Supporting Information

for

Three-component synthesis, utilization and biological activity of phosphinoyl-functionalized isoindolinones

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Table of contents

General information

The reactions were carried out at 25 °C under N_2 atmosphere.

High-performance liquid chromatography-mass spectrometry (HPLC-MS) measurements were performed with an Agilent 1200 liquid chromatography system coupled with a 6130 quadrupole mass spectrometer equipped with an ESI ion source (Agilent Technologies, Palo Alto, CA, USA). Analysis was performed at 40 ºC on a Gemini C18 column (150 mm × 4.6 mm, 3 μm; Phenomenex, Torrance, CA, USA) with a mobile phase flow rate of 0.6 mL/min. Composition of eluent A was 0.1% $(NH_4)(HCOO)$ in water; eluent B was 0.1% $(NH_4)(HCOO)$ and 8% water in acetonitrile, 0–3 min 5% B, 3–13 min gradient, 13–20 min 100% B. The injection volume was 2 μL. The chromatographic profile was registered at 254 nm. The MSD operating parameters were as follows: positive ionization mode, scan spectra from m/z 120 to 1000, drying gas temperature 300 ºC, nitrogen flow rate 12 L/min, nebulizer pressure 60 psi, capillary voltage 4000 V.

The ^{31}P, ^{13}C, ^{1}H NMR spectra were taken in $CDCl_3$ solution on a Bruker AV-300 or DRX-500 spectrometer operating at 121.5, 75.5 and 300 or 202.4, 125.7 and 500 MHz, respectively. Chemical shifts are downfield relative to 85% H_3PO_4 and TMS. Non-equivalence effects were observed in ^{1}H and $^{13}C\{^{1}H\}$ NMR spectra. Corresponding pairs of resonances were marked with (I) and (II), respectively.

High resolution measurements were performed on a Sciex TripleTOF 5600+ high resolution tandem mass spectrometer equipped with DuoSpray ion source. Electrospray ionization was applied in positive ion detection mode. Samples were dissolved in acetonitrile and flow injected into acetonitrile:water 50:50 flow. The flow rate was 0.2 mL/min. The resolution of the mass spectrometer was 35000.

General procedure for the synthesis of 3-oxoisoindolin-1-ylphosphine oxides (7-20)

A mixture of 1.0 mmol (0.15 g) of 2-formylbenzoic acid, 1.0 mmol of primary amine (0.10 mL of butylamine, 0.12 mL of cyclohexylamine, 0.11 mL of benzylamine or 0.09 mL of aniline) and 1.0 mmol of secondary phosphine oxide (0.20 g of diphenylphosphine oxide, 0.23 g of bis(*p*-tolyl)phosphine oxide, 0.26 g of bis(3,5-dimethylphenyl)phosphine oxide, 0.30 g of bis(2-naphthyl)phosphine oxide, 0.23 g of dibenzylphosphine oxide, 0.18 g of *tert*-butyl(pheny)phosphine oxide, 0.22 g of 2-methylphenyl(phenyl)phosphine oxide, 0.27 g of 2-trifluoromethylphenyl(phenyl)phosphine oxide, 0.27 g of 3-trifluoromethylphenyl-(phenyl)-phosphine oxide, 0.27 g of 4-trifluoromethylphenyl-(phenyl)phosphine oxide, 0.28 g of 2-phenylphenyl(phenyl)phosphine oxide or 0.25 g of 1-naphthyl(phenyl)phosphine oxide)

was stirred without solvent or in 1 mL of ethanol, toluene or acetonitrile at room temperature under nitrogen atmosphere. The reaction mixtures were analyzed by HPLC chromatography. The solvent and the water formed were eliminated in vacuum, and the crude product so obtained was passed through a 1 cm silica layer using dichloromethane:methanol 97:3 as the eluent. The following products were thus prepared:

Diphenyl (2-butyl-3-oxo-2,3-dihydro-2*H*-isoindol-1-yl)phosphine oxide (7a)

Yield: 98% (0.38 g), white crystals; Mp: 74–75 °C; ^{1}H NMR ($CDCl_3$) δ 0.86 (t, J_{HH} = 7.4, 3H, CH_3(CH_2)$_3$N), 1.10–1.26 (m, 2H, CH_2(CH_2)$_2$N), 1.48–1.66 (m, 2H, C$H_2$$CH_2$N), 3.17–3.25 (m, 1H, CH_A, CH_2N), 3.92–4.01 (m, 1H, CH_B, CH_2N), 5.49 (d, 1H, $^{2}J_{HP}$ = 11.1, C_1H), 6.94 (d, 1H, J_{HH} = 7.7, ArH), 7.28–7.36 (m, 1H, ArH), 7.36–7.44 (m, 5H, ArH), 7.44–7.49 (m, 2H, ArH), 7.52–7.60 (m, 2H, ArH), 7.64–7.71 (m, 3H, ArH); ^{13}C NMR ($CDCl_3$) δ 13.7 ($C$$H_3$($CH_2$)$_3$N), 19.9 ($C$$H_2$($CH_2$)$_2$N), 30.0 ($C$$H_2$$CH_2$N), 41.7 ($CH_2$N), 61.0 (d, $^{1}J_{CP}$ = 72.8, C_1), 123.7 (d, J_{CP} = 1.2, C_4), 124.0 (d, $^{3}J_{CP}$ = 2.4, C_7), 127.8 (d, $^{1}J_{CP}$ = 81.7, $C_1$$^{'I}$), 128.6 (d, $^{1}J_{CP}$ = 81.8, $C_1$$^{'II}$), 128.65 (d, $^{3}J_{CP}$ = 11.7, $C_3$$^{'I}$), 128.66 (d, J_{CP} = 1.9, C_5), 128.67 (d, $^{3}J_{CP}$ = 11.7, $C_3$$^{'II}$), 131.1 (d, J_{CP} = 2.2, C_6), 131.6 (d, $^{2}J_{CP}$ = 8.8, $C_2$$^{'I}$), 131.7 (d, $^{2}J_{CP}$ = 9.0, $C_2$$^{'II}$), 132.75 (d, J_{CP} = 2.9, C_{3a}), 132.77 (d, J_{CP} = 2.6, $C_4$$^{'I}$), 132.9 (d, $^{3}J_{CP}$ = 2.8, $C_4$$^{'II}$), 138.6 (d, $^{2}J_{CP}$ = 2.5, C_{7a}), 168.6 (d, $^{3}J_{CP}$ = 1.9, C_3); ^{31}P ($CDCl_3$) δ 30.6; $[M+H]^{+}_{found}$ = 390.1614, $C_{24}H_{25}NO_2P$ requires 390.1622.

Diphenyl (2-cyclohexyl-3-oxo-2,3-dihydro-2*H*-isoindol-1-yl)phosphine oxide (7b)

Yield: 94% (0.39 g), white crystals; Mp: 59–61 °C; ^{1}H NMR ($CDCl_3$) δ 1.13–1.36 (m, 3H, ^{c}HexH), 1.48–1.83 (m, 5H, ^{c}HexH), 2.01–2.22 (m, 1H, ^{c}HexH), 2.36–2.63 (m, 1H, ^{c}HexH), 3.55–3.73 (m, 1H, $C_1$$^{'}$H), 5.42 (d, 1H, $^{2}J_{HP}$ = 11.7, C_1H), 6.63 (d, 1H, J_{HH} = 7.7, ArH), 7.17–7.43 (m, 7H, ArH), 7.44–7.56 (m, 2H, ArH), 7.56–7.64 (m, 1H, ArH), 7.64–7.82 (m, 3H, ArH); ^{13}C NMR ($CDCl_3$) δ 25.2 ($C_4$$^{'}$), 26.0 ($C_3$$^{'I}$), 26.3 ($C_3$$^{'II}$), 29.2 ($C_2$$^{'I}$), 30.0 ($C_2$$^{'II}$), 57.5 ($C_1$$^{'}$), 63.4 (d, $^{1}J_{CP}$ = 73.4, C_1), 123.5 (d, J_{CP} = 1.1, C_4), 123.7 (d, $^{3}J_{CP}$ = 2.4, C_7), 126.8 (d, $^{1}J_{CP}$ = 98.6, $C_1$$^{''I}$), 128.4 (d, $^{3}J_{CP}$ = 11.8, $C_3$$^{''I}$), 128.7 (d, J_{CP} = 2.6, C_5), 128.8 (d, $^{3}J_{CP}$ = 11.8, $C_3$$^{''II}$), 130.1 (d, $^{1}J_{CP}$ = 97.4, $C_1$$^{''II}$), 130.9 (d, J_{CP} = 2.3, C_6), 131.6 (d, $^{2}J_{CP}$ = 8.8, $C_2$$^{''I}$), 132.2 (d, $^{2}J_{CP}$ = 8.6, $C_2$$^{''II}$), 132.7 (d, J_{CP} = 2.0, $C_4$$^{''I}$), 13.,8 (d, J_{CP} = 2.3, $C_4$$^{''II}$), 134.4 (d, $^{3}J_{CP}$ = 3.1, C_{3a}), 138.9 (d, $^{2}J_{CP}$ = 1.3, C_{7a}), 169.0 (d, $^{3}J_{CP}$ = 1.8, C_3); ^{31}P ($CDCl_3$) δ 30.8; $[M+H]^{+}_{found}$ = 416.1772, $C_{26}H_{27}NO_2P$ requires 416.1779.

Diphenyl (2-benzyl-3-oxo-2,3-dihydro-2*H*-isoindol-1-yl)phosphine oxide (7c)

Yield: 97% (0.41 g), light yellow crystals; Mp: 80–81 °C; ^{1}H NMR ($CDCl_3$) δ 4.37 (d, 1H, J_{HH} = 15.0, CH_A, CH_2N), 5.31 (d, 1H, $^{2}J_{HP}$ = 10.7, C_1H), 5.40 (d, 1H, J_{HH} = 15.0, CH_B, CH_2N), 6.83 (d, 1H, J_{HH} = 7.6, ArH), 7.08–7.20 (m, 2H, ArH), 7.21–7.52 (m, 12H, ArH), 7.52–7.79 (m, 4H, ArH); ^{13}C NMR ($CDCl_3$) δ 45.3 (CH_2N), 60.2 (d, $^{1}J_{CP}$ = 73.1, C_1), 124.0 (d, J_{CP} = 0.4, C_4), 124.1 (d, $^{3}J_{CP}$ = 1.8, C_7), 127.55 (d, $^{1}J_{CP}$ = 97.9, C_1''^{I}), 127.59 (C_4'), 128.3 (C_3'), 128.66 (C_2'), 128.69 (d, $^{3}J_{CP}$ = 11.6, C_3''^{I}), 128.74 (d, J_{CP} = 2.3, C_5), 128.75 (d, $^{3}J_{CP}$ = 11.7, C_3''^{II}), 128.9(d, $^{1}J_{CP}$ = 97.7, C_1''^{II}), 131.3 (d, J_{CP} = 2.2, C_6), 131.6 (d, $^{2}J_{CP}$ = 8.9, C_2''^{I}), 132.0 (d, $^{2}J_{CP}$ = 8.9, C_2''^{II}), 132.5 (d, $^{3}J_{CP}$ = 3.0, C_{3a}), 132.8 (d, J_{CP} = 2.8, C_4''^{I}), 132.9 (d, J_{CP} = 2.8, C_4''^{II}), 136.6 (C_1'), 138.9 (d, $^{2}J_{CP}$ = 2.4, C_{7a}), 168.9 (d, $^{3}J_{CP}$ = 1.5, C_3); ^{31}P ($CDCl_3$) δ 30.8; $[M+H]^{+}_{found}$ = 424.1457, $C_{27}H_{23}NO_2P$ requires 424.1466.

Diphenyl (2-phenyl-3-oxo-2,3-dihydro-2*H*-isoindol-1-yl)phosphine oxide (7d)

Yield: 96% (0.39 g), white crystals; Mp: 268–270 °C; ^{1}H NMR ($CDCl_3$) δ 6.50 (t, 1H, J_{HH} = 7.2, ArH), 6.57 (dd, 1H, J_{HH} = 5.7, $^{2}J_{HP}$ = 11.0, C_1H), 6.83 (d, 2H, J_{HH} = 8.0, ArH), 6.97 (t, 2H, J_{HH} = 7.6, ArH), 7.17–7.28 (m, 4H, ArH), 7.32 (t, 1H, J_{HH} = 11.6, ArH), 7.36–7.42 (m, 1H, ArH), 7.54 (t, 1H, J_{HH} = 7.6, ArH), 7.58–7.67 (m, 4H, ArH), 7.89–7.98 (m, 3H, ArH); ^{13}C NMR ($CDCl_3$) δ 50.7 (d, $^{1}J_{CP}$ = 76.6, C_1), 113.9 (d, J_{CP} = 0.7, C_4), 117.6 (d, $^{3}J_{CP}$ = 0.5, C_7), 127.7 (d, J_{CP} = 2.0, C_5), 128.3 (d, $^{3}J_{CP}$ = 11.6, C_3''^{I}), 129.3 (C_4'), 129.4 (d, $^{3}J_{CP}$ = 11.5, C_3''^{II}), 129.8 (d, J_{CP} = 4.8, C_3'), 129.9 (d, J_{CP} = 5.0, C_2'), 130.7 (d, J_{CP} = 5.5, C_6), 131.3 (d, $^{1}J_{CP}$ = 97.7, C_1''^{I}), 131.36 (d, $^{2}J_{CP}$ = 8.7, C_2''^{I}), 131.40 (d, $^{2}J_{CP}$ = 9.0, C_2''^{II}), 132.0 (d, $^{1}J_{CP}$ = 96.8, C_1''^{II}), 132.1 (d, $^{3}J_{CP}$ = 1.9, C_{3a}), 132.55 (d, J_{CP} = 2.4, C_4''^{I}), 132.62 (d, J_{CP} = 2.3, C_4''^{II}), 139.6 (C_{7a}), 147.6 (d, $^{3}J_{CP}$ = 11.8, C_1''), 169.1 (d, $^{3}J_{CP}$ = 0.9, C_3); ^{31}P ($CDCl_3$) δ 31.8; $[M+H]^{+}_{found}$ = 410.1322, $C_{26}H_{21}NO_2P$ requires 410.1304.

Bis(*p*-tolyl) (2-butyl-3-oxo-2,3-dihydro-2*H*-isoindol-1-yl)phosphine oxide (8a)

Yield: 99% (0.41 g), light yellow crystals; Mp: 72–74 °C; ^{1}H NMR ($CDCl_3$) δ 0.86 (t, J_{HH} = 7.2, 3H, CH_3(CH_2)$_3$N), 1.10–1.28 (m, 2H, CH_2(CH_2)$_2$N), 1.47–1.69 (m, 2H, C$H_2$$CH_2$N), 2.37 (s, 3H, C_4'CH_3^{I}), 2.41 (s, 3H, C_4'CH_3^{II}), 3.20–3.35 (m, 1H, CH_A, CH_2N), 3.89–4.04 (m, 1H, CH_B, CH_2N), 5.44 (d, 1H, $^{2}J_{HP}$ = 11.4, C_1H), 6.94 (d, 1H, J_{HH} = 7.5, ArH), 7.11–7.44 (m, 9H, ArH), 7.45–7.62 (m, 2H, ArH), 7.68 (d, 1H, J_{HH} = 7.3, ArH); ^{13}C NMR ($CDCl_3$) δ 13.7 (CH_3(CH_2)$_3$N), 19.9 (CH_2(CH_2)$_2$N), 21.6 (C_4'CH_3^{I}), 21.7 (C_4'CH_3^{II}), 30.0 (CH_2CH_2N), 41.8 (CH_2N), 61.2 (d, $^{1}J_{CP}$ = 72.7, C_1), 123.6 (d, J_{CP} = 1.2, C_4), 124.1 (d, $^{3}J_{CP}$ = 2.5, C_7), 124.4 (d,

$^{1}J_{CP}$ = 84.5, C_1'^{I}), 125.8 (d, $^{1}J_{CP}$ = 84.3, C_1'^{II}), 128.5 (d, J_{CP} = 1.7, C_5), 129.36 (d, $^{3}J_{CP}$ = 12.1, C_3'^{I}), 129.40 (d, $^{3}J_{CP}$ = 12.1, C_3'^{II}), 131.0 (d, J_{CP} = 1.8, C_6), 131.6 (d, $^{2}J_{CP}$ = 8.7, C_2'^{I}), 131.7 (d, $^{2}J_{CP}$ = 8.9, C_2'^{II}), 132.9 (d, $^{3}J_{CP}$ = 3.1, C_{3a}), 138.9 (d, $^{2}J_{CP}$ = 2.7, C_{7a}), 143.4 (d, J_{CP} = 2.8, C_4'^{I}), 143.5 (d, J_{CP} = 2.9, C_4'^{II}), 168.6 (d, $^{3}J_{CP}$ = 1.5, C_3); ^{31}P ($CDCl_3$) δ 31.2; $[M+H]^{+}_{found}$ = 418.1922, $C_{26}H_{29}NO_2P$ requires 418.1935.

Bis(*p*-tolyl) (2-cyclohexyl-3-oxo-2,3-dihydro-2*H*-isoindol-1-yl)phosphine oxide (8b)

Yield: 97% (0.43 g), white crystals; Mp: 76–78 °C; ^{1}H NMR ($CDCl_3$) 1.06–1.16 (m, 1H, ^{c}HexH), 1.17–1.30 (m, 2H, ^{c}HexH), 1.53–1.65 (m, 2H, ^{c}HexH), 1.67–1.80 (m, 3H, ^{c}HexH), 2.08–2.18 (m, 1H, ^{c}HexH), 2.34 (s, 3H, C_4''CH_3^{I}), 2.45–2.48 [2.44 (s, C_4''CH_3^{II}), overlapped by the multiplet of ^{c}HexH total int. 4H], 3.69–3.78 (m, 1H, C_1'H), 5.40 (d, 1H, $^{2}J_{HP}$ = 11.9, C_1H), 6.59 (d, 1H, J_{HH} = 7.7, ArH), 7.04–7.13 (m, 4H, ArH), 7.24–7.33 (m, 3H, ArH), 7.36–7.42 (m, 1H, ArH), 7.57–7.64 (m, 2H, ArH), 7.68 (d, 1H, J_{HH} = 7.7, ArH); ^{13}C NMR ($CDCl_3$) δ 21.5 (d, J_{CP} = 1.2, C_4''CH_3^{I}), 21.7 (d, J_{CP} = 1.1, C_4''CH_3^{II}), 25.2 (C_4'), 26.0 (C_3'^{I}), 26.3 (C_3'^{II}), 29.2 (C_2'^{I}), 30.0 (C_2'^{II}), 57.5 (C_1'), 63.5 (d, $^{1}J_{CP}$ = 74.4, C_1), 123.2 (d, $^{1}J_{CP}$ = 100.9, C_1''^{I}), 123.5 (d, J_{CP} = 1.2, C_4), 123.7 (d, $^{3}J_{CP}$ = 2.4, C_7), 127.3 (d, $^{1}J_{CP}$ = 99.8, C_1''^{II}), 126.6 (d, J_{CP} = 2.1, C_5), 129.1 (d, $^{3}J_{CP}$ = 12.2, C_3''^{I}), 129.5 (d, $^{3}J_{CP}$ = 12.0, C_3''^{II}), 130.8 (d, J_{CP} = 2.4, C_6), 131.6 (d, $^{2}J_{CP}$ = 9.3, C_2''^{I}), 132.3 (d, $^{2}J_{CP}$ = 8.8, C_2''^{II}), 134.5 (d, $^{3}J_{CP}$ = 3.4, C_{3a}), 139.1 (d, $^{2}J_{CP}$ = 1.1, C_{7a}), 143.30 (C_4''^{I}), 143.33 (C_4''^{II}), 169.0 (d, $^{3}J_{CP}$ = 2.0, C_3); ^{31}P ($CDCl_3$) δ 31.7; $[M+H]^{+}_{found}$ = 444.2077, $C_{28}H_{31}NO_2P$ requires 444.2086.

Bis(*p*-tolyl) (2-benzyl-3-oxo-2,3-dihydro-2*H*-isoindol-1-yl)phosphine oxide (8c)

Yield: 97% (0.44 g), light yellow crystals; Mp: 80–82 °C; ^{1}H NMR ($CDCl_3$) δ 2.39 (s, 3H, C_4''CH_3^{I}), 2.41 (s, 3H, C_4''CH_3^{II}), 4.45 (d, 1H, J_{HH} = 14.9, CH_A, CH_2N), 5.27 (d, 1H, $^{2}J_{HP}$ = 10.9, C_1H), 5.38 (d, 1H, J_{HH} = 14.9, CH_B, CH_2N), 6.82 (d, 1H, J_{HH} = 7.7, ArH), 7.08–7.45 (m, 13H, ArH), 7.46–7.64 (m, 2H, ArH), 7.74 (d, 1H, J_{HH} = 7.5, ArH); ^{13}C NMR ($CDCl_3$) δ 21.6 (C_4''CH_3^{I}), 21.7 (C_4''CH_3^{II}), 45.2 (CH_2N), 60.3 (d, $^{1}J_{CP}$ = 73.1, C_1), 124.0 (d, J_{CP} = 1.0, C_4), 124.06 (d, $^{3}J_{CP}$ = 2.3, C_7), 124.12 (d, $^{1}J_{CP}$ = 101.1 C_1''^{I}), 126.0 (d, $^{1}J_{CP}$ = 100.1, C_1''^{II}), 127.5 (C_4'), 128.4 (C_3'), 128.60 (d, J_{CP} = 3.3, C_5), 128.61 (C_2'), 129.36 (d, $^{3}J_{CP}$ = 12.0, C_3''^{I}), 129.44 (d, $^{3}J_{CP}$ = 12.2, C_3''^{II}), 131.2 (d, J_{CP} = 1.8, C_6), 131.6 (d, $^{2}J_{CP}$ = 9.3, C_2''^{I}), 132.0 (d, $^{2}J_{CP}$ = 9.2, C_2''^{II}), 132.6 (d, $^{3}J_{CP}$ = 2.9, C_{3a}), 136.8 (C_1'), 139.1 (d, $^{2}J_{CP}$ = 2.1, C_{7a}), 143.4 (d, J_{CP} = 2.8,

C_4''^{I}), 143.7 (d, J_{CP} = 3.0, C_4''^{II}), 168.8 (d, $^3J_{CP}$ = 1.6, C_3); ^{31}P ($CDCl_3$) δ 31.4; $[M+H]^+_{found}$ = 452.1765, $C_{29}H_{27}NO_2P$ requires 452.1779.

Bis(*p*-tolyl) (2-phenyl-3-oxo-2,3-dihydro-2*H*-isoindol-1-yl)phosphine oxide (8d)

Yield: 98% (0.43 g), white crystals; Mp: 188–190 °C; ^{1}H NMR ($CDCl_3$) δ 2.22 (s, 3H, C_4''CH_3^{I}), 2.36 (s, 3H, C_4''CH_3^{II}), 6.41–6.55 [6.50 (d, 2H, $^2J_{HP}$ = 6.8, C_1H) overlapped by the multiplet of ArH, total int. 2H], 6.80 (d, 2H, J_{HH} = 8.1, ArH), 6.97 (t, 2H, J_{HH} = 7.7, ArH), 7.00–7.15 (m, 3H, ArH), 7.17–7.31 (m, 2H, ArH), 7.40 (dd, 2H, J_{HH} = 8.1, J_{HH} = 2.8, ArH), 7.52 (t, 1H, J_{HH} = 7.4, ArH), 7.67 (d, 1H, J_{HH} = 7.8, ArH), 7.78 (d, 1H, J_{HH} = 7.8, ArH), 7.81 (d, 1H, J_{HH} = 7.9, ArH), 7.89 (d, 1H, J_{HH} = 7.9, ArH); ^{13}C NMR ($CDCl_3$) δ 21.5 (C_4''CH_3^{I}), 21.6 (C_4''CH_3^{II}), 50.8 (d, $^1J_{CP}$ = 77.0, C_1), 113.8 (d, J_{CP} = 0.6, C_4), 117.5 (d, $^3J_{CP}$ = 0.5, C_7), 127.6 (d, J_{CP} = 1.7, C_5), 128.4 (d, $^1J_{CP}$ = 101.3, C_1''^{I}), 128.9 (d, $^3J_{CP}$ = 11.8, C_3''^{I}), 129.0 (d, $^1J_{CP}$ = 99.0, C_1''^{II}), 129.3 (C_4'), 129.8 (d, J_{CP} = 4.3, C_3'), 129.9 (d, $^3J_{CP}$ = 12.0, C_3''^{II}), 130.1 (d, J_{CP} = 5.0, C_2'), 130.7 (d, J_{CP} = 2.2, C_6), 131.4 (d, $^2J_{CP}$ = 9.0, C_2''^{I}), 131.5 (d, $^2J_{CP}$ = 9.5, C_2''^{II}), 132.4 (d, J_{CP} = 2.2, C_{3a}), 139.8 (C_{7a}), 142.0 (d, J_{CP} = 2.8, C_4''^{I}), 142.6 (d, J_{CP} = 2.7, C_4''^{II}), 147.7 (d, $^3J_{CP}$ = 12.0, C_1'), 169.1 (d, $^3J_{CP}$ = 1.5, C_3); ^{31}P ($CDCl_3$) δ 31.3; $[M+H]^+_{found}$ = 438.1637, $C_{28}H_{25}NO_2P$ requires 438.1617.

Bis(3,5-dimethylphenyl) (2-butyl-3-oxo-2,3-dihydro-2*H*-isoindol-1-yl)phosphine oxide (9a)

Yield: 97% (0.43 g), yellow crystals; Mp: 168–170 °C; ^{1}H NMR ($CDCl_3$) δ 0.89 (t, J_{HH} = 7.3, 3H, CH_3(CH_2)$_3$N), 1.14–1.30 (m, 2H, CH_2(CH_2)$_2$N), 1.47–1.72 (m, 2H, C$H_2$$CH_2$N), 2.23 (s, 6H, C_3'CH_3^{I}), 2.34 (s, 6H, C_3'CH_3^{II}), 3.25–3.37 (m, 1H, CH_A, CH_2N), 3.90–4.04 (m, 1H, CH_B, CH_2N), 5.47 (d, 1H, $^2J_{HP}$ = 10.9, C_1H), 6.83–6.94 (m, 2H, ArH) 7.12–7.45, (m, 7H, ArH), 7.71 (d, 1H, J_{HH} = 7.4, ArH); ^{13}C NMR ($CDCl_3$) δ 13.8 (*C*H$_3$(CH_2)$_3$N), 20.0 (*C*H$_2$(CH_2)$_2$N), 21.2 (C_3'*C*H_3^{I}), 21.3 (C_3'*C*H_3^{II}), 30.2 (*C*H$_2$$CH_2$N), 41.8 ($CH_2$N), 61.2 (d, $^1J_{CP}$ = 71.8, C_1), 123.5 (d, J_{CP} = 1.2, C_4), 124.2 (d, $^3J_{CP}$ = 2.3, C_7), 127.2 (d, $^1J_{CP}$ = 97.5, C_1'^{I}), 128.6 (d, J_{CP} = 1.6, C_5), 129.1 (d, $^1J_{CP}$ = 97.0, C_1'^{II}), 129.2 (d, $^2J_{CP}$ = 9.0, C_2'^{I}), 129.4 (d, $^2J_{CP}$ = 8.9, C_2'^{II}), 130.9 (d, J_{CP} = 2.2, C_6), 133.2 (d, $^3J_{CP}$ = 3.1, C_{3a}), 134.46 (d, J_{CP} = 3.1, C_4'^{I}), 134.54 (d, J_{CP} = 2.9, C_4'^{II}), 138.3 (d, $^3J_{CP}$ = 12.4, C_3'^{I}), 138.5 (d, $^3J_{CP}$ = 12.3, C_3'^{II}), 138.9 (d, $^2J_{CP}$ = 2.3, C_{7a}), 168.6 (d, $^3J_{CP}$ = 1.5, C_3); ^{31}P ($CDCl_3$) δ 31.6; $[M+H]^+_{found}$ = 446.2237, $C_{28}H_{33}NO_2P$ requires 446.2248.

Bis(3,5-dimethylphenyl) (2-cyclohexyl-3-oxo-2,3-dihydro-2*H*-isoindol-1-yl)phosphine oxide (9b)

Yield: 96% (0.45 g), white crystals; Mp: 180–182 °C; ^{1}H NMR ($CDCl_3$) δ 1.15–1.32 (m, 3H, ^{c}HexH), 1.51–1.67 (m, 2H, ^{c}HexH), 1.67–1.83 (m, 3H, ^{c}HexH), 2.04–2.22 [2.18 (s, $C_3''CH_3^{I}$), overlapped by the multiplet of ^{c}HexH total int. 7H), 2.35 (s, 6H, $C_3''CH_3^{II}$), 2.38–2.51 (m, 1H, ^{c}HexH), 3.62–3.76 (m, 1H, $C_1'H$), 5.40 (d, 1H, $^{2}J_{HP}$ = 11.3, C_1H), 6.60 (d, 1H, J_{HH} = 7.7, ArH), 6.77 (d, 2H, J_{HH} = 11.3, ArH), 7.11 (s, 1H, ArH), 7.19–7.44 (m, 5H, ArH), 7.69 (d, 1H, J_{HH} = 7.7, ArH);^{13}C NMR ($CDCl_3$) δ 21.1 ($C_3''CH_3^{I}$), 21.3 ($C_3''CH_3^{II}$), 25.2 (C_4'), 26.0 ($C_3'^{I}$), 26.3 ($C_3'^{II}$), 29.2 ($C_2'^{I}$), 29.9 ($C_2'^{II}$), 57.4 (C_1'), 63.4 (d, $^{1}J_{CP}$ = 72.4, C_1), 123.3 (d, J_{CP} = 1.4, C_4), 123.8 (d, $^{3}J_{CP}$ = 2.2, C_7), 126.0 (d, $^{1}J_{CP}$ = 98.0, $C_1''^{I}$), 128.5 (d, J_{CP} = 2.0, C_5), 129.1 (d, $^{2}J_{CP}$ = 9.0, $C_2''^{I}$), 129.9 (d, $^{2}J_{CP}$ = 8.5, $C_2''^{II}$), 130.4 (d, $^{1}J_{CP}$ = 96.3, $C_1''^{II}$), 130.7 (d, J_{CP} = 2.3, C_6), 134.32 (d, J_{CP} = 3.0, $C_4''^{I}$), 134.34 (d, J_{CP} = 2.9, $C_4''^{II}$), 134.6 (d, $^{3}J_{CP}$ = 3.1, C_{3a}), 137.8 (d, $^{3}J_{CP}$ = 12.4, $C_3''^{I}$), 138.5 (d, $^{3}J_{CP}$ = 12.3, $C_3''^{II}$), 139.1 (d, $^{2}J_{CP}$ = 1.4, C_{7a}), 168.9 (d, $^{3}J_{CP}$ = 2.1, C_3); ^{31}P ($CDCl_3$) δ 31.7; $[M+H]^{+}_{found}$ = 472.2378, $C_{30}H_{35}NO_2P$ requires 472.2399.

Bis(3,5-dimethylphenyl) (2-benzyl-3-oxo-2,3-dihydro-2*H*-isoindol-1-yl)phosphine oxide (9c)

Yield: 97% (0.46 g), white crystals; Mp: 88–90 °C; ^{1}H NMR ($CDCl_3$) δ 2.23 (s, 6H, $C_3''CH_3^{I}$), 2.31 (s, 6H, $C_3''CH_3^{II}$), 4.35 (d, 1H, J_{HH} = 15.1, CH_A, CH_2N), 5.29 (d, 1H, $^{2}J_{HP}$ = 10.0, C_1H), 5.39 (d, 1H, J_{HH} = 15.1, CH_B, CH_2N), 6.83 (d, 1H, J_{HH} = 7.7, ArH), 6.91 (d, 2H, J_{HH} = 11.5, ArH), 7.07–7.46 (m, 11H, ArH), 7.77 (d, 1H, J_{HH} = 7.5, ArH); ^{13}C NMR ($CDCl_3$) δ 21.2 ($C_3''CH_3^{I}$), 21.3 ($C_3''CH_3^{II}$), 45.2 (CH_2N), 60.1 (d, $^{1}J_{CP}$ = 71.7, C_1), 123.8 (d, J_{CP} = 1.2, C_4), 124.2 (d, $^{3}J_{CP}$ = 2.1, C_7), 127.39 (d, $^{1}J_{CP}$ = 97.6, $C_1''^{I}$), 127.44 (C_4'), 128.2 (C_3'), 128.56 (d, J_{CP} = 2.0, C_5), 128.58 (C_2'), 129.0 (d, $^{1}J_{CP}$ = 96.9, $C_1''^{II}$), 129.1 (d, $^{2}J_{CP}$ = 8.9, $C_2''^{I}$), 129.5 (d, $^{2}J_{CP}$ = 8.9, $C_2''^{II}$), 131.1 (d, J_{CP} = 1.8, C_6), 132.7 (d, $^{3}J_{CP}$ = 2.8, C_{3a}), 134.4 (d, J_{CP} = 3.0, $C_4''^{I}$), 134.5 (d, J_{CP} = 2.9, $C_4''^{II}$), 136.8 (C_1'), 138.3 (d, $^{3}J_{CP}$ = 12.5, $C_3''^{I}$), 138.5 (d, $^{3}J_{CP}$ = 12.4, $C_3''^{II}$), 139.1 (d, $^{2}J_{CP}$ = 2.2, C_{7a}), 168.8 (d, $^{3}J_{CP}$ = 1.5, C_3); ^{31}P ($CDCl_3$) δ 31.3; $[M+H]^{+}_{found}$ = 480.2086, $C_{31}H_{31}NO_2P$ requires 480.2092.

Bis(3,5-dimethylphenyl) (2-phenyl-3-oxo-2,3-dihydro-2*H*-isoindol-1-yl)phosphine oxide (9d)

Yield: 97% (0.45 g), white crystals; Mp: 200–202 °C; ^{1}H NMR ($CDCl_3$) δ 2.09 (s, 6H, $C_3''CH_3^{I}$), 2.31 (s, 6H, $C_3''CH_3^{II}$), 6.41 (dd, 1H, $^{2}J_{HP}$ = 10.6, J_{HH} = 6.4, C_1H), 6.49 (t, 1H, J_{HH} = 7.1, ArH), 6.81 (t, 3H, J_{HH} = 9.8, ArH), 6.92–7.03 (m, 3H, ArH), 7.18–7.31 (m, 3H, ArH), 7.46–7.59 (m, 3H, ArH), 7.65 (d, 1H, J_{HH} = 7.8, ArH), 7.87 (d, 1H, J_{HH} = 7.9, ArH);

^{13}C NMR ($CDCl_3$) δ 21.2 (C_3''CH_3^{I}), 21.5 (C_3''CH_3^{II}), 50.8 (d, $^1J_{CP}$ = 75.6, C_1), 113.9 (d, J_{CP} = 2.6, C_4), 117.5 (d, $^3J_{CP}$ = 1.2, C_7), 127.5 (d, J_{CP} = 2.5, C_5), 128.90 (d, $^2J_{CP}$ = 9.0, C_2''^{I}), 128.92 (d, $^2J_{CP}$ = 9.0, C_2''^{II}), 129.3 (C_4'), 129.6 (d, J_{CP} = 4.8, C_3'), 129.9 (d, J_{CP} = 4.9, C_2'), 130.7 (d, J_{CP} = 1.3, C_6), 131.1 (d, $^1J_{CP}$ = 97.3, C_1''^{I}), 131.9 (d, $^1J_{CP}$ = 95.3, C_1''^{II}), 132.5 (d, $^3J_{CP}$ = 2.4, C_{3a}), 133.4 (d, J_{CP} = 2.6, C_4''^{I}), 134.0 (d, J_{CP} = 2.9, C_4''^{II}), 137.4 (d, $^3J_{CP}$ = 12.1, C_3''^{I}), 138.4 (d, $^3J_{CP}$ = 12.0, C_3''^{II}), 140.1 (C_{7a}), 147.6 (d, $^3J_{CP}$ = 11.5, C_1'), 169.3 (d, $^3J_{CP}$ = 1.1, C_3); ^{31}P ($CDCl_3$) δ 32.2; $[M+H]^+_{found}$ = 466.1949, $C_{30}H_{29}NO_2P$ requires 466.1930.

Bis(2-naphthyl) (2-butyl-3-oxo-2,3-dihydro-2*H*-isoindol-1-yl)phosphine oxide (10a)

Yield: 96% (0.47 g), light yellow crystals; Mp: 105–107 °C; ^{1}H NMR ($CDCl_3$) δ 0.81 (t, 3H, J_{HH} = 7.4, CH_3(CH$_2$)$_3$N), 1.07–1.23 (m, 2H, CH_2(CH$_2$)$_2$N), 1.52–1.71 (m, 2H, CH_2CH$_2$N), 3.30–3.39 (m, 1H, CH$_A$, CH$_2$N), 3.94–4.03 (m, 1H, CH$_B$, CH$_2$N), 5.68 (d, 1H, $^2J_{HP}$ = 11.1, C_1H), 6.95 (d, 1H, J_{HH} = 7.7, ArH), 7.20 (t, 1H, J_{HH} = 8.8, ArH), 7.25–7.31 (m, 1H, ArH), 7.37 (t, 1H, J_{HH} = 7.5, ArH), 7.52–7.66 (m, 4H, ArH), 7.67 (d, 1H, J_{HH} = 7.5, ArH), 7.72 (t, 2H, J_{HH} = 8.7, ArH), 7.76–7.83 (m, 2H, ArH), 7.86 (d, 2H, J_{HH} = 8.2, ArH), 7.90 (d, 1H, J_{HH} = 8.2, ArH), 7.95 (dd, 1H, J_{HH} = 8.5, J_{HH} = 3.1, ArH), 8.15 (d, 1H, J_{HH} = 13.5, ArH), 8.29 (d, 1H, J_{HH} = 13.4, ArH); ^{13}C NMR ($CDCl_3$) δ 13.6 (*C*H$_3$(CH$_2$)$_3$N), 19.9 (*C*H$_2$(CH$_2$)$_2$N), 30.1 (*C*H$_2$CH$_2$N), 41.9 (CH$_2$N), 61.2 (d, $^1J_{CP}$ = 73.0, C_1), 123.8 (d, J_{CP} = 1.2, C_4), 124.1 (d, $^3J_{CP}$ = 2.3, C_7), 124.9 (d, $^1J_{CP}$ = 98.4, C_2'^{I}), 125.7 (d, J_{CP} = 9.9, C'^{I}), 125.9 (d, J_{CP} = 10.0, C'^{II}), 126.3 (d, $^1J_{CP}$ = 98.1, C_2'^{II}), 127.2 (C'^{I}), 127.3 (C'^{II}), 127.8 (C'^{I}), 127.9 (C'^{II}), 128.4 (d, J_{CP} = 11.5, C'^{I}), 128.6 (d, J_{CP} = 11.5, C'^{II}), 128.7 (C'^{I}), 128.75 (d, J_{CP} = 1.0, C_5) 128.77 (C'^{II}), 128.9 (C'^{I}), 129.0 (C'^{II}), 131.2 (d, J_{CP} = 2.3, C_6), 132.35 (d, $^2J_{CP}$ = 12.9, C'^{I}), 132.39 (d, $^2J_{CP}$ = 13.0, C'^{II}), 132.9 (d, $^3J_{CP}$ = 3.1, C_{3a}), 134.2 (d, $^2J_{CP}$ = 8.5, C'^{I}), 134.7 (d, $^2J_{CP}$ = 8.5, C'^{II}), 134.95 (d, J_{CP} = 2.3, C'^{I}), 135.02 (d, J_{CP} = 2.5, C'^{II}), 138.7 (d, $^2J_{CP}$ = 2.4, C_{7a}), 168.6 (d, $^3J_{CP}$ = 1.6, C_3); ^{31}P ($CDCl_3$) δ 31.2; $[M+H]^+_{found}$ = 490.1930, $C_{32}H_{29}NO_2P$ requires 490.1930.

Bis(2-naphthyl) (2-cyclohexyl-3-oxo-2,3-dihydro-2*H*-isoindol-1-yl)phosphine oxide (10b)

Yield: 95% (0.49 g), light yellow crystals; Mp: 208–210 °C; ^{1}H NMR ($CDCl_3$) δ 0.79–1.08 (m, 1H, ^{c}HexH), 1.13–1.37 (m, 2H, ^{c}HexH), 1.48–1.61 (m, 1H, ^{c}HexH), 1.61–1.90 (m, 4H, ^{c}HexH), 2.09–2.26 (m, 1H, ^{c}HexH), 2.38–2.57 (m, 1H, ^{c}HexH), 3.71–3.89 (m, 1H, C_1'H),

5.64 (d, 1H, $^{2}J_{HP}$ = 11.5, C_1H), 6.66 (d, 1H, J_{HH} = 7.7, ArH), 7.10 (t, 1H, J_{HH} = 8.8, ArH), 7.19–7.32 (m, 1H, ArH), 7.41 (t, 1H, J_{HH} = 7.6, ArH), 7.51–7.73 (m, 5H, ArH), 7.73–7.82 (m, 2H, ArH), 7.82–7.92 (m, 2H, ArH), 7.95 (d, 1H, J_{HH} = 8.2, ArH), 7.97–8.07 (m, 2H, ArH), 8.32 (d, 1H, J_{HH} = 13.3, ArH); ^{13}C NMR ($CDCl_3$) δ 25.2 (C_4'), 26.0 (C_3'^{I}), 26.2 (C_3'^{II}), 29.3 (C_2'^{I}), 30.1 (C_2'^{II}), 57.7 (C_1'), 63.5 (d, $^{1}J_{CP}$ = 73.5, C_1), 123.6 (d, $^{1}J_{CP}$ = 92.0, C_1''^{I}), 123.7 (d, J_{CP} = 1.8, C_4), 123.8 (d, $^{3}J_{CP}$ = 2.4, C_7), 126.1 (d, J_{CP} = 9.8, C''^{I}), 126.3 (d, J_{CP} = 9.4, C''^{II}), 127.1 (C''^{I}), 127.4 (C''^{II}), 127.7 (d, J_{CP} = 97.6, C_2''^{I}), 128.1 (d, J_{CP} = 11.6, C''^{I}), 128.76 (d, J_{CP} = 11.2, C''^{II}), 128.78 (C''^{I}), 128.84 (d, J_{CP} = 1.8, C_5), 128.96 (C''^{II}), 128.99 (C''^{I}), 129.1 (C''^{II}), 131.1 (d, J_{CP} = 2.3, C_6), 132.3 (d, J_{CP} = 12.9, C''^{I}), 132.5 (d, J_{CP} = 12.8, C''^{II}), 134.0 (d, J_{CP} = 8.8, C''^{I}), 134.6 (d, $^{3}J_{CP}$ = 3.0, C_{3a}), 135.02 (d, J_{CP} = 2.1, C''^{I}), 135.04 (d, J_{CP} = 2.2, C''^{II}), 135.3 (d, J_{CP} = 7.8, C''^{II}), 138.9 (d, $^{2}J_{CP}$ = 1.3, C_{7a}), 169.0 (d, $^{3}J_{CP}$ = 2.0, C_3); ^{31}P ($CDCl_3$) δ 31.4; $[M+H]^{+}_{found}$ = 516.2104, $C_{34}H_{31}NO_2P$ requires 516.2086.

Bis(2-naphthyl) (2-benzyl-3-oxo-2,3-dihydro-2*H*-isoindol-1-yl)phosphine oxide (10c)

Yield: 97% (0.51 g), light yellow crystals; Mp: 174–176 °C; ^{1}H NMR ($CDCl_3$) δ 4.48 (d, 1H, J_{HH} = 15.0, CH_A, CH_2N), 5.44 (d, 1H, J_{HH} = 15.0, CH_B, CH_2N), 5.53 (d, 1H, $^{2}J_{HP}$ = 10.4, C_1H), 6.90 (d, 1H, J_{HH} = 7.7, ArH), 7.11–7.22 (m, 3H, ArH), 7.23–7.34 (m, 4H, ArH), 7.41 (t, 2H, J_{HH} = 7.5, ArH), 7.53–8.01 (m, 12H, ArH), 8.20 (d, 1H, J_{HH} = 13.4, ArH), 8.27 (d, 1H, J_{HH} = 13.4, ArH); ^{13}C NMR ($CDCl_3$) δ 45.5 (CH_2N), 60.4 (d, $^{1}J_{CP}$ = 73.4, C_1), 124.25 (d, $^{3}J_{CP}$ = 1.6, C_7), 124.28 (d, J_{CP} = 0.5, C_4), 125.0 (d, $^{1}J_{CP}$ = 98.6, C_2''^{I}), 125.96 (d, J_{CP} = 9.9, C''^{I}), 126.00 (d, J_{CP} = 9.6, C''^{II}), 127.27 (C''^{I}), 127.33 (C''^{II}), 127.7 (C_4') 127.8 (d, $^{1}J_{CP}$ = 92.1, C_2''^{II}), 127.9 (C''^{I}), 128.0 (C''^{II}), 128.40 (C_2'), 128.42 (d, J_{CP} = 11.8 C''^{I}), 128.71 (d, J_{CP} = 11.8, C''^{II}), 128.74 (C_3'), 128.78 (C''^{I}), 128.80 (C''^{II}), 128.86 (C''^{I}), 128.88 (C''^{II}), 129.1 (d, J_{CP} = 1.0, C_5), 131.5 (d, J_{CP} = 2.0, C_6), 132.4 (d, J_{CP} = 12.9, C''^{I}), 132.5 (d, J_{CP} = 13.1, C''^{II}), 132.6 (d, $^{3}J_{CP}$ = 3.0, C_{3a}), 134.2 (d, J_{CP} = 8.6, C''^{I}), 135.0 (d, J_{CP} = 2.5, C''^{I}), 135.06 (d, J_{CP} = 8.3, C''^{II}), 135.13 (d, J_{CP} = 2.5, C''^{II}), 136.7 (C_1'), 139.0 (d, $^{2}J_{CP}$ = 2.3, C_{7a}), 167.0 (d, $^{3}J_{CP}$ = 2.0, C_3); ^{31}P ($CDCl_3$) δ 31.1; $[M+H]^{+}_{found}$ = 524.1793, $C_{35}H_{27}NO_2P$ requires 524.1773.

Dibenzyl (2-butyl-3-oxo-2,3-dihydro-2*H*-isoindol-1-yl)phosphine oxide (11a)

Yield: 96% (0.40 g), colourless oil; ^{1}H NMR ($CDCl_3$) δ 0.85 (t, J_{HH} = 7.3, 3H, $CH_3(CH_2)_3N$), 1.13–1.30 (m, 2H, $CH_2(CH_2)_2N$), 1.36–1.55 (m, 2H, CH_2CH_2N), 2.71–2.95 (m, 2H, CH_2P^{I}), 3.00–3.19 (m, 2H, CH_2P^{II}), 3.47–3.59 (m, 1H, CH_A, CH_2N), 3.98–4.11 (m, 1H, CH_B, CH_2N),

4.96 (d, 1H, $^{2}J_{HP}$ = 8.9, C_1H), 7.03–7.13 (m, 2H, ArH), 7.17–7.32 (m, 8H, ArH), 7.49–7.64 (m, 2H, ArH), 7.71 (d, 1H, J_{HH} = 7.4, ArH), 7.89 (d, 1H, J_{HH} = 7.2, ArH); ^{13}C NMR ($CDCl_3$) δ 13.7 ($CH_3(CH_2)_3N$), 19.9 ($CH_2(CH_2)_2N$), 30.0 (CH_2CH_2N), 33.5 (d, $^{1}J_{CP}$ = 60.1, CH_2P^{I}), 33.8 (d, $^{1}J_{CP}$ = 59.0, CH_2P^{II}), 42.3 (CH_2N), 58.4 (d, $^{1}J_{CP}$ = 65.0, C_1), 123.8 (d, J_{CP} = 2.2, C_4), 124.4 (d, $^{3}J_{CP}$ = 1.3, C_7), 127.17 (d, J_{CP} = 2.7, $C_4{}'^{I}$), 127.24 (d, J_{CP} = 2.5, $C_4{}'^{II}$), 128.76 (d, J_{CP} = 12.1, $C_3{}'^{I}$), 128.79 (d, J_{CP} = 12.1, $C_3{}'^{II}$), 129.0 (d, J_{CP} = 1.9, C_5), 129.7 (d, $^{3}J_{CP}$ = 7.7, $C_2{}'^{I}$), 129.8 (d, $^{3}J_{CP}$ = 7.6, $C_2{}'^{II}$), 130.1 (d, $^{2}J_{CP}$ = 11.4, $C_1{}'^{I}$), 130.2 (d, $^{2}J_{CP}$ = 11.4, $C_1{}'^{II}$), 131.7 (d, J_{CP} = 2.1, C_6), 132.7 (d, $^{3}J_{CP}$ = 2.8, C_{3a}), 138.8 (d, $^{2}J_{CP}$ = 2.0, C_{7a}), 168.7 (d, $^{3}J_{CP}$ = 2.0, C_3); ^{31}P ($CDCl_3$) δ 41.7; $[M+H]^{+}_{found}$ = 418.1942, $C_{26}H_{29}NO_2P$ requires 418.1936.

Dibenzyl (2-cyclohexyl-3-oxo-2,3-dihydro-2*H*-isoindol-1-yl)phosphine oxide (11b)

Yield: 94% (0.42 g), white crystals; Mp: 64–65 °C; ^{1}H NMR ($CDCl_3$) δ 1.16–1.45 (m, 3H, ^{c}HexH), 1.52–1.69 (m, 2H, ^{c}HexH), 1.70–2.07 (m, 3H, ^{c}HexH), 2.11–2.30, (m, 1H, ^{c}HexH), 2.46–2.72 (m, 2H, ^{c}HexH, CH_A, CH_2P^{I}), 2.81–3.00 (m, 1H, CH_B, CH_2P^{I}), 3.02–3.24 (m, 2H, CH_2P^{II}), 3.60–3.76 (m, $C_1{}'H$), 4.94 (d, 1H, $^{2}J_{HP}$ = 8.9, C_1H), 6.97–7.09 (m, 2H, ArH), 7.17–7.32 (m, 8H, ArH), 7.47–7.63 (m, 2H, ArH), 7.68 (d, 1H, J_{HH} = 7.5, ArH), 7.87 (d, 1H, J_{HH} = 7.0, ArH); ^{13}C NMR ($CDCl_3$) δ 25.1 ($C_4{}'$), 25.9 ($C_3{}'^{I}$), 26.3 ($C_3{}'^{II}$), 28.8 ($C_2{}'^{I}$), 30.0 ($C_2{}'^{II}$), 32.7 (d, $^{1}J_{CP}$ = 60.6, CH_2P^{I}), 33.3 (d, $^{1}J_{CP}$ = 59.3, CH_2P^{II}), 57.9 ($C_1{}'$), 60.9 (d, $^{1}J_{CP}$ = 64.7, C_1), 123.5 (d, J_{CP} = 2.2, C_4), 124.2 (d, J_{CP} = 1.2, C_7), 127.1 (d, J_{CP} = 2.7, $C_4{}''^{I}$), 127.2 (d, J_{CP} = 2.5, $C_4{}''^{II}$), 128.75 (d, J_{CP} = 13.6, $C_3{}''^{I}$), 128.78 (d, J_{CP} = 13.5, $C_3{}''^{II}$), 129.0 (d, J_{CP} = 1.9, C_5), 129.83 (d, $^{3}J_{CP}$ = 5.5 $C_2{}''^{I}$), 129.84 (d, $^{3}J_{CP}$ = 5.6, $C_2{}''^{II}$), 130.2 (d, $^{2}J_{CP}$ = 10.7, $C_1{}''^{I}$), 130.3 (d, $^{2}J_{CP}$ = 10.7, $C_1{}''^{II}$), 131.6 (d, J_{CP} = 2.2, C_6), 134.1 (d, $^{3}J_{CP}$ = 3.0, C_{3a}), 139.1 (d, $^{2}J_{CP}$ = 1.4, C_{7a}), 169.2 (d, $^{3}J_{CP}$ = 2.2, C_3); ^{31}P ($CDCl_3$) δ 41.4; $[M+H]^{+}_{found}$ = 444.2098, $C_{28}H_{31}NO_2P$ requires 444.2092.

Dibenzyl (2-benzyl-3-oxo-2,3-dihydro-2*H*-isoindol-1-yl)phosphine oxide (11c)

Yield: 96% (0.43 g), white crystals; Mp: 68–70 °C; ^{1}H NMR ($CDCl_3$) δ 2.54–2.68 (m, 1H, CH_A, CH_2P^{I}), 2.77–2.91 (m, 1H, CH_B, CH_2P^{I}), 3.07–3.23 (m, 2H, CH_2P^{II}), 4.77 (d, 1H, J_{HH} = 14.7, CH_A, CH_2N), 4.79 (d, 1H, $^{2}J_{HP}$ = 8.8, C_1H),), 5.34 (d, 1H, J_{HH} = 14.6, CH_B, CH_2N), 6.95–7.04 (m, 2H, ArH), 7.13–7.31 (m, 13H, ArH), 7.51–7.60 (m, 3H, ArH), 7.94 (d, 1H, J_{HH} = 6.3, ArH); ^{13}C NMR ($CDCl_3$) δ 33.0 (d, $^{1}J_{CP}$ = 60.3, CH_2P^{I}), 34.4 (d, $^{1}J_{CP}$ = 58.4, CH_2P^{II}), 45.9 (CH_2N), 57.5 (d, $^{1}J_{CP}$ = 65.3, C_1), 123.2 (d, J_{CP} = 2.1, C_4), 124.9 (d, J_{CP} = 1.1,

C_7), 127.1 (d, J_{CP} = 2.5, C_4"I), 127.3 (d, J_{CP} = 2.5, C_4"II), 127.5 (C_4'), 128.6 (C_3'), 128.75 (d, J_{CP} = 16.0, C_3"I), 128.77 (d, J_{CP} = 15.8, C_3"II), 128.8 (C_2'), 129.0 (d, J_{CP} = 1.9, C_5), 129.71 (d, $^3J_{CP}$ = 5.5, C_2"I), 129.8 (d, $^3J_{CP}$ = 5.4, C_2"II), 129.9 (d, $^2J_{CP}$ = 17.8, C_1"I), 130.0 (d, $^2J_{CP}$ = 17.6, C_1"II), 131.9 (d, J_{CP} = 2.2, C_6), 132.5 (d, $^3J_{CP}$ = 2.8, C_{3a}), 136.6 (C_1'), 139.0 (d, $^2J_{CP}$ = 2.0, C_{7a}), 168.6 (d, $^3J_{CP}$ = 2.2, C_3); ^{31}P ($CDCl_3$) δ 41.5; $[M+H]^+_{found}$ = 452.1783, $C_{29}H_{27}NO_2P$ requires 452.1779.

***tert*-Butyl(phenyl) (2-butyl-3-oxo-2,3-dihydro-2*H*-isoindol-1-yl)phosphine oxide (12)**

Yield: 94% (0.44 g), *dr*: 40:60, colourless oil; characterized as a mixture, **Isomer A:** ^{1}H NMR ($CDCl_3$) δ 0.78 (t, J_{HH} = 7.3, 3H, CH_3(CH_2)$_3$N), 1.00-1.27 [1.22 (d, $^3J_{HP}$ = 14.9, C(CH_3)$_3$) overlapped by the multiplet of CH_2(CH_2)$_2$N, total int. 11H], 1.27–1.43 (m, 2H, C$H_2$$CH_2$N), 3.27–3.38 (m, 1H, CH_A, CH_2N), 3.87–4.01 (m, 1H, CH_B, CH_2N), 5.27 (d, 1H, $^2J_{HP}$ = 11.0, C_1H), 6.97 (d, 1H, J_{HH} = 7.4, ArH), 7.31–7.43 (m, 2H, ArH), 7.44–7.63 (m, 2H, ArH), 7.77–7.88 (m, 2H, ArH); ^{13}C NMR ($CDCl_3$) δ 13.7 (*C*H_3(CH_2)$_3$N), 19.9 (*C*H_2(CH_2)$_2$N), 26.0 (C(*C*H_3)$_3$), 29.6 (*C*$H_2$$CH_2$N), 35.3 (d, $^1J_{P-C}$ = 62.0, *C*(CH_3)$_3$), 42.4 (CH_2N), 61.8 (d, $^1J_{CP}$ = 60.0, C_1), 124.1 (d, J_{CP} = 1.1, C_4), 125.3 (d, $^3J_{CP}$ = 1.8, C_7), 128.4 (d, $^3J_{CP}$ = 10.7, C_3'), 129.0 (d, J_{CP} = 1.5, C_5), 131.1 (d, J_{CP} = 2.0, C_6), 131.9 (d, $^2J_{CP}$ = 8.1, C_2'), 132.35 (d, J_{CP} = 2.0, C_4'), 132.39 (d, J_{CP} = 2.7, C_{3a}), 132.9 (d, $^1J_{CP}$ = 39.1, C_1'), 140.0 (d, $^2J_{CP}$ = 2.1, C_{7a}), 169.5 (d, $^3J_{CP}$ = 1.3, C_3); ^{31}P ($CDCl_3$) δ 45.8; **Isomer B:** ^{1}H NMR ($CDCl_3$) δ 0.94 (t, J_{HH} = 7.2, 3H, CH_3(CH_2)$_3$N), 1.14 (d, 9H, $^3J_{HP}$ = 15.0, C(CH_3)$_3$), 1.27–1.43 (m, 2H, CH_2(CH_2)$_2$N), 1.60–1.77 (m, 2H, C$H_2$$CH_2$N), 3.87–4,01 (m, 1H, CH_A, CH_2N), 4,23–4.36 (m, 1H, CH_B, CH_2N), 5.15 (d, 1H, $^2J_{HP}$ = 11.9, C_1H), 7.31–7.43 (m, 2H, ArH), 7.44–7.63 (m, 2H, ArH), 7.77–7.88 (m, 2H, ArH), 8.02 (d, 1H, J_{HH} = 7.5, ArH); ^{13}C NMR ($CDCl_3$) δ 13.8 (*C*H_3(CH_2)$_3$N), 20.1 (*C*H_2(CH_2)$_2$N), 25.9 (C(*C*H_3)$_3$), 30.0 (*C*$H_2$$CH_2$N), 35.9 (d, $^1J_{P-C}$ = 60.8, *C*(CH_3)$_3$), 43.2 (CH_2N), 62.4 (d, $^1J_{CP}$ = 62.0, C_1), 123.9 (d, J_{CP} = 1.3, C_4), 124.3 (d, $^3J_{CP}$ = 2.2, C_7), 128.5 (d, $^3J_{CP}$ = 10.5, C_3'), 128.7 (d, J_{CP} = 1.6, C_5), 129.8 (d, $^1J_{CP}$ = 45.1, C_1'), 131.0 (d, J_{CP} = 1.9, C_6), 132.3 (d, $^2J_{CP}$ = 7.8, C_2'), 132.40 (d, J_{CP} = 1.9, C_4'), 132.41 (d, J_{CP} = 2.9, C_{3a}), 139.9 (d, $^2J_{CP}$ = 1.7, C_{7a}), 169.3 (d, $^3J_{CP}$ = 1.9, C_3); ^{31}P ($CDCl_3$) δ 44.4; $[M+H]^+_{found}$ = 370.1946, $C_{22}H_{29}NO_2P$ requires 370.1930.

2-Methylphenyl(phenyl) (2-butyl-3-oxo-2,3-dihydro-2*H*-isoindol-1-yl)phosphine oxide (13)

Yield: 96% (0.39 g), *dr*: 40:60, light yellow crystals; Mp: 118–120 °C; characterized as a mixture, **Isomer A:** ^{1}H NMR ($CDCl_3$) δ 0.80 (t, J_{HH} = 7.3, 3H, CH_3(CH_2)$_3$N), 0.85-0.96 (m,

1H, CH_A, $CH_2(CH_2)_2N$), 1.04-1.17 (m, 1H, CH_B, $CH_2(CH_2)_2N$), 1.37−1.55 (m, 2H, CH_2CH_2N), 2.64–2.77 (m, 1H, CH_A, CH_2N), 2.89 (s, 3H, $C_2'CH_3$), 3.86–4.02 (m, 1H, CH_B, CH_2N), 5.55 (d, 1H, $^2J_{HP}$ = 10.1, C_1H), 6.63 (d, 1H, J_{HH} = 7.7, ArH), 7.08−7.22 (m, 2H, ArH), 7.23–7.39 (m, 4H, ArH), 7.39−7.60 (m, 5H, ArH), 7.63 (d, 1H, J_{HH} = 6.9, ArH); ^{13}C NMR ($CDCl_3$) δ 13.6 ($CH_3(CH_2)_3N$), 19.9 ($CH_2(CH_2)_2N$), 21.8 (d, $^3J_{CP}$ = 8.0, $C_2'CH_3$), 30.2 (CH_2CH_2N), 41.6 (CH_2N), 60.5 (d, $^1J_{CP}$ = 71.5, C_1), 123.4 (d, J_{CP} = 1.5, C_4), 123.6 (d, $^3J_{CP}$ = 2.1, C_7), 125.1 (d, $^1J_{CP}$ = 94.6, C_1'')*, 125.4 (d, $^3J_{CP}$ = 12.5, C_5'), 128.3 (d, $^3J_{CP}$ = 11.6, C_3'')*, 128.5 (d, J_{CP} = 1.6, C_5), 130.9 (d, $^1J_{CP}$ = 95.6, C_1')*, 131.1 (d, J_{CP} = 1.7, C_6), 131.8 (d, $^2J_{CP}$ = 10.0, C_2'')*, 132.3 (d, $^3J_{CP}$ = 11.9, C_3')*, 132.4 (d, J_{CP} = 3.2, C_4')*, 132.7 (d, $^2J_{CP}$ = 9.5, C_6')*, 132.8 (d, J_{CP} = 2.3, C_4'')*, 133.3 (d, J_{CP} = 1.3, C_{3a}), 138.5 (d, $^2J_{CP}$ = 1.7, C_{7a}), 142.3 (d, $^2J_{CP}$ = 8.0, C_2'), 168.3 (d, $^3J_{CP}$ = 1.9, C_3), *tentative assignments; ^{31}P ($CDCl_3$) δ 31.1; **Isomer B:** ^{1}H NMR ($CDCl_3$) δ 0.90 (t, J_{HH} = 7.2, 3H, $CH_3(CH_2)_3N$), 1.19-1.37 (m, 2H, $CH_2(CH_2)_2N$), 1.56−1.78 (m, 2H, CH_2CH_2N), 2.91 (s, 3H, $C_2'CH_3$), 3.56–3.68 (m, 1H, CH_A, CH_2N), 3.86–4.02 (m, 1H, CH_B, CH_2N), 5.64 (d, 1H, J_{HP} = 11.6, C_1H), 7.08−7.22 (m, 3H, ArH), 7.23–7.39 (m, 4H, ArH), 7.39−7.60 (m, 5H, ArH), 7.75 (d, 1H, J_{HH} = 7.5, ArH); ^{13}C NMR ($CDCl_3$) δ 13.8 ($CH_3(CH_2)_3N$), 20.0 ($CH_2(CH_2)_2N$), 21.8 (d, $^3J_{CP}$ = 8.2, $C_2'CH_3$), 30.0 (CH_2CH_2N), 42.0 (CH_2N), 61.5 (d, $^1J_{CP}$ = 70.8, C_1), 123.9 (d, J_{CP} = 1.0, C_4), 124.5 (d, $^3J_{CP}$ = 2.3, C_7), 125.8 (d, $^3J_{CP}$ = 12.5, C_5'), 126.8 (d, $^1J_{CP}$ = 99.9, C_1'')*, 128.3 (d, $^3J_{CP}$ = 11.9, C_3'')*, 128.8 (d, J_{CP} = 2.2, C_5), 130.9 (d, $^1J_{CP}$ = 96.3, C_1')*, 131.2 (d, J_{CP} = 2.1, C_6), 131.9 (d, $^2J_{CP}$ = 9.8, C_2'')*, 132.58 (d, $^3J_{CP}$ = 11.3, C_3')*, 132.60 (d, J_{CP} = 1.8, C_4')*, 132.7 (d, $^2J_{CP}$ = 9.9, C_6')*, 133.3 (d, J_{CP} = 3.3, C_4'')*, 133.6 (d, J_{CP} = 1.6, C_{3a}), 139.7 (d, $^2J_{CP}$ = 0.9, C_{7a}), 143.7 (d, $^2J_{CP}$ = 7.8, C_2'), 169.3 (d, $^3J_{CP}$ = 1.3, C_3), *tentative assignments; ^{31}P ($CDCl_3$) δ 34.7; $[M+H]^+_{found}$ = 404.1790, $C_{25}H_{27}NO_2P$ requires 404.1773.

2-Methoxyphenyl(phenyl) (2-butyl-3-oxo-2,3-dihydro-2*H*-isoindol-1-yl)phosphine oxide (14)

Yield: 95% (0.40 g), *dr*: 45:55 white crystals; Mp: 133−135 °C; characterized as a mixture, **Isomer A:** ^{1}H NMR ($CDCl_3$) δ 0.79 (t, J_{HH} = 7.2, 3H, $CH_3(CH_2)_3N$), 0.99-1.15 (m, 2H, $CH_2(CH_2)_2N$), 1.36−1.44 (m, 1H, CH_A, CH_2CH_2N), 1.46–1.53 (m, 1H, CH_B, CH_2CH_2N), 2.66–2.74 (m, 1H, CH_A, CH_2N), 3.86–3.94 (m, 1H, CH_B, CH_2N), 3.96 (s, 3H, CH_3O), 5.86 (d, 1H, $^2J_{HP}$ = 10.4, C_1H), 6.99 (t, 1H, J_{HH} = 6.9, ArH), 7.03−7.12 (m, 1H, ArH), 7.15−7.22 (m, 1H, ArH), 7.22–7.31 (m, 4H, ArH), 7.32–7.42 (m, 2H, ArH), 7.45 (t, 1H, J_{HH} = 7.6, ArH), 7.52−7.59 (m, 2H, ArH), 7.68 (d, 1H, J_{HH} = 7.6, ArH); ^{13}C NMR ($CDCl_3$) δ 13.7 ($CH_3(CH_2)_3N$), 20.0 ($CH_2(CH_2)_2N$), 30.2 (CH_2CH_2N), 41.4 (CH_2N), 55.7 (CH_3O), 60.1 (d,

$^{1}J_{CP}$ = 74.0, C_1), 111.2 (d, $^{2}J_{CP}$ = 6.6, C_6'), 119.5 (d, $^{1}J_{CP}$ = 94.6, C_1'')*, 121.3 (d, $^{3}J_{CP}$ = 11.5, C_5'), 123.2 (d, J_{CP} = 1.1, C_4), 123.4 (d, $^{3}J_{CP}$ = 2.2, C_7), 126.6 (d, $^{1}J_{CP}$ = 99.8, C_1')*, 128.0 (d, $^{3}J_{CP}$ = 11.7, C_3''), 128.2 (d, J_{CP} = 0.8, C_5), 131.0 (d, J_{CP} = 2.0, C_6), 131.7 (d, $^{2}J_{CP}$ = 8.3, C_2''), 132.2 (d, J_{CP} = 3.0, C_4'')*, 133.5 (d, J_{CP} = 3.3, C_4')*, 134.3 (d, $^{3}J_{CP}$ = 6.9, C_3'), 135.0 (d, J_{CP} = 2.2, C_{3a}), 139.7 (d, $^{2}J_{CP}$ = 3.3, C_{7a}), 161.5 (d, $^{2}J_{CP}$ = 4.1, C_2'), 168.2 (d, $^{3}J_{CP}$ = 1.3, C_3), *tentative assignments; ^{31}P ($CDCl_3$) δ 29.3; **Isomer B:** ^{1}H NMR ($CDCl_3$) δ 0.87 (t, J_{HH} = 7.3, 3H, CH_3(CH_2)$_3$N), 1.18-1.28 (m, 2H, CH_2(CH_2)$_2$N), 1.54–1.62 (m, 1H, CH_A, C$H_2$$CH_2$N), 1.63–1.72 (m, 1H, CH_B, C$H_2$$CH_2$N), 3.48–3.56 (m, 1H, CH_A, CH_2N), 3.86–3.94 (m, 1H, CH_B, CH_2N), 4.05 (s, 3H, CH_3O), 5.92 (d, 1H, $^{2}J_{HP}$ = 11.9, C_1H), 6.84 (d, 1H, J_{HH} = 7.6, ArH), 6.92 (t, 1H, J_{HH} = 7.2, ArH), 7.03–7.12 (m, 1H, ArH), 7.15–7.22 (m, 1H, ArH), 7.22–7.31 (m, 4H, ArH), 7.32–7.42 (m, 2H, ArH), 7.52–7.59 (m, 3H, ArH); ^{13}C NMR ($CDCl_3$) δ 13.8 (*C*H_3(CH_2)$_3$N), 20.0 (*C*H_2(CH_2)$_2$N), 30.0 (*C*$H_2$$CH_2$N), 41.9 ($CH_2$N), 56.0 ($CH_3$O), 61.5 (d, $^{1}J_{CP}$ = 72.9, C_1), 111.3 (d, $^{2}J_{CP}$ = 6.8, C_6'), 119.5 (d, $^{1}J_{CP}$ = 94.7, C_1'')*, 121.2 (d, $^{3}J_{CP}$ = 11.6, C_5'), 123.7 (d, J_{CP} = 1.1, C_4), 124.4 (d, $^{3}J_{CP}$ = 2.1, C_7), 126.7 (d, $^{1}J_{CP}$ = 99.9, C_1')*, 128.0 (d, $^{3}J_{CP}$ = 11.7, C_3''), 128.5 (d, J_{CP} = 1.2, C_5), 130.9 (d, J_{CP} = 2.2, C_6), 132.0 (d, $^{2}J_{CP}$ = 8.6, C_2''), 132.5 (d, J_{CP} = 2.9, C_4'')*, 133.5 (d, J_{CP} = 3.0, C_4')*, 134.3 (d, $^{3}J_{CP}$ = 7.4, C_3'), 134.8 (d, J_{CP} = 1.9, C_{3a}), 138.5 (d, $^{2}J_{CP}$ = 2.4, C_{7a}), 161.2 (d, $^{2}J_{CP}$ = 3.5, C_2'), 169.3 (d, $^{3}J_{CP}$ = 1.8, C_3), *tentative assignments; ^{31}P ($CDCl_3$) δ 33.7; $[M+H]^{+}_{found}$ = 420.1739, $C_{25}H_{27}NO_3P$ requires 420.1723.

2-Trifluoromethylphenyl(phenyl) (2-butyl-3-oxo-2,3-dihydro-2*H*-isoindol-1-yl)phosphine oxide (15)

Yield: 97% (0.44 g), *dr*: 35:65, colourless oil; characterized as a mixture, **Isomer A:** ^{1}H NMR ($CDCl_3$) δ 0.77 (t, J_{HH} = 7.4, 3H, CH_3(CH_2)$_3$N), 0.97-1.17 (m, 2H, CH_2(CH_2)$_2$N), 1.19–1.39 (m, 1H, CH_A, C$H_2$$CH_2$N), 1.38–1.52 (m, 1H, CH_B, C$H_2$$CH_2$N), 2.54–2.64 (m, 1H, CH_A, CH_2N), 3.84–3.95 (m, 1H, CH_B, CH_2N), 5.63 (d, 1H, $^{2}J_{HP}$ = 10.7, C_1H), 6.57 (d, 1H, J_{HH} = 7.6, ArH), 7.13 (d, 1H, J_{HH} = 6.6, ArH), 7.29–7.41 (m, 3H, ArH), 7.42–7.60 (m, 4H, ArH), 7.67 (d, 1H, J_{HH} = 7.2, ArH), 7.74 (d, 1H, J_{HH} = 6.9, ArH), 7.98–8.02 (m, 4H, ArH); ^{13}C NMR ($CDCl_3$) δ 13.5 (*C*H_3(CH_2)$_3$N), 19.9 (*C*H_2(CH_2)$_2$N), 29.7 (*C*$H_2$$CH_2$N), 41.9 ($CH_2$N), 61.7 (dd, $^{1}J_{CP}$ = 74.9, J_{CF} = 2.5, C_1), 123.6 (d, $^{3}J_{CP}$ = 0.9, C_7), 124.5 (d, J_{CP} = 2.3, C_4), 126.6 (d, $^{1}J_{CP}$ = 103.6, C_1''), 127.2 ($^{1}J_{CP}$ = 100.7, C_1'), 128.5 (d, $^{3}J_{CP}$ = 11.6, C_3''), 128.7 (m, C_3'), 129.1 (d, J_{CP} = 1.8, C_5), 130.3 (dd, $^{3}J_{CP}$ = 2.1, $^{1}J_{CF}$ = 235.0, CF_3), 131.6 (dd, $^{2}J_{CP}$ = 11.3, $^{2}J_{CF}$ = 36.4, C_2'), 131.5 (d, J_{CP} = 2.1, C_6), 131.9 (d, $^{2}J_{CP}$ = 8.2, C_2''), 132.7 (d, J_{CP} = 4.0, C_4''),

132.9 (d, J_{CP} = 3.1, C_4'), 133.0 (d, $^2J_{CP}$ = 6.6, C_6'), 133.6 (d, J_{CP} = 3.2, C_{3a}), 134.2 (d, $^3J_{CP}$ = 10.5, C_5'), 139.7 (d, $^2J_{CP}$ = 2.4, C_{7a}), 169.6 (d, $^3J_{CP}$ = 2.1, C_3); ^{31}P ($CDCl_3$) δ 28.4; **Isomer B:** ^{1}H NMR ($CDCl_3$) δ 0.89 (t, J_{HH} = 7.2, 3H, CH_3(CH_2)$_3$N), 1.19-1.31 (m, 2H, CH_2(CH_2)$_2$N), 1.54–1.66 (m, 1H, CH_A, C$H_2$$CH_2$N), 1.66–1.76 (m, 1H, CH_B, C$H_2$$CH_2$N), 3.47–3.56 (m, 1H, CH_A, CH_2N), 3.84–3.95 (m, 1H, CH_B, CH_2N), 5.72 (d, 1H, $^2J_{HP}$ = 12.6, C_1H), 7.11 (d, 1H, J_{HH} = 7.6, ArH), 7.28 (d, 1H, J_{HH} = 5.1, ArH), 7.29–7.41 (m, 3H, ArH), 7.42–7.60 (m, 4H, ArH), 7.80 (d, 1H, J_{HH} = 7.3, ArH), 7.74 (d, 1H, J_{HH} = 6.9, ArH), 8.02–8.07 (m, 4H, ArH); ^{13}C NMR ($CDCl_3$) δ 13.7 (*C*H_3(CH_2)$_3$N), 19.9 (*C*H_2(CH_2)$_2$N), 29.9 (*C*$H_2$$CH_2$N), 42.1 ($CH_2$N), 61.9 (dd, $^1J_{CP}$ = 72.6, J_{CF} = 3.0, C_1), 123.5 (d, J_{CP} = 2.1, C_4), 124.2 (d, $^3J_{CP}$ = 0.9, C_7), 126.6 (d, $^1J_{CP}$ = 103.8, C_1''), 127.2 ($^1J_{CP}$ = 100.9, C_1), 128.5 (d, $^3J_{CP}$ = 11.6, C_3''), 128.7 (m, C_3'), 129.1 (d, J_{CP} = 1.4, C_5), 130.3 (dd, $^3J_{CP}$ = 2.1, $^1J_{CF}$ = 239.8, CF_3), 131.2 (d, J_{CP} = 1.8, C_6), 131.6 (dd, $^2J_{CP}$ = 11.3, $^2J_{CF}$ = 37.2, C_2'), 132.2 (d, $^2J_{CP}$ = 7.8, C_2''), 132.7 (d, J_{CP} = 3.3, C_4''), 133.00 (d, $^2J_{CP}$ = 6.6, C_6'), 133.03 (d, J_{CP} = 3.1, C_4'), 133.6 (d, J_{CP} = 1.8, C_{3a}), 134.5 (d, $^3J_{CP}$ = 10.5, C_5'), 138.2 (d, $^2J_{CP}$ = 1.8, C_{7a}), 168.3 (d, $^3J_{CP}$ = 2.1, C_3); ^{31}P ($CDCl_3$) δ 32.7; $[M+H]^+_{found}$ = 458.1504, $C_{25}H_{24}NO_2F_3P$ requires 458.1491.

3-Trifluoromethylphenyl(phenyl) (2-butyl-3-oxo-2,3-dihydro-2*H*-isoindol-1-yl)phosphine oxide (16)

Yield: 96% (0.44 g), *dr*: 50:55, colourless oil; characterized as a mixture, **Isomer A:** ^{1}H NMR ($CDCl_3$) δ 0.77 (t, J_{HH} = 7.5, 3H, CH_3(CH_2)$_3$N), 1.01-1.23 (m, 2H, CH_2(CH_2)$_2$N), 1.37–1.64 (m, 2H, C$H_2$$CH_2$N), 2.94–3.02 (m, 1H, CH_A, CH_2N), 3.83–3.97 (m, 1H, CH_B, CH_2N), 5.43 (d, 1H, $^2J_{HP}$ = 10.5, C_1H), 6.70 (d, 1H, J_{HH} = 7.6, ArH), 7.24–7.65 (m, 10H, ArH), 7.67–7.78 (m, 2H, ArH); ^{13}C NMR ($CDCl_3$) δ 13.6 (*C*H_3(CH_2)$_3$N), 19.8 (*C*H_2(CH_2)$_2$N), 29.9 (*C*$H_2$$CH_2$N), 41.7 ($CH_2$N), 60.7 (d, $^1J_{CP}$ = 73.8, C_1), 123.2 (dd, J_{CP} = 1.6, $^1J_{CF}$ = 274.3, CF_3), 123.76 (d, $^3J_{CP}$ = 2.5, C_7), 123.83 (d, J_{CP} = 0.9, C_4), 127.7 (d, $^1J_{CP}$ = 98.6, C_1')*, 128.4 (d, $^1J_{CP}$ = 97.3, C_1'')*, 128.6 (m, C_2'), 128.7 (dd, $^3J_{CP}$ = 9.4, $^2J_{CF}$ = 30.6, C_3'), 129.00 (d, $^3J_{CP}$ = 11.8, C_3''), 129.04 (d, $^3J_{CP}$ = 13.3, C_5'), 129.3 (d, J_{CP} = 2.8, C_5), 129.4 (d, J_{CP} = 4.0, C_4''), 131.3 (d, J_{CP} = 1.9, C_6), 131.4 (d, $^2J_{CP}$ = 9.1, C_2''), 132.6 (d, J_{CP} = 3.1, C_4'), 133.3 (d, J_{CP} = 2.8, C_{3a}), 134.5 (d, $^2J_{CP}$ = 8.6, C_6'), 137.9 (d, $^2J_{CP}$ = 2.0, C_{7a}), 168.3 (d, $^3J_{CP}$ = 1.6, C_3), *tentative assignments; ^{31}P ($CDCl_3$) δ 29.2; **Isomer B:** ^{1}H NMR ($CDCl_3$) δ 0.81 (t, J_{HH} = 7.3, 3H, CH_3(CH_2)$_3$N), 1.01-1.23 (m, 2H, CH_2(CH_2)$_2$N), 1.37–1.64 (m, 2H, C$H_2$$CH_2$N), 3.29–3.97 (m, 1H, CH_A, CH_2N), 3.83–3.97 (m, 1H, CH_B, CH_2N), 5.47 (d, 1H, $^2J_{HP}$ = 10.9, C_1H), 6.98 (d, 1H, J_{HH} = 7.2, ArH), 7.24–7.65 (m, 10H, ArH), 7.67–7.78 (m, 1H, ArH), 7.88 (d, 1H,

J_{HH} = 11.3, ArH); ^{13}C NMR ($CDCl_3$) δ 13.6 ($CH_3(CH_2)_3N$), 19.9 ($CH_2(CH_2)_2N$), 30.0 (CH_2CH_2N), 42.0 (CH_2N), 61.0 (d, $^1J_{CP}$ = 73.8, C_1), 123.3 (dd, J_{CP} = 1.4, $^1J_{CF}$ = 273.1, CF_3), 123.99 (d, $^3J_{CP}$ = 2.5, C_7), 124.00 (d, J_{CP} = 1.4, C_4), 128.5 (d, $^1J_{CP}$ = 98.4, C_1')*, 128.77 (dd, $^3J_{CP}$ = 9.4, $^2J_{CF}$ = 31.3, C_3'), 128.80 (m, C_2'), 129.00 (d, $^3J_{CP}$ = 11.8, C_3''), 129.2 (d, $^3J_{CP}$ = 11.6, C_5'), 129.51 (d, J_{CP} = 3.2, C_4''), 129.53 (d, J_{CP} = 2.9, C_5), 129.6 (d, $^1J_{CP}$ = 96.3, C_1'')*, 131.3 (d, J_{CP} = 2.2, C_6), 131.5 (d, $^2J_{CP}$ = 9.4, C_2''), 132.9 (d, J_{CP} = 3.2, C_4'), 133.3 (d, J_{CP} = 2.8, C_{3a}), 135.3 (d, $^2J_{CP}$ = 8.4, C_6'), 138.3 (d, $^2J_{CP}$ = 3.2, C_{7a}), 168.6 (d, $^3J_{CP}$ = 1.6, C_3), *tentative assignments; ^{31}P ($CDCl_3$) δ 30.5; $[M+H]^+_{found}$ = 458.1505, $C_{25}H_{24}NO_2F_3P$ requires 458.1491.

4-Trifluoromethylphenyl(phenyl) (2-butyl-3-oxo-2,3-dihydro-2*H*-isoindol-1-yl)phosphine oxide (17)

Yield: 98% (0.45 g), *dr*: 50:50, colourless oil; characterized as a mixture, **Isomer A:** ^{1}H NMR ($CDCl_3$) δ 0.82 (t, J_{HH} = 7.2, 3H, $CH_3(CH_2)_3N$), 1.06-1.33 (m, 2H, $CH_2(CH_2)_2N$), 1.41–1.69 (m, 2H, CH_2CH_2N), 2.95–3.04 (m, 1H, CH_A, CH_2N), 3.89–4.02 (m, 1H, CH_B, CH_2N), 5.48 (d, 1H, $^2J_{HP}$ = 11.1, C_1H), 6.75 (d, 1H, J_{HH} = 7.1, ArH), 7.29–7.35 (m, 1H, ArH), 7.40–7.56 (m, 5H, ArH), 7.57–7.73 (m, 5H, ArH) 7.73–7.80 (m, 1H, ArH); ^{13}C NMR ($CDCl_3$) δ 13.6 ($CH_3(CH_2)_3N$), 19.8 ($CH_2(CH_2)_2N$), 29.9 (CH_2CH_2N), 41.7 (CH_2N), 60.7 (d, $^1J_{CP}$ = 74.2, C_1), 123.87 (d, J_{CP} = 1.2, C_4), 123.90 (d, $^3J_{CP}$ = 2.4, C_7), 125.4 (d, $^1J_{CF}$ = 261.1, CF_3), 125.4 (m, C_3'), 129.02 (d, $^3J_{CP}$ = 11.5, C_3''), 129.03 (d, J_{CP} = 1.4, C_5), 131.3 (dd, J_{CP} = 1.8, $^2J_{CF}$ = 16.0, C_4'), 131.47 (d, J_{CP} = 2.2, C_6), 131.49 (d, $^2J_{CP}$ = 9.3, C_2')*, 132.22 (d, $^2J_{CP}$ = 9.0, C_2'')*, 132.26 (d, J_{CP} = 1.8, C_{3a}), 132.27 (d, $^1J_{CP}$ = 92.8, C_1')*, 132.5 (d, $^1J_{CP}$ =104.3, C_1'')*, 133.4 (d, J_{CP} = 1.4, C_4''), 138.0 (d, $^2J_{CP}$ = 2.4, C_{7a}), 168.4 (d, $^3J_{CP}$ = 0.9, C_3), *tentative assignments; ^{31}P ($CDCl_3$) δ 29.1; **Isomer B:** ^{1}H NMR ($CDCl_3$) δ 0.86 (t, J_{HH} = 7.1, 3H, $CH_3(CH_2)_3N$), 1.06-1.33 (m, 2H, $CH_2(CH_2)_2N$), 1.41–1.69 (m, 2H, CH_2CH_2N), 3.31–3.40 (m, 1H, CH_A, CH_2N), 3.89–4.02 (m, 1H, CH_B, CH_2N), 5.51 (d, 1H, $^2J_{HP}$ = 11.2, C_1H), 7.14 (d, 1H, J_{HH} = 6.4, ArH), 7.35–7.40 (m, 1H, ArH), 7.40–7.56 (m, 5H, ArH), 7.57–7.73 (m, 5H, ArH) 7.73–7.80 (m, 1H, ArH); ^{13}C NMR ($CDCl_3$) δ 13.7 ($CH_3(CH_2)_3N$), 19.9 ($CH_2(CH_2)_2N$), 30.0 (CH_2CH_2N), 42.0 (CH_2N), 61.1 (d, $^1J_{CP}$ = 73.7, C_1), 124.04 (d, J_{CP} = 1.4, C_4), 124.06 (d, $^3J_{CP}$ = 1.7, C_7), 125.4 (d, $^1J_{CF}$ = 261.1, CF_3), 125.4 (m, C_3'), 129.0 (d, $^3J_{CP}$ = 11.0, C_3''), 129.1 (d, J_{CP} = 1.4, C_5), 131.4 (dd, J_{CP} = 1.6, $^2J_{CF}$ = 15.4, C_4'), 131.5 (d, $^2J_{CP}$ = 9.3, C_2')*, 131.6 (d, J_{CP} = 1.6, C_6), 132.3 (d, $^1J_{CP}$ = 94.0, C_1')*, 132.41 (d, $^2J_{CP}$ = 9.0, C_2'')*, 132.44 (d, J_{CP} = 2.3, C_{3a}), 134.5 (d, $^1J_{CP}$ = 103.9, C_1'')*, 133.4 (d, J_{CP} = 1.4, C_4''), 138.4 (d, $^2J_{CP}$ = 2.7, C_{7a}), 168.8 (d, $^3J_{CP}$ = 0.9,

C_3), *tentative assignments; ^{31}P ($CDCl_3$) δ 30.1; $[M+H]^+_{found}$ = 458.1506, $C_{25}H_{24}NO_2F_3P$ requires 458.1491.

2-Phenyl-phenyl(phenyl) (2-butyl-3-oxo-2,3-dihydro-2*H*-isoindol-1-yl)phosphine oxide (18)

Yield: 96% (0.45 g), *dr*: 40:60, yellow oil; characterized as a mixture, **Isomer A:** ^1H NMR ($CDCl_3$) δ 0.83 (t, J_{HH} = 7.5, 3H, C*H*$_3$(CH$_2$)$_3$N), 0.98-1.09 (m, 2H, C*H*$_2$(CH$_2$)$_2$N), 1.19–1.36 (m, 2H, C*H*$_2$CH$_2$N), 2.47–2.55 (m, 1H, CH$_A$, CH$_2$N), 3.65–3.76 (m, 1H, CH$_B$, CH$_2$N), 4.47 (d, 1H, $^2J_{HP}$ = 12.3, C$_1$H), 6.56 (d, 1H, J_{HH} = 7.7, ArH), 7.07–7.19 (m, 2H, ArH), 7.21–7.28 (m, 2H, ArH), 7.28–7.43 (m, 5H, ArH), 7.43–7.49 (m, 2H, ArH), 7.50–7.55 (m, 1H, ArH), 7.55–7.61 (m, 1H, ArH), 7.61–7.66 (m, 1H, ArH), 7.66–7.74 (m, 1H, ArH), 7.78 (d, 1H, J_{HH} = 7.8, ArH), 7.86–8.02 (m, 1H, ArH); ^{13}C NMR ($CDCl_3$) δ 13.9 (*C*H$_3$(CH$_2$)$_3$N), 20.0 (*C*H$_2$(CH$_2$)$_2$N), 29.6 (*C*H$_2$CH$_2$N), 41.9 (CH$_2$N), 58.6 (d, $^1J_{CP}$ = 70.0, C$_1$), 123.0 (d, J_{CP} = 1.3, C$_4$), 123.1 (d, $^3J_{CP}$ = 2.4, C$_7$), 125.3 (d, J_{CP} = 1.8, ArC), 127.3 (d, J_{CP} = 12.1, ArC), 127.7 (d, J_{CP} = 11.6, ArC), 128.0 (d, J_{CP} = 100.2, ArC), 128.35 (d, J_{CP} = 2.0, C$_5$), 128.38 (ArC), 128.8 (ArC), 129.7 (d, J_{CP} = 1.8, C$_6$), 129.8 (ArC), 131.0 (d, J_{CP} = 10.1, ArC), 131.7 (d, J_{CP} = 102.7, ArC), 132.2 (d, J_{CP} = 2.6, C$_{3a}$), 132.6 (d, J_{CP} = 8.7, ArC), 132.7 (d, J_{CP} = 4.7, ArC), 132.9 (d, J_{CP} = 5.0, ArC), 133.5 (d, J_{CP} = 11.9, ArC), 138.4 (d, $^2J_{CP}$ = 1.7, C$_{7a}$), 140.2 (d, J_{CP} = 3.1, ArC), 147.4 (d, J_{CP} = 8.8, ArC), 167.9 (d, $^3J_{CP}$ = 1.8, C$_3$); ^{31}P ($CDCl_3$) δ 33.4; **Isomer B:** ^1H NMR ($CDCl_3$) δ 0.86 (t, J_{HH} = 7.5, 3H, C*H*$_3$(CH$_2$)$_3$N), 1.09-1.18 (m, 2H, C*H*$_2$(CH$_2$)$_2$N), 1.19–1.36 (m, 2H, C*H*$_2$CH$_2$N), 3.65–3.76 (m, 1H, CH$_A$, CH$_2$N), 3.82–3.91 (m, 1H, CH$_B$, CH$_2$N), 4.61 (d, 1H, $^2J_{HP}$ = 8.7, C$_1$H), 6.85 (d, 1H, J_{HH} = 11.4, ArH), 7.07–7.19 (m, 3H, ArH), 7.21–7.28 (m, 2H, ArH), 7.28–7.43 (m, 5H, ArH), 7.43–7.49 (m, 2H, ArH), 7.50–7.55 (m, 1H, ArH), 7.55–7.61 (m, 1H, ArH), 7.61–7.66 (m, 1H, ArH), 7.66–7.74 (m, 1H, ArH), 7.86–8.02 (m, 1H, ArH); ^{13}C NMR ($CDCl_3$) δ 14.0 (*C*H$_3$(CH$_2$)$_3$N), 20.3 (*C*H$_2$(CH$_2$)$_2$N), 30.5 (*C*H$_2$CH$_2$N), 42.1 (CH$_2$N), 59.2 (d, $^1J_{CP}$ = 71.0, C$_1$), 124.2 (d, J_{CP} = 0.9, C$_4$), 124.5 (d, $^3J_{CP}$ = 1.0, C$_7$), 125.6 (d, J_{CP} = 2.3, ArC), 127.4 (d, J_{CP} = 11.9, ArC), 127.9 (d, J_{CP} = 11.4, ArC), 128.1 (d, J_{CP} = 95.5, ArC), 128.6 (ArC), 128.7 (d, J_{CP} = 2.3, C$_5$), 128.9 (ArC), 129.8 (ArC), 130.6 (d, J_{CP} = 1.4, C$_6$), 131.0 (d, J_{CP} = 10.0, ArC), 131.7 (d, J_{CP} = 95.0, ArC), 132.86 (d, J_{CP} = 9.0, ArC), 132.87 (d, J_{CP} = 5.0, ArC), 133.0 (d, J_{CP} = 3.8, ArC), 133.5 (d, J_{CP} =11.6, ArC), 133.9 (d, J_{CP} = 3.2, C$_{3a}$), 139.5 (d, $^2J_{CP}$ = 4.1, C$_{7a}$), 140.7 (d, J_{CP} = 3.4, ArC), 147.5 (d, J_{CP} = 9.0, ArC), 169.3 (d, $^3J_{CP}$ = 1.3, C$_3$); ^{31}P ($CDCl_3$) δ 36.2; $[M+H]^+_{found}$ = 466.1942, $C_{30}H_{29}NO_2P$ requires 466.1930.

1-Naphthyl(phenyl) (2-butyl-3-oxo-2,3-dihydro-2*H*-isoindol-1-yl)phosphine oxide (19)

Yield: 97% (0.43 g), *dr*: 45:55; characterized after separation by column chromatography: **Isomer A:** white crystals; Mp: 178–180 °C; ^{1}H NMR ($CDCl_3$) δ 0.43 (t, J_{HH} = 6.5, 3H, C*H*$_3$(CH$_2$)$_3$N), 0.40-0.51 (m, 1H, CH$_A$, C*H*$_2$(CH$_2$)$_2$N), 0.64–0.76 (m, 1H, CH$_B$, C*H*$_2$(CH$_2$)$_2$N), 0.78–0.90 (m, 1H, CH$_A$, C*H*$_2$CH$_2$N), 0.90–1.00 (m, 1H, CH$_B$, C*H*$_2$CH$_2$N), 1.90–1.98 (m, 1H, CH$_A$, CH$_2$N), 3.67–3.76 (m, 1H, CH$_B$, CH$_2$N), 5.81 (d, 1H, $^{2}J_{HP}$ = 10.5, C$_1$H), 7.28–7.37 (m, 3H, ArH), 7.38–7.52 (m, 4H, ArH), 7.57–7.70 (m, 4H, ArH), 7.76 (d, 1H, J_{HH} = 7.8, ArH), 7.92 (d, 1H, J_{HH} = 7.8, ArH), 8.00 (d, 1H, J_{HH} = 8.3, ArH), 8.10 (d, 1H, J_{HH} = 8.2, ArH), 9.26 (d, 1H, J_{HH} = 8.7, ArH); ^{13}C NMR ($CDCl_3$) δ 13.2 (*C*H$_3$(CH$_2$)$_3$N), 19.5 (*C*H$_2$(CH$_2$)$_2$N), 29.8 (*C*H$_2$CH$_2$N), 41.1 (CH$_2$N), 60.3 (d, $^{1}J_{CP}$ = 72.1, C$_1$), 123.4 (d, J_{CP} = 1.7, C$_4$), 124.59 (d, $^{3}J_{CP}$ = 14.4, C$_3$'), 123.64 (d, $^{3}J_{CP}$ = 2.1, C$_7$), 125.7 (d, $^{1}J_{CP}$ = 100.1, C$_1$'), 126.4 (d, $^{2}J_{CP}$ = 4.4, C$_2$'), 127.1 (C$_6$'), 127.2 (d, $^{1}J_{CP}$ = 93.7, C$_1$''), 128.1 (C$_5$'), 128.3 (d, $^{3}J_{CP}$ = 11.4, C$_3$''), 128.5 (d, J_{CP} = 1.7, C$_5$), 129.5 (d, $^{4}J_{CP}$ = 1.7, C$_4$'), 131.4 (d, J_{CP} = 1.7, C$_6$), 131.9 (d, J_{CP} = 3.1, C$_4$''), 131.0 (d, $^{2}J_{CP}$ = 7.8, C$_2$''), 132.5 (d, J_{CP} = 2.5, C$_{3a}$), 132.5 (d, $^{3}J_{CP}$ = 11.5, C$_8$'), 134.0 (d, $^{2}J_{CP}$ = 5.2, C$_9$'), 134.1 (d, $^{3}J_{CP}$ = 5.3, C$_{10}$'), 134.1 (d, J_{CP} = 2.9, C$_7$'), 140.0 (d, $^{2}J_{CP}$ = 3.6, C$_{7a}$), 169.4 (d, $^{3}J_{CP}$ = 2.3, C$_3$); ^{31}P ($CDCl_3$) δ 30.4; $[M+H]^{+}_{found}$ = 440.1794, $C_{28}H_{27}NO_2P$ requires 440.1773.

Isomer B: colourless oil; ^{1}H NMR ($CDCl_3$) δ 0.95 (t, J_{HH} = 7.3, 3H, C*H*$_3$(CH$_2$)$_3$N), 1.27-1.37 (m, 2H, C*H*$_2$(CH$_2$)$_2$N), 1.64–1.87 (m, 2H, C*H*$_2$CH$_2$N), 3.72–3.80 (m, 1H, CH$_A$, CH$_2$N), 3.94–4.04 (m, 1H, CH$_B$, CH$_2$N), 5.83 (d, 1H, $^{2}J_{HP}$ = 11.8, C$_1$H), 5.94 (d, 1H, J_{HH} = 7.7, ArH), 7.09–7.21 (m, 3H, ArH), 7.29–7.42 (m, 5H, ArH), 7.52 (t, 1H, J_{HH} = 7.4, ArH), 7.67 (t, 1H, J_{HH} = 7.5, ArH), 7.71–7.80 (m, 2H, ArH), 8.02 (d, 1H, J_{HH} = 8.2, ArH), 8.12 (d, 1H, J_{HH} = 6.4, ArH), 9.22 (d, 1H, J_{HH} = 8.5, ArH); ^{13}C NMR ($CDCl_3$) δ 13.9 (*C*H$_3$(CH$_2$)$_3$N), 20.1 (*C*H$_2$(CH$_2$)$_2$N), 30.2 (*C*H$_2$CH$_2$N), 42.1 (CH$_2$N), 61.9 (d, $^{1}J_{CP}$ = 71.2, C$_1$), 123.5 (d, J_{CP} = 2.0, C$_4$), 123.8 (d, $^{3}J_{CP}$ = 0.9, C$_7$), 124.2 (d, $^{3}J_{CP}$ = 13.9, C$_3$'), 126.3 (d, $^{1}J_{CP}$ = 99.5, C$_1$'), 126.5 (d, $^{1}J_{CP}$ = 94.7, C$_1$''), 126.6 (d, $^{2}J_{CP}$ = 4.1, C$_2$'), 127.1 (C$_6$'), 128.3 (C$_5$'), 128.3 (d, $^{3}J_{CP}$ = 11.4, C$_3$''), 128.8 (d, J_{CP} = 1.6, C$_5$), 129.4 (d, J_{CP} = 0.8, C$_4$'), 131.0 (d, J_{CP} = 1.5, C$_6$), 132.3 (d, $^{2}J_{CP}$ = 8.3, C$_2$''), 132.5 (d, $^{3}J_{CP}$ = 11.0, C$_8$'), 132.9 (d, J_{CP} = 2.9, C$_{3a}$), 133.3 (d, J_{CP} = 3.3, C$_4$''), 134.00 (d, J_{CP} = 3.4, C$_7$'), 134.02 (d, $^{2}J_{CP}$ = 4.9, C$_9$'), 134.1 (d, $^{3}J_{CP}$ = 4.3, C$_{10}$'), 138.5 (d, $^{2}J_{CP}$ = 2.1, C$_{7a}$), 168.3 (d, $^{3}J_{CP}$ = 1.8, C$_3$); ^{31}P ($CDCl_3$) δ 34.8; $[M+H]^{+}_{found}$ = 440.1788, $C_{28}H_{27}NO_2P$ requires 440.1773.

General procedure for the synthesis of diphenyl (2-butyl-3-oxo-2,3-dihydro-2*H*-isoindol-1-yl)phosphine (20)

A mixture of 1.0 mmol (0.39 g) of diphenyl (2-butyl-3-oxo-2,3-dihydro-2*H*-isoindol-1-yl)phosphine oxide (**7a**) and 3.0 mmol (0.37 ml) of phenylsilane was irradiated in a sealed tube at 100-140 °C for 2-6 h under N_2 atmosphere in a CEM® Discover Microwave reactor equipped with a pressure controller. The product (**20**) was utilized without work-up in the next reactions.

General procedure for the synthesis of diphenyl (2-butyl-3-oxo-2,3-dihydro-2*H*-isoindol-1-yl)phosphine sulphide (21)

A mixture of 1.0 mmol (0.37 g) of diphenyl (2-butyl-3-oxo-2,3-dihydro-2*H*-isoindol-1-yl)phosphine (**20**) and 1.2 mmol (0.30 g) of sulphur in 10 mL of degassed dichloromethane was stirred at 25 °C for 12 h under N_2 atmosphere. The product **21** was obtained by column chromatography using silica gel as the absorbent and dichloromethane:methanol (97:3) as the eluent.

Diphenyl (2-butyl-3-oxo-2,3-dihydro-2*H*-isoindol-1-yl)phosphine sulphide (21)

Yield: 81% (0.42 g), white crystal; Mp: 184–186 °C; ^{1}H NMR ($CDCl_3$) δ 0.79 (t, J_{HH} = 7.3, 3H, CH_3(CH_2)$_3$N), 0.93–1.16 (m, 2H, CH_2(CH_2)$_2$N), 1.33–1.56 (m, 2H, CH_2CH_2N), 2.66–2.82 (m, 1H, CH_A, CH_2N), 3.82–3.99 (m, 1H, CH_B, CH_2N), 5.64 (d, 1H, $^2J_{HP}$ = 3.1, C_1H), 7.04 (d, 1H, J_{HH} = 7.7, ArH), 7.20–7.30 (m, 1H, ArH), 7.31–7.62 (m, 7H, ArH), 7.64–7.81 (m, 3H, ArH), 7.82–7.95 (m, 2H, ArH); ^{13}C NMR ($CDCl_3$) δ 13.6 (*C*H_3(CH_2)$_3$N), 19.8 (*C*H_2(CH_2)$_2$N), 29.8 (*C*H_2CH_2N), 41.4 (CH_2N), 63.5 (d, $^1J_{CP}$ = 53.3, C_1), 123.5 (d, J_{CP} = 1.5, C_4), 124.1 (d, $^3J_{CP}$ = 2.7, C_7), 128.0 (d, $^1J_{CP}$ = 77.5, C_1'^{I}), 128.6 (d, $^3J_{CP}$ = 11.9, C_3'^{I}), 128.86 (d, $^3J_{CP}$ = 12.1, C_3'^{II}), 128.87 (d, J_{CP} = 1.7, C_5), 129.8 (d, $^1J_{CP}$ = 77.9, C_1'^{II}), 130.8 (d, J_{CP} = 2.5, C_6), 130.0 (d, $^2J_{CP}$ = 9.9, C_2'^{I}), 132.1 (d, $^2J_{CP}$ = 9.3, C_2'^{II}), 132.36 (d, J_{CP} = 3.0, C_4'^{I}), 132.44 (d, J_{CP} = 3.0, C_4'^{II}), 132.7 (d, $^3J_{CP}$ = 3.0, C_{3a}), 138.4 (d, $^2J_{CP}$ = 2.8, C_{7a}), 169.0 (d, $^3J_{CP}$ = 0.9, C_3); ^{31}P ($CDCl_3$) δ 44.6; $[M+H]^+_{found}$ = 406.1338, $C_{24}H_{25}NOPS$ requires 406.1340.

General procedure for the synthesis of [diphenyl (2-butyl-3-oxo-2,3-dihydro-2*H*-isoindol-1-yl)phosphine] dichloroplatinum(II) (22)

A mixture of 1.0 mmol (0.37 g) of diphenyl (2-butyl-3-oxo-2,3-dihydro-2*H*-isoindol-1-yl)phosphine (**20**) and 0.5 mmol (0.24 g) of bis(benzonitrile)dichloroplatinum in 10 mL of degassed dichloromethane was stirred at 25 °C for 12 h under N_2 atmosphere. The product **22**

was obtained by column chromatography using silica gel as the absorbent and dichloromethane:methanol (97:3) as the eluent.

[Diphenyl (2-butyl-3-oxo-2,3-dihydro-2*H*-isoindol-1-yl)phosphine] dichloroplatinum(II) (22) Yield: 80% (0.81 g), yellow crystals; characterized as a mixture, **Isomer A:** ^{1}H NMR ($CDCl_3$) δ 0.75 (t, J_{HH} = 7.6, 3H, CH_3(CH$_2$)$_3$N), 0.94–1.11 (m, 2H, CH_2(CH$_2$)$_2$N), 1.34–1.54 (m, 2H, CH_2CH$_2$N), 3.20–3.31 (m, 1H, CH$_A$, CH$_2$N), 3.75–4.87 (m, 1H, CH$_B$, CH$_2$N), 6.67 (d, 1H, $^{2}J_{HP}$ = 9.5, C$_1$H), 7.07–7.48 (m, 11H, ArH), 7.52–7.61 (m, 2H, ArH), 7.63–7.75 (m, 1H, ArH); ^{13}C NMR ($CDCl_3$) δ 13.8 (*C*H$_3$(CH$_2$)$_3$N), 19.9 (*C*H$_2$(CH$_2$)$_2$N), 30.6 (*C*H$_2$CH$_2$N), 41.4 (CH$_2$N), 53.6 (dd, $^{1}J_{CP}$ = 14.7, $^{3}J_{CP}$ = 1.3, C$_1$), 123.4 (d, J_{CP} = 1.8, C$_4$), 124.7 (d, $^{3}J_{CP}$ = 0.9, C$_7$), 128.1 (d, $^{3}J_{CP}$ = 5.5, C$_3$'^{I}), 128.2 (d, $^{3}J_{CP}$ = 5.0, C$_3$'^{II}), 128.5 (d, J_{CP} = 2.3, C$_5$), 131.2 (dd, $^{1}J_{CP}$ = 69.9, $^{3}J_{CP}$ = 1.1, C$_1$'^{I}), 131.3 (dd, $^{1}J_{CP}$ = 74.0, $^{3}J_{CP}$ = 1.1, C$_1$'^{II}), 131.5 (d, J_{CP} = 1.9, C$_6$), 132.7 (d, J_{CP} = 1.4, C$_{3a}$), 133.27 (d, J_{CP} = 5.0, C$_4$'^{I}), 133.32 (d, $^{3}J_{CP}$ = 5.1, C$_4$'^{II}), 134.4 (d, $^{2}J_{CP}$ = 5.5, C$_2$'^{I}), 134.5 (d, $^{2}J_{CP}$ = 6.0, C$_2$'^{II}), 140.1 (d, $^{2}J_{CP}$ = 2.8, C$_{7a}$), 168.4 (d, $^{3}J_{CP}$ = 0.9, C$_3$); ^{31}P ($CDCl_3$) δ 21.2 (t, $^{1}J_{CPt}$ = 2519); **Isomer B:** ^{1}H NMR ($CDCl_3$) δ 0.77 (t, J_{HH} = 7.7, 3H, CH_3(CH$_2$)$_3$N), 0.94–1.11 (m, 2H, CH_2(CH$_2$)$_2$N), 1.34–1.54 (m, 2H, CH_2CH$_2$N), 3.20–3.31 (m, 1H, CH$_A$, CH$_2$N), 3.75–4.87 (m, 1H, CH$_B$, CH$_2$N), 6.67 (d, 1H, $^{2}J_{HP}$ = 9.5, C$_1$H), 7.07–7.48 (m, 11H, ArH), 7.52–7.61 (m, 2H, ArH), 7.63–7.75 (m, 1H, ArH); ^{13}C NMR ($CDCl_3$) δ 13.8 (*C*H$_3$(CH$_2$)$_3$N), 19.9 (*C*H$_2$(CH$_2$)$_2$N), 30.6 (*C*H$_2$CH$_2$N), 41.5 (CH$_2$N), 53.6 (dd, $^{1}J_{CP}$ = 15.1, $^{3}J_{CP}$ = 1.3, C$_1$), 123.4 (d, J_{CP} = 1.8, C$_4$), 124.7 (d, $^{3}J_{CP}$ = 0.9, C$_7$), 128.1 (d, $^{3}J_{CP}$ = 5.5, C$_3$'^{I}), 128.48 (d, $^{3}J_{CP}$ = 5.0, C$_3$'^{II}), 128.51 (d, J_{CP} = 2.3, C$_5$), 131.2 (dd, $^{1}J_{CP}$ = 69.9, $^{3}J_{CP}$ = 0.8, C$_1$'^{I}), 131.3 (dd, $^{1}J_{CP}$ = 74.3, $^{3}J_{CP}$ = 0.9, C$_1$'^{II}), 131.6 (d, J_{CP} = 1.4, C$_6$), 132.8 (d, J_{CP} = 1.4, C$_{3a}$), 133.31 (d, J_{CP} = 4.9, C$_4$'^{I}), 133.33 (d, $^{3}J_{CP}$ = 5.1, C$_4$'^{II}), 134.46 (d, $^{2}J_{CP}$ = 5.5, C$_2$'^{I}), 134.50 (d, $^{2}J_{CP}$ = 6.0, C$_2$'^{II}), 140.1 (d, $^{2}J_{CP}$ = 2.8, C$_{7a}$), 168.5 (d, $^{3}J_{CP}$ = 0.9, C$_3$); ^{31}P ($CDCl_3$) δ 21.2 (t, $^{1}J_{CPt}$ = 2519); $[M+Na]^{+}_{found}$ = 1033.2107, $C_{48}H_{48}N_2O_2P_2PtNa$ requires 1033.2087.

Single crystal X-ray diffraction measurements

Single-crystal X-ray diffraction data of **7a** and **22** were collected on an Agilent Technologies SuperNova Dual diffractometer using Mo-Kα radiation (λ = 0.71073 Å) at 150 K. The data were processed using CrysAlis Pro [S1]. Structure was solved by ShelXT [S2] using intrinsic phasing and refined by a full-matrix least-squares procedure based on F^2 with ShelXL [S3]

using Olex2 program suite [S4]. All the non-hydrogen atoms were refined anisotropically. Hydrogen atoms were readily located in difference Fourier maps, and were subsequently treated as riding atoms in geometrically idealized positions with C–H = 0.95 Å (aromatic), 1.00 Å (methine), 0.99 Å (methylene) or 0.98 Å (methyl), and with $U_{iso}(H) = kU_{eq}(C)$, where k = 1.5 for methyl group and 1.2 for all other H atoms. The crystallographic data are listed in Table S1. Deposition Numbers CCDC 2100126 and 2100127 contain the supplementary crystallographic data for this paper. These data are provided free of charge by the joint Cambridge Crystallographic Data Centre and Fachinformationszentrum Karlsruhe Access Structures service www.ccdc.cam.ac.uk/structures.

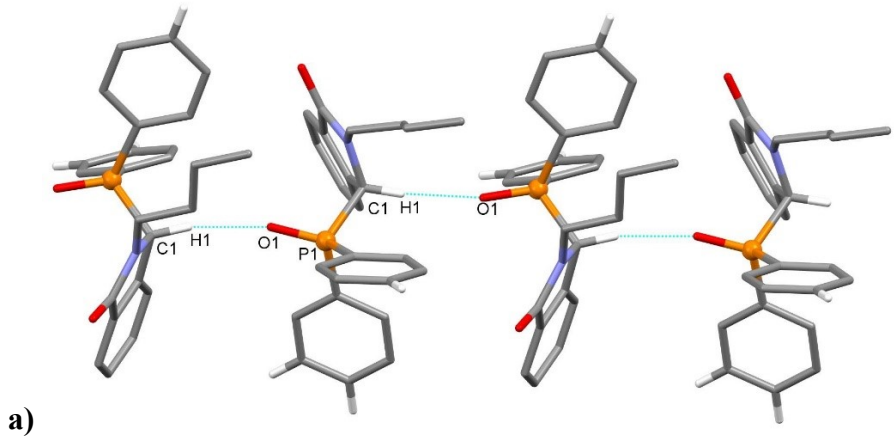
Table S1: Crystal data and structure refinement for compounds **7a** and **22**.

	7a	**22**
CCDC number	2100126	2100127
Empirical formula	$C_{24}H_{24}NO_2P$	$C_{48}H_{48}Cl_2N_2O_2P_2Pt$
Formula weight	389.41	1012.81
***T*/K**	150.00(10)	150.00(10)
Crystal system	monoclinic	monoclinic
Space group	$P2_1/c$	$P2_1/n$
***a*/Å**	11.7785(7)	11.3292(4)
***b*/Å**	17.1967(9)	10.3205(3)
***c*/Å**	11.2241(6)	18.9713(8)
***α*/°**	90	90
***β*/°**	115.786(8)	106.630(4)
***γ*/°**	90	90
***V*/Å^3**	2047.1(2)	2125.40(14)
Z	4	2
D_{calc} **/g cm^{-3}**	1.264	1.583
***μ*/mm^{-1}**	0.154	3.544
***F*(000)**	824.0	1016.0
Reflections collected	11169	17175
Data/restraints/parameters	4703/0/254	4870/0/260
R_{int}	0.0317	0.0411
GOF, *S*	1.059	1.062
R_1, wR_2 [$I \geq 2\sigma(I)$]	0.0429, 0.1008	0.0260, 0.0559
R_1, wR_2 [all data]	0.0597, 0.1157	0.0361, 0.0614
$\Delta\rho_{min}$, $\Delta\rho_{max}$ [e Å^{-3}]	0.31/–0.31	0.93/–1.23

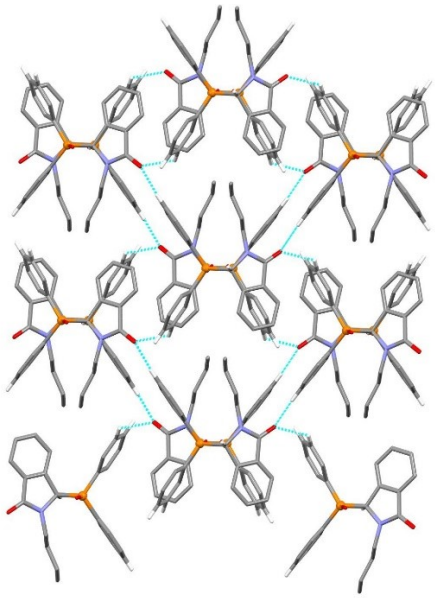
Table S2. Hydrogen bond geometry in **7a** and **22**.

D–H···A	D–H (Å)	H···A (Å)	D···A (Å)	D–H···A (°)	Symmetry code
7a					
C1–H1···O1	1.00	2.18	3.1622(18)	166.7	*x*, ½ – *y*, –½ + *z*
C15–H15···O2	0.95	2.54	3.256(2)	132.1	1 – *x*, –½ + *y*, 1½ – *z*
C22–H22···O2	0.95	2.32	3.248(2)	164.1	2 – *x*, –½ + *y*, 1½- *z*
C11–H11b···*Cg*4	0.99	2.99	3.843(2)	145	*x*, *y*, *z*
C16–H16···*Cg*4	0.95	2.74	3.616(2)	154	1 – *x*, –*y*, 1 – *z*
22					
C21–H21···O1	0.95	2.48	3.139(4)	127	½ + *x*, 1½ – *y*, ½ + *z*
C24–H24···*Cg*2	0.95	2.74	3.616(2)	154	–*x*, 1 – *y*, 1 – *z*

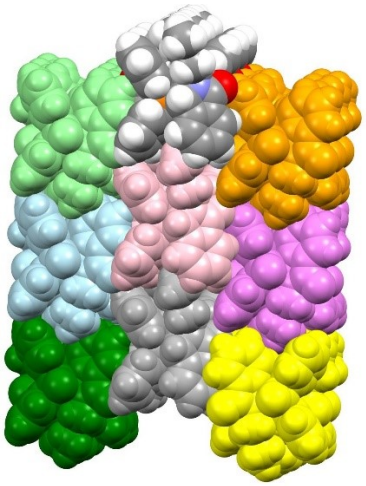
*Cg*4 (for **7a**) and *Cg*2 (for **22**) are C19–C24 and C2–C7 ring centroids, respectively.



a)



b)



c)

Figure S1. (**a**) Hydrogen-bonded chain formation in **7a** *via* C1–H1···O1=P1 interactions along *c*-axis. (**b**) Hydrogen-bonded network along *ab*-plane formed by C15–H15···O2 and

C22–H22···O2 interactions. (**c**) Packing of chains (arbitrary colors). Blue dashed lines indicate hydrogen bonds.

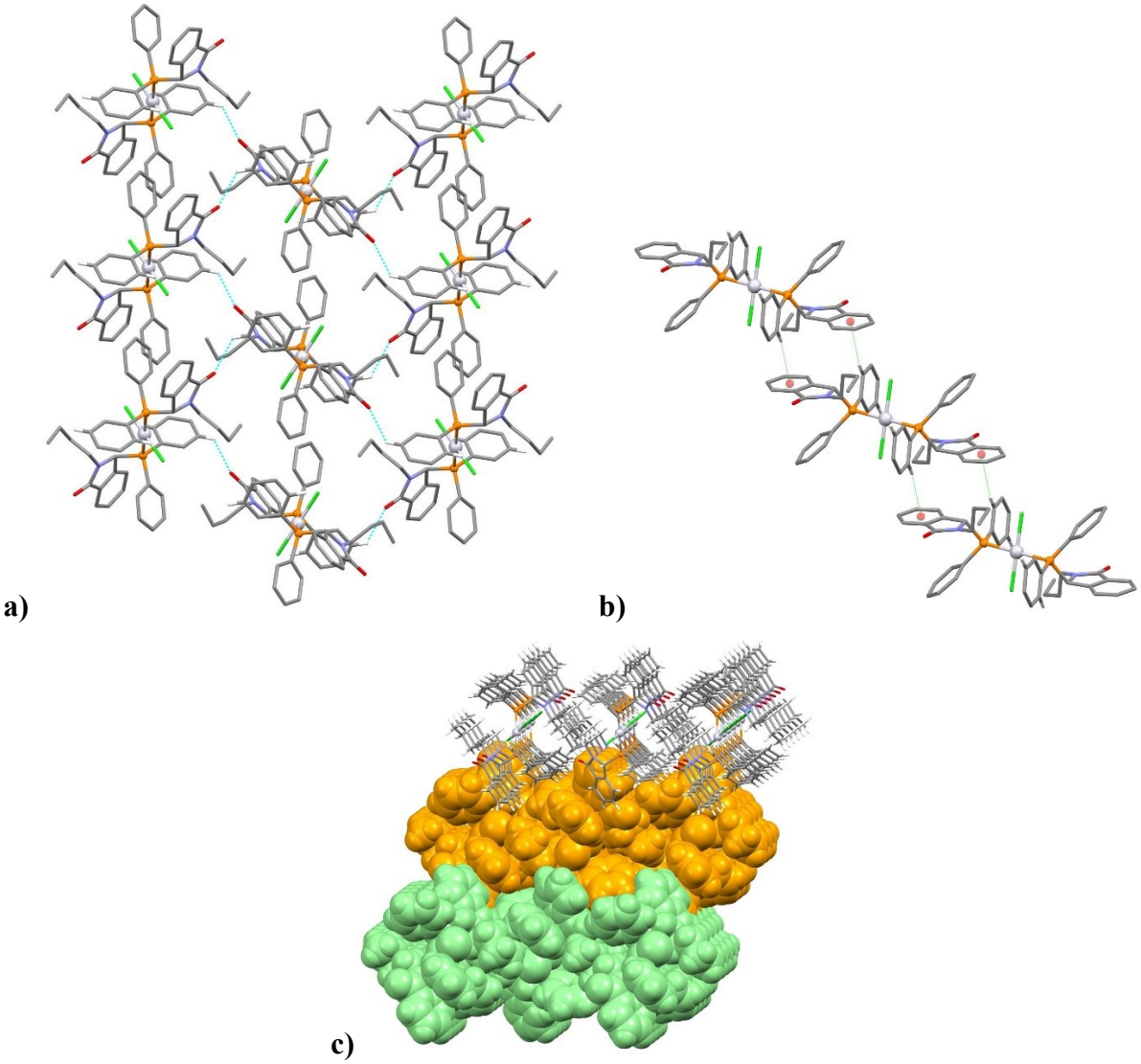
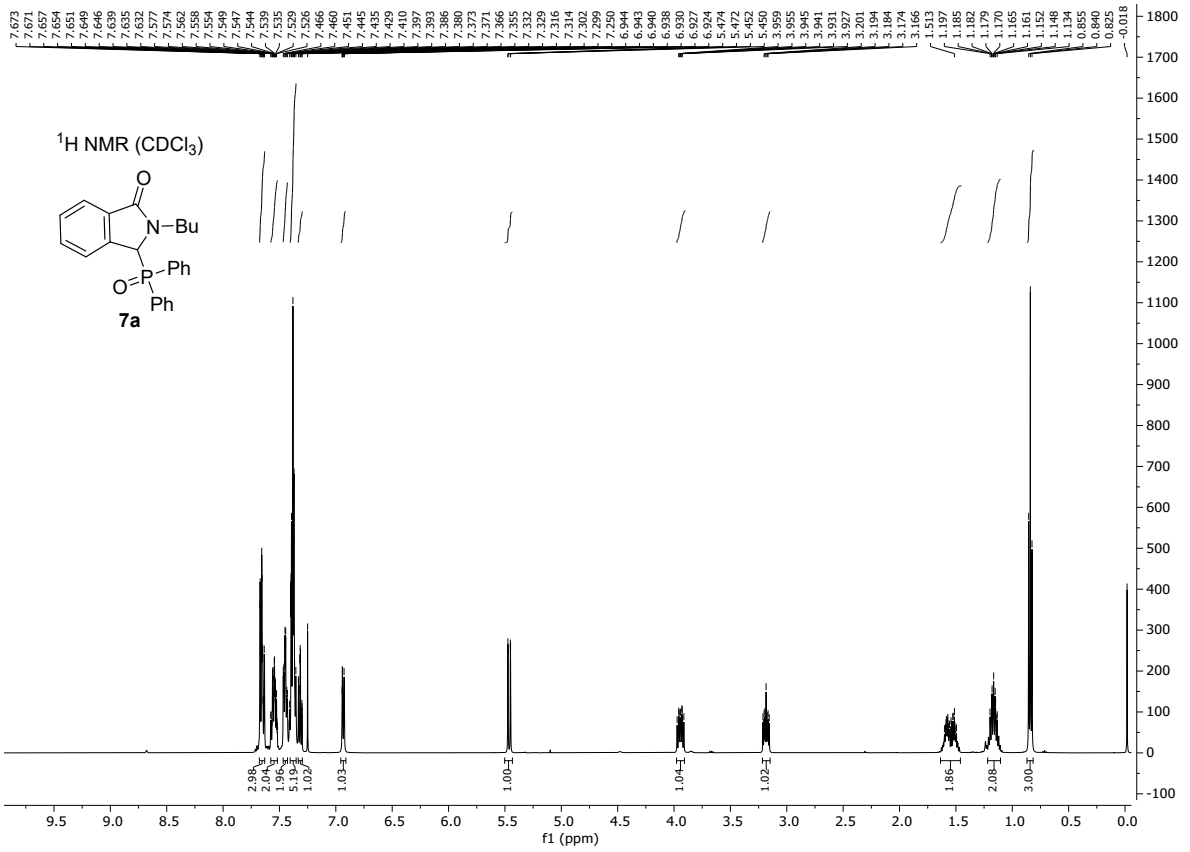
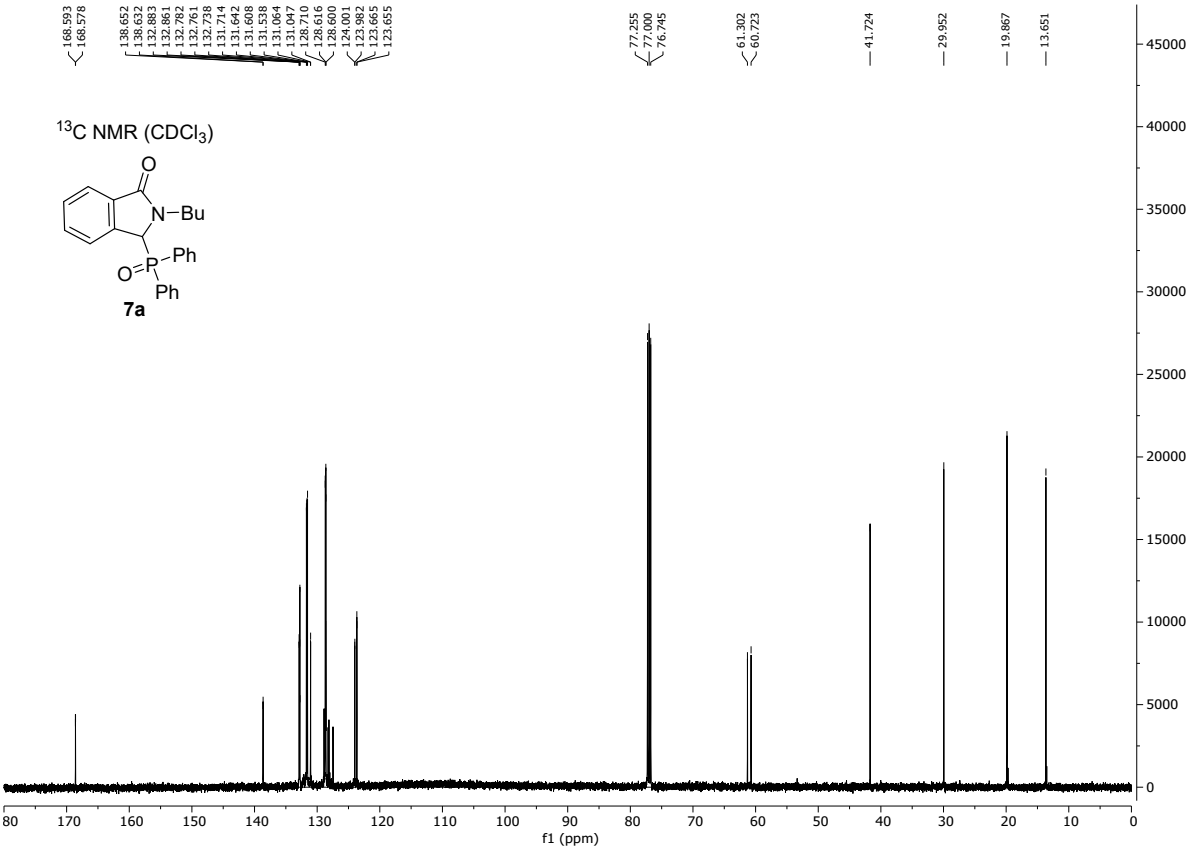
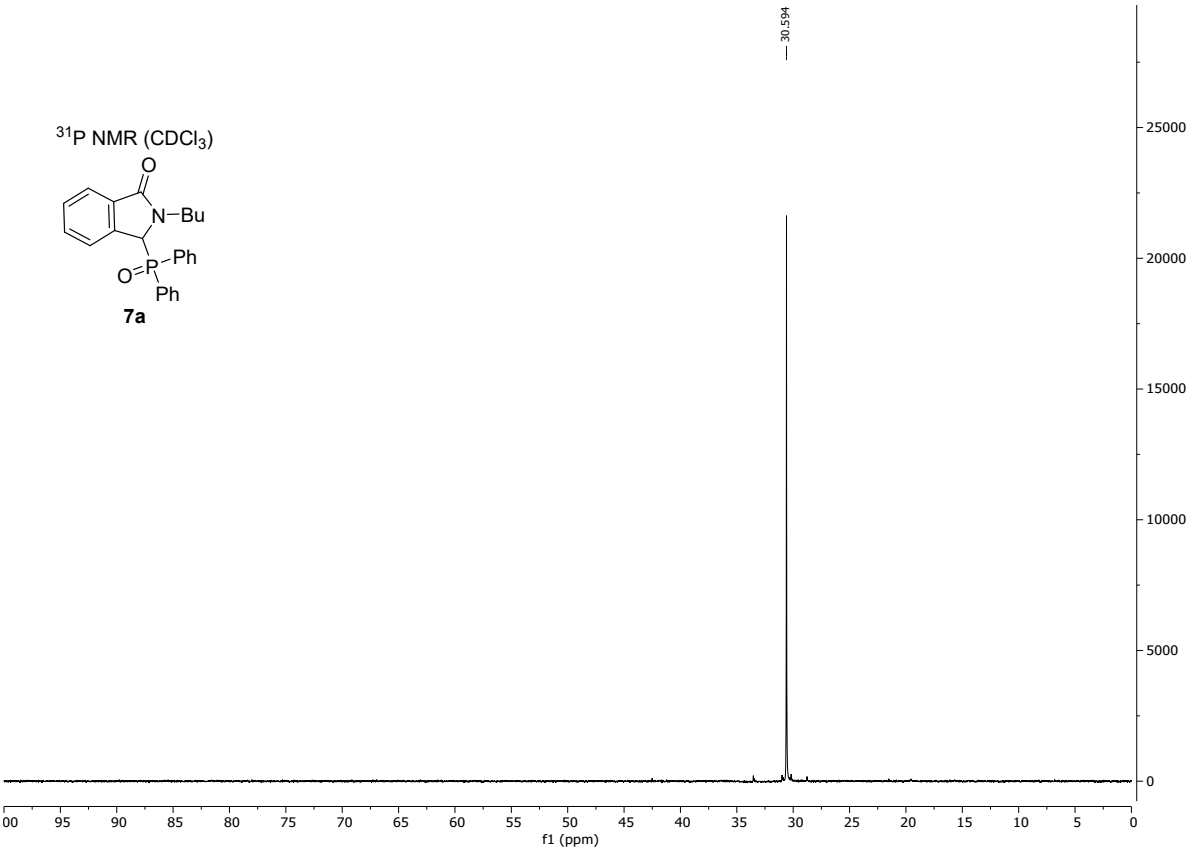


Figure S2. (**a**) Hydrogen-bonded layer formation in **22** *via* C21–H21···O1 interactions. (**b**) C24–H24···*Cg*2 interactions. (**c**) Packing of layers (arbitrary colours). Blue dashed lines indicate hydrogen bonds.

^{1}H NMR, ^{13}C NMR and ^{31}P NMR spectra



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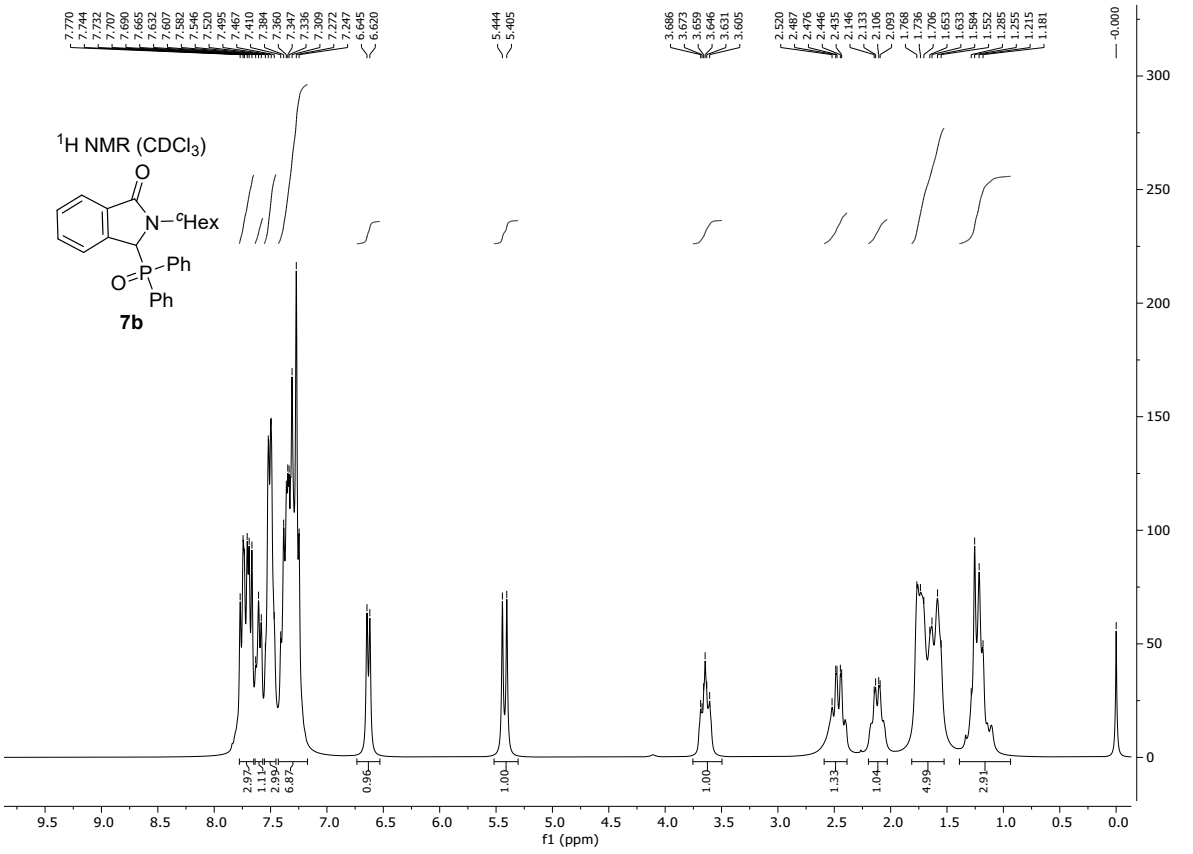
f1 (ppm)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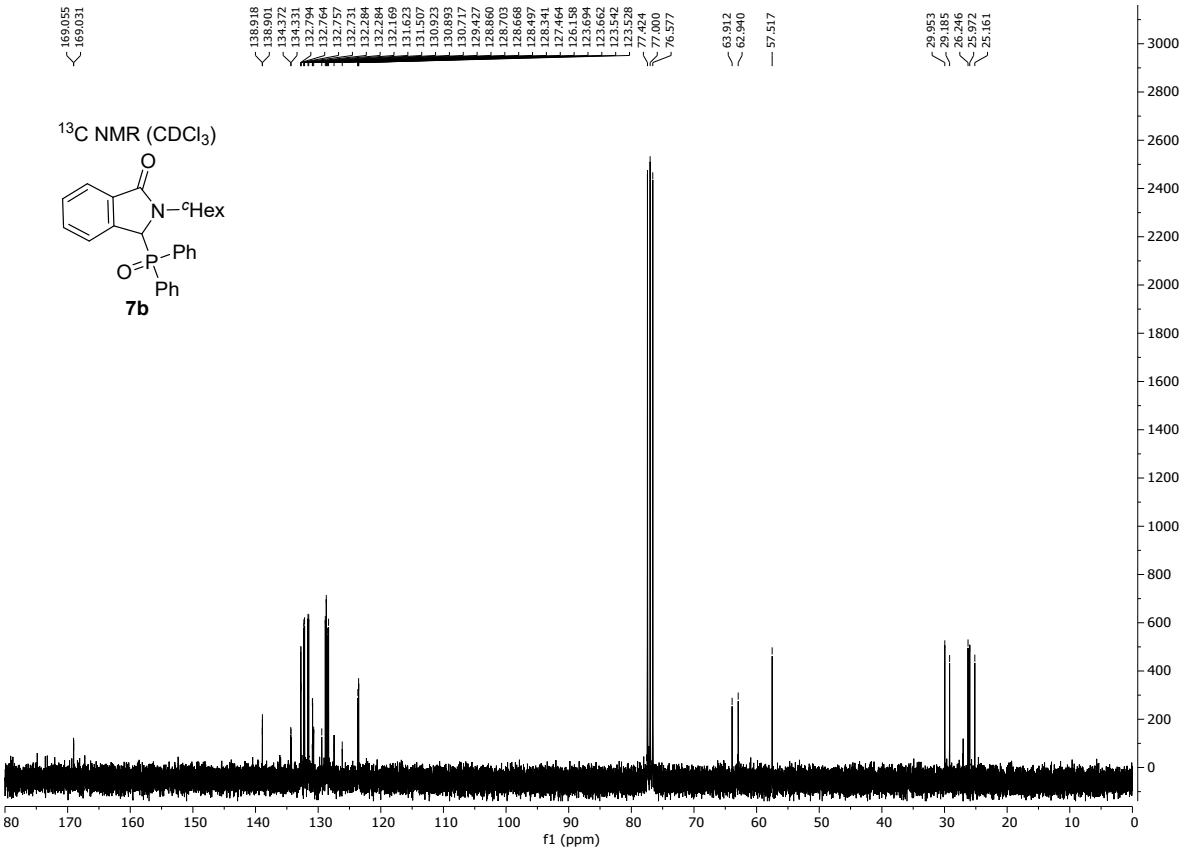
N–cHex
Ph
Ph
7b
f1 (ppm)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132.169
131.623
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130.717
129.427
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128.703
128.668
128.497
128.341
127.464
126.158
123.694
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76.577
63.912
62.940
57.517
29.953
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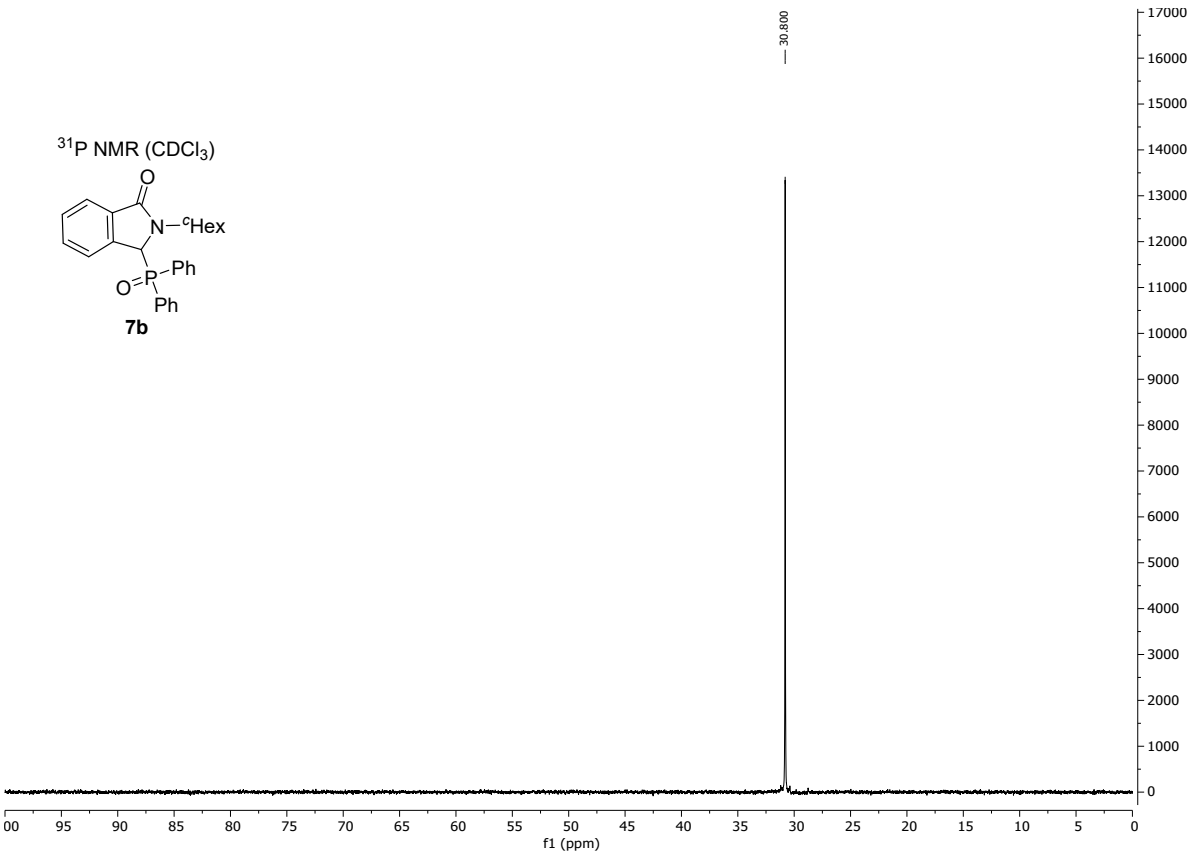
f1 (ppm)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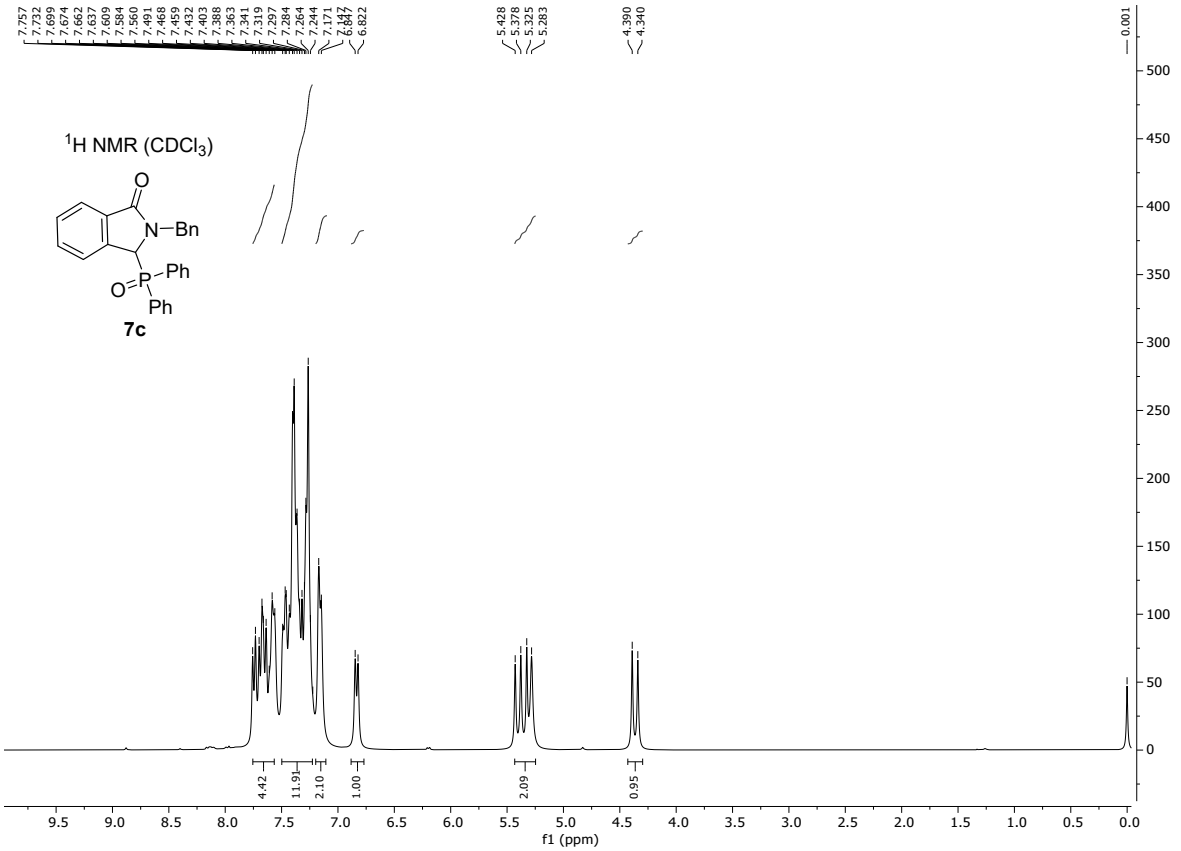
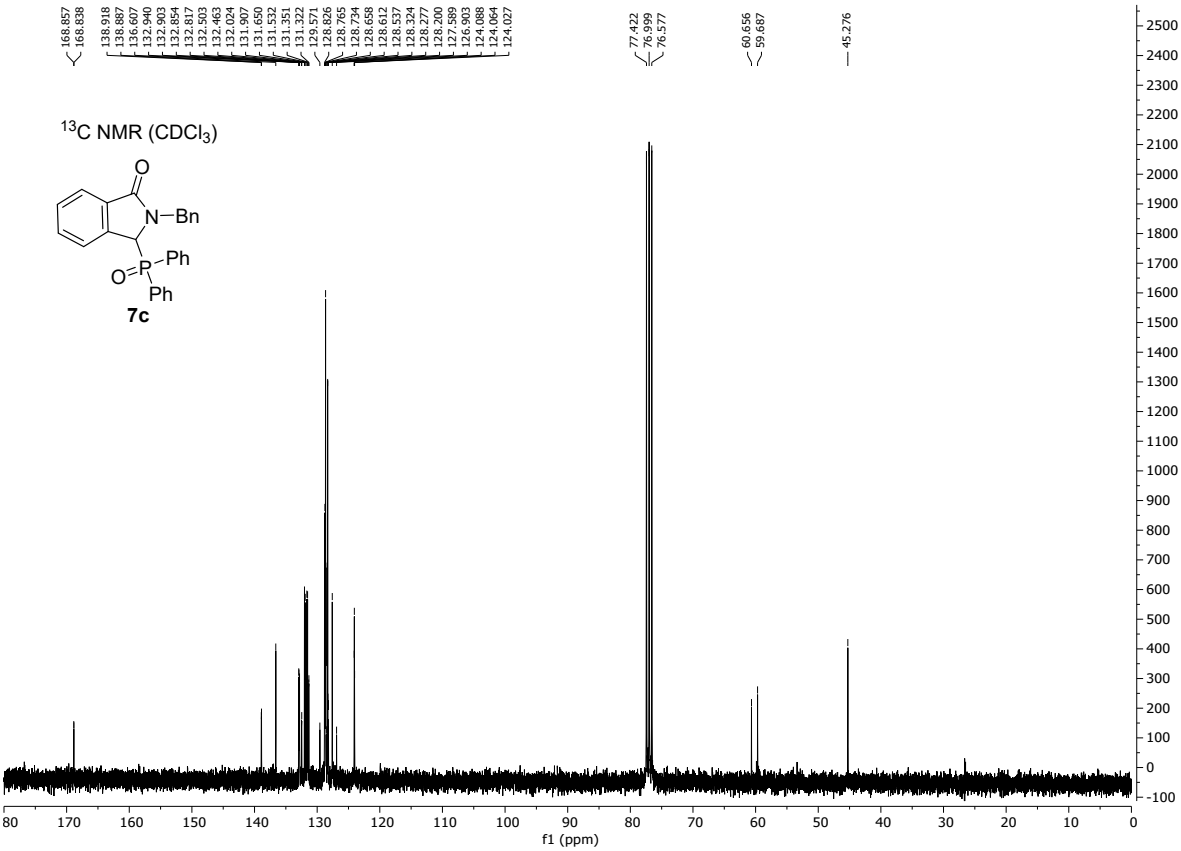
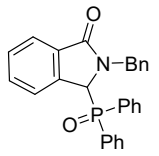
f1 (ppm)


^{1}H NMR ($CDCl_3$)
7c
f1 (ppm)

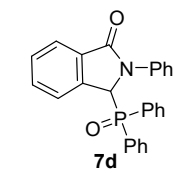

^{13}C NMR ($CDCl_3$)
7c
f1 (ppm)

^{31}P NMR ($CDCl_3$)

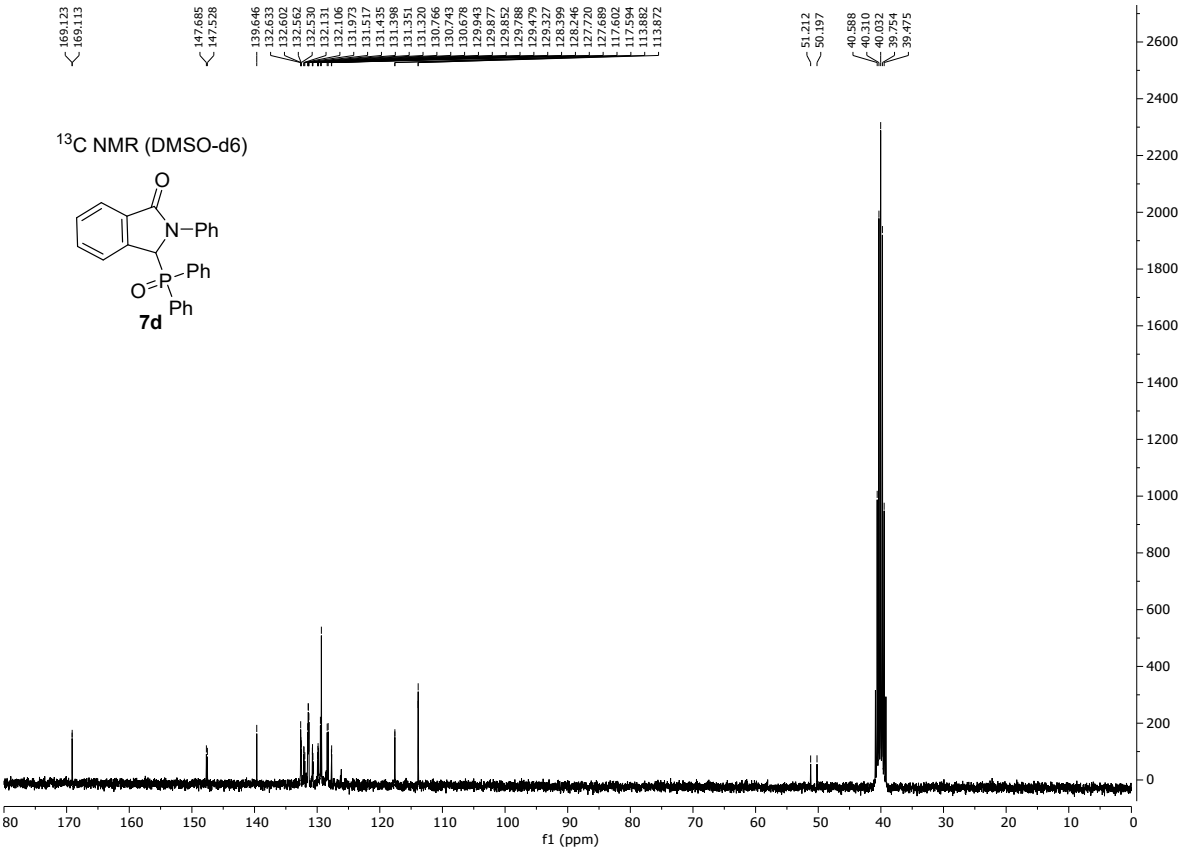


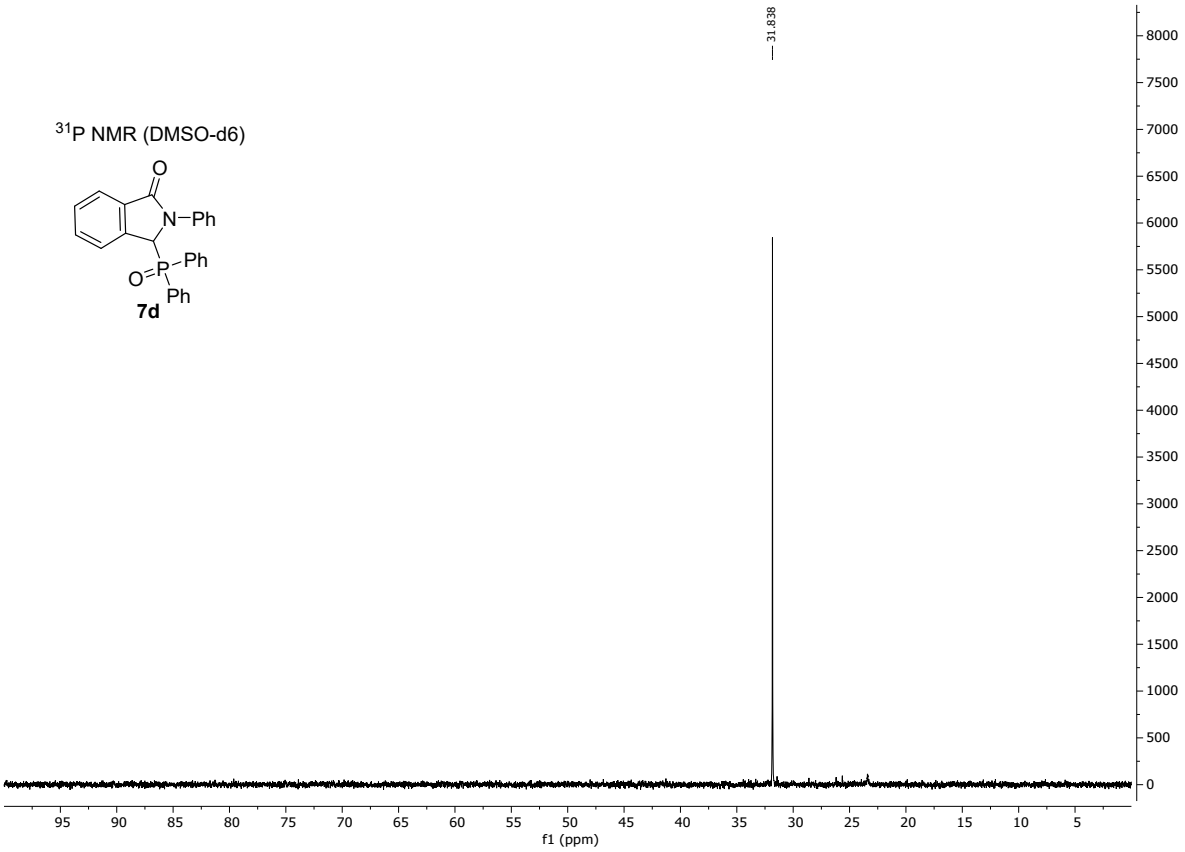
7c

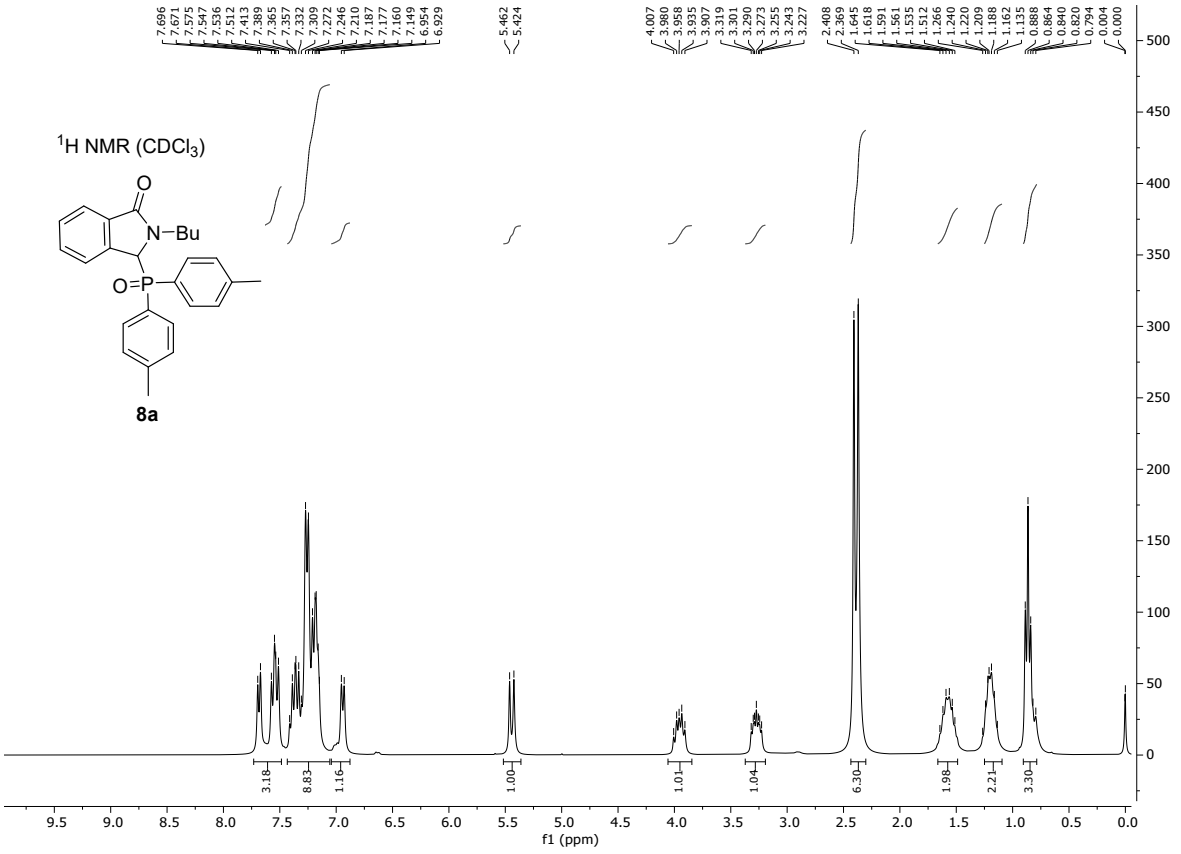
^{1}H NMR (DMSO-d6)

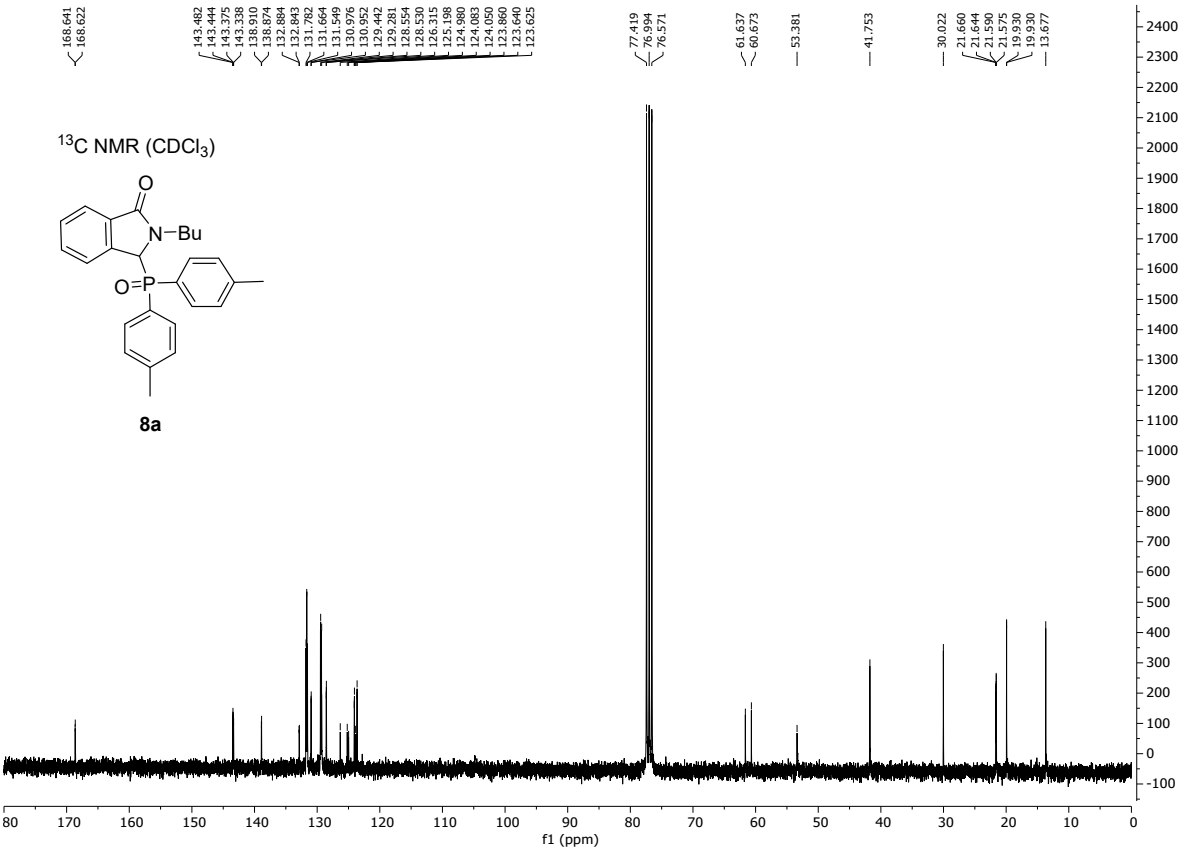


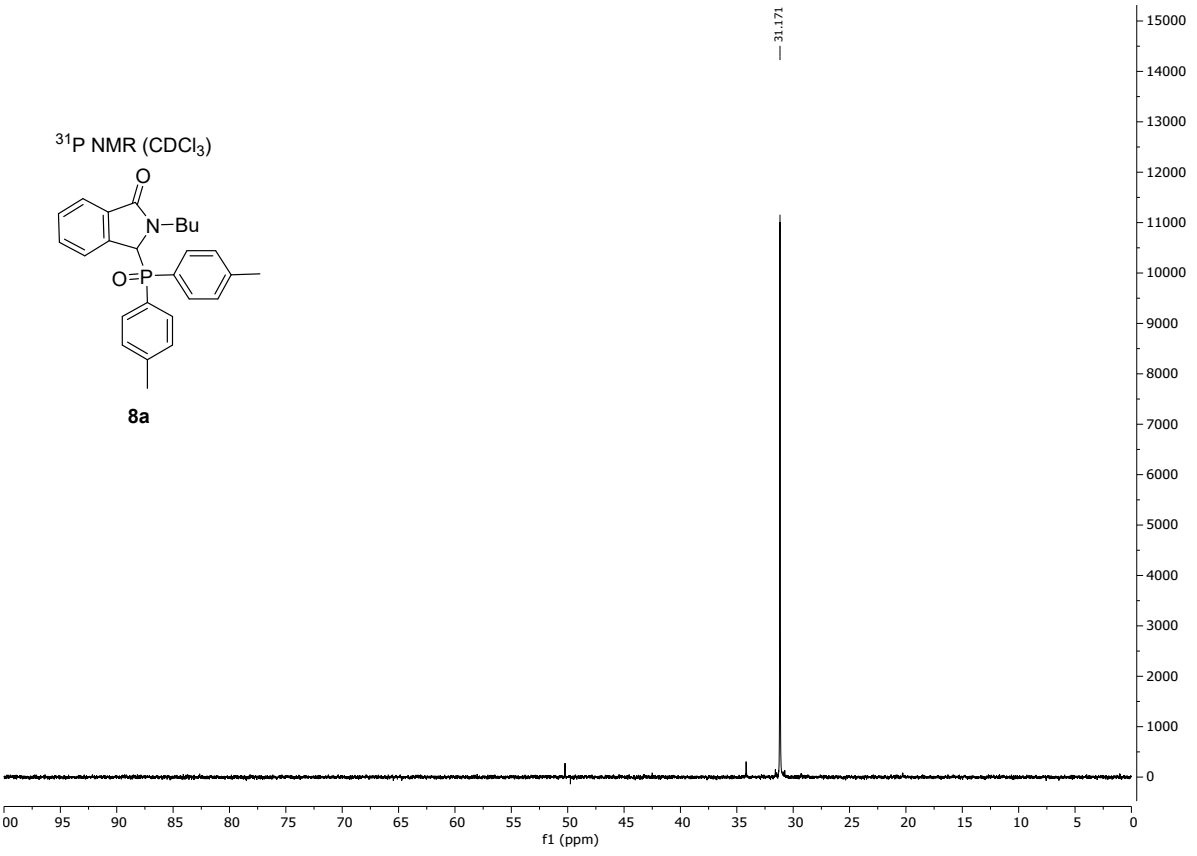
7d

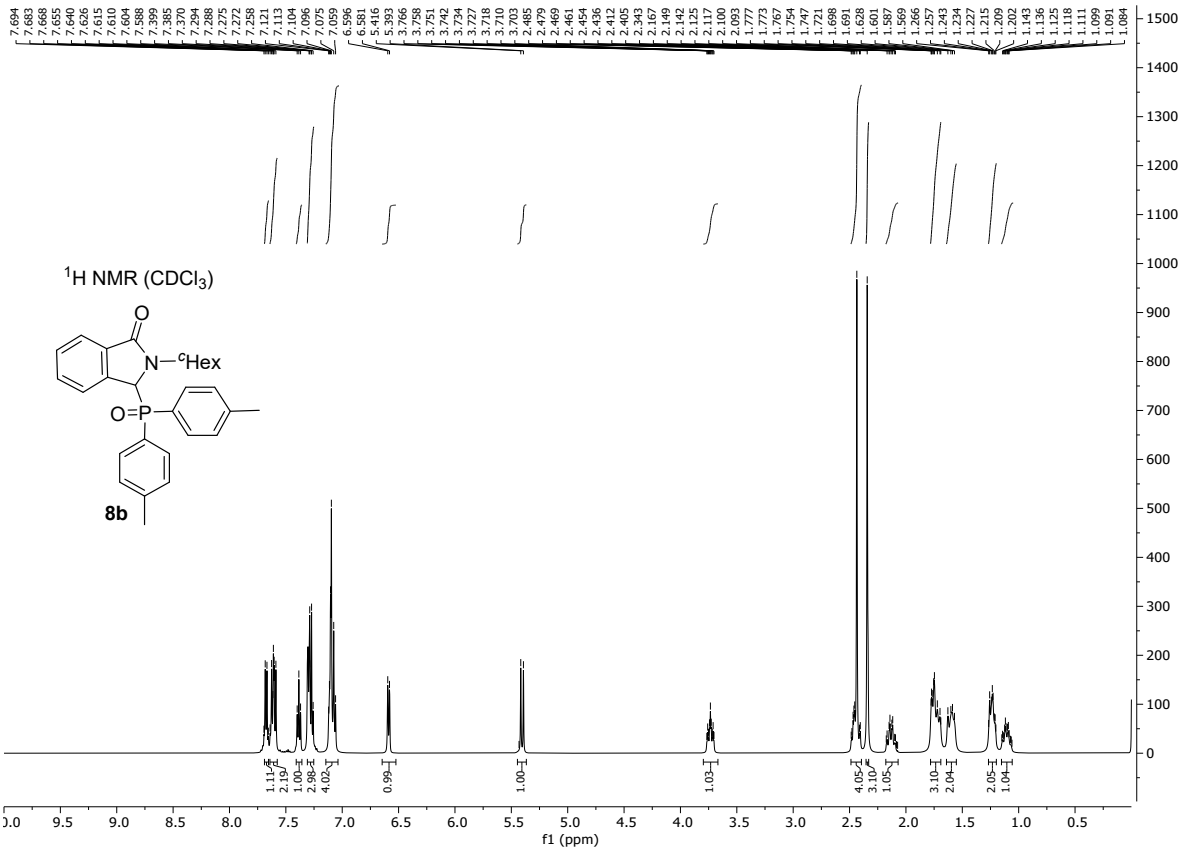

169.123
169.113
147.685
147.528
139.646
132.633
132.602
132.562
132.530
132.131
132.106
131.973
131.517
131.435
131.398
131.351
131.320
130.766
130.743
130.678
129.943
129.877
129.852
129.788
129.479
129.327
128.399
128.246
127.720
127.689
117.602
117.594
113.882
113.872
51.212
50.197
40.588
40.310
40.032
39.754
39.475
^{13}C NMR (DMSO-d6)
O
N–Ph
O=P–Ph
Ph
7d
f1 (ppm)

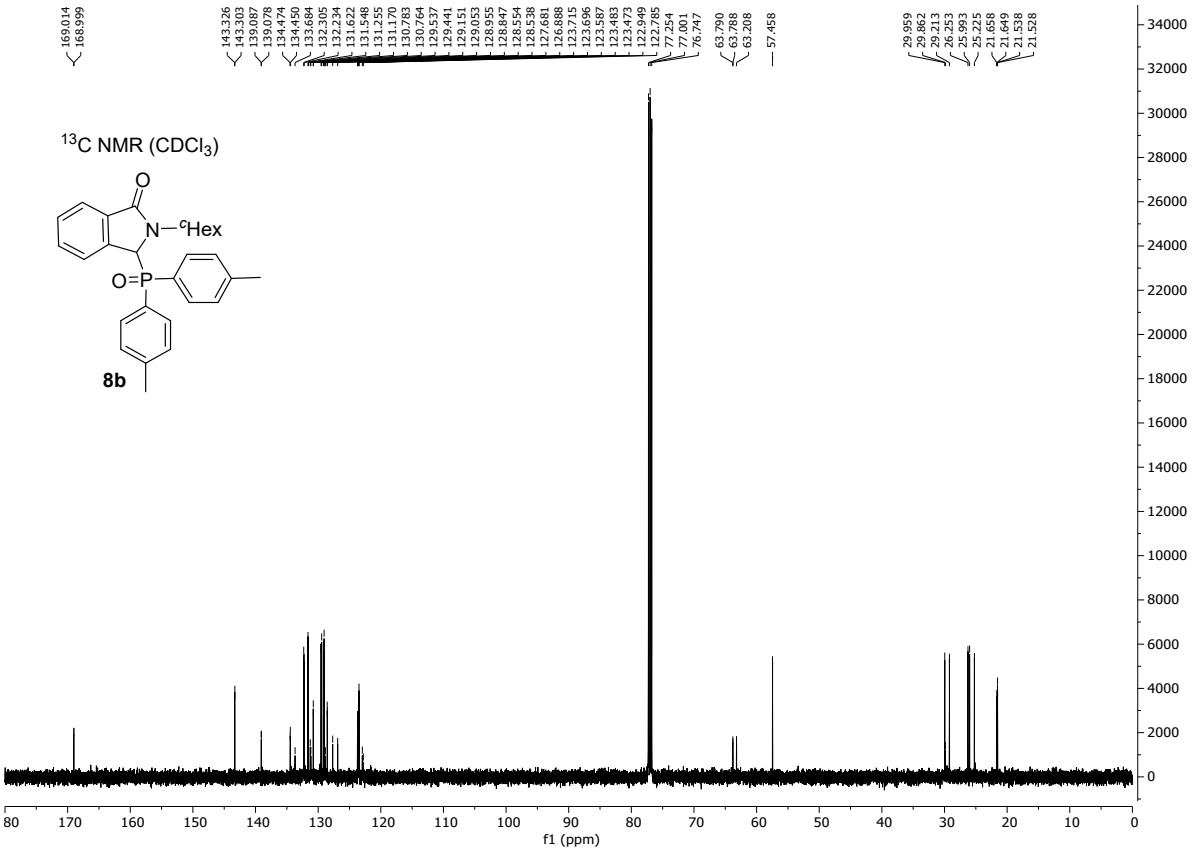

31.838
^{31}P NMR (DMSO-d6)
O
N–Ph
O=P–Ph
Ph
7d
f1 (ppm)

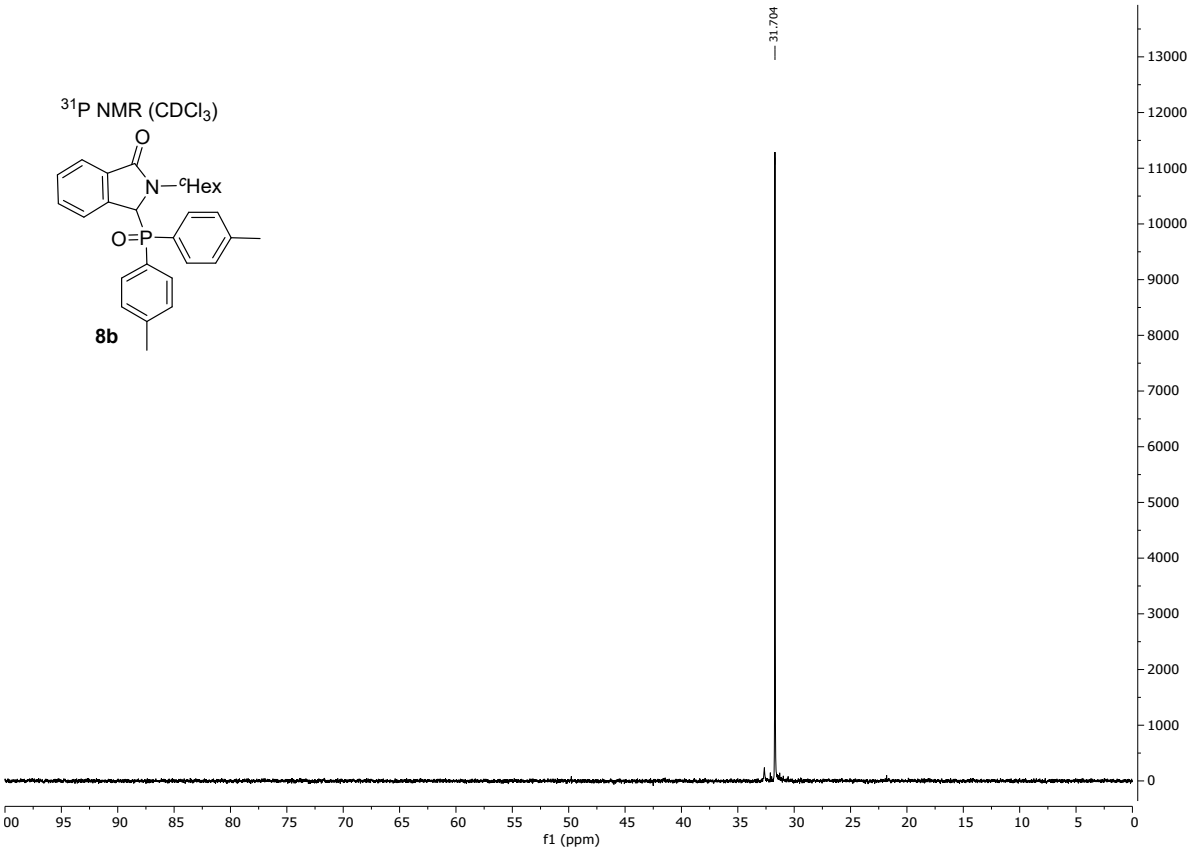

^{1}H NMR ($CDCl_3$)
O
N−Bu
O=P
8a
f1 (ppm)

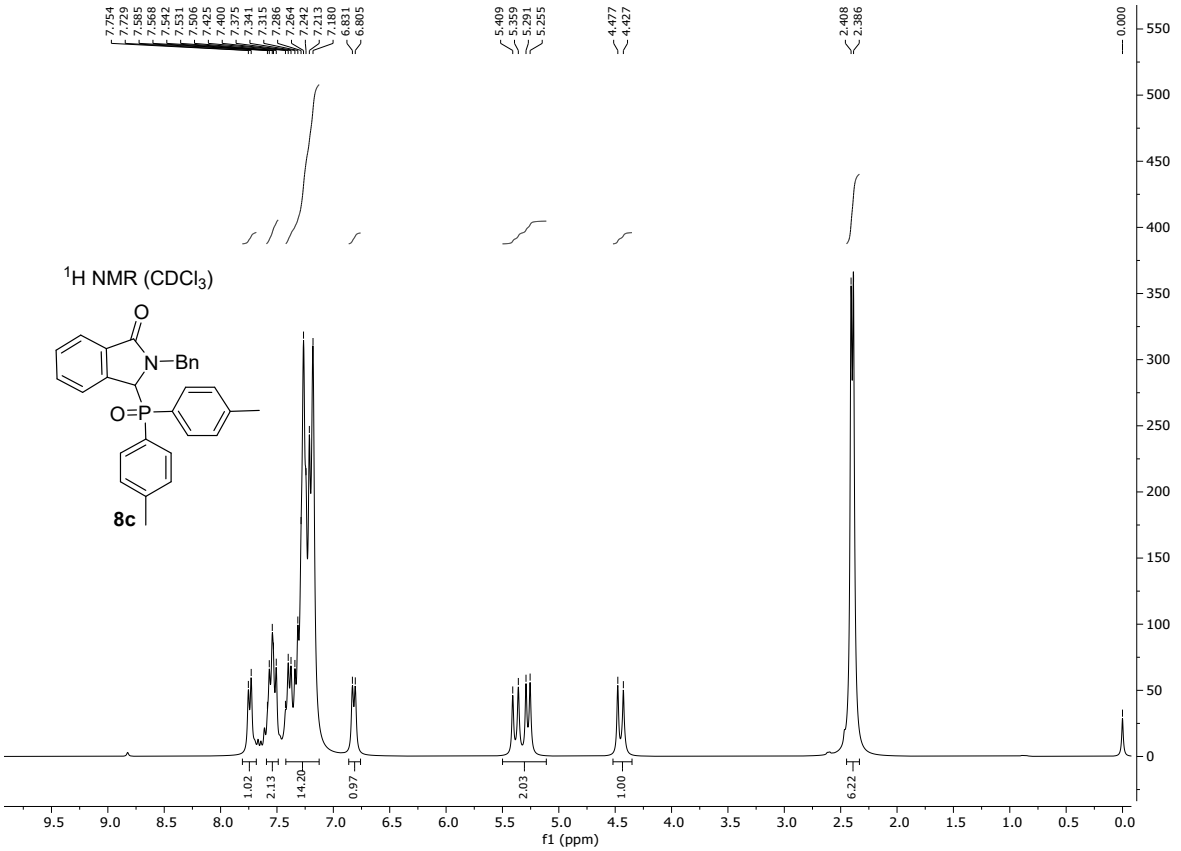

^{13}C NMR ($CDCl_3$)
O
N−Bu
O=P
8a
f1 (ppm)

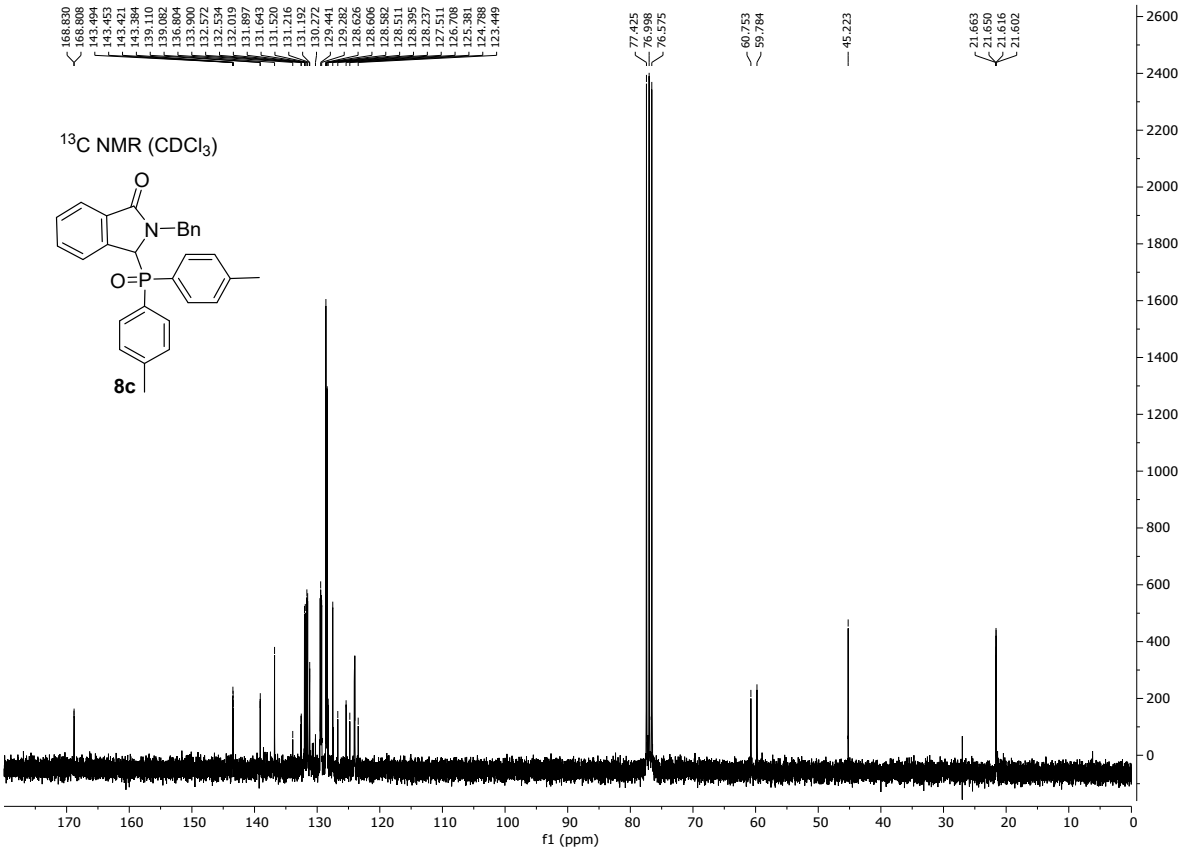

31P NMR (CDCl3)
O
N−Bu
O=P
8a
31.171
f1 (ppm)

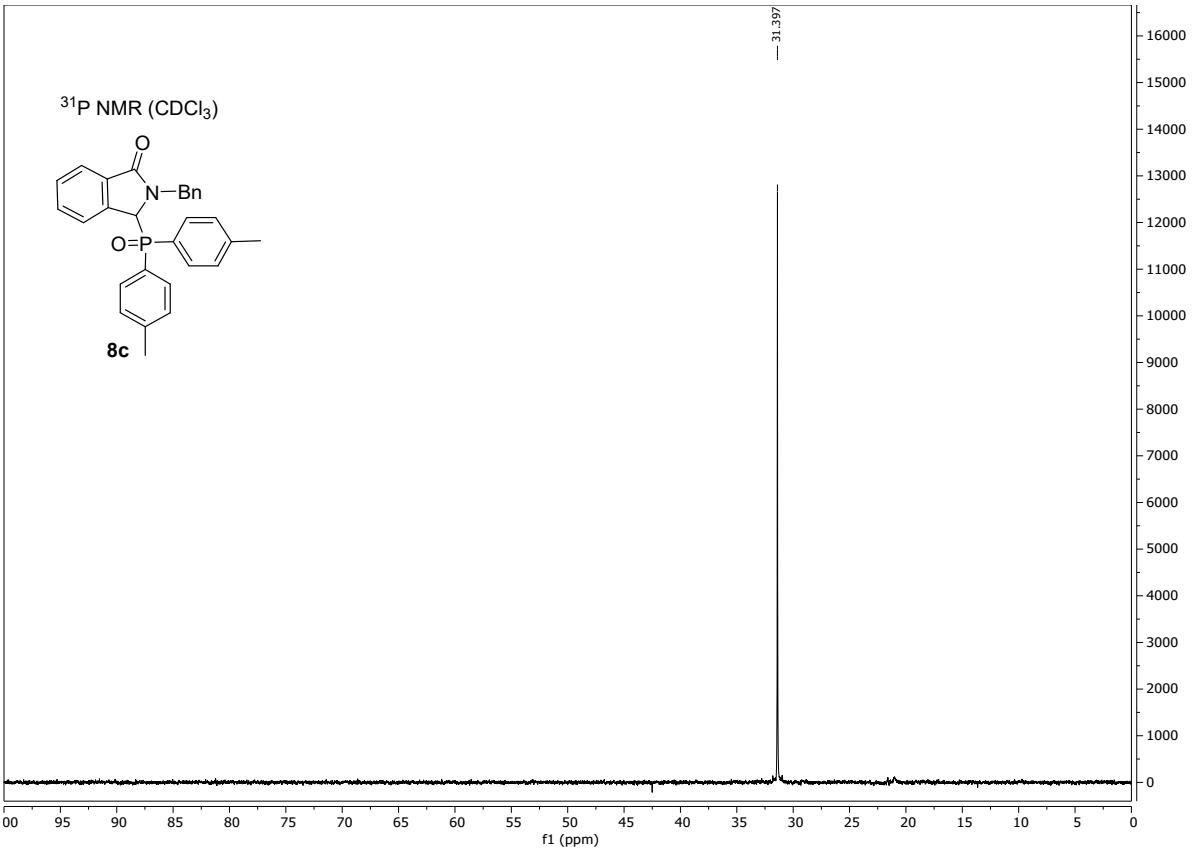

1H NMR (CDCl3)
O
N−cHex
O=P
8b
f1 (ppm)

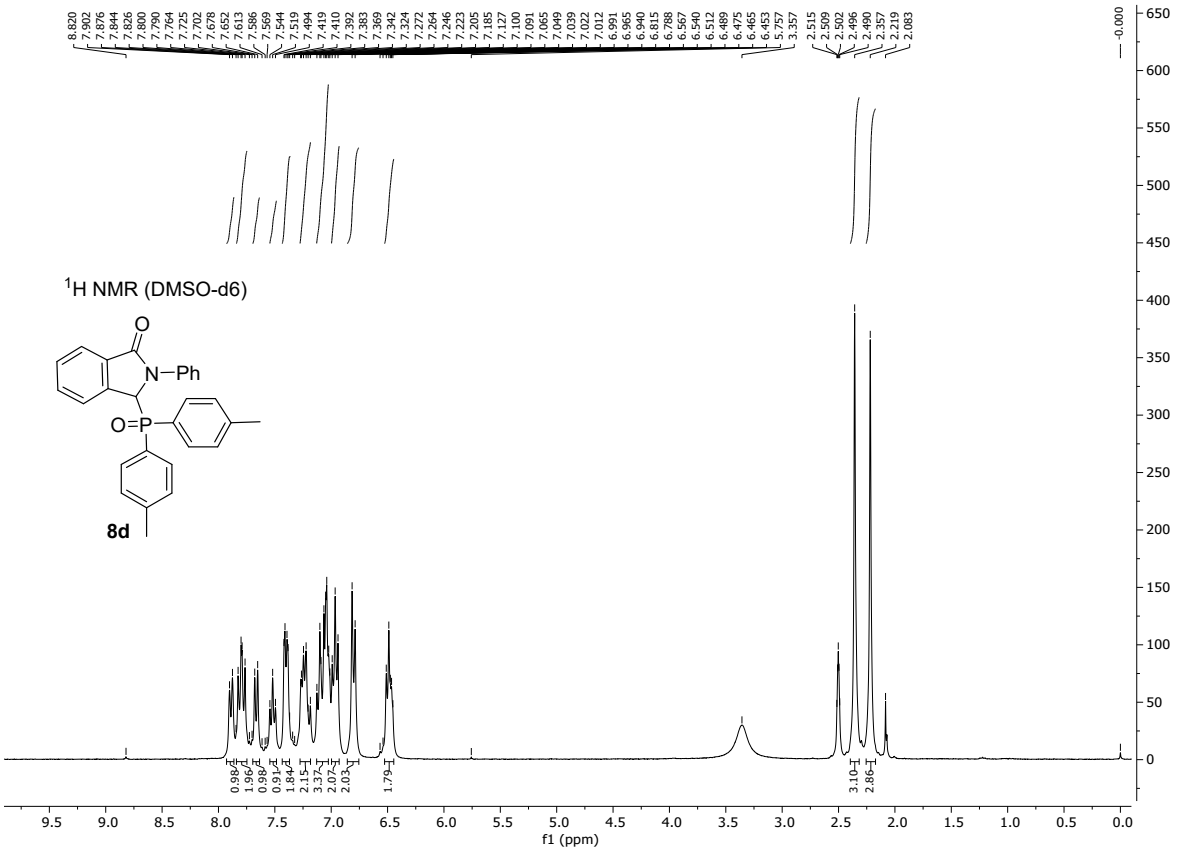

169.014
168.999
143.326
143.303
139.087
139.078
134.474
134.450
133.684
132.305
132.234
131.622
131.548
131.255
131.170
130.783
130.764
129.537
129.441
129.151
129.053
128.955
128.847
128.554
128.538
127.681
126.888
123.715
123.696
123.587
123.493
123.473
122.946
122.785
77.254
77.001
76.747
63.790
63.788
63.208
57.458
29.959
29.862
29.213
26.253
25.993
25.225
21.658
21.649
21.538
21.528
^{13}C NMR (CDCl$_3$)
O
N—^{c}Hex
O=P
8b
f1 (ppm)

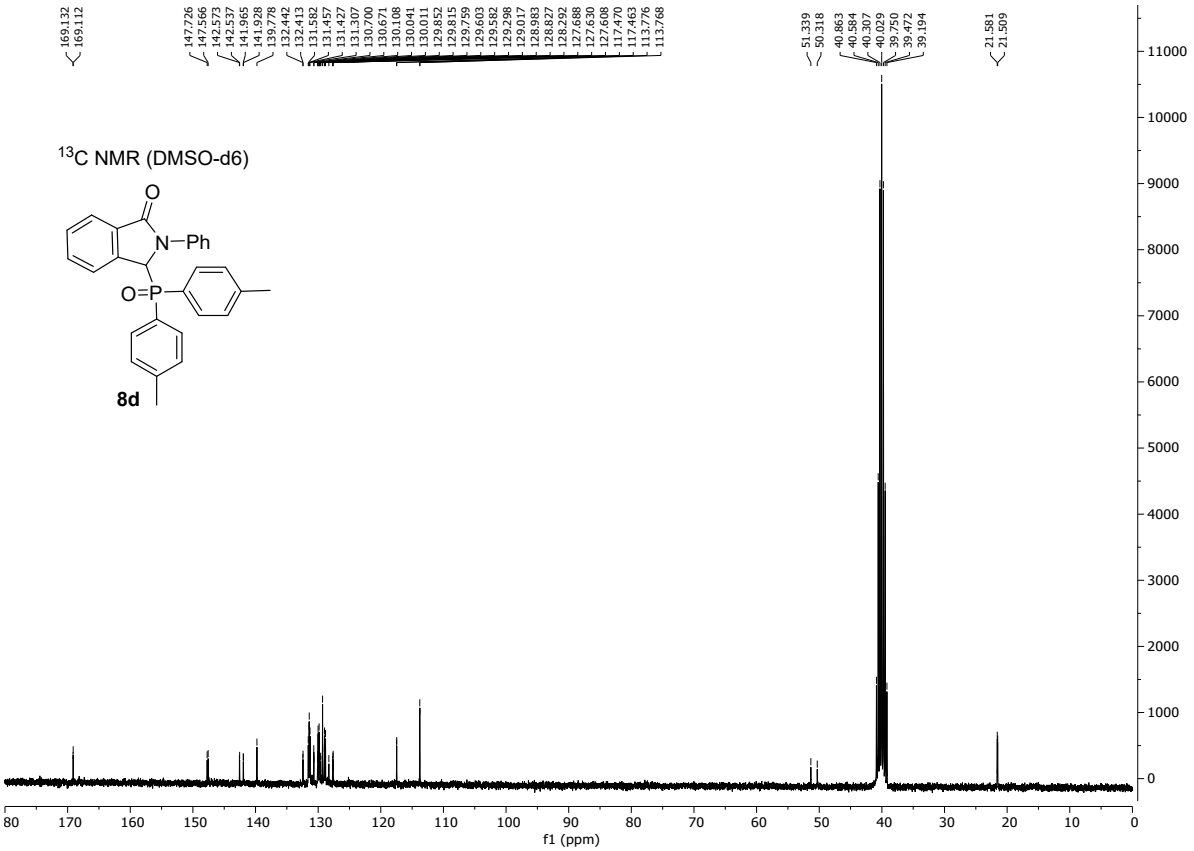

31.704
^{31}P NMR (CDCl$_3$)
O
N—^{c}Hex
O=P
8b
f1 (ppm)

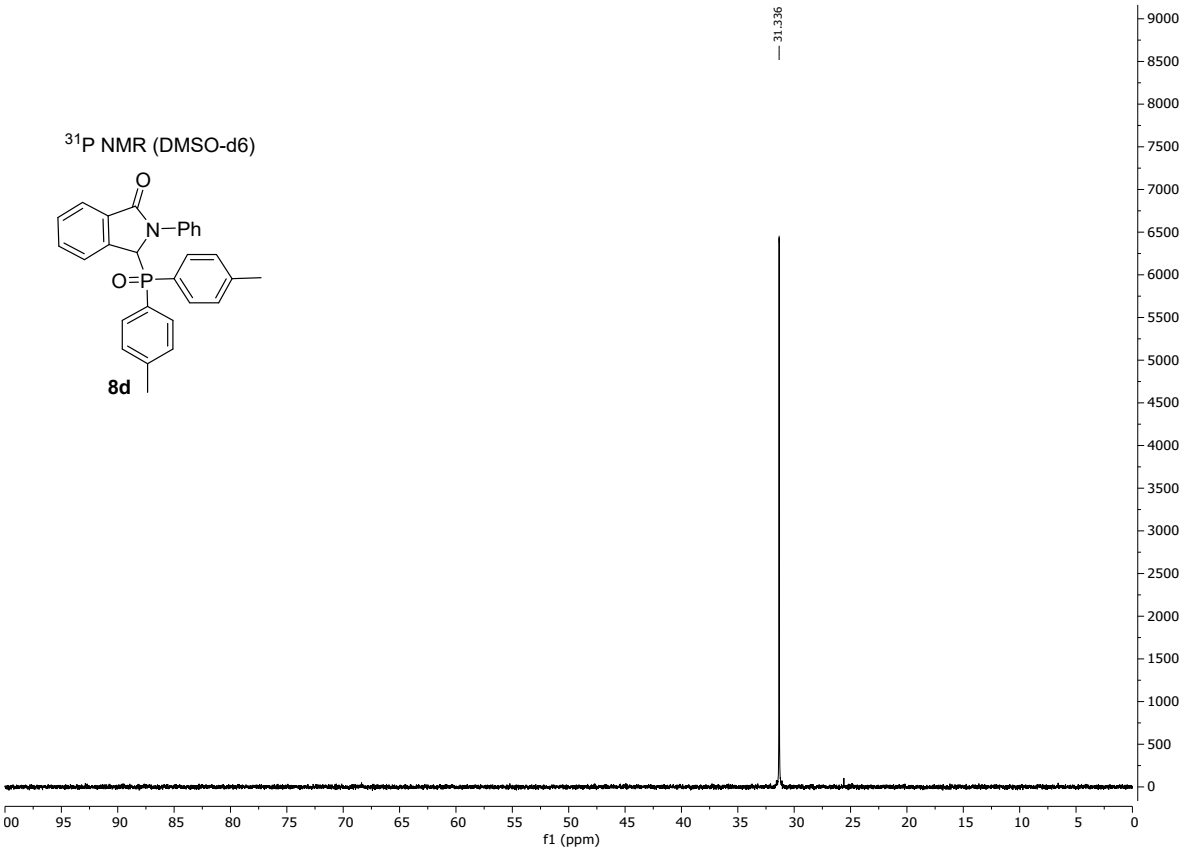

7.754
7.729
7.585
7.568
7.542
7.531
7.506
7.425
7.400
7.375
7.341
7.315
7.286
7.264
7.242
7.213
7.180
6.831
6.805
5.409
5.359
5.291
5.255
4.477
4.427
2.408
2.386
0.000
1H NMR (CDCl3)
O
N—Bn
O=P
8c
1.02
2.13
14.20
0.97
2.03
1.00
6.22
f1 (ppm)

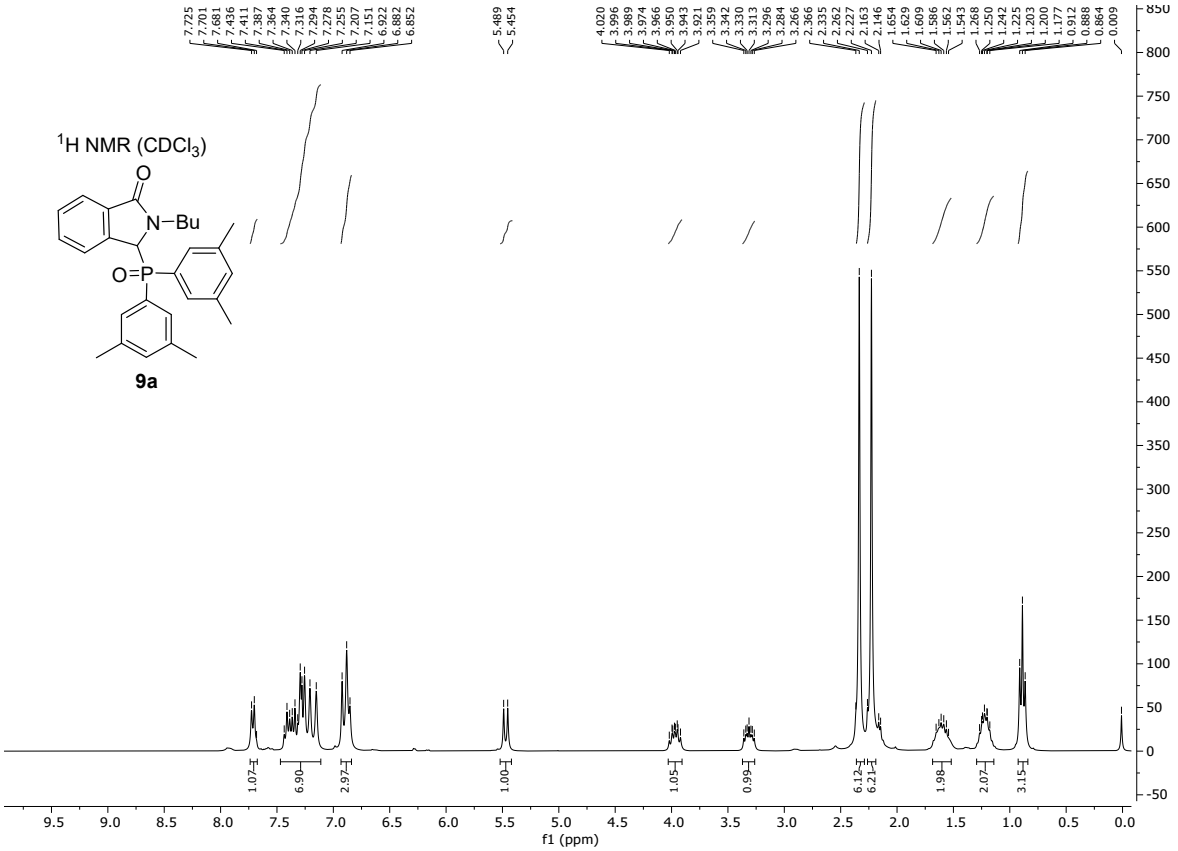

168.830
168.808
143.494
143.453
143.421
143.384
139.110
139.082
136.804
133.900
132.572
132.534
132.019
131.897
131.643
131.520
131.216
131.192
130.272
129.441
129.282
128.626
128.606
128.582
128.511
128.395
128.237
127.511
126.708
125.381
124.788
123.449
77.425
76.998
76.575
60.753
59.784
45.223
21.663
21.650
21.616
21.602
13C NMR (CDCl3)
O
N—Bn
O=P
8c
f1 (ppm)

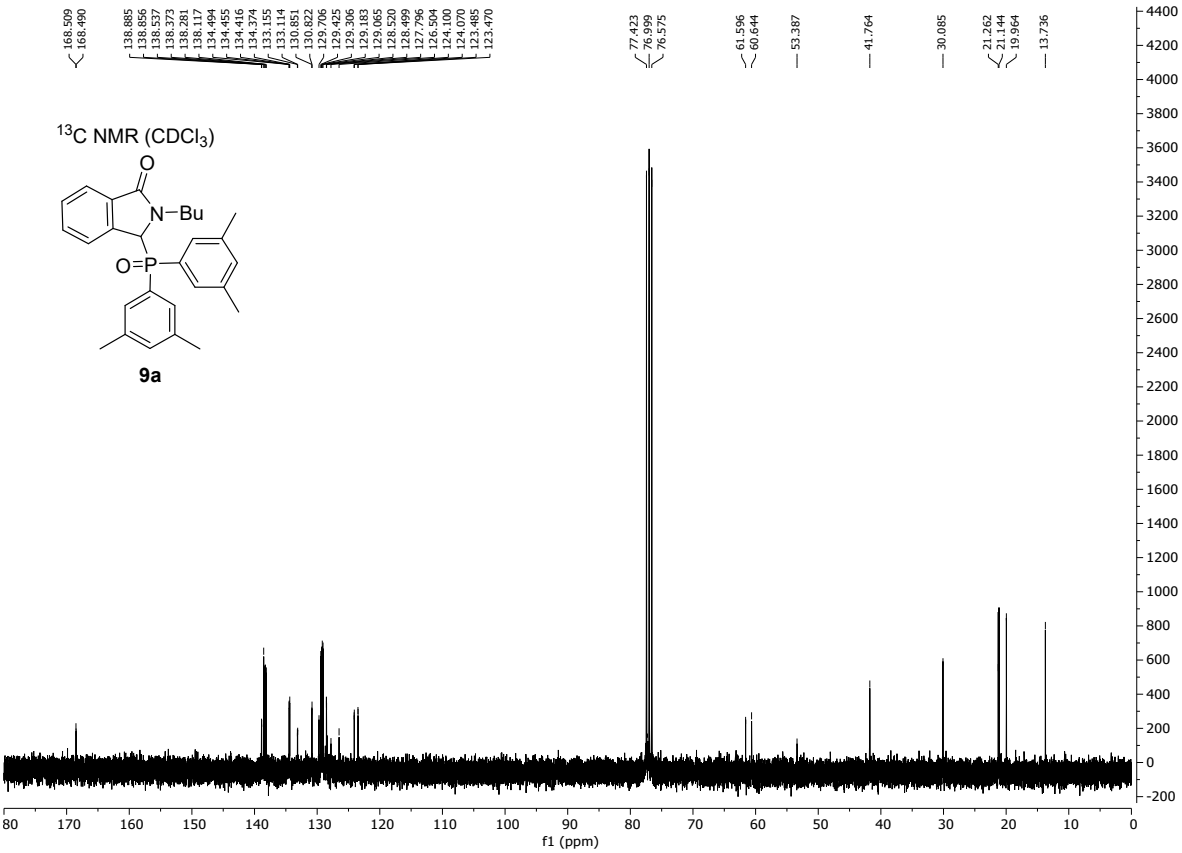

31.397
^{31}P NMR ($CDCl_3$)
O
N—Bn
O=P
8c
f1 (ppm)

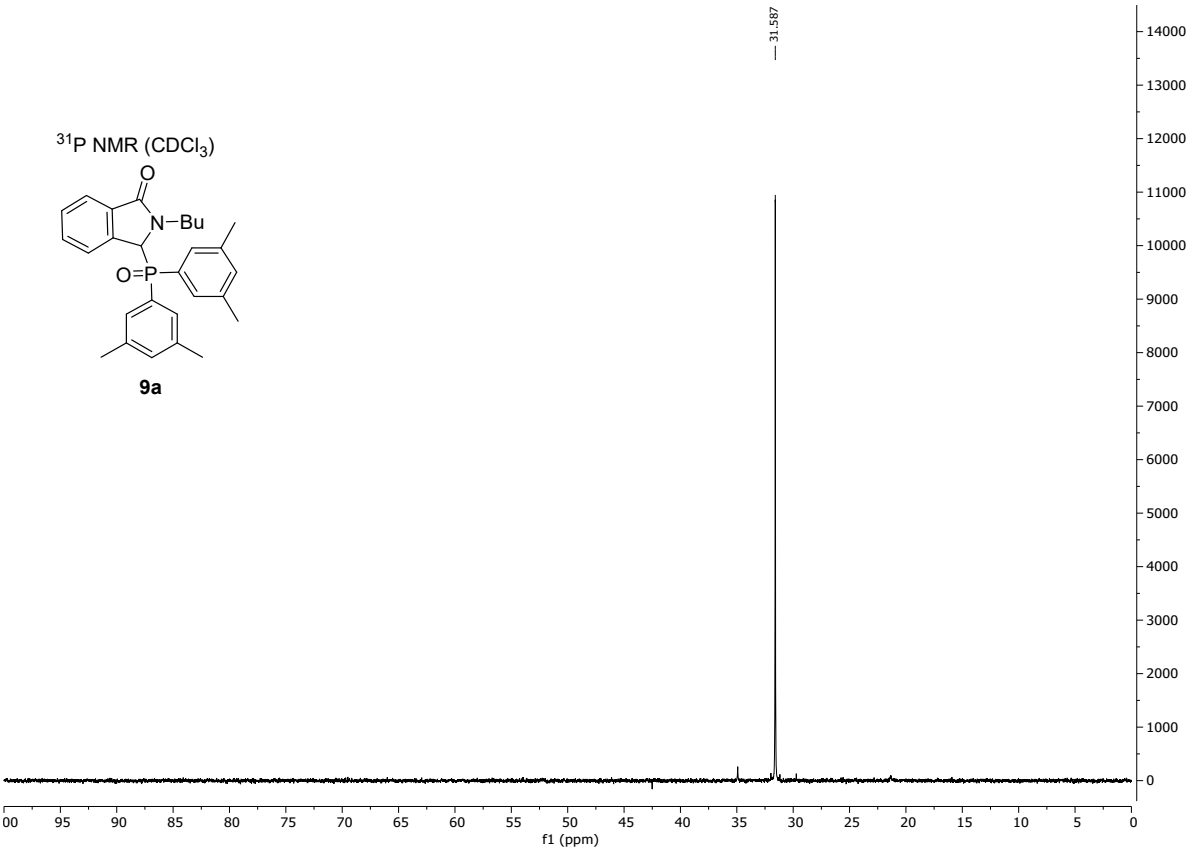

8.820
7.902
7.876
7.844
7.826
7.800
7.790
7.764
7.725
7.702
7.678
7.652
7.613
7.586
7.569
7.544
7.519
7.494
7.419
7.410
7.392
7.383
7.369
7.342
7.324
7.272
7.264
7.246
7.223
7.205
7.185
7.127
7.100
7.091
7.065
7.049
7.039
7.022
7.012
6.991
6.965
6.940
6.815
6.788
6.567
6.540
6.512
6.489
6.475
6.465
6.453
5.757
3.357
2.515
2.509
2.502
2.496
2.490
2.357
2.219
2.083
-0.000
^{1}H NMR (DMSO-d6)
O
N—Ph
O=P
8d
0.98
1.96
1.96
0.91
1.84
2.15
3.37
2.07
2.03
1.79
3.10
2.86
f1 (ppm)

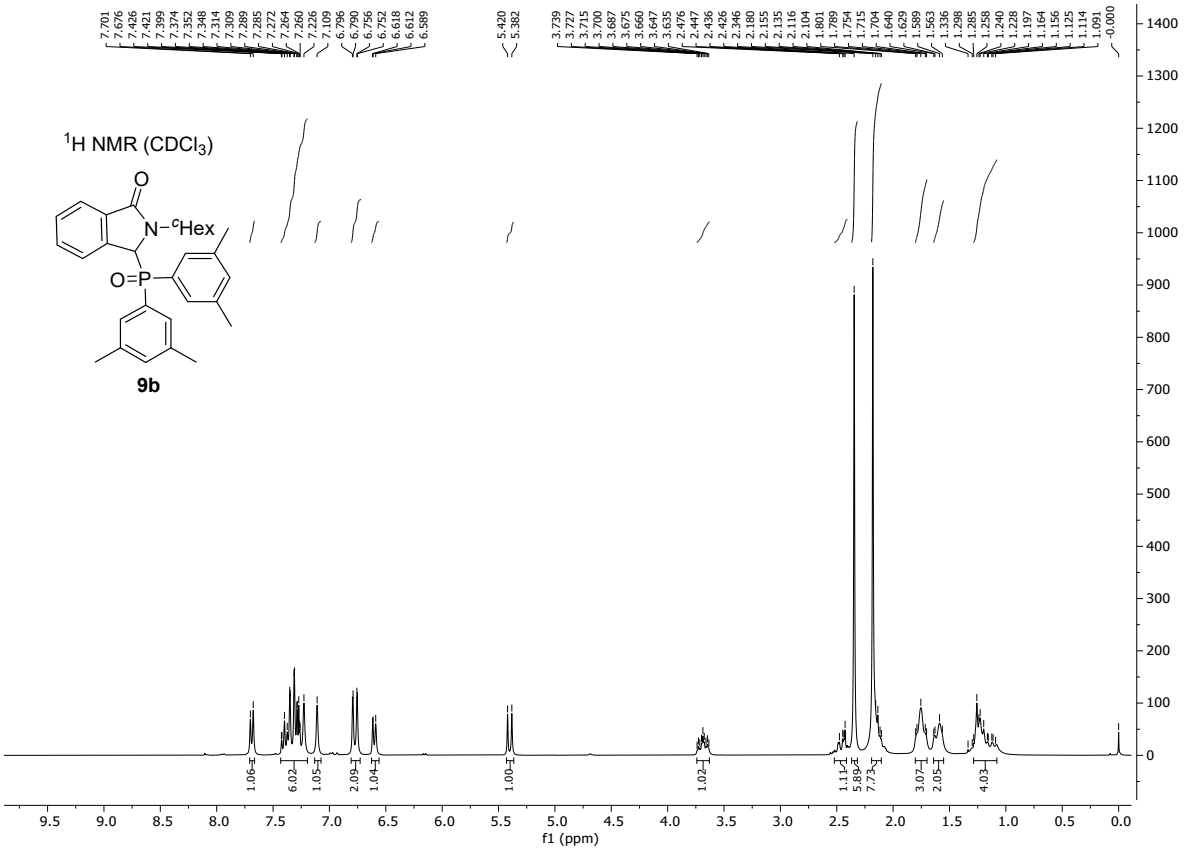

169.132
169.112
147.726
147.566
142.573
142.537
141.965
141.928
139.778
132.442
132.413
131.582
131.457
131.427
131.307
130.700
130.671
130.108
130.041
130.011
129.852
129.815
129.759
129.603
129.582
129.298
129.017
128.983
128.827
128.292
127.688
127.630
127.608
117.470
117.463
113.776
113.768
51.339
50.318
40.863
40.584
40.307
40.029
39.750
39.472
39.194
21.581
21.509
13C NMR (DMSO-d6)
O
N—Ph
O=P
8d
11000
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
80 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)

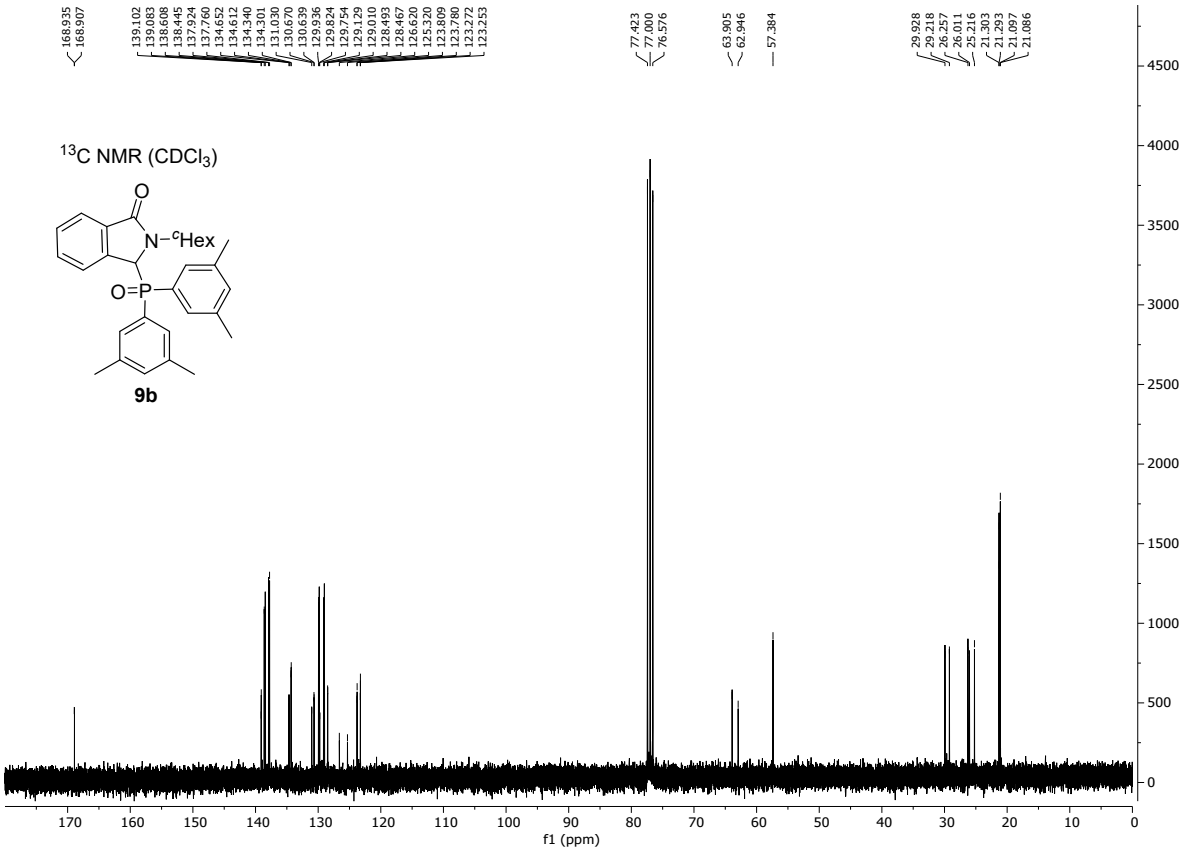

31.336
31P NMR (DMSO-d6)
O
N—Ph
O=P
8d
9000
8500
8000
7500
7000
6500
6000
5500
5000
4500
4000
3500
3000
2500
2000
1500
1000
500
0
00 95 90 85 80 75 70 65 60 55 50 45 40 35 30 25 20 15 10 5 0
f1 (ppm)

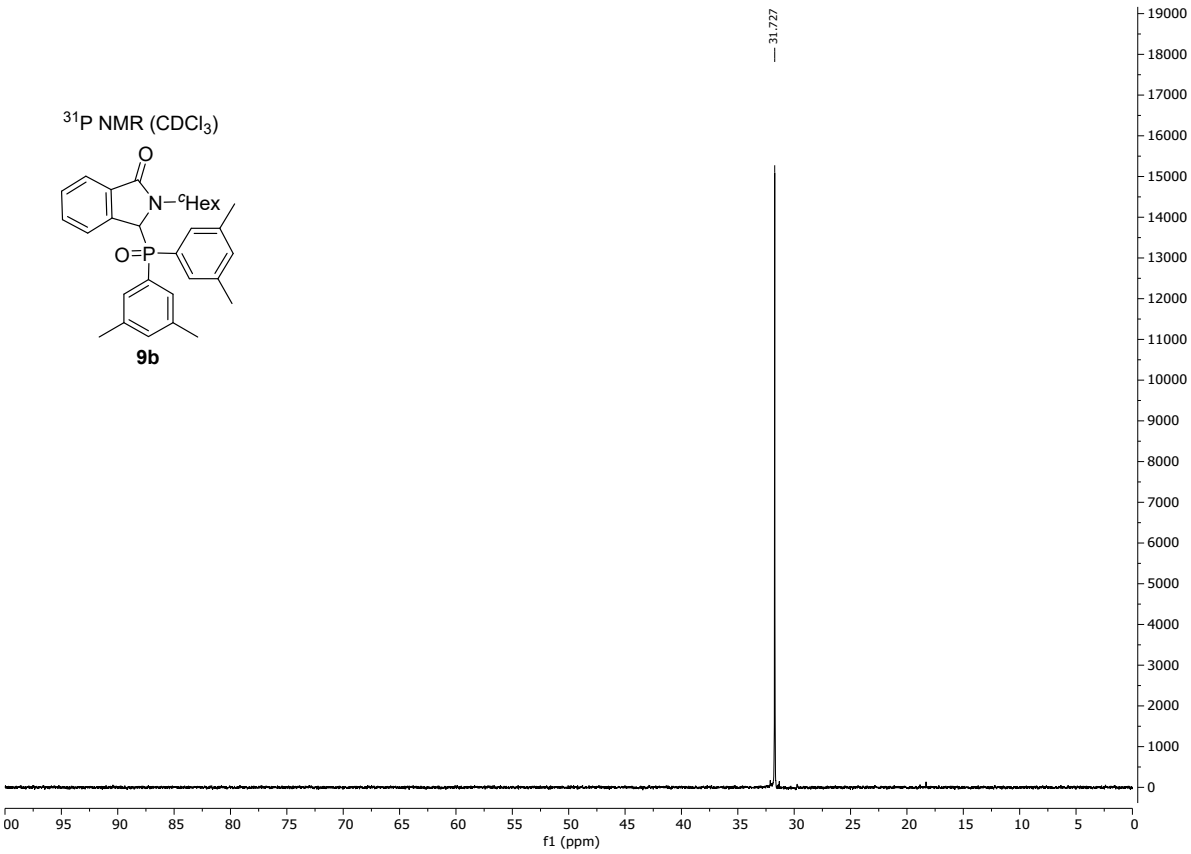

^{1}H NMR ($CDCl_3$)
9a
f1 (ppm)

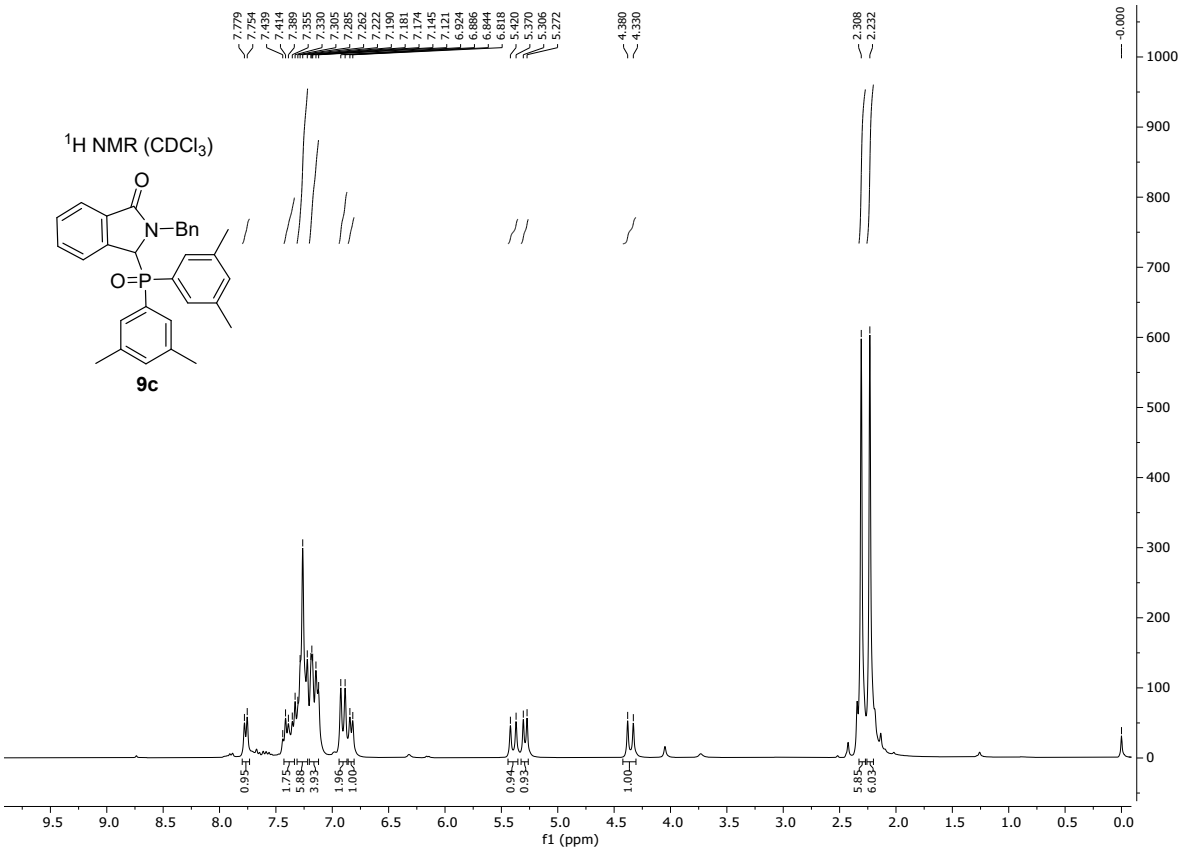

^{13}C NMR ($CDCl_3$)
9a
f1 (ppm)

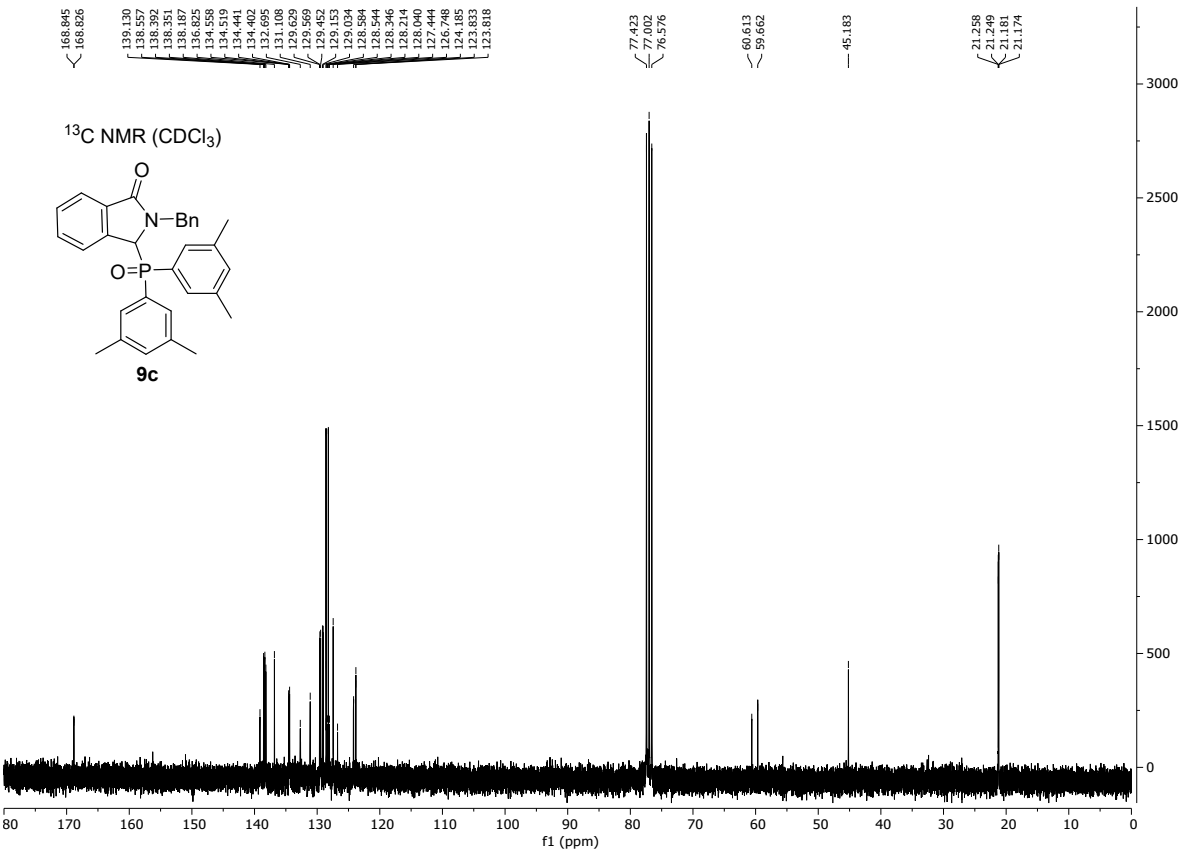

31P NMR (CDCl3)
O
N–Bu
O=P
9a
31.587
f1 (ppm)

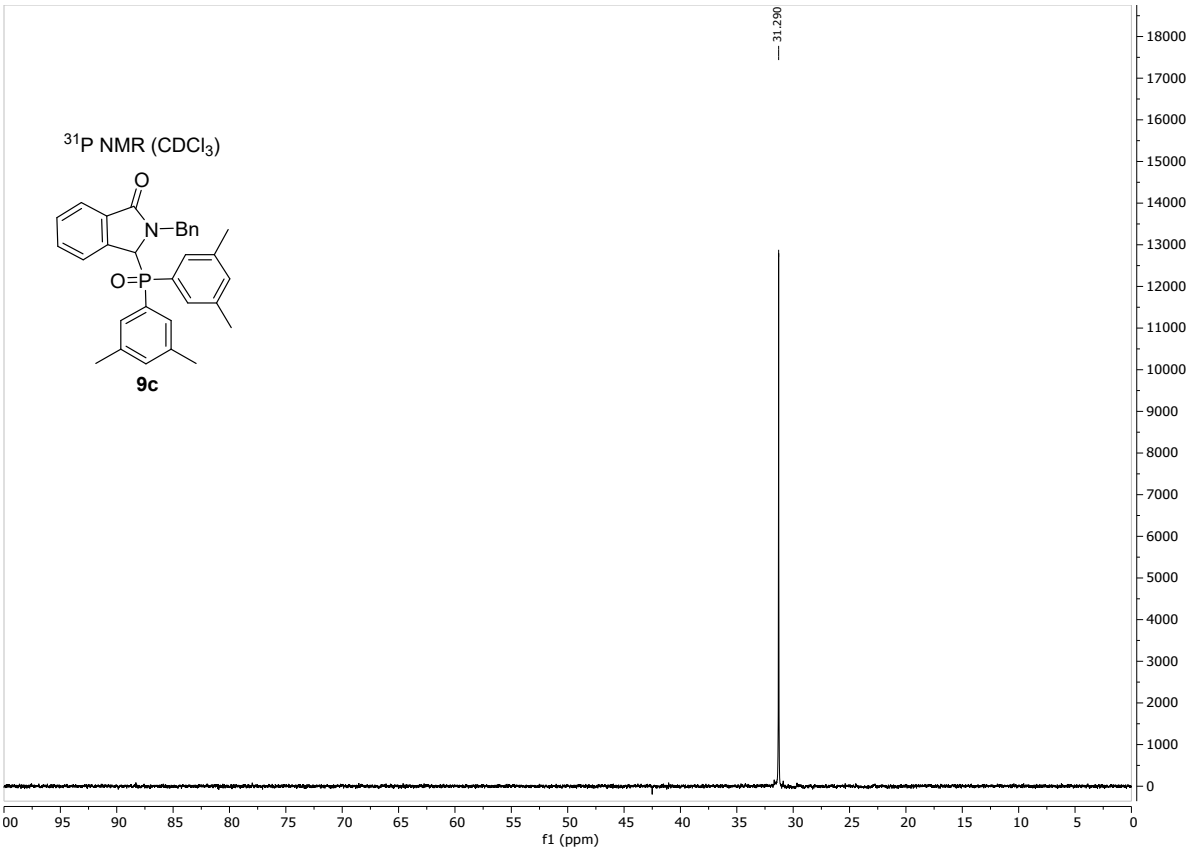

1H NMR (CDCl3)
O
N–cHex
O=P
9b
f1 (ppm)

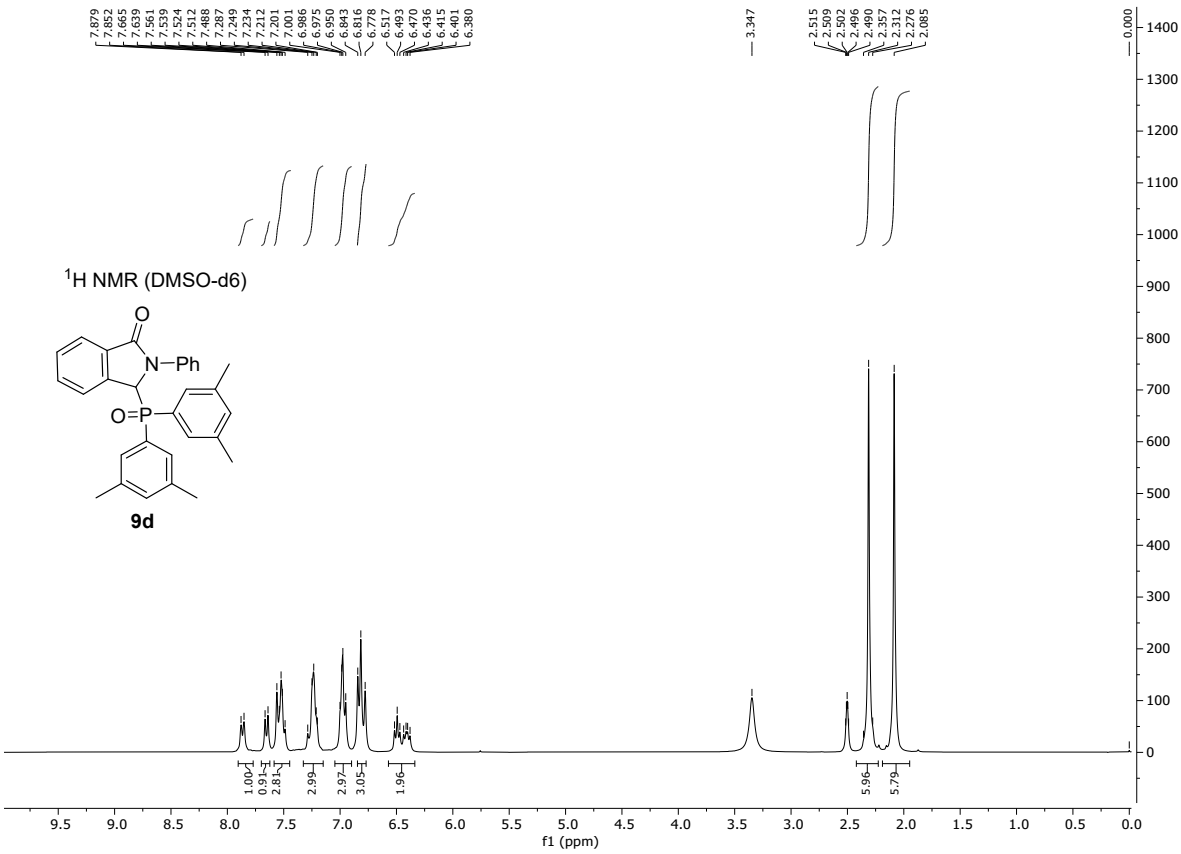

168.935
168.907
139.102
139.083
138.608
138.445
137.924
137.760
134.652
134.612
134.340
134.301
131.030
130.670
130.639
129.936
129.824
129.754
129.129
129.010
128.493
128.467
126.620
125.320
123.809
123.780
123.272
123.253
77.423
77.000
76.576
63.905
62.946
57.384
29.928
29.218
26.257
26.011
25.216
21.303
21.293
21.097
21.086
^{13}C NMR ($CDCl_3$)
O
N–^{c}Hex
O=P
9b
f1 (ppm)

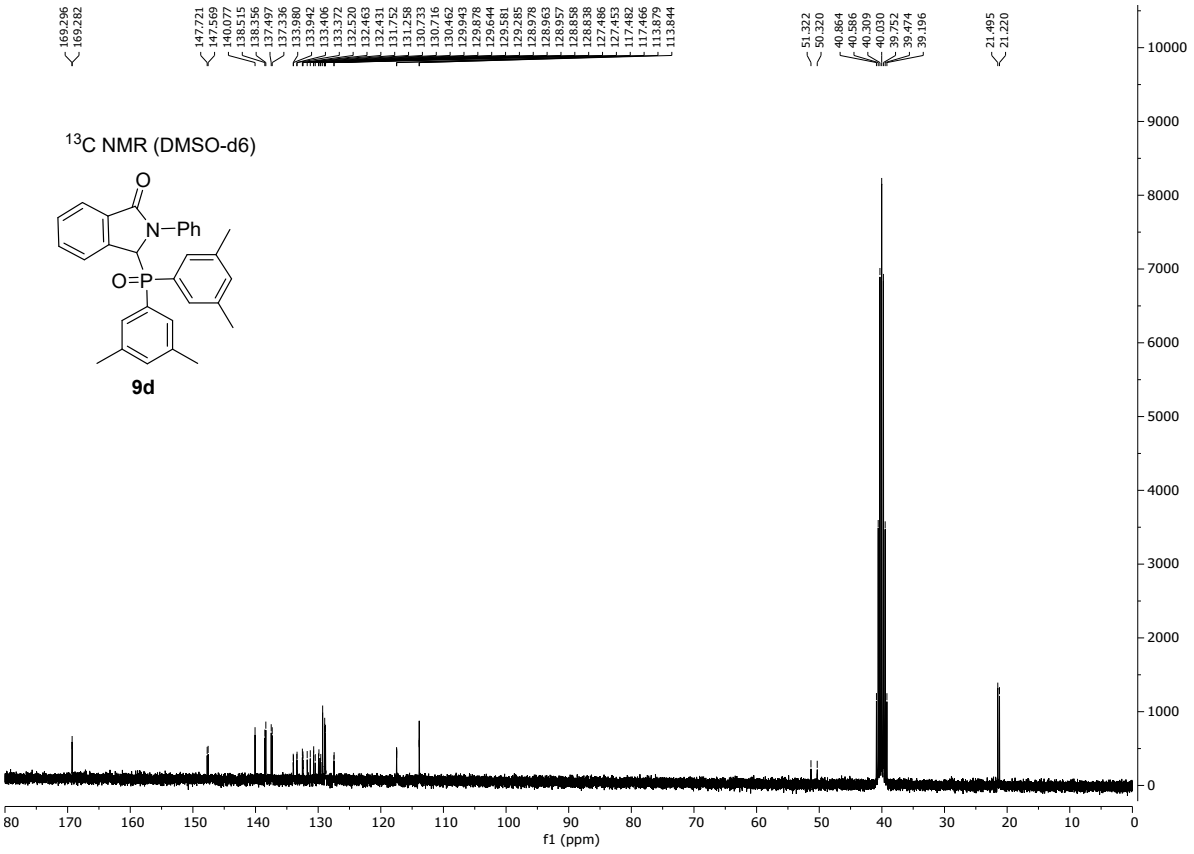

31.727
^{31}P NMR ($CDCl_3$)
O
N–^{c}Hex
O=P
9b
f1 (ppm)

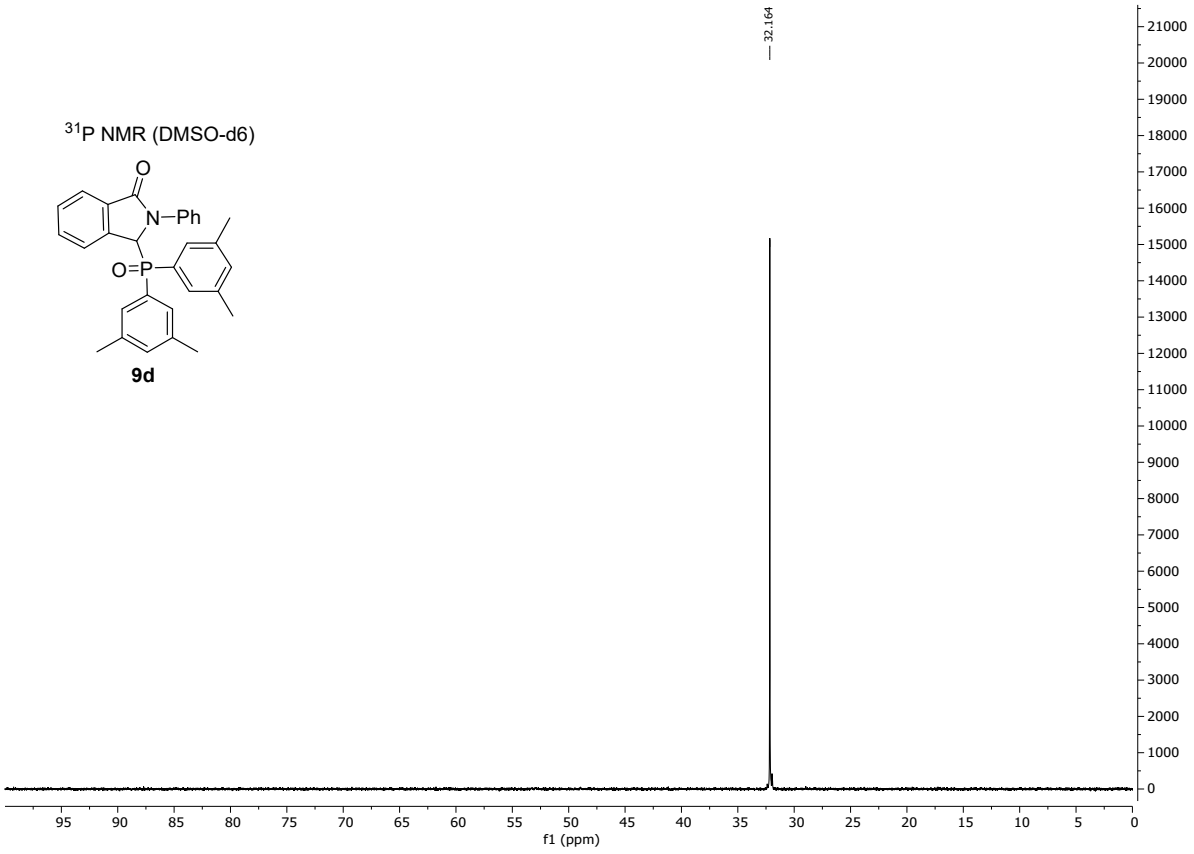

^{1}H NMR ($CDCl_3$)
9c
f1 (ppm)

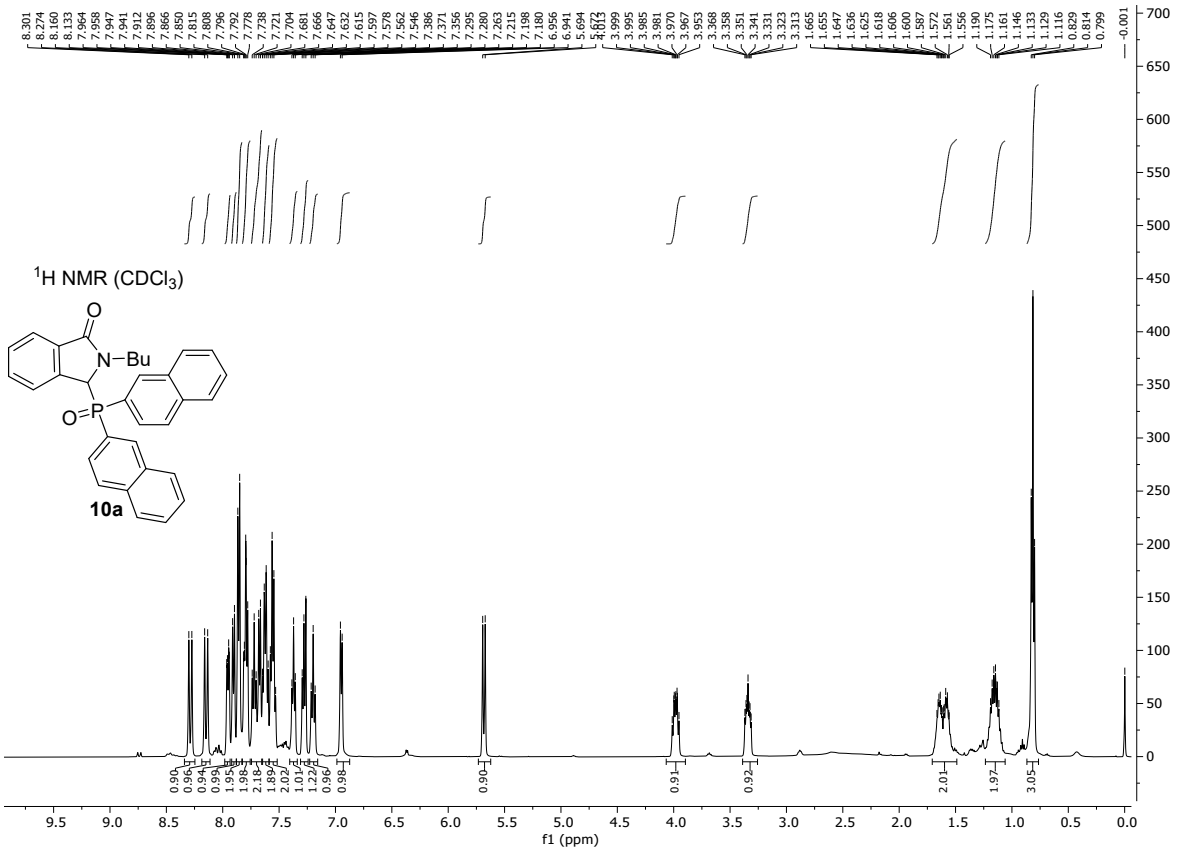

^{13}C NMR ($CDCl_3$)
9c
f1 (ppm)

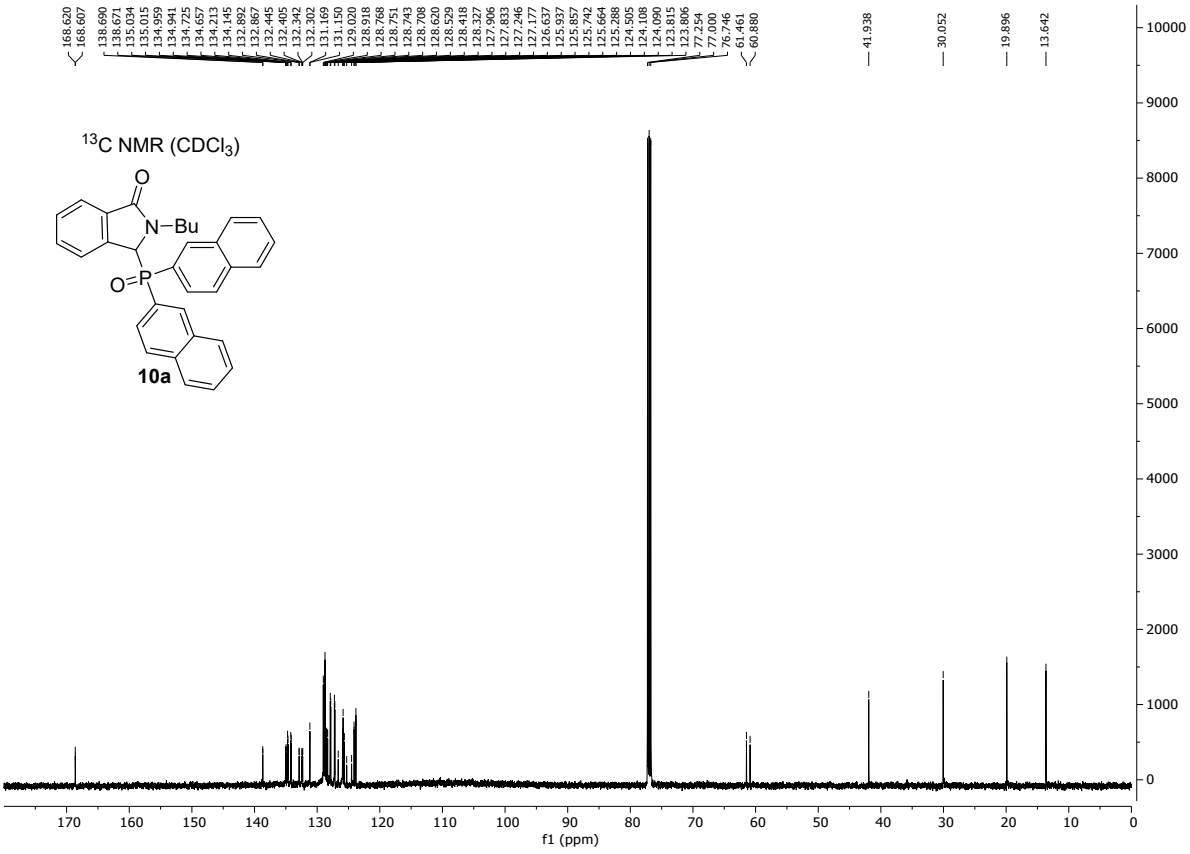

31.290
^{31}P NMR ($CDCl_3$)
O
N−Bn
O=P
9c
f1 (ppm)

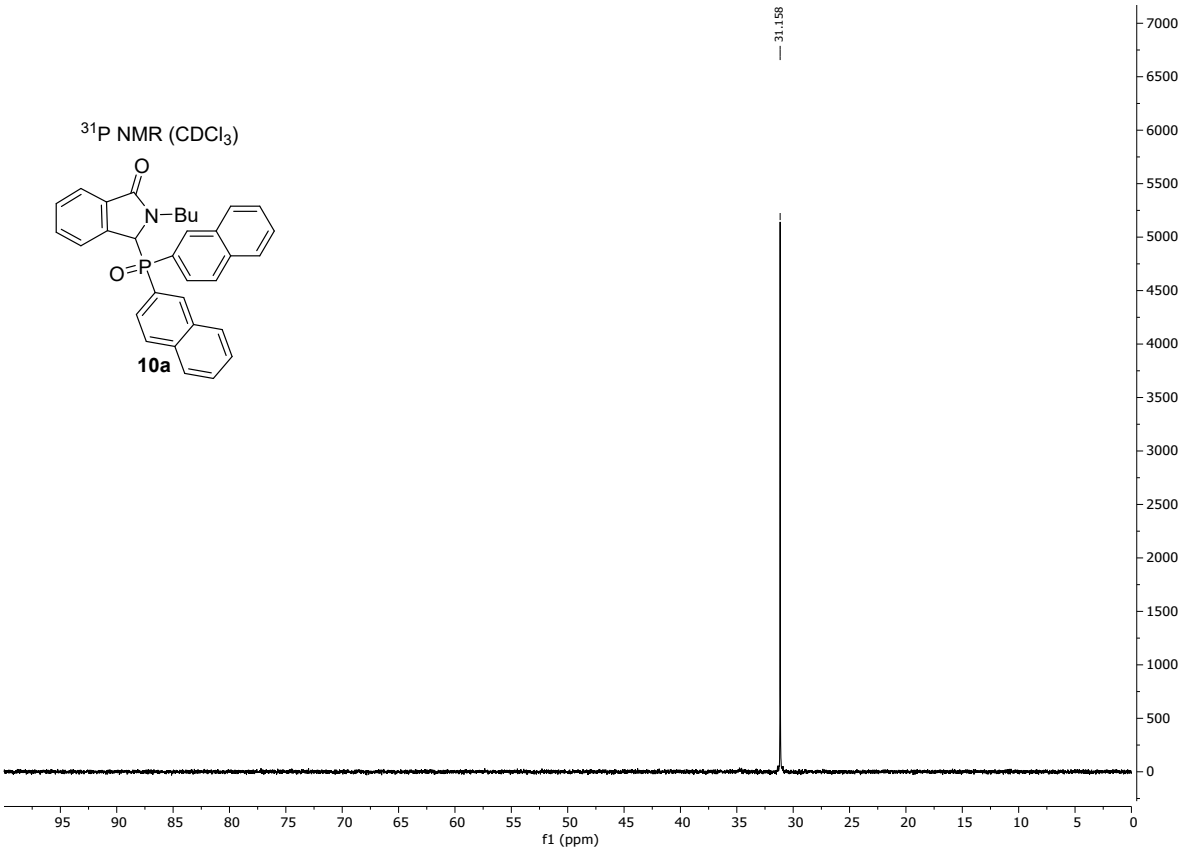

7.879
7.852
7.665
7.639
7.561
7.539
7.524
7.512
7.488
7.287
7.249
7.234
7.212
7.201
7.001
6.986
6.975
6.950
6.843
6.816
6.778
6.517
6.493
6.470
6.436
6.415
6.401
6.380
3.347
2.515
2.509
2.502
2.496
2.490
2.357
2.312
2.276
2.085
0.000
^{1}H NMR (DMSO-d6)
O
N−Ph
O=P
9d
1.00
0.91
2.81
2.99
2.97
3.05
1.96
5.96
5.79
f1 (ppm)

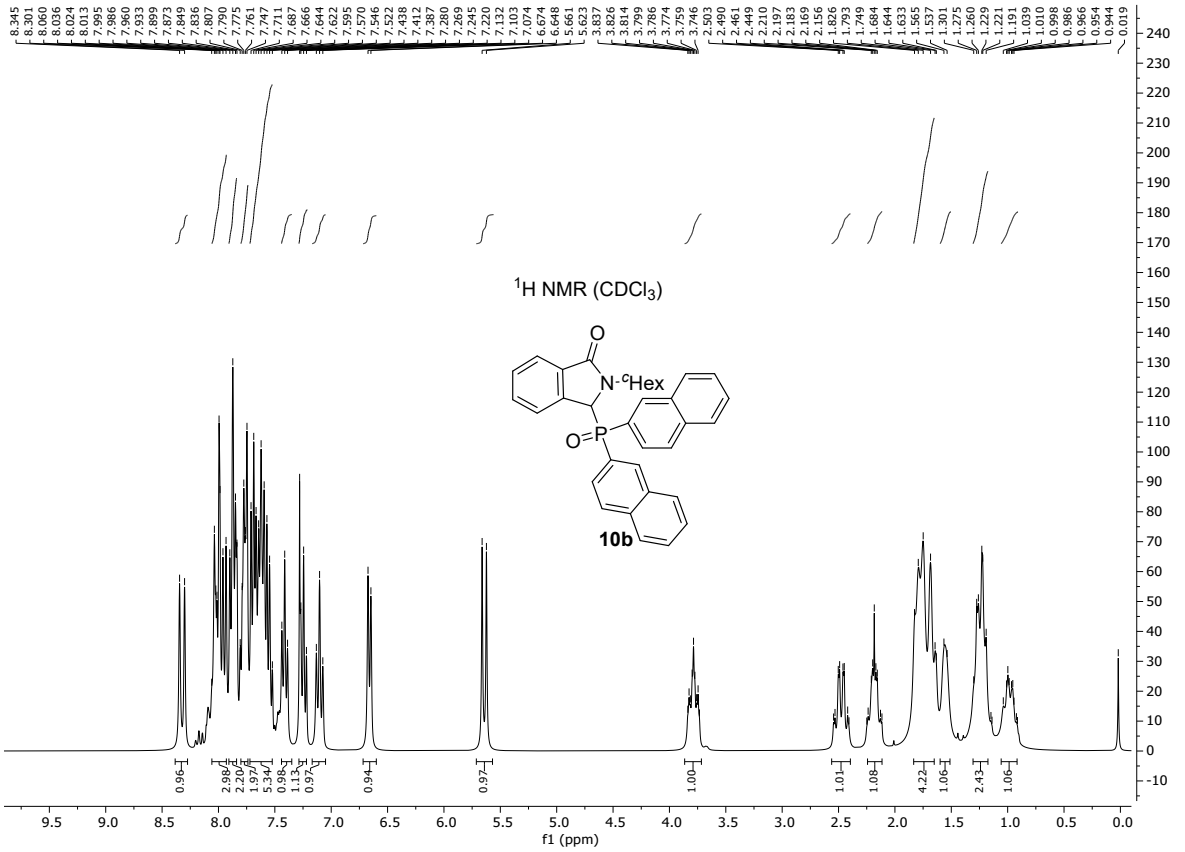

169.296
169.282
147.721
147.569
140.077
138.515
138.356
137.497
137.336
133.980
133.942
133.406
133.372
132.520
132.463
132.431
131.752
131.258
130.733
130.716
130.462
129.943
129.878
129.644
129.581
129.285
128.978
128.963
128.957
128.858
128.838
127.486
127.453
117.482
117.466
113.879
113.844
51.322
50.320
40.864
40.586
40.309
40.030
39.752
39.474
39.196
21.495
21.220
13C NMR (DMSO-d6)
O
N—Ph
O=P
9d
f1 (ppm)

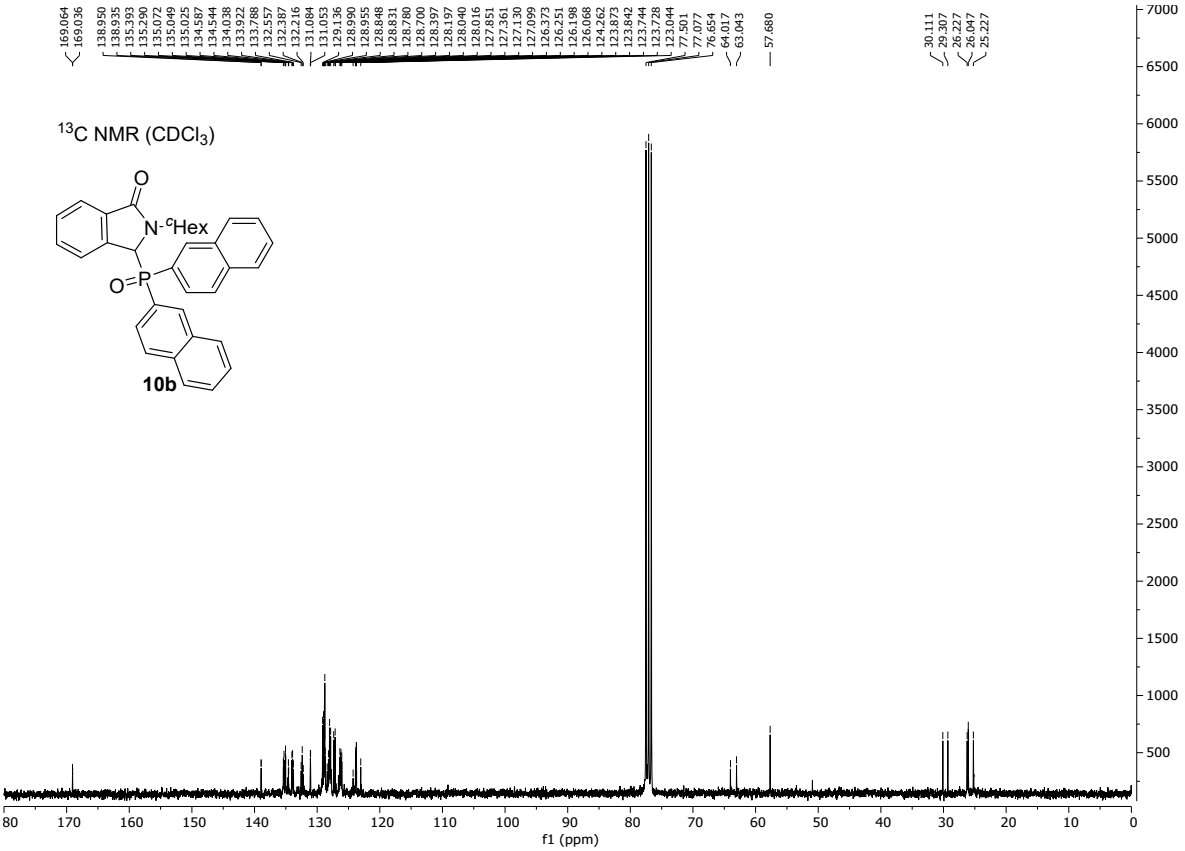

32.164
31P NMR (DMSO-d6)
O
N—Ph
O=P
9d
f1 (ppm)

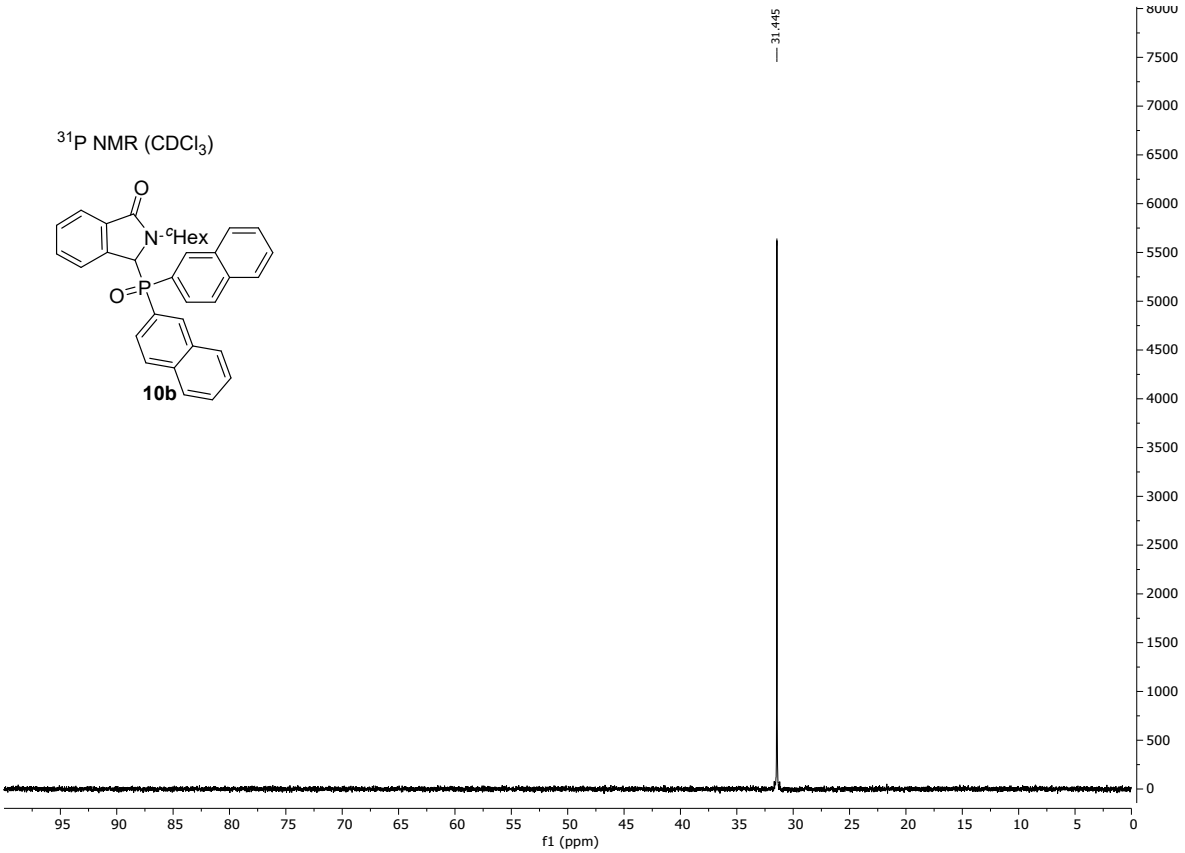

^{1}H NMR ($CDCl_3$)
10a
f1 (ppm)

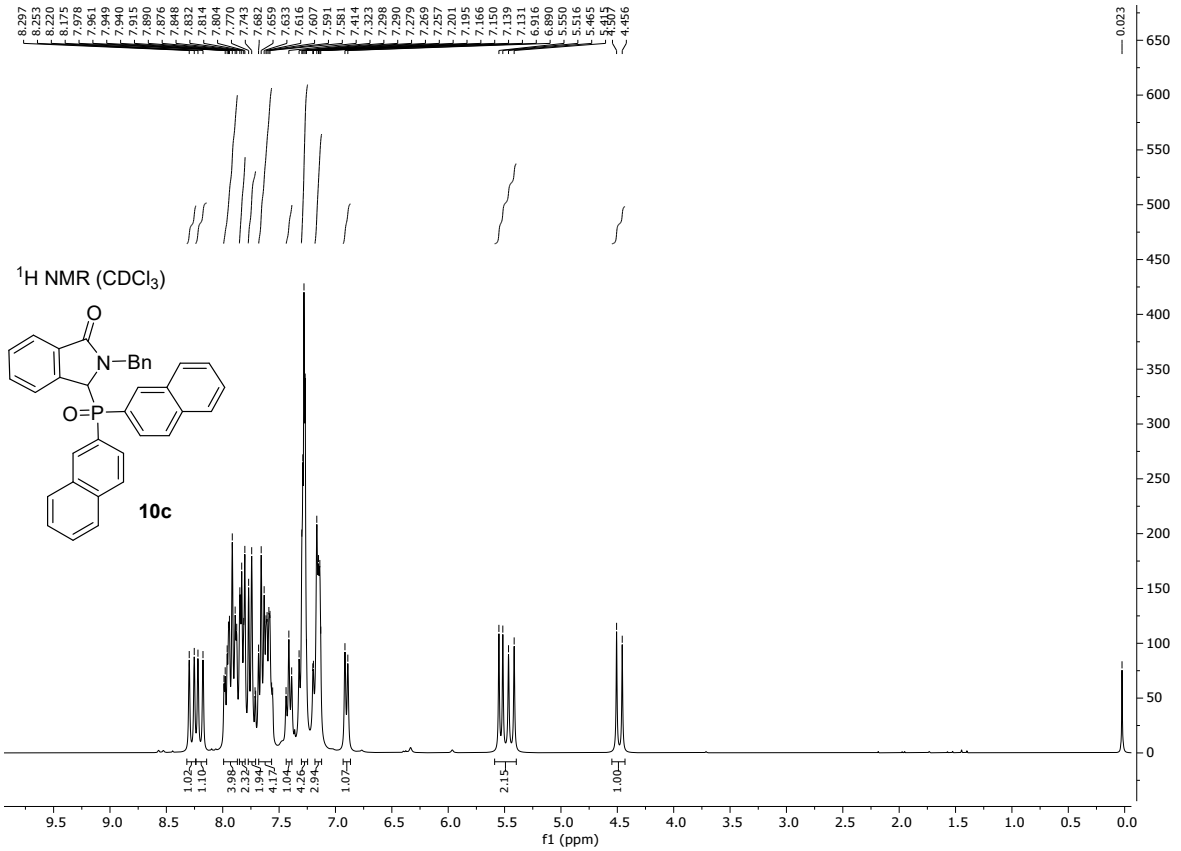

^{13}C NMR ($CDCl_3$)
10a
f1 (ppm)

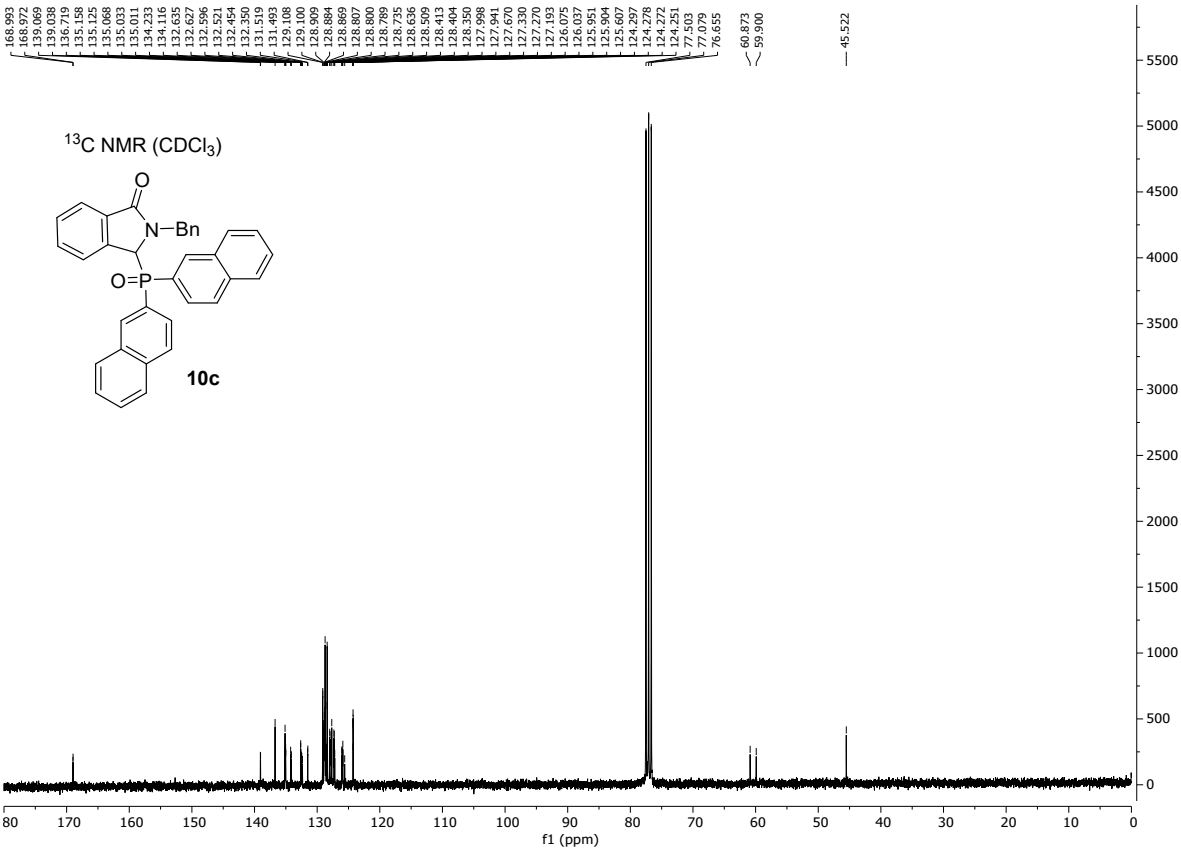

31P NMR (CDCl3)
O
N−Bu
O=P
10a
31.158
f1 (ppm)


1H NMR (CDCl3)
O
N-cHex
O=P
10b
f1 (ppm)

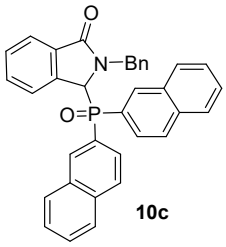

169.064
169.036
138.950
138.935
135.393
135.290
135.072
135.049
135.025
134.587
134.544
134.038
133.922
133.788
132.557
132.387
132.216
131.084
131.053
129.136
128.990
128.955
128.848
128.831
128.780
128.700
128.397
128.197
128.040
128.016
127.851
127.361
127.130
127.099
126.373
126.251
126.198
126.068
124.262
123.873
123.842
123.744
123.728
123.044
77.501
77.077
76.654
64.017
63.043
57.680
30.111
29.307
26.227
26.047
25.227
^{13}C NMR ($CDCl_3$)
O
N-^{c}Hex
O=P
10b
f1 (ppm)


31.445
^{31}P NMR ($CDCl_3$)
O
N-^{c}Hex
O=P
10b
f1 (ppm)


^{1}H NMR ($CDCl_3$)
10c
f1 (ppm)

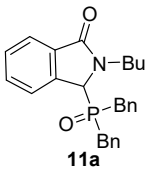

^{13}C NMR ($CDCl_3$)
10c
f1 (ppm)

^{31}P NMR ($CDCl_3$)

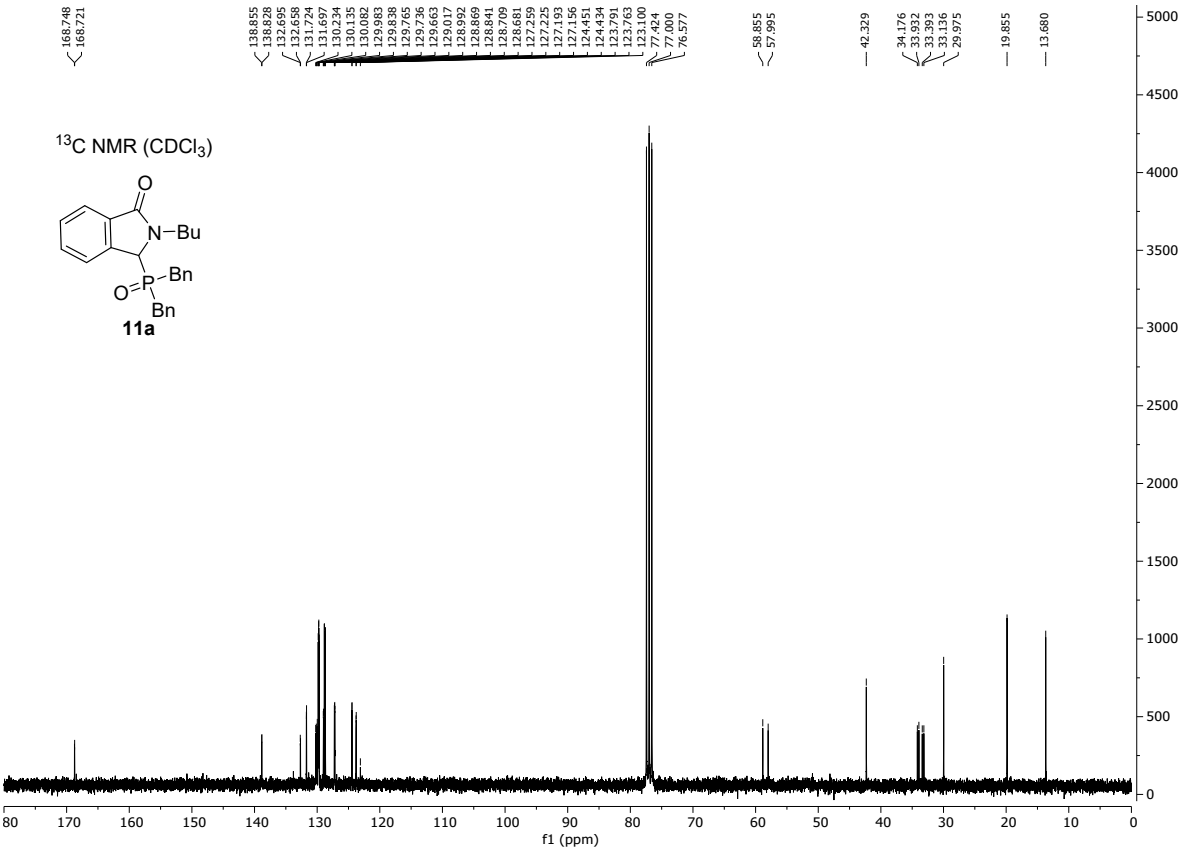


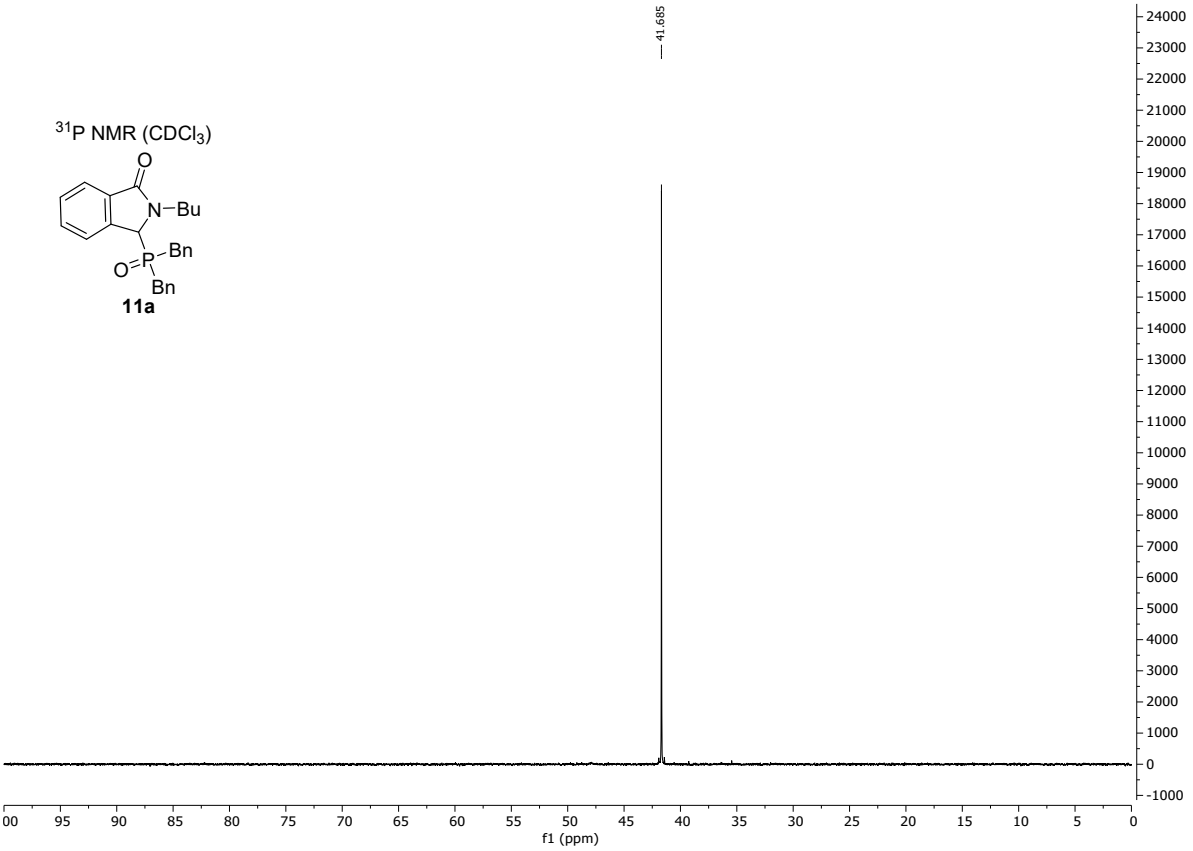
10c

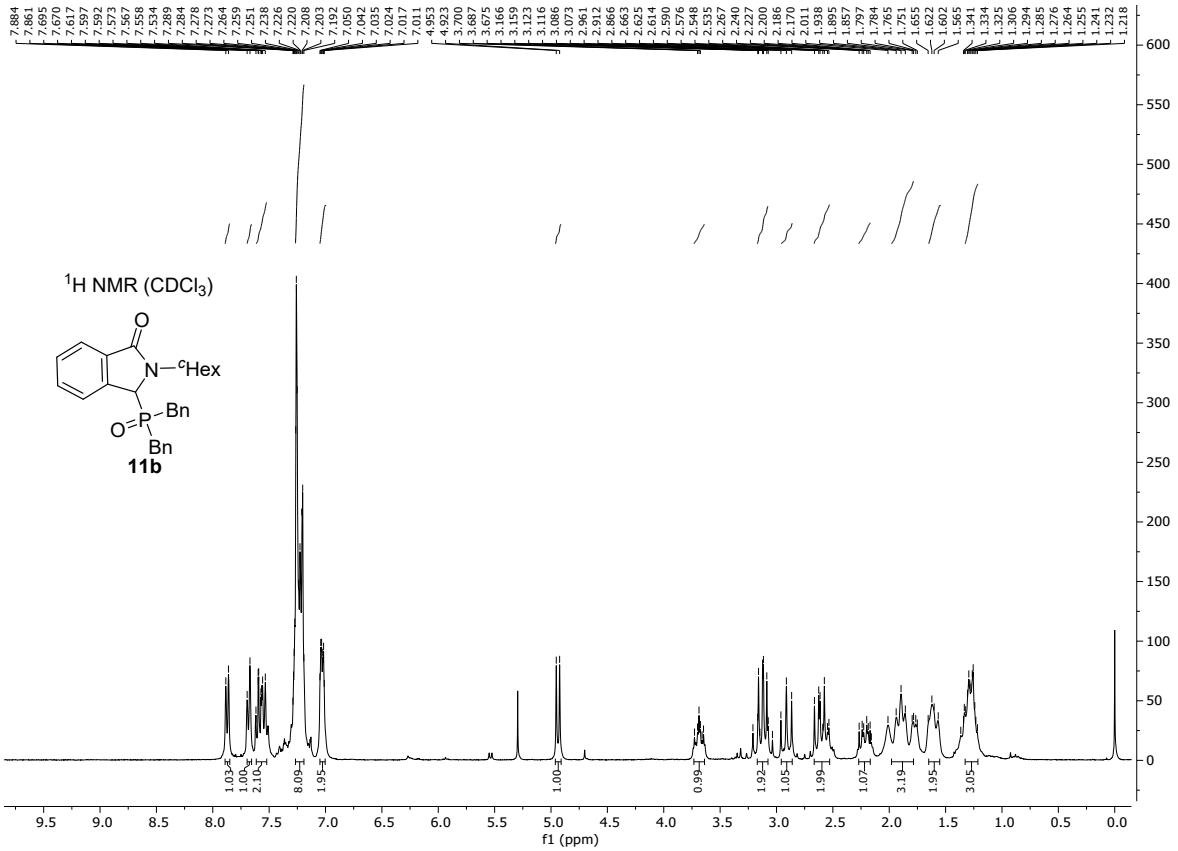
^{1}H NMR ($CDCl_3$)

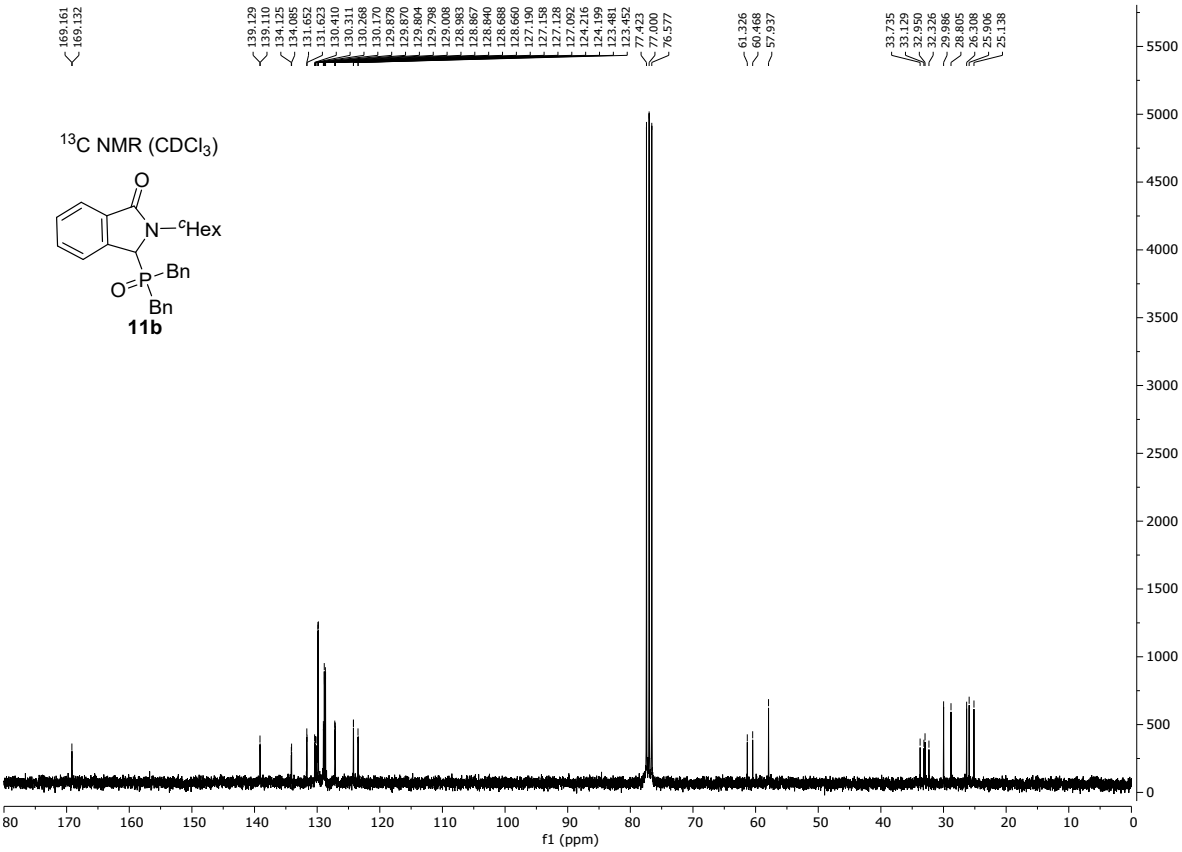


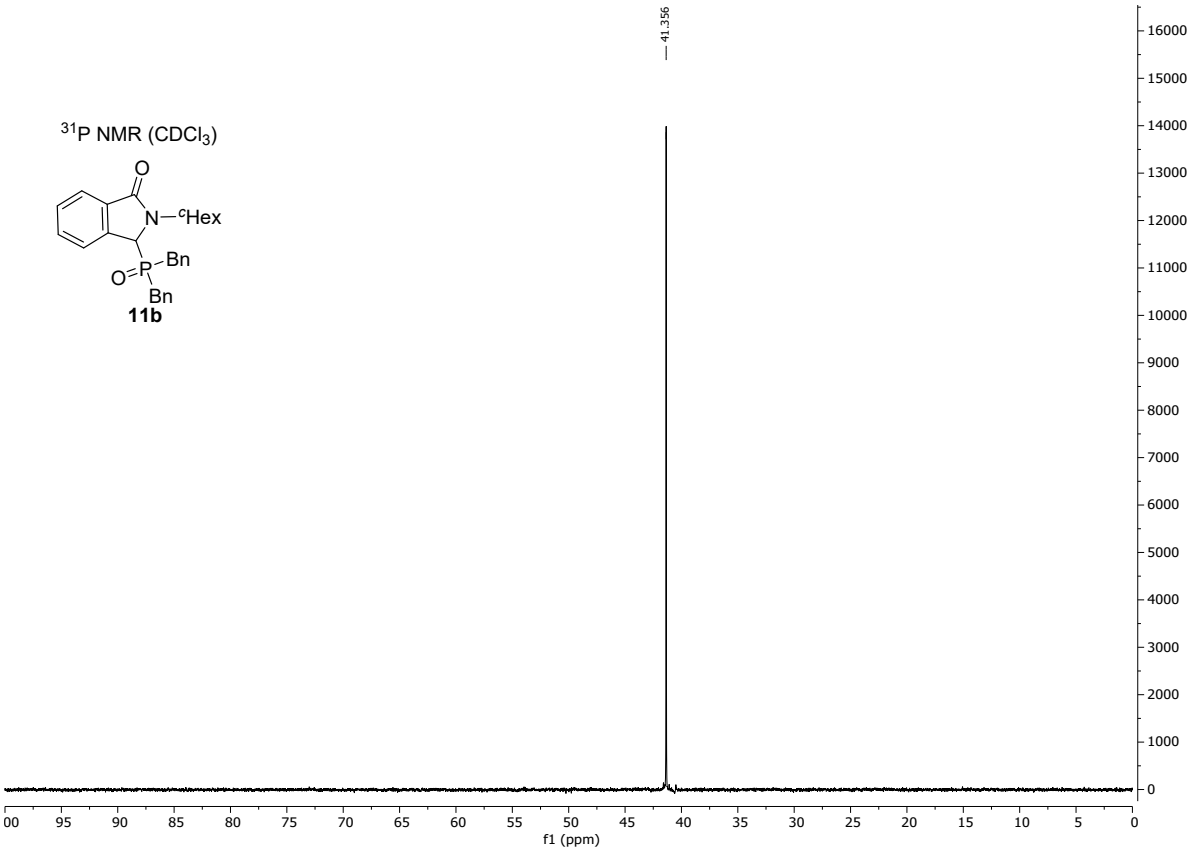
11a

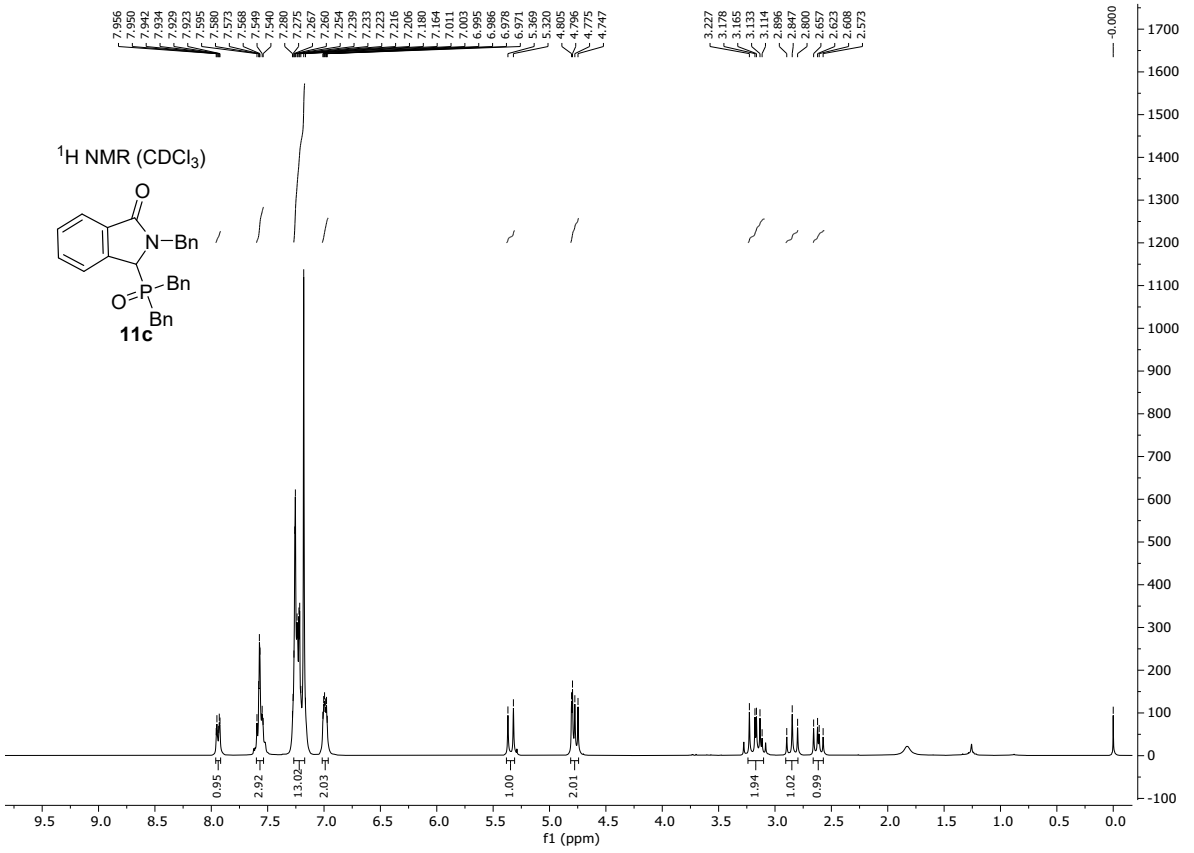

168.748
168.721
138.855
138.828
132.695
132.658
131.724
131.697
130.234
130.135
130.082
129.983
129.838
129.765
129.736
129.663
129.017
128.992
128.869
128.841
128.709
128.681
127.259
127.225
127.193
127.156
124.451
124.434
123.791
123.763
123.100
77.424
77.000
76.577
58.855
57.995
42.329
34.176
33.932
33.393
33.136
29.975
19.855
13.680
^{13}C NMR ($CDCl_3$)
N−Bu
O=P−Bn
Bn
11a
f1 (ppm)

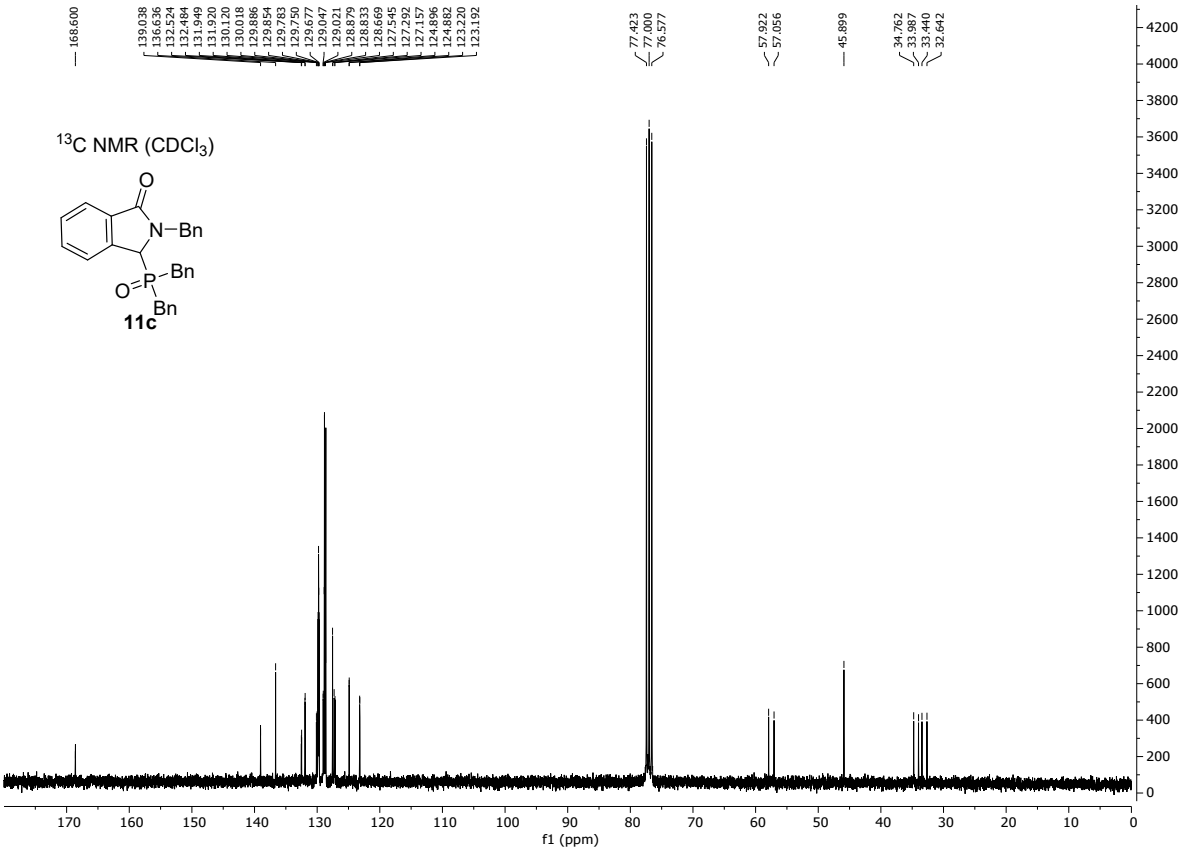

41.685
^{31}P NMR ($CDCl_3$)
N−Bu
O=P−Bn
Bn
11a
f1 (ppm)

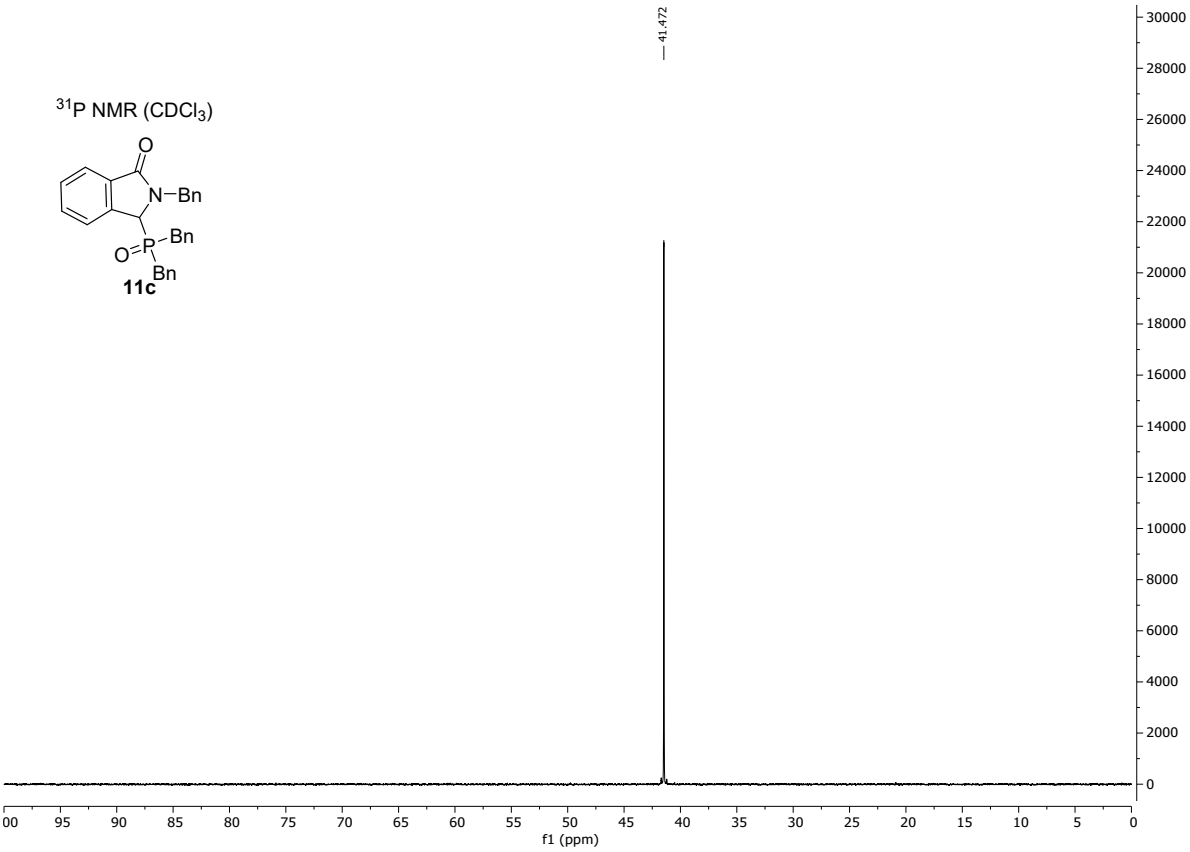

^{1}H NMR ($CDCl_3$)
O
N—^{c}Hex
O=P—Bn
Bn
11b
f1 (ppm)

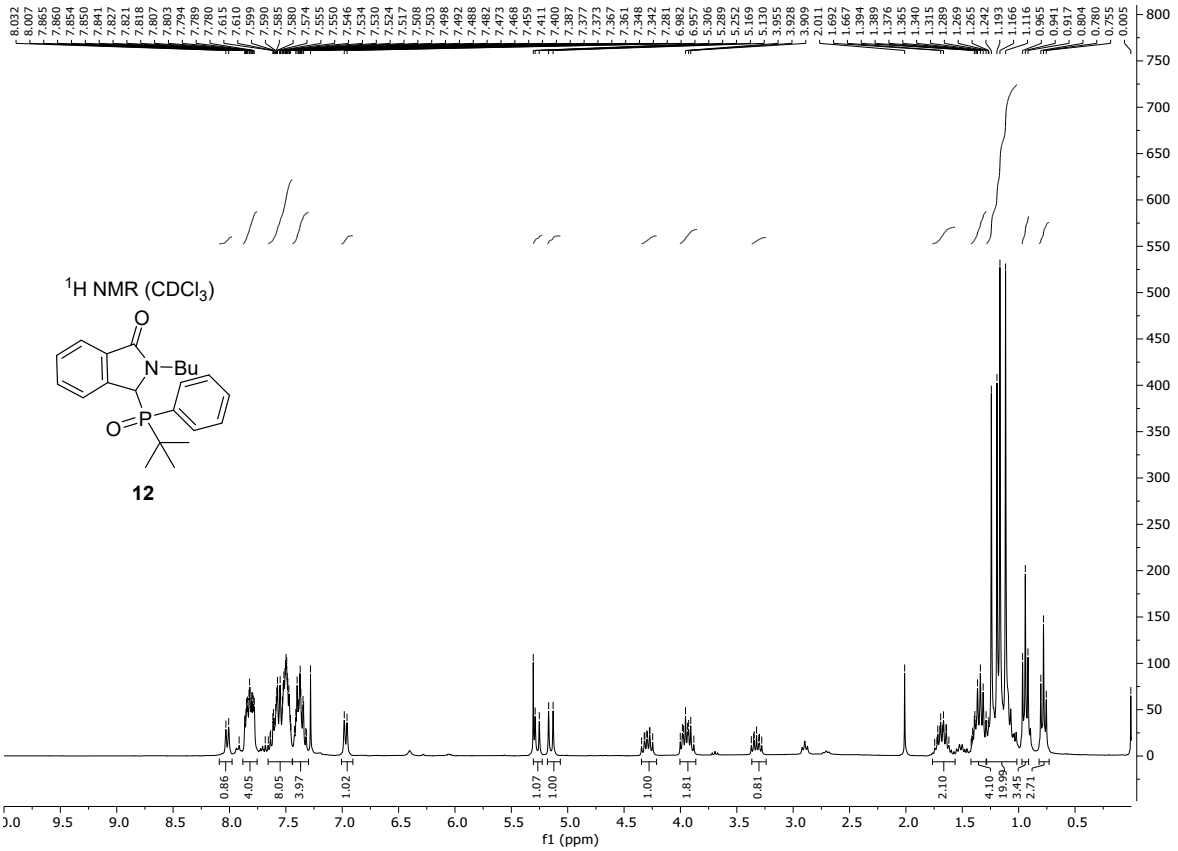

^{13}C NMR ($CDCl_3$)
O
N—^{c}Hex
O=P—Bn
Bn
11b
f1 (ppm)

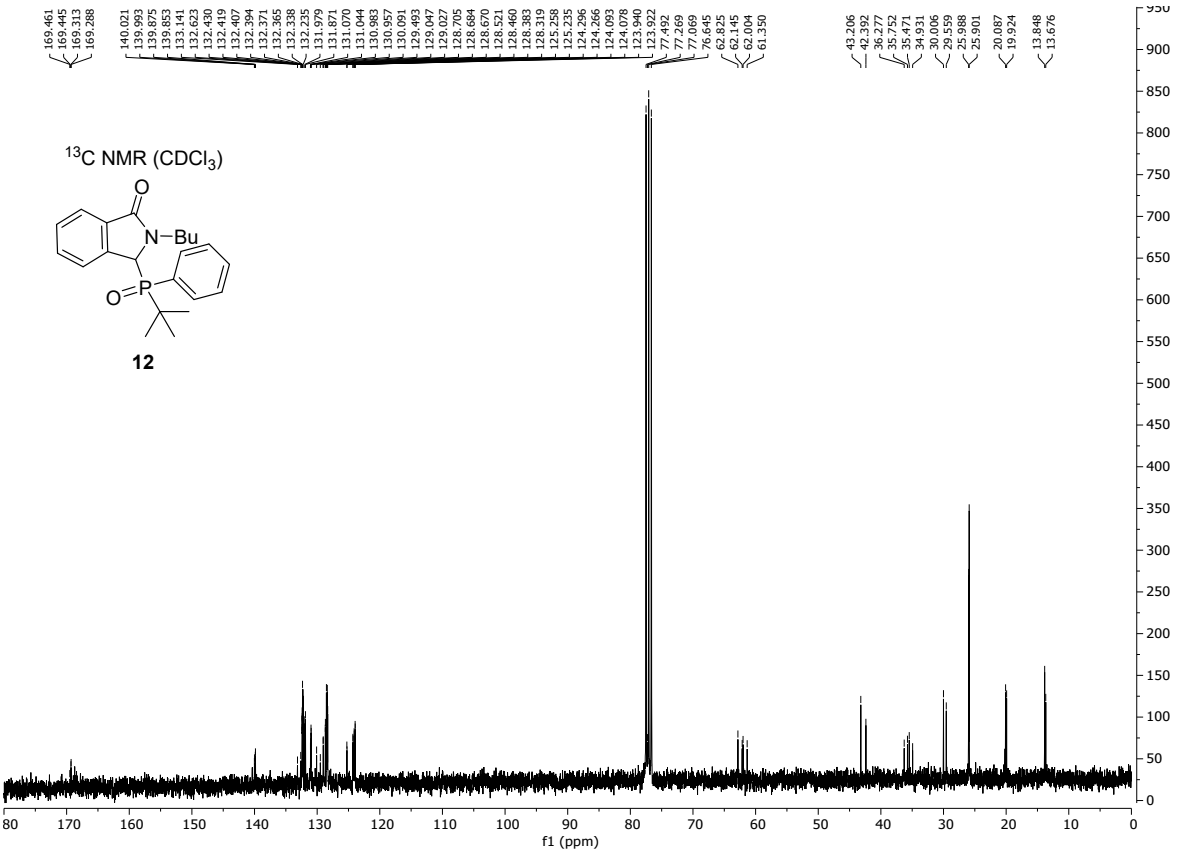

41.356
31P NMR (CDCl3)
N—cHex
Bn
Bn
11b
f1 (ppm)

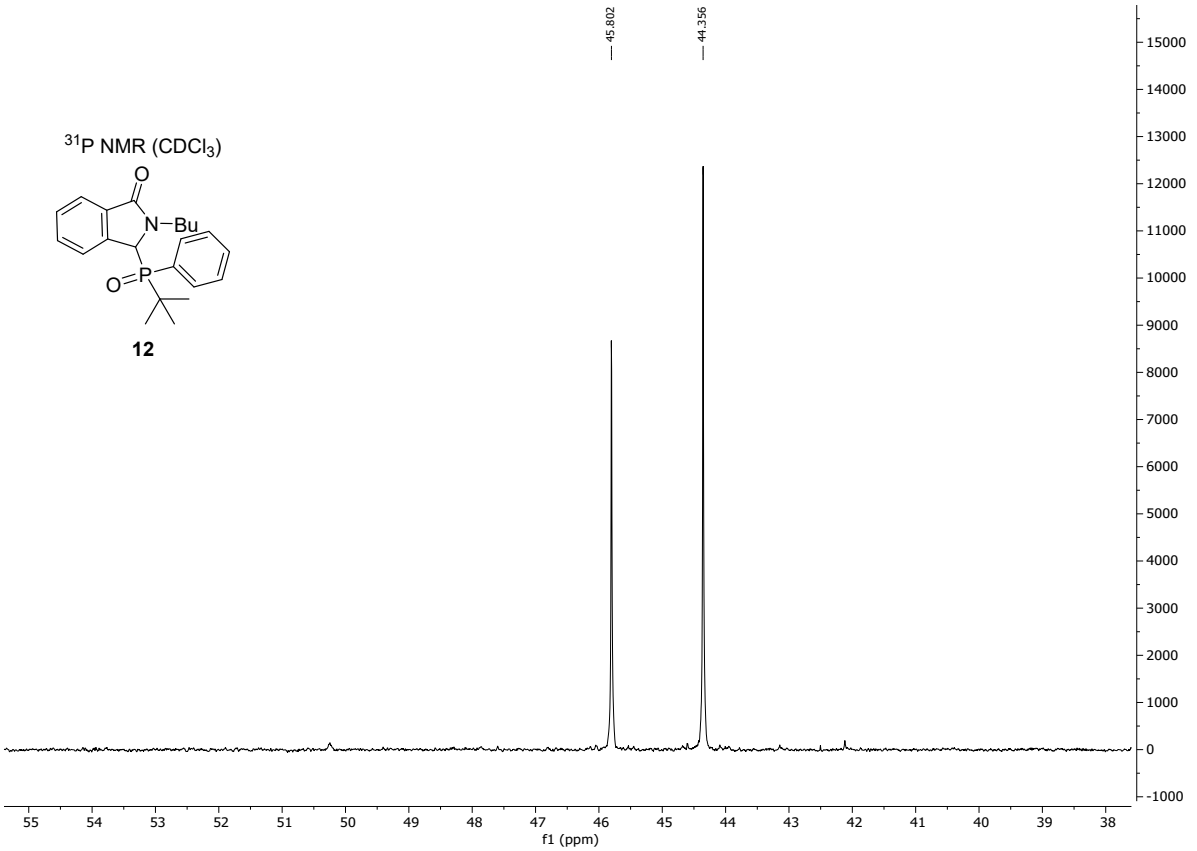

7.956
7.950
7.942
7.934
7.929
7.923
7.595
7.580
7.573
7.568
7.549
7.540
7.280
7.275
7.267
7.260
7.254
7.239
7.233
7.223
7.216
7.206
7.180
7.164
7.011
7.003
6.995
6.986
6.978
6.971
5.369
5.320
4.805
4.796
4.775
4.747
3.227
3.178
3.165
3.133
3.114
2.896
2.847
2.800
2.657
2.623
2.608
2.573
-0.000
1H NMR (CDCl3)
N—Bn
Bn
Bn
11c
0.95
2.92
13.02
2.03
1.00
2.01
1.94
1.02
0.99
f1 (ppm)

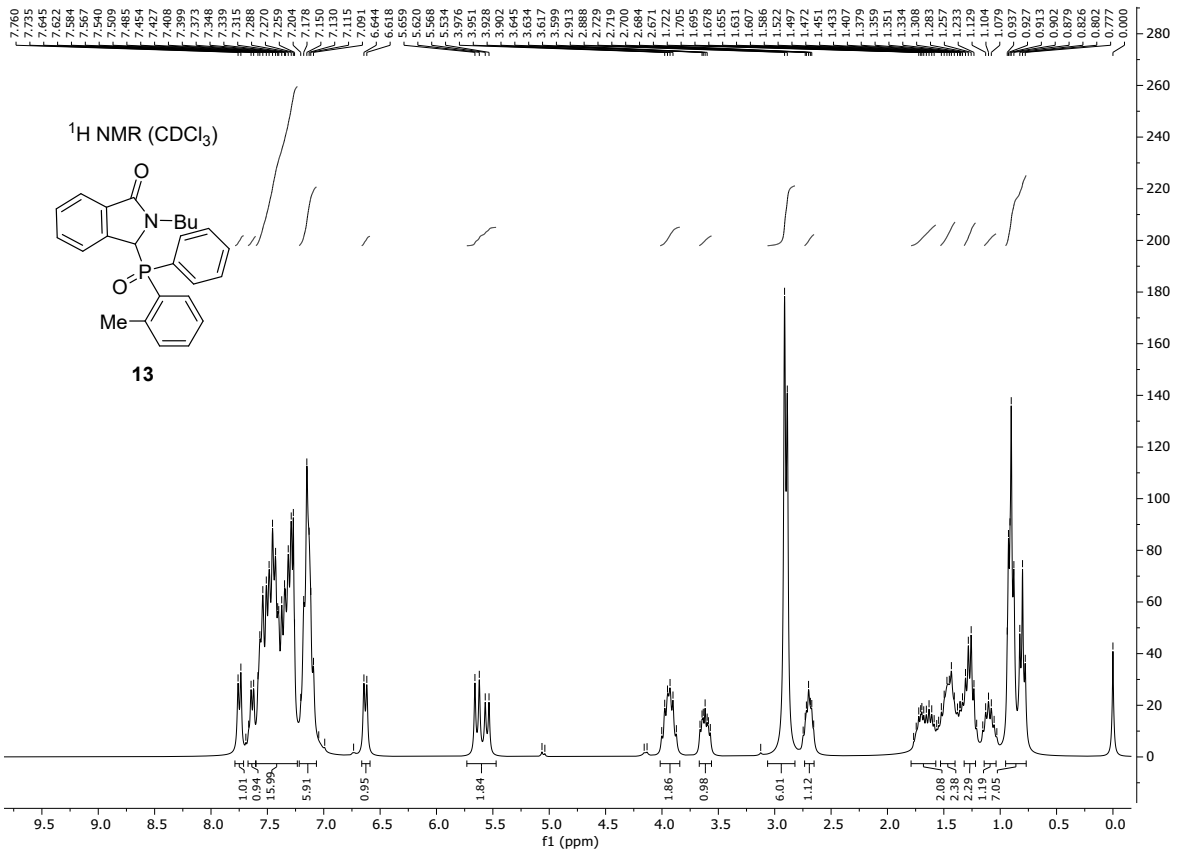

168.600
139.038
136.636
132.524
132.484
131.949
131.920
130.120
130.018
129.886
129.854
129.783
129.750
129.677
129.047
129.021
128.879
128.833
128.669
127.545
127.292
127.157
124.896
124.882
123.220
123.192
77.423
77.000
76.577
57.922
57.056
45.899
34.762
33.987
33.440
32.642
13C NMR (CDCl3)
O
N−Bn
O=P−Bn
Bn
11c
f1 (ppm)

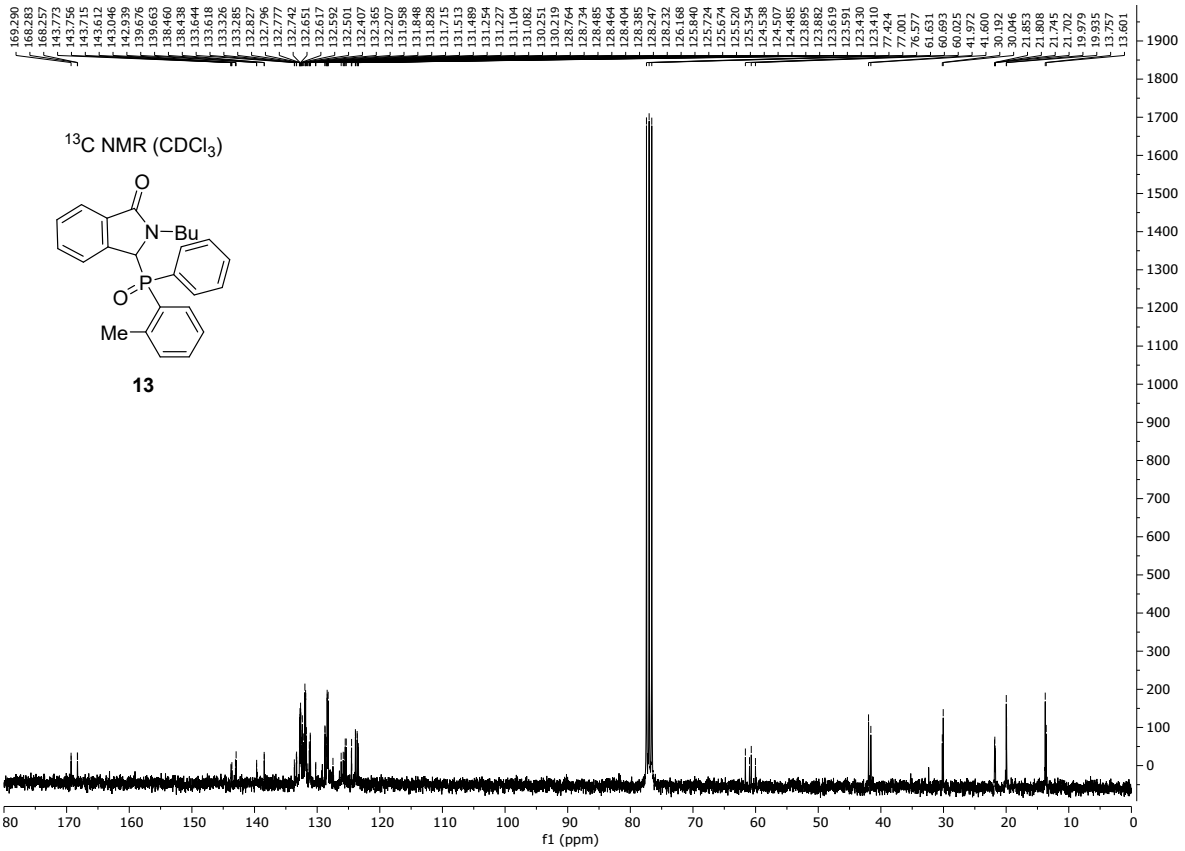

41.472
31P NMR (CDCl3)
O
N−Bn
O=P−Bn
Bn
11c
f1 (ppm)

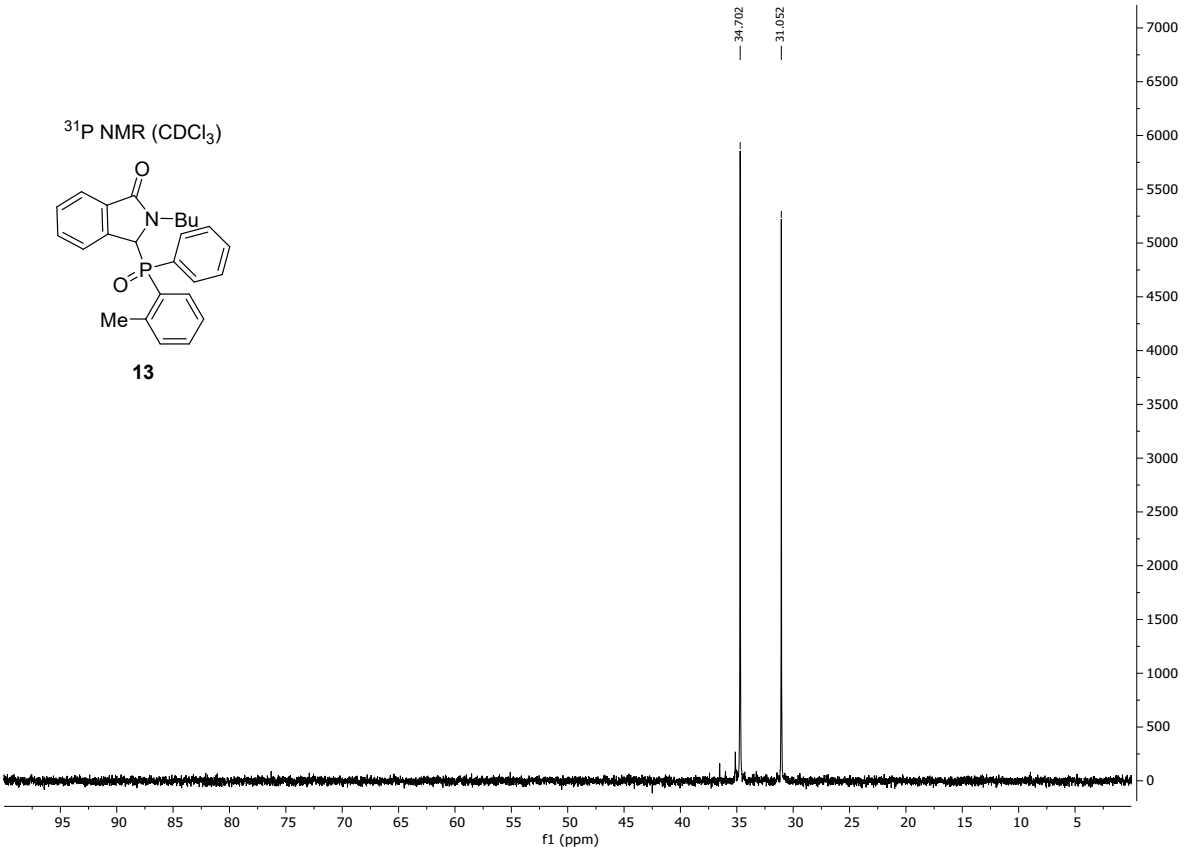

^{1}H NMR ($CDCl_3$)
O
N−Bu
O=P
12
f1 (ppm)

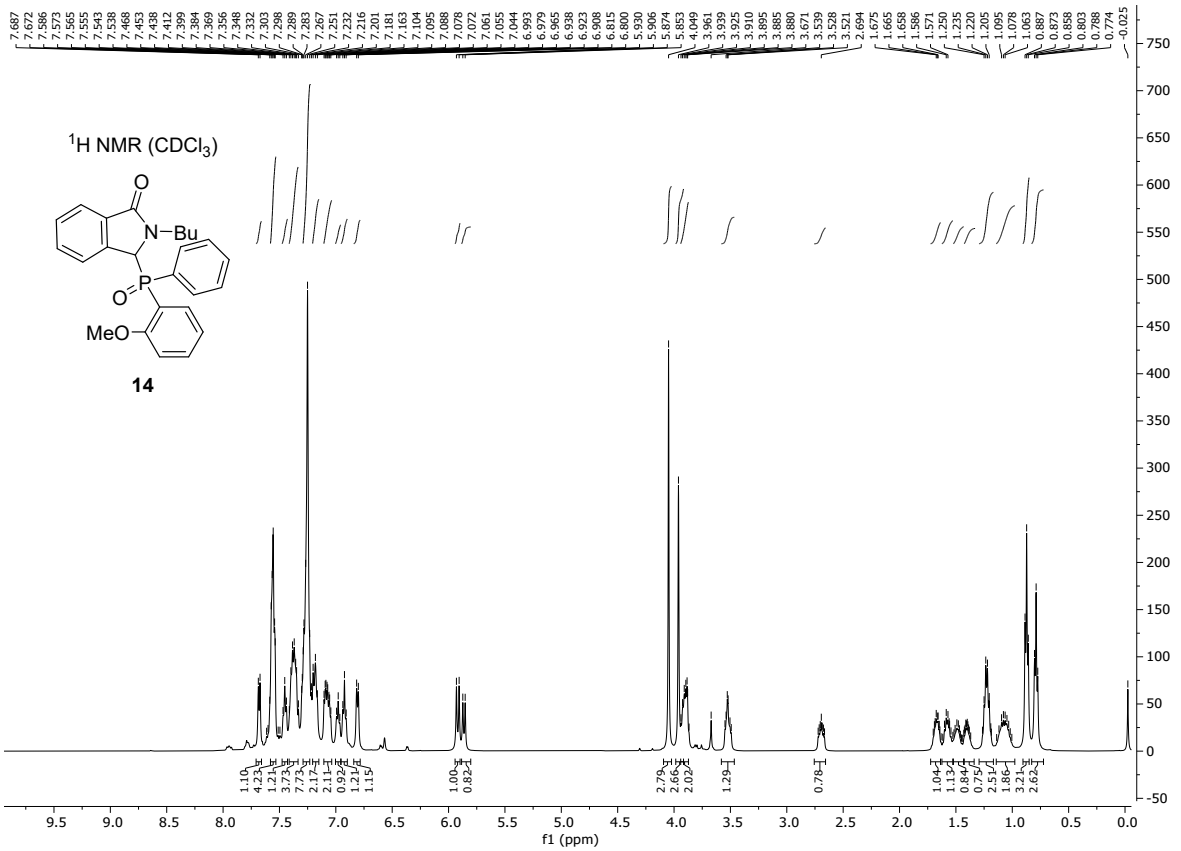

^{13}C NMR ($CDCl_3$)
O
N−Bu
O=P
12
f1 (ppm)

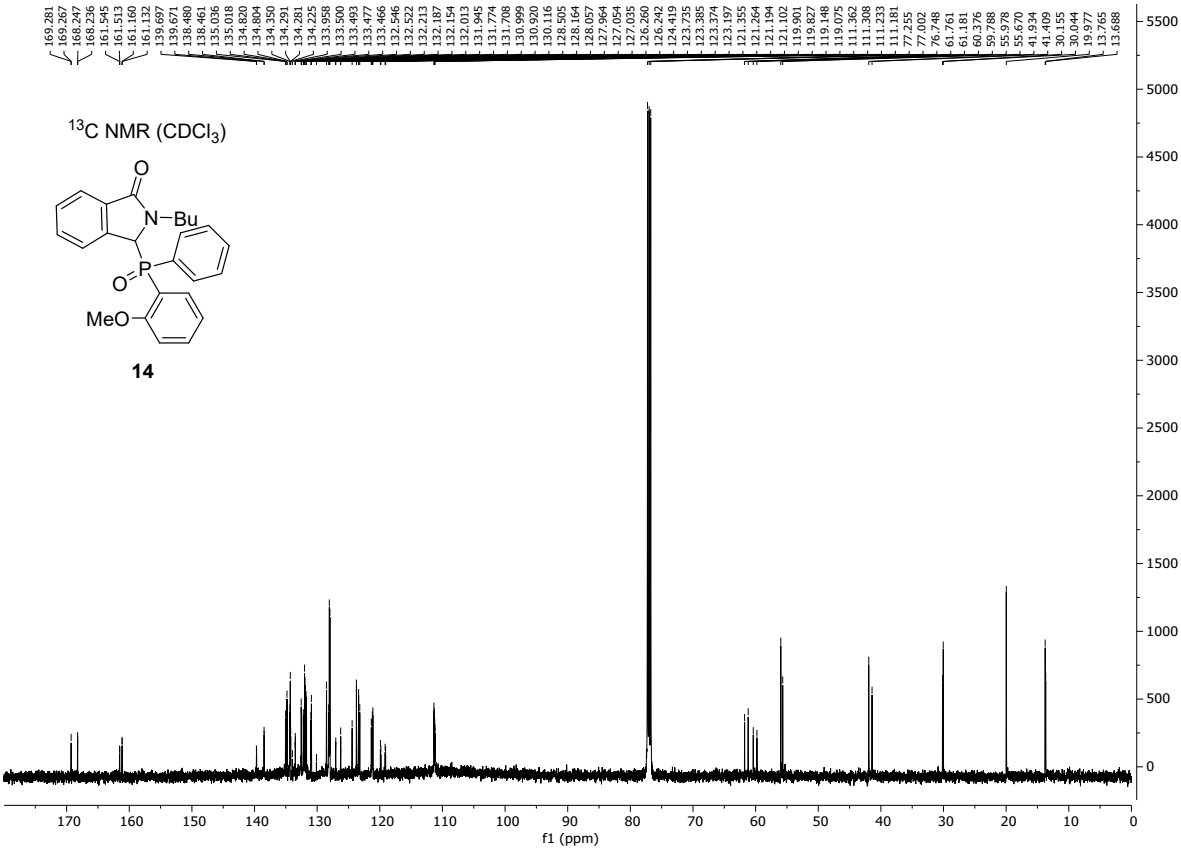

31P NMR (CDCl3)
12
45.802
44.356
f1 (ppm)

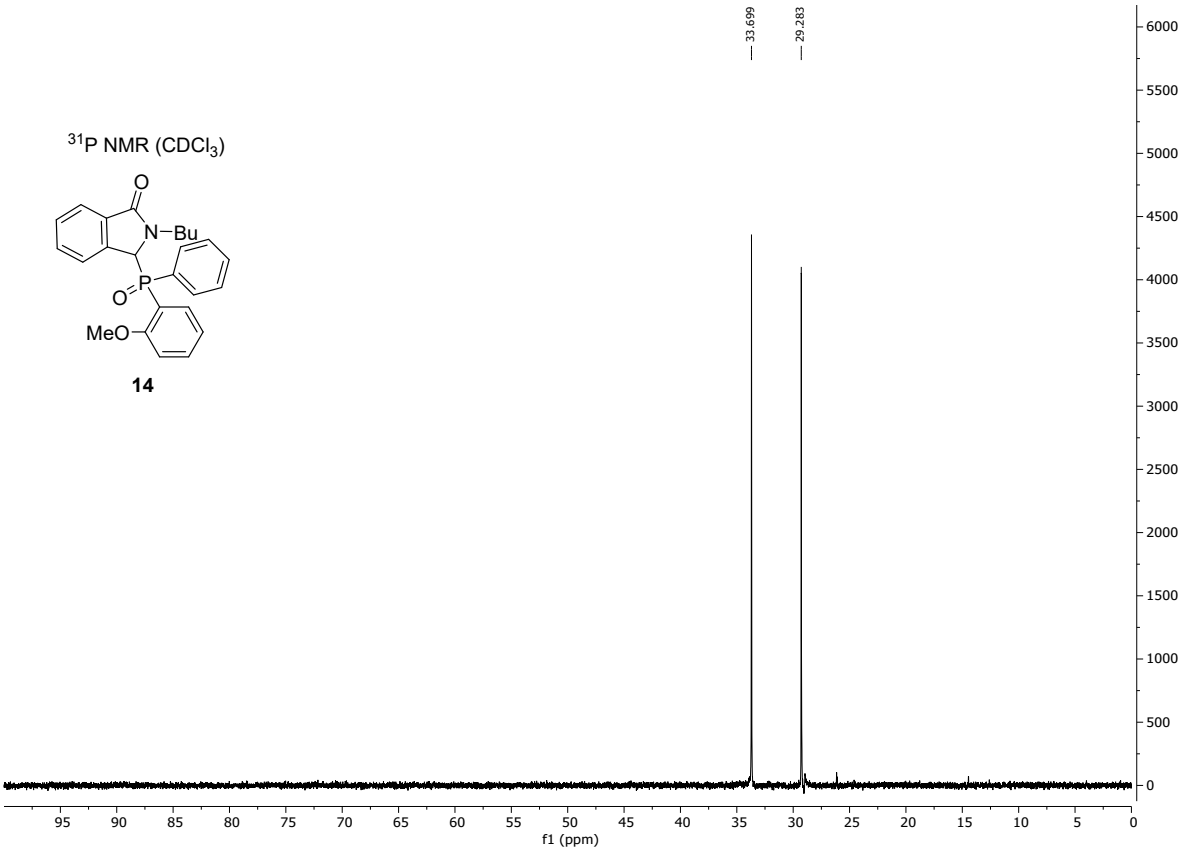

1H NMR (CDCl3)
13
f1 (ppm)

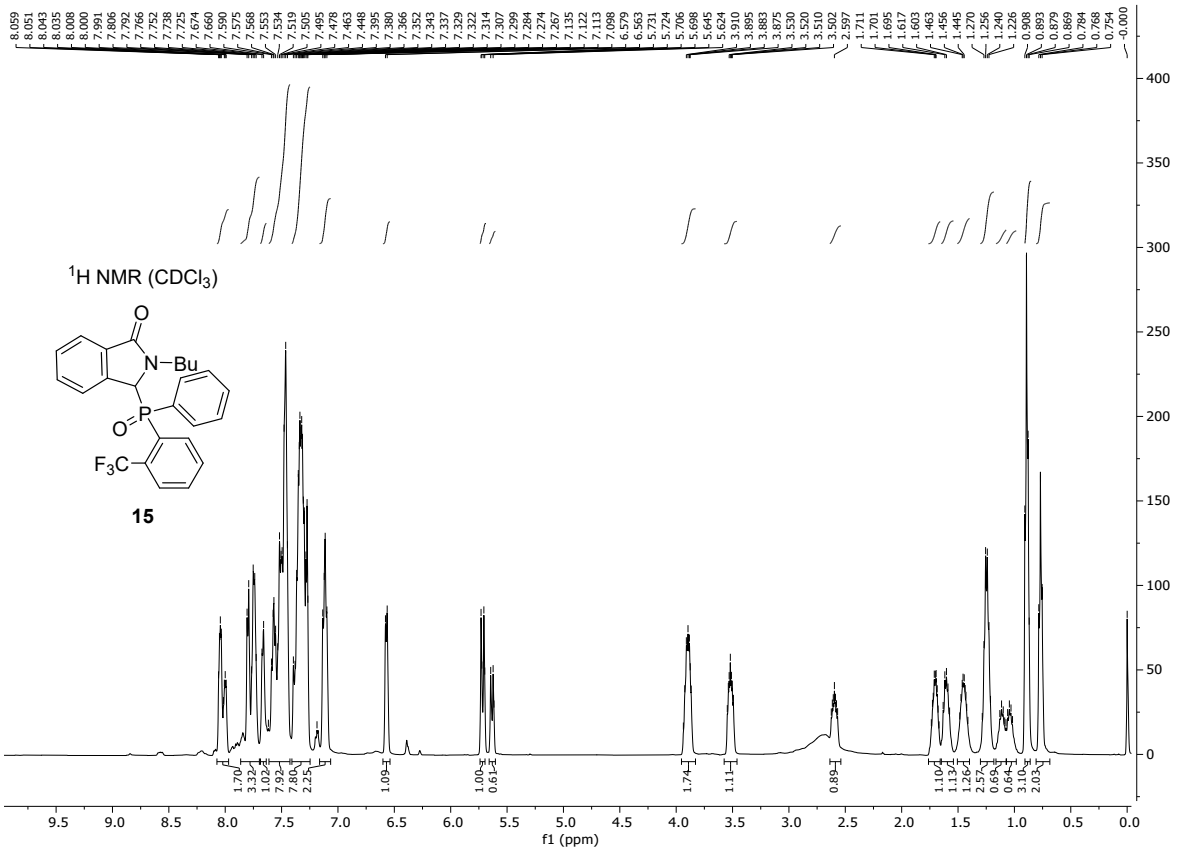

169.290
168.283
168.257
143.773
143.756
143.715
143.612
143.046
142.939
139.676
139.663
138.460
138.438
133.644
133.618
133.326
133.285
132.827
132.796
132.777
132.742
132.651
132.617
132.592
132.501
132.407
132.265
132.207
131.998
131.848
131.828
131.715
131.513
131.489
131.254
131.227
131.104
131.082
130.251
130.219
128.764
128.734
128.485
128.464
128.404
128.385
128.247
128.232
126.168
125.840
125.724
125.674
125.520
125.354
124.538
124.507
124.485
123.895
123.882
123.619
123.591
123.430
123.410
77.424
77.001
76.577
61.631
60.693
60.025
41.972
41.600
30.192
30.046
21.853
21.808
21.745
21.702
19.979
19.935
13.757
13.601
^{13}C NMR ($CDCl_3$)
O
N–Bu
O
P
Me
13
f1 (ppm)

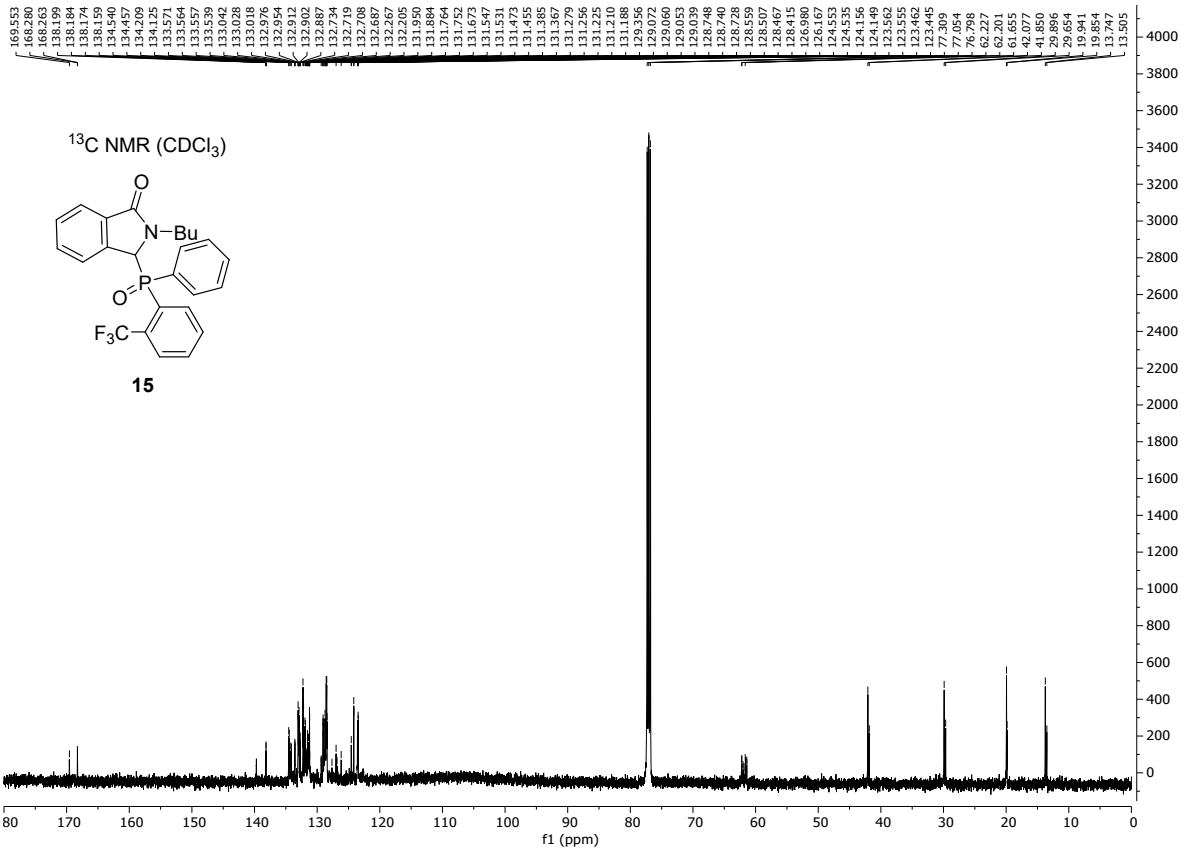

34.702
31.052
^{31}P NMR ($CDCl_3$)
O
N–Bu
O
P
Me
13
f1 (ppm)

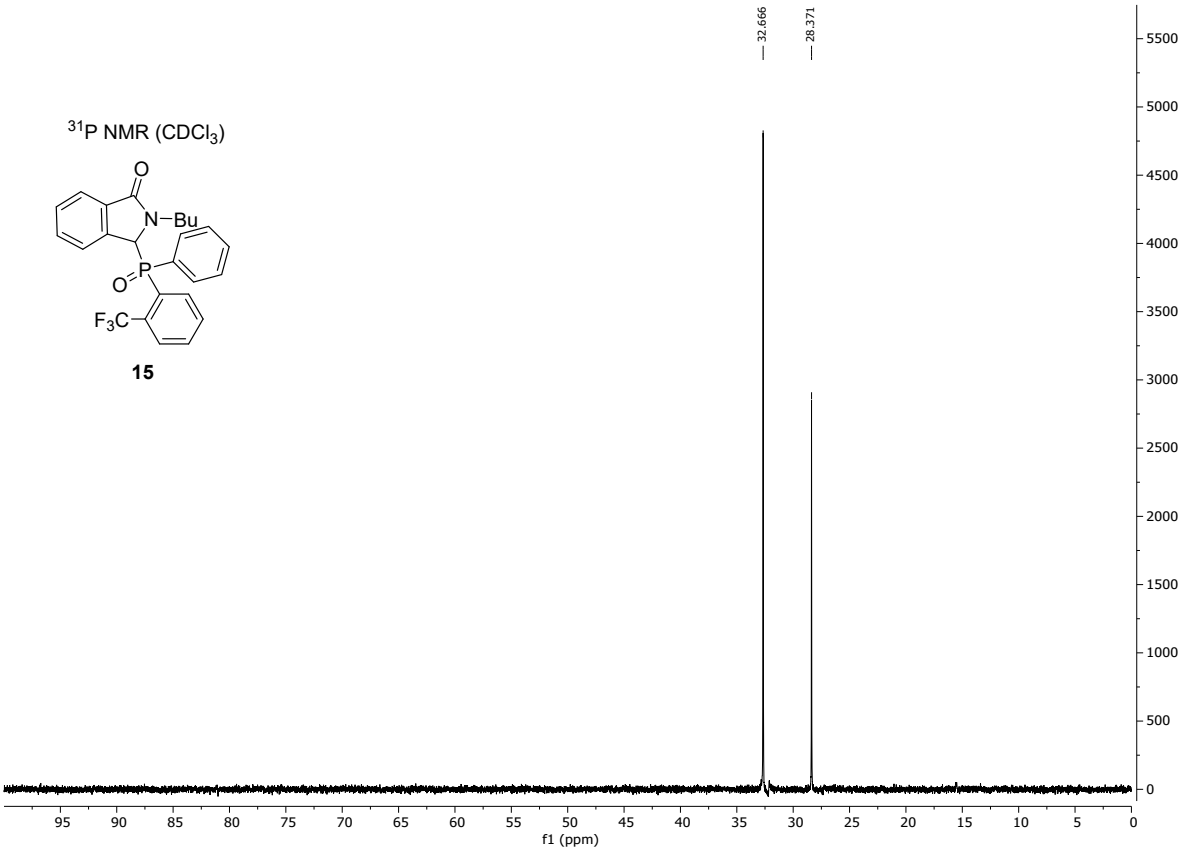

^{1}H NMR ($CDCl_3$)
O
N−Bu
O
P
MeO
14
f1 (ppm)

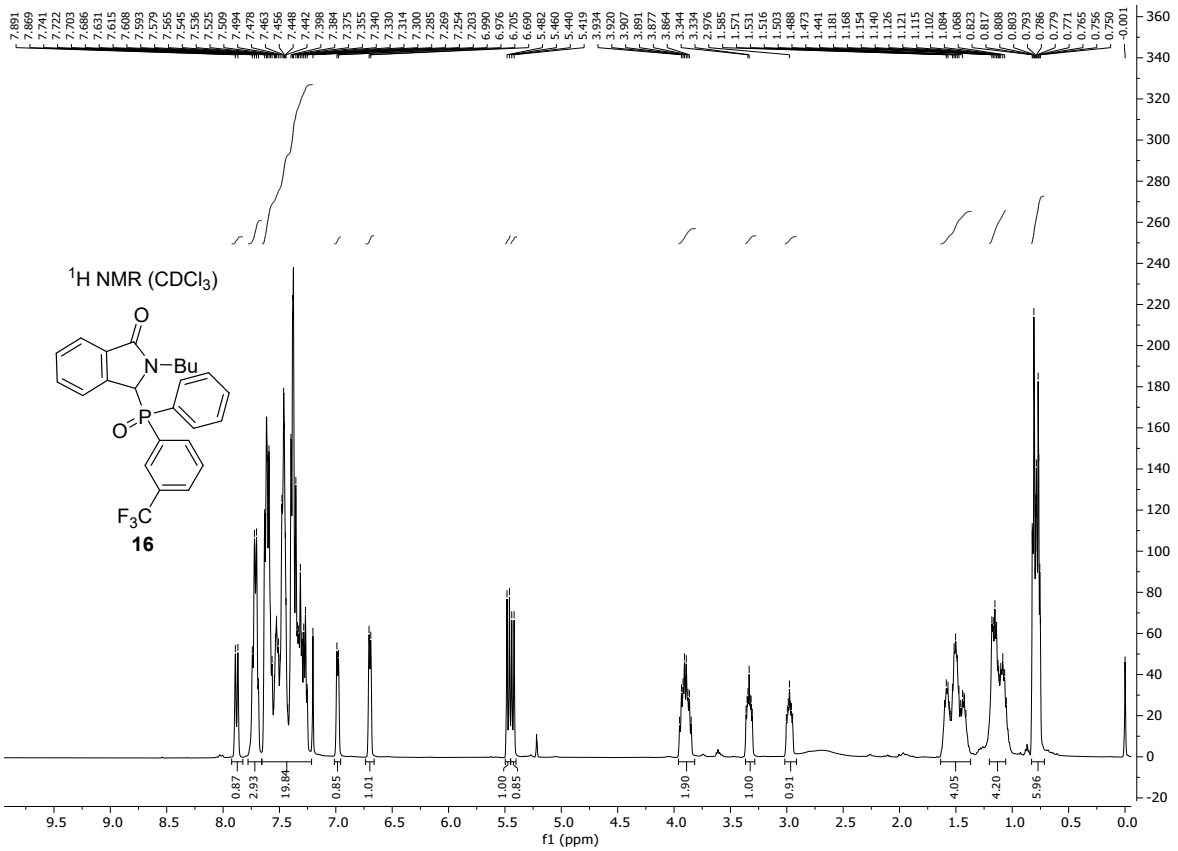

^{13}C NMR ($CDCl_3$)
O
N−Bu
O
P
MeO
14
f1 (ppm)

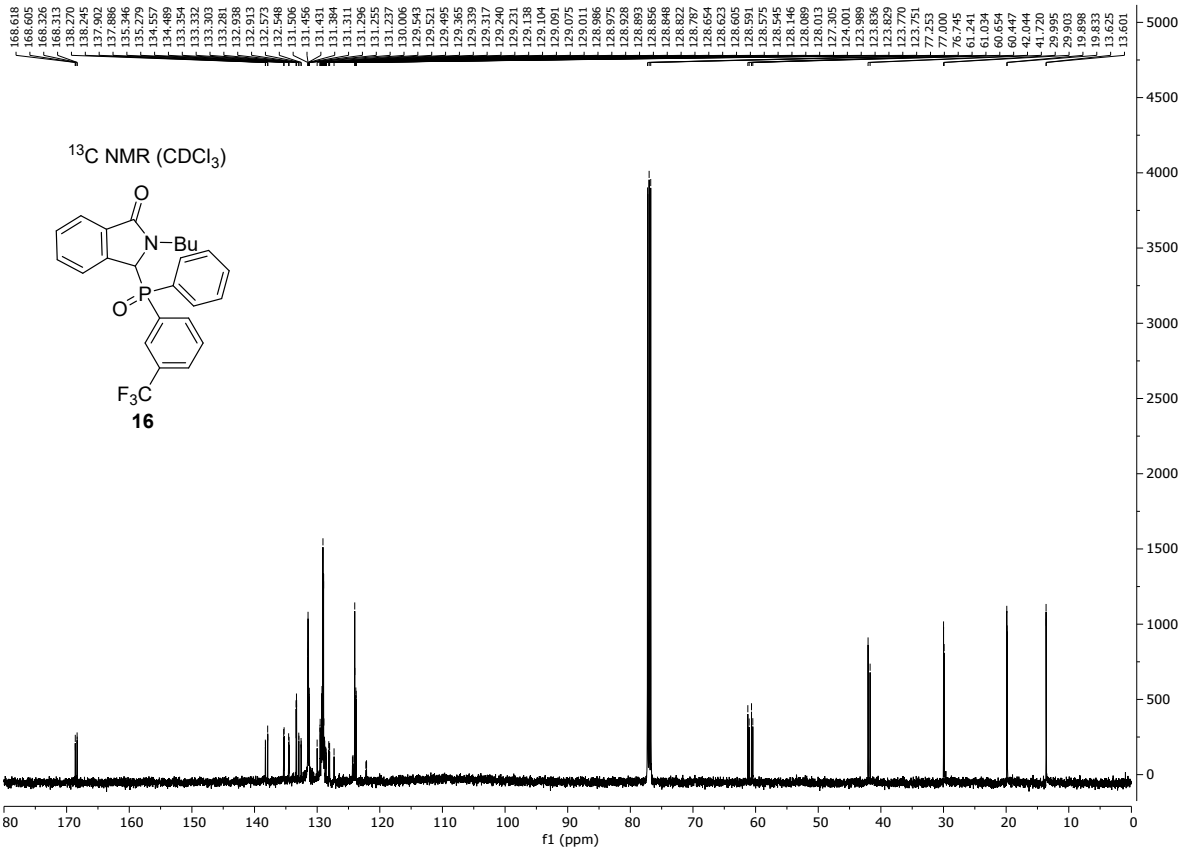

33.699
29.283
31P NMR (CDCl3)
O
N−Bu
O
P
MeO
14
f1 (ppm)

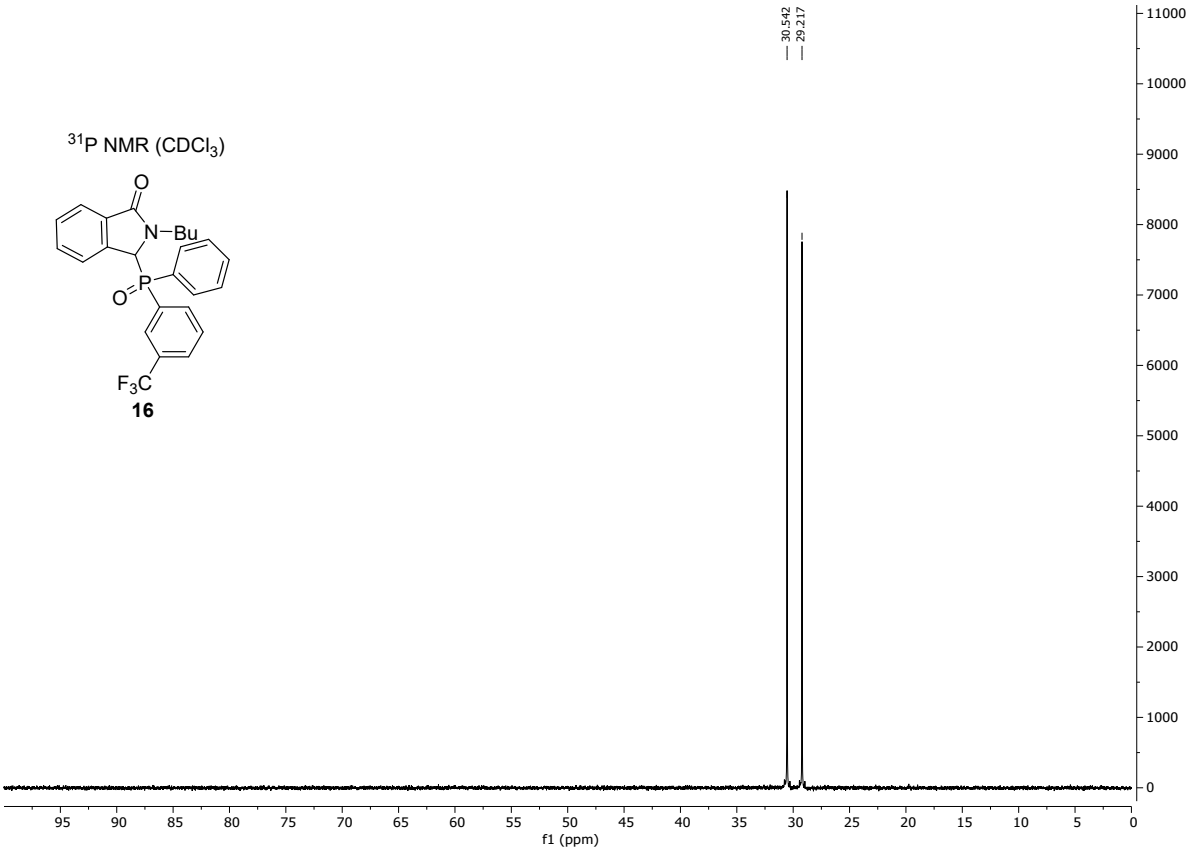

1H NMR (CDCl3)
O
N−Bu
O
P
F3C
15
f1 (ppm)

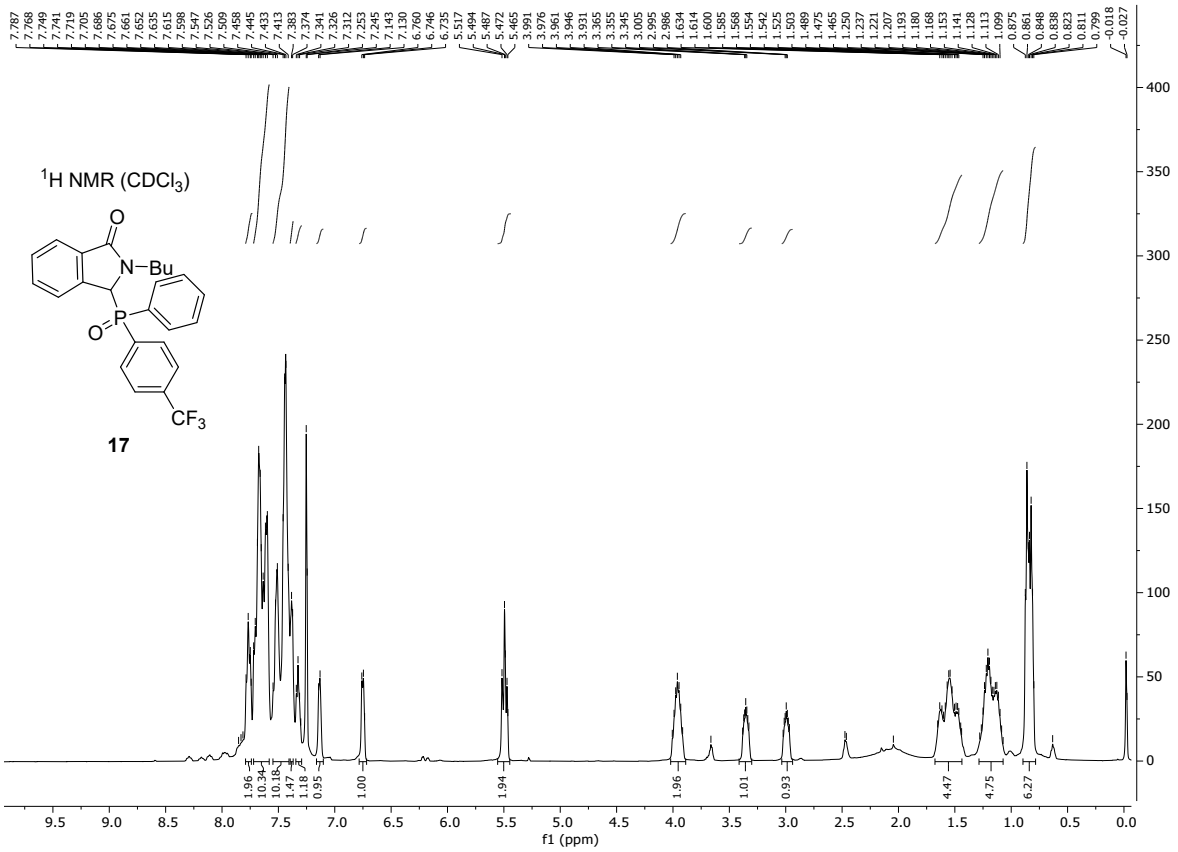

169.553
168.280
168.263
138.199
138.184
138.174
138.159
134.540
134.457
134.209
134.125
133.571
133.564
133.557
133.539
133.042
133.028
133.018
132.976
132.954
132.912
132.902
132.887
132.734
132.719
132.708
132.687
132.267
132.205
131.950
131.884
131.764
131.752
131.673
131.547
131.531
131.473
131.455
131.385
131.367
131.279
131.256
131.225
131.210
131.188
129.356
129.072
129.060
129.053
129.039
128.748
128.740
128.728
128.559
128.507
128.467
128.415
126.980
126.167
124.553
124.535
124.156
124.149
123.562
123.555
123.462
123.445
77.309
77.054
76.798
62.227
62.201
61.655
42.077
41.850
29.896
29.654
19.941
19.854
13.747
13.505
^{13}C NMR ($CDCl_3$)
O
N−Bu
O
P
F_3C
15
f1 (ppm)

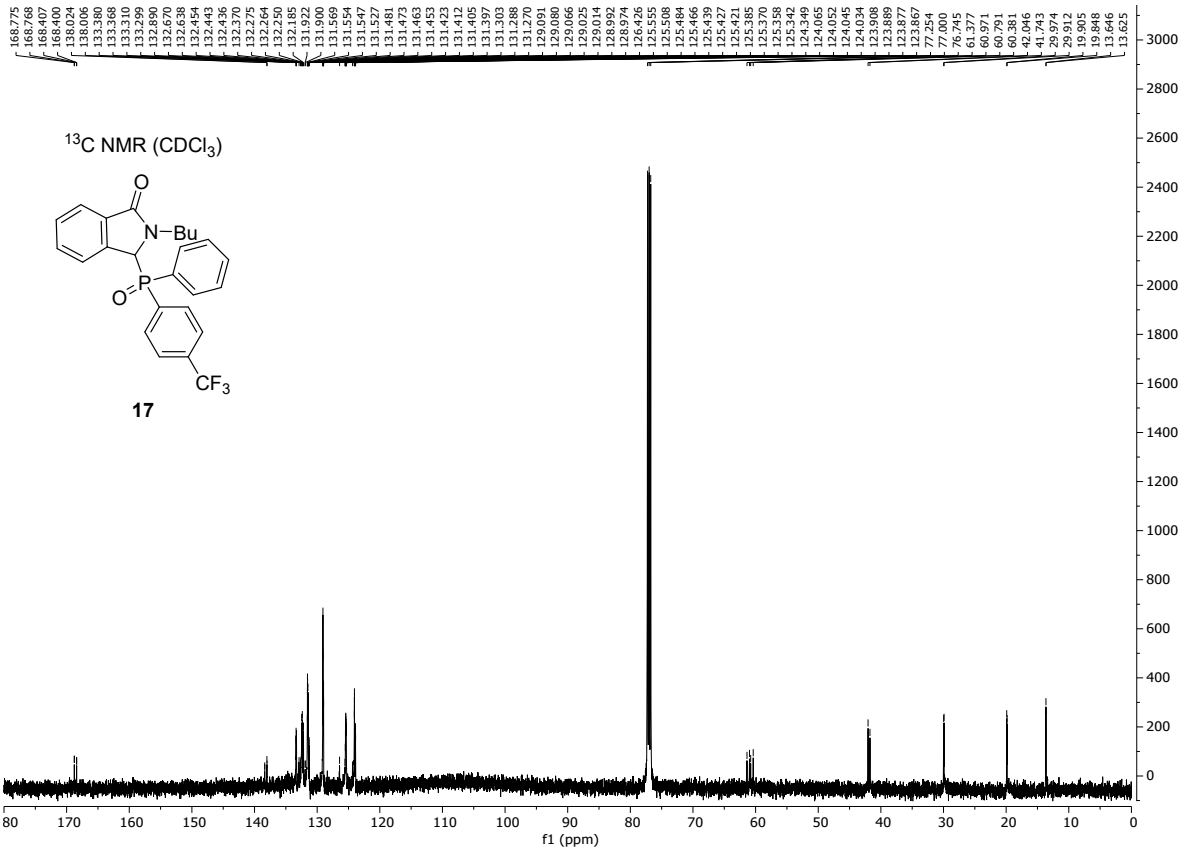

32.666
28.371
^{31}P NMR ($CDCl_3$)
O
N−Bu
O
P
F_3C
15
f1 (ppm)

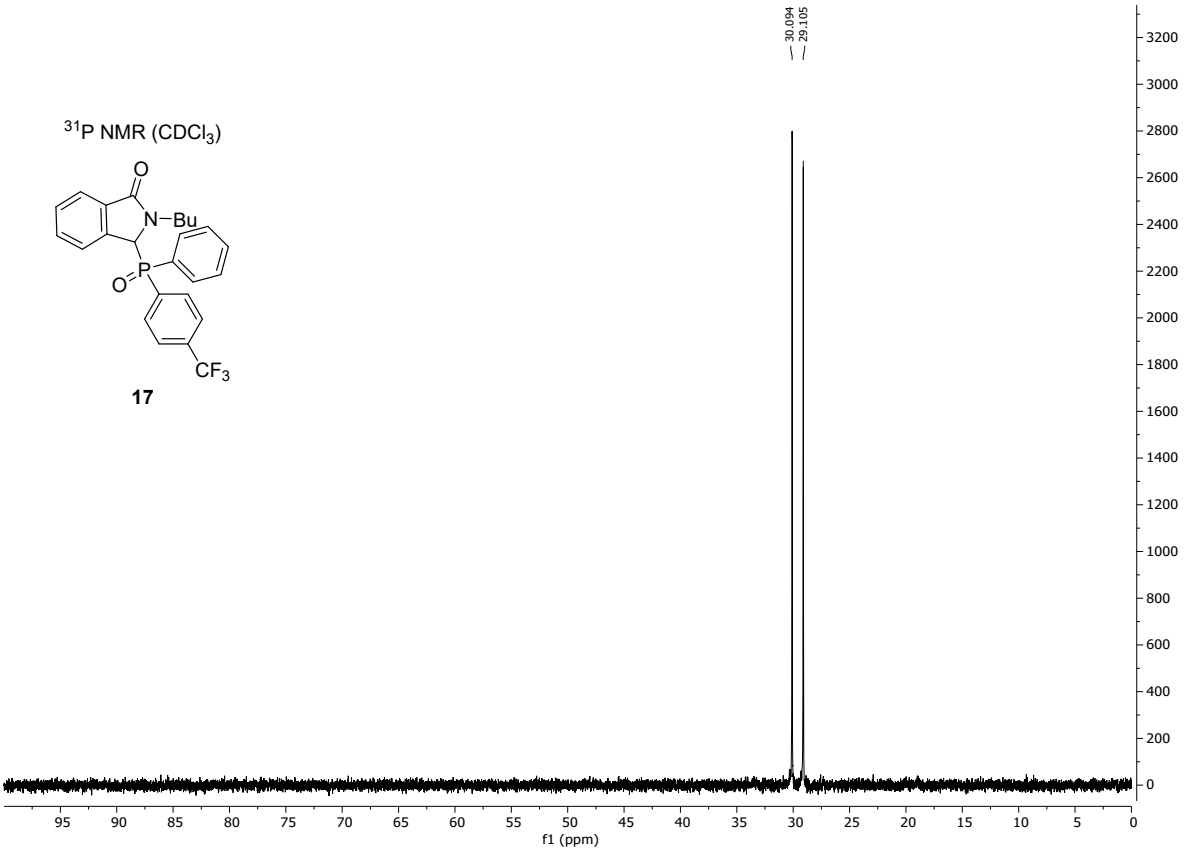

^{1}H NMR ($CDCl_3$)
O
N−Bu
O
P
F_3C
16
f1 (ppm)

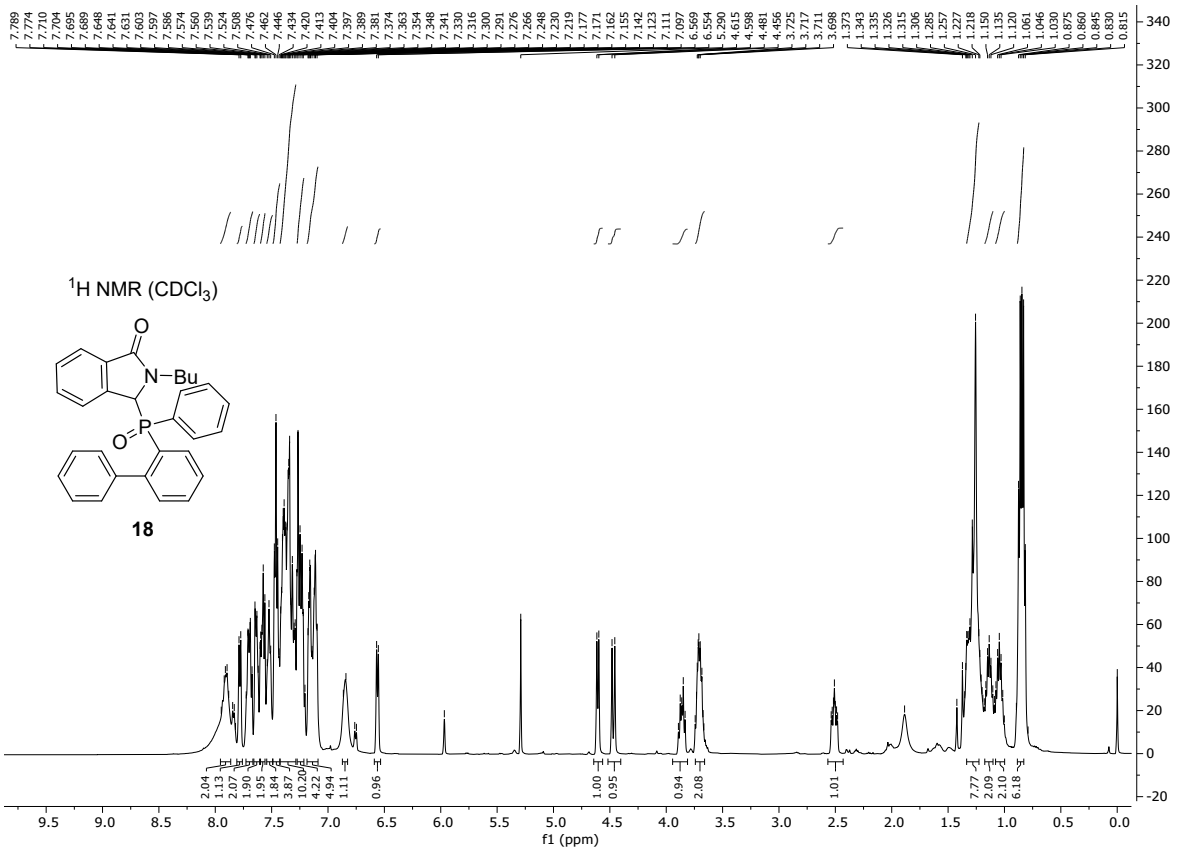

^{13}C NMR ($CDCl_3$)
O
N−Bu
O
P
F_3C
16
f1 (ppm)

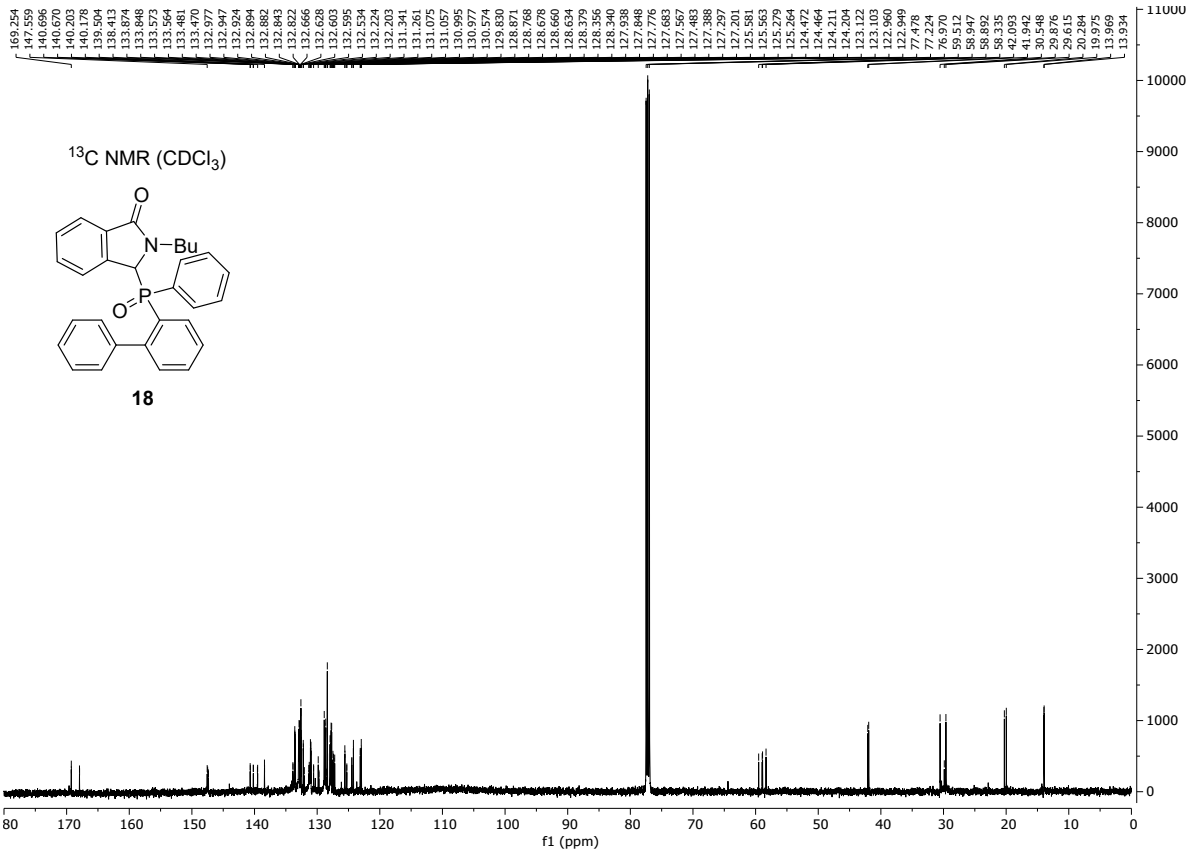

31P NMR (CDCl3)
16
30.542
29.217
f1 (ppm)


1H NMR (CDCl3)
17
f1 (ppm)

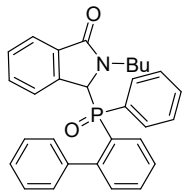

168.775
168.768
168.407
168.400
138.024
138.006
133.380
133.368
133.310
133.299
132.890
132.670
132.638
132.454
132.443
132.436
132.370
132.275
132.264
132.250
132.185
131.922
131.900
131.569
131.554
131.547
131.527
131.491
131.473
131.463
131.453
131.423
131.412
131.405
131.397
131.303
131.288
131.270
129.091
129.080
129.066
129.025
129.014
128.992
128.974
126.426
125.555
125.508
125.484
125.466
125.439
125.427
125.421
125.385
125.370
125.358
125.342
124.349
124.065
124.052
124.045
124.034
123.908
123.889
123.877
123.867
77.254
77.000
76.745
61.377
60.971
60.791
60.381
42.046
41.743
29.974
29.912
19.905
19.848
13.646
13.625
^{13}C NMR ($CDCl_3$)
O
N−Bu
O
P
CF_3
17
3000
2800
2600
2400
2200
2000
1800
1600
1400
1200
1000
800
600
400
200
0
80
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)


30.094
29.105
^{31}P NMR ($CDCl_3$)
O
N−Bu
O
P
CF_3
17
3200
3000
2800
2600
2400
2200
2000
1800
1600
1400
1200
1000
800
600
400
200
0
95
90
85
80
75
70
65
60
55
50
45
40
35
30
25
20
15
10
5
0
f1 (ppm)


^{1}H NMR ($CDCl_3$)
18
f1 (ppm)

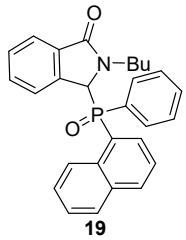

^{13}C NMR ($CDCl_3$)
18
f1 (ppm)

^{31}P NMR ($CDCl_3$)

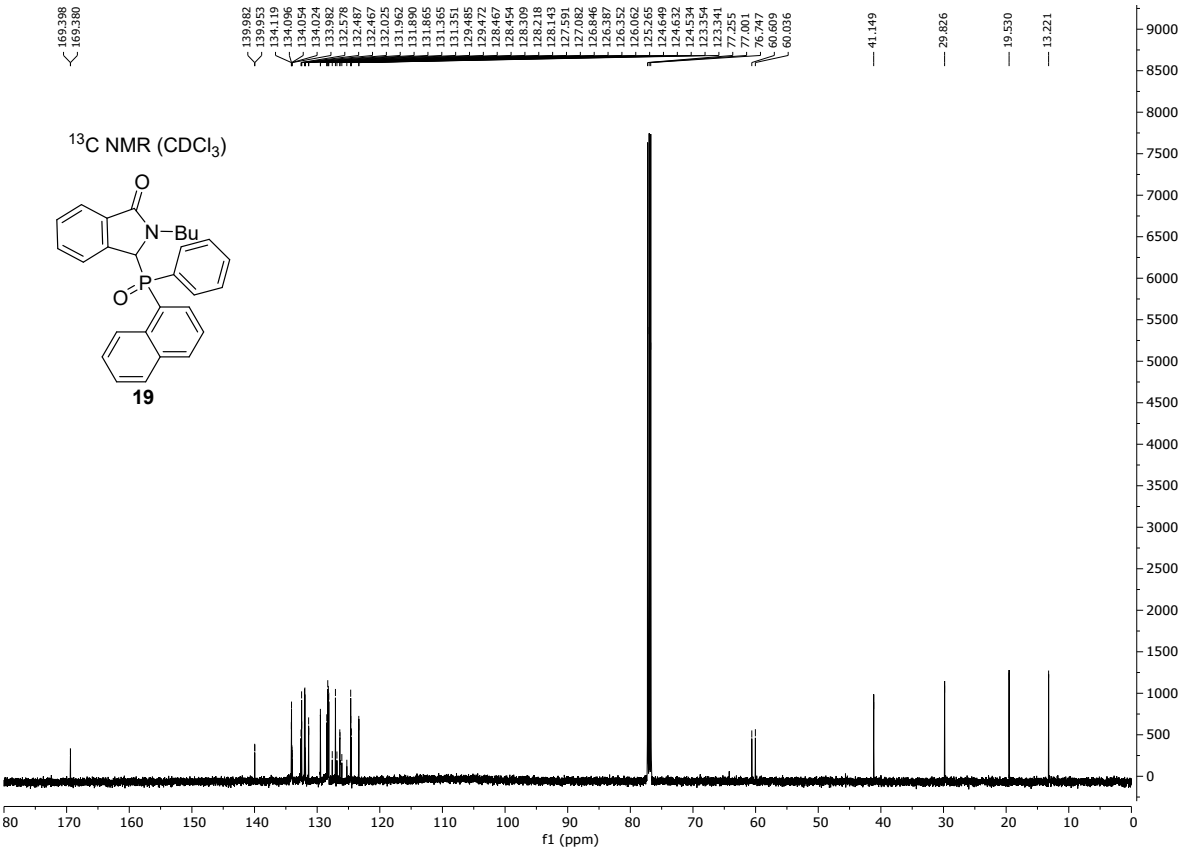


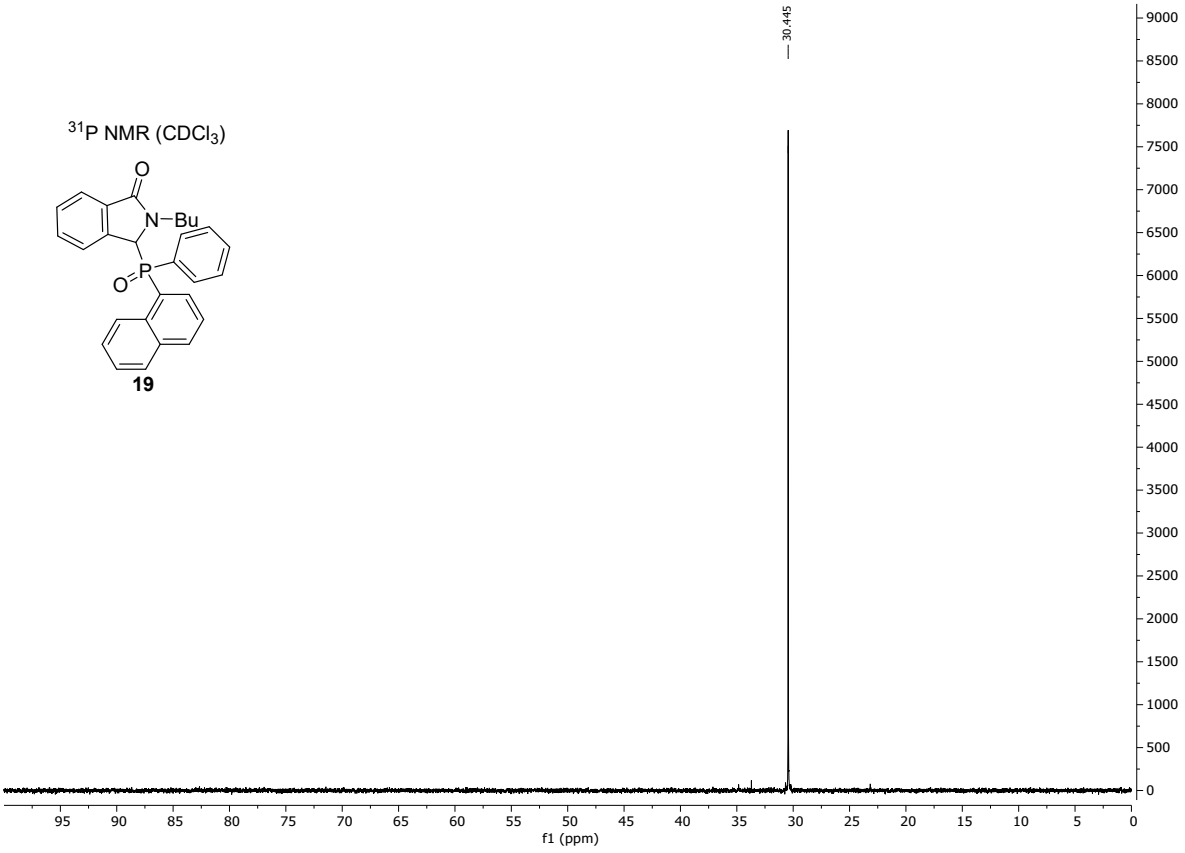
18

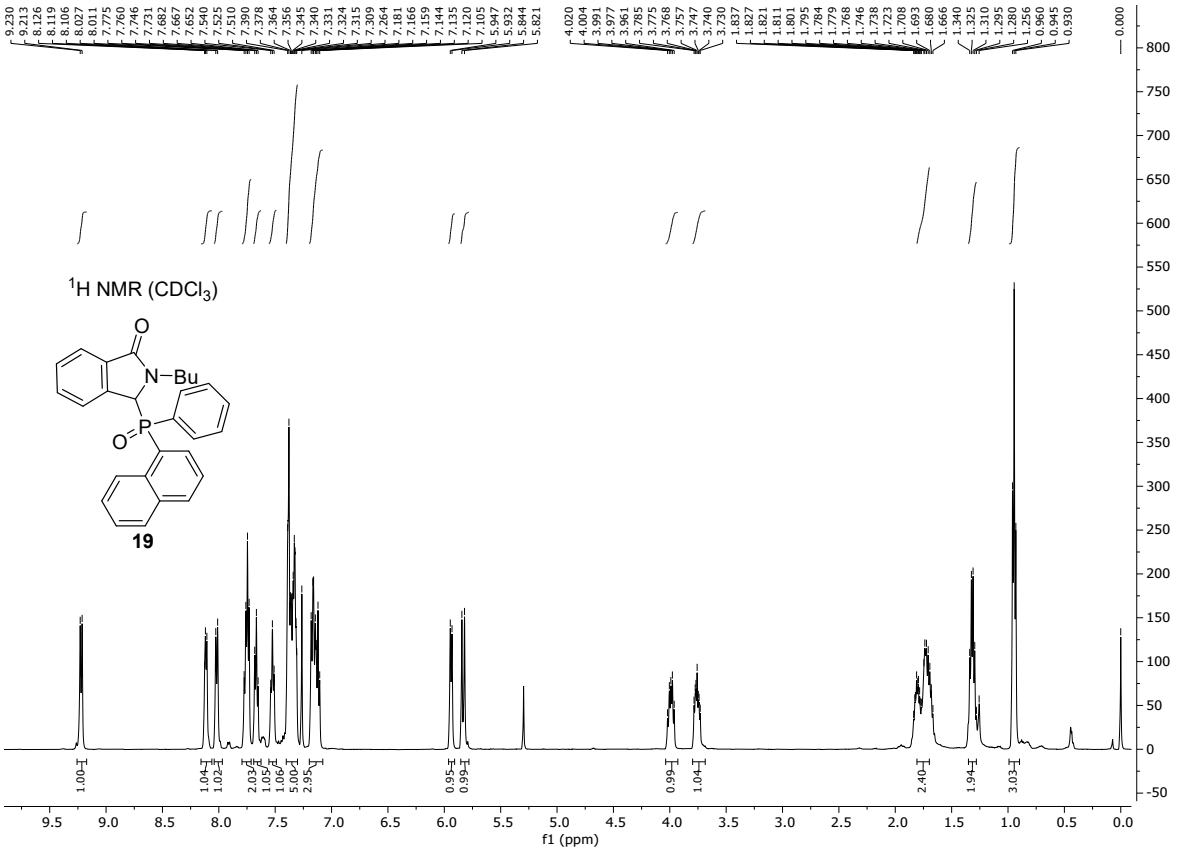
^{1}H NMR ($CDCl_3$)

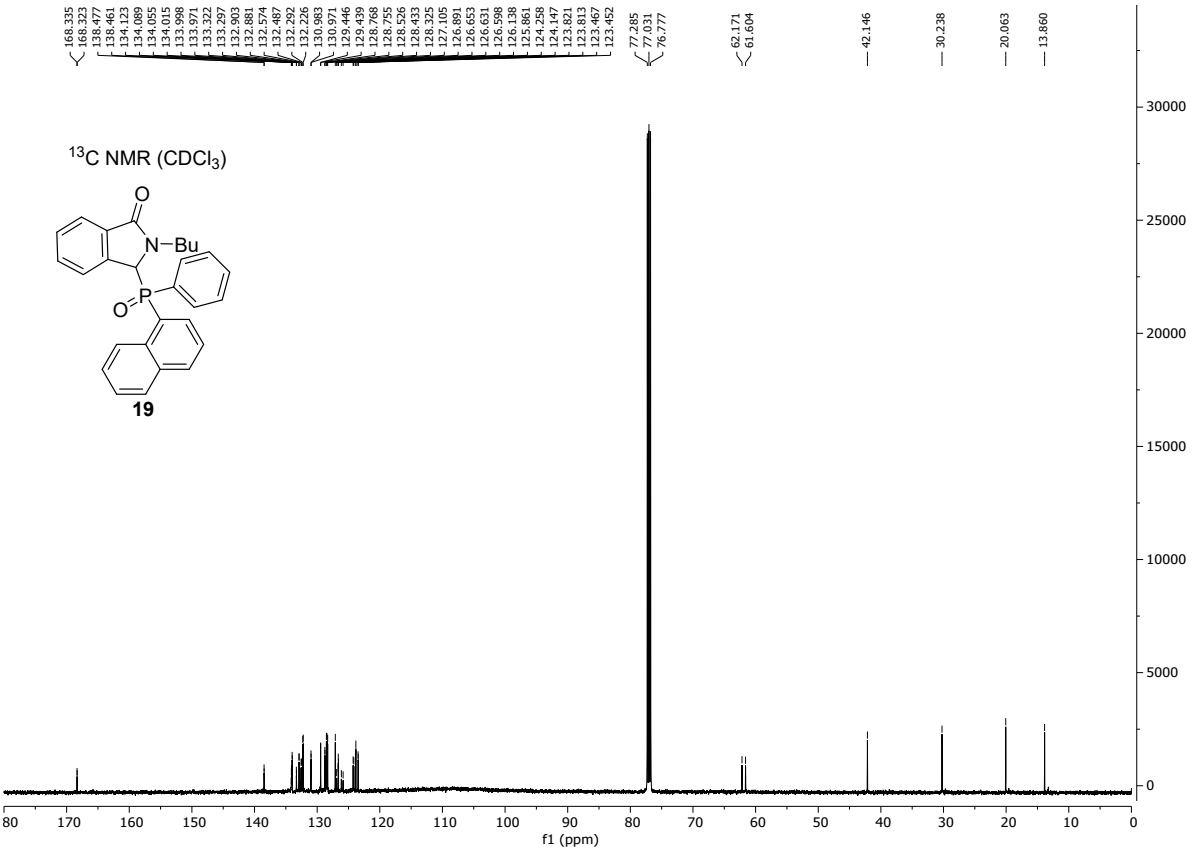


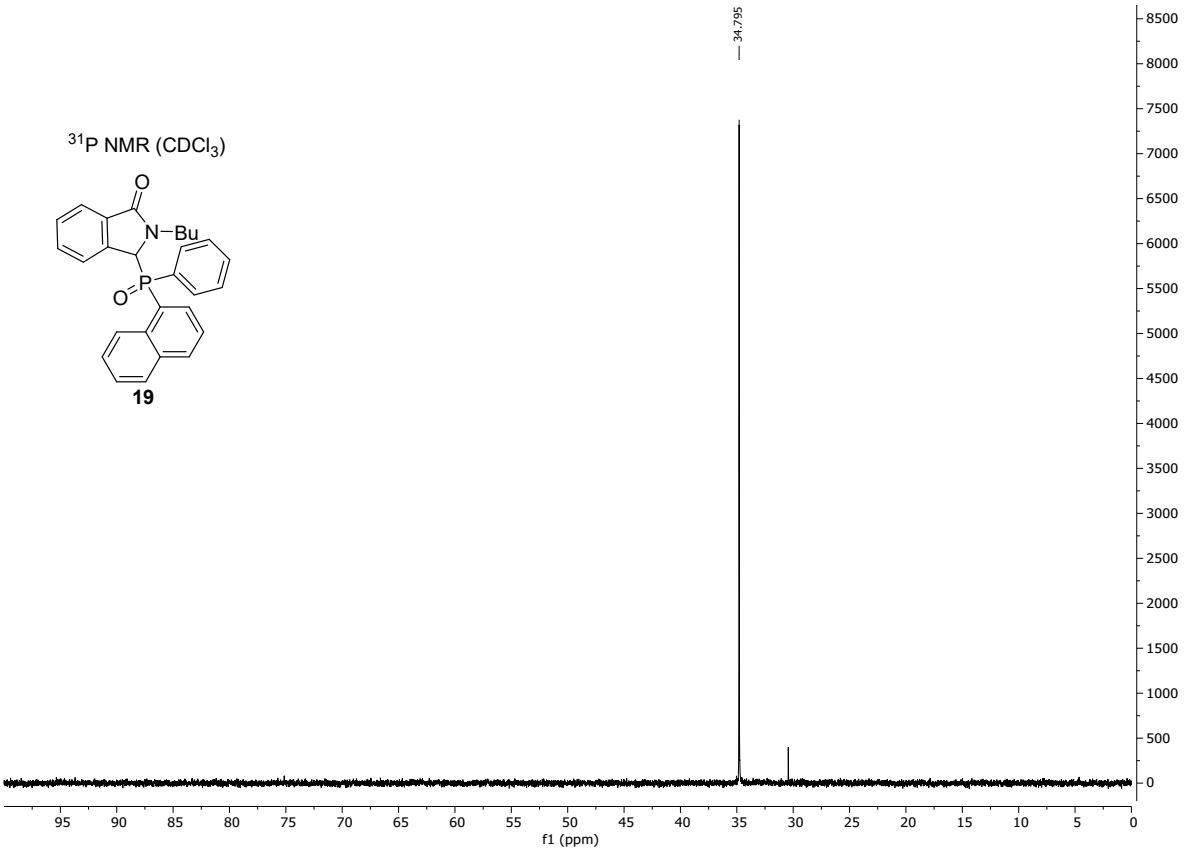
19

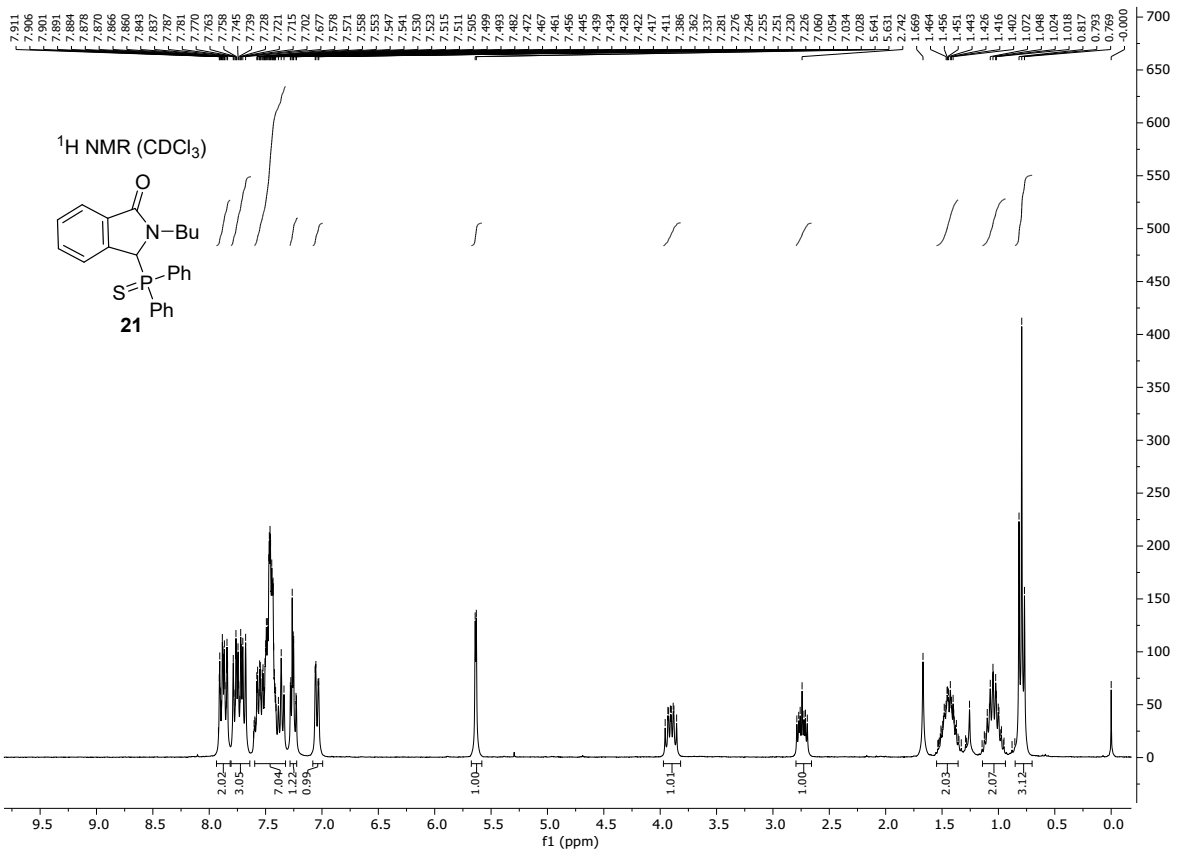

169.398
169.380
139.982
139.953
134.119
134.096
134.054
134.024
133.982
132.578
132.487
132.467
132.025
131.962
131.890
131.865
131.365
131.351
129.485
129.472
128.467
128.454
128.309
128.218
128.143
127.591
127.082
126.846
126.387
126.352
126.062
125.265
124.649
124.632
124.534
123.354
123.341
77.255
77.001
76.747
60.609
60.036
41.149
29.826
19.530
13.221
^{13}C NMR ($CDCl_3$)
O
N−Bu
O=P
19
f1 (ppm)

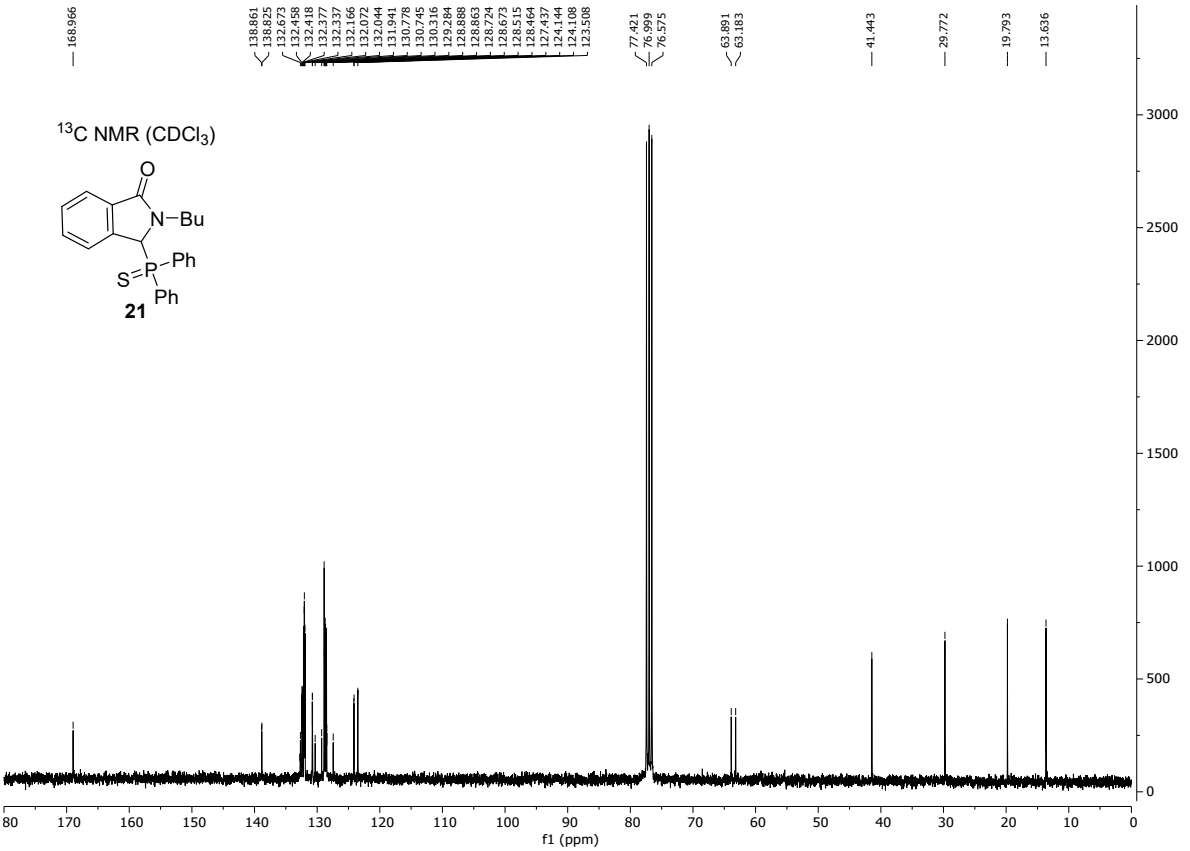

30.445
^{31}P NMR ($CDCl_3$)
O
N−Bu
O=P
19
f1 (ppm)

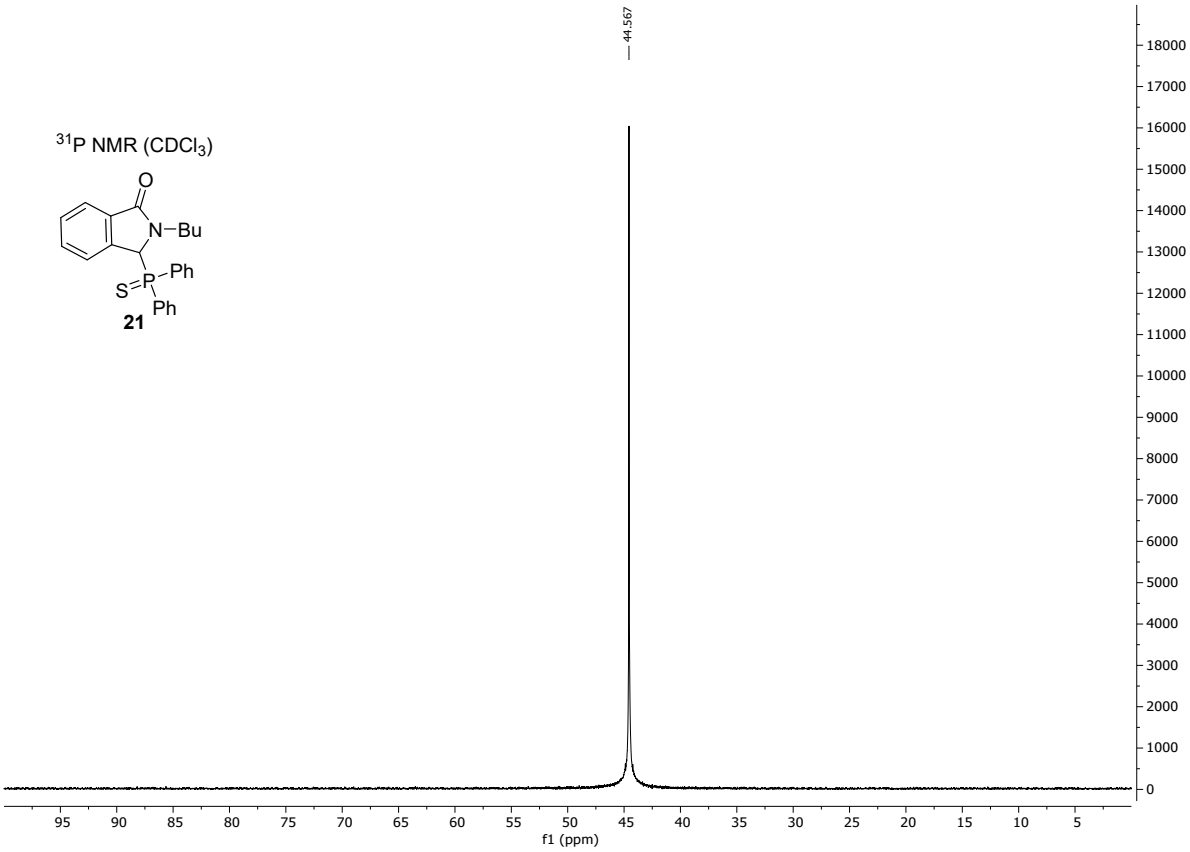

^{1}H NMR ($CDCl_3$)
O
N−Bu
P
O
19
f1 (ppm)

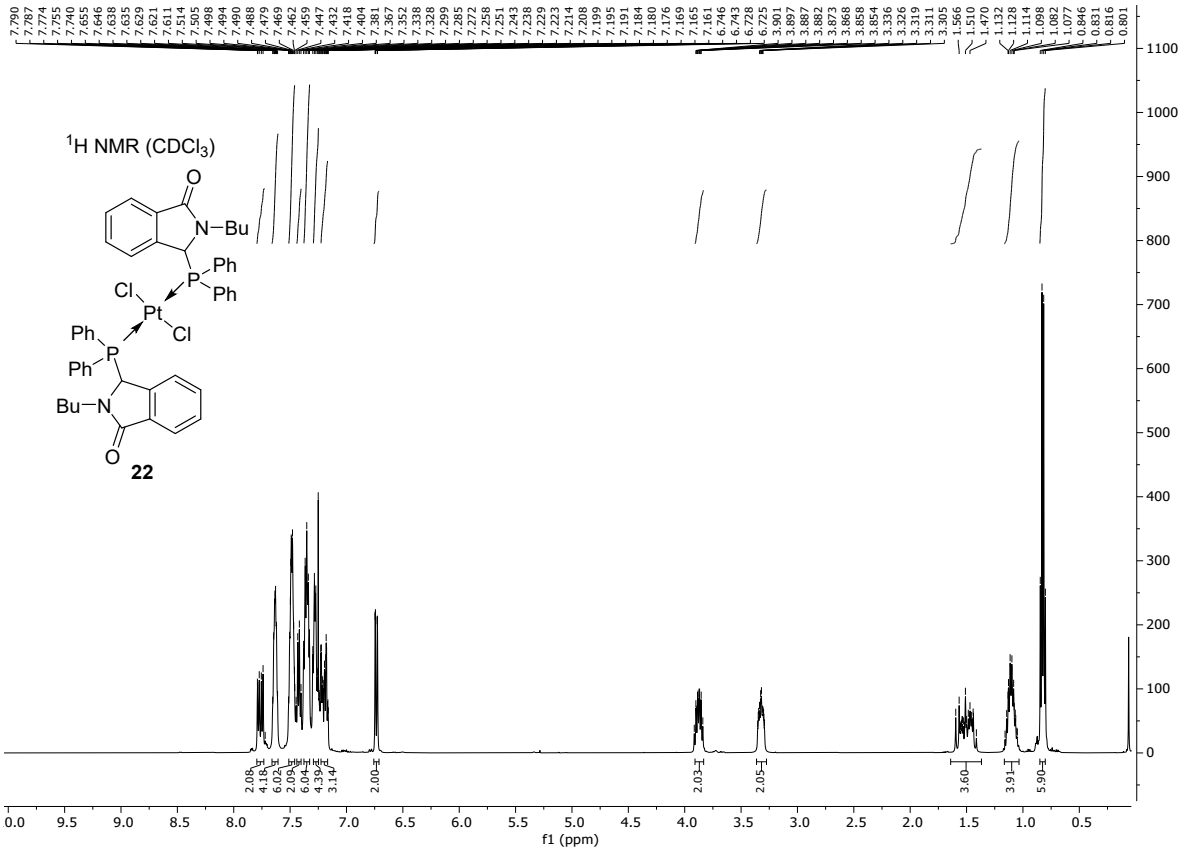

^{13}C NMR ($CDCl_3$)
O
N−Bu
P
O
19
f1 (ppm)

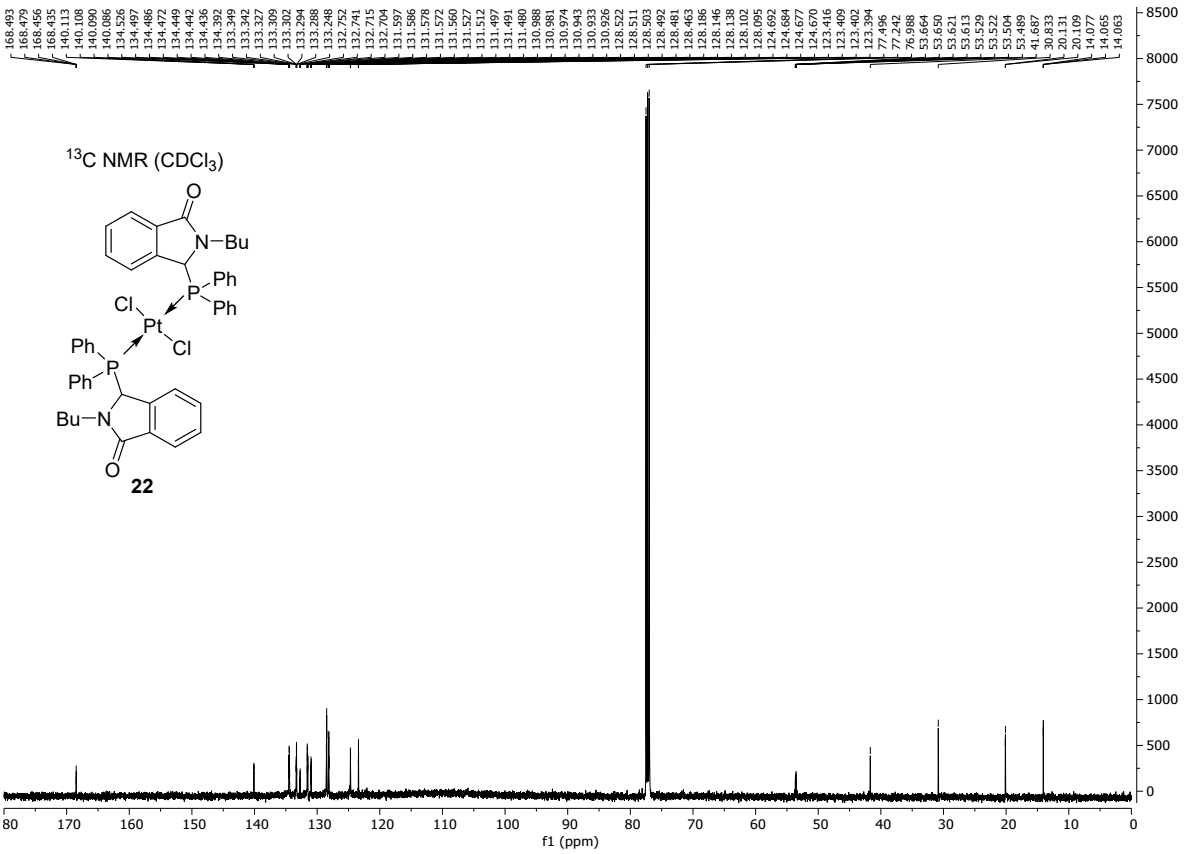

31P NMR (CDCl3)
19
34.795
f1 (ppm)


1H NMR (CDCl3)
21
f1 (ppm)

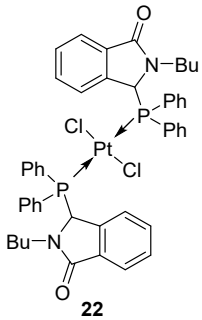

168.966
138.861
138.825
132.673
132.458
132.418
132.377
132.337
132.166
132.072
132.044
131.941
130.778
130.745
130.316
129.284
128.888
128.863
128.724
128.673
128.515
128.464
127.437
124.144
124.108
123.508
77.421
76.999
76.575
63.891
63.183
41.443
29.772
19.793
13.636
13C NMR (CDCl3)
O
N–Bu
S
P
Ph
Ph
21
3000
2500
2000
1500
1000
500
0
80
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)


44.567
31P NMR (CDCl3)
O
N–Bu
S
P
Ph
Ph
21
18000
17000
16000
15000
14000
13000
12000
11000
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
95
90
85
80
75
70
65
60
55
50
45
40
35
30
25
20
15
10
5
f1 (ppm)


^{1}H NMR ($CDCl_3$)
22
f1 (ppm)

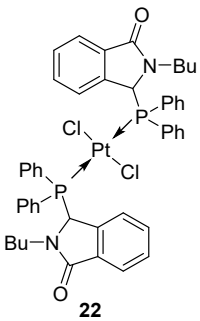

^{13}C NMR ($CDCl_3$)
22
f1 (ppm)

^{31}P NMR ($CDCl_3$)

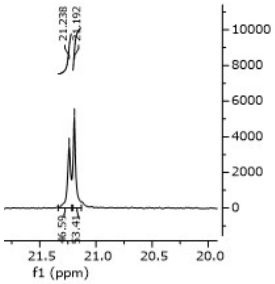


22

^{31}P NMR ($CDCl_3$)



22



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[S2] G. M. Sheldrick, *Acta Cryst.* **2015**, *A71*, 3-8.

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