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General Information

Reactions involving moisture sensitive reagents were carried out in flame-dried glassware under an inert atmosphere (N₂) using standard vacuum line techniques. Anhydrous solvents (CH₂Cl₂ and THF) were obtained after passing through an alumina column (Mbraun SPS-800) and MeCN was stored over activated molecular sieves. All other solvents and commercial reagents were used as received without further purification unless otherwise stated.

Room temperature (rt) refers to 20-25 °C. Temperatures of 0 °C for overnight reactions were obtained using an immersion cooler (HAAKE EK 90). Reaction involving heating were performed using DrySyn blocks and a contact thermocouple.

In vacuo refers to the use of either a Büchi Rotavapor R-200 with a Büchi V-491 heating bath and Büchi V-800 vacuum controller, a Büchi Rotavapor R-210 with a Büchi V-491 heating bath and Büchi V-850 vacuum controller, a Heidolph Laborota 4001 with vacuum controller, an IKA RV10 rotary evaporator with a IKA HB10 heating bath and ILMVAC vacuum controller, or an IKA RV10 rotary evaporator with a IKA HB10 heating bath and Vacuubrand CVC3000 vacuum controller. Rotary evaporator condensers are fitted to Julabo FL601 Recirculating Coolers filled with ethylene glycol and set to -5 °C.

Analytical thin layer chromatography was performed on pre-coated aluminium plates (Kieselgel 60 F254 silica) and visualization was achieved using ultraviolet light (254 nm) and/or staining with aqueous KMnO₄ solution followed by heating. Manual column chromatography was performed in glass columns fitted with porosity 3 sintered discs over Kieselgel 60 silica using the solvent system stated.

Melting points were recorded on an Electrothermal 9100 melting point apparatus. Optical rotations were measured on a Perkin Elmer Precisely/Model-341 polarimeter operating at the sodium D line with a 100 mm path cell at 20 °C.

HPLC analysis were obtained on either a Shimadzu HPLC consisting of a DGU-20A5 degassing unit, LC-20AT liquid chromatography pump, SIL-20AHT autosampler, CMB-20A communications bus module, SPD-M20A diode array detector and a CTO-20A column oven or a Shimadzu HPLC consisting of a DGU-20A5R degassing unit, LC-20AD liquid chromatography pump, SIL-20AHT autosampler, SPD-20A UV/Vis detector and a CTO-20A column oven. Separation was achieved using either a DAICEL CHIRALCEL OD-H column or DAICEL CHIRALPAK AD-H, IB, IC and ID columns using the method stated. HPLC traces of enantiomerically enriched compounds were compared with authentic racemic spectra.

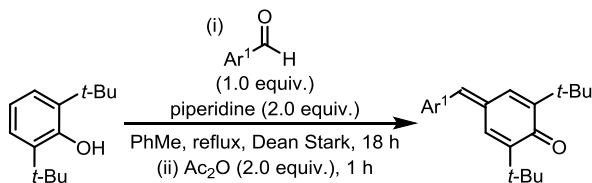
Infrared spectra were recorded on a Shimadzu IRAffinity-1 Fourier transform IR spectrophotometer fitted with a Specac Quest ATR accessory (diamond puck). Spectra were recorded of either thin films or solids, with characteristic absorption wavenumbers (ν_{\max}) reported in cm^{-1} .

^1H , $^{13}\text{C}\{^1\text{H}\}$ and $^{19}\text{F}\{^1\text{H}\}$ NMR spectra were acquired on either a Bruker AV400 with a BBFO probe (^1H 400 MHz; $^{13}\text{C}\{^1\text{H}\}$ 101 MHz; $^{19}\text{F}\{^1\text{H}\}$ 376 MHz), a Bruker AVII 400 with a BBFO probe (^1H 400 MHz; $^{13}\text{C}\{^1\text{H}\}$ 101 MHz; $^{19}\text{F}\{^1\text{H}\}$ 376 MHz), a Bruker AVIII-HD 500 with a SmartProbe BBFO+ probe (^1H 500 MHz, $^{13}\text{C}\{^1\text{H}\}$ 126 MHz) or a Bruker AVIII 500 with a CryoProbe Prodigy BBO probe (^1H 500 MHz, $^{13}\text{C}\{^1\text{H}\}$ 126 MHz), in the deuterated solvent stated. All chemical shifts are quoted in parts per million (ppm) relative to the residual solvent peak. All coupling constants, J , are quoted in Hz. Multiplicities are indicated as s (singlet), d (doublet), t (triplet), q (quartet), m (multiplet), and multiples thereof. The abbreviation Ar denotes aromatic. NMR peak assignments were confirmed using 2D ^1H correlated spectroscopy (COSY), 2D ^1H – ^{13}C heteronuclear multiple-bond correlation spectroscopy (HMBC), and 2D ^1H – ^{13}C heteronuclear single quantum coherence spectroscopy (HSQC) where necessary.

Mass spectrometry (m/z) data were acquired by either electrospray ionization (ESI), nanospray ionization (NSI) or atmospheric solids analysis probe (ASAP) at either the University of St Andrews Mass Spectrometry Facility, at the EPSRC UK National Mass Spectrometry Facility at Swansea University or at AstraZeneca in Cambridge. Waters Xevo Qtof with Acquity BSM/SM/PDA/CM or Thermo Orbitrap Mass Spectrometer with Accela pump and Thermo CTC and Surveyor PDA+ were used at AstraZeneca. 5 or 10 μL of the sample were injected into a Waters CSH C18 1.7 μm 50 \times 2.1 (at 45 $^{\circ}\text{C}$) column using 0.1% aqueous formic acid and 0.1% formic acid in methanol gradients.

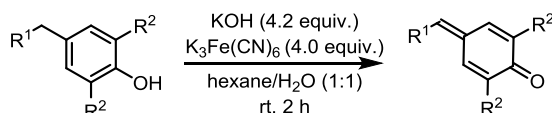
General Procedures

General Procedure A: Preparation of 2,6-di-*tert*-butyl *para*-quinone methides



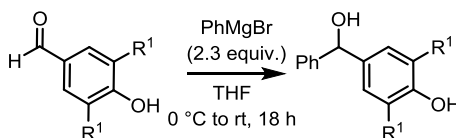
Following a literature procedure,^[1] a solution of 2,6-di-*tert*-butylphenol (1.0 equiv.) and the requisite aldehyde (1.0 equiv.) in PhMe was heated to reflux in a Dean-Stark apparatus. Piperidine (2.0 equiv.) was added dropwise within 1 h. The reaction mixture was continued to reflux for 18 h before cooling the reaction mixture to below the boiling point. Acetic anhydride (2.0 equiv.) was added and stirring was continued for 1 h before the reaction mixture was poured on ice-water and extracted with EtOAc ($\times 3$). The combined organic layers were dried over anhydrous Na₂SO₄, and the filtrate concentrated *in vacuo*. The crude material was purified by flash silica column chromatography to give the desired 2,6-di-*tert*-butyl *para*-quinone methide.

General Procedure B: Preparation of *para*-quinone methides from 4-benzylphenols



Following a literature procedure,^[1] the requisite 4-benzylphenol (1.0 equiv.), KOH (4.2 equiv.) and K₃Fe(CN)₆ (4.0 equiv.) in hexane/H₂O (1:1) was vigorously stirred for 2 h at rt before being diluted with EtOAc ($\times 1$) and washed with distilled water ($\times 4$). The combined organic layers were dried over anhydrous Na₂SO₄, and the filtrate concentrated *in vacuo*. The crude material was purified by flash silica column chromatography to give the desired *para*-quinone methide.

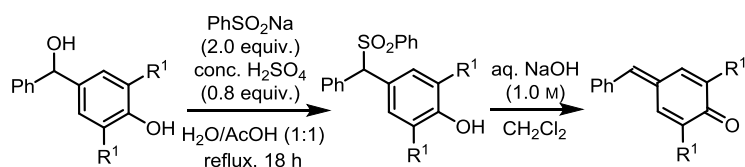
General Procedure C: Preparation of 4-hydroxy(phenyl)methylphenols



Following a literature procedure,^[2] in a flame-dried two-neck round bottom flask under N₂ was added the requisite aldehyde (1.0 equiv.) and anhydrous THF. The solution was cooled

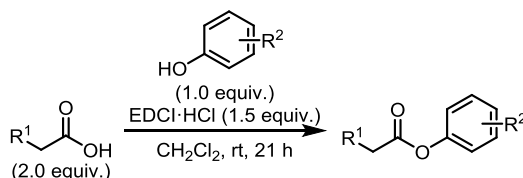
to 0 °C before the dropwise addition of PhMgBr (2.3 equiv., 3.0 M in THF). The reaction mixture was warmed to rt and stirred for 18 h before being quenched with saturated aqueous NH₄Cl at 0 °C. The aqueous layer was extracted with EtOAc (× 3) and the combined organic layers were dried over anhydrous Na₂SO₄, and the filtrate concentrated *in vacuo*. The crude material was purified by flash silica column chromatography or recrystallization to give the desired 4-hydroxy(phenyl)methylphenol.

General Procedure D: Preparation of 2,6-disubstituted *para*-quinone methides *via* sulfones

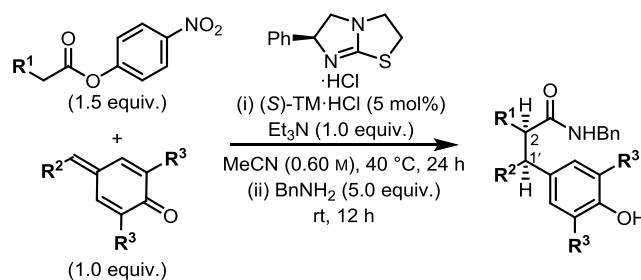


Following a literature procedure,^[2] conc. H₂SO₄ (0.8 equiv.) was added to a solution of the requisite 4-hydroxy(phenyl)methylphenol (1.0 equiv.) and PhSO₂Na (2.0 equiv.) in H₂O/AcOH (1:1). The reaction mixture was heated to 100 °C for 18 h before being cooled down to rt. The resulting precipitate upon addition of distilled water was filtered and the solid dried under high vacuum to give the desired sulfone. The sulfone (1.0 equiv.) was dissolved in CH₂Cl₂ (× 1) and shaken with aqueous 1 M NaOH. The organic layer and the aqueous layer washed with CH₂Cl₂ (× 2). The combined organic layers were dried over anhydrous Na₂SO₄, and the filtrate concentrated *in vacuo*. The crude material was purified by flash silica column chromatography to give the desired 2,6-disubstituted *para*-quinone methide.

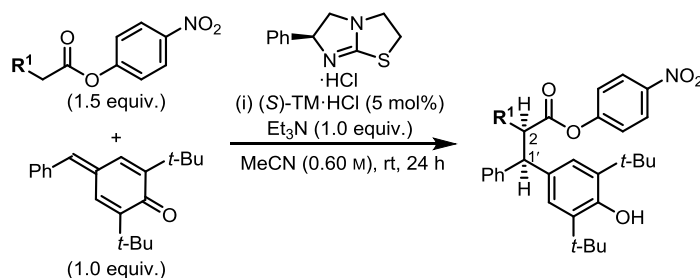
General Procedure E: Preparation of activated aryl esters



The requisite aryl/alkenyl/alkyl acetic acid (2.0 equiv.) and *N*-(3-dimethylaminopropyl)-*N'*-ethylcarbodiimide hydrochloride, EDCI·HCl (1.5 equiv.) were dissolved in CH₂Cl₂ and allowed to stir at rt for 5 min before the addition of the requisite phenol (1.0 equiv.). The reaction mixture was stirred at rt for 21 h before being diluted with CH₂Cl₂ (× 1) and washed with saturated, aqueous NaHCO₃ (× 2). The organic layer was extracted, dried over MgSO₄ and the filtrate concentrated *in vacuo*. The crude material was purified by flash silica column chromatography to give the desired activated aryl ester.

General Procedure F: Isothiourea catalysis to give amide products

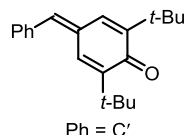
In a flame-dried vial was added the requisite *para*-quinone methide (1.0 equiv.), aryl ester (1.5 equiv.), (S)-TM·HCl (5 mol%), Et₃N (1.0 equiv.) and anhydrous MeCN (0.6 M) and was stirred at rt for 24 h. The reaction was then quenched with benzylamine (5.0 equiv.) and stirred at rt for a further 12 h before being concentrated *in vacuo*. The residue was diluted with EtOAc (20 mL) and washed successively with 10% citric acid (20 mL × 1), aqueous NaOH (20 mL × 3) and brine (20 mL × 1). The organic layer was extracted, dried over MgSO₄ and the filtrate concentrated *in vacuo*. The crude material was purified by flash silica column chromatography to give the desired product.

General Procedure G: Isothiourea catalysis to give PNP ester products

In a flame-dried vial was added the requisite *para*-quinone methide (1.0 equiv.), aryl ester (1.5 equiv.), (S)-TM·HCl (5 mol%), Et₃N (1.0 equiv.) and anhydrous MeCN (0.6 M) and was stirred at rt for 24 h. The crude material was purified and the diastereoisomers separated by flash silica column chromatography.

Synthesis of para-Quinone Methides

4-Benzylidene-2,6-di-*tert*-butylcyclohexa-2,5-dien-1-one (5)

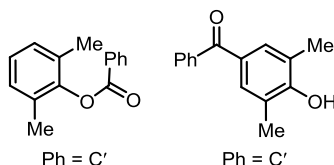


The title compound was prepared according to *General Procedure A* from a mixture of 2,6-di-*tert*-butylphenol (1.2 g, 5.8 mmol), benzaldehyde (0.6 mL, 5.8 mmol) and piperidine (1.2 mL, 11.6 mmol) in PhMe (50 mL) that was heated to reflux in a Dean-Stark apparatus. The reaction mixture was continued to reflux for 18 h before cooling the reaction mixture to below the boiling point. Acetic anhydride (1.1 mL, 11.6 mmol) was added and stirring was continued for 1 h before the workup was performed. The crude material that was purified by flash silica column chromatography (petroleum ether/CH₂Cl₂, 95:5) to give the title compound **5** (1.33 g, 78%) as an orange solid.

mp 52-54 °C; **¹H NMR** (400 MHz, CDCl₃) δ_{H} : 1.30 (9H, s, (C(2)C(CH₃)₃), 1.34 (9H, s, (C(6)C(CH₃)₃), 7.02 (1H, d, *J* 2.5, C(3)*H*), 7.19 (1H, s, C(4)=CH), 7.36-7.42 (1H, m, C(4')*H*), 7.44-7.48 (4H, m, C(2')*H*, C(3')*H*, C(5')*H*, C(6')*H*), 7.53 (1H, d, *J* 2.5, C(5)*H*).

Spectroscopic data in accordance with the literature.^[2]

2,6-Dimethylphenyl benzoate (**S1**) and (4-Hydroxy-3,5-dimethylphenyl)(phenyl)methanone (**S2**)



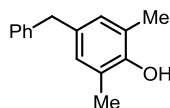
2,6-Dimethylphenol (2.45 g, 20 mmol) was dissolved in PhMe (20 mL) and benzoyl chloride (4.15 mL, 36 mmol) was added dropwise. AlCl₃ (3.30 g, 25 mmol) was slowly added and the reaction mixture was heated and stirred at 170 °C for 20 h. The reaction mixture was cooled to rt and then concentrated *in vacuo*. The resulting residue was purified by flash silica column chromatography (petroleum ether/EtOAc, 90:10 to 75:25) to afford predominately the *O*-acylated product **S1** as a yellow oil (3.57 g, 80%) and the desired *C*-acylated product **S2** (0.67 g, 15%) as a yellow solid.

2,6-Dimethylphenyl benzoate (S1): **¹H NMR** (400 MHz, CDCl₃) δ_{H} : 2.21 (3H, s, C(2)CH₃), 2.22 (3H, s, C(6)CH₃), 7.10-7.14 (3H, m, C(3)*H*, C(4)*H*, C(5)*H*), 7.51-7.59 (2H, m, C(3')*H*, C(5')*H*), 7.64-7.70 (1H, m, C(4')*H*), 8.24-8.29 (2H, m, C(2')*H*, C(6')*H*).

(4-Hydroxy-3,5-dimethylphenyl)(phenyl)methanone (S2): mp 116-118 °C; $^1\text{H NMR}$ (400 MHz, CDCl_3) δ_{H} : 2.29 (6H, s, C(2) CH_3 , C(6) CH_3), 5.12 (1H, s, C(1)OH), 7.44-7.50 (2H, m, C(3')H, C(5')H), 7.52 (2H, s, C(3)H, C(5)H), 7.52-7.61 (1H, m, C(4')H), 7.72- 7.77 (2H, m, C(2)H, C(6)H).

Spectroscopic data in accordance with the literature.^[3]

4-Benzyl-2,6-dimethylphenol (S3)

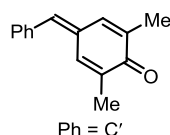


To palladium on carbon (10 wt.%, 0.12 g) under H_2 was added a solution of (4-hydroxy-3,5-dimethylphenyl)(phenyl)methanone **S2** (0.66 g, 3 mmol) in EtOH (5 mL). The reaction mixture was stirred at rt for 18 h before being filtered through a pad of Celite. The filtrate was concentrated *in vacuo* to give a yellow residue which was purified by flash silica column chromatography (petroleum ether/EtOAc, 85:25) to yield the title compound **S3** (0.40 g, 63%) as a yellow solid.

mp 48-50 °C; $^1\text{H NMR}$ (500 MHz, CDCl_3) δ_{H} : 2.23 (6H, s, C(2) CH_3 , C(6) CH_3), 3.87 (2H, C(4) CH_2), 4.50 (1H, s, C(1)OH), 6.83 (2H, s, C(3)H, C(5)H), 7.19-7.23 (3H, m, Ar), 7.27-7.33 (2H, m, Ar).

Spectroscopic data in accordance with the literature.^[3]

4-Benzylidene-2,6-dimethylcyclohexa-2,5-dien-1-one (9)

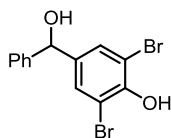


The title compound was prepared according to *General Procedure B* from 4-benzyl-2,6-dimethylphenol **S3** (0.40 g, 1.88 mmol), KOH (0.42 g, 7.91 mmol) and $\text{K}_3\text{Fe}(\text{CN})_6$ (2.48 g, 7.54 mmol) in hexane (10 mL) and H_2O (10 mL). The crude material was purified by flash silica column chromatography (petroleum ether/EtOAc, 90:10) to yield the title compound **9** (72 mg, 18%) as a yellow oil.

$^1\text{H NMR}$ (400 MHz, CDCl_3) δ_{H} : 2.09 (6H, s, (C(2) CH_3 , (C(6) CH_3), 7.07 (1H, s C(3)H), 7.18 (1H, s, C(4)=CHPh), 7.39-7.45 (1H, m, C(4')H), 7.48 (4H, d, J 4.5, C(2')H, C(3')H, C(5')H, C(6')H), 7.54 (1H, s, C(5)H).

Spectroscopic data in accordance with the literature.^[3]

2,6-Dibromo-4-(hydroxy(phenyl)methyl)phenol (**S4**)

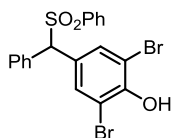


The title compound was prepared according to *General Procedure C* from 3,5-dibromo-4-hydroxybenzaldehyde (700 mg, 2.5 mmol) and PhMgBr (2 mL, 5.8 mmol) in anhydrous THF (13 mL). The crude material was purified by flash silica column chromatography (petroleum ether/EtOAc, 80:20) to give the title compound **S4** (769 mg, 86%) as a beige solid.

mp 130-132 °C; **¹H NMR** (400 MHz, CDCl₃) δ_{H} : 5.74 (1H, s, C(4)CH), 5.85 (1H, s, C(4)COH), 7.28-7.40 (5H, m, Ar), 7.50 (2H, d, *J* 0.7, C(3)H, C(5)H).

Spectroscopic data in accordance with the literature.^[2]

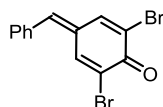
2,6-Dibromo-4-(phenyl(phenylsulfonyl)methyl)phenol (**S5**)



The title compound was prepared according to *General Procedure D* from conc. H₂SO₄ (1 mL), 2,6-dibromo-4-(hydroxy(phenyl)methyl)phenol **S4** (500 mg, 1.4 mmol), PhSO₂Na (450 mg, 2.7 mmol) in H₂O (18 mL) and AcOH (18 mL). The reaction mixture was heated to 100 °C for 18 h before being cooled down to rt. The resulting precipitate upon addition of distilled water was filtered and the solid dried under high vacuum to give the title compound **S5** (562 mg, 83%) as a colourless solid.

mp 184-186 °C; **¹H NMR** (400 MHz, CDCl₃) δ_{H} : 5.17 (1H, s, C(4)CH), 5.98 (1H, s, C(1)OH), 7.29 (1H, s, C(3)H, C(5)H), 7.31-7.40 (2H, m, Ar), 7.40-7.50 (4H, m, Ar), 7.59 (1H, t, *J* 7.5, Ar), 7.62-7.69 (3H, m, Ar).

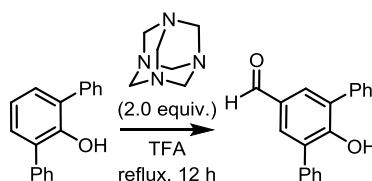
Spectroscopic data in accordance with the literature.^[2]

4-Benzylidene-2,6-dibromocyclohexa-2,5-dien-1-one (10)

The title compound was prepared according to *General Procedure D* from sulfone **S5** (562 mg, 1.16 mmol). The crude material obtained after the workup was purified by flash silica column chromatography (petroleum ether/ CH_2Cl_2 , 95:5) to give the title compound **10** (220 mg, 56%) as a green solid.

mp > 230 °C; ^1H NMR (400 MHz, CDCl_3) δ_{H} : 7.16-7.42 (6H, m, Ar), 7.42-7.73 (3H, m, Ar).

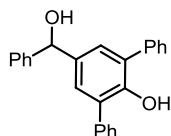
Spectroscopic data in accordance with the literature.^[2]

4-Hydroxy-3,5-diphenylbenzaldehyde (S6)

2,6-Diphenylphenol (1.10 g, 4.5 mmol), hexamethylenetetramine (1.26 g, 9.0 mmol) and TFA (4.5 mL) were mixed and heated to reflux (90 °C) for 12 h. The reaction mixture was cooled to rt and neutralised with saturated aqueous NaHCO_3 . The aqueous layer was extracted with EtOAc ($\times 3$) and the combined organic layers were dried over anhydrous Na_2SO_4 , and the filtrate concentrated *in vacuo*. The crude material was purified by recrystallization from Et_2O to give the title compound **S6** (0.71 g, 58%) as a pale yellow solid.

mp 150-152 °C (Et_2O); ^1H NMR (400 MHz, CDCl_3) δ_{H} : 5.98 (1H, s, C(4)OH), 5.98 (s, 1H, C(4)OH), 7.40-7.48 (2H, m, Ar), 7.50-7.54 (4H, m, Ar), 7.55-7.60 (4H, m, Ar), 7.83 (2H, s, C(2)H, C(6)H), 9.96 (1H, s, C(1)COH).

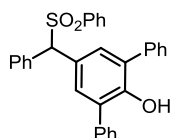
Spectroscopic data in accordance with the literature.^[2]

2,6-Diphenyl-4-(hydroxy(phenyl)methyl)phenol (S7)

The title compound was prepared according to *General Procedure C* from 4-hydroxy-3,5-diphenylbenzaldehyde **S6** (686 mg, 2.5 mmol) and PhMgBr (2 mL, 5.8 mmol) in anhydrous THF (13 mL). The crude material was purified by flash silica column chromatography (petroleum ether/EtOAc, 80:20) to give the title compound **S7** (500 mg, 57%) as a pale yellow oil.

¹H NMR (400 MHz, CDCl₃) δ_{H} : 5.43 (1H, s, C(4)OH), 5.90 (1H, s, C(4)CH), 7.23-7.34 (3H, m, C(3)H, C(5)H, Ar), 7.34-7.44 (4H, m, Ar), 7.45-7.53 (6H, m, Ar), 7.52-7.61 (4H, m, Ar).

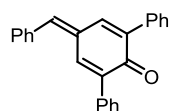
Spectroscopic data in accordance with the literature.^[2]

5'-(Phenyl(phenylsulfonyl)methyl)-[1,1':3',1''-terphenyl]-2'-ol (S8)

The title compound was prepared according to *General Procedure D* from conc. H₂SO₄ (1 mL), 2,6-diphenyl-4-(hydroxy(phenyl)methyl)phenol **S7** (300 mg, 0.85 mmol), PhSO₂Na (272 mg, 1.64 mmol) in H₂O (11 mL) and AcOH (11 mL). The reaction mixture was heated to 100 °C for 18 h before being cooled down to rt. The resulting precipitate upon addition of distilled water was filtered and the solid dried under high vacuum to yield the title compound **S8** (305 mg, 75%) as a pink solid.

mp 150-152 °C; **¹H NMR** (400 MHz, CDCl₃) δ_{H} : 5.32 (1H, s, C(4)CH), 7.28- 7.38 (3H, m, Ar), 7.39-7.53 (14H, m, Ar), 7.54-7.64 (3H, m, Ar), 7.70 (2H, d, *J* 7.7, Ar).

Spectroscopic data in accordance with the literature.^[2]

5'-Benzylidene-[1,1':3',1''-terphenyl]-2'(5'H)-one (11)

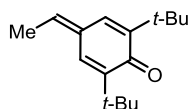
The title compound was prepared according to *General Procedure D* from sulfone **S8** (334 mg, 0.70 mmol). The crude material obtained after the workup was purified by flash silica

column chromatography (petroleum ether/ CH_2Cl_2 , 95:5) to give the title compound **11** (68 mg, 29%) as a yellow solid.

mp 120-122 °C; ^1H NMR(400 MHz, CDCl_3) δ_{H} : 7.40-7.53 (11H, m, Ar), 7.55-7.76 (6H, m, Ar), 7.92 (1H, d, J 2.5, C(5) H).

Spectroscopic data in accordance with the literature.^[2]

2,6-Di-*tert*-butyl-4-ethylidenecyclohexa-2,5-dien-1-one (12)

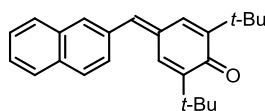


The title compound was prepared according to *General Procedure B* from 2,6-di-*tert*-butyl-4-ethylphenol (1.80 g, 7.7 mmol), KOH (1.73 g, 30.9 mmol) and $\text{K}_3\text{Fe}(\text{CN})_6$ (10.14 g, 30.8 mmol) in hexane (28 mL) and H_2O (28 mL). The crude material was purified by flash silica column chromatography (petroleum ether/EtOAc, 90:10) to yield the title compound **12** (1.50 g, 84%) as a green solid.

mp 68-70 °C; ^1H NMR (400 MHz, CDCl_3) δ_{H} : 1.22 (9H, s, (C(2)C(CH_3) $_3$), 1.25 (9H, s, (C(6)C(CH_3) $_3$), 2.04 (3H, d, J 7.7, C(4)=CHCH $_3$), 6.34 (1H, q, J 7.7, C(3) H), 6.78 (1H, d, J 2.5, C(4)=CHCH $_3$), 7.24 (1H, d, J 2.5, C(5) H).

Spectroscopic data in accordance with the literature.^[3]

2,6-Di-*tert*-butyl-4-(naphthalen-2-ylmethylene)cyclohexa-2,5-dien-1-one (13)



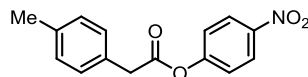
The title compound was prepared according to *General Procedure A* from a mixture of 2,6-di-*tert*-butylphenol (1.2 g, 5.8 mmol), 2-naphthaldehyde (0.91 g, 5.8 mmol) and piperidine (1.2 mL, 11.6 mmol) in PhMe (50 mL) that was heated to reflux in a Dean-Stark apparatus. The reaction mixture was continued to reflux for 18 h before cooling the reaction mixture to below the boiling point. Acetic anhydride (1.1 mL, 11.6 mmol) was added and stirring was continued for 1 h before the workup was performed. The crude material that was purified by flash silica column chromatography (petroleum ether/ CH_2Cl_2 , 95:5) to give the title compound **13** (1.45 g, 73%) as an orange solid.

mp 76-78 °C; **¹H NMR** (400 MHz, CDCl₃) δ_H: 1.34 (9H, s, (C(2)C(CH₃)₃), 1.38 (9H, s, (C(6)C(CH₃)₃), 7.11 (1H, d, *J* 2.3, C(3)*H*), 7.37 (1H, s, C(4)=*CH*), 7.54-7.62 (3H, m, *Ar*), 7.67 (1H, d, *J* 2.3, C(5)*H*), 7.86-7.98 (4H, m, *Ar*).

Spectroscopic data in accordance with the literature.^[2]

Synthesis of Aryl Esters

4'-Nitrophenyl 2-(*p*-tolyl)acetate (**1**)

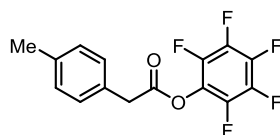


The title compound was prepared according to *General Procedure E* from *p*-tolyl acetic acid (1.25 g, 8.63 mmol), EDCI·HCl (1.20 g, 6.47 mmol) and 4-nitrophenol (0.60 g, 4.31 mmol) in CH₂Cl₂ (14 mL) to give crude material that was purified by flash silica column chromatography (hexane/EtOAc, 85:15) to give **1** (0.93 g, 79%) as a colourless crystalline solid.

mp 60-62 °C; ¹H NMR (400 MHz, CDCl₃) δ_H: 2.42 (3H, s, CH₃), 3.92 (2H, s, C(2)H₂), 7.25 (2H, d, *J* 7.9, C(3')H, C(5')H), 7.29-7.35 (4H, m, C(2')H, C(6')H, C(3'')H, C(5'')H), 8.30 (2H, d, *J* 9.2, C(3')H, C(5')H).

Spectroscopic data in accordance with the literature.^[4]

Perfluorophenyl 2-(*p*-tolyl)acetate (**2**)

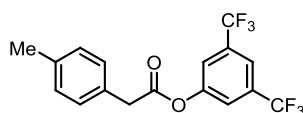


The title compound was prepared according to *General Procedure E* from *p*-tolyl acetic acid (10.1 g, 67.0 mmol), EDCI·HCl (9.63 g, 50.3 mmol) and 2,3,4,5,6-pentafluorophenol (6.17 g, 33.5 mmol) in CH₂Cl₂ (56 mL) to give crude material that was purified by flash silica column chromatography (CH₂Cl₂) to give **2** (6.88 g, 65%) as a colourless solid.

mp 27-29 °C; ¹H NMR (400 MHz, CDCl₃) δ_H: 2.40 (3H, s, CH₃), 3.96 (2H, s, CH₂), 7.22 (2H, d, *J* 7.9, C(3')H, C(5')H), 7.28 (2H, d, *J* 8.1, C(2')H, C(6')H); ¹⁹F{¹H} NMR (376 MHz, CDCl₃) δ_F: -162.5 - -162.3 (m), -157.9 (t, *J* 21.7), -152.7 - -152.6 (m).

Spectroscopic data in accordance with the literature.^[5]

3',5'-Bis(trifluoromethyl)phenyl 2-(*p*-tolyl)acetate (**3**)



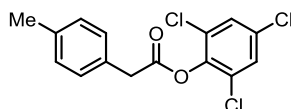
The title compound was prepared according to *General Procedure E* from *p*-tolyl acetic acid (2.50 g, 16.7 mmol), EDCI·HCl (2.40 g, 12.5 mmol) and 3,5-bis(trifluoromethyl)phenol (1.92

g, 8.33 mmol) in CH_2Cl_2 (30 mL) to give crude material that was purified by flash silica column chromatography (hexane/EtOAc, 95:5) to give **3** (2.84 g, 94%) as a colourless solid.

mp 57-58 °C; **^1H NMR** (500 MHz, CDCl_3) δ_{H} : 2.40 (3H, s, CH_3), 3.90 (2H, s, $\text{C}(2)\text{H}_2$), 7.24 (2H, d, J 7.9, $\text{C}(2'')\text{H}$, $\text{C}(6'')\text{H}$), 7.30 (2H, d, J 7.9, $\text{C}(3'')\text{H}$, $\text{C}(5'')\text{H}$), 7.61 (2H, d, J 1.8, Ar), 7.78 (1H, s, Ar).

Spectroscopic data in accordance with the literature.^[4]

2',4',6'-Trichlorophenyl 2-(*p*-tolyl)acetate (**4**)

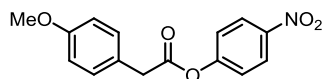


The title compound was prepared according to *General Procedure E* from *p*-tolyl acetic acid (2.50 g, 16.7 mmol), EDCI·HCl (2.40 g, 12.5 mmol) and trichlorophenol (1.60 g, 8.33 mmol) in CH_2Cl_2 (29 mL) to give crude material that was purified by flash silica column chromatography (hexane/EtOAc, 95:5) to give **4** (2.47 g, 91%) as a colourless solid.

mp 49-51 °C; **^1H NMR** (500 MHz, CDCl_3) δ_{H} : 2.39 (3H, s, CH_3), 3.96 (2H, s, $\text{C}(2)\text{H}_2$), 7.21 (2H, d, J 7.8, $\text{C}(3'')\text{H}$, $\text{C}(5'')\text{H}$), 7.32 (2H, d, J 7.8, $\text{C}(2'')\text{H}$, $\text{C}(6'')\text{H}$), 7.38 (2H, s, Ar).

Spectroscopic data in accordance with the literature.^[4]

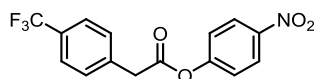
4'-Nitrophenyl 2-(4'-methoxyphenyl)acetate (**21**)



The title compound was prepared according to *General Procedure E* from 2-(4-methoxyphenyl)acetic acid (1.55 g, 9.34 mmol), EDCI·HCl (1.30 g, 7.01 mmol) and 4-nitrophenol (0.65 g, 4.67 mmol) in CH_2Cl_2 (14 mL) to give crude material that was purified by flash silica column chromatography (hexane/EtOAc, 85:15) to give **21** (0.93 g, 69%) as a pale yellow crystalline solid.

mp 88-90 °C; **^1H NMR** (400 MHz, CDCl_3) δ_{H} : 3.84 (3H, s, CH_3), 3.86 (2H, s, $\text{C}(2)\text{H}_2$), 6.94 (2H, d, J 8.8, $\text{C}(3'')\text{H}$, $\text{C}(5'')\text{H}$), 7.28 (2H, J 9.2, $\text{C}(2'')\text{H}$, $\text{C}(6'')\text{H}$), 7.31 (2H, d, J 8.8, $\text{C}(2'')\text{H}$, $\text{C}(6'')\text{H}$), 8.27 (2H, d, J 9.2, $\text{C}(3'')\text{H}$, $\text{C}(5'')\text{H}$).

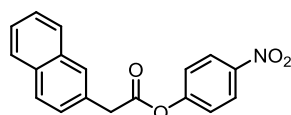
Spectroscopic data in accordance with the literature.^[4]

4'-Nitrophenyl 2-(4''-(trifluoromethyl)phenyl)acetate (22)

The title compound was prepared according to *General Procedure E* from 2-(4-(trifluoromethyl)phenyl)acetic acid (1.91 g, 9.34 mmol), EDCI·HCl (1.30 g, 7.01 mmol) and 4-nitrophenol (0.65 g, 4.67 mmol) in CH₂Cl₂ (14 mL) to give crude material that was purified by flash silica column chromatography (hexane/EtOAc, 85:15) to give **22** (0.96 g, 64%) as a colourless solid.

mp 65-67 °C; **¹H NMR** (400 MHz, CDCl₃) δ_H: 4.00 (2H, s, C(2)H₂), 7.30 (2H, d, *J* 9.2, C(2')H, C(6')H), 7.53 (2H, d, *J* 8.0, C(2'')H, C(6'')H), 7.68 (2H, d, *J* 8.0, C(3'')H, C(5'')H), 8.29 (2H, d, *J* 9.2, C(3')H, C(5')H); **¹⁹F{¹H} NMR** (376 MHz, CDCl₃) δ_F: 62.6 (CF₃).

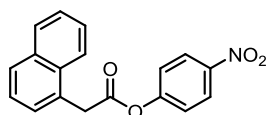
Spectroscopic data in accordance with the literature.^[4]

4'-Nitrophenyl 2-(naphthalen-2''-yl)acetate (23)

The title compound was prepared according to *General Procedure E* from 2-(naphthalen-2-yl)acetic acid (1.74 g, 9.34 mmol), EDCI·HCl (1.30 g, 7.01 mmol) and 4-nitrophenol (0.65 g, 4.67 mmol) in CH₂Cl₂ (14 mL) to give crude material that was purified by flash silica column chromatography (hexane/EtOAc, 85:15) to give **23** (0.95 g, 66%) as a colourless crystalline solid.

mp 94-96 °C; **¹H NMR** (400 MHz, CDCl₃) δ_H: 4.09 (2H, s, C(2)H₂), 7.29 (2H, d, *J* 9.2, C(2')H, C(6')H), 7.46-7.63 (3H, m, *Ar*), 7.82-8.00 (4H, m, *Ar*), 8.27 (2H, d, *J* 9.2, C(3')H, C(5')H).

Spectroscopic data in accordance with the literature.^[4]

4'-Nitrophenyl 2-(naphthalen-1''-yl)acetate (24)

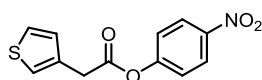
The title compound was prepared according to *General Procedure E* from 2-(naphthalen-1-yl)acetic acid (1.74 g, 9.34 mmol), EDCI·HCl (1.30 g, 7.01 mmol) and 4-nitrophenol (0.65 g,

4.67 mmol) in CH₂Cl₂ (14 mL) to give crude material that was purified by flash silica column chromatography (hexane/EtOAc, 85:15) to give **24** (0.87 g, 61%) as a colourless crystalline solid.

mp 79-81 °C; **¹H NMR** (400 MHz, CDCl₃) δ_H: 4.37 (2H, s, C(2)H₂), 7.22 (2H, d, *J* 9.0, C(2')H, C(6')H), 7.46-7.67 (4H, m, *Ar*), 7.89 (1H, d, *J* 7.9, C(8'')H), 7.94 (1H, d, *J* 7.9, C(5'')H), 8.10 (1H, d, *J* 8.4, C(4'')H), 8.23 (2H, d, *J* 9.1, C(3')H, C(5')H).

Spectroscopic data in accordance with the literature.^[4]

4'-Nitrophenyl 2-(thiophen-3'-yl)acetate (**25**)



The title compound was prepared according to *General Procedure E* from 2-(thiophen-3-yl)acetic acid (1.33 g, 9.34 mmol), EDCI·HCl (1.30 g, 7.01 mmol) and 4-nitrophenol (0.65 g, 4.67 mmol) in CH₂Cl₂ (14 mL) to give crude material that was purified by flash silica column chromatography (hexane/EtOAc, 85:15) to give **25** (0.76 g, 61%) as a colourless solid.

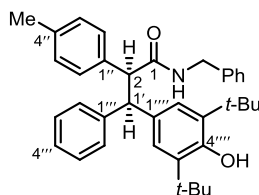
mp 55-57 °C; **¹H NMR** (400 MHz, CDCl₃) δ_H: 3.97 (2H, s, C(2)H₂), 7.15 (1H, dd, *J* 5.0, 1.3, C(4'')H), 7.28-7.33 (3H, m, C(2')H, C(6')H, C(2'')H), 7.39 (1H, dd, *J* 5.0, 3.0, C(5'')H), 8.29 (2H, d, *J* 9.2, C(3')H, C(5')H).

Spectroscopic data in accordance with the literature.^[4]

Amide Products Derived from Isothiourea Catalysis

Only the structure of the major diastereoisomer is shown in each case.

(2*S*,1'*R*)-*N*-Benzyl-1'-(3''',5'''-di-*tert*-butyl-4'''-hydroxyphenyl)-2-(*p*-tolyl)-1'-phenyl propenamide (7) (Table 1, entry 8)



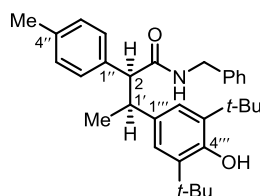
By following *General Procedure F*, 4-benzylidene-2,6-di-*tert*-butylcyclohexa-2,5-dien-1-one **5** (74 mg, 0.25 mmol), 4'-nitrophenyl 2-(*p*-tolyl)acetate **1** (102 mg, 0.375 mmol), (*S*)-TM·HCl (3 mg, 5 mol%) and Et₃N (35 μ L, 0.25 mmol) were dissolved in anhydrous MeCN (0.42 mL). The reaction mixture was stirred at 40 $^{\circ}$ C for 24 h before being quenched with benzylamine (137 μ L, 1.25 mmol) at rt to give a crude mixture containing the title compound in 60:40 dr. The mixture was purified by flash silica column chromatography (petroleum ether/EtOAc, 85:15) to afford the title compound **7** (132 mg, 99%) as a pale yellow solid in 65:35 dr.

mp 126-128 $^{\circ}$ C; $[\alpha]_D^{20} +10.0$ (*c* 1.0, CHCl₃); **Chiral HPLC analysis**, Chiralpak AD-H (10% *i*-PrOH/hexane, flow rate 1.5 mLmin⁻¹, 211 nm, 40 $^{\circ}$ C), *t_R* major: 8.5 min and 29.3 min, 92:8 er, *t_R* minor: 3.8 min and 18.6 min, 85:15 er; **IR** ν_{\max} (film)/cm⁻¹ 3638 (O–H) 3304 (N–H), 2955 (C–H), 1645 (C=O); **¹H NMR** (500 MHz, CDCl₃) δ_H : 1.42 (18H, s, (C(3'''))C(CH₃)₃, C(5'''))C(CH₃)₃), 2.24 (3H, s, C(4'')CH₃), 3.90-4.05 (2H, m, C(2)*H*, CH_APh), 4.44 (1H, dd, *J* 15.0, 6.8, CH_BPh), 4.82 (1H, d, *J* 11.7, C(1')*H*), 5.14 (1H, s, OH), 5.55 (1H, t, *J* 5.6, NH), 6.71-6.76 (2H, m, Ar), 6.96-7.05 (2H, m, Ar), 7.09-7.15 (2H, m, Ar), 7.15-7.22 (4H, m, Ar), 7.23-7.30 (4H, m, C(4''')*H*, C(2''')*H*, C(6''')*H*, Ar), 7.34 (1H, t, *J* 7.6, Ar), 7.43-7.51 (1H, m, Ar); **¹³C{¹H} NMR** (126 MHz, CDCl₃) δ_C : 21.0 (C(4'')CH₃), 30.4 (C(3'''))C(CH₃)₃, C(5'''))C(CH₃)₃), 34.4 (C(3'''))C(CH₃)₃, C(5'''))C(CH₃)₃), 43.6 (CH₂Ph), 54.1 (C(1')), 59.5 (C(2)), 124.7 (C(2'''), C(6''')), 125.8 (C(4''')), 128.2 (Ar), 127.2 (Ar), 127.3 (Ar), 128.0 (Ar), 128.4 (Ar), 128.5 (Ar), 128.6 (Ar), 129.0 (Ar), 133.8 (C(1''')), 135.2 (C(1')), 135.6 (C(3''')), C(5''')), 136.4 (C(4'')), 137.9 (*i*-Ph), 142.4 (C(1''')), 152.4 (C(4''')), 172.1 (C(1)); **HRMS** (ESI⁺) C₃₇H₄₃NO₂ ([M+H]⁺), found 534.3359, requires 534.3367 (–1.4 ppm).

Selected data for minor diastereoisomer (8): **¹H NMR** (500 MHz, CDCl₃) δ_H : 1.27 (18H, s, (C(3'''))C(CH₃)₃, C(5'''))C(CH₃)₃), 2.27 (3H, s, C(4'')CH₃), 3.90-4.05 (2H, m, C(2)*H*, CH_APh), 4.50 (1H, dd, *J* 15.0, 6.8, CH_BPh), 4.69 (1H, d, *J* 11.7, C(1')*H*), 4.89 (1H, s, OH), 5.69 (1H, t,

J 5.6, NH), 6.81-6.84 (2H, m, Ar); $^{13}C\{^1H\}$ NMR (126 MHz, $CDCl_3$) δ_C : 21.0 ($C(4'')$ CH_3), 30.2 ($C(3''')$ $C(CH_3)_3$, $C(5''')$ $C(CH_3)_3$), 34.2 ($C(3''')$ $C(CH_3)_3$, $C(5''')$ $C(CH_3)_3$), 43.4 (CH_2Ph), 54.7 ($C(1')$), 59.5 ($C(2)$), 125.3 ($C(2''')$, $C(6''')$), 126.3 ($C(4''')$), 127.5 (Ar), 128.2 (Ar), 128.4 (Ar), 128.8 (Ar), 132.1 ($C(1''')$), 134.9 ($C(3''')$, $C(5''')$), 135.5 ($C(1'')$), 136.4 ($C(4'')$), 138.2 ($i-Ph$), 143.6 ($C(1''')$), 151.7 ($C(4''')$), 172.0 ($C(1)$).

(2*S*,1'*R*)-*N*-Benzyl-1'-(3''',5'''-di-*tert*-butyl-4'''-hydroxyphenyl)-2-(*p*-tolyl)-1'-phenyl pentanamide (17)

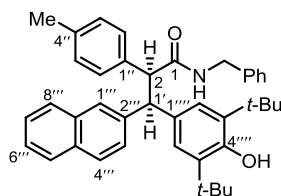


By following *General Procedure F*, 2,6-di-*tert*-butyl-4-ethylidenecyclohexa-2,5-dien-1-one **12** (58 mg, 0.25 mmol), 4'-nitrophenyl 2-(*p*-tolyl)acetate **1** (102 mg, 0.375 mmol), (*S*)-TM·HCl (3 mg, 5 mol%) and Et_3N (35 μ L, 0.25 mmol) were dissolved in anhydrous MeCN (0.42 mL). The reaction mixture was stirred at 40 °C for 24 h before being quenched with benzylamine (137 μ L, 1.25 mmol) at rt to give a crude mixture containing the title compound in 60:40 dr. The mixture was purified by flash silica column chromatography (petroleum ether/EtOAc, 85:15) to afford the title compound **17** (59 mg, 50%) as a pale yellow solid in 65:35 dr.

mp 56-58 °C; $[\alpha]_D^{20} +18.7$ (c 1.0, $CHCl_3$); **Chiral HPLC analysis**, Chiralpak AD-H (5% *i*-PrOH/hexane, flow rate 1.5 mLmin⁻¹, 211 nm, 40 °C), t_R major: 5.9 min and 11.8 min, 89:11 er, t_R minor: 4.8 min and 14.2 min, 81:19 er; **IR** ν_{max} (film)/cm⁻¹ 3649 (O–H) 3285 (N–H), 2957 (C–H), 1643 (C=O); 1H NMR (400 MHz, $CDCl_3$) δ_H : 1.34 (18H, s, ($C(3''')$ $C(CH_3)_3$, $C(5''')$ $C(CH_3)_3$), 1.45-1.50 (3H, m, $C(1')CH_3$), 2.26 (3H, s, $C(4'')CH_3$), 3.21 (1H, d, J 10.4, $C(2)H$), 3.44-3.53 (1H, m, $C(1')H$), 4.30 (1H, dd, J 14.8, 5.2, CH_APh), 4.62 (dd, J = 14.8, 6.2, CH_BPh), 4.97 (1H, s, OH), 6.02 (1H, t, J 5.6, NH), 6.70 (2H, s, Ar), 6.91-7.00 (2H, m, Ar), 7.09-7.15 (2H, m, Ar), 7.16-7.24 (4H, m, $C(2''')H$, $C(6''')H$, Ar), 7.26-7.35 (3H, m, Ar); $^{13}C\{^1H\}$ NMR (101 MHz, $CDCl_3$) δ_C : 19.8 ($C(1')CH_3$), 20.9 ($C(4'')CH_3$), 30.3 ($C(3''')$ $C(CH_3)_3$, $C(5''')$ $C(CH_3)_3$), 34.2 ($C(3''')$ $C(CH_3)_3$, $C(5''')$ $C(CH_3)_3$), 43.5 ($C(1')$), 43.7 (CH_2Ph), 61.9 ($C(2)$), 124.4 ($C(2''')$, $C(6''')$), 127.2 (Ar), 127.4 (Ar), 127.7 (Ar), 128.3 (Ar), 128.5 (Ar), 128.6 (Ar), 128.7 (Ar), 129.1 (Ar), 135.0 ($C(3''')$, $C(5''')$), 135.6 ($C(1''')$), 136.1 ($C(1'')$), 136.1 ($C(4'')$), 138.4 ($i-Ph$), 151.8 ($C(4''')$), 173.1 ($C(1)$); **HRMS** (NSI⁺) $C_{32}H_{42}NO_2$ ($[M+H]^+$), found 472.3210, requires 472.3201 (−1.9 ppm).

Selected data for minor diastereoisomer: ^1H NMR (400 MHz, CDCl_3) δ_{H} : 1.10 (3H, d, J 7.0, $\text{C}(1')\text{CH}_3$), 1.48 (18H, s, ($\text{C}(3''')\text{C}(\text{CH}_3)_3$, $\text{C}(5''')\text{C}(\text{CH}_3)_3$), 2.39 (3H, s, $\text{C}(4'')\text{CH}_3$), 3.28 (1H, d, J 10.4, $\text{C}(2)\text{H}$), 3.54-3.61 (1H, m, $\text{C}(1')\text{H}$), 3.87 (1H, dd, J 15.0, 4.1, CH_APh), 4.45 (1H, dd, J 15.0, 7.0, CH_BPh), 5.23 (1H, s, OH), 5.53 (1H, t, J 5.6, NH), 6.64-6.69 (2H, m, Ar), 7.40-7.49 (2H, m, Ar); $^{13}\text{C}\{^1\text{H}\}$ NMR (101 MHz, CDCl_3) δ_{C} : 19.6 ($\text{C}(1')\text{CH}_3$), 21.1 ($\text{C}(4'')\text{CH}_3$), 30.5 ($\text{C}(3''')\text{C}(\text{CH}_3)_3$, $\text{C}(5''')\text{C}(\text{CH}_3)_3$), 34.5 ($\text{C}(3''')\text{C}(\text{CH}_3)_3$, $\text{C}(5''')\text{C}(\text{CH}_3)_3$), 42.9 ($\text{C}(1')$), 43.3 (CH_2Ph), 62.5 ($\text{C}(2)$), 124.1 ($\text{C}(2''')$, $\text{C}(6''')$), 127.1 (Ar), 132.1 (Ar), 134.9 ($\text{C}(3''')$, $\text{C}(5''')$), 134.0 ($\text{C}(1'')$), 135.7 (Ar), 135.8 (Ar), 134.0 ($\text{C}(3'')$, $\text{C}(5'')$), 135.7 ($\text{C}(1''')$), 135.8 ($\text{C}(1''')$), 136.8 ($\text{C}(4'')$), 138.0 (*i*-Ph), 152.4 ($\text{C}(4''')$), 172.6 ($\text{C}(1)$).

(2*S*,1'*R*)-*N*-Benzyl-1'-(3''',5'''-di-*tert*-butyl-4'''-hydroxyphenyl)-2-(*p*-tolyl)-1'-(naphthalen-2''-yl)-propenamide (18)



By following *General Procedure F*, 2,6-di-*tert*-butyl-4-(naphthalen-2-ylmethylene)cyclohexa-2,5-dien-1-one **13** (86 mg, 0.25 mmol), 4'-nitrophenyl 2-(*p*-tolyl)acetate **1** (102 mg, 0.375 mmol), (*S*)-TM·HCl (3 mg, 5 mol%) and Et_3N (35 μL , 0.25 mmol) were dissolved in anhydrous MeCN (0.42 mL). The reaction mixture was stirred at 40 $^\circ\text{C}$ for 24 h before being quenched with benzylamine (137 μL , 1.25 mmol) at rt to give a crude mixture containing the title compound in 70:30 dr. The mixture was purified by flash silica column chromatography (petroleum ether/EtOAc, 85:15) to afford the title compound **18** (121 mg, 83%) as a pale yellow solid in > 95:5 dr as the major diastereoisomer.

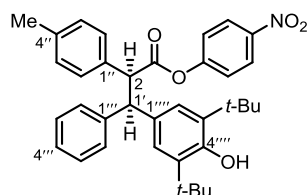
mp 78-80 $^\circ\text{C}$; $[\alpha]_{\text{D}}^{20} +22.8$ (*c* 0.5, CHCl_3); **Chiral HPLC analysis**, Chiralpak AD-H (10% *i*-PrOH/hexane, flow rate 1.5 mLmin $^{-1}$, 211 nm, 40 $^\circ\text{C}$), t_{R} major: 11.9 min and 17.6 min, 94:6 er, t_{R} minor: 2.2 min and 5.1 min, 63:37 er; **IR** ν_{max} (film)/cm $^{-1}$ 3630 (O–H) 3287 (N–H), 2953 (C–H), 1641 (C=O); ^1H NMR (500 MHz, CDCl_3) δ_{H} : 1.27 (18H, s, ($\text{C}(3''')\text{C}(\text{CH}_3)_3$, $\text{C}(5''')\text{C}(\text{CH}_3)_3$), 2.28 (3H, s, $\text{C}(4'')\text{CH}_3$), 3.84 (1H, dd, J 14.9, 3.7, CH_APh), 4.10 (1H, d, J 11.6, $\text{C}(2)\text{H}$), 4.47 (1H, dd, J 14.9, 7.3, CH_BPh), 4.88 (1H, d, J 11.8, $\text{C}(1')\text{H}$), 4.90 (1H, s, OH), 5.83 (1H, broad-s, NH), 6.60 (2H, d, J 7.4, *o*-Ph), 6.81 (2H, s, $\text{C}(2''')$ H, $\text{C}(6''')$ H), 6.86 (2H, t, J 7.7, *m*-Ph), 7.00 (2H, d, J 7.6, $\text{C}(3'')$ H, $\text{C}(5'')$ H), 7.06 (1H, t, J 7.3, *p*-Ph), 7.18 (2H, d, J 7.7, $\text{C}(2'')$ H, $\text{C}(6'')$ H), 7.45-7.51 (2H, m, Ar), 7.57 (1H, d, J 8.2, Ar), 7.78 (1H, d, J 8.5, Ar), 7.79-7.86 (2H, m, Ar), 7.94 (1H, s, Ar). $^{13}\text{C}\{^1\text{H}\}$ NMR (126 MHz, CDCl_3) δ_{C} : 21.1

(C(4'')CH₃), 30.3 (C(3''')C(CH₃)₃, C(5''')C(CH₃)₃), 34.2 (C(3''')C(CH₃)₃, C(5''')C(CH₃)₃), 43.4 (CH₂Ph), 54.8 (C(1')), 59.4 (C(2)), 125.5 (C(2'''), C(6''')), 126.0 (*Ar*), 126.3 (*Ar*), 127.1 (*p*-Ph), 127.3 (*Ar*), 127.4 (*o*-Ph), 127.7 (*Ar*), 128.1 (*Ar*), 128.3 (*m*-Ph), 128.4 (*Ar*), 128.6 (*Ar*), 129.0 (C(3''), C(5'')), 132.0 (*Ar*), 132.5 (*Ar*), 133.8 (*Ar*), 135.1 (C(3'''), C(5''')), 135.6 (C(1'')), 136.6 (C(4'')), 138.1 (*i*-Ph), 141.3 (C(1''')), 151.9 (C(4''')), 172.2 (C(1)). **HRMS** (NSI⁺) C₄₁H₄₆NO₂ ([M+H]⁺), found 584.3515, requires 584.3523 (−1.4 ppm).

PNP Ester Products from Isothiourea Catalysis

Only the structure of the major diastereoisomer is shown in each case.

(2*S*,1'*R*)-4-Nitrophenyl 1'-(3''',5'''-di-*tert*-butyl-4'''-hydroxyphenyl)-2-(*p*-tolyl)-1'-phenylpropanoate propanoate (19)



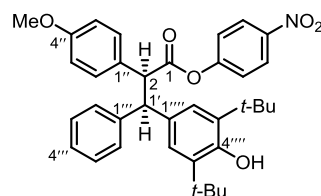
By following *General Procedure G*, 4-benzylidene-2,6-di-*tert*-butylcyclohexa-2,5-dien-1-one **5** (370 mg, 1.25 mmol), 4'-nitrophenyl 2-(*p*-tolyl)acetate **1** (510 mg, 1.88 mmol), (*S*)-TM·HCl (15 mg, 5 mol%) and Et₃N (175 μ L, 1.25 mmol) were dissolved in anhydrous MeCN (2.1 mL). The reaction mixture was stirred at rt for 24 h before being concentrated *in vacuo*. The crude material (55:45 dr) was purified and the diastereoisomers separated by flash silica column chromatography (petroleum ether/EtOAc, 95:5). The diastereoisomers were obtained as pale yellow solids (combined: 601 mg, 85%).

mp 83-85 °C; **Chiral HPLC analysis**, Chiralpak AD-H (2% *i*-PrOH/hexane, flow rate 1.5 mLmin⁻¹, 211 nm, 30 °C), *t*_R major: 12.9 min and 23.6 min, 92:8 er, *t*_R minor: 20.5 min and 35.1 min, 87:13 er; **IR** ν_{max} (film)/cm⁻¹ 3615 (O-H), 2953 (C-H), 1769 (C=O), 1522 (N-O), 1489 (C=C), 1346 (N-O), 1109 (C-O); **HRMS** (ASAP⁺) C₃₆H₃₉NO₅ ([M]⁺), found 565.2822, requires 565.2834 (-2.1 ppm).

Data for major diastereoisomer (19): $[\alpha]_D^{20}$ +109 (*c* 0.1, CHCl₃); **¹H NMR** (500 MHz, CDCl₃) δ_{H} : 1.28 (18H, s, (C(3'''))C(CH₃)₃, C(5'''))C(CH₃)₃), 2.32 (3H, s, C(4'')CH₃), 4.48 (1H, d, *J* 12.1, C(2')H), 4.59 (1H, d, *J* 12.1, C(1')H), 4.97 (1H, s, OH), 6.74 (2H, d, *J* 8.8, ester C(1)OC(2')H, ester C(1)OC(6')H), 6.75 (2H, s, C(2''')H, C(6''')H), 7.08 (2H, d, *J* 7.5, C(3'')H, C(5'')H), 7.19 (2H, d, *J* 8.1, C(2'')H, C(6'')H), 7.31 (1H, d, *J* 7.5, C(4'')H), 7.41 (2H, t, *J* 7.5, C(3'')H, C(5'')H), 7.55 (2H, d, *J* 6.8, C(2''')H, C(6''')H), 8.13 (2H, d, *J* 8.8, ester C(3')H, ester C(5')H); **¹³C{¹H} NMR** (126 MHz, CDCl₃) δ_{C} : 21.3 (C(4'')CH₃), 30.6 (C(3'''))C(CH₃)₃, C(5'''))C(CH₃)₃, 34.3 (C(3'''))C(CH₃)₃, C(5'''))C(CH₃)₃, 55.8 (C(1')), 57.8 (C(2')), 122.5 (ester C(2'), ester C(6')), 125.1 (ester C(3'), ester C(5')), 125.2 (C(2'''), C(6''')), 127.0 (C(4'')), 128.3 (C(2''), C(6'')), 128.6 (C(3''), C(5'')), 128.9 (C(2''), C(6'')), 129.4 (C(3''), C(5'')), 131.1 (C(1'')), 133.3 (C(1'')), 135.4 (C(3''), C(5'')), 137.5 (C(4'')), 142.6 (C(1'')), 145.4 (ester C(1)OC(4')NO₂), 152.2 (C(4'')), 155.4 (ester C(1)OC(1')), 171.0 (C(1)O).

Data for minor diastereoisomer (20): $[\alpha]_D^{20} +30.0$ (*c* 0.1, CHCl₃); ^1H NMR (500 MHz, CDCl₃) δ_{H} : 1.45 (18H, s, (C(3'''))C(CH₃)₃, C(5''')C(CH₃)₃), 2.30 (3H, s, C(4'')CH₃), 4.65 (2H, s, C(2)H, C(1')H), 5.20 (1H, s, OH), 6.56 (2H, d, *J* 9.0, ester C(1)OC(2)H, ester C(1)OC(6)H), 7.06-7.11 (3H, m, C(3'')H, C(5'')H, C(4'')H), 7.14-7.23 (4H, m, C(2''), C(6''), C(3'')H, C(5'')H), 7.31-7.37 (4H, m, C(3'')H, C(5'')H, C(2'')H, C(6'')H), 8.11 (2H, d, *J* 9.0, ester C(3)H, ester C(5)H); $^{13}\text{C}\{^1\text{H}\}$ NMR (126 MHz, CDCl₃) δ_{C} : 21.3 (C(4'')CH₃), 30.3 (C(3''')C(CH₃)₃, C(5''')C(CH₃)₃), 34.3 (C(3''')C(CH₃)₃, C(5''')C(CH₃)₃), 55.5 (C(1')), 57.4 (C(2')), 122.4 (ester C(2), ester C(6)), 124.6 (ester C(3), ester C(5)), 125.2 (C(2''), C(6'')), 126.3 (C(4'')), 128.0 (C(2''), C(6'')), 128.3 (C(3''), C(5'')), 128.6 (C(2''), C(6'')), 129.4 (C(3''), C(5'')), 132.8 (C(1''), C(1')), 135.4 (C(3''), C(5'')), 137.4 (C(4'')), 141.5 (C(1'')), 145.2 (ester C(1)OC(4)NO₂), 152.2 (C(4'')), 155.4 (ester C(1)OC(1)), 171.0 (C(1)O).

(2*S*,1'*R*)-4-Nitrophenyl 1-(3''',5'''-di-*tert*-butyl-4'''-hydroxyphenyl)-2-(4-methoxyphenyl)-1'-phenylpropanoate (26)



By following *General Procedure G*, 4-benzylidene-2,6-di-*tert*-butylcyclohexa-2,5-dien-1-one **5** (74 mg, 0.25 mmol), 4'-nitrophenyl 2-(4''-methoxyphenyl)acetate **21** (108 mg, 0.375 mmol), (*S*)-TM·HCl (3 mg, 5 mol%) and Et₃N (35 μ L, 0.25 mmol) were dissolved in anhydrous MeCN (0.42 mL). The reaction mixture was stirred at rt for 24 h before being concentrated *in vacuo*. The crude material (60:40 dr) was purified and the diastereoisomers separated by flash silica column chromatography (petroleum ether/EtOAc, 95:5). The diastereoisomers were obtained as pale yellow solids (combined: 144 mg, 99%).

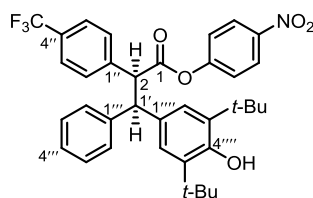
mp 51-53 °C; **Chiral HPLC analysis**, Chiralpak AD-H (4.5% *i*-PrOH/hexane, flow rate 1.5 mLmin⁻¹, 211 nm, 40 °C), *t*_R major: 9.8 min and 18.6 min, 92:8 er, *t*_R minor: 13.1 min and 14.7 min, 87:13 er; **IR** ν_{max} (film)/cm⁻¹ 3628 (O-H), 2953 (C-H), 1757 (C=O), 1524 (N-O), 1489 (C=C), 1344 (N-O), 1103 (C-O); **HRMS** (ASAP⁺) C₃₆H₃₉NO₆ ([M]⁺), found 581.2771, requires 581.2783 (-2.1 ppm).

Data for major diastereoisomer: $[\alpha]_D^{20} +85.0$ (*c* 0.1, CHCl₃); ^1H NMR (500 MHz, CDCl₃) δ_{H} : 1.30 (18H, s, (C(3'''))C(CH₃)₃, C(5''')C(CH₃)₃), 3.70 (3H, s, OCH₃), 4.49 (1H, d, *J* 12.1, C(2)H), 4.59 (1H, d, *J* 12.1, C(1')H), 4.99 (1H, s, OH), 6.74 (2H, d, *J* 9.1, ester C(1)OC(2)H,

ester C(1)OC(6)H), 6.78 (2H, s, C(2'')H, C(6'')H), 6.83 (2H, d, *J* 8.7, C(3'')H, C(5'')H), 7.25 (2H, d, *J* 8.7, C(2'')H, C(6'')H), 7.32 (1H, d, *J* 7.4, C(4'')H), 7.41 (2H, t, *J* 7.4, C(3'')H, C(5'')H), 7.56 (2H, d, *J* 7.4, C(2'')H, C(6'')H), 8.14 (2H, d, *J* 9.1, ester C(3)H, ester C(5)H); $^{13}\text{C}\{^1\text{H}\}$ NMR (126 MHz, CDCl_3) δ_{C} : 30.2 (C(3'')C(CH₃)₃, C(5'')C(CH₃)₃), 34.3 (C(3'')C(CH₃)₃, C(5'')C(CH₃)₃), 55.3 (OCH₃), 55.7 (C(1')), 57.2 (C(2)), 113.8 (C(3''), C(5'')), 122.6 (ester C(2), ester C(6)), 124.9 (ester C(3), ester C(5)), 125.1 (C(2''), C(6'')), 127.0 (C(4'')), 128.7 (C(2''), C(6'')), 128.6 (C(3''), C(5'')), 129.7 (C(2''), C(6'')), 131.0 (C(1'')), 133.3 (C(1')), 135.3 (C(3''), C(5'')), 142.6 (C(1'')), 145.1 (ester C(1)OC(4)NO₂), 152.2 (C(4'')), 155.2 (ester C(1)OC(1)), 159.1 (C(4'')), 170.9 (C(1)O).

Data for minor diastereoisomer: $[\alpha]_{\text{D}}^{20} +38.0$ (*c* 0.1, CHCl_3); ^1H NMR (500 MHz, CDCl_3) δ_{H} : 1.44 (18H, s, (C(3'')C(CH₃)₃, C(5'')C(CH₃)₃), 3.78 (3H, s, OCH₃), 4.62 (2H, s, C(2)H, C(1')H), 5.20 (1H, s, OH), 6.57 (2H, d, *J* 9.1, ester C(1)OC(2)H, ester C(1)OC(6)H), 6.81 (2H, d, *J* 8.8, C(2'')H, C(6'')H), 7.06-7.11 (1H, m, C(4'')H), 7.16-7.19 (2H, m, C(3'')H, C(5'')H), 7.18 (2H, s, C(2'')H, C(6'')H), 7.33 (s, C(2'')H, C(6'')H), 7.37 (2H, d, *J* 8.8, C(3'')H, C(5'')H), 8.11 (2H, d, *J* 9.1, ester C(3)H, ester C(5)H); $^{13}\text{C}\{^1\text{H}\}$ NMR (126 MHz, CDCl_3) δ_{C} : 30.2 (C(3'')C(CH₃)₃, C(5'')C(CH₃)₃), 34.5 (C(3'')C(CH₃)₃, C(5'')C(CH₃)₃), 55.1 (OCH₃), 55.8 (C(1')), 57.0 (C(2)), 114.0 (C(2''), C(6'')), 122.6 (ester C(2), ester C(6)), 124.8 (C(2''), C(6'')), 125.0 (ester C(3), ester C(5)), 127.0 (C(4'')), 127.8 (C(1'')), 128.0 (C(3''), C(5'')), 128.4 (C(2''), C(6'')), 129.7 (C(3''), C(5'')), 132.7 (C(1'')), 136.0 (C(3''), C(5'')), 141.3 (C(1'')), 145.1 (ester C(1)OC(4)NO₂), 152.7 (C(4'')), 155.4 (ester C(1)OC(1)), 158.9 (C(4'')), 171.1 (C(1)O).

(2*S*,1'*R*)-4-Nitrophenyl 1-(3''',5'''-di-*tert*-butyl-4'''-hydroxyphenyl)-2-(4''-(trifluoromethyl)phenyl)-1'-phenylpropanoate (27)



By following *General Procedure G*, 4-benzylidene-2,6-di-*tert*-butylcyclohexa-2,5-dien-1-one **5** (74 mg, 0.25 mmol), 4'-nitrophenyl 2-(4''-(trifluoromethyl)phenyl)acetate **22** (122 mg, 0.375 mmol) and (*S*)-TM (2.6 mg, 5 mol%) were dissolved in anhydrous MeCN (0.42 mL). The reaction mixture was stirred at rt for 24 h before being concentrated *in vacuo*. The crude material (55:45 dr) was purified and the diastereoisomers separated by flash silica column

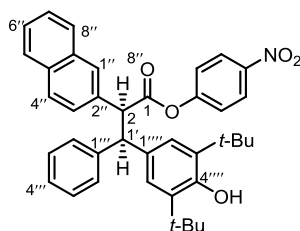
chromatography (petroleum ether/EtOAc, 95:5). The diastereoisomers were obtained as pale yellow solids (combined: 146 mg, 94%).

mp 91-93 °C; **Chiral HPLC analysis**, Chiralpak AD-H (0.8% *i*-PrOH/hexane, flow rate 1.5 mLmin⁻¹, 254 nm, 30 °C), *t_R* major: 28.4 min and 83.8 min, 88:12 er, *t_R* minor: 29.4 min and 42.8 min, 79:21 er; **IR** ν_{max} (film)/cm⁻¹ 3616 (O-H), 2955 (C-H), 1755 (C=O), 1522 (N-O), 1489 (C=C), 1323 (N-O), 1121 (C-O); **HRMS** (ASAP⁻) C₃₆H₃₆F₃NO₅ ([M]), found 619.2540, requires 619.2551 (-1.8 ppm).

Data for major diastereoisomer (88:12 dr): $[\alpha]_D^{20}$ +50.0 (*c* 0.1, CHCl₃); **¹H NMR** (500 MHz, CDCl₃) δ_{H} : 1.25 (18H, s, (C(3'''))C(CH₃)₃, C(5'''))C(CH₃)₃), 4.57 (2H, s, C(2)*H*, C(1')*H*), 4.98 (1H, s, OH), 6.63-6.77 (4H, m, C(2''')*H*, C(6''')*H*, ester C(1)OC(2)*H*, ester C(1)OC(6)*H*), 7.29-7.35 (1H, m, C(4''')*H*), 7.38-7.44 (4H, m, *Ar*), 7.53 (4H, t, *J* 8.6, *Ar*), 8.13 (2H, d, *J* 9.1, ester C(3)*H*, ester C(5)*H*); **¹³C{¹H} NMR** (126 MHz, CDCl₃) δ_{C} : 30.2 (C(3''')C(CH₃)₃, C(5''')C(CH₃)₃), 34.3 (C(3''')C(CH₃)₃, C(5''')C(CH₃)₃), 56.2 (C(1')), 58.0 (C(2')), 122.4 (ester C(2), ester C(6)), 124.9 (ester C(3), ester C(5)), 125.3 (C(2'''), C(6''')), 125.5 (q, ³*J*_{C-F} 3.1, C(3''), C(5'')), 127.4 (C(4''')), 128.2 (*Ar*), 129.0 (*Ar*), 129.2 (*Ar*), 130.5 (C(1''')), 135.8 (C(3'''), C(5''')), 140.6 (C(1'')), 142.0 (ester C(1)OC(4)NO₂), 145.6 (C(1'')), 152.6 (C(4''')), 155.2 (ester C(1)OC(1)), 170.4 (C(1)O); **¹⁹F NMR** (376 MHz, CDCl₃) δ_{F} : -62.7 (CF₃).

Data for minor diastereoisomer (79:21 dr): $[\alpha]_D^{20}$ +16.0 (*c* 0.1, CHCl₃); **¹H NMR** (500 MHz, CDCl₃) δ_{H} : 1.42 (18H, s, (C(3'''))C(CH₃)₃, C(5'''))C(CH₃)₃), 4.62 (1H, d, *J* 12.2, C(2)*H*), 4.73 (1H, d, *J* 12.2, C(1')*H*), 5.20 (1H, s, OH), 6.54 (2H, d, *J* 9.1, ester C(1)OC(2)*H*, ester C(1)OC(6)*H*), 7.06-7.12 (1H, m, C(4''')*H*), 7.13-7.19 (4H, m, C(2''')*H*, C(3''')*H*, C(5''')*H*, C(6''')*H*), 7.31 (2H, s, C(2''')*H*, C(6''')*H*), 7.48-7.54 (2H, m, *J* 8.2, C(2'')*H*, C(6'')*H*), 7.57 (2H, d, *J* 8.3, C(3'')*H*, C(5'')*H*), 8.09 (2H, d, *J* 9.1, ester C(3)*H*, ester C(5)*H*); **¹³C{¹H} NMR** (126 MHz, CDCl₃) δ_{C} : 30.4 (C(3''')C(CH₃)₃, C(5''')C(CH₃)₃), 34.6 (C(3''')C(CH₃)₃, C(5''')C(CH₃)₃), 56.2 (C(1')), 57.7 (C(2')), 122.4 (ester C(2), ester C(6)), 124.9 (C(2'''), C(6''')), 125.2 (ester C(3), ester C(5)), 125.7 (q, ³*J*_{C-F} 3.9, C(3''), C(5'')), 126.9 (*Ar*), 128.0 (*Ar*), 128.7 (*Ar*), 129.3 (C(2''), C(6'')), 132.2 (C(1''')), 136.4 (C(3'''), C(5''')), 140.1 (C(1'')), 140.9 (ester C(1)OC(4)NO₂), 145.6 (C(1'')), 153.1 (C(4''')), 155.3 (ester C(1)OC(1)), 170.5 (C(1)O); **¹⁹F NMR** (376 MHz, CDCl₃) δ_{F} : -62.6 (CF₃).

(2*S*,1'*R*)-4-Nitrophenyl 1-(3''',5'''-di-*tert*-butyl-4'''-hydroxyphenyl)-2-(naphthalen-2''-yl)-1'-phenylpropanoate (28)



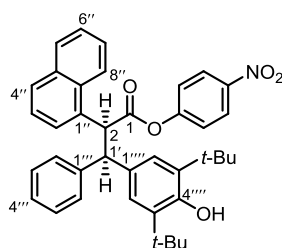
By following *General Procedure G*, 4-benzylidene-2,6-di-*tert*-butylcyclohexa-2,5-dien-1-one **5** (74 mg, 0.25 mmol), 4'-nitrophenyl 2-(naphthalen-2''-yl)acetate **23** (115 mg, 0.375 mmol) and (*S*)-TM (2.6 mg, 5 mol%) were dissolved in anhydrous MeCN (0.42 mL). The reaction mixture was stirred at rt for 24 h before being concentrated *in vacuo*. The crude material (55:45 dr) was purified and the diastereoisomers separated by flash silica column chromatography (petroleum ether/EtOAc, 95:5). The diastereoisomers were obtained as pale yellow solids (combined: 149 mg, 99%).

mp 48-50 °C; **Chiral HPLC analysis**, Chiralpak AD-H (1.5% *i*-PrOH/hexane, flow rate 1.5 mLmin⁻¹, 211 nm, 30 °C), *t*_R major: 27.9 min and 53.4 min, 91:9 er, *t*_R minor: 22.6 min and 36.7 min, 85:15 er; **IR** *v*_{max} (film)/cm⁻¹ 3628 (O–H), 2958 (C–H), 1757 (C=O), 1524 (N–O), 1489 (C=C), 1344 (N–O), 1103 (C–O); **HRMS** (ASAP⁺) C₃₉H₃₉NO₅ ([M]⁺), found 601.2831, requires 601.2835 (−0.7 ppm).

Data for major diastereoisomer: [α]_D²⁰ +93.0 (*c* 0.1, CHCl₃); **¹H NMR** (500 MHz, CDCl₃) δ _H: 1.15 (18H, s, (C(3''')C(CH₃)₃, C(5''')C(CH₃)₃), 4.71 (2H, d, *J* 2.2, C(2)*H*), C(1')*H*), 4.87 (1H, s, OH), 6.74 (2H, d, *J* 9.2, ester C(1)OC(2)*H*, ester C(1)OC(6)*H*), 6.75 (2H, s, C(2''')*H*, C(6''')*H*), 7.31 (1H, t, *J* 7.4, C(4'')*H*), 7.42 (2H, d, *J* 7.7, Ar), 7.44-7.47 (2H, m, C(3''')*H*, C(5''')*H*), 7.50 (1H, dd, *J* 8.5, 1.8, Ar), 7.59 (2H, d, *J* 7.2, C(2''')*H*, C(6''')*H*), 7.69 (1H, s, Ar), 7.72 (1H, dd, *J* 6.0, 3.4, Ar), 7.76 (1H, d, *J* 8.5, Ar), 7.79 (1H, dd, *J* 6.1, 3.4, Ar), 8.12 (2H, d, *J* 9.1, ester C(3)*H*, ester C(5)*H*); **¹³C{¹H} NMR** (126 MHz, CDCl₃) δ _C: 30.1 (C(3''')C(CH₃)₃, C(5''')C(CH₃)₃), 34.2 (C(3''')C(CH₃)₃, C(5''')C(CH₃)₃), 55.8 (C(1')), 58.2 (C(2)), 122.5 (ester C(2), ester C(6)), 125.0 (ester C(3), ester C(5)), 125.2 (C(2'''), C(6''')), 126.2 (Ar), 126.3 (Ar), 126.4 (Ar), 127.1 (C(4'')), 127.6 (Ar), 127.9 (Ar), 128.3 (C(2''), C(6'')), 128.4 (Ar), 128.4 (Ar), 128.9 (C(3''), C(5'')), 131.1 (C(4''a)), 132.9 (C(8''a)), 133.4 (C(1'')), 133.8 (C(2'')), 135.5 (C(3''), C(5'')), 142.6 (C(3'')), 145.5 (ester C(1)OC(4)NO₂), 152.3 (C(4'')), 155.4 (ester C(1)OC(1)), 171.0 (C(1)O).

Data for minor diastereoisomer: $[\alpha]_D^{20} +38.0$ (c 0.1, CHCl_3); $^1\text{H NMR}$ (500 MHz, CDCl_3) δ_{H} : 1.46 (18H, s, $(\text{C}(3''''')\text{C}(\text{CH}_3)_3, \text{C}(5''''')\text{C}(\text{CH}_3)_3)$, 4.80 (1H, d, J 12.2, $\text{C}(2)H$), 4.87 (1H, d, J 12.2, $\text{C}(1')H$), 5.22 (1H, s, OH), 6.57 (2H, d, J 9.1, ester $\text{C}(1)\text{OC}(2)H$, ester $\text{C}(1)\text{OC}(6)H$), 7.03 (1H, t, J 7.4, $\text{C}(4''')H$), 7.12 (2H, t, J 7.4, $\text{C}(3''')H$, $\text{C}(5''')H$), 7.22 (2H, t, J 7.4, $\text{C}(2''')H$, $\text{C}(6''')H$), 7.38 (2H, s, $\text{C}(2''''')H$, $\text{C}(6''''')H$), 7.48 (2H, t, J 4.2, Ar), 7.52 (1H, dd, J 8.5, 1.7, Ar), 7.77-7.82 (3H, m, Ar), 7.92 (1H, s, Ar), 8.10 (2H, d, J 9.1, ester $\text{C}(3)H$, ester $\text{C}(5)H$); $^{13}\text{C}\{^1\text{H}\}$ **NMR** (126 MHz, CDCl_3) δ_{C} : 30.4 ($\text{C}(3''''')\text{C}(\text{CH}_3)_3$, $\text{C}(5''''')\text{C}(\text{CH}_3)_3$), 34.3 ($\text{C}(3''''')\text{C}(\text{CH}_3)_3$, $\text{C}(5''''')\text{C}(\text{CH}_3)_3$), 51.2 ($\text{C}(1')$), 54.3 ($\text{C}(2)$), 122.4 (ester $\text{C}(2)$, ester $\text{C}(6)$), 124.7 ($\text{C}(2''''')$, $\text{C}(6''''')$), 125.0 (ester $\text{C}(3)$, ester $\text{C}(5)$), 126.2 (Ar), 126.3 (Ar), 126.5 ($\text{C}(4''''')$), 127.6 (Ar), 127.8 (Ar), 127.9 ($\text{C}(2''''')$, $\text{C}(6''''')$), 128.2 (Ar), 128.4 (Ar), 128.5 ($\text{C}(3''''')$, $\text{C}(5''''')$), 132.7 (Ar), 132.8 (Ar), 133.3 (Ar), 133.4 (Ar), 136.0 ($\text{C}(3''''')$, $\text{C}(5''''')$), 141.3 ($\text{C}(3''''')$), 145.3 (ester $\text{C}(1)\text{OC}(4)\text{NO}_2$), 152.7 ($\text{C}(4''''')$), 155.4 (ester $\text{C}(1)\text{OC}(1)$), 170.9 ($\text{C}(1)\text{O}$).

(2*S*,1'*R*)-4-Nitrophenyl 1-(3''',5'''-di-*tert*-butyl-4''''-hydroxyphenyl)-2-(naphthalen-1''-yl)-1'-phenylpropanoate (29)



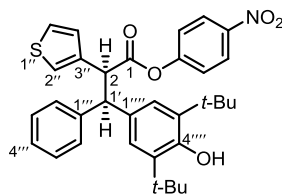
By following *General Procedure G*, 4-benzylidene-2,6-di-*tert*-butylcyclohexa-2,5-dien-1-one **5** (74 mg, 0.25 mmol), 4'-nitrophenyl 2-(naphthalen-1''-yl)acetate **24** (115 mg, 0.375 mmol), (*S*)-TM·HCl (3 mg, 5 mol%) and Et_3N (35 μL , 0.25 mmol) were dissolved in anhydrous MeCN (0.42 mL). The reaction mixture was stirred at rt for 24 h before being concentrated *in vacuo*. The crude material (60:40 dr) was purified and the diastereoisomers separated by flash silica column chromatography (petroleum ether/EtOAc, 95:5). The diastereoisomers were obtained as pale yellow solids (combined: 149 mg, 99%).

mp 54-56 °C; **Chiral HPLC analysis**, Chiralcel OD-H (2% *i*-PrOH/hexane, flow rate 1.5 mLmin⁻¹, 211 nm, 30 °C), t_{R} major: 9.8 min and 21.2 min, 93:7 er, t_{R} minor: 6.1 min and 28.2 min, 94:6 er; **IR** ν_{max} (film)/cm⁻¹ 3620 (O-H), 2957 (C-H), 1757 (C=O), 1524 (N-O), 1489 (C=C), 1344 (N-O), 1105 (C-O); **HRMS** (ASAP⁻) $\text{C}_{39}\text{H}_{39}\text{NO}_5$ ($[\text{M}]^-$), found 601.2828, requires 601.2835 (−1.2 ppm).

Data for major diastereoisomer: $[\alpha]_D^{20} +124$ (c 0.1, CHCl₃); ^1H NMR (500 MHz, CDCl₃) δ_{H} : 1.12 (18H, s, (C(3'''))C(CH₃)₃, C(5'''))C(CH₃)₃), 4.80 (1H, s, OH), 4.86 (1H, d, *J* 11.7, C(2)H), 5.54 (1H, d, *J* 11.7, C(1')H), 6.70 (2H, s, C(2''')H, C(6''')H), 6.79 (2H, d, *J* 9.1, ester C(1)OC(2)H, ester C(1)OC(6)H), 7.37 (1H, t, *J* 7.4, C(4'')H), 7.42 (2H, q, *J* 8.0, 7.4, *Ar*), 7.48 (2H, t, *J* 7.4, C(3'')H, C(5'')H), 7.55 (2H, t, *J* 7.6, *Ar*), 7.69 (2H, d, *J* 7.4, C(2'')H, C(6'')H), 7.78-7.84 (2H, m, *Ar*), 7.94-8.03 (2H, m, C(5'')H, C(8'')H), 8.14 (2H, d, *J* 9.1, ester C(3)H, ester C(5)H); $^{13}\text{C}\{^1\text{H}\}$ NMR (126 MHz, CDCl₃) δ_{C} : 30.6 (C(3'''))C(CH₃)₃, C(5'''))C(CH₃)₃, 33.9 (C(3'''))C(CH₃)₃, C(5'''))C(CH₃)₃, 50.8 (C(1')), 55.9 (C(2)), 122.2 (ester C(2), ester C(6)), 124.8 (*Ar*), 125.0 (ester C(3), ester C(5)), 125.2 (C(2'''), C(6''')), 125.4 (*Ar*), 125.5 (*Ar*), 126.2 (*Ar*), 127.1 (C(4'')), 128.2 (C(2''), C(6'')), 128.4 (*Ar*), 128.7 (*Ar*), 128.9 (C(3''), C(5'')), 130.6 (C(8'')a), 132.1 (C(4'')a), 132.9 (C(1''')), 133.6 (C(1'')), 134.8 (C(3''), C(5'')), 142.6 (C(3'')), 145.1 (ester C(1)OC(4)NO₂), 155.9 (C(4'')), 155.2 (ester C(1)OC(1)), 171.1 (C(1)O).

Data for minor diastereoisomer: $[\alpha]_D^{20} +33.0$ (c 0.1, CHCl₃); ^1H NMR (500 MHz, CDCl₃) δ_{H} : 1.48 (18H, s, (C(3'''))C(CH₃)₃, C(5'''))C(CH₃)₃), 5.04 (1H, d, *J* 12.1, C(2)H), 5.24 (1H, s, OH), 5.66 (1H, d, *J* 12.1, C(1')H), 6.54 (2H, d, *J* 8.6, ester C(1)OC(2)H, ester C(1)OC(6)H), 6.98 (1H, t, *J* 7.5, *Ar*), 7.06 (2H, t, *J* 7.5, *Ar*), 7.21 (2H, d, *J* 7.5, *Ar*), 7.41 (2H, s, C(2''')H, C(6''')H), 7.47 (1H, t, *J* 7.5, *Ar*), 7.52 (1H, t, *J* 7.5, *Ar*), 7.63 (1H, t, *J* 7.5, *Ar*), 7.77 (1H, d, *J* 8.2, *Ar*), 7.87 (1H, d, *J* 8.2, *Ar*), 7.91 (1H, d, *J* 7.5, *Ar*), 8.08 (2H, d, *J* 8.6, ester C(3)H, ester C(5)H), 8.42 (1H, d, *J* 8.6, *Ar*); $^{13}\text{C}\{^1\text{H}\}$ NMR (126 MHz, CDCl₃) δ_{C} : 30.4 (C(3'''))C(CH₃)₃, C(5'''))C(CH₃)₃, 34.3 (C(3'''))C(CH₃)₃, C(5'''))C(CH₃)₃, 51.2 (C(1')), 54.3 (C(2)), 122.4 (ester C(2), ester C(6)), 122.6 (*Ar*), 124.9 (ester C(3), ester C(5)), 125.1 (C(2'''), C(6''')), 125.5 (*Ar*), 125.6 (*Ar*), 126.3 (*Ar*), 126.5 (*Ar*), 127.7 (*Ar*), 128.3 (*Ar*), 129.1 (*Ar*), 131.7 (C(8'')a), 132.1 (C(4'')a), 132.8 (C(1''')), 133.8 (C(1'')), 136.1 (C(3''), C(5'')), 141.3 (C(3'')), 145.3 (ester C(1)OC(4)NO₂), 152.8 (C(4'')), 155.3 (ester C(1)OC(1)), 170.9 (C(1)O).

(2*S*,1'*R*)-4-Nitrophenyl 1-(3''',5'''-di-*tert*-butyl-4'''-hydroxyphenyl)-2-(thiophen-3''-yl)-1'-phenylpropanoate (30)



By following *General Procedure G*, 4-benzylidene-2,6-di-*tert*-butylcyclohexa-2,5-dien-1-one **5** (74 mg, 0.25 mmol), 4'-nitrophenyl 2-(thiophen-3''-yl)acetate **25** (99 mg, 0.375 mmol), (*S*)-TM·HCl (3 mg, 5 mol%) and Et₃N (35 μ L, 0.25 mmol) were dissolved in anhydrous MeCN (0.42 mL). The reaction mixture was stirred at rt for 24 h before being concentrated *in vacuo*. The crude material (55:45 dr) was purified and the diastereoisomers separated by flash silica column chromatography (petroleum ether/EtOAc, 95:5). The diastereoisomers were obtained as pale yellow solids (combined: 131 mg, 94%).

mp 54-56 °C; **Chiral HPLC analysis**, Chiralpak AD-H (1.5% *i*-PrOH/hexane, flow rate 1.5 mLmin⁻¹, 211 nm, 30 °C), *t_R* major: 19.6 min and 28.7 min, 88:12 er, *t_R* minor: 22.6 min and 24.0 min, 90:10 er; **IR** ν_{max} (film)/cm⁻¹ 3612 (O–H), 2955 (C–H), 1759 (C=O), 1524 (N–O), 1489 (C=C), 1344 (N–O), 1107 (C–O); **HRMS** (ASAP⁺) C₃₃H₃₅NO₅S ([M]⁺), found 557.2226, requires 557.2241 (–2.7 ppm).

Data for major diastereoisomer: [α]_D²⁰ +54.0 (*c* 0.1, CHCl₃); **¹H NMR** (400 MHz, CDCl₃) δ_{H} : 1.33 (18H, s, (C(3''')C(CH₃)₃, C(5''')C(CH₃)₃), 4.57 (1H, d, *J* 12.0, C(2)*H*), 4.67 (1H, d, *J* 12.0, C(1')*H*), 5.02 (1H, s, OH), 6.72 (2H, d, *J* 9.1, ester C(1)OC(2)*H*, ester C(1)OC(6)*H*), 6.82 (2H, s, C(2''')*H*, C(6''')*H*), 7.02 (2H, dd, *J* 5.0, 1.2, C(4'')*H*), 7.08 (2H, dd, *J* 2.9, 1.2, C(2'')*H*), 7.23-7.27 (1H, m, C(5'')*H*), 7.32 (1H, d, *J* 7.4, C(4''')*H*), 7.41 (2H, t, *J* 7.4, C(3''')*H*, C(5''')*H*), 7.55 (2H, d, *J* 7.4, C(2'')*H*, C(6'')*H*), 8.15 (2H, d, *J* 9.1, ester C(3)*H*, ester C(5)*H*); **¹³C{¹H} NMR** (101 MHz, CDCl₃) δ_{C} : 30.3 (C(3''')C(CH₃)₃, C(5''')C(CH₃)₃), 34.0 (C(3''')C(CH₃)₃, C(5''')C(CH₃)₃), 53.7 (C(1')), 55.8 (C(2)), 122.3 (ester C(2), ester C(6)), 123.4 (C(2'')), 124.8 (C(2'''), C(6''')), 125.2 (ester C(3), ester C(5)), 125.6 (C(5'')), 127.0 (C(4''')), 127.5 (C(4'')), 128.2 (C(2''), C(6'')), 128.7 (C(3''), C(5'')), 131.1 (C(3'')), 135.4 (C(3'''), C(5''')), 136.5 (ester C(1)OC(4)NO₂), 142.2 (C(3''')), 145.2 (C(1''')), 152.2 (C(4''')), 155.0 (ester C(1)OC(1)), 170.3 (C(1)O).

Data for minor diastereoisomer: [α]_D²⁰ +35.0 (*c* 0.1, CHCl₃); **¹H NMR** (400 MHz, CDCl₃) δ_{H} : 1.44 (18H, s, (C(3''')C(CH₃)₃, C(5''')C(CH₃)₃), 4.56 (1H, d, *J* 12.1, C(2)*H*), 4.81 (1H, d, *J* 12.1, C(1')*H*), 5.20 (1H, s, OH), 6.56 (2H, d, *J* 9.2, ester C(1)OC(2)*H*, ester C(1)OC(6)*H*), 7.11-7.16 (2H, m, *Ar*), 7.17-7.22 (5H, m, *Ar*), 7.24 (1H, dd, *J* 5.0, 3.0, *Ar*), 7.34 (2H, s,

C(2''')H, C(6''')H), 8.11 (2H, d, *J* 9.2, ester C(3)H, ester C(5)H); $^{13}\text{C}\{^1\text{H}\}$ NMR (101 MHz, CDCl_3) δ_{C} : 30.1 (C(3''')C(CH₃)₃, C(5''')C(CH₃)₃), 34.3 (C(3'')C(CH₃)₃, C(5'')C(CH₃)₃), 53.3 (C(1')), 56.1 (C(2)), 122.5 (ester C(2), ester C(6)), 123.6 (*Ar*), 124.8 (C(2'''), C(6''')), 125.0 (ester C(3), ester C(5)), 125.8 (*Ar*), 126.5 (*Ar*), 127.3 (*Ar*), 127.9 (*Ar*), 128.4 (*Ar*), 132.3 (C(3'')), 136.1 (C(3'''), C(5''')), 136.2 (ester C(1)OC(4)NO₂), 141.3 (C(3'')), 145.2 (C(1''')), 152.7 (C(4''')), 155.2 (ester C(1)OC(1)), 170.5 (C(1)O).

Additional Reaction Optimization Tables

Solvent Screen:

Reaction scheme showing the conversion of starting materials **1** (1.5 equiv.) and **5** (1.0 equiv.) to products **7** and **8** using catalyst **6** (20 mol%) and *i*-Pr₂NEt (1.5 equiv.) in solvent at r.t. for 24 h, followed by BnNH₂ (5.0 equiv.) at r.t. for 12 h.

Entry	Solvent	Yield (%)	dr (7:8)	er (7)	er (8)
1	PhMe	0	-	-	-
2	CH ₂ Cl ₂	0	-	-	-
3	THF	0	-	-	-
4	CHCl ₃	0	-	-	-
5	1,4-Dioxane	0	-	-	-
6	MeCN	82	53:47	97:3	94:6
7	DMF	93	50:50	93:7	85:15

Table S1. Solvent screen. Isolated yield is a mixture of diastereoisomers **7** and **8**; dr determined by ¹H NMR spectroscopic analysis of the crude reaction mixture; er determined by chiral stationary phase (CSP) HPLC analysis: **7** (2*S*,1'*R*:2*R*,1'*S*) and **8** (2*S*,1'*S*:2*R*,1'*R*).

Solvent/Catalyst Screen:

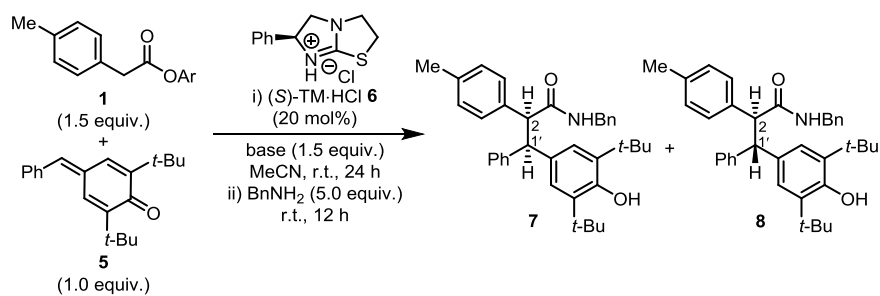
Reaction scheme showing the conversion of starting materials **1** (1.5 equiv.) and **5** (1.0 equiv.) to products **7** and **8** using catalyst (20 mol%) and *i*-Pr₂NEt (1.5 equiv.) in solvent at r.t. for 24 h, followed by BnNH₂ (5.0 equiv.) at r.t. for 12 h.

Chemical structures of catalysts **6**, **(S)-BTM**, and **(2*R*,3*S*)-HyperBTM**.

Entry	Catalyst	Solvent	Yield (%)	dr (7:8)	er (7)	er (8)
1	-	MeCN	0	-	-	-
2	-	DMF	84	65:35	50:50	50:50
3	6	MeCN	82	55:45	97:3	94:6
4	6	DMF	93	50:50	93:7	85:15
5	BTM	MeCN	64	60:40	98:2	93:7
6	BTM	DMF	98	55:45	90:10	77:23
7	HyperBTM	MeCN	4	55:45	70:30	69:31
8	HyperBTM	DMF	62	60:40	68:32	62:38

Table S2. Solvent/Catalyst screen. Isolated yield is a mixture of diastereoisomers **7** and **8**; dr determined by ¹H NMR spectroscopic analysis of the crude reaction mixture; er determined by chiral stationary phase (CSP) HPLC analysis: **7** (2*S*,1'*R*:2*R*,1'*S*) and **8** (2*S*,1'*S*:2*R*,1'*R*).

Base Screen:



Entry	Base	Yield (%)	dr (7:8)	er (7)	er (8)
1	<i>i</i> -Pr ₂ NEt	82	55:45	97:3	94:6
2	<i>i</i> -Pr ₂ NH	16	55:45	96:4	94:6
3	Et ₃ N	98	60:40	97:3	94:6
4	DBU	70	60:40	76:24	81:19
5	DABCO	99	60:40	80:20	71:29
6	K ₃ PO ₄	71	55:45	86:14	83:17
7	Cs ₂ CO ₃	83	55:45	80:20	85:15
8	Na ₂ CO ₃	87	60:40	97:3	96:4
9	K ₂ CO ₃	99	60:40	96:4	91:9

Table S3. Base screen. Isolated yield is a mixture of diastereoisomers **7** and **8**; dr determined by ¹H NMR spectroscopic analysis of the crude reaction mixture; er determined by chiral stationary phase (CSP) HPLC analysis: **7** (2*S*,1'*R*:2*R*,1'*S*) and **8** (2*S*,1'*S*:2*R*,1'*R*).

Control Reactions

(a) PNP ester product (19 and 20) epimerization studies (Scheme 2)

A control reaction was conducted individually on diastereoisomers **19** and **20** to check for any change in dr (*via* epimerization) under the catalysis conditions. The diastereoisomers **19** and **20** were added to separate NMR tubes and dissolved in CD₃CN (0.18 M). At room temperature, *i*-Pr₂NEt (1.5 equiv.) was added to each sample. After 5 h, there was no change in ¹H NMR of either diastereoisomer. Therefore, **6** (20 mol%) was added and the mixture left for a further 15 h. Again, there was no evidence of epimerization. To mimic the aryloxide expected to be present under reaction conditions, tetrabutylammonium 4-nitrophenoxide (0.2 equiv.) was added. After a further 7 h, still no change in dr was observed. Addition of BnNH₂ (5.0 equiv.) formed the corresponding amide products **7** and **8** (from PNP esters **19** and **20**), each as a single diastereoisomer. Overall, sequential addition of the reagents under reaction conditions did not lead to formation of the opposite diastereoisomer in either case. This is consistent with no epimerization of the diastereoisomers **19** and **20** under the reaction conditions, and therefore the crude dr is representative of the kinetic dr of the reaction.

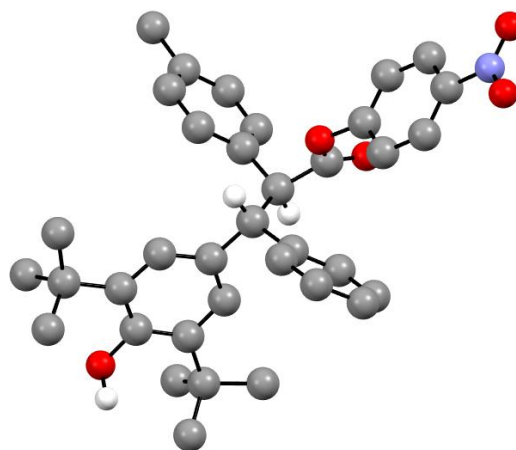
(b) Reagent compatibility

A series of control reactions were conducted to investigate reagent compatibility. Firstly, *p*-QM **5** (1.0 equiv.) was mixed with free base tetramisole **6** (1.0 equiv.) and stirred in CD₃CN at room temperature for 24 h. Only *p*-QM **5** and tetramisole **6** were observed, with no indication of any new species by ¹H NMR spectroscopic analysis. Next, *p*-QM **5** (1.0 equiv.) was mixed with tetrabutylammonium 4-nitrophenoxide (1.0 equiv.) and stirred in CD₃CN at room temperature for 24 h. ¹H NMR spectroscopy revealed only *p*-QM **5** and tetrabutylammonium 4-nitrophenoxide were present suggesting no side reactions between the *p*-QM **5** and the phenoxide counterion were taking place. These control reactions help explain the success of the aryloxide-promoted catalyst turnover concept since the reagents involved are compatible.

X-Ray Crystal Structure Information for 19

X-ray diffraction data were collected at 173 K using a Rigaku MM-007HF High Brilliance RA generator/confocal optics with XtaLAB P100 diffractometer [Cu K α radiation (λ = 1.54187 Å)]. Data were collected using CrystalClear^[6] and processed (including correction for Lorentz, polarization and absorption) using CrysAlisPro.^[7] Structures were solved by dual-space (SHELXT^[8]), direct (SIR2011^[9]) or charge-flipping (Superflip^[10]) methods and refined by full-matrix least-squares against F^2 (SHELXL-2018/3^[11]). Non-hydrogen atoms were refined anisotropically, and all hydrogen atoms were refined using a riding model. All calculations were performed using the CrystalStructure^[12] interface.

(2<i>S</i>,1'<i>R</i>)-19	
CCDC	1992504
empirical formula	C ₃₆ H ₃₉ NO ₅
fw	565.71
crystal description	colourless prism
crystal size [mm]	0.10×0.10×0.10
space group	<i>P</i> 1 (#1)
<i>a</i> [Å]	11.8586(2)
<i>b</i> [Å]	11.9458(3)
<i>c</i> [Å]	12.2838(3)
vol [Å] ³	1562.80(6)
α [°]	75.9529(19)
β [°]	72.0808(19)
γ [°]	73.2733(18)
<i>Z</i>	2
ρ (calc) [g/cm ³]	1.202
μ [mm ⁻¹]	0.635
F(000)	604
reflections collected	15725
independent reflections (R_{int})	7160 (0.0270)
data/parameters	7160/760
GOF on F^2	1.133
R_1 [$I > 2\sigma(I)$]	0.0542
wR_2 (all data)	0.1210
largest diff. peak/hole [e/Å ³]	0.45, -0.52
Flack parameter	-0.04(18)

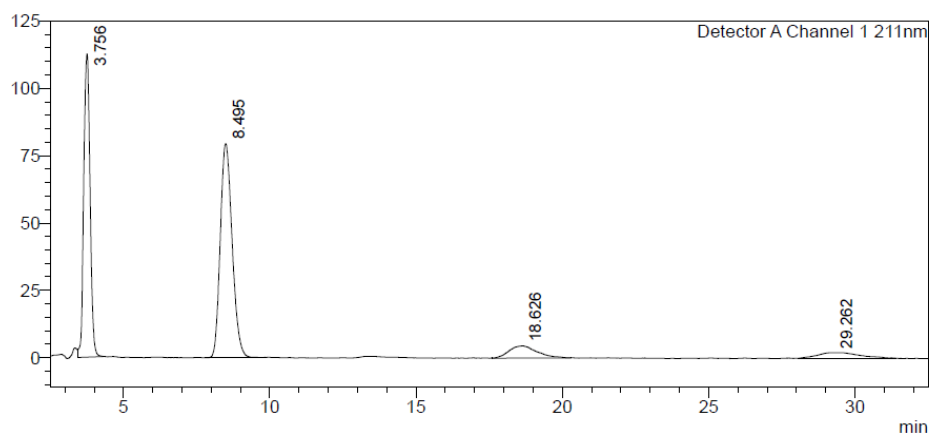
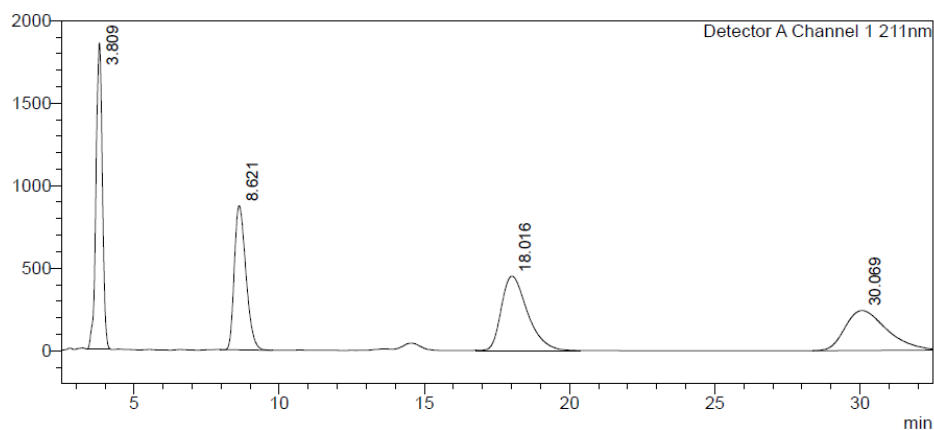
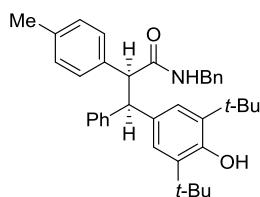


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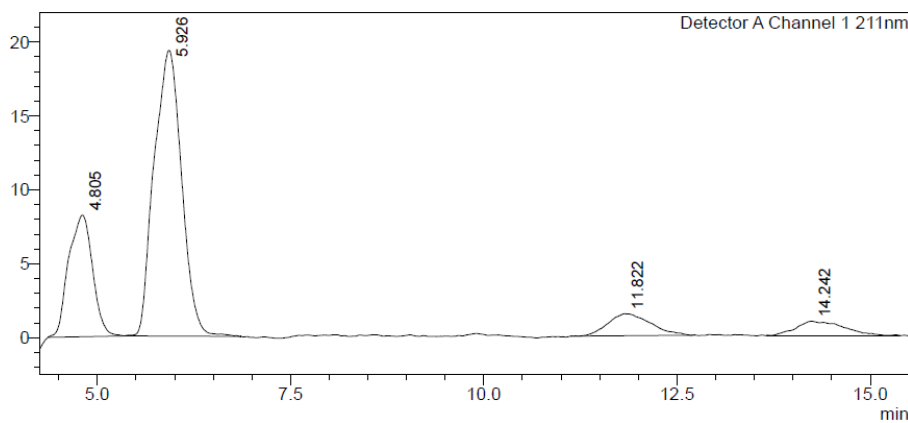
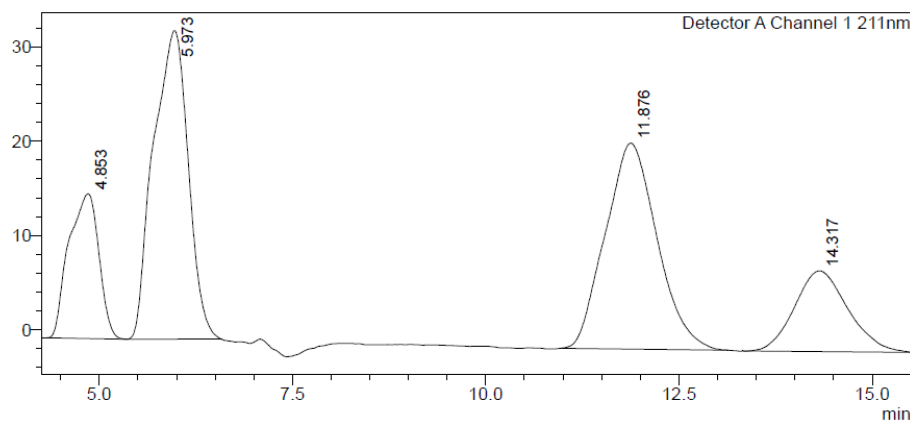
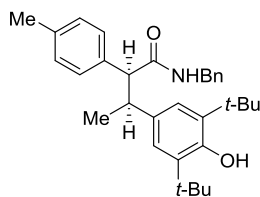
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HPLC Traces

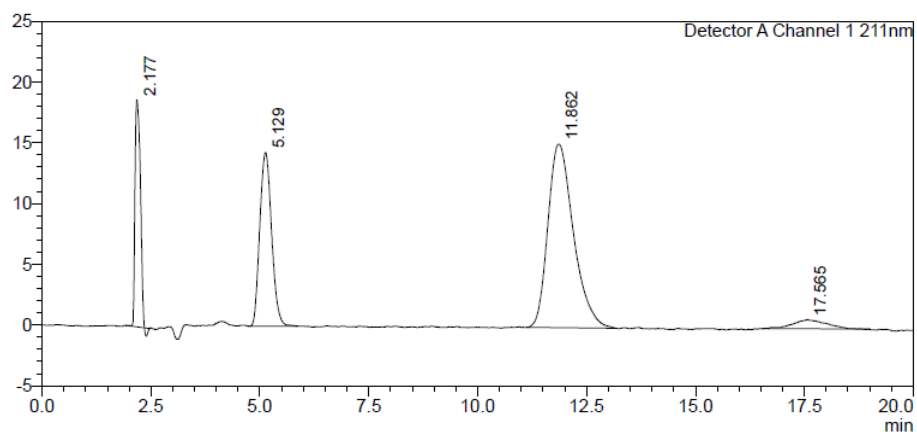
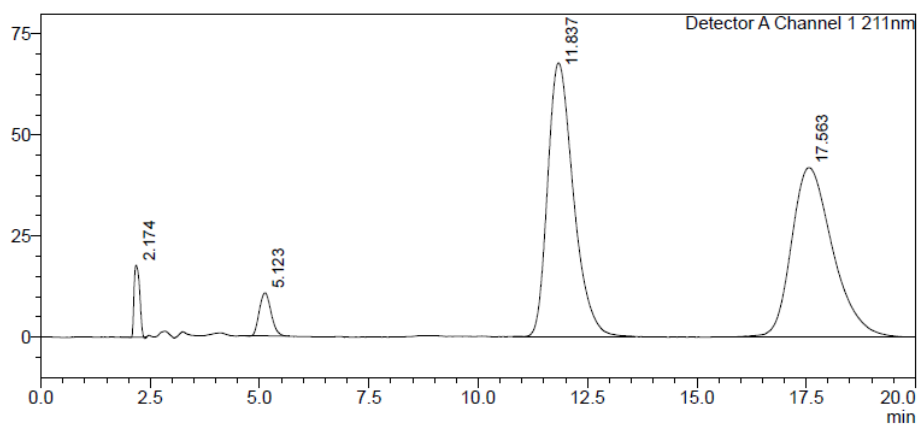
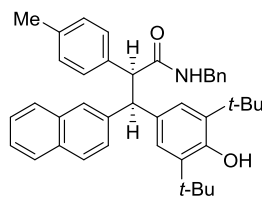
HPLC data for **7 & 8** (Table 1, entry 8): Chiralpak AD-H (10% *i*-PrOH/hexane, flow rate 1.5 mLmin⁻¹, 211 nm, 40 °C), *t*_R major: 8.5 min and 29.3 min, 92:8 er, *t*_R minor: 3.8 min and 18.6 min, 85:15 er.



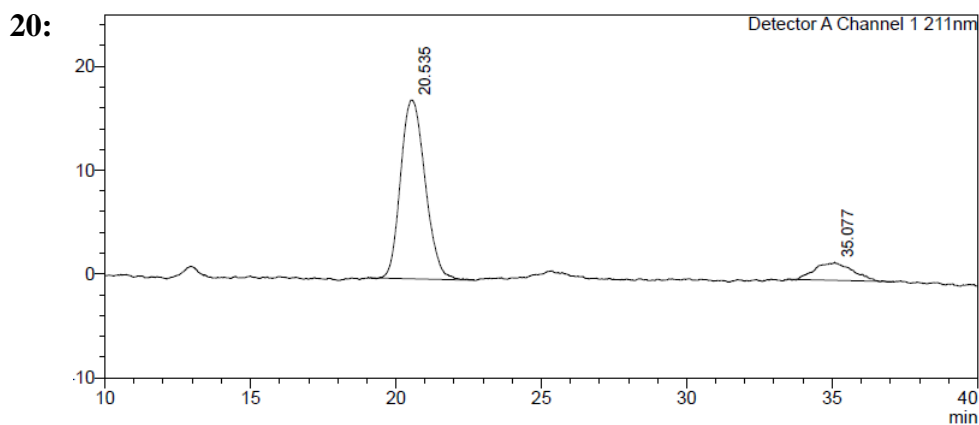
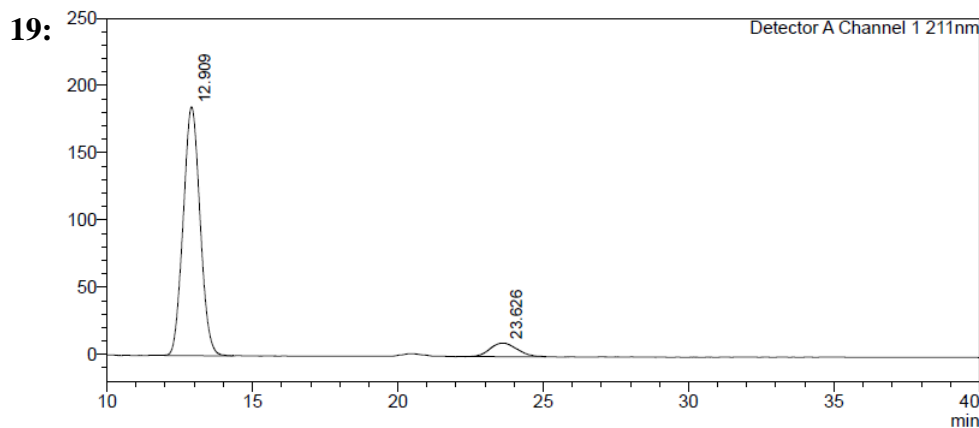
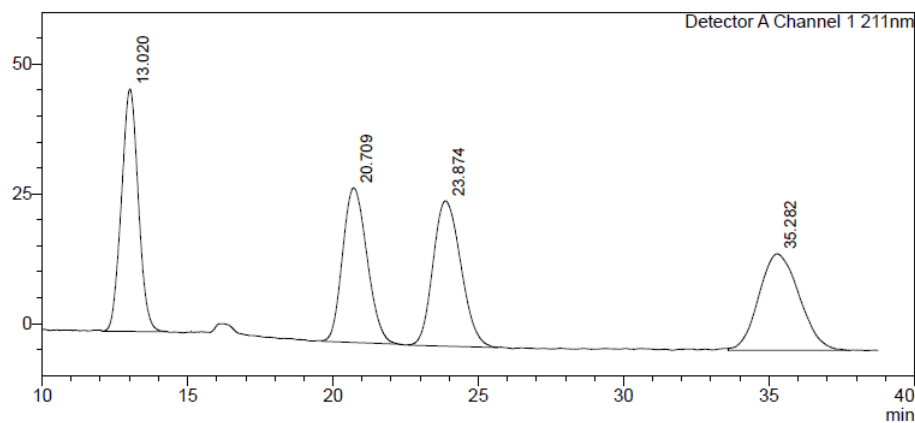
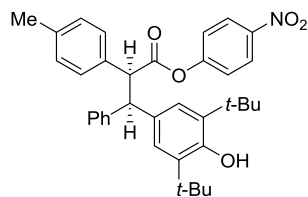
HPLC data for **17**: Chiralpak AD-H (5% *i*-PrOH/hexane, flow rate 1.5 mLmin⁻¹, 211 nm, 40 °C), *t*_R major: 5.9 min and 11.8 min, 89:11 er, *t*_R minor: 4.8 min and 14.2 min, 81:19 er.



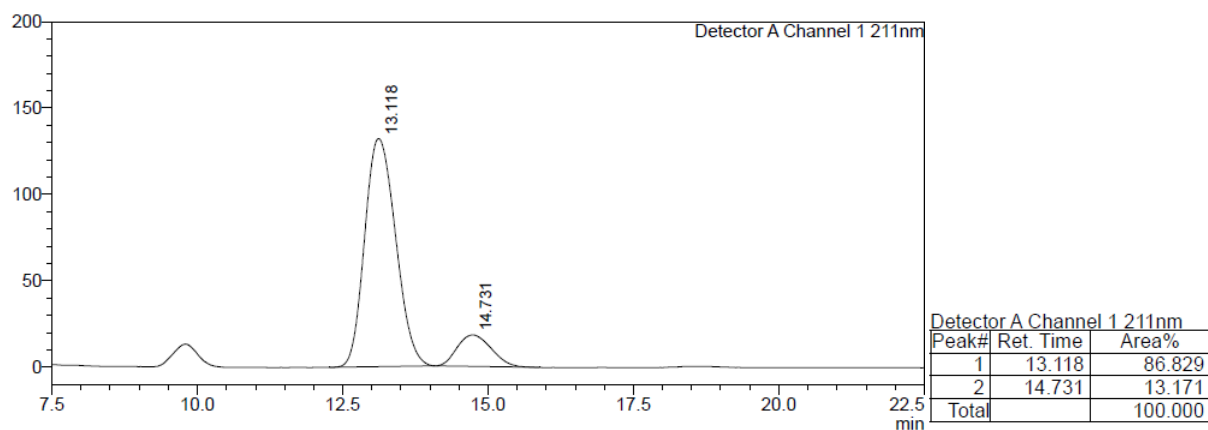
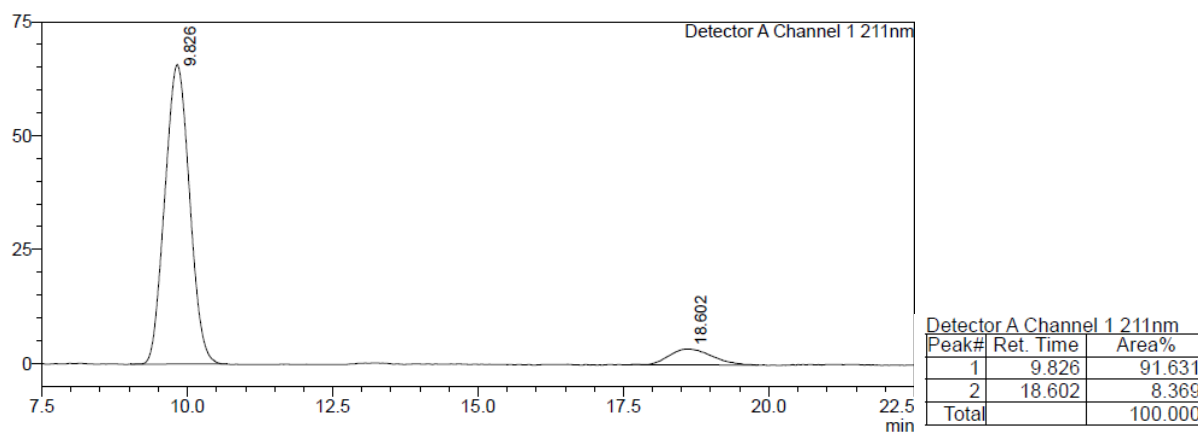
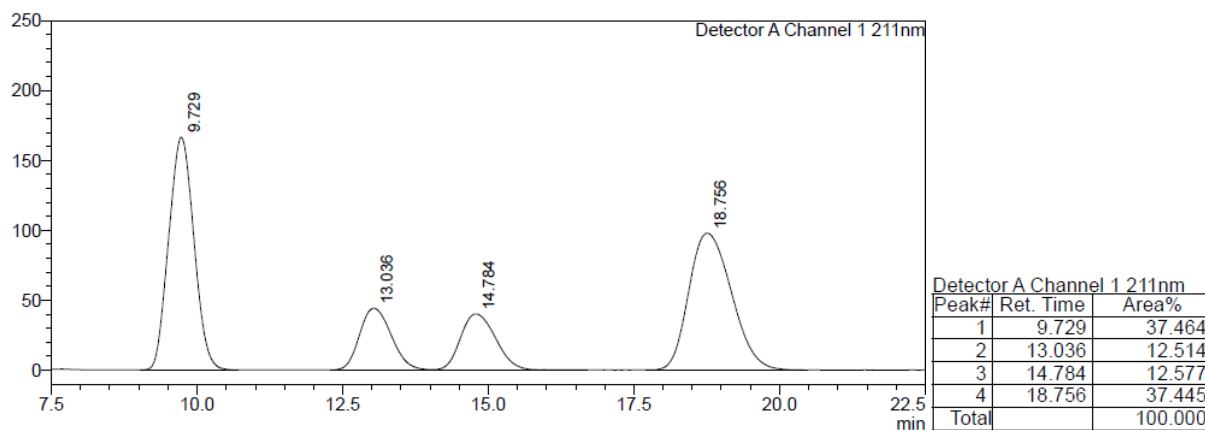
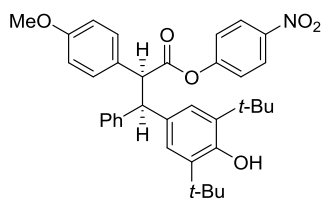
HPLC data for **18**: Chiralpak AD-H (10% *i*-PrOH/hexane, flow rate 1.5 mLmin⁻¹, 211 nm, 40 °C), *t*_R major: 11.9 min and 17.6 min, 94:6 er, *t*_R minor: 2.2 min and 5.1 min, 63:37 er.



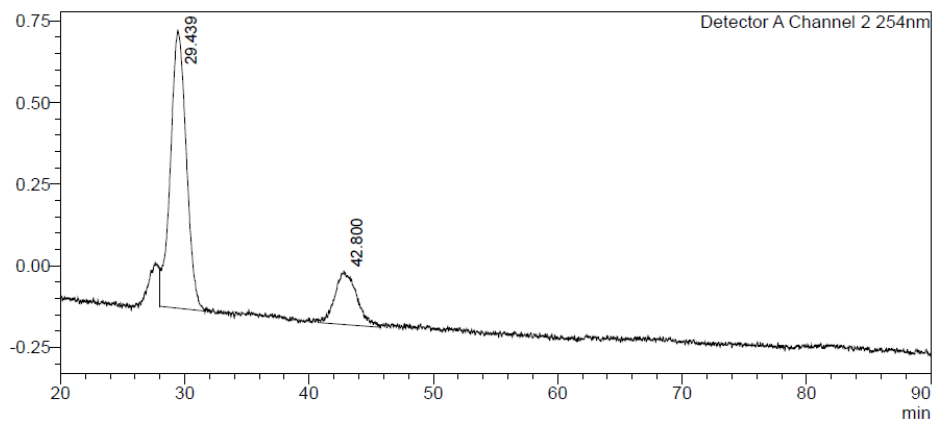
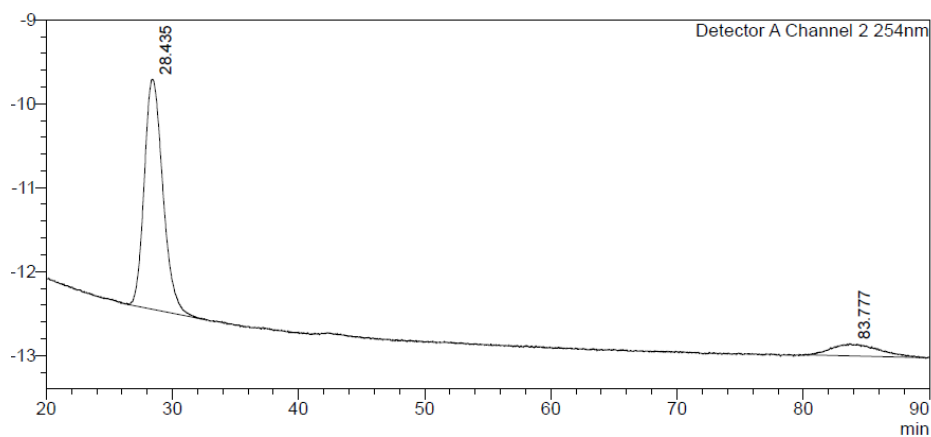
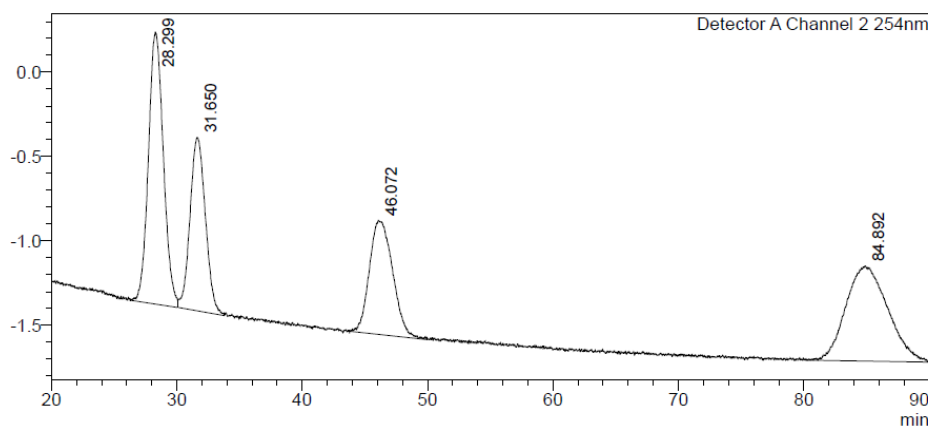
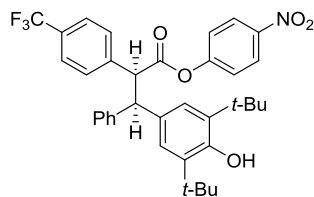
HPLC data for **19** & **20**: Chiralpak AD-H (2% *i*-PrOH/hexane, flow rate 1.5 mLmin⁻¹, 211 nm, 30 °C), *t*_R major: 12.9 min and 23.6 min, 92:8 er, *t*_R minor: 20.5 min and 35.1 min, 87:13 er.



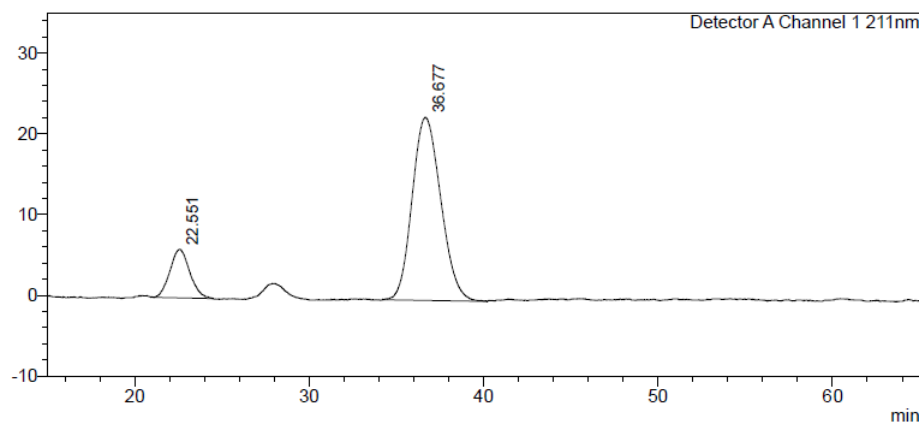
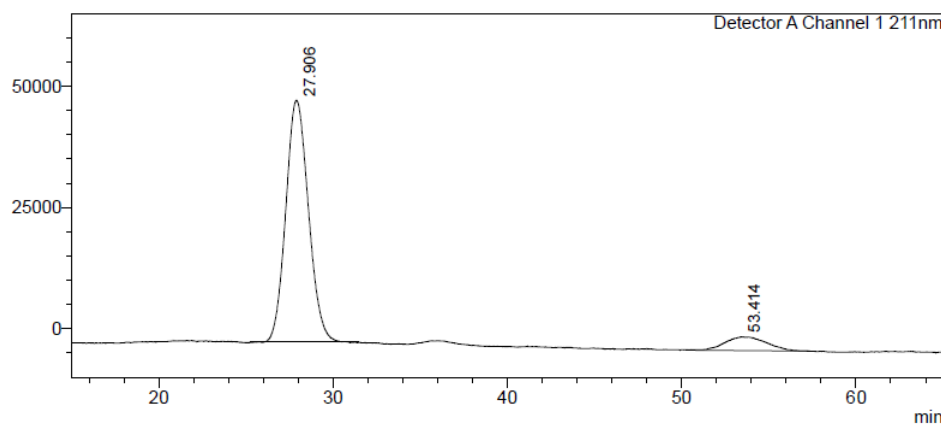
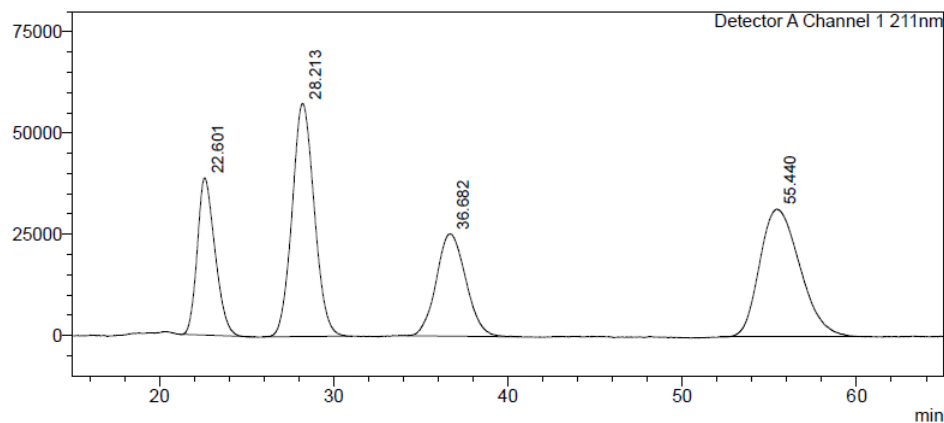
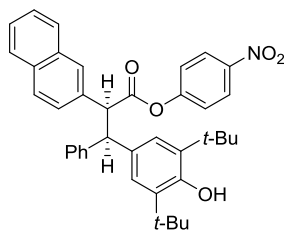
HPLC data for **26**: Chiralpak AD-H (4.5% *i*-PrOH/hexane, flow rate 1.5 mLmin⁻¹, 211 nm, 40 °C), *t*_R major: 9.8 min and 18.6 min, 92:8 er, *t*_R minor: 13.1 min and 14.7 min, 87:13 er.



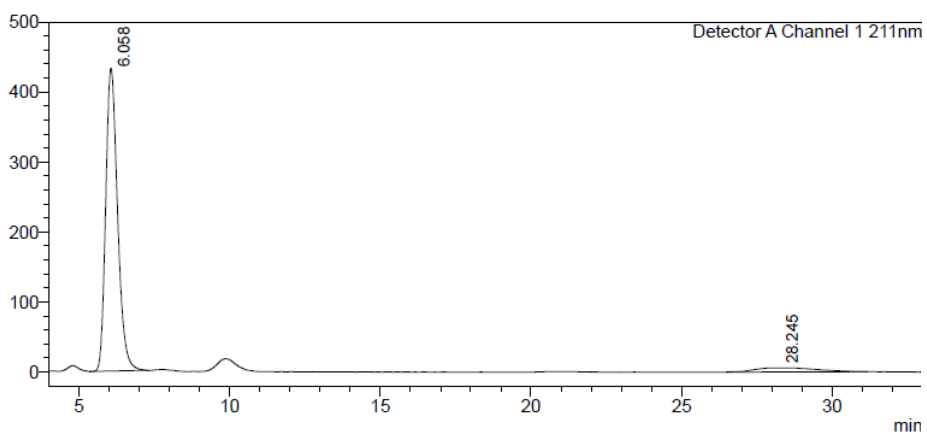
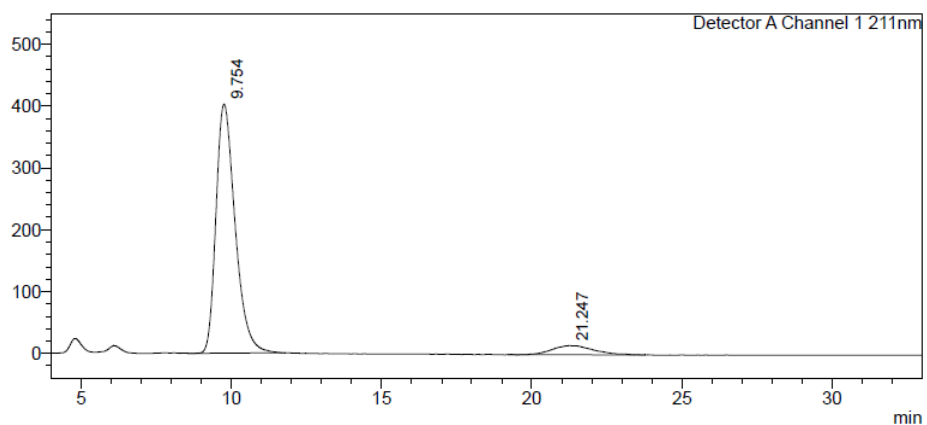
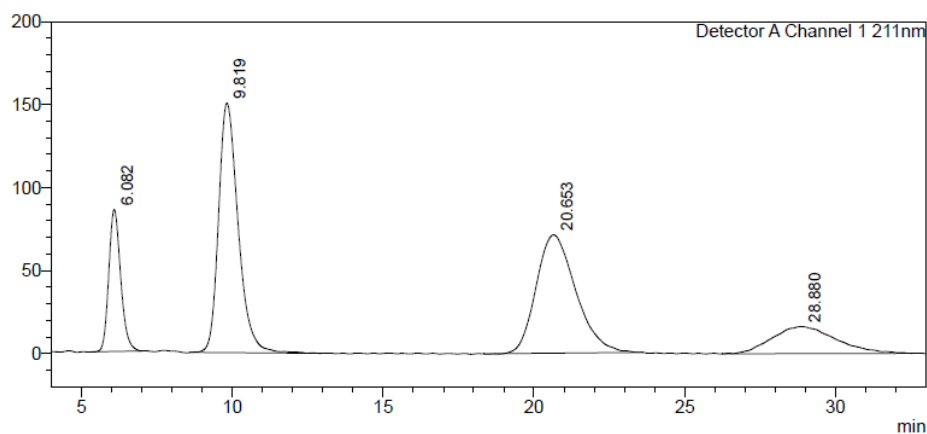
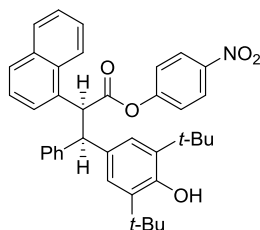
HPLC data for **27**: Chiralpak AD-H (0.8% *i*-PrOH/hexane, flow rate 1.5 mLmin⁻¹, 254 nm, 30 °C), *t*_R major: 28.4 min and 83.8 min, 88:12 er, *t*_R minor: 29.4 min and 42.8 min, 79:21 er.



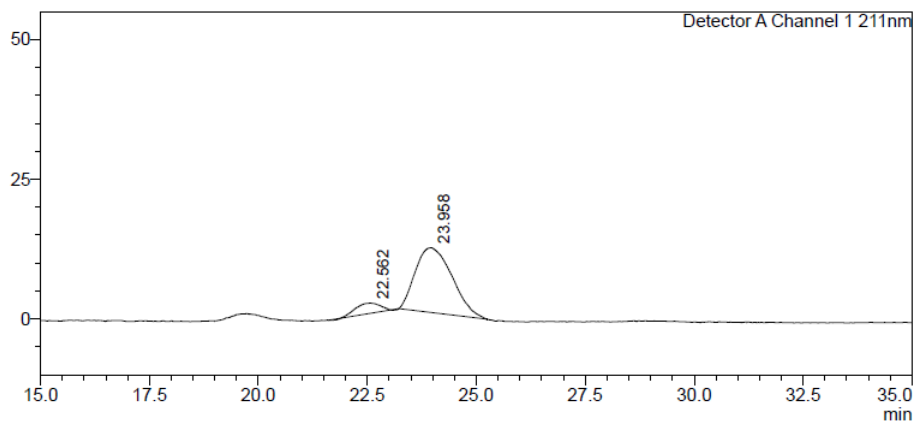
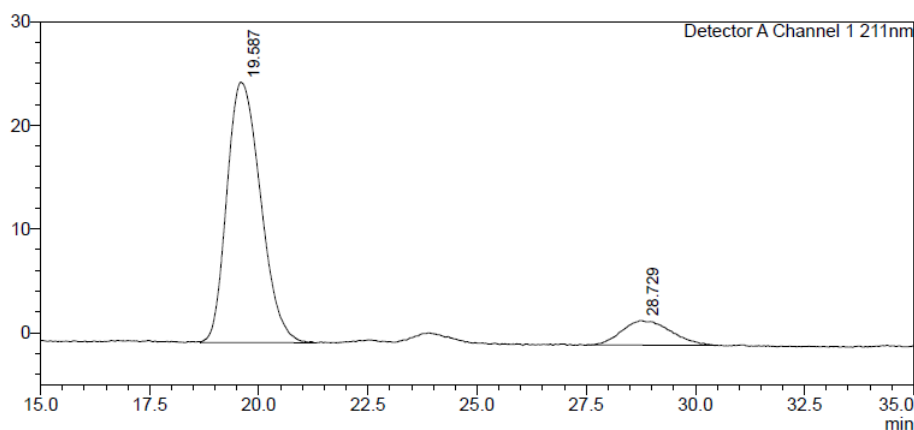
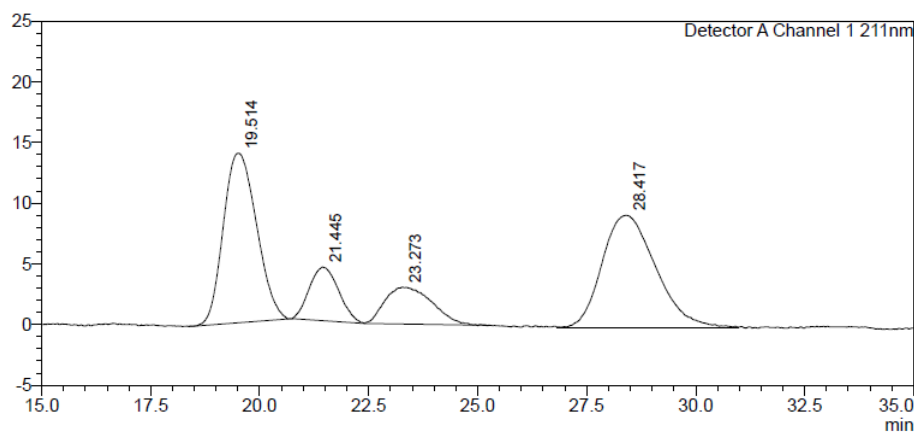
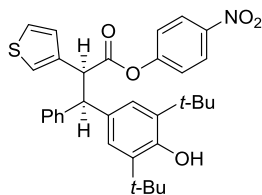
HPLC data for **28**: Chiralpak AD-H (1.5% *i*-PrOH/hexane, flow rate 1.5 mLmin⁻¹, 211 nm, 30 °C), *t*_R major: 27.9 min and 53.4 min, 91:9 er, *t*_R minor: 22.6 min and 36.7 min, 85:15 er.

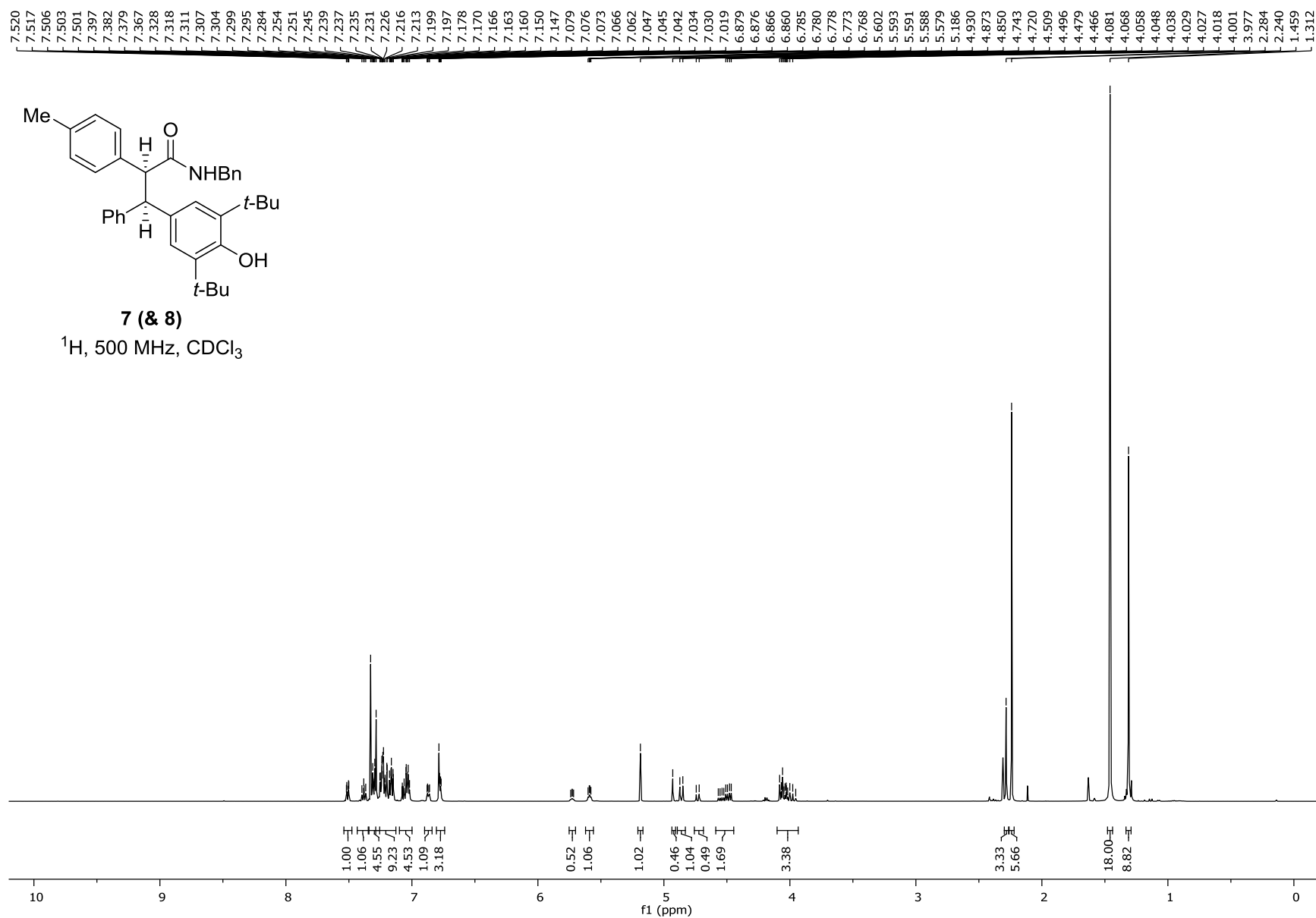


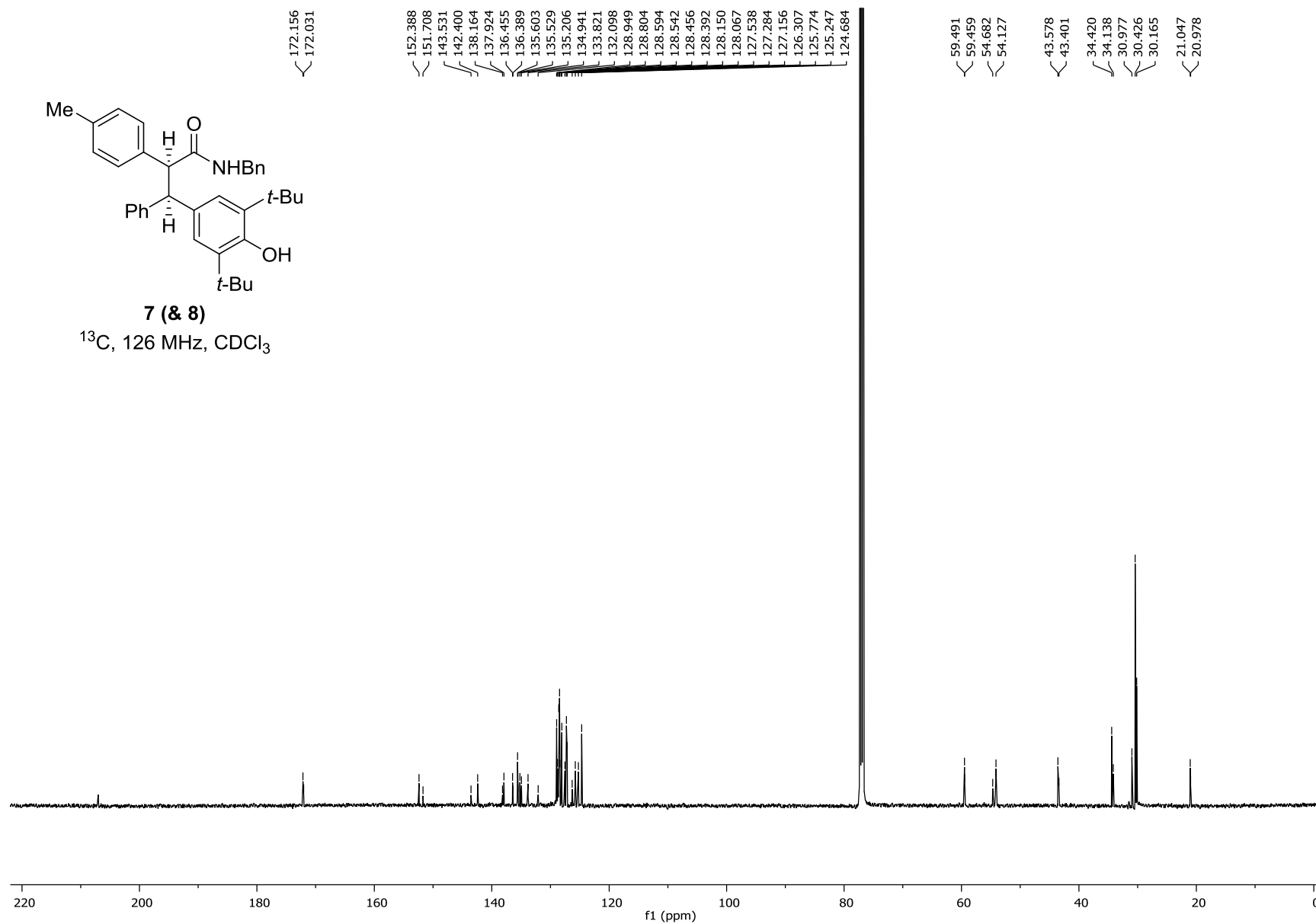
HPLC data for **29**: Chiralcel OD-H (2% *i*-PrOH/hexane, flow rate 1.5 mLmin⁻¹, 211 nm, 30 °C), *t*_R major: 9.8 min and 21.2 min, 93:7 er, *t*_R minor: 6.1 min and 28.2 min, 94:6 er.

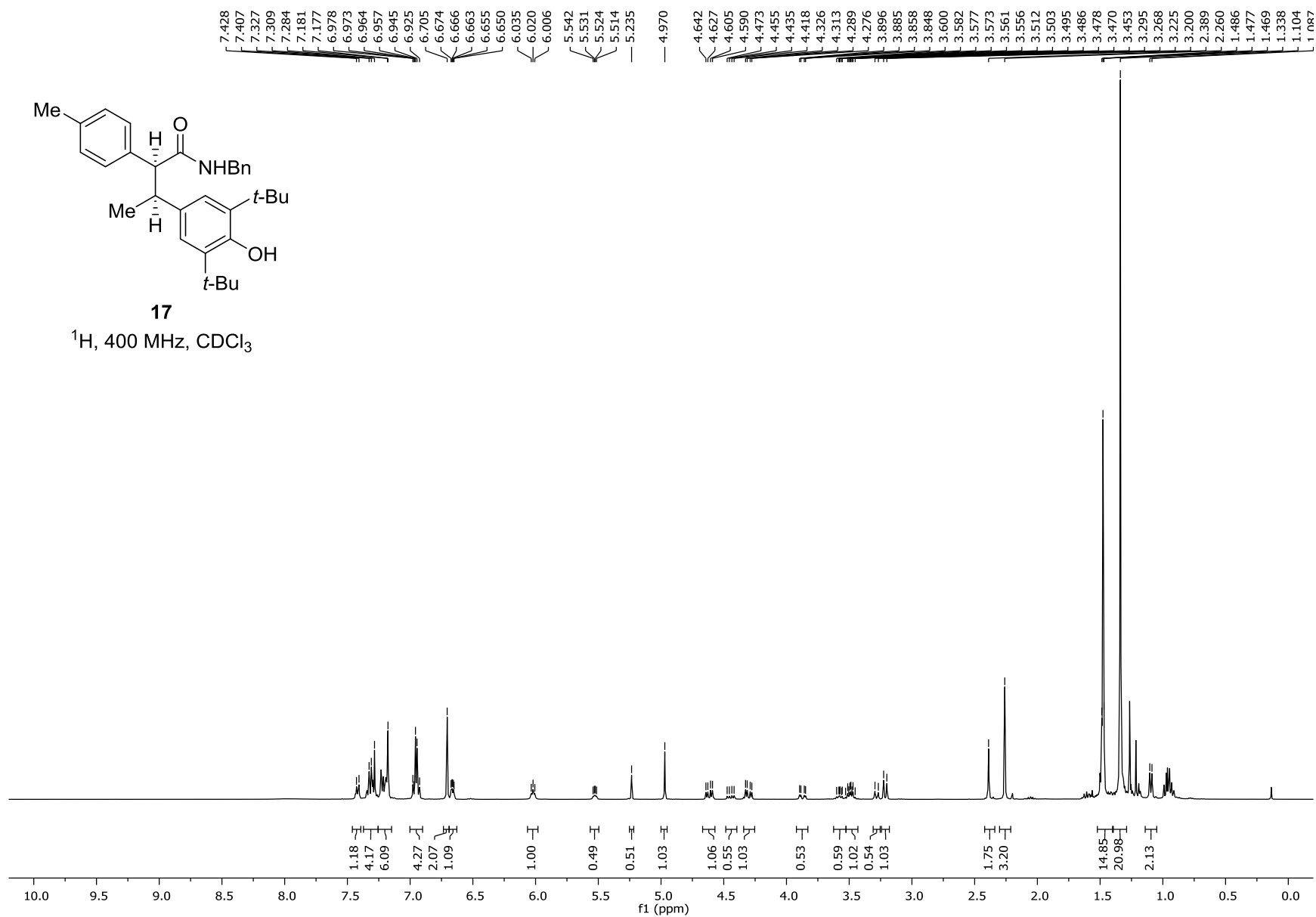


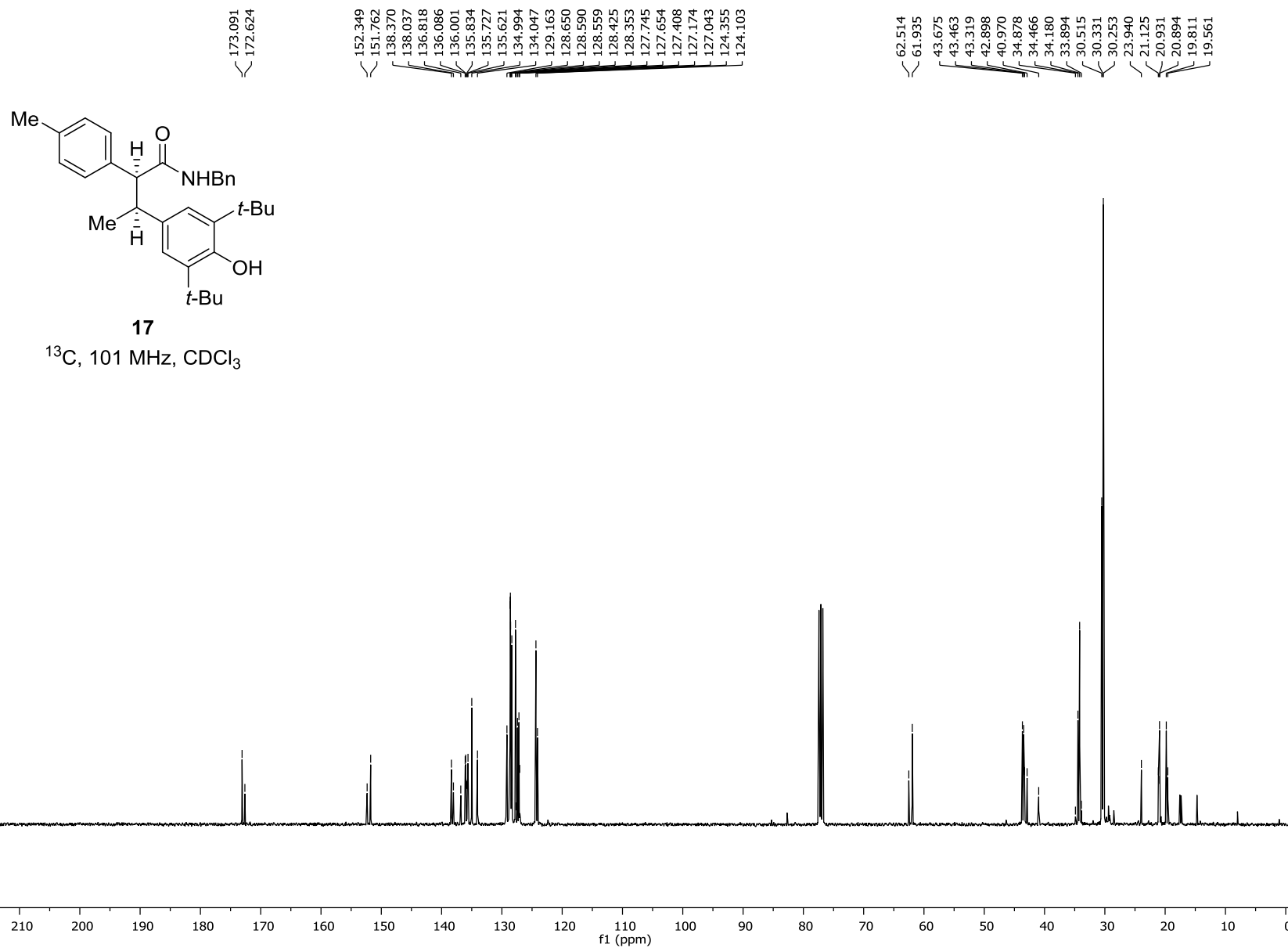
HPLC data for **30**: Chiralpak AD-H (1.5% *i*-PrOH/hexane, flow rate 1.5 mLmin⁻¹, 211 nm, 30 °C), *t*_R major: 19.6 min and 28.7 min, 88:12 er, *t*_R minor: 22.6 min and 24.0 min, 90:10 er.

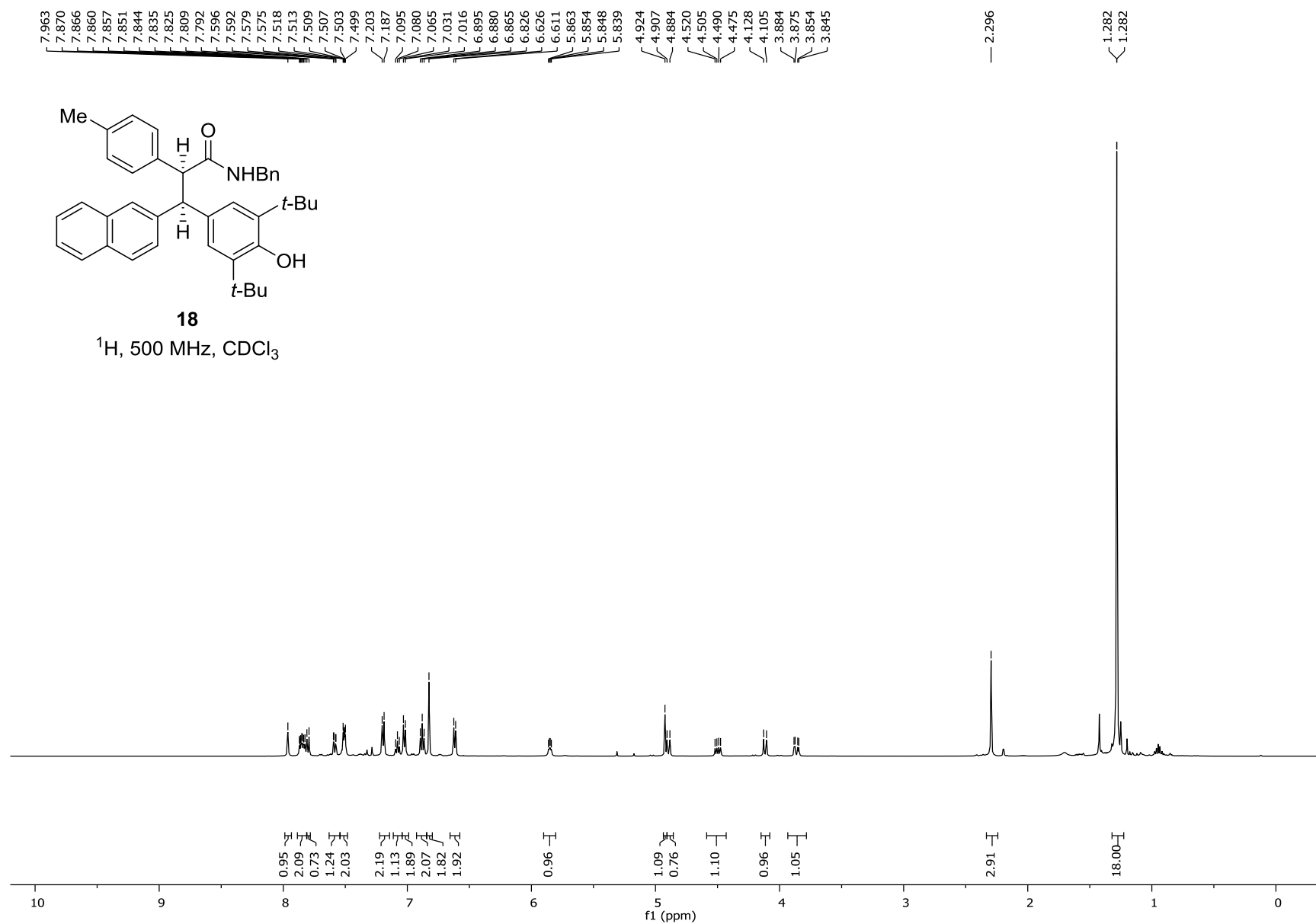


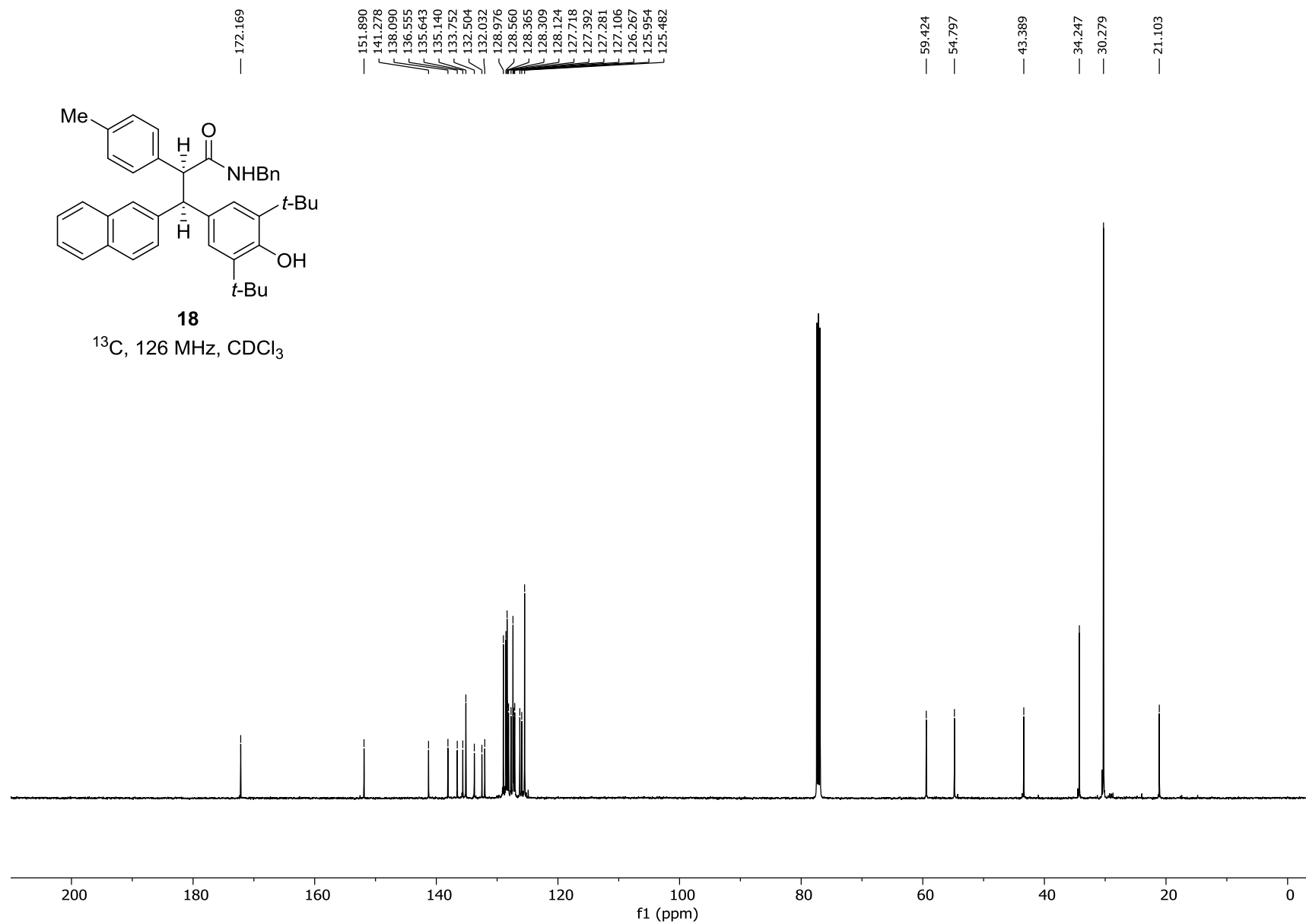


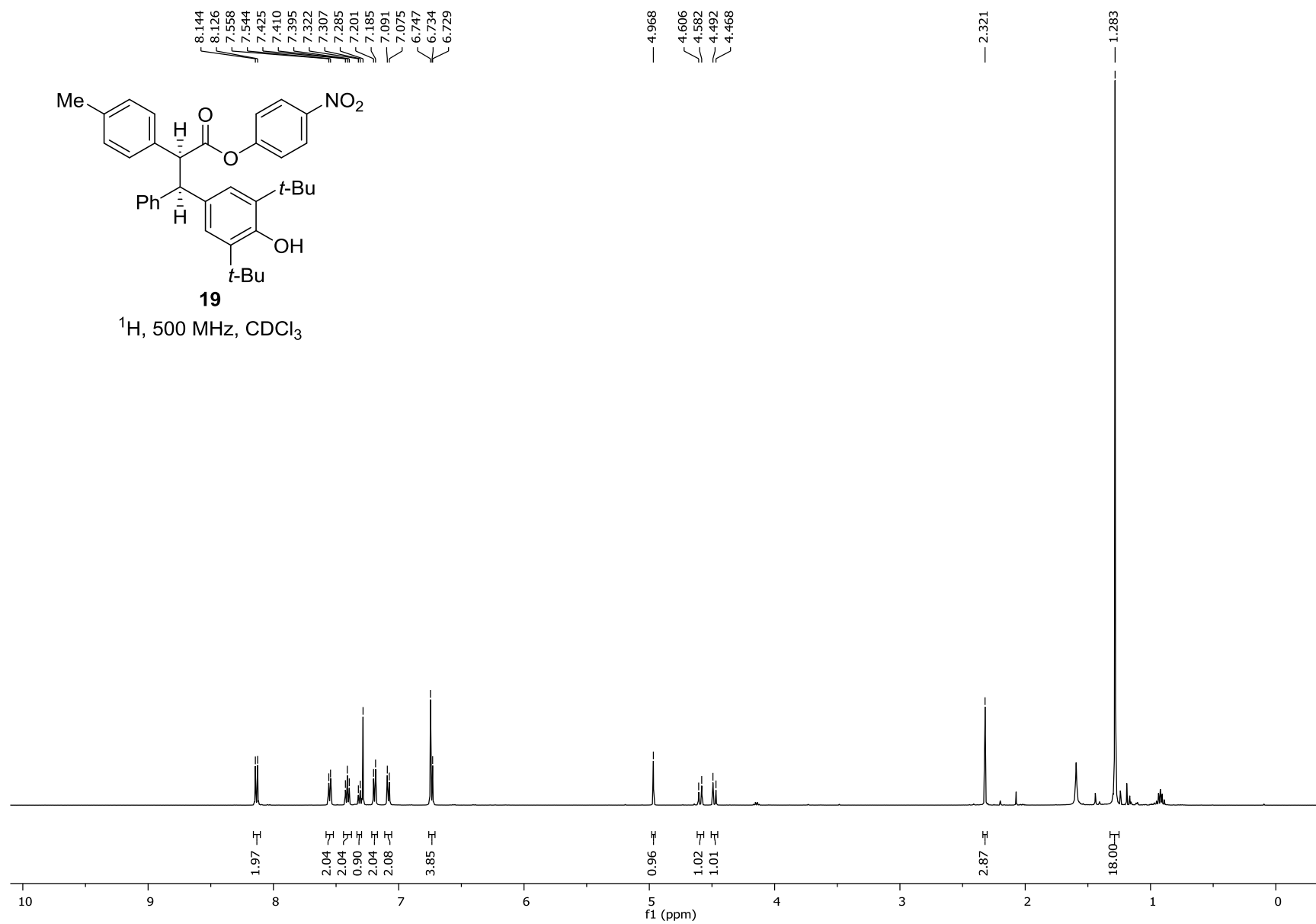


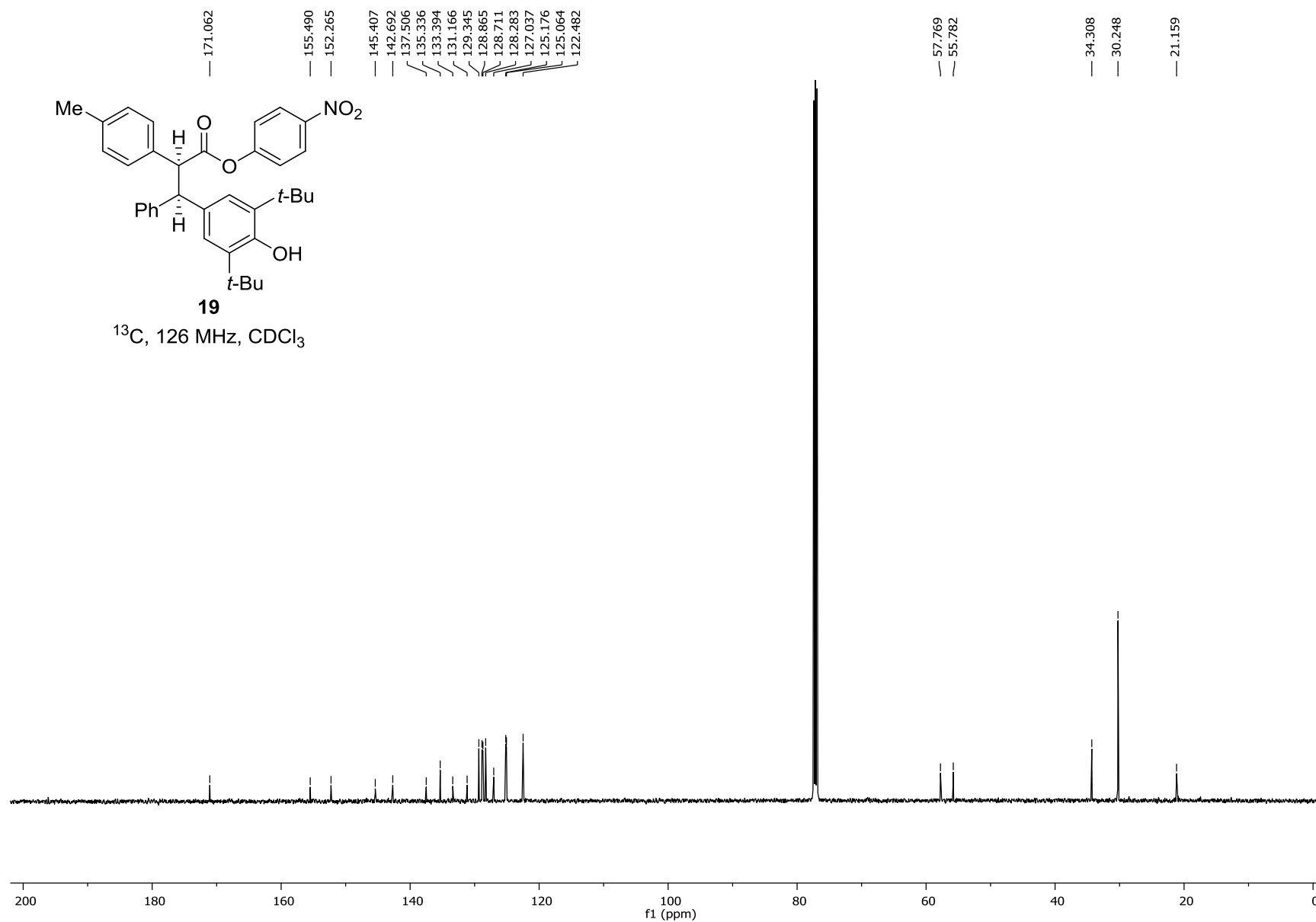


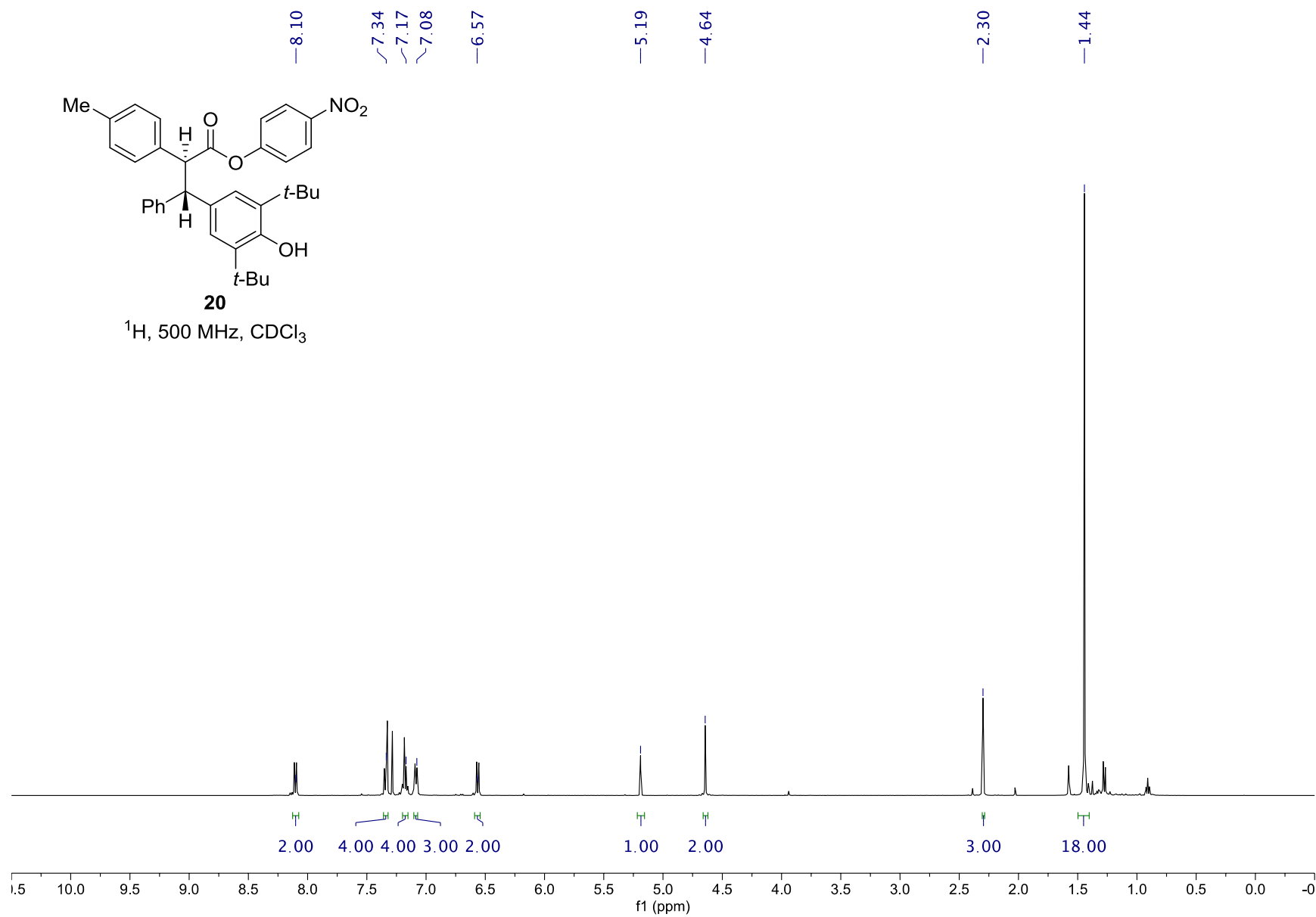


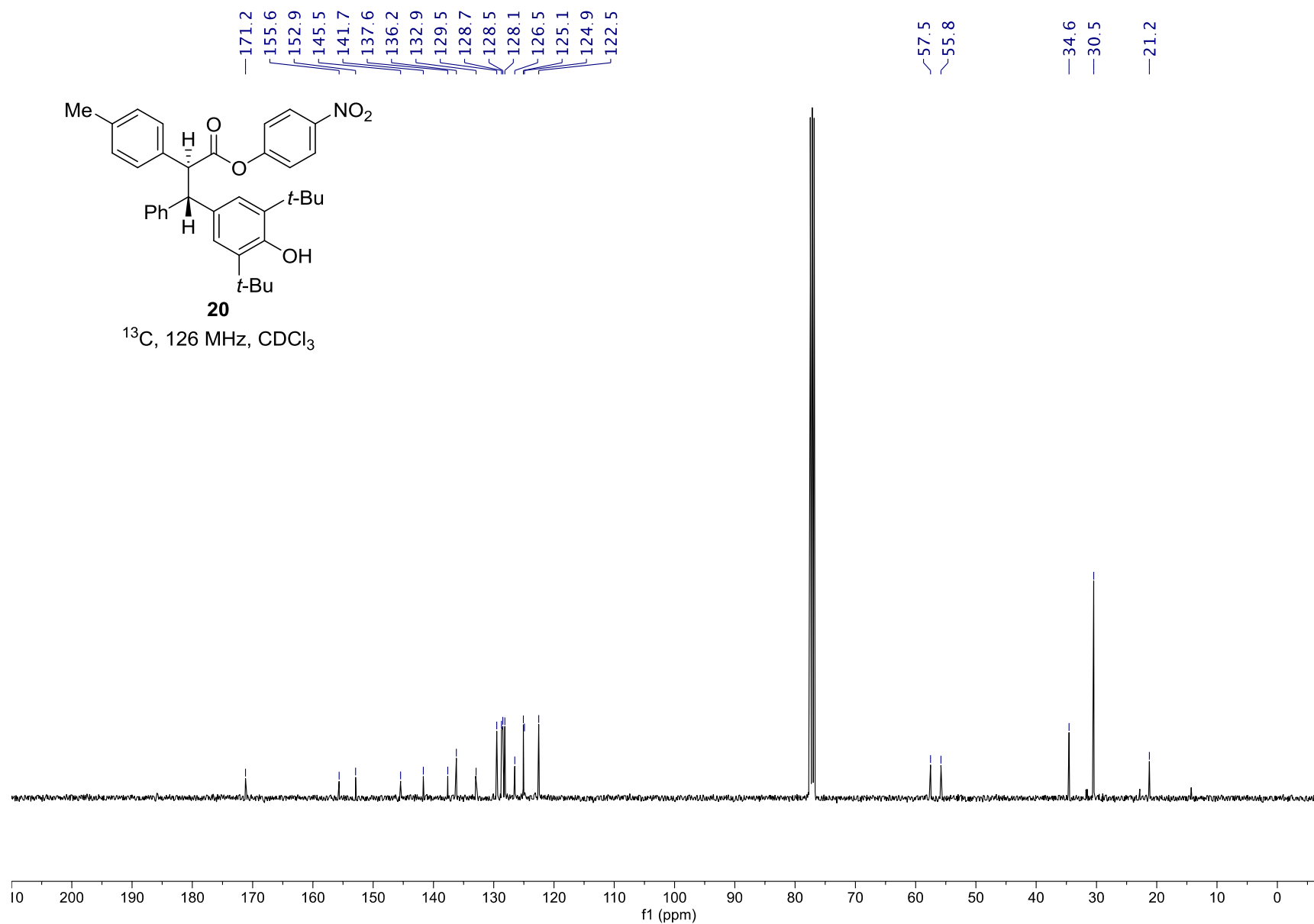


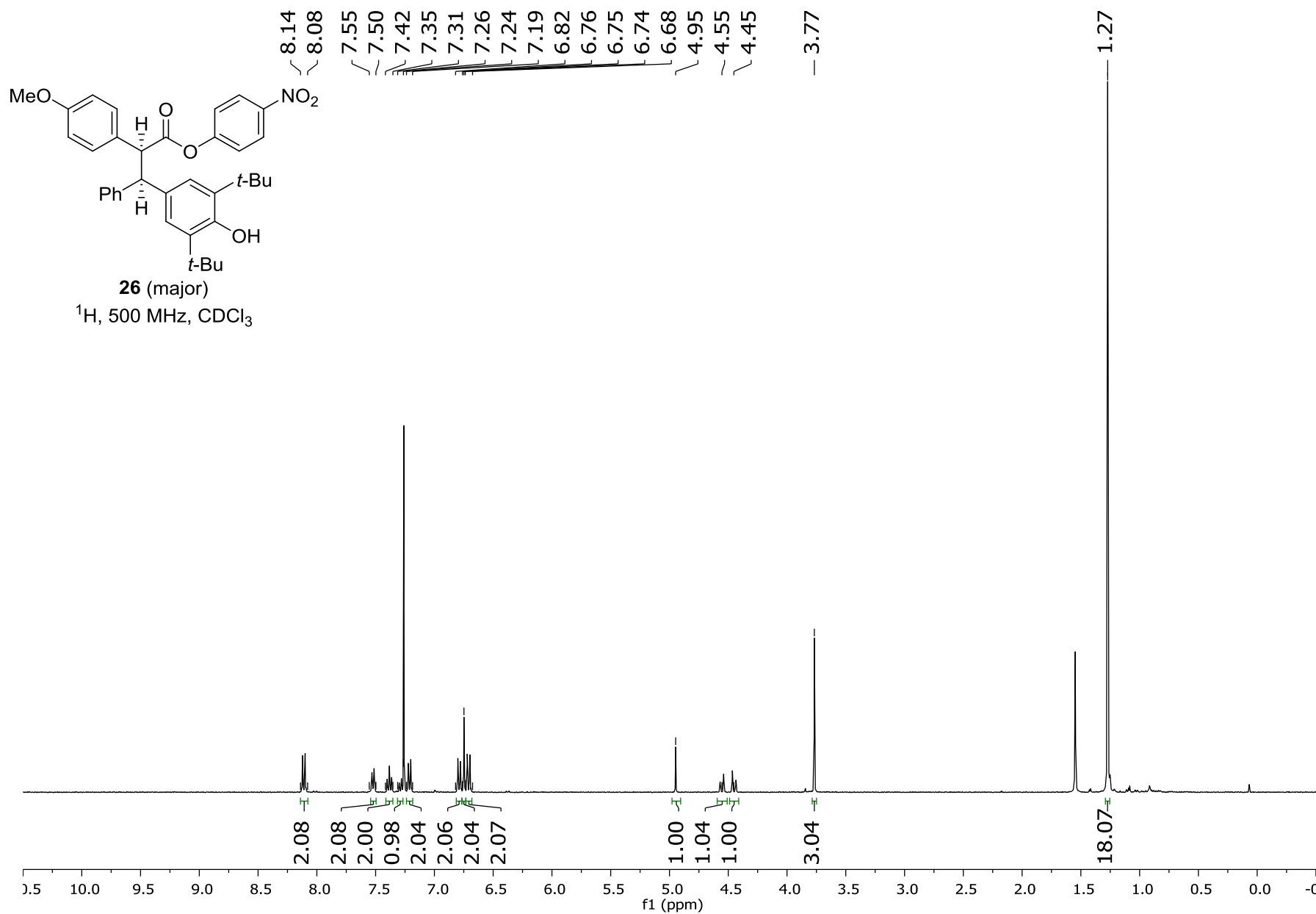


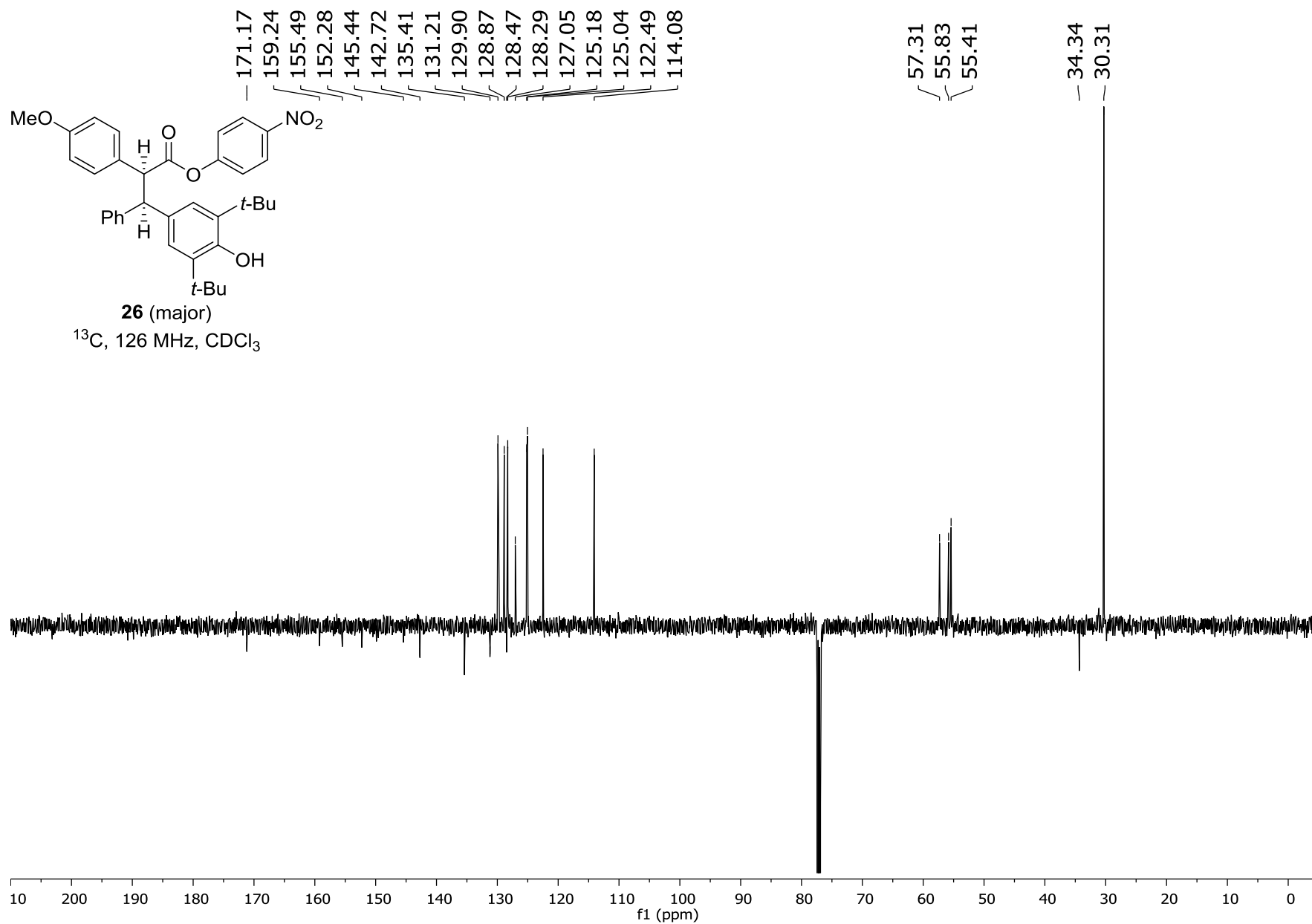


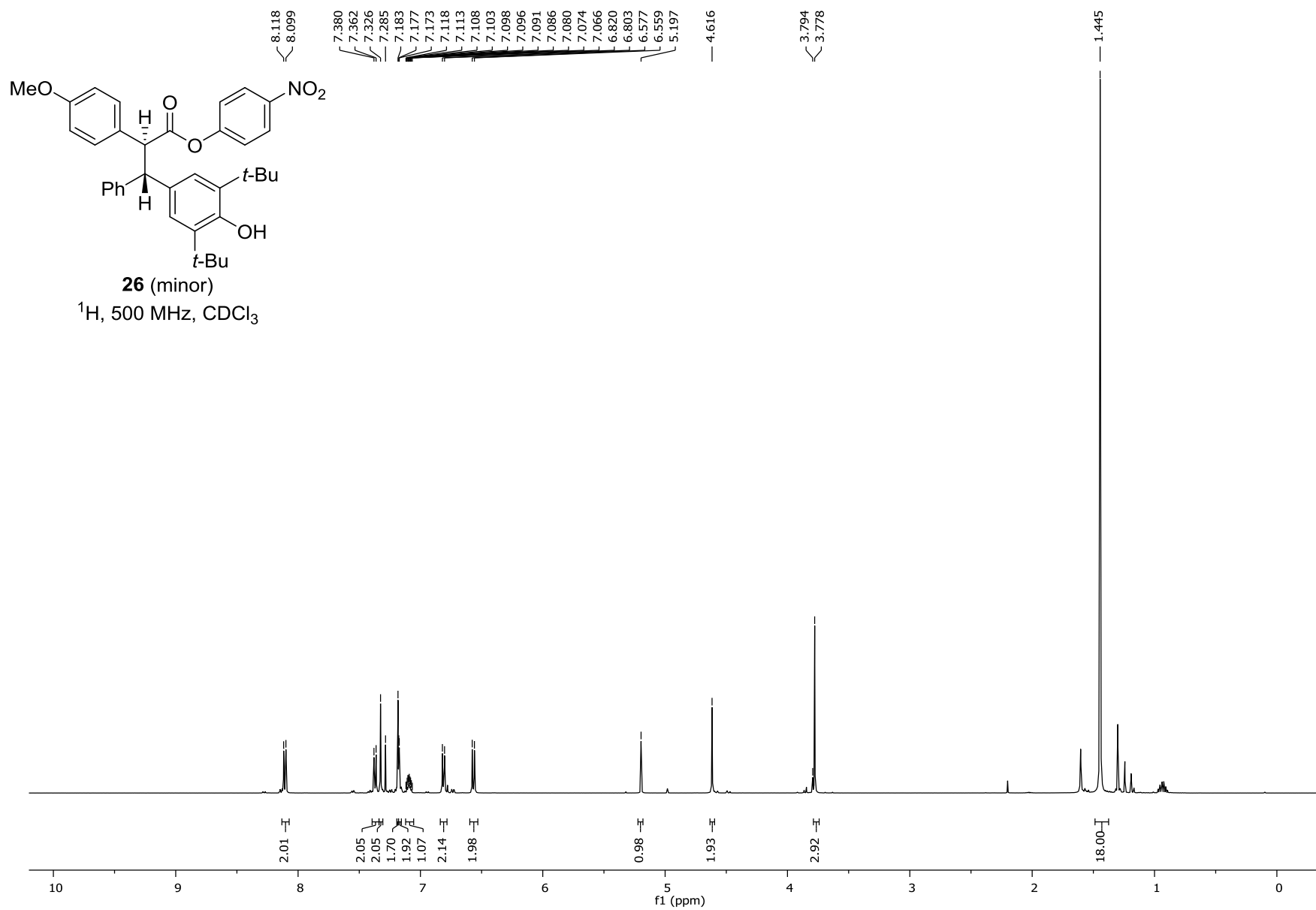


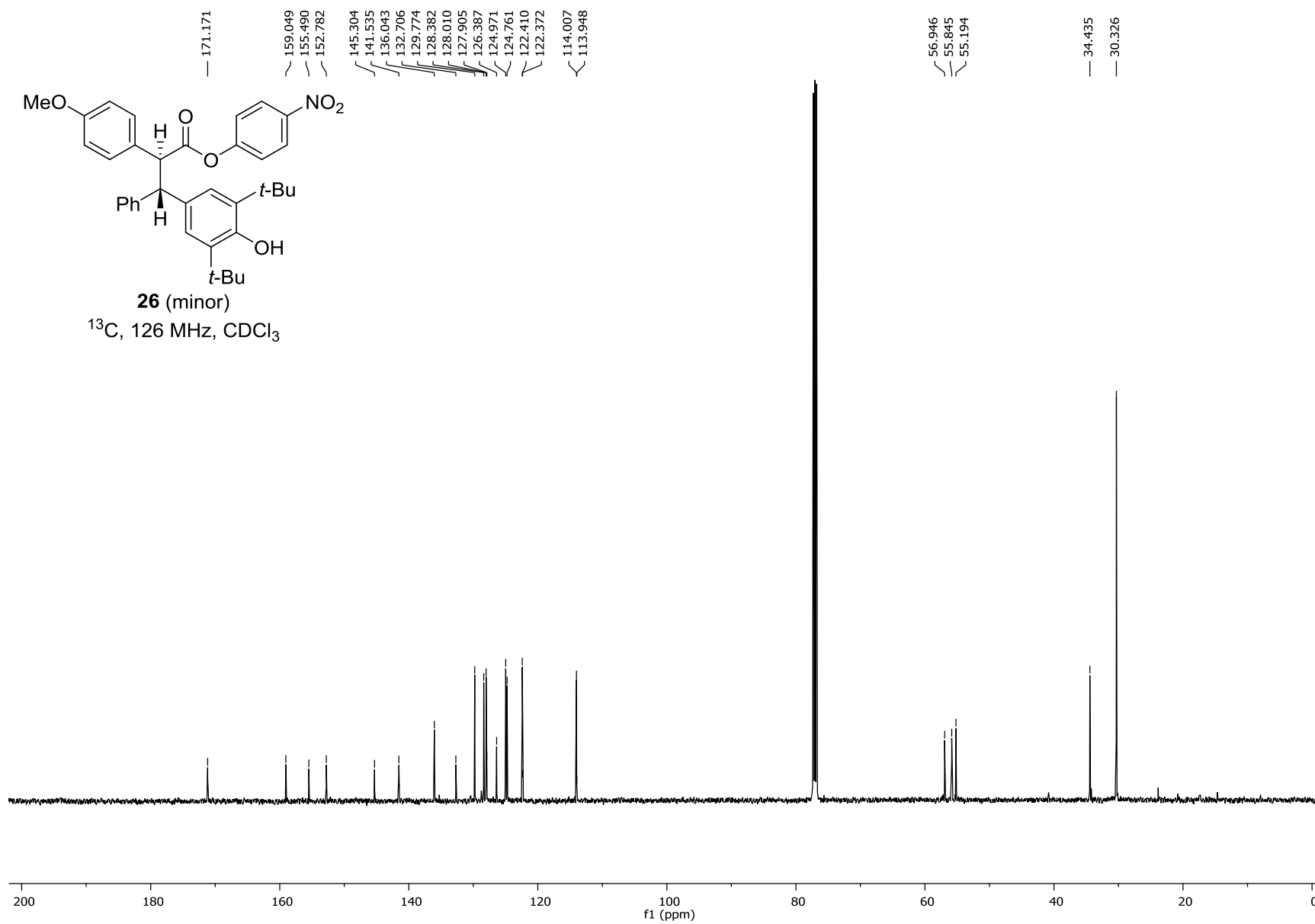


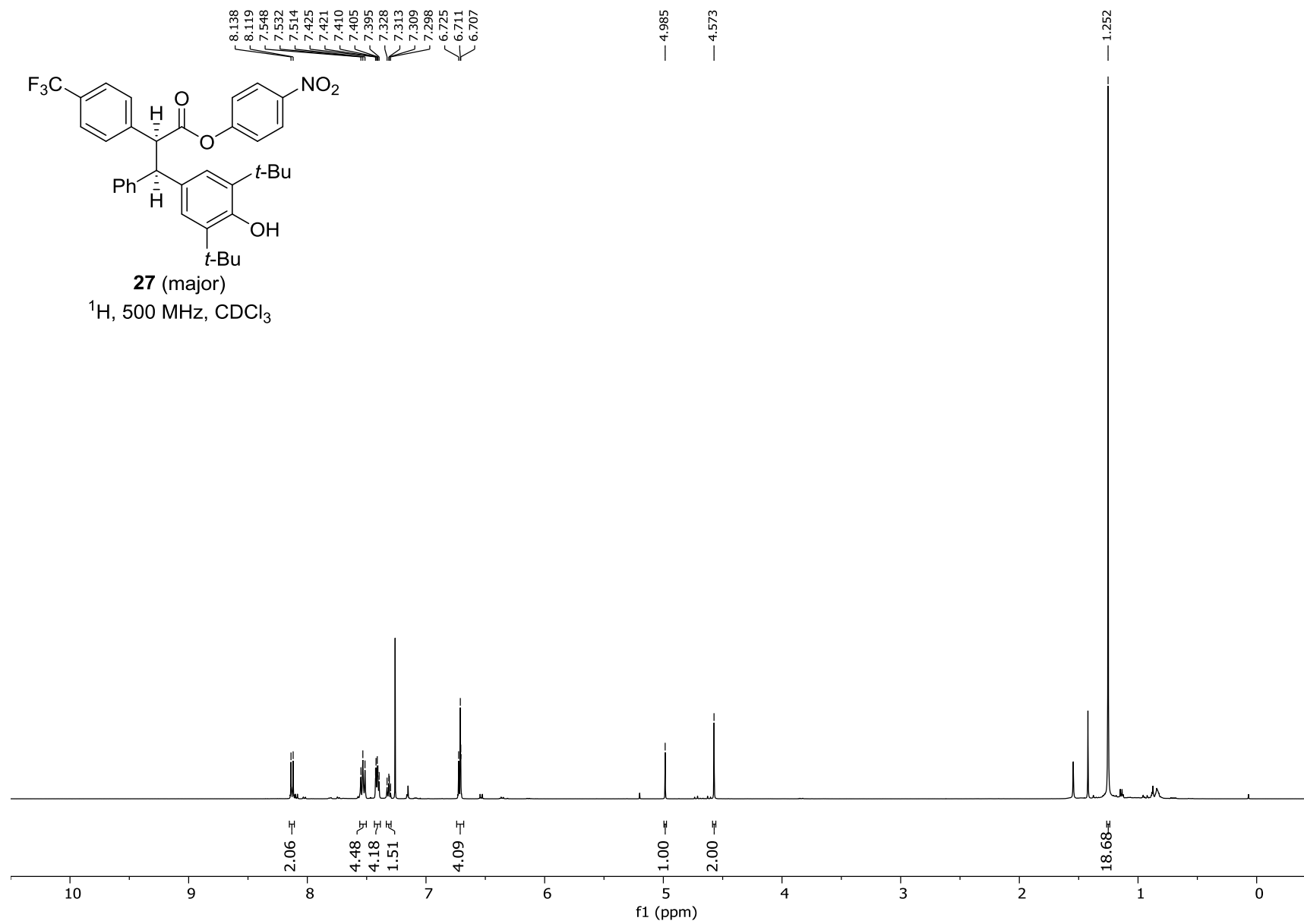


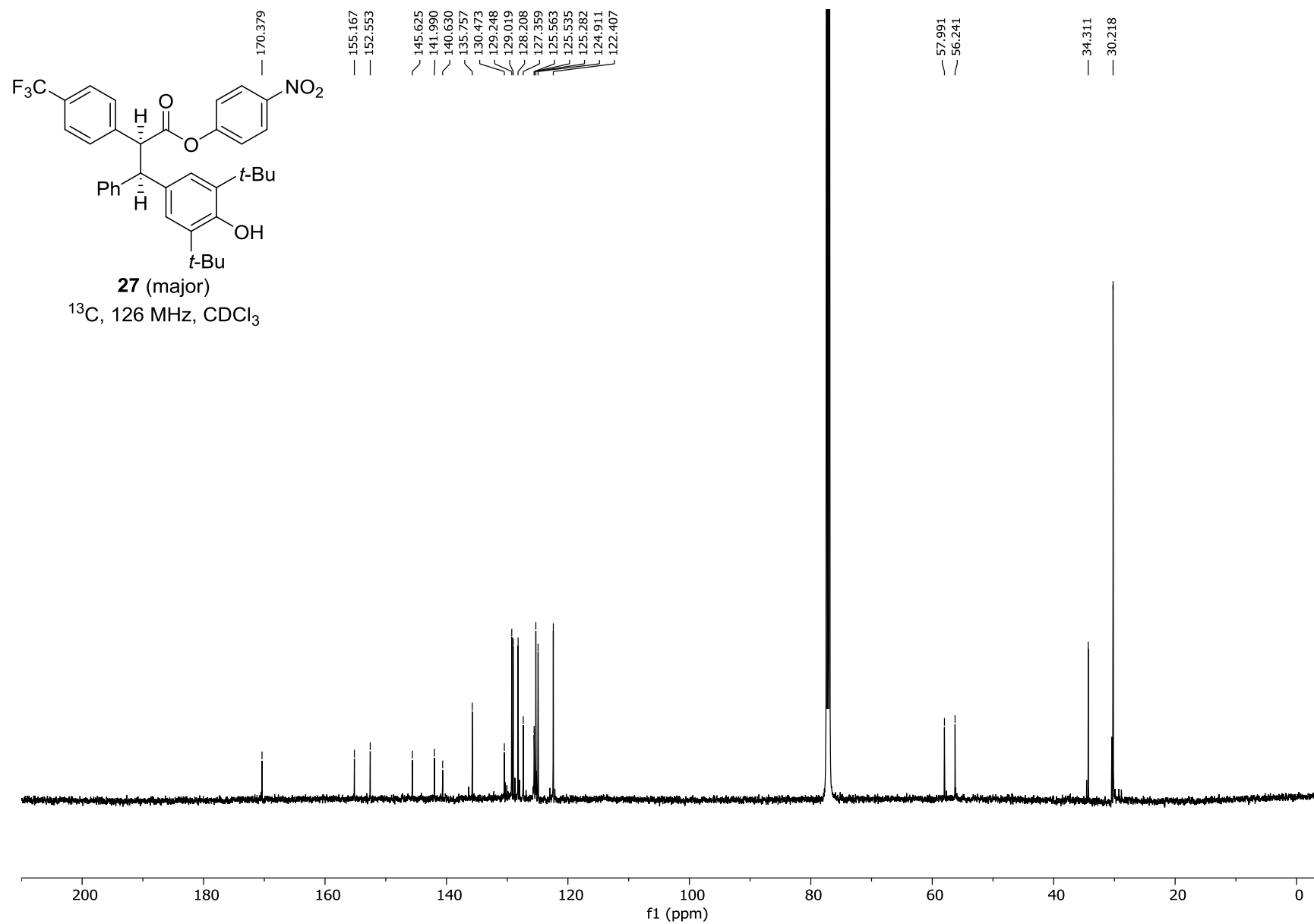


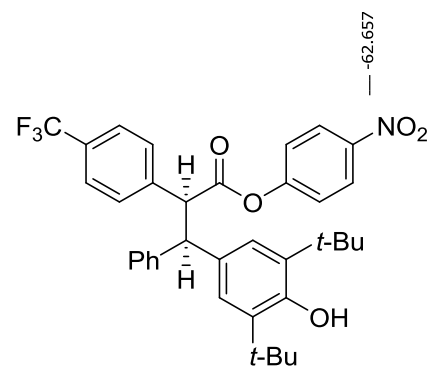




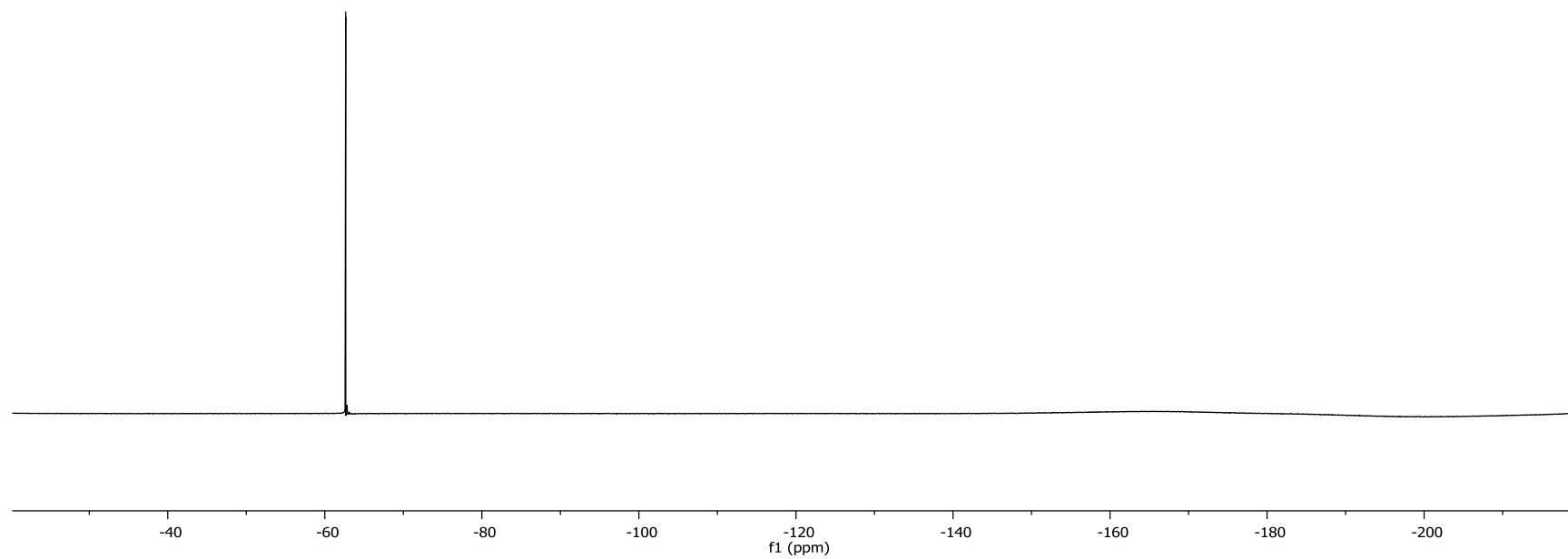


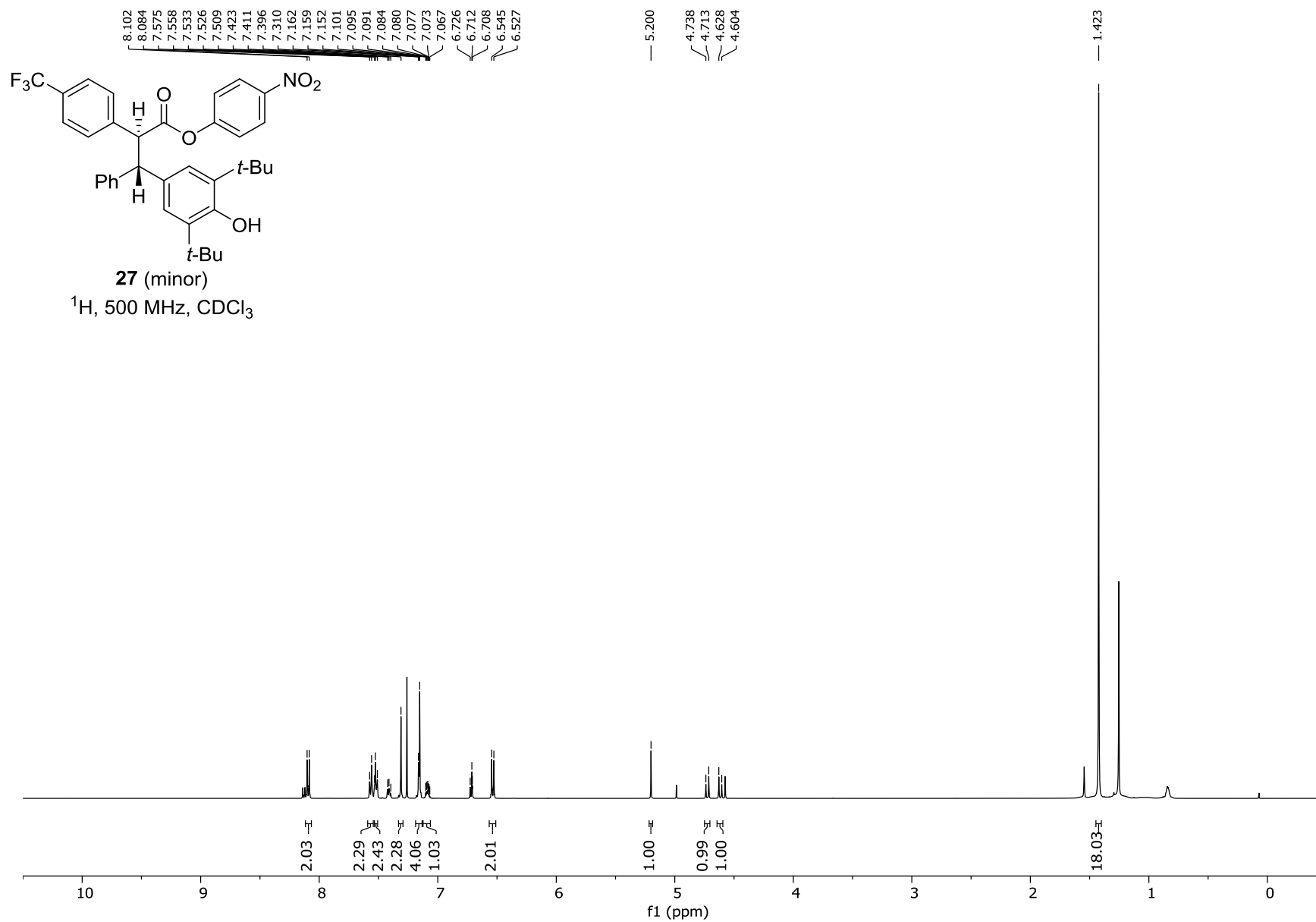


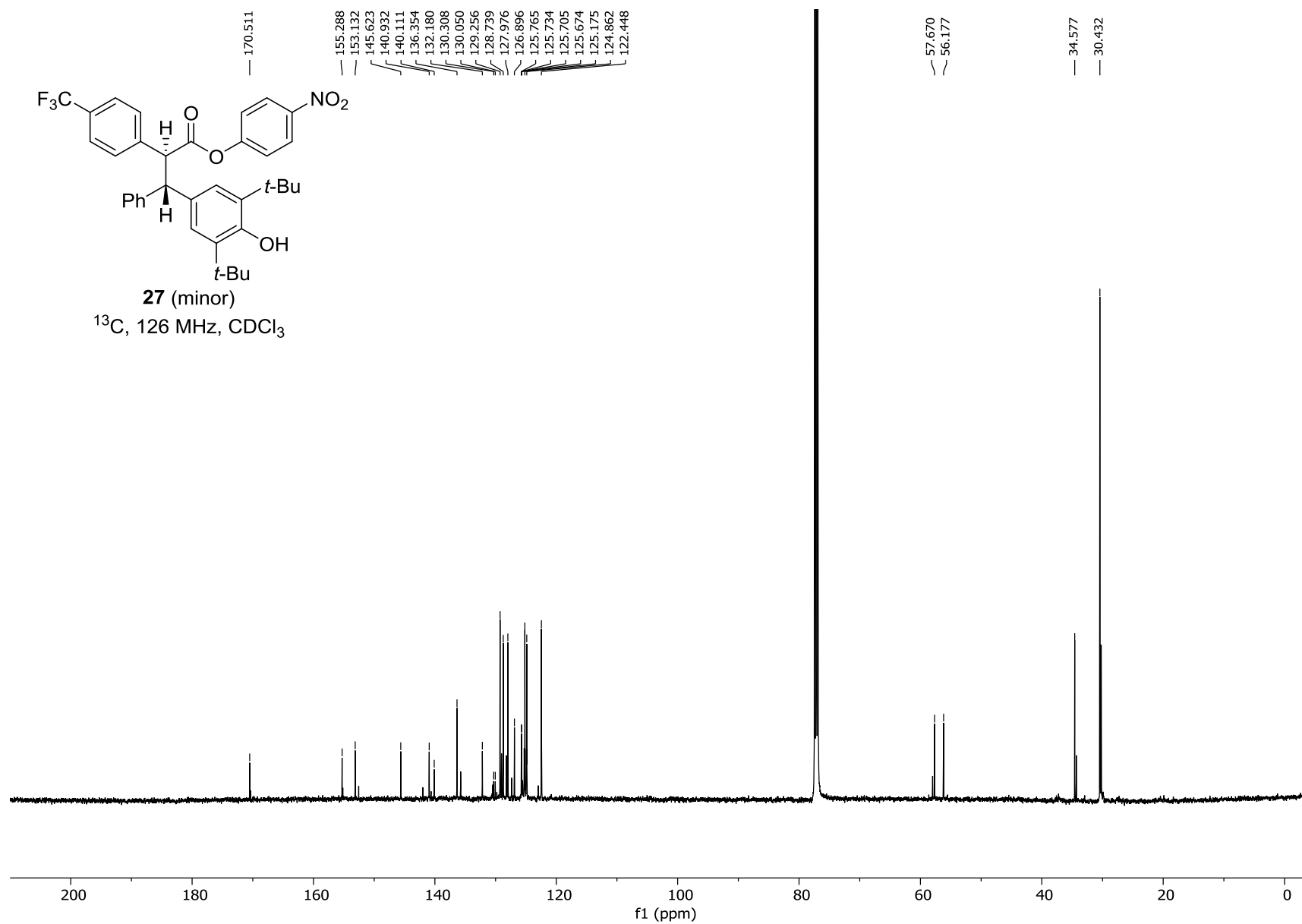


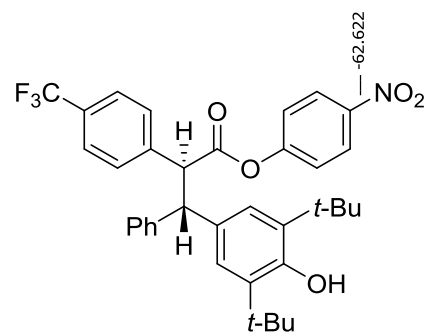


27 (major)
¹⁹F, 376 MHz, CDCl₃









27 (minor)
¹⁹F, 376 MHz, CDCl₃

