Supporting Information

Practical access to highly enantioenriched quaternary carbon Michael adducts using simple organocatalysts

Thomas C. Nugent,* Mohammad Shoaib, and Amna Shoaib

General information:
All 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). 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. Evaporation of solvent was performed at reduced pressure.

Materials: Commercial reagents were used as received from Sigma-Aldrich.

Nitroalkenes: *trans*-β-Nitrostyrene (Ald. Cat. No. N26806), *trans*-4-methoxy-β-nitrostyrene (Ald. Cat. No. 399299), *trans*-4-methyl-β-nitrostyrene (Ald. Cat. No. 424757), *trans*-4-chloro-β-nitrostyrene (Ald. Cat. No. 642177), *trans*-4-fluoro-β-nitrostyrene (Ald. Cat. No. 09506), *trans*-2-methoxy-β-nitrostyrene (Ald. Cat. No. 639710), *trans*-2-bromo-β-nitrostyrene (Ald. Cat. No. 642215), *trans*-2-(2-nitrovinyl)furan(Ald. Cat. No. 478717). 2-isobutyl-1-nitroethene[1] and 2-styryl-1-nitroethene [(1E,2E)-4-nitrobuta-1,3-dienyl benzene][2] were synthesized according to previously published procedures.

Aldehydes: Isobutyraldehyde (2-methylpropanal, Ald. Cat. No. 240788, 99% pure), 2-methylbutanal (Ald. Cat. No. M33476, 95% pure), cyclopentanecarbaldehyde (Ald. Cat. No. 526037, 97% pure), cyclohexanecarbaldehyde (Ald. Cat. No. 108464, 97% pure), 2-methylundecanal (Ald. Cat. No. M86758, 95% pure), 2,6-dimethylhept-5-enal (Ald. Cat. No. W238902).

Catalyst components: DMAP (Ald. Cat. No. 29224), sulfamide (Ald. Cat. No. 211370), O^{t}Bu-L-threonine (Ald. Cat. No. 20644) were purchased from Sigma-Aldrich. Schreiner's thiourea can be purchased from many smaller sized chemical companies or synthesized.[3]

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 were performed on a CHIRALCEL OD-H column with *n*-heptane and *i*-propanol as eluents.

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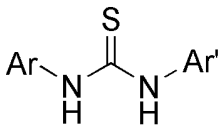
[1] O. Bassas, J. Huuskonen, K. Rissanen, A. M. P. Koskinen, *Eur. J. Chem*. **2009**, 1340-1351.
[2] C. Dockendorff, S. Sahli, M. Olsen, L. Milhau, M. Lautens, *J. Am. Chem. Soc.* **2005**, *127*, 15028-15029.
[3] M. Kotke, P. R. Schreiner, *Tetrahedron* **2006**, *62*, 434-439.

Preliminary screening: Different amino acids, bases and hydrogen bond donors were screened to better understand the important reaction partners.

Amino Acids: L-proline, L-isoleucine L-tryptophan, L-phenylglycine, L-leucine, L-phenylalanine, L-valine, O^{t}Bu-L-threonine.

Bases: DMAP, imidazole, DABCO, LiOH, tetrabutylammoniumhydroxide (30 hydrate), DBU, iPr_2NEt, N-methylmorpholine, Et_3N.

Hydrogen bond donors: In addition to the hydrogen bond donors shown in the Fig. 1 of the manuscript, the following hydrogen bond donors were also screened but found to be less effective in terms of reaction rate and enantioinduction.



Ar = Ar' = benzyl
Ar = Ar' = 2, 6-dimethylphenyl
Ar = Ar' = 2, 5-dimethylphenyl
Ar = Ar' = 3, 5-dimethylphenyl
Ar = benzyl, Ar' = 1, 3-bis(trifluoromethyl)phenyl

Absolute and relative configuration:
The absolute configuration of compounds **8**-**22** was determined by chiral HPLC data comparison with the reported literature values.[4,5,6,7,8,9] For compounds **8**-**17** see references 4-6. For compounds **18**-**22** see references 7-9. The absolute configuration of compounds **23** and **24** are assumed based on the general trend observed for compound **22**, and the related compounds **20** and **21**. The relative stereochemistry (*anti* and *syn* assignment) followed a similar analysis using the above noted references, but additionally included ^{1}H NMR comparisons.

Racemate formation:
To a screw cap vial was added sulfamide (**3**) (2.4 mg, 0.025 mmol, 5.0 mol%), glycine (1.9 mg, 0.025 mmol, 5.0 mol%) and DMAP (3.1 mg, 0.025 mmol, 5.0 mol%). To this mixture was added toluene (1.0 M, 0.50 mL), and the aldehyde (2.00 equiv, 1.00 mmol). This mixture was then stirred for 2 minutes at room temperature. The nitroalkene (1.00 equiv, 0.50 mmol) was then added and the reaction stirred at room temperature. TLC was used to monitor the reaction. After completion the reaction was quenched by adding water (15 mL) and the resulting mixture was extracted with EtOAc (20 mL x 3). The combined organic extracts were dried over sodium sulfate, and evaporated under reduced pressure. The crude racemate was purified by column chromatography using EtOAc/pet ether.

General procedure for the enantioselective Michael addition of α,α- and α,α'-disubstituted aldehydes to nitroalkenes:

[4] X. Zhang, S. Liu, X. Li, M. Yan, A. S. C. Chan, *Chem. Commun*. **2009**, 833–835.
[5] C. Chang, S. H. Li, R. J. Reddy, K. Chen, *Adv. Synth. Catal*. **2009**, *351*, 1273 – 1278.
[6] S. H. McCooey, S. J. Connon, *Org. Lett.*, **2007**, *9*, 599-602.
[7] J. Wang, H. Li, B. Lou, L. Zu, H. Guo, W. Wang, *Chem. Eur. J.* **2006**, *12*, 4321 – 4332.
[8] N. Mase, R. Thayumanavan, F. Tanaka, C. F. Barbas, *Org. Lett.* **2004**, *6*, 2527-2530.
[9] M. P. Lalonde, Y. Chen, E. N. Jacobsen, *Angew. Chem. Int. Ed.* **2006**, *45*, 6366 –6370.

Three general reaction conditions were found to be optimal depending on the aldehyde examined. The limiting reagent was the nitroalkene, which was always used at the 0.50 mmol scale:

Method A (Schreiner's thiourea 4):
To a screw cap vial was added O^{t}Bu-L-threonine (1.8 mg, 0.01 mmol, 2.0 mol%), Schreiner's thiourea **4** (5.0 mg, 0.01 mmol, 2.0 mol%), and DMAP (4.9 mg, 0.04 mmol, 8.0 mol%). To this mixture was added cyclohexane (1.0 M, 0.50 mL), and the aldehyde (1.2 equiv (0.6 mmol) or 2.00 equiv (1.0 mmol)). This mixture was then stirred for 2 minutes at room temperature. The nitroalkene (1.00 equiv, 0.50 mmol) was then added and the reaction mixture was stirred for the indicated time at room temperature. TLC was used to monitor the reaction. After completion, the reaction was quenched by adding water (15 mL) and the resulting mixture was extracted with EtOAc (20 mL x 3). The combined organic extracts were dried over sodium sulfate, filtered, rototary evaporated, and finally dried under high vacuum. When the crude product was not chemical pure it was purified by column chromatography using EtOAc/pet ether.

Method B (Sulfamide 3, Table 2 reactions):
To a screw cap vial was added O^{t}Bu-L-threonine (4.4 mg, 0.025 mmol, 5.0 mol%), sulfamide (**3**) (2.40 mg, 0.025 mmol, 5.0 mol%), and DMAP (3.05 mg, 0.025 mmol, 5.0 mol%). To this mixture was added toluene (1.0 M, 0.50 mL), and the aldehyde (1.2 equiv, 0.6 mmol). This mixture was then stirred for 2 minutes at room temperature. The nitroalkene (1.00 equiv, 0.50 mmol) was then added and the reaction became homogenous within 10 minutes of stirring. The reaction time is indicated in the individual descriptions on the pages that follow. TLC was used to monitor the reaction. Work-up as in Method A. Note: Schreiner's thiourea (**4**) is organic soluble, while sulfamide (**3**) is water soluble.

Method C (Sulfamide 3, Table 3 reactions):
Same as method B, except 15 mol% of the DMAP (9.2 mg) and 2.00 equivalents (1.0 mmol) of the aldehyde were used.

On the following pages all synthesized products, **8**-**24**, are detailed. Note, compounds **23** and **24** are described here for the first time in the literature.

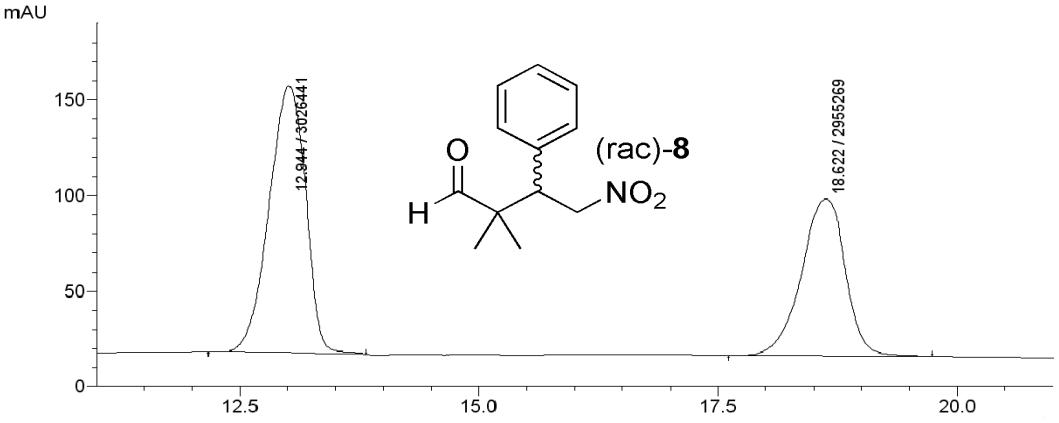
(S)-2,2-dimethyl-4-nitro-3-phenylbutanal (8):

The title compound was prepared from *trans*-β-nitrostyrene and isobutyraldehyde using methods A and B.

Compound obtained using method A (2 equiv. of isobutyraldehyde): Reaction time: 5 h; flash column chromatography: (EtOAc/Pet ether = 7:93); yield = 82%; ee = 93% as determined by HPLC (CHIRALCEL OD-H, *i*-PrOH/n-heptane 20/80, flow rate = 1.0 mL/min, λ = 220 nm); t_{minor}= 13.8 min, t_{major}= 18.9 min.

Compound obtained using method B: Reaction time: 7 h; No column chromatography was required, ^{1}H NMR (see spectrum on p. S-12) and HPLC (chromatogram on p. S-11) of the crude product showed it to be of very high chemical purity; yield = 97%; ee = 98% as determined by HPLC (conditions and retention times as above). ^{1}H NMR (400 MHz, $CDCl_3$) (ppm): 1.00 (s, 3H), 1.13 (s, 3H), 3.78 (dd, 1H, *J* = 4.1, 11.4 Hz), 4.69 (dd, 1H, *J* = 4.1, 12.8 Hz), 4.86 (dd, 1H, *J* = 11.4, 12.8 Hz), 7.19-7.20 (m, 2H), 7.26-7.35 (m, 3H), 9.52 (s, 1H).

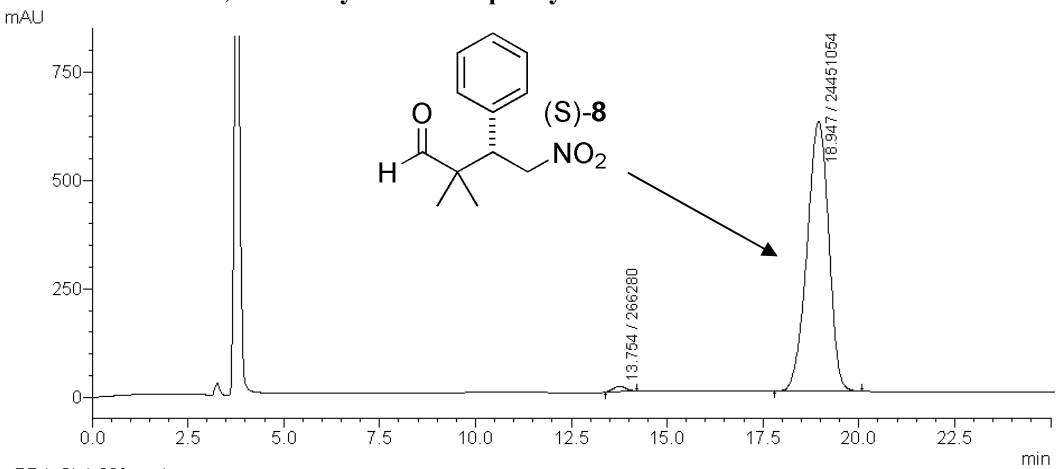
Racemic 2,2-dimethyl-4-nitro-3-phenylbutanal



PDA Ch1 220nm 4nm

Peak #	Ret. Time	Area	Height	Area %	Height %	Width at 10% Height	Mark
1	12.944	3026441	120607	50.595	60.265	0.728	
2	18.622	2955269	79521	49.405	39.735	1.080	
Total		5981710	200128	100.000	100.000		

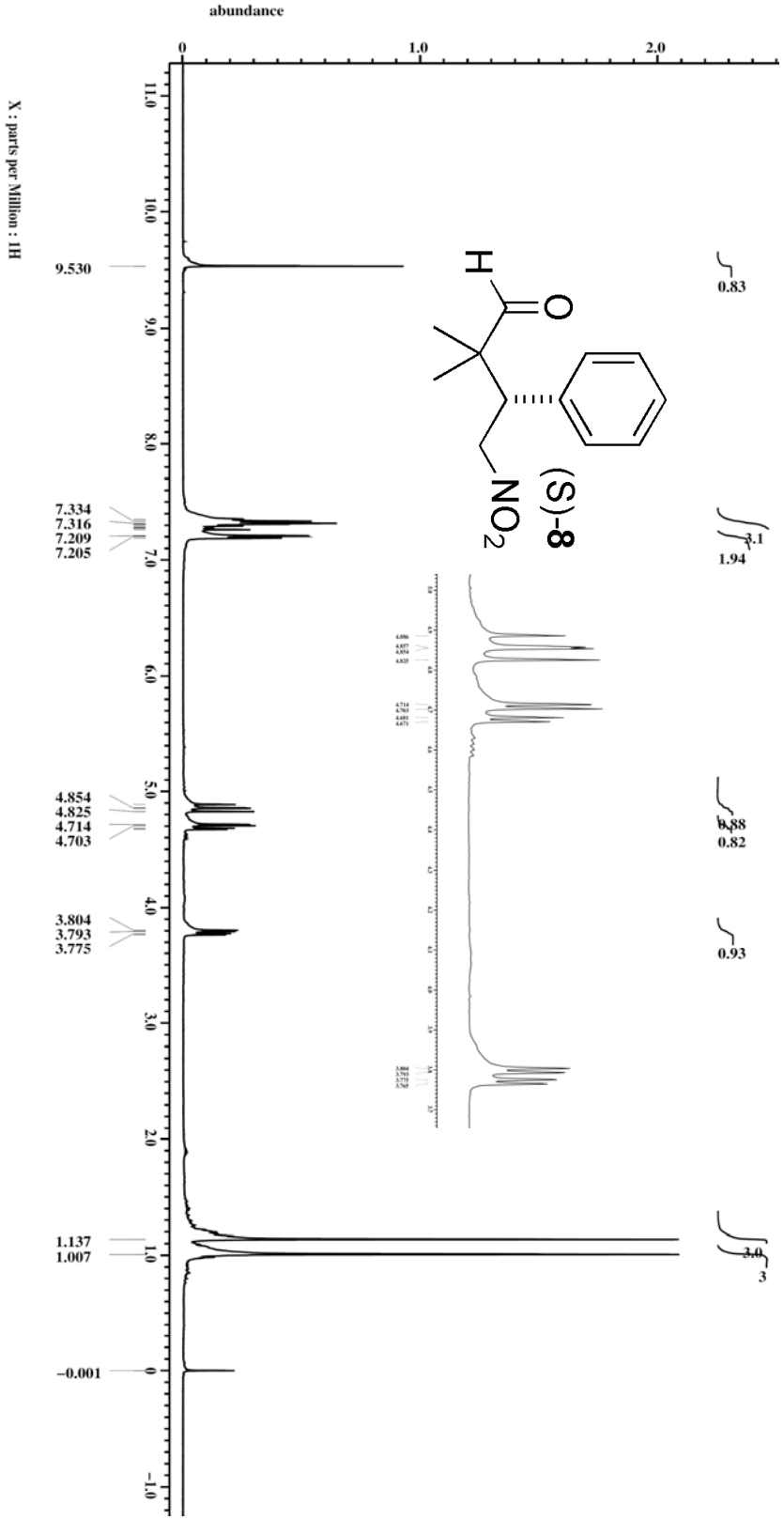
Enantioenriched 2,2-dimethyl-4-nitro-3-phenylbutanal



PDA Ch1 220nm 4nm

Peak #	Ret. Time	Area	Height	Area %	Height %	Width at 10% Height	Mark
1	13.754	266280	11675	1.077	1.844	0.632	
2	18.947	24451054	621426	98.923	98.156	1.125	
Total		24717335	633101	100.000	100.000		

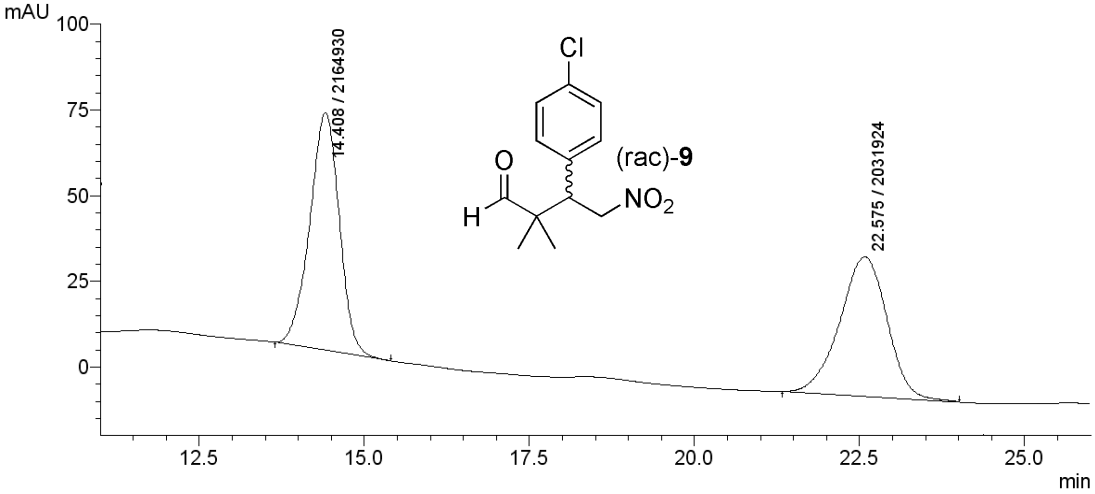
^{1}H NMR of (S)-2,2-dimethyl-4-nitro-3-phenylbutanal (8)



(S)-3-(4-chlorophenyl)-2,2-dimethyl-4-nitrobutanal (9):

The title compound was prepared from *trans*-4-chloro-β-nitrostyrene and isobutyraldehyde using method B. Reaction time: 24 h; No column chromatography was required, ^{1}H NMR (see spectrum on p. S-14) and HPLC (chromatogram on p. S-13) of the crude product showed it to be of very high chemical purity; yield = 98%; ee = 96% as determined by HPLC (CHIRALCEL OD-H, *i*-PrOH/n-heptane 20/80, flow rate = 0.8 mL/min, λ = 220 nm); t_{minor}= 14.1 min, t_{major}= 22.3 min. ^{1}H NMR (400 MHz, $CDCl_3$) (ppm): 1.01 (s, 3H), 1.11 (s, 3H), 3.77 (dd, 1H, *J* = 4.2, 11.4 Hz), 4.69 (dd, 1H, *J* = 4.2, 13.2 Hz), 4.82 (dd, 1H, *J* = 11.4, 13.2 Hz), 7.15 (d, 2H, *J* = 8.2 Hz), 7.31 (d, 2H, *J* = 8.2 Hz), 9.49 (s, 1H).

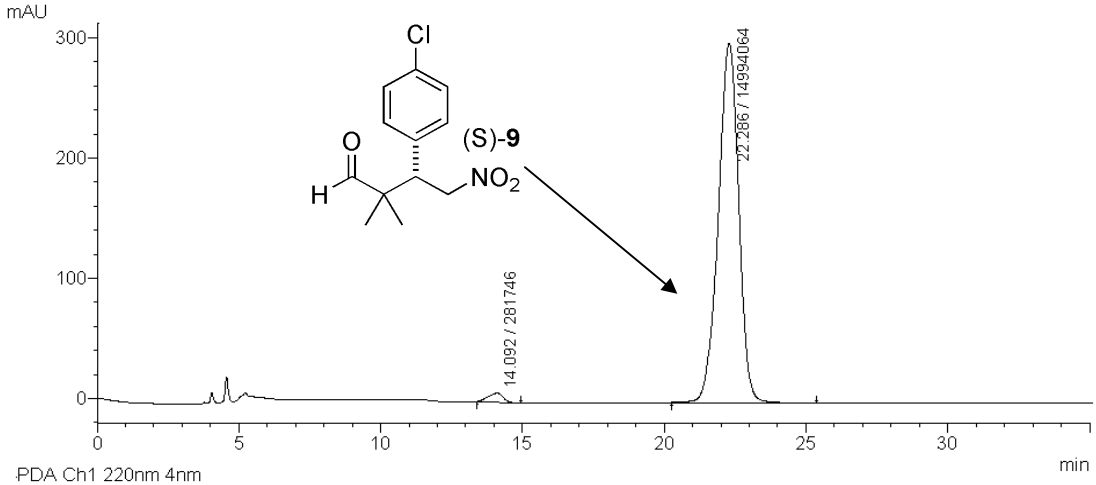
Racemic 3-(4-chlorophenyl)-2,2-dimethyl-4-nitrobutanal



PDA Ch1 220nm 4nm

Peak #	Ret. Time	Area	Height	Area %	Height %	Width at 10% Height	Mark
1	14.408	2164930	69382	51.585	63.01	0.914	
2	22.575	2031924	40718	48.415	36.983	1.447	
Total		4196854	110100	100.000	100.000		

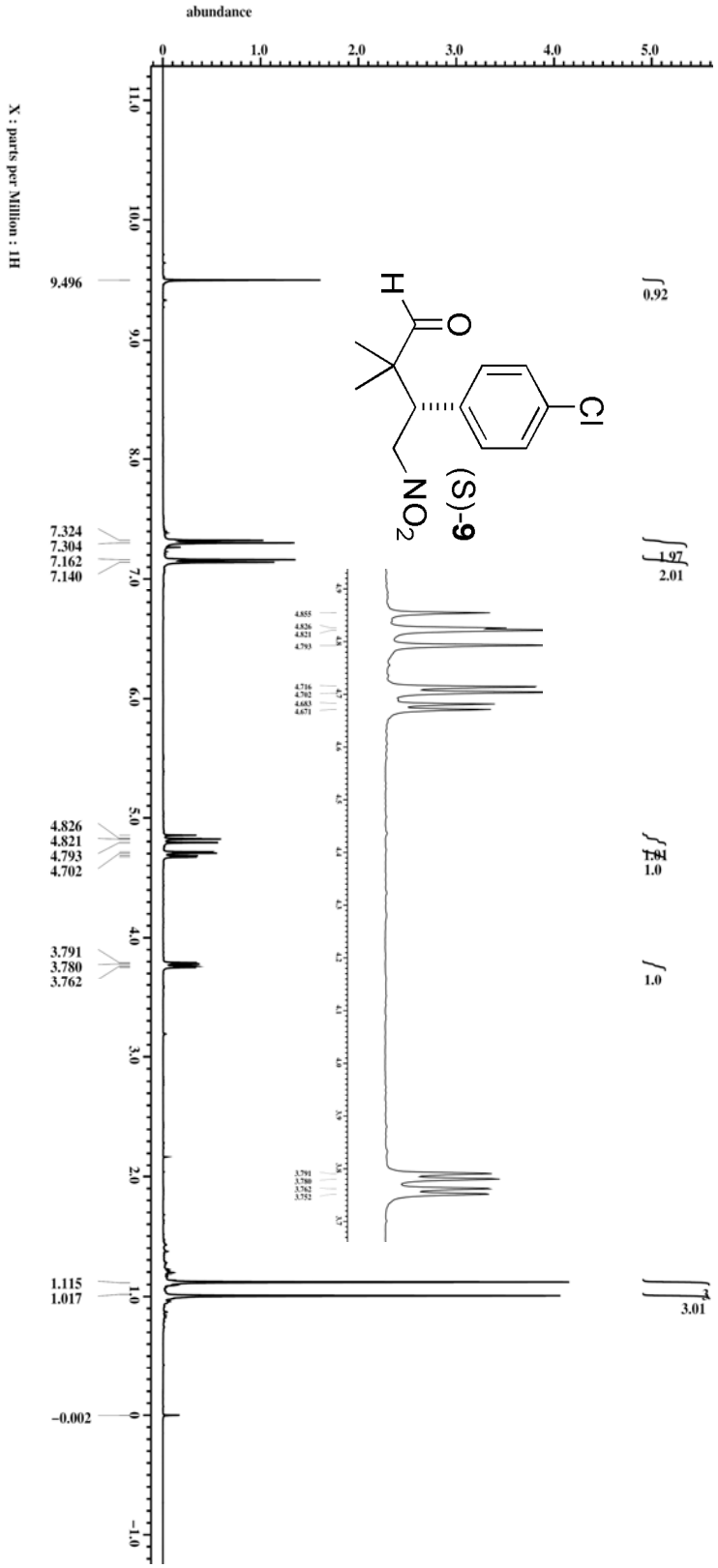
Enantioenriched 3-(4-chlorophenyl)-2,2-dimethyl-4-nitrobutanal



PDA Ch1 220nm 4nm

Peak #	Ret. Time	Area	Height	Area %	Height %	Width at 10% Height	Mark
1	14.092	281746	7618	1.844	2.487	1.038	
2	22.286	14994064	298639	98.156	97.513	1.454	
Total		15275810	306257	100.000	100.000		

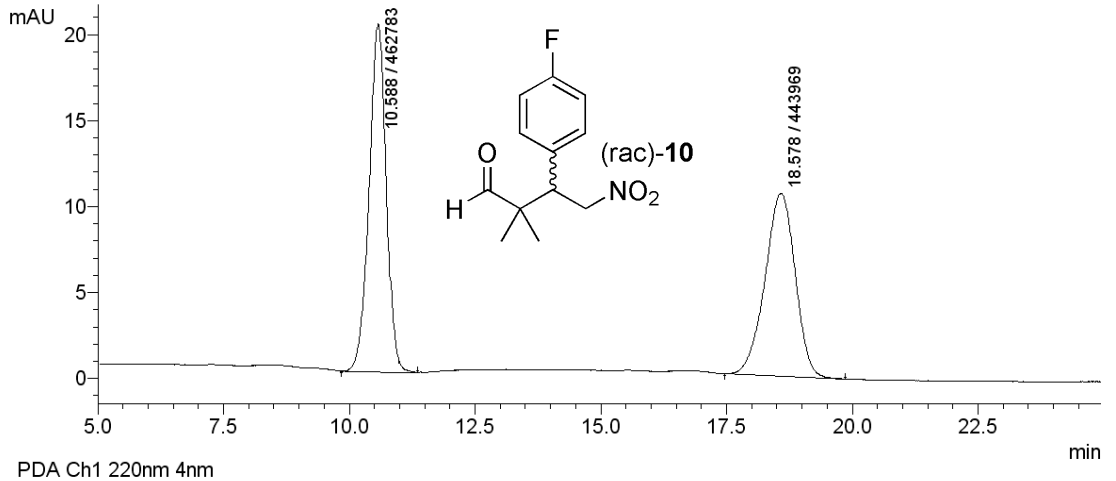
^{1}H NMR of (S)-3-(4-chlorophenyl)-2,2-dimethyl-4-nitrobutanal (9)



(S)-3-(4-fluorophenyl)-2,2-dimethyl-4-nitrobutanal (10):

The title compound was prepared from *trans*-4-fluoro-β-nitrostyrene and isobutyraldehyde using method B. Reaction time: 24 h; No column chromatography was required, ^{1}H NMR (see spectrum on p. S-16) and HPLC (chromatogram on p. S-15) of the crude product showed it to be of very high chemical purity; yield = 93%; ee = 98% as determined by HPLC (CHIRALCEL OD-H, *i*-PrOH/n-heptane 20/80, flow rate = 1.0 mL/min, λ = 220 nm); t_{minor}= 10.3 min, t_{major}= 17.5 min. The compound was tentatively assigned the S configuration according to the general trend of our Michael addition products. ^{1}H NMR (400 MHz, $CDCl_3$) (ppm): 1.00 (s, 3H), 1.12 (s, 3H), 3.78 (dd, 1H, *J* = 4.1, 11.4 Hz), 4.69 (dd, 1H, *J* = 4.1, 12.8 Hz), 4.82 (dd, 1H, *J* = 11.4, 12.8 Hz), 6.99-7.01 (m, 2H), 7.16-7.20 (m, 2H), 9.5 (s, 1H).

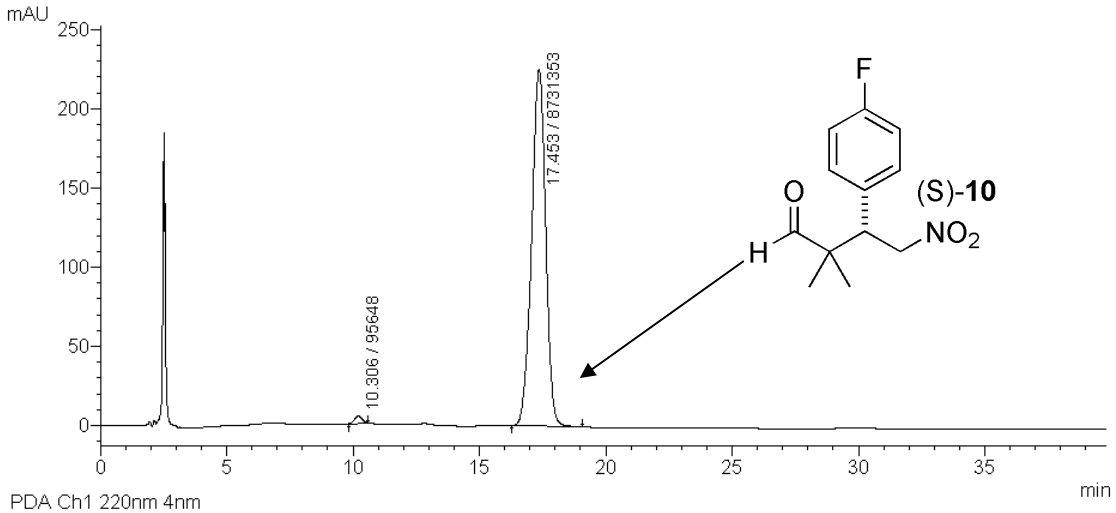
Racemic 3-(4-fluorophenyl)-2,2-dimethyl-4-nitrobutanal



PDA Ch1 220nm 4nm

Peak #	Ret. Time	Area	Height	Area %	Height %	Width at 10% Height	Mark
1	10.588	462783	20204	51.037	65.503	0.671	
2	18.578	443969	10641	48.963	34.497	1.213	
Total		906752	30845	100.000	100.000		

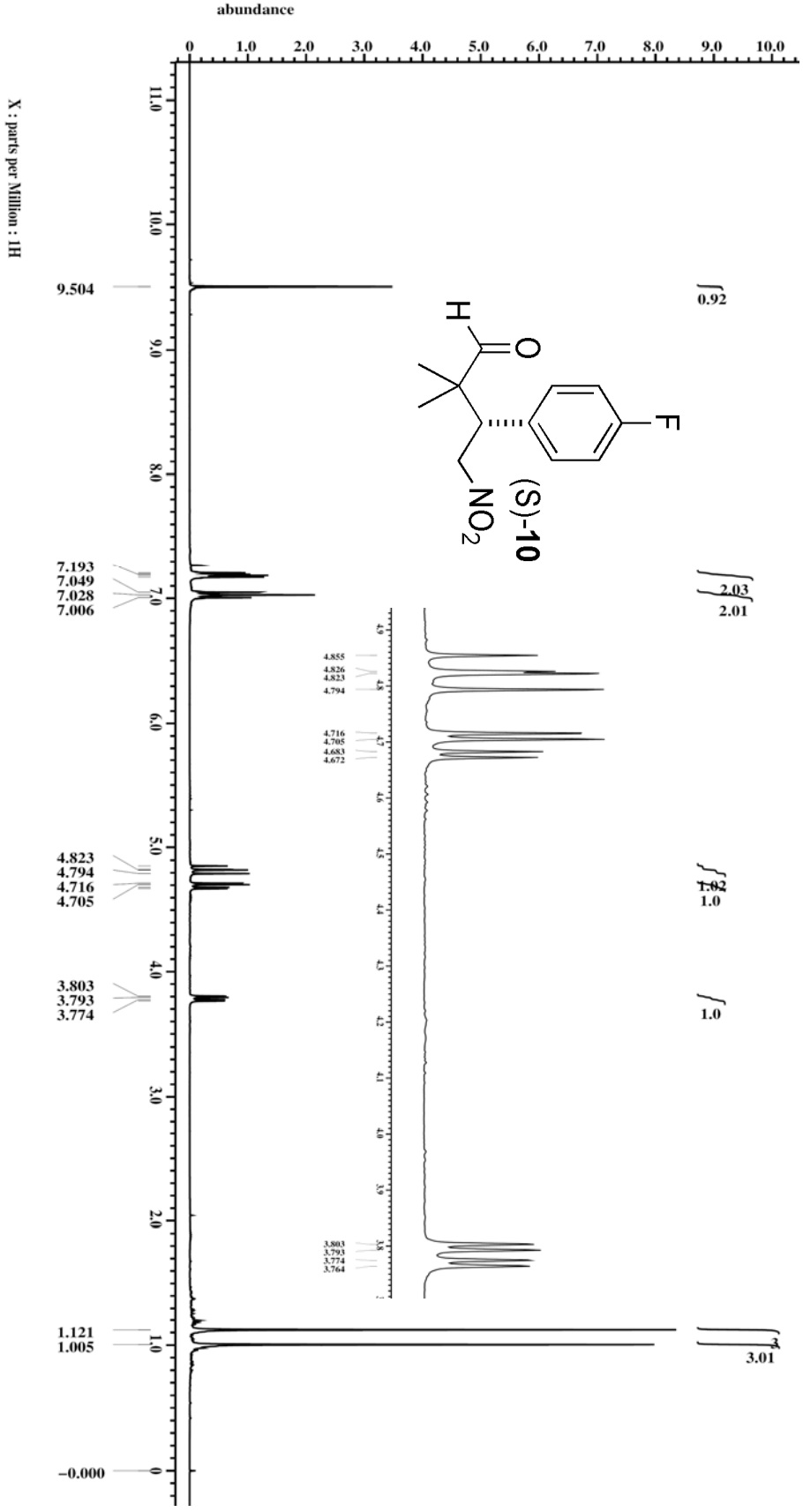
Enantioenriched 3-(4-fluorophenyl)-2,2-dimethyl-4-nitrobutanal



PDA Ch1 220nm 4nm

Peak #	Ret. Time	Area	Height	Area %	Height %	Width at 10% Height	Mark
1	10.306	95648	4685	1.084	2.036	0.602	
2	17.453	8731353	225368	98.916	97.964	1.127	
Total		8827001	230053	100.000	100.000		

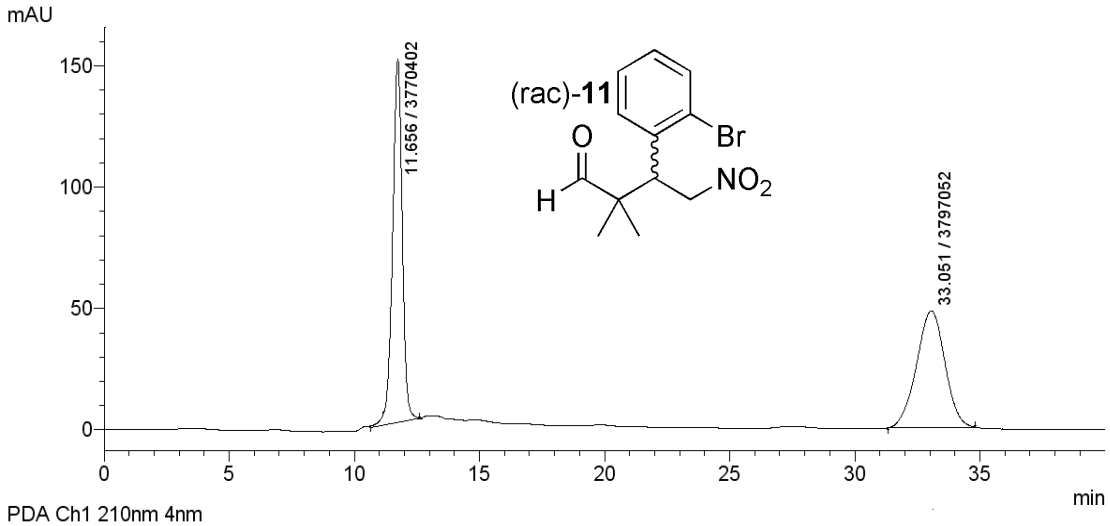
^{1}H NMR of (S)-3-(4-fluorophenyl)-2,2-dimethyl-4-nitrobutanal (10)



(R)-3-(2-bromophenyl)-2,2-dimethyl-4-nitrobutanal (11):

The title compound was prepared from *trans*-2-bromo-β-nitrostyrene and isobutyraldehyde using method B. Reaction time: 24 h; No column chromatography was required, ^{1}H NMR (see spectrum on p. S-18) and HPLC (chromatogram on p. S-17) of the crude product showed it to be of very high chemical purity; yield = 88%; ee = 96% as determined by HPLC (CHIRALCEL OD-H, *i*-PrOH/n-heptane 20/80, flow rate = 1.0 mL/min, λ = 200 nm); t_{minor}= 11.4 min, t_{major}= 30.7 min. ^{1}H NMR (400 MHz, $CDCl_3$) (ppm): 1.09 (s, 3H), 1.17 (s, 3H), 4.62 (dd, 1H, *J* = 4.1, 11.4 Hz), 4.71 (dd, 1H, *J* = 4.1, 13.3 Hz), 4.83 (dd, 1H, *J* = 11.4, 13.3 Hz), 7.13-7.17 (m, 1H), 7.26-7.34 (m, 2H), 7.61 (d, 1H, *J* = 7.3Hz) 9.56 (s, 1H).

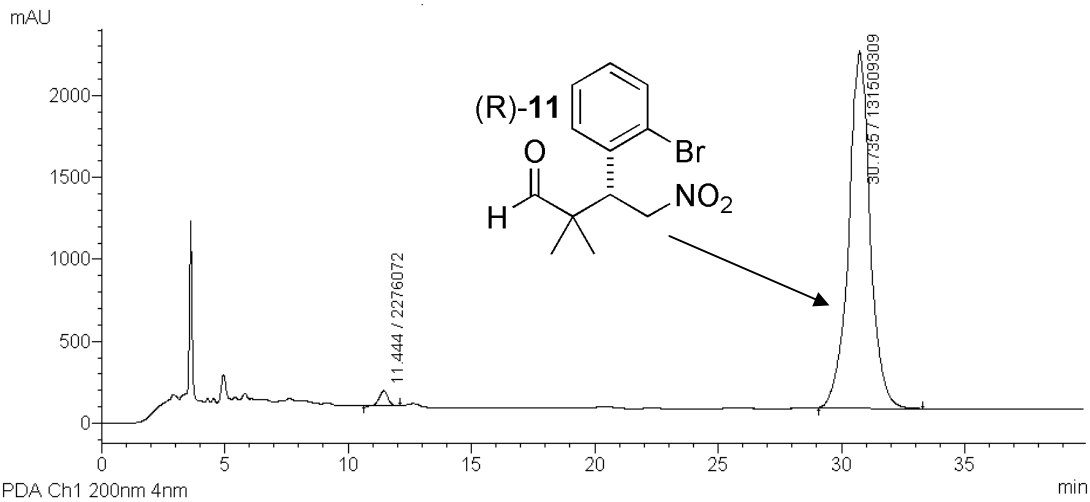
Racemic 3-(2-bromophenyl)-2,2-dimethyl-4-nitrobutanal



PDA Ch1 210nm 4nm

Peak #	Ret. Time	Area	Height	Area %	Height %	Width at 10% Height	Mark
1	11.656	3770402	146605	49.824	75.333	0.746	
2	33.051	3797052	48004	50.176	24.667	2.307	
Total		7567455	194609	100.000	100.000		

Enantioenriched 3-(2-bromophenyl)-2,2-dimethyl-4-nitrobutanal



PDA Ch1 200nm 4nm

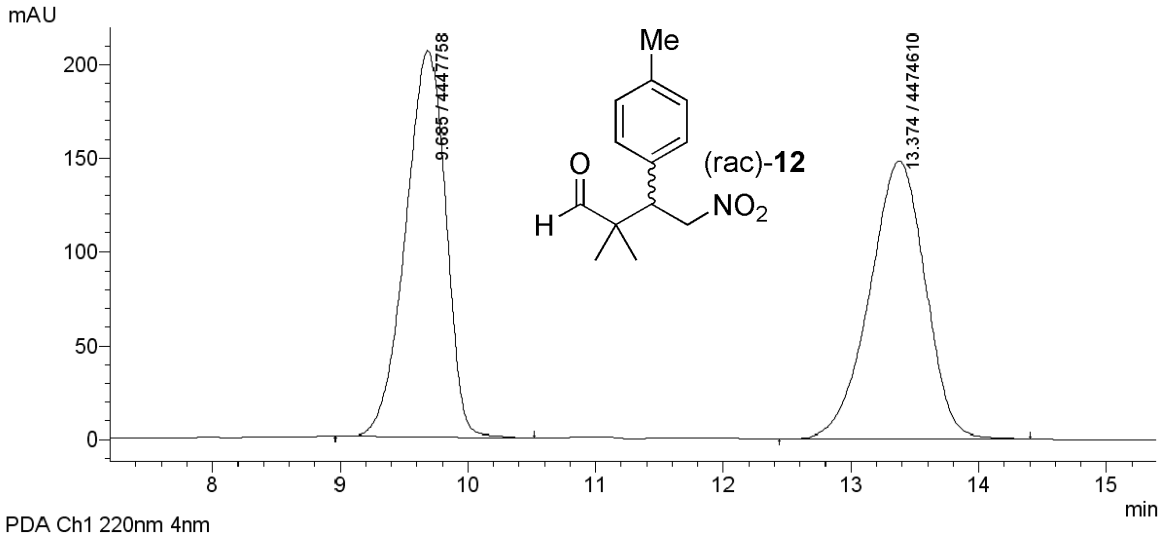
Peak #	Ret. Time	Area	Height	Area %	Height %	Width at 10% Height	Mark
1	11.444	2276072	93958	1.701	4.130	0.710	
2	30.735	131509309	2180908	98.299	95.870	1.900	
Total		133785381	2274866	100.000	100.000		

^{1}H NMR of (R)-3-(2-bromophenyl)-2,2-dimethyl-4-nitrobutanal (11)

(S)-2,2-dimethyl-4-nitro-3-p-tolylbutanal (12):

The title compound was prepared from *trans*-4-methyl-β-nitrostyrene and isobutyraldehyde using method B. Reaction time: 24 h; flash column chromatography: (EtOAc/Pet ether = 7:93); yield = 85%; ee = 99% as /min, λ = 220 nm); determined by HPLC (CHIRALCEL OD-H, *i*-PrOH/n-heptane 20/80, flow rate = 1.0 mLt_{minor}= 10.2 min, t_{major}= 13.9 min. ^{1}H NMR (400 MHz, $CDCl_3$) (ppm): 0.98 (s, 3H), 1.12 (s, 3H), 2.31 (s, 3H), 3.74 (dd, 1H, *J* = 4.1, 11.4 Hz), 4.66 (dd, 1H, *J* = 4.1, 12.8 Hz), 4.82 (dd, 1H, *J* = 11.4, 12.8 Hz), 7.07 (d, 2H, *J* = 8.2 Hz), 7.12 (d, 2H, *J* = 8.2 Hz), 9.51 (s, 1H).

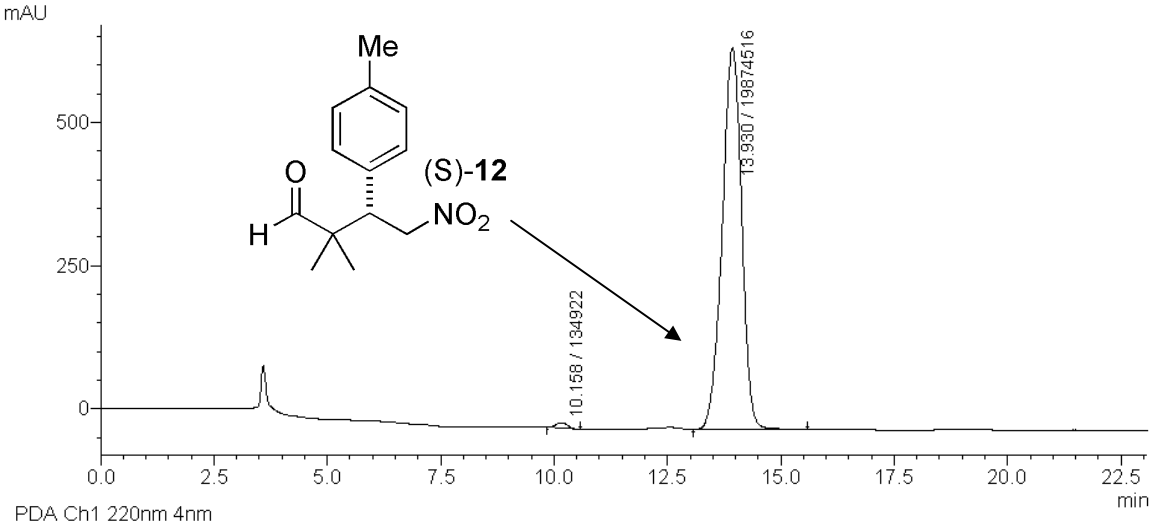
Racemic 2,2-dimethyl-4-nitro-3-p-tolylbutanal



PDA Ch1 220nm 4nm

Peak #	Ret. Time	Area	Height	Area %	Height %	Width at 10% Height	Mark
1	9.685	4447758	206001	49.850	58.167	0.612	
2	13.374	4474610	148151	50.150	41.833	0.870	
Total		8922368	354152	100.000	100.000		

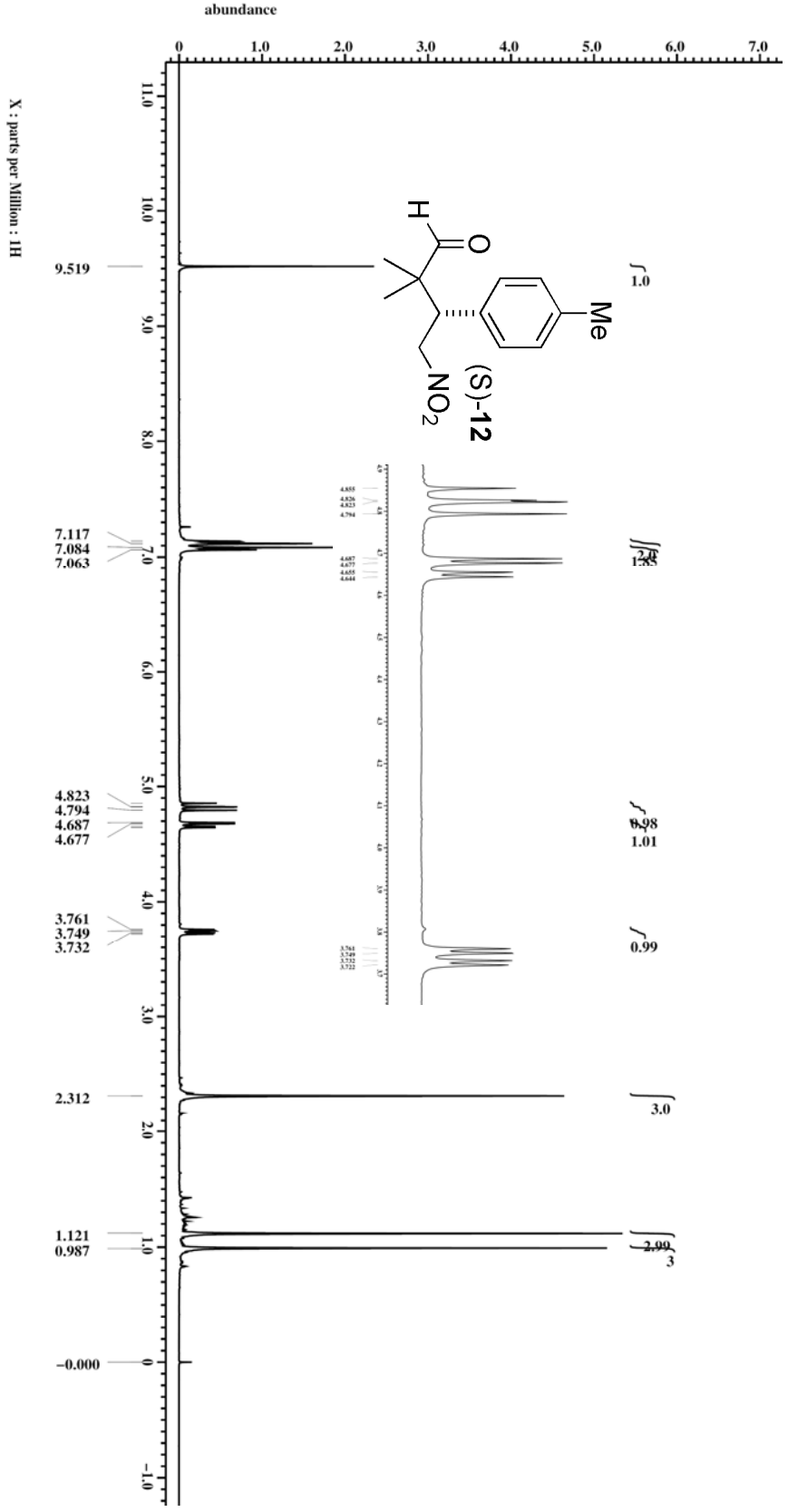
Enantioenriched 2,2-dimethyl-4-nitro-3-p-tolylbutanal



PDA Ch1 220nm 4nm

Peak #	Ret. Time	Area	Height	Area %	Height %	Width at 10% Height	Mark
1	10.158	134922	8658	0.674	1.284	0.434	
2	13.930	19874516	665829	99.326	98.716	0.858	
Total		20009438	674487	100.000	100.000		

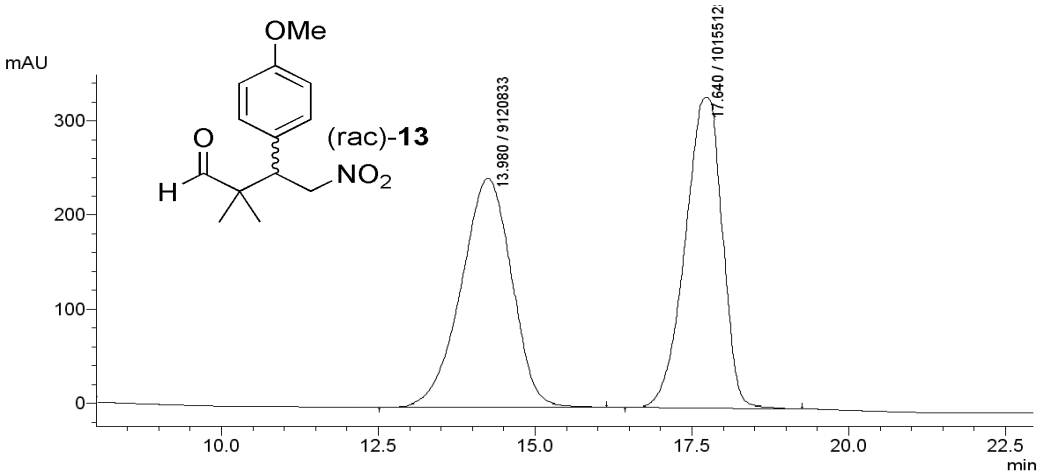
^{1}H NMR of (S)- 2,2-dimethyl-4-nitro-3-p-tolylbutanal (12)



(S)-3-(4-methoxyphenyl)-2,2-dimethyl-4-nitrobutanal (13):

The title compound was prepared from *trans*-2-methoxy-β-nitrostyrene and isobutyraldehyde using method B. Reaction time: 24 h; flash column chromatography: (EtOAc/Pet ether = 7:93); yield = 90%; ee = 98% as determined by HPLC (CHIRALCEL OD-H, *i*-PrOH/n-heptane 10/90, flow rate = 1.0 mL/min, λ = 220 nm); t_{minor}= 11.9 min, t_{major}= 17.3 min. ^{1}H NMR (400 MHz, $CDCl_3$) (ppm): 0.99 (s, 3H), 1.11 (s, 3H), 3.72 (dd, 1H, *J* = 4.1, 11.5 Hz), 3.78 (s, 3H), 4.66 (dd, 1H, *J* = 4.1, 12.8 Hz), 4.80 (dd, 1H, *J* = 11.5, 12.8 Hz), 6.85 (d, 2H, *J* = 8.7 Hz), 7.11 (d, 2H, *J* = 8.7 Hz), 9.51 (s, 1H).

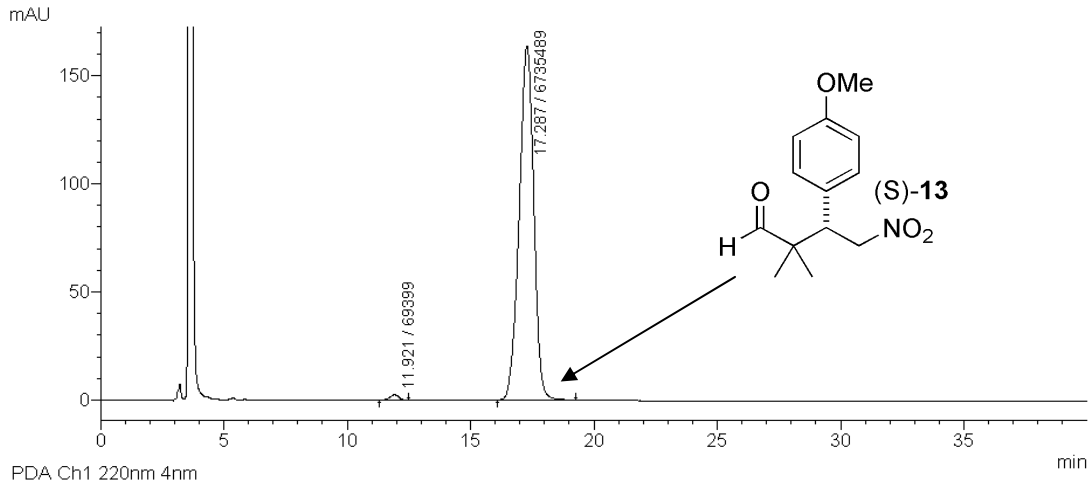
Racemic 3-(4-methoxyphenyl)-2,2-dimethyl-4-nitrobutanal



PDA Ch1 220nm 4nm

Peak #	Ret. Time	Area	Height	Area %	Height %	Width at 10% Height	Mark
1	13.980	9120833	195940	47.317	44.914	1.359	
2	17.640	10155128	240320	52.683	55.086	1.229	
Total		19275961	436261	100.000	100.000		

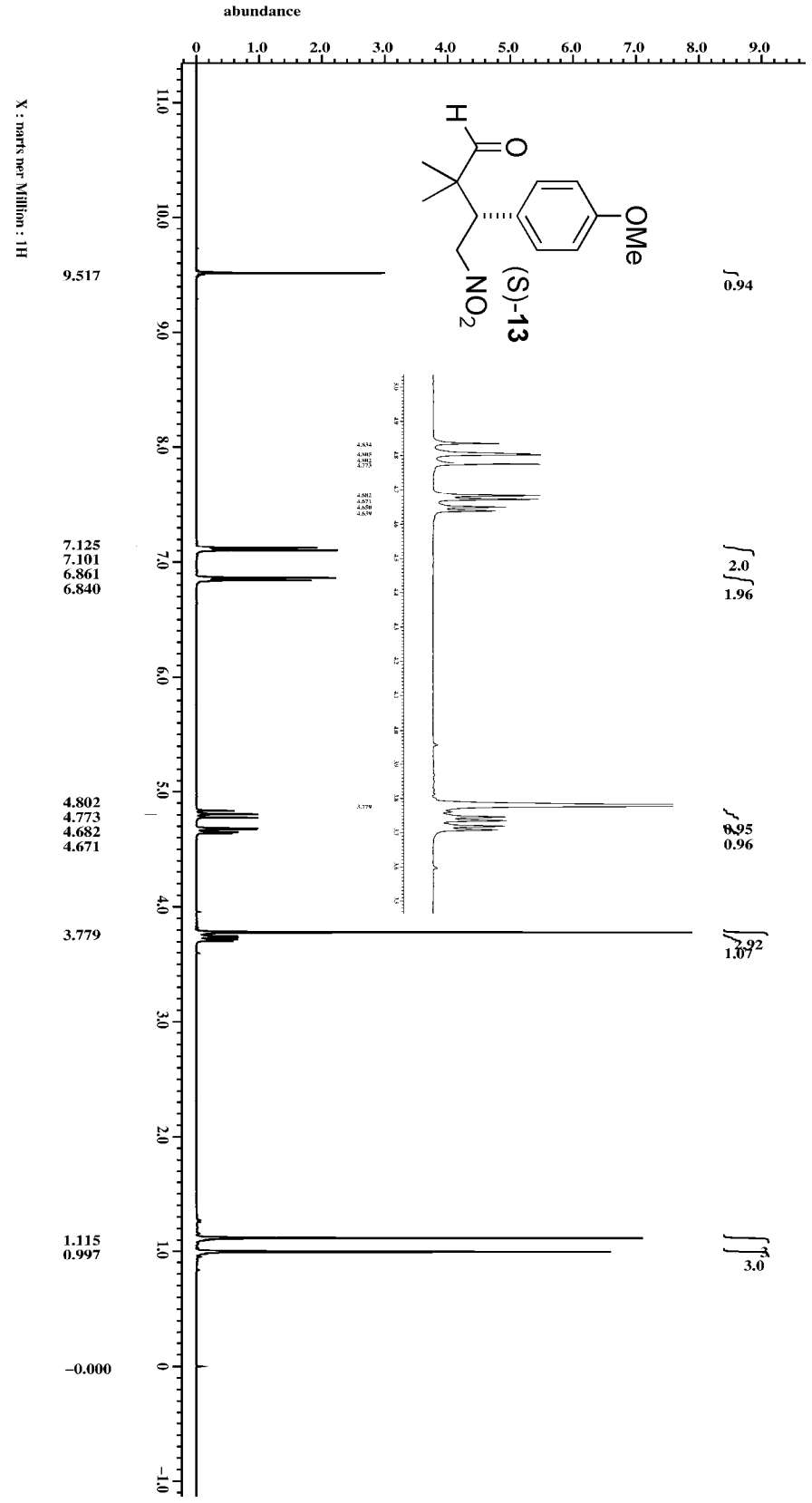
Enantioenriched 3-(4-methoxyphenyl)-2,2-dimethyl-4-nitrobutanal



PDA Ch1 220nm 4nm

Peak #	Ret. Time	Area	Height	Area %	Height %	Width at 10% Height	Mark
1	11.921	69399	2595	1.020	1.561	0.776	
2	17.287	6735489	163659	98.980	98.439	1.195	
Total		6804888	166254	100.000	100.000		

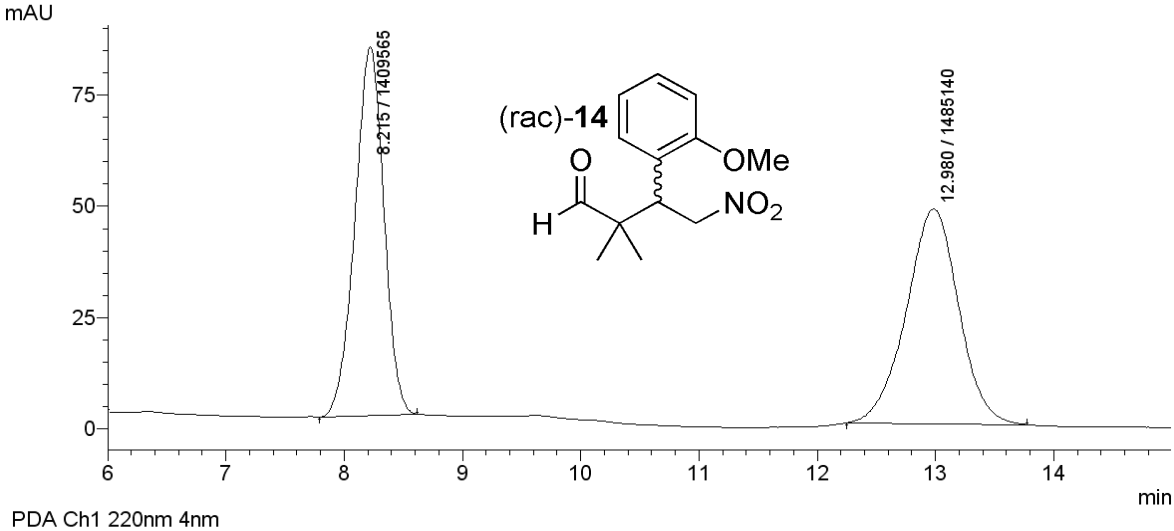
^{1}H NMR of (S)-3-(4-methoxyphenyl)-2,2-dimethyl-4-nitrobutanal (13)



(S)-3-(2-methoxyphenyl)-2,2-dimethyl-4-nitrobutanal (14):

The title compound was prepared from *trans*-2-methoxy-β-nitrostyrene and isobutyraldehyde accoding to general procedure B. Reaction time: 36 h; flash column chromatography: (EtOAc/Pet ether = 7:93); yield = 72% ; ee = 96% as determined by HPLC (CHIRALCEL OD-H, *i*-PrOH/n-heptane 20/80, flow rate = 1.0 mL/min, λ = 220 nm); t_{minor}= 8.2 min, t_{major}= 12.9 min. ^{1}H NMR (400 MHz, $CDCl_3$) (ppm): 1.05 (s, 3H), 1.10 (s, 3H), 3.82 (s, 3H), 4.10-4.27 (m, 1H), 4.73 (dd, 1H, *J* = 4.6, 12.8 Hz), 4.90 (dd, 1H, *J* = 11.0, 12.8 Hz), 6.89 (d, 1H, *J* = 7.7 Hz), 6.93 (t, 1H, *J* = 7.5 Hz), 7.13 (dd, 1H, *J* = 1.4, 7.7 Hz), 7.24-7.28 (m, 1H), 9.50 (s, 1H).

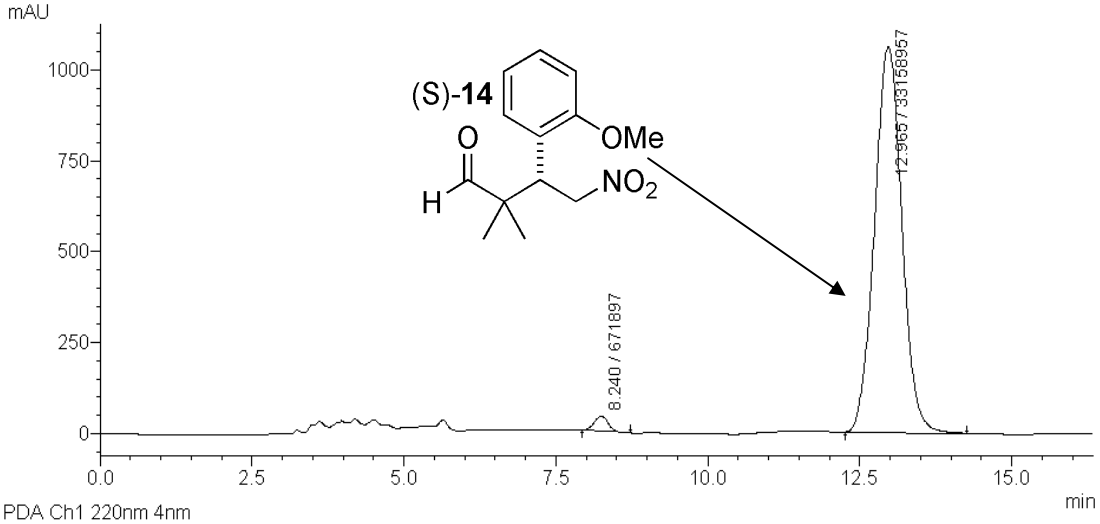
Racemic 3-(2-methoxyphenyl)-2,2-dimethyl-4-nitrobutanal



PDA Ch1 220nm 4nm

Peak #	Ret. Time	Area	Height	Area %	Height %	Width at 10% Height	Mark
1	8.215	1409565	82738	48.695	63.172	0.499	
2	12.980	1485140	48234	51.305	36.828	0.914	
Total		2894705	130972	100.000	100.000		

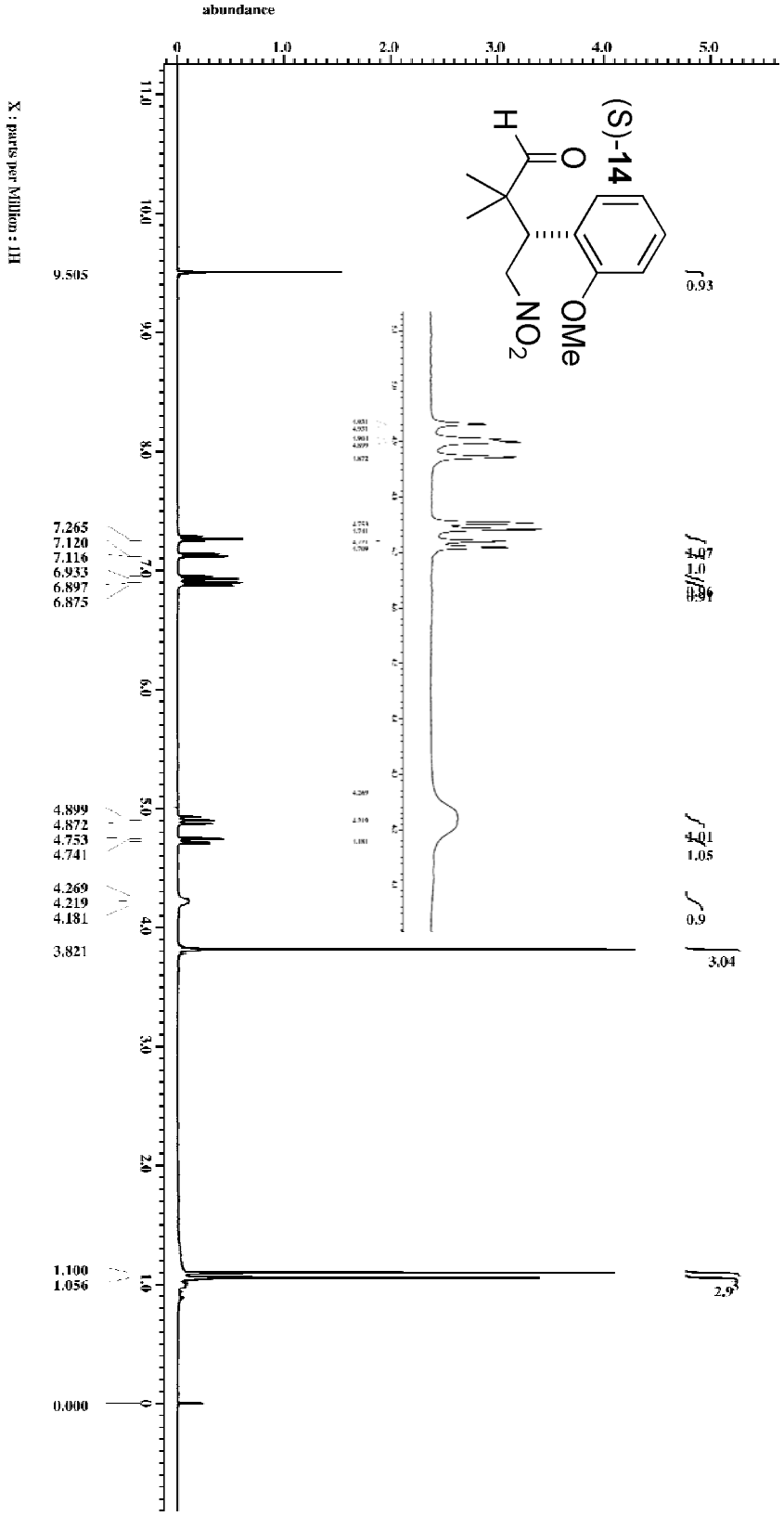
Enantioenriched 3-(2-methoxyphenyl)-2,2-dimethyl-4-nitrobutanal



PDA Ch1 220nm 4nm

Peak #	Ret. Time	Area	Height	Area %	Height %	Width at 10% Height	Mark
1	8.240	671897	42117	1.986	3.818	0.458	
2	12.965	33158957	1060869	98.014	96.182	0.906	
Total		33830854	1102986	100.000	100.000		

^{1}H NMR of (S)-3-(2-methoxyphenyl)-2,2-dimethyl-4-nitrobutanal (14)

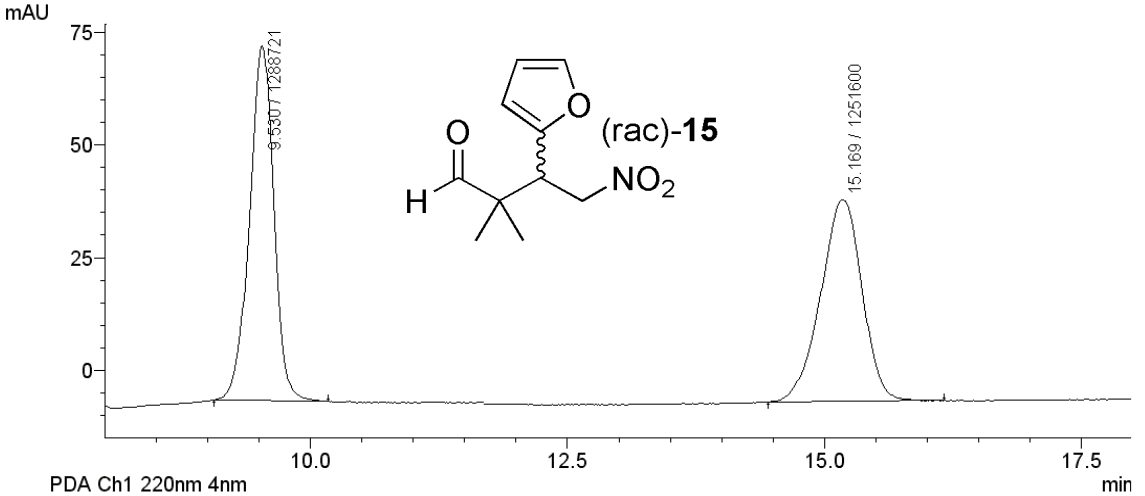


(S)-3-(furan)-2-yl)-2,2-dimethyl-4-nitrobutanal (15):

The title compound was prepared from 2-(2-nitrovinyl)furan and isobutyraldehyde using method B. Reaction time: 10 h; No column chromatography was required, ^{1}H NMR (see spectrum on p. S-26) and HPLC (chromatogram on p. S-25) of the crude product showed it to be of very high chemical purity; yield = 98%; ee = 98% as determined by HPLC (CHIRALCEL OD-H, *i*-PrOH/n-heptane 25/75, flow rate = 0.8 mL/min, λ = 220 nm); t_{minor}= 9.4 min, t_{major}= 14.2 min.

^{1}H NMR (400 MHz, $CDCl_3$) (ppm): 1.05 (s, 3H), 1.18 (s, 3H), 3.91 (dd, 1H, *J* = 3.7, 11.0 Hz), 4.58 (dd, 1H, *J* = 3.7, 12.8 Hz), 4.75 (dd, 1H, *J* = 11.0, 12.8 Hz), 6.22 (d, 1H, *J* = 3.2), 6.31 (dd, 1H, *J* = 1.8, 3.2 Hz), 7.36 (d, 1H, *J* = 1.8 Hz), 9.52 (s, 1H).

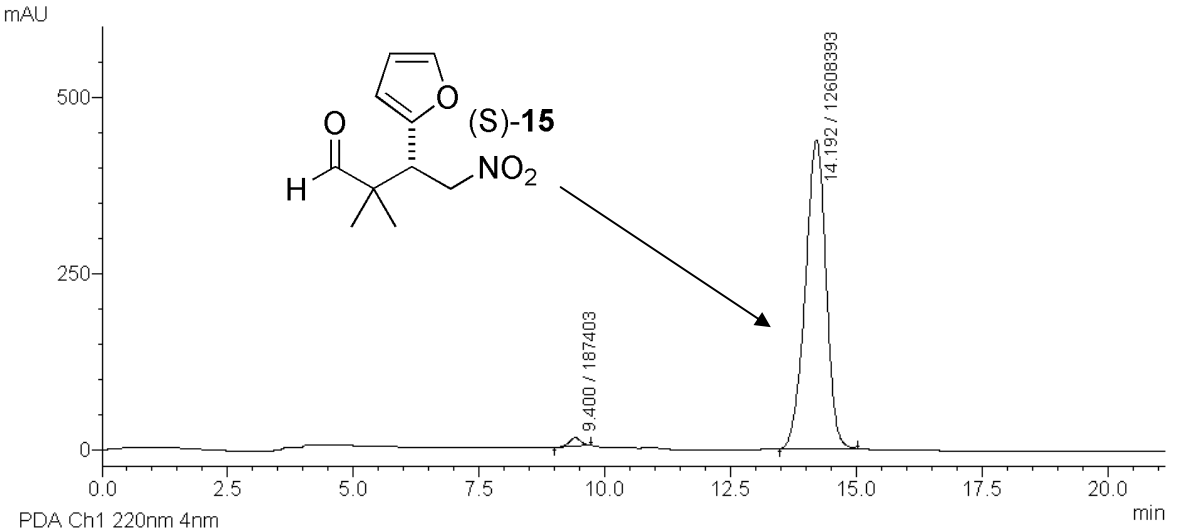
Racemic 3-(furan)-2-yl)-2,2-dimethyl-4-nitrobutanal



PDA Ch1 220nm 4nm

Peak #	Ret. Time	Area	Height	Area %	Height %	Width at 10% Height	Mark
1	9.530	1288721	78615	50.731	63.722	0.482	
2	15.169	1251600	44757	49.269	36.278	0.813	
Total		2540322	123372	100.000	100.000		

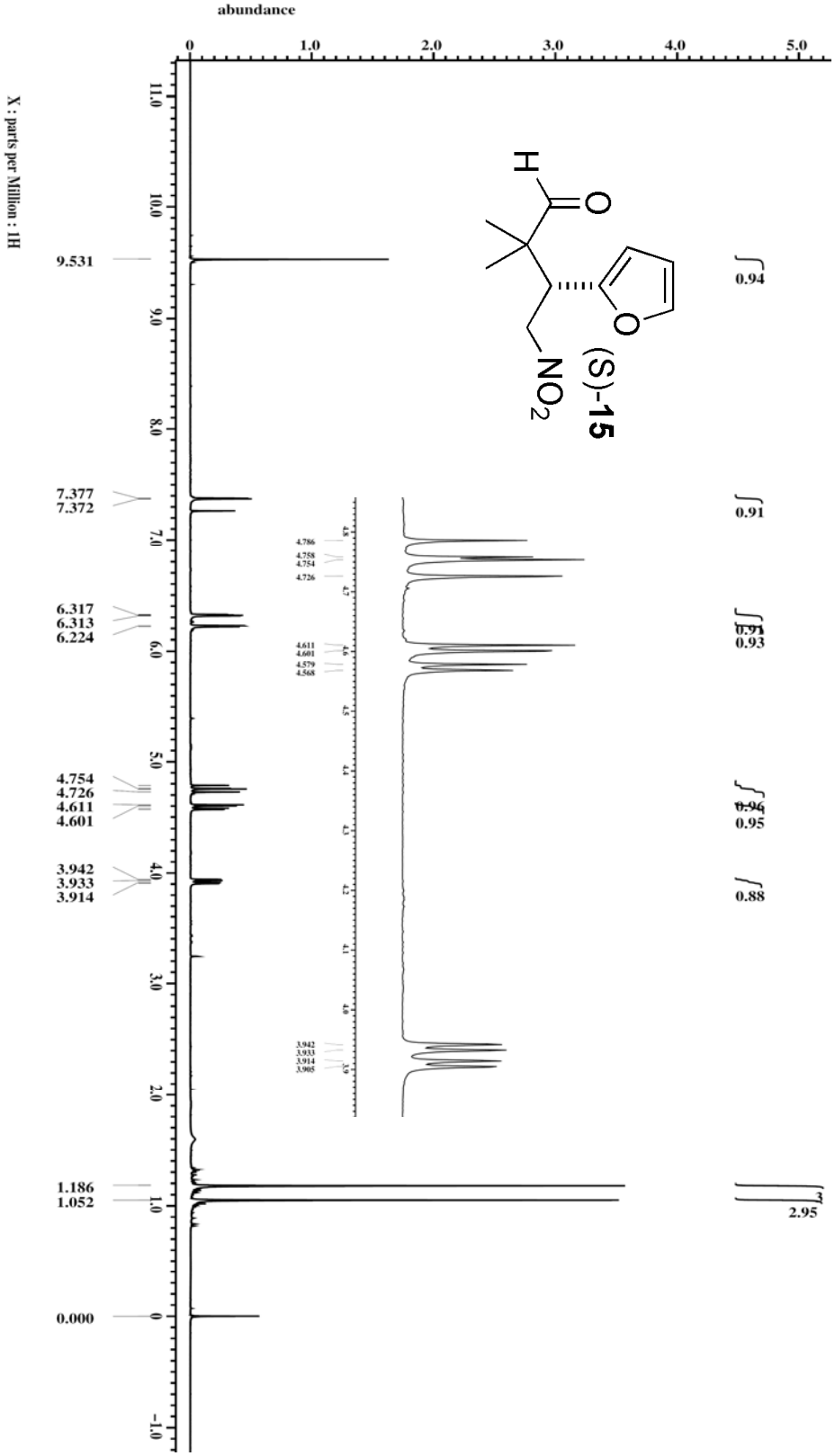
Enantioenriched 3-(furan)-2-yl)-2,2-dimethyl-4-nitrobutanal



PDA Ch1 220nm 4nm

Peak #	Ret. Time	Area	Height	Area %	Height %	Width at 10% Height	Mark
1	9.400	187403	11880	1.465	2.636	0.466	
2	14.192	12608393	438854	98.535	97.364	0.840	
Total		12795796	450734	100.000	100.000		

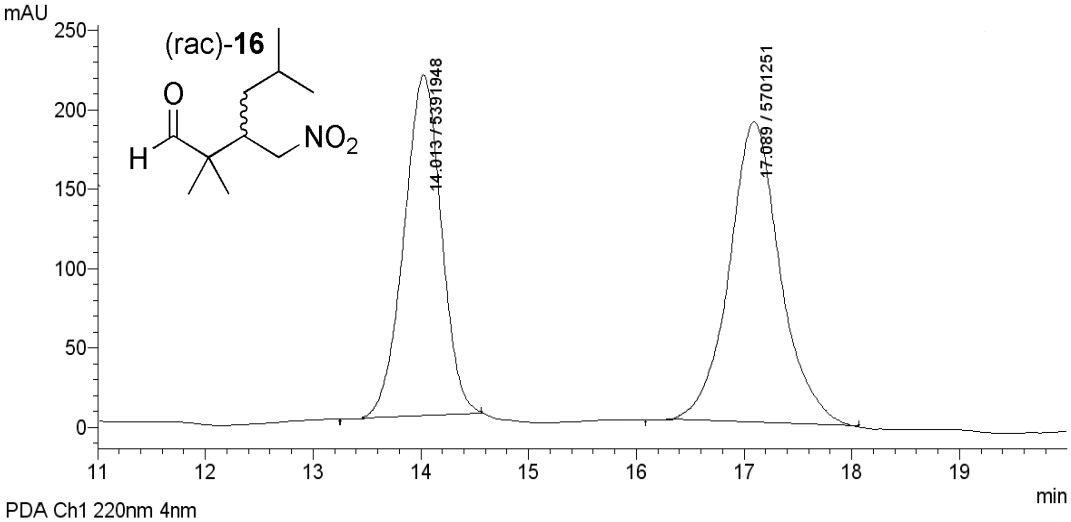
^{1}H NMR of (S)-3-(furan)-2-yl)-2,2-dimethyl-4-nitrobutanal (15)



(2S)-2,2,5-trimethyl-3-nitromethyl-hexanal (16):

The title compound was prepared from 2-isobutyl-1-nitroethene and isobutyraldehyde using method B. Reaction time: 36 h; flash column chromatography: (EtOAc/Pet ether = 7:93); yield = 70%; ee = 96% as determined by HPLC (CHIRALCEL OD-H, *i*-PrOH/n-heptane 10/90, flow rate = 0.4 mL/min, λ = 220 nm); t_{minor}= 13.9 min, t_{major}= 16.9 min. ^{1}H NMR (400 MHz, $CDCl_3$) (ppm): 0.90 (d, 3H, *J* = 5.8 Hz), 0.91 (d, 3H, *J* = 5.8 Hz), 1.06 (s, 3H), 1.07 (s, 3H), 1.09-1.16 (m, 1H), 1.21-1.30 (m, 1H), 2.62-2.68 (m, 1H), 4.23 (dd, 1H, *J* = 5.4, 13.0 Hz), 4.44 (dd, 1H, *J* = 5.4, 13.0 Hz), 9.43 (s, 1H).

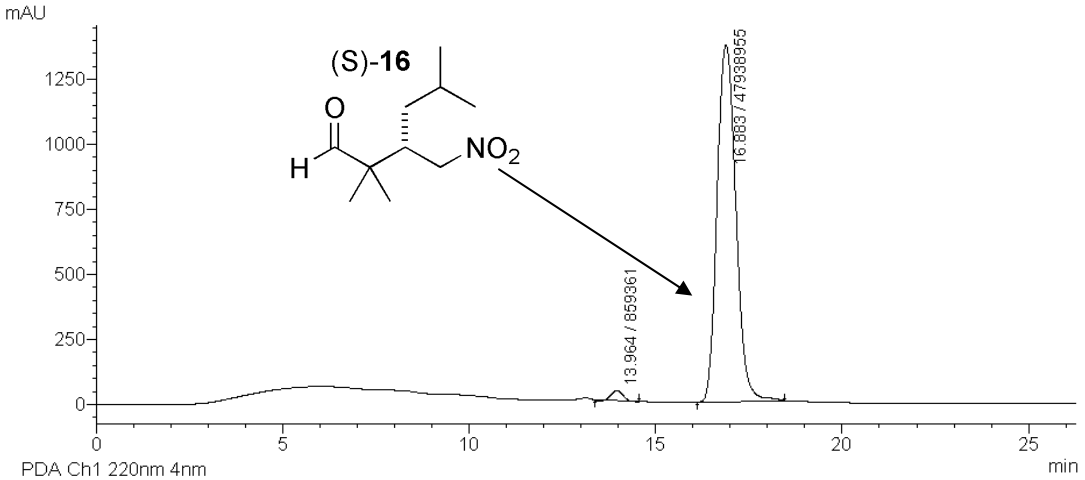
Racemic 2,2,5-trimethyl-3-nitromethyl-hexanal



PDA Ch1 220nm 4nm

Peak #	Ret. Time	Area	Height	Area %	Height %	Width at 10% Height	Mark
1	14.013	5391948	215623	48.606	54.035	0.000	
2	17.089	5701251	183417	51.394	45.965	0.950	
Total		11093199	399040	100.000	100.000		

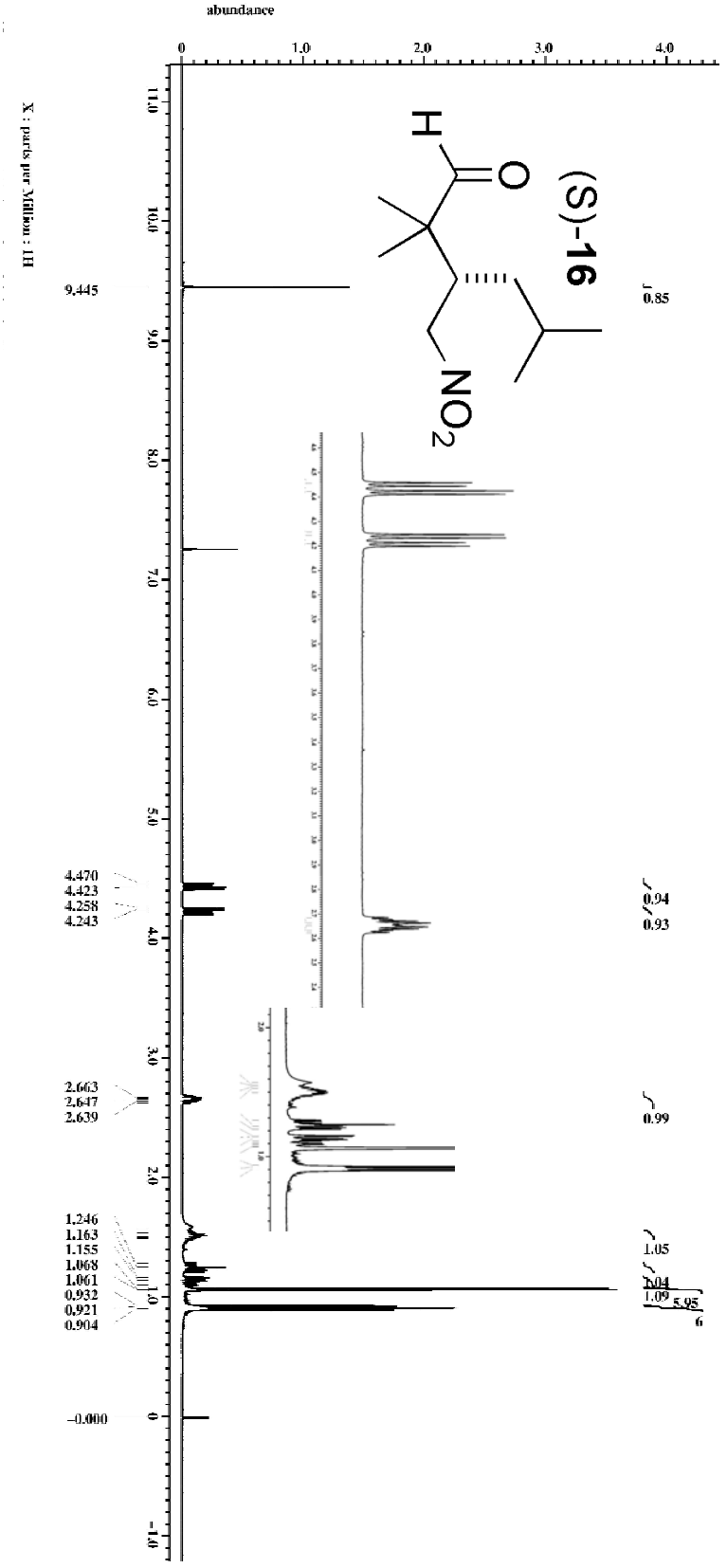
Enantioenriched 2,2,5-trimethyl-3-nitromethyl-hexanal



PDA Ch1 220nm 4nm

Peak #	Ret. Time	Area	Height	Area %	Height %	Width at 10% Height	Mark
1	13.964	859361	40614	1.761	2.876	0.613	
2	16.883	47938955	1371442	98.239	97.124	0.969	
Total		48798316	1412056	100.000	100.000		

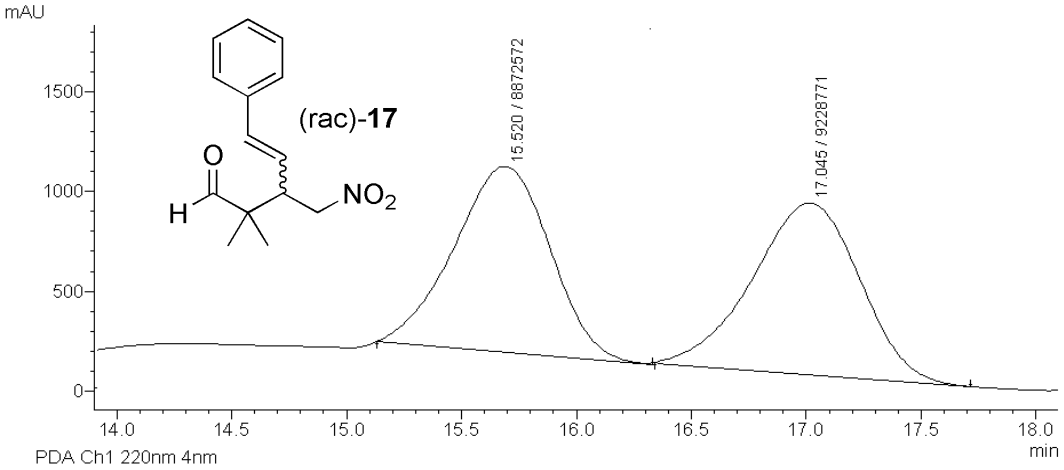
^{1}H NMR of (2S)-2,2,5-trimethyl-3-nitromethyl-hexanal (16)



(S)-E-2,2-dimethyl-3-(nitromethyl)-5-phenylpent-4-enal (17):

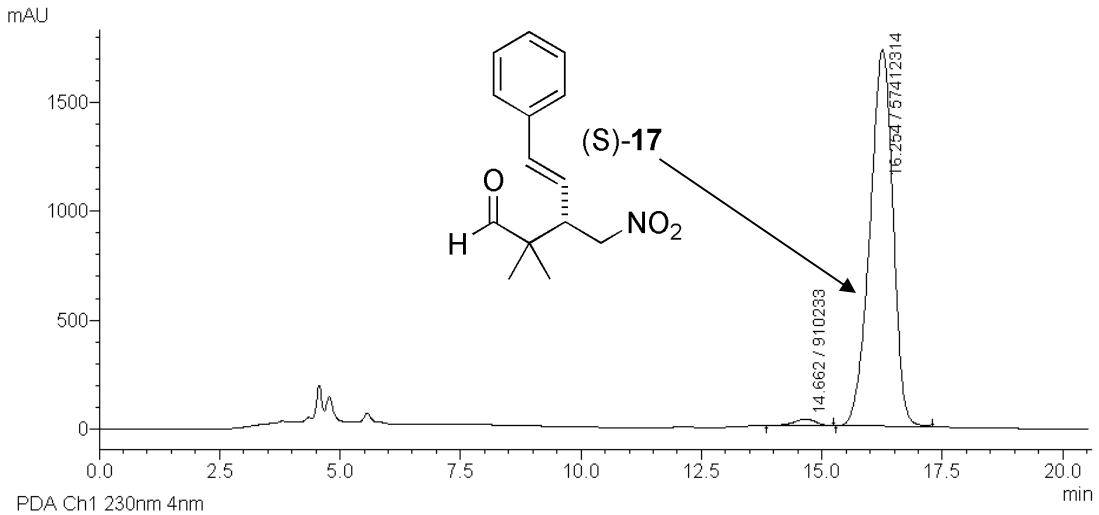
The title compound was prepared from (1E,2E)-4-nitrobuta-1,3-dienylbenzene and isobutyraldehyde using method B. Reaction time: 6 h; No column chromatography was required, ^{1}H NMR (see spectrum on p. S-30) and HPLC (chromatogram on p. S-29) of the crude product showed it to be of very high chemical purity; yield = 98%; ee = 97% as determined by HPLC (CHIRALCEL OD-H, *i*-PrOH/n-heptane 20/80, flow rate = 0.8 mL/min, λ = 220 nm); t_{minor}= 14.7 min, t_{major}= 16.3 min. ^{1}H NMR (400 MHz, $CDCl_3$) (ppm): 1.16 (s, 3H), 1.17 (s, 3H), 3.28 (dt, 1H, *J* = 4.1, 10.5 Hz), 4.45-4.48 (m, 1H), 4.51 (dd, 1H, *J* = 4.1, 12 Hz), 6.01 (dd, 1H, *J* = 10.1, 15.8 Hz), 6.53 (d, 1H, *J* = 15.8 Hz), 7.21-7.35 (m, 5H), 9.51 (s, 1H).

Racemic E-2,2-dimethyl-3-(nitromethyl)-5-phenylpent-4-enal



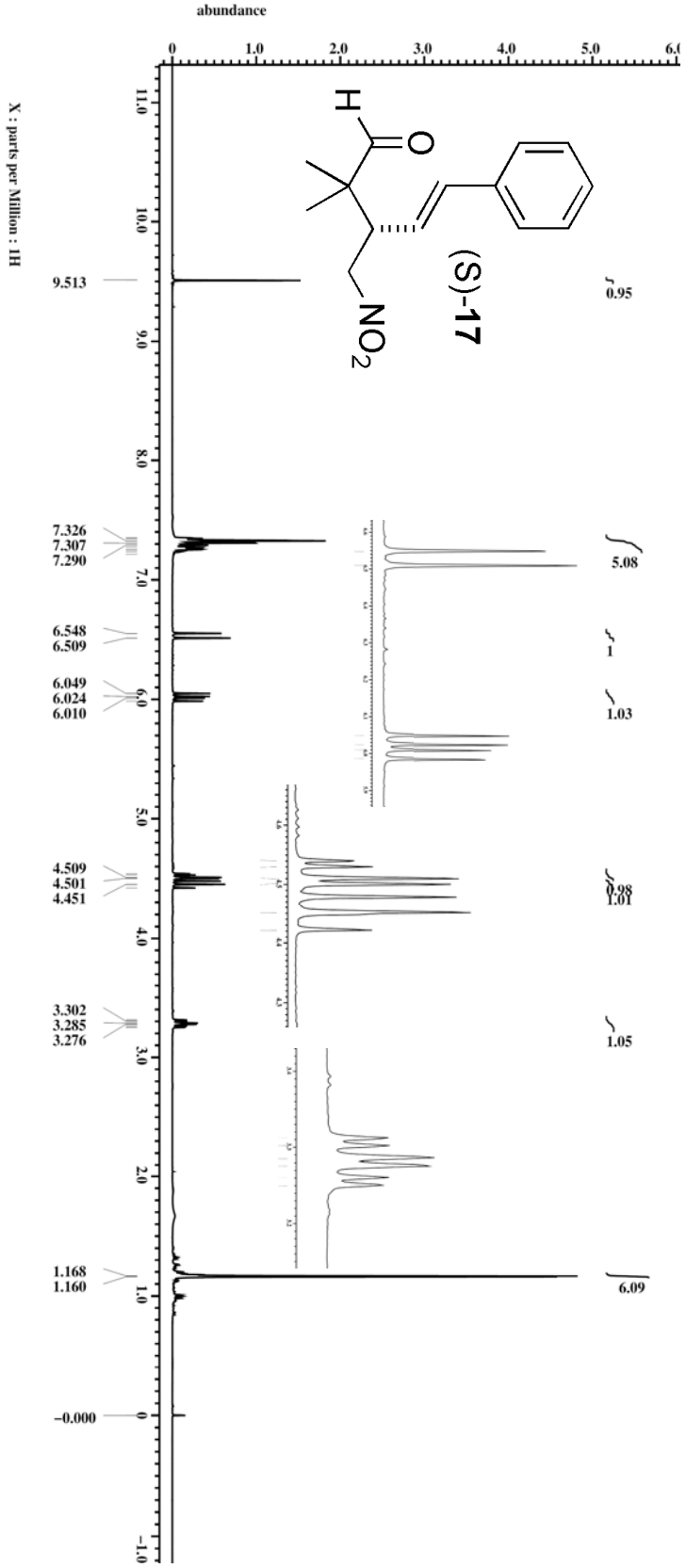
Peak #	Ret. Time	Area	Height	Area %	Height %	Width at 10% Height	Mark
1	15.520	8872572	322497	49.016	51.918	0.792	
2	17.045	9228771	298675	50.984	48.082	0.897	
Total		18101343	621171	100.000	100.000		

Enantioenriched E-2,2-dimethyl-3-(nitromethyl)-5-phenylpent-4-enal



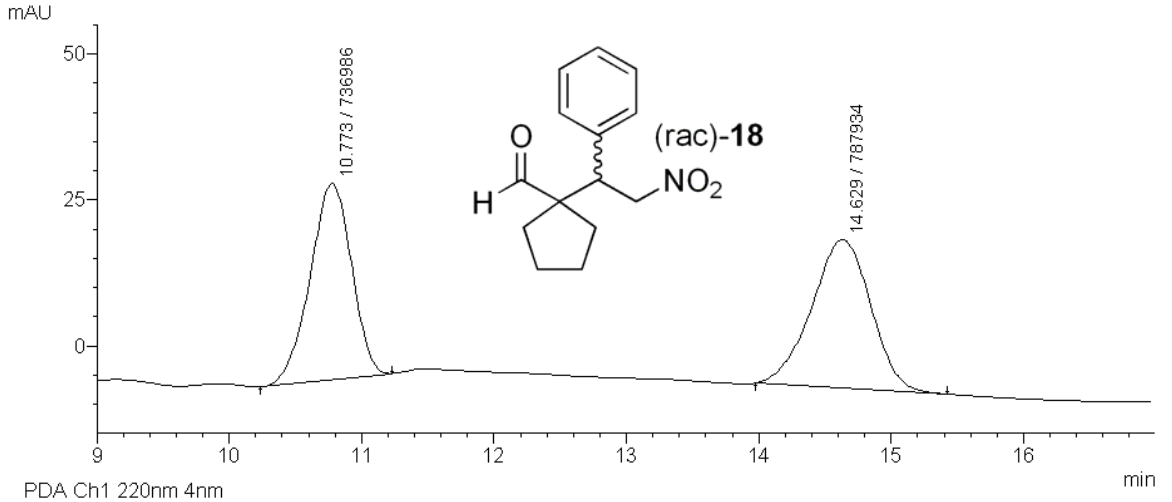
Peak #	Ret. Time	Area	Height	Area %	Height %	Width at 10% Height	Mark
1	14.662	910233	30161	1.561	1.714	0.882	
2	16.254	57412314	1729030	98.439	98.286	0.963	
Total		58322546	1759191	100.000	100.000		

^{1}H NMR of (S)-E-2,2-dimethyl-3-(nitromethyl)-5-phenylpent-4-enal (17)



(S)-1-(2-nitro-1-phenyl-ethyl)-cyclopentanecarbaldehyde (18):
The title compound was prepared from *trans*-β-nitrostyrene and cyclopentanecarbaldehyde using method C. Reaction time: 7 h; purified by flash column chromatography; yield = 89%; ee = 97% as determined by HPLC (CHIRALCEL OD-H, *i*-PrOH/n-heptane 20/80, flow rate = 1.0 mL/min, λ = 220 nm); t_{minor}= 10.6 min, t_{major}= 14.6 min. ^{1}H NMR (400 MHz, $CDCl_3$) (ppm): 1.51-1.67 (m, 6H), 1.86-1.92 (m, 1H), 2.02-2.07 (m, 1H), 3.69 (dd, 1H, *J* = 3.7, 11.5 Hz), 4.7 (dd, 1H, *J* = 3.7, 13.3 Hz), 4.96 (dd, 1H, *J* = 11.5, 13.3 Hz), 7.18-7.20 (m, 2H), 7.26-7.33 (m, 3H), 9.49 (s, 1H).

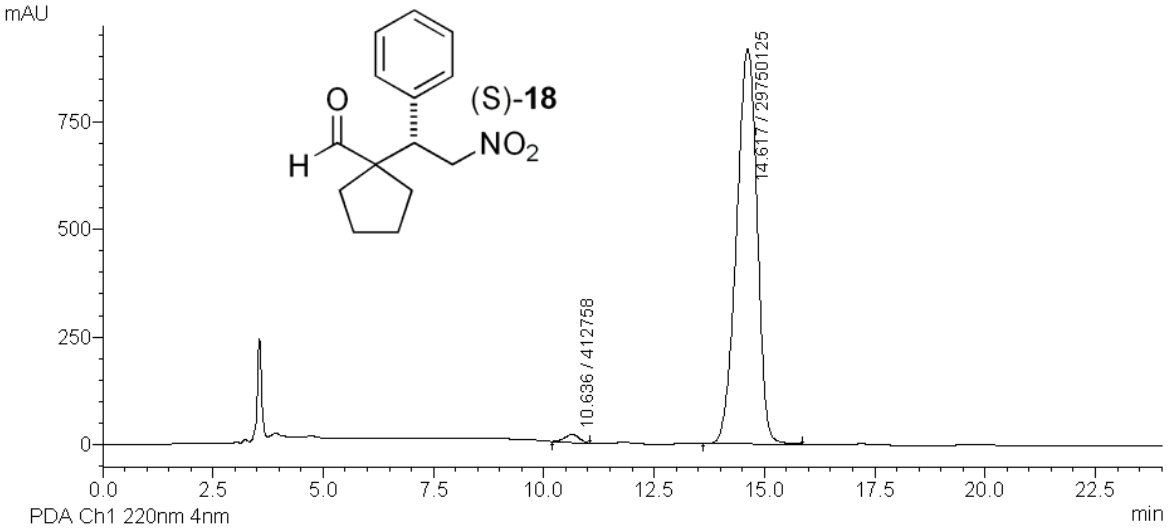
Racemic 1-(2-nitro-1-phenyl-ethyl)-cyclopentanecarbaldehyde



PDA Ch1 220nm 4nm

Peak #	Ret. Time	Area	Height	Area %	Height %	Width at 10% Height	Mark
1	10.773	736986	33698	48.330	57.000	0.635	
2	14.629	787934	25421	51.670	43.000	0.900	
Total		1524920	59120	100.000	100.000		

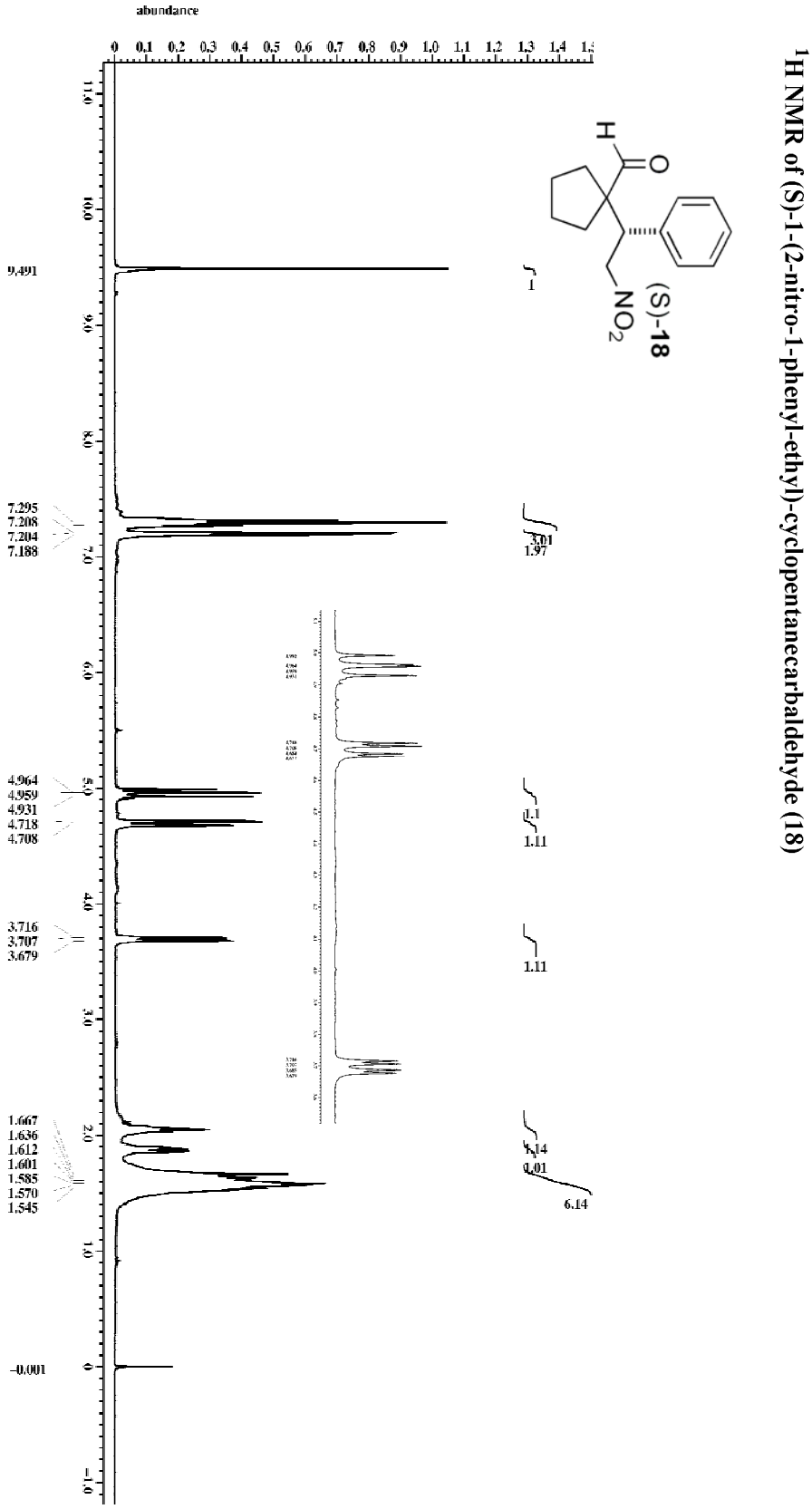
Enantioenriched 1-(2-nitro-1-phenyl-ethyl)-cyclopentanecarbaldehyde



PDA Ch1 220nm 4nm

Peak #	Ret. Time	Area	Height	Area %	Height %	Width at 10% Height	Mark
1	10.636	412758	18470	1.368	1.976	0.645	
2	14.617	29750125	916087	98.632	98.024	0.916	
Total		30162883	934557	100.000	100.000		

^{1}H NMR of (S)-1-(2-nitro-1-phenyl-ethyl)-cyclopentanecarbaldehyde (18)



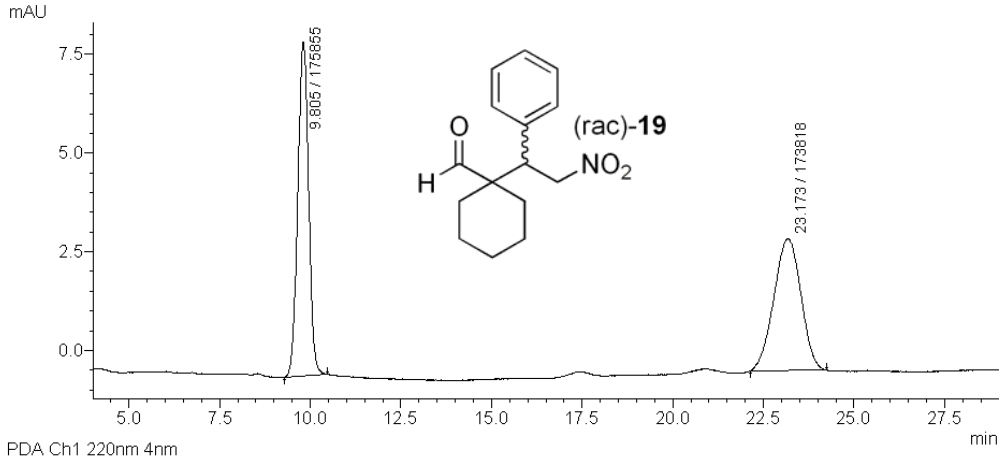
(S)-1-(2-nitro-1-phenyl-ethyl)-cyclohexanecarbaldehyde (19):

The title compound was prepared from *trans*-β-nitrostyrene and cyclohexanecarbaldehyde using method C, and using a catalytic system having 10 mol% each of sulfamide, DMAP and O^{t}Bu-L-threonine.

Compound obtained using method C: Reaction time: 30 h; flash column chromatography: (EtOAc/Pet ether = 7:93); yield = 64%; ee = 90% as determined by HPLC (CHIRALCEL OD-H, *i*-PrOH/n-heptane 20/80, flow rate = 1.0 mL/min, λ = 220 nm); t_{minor}= 9.4 min, t_{major}= 20.8 min.

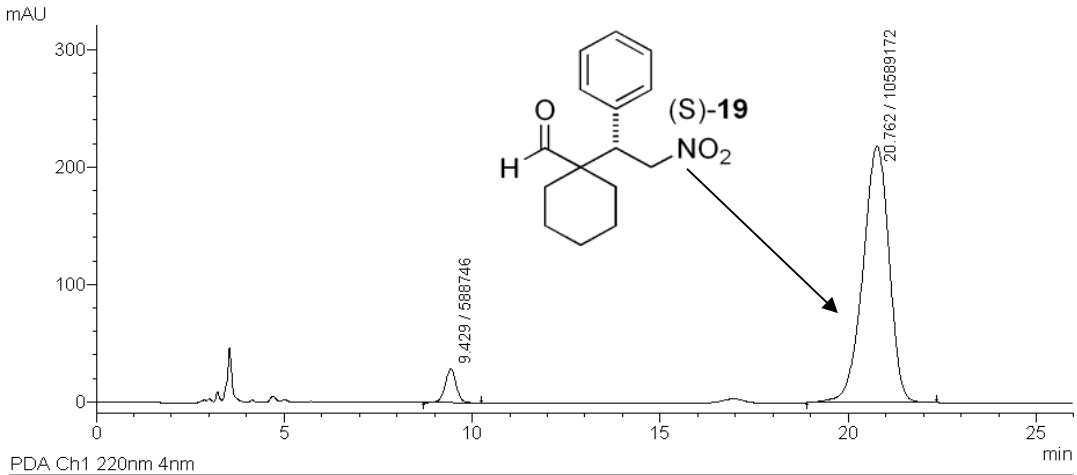
Compound obtained using 10 mol% sulfamide, DMAP and O^{t}Bu-L-threonine: Reaction time: 48 h; flash column chromatography: (EtOAc/Pet ether = 7:93); yield = 88%; ee = 91% as determined by HPLC (conditions and retention times as above). ^{1}H NMR (400 MHz, $CDCl_3$) (ppm): 1.06-1.27 (m, 4H), 1.36-1.43 (m, 1H), 1.56-1.68 (m, 3H), 1.84-1.88 (m, 1H), 2.06-2.09 (m, 1H), 3.54 (dd, 1H, *J* = 4.6, 11 Hz), 4.73 (dd, 1H, *J* = 4.6, 13.3 Hz), 4.8 (dd, 1H, *J* = 11, 13.3 Hz), 7.10-7.14 (m, 2H), 7.26-7.33 (m, 3H), 9.54 (s, 1H)

Racemic 1-(2-nitro-1-phenyl-ethyl)-cyclohexanecarbaldehyde



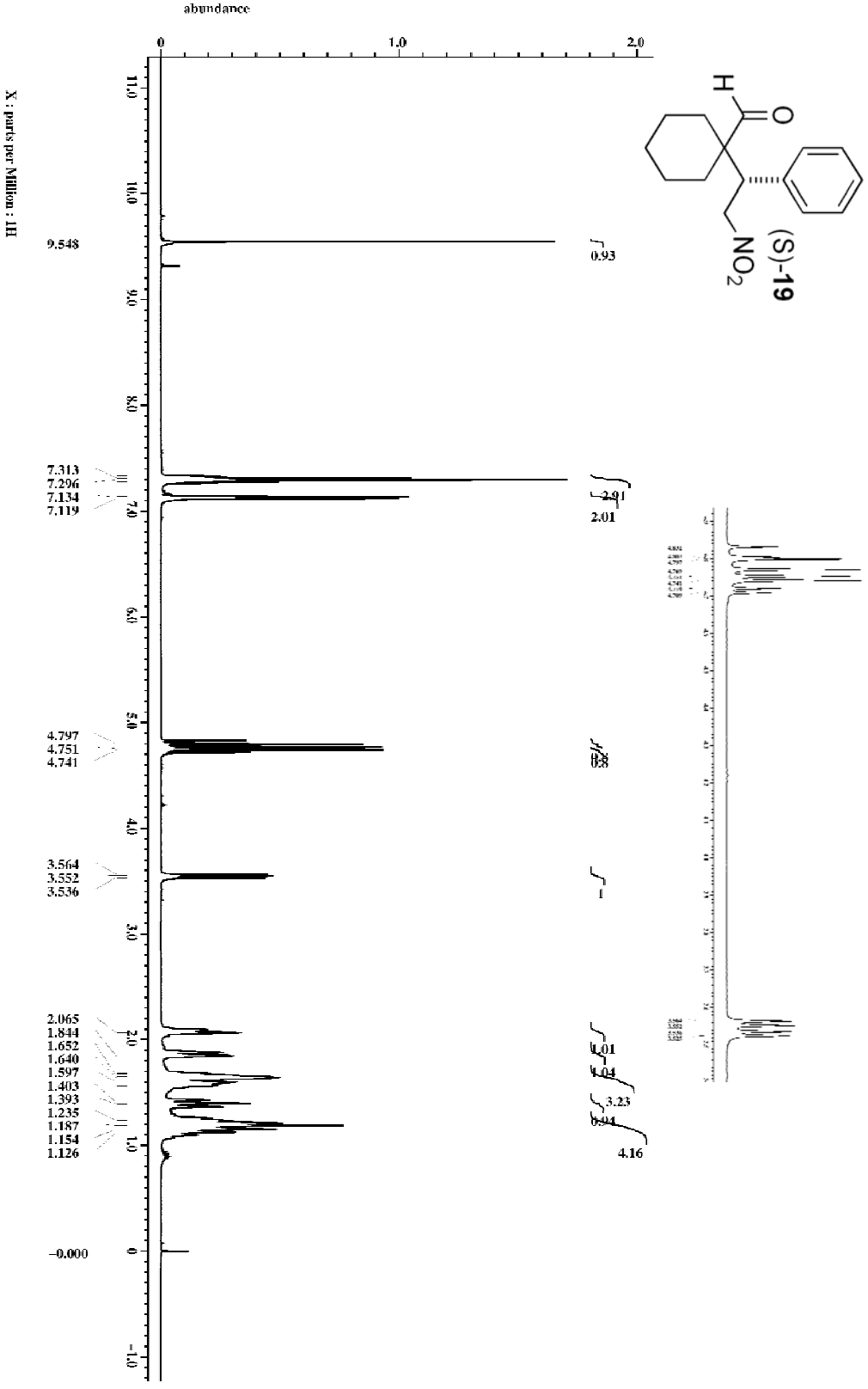
Peak #	Ret. Time	Area	Height	Area %	Height %	Width at 10% Height	Mark
1	9.805	175855	8453	50.291	71.658	0.595	
2	23.173	173818	3343	49.709	28.342	1.481	
Total		349673	11797	100.000	100.000		

Enantioenriched 1-(2-nitro-1-phenyl-ethyl)-cyclohexanecarbaldehyde



Peak #	Ret. Time	Area	Height	Area %	Height %	Width at 10% Height	Mark
1	9.429	588746	28891	5.267	11.673	0.600	
2	20.762	10589172	218616	94.733	88.327	1.389	
Total		11177918	247506	100.000	100.000		

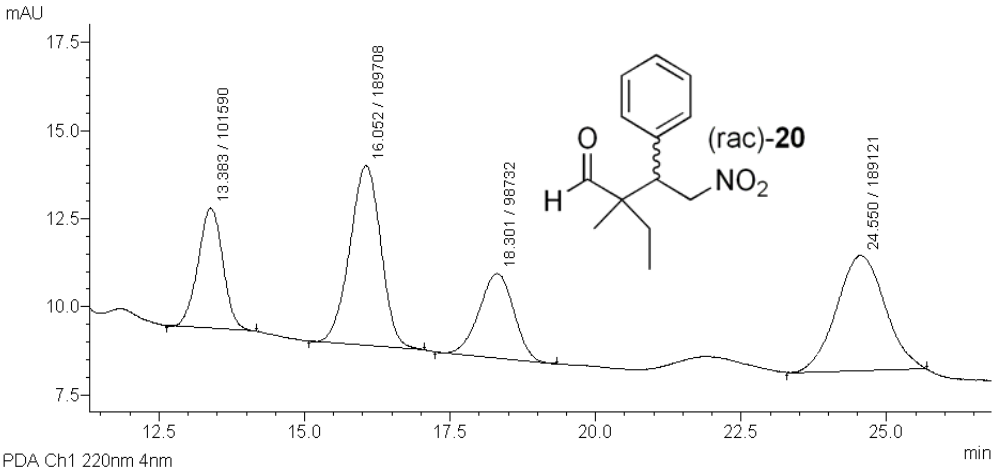
^{1}H NMR of (S)-1-(2-nitro-1-phenyl-ethyl)-cyclohexanecarbaldehyde (19)



(2S,3S)-2-ethyl-2-methyl-4-nitro-3-phenyl-butyraldehyde (20):

The title compound was prepared from trans-β-nitrostyrene and 2-methylbutanal using method C. Reaction time: 12 h; flash column chromatography: (EtOAc/Pet ether = 7:93); yield = 84%; ee = 97%, dr = 70:30 (syn/anti) as determined by HPLC (CHIRALCEL OD-H, *i*-PrOH/n-heptane 10/90, flow rate = 1.0 mL/min, λ = 220 nm); $t_{(anti,\ minor)}$= 13.4 min, $t_{(syn,\ minor)}$= 15.9 min, $t_{(anti,\ major)}$= 17.8 min, $t_{(syn,\ major)}$= 24.1 min. ^{1}H NMR (400 MHz, $CDCl_3$, diastereomer mixture) (ppm): 0.8 (*syn*) and 0.88 (*anti*) (t, 3H, *J* = 7.5 and 7.4 Hz), 1.1 (*syn*) and 1.13 (*anti*) (s, 3H), 1.24-1.34 (m, 1H), 1.5-1.77 (m, 1H), 3.77 (*anti*) and 3.79 (*syn*) (dd, 1H, *J* = 4.4, 11.2 and 4.0, 11.5 Hz), 4.61 (*syn*) and 4.76 (*anti*) (dd, 1H, *J* = 4.0, 13.0 and 4.4, 13.1 Hz), 4.83 (*syn*) and 4.85 (*anti*) (dd, 1H, *J* = 11.5, 13.0 and 11.2, 13.1 Hz), 7.15-7.21 (m, 2H), 7.27-7.34 (m, 3H), 9.51(*anti*) and 9.53 (*syn*) (s, 1H).

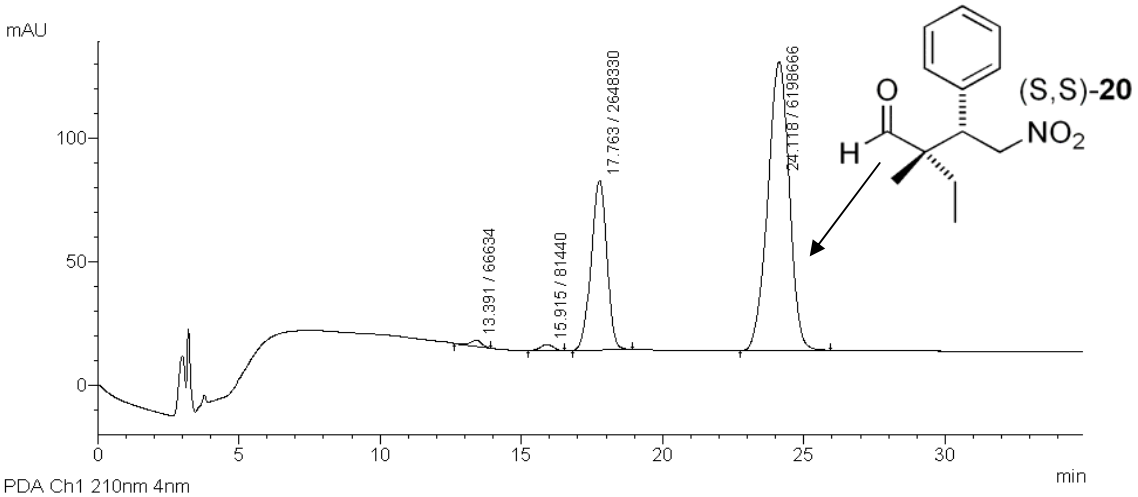
Racemic 2-ethyl-2-methyl-4-nitro-3-phenyl-butyraldehyde



PDA Ch1 220nm 4nm

Peak #	Ret. Time	Area	Height	Area %	Height %	Width at 10% Height	Mark
1	13.383	101590	3416	17.541	24.089	0.858	
2	16.052	189708	5103	32.756	35.984	1.068	
3	18.301	98732	2393	17.048	16.879	1.185	
4	24.550	189121	3268	32.655	23.048	1.703	

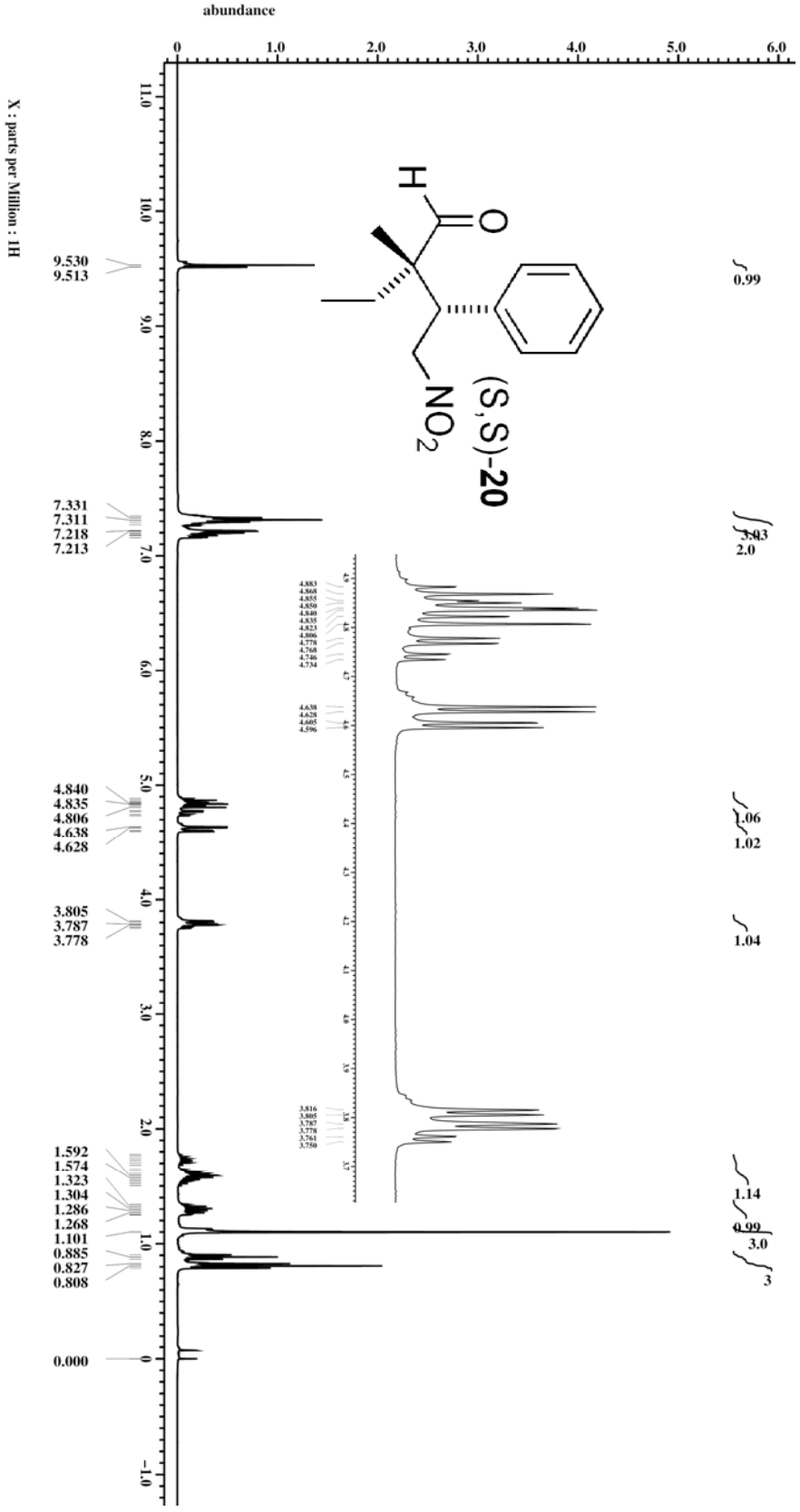
Enantioenriched 2-ethyl-2-methyl-4-nitro-3-phenyl-butyraldehyde



PDA Ch1 210nm 4nm

Peak #	Ret. Time	Area	Height	Area %	Height %	Width at 10% Height	Mark
1	13.391	66634	2411	0.741	1.266	0.805	
2	15.915	81440	2490	0.905	1.308	0.933	
3	17.763	2648330	68580	29.442	36.012	1.118	
4	24.118	6198666	116954	68.912	61.414	1.535	
Total		8995070	190435	100.000	100.000		

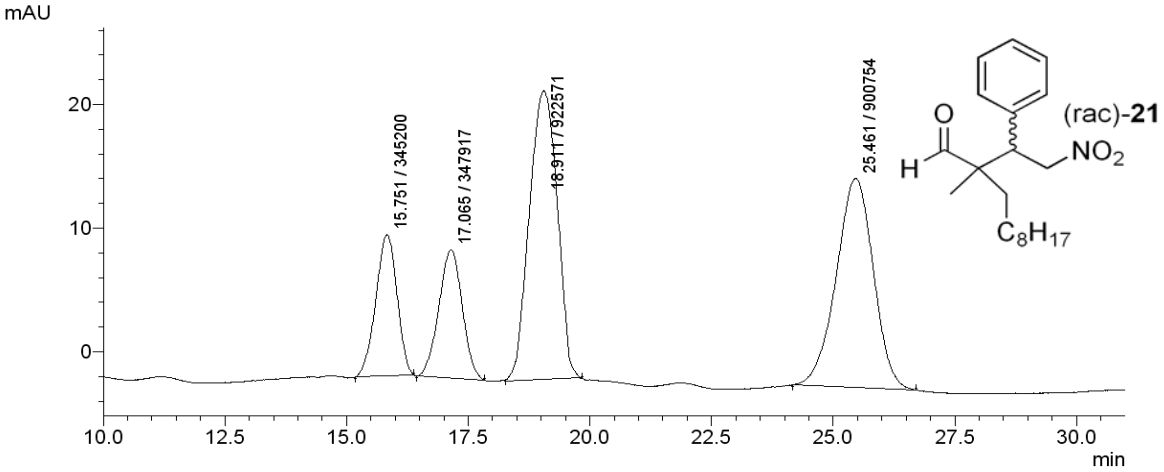
^{1}H NMR of (2S,3S)-2-ethyl-2-methyl-4-nitro-3-phenyl-butyraldehyde (20)



(2S)-2-methyl-2-[(2S)-2-nitro-1-phenylethyl]undecanal (21):

The title compound was prepared from *trans*-β-nitrostyrene and 2-methylundecanal using method C. Reaction time: 12 h flash column chromatography: (EtOAc/Pet ether = 7:93); yield = 71%; ee = 91%, dr = 78:22 (syn/anti) as determined by HPLC (CHIRALCEL OD-H, *i*-PrOH/n-heptane 5/95, flow rate = 0.7 mL/min, λ = 220 nm); $t_{(anti,\ minor)}$= 14.9 min, $t_{(anti,\ major)}$= 16.1 min, $t_{(syn,\ minor)}$= 17.5 min, $t_{(syn,\ major)}$= 23.7 min. ^{1}H NMR (400 MHz, $CDCl_3$) (ppm): 0.87-0.88 (m, 3H), 1.1 (s, 3H), 1.14-1.72 (m, 16H), 3.79 (dd, 1H, *J* = 4.1, 11.5 Hz), 4.62 (dd, 1H, *J* = 4.1, 12.8 Hz), 4.84 (dd, 1H, *J* = 11.5, 12.8 Hz), 7.15-7.21 (m, 2H), 7.26-7.35 (m, 3H), 9.52 (s, 1H).

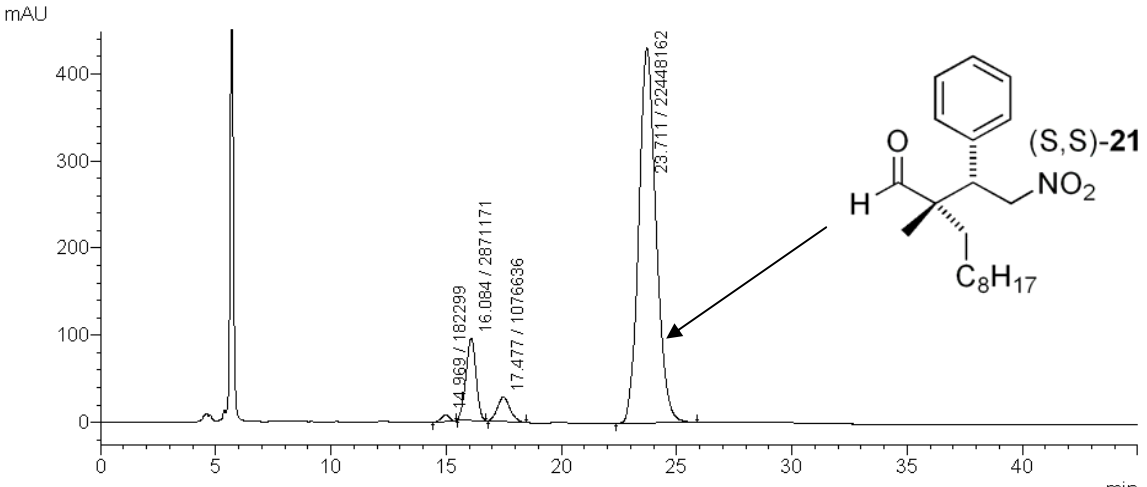
Racemic 2-methyl-2-(2-nitro-1-phenylethyl)undecanal



PDA Ch1 207nm 4nm

Peak #	Ret. Time	Area	Height	Area %	Height %	Width at 10% Height	Mark
1	15.751	345200	11402	13.718	18.369	0.874	
2	17.065	347917	10373	13.826	16.711	0.972	
3	18.911	922571	23366	36.662	37.645	1.053	
4	25.461	900754	16929	35.795	27.274	1.554	
Total		2516441	62070	100.000	100.000		

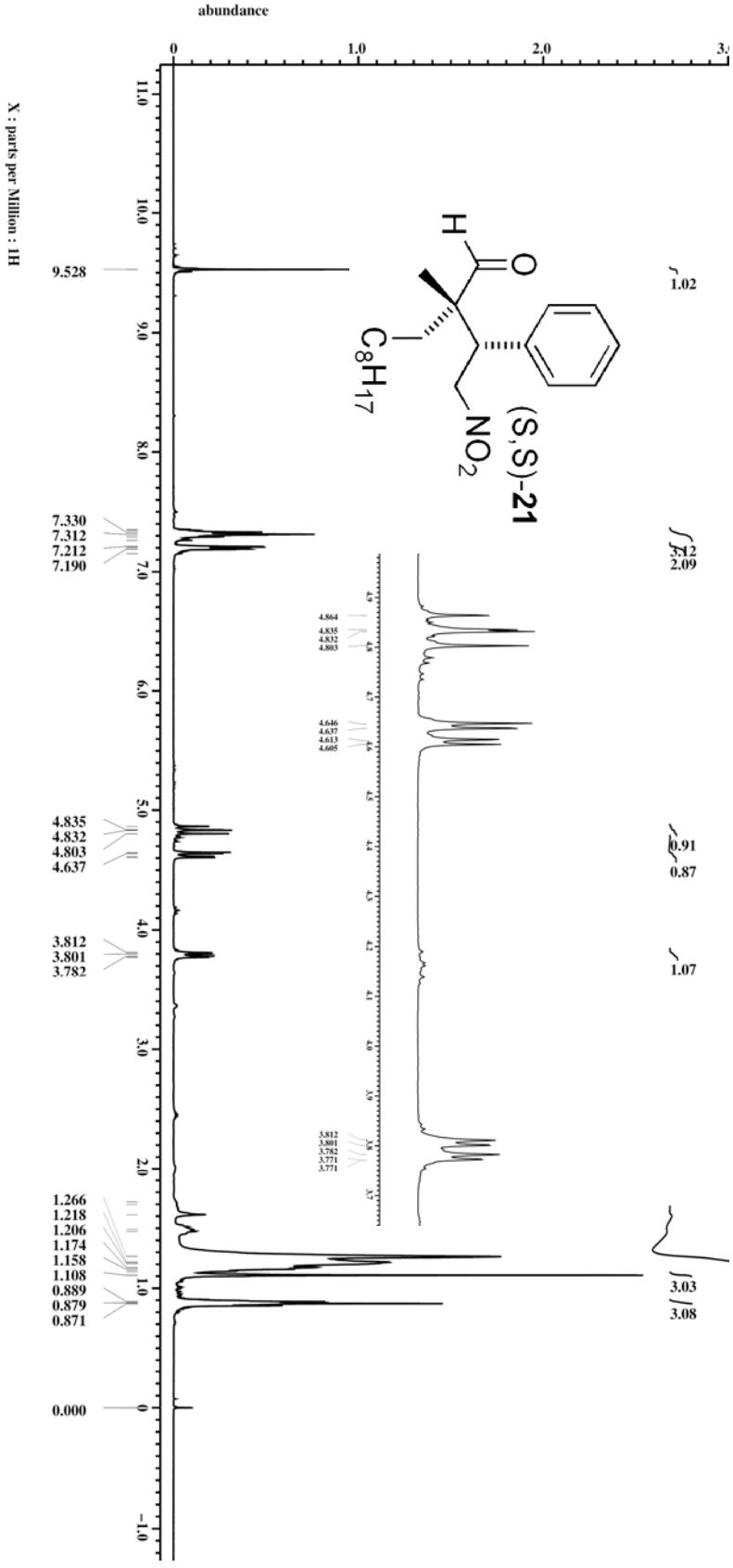
Enantioenriched 2-methyl-2-(2-nitro-1-phenylethyl)undecanal



PDA Ch1 220nm 4nm

Peak #	Ret. Time	Area	Height	Area %	Height %	Width at 10% Height	Mark
1	14.969	182299	7444	0.686	1.328	0.696	
2	16.084	2871171	94528	10.803	16.860	0.888	
3	17.477	1076636	28153	4.051	5.021	1.157	
4	23.711	22448162	430549	84.461	76.791	1.569	
Total		26578269	560674	100.000	100.000		

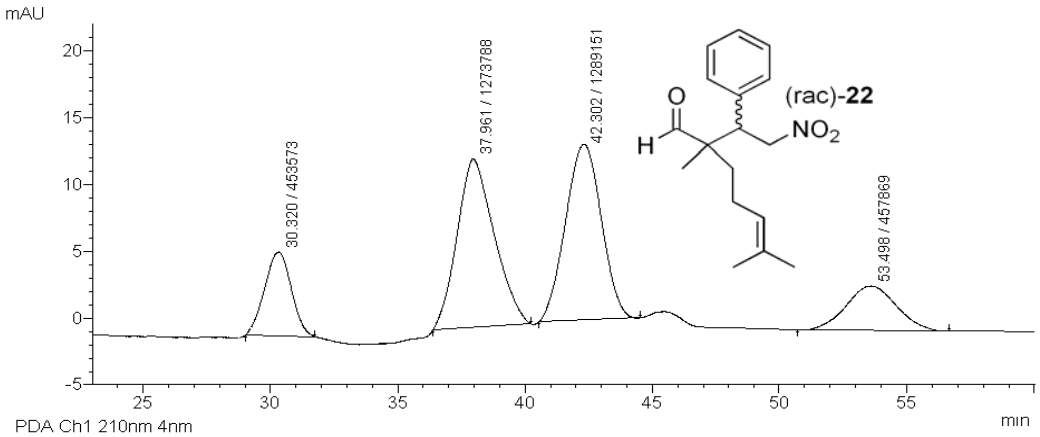
^{1}H NMR of (2S)-2-methyl-2-[(2S)-2-nitro-1-phenylethyl]undecanal (21)



(2S)-2,6-dimethyl-2-[(1S)-2-nitro-1-phenylethyl]hept-5-enal (22):

The title compound was prepared from *trans*-β-nitrostyrene and 2,6-dimethylhept-5-enal using method C. Reaction time: 12 h; flash column chromatography: (EtOAc/Pet ether = 7:93); yield = 70%; ee = 98%, dr = 77:23 (*syn*/*anti*) as determined by HPLC (CHIRALCEL OD-H, *i*-PrOH/n-heptane 1/99, flow rate = 1.5 mL/min, λ = 220 nm); $t_{(anti,\ minor)}$= 28.9 min, $t_{(syn,\ minor)}$= 35.6 min, $t_{(syn,\ major)}$= 38.8 min, $t_{(anti,\ major)}$= 48.3 min. ^{1}H NMR (400 MHz, $CDCl_3$, diastereomer mixture) (ppm): 1.12 (*anti*) and 1.13 (*syn*) (s, 3H), 1.23-1.31 (m, 1H), 1.54-1.72 (m, 1H), 1.52 (*syn*) and 1.55 (*anti*) (s, 3H), 1.63 (*syn*) and 1.65 (*anti*) (s, 3H), 1.83-1.88 (m, 2H), 3.76 (*anti*) and 3.78 (*syn*) (dd, 1H, *J* =4.5, 11 and 4.1, 11.5 Hz), 4.63 (*syn*) and 4.76 (*anti*) (dd, 1H, *J* = 4.1, 12.8 and 4.5, 13.1 Hz), 4.82 (*syn*) and 4.84 (*anti*) (dd, 1H, *J* = 11.5, 12.8 and 11, 13.1Hz), 4.92 (*syn*) and 4.99 (*anti*) (t, 1H, *J* = 7.3 Hz), 7.15-7.21 (m, 2H), 7.27-7.35 (m, 3H), 9.53 (*anti*) and 9.54 (*syn*) (s, 1H).

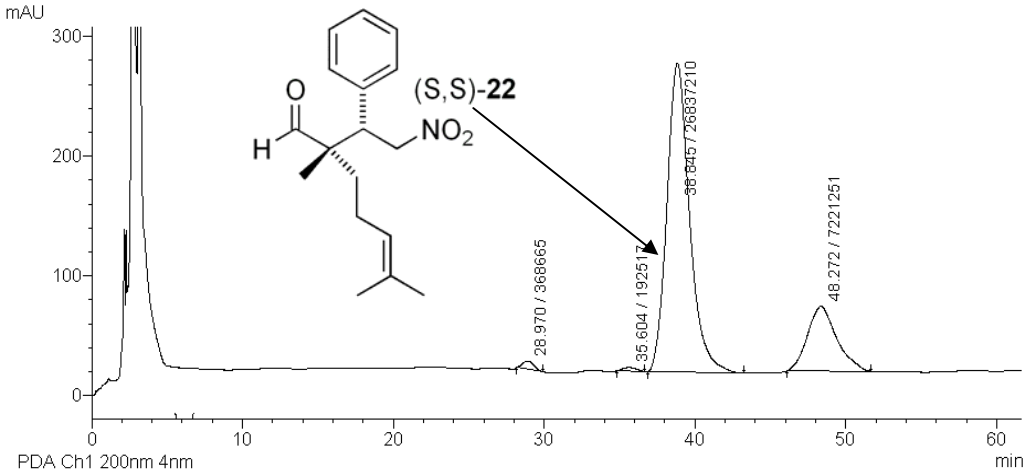
Racemic 2,6-dimethyl-2-(2-nitro-1-phenylethyl)hept-5-enal



PDA Ch1 210nm 4nm

Peak #	Ret. Time	Area	Height	Area %	Height %	Width at 10% Height	Mark
1	30.320	453573	6256	13.055	17.694	2.071	
2	37.961	1273788	12599	36.662	35.632	3.032	
3	42.302	1289151	13168	37.104	37.241	2.768	
4	53.498	457869	3335	13.178	9.433	4.016	
Total		3474381	35358	100.000	100.000		

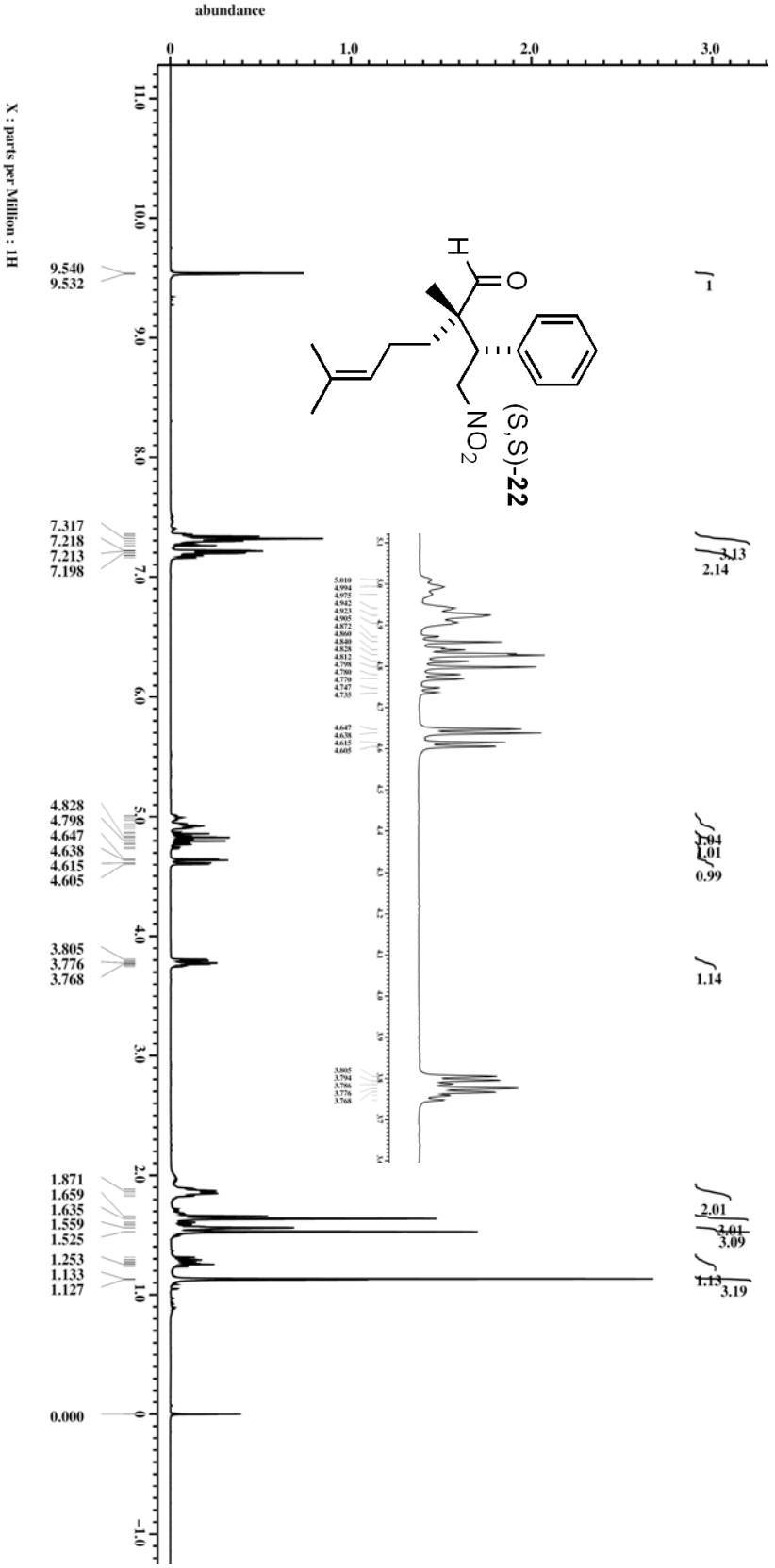
Enantioenriched 2,6-dimethyl-2-(2-nitro-1-phenylethyl)hept-5-enal



PDA Ch1 200nm 4nm

Peak #	Ret. Time	Area	Height	Area %	Height %	Width at 10% Height	Mark
1	28.970	368665	6961	1.065	2.161	1.450	
2	35.604	192517	3187	0.556	0.990	1.646	
3	38.845	26837210	257854	77.520	80.059	3.136	
4	48.272	7221251	54075	20.859	16.789	4.174	
Total		34619643	322078	100.000	100.000		

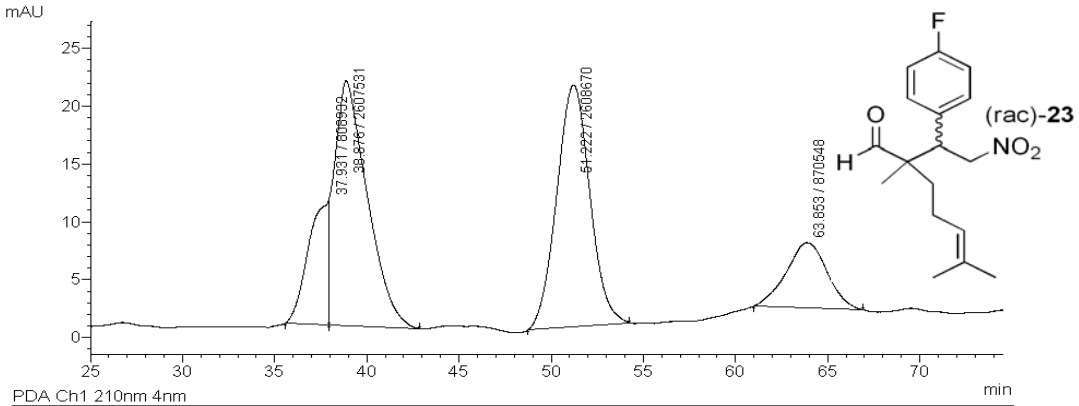
^{1}H NMR of (2S)-2,6-dimethyl-2-[(1S)-2-nitro-1-phenylethyl]hept-5-enal (22)



(2S)-2,6-dimethyl-2-[(1S)-2-nitro-1-(4-fluorophenyl)ethyl]hept-5-enal (23):

The title compound was prepared from *trans*-4-fluoro-β-nitrostyrene and 2,6-dimethylhept-5-enal using method C. Reaction time: 36 h; R_f = 0.58 (*syn*) EtOAc/pet ether (2:8); flash column chromatography: (EtOAc/Pet ether = 7:93); yield = 80%; ee 99%, dr = 77:23 (syn/anti) as determined by HPLC (CHIRALCEL OD-H, *i*-PrOH/heptane 1/99, flow rate = 1.5 mL/min, λ = 220 nm); $t_{(anti,\ minor)}$= 36.6 min, $t_{(syn,\ minor)}$= 38.9 min, $t_{(syn,\ major)}$= 50.8 min, $t_{(anti,\ major)}$= 63.7 min. The compound was tentatively assigned the S,S (*syn*) configuration according to the ^{1}H NMR chemical shift trend for the *syn* and *anti* products of compound **22**. ^{1}H NMR (400 MHz, $CDCl_3$, diastereomer mixture) (ppm): 1.12 (s, 3H), 1.21-1.30 (m, 1H), 1.48-1.64 (m, 1H), 1.53 (*syn*) and 1.55 (*anti*) (s, 3H), 1.63 (*syn*) and 1.66 (*anti*) (s, 3H), 1.80-1.20 (m, 2H), 3.78 (*syn*) (dd, 1H, *J* =3.7, 11.4 Hz), 4.62 (syn) (dd, 1H, *J* = 4.0, 13.2 Hz), 4.75-4.82 (syn) (m, 1H), 4.90-5.00 (m, 1H), 7.01-7.05 (m, 2H), 7.15-7.26 (m, 2H), 9.50 (*anti*) and 9.52 (*syn*) (s, 1H). ^{13}C NMR (100MHz, $CDCl_3$) (ppm): 15.9, 17.7, 22.6, 25.6, 35.5, 47.0, 51.6, 76.4, 116, 122.8, 130.9, 133.1, 161.1, 163.7, 204.9. FT-IR: (KBr), ν_{max}: 1630, 1556, 1511, 1377, 1105, 741, 470 cm^{-1}; MS: HRMS (ESI-TOF) calculated for $C_{17}H_{22}FNO_3$ $[M+Na]^+$: 330.1461; found: 330.1476.

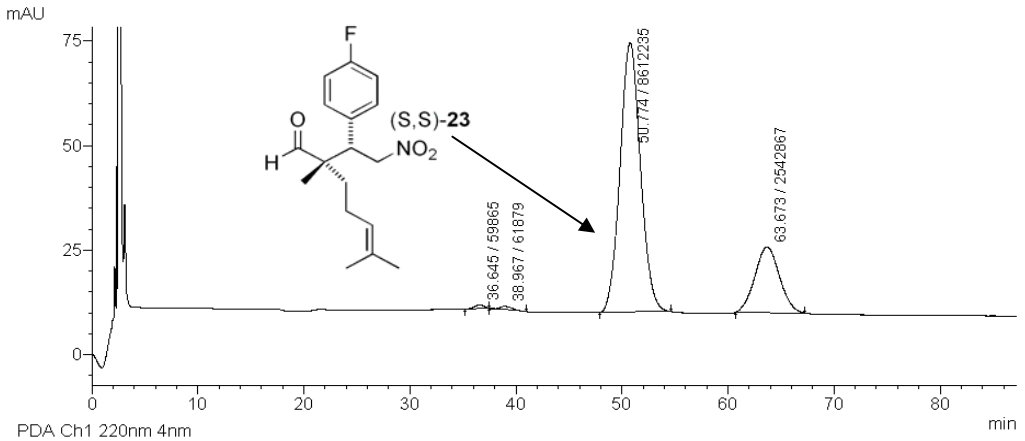
Racemic 2,6-dimethyl-2-[2-nitro-1-(4-fluorophenyl)ethyl]hept-5-enal



PDA Ch1 210nm 4nm

Peak #	Ret. Time	Area	Height	Area %	Height %	Width at 10% Height	Mark
1	37.931	808932	10800	11.731	18.468	0.000	
2	38.876	2607531	21168	37.814	36.198	0.000	V
3	51.222	2608670	20868	37.830	35.685	3.632	
4	63.853	870548	5643	12.625	9.649	4.579	
Total		6895681	58479	100.000	100.000		

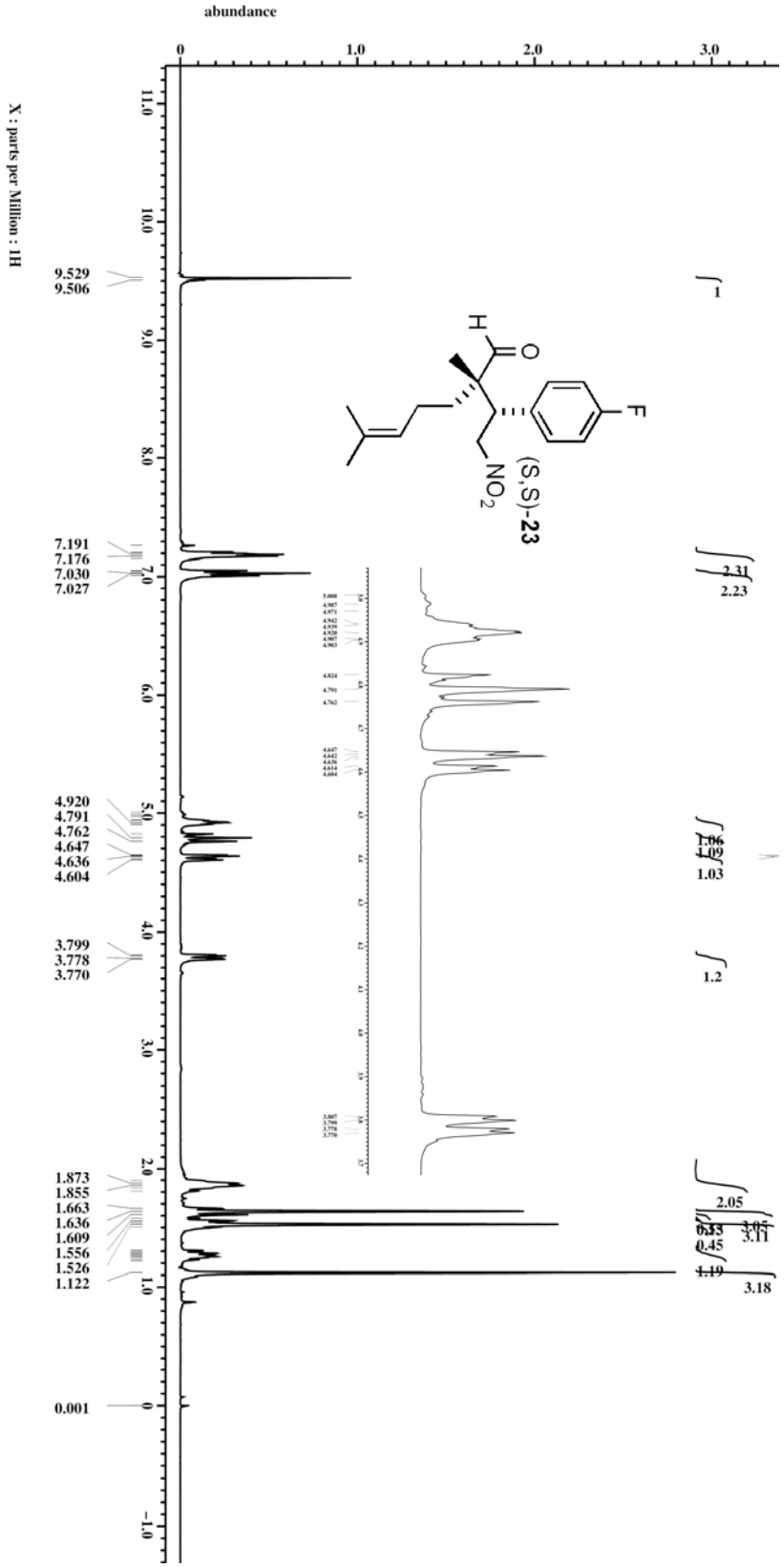
Enantioenriched 2,6-dimethyl-2-[2-nitro-1-(4-fluorophenyl)ethyl]hept-5-enal



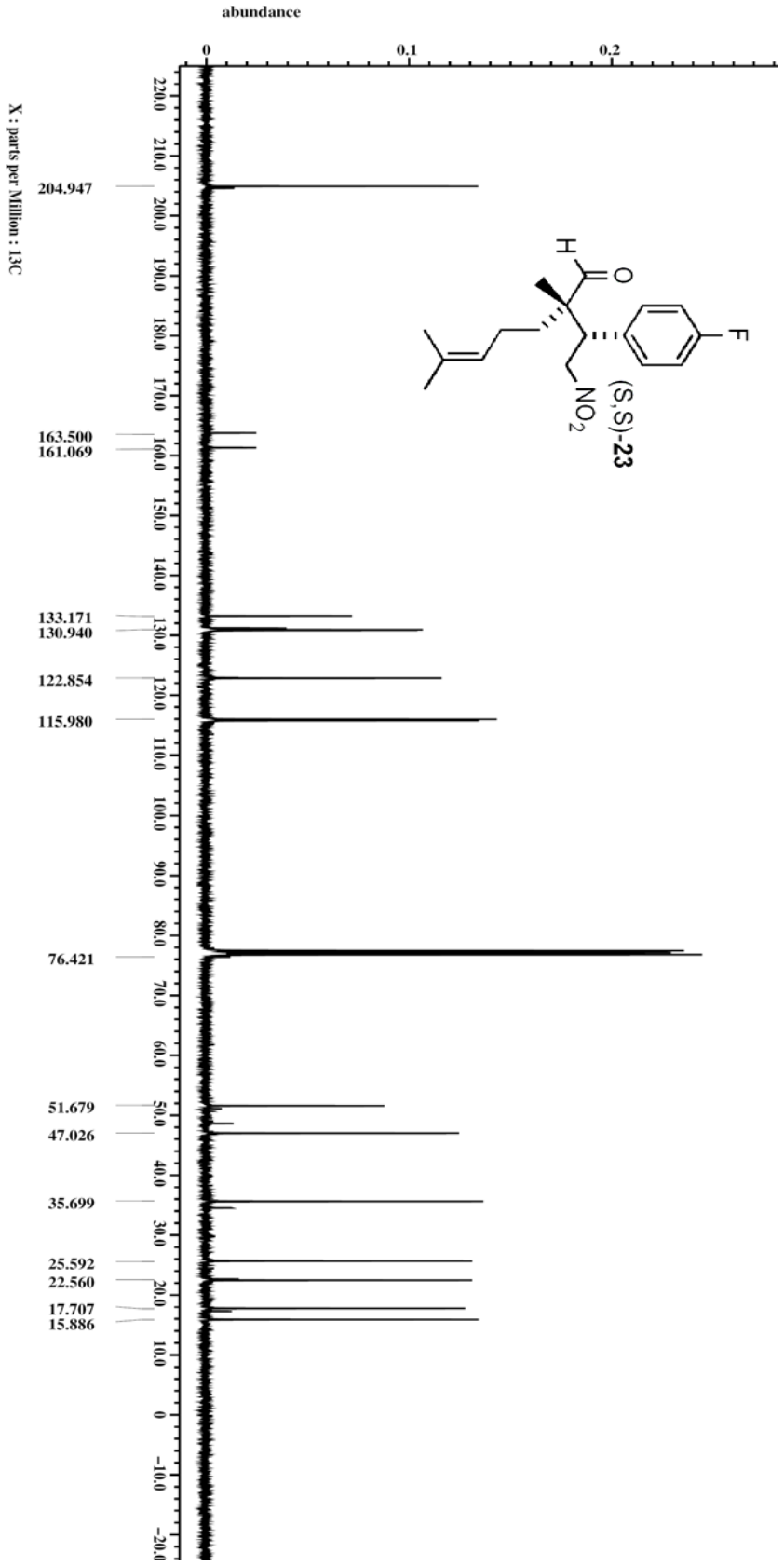
PDA Ch1 220nm 4nm

Peak #	Ret. Time	Area	Height	Area %	Height %	Width at 10% Height	Mark
1	36.645	59865	876	0.531	1.070	1.890	
2	38.967	61879	837	0.549	1.022	2.179	
3	50.774	8612235	64397	76.371	78.645	3.930	
4	63.673	2542867	15773	22.549	19.263	4.714	
Total		11276846	81883	100.000	100.000		

^{1}H NMR of (2S)-2,6-dimethyl-2-[(1S)-2-nitro-1-(4-fluorophenyl)ethyl]hept-5-enal (23)



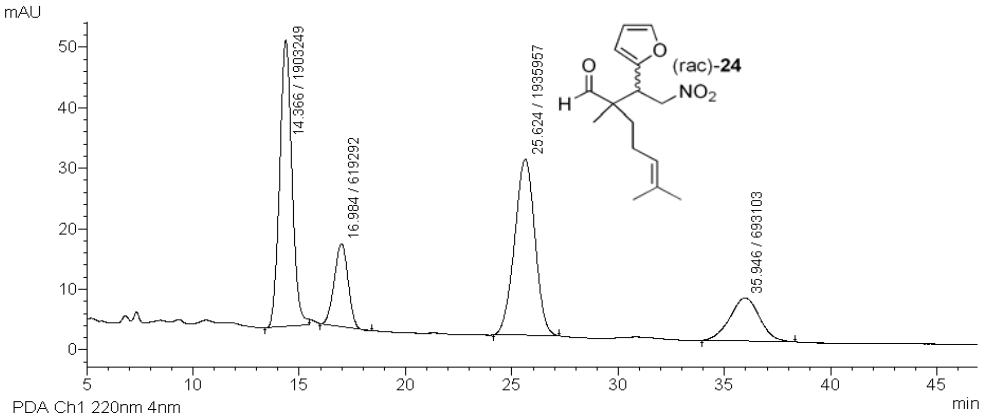
^{13}C NMR of (2S)-2,6-dimethyl-2-[(1S)-2-nitro-1-(4-fluorophenyl)ethyl]hept-5-enal (23)



(2S)-2,6-dimethyl-2-[(1S)-2-nitro-1-(furan-2-yl)ethyl]hept-5-enal (24):

The title compound was prepared from *trans*-2-(2-nitrovinyl)furan and 2,6-dimethylhept-5-enal using method C. Reaction time: 16 h; R_f = 0.63 (*syn*) EtOAc/pet ether (2:8); flash column chromatography: (EtOAc/Pet ether = 7:93); yield = 83% (*syn* and *anti*); ee = 97%, dr = 76:24 (*syn*/*anti*) as determined by HPLC (CHIRALCEL OD-H, *i*-PrOH/n-heptane 1/99, flow rate = 1.5 mL/min, λ = 220 nm); $t_{(syn,\ minor)}$= 15.6 min, $t_{(anti,\ minor)}$= 18.3 min, $t_{(syn,\ major)}$= 25.6 min, $t_{(anti,\ major)}$= 39.3 min. The compound was tentatively assigned the S, S (*syn*) configuration according to the general trend of our Michael addition products. ^{1}H NMR (400 MHz, $CDCl_3$, *syn* product) (ppm): 1.18 (s, 3H), 1.34-1.53 (m, 2H), 1.54 (s, 3H), 1.64 (s, 3H), 1.78-1.88 (m, 1H), 1.89-1.99 (m, 1H), 3.96 (dd, 1H, *J* =3.9, 11.0 Hz), 4.56 (dd, 1H, *J* = 3.9, 12.8 Hz), 4.72 (dd, 1H, *J* = 11.0, 12.8 Hz), 4.92-5.01 (m, 1H), 6.23-6.24 (d, 1H, *J* = 3.2 Hz), 6.31-6.32 (m, 1H), 7.38 (s, 1H), 9.50 (s, 1H). ^{13}C NMR (100MHz, $CDCl_3$) (ppm): 16.5, 17.5, 22.6, 25.8, 35.5, 40.5, 51.7, 75.3, 109.9, 110.5, 122.8, 132.9, 142.8, 149.5, 204.1. FT-IR: (KBr), ν_{max}: 1723, 1630, 1558, 1506, 1435, 1376, 1275, 1261, 1148, 1016, 915, 749 cm^{-1}; MS: HRMS (ESI-TOF) calculated for $C_{15}H_{21}NO_4$ $[M+Na]^+$: 302.1355; found: 330.1363.

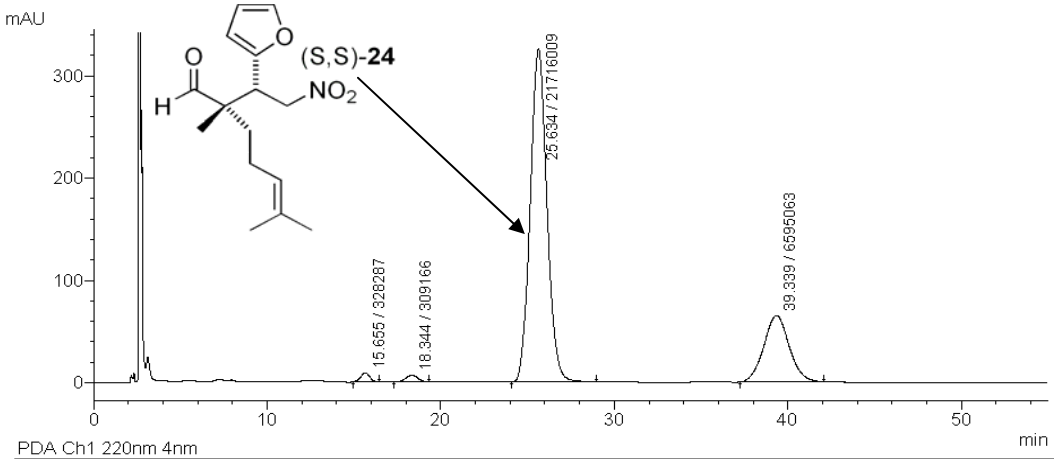
Racemic 2,6-dimethyl-2-[2-nitro-1-(furan-2-yl)ethyl]hept-5-enal



PDA Ch1 220nm 4nm

Peak #	Ret. Time	Area	Height	Area %	Height %	Width at 10% Height	Mark
1	14.366	1903249	47338	36.945	48.652	1.181	
2	16.984	619292	13755	12.021	14.137	1.295	
3	25.624	1935957	29080	37.580	29.887	1.925	
4	35.946	693103	7127	13.454	7.325	2.847	
Total		5151601	97300	100.000	100.000		

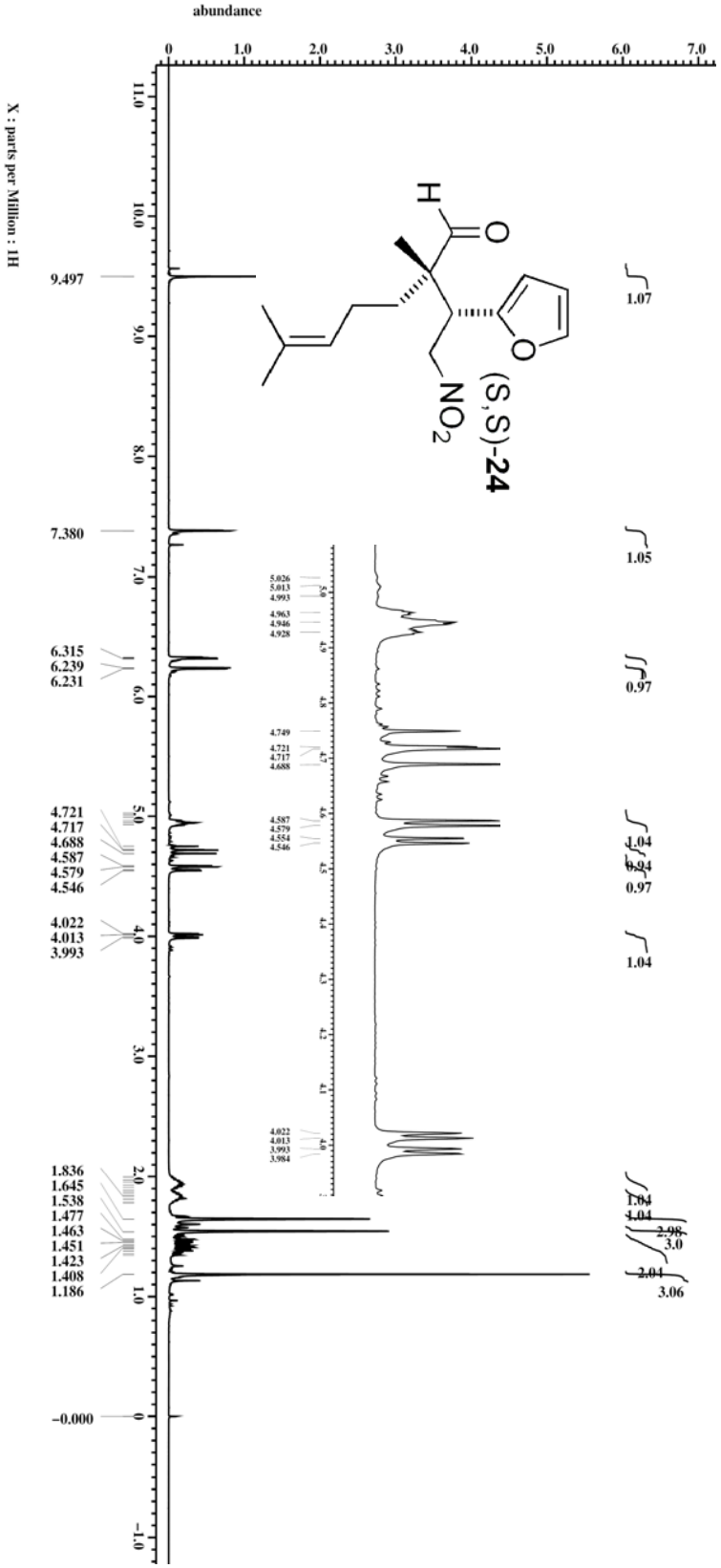
Enantioenriched 2,6-dimethyl-2-[2-nitro-1-(furan-2-yl)ethyl]hept-5-enal



PDA Ch1 220nm 4nm

Peak #	Ret. Time	Area	Height	Area %	Height %	Width at 10% Height	Mark
1	15.655	328287	8930	1.134	2.199	1.060	
2	18.344	309166	6607	1.068	1.627	1.358	
3	25.634	21716009	325649	75.016	80.175	1.968	
4	39.339	6595063	64985	22.782	15.999	3.006	

^{1}H NMR of (2S)-2,6-dimethyl-2-[(1S)-2-nitro-1-(furan-2-yl)ethyl]hept-5-enal (24)



^{13}C NMR of (2S)-2,6-dimethyl-2-[(1S)-2-nitro-1-(furan-2-yl)ethyl]hept-5-enal (24)