 2.58-2.66 (m, 1H), 3.96 (s, 1H), 4.79 (d, *J* = 8.8 Hz, 1H), 7.26-7.35 (m, 5H).
Y. Hayashi, T. Sumiya, J. Takahashi, H. Gotoh, T. Urushima, M. Shoji, *Angew. Chem. Int. Ed.* **2006**, *45*, 958-961.

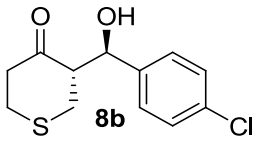


(S)-2-((R)-hydroxy(naphthalen-3-yl)methyl)cyclohexanone (7c).
Reaction time: 14 h; The crude product was purified by flash column chromatography (EtOAc/pet ether = 10:90); yield: 85%; The *ee* was determined by HPLC analysis (Chiralcel OD-H, *i*-PrOH/heptane 10/90, flow rate = 1 mL/min, λ = 210 nm): t_{major} = 17.8 min, t_{minor} = 19.9min, *ee* = 96%; *dr* = 34:1 (*anti/syn*);
^{1}H NMR (400 MHz, CDCl3) (ppm) (major diastereomer): 1.30-1.36 (m, 1H), 1.47-1.52 (m, 1H), 1.54-1.57 (m, 1H), 1.63-1.70 (m, 1H), 1.73-1.78 (m, 1H), 2.06-2.12 (m, 1H),

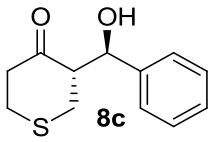
2.34-2.43 (m, 1H), 2.48-2.54 (m, 1H), 2.69-2.76 (m, 1H), 4.06 (d, *J* = 2.6 Hz, 1H), 4.97 (dd, *J* = 2.6, 8.8 Hz, 1H), 7.45-7.50 (m, 3H), 7.76 (s, 1H), 7.82-7.86 (m, 3H).
X. Wu, Z. Jiang, H.-M. Shen, Y. Lu, *Adv. Synth. Catal*. **2007**, *349*, 812-816.



(S)-tetrahydro-3-((R)-hydroxy(4-nitrophenyl)methyl)thiopyran-4-one (8a).
Reaction time: 16 h; The crude product was purified by flash column chromatography (EtOAc/pet ether = 10:90); yield: 92%; The *ee* was determined by chiral HPLC (Chiralcel AS-H, *i*-PrOH/heptane 10/90, flow rate = 1 mL/min, λ = 210 nm): t_{major} =40.9 min, t_{minor} = 55.8 min, *ee* = 98%, *dr* = 20:1 (anti/syn), R_f = 0.37, 40 % EtOAc/pet ether.
^{1}H NMR (400 MHz, $CDCl_3$) (ppm) (major diastereomer): 2.51-2.56 (m, 1H), 2.63-2.70 (m, 1H), 2.77-2.85 (m, 2H), 2.93-3.06 (m, 3H), 5.07 (d, *J* = 8.1 Hz, 1H), 7.54 (d, *J* = 8.6 Hz, 2H), 8.22 (d, *J* = 8.7 Hz, 2H).
In this reference the authors used the chiralpak AD column: J. Chen, X. Li, X. Xing, W. Xiao, *J. Org. Chem.* **2006**, *71*, 8198-8202.

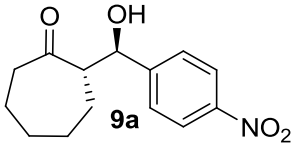


(S)-3-((R)-(4-chlorophenyl)(hydroxy)methyl)-tetrahydrothiopyran-4-one (8b)
Reaction time: 20 h; The crude product was purified by flash column chromatography (EtOAc/pet ether = 10:90); yield: 90%; The *ee* was determined by chiral HPLC (Chiralcel OD-H, *i*-PrOH/heptane 5/95, flow rate = 1 mL/min, λ = 210 nm): t_{major} =21.2 min, t_{minor} = 26.2 min, *ee* = ≥ 99%, *dr* = 15:1 (*anti/syn*), R_f = 0.30, 30% EtOAc/pet ether.
^{1}H NMR (400 MHz, $CDCl_3$) (ppm) (major diastereomer): 2.47-2.60 (m, 2H), 2.73-2.87 (m, 2H), 2.93-3.02 (m, 3H), 3.46 (s, 1H), 4.94 (d, *J* = 8.5 Hz, 1H), 7.25-7.30 (m, 2H), 7.32-7.36 (m, 2H).
B. Rodriguez, A. Bruckmann, C. Bolm, *Chem. Eur. J.* **2007**, *13*, 4710-4722.

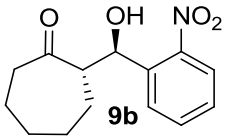


(S)-tetrahydro-3-((R)-hydroxy(phenyl)methyl)thiopyran-4-one (8c).
Reaction time: 26 h; The crude product was purified by flash column chromatography (EtOAc/pet ether = 10:90); yield: 40%; The ee was determined by chiral HPLC (Chiralcel OD-H, *i*-PrOH/heptane 5/95, flow rate = 1 mL/min, λ = 210 nm): t_{major} =19.5 min, t_{minor} = 27.8 min, *ee* = 95%, *dr* = 17:1 (*anti/syn*), R_f = 0.46, 40% EtOAc/pet ether.

^{1}H NMR (400 MHz, $CDCl_3$) (ppm) (major diastereomer): 2.47-2.59 (m, 2H), 2.73-2.89 (m, 2H), 2.95-3.04 (m, 3H), 3.40 (s, 1H), 4.97 (d, *J* = 8.8 Hz, 1H), 7.30-7.39 (m, 5H). V. Maya, M. Raj, V. K. Singh, *Org. Lett*. **2007**, *9*, 2593-2595.



(S)-2-((R)-hydroxy(4-nitrophenyl)methyl)cycloheptanone (9a).
Reaction time: 24 h; The crude product was purified by flash column chromatography (EtOAc/pet ether = 7:93); yield: 94%; The *ee* was determined by chiral HPLC (Chiralcel AS-H, *i*-PrOH/heptane 5/95, flow rate = 0.5 mL/min, λ = 254 nm): t_{major} =32.6 min, t_{minor} = 35.1 min, *ee* = 96%, *dr* = 5:1 (*anti/syn*), R_f = 0.27, 20% EtOAc/pet ether.
^{1}H NMR (400 MHz, $CDCl_3$) (ppm) (major diastereomer): 1.28-1.41 (m, 3H), 1.56-1.89 (m, 5H), 2.43-2.57 (m, 3H), 2.96-3.01 (m, 1H), 3.80 (s, 1H), 4.92 (d, *J* = 7.5 Hz, 1H), 7.53 (d, *J* = 8.5 Hz, 2H), 8.21 (d, *J* = 8.5 Hz 2H).
Y. Wu, Y. Zhang, M. Yu, G. Zhao, S. Wang, *Org. Lett*, **2006**, 8, 4417-4420.



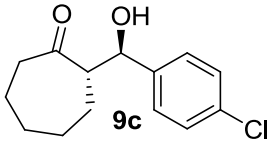
(S)-2-((R)-hydroxy(2-nitrophenyl)methyl)cycloheptanone (9b).
Reaction time: 30 h, The crude product was purified by flash column chromatography (EtOAc/pet ether = 8:92); yield: 85%; The *ee* was determined by chiral HPLC (Chiralcel AS-H, *i*-PrOH/heptane 5/95, flow rate = 0.5 mL/min, λ = 254 nm): t_{major} =31.4 min, t_{minor} = 27.1 min, *ee* = 94%, *dr* = 15:1 (*anti/syn*), R_f = 0.30, 20% EtOAc/pet ether.

The absolute stereochemistry of aldol product **9b** (Table 4, entry 8) was determined by comparison of the HPLC data reported by Córdova [G. Ma, A. Bartoszewicz, I. Ibrahem, A. Córdova, *Adv. Synth. Catal*. **2011**, *353*, 3114 – 3122]. He used the AS HPLC column to separate the enantiomers of product **9b**. We used the AS-H HPLC column to separate the enantiomers of product **9b** and obtained the same retention time trend for the major and minor enantiomers as reported by Córdova. It is our understanding that the 'hyphen H' implies that column particle size is smaller resulting in greater resolution capabilities for the AS-H column verses the AS column. For a related discussion, regarding the OD and OD-H HPLC columns, see: F. Wang, T. Dowling, D. Ellison, J. Wyvratt, *J. Chromatography A*, **2004**, 1034, 117-123.

^{1}H NMR (400 MHz, $CDCl_3$) (ppm) (major diastereomer): 1.26-1.33 (m, 1H), 1.40-1.49 (m, 1H), 1.58-1.70 (m, 2H), 1.76-1.91 (m, 4H), 2.46-2.49 (m, 2H), 3.08-3.13 (m, 1H), 4.28 (s, 1H), 5.44 (d, *J* = 5.8 Hz, 1H), 7.41-7.45 (m, 1H), 7.62-7.66 (m, 1H), 7.71-7.74 (m, 1H), 7.89-7.91 (m, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) (ppm): 23.52, 28.53, 28.75, 29.35, 44.17, 56.60, 71.42, 124.34, 128.36, 129.02, 133.25, 137.59, 148.45, 217.60; FT-

IR: (KBr) v_{max}: 3436, 2928, 1697, 1525, 1347, cm^{-1}; MS (EI), *m/z* (relative intensity): 264 $[M+H]^+$; HRMS (ESI-TOF) calculated for $C_{20}H_{29}NO_4$ $(M+Na^+)$: 286.1055, found 286.1054.

G. Ma, A. Bartoszewicz, I. Ibrahem, A. Córdova, *Adv. Synth. Catal*. **2011**, *353*, 3114–3122.



(S)-2-((R)-(4-chlorophenyl)(hydroxy)methyl)cycloheptanone (9c).

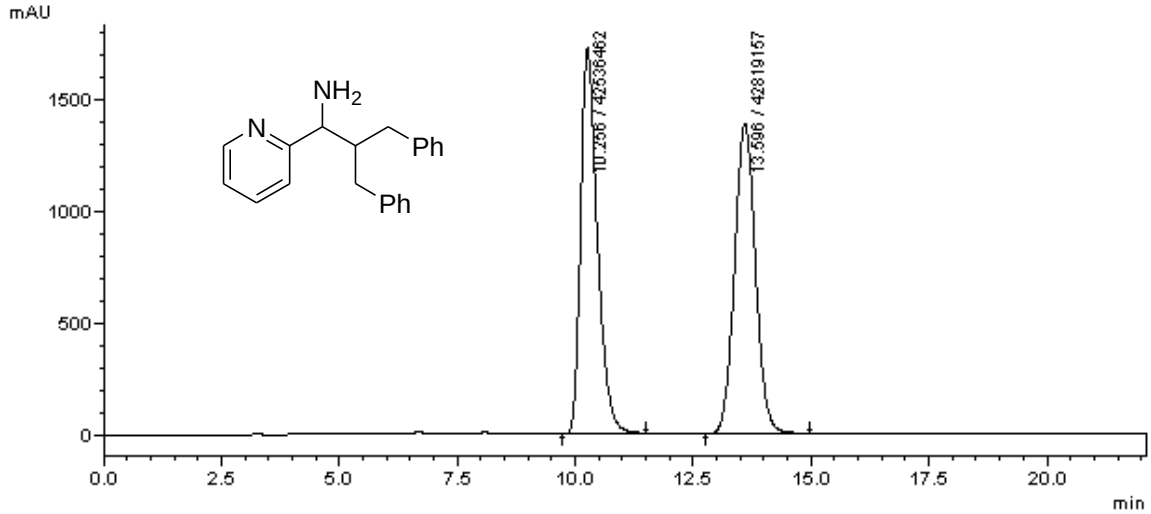
Reaction time: 30 h, The crude product was purified by flash column chromatography (EtOAc/pet ether = 8:92): yield: 86%; The *ee* was determined by chiral HPLC (Chiralcel AS-H, *i*-PrOH/heptane 15/85, flow rate = 0.5 mL/min, λ = 254 nm): t_{major} =23.5 min, t_{minor} = 25.1 min, *ee* = 90%, *dr* = 4:1 *(anti/syn)*, R_f= 0.32, 20% EtOAc/pet ether.

^1H NMR (400 MHz, $CDCl_3$) (ppm) (major diastereomer):1.25-1.33 (m, 3H), 1.52-1.55 (m, 1H), 1.65-1.78 (m, 2H), 1.85-1.87 (m, 2H), 2.45-2.60 (m, 2H), 2.91-2.96 (m, 1H), 3.36 (s, 1H), 4.79 (d, *J* = 8.1 Hz, 1H), 7.26-7.34 (m, 4H); ^{13}C NMR (100 MHz, $CDCl_3$) (ppm): 23.57, 28.03, 28.64, 28.72, 44.04, 58.25, 74.78, 128.37, 128.62, 133.58, 140.23, 217.28; FT-IR: (KBr) v_{max}: 3447, 2927, 1696, 1489, 830 cm^{-1}; MS (EI), *m/z* (relative intensity): 275 $[M+Na]^+$; HRMS (ESI-TOF) calculated for $C_{20}H_{29}NO_4$ $(M+Na^+)$: 275.0814, found 275.0803.

HPLC and NMR data start on the next page.

HPLC and NMR data for Catalysts: PicAm-1-3

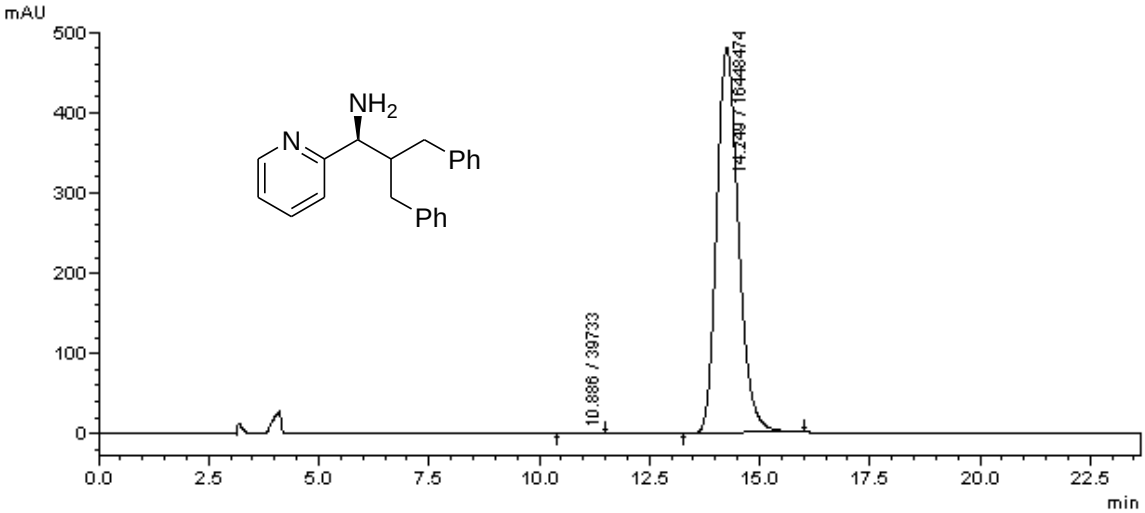
HPLC of racemic PicAm-**1**



PDA Ch1 254nm 4nm

Peak #	Ret. Time	Area	Height	Area %	Height %
1	10.256	42536462	1728862	49.834	55.535
2	13.596	42819157	1384240	50.166	44.465
Total		85355619	3113102	100.000	100.000

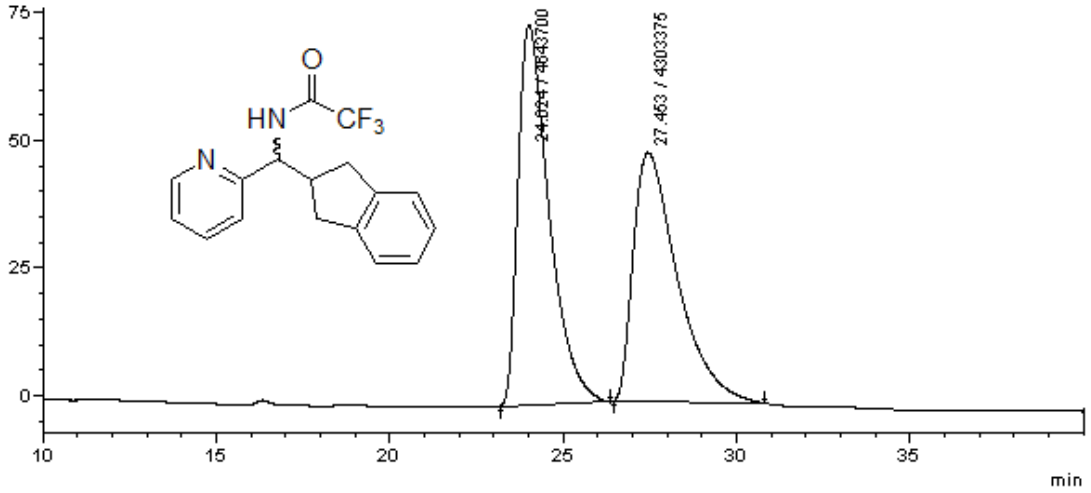
HPLC of enantiopure PicAm-**1**



PDA Ch1 254nm 4nm

Peak #	Ret. Time	Area	Height	Area %	Height %
1	10.886	39733	1349	0.241	0.280
2	14.249	16448474	480028	99.759	99.720
Total		16488207	481377	100.000	100.000

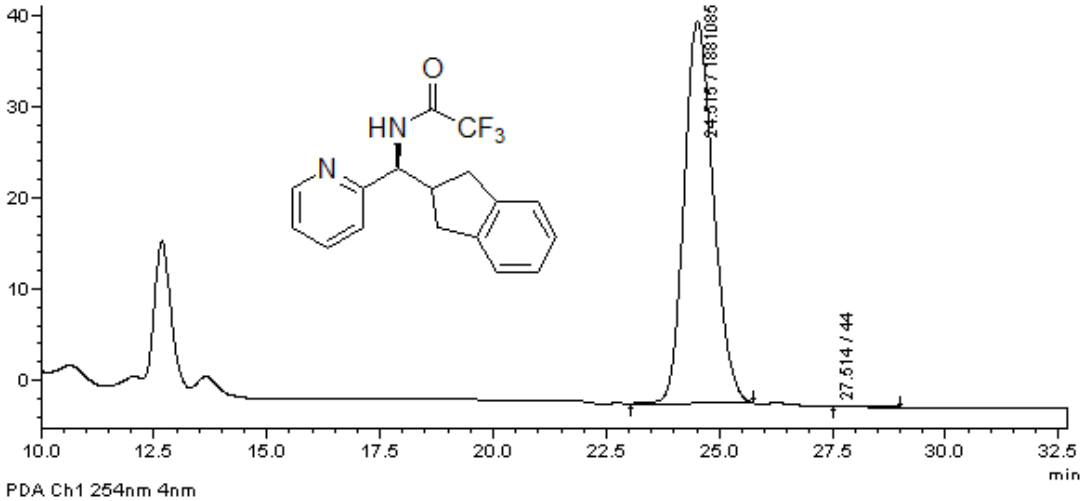
HPLC of racemic PicAm-**2** derivative



PDA Ch1 254nm 4nm

Peak#	Ret. Time	Area	Height	Area %	Height %	Width at 10% Height	Mark
1	24.024	4643700	74519	51.902	60.481	1.870	
2	27.453	4303375	48692	48.098	39.519	2.664	
Total		8947075	123211	100.000	100.000		

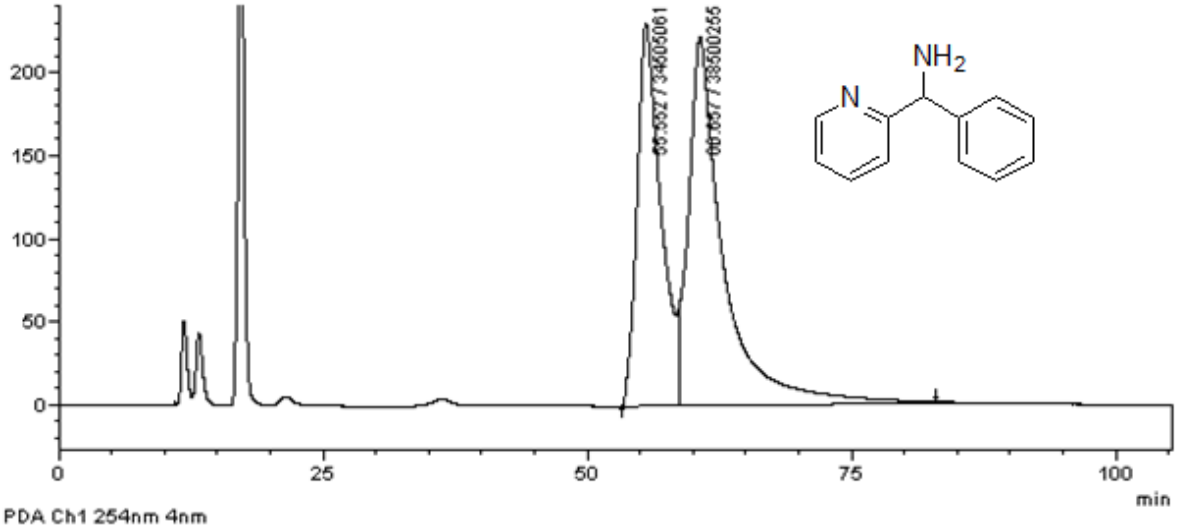
HPLC of enantiopure PicAm-**2** derivative



PDA Ch1 254nm 4nm

Peak#	Ret. Time	Area	Height	Area %	Height %	Width at 10% Height	Mark
1	24.515	1881085	41829	99.998	99.986	1.301	
2	27.514	44	6	0.002	0.014	0.004	
Total		1881129	41835	100.000	100.000		

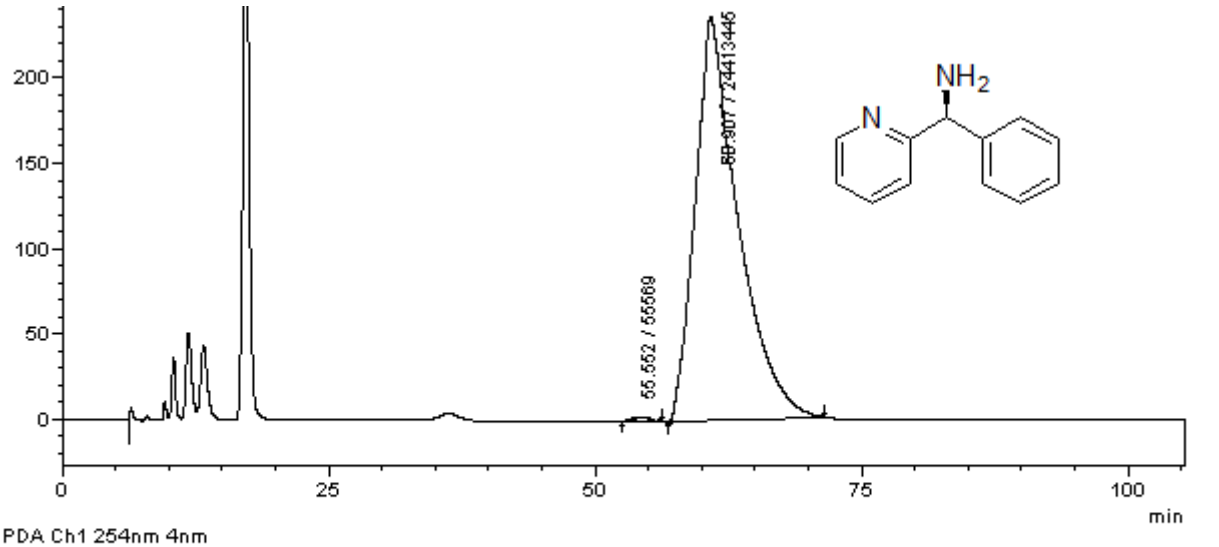
HPLC of racemic phenyl(pyridin-2-yl)methanamine (PicAm-**3**)



PDA Ch1 254nm 4nm

Peak#	Ret. Time	Area	Height	Area %	Height %	Width at 10% Height	Mark
1	55.552	34605061	226593	47.264	51.902	0.000	
2	60.657	38500255	209986	52.736	48.098	0.000	V
Total		73005315	436579	100.000	100.000		

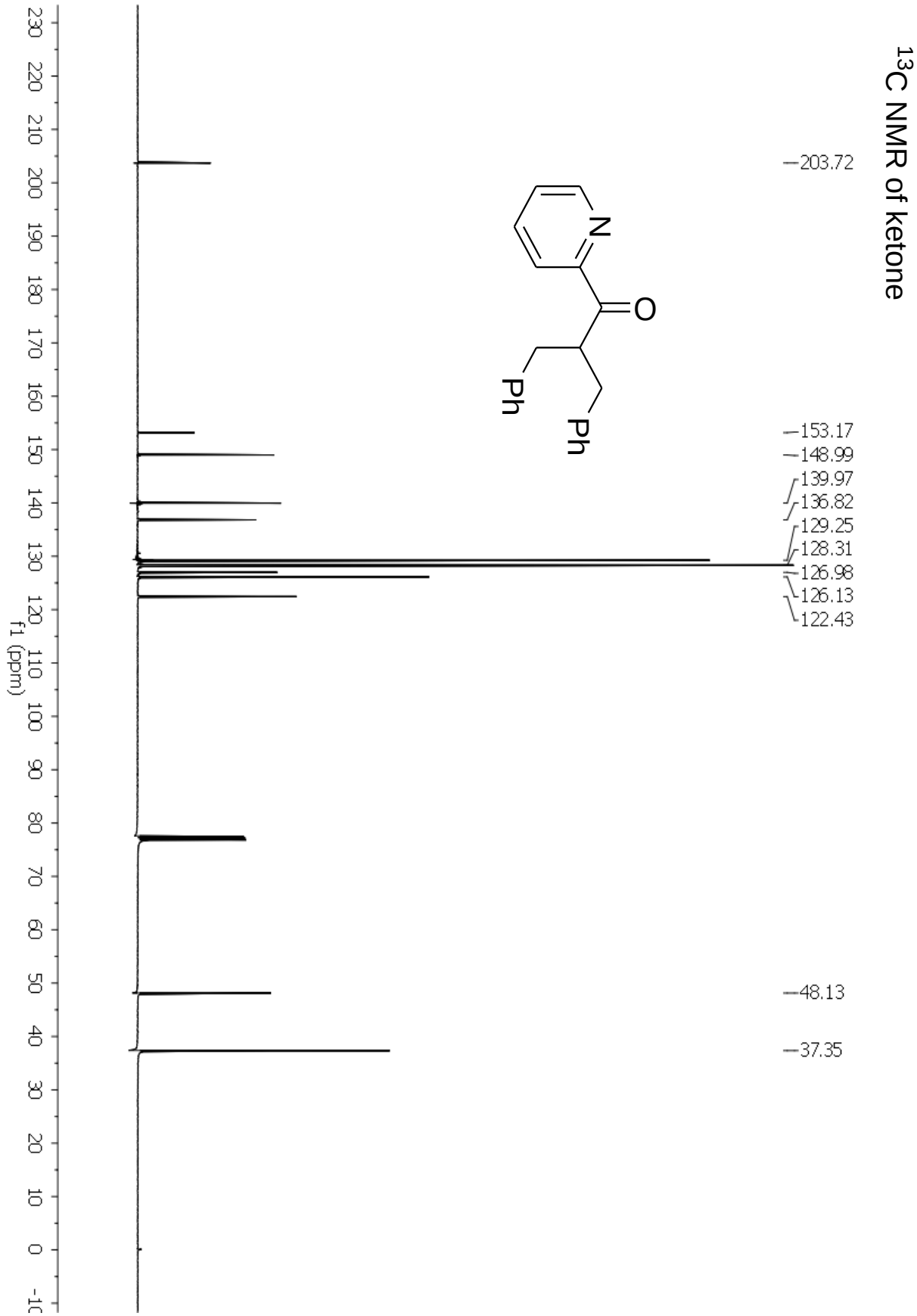
HPLC of (*S*)-phenyl(pyridin-2-yl)methanamine (PicAm-**3**)

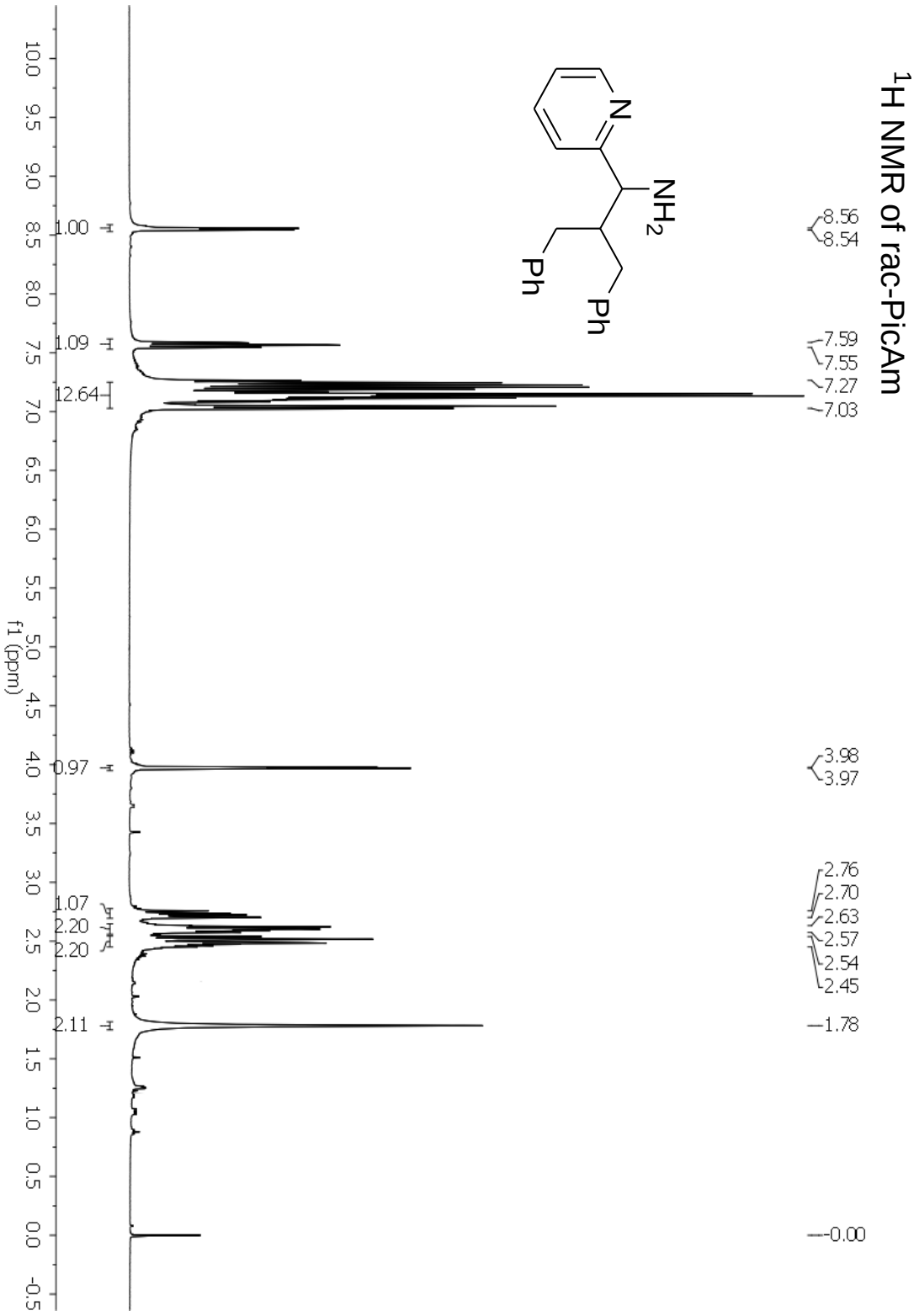


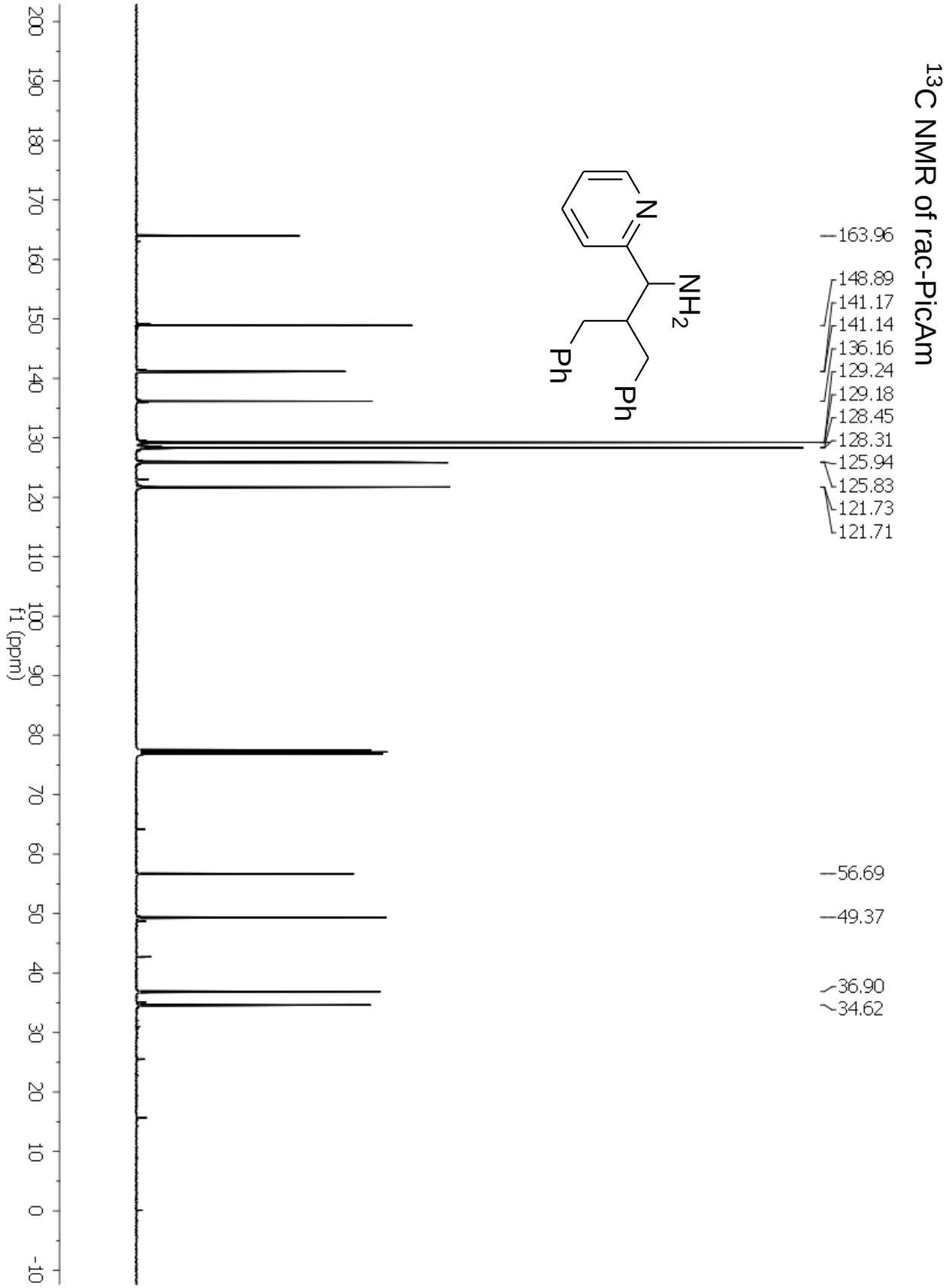
PDA Ch1 254nm 4nm

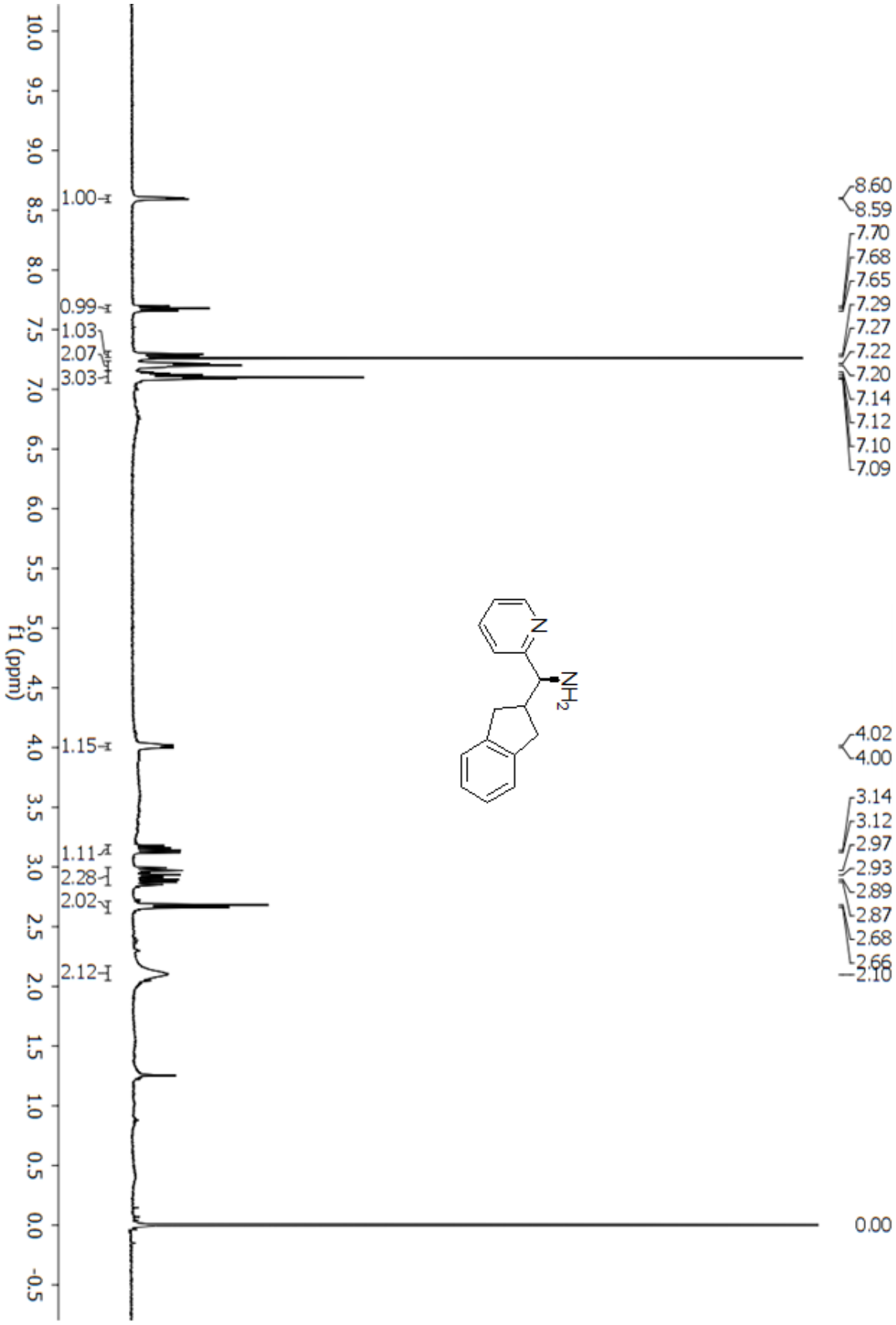
Peak#	Ret. Time	Area	Height	Area %	Height %	Width at 10% Height	Mark
1	55.552	55569	4625	0.227	2.103	0.283	
2	60.907	24413445	215301	99.773	97.897	0.000	
Total		24469013	219926	100.000	100.000		

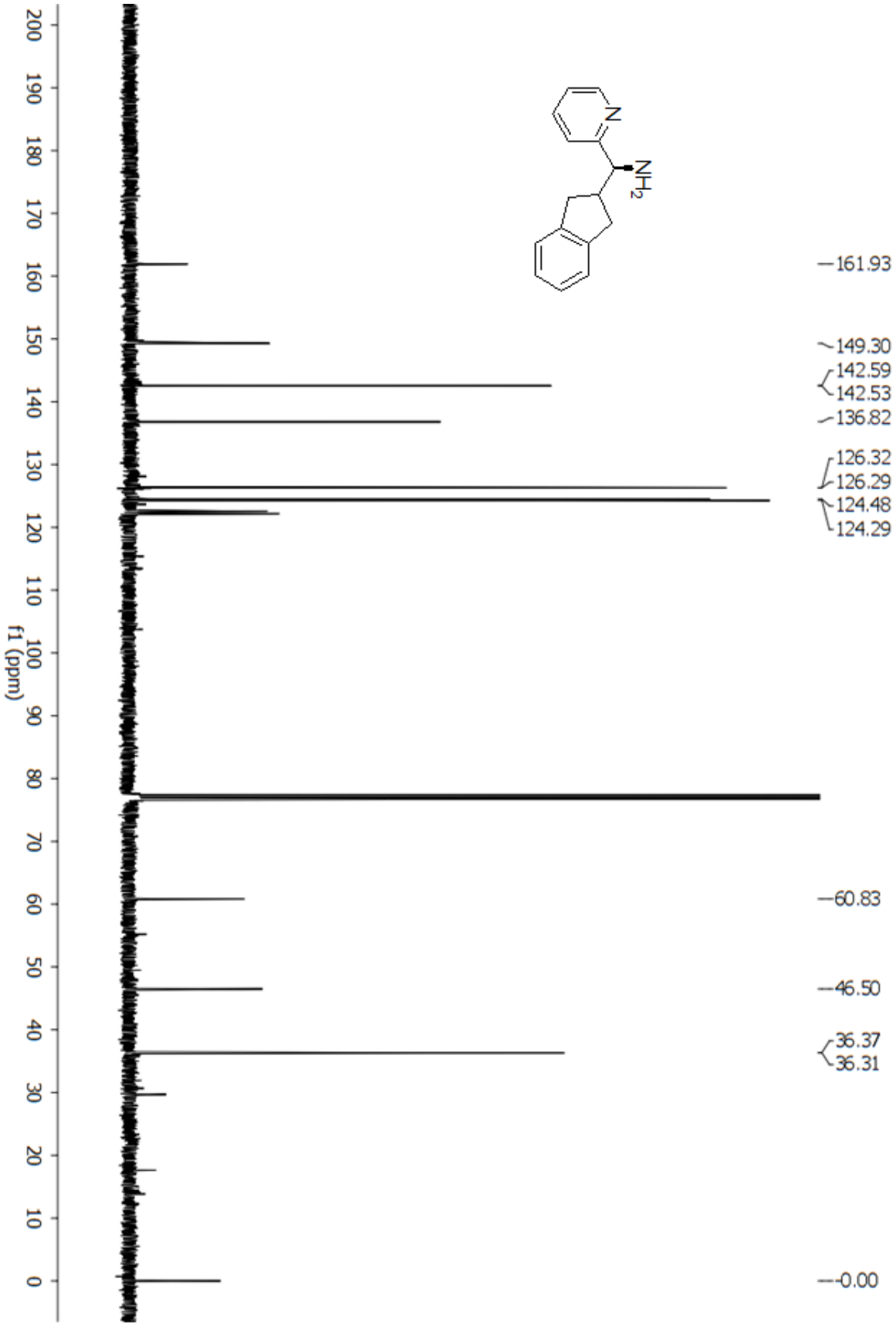
^{13}C NMR of ketone

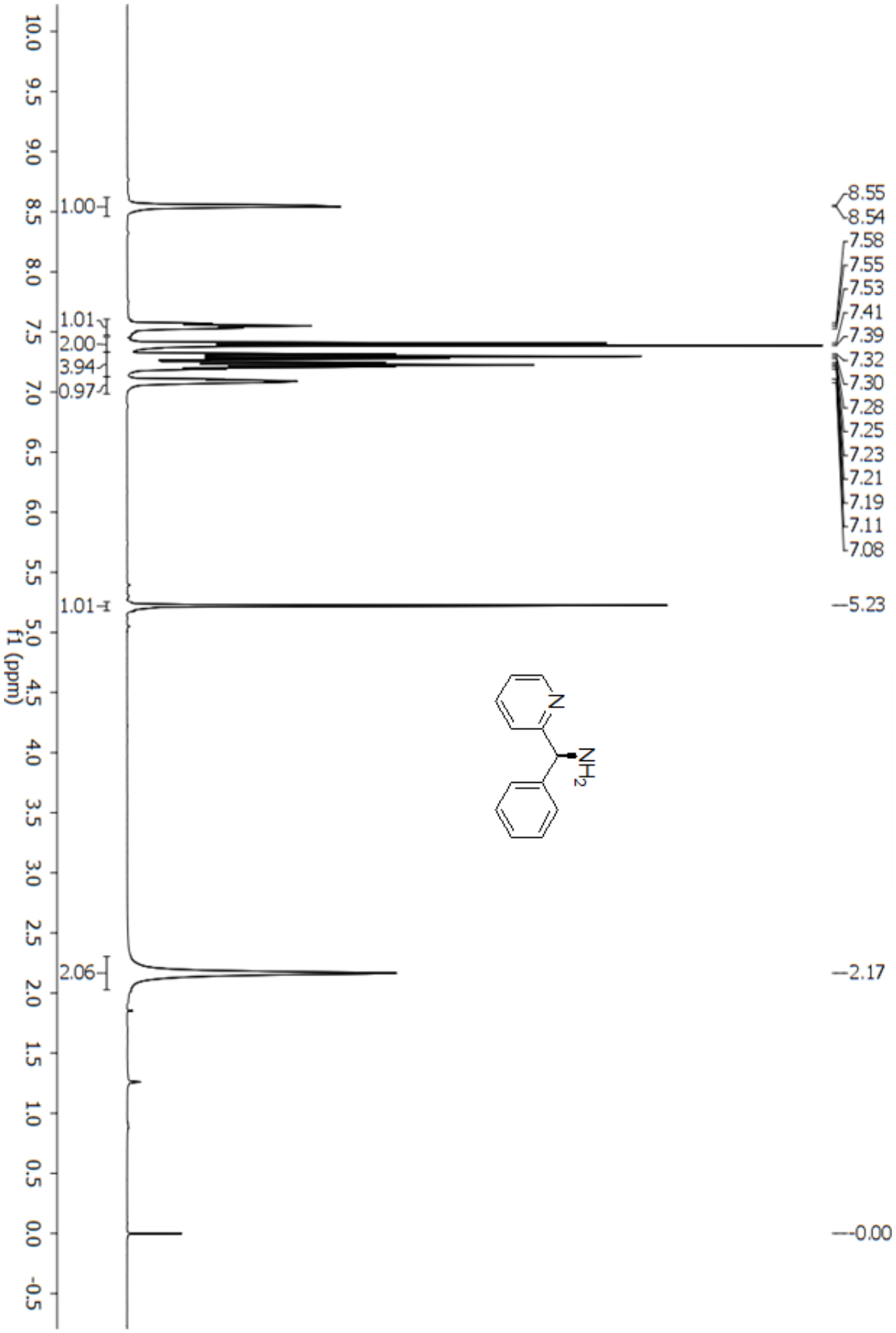






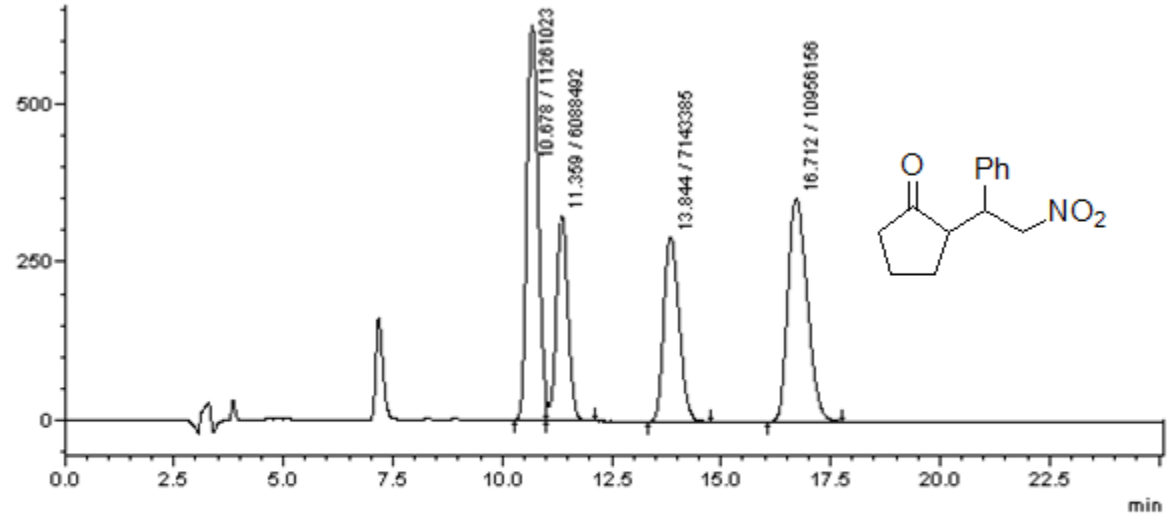






HPLC and NMR data for Michael products

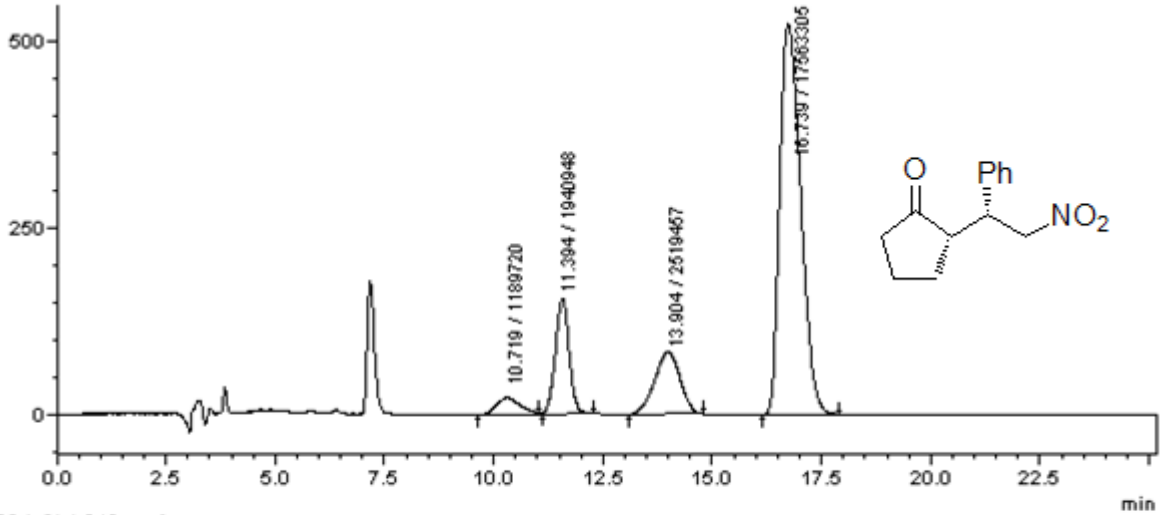
HPLC of racemic 2-(2-nitro-1-phenylethyl)cyclopentanone (**4a**), **Chiral AS-H**



PDA Ch1 210nm 4nm

Peak#	Ret. Time	Area	Height	Area %	Height %	Width at 10% Height	Mark
1	10.678	11261023	624469	31.767	39.206	0.510	
2	11.359	6088492	322557	17.175	20.251	0.529	V
3	13.844	7143385	292766	20.151	18.381	0.686	
4	16.712	10956156	353000	30.907	22.162	0.869	
Total		35449057	1592791	100.000	100.000		

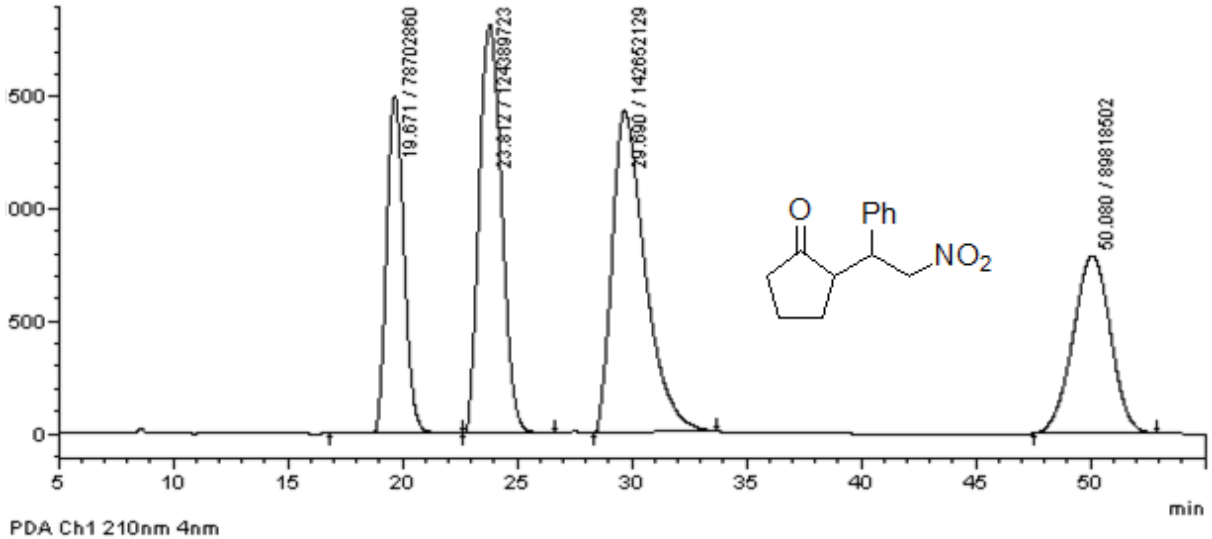
HPLC of (*S*)-2-((*R*)-2-nitro-1-phenylethyl)cyclopentanone (**4a**), **Chiral AS-H**



PDA Ch1 210nm 4nm

Peak#	Ret. Time	Area	Height	Area %	Height %	Width at 10% Height	Mark
1	10.719	1189720	112852	5.125	5.044	0.266	
2	11.394	1940948	151057	8.361	18.122	0.330	
3	13.904	2519457	149466	10.853	13.952	0.429	
4	16.739	17563305	523602	75.660	62.882	0.926	
Total		23213431	936977	100.000	100.000		

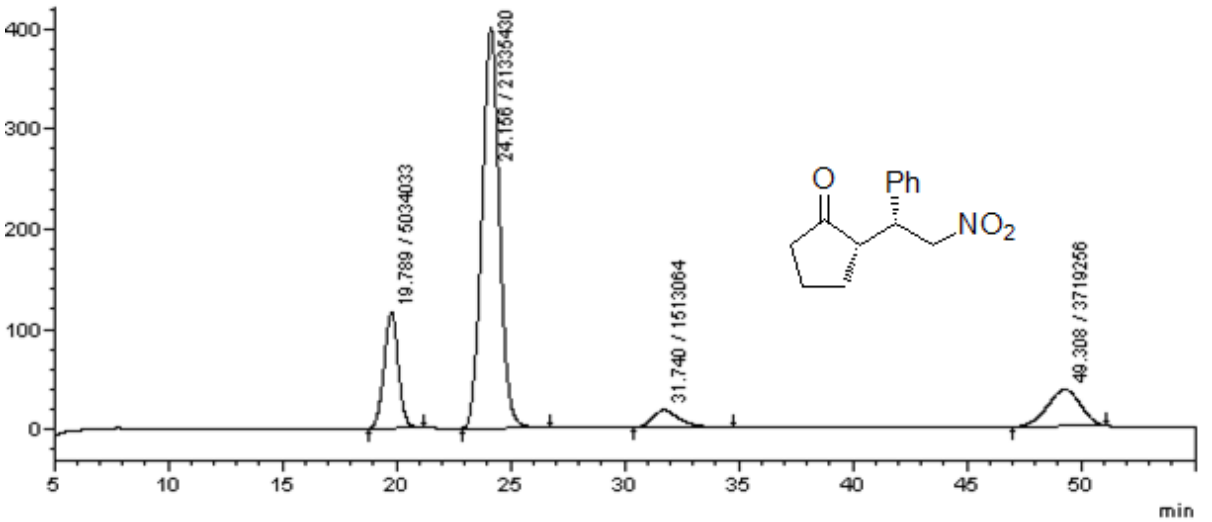
HPLC of racemic 2-(2-nitro-1-phenylethyl)cyclopentanone (**4a**), **Chiral OD-H**



PDA Ch1 210nm 4nm

Peak#	Ret. Time	Area	Height	Area %	Height %	Width at 10% Height
1	19.671	78702860	1500920	18.069	27.099	1.494
2	23.812	124389723	1816011	28.558	32.788	1.898
3	29.690	142652129	1432198	32.751	25.858	3.028
4	50.080	89818502	789518	20.621	14.255	3.266
Total		435563213	5538647	100.000	100.000	

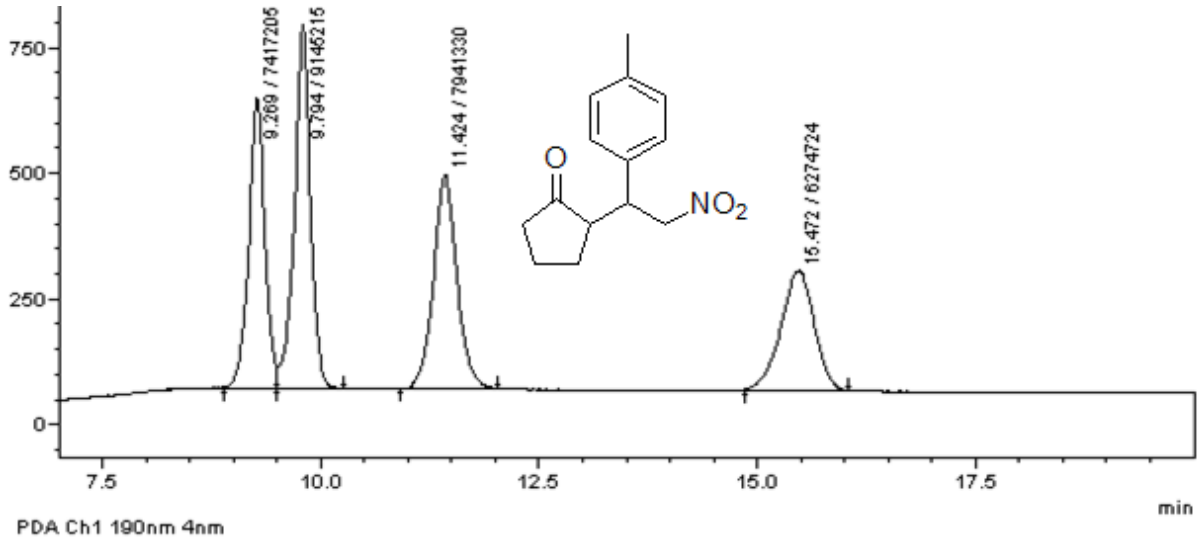
HPLC of (*S*)-2-((*R*)-2-nitro-1-phenylethyl)cyclopentanone (**4a**), **Chiral OD-H**



PDA Ch1 210nm 4nm

Peak#	Ret. Time	Area	Height	Area %	Height %	Width at 10% Height
1	19.789	5034033	116638	15.930	20.427	1.268
2	24.156	21335430	399881	67.513	70.031	1.567
3	31.740	1513064	17752	4.788	3.109	2.685
4	49.308	3719256	36738	11.769	6.434	2.910
Total		31601783	571010	100.000	100.000	

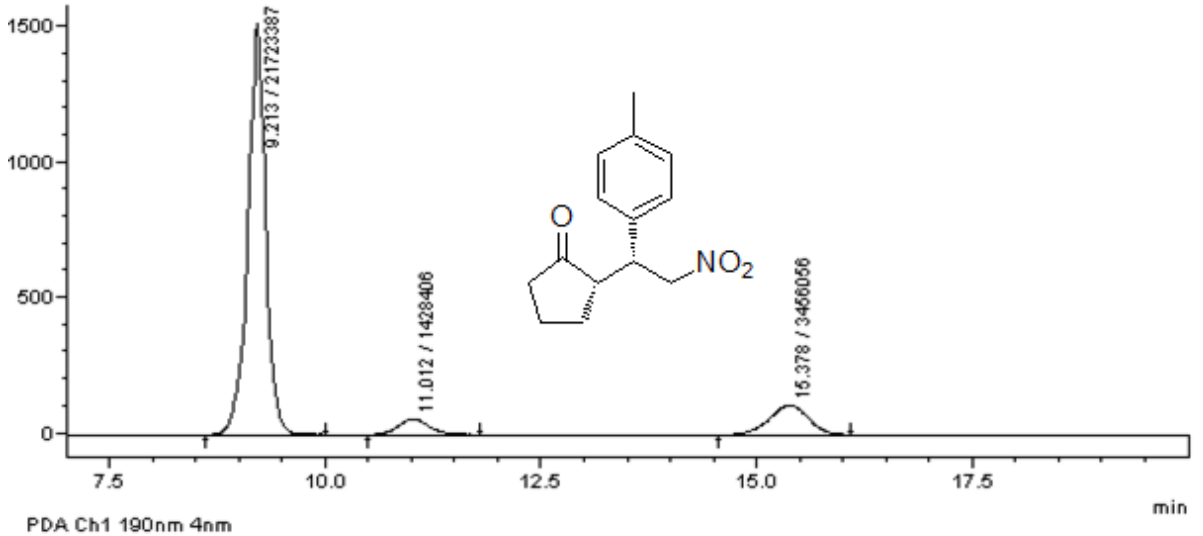
HPLC of racemic 2-(2-nitro-1-p-tolylethyl)cyclopentanone (**4b**)



PDA Ch1 190nm 4nm

Peak#	Ret. Time	Area	Height	Area %	Height %	Width at 10% Height
1	9.269	7417205	576852	24.099	29.398	0.407
2	9.794	9145215	723959	29.713	36.895	0.410
3	11.424	7941330	424339	25.802	21.626	0.577
4	15.472	6274724	237058	20.387	12.081	0.783
Total		30778475	1962209	100.000	100.000	

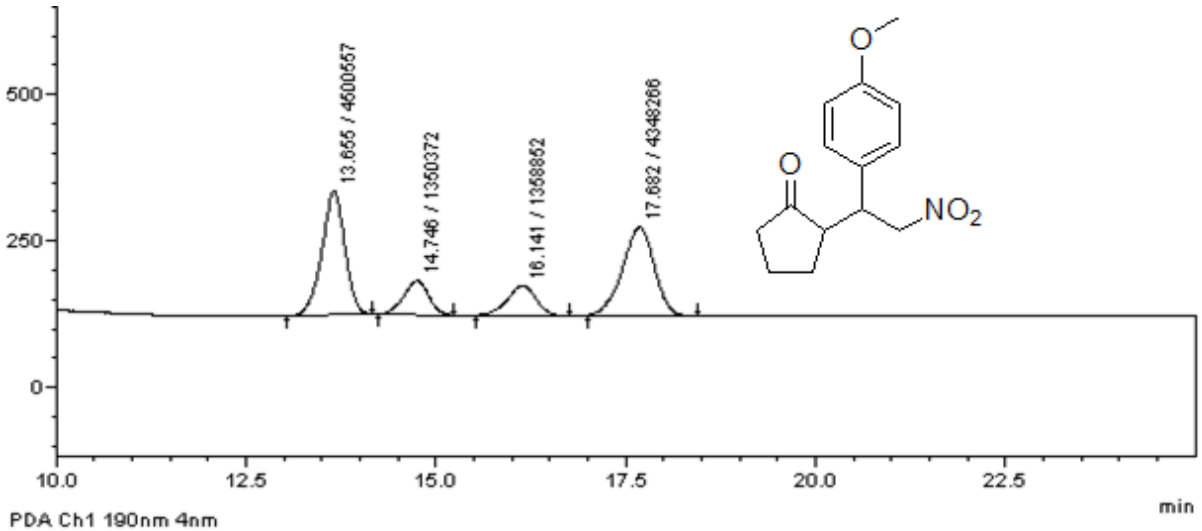
HPLC of (*S*)-2-((*R*)-2-nitro-1-p-tolylethyl)cyclopentanone (**4b**)



PDA Ch1 190nm 4nm

Peak#	Ret. Time	Area	Height	Area %	Height %	Width at 10% Height
1	9.213	21723387	1516914	81.643	90.054	0.457
2	11.012	1428406	57886	5.368	3.437	0.732
3	15.378	3456056	109642	12.989	6.509	0.918
Total		26607849	1684443	100.000	100.000	

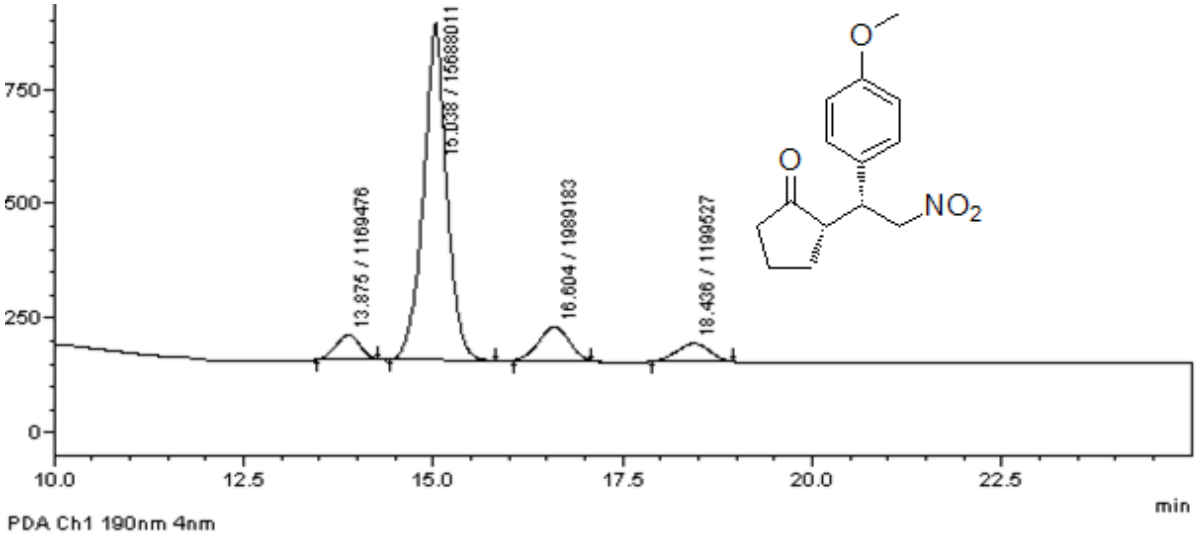
HPLC of racemic 2-(1-(4-methoxyphenyl)-2-nitroethyl)cyclopentanone (**4c**)



PDA Ch1 190nm 4nm

Peak #	Ret. Time	Area	Height	Area %	Height %	Width at 10% Height
1	13.655	4500557	210469	38.939	44.644	0.640
2	14.746	1350372	58465	11.683	12.401	0.687
3	16.141	1358852	51553	11.757	10.935	0.787
4	17.682	4348266	150953	37.621	32.020	0.857
Total		11558047	471440	100.000	100.000	

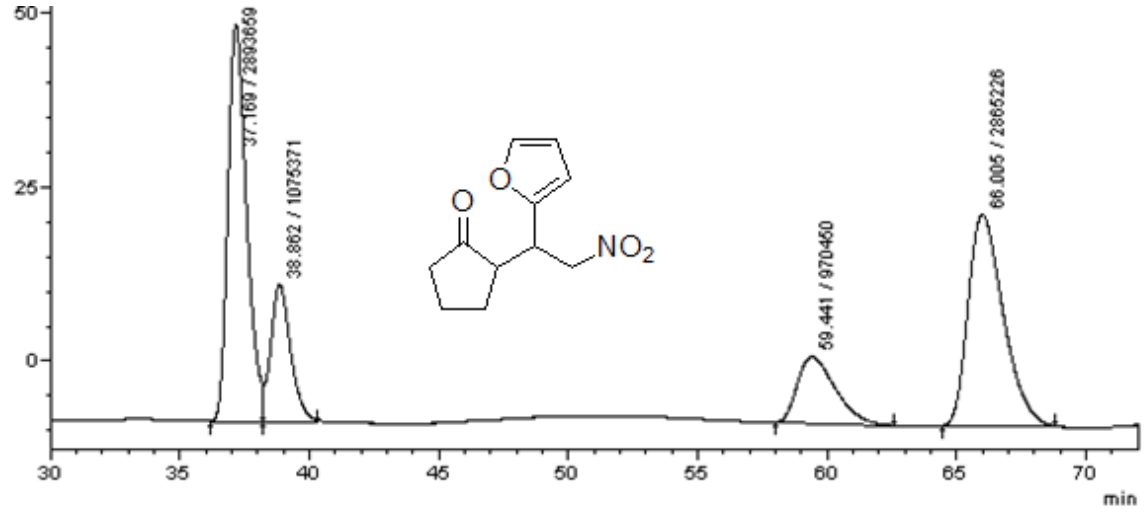
HPLC of (*S*)-2-((*R*)-1-(4-methoxyphenyl)-2-nitroethyl)cyclopentanone (**4c**)



PDA Ch1 190nm 4nm

Peak #	Ret. Time	Area	Height	Area %	Height %	Width at 10% Height
1	13.875	1169476	53552	5.834	5.930	0.632
2	15.038	15688011	736801	78.259	81.583	0.678
3	16.604	1989183	72924	9.923	8.075	0.779
4	18.436	1199527	39852	5.984	4.413	0.862
Total		20046196	903129	100.000	100.000	

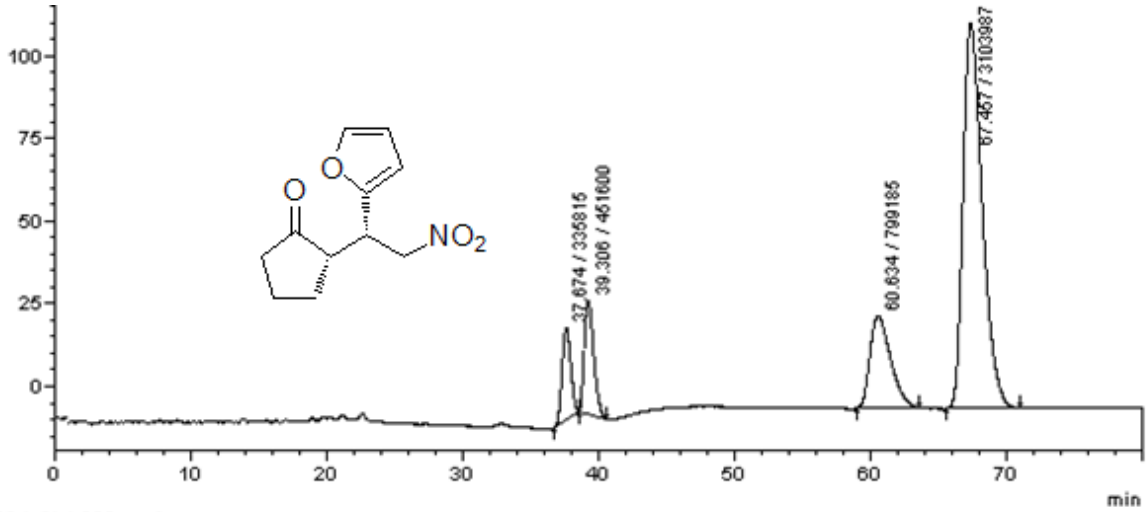
HPLC of racemic 2-(1-(furan-2-yl)-2-nitroethyl)cyclopentanone (**4d**)



PDA Ch1 230nm 4nm

Peak#	Ret. Time	Area	Height	Area %	Height %	Width at 10% Height	Mark
1	37.169	2893659	57310	37.076	48.857	1.581	
2	38.862	1075371	20005	13.778	17.054	0.000	
3	59.441	970450	9538	12.434	8.131	2.949	
4	66.005	2865226	30460	36.712	25.958	2.765	
Total		7804707	117302	100.000	100.000		

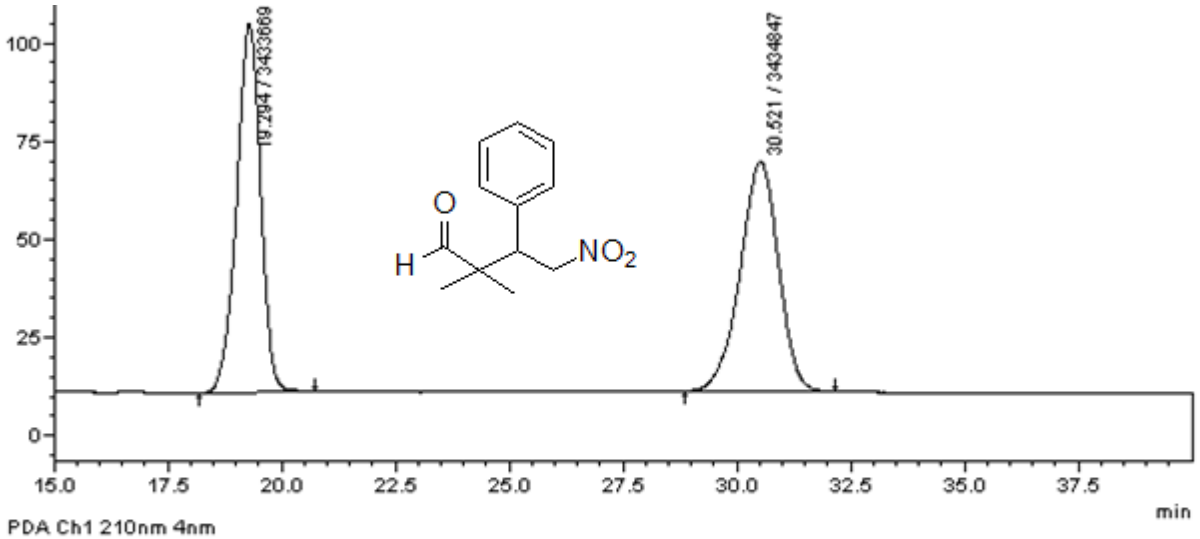
HPLC of (*S*)-2-((*S*)-1-(furan-2-yl)-2-nitroethyl)cyclopentanone (**4d**)



PDA Ch1 230nm 4nm

Peak#	Ret. Time	Area	Height	Area %	Height %	Width at 10% Height	Mark
1	37.674	335815	7585	7.159	13.566	1.252	
2	39.306	451600	9277	9.628	16.591	1.420	
3	60.634	799185	7541	17.038	13.488	3.084	
4	67.457	3103987	31509	66.175	56.355	2.894	
Total		4690587	55912	100.000	100.000		

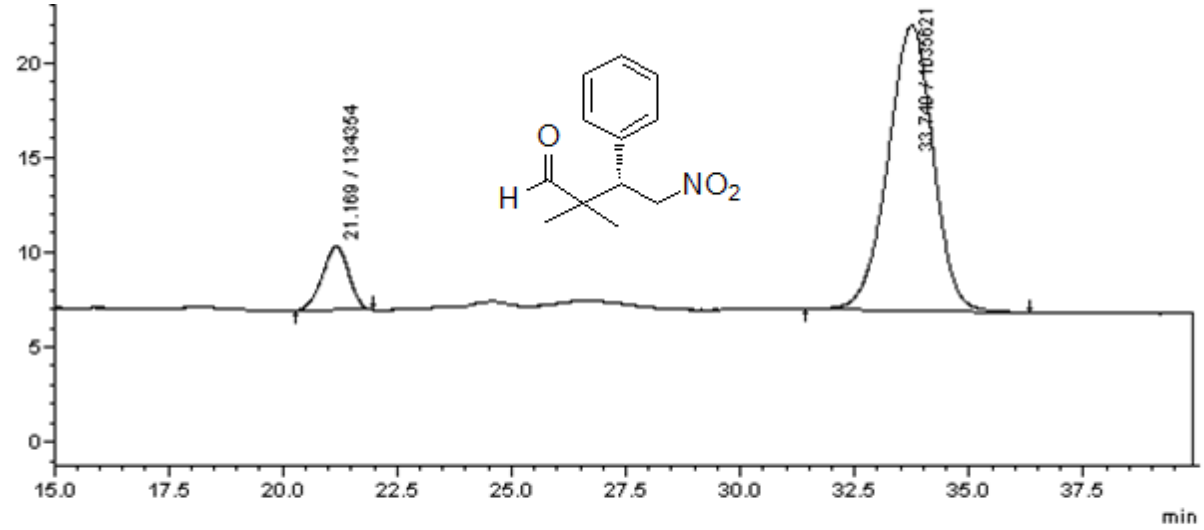
HPLC of racemic 2,2-dimethyl-4-nitro-3-phenylbutanal (**5a**)



PDA Ch1 210nm 4nm

Peak#	Ret. Time	Area	Height	Area %	Height %	Width at 10% Height
1	19.294	3433669	93860	49.991	61.647	1.071
2	30.521	3434847	58393	50.009	38.353	1.726
Total		6868516	152252	100.000	100.000	

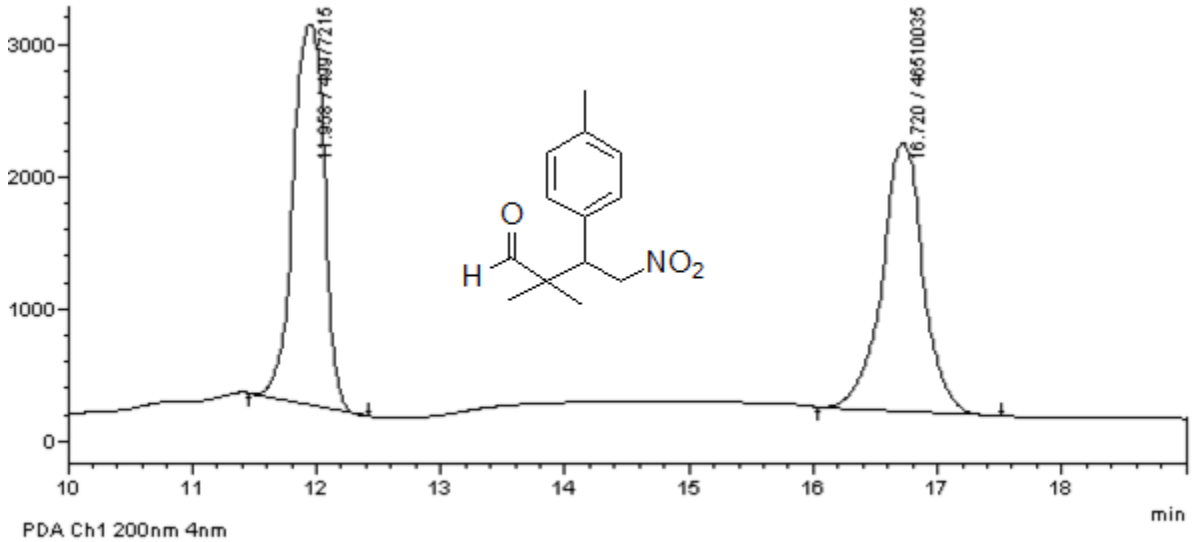
HPLC of (*S*)-2,2-dimethyl-4-nitro-3-phenylbutanal (**5a**)



PDA Ch1 210nm 4nm

Peak#	Ret. Time	Area	Height	Area %	Height %	Width at 10% Height
1	21.169	134354	3336	11.483	18.146	1.158
2	33.740	1035621	15047	88.517	81.854	1.985
Total		1169975	18383	100.000	100.000	

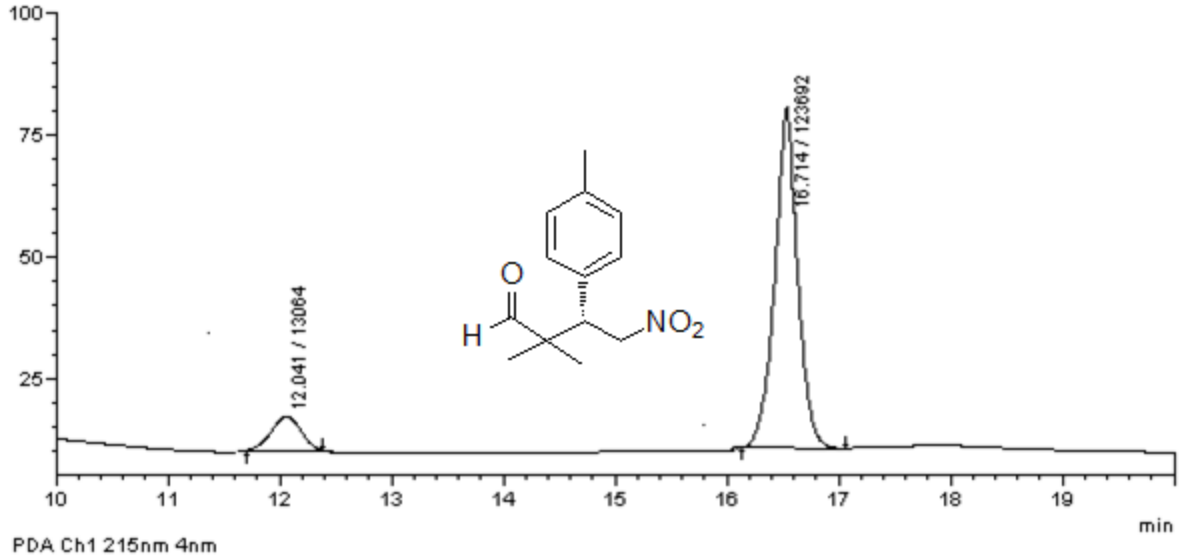
HPLC of racemic 2,2-dimethyl-4-nitro-3-p-tolylbutanal (**5b**)



PDA Ch1 200nm 4nm

Peak #	Ret. Time	Area	Height	Area %	Height %	Width at 10% Height
1	11.958	49977215	2870365	51.797	58.573	0.465
2	16.720	46510035	2030102	48.203	41.427	0.710
Total		96487250	4900467	100.000	100.000	

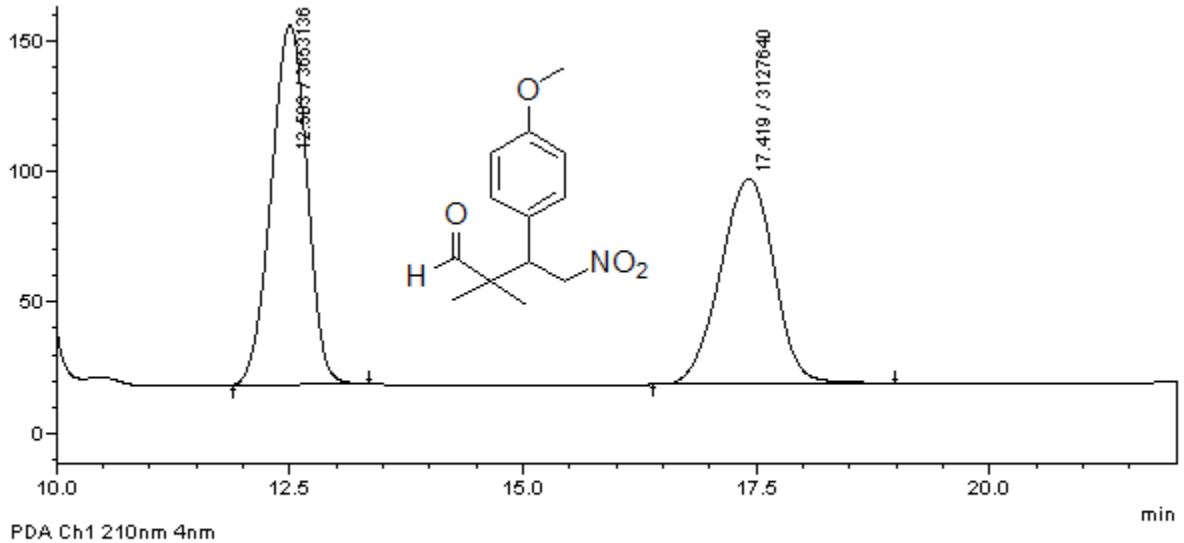
HPLC of (*S*)-2,2-dimethyl-4-nitro-3-p-tolylbutanal (**5b**)



PDA Ch1 215nm 4nm

Peak #	Ret. Time	Area	Height	Area %	Height %	Width at 10% Height
1	12.041	13064	887	9.552	16.396	0.392
2	16.714	123692	4524	90.448	83.604	0.777
Total		136756	5411	100.000	100.000	

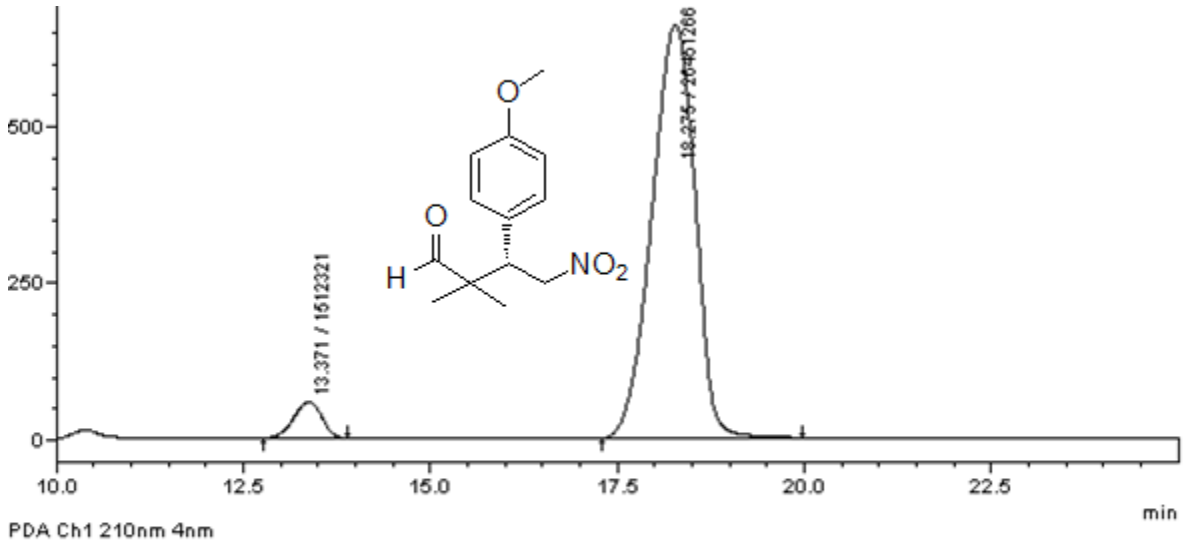
HPLC of racemic 3-(4-methoxyphenyl)-2,2-dimethyl-4-nitrobutanal (**5c**)



PDA Ch1 210nm 4nm

Peak#	Ret. Time	Area	Height	Area %	Height %	Width at 10% Height
1	12.503	3653136	137410	53.875	63.640	0.749
2	17.419	3127640	78507	46.125	36.360	1.120
Total		6780775	215917	100.000	100.000	

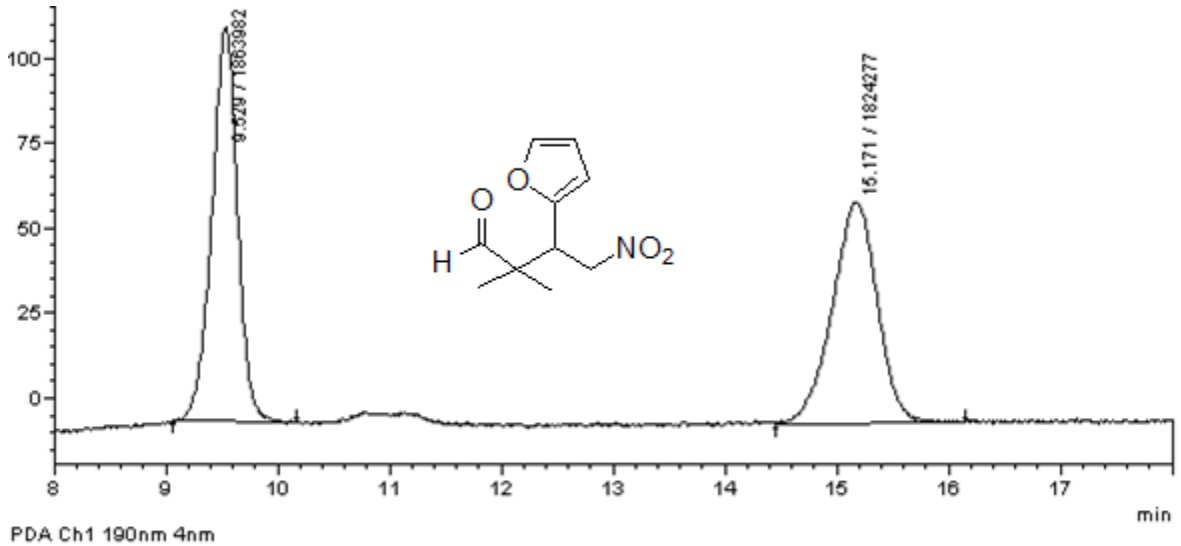
HPLC of (*S*)-3-(4-methoxyphenyl)-2,2-dimethyl-4-nitrobutanal (**5c**)



PDA Ch1 210nm 4nm

Peak#	Ret. Time	Area	Height	Area %	Height %	Width at 10% Height
1	13.371	1512321	57633	5.408	8.042	0.742
2	18.275	26451266	658996	94.592	91.958	1.109
Total		27963587	716629	100.000	100.000	

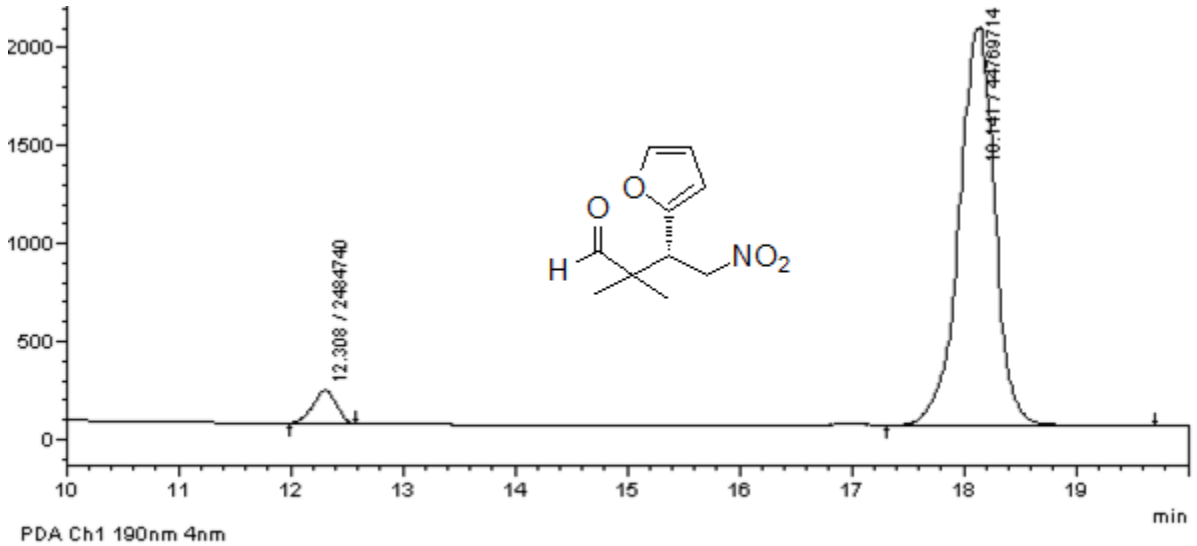
HPLC of racemic 3-(furan-2-yl)-2,2-dimethyl-4-nitrobutanal (**5d**)



PDA Ch1 190nm 4nm

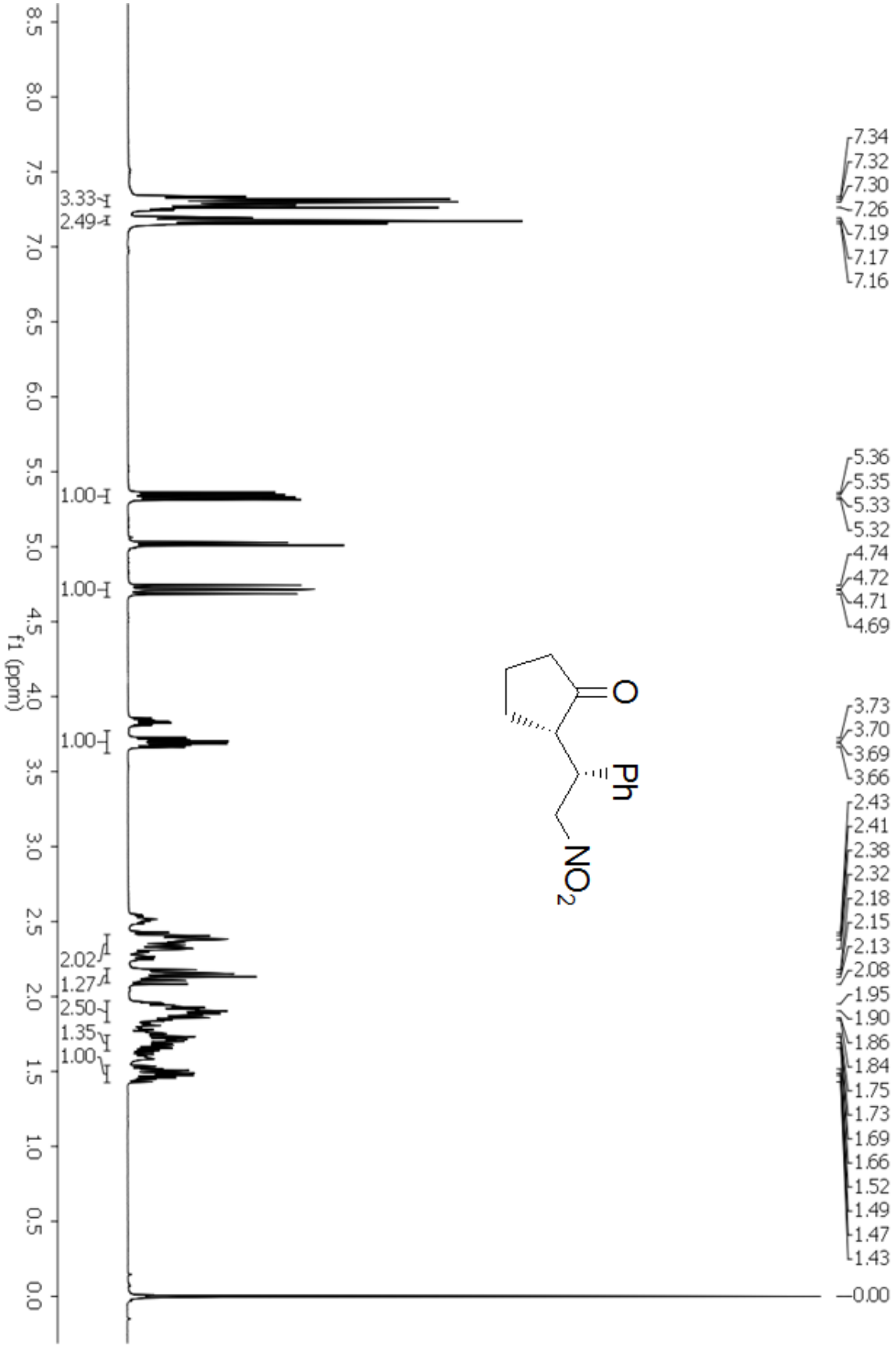
Peak#	Ret. Time	Area	Height	Area %	Height %	Width at 10% Height
1	9.529	1863982	115908	50.538	64.065	0.475
2	15.171	1824277	65015	49.462	35.935	0.829
Total		3688258	180923	100.000	100.000	

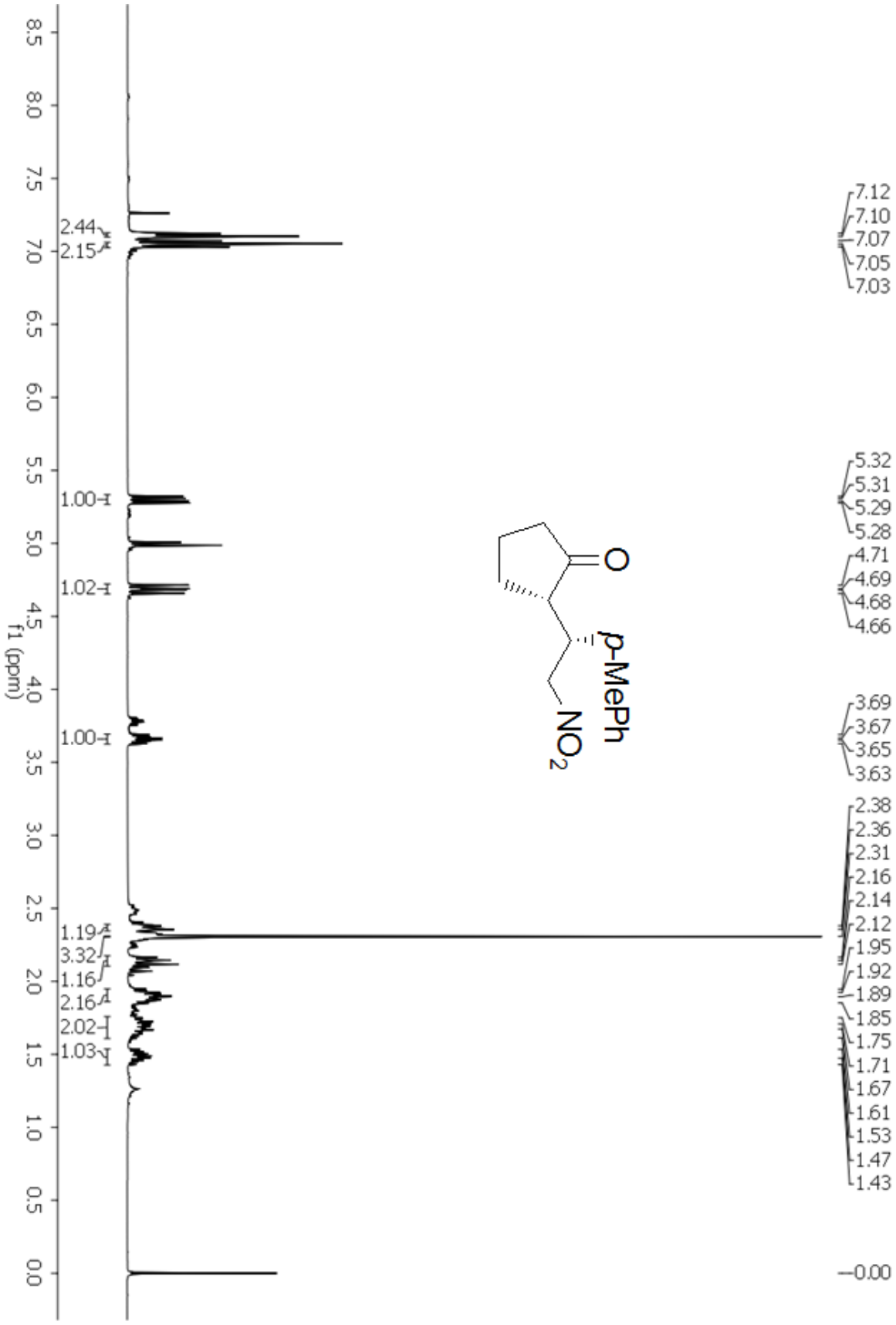
HPLC of (*S*)-3-(furan-2-yl)-2,2-dimethyl-4-nitrobutanal (**5d**)

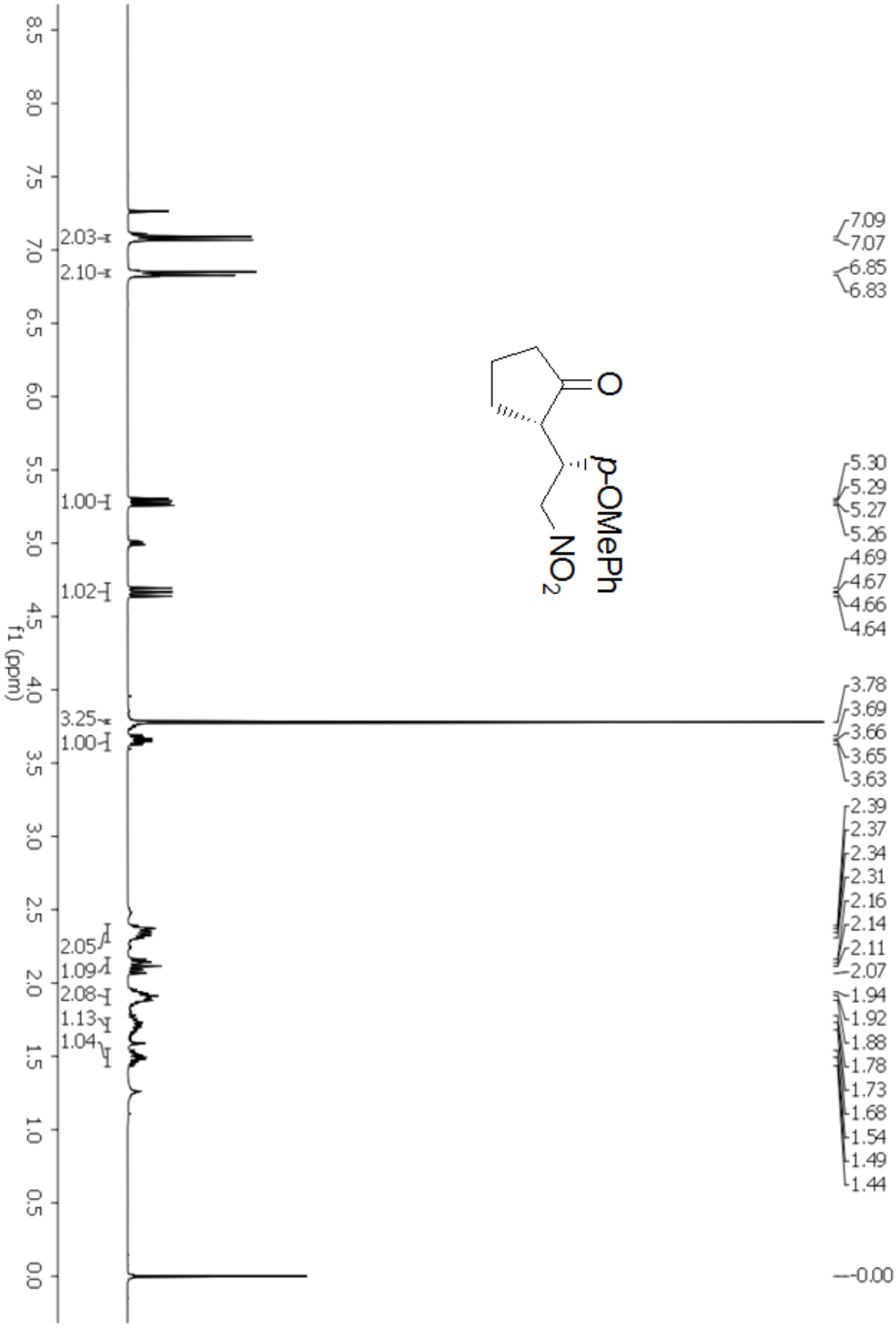


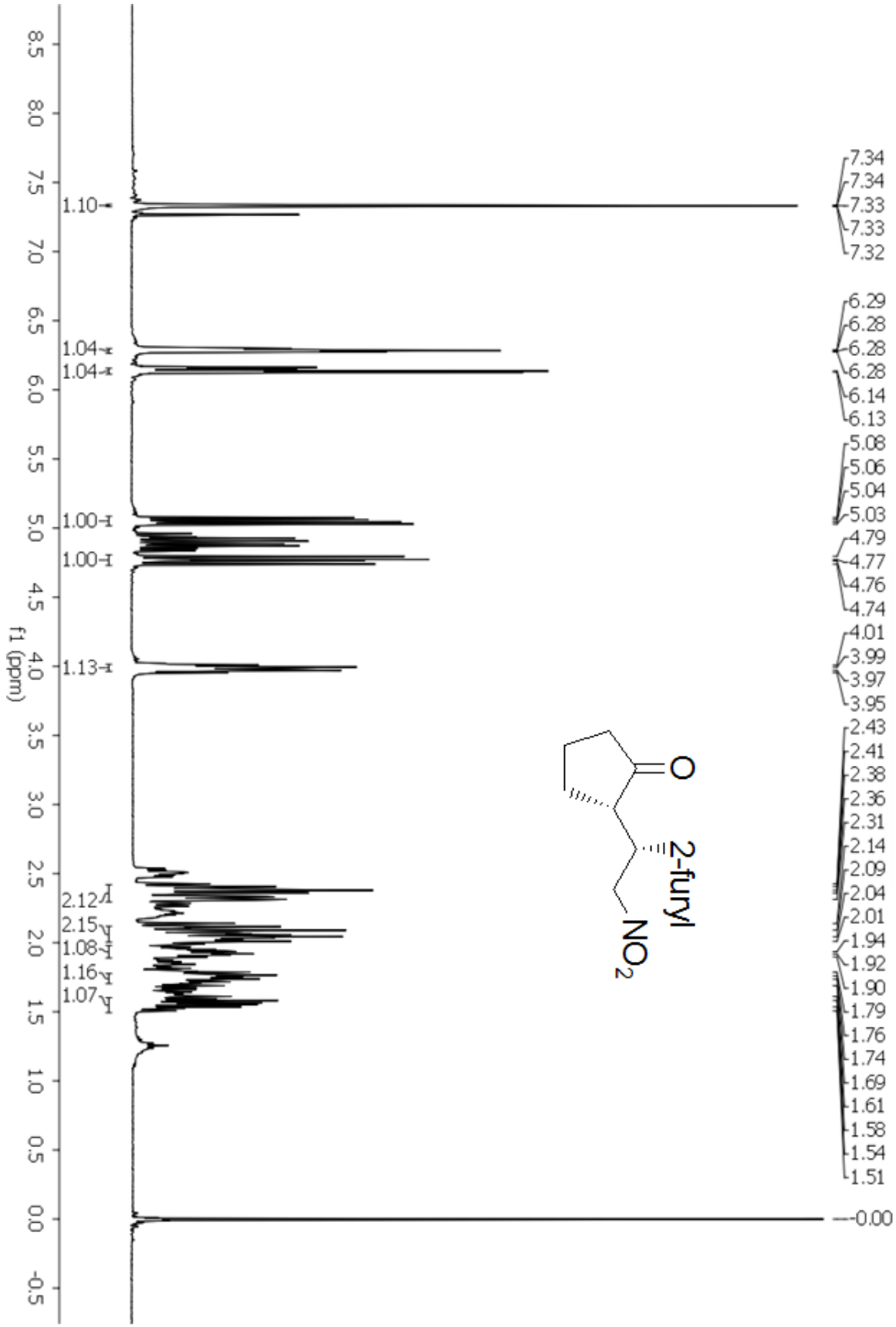
PDA Ch1 190nm 4nm

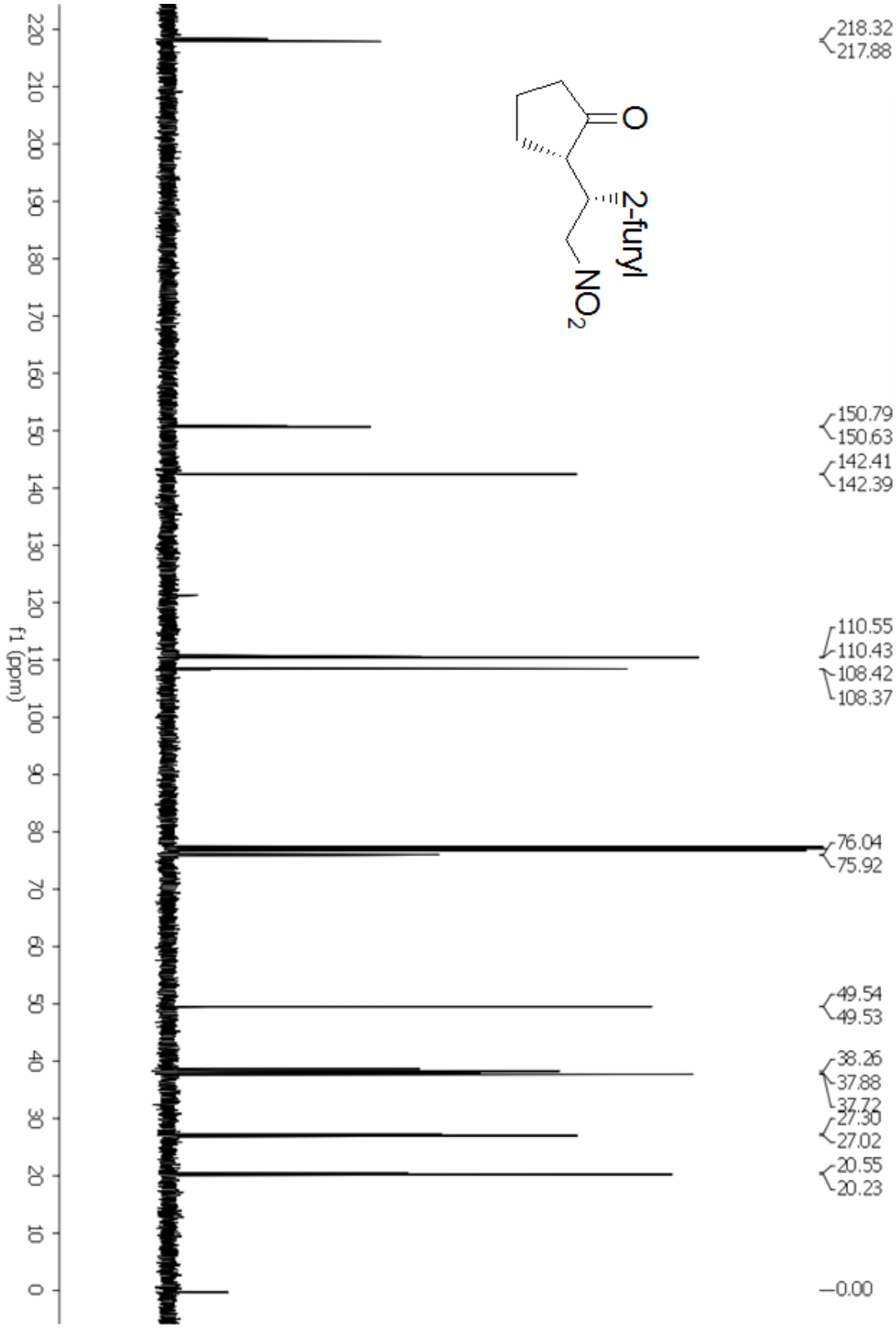
Peak#	Ret. Time	Area	Height	Area %	Height %	Width at 10% Height
1	12.308	2484740	169907	5.258	7.708	0.429
2	18.141	44769714	2034413	94.742	92.292	0.650
Total		47254454	2204320	100.000	100.000	

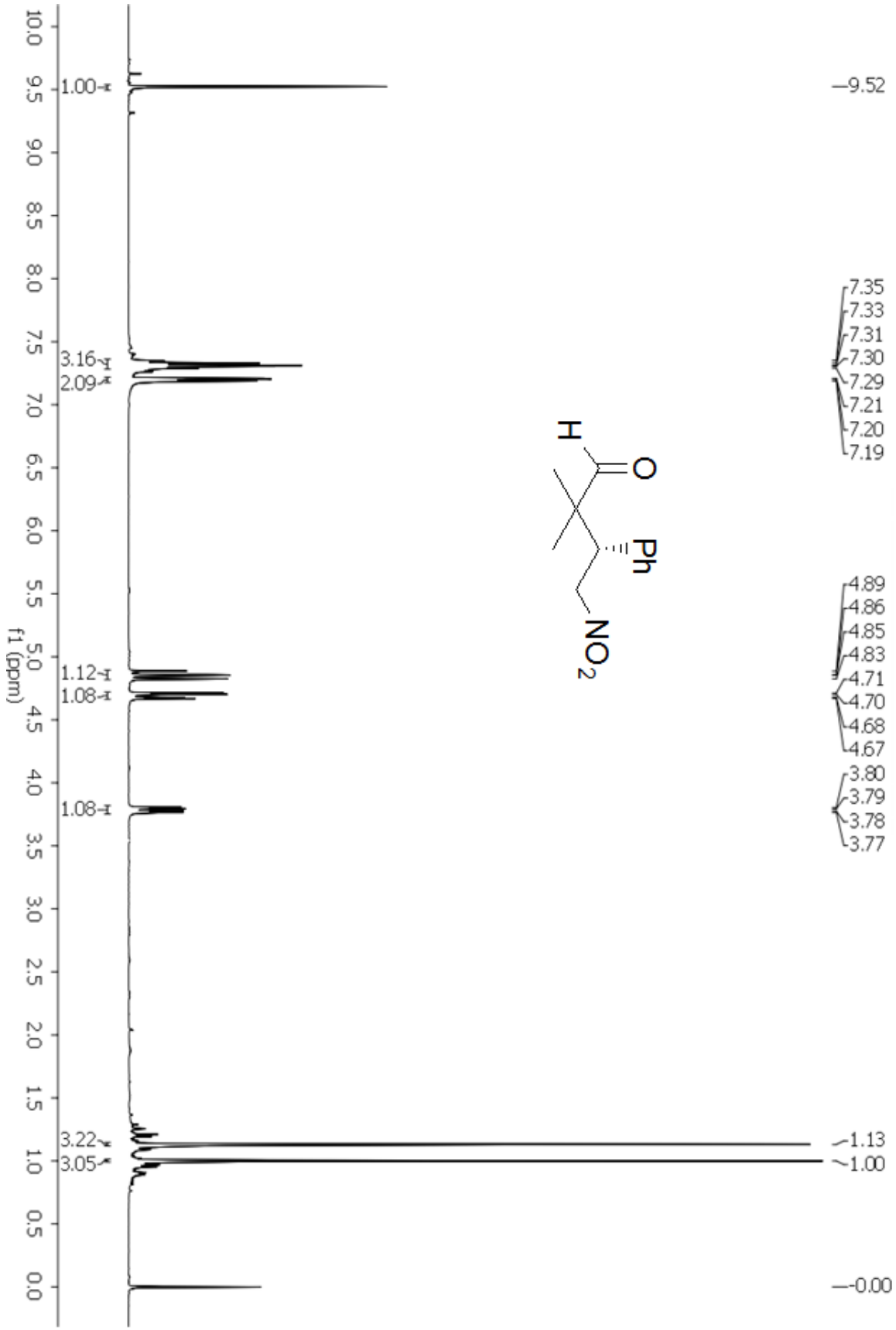


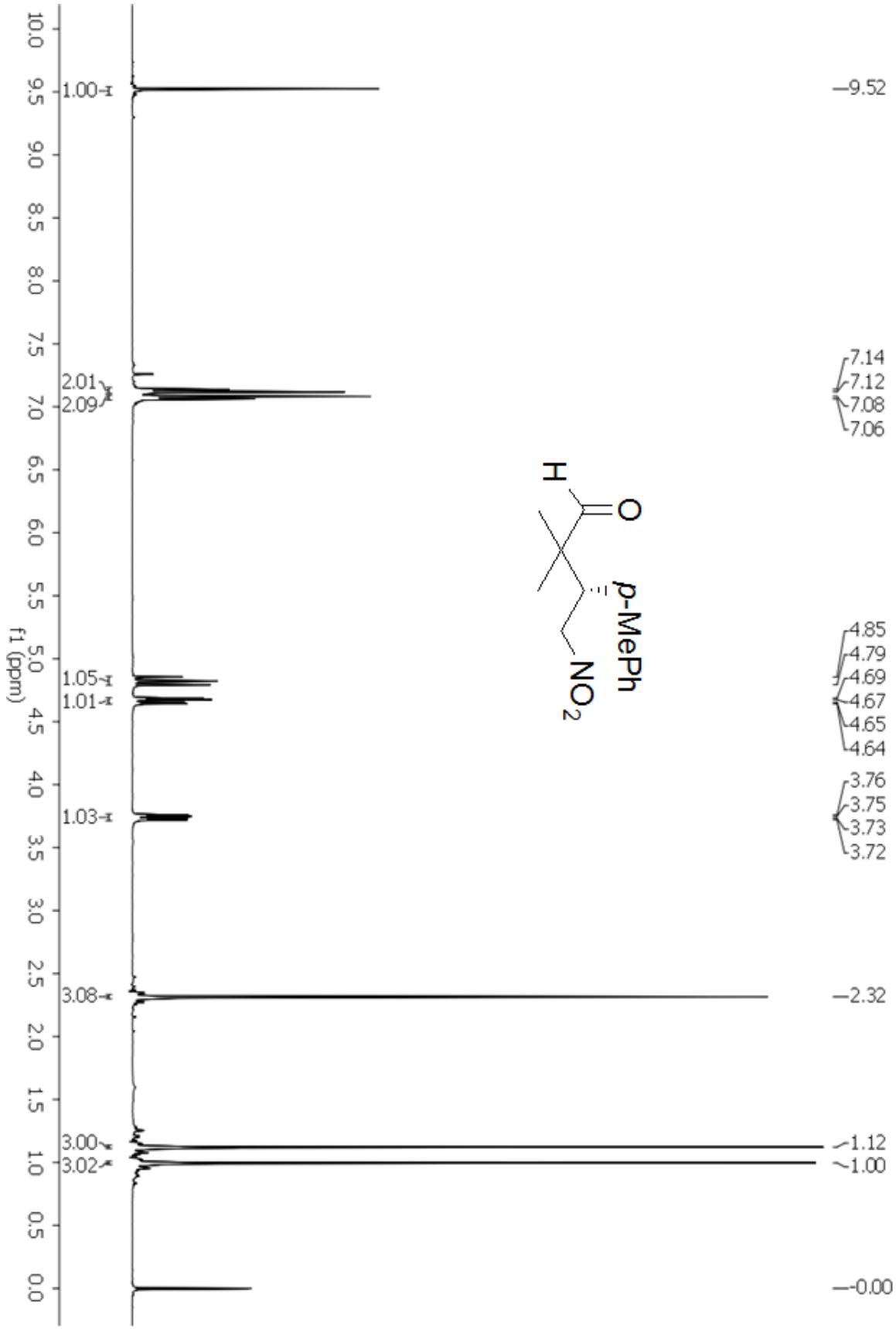


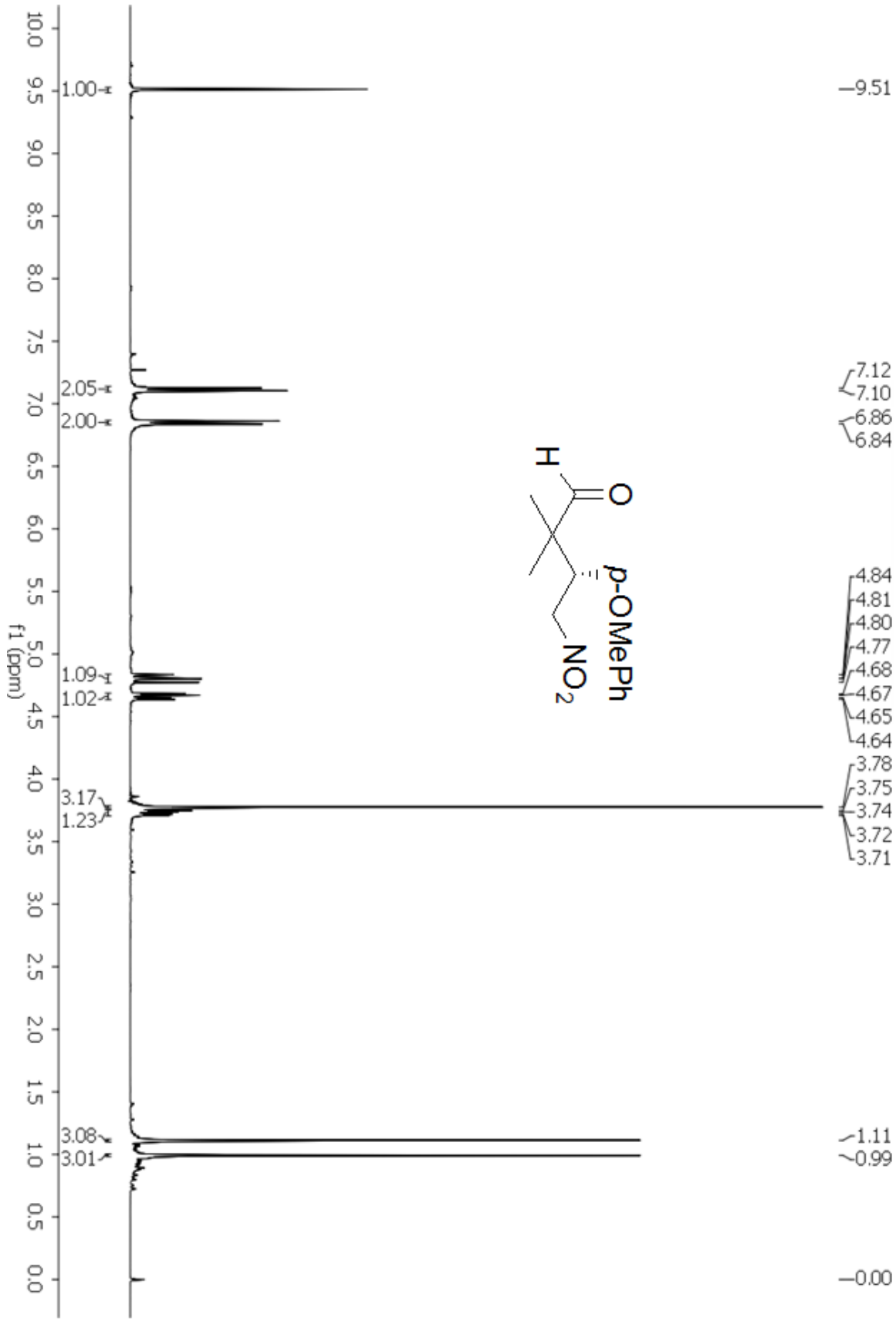


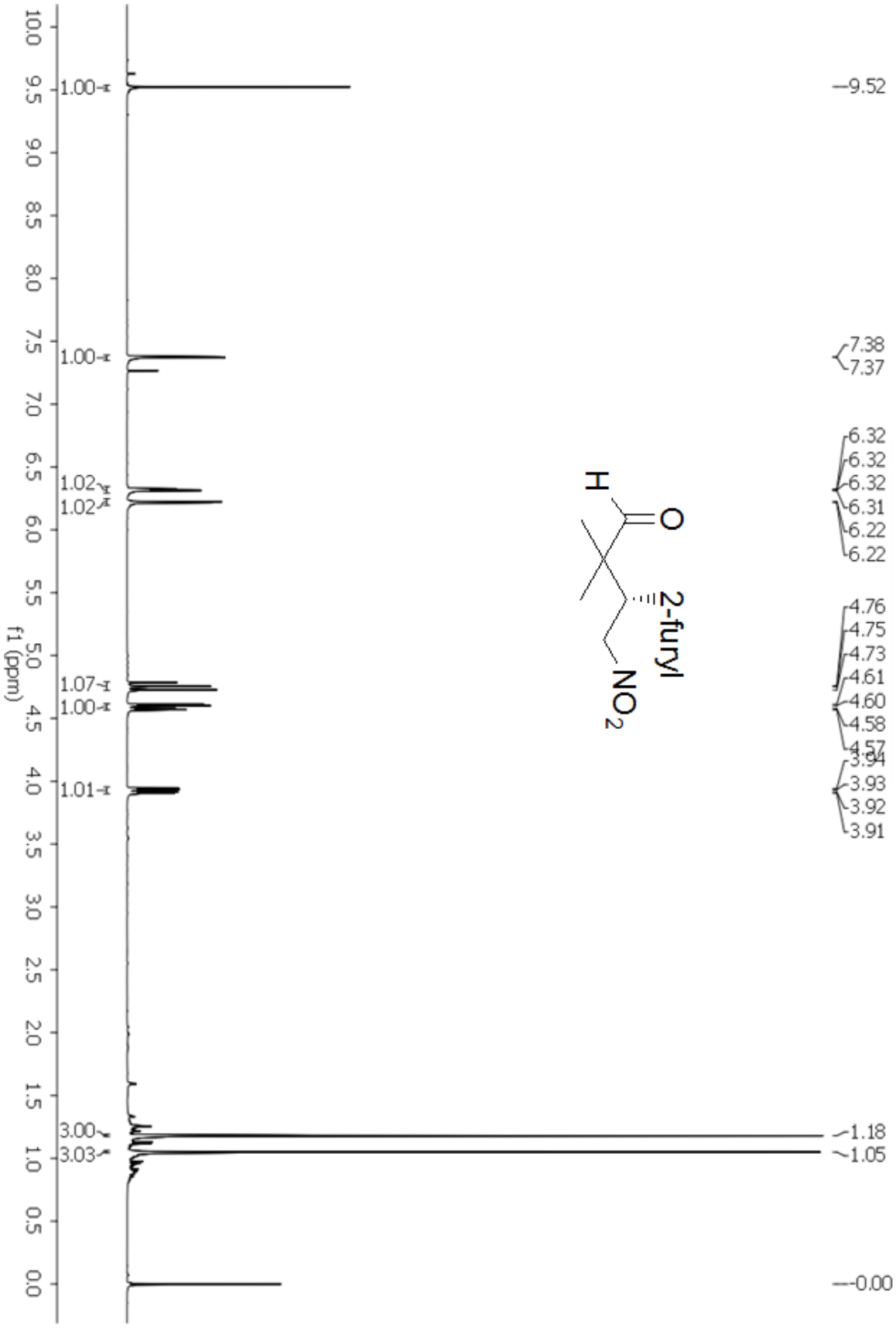






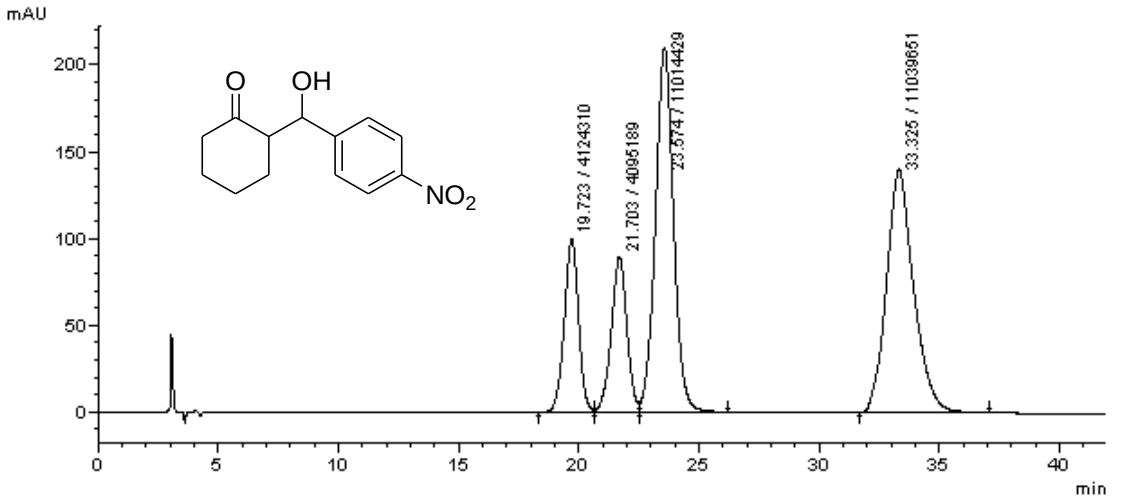






HPLC and NMR data for aldol products

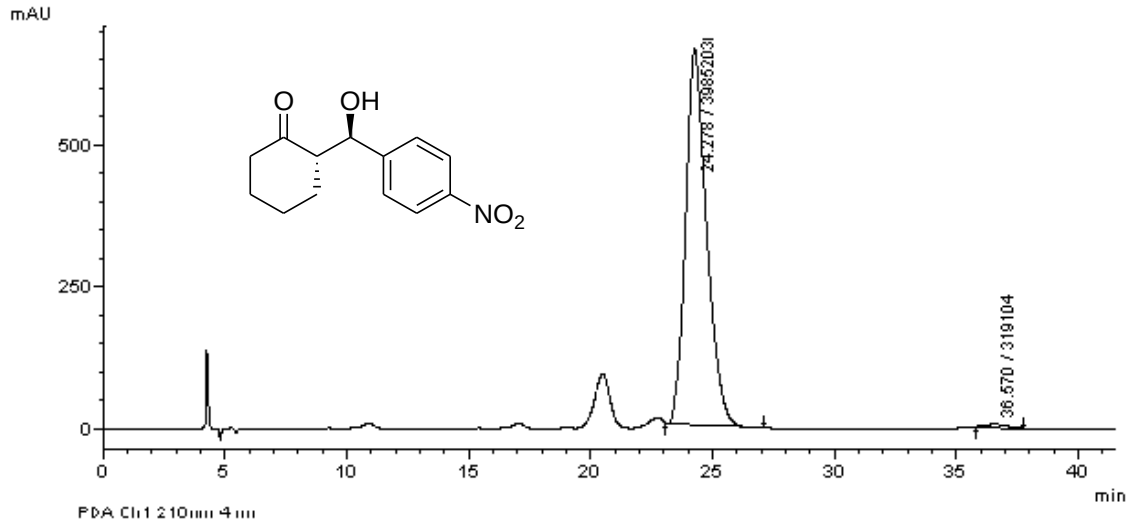
HPLC of racemic 2-hydroxy(4-nitrophenyl)methyl)cyclohexanone (**7a**)
Note **7a** is only included as a reference, we have previously reported **7a**.
7b, 7c, 8a-c, 9a-c we report here for the first time.



PDA Ch1 210nm 4nm

Peak #	Ret. Time	Area	Height	Area %	Height %	Width at 10% Height	Mark
1	19.723	4124310	99829	13.023	18.507	1.224	
2	21.703	4095109	09573	10.527	16.606	1.071	V
3	23.574	11014420	209828	36.393	39.900	1.571	V
4	33.325	1103905	140160	30.400	25.989	2.438	
Total		00270579	539415	100.000	100.000		

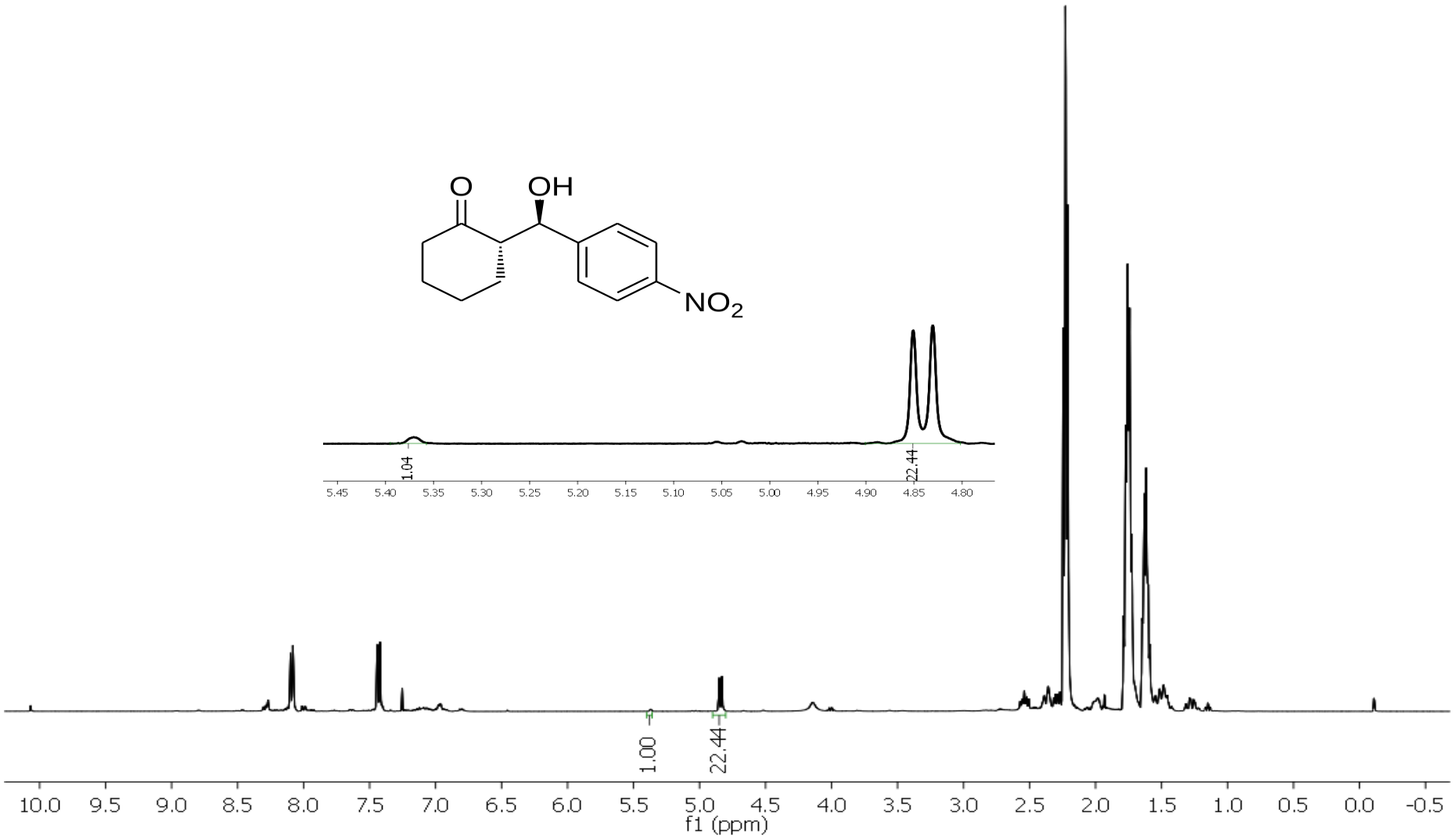
HPLC of (S)-2-((R)-hydroxy(4-nitrophenyl)methyl)cyclohexanone (**7a**)



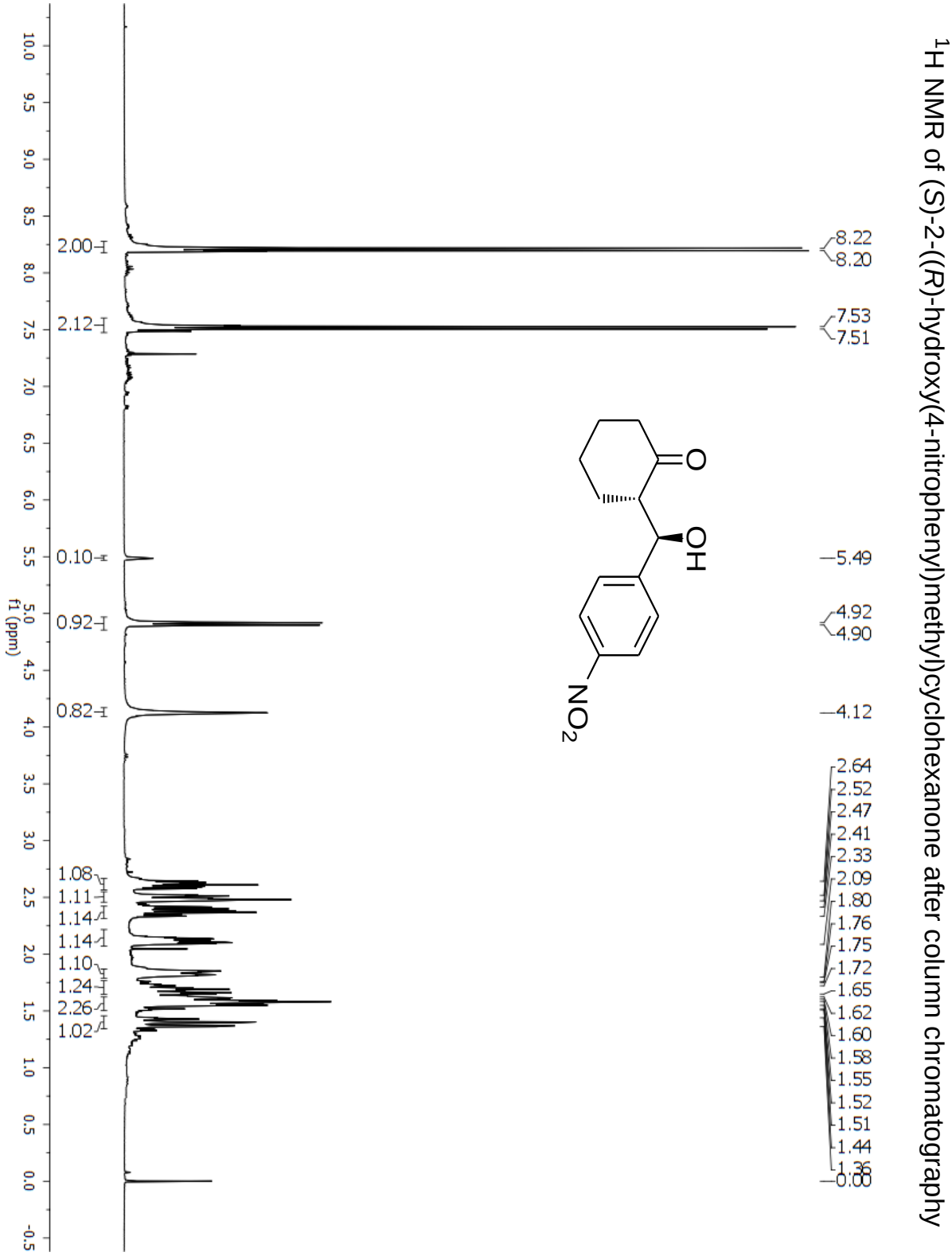
PDA Ch1 210nm 4nm

Peak #	Ret. Time	Area	Height	Area %	Height %	Width at 10% Height	Mark
1	24.278	39852030	662861	99.206	99.220	1.852	
2	36.570	319104	5213	0.794	0.780	1.640	
Total		4017 134	668074	100.000	100.000		

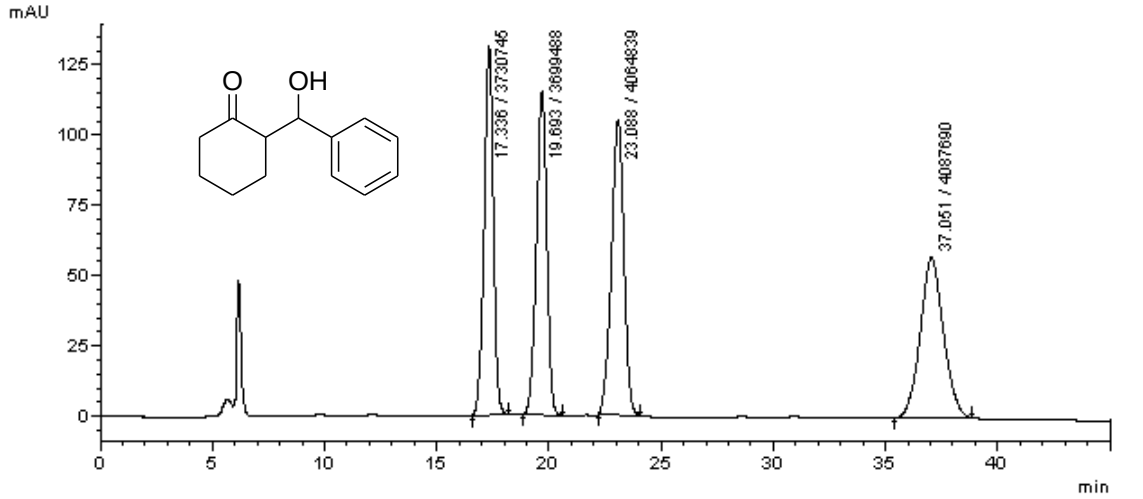
Crude ^{1}H NMR of (*S*)-2-((*R*)-hydroxy(4-nitrophenyl)methyl)cyclohexanone for dr assessement



^{1}H NMR of (*S*)-2-((*R*)-hydroxy(4-nitrophenyl)methyl)cyclohexanone after column chromatography



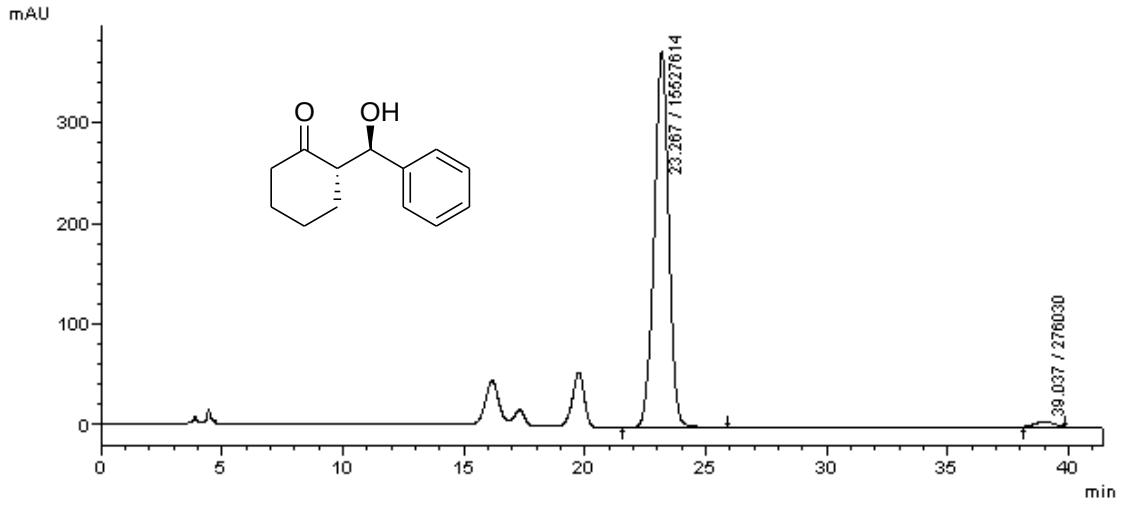
HPLC of racemic 2-(hydroxy(phenyl)methyl)cyclohexanone (**7b**)



PDA Ch1 210nm 4nm

Peak #	Ret. Time	Area	Height	Area %	Height %	Width at 10% Height
1	17.336	3730745	131194	23.941	32.135	0.837
2	19.693	3699488	115088	23.741	28.190	0.941
3	23.088	4064839	104921	26.085	25.700	1.139
4	37.051	4087690	57055	26.232	13.975	2.169
Total		15582762	408258	100.000	100.000	

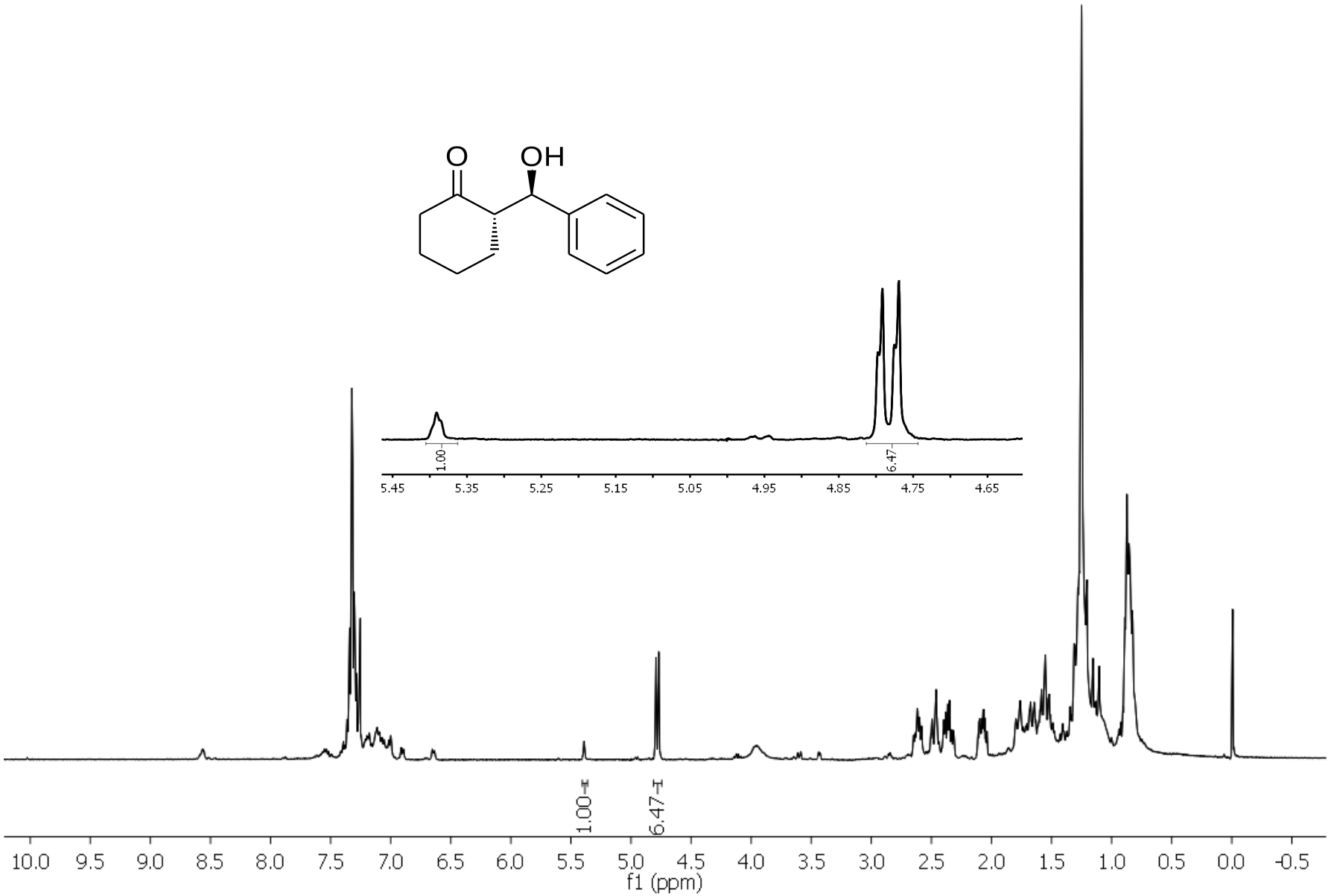
HPLC of enantioenriched (S)-2-((R)-hydroxy(phenyl)methyl)cyclohexanone (**7b**)



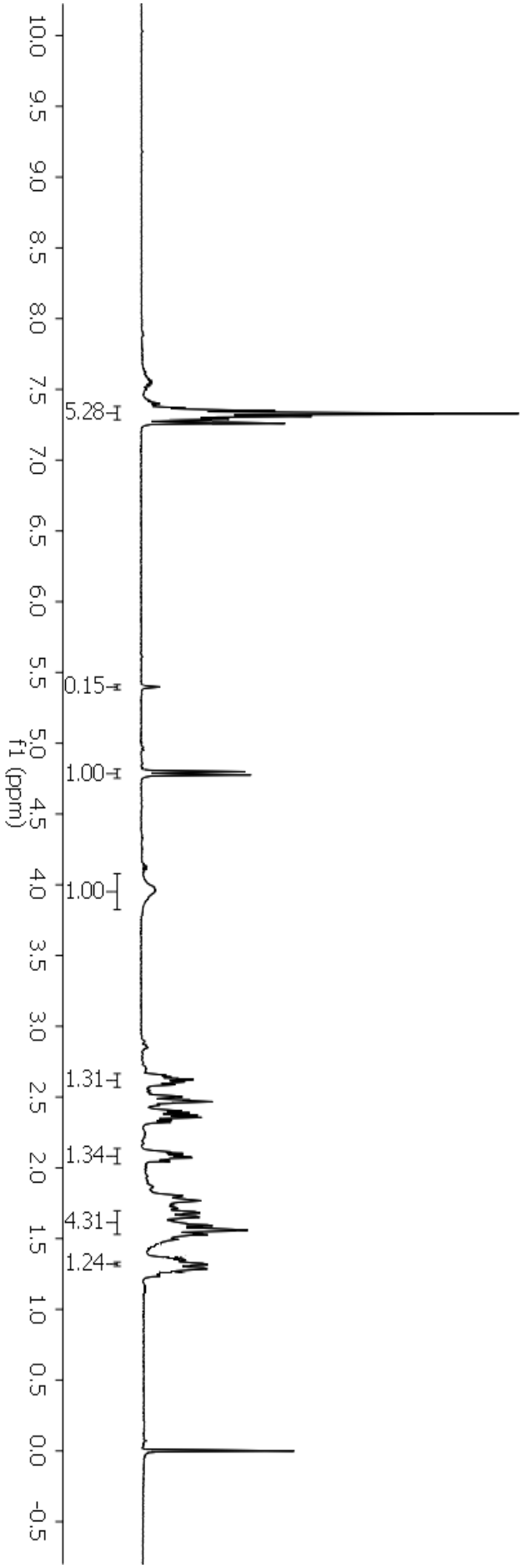
PDA Ch1 210nm 4nm

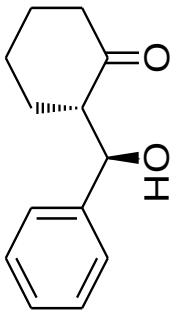
Peak #	Ret. Time	Area	Height	Area %	Height %	Width at 10% Height
1	23.267	15527614	372059	98.253	98.700	1.236
2	39.037	276030	4902	1.747	1.300	1.521
Total		15803644	376961	100.000	100.000	

Crude ^{1}H NMR of (*S*)-2-((*R*)-hydroxy(phenyl)methyl)cyclohexanone for dr assessment



^{1}H NMR of (S)-2-((*R*)-hydroxy(phenyl)methyl)cyclohexanone after column chromatography





7.37
7.35
7.33

5.40

4.80
4.78

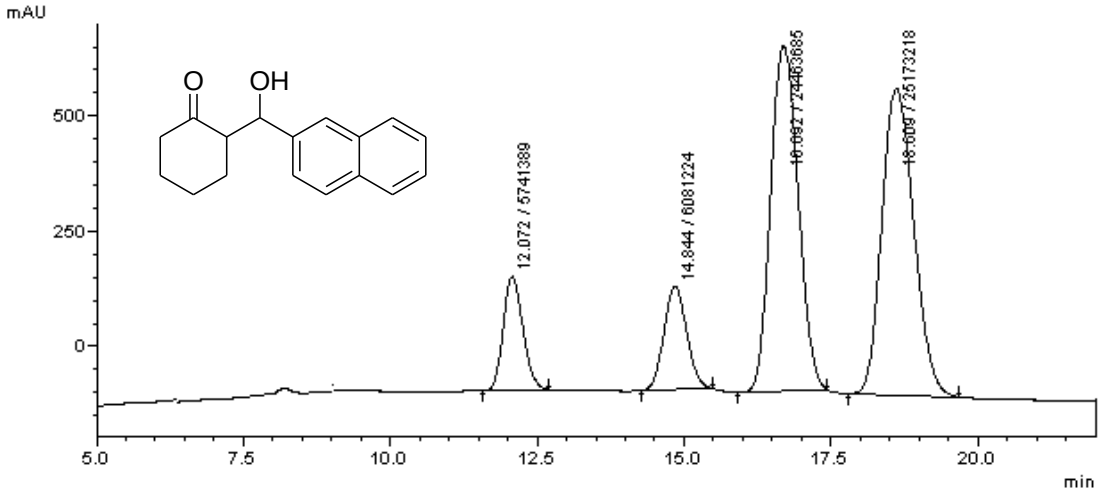
3.96

2.65
2.63
2.62
2.61
2.58

2.11
2.10
2.09
2.07
1.68
1.65
1.60
1.58
1.56
1.35
1.31

0.00
-0.00

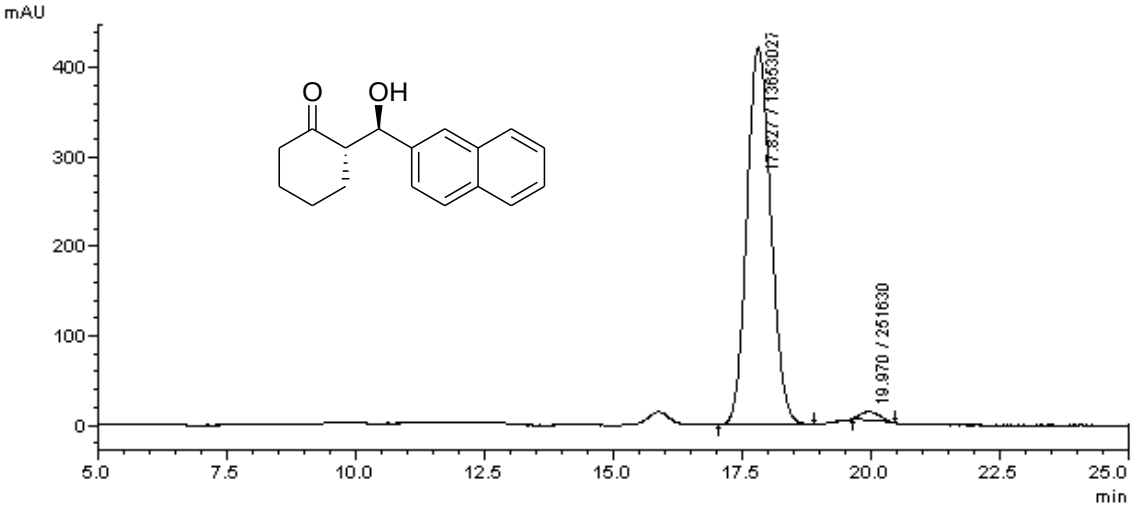
HPLC of racemic 2-(hydroxy(naphthalen-3-yl)methyl)cyclohexanone (**7c**)



PDA Ch1 210nm 4nm

Peak #	Ret. Time	Area	Height	Area %	Height %
1	12.072	5741389	246086	9.342	13.067
2	14.844	6081224	224291	9.895	11.910
3	16.692	24463685	748774	39.805	39.760
4	18.609	25173218	664061	40.959	35.262
Total		61459516	1883211	100.000	100.000

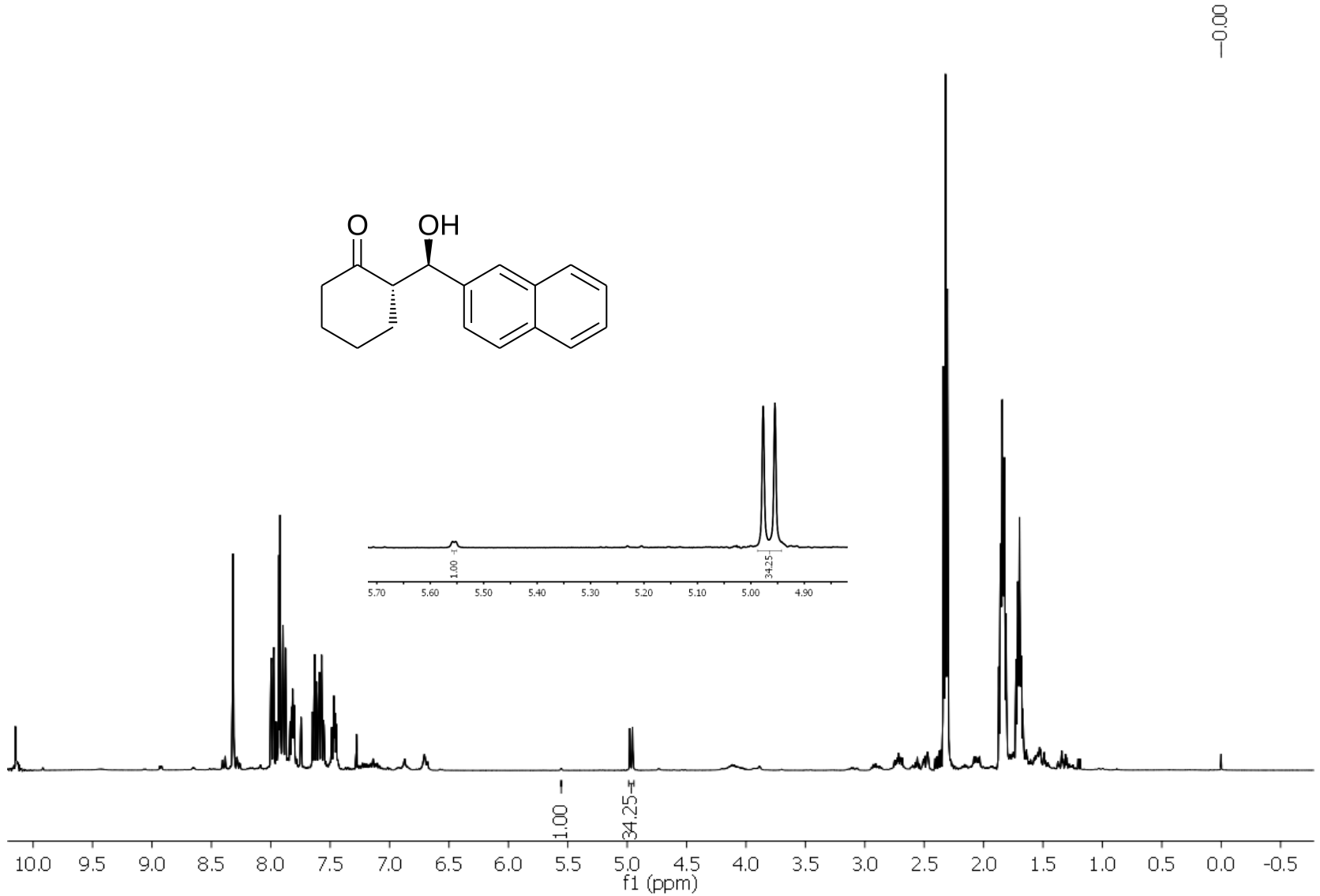
HPLC of (S)-2-((R)-hydroxy(naphthalen-3-yl)methyl) cyclohexanone (**7c**)



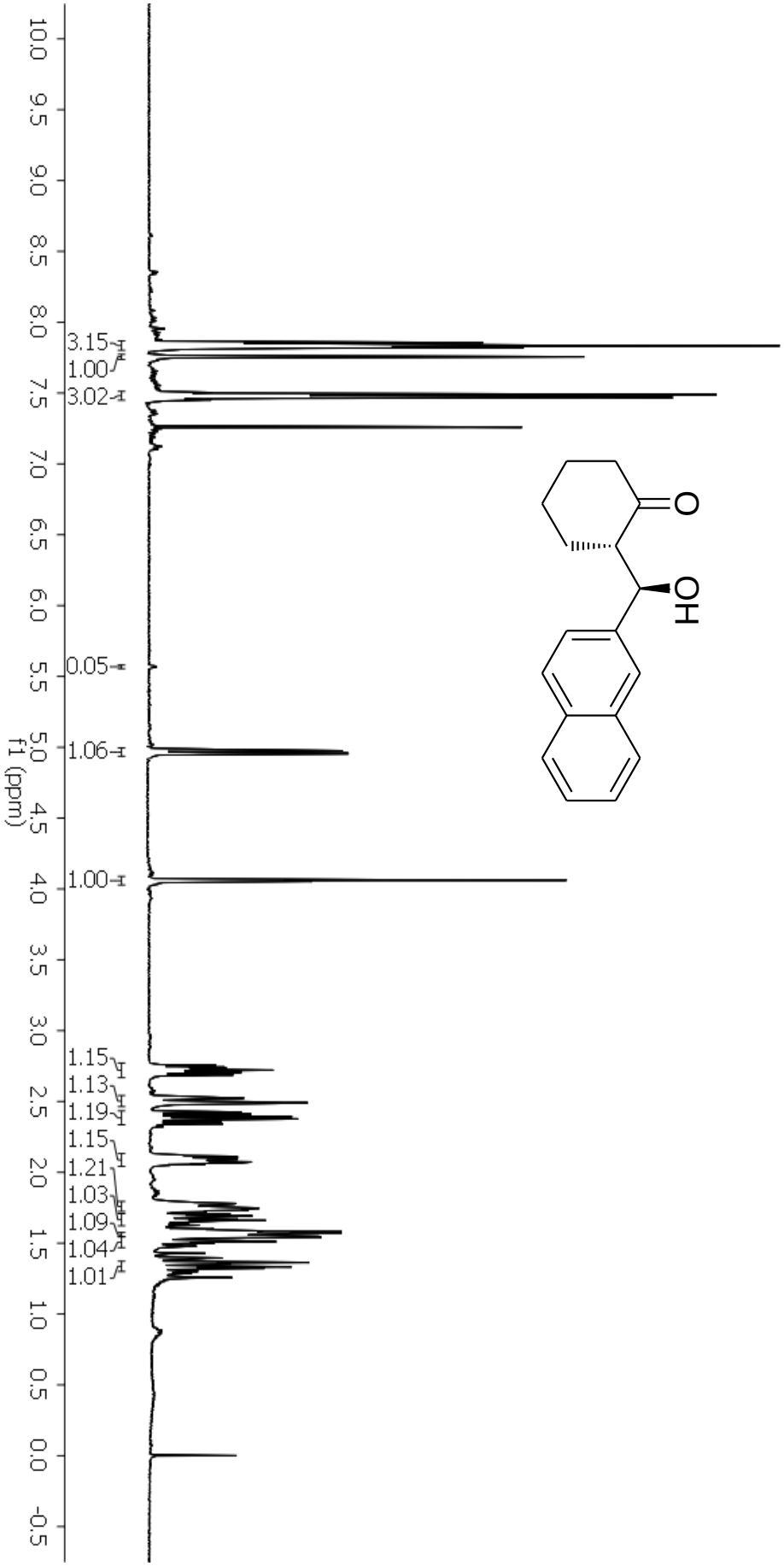
PDA Ch1 210nm 4nm

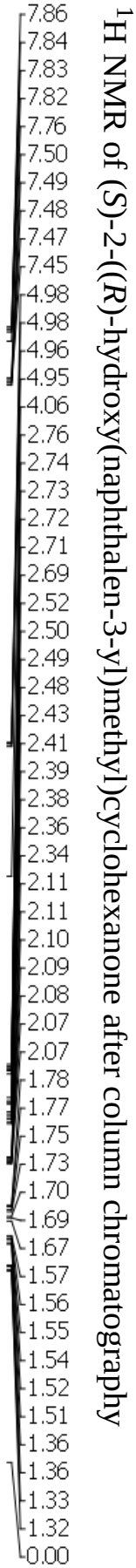
Peak #	Ret. Time	Area	Height	Area %	Height %
1	17.827	13653027	422224	98.190	97.832
2	19.970	251630	9357	1.810	2.168
Total		13904657	431581	100.000	100.000

Crude ^{1}H NMR of (*S*)-2-((*R*)-hydroxy(naphthalen-3-yl)methyl)cyclohexanone for dr assessment

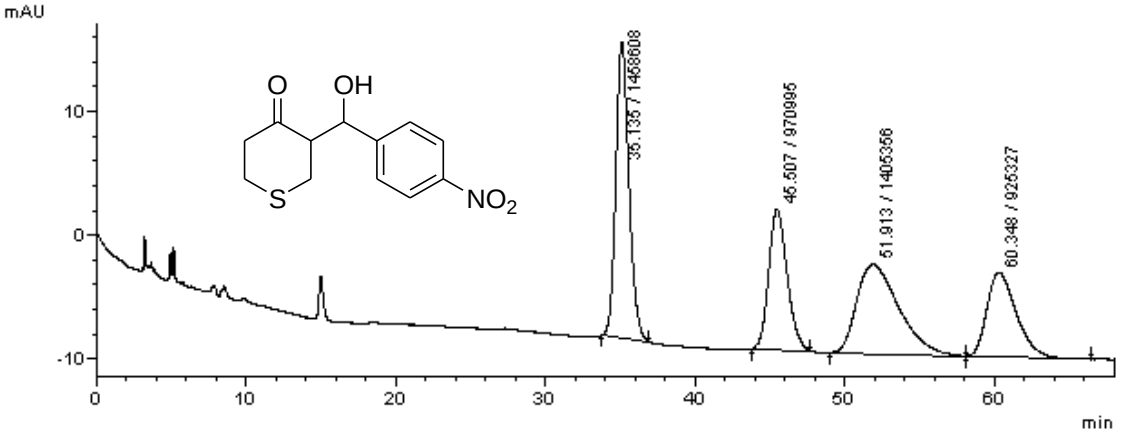


^{1}H NMR of (*S*)-2-((*R*)-hydroxy(naphthalen-3-yl)methyl)cyclohexanone after column chromatography





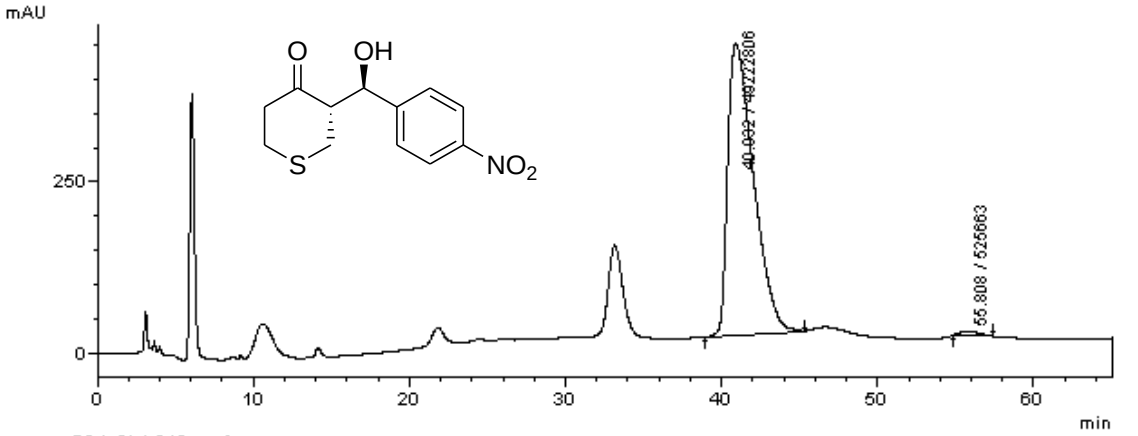
HPLC of racemic tetrahydro-3-(hydroxy(4-nitrophenyl)methyl)thiopyran-4-one (**8a**)



PDA Ch1 254nm 4nm

Peak #	Ret. Time	Area	Height	Area %	Height %	Width at 10% Height
1	35.135	1458608	23832	30.641	48.471	1.804
2	45.507	970995	11329	20.398	23.043	2.521
3	51.913	1405356	7208	29.523	14.659	5.677
4	60.348	925327	6798	19.438	13.827	3.989
Total		4760286	49167	100.000	100.000	

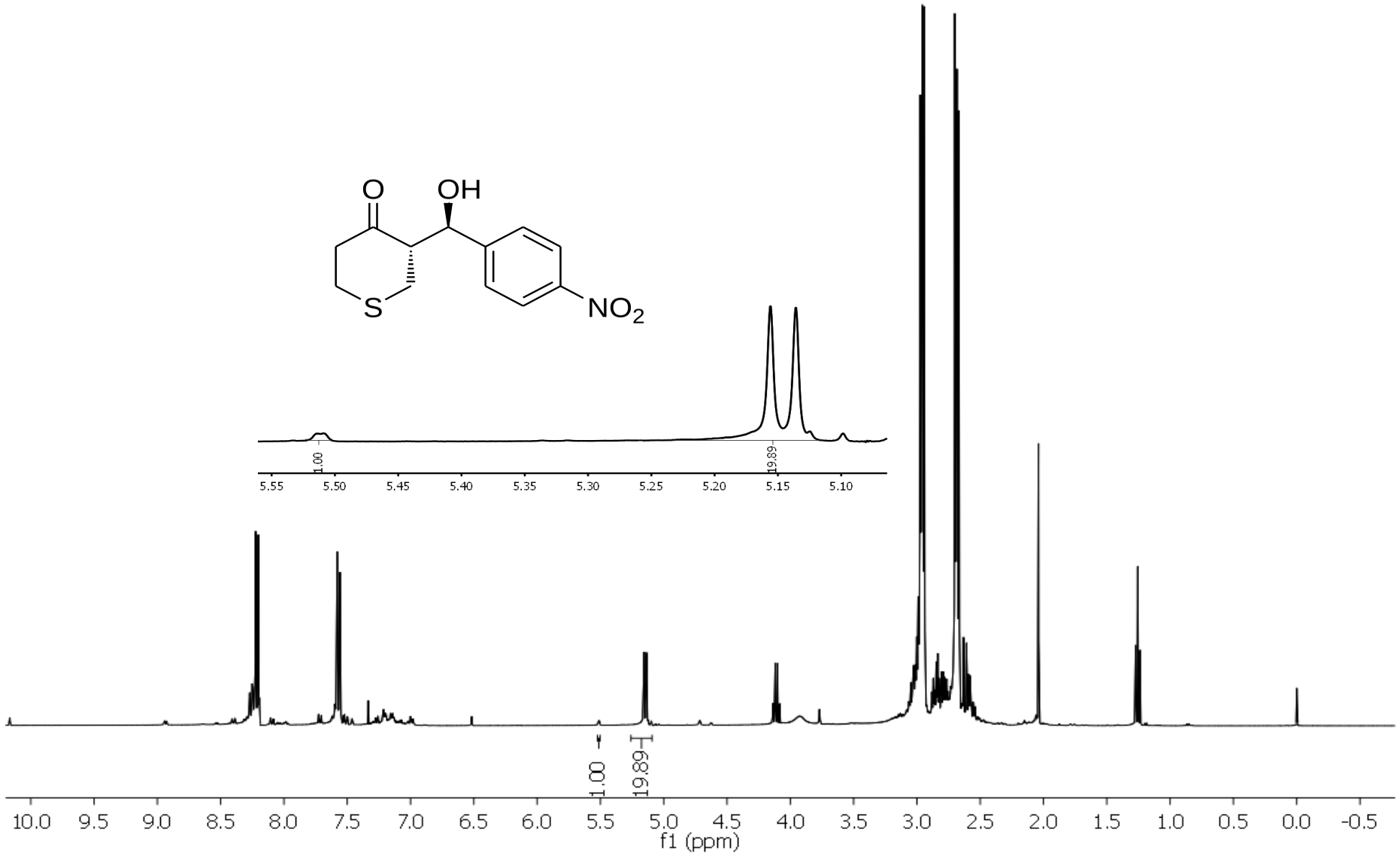
HPLC of (S)-tetrahydro-3-((R)-hydroxy(4-nitrophenyl)methyl) thiopyran-4-one (**8a**)



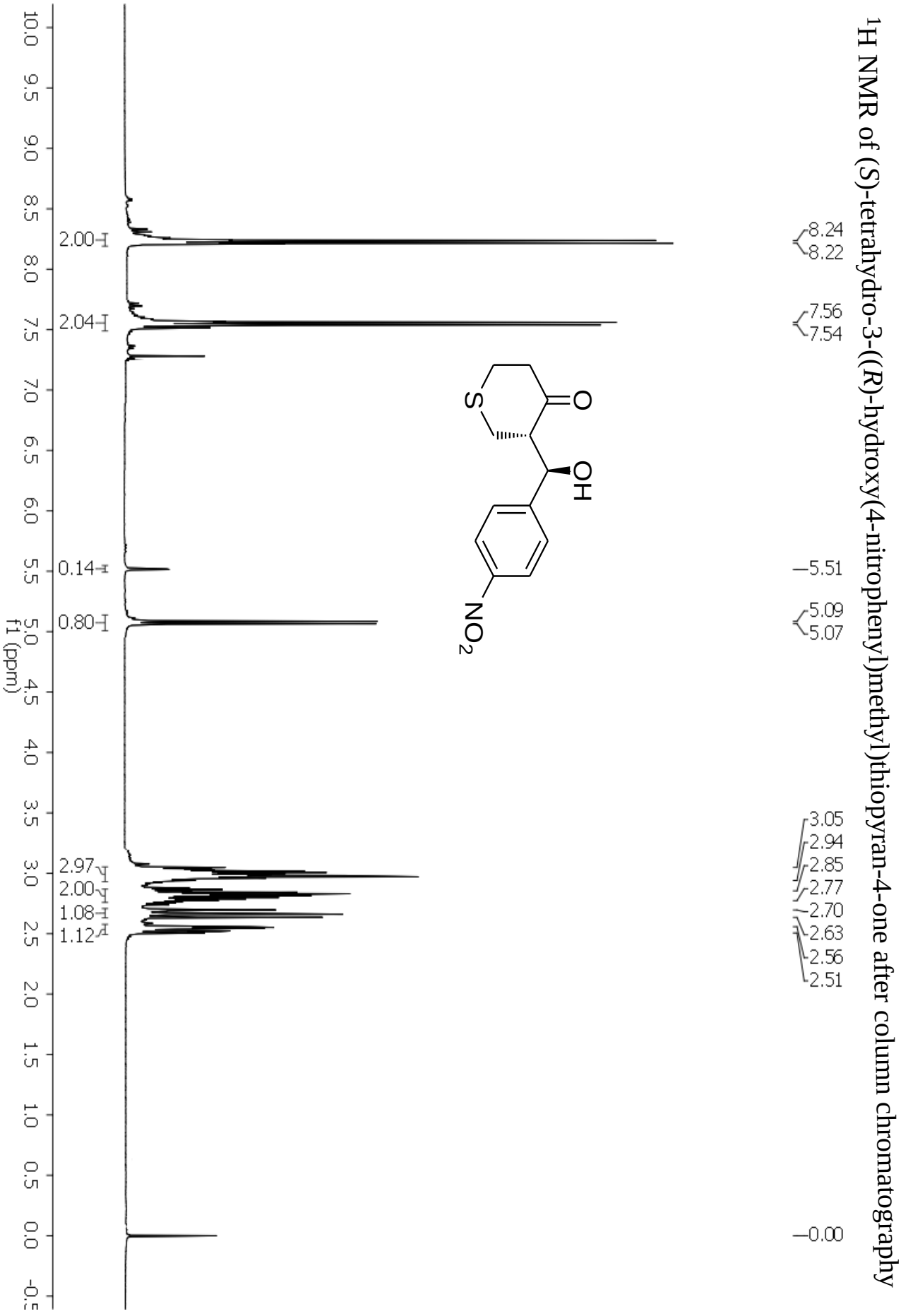
PDA Ch1 210nm 4nm

Peak #	Ret. Time	Area	Height	Area %	Height %	Width at 10% Height
1	40.932	49222806	427087	98.943	98.647	3.300
2	55.808	525663	5857	1.057	1.353	2.337
Total		49748468	432944	100.000	100.000	

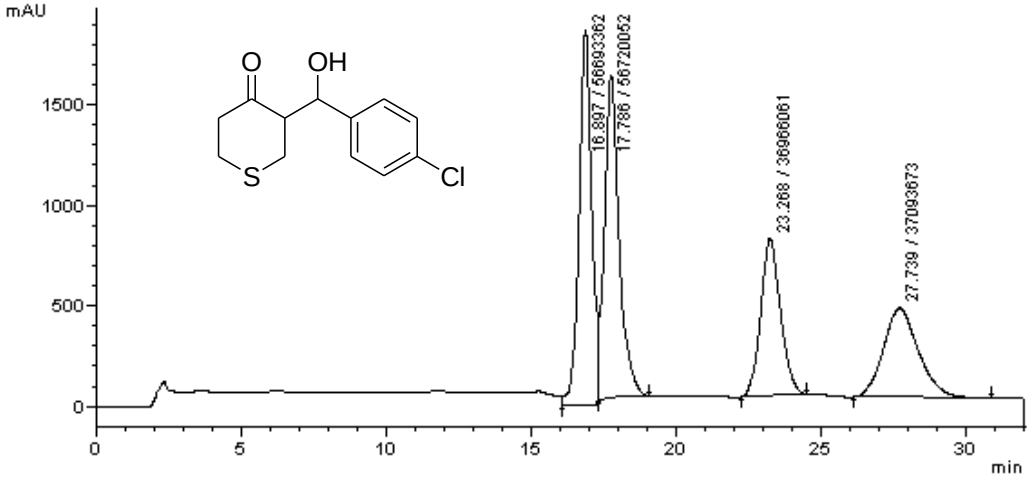
Crude ^{1}H NMR of (*S*)-tetrahydro-3-((*R*)-hydroxy(4-nitrophenyl)methyl)thiopyran-4-one for dr assessment



^{1}H NMR of (S)-tetrahydro-3-((*R*)-hydroxy(4-nitrophenyl)methyl)thiopyran-4-one after column chromatography



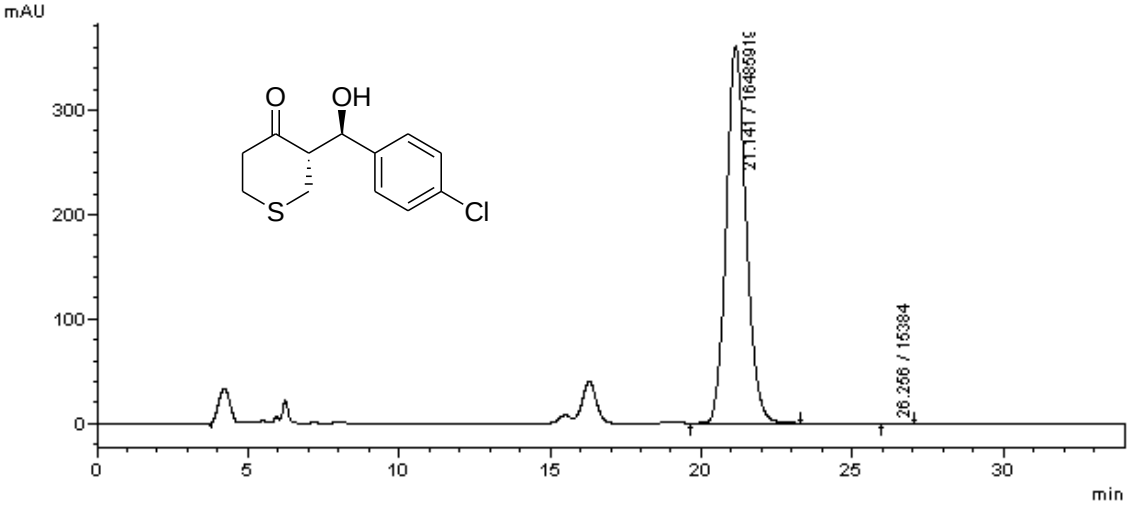
HPLC of racemic 3-((4-chlorophenyl)(hydroxy)methyl)-tetrahydrothiopyran-4-one (**8b**)



PDA Ch1 210nm 4nm

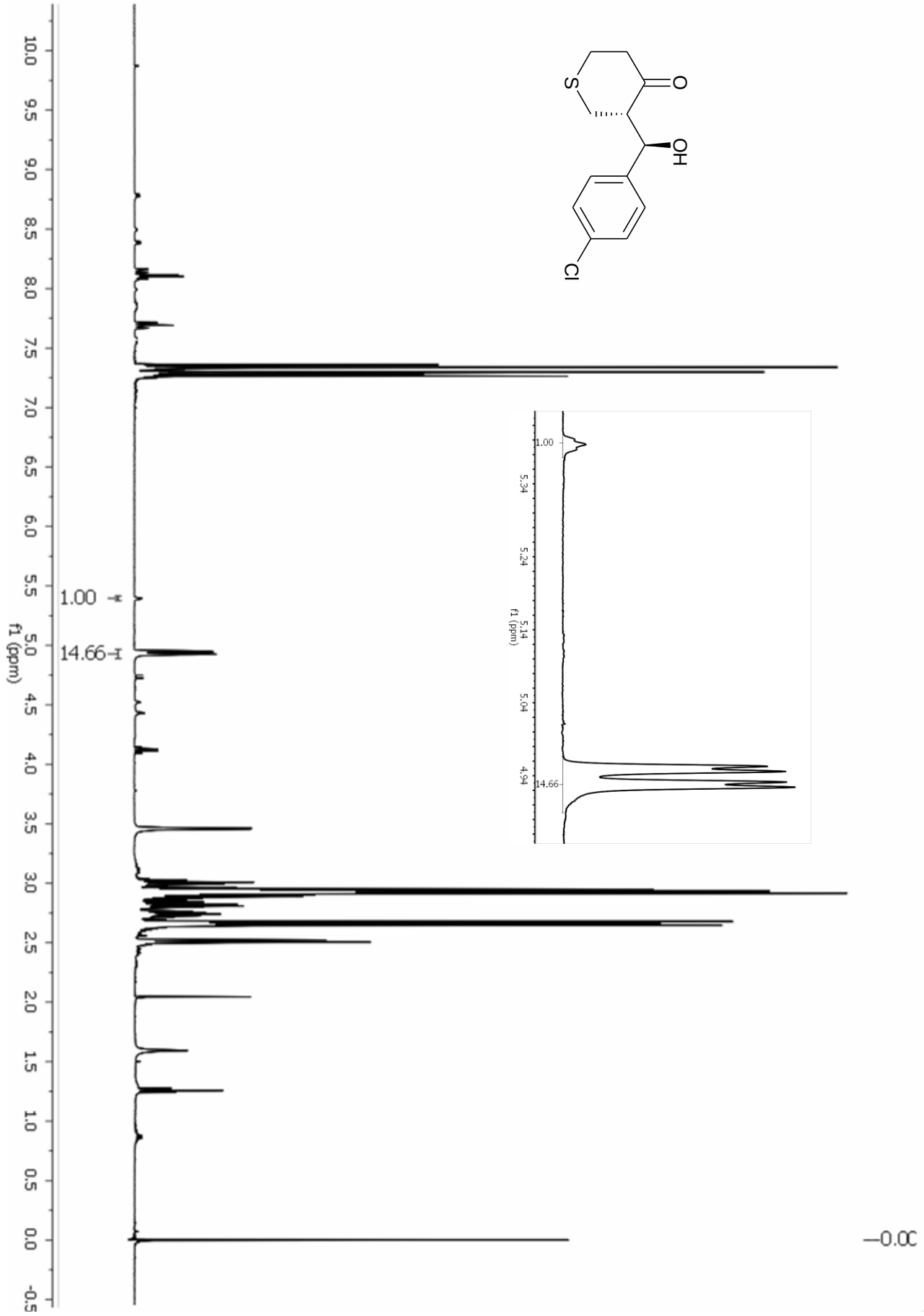
Peak #	Ret. Time	Area	Height	Area %	Height %	Width at 10% Height
1	16.897	56693362	1867717	30.241	39.740	0.000
2	17.786	56720052	1604396	30.255	34.137	0.000
3	23.268	36966061	782744	19.718	16.655	1.442
4	27.739	37093673	444951	19.786	9.467	2.522
Total		187473148	4699808	100.000	100.000	

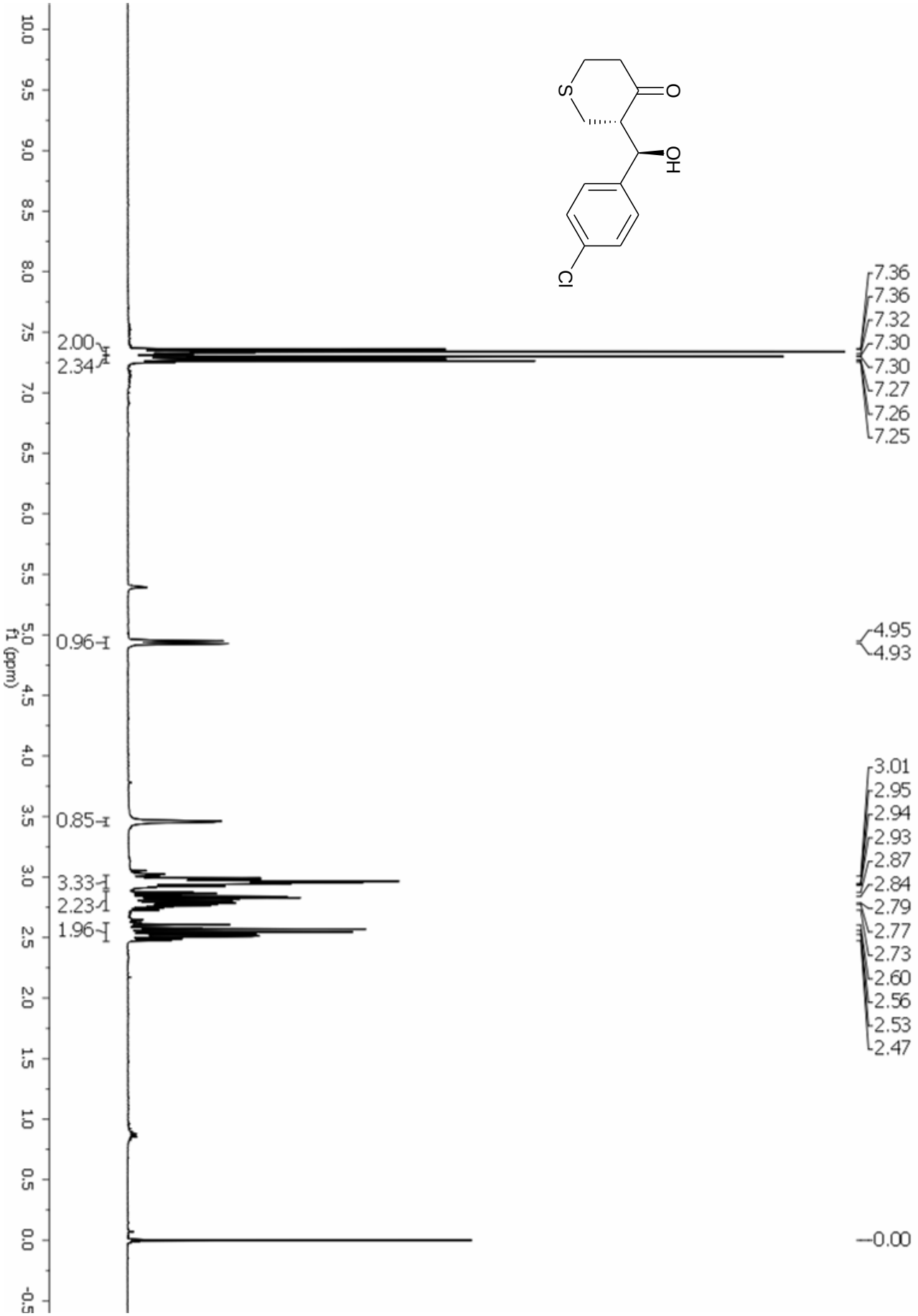
HPLC of (S)-3-((R)-(4-chlorophenyl)(hydroxy)methyl)-tetrahydrothiopyran-4-one (**8b**)



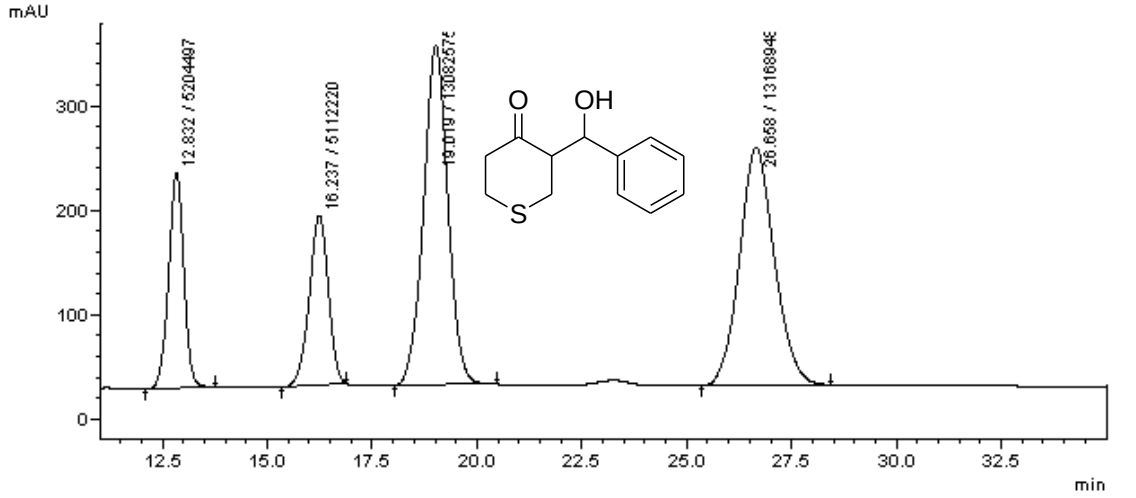
PDA Ch1 210nm 4nm

Peak #	Ret. Time	Area	Height	Area %	Height %
1	21.141	16485919	360729	99.907	99.927
2	26.256	15384	262	0.093	0.073
Total		16501303	360992	100.000	100.000





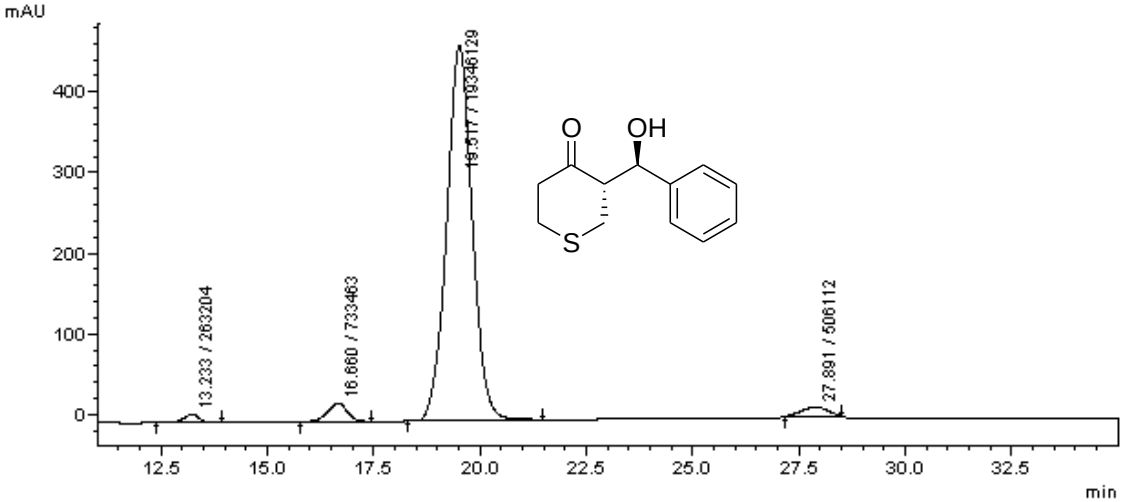
HPLC of racemic (S)-tetrahydro-3-((R)-hydroxy(phenyl)methyl)thiopyran-4-one (**8c**)



PDA Ch1 210nm 4nm

Peak#	Ret. Time	Area	Height	Area %	Height %	Width at 10% Height
1	12.832	5204497	206235	14.232	22.357	0.744
2	16.237	5112220	162753	13.980	17.644	0.924
3	19.019	13082575	325332	35.776	35.268	1.197
4	26.658	13168948	228130	36.012	24.731	1.739
Total		36568240	922449	100.000	100.000	

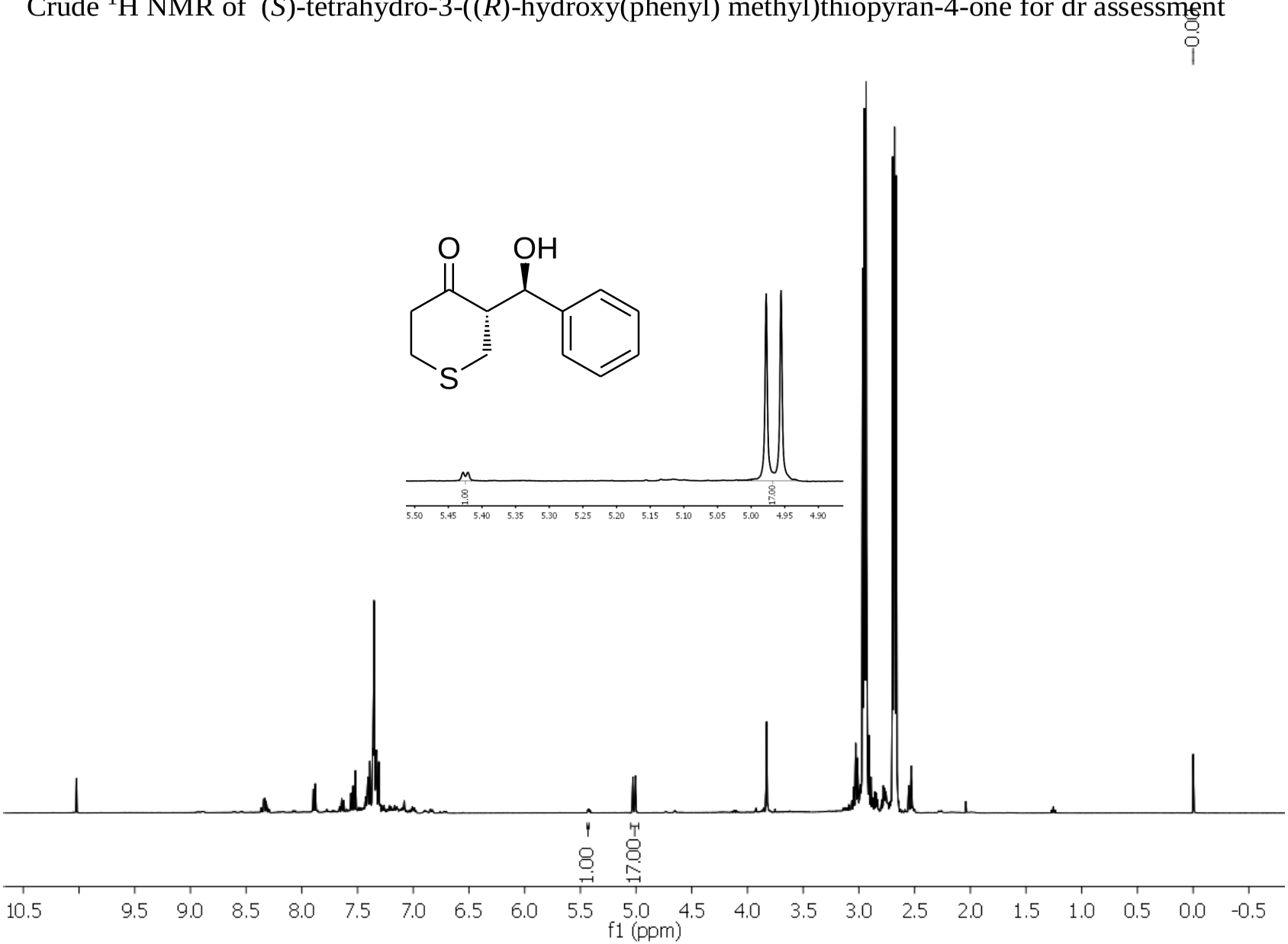
HPLC of (S)-tetrahydro-3-((R)-hydroxy(phenyl)methyl)thiopyran-4-one (**8c**)



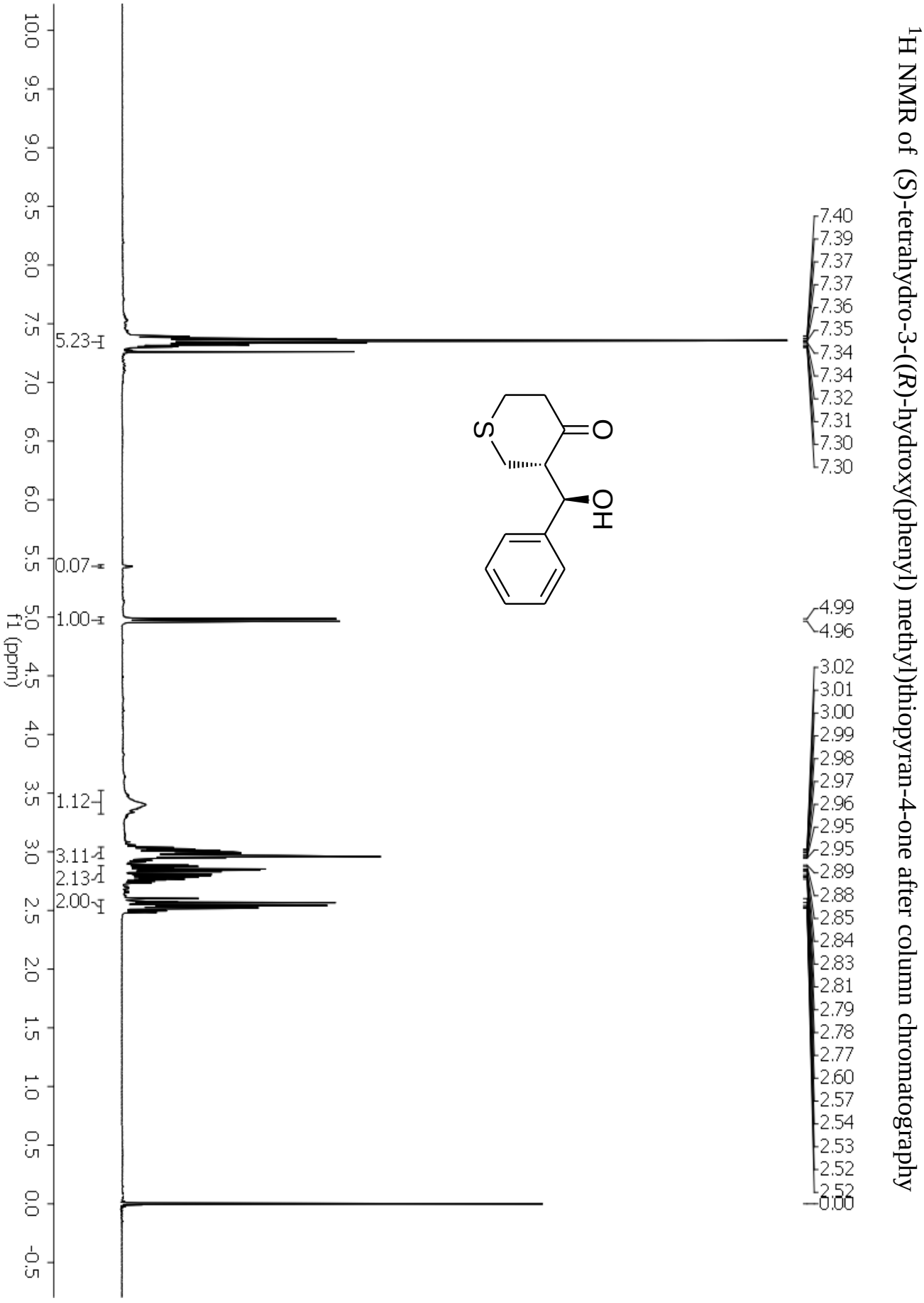
PDA Ch1 210nm 4nm

Peak#	Ret. Time	Area	Height	Area %	Height %	Width at 10% Height
1	13.233	263204	10246	1.262	2.013	0.758
2	16.660	733463	22759	3.518	4.472	0.949
3	19.517	19346129	464501	92.792	91.269	1.246
4	27.891	506112	11433	2.428	2.246	1.186
Total		20848908	508939	100.000	100.000	

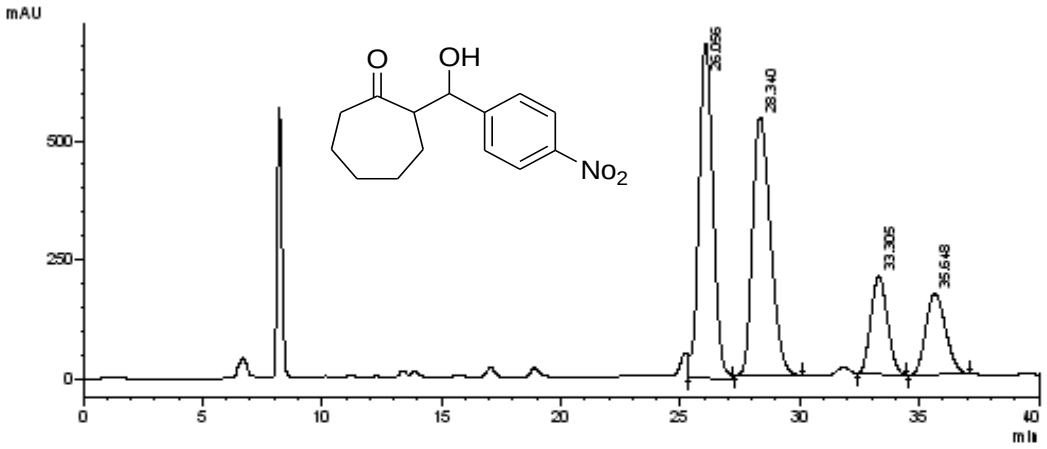
Crude ^{1}H NMR of (*S*)-tetrahydro-3-((*R*)-hydroxy(phenyl) methyl)thiopyran-4-one for dr assessment



^{1}H NMR of (*S*)-tetrahydro-3-((*R*)-hydroxy(phenyl) methyl)thiopyran-4-one after column chromatography



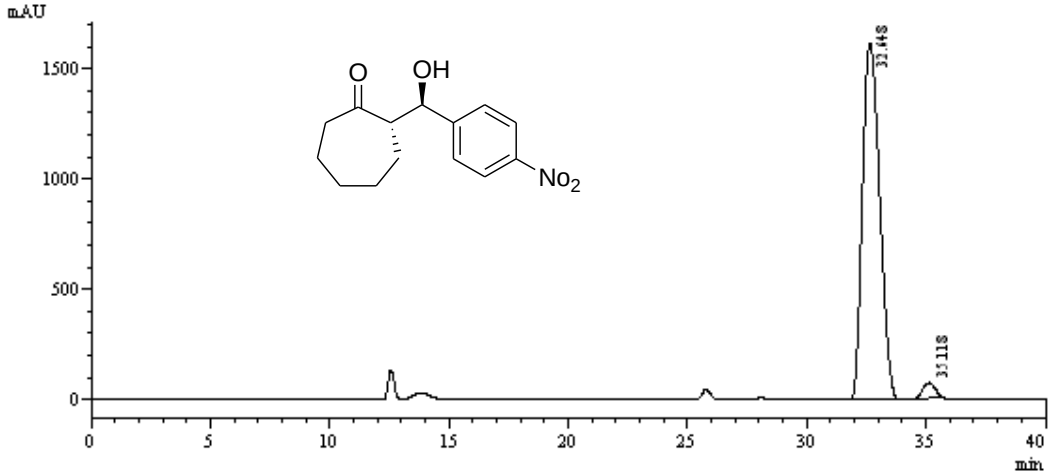
HPLC of racemic 2-(hydroxy(4-nitrophenyl)methyl)cycloheptanone (**9a**)



PDA Ch1 210nm 4nm

Peak#	Ret. Time	Area	Height	Area %	Height %
1	26.056	28837526	700861	37.527	43.326
2	28.340	28166108	540757	36.654	33.428
3	33.305	9939644	205561	12.935	12.707
4	35.648	9900593	170477	12.884	10.539
Total		76843872	1617655	100.000	100.000

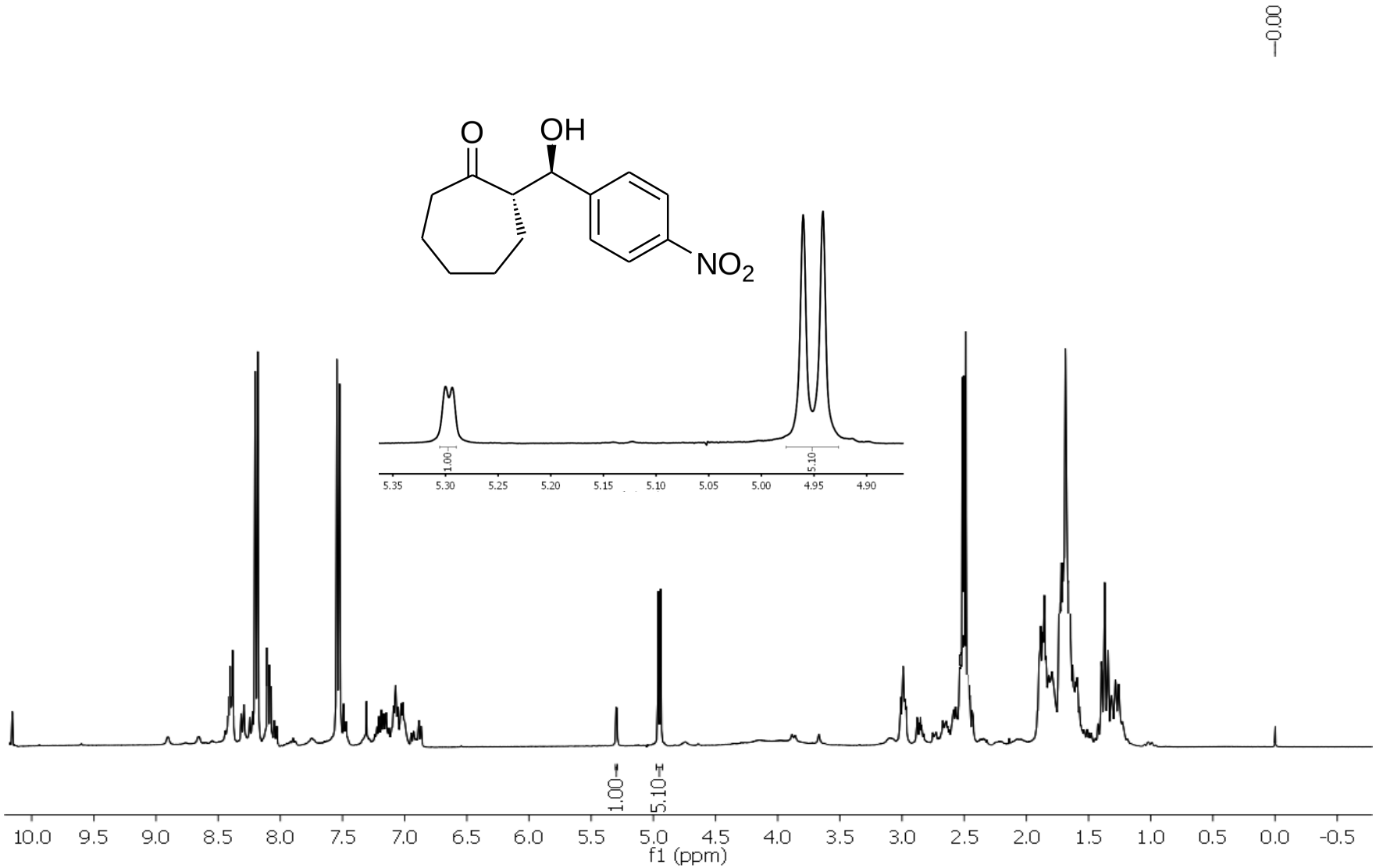
HPLC of (S)-2-((R)-hydroxy(4-nitrophenyl)methyl)cycloheptanone (**9a**)



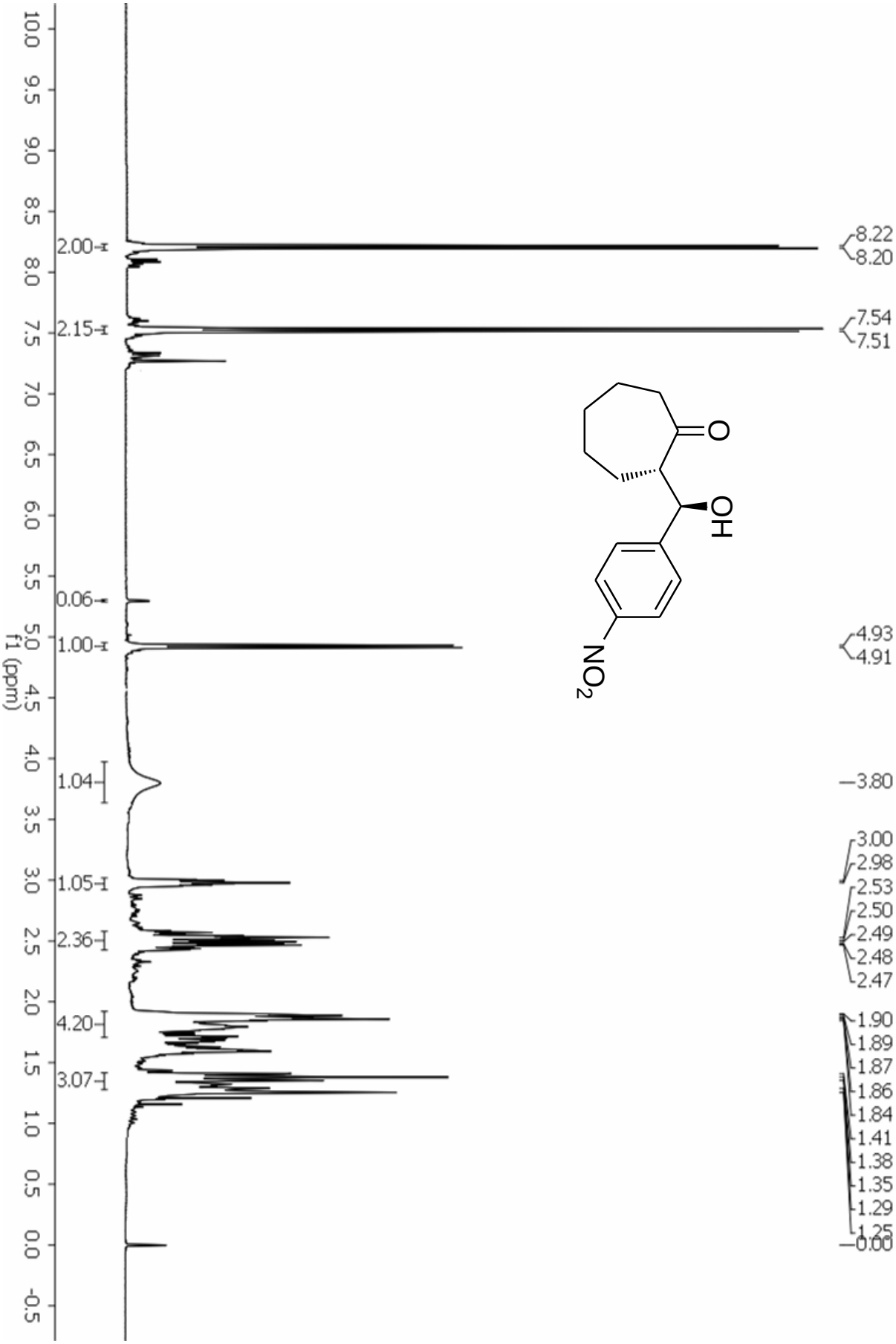
PDA Ch1 254nm 4nm

Peak#	Ret. Time	Area	Height	Area %	Height %
1	32.648	80792884	1613779	97.026	95.911
2	35.118	2476803	68795	2.974	4.089
Total		83269686	1682574	100.000	100.000

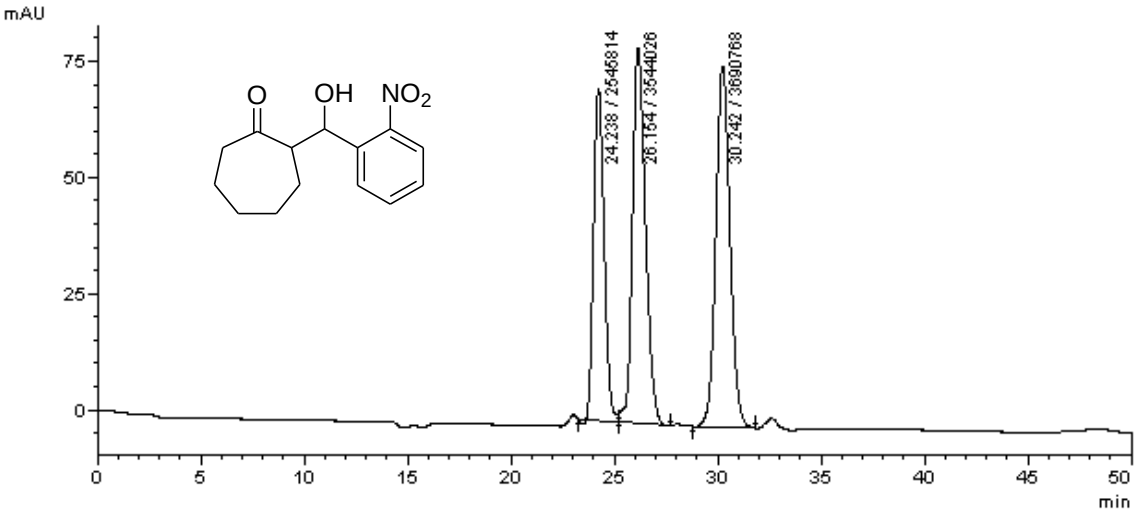
Crude ^{1}H NMR of (*S*)-2-((*R*)-hydroxy(4-nitrophenyl)methyl)cycloheptanone for dr assessment



^{1}H NMR of (*S*)-2-((*R*)-hydroxy(4-nitrophenyl)methyl)cycloheptanone after column chromatography



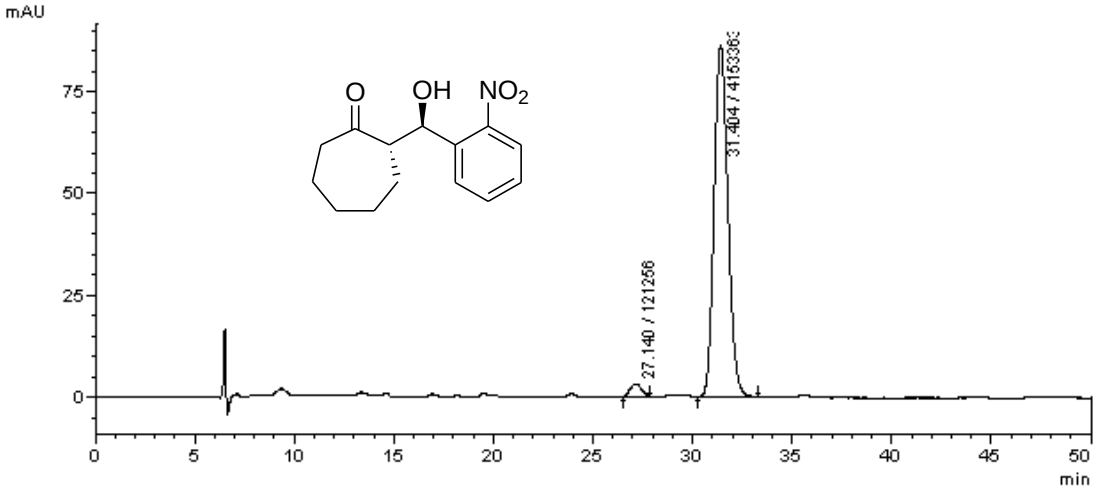
HPLC of racemic 2-(hydroxy(2-nitrophenyl)methyl)cycloheptanone (**9b**)



PDA Ch1 254nm 4nm

Peak #	Ret. Time	Area	Height	Area %	Height %
1	24.238	2545814	71502	26.029	31.110
2	26.154	3544026	80681	36.235	35.105
3	30.242	3690768	77649	37.736	33.785
Total		9780609	229832	100.000	100.000

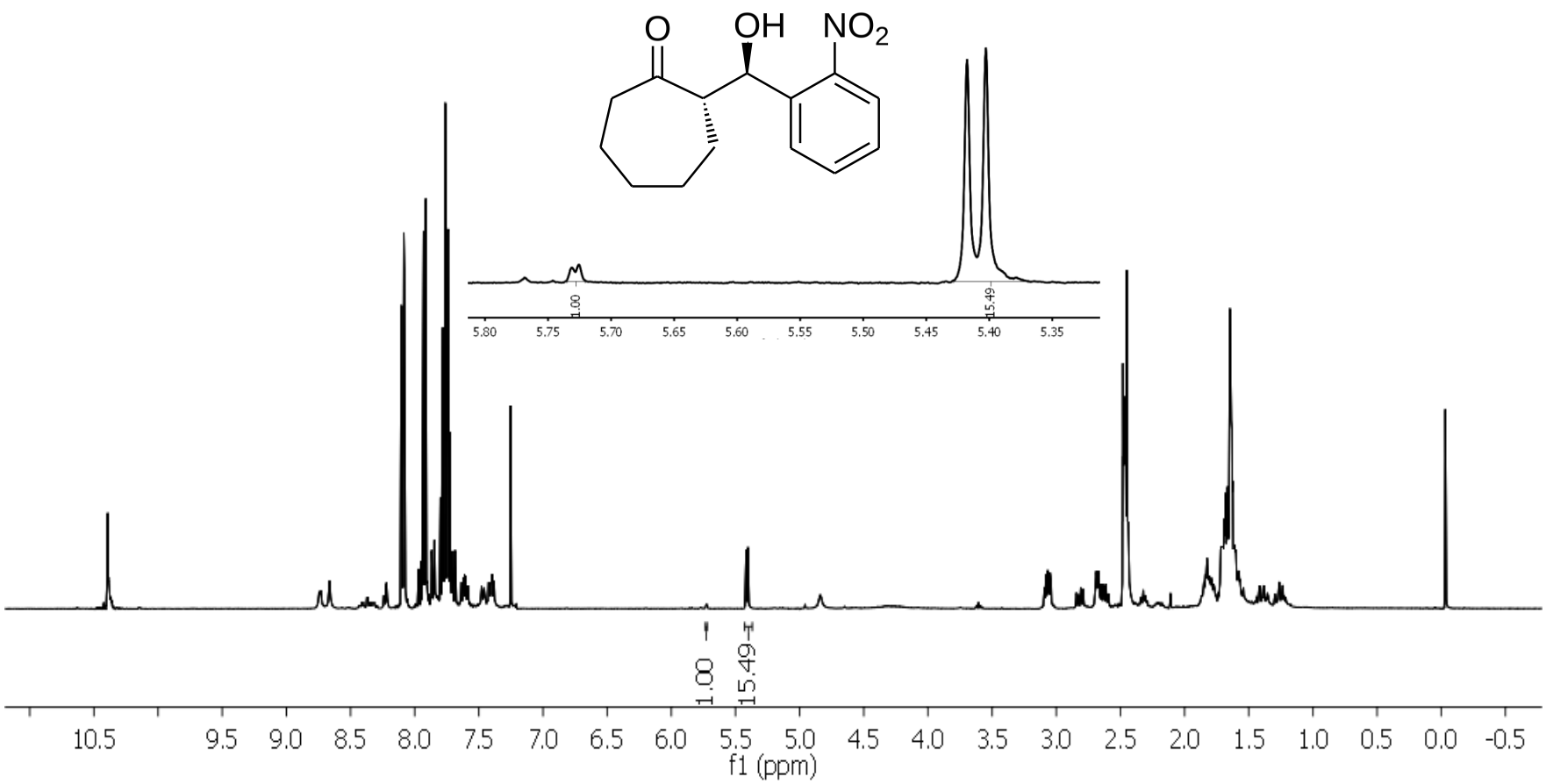
HPLC of (S)-2-((R)-hydroxy(2-nitrophenyl)methyl)cycloheptanone (**9b**)



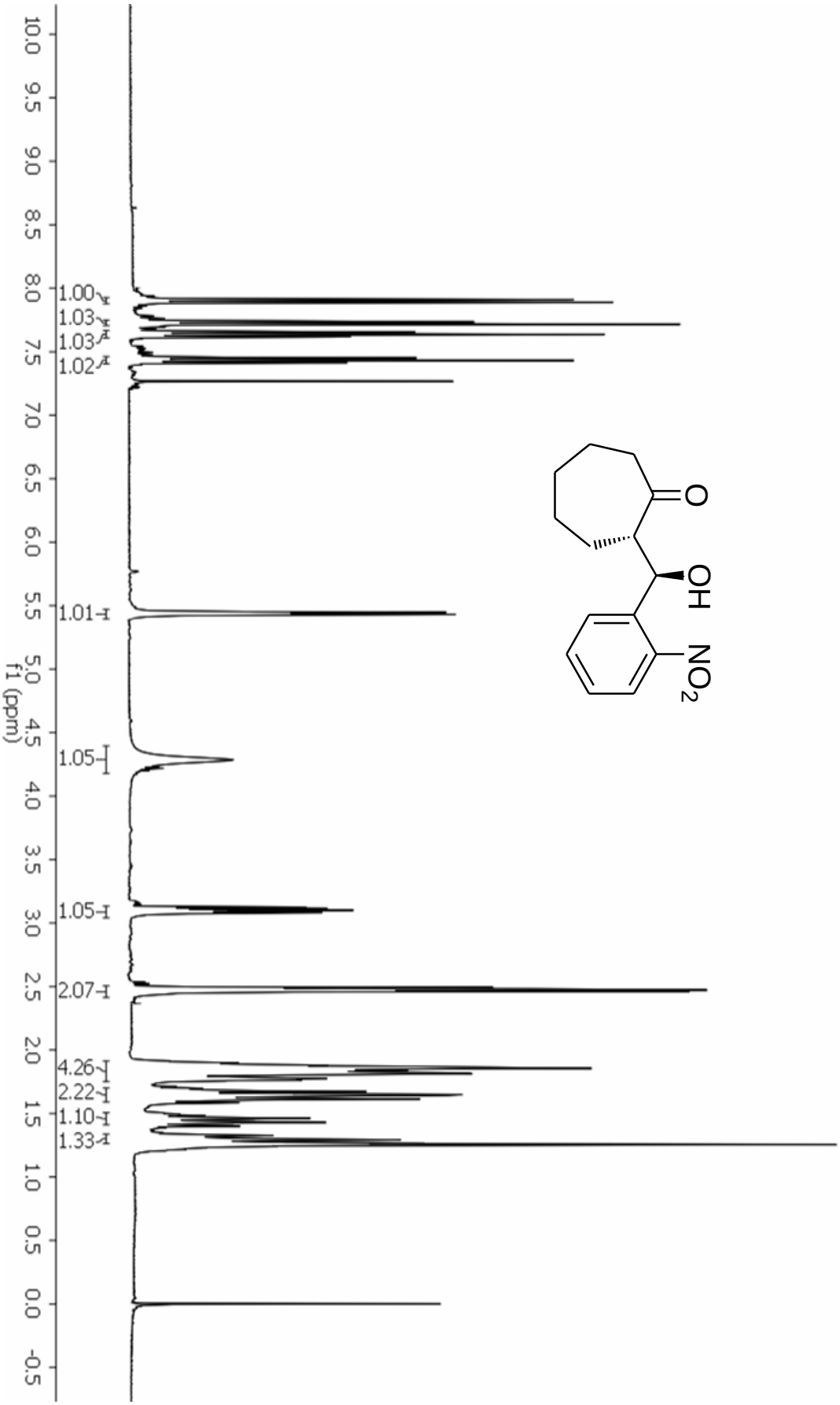
PDA Ch1 254nm 4nm

Peak #	Ret. Time	Area	Height	Area %	Height %	Width at 10% Height
1	27.140	121256	3117	2.837	3.489	1.087
2	31.404	4153363	86235	97.163	96.511	1.383
Total		4274619	89353	100.000	100.000	

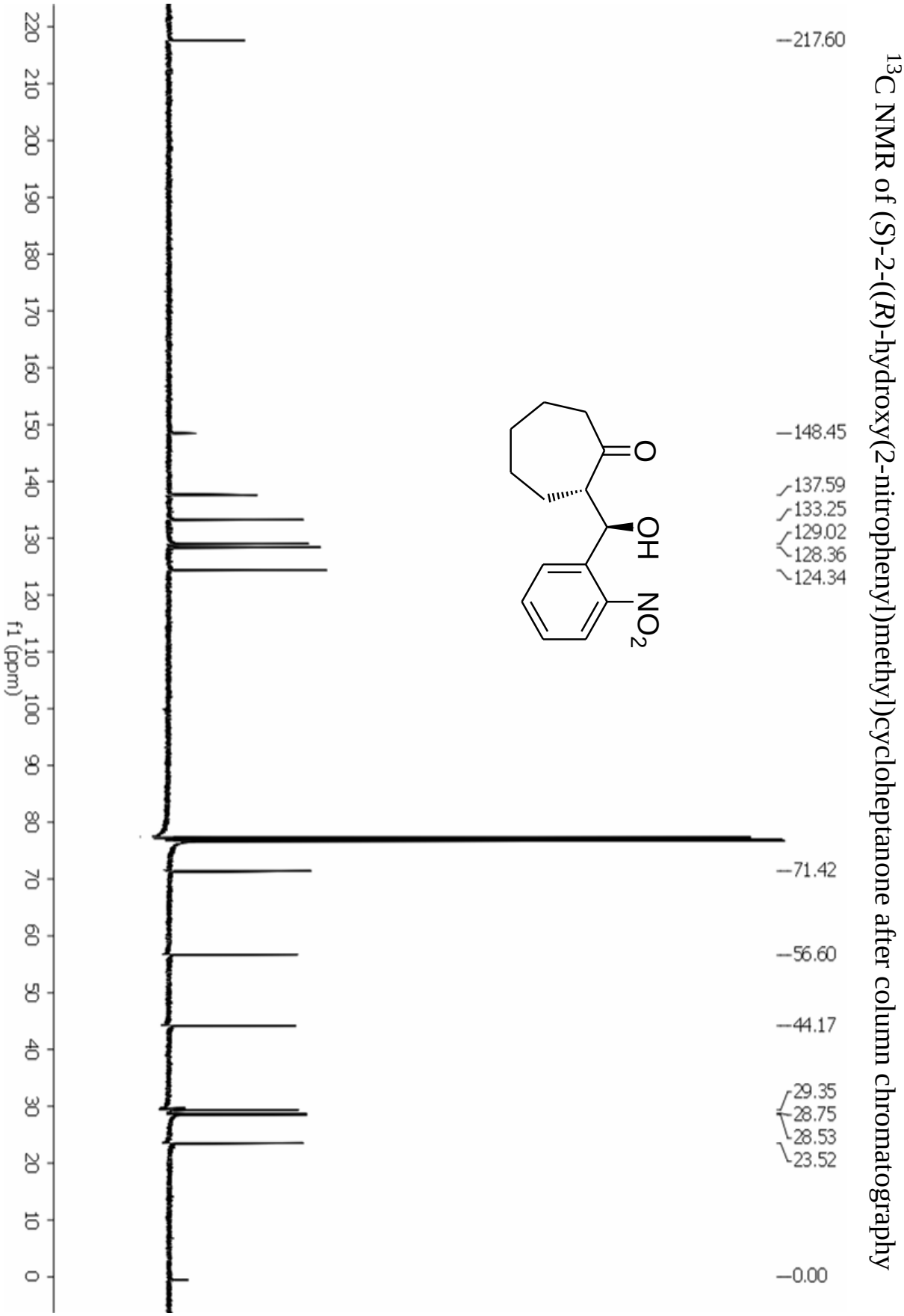
Crude ^{1}H NMR of (*S*)-2-((*R*)-hydroxy(2-nitrophenyl)methyl)cycloheptanone for dr assessment



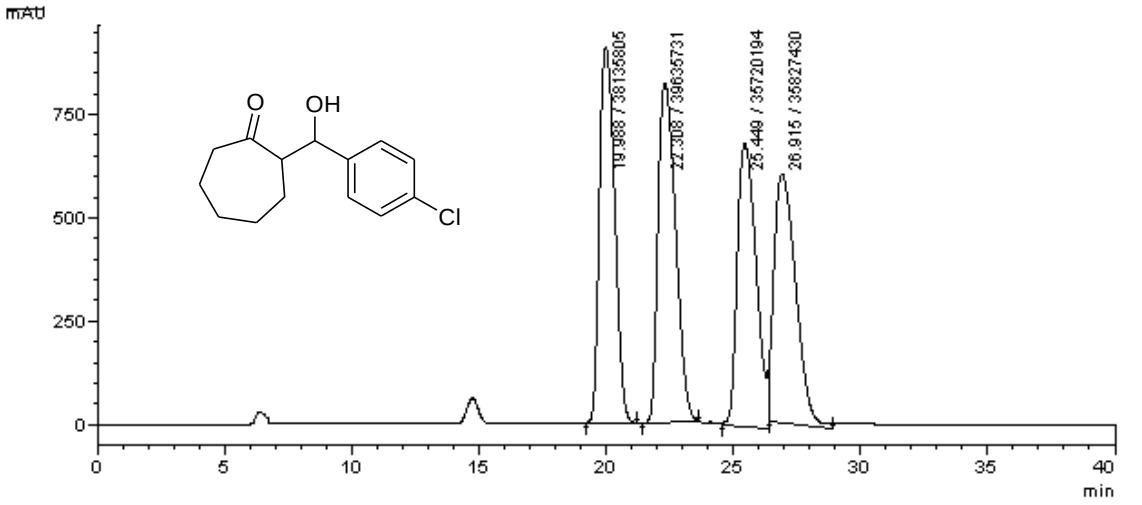
1H NMR of (*S*)-2-((*R*)-hydroxy(2-nitrophenyl)methyl)cycloheptanone after column chromatography



^{13}C NMR of (*S*)-2-((*R*)-hydroxy(2-nitrophenyl)methyl)cycloheptanone after column chromatography



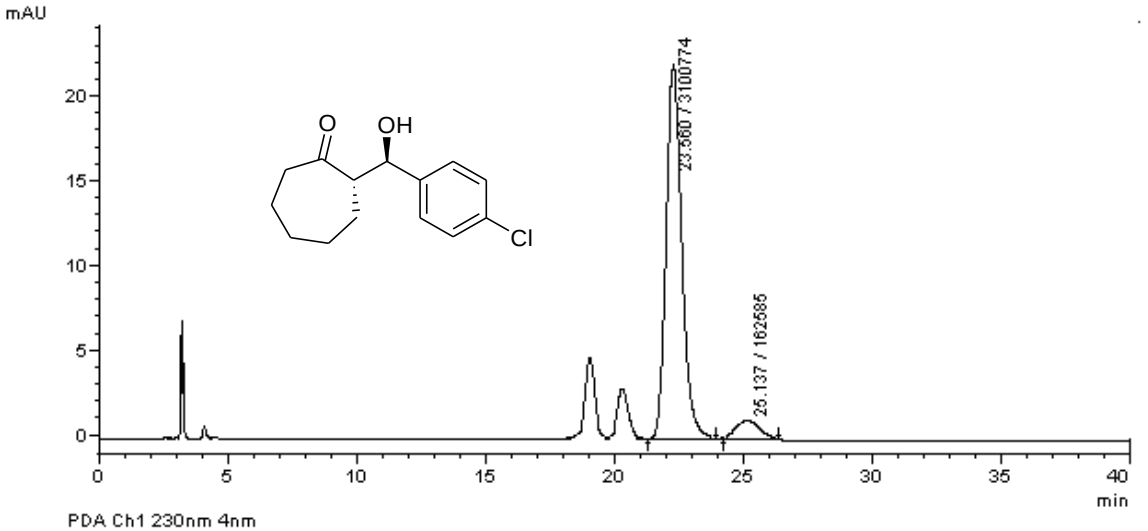
HPLC of racemic 2-((4-chlorophenyl)(hydroxy)methyl)cycloheptanone (**9c**)



PDA Ch1 230nm 4nm

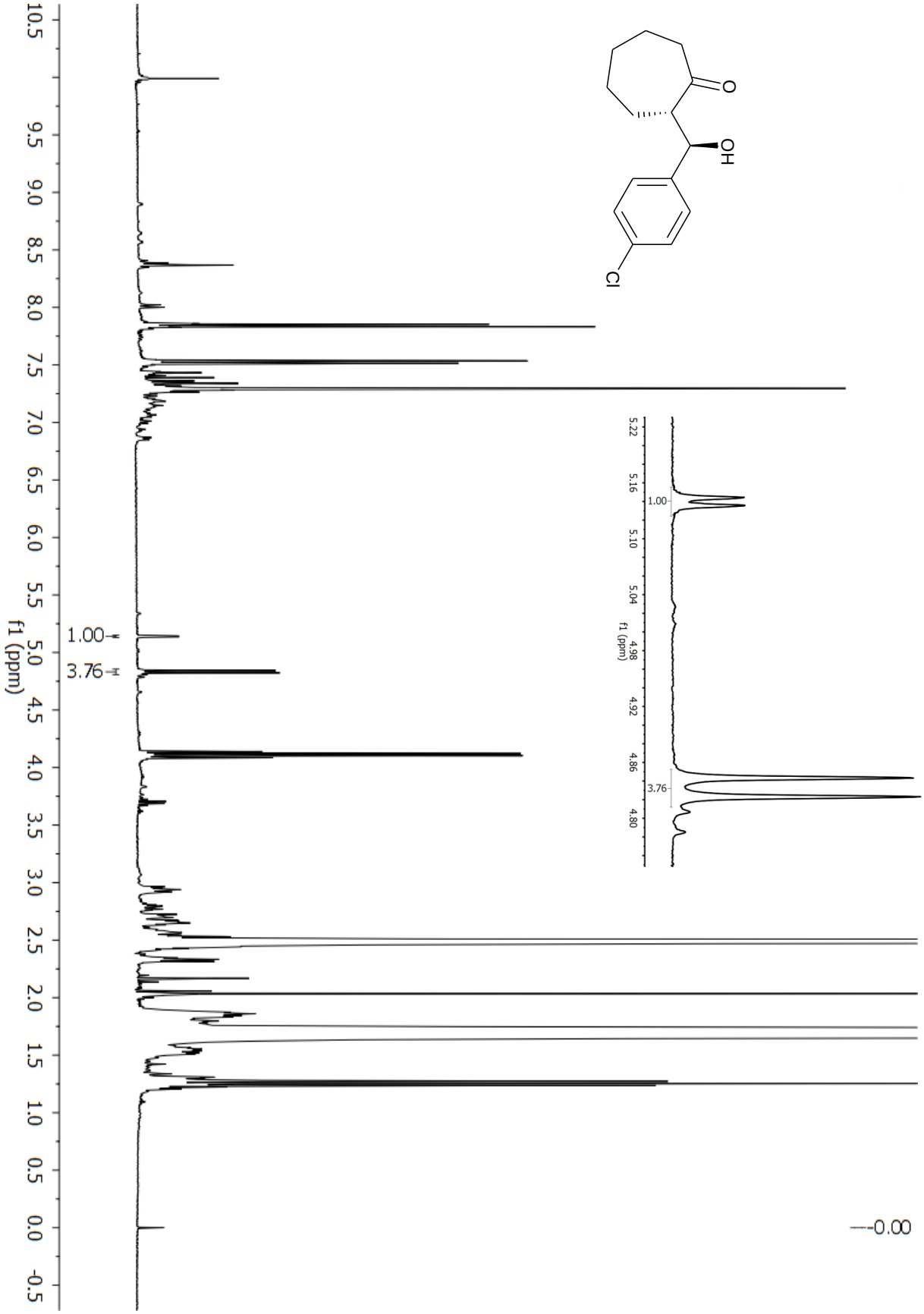
Peak #	Ret. Time	Area	Height	Area %	Height %	Width at 10% Height
1	19.988	38135805	909568	25.540	30.160	1.119
2	22.308	39635731	821170	26.544	27.229	1.315
3	25.449	35720194	683509	23.922	22.664	0.000
4	26.915	35827430	601586	23.994	19.948	0.000
Total		149319159	3015834	100.000	100.000	

HPLC of (S)-2-((R)-(4-chlorophenyl)(hydroxy)methyl)cycloheptanone (**9c**)

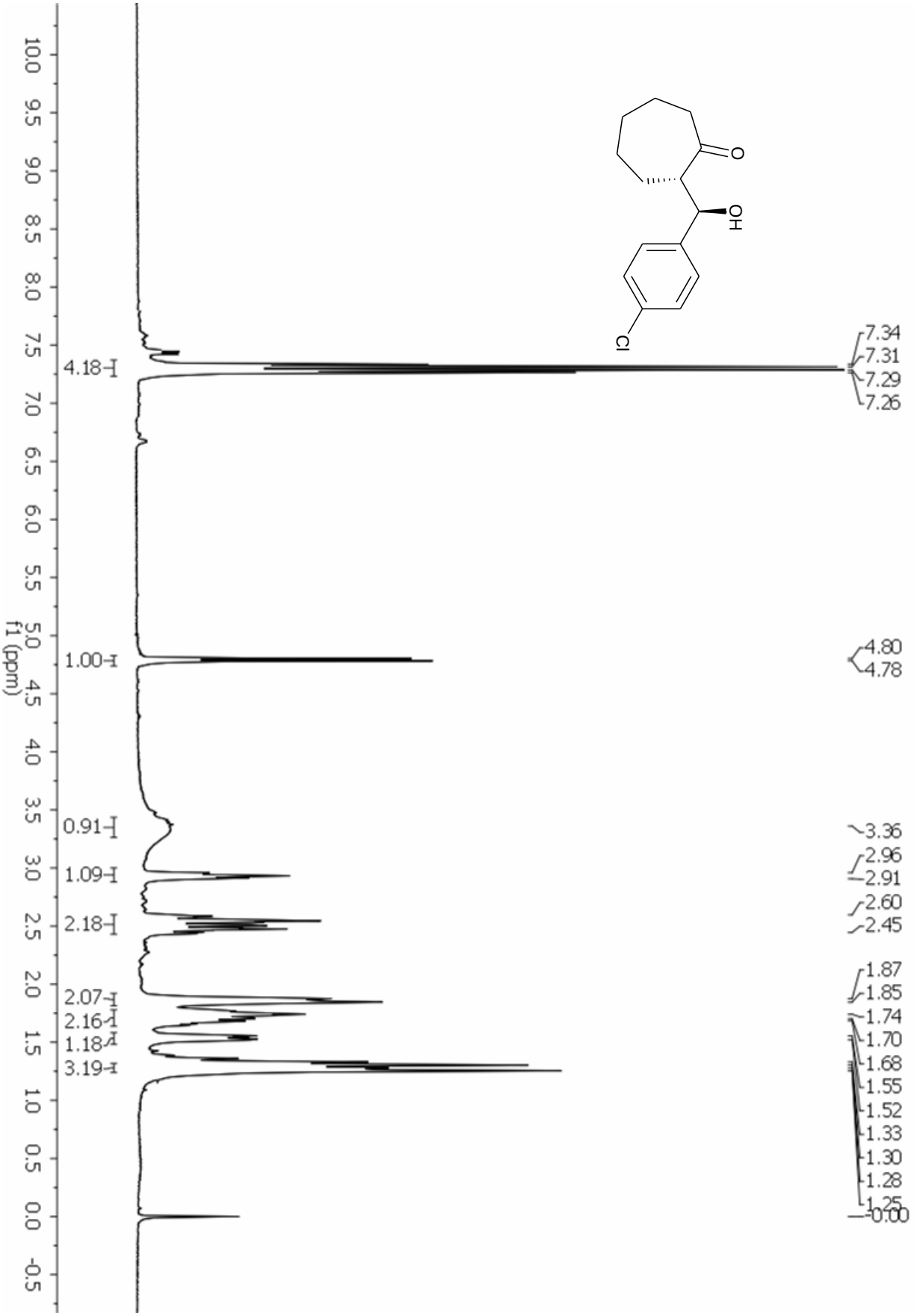


PDA Ch1 230nm 4nm

Peak #	Ret. Time	Area	Height	Area %	Height %	Width at 10% Height
1	23.560	3100774	80691	95.018	93.412	1.180
2	25.137	162585	5691	4.982	6.588	0.776
Total		3263359	86382	100.000	100.000	



^{1}H NMR of (*S*)-2-((*R*)-(4-chlorophenyl)(hydroxy)methyl)cycloheptanone after column chromatography



^{13}C NMR of (*S*)-2-((*R*)-(4-chlorophenyl)(hydroxy)methyl)cycloheptanone after column chromatography