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The Inverted Ketene Synthon: A Double Umpolung Approach to Enantioselective β[2,3]-Amino Amide Synthesis

Mahesh Vishe and Jeffrey N. Johnston*

Department of Chemistry & Vanderbilt Institute of Chemical Biology
Vanderbilt University
2301 Vanderbilt Place, Nashville, TN 37235-1822

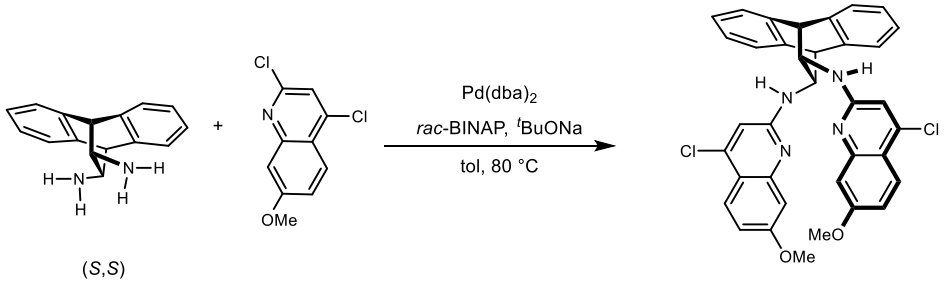
SI1-X

Experimental Section

All reagents and solvents were commercial grade and purified prior to use when necessary. Toluene and tetrahydrofuran were dried by passage through a column of activated alumina as described by Grubbs.[1] Thin layer chromatography (TLC) was performed using glass-backed silica gel (250 μm) plates and flash chromatography utilized 230–400 mesh silica gel from Sorbent Technologies. UV light, and/or the use of PMA and potassium permanganate solutions were used to visualize products.

Nuclear magnetic resonance spectra (NMR) were acquired on a Bruker DRX-500 (500 MHz), Bruker AV-400 (400 MHz) or Bruker AV II-600 (600 MHz) instrument. Chemical shifts are measured relative to residual solvent peaks as an internal standard set to δ 7.26 and δ 77.0 ($CDCl_3$). IR spectra were recorded on a Thermo Nicolet IR100 spectrophotometer and are reported in wavenumbers (cm^{-1}). Compounds were analyzed as neat films on a NaCl plate (transmission). Mass spectra were recorded on a Waters LCT spectrometer by use of the ionization method noted. Melting points were obtained using an OptiMelt automated melting point system (Stanford Research Systems). Optical rotations were measured on a JASCO-P-2000 polarimeter.

Catalyst synthesis

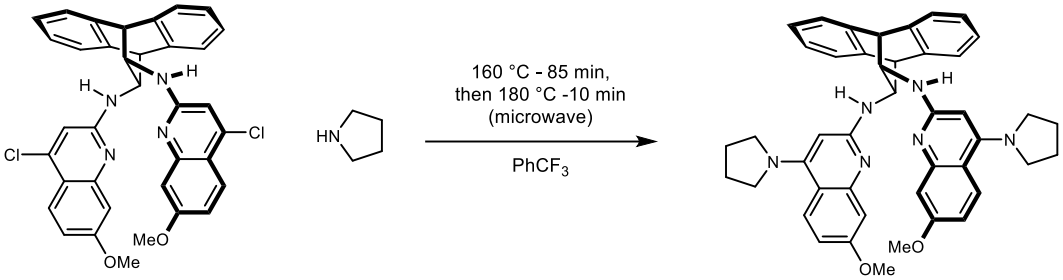


(*S*,*S*)

(11*S*,12*S*)-*N*11,*N*12-bis(4-Chloro-7-methoxyquinolin-2-yl)-9,10-dihydro-9,10-ethanoanthracene-11,12-diamine (S1). A 50-mL round-bottomed flask equipped with a stir bar was charged with (11*S*,12*S*)-9,10-dihydro-9,10-ethanoanthracene-11,12-diamine (330 mg, 1.40 mmol),[2] $Pd(dba)_2$ (10.5 mg, 18.0 μmol), *rac*-BINAP (22.7 mg, 36.0 μmol), sodium *tert*-butoxide (336 mg, 2.50 mmol), and 2,4-dichloro-7-methoxyquinoline (638 mg, 2.80 mmol). The reaction vessel was placed under an argon atmosphere, toluene (7 mL) was dispensed into the flask, and the resulting solution was placed into an oil bath heated to 80 °C with stirring. The reaction was monitored by TLC, and after 3 h, nearly complete conversion was observed. The reaction was stirred for an additional 1 h, cooled to 25 °C, diluted with CH_2Cl_2, and filtered through a plug of silica gel using 50% EtOAc/hexanes. The organic mixture was concentrated and the crude solid was recrystallized using a CH_2Cl_2/hexanes (25/75) mixture. The solid was filtered and dried under vacuum to give a light yellow crystalline solid (695 mg, 80%). Mp 168-170 °C; R_f = 0.61 (50% EtOAc/hexanes); $[\alpha]_D^{20}$ -217 (*c* 1.0, $CHCl_3$); IR (film) 3407, 2952, 1607, 1519, 1401, 1360, 1216, 1178, 1124, 1030, 907 cm^{-1}; ^1H NMR (400 MHz, $CDCl_3$) δ 7.74 (d, *J* = 8.9 Hz, 2H), 7.47 (d, *J* = 6.7 Hz, 2H), 7.36 (d, *J* = 6.4 Hz, 2H), 7.27-7.19 (m, 4H), 6.84 (dd, *J* = 11.5, 9.0 Hz, 2H), 6.74 (d, *J* = 2.3 Hz, 2H), 6.46 (s, 2H), 4.63-4.61 (m, 4H), 4.24 (br d, *J* = 8.1 Hz, 2H), 3.78 (s, 6H); ^{13}C NMR (100 MHz, ($CDCl_3$) ppm 161.6, 156.1, 150.4, 142.4, 141.6, 139.3, 127.0, 126.8, 126.1, 125.1, 124.9, 116.4, 115.1, 109.1, 105.7, 59.9, 55.4, 49.4; HRMS (ESI): Exact mass calcd for $C_{36}H_{29}Cl_2N_4O_2$ [M+H] 619.1667, found 619.1686.

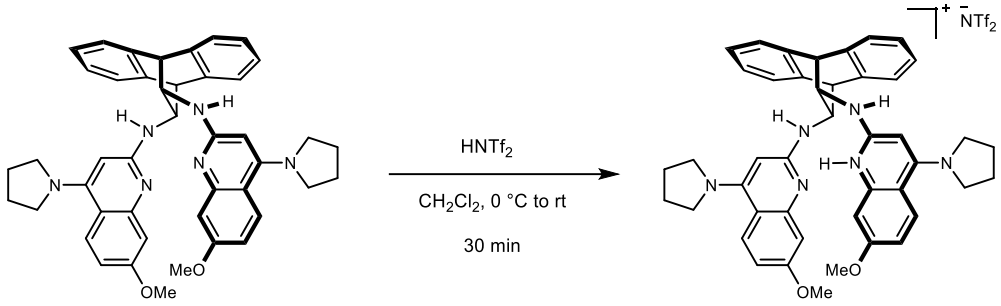
[1] Pangborn, A. B.; Giardello, M. A.; Grubbs, R. H.; Rosen, R. K.; Timmers, F. J. *Organometallics* **1996**, *15*, 1518-1520.

[2] (a) Coffinier, R.; Assal, M. E.; Peixoto, P. A.; Bosset, C.; Miqueu, K.; Sotiropoulos, J.-M.; Pouységu, L.; Quideau, S. *Org. Lett.* **2016**, *18*, 1120 (b) Trost, B. M.; Van Vranken, D. L.; Bingel, C. *J. Am. Chem. Soc.* **1992**, *114*, 9327.



(*S*,*S*)-^{7}(MeO)AnthPBAM (11*S*,12*S*)-*N*11,*N*12-bis(7-methoxy-4-(pyrrolidin-1-yl)quinolin-2-yl)-9,10-dihydro-9,10-ethanoanthracene-11,12-diamine (3).

A 2-5 mL microwave vial equipped with a stir bar was charged with (11*S*,12*S*)-*N*11,*N*12-bis(4-chloro-7-methoxyquinolin-2-yl)-9,10-dihydro-9,10-ethanoanthracene-11,12-diamine (800 mg, 1.29 mmol), pyrrolidine (425 μL, 5.16 mmol), and trifluoromethylbenzene (8 mL). The vial was sealed, and this suspension was heated with stirring at 160 °C in the microwave for 85 min and then for an additional 10 min at 180 °C. The reaction mixture was cooled, diluted with dichloromethane, and concentrated in vacuo. The resulting solid was dissolved in dichloromethane and transferred to a 250 mL separatory funnel, washed with 5 M NaOH (50 mL) and water (3 x 50mL). The resulting organic layer was dried ($MgSO_4$) and concentrated to provide a light brown powder. This solid was precipitated from CH_2Cl_2/Et_2O and hexanes (1:1:5 ratio) to provide an off-white solid (780 mg, 87%). Mp 192-194 °C; R_f = 0.12 (10% MeOH/CH_2Cl_2); $[\alpha]_D^{20}$ +62 (*c* 1.0, $CHCl_3$); IR (film) 3400, 2954, 1584, 1521, 1434, 1278, 1216 cm^{-1}; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.79 (d, *J* = 9.2 Hz, 2H), 7.40 (dd, *J* = 5.4, 1.8 Hz, 4H), 7.23-7.20 (m, 4H), 6.84 (d, *J* = 2.6 Hz, 2H), 6.64 (dd, *J* = 9.2, 2.7 Hz, 2H), 5.50 (s, 2H), 4.47-4.43 (m, 4H), 3.95 (br d, *J* = 6.3 Hz, 2H), 3.81 (s, 6H), 3.29-3.24 (m, 4H), 3.16-3.11 (m, 4H), 1.63-1.59 (m, 8H); ^{13}C NMR (100 MHz, $CDCl_3$) ppm 160.1, 157.2, 153.9, 151.8. 141.6, 139.3, 126.9, 126.8, 126.3, 126.2, 124.6, 112.5, 111.2, 105.5, 88.4, 60.6, 55.2, 51.8, 50.1, 25.6; HRMS (ESI): Exact mass calcd for $C_{44}H_{45}N_6O_2$ [M+H] 689.3604, found 689.3620

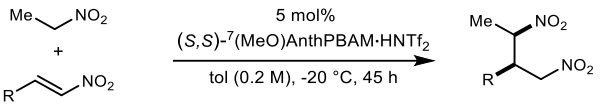


(*S*,*S*)-^{7}(MeO)AnthPBAM•HNTf$_2$ (3•HNTf$_2$). A flame-dried vial equipped with a stir bar was charged with bis(trifluoromethanesulfon)imide (141 mg, 500 μmol) and dichloromethane (5 mL), cooled to 0 °C, and treated with (*S*,*S*)-^{7}(MeO)AnthPBAM (344 mg, 500 μmol). The solution was stirred for 30 minutes before the solvent was removed *in vacuo* to give the catalyst as a beige solid that was used without further purification.

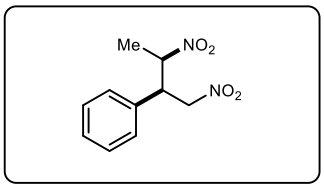
General Procedure for the Addition of Nitroalkanes to Nitroalkenes (Racemate Assay Development)

Racemic material for the Michael additions of nitroalkanes to nitroalkenes were synthesized using 1 M aq $NaHCO_3$ solution. It was possible to isolate the major diastereomer in all cases except two (**6k** and **6q**), and the major diastereomer was used to develop the HPLC assay.

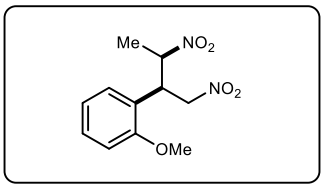
General Procedure for the Enantioselective Addition of Nitroalkanes to Nitroalkenes



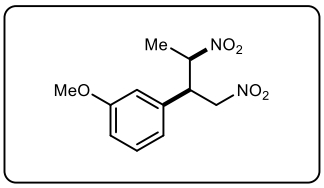
To a flame-dried microwave vial equipped with a stir bar was added (*S*,*S*)-^{7}(MeO)AnthPBAM•$HNTf_2$ (5 mol%), nitroethane (20 equiv, 6.00 mmol), and toluene (0.2 M), and the reaction mixture was cooled to -20 °C. Nitro styrene (1 equiv) was added to the reaction mixture after 15 min, and the solution was stirred for 45 h. The crude reaction mixture was passed (cold) through a pad of silica gel using 50% EtOAc/hexanes solution, and then concentrated under vacuum. The residue was purified by flash column chromatography to give the addition product.



((2*R*,3*R*)-1,3-Dinitrobutan-2-yl)benzene (6a). Prepared according to the general procedure using (*E*)-(2-nitrovinyl)benzene (45.0 mg, 300 μmol) and nitroethane (430 μL, 6.00 mmol). Flash column chromatography (SiO_2, 10-30% EtOAc/hexanes) yielded the product as a white solid (57.0 mg, 85%). The product was determined to be >20:1 dr by ^{1}H NMR. Major diastereomer (*syn*) 94% ee by chiral HPLC analysis (Chiralpak IC, 10% ^{i}PrOH/hexanes, 1 mL/min, t_r(*e*$_1$, minor) = 14.9 min, t_r(*e*$_2$, major) = 23.2 min) [3]; $[\alpha]_D^{20}$ +14 (*c* 1.0, CH_2Cl_2); ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.36-7.34 (m, 3H), 7.16-7.14 (m, 2H), 4.98-4.91 (m, 2H), 4.82 (dd, *J* = 13.6, 8.2 Hz, 1H), 4.02 (ddd, *J* = 8.0, 6.3, 6.2 Hz, 1H), 1.59 (d, *J* = 6.7 Hz, 3H); ^{13}C NMR (150 MHz, $CDCl_3$) ppm 133.5, 129.4, 129.2, 128.0, 84.1, 76.2, 47.4, 16.8; ^{1}H NMR data is identical to that reported in literature. [3]

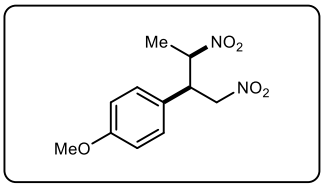


1-((2*R*,3*R*)-1,3-Dinitrobutan-2-yl)-2-methoxybenzene (6b). Prepared according to the general procedure using (*E*)-1-methoxy-2-(2-nitrovinyl)benzene (54.0 mg, 300 μmol) and nitroethane (430 μL, 6.00 mmol). Flash column chromatography (SiO_2, 10-30% EtOAc/hexanes) yielded the product as a white solid (72.0 mg, 95%). The product was determined to be 20:1 dr by ^{1}H NMR. Major diastereomer (*syn*) 92% ee by chiral HPLC analysis (Chiralpak IC, 10% ^{i}PrOH/hexanes, 1 mL/min, t_r(*e*$_1$, minor) = 11.8 min, t_r(*e*$_2$, major) = 17.7 min); ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.29 (ddd, *J* = 9.1, 7.6, 1.7 Hz, 1H), 7.05 (dd, *J* = 7.8, 1.7 Hz, 1H), 6.92-6.89 (series of m, 2H), 5.17 (dq, *J* = 6.8, 6.8 Hz, 1H), 4.87 (d, *J* = 6.9 Hz, 2H), 4.31 (ddd, *J* = 7.1, 7.1, 7.1 Hz, 1H), 3.86 (s, 3H), 1.59 (d, *J* = 6.7 Hz, 3H); ^{13}C NMR (150 MHz, $CDCl_3$) ppm 157.2, 130.3, 130.0, 122.0, 121.3, 111.4, 83.1, 75.2, 55.6, 43.9, 17.1; ^{1}H NMR data is identical to that reported in literature. [4]

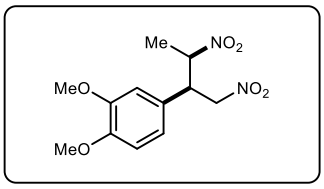


1-((2*R*,3*R*)-1,3-Dinitrobutan-2-yl)-3-methoxybenzene (6c). Prepared according to the general procedure using (*E*)-1-methoxy-3-(2-nitrovinyl)benzene (54.0 mg, 300 μmol) and nitroethane (430 μL, 6.00 mmol). Flash column chromatography (SiO_2, 10-30% EtOAc/hexanes) yielded the product as a white solid (65.0 mg, 85%). The product was determined to be >20:1 dr by ^{1}H NMR. Major diastereomer (*syn*) 93% ee by chiral HPLC analysis (Chiralpak IC, 10% ^{i}PrOH/hexanes, 1 mL/min, t_r(*e*$_1$, minor) = 18.5 min, t_r(*e*$_2$, major) = 27.1 min); ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.26 (dd, *J* = 8.0, 8.0 Hz, 1H), 6.86 (ddd, *J* = 8.3, 2.5, 0.7 Hz, 1H), 6.73 (br d, *J* = 7.6 Hz, 1H), 6.67 (dd, *J* = 2.1, 2.1 Hz, 1H), 4.94 (dq, *J* = 6.7, 6.7 Hz, 1H), 4.91 (dd, *J* = 13.7, 6.3 Hz, 1H) 4.80 (dd, *J* = 13.6, 8.2 Hz, 1H), 4.00 (ddd, *J* = 8.0, 6.3, 6.3 Hz, 1H), 3.78 (s, 3H), 1.59 (d, *J* = 6.7 Hz, 3H); ^{13}C NMR (150 MHz, $CDCl_3$) ppm 160.1, 135.1, 130.5, 120.0, 114.4, 114.1, 84.1, 76.1, 55.3, 47.3, 16.8; ^{1}H NMR data is identical to that reported in literature.[3]

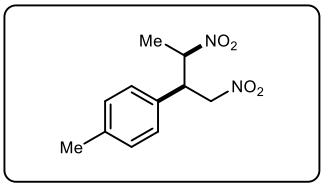
[3] Lu, S.-F.; Du, D.-M.; Xu, J.; Zhang, S.-W. *J. Am. Chem. Soc.* **2006**, *128*, 7418.
[4] Dong, X.-Q.; Teng, H.-L.; Wang, C.-J. *Org. Lett.* **2009**, *11*, 1265.



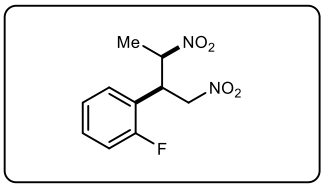
1-((2*R*,3*R*)-1,3-Dinitrobutan-2-yl)-4-methoxybenzene (6d). Prepared according to the general procedure using (*E*)-1-methoxy-4-(2-nitrovinyl)benzene (54.0 mg, 300 μmol) and nitroethane (430 μL, 6.00 mmol). Flash column chromatography (SiO_2, 10-30% EtOAc/hexanes) yielded the product as a white solid (62.5 mg, 81%). The product was determined to be >20:1 dr by ^{1}H NMR. Major diastereomer (*syn*) 95% ee by chiral HPLC analysis (Chiralpak IC, 10% *i*PrOH/hexanes, 1 mL/min, t_r(*e*$_1$, minor) = 21.7 min, t_r(*e*$_2$, major) = 29.5 min); ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.06 (d, *J* = 8.7 Hz, 2H), 6.86 (d, *J* = 8.7 Hz, 2H), 4.92 (dq, *J* = 6.6, 6.6 Hz, 1H), 4.90 (dd, *J* = 13.7, 6.3 Hz, 1H), 4.78 (dd, *J* = 13.4, 8.3 Hz, 1H), 3.95 (ddd, *J* = 8.2, 6.3, 6.3 Hz, 1H), 3.78 (s, 3H), 1.57 (d, *J* = 6.7 Hz, 3H); ^{13}C NMR (150 MHz, $CDCl_3$) ppm 160.1, 129.2, 125.2, 114.8, 84.2, 76.5, 55.4, 46.9, 16.8; ^{1}H NMR data is identical to that reported in literature.[3]



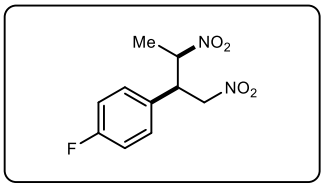
4-((2*R*,3*R*)-1,3-Dinitrobutan-2-yl)-1,2-dimethoxybenzene (6e). Prepared according to the general procedure using (*E*)-1,2-dimethoxy-4-(2-nitrovinyl)benzene (62.7 mg, 300 μmol) and nitroethane (430 μL, 6.00 mmol). Flash column chromatography (SiO_2, 10-40% EtOAc/hexanes) yielded the product as a white solid (71.0 mg, 83%). The product was determined to be 20:1 dr by ^{1}H NMR. Major diastereomer (*syn*) 93% ee by chiral HPLC analysis (Chiralpak IC, 20% EtOH/hexanes, 1 mL/min, t_r(*e*$_1$, minor) = 11.8 min, t_r(*e*$_2$, major) = 13.7 min); ^{1}H NMR (400 MHz, $CDCl_3$) δ 6.81 (d, *J* = 8.2 Hz, 1H), 6.70 (dd, *J* = 8.2, 2.0 Hz, 1H), 6.61 (d, *J* = 2.1 Hz, 1H), 4.92 (dq, *J* = 6.7, 6.7 Hz, 1H), 4.90 (dd, *J* = 13.7, 6.5 Hz, 1H), 4.79 (dd, *J* = 13.5, 8.2 Hz, 1H), 3.94 (ddd, *J* = 8.0, 6.3, 6.3 Hz, 1H), 3.85 (s, 6H), 1.58 (d, *J* = 6.7 Hz, 3H); ^{13}C NMR (150 MHz, $CDCl_3$) ppm 149.6, 149.4, 125.7, 120.2, 111.6, 111.2, 84.2, 76.4, 56.0, 55.9, 47.2, 16.8; ^{1}H NMR data is identical to that reported in literature.[2]



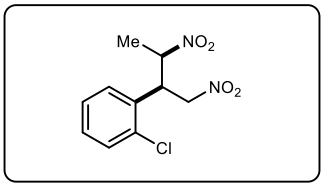
1-((2*R*,3*R*)-1,3-Dinitrobutan-2-yl)-4-methylbenzene (6f). Prepared according to the general procedure using (*E*)-1-methyl-4-(2-nitrovinyl)benzene (49.0 mg, 300 μmol) and nitroethane (430 μL, 6.00 mmol). Flash column chromatography (SiO_2, 10-40% EtOAc/hexanes) yielded the product as a white solid (63.0 mg, 88%). The product was determined to be >20:1 dr by ^{1}H NMR. Major diastereomer (*syn*) 95% ee by chiral HPLC analysis (Chiralpak IC, 10% ^{i}PrOH/hexanes, 1 mL/min, t_r(*e*$_1$, minor) = 13.9 min, t_r(*e*$_2$, major) = 21.7 min); ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.15 (d, *J* = 7.9 Hz, 2H), 7.03 (d, *J* = 8.0 Hz, 2H), 4.96-4.88 (m, 2H), 4.88 (dd, *J* = 13.5, 8.2 Hz, 1H), 3.97 (ddd, *J* = 8.0, 6.2, 6.2 Hz, 1H), 2.32 (s, 3H), 1.57 (d, *J* = 6.7 Hz, 3H); ^{13}C NMR (150 MHz, $CDCl_3$) ppm 139.1, 130.4, 130.1, 127.9, 84.1, 76.3, 47.2, 21.2, 16.8; ^{1}H NMR data is identical to that reported in literature.[3]



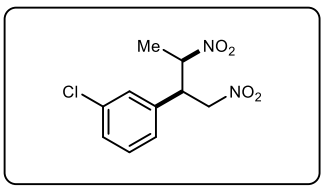
1-((2*R*,3*R*)-1,3-Dinitrobutan-2-yl)-2-fluorobenzene (6g). Prepared according to the general procedure using (*E*)-1-fluoro-2-(2-nitrovinyl)benzene (50.0 mg, 300 μmol) and nitroethane (430 μL, 6.00 mmol). Flash column chromatography (SiO_2, 10-30% EtOAc/hexanes) yielded the product as a viscous colorless liquid (62.0 mg, 85%). The product was determined to be 20:1 dr by ^{1}H NMR. Major diastereomer (*syn*) 94% ee by chiral HPLC analysis (Chiralpak OD-H, 30% ^{i}PrOH/hexanes, 1 mL/min, t_r(*e*$_1$, major) = 10.1 min, t_r(*e*$_2$, minor) = 14.9 min); ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.37-7.31 (m, 1H), 7.15-7.08 (m, 3H), 5.06 (dq, *J* = 6.8, 6.8 Hz, 1H), 4.92 (dd, *J* = 13.7, 6.1 Hz, 1H), 4.84 (dd, *J* = 13.7, 6.8 Hz, 1H), 4.32 (ddd, *J* = 7.0, 7.0, 7.0 Hz, 1H), 1.62 (d, *J* = 7.2 Hz, 3H); ^{13}C NMR (150 MHz, $CDCl_3$) ppm 160.9 (d, *J* = 246.9 Hz), 131.1 (d, *J* = 8.6 Hz), 129.7 (d, *J* = 3.3 Hz), 125.1 (d, *J* = 3.3 Hz),120.0 (d, *J* = 13.6 Hz), 116.4 (d, *J* = 22.2 Hz), 83.3, 75.2 (d, *J* = 2.1 Hz), 42.2, 17.1; ^{1}H NMR data is identical to that reported in literature.[2]



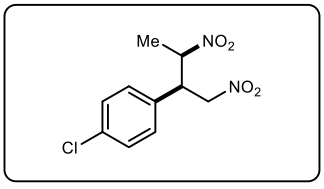
1-((2*R*,3*R*)-1,3-Dinitrobutan-2-yl)-4-fluorobenzene (6h). Prepared according to the general procedure using (*E*)-1-fluoro-4-(2-nitrovinyl)benzene (50.0 mg, 300 μmol) and nitroethane (430 μL, 6.00 mmol). Flash column chromatography (SiO_2, 10-40% EtOAc/hexanes) yielded the product as a white solid (64.0 mg, 88%). The product was determined to be >20:1 dr by ^{1}H NMR. Major diastereomer (*syn*) 95% ee by chiral HPLC analysis (Chiralpak IC, 10% ^{i}PrOH/hexanes, 1 mL/min, t_r(e_1, minor) = 13.4 min, t_r(e_2, major) = 19.3 min); ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.14 (dd, *J* = 8.5, 5.3 Hz, 2H), 7.05 (dd, *J* = 8.5, 8.5 Hz, 2H), 4.97-4.88 (m, 2H), 4.78 (dd, *J* = 13.5, 8.4 Hz, 1H), 4.0 (ddd, *J* = 8.6, 6.4, 6.4 Hz, 1H), 1.59 (d, *J* = 6.7 Hz, 3H); ^{13}C NMR (150 MHz, $CDCl_3$) ppm 163.0 (d, *J* = 249.1 Hz), 129.9 (d, *J* = 8.4 Hz), 129.3 (d, *J* = 3.3 Hz), 116.5 (d, *J* = 21.9 Hz), 84.1, 76.3, 46.9, 16.9; ^{1}H NMR data is identical to that reported in literature.[3]



1-Chloro-2-((2*R*,3*R*)-1,3-dinitrobutan-2-yl)benzene (6i). Prepared according to the general procedure using (*E*)-1-chloro-2-(2-nitrovinyl)benzene (49.0 mg, 300 μmol) and nitroethane (430 μL, 6.00 mmol). Flash column chromatography (SiO_2, 10-40% EtOAc/hexanes) yielded the product as a white solid (63.0 mg, 88%). The product was determined to be >20:1 dr by ^{1}H NMR. Major diastereomer (*syn*) 95% ee by chiral HPLC analysis (Chiralpak IC, 10% ^{i}PrOH/hexanes, 1 mL/min, t_r(e_1, minor) = 11.6 min, t_r(e_2, major) = 21.9 min); ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.42 (dd, *J* = 6.8, 2.1 Hz, 1H), 7.29-7.22 (m, 2H), 7.11 (dd, *J* = 7.0, 1.9 Hz, 1H), 5.14 (dq, *J* = 6.7, 6.7 Hz, 1H), 4.91 (dd, *J* = 13.8, 6.1 Hz, 1H), 4.85 (dd, *J* = 13.8, 7.3 Hz, 1H), 4.68 (ddd, *J* = 6.6, 6.6, 6.6 Hz, 1H), 1.60 (d, *J* = 6.7 Hz, 3H); ^{13}C NMR (150 MHz, $CDCl_3$) ppm 134.5, 131.5, 130.7, 130.2, 128.2, 127.8, 83.0, 75.0, 43.1, 16.4; ^{1}H NMR data is identical to that reported in literature.[3]

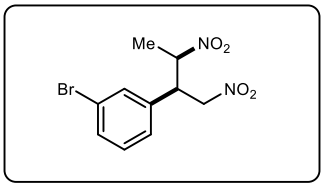


1-Chloro-3-((2*R*,3*R*)-1,3-dinitrobutan-2-yl)benzene (6j). Prepared according to the general procedure using (*E*)-1-chloro-3-(2-nitrovinyl)benzene (55.0 mg, 300 μmol) and nitroethane (430 μL, 6.00 mmol). Flash column chromatography (SiO_2, 5-20% EtOAc/hexanes) yielded the product as a white solid (62.0 mg, 80%). The product was determined to be 18:1 dr by ^{1}H NMR. Major diastereomer (*syn*) 97% ee by chiral HPLC analysis (Chiralpak IC, 10% ^{i}PrOH/hexanes, 1 mL/min, t_r(e_1, minor) = 12.5 min, t_r(e_2, major) = 20.5 min); ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.33 (ddd, *J* = 8.0, 1.5, 1.5 Hz, 1H), 7.29 (dd, *J* = 7.9, 7.9 Hz, 1H), 7.17 (dd, *J* = 1.8, 1.8 Hz, 1H), 7.04 (ddd, *J* = 7.2, 1.6, 1.6 Hz, 1H), 4.93 (dq, *J* = 6.8, 6.8 Hz, 1H), 4.89 (dd, *J* = 13.7, 6.0 Hz, 1H), 4.79 (dd, *J* = 13.7, 8.2 Hz, 1H), 4.00 (ddd, *J* = 8.1, 6.3, 6.3 Hz, 1H), 1.60 (d, *J* = 6.7 Hz, 3H); ^{13}C NMR (150 MHz, $CDCl_3$) ppm 135.6, 135.3, 130.7, 129.5, 128.5, 126.1, 83.9, 76.9, 47.0, 16.9; ^{1}H NMR data is identical to that reported in literature.[3]

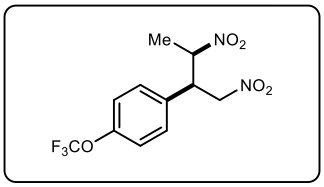


1-Chloro-4-((2*R*,3*R*)-1,3-dinitrobutan-2-yl)benzene (6k). Prepared according to the general procedure using (*E*)-1-chloro-4-(2-nitrovinyl)benzene (55.0 mg, 300 μmol) and nitroethane (430 μL, 6.00 mmol). Flash column chromatography (SiO_2, 10-30% EtOAc/hexanes) yielded the product as a white solid (62.0 mg, 80%). The product was determined to be 20:1 dr by ^{1}H NMR. Major diastereomer (*syn*) 96% ee by chiral HPLC analysis (Chiralpak ODH, 20% ^{i}PrOH/hexanes, 1 mL/min, t_r(e_1, major) = 18.6 min, t_r(e_2, minor) = 34.0 min); ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.33 (d, *J* = 8.4 Hz, 2H), 7.10 (d, *J* = 8.4 Hz, 2H), 4.93 (dq, *J* = 6.7, 6.7 Hz, 1H), 4.90 (dd, *J* = 13.7, 6.0 Hz, 1H), 4.78 (dd, *J* = 13.7, 8.5 Hz, 1H), 3.99 (ddd, *J* = 8.4, 6.3, 6.2 Hz, 1H), 1.59 (d, *J* = 6.7 Hz, 3H); ^{13}C NMR (150 MHz, $CDCl_3$) ppm 135.4, 132.0, 129.7, 129.4, 84.0, 76.1, 46.9, 16.9; ^{1}H NMR data is identical to that reported in literature.[5]

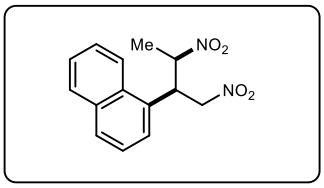
[5] Deng, Y.-Q.; Zhang, Z.-W.; Feng, Y.-H.; Chan, A. S. C.; Lu, G. *Tetrahedron: Asymmetry* **2012**, *23*, 1647.



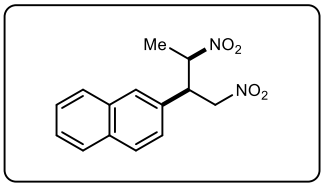
1-Bromo-3-((2*R*,3*R*)-1,3-dinitrobutan-2-yl)benzene (6l). Prepared according to the general procedure using (*E*)-1-bromo-3-(2-nitrovinyl)benzene (68.4 mg, 300 μmol) and nitroethane (430 μL, 6.00 mmol). Flash column chromatography (SiO_2, 10-30% ethyl acetate in hexanes) yielded the product as a white solid (71.0 mg, 78%). The product was determined to be 15:1 dr by ^{1}H NMR. Major diastereomer (*syn*) 97% ee by chiral HPLC analysis (Chiralpak IC, 20% ^{i}PrOH/hexanes, 1 mL/min, t_r(*e*$_{1,}$ minor) = 16.7 min, t_r(*e*$_{2,}$ major) = 26.9 min); mp 93-95 °C; R_f = 0.4 (30% EtOAc/hexanes); $[\alpha]_D^{20}$ +6.6 (*c* 1.0, $CHCl_3$); IR (film) 2920, 2347, 1549, 1366, 1075 cm^{-1}; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.49 (br d, *J* = 8.0 Hz, 1H), 7.30 (dd, *J* = 1.7, 1.7 Hz, 1H), 7.23 (dd, *J* = 7.9, 7.9 Hz, 1H), 7.09 (br d, *J* = 7.7 Hz, 1H), 4.97-4.87 (m, 2H), 4.79 (dd, *J* = 13.7, 8.3 Hz, 1H), 4.0 (ddd, *J* = 8.2, 6.3, 6.3 Hz, 1H), 1.60 (d, *J* = 6.7 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) ppm 135.9, 132.5, 131.4, 131.0, 126.5, 123.4, 83.9, 75.9, 47.0, 16.9; HRMS (ESI): Exact mass calcd for $C_{10}H_{12}BrN_2O_4$ $[M+H]^+$ 301.9897, found 301.9908.



1-((2*R*,3*R*)-1,3-Dinitrobutan-2-yl)-4-(trifluoromethoxy)benzene (6m). Prepared according to the general procedure using (*E*)-1-(2-nitrovinyl)-4-(trifluoromethoxy)benzene (70.0 mg, 300 μmol) and nitroethane (430 μL, 6.00 mmol). Flash column chromatography (SiO_2, 10-30% EtOAc/hexanes) yielded the product as a viscous colorless liquid (75.0 mg, 81%). The product was determined to be 20:1 dr by ^{1}H NMR. Major diastereomer (*syn*) 94% ee by chiral HPLC analysis (Chiralpak IC, 10% ^{i}PrOH/hexanes, 1 mL/min, t_r(*e*$_{1,}$ minor) = 9.3 min, t_r(*e*$_{2,}$ major) = 13.6 min); R_f = 0.4 (30% EtOAc/hexanes); $[\alpha]_D^{20}$ +7.6 (*c* 1.0, $CHCl_3$); IR (film) 2922, 2360, 1553, 1513, 1375, 1259, 1217, 1164, 915 cm^{-1}; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.20 (br s, 4H), 4.95 (dq, *J* = 6.7, 6.7 Hz, 1H), 4.91 (dd, *J* = 13.7, 6.0 Hz, 1H), 4.80 (dd, *J* = 13.7, 8.4 Hz, 1H), 4.04 (ddd, *J* = 8.3, 6.2, 6.2 Hz, 1H), 1.60 (d, *J* = 6.7 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) ppm 149.8, 132.1, 129.7, 121.7, 120.5 (q, *J* = 283 Hz), 83.9, 76.1, 46.8, 16.9; ^{19}F NMR (282 MHz, $CDCl_3$) ppm -57.8; HRMS (ESI): Exact mass calcd for $C_{11}H_{12}F_3N_2O_5$ $[M+H]^+$ 309.0693, found 309.0679.

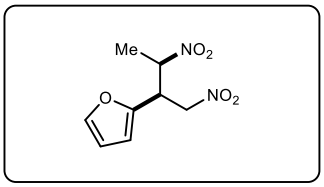


1-((2*R*,3*R*)-1,3-Dinitrobutan-2-yl)naphthalene (6n). Prepared according to the general procedure using (*E*)-1-(2-nitrovinyl)naphthalene (60.0 mg, 300 μmol) and nitroethane (430 μL, 6.00 mmol). Flash column chromatography (SiO_2, 10-30% EtOAc/hexanes) yielded the product as a yellow solid (77.0 mg, 93%). The product was determined to be >20:1 dr by ^{1}H NMR. Major diastereomer (*syn*) 95% ee by chiral HPLC analysis (Chiralpak IC, 20% ^{i}PrOH/hexanes, 1 mL/min, t_r(*e*$_{1,}$ minor) = 11.2 min, t_r(*e*$_{2,}$ major) = 21.1 min); ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.18 (d, *J* = 8.4 Hz, 1H), 7.90 (d, *J* = 8.1 Hz, 1H), 7.85 (d, *J* = 8.2 Hz, 1H), 7.65 (ddd, *J* = 8.2, 8.2, 1.2 Hz, 1H), 7.56 (ddd, *J* = 7.9, 7.9, 0.8 Hz, 1H), 7.45 (dd, *J* = 7.4, 7.4 Hz, 1H), 7.33 (d, *J* = 6.6 Hz, 1H), 5.21-5.12 (m, 2H), 5.00 (d, *J* = 7.1 Hz, 2H), 1.59 (d, *J* = 6.6 Hz, 3H); ^{13}C NMR (150 MHz, $CDCl_3$) ppm 134.3, 131.2, 130.1, 129.7, 129.5, 127.5, 126.4, 125.2, 123.9, 121.9, 83.8, 75.1, 40.8, 15.8; ^{1}H NMR data is identical to that reported in literature.[3]

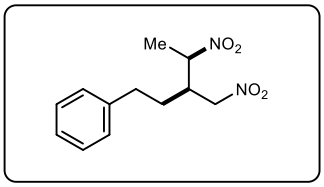


2-((2*R*,3*R*)-1,3-Dinitrobutan-2-yl)naphthalene (6o). Prepared according to the general procedure using (*E*)-2-(2-nitrovinyl)naphthalene (60.0 mg, 300 μmol) and nitroethane (430 μL, 6.00 mmol). Flash column chromatography (SiO_2, 10-30% EtOAc/hexanes) yielded the product as a yellow solid (72.0 mg, 88%). The product was determined to be >20:1 dr by ^{1}H NMR. Major diastereomer (*syn*) 95% ee by chiral HPLC analysis (Chiralpak IC, 20% ^{i}PrOH/hexanes, 1 mL/min, t_r(*e*$_{1,}$ minor) = 10.8 min, t_r(*e*$_{2,}$ major) = 14.7 min); ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.84 (d, *J* = 8.4 Hz, 1H), 7.82-7.79 (m, 2H), 7.63 (br s, 1H), 7.53-7.49 (m, 2H), 7.24 (dd, *J* = 8.4, 1.8 Hz, 1H), 5.05 (dq, *J* = 6.6, 6.6 Hz, 1H), 5.00 (dd, *J* = 13.6, 6.3 Hz, 1H), 4.92 (dd, *J* =

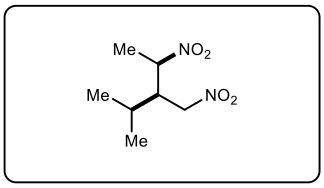
13.6, 8.2 Hz, 1H), 4.20 (ddd, *J* = 8.0, 6.3, 6.3 Hz, 1H), 1.63 (d, *J* = 6.7 Hz, 3H); ^{13}C NMR (150 MHz, $CDCl_3$) ppm 133.4, 133.3, 130.9, 129.5, 128.1, 127.8, 127.8, 127.0, 126.9, 125.0, 84.1, 76.2, 47.6, 16.9; ^{1}H NMR data is identical to that reported in literature.[2]



2-((2*R*,3*R*)-1,3-Dinitrobutan-2-yl)furan (6p). Prepared according to the general procedure using (*E*)-2-(2-nitrovinyl)furan (42.0 mg, 300 μmol) and nitroethane (430 μL, 6.00 mmol). Flash column chromatography (SiO_2, 10-30% EtOAc/hexanes) yielded the product as a brown solid (53.0 mg, 82%). The product was determined to be 9:1 dr by ^{1}H NMR. Major diastereomer (*syn*) 85% ee by chiral HPLC analysis (Chiralpak IC, 10% ^{i}PrOH/hexanes, 1 mL/min, t_r(*e1*, minor) = 14.9 min, t_r(*e2*, major) = 23.9 min); ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.38 (dd, *J* = 1.8, 0.7 Hz, 1H), 6.33 (dd, *J* = 3.2, 1.8 Hz, 1H), 6.26 (br d, *J* = 3.2, 1.8 Hz, 1H), 4.93 (qd, *J* = 6.8, 5.3 Hz, 1H), 4.90 (dd, *J* = 13.6, 6.2 Hz, 1H), 4.83 (dd, *J* = 13.6, 8.4 Hz, 1H), 4.20 (ddd, *J* = 8.0, 5.6, 5.6 Hz, 1H), 1.61 (d, *J* = 6.8 Hz, 3H); ^{13}C NMR (150 MHz, $CDCl_3$) ppm 147.0, 143.6, 110.9, 109.7, 82.5, 74.2, 41.2, 16.4; ^{1}H NMR data is identical to that reported in literature.[2]

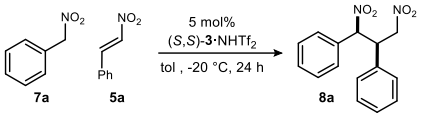


((3*R*,4*R*)-4-Nitro-3-(nitromethyl)pentyl)benzene (6q). Prepared according to the general procedure using (*E*)-(4-nitrobut-3-en-1-yl)benzene (54.0 mg, 300 μmol) and nitroethane (430 μL, 6.00 mmol). Flash column chromatography (SiO_2, 5-15% EtOAc/hexanes) yielded the product as a viscous colorless liquid (61.0 mg, 80%). The product was determined to be 10:1 dr by ^{1}H NMR. Major diastereomer (*syn*) 90% ee by chiral HPLC analysis (Chiralpak IC, 10% ^{i}PrOH/hexanes, 1 mL/min, t_r(*e1*, minor) = 12.1 min, t_r(*e2*, major) = 15.0 min); ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.31 (dd, *J* = 7.0, 7.0 Hz, 2H), 7.23 (tt, *J* = 7.3, 1.5 Hz, 1H), 7.14 (d, *J* = 8.6, 2H), 4.74 (qd, *J* = 6.8, 5.3 Hz, 1H), 4.67 (dd, *J* = 13.6, 6.6 Hz, 1H), 4.47 (dd, *J* = 13.6, 5.3 Hz, 1H), 2.82-2.59 (m, 3H), 1.83 (dddd, *J* = 14.3, 9.3, 7.1, 4.5 Hz, 1H), 1.69-1.59 (m, 1H), 1.55 (d, *J* = 6.7 Hz, 3H); ^{13}C NMR (150 MHz, $CDCl_3$) ppm 139.7, 128.9, 128.3, 126.8, 83.4, 75.0, 40.5, 32.9, 29.3, 16.2; ^{1}H NMR data is identical to that reported in literature.[2]



(3*R*,4*R*)-2-Methyl-4-nitro-3-(nitromethyl)pentane (6r). Prepared according to the general procedure using (*E*)-3-methyl-1-nitrobut-1-ene (34.5 mg, 300 μmol) and nitroethane (430 μL, 6.00 μmol). Flash column chromatography (SiO_2, 5-10% EtOAc/hexanes) yielded the product as a viscous colorless liquid (14.5 mg, 25%). The product was determined to be 11:1 dr by ^{1}H NMR. Major diastereomer (*syn*) 91% ee by chiral HPLC analysis (Chiralpak IC, 10% ^{i}PrOH/hexanes, 1 mL/min, t_r(minor) = 9.59 min, t_r(major) = 11.8 min); ^{1}H NMR (400 MHz, $CDCl_3$) δ 4.77 (dq, *J* = 6.7, 6.7 Hz, 1H), 4.48 (d, *J* = 6.3 Hz, 1H), 4.43 (d, *J* = 6.0 Hz, 1H), 2.86 (dddd, *J* = 6.5, 6.5, 4.9, 4.9 Hz, 1H), 1.86 (qqd, *J* = 6.8, 6.8, 4.8 Hz, 1H), 1.56 (d, *J* = 6.8 Hz, 3H), 1.05 (d, *J* = 6.8 Hz, 3H), 0.91 (d, *J* = 6.9 Hz, 3H); ^{13}C NMR (150 MHz, $CDCl_3$) ppm 83.1, 73.2, 46.2, 28.1, 20.8, 17.8 16.5;^{1}H NMR data is identical to that reported in literature.[3]

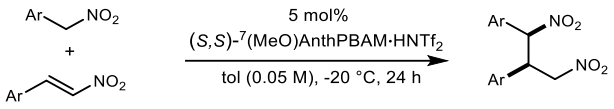
Optimization of the Enantioselective Addition of Phenylnitroalkanes to Nitroalkenes



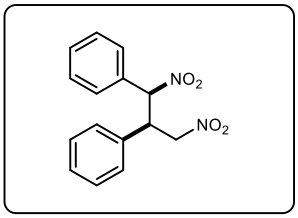
Entry[a]	**7a** (equiv.)	Conc. (M)	dr	ee[b]	Yield (%)[c]
1	**20**	0.2	10:1	84	99
2	**8**	0.2	14:1	90	98
3	**5**	0.2	16:1	89	97
4	**2**	0.4	18:1	88	96
5	**2**	0.1	15:1	90	95
6	**2**	0.05	15:1	92	95
7	**2**	0.033	17:1	93	96
8	**2**	0.025	18:1	93	95
9	**1**	0.05	15:1	92	95

[a] All reactions were performed on a 0.1 mmol scale. [b] Enantiomeric ratios were measured using HPLC with a chiral stationary phase. [c] Yield determined by ^{1}H NMR analysis relative to an internal standard (CH_2Br_2).

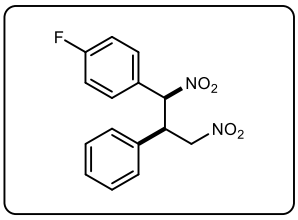
General Procedure for the Enantioselective Addition of Phenylnitroalkanes to Nitroalkenes



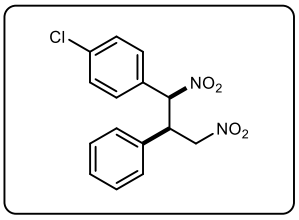
To a flame-dried microwave vial equipped with a stir bar was added (*S*,*S*)-^{7}(MeO)AnthPBAM•NHTf$_2$ (5 mol%), phenylnitro methane derivative (1 equiv), and toluene (0.05 M), and then the reaction mixture was cooled to -20 °C. β-Nitro styrene (1 equiv) was added to the reaction mixture after 15 min, and the solution was stirred for 24 h. The crude reaction mixture was passed (cold) through a pad of silica gel using 50% EtOAc/hexanes solution, and then concentrated under vacuum. The residue was purified by flash column chromatography to give the addition product.



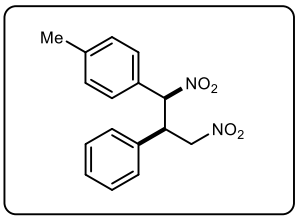
((1*S*,2*R*)-1,3-Dinitropropane-1,2-diyl)dibenzene (8a). Prepared according to the general procedure using (*E*)-(2-nitrovinyl)benzene (14.9 mg, 100 μmol) and (nitromethyl)benzene (13.7 mg, 100 μmol). Flash column chromatography (SiO_2, 5-30% ethyl acetate in hexanes) yielded the product as a white solid (27.0 mg, 95%); the product was determined to be 15:1 dr by ^{1}H NMR. Major diastereomer, *syn*: 92% ee by chiral HPLC analysis (Chiralpak IC, 10% ^{i}PrOH/hexanes, 1 mL/min, t_r (*e*$_1$, minor) = 11.7 min, t_r (*e*$_2$, major) = 13.6 min). Mp 140-142 °C; R_f = 0.50 (20% EtOAc/hexanes); $[\alpha]_D^{20}$ +2 (*c* 1.0, $CHCl_3$); IR (film) 2923, 1548, 1366, 1233, 709 cm^{-1}; Major diastereomer: ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.67-7.65 (m, 2H), 7.53-7.47 (m, 3H), 7.40-7.29 (m, 5H), 5.91 (d, *J* = 11.6 Hz, 1H), 4.60 (ddd, *J* = 13.0, 9.1, 4.4 Hz, 1H), 4.46 (dd, *J* = 12.9, 9.1 Hz, 1H), 4.32 (dd, *J* = 12.9, 4.4 Hz, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) ppm 134.3, 131.4, 131.2, 129.9, 129.5, 129.2, 128.2, 127.9, 92.9, 77.0, 47.6; HRMS (ESI): Exact mass calcd for $C_{15}H_{14}NO_2$ [M-NO_2] 240.1019, found 240.1017.



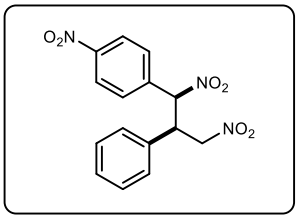
1-((1*S*,2*R*)-1,3-Dinitro-2-phenylpropyl)-4-fluorobenzene (8b). Prepared according to the general procedure using (*E*)-(2-nitrovinyl)benzene (14.9 mg, 100 μmol) and 1-fluoro-4-(nitromethyl)benzene (15.5 mg, 100 μmol). Flash column chromatography (SiO_2, 5-30% ethyl acetate in hexanes) yielded the product as a white solid (28.0 mg, 98%). The product was determined to be 9.5:1 dr (crude reaction mixture, ^{1}H NMR) but changed to 8:1 dr after purification. Major diastereomer, *syn*: 92% ee by chiral HPLC analysis (Chiralpak IC, 10% ^{i}PrOH/hexanes, 1 mL/min, t_r(*e*$_1$, minor) = 9.6 min, t_r(*e*$_2$, major) = 12.1 min). Mp 138-140 °C; R_f = 0.65 (20% EtOAc/hexanes); $[\alpha]_D^{20}$ -10 (*c* 1.0, $CHCl_3$); IR (film) 2921, 1555, 1510, 1372, 1233, 770 cm^{-1}; ^{1}H NMR (400 MHz, $CDCl_3$, 8:1 mixture of diastereomers) Major diastereomer: δ 7.67 (dd, *J* = 8.7, 5.0 Hz, 2H), 7.41-7.30 (m, 2H), 7.19 (dd, *J* = 8.4, 8.4 Hz, 2H) 5.93 (d, *J* = 11.5 Hz, 1H), 4.55 (ddd, *J* = 13.0, 8.5, 4.4 Hz, 1H), 4.45 (dd, *J* = 12.8, 8.6 Hz, 1H), 4.33 (dd, *J* = 12.8, 4.4 Hz, 1H). ^{13}C NMR (100 MHz, $CDCl_3$) ppm Major dia: 164.3 (d, *J* = 252.0 Hz) 134.0, 130.4, 130.3, 129.6, 129.3, 127.8, 117.0 (d, *J* = 22.0 Hz), 92.0, 76.9, 47.7. Minor dia *: 163.6, (d, *J* = 251.6 Hz), 133.1, 130.2, 130.1, 129.4, 128.9, 128.2, 127.4, 127.3, 116.3 (d, *J* = 22.1 Hz), 91.5, 77.2, 47.7; HRMS (ESI): Exact mass calcd for $C_{15}H_{13}FNO_2$ [M-NO_2] 258.0925, found 258.0930.



1-Chloro-4-((1*S*,2*R*)-1,3-dinitro-2-phenylpropyl)benzene (8c). Prepared according to the general procedure using (*E*)-(2-nitrovinyl)benzene (14.9 mg, 100 μmol) and 1-chloro-4-(nitromethyl)benzene (17.1 mg, 100 μmol). Flash column chromatography (SiO_2, 5-30% EtOAc/hexanes) yielded the product as a white solid (31.0 mg, 96%). The product was determined to be 12:1 dr (crude reaction mixture, ^{1}H NMR) which changed to 7:1 dr after purification by flash chromatography. Major diastereomer: *syn*, 91% ee by chiral HPLC analysis (Chiralpak IC, 10% ^{i}PrOH/hexanes, 1 mL/min, t_r(*e*$_1$, minor) = 8.8 min, t_r(*e*$_2$, major) = 10.7 min). Mp 135-137 °C; R_f = 0.70 (20% EtOAc/hexanes); $[\alpha]_D^{20}$ -18 (*c* 1.0, $CHCl_3$); IR (film) 2923, 1556, 1494, 1370, 1093, 765 cm^{-1}; ^{1}H NMR (400 MHz, $CDCl_3$, 7:1 mixture of diastereomers) Major diastereomer: δ 7.61 (d, *J* = 8.0, 2H), 7.48 (d, *J* = 8.0, 2H), 7.38-7.34 (m, 2H), 5.93 (d, *J* = 11.4 Hz, 1H; 4.53 (ddd, *J* = 11.7, 7.8, 4.4 Hz, 1H), 4.45 (dd, *J* = 12.6, 8.9 Hz, 1H), 4.34 (dd, *J* = 12.7, 3.8 Hz, 1H). ^{13}C NMR (100 MHz, $CDCl_3$) ppm Major dia: 137.6, 133.9, 130.2, 129.8, 129.6, 129.4, 127.8, 92.1, 76.9, 47.6. Minor dia*: 136.5, 133.0, 129.5, 129.4, 129.4, 129.0, 128.2, 91.5, 77.2, 47.6; HRMS (ESI): Exact mass calcd for $C_{15}H_{13}ClNO_2$ [M-NO_2] 274.0629, found 274.0624.

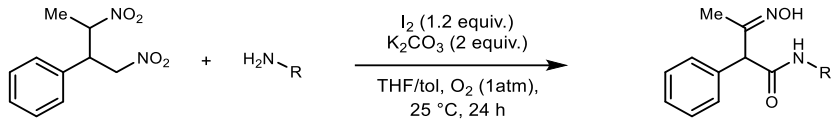


1-((1*S*,2*R*)-1,3-Dinitro-2-phenylpropyl)-4-methylbenzene (8d). Prepared according to the general procedure using (*E*)-(2-nitrovinyl)benzene (14.9 mg, 100 μmol) and 1-methyl-4-(nitromethyl)benzene (15.1 mg, 100 μmol). Flash column chromatography (SiO_2, 10-30% ethyl acetate in hexanes) yielded the product as a white solid (29.5 mg, 98%). The product was determined to be 16:1 dr by ^{1}H NMR. Major diastereomer: *syn*, 93% ee by chiral HPLC analysis (Chiralpak IC, 10% ^{i}PrOH/hexanes, 1 mL/min, t_r(*e*$_1$,minor) = 8.9 min, t_r(*e*$_2$,major) = 9.8 min). Mp 153-155 °C; R_f = 0.42 (20% EtOAc/hexanes); $[\alpha]_D^{20}$ -9 (*c* 1.0, $CHCl_3$); IR (film) 2922, 1552, 1372, 1216, 756, 699 cm^{-1}; Major diastereomer: ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.54 (br d, *J* = 8.0 Hz, 2H), 7.39-7.32 (m, 5H), 7.29 (br d, *J* = 7.9 Hz, 2H), 5.86 (d, *J* = 11.7 Hz, 1H); 4.59 (ddd, *J* = 12.0, 9.2, 4.4 Hz, 1H), 4.45 (dd, *J* = 12.9, 9.2 Hz, 1H), 4.32 (dd, *J* = 12.9, 4.3 Hz, 1H), 2.40 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) ppm 141.6, 134.4, 130.5, 129.5, 129.2, 128.5, 128.0, 127.9, 92.7, 77.1, 47.7, 21.4.; HRMS (ESI): Exact mass calcd for $C_{16}H_{16}NO_2$ [M-NO_2] 254.1176, found 254.1180.

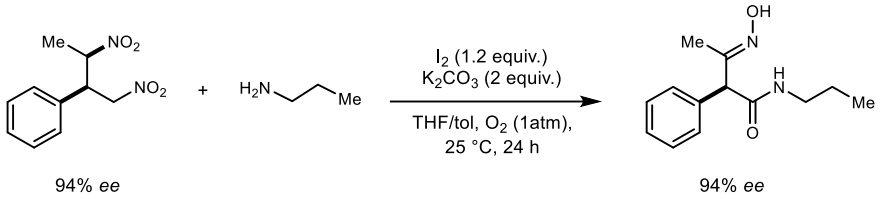


1-((1*S*,2*R*)-1,3-Dinitro-2-phenylpropyl)-4-nitrobenzene (8e). Prepared according to the general procedure using (*E*)-(2-nitrovinyl)benzene (14.9 mg, 100 μmol) and 1-nitro-4-(nitromethyl)benzene (18.2 mg, 100 μmol). Flash column chromatography (SiO_2, 5-30% ethyl acetate in hexanes) yielded the product as a white solid (32.0 mg, 97%). The product was determined to be 6:1 dr (crude reaction mixture, ^{1}H NMR) which changed to 3:1 dr after purification. Major diastereomer: *syn*, 75% ee and minor diastereomer: *anti*: 70% ee by chiral HPLC analysis (Chiralpak IC, 20% ^{i}PrOH/hexanes, 1 mL/min, t_r(*d*$_1$*e*$_1$, minor) = 9.4 min, t_r(*d*$_1$*e*$_2$, major) = 10.1 min, t_r(*d*$_2$*e*$_1$, major) = 16.0 min, t_r(*d*$_2$*e*$_2$, minor) = 16.19 min). Mp 102-104 °C; R_f = 0.55 (20% EtOAc/hexanes); $[\alpha]_D^{20}$ -15 (*c* 1.0, $CHCl_3$); IR (film) 2932, 1556, 1527, 1350, 1216, 771 cm^{-1}; ^{1}H NMR (400 MHz, $CDCl_3$, 3:1 mixture of diastereomers) Major diastereomer: δ 8.35 (d, *J* = 8.7 Hz, 2H), 7.88 (d, *J* = 8.7 Hz, 2H), 7.41-7.32 (m, 5H), 6.12 (d, *J* = 11.3 Hz, 1H), 4.60-4.52 (m, 1H, 4.46 (dd, *J* = 12.9), 7.6 Hz, 1H), 4.38 (dd, *J* = 12.9, 4.8 Hz, 1H). ^{13}C NMR (100 MHz, ($CDCl_3$) ppm Major dia: 149.6, 137.6, 133.4, 129.8, 129.6, 127.8, 124.9, 91.7, 76.7, 47.7. Minor dia*: 148.9, 138.0, 132.4, 129.4, 129.3, 128.2, 124.2, 91.1, 77.0, 47.7; HRMS (ESI): Exact mass calcd for $C_{15}H_{13}N_2O_4$ [M-NO_2] 285.0870, found 285.0862.
* See image of NMR spectra for additional details

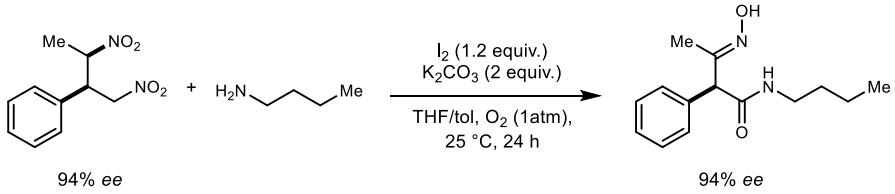
General Procedure for the Amidation of 1,3-Dinitroalkanes using UmAS



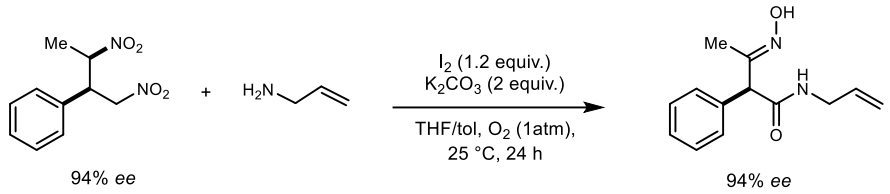
To a (2-5 mL) microwave vial equipped with a stir bar was added dinitroalkane (1 equiv) in dry 1:1 (v/v) THF/toluene (0.1 M), and this was followed by the sequential addition of K_2CO_3 (2 equiv), I_2 (1.2 equiv) and amine (2 equiv) was added after 5 min. The vial was equipped with an O_2 balloon and stirred at 25 °C for 24 h. The crude reaction mixture was passed through a pad of 15% $Na_2S_2O_3$/silica (w/w) using 50% CH_2Cl_2/EtOAc solution, and then concentrated under vacuum. The residue was purified by flash column chromatography to give the desired product.



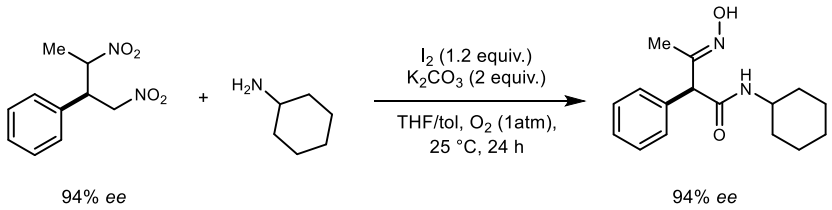
(*S*,*E*)-3-(Hydroxyimino)-2-phenyl-*N*-propylbutanamide (10a). Prepared according to the general procedure using (1,3-dinitrobutan-2-yl)benzene (44.8 mg, 200 μmol) and *n*-propylamine (32.8 μL, 400 μmol). Flash column chromatography (SiO_2, 20-50% EtOAc/hexanes) yielded the amide as a white solid (33.0 mg, 70%); The product was determined to be 94% ee by chiral HPLC analysis (Chiralpak IC, 10% ^{i}PrOH/hexanes, 1.0 mL/min, t_r(*e*$_1$, major) = 21.7 min, t_r(*e*$_2$, minor) = 33.3 min; Mp 126-128 °C; R_f = 0.34 (50% EtOAc/hexanes, visualized using PMA); $[\alpha]_D^{20}$ +19 (*c* 1.0, $CHCl_3$); IR (film) 3288, 2945, 1648, 1541, 1451, 1002 cm^{-1}; ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.02 (br s, 1H), 7.37-7.28 (m, 5H), 6.02 (br s, 1H), 4.41 (s, 1H), 3.19 (dt, *J* = 6.8, 6.8 Hz, 2H), 1.90 (s, 3H), 1.46 (tq, 7.2, 7.2 Hz, 2H), 0.84 (t, *J* =7.2 Hz, 3H); ^{13}C NMR (100 MHz, ($CDCl_3$) ppm 169.7, 157.4, 136.1, 129.1, 128.8, 128.0, 59.1, 41.5, 22.7, 13.7, 11.4; HRMS (ESI): Exact mass calcd for $C_{13}H_{19}N_2O_2$ $[M+H]^+$ 235.1447, found 235.1458.



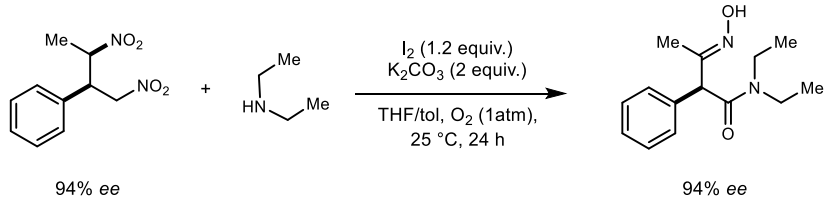
(*S*,*E*)-*N*-Butyl-3-(Hydroxyimino)-2-phenylbutanamide (10b). Prepared according to the general procedure using (1,3-dinitrobutan-2-yl)benzene (44.8 mg, 200 μmol) and *n*-butylamine (40.0 μL, 400 μmol). Flash column chromatography (SiO_2, 20-50% EtOAc/hexanes) yielded the amide as a white solid (35.0 mg, 70%). The product was determined to be 94% ee by chiral HPLC analysis (Chiralpak IC, 15% ^{i}PrOH/hexanes, 1.0 mL/min, t_r(*e*$_1$, major) = 10.9 min, t_r(*e*$_2$, minor) = 15.9 min). Mp 127-129 °C; R_f = 0.2 (30% EtOAc/hexanes, visualized using PMA); $[\alpha]_D^{20}$ +20 (*c* 1.0, $CHCl_3$); IR (film) 3300, 2932, 1650, 1541, 701 cm^{-1}; ^{1}H NMR (400 MHz, ($CDCl_3$) δ 8.00 (br s, 1H), 7.40-7.28 (m, 5H), 5.99 (br s, 1H), 4.40 (s, 1H), 3.22 (dt, *J* = 7.0, 7.0 Hz, 2H), 1.89 (s, 3H), 1.42 (tt, 6.7, 6.7 Hz, 2H), 1.26 (tq, 7.2, 7.2 Hz, 2H), 0.87 (t, 7.3 Hz, 3H); ^{13}C NMR (100 MHz, ($CDCl_3$) ppm 169.7, 157.4, 136.1, 129.1, 128.8, 128.0, 59.1, 39.6, 31.5, 20.1, 13.8, 13.7; HRMS (ESI): Exact mass calcd for $C_{14}H_{21}N_2O_2$ $[M+H]^+$ 249.1603, found 249.1612.



(*S*,*E*)-*N*-Allyl-3-(Hydroxyimino)-2-phenylbutanamide (10c). Prepared according to the general procedure using (1,3-dinitrobutan-2-yl)benzene (44.8 mg, 200 μmol) and allylamine (30.0 μL, 400 μmol). Flash column chromatography (SiO_2, 20-50% EtOAc/hexanes) yielded the amide as a white solid (33 mg, 72%). The product was determined to be 94% ee by chiral HPLC analysis (Chiralpak IC, 20% ^{i}PrOH/hexanes, 1.0 mL/min, t_r(*e*$_1$, major) = 7.9 min, t_r(*e*$_2$, minor) = 10.2 min; Mp 132-134.°C; R_f = 0.2 (30% EtOAc/hexanes, visualized using PMA); $[\alpha]_D^{20}$ +24. (*c* 1.0, $CHCl_3$); IR (film) 3330, 2923, 1643, 1534, 1202 cm^1; ^{1}H NMR (400 MHz, ($CDCl_3$) δ 7.82 (br s, 1H), 7.38-7.30 (m, 5H), 6.13 (br s, 1H), 5.78 (ddt, *J* = 16.9, 12.6, 5.5 Hz, 1H), 5.11-5.05 (m, 2H), 4.44 (s, 1H), 3.86 (dddd, 5.6, 5.6, 1.8, 1.8 Hz, 2H), 1.90 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) ppm 169.6, 157.2, 135.9, 134.0, 129.1, 128.8, 128.1, 116.4, 59.1, 42.1, 13.7; HRMS (ESI): Exact mass calcd for $C_{13}H_{16}N_2O_2Na$ $[M+Na]^+$ 255.1109, found 255.1112.

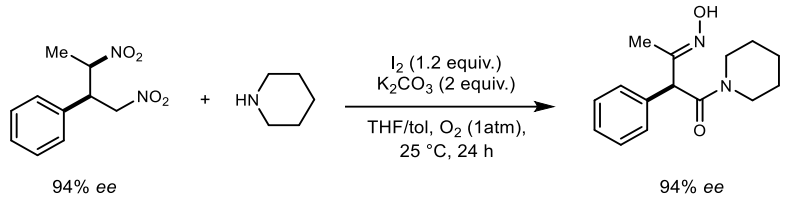


(*S*,*E*)-*N*-Cyclohexyl-3-(Hydroxyimino)-2-phenylbutanamide (10d). Prepared according to the general procedure using (1,3-dinitrobutan-2-yl)benzene (44.8 mg, 200 μmol) and cyclohexylamine (46.0 μL, 400 μmol). Flash column chromatography (SiO_2, 20-50% EtOAc/hexanes) yielded the amide as a white solid (40 mg, 74%). The product was determined to be 94% ee by chiral HPLC analysis (Chiralpak IC, 20% ^{i}PrOH/hexanes, 1.0 mL/min, t_r(*e*$_1$, major) = 7.1 min, t_r(*e*$_2$, minor) = 9.7 min). Mp 172-174 °C; R_f = 0.25 (30% EtOAc/hexanes, visualized using PMA); $[\alpha]_D^{20}$ -106 (*c* 1.0, $CHCl_3$); IR (film) 3285, 2925, 1640, 1551, 709 cm^{-1}; ^{1}H NMR (400 MHz, ($CDCl_3$) δ 7.54 (br s, 1H), 7.37-7.28 (m, 5H), 5.99 (br d, *J* = 7.0 Hz, 1H), 4.37 (s, 1H), 3.82-3.73 (m, 1H), 1.90 (s, 3H), 1.90-1.82 (m, 2H), 1.65-1.55 (m, 4H), 1.38-1.28 (m, 2H), 1.17-1.09 (m, 2H); ^{13}C NMR (100 MHz, $CDCl_3$) ppm 168.7, 157.8, 136.2, 129.0, 128.8, 127.9, 59.1, 48.5, 32.9, 32.9, 31.5, 25.6, 24.8, 13.5; HRMS (ESI): Exact mass calcd for $C_{16}H_{23}N_2O_2$ $[M+H]^+$ 275.1760, found 275.1772.

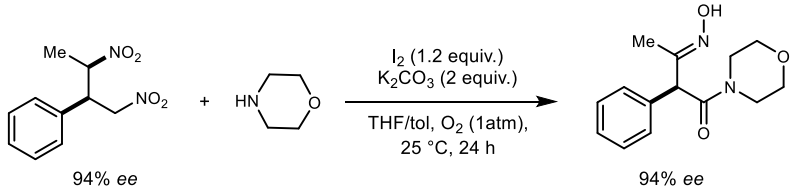


(*S*,*E*)-*N*,*N*-Diethyl-3-(Hydroxyimino)-2-phenylbutanamide (10e). Prepared according to the general procedure using (1,3-dinitrobutan-2-yl)benzene (44.8 mg, 200 μmol) and diethylamine (42.0 μL, 400 μmol). Flash column chromatography (SiO_2, 20-50% EtOAc/hexanes) yielded the amide as an off-white solid (40.0 mg, 80%). The product was determined to be 94% ee by chiral HPLC analysis (Chiralpak IC, 15% ^{i}PrOH/hexanes, 1.0 mL/min, t_r(*e*$_1$, minor) = 13.0 min, t_r(*e*$_2$, major) = 14.5 min. Mp 100-102 °C; R_f = 0.2 (30% EtOAc/hexanes, visualized using PMA); $[\alpha]_D^{20}$ -133 (*c* 1.0, $CHCl_3$); IR (film) 3315, 2964, 1632, 1449, 1006 cm^{-1}; ^{1}H NMR (400 MHz, $CDCl_3$) δ

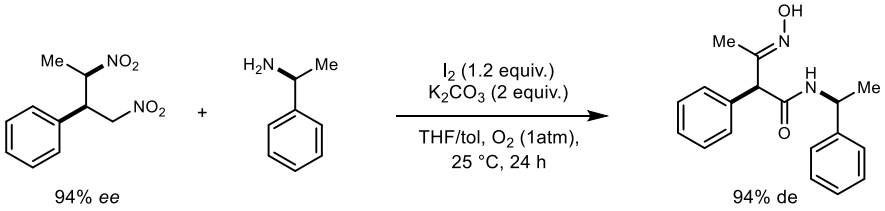
8.18 (br s, 1H), 7.35-7.25 (m, 5H), 4.70 (s, 1H), 3.53 (dq, *J* = 14.0, 7.0 Hz, 1H), 3.33-3.18 (m, 2H), 3.12 (dq, *J* = 14.7, 7.2 Hz, 1H), 1.89 (s, 3H), 1.13 (t, *J* = 7.0 Hz, 3H), 1.05 (t, *J* = 7.1 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) ppm 169.3, 158.5, 135.9, 128.9, 128.7, 127.7, 54.6, 42.2, 40.4, 14.3, 13.2, 12.9; HRMS (ESI): Exact mass calcd for $C_{14}H_{21}N_2O_2$ $[M+H]^+$ 249.1603, found 249.1609.



(*S*,*E*)-3-(Hydroxyimino)-2-phenyl-1-(piperidin-1-yl)butan-1-one (10f). Prepared according to the general procedure using (1,3-dinitrobutan-2-yl)benzene (44.8 mg, 200 μmol) and piperidine (40.0 μL, 400 μmol). Flash column chromatography (SiO_2, 20-50% EtOAc/hexanes) yielded the amide as a foamy off-white solid (43.0 mg, 83%). The product was determined to be 94% ee by chiral HPLC analysis (Chiralpak IC, 20% ^{i}PrOH/hexanes, 1.0 mL/min, t_r(*e*$_1$, major) = 14.6 min, t_r(*e*$_2$, minor) = 16.4 min); R_f = 0.25 (30% EtOAc/hexanes, visualized using PMA); $[\alpha]_D^{20}$ -121 (*c* 1.0, $CHCl_3$); IR (film) 3312, 2935, 2860, 1631, 1445, 1015, 712 cm^{-1}; ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.38 (br s, 1H), 7.35 -7.25 (m, 5H), 4.73 (s, 1H), 3.70-3.65 (m, 1H), 3.50-3.46 (m, 1H), 3.25-3.21 (m, 2H), 1.87 (s, 3H), 1.55-1.53 (m, 4H), 1.41-1.37 (m, 1H), 1.18-1.12 (m, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) ppm 168.5, 158.3, 135.7, 128.9, 128.8, 127.6, 55.1, 47.0, 43.0, 26.0, 25.5, 24.5, 13.3; HRMS (ESI): Exact mass calcd for $C_{15}H_{21}N_2O_2$ $[M+H]^+$ 261.1598, found 261.1599.

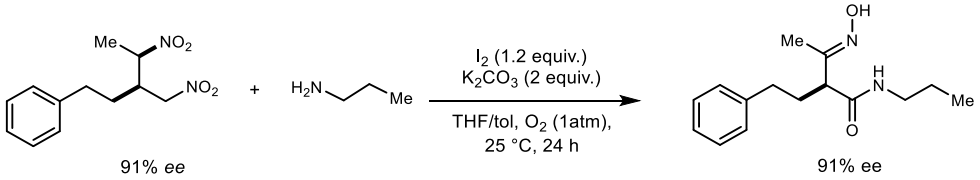


(*S*,*E*)-3-(Hydroxyimino)-1-morpholino-2-phenylbutan-1-one (10g). Prepared according to the general procedure using (1,3-dinitrobutan-2-yl)benzene (44.8 mg, 200 μmol) and morpholine (35.0 μL, 400 μmol). Flash column chromatography (SiO_2, 20-30-100% EtOAc/hexanes) yielded the amide as a off-white solid (43.0 mg, 82%). The product was determined to be 94% ee by chiral HPLC analysis (Chiralpak AD-H, 20% ^{i}PrOH/hexanes, 1.0 mL/min, t_r(*e*$_1$, minor) = 15.1 min, t_r(*e*$_2$, major) = 17.5 min. Mp 127-129 °C; R_f = 0.1 (40% EtOAc/hexanes, visualized using PMA); $[\alpha]_D^{20}$ -113 (*c* 1.0, $CHCl_3$); IR (film) 3323, 2858, 1637, 1438, 1112 cm^{-1}; ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.68 (br s, 1H), 7.36-7.24 (m, 5H), 4.69 (s, 1H), 3.73-3.66 (m, 2H), 3.61-3.48 (m, 3H), 3.35-3.20 (m, 3H), 1.86 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) ppm 169.0, 157.6, 135.2, 129.0, 128.8, 127.9, 66.8, 66.3, 55.0, 46.4, 42.3, 13.3; HRMS (ESI): Exact mass calcd for $C_{14}H_{19}N_2O_3$ $[M+H]^+$ 263.1390, found 263.1393.

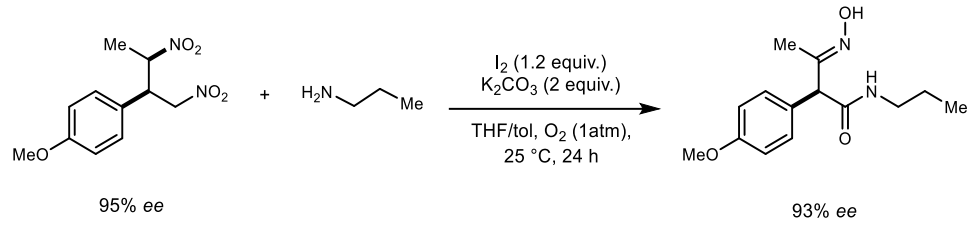


(*S*,*E*)-3-(Hydroxyimino)-2-phenyl-*N*-((S)-1-phenylethyl)butanamide (10h). Prepared according to the general procedure using (1,3-dinitrobutan-2-yl)benzene (44.8 mg, 200 μmol) and *(S)*-1-phenylethan-1-amine (52.0 μL,

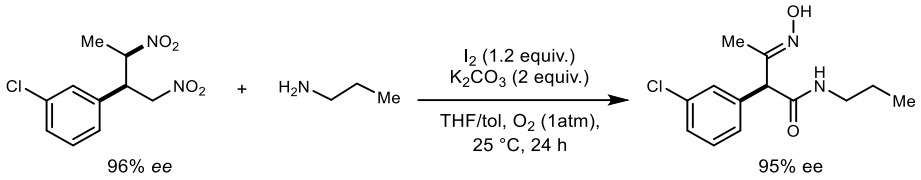
400 μmol). Flash column chromatography (SiO_2, 10-30% EtOAc/hexanes) yielded the amide as a foamy white solid (40 mg, 67%). R_f = 0.55 (50% EtOAc/hexanes, visualized using PMA); $[\alpha]_D^{20}$ -22 (*c* 1.0, $CHCl_3$); IR (film) 3289, 3062, 1647, 1537, 1495, 1267 cm^{-1}; ^1H NMR (400 MHz, $CDCl_3$) δ 8.28 (br s, 1H), 7.34-7.15 (m, 10H), 6.33 (d, *J* = 7.7 Hz, 1H), 5.08 (dq, *J* = 7.0, 7.0 Hz, 1H), 4.41 (s, 1H), 1.86 (s, 3H), 1.40 (d, 6.9 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) ppm 169.0, 157.2, 143.1, 136.0, 129.1, 128.8, 128.7, 128.0, 127.3, 126.1, 58.9, 49.1, 21.8, 13.6; HRMS (ESI): Exact mass calcd for $C_{18}H_{21}N_2O_2$ $[M+H]^+$ 297.1598, found 297.1601.



(*S*,*E*)-3-(Hydroxyimino)-2-phenethyl-N-propylbutanamide (11). Prepared according to the general procedure using ((3*R*,4*R*)-4-nitro-3-(nitromethyl)pentyl)benzene (25.2 mg, 100 μmol) and *n*-propylamine (16.5 μL, 200 μmol). Flash column chromatography (SiO_2, 20-50% EtOAc/hexanes) yielded the amide as a white solid (21 mg, 80%). The product was determined to be 91% ee by chiral HPLC analysis (Chiralpak AD-H, 10% ^{i}PrOH/hexanes, 1.0 mL/min, t_r(*e*$_1$, minor) = 16.8 min, t_r(*e*$_2$, major) = 18.2 min. Mp 86-88 °C; R_f = 0.35 (40% EtOAc/hexanes, visualized using PMA); $[\alpha]_D^{20}$ +55.4 (*c* 1.0, $CHCl_3$); IR (film) 3292, 2932, 1647, 1544, 1450, 1369 cm^{-1}; ^1H NMR (400 MHz, $CDCl_3$) δ 7.62 (br s, 1H), 7.29-7.22 (m, 2H), 7.19-7.16 (m, 3H), 5.72 (br s, 1H), 3.19 (dt, *J* = 6.7, 6.7 Hz, 2H), 3.04 (dd, *J* = 7.5, 7.5 Hz, 1H), 2.66-2.53 (m, 2H), 2.24 (ddt, *J* = 15.8, 8.6, 7.1 Hz, 1H), 2.05-1.94 (m, 1H), 1.89 (s, 3H), 1.49 (tq, 7.3, 7.3 Hz, 2H), 0.89 (t, 7.4 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) ppm 170.5, 158.3, 141.3, 128.6, 128.5, 126.1, 52.3, 41.4, 33.4, 30.5, 22.9, 11.4, 11.4; HRMS (ESI): Exact mass calcd $C_{15}H_{22}N_2O_2Na$ $[M+Na]^+$ 285.1573, found 285.1575.

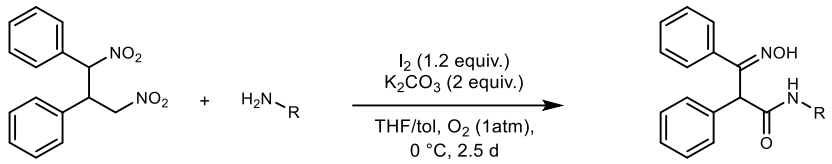


(*S*,*E*)-3-(Hydroxyimino)-2-(4-methoxyphenyl)-*N*-propylbutanamide (12). Prepared according to the general procedure using (1,3-dinitrobutan-2-yl)benzene (25.4 mg, 100 μmol) and *n*-propylamine (16.5 μL, 200 μmol). Flash column chromatography (SiO_2, 20-50% EtOAc/hexanes) yielded the amide as a white solid (20 mg, 75%). The product was determined to be 93% ee by chiral HPLC analysis (Chiralpak IC, 30% ^{i}PrOH/hexanes, 1.0 mL/min, t_r(*e*$_1$, major) = 7.0 min, t_r(*e*$_2$, minor) = 8.8 min). Mp 105-107 °C; R_f = 0.17 (40% EtOAc/hexanes, visualized using PMA); $[\alpha]_D^{20}$ +10 (*c* 1.0, $CHCl_3$); IR (film) 3295, 2928, 1648, 1512, 1456, 1251 cm^{-1}; ^1H NMR (400 MHz, $CDCl_3$) δ 8.20 (br s, 1H), 7.24 (d, *J* = 8.7 Hz, 2H), 6.88 (d, *J* = 8.7 Hz, 2H), 6.0 (br s, 1H), 4.36 (s, 1H), 3.79 (s, 3H), 3.20-3.14 (m, 2H), 1.88 (s, 3H), 1.45 (tq, 7.3, 7.3 Hz, 2H), 0.83 (t, 7.3 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) ppm 170.1, 159.3, 157.5, 130.0, 128.0, 114.5, 58.3, 55.4, 41.5, 22.7, 13.6, 11.4; HRMS (ESI): Exact mass calcd for $C_{14}H_{20}N_2O_3Na$ $[M+Na]^+$ 287.1372, found 287.1367.

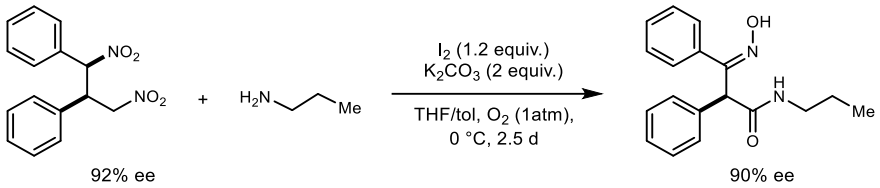


(*S*,*E*)-2-(3-Chlorophenyl)-3-(hydroxyimino)-*N*-propylbutanamide (13). Prepared according to the general procedure using (1,3-dinitrobutan-2-yl)benzene (25.8 mg, 100 μmol) and *n*-propylamine (16.5 μL, 200 μmol). Flash column chromatography (SiO_2, 20-50% EtOAc/hexanes) yielded the amide as a white solid (20 mg, 75%). The product was determined to be 95% ee by chiral HPLC analysis (Chiralpak IC, 15% ^{i}PrOH/hexanes, 1.0 mL/min, t_r(*e*$_1$, major) = 7.9 min, t_r(*e*$_2$, minor) = 9.7 min. Mp 134-136 °C; R_f = 0.17 (40% EtOAc/hexanes, visualized using PMA); $[\alpha]_D^{20}$ +12 (*c* 1.0, $CHCl_3$); IR (film) 3291, 2961, 1648, 1555, 1200 cm^{-1}; ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.24 (br s, 1H), 7.33-7.21 (m, 4H), 6.21 (br s, 1H), 4.36 (s, 1H), 3.18 (dt, *J* = 6.9, 6.9 Hz, 2H), 1.89 (s, 3H), 1.47 (tq, 7.2, 7.2 Hz, 2H), 0.85 (t, 7.3 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) ppm 169.1, 156.9, 138.1, 134.8, 130.2, 129.0, 128.2, 127.1, 58.5, 41.6, 22.7, 13.6, 11.4; HRMS (ESI): Exact mass calcd for $C_{13}H_{17}ClN_2O_2Na$ $[M+Na]^+$ 291.0876, found 291.0876.

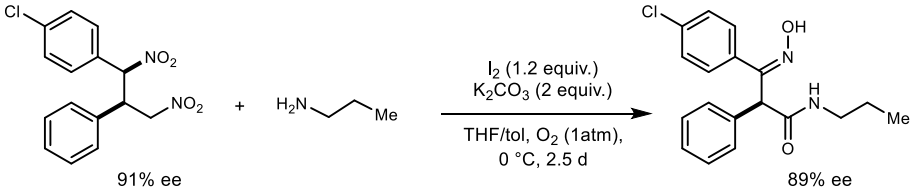
General Procedure for the Amidation of Phenyl Nitromethane Adducts using UmAS



To a (2-5 mL) microwave vial equipped with a stir bar was added dinitroalkane (1 equiv.) in dry 1:1 (v/v) THF/toluene (0.1 M) at 0 °C. To this was added K_2CO_3 (2 equiv.), amine (2 equiv.) sequentially and I_2 (1.2 equiv.) was added after 10 min. The vial was equipped with an O_2 balloon and stirred at 0 °C for 2.5 d. The crude reaction mixture was passed through a pad of 15% $Na_2S_2O_3$/silica (w/w) using 50% CH_2Cl_2/EtOAc solution, and then concentrated under vacuum. The residue was purified by flash column chromatography to give the desired product.

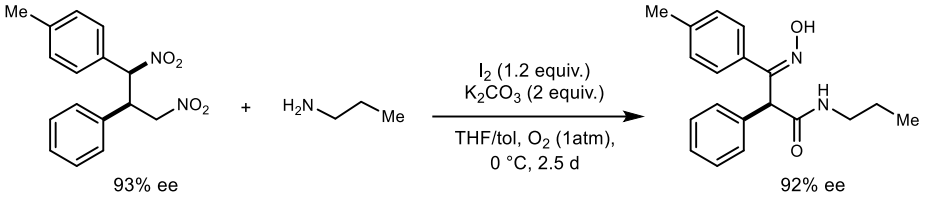


(S,*Z*)-3-(Hydroxyimino)-2,3-diphenyl-*N*-propylpropanamide (14). Prepared according to the general procedure using ((1*S*,2*R*)-1,3-dinitropropane-1,2-diyl)dibenzene (28.6 mg, 100 μmol) and *n*-propyl amine (16.5 μL, 200 μmol). Flash column chromatography (SiO_2, 20-60% ethyl acetate in hexanes) yielded the amide as a white solid (22.0 mg, 75%). The product was determined to be 90% ee by chiral HPLC analysis (Chiralpak IC, 20% ^{i}PrOH/hexanes, 1.0 mL/min, t_r(*e*$_1$, major) = 11.0 min, t_r(*e*$_2$,minor) = 14.5 min). Mp 112-114 °C; R_f = 0.4 (40% EtOAc/hexanes, visualized using PMA); $[\alpha]_D^{20}$ +13 (*c* 1.0, MeOH); IR (film) 3294, 2931, 1649, 1547, 1450, 1244, 986 cm^{-1}; ^{1}H NMR (600 MHz, $(CD_3)_2CO$) δ 10.06 (br s, 1H), 7.44-7.42 (m, 4H), 7.36-7.30 (m, 4H merged with NH), 7.29-7.23 (m, 3H), 4.89 (s, 1H), 3.13 (dtd, *J* =13.0, 6.9, 6.9 Hz, 2H), 1.43 (tq, *J* = 7.3, 7.3 Hz, 2H), 0.81 (t, *J* = 7.4 Hz, 3H); ^{13}C NMR (150 MHz, $(CD_3)_2CO$) ppm 170.6, 156.9, 138.8, 136.0, 131.2, 130.0, 129.7, 129.5, 129.1, 128.4, 60.4, 42.5, 24.1, 12.3; HRMS (ESI): Exact mass calcd for $C_{18}H_{21}N_2O_2$ $[M+H]^+$ 297.1598, found 297.1602.



(S,*Z*)-3-(4-Chlorophenyl)-3-(hydroxyimino)-2-phenyl-N-propylpropanamide (15). Prepared according to the general procedure using 1-chloro-4-((1*S*,2*R*)-1,3-dinitro-2-phenylpropyl)benzene (32.0 mg, 100 μmol) and *n*-propyl amine (16.5 μL, 200 μmol). Flash column chromatography (SiO_2, 20-60% ethyl acetate in hexanes) yielded the amide as a white solid (26.0 mg, 78%). The product was determined to be 89% ee by chiral HPLC analysis (Chiralpak AD-H, 10% ^{i}PrOH/hexanes, 1.0 mL/min, t_r(*e*$_1$, major) = 25.0 min, t_r(*e*$_2$, minor) = 28.7 min). Mp 136-138 °C; R_f = 0.50 (50% EtOAc/hexanes, visualized using PMA); $[\alpha]_D^{20}$ +10 (*c* 1.0, MeOH); IR (film) 3298, 2928, 1641, 1554, 1269, cm^{-1}; ^{1}H NMR (600 MHz, $(CD_3)_2CO$) δ 10.18 (br s, 1H), 7.43-7.37 (m, 6H), 7.31-7.23 (m, 4H, merged with NH), 4.90 (s, 1H), 3.13 (dtd, *J* =13.1, 6.2, 6.2 Hz, 2H), 1.43 (tq, *J* = 7.3, 7.3 Hz, 2H), 0.81 (t, *J* =7.4

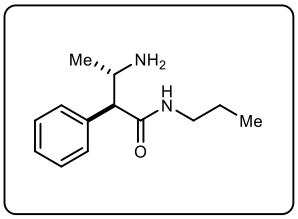
Hz, 3H); ^{13}C NMR (150 MHz, $(CD_3)_2CO$) ppm 170.6, 156.2, 138.5, 135.0, 134.5, 131.9, 131.2, 129.5, 129.2, 128.6, 60.1, 42.5, 24.1, 12.3; HRMS (ESI): Exact mass calcd for $C_{18}H_{20}ClN_2O_2$ $[M+H]^+$ 331.1208, found 331.1212.



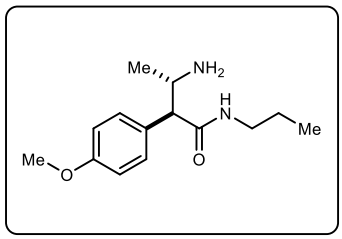
(S,*Z*)-3-(Hydroxyimino)-2-phenyl-*N*-propyl-3-(p-tolyl)propanamide (16). Prepared according to the general procedure using 1-((1*S*,2*R*)-1,3-dinitro-2-phenylpropyl)-4-methylbenzene (30.0 mg, 100 μmol) and *n*-propyl amine (16.5 μL, 200 μmol). Flash column chromatography (SiO_2, 20-60% ethyl acetate in hexanes) yielded the amide as a white solid (24.0 mg, 77%). The product was determined to be 92% ee by chiral HPLC analysis (Chiralpak IC, 20% ^{i}PrOH/hexanes, 1.0 mL/min, t_r(*e*$_1$, major) = 11.3 min, t_r(*e*$_2$, minor) = 13.2 min. Mp 132-134 °C; R_f = 0.39 (50% ethyl acetate in hexanes, visualized using PMA); $[\alpha]_D^{20}$ +19 (*c* 1.0, MeOH); IR (film) 3291, 2940, 1652, 1567, 1268 cm^{-1}; ^{1}H NMR (600 MHz, $(CD_3)_2CO$) δ 10.04 (br s, 1H), 7.43 (d, *J* =7.4 Hz, 2H), 7.35 (d, *J* = 8.0 Hz, 2H),7.30-7.22 (m, 4H, merged with NH), 7.15 (d, *J* =7.9 Hz, 2H), 4.88 (s, 1H), 3.13 (dtd, *J* =13.1, 6.7, 6.7 Hz, 2H), 2.32 (s, 3H), 1.43 (tq, *J* =7.2, 7.2 Hz, 2H), 0.82 (t, *J* =7.3 Hz, 3H); ^{13}C NMR (150 MHz, $(CD_3)_2CO$) ppm 170.7, 156.8, 139.4, 138.9, 132.9, 131.1, 130.0, 129.7, 129.4, 128.4, 60.4, 42.5, 24.1, 21.9, 12.3; HRMS (ESI): HRMS (ESI): Exact mass calcd for $C_{19}H_{22}N_2O_2Na$ [M+Na] 333.1573, found 333.1577.

General Procedure for the Reduction of Oximes

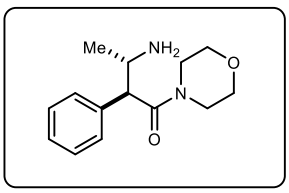
To a flame-dried vial (5 mL) equipped with a magnetic stir bar was added oxime (100 μmol) and MoO_3 (150 μmol) followed by dry MeOH (500 μL). To this solution was added $NaBH_4$ (19.0 mg, 500 μmol) and the resulting mixture was stirred at 25 °C for 5 hours. After completion of the reaction, 5% aqueous $NaHCO_3$ was added dropwise (200 μL) and the mixture was extracted with CH_2Cl_2. The extracts were combined and dried ($MgSO_4$). The solvent was removed under reduced pressure and the crude reaction mixture was purified using a silica pad in a pipette to obtain the desired amino amide.



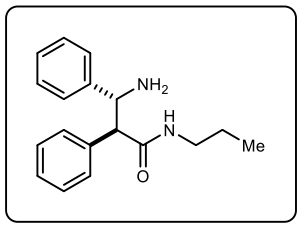
(2*S*,3*S*)-3-Amino-2-phenyl-*N*-propylbutanamide (17). Prepared according to the general procedure using oxime (23.4 mg, 100 μmol) and MoO_3 (21.6 mg, 150 μmol) in dry MeOH (500 μL) and $NaBH_4$ (19.0 mg, 500 μmol). The crude reaction mixture was passed through a short pad of silica in a pipette, using ethyl acetate followed by 20% methanol in dichloromethane to afford the pure amino amide (10.0 mg, 45%) as a viscous liquid (dr = 10:1, ^{1}H NMR). R_f = 0.15 (5% MeOH/CH_2Cl_2); $[\alpha]_D^{20}$ -45.2 (*c* 1.00, $CHCl_3$); IR (film) 3290, 2952, 1649, 1551, 1366 cm^{-1}; Major diastereomer: ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.38-7.28 (m, 5H), 6.33 (br s, 1H), 3.60 (dq, *J* = 6.4, 6.4 Hz, 1H), 3.27-3.10 (m, 2H), 3.19 (d, *J* = 6.8 Hz, 1H, overlapping with m), 2.03 (br s, 2H), 1.48 (ddq, *J* = 7.3, 7.3, 7.3 Hz, 2H), 1.14 (d, *J* = 6.4 Hz, 3H), 0.86 (t, *J* =7.4 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) ppm 172.6, 136.9, 129.1, 128.8, 127.7, 60.7, 49.0, 41.2, 22.9, 22.1, 11.4; HRMS (ESI): Exact mass calcd for $C_{13}H_{21}N_2O$ $[M+H]^+$ 221.1648, found 221.1647.



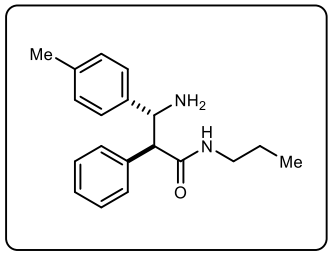
(2*S*,3*S*)-3-Amino-2-(4-methoxyphenyl)-*N*-propylbutanamide (18). Prepared according to the general procedure using oxime (26.4 mg, 100 μmol) and MoO_3 (21.6 mg, 150 μmol) in dry MeOH (500 μL) and $NaBH_4$ (19.0 mg, 500 μmol). The crude reaction mixture was passed through a short pad of silica in a pipette, using ethyl acetate followed by 20% methanol in dichloromethane to afford the pure amino amide (12.0 mg, 48%) as a viscous liquid (dr = 9:1, ^{1}H NMR). R_f = 0.15 (5% MeOH/CH_2Cl_2); $[\alpha]_D^{20}$ -28.2 (*c* 1.00, $CHCl_3$); IR (film) 3276, 2944, 1643, 1526, 1249 cm^{-1}; Major diastereomer: ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.29 (d, *J* = 8.3 Hz, 2H), 6.86 (d, *J* = 8.3 Hz, 2H), 6. 29 (br s, 1H), 3.78 (s, 3H) 3.57 (dq, *J* = 6.5, 6.5 Hz, 1H), 3.25-3.09 (m, 3H), 2.91 (br s, 2H), 1.46 (ddq, *J* = 7.3, 7.3, 7.3 Hz, 2H), 1.15 (d, *J* = 5.6 Hz, 3H), 0.86 (t, *J* = 7.1 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) ppm 172.8, 159.2, 130.2, 128.7, 114.2, 59.2, 55.4, 49.2, 41.2, 22.9, 21.4, 11.4; HRMS (ESI): Exact mass calcd for $C_{14}H_{23}N_2O_2$ $[M+H]^+$ 251.1754, found 251.1763.



(2*S*,3*S*)-3-Amino-1-morpholino-2-phenylbutan-1-one (19). Prepared according to the general procedure using oxime (26.2 mg, 100 μmol) and MoO_3 (21.6 mg, 150 μmol) in dry MeOH (500 μL) and $NaBH_4$ (19.0 mg, 500 μmol). The crude reaction mixture was passed through a short pad of silica in a pipette, using ethyl acetate followed by 20% methanol in dichloromethane to afford the pure amino amide (13.0 mg, 52%) as a viscous liquid (dr = 20:1, ^{1}H NMR). R_f = 0.15 (5% MeOH/CH_2Cl_2); $[\alpha]_D^{20}$ -24.6 (*c* 1.00, $CHCl_3$); IR (film) 3364, 2921, 2858, 1632, 1446, 1228 cm^{-1}; Major diastereomer: ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.37-7.27 (m, 5H), 3.75-3.60 (m, 4H), 3.52-3.41 (m, 4H), 3.32-3.27 (m, 1H), 3.20 (s, 2H), 3.10-3.05 (m, 1H), 1.21 (d, *J* = 5.5 Hz, 3H), ^{13}C NMR (100 MHz, $CDCl_3$) ppm 170.9, 136.0, 129.2, 128.9, 127.9, 66.8, 66.4, 55.2, 49.9, 46.3, 42.3, 20.9; HRMS (ESI): Exact mass calcd for $C_{14}H_{21}N_2O_2$ $[M+H]^+$ 249.1548, found 249.1592.



(2*S*,3*R*)-3-Amino-2,3-diphenyl-*N*-propylpropanamide (20). Prepared according to the general procedure, but at higher dilution,[6] using oxime (14.8 mg, 50 μmol) and MoO_3 (10.7 mg, 75 μmol) in dry MeOH (500 μL) and $NaBH_4$ (10.0 mg, 250 μmol). The crude reaction mixture was passed through a short pad of silica in a pipette, using 30% ethyl acetate in hexanes followed by 100% ethyl acetate and 5% methanol in dichloromethane to afford the pure amino amide (7.0 mg, 52%) as a viscous liquid (dr = 20:1, ^{1}H NMR). R_f = 0.2 (100% EtOAc); $[\alpha]_D^{20}$ -51.2 (*c* 1.00, $CHCl_3$); IR (film) 3302, 3067, 2932, 1648, 1552, 1367 cm^{-1}; Major diastereomer: ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.34-7.27 (m, 6H), 7.24-7.19 (m, 4H), 6.11 (t, *J* = 5.4 Hz, 1H), 4.58 (d, *J* = 7.7 Hz, 1H), 3.54 (d, *J* = 7.8 Hz, 1H), 3.02 (dtd, *J* =13.3, 6.8, 6.8 Hz, 1H), 3.02 (dtd, *J* =13.0, 6.9, 6.9 Hz, 1H), 2.69 (br s, 2H), 1.21-1.16 (m, 2H), 0.64 (t, *J* = 7.4 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) ppm 171.6, 142.3, 136.2, 129.2, 128.7, 128.5, 127.9, 127.8, 127.2, 61.2, 58.0, 41.1, 22.6, 11.2; HRMS (ESI): Exact mass calcd for $C_{18}H_{23}N_2O$ $[M+H]^+$ 283.1805, found 283.1798.

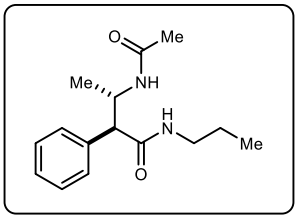


(2*S*,3*R*)-3-Amino-2-phenyl-*N*-propyl-3-(*p*-tolyl)propanamide (21). Prepared according to the general procedure, but at higher dilution,[6] using oxime (15.0 mg, 48 μmol) and MoO_3 (10.5 mg, 72 μmol) in dry MeOH (480 μL) and $NaBH_4$ (9.1 mg, 240 μmol). The crude reaction mixture was passed through a short pad of silica in a pipette, using 30% ethyl acetate in hexanes followed by 100% ethyl acetate and 5% methanol in dichloromethane to afford the pure amino amide (7.0 mg, 49%) as a viscous liquid (dr = 20:1, ^{1}H NMR). R_f = 0.1 (100% EtOAc); $[\alpha]_D^{20}$ -52.4 (*c* 1.00, $CHCl_3$); IR (film) 3310, 3069, 2930, 1647, 1552, 1368 cm^{-1}; Major diastereomer: ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.33-7.27 (m, 5H), 7.16 (d, *J* = 8.0 Hz, 2H), 7.08 (d, *J* = 8.0 Hz, 2H), 6.15 (t, *J* = 5.4 Hz, 1H), 4.54 (d, *J* = 7.8 Hz, 1H), 3.62 (d, *J* = 7.7 Hz, 1H) 3.45 (br s, 2H), 1H), 3.03 (dtd, *J* = 13.4, 6.7, 6.7 Hz, 1H), 2.90 (dtd, *J* =12.9, 6.7, 6.7 Hz, 1H), 2.30 (s, 3H),1.23-1.19 (m, 2H), 0.66 (t, *J* = 7.4 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) ppm 177.6, 138.4, 137.6, 136.1, 129.3, 129.2, 128.8, 128.0, 127.2, 60.4, 57.9, 41.1, 22.5, 21.2, 11.2; HRMS (ESI): Exact mass calcd for $C_{19}H_{25}N_2O$ $[M+H]^+$ 297.1961, found 297.1954.

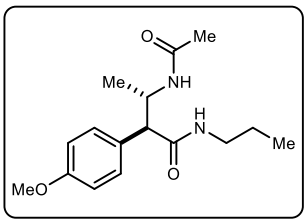
[6] This reaction required 3 h at higher dilution than other substrates since the starting material is insoluble in the standard reaction medium.

General Procedure for the Functionalization of Amines

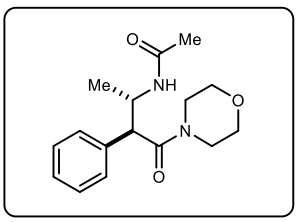
To a flame-dried vial (5 mL) equipped with a magnetic stir bar was added the amine (1 equiv) in CH_2Cl_2 (0.1 M) and it was cooled to 0 °C, after 10 min corresponding reagent (1.5 equiv) and Et_3N (2 equiv) was added and the reaction was allowed to stir for 1 h. After completion of the reaction, H_2O (500 μL) was added dropwise and the mixture was extracted with CH_2Cl_2. The extracts were combined and dried ($MgSO_4$). The solvent was removed under reduced pressure. The residue was purified by flash column chromatography to give the desired product.



(2*S*,3*S*)-3-Acetamido-2-phenyl-*N*-propylbutanamide (22). Prepared according to the general procedure using (2*S*)-3-amino-2-phenyl-*N*-propylbutanamide (**17**) (7.0 mg, 31 μmol), CH_3COCl (4.0 μL, 47 μmol) and Et_3N (8.6 μL, 62 μmol) in dry CH_2Cl_2 (310 μL). Flash column chromatography (SiO_2, 100% ethyl acetate then 20% methanol in dichloromethane) yielded amide product (7.0 mg, 86%) as a white solid (dr = 10:1, ^{1}H NMR). The product was determined to be 94% ee by chiral HPLC analysis (Chiralpak IC, 15% ^{i}PrOH/hexanes, 1.0 mL/min, t_r(*e*$_1$, major) = 11.1 min, t_r(*e*$_2$, minor) = 17.8 min). Mp 220-222 °C; R_f = 0.15 (50% EtOAc/hexanes); $[\alpha]_D^{20}$ -12 (*c* 0.50, $CHCl_3$); IR (film) 3299, 2934, 1641, 1544, 1371 cm^{-1}; Major diastereomer: ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.36-7.28 (m, 5H), 6.21 (d, *J* = 8.3 Hz, 1H), 5.69 (br s, 1H), 4.35 (ddq, *J* = 13.5, 6.7, 6.7 Hz, 1H), 3.81 (d, *J* = 5.7 Hz, 1H), 3.18 (dtd, *J* = 13.5, 6.8, 6.8 Hz, 2H), 1.90 (s, 3H), 1.46 (ddq, *J* = 7.3, 7.3, 7.3 Hz, 2H), 1.25 (d, *J* = 6.7 Hz, 3H), 0.86 (t, *J* =7.4 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) ppm 171.8, 169.3, 137.1, 128.9, 128.7, 127.5, 56.3, 48.0, 41.1, 23.4, 22.6, 17.0, 11.2; HRMS (ESI): Exact mass calcd for $C_{15}H_{23}N_2O_2$ $[M+H]^+$ 263.1754, found 263.1764.

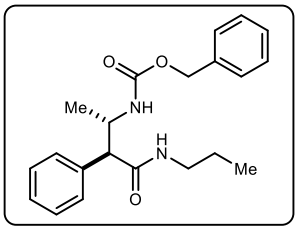


(2*S*,3*S*)-3-Acetamido-2-(4-methoxyphenyl)-*N*-propylbutanamide (23). Prepared according to the general procedure using ((2*S*,3*S*)-3-amino-2-(4-methoxyphenyl)-*N*-propylbutanamide (**18**) (11.0 mg, 44 μmol), CH_3COCl (5.0 μL, 66 μmol) and Et_3N (12.2 μL, 88 μmol) in dry CH_2Cl_2 (430 μL). Flash column chromatography (SiO_2, 100% ethyl acetate then 20% methanol in dichloromethane) yielded amide product (10.0 mg, 78%) as a white solid (dr = 8.5:1, ^{1}H NMR). The product was determined to be 93% ee by chiral HPLC analysis (Chiralpak AD-H, 10% ^{i}PrOH/hexanes, 1.0 mL/min, t_r(*e*$_1$, major) = 9.3 min, t_r(*e*$_2$, minor) = 12.2 min). Mp 204-206 °C; R_f = 0.13 (50% EtOAc/hexanes); $[\alpha]_D^{20}$ -21 (*c* 0.50, $CHCl_3$); IR (film) 3299, 2942, 1636, 1532 cm^{-1}; Major diastereomer: ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.21 (d, *J* = 8.7 Hz, 2H), 6.86 (d, *J* = 8.6 Hz, 2H), 6.26 (d, *J* = 8.6 Hz, 1H), 5.68 (br s, 1H), 4.31 (ddq, *J* = 13.5, 6.7, 6.7 Hz, 1H), 3.79 (s, 3H), 3.73 (d, *J* = 5.7 Hz, 1H), 3.18 (dtd, *J* = 13.3, 6.3, 6.3 Hz, 2H), 1.90 (s, 3H), 1.46 (ddq, *J* = 7.3, 7.3, 7.3 Hz, 2H), 1.25 (d, *J* = 6.7 Hz, 3H), 0.86 (t, *J* =7.4 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) ppm 172.4, 169.5, 159.1, 130.2, 129.3, 114.3, 55.8, 55.4, 48.2, 41.3, 23.7, 22.8, 17.2, 11.4; HRMS (ESI): Exact mass calcd for $C_{16}H_{25}N_2O_3$ $[M+H]^+$ 293.1860, found 293.1868.

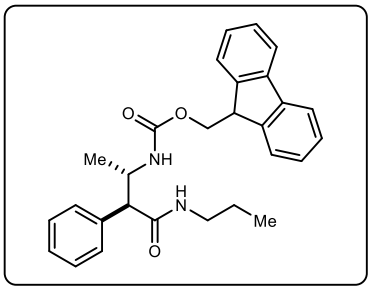


***N*-((2*S*,3*S*)-4-Morpholino-4-oxo-3-phenylbutan-2-yl)acetamide (24).** Prepared according to the general procedure using (2*S*,3*S*)-3-amino-1-morpholino-2-phenylbutan-1-one (**19**) (7.0 mg, 28 μmol), CH_3COCl (3.3 μL, 42 μmol) and Et_3N (8.0 μL, 56 μmol) in dry CH_2Cl_2 (300 μL). Flash column chromatography (SiO_2, 100% ethyl acetate then 20% methanol in dichloromethane) yielded the amide product (6.5 mg, 80%) as a viscous oil (dr = 20:1, ^{1}H NMR). The product was determined to be 94% ee by chiral HPLC analysis (Chiralpak OZH, 15% EtOH/hexanes, 1.0 mL/min, t_r(*e*$_1$, major) = 13.9 min, t_r(*e*$_2$, minor) = 18.3 min). R_f = 0.2 (50% EtOAc/hexanes); $[\alpha]_D^{20}$ -26 (*c* 0.50, $CHCl_3$); IR (film) 3309, 2934, 1640, 1544, 1444 cm^{-1}; Major diastereomer: ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.36-7.32 (m, 2H), 7.29-7.23 (m, 3H), 6.03 (d, *J* = 8.2 Hz, 1H), 4.35 (ddq, *J* = 13.5, 6.8, 6.8 Hz, 1H), 4.17 (d, *J* = 6.2 Hz, 1H), 3.80-3.76 (m, 1H), 3.69-3.64 (m, 1H), 3.57-3.39 (m, 3H), 3.30-3.24 (m, 1H), 3.16-3.11 (m, 1H), 3.08-3.03 (m, 1H), 1.90 (s,

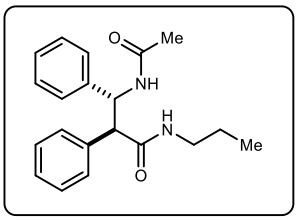
3H), 1.21 (d, *J* = 6.8 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) ppm 170.6, 169.6, 137.0, 129.1, 128.5, 127.6, 66.8, 66.2, 52.1, 49.0, 46.4, 42.1, 23.8,17.0; HRMS (ESI): Exact mass calcd for $C_{16}H_{23}N_2O_3$ $[M+H]^+$ 291.1703, found 291.1718.



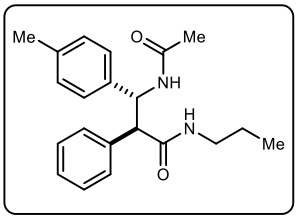
Benzyl ((2*S*,3*S*)-4-oxo-3-phenyl-4-(propylamino)butan-2-yl)carbamate (25). Prepared according to the general procedure using (2*S*,3*S*)-3-amino-2-phenyl-*N*-propylbutanamide (**17**) (7.5 mg, 34 μmol), benzyl chloroformate (7.5 μL, 51 μmol) and Et_3N (9.5 μL, 68 μmol) in dry CH_2Cl_2 (340 μL). Flash column chromatography (SiO_2, 30-50-100% ethyl acetate in hexanes) yielded amide product (8.0 mg, 66%) as a white solid (dr = 10:1, ^{1}H NMR). The product was determined to be 93% ee by chiral HPLC analysis (Chiralpak IC, 15% ^{i}PrOH/hexanes, 1.0 mL/min, t_r(*e*$_1$, major) = 11.9 min, t_r(*e*$_2$, minor) = 14.1 min). Mp 167-169 °C; R_f = 0.4 (50% EtOAc/hexanes); $[\alpha]_D^{20}$ -34 (*c* 0.50, $CHCl_3$); IR (film) 3314, 2925, 1667, 1536, cm^{-1}; Major diastereomer: ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.35-7.26 (m, 10H), 5.57 (br s, 1H), 5.20 (br s, 1H), 5.02 (br d, *J* = 3.8 Hz, 2H), 4.21-4.10 (br, m 1H), 3.70 (br s, 1H), 3.16 (dtd, *J* = 13.3, 7.1, 7.1 Hz, 2H), 1.44 (ddq, *J* = 7.3, 7.3, 7.3 Hz, 2H), 1.29 (d, *J* = 6.7 Hz, 3H), 0.82 (t, *J* =7.4 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) ppm 171.4, 155.6, 137.1, 136.5, 128.7, 128.6, 128.3, 127.9, 127.8, 127.5, 66.3, 57.2, 49.9, 41.1, 22.6, 17.9, 11.1; HRMS (ESI): Exact mass calcd for $C_{21}H_{27}N_2O_3$ $[M+H]^+$ 355.2016, found 355.2054.



(9H-Fluoren-9-yl)methyl ((2*S*,3*S*)-4-oxo-3-phenyl-4-(propylamino)butan-2-yl)carbamate (26). Prepared according to the general procedure using (2*S*,3*S*)-3-amino-2-phenyl-*N*-propylbutanamide (**17**) (7.5 mg, 34 μmol), FmocCl (13.0 mg, 51 μmol) and Et_3N (9.5 μL, 68 μmol) in dry CH_2Cl_2 (340 μL). Flash column chromatography (SiO_2, 30-50% ethyl acetate in hexanes) yielded product (8.0 mg, 60%) as a white solid (dr = 10:1, ^{1}H NMR). The product was determined to be 94% ee by chiral HPLC analysis (Chiralpak IC, 15% ^{i}PrOH/hexanes, 1.0 mL/min, t_r(*e*$_1$, major) = 11.9 min, t_r(*e*$_2$, minor) = 13.5 min). Mp 201-203 °C; R_f = 0.5 (50% EtOAc/hexanes); $[\alpha]_D^{20}$ -28.3 (*c* 0.20, CH_3OH); IR (film) 3317, 2923, 1669, 1533, 1446 cm^{-1}; Major diastereomer: ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.75 (br d, *J* = 7.3 Hz, 2H), 7.49-7.37 (br m, 2H) 7.31-7.25 (br m, 9H), 5.61 (br s, 1H), 5.29 (br s, 1H), 4.29 (br s, 2H), 4.16 (br s, 2H), 3.73 (br s, 1H), 3.18 (br s, 2H), 1.46 (ddq, *J* = 7.2, 7.2, 7.2 Hz, 2H), 1.32 (br s, 3H), 0.85 (t, *J* =7.3 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) ppm 171.1, 155.5, 144.1, 141.4, 137.4, 128.9, 127.7 (2C), 127.1, 125.2, 120.0 (2C), 66.7, 57.4, 50.1, 47.3, 71.3, 22.9, 18.1, 11.4; HRMS (ESI): Exact mass calcd for $C_{28}H_{31}N_2O_3$ $[M+H]^+$ 443.2329, found 443.2359.

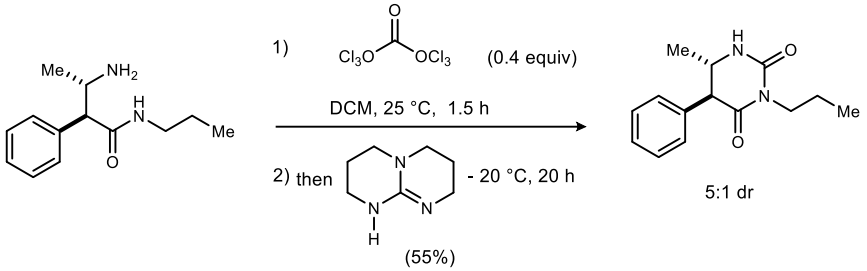


(2*S*,3*R*)-3-Acetamido-2,3-diphenyl-*N*-propylpropanamide (27). Prepared according to the general procedure using (2*S*,3*R*)-3-amino-2,3-diphenyl-*N*-propylpropanamide (**20**) (11.0 mg, 38 μmol), CH_3COCl (4.5 μL, 58 μmol) and Et_3N (10.5 μL, 76 μmol) in dry CH_2Cl_2 (380 μL). Flash column chromatography (SiO_2, 50-100% ethyl acetate then 20% methanol in dichloromethane) yielded amide product (10.5 mg, 85%) as a white solid (dr = 20:1, ^{1}H NMR). The product was determined to be 90% ee by chiral HPLC analysis (Chiralpak IC, 20% ^{i}PrOH/hexanes, 1.0 mL/min, t_r(*e*$_1$, major) = 11.1 min, t_r(*e*$_2$, minor) = 19.3 min). Mp 268-270 °C; R_f = 0.3 (50% EtOAc/hexanes); $[\alpha]_D^{20}$ -28 (*c* 0.20, CH_3OH); IR (film) 3304, 2921, 1639, 1537 cm^{-1}; Major diastereomer: ^{1}H NMR (400 MHz, CD_3OD) δ 7.51 (d, *J* = 7.0 Hz, 2H), 7.46 (d, *J* = 7.0 Hz, 2H), 7.32-7.25 (m, 4H), 7.26-7.21 (m, 2H), 5.70 (d, *J* = 11.7 Hz, 1H), 3.93 (d, *J* = 11.7 Hz, 1H), 2.90 (dtd, *J* = 13.3, 6.8, 6.8 Hz, 1H), 2.69 (dtd, *J* = 13.5, 6.9, 6.9 Hz, 1H), 1.61 (s, 3H), 1.10 (ddq, *J* = 7.0, 7.0, 7.0 Hz, 2H), 0.53 (t, *J* =7.4 Hz, 3H) [N-*H* protons not observed due to exchange with deuterated solvent.]; ^{13}C NMR (100 MHz, $CDCl_3$) ppm 173.2, 171.9, 142.4, 138.9, 129.6, 129.3, 129.2, 128.8, 128.5, 128.4, 59.8, 56.0, 41.8, 23.2, 22.2, 11.3; HRMS (ESI): Exact mass calcd for $C_{20}H_{25}N_2O_2$ $[M+H]^+$ 325.1911, found 325.1922.



(2*S*,3*R*)-3-Acetamido-2-phenyl-*N*-propyl-3-(*p*-tolyl)propanamide (28). Prepared according to the general procedure using ((2*S*,3*R*)-3-amino-2-phenyl-*N*-propyl-3-(*p*-tolyl)propanamide (**21**) (11.0 mg, 38 μmol), CH_3COCl (4.5 μL, 58 μmol) and Et_3N (10.5 μL, 76 μmol) in dry CH_2Cl_2 (380 μL). Flash column chromatography (SiO_2, 50-100% ethyl acetate then 20% methanol in dichloromethane) yielded the amide product (11.0 mg, 85%) as a white solid (dr = 20:1, ^{1}H NMR). The product was determined to be 92% ee by chiral HPLC analysis (Chiralpak IC, 20% ^{i}PrOH/hexanes, 1.0 mL/min, t_r(e_1, major) = 14.3 min, t_r(e_2, minor) = 20.8 min). Mp 275-277 °C; R_f = 0.2 (50% EtOAc/hexanes); $[\alpha]_D^{20}$ -30 (*c* 0.20, CH_3OH); IR (film) 3334, 2980, 1644, 1377 cm^{-1}; Major diastereomer: ^{1}H NMR (400 MHz, CD_3OD) δ 7.51 (d, *J* = 7.0 Hz, 2H), 7.35-7.22 (m, 5H), 7.12 (d, *J* = 7.9 Hz, 2H), 5.68 (d, *J* = 11.7 Hz, 1H), 3.92 (d, *J* = 11.7 Hz, 1H), 2.91 (dtd, *J* = 13.4, 6.8, 6.8 Hz, 1H), 2.71 (dtd, *J* = 13.5, 6.9, 6.9 Hz, 1H), 2.30 (s, 3H), 1.61 (s, 3H), 1.13 (ddq, *J* = 6.8, 6.8, 6.8 Hz, 2H), 0.53 (t, *J* =7.4 Hz, 3H) [N-*H* protons not observed due to exchange with deuterated solvent.]; ^{13}C NMR (100 MHz, $CDCl_3$) ppm 173.3, 171.8, 139.4, 138.9, 138.2, 129.9, 129.6, 129.2, 128.7, 128.3, 59.8, 55.7, 41.8, 23.2, 22.2, 21.1, 11.2; HRMS (ESI): Exact mass calcd for $C_{21}H_{27}N_2O_2$ $[M+H]^+$ 339.2067, found 339.2080.

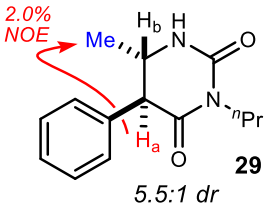
Determination of relative stereochemistry

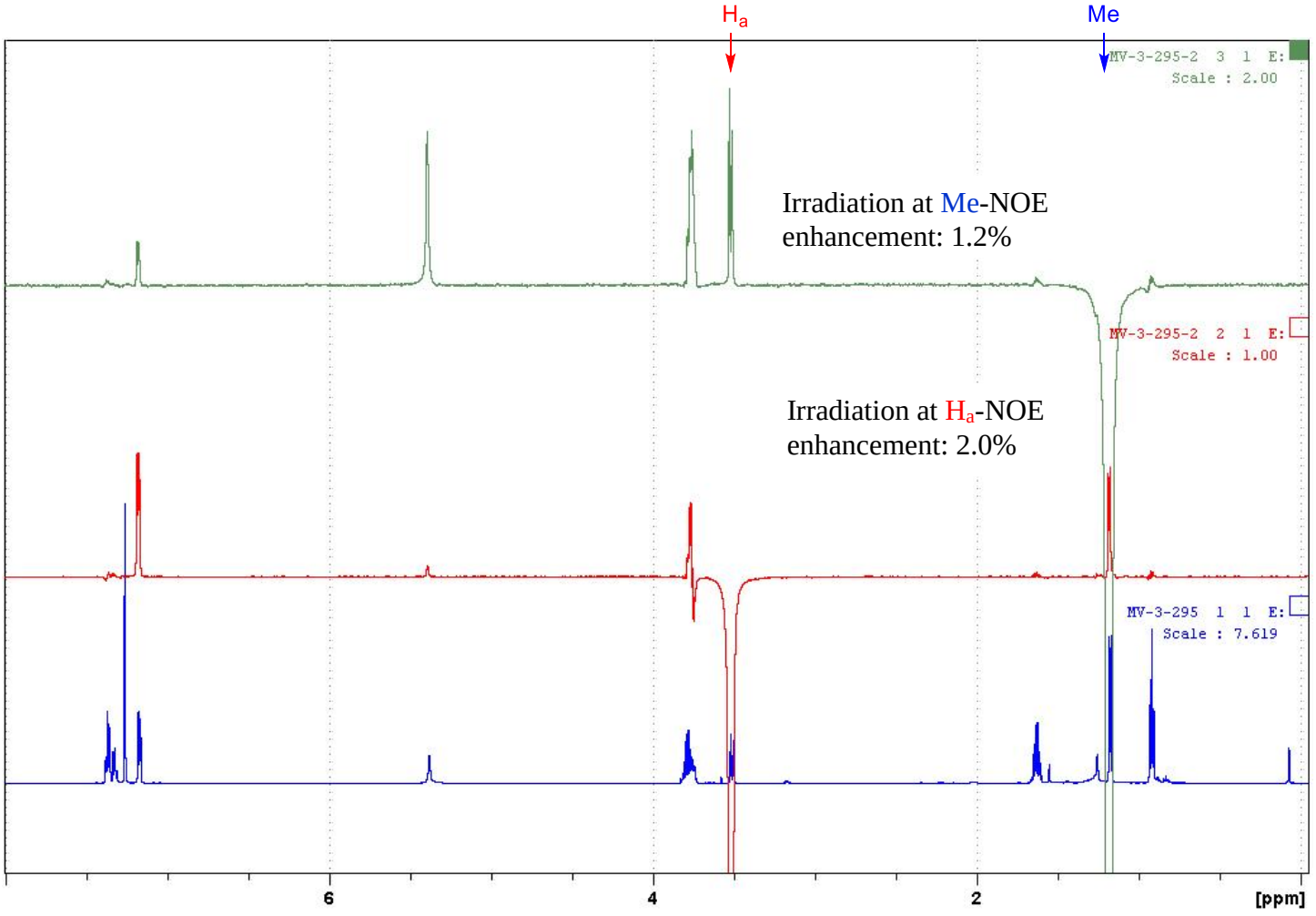


(5*S*,6*S*)-6-Methyl-5-phenyl-3-propyldihydropyrimidine-2,4(1*H*,3*H*)-dione (29). To a flame-dried vial (5 mL) equipped with a magnetic stir bar was added amine (20.0 mg, 90 μmol) in CH_2Cl_2 (450 μL). To this was added triphosgene (10.8 mg, 36 μmol) and the solution was stirred for 1.5 h at 25 °C. The solution was then cooled to -20 °C, and after 20 min, TBD (15.0 mg, 110 μmol) was added and the solution was stirred for 20 h. The reaction was quenched using HCl (1 M) and the mixture was extracted with CH_2Cl_2. The extracts were combined, dried ($MgSO_4$), filtered, and concentrated under reduced pressure. The residue was purified by flash column chromatography (30-100% ethyl acetate in hexanes) to afford the product (12.0 mg, 55%) as a white solid (5.5:1 dr, ^{1}H NMR). The product was determined to be 87% ee by chiral HPLC analysis (Chiralpak IC, 15% ^{i}PrOH/hexanes, 1.0 mL/min, t_r(*e*$_1$, minor) = 11.5 min, t_r(*e*$_2$, major) = 14.7 min; R_f = 0.55 (50% EtOAc/hexanes), Mp 184-186 °C; $[\alpha]_D^{20}$ -4 (*c* 1.0, $CHCl_3$); IR (film) 3290, 2952, 1649, 1551, 1366 cm^{-1}; Major diastereomer: ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.38-7.29 (m, 3H), 7.18-7.16 (m, 2H), 5.69 (br s, 1H), 3.83-3.71 (m, 3H), 3.50 (d, *J* = 9.4 Hz, 1H), 1.62 (ddq, *J* = 7.5, 7.5, 7.5 Hz, 2H), 1.16 (d, *J* = 6.4 Hz, 3H), 0.91 (app t, *J* = 7.4 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) ppm 170.5, 154.1. 135.6, 129.0, 128.8, 128.0, 55.1, 48.4, 42.5, 21.7, 20.5, 11.4; HRMS (ESI): Exact mass calcd for $C_{14}H_{18}N_2O_2Na$ $[M+Na]^+$ 269.1260, found 269.1261.

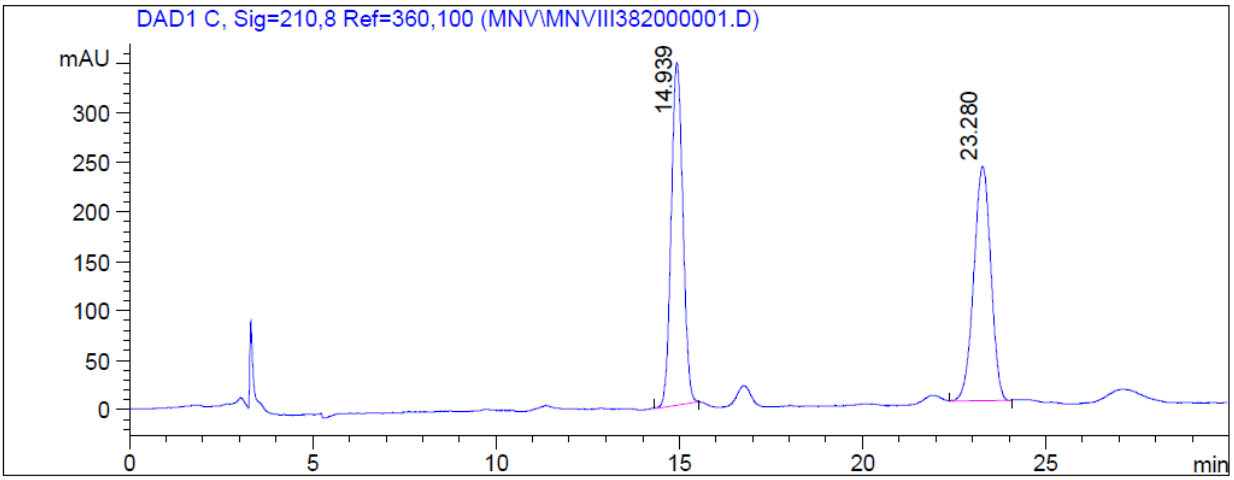
Measurement of 1D NOE for 29

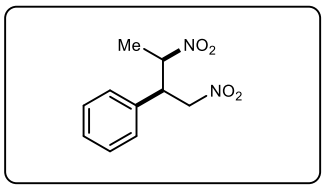
Measurement of 1D NOE (600 MHz, $CDCl_3$) identified a 2.0% enhancement of the methyl (Me) when the vicinal H_a was irradiated. Similarly a 1.2% enhancement of the vicinal H_a was observed when methyl (Me) was irradiated. This supports assignment of the major diastereomer as '*anti*' according to convention for Mannich additions.





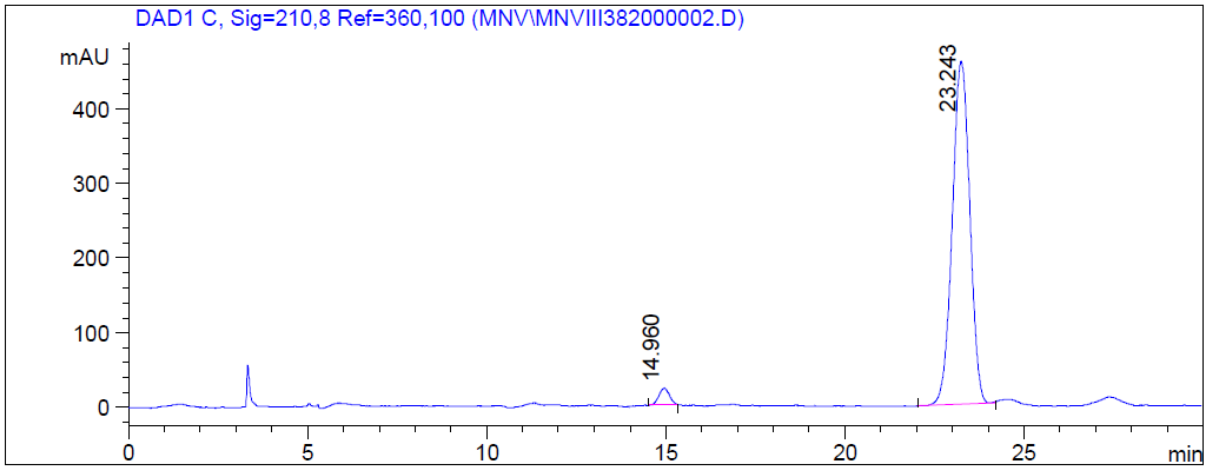
HPLC trace of 6a





Signal 1: DAD1 C, Sig=210,8 Ref=360,100

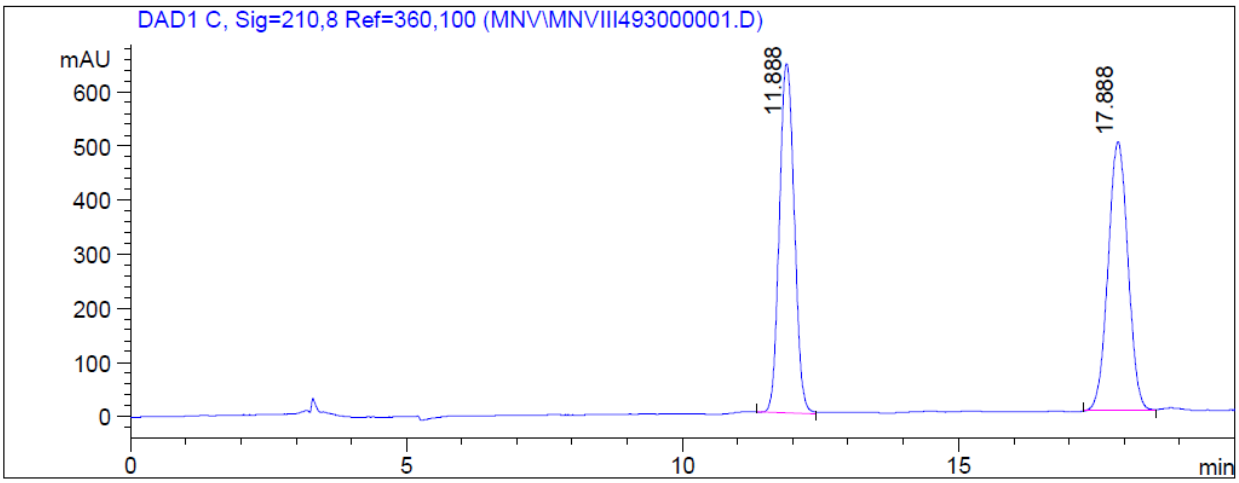
Peak #	RT [min]	Width [min]	Area	Area %
1	14.939	0.369	7662.591	50.027
2	23.280	0.538	7654.281	49.973

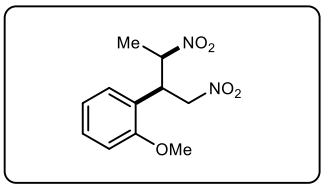


Signal 1: DAD1 C, Sig=210,8 Ref=360,100

Peak #	RT [min]	Width [min]	Area	Area %
1	14.960	0.340	462.913	2.876
2	23.243	0.567	15632.305	97.124

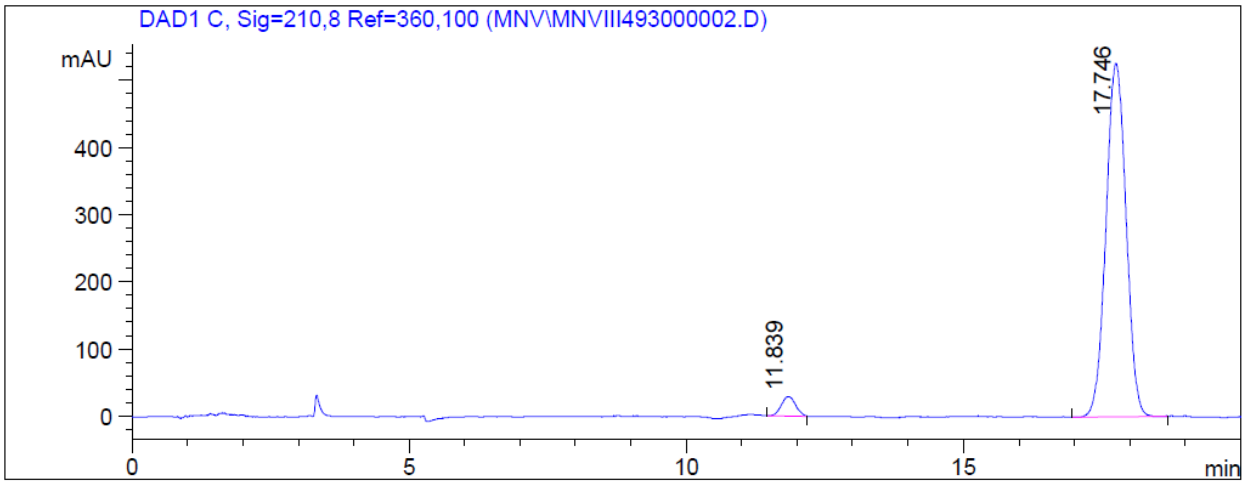
HPLC trace of 6b





Signal 1: DAD1 C, Sig=210,8 Ref=360,100

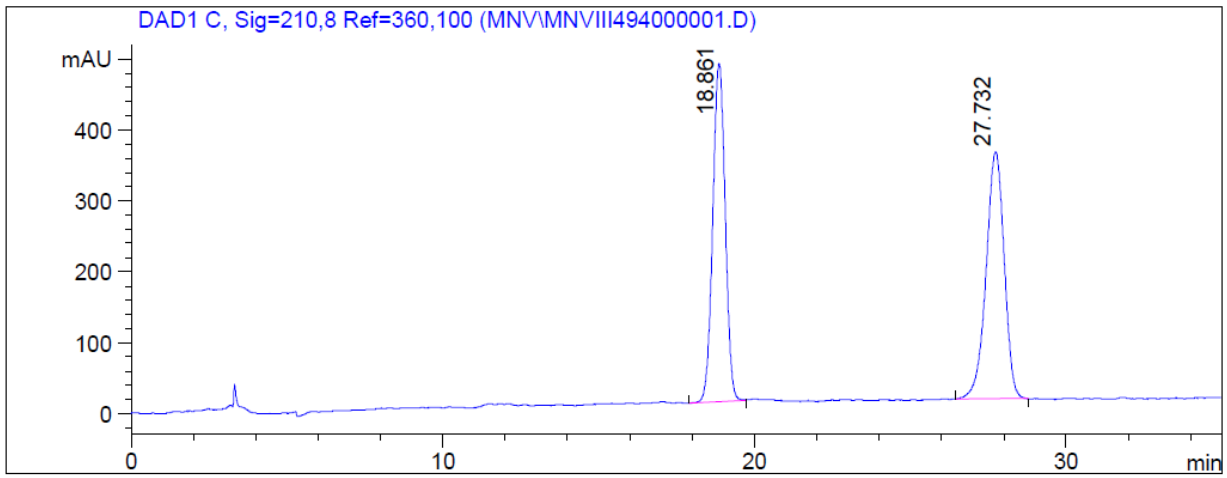
Peak #	RT [min]	Width [min]	Area	Area %
1	11.888	0.313	12136.632	49.590
2	17.888	0.415	12337.221	50.410

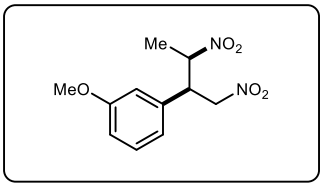


Signal 1: DAD1 C, Sig=210,8 Ref=360,100

Peak #	RT [min]	Width [min]	Area	Area %
1	11.839	0.301	530.124	3.837
2	17.746	0.421	13284.720	96.163

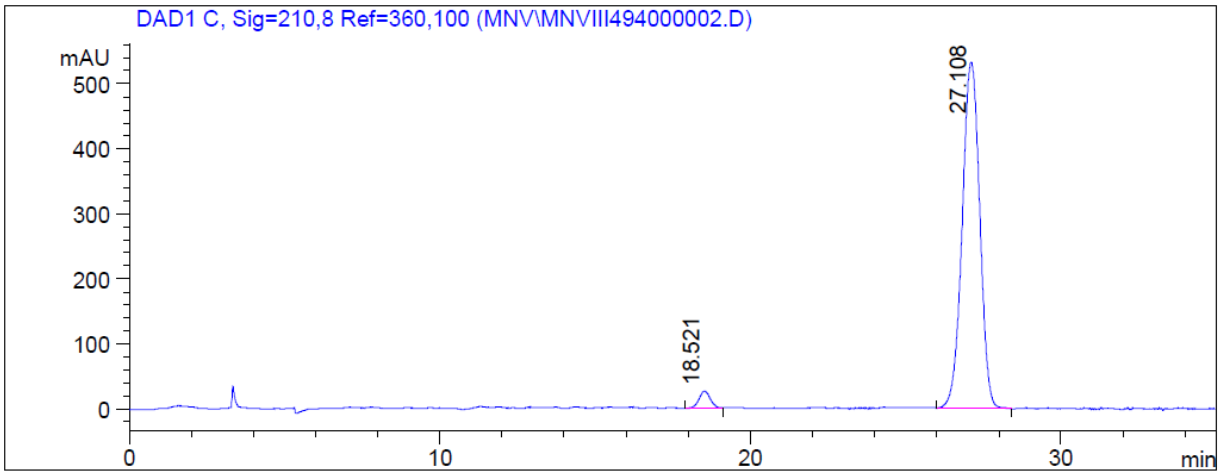
HPLC trace of 6c





Signal 1: DAD1 C, Sig=210,8 Ref=360,100

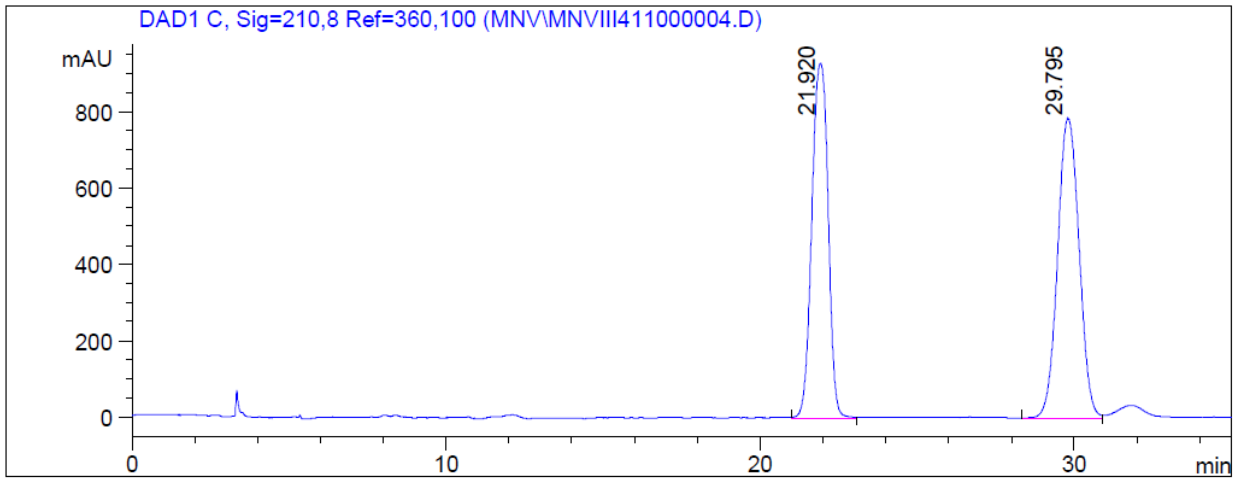
Peak #	RT [min]	Width [min]	Area	Area %
1	18.861	0.466	13345.317	48.671
2	27.732	0.673	14074.090	51.329

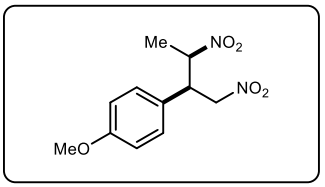


Signal 1: DAD1 C, Sig=210,8 Ref=360,100

Peak #	RT [min]	Width [min]	Area	Area %
1	18.521	0.421	672.438	3.102
2	27.108	0.657	21004.209	96.898

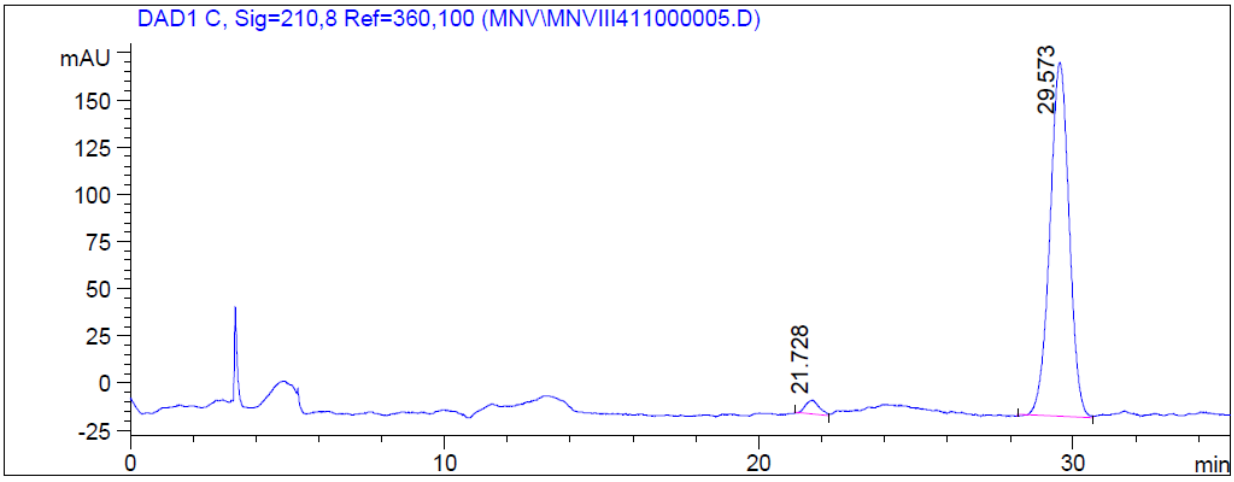
HPLC trace of 6d





Signal 1: DAD1 C, Sig=210,8 Ref=360,100

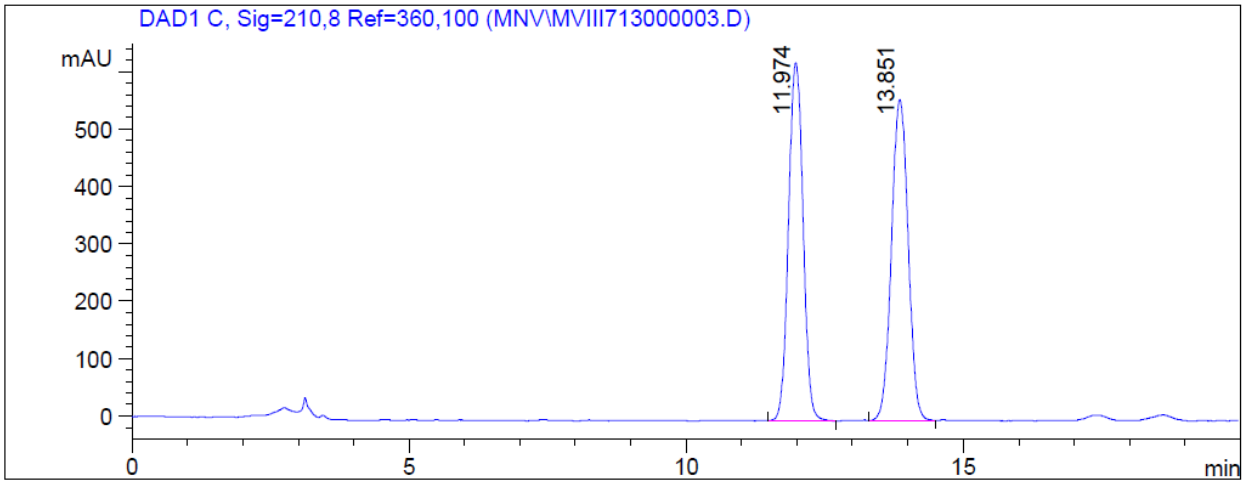
Peak #	RT [min]	Width [min]	Area	Area %
1	21.920	0.584	33802.699	47.468
2	29.795	0.747	37408.266	52.532

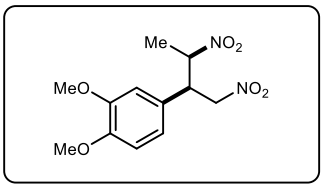


Signal 1: DAD1 C, Sig=210,8 Ref=360,100

Peak #	RT [min]	Width [min]	Area	Area %
1	21.728	0.499	209.264	2.563
2	29.573	0.707	7955.796	97.437

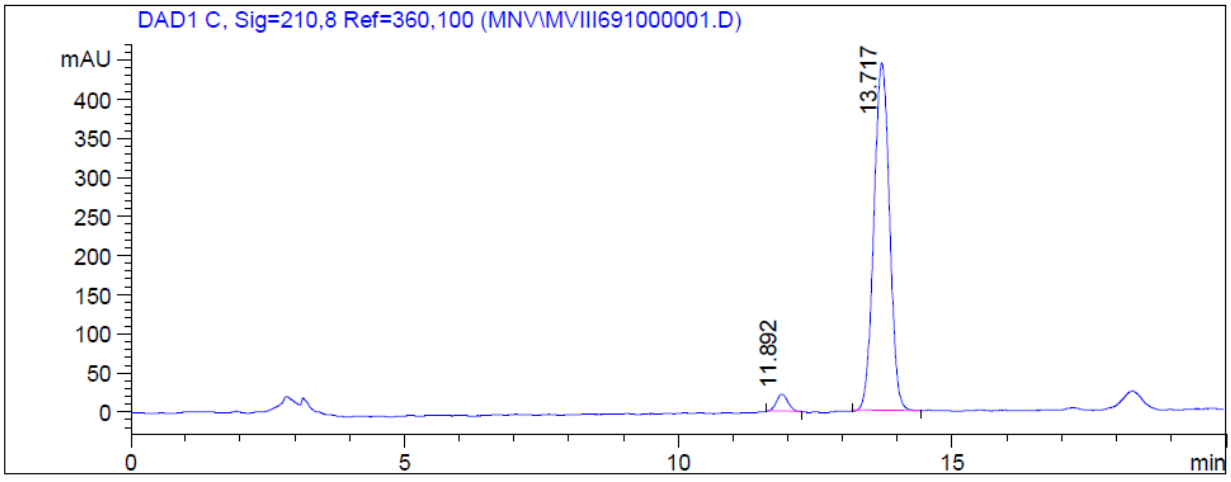
HPLC trace of 6e





Signal 1: DAD1 C, Sig=210,8 Ref=360,100

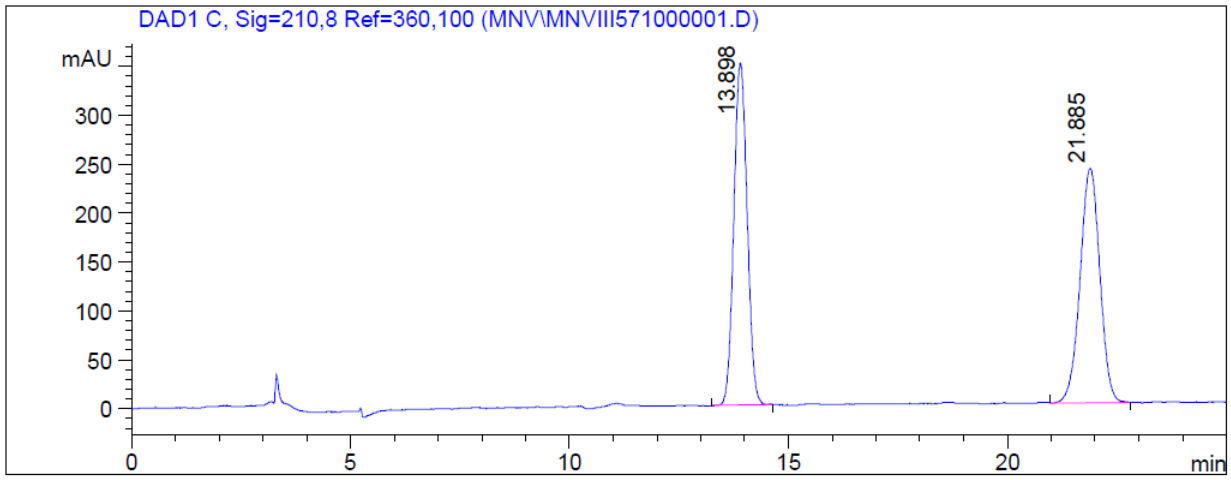
Peak #	RT [min]	Width [min]	Area	Area %
1	11.974	0.290	11445.951	49.298
2	13.851	0.329	11771.783	50.702

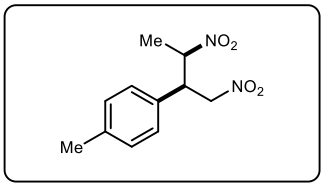


Signal 1: DAD1 C, Sig=210,8 Ref=360,100

Peak #	RT [min]	Width [min]	Area	Area %
1	11.892	0.244	317.244	3.461
2	13.717	0.331	8849.635	96.539

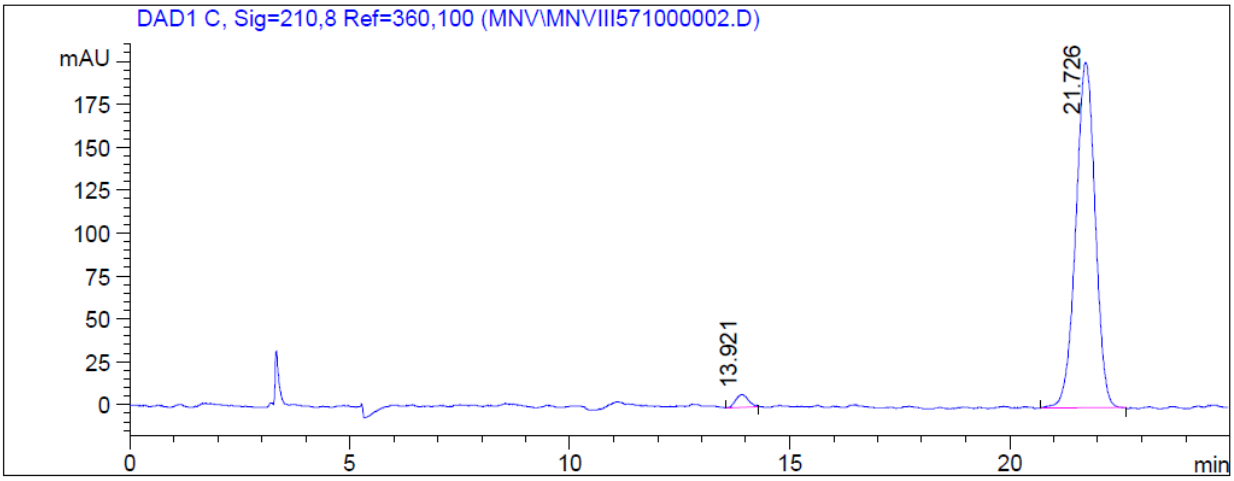
HPLC trace of 6f





Signal 1: DAD1 C, Sig=210,8 Ref=360,100

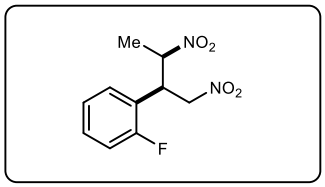
Peak #	RT [min]	Width [min]	Area	Area %
1	13.898	0.352	7382.314	49.510
2	21.885	0.523	7528.432	50.490

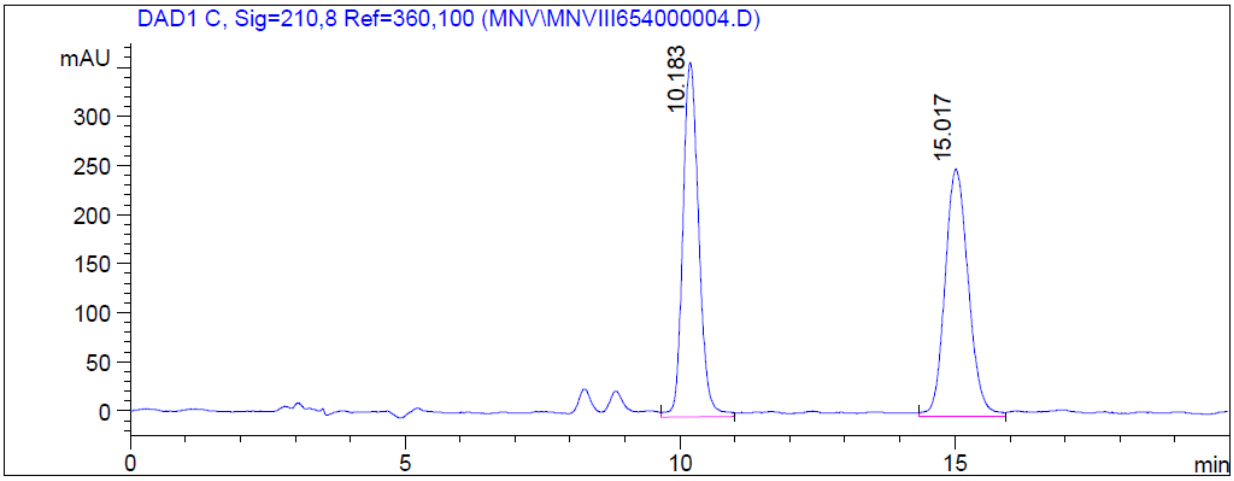


Signal 1: DAD1 C, Sig=210,8 Ref=360,100

Peak #	RT [min]	Width [min]	Area	Area %
1	13.921	0.334	147.778	2.340
2	21.726	0.511	6167.729	97.660

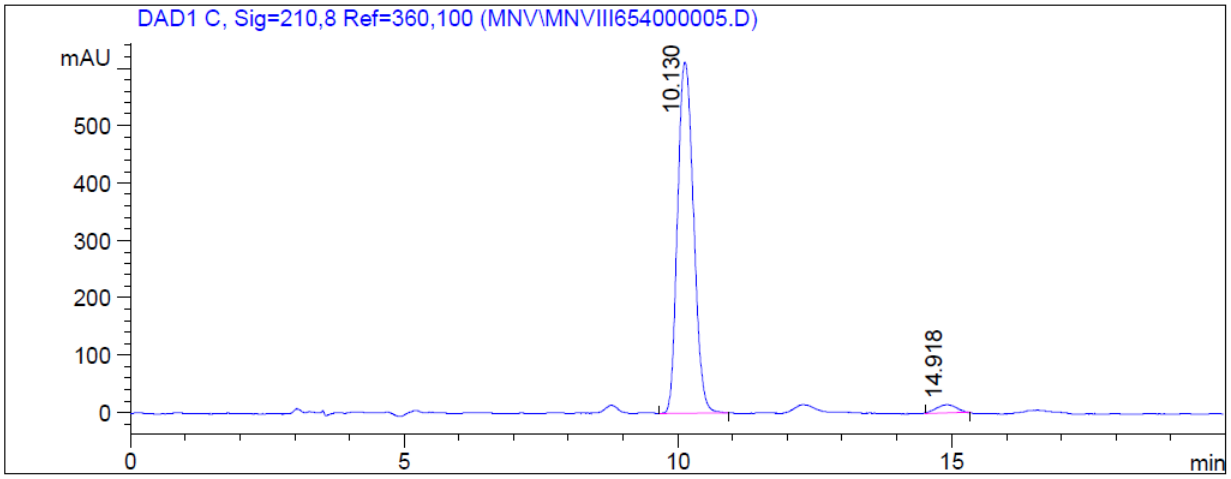
HPLC trace of 6g





Signal 1: DAD1 C, Sig=210,8 Ref=360,100

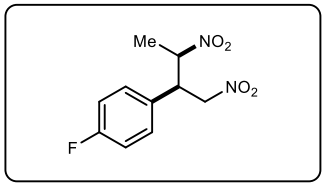
Peak #	RT [min]	Width [min]	Area	Area %
1	10.183	0.313	7288.940	49.591
2	15.017	0.460	7409.265	50.409

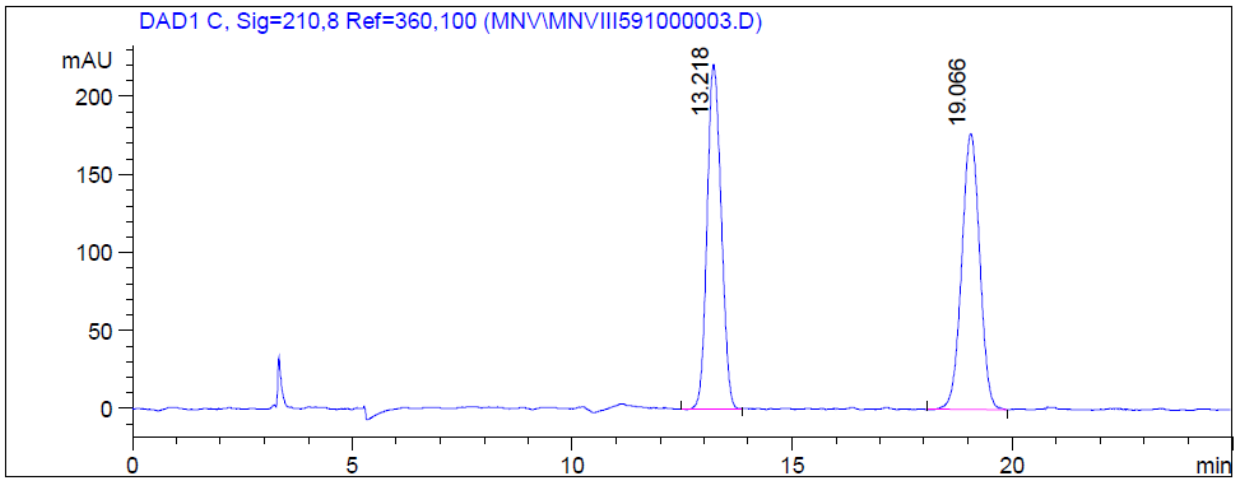


Signal 1: DAD1 C, Sig=210,8 Ref=360,100

Peak #	RT [min]	Width [min]	Area	Area %
1	10.130	0.339	12449.193	97.103
2	14.918	0.425	371.476	2.897

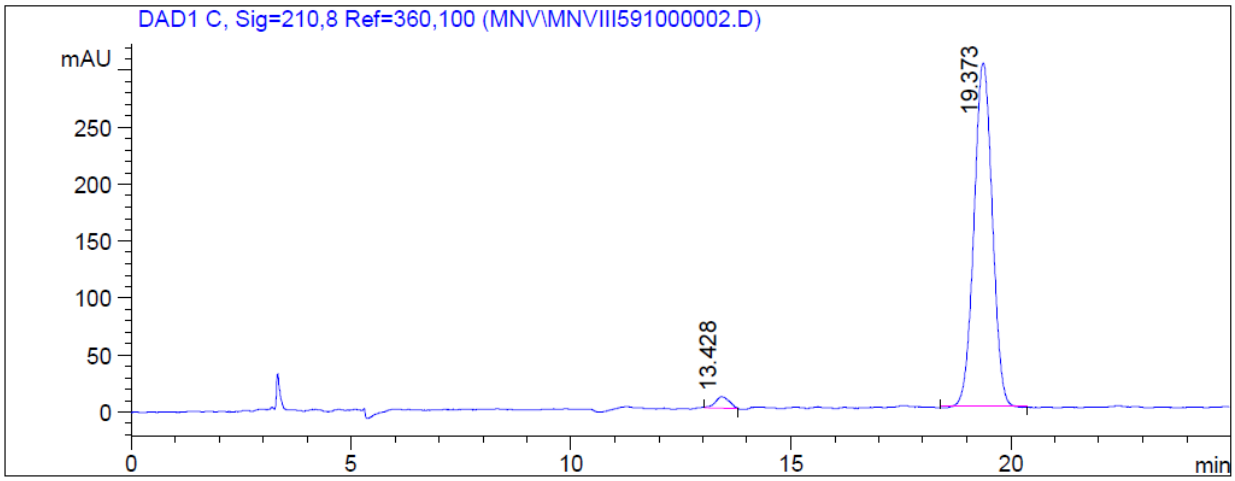
HPLC trace of 6h





Signal 1: DAD1 C, Sig=210,8 Ref=360,100

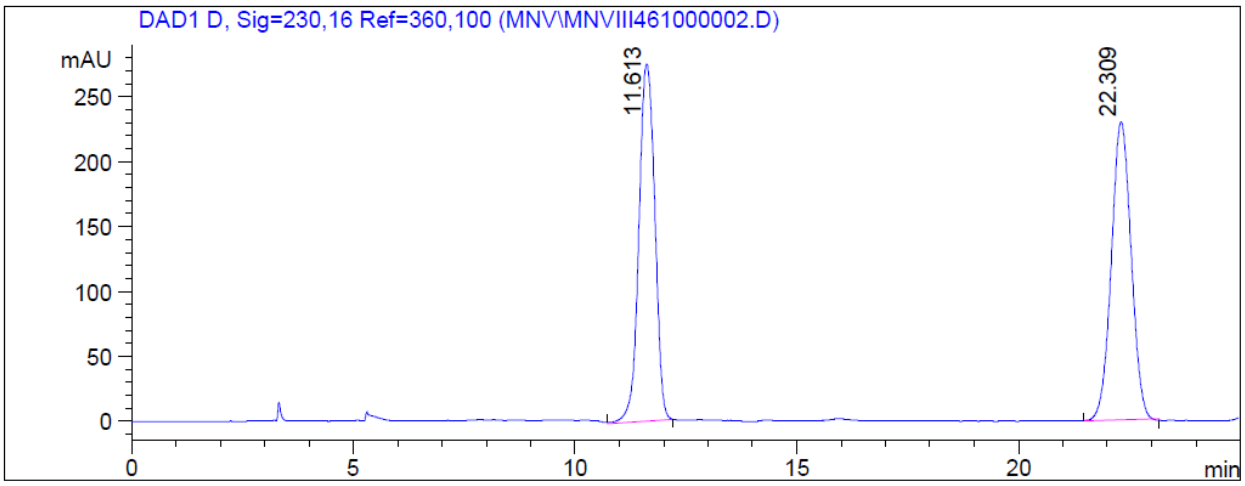
Peak #	RT [min]	Width [min]	Area	Area %
1	13.218	0.371	4918.513	49.512
2	19.066	0.473	5015.438	50.488

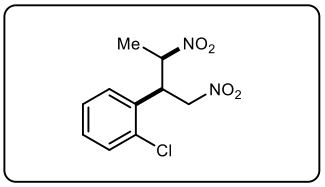


Signal 1: DAD1 C, Sig=210,8 Ref=360,100

Peak #	RT [min]	Width [min]	Area	Area %
1	13.428	0.369	223.461	2.492
2	19.373	0.483	8744.991	97.508

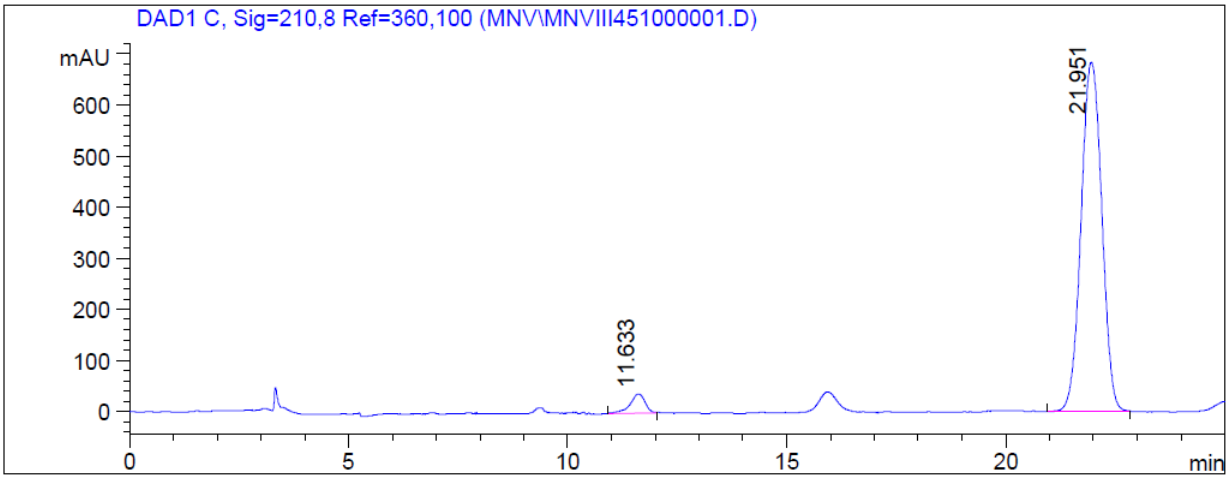
HPLC trace of 6i





Signal 1: DAD1 D, Sig=230,16 Ref=360,100

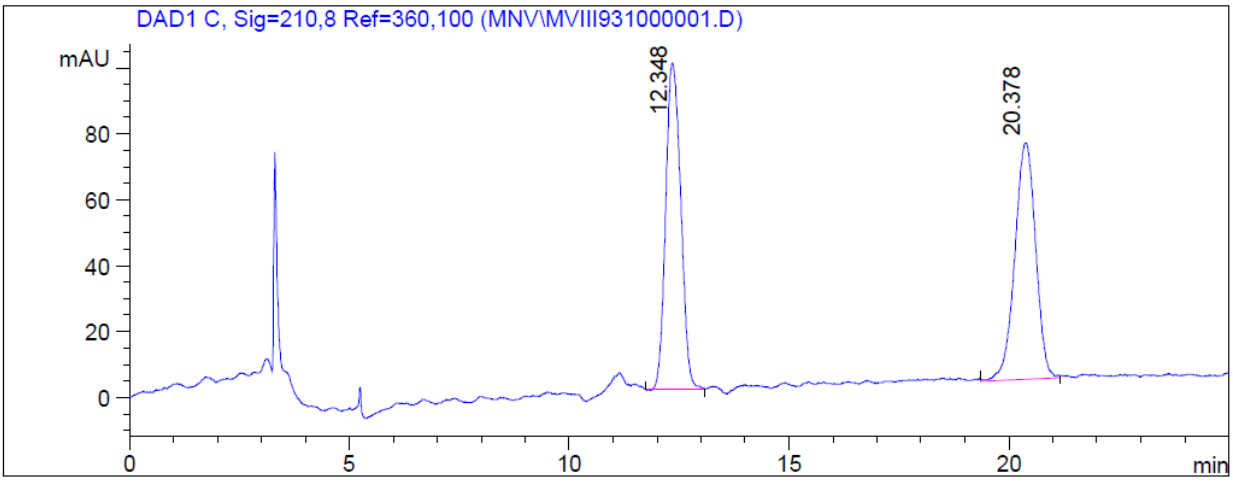
Peak #	RT [min]	Width [min]	Area	Area %
1	11.613	0.417	6889.010	49.203
2	22.309	0.517	7112.232	50.797

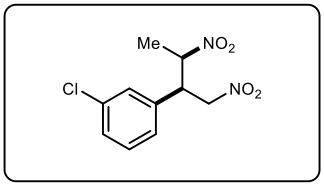


Signal 1: DAD1 C, Sig=210,8 Ref=360,100

Peak #	RT [min]	Width [min]	Area	Area %
1	11.633	0.408	935.618	3.988
2	21.951	0.548	22524.932	96.012

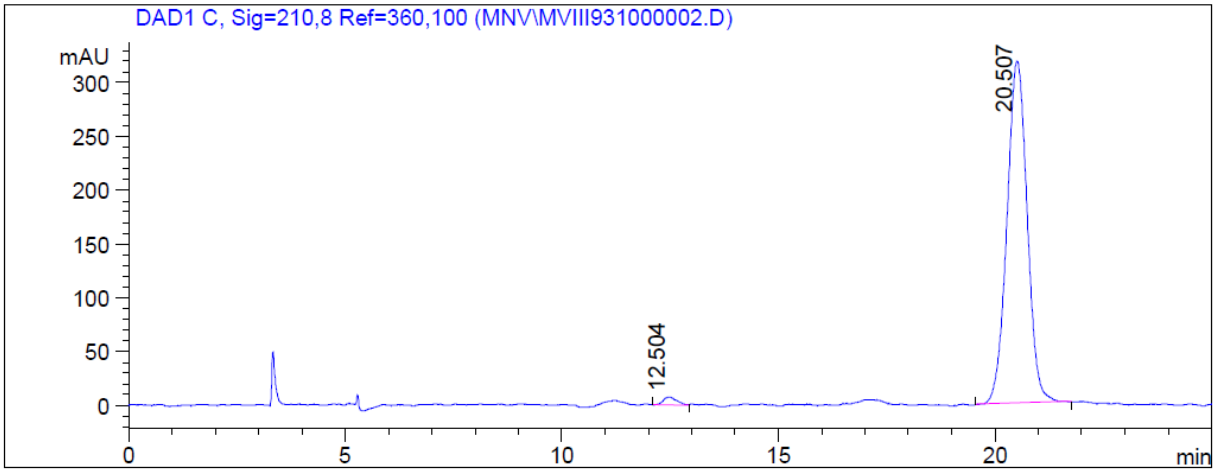
HPLC trace of 6j





Signal 1: DAD1 C, Sig=210,8 Ref=360,100

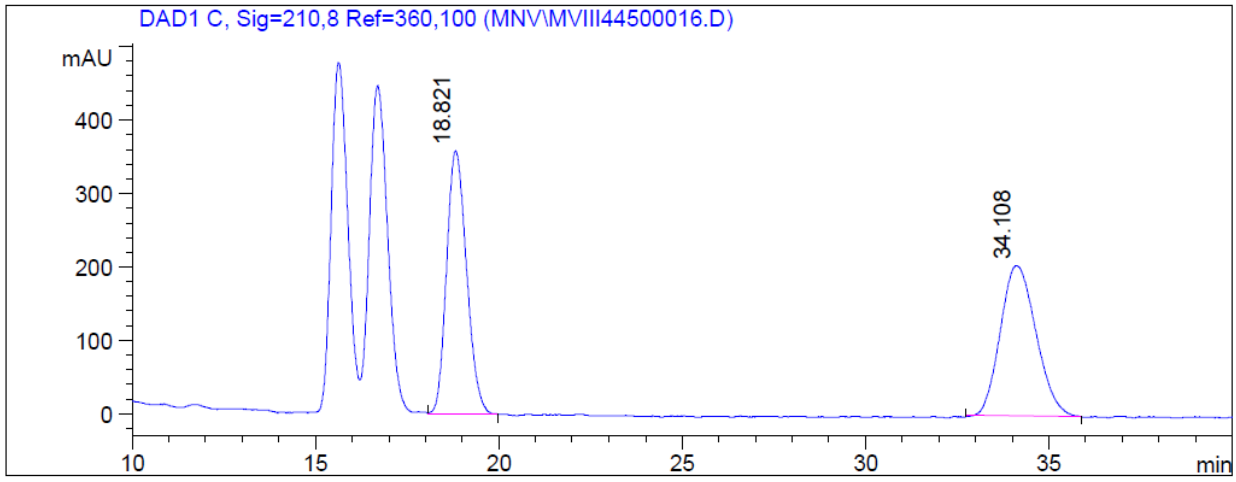
Peak #	RT [min]	Width [min]	Area	Area %
1	12.348	0.396	2349.041	49.851
2	20.378	0.549	2363.047	50.149

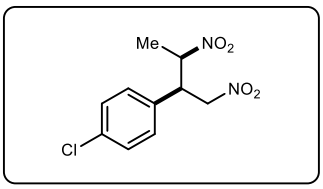


Signal 1: DAD1 C, Sig=210,8 Ref=360,100

Peak #	RT [min]	Width [min]	Area	Area %
1	12.504	0.356	156.045	1.494
2	20.507	0.539	10288.186	98.506

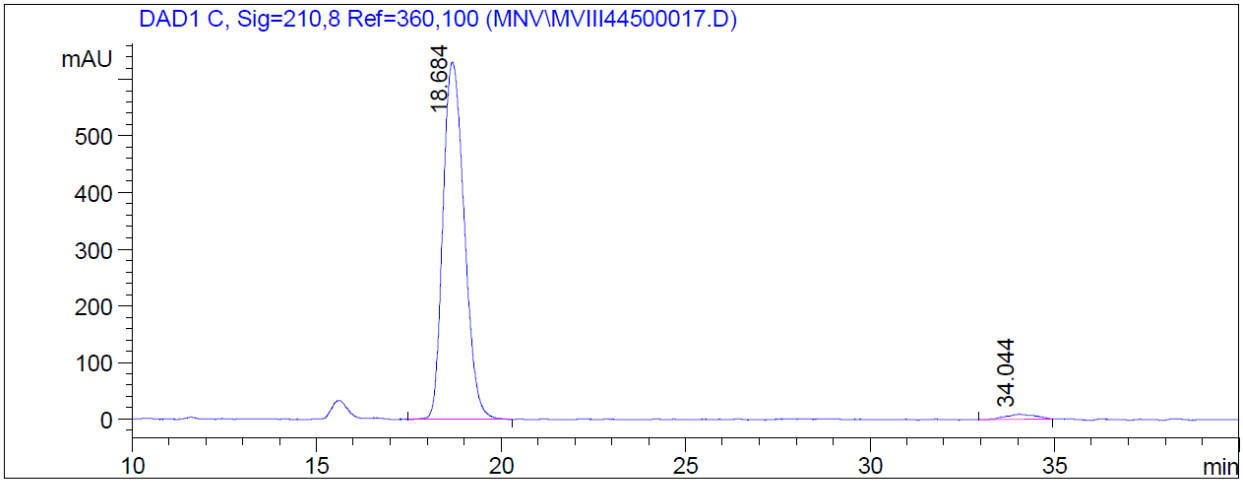
HPLC trace of 6k





Signal 1: DAD1 C, Sig=210,8 Ref=360,100

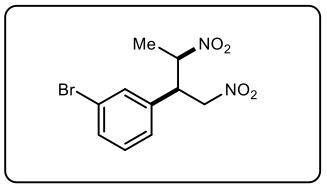
Peak #	RT [min]	Width [min]	Area	Area %
1	18.821	0.632	13549.467	49.557
2	34.108	1.126	13791.650	50.443

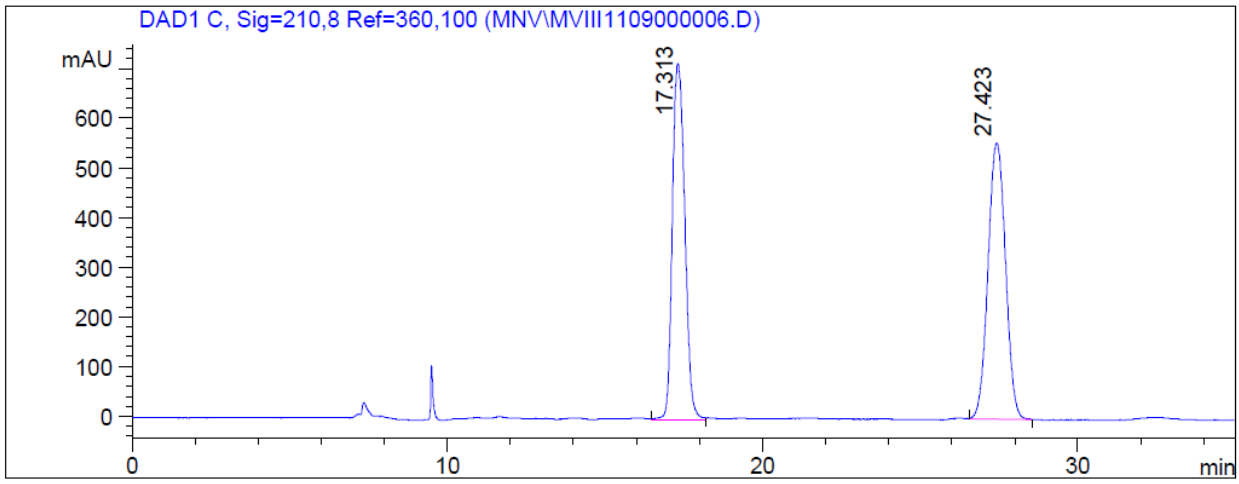


Signal 1: DAD1 C, Sig=210,8 Ref=360,100

Peak #	RT [min]	Width [min]	Area	Area %
1	18.684	0.668	25320.002	98.020
2	34.044	0.953	511.440	1.980

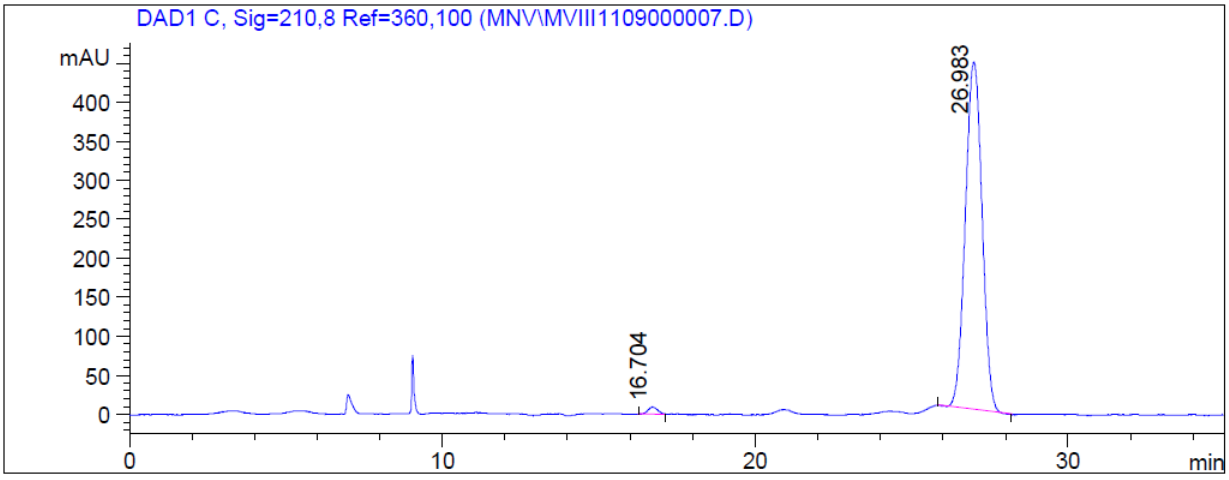
HPLC trace of 6l





Signal 1: DAD1 C, Sig=210,8 Ref=360,100

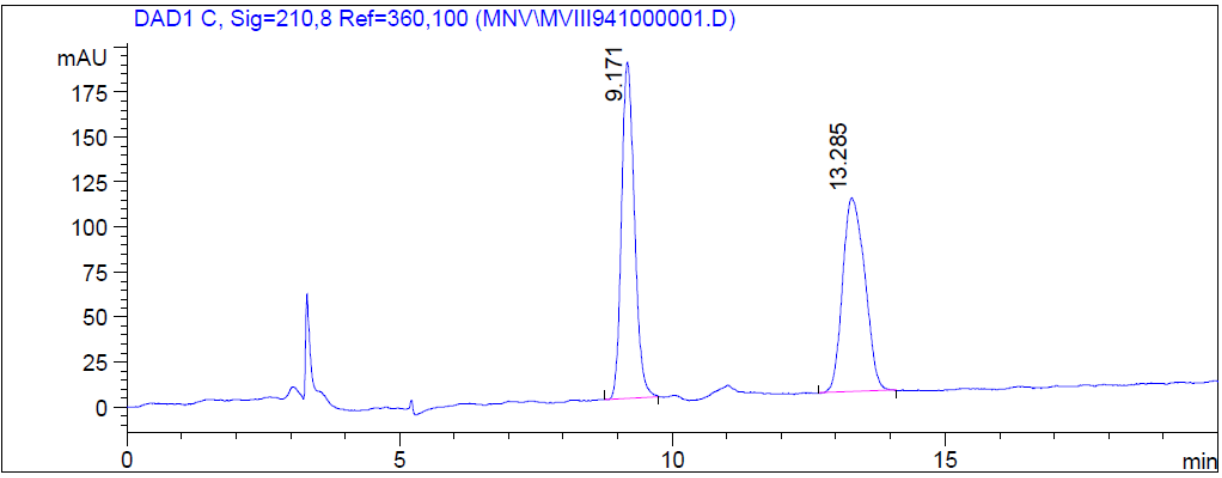
Peak #	RT [min]	Width [min]	Area	Area %
1	17.313	0.441	19810.025	48.029
2	27.423	0.642	21436.027	51.971

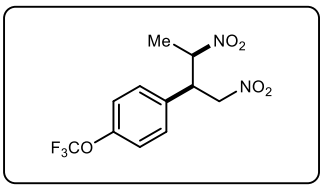


Signal 1: DAD1 C, Sig=210,8 Ref=360,100

Peak #	RT [min]	Width [min]	Area	Area %
1	16.704	0.344	186.982	1.117
2	26.983	0.619	16554.299	98.883

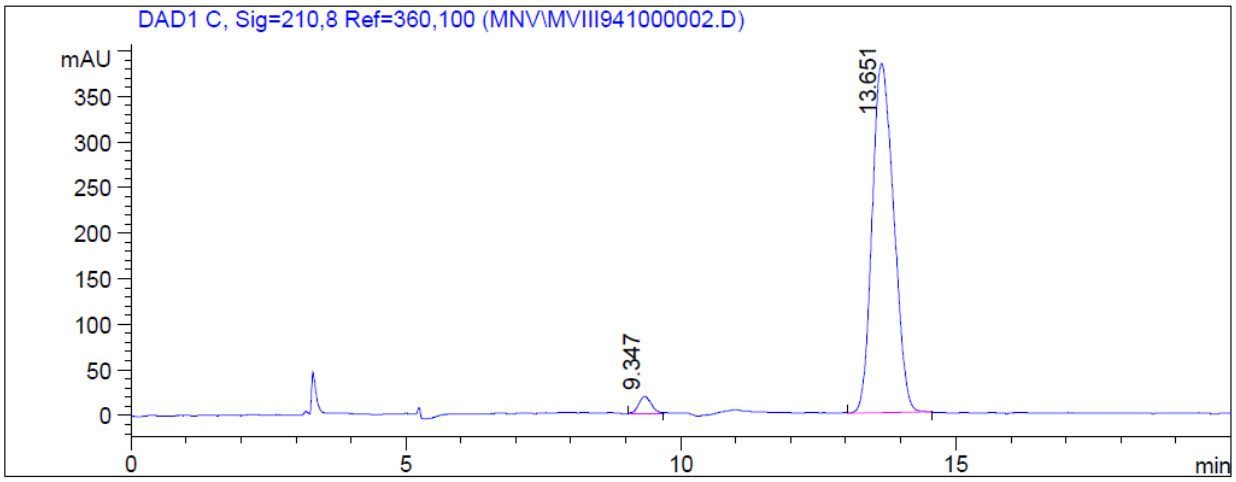
HPLC trace of 6m





Signal 1: DAD1 C, Sig=210,8 Ref=360,100

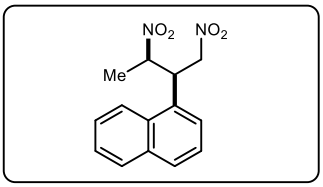
Peak #	RT [min]	Width [min]	Area	Area %
1	9.171	0.273	3062.125	50.110
2	13.285	0.472	3048.668	49.890

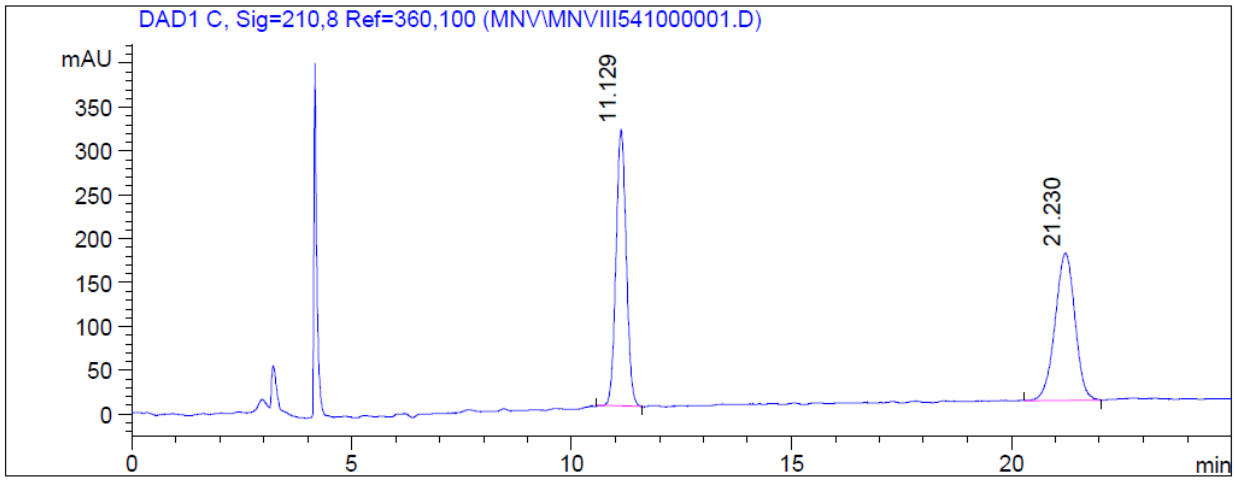


Signal 1: DAD1 C, Sig=210,8 Ref=360,100

Peak #	RT [min]	Width [min]	Area	Area %
1	9.347	0.256	286.005	2.659
2	13.651	0.455	10470.630	97.341

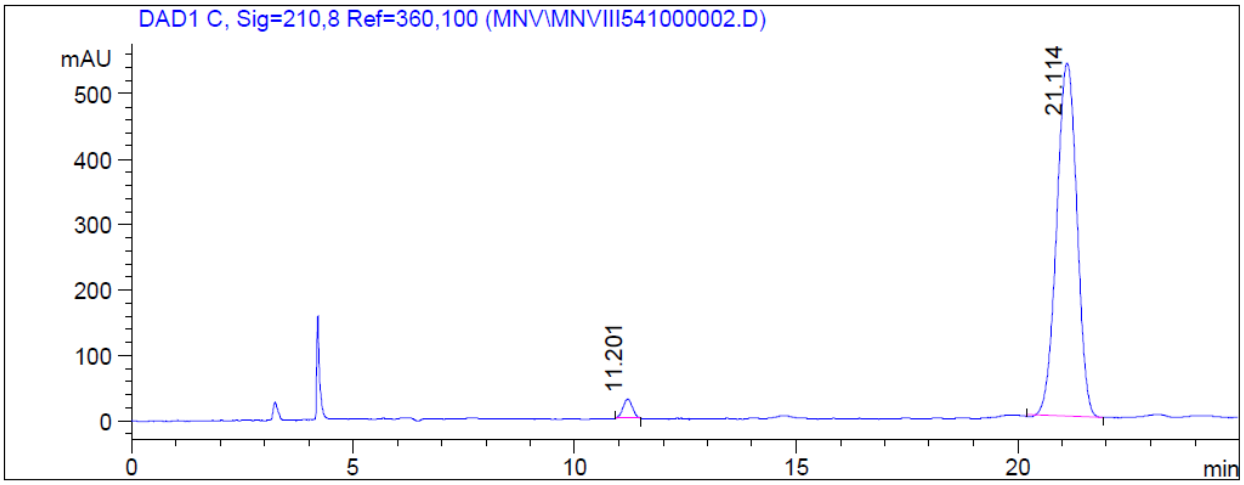
HPLC trace of 6n





Signal 1: DAD1 C, Sig=210,8 Ref=360,100

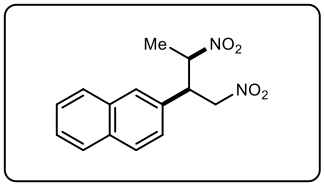
Peak #	RT [min]	Width [min]	Area	Area %
1	11.129	0.271	5112.963	49.279
2	21.230	0.524	5262.528	50.721

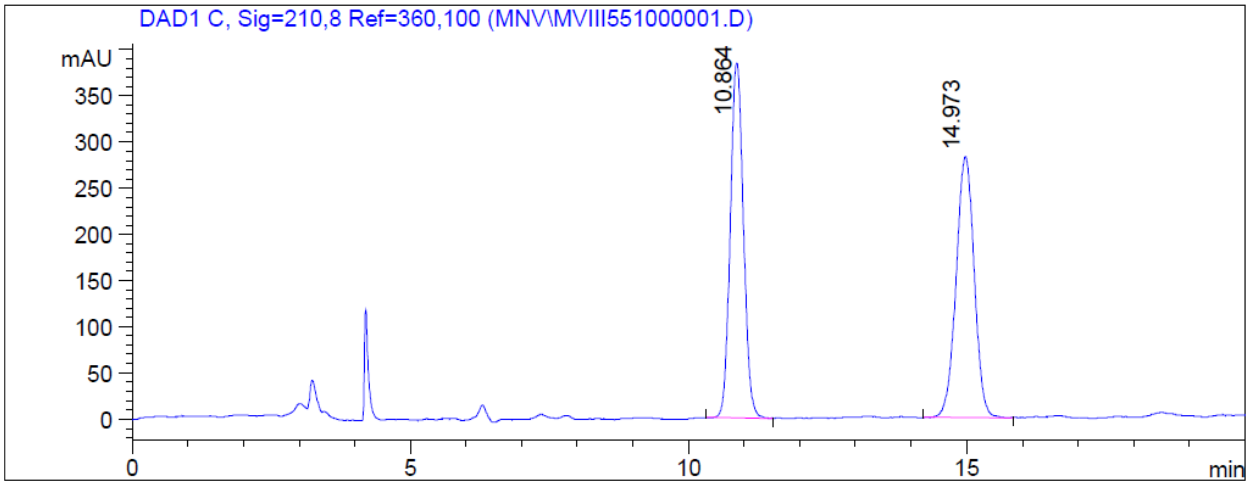


Signal 1: DAD1 C, Sig=210,8 Ref=360,100

Peak #	RT [min]	Width [min]	Area	Area %
1	11.201	0.243	423.253	2.410
2	21.114	0.529	17137.150	97.590

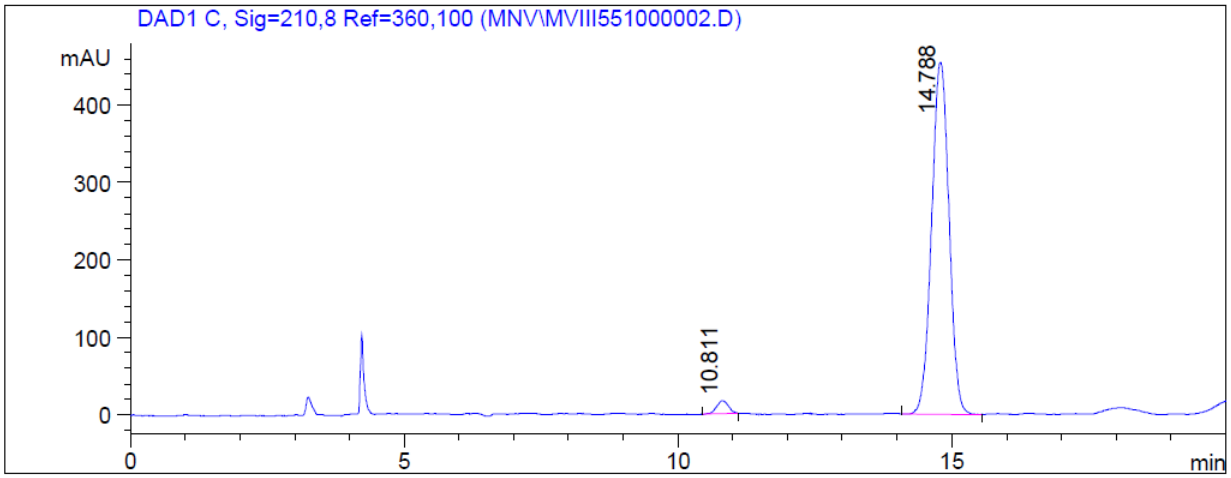
HPLC trace of 6o





Signal 1: DAD1 C, Sig=210,8 Ref=360,100

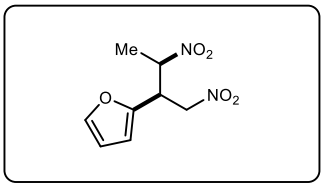
Peak #	RT [min]	Width [min]	Area	Area %
1	10.864	0.274	6315.672	49.659
2	14.973	0.378	6402.286	50.341

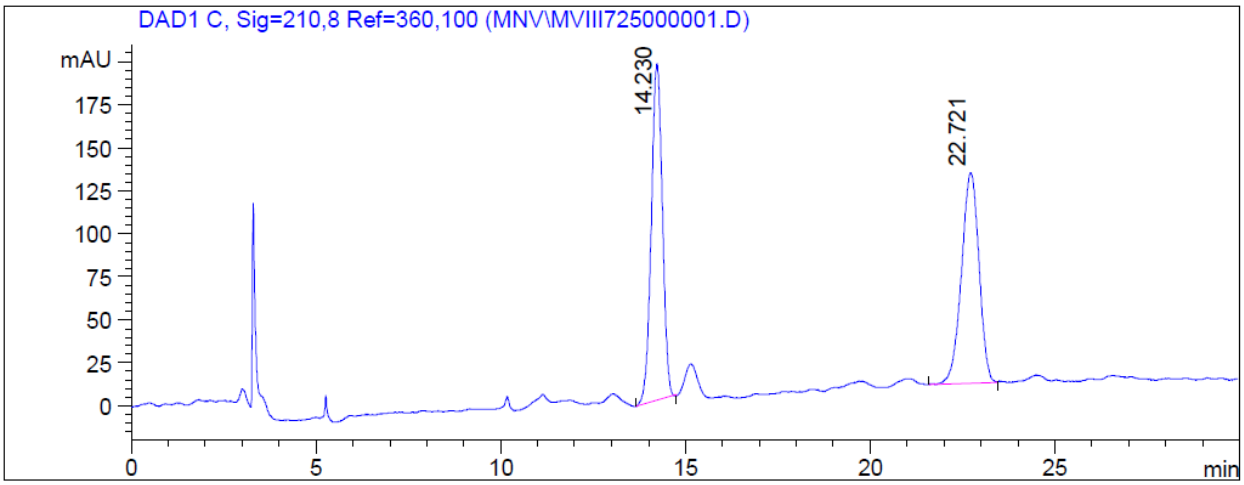


Signal 1: DAD1 C, Sig=210,8 Ref=360,100

Peak #	RT [min]	Width [min]	Area	Area %
1	10.811	0.251	253.694	2.455
2	14.788	0.369	10080.985	97.545

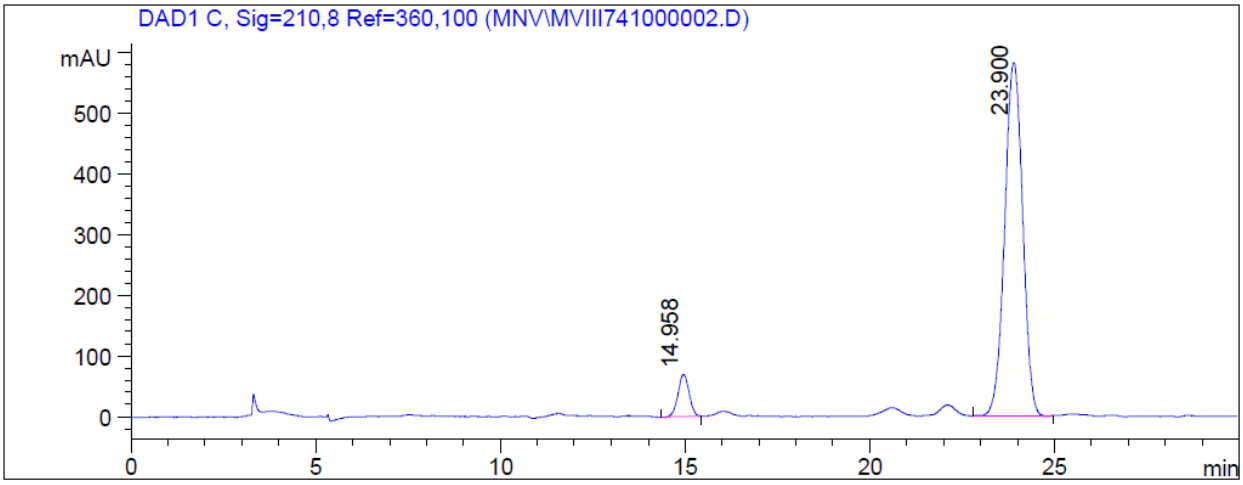
HPLC trace of 6p





Signal 1: DAD1 C, Sig=210,8 Ref=360,100

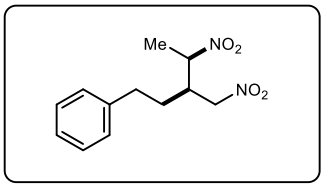
Peak #	RT [min]	Width [min]	Area	Area %
1	14.230	0.348	4076.173	50.229
2	22.721	0.550	4039.006	49.771

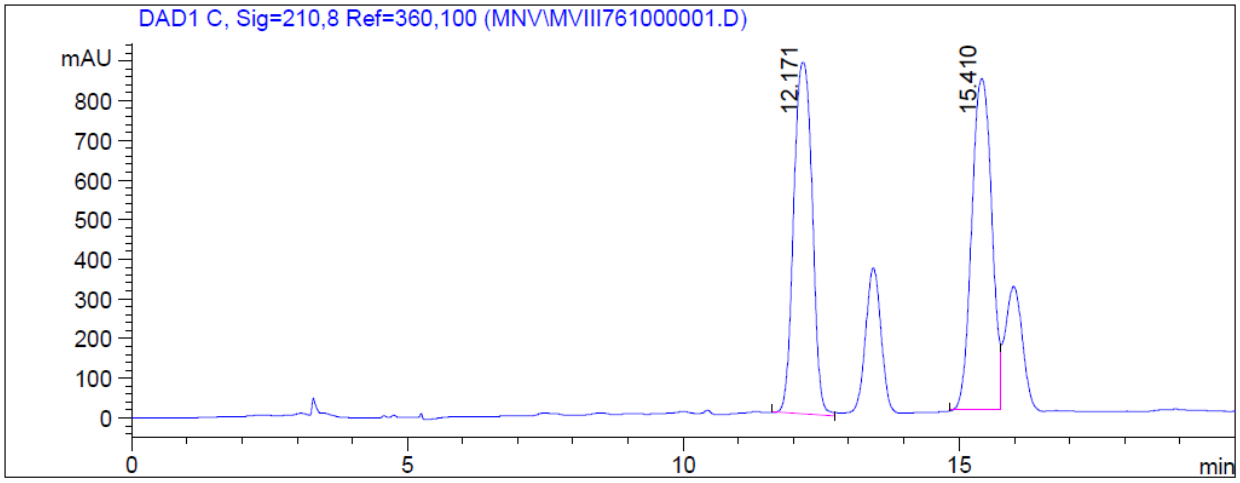


Signal 1: DAD1 C, Sig=210,8 Ref=360,100

Peak #	RT [min]	Width [min]	Area	Area %
1	14.958	0.346	1438.438	6.828
2	23.900	0.563	19628.551	93.172

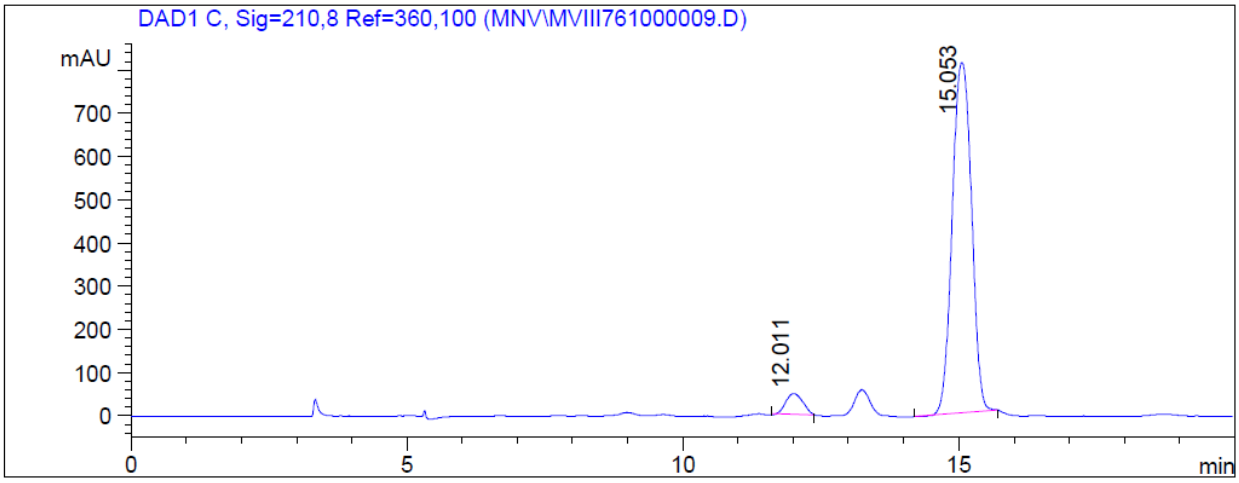
HPLC trace of 6q





Signal 1: DAD1 C, Sig=210,8 Ref=360,100

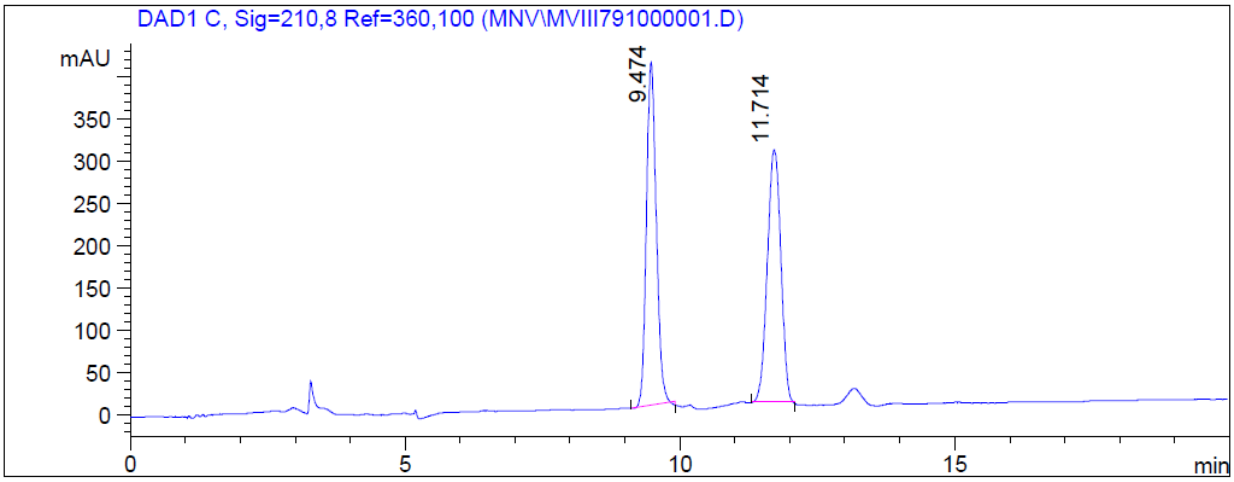
Peak #	RT [min]	Width [min]	Area	Area %
1	12.171	0.388	20634.051	49.559
2	15.410	0.420	21000.996	50.441

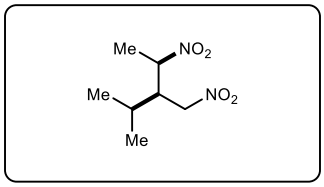


Signal 1: DAD1 C, Sig=210,8 Ref=360,100

Peak #	RT [min]	Width [min]	Area	Area %
1	12.011	0.359	1035.360	4.995
2	15.053	0.404	19690.719	95.005

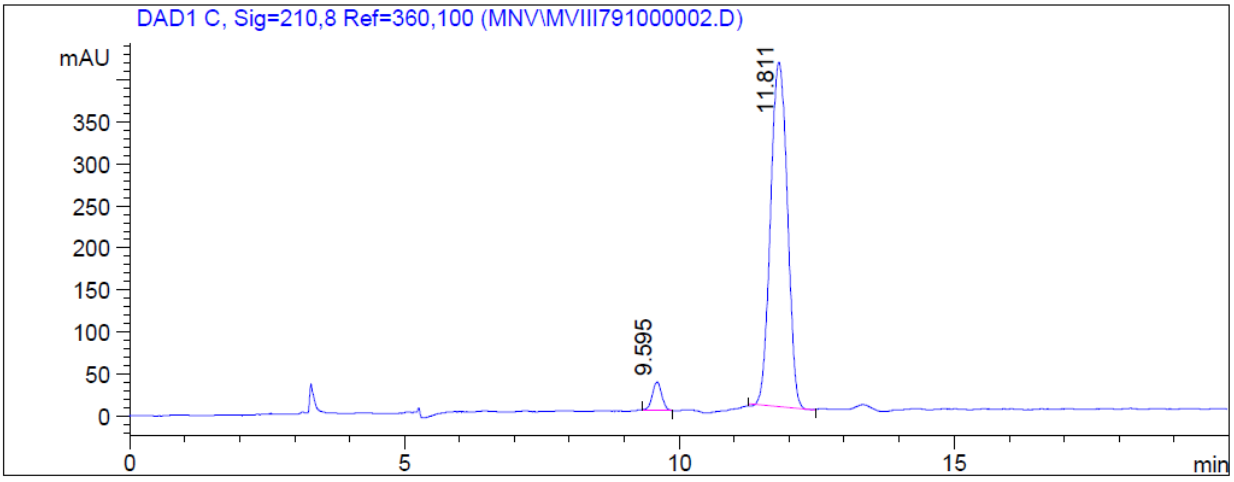
HPLC trace of 6r





Signal 1: DAD1 C, Sig=210,8 Ref=360,100

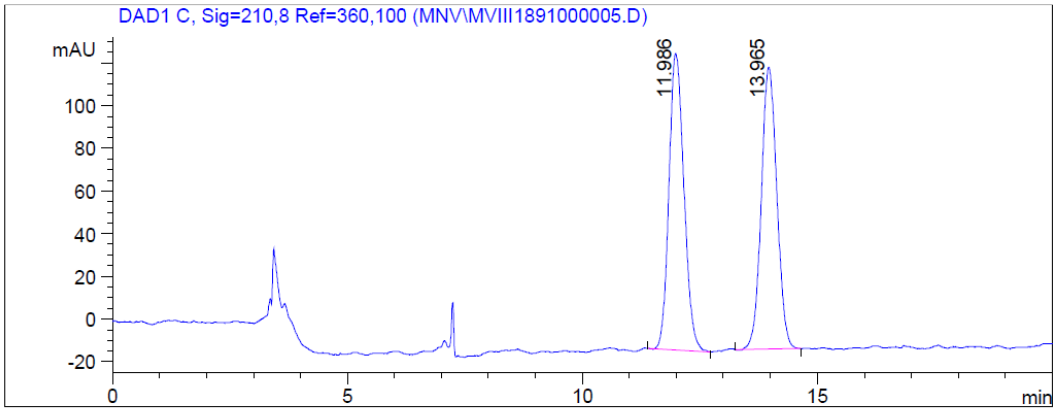
Peak #	RT [min]	Width [min]	Area	Area %
1	9.474	0.207	5056.245	49.918
2	11.714	0.283	5072.842	50.082

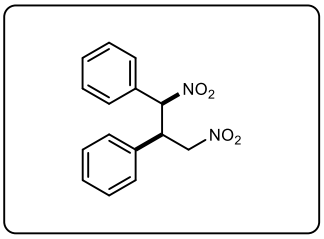


Signal 1: DAD1 C, Sig=210,8 Ref=360,100

Peak #	RT [min]	Width [min]	Area	Area %
1	9.595	0.196	394.445	4.306
2	11.811	0.355	8764.885	95.694

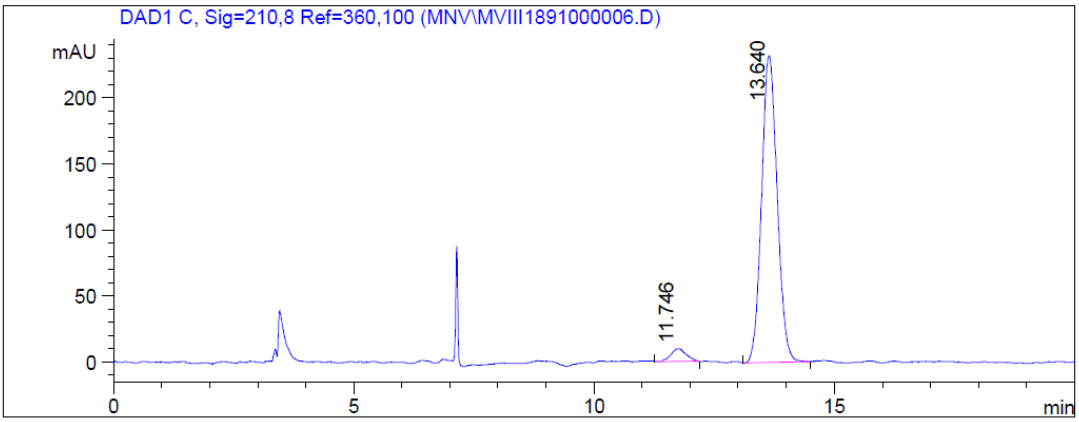
HPLC data for 8a





Signal 1: DAD1 C, Sig=210,8 Ref=360,100

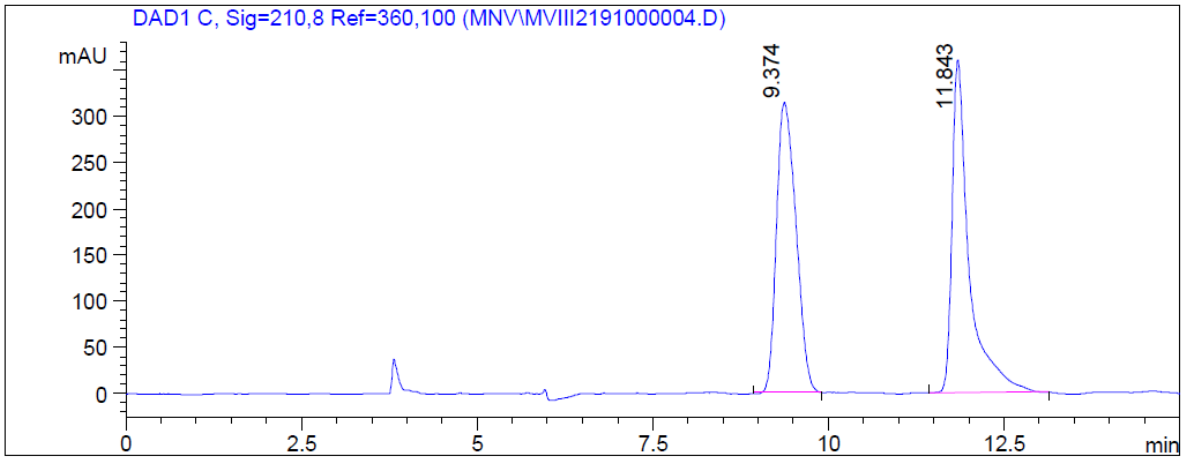
Peak #	RT [min]	Width [min]	Area	Area %
1	11.986	0.371	3095.012	50.478
2	13.965	0.384	3036.456	49.522

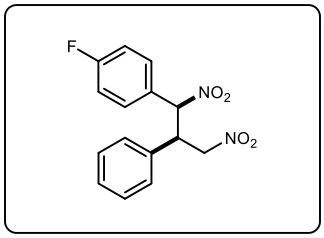


Signal 1: DAD1 C, Sig=210,8 Ref=360,100

Peak #	RT [min]	Width [min]	Area	Area %
1	11.746	0.366	217.257	3.974
2	13.640	0.377	5250.355	96.026

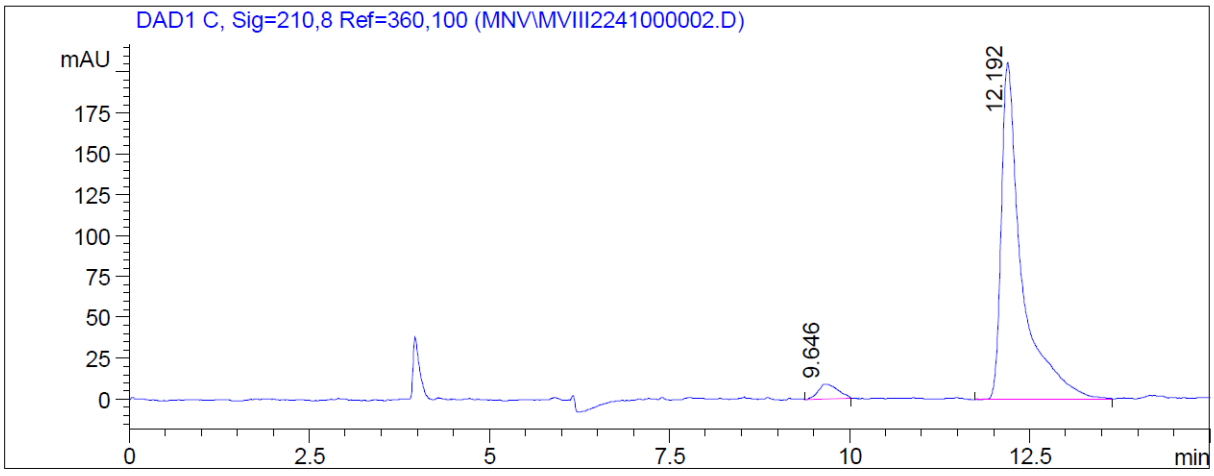
HPLC data for 8b





Signal 1: DAD1 C, Sig=210,8 Ref=360,100

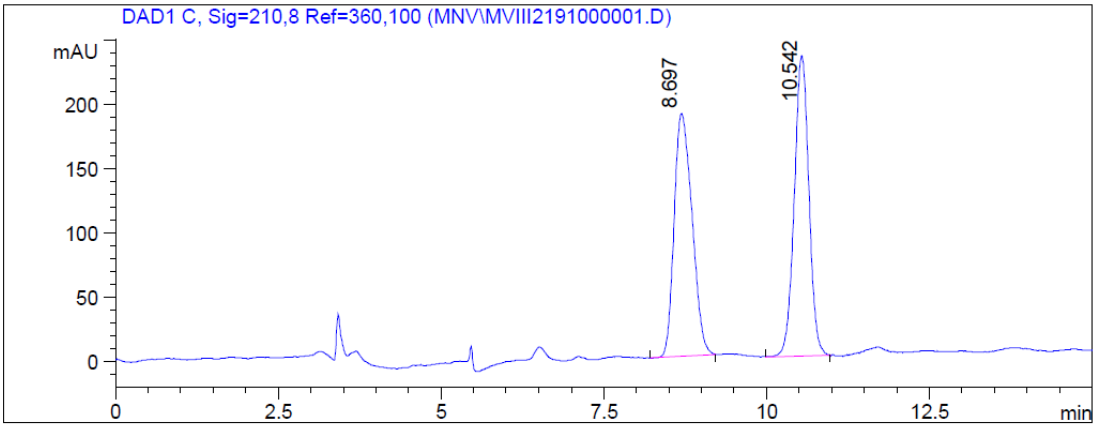
Peak #	RT [min]	Width [min]	Area	Area %
1	9.374	0.320	6009.503	49.778
2	11.843	0.280	6063.034	50.222

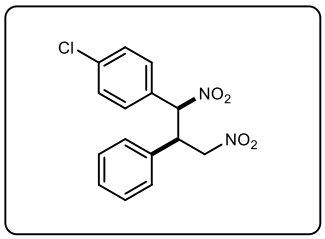


Signal 1: DAD1 C, Sig=210,8 Ref=360,100

Peak #	RT [min]	Width [min]	Area	Area %
1	9.646	0.315	169.693	4.034
2	12.192	0.327	4037.221	95.966

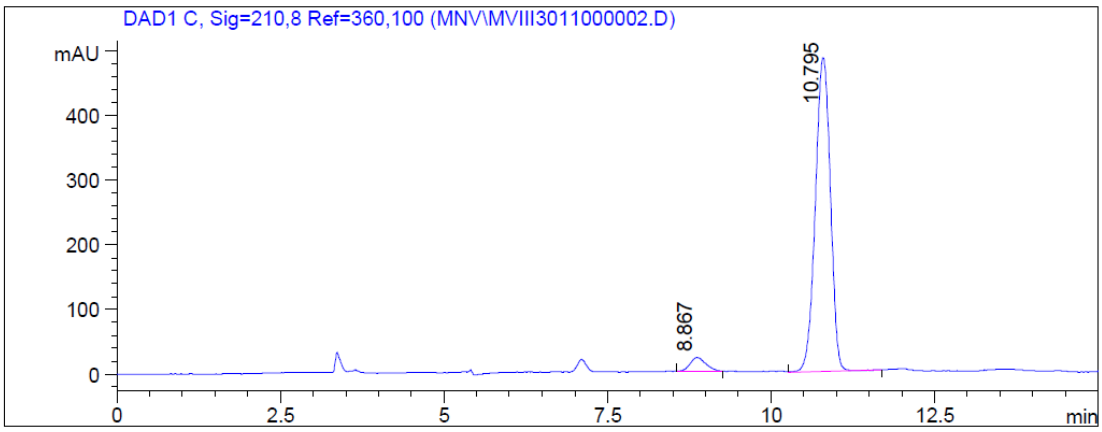
HPLC data for 8c





Signal 1: DAD1 C, Sig=210,8 Ref=360,100

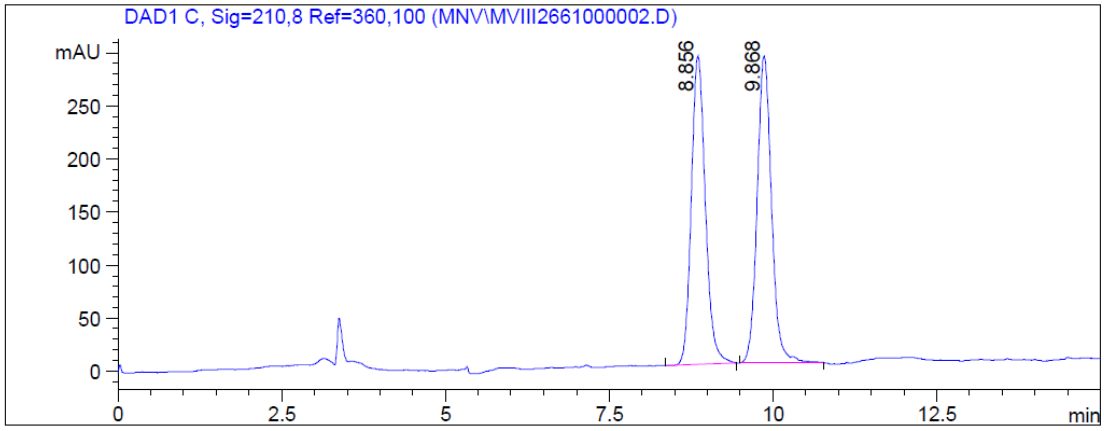
Peak #	RT [min]	Width [min]	Area	Area %
1	8.697	0.318	3608.329	49.701
2	10.542	0.260	3651.746	50.299

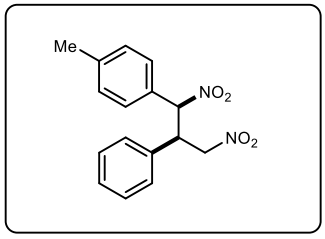


Signal 1: DAD1 C, Sig=210,8 Ref=360,100

Peak #	RT [min]	Width [min]	Area	Area %
1	8.867	0.278	357.159	4.399
2	10.795	0.267	7761.895	95.601

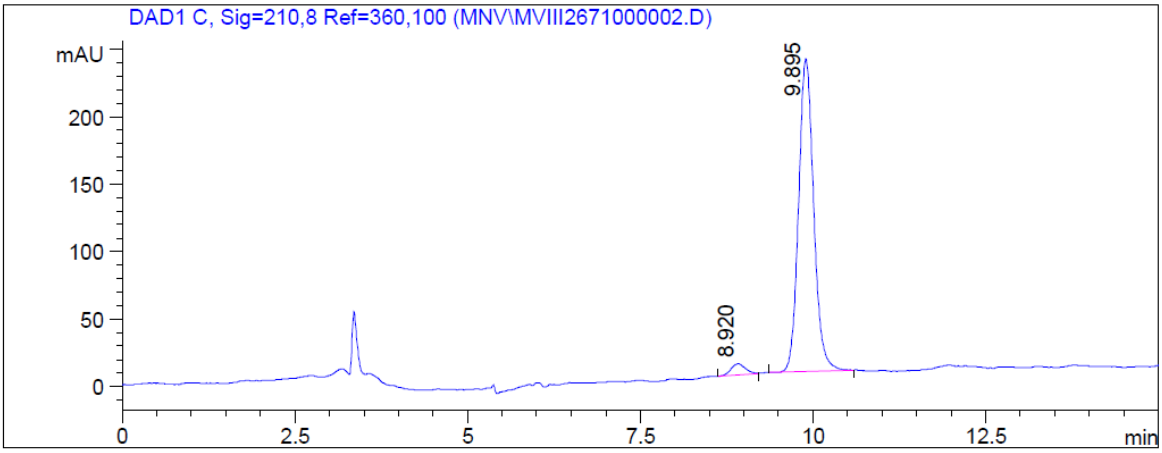
HPLC data for 8d





Signal 1: DAD1 C, Sig=210,8 Ref=360,100

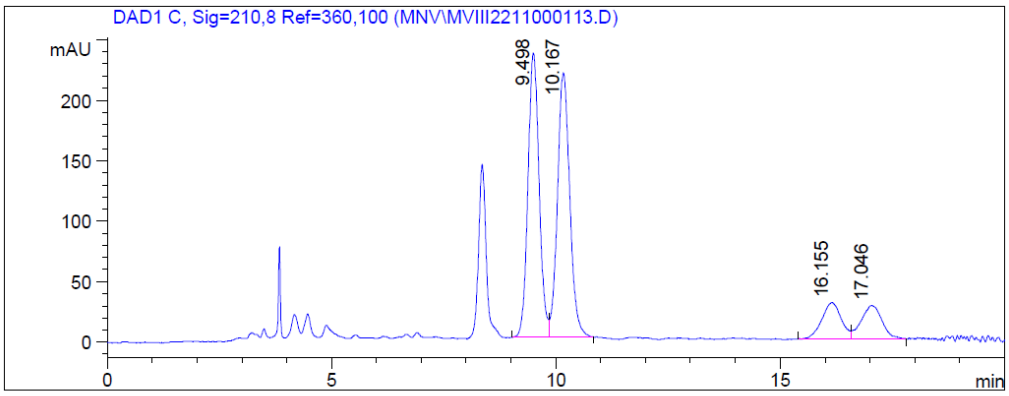
Peak #	RT [min]	Width [min]	Area	Area %
1	8.856	0.247	4315.642	49.534
2	9.868	0.254	4396.761	50.466

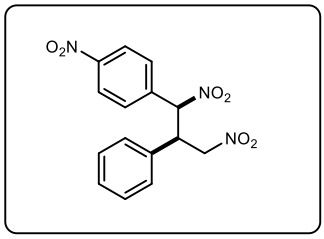


Signal 1: DAD1 C, Sig=210,8 Ref=360,100

Peak #	RT [min]	Width [min]	Area	Area %
1	8.920	0.242	115.389	3.178
2	9.895	0.252	3515.740	96.822

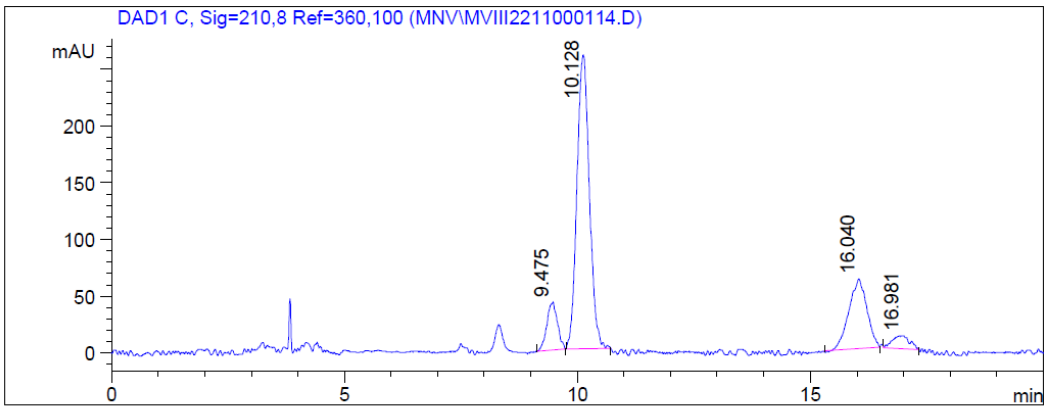
HPLC data for 8e





Signal 1: DAD1 C, Sig=210,8 Ref=360,100

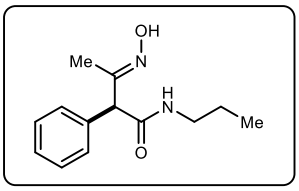
Peak #	RT [min]	Width [min]	Area	Area %
1	9.498	0.289	4064.717	40.664
2	10.167	0.317	4143.490	41.452
3	16.155	0.505	907.537	9.079
4	17.046	0.529	880.229	8.806

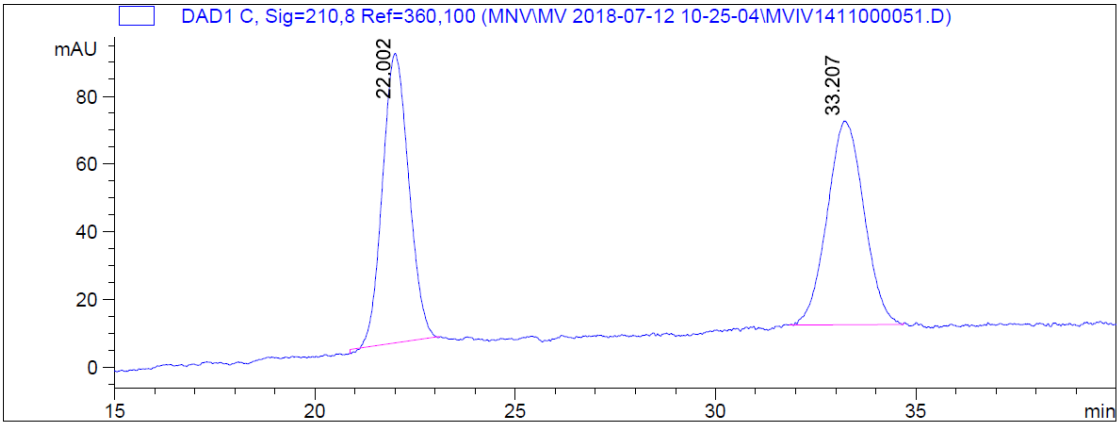


Signal 1: DAD1 C, Sig=210,8 Ref=360,100

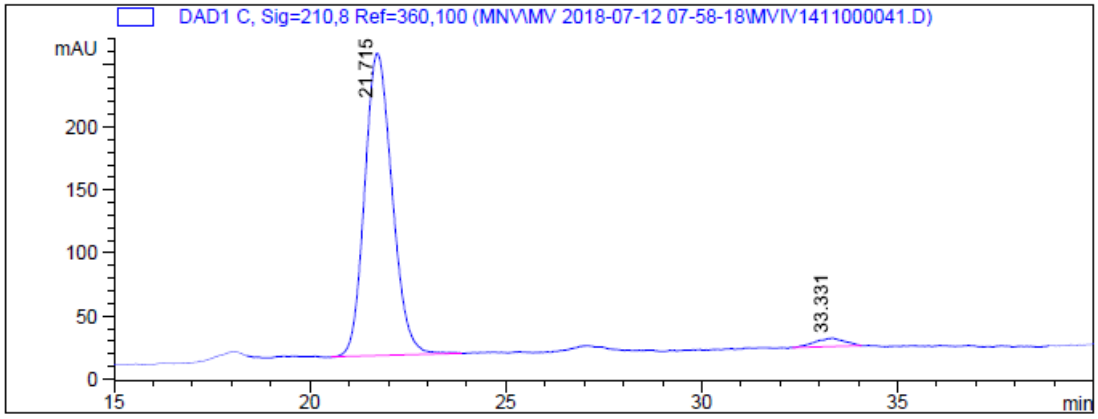
Peak #	RT [min]	Width [min]	Area	Area %
1	9.475	0.262	664.517	8.948
2	10.128	0.310	4820.594	64.913
3	16.040	0.448	1651.050	22.233
4	16.981	0.423	290.128	3.907

HPLC trace of 10a



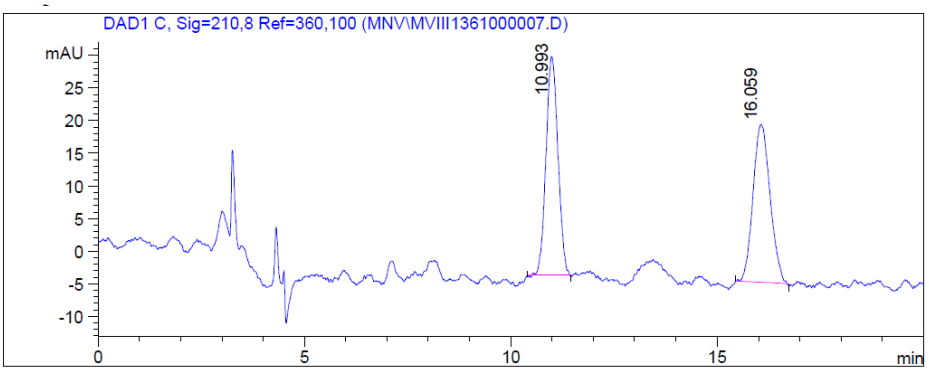


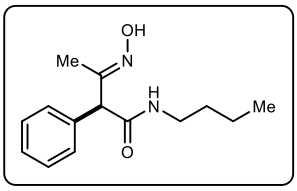
Meas.RT min	Area	Width min	Area %
22.00	3893.9	0.760	50.3
33.21	3843.8	1.067	49.7



Meas.RT min	Area	Width min	Area %
21.72	11699.5	0.813	97.1
33.33	349.6	0.883	2.9

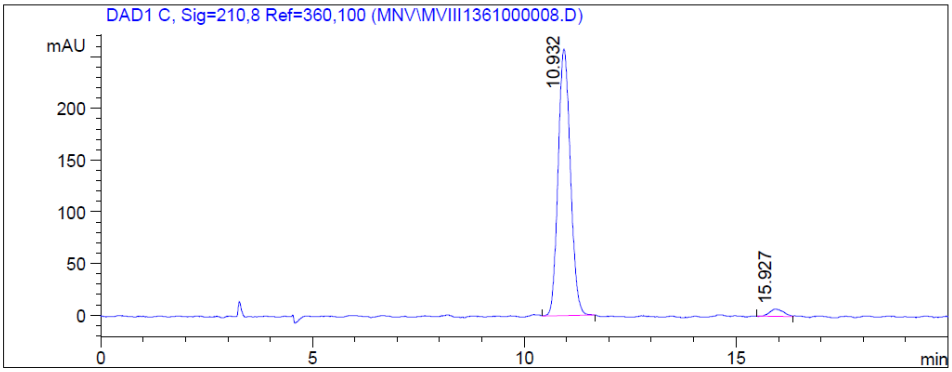
HPLC trace of 10b





Signal 1: DAD1 C, Sig=210,8 Ref=360,100

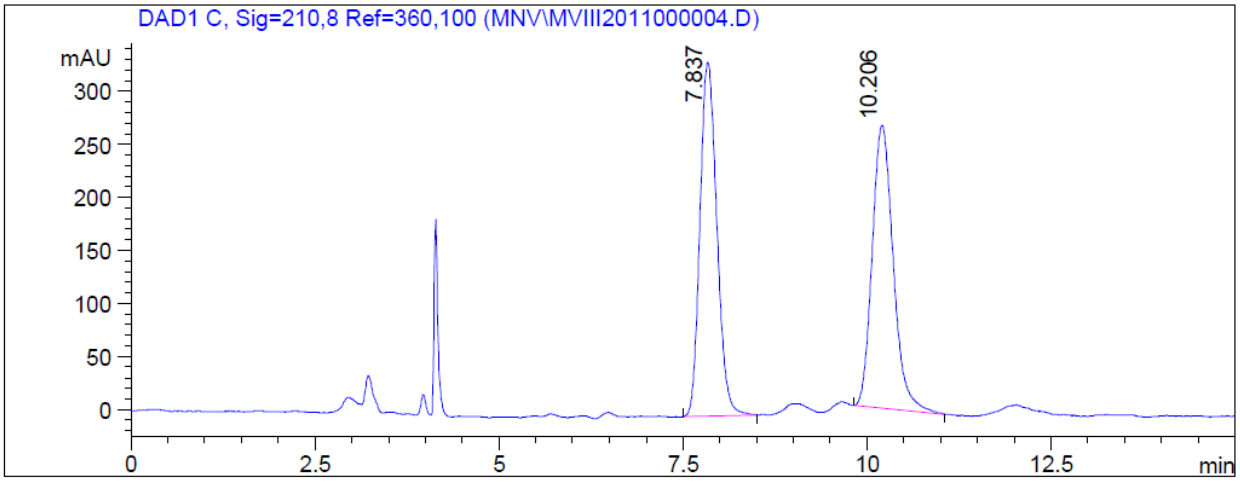
Peak #	RT [min]	Width [min]	Area	Area %
1	10.993	0.335	673.654	49.293
2	16.059	0.478	692.982	50.707

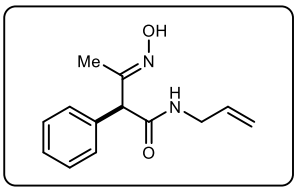


Signal 1: DAD1 C, Sig=210,8 Ref=360,100

Peak #	RT [min]	Width [min]	Area	Area %
1	10.932	0.336	5201.111	97.044
2	15.927	0.371	158.406	2.956

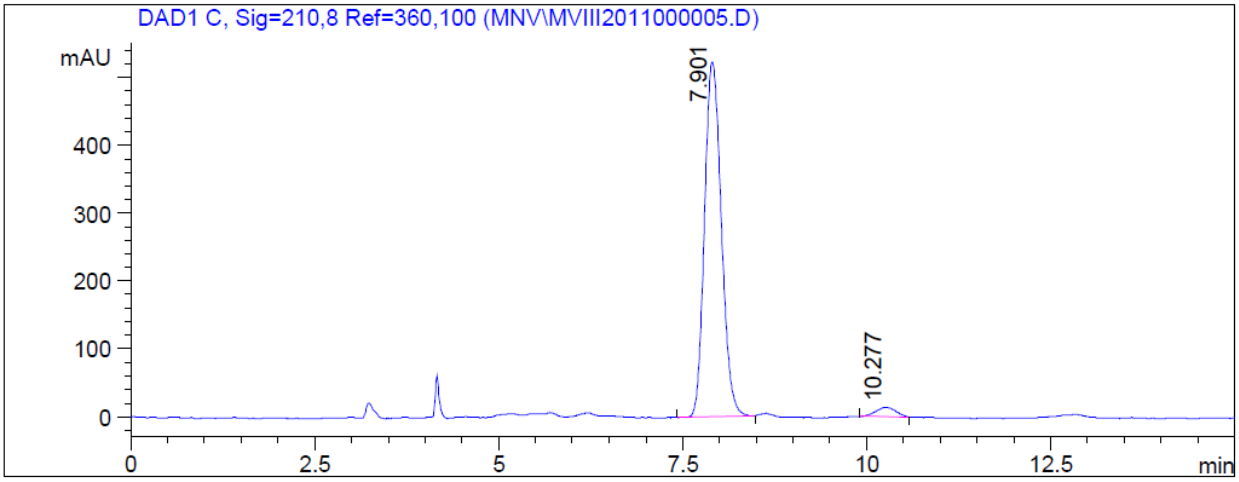
HPLC trace of 10c





Signal 1: DAD1 C, Sig=210,8 Ref=360,100

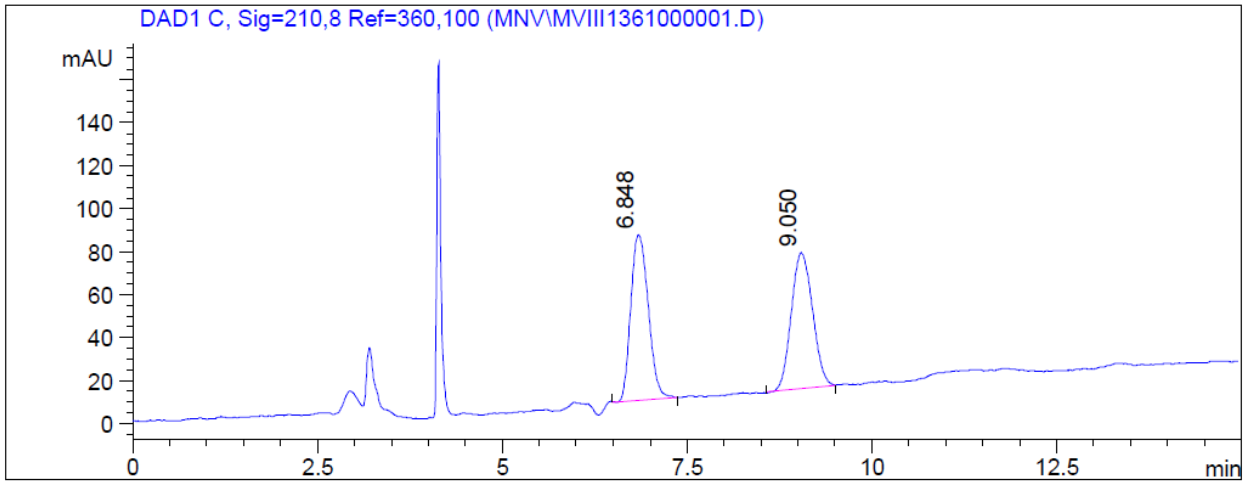
Peak #	RT [min]	Width [min]	Area	Area %
1	7.837	0.265	5316.833	50.110
2	10.206	0.331	5293.554	49.890

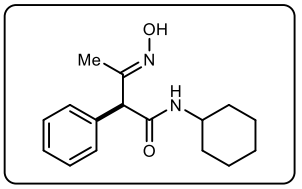


Signal 1: DAD1 C, Sig=210,8 Ref=360,100

Peak #	RT [min]	Width [min]	Area	Area %
1	7.901	0.265	8327.105	96.949
2	10.277	0.316	262.070	3.051

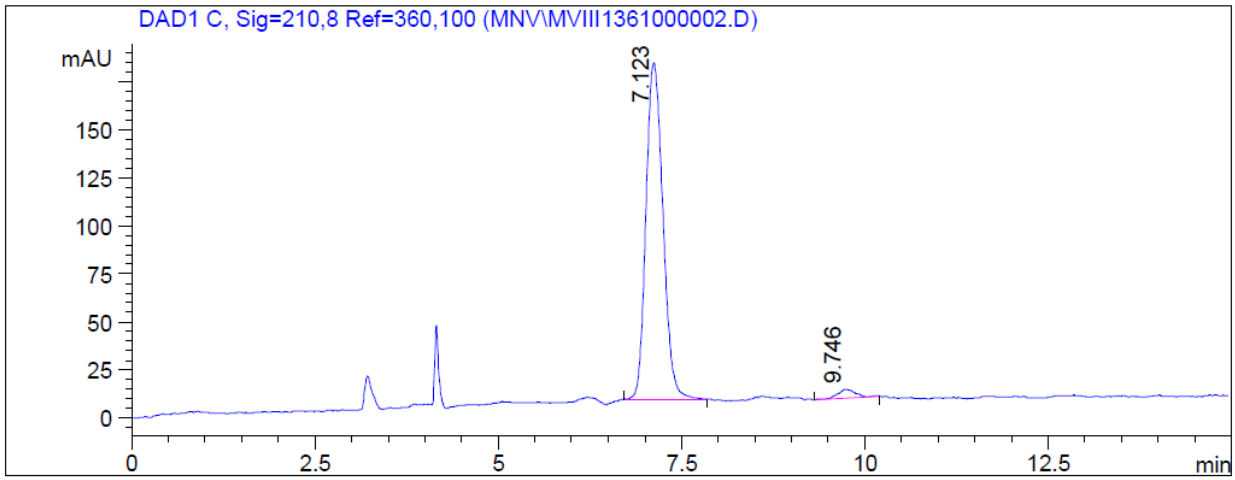
HPLC trace of 10d





Signal 1: DAD1 C, Sig=210,8 Ref=360,100

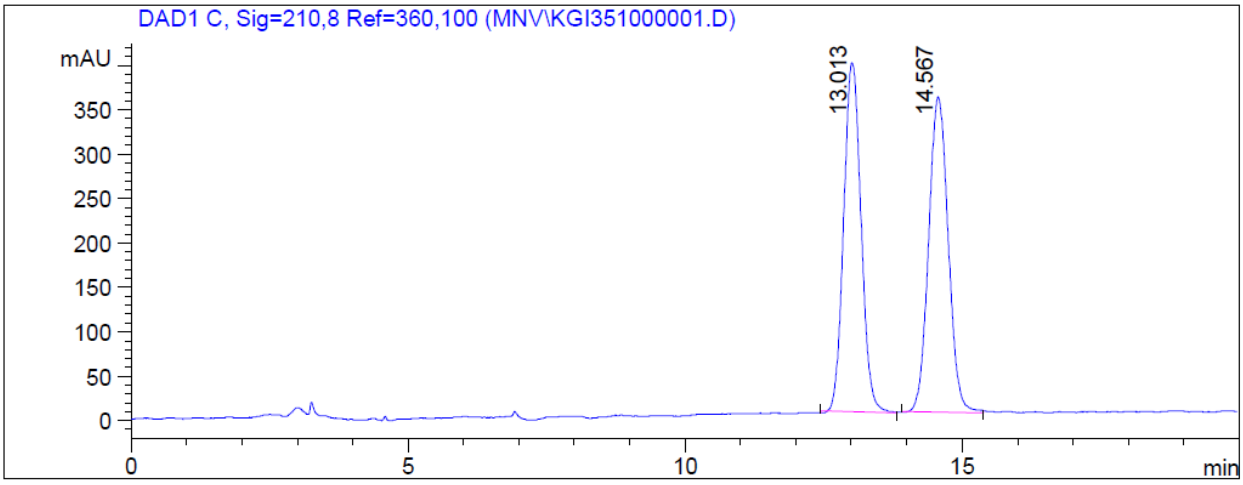
Peak #	RT [min]	Width [min]	Area	Area %
1	6.848	0.276	1276.239	50.101
2	9.050	0.334	1271.115	49.899

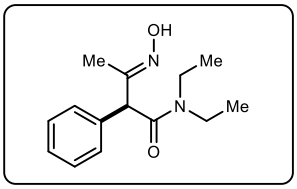


Signal 1: DAD1 C, Sig=210,8 Ref=360,100

Peak #	RT [min]	Width [min]	Area	Area %
1	7.123	0.267	2808.563	97.422
2	9.746	0.273	74.317	2.578

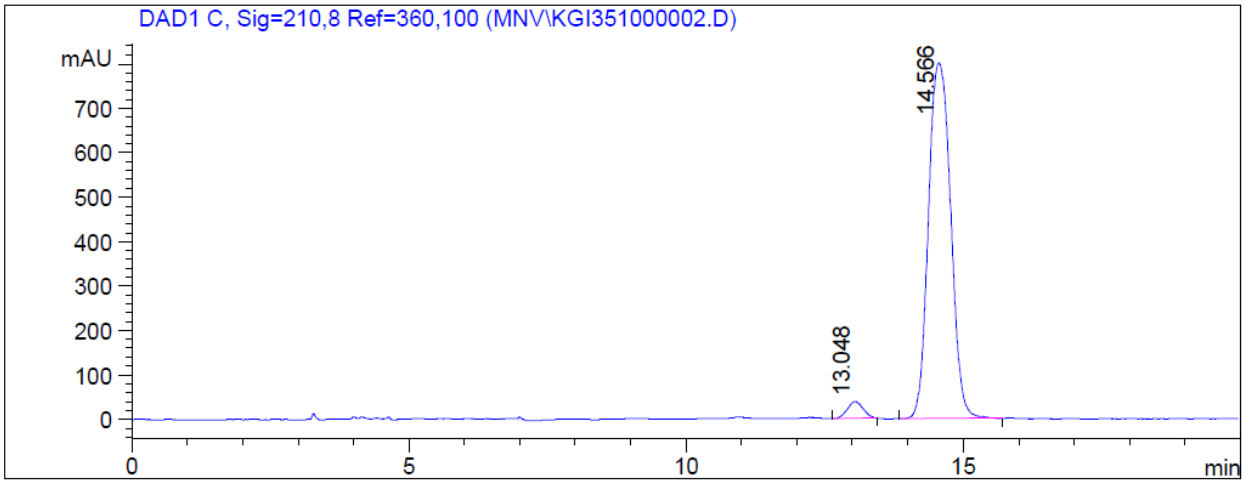
HPLC trace of 10e





Signal 1: DAD1 C, Sig=210,8 Ref=360,100

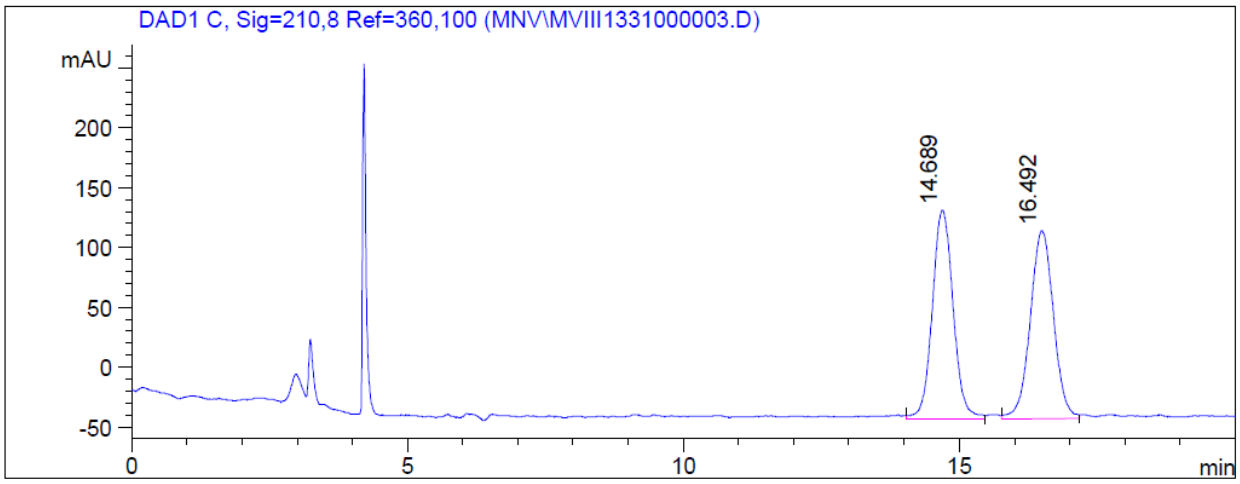
Peak #	RT [min]	Width [min]	Area	Area %
1	13.013	0.363	8549.721	49.523
2	14.567	0.409	8714.270	50.477

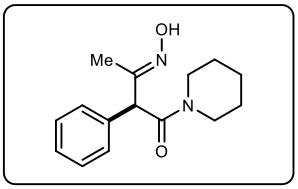


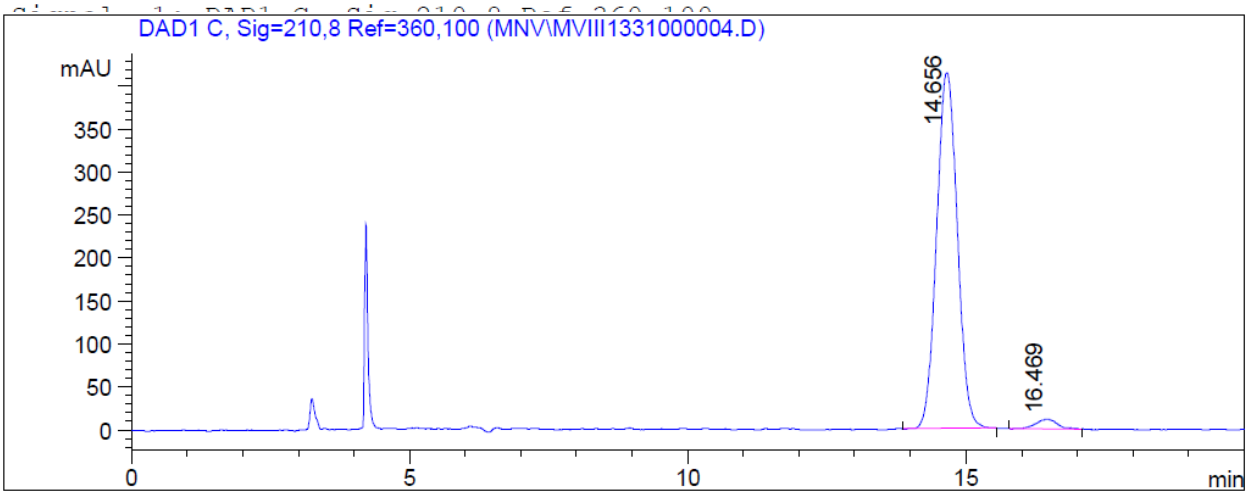
Signal 1: DAD1 C, Sig=210,8 Ref=360,100

Peak #	RT [min]	Width [min]	Area	Area %
1	13.048	0.331	743.598	3.226
2	14.566	0.464	22309.018	96.774

HPLC trace of 10f



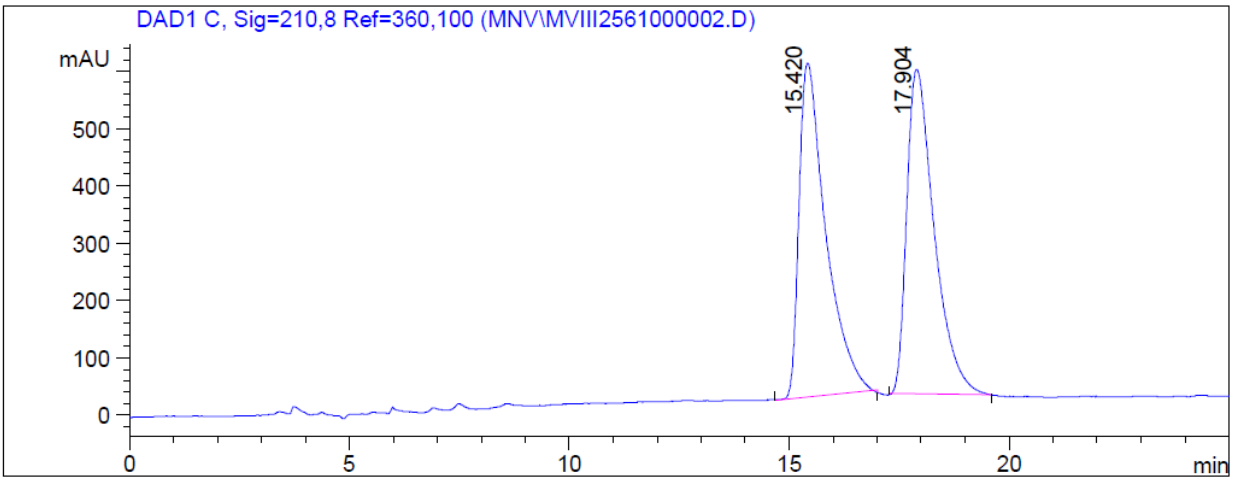


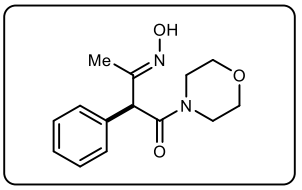


Signal 1: DAD1 C, Sig=210,8 Ref=360,100

Peak #	RT [min]	Width [min]	Area	Area %
1	14.656	0.431	10719.008	97.354
2	16.469	0.439	291.326	2.646

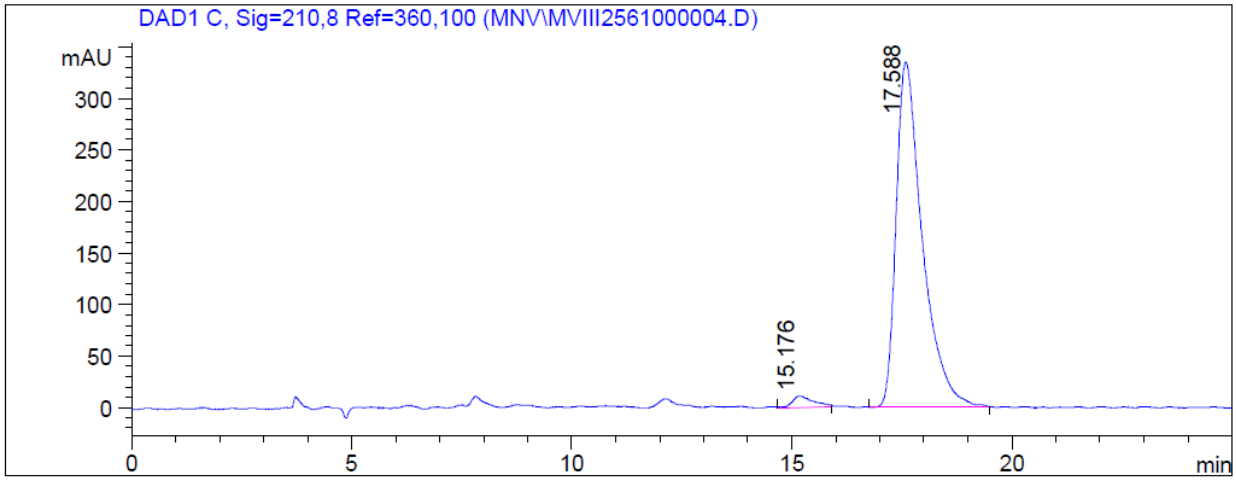
HPLC trace of 10g





Signal 1: DAD1 C, Sig=210,8 Ref=360,100

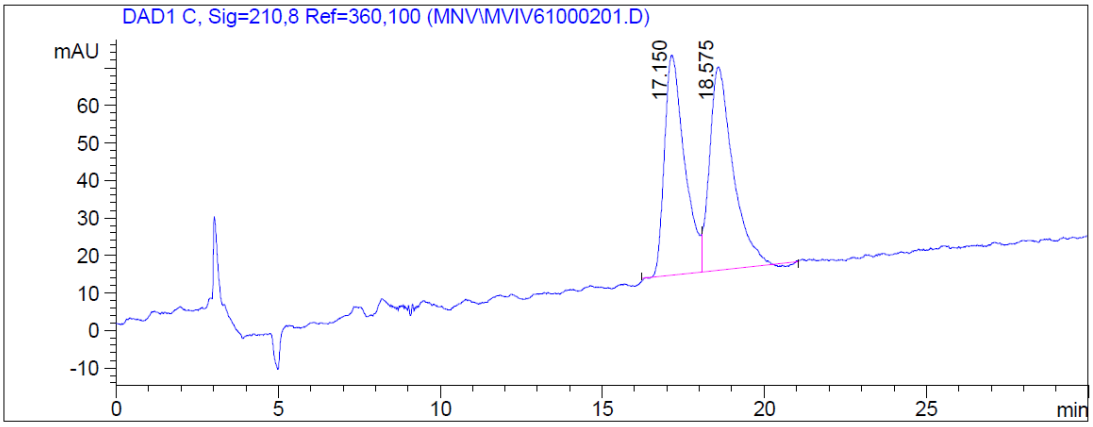
Peak #	RT [min]	Width [min]	Area	Area %
1	15.420	0.703	24553.059	49.989
2	17.904	0.724	24564.307	50.011

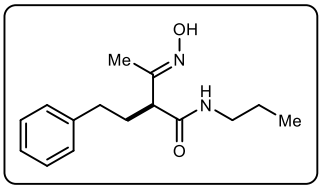


Signal 1: DAD1 C, Sig=210,8 Ref=360,100

Peak #	RT [min]	Width [min]	Area	Area %
1	15.176	0.561	381.985	2.693
2	17.588	0.688	13802.241	97.307

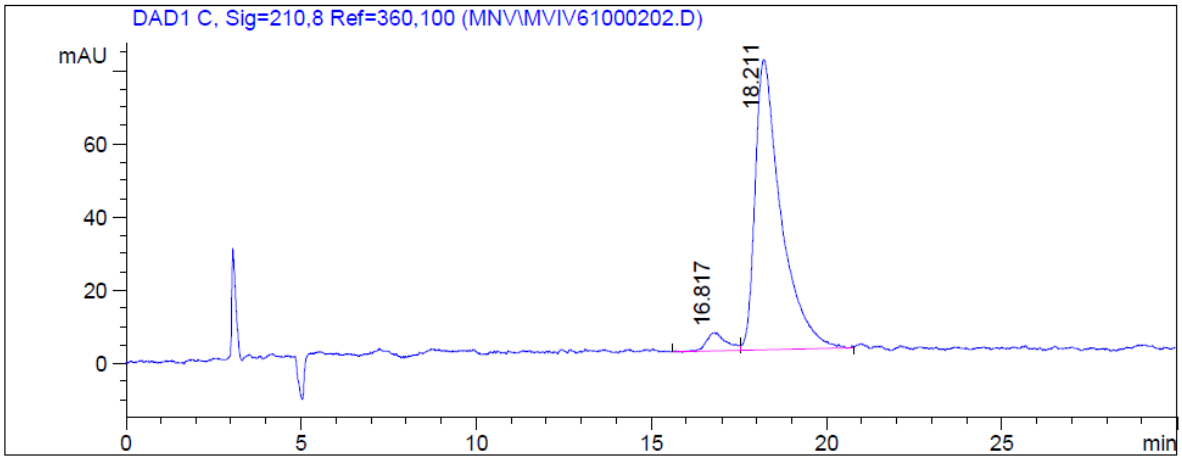
HPLC trace of 11





Signal 1: DAD1 C, Sig=210,8 Ref=360,100

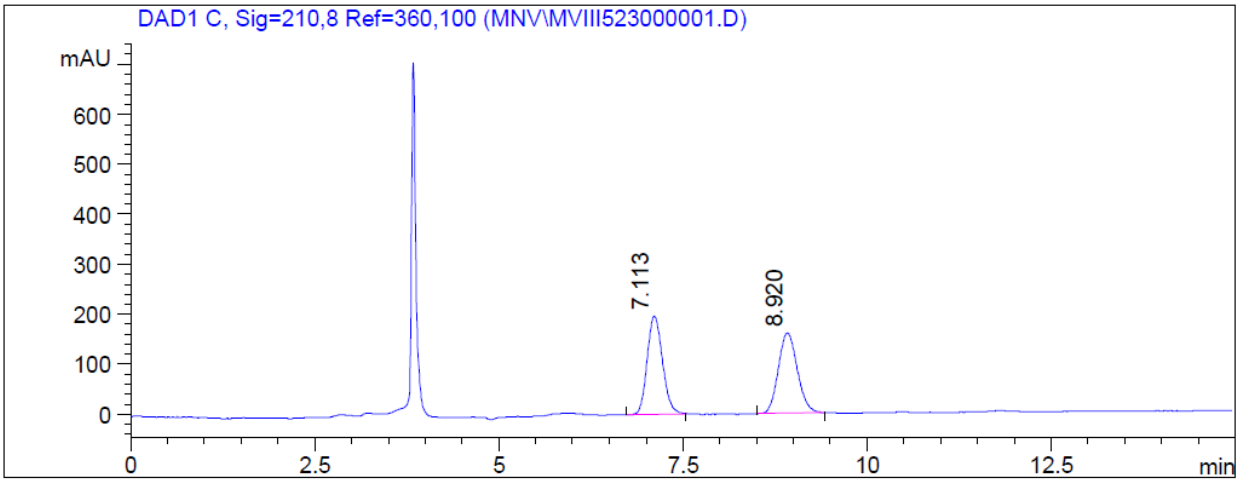
Peak #	RT [min]	Width [min]	Area	Area %
1	17.150	0.720	2534.405	48.194
2	18.575	0.838	2724.403	51.806

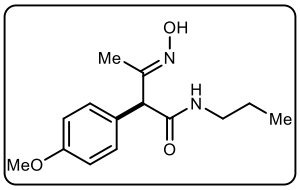


Signal 1: DAD1 C, Sig=210,8 Ref=360,100

Peak #	RT [min]	Width [min]	Area	Area %
1	16.817	0.664	197.183	4.620
2	18.211	0.855	4071.214	95.380

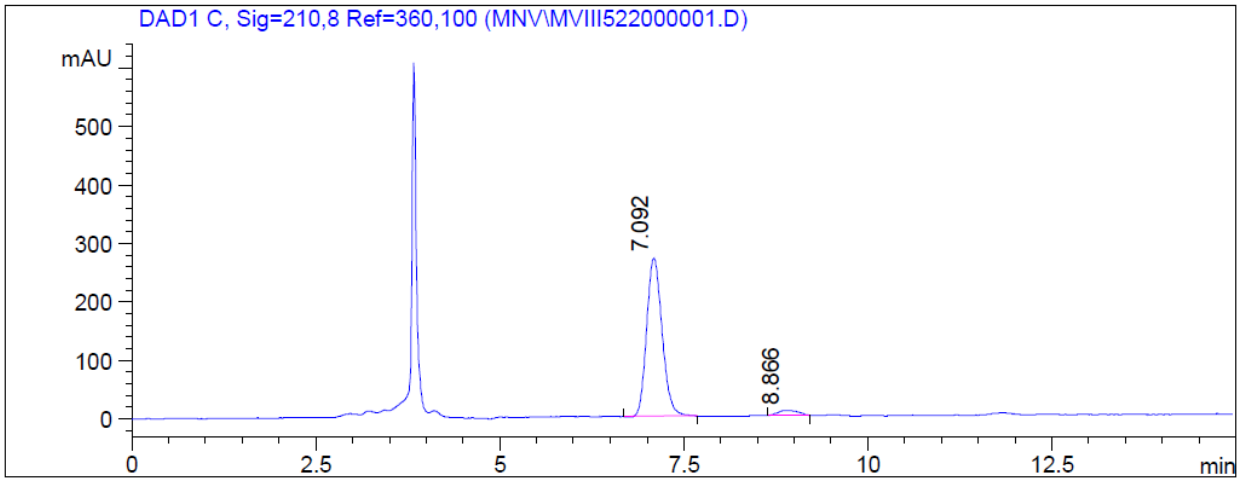
HPLC trace of 12





Signal 1: DAD1 C, Sig=210,8 Ref=360,100

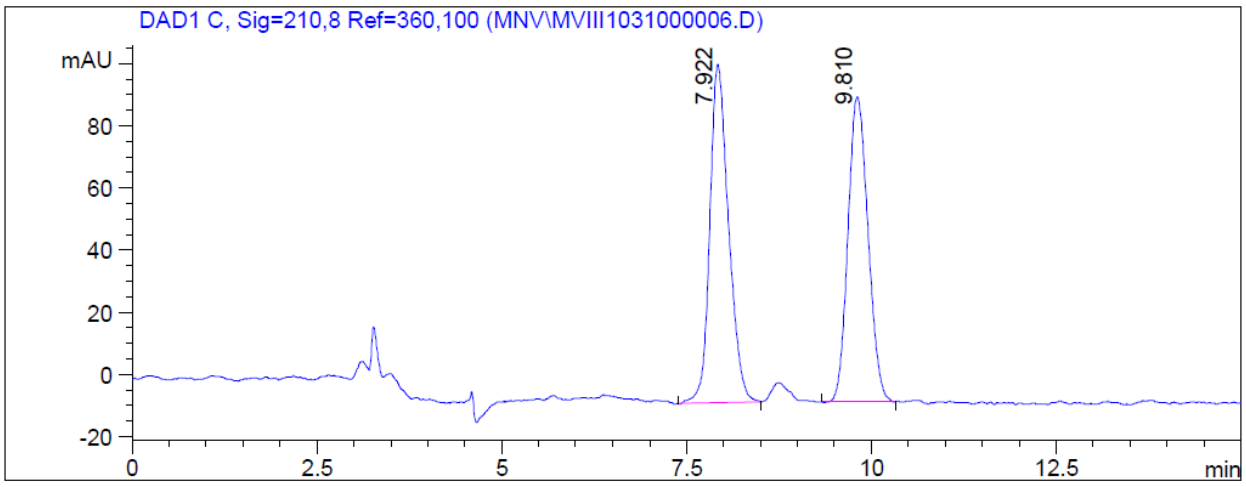
Peak #	RT [min]	Width [min]	Area	Area %
1	7.113	0.243	2874.242	50.098
2	8.920	0.297	2863.043	49.902

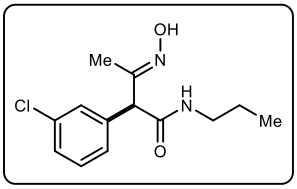


Signal 1: DAD1 C, Sig=210,8 Ref=360,100

Peak #	RT [min]	Width [min]	Area	Area %
1	7.092	0.243	3928.871	96.723
2	8.866	0.290	133.118	3.277

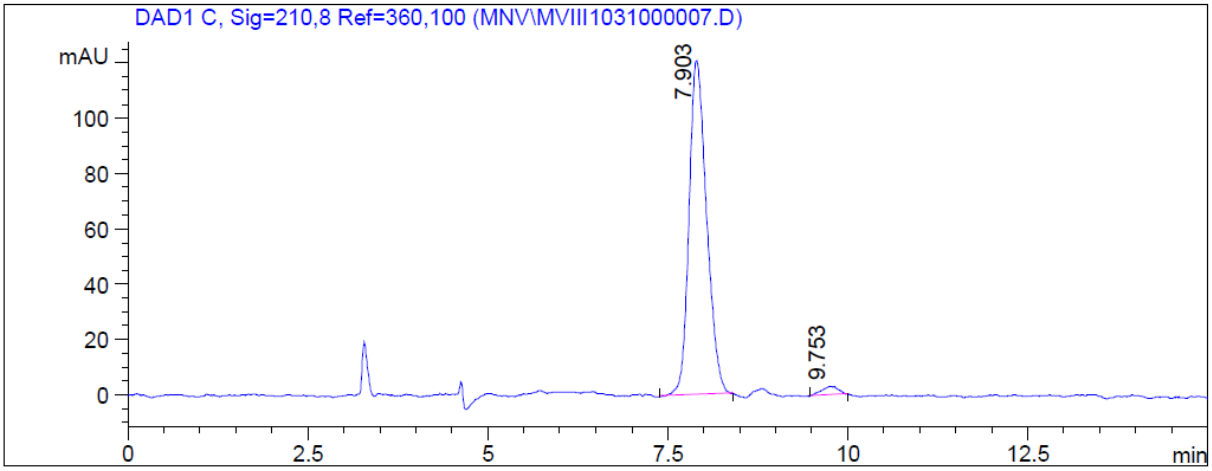
HPLC trace of 13





Signal 1: DAD1 C, Sig=210,8 Ref=360,100

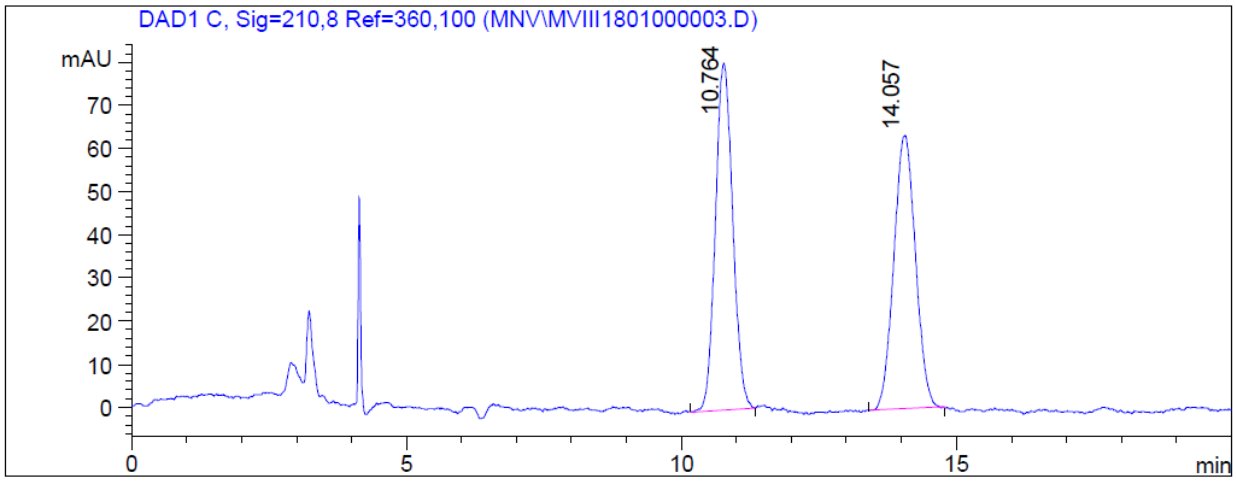
Peak #	RT [min]	Width [min]	Area	Area %
1	7.922	0.293	1913.334	50.786
2	9.810	0.315	1854.085	49.214

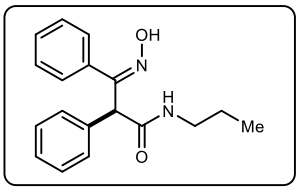


Signal 1: DAD1 C, Sig=210,8 Ref=360,100

Peak #	RT [min]	Width [min]	Area	Area %
1	7.903	0.282	2041.467	97.873
2	9.753	0.262	44.360	2.127

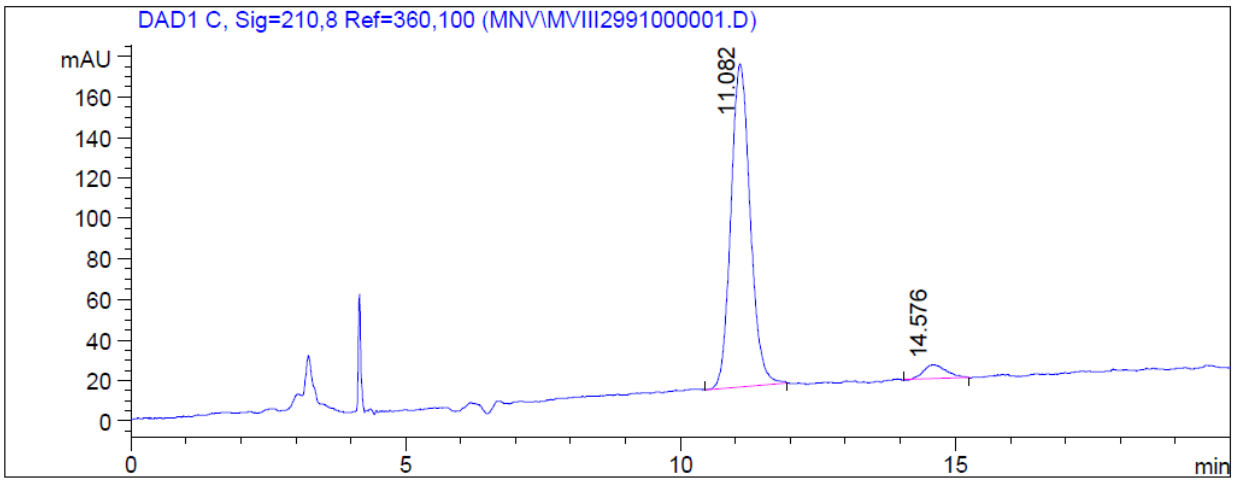
HPLC trace of 14





Signal 1: DAD1 C, Sig=210,8 Ref=360,100

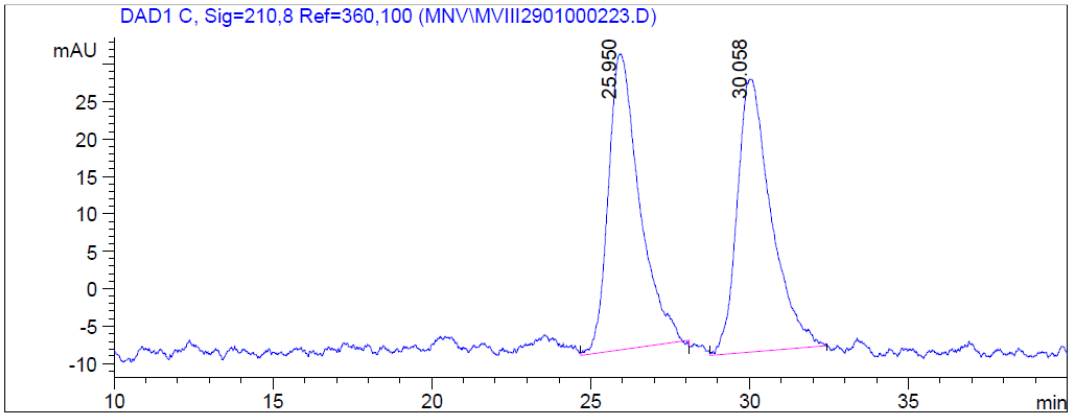
Peak #	RT [min]	Width [min]	Area	Area %
1	10.764	0.366	1768.465	50.606
2	14.057	0.455	1726.113	49.394

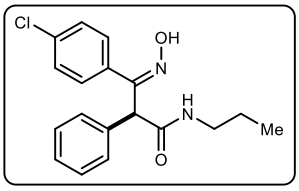


Signal 1: DAD1 C, Sig=210,8 Ref=360,100

Peak #	RT [min]	Width [min]	Area	Area %
1	11.082	0.407	3893.584	95.198
2	14.576	0.481	196.412	4.802

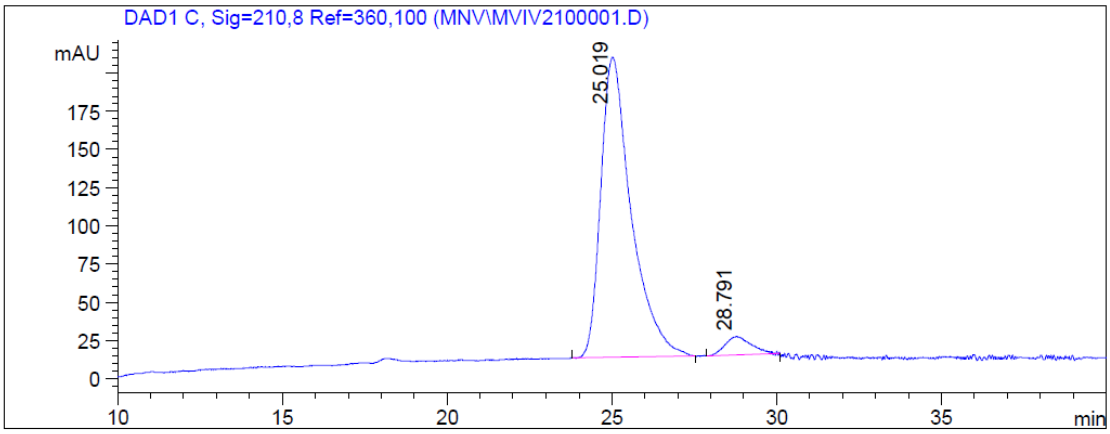
HPLC trace of 15





Signal 1: DAD1 C, Sig=210,8 Ref=360,100

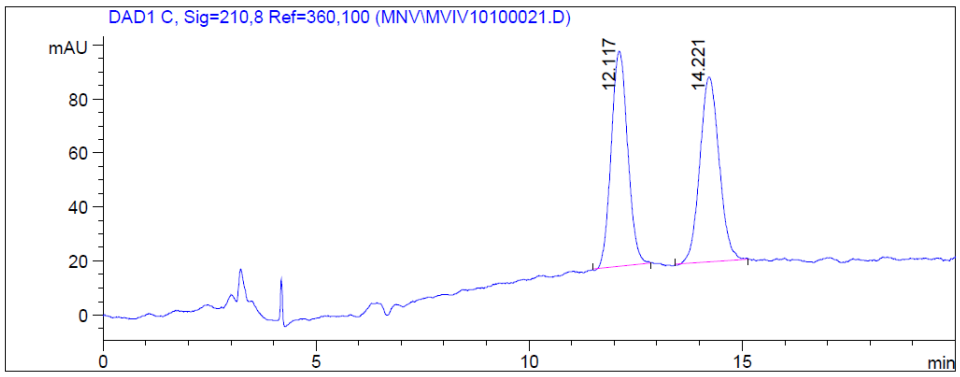
Peak #	RT [min]	Width [min]	Area	Area %
1	25.950	1.140	2706.352	49.861
2	30.058	1.245	2721.477	50.139

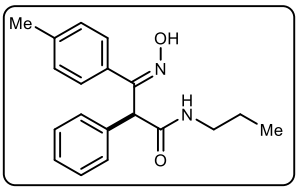


Signal 1: DAD1 C, Sig=210,8 Ref=360,100

Peak #	RT [min]	Width [min]	Area	Area %
1	25.019	1.071	12628.146	94.885
2	28.791	0.931	680.805	5.115

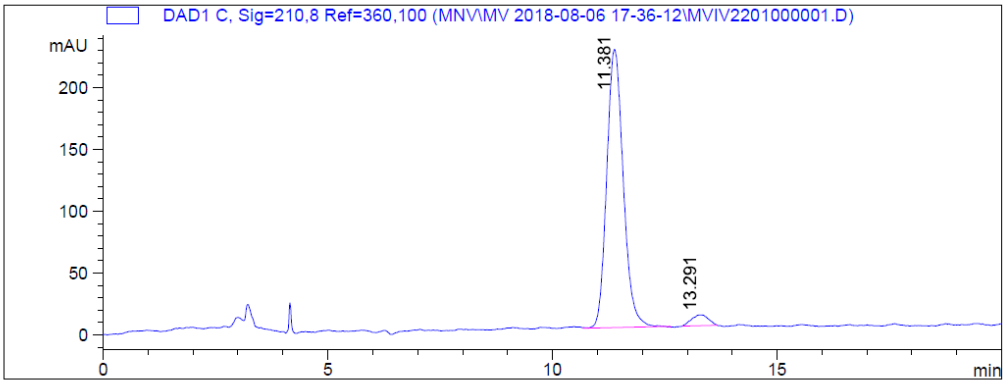
HPLC trace of 16





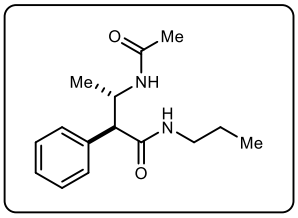
Signal 1: DAD1 C, Sig=210,8 Ref=360,100

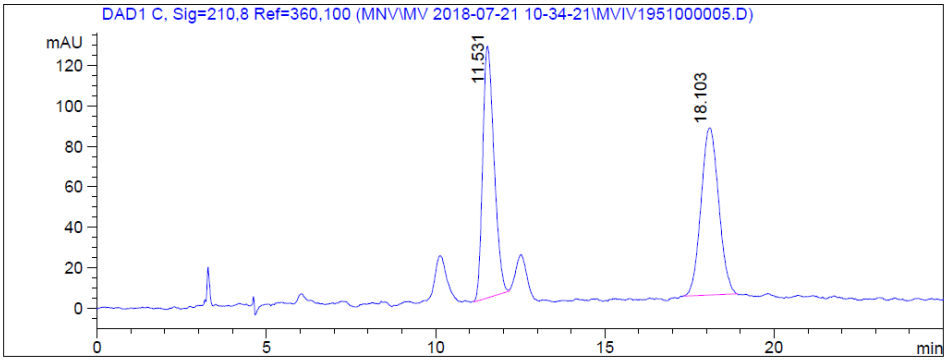
Peak #	RT [min]	Width [min]	Area	Area %
1	12.117	0.447	2139.081	49.845
2	14.221	0.524	2152.404	50.155



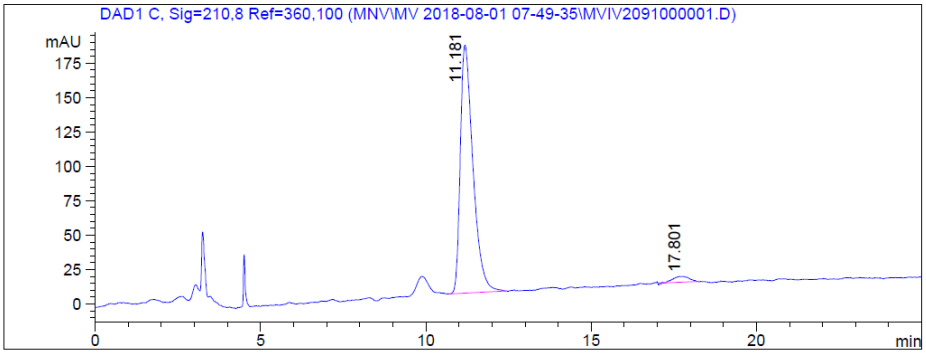
Meas.RT min	Area	Width min	Area %
11.38	5770.8	0.427	96.2
13.29	227.2	0.441	3.8

HPLC trace of 22



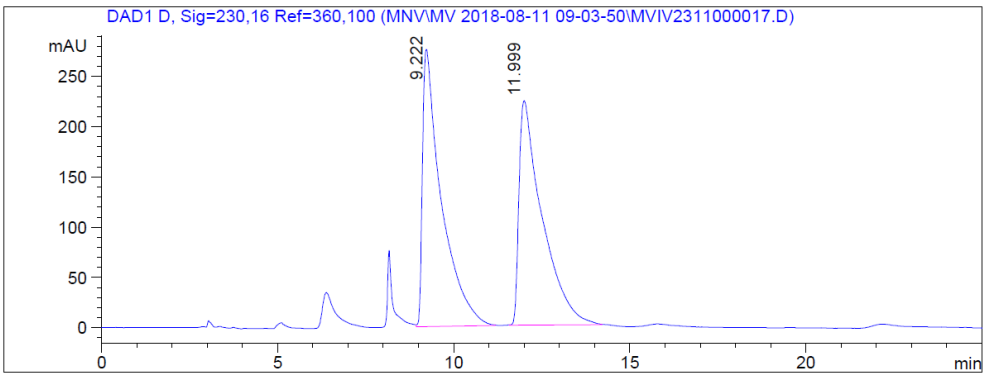


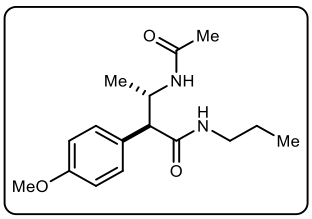
Meas.RT min	Area	Width min	Area %
11.53	2900.2	0.389	49.1
18.10	3001.1	0.606	50.9



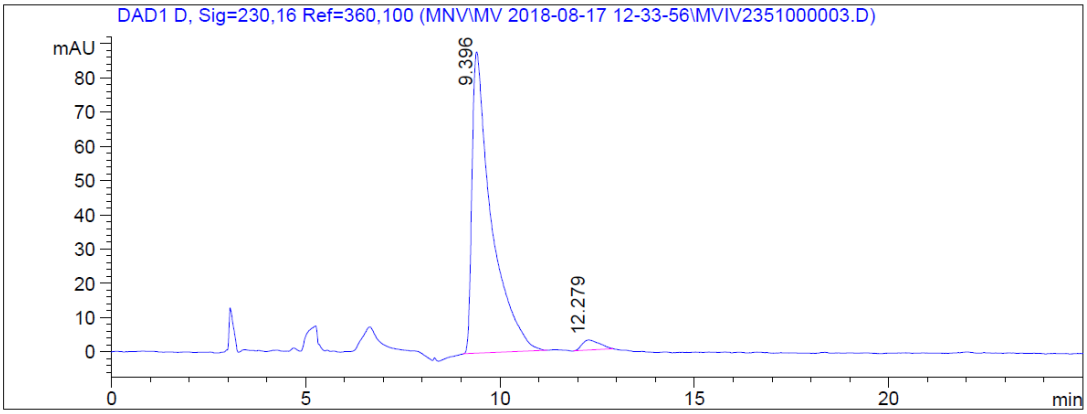
Meas.RT min	Area	Width min	Area %
11.18	4792.7	0.443	97.1
17.80	143.2	0.564	2.9

HPLC trace of 23



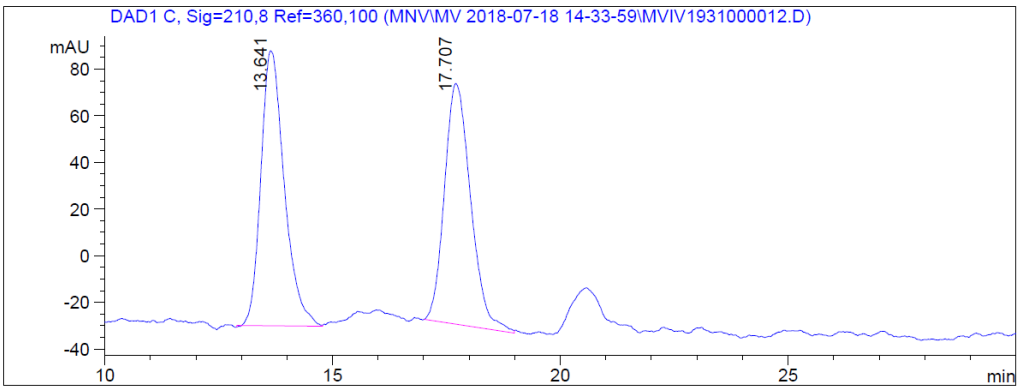


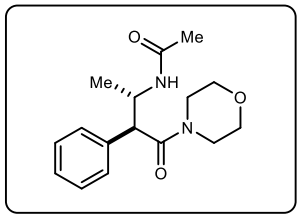
Meas.RT min	Area	Width min	Area %
9.22	10293.8	0.507	50.2
12.00	10195.0	0.628	49.8



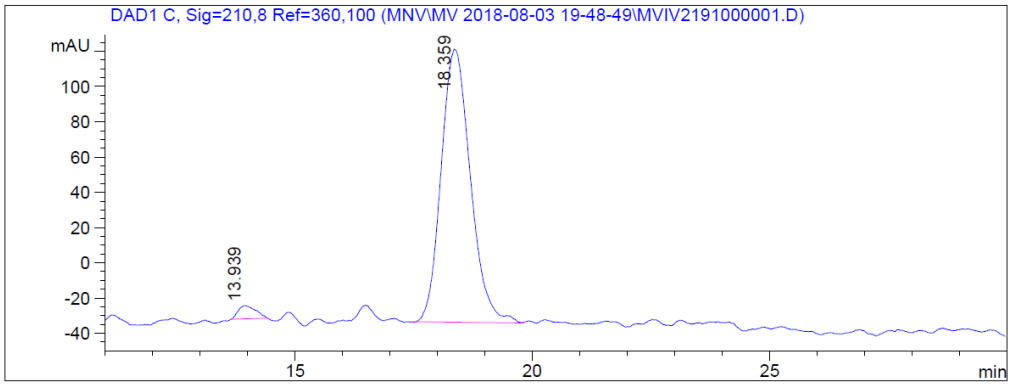
Meas.RT min	Area	Width min	Area %
9.40	3044.3	0.576	97.1
12.28	91.1	0.518	2.9

HPLC trace of 24



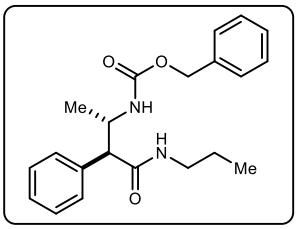


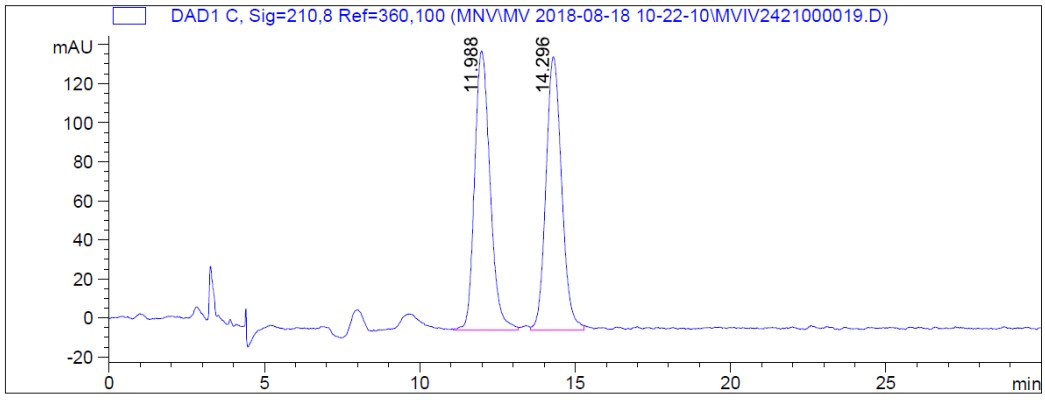
Meas.RT min	Area	Width min	Area %
13.64	4226.0	0.597	50.6
17.71	4124.7	0.666	49.4



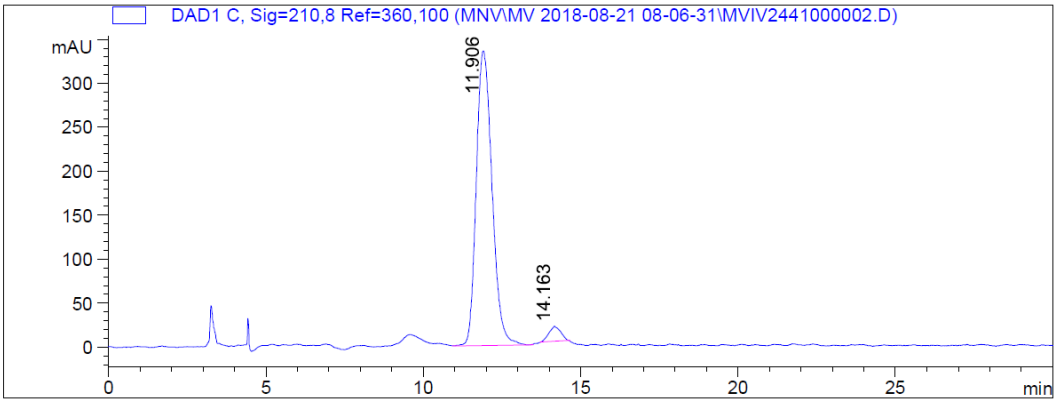
Meas.RT min	Area	Width min	Area %
13.94	191.9	0.429	2.8
18.36	6647.1	0.715	97.2

HPLC trace of 25



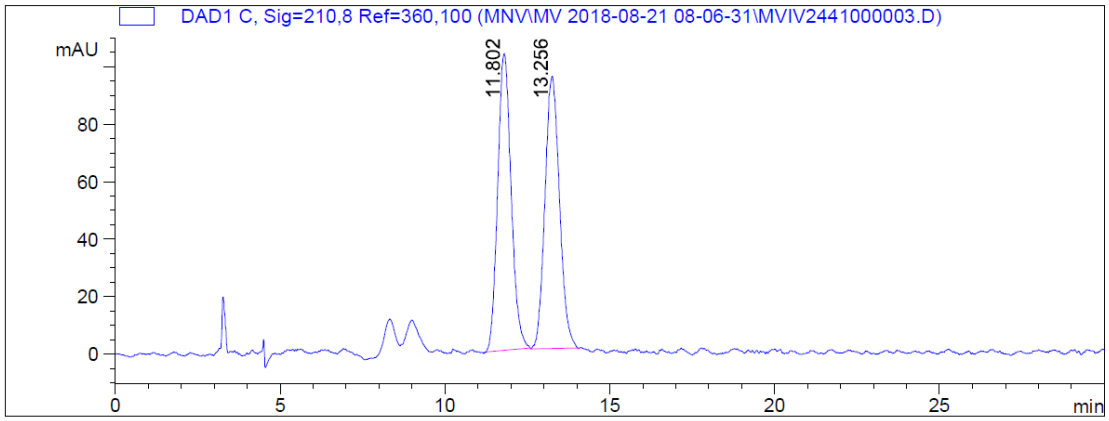


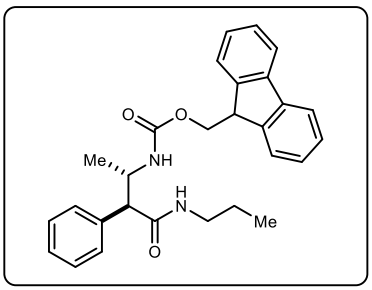
Meas.RT min	Area	Width min	Area %
11.99	4931.1	0.505	50.2
14.30	4897.5	0.493	49.8



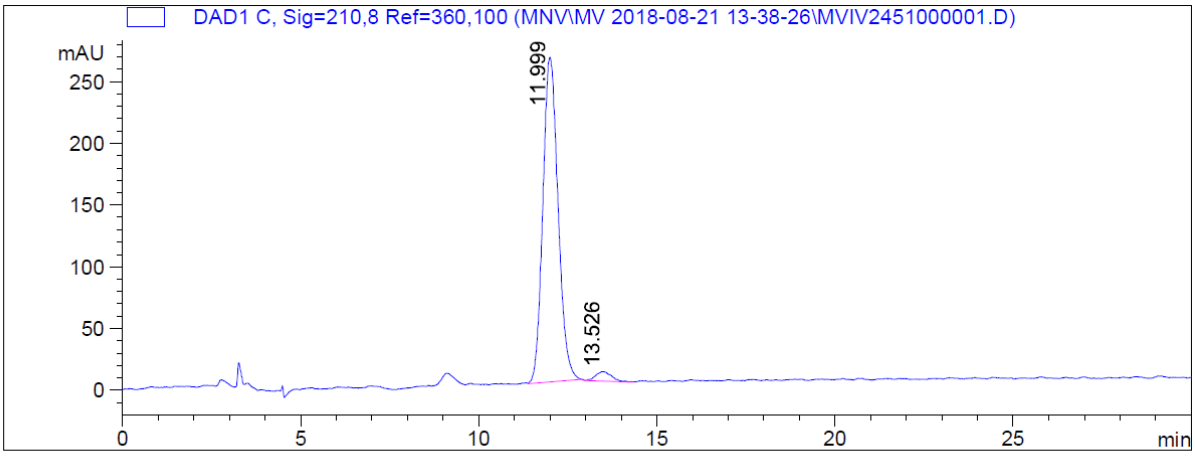
Meas.RT min	Area	Width min	Area %
11.91	11691.9	0.581	96.4
14.16	431.7	0.420	3.6

HPLC trace of 26



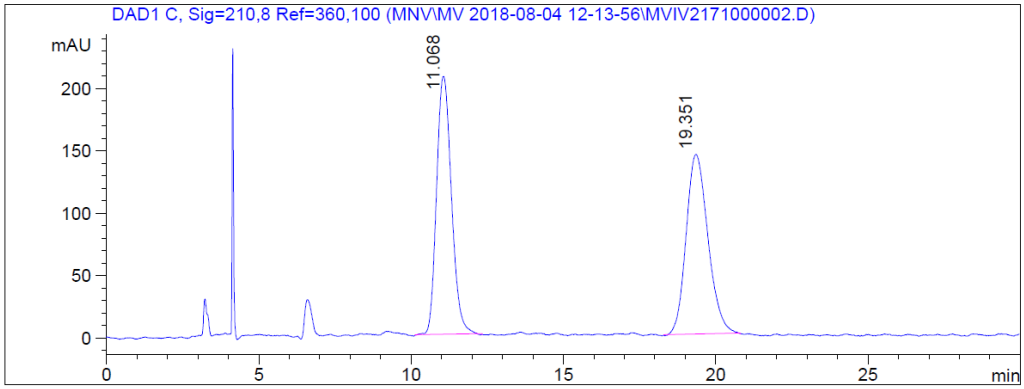


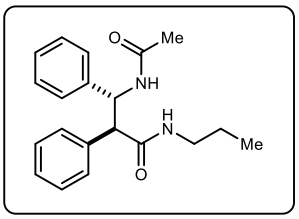
Meas.RT min	Area	Width min	Area %
11.80	2937.0	0.474	50.3
13.26	2903.2	0.511	49.7



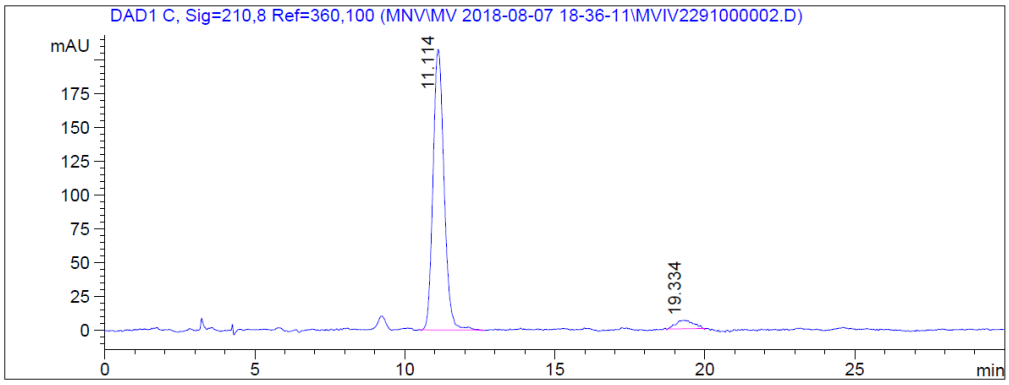
Meas.RT min	Area	Width min	Area %
12.00	7809.5	0.495	97.1
13.53	232.6	0.511	2.9

HPLC trace of 27



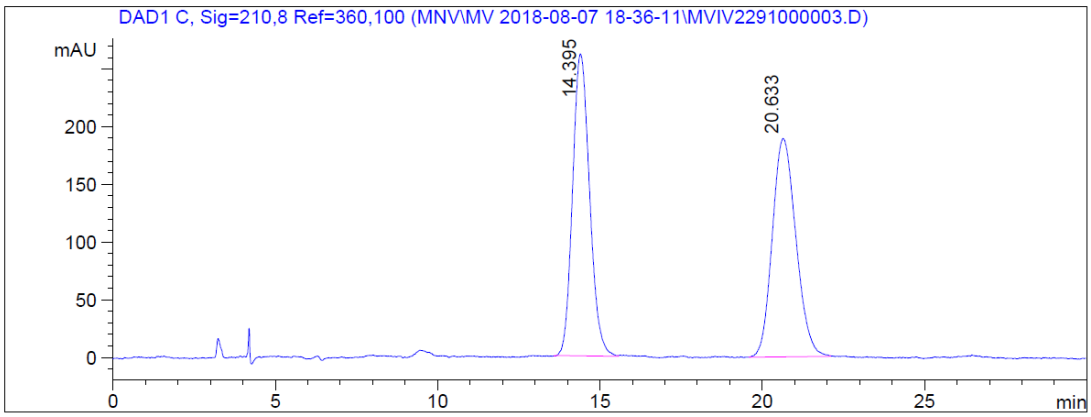


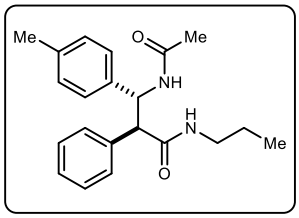
Meas.RT min	Area	Width min	Area %
11.07	7020.9	0.566	49.5
19.35	7176.9	0.829	50.5



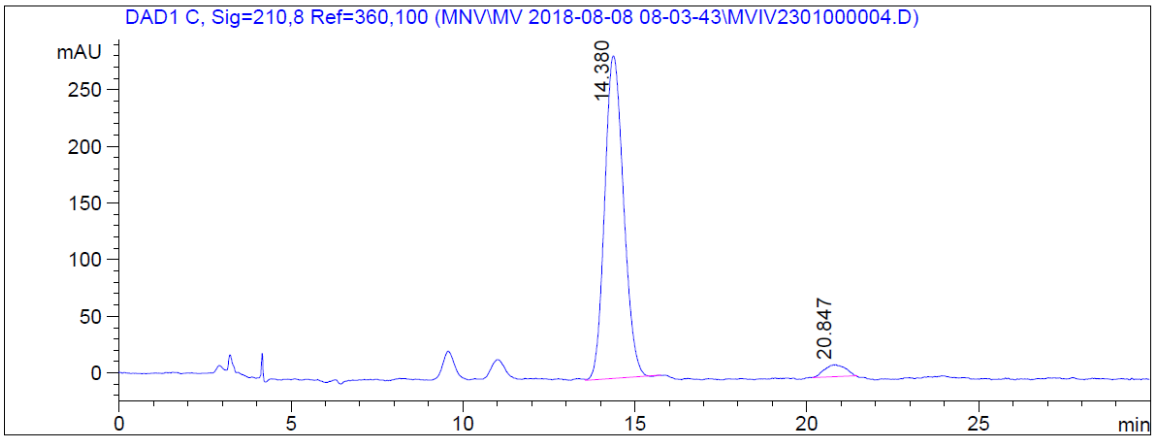
Meas.RT min	Area	Width min	Area %
11.11	5293.0	0.426	95.3
19.33	260.7	0.672	4.7

HPLC trace of 28



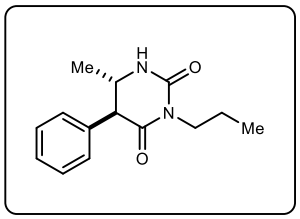


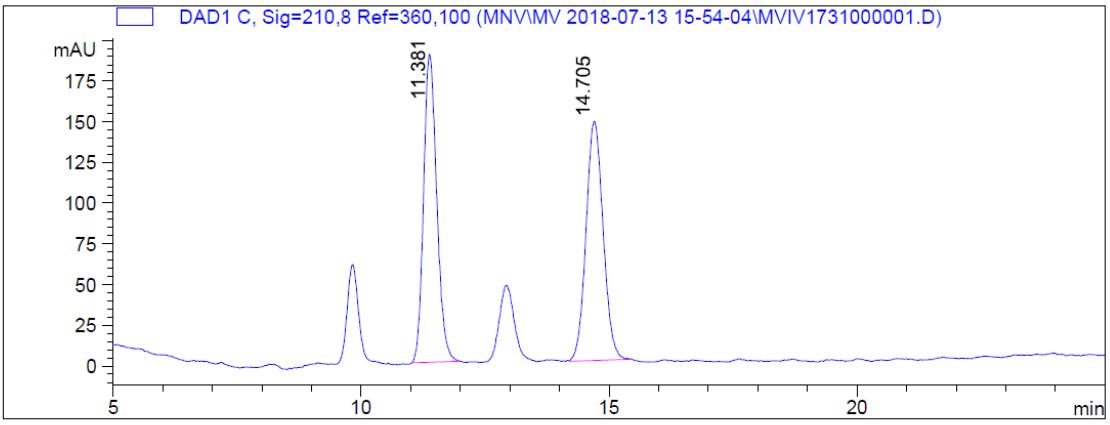
Meas.RT min	Area	Width min	Area %
14.40	9540.9	0.608	49.9
20.63	9574.4	0.843	50.1



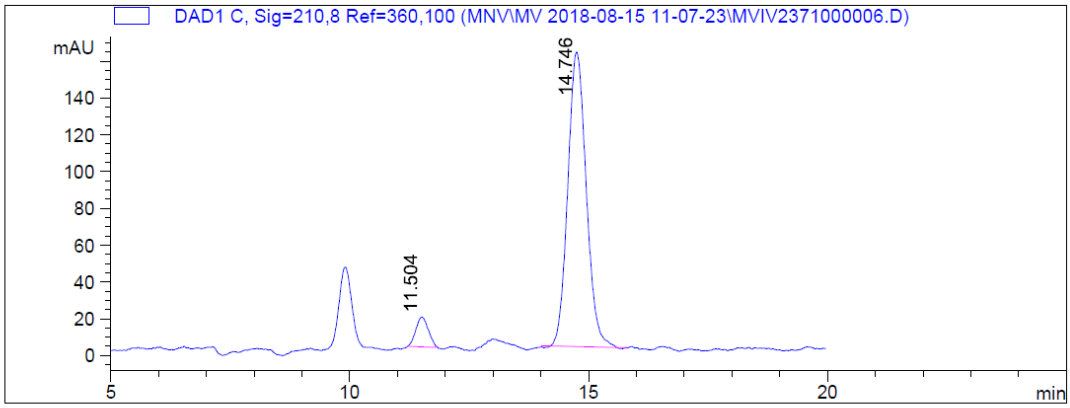
Meas.RT min	Area	Width min	Area %
14.38	10877.5	0.637	96.0
20.85	448.1	0.720	4.0

HPLC trace of 29





Meas.RT min	Area	Width min	Area %
11.38	3498.1	0.308	49.8
14.70	3526.1	0.400	50.2



Meas.RT min	Area	Width min	Area %
11.50	296.1	0.303	6.4
14.75	4305.7	0.448	93.6