Poly(methylhydrosiloxane) as a green reducing agent in organophosphorus-catalysed amide bond formation

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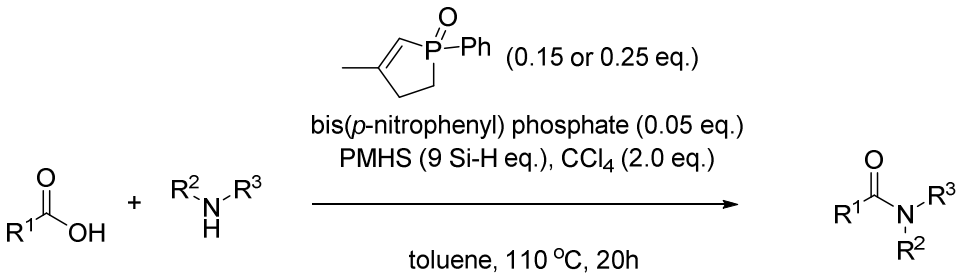
1. General considerations

All chemicals and solvents were obtained from commercial suppliers and used without further purification unless stated otherwise. Benzylamine was distilled over zinc dust prior to use. Reactions were carried out with constant magnetic stirring under air using a radleys carousel (Carousel 12 Plus Reaction Station™). All compounds were transferred using standard syringe techniques. After cooling to room temperature, a screening for product was performed using thin-layer chromatography (TLC) with a 50/50 *n*-heptane/ethyl acetate solvent mixture on EMD Silica Gel 60 F_{254} glass plates. Visualization of the developed plates was performed under UV light (254 nm) and/or stained with ninhydrin or potassium permanganate ($KMnO_4$). In case of isolated yields, silica gel flash column chromotography was performed on SILICYCLE SiliaSep™ Flash Cartridges P60, 40-43 µm silica gel (*n*-heptane/ethyl acetate). NMR yields were determined by an internal standard (1,3,5-tri-*tert*-butylbenzene)

Nuclear magnetic spectroscopy (NMR) data were recorded at ambient temperature on a Bruker Avance III 400 (400 MHz), Varian 400 (400 MHz), or Bruker Avance III 500 (500 MHz, equipped with a Prodigy cryoprobe) spectrometers. Solvents used were $CDCl_3$ or DMSO-d_6. ^{1}H NMR chemical shifts are reported as δ in units of parts per million (ppm) relative to the internal standard tetramethylsilane (TMS, δ = 0 ppm). ^{13}C NMR shifts are reported as δ in units of parts per million (ppm) and the spectra were internally referenced to the residual solvent signal ($CHCl_3$ δ = 77.0 ppm, DMSO δ = 30.0). Multiplicities are given as: s (singlet), bs (broad singlet), d (doublet), t (triplet), q (quartet), quin (quintet), sext (sextet), hept (heptet), m (multiplet). Coupling constants are reported as *J*-values in Hertz (Hz). *In situ* NMR experiments were performed accordingly; the temperature was calibrated to a pure ethylene glycol standard. *In situ* 2D kinetic experiments were performed using a 30 degrees pulse with 14 number of scans and 0 number of dummy scans, using a relaxation delay of 30 seconds (measured to be greater than 3 times $T_{1\ slowest}$; $T_{1,\ slowest}$ 10 seconds. Quantitative ^{31}P NMR experiments of 3-methyl-1-phenyl-2-phospholene 1-oxide were performed by using a 30 degrees pulse with 16 number of scans and 0 number of dummy scans, using a relaxation delay of 63 seconds (measured to be greater than 3 times $T_{1\ slowest}$; $T_{1,\ slowest}$ 21 seconds. Quantitative ^{31}P NMR experiments of triphenylphosphine (oxide) were performed by using a 30 degrees pulse with 16 number of scans and 0 number of dummy scans, using a relaxation delay of 87 seconds (measured to be greater than 3 times $T_{1\ slowest}$; $T_{1,\ slowest}$ 29 seconds. Fourier-transform infrared (FT-IR) spectra are reported in wavenumbers (cm^{-1}) and were recorded with a Bruker Tensor 27 containing a standard KBr beamsplitter. Low resolution mass spectra (MS, *m/z*) were recorded on a LCQ Advantage MAX (Finnigan) or a Thermo Finnigan LCQ-Fleet ESI-ion trap (Thermofischer). Each mass spectrum was measured bypassing the column. High resolution mass spectra were recorded on a JEOL AccuTOF (ESI-ion trap). Chiral HPLC measurements were performed on a Shimadzu LC2010C Analytical

HPLC system equipped with a 250 x 4.6 ID mm Diacel Chiralpak AD-H column with *n*-heptane/isopropanol (90:10 v/v)

2. General procedure



A Radleys tube equipped with a magnetic stirbar was charged with carboxylic acid (0.5 mmol, 1.0 equiv.), phosphine oxide (0.075 mmol, 0.15 or 0.25 equiv.), and bis(*p*-nitrophenyl) phosphate (0.025 mmol, 0.05 equiv.). Subsequently toluene (2.5 mL, 0.2 M) was added and to the formed suspension were added benzylamine (0.65 mmol, 1.3 equiv.), CCl_4 (1.0 mmol, 2.0 equiv.), and poly(methylhydrosiloxane) (0.12 mmol, 9 Si-H equiv.). The reaction was stirred at 110 °C for 20 hours. After cooling to room temperature, toluene was removed under reduced pressure and the crude product was resuspended in ethyl acetate (20 mL). The organic phase was washed with sat. aqueous $NaHCO_3$ (2 x 20 mL), brine (1 x 20 mL), dried over Na_2SO_4, filtered, and evaporated. The crude product was purified by silica column chromatography (ethyl acetate in *n*-heptane) to afford the desired amide.

3. Optimisation

Table S1: Effect of solvent on organophosphorus catalysed amide bond formation[a]

Entry	Solvent	NMR yield (%)
1	toluene	82
2	1,4-dioxane	42
3	*n*-heptane	48
4	*o*-xylene	52

a) *p*-Nitrobenzoic acid (0.5 mmol), benzylamine (1.3 equiv.), 3-methyl-1-phenyl-2-phospholene 1-oxide (0.25 equiv.), CCl_4 (2.0 equiv.), PMHS (Mw: 390, 9 Si-H equiv.), bis(*p*-nitrophenyl) phosphate (0.05 equiv.), solvent (2.5 mL), 110 °C, 20 h.

Table S2: Product yield of *N*-benzyl-*p*-nitrobenzamide after 8 hours[a]

Entry	Phosphine (%)	NMR yield (%)
1	15%	49
2	25%	66
3	-	-

a) *p*-Nitrobenzoic acid (0.5 mmol), benzylamine (1.3 equiv.), 3-methyl-1-phenyl-2-phospholene 1-oxide (0.25 equiv.), CCl_4 (2.0 equiv.), PMHS (Mw: 390, 9 Si-H equiv.), bis(*p*-nitrophenyl) phosphate (0.05 equiv.), solvent (2.5 mL, 0.2 M), 110 °C, 8 h.

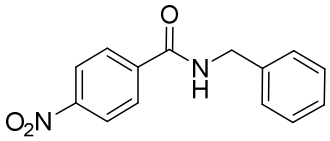
Table S3: Product yield of *N*-Benzyl-*p*-nitrobenzamide employing various equivalents of benzylamine

Entry	Benzylamine (equiv.)	NMR yield (%)
1	1.1	81
2	1.3	92
3	1.5	79
4	2.0	72
5[b]	2.0	60

a) p-Nitrobenzoic acid (0.5 mmol), benzylamine, 3-methyl-1-phenyl-2-phospholene 1-oxide (0.25 equiv.), CCl_4 (2.0 equiv.), PMHS (Mw: 2450, 9 Si-H equiv.), bis(*p*-nitrophenyl) phosphate (0.05 equiv.), solvent (2.5 mL, 0.2 M), 110 °C, 20 h. b) 3-methyl-1-phenyl-2-phospholene 1-oxide (0.15 equiv.)

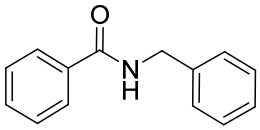
4. Characterisation of compounds

***N*-benzyl-*p*-nitrobenzamide (5)**



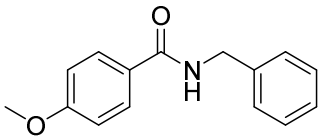
Prepared according to general procedure using *p*-nitrobenzoic acid (0.5 mmol) and benzylamine (1.3 equiv., 0.65 mmol). Affording the desired amide as a light yellow solid. R_f = 0.59 (*n*-heptane/EtOAc 1:1); ^{1}H NMR (500 MHz, $CDCl_3$) δ 8.30 (d, *J* = 8.8 Hz, 2H, Ar-*H*), 7.99 (d, *J* = 8.8 Hz, 2H, Ar-*H*), 7.46 – 7.31 (m, 5H, Ar-*H*), 6.53 (s, 1H, N*H*), 4.69 (d, *J* = 5.6 Hz, 2H, -CH_2-). ^{13}C NMR (126 MHz, $CDCl_3$) δ 165.28, 149.65, 139.91, 137.41, 128.96, 128.18, 128.03, 127.99, 123.86, 44.51; MS (ESI) m/z 257.80 $[M+H]^+$. Data are in accordance to that previously reported.[1]

***N*-benzylbenzamide (6)**



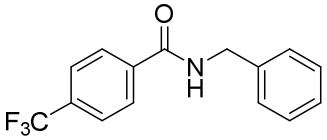
Prepared according to general procedure using benzoic acid (0.5 mmol) and benzylamine (1.3 equiv., 0.65 mmol). Affording the desired amide as a white solid. R_f = 0.58 (*n*-heptane/EtOAc 1:1); ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.92 – 7.70 (m, 2H, Ar-*H*), 7.64 – 7.16 (m, 8H, Ar-*H*), 6.63 (bs, 1H, N*H*), 4.65 (d, *J* = 5.7 Hz, 2H, -CH_2-). ^{13}C NMR (126 MHz, $CDCl_3$) δ 167.45, 138.20, 134.36, 131.56, 128.78, 128.59, 127.90, 127.60, 127.00, 44.13; MS (ESI) m/z 212.1 $[M+H]^+$. Data are in accordance to that previously reported.[1]

***N*-benzyl-4-methoxybenzamide (7)**



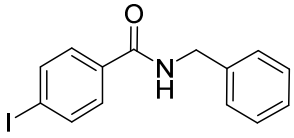
Prepared according to general procedure using 4-methoxybenzoic acid (0.5 mmol) and benzylamine (1.3 eq, 0.65 mmol). Affording the desired amide as a white solid. R_f = 0.44 (*n*-heptane/EtOAc 1:1); ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.78 (d, *J* = 8.8 Hz, 1H, Ar-*H*), 7.37 (m, 5H, Ar-*H*), 6.92 (d, *J* = 8.8 Hz, 1H, Ar-*H*), 6.41 (bs, 1H, N*H*), 4.65 (d, *J* = 5.6 Hz, 2H, -CH_2-), 3.86 (s, 3H, -CH_3). ^{13}C NMR (126 MHz, $CDCl_3$) δ 166.86, 162.22, 138.40, 128.77, 128.76, 127.91, 127.56, 126.64, 113.77, 55.41, 44.08; MS (ESI) m/z 242.0 $[M+H]^+$. Data are in accordance to that previously reported.[1]

***N*-benzyl-*p*-(trifluoromethyl)benzamide (8)**



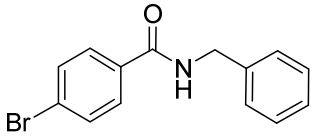
Prepared according to general procedure using *p*-(trifluoromethyl)benzoic acid (0.5 mmol) and benzylamine (1.3 equiv., 0.65 mmol). Affording the desired amide as a white solid. R_f = 0.69 (*n*-heptane/EtOAc 1:1); ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.90 (d, *J* = 8.1 Hz, 2H, Ar-*H*), 7.69 (d, *J* = 8.1 Hz, 2H, Ar-*H*), 7.45 – 7.28 (m, 5H, Ar-*H*), 6.45 (bs, 1H, N*H*), 4.66 (d, *J* = 5.7 Hz, 2H, -CH_2-). ^{13}C NMR (101 MHz, $CDCl_3$) ^{13}C NMR (101 MHz, $CDCl_3$) δ 166.0, 137.7, 137.6, 133.5 (q, *J* = 32.7 Hz), 128.9, 128.0, 127.9, 127.4, 125.7 (q, *J* = 3.6 Hz), 123.6 (q *J* = 272.7 Hz), 44.4.; MS (ESI) m/z 280.36 $[M+H]^+$. Data are in accordance to that previously reported.[1]

***N*-benzyl-*p*-iodobenzamide (9)**



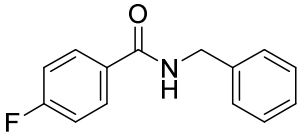
Prepared according to general procedure using *p*-iodobenzoic acid (0.5 mmol) and benzylamine (1.3 equiv., 0.65 mmol). Affording the desired amide as a white solid. R_f = 0.69 (*n*-heptane/EtOAc 1:1); ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.80 (d, *J* = 8.5 Hz, 2H, Ar-*H*), 7.54 (d, *J* = 8.5 Hz, 2H, Ar-*H*), 7.44 – 7.30 (m, 5H, Ar-*H*), 6.40 (bs, 1H, N*H*), 4.65 (d, *J* = 5.6 Hz, 2H, -CH_2-). ^{13}C NMR (126 MHz, $CDCl_3$) δ 166.52, 137.82, 133.76, 128.86, 128.56, 127.97, 127.77, 98.51, 44.25; MS (ESI) m/z 337.9 $[M+H]^+$. Data are in accordance to that previously reported.[1]

***N*-benzyl-*p*-bromobenzamide (10)**



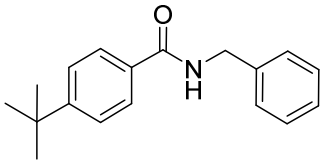
Prepared according to general procedure using *p*-bromobenzoic acid (0.5 mmol) and benzylamine (1.3 equiv., 0.65 mmol). Affording the desired amide as a white solid. R_f = 0.68 (*n*-heptane/EtOAc 1:1); ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.68 (d, *J* = 8.6 Hz, 2H, Ar-*H*), 7.59 (d, *J* = 8.6 Hz, 2H, Ar-*H*), 7.42 – 7.31 (m, 5H, Ar-*H*), 6.40 (bs, 1H, N*H*), 4.66 (d, *J* = 5.6 Hz, 2H, -CH_2-). ^{13}C NMR (126 MHz, $CDCl_3$) δ 166.34, 137.89, 133.19, 131.84, 128.86, 128.58, 127.97, 127.77, 126.26, 44.27; MS (ESI) m/z 289.9 $[M+H]^+$. Data are in accordance to that previously reported.[1]

***N*-benzyl-*p*-fluorobenzamide (11)**



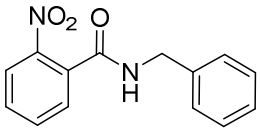
Prepared according to general procedure using *p*-fluorobenzoic acid (0.5 mmol) and benzylamine (1.3 equiv., 0.65 mmol). Affording the desired amide as a white solid. R_f = 0.64 (*n*-heptane/EtOAc 1:1); ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.90 – 7.67 (m, 2H, Ar-*H*), 7.50 – 7.24 (m, 5H, Ar-*H*), 7.20 – 7.00 (m, 2H, Ar-*H*), 6.38 (bs, 1H, N*H*), 4.63 (d, *J* = 5.7 Hz, 2H, -CH_2-). ^{13}C NMR (101 MHz, $CDCl_3$) δ 166.27, 164.8 (d, J = 251.99 Hz), 138.03, 130.6 (d, *J* = 3.19 Hz), 129.3 (d, *J* = 8.96 Hz), 128.84, 127.95, 127.72, 115.6 (d, *J* = 19.8 Hz), 44.24; MS (ESI) m/z 230.0 $[M+H]^+$. Data are in accordance to that previously reported.[1]

***N*-benzyl-*p*-(tert-butyl)benzamide (12)**



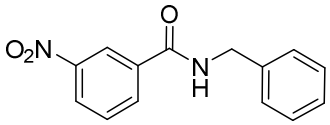
Prepared according to general procedure using *p*-(*tert*-butyl)benzoic acid (0.5 mmol) and benzylamine (1.3 equiv., 0.65 mmol). Affording the desired amide as a white solid. R_f = 0.69 (*n*-heptane/EtOAc 1:1); ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.76 (d, *J* = 8.55 Hz, 2H, Ar-*H*), 7.47 (d, *J* = 8.55 Hz, 2H, Ar-*H*), 7.37 (m, 5H, Ar-*H*), 6.41 (bs, 1H, N*H*), 4.68 (d, *J* = 5.7 Hz, 2H, -CH_2-), 1.35 (s, 9H, -CH_3). ^{13}C NMR (126 MHz, $CDCl_3$) δ 167.24, 155.08, 138.32, 131.49, 128.77, 127.89, 127.58, 126.78, 125.54, 44.07, 34.93, 31.12; MS (ESI) m/z 267.1 $[M+H]^+$. Data are in accordance to that previously reported.[1]

***N*-benzyl-*o*-nitrobenzamide (13)**



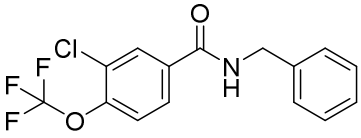
Prepared according to general procedure using *o*-nitrobenzoic acid (0.5 mmol) and benzylamine (1.3 equiv., 0.65 mmol). Affording the desired amide as a white solid. R_f = 0.33 (*n*-heptane/EtOAc 1:1); ^{1}H NMR (500 MHz, $CDCl_3$) δ 8.09 (d, *J* = 8.0 Hz, 1H, Ar-*H*), 7.75 – 7.65 (m, 1H, Ar-*H*), 7.63 – 7.53 (m, 2H, Ar-*H*), 7.47 – 7.30 (m, 5H, Ar-*H*), 6.13 (bs, 1H, N*H*), 4.68 (d, *J* = 5.5 Hz, 2H, -CH_2-). ^{13}C NMR (126 MHz, $CDCl_3$) δ 166.29, 146.48, 137.38, 133.71, 132.88, 130.55, 128.86, 128.70, 128.10, 127.86, 124.64, 44.39; MS (ESI) m/z 256.9 $[M+H]^+$; IR (KBr) 3295 (N-H), 2975 (-CH_2-), 1623 (C=O), 1553 (C=C), 1423 (-CH2-), 1376 (NO2) cm^{-1}; HRMS (ESI found m/z 279.07412 $[M+Na]^+$, $C_{14}H_{12}N_2O_3Na^+$ requires *m/z* 279.07456.

***N*-benzyl-*m*-nitrobenzamide (14)**



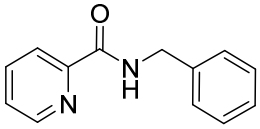
Prepared according to general procedure using *m*-nitrobenzoic acid (0.5 mmol) and benzylamine (1.3 equiv., 0.65 mmol). Affording the desired amide as a light yellow solid. R_f = 0.55 (*n*-heptane/EtOAc 1:1); ^{1}H NMR (500 MHz, $CDCl_3$) δ 8.62 (t, *J* = 2.3 Hz, 1H, Ar-*H*), 8.36 (ddd, *J* = 8.2, 2.3, 1.0 Hz, 1H, Ar-*H*), 8.19 (dt, *J* = 8.2, 1.0 Hz, 1H, Ar-*H*), 7.65 (t, *J* = 8.2 Hz, 1H, Ar-*H*), 7.38 (m, 5H, Ar-*H*), 6.78 (bs, 1H, N*H*) 4.68 (d, *J* = 5.65 Hz, 2H, -CH_2-). ^{13}C NMR (126 MHz, $CDCl_3$) δ 164.96, 148.17, 137.50, 135.96, 133.29, 129.87, 128.90, 128.01, 127.89, 126.13, 121.81, 44.46; MS (ESI) m/z 257.68 $[M+H]^+$. Data are in accordance to that previously reported.[2]

***N*-benzyl-*m*-chloro-*p*-(trifluoromethoxy)benzamide (15)**



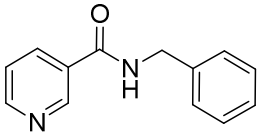
Prepared according to general procedure using *m*-chloro-*p*-(trifluoromethoxy)benzoic acid (0.5 mmol) and benzylamine (1.3 equiv., 0.65 mmol). Affording the desired amide as a white solid. R_f = 0.73 (*n*-heptane/EtOAc 1:1); ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.91 (d, *J* = 2.2 Hz, 1H, Ar-*H*), 7.71 (dd, *J* = 8.6, 2.2 Hz, 1H, Ar-*H*), 7.42 – 7.28 (m, 6H, Ar-*H*), 6.39 (s, *J* = 5.8 Hz, 1H, N*H*), 4.63 (d, *J* = 5.6 Hz, 2H, -CH_2-). ^{13}C NMR (101 MHz, $CDCl_3$)) δ 164.87, 147.44 (q, *J* = 1.8 Hz), 137.57, 134.05, 129.91, 128.92, 127.98, 127.90, 127.76, 126.61, 124.20, 122.18 (q, *J* = 1.5 Hz), 120.32 (q, *J* = 260.2 Hz), 116.44, 44.42; IR (KBr) 3263 (N-H), 3072 (-CH_2-), 3036 (-CH_2-), 1634 (C=O), 1548 (C=C), 1494 (C=C), 1202 (C-O-C), 1142 (C-F), 651 (C-Cl) cm^{-1}; MS (ESI) m/z 329.70 $[M+H]^+$; HRMS (ESI found m/z 330.05354 $[M+H]^+$, $C_{15}H_{12}ClF_3NO_2^+$ requires *m/z* 330.05032.

***N*-benzylpicolinamide (16)**



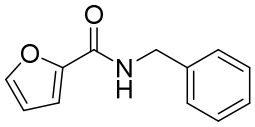
Prepared according to general procedure using picolinic acid (0.5 mmol) and benzylamine (1.3 equiv., 0.65 mmol). Affording the desired amide as a white solid. R_f = 0.52 (*n*-heptane/EtOAc 1:1); ^{1}H NMR (500 MHz, $CDCl_3$) δ 8.55 (d, *J* = 4.5 Hz, 1H, Ar-*H*), 8.41 (bs, 1H, N*H*), 8.26 (d, *J* = 7.7 Hz, 1H, Ar-*H*), 7.87 (td, *J* = 7.7, 1.7 Hz, 1H, Ar-*H*), 7.44 (ddd, *J* = 7.7, 4.5, 1.7 Hz, 1H, Ar-*H*) 7.42 – 7.22 (m, 5H, Ar-*H*), 4.70 (d, *J* = 6.1 Hz, 2H, -CH_2-). ^{13}C NMR (126 MHz, $CDCl_3$) δ 164.24, 149.84, 148.09, 138.22, 137.36, 128.71, 127.86, 127.47, 126.21, 122.36, 43.51; MS (ESI) m/z 212.9 $[M+H]^+$. Data are in accordance to that previously reported.[1]

***N*-benzylnicotinamide (17)**



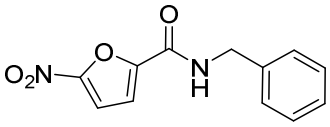
Prepared according to general procedure using nicotinic acid (0.5 mmol) and benzylamine (1.3 equiv., 0.65 mmol). Affording the desired amide as a white solid. R_f = 0.08 (*n*-heptane/EtOAc 1:1); ^{1}H NMR (500 MHz, $CDCl_3$) δ 8.98 (d, *J* = 2.2 Hz, 1H, Ar-*H*), 8.71 (dd, *J* = 4.9, 1.7 Hz, 1H, Ar-*H*), 8.15 (dt, *J* = 7.9, 2.2 Hz, 1H, Ar-*H*), 7.45 – 7.29 (m, 6H, Ar-*H*), 6.68 (bs, 1H, N*H*), 4.67 (d, *J* = 5.6 Hz, 2H, -CH_2-). ^{13}C NMR (126 MHz, $CDCl_3$) δ 165.46, 152.29, 147.85, 137.71, 135.20, 130.09, 128.88, 127.98, 127.82, 123.53, 44.24; MS (ESI) m/z 213.1 $[M+H]^+$. Data are in accordance to that previously reported.[3]

***N*-benzylfuran-2-carboxamide (18)**



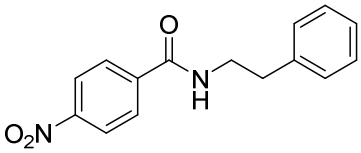
Prepared according to general procedure using furan-2-carboxylic acid (0.5 mmol) and benzylamine (1.3 equiv., 0.65 mmol). Affording the desired amide as a white solid. R_f = 0.44 (*n*-heptane/EtOAc 1:1); ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.45 – 7.39 (m, 1H, Ar-*H*), 7.38 – 7.27 (m, 5H, Ar-*H*), 7.15 (d, *J* = 3.5 Hz, 1H, Ar-*H*), 6.50 (dd, *J* = 3.5, 1.8 Hz, Ar-*H*), 4.62 (d, *J* = 5.9 Hz, 2H, -CH_2-).^{13}C NMR (101 MHz, $CDCl_3$) δ 158.24, 147.91, 143.87, 138.00, 128.77, 127.92, 127.64, 114.41, 112.19, 43.19. ; MS (ESI) m/z 202.0 $[M+H]^+$. Data are in accordance to that previously reported.[4]

***N*-benzyl-5-nitrofuran-2-carboxamide (19)**



Prepared according to general procedure using 5-nitrofuran-2-carboxylic acid (0.5 mmol) and benzylamine (1.3 equiv., 0.65 mmol). Affording the desired amide as a brown oil. R_f = 0.55 (*n*-heptane/EtOAc 1:1); ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.66 – 7.17 (m, 6H, Ar-*H*), 7.05 (d, *J* = 6.3 Hz, 1H, Ar-*H*), 4.65 (d, *J* = 5.9 Hz, 2H, -CH_2-). ^{13}C NMR (126 MHz, $CDCl_3$) δ 156.21, 151.22, 147.95, 137.01, 128.89, 128.04, 127.98, 116.15, 112.47, 43.60.; MS (ESI) m/z 248.32 $[M+H]^+$. Data are in accordance to that previously reported.[5]

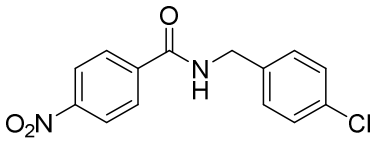
***p*-nitro-*N*-phenethylbenzamide (20)**



Prepared according to general procedure using *p*-nitrobenzoic acid (0.5 mmol) and 2-phenethylamine (1.3

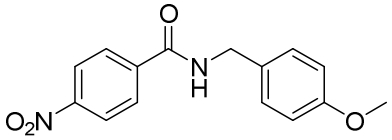
equiv., 0.65 mmol). Affording the desired amide as a white solid. R_f = 0.57 (*n*-heptane/EtOAc 1:1); ^{1}H NMR (500 MHz, $CDCl_3$) δ 8.28 (d, *J* = 8.8 Hz, 2H, Ar-*H*), 7.85 (d, *J* = 8.8 Hz, 2H, Ar-*H*), 7.46 – 7.17 (m, 5H, Ar-*H*), 6.23 (bs, 1H, N*H*), 3.77 (app. q, *J* = 6.7 Hz, 2H, -CH_2-), 2.98 (t, *J* = 6.7 Hz, 2H, -CH_2-). ^{13}C NMR (126 MHz, $CDCl_3$) δ 165.44, 149.55, 140.19, 138.46, 128.85, 128.77, 128.00, 126.83, 123.84, 41.37, 35.48; MS (ESI) m/z 271.28 $[M+H]^+$. Data are in accordance to that previously reported.[1]

_N_-(_p_-chlorobenzyl)-_p_-nitrobenzamide (21)



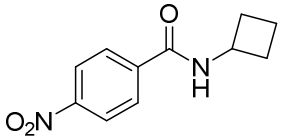
Prepared according to general procedure using *p*-nitrobenzoic acid (0.5 mmol) and *p*-chlorobenzylamine (1.3 equiv., 0.65 mmol). Affording the desired amide as a yellow solid. R_f = 0.55 (*n*-heptane/EtOAc 1:1); ^{1}H NMR (500 MHz, $CDCl_3$) δ 8.31 (d, *J* = 8.8 Hz, 2H, Ar-*H*), 7.97 (d, *J* = 8.8 Hz, 2H, Ar-*H*), 7.41 – 7.30 (m, 4H, Ar-*H*), 6.52 (bs, 1H, N*H*), 4.66 (d, *J* = 5.8 Hz, 2H, -CH_2-). ^{13}C NMR (126 MHz, $CDCl_3$) δ 165.32, 149.73, 139.68, 135.99, 133.84, 129.35, 129.08, 128.17, 123.91, 43.76; MS (ESI) m/z 292.24 $[M+H]^+$. Data are in accordance to that previously reported.[6]

_N_-(_p_-methoxybenzyl)-_p_-nitrobenzamide (22)



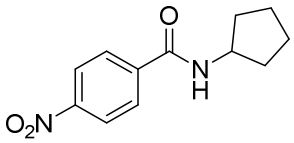
Prepared according to general procedure using *p*-nitrobenzoic acid (0.5 mmol) and *p*-methoxybenzylamine (1.3 equiv., 0.65 mmol). Affording the desired amide as a yellow solid. R_f = 0.48 (*n*-heptane/EtOAc 1:1); ^{1}H NMR (500 MHz, $CDCl_3$) δ 8.28 (d, *J* = 8.8, 2H, Ar-*H*), 7.95 (d, *J* = 8.8, 2H, Ar-*H*), 7.30 (d, *J* = 8.6, 2H, Ar-*H*), 6.91 (d, *J* = 8.6, 2H, Ar-*H*), 6.50 (bs, 1H, N*H*), 4.61 (d, *J* = 5.5 Hz, 2H, -CH_2-), 3.83 (s, 3H, -OCH_3). ^{13}C NMR (126 MHz, $CDCl_3$) δ 165.19, 159.36, 149.60, 139.99, 129.46, 129.43, 128.16, 123.82, 114.30, 55.34, 44.00; MS (ESI) m/z 287.56 $[M+H]^+$. Data are in accordance to that previously reported.[1]

_N_-cyclobutyl-_p_-nitrobenzamide (23)



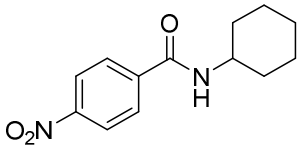
Prepared according to general procedure using *p*-nitrobenzoic acid (0.5 mmol) and cyclobutylamine (1.3 equiv., 0.65 mmol). Affording the desired amide as a yellow solid. R_f = 0.47 (*n*-heptane/EtOAc 1:1); ^{1}H NMR (400 MHz, $CDCl_3$) δ = 8.28 (d, *J* = 8.87, 1H, Ar-*H*), 7.92 (d, *J* = 8.87, 1H, Ar-*H*), 6.34 (bs, 1H, N*H*), 4.68 – 4.51 (m, 1H, C*H*), 2.52 – 2.37 (m, 2H, -CH_2-), 2.09 – 1.92 (m, 2H, -CH_2-), 1.89 – 1.75 (m, 2H, -CH_2-). ^{13}C NMR (101 MHz, $CDCl_3$) δ 164.49, 149.55, 140.18, 128.09, 128.08, 123.80, 45.53, 31.21, 15.24; MS (ESI) m/z 221.04 $[M+H]^+$. Data are in accordance to that previously reported.[1]

***N*-cyclopentyl-*p*-nitrobenzamide (24)**



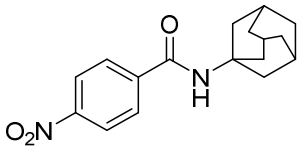
Prepared according to general procedure using *p*-nitrobenzoic acid (0.5 mmol) and cyclopentylamine (1.3 equiv., 0.65 mmol). Affording the desired amide an off-white solid. R_f = 0.40 (*n*-heptane/EtOAc 1:1); ^{1}H NMR (400 MHz, $CDCl_3$) δ = 8.28 (d, *J* = 8.93, 2H, Ar-*H*), 7.90 (d, *J* = 8.93, 2H, Ar-*H*), 6.09 (bs, 1H, N*H*), 4.47 – 4.36 (m, 1H, C*H*), 2.19 – 2.08 (m, 2H, -CH_2-), 1.81 – 1.63 (m, 4H, -CH_2-), 1.56 – 1.46 (m, 2H, -CH_2-). ^{13}C NMR (101 MHz, $CDCl_3$) δ 165.07, 149.49, 140.49, 128.03, 123.79, 52.14, 33.22, 23.83. MS (ESI) m/z 235.12 $[M+H]^+$. Data are in accordance to that previously reported.[1]

***N*-cyclohexyl-*p*-nitrobenzamide (25)**



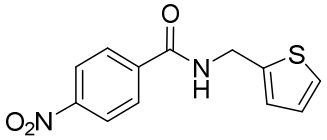
Prepared according to general procedure using *p*-nitrobenzoic acid (0.5 mmol) and cyclohexanamine (1.3 equiv., 0.65 mmol). Affording the desired amide as a white solid. R_f = 0.44 (*n*-heptane/EtOAc 1:1); ^{1}H NMR (500 MHz, $CDCl_3$) δ 8.30 (d, *J* = 8.8 Hz, 2H, Ar-*H*), 7.93 (d, *J* = 8.8 Hz, 2H, Ar-*H*), 6.06 (bs, 1H, N*H*), 4.01 (m, 1H, C*H*), 2.03-2.07 (m, 2H, -CH_2-), 1.86 – 1.75 (m, 2H, -CH_2-), 1.74 – 1.53 (m, 2H, -CH_2-), 1.54 – 1.39 (m, 2H, -CH_2-), 1.37 – 1.15 (m, 4H, -CH_2-). ^{13}C NMR (126 MHz, $CDCl_3$) δ 164.57, 149.47, 140.67, 128.04, 123.78, 49.24, 33.12, 25.47, 24.87; MS (ESI) m/z 249.56 $[M+H]^+$. Data are in accordance to that previously reported.[1].

***N*-(1-adamantyl)-*p*-nitrobenzamide (26)**



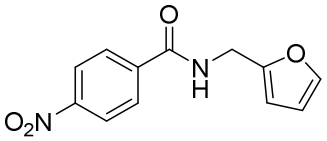
Prepared according to general procedure using *p*-nitrobenzoic acid (0.5 mmol) and 1-adamantylamine (1.3 equiv., 0.65 mmol). Affording the desired amide as a white solid. R_f = 0.75 (*n*-heptane/EtOAc 1:1); ^{1}H NMR (500 MHz, $CDCl_3$) δ 8.83 (d, *J* = 8.80 Hz, 2H, Ar-*H*), 7.89 (d, *J* = 8.80 Hz, 2H, Ar-*H*), 5.84 (bs, 1H, N*H*), 2.15 (m, 9H), 1.76 (bs, 6H). ^{13}C NMR (126 MHz, $CDCl_3$) δ 164.53, 149.32, 141.65, 127.91, 123.74, 53.00, 41.57, 36.27, 29.46; MS (ESI) m/z 301.48 $[M+H]^+$. Data are in accordance to that previously reported.[7]

***p*-nitro-*N*-(thiophen-2-ylmethyl)benzamide (27)**



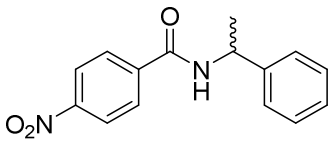
Prepared according to general procedure using *p*-nitrobenzoic acid (0.5 mmol) and 2-thiophenemethylamine (1.3 equiv., 0.65 mmol). Affording the desired amide as a light yellow solid. R_f = 0.57 (*n*-heptane/EtOAc 1:1); ^{1}H NMR (500 MHz, $CDCl_3$) δ 8.30 (d, *J* = 8.8 Hz, 2H, Ar-*H*), 7.97 (d, *J* = 8.8 Hz, 2H, Ar-*H*), 7.35 – 7.26 (m, 1H, Ar-*H*), 7.14 – 7.06 (m, 1H, Ar-*H*), 7.01 (m, 1H, Ar-*H*), 6.57 (bs, 1H, N*H*), 4.86 (d, *J* = 5.5 Hz, 2H, -CH_2-). ^{13}C NMR (126 MHz, $CDCl_3$) δ 165.08, 149.70, 139.79, 139.67, 128.22, 127.13, 126.71, 125.76, 123.87, 39.09.; MS (ESI) m/z 264.24 $[M+H]^+$. Data are in accordance to that previously reported.[1]

***N*-(furan-2-ylmethyl)-*p*-nitrobenzamide (28)**



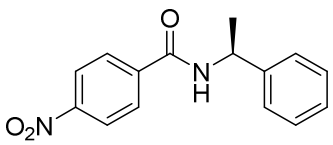
Prepared according to general procedure using *p*-nitrobenzoic acid (0.5 mmol) and Furfurylamine (1.3 equiv., 0.65 mmol). Affording the desired amide as a white solid. R_f = 0.57 (*n*-heptane/EtOAc 1:1); ^{1}H NMR (500 MHz, $CDCl_3$) δ 8.30 (d, *J* = 8.8 Hz, 2H, Ar-*H*), 7.97 (d, *J* = 8.8 Hz, 2H, Ar-*H*), 7.42 (dd, *J* = 1.9, 0.9 Hz, 1H, Ar-*H*), 6.56 (bs, 1H, N*H*), 6.37 (app. ddd, *J* = 15.2, 3.3, 1.4 Hz, 2H, Ar-*H*), 4.73 – 4.66 (d, *J* = 4.9, 2H, -CH_2-). ^{13}C NMR (126 MHz, $CDCl_3$) δ 165.15, 150.34, 149.69, 142.61, 139.69, 128.23, 123.85, 110.64, 108.22, 37.26: MS (ESI) m/z 247.44 $[M+H]^+$. Data are in accordance to that previously reported.[8]

(*R,S*)-*N*-(1phenylethyl)-*p*-nitrobenzamide (29)



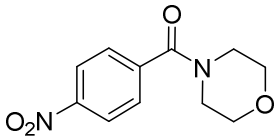
Prepared according to general procedure using *p*-nitrobenzoic acid (0.5 mmol) and (*R,S*)-1-phenylethan-1-amine (1.3 equiv., 0.65 mmol). Affording the desired amide as a white solid in a 50:50 ratio of *R* and *S*. R_f = 0.60 (*n*-heptane/EtOAc 1:1); ^{1}H NMR (500 MHz, $CDCl_3$) δ 8.29 (d, *J* = 8.8 Hz, 2H, Ar-*H*), 7.94 (d, *J* = 8.8 Hz, 2H, Ar-*H*), 7.45 – 7.30 (m, 5H, Ar-*H*), 6.42 (s, 1H, N*H*), 5.49 – 5.22 (m, 1H, C*H*), 1.66 (d, *J* = 6.9 Hz, 3H, -CH_3). ^{13}C NMR (126 MHz, $CDCl_3$) δ 164.53, 149.59, 142.40, 140.12, 128.92, 128.14, 127.82, 126.27, 123.81, 49.78, 21.54; MS (ESI) m/z 271.40 $[M+H]^+$. Data are in accordance to that previously reported.[1]

(*S*)-*p*-Nitro-*N*-(1-phenylethyl)benzamide (30)



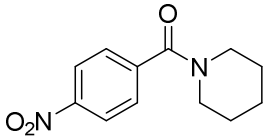
Prepared according to general procedure using *p*-nitrobenzoic acid (0.5 mmol) and (*S*)-1-phenylethan-1-amine (1.3 equiv., 0.65 mmol). Affording the desired amide as a white solid with a enantiomeric excess of 98.3% (*S*). R_f = 0.60 (*n*-heptane/EtOAc 1:1); ^{1}H NMR (500 MHz, $CDCl_3$) δ 8.29 (d, *J* = 8.8 Hz, 2H, Ar-*H*), 7.94 (d, *J* = 8.8 Hz, 2H, Ar-*H*), 7.46 – 7.37 (m, 5H), 6.44 (bs, 1H, N*H*), 5.35 (m, 1H, C*H*), 1.66 (d, *J* = 6.9 Hz, 3H, -CH_3). ^{13}C NMR (126 MHz, $CDCl_3$) δ 164.53, 149.59, 142.40, 140.12, 128.92, 128.14, 127.82, 126.27, 123.81, 49.78, 21.54; MS (ESI) m/z 271.24 $[M+H]^+$. Data are in accordance to that previously reported.[1]

Morpholino(*p*-nitrophenyl)methanone (31)



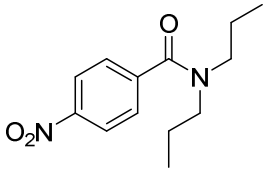
Prepared according to general procedure using *p*-nitrobenzoic acid (0.5 mmol) and morpholine (1.3 equiv., 0.65 mmol). Affording the desired amide as a light yellow solid. R_f = 0.14 (*n*-heptane/EtOAc 1:1); ^{1}H NMR (500 MHz, $CDCl_3$) δ 8.31 (d, *J* = 8.7 Hz, 2H, Ar-*H*), 7.61 (d, *J* = 8.7 Hz, 2H, Ar-*H*), 4.11 – 3.09 (m, 8H, -CH_2-). ^{13}C NMR (126 MHz, $CDCl_3$) δ 168.04, 148.50, 141.42, 128.15, 123.98, 66.75, 48.09, 42.57; MS (ESI) m/z 237.40 $[M+H]^+$. Data are in accordance to that previously reported.[1]

(*p*-nitrophenyl)(piperidin-1-yl)methanone (32)



Prepared according to general procedure using *p*-nitrobenzoic acid (0.5 mmol) and piperidine (1.3 equiv., 0.65 mmol). Affording the desired amide as a slightly yellow solid. R_f = 0.33 (*n*-heptane/EtOAc 1:1); ^{1}H NMR (500 MHz, $CDCl_3$) δ 8.29 (d, *J* = 8.6 Hz, 2H, Ar-*H*), 7.58 (d, *J* = 8.6 Hz, 2H, Ar-*H*), 3.75 (t, *J* = 5.1 Hz, 2H, -CH_2-), 3.30 (t, *J* = 5.6 Hz, 2H, -CH_2-), 1.72 (m, 4H, -CH_2-), 1.56 (m, 2H, -CH_2). ^{13}C NMR (126 MHz, $CDCl_3$) δ 167.88, 148.20, 142.71, 127.79, 123.85, 48.65, 43.21, 26.53, 25.51, 24.42; MS (ESI) m/z 235.1 $[M+H]^+$. Data are in accordance to that previously reported.[1]

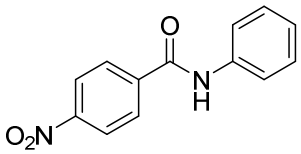
4-nitro-*N*,*N*-dipropylbenzamide (33)



Prepared according to general procedure using 4-nitrobenzoic acid (0.5 mmol) and dipropylamine (1.3 eq, 0.65 mmol). Affording the desired amide as a yellow solid. R_f = 0.56; ^{1}H NMR (500 MHz, $CDCl_3$) δ 8.29 (d, *J* = 8.68 Hz, 2H, Ar-*H*), 7.54 (d, *J* = 8.71 Hz, 2H, Ar-*H*), 3.50 (t, *J* = 7.68, 2H, -CH_2-), 3.13 (t, *J* = 7.64, 2H, -CH_2-), 1.73 (h, *J* = 7.48, 2H, -CH_2-), 1.55 (h, *J* = 7.47, 2H, -CH_2-), 1.02 (t, *J* = 7.38, 3H, -CH_3), 0.78 (t, *J* = 7.36, 3H, -CH_3). ^{13}C NMR (126 MHz, Chloroform-*d*) δ 169.42, 148.00, 143.54, 127.51, 123.84, 50.63, 46.47,

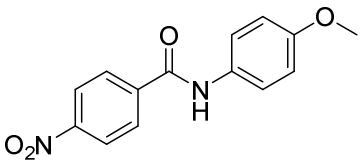
21.93, 20.69, 11.41, 11.01; MS (ESI) m/z 251.2 $[M+H]^+$. Data are in accordance to that previously reported.[9]

_p_-nitro-_N_-phenylbenzamide (34)



Prepared according to general procedure using 4-nitrobenzoic acid (0.5 mmol) and aniline (1.3 equiv., 0.65 mmol). Besides purification by column chromatography, an additional acidic washing step (1.0 M HCl) was performed in order to remove the remaining aniline. Affording the desired amide as a light yellow solid. R_f = 0.67 (*n*-heptane/EtOAc 1:1); ^{1}H NMR (500 MHz, DMSO-d_6) δ 10.57 (s, 1H, N*H*), 8.38 (d, *J* = 8.8 Hz, 2H, Ar-*H*), 8.19 (d, *J* = 8.8 Hz, 2H, Ar-*H*), 7.78 (d, *J* = 7.9 Hz, 2H, Ar-*H*), 7.39 (t, *J* = 7.9 Hz, 2H, Ar-*H*), 7.15 (t, *J* = 7.4 Hz, 1H, Ar-*H*). ^{13}C NMR (126 MHz, DMSO-d_6) δ 164.36, 149.60, 141.09, 139.14, 129.66, 129.18, 124.65, 124.01, 120.95.; MS (ESI) m/z 243.72 $[M+H]^+$. Data are in accordance to that previously reported.[10]

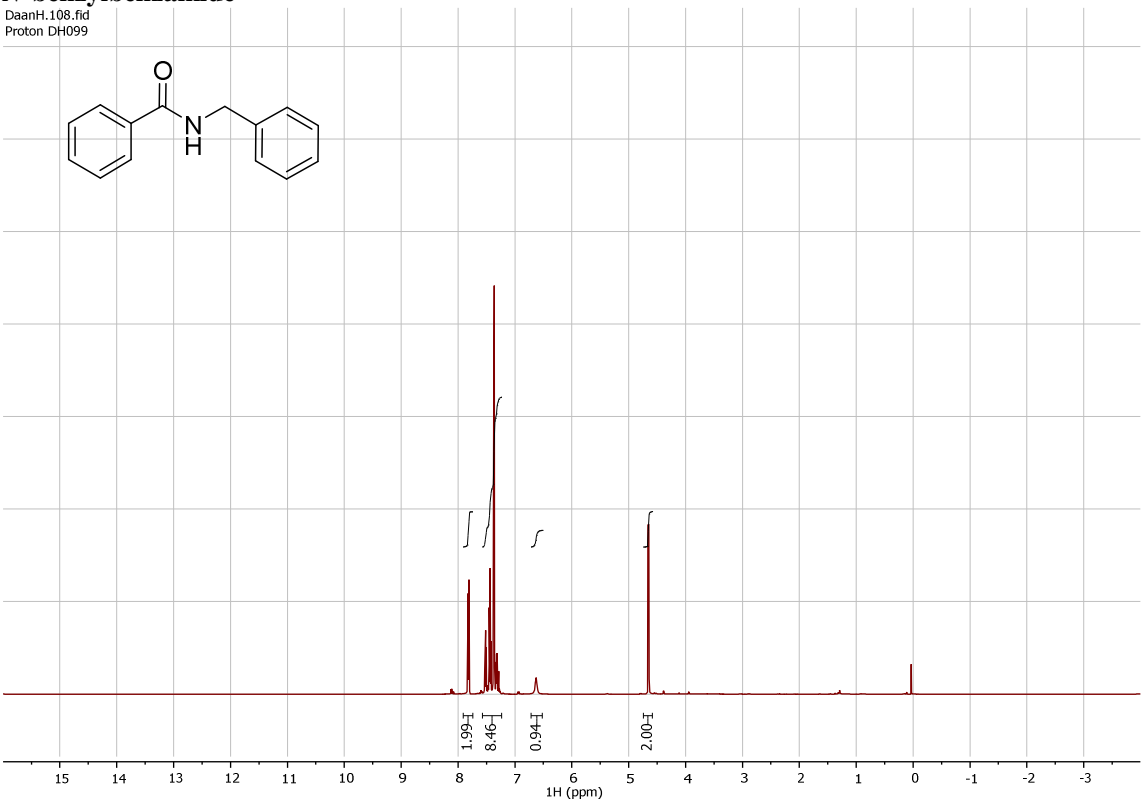
(_N_-(_p_-methoxyphenyl)-_p_-nitrobenzamide (35)

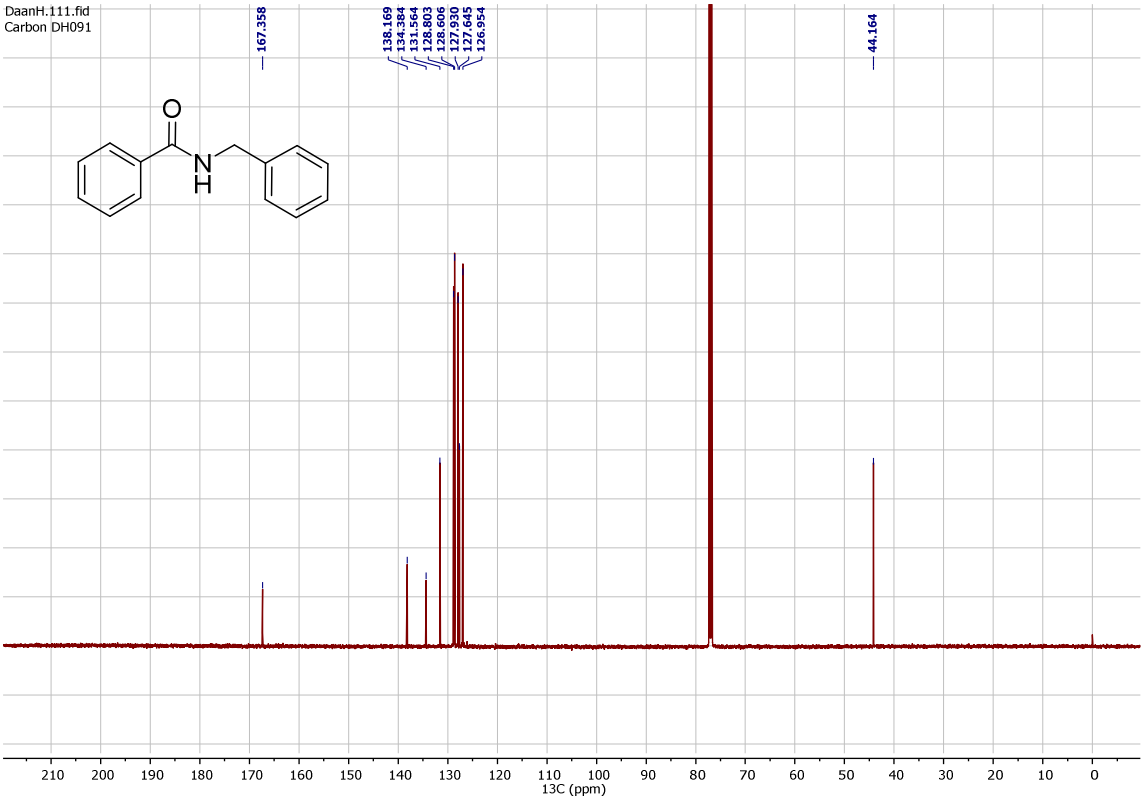


Prepared according to general procedure using *p*-nitrobenzoic acid (0.5 mmol) and *p*-anisidine (1.3 equiv., 0.65 mmol). Affording the desired amide as a brown solid. R_f = 0.61 (*n*-heptane/EtOAc 1:1); ^{1}H NMR (500 MHz, $CDCl_3$) δ 8.36 (d, *J* = 8.4 Hz, 2H, Ar-*H*), 8.05 (d, *J* = 8.4 Hz, 2H, Ar-*H*), 7.80 (s, 1H, N*H*), 7.56 (d, *J* = 8.9 Hz, 2H, Ar-*H*), 6.95 (d, *J* = 8.9 Hz, 2H, Ar-*H*), 3.85 (s, 3H, -OCH_3). ^{13}C NMR (126 MHz, $CDCl_3$) δ 163.49, 157.16, 149.69, 140.59, 130.19, 128.20, 124.01, 122.29, 114.39, 55.53; MS (ESI) m/z 272.26 $[M+H]^+$. Data are in accordance to that previously reported.[11]

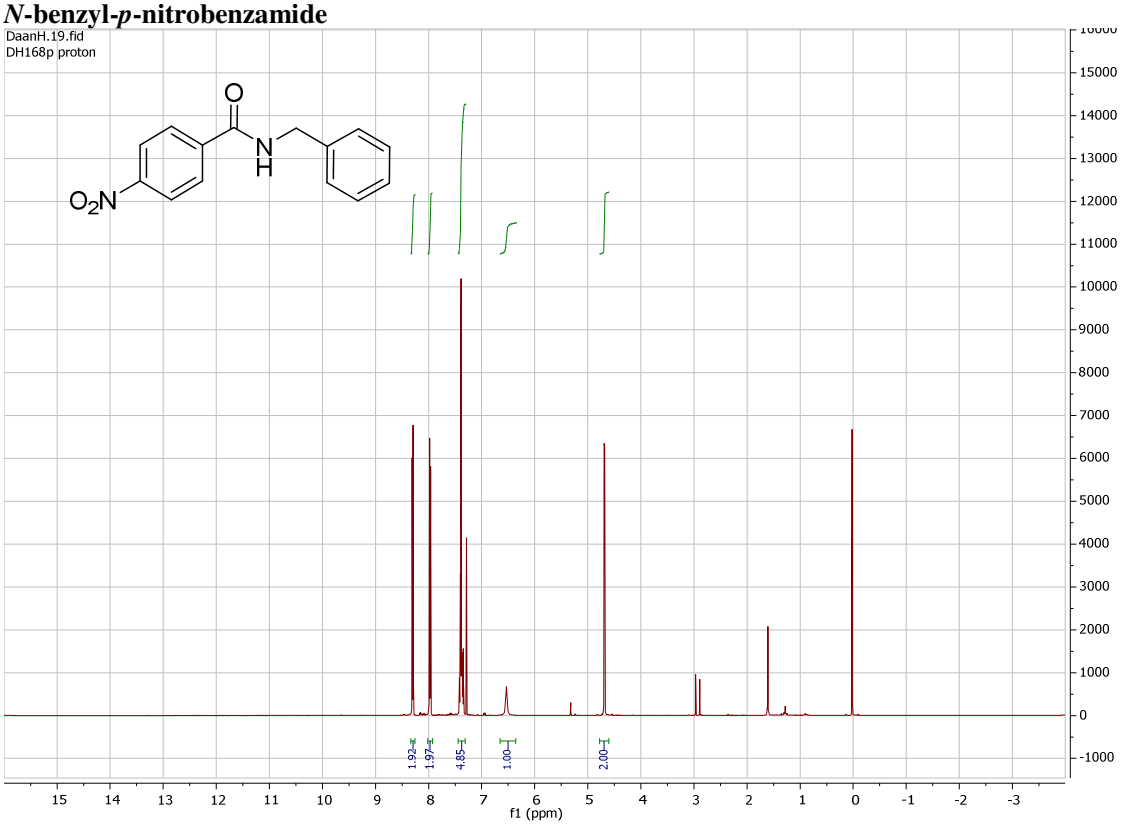
5. ^{1}H and ^{13}C NMR Spectra

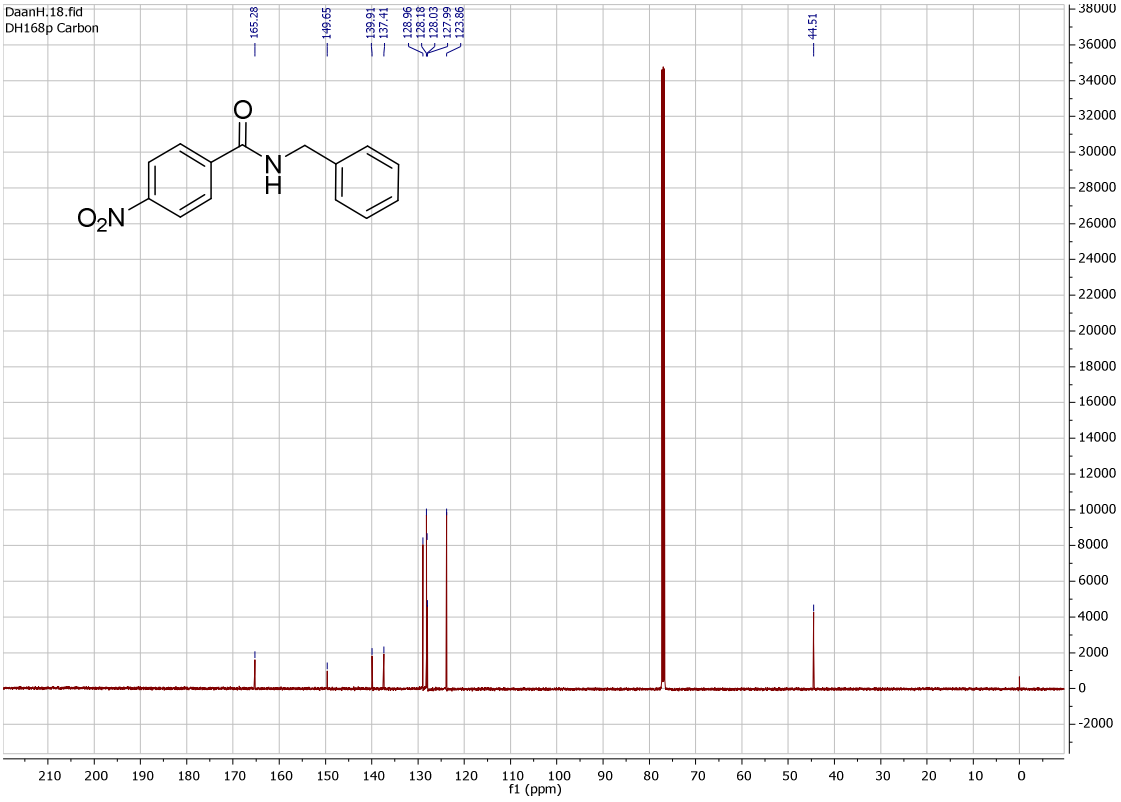
***N*-benzylbenzamide**



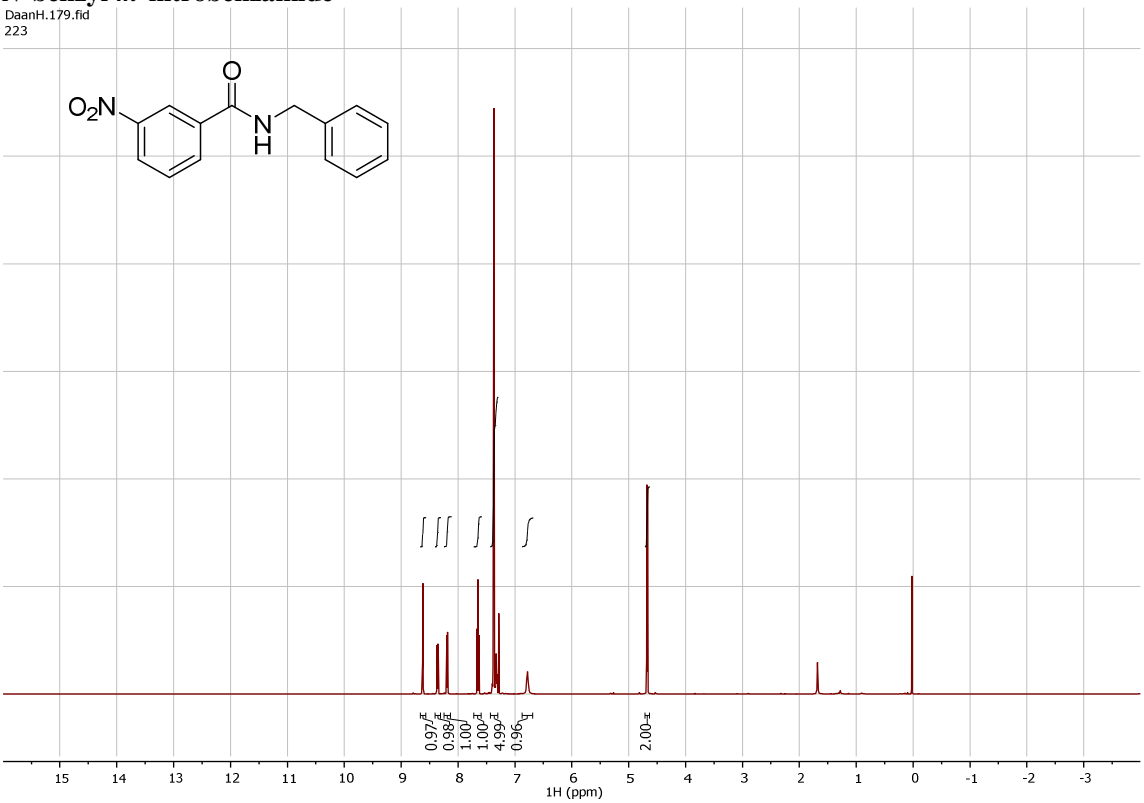


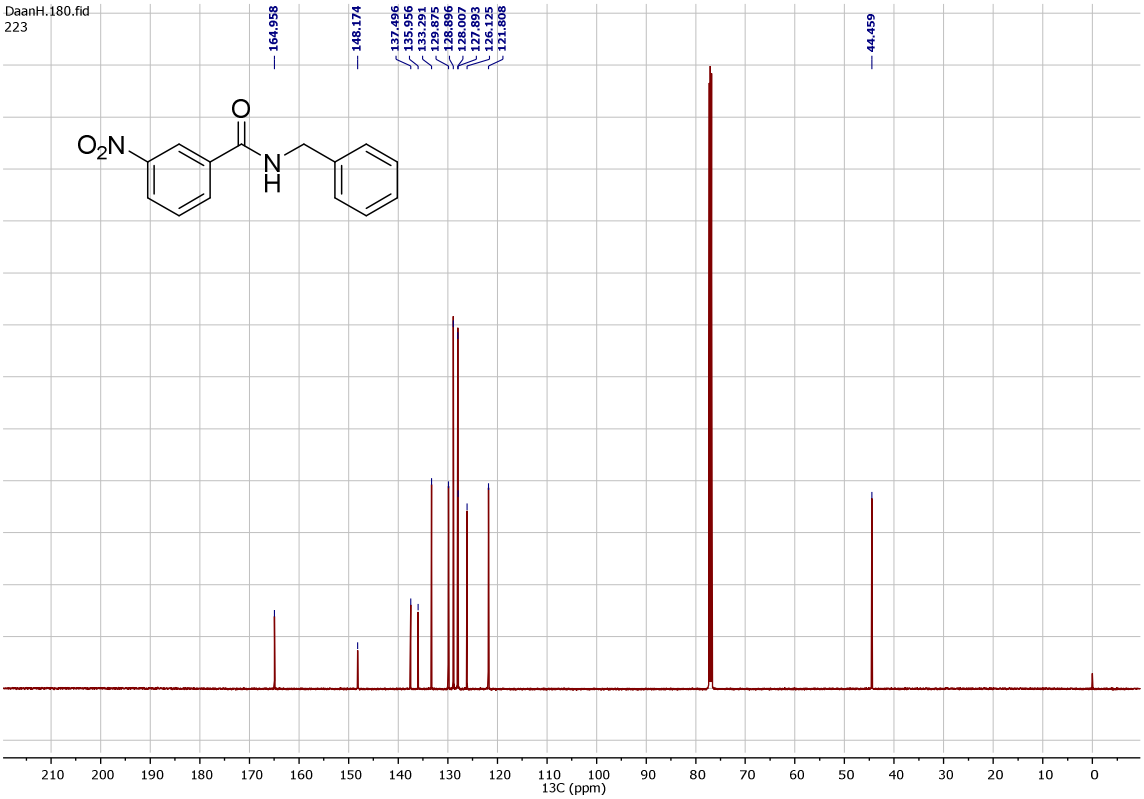
***N*-benzyl-*p*-nitrobenzamide**



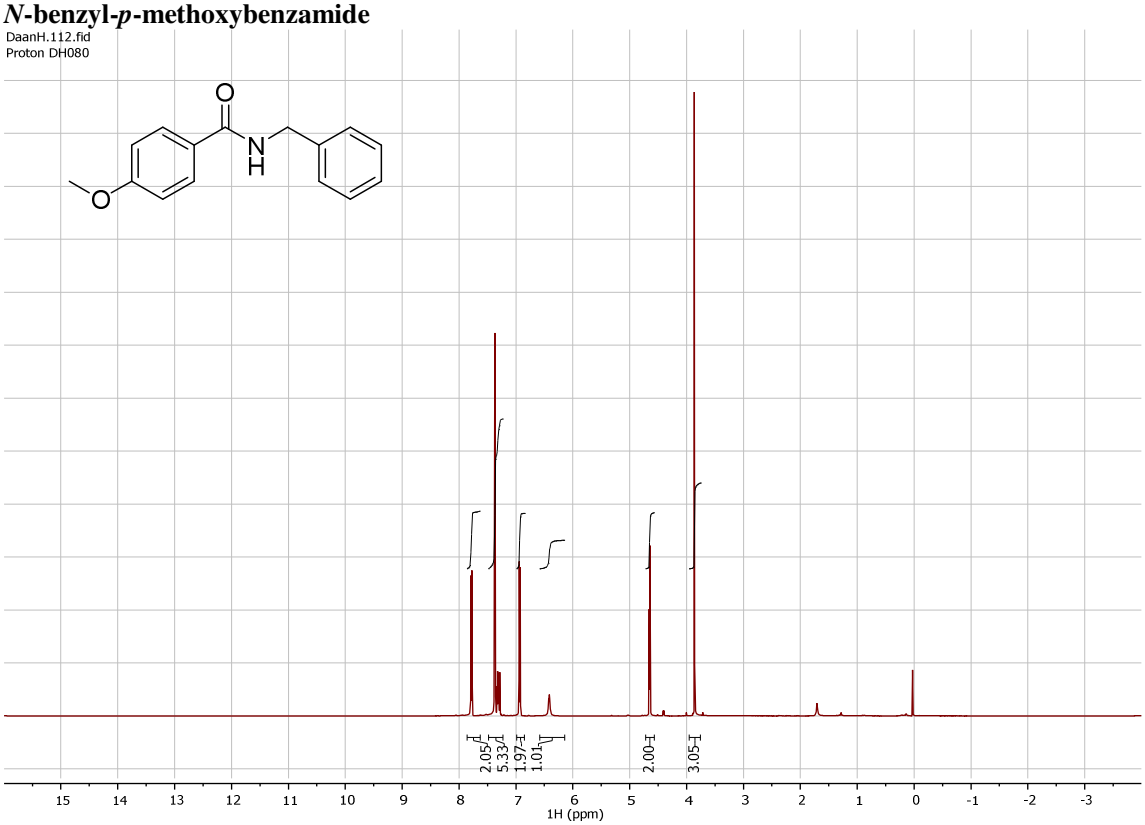


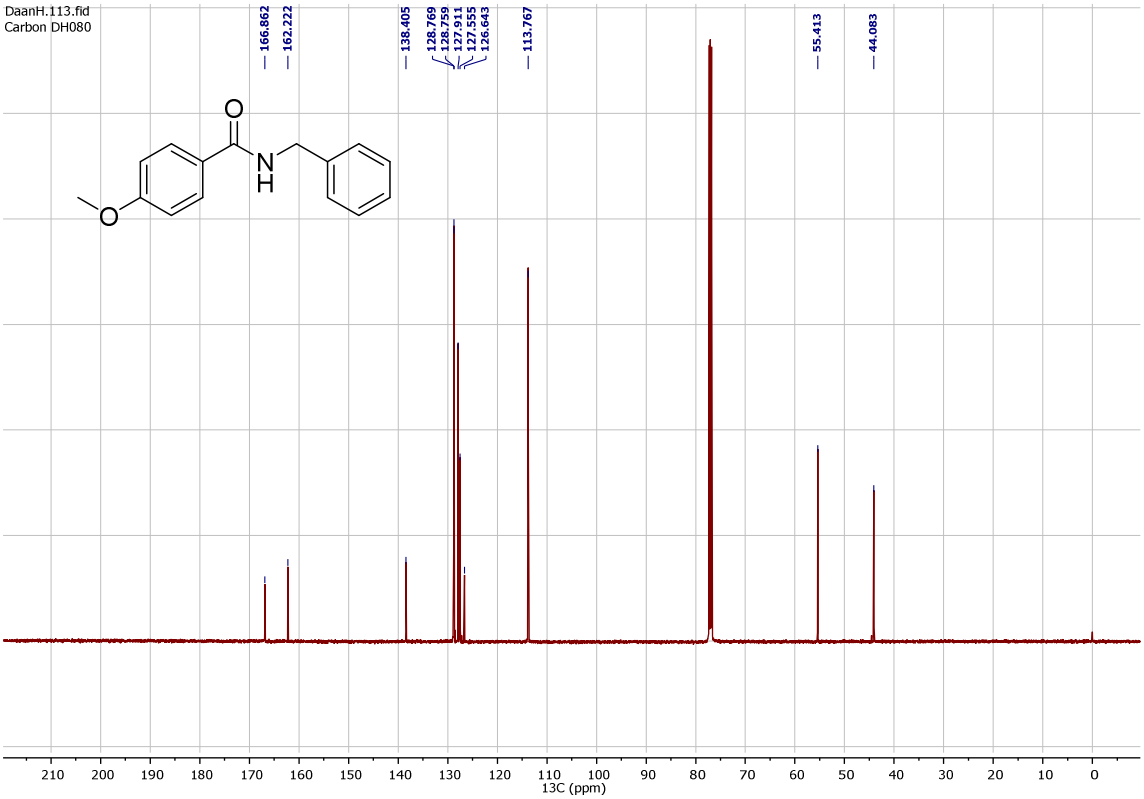
_N_-benzyl-_m_-nitrobenzamide



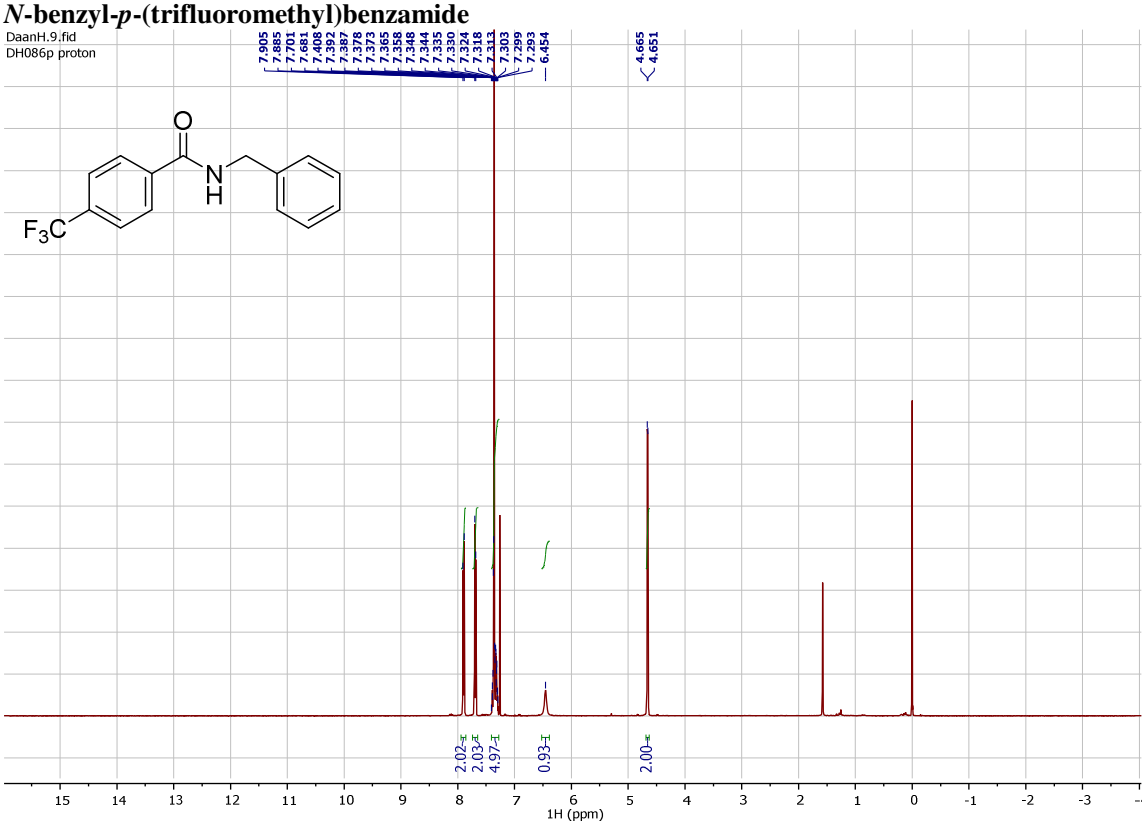


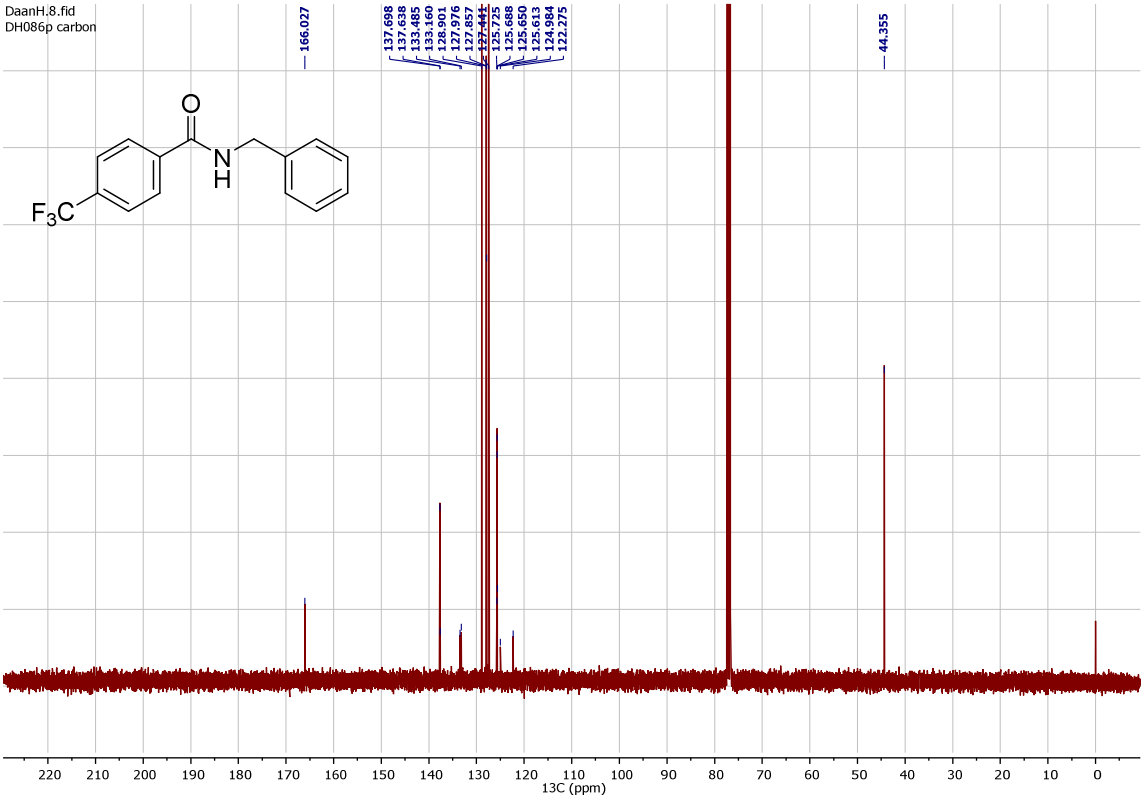
_N_-benzyl-_p_-methoxybenzamide



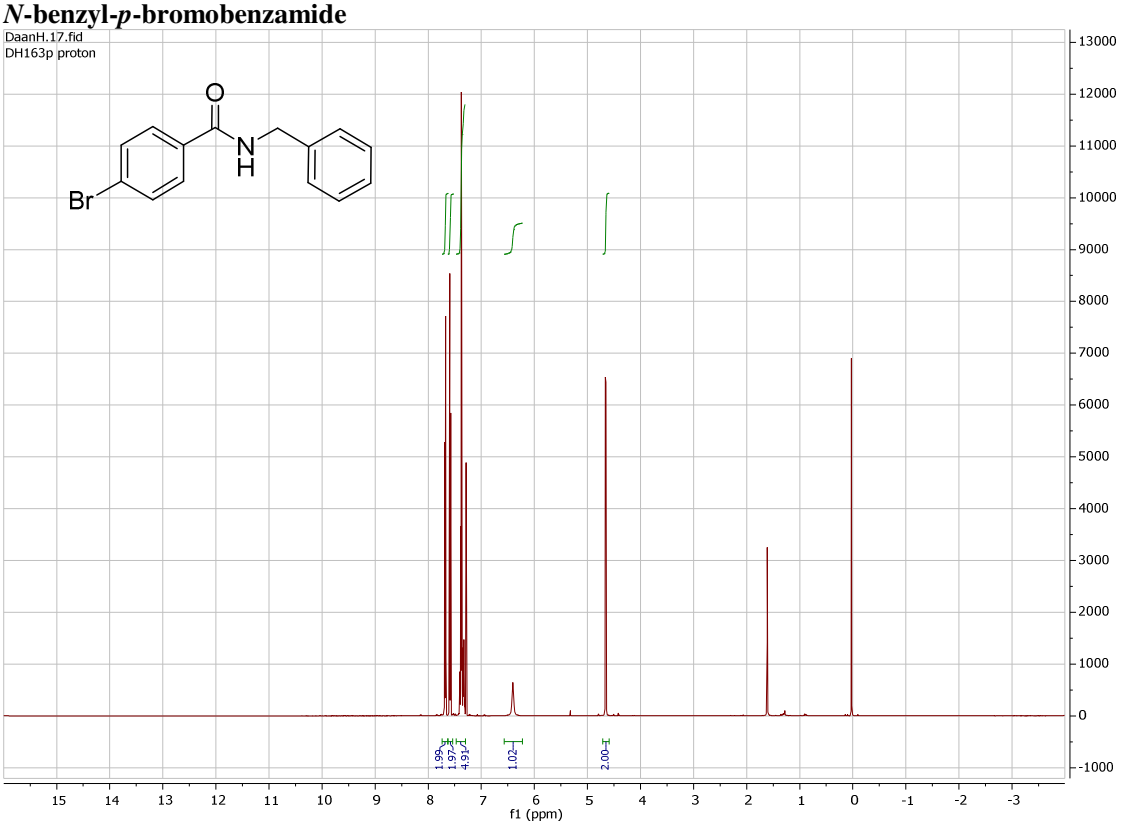


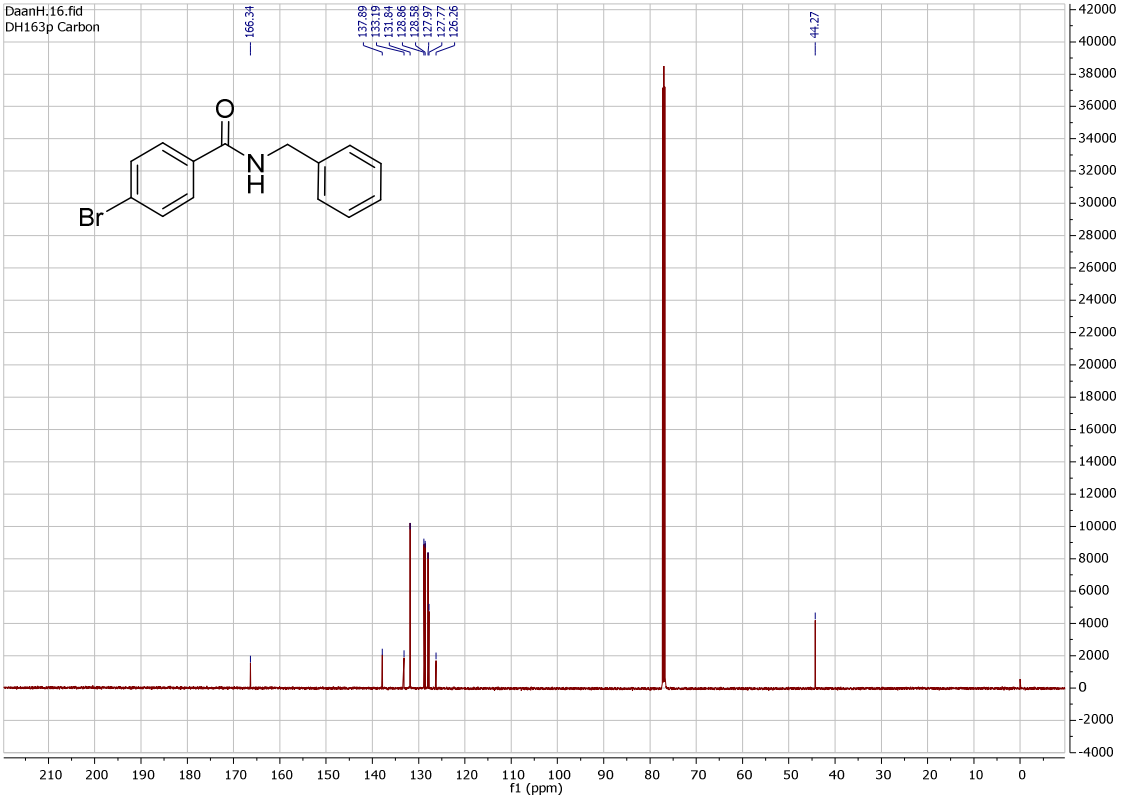
_N_-benzyl-_p_-(trifluoromethyl)benzamide



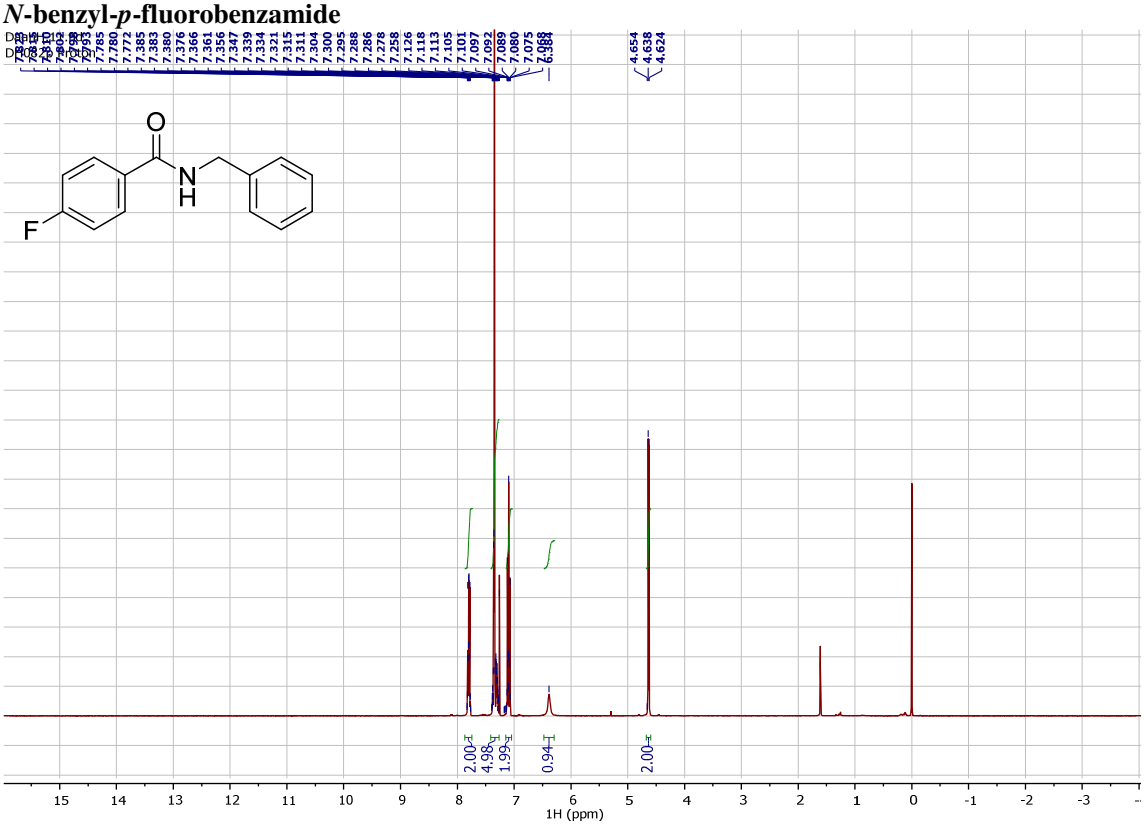


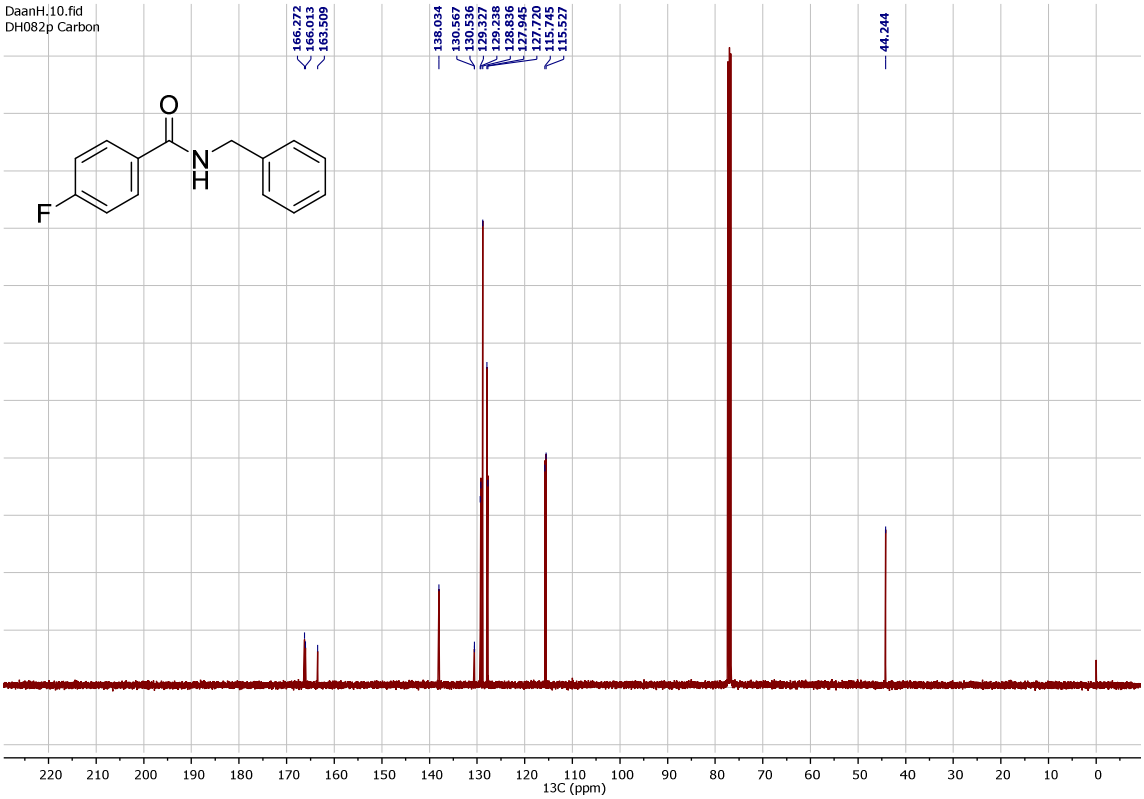
_N_-benzyl-_p_-bromobenzamide



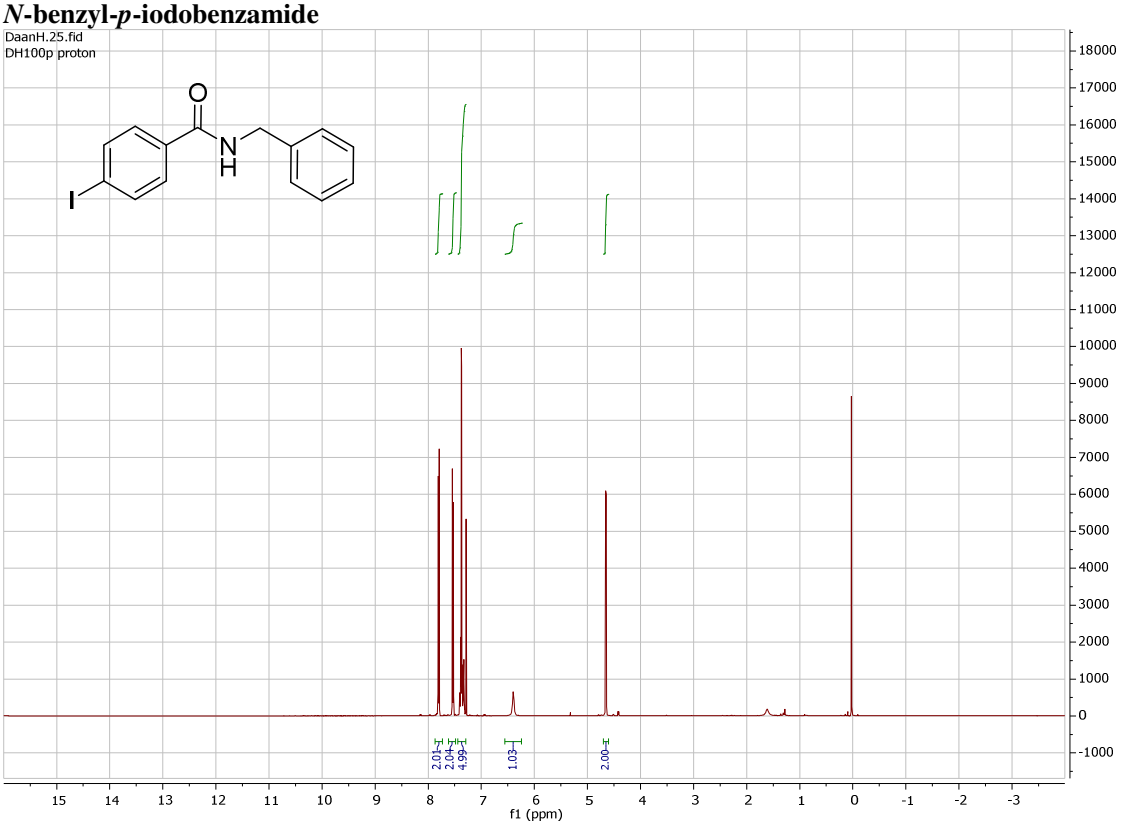


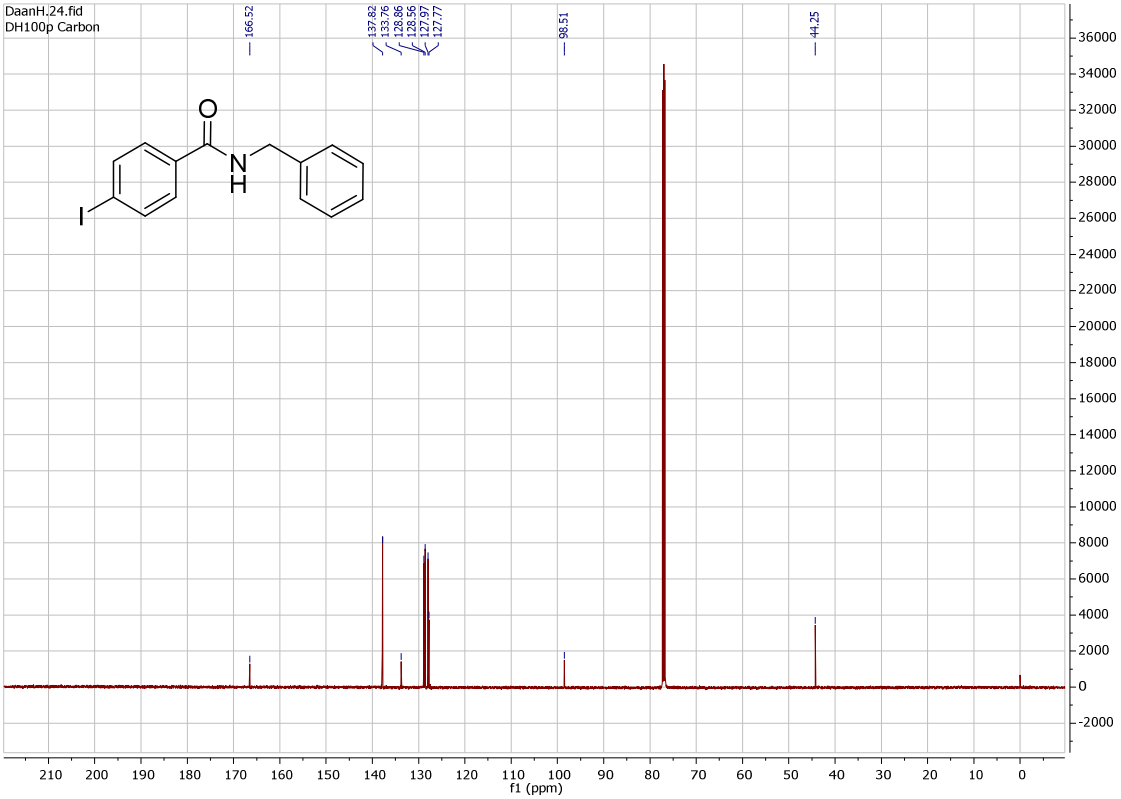
_N_-benzyl-_p_-fluorobenzamide



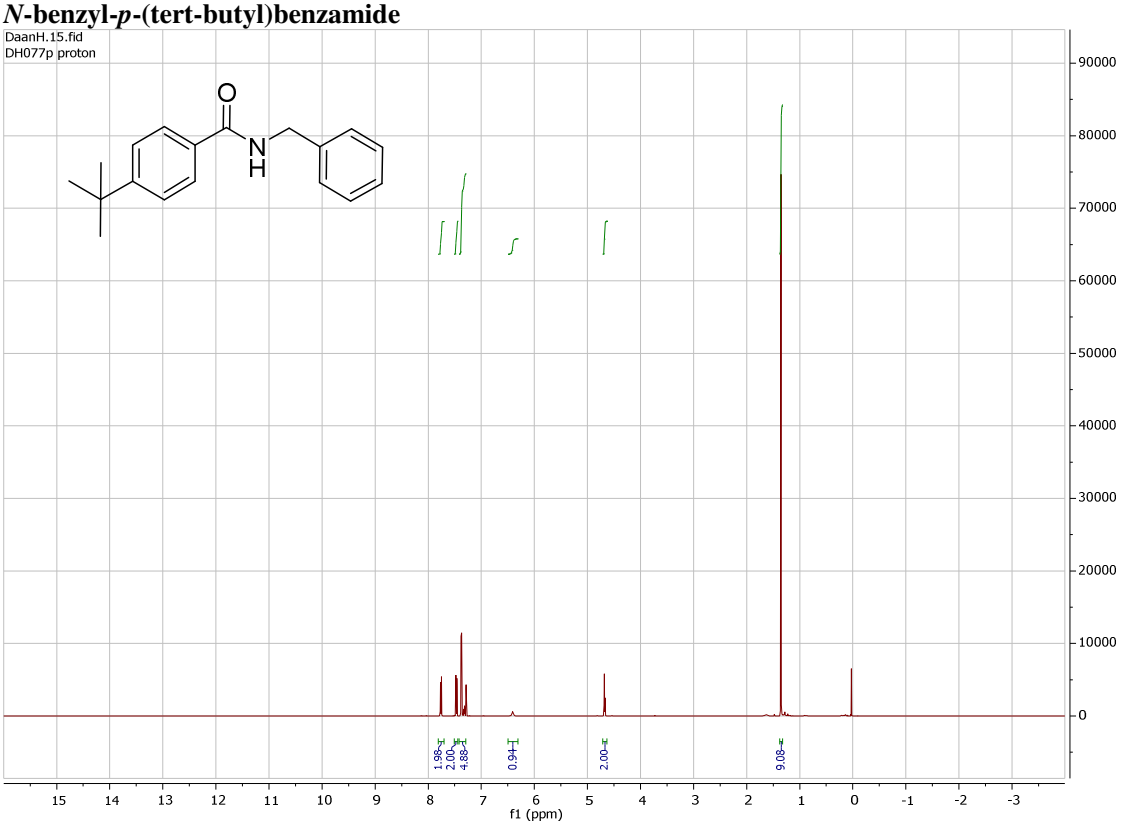


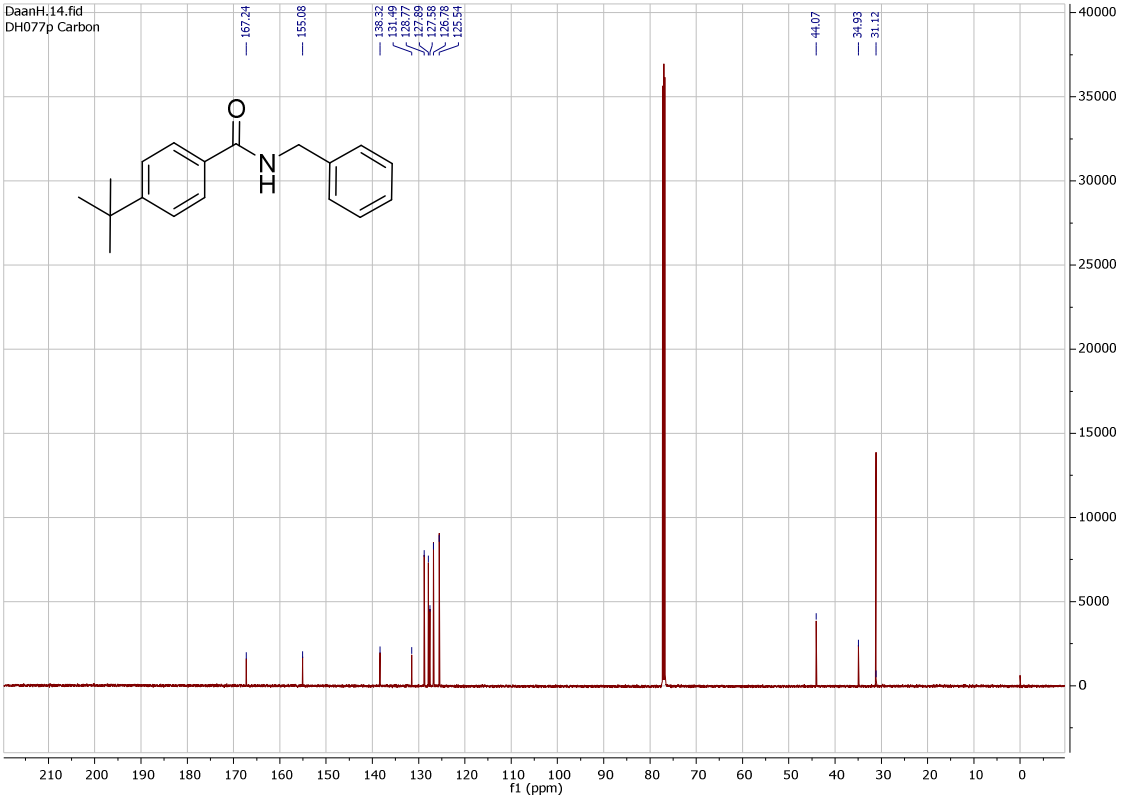
_N_-benzyl-_p_-iodobenzamide



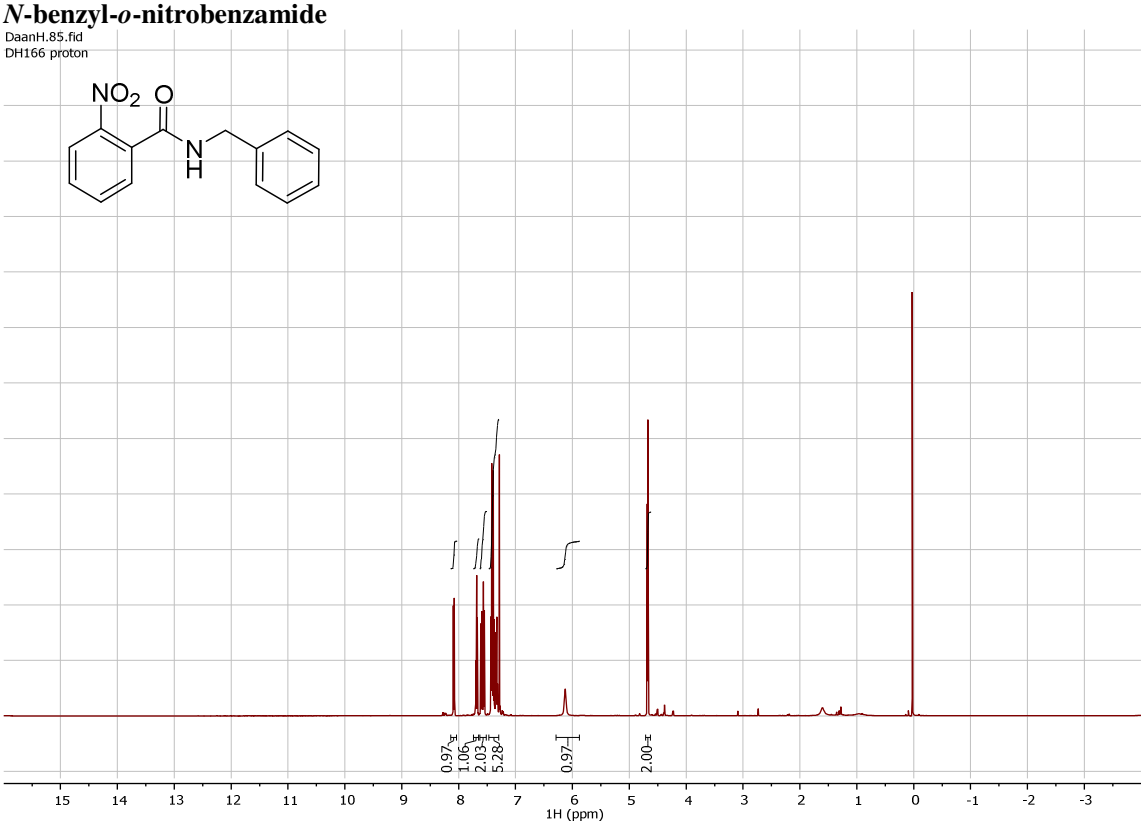


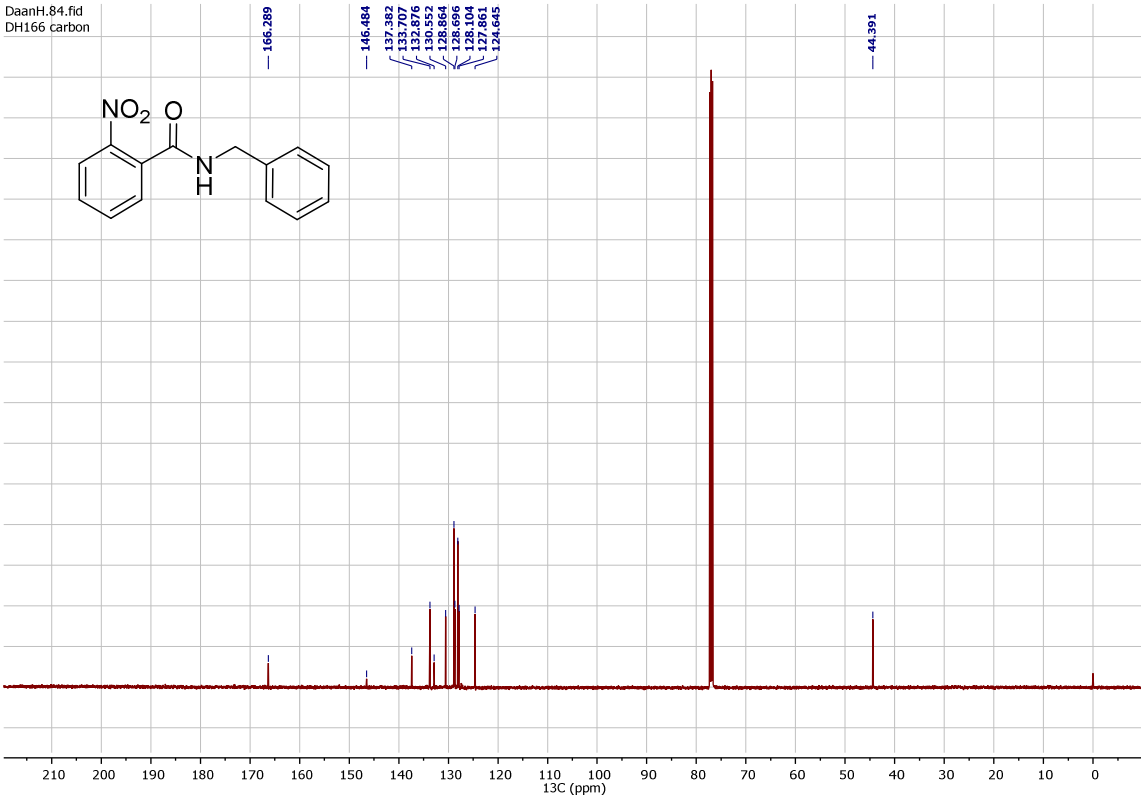
_N_-benzyl-_p_-(tert-butyl)benzamide



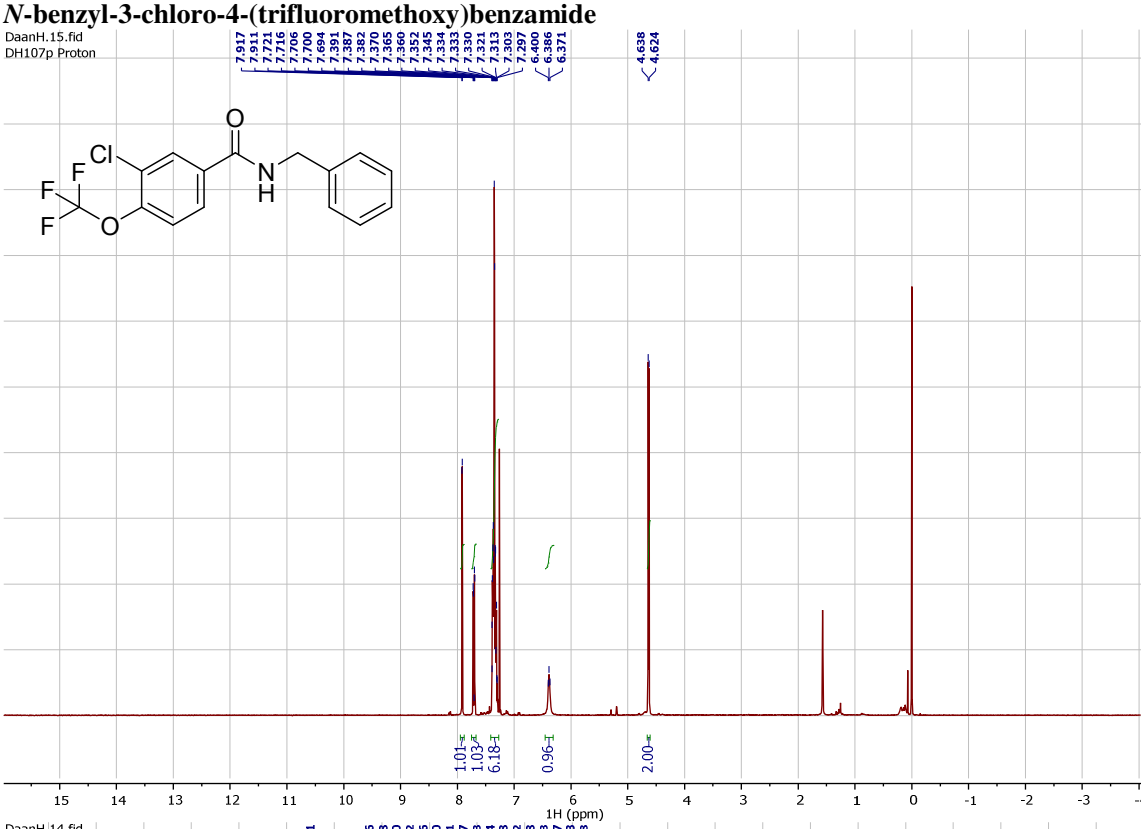


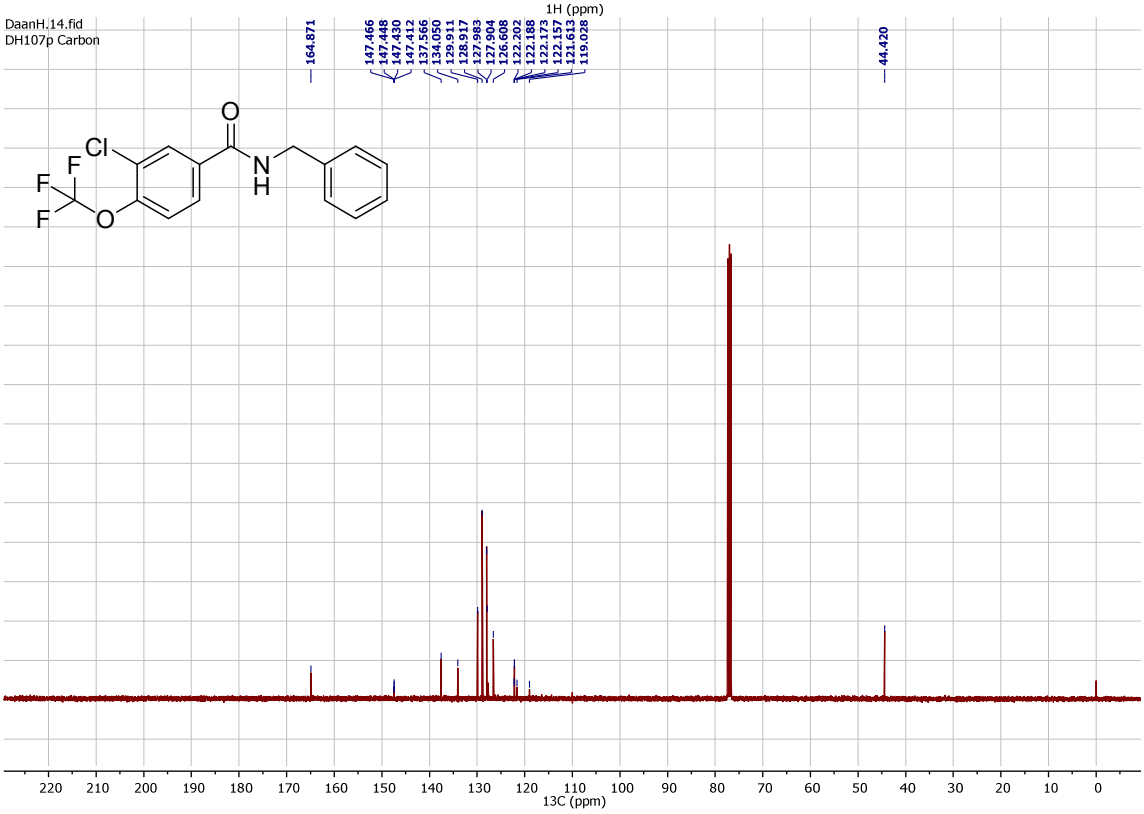
_N_-benzyl-_o_-nitrobenzamide



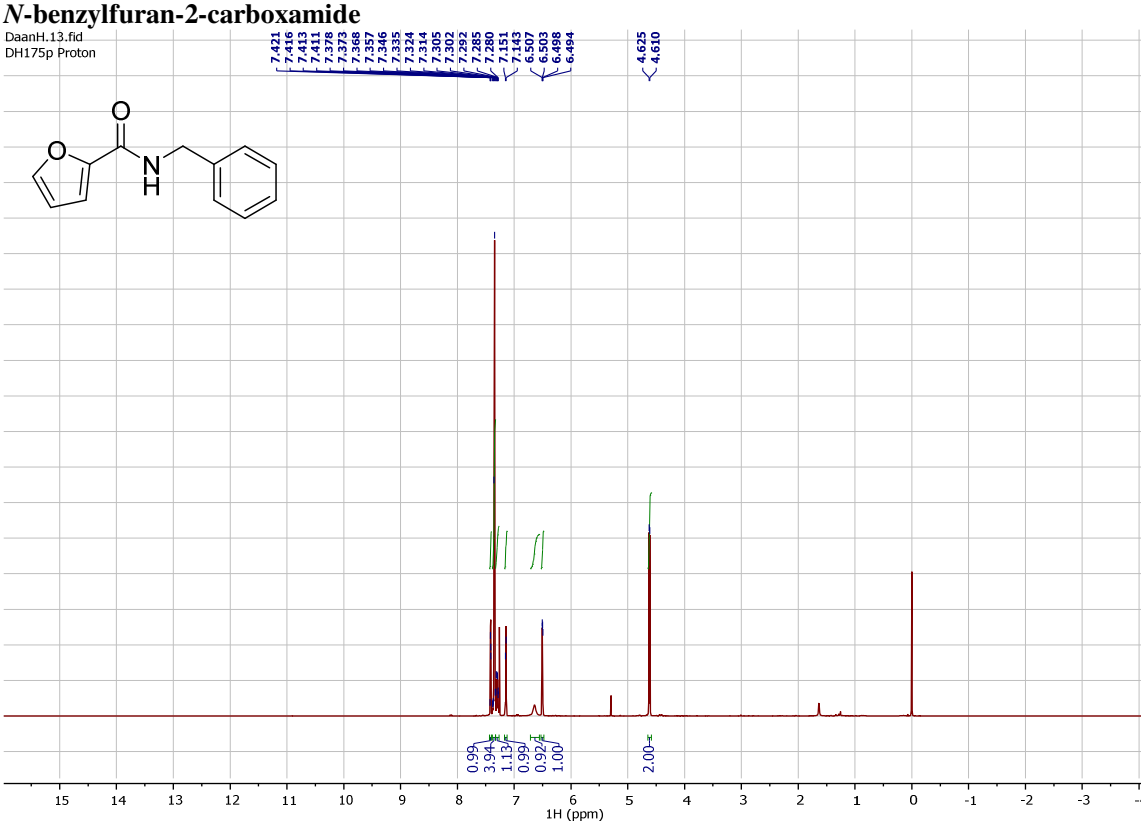


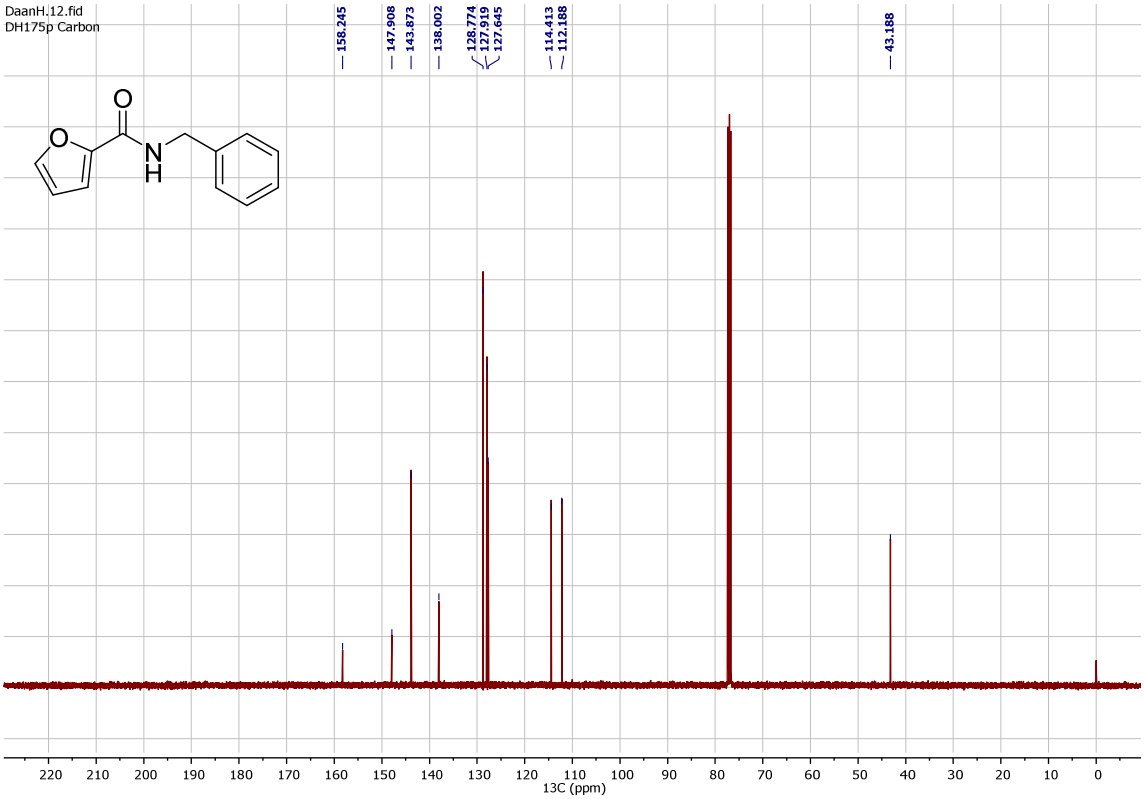
_N_-benzyl-3-chloro-4-(trifluoromethoxy)benzamide



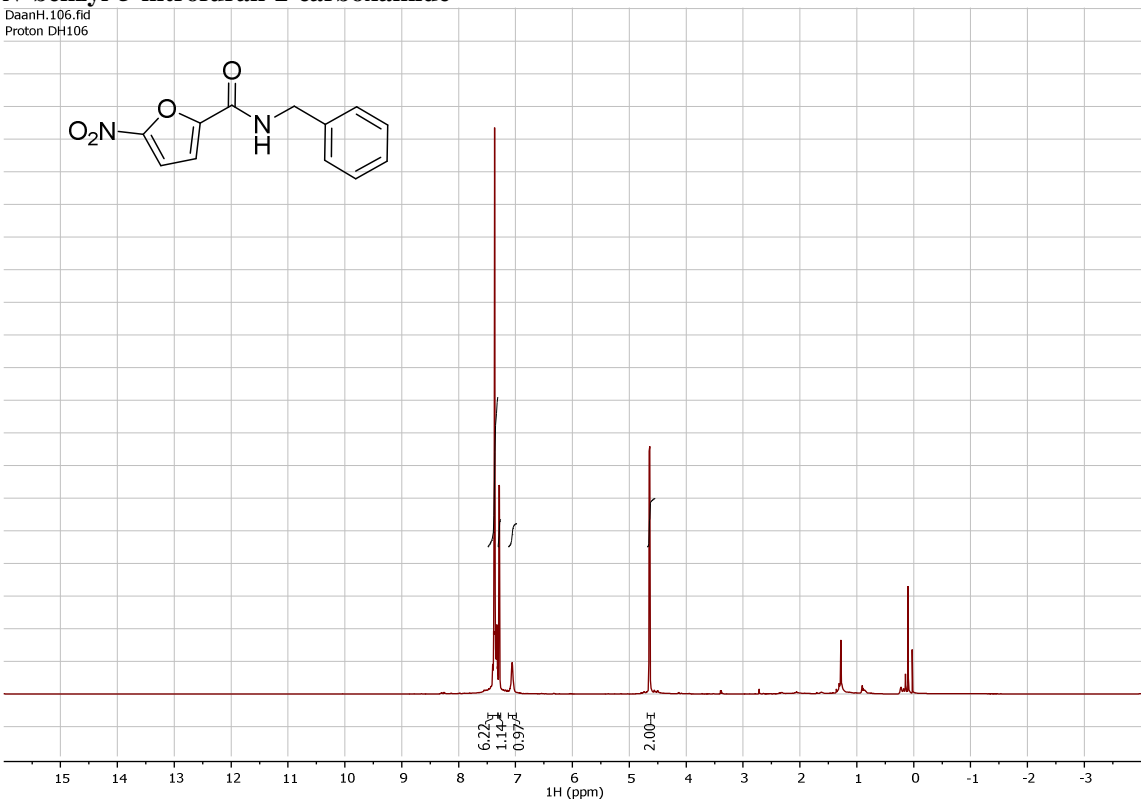


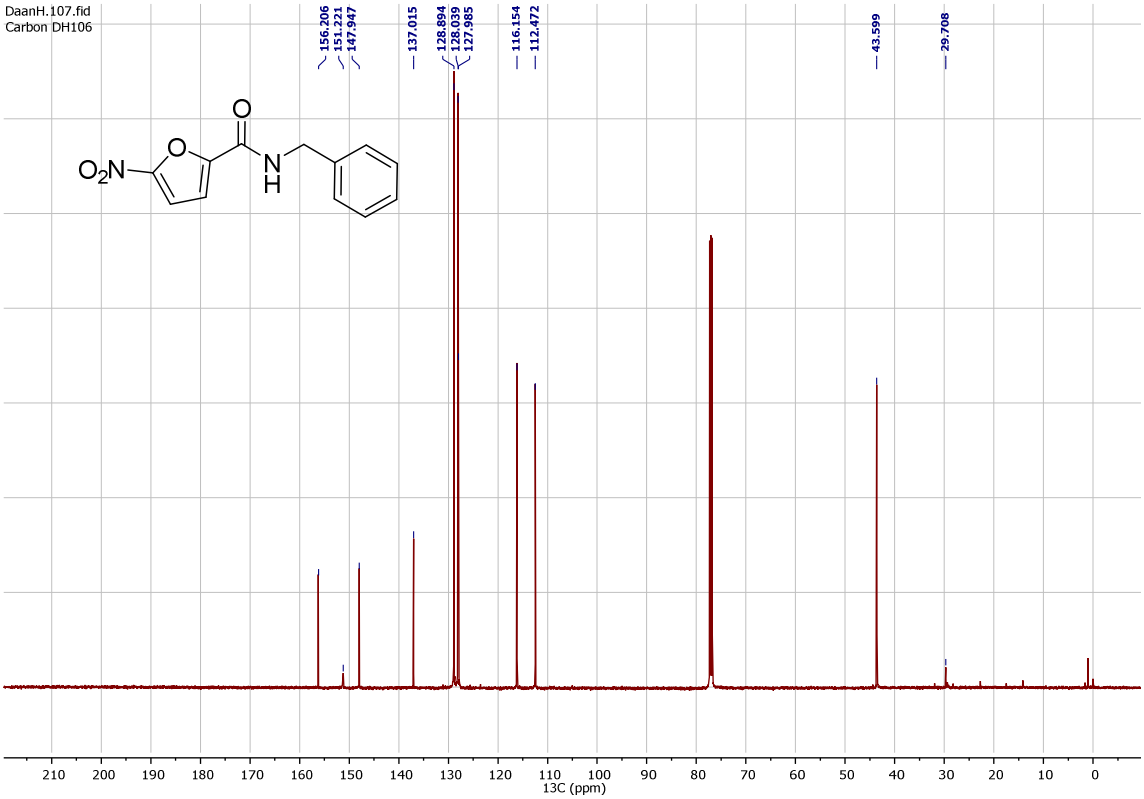
_N_-benzylfuran-2-carboxamide



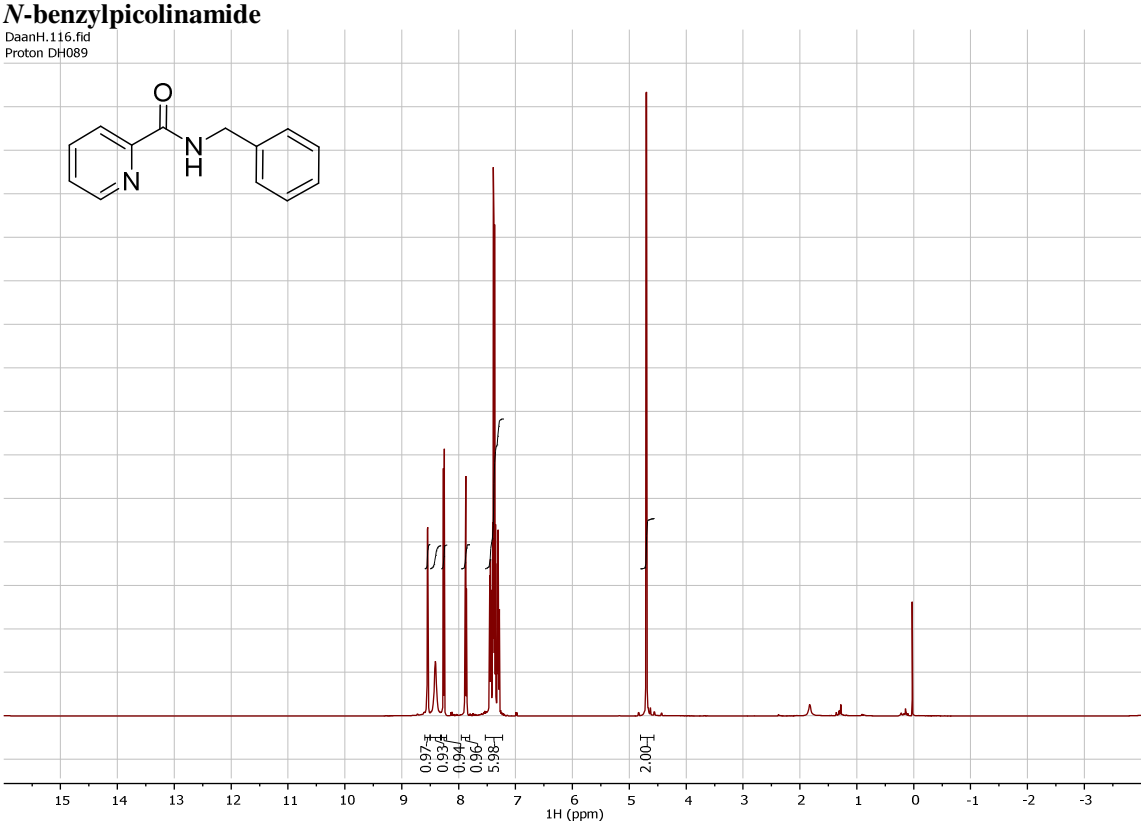


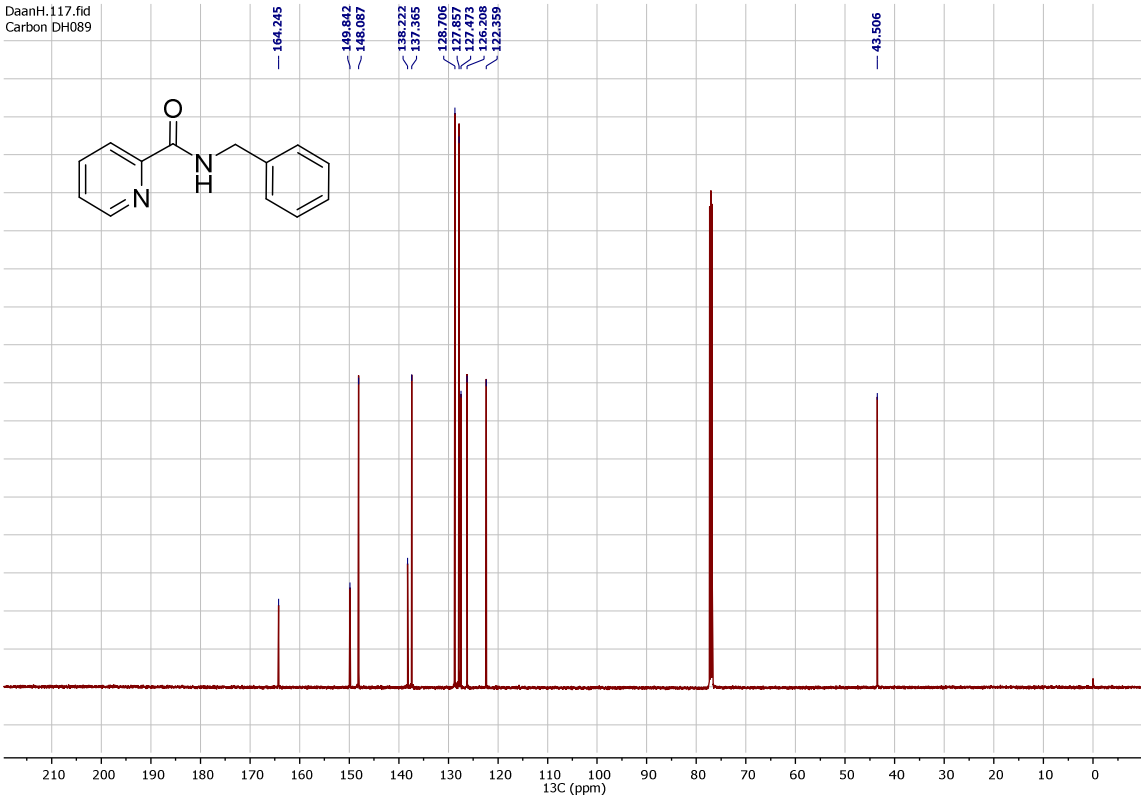
_N_-benzyl-5-nitrofuran-2-carboxamide



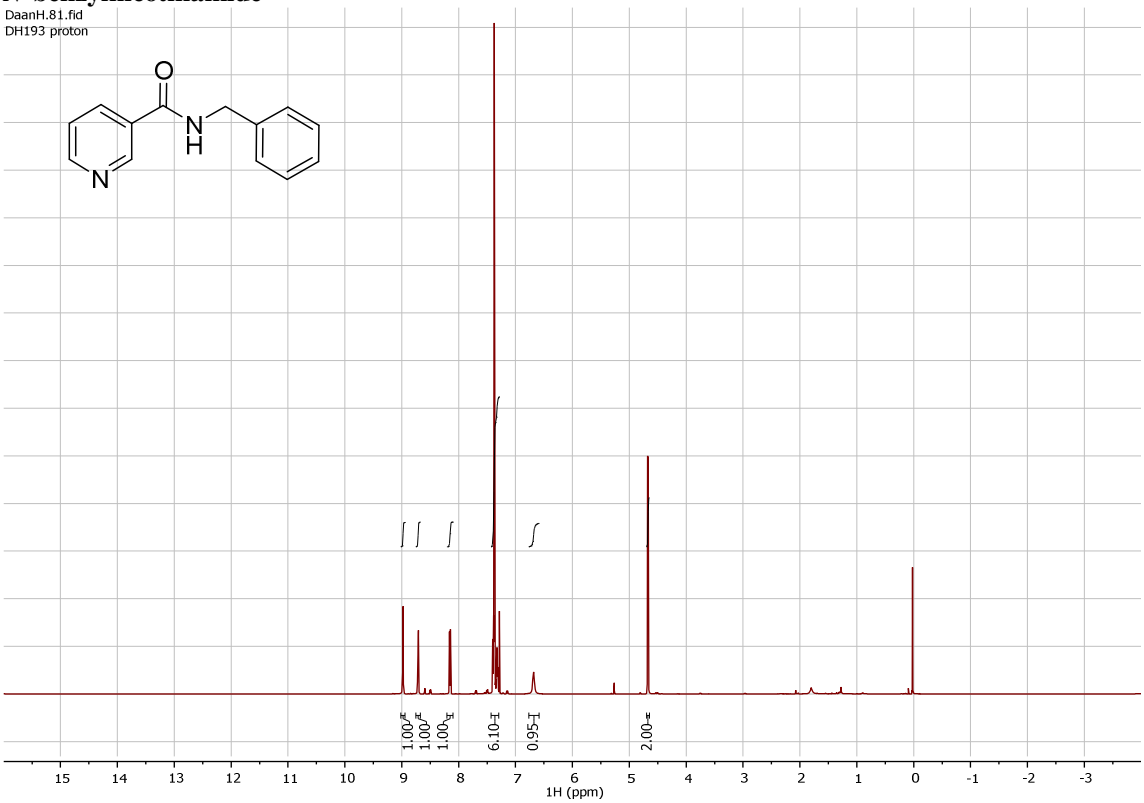


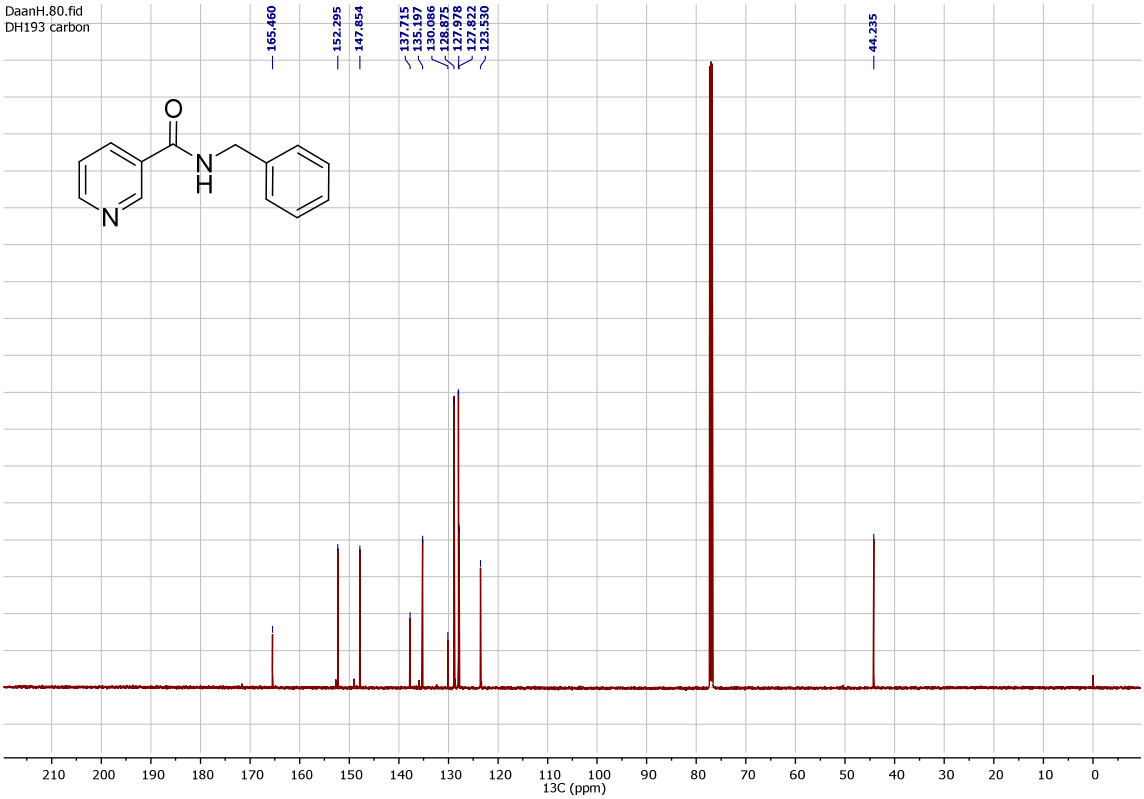
_N_-benzylpicolinamide



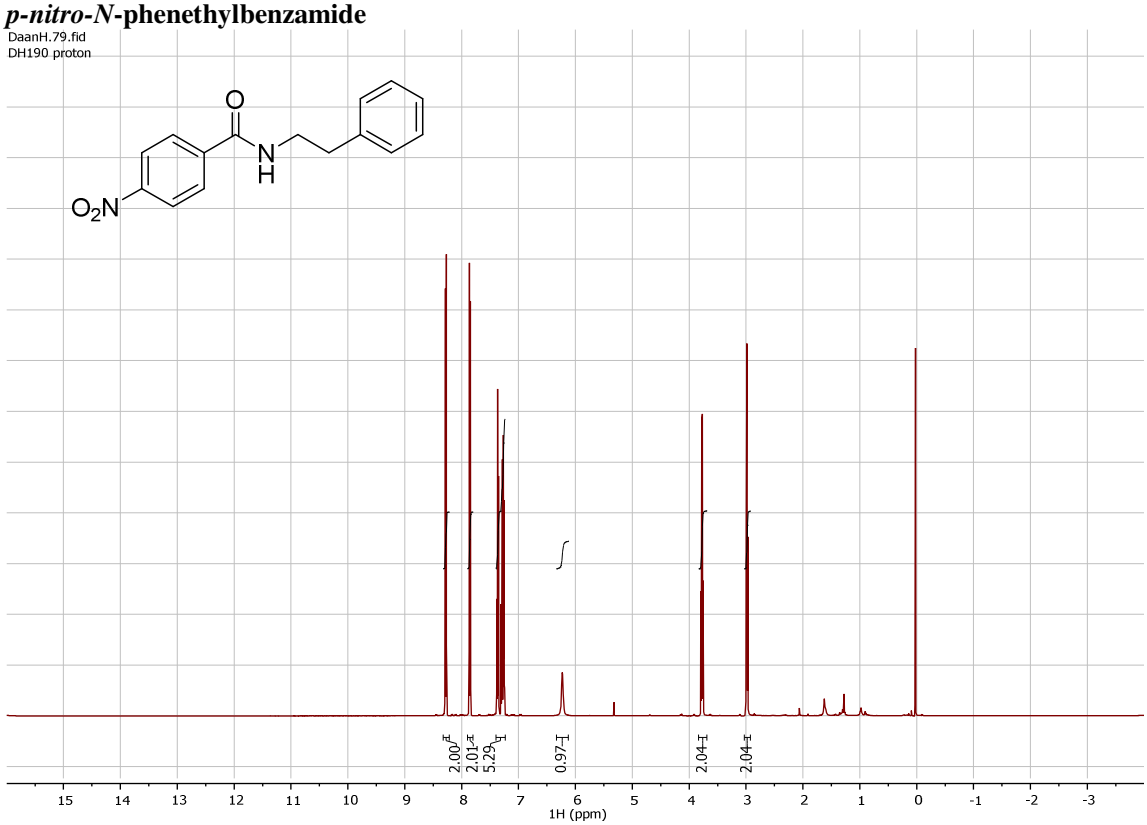


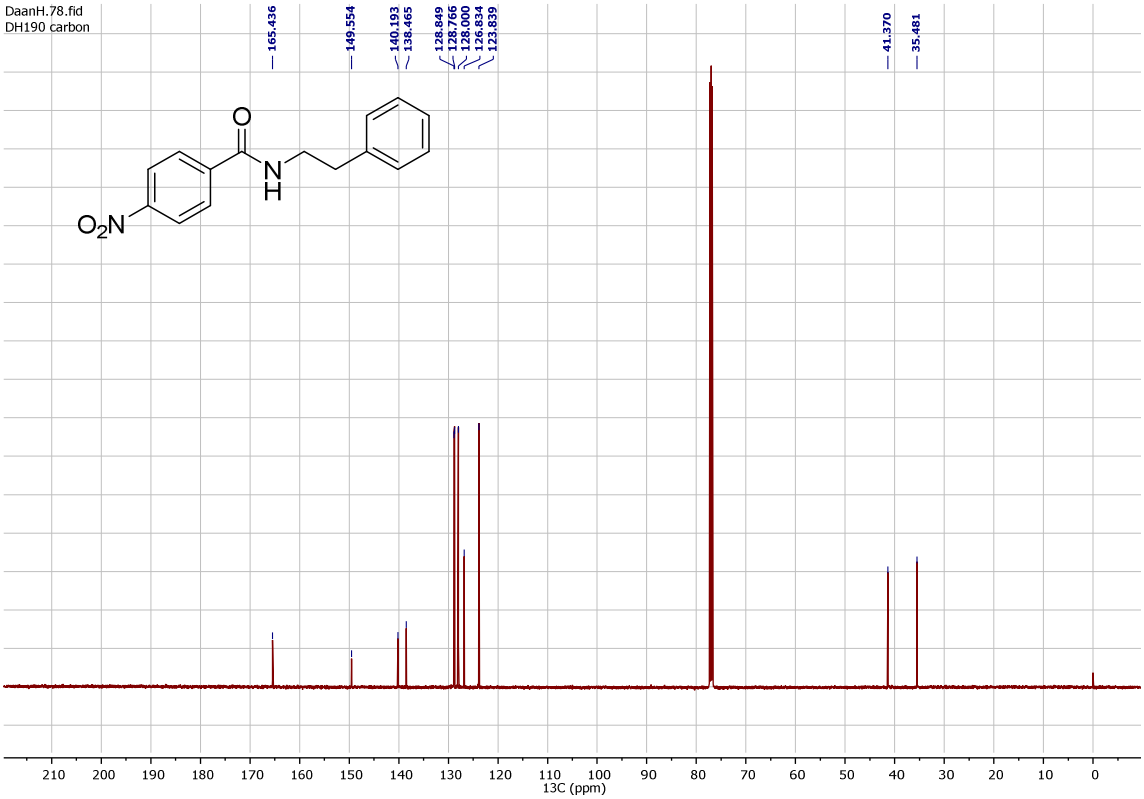
N-benzylnicotinamide



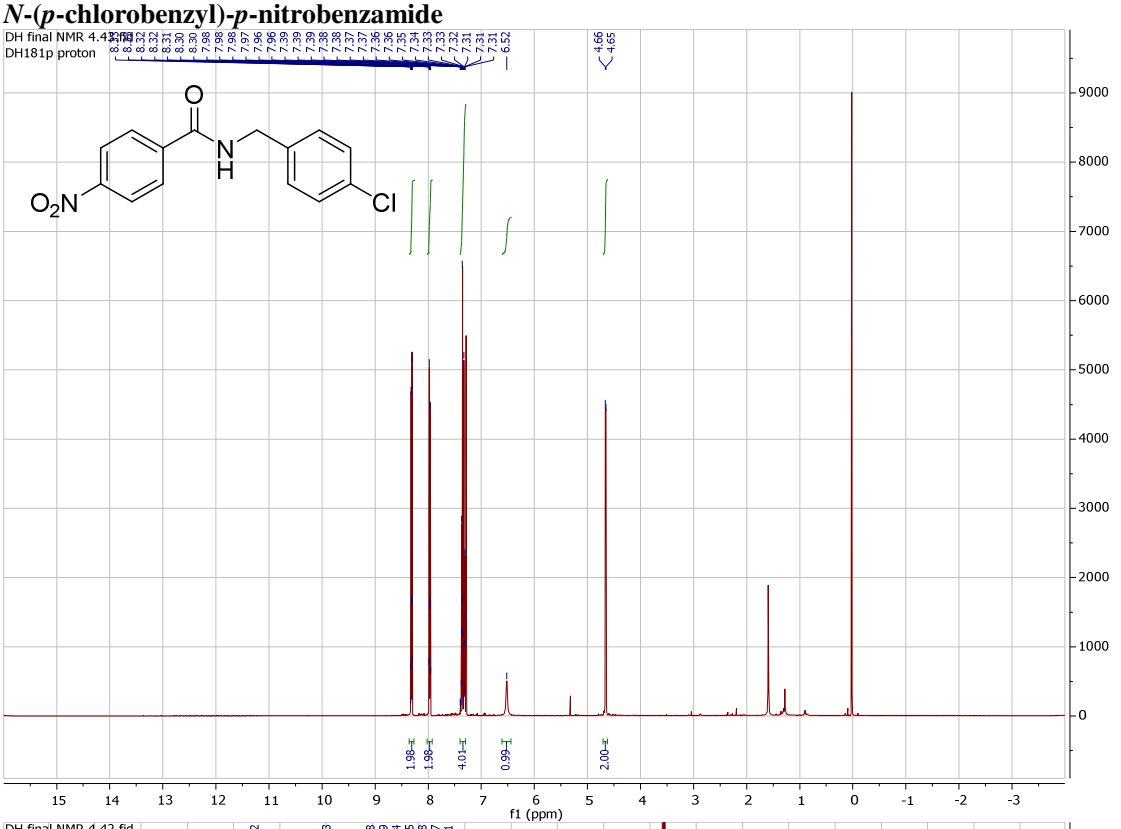


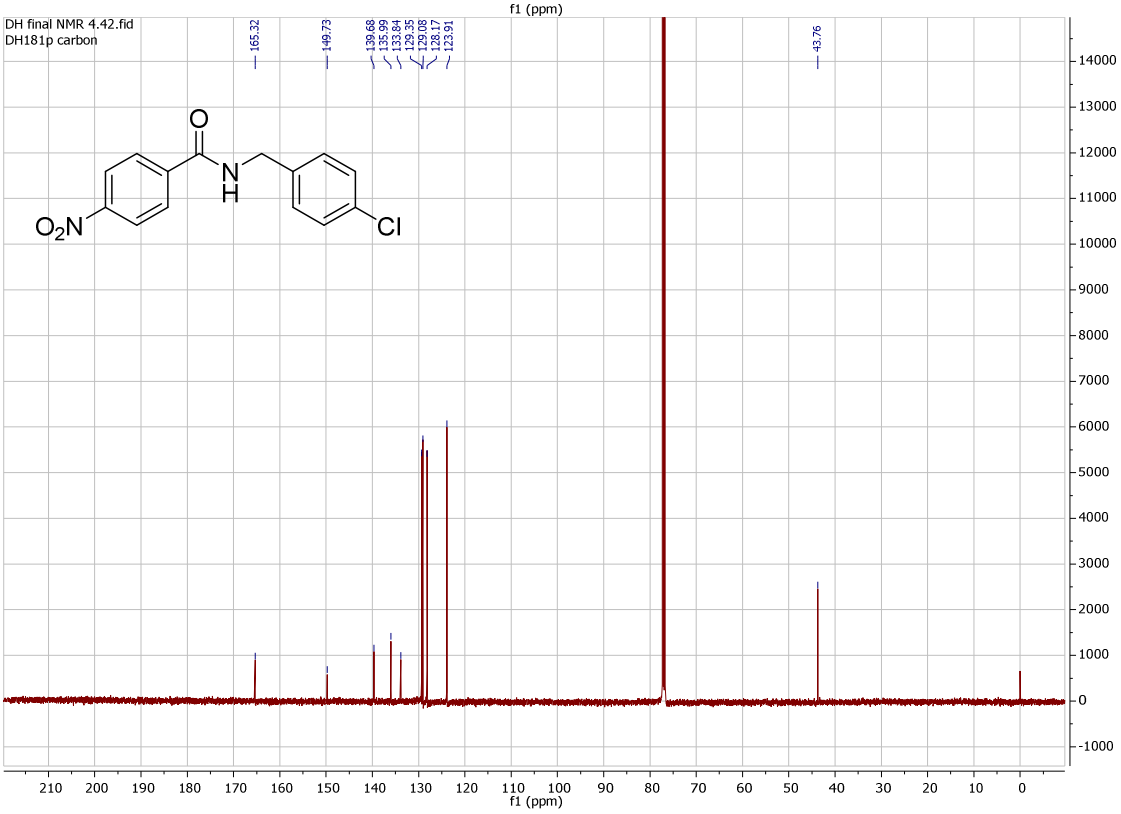
***p-nitro-N*-phenethylbenzamide**



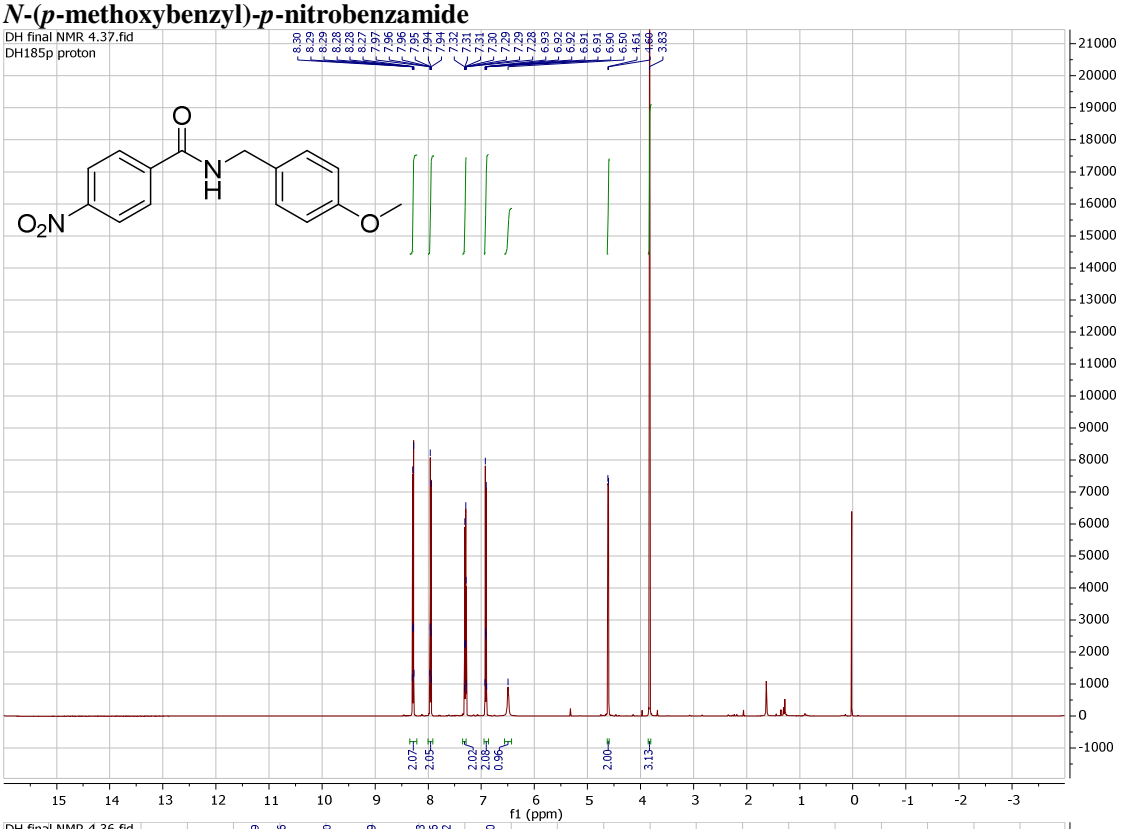


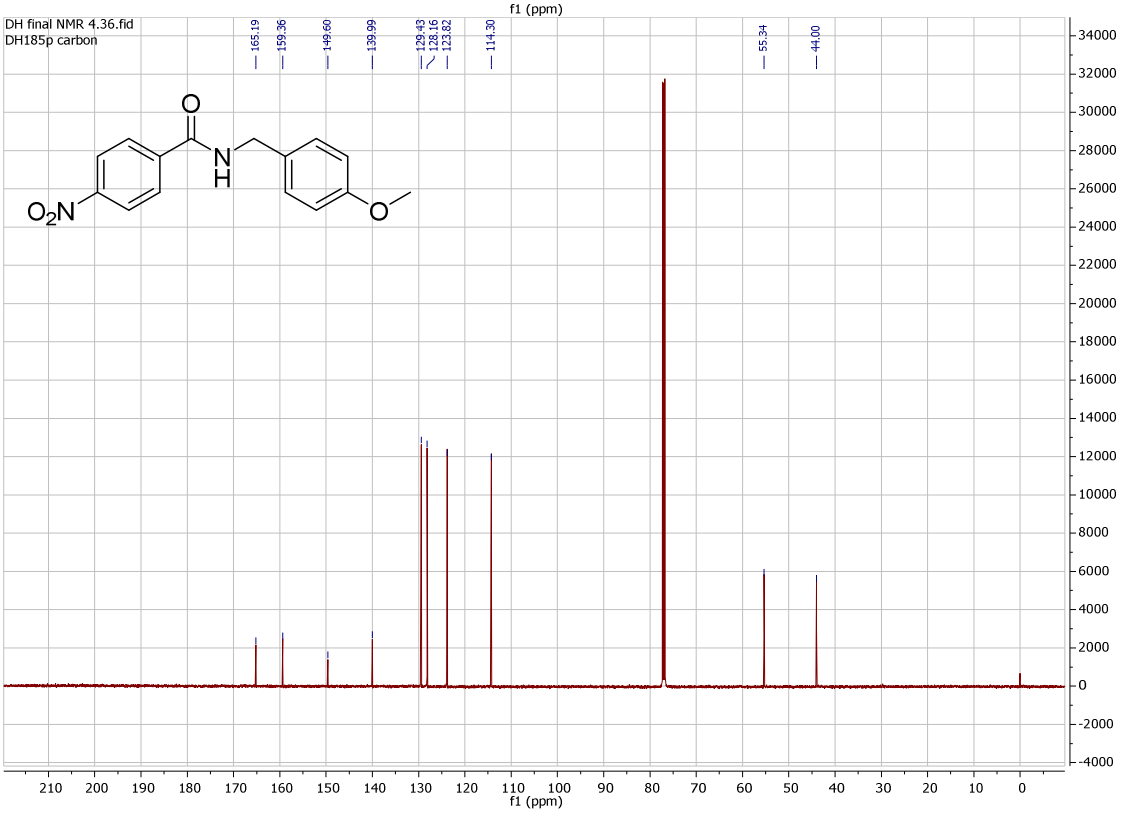
N-(*p*-chlorobenzyl)-*p*-nitrobenzamide



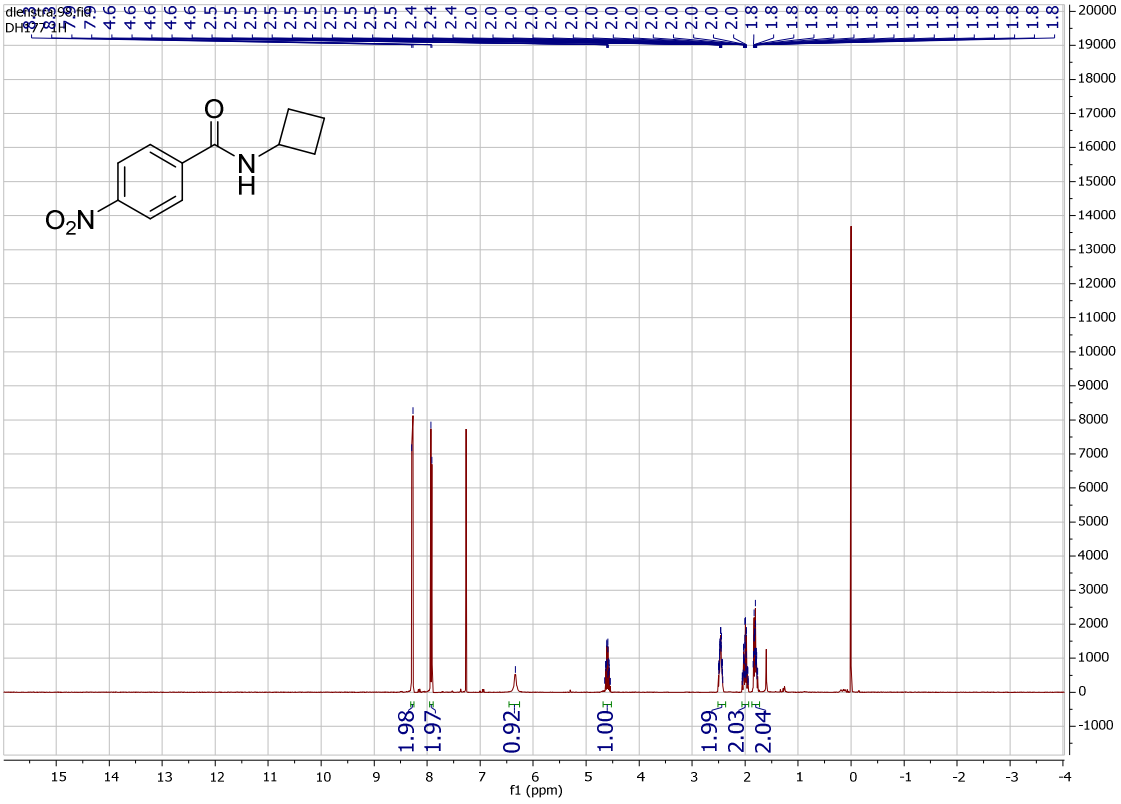


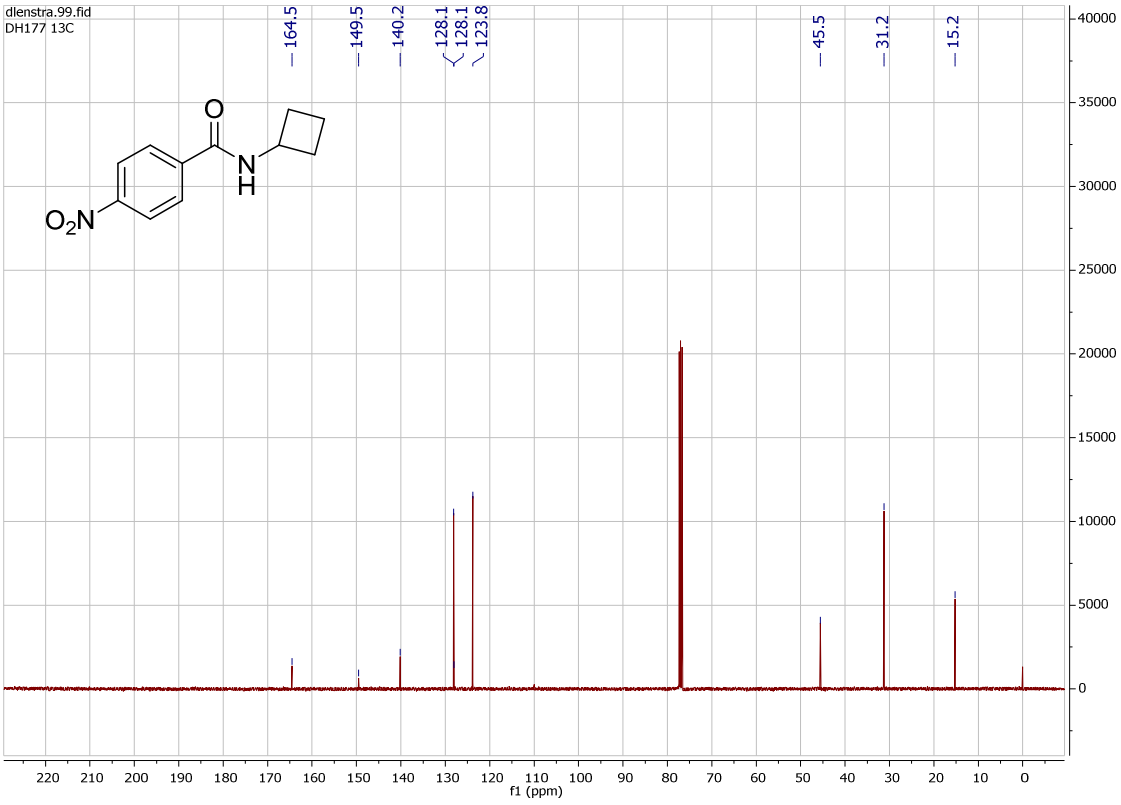
_N_-(_p_-methoxybenzyl)-_p_-nitrobenzamide



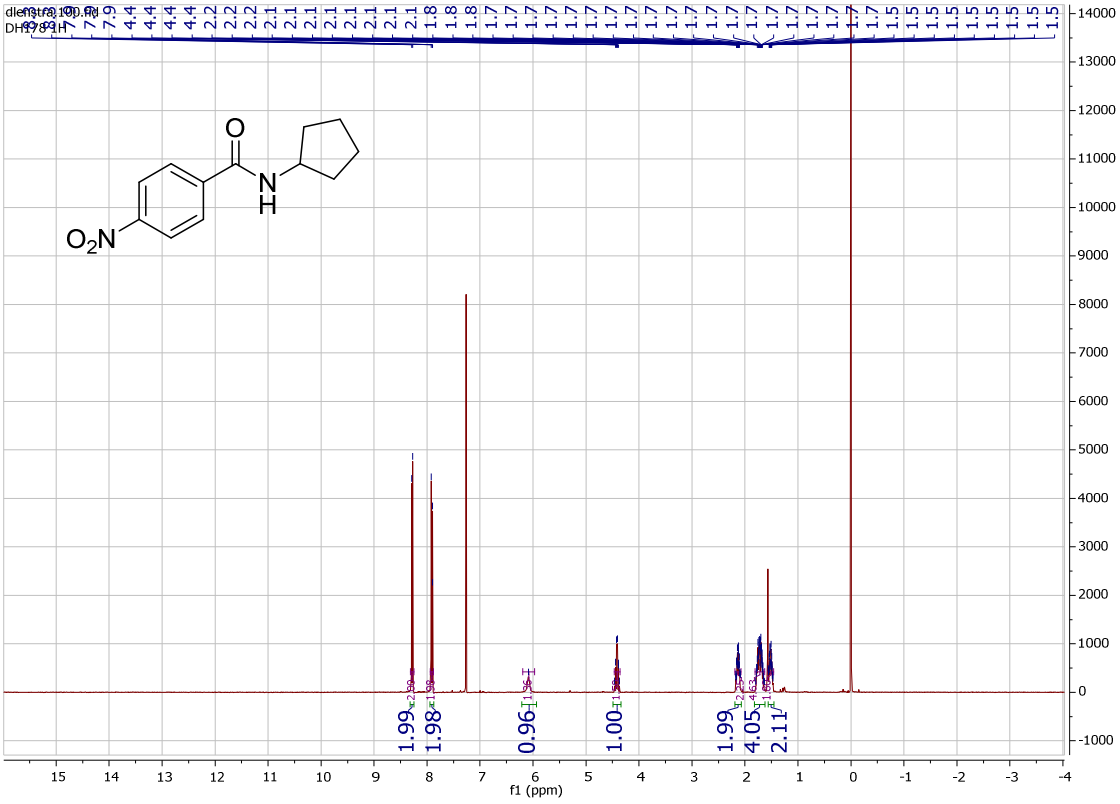


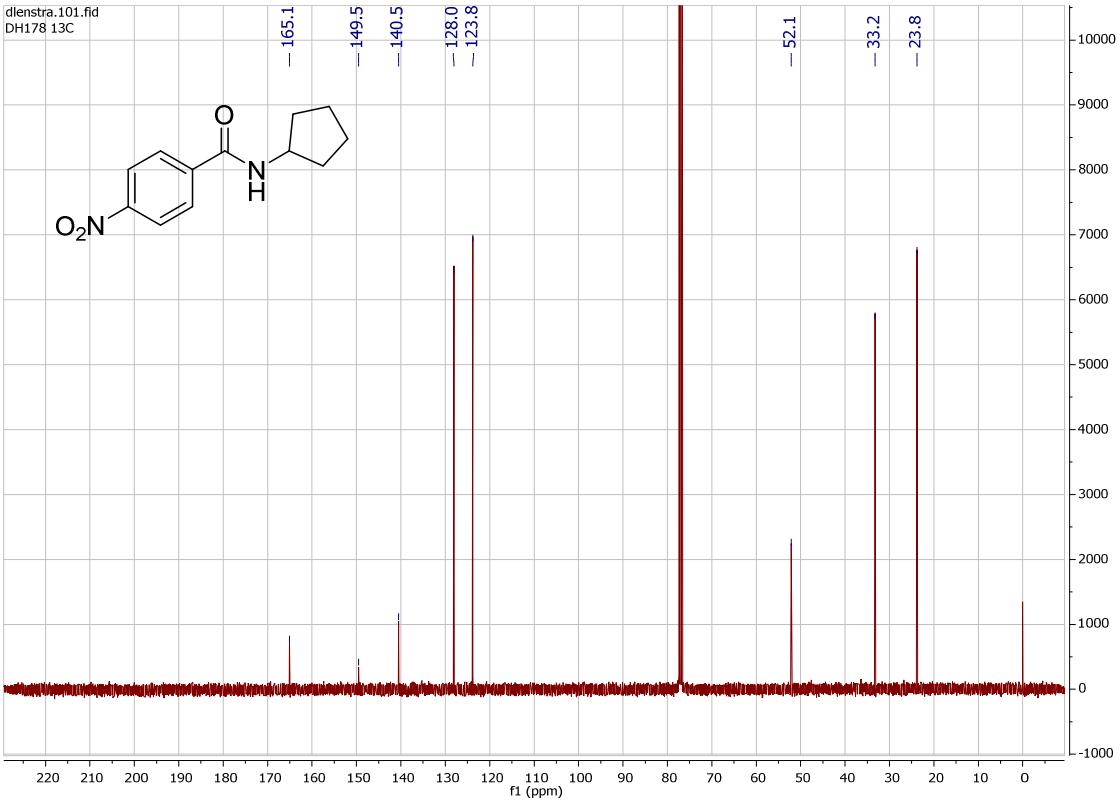
***N*-cyclobutyl-*p*-nitrobenzamide**



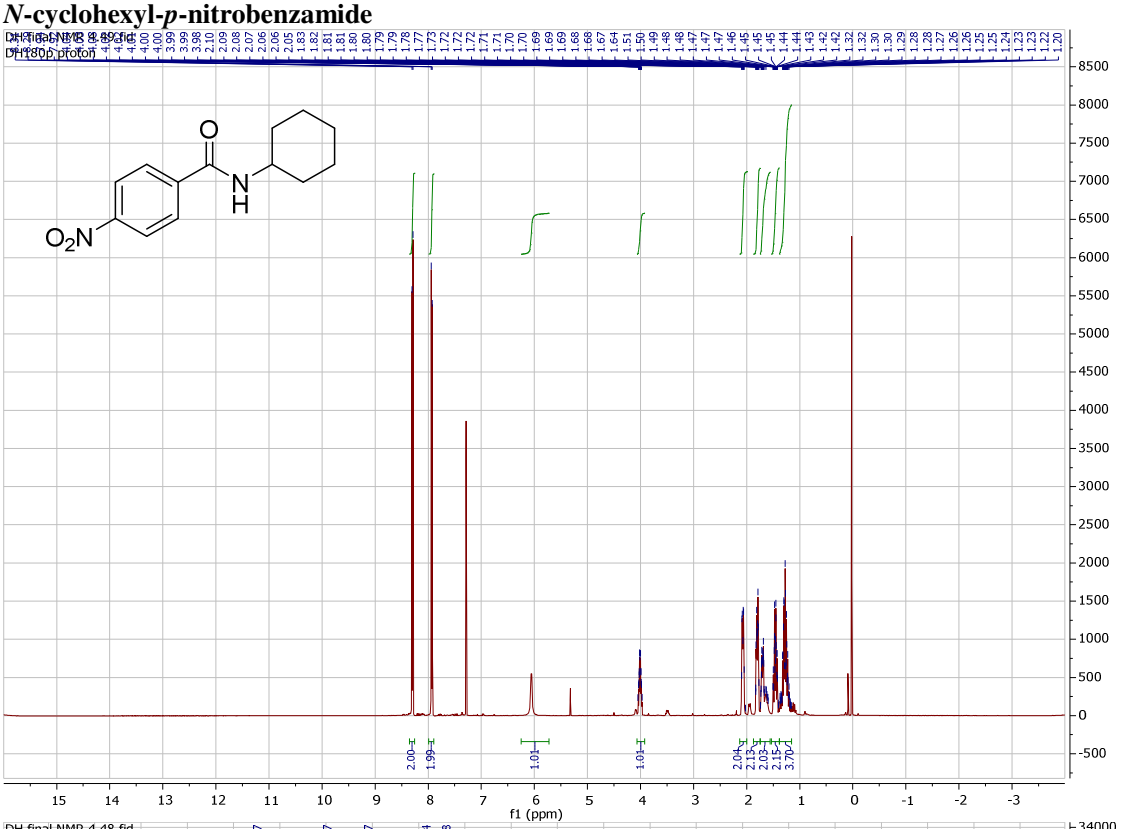


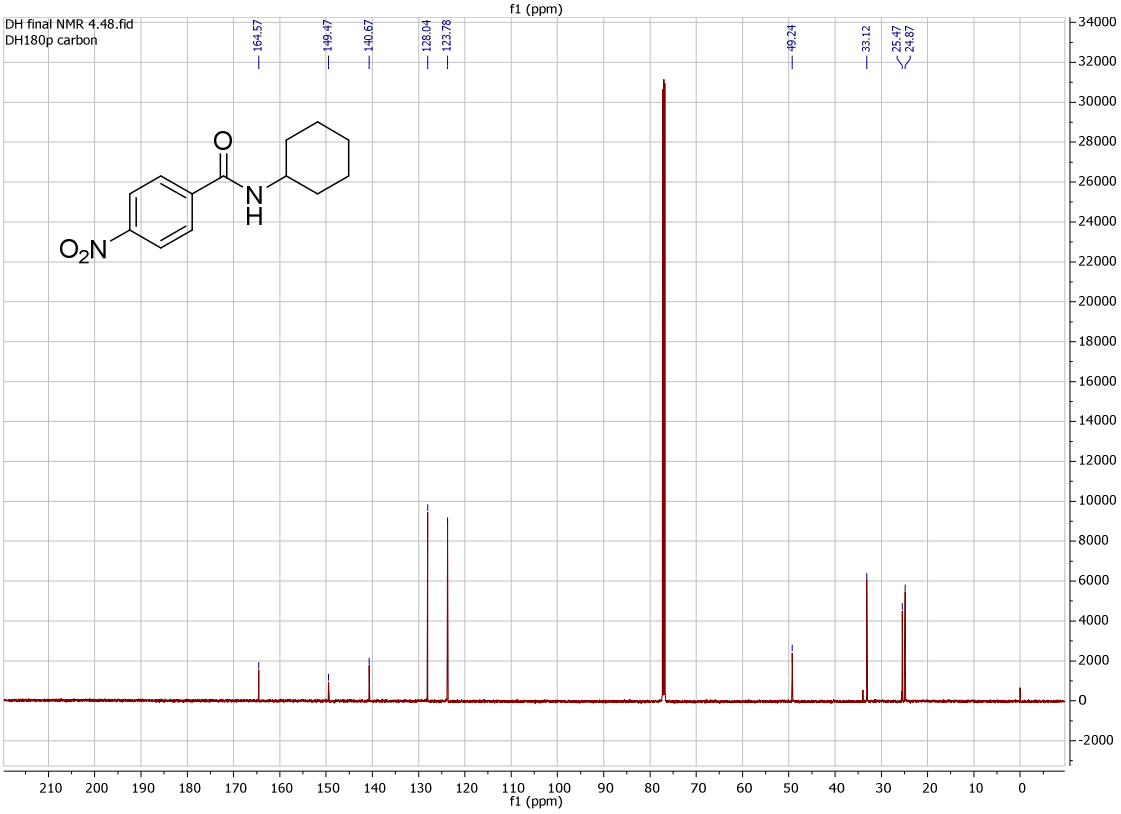
***N*-cyclopentyl-*p*-nitrobenzamide**



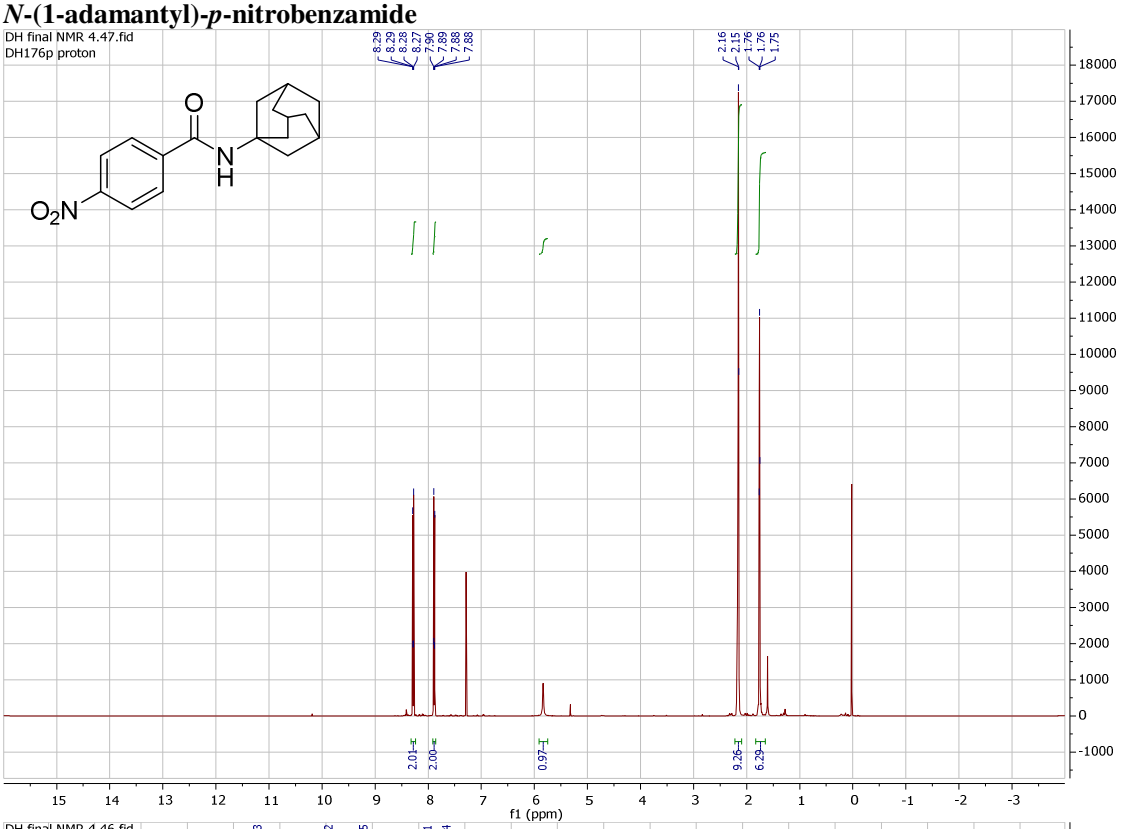


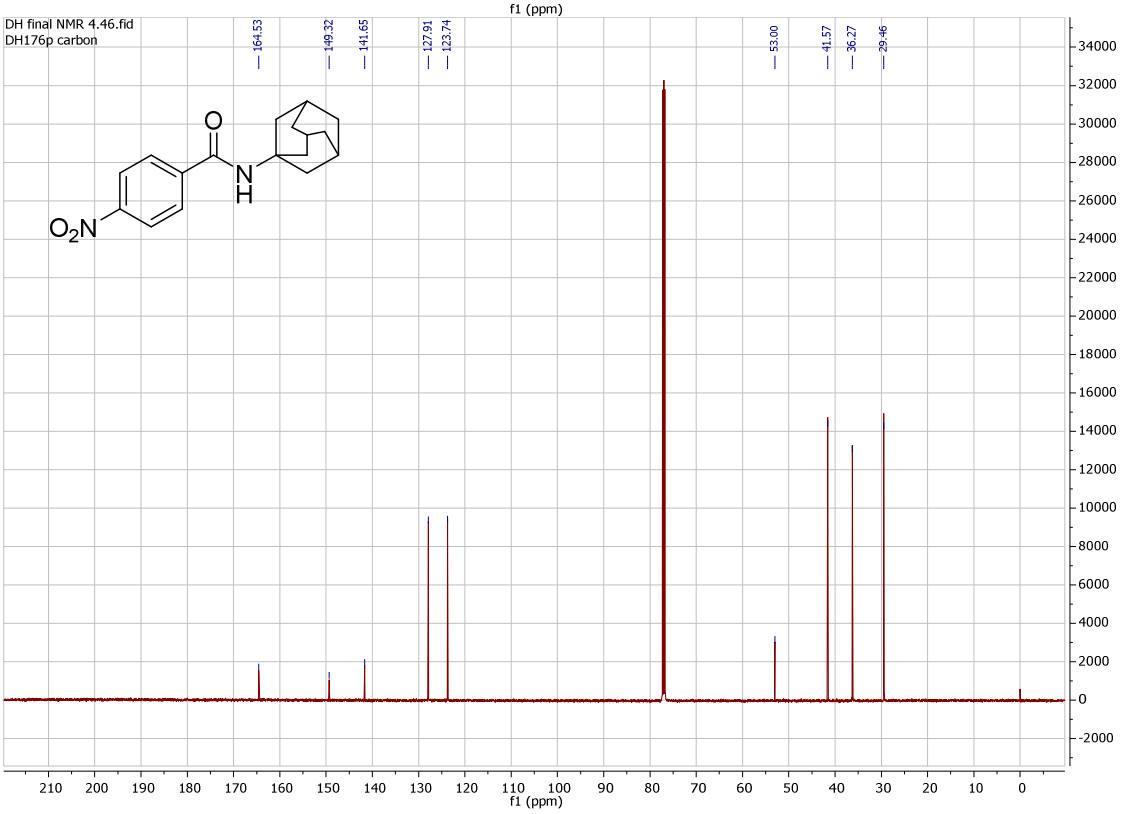
N-cyclohexyl-*p*-nitrobenzamide



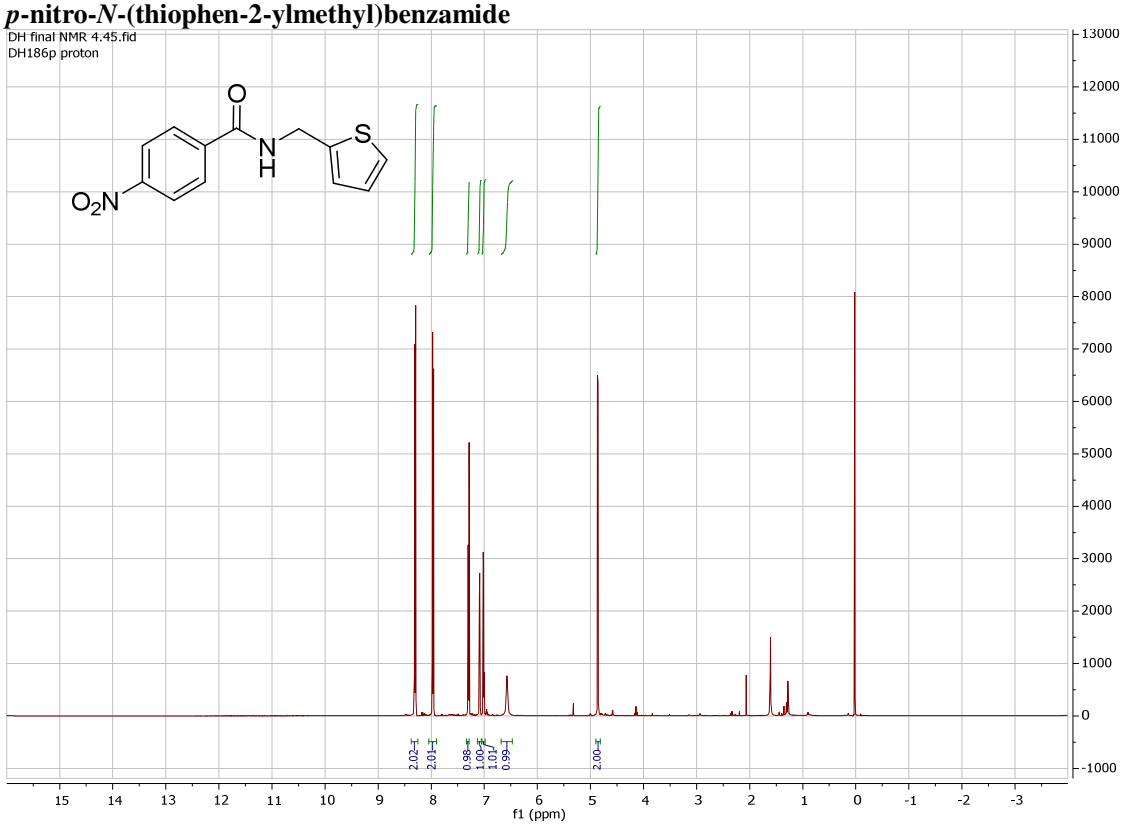


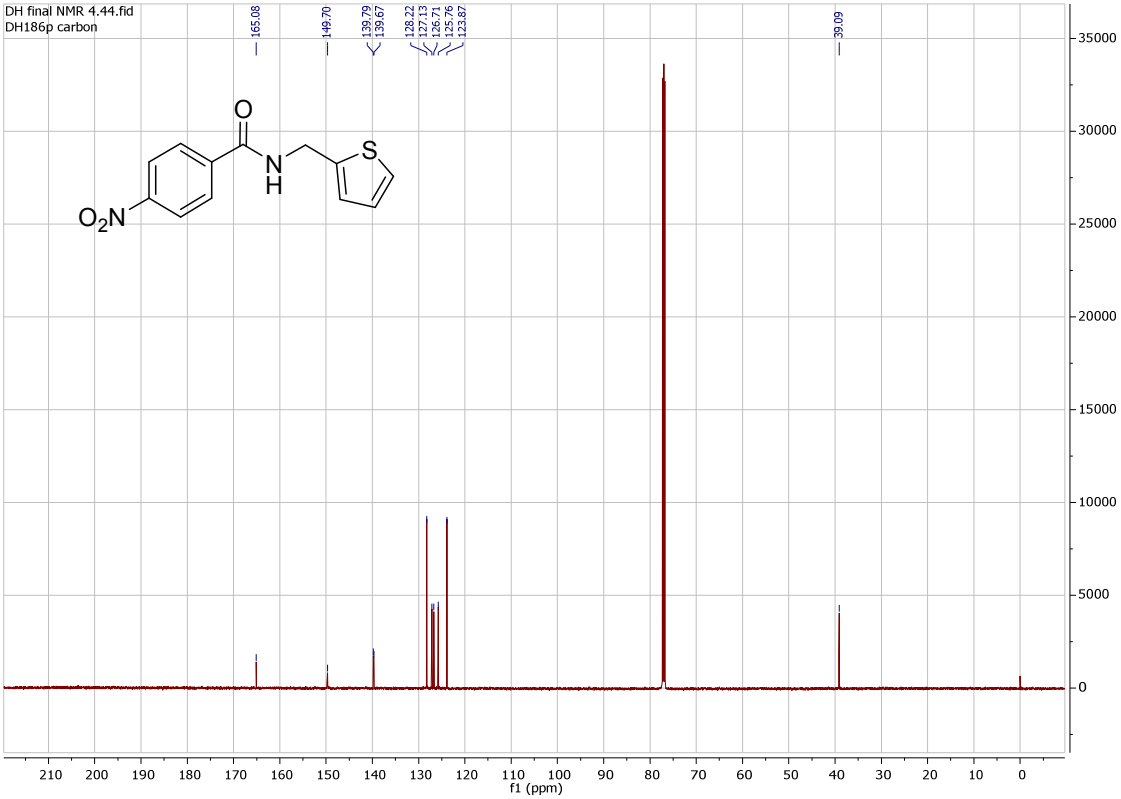
_N_-(1-adamantyl)-_p_-nitrobenzamide



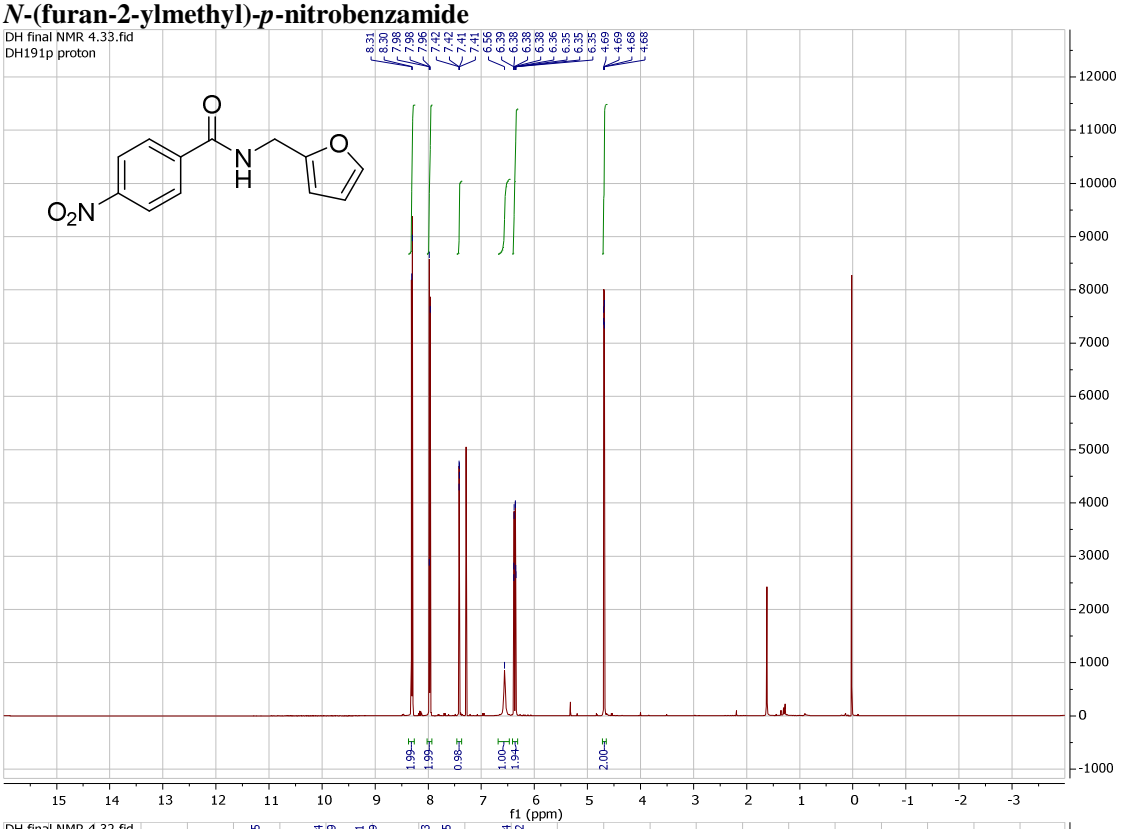


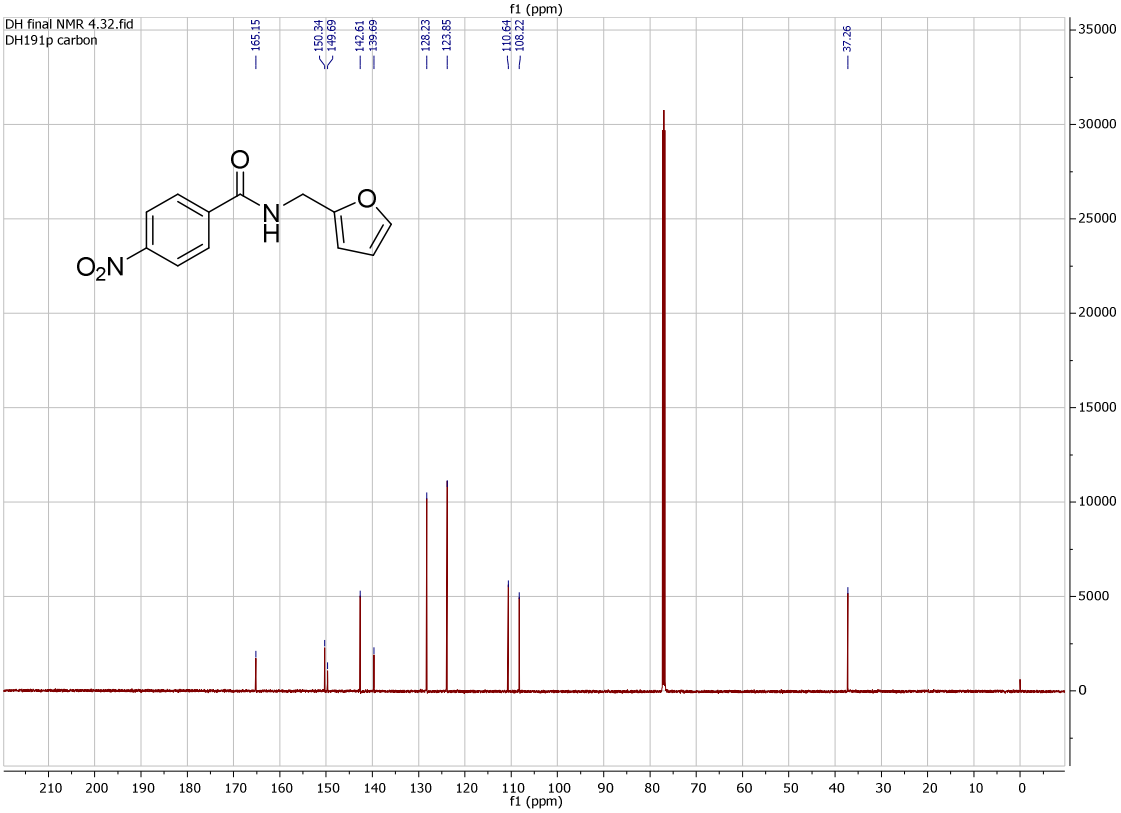
***p*-nitro-*N*-(thiophen-2-ylmethyl)benzamide**



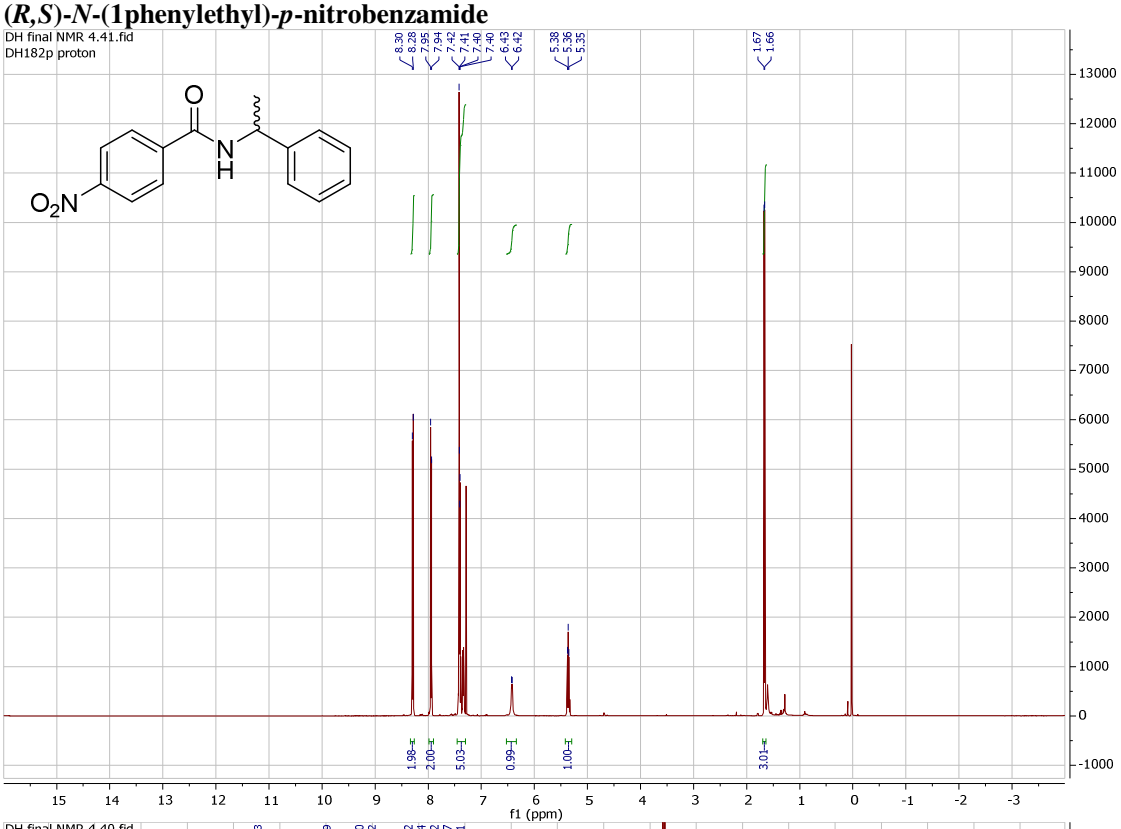


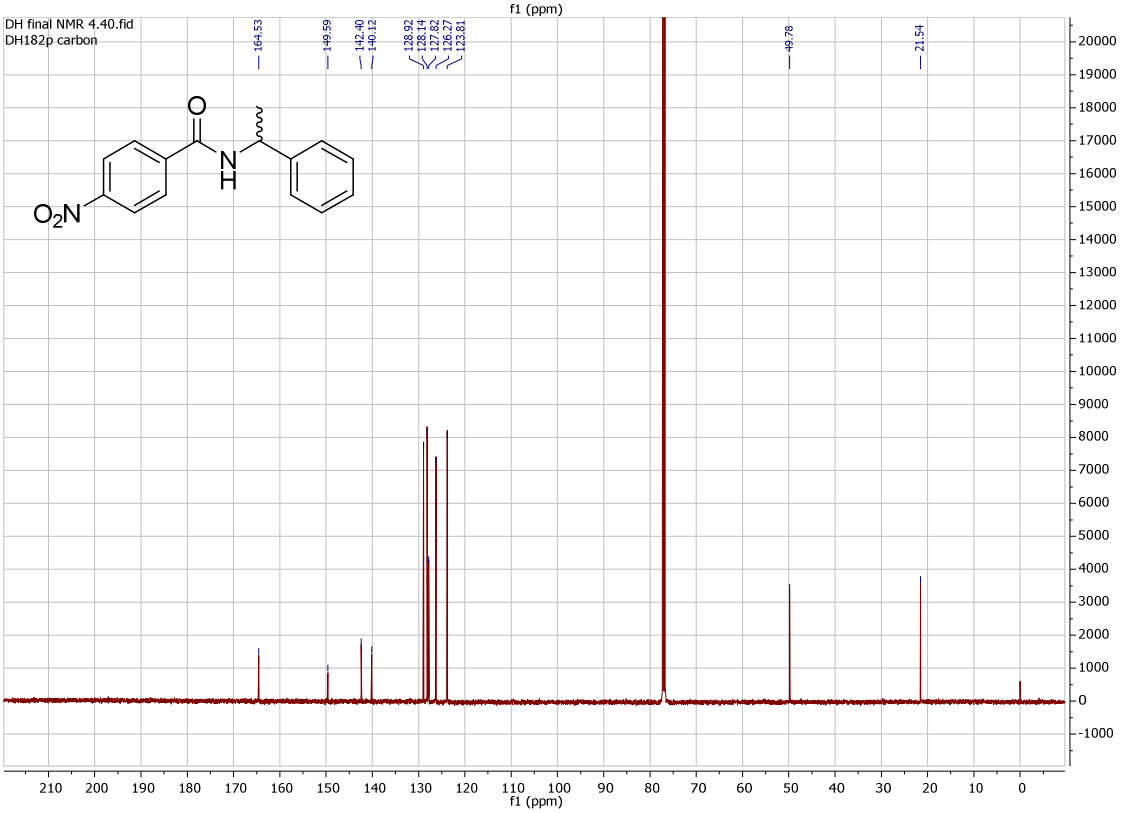
_N_-(furan-2-ylmethyl)-_p_-nitrobenzamide



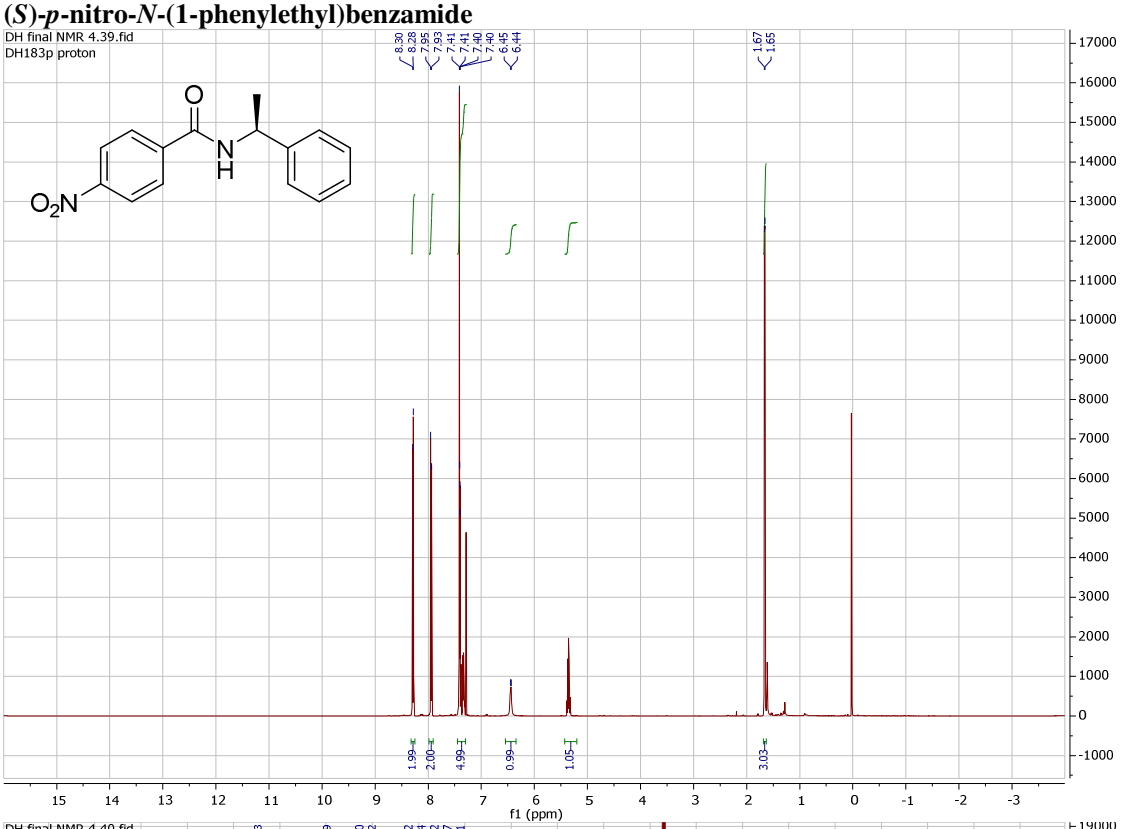


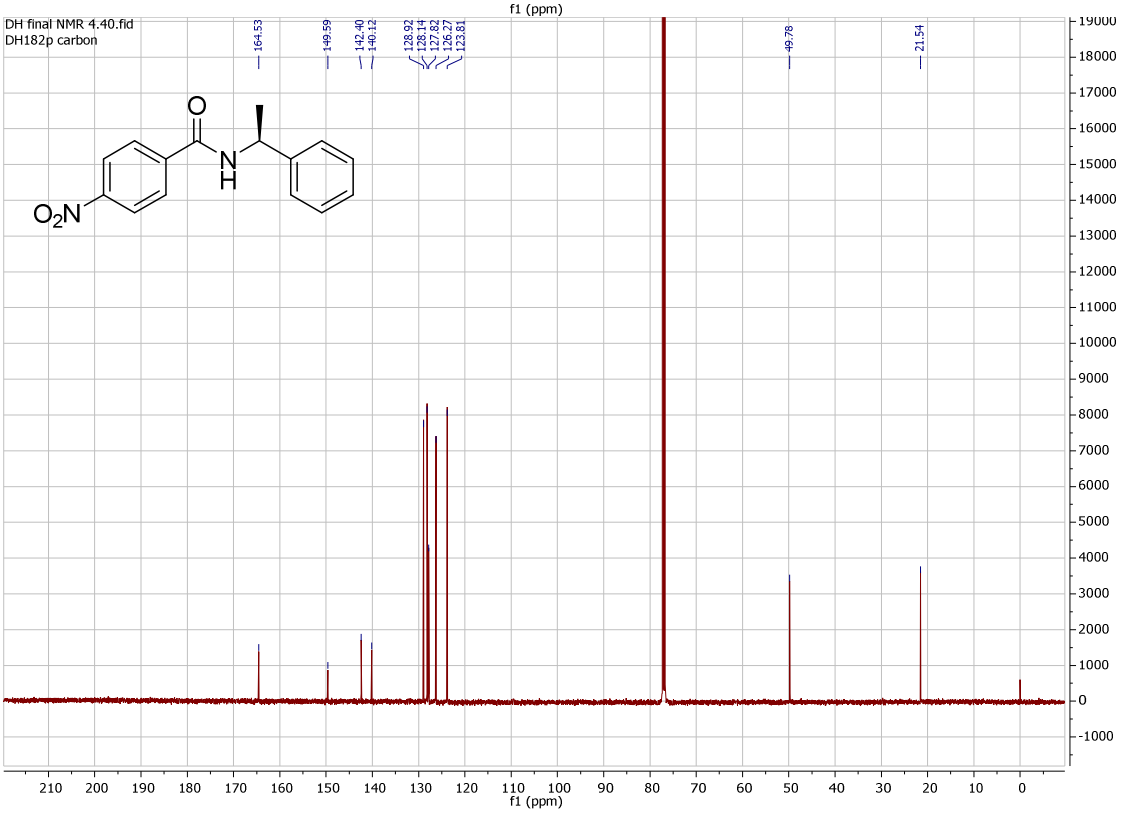
(*R*,*S*)-*N*-(1phenylethyl)-*p*-nitrobenzamide



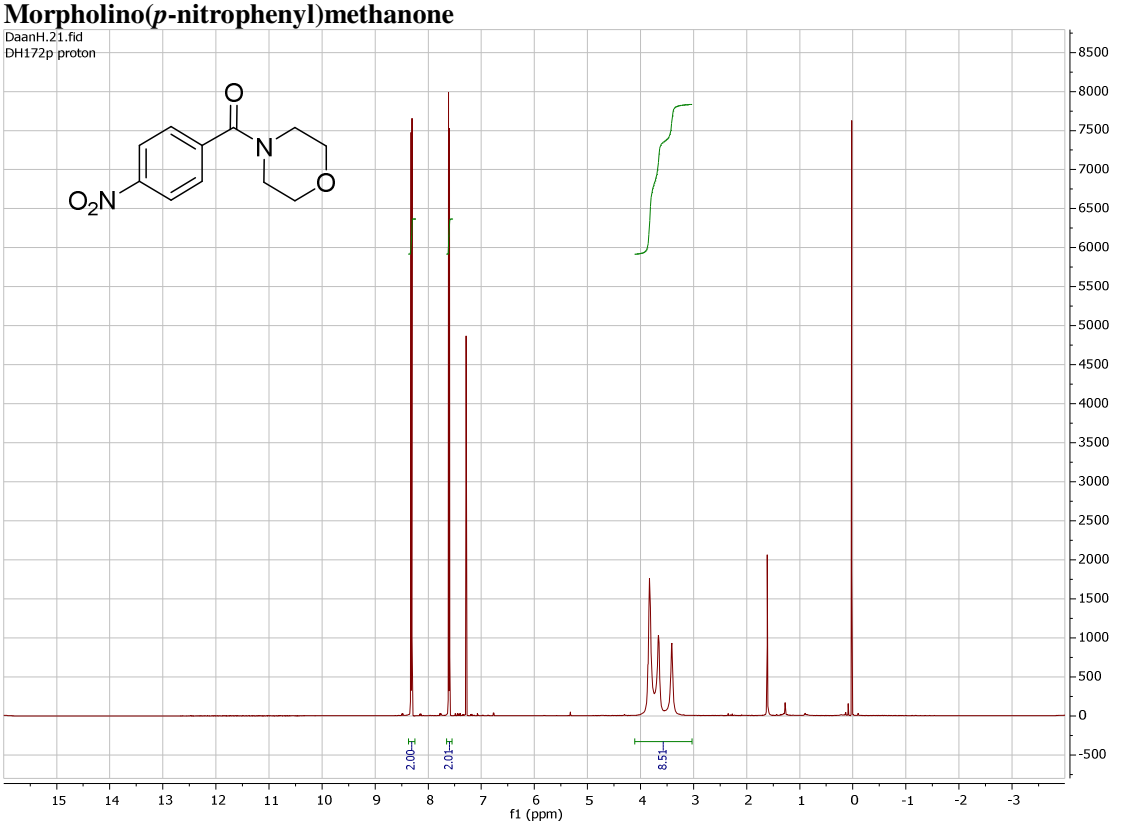


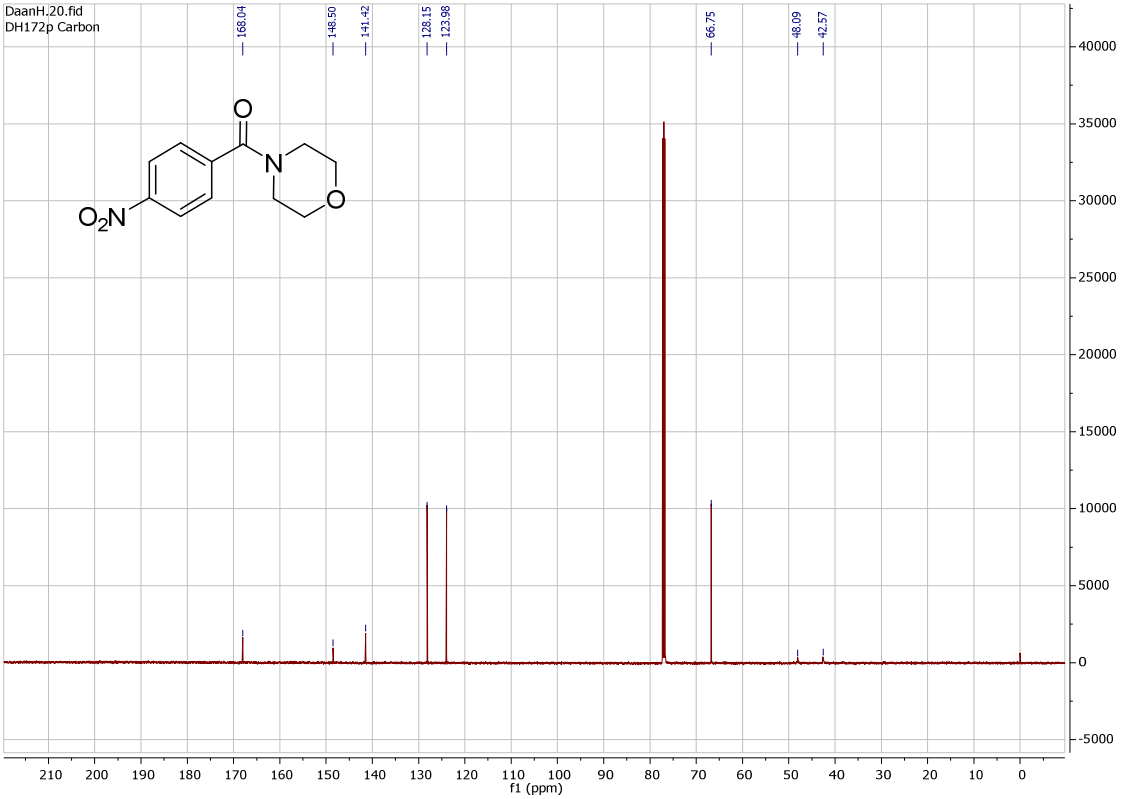
(*S*)-*p*-nitro-*N*-(1-phenylethyl)benzamide



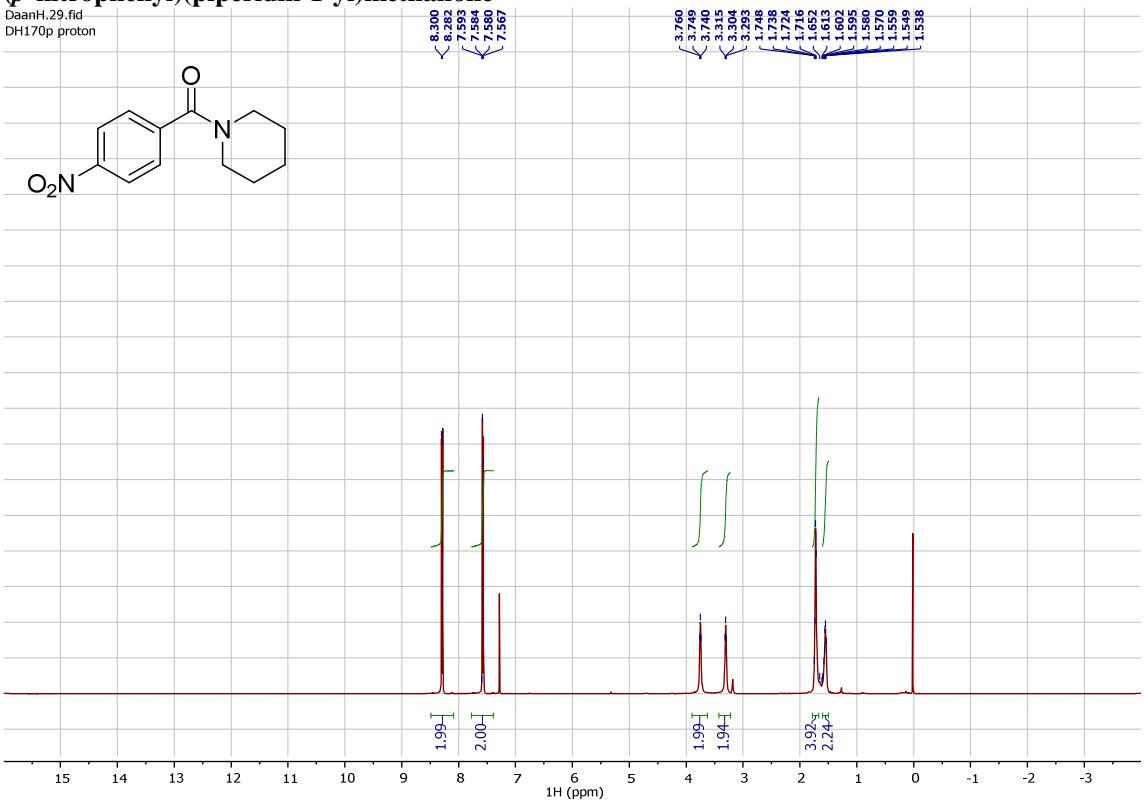


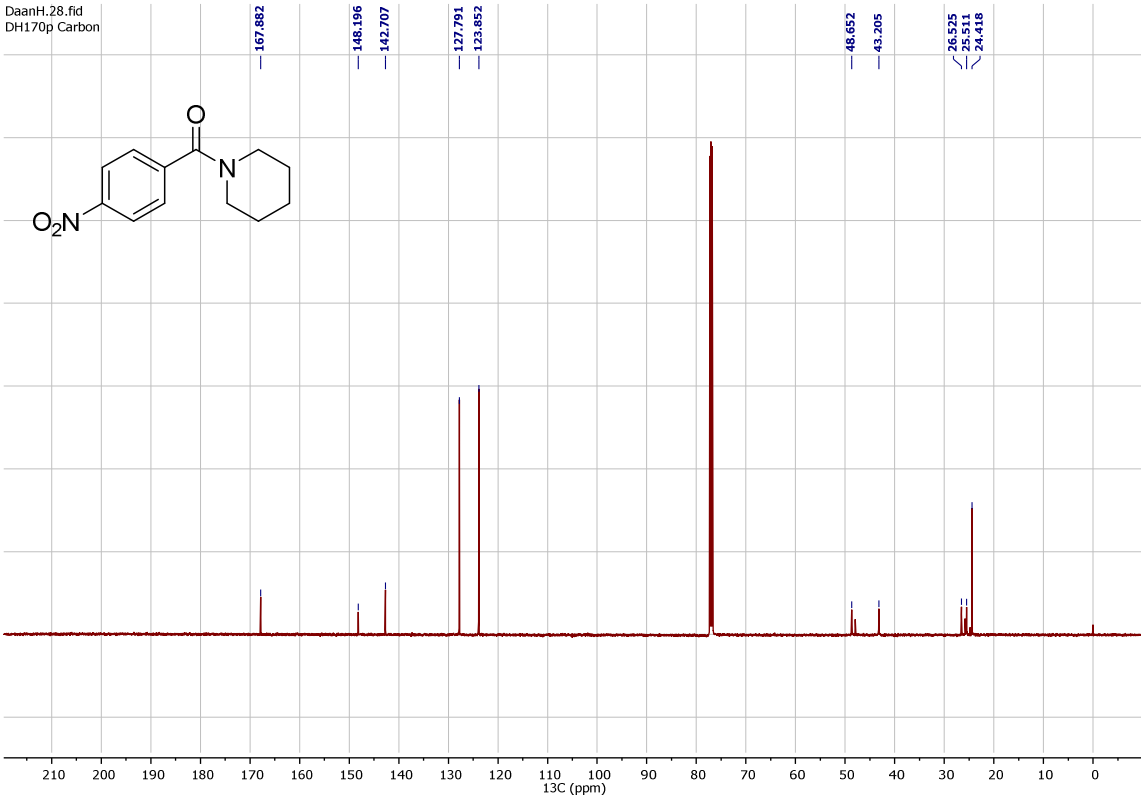
Morpholino(*p*-nitrophenyl)methanone



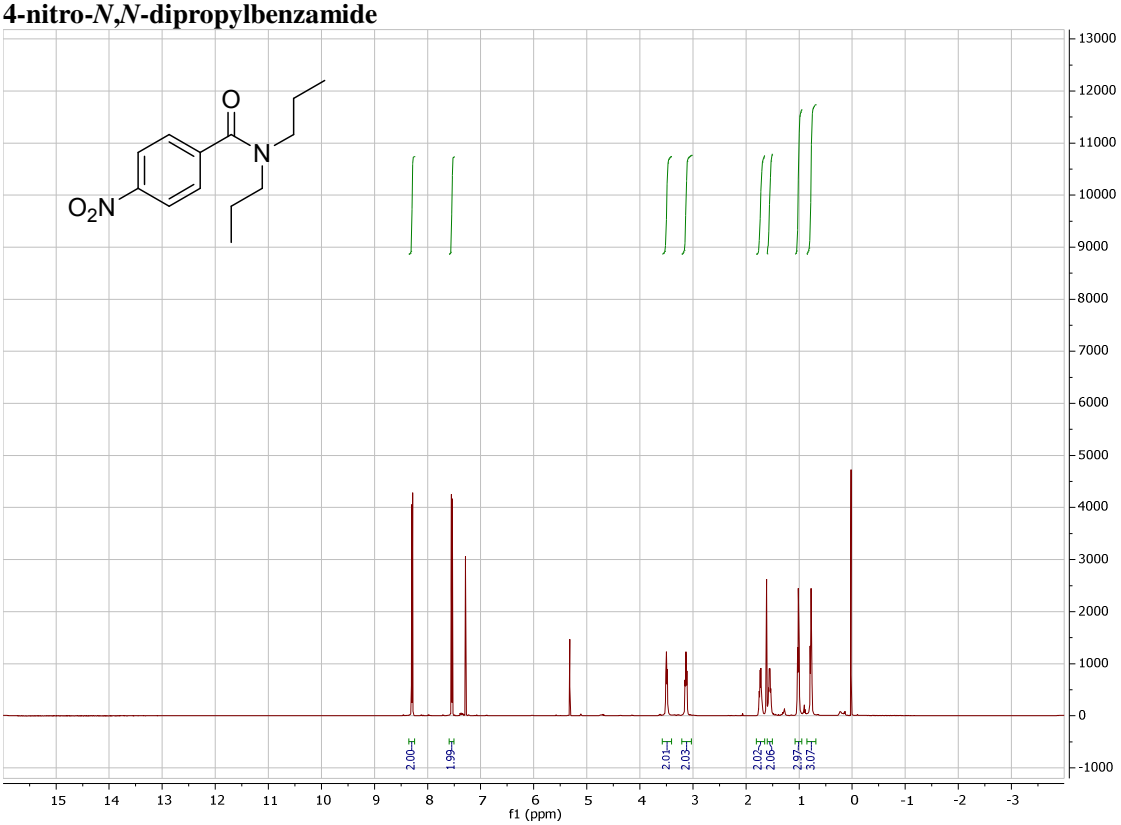


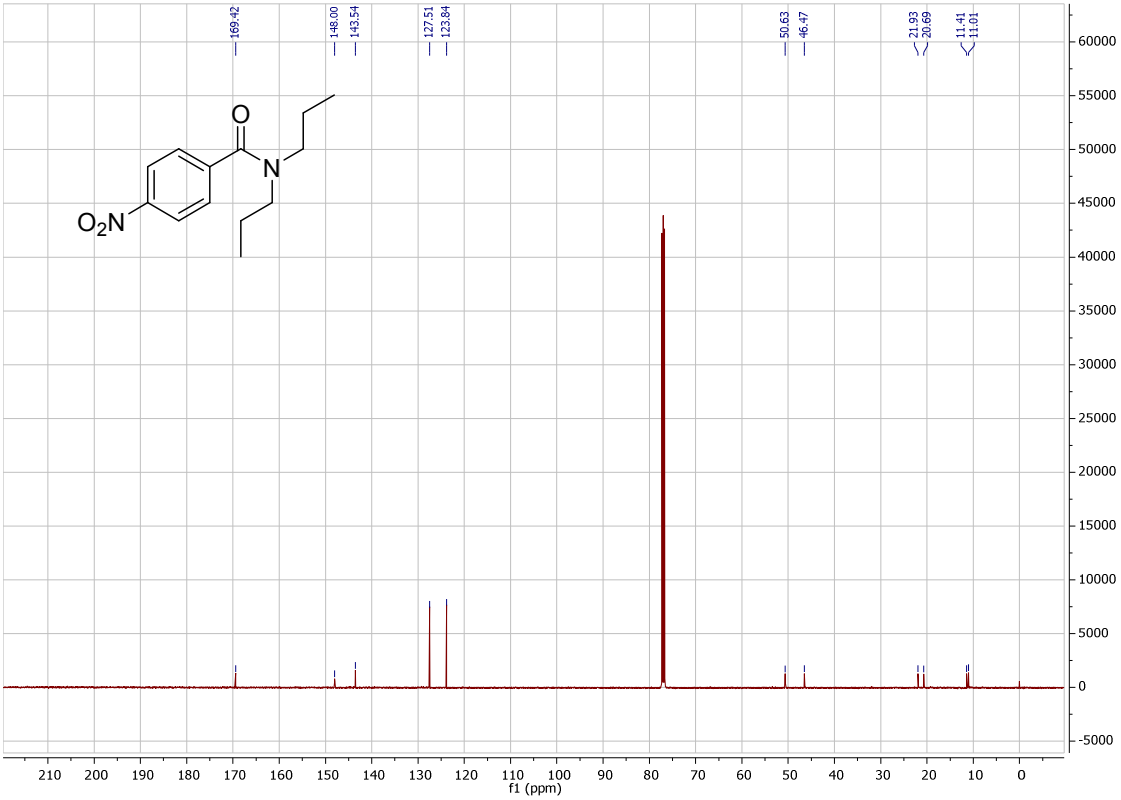
(*p*-nitrophenyl)(piperidin-1-yl)methanone



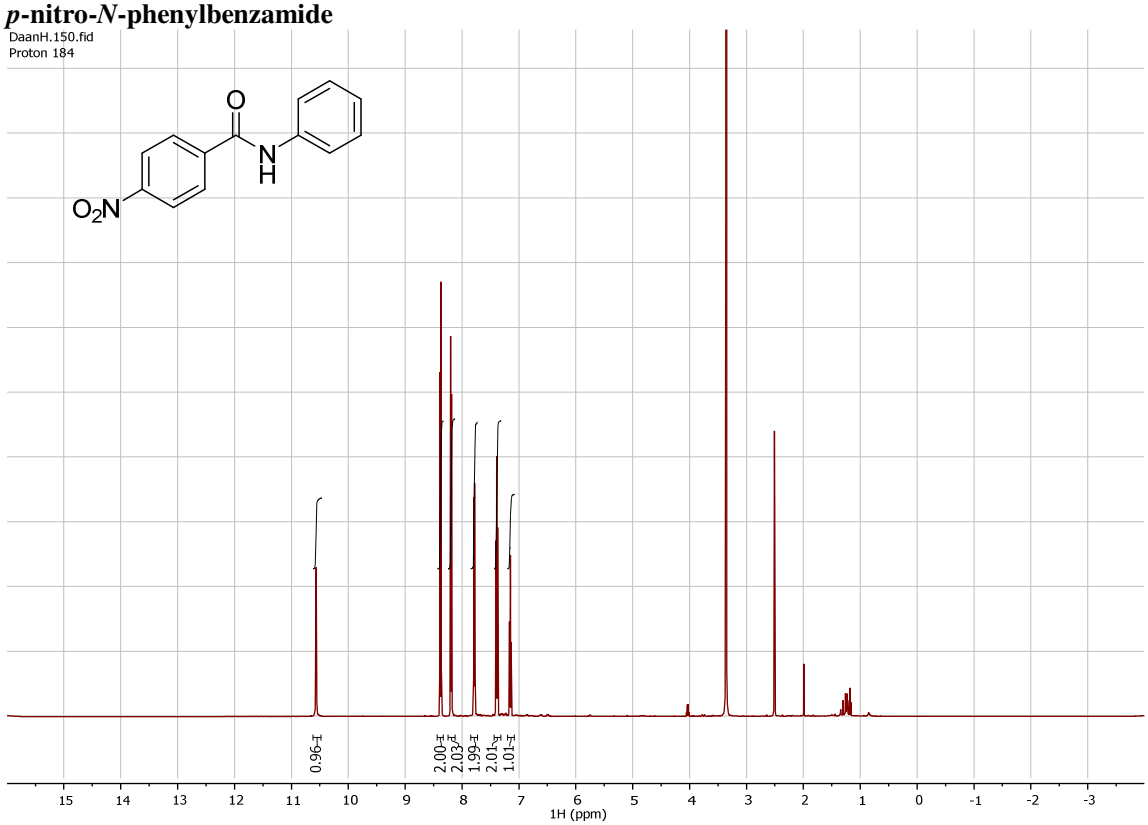


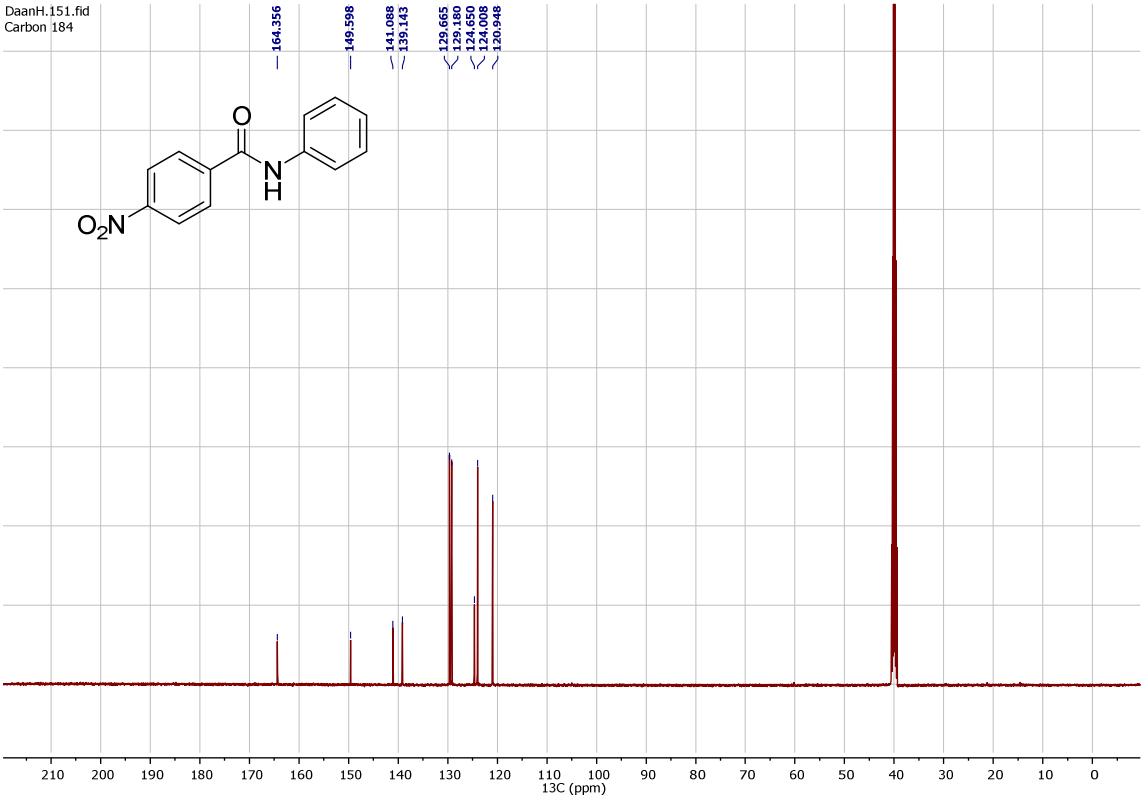
4-nitro-*N*,*N*-dipropylbenzamide



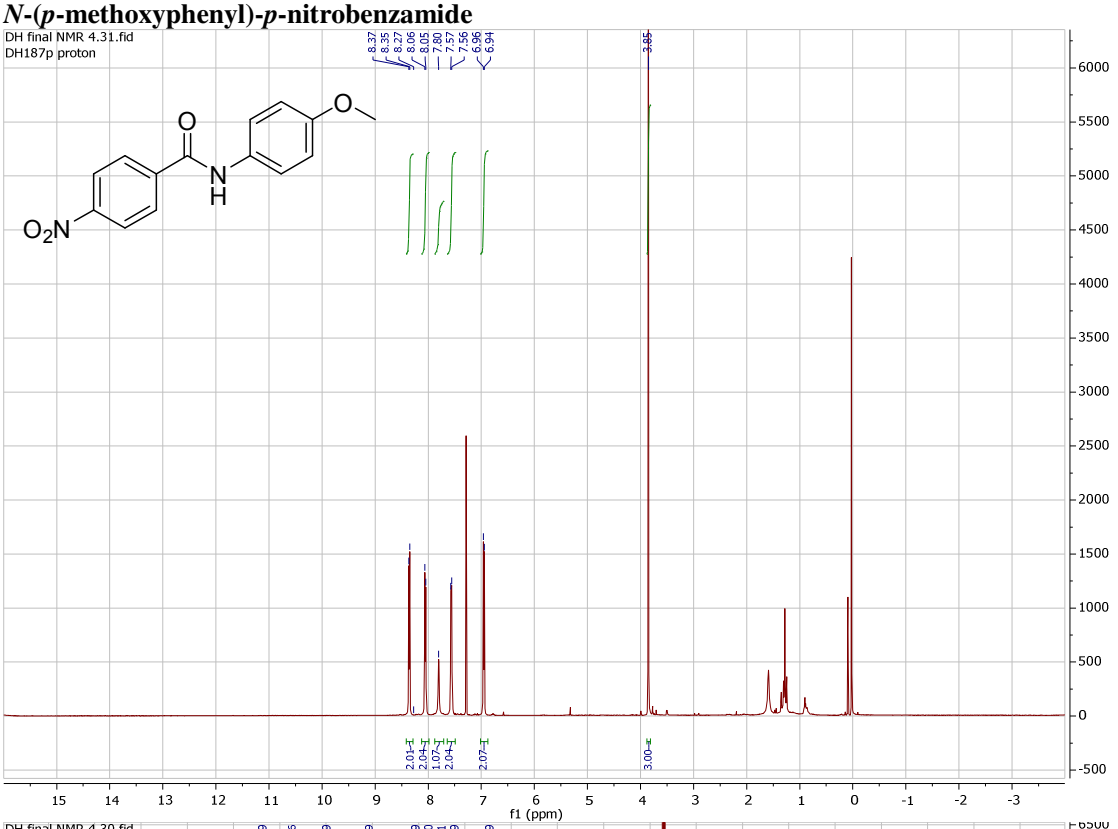


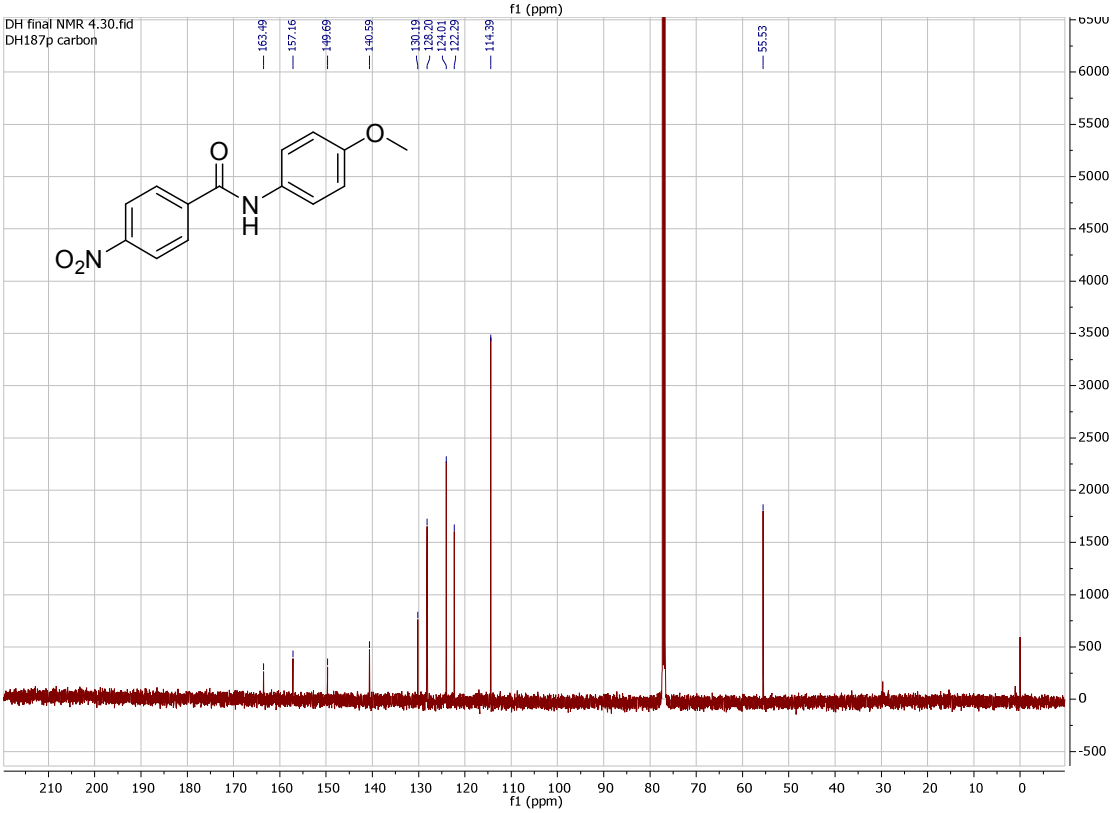
***p*-nitro-*N*-phenylbenzamide**





_N_-(_p_-methoxyphenyl)-_p_-nitrobenzamide





6. Chiral HPLC data

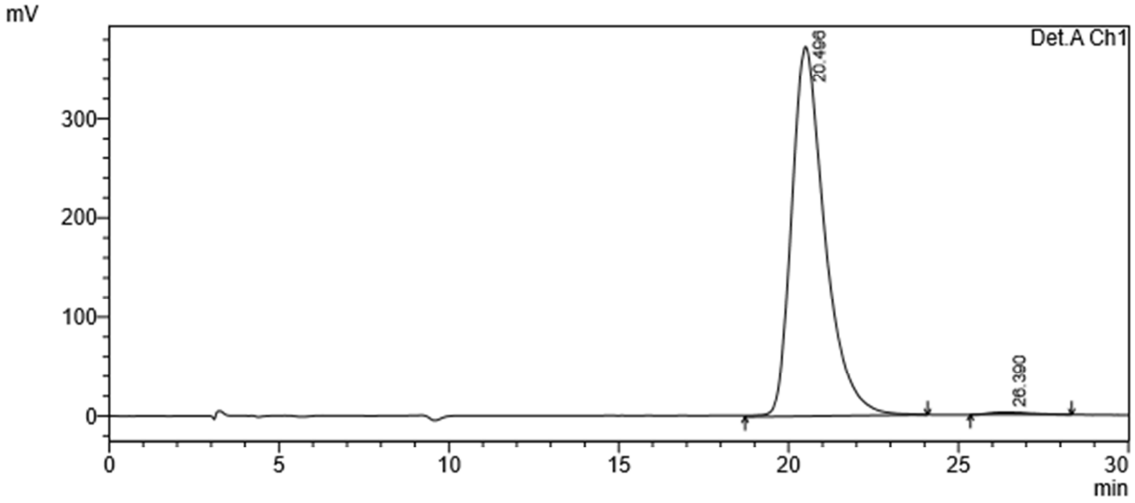


Figure S1 Chiral HPLC chromatogram of a enantiopure (*S*)-*p*-nitro-*N*-(1-phenylethyl)benzamide

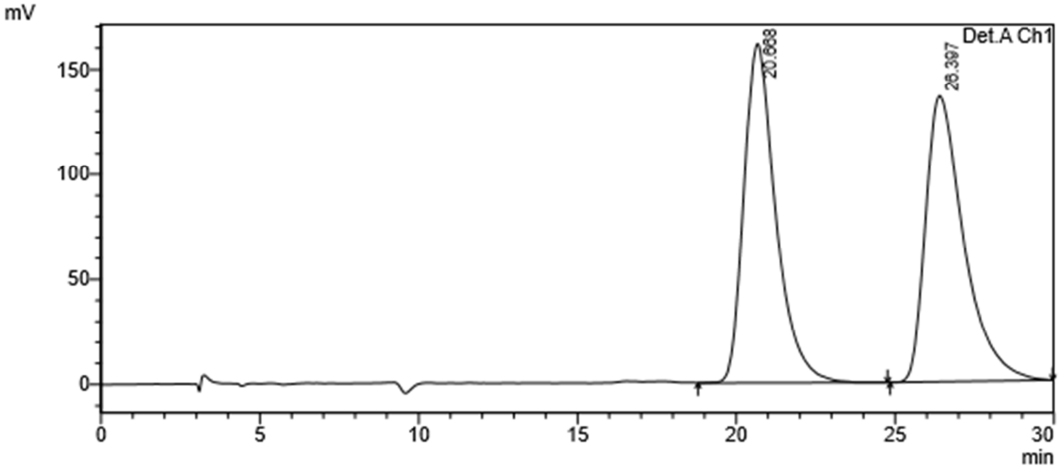


Figure S2 Chiral HPLC chromatogram of a racemic (*R*,*S*)-*p*-nitro-*N*-(1-phenylethyl)benzamide.

7. NMR investigation of phosphine oxide reduction by PMHS/bis(*p*-nitrophenyl) phosphate

^{1}H NMR spectra of the reduction of 3-methyl-1-phenyl-2-phospholene 1-oxide applying PMHS/bis(*p*-nitrophenyl) phosphate[a]

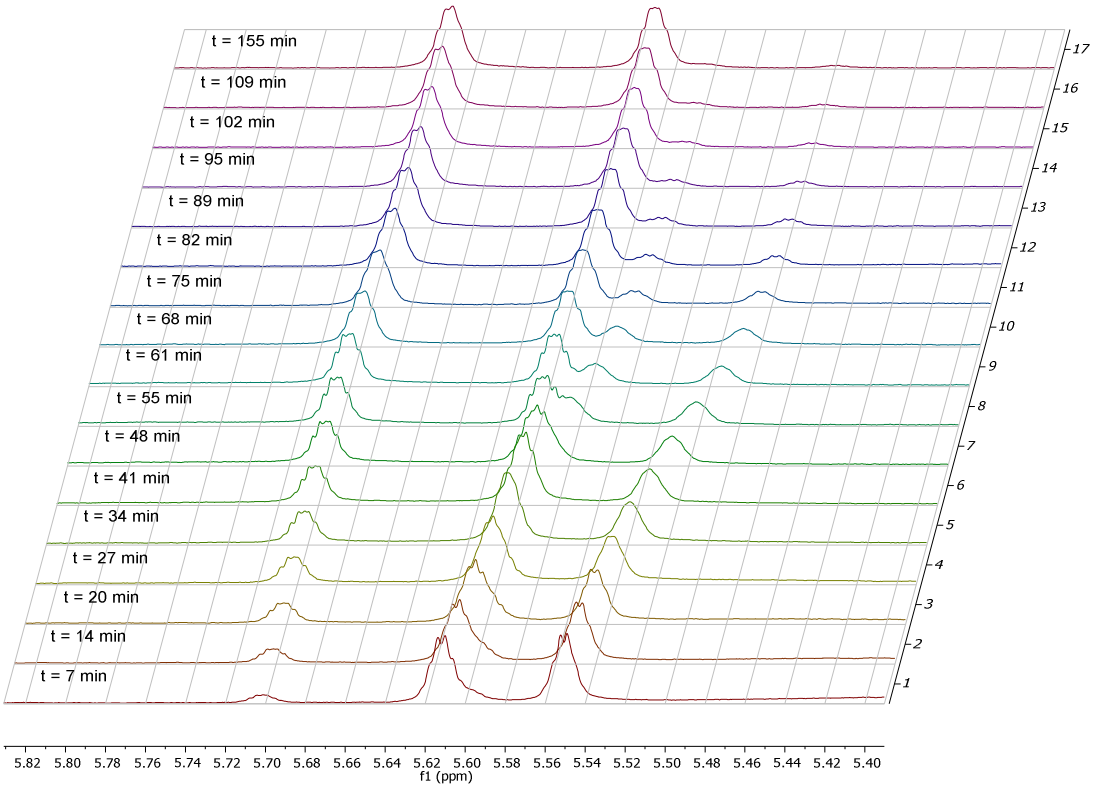


Figure S3 a) Conditions *in situ* VT NMR: 3-methyl-1-phenyl-2-phospholene 1-oxide (0.05 M), $PMHS_{2450}$ (0.048 M), bis(*p*-nitrophenyl) phosphate (0.01 M), toluene-d_8, 100 °C.

^{1}H NMR spectra (stacked) of the reduction of 3-methyl-1-phenyl-2-phospholene 1-oxide[a]

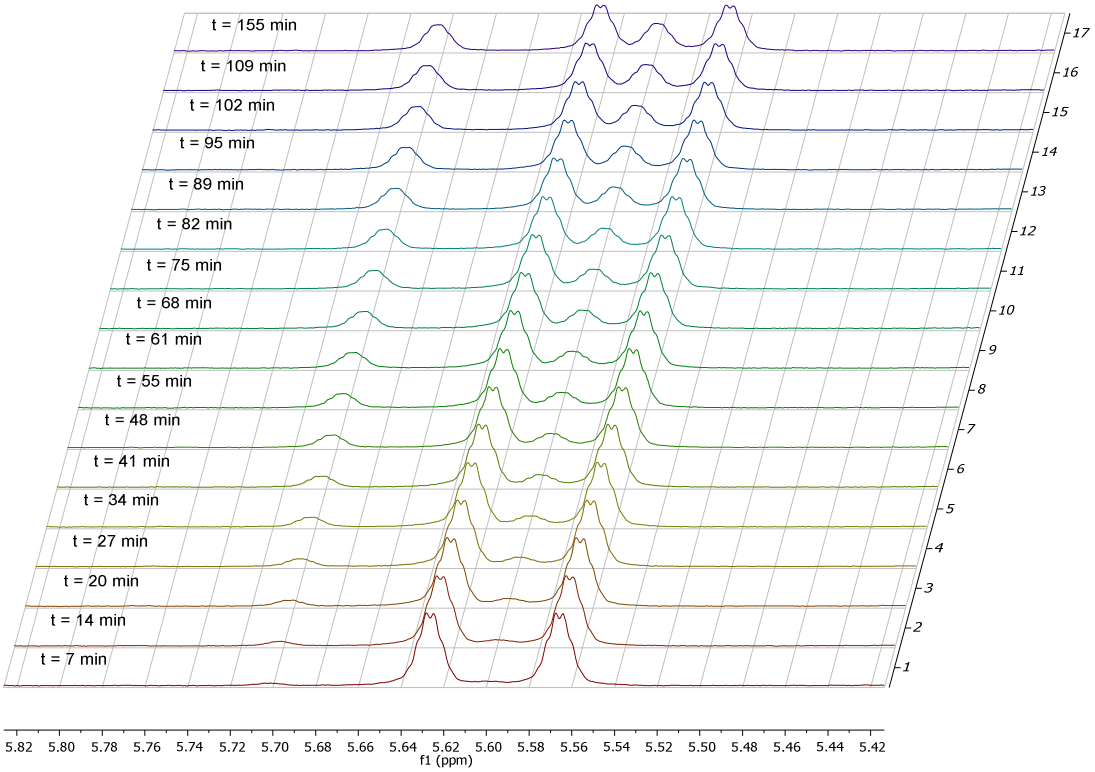


Figure S4 a) Conditions *in situ* VT NMR: 3-methyl-1-phenyl-2-phospholene 1-oxide (0.05 M), $PMHS_{2450}$ (0.048 M), toluene-d_8, 100 °C.

^{31}P NMR spectra for the reduction 3-methyl-1-phenyl-2-phospholene 1-oxide[a,b]

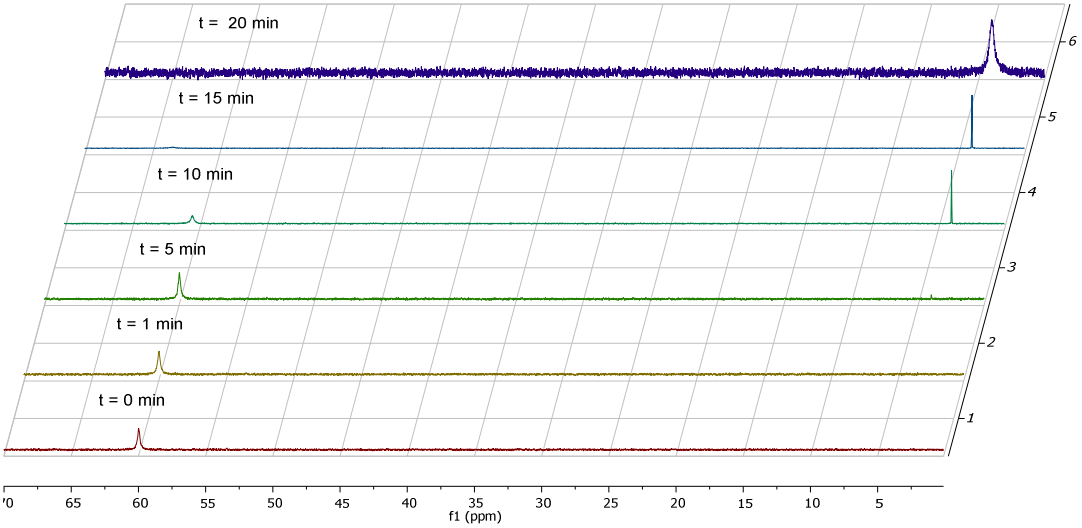


Figure S5 a) Conditions: 3-methyl-1-phenyl-2-phospholene 1-oxide (0.25 mmol), $PMHS_{2450}$ (0.24 mmol), bis(*p*-nitrophenyl) phosphate (0.050 mmol), 5 mL toluene, 110 °C. Aliquots were taken at the respective time points shown in the stacked spectra. b) Full consumption of 3-methyl-1-phenyl-2-phospholene 1-oxide (δ 60.0 ppm) was observed within 20 minutes. However, quantitative data could not be obtained due to insolubility of the corresponding phosphine (δ 4.0 ppm) at room temperature ^{31}P NMR experiments. Therefore; *in situ* VT NMR ^{1}H NMR was performed (See figure S3 and S4).

8. References

[1] D. C. Lenstra, F. P. J. T. Rutjes, J. Mecinovic, *Chem. Commun.* **2014**, *50*, 5763-5766.

[2] T. K. Achar, P. Mal, *J. Org. Chem.* **2015**, *80*, 666-672.

[3] A. Orliac, D. G. Pardo, A. Bombrun, J. Cossy, *Org. Lett.* **2013**, *15*, 902-905.

[4] R. A. Green, D. Pletcher, S. G. Leach, R. C. D. Brown, *Org. Lett.* **2016**, *18*, 1198-1201.

[5] D. G. Arias, F. E. Herrera, A. S. Garay, D. Rodrigues, P. S. Forastieri, L. E. Luna, M. D. L. M. Burgi, C. Prieto, A. A. Iglesias, R. M. Cravero, S. A. Guerrero, *Eur J Med Chem* **2017**, *125*, 1088-1097.

[6] P. Nordeman, L. R. Odell, M. Larhed, *J. Org. Chem.* **2012**, *77*, 11393-11398.

[7] G. Singh, R. Dada, S. Yaragorla, *Tetrahedron Lett.* **2016**, *57*, 4424-4427.

[8] R. Z. Fu, Y. Yang, J. Zhang, J. T. Shao, X. M. Xia, Y. S. Ma, R. X. Yuan, *Org. Biomol. Chem.* **2016**, *14*, 1784-1793.

[9] H. Yang, W. Hu, S. Deng, T. Wu, H. Cen, Y. Chen, D. Zhang, B. Wang, *New Journal of Chemistry* **2015**, *39*, 5912-5915.

[10] X. F. Guo, L. Tang, Y. Yang, Z. G. Zha, Z. Y. Wang, *Green Chem* **2014**, *16*, 2443-2447.

[11] A. F. Martins, J. F. Morfin, A. Kubickova, V. Kubicek, F. Buron, F. Suzenet, M. Salerno, A. N. Lazar, C. Duyckaerts, N. Arlicot, D. Guilloteau, C. F. G. C. Geraldes, E. Toth, *Acs Med Chem Lett* **2013**, *4*, 436-440.