Supporting Information

Novel method for the synthesis of $\alpha$-amino-$\alpha'$-hydroxyalkylphosphinic acids and bis($\alpha$-aminoalkyl)phosphinic acids: Nucleophilic addition of $\alpha$-hydroxy-H-phosphinic acids to diimines

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Table of Contents

Experimental 2-6
NMR spectra compounds 3a-3m, 6d ..............................................................3-48
Experimental

General

All chemicals were commercial products and distilled or recrystallized before use. NMR spectra were taken with a 400 MHz Brucker Avance instrument with the chemical shifts being reported as δ ppm and couplings expressed in Hertz. Silica gel column chromatography was carried out with Silica gel 100 (Merck No. 10184). Merck Silica-gel 60 F254 plates (No. 5744) were used for the preparative TLC. Mass spectra were measured on a LCMASS micromass LCT and Micromass Autospec. Melting points are uncorrected.

General procedure for the preparation of α-Hydroxy-H-phosphinic acids (1)

This compound was obtained according to the method reported in the literature. The aldehyde (30 mmol) was added to a solution of hypophosphorus acid (30 mmol-anhydrous) in 100 mL of ethanol and the resulting solution was stirred for 48 h at reflux. The solvent was evaporated and chromatography on silica gel with MeOH/CHCl₃ (1:9 to 10/0) gave the pure product in 48-63 % isolated yield. All products gave satisfactory spectral data in accord with the assigned structures.

[α-Hydroxy-(phenyl)methyl]phosphinic acid (1a)

White solid: mp 111-112 °C (Methanol) [Lit. mp 107-108 °C].

FT IR (KBr) νmax: 3371, 3300-2200, 1639, 1191 (P=O), 981.

1H-NMR (CD₃SOCD₃-400 MHz): 4.77 (1H, d, J=8.8 Hz), 6.76 (1H, d, JHP=529 Hz), 6.10-7.0 (1H, br, OH), 7.20-7.50 (5H, m).

31P-NMR (CD₃SOCD₃/H₃PO₄-162.0 MHz): 28.36.

13C-NMR (CD₃SOCD₃-100.6 MHz): 72.0 (d, JPC=108 Hz), 127.5 (d, JPC=6.0 Hz), 127.7 (d, JPC=3.0 Hz), 128.3 (d, JPC=2.0 Hz) 138.1.


[α-Hydroxy-((o-chlorophenyl)methyl]phosphinic acid (1b)

White solid: mp 169-170 °C (Methanol).

FT IR (KBr) νmax: 3299, 3300-2200, 1163 (P=O), 1027.

1H-NMR (CD₃SOCD₃-400 MHz): 5.16 (1H, d, J = 10.0 Hz), 6.81 (1H, d, JHP=536 Hz), 6.10-6.8 (1H, br, OH), 7.30-7.60 (4H, m).

31P-NMR (CD₃SOCD₃/H₃PO₄-162.0 MHz): 26.83.

13C-NMR (CD₃SOCD₃-100.6 MHz): 72.0 (d, JPC=109 Hz), 127.5 (d, JPC=6.0 Hz), 129.4 (d, JPC=2.0 Hz), 129.5 (d, JPC=3.0 Hz), 129.7 (d, JPC=5.0 Hz), 132.2 (d, JPC=6.0 Hz) 136.3.


[α-Hydroxy-((p-chlorophenyl)methyl]phosphinic acid (1c)

White solid: mp 122-123 °C (Methanol).

FT IR (KBr) νmax: 3285, 3300-2200, 1163 (P=O), 971.

1H-NMR (CD₃SOCD₃-400 MHz): 5.58 (1H, d, J = 10 Hz), 6.92 (1H, d, JHP=540 Hz), 6.10-7.0 (1H, br, OH), 7.25-7.50 (4H, m).

31P-NMR (CD₃SOCD₃/H₃PO₄-162.0 MHz): 27.68.

13C-NMR (CD₃SOCD₃-100.6 MHz): 71.1 (d, JPC=107 Hz), 128.4 (d, JPC=2.0 Hz), 129.2 (d, JPC=5.0 Hz), 132.4, 137.1.

HRMS calcd for C₁₀H₉O₃ClPNa (MNa⁺): 228.9797 Found: 228.9800.

[α-Hydroxy-((α-naphthyl)methyl]phosphinic acid (1d)

White solid: mp 185-186 °C (Methanol).

1H-NMR (CD₃SOCD₃-400 MHz): 5.58 (1H, d, J=10 Hz), 6.92 (1H, d, JHP=540 Hz), 6.10-7.0 (1H, br, OH), 7.50-7.70 (4H, m), 7.80-7.98 (m, 2H), 8.10-8.20 (m, 1H).

31P-NMR (CD₃SOCD₃/H₃PO₄-162.0 MHz): 28.70.

13C-NMR (CD₃SOCD₃-100.6 MHz): 69.0 (d, JPC=109 Hz), 124.9, 125.7, 125.8, 126.0, 126.2, 128.2 (d, JPC=3.0 Hz), 128.8, 131.2 (d, JPC=5.0 Hz), 133.7, 134.6.
HRMS calcd for C_{11}H_{11}O_{3}PNa (MNa\(^+\)): 245.0344 Found: 245.0344.

**α-Hydroxy-heptylphosphinic acid (1e):**

White solid: mp 65-66 °C (Methanol).

\(^1\)H-NMR (CDCl\(_3\)-400 MHz): 0.80-0.95 (m, 3H), 1.25-1.85 (m, 10 H), 3.85-3.95 (m, 1H), 6.86 (1H, d, \(J_{HP} = 532 \text{ Hz}\)), 7.57 (s, OH).

\(^31\)P-NMR (CD\(_2\)SOCD\(_3\)/H\(_3\)PO\(_4\)-162.0 MHz): 31.81 ppm.

\(^13\)C-NMR (CD\(_2\)SOCD\(_3\)-100.6 MHz): 14.4, 22.5, 25.4 (d, \(J_{PC} = 11 \text{ Hz}\)), 28.9, 19.8, 31.3, 68.7 (d, \(J_{PC} = 112 \text{ Hz}\)).

**General Procedure for the Synthesis of Diimine 1:**

The aldehyde (15 mmol) was added to ammonium hydroxide (30%, 15 mL) and the solution was stirred for 5 h at reflux. During this time, a white precipitate formed. The precipitate (diimine) was removed by filtration and dried. All products are known and gave satisfactory spectral data in accordance with the assigned structures.

**General procedure for preparation of α-(aminoalkyl)-α-(hydroxyalkyl) phosphinic acid (3):**

Trimethylsilyl chloride (6 mmol, 0.75 mL) was added dropwise to a suspension of 1-hydroxy-H-phosphinic acid (2 mmol) in 10 mL of anhydrous toluene under argon and the mixture was stirred at 0 °C for 30 min. A solution of diimine (3 mmol) in toluene (5 mL) was added to the reaction mixture, and the mixture was stirred at reflux for 4 h. EtOH (5 mL) was added to this mixture and the mixture was stirred at reflux for 1 h. During stirring, a white solid was precipitated. The white solid that precipitated was collected by filtration, washed with EtOH (2 mL) and air drying gave a mixture of diastereoisomers of α-amino-α’-hydroxyphosphinic acid in 41-83% yield. All products gave satisfactory spectral data in accordance with the assigned structures.

**α-Amino(phenyl)methy[α’-hydroxy(phenyl)methyl]phosphinic acid (3a):**

White solid, mixture of two diastereoisomers;

\(^1\)H-NMR (D\(_2\)O-400 MHz): 4.02 (d, 1H, \(J = 12.4 \text{ Hz}\)), 4.08 (d, 1H, \(J = 8.8 \text{ Hz}\)), 4.60 (d, 1H, \(J = 4.8 \text{ Hz}\)), 4.85 (d, 1H, overlap with D\(_2\)O signal), 7.19-7.45 (m, 20 H);

\(^13\)C-NMR (D\(_2\)O/TMS-100 MHz): 54.0 (d, \(J_{PC} = 89.0 \text{ Hz}\)), 54.2 (d, \(J_{PC} = 89.0 \text{ Hz}\)), 72.2 (d, \(J_{PC} = 101.0 \text{ Hz}\)), 72.4 (d, \(J_{PC} = 102.0 \text{ Hz}\)), 72.6 (d, \(J_{PC} = 4 \text{ Hz}\)), 127.0-127.5 (Ar), 128.1 (d, \(J_{PC} = 1 \text{ Hz}\)), 128.3 (d, \(J_{PC} = 2 \text{ Hz}\)), 128.4 (d, \(J_{PC} = 1 \text{ Hz}\)), 138.6 (d, \(J_{PC} = 5 \text{ Hz}\)), 138.8 (d, \(J_{PC} = 2 \text{ Hz}\)), 139.1 (d, \(J_{PC} = 2 \text{ Hz}\)).

\(^31\)P-NMR (D\(_2\)O /H\(_3\)PO\(_4\)-162): 32.90 and 33.37 ppm.

HRMS calcd for C\(_{14}\)H\(_{15}\)NO\(_3\)PNa\(_2\) (M+2Na\(^+\)): 322.0585. Found 322.0581.

**α-Amino(p-methylphenyl)methy[α’-hydroxy(phenyl)methyl]phosphinic acid (3b):**

White solid, mixture of two diastereoisomers;

\(^1\)H-NMR (D\(_2\)O -400 MHz): 2.13 (s, 6H), 3.90 (d, 1H, \(J = 12.0 \text{ Hz}\)), 3.99 (d, 1H, \(J = 8.4 \text{ Hz}\)), 4.53 (d, 1H, \(J = 5.6 \text{ Hz}\)), 4.72 (d, 1H, overlap with D\(_2\)O signal), 7.03-7.25 (m, 18 H);

\(^13\)C-NMR (D\(_2\)O /TMS-100 MHz): 53.6 (d, \(J_{PC} = 89.0 \text{ Hz}\)), 53.8 (d, \(J_{PC} = 89.0 \text{ Hz}\)), 72.2 (d, \(J_{PC} = 101.0 \text{ Hz}\)), 72.3 (d, \(J_{PC} = 100.0 \text{ Hz}\)), 127.2-127.7 (Ar), 128.1 (d, \(J_{PC} = 1 \text{ Hz}\)), 128.8 (d, \(J_{PC} = 2 \text{ Hz}\)), 136.0 (d, \(J_{PC} = 2 \text{ Hz}\)), 137.0 (d, \(J_{PC} = 3 \text{ Hz}\)), 137.1 (d, \(J_{PC} = 2 \text{ Hz}\)), 138.8 (d, \(J_{PC} = 3 \text{ Hz}\)), 139.0 (d, \(J_{PC} = 2 \text{ Hz}\)).

\(^31\)P-NMR (D\(_2\)O /H\(_3\)PO\(_4\)-162): 33.26 and 33.66 ppm.

HRMS calcd for C\(_{15}\)H\(_{18}\)NO\(_3\)PNa (M+Na\(^+\)): 314.0922. Found 314.0924.

**α-Amino(p-fluorophenyl)methy[α’-hydroxy(phenyl)methyl]phosphinic acid (3c):**

White solid, mixture of two diastereoisomers;

\(^1\)H-NMR (D\(_2\)O -400 MHz): 4.00 (d, 1H, \(J = 12.0 \text{ Hz}\)), 4.05 (d, 1H, \(J = 8.8 \text{ Hz}\)), 4.56 (d, 1H, overlap with D\(_2\)O signal), 6.92-7.27 (m, 18H);

\(^13\)C-NMR (D\(_2\)O /TMS-100 MHz): 53.1 (d, \(J_{PC} = 90.0 \text{ Hz}\)), 53.4 (d, \(J_{PC} = 88.0 \text{ Hz}\)), 72.2 (d, \(J_{PC} = 102.0 \text{ Hz}\)), 72.4 (d, \(J_{PC} = 102.0 \text{ Hz}\)), 114.7 (d, \(J_{PC} = 1 \text{ Hz}\)), 114.8 (d, \(J_{PC} = 2 \text{ Hz}\)), 114.9 (d, \(J_{PC} = 1 \text{ Hz}\)), 115.0 (d, \(J_{PC} = 2 \text{ Hz}\)).
White solid, mixture of two diastereoisomers; 1H-NMR (D2O-400 MHz): 3.66 (s, 6H), 3.99 (d, 1H, J = 1 Hz), 73.6 (d, JPC = 1 Hz), 138.7 (d, JPC = 3 Hz), 138.9 (d, JPC = 2 Hz), 161.4 (dd, JPC = 3 Hz, JFC = 240 Hz), 161.6 (dd, JPC = 3 Hz, JFC = 240 Hz).

31P-NMR (D2O /H3PO4-162): 32.88 and 33.41 ppm;

31P-NMR (D2O /H3PO4-162): 33.18 and 34.24 ppm;


1H-NMR (D2O-400 MHz): 4.02 (d, 1H, J = 11.6 Hz), 4.05 (d, 1H, J = 8.4 Hz), 4.55 (d, 1H, J = 5.2 Hz), 4.78 (d, 1H, overlap with D2O signal); 6.93-7.21 (m, 16H).

13C-NMR (D2O /TMS-100 MHz): 53.0 (d, JPC = 90.0 Hz), 53.4 (d, JPC = 88.0 Hz), 71.7 (d, JPC = 102.0 Hz), 72.0 (d, JPC = 101.0 Hz), 114.7 (d, JPC = 9 Hz), 115.0 (d, JPC = 9 Hz), 127.9, 128.6 (d, JPC = 5 Hz), 128.7 (d, JPC = 6 Hz), 129.2 (d, JPC = 4 Hz), 129.3 (d, JPC = 5 Hz), 132.1 (d, JPC = 3 Hz), 132.2 (d, JPC = 3 Hz), 134.7 (d, JPC = 3 Hz), 134.9 (d, JPC = 3 Hz), 137.8 (d, JPC = 1 Hz), 138.1 (d, JPC = 1 Hz), 161.6 (d, JPC = 241 Hz.), 161.7 (d, JPC = 241 Hz.).

31P-NMR (D2O /H3PO4-162): 32.81 and 33.61 ppm;

HRMS calcld for C14H14NO3FPClNa (M+Na+): 352.0276. Found 352.0276.

α-Amino(α-naphthyl)methyl[α'-hydroxy(α-chlorophenyl)methyl]phosphinic acid (3i):

White solid, mixture of two diastereoisomers;

1H-NMR (D2O-400 MHz): 4.16 (d, 1H, J = 12.0 Hz), 4.20 (d, 1H, J = 9.2 Hz), 4.53 (d, 1H, J = 5.6 Hz), 4.73 (d, 1H, overlap with D2O signal); 7.12-7.75 (m, 2H).

13C-NMR (D2O /TMS-100 MHz): 53.9 (d, JPC = 88.0 Hz), 54.3 (d, JPC = 87.0 Hz), 71.9 (d, JPC = 101.0 Hz), 72.2 (d, JPC = 102.0 Hz), 125.7-126.4 (Ar), 127.5, 127.6, 127.8 (d, JPC = 2 Hz), 128.6 (d, JPC = 4 Hz), 128.7 (d, JPC = 6 Hz), 132.0 (d, JPC = 2 Hz), 132.0, 132.1, 132.8 (d, JPC = 1 Hz), 132.8 (d, JPC = 3 Hz), 136.7 (d, JPC = 3 Hz), 136.9 (d, JPC = 1 Hz), 138.1 (d, JPC = 2 Hz), 138.3 (d, JPC = 2 Hz);

31P-NMR (D2O /H3PO4-162): 33.13 and 34.96 ppm;


α-Amino(phenyl)methyl[α'-hydroxy(α-naphthyl)methyl]phosphinic acid (3j):

White solid, mixture of two diastereoisomers;

1H-NMR (D2O-400 MHz): 3.91 (d, 1H, J = 9.6 Hz), 4.10 (d, 1H, J = 12.4 Hz), 5.43 (s, 1H), 5.69 (d, 1H, J = 6.8 Hz), 7.19-7.92 (m, 2H).

13C-NMR (D2O /TMS-100 MHz): 54.4 (d, JPC = 89.0 Hz), 54.8 (d, JPC = 87.0 Hz), 67.3 (d, JPC = 102.0 Hz), 67.6 (d, JPC = 99.0 Hz), 123.8, 123.9, 125.4, 125.5, 125.6, 125.7, 125.9, 127.0 (d, JPC = 1 Hz), 127.2 (d, JPC = 1 Hz), 127.6 (d, JPC = 5 Hz), 127.8, 128.3 (d, JPC = 8 Hz), 128.4, 128.8 (d, JPC = 4 Hz), 133.1, 133.0 (d, JPC = 2 Hz), 135.2 (d, JPC = 2 Hz), 139.0 (d, JPC = 3 Hz), 139.5 (d, JPC = 2 Hz);

31P-NMR (D2O /H3PO4-162): 32.99 and 33.77 ppm;


α-Amino(p-methylphenyl)methyl[α'-hydroxy(α-naphthyl)methyl]phosphinic acid (3k):

White solid, mixture of two diastereoisomers;

1H-NMR (D2O -400 MHz): 2.16 (s, 3H), 2.22 (s, 3H), 4.04 (d, 1H, J = 12.1 Hz), 4.11 (d, 1H, J = 8.8 Hz), 5.41 (d, 1H, J = 4.8 Hz), 5.67 (d, 1H, J = 6.8 Hz), 7.04-7.64 (m, 2H).

13C-NMR (D2O /TMS-100 MHz): 20.11, 20.16, 54.1 (d, JPC = 90.0 Hz), 54.5 (d, JPC = 89.0 Hz), 67.2 (d, JPC = 101.0 Hz), 67.5 (d, JPC = 102.0 Hz), 123.7, 123.8, 125.4-125.6 (Ar), 125.9, 127.5 (d, JPC = 4 Hz), 127.6 (d, JPC = 2 Hz), 127.7 (d, JPC = 5 Hz), 127.8, 128.3 (d, JPC = 8 Hz), 128.4, 130.8 (d, JPC = 4 Hz), 133.1, 133.0 (d, JPC = 5 Hz), 135.1 (d, JPC = 2 Hz), 135.8 (d, JPC = 3 Hz), 136.1 (d, JPC = 2 Hz), 137.1 (d, JPC = 3 Hz), 137.3 (d, JPC = 2 Hz);

31P-NMR (D2O /H3PO4-162): 33.14 and 33.82 ppm;

HRMS calcld for C18H16NO3PClNa2 (M+2Na+): 386.0898. Found 386.0905.

α-Amino(p-fluorophenyl)methyl[α'-hydroxy(α-naphthyl)methyl]phosphinic acid (3l):

White solid, mixture of two diastereoisomers;

1H-NMR (D2O-400 MHz): 4.09 (d, 1H, J = 12.0 Hz), 4.14 (d, 1H, J = 9.2 Hz), 5.43 (d, 1H, J = 4.8 Hz), 5.69 (d, 1H, J = 6.8 Hz), 6.92-7.85 (m, 2H).

13C-NMR (D2O /TMS-100 MHz): 53.6 (d, JPC = 90.0 Hz), 54.1 (d, JPC = 88.0 Hz), 67.3 (d, JPC = 102.0 Hz), 67.7 (d, JPC = 102.0 Hz), 114.7 (d, JPC = 1 Hz), 114.9 (d, JPC = 1 Hz), 115.0 (d, JPC = 2 Hz), 115.1 (d, JPC = 2 Hz), 123.7, 123.8, 125.5-125.8 (Ar), 125.9, 127.7 (d, JPC = 2 Hz), 128.4, 129.0-129.5 (Ar), 130.7 (d, JPC = 5 Hz), 130.8 (d, JPC = 5 Hz), 133.1, 134.8 (d, JPC = 2 Hz), 134.9 (d, JPC = 2 Hz), 135.2 (d, JPC = 1 Hz), 135.3 (d, JPC = 2 Hz), 160.4 (d, JPC = 234 Hz), 162.9 (d, JPC = 230 Hz);

31P-NMR (D2O /H3PO4-162): 32.88 and 33.72 ppm;
HRMS calcd for C_{18}H_{16}NO_{3}FPNa_{2} (M+2Na)^{+}: 390.0647. Found 390.0650

**α-Amino(phenyl)methyl[α'-hydroxyheptyl]phosphinic acid (3m):**

White solid, single diastereoisomer, mp: 234–236 °C;

$^1$H-NMR (D$_2$O-400 MHz): 0.68 (t, 3H, $J$= 6.8 Hz), 1.09-1.50 (m, 10H), 3.53 (d, 1H, $J$= 10.8 Hz), 3.96 (d, 1H, $J$= 12.8 Hz), 7.17-7.26 (m, 5H);

$^{13}$C-NMR (D$_2$O /TMS-100 MHz): 13.3, 21.8 , 25.2 (d, $J_{PC}$= 11.0 Hz), 27.9, 29.5, 30.8, 54.0 (d, $J_{PC}$= 87.0 Hz), 68.2 (d, $J_{PC}$=108.0 Hz), 127.0 (d, $J_{PC}$=2 Hz), 127.5 (d, $J_{PC}$=4 Hz), 128.2 (d, $J_{PC}$=1 Hz), 138.9 (d, $J_{PC}$=1 Hz).

$^{31}$P-NMR (D$_2$O /H$_3$PO$_4$-162): 36.70 ppm

Anal. Calcd for C$_{14}$H$_{24}$NO$_3$P. C, 58.91; H, 8.48; N, 4.91. Found: C, 58.82; H, 8.41; N, 4.68.

**Procedure for the preparation of bis[α-amino(ρ-methoxyphenyl)]phosphinic acid (6d):**

Trimethylsilyl chloride (6 mmol, 0.75 mL) was added dropwise to a suspension of [α-hydroxy-(o-chlorophenyl)methyl]phosphinic acid (1b) (2 mmol) in 10 mL of anhydrous toluene under argon and the mixture was stirred at 0 °C for 30 min. A solution of diimine 2d (3 mmol) in toluene (5 mL) was added to the reaction mixture, and the mixture was stirred at reflux for 24 h. EtOH (5 mL) was added to this mixture and the mixture was stirred at reflux for 1 h. During stirring, a white solid was precipitated. The white solid that precipitated was collected by filtration, washed with EtOH (2 mL) and air drying gave a single diastereoisomer of bis[α-amino(ρ-methoxyphenyl)]phosphinic acid (6d) in 42% yield.

**Bis[α-amino(ρ-methoxyphenyl)]phosphinic acid (6d):** White solid, single diastereoisomer;

$^1$H-NMR (D$_2$O-400 MHz): 3.68 (s, 6H), 3.80 (d, 2H, $J$= 9.2 Hz), 6.80 (d, 4H, $J$= 8.8 Hz), 7.20 (d, 4H, $J$= 8.8 Hz)

$^{13}$C-NMR (D$_2$O /TMS-100 MHz): 53.0 (d, $J_{PC}$ = 90.0 Hz), 55.3 (d, $J_{PC}$ =2 Hz), 113.8 ,129.0 (d, $J_{PC}$ = 5 Hz), 131.6 (d, $J_{PC}$ = 2 Hz), 157.8 (d, $J_{PC}$ = 2 Hz);

$^{31}$P-NMR (D$_2$O /H$_3$PO$_4$-162): 36.14 ppm.

HRMS calcd for C$_{16}$H$_{20}$N$_2$O$_4$PNa$_2$ (M+2Na)$^+$: 381.0956. Found 381.0961
$^1$H-NMR-3a
$^{13}$C-NMR-3a
$^{31}$P-NMR-3b
$^{13}$C-NMR-3b
$^1$H-NMR-3c
$^{31}\text{P-NMR-3c}$
$^{13}$C-NMR-3c
"\textsuperscript{1}H-NMR-3d"
$^{31}$P-NMR-3d
$^{13}$C-NMR-3d
$^{1}H$-NMR-3e
$^{31}$P-NMR-3e

![NMR spectrum and chemical structure](image)
$^{13}$C-NMR-3e
$^1$H-NMR-3f
NMR spectrum and chemical structures.
$^{31}$P-NMR-3g
$^1$H-NMR-3h
$^{31}\text{P-NMR-3h}$
$^{13}$C-NMR-3h
$^{1}H$-NMR-3i
$^{31}\text{P-NMR-3i}$
$^{13}$C-NMR-3i
\(^{13}\)C-NMR-3j
$^{31}$P-NMR-3k
$^1$H-NMR-3I
$^{31}$P-NMR-3I
$^1$H-NMR-3m
$^{31}$P-NMR-3m

![Chemical Structure Image]
$^{13}$C-NMR-3m

\[ \text{Diagram of chemical structure} \]

\[ \text{NMR spectrum graph} \]
$^1$H-NMR-6d

MeO
$\text{O}^\text{P}$
OH
MeO

NH$_2$
NH$_2$

\[ \text{MeO} \quad \text{O}^\text{P} \quad \text{OH} \quad \text{MeO} \quad \text{NH}_2 \quad \text{NH}_2 \]
$^{31}$P-NMR-6d
$^{13}$C-NMR-6d

**Chemical Structure:**

- MeO
- O\(\text{P}\)OH
- NH\(_2\)
- OMe

**NMR Spectrum:**

The spectrum shows peaks at various ppm values, indicating the chemical shifts of the different functional groups in the molecule.

**ppm Scale:**

- 240 to 200
- 180 to 160
- 140 to 120
- 100 to 80
- 60 to 40
- 20 ppm