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Supporting information

Mastering the coating of metal oxide nanoparticles and surfaces through phosphonated dendrons

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Supporting Information

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General methods

Reactions under anhydrous conditions were realized in flame-dried flasks and under an atmosphere of argon. Dichloromethane (CH_2Cl_2), tetrahydrofuran (THF), acetonitrile (CH_3CN), *N*,*N*-dimethylformamide (DMF), dimethylsulfoxide (DMSO) (AcroSeal^{TM}, Acros) were dried over 4 Å molecular sieves. Other reagents were obtained from commercial suppliers and used as received.

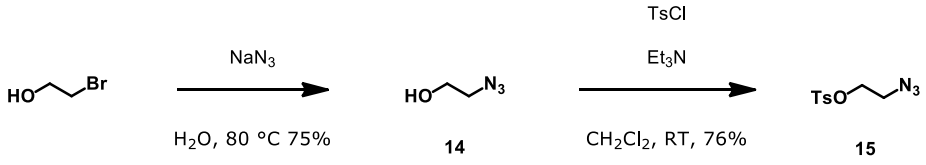
Thin-layer chromatography (TLC) was performed using 0.25 mm Merck silica plates (60F-254), visualized with a UV lamp (254 nm), and *p*-anisaldehyde-sulfuric acid (H_2SO_4)-acetic acid (AcOH) in ethanol (EtOH), $KMnO_4$-K_2CO_3 in water, phosphomolybdic acid-$Ce(SO_4)_2$ in EtOH and heat as developing agents. NMR spectra were recorded with a Bruker Avance instrument.

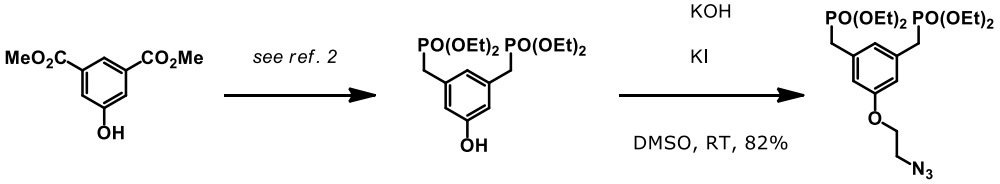
^{1}H NMR spectra were recorded at 300 or 500 MHz and data are reported as (chemical shift [ppm] relative to tetramethylsilane, multiplicity, coupling constant [Hz], integration). ^{13}C NMR spectra were recorded at 125 MHz and data are reported as (chemical shift [ppm] relative to the deuterated solvent signal). ^{31}P NMR spectra were recorded at 202 MHz and data are reported as (chemical shift [ppm] relative to the deuterated solvent signal). ^{19}F NMR spectra were recorded at 282 MHz and data are reported as (chemical shift [ppm] relative to the deuterated solvent signal). The following abbreviations were used to explain multiplicities: s = singulet, d = doublet, t = triplet, q = quartet, m = multiplet, br = broad).

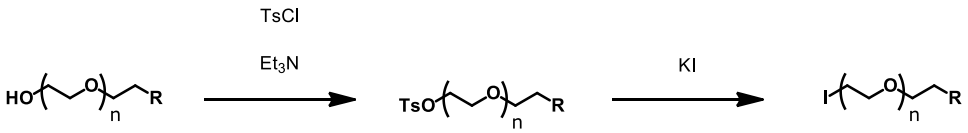
Flash chromatography was performed on silica gel (Sigma Aldrich, 230-400 mesh) or C_{18}-reversed phase silica gel (Sigma Aldrich, 90 Å pore size).

MALDI-TOF mass spectra were performed at Laboratoire de Spectrométrie de Masse BioOrganique, Ecole européeenne d'Ingénieurs de chimie, polymères et matériaux.

Preparation of starting building blocks

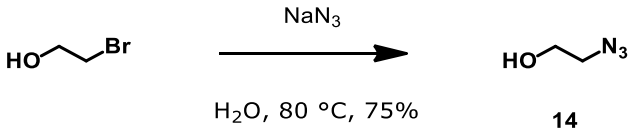






18	n = 3	R = OMe	82%	**22**	n = 3	R = OMe	94%
19	n = 4	R = CO_2tBu	81%	**23**	n = 4	R = CO_2tBu	96%
20	n = 8	R = CO_2tBu	99%	**24**	n = 8	R = CO_2tBu	99%
21	n = 7	R = OMe	99%	**25**	n = 7	R = OMe	89%

Compound 14



To a solution of 2-Bromoethanol (10.0 mL, 136.9 mmol) in H_2O (20.0 mL) was added sodium azide (14.7 g, 169.3 mmol, 1.2 equiv.). The resulting solution was heated to 80 °C for 16 h, cooled to RT, diluted with water and EtOAc. The aqueous layer was extracted with EtOAc (three times), the combined organic layers were washed with brine, dried over Na_2SO_4, filtered and concentrated und reduced pressure to afford 8.88 g (102.0 mmol, 75%) of the title compound **14**.

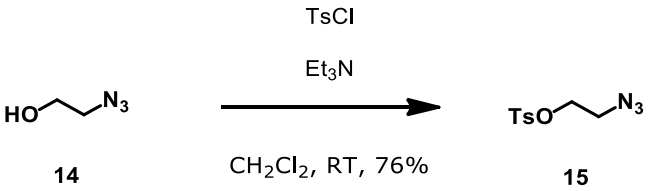
Physical state: colorless liquid.

^{1}H NMR (300 MHz, $CDCl_3$): δ 3.78 (dd, *J* = 10.0, 5.4 Hz, 2H), 3.44 (t, *J* = 4.7 Hz, 2H)**,** 2.02 (t, *J* = 5.4 Hz, 1H) ppm

TLC: R_f = 0.3 (CH_2Cl_2/MeOH 98/2, $KMnO_4$).

Spectral data matches the literature. [1]

Compound 15



14 **15**

To a solution of **14** (8.88 g, 102.0 mmol) in CH_2Cl_2 (300.0 mL) were successively added tosyl chloride (TsCl) (23.3 g, 122.4 mmol, 1.2 equiv.) and triethylamine (Et_3N) (22.0 mL, 157.8 mmol, 1.5 equiv.). The resulting solution was stirred at RT for 16 h, diluted with water and CH_2Cl_2. The aqueous layer was extracted with CH_2Cl_2 (three times), the combined organic layers were washed with brine, dried over Na_2SO_4, filtered and concentrated und reduced pressure. Purification by chromatography on silica gel (Cyclohexane/Toluene 1/1 then Cyclohexane/EtOAc 9/1 to 85/15 to 0/1) afforded 18.7 g (77.6 mmol, 76%) of the title compound **15**.

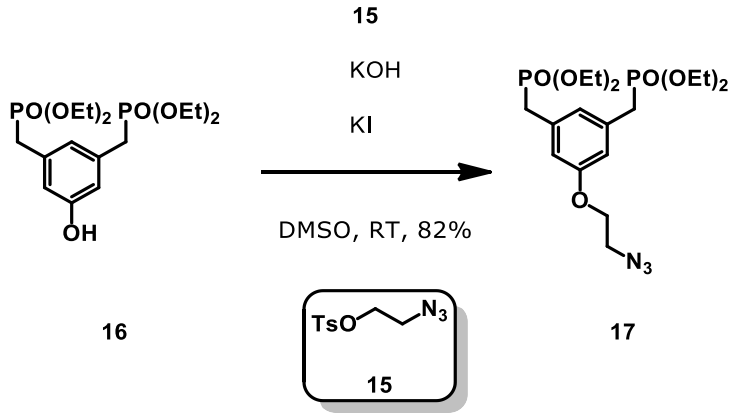
Physical state: colorless oil.

^{1}H NMR (300 MHz, $CDCl_3$): δ 7.82 (d, *J* = 8.4 Hz, 2H), 7.37 (d, *J* = 8.4 Hz, 2H), 4.16 (t, *J* = 4.8 Hz, 2H), 3.48 (t, *J* = 4.8 Hz, 2H)**,** 2.46 (s, 3H) ppm

TLC: R_f = 0.4 (Cyclohexane/EtOAc 7/3, phosphomolybdic acid).

Spectral data matches the literature. [1]

Compound 17



To a solution of **16** (3.95 g, 10.0 mmol) in DMSO (30.0 mL) were successively added KOH (840.0 mg, 15.0 mmol, 1.5 equiv.), KI (83.0 mg, 0.5 mmol, 0.05 equiv.) and **15** (2.9 g, 12.0 mmol, 1.2 equiv.). The resulting solution was stirred at RT for 16 h, quenched with an aqueous solution of HCl 2N (10.0 mL). The aqueous layer was extracted with EtOAc (three times), the combined organic layers were washed with brine, dried over Na_2SO_4, filtered and concentrated und reduced pressure. Purification by chromatography on silica gel (CH_2Cl_2/MeOH 96/4 to 9/1 to 7/3) afforded 3.79 g (8.19 mmol, 82%) of the title compound **17**.

Physical state: yellow oil.

^{1}H NMR (500 MHz, $CDCl_3$): δ 7.82 (d, *J* = 8.4 Hz, 2H), 7.37 (d, *J* = 8.4 Hz, 2H), 4.14 (t, *J* = 5.2 Hz, 2H), 4.02 (qt, *J* = 7.0 Hz, 8H), 3.56 (t, *J* = 4.7 Hz, 2H)**,** 3.09 (d, $^2J_{P\text{-}H}$ = 21.5 Hz, 4H), 1.25 (t, *J* = 6.9 Hz, 12H) ppm

^{13}C NMR (125 MHz, $CDCl_3$): δ 158.3, 133.2, (t, $^2J_{C\text{-}P}$ = 10.7 Hz), 124.3 (t, $^3J_{C\text{-}P}$ = 6.4 Hz), 114.6 (t, $^3J_{C\text{-}P}$ = 4.6 Hz), 66.9, 62.1 (d, $^2J_{C\text{-}P}$ = 6.7 Hz), 50.1, 33.6 (d, $^1J_{C\text{-}P}$ = 138.5 Hz), 16.4 (d, $^3J_{C\text{-}P}$ = 6.0 Hz) ppm

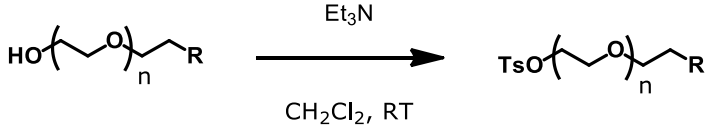
^{31}P NMR (202 MHz, $CDCl_3$): δ 26.0 ppm

MALDI-TOF: m/z calcd for $C_{18}H_{32}N_3O_7P_2$ $[M+H]^+$ 464.172, found 464.162

TLC: R_f = 0.4 (Cyclohexane/EtOAc 7/3, phosphomolybdic acid).

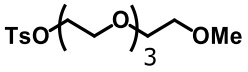
General procedure for synthesis of OEG 18-21 and 22-25

Installation of tosylate leaving group



18	n = 3	R = OMe
19	n = 4	R = CO_2tBu
20	n = 8	R = CO_2tBu
21	n = 7	R = OMe

To a solution of **OEG-OH** in CH_2Cl_2 (0.1 M) were successively added TsCl (1.5 equiv.) and Et_3N (3.0 equiv.). The resulting solution was stirred at RT for 16 h, then concentrated under reduced pressure. The crude residue was purified by chromatography on silica gel to afford the corresponding tosylate OEG.



18

8.9 g isolated (24.8 mmol, 82%)

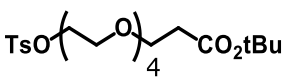
Eluents: 100% EtOAc.

Physical state: yellow oil.

^{1}H NMR (300 MHz, $CDCl_3$): δ 7.80 (d, *J* = 8.2 Hz, 2H), 7.34 (d, *J* = 8.2 Hz, 2H), 4.16 (t, *J* = 4.6 Hz, 2H), 3.70—3.52 (m, 15H), 3.37 (s, 3H), 2.45 (s, 3H) ppm

TLC: R_f = 0.4 (100% EtOAc, phosphomolybdic acid).

Spectral data matches the literature. [2]



19

6.9 g isolated (14.5 mmol, 81%)

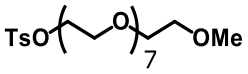
Eluents: CH_2Cl_2/MeOH 98/2 to 9/1.

Physical state: yellow oil.

^{1}H NMR (300 MHz, $CDCl_3$): δ 7.79 (d, *J* = 8.2 Hz, 2H), 7.33 (d, *J* = 8.2 Hz, 2H), 4.15 (t, *J* = 4.5 Hz, 2H), 3.74—3.57 (m, 16H), 2.49 (t, *J* = 6.5 Hz, 2H), 2.44 (s, 3H), 1.44 (s, 9H) ppm

TLC: R_f = 0.5 (Cyclohexane/EtOAc 3/7, phosphomolybdic acid).

Spectral data matches the literature. [3]



21

1.6 g isolated (2.6 mmol, 99%)

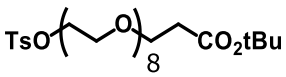
Eluents: CH_2Cl_2/MeOH 9/1.

Physical state: yellow oil.

^{1}H NMR (300 MHz, $CDCl_3$): δ 7.78 (d, *J* = 7.4 Hz, 2H), 7.32 (d, *J* = 8.2 Hz, 2H), 4.14 (t, *J* = 4.8 Hz, 2H), 3.67 (t, *J* = 4.8 Hz, 2H), 3.64—3.52 (m, 30H), 3.36 (s, 3H), 2.43 (s, 3H) ppm

TLC: R_f = 0.3 (CH_2Cl_2/MeOH 94/6, phosphomolybdic acid).

Spectral data matches the literature. [4]



20

5.2 g isolated (8.0 mmol, 99%)

Eluents: CH_2Cl_2/MeOH 92/8.

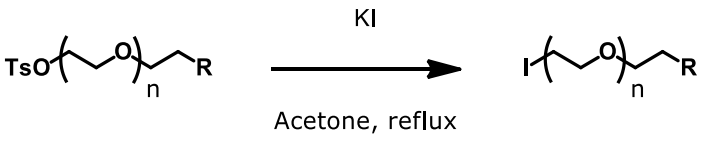
Physical state: yellow oil.

^{1}H NMR (300 MHz, $CDCl_3$): δ 7.79 (d, *J* = 8.2 Hz, 2H), 7.33 (d, *J* = 8.2 Hz, 2H), 4.15 (t, *J* = 4.6 Hz, 2H), 3.72—3.57 (m, 32H), 2.49 (t, *J* = 6.5 Hz, 2H), 2.44 (s, 3H), 1.44 (s, 3H) ppm

TLC: R_f = 0.4 (CH_2Cl_2/MeOH 92/8, phosphomolybdic acid).

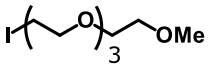
Spectral data matches the literature. [2]

Displacement of tosylate by potassium iodide (KI)



22	n = 3	R = OMe
23	n = 4	R = CO_2tBu
24	n = 8	R = CO_2tBu
25	n = 7	R = OMe

To a solution of tosylate OEG in Acetone (0.1 M) was added KI (2.0 equiv.). The yellow solution was heated to reflux for 16 h then cooled to RT. Acetone was removed and the crude residue was suspended in CH_2Cl_2. The white precipitate was filtered over Celite, the organic filtrate was washed with an aqueous solution of $Na_2S_2O_3$ (2.0 M), the aqueous layer was extracted with CH_2Cl_2 (three times), the combined organic layers were washed with brine, dried over Na_2SO_4, filtered and concentrated under reduced pressure to provide the corresponding iodide OEG.



22

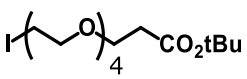
2.98 g isolated (9.4 mmol, 94%)

Physical state: yellow oil.

^{1}H NMR (300 MHz, $CDCl_3$): δ 3.76 (t, *J* = 6.8 Hz, 2H), 3.68—3.64 (m, 10H), 3.55 (t, *J* = 5.2 Hz, 2H), 3.38 (s, 3H), 3.26 (t, *J* = 7.1 Hz, 2H) ppm

TLC: R_f = 0.4 (100% EtOAc, phosphomolybdic acid).

Spectral data matches the literature. [5]



23

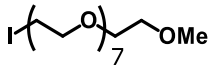
2.5 g isolated (5.8 mmol, 96%)

Physical state: yellow oil.

^{1}H NMR (300 MHz, $CDCl_3$): δ 3.74 (t, *J* = 6.8 Hz, 2H), 3.70 (t, *J* = 6.5 Hz, 2H), 3.65—3.59 (m, 12H), 3.25 (t, *J* = 7.2 Hz, 2H), 2.49 (t, *J* = 6.5 Hz, 2H), 1.43 (s, 9H) ppm

TLC: R_f = 0.8 (100% EtOAc, phosphomolybdic acid).

Spectral data matches the literature. [6]



25

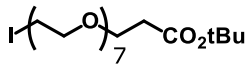
439.3 mg isolated (0.89 mmol, 89%)

Physical state: yellow oil.

^{1}H NMR (300 MHz, $CDCl_3$): δ 3.76 (t, *J* = 6.7 Hz, 2H), 3.67—3.64 (m, 29H), 3.55 (t, *J* = 5.0 Hz, 2H), 3.39 (s, 3H), 3.27 (t, *J* = 7.0 Hz, 2H) ppm

TLC: R_f = 0.3 (CH_2Cl_2/MeOH 96/4, phosphomolybdic acid).

Spectral data matches the literature. [4]



24

1.23 g isolated (2.0 mmol, 99%)

Physical state: yellow oil.

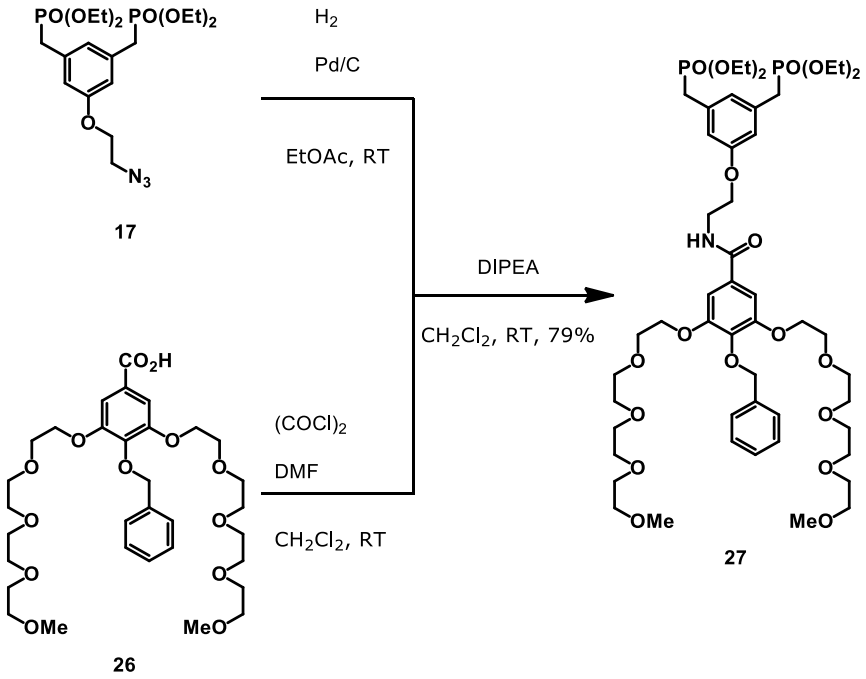
^{1}H NMR (500 MHz, $CDCl_3$): δ 3.77 (t, *J* = 6.6 Hz, 2H), 3.72 (t, *J* = 6.5 Hz, 2H), 3.67—3.60 (m, 27H), 3.27 (t, *J* = 7.0 Hz, 2H), 2.51 (t, *J* = 6.4 Hz, 2H), 1.46 (s, 9H) ppm

^{13}C NMR (125 MHz, $CDCl_3$): δ 170.9, 80.5, 72.0, 70.6, 70.5 (several peaks), 70.3, 70.2, 66.9, 36.2, 28.1, 2.9 ppm

TLC: R_f = 0.4 (CH_2Cl_2/MeOH 94/6, phosphomolybdic acid).

Part 1: Development of dendritic coating for plane surfaces

Compound 27



To a solution of **17** (2962.7 mg, 6.4 mmol, 1.1 equiv.) in EtOAc (60.0 mL) was added Pd/C 10% (680.4 mg, 0.6 mmol, 0.1 equiv.). The heterogeneous mixture was evacuated and backfilled with hydrogen (balloon) five times, then vigorously stirred at RT for 3 h, the catalyst was next filtered over Celite and the crude product was concentrated under reduced pressure *(Caution: the water bath must be kept at **ROOM TEMPERATURE**, a heating water bath will lead to decomposition of the crude primary amine)*. *In a separate flask*, **26**[2] (3724.0 mg, 5.8 mmol) was dissolved in CH_2Cl_2 (16.0 mL) before $(COCl)_2$ (1.5 mL, 17.4 mmol, 3.0 equiv.) and DMF (4 drops) were added. The yellow solution was stirred at RT for 3 h, then concentrated under reduced pressure to remove volatiles, dissolved in CH_2Cl_2 (40.0 mL) before a solution of the crude primary amine above in CH_2Cl_2 (20.0 mL) and DIPEA (2.3 mL, 13.3 mmol, 2.3 equiv.) were successively added. The yellow solution was stirred at RT for 16 h, then diluted with CH_2Cl_2 and brine. The aqueous layer was extracted with CH_2Cl_2 (five times), the combined organic layer was dried over Na_2SO_4, filtered and concentrated under reduced pressure. Purification by chromatography on silica gel (CH_2Cl_2/MeOH/EtOAc 80/8/12 to 6/4/0) afforded 4.9 g (4.6 mmol, 79%) of the title compound **27**.

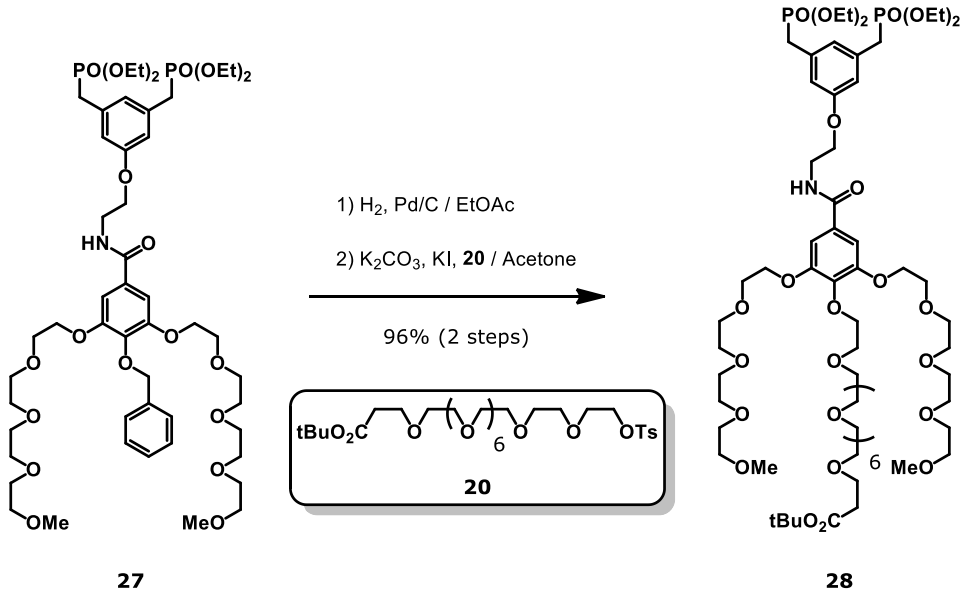
Physical state: yellow oil.

^{1}H NMR (300 MHz, $CDCl_3$): δ 7.49 (d, *J* = 7.9 Hz, 2H), 7.36—7.29 (m, 3H), 7.08 (s, 2H), 6.82—6.78 (m, 3H), 5.09 (s, 2h), 4.19 (t, *J* = 4.7 Hz, 4H), 4.13 (t, *J* = 4.8 Hz, 2H), 4.02 (qt, *J* = 7.2 Hz, 8H)**,** 3.86—3.80 (m, 6H), 3.71—3.48 (m, 24H), 3.35 (s, 6H), 3.08 (d, $^2J_{P\text{-}H}$ = 22.0 Hz, 4H), 1.25 (t, *J* = 7.0 Hz, 12H) ppm

TLC: R_f = 0.4 (CH_2Cl_2/MeOH 94/6, $KMnO_4$).

Spectral data matches the literature. [2]

Compound 28



To a solution of **27** (4871.1 mg, 4.6 mmol) in EtOAc (40.0 mL) was added Pd/C 10% (489.0 mg, 0.46 mmol, 0.1 equiv.). The heterogeneous mixture was evacuated and backfilled with hydrogen (balloon) five times, then vigorously stirred at RT for 5 h. The catalyst was next filtered over Celite, the crude product was concentrated under reduced pressure, then dissolved in Acetone (40.0 mL) before K_2CO_3 (952.6 mg, 6.9 mmol, 1.5 equiv.), KI (76.3 mg, 0.46 mmol, 0.1 equiv.) and **20** (3149.5 mg, 4.8 mmol, 1.05 equiv.) were added. The resulting solution was heated to reflux for 16 h, cooled to RT. The solvent was removed, the crude product was suspended in CH_2Cl_2, filtered over Celite and the crude product was concentrated under reduced pressure. Purification by chromatography on silica gel (CH_2Cl_2/MeOH/EtOAc 80/8/12 to 8/2/0) afforded 6.4 g (4.4 mmol, 96%) of the title compound **28**.

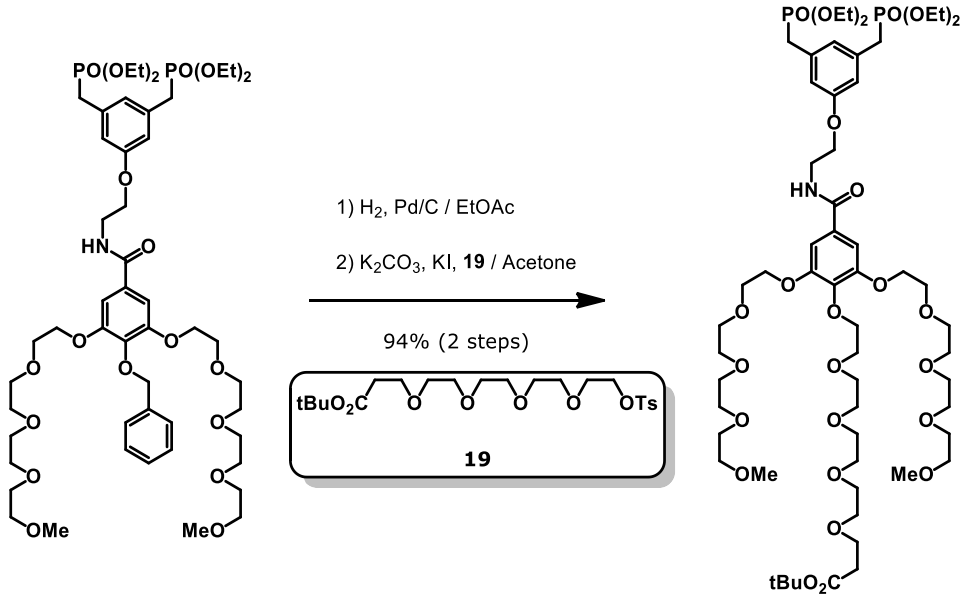
Physical state: yellow oil.

^{1}H NMR (500 MHz, $CDCl_3$): δ 7.11 (s, 2H), 6.88 (brs, 1H), 6.82 (s, 1H), 6.78 (d, *J* = 2.2 Hz, 1H), 4.22 (t, *J* = 4.7 Hz, 4H), 4.14 (t, *J* = 4.9 Hz, 2H), 4.02 (qt, *J* = 7.4 Hz, 8H), 3.85 (t, *J* = 5.1 Hz, 4H), 3.82—3.77 (m, 4H), 3.72—3.60 (m, 56H), 3.54—3.52 (m, 4H), 3.36 (s, 6H), 3.09 (d, $^2J_{P\text{-}H}$ = 22.3 Hz, 4H), 2.50 (t, *J* = 6.2 Hz, 2H), 1.44 (s, 9H), 1.25 (t, *J* = 7.2 Hz, 12H) ppm

TLC: R_f = 0.3 (CH_2Cl_2/MeOH 92/8, $KMnO_4$).

Spectral data matches the literature. [2]

Compound 29



To a solution of **27** (577.3 mg, 0.54 mmol) in EtOAc (20.0 mL) was added Pd/C 10% (58.0 mg, 1.0 mmol, 0.1 equiv.). The heterogeneous mixture was evacuated and backfilled with hydrogen (balloon) five times, then vigorously stirred at RT for 5 h. The catalyst was next filtered over Celite, the crude product was concentrated under reduced pressure, then dissolved in Acetone (20.0 mL) before K_2CO_3 (112.9 mg, 0.82 mmol, 1.5 equiv.), KI (9.0 mg, 0.05 mmol, 0.1 equiv.) and **19** (285.5 mg, 0.6 mmol, 1.1 equiv.) were added. The resulting solution was heated to reflux for 16 h, cooled to RT. The solvent was removed, the crude product was suspended in CH_2Cl_2, filtered over Celite and the crude product was concentrated under reduced pressure. Purification by chromatography on silica gel (CH_2Cl_2/MeOH/EtOAc 90/6/4 to 8/2/0) afforded 547.2 mg (0.43 mmol, 79%) of the title compound **29**.

Physical state: yellow oil.

^{1}H NMR (500 MHz, $CDCl_3$): δ 7.11 (s, 2H), 6.88 (brs, 1H), 6.82 (s, 1H), 6.78 (d, *J* = 2.2 Hz, 1H), 4.22 (t, *J* = 4.7 Hz, 4H), 4.14 (t, *J* = 4.9 Hz, 2H), 4.02 (qt, *J* = 7.4 Hz, 8H), 3.85 (t, *J* = 5.1 Hz, 4H), 3.82—3.77 (m, 4H), 3.72—3.60 (m, 56H), 3.54—3.52 (m, 4H), 3.36 (s, 6H), 3.09 (d, $^2J_{P\text{-}H}$ = 22.3 Hz, 4H), 2.50 (t, *J* = 6.2 Hz, 2H), 1.44 (s, 9H), 1.25 (t, *J* = 7.2 Hz, 12H) ppm

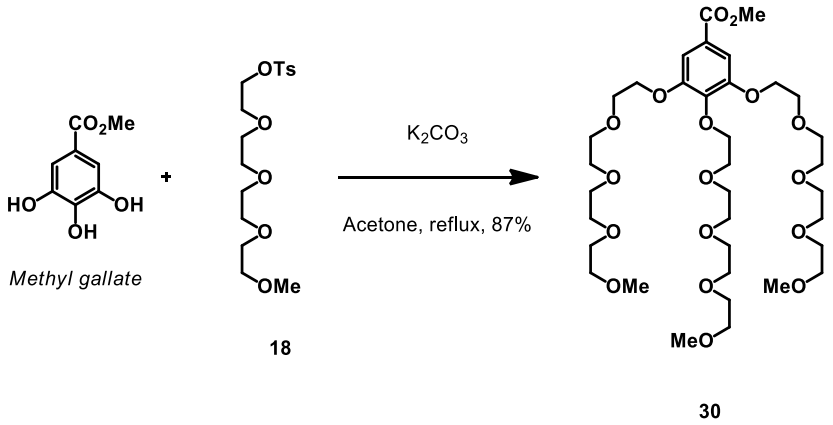
^{13}C NMR (125 MHz, $CDCl_3$): δ 170.9, 167.2, 152.4, 133.3, 129.5, 114.6, 107.3, 80.5, 72.3, 71.9, 70.6—70.5 (several peaks), 70.3, 69.7, 69.1, 66.9, 66.7, 62.1 (d, $^2J_{C\text{-}P}$ = 6.6 Hz), 59.0, 39.5, 36.2, 33.6 (d, $^1J_{C\text{-}P}$ = 138.4 Hz), 28.1, 16.4 (d, $^3J_{C\text{-}P}$ = 5.4 Hz) ppm

^{31}P NMR (202 MHz, $CDCl_3$): δ 26.0 ppm

MALDI-TOF: m/z calcd for $C_{58}H_{101}NO_{25}P_2Na$ $[M+Na]^+$ 1296.595, found 1296.590

TLC: R_f = 0.3 (CH_2Cl_2/MeOH 94/6, $KMnO_4$).

Compound 30



To a solution of Methyl gallate (1.8 g, 9.8 mmol) in Acetone (50.0 mL) were successively added K_2CO_3 (6.1 g, 44.1 mmol, 4.5 equiv.) then **18** (11.2 g, 30.9 mmol, 3.15 equiv.). The resulting solution was heated to reflux for 72 h, cooled to RT. The solvent was removed, then the residue was suspended in CH_2Cl_2, filtered over Celite and the crude product was concentrated under reduced pressure. Purification by chromatography on silica gel (100% EtOAc then CH_2Cl_2/MeOH 95/5 to 7/3) afforded 6.5 g (8.6 mmol, 87%) of the title compound **30**.

Physical state: brown oil.

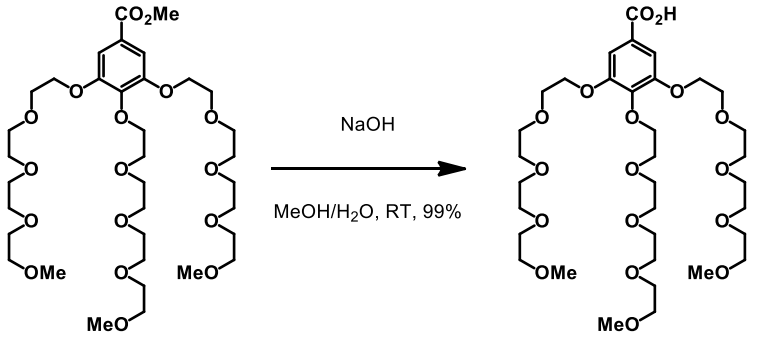
^{1}H NMR (500 MHz, $CDCl_3$): δ 7.27 (d, *J* = 2.0 Hz, 2H), 4.14 (t, *J* = 4.5 Hz, 2H), 4.12 (t, *J* = 5.3 Hz, 4H), 3.81 (s, 3H), 3.79 (t, *J* = 5.1 Hz, 2H), 3.72 (t, *J* = 4.8 Hz, 2H), 3.65—3.55 (m, 32H), 3.48—3.45 (m, 6H), 3.31 (s, 3H), 3.30 (s, 6H) ppm

^{13}C NMR (125 MHz, $CDCl_3$): δ 166.5, 152.2, 142.5, 124.9, 109.0, 72.4, 71.9, 70.8, 70.6—70.5 (several peaks), 69.6, 68.8, 59.0, 52.1 ppm

MALDI-TOF: m/z calcd for $C_{35}H_{62}O_{17}Na$ $[M+Na]^+$ 777.392, found 777.388

TLC: R_f = 0.5 (CH_2Cl_2/MeOH 95/5, phosphomolybdic acid).

Compound 31



30 **31**

To a solution of **30** (5.1 g, 6.9 mmol) in MeOH (18.0 mL) and H_2O (2.0 mL) at RT was added NaOH (1.4 g, 34.5 mmol, 5.0 equiv.). The yellow solution was stirred at RT for 16h, then MeOH was removed. The crude product was next dissolved in CH_2Cl_2 (30.0 mL) and an aqueous solution of HCl 2N (30.0 mL), stirred at RT for 15 min then poured into a separatory funnel. The aqueous layer was extracted with CH_2Cl_2 (five times), the combined organic layer was washed with brine, dried over Na_2SO_4, filtered and concentrated under reduced pressure to afford 5.1 g (6.8 mmol, 99%) of the title compound **31**.

Physical state: yellow oil.

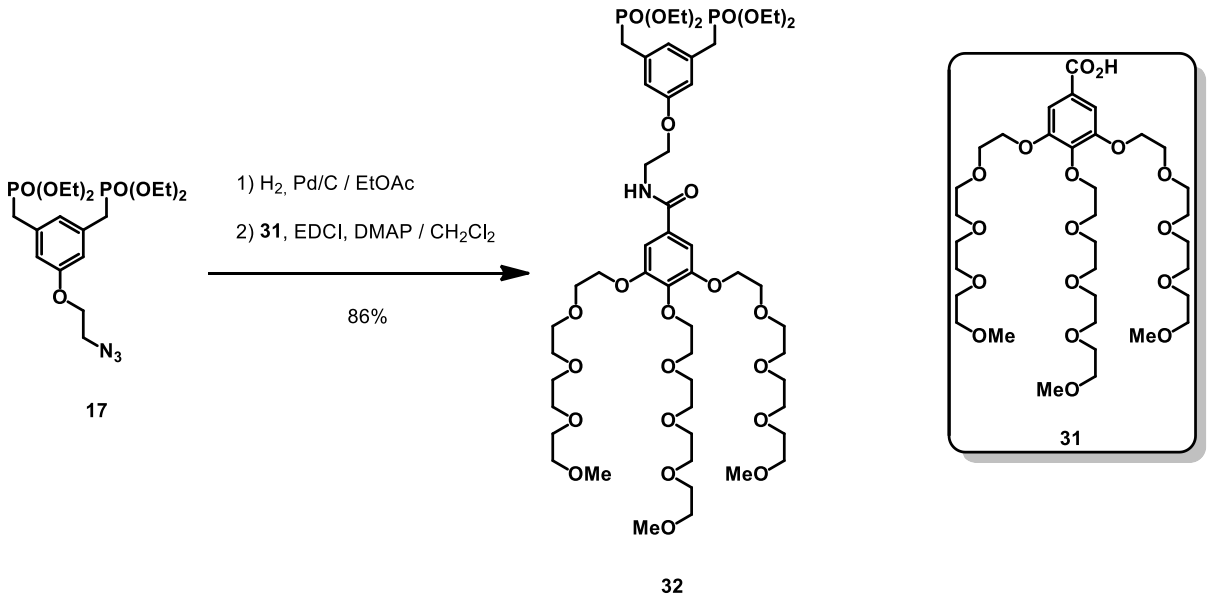
^{1}H NMR (500 MHz, $CDCl_3$): δ 7.37 (d, *J* = 2.5 Hz, 2H), 4.23 (t, *J* = 4.7 Hz, 2H), 4.21 (t, *J* = 4.9 Hz, 4H), 3.85 (t, *J* = 4.8 Hz, 4H), 3.79 (t, *J* = 4.9 Hz, 2H), 3.74—3.62 (m, 31H), 3.56—3.53 (m, 6H), 3.38 (s, 6H), 3.37 (s, 3H) ppm

^{13}C NMR (125 MHz, $CDCl_3$): δ 169.6, 152.3, 143.1, 124.3, 109.8, 72.5, 72.4, 71.9, 70.8, 70.6—70.5 (several peaks), 70.4, 70.3, 69.7, 68.9, 59.0, 58.9 ppm

MALDI-TOF: m/z calcd for $C_{34}H_{59}O_{17}$ $[M-H]^+$ 739.385, found 739.375

TLC: R_f = 0.2 (CH_2Cl_2/MeOH 95/5, phosphomolybdic acid).

Compound 32



To a solution of **17** (101.9 mg, 0.22 mmol, 1.1 equiv.) in EtOAc (4.0 mL) was added Pd/C 10% (21.3 mg, 0.02 mmol, 0. 1 equiv.). The heterogeneous mixture was evacuated and backfilled with hydrogen (balloon) five times, then vigorously stirred at RT for 3 h, the catalyst was next filtered over Celite and the crude product was concentrated under reduced pressure *(Caution: the water bath must be kept at **ROOM TEMPERATURE**, a heating water bath will lead to decomposition of the crude primary amine)*. The as obtained crude primary amine was then dissolved in CH_2Cl_2 (2.0 mL), transferred to a solution of **31** (148.2 mg, 0.2 mmol) in CH_2Cl_2 (2.0 mL) followed by addition of EDCI (46.0 mg, 0.24 mmol, 1.2 equiv.) and DMAP (2.4 mg, 0.02 mmol, 0.1 equiv.). The yellow solution was stirred at RT for 16 h, then diluted with CH_2Cl_2 and brine. The aqueous layer was extracted with CH_2Cl_2 (five times), the combined organic layer was dried over Na_2SO_4, filtered and concentrated under reduced pressure. Purification by chromatography on silica gel (CH_2Cl_2/MeOH 95/5 to 9/1) afforded 199.0 mg (0.17 mmol, 86%) of the title compound **32**.

Physical state: yellow oil.

^{1}H NMR (500 MHz, $CDCl_3$): δ 7.11 (s, 2H), 6.87 (t, *J* = 5.4 Hz, 1H), 6.82 (s, 1H), 6.78 (dd, *J* = 3.7, 2.1 Hz, 2H), 4.21 (t, *J* = 4.8 Hz, 4H), 4.19 (t, *J* = 4.8 Hz, 2H), 4.13 (t, *J* = 5.3 Hz, 2H), 4.02 (qt, *J* = 7.6 Hz, 8H), 3.8 (t, *J* = 5.1 Hz, 4H), 3.72—3.62 (m, 30H), 3.55—3.52 (m, 6H), 3.37 (s, 3H), 3.36 (s, 6H), 3.09 (d, $^2J_{P\text{-}H}$ = 21.6 Hz, 4H), 1.25 (t, *J* = 7.0 Hz, 12H) ppm

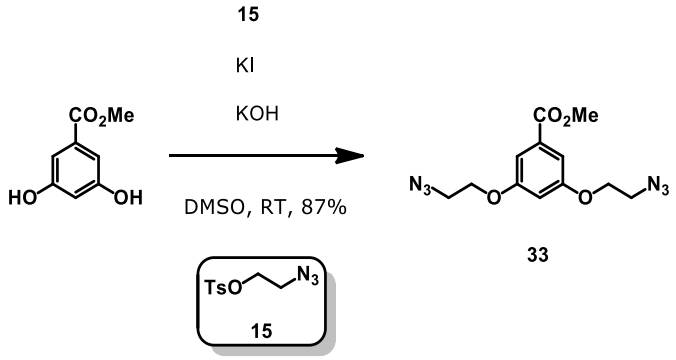
^{13}C NMR (125 MHz, $CDCl_3$): δ 167.2, 158.6 (t, $^4J_{C\text{-}P}$ = 3.3 Hz), 152.4, 141.5, 133.2 (d, $^2J_{C\text{-}P}$ = 6.2 Hz), 129.5, 124.1 (t, $^3J_{C\text{-}P}$ = 7.0 Hz) , 114.6 (t, $^3J_{C\text{-}P}$ = 4.5 Hz), 107.3, 72.3, 71.9, 70.6—70.4 (several peaks), 69.7, 69.1, 66.7, 62.1 (d, $^2J_{C\text{-}P}$ = 6.8 Hz), 59.0, 39.5, 33.6 (d, $^1J_{C\text{-}P}$ = 138.0 Hz), 16.4 (d, $^3J_{C\text{-}P}$ = 6.4 Hz) ppm

^{31}P NMR (202 MHz, $CDCl_3$): δ 26.0 ppm

MALDI-TOF: m/z calcd for $C_{52}H_{91}NO_{23}P_2Na$ $[M+Na]^+$ 1182.546, found 1182.548

TLC: R_f = 0.4 (CH_2Cl_2/MeOH 94/6, $KMnO_4$).

Compound 33



To a solution of Methyl-3,5-dihydroxybenzoate (866.8 mg, 5.0 mmol) in DMSO (50.0 mL) at RT were successively added KOH (840.0 mg, 15.0 mmol, 3.0 equiv.), KI (215.8 mg, 1.3 mmol, 0.2 equiv.) and **15** (2533.3 mg, 10.5 mmol, 2.1 equiv.). The yellow solution was stirred at RT for 16 h, then quenched with an aqueous solution of HCl 2N (50.0 mL) and diluted with EtOAc (30.0 mL). The aqueous layer was extracted with EtOAc (three times), the combined organic layers were washed with brine (five times), dried over Na_2SO_4, filtered and concentrated under reduced pressure. Purification by chromatography on silica gel (Cyclohexane/CH_2Cl_2/EtOAc 6/3/1) afforded 1.4 g (4.5 mmol, 87%) of the title compound **33**.

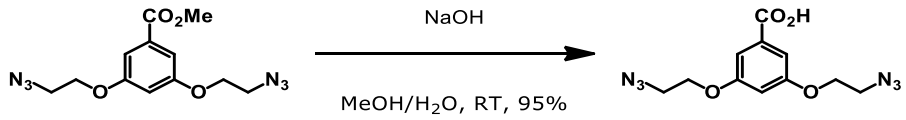
Physical state: colorless oil.

^{1}H NMR (300 MHz, $CDCl_3$): δ 7.28 (d, *J* = 2.3 Hz, 2H), 6.76 (d, *J* = 2.4 Hz, 1H), 4.23 (t, *J* = 4.8 Hz, 4H), 3.96 (s, 3H), 3.66 (t, *J* = 5.0 Hz, 4H) ppm

TLC: R_f = 0.2 (Cyclohexane/EtOAc 95/5, $KMnO_4$).

Spectral data matches the literature. [7]

Compound 34



33 **34**

To a solution of **33** (1.33 g, 4.3 mmol) in MeOH (18.0 mL) at RT were successively added NaOH (0.87 g, 21.7 mmol, 5.0 equiv.) and H_2O (2.0 mL). The yellow solution was stirred at RT for 16 h, then quenched with an aqueous solution of HCl 2N (15.0 mL) and diluted with EtOAc (30.0 mL). The aqueous layer was extracted with EtOAc (three times), the combined organic layers were washed with brine, dried over Na_2SO_4, filtered and concentrated under reduced pressure to afford 1.2 g (4.1 mmol, 95%) of the title compound **34**.

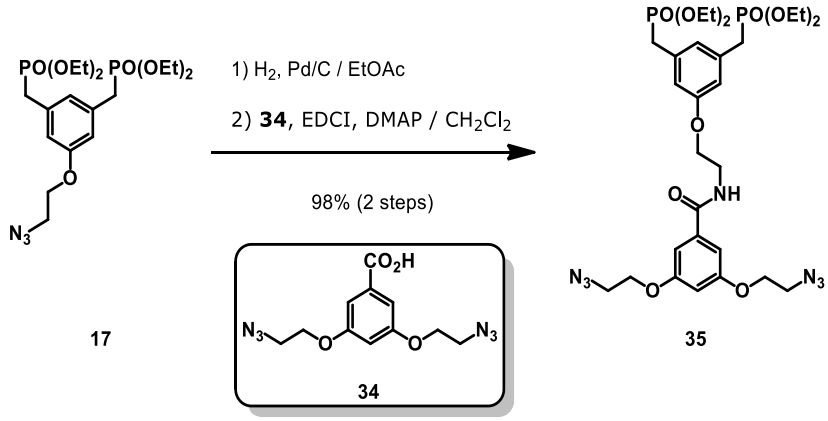
Physical state: white solid.

^{1}H NMR (300 MHz, $CDCl_3$): δ 7.30 (d, *J* = 2.2 Hz, 2H), 6.76 (d, *J* = 2.2 Hz, 1H), 4.20 (t, *J* = 5.0 Hz, 4H), 3.63 (t, *J* = 4.8 Hz, 4H) ppm

TLC: R_f = 0.2 (Cyclohexane/EtOAc 8/2, $KMnO_4$).

Spectral data matches the literature. [7]

Compound 35



To a solution of **17** (2103.5 mg, 4.5 mmol, 1.1 equiv.) in EtOAc (20.0 mL) at RT was added Pd/C 10% (242.0 mg, 0.2 mmol, 0.05 equiv.). The heterogeneous solution was evacuated and backfilled with an atmosphere of hydrogen (balloon), vigorously stirred at RT for 5 h, then the catalyst was filtered off over Celite and the crude product was concentrated under reduced pressure *(Caution: the water bath must be kept at **ROOM TEMPERATURE**, a heating water bath will lead to decomposition of the crude primary amine)*. *In a separate flask*, **34** (1206.0 mg, 4.1 mmol) was dissolved in CH_2Cl_2 (15.0 mL) before EDCI (943.2 mg, 4.9 mmol, 1.2 equiv.) and DMAP (4.9 mg, 0.41 mmol, 0.1 equiv.) were added. The resulting solution was stirred at RT for 15 min, before the crude primary amine was added as a solution of CH_2Cl_2 (5.0 mL). The yellow solution was stirred at RT for 16 h, then concentrated under reduced pressure. The crude residue was purified by chromatography on silica gel (CH_2Cl_2/MeOH 95/5 to 9/1) to afford 2.9 g (4.1 mmol, 98%) of the title compound **35**.

Physical state: yellow viscous oil.

^{1}H NMR (500 MHz, $CDCl_3$): δ 6.96 (d, *J* = 2.1 Hz, 2H), 6.82 (s, 1H), 6.78 (dd, *J* = 3.6, 2.1 Hz, 2H), 6.64 (brs, 1H), 6.62 (t, *J* = 2.2 Hz, 1H), 4.18 (t, *J* = 4.8 Hz, 4H), 4.13 (t, *J* = 5.0 Hz, 2H), 4.02 (qt, *J* = 7.8 Hz, 8H), 3.82 (q, *J* = 5.0 Hz, 2H), 3.60 (t, *J* = 5.0 Hz, 4H), 3.09 (d, $^2J_{P\text{-}H}$ = 21.9 Hz, 4H), 1.25 (t, *J* = 7.0 Hz, 12H) ppm

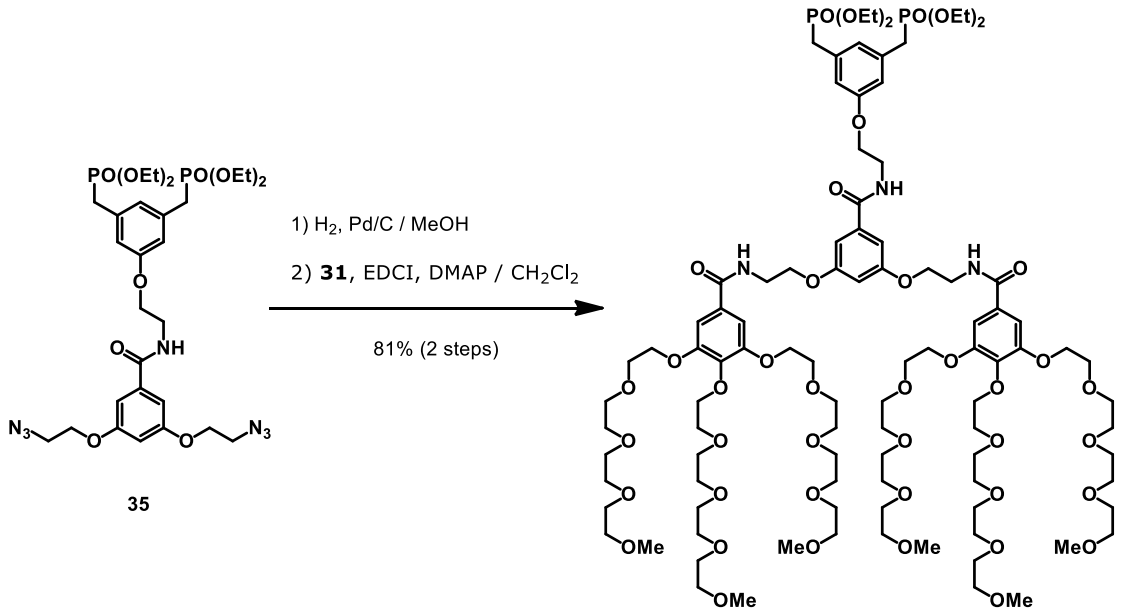
^{13}C NMR (500 MHz, $CDCl_3$): δ 167.0, 159.5, 158.5, 136.8, 133.3 (d, $^2J_{C\text{-}P}$ = 11.0 Hz), 124.2 (t, $^3J_{C\text{-}P}$ = 6.3 Hz), 114.6 (t, $^3J_{C\text{-}P}$ = 5.0 Hz), 106.1, 104.9, 67.2, 66.7, 62.1 (d, $^2J_{C\text{-}P}$ = 6.9 Hz), 39.5, 33.6 (d, $^1J_{C\text{-}P}$ = 138.1 Hz), 16.4 (d, $^1J_{C\text{-}P}$ = 6.3 Hz) ppm

^{31}P NMR (202 MHz, $CDCl_3$): δ 26.0 ppm

MALDI-TOF: m/z calcd for $C_{29}H_{44}N_7O_{10}P_2$ $[M+H]^+$ 712.257, found 712.262

TLC: R_f = 0.3 (CH_2Cl_2/MeOH 96/4, $KMnO_4$).

Compound 36



To a solution of **35** (711.6 mg, 1.0 mmol) in MeOH (10.0 mL) at RT was added Pd/C 10% (106.4 mg, 0.1 mmol, 0.1 equiv.). The heterogeneous solution was evacuated and backfilled with an atmosphere of hydrogen (balloon), vigorously stirred at RT for 5 h, then the catalyst was filtered off over Celite and the crude product was concentrated under reduced pressure. *In a separate flask*, **31** (1481.3 mg, 2.0 mmol, 2.0 equiv.) was dissolved in CH_2Cl_2 (6.0 mL) before EDCI (460.0 mg, 2.4 mmol, 2.4 equiv.) and DMAP (24.4 mg, 0.2 mmol, 0.2 equiv.) were added. The resulting solution was stirred at RT for 15 min, before the crude primary amine was added as a solution of CH_2Cl_2 (4.0 mL). The yellow solution was stirred at RT for 48 h, then diluted with CH_2Cl_2 and brine. The aqueous layer was extracted with CH_2Cl_2 (five times), the combined organic layer was dried over Na_2SO_4, filtered and concentrated under reduced pressure. The crude residue was purified by chromatography on silica gel (CH_2Cl_2/MeOH/EtOAc 7/2/1 to 7/3/0) to afford 1.7 g (0.8 mmol, 81%) of the title compound **36**.

Physical state: yellow oil.

^{1}H NMR (500 MHz, CD_3OD-*d*$_4$): δ 7.24—7.20 (m, 4H), 7.07 (d, 2H), 6.86 (s, 3H), 6.78 (s, 1H), 4.24—4.17 (m, 18H), 4.04 (qt, *J* = 7.1 Hz, 8H), 3.88 (t, *J* = 4.4 Hz, 8H), 3.80—3.60 (m, 74H), 3.53—3.51 (m, 12H), 3.33 (s, 18H), 3.21 (d, $^2J_{P\text{-}H}$ = 21.7 Hz, 4H), 1.26 (t, *J* = 6.8 Hz, 12H) ppm

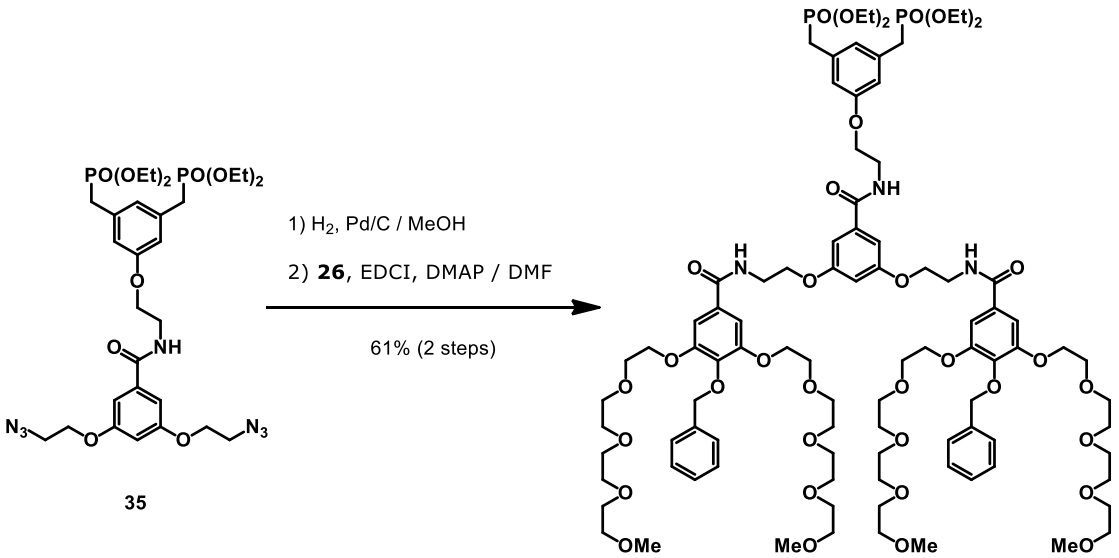
^{13}C NMR (500 MHz, CD_3OD-*d*$_4$): δ 168.3, 160.0, 152.2, 136.2, 133.0 (d, $^2J_{C\text{-}P}$ = 11.8 Hz), 129.4, 123.8 (t, $^3J_{C\text{-}P}$ = 6.6 Hz), 114.6 (t, $^3J_{C\text{-}P}$ = 4.8 Hz), 109.2, 107.8, 106.3, 104.4, 73.3, 72.3, 71.5 (several peaks), 70.6, 69.9, 67.7, 67.4, 63.7 (t, $^2J_{C\text{-}P}$ = 7.2 Hz), 59.1, 50.7, 33.6 (d, $^1J_{C\text{-}P}$ = 136.5 Hz), 16.7 (d, $^3J_{C\text{-}P}$ = 4.5 Hz) ppm

^{31}P NMR (202 MHz, CD_3OD-*d*$_4$): δ 27.2 ppm

MALDI-TOF: m/z calcd for $C_{97}H_{163}N_3O_{42}P_2Na$ $[M+Na]^+$ 2127.019, found 2127.022

TLC: R_f = 0.3 (CH_2Cl_2/MeOH 9/1, $KMnO_4$).

Compound 37



To a solution of **35** (711.6 mg, 1.0 mmol) in MeOH (8.0 mL) at RT was added Pd/C 10% (53.2 mg, 0.05 mmol, 0.05 equiv.). The heterogeneous solution was evacuated and backfilled with an atmosphere of hydrogen (balloon), vigorously stirred at RT for 5 h, then the catalyst was filtered off over Celite and the crude product was concentrate under reduced pressure. *In a separate flask*, **26** (1281.4 mg, 2.0 mmol, 2.0 equiv.) was dissolved in DMF (2.0 mL) before EDCI (575.1 mg, 3.0 mmol, 3.0 equiv.) and DMAP (24.4 mg, 0.2 mmol, 0.2 equiv.) were added. The resulting solution was stirred at RT for 15 min, before the crude primary amine was added as a solution of DMF (2.0 mL). The yellow solution was stirred at RT for 48 h, then diluted with CH_2Cl_2 and brine. The aqueous layer was extracted with CH_2Cl_2 (five times), the combined organic layer was dried over Na_2SO_4, filtered and concentrated under reduced pressure. The crude residue was purified by chromatography on silica gel (CH_2Cl_2/MeOH/EtOAc 80/4/16 to 80/8/12 to 9/1/0 to 7/3/0) to afford 1.2 g (0.6 mmol, 61%) of the title compound **37**.

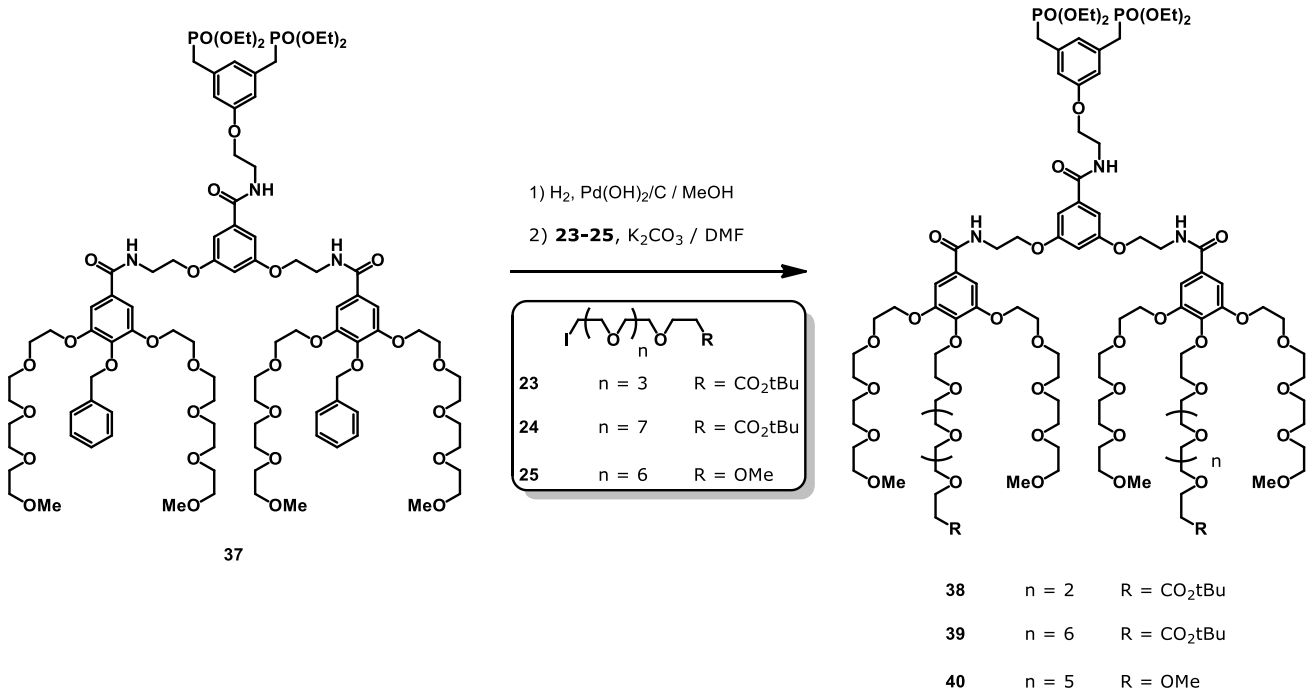
Physical state: yellow viscous oil.

^{1}H NMR (300 MHz, $CDCl_3$): δ 7.47 (d, *J* = 6.8 Hz, 4H), 7.34—7.29 (m, 7H), 7.10—7.02 (m, 8H), 6.80—6.76 (m, 3H), 6.66 (s, 1H), 5.08 (s, 4H), 4.22—4.11 (m, 18H), 4.02 (qt, *J* = 7.2 Hz, 8H), 3.81—3.49 (m, 72H), 3.33 (s, 12H), 3.10 (d, $^2J_{P\text{-}H}$ = 21.2 Hz, 4H), 1.24 (t, *J* = 6.9 Hz, 12H) ppm

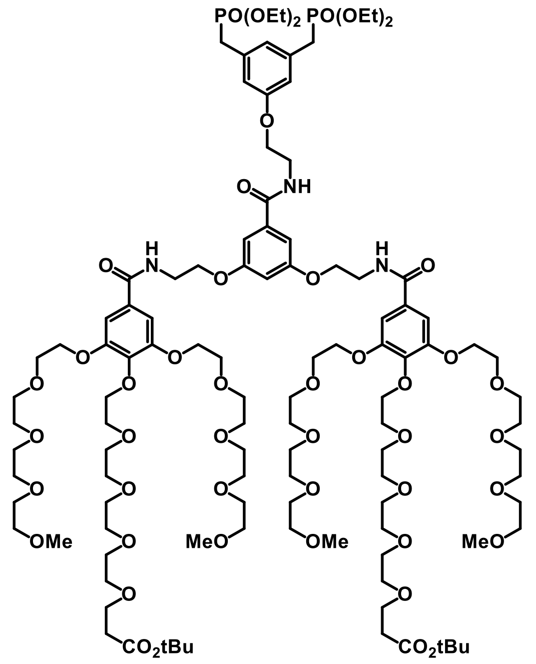
TLC: R_f = 0.4 (CH_2Cl_2/MeOH 9/1, $KMnO_4$).

Spectral data matches the literature. [2]

General procedure for synthesis of dendron 38-10 with OEG 23—25



To a solution of dendron **37** in MeOH was added $Pd(OH)_2/C$ 20% (0.15 equiv.). The heterogeneous solution was evacuated and backfilled with an atmosphere of hydrogen (balloon), vigorously stirred at RT for 16 h, then the catalyst was filtered off over Celite and the crude product was concentrate under reduced pressure. The crude phenol was next dissolved in DMF (0.05 M) before K_2CO_3 (6.0 equiv.) and the corresponding OEG (**23**—**25**, 2.4 equiv.) were added. The resulting solution was heated to 80 °C for 48 h, cooled to RT, then diluted with CH_2Cl_2 and brine. The aqueous layer was extracted with CH_2Cl_2 (five times), the combined organic layer was dried over Na_2SO_4, filtered and concentrated under reduced pressure. Purification by reverse phase C_{18} chromatography afforded the desired dendron **38**—**40**.



38

Obtained from OEG **23**, 116.1 mg isolated (0.05 mmol, 73%)

Eluents: CH_3CN/H_2O + 0.1% TFA 6/4 to 1/0.

Physical state: light yellow oil.

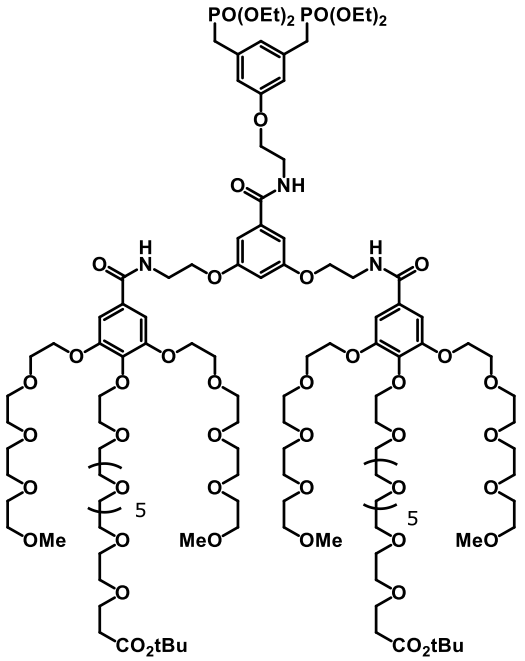
^{1}H NMR (500 MHz, CD_3OD-*d_4*): δ 7.18 (s, 4H), 7.04 (d, *J* = 2.1 Hz, 2H), 6.83 (t, *J* = 2.1 Hz, 3H), 6.76 (t, *J* = 2.1 Hz, 1H), 4.21—4.18 (m, 14H), 4.01 (qt, *J* = 7.2 Hz, 8H), 3.85 (t, *J* = 4.5 Hz, 8H), 3.79 (t, *J* = 4.7 Hz, 4H), 3.76—3.73 (m, 7H), 3.70—3.57 (m, 80H), 3.50—3.48 (m, 8H), 3.31 (s, 12H), 3.17 (d, $^2J_{P\text{-}H}$ = 21.7 Hz, 4H), 2.45 (t, *J* = 6.2 Hz, 4H), 1.43 (s, 18H), 1.24 (t, *J* = 7.0 Hz, 12H) ppm

^{13}C NMR (125 MHz, CD_3OD-*d_4*): δ 172.7, 169.5, 161.4, 153.7, 142.3, 137.5, 130.4, 115.9, 107.9, 107.2, 81.7, 73.5, 72.4, 71.7, 71.6, 71.5 (several peaks), 71.4, 71.3, 70.7, 70.0, 67.8, 67.7, 67.4, 63.7 ($^2J_{P\text{-}C}$ = 7.3 Hz), 59.1, 43.7, 40.6, 37.2, 33.6 ($^1J_{P\text{-}C}$ = 139.0 Hz), 28.3, 16.7 ($^3J_{P\text{-}C}$ = 5.5 Hz) ppm

^{31}P NMR (202 MHz, CD_3OD-*d_4*): δ 27.2 ppm

MALDI-TOF: m/z calcd for $C_{109}H_{183}N_3O_{46}P_2Na$ $[M+Na]^+$ 2355.144, found 2355.150

TLC: R_f = 0.3 (CH_2Cl_2/MeOH 9/1, phosphomolybdic acid).



39

Obtained from OEG **24**, 585.8 mg isolated (0.23 mmol, 73%)

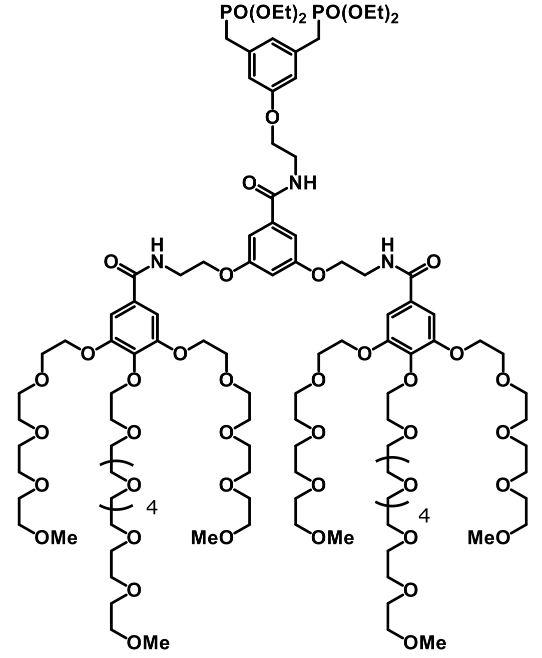
Eluents: CH_3CN/H_2O + 0.1% TFA 1/1 to 1/0.

Physical state: light yellow oil.

^{1}H NMR (300 MHz, CD_3OD-*d*$_4$): δ 7.26 (s, 4H), 7.11 (d, *J* = 2.2 Hz, 2H), 6.90 (t, *J* = 2.3 Hz, 3H), 6.84 (t, *J* = 2.2 Hz, 1H), 4.26—4.21 (m, 18H), 4.08 (qt, *J* = 7.3 Hz, 8H), 3.85 (t, *J* = 4.5 Hz, 8H), 3.93—3.54 (m, 144H), 3.38 (s, 12H), 3.24 (d, $^2J_{P\text{-}H}$ = 22.1 Hz, 4H), 2.52 (t, *J* = 6.5 Hz, 4H), 1.51 (s, 18H), 1.31 (t, *J* = 7.6 Hz, 12H) ppm

TLC: R_f = 0.4 (CH_2Cl_2/MeOH 86/14, phosphomolybdic acid).

Spectral data matches the literature. [2]



40

Obtained from OEG **25**, 75.2 mg isolated (0.03 mmol, 44%)

Eluents: CH_3CN/H_2O + 0.1% TFA 1/1 to 6/4.

Physical state: light yellow oil.

^{1}H NMR (500 MHz, CD_3OD-*d_4*): δ 7.22 (d, *J* = 1,2 Hz, 4H), 7.04 (d, *J* = 2.2 Hz, 2H), 6.83 (t, *J* = 2.0 Hz, 3H), 6.76 (t, *J* = 2.1 Hz, 1H), 4.25—4.21 (m, 10H), 4.19 (t, *J* = 5.7 Hz, 4H), 4.15 (t, *J* = 5.5 Hz, 2H), 4.01 (qt, *J* = 7.1 Hz, 8H), 3.86 (t, *J* = 4.4 Hz, 8H), 3.77—3.48 (m, 136H), 3.33 (s, 6H), 3.31 (s, 12H), 3.31 (s, 12H), 3.17 (d, $^2J_{P\text{-}H}$ = 21.8 Hz, 4H), 1.23 (t, *J* = 7.1 Hz, 12H) ppm

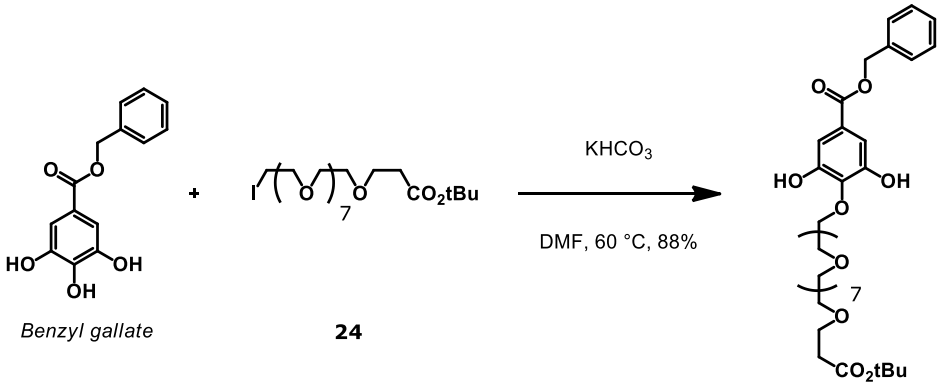
^{13}C NMR (125 MHz, CD_3OD-*d_4*): δ 169.8, 169.5, 161.5, 153.7, 137.7, 134.4, 131.1, 116.0, 107.3, 105.9, 73.5, 72.9, 72.8, 71.5, 71.4, 71.4, 71.2, 71.1 (several peaks), 71.0, 70.5, 69.5, 67.7, 67.4, 63.7 ($^2J_{P\text{-}C}$ = 7.4 Hz), 61.9, 59.1, 59.0, 43.9, 40.7, 33.6 ($^1J_{P\text{-}C}$ = 137.0 Hz), 16.7 ($^3J_{P\text{-}C}$ = 5.9 Hz) ppm

^{31}P NMR (202 MHz, CD_3O-*d_4*): δ 27.2 ppm

MALDI-TOF: m/z calcd for $C_{101}H_{171}N_3O_{44}P_2Na$ $[M+Na]^+$ 2215.069, found 2215.059

TLC: R_f = 0.3 (CH_2Cl_2/MeOH 9/1, phosphomolybdic acid).

Compound 41



Benzyl gallate **24** **41**

To a solution of **Benzyl gallate** (102.8 mg, 0.4 mmol, 1.3 equiv.) in DMF (2.0 mL) at RT were added $KHCO_3$ (78.1 mg, 0.8 mmol, 3.9 equiv.) and **24** (121.6 mg, 0.2 mmol). The resulting solution was heated to 60 °C for 16 h, cooled to RT, quenched with an aqueous solution of HCl 2N (2.0 mL). The aqueous layer was extracted with EtOAc, the combined organic layers were washed with brine (five times), dried over Na_2SO_4, filtered and concentrated under reduced pressure. The crude residue was purified by chromatography on silica gel (CH_2Cl_2/MeOH 96/4 to 92/8) to afford 130.6 mg (0.18 mmol, 88%) of the title compound **41**.

Physical state: brown oil.

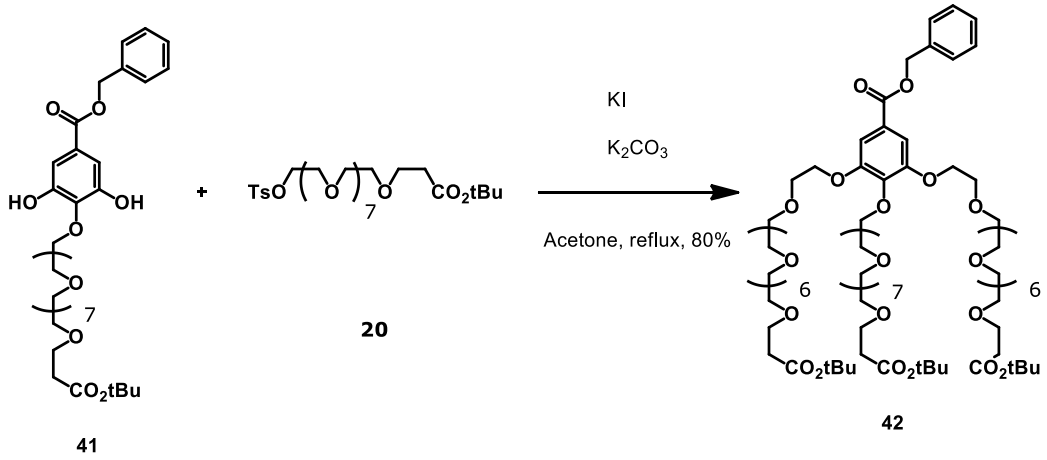
^{1}H NMR (500 MHz, $CDCl_3$): δ 7.42 (d, *J* = 7.2 Hz, 2H), 7.37 (d, *J* = 7.6 Hz, 2H), 7.32 (td, *J* = 7.3, 1.3 Hz, 1H), 7.20 (d, *J* = 1.1 Hz, 2H), 7.17—7.13 (brs, 2H), 5.30 (s, 2H), 4.20—4.18 (m, 2H), 3.84—3.82 (m, 2H), 3.79—3.7 (m, 2H), 3.72—3.57 (m, 32H), 2.48 (t, *J* = 6.7 Hz, 2H), 1.43 (s, 9H) ppm

^{13}C NMR (125 MHz, $CDCl_3$): δ 174.0, 166.0, 149.8, 138.1, 136.1, 128.5, 128.1, 128.0, 126.6, 109.6, 80.5, 73.5, 70.7, 70.6, 70.5—70.4 (several peaks), 70.3, 70.0, 66.8, 66.5, 36.2, 28.0 ppm

MALDI-TOF: m/z calcd for $C_{37}H_{57}O_{15}$ $[M+H]^+$ 741.367, found 741.350

TLC: R_f = 0.3 (CH_2Cl_2/MeOH 94/6, $KMnO_4$).

Compound 42



41 **20** **42**

To a solution of **41** (130.6 mg, 0.18 mmol) in Acetone (4.0 mL) at RT were added K_2CO_3 (74.6 mg, 0.54 mmol, 3.0 equiv.), KI (2.9 mg, 0.02 mmol, 0.1 equiv.) and **20** (241.5 mg, 0.37 mmol, 2.1 equiv.). The resulting solution was heated to reflux for 36 h, cooled to RT. The solvent was removed, the crude residue was next suspended in CH_2Cl_2, filtered over Celite and concentrated under reduced pressure. The crude residue was purified by reverse phase C_{18} chromatography (CH_3CN/H_2O + 1% TFA 6/4 to 7/3) to afford 241.5 mg (0.14 mmol, 80%) of the title compound **42**.

Physical state: brown oil.

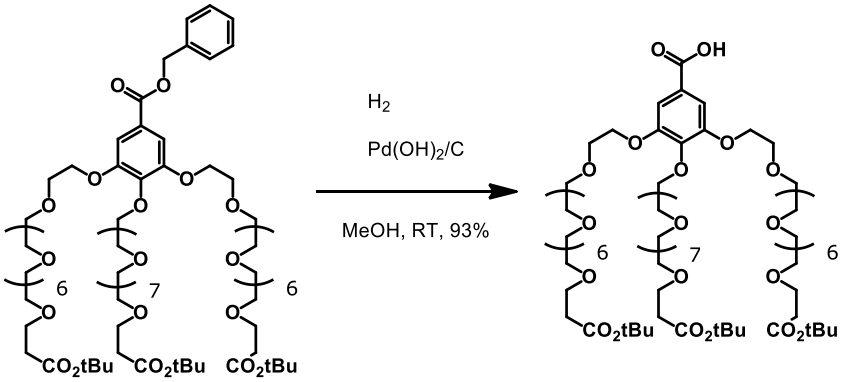
^{1}H NMR (500 MHz, $CDCl_3$): δ 7.41 (dd, *J* = 7.8, 1.5 Hz, 2H), 7.37 (td, *J* = 7.2, 2.4 Hz, 2H), 7.34—7.33 (m, 1H), 7.31 (s, 2H), 5230 (s, 2H), 4.19 (t, *J* = 4.9 Hz, 2H), 4.16 (t, *J* = 4.9 Hz, 4H), 3.83 (t, *J* = 5.0 Hz, 4H), 3.77 (t, *J* = 4.9 Hz, 2H), 3.71—3.59 (m, 96H), 2.49 (t, *J* = 6.5 Hz, 6H), 1.43 (s, 9H) ppm

^{13}C NMR (125 MHz, $CDCl_3$): δ 171.0, 165.9, 158.7, 152.3, 142.7, 136.0, 128.6, 128.2, 125.0, 109.2, 80.6, 72.4, 70.7, 70.6—70.4 (several peaks), 70.3, 69.6, 68.8, 66.9, 66.8, 36.2, 28.1 ppm

MALDI-TOF: m/z calcd for $C_{83}H_{144}O_{35}Na$ $[M+Na]^+$ 1723.951, found 1723.940

TLC: R_f = 0.3 (CH_2Cl_2/MeOH 94/6, $KMnO_4$).

Compound 43



42 43

To a solution of **42** (241.5 mg, 0.14 mmol) in MeOH (4.0 mL) at RT was added $Pd(OH)_2/C$ 20% (9.8 mg, 0.01 mmol, 0.1 equiv.). The heterogeneous solution was evacuated and backfilled with an atmosphere of hydrogen (balloon), vigorously stirred at RT for 5 h, then the catalyst was filtered off over Celite and the crude product was concentrated under reduced pressure to afford 212.4 mg (0.13 mmol, 93%) of the title compound **43**.

Physical state: yellow oil.

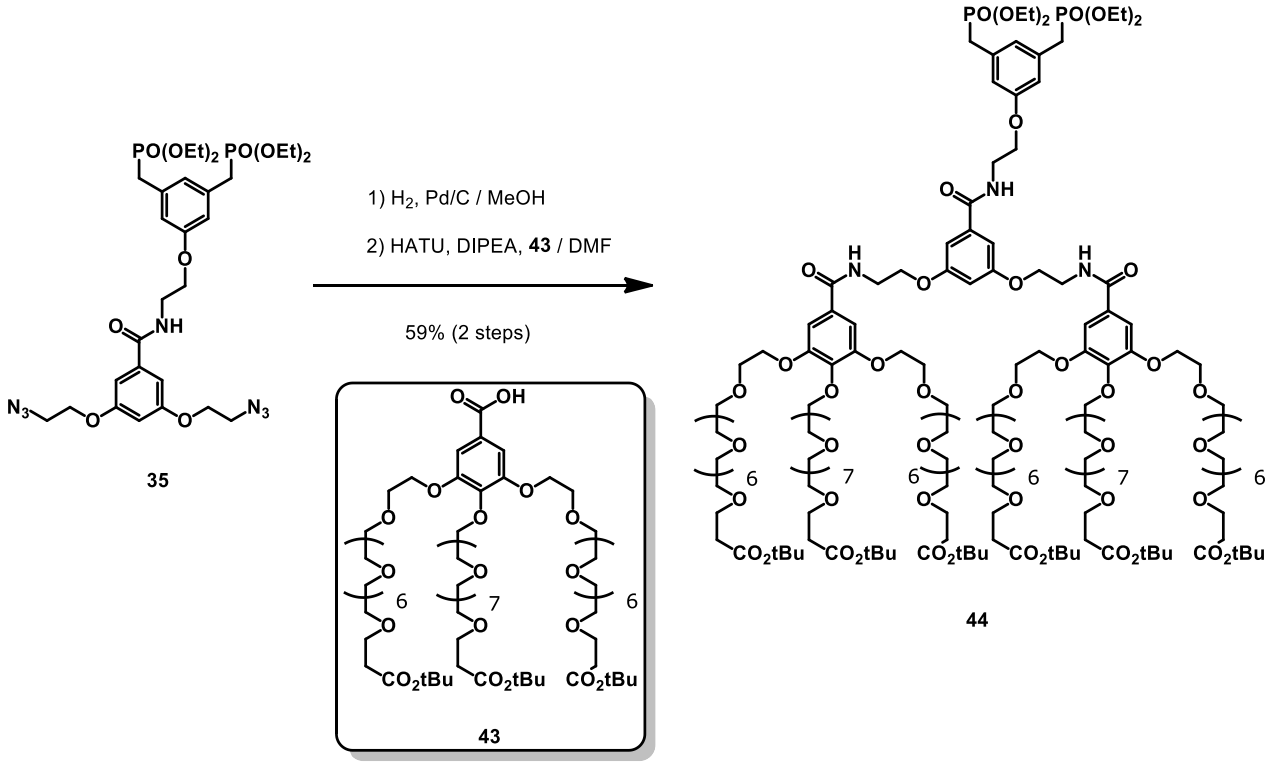
^{1}H NMR (500 MHz, $CDCl_3$): δ 7.35 (s, 2H), 4.22 (t, *J* = 4.9 Hz, 2H), 4.20 (t, *J* = 4.8 Hz, 4H), 3.83 (t, *J* = 5.1 Hz, 6H), 3.77 (t, *J* = 4.9 Hz, 2H), 3.71—3.60 (m, 94H), 2.49 (t, *J* = 6.4 Hz, 6H), 1.43 (s, 9H) ppm

^{13}C NMR (125 MHz, $CDCl_3$): δ 171.0, 167.8, 152.2, 142.8, 124.9, 109.7, 80.6, 72.5, 70.8, 70.6—70.4 (several peaks), 70.3, 69.7, 68.9, 66.9, 36.2, 28.1 ppm

MALDI-TOF: m/z calcd for $C_{76}H_{137}O_{35}$ $[M-H]^+$ 1609.900, found 1609.891

TLC: R_f = 0.1 (CH_2Cl_2/MeOH 94/6, $KMnO_4$).

Compound 44



To a solution of **35** (42.1 mg, 0.06 mmol) in MeOH (4.0 mL) at RT was added Pd/C 10% (12.6 mg, 0.01 mmol, 0.2 equiv.). The heterogeneous solution was evacuated and backfilled with an atmosphere of hydrogen (balloon), vigorously stirred at RT for 5 h, then the catalyst was filtered off over Celite and the crude product was concentrated under reduced pressure. The crude primary amine was next dissolved in DMF (1.0 mL) before **43** (219.3 mg, 0.13 mmol, 2.2 equiv.), HATU (67.5 mg, 0.18 mmol, 3.0 equiv.) and DIPEA (90.0 µl, 0.54 mmol, 9.0 equiv.) were added. The resulting solution was stirred at RT for 40 h, then diluted with CH_2Cl_2 and brine. The aqueous layer was extracted with CH_2Cl_2 (five times), the combined organic layer was dried over Na_2SO_4, filtered and concentrated under reduced pressure. Purification by reverse phase C_{18} chromatography (CH_3CN/H_2O + 1% TFA 9/1 to 1/0) afforded 130.7 mg (0.03 mmol, 59%) of the title compound **44**.

Physical state: yellow oil.

^{1}H NMR (500 MHz, CD_3OD-*d*$_4$): δ 7.21 (s, 4H), 7.06 (d, *J* = 2.1 Hz, 2H), 6.84 (t, *J* = 2.1 Hz, 3H), 6.7 (t, *J* = 1.8 Hz, 1H), 4.21 (t, *J* = 5.0 Hz, 16H), 4.16 (t, *J* = 5.5 Hz, 2H), 4.02 (qt, *J* = 7.2 Hz, 8H), 3.86 (t, *J* = 4.7 Hz, 8H), 3.79 (t, *J* = 4.6 Hz, 4H), 3.77—3.57 (m, 188H), 3.19 (d, $^2J_{P\text{-}H}$ =22.0 Hz, 4H), 2.46 (t, *J* = 5.9 Hz, 12H), 1.44 (s, 54H), 1.24 (t, *J* = 7.0 Hz, 12H) ppm

^{13}C NMR (125 MHz, CD_3OD-*d_4*): δ 172.7, 169.6, 161.5, 153.8, 142.4, 137.7, 134.5, 130.5, 120.7, 116.0, 108.0, 107.3, 105.9, 81.6, 73.6, 71.7, 71.6, 71.5 (several peaks), 71.4, 70.8, 70.1, 67.9, 63.7, 40.7, 37.2, 28.4, 16.7 ppm

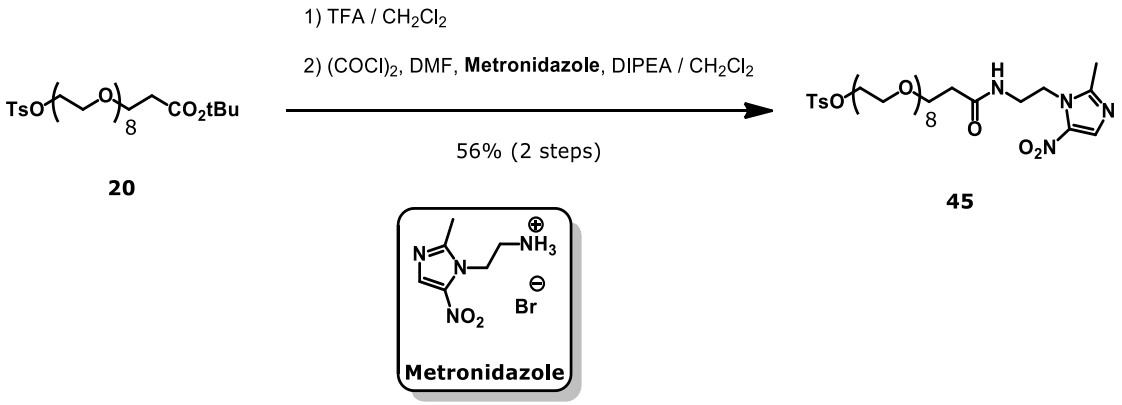
^{31}P NMR (202 MHz, CD_3OD-*d_4*): δ 27.2 ppm

MALDI-TOF: m/z calcd for $C_{177}H_{311}N_3O_{76}P_2Na$ $[M+Na]^+$ 3779.992, found 3779.720

TLC: R_f = 0.2 (CH_2Cl_2/MeOH 8/2, $KMnO_4$).

Part 2: Development of dendritic coating for metallic oxide nanoparticles

Compound 45



To a solution of **20** (1347.4 mg, 2.1 mmol) in CH_2Cl_2 (20.0 mL) at RT was added TFA (1.3 mL, 16.5 mmol, 8.0 equiv.). The resulting solution was stirred at RT for 16 h, then concentrated under reduced pressure. The crude carboxylic acid was next dissolved in CH_2Cl_2 before $(COCl)_2$ (0.5 mL, 5.9 mmol, 2.8 equiv.) and DMF (4 drops) were added at RT. The yellow solution was stirred at RT for 4 h, then concentrated under reduced pressure. The acyl chloride was next dissolved in CH_2Cl_2 before **Metronidazole**[8] (529.0 mg, 2.1 mmol, 1.02 equiv.) and DIPEA (5.0 mL, 28.7 mmol, 13.7 equiv.) were added at RT. The resulting solution was stirred at RT for 16 h, then concentrated under reduced pressure. The crude residue was purified by reverse phase C_{18} chromatography (CH_3CN/H_2O + 1% TFA 3/7 to 4/6 to 1/1) to afford 870.0 mg (1.16 mmol, 56%) of the title compound **45**.

Physical state: brown oil.

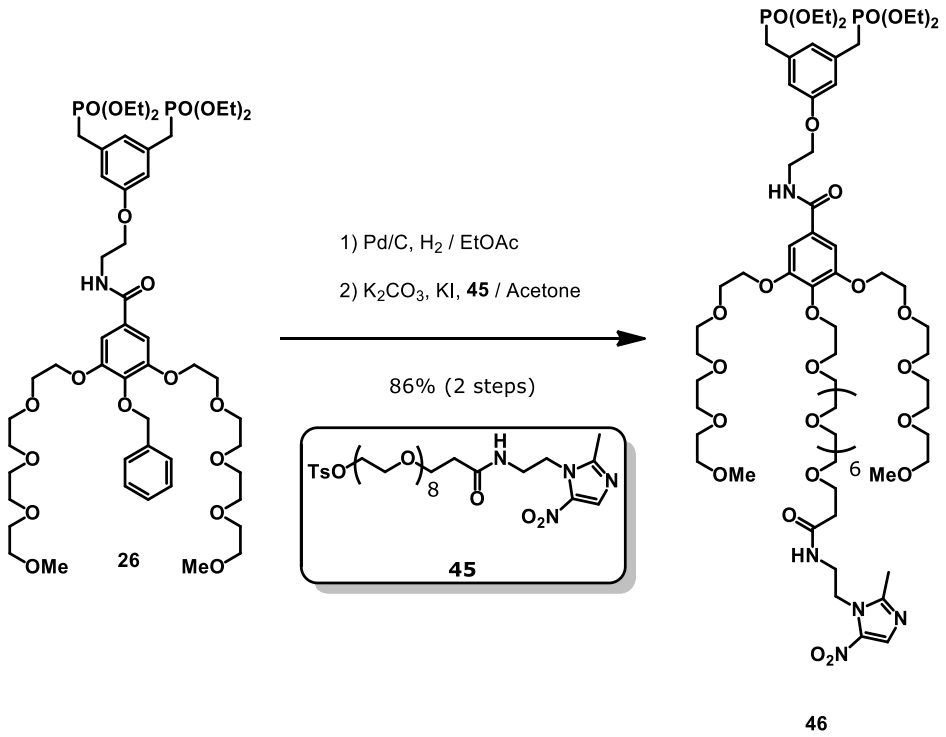
^{1}H NMR (500 MHz, $CDCl_3$): δ 7.94 (s, 1H), 7.80 (dd, *J* = 8.2, 1.9 Hz, 2H), 7.35 (dd, *J* = 8.0, 2.0 Hz, 2H), 4.47 (t, *J* = 6.2 Hz, 2H), 4.16 (t, *J* = 4.7 Hz, 2H), 3.70—3.57 (m, 36H), 3.07 (s, 3H), 2.46 (t, *J* = 5.5 Hz, 2H), 2.45 (s, 3H) ppm

^{13}C NMR (125 MHz, $CDCl_3$): δ 172.7, 151.3, 144.8, 138.5, 133.2, 133.07, 129.8, 127.9, 70.7, 70.5, 70.4 (several peaks), 70.3, 70.1, 70.0, 69.2, 68.6, 66.8, 45.1, 39.1, 36.6, 21.6, 14.2 ppm

MALDI-TOF: m/z calcd for $C_{32}H_{53}N_4O_{14}S$ $[M+H]^+$ 749.322, found 749.256

TLC: R_f = 0.4 (CH_2Cl_2/MeOH 9/1, $KMnO_4$).

Compound 46



To a solution of **26** (161.2 mg, 0.15 mmol) in EtOAc (4.0 mL) at RT was added Pd/C 10% (16.2 mg, 0.02 mmol, 0.1 equiv.). The heterogeneous solution was evacuated and backfilled with an atmosphere of hydrogen (balloon), vigorously stirred at RT for 16 h, then the catalyst was filtered off over Celite and the crude product was concentrated under reduced pressure. The crude phenol was next dissolved in Acetone (4.0 mL) before **45** (119.6 mg, 0.16 mmol, 1.05 equiv.), K_2CO_3 (31.5 mg, 0.23 mmol, 1.5 equiv.) and KI (2.5 mg, 0.02 mmol, 0.1 equiv.) were added. The resulting solution was heated to reflux for 16 h, cooled to RT, then concentrated under reduced pressure. The crude residue was suspended in CH_2Cl_2, the solids were filtered over Celite and the crude product was concentrated under reduced pressure. Purification by chromatography on silica gel (CH_2Cl_2/MeOH 96/4 to 92/8 to 84/16) afforded 202.3 mg (0.13 mmol, 86%) of the title compound **46**.

Physical state: orange oil.

^{1}H NMR (300 MHz, $CDCl_3$): δ 7.96 (s, 1H), 7.13 (brs, 1H), 7.09 (s, 2H), 6.85 (brs, 1H), 6.80 (s, 1H), 6.76 (s, 2H), 4.45 (t, *J* = 6.3 Hz, 2H), 4.20 (t, *J* = 4.8 Hz, 4H), 4.18 (t, *J* = 5.0 Hz, 2H), 4.12 (t, *J* = 5.1 Hz, 2H), 4.01 (qt, *J* = 7.4 Hz, 8H), 3.83 (t, *J* = 4.8 Hz, 4H), 3.81—3.76 (m, 4H), 3.60—3.51 (m, 61H), 3.35 (s, 6H), 3.07 (d, $^2J_{P\text{-}H}$ = 21.7 Hz, 4H), 2.50 (s, 3H), 2.43 (t, *J* = 5.7 Hz, 2H), 1.24 (t, *J* = 7.3 Hz, 12H) ppm

^{13}C NMR (125 MHz, $CDCl_3$): δ 172.7, 167.2, 158.6, 152.4, 151.3, 141.5, 138.5, 133.3 (t, $^2J_{C\text{-}P}$ = 6.1 Hz), 133.2, 129.4, 124.0 (t, $^3J_{C\text{-}P}$ = 6.4 Hz), 114.6 (t, $^3J_{C\text{-}P}$ = 4.5 Hz), 107.3, 72.3, 71.9, 70.7, 70.6, 70.5 (several

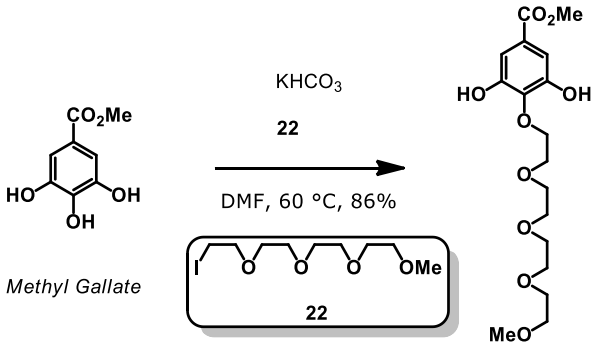
peaks), 70.4, 70.1, 69.7, 69.1 66.7, 62.1 (d, $^{2}J_{C\text{-}P}$ = 7.0 Hz), 59.0, 45.0, 39.6, 39.1, 36.6, 33.6 (d, $^{1}J_{C\text{-}P}$ = 138.6 Hz), 16.4 (d, $^{3}J_{C\text{-}P}$ = 5.7 Hz), 14.1 ppm

^{31}P NMR (121 MHz, $CDCl_3$): δ 26.0 ppm

MALDI-TOF: m/z calcd for $C_{68}H_{117}N_5O_{30}P_2Na$ $[M+Na]^+$ 1568.727, found 1568.686

TLC: R_f = 0.4 (CH_2Cl_2/MeOH 9/1, $KMnO_4$).

Compound 47



To a solution of **Methyl Gallate** (165.7 mg, 0.9 mmol, 1.3 equiv.) in DMF (2.0 mL) at RT was added $KHCO_3$ (270.3 mg, 2.7 mmol, 3.9 equiv.). The resulting solution was stirred at RT for 10 mn before **22** (217.2 mg, 0.7 mmol) was added. The resulting solution was heated to 60 °C for 16 h, cooled to RT and quenched with an aqueous solution of HCl 2N (3.0 mL). The aqueous layer was extracted with CH_2Cl_2, the combined organic layers were washed with brine, dried over Na_2SO_4, filtered and concentrated under reduced pressure. Purification by chromatography on silica gel (CH_2Cl_2/MeOH 96/4 to 92/8) afforded 192.6 mg (0.51 mmol, 86%) of the title compound **47**.

Physical state: yellow oil.

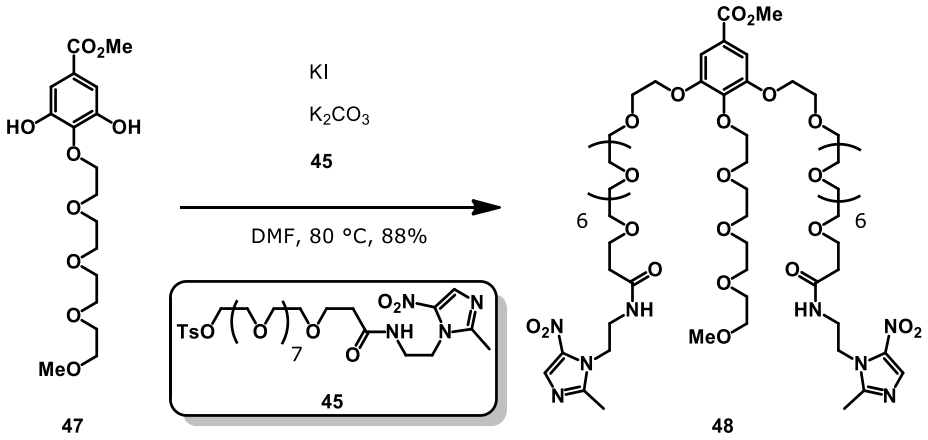
^{1}H NMR (300 MHz, $CDCl_3$): δ 7.17 (d, *J* = 1.0 Hz, 2H), 4.18 (t, *J* = 3.8 Hz, 2H), 3.86—3.79 (m, 6H), 3.75—3.63 (m, 10H), 3.54 (t, *J* = 4.0 Hz, 2H), 3.37 (s, 3H) ppm

^{13}C NMR (125 MHz, $CDCl_3$): δ 166.7, 149.6, 137.9, 126.8, 109.5, 73.5, 71.9, 70.7, 70.6, 70.5, 70.4, 70.2, 70.0, 59.0, 52.1 ppm

MALDI-TOF: m/z calcd for $C_{17}H_{261}O_9H$ $[M+H]^+$ 375.164, found 375.160

TLC: R_f = 0.3 (CH_2Cl_2/MeOH 98/2, $KMnO_4$).

Compound 48



To a solution of **47** (26.5 mg, 0.08 mmol) in DMF (1.5 mL) at RT were successively added K_2CO_3 (32.1 mg, 0.23 mmol, 3.0 equiv.), KI (2.5 mg, 0.02 mmol, 0.2 equiv.) and **45** (111.3 mg, 0.15 mmol, 2.1 equiv.). The orange solution was heated to 80 °C for 48 h, cooled to RT and concentrated under reduced pressure. Purification by reverse phase C_{18} chromatography (CH_3CN/H_2O + 0.1% TFA 2/8 to 4/6) afforded 95.1 mg (0.06 mmol, 88%) of the title compound **48**.

Physical state: orange oil.

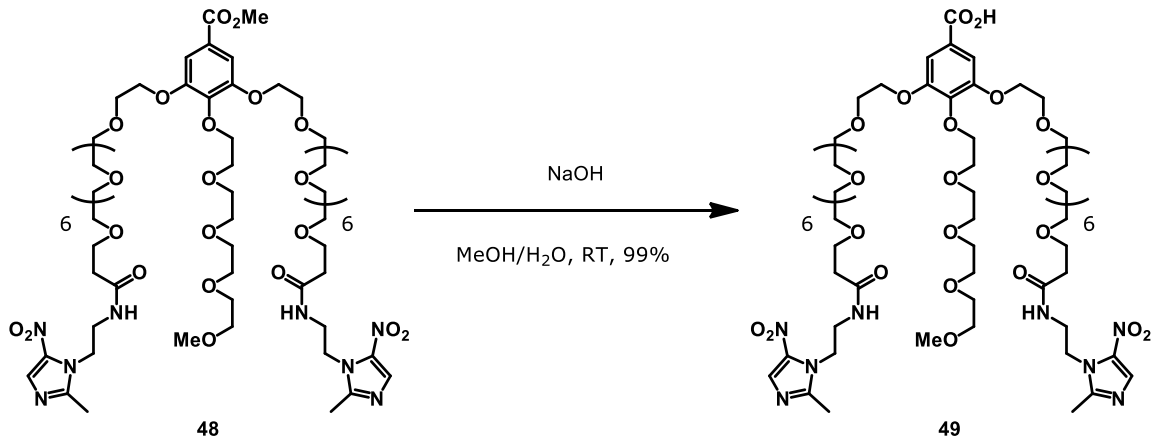
^{1}H NMR (500 MHz, $CDCl_3$): δ 7.98 (s, 2H), 7.30 (s, 2H), 7.21 (brs, 2H), 4.49 (t, *J* = 6.4 Hz, 4H), 4.22 (t, *J* = 5.0 Hz, 2H), 4.20 (t, *J* = 5.0 Hz, 4H), 3.89 (s, 3H), 3.87 (t, *J* = 5.0 Hz, 6H), 3.79 (t, *J* = 4.8 Hz, 4H), 3.73—3.59 (m, 86H), 3.55 (t, *J* = 4.9 H, 4H), 3.38 (s, 3H), 2.56 (s, 6H), 2.46 (t, *J* = 5.4 Hz, 4H) ppm

^{13}C NMR (125 MHz, $CDCl_3$): δ 172.8, 166.5, 152.2, 151.1, 142.5, 132.6, 124.9, 109.0, 72.4, 71.9, 70.8, 70.6—70.5 (several peaks), 70.4, 70.2, 70.1, 69.6, 68.8, 59.0, 52.1, 45.2, 39.0, 36.6, 14.0 ppm

MALDI-TOF: m/z calcd for $C_{67}H_{114}N_8O_{31}Na$ $[M+Na]^+$ 1549.750, found 1549.642

TLC: R_f = 0.3 (CH_2Cl_2/MeOH 9/1, $KMnO_4$).

Compound 49



To a solution of **48** (95.1 mg, 0.06 mmol) in MeOH (0.9 mL) and H_2O (0.1 mL) at RT was added NaOH (12.5 mg, 0.3 mmol, 5.0 equiv.). The orange solution was stirred at RT for 16 h, then quenched with an aqueous solution of HCl 2N (2.0 mL). The aqueous layer was extracted with CH_2Cl_2, the combined organic layers were washed with brine, dried over Na_2SO_4, filtered and concentrated under reduced pressure to afford 94.7 mg (0.06 mmol, 99%) of the title compound **49**.

Physical state: orange oil.

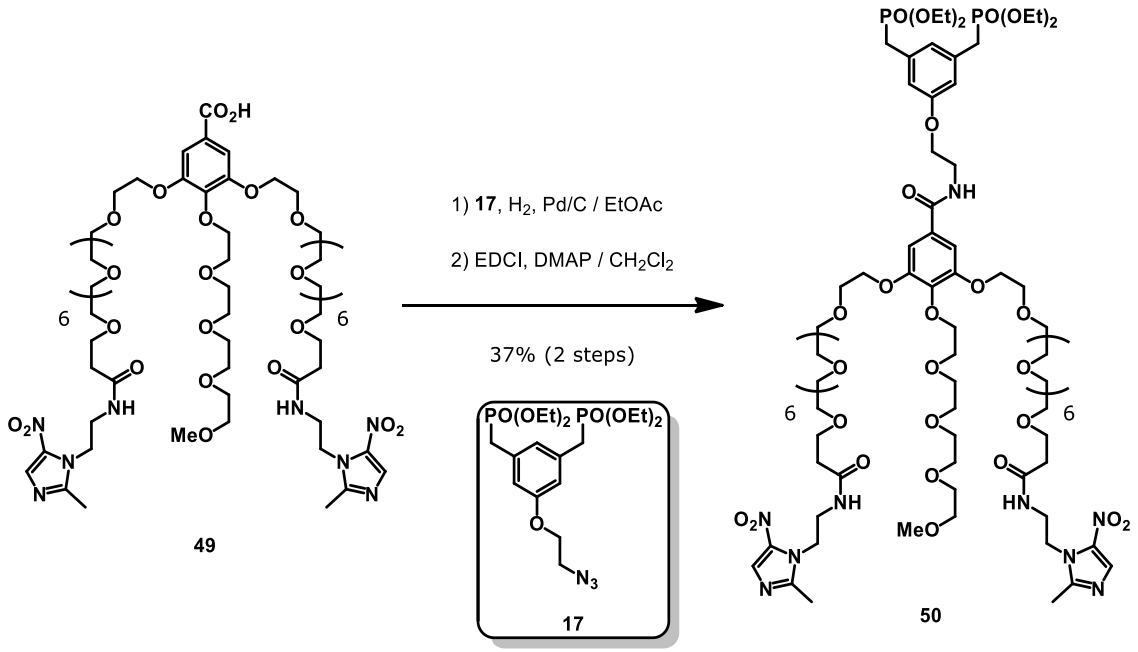
^{1}H NMR (500 MHz, $CDCl_3$): δ 7.98 (s, 2H), 7.38 (s, 2H), 7.34 (brs, 1H), 4.49 (t, *J* = 6.0 Hz, 4H), 4.24—4.22 (m, 8H), 3.87 (t, *J* = 5.1 Hz, 6H), 3.80 (t, *J* = 5.4 Hz, 4H), 3.73—3.54 (m, 115H), 3.38 (s, 3H), 2.54 (s, 6H), 2.48 (t, *J* = 5.5 Hz, 4H) ppm

^{13}C NMR (125 MHz, $CDCl_3$): δ 173.0, 167.8, 152.2, 151.2, 142.6, 138.5, 132.8, 109.7, 72.4, 71.9, 70.8, 70.6, 70.5—70.4 (several peaks), 70.1, 70.0, 69.7, 68.9, 66.8, 59.0, 45.1, 39.2, 36.6, 14.0 ppm

MALDI-TOF: m/z calcd for $C_{66}H_{111}N_8O_{31}$ $[M-H]^+$ 1511.744, found 1511.660

TLC: R_f = 0.1 (CH_2Cl_2/MeOH 9/1, $KMnO_4$).

Compound 50



To a solution of **17** (58.6 mg, 0.12 mmol, 1.1 equiv.) in EtOAc (4.0 mL) was added Pd/C 10% (13.4 mg, 0.01 mmol, 0.1 equiv.) The heterogeneous solution was evacuated and backfilled with hydrogen (balloon), then vigorously stirred at RT for 3 h. The catalyst was filtered over Celite, the crude product was concentrated under reduced pressure. *In a separate flask*, **49** (174.0 mg, 0.11 mmol) was dissolved in CH_2Cl_2 (4.0 mL) before EDCI (25.3 mg, 0.13 mmol, 1.2 equiv.) and DMAP (1.4 mg, 0.01 mmol, 0.1 equiv.) were added. The resulting solution was stirred at RT for 10 mn, then the crude primary amine was added. The yellow solution was stirred at RT for 16h, then diluted with CH_2Cl_2 and brine. The aqueous layer was extracted with CH_2Cl_2 (five times), the combined organic layer was dried over Na_2SO_4, filtered and concentrated under reduced pressure. Purification by chromatography on silica gel (CH_2Cl_2/MeOH 9/1 to 8/2) afforded 104.0 mg (0.05 mmol, 37%) of the title compound **50**.

Physical state: yellow viscous oil.

^{1}H NMR (500 MHz, $CDCl_3$): δ 7.96 (s, 2H), 7.23 (brs, 2H), 7.12 (s, 2H), 6.82 (s, 1H), 6.78 (s, 2H), 4.47 (t, *J* = 6.1 Hz, 4H), 4.21 (t, *J* = 3.9 Hz, 6H), 4.19 (t, *J* = 5.4 Hz, 2H), 4.14 (t, *J* = 5.2 Hz, 2H), 4.03 (qt, *J* = 7.6 Hz, 8H), 3.85 (t, *J* = 4.6 Hz, 6H), 3.82—3.78 (m, 6H), 3.74—3.54 (m, 94H), 3.38 (s, 3H), 3.09 (d, $^2J_{P\text{-}H}$ = 21.5 Hz, 4H), 2.53 (s, 6H), 2.45 (t, *J* = 5.3 Hz, 4H), 1.26 (t, *J* = 6.9 Hz, 12H) ppm

^{13}C NMR (125 MHz, $CDCl_3$): δ 172.7, 167.2, 158.6, 152.4, 151.2, 138.5, 133.3, 132.8, 129.5, 124.0, 114.6, 107.2, 72.5, 72.3, 71.9, 70.7, 70.6—70.4 (several peaks), 70.1, 69.7, 69.0, 66.8, 62.1 (d, $^2J_{C\text{-}P}$ = 6.8 Hz), 59.0, 45.2, 39.6, 39.1, 36.6, 33.6 (d, $^1J_{C\text{-}P}$ = 5.7 Hz), 16.4 (d, $^3J_{C\text{-}P}$ = 137.9 Hz), 14.0 ppm

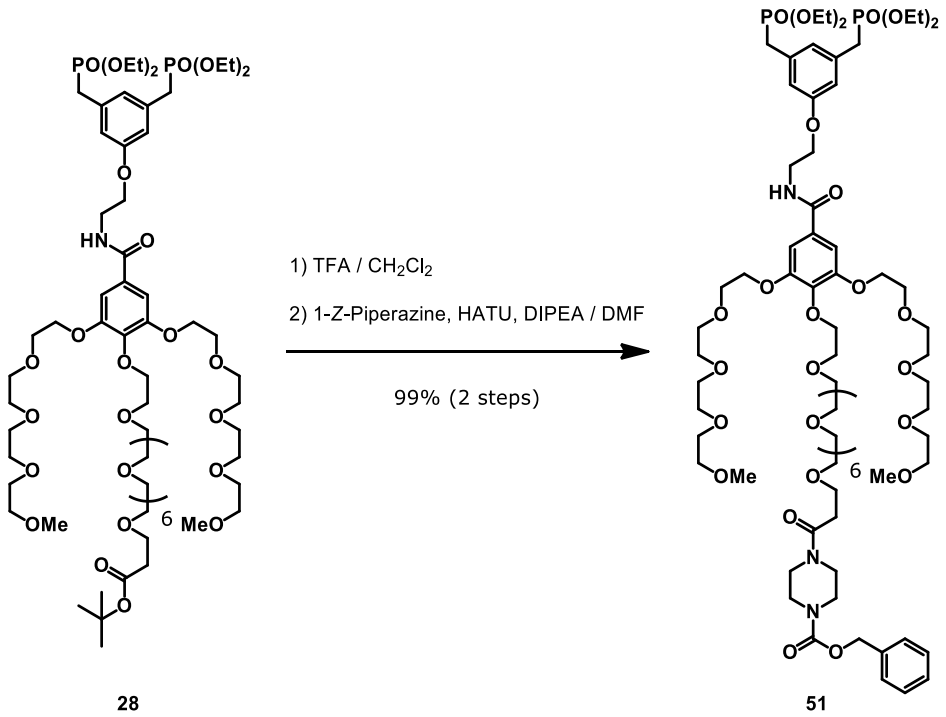
^{31}P NMR (202 MHz, $CDCl_3$): δ 26.0 ppm

MALDI-TOF: m/z calcd for $C_{84}H_{143}N_9O_{37}P_2Na$ $[M+Na]^+$ 1954.960, found 1954.722

TLC: R_f = 0.2 (CH_2Cl_2/MeOH 9/1, $KMnO_4$).

Part 3: Development of dendritic coating for the development of hybrid microbubbles

Compound 51



To a solution of **28** (258.3 mg, 0.18 mmol) in CH_2Cl_2 (2.0 mL) at RT was added TFA (0.4 mL, 5.2 mmol, 29.0 equiv.). The yellow solution was stirred at RT for 4 h, concentrated under reduced pressure, dissolved in DMF (2.0 mL) before 1-*Z*-Piperazine (45.0 µL, 0.21 mmol, 1.2 equiv.), DIPEA (1.0 mL, 5.7 mmol, 32.0 equiv.) and HATU (81.2 mg, 0.21 mmol, 1.2 equiv.) were added. The resulting solution was stirred at RT for 16 h, then diluted with CH_2Cl_2 and brine. The aqueous layer was extracted with CH_2Cl_2 (five times), the combined organic layer was washed with brine, dried over Na_2SO_4, filtered and concentrated under reduced pressure. Purification by chromatography on silica gel (CH_2Cl_2/MeOH 95/5 to 9/1) followed by a reverse phase C_{18} chromatography (CH_3CN/H_2O + 0.1% TFA 45/55) afforded 283.6 mg (0.18 mmol, 99%) of the title compound **51**.

Physical state: yellow oil.

^{1}H NMR (500 MHz, $CDCl_3$): δ 7.37—7.30 (m, 5H), 7.11 (s, 2H), 6.94 (brs, 1H), 6.80 (s, 1H), 6.76 (s, 2H), 5.14 (s, 2H), 4.21—4.18 (m, 6H), 4.12 (t, *J* = 5.1 Hz, 2H), 4.04 (qt, *J* = 7.4 Hz, 8H), 3.84 (t, *J* = 4.7 Hz, 4H), 3.82—3.81 (m, 2H), 3.78 (t, *J* = 5.6 Hz, 4H), 3.71—3.60 (m, 56H), 3.54—3.48 (m, 12H), 3.35 (s, 6H), 3.12 (d, $^2J_{P\text{-}H}$ = 21.8 Hz, 4H), 2.65 (t, *J* = 6.5 Hz, 2H), 1.26 (t, *J* = 7.1 Hz, 12H) ppm

^{13}C NMR (125 MHz, $CDCl_3$): δ 170.3, 167.6, 159.1, 158.7, 155.1, 152.4, 141.5, 136.3, 132.7 (t, $^2J_{C\text{-}P}$ = 11.6 Hz), 129.2, 128.5, 128.2, 128.0, 124.0 (t, $^3J_{C\text{-}P}$ = 7.1 Hz), 116.1, 114.8 (t, $^3J_{C\text{-}P}$ = 4.5 Hz), 113.8, 107.3, 72.3, 71.9, 70.6—70.4 (several peaks), 69.7, 69.0, 67.5, 67.4, 66.6, 62.8 (d, $^2J_{C\text{-}P}$ = 6.8 Hz), 58.9, 45.6, 43.6, 41.5, 39.6, 33.6, 33.4 (d, $^1J_{C\text{-}P}$ = 138.1 Hz), 16.3 (d, $^3J_{C\text{-}P}$ = 5.5 Hz) ppm

^{31}P NMR (202 MHz, $CDCl_3$): δ 26.3 ppm

MALDI-TOF: m/z calcd for $C_{74}H_{123}N_3O_{30}P_2Na$ $[M+Na]^+$ 1618.762, found 1618.460

TLC: R_f = 0.4 (CH_2Cl_2/MeOH 9/1, $KMnO_4$).

Compound 55

28 **55**

To a solution of **28** (228.2 mg, 0.16 mmol) in CH_2Cl_2 (2.0 mL) at RT was added TFA (0.1 mL, 1.3 mmol, 8.2 equiv.). The yellow solution was stirred at RT for 4 h, concentrated under reduced pressure, dissolved in CH_3CN (2.0 mL) before K_2CO_3 (217.4 mg, 1.6 mmol, 10.0 equiv.), 1,1,1,2,2-Pentafluoro-6-pentafluoroiodohexane (100.0 mg, 0.32 mmol, 2.0 equivwere added. The resulting solution was heated to reflux for 16 h, cooled to RT. The solvent was removed, the crude product was suspended in CH2Cl2, the solids were filtered and the crude product was concentrated under reduced pressure. Purification by chromatography on silica gel (CH_2Cl_2/MeOH 9/1) afforded 233.8 mg (0.15 mmol, 92%) of the title compound **55**.

Physical state: yellow oil.

^{1}H NMR (500 MHz, $CDCl_3$): δ 7.10 (s, 2H), 7.00 (brs, 1H), 6.80 (s, 1H), 6.76 (s, 2H), 5.14 (s, 2H), 4.20 (t, *J* = 4.4 Hz, 4H), 4.17 (t, *J* = 4.6 Hz, 2H), 4.13—4.09 (m, 4H), 4.00 (qt, *J* = 7.4 Hz, 8H), 3.83 (t, *J* = 4.7 Hz, 4H), 3.79—3.75 (m, 4H), 3.73 (t, *J* = 6.4 Hz, 2H), 3.70—3.60 (m, 50H), 3.52—3.50 (m, 4H), 3.34 (s, 6H), 3.07 (d, $^2J_{P\text{-}H}$ = 22.2 Hz, 4H), 2.58 (t, *J* = 6.6 Hz, 2H), 2.11—1.99 (m, 4H), 1.74—1.62 (m, 4H), 1.23 (t, *J* = 7.1 Hz, 12H) ppm

^{13}C NMR (125 MHz, $CDCl_3$): δ 171.5, 167.2, 158.6, 152.4, 141.4, 133.2, 129.5, 124.0, 114.7, 107.3, 72.3, 71.9, 70.6—70.4 (several peaks), 69.7, 69.0, 66.7, 66.5, 63.6, 62.2 (d, $^2J_{C\text{-}P}$ = 6.9 Hz), 59.0, 39.5, 35.0, 34.1, 33.0, 30.9, 30.4, 30.2, 30.0, 29.7, 28.0, 17.1, 16.4 (d, $^3J_{C\text{-}P}$ = 5.8 Hz) ppm

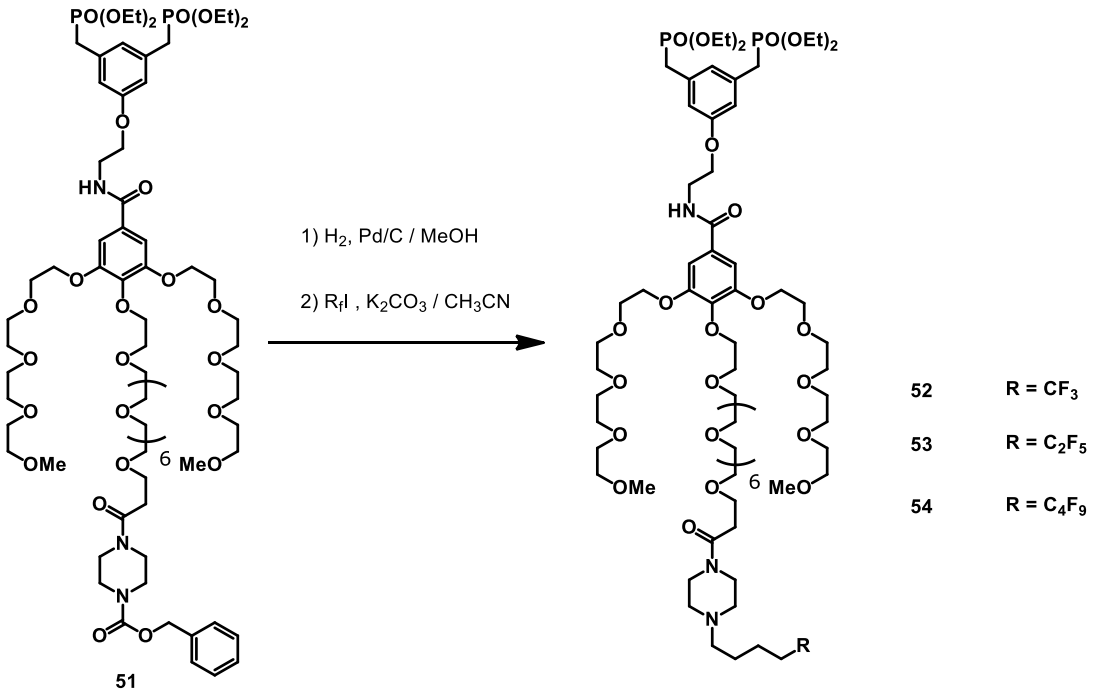
^{31}P NMR (202 MHz, $CDCl_3$): δ 26.3 ppm

^{19}F NMR (282 MHz, $CDCl_3$): δ -85.4, -118.3 ppm

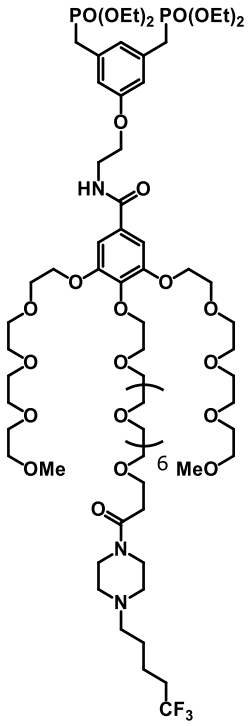
MALDI-TOF: m/z calcd for $C_{68}H_{116}F_5NO_{29}P_2Na$ $[M+Na]^+$ 1590.699, found 1590.120

TLC: R_f = 0.4 (CH_2Cl_2/MeOH 9/1, $KMnO_4$).

General procedure for the *N*-alkylation



To a solution of dendron **51** (1.0 equiv.) in MeOH (0.05 M) at RT was added Pd/C 10% (0.1 equiv.). The heterogeneous solution was evacuated and backfilled with an atmosphere of hydrogen (balloon), vigorously stirred at RT for 5 h, then the catalyst was filtered off over Celite. The crude product was concentrated under reduced pressure, dissolved in CH_3CN (0.1 M) at RT before K2CO3 (2.0 equiv.) and the perfluoroalkyl iodide (1.2 equiv.) were added. The resulting solution was heated to 60 °C for 16 h, cooled to RT. The solvent was removed, then the crude residue was suspended in CH_2Cl_2, the solids were filtered and the crude product was concentrated under reduced pressure. Purification by flash chromatography on silica gel (deactivated with an aqueous solution of NH_4OH) afforded the desired dendron **52**—**54**.



52

Starting from 72.5 mg (0.05 mmol) of dendron **51** and 5-Iodo-1,1,1-trifluoropentane (19.0 mg, 0.08 mmol), 62.0 mg isolated (0.04 mmol, 78%)

Eluents: CH_2Cl_2/MeOH 9/1 to 8/2.

Physical state: yellow oil.

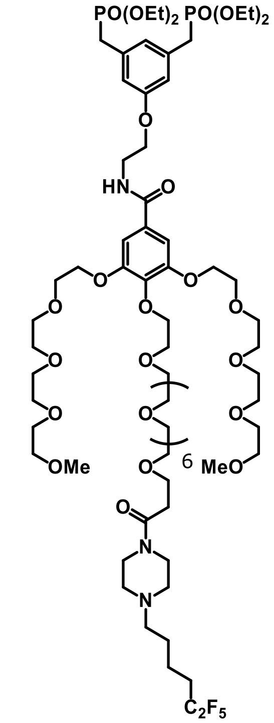
^{1}H NMR (500 MHz, CD_3OD-*d*$_4$): δ 7.21 (s, 2H), 6.84 (t, *J* = 2.3 Hz, 3H), 4.22—4.19 (m, 6H), 4.16 (t, *J* = 5.8 Hz, 2H), 4.02 (qt, *J* = 7.4 Hz, 8H), 3.86 (t, *J* = 4.6 Hz, 4H), 3.79 (t, *J* = 4.7 Hz, 2H), 3.76—3.56 (m, 60H), 3.49 (t, *J* = 4.9 Hz, 4H), 3.32 (s, 6H), 3.18 (d, $^2J_{P\text{-}H}$ = 22.2 Hz, 4H), 2.63 (t, *J* = 6.3 Hz, 2H), 2.49 (t, *J* = 4.3 Hz, 2H), 2.44 (t, *J* = 4.9 Hz, 2H), 2.41 (t, *J* = 7.5 Hz, 2H), 2.22—2.15 (m, 2H), 1.63—1.54 (m, 4H), 1.24 (t, *J* = 6.9 Hz, 12H) ppm

^{13}C NMR (125 MHz, CD_3OD-*d*$_4$): δ 171.9, 169.5, 160.3, 153.8, 142.3, 134.4 (t, $^2J_{C\text{-}P}$ = 12.0 Hz), 130.4, 125.1 (t, $^3J_{C\text{-}P}$ = 6.5 Hz), 115.9 (t, $^3J_{C\text{-}P}$ = 4.6 Hz), 107.9, 73.6, 72.9, 71.7, 71.6, 71.5—71.4 (several peaks), 71.3, 70.8, 70.1, 68.4, 67.5, 63.7 (d, $^2J_{C\text{-}P}$ = 7.1 Hz), 59.1, 58.7, 54.3, 53.8, 46.6, 42.4, 40.8, 34.3, 34.0, 33.6 (d, $^1J_{C\text{-}P}$ = 138.3 Hz), 26.4, 20.9, 16.7 (d, $^3J_{C\text{-}P}$ = 5.2 Hz) ppm

^{19}F NMR (470 MHz, CD_3OD-*d*$_4$): δ -63.9 ppm

^{31}P NMR (202 MHz, CD_3OD-*d*$_4$): δ 31.2 ppm

MALDI-TOF: m/z calcd for $C_{71}H_{125}F_3N_3O_{28}P_2$ $[M+H]^+$ 1587.693, found 1587.425



53

Starting from 72.5 mg (0.05 mmol) of dendron **51** and 1,1,1,2,2-Pentafluoro-6-iodohexane (0.08 mmol), 65.5 mg isolated (0.04 mmol, 80%)

Eluents: CH_2Cl_2/MeOH 9/1 to 8/2.

Physical state: yellow oil.

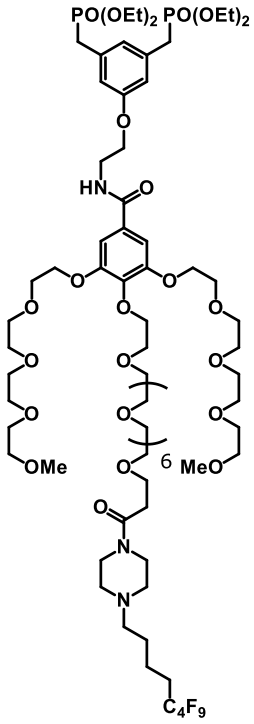
^{1}H NMR (500 MHz, CD_3OD-*d₄*): δ 7.20 (s, 2H), 6.84 (t, *J* = 2.3 Hz, 3H), 4.22—4.19 (m, 6H), 4.16 (t, *J* = 5.7 Hz, 2H), 4.02 (qt, *J* = 7.3 Hz, 8H), 3.86 (t, *J* = 4.7 Hz, 4H), 3.79 (t, *J* = 4.7 Hz, 2H), 3.76—3.56 (m, 58H), 3.49 (t, *J* = 4.9 Hz, 4H), 3.32 (s, 6H), 3.18 (d, $^{2}J_{P-H}$ = 22.2 Hz, 4H), 2.63 (t, *J* = 6.4 Hz, 2H), 2.48 (t, *J* = 4.9 Hz, 2H), 2.44—2.39 (m, 4H), 2.20—2.09 (m, 2H), 1.63—1.60 (m, 4H), 1.24 (t, *J* = 6.9 Hz, 12H) ppm

^{13}C NMR (125 MHz, CD_3OD-*d₄*): δ 171.9, 169.6, 160.4, 153.8, 142.4, 134.4 (t, $^{2}J_{C-P}$ = 10.9 Hz), 130.4, 125.2 (t, $^{3}J_{C-P}$ = 6.6 Hz), 115.9 (t, $^{3}J_{C-P}$ = 5.2 Hz), 107.9, 73.6, 72.9, 71.7, 71.6, 71.5—71.4 (several peaks), 71.3, 70.8, 70.1, 68.4, 67.5, 63.7 (d, $^{2}J_{C-P}$ = 7.1 Hz), 59.1, 58.7, 54.3, 53.8, 46.7, 42.5, 40.8, 34.3, 33.6 (d, $^{1}J_{C-P}$ = 137.3 Hz), 31.2, 28.8, 26.8, 19.4, 16.7 (d, $^{3}J_{C-P}$ = 5.8 Hz) ppm

^{19}F NMR (470 MHz, CD_3OD-*d₄*): δ -83.0, -115.4 ppm

^{31}P NMR (202 MHz, CD_3OD-*d₄*): δ 31.2 ppm

MALDI-TOF: m/z calcd for $C_{72}H_{125}F_5N_3O_{28}P_2$ $[M+H]^+$ 1636.788, found 1636.525



54

Starting from 95.8 mg (0.06 mmol) of dendron **51** and 8-Iodo-1,1,1,2,2,3,3,4,4-nonafluorooctane (0.07 mmol), 57.5 mg isolated (0.03 mmol, 55%)

Eluents: CH_2Cl_2/MeOH 9/1 to 8/2.

Physical state: yellow oil.

^{1}H NMR (500 MHz, CD_3OD-*d*$_4$): δ 7.22 (s, 2H), 6.85 (t, *J* = 2.1 Hz, 3H), 4.23—4.20 (m, 6H), 4.17 (t, *J* = 5.8 Hz, 2H), 4.03 (qt, *J* = 7.4 Hz, 8H), 3.87 (t, *J* = 4.3 Hz, 4H), 3.81 (t, *J* = 4.6 Hz, 2H), 3.76 (t, *J* = 5.8 Hz, 2H), 3.73—3.53 (m, 58H), 3.50 (t, *J* = 4.8 Hz, 4H), 3.33 (s, 6H), 3.19 (d, $^2J_{P\text{-}H}$ = 21.5 Hz, 4H), 2.34—2.23 (m, 2H), 1.92—1.85 (m, 2H), 1.74—1.68 (m, 2H), 1.25 (t, *J* = 7.1 Hz, 12H) ppm

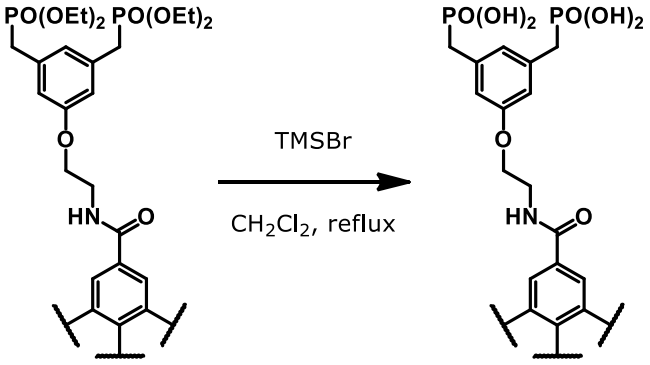
^{13}C NMR (125 MHz, CD_3OD-*d*$_4$): δ 172.7, 169.5, 153.8, 142.2, 134.5, 132.6, 130.6, 125.2, 116.0, 107.8, 73.6, 72.9, 71.8—71.2 (several peaks), 70.8, 70.1, 68.7, 67.5, 63.7 (d, $^2J_{C\text{-}P}$ = 7.5 Hz), 59.1, 57.5, 40.8, 39.8, 34.1, 33.7 (d, $^1J_{C\text{-}P}$ = 157.9 Hz), 31.0, 24.4, 18.6, 16.7 (d, $^3J_{C\text{-}P}$ = 5.6 Hz) ppm

^{19}F NMR (282 MHz, CD_3OD-*d*$_4$): δ -81.0, -114.7, -124.5, -126.0 ppm

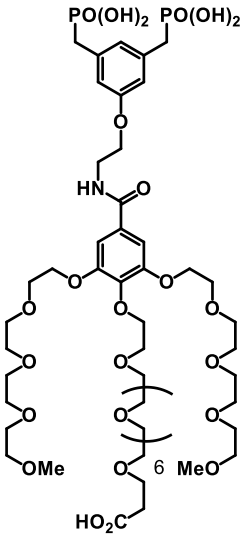
^{31}P NMR (202 MHz, CD_3OD-*d*$_4$): δ 27.2 ppm

MALDI-TOF: m/z calcd for $C_{74}H_{125}F_9N_3O_{28}P_2$ $[M+H]^+$ 1736.772, found 1736.468

Part 4: General procedure for the deprotection of phosphonate dendrons



To a solution of dendron in CH_2Cl_2 (0.05 M) at RT was added TMSBr (8 to 15 equiv.). The resulting solution was heated to reflux for 2 h, then cooled to RT and quenched with MeOH. The orange solution was stirred at RT for another 15 min then concentrated under reduced pressure. The crude residue was purified by LH20, eluted with MeOH HPLC to afford the corresponding dendron phosphonic acid.



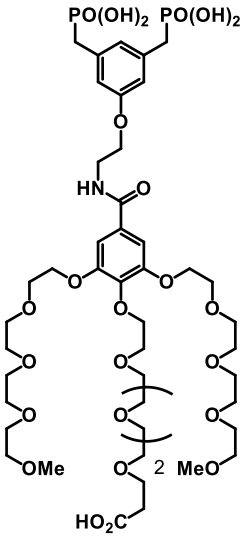
1

Starting from 3.7 mmol of dendron **28** with 5.0 mL of TMSBr (37.9 mmol, 10.0 equiv.). 4218.0 mg isolated (3.3 mmol, 90%).

Physical state: yellow gum.

^{1}H NMR (300 MHz, CD_3OD-*d*$_4$): δ 7.21 (s, 2H), 6.81 (s, 3H), 4.21 (t, *J* = 4.4 Hz, 6H), 4.16 (t, *J* = 5.2 Hz, 2H), 3.87 (t, *J* = 4.6 Hz, 4H), 3.80 (t, *J* = 5.0 Hz, 2H), 3.76—3.49 (m, 64H), 3.33 (s, 6H), 3.05 (d, $^2J_{P\text{-}H}$ = 22.4 Hz, 4H), 2.57 (t, *J* = 6.2 Hz, 2H) ppm

Spectral data matches the literature. [2]



2

Starting from 0.05 mmol of dendron **29** with 0.1 mL of TMSBr (0.8 mmol, 15.0 equiv.). 50.3 mg isolated (0.05 mmol, 94%).

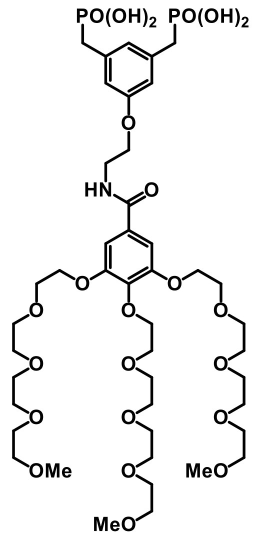
Physical state: yellow gum.

^{1}H NMR (500 MHz, CD_3OD-d_4): δ 7.17 (s, 2H), 6.79 (s, 3H), 4.18 (t, *J* = 3.7 Hz, 6H), 4.13 (t, *J* = 5.6 Hz, 4H), 3.83 (t, *J* = 4.4 Hz, 6H), 3.77 (t, *J* = 4.7 Hz, 2H), 3.72—3.46 (m, 54H), 3.30 (s, 6H), 3.04 (d, $^{2}J_{P\text{-}H}$ = 22.4 Hz, 4H), 2.53 (t, *J* = 6.0 Hz, 2H) ppm

^{13}C NMR (125 MHz, CD_3OD-d_4): δ 173.7, 169.6, 160.1, 153.7, 142.3, 135.8, 130.4, 125.1, 115.5, 107.8, 73.6, 72.9, 71.7—71.3 (several peaks), 70.8, 70.1, 67.6, 62.2, 59.0, 52.1, 40.8, 35.7 ppm

^{31}P NMR (202 MHz, CD_3OD-d_4): δ 23.9 ppm

MALDI-TOF: m/z calcd for $C_{44}H_{68}NO_{24}P_2$ $[M\text{-}5H]^+$ 1056.880, found 1056.482



3

Starting from 0.17 mmol of dendron **32** with 0.2 mL of TMSBr (1.5 mmol, 9.0 equiv.). 161.0 mg isolated (0.15 mmol, 90%).

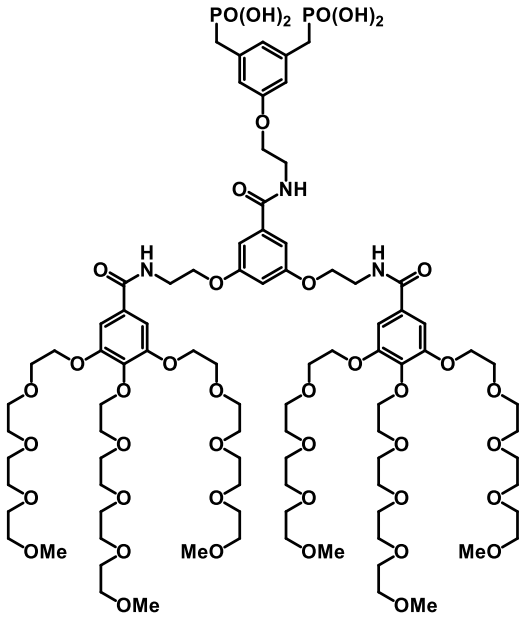
Physical state: yellow gum.

^{1}H NMR (500 MHz, CD_3OD-*d_4*): δ 7.20 (s, 2H), 6.83 (s, 1H), 6.82 (s, 2H), 4.21 (t, *J* = 4.0 Hz, 6H), 4.16 (t, *J* = 5.5 Hz, 2H), 3.87 (t, *J* = 5.0 Hz, 4H), 3.80 (t, *J* = 4.7 Hz, 2H), 3.75—3.59 (m, 34H), 3.55—3.49 (m, 6H), 3.06 (d, $^{2}J_{P\text{-}H}$ = 21.6 Hz, 4H) ppm

^{13}C NMR (125 MHz, CD_3OD-*d_4*): δ 169.6, 160.2, 152.4, 141.0, 134.4, 129.1, 123.7, 114.1, 106.5, 73.6, 72.9, 71.7—71.5 (several peaks), 71.4, 71.3, 70.8, 70.1, 67.4, 62.2, 54.8, 40.8, 36.4, 35.3 ppm

^{31}P NMR (202 MHz, CD_3OD-*d_4*): δ 23.9 ppm

MALDI-TOF: m/z calcd for $C_{44}H_{71}NO_{23}P_2$ $[M\text{-}4H]^+$ 1043.426, found 1043.664



4

Starting from 0.04 mmol of dendron **36** with 80.0 µL of TMSBr (0.6 mmol, 17.0 equiv.). 51.9 mg isolated (0.03 mmol, 73%).

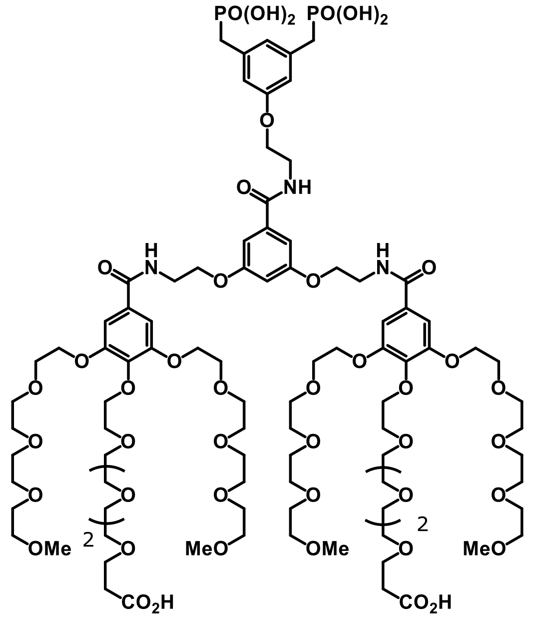
Physical state: yellow gum.

^{1}H NMR (500 MHz, CD_3OD-*d_4*): δ 7.19 (s, 4H), 7.04 (s, 2H), 6.83 (s, 1H), 6.78 (s, 2H), 6.73 (s, 1H), 4.22—4.10 (m, 16H), 3.84—3.48 (m, 86H), 3.02 (d, $^{2}J_{P\text{-}H}$ = 17.6 Hz, 4H) ppm

^{13}C NMR (125 MHz, CD_3OD-*d_4*): δ 176.8, 169.6, 153.7, 142.3, 130.5, 115.5, 107.9, 73.6, 72.9, 71.7, 71.6, 71.5 (several peaks), 71.3, 70.7, 70.0, 62.2, 59.1, 40.7 ppm

^{31}P NMR (202 MHz, CD_3OD-*d_4*): δ 23.1 ppm

MALDI-TOF: m/z calcd for $C_{89}H_{143}N_3O_{42}P_2$ $[M\text{-}4H]^+$ 1987.892, found 1987.652



5

Starting from 0.05 mmol of dendron **38** with 0.1 mL of TMSBr (0.76 mmol, 15.0 equiv.). 71.5 mg isolated (0.03 mmol, 68%).

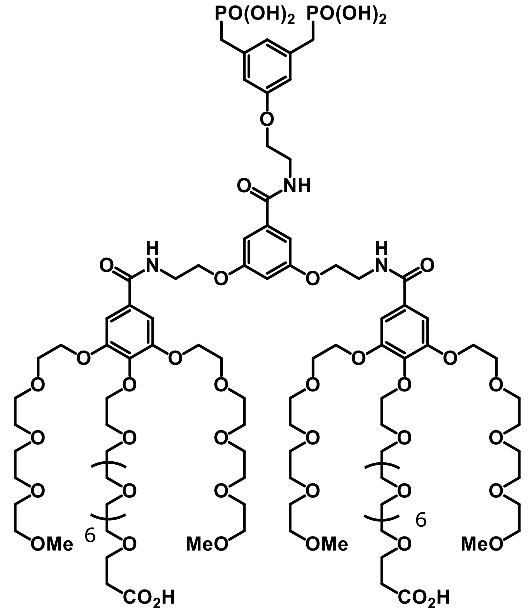
Physical state: yellow gum.

^{1}H NMR (500 MHz, CD_3OD-*d₄*): δ 7.18 (s, 4H), 7.03 (s, 2H), 6.83 (s, 1H), 6.79 (s, 2H), 6.72 (s, 1H), 4.20—4.13 (m, 20H), 3.84 (t, *J* = 4.3 Hz, 8H), 3.78 (t, *J* = 4.9 Hz, 4H), 3.74—3.48 (m, 97H), 3.31 (s, 12H), 3.04 (d, $^2J_{P\text{-}H}$ = 21.3 Hz, 4H), 2.55 (t, *J* = 6.2 Hz, 4H) ppm

^{13}C NMR (125 MHz, CD_3OD-d_4): δ 173.7, 169.6, 161.4, 153.7, 142.3, 137.5, 130.4, 115.5, 107.9, 107.2, 105.9, 73.6, 72.9, 71.7, 71.6, 71.5 (several peaks), 71.4, 71.3, 70.8, 70.1, 67.6, 59.1, 52.1, 40.7, 35.7 ppm

^{31}P NMR (202 MHz, CD_3OD-d_4): δ 23.7 ppm

MALDI-TOF: m/z calcd for $C_{93}H_{145}N_3O_{46}P_2$ $[M\text{-}6H]^+$ 2101.905, found 2101.774



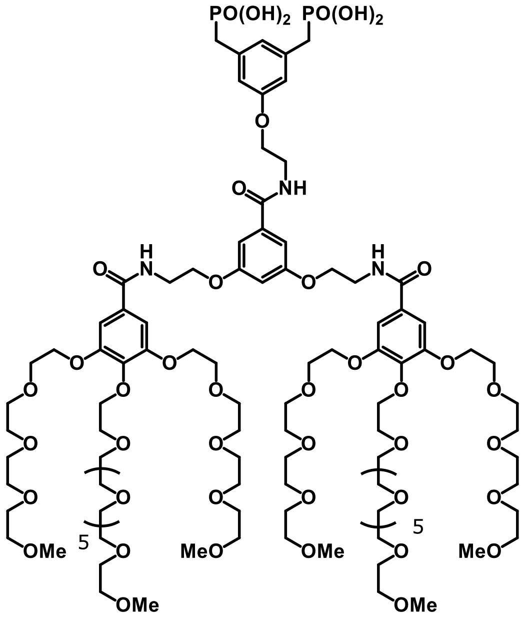
6

Starting from 0.03 mmol of dendron **39** with 0.2 mL of TMSBr (3.0 mmol, 101.0 equiv.). 52.4 mg isolated (0.02 mmol, 71%).

Physical state: yellow gum.

^{1}H NMR (300 MHz, CD_3OD-*d_4*): δ 7.26 (s, 4H), 7.11 (s, 2H), 6.90 (s, 1H), 6.86 (s, 2H), 6.82 (s, 1H), 4.28—4.17 (m, 20H), 3.92 (t, *J* = 4.7 Hz, 8H), 3.87—3.54 (m, 130H), 3.38 (s, 12H), 3.09 (d, $^2J_{P\text{-}H}$ = 21.2 Hz, 4H), 2.63 (t, *J* = 6.2 Hz, 4H) ppm

Spectral data matches the literature. [2]



7

Starting from 0.03 mmol of dendron **40** with 0.1 mL of TMSBr (0.76 mmol, 25.0 equiv.). 43.2 mg isolated (0.02 mmol, 60%).

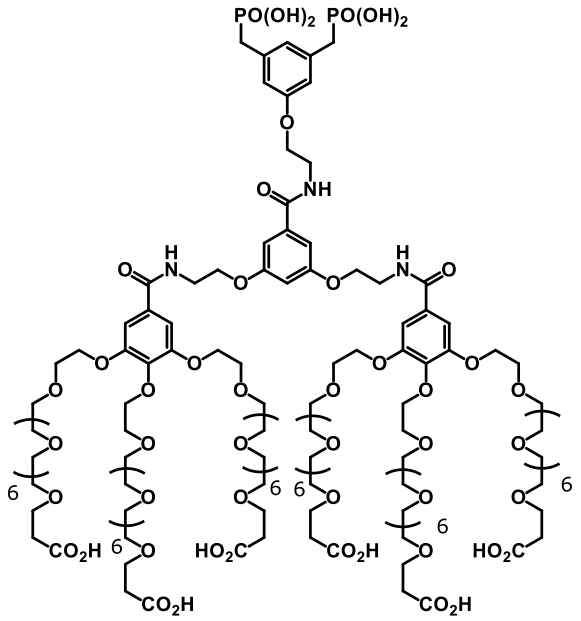
Physical state: yellow gum.

^{1}H NMR (500 MHz, CD_3OD-*d_4*): δ 7.19 (s, 4H), 7.04 (s, 2H), 6.84 (s, 1H), 6.78 (s, 2H), 6.74 (s, 1H), 4.21—4.12 (m, 20H), 3.85 (t, *J* = 4.2 Hz, 8H), 3.79 (t, *J* = 4.4 Hz, 6H), 3.75—3.48 (m, 127H), 3.33 (s, 6H), 3.31 (s, 12H), 3.03 (d, $^2J_{P-H}$ = 21.0 Hz, 4H) ppm

^{13}C NMR (125 MHz, CD_3OD-*d_4*): δ 169.6, 161.4, 160.1, 153.7, 142.3, 137.6, 130.4, 115.5, 107.9, 107.3, 106.0, 73.6, 72.9, 71.7, 71.6, 71.5 (several peaks), 71.4, 71.3, 70.8, 70.0, 67.7, 62.2, 59.1, 40.7, 35.7 ppm

^{31}P NMR (202 MHz, CD_3OD-*d_4*): δ 23.2 ppm

MALDI-TOF: m/z calcd for $C_{105}H_{175}N_3O_{50}P_2$ [M-4H]$^+$ 2340.176, found 2340.650



8

Starting from 0.01 mmol of dendron **44** with 0.2 mL of TMSBr (1.5 mmol, 152.0 equiv.). 36.7 mg isolated (0.01 mmol, 80%).

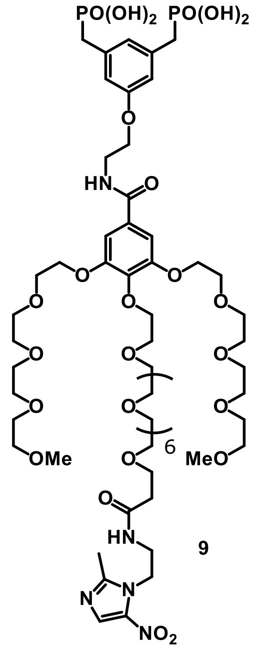
Physical state: colorless gum.

^{1}H NMR (500 MHz, D_2O): δ 7.13 (s, 4H), 6.96 (s, 2H), 6.82 (s, 1H), 6.77 (s, 2H), 6.70 (s, 1H), 4.25—4.12 (m, 20H), 3.91—3.47 (m, 242H), 3.03 (d, $^{2}J_{P\text{-}H}$ = 19.8 Hz, 4H), 2.64 (t, *J* = 5.8 Hz, 12H) ppm

^{13}C NMR (125 MHz, D_2O): δ 174.6, 168.8, 159.7, 158.2, 151.9, 139.9, 135.6, 129.1, 114.1, 106.3, 72.1, 70.1, 69.8, 69.6, 69.5 (several peaks), 69.4, 69.1, 68.4, 66.1, 52.2, 39.5, 34.2 ppm

^{31}P NMR (202 MHz, D_2O): δ 23.4 ppm

MALDI-TOF: m/z calcd for $C_{145}H_{237}N_3O_{76}P_2$ $[M\text{-}10H]^+$ 3298.526, found 3298.142



9

Starting from 0.1 mmol of dendron **43** with 0.2 mL of TMSBr (1.5 mmol, 15.0 equiv.). 113.7 mg isolated (0.08 mmol, 81%).

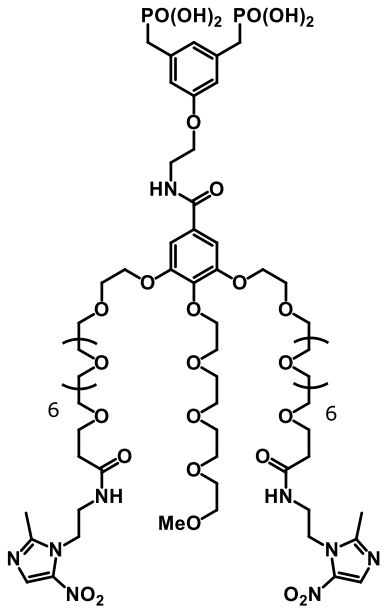
Physical state: yellow gum.

^{1}H NMR (500 MHz, CD_3OD-*d$_4$*): δ 7.95 (s, 1H), 7.20 (s, 2H), 6.84 (s, 1H), 6.81 (s, 2H), 4.46 (t, *J* = 6.1 Hz, 2H), 4.23—4.19 (m, 6H), 4.16 (t, *J* = 5.8 Hz, 2H), 3.86 (t, *J* = 4.7 Hz, 4H), 3.79 (t, *J* = 4.7 Hz, 2H), 3.76—3.50 (m, 64H), 3.30 (s, 3H), 3.05 (d, $^{2}J_{P\text{-}H}$ = 20.2 Hz, 4H), 2.48 (s, 3H), 2.35 (t, *J* = 5.0 Hz, 2H) ppm

^{13}C NMR (125 MHz, CD_3OD-*d$_4$*): δ 174.5, 169.5, 160.1, 153.7, 142.3, 135.8, 132.2, 130.4, 125.1, 115.5, 107.9, 73.6, 73.5, 72.9, 71.7—71.5 (several peaks), 71.4, 71.3, 71.2, 70.8, 70.0, 67.8, 67.4, 62.2, 59.1, 46.8, 40.8, 39.6, 37.4, 36.0 (d, $^{1}J_{C\text{-}P}$ = 131.1 Hz), 13.9 ppm

^{31}P NMR (202 MHz, CD_3OD-*d$_4$*): δ 23.9 ppm

MALDI-TOF: m/z calcd for $C_{60}H_{101}N_5O_{30}P_2$ $[M\text{-}4H]^+$ 1429.606, found 1429.950



10

Starting from 0.04 mmol of dendron **47** with 0.2 mL of TMSBr (1.5 mmol, 76.0 equiv.). 55.6 mg isolated (0.03 mmol, 72%).

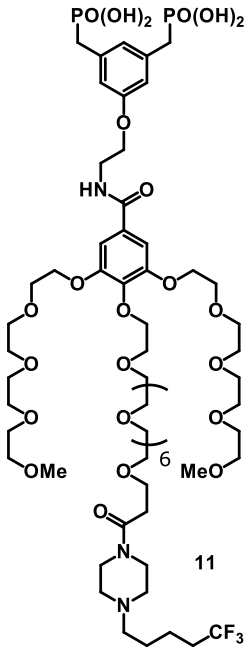
Physical state: yellow gum.

^{1}H NMR (500 MHz, CD_3OD-*d_4*): δ 8.02 (s, 2H), 7.25 (s, 2H), 6.85 (s, 1H), 6.83 (s, 2H), 4.50 (t, *J* = 5.4 Hz, 4H), 4.24—4.22 (m, 8H), 4.168(t, *J* = 5.6 Hz, 2H), 3.88 (t, *J* = 4.7 Hz, 6H), 3.81 (t, *J* = 4.7 Hz, 2H), 3.76 (t, *J* = 5.4 Hz, 2H), 3.74—3.53 (m, 97H), 3.36 (s, 3H), 3.08 (d, $^{2}J_{P\text{-}H}$ = 21.6 Hz, 4H), 2.52 (s, 6H), 2.37 (t, *J* = 5.8 Hz, 4H) ppm

^{13}C NMR (125 MHz, CD_3OD-*d_4*): δ 174.6, 169.5, 160.1, 153.7, 152.2, 142.3, 140.2, 135.8, 131.6, 130.4, 125.1, 115.5, 107.9, 73.6, 73.5, 72.9, 71.7, 71.6—71.4 (several peaks), 71.3, 71.2, 70.8, 70.1, 67.8, 67.4, 62.2, 59.1, 46.9, 40.8, 39.5, 37.4, 35.9 (d, $^{1}J_{C\text{-}P}$ = 135.7 Hz), 13.8 ppm

^{31}P NMR (202 MHz, CD_3OD-*d_4*): δ 23.9 ppm

MALDI-TOF: m/z calcd for $C_{76}H_{123}N_9O_{37}P_2$ $[M\text{-}4H]^+$ 1815.788, found 1815.190



Starting from 0.03 mmol of dendron **49** with 0.2 mL of TMSBr (1.5 mmol, 48.0 equiv.). 35.6 mg isolated (0.02 mmol, 78%).

Physical state: colorless foam.

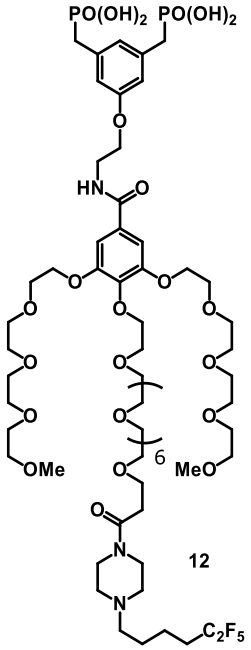
^{1}H NMR (500 MHz, CD_3OD-*d*$_4$): δ 7.24 (s, 2H), 6.83 (s, 1H), 6.79 (s, 2H), 4.22 (t, *J* = 4.3 Hz, 6H), 4.15 (t, *J* = 5.6 Hz, 2H), 3.87 (t, *J* = 4.5 Hz, 4H), 3.81 (t, *J* = 4.5 Hz, 2H), 3.76—3.49 (m, 60H), 3.33 (s, 6H), 3.09—3.06 (m, 2H), 3.03 (d, $^{2}J_{P\text{-}H}$ = 21.4 Hz, 4H), 2.65—2.58 (m, 2H), 2.29—2.19 (m, 2H), 1.86—1.79 (m, 2H), 1.64—1.57 (m, 2H) ppm

^{13}C NMR (125 MHz, CD_3OD-*d*$_4$): δ 172.3, 169.6, 160.2, 153.8, 142.3, 136.6, 130.4, 129.7, 125.2, 115.2, 108.0, 73.6, 72.9, 71.9, 71.8—71.3 (several peaks), 70.8, 70.1, 68.5, 67.4, 62.6, 59.1, 57.3, 53.0, 52.6, 43.8, 41.0, 39.5, 36.8, 35.8, 34.2, 33.9, 23.9 ppm

^{19}F NMR (282 MHz, CD_3OD-*d*$_4$): δ -67.8 ppm

^{31}P NMR (202 MHz, CD_3OD-*d*$_4$): δ 22.6 ppm

MALDI-TOF: m/z calcd for $C_{63}H_{104}F_3N_3O_{28}P_2$ $[M\text{-}4H]^+$ 1469.656, found 1469.204



Starting from 0.03 mmol of dendron **50** with 0.2 mL of TMSBr (1.5 mmol, 51.0 equiv.). 34.8 mg isolated (0.02 mmol, 79%).

Physical state: colorless foam.

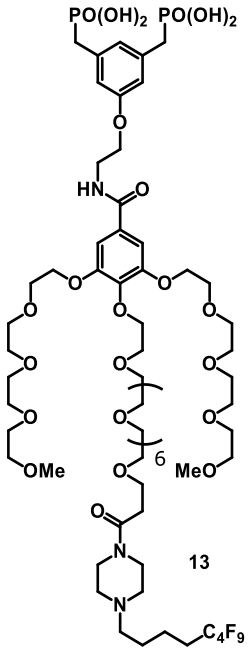
^{1}H NMR (500 MHz, CD_3OD-d_4): δ 7.25 (s, 2H), 6.84 (s, 1H), 6.79 (s, 2H), 4.22 (t, *J* = 4.5 Hz, 6H), 4.15 (t, *J* = 5.5 Hz, 2H), 3.87 (t, *J* = 4.7 Hz, 4H), 3.80 (t, *J* = 4.7 Hz, 2H), 3.76—3.50 (m, 52H), 3.33 (s, 6H), 3.12—3.09 (m, 2H), 3.03 (d, $^{2}J_{P\text{-}H}$ = 21.1 Hz, 4H), 2.65—2.62 (m, 2H), 2.27—2.16 (m, 2H), 1.88—1.82 (m, 2H), 1.68—1.62 (m, 2H) ppm

^{13}C NMR (125 MHz, CD_3OD-d_4): δ 172.3, 169.5, 160.1, 153.8, 142.4, 136.6, 130.5, 115.3, 107.8, 73.6, 73.0, 71.9, 71.7—71.3 (several peaks), 70.8, 70.1, 68.5, 67.4, 62.2, 59.1, 57.3, 41.0, 39.6, 34.2, 24.2 ppm

^{19}F NMR (282 MHz, CD_3OD-d_4): δ -86.9, -119.4 ppm

^{31}P NMR (202 MHz, CD_3OD-d_4): δ 22.7 ppm

MALDI-TOF: m/z calcd for $C_{64}H_{104}F_5N_3O_{28}P_2$ $[M\text{-}4H]^+$ 1519.651, found 1519.002



Starting from 0.03 mmol of dendron **51** with 0.2 mL of TMSBr (1.5 mmol, 51.0 equiv.). 43.0 mg isolated (0.03 mmol, 80%).

Physical state: colorless foam.

^{1}H NMR (500 MHz, CD_3OD-d_4): δ 7.25 (s, 2H), 6.83 (s, 1H), 6.78 (s, 2H), 4.22 (t, *J* = 4.5 Hz, 6H), 4.14 (t, *J* = 5.6 Hz, 2H), 3.87 (t, *J* = 4.7 Hz, 4H), 3.80 (t, *J* = 4.6 Hz, 2H), 3.76—3.50 (m, 74H), 3.33 (s, 6H), 3.10—3.06 (m, 2H), 3.02 (d, $^{2}J_{P\text{-}H}$ = 21.0 Hz, 4H), 2.64—2.59 (m, 2H), 2.32—2.21 (m, 2H), 1.89—1.83 (m, 2H), 1.70—1.63 (m, 2H) ppm

^{13}C NMR (125 MHz, CD_3OD-d_4): δ 172.3, 169.5, 160.1, 153.8, 142.4, 136.6, 130.5, 125.3, 115.3, 108.9, 79.3, 73.6, 73.0, 72.1, 71.9—71.3 (several peaks), 70.8, 70.0, 68.5, 67.4, 62.2, 59.1, 57.3, 52.9, 52.5, 43.7, 41.0, 39.6, 34.2, 30.8, 24.2, 18.7 ppm

^{19}F NMR (470 MHz, CD_3OD-d_4): δ -82.6, -115.6, -125.3, -127.1 ppm

^{31}P NMR (202 MHz, CD_3OD-d_4): δ 22.4 ppm

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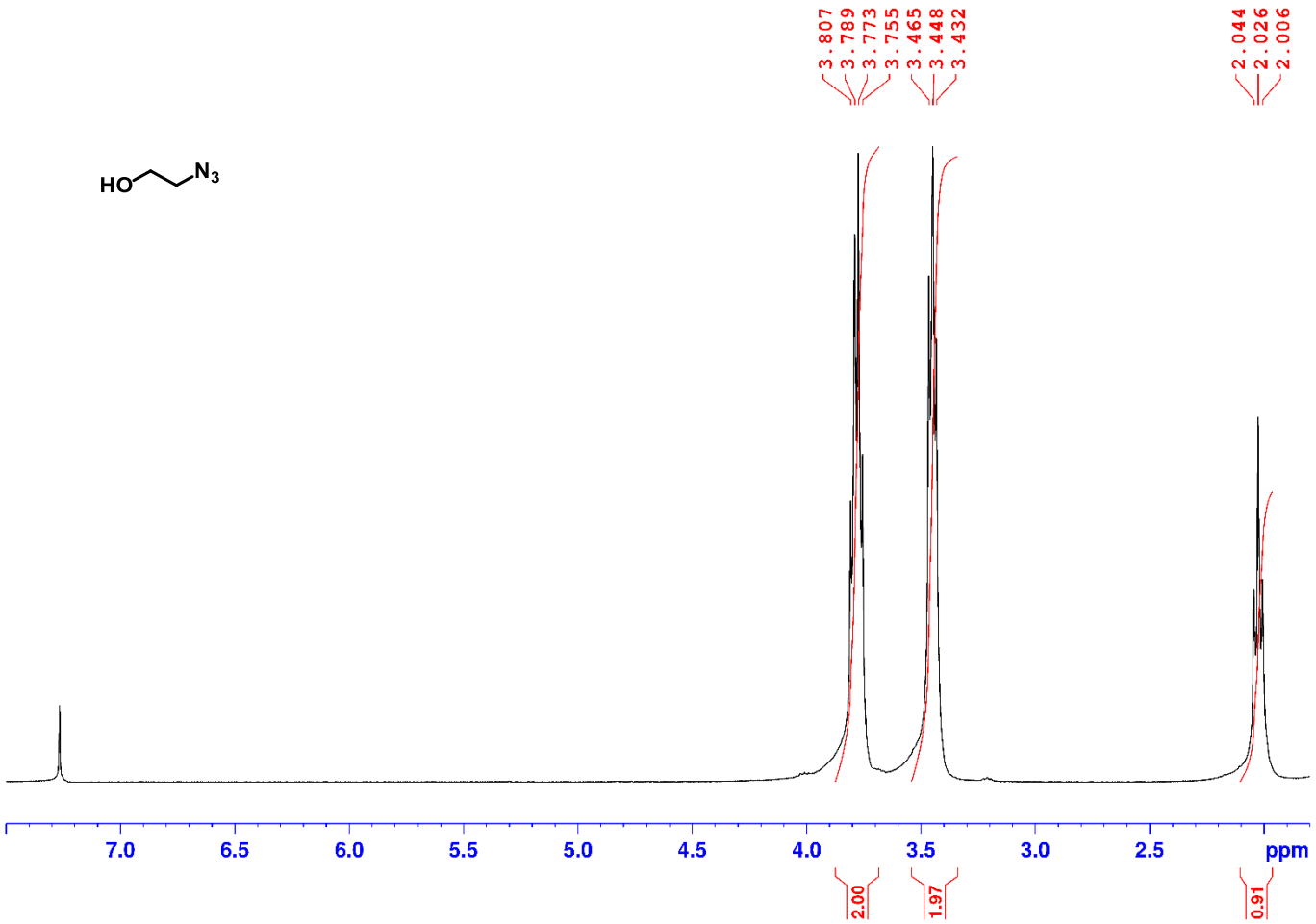
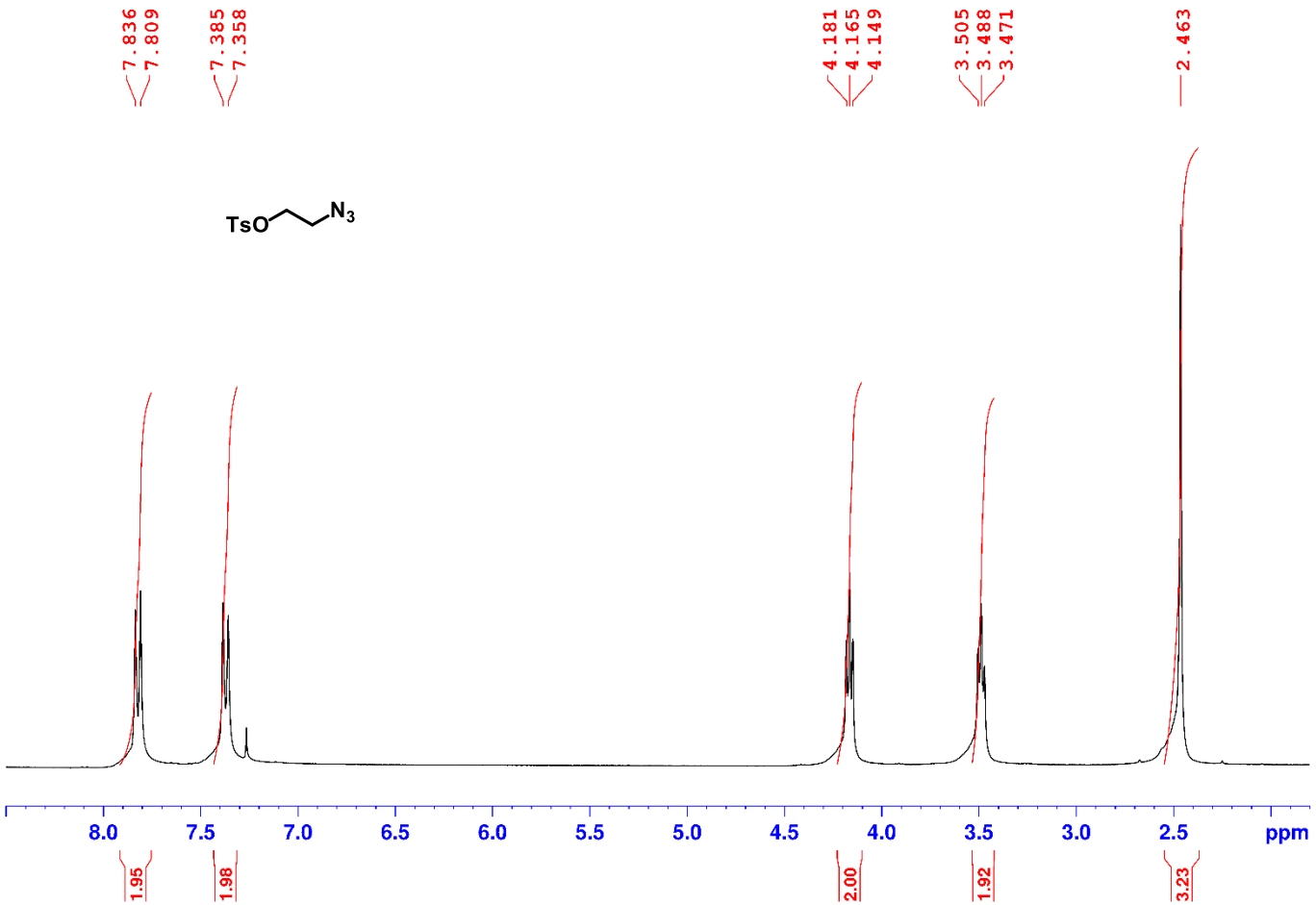
NMR Spectra

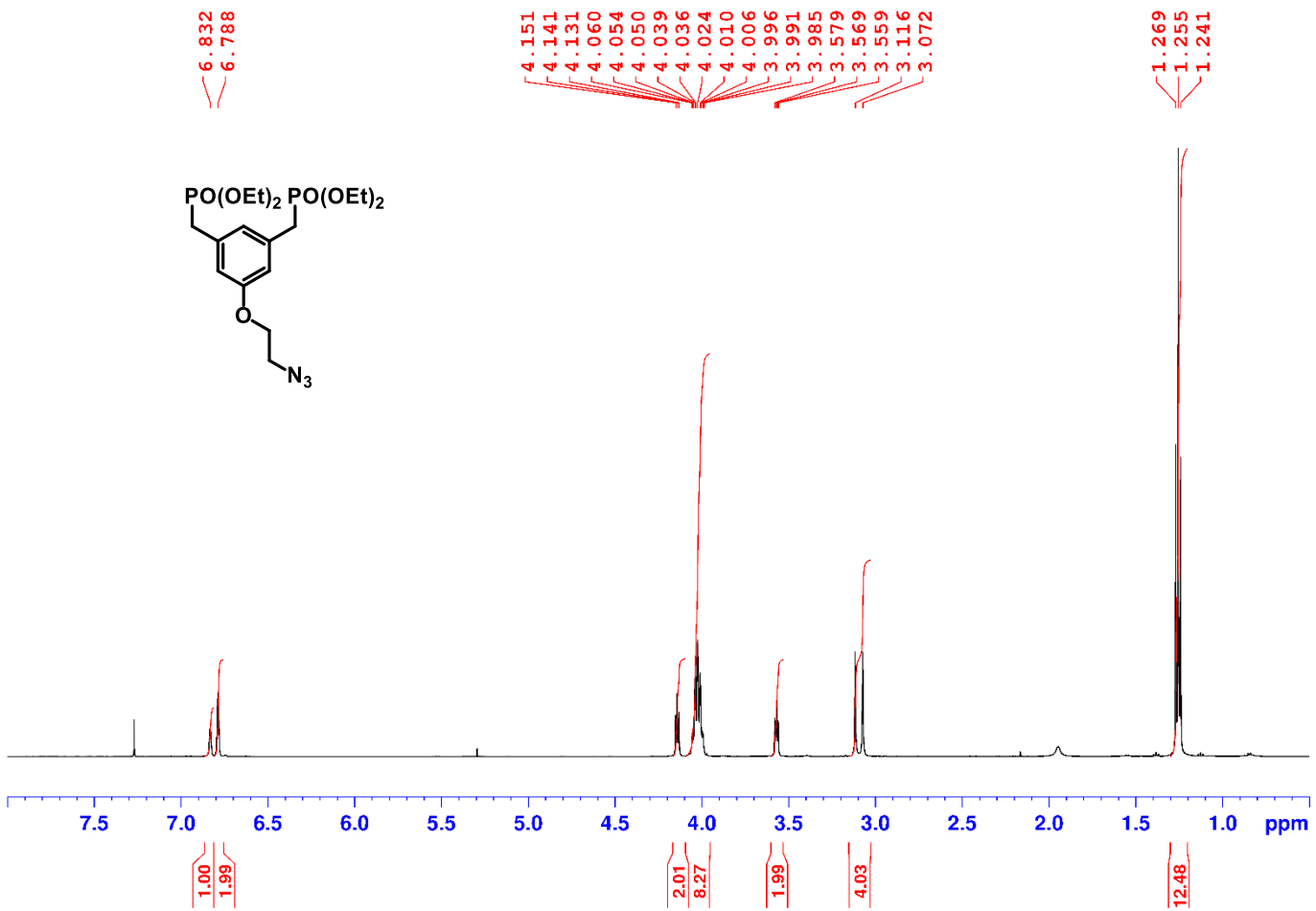
Compound 14 – ^{1}H NMR (300 MHz, $CDCl_3$)



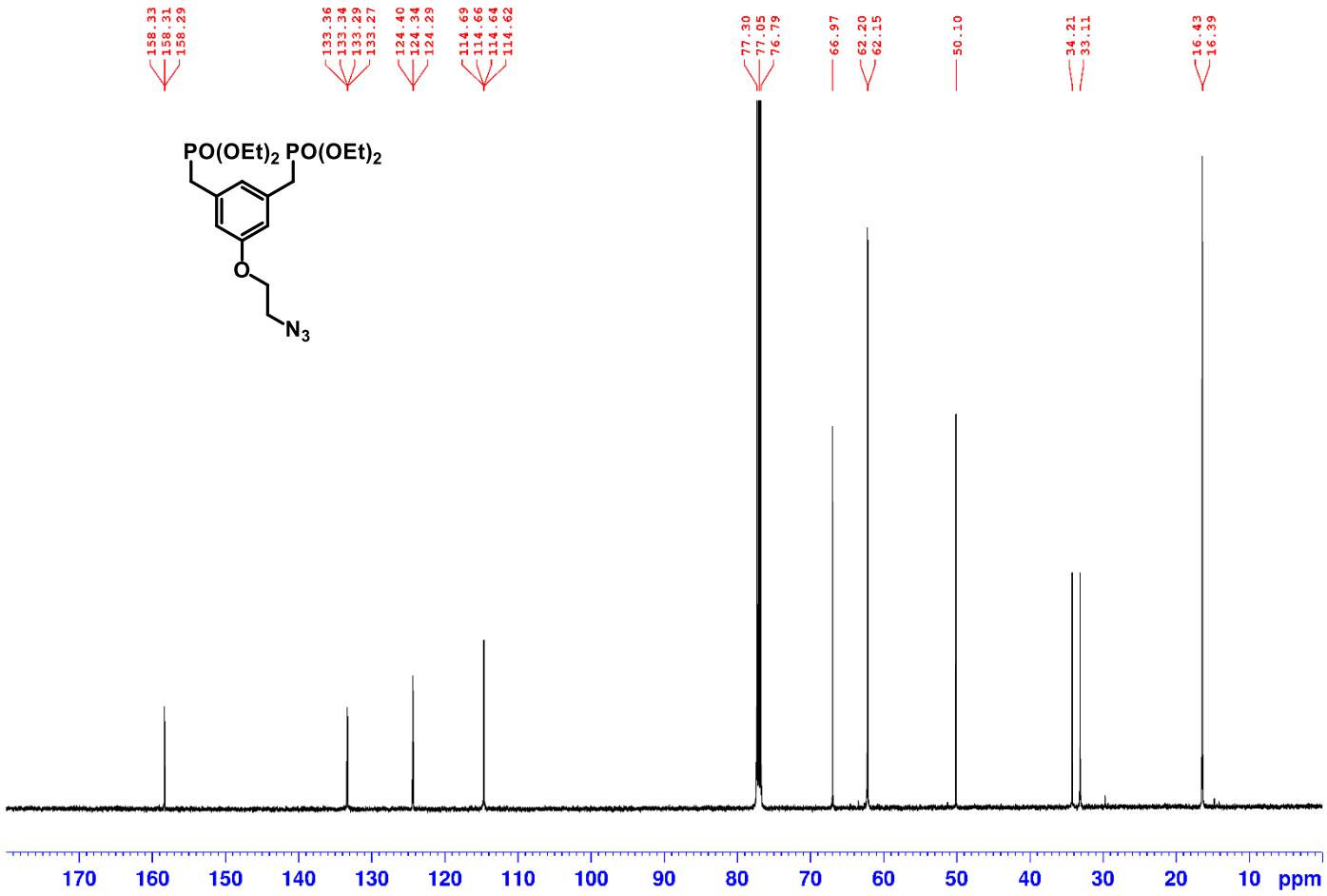
Compound 15 – ^{1}H NMR (300 MHz, $CDCl_3$)



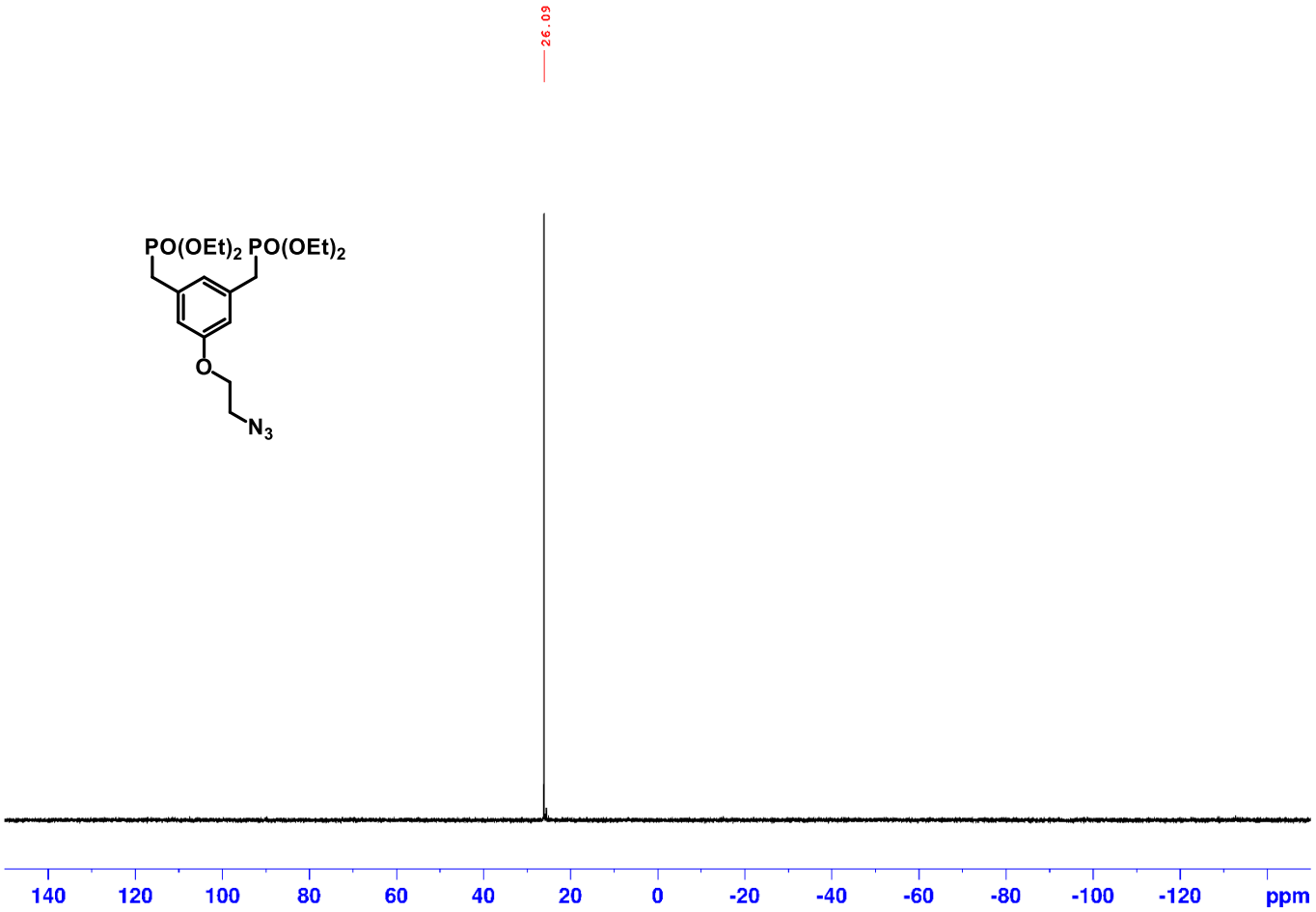
Compound 17 – ^{1}H NMR (500 MHz, $CDCl_3$)



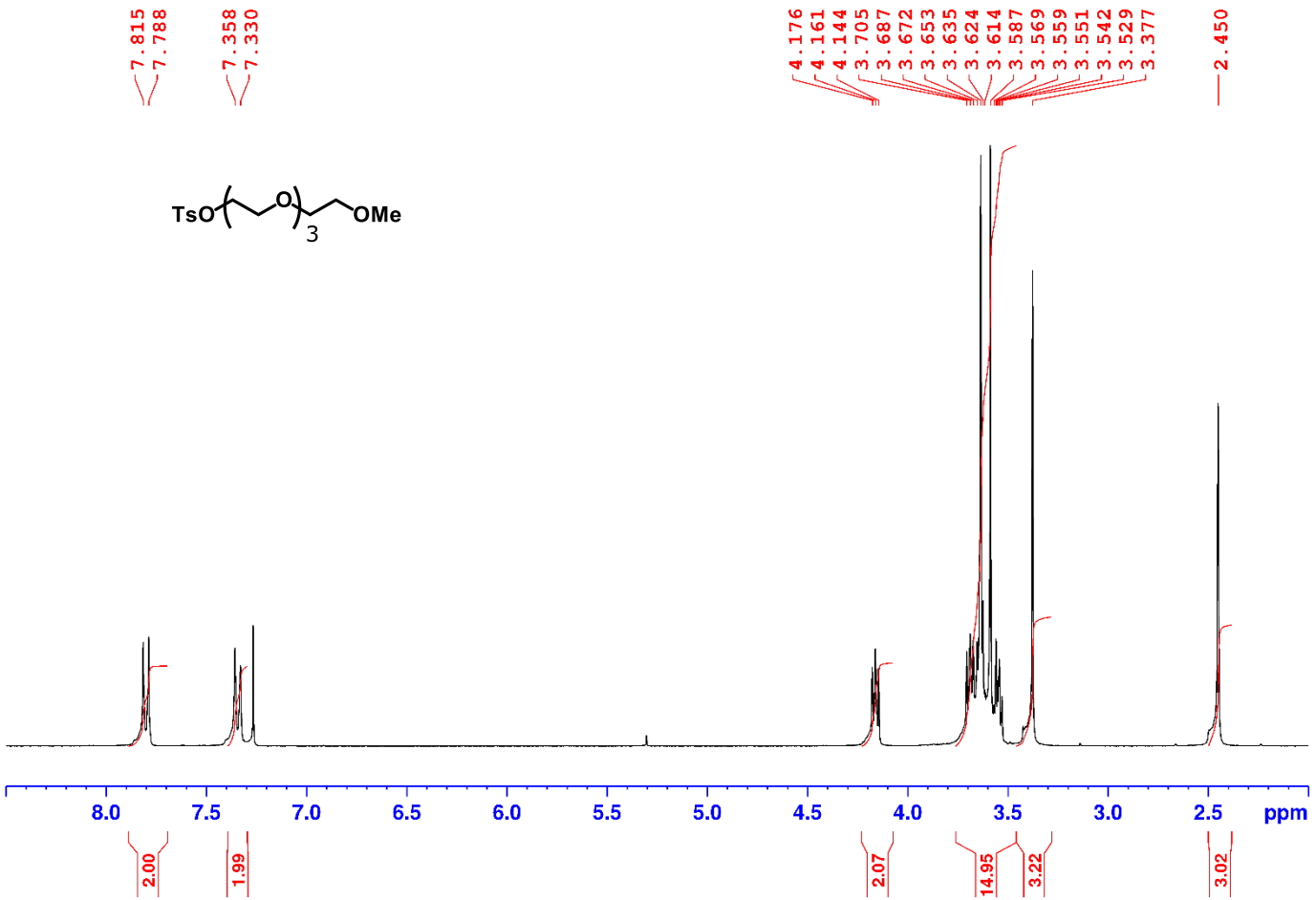
Compound 17 – ^{13}C NMR (125 MHz, $CDCl_3$)



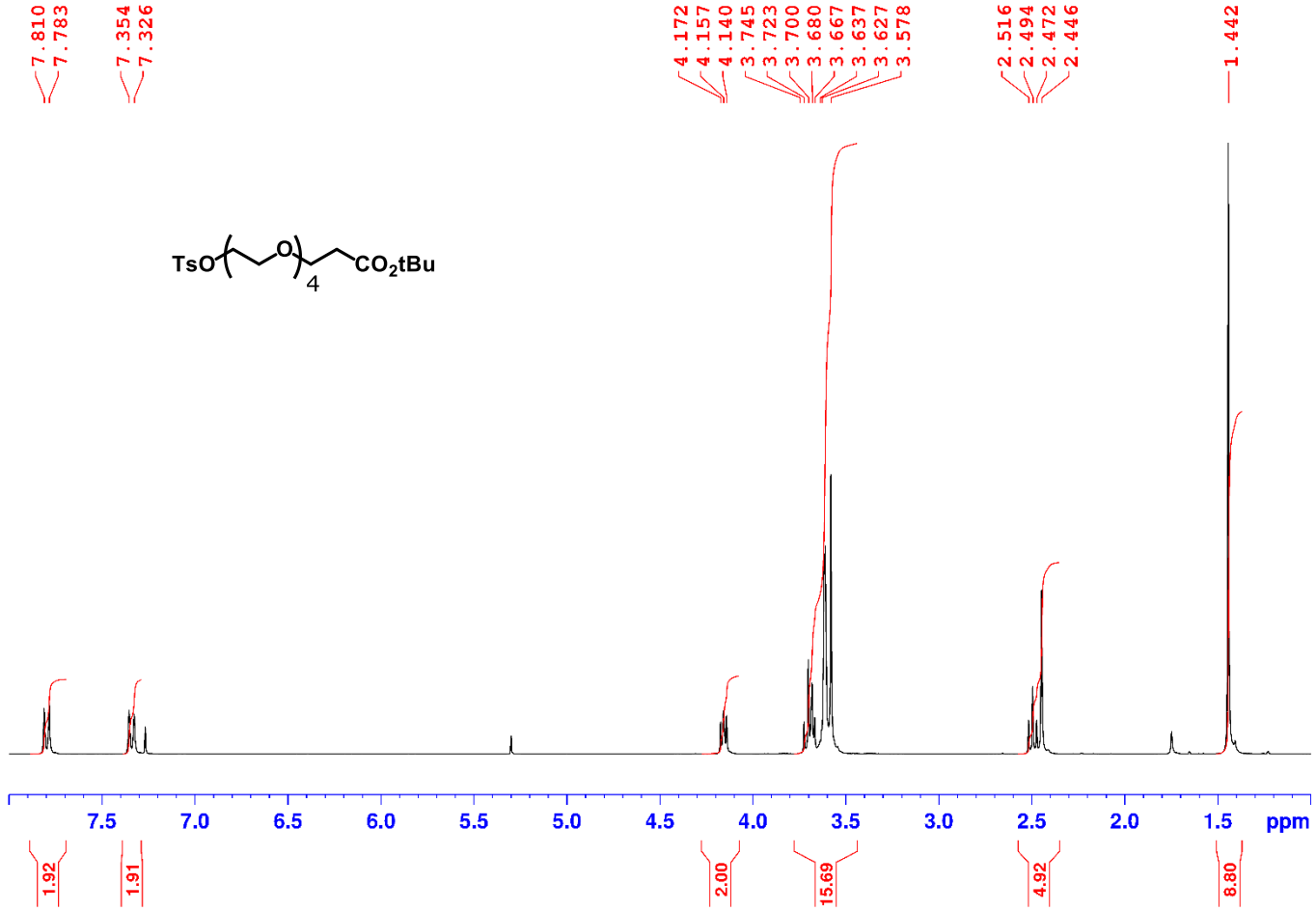
Compound 17 – ^{31}P NMR (202 MHz, $CDCl_3$)



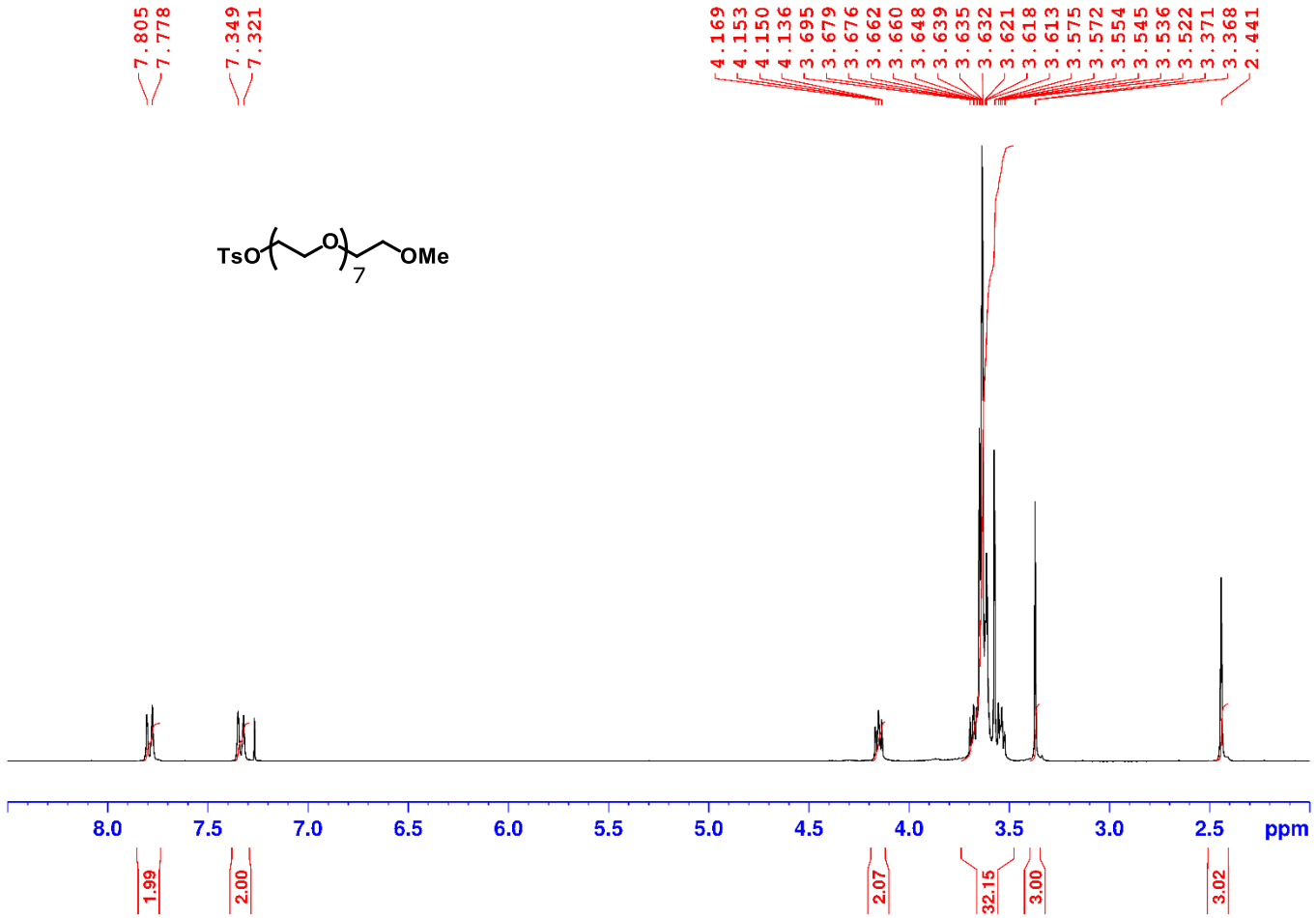
Compound 18 – ^{1}H NMR (300 MHz, $CDCl_3$)



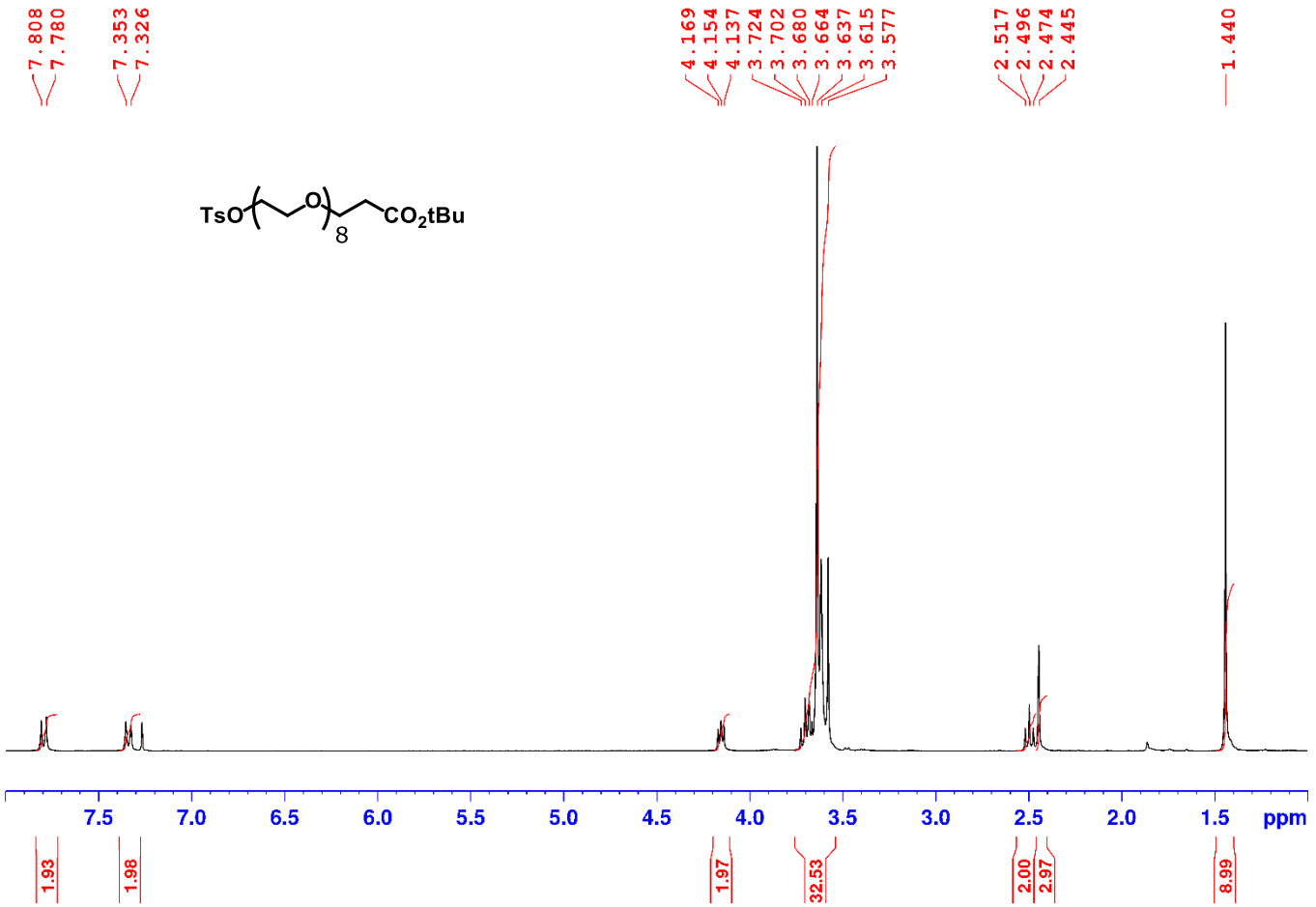
Compound 19 – ^{1}H NMR (300 MHz, $CDCl_3$)



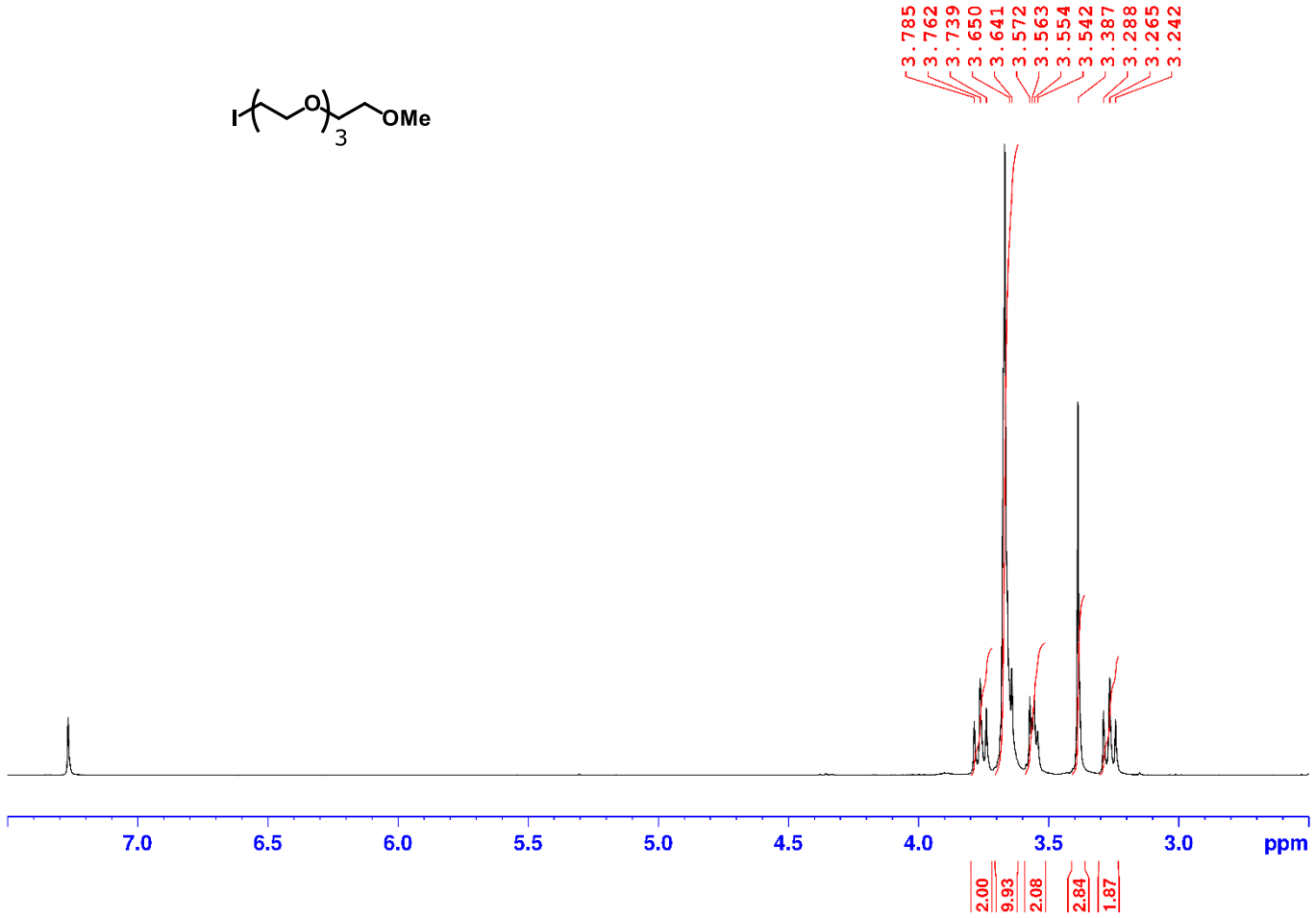
Compound 21 – ^{1}H NMR (300 MHz, $CDCl_3$)



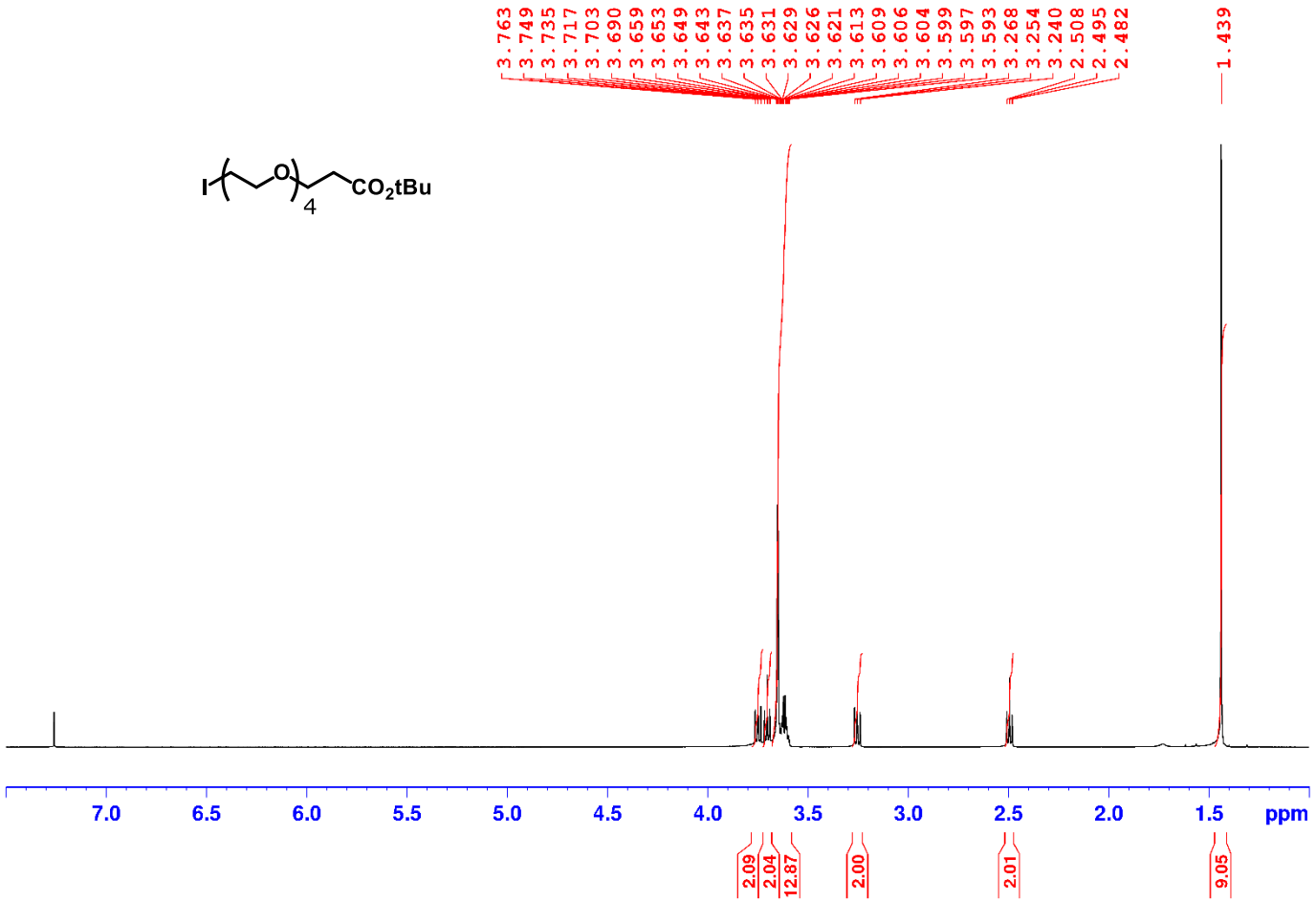
Compound 20 – ^{1}H NMR (300 MHz, $CDCl_3$)



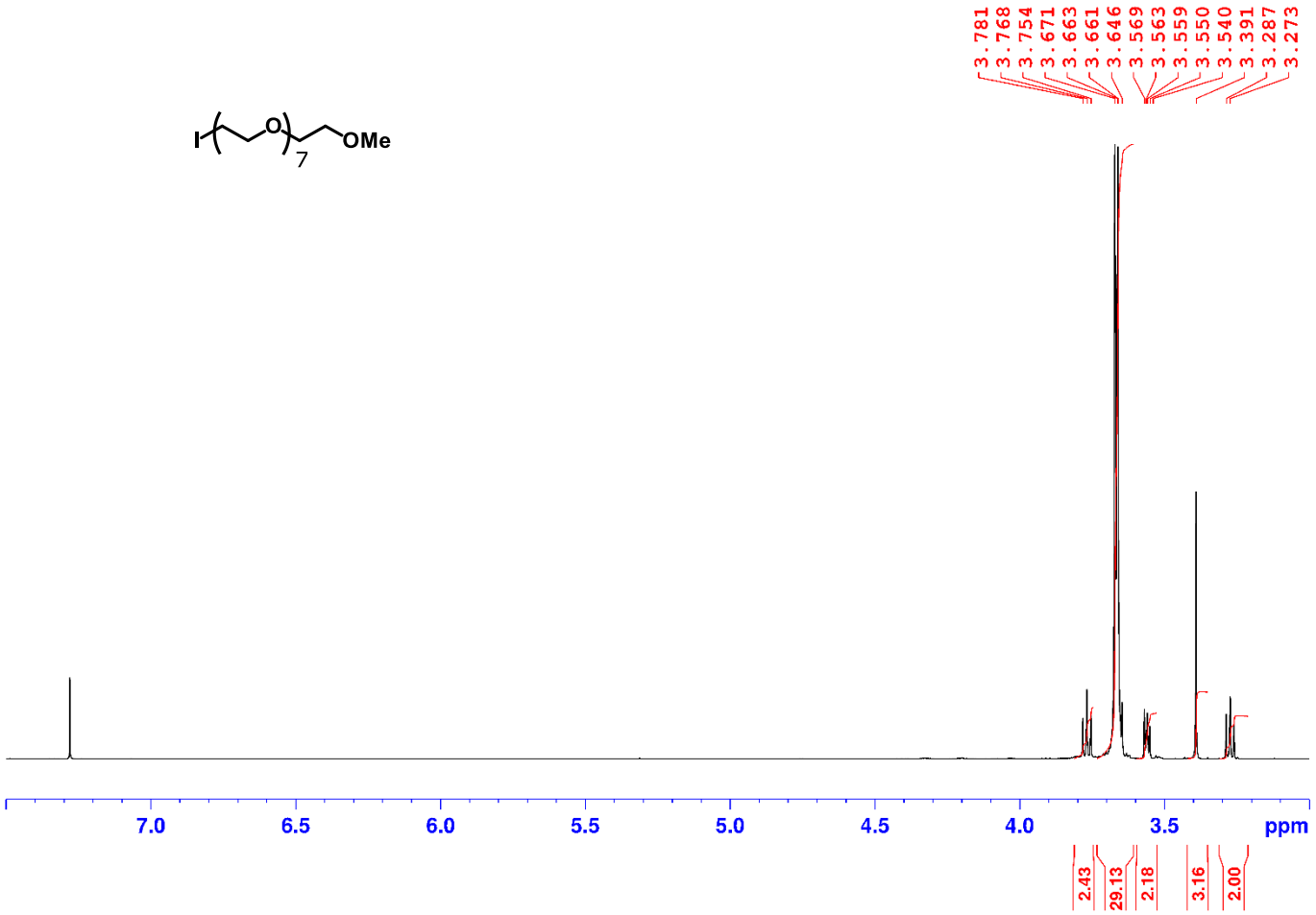
Compound 22 – ^{1}H NMR (300 MHz, $CDCl_3$)



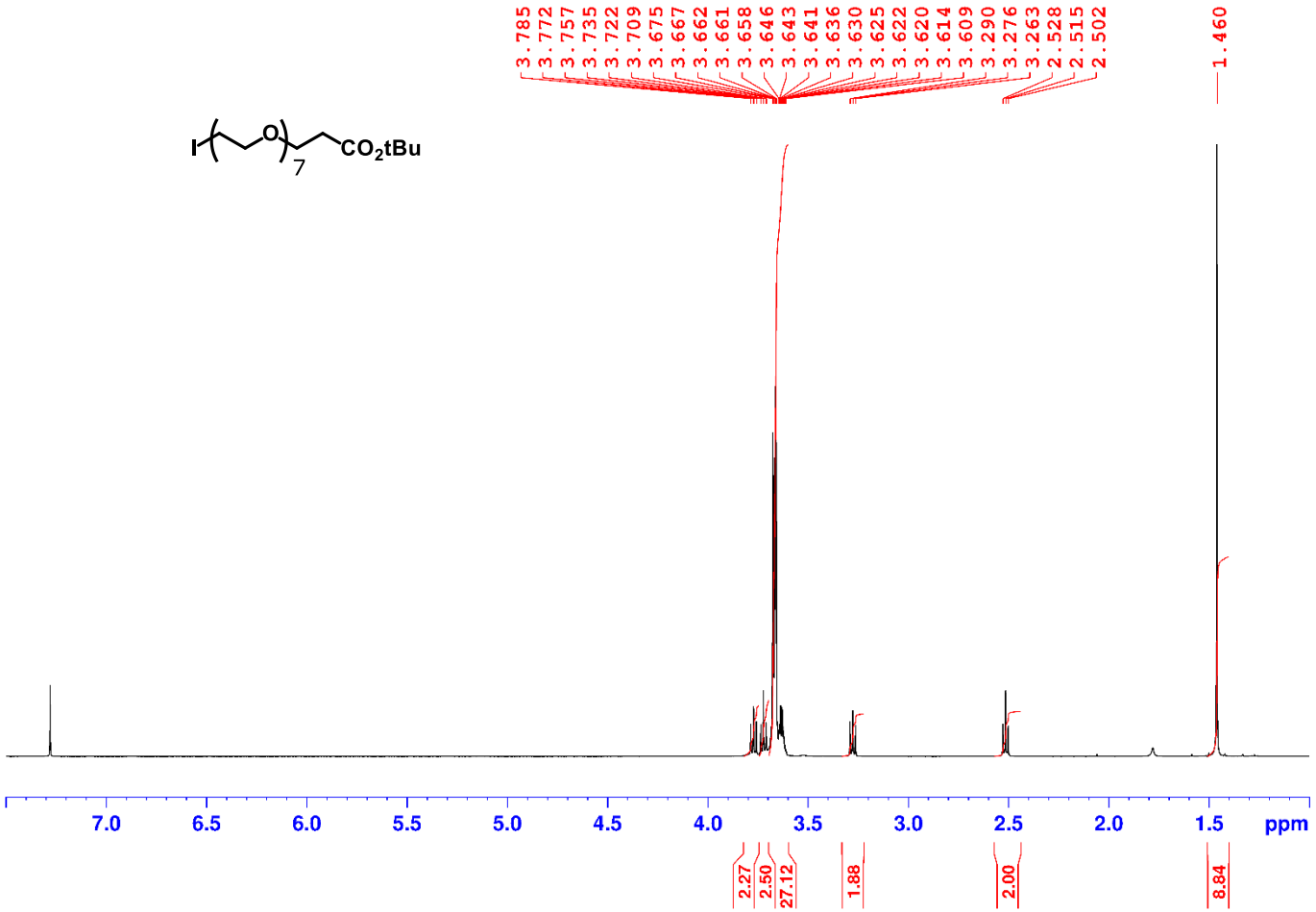
Compound 23 – ^{1}H NMR (300 MHz, $CDCl_3$)



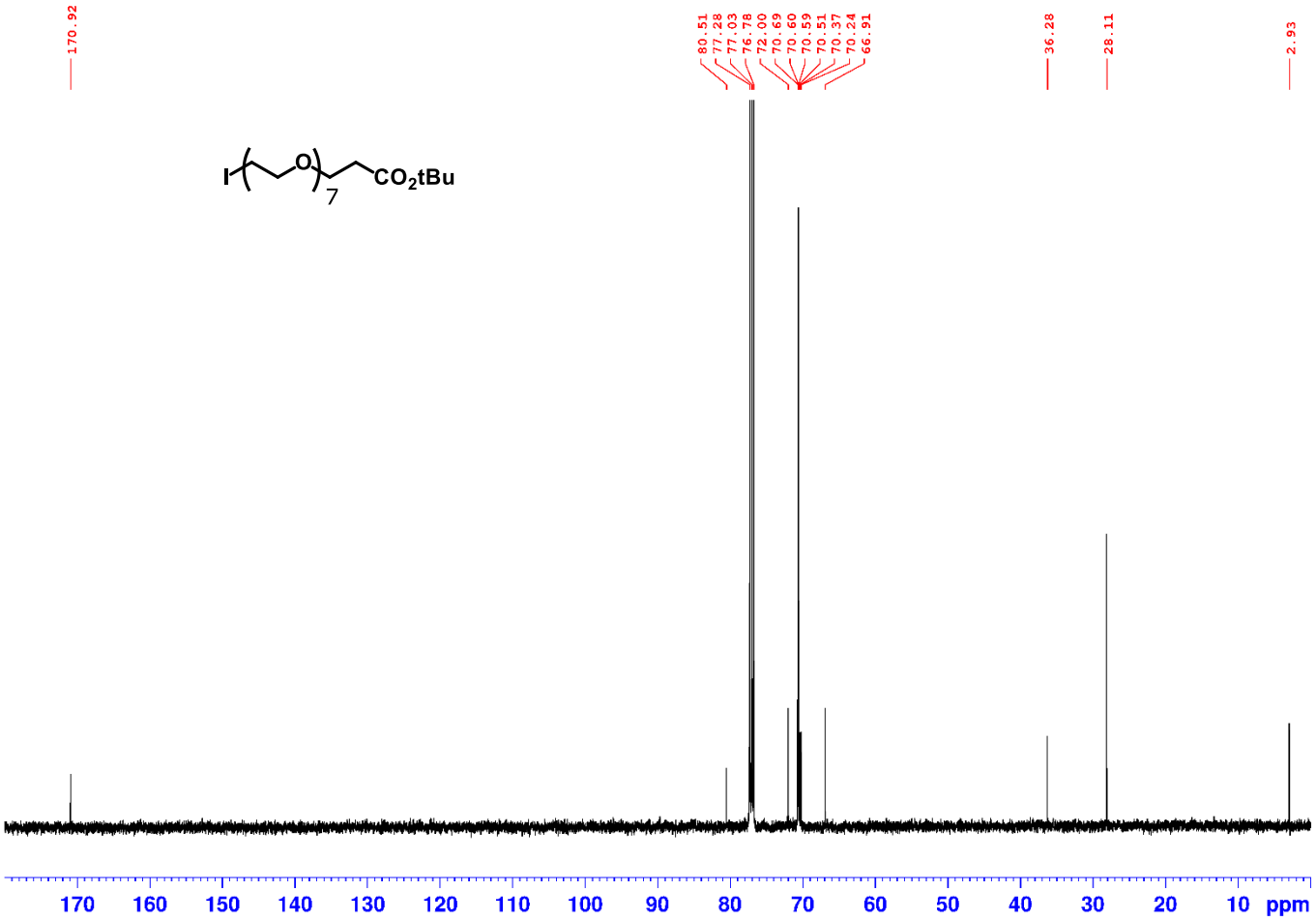
Compound 25 – ^{1}H NMR (300 MHz, $CDCl_3$)



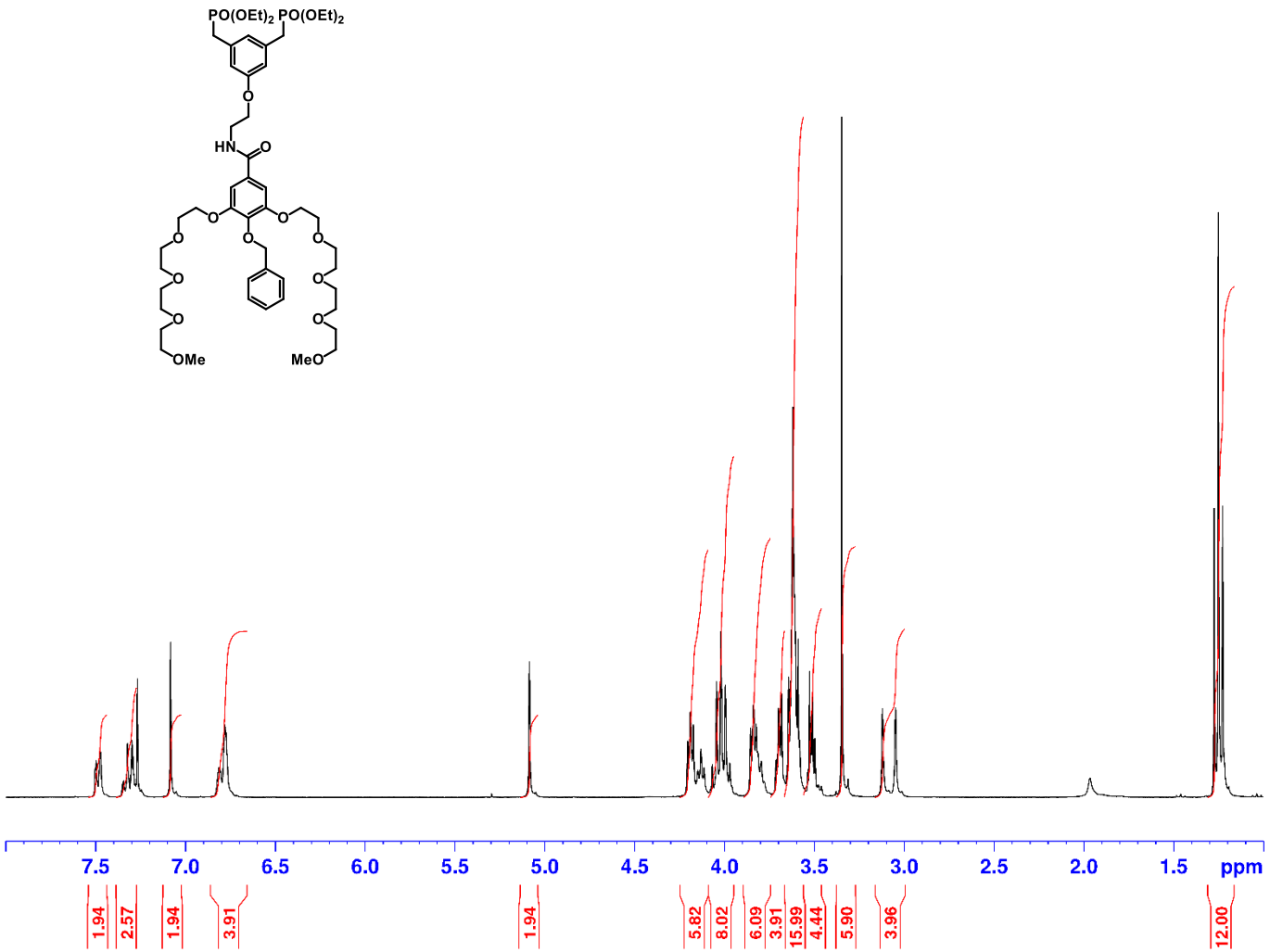
Compound 24 – ^{1}H NMR (500 MHz, $CDCl_3$)



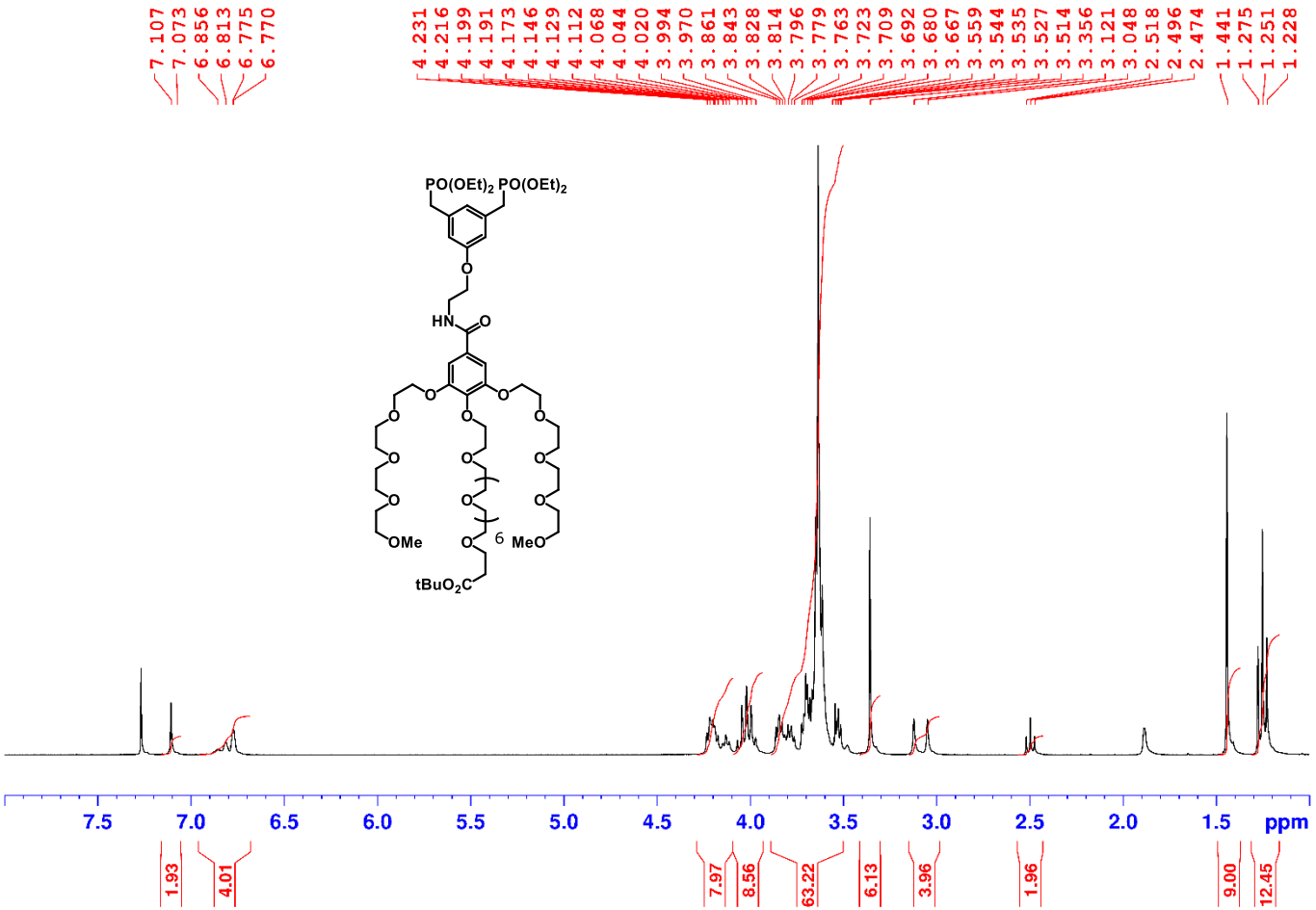
Compound 24 – ^{13}C NMR (125 MHz, $CDCl_3$)



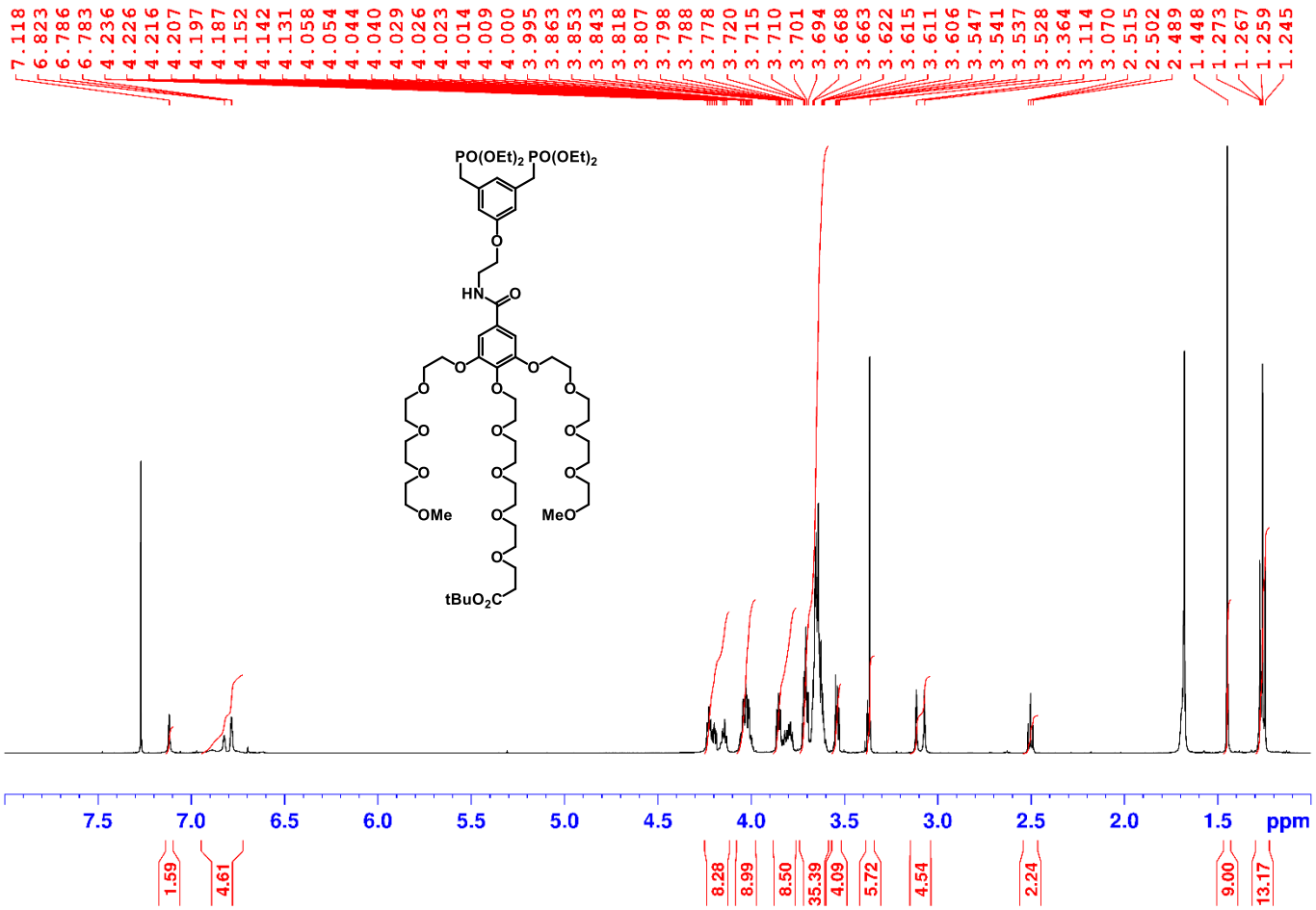
Compound 27 – ^{1}H NMR (300 MHz, $CDCl_3$)



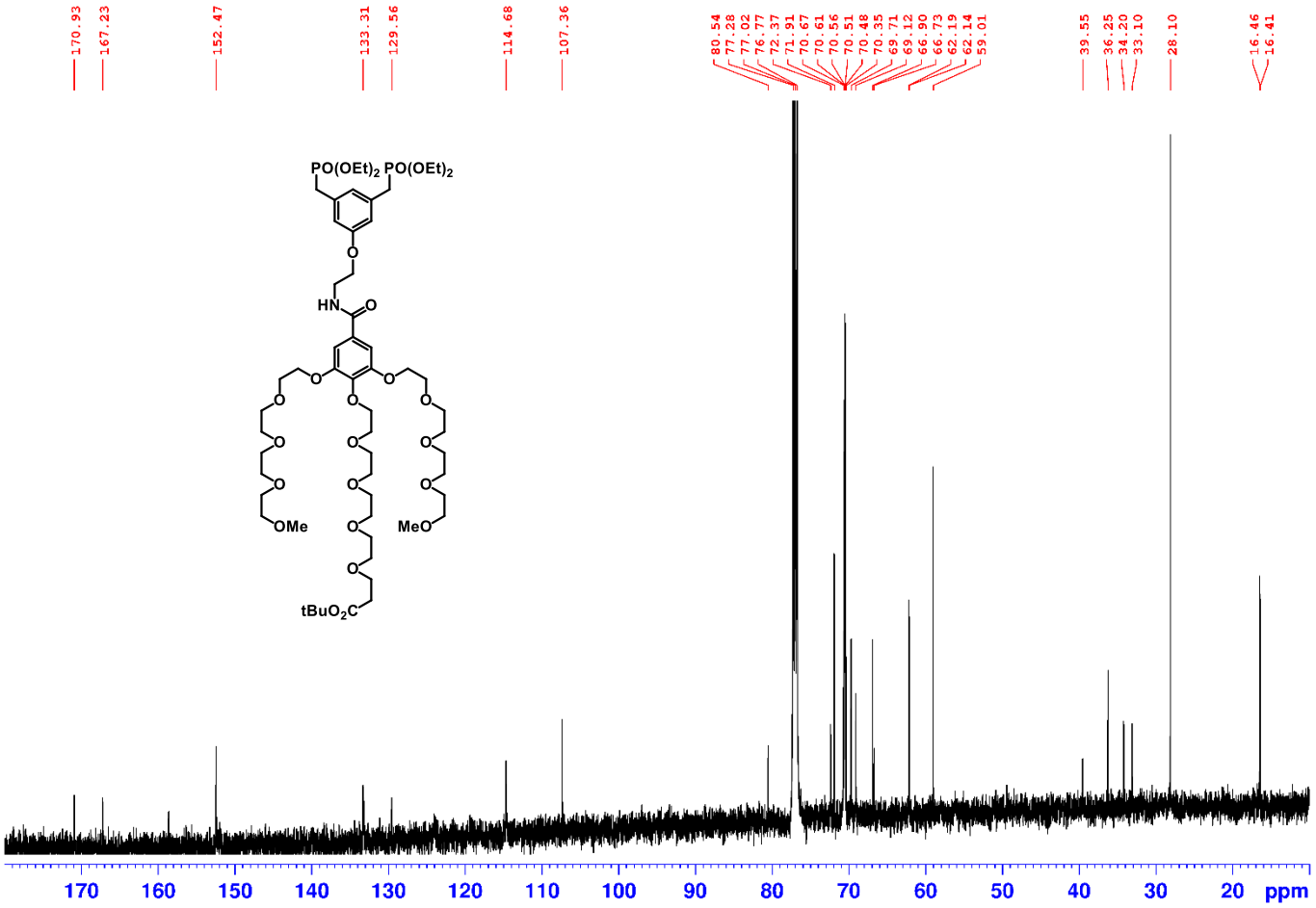
Compound 28 – ^{1}H NMR (300 MHz, $CDCl_3$)



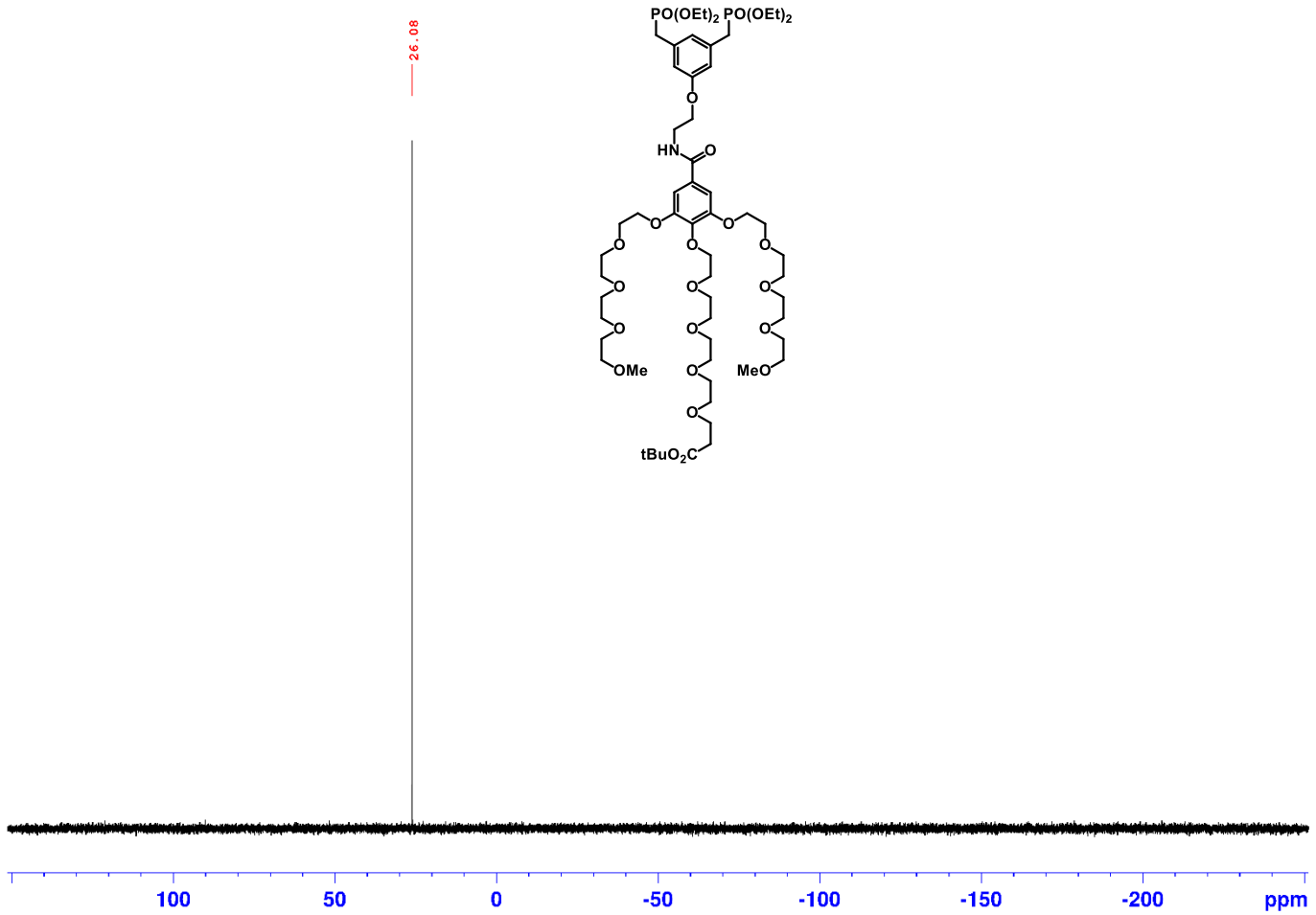
Compound 29 – ^{1}H NMR (500 MHz, $CDCl_3$)



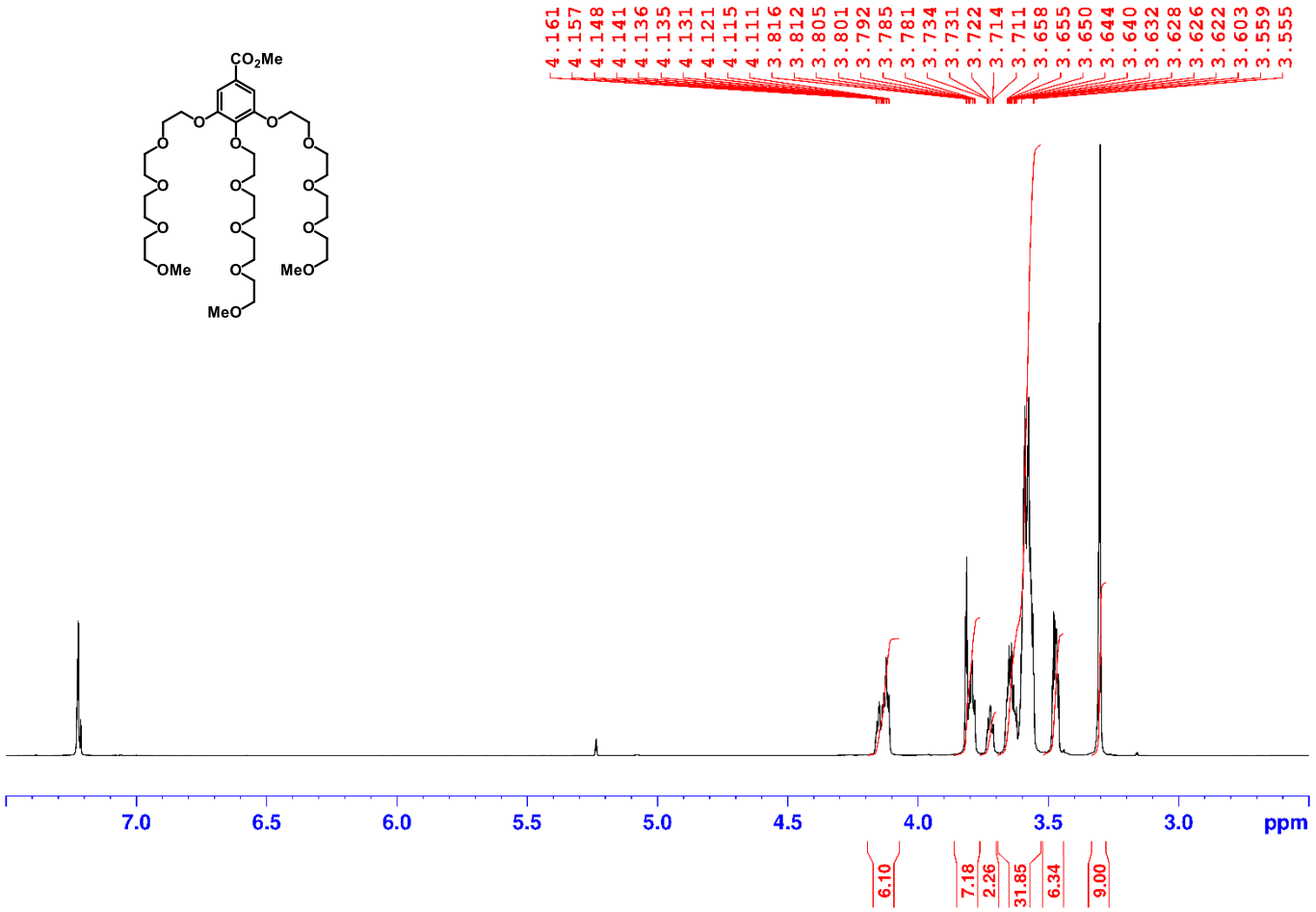
Compound 29 – ^{13}C NMR (125 MHz, $CDCl_3$)



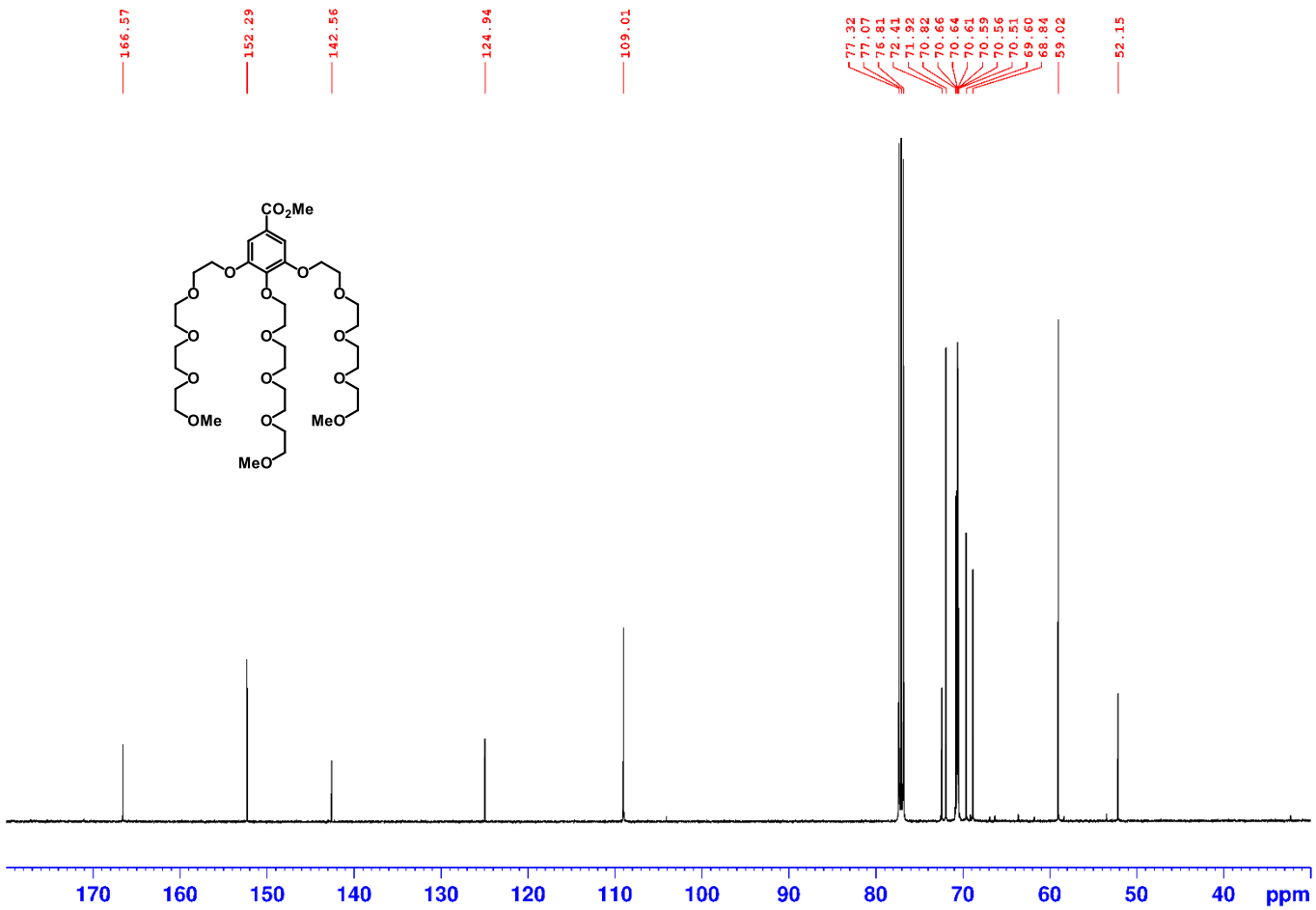
Compound 29 – ^{31}P NMR (202 MHz, $CDCl_3$)



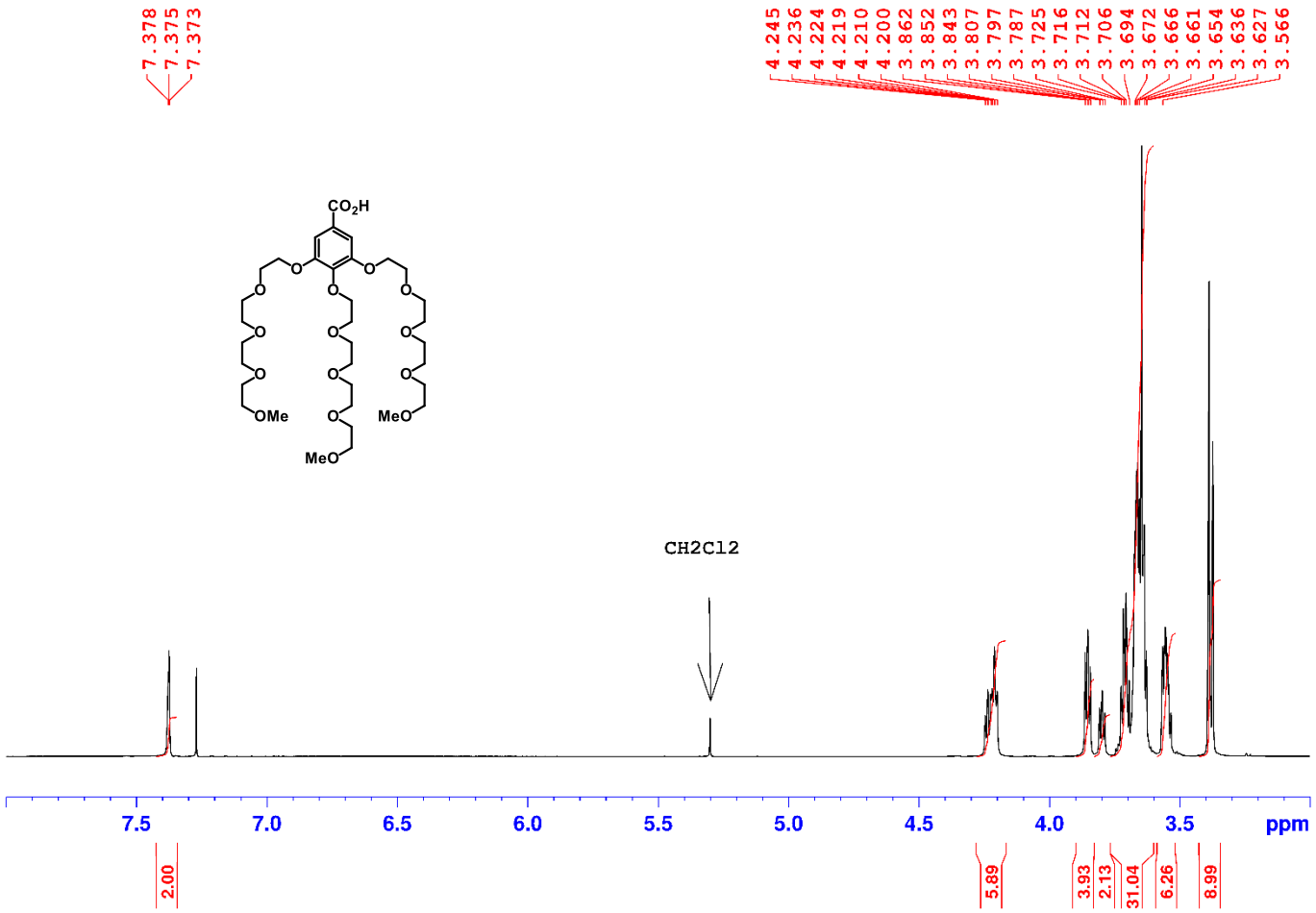
Compound 30 – ^{1}H NMR (500 MHz, $CDCl_3$)



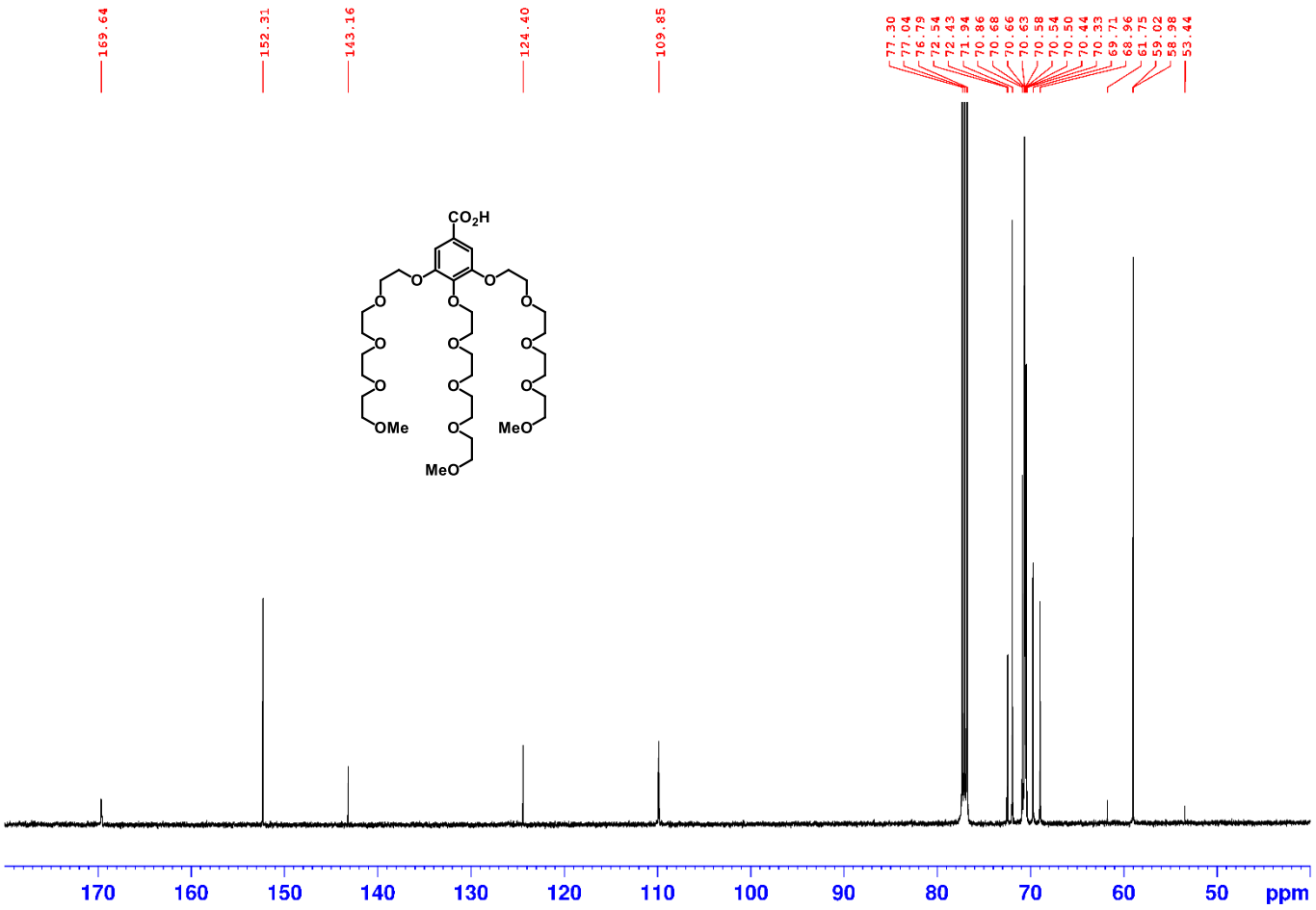
Compound 30 – ^{13}C NMR (125 MHz, $CDCl_3$)



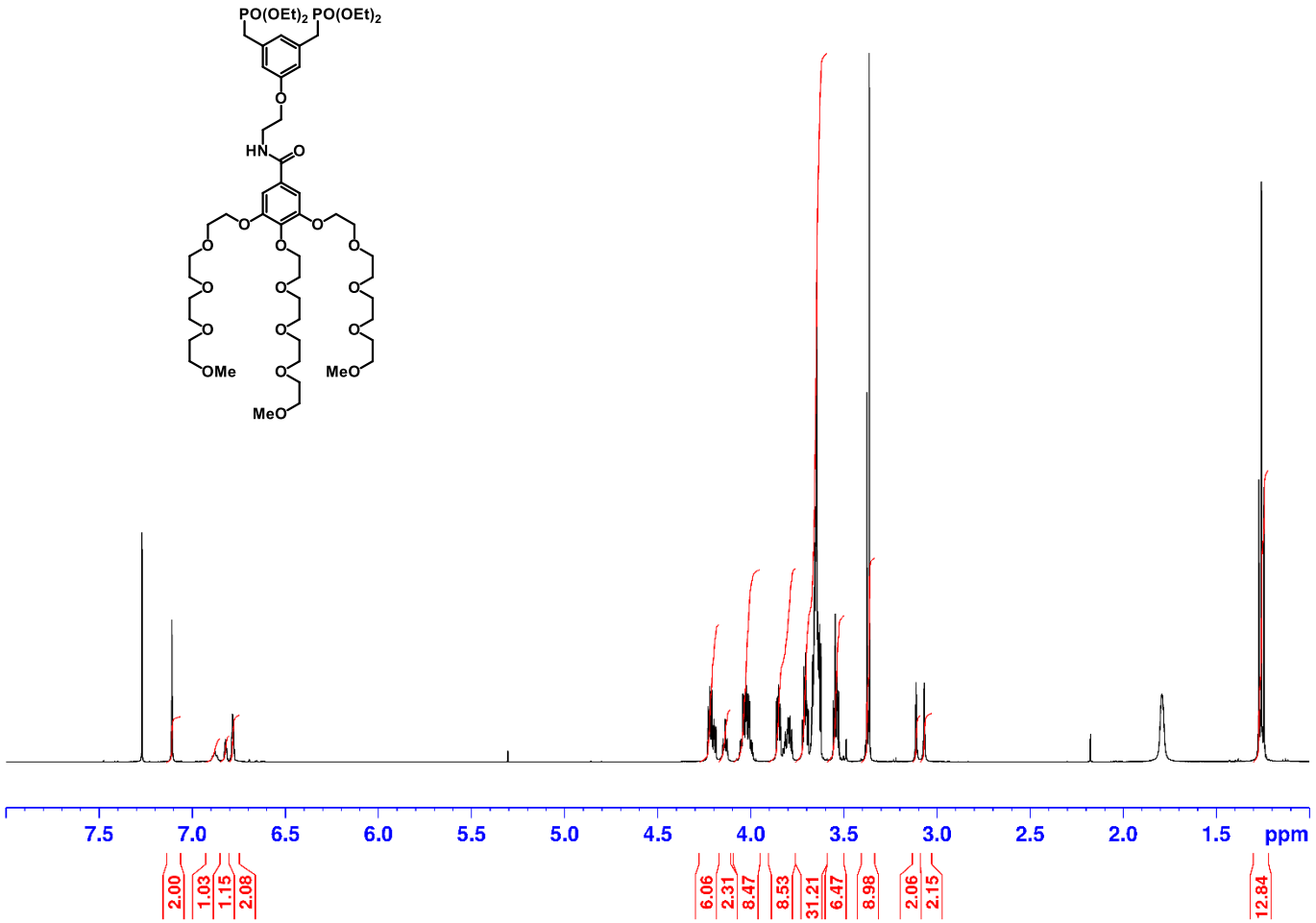
Compound 31 – ^{1}H NMR (500 MHz, $CDCl_3$)



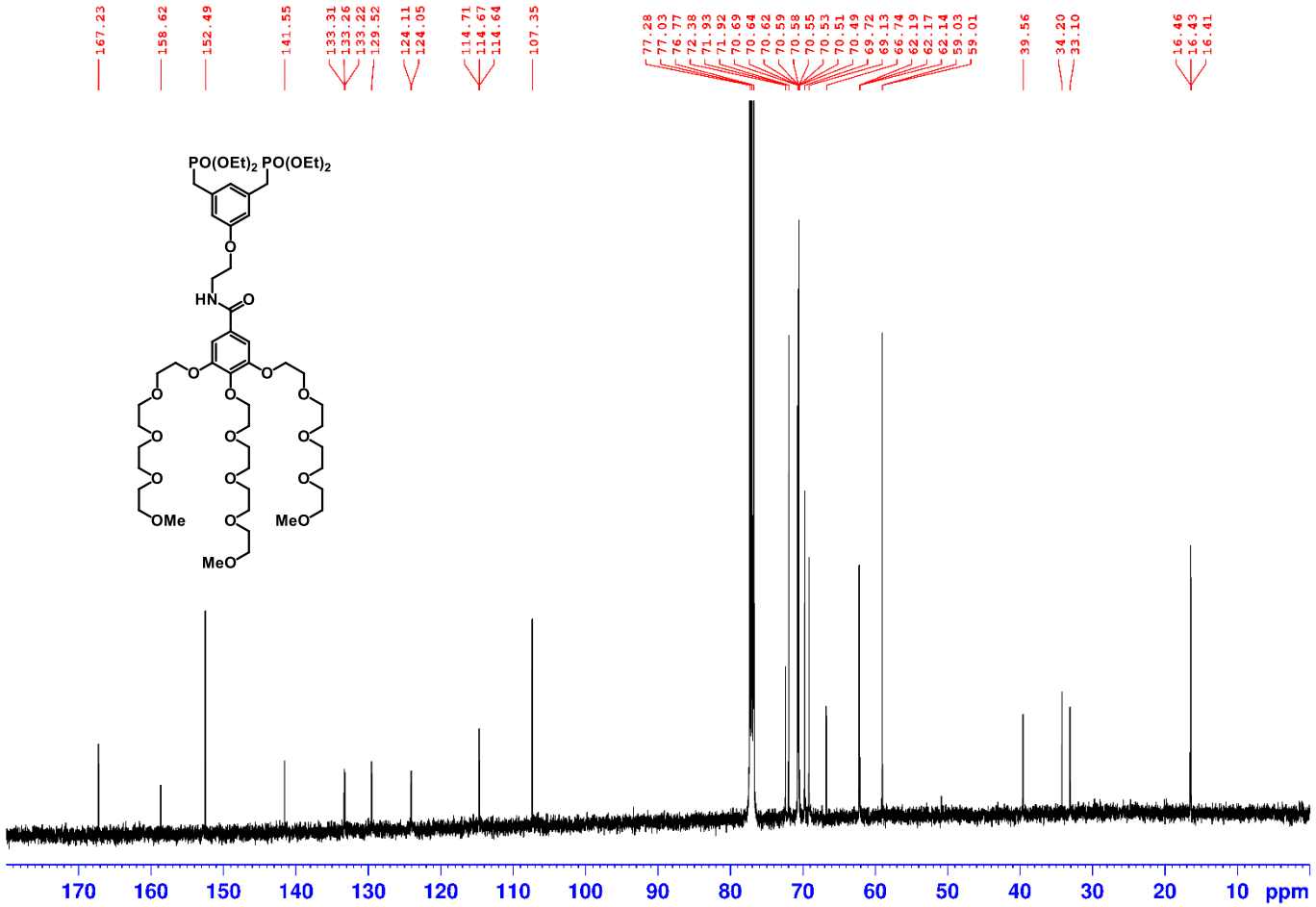
Compound 31 – ^{13}C NMR (125 MHz, $CDCl_3$)



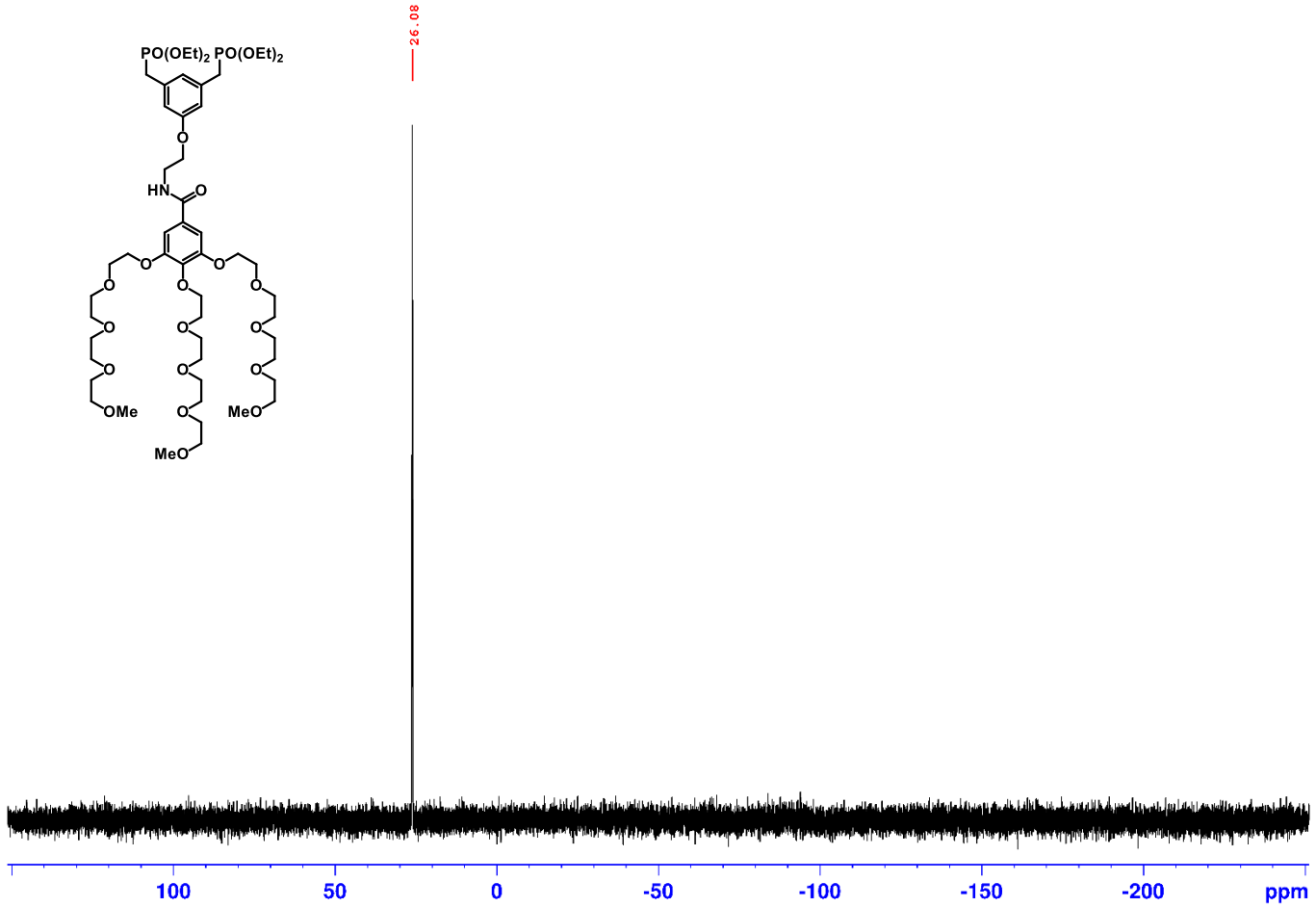
Compound 32 – ^{1}H NMR (500 MHz, $CDCl_3$)



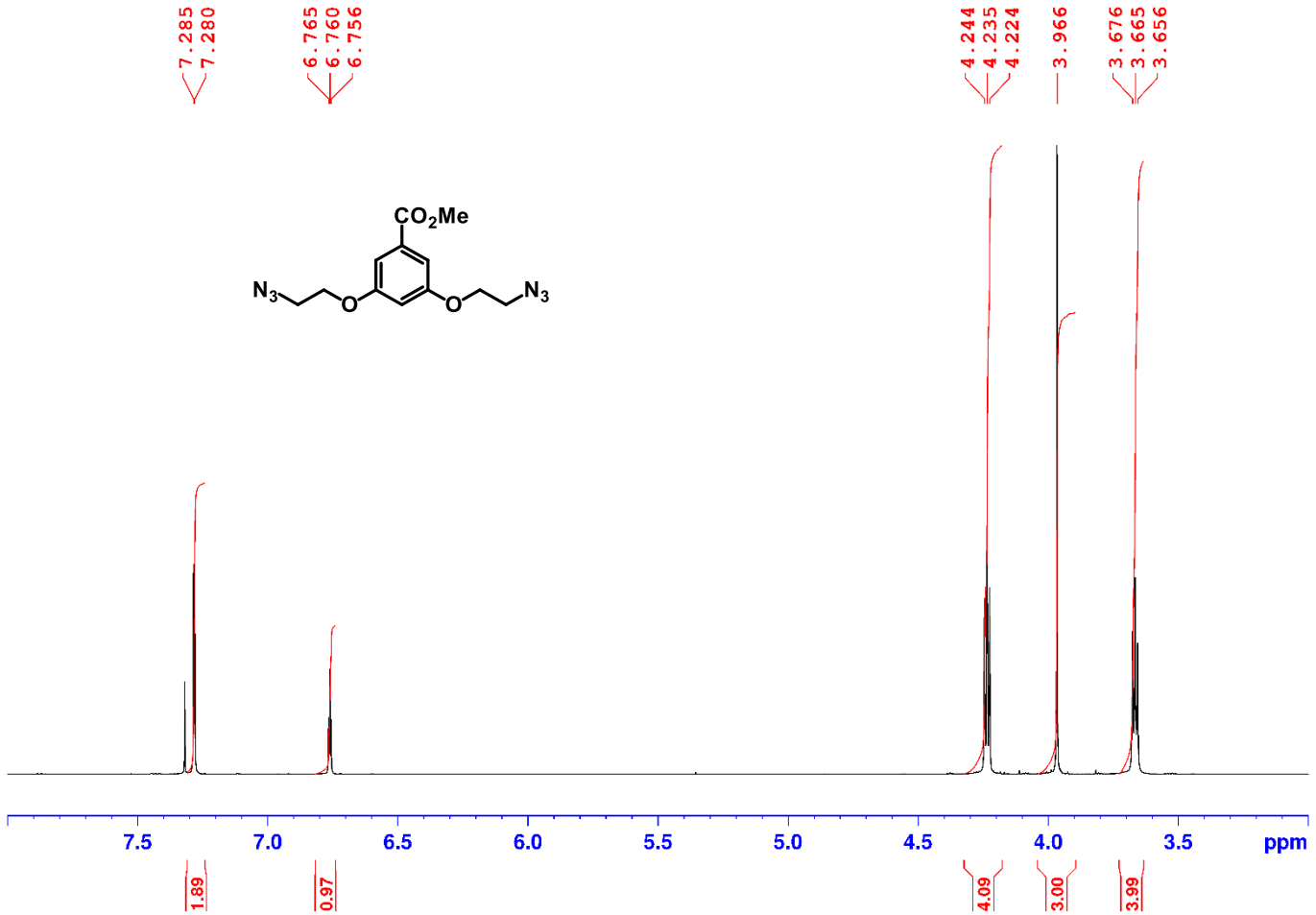
Compound 32 – ^{13}C NMR (125 MHz, $CDCl_3$)



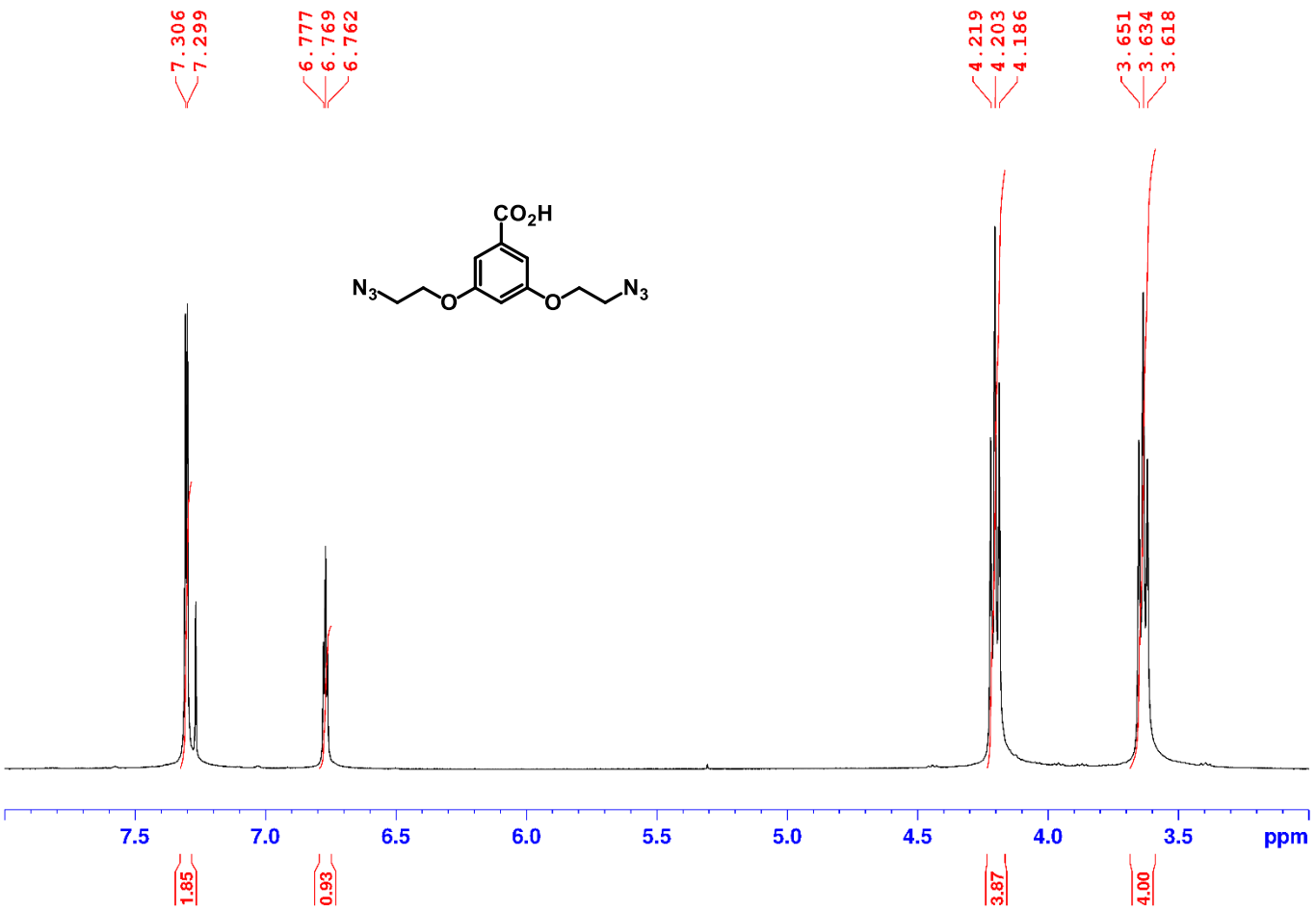
Compound 32 – ^{31}P NMR (202 MHz, $CDCl_3$)



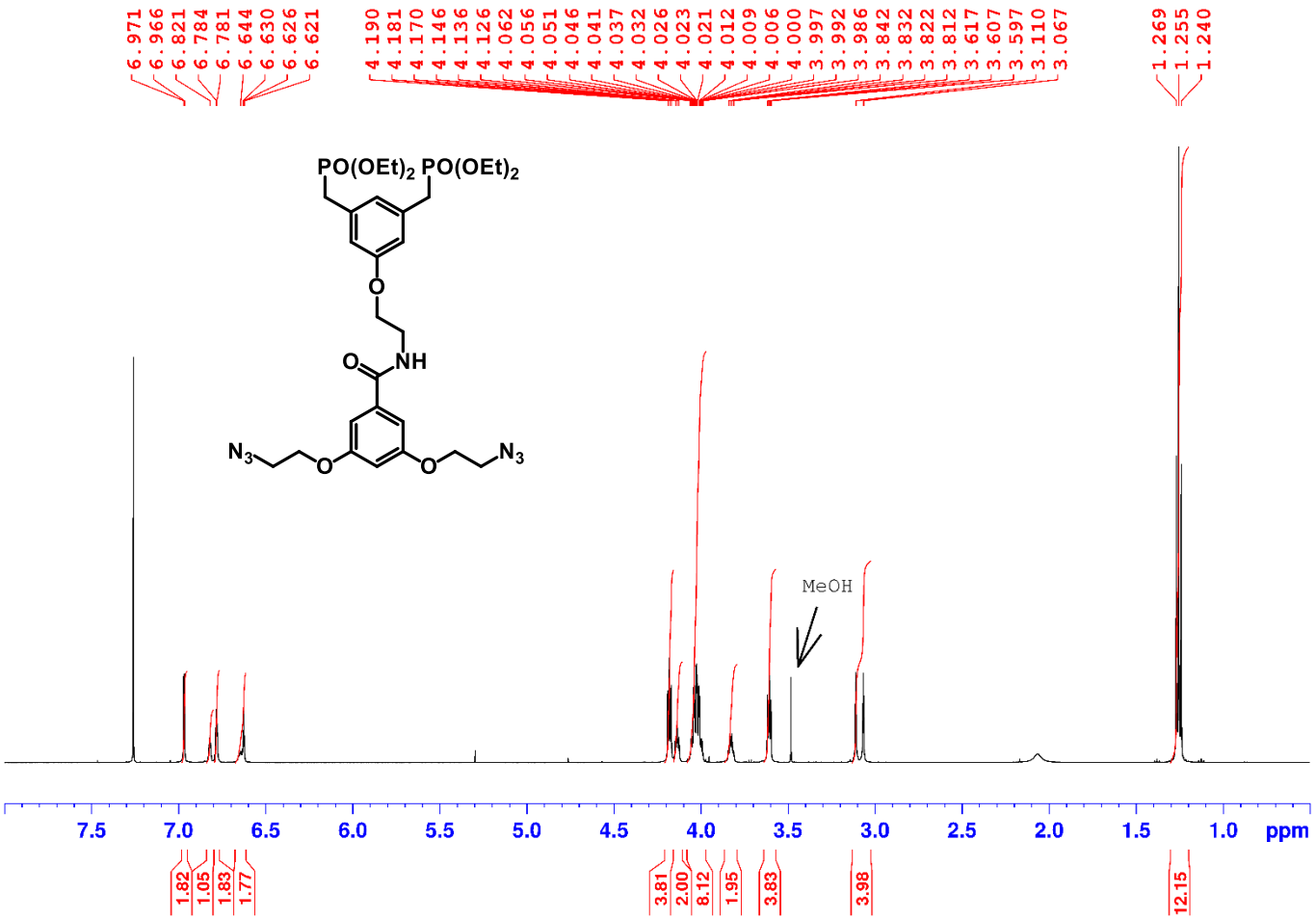
Compound 33 – ^{1}H NMR (300 MHz, $CDCl_3$)



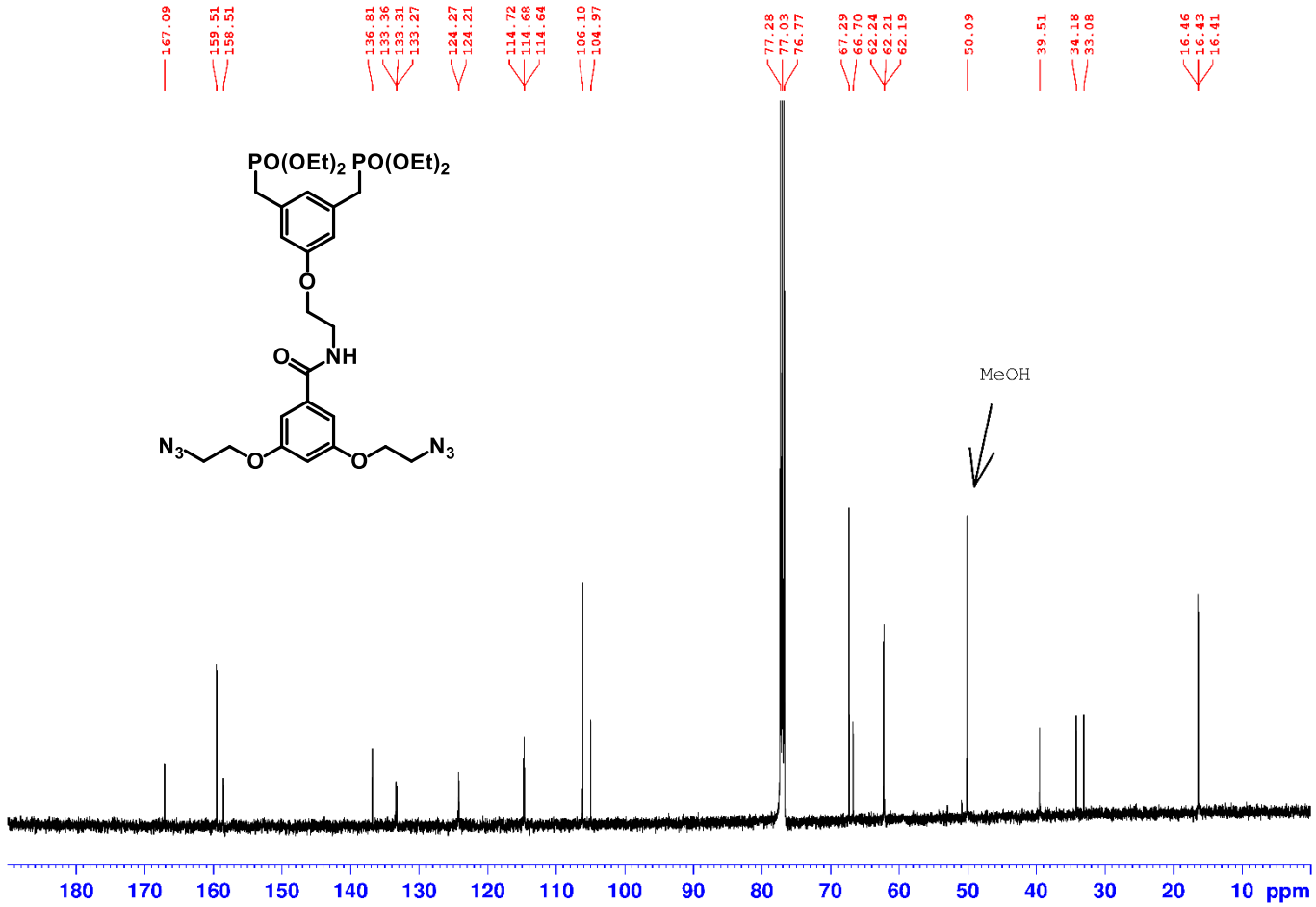
Compound 34 – ^{1}H NMR (300 MHz, $CDCl_3$)



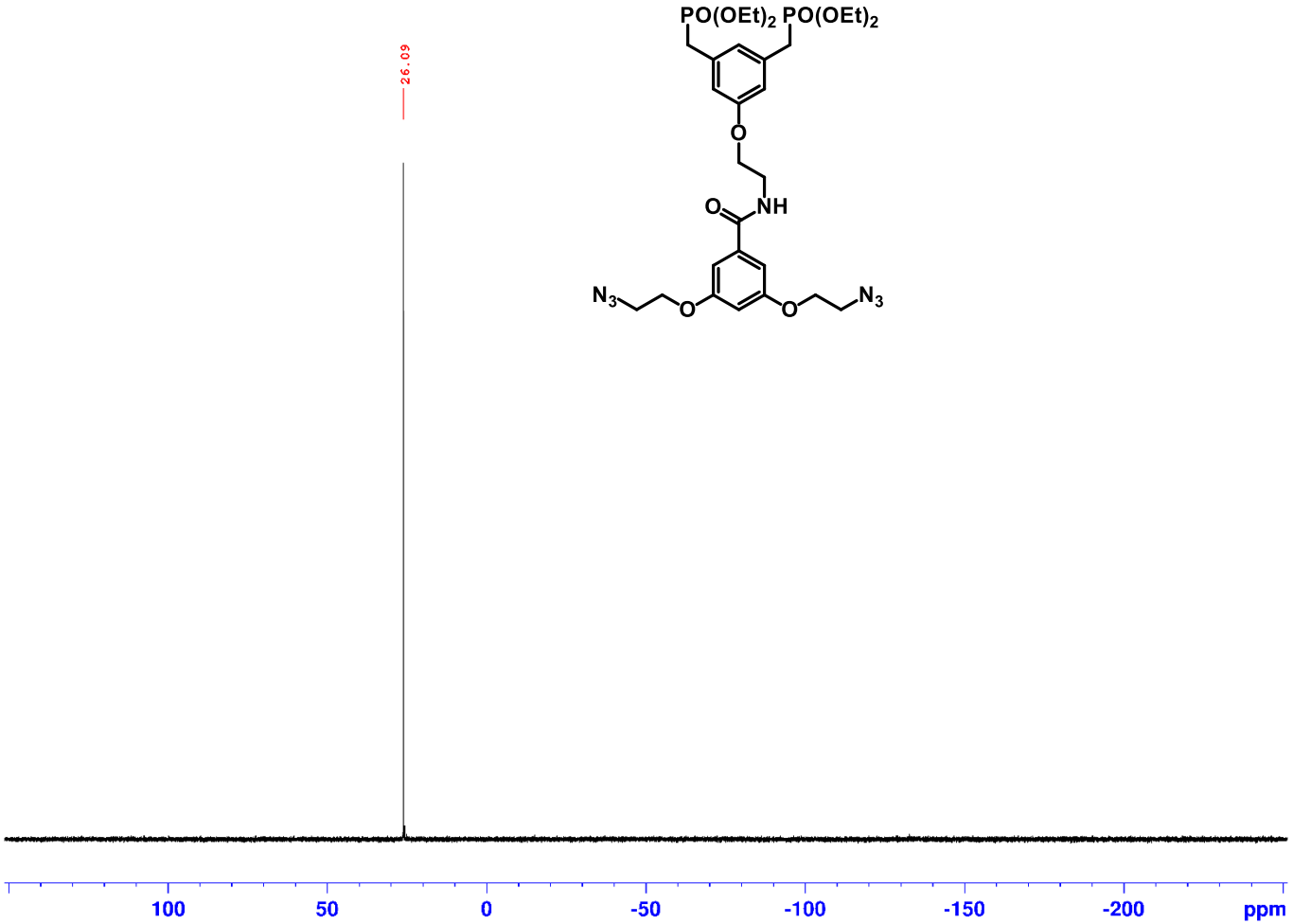
Compound 35 – ^{1}H NMR (500 MHz, $CDCl_3$)



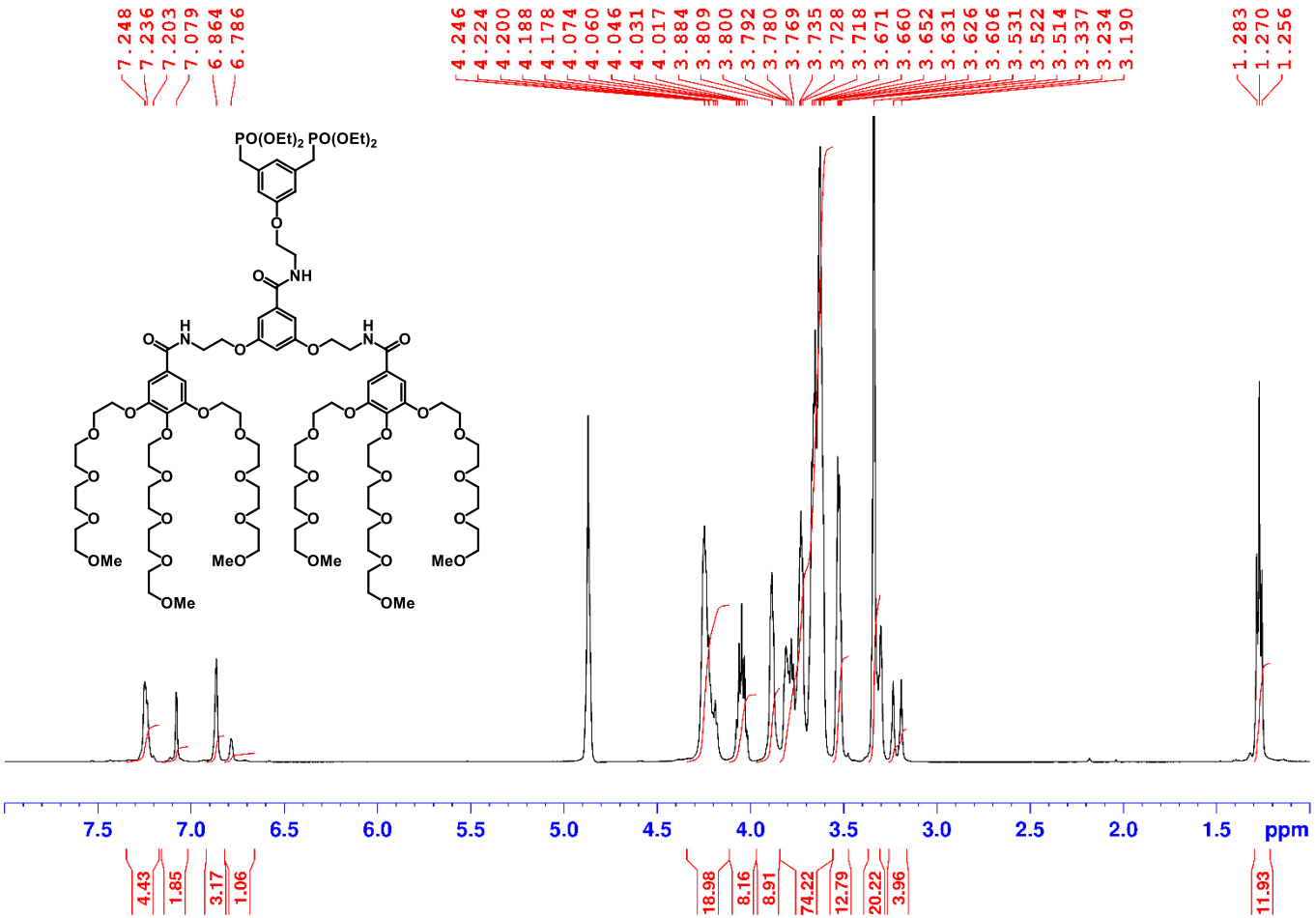
Compound 35 – ^{13}C NMR (125 MHz, $CDCl_3$)



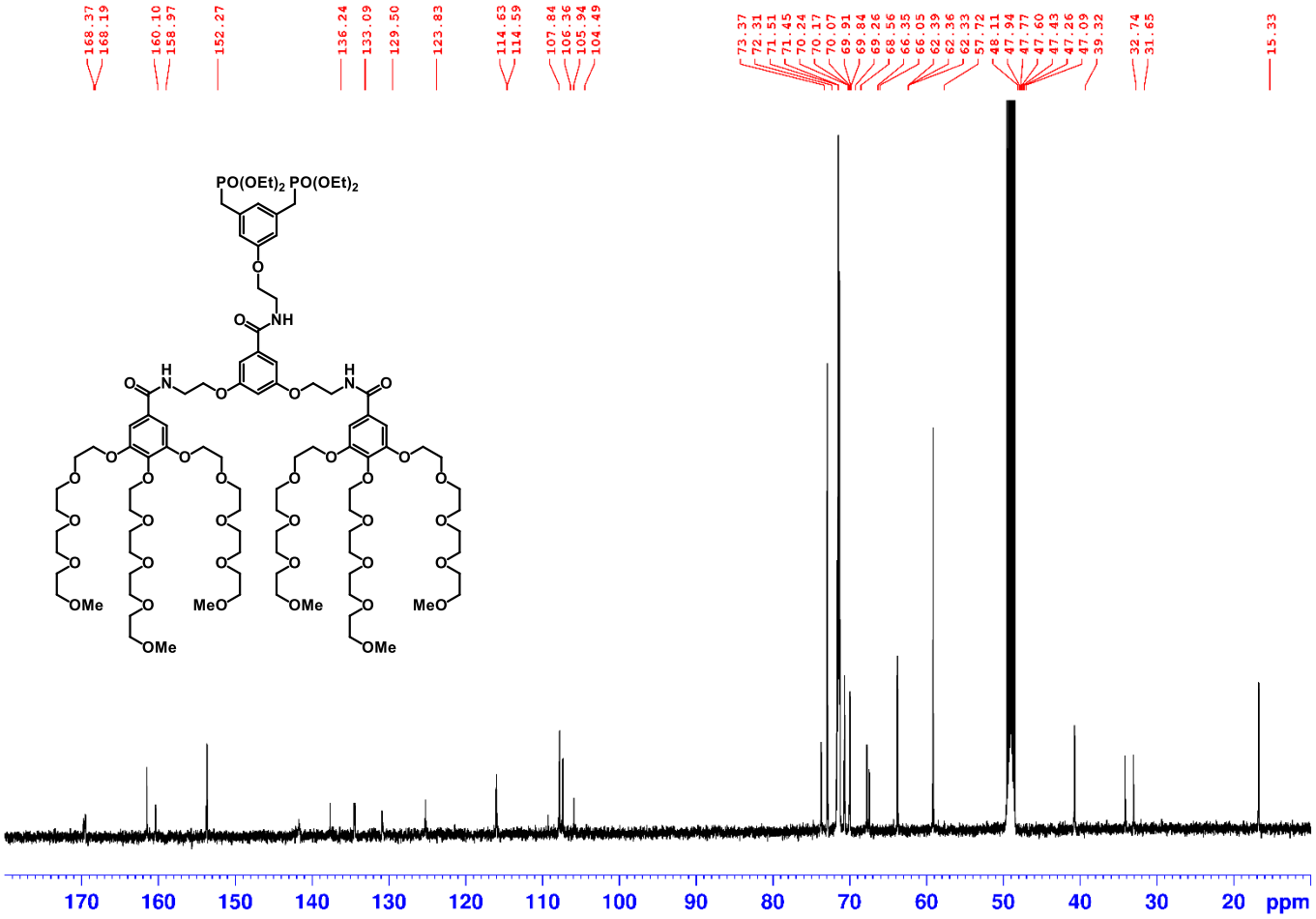
Compound 35 – ^{31}P NMR (202 MHz, $CDCl_3$)



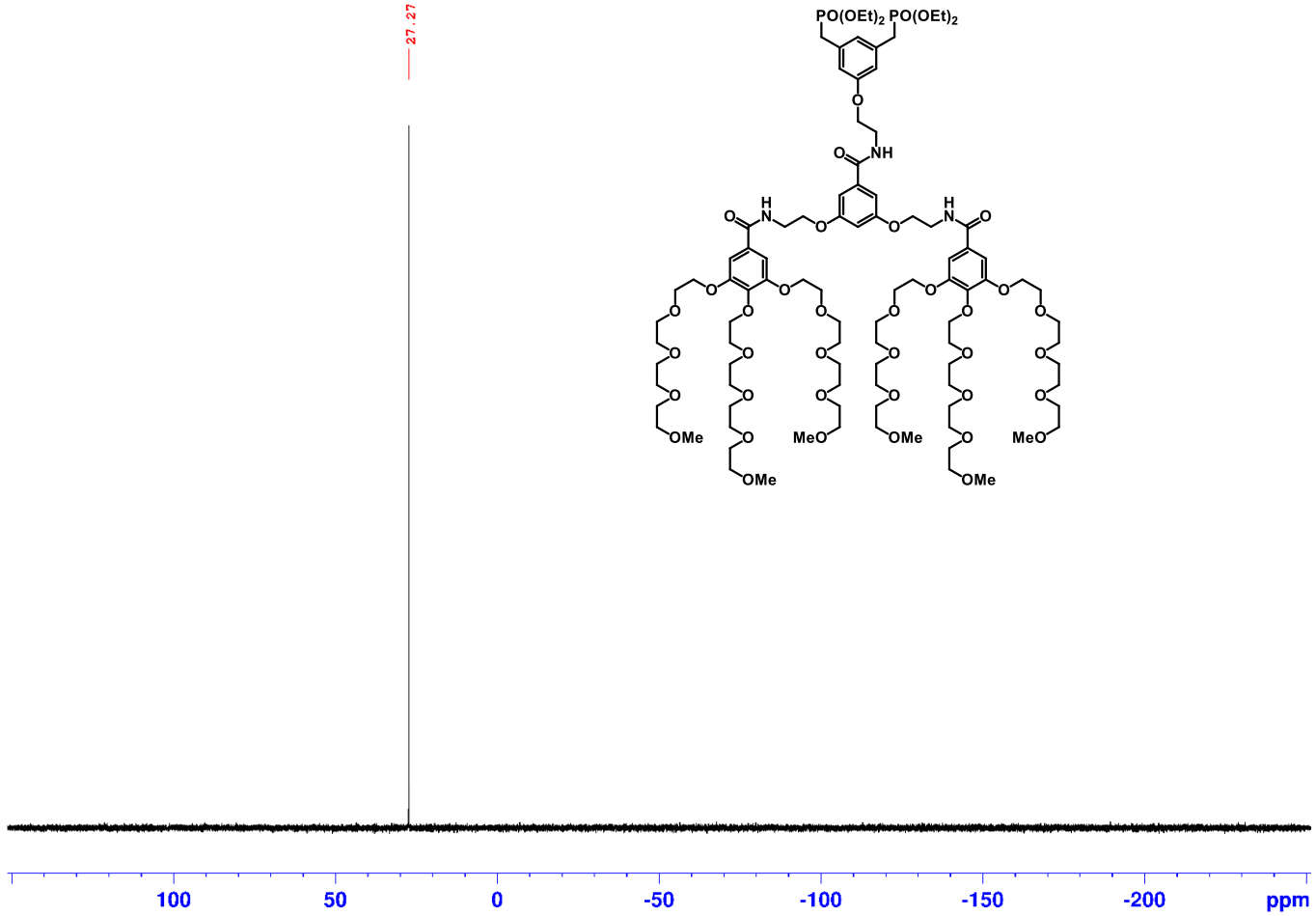
Compound 36 – ^{1}H NMR (500 MHz, CD_3OD-d_4)



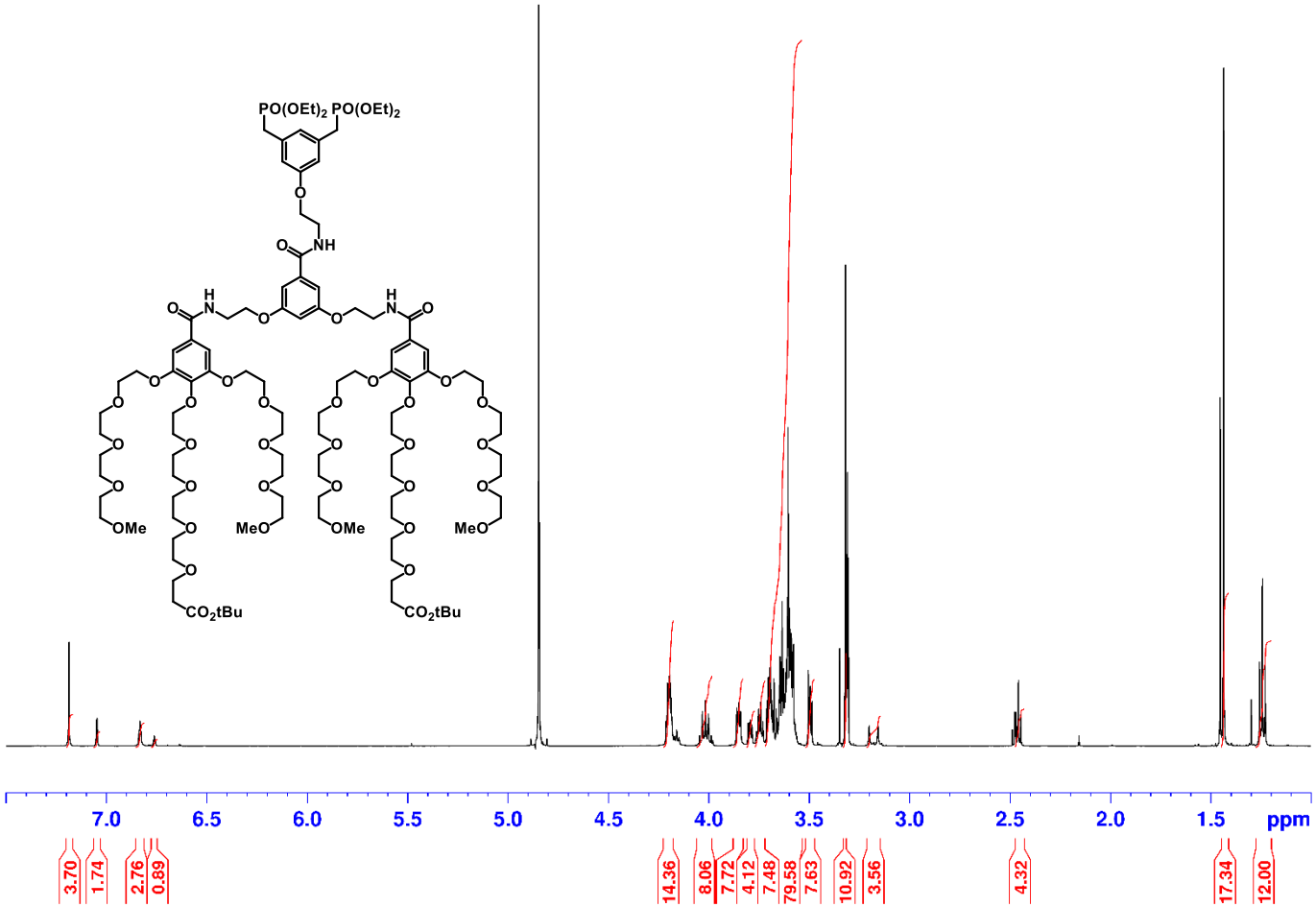
Compound 36 – ^{13}C NMR (125 MHz, CD_3OD-d_4)



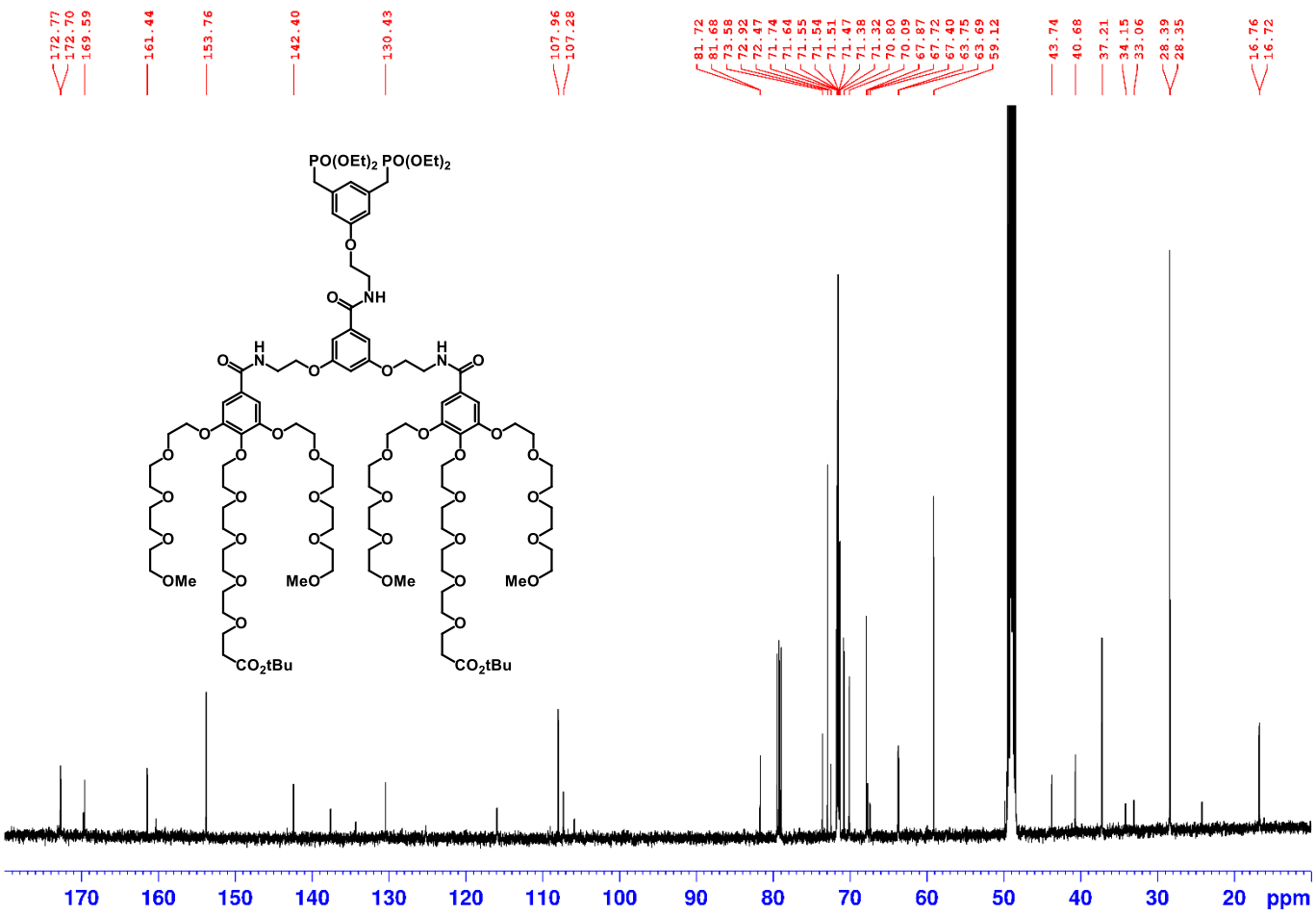
Compound 36 – ^{31}P NMR (202 MHz, CD_3OD-d_4)



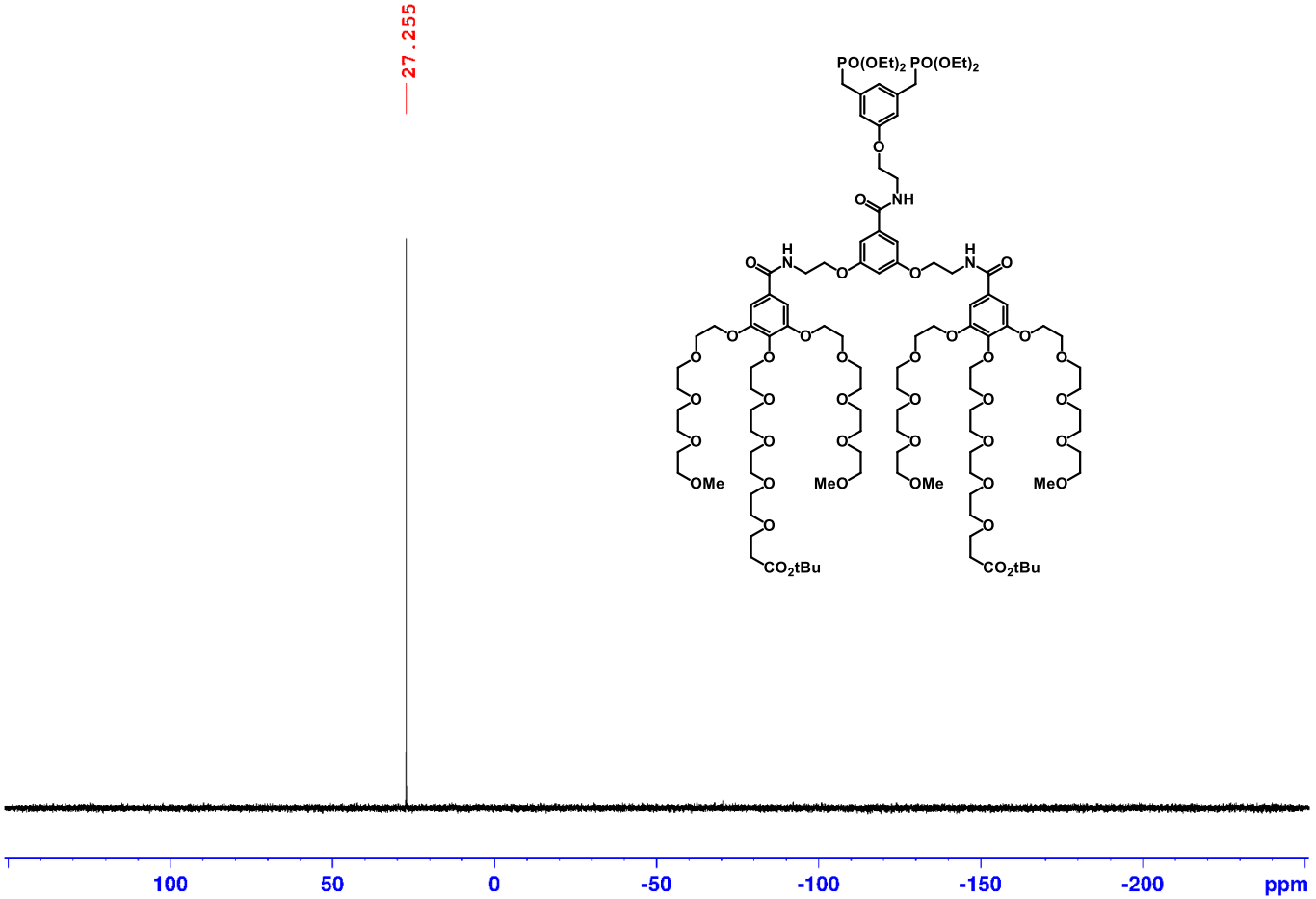
Compound 38 – ^{1}H NMR (500 MHz, CD_3OD-d_4)



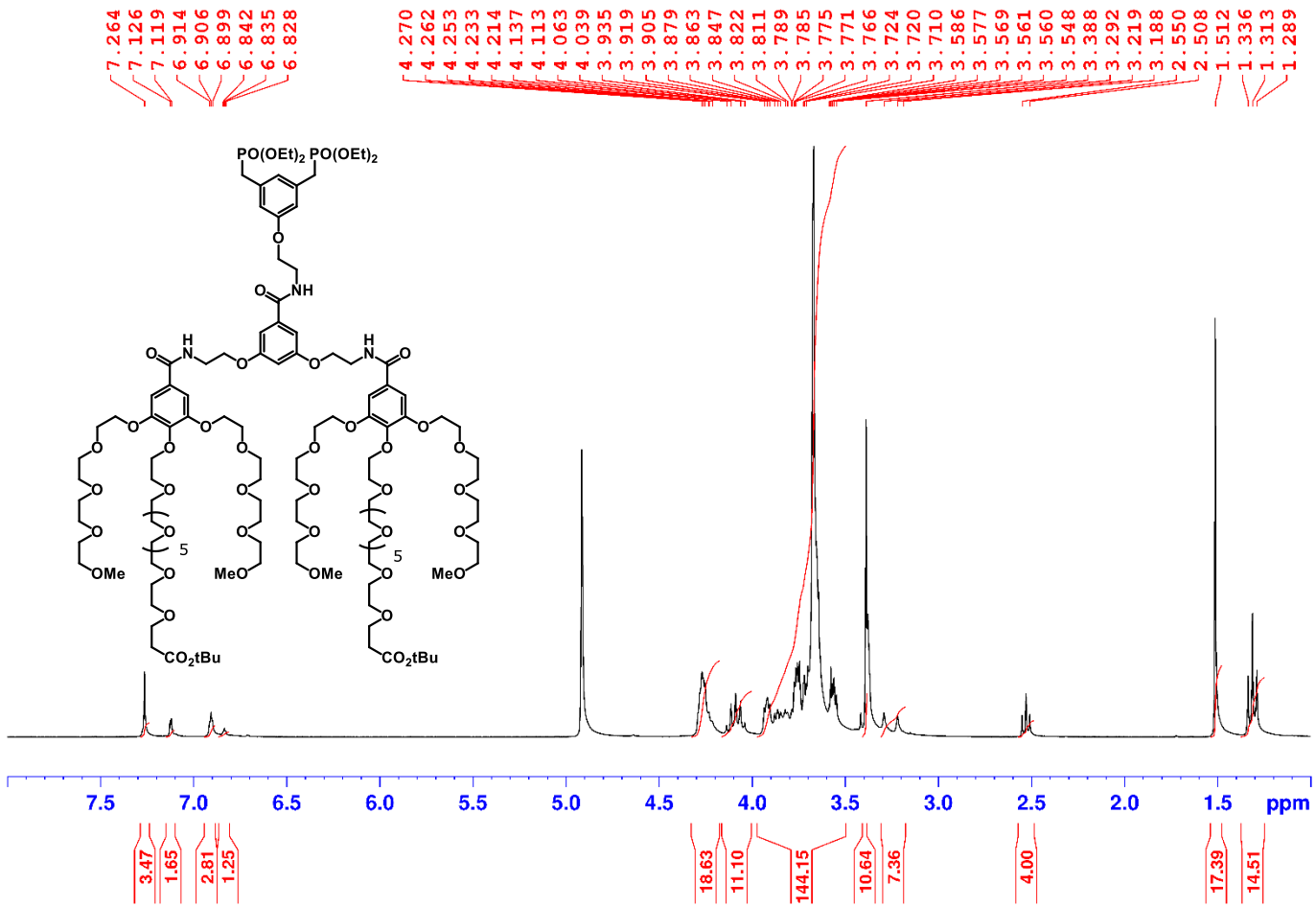
Compound 38 – ^{13}C NMR (125 MHz, CD_3OD-d_4)



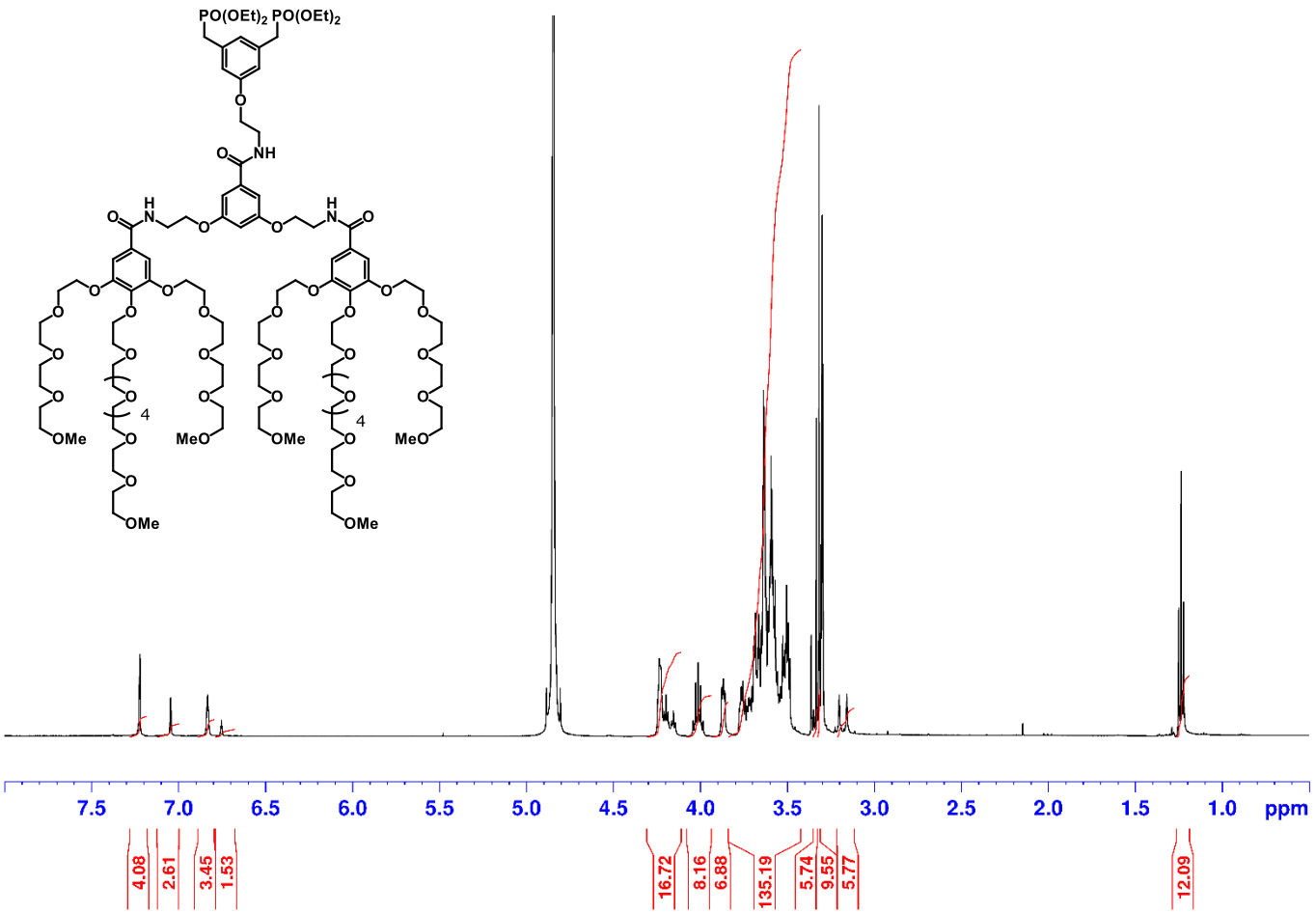
Compound 38 – ^{31}P NMR (202 MHz, CD_3OD-d_4)



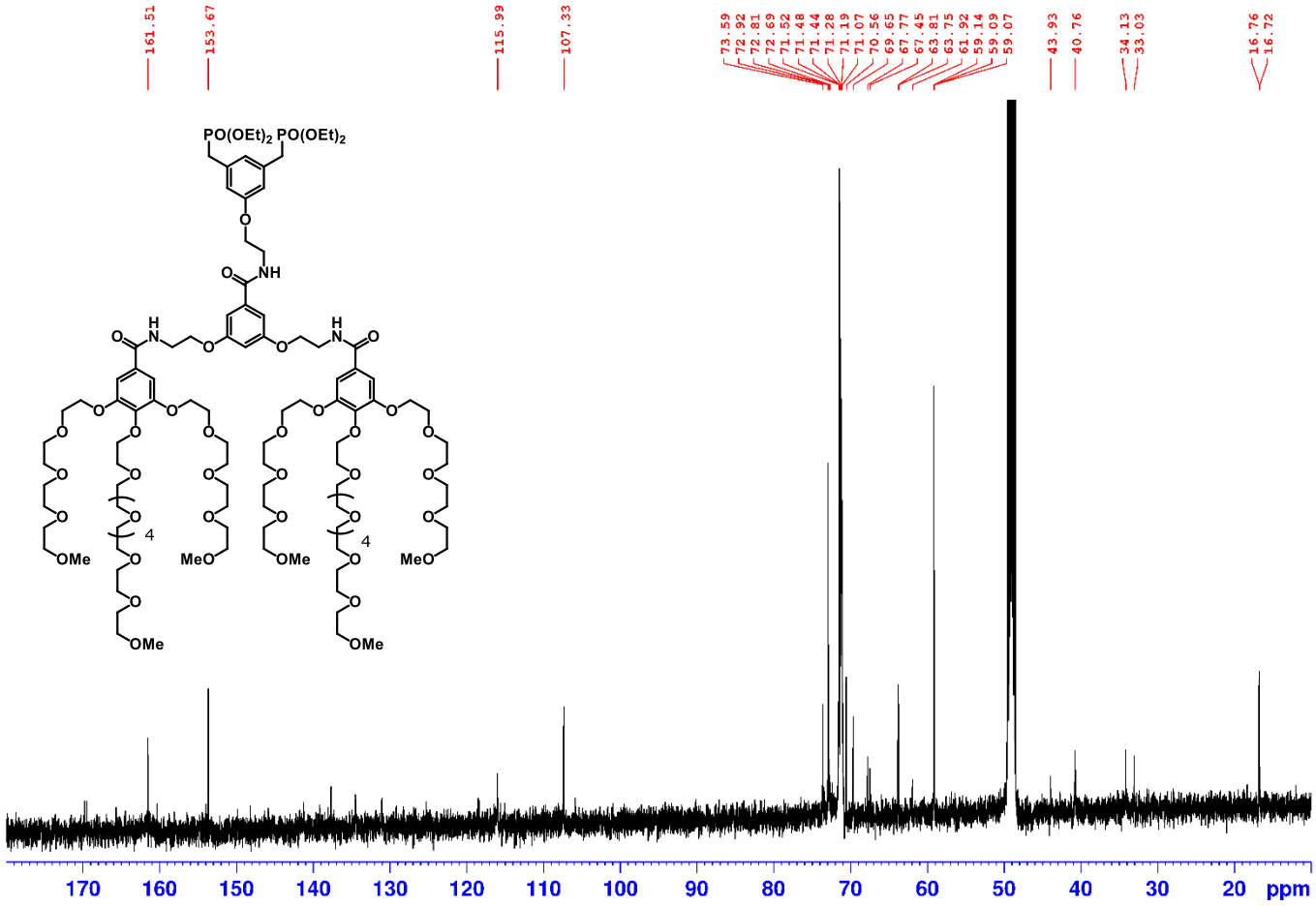
Compound 39 – ^{1}H NMR (500 MHz, CD_3OD-d_4)



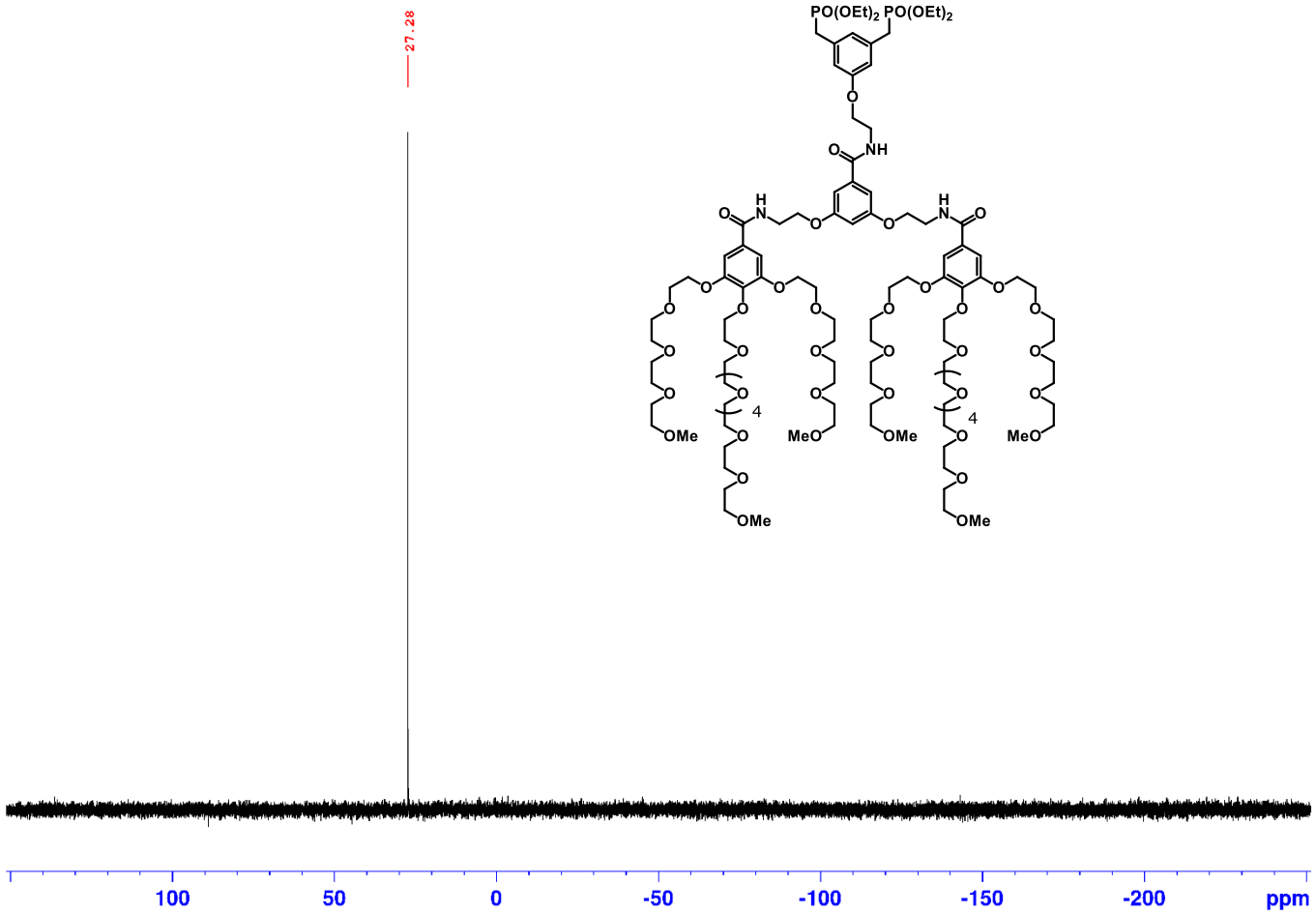
Compound 40 – ^{1}H NMR (500 MHz, CD_3OD-d_4)



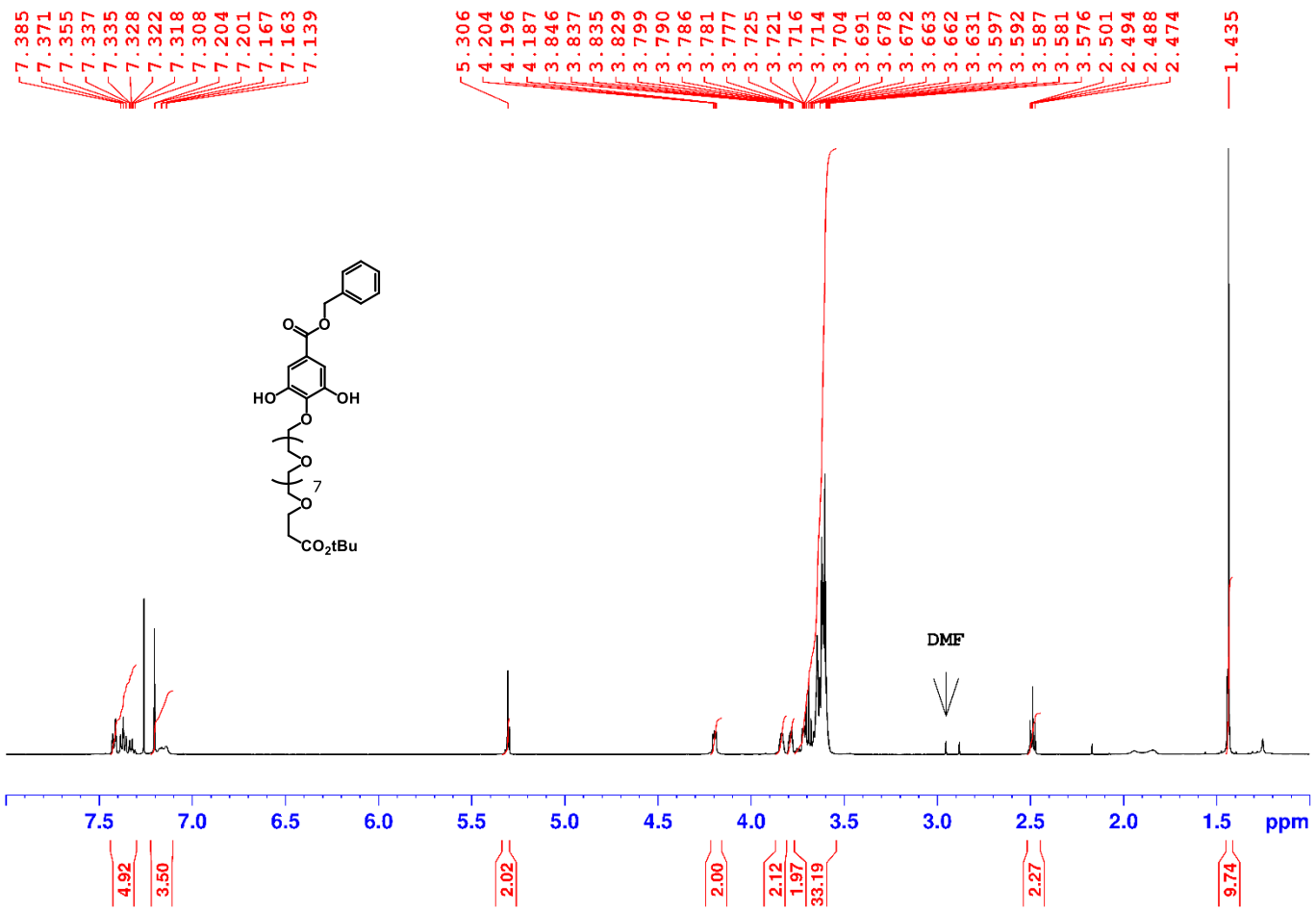
Compound 40 – ^{13}C NMR (125 MHz, CD_3OD-d_4)



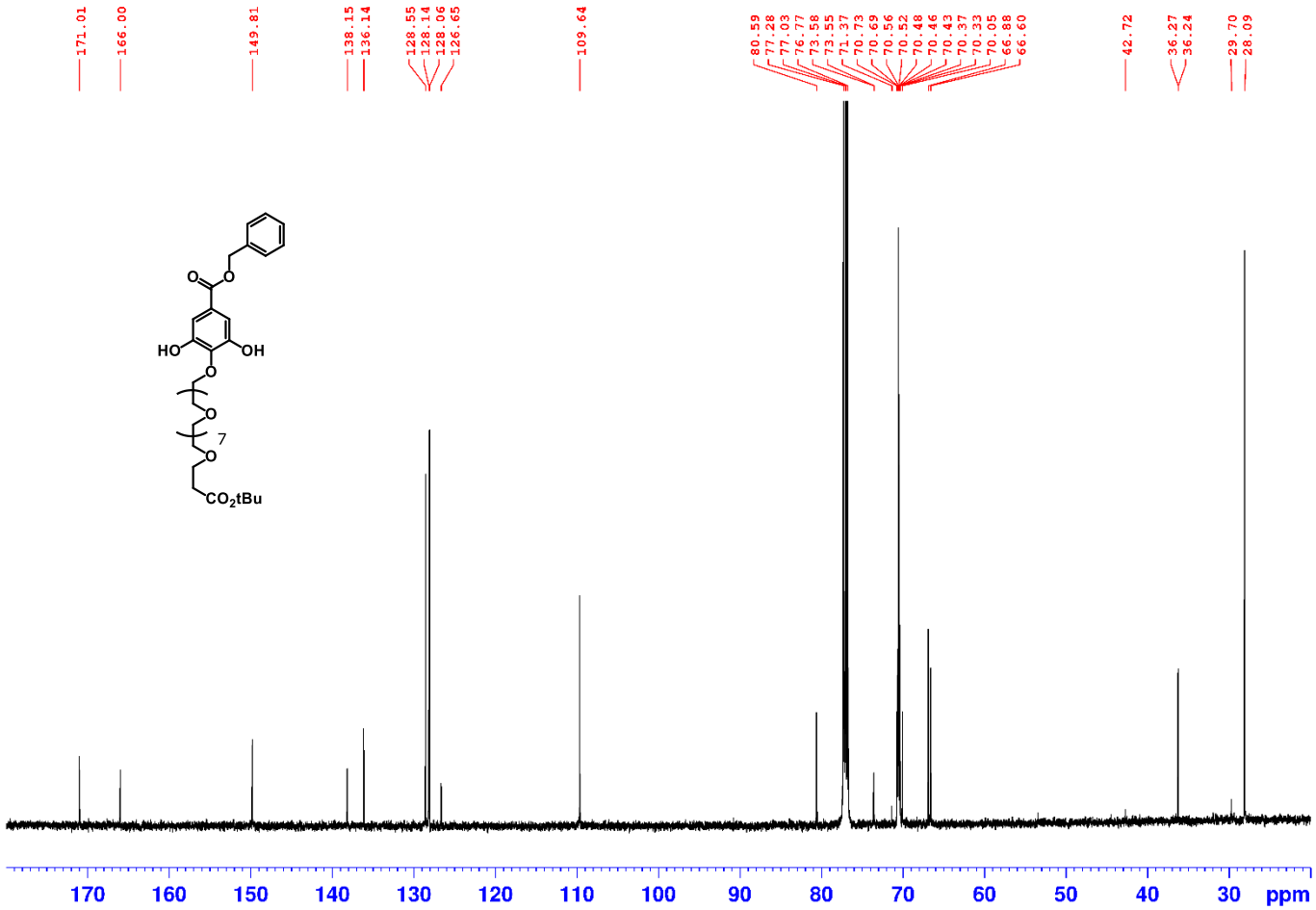
Compound 40 – ^{31}P NMR (202 MHz, CD_3OD-d_4)



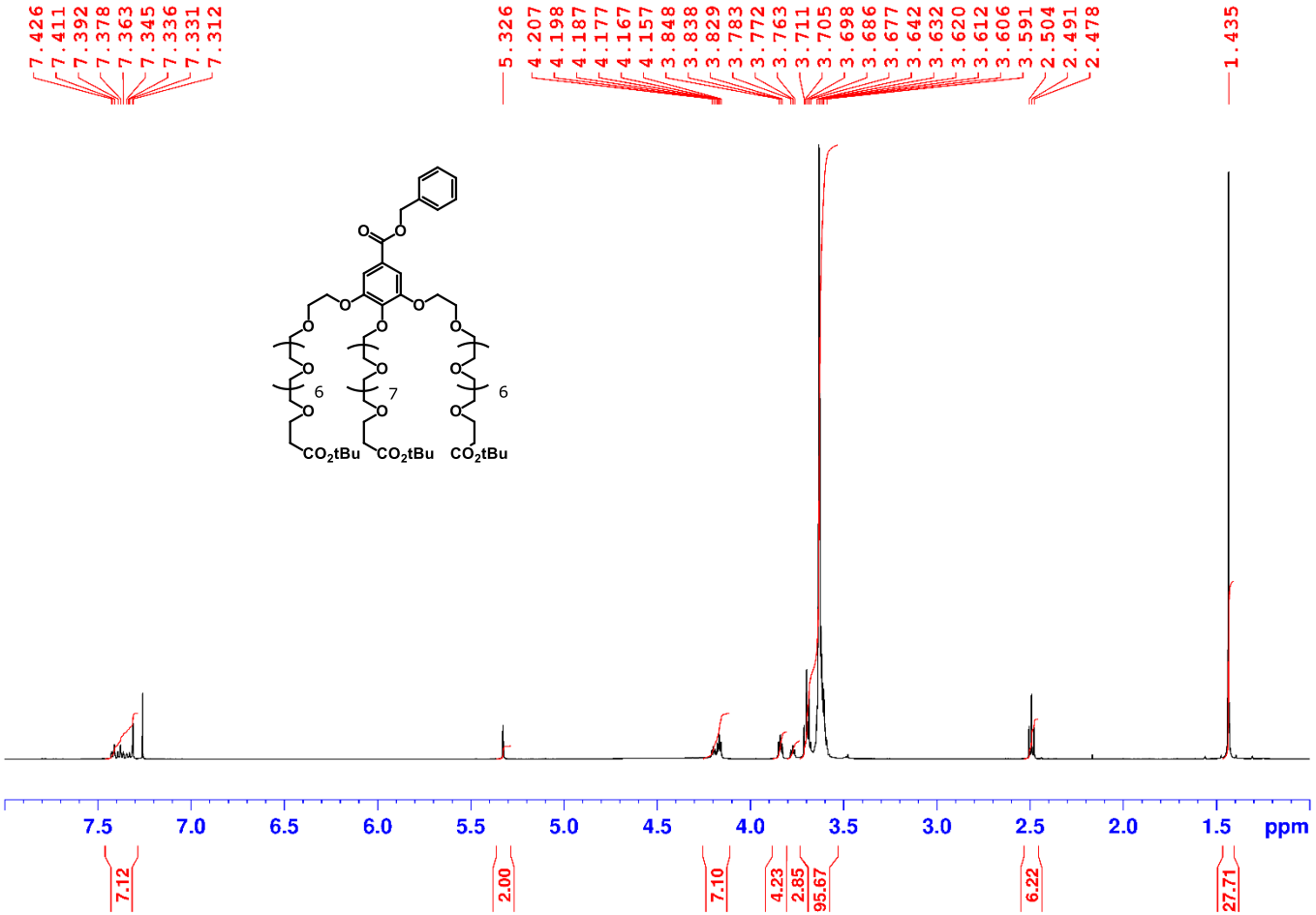
Compound 41 – ^{1}H NMR (500 MHz, $CDCl_3$)



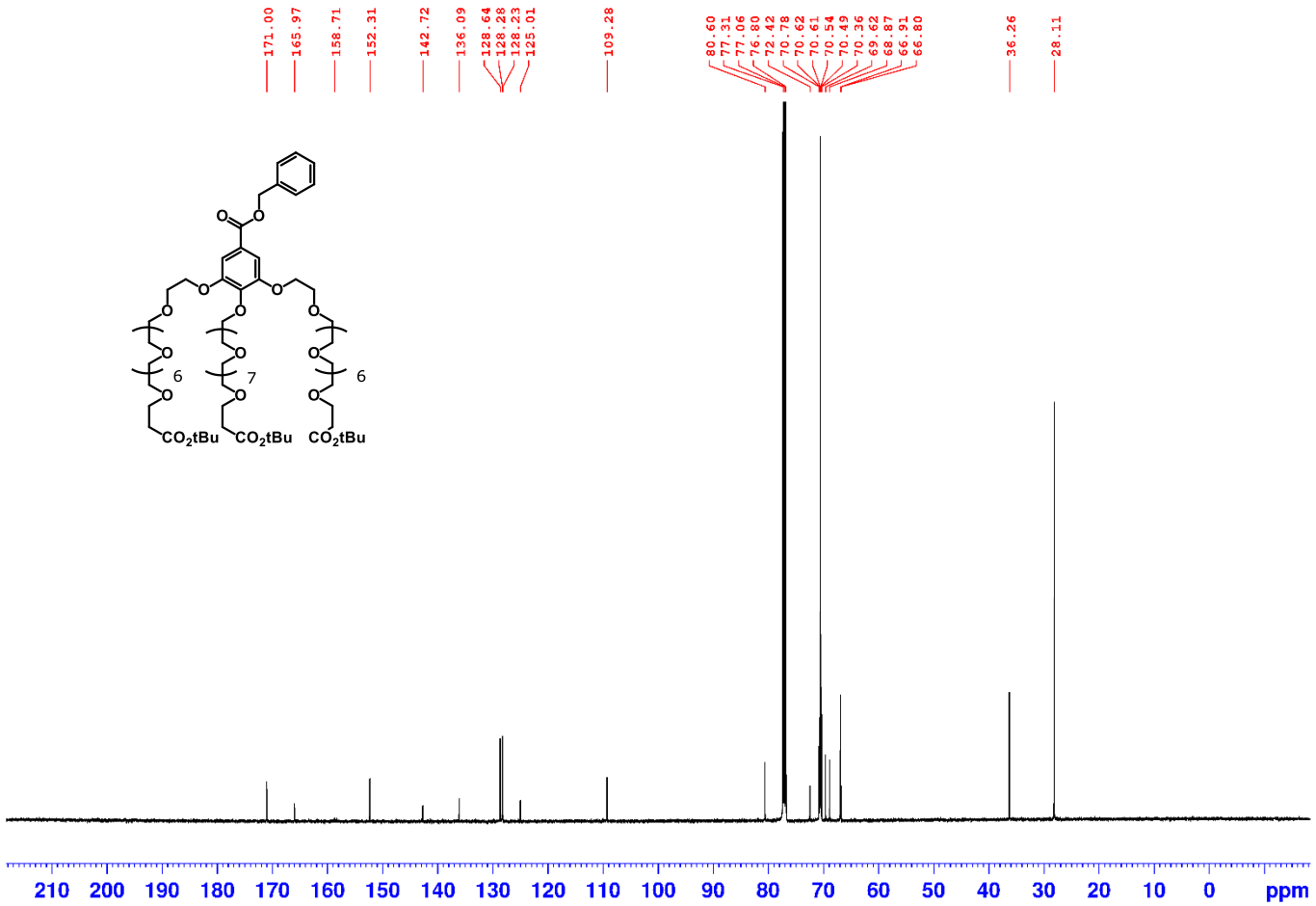
Compound 41 – ^{13}C NMR (125 MHz, $CDCl_3$)



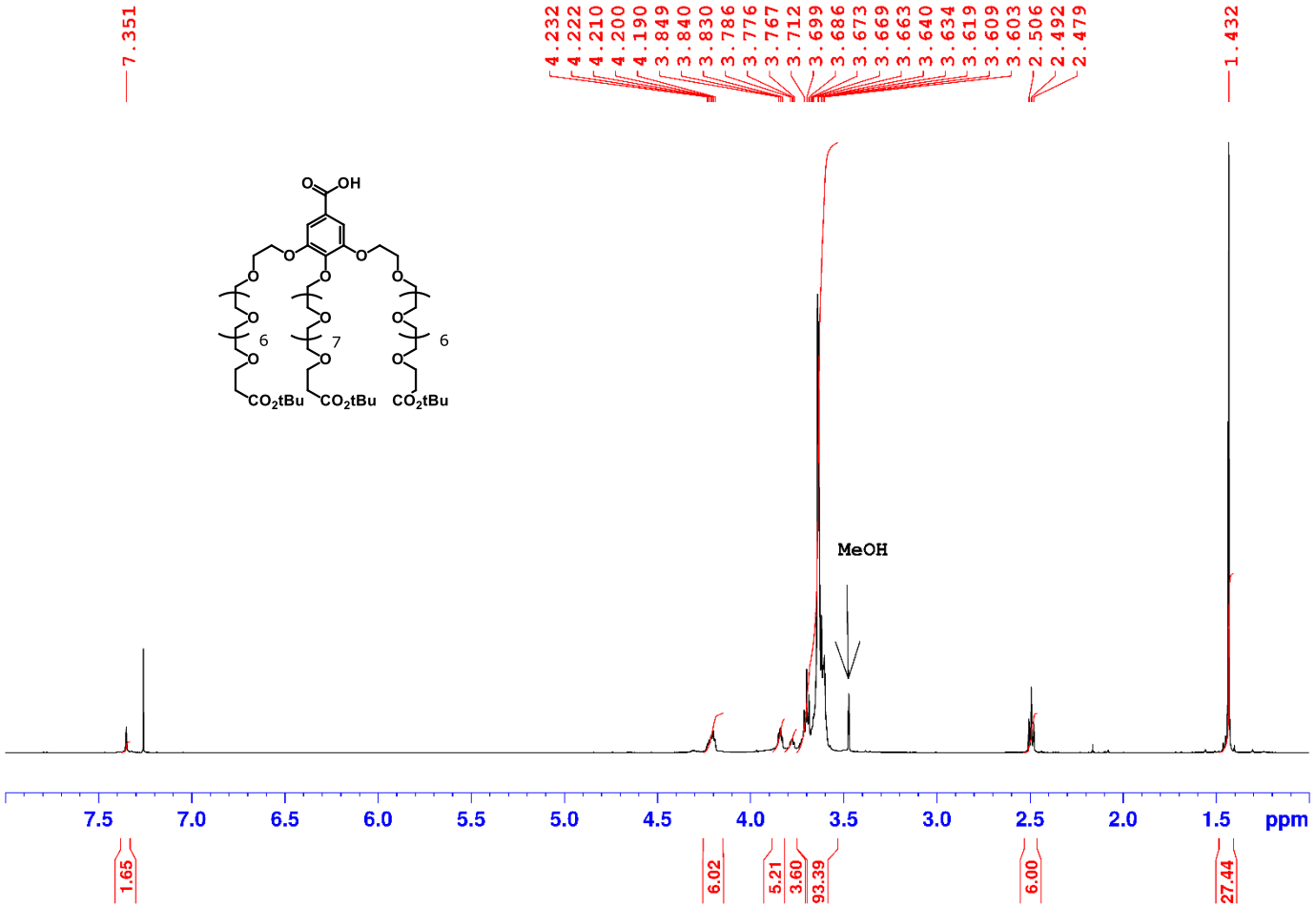
Compound 42 – ^{1}H NMR (500 MHz, $CDCl_3$)



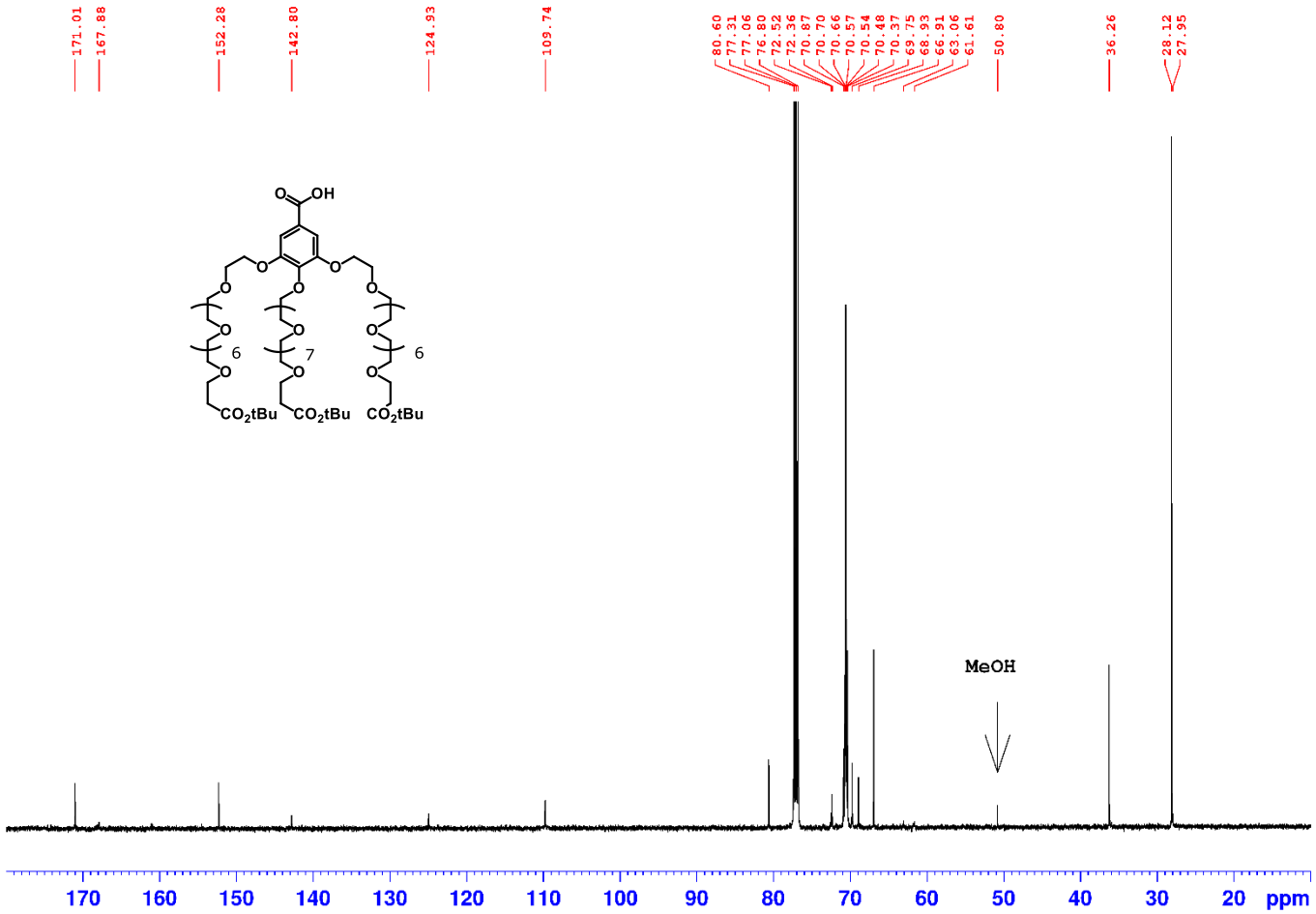
Compound 42 – ^{13}C NMR (125 MHz, $CDCl_3$)



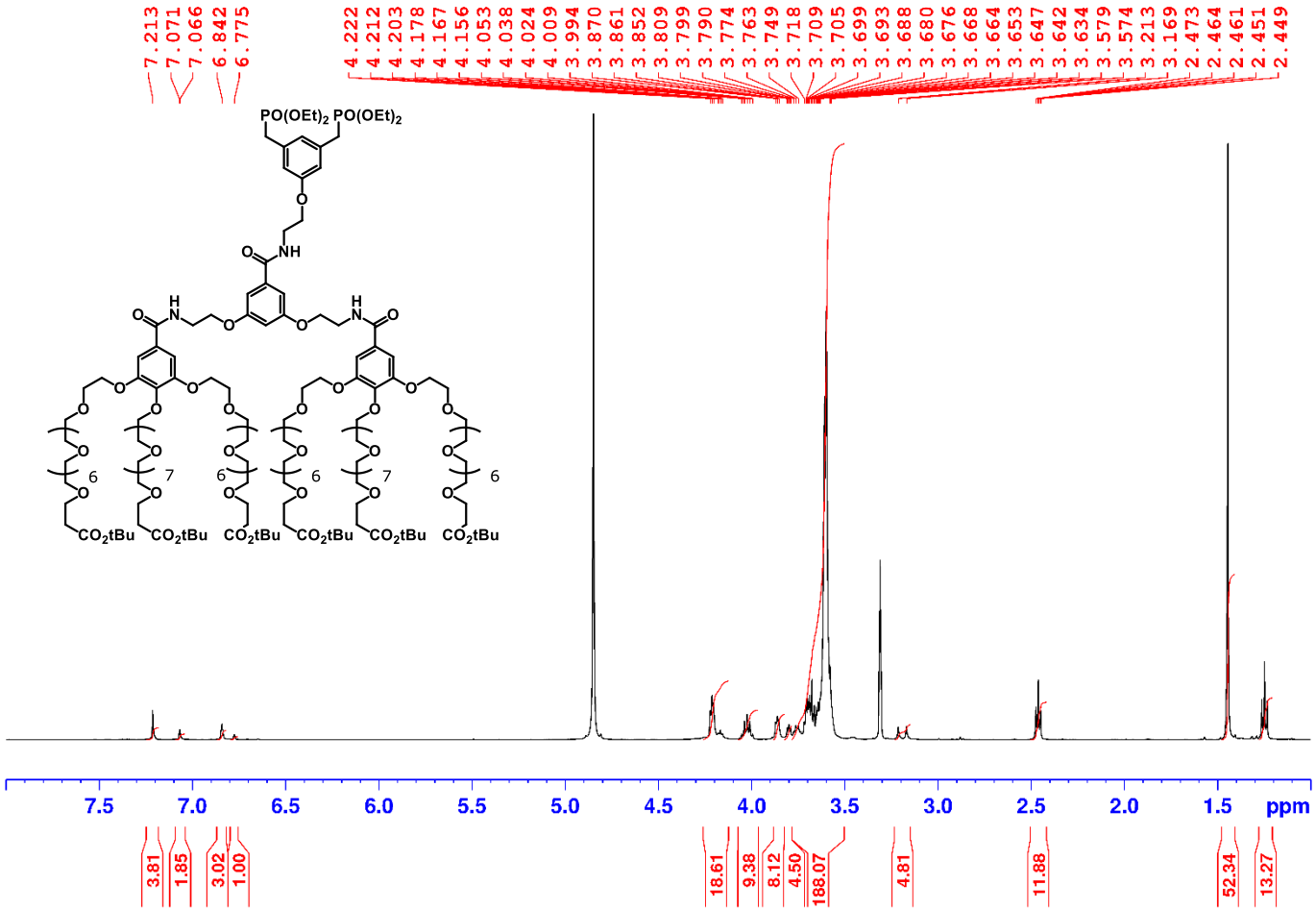
Compound 43 – ^{1}H NMR (500 MHz, $CDCl_3$)



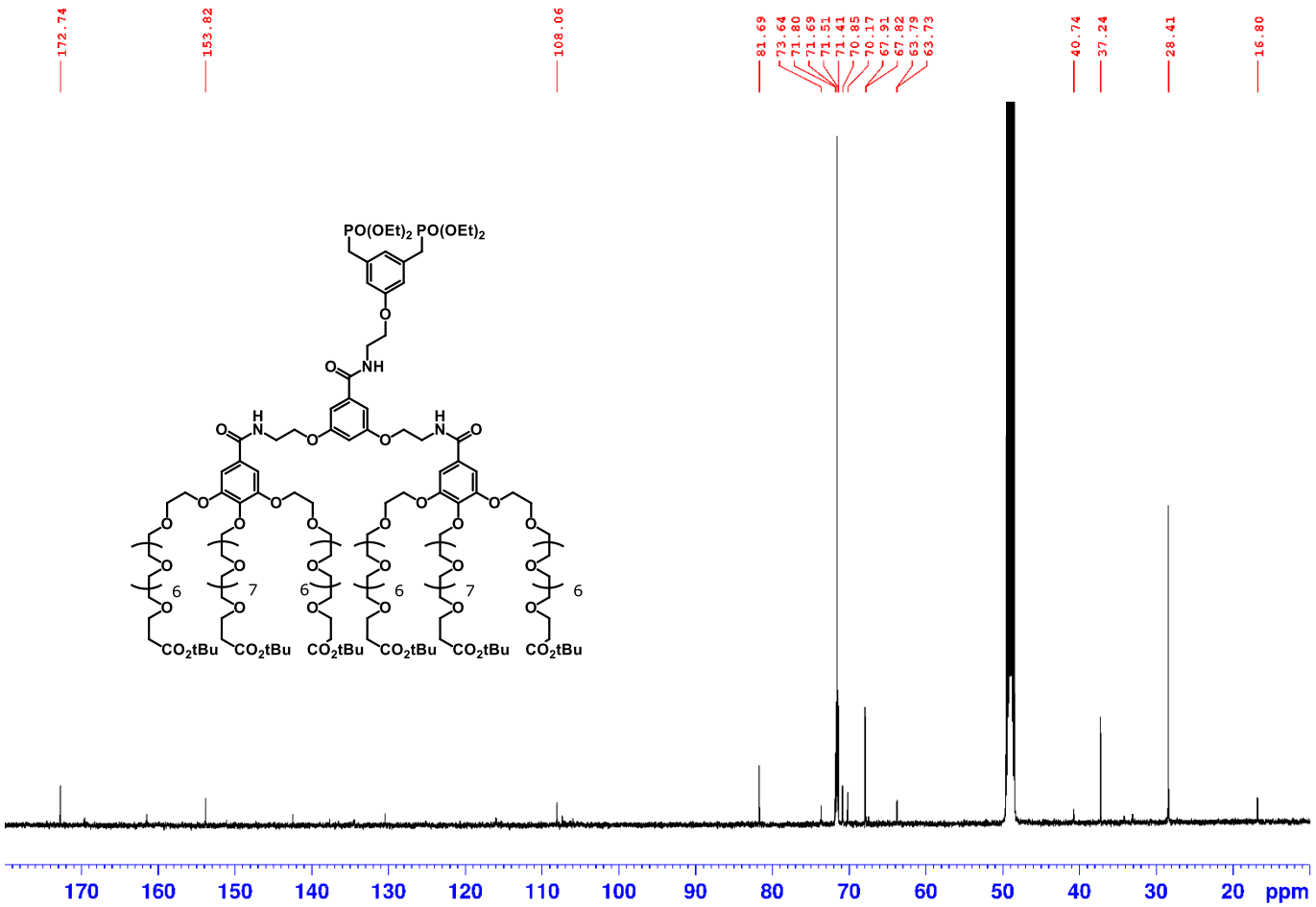
Compound 43 – ^{13}C NMR (125 MHz, $CDCl_3$)



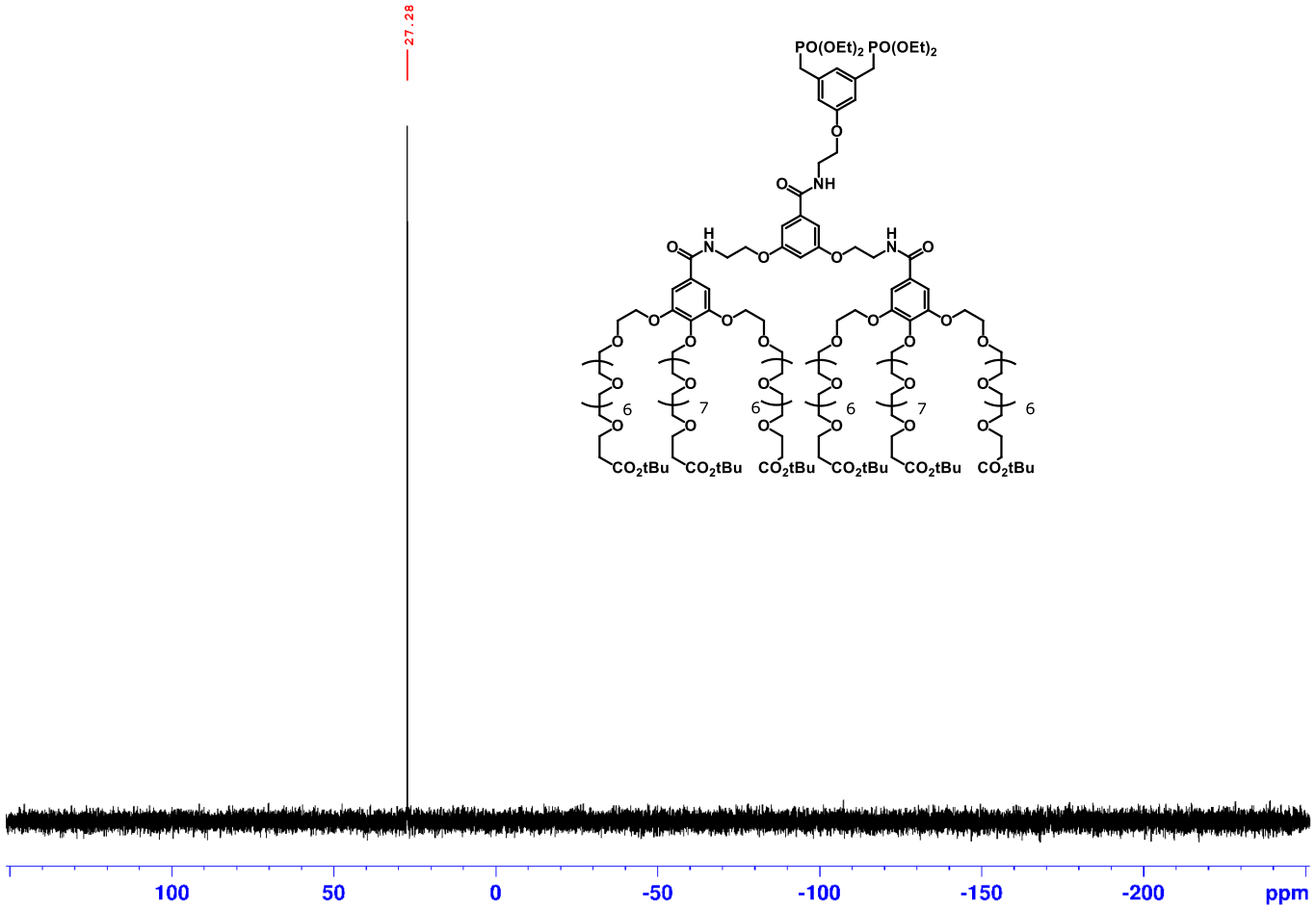
Compound 44 – ^{1}H NMR (500 MHz, CD_3OD-d_4)



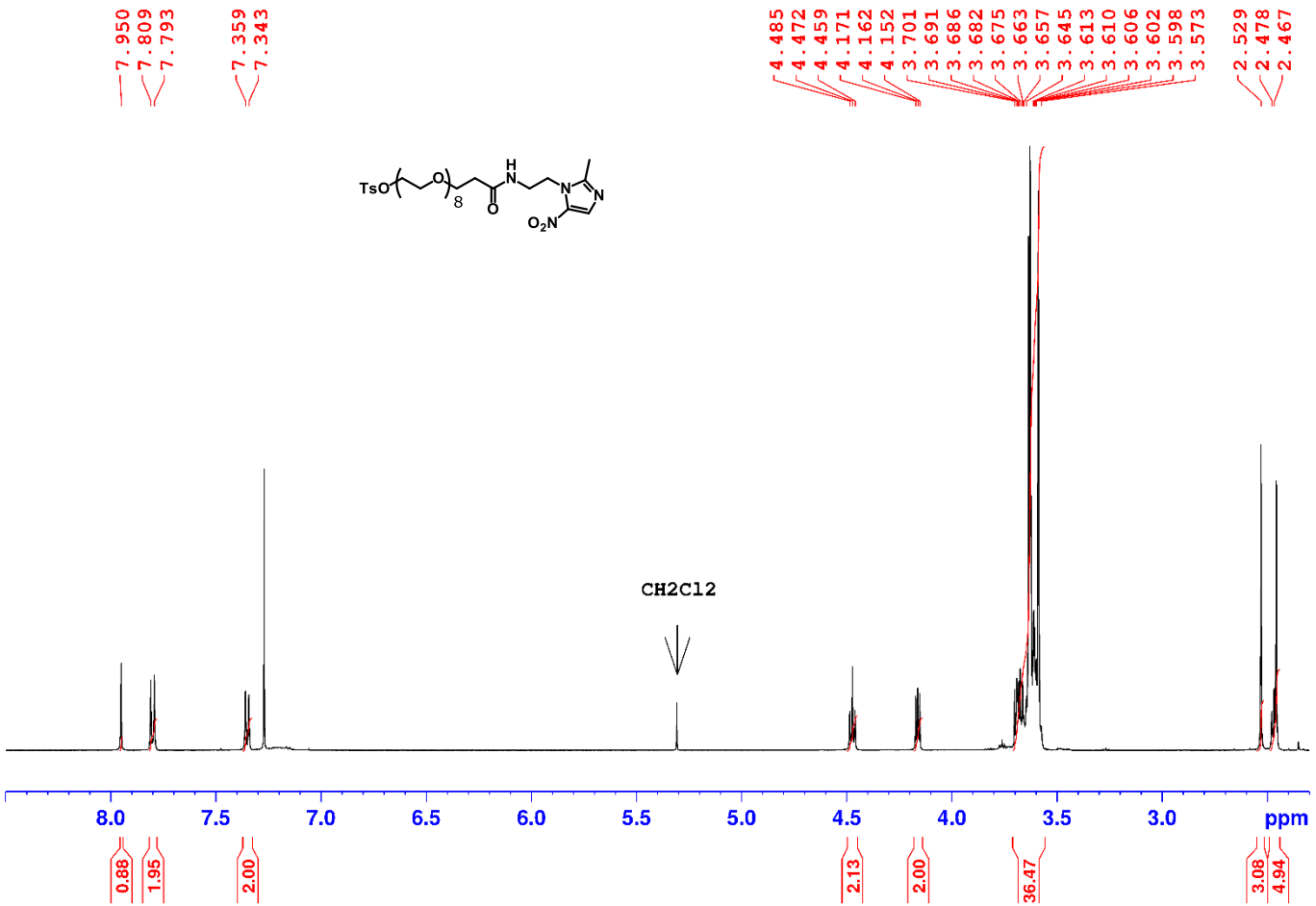
Compound 44 – ^{13}C NMR (125 MHz, CD_3OD-d_4)



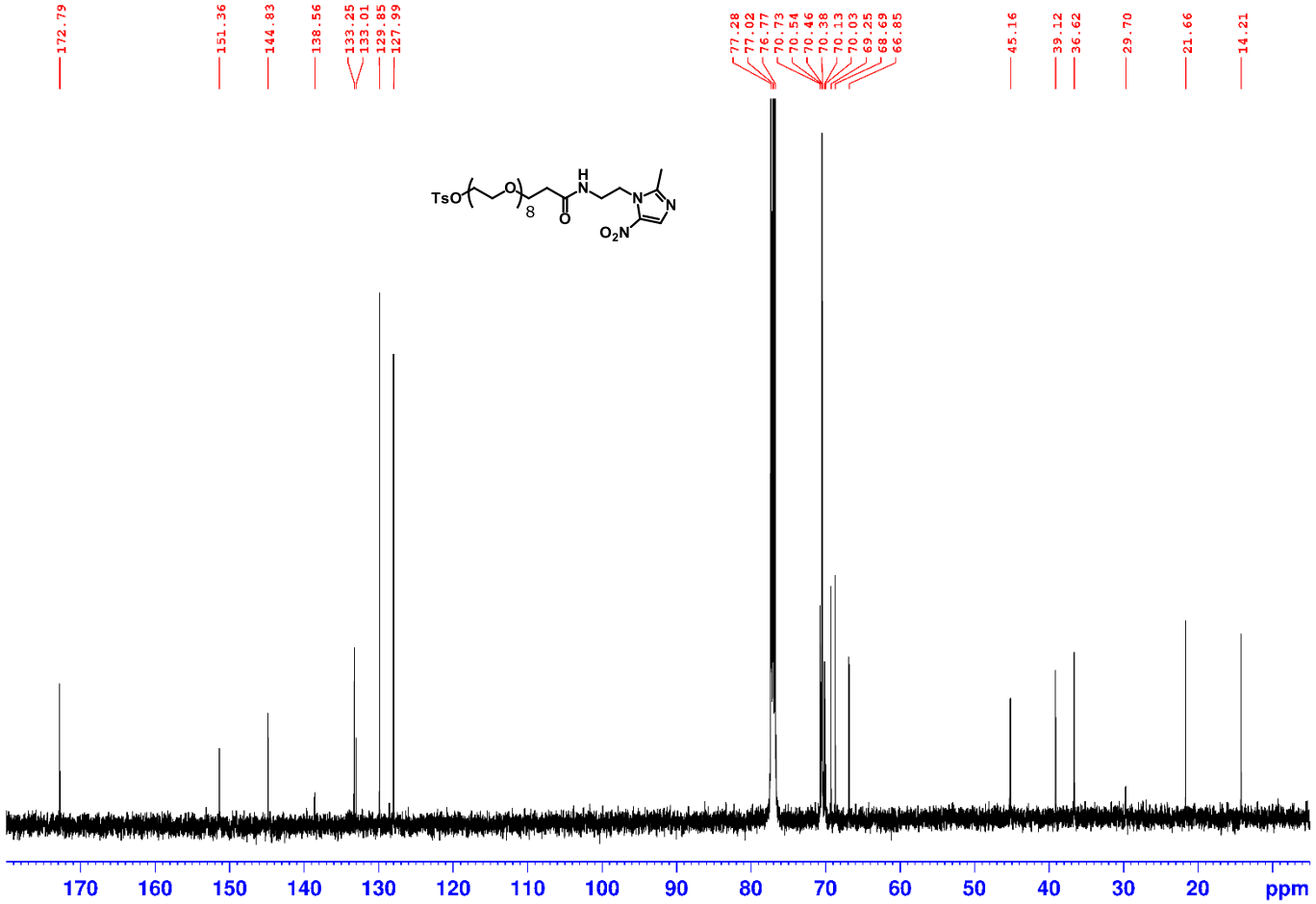
Compound 44 – ^{31}P NMR (202 MHz, CD_3OD-d_4)



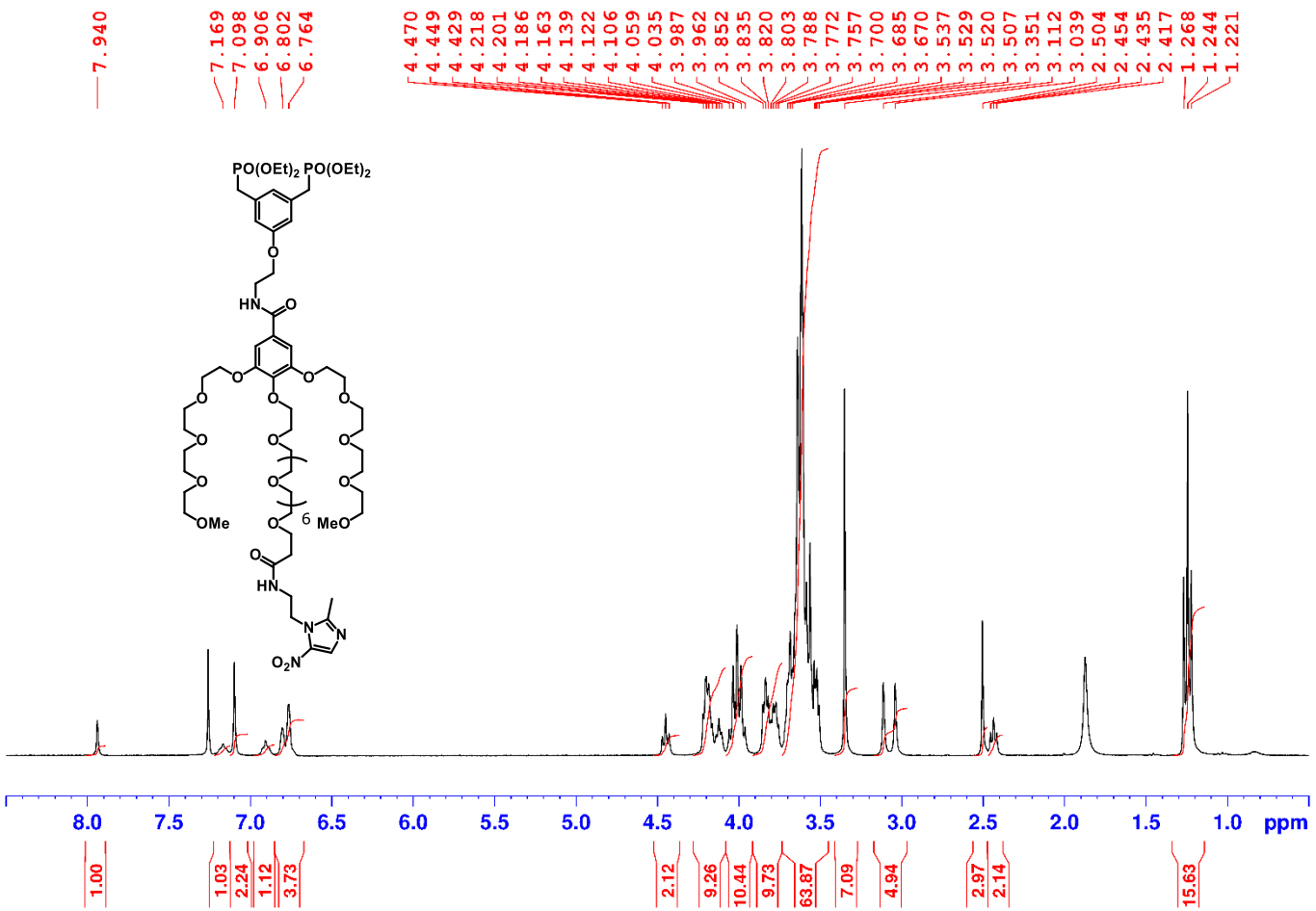
Compound 45 – ^{1}H NMR (500 MHz, $CDCl_3$)



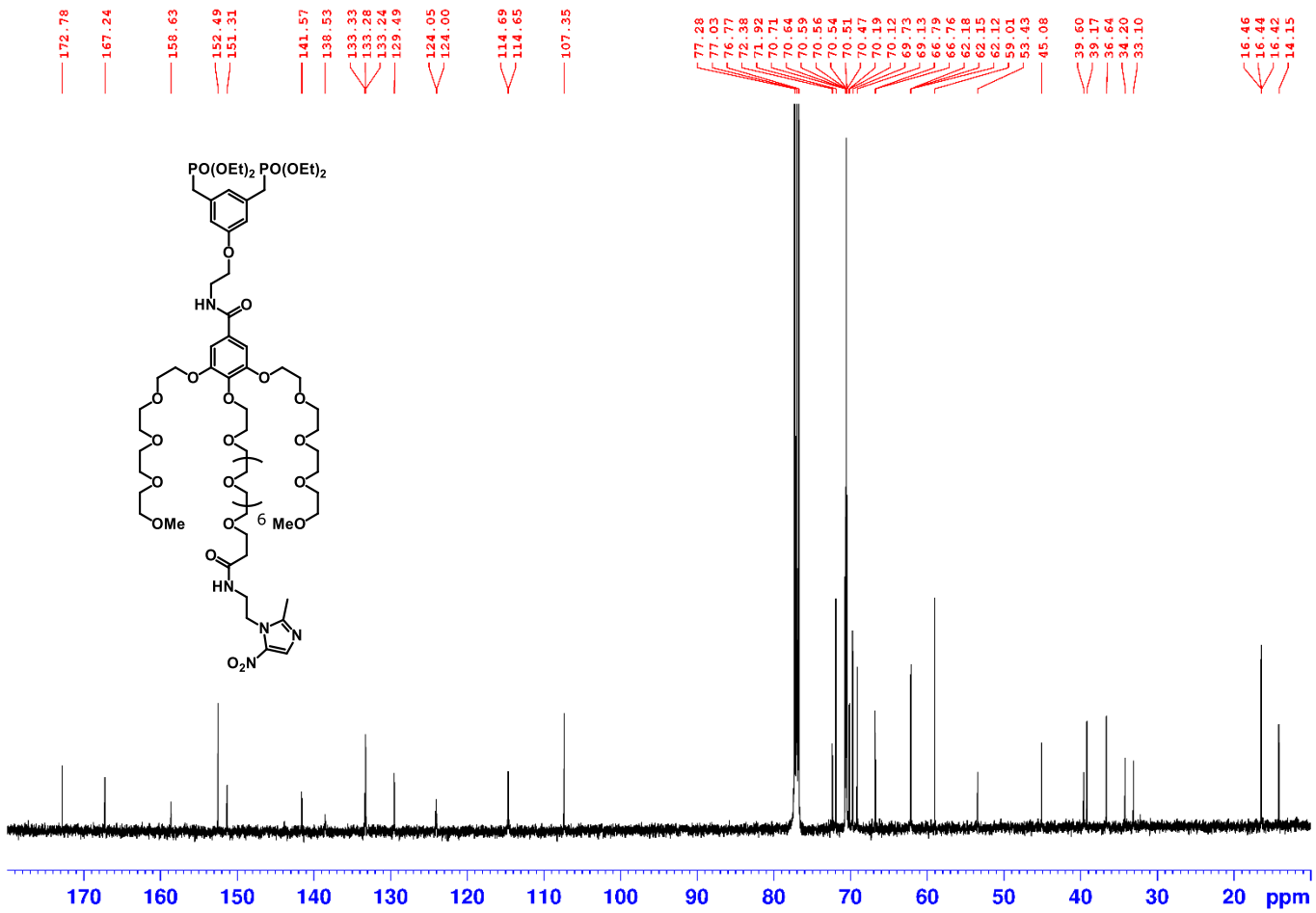
Compound 45 – ^{13}C NMR (125 MHz, $CDCl_3$)



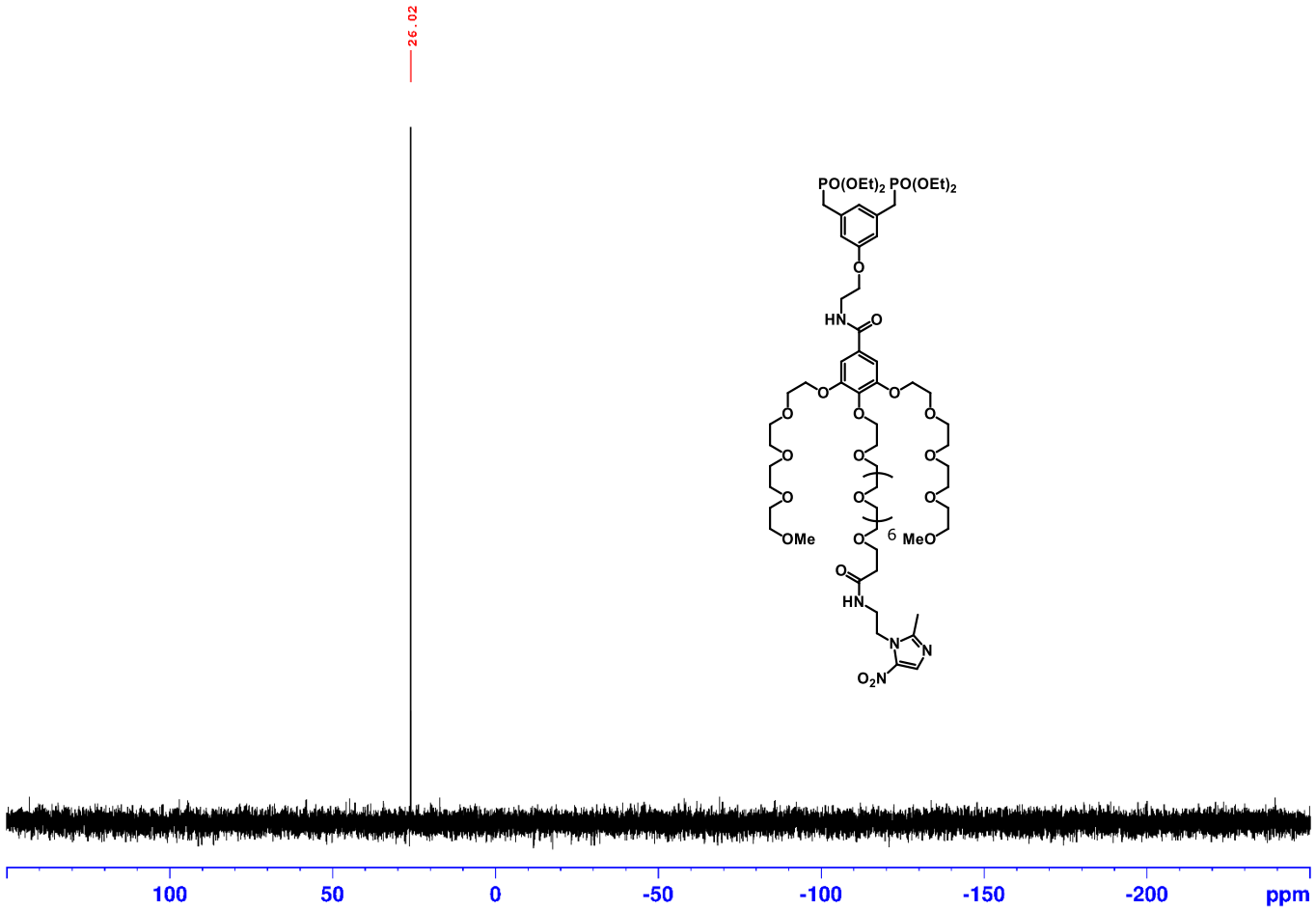
Compound 46 – ^{1}H NMR (300 MHz, $CDCl_3$)



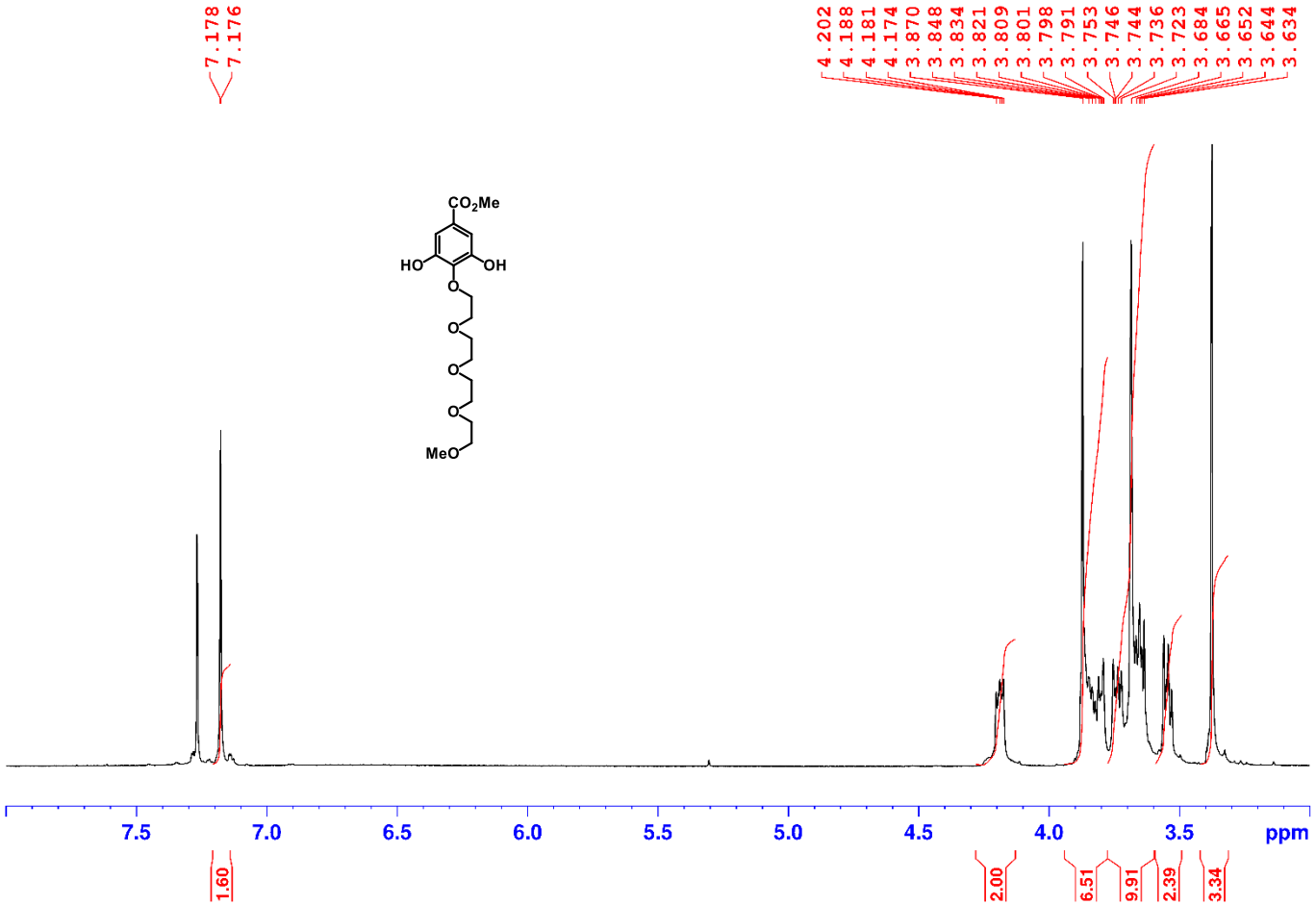
Compound 46 – ^{13}C NMR (125 MHz, $CDCl_3$)



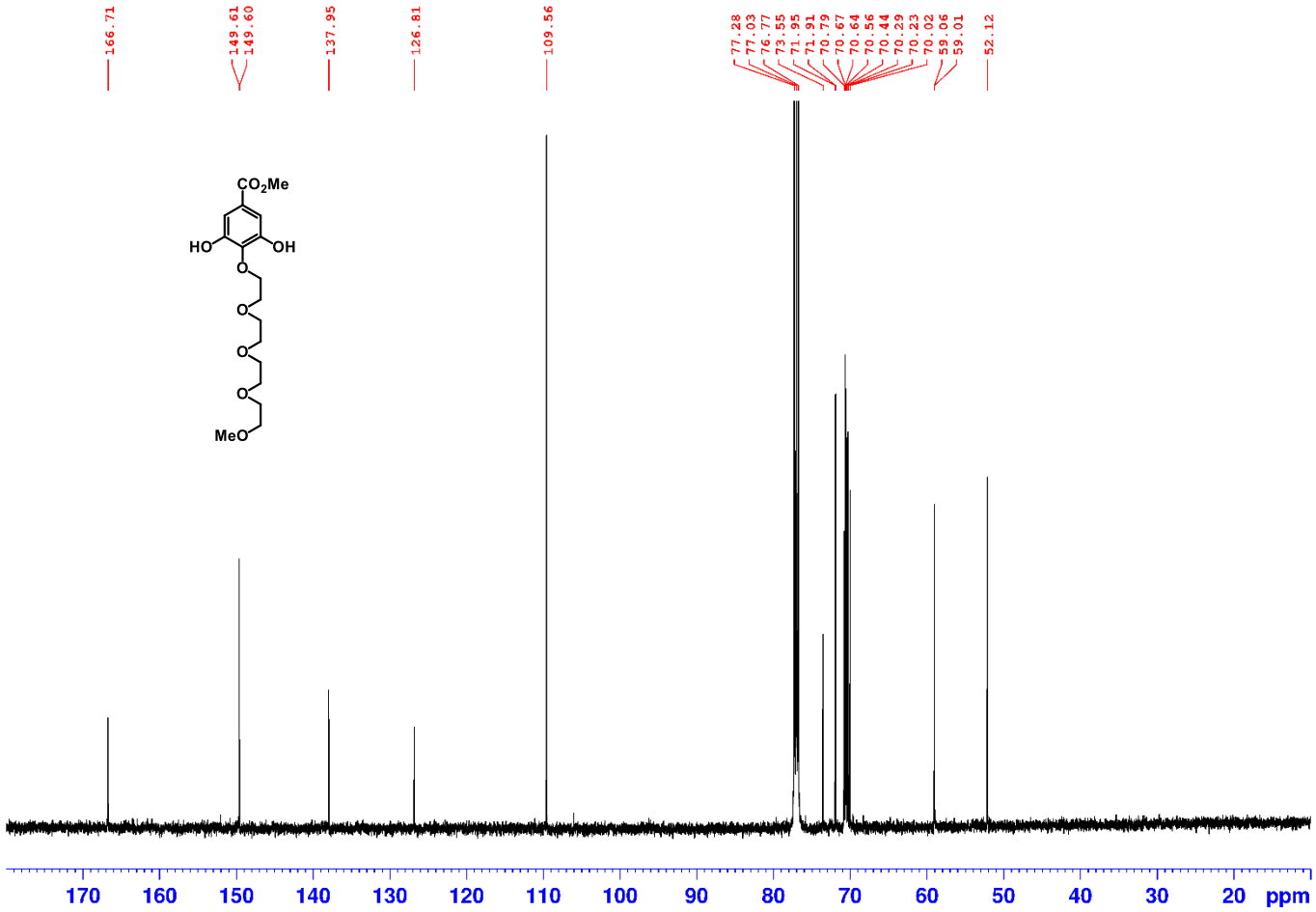
Compound 46 – ^{31}P NMR (121 MHz, $CDCl_3$)



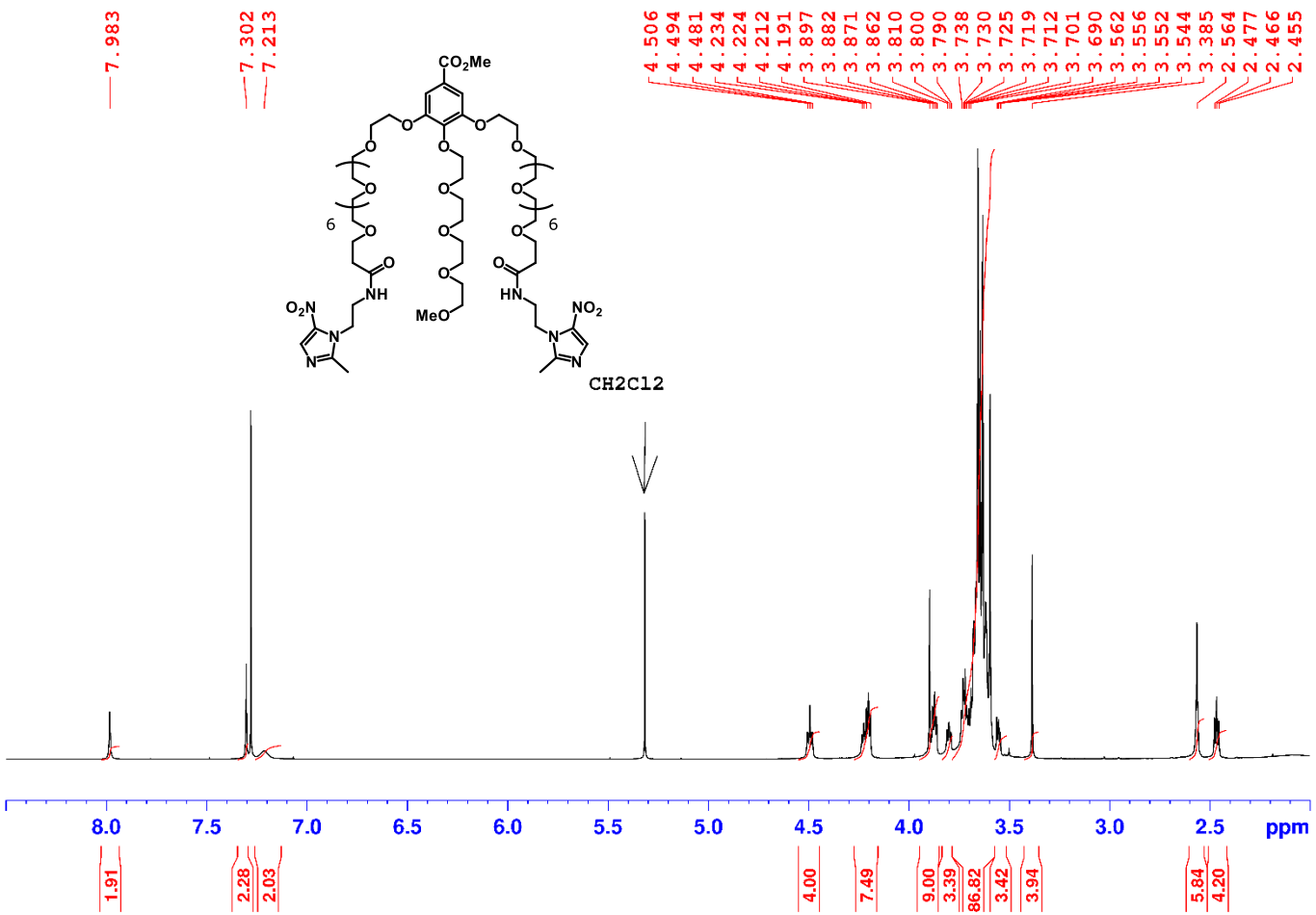
Compound 47 – ^{1}H NMR (300 MHz, $CDCl_3$)



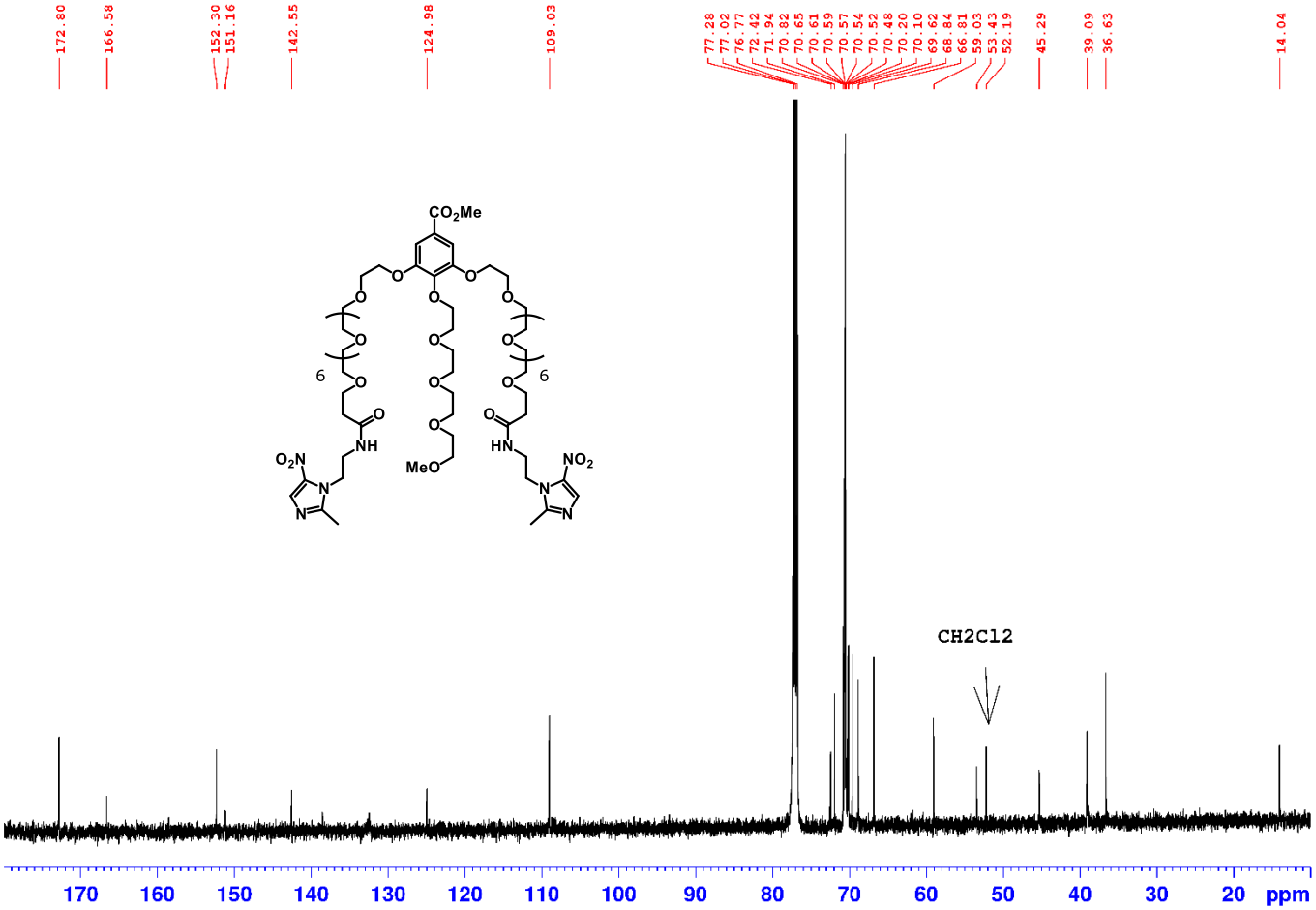
Compound 47 – ^{13}C NMR (125 MHz, $CDCl_3$)



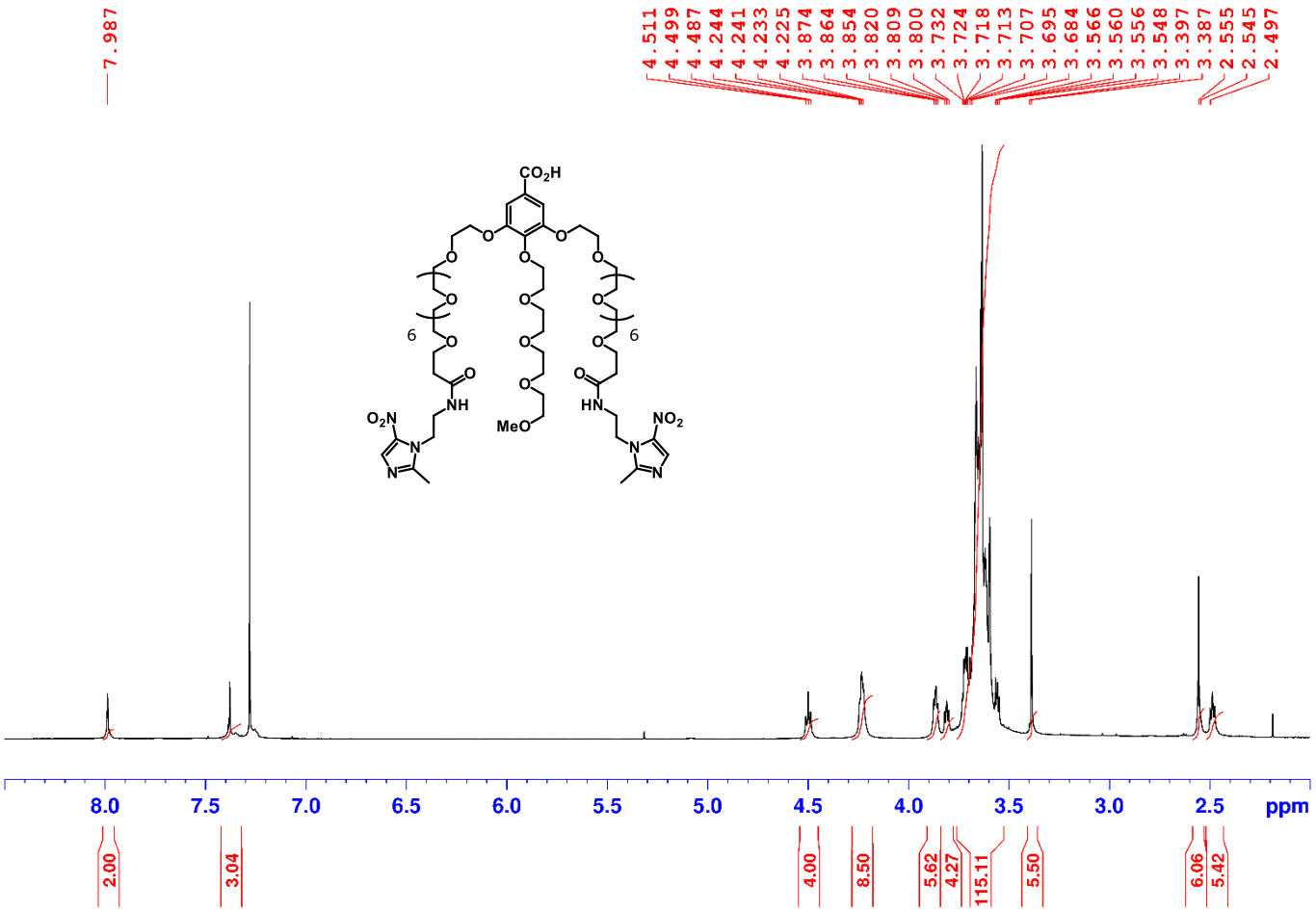
Compound 48 – ^{1}H NMR (500 MHz, $CDCl_3$)



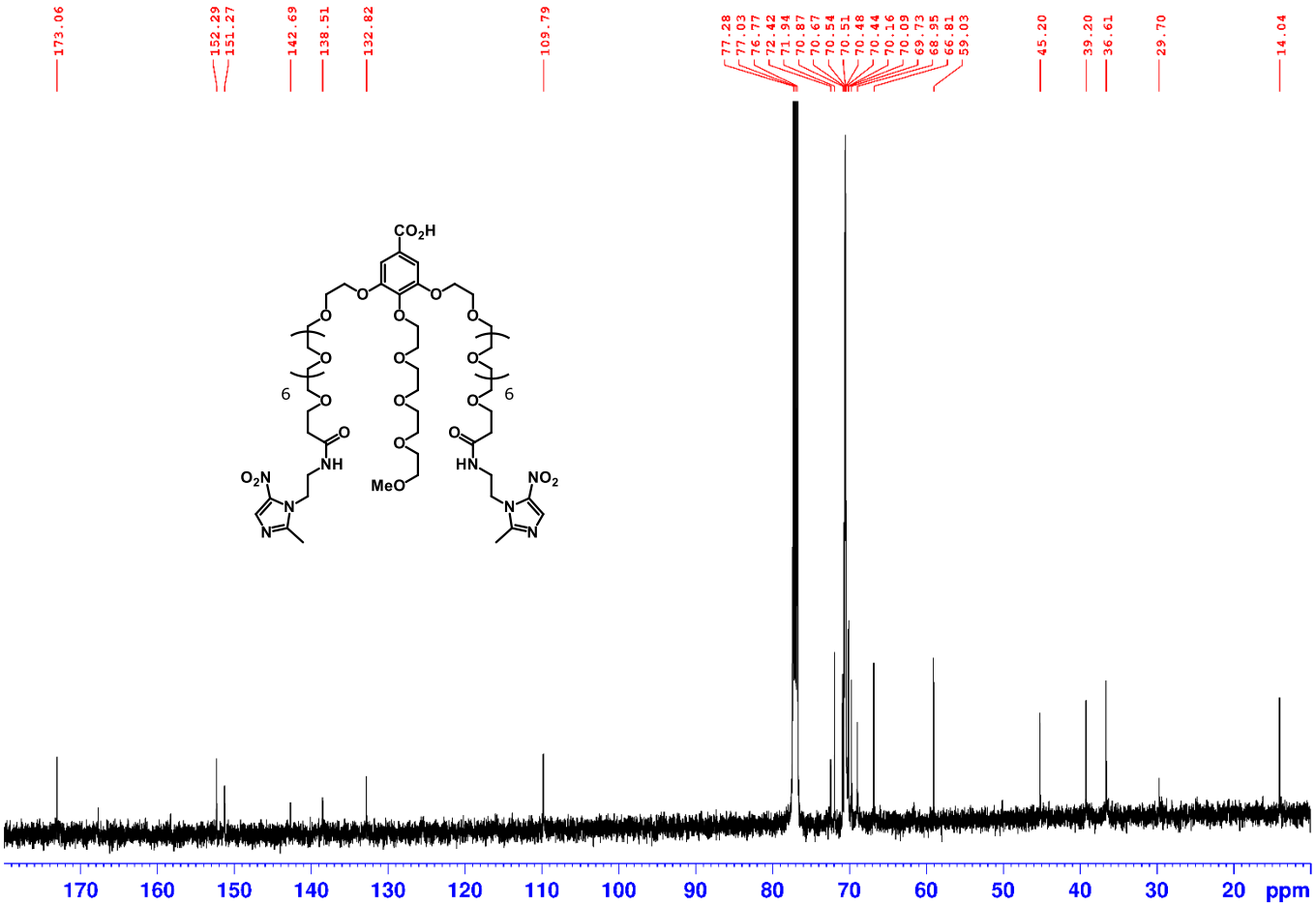
Compound 48 – ^{13}C NMR (125 MHz, $CDCl_3$)



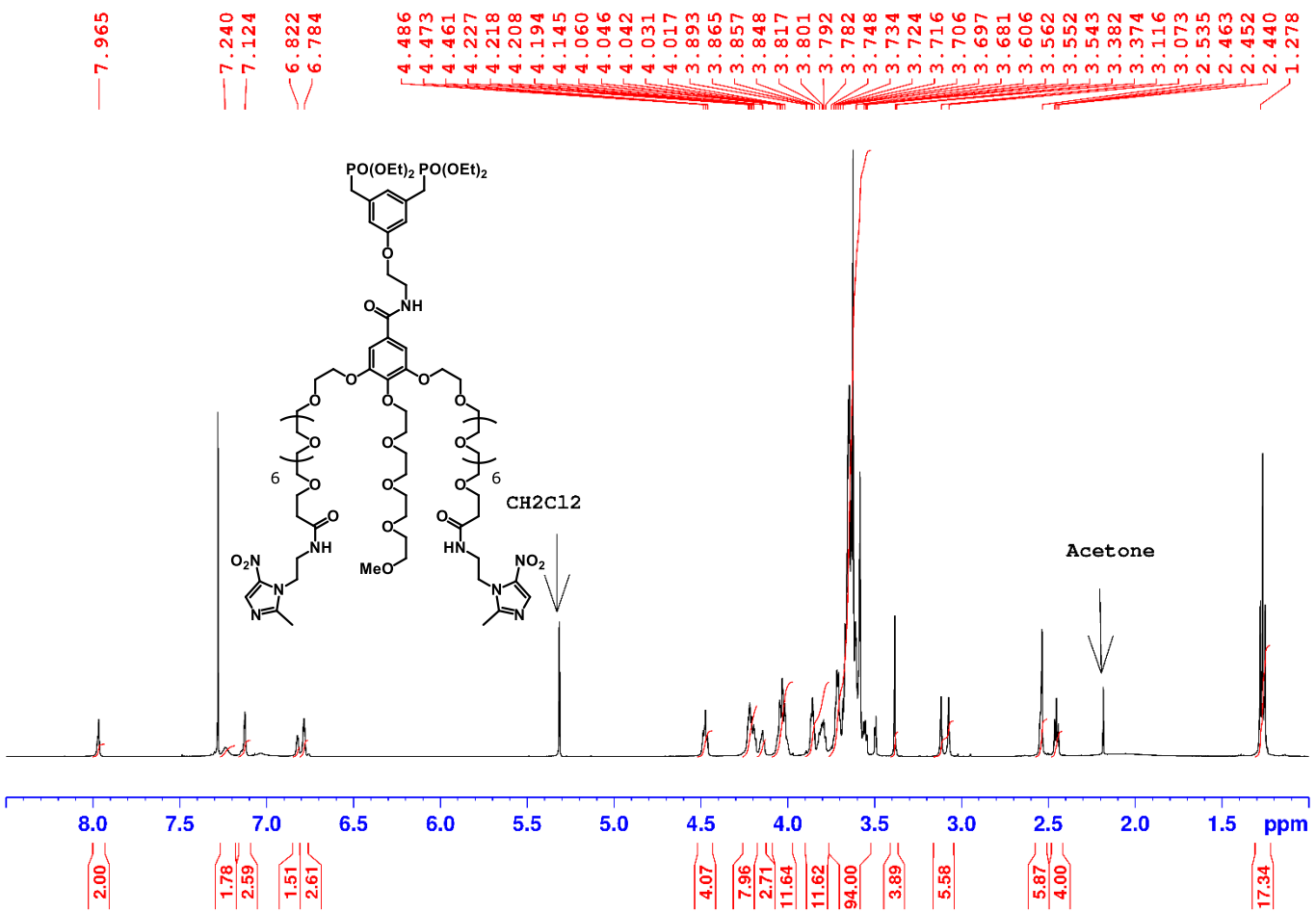
Compound 49 – ^{1}H NMR (500 MHz, $CDCl_3$)



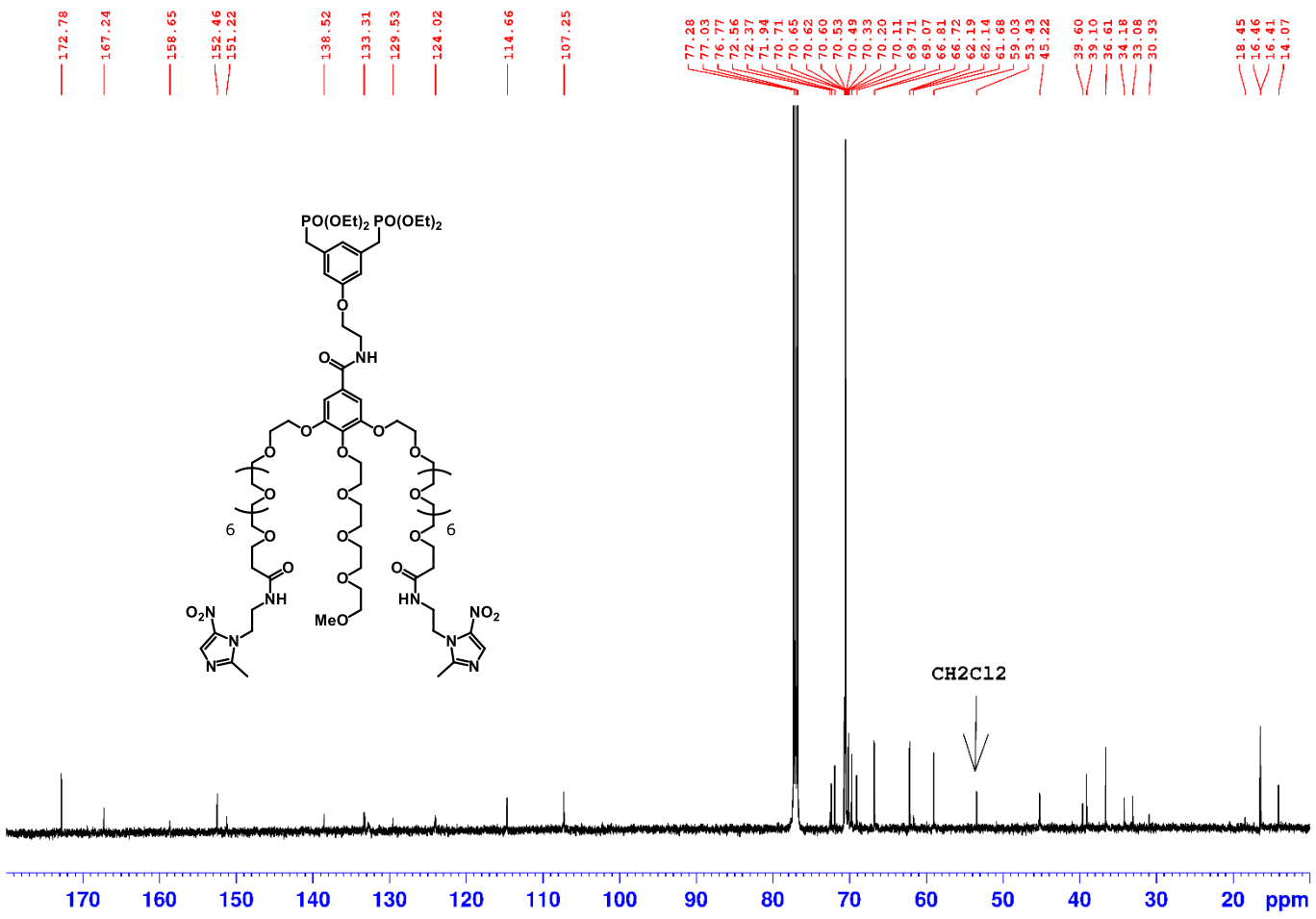
Compound 49 – ^{13}C NMR (125 MHz, $CDCl_3$)



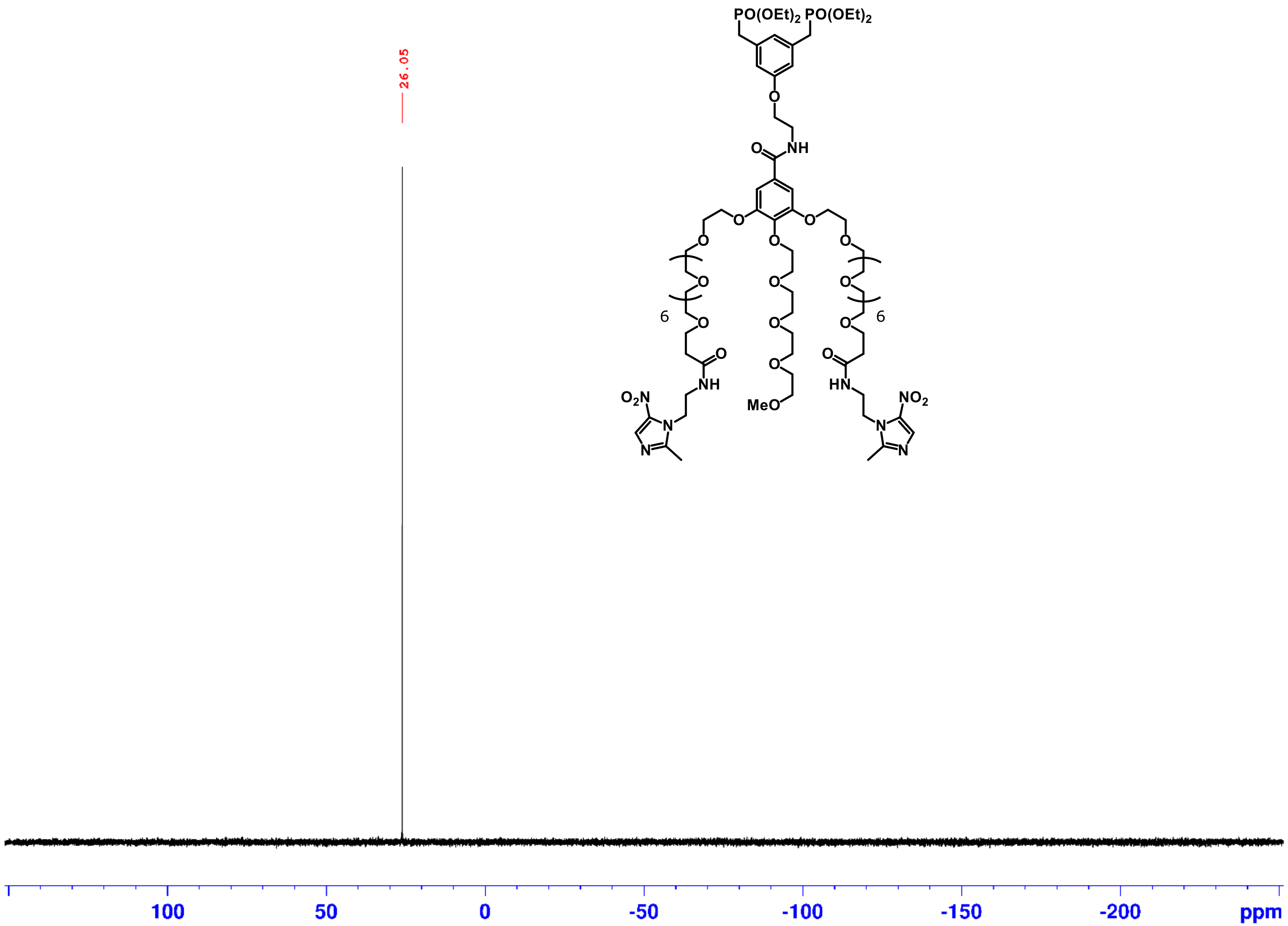
Compound 50 – ^{1}H NMR (500 MHz, $CDCl_3$)



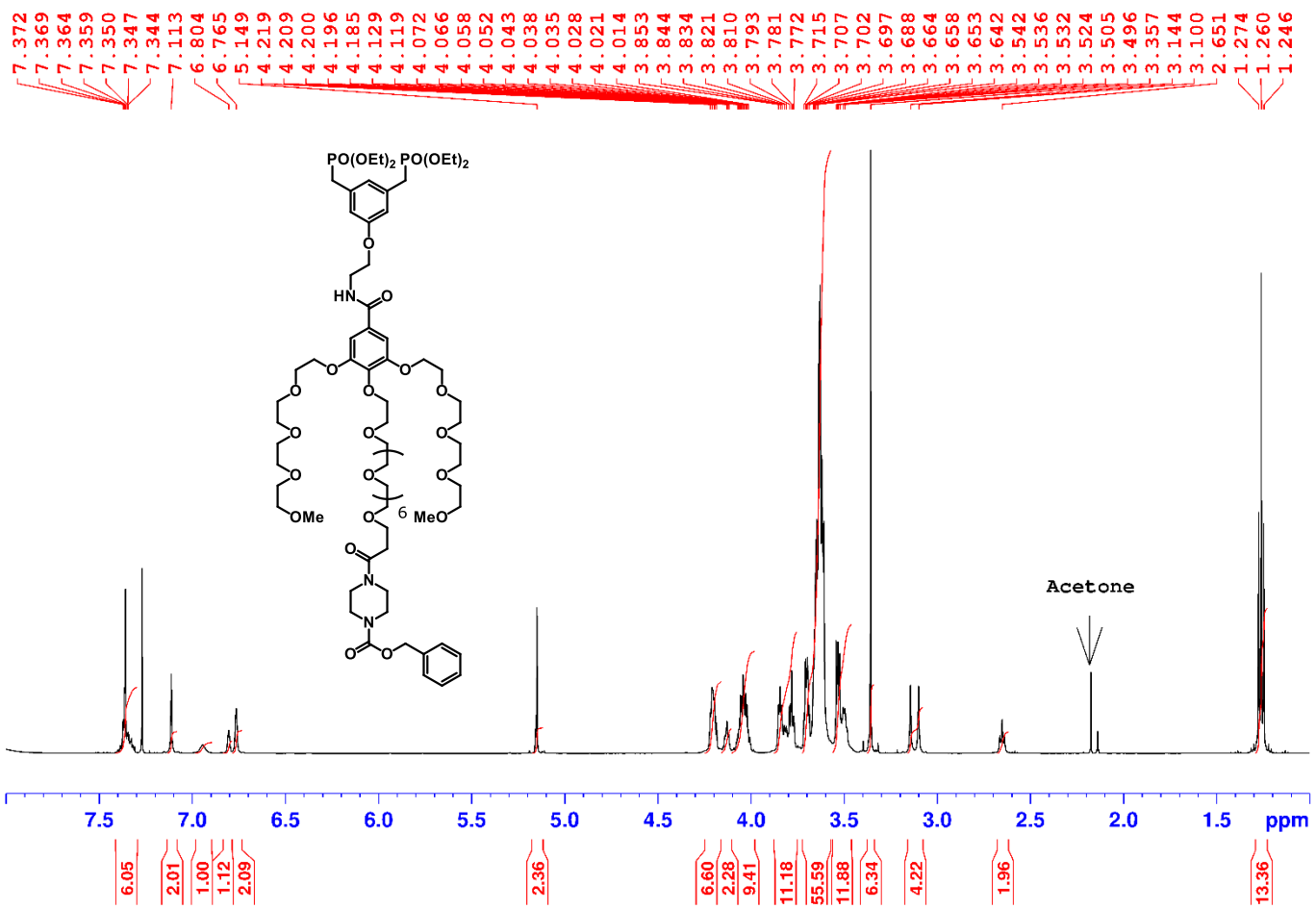
Compound 50 – ^{13}C NMR (125 MHz, $CDCl_3$)



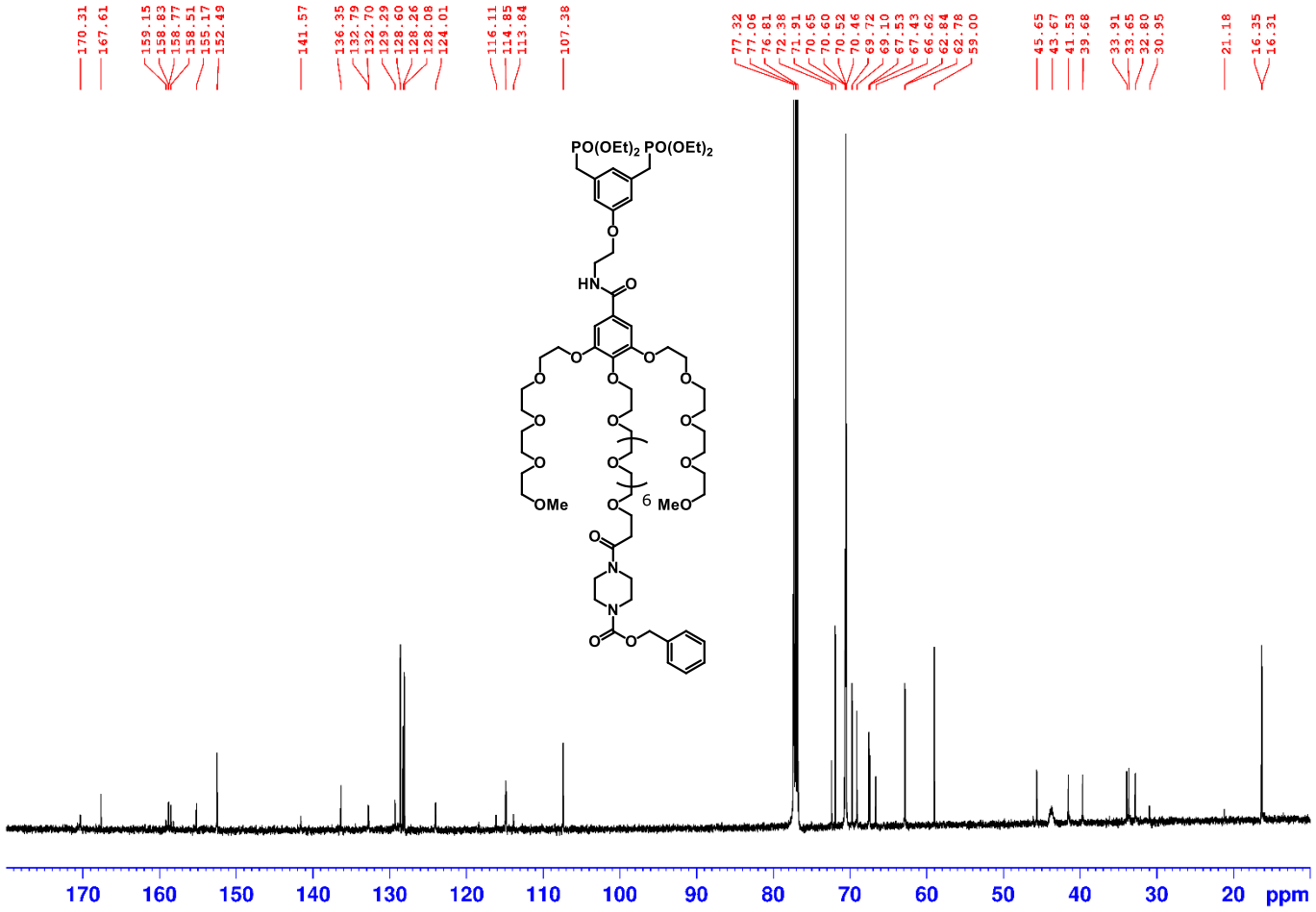
Compound 50 – ^{31}P NMR (202 MHz, $CDCl_3$)



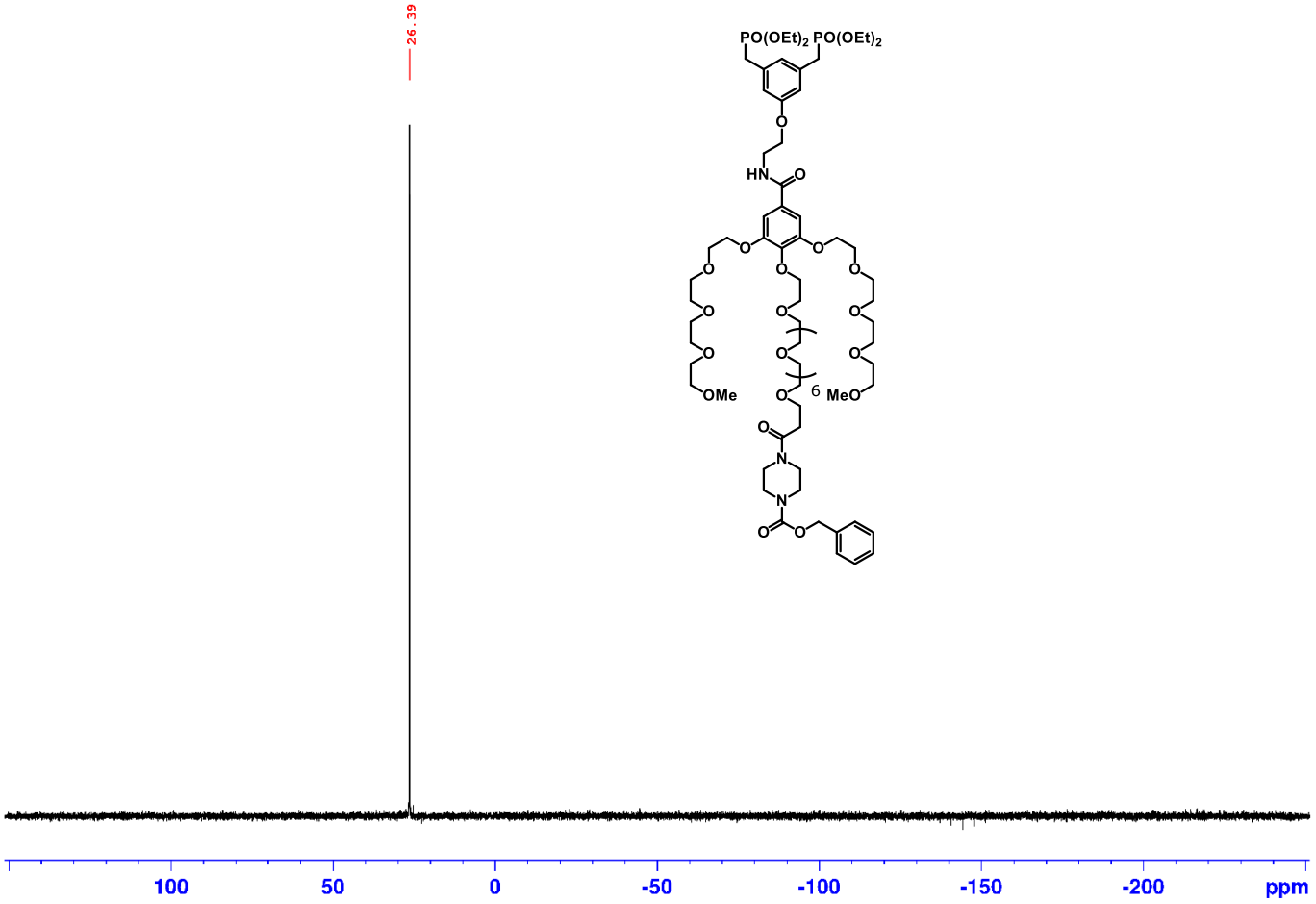
Compound 51 – ^{1}H NMR (500 MHz, $CDCl_3$)



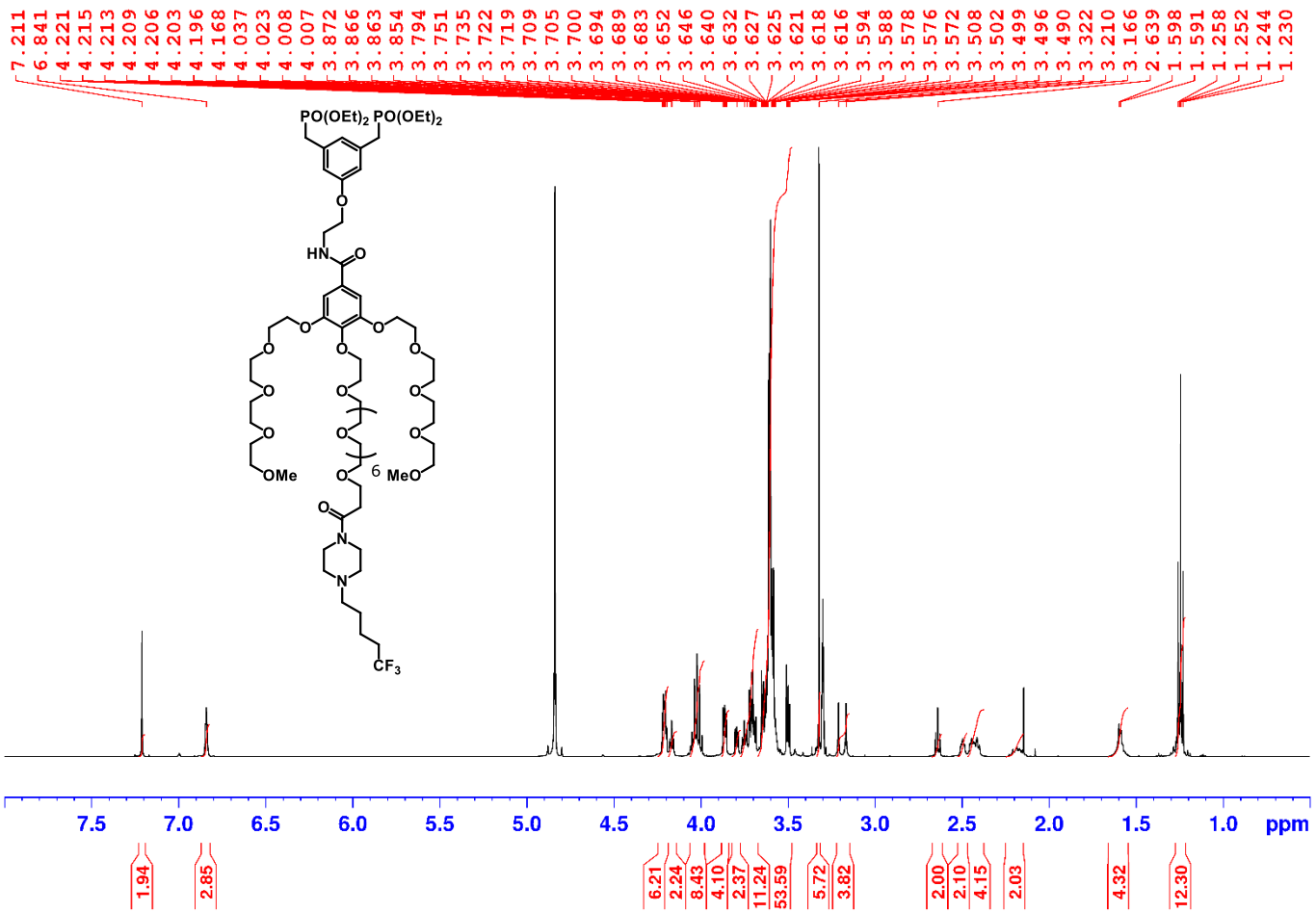
Compound 51 – ^{13}C NMR (125 MHz, $CDCl_3$)


170.31
167.61
159.15
158.83
158.77
158.51
155.17
152.49
141.57
136.35
132.79
132.70
129.29
128.60
128.26
128.08
124.01
116.11
114.85
113.84
107.38
77.32
77.06
76.81
72.38
71.91
70.65
70.60
70.52
70.46
69.72
69.10
67.53
67.43
66.62
62.84
62.78
59.00
45.65
43.67
41.53
39.68
33.91
33.65
32.80
30.95
21.18
16.35
16.31
PO(OEt)2 PO(OEt)2
HN
OMe
6
MeO
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
ppm

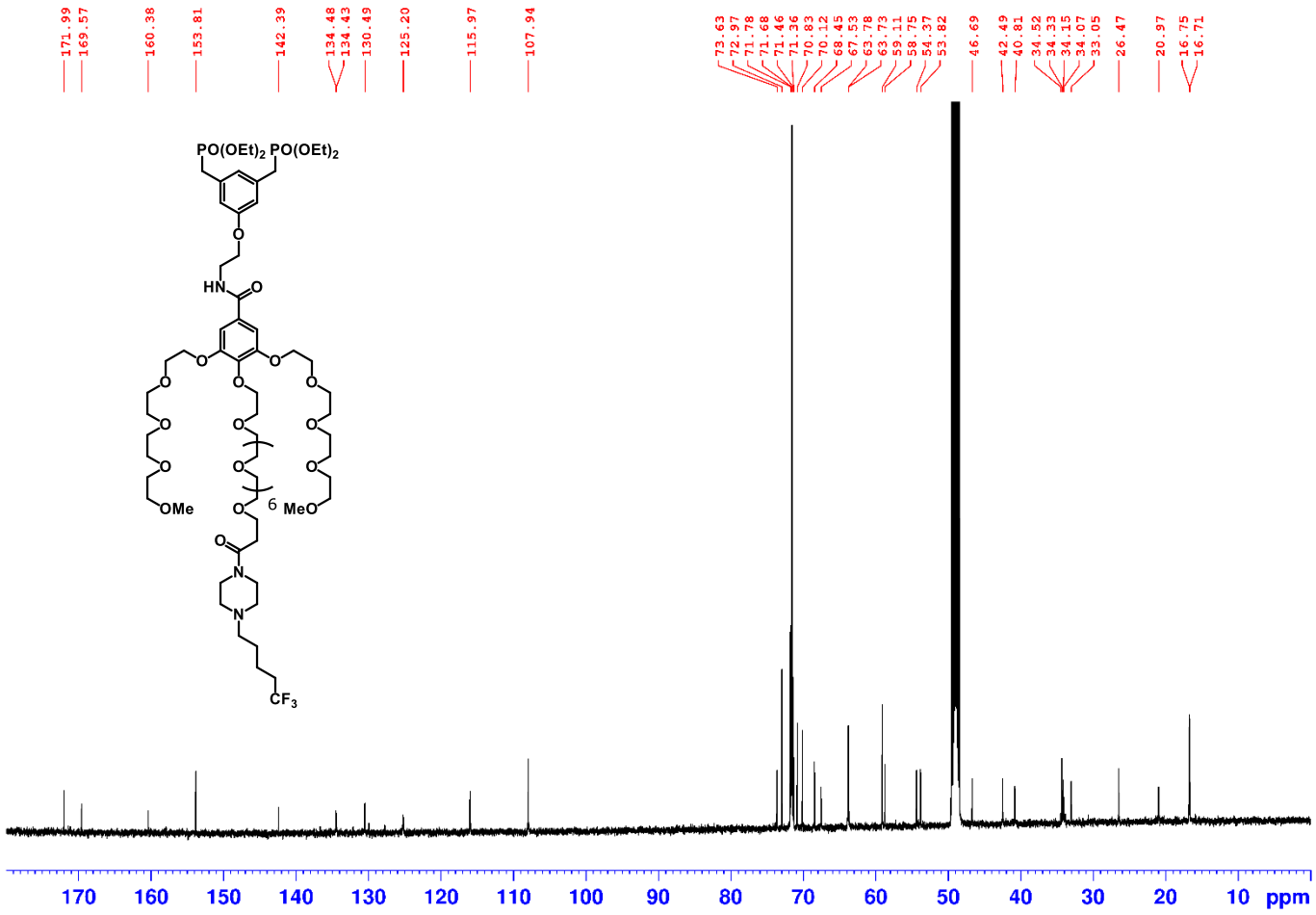
Compound 51 – ^{31}P NMR (202 MHz, $CDCl_3$)



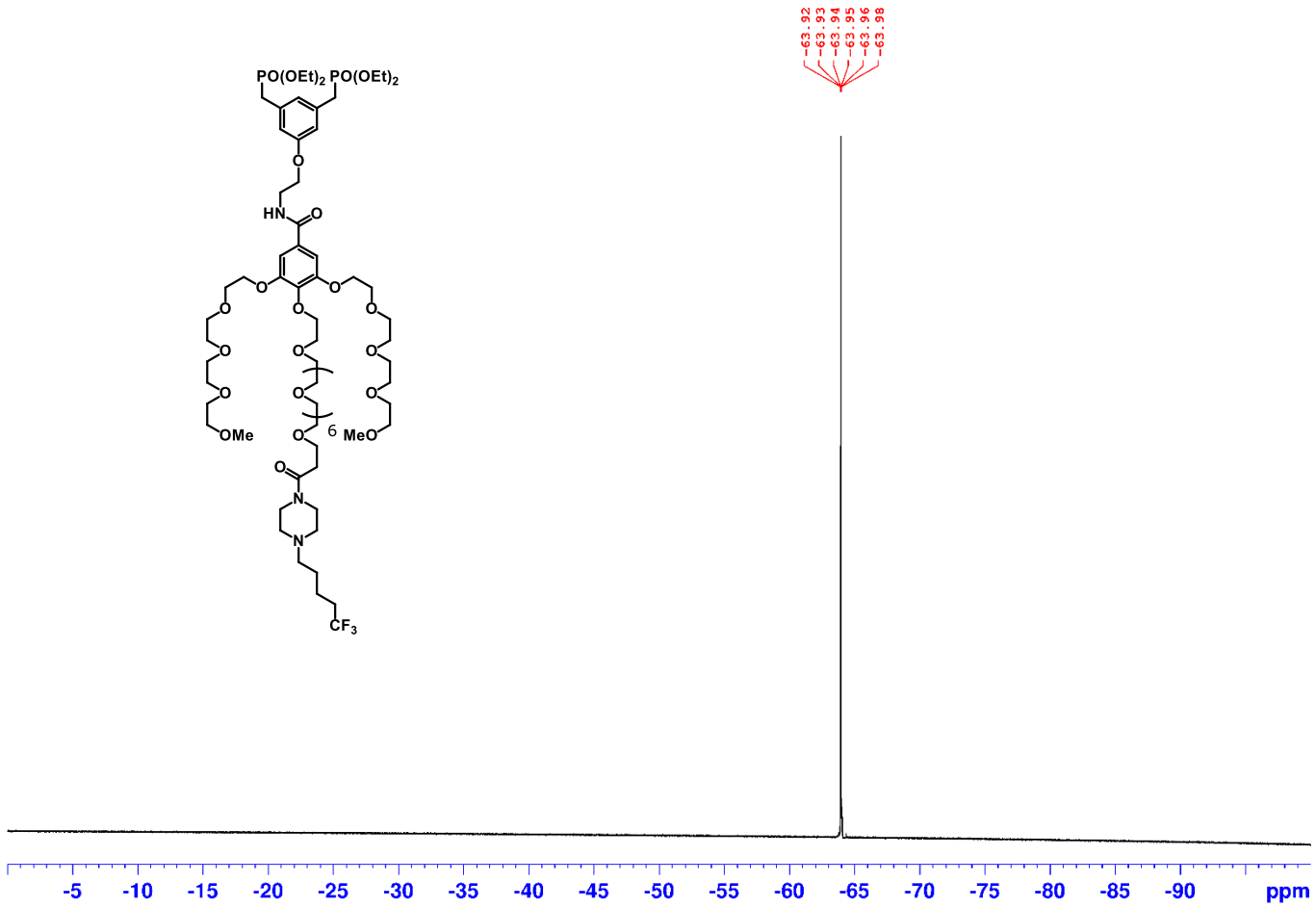
Compound 52 – ^{1}H NMR (500 MHz, CD_3OD-d_4)



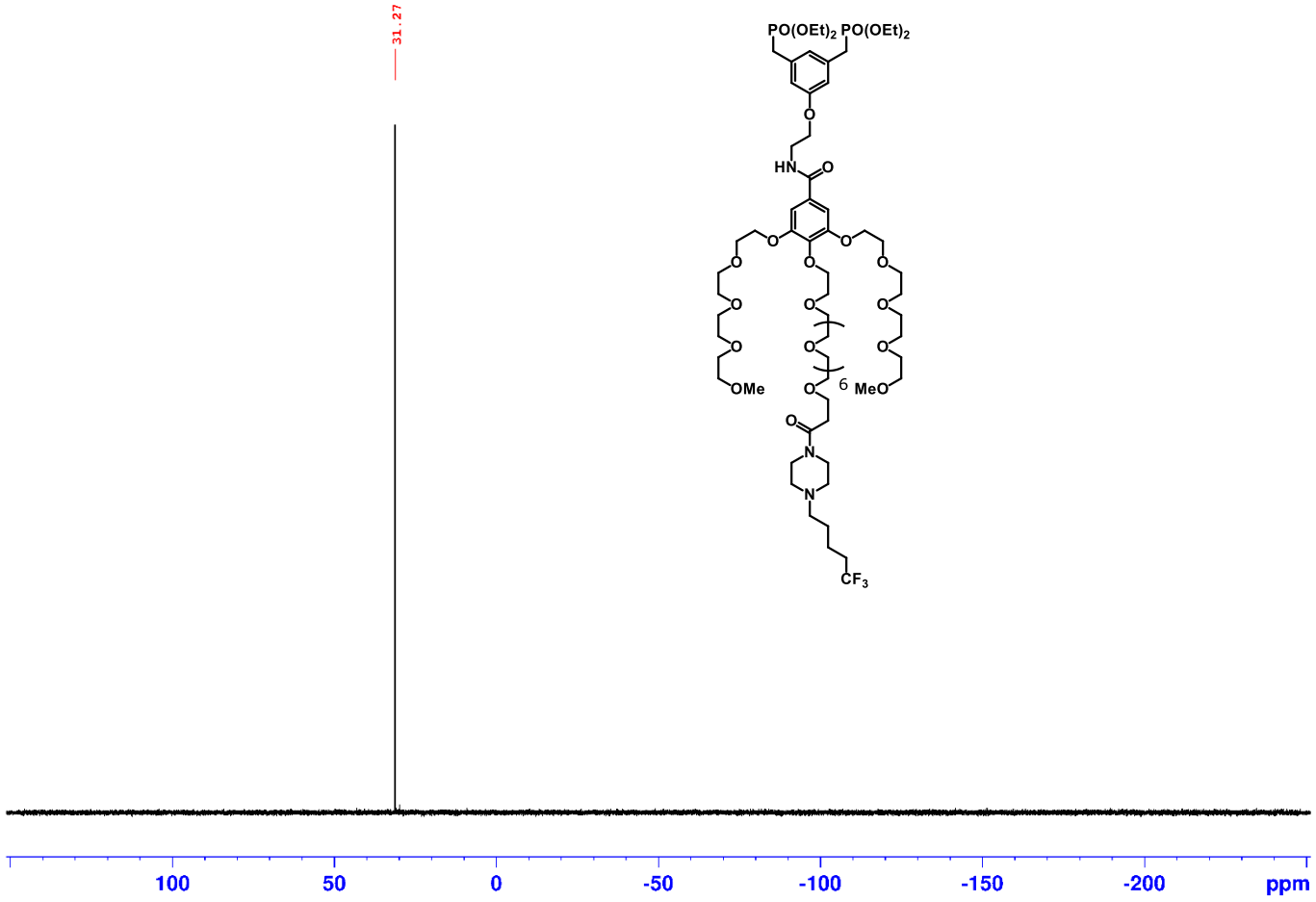
Compound 52 – ^{13}C NMR (125 MHz, CD_3OD-d_4)



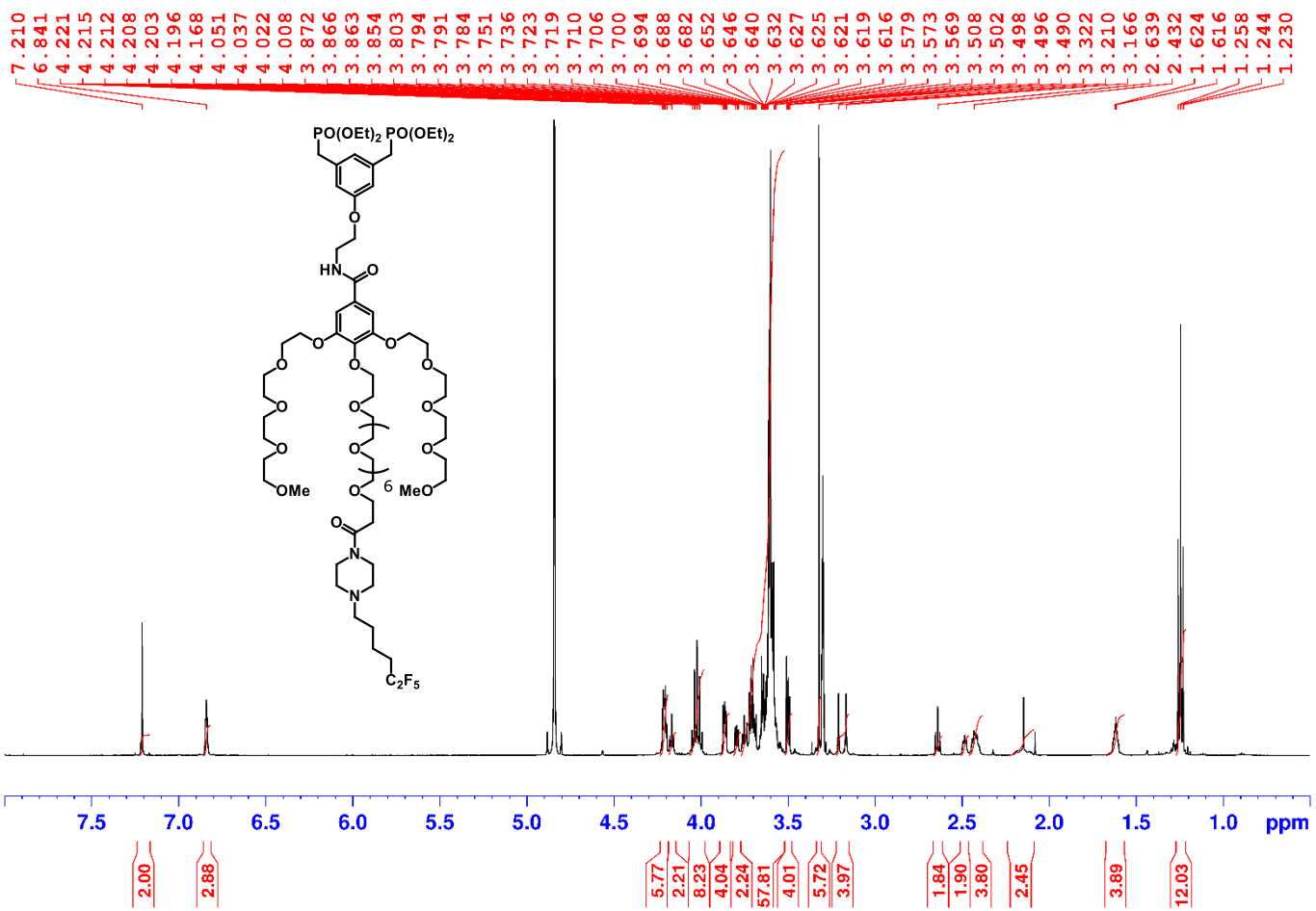
Compound 52 – ^{19}F NMR (470 MHz, CD_3OD-d_4)



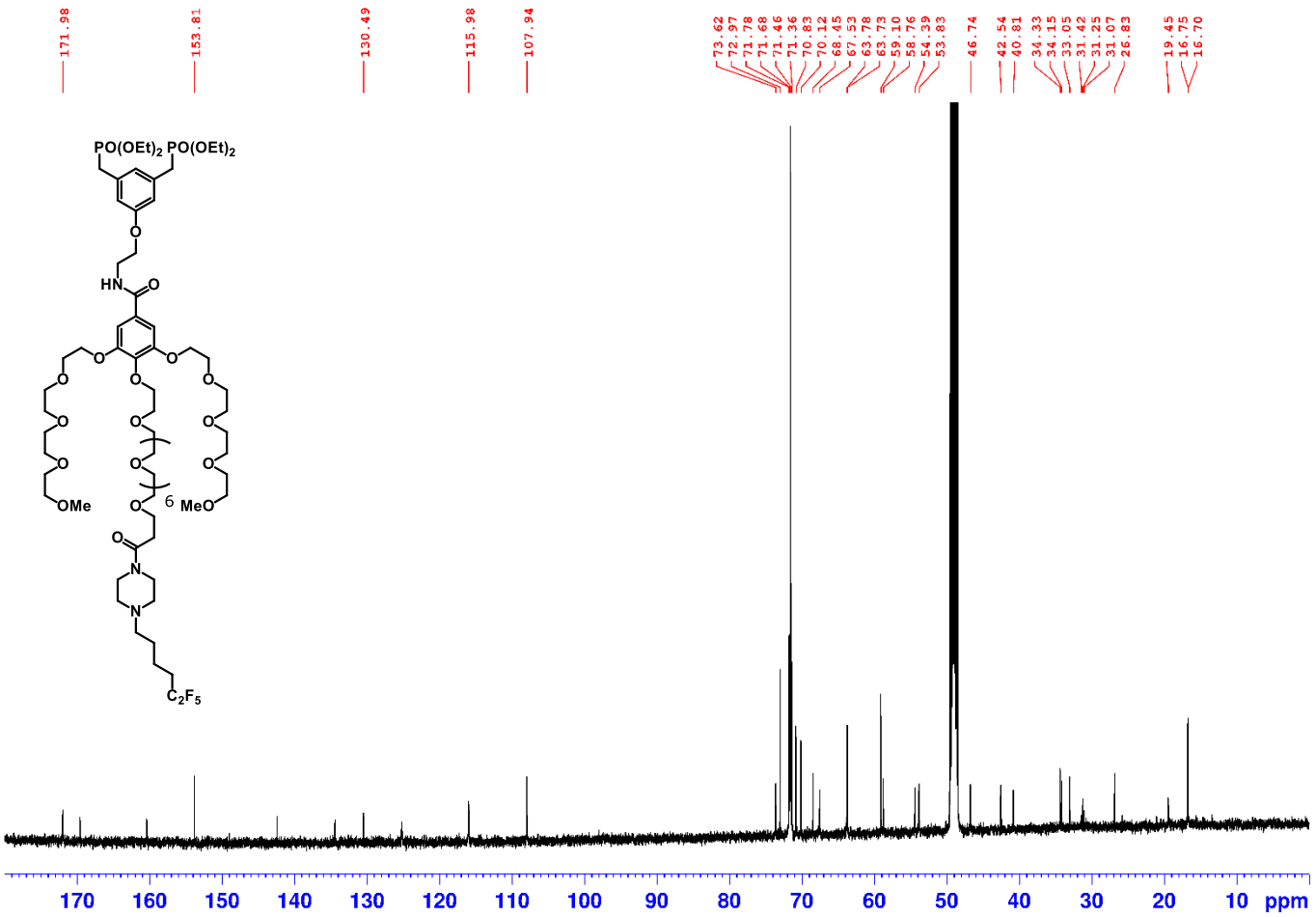
Compound 52 – ^{31}P NMR (202 MHz, CD_3OD-d_4)



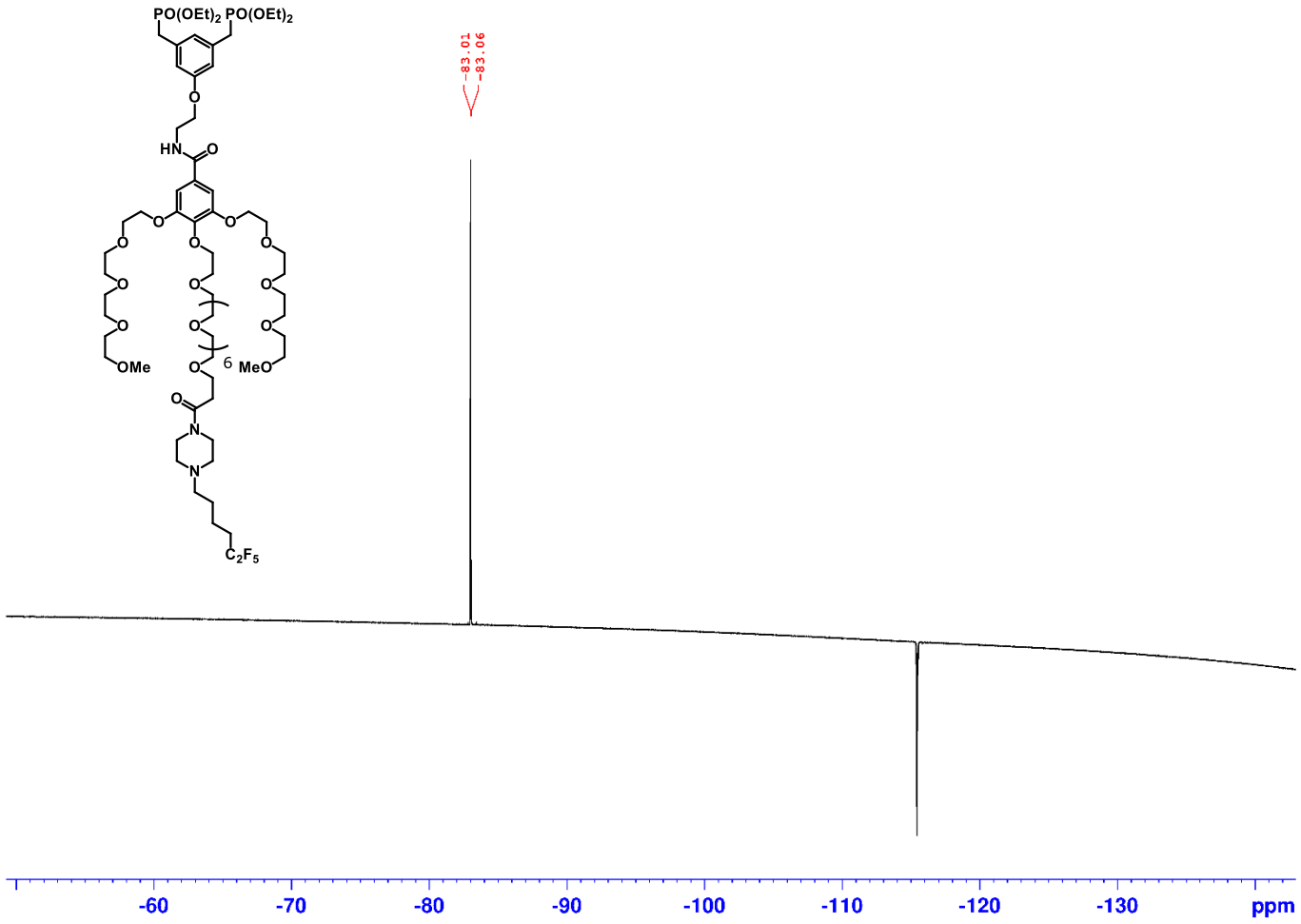
Compound 53 – ^{1}H NMR (500 MHz, CD_3OD-d_4)



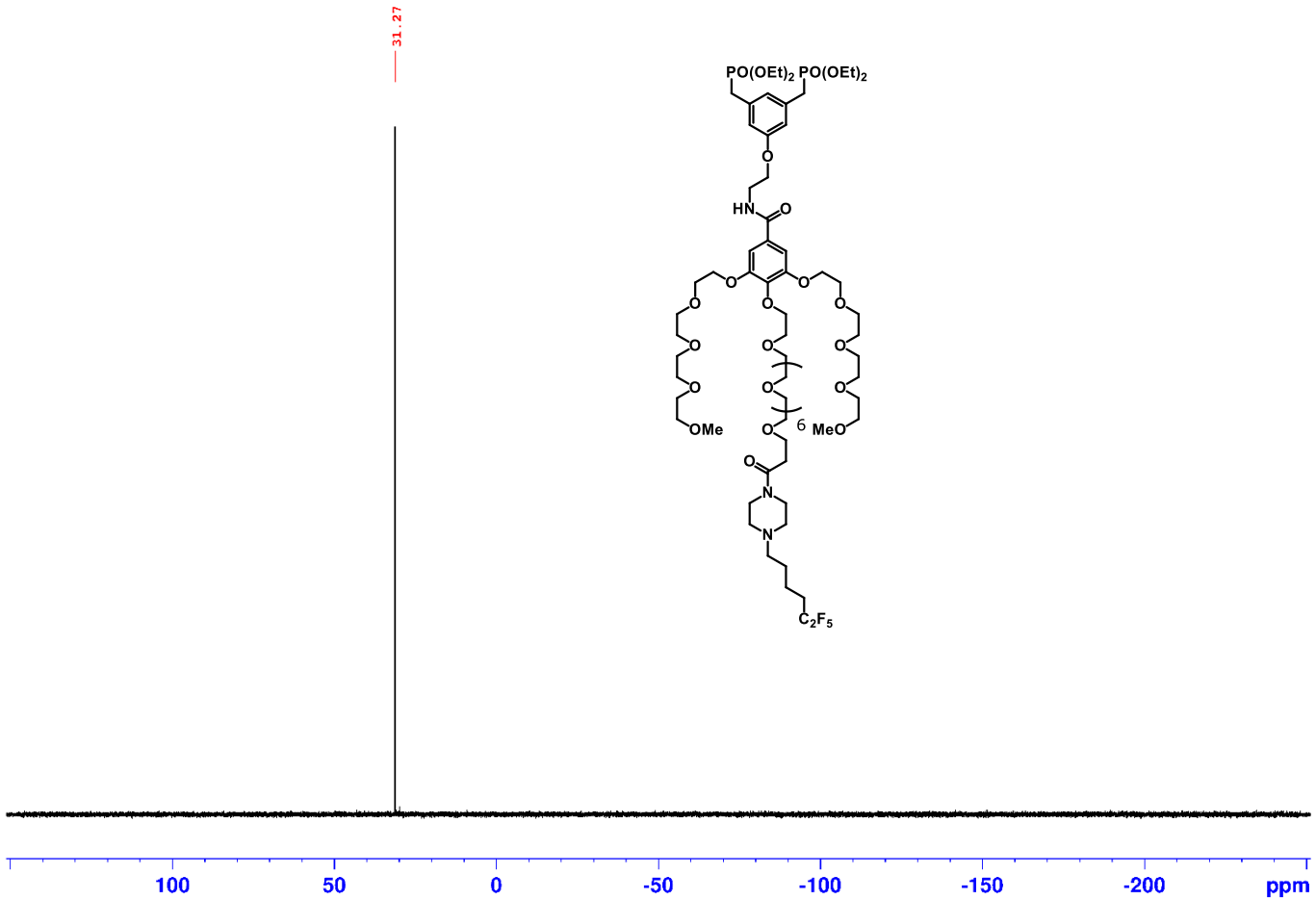
Compound 53 – ^{13}C NMR (125 MHz, CD_3OD-d_4)



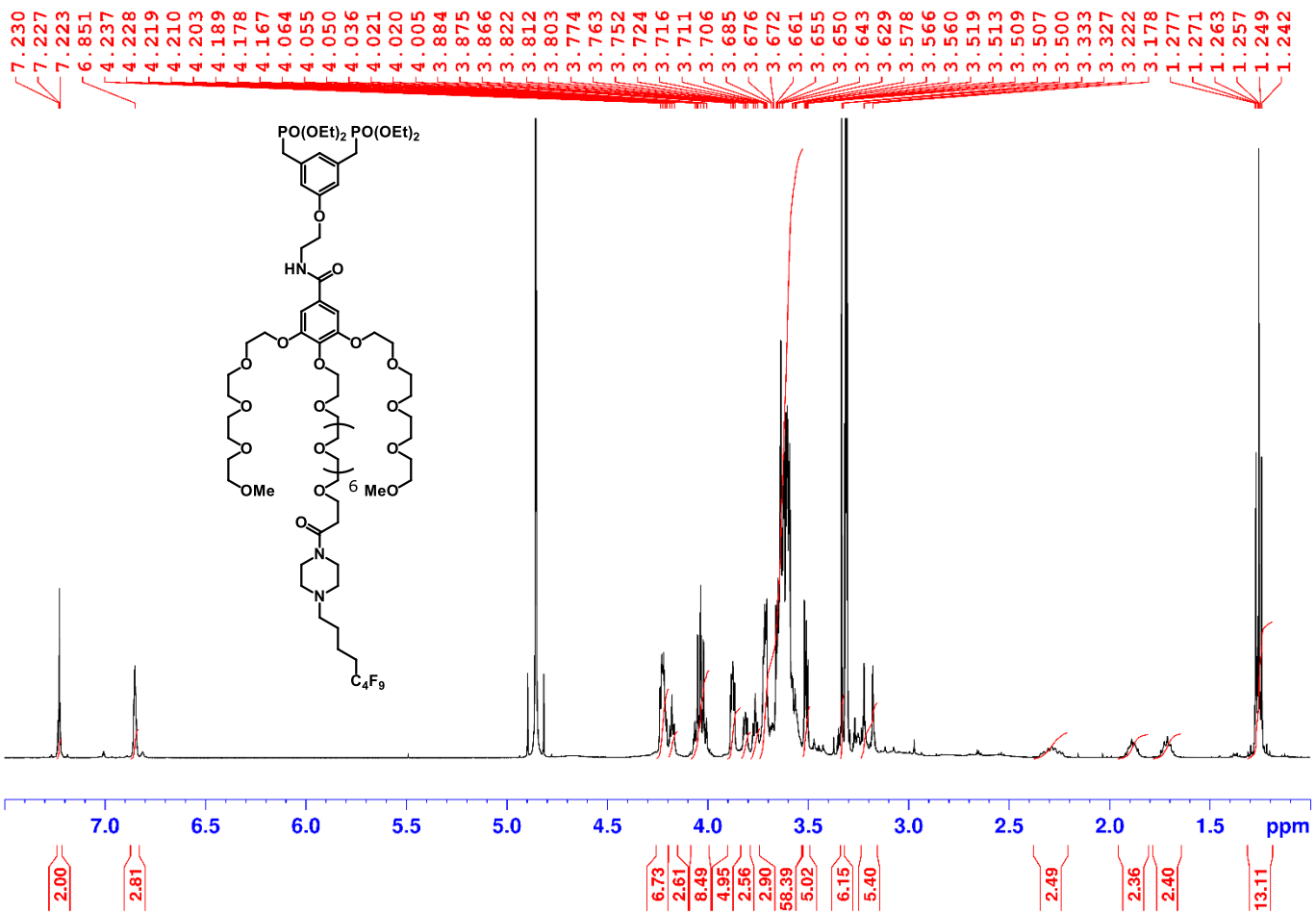
Compound 53 – ^{19}F NMR (470 MHz, CD_3OD-d_4)



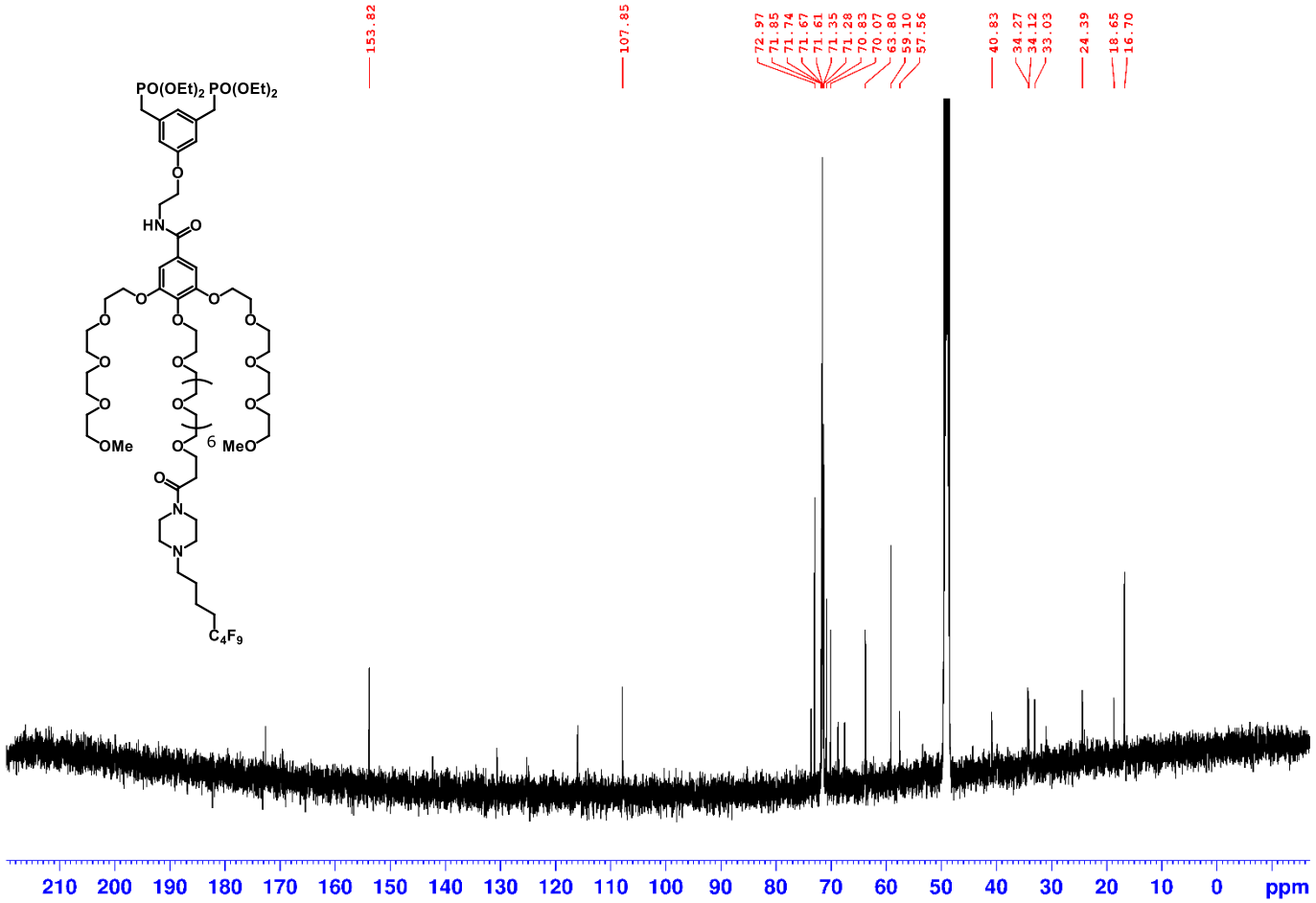
Compound 53 – ^{31}P NMR (202 MHz, CD_3OD-d_4)



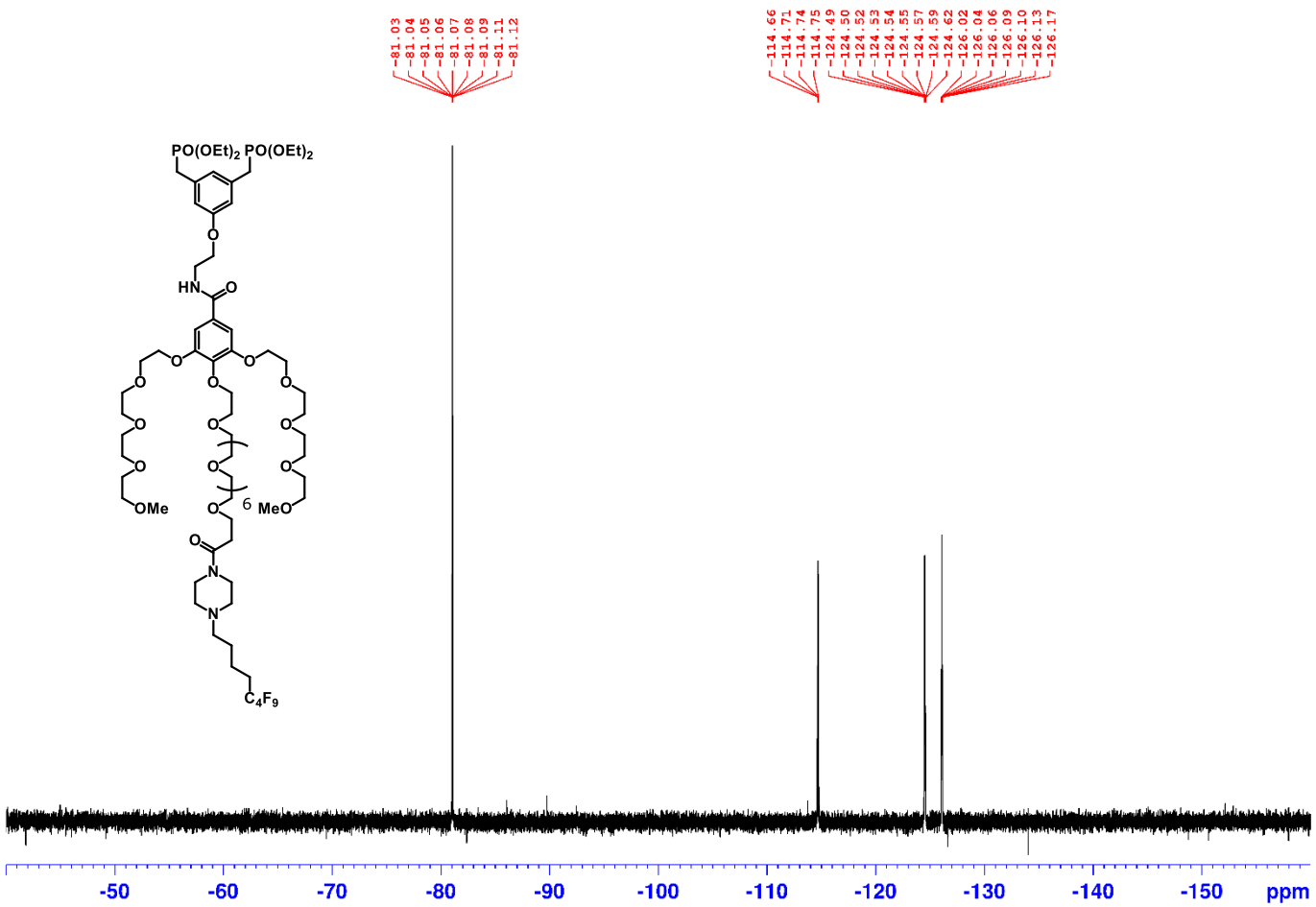
Compound 54 – ^{1}H NMR (500 MHz, CD_3OD-d_4)



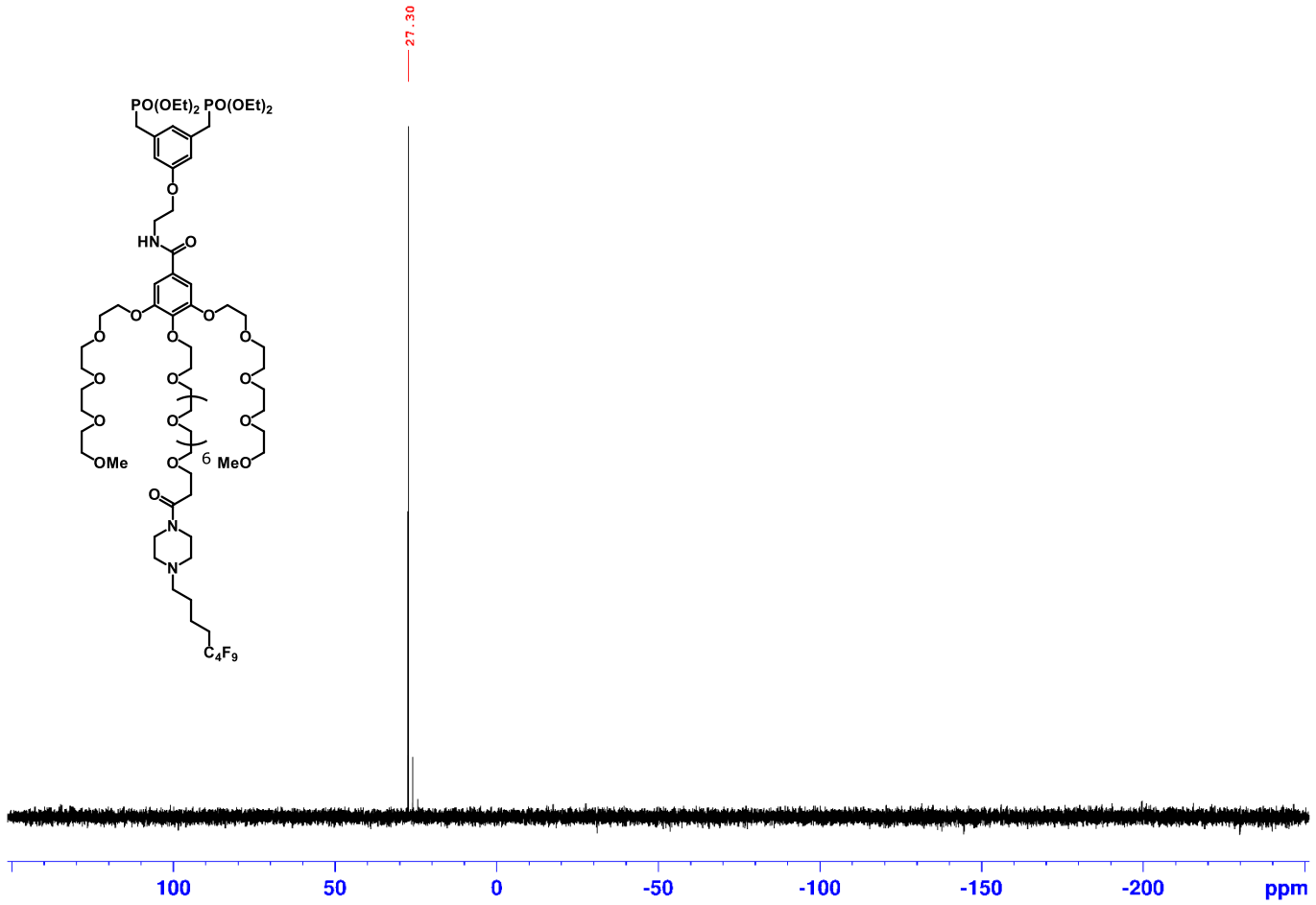
Compound 54 – ^{13}C NMR (125 MHz, CD_3OD-d_4)



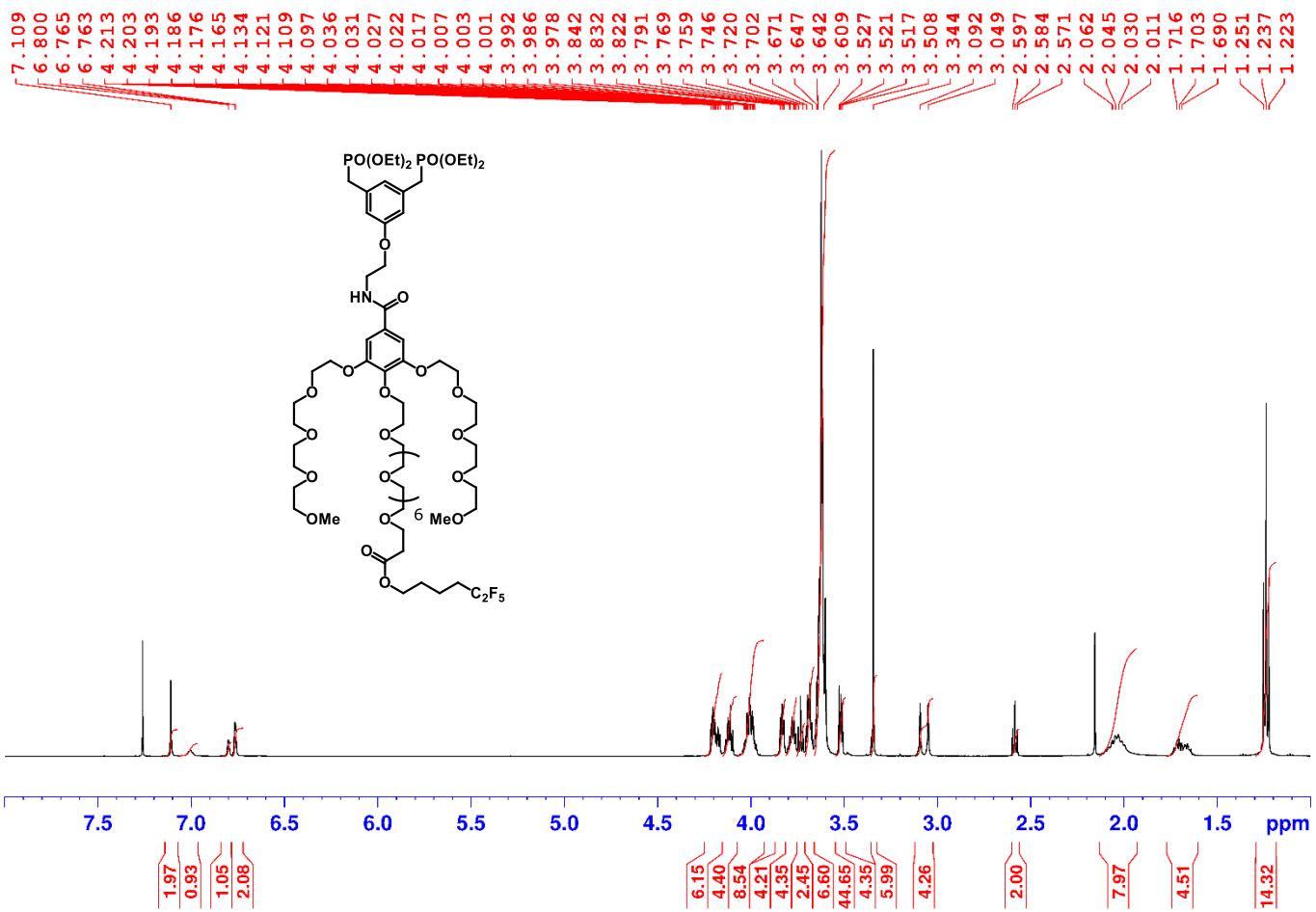
Compound 54 – ^{19}F NMR (282 MHz, CD_3OD-d_4)



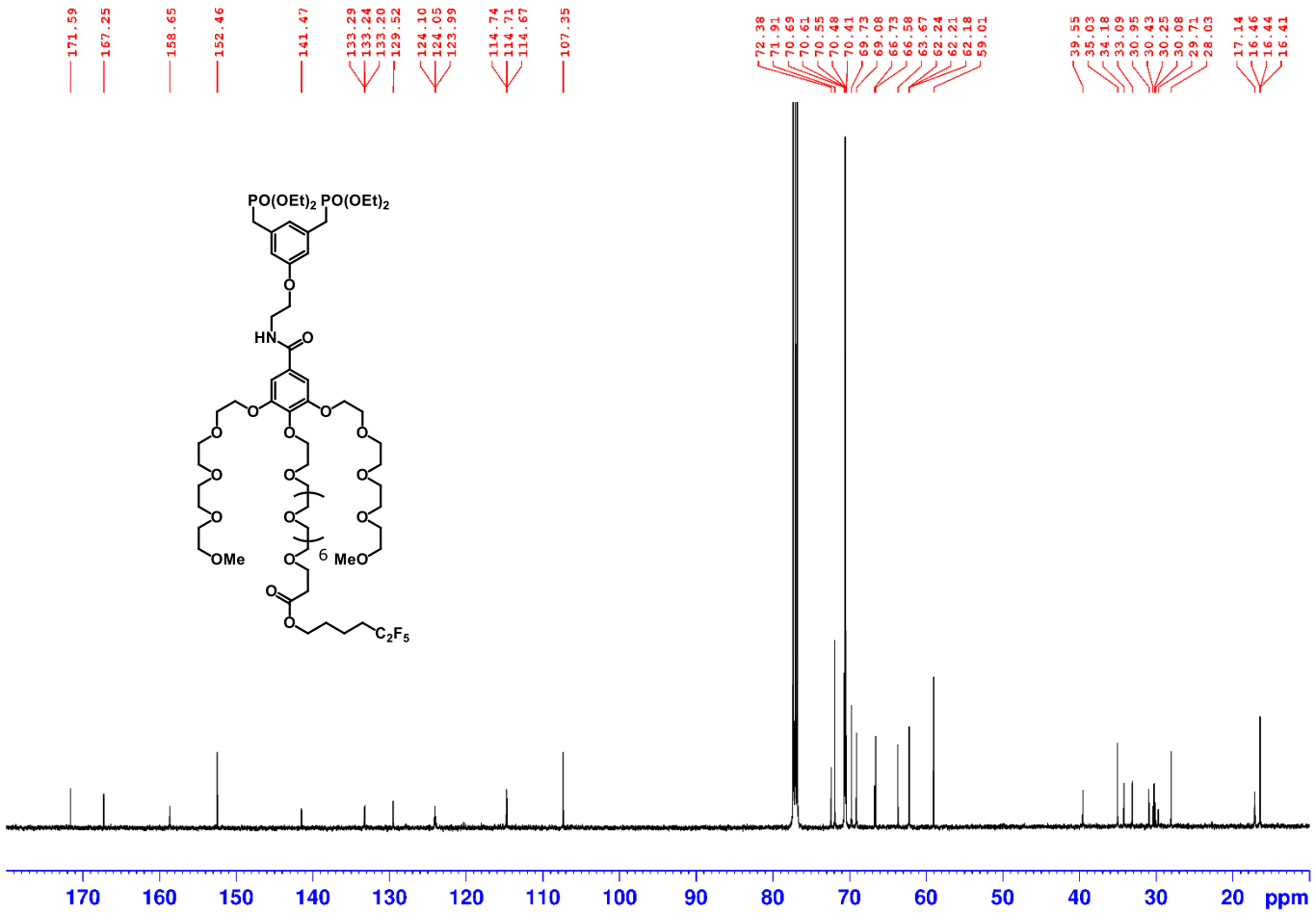
Compound 54 – ^{31}P NMR (202 MHz, CD_3OD-d_4)



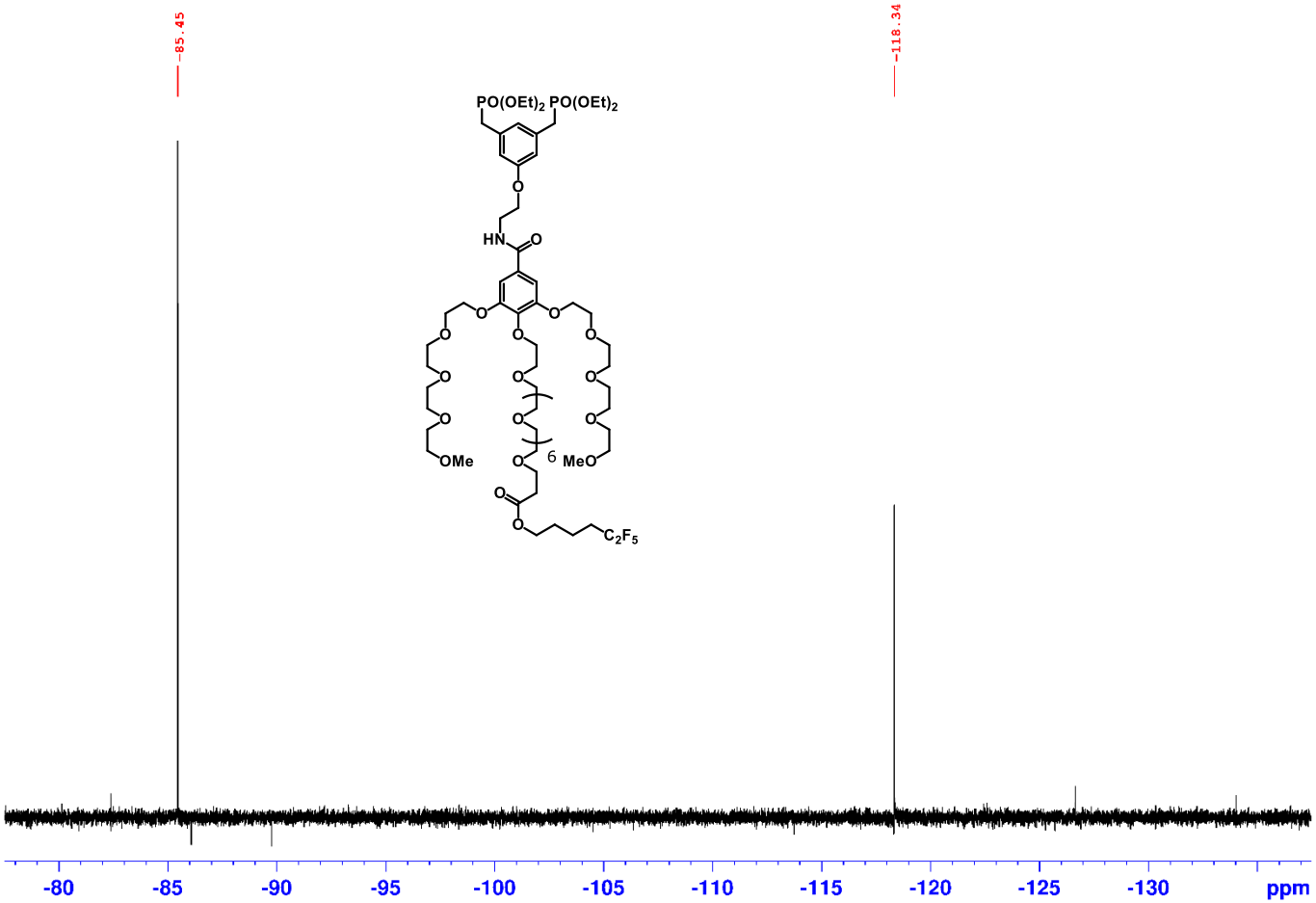
Compound 55 – ^{1}H NMR (500 MHz, $CDCl_3$)



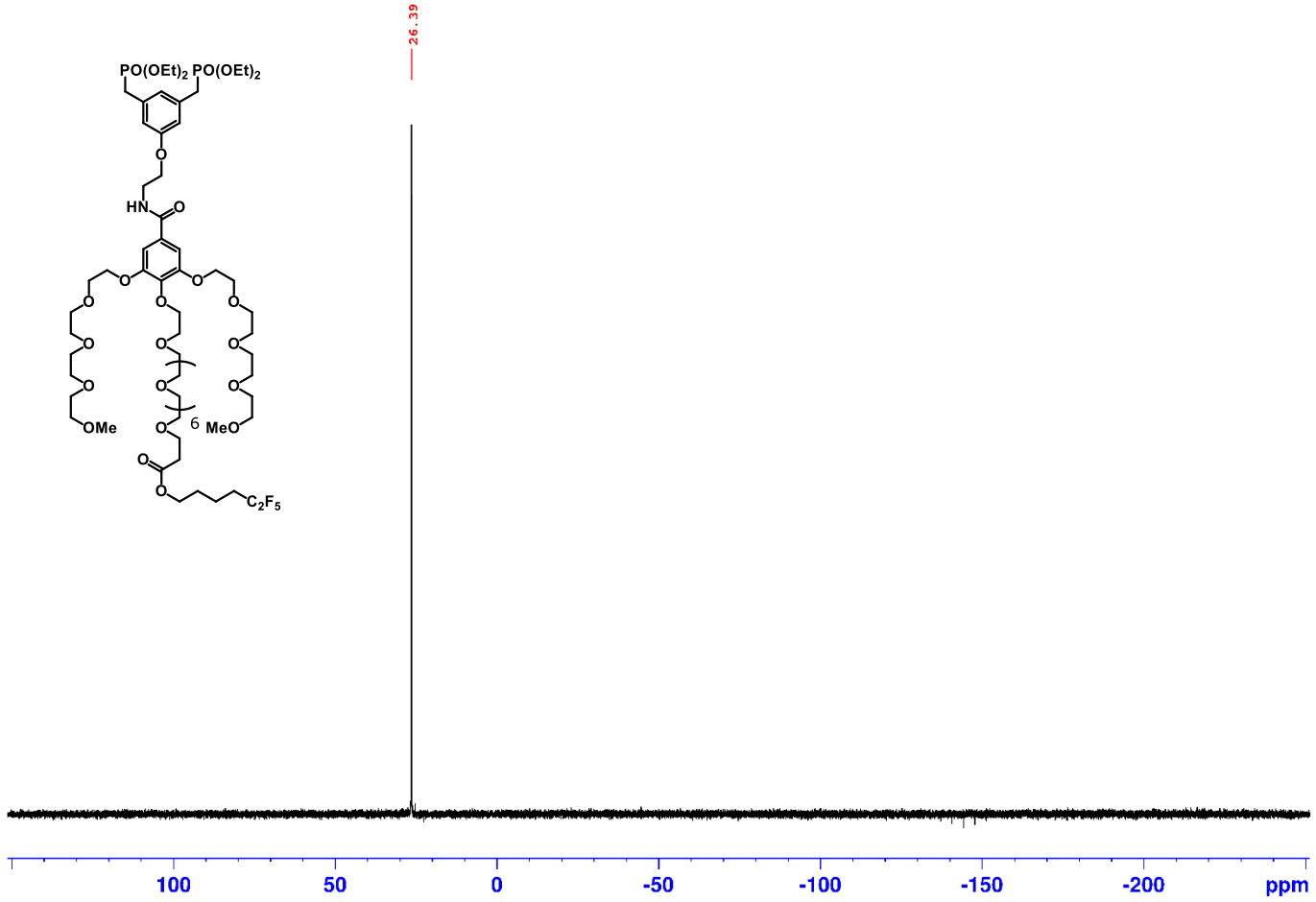
Compound 55 – ^{13}C NMR (125 MHz, $CDCl_3$)



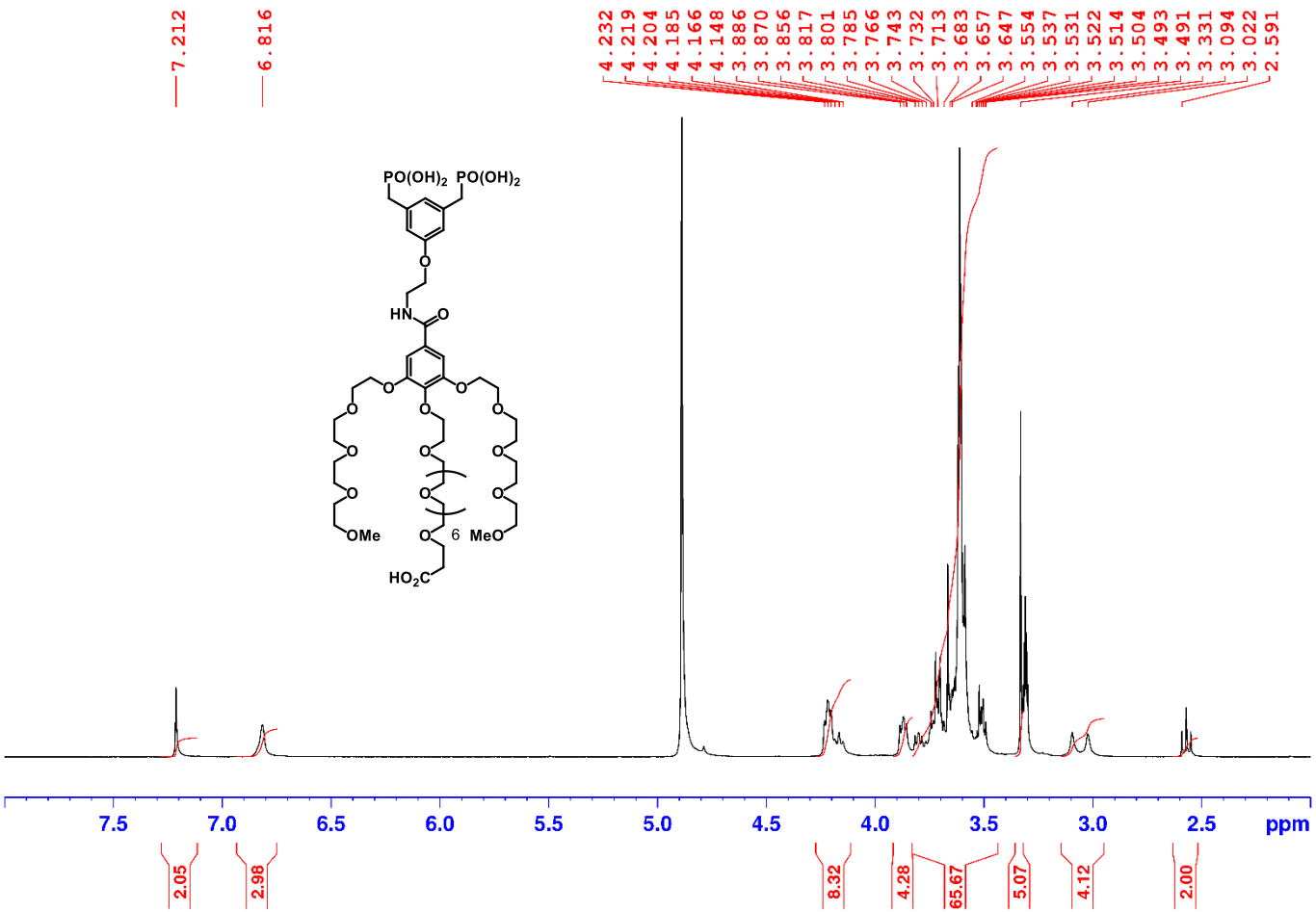
Compound 55 – ^{19}F NMR (282 MHz, $CDCl_3$)



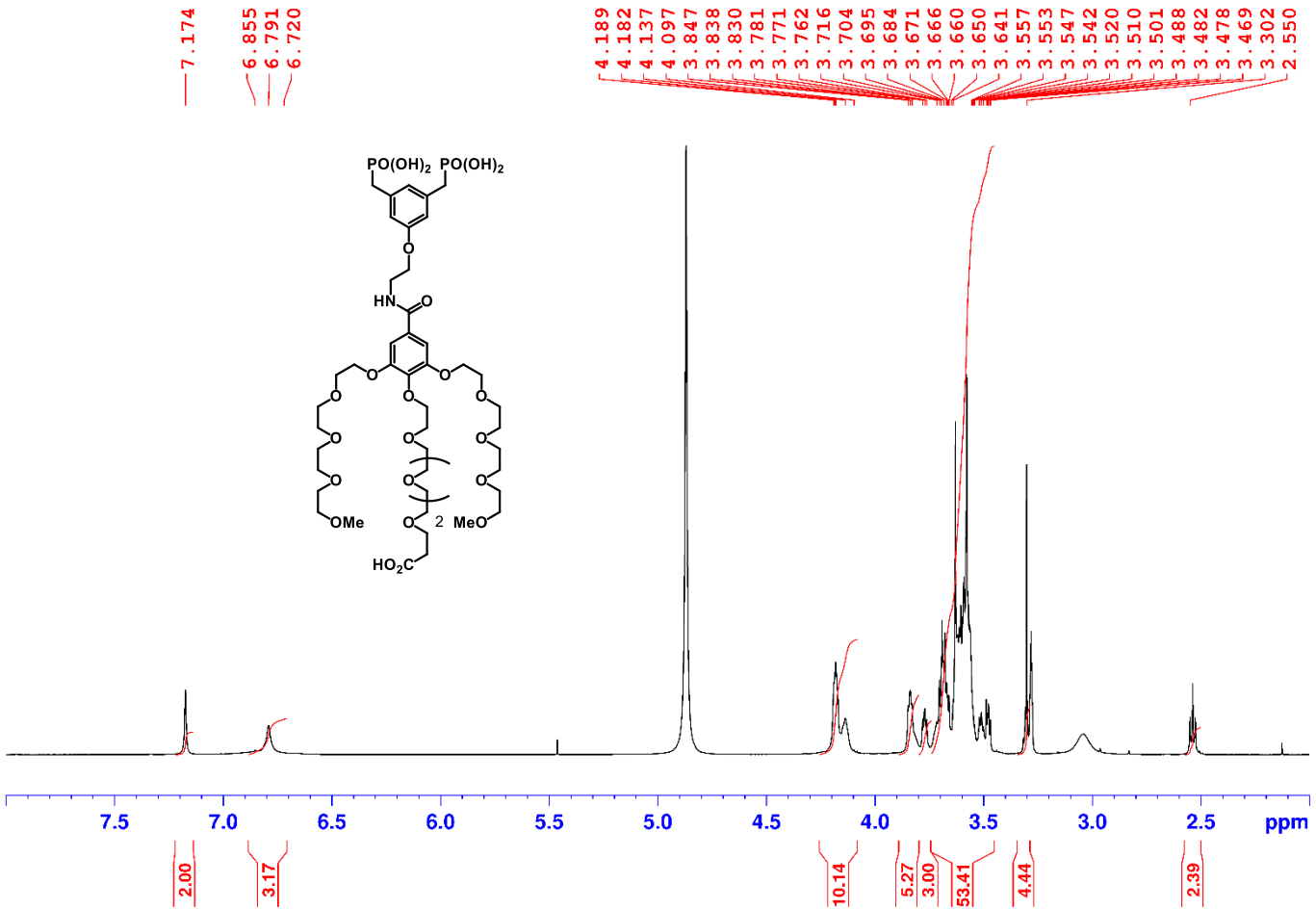
Compound 55 – ^{31}P NMR (202 MHz, $CDCl_3$)



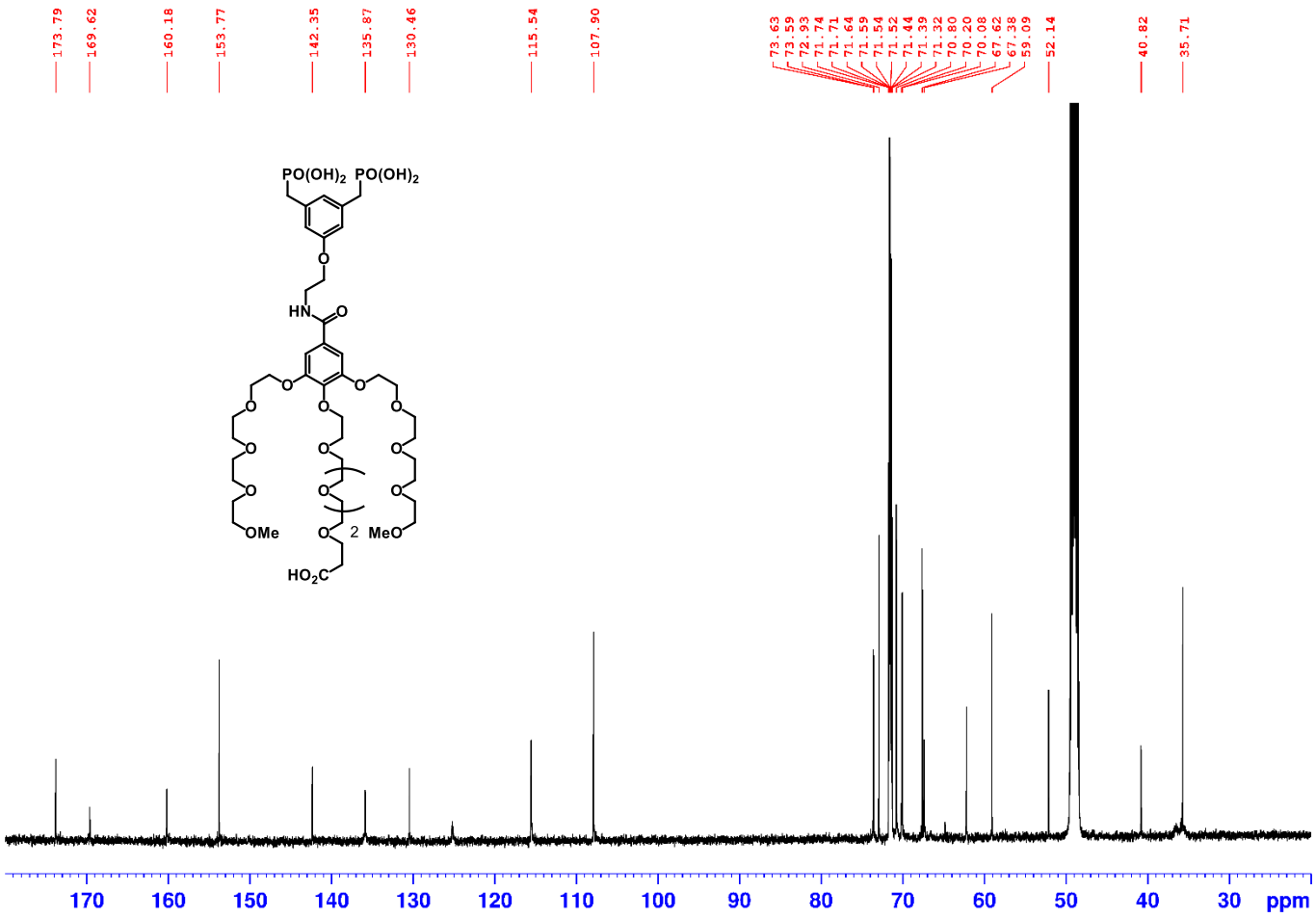
Compound 1 – ^{1}H NMR (300 MHz, CD_3OD-d_4)



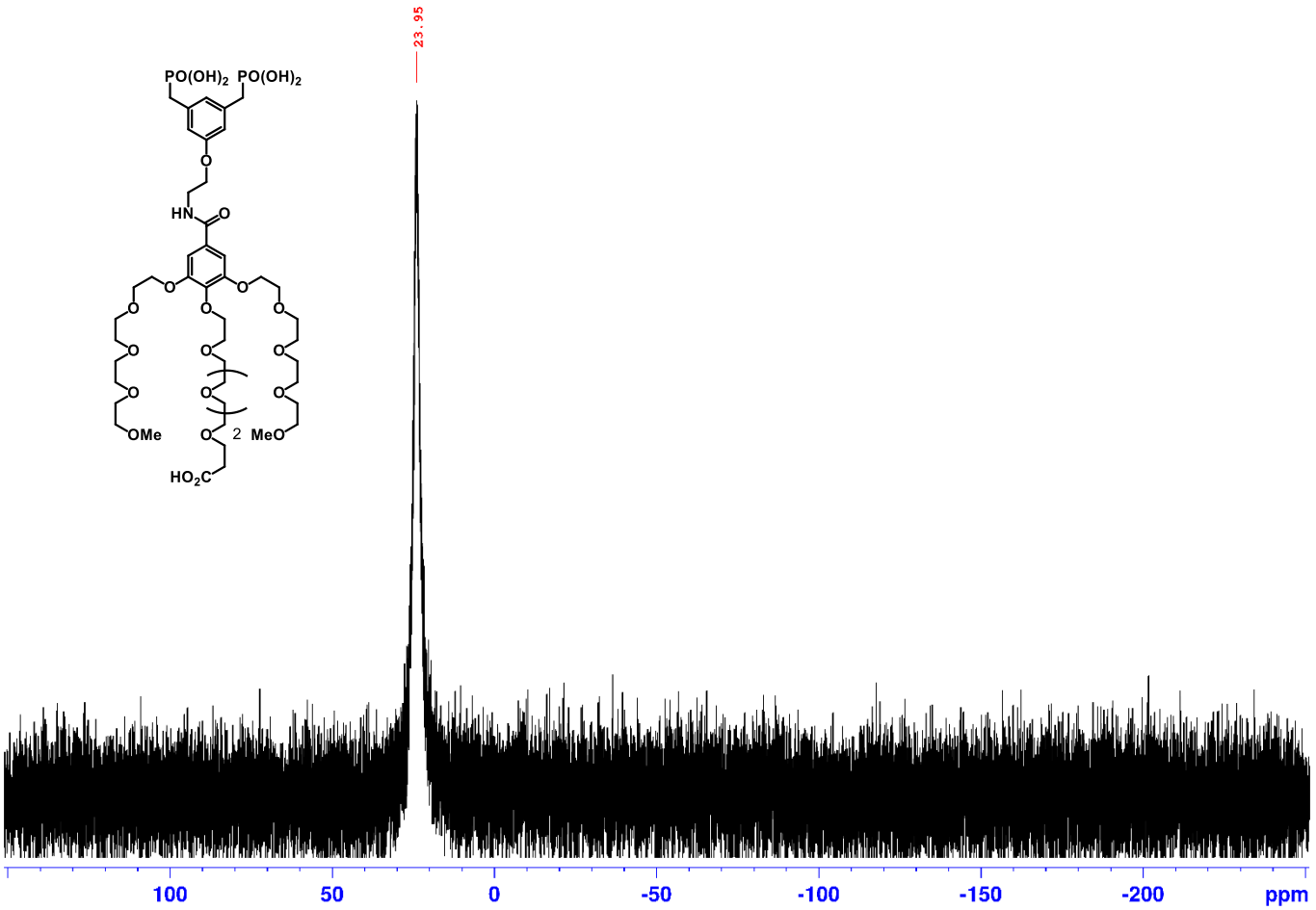
Compound 2 – ^{1}H NMR (500 MHz, CD_3OD-d_4)



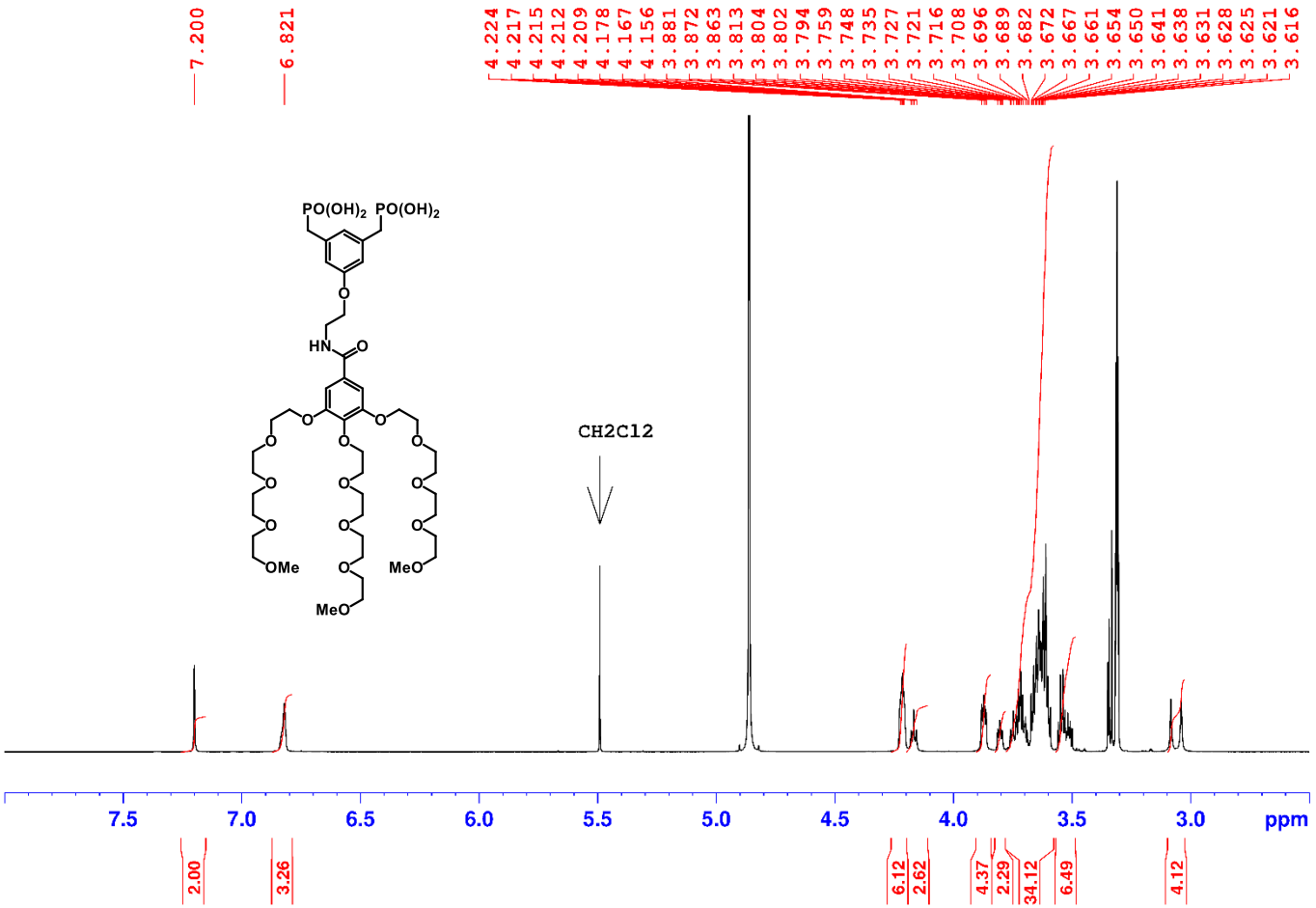
Compound 2 – ^{13}C NMR (125 MHz, CD_3OD-d_4)



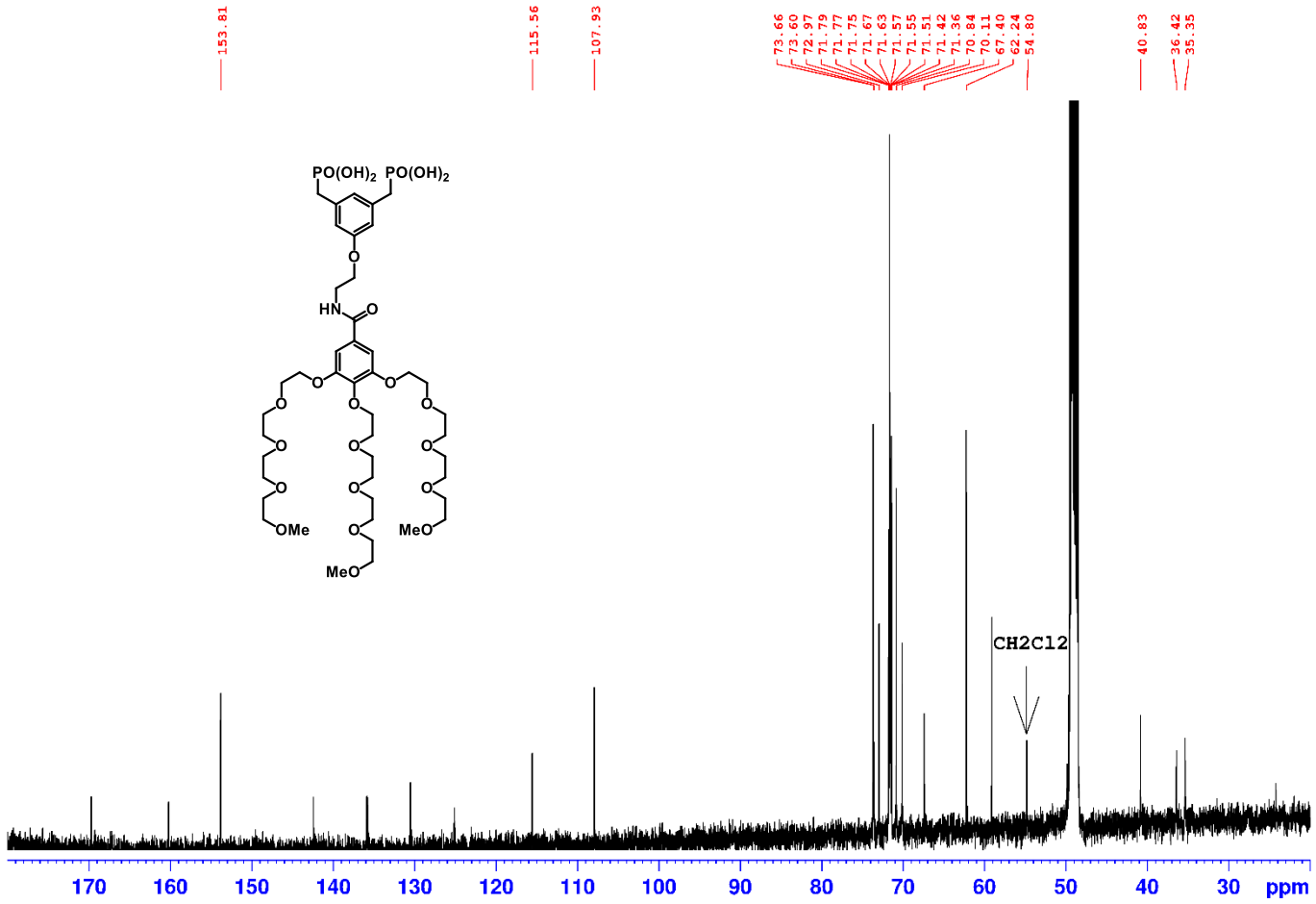
Compound 2 – ^{31}P NMR (202 MHz, CD_3OD-d_4)



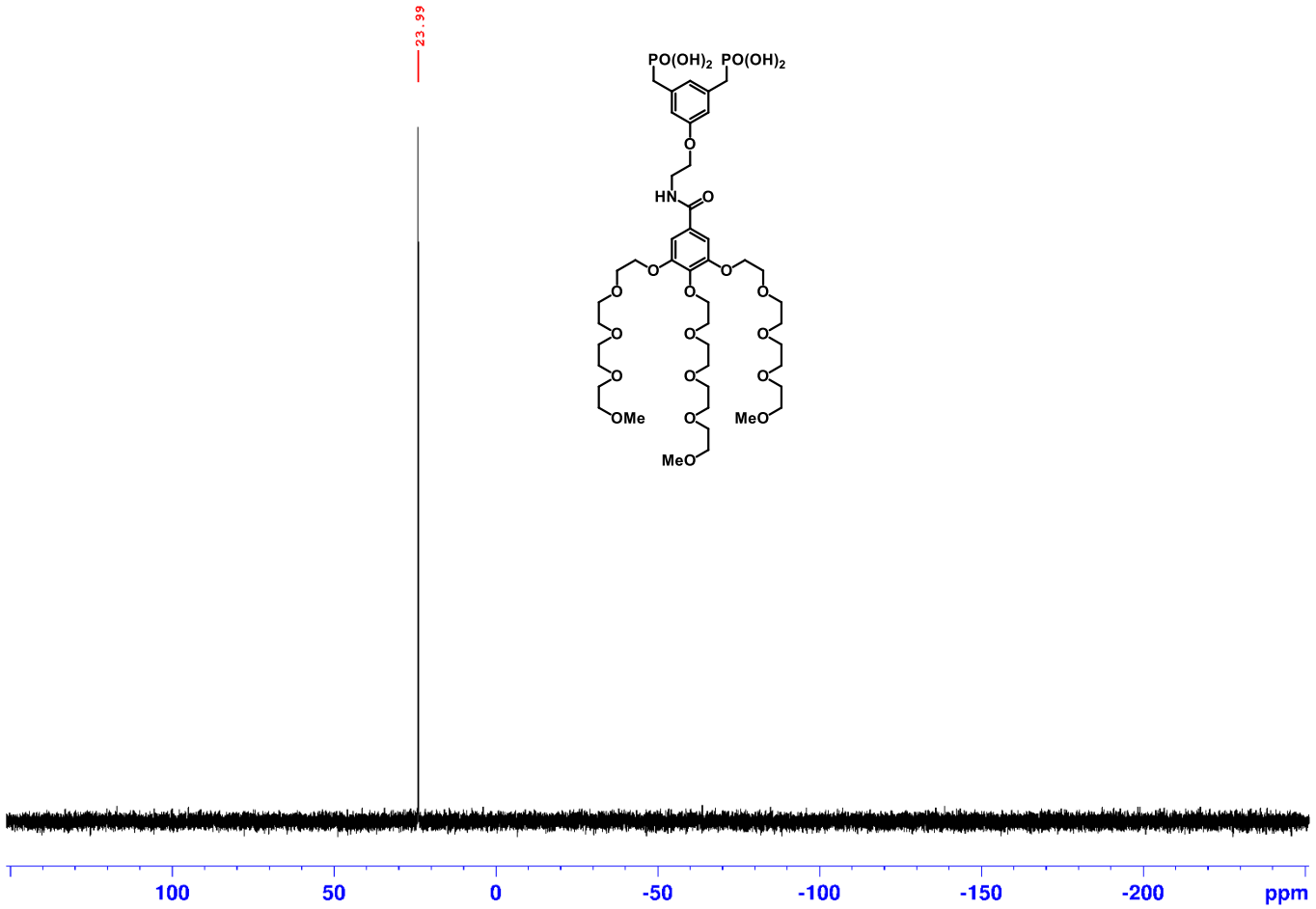
Compound 3 – ^{1}H NMR (500 MHz, CD_3OD-d_4)



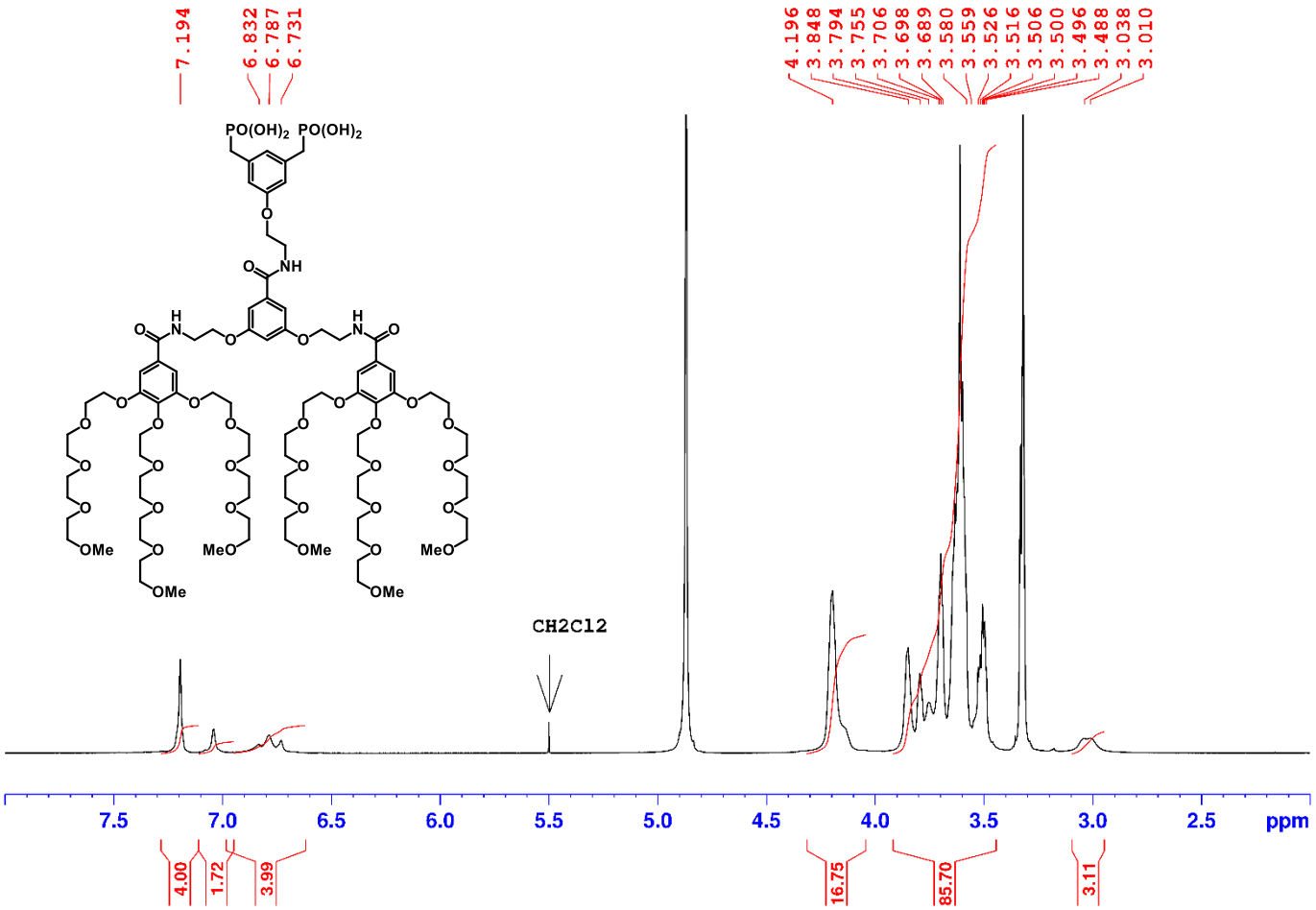
Compound 3 – ^{13}C NMR (125 MHz, CD_3OD-d_4)



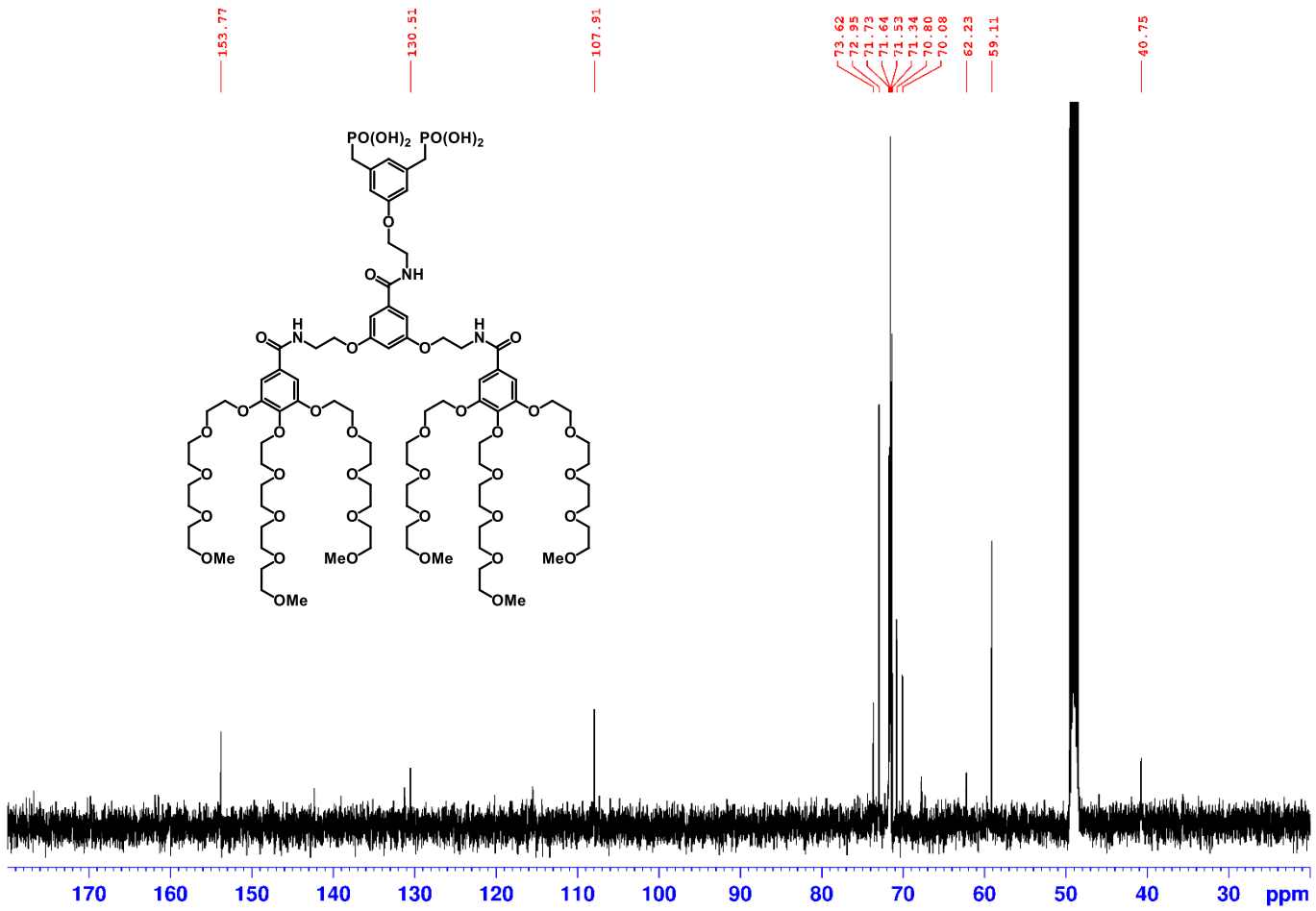
Compound 3 – ^{31}P NMR (202 MHz, CD_3OD-d_4)



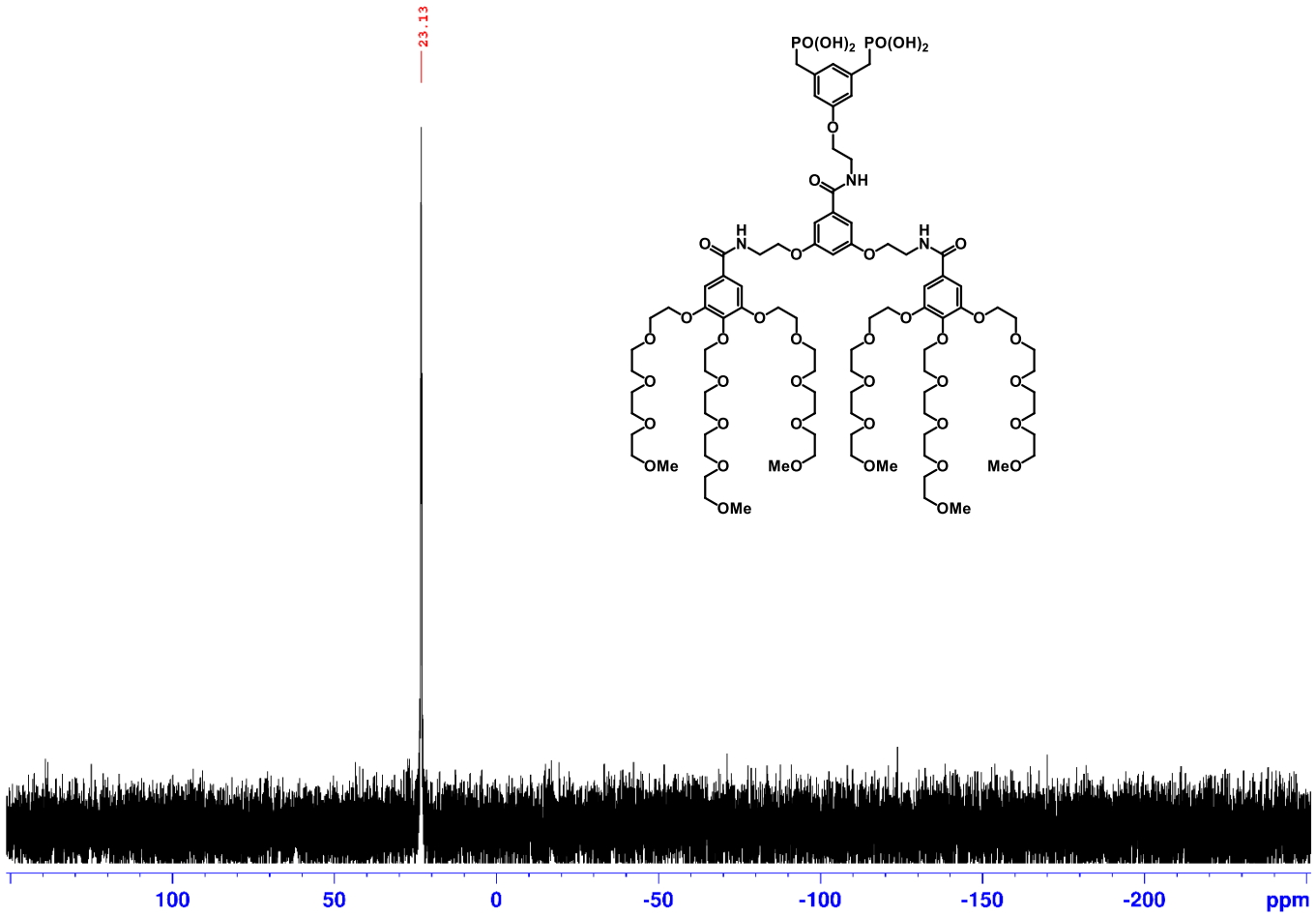
Compound 4 – ^{1}H NMR (500 MHz, CD_3OD-*d_4*)



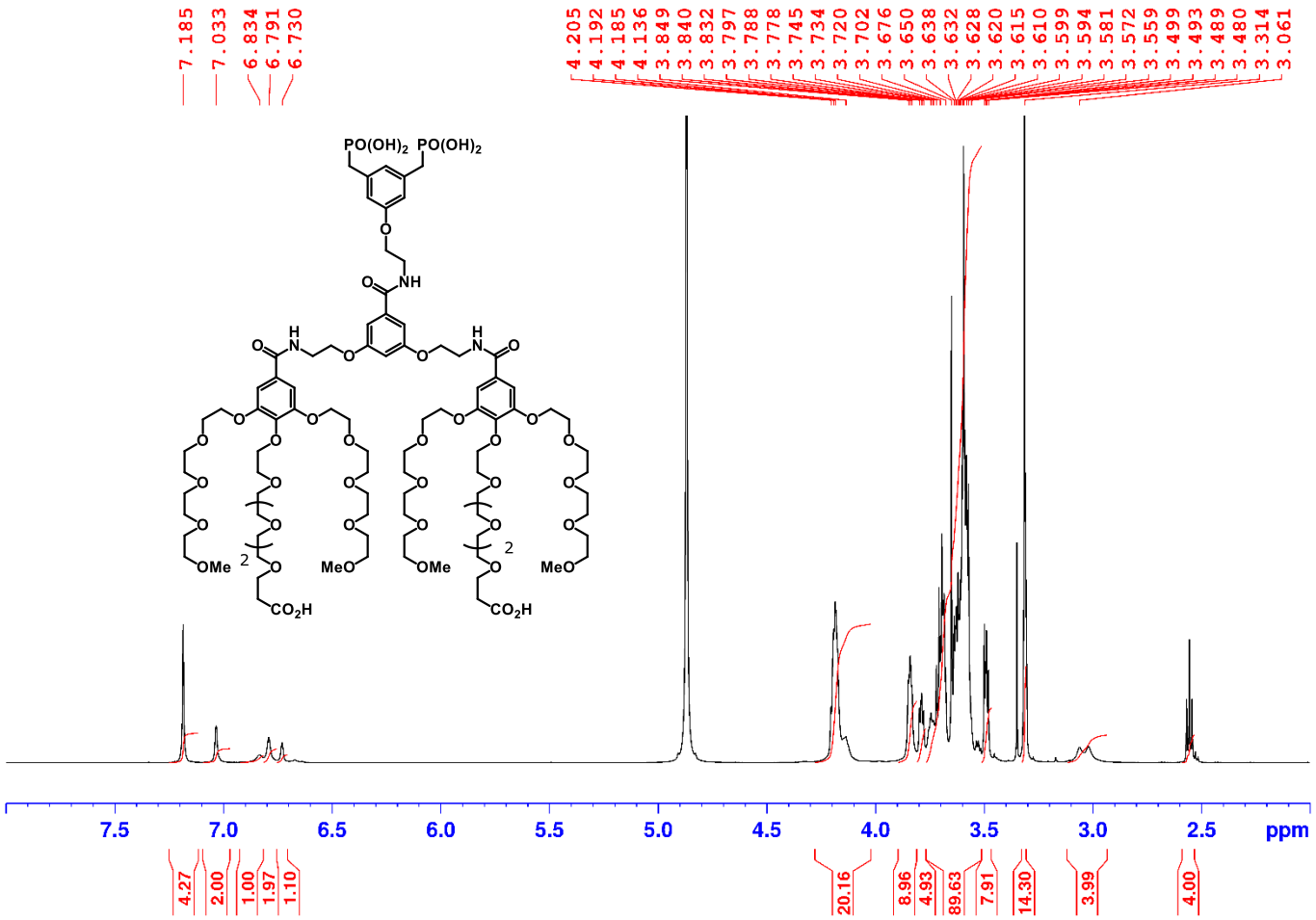
Compound 4 – ^{13}C NMR (125 MHz, CD_3OD-d_4)



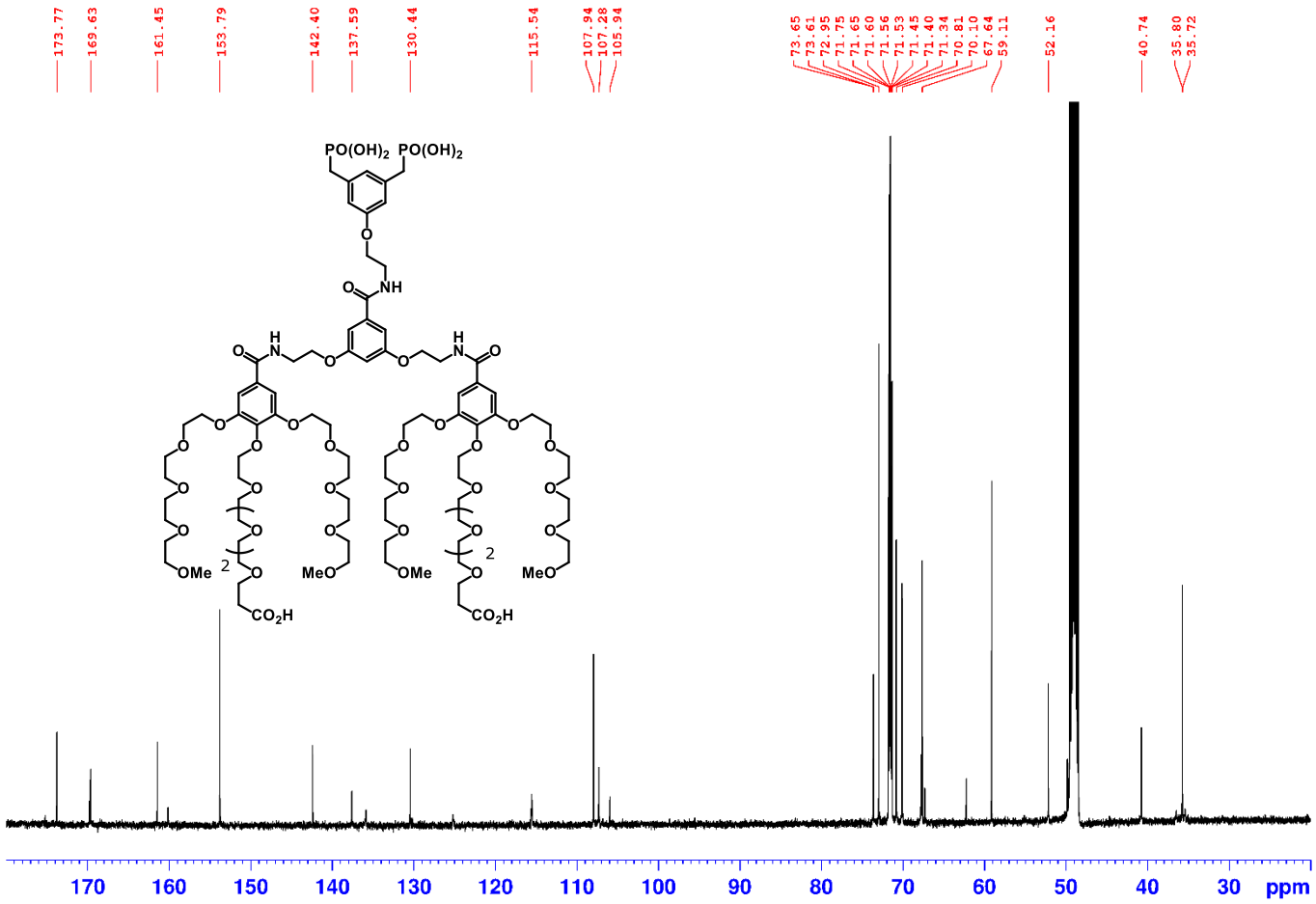
Compound 4 – ^{31}P NMR (202 MHz, CD_3OD-d_4)



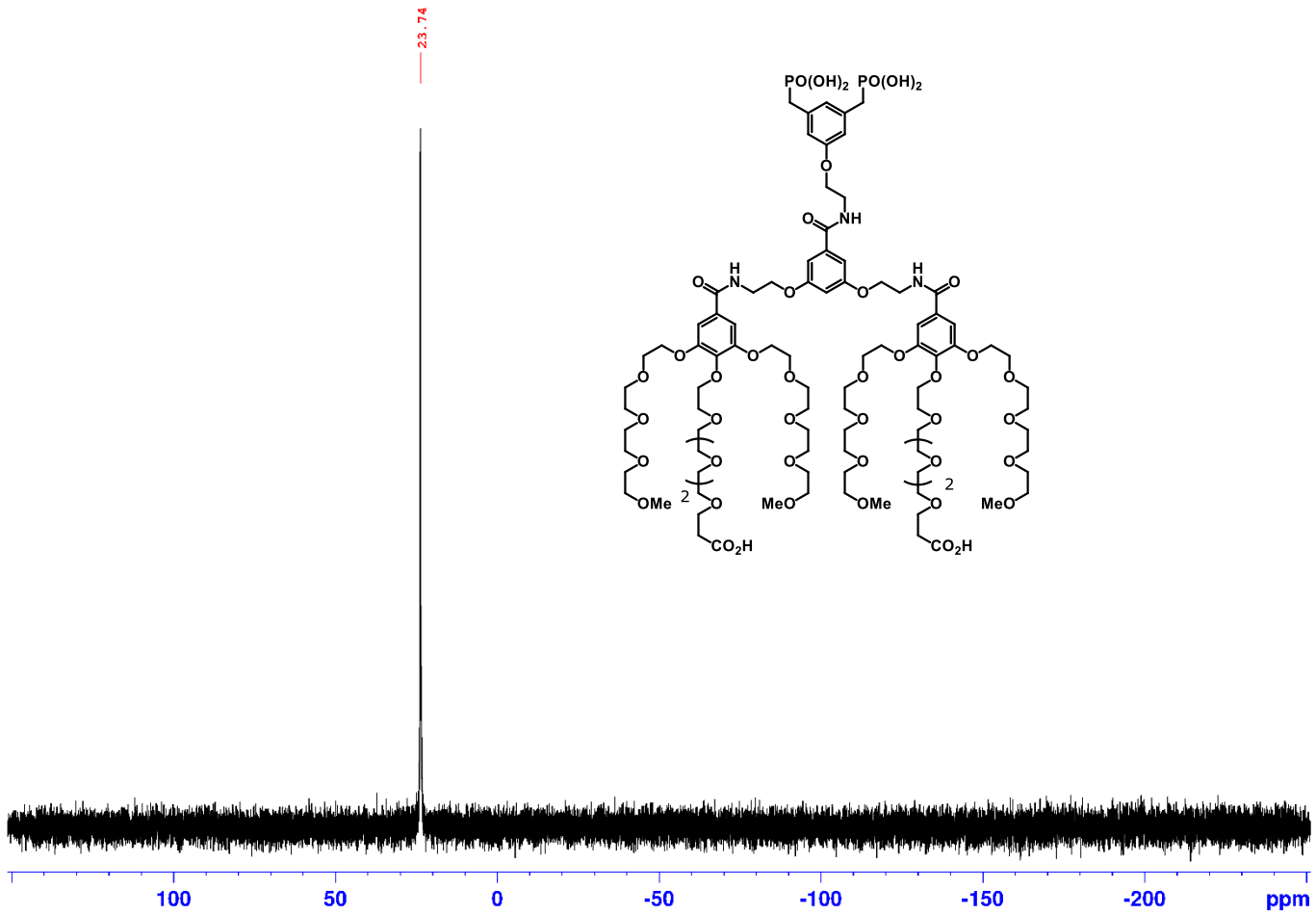
Compound 5 – ^{1}H NMR (500 MHz, CD_3OD-d_4)



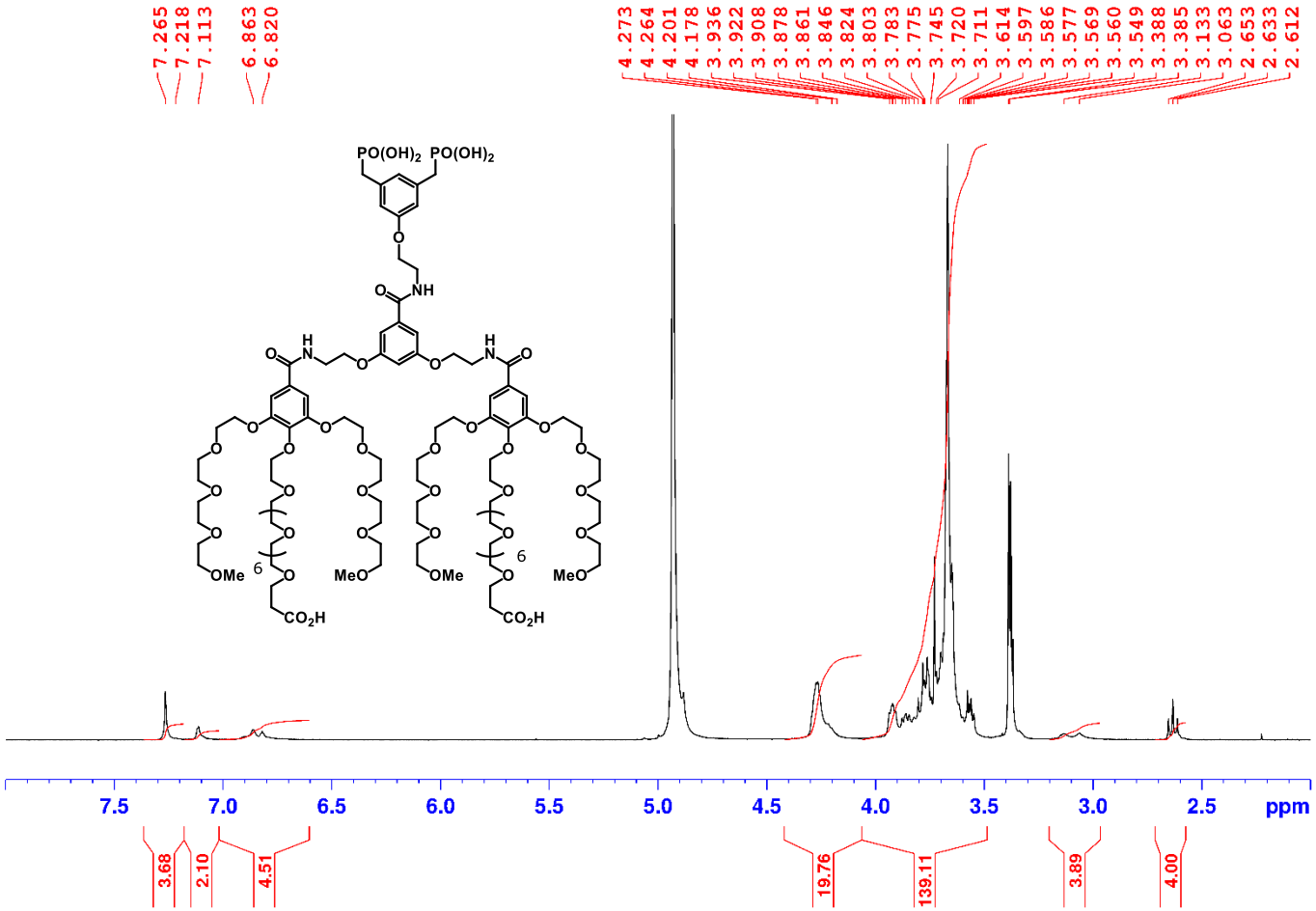
Compound 5 – ^{13}C NMR (125 MHz, CD_3OD-d_4)



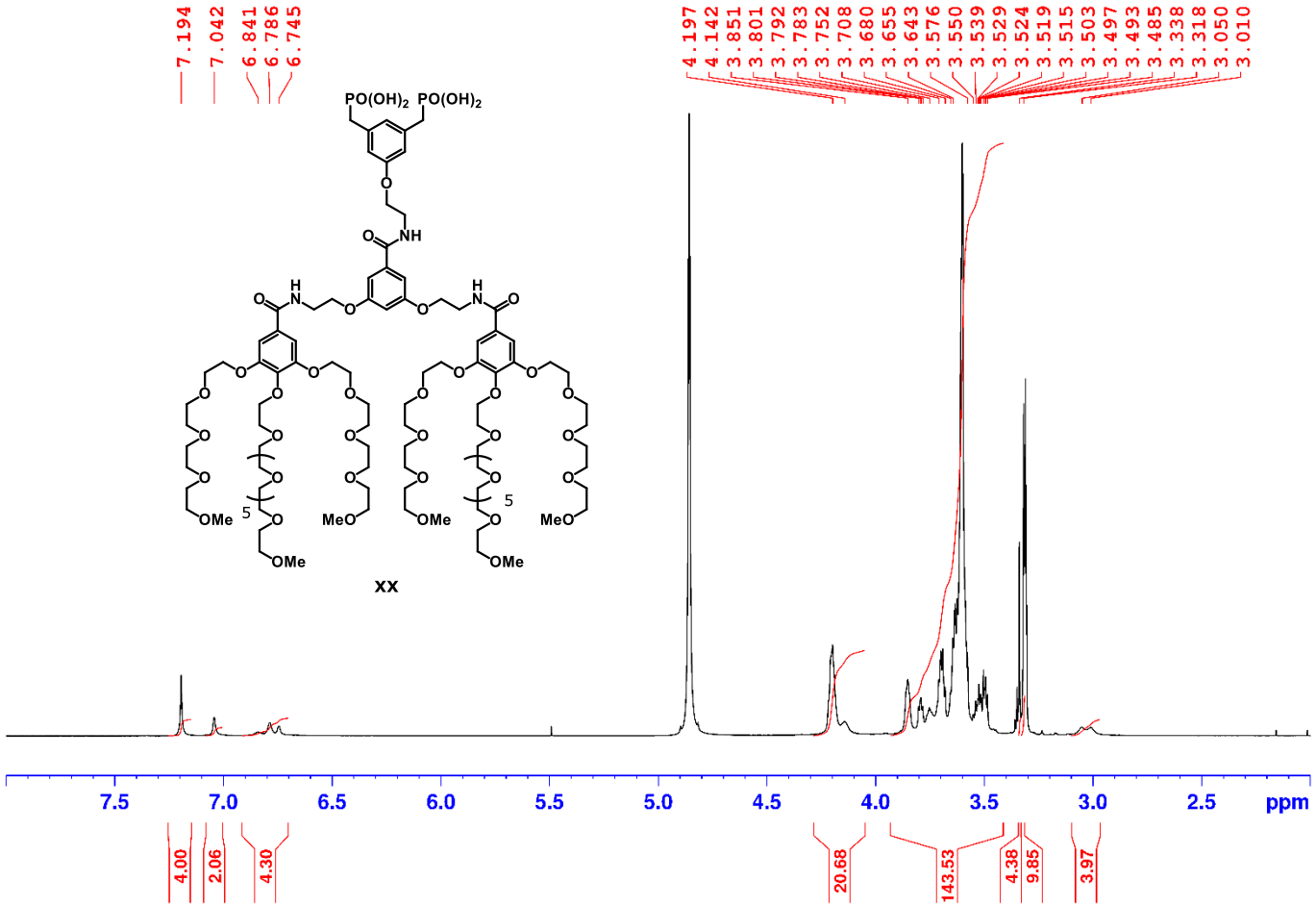
Compound 5 – ^{31}P NMR (202 MHz, CD_3OD-d_4)



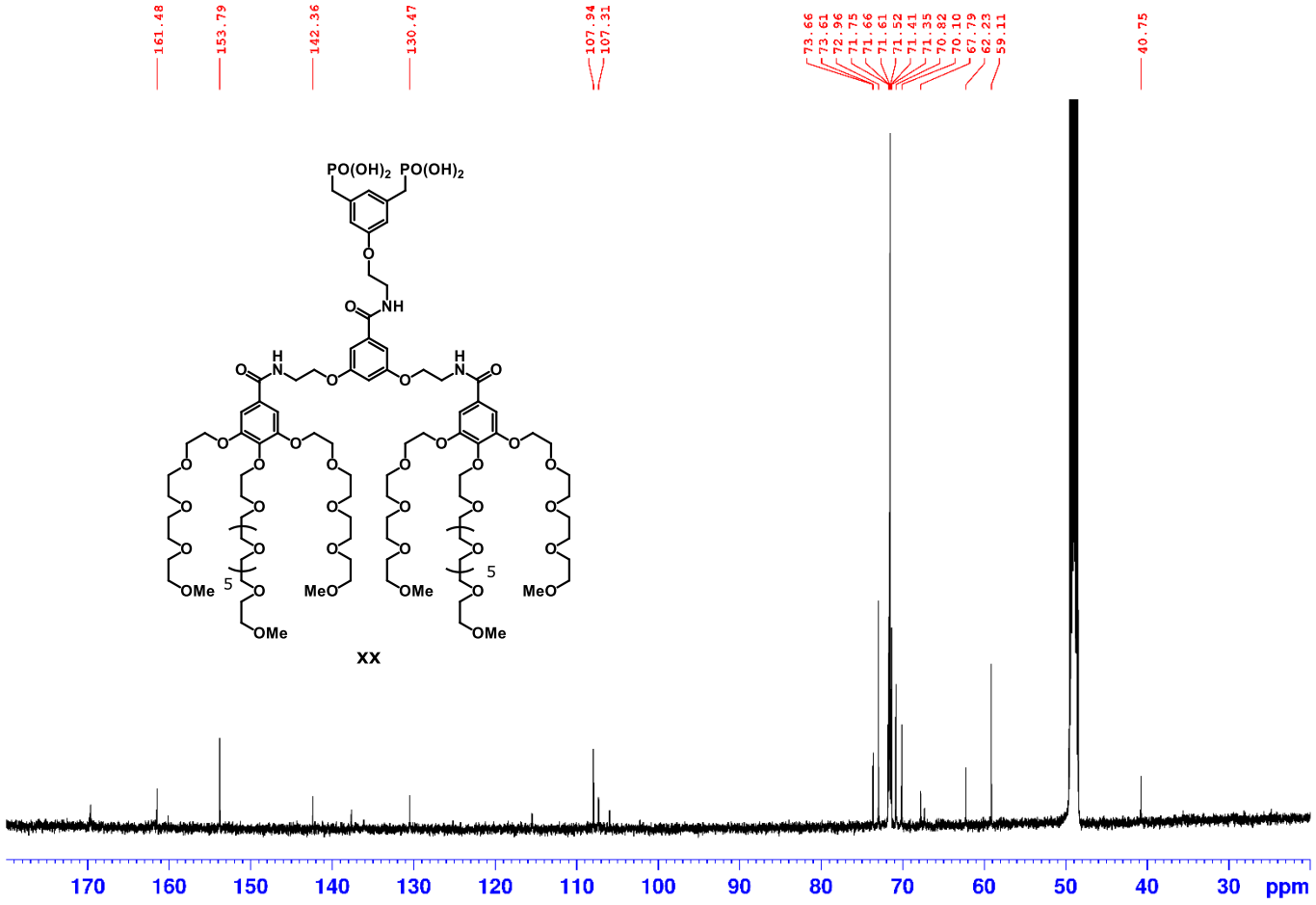
Compound 6 – ^{1}H NMR (300 MHz, CD_3OD-d_4)



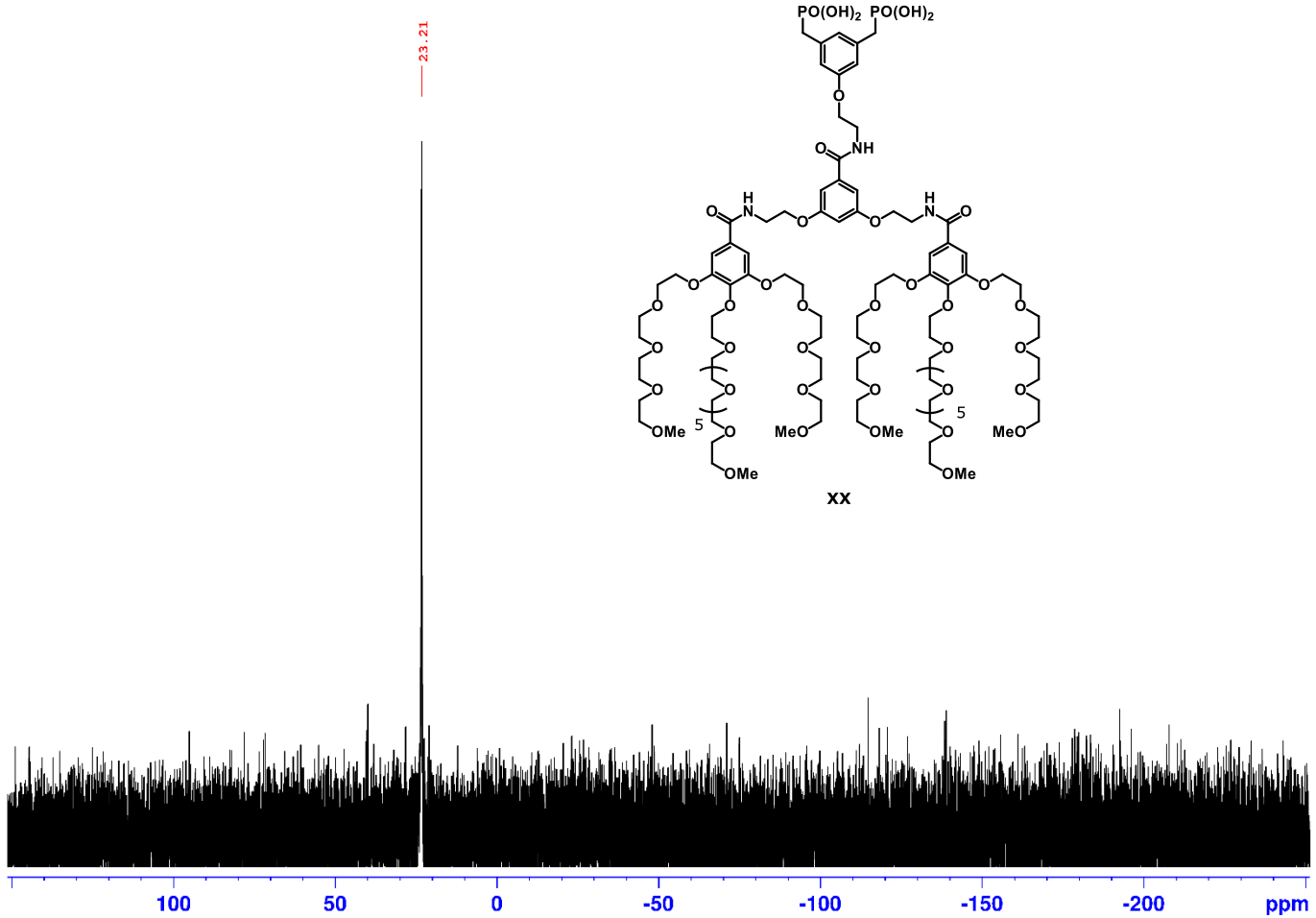
Compound 7 – ^{1}H NMR (500 MHz, CD_3OD-d_4)



Compound 7 – ^{13}C NMR (125 MHz, CD_3OD-d_4)

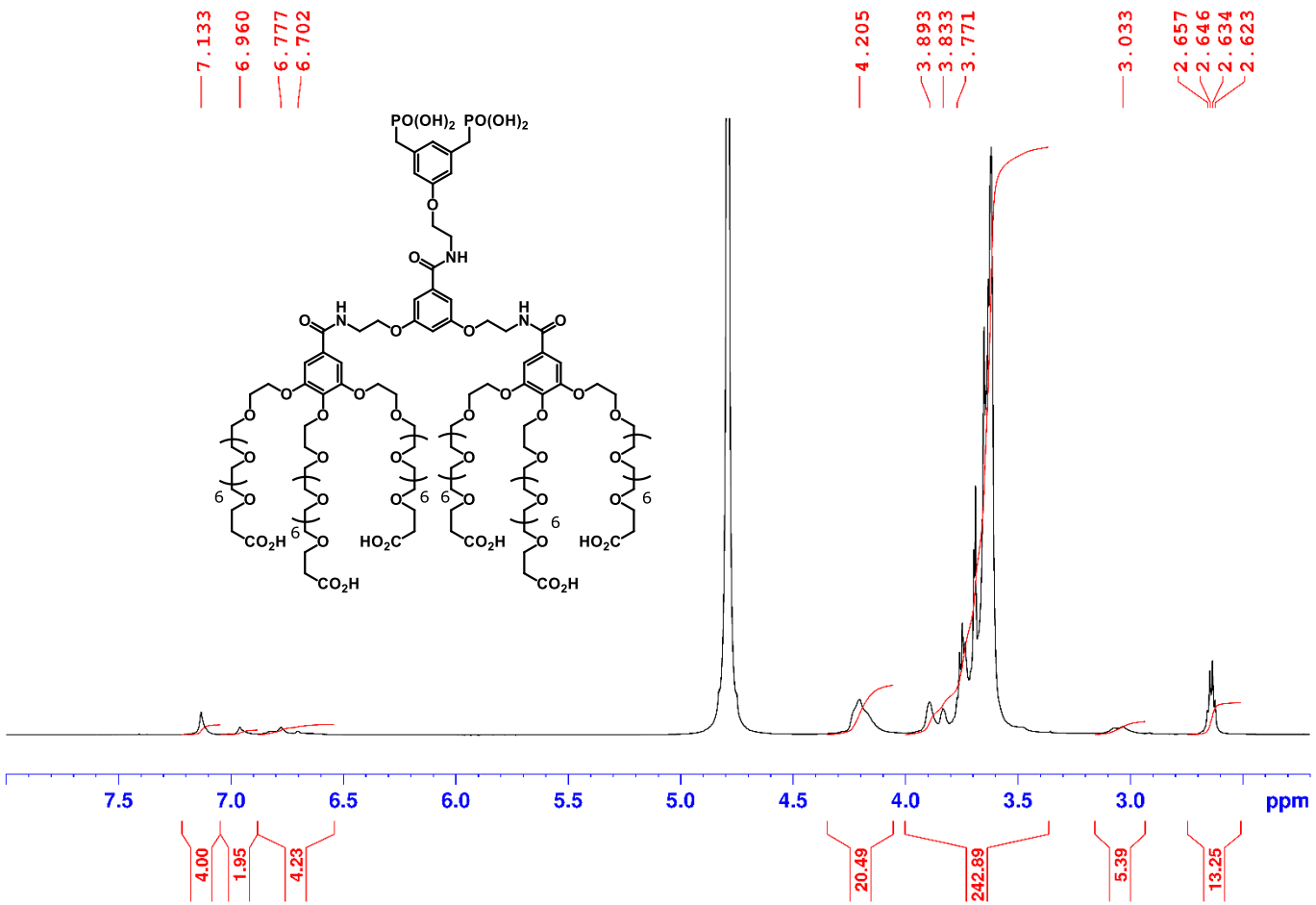


Compound 7 – ^{31}P NMR (202 MHz, CD_3OD-d_4)

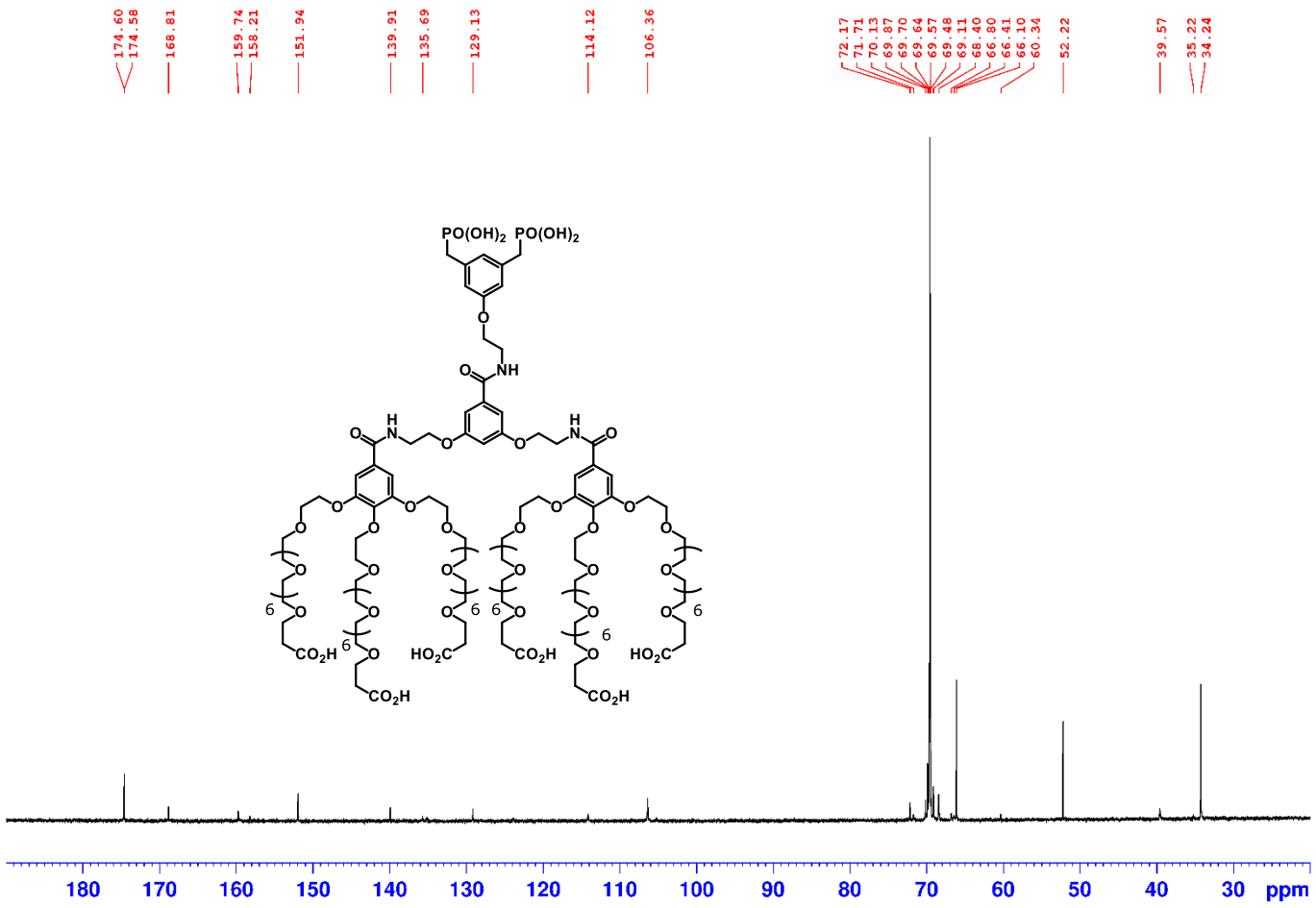


xx

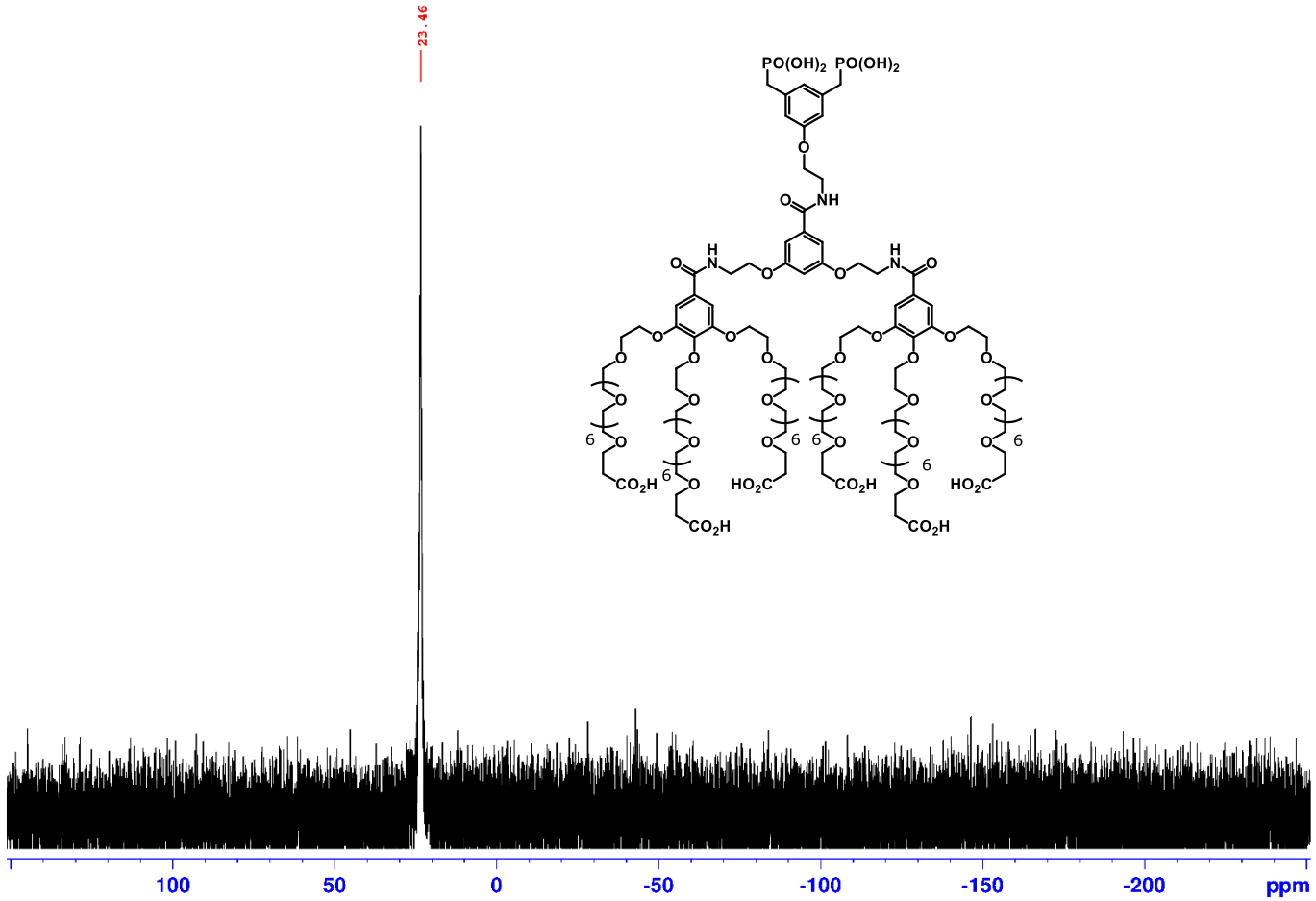
Compound 8 – ^{1}H NMR (500 MHz, D_2O)



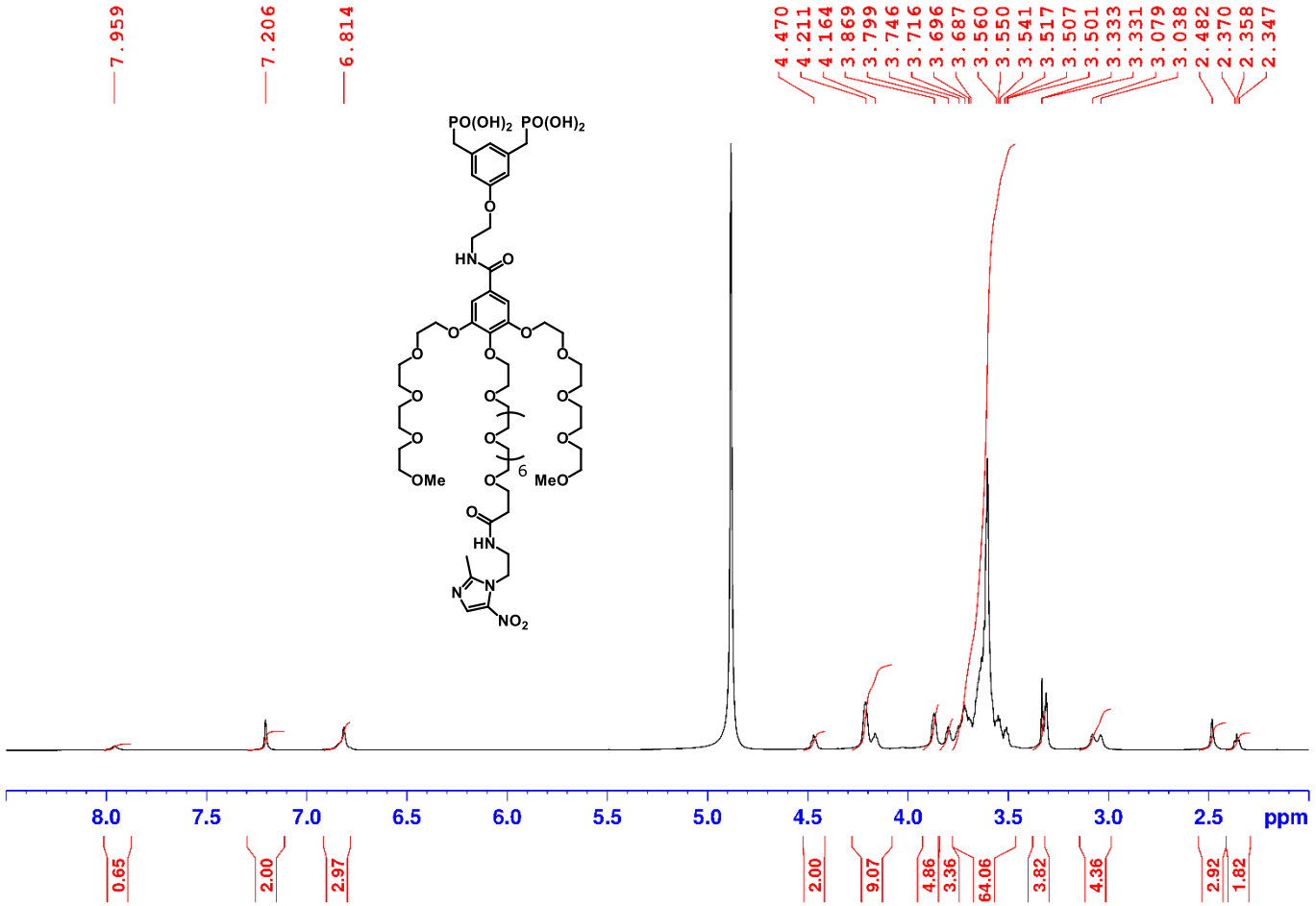
Compound 8 – ^{13}C NMR (125 MHz, D_2O)



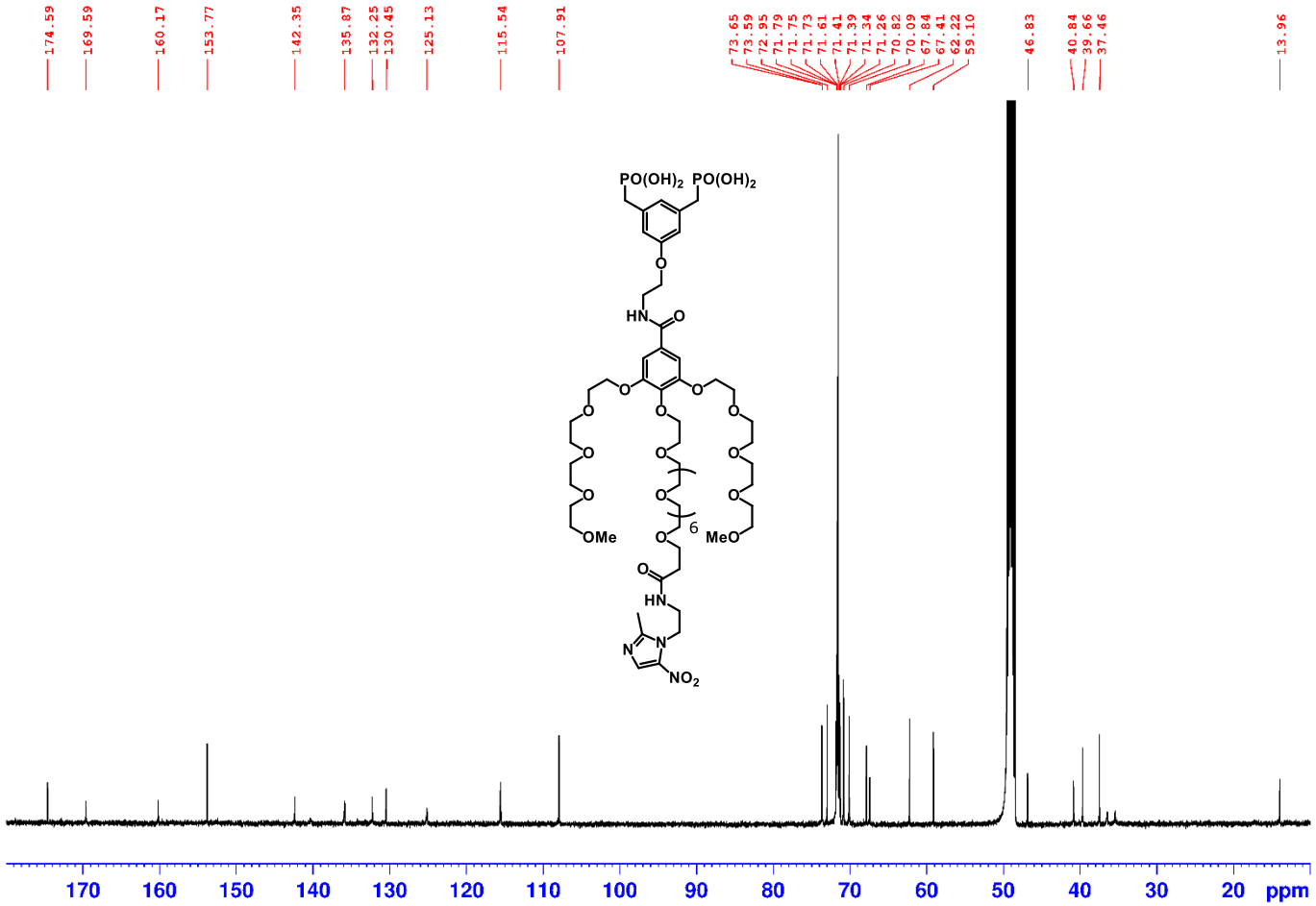
Compound 8 – ^{31}P NMR (202 MHz, D_2O)



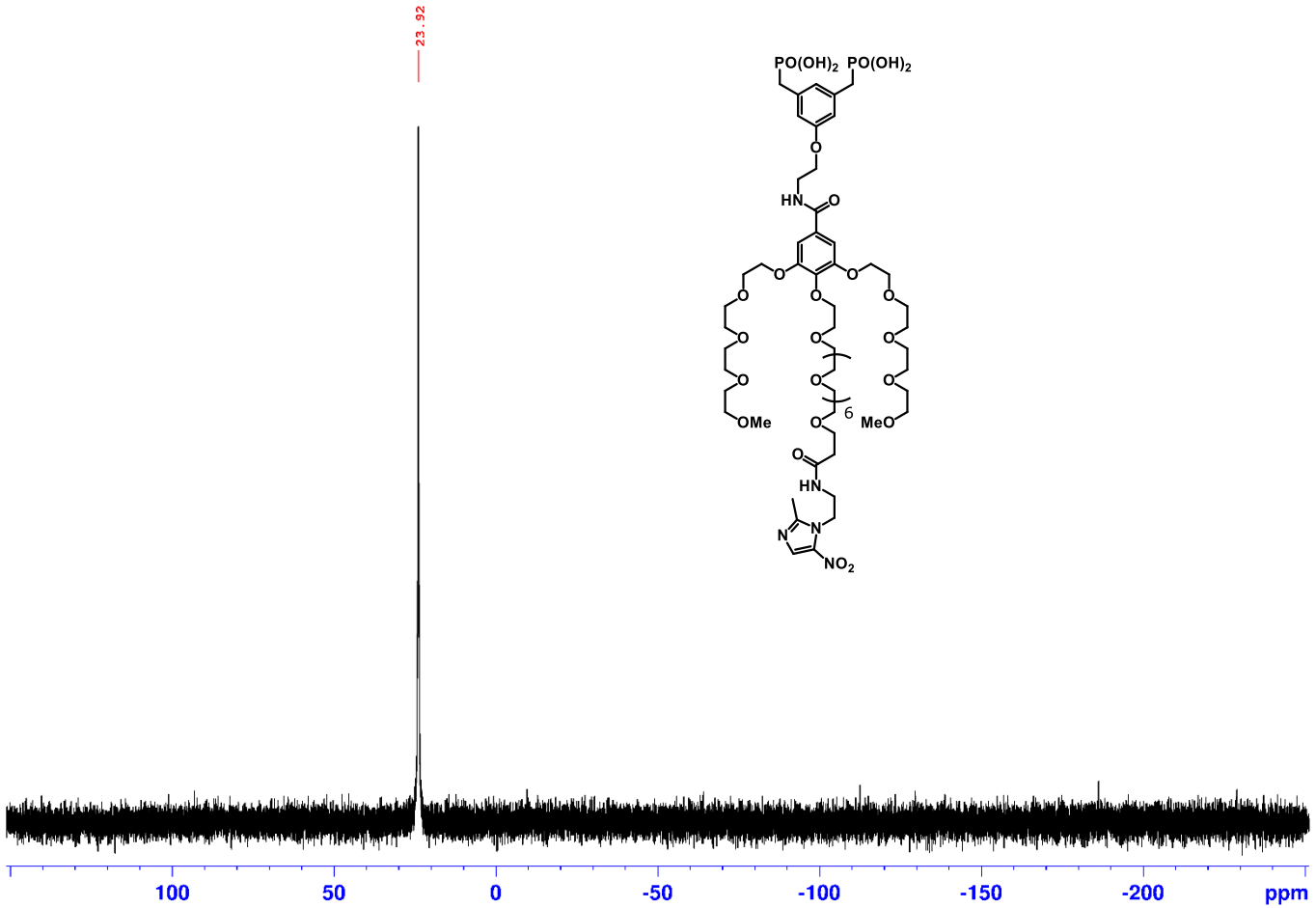
Compound 9 – ^{1}H NMR (500 MHz, CD_3OD-d_4)



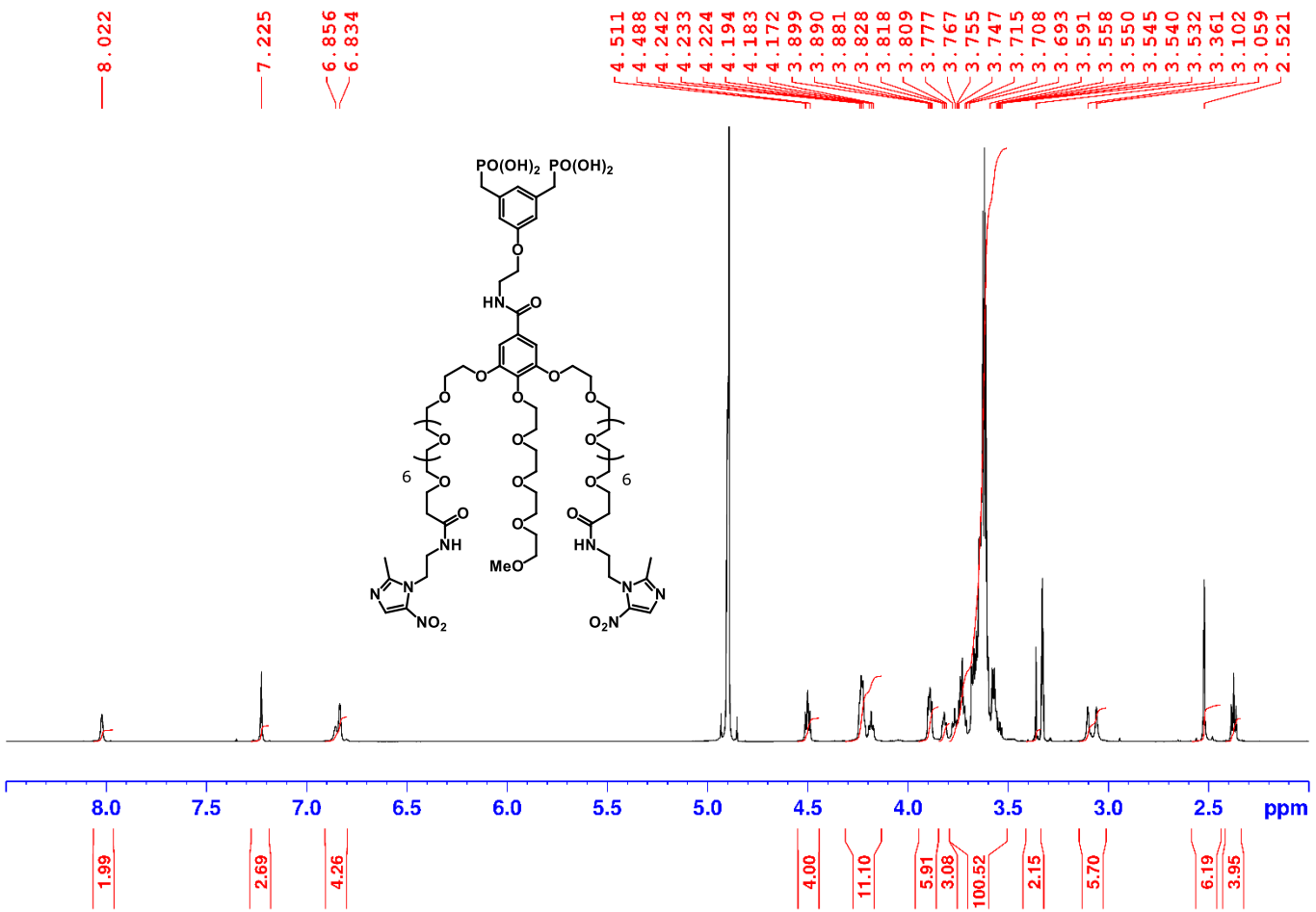
Compound 9 – ^{13}C NMR (125 MHz, CD_3OD-d_4)



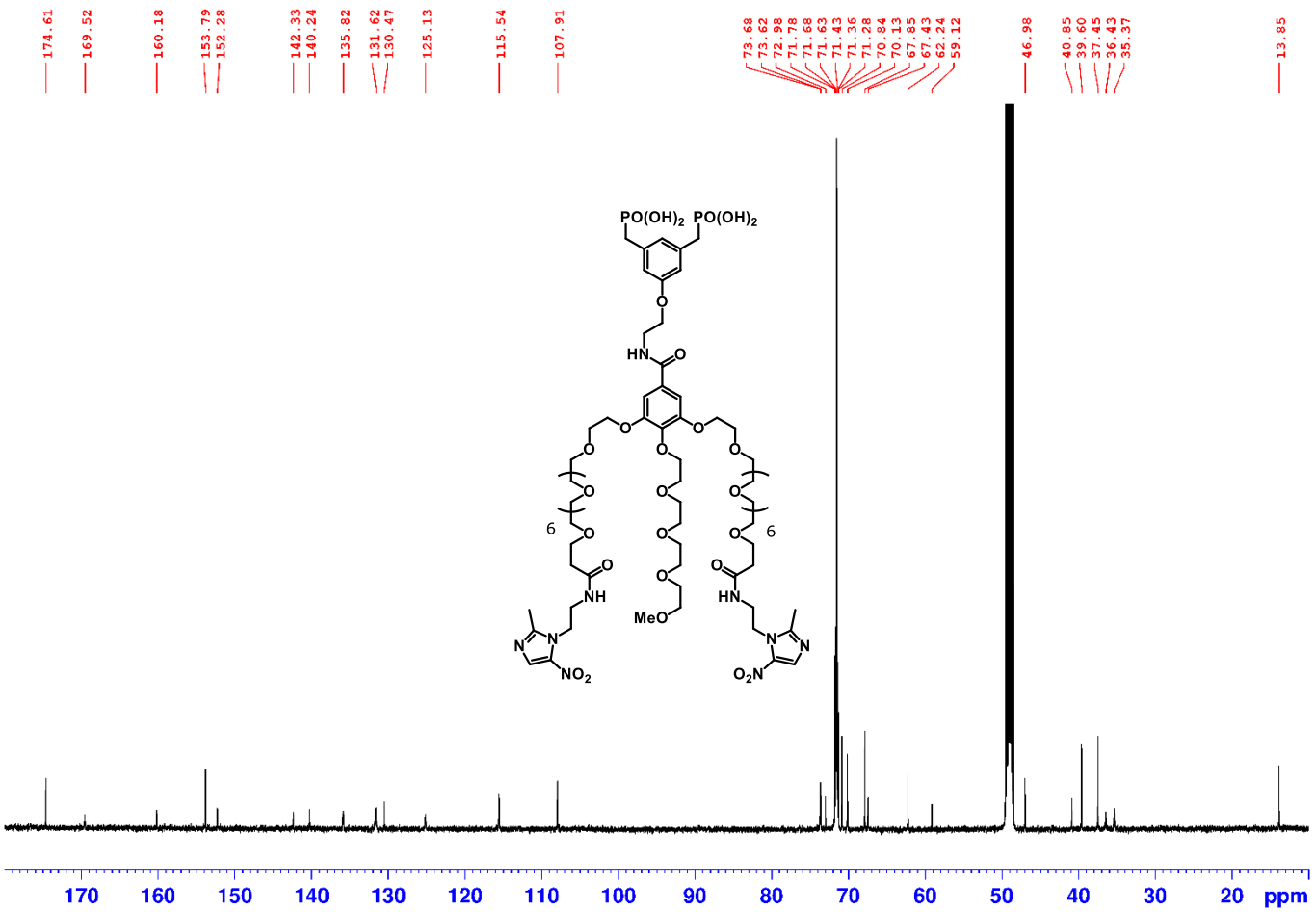
Compound 9 – ^{31}P NMR (202 MHz, CD_3OD-d_4)



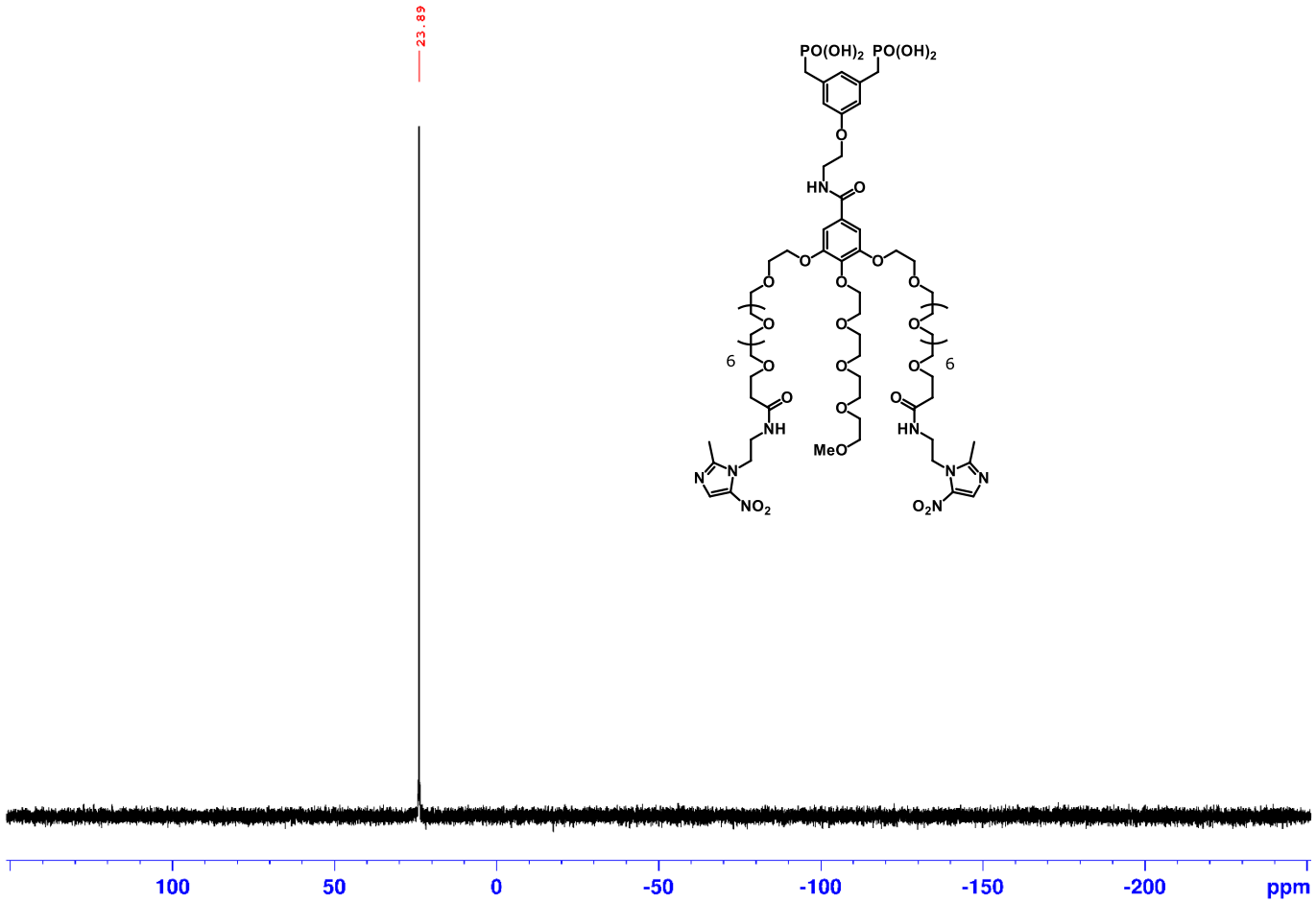
Compound 10 – ^{1}H NMR (500 MHz, CD_3OD-d_4)



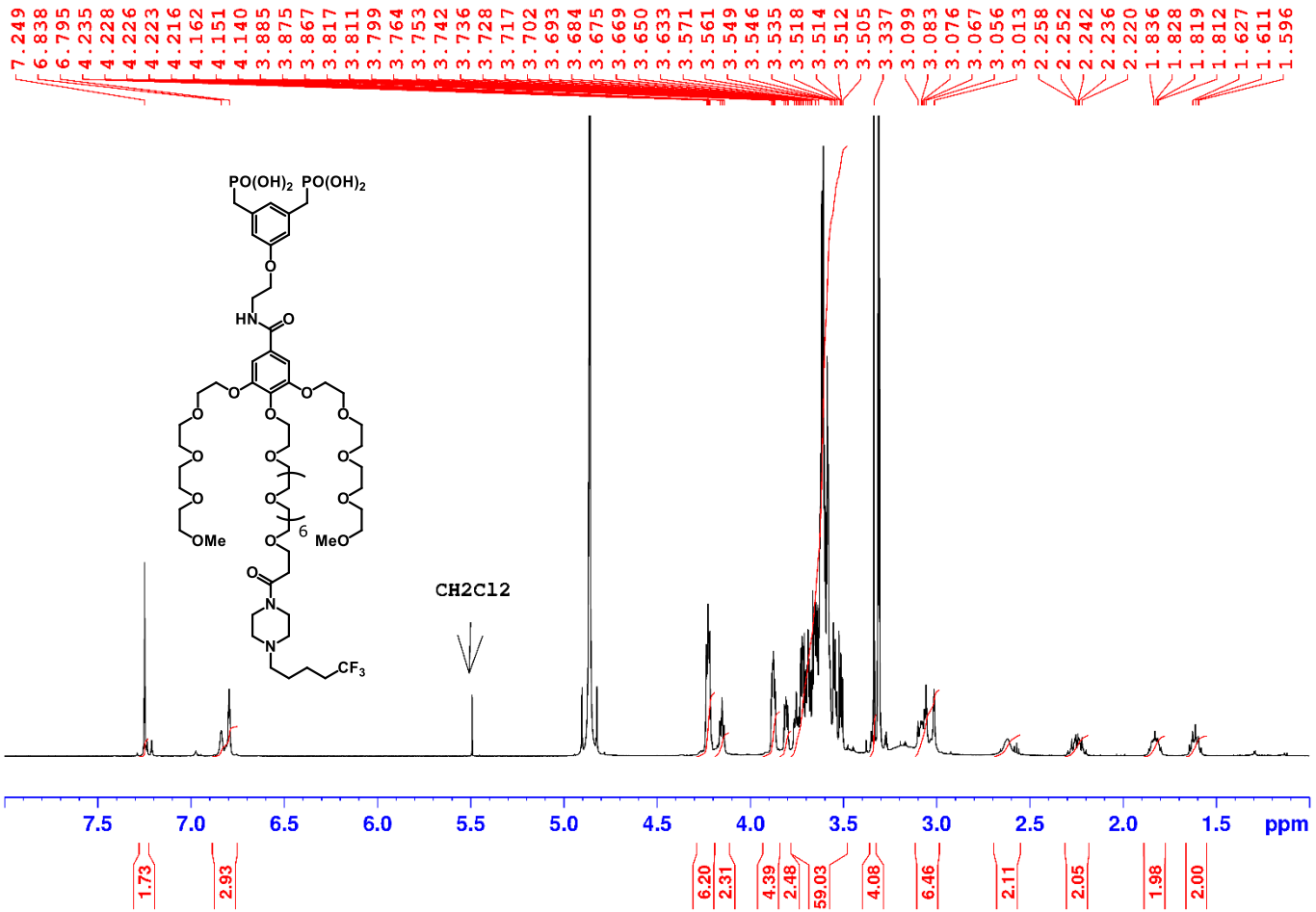
Compound 10 – ^{13}C NMR (125 MHz, CD_3OD-d_4)



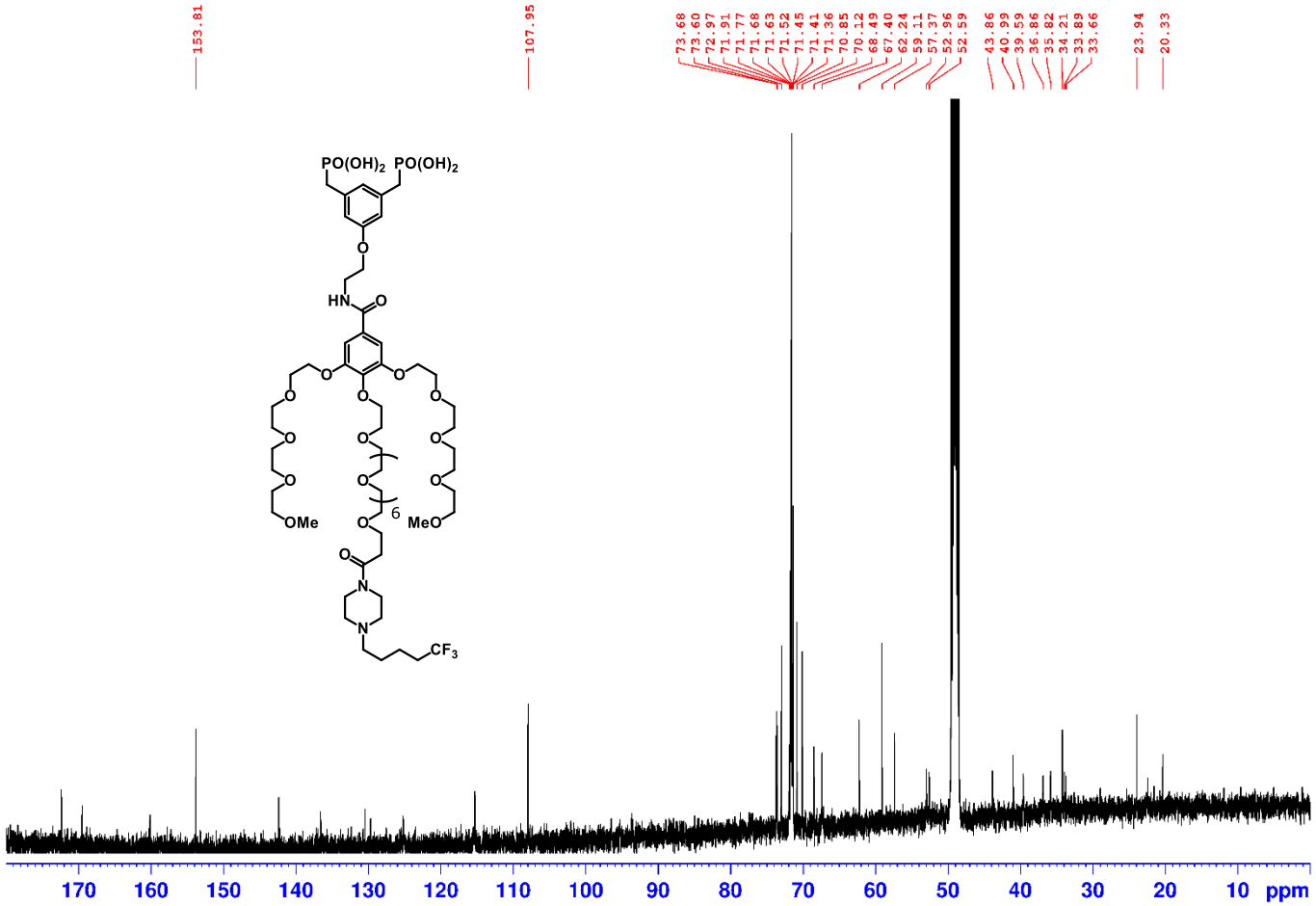
Compound 10 – ^{31}P NMR (202 MHz, CD_3OD-d_4)



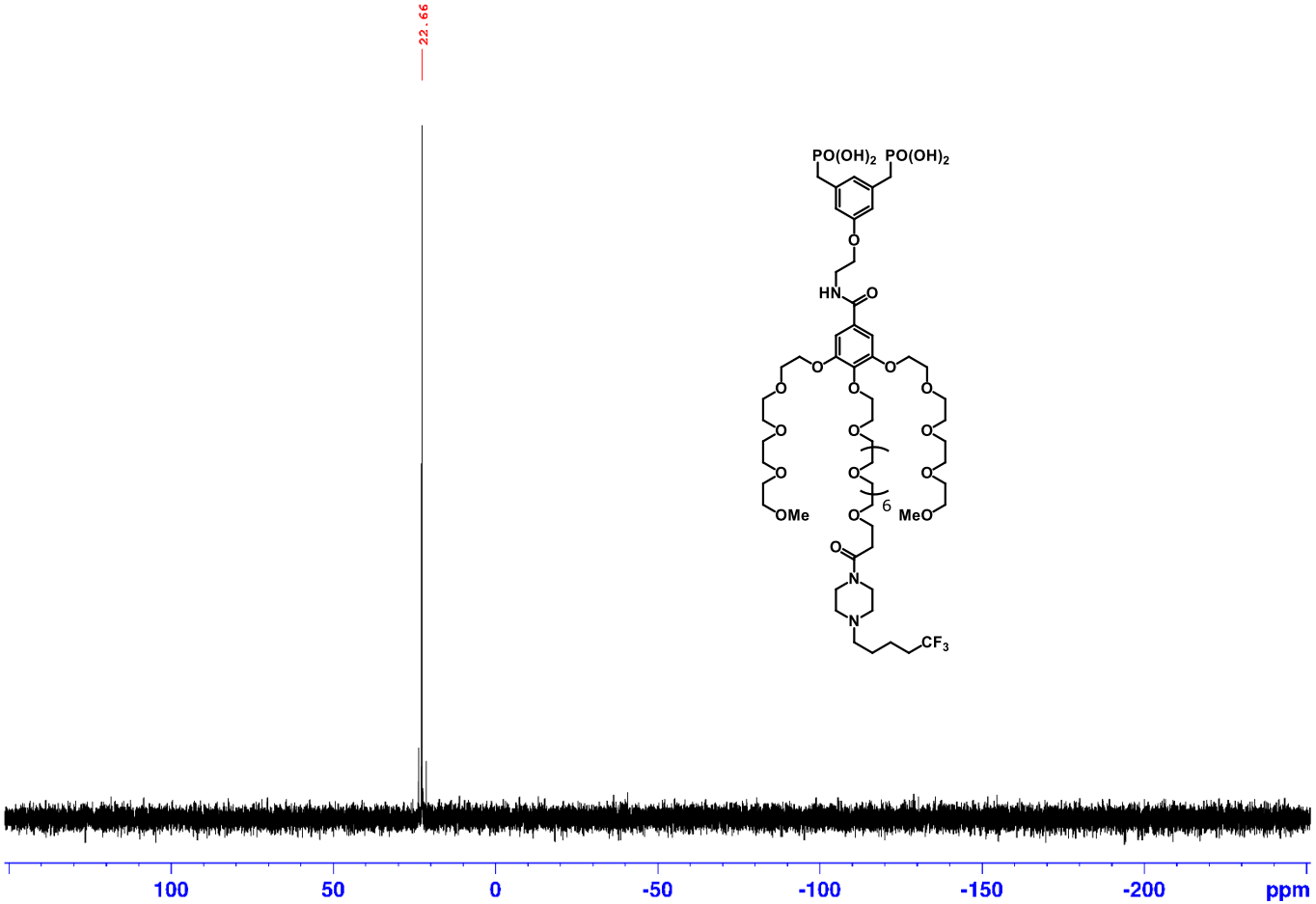
Compound 11 – ^{1}H NMR (500 MHz, CD_3OD-d_4)



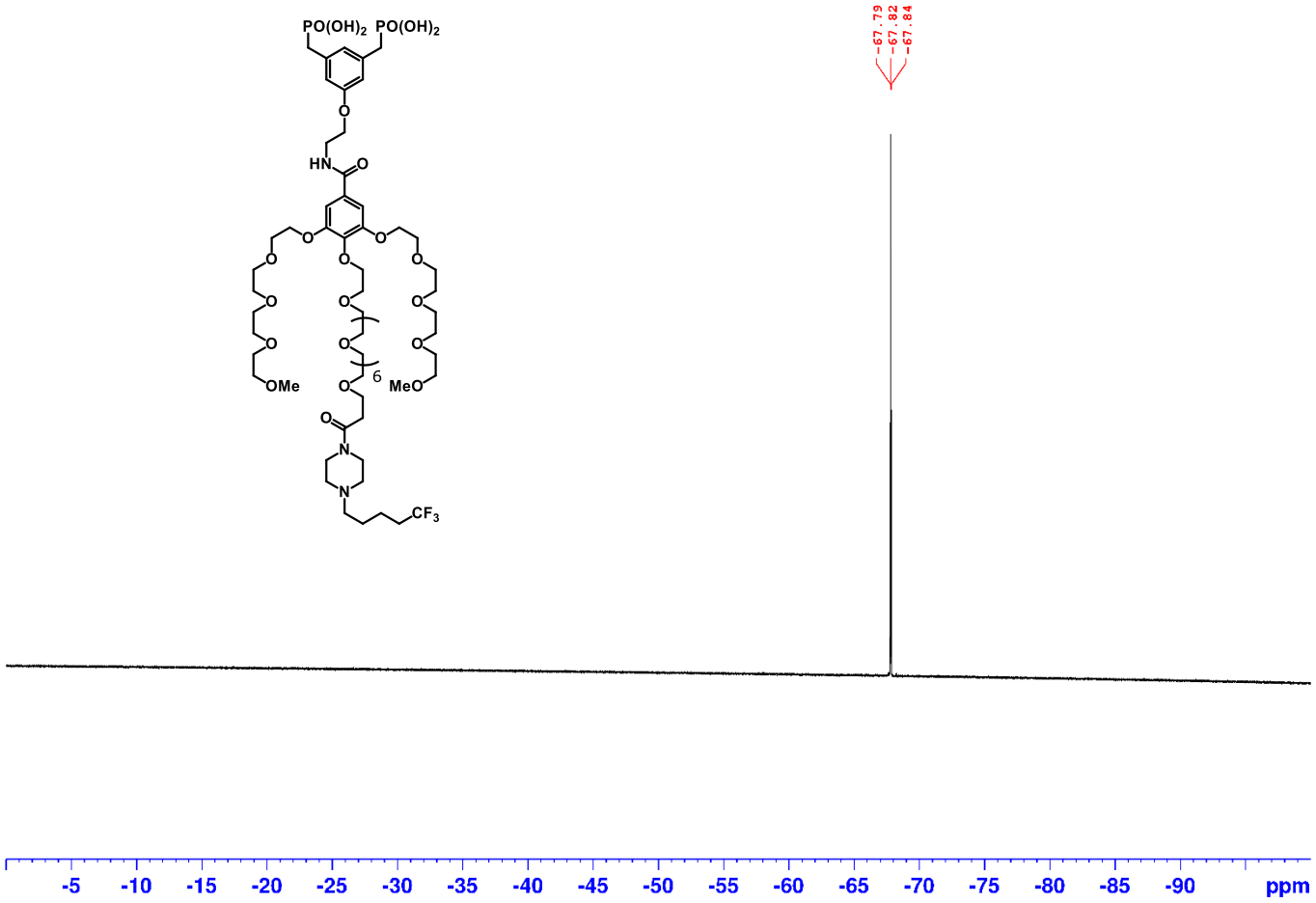
Compound 11 – ^{13}C NMR (125 MHz, CD_3OD-d_4)



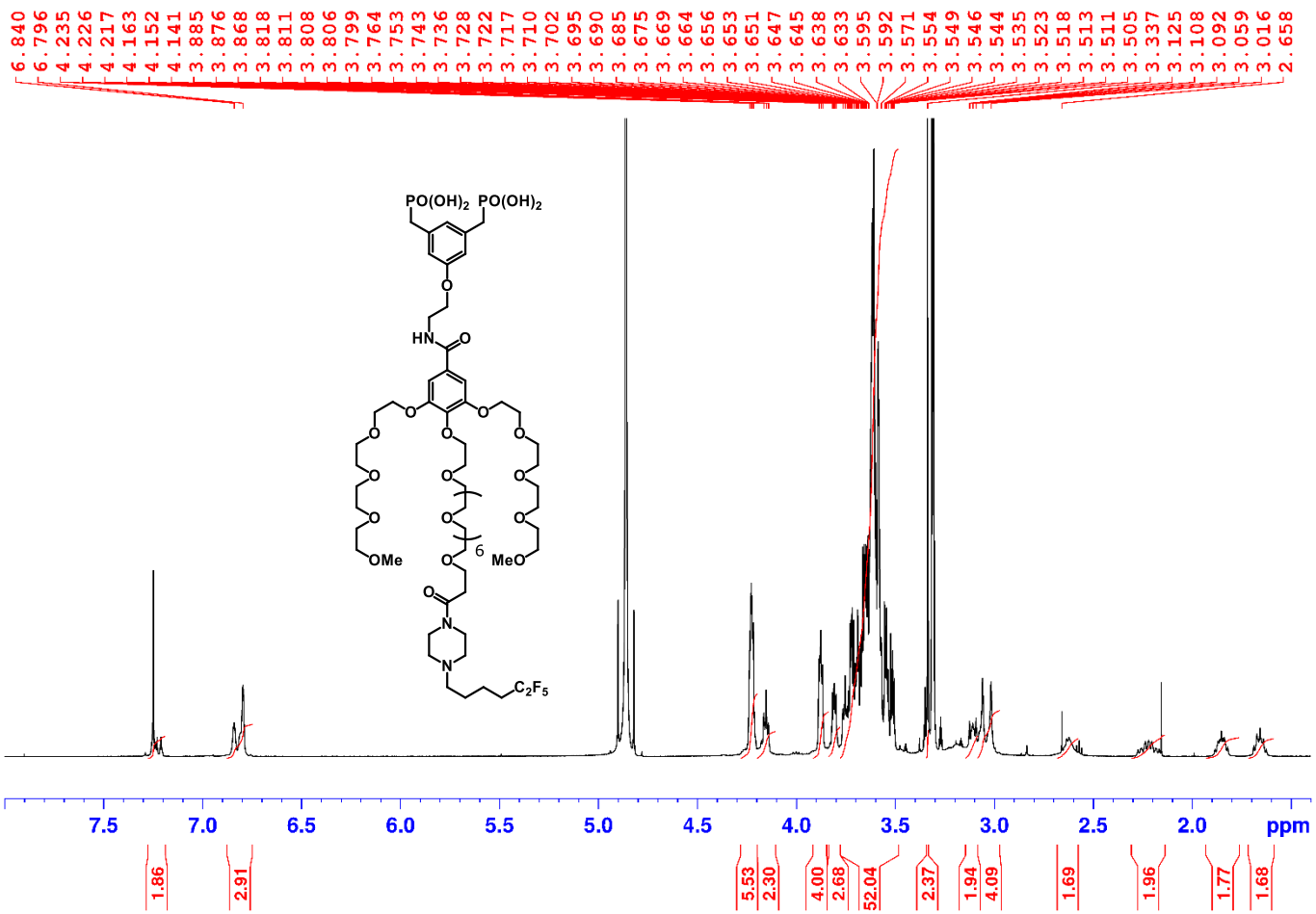
Compound 11 – ^{31}P NMR (202 MHz, CD_3OD-d_4)



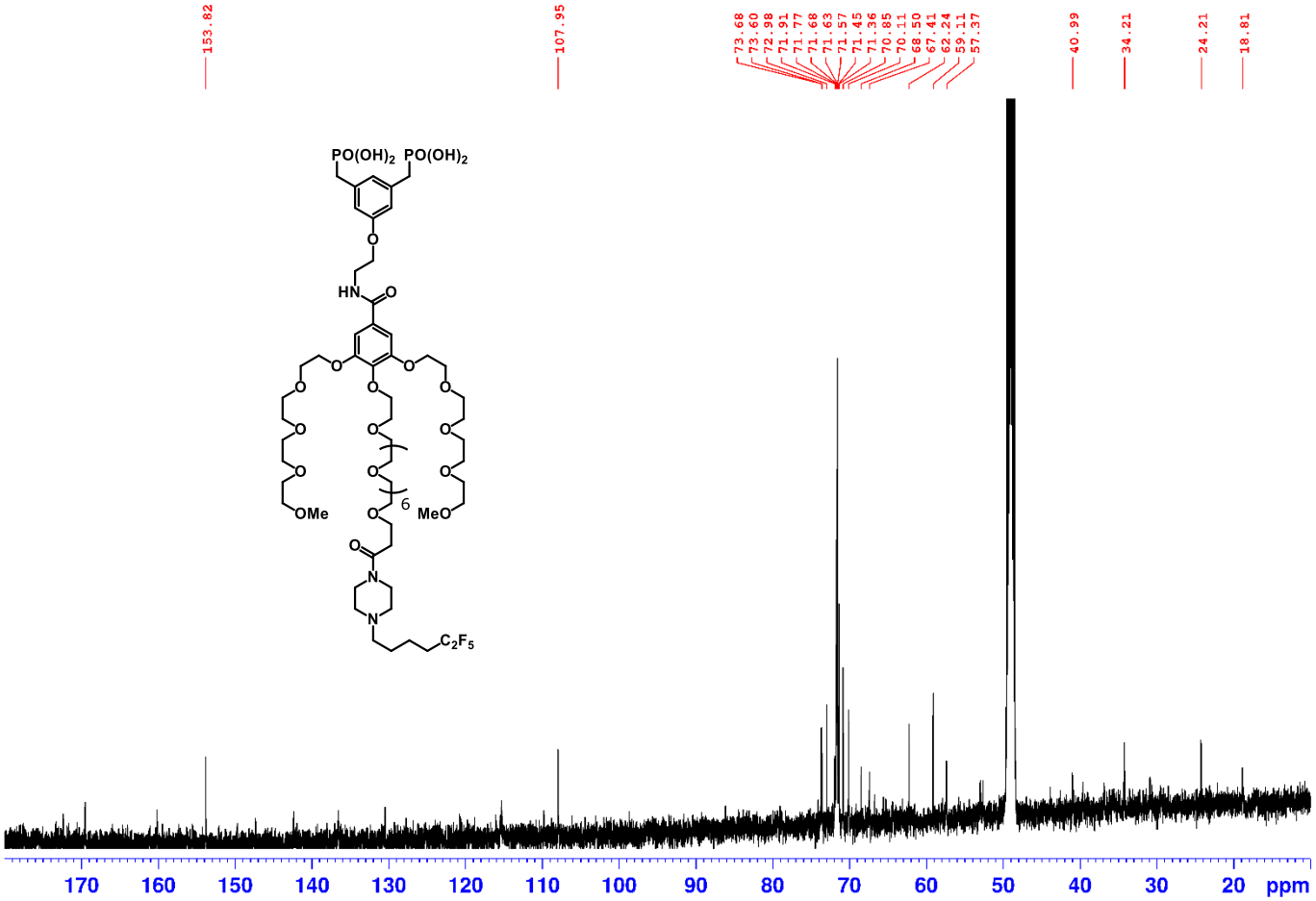
Compound 11 – ^{19}F NMR (470 MHz, CD_3OD-d_4)



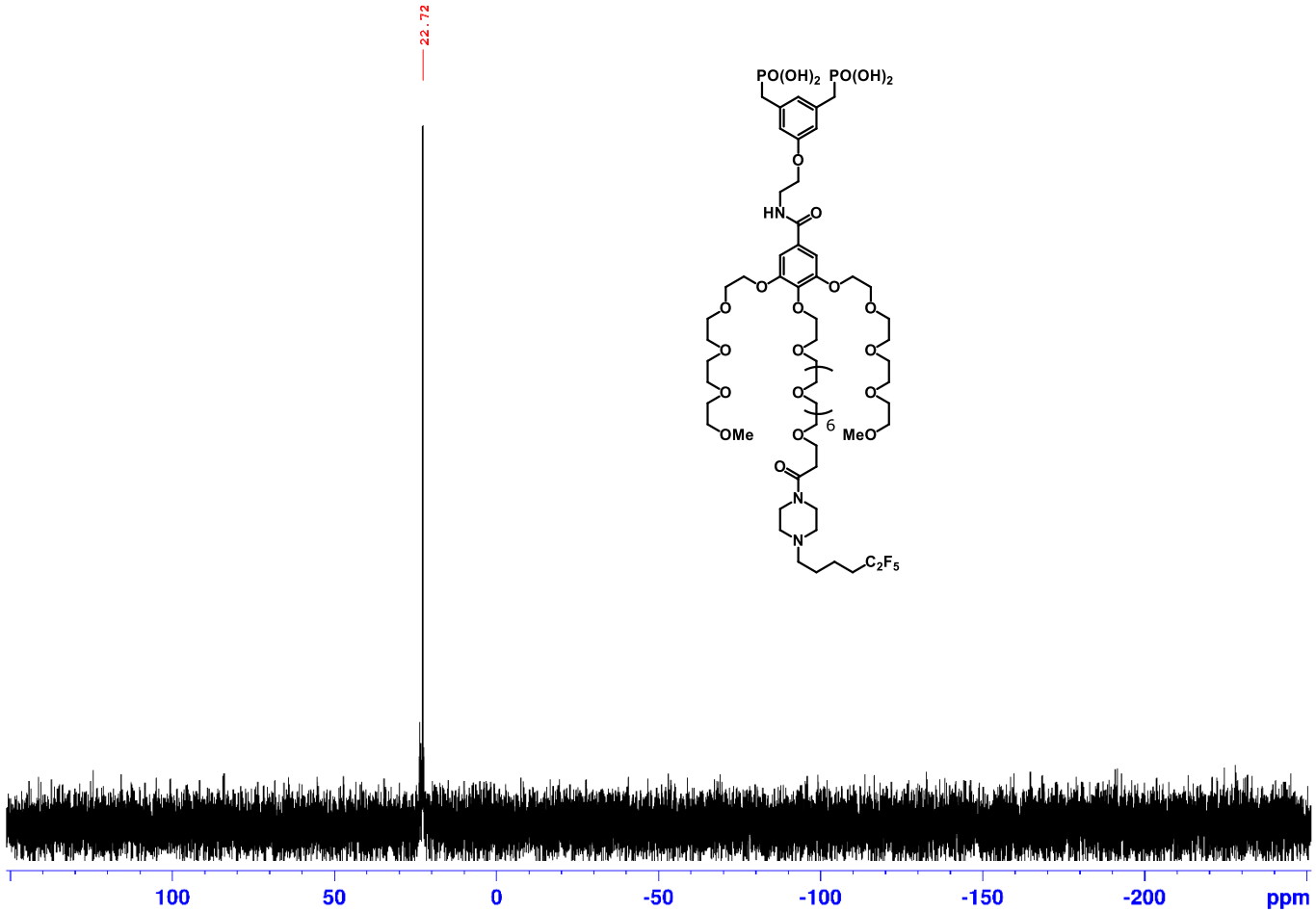
Compound 12 – ^{1}H NMR (500 MHz, CD_3OD-d_4)



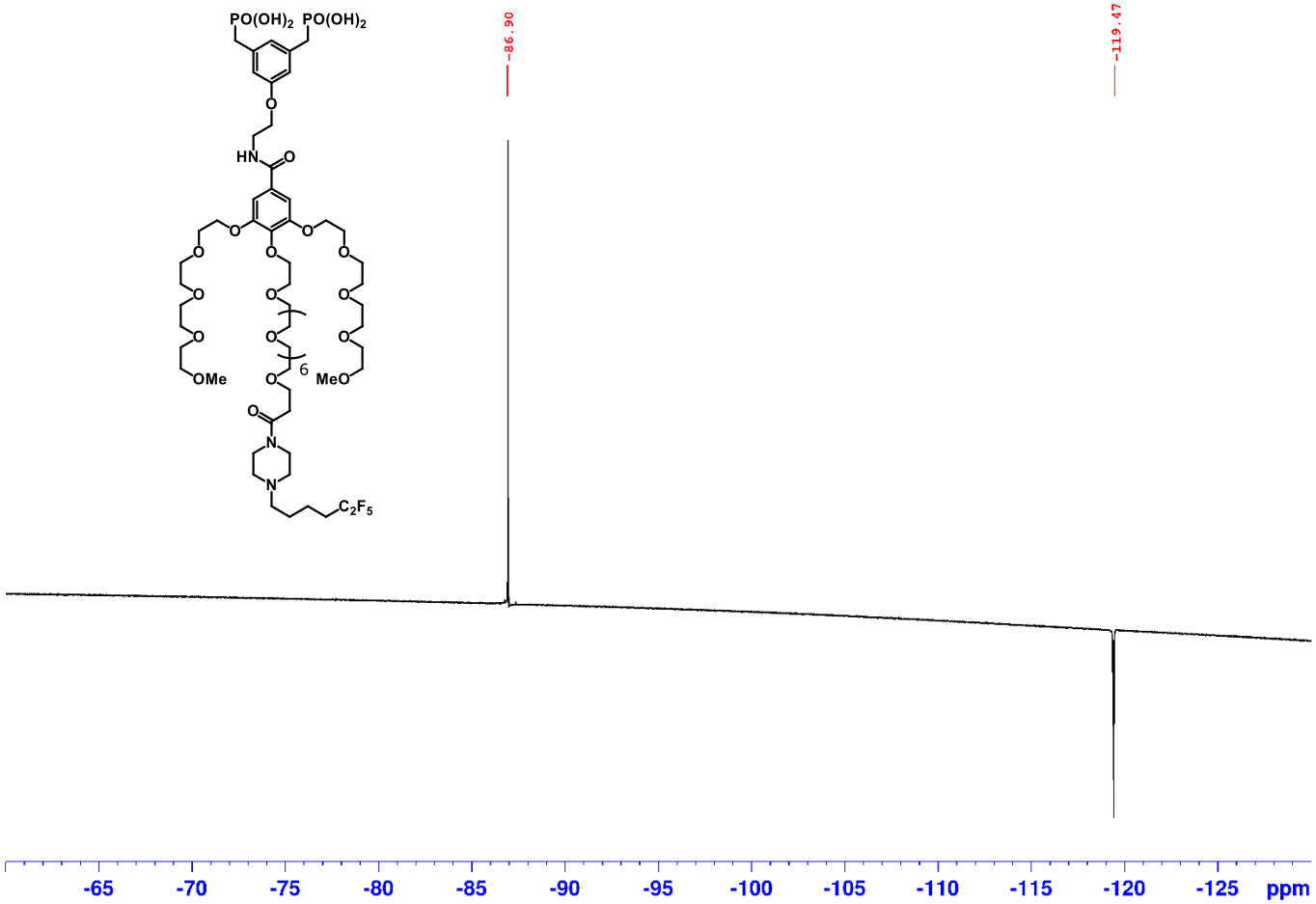
Compound 12 – ^{13}C NMR (125 MHz, CD_3OD-d_4)



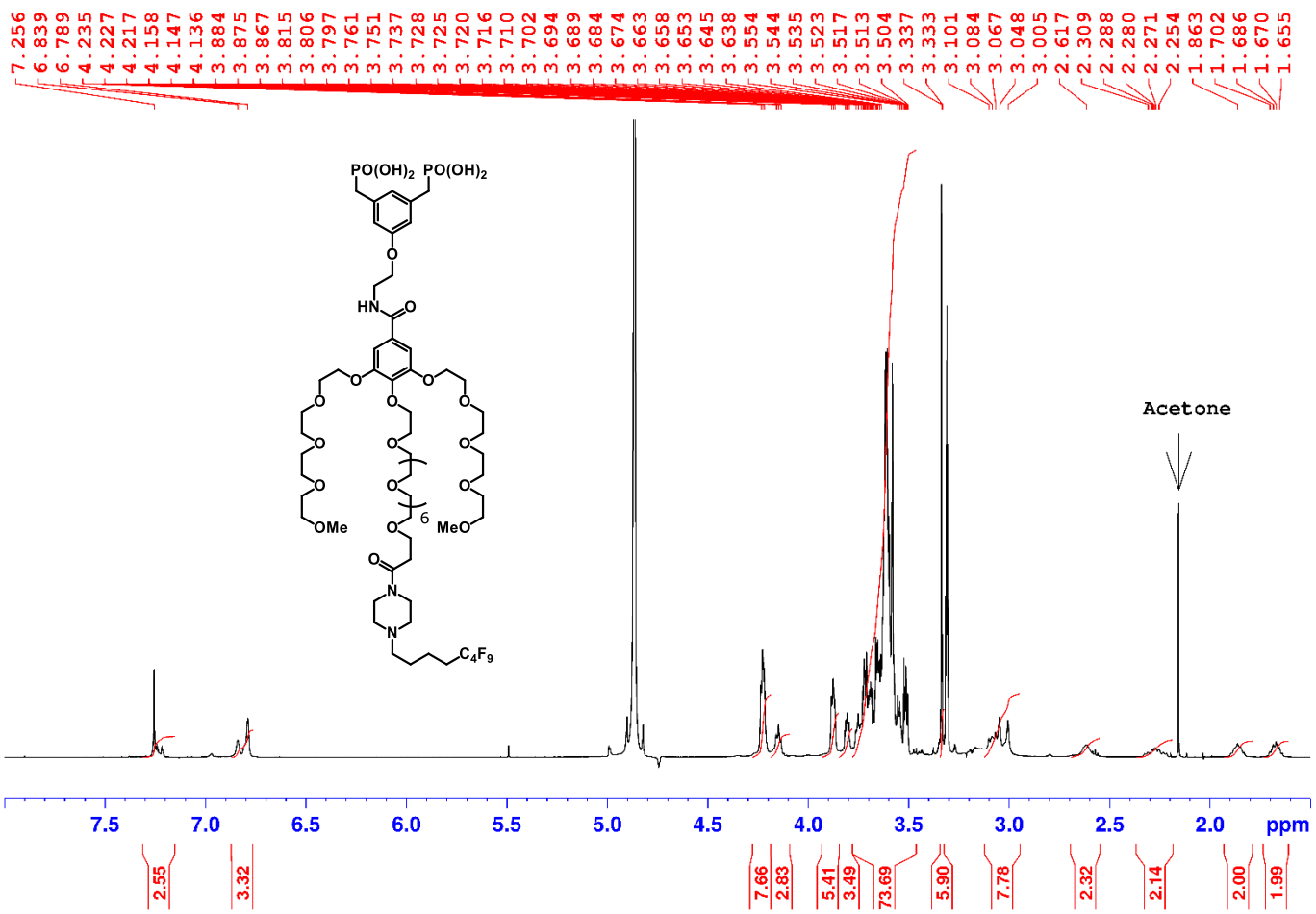
Compound 12 – ^{31}P NMR (202 MHz, CD_3OD-d_4)



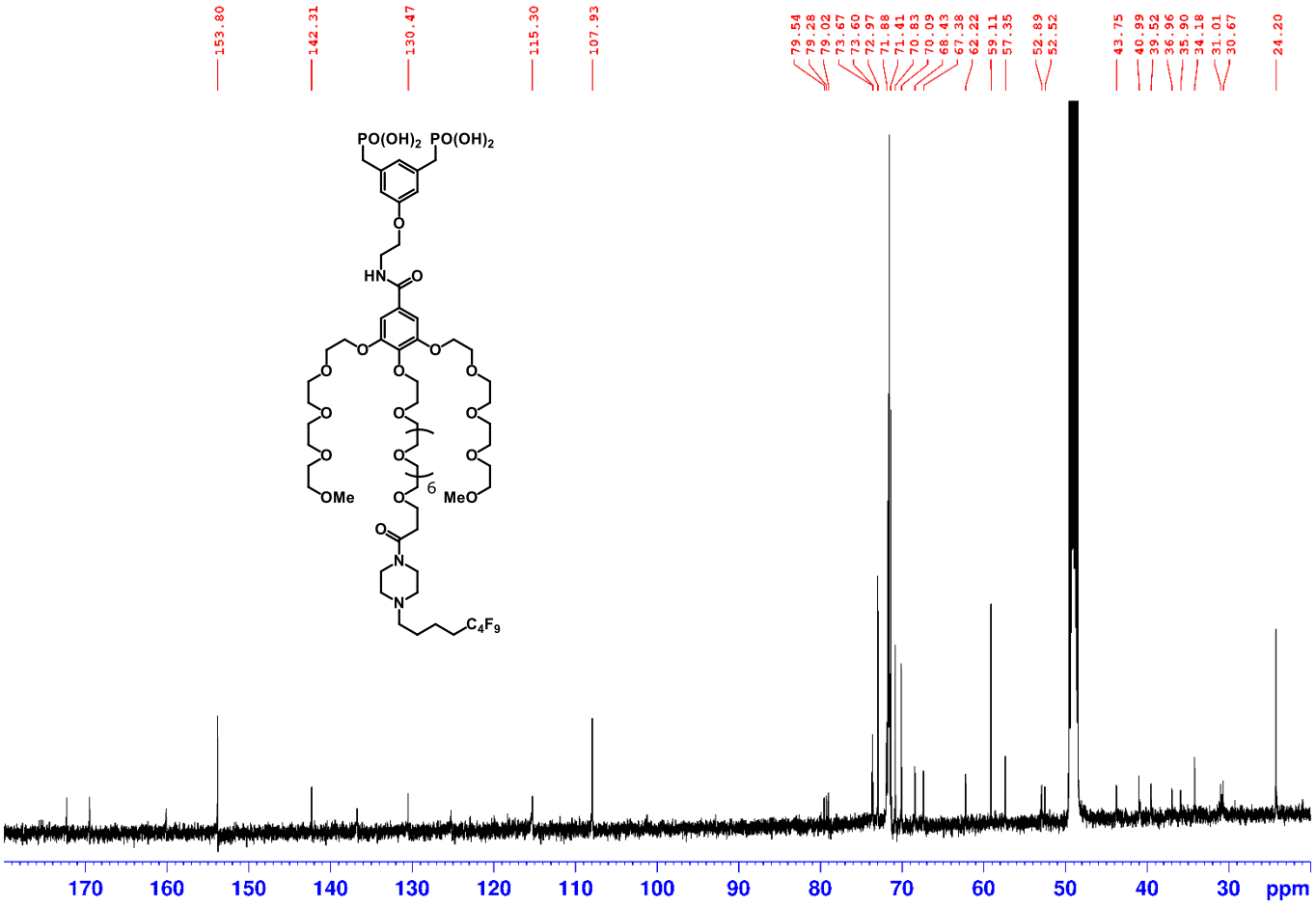
Compound 12 – ^{19}F NMR (470 MHz, CD_3OD-d_4)



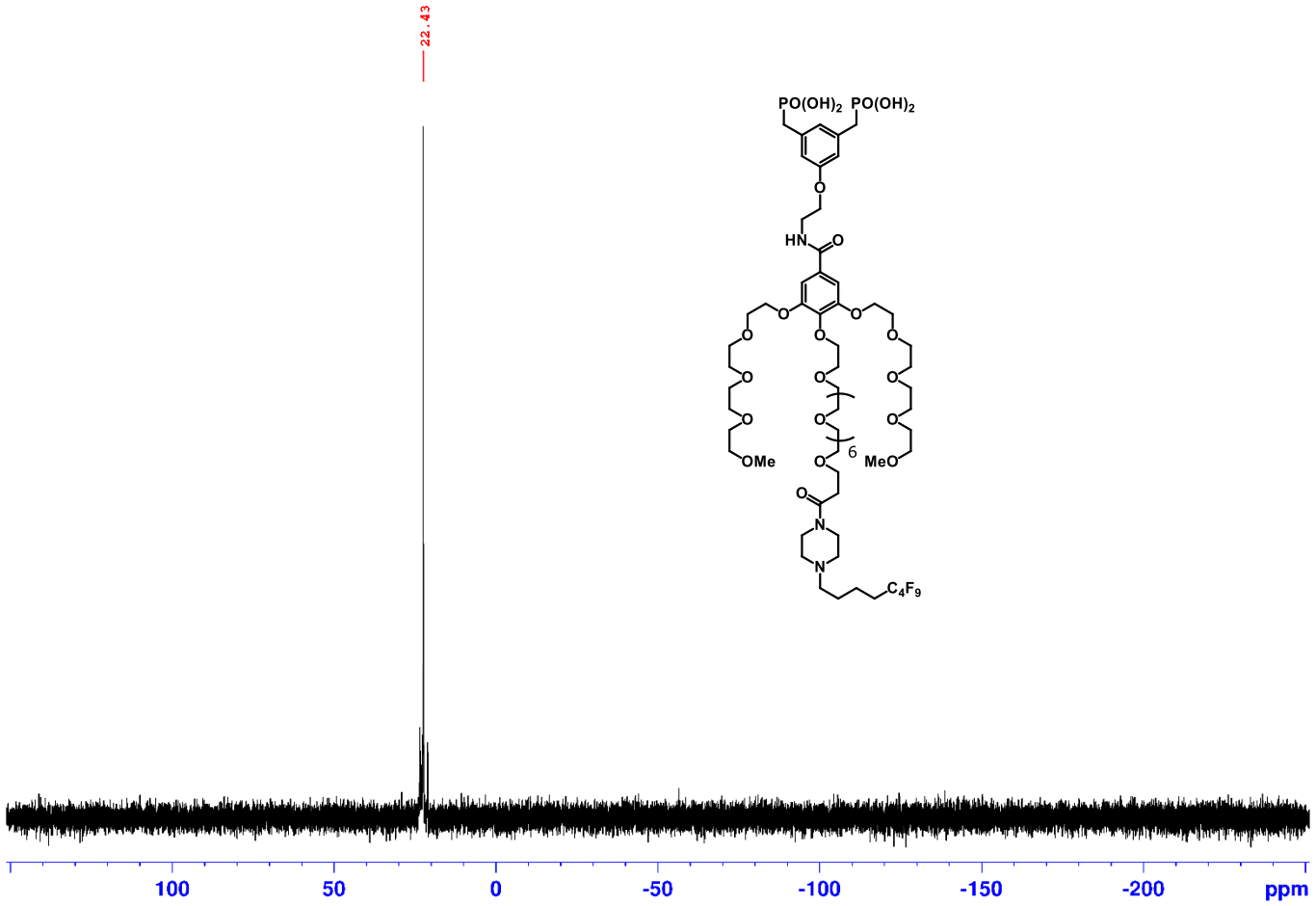
Compound 13 – ^{1}H NMR (500 MHz, CD_3OD-d_4)



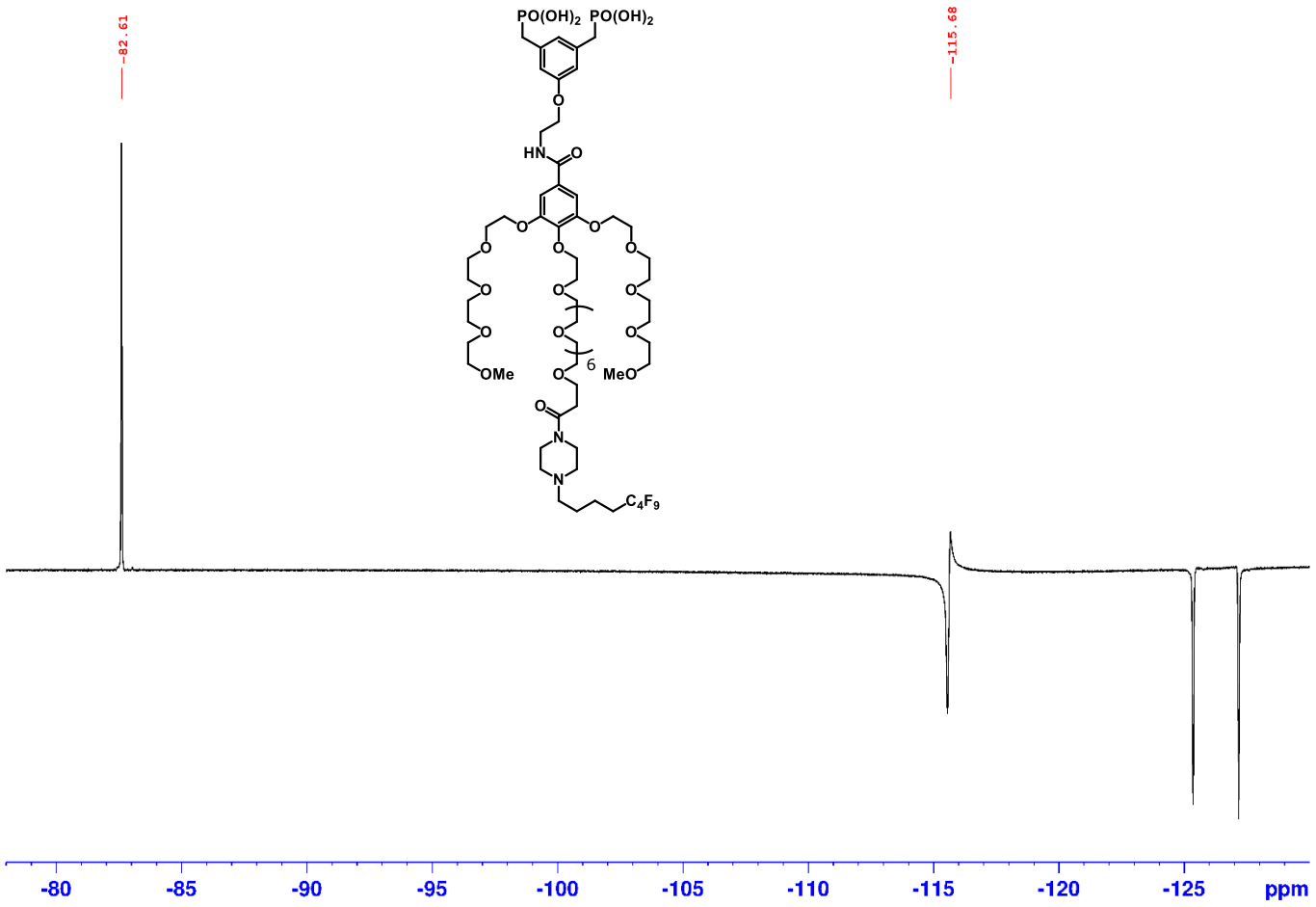
Compound 13 – ^{13}C NMR (125 MHz, CD_3OD-d_4)



Compound 13 – ^{31}P NMR (202 MHz, CD_3OD-d_4)



Compound 13 – ^{19}F NMR (470 MHz, CD_3OD-d_4)



Functionnalization of nanoparticles

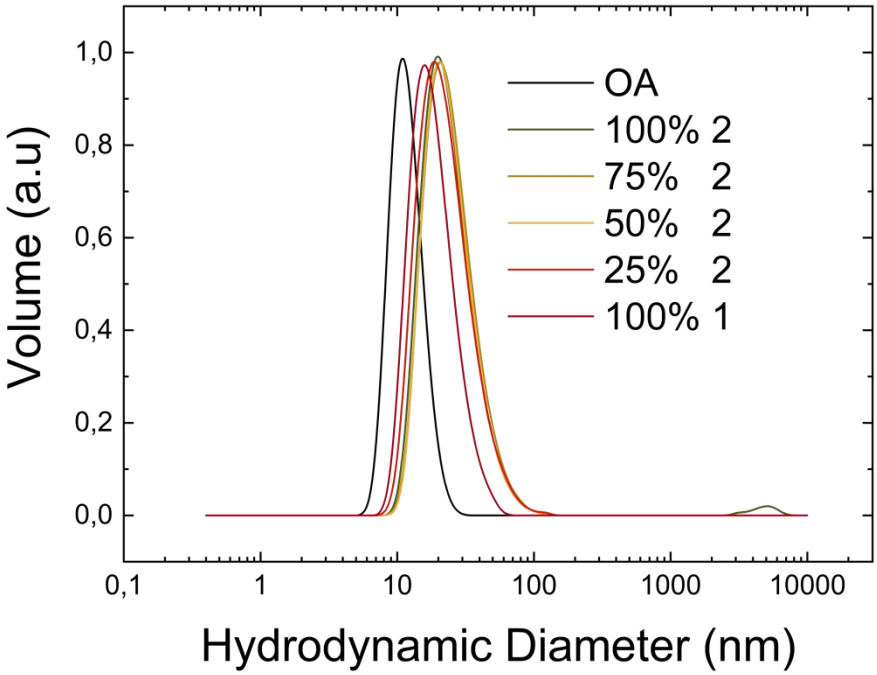


*Figure 1 : Variation of Dynamic light scattering (DLS) with the ratio of ligand **9***

The DLS measurements assess the good colloidal stability of the nanoparticles after functionalization. A slight shift is observed when ligand **9** was introduced, which could be attributed to the influence of long chain of OEG.

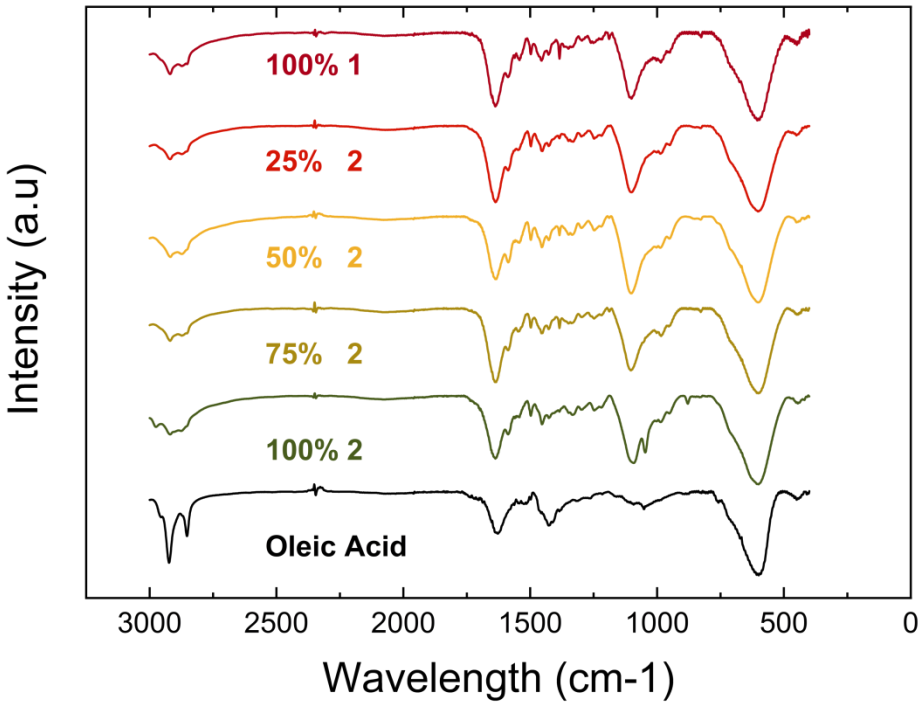


*Figure 2 : Comparison of IR spectra before and after functionalization with different ratio of ligand **9***

The functionalization is confirmed by the disappearance of the alkyl bands (2926-2850 cm^{-1}) and the apparition of the OEG characteristic signal (1096 cm^{-1}). No major distinction can be made between the different ratio of **9**:**1**.

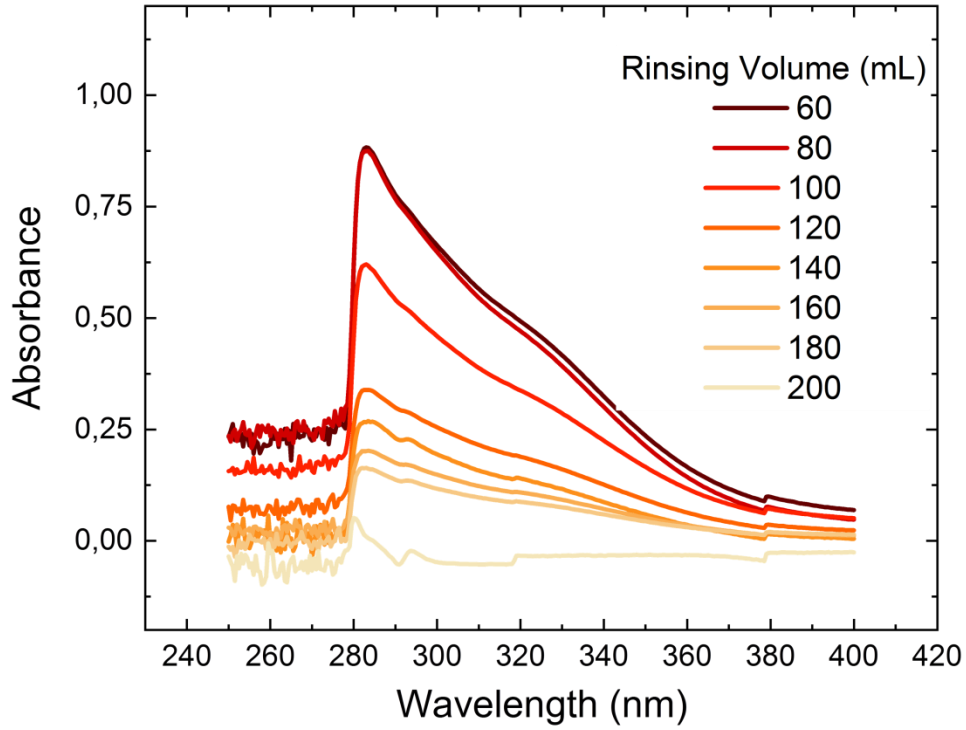


Figure 3 : Monitoring the purification by ultrafiltration with UV-Visible measurement

During the filtration step, the amount of dendron in the filtrate is monitored by UV-visible spectroscopy. The signal of the dendron (about 280 nm) in the filtrate decreases with the filtration step.