Electronic Supplementary Material (ESI) for Organic Chemistry Frontiers.

Supporting Information

for

Cross-Coupling of Aldehydes and α-Bromophosphonates to Modularly Access α-Substituted-β-Ketophosphonates under Dual Nickel/Photoredox Catalysis

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1. General Considerations

^{1}H and ^{13}C spectra were recorded on a Bruker Avance 400, 600 spectrometers, and $CDCl_3$ was purchased from J&K. Chemical shifts are given in ppm with the internal standards as TMS (0 ppm for ^{1}H) and $CDCl_3$ (77.0 ppm for ^{13}C). Flash column chromatography was performed on silica gel 60 (particle size 200-400 mesh ASTM, purchased from Yantai, China) and eluted with petroleum ether/ethyl acetate. GC spectra were recorded on Agilent Technologies 7890A spectrometer; GC-MS spectra were conducted on Shimadzu GC-MS-QP2010 SE W spectrometer; High-resolution mass spectra HRMS-ESI were obtained from a Bruker microTOF-II instrument;

The 390nm LEDs were purchased from www.taobao.com. The reaction tubes were positioned 4-6 cm from the LEDs (**Figure S1**), and the temperature was controlled between 20 °C and 30 °C using fans and an air conditioner.

Figure S1. Photochemical Setup

α-bromophosphonates, *α*-bromosulfonamides and *α*-bromosulfones were conveniently synthesized in gram scale according to the literature[S1-3]. The aldehydes were purified before using, and other reagents and starting materials were purchased from commercial sources and used without further purification. TBADT and TBPDT were prepared according to the literature[S4,5]. All reactions were performed under a N_2 atmosphere using dried solvents which were dried and purified according to the procedure from 'Purification of Laboratory Chemicals book'. For the NMR spectra, data are reported as follows: s = singlet, d = doublet, t = triplet, q =quartet, dd = doublet of doublets, dt = doublet of triplets, m = multiplet; coupling constants in Hz; integration.

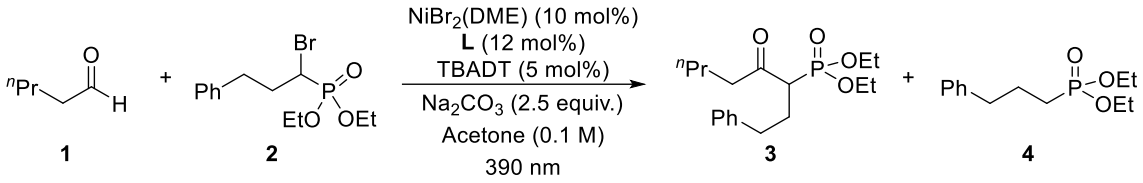
2. Reaction Optimization

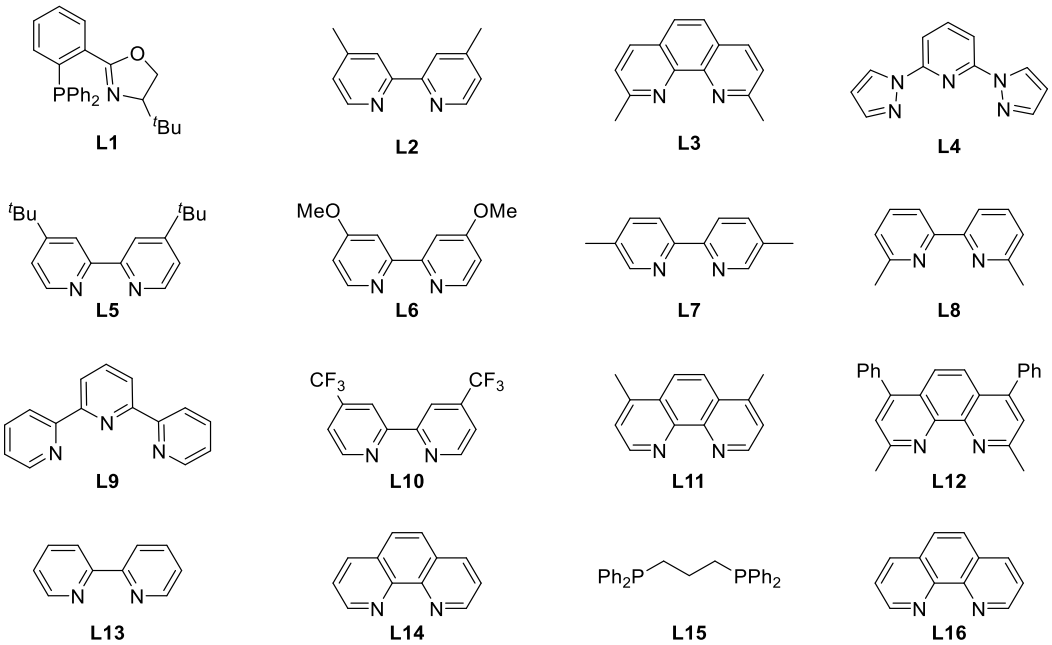
General procedure for Reaction Optimization

All optimization reactions were set up in a glove box under a N_2 atmosphere.

An oven-dried 10-mL Schlenk tube containing a Teflon stir bar was charged with TBADT (0.005 mmol, 5 mol%), Ni-catalyst (0.01 mmol, 10 mol%), ligand (0.012 mmol, 12 mol%), base (0.25 mmol, 2.5 equiv.), and solvent (1 mL). Then aldehyde **1** (0.15 mmol, 1.5 equiv.) and **2** (0.1 mmol, 1.0 equiv.) were added via micro-syringes. Once added, the tube was sealed, and the reaction mixture was stirred and irradiated under LED lamps (λ = 390-395 nm) for 12 hours, while the temperature was controlled at approximately 18 ^{o}C-25 ^{o}C by cooling with fans and an air-conditioner. Upon completion, the reaction mixture was quenched with water and diluted with EtOAc before the internal standard (*n*-dodecane) was added. The yield was determined by GC analysis.

Supplementary Table 1. Screening results on ligand



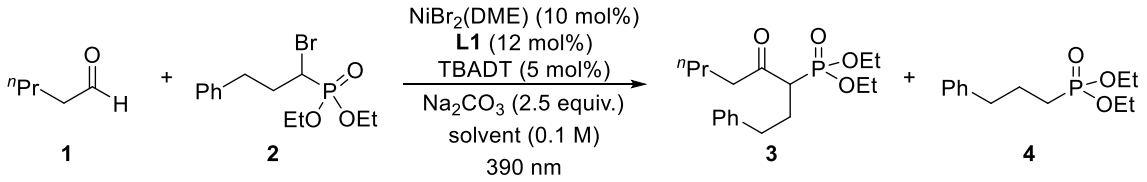


Entry	Ni-cat	Ligand	solvent	base	PC	3 Yield (%)	4 Yield (%)
1	$NiBr_2$(DME)	**L1**	Acetone	Na_2CO_3	TBADT	96(91)[a]	2
2	$NiBr_2$(DME)	**L2**	Acetone	Na_2CO_3	TBADT	42	36
3	$NiBr_2$(DME)	**L3**	Acetone	Na_2CO_3	TBADT	50	29

4	$NiBr_2$(DME)	**L4**	Acetone	Na_2CO_3	TBADT	17	60
5	$NiBr_2$(DME)	**L5**	Acetone	Na_2CO_3	TBADT	77	22
6	$NiBr_2$(DME)	**L6**	Acetone	Na_2CO_3	TBADT	39	25
7	$NiBr_2$(DME)	**L7**	Acetone	Na_2CO_3	TBADT	40	26
8	$NiBr_2$(DME)	**L8**	Acetone	Na_2CO_3	TBADT	38	38
9	$NiBr_2$(DME)	**L9**	Acetone	Na_2CO_3	TBADT	30	67
10	$NiBr_2$(DME)	**L10**	Acetone	Na_2CO_3	TBADT	52	25
11	$NiBr_2$(DME)	**L11**	Acetone	Na_2CO_3	TBADT	35	27
12	$NiBr_2$(DME)	**L12**	Acetone	Na_2CO_3	TBADT	11	84
13	$NiBr_2$(DME)	**L13**	Acetone	Na_2CO_3	TBADT	n.d.	23
14	$NiBr_2$(DME)	**L14**	Acetone	Na_2CO_3	TBADT	n.d.	24
15	$NiBr_2$(DME)	**L15**	Acetone	Na_2CO_3	TBADT	17	60
16	$NiBr_2$(DME)	**L16**	Acetone	Na_2CO_3	TBADT	77	22

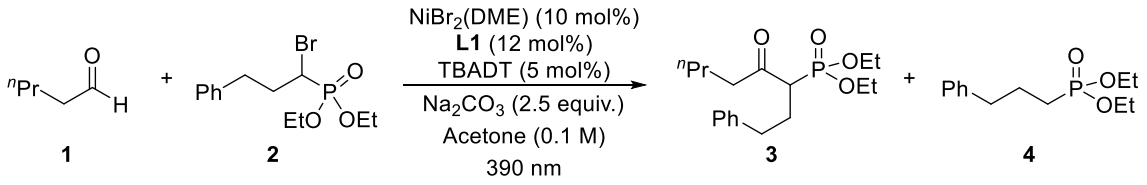
[a] Isolated yield on 0.2 mmol scale

Supplementary Table 2. Screening results on solvent



Entry	Ni-cat	Ligand	solvent	base	PC	3 Yield (%)	4 Yield (%)
1	$NiBr_2$(DME)	**L1**	Acetone	Na_2CO_3	TBADT	96(91)	2
2	$NiBr_2$(DME)	**L1**	MeCN	Na_2CO_3	TBADT	89	9
3	$NiBr_2$(DME)	**L1**	DMA	Na_2CO_3	TBADT	n.d.	57
4	$NiBr_2$(DME)	**L1**	THF	Na_2CO_3	TBADT	n.d.	17
5	$NiBr_2$(DME)	**L1**	Dioxane	Na_2CO_3	TBADT	n.d.	5
6	$NiBr_2$(DME)	**L1**	DME	Na_2CO_3	TBADT	n.d.	17

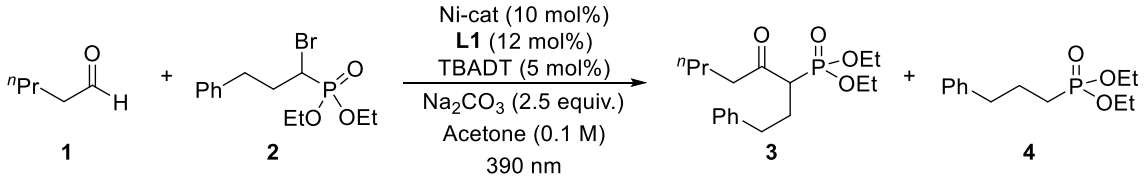
Supplementary Table 3. Screening results on base



1 2 3 4

Entry	Ni-cat	Ligand	solvent	base	PC	3 Yield (%)	4 Yield (%)
1	$NiBr_2$(DME)	L1	Acetone	Na_2CO_3	TBADT	96(91)	2
2	$NiBr_2$(DME)	L1	Acetone	$NaHCO_3$	TBADT	66	5
3	$NiBr_2$(DME)	L1	Acetone	Li_3PO_4	TBADT	n.d.	22
4	$NiBr_2$(DME)	L1	Acetone	K_2HPO_4	TBADT	65	8
5	$NiBr_2$(DME)	L1	Acetone	Cs_2CO_3	TBADT	48	15
6	$NiBr_2$(DME)	L1	Acetone	KH_2PO_4	TBADT	n.d.	14

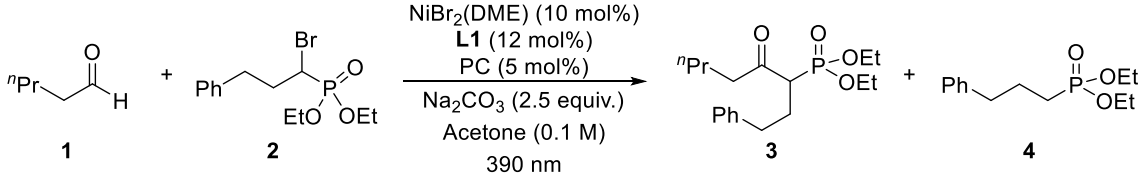
Supplementary Table 4. Screening results on Ni-cat



1 2 3 4

Entry	Ni-cat	Ligand	solvent	base	PC	3 Yield (%)	4 Yield (%)
1	$NiBr_2$(DME)	L1	Acetone	Na_2CO_3	TBADT	96(91)	2
2	$NiCl_2$(DME)	L1	Acetone	Na_2CO_3	TBADT	85	9
3	NiI_2	L1	Acetone	Na_2CO_3	TBADT	79	6
4	$Ni(COD)_2$	L1	Acetone	Na_2CO_3	TBADT	84	10
5	$NiBr_2$	L1	Acetone	Na_2CO_3	TBADT	83	12

Supplementary Table 5. Screening results on PC

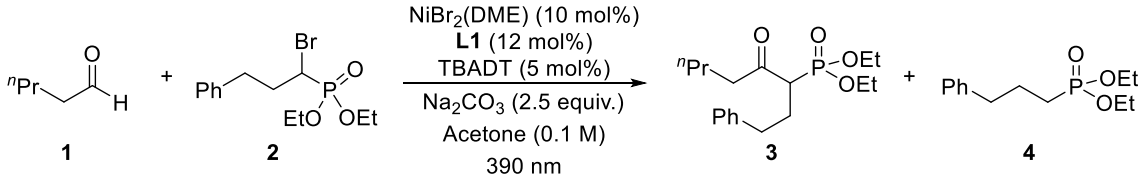


1 2 3 4

Entry	Ni-cat	Ligand	solvent	base	PC	3 Yield (%)	4 Yield (%)

1	$NiBr_2$(DME)	**L1**	Acetone	Na_2CO_3	TBADT	96(91)	2
2	$NiBr_2$(DME)	**L1**	Acetone	Na_2CO_3	TBPDT	74	11

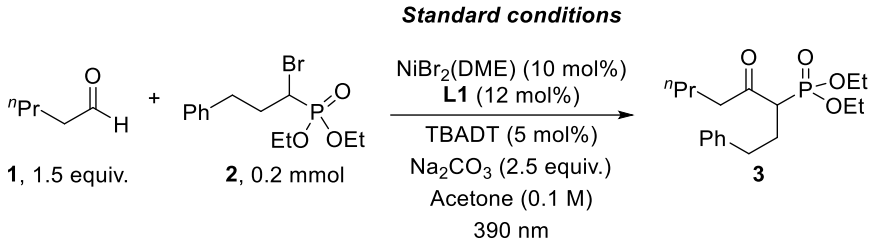
Supplementary Table 6. Control reactions



Entry	Change	3 Yield (%)	4 Yield (%)
1	No changes	96(91)	2
2	Without Ni-cat	n.d.	n.d.
3	Without ligand	85	n.d.
4	Without base	n.d.	8
5	Without TBADT	n.d.	n.d.
6	Without light	n.d.	n.d.

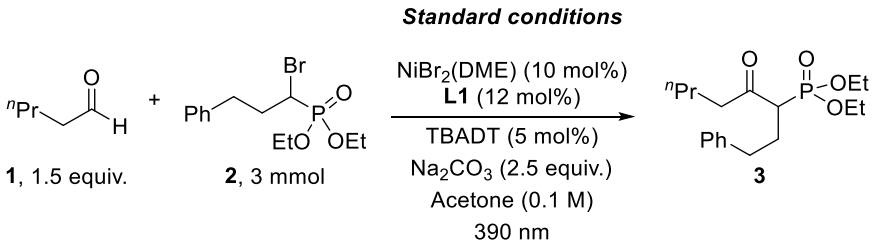
3. Supplementary Methods

3.1 General procedure for *β*-ketophosphonates:



In a glove box, an oven-dried 10-mL Schlenk tube containing a Teflon stir bar was charged with TBADT (0.01 mmol, 5 mol%), $NiBr_2$(DME) (0.02 mmol, 10 mol%), ligand **L1** (0.024mmol, 12 mol%), Na_2CO_3 (0.5 mmol, 2.5 equiv.), and Acetone (2 ml). Then aldehyde **1** (0.3 mmol, 1.5 equiv.) and alkyl bromide (0.2 mmol, 1.0 equiv.) were added via micro-syringes. Once added, the tube was sealed, and the reaction mixture was stirred and irradiated under LED lamps (λ = 390-395 nm) for 12 hours, while the temperature was controlled at approximately 18ºC-25ºC by cooling with fans and an air-conditioner. Upon completion, the reaction mixture was quenched with water and diluted with EtOAc. The aqueous solution was extracted with EtOAc three times. The combined organic layers were dried over anhydrous Na_2SO_4, filtered through Celite, and concentrated *in vacuo*. The residues were purified by silica gel column chromatography with a gradient eluent of petroleum ether/ethyl acetate or petroleum ether/dichloromethane affording product **3** (61.8 mg, 91% yield).

3.2 General procedure for the scale-up reaction:

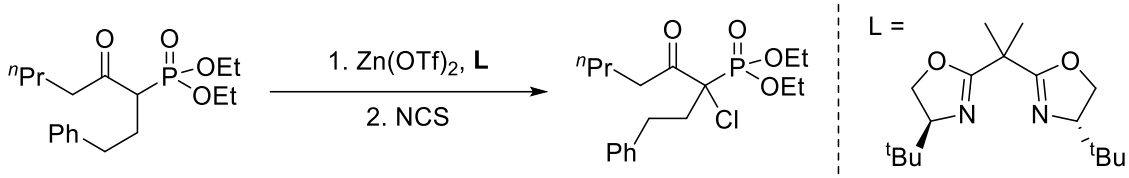


In a glove box, an oven-dried 50-mL Schlenk tube containing a Teflon stir bar was charged with TBADT (0.15 mmol, 5 mol%), $NiBr_2$(DME) (0.3 mmol, 10 mol%), **L1** (0.36 mmol, 12 mol%), Na_2CO_3 (7.5 mmol, 2.5 equiv.), and Acetone (15 ml). Then aldehyde **1** (4.5 mmol, 1.5 equiv.) and **2** (3 mmol, 1.0 equiv.) were added via micro-syringes. Once added, the tube was sealed, and the reaction mixture was stirred and irradiated under LED lamps (λ = 390-395 nm) for 24 hours, while the temperature was controlled at approximately 18ºC-25ºC by cooling with fans and an air-conditioner. Upon completion, the reaction mixture was quenched with water and diluted with EtOAc. The aqueous solution was extracted with EtOAc three times. The combined organic layers were dried over anhydrous Na_2SO_4, filtered through Celite, and concentrated *in vacuo*. The residues were purified by silica gel column

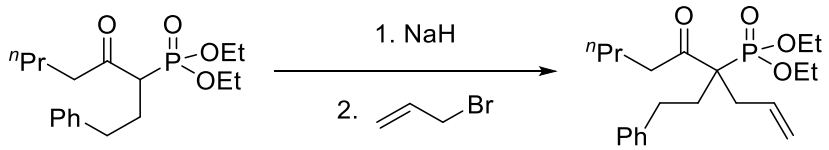
chromatography with a gradient eluent of petroleum ether/ethyl acetate or petroleum ether/dichloromethane affording product **3** (0.903 g, 88% yield).

3.3 General procedure for applications of the products:

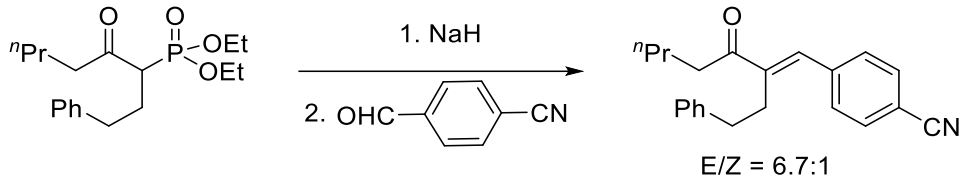
According to the literature[S6], *β*-ketophosphonate **3** (0.1 mmol) was mixed with bromotrimethylsilane (0.13 mL, 1 mmol, 10 equiv.) and stirred at room temperature for 36 hours. The excess of bromotrimethylsilane was then evaporated, and the mixture was hydrolyzed with MeOH (5 ml) for 5 hours. MeOH was then evaporated and the crude dried under high vacuum conditions, affording the desired product **50** (27.0 mg 96% yield) as an orange solid.



According to the literature[S7], In a flame-dried Schlenk tube equipped with a magnetic stirring bar, $Zn(OTf)_2$ (0.01 mmol, 0.1 equiv.) and (*S*,*S*)-(-)-2,2'-isopropylidenebis(4-tert-butyl-2-oxazoline) (0.011 mmol, 0.12 equiv.) were added, followed by dry CH_2Cl_2 (1 mL) and the suspension was stirred in the dark for 6 h. *β*- ketophosphonates **3** (0.1 mmol, 1 equiv.) was then added, followed by *N*-chlorosuccinimide (0.11 mmol, 1.1 equiv.). After 20 h stirring in the dark at room temperature, the solution was concentrated *in vacuo*. The residues were purified by silica gel column chromatography (petroleum ether / ethyl acetate = 7:1) to give compound **51** (35.8 mg 96% yield) as a colorless oil.

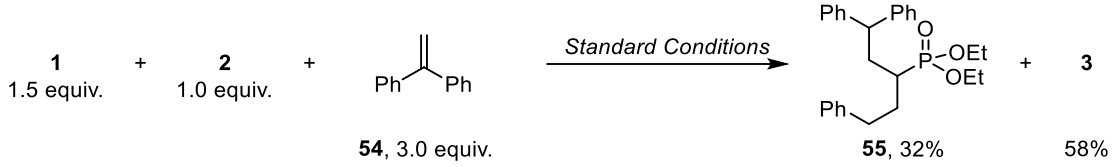


According to the literature[S8], to a suspension of 60% NaH (0.2 mmol, 1 equiv.) in dry THF (1 mL), *β*-ketophosphonate **3** (0.2 mmol, 1 equiv.) in dry THF (1 mL) was added slowly under N_2 at rt. The mixture was stirred for 1 hour. Allyl bromide (0.4 mmol, 2 equiv.) was added followed by stirring of the mixture for 4 h. NH_4Cl (2 mL, aq) was added, and the resulting solution was extracted with Et_2O (3 × 3 mL). The combined organic extracts were washed with H_2O (2 × 5 mL) and dried ($MgSO_4$). After removal of the solvent, the residue was chromatographed (silica gel, petroleum ether / ethyl acetate) to give compound **52** (18.4 mg, 48 % yield) as a colorless oil.

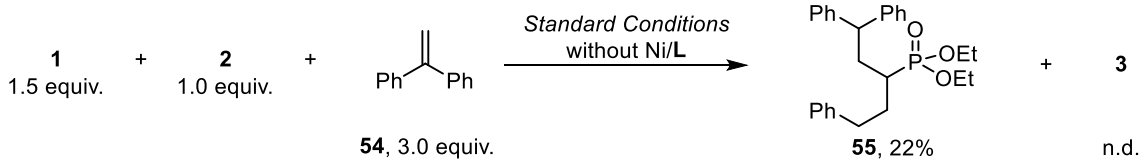


According to the literature[S9], to a suspension of 60% NaH (0.22 mmol, 1.1 equiv.) in dry THF (1 mL), *β*-ketophosphonate **3** (0.2 mmol, 1 equiv.) in dry THF (1 mL) was added under N_2 at rt. The mixture was stirred for 1 hour. 4-Cyanobenzaldehyde (0.4 mmol, 2 equiv.) was added followed by stirring of the mixture overnight. NH_4Cl (2 mL, aq) was added, and the resulting solution was extracted with Et_2O (3 × 3 mL). The combined organic extracts were washed with H_2O (2 × 5 mL) and dried ($MgSO_4$). After removal of the solvent, the residue was chromatographed (silica gel, petroleum ether / ethyl acetate) to give compound **53** (54.9 mg, 86% yield, E/Z = 6.7:1, determined by HNMR) as a colorless oil.

3.4 General procedure for mechanism studies:



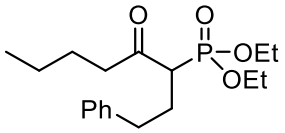
An oven-dried 10-mL Schlenk tube containing a Teflon stir bar was charged with TBADT (0.01 mmol, 5 mol%), Ni-catalyst (0.02 mmol, 10 mol%), ligand (0.024 mmol, 12 mol%), base (0.5 mmol, 2.5 equiv.), and solvent (2 mL). Then aldehyde **1** (0.3 mmol, 1.5 equiv.), **2** (0.2 mmol, 1.0 equiv.), and compound **54** (0.6 mmol, 3.0 equiv.) were added via micro-syringes. Once added, the tube was sealed, and the reaction mixture was stirred and irradiated under LED lamps (λ = 390-395 nm) for 12 hours, while the temperature was controlled at approximately 18 ^{o}C-25 ^{o}C by cooling with fans and an air-conditioner. Upon completion, the reaction mixture was quenched with water and diluted with EtOAc. The combined organic layers were dried over anhydrous Na_2SO_4, filtered through Celite, and concentrated *in vacuo*. Flash chromatography on silica gel eluting with petroleum ether/ethyl acetate afforded the pure product **55** (27.9 mg, 32% yield, light yellow oil).



An oven-dried 10-mL Schlenk tube containing a Teflon stir bar was charged with TBADT (0.01 mmol, 5 mol%), 20base (0.5 mmol, 2.5 equiv.), and solvent (2 mL). Then aldehyde **1** (0.3 mmol, 1.5 equiv.), **2** (0.2 mmol, 1.0 equiv.), and compound **54**

(0.6 mmol, 3.0 equiv.) were added via micro-syringes. Once added, the tube was sealed, and the reaction mixture was stirred and irradiated under LED lamps (λ = 390-395 nm) for 12 hours, while the temperature was controlled at approximately 18 ^{o}C-25 ^{o}C by cooling with fans and an air-conditioner. Upon completion, the reaction mixture was quenched with water and diluted with EtOAc. The yields were determined by FNMR analysis.

4. The characterization of the compounds



3

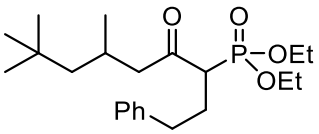
The title compound **3** was synthesized according to General Procedure (SI 3.1), and it was purified by column chromatography on silica gel (PE:EA = 5:1, 91% yield, 61.8 mg, colorless oil).

^{1}H NMR (600 MHz, $CDCl_3$) δ 7.35-7.26 (m, 2H), 7.22-7.18 (m, 1H), 7.18-7.12 (m, 2H), 4.14-4.03 (m, 4H), 3.16 (ddd, *J* = 24.7, 10.6, 3.3 Hz, 1H), 2.79-2.71 (m, 1H), 2.69-2.61 (m, 1H), 2.54-2.46 (m, 1H), 2.44-2.33 (m, 2H), 2.13-2.03 (m, 1H), 1.58-1.50 (m, 2H), 1.35-1.27 (m, 8H), 0.90 (t, *J* = 7.3 Hz, 3H).

^{13}C NMR (151 MHz, $CDCl_3$) δ 205.8 (d, *J* = 4.4 Hz), 140.5, 128.49, 128.48, 126.2, 62.6 (d, *J* = 6.7 Hz), 62.5 (d, *J* = 6.7 Hz), 51.8 (d, *J* = 124.5 Hz), 44.1, 34.2 (d, *J* = 15.1 Hz), 27.8 (d, *J* = 4.6 Hz), 25.5, 22.1, 16.3 (d, *J* = 6.1 Hz), 16.3 (d, *J* = 6.1 Hz), 13.9.

^{31}P NMR (243 MHz, $CDCl_3$) δ 22.43.

HRMS (ESI) m/z: $[M+H]^+$ calcd. for $C_{18}H_{30}O_4P$: 341.1786, found: 341.1786.



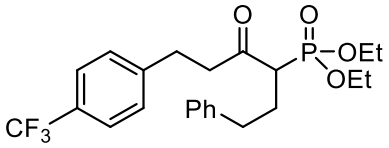
5

The title compound **5** was synthesized according to General Procedure (SI 3.1), and it was purified by column chromatography on silica gel (PE:EA = 3:1, 65% yield, 51.3 mg, yellow oil, 1:1 *dr* determined by H NMR).

^{1}H NMR (600 MHz, $CDCl_3$) δ 7.30-7.26 (m, 4H), 7.20 (t, *J* = 7.6 Hz, 2H), 7.15 (d, *J* = 7.5 Hz, 4H), 4. 14-4.03 (m, 8H), 3.17-3.07 (m, 2H), 2.79 (dd, *J* = 18.1, 5.4 Hz, 1H), 2.70-2.64 (m, 2H), 2.62 (dd, *J* = 17.5, 8.8 Hz, 1H), 2.53-2.46 (m, 2H), 2.44 (dd, *J* = 17.6, 4.3 Hz, 1H), 2.41-2.32 (m, 2H), 2.28 (dd, *J* = 18.1, 7.6 Hz, 1H), 2.19-2.13 (m, 1H), 2.13-2.04 (m, 3H), 1.30 (td, *J* = 7.1, 3.2 Hz, 12H), 1.23-1.13 (m, 2H), 1.12-1.05 (m, 2H), 0.93 (dd, *J* = 10.5, 6.7 Hz, 6H), 0.91 (s, 18H).

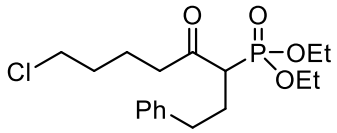
^{13}C NMR (151 MHz, CDCl3) δ 205.10, 205.07, 204.98, 204.95, 140.6, 140.50, 128.49, 128.47, 126.25, 126.24, 62.6 (d, *J* = 6.7 Hz), 62.5 (d, *J* = 3.3 Hz), 62.4 (d, *J* = 3.4 Hz), 54.01, 54.00, 52.2 (d, *J* = 124.9 Hz), 51.8 (d, *J* = 124.4 Hz), 50.9, 50.5, 34.2 (d, *J* = 11.6 Hz), 34.1 (d, *J* = 11.6 Hz), 31.1, 31.1, 30.03, 29.98, 27.9 (d, *J* = 4.7 Hz), 27.6 (d, *J* = 4.6 Hz), 25.0, 24.9, 22.8, 22.4, 16.34 (d, *J* = 6.1 Hz), 16.33 (d, *J* = 6.1 Hz).

^{31}P NMR (243 MHz, $CDCl_3$) δ 22.53, 22.44.
HRMS (ESI) m/z: $[M+H]^+$ calcd. for $C_{22}H_{38}O_4P$: 397.2502, found: 397.2502.



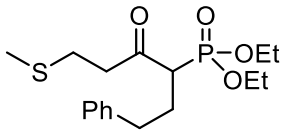
6

The title compound **6** was synthesized according to General Procedure (SI 3.1), and it was purified by column chromatography on silica gel (PE:EA = 3.5:1, 69% yield, 63.4 mg, yellow oil).
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.52 (d, *J* = 7.8 Hz, 2H), 7.35-7.17 (m, 5H), 7.07 (d, *J* = 7.4 Hz, 2H), 4.10-3.93 (m, 4H), 3.24-3.05 (m, 2H), 2.94 (t, *J* = 7.4 Hz, 2H), 2.70-2.54 (m, 2H), 2.52-2.29 (m, 2H), 2.20-1.93 (m, 1H), 1.33-1.20 (m, 6H).
^{13}C NMR (101 MHz, $CDCl_3$) δ 204.0 (d, *J* = 4.4 Hz), 145.1, 140.3, 128.9, 128.5, 128.44, 128.42 (q, *J* = 32.4 Hz), 126.3, 125.2 (q, *J* = 3.8 Hz), 124.2 (q, *J* = 272.7 Hz), 62.7 (d, *J* = 6.8 Hz), 62.5 (d, *J* = 6.7 Hz), 52.0 (d, *J* = 124.5 Hz), 45.1, 34.0 (d, *J* = 14.6 Hz), 29.1, 27.5 (d, *J* = 4.7 Hz), 16.25 (d, *J* = 5.9 Hz), 16.22 (d, *J* = 6.2 Hz).
^{31}P NMR (162 MHz, $CDCl_3$) δ 21.93.
HRMS (ESI) m/z: $[M+H]^+$ calcd. for $C_{23}H_{29}FO_4P$: 457.1750, found: 457.1750.



7

The title compound **7** was synthesized according to General Procedure (SI 3.1), and it was purified by column chromatography on silica gel (PE:EA = 3:1, 81% yield, 60.6 mg, colorless oil).
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.39-7.18 (m, 5H), 4.22-4.01 (m, 4H), 3.60 (t, *J* = 6.2 Hz, 2H), 3.22 (ddd, *J* = 24.7, 10.4, 3.3 Hz, 1H), 2.89 (dt, *J* = 18.1, 6.8 Hz, 1H), 2.72 (ddd, *J* = 14.1, 8.9, 5.5 Hz, 1H), 2.59 (dt, *J* = 13.6, 7.8 Hz, 1H), 2.51-2.40 (m, 2H), 2.24-2.09 (m, 1H), 1.90-1.72 (m, 4H), 1.38 (t, *J* = 7.1 Hz, 6H).
^{13}C NMR (101 MHz, $CDCl_3$) δ 204.9 (d, *J* = 4.6 Hz), 140.4, 128.5, 128.4, 126.2, 62.7 (d, *J* = 6.7 Hz), 62.5 (d, *J* = 6.9 Hz), 51.9 (d, *J* = 124.6 Hz), 44.5, 43.2, 34.1 (d, *J* = 14.7 Hz), 31.6, 27.6 (d, *J* = 4.8 Hz), 20.6, 16.3 (d, *J* = 6.0 Hz).
^{31}P NMR (162 MHz, $CDCl_3$) δ 22.19.
HRMS (ESI) m/z: $[M+H]^+$ calcd. for $C_{18}H_{29}ClO_4P$: 375.1487, found: 375.1487.



8

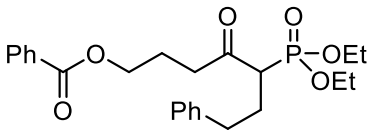
The title compound **8** was synthesized according to General Procedure (SI 3.1), and it was purified by column chromatography on silica gel (PE:EA = 3:1, 46% yield, 33.3 mg, colorless oil).

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.25-7.17 (m, 2H), 7.17-7.10 (m, 1H), 7.10-7.05 (m, 2H), 4.09-3.94 (m, 4H), 3.08 (ddd, *J* = 24.9, 10.6, 3.3 Hz, 1H), 3.04-2.93 (m, 1H), 2.70-2.53 (m, 4H), 2.51-2.41 (m, 1H), 2.39-2.26 (m, 1H), 2.04 (s, 3H), 2.03-1.94 (m, 1H)1.23 (td, *J* = 7.1, 2.1 Hz, 6H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 203.9 (d, *J* = 4.4 Hz), 140.4, 128.49, 128.48, 126.3, 62.7 (d, *J* = 7.0 Hz), 62.5 (d, *J* = 6.6 Hz), 52.0 (d, *J* = 124.7 Hz), 43.9, 34.1 (d, *J* = 14.7 Hz), 27.7, 27.6 (d, *J* = 4.4 Hz), 16.3 (d, J = 5.9 Hz), 15.7.

^{31}P NMR (162 MHz, $CDCl_3$) δ 21.91.

HRMS (ESI) m/z: $[M+H]^+$ calcd. for $C_{17}H_{28}O_4PS$: 359.1440, found: 359.1440.



9

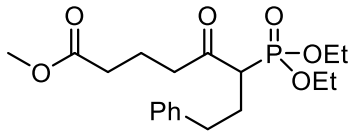
The title compound **9** was synthesized according to General Procedure (SI 3.1), and it was purified by column chromatography on silica gel (PE:EA = 2:1, 54% yield, 48.2 mg, yellow oil).

^{1}H NMR (400 MHz, $CDCl_3$) δ 8.07-8.00 (m, 2H), 7.60-7.51 (m, 1H), 7.47-7.39 (m, 2H), 7.28-7.22 (m, 2H), 7.21-7.15 (m, 1H), 7.14-7.10 (m, 2H), 4.32 (td, *J* = 6.5, 2.1 Hz, 2H), 4.15-4.02 (m, 4H), 3.16 (ddd, *J* = 24.7, 10.4, 3.4 Hz, 1H), 2.97 (dt,1H), 2.72-2.61 (m, 1H), 2.59-2.46 (m, 2H), 2.45-2.33 (m, 1H), 2.17-2.09 (m, 1H), 2.09-2.00 (m, 2H), 1.28 (td, *J* = 7.1, 3.5 Hz, 6H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 204.4 (d, *J* = 4.8 Hz), 166.4, 140.3, 132.9, 130.2, 129.49, 128.47, 128.46, 128.3, 126.3, 63.9, 62.7 (d, *J* = 6.7 Hz), 62.4 (d, *J* = 6.7 Hz), 51.9 (d, *J* = 124.8 Hz), 40.5, 34.1 (d, *J* = 14.7 Hz), 27.6 (d, *J* = 4.7 Hz), 22.7, 16.27 (d, *J* = 6.2 Hz), 16.25 (d, *J* = 5.9 Hz).

^{31}P NMR (162 MHz, $CDCl_3$) δ 22.17.

HRMS (ESI) m/z: $[M+H]^+$ calcd. for $C_{24}H_{32}O_6P$: 447.1931, found: 447.1923.



10

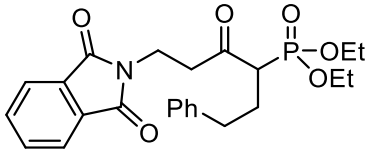
The title compound **10** was synthesized according to General Procedure (SI 3.1), and it was purified by column chromatography on silica gel (PE:EA = 5:1, 63% yield, 48.4 mg, yellow oil).

^{1}H NMR (600 MHz, $CDCl_3$) δ 7.32-7.26 (m, 2H), 7.22-7.18 (m, 1H), 7.16-7.11 (m, 2H), 4.13-4.03 (m, 4H), 3.67 (s, 3H), 3.13 (ddd, *J* = 24.7, 10.6, 3.4 Hz, 1H), 2.85 (dt, *J* = 18.3, 7.1 Hz, 1H), 2.64 (ddd, *J* = 14.1, 9.0, 5.4 Hz, 1H), 2.51 (dt, *J* = 13.7, 7.9 Hz, 1H), 2.47-2.36 (m, 2H), 2.36-2.29 (m, 2H), 2.13-2.04 (m, 1H), 1.93-1.83 (m, 2H), 1.30 (td, *J* = 7.1, 2.8 Hz, 6H).

^{13}C NMR (151 MHz, $CDCl_3$) δ 204.8 (d, *J* = 4.6 Hz), 173.5, 140.4, 128.48, 128.46 126.3, 62.7 (d, *J* = 6.7 Hz), 62.5 (d, *J* = 6.9 Hz), 51.8 (d, *J* = 124.8 Hz), 51.5, 43.1, 34.1 (d, *J* = 14.8 Hz), 32.8, 27.7 (d, *J* = 4.8 Hz), 18.5, 16.3 (d, *J* = 6.0 Hz).

^{31}P NMR (243 MHz, $CDCl_3$) δ 22.16.

HRMS (ESI) m/z: $[M+H]^+$ calcd. for $C_{19}H_{30}O_6P$: 385.1775, found: 385.1764.



11

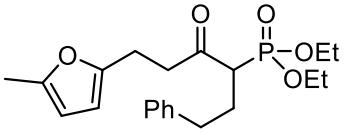
The title compound **11** was synthesized according to General Procedure (SI 3.1), and it was purified by column chromatography on silica gel (PE:EA = 1:1, 59% yield, 53.6 mg, white powder).

^{1}H NMR (600 MHz, $CDCl_3$) δ 7.87-7.68 (m, 4H), 7.30-7.10 (m, 5H), 4.11-4.03 (m, 4H), 4.01-3.90 (m, 2H), 3.22 (dt, *J* = 17.4, 7.5 Hz, 1H), 3.13 (ddd, *J* = 25.0, 10.5, 3.3 Hz, 1H), 2.81 (dt, *J* = 17.3, 7.1 Hz, 1H), 2.69-2.62 (m, 1H), 2.57-2.48 (m, 1H), 2.43-2.33 (m, 1H), 2.15-2.06 (m, 1H), 1.33-1.24 (m, 6H).

^{13}C NMR (151 MHz, $CDCl_3$) δ 202.8 (d, *J* = 4.6 Hz), 167.9, 140.2, 133.9, 132.0, 128.5, 128.4, 126.2, 123.1, 62.7 (d, *J* = 6.7 Hz), 52.0 (d, *J* = 124.5 Hz), 41.7, 34.0 (d, *J* = 14.6 Hz), 32.7, 27.4 (d, *J* = 4.4 Hz), 16.23 (d, *J* = 5.5 Hz), 16.21 (d, *J* = 6.1 Hz).

^{31}P NMR (243 MHz, $CDCl_3$) δ 22.43.

HRMS (ESI) m/z: $[M+CH_3OH+H]^+$ calcd. for $C_{25}H_{33}NO_7P$: 490.1989, found: 490.1990.



12

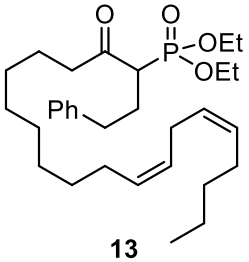
The title compound **12** was synthesized according to General Procedure (SI 3.1), and it was purified by column chromatography on silica gel (PE:EA = 5:1, 60% yield, 47.1 mg, yellow oil).

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.30-7.24 (m, 1H), 7.11-7.16 (m, 1H), 7.14-7.05 (m, 2H), 5.85 (dd, *J* = 21.0, 3.4 Hz, 2H), 4.16–3.98 (m, 4H), 3.23–3.04 (m, 2H), 2.93-2.78 (m, 2H), 2.75-2.65 (m, 1H), 2.62 (td, *J* = 8.8, 4.7 Hz, 1H), 2.51–2.43 (m, 1H), 2.42-2.30 (m, 1H), 2.23 (s, 3H), 2.13–2.02 (m, 1H), 1.29 (td, *J* = 7.1, 2.4 Hz, 6H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 204.2 (d, J = 4.6 Hz), 152.5, 150.4, 140.5, 128.47, 128.46, 126.2, 105.90, 105.89, 62.7 (d, *J* = 6.6 Hz), 62.5 (d, *J* = 7.0 Hz), 51.9 (d, *J* = 124.7 Hz), 42.6, 34.1 (d, *J* = 14.8 Hz), 27.8 (d, *J* = 4.7 Hz), 22.0, 16.28 (d, *J* = 5.9 Hz), 16.26 (d, *J* = 6.1 Hz), 13.4.

^{31}P NMR (162 MHz, $CDCl_3$) δ 22.09.

HRMS (ESI) m/z: $[M+H]^+$ calcd. for $C_{21}H_{30}O_5P$: 393.1825, found: 393.1816.



13

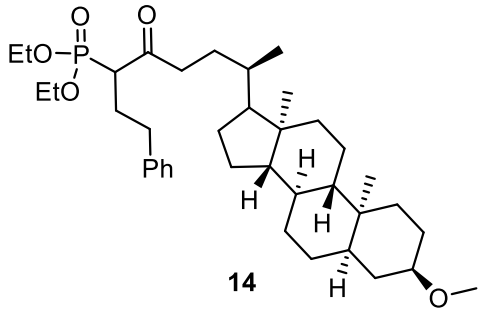
The title compound **13** was synthesized according to General Procedure (SI 3.1), and it was purified by column chromatography on silica gel (PE:EA = 6:1, 49% yield, 50.4 mg, yellow oil).

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.40-7.05 (m, 5H), 5.45-5.27 (m, 4H), 4.15-3.99 (m, 4H), 3.15 (ddd, *J* = 24.6, 10.4, 3.4 Hz, 1H), 2.82-2.74 (m, 2H), 2.72 (t, *J* = 7.3 Hz, 1H), 2.69-2.60 (m, 1H), 2.56-2.44 (m, 1H), 2.44-2.32 (m, 2H), 2.05 (q, *J* = 7.0 Hz, 4H), 2.00-1.92 (m, 1H), 1.59-1.47 (m, 2H), 1.37-1.26 (m, 20H), 0.89 (t, *J* = 6.8 Hz, 3H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 205.6 (d, *J* = 4.5 Hz), 140.5, 130.2, 130.0, 128.47, 128.46, 128.0, 127.9, 126.2, 62.6 (d, *J* = 7.0 Hz), 62.4 (d, *J* = 7.0 Hz), 51.8 (d, *J* = 124.7 Hz), 44.3, 34.2 (d, *J* = 14.8 Hz), 31.5, 29.6, 29.3, 29.1, 29.0, 27.8 (d, *J* = 4.8 Hz), 27.18, 27.17, 25.6, 23.4, 22.5, 16.3 (d, *J* = 6.1 Hz), 14.0.

^{31}P NMR (162 MHz, $CDCl_3$) δ 22.43.

HRMS (ESI) m/z: $[M+H]^+$ calcd. for $C_{31}H_{52}O_4P$: 519.3598, found: 519.3595.



14

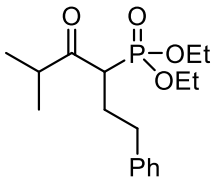
The title compound **14** was synthesized according to General Procedure (SI 3.1), and it was purified by column chromatography on silica gel (PE:EA = 6:1, 53% yield, 66.9 mg, yellow oil).

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.46-7.02 (m, 5H), 4.17-4.02 (m, 4H), 3.35 (s, 3H), 3.24-3.10 (m, 2H), 2.82-2.67 (m, 1H), 2.67-2.59 (m, 1H), 2.57-2.45 (m, 1H), 2.44-2.37 (m, 1H), 2.36-2.24 (m, 1H), 2.15-2.06 (m, 1H), 1.94 (d, *J* = 11.7 Hz, 1H), 1.90-1.63 (m, 8H), 1.59 (d, *J* = 14.0 Hz, 2H), 1.44-1.35 (m, 5H), 1.30 (t, *J* = 7.4 Hz, 6H), 1.27-1.19 (m, 5H), 1.17-0.99 (m, 5H), 0.92 (s, 3H), 0.89 (d, *J* = 6.2 Hz, 3H), 0.63 (s, 3H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 206.0, 140.6, 128.51, 128.48, 126.2, 80.4, 62.6 (d, *J* = 6.6 Hz), 62.5 (d, *J* = 6.3 Hz), 56.5, 56.4, 56.01, 55.99, 55.5, 52.6, 52.5, 51.4, 51.2, 42.7, 42.1, 41.3, 41.2, 40.4, 40.2, 35.9, 35.3, 35.2, 35.0, 34.9, 34.2 (d, *J* = 14.9 Hz), 32.8, 29.4, 28.2 (d, *J* = 2.6 Hz), 27.8, 27.3, 26.8, 26.4, 24.2, 23.4, 20.8, 18.5, 18.4, 16.4 (d, *J* = 6.0 Hz), 12.05, 12.03.

^{31}P NMR (162 MHz, $CDCl_3$) δ 22.53.

HRMS (ESI) m/z: $[M+H]^+$ calcd. for $C_{38}H_{62}O_5P$: 629.4329, found: 629.4304.



15

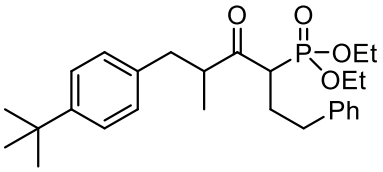
The title compound **15** was synthesized according to General Procedure (SI 3.1), and it was purified by column chromatography on silica gel (PE:EA = 4:1, 70% yield, 45.3 mg, yellow oil).

^{1}H NMR (600 MHz, $CDCl_3$) δ 7.34-7.25 (m, 3H), 7.23-7.15 (m, 1H), 4.16-4.03 (m, 4H), 3.38 (ddd, *J* = 25.0, 10.3, 3.5 Hz, 1H), 2.95 (hept, *J* = 6.9 Hz, 1H), 2.62 (ddd, *J* = 13.5, 9.9, 5.2 Hz, 1H), 2.47 (ddd, *J* = 13.5, 9.5, 6.6 Hz, 1H), 2.42-2.32 (m, 1H), 2.09 (m, 1H), 1.30 (td, *J* = 7.1, 1.4 Hz, 6H), 1.11 (d, *J* = 6.6 Hz, 3H), 1.05 (d, *J* = 7.3 Hz, 3H).

^{13}C NMR (151 MHz, $CDCl_3$) δ 209.6 (d, *J* = 4.5 Hz), 140.7, 128.5, 128.4, 126.2, 62.7 (d, *J* = 6.7 Hz), 62.6 (d, *J* = 6.7 Hz), 50.4 (d, *J* = 124.7 Hz), 41.8, 34.4 (d, *J* = 14.9 Hz), 27.8 (d, *J* = 4.5 Hz), 18.6, 17.4, 16.4 (d, *J* = 5.5 Hz).

^{31}P NMR (243 MHz, $CDCl_3$) δ 22.40.

HRMS (ESI) m/z: $[M+H]^+$ calcd. for $C_{17}H_{28}O_4P$: 327.1720, found: 327.1720.



16(1:1 *dr*)

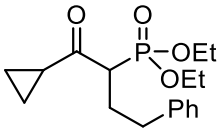
The title compound **16** was synthesized according to General Procedure (SI 3.1), and it was purified by column chromatography on silica gel (PE:EA = 3:1, 40% yield, 36.7 mg, yellow oil, 1:1 *dr* determined by H NMR).

^{1}H NMR (600 MHz, $CDCl_3$) δ 7.37-7.23 (m, 8H), 7.21-7.04 (m, 10H), 4.15-3.97 (m, 6H), 3.94-3.87 (m, 2H), 3.36 (ddd, *J* = 25.7, 10.2, 3.3 Hz, 1H), 3.26-3.16 (m, 2H), 3.10 (ddd, *J*=25.3, 8.9, 4.1 Hz, 1H), 3.04 (dd, *J* = 13.7, 5.8 Hz, 1H), 2.84 (dd, *J* = 13.5, 7.3 Hz, 1H), 2.66-2.59 (m, 1H), 2.57-2.47 (m, 2H), 2.47-2.41 (m, 1H), 2.41-2.32 (m, 1H), 2.32-2.25 (m, 1H), 2.23-2.13 (m, 2H), 2.13-2.05 (m, 1H), 2.01-1.91 (m, 1H), 1.31 (t, *J* = 6.3 Hz, 3H), 1.30-1.25 (m, 24H), 1.23 (t, *J* = 7.1 Hz, 3H), 1.13 (d, *J* = 6.6 Hz, 3H), 1.00 (d, *J* = 7.2 Hz, 3H).

^{13}C NMR (151 MHz, $CDCl_3$) δ 209.4 (d, *J* = 4.8 Hz), 208.5 (d, *J* = 4.3 Hz), 149.4, 148.8, 141.0, 140.7, 136.7, 136.1, 129.0, 128.7, 128.45, 128.44, 128.37, 128.3, 126.2, 126.1, 125.4, 125.0, 62.6 (d, *J* = 10.5 Hz), 62.53 (d, *J* = 6.6 Hz), 62.52 (d, *J* = 16.6 Hz), 52.7 (d, *J* = 124.0 Hz), 50.7 (d, *J* = 124.2 Hz), 49.2, 48.7, 39.4, 37.2, 34.4, 34.31, 34.28 (d, *J* = 6.7 Hz), 34.2 (d, *J* = 5.3 Hz), 31.4, 31.3, 27.8 (d, *J* = 4.5 Hz), 27.5 (d, *J* = 4.7 Hz), 16.37 (d, *J* = 6.1 Hz), 16.35 (d, *J* = 6.6 Hz), 16.2.

^{31}P NMR (243 MHz, $CDCl_3$) δ 22.54, 22.07.

HRMS (ESI) m/z: $[M+H]^+$ calcd. for $C_{27}H_{40}O_4P$: 459.2659, found: 459.2659.



17

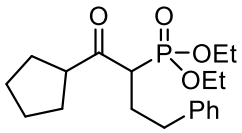
The title compound **17** was synthesized according to General Procedure (SI 3.1), and it was purified by column chromatography on silica gel (PE:EA = 3:1, 71% yield, 46.3 mg, yellow oil).

^{1}H NMR (600 MHz, $CDCl_3$) δ 7.31-7.26 (m, 2H), 7.20 (t, *J* = 7.3 Hz, 1H), 7.16 (d, *J* = 7.5 Hz, 2H), 4.16-4.03 (m, 4H), 3.30 (ddd, *J* = 24.3, 10.8, 3.4 Hz, 1H), 2.72-2.65 (m, 1H), 2.56-2.48 (m, 1H), 2.47-2.37 (m, 1H), 2.24-2.17 (m, 1H), 2.16-2.07 (m, 1H), 1.30 (td, *J* = 7.1, 2.7 Hz, 6H), 1.18-1.13 (m, 1H), 1.10-1.05 (m, 1H), 1.01-0.92 (m, 2H).

^{13}C NMR (151 MHz, $CDCl_3$) δ 205.5 (d, *J* = 4.0 Hz), 140.6, 128.5, 128.4, 126.2, 62.53 (d, *J* = 6.6 Hz), 62.48 (d, *J* = 7.2 Hz), 53.0 (d, *J* = 125.5 Hz), 34.2 (d, *J* = 15.4 Hz), 27.9 (d, *J* = 4.4 Hz), 21.7, 16.34 (d, *J* = 6.1 Hz), 16.32 (d, *J* = 6.1 Hz), 12.2, 12.0.

^{31}P NMR (243 MHz, $CDCl_3$) δ 22.68.

HRMS (ESI) m/z: $[M+H]^+$ calcd. for $C_{17}H_{26}O_4P$: 325.1563, found: 325.1563.



18

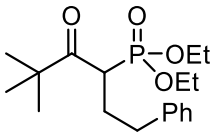
The title compound **18** was synthesized according to General Procedure (SI 3.1), and it was purified by column chromatography on silica gel (PE:EA = 3:1, 64% yield, 45.3 mg, yellow oil).

^{1}H NMR (600 MHz, $CDCl_3$) δ 7.31-7.26 (m, 2H), 7.22-7.14 (m, 3H), 4.14-4.02 (m, 4H), 3.32 (ddd, *J* = 24.8, 10.4, 3.4 Hz, 1H), 3.26-3.19 (m, 1H), 2.67-2.59 (m, 1H), 2.52-2.43 (m, 1H), 2.43-2.32 (m, 1H), 2.14-2.04 (m, 1H), 1.99-1.92 (m, 1H), 1.92-1.85 (m, 1H), 1.77-1.68 (m, 2H), 1.68-1.62 (m, 1H), 1.62-1.54 (m, 2H), 1.53-1.46 (m, 1H), 1.30 (t, *J* = 7.1 Hz, 6H).

^{13}C NMR (151 MHz, $CDCl_3$) δ 208.4 (d, *J* = 4.3 Hz), 140.6, 128.39, 128.37, 126.1, 62.6 (d, *J* = 6.7 Hz), 62.4 (d, *J* = 6.9 Hz), 52.4, 51.7 (d, *J* = 124.4 Hz), 34.3 (d, *J* = 14.8 Hz), 30.3, 28.0, 27.8 (d, *J* = 4.8 Hz), 26.0, 25.9, 16.31 (d, *J* = 6.1 Hz), 16.29 (d, *J* = 6.1 Hz).

^{31}P NMR (243 MHz, $CDCl_3$) δ 22.52.

HRMS (ESI) m/z: $[M+H]^+$ calcd. for $C_{19}H_{30}O_4P$: 353.1876, found: 353.1876.



19

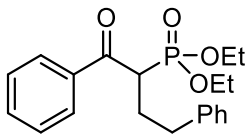
The title compound **19** was synthesized according to General Procedure (SI 3.1, without **L1**), and it was purified by column chromatography on silica gel (PE:EA = 5:1, 25% yield, 17.3 mg, colorless oil).

^{1}H NMR (600 MHz, $CDCl_3$) δ 7.23-7.18 (m, 2H), 7.16-7.08 (m, 3H), 4.16-3.96 (m, 4H), 3.61 (ddd, *J* = 20.7, 8.0, 5.9 Hz, 1H), 2.54 (t, J = 8.0 Hz, 2H), 2.20-2.06 (m, 2H), 1.25 (t, J = 7.0 Hz, 6H)), 1.08 (s, 9H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 212.0 (d, *J* = 5.5 Hz), 140.8, 128.45, 128.41, 126.2, 62.6 (d, *J* = 6.6 Hz), 62.4 (d, *J* = 7.0 Hz), 45.8 (d, *J* = 129.5 Hz), 45.4 (d, *J* = 1.8 Hz), 34.5 (d, *J* = 11.7 Hz), 30.8 (d, *J* = 5.5 Hz), 26.6, 16.4 (d, *J* = 6.2 Hz).

^{31}P NMR (243 MHz, $CDCl_3$) δ 23.38.

HRMS (ESI) m/z: $[M+H]^+$ calcd. for $C_{18}H_{30}O_4P$: 341.1876, found: 341.1875.



20

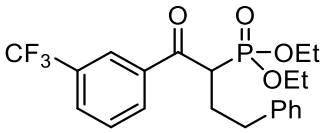
The title compound **20** was synthesized according to General Procedure (SI 3.1), and it was purified by column chromatography on silica gel (PE:EA = 2:1, 42% yield, 30.3 mg, yellow oil).

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.98-7.85 (m, 2H), 7.59 (t, *J* = 7.4 Hz, 1H), 7.47 (t, *J* = 7.6 Hz, 2H), 7.31-7.19 (m, 3H), 7.15-7.08 (m, 2H), 4.18-3.98 (m, 5H), 2.80-2.69 (m, 1H), 2.67-2.49 (m, 2H), 2.36-2.24 (m, 1H), 1.27 (t, *J* = 7.0 Hz, 3H), 1.16 (t, *J* = 7.1 Hz, 3H).

^{13}C NMR (151 MHz, $CDCl_3$) δ 196.0 (d, *J* = 5.3 Hz), 140.4, 137.5, 133.3, 128.7, 128.6, 128.42, 128.39, 126.2, 62.8 (d, *J* = 7.0 Hz), 62.5 (d, *J* = 6.7 Hz), 46.2 (d, *J* = 127.7 Hz), 34.0 (d, *J* = 15.1 Hz), 28.9 (d, *J* = 4.4 Hz), 16.3 (d, *J* = 6.0 Hz), 16.1 (d, *J* = 6.2 Hz).

^{31}P NMR (243 MHz, $CDCl_3$) δ 22.21.

HRMS (ESI) m/z: $[M+H]^+$ calcd. for $C_{20}H_{26}O_4P$: 361.1563, found: 361.1563.



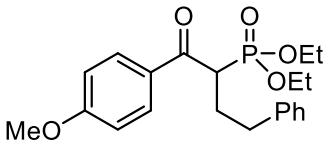
21

The title compound **21** was synthesized according to General Procedure (SI 3.1), and it was purified by column chromatography on silica gel (PE:EA = 3:1, 48% yield, 40.9 mg, yellow oil).

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.52 (d, *J* = 7.8 Hz, 2H), 7.35-7.17 (m, 5H), 7.07 (d, *J* = 7.4 Hz, 2H), 4.10-3.93 (m, 4H), 3.24-3.05 (m, 1H), 2.94 (t, *J* = 7.4 Hz, 1H), 2.70-2.54 (m, 1H), 2.52-2.29 (m, 1H), 2.20-1.93 (m, 1H), 1.33-1.20 (m, 6H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 204.0 (d, *J* = 4.4 Hz), 140.1, 138.1, 131.8, 131.1 (q, *J* = 33.2 Hz), 129.6 (q, *J* = 3.3 Hz), 129.1, 128.6, 128.5, 126.4, 125.5 (q, *J* = 3.9 Hz), 123.6 (q, *J* = 273.3 Hz), 63.0 (d, *J* = 6.9 Hz), 62.7 (d, *J* = 6.9 Hz), 46.6 (d, *J* = 127.2 Hz), 34.0 (d, *J* = 14.8 Hz), 28.7 (d, *J* = 4.3 Hz), 16.3 (d, *J* = 5.9 Hz), 16.0 (d, *J* = 6.3 Hz).

HRMS (ESI) m/z: $[M+H]^+$ calcd. for $C_{21}H_{25}F_3O_4P$: 429.1437, found: 429.1435.



22

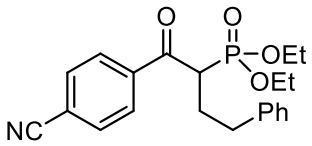
The title compound **22** was synthesized according to General Procedure (SI 3.1), and it was purified by column chromatography on silica gel (PE:EA = 1:1, 73% yield, 57.0 mg, yellow oil).

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.94-7.86 (m, 2H), 7.28-7.13 (m, 3H), 7.13-7.05 (m, 2H), 6.96-6.88 (m, 2H), 4.17-3.92 (m, 5H), 3.88 (s, 3H), 2.71 (ddd, *J* = 13.4, 9.0, 4.6 Hz, 1H), 2.63-2.54 (m, 1H), 2.54-2.45 (m, 1H), 2.32-2.20 (m, 1H), 1.25 (t, *J* = 7.0 Hz, 3H), 1.17 (t, *J* = 7.1 Hz, 3H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 194.2 (d, *J* = 5.2 Hz), 163.8, 140.7, 131.2, 130.7, 128.6, 128.4, 126.2, 113.6, 62.7 (d, *J* = 6.9 Hz), 62.5 (d, *J* = 6.9 Hz), 55.5, 45.9 (d, *J* = 128.0 Hz), 34.1 (d, *J* = 15.0 Hz), 29.1 (d, *J* = 4.6 Hz), 16.3 (d, *J* = 5.9 Hz), 16.2 (d, *J* = 6.3 Hz).

^{31}P NMR (162 MHz, $CDCl_3$) δ 22.67.

HRMS (ESI) m/z: $[M+H]^+$ calcd. for $C_{21}H_{28}O_5P$: 391.1669, found: 391.1654.



23

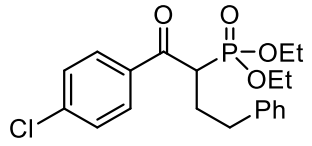
The title compound **23** was synthesized according to General Procedure (SI 3.1), and it was purified by column chromatography on silica gel (PE:EA = 4:1, 36% yield, 28.0 mg, yellow oil).

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.99-7.68 (m, 4H), 7.25-7.14 (m, 3H), 7.09-7.02 (m, 2H), 4.19-3.92 (m, 5H), 2.78-2.67 (m, 1H), 2.65-2.47 (m, 2H), 2.37-2.23 (m, 1H), 1.27 (t, *J* = 7.1 Hz, 3H), 1.16 (t, *J* = 7.1 Hz, 3H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 194.9 (d, *J* = 5.6 Hz), 140.5, 140.0, 132.2, 129.0, 128.61, 128.55, 126.4, 117.8, 116.4, 63.0 (d, *J* = 6.9 Hz), 62.8 (d, *J* = 6.9 Hz), 46.9 (d, *J* = 127.0 Hz), 34.0 (d, *J* = 14.4 Hz), 28.6 (d, *J* = 4.4 Hz), 16.3 (d, *J* = 5.9 Hz), 16.2 (d, *J* = 6.1 Hz).

^{31}P NMR (162 MHz, $CDCl_3$) δ 21.08.

HRMS (ESI) m/z: $[M+H]^+$ calcd. for $C_{21}H_{25}NO_4P$: 386.1516, found: 386.1486.



24

The title compound **24** was synthesized according to General Procedure (SI 3.1), and it was purified by column chromatography on silica gel (PE:EA = 4:1, 57% yield, 45.3 mg, yellow oil).

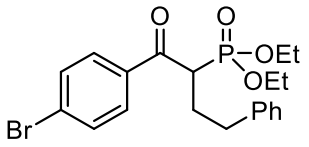
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.86-7.78 (m, 2H), 7.47-7.37 (m, 2H), 7.29-7.13 (m, 3H), 7.10-7.04 (m, 2H), 4.18-3.92 (m, 5H), 2.76-2.67 (m, 1H), 2.65-2.56 (m, 1H),

2.55-2.46 (m, 1H), 2.34-2.22 (m, 1H), 1.26 (t, *J* = 7.0 Hz, 3H), 1.17 (t, *J* = 7.0 Hz, 3H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 194.7 (d, *J* = 5.3 Hz), 140.3, 139.8, 135.9, 130.1, 128.69, 128.6, 128.4, 126.3, 62.8 (d, *J* = 6.9 Hz), 62.6 (d, *J* = 6.9 Hz), 46.3 (d, *J* = 127.7 Hz), 34.0 (d, *J* = 14.7 Hz), 28.8 (d, *J* = 4.5 Hz), 16.2 (d, *J* = 5.9 Hz), 16.1 (d, *J* = 6.2 Hz).

^{31}P NMR (162 MHz, $CDCl_3$) δ 21.84.

HRMS (ESI) m/z: $[M+H]^+$ calcd. for $C_{20}H_{25}ClO_4P$: 395.1173, found: 395.1173.



25

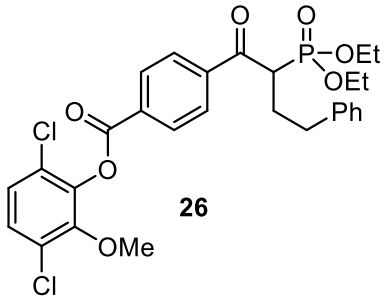
The title compound **25** was synthesized according to General Procedure (SI 3.1), and it was purified by column chromatography on silica gel (PE:EA = 4:1, 52% yield, 45.5 mg, yellow oil).

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.78-7.70 (m, 2H), 7.62-7.54 (m, 2H), 7.27-7.15 (m, 3H), 7.10-7.04 (m, 2H), 4.17-3.92 (m, 5H), 2.76-2.66 (m, 1H), 2.65-2.55 (m, 1H), 2.55-2.46 (m, 1H), 2.35-2.21 (m, 1H), 1.26 (t, *J* = 7.1 Hz, 3H), 1.17 (t, *J* = 7.1 Hz, 3H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 194.9 (d, *J* = 5.4 Hz), 140.3, 136.3, 131.7, 130.2, 128.58, 128.57, 128.5, 126.3, 62.8 (d, *J* = 6.9 Hz), 62.7 (d, *J* = 7.0 Hz), 46.3 (d, *J* = 127.7 Hz), 34.0 (d, *J* = 14.8 Hz), 28.8 (d, *J* = 4.4 Hz), 16.3 (d, *J* = 5.9 Hz), 16.1 (d, *J* = 6.2 Hz).

^{31}P NMR (162 MHz, $CDCl_3$) δ 21.79.

HRMS (ESI) m/z: $[M+H]^+$ calcd. for $C_{20}H_{25}BrO_4P$: 439.0668, found: 439.0673.

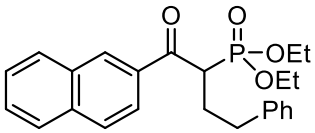


26

The title compound **26** was synthesized according to General Procedure (SI 3.1), and it was purified by column chromatography on silica gel (PE:EA = 4:1, 58% yield, 67.4 mg, yellow oil).

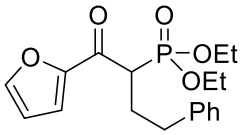
^{1}H NMR (400 MHz, $CDCl_3$) δ 8.03-7.97 (m, 2H), 7.44 (d, *J* = 8.7 Hz, 1H), 7.40-7.32 (m, 2H), 7.28-7.18 (m, 4H), 7.14-7.06 (m, 2H), 4.16-4.02 (m, 5H), 4.01 (s, 3H), 2.78-2.68 (m, 1H), 2.67-2.48 (m, 2H), 2.36-2.25 (m, 1H), 1.27 (t, *J* = 7.1 Hz, 3H), 1.18 (t, *J* = 7.0 Hz, 3H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 194.7 (d, *J* = 5.5 Hz), 162.4, 154.20, 154.16, 140.4, 135.7, 132.6, 130.6, 129.8, 129.4, 128.6, 128.5, 126.9, 126.3, 126.0, 121.5, 62.8 (d, *J* = 6.9 Hz), 62.7 (d, *J* = 6.9 Hz), 62.4, 46.5 (d, *J* = 127.6 Hz), 34.1 (d, *J* = 14.8 Hz), 28.9 (d, *J* = 4.4 Hz), 16.3 (d, *J* = 6.0 Hz), 16.2 (d, *J* = 6.2 Hz).
^{31}P NMR (162 MHz, $CDCl_3$) δ 21.90.
HRMS (ESI) m/z: $[M+NH_4]^+$ calcd. for $C_{28}H_{33}Cl_2NO_7P$: 596.1366, found: 596.1343.



27

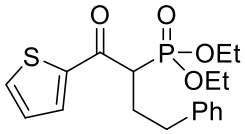
The title compound **27** was synthesized according to General Procedure (SI 3.1), and it was purified by column chromatography on silica gel (PE:EA = 5:1, 67% yield, 55.1 mg, yellow oil).
^{1}H NMR (400 MHz, $CDCl_3$) δ 8.34 (s, 1H), 8.00 (dd, *J* = 8.7, 2.0 Hz, 1H), 7.94-7.84 (m, 3H), 7.65-7.50 (m, 2H), 7.28-7.15 (m, 3H), 7.11 (dd, *J* = 8.0, 1.7 Hz, 2H), 4.27 (ddd, *J* = 23.4, 10.1, 3.5 Hz, 1H), 4.17-3.95 (m, 4H), 2.82-2.72 (m, 1H), 2.71-2.62 (m, 1H), 2.61-2.51 (m, 1H), 2.43-2.28 (m, 1H), 1.26 (t, *J* = 7.1 Hz, 3H), 1.12 (t, *J* = 7.0 Hz, 3H).
^{13}C NMR (101 MHz, $CDCl_3$) δ 195.8 (d, *J* = 5.5 Hz), 140.5, 135.6, 134.91, 134.89, 132.3, 130.7, 129.7, 128.6, 128.4, 128.3, 127.6, 126.7, 126.2, 124.2, 62.8 (d, *J* = 6.9 Hz), 62.5 (d, *J* = 6.9 Hz), 46.2 (d, *J* = 128.3 Hz), 34.0 (d, *J* = 14.8 Hz), 29.0 (d, *J* = 4.4 Hz), 16.3 (d, *J* = 6.0 Hz), 16.1 (d, *J* = 6.2 Hz).
^{31}P NMR (162 MHz, $CDCl_3$) δ 22.45.
HRMS (ESI) m/z: $[M+H]^+$ calcd. for $C_{24}H_{28}O_4P$: 411.1720, found: 411.1713.



28

The title compound **28** was synthesized according to General Procedure (SI 3.1), and it was purified by column chromatography on silica gel (PE:EA = 3:1, 38% yield, 26.4 mg, yellow oil).
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.53 (d, *J* = 2.1 Hz, 1H), 7.20-7.07 (m, 4H), 7.06-7.01 (m, 2H), 6.48 (dd, *J* = 3.7, 1.7 Hz, 1H), 4.10-3.93 (m, 4H), 3.85 (ddd, *J* = 23.7, 10.5, 3.7 Hz, 1H), 2.70-2.57 (m, 1H), 2.56-2.40 (m, 2H), 2.26-2.07 (m, 1H), 1.20 (t, *J* = 7.1 Hz, 3H), 1.12 (t, *J* = 7.1 Hz, 3H).
^{13}C NMR (101 MHz, $CDCl_3$) δ 184.0 (d, *J* = 5.5 Hz), 153.0, 146.8, 140.5, 128.6, 128.4, 126.2, 112.6, 62.73 (d, *J* = 2.9 Hz), 62.66 (d, *J* = 2.9 Hz), 46.9 (d, *J* = 128.4 Hz), 34.2 (d, *J* = 15.0 Hz), 28.4 (d, *J* = 4.8 Hz), 16.3 (d, *J* = 5.9 Hz), 16.2 (d, *J* = 6.2 Hz).
31P NMR (162 MHz, CDCl3) δ 21.99.

MS (EI): $[M]^+$:350.15.



29

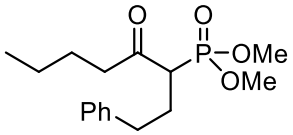
The title compound **29** was synthesized according to General Procedure (SI 3.1), and it was purified by column chromatography on silica gel (PE:EA = 3:1, 57% yield, 42.0 mg, yellow oil).

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.59 (ddd, *J* = 13.4, 4.4, 1.2 Hz, 2H), 7.20-7.14 (m, 2H), 7.14-7.08 (m, 1H), 7.07-7.00 (m, 3H), 4.14-3.87 (m, 4H), 3.79 (ddd, *J* = 23.0, 10.3, 3.5 Hz, 1H), 2.72-2.61 (m, 1H), 2.56-2.40 (m, 2H), 2.26-2.11 (m, 1H), 1.20 (t, *J* = 7.0 Hz, 3H), 1.12 (t, *J* = 7.1 Hz, 3H).

^{13}C NMR (151 MHz, $CDCl_3$) δ 188.1 (d, *J* = 5.0 Hz), 144.9, 140.4, 134.7, 133.2, 128.6, 128.4, 128.2, 126.2, 62.9 (d, *J* = 6.6 Hz), 62.7 (d, *J* = 6.6 Hz), 48.1 (d, *J* = 128.8 Hz), 34.1 (d, *J* = 14.9 Hz), 28.9 (d, *J* = 4.4 Hz), 16.3 (d, *J* = 6.1 Hz), 16.2 (d, *J* = 6.1 Hz).

31P NMR (162 MHz, CDCl3) δ 21.83.

MS (EI): $[M]^+$:366.15.



30

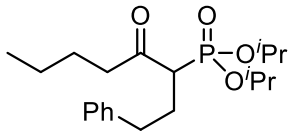
The title compound **30** was synthesized according to General Procedure (SI 3.1), and it was purified by column chromatography on silica gel (PE:EA = 5:1, 64% yield, 39.7 mg, yellow oil).

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.40-7.00 (m, 5H), 3.74 (dd, *J* = 11.0, 3.6 Hz, 6H), 3.20 (ddd, *J* = 24.6, 10.4, 3.5 Hz, 1H), 2.83-2.71 (m, 1H), 2.70-2.61 (m, 1H), 2.57-2.47 (m, 1H), 2.46-2.33 (m, 2H), 2.17-2.02 (m, 1H), 1.63-1.48 (m, 2H), 1.39-1.25 (m, 2H), 0.92 (t, *J* = 7.3 Hz, 3H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 205.5 (d, *J* = 4.4 Hz), 140.4, 128.5, 128.4, 126.3, 53.2 (d, *J* = 6.7 Hz), 53.0 (d, *J* = 6.8 Hz), 51.2 (d, *J* = 125.1 Hz), 44.1, 34.1 (d, *J* = 14.9 Hz), 27.8 (d, *J* = 4.8 Hz), 25.4, 22.0, 13.8.

^{31}P NMR (162 MHz, $CDCl_3$) δ 24.99.

HRMS (ESI) m/z: $[M+H]^+$ calcd. for $C_{16}H_{26}O_4P$: 313.1563, found: 313.1554.



31

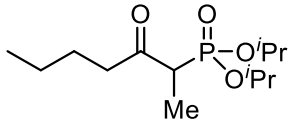
The title compound **31** was synthesized according to General Procedure (SI 3.1), and it was purified by column chromatography on silica gel (PE:EA = 5:1, 86% yield, 63.0 mg, yellow oil).

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.31-7.24 (m, 2H), 7.22–7.17 (m, 1H), 7.17–7.11 (m, 2H), 4.74–4.56 (m, 2H), 3.17 – 3.02 (ddd, *J* = 25.0, 10.6, 3.2 Hz, 1H), 2.78 (dt, *J* = 17.7, 7.5 Hz, 1H), 2.64 (ddd, *J* = 13.9, 9.2, 5.2 Hz, 1H), 2.54–2.28 (m, 3H), 2.13–1.99 (m, 1H), 1.54 (p, J = 7.5 Hz, 2H), 1.40–1.23 (m, 14H), 0.90 (t, *J* = 7.3 Hz, 3H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 205.7 (d, *J* = 4.4 Hz), 140.7, 128.5, 128.4, 126.1, 71.3 (d, *J* = 7.0 Hz), 71.0 (d, *J* = 7.0 Hz), 52.6 (d, *J* = 125.7 Hz), 43.9, 34.2 (d, *J* = 15.0 Hz), 27.8 (d, *J* = 4.8 Hz), 25.5, 24.0 (t, *J* = 3.8 Hz), 23.8 (d, *J* = 5.1 Hz), 23.7 (d, J = 5.1 Hz), 22.1, 13.8.

^{31}P NMR (162 MHz, $CDCl_3$) δ 20.42.

HRMS (ESI) m/z: $[M+H]^+$ calcd. for $C_{20}H_{34}O_4P$: 369.2189, found: 369.2189.



32

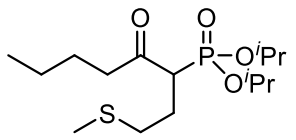
The title compound **32** was synthesized according to General Procedure (SI 3.1), and it was purified by column chromatography on silica gel (PE:EA = 3:1, 64% yield, 35.4 mg, yellow oil).

^{1}H NMR (600 MHz, $CDCl_3$) δ 4.77-4.62 (m, 2H), 3.17 (dq, *J* = 25.3, 7.1 Hz, 1H), 2.81 (dt, *J* = 17.6, 7.4 Hz, 1H), 2.54 (dt, *J* = 17.5, 7.2 Hz, 1H), 1.59-1.52 (m, 2H), 1.35-1.30 (m, 17H), 0.91 (t, *J* = 7.4 Hz, 3H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 206.2 (d, *J* = 3.9 Hz), 71.2 (d, *J* = 7.0 Hz), 71.0 (d, *J* = 7.0 Hz), 47.3 (d, *J* = 128.1 Hz), 42.8, 25.7, 24.0 (t, *J* = 3.9 Hz), 23.8 (t, *J* = 4.8 Hz), 22.1, 13.8, 11.0 (d, *J* = 6.5 Hz).

^{31}P NMR (162 MHz, $CDCl_3$) δ 21.73.

HRMS (ESI) m/z: $[M+H]^+$ calcd. for $C_{13}H_{28}O_4P$: 279.1720, found: 279.1720.



33

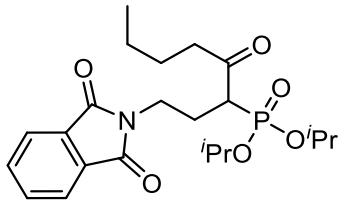
The title compound **33** was synthesized according to General Procedure (SI 3.1), and it was purified by column chromatography on silica gel (PE:EA = 5:1, 41% yield, 27.6 mg, yellow oil).

^{1}H NMR (400 MHz, $CDCl_3$) δ 4.72-4.50 (m, 2H), 3.33 (ddd, *J* = 25.4, 10.1, 3.3 Hz, 1H), 2.84-2.71 (m, 1H), 2.56-2.38 (m, 2H), 2.38-2.20 (m, 2H), 1.97 (s, 3H), 1.94-1.85 (m, 1H), 1.56-1.43 (m, 2H), 1.34-1.16 (m, 14H), 0.84 (t, *J* = 7.3 Hz, 3H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 205.4 (d, *J* = 4.4 Hz), 71.4 (d, *J* = 7.0 Hz), 71.2 (d, *J* = 7.0 Hz), 51.7 (d, *J* = 125.8 Hz), 44.2, 32.7 (d, *J* = 15.8 Hz), 25.6, 25.1 (d, *J* = 4.4 Hz), 24.05 (d, *J* = 3.3 Hz), 24.0 (d, *J* = 3.7 Hz), 23.84 (d, *J* = 4.8 Hz), 23.77 (d, *J* = 5.5 Hz), 22.1, 14.8, 13.8.

^{31}P NMR (162 MHz, $CDCl_3$) δ 20.23.

HRMS (ESI) m/z: $[M+H]^+$ calcd. for $C_{15}H_{32}O_4PS$: 339.1753, found: 339.1753.



34

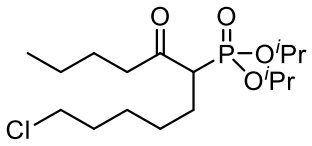
The title compound **34** was synthesized according to General Procedure (SI 3.1), and it was purified by column chromatography on silica gel (PE:EA = 3:1, 86% yield, 75.2 mg, white solid).

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.80 (ddd, *J* = 46.8, 5.5, 3.1 Hz, 4H), 4.75-4.55 (m, 2H), 3.77-3.57 (m, 2H), 3.19 (ddd, *J* = 26.0, 10.9, 2.9 Hz, 1H), 2.93 (dt, *J* = 18.1, 7.4 Hz, 1H), 2.58 (dt, *J* = 18.3, 7.2 Hz, 1H), 2.52-2.37 (m, 1H), 2.18-2.02 (m, 1H), 1.59-1.48 (m, 2H), 1.38-1.32 (m, 2H), 1.32-1.24 (m, 12H), 0.91 (t, *J* = 7.3 Hz, 3H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 205.0, 168.3, 134.0, 132.0, 123.2, 71.6 (d, *J* = 7.1 Hz), 71.3 (d, *J* = 7.0 Hz), 51.2 (d, *J* = 126.0 Hz), 43.7, 36.6 (d, *J* = 16.3 Hz), 25.42, 25.37, 24.0 (d, *J* = 3.7 Hz), 23.9 (d, *J* = 4.0 Hz), 23.7 (d, *J* = 5.2 Hz), 22.1, 13.9.

^{31}P NMR (162 MHz, $CDCl_3$) δ 19.62.

HRMS (ESI) m/z: $[M+NH_4]^+$ calcd. for $C_{22}H_{36}N_2O_6P$: 455.2305, found: 455.2305.



35

The title compound **35** was synthesized according to General Procedure (SI 3.1), and it was purified by column chromatography on silica gel (PE:EA = 3:1, 86% yield, 63.1 mg, yellow oil).

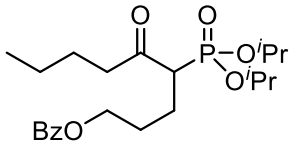
^{1}H NMR (400 MHz, $CDCl_3$) δ 4.76-4.60 (m, 2H), 3.51 (t, *J* = 6.6 Hz, 2H), 3.09 (ddd, *J* = 24.6, 10.8, 3.4 Hz, 1H), 2.77 (dt, *J* = 17.5, 7.2 Hz, 1H), 2.48 (ddd, *J* = 17.5, 8.1, 6.5 Hz, 1H), 2.11-1.96 (m, 1H), 1.88-1.80 (m, 1H), 1.79-1.70 (m, 2H), 1.62-1.51 (m,

2H), 1.50-1.38 (m, 2H), 1.36-1.30 (m, 12H), 1.30-1.24 (m, 4H), 0.91 (t, *J* = 7.3 Hz, 3H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 205.9 (d, *J* = 4.5 Hz), 71.3 (d, *J* = 7.0 Hz), 71.1 (d, *J* = 7.1 Hz), 53.6 (d, *J* = 126.1 Hz), 44.8, 43.9, 32.1, 27.8 (d, *J* = 15.0 Hz), 26.6, 26.2 (d, *J* = 5.1 Hz), 25.6, 24.05 (d, *J* = 3.5 Hz), 23.99 (d, *J* = 3.9 Hz), 23.8 (t, *J* = 5.4 Hz), 22.2, 13.8.

^{31}P NMR (162 MHz, $CDCl_3$) δ 20.51.

HRMS (ESI) m/z: $[M+H]^+$ calcd. for $C_{17}H_{35}ClO_4P$: 369.1956, found: 369.1953.



36

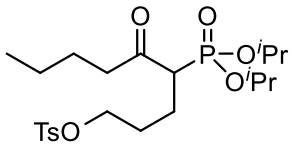
The title compound **36** was synthesized according to General Procedure (SI 3.1), and it was purified by column chromatography on silica gel (PE:EA = 4:1, 75% yield, 63.9 mg, yellow oil).

^{1}H NMR (400 MHz, $CDCl_3$) δ 8.07-8.01 (m, 2H), 7.58-7.52 (m, 1H), 7.47-7.38 (m, 2H), 4.76-4.60 (m, 2H), 4.30 (t, *J* = 6.3 Hz, 2H), 3.17 (ddd, *J* = 24.8, 10.6, 3.7 Hz, 1H), 2.82 (dt, *J* = 17.5, 7.3 Hz, 1H), 2.56-2.44 (m, 1H), 2.25-2.08 (m, 1H), 2.02-1.85 (m, 1H), 1.83-1.64 (m, 2H), 1.61-1.50 (m, 2H), 1.34-1.26 (m, 14H), 0.90 (t, *J* = 7.4 Hz, 3H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 205.6 (d, *J* = 4.5 Hz), 166.4, 132.8, 130.2, 129.5, 128.3, 71.4 (d, *J* = 7.0 Hz), 71.1 (d, *J* = 7.1 Hz), 64.2, 53.1 (d, *J* = 126.2 Hz), 43.9, 27.5 (d, *J* = 14.7 Hz), 25.5, 24.0 (d, *J* = 3.6 Hz), 23.9 (d, *J* = 3.9 Hz), 23.8 (d, *J* = 5.1 Hz), 23.7 (d, *J* = 5.4 Hz), 23.1 (d, *J* = 5.0 Hz), 22.1, 13.8.

^{31}P NMR (162 MHz, $CDCl_3$) δ 20.05.

HRMS (ESI) m/z: $[M+H]^+$ calcd. for $C_{22}H_{36}O_6P$: 427.2244, found: 427.2244.

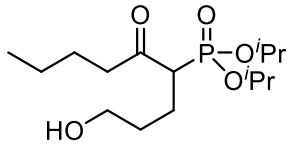


37

The title compound **37** was synthesized according to General Procedure (SI 3.1), and it was purified by column chromatography on silica gel (PE:EA = 2:1, 49% yield, 46.7 mg, yellow oil).

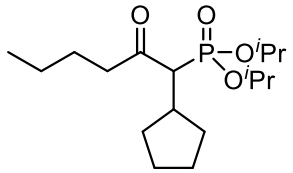
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.78 (d, *J* = 8.3 Hz, 2H), 7.35 (d, *J* = 8.0 Hz, 2H), 4.73-4.59 (m, 2H), 3.99 (t, *J* = 6.3 Hz, 2H), 3.06 (ddd, *J* = 25.0, 10.3, 3.9 Hz, 1H), 2.78 (dt, *J* = 17.5, 7.5 Hz, 1H), 2.50-2.40 (m, 4H), 2.06-1.92 (m, 1H), 1.81-1.73 (m, 1H), 1.67-1.58 (m, 2H), 1.56-1.47 (m, 2H), 1.37-1.34 (m, 2H), 1.33-1.29 (m, 12H), 0.90 (t, *J* = 7.3 Hz, 3H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 205.4, 144.7, 133.1, 129.8, 127.8, 71.5 (d, *J* = 6.9 Hz), 71.2 (d, *J* = 7.1 Hz), 69.8, 52.8 (d, *J* = 127.2 Hz), 43.8, 27.6 (d, *J* = 14.4 Hz), 25.5, 24.0 (d, *J* = 3.3 Hz), 23.9 (d, *J* = 3.7 Hz), 23.8 (d, *J* = 4.8 Hz), 23.7 (d, *J* = 5.1 Hz), 22.6 (d, *J* = 4.7 Hz), 22.1, 21.5, 13.8.
^{31}P NMR (162 MHz, $CDCl_3$) δ 19.69.
HRMS (ESI) m/z: $[M+H]^+$ calcd. for $C_{22}H_{38}O_7PS$: 477.2070, found: 477.2070.



38

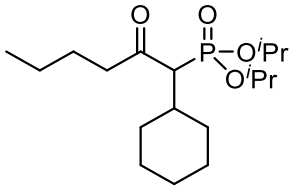
The title compound **38** was synthesized according to General Procedure (SI 3.1), and it was purified by column chromatography on silica gel (PE:EA = 1:3, 73% yield, 47.1 mg, yellow oil).
^{1}H NMR (400 MHz, $CDCl_3$) δ 4.77-4.61 (m, 2H), 3.37 (t, *J* = 6.5 Hz, 2H), 3.10 (ddd, *J* = 24.9, 10.3, 3.6 Hz, 1H), 2.81 (dt, *J* = 17.6, 7.2 Hz, 1H), 2.55-2.43 (m, 1H), 2.18-2.05 (m, 1H), 1.99-1.89 (m, 1H), 1.87-1.73 (m, 2H), 1.67-1.50 (m, 2H), 1.40-1.28 (m, 14H), 0.91 (t, *J* = 7.3 Hz, 3H).
^{13}C NMR (101 MHz, $CDCl_3$) δ 205.5 (d, *J* = 4.4 Hz), 71.5 (d, *J* = 7.0 Hz), 71.2 (d, *J* = 7.1 Hz), 52.8 (d, *J* = 126.4 Hz), 43.8, 32.6, 31.3 (d, *J* = 14.6 Hz), 25.5, 25.1 (d, *J* = 5.1 Hz), 24.03 (d, *J* = 3.6 Hz), 23.97 (d, *J* = 4.0 Hz), 23.8 (d, *J* = 5.1 Hz), 23.7 (d, *J* = 5.3 Hz), 22.1, 13.8.
^{31}P NMR (162 MHz, $CDCl_3$) δ 19.82.
HRMS (ESI) m/z: $[M+Na]^+$ calcd. for $C_{15}H_{31}NaO_5P$: 345.1801, found: 345.1801.



39

The title compound **39** was synthesized according to General Procedure (SI 3.1), and it was purified by column chromatography on silica gel (PE:EA = 5:1, 67% yield, 44.3 mg, yellow oil).
^{1}H NMR (400 MHz, $CDCl_3$) δ 4.80-4.60 (m, 2H), 2.92 (dd, *J* = 21.2, 10.9 Hz, 1H), 2.75-2.62 (m, 1H), 2.54-2.33 (m, 2H), 2.07-1.94 (m, 1H), 1.80-1.70 (m, 1H), 1.69-1.60 (m, 2H), 1.59-1.48 (m, 4H), 1.37-1.25 (m, 16H), 0.91 (t, *J* = 7.3 Hz, 3H).
^{13}C NMR (101 MHz, $CDCl_3$) δ 206.6 (d, *J* = 4.2 Hz), 71.0 (d, *J* = 6.8 Hz), 70.7 (d, *J* = 7.2 Hz), 59.3 (d, *J* = 127.7 Hz), 43.9, 39.0 (d, *J* = 5.3 Hz), 32.2 (d, *J* = 17.0 Hz), 31.6 (d, *J* = 1.8 Hz), 25.4, 24.71, 24.15, 24.14 (d, *J* = 2.9 Hz), 24.06 (d, *J* = 3.8 Hz), 23.88 (d, *J* = 5.1 Hz), 23.78 (d, *J* = 5.5 Hz), 22.16, 13.84.
^{31}P NMR (162 MHz, $CDCl_3$) δ 20.46.

HRMS (ESI) m/z: $[M+H]^+$ calcd. for $C_{17}H_{34}O_4P$: 333.2189, found: 333.2198.



40

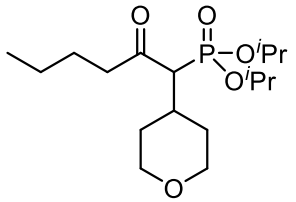
The title compound **40** was synthesized according to General Procedure (SI 3.1), and it was purified by column chromatography on silica gel (PE:EA = 9:1, 46% yield, 32.0 mg, yellow oil).

^{1}H NMR (400 MHz, $CDCl_3$) δ 4.80-4.63 (m, *J* = 5.9 Hz, 2H), 2.93 (dd, *J* = 21.3, 9.9 Hz, 1H), 2.65 (ddd, *J* = 18.1, 8.7, 6.4 Hz, 1H), 2.44 (ddd, *J* = 18.0, 8.6, 6.2 Hz, 1H), 2.11-2.07 (m, 1H), 1.79-1.68 (m, 2H), 1.66-1.43 (m, 6H), 1.34-1.25 (m, 16H), 1.17-1.05 (m, 2H), 0.90 (t, *J* = 7.3 Hz, 3H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 206.8 (d, *J* = 4.8 Hz), 71.0 (d, *J* = 7.0 Hz), 70.8 (d, *J* = 7.3 Hz), 60.0 (d, *J* = 128.0 Hz), 44.6, 37.6 (d, *J* = 4.8 Hz), 32.2 (d, *J* = 15.8 Hz), 31.7 (d, *J* = 3.7 Hz), 26.10, 26.06, 26.04, 26.00, 25.3, 24.14 (d, *J* = 3.3 Hz), 24.07 (d, *J* = 3.7 Hz), 23.85 (d, *J* = 4.8 Hz), 23.78 (d, *J* = 5.5 Hz), 13.9.

^{31}P NMR (162 MHz, $CDCl_3$) δ 20.74.

HRMS (ESI) m/z: $[M+H]^+$ calcd. for $C_{18}H_{36}O_4P$: 347.2346, found: 347.2346.



41

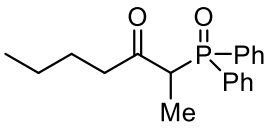
The title compound **41** was synthesized according to General Procedure (SI 3.1), and it was purified by column chromatography on silica gel (PE:EA = 3:1, 77% yield, 53.8 mg, yellow oil).

^{1}H NMR (400 MHz, $CDCl_3$) δ 4.83-4.62 (m, 2H), 3.93 (ddd, *J* = 26.0, 11.6, 4.3 Hz, 2H), 3.44-3.32 (m, 2H), 2.97 (dd, *J* = 21.5, 10.2 Hz, 1H), 2.78-2.65 (m, 1H), 2.50-2.37 (m, 1H), 2.37-2.25 (m, 1H), 1.64-1.51 (m, 2H), 1.50-1.41 (m, 2H), 1.38-1.27 (m, 16H), 0.91 (t, *J* = 7.3 Hz, 3H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 206.2 (d, *J* = 4.9 Hz), 71.3 (d, *J* = 6.9 Hz), 71.0 (d, *J* = 7.3 Hz), 67.7, 67.6 (d, *J* = 2.0 Hz), 59.3 (d, *J* = 127.5 Hz), 45.2, 34.8 (d, *J* = 4.8 Hz), 32.0 (d, *J* = 16.3 Hz), 31.7 (d, *J* = 3.4 Hz), 25.2, 24.1 (d, *J* = 3.3 Hz), 24.0 (d, *J* = 3.9 Hz), 23.9 (d, *J* = 5.0 Hz), 23.8 (d, *J* = 5.5 Hz), 22.1, 13.8.

^{31}P NMR (162 MHz, $CDCl_3$) δ 19.46.

HRMS (ESI) m/z: $[M+H]^+$ calcd. for $C_{17}H_{34}O_5P$: 349.2138, found: 349.2138.



42

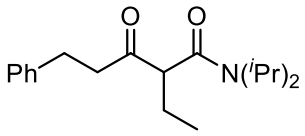
The title compound **42** was synthesized according to General Procedure (SI 3.1), and it was purified by column chromatography on silica gel (PE:EA = 2:1, 88% yield, 55.4 mg, yellow solid).

^{1}H NMR (600 MHz, $CDCl_3$) δ 7.86-7.74 (m, 4H), 7.57-7.44 (m, 6H), 3.68 (dq, *J* = 14.2, 7.2 Hz, 1H), 2.53 (t, *J* = 7.3 Hz, 2H), 1.43-1.35 (m, 5H), 1.14 (h, *J* = 7.4 Hz, 2H), 0.80 (t, *J* = 7.4 Hz, 3H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 207.5 (d, *J* = 2.6 Hz), 132.1 (d, *J* = 2.9 Hz), 132.0 (d, *J* = 2.9 Hz), 131.3 (d, *J* = 8.8 Hz), 131.2 (d, *J* = 8.7 Hz), 131.0 (d, *J* = 99.8 Hz), 130.9 (d, *J* = 108.9 Hz), 128.6 (d, *J* = 5.3 Hz), 128.5 (d, *J* = 5.2 Hz), 50.3 (d, *J* = 57.6 Hz), 42.6, 25.3, 21.9, 13.7, 11.4 (d, *J* = 3.6 Hz).

^{31}P NMR (162 MHz, $CDCl_3$) δ 30.37.

HRMS (ESI) m/z: $[M+H]^+$ calcd. for $C_{19}H_{24}O_2P$: 315.1508, found: 315.1489.



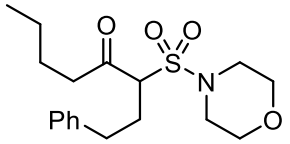
45

The title compound **45** was synthesized according to General Procedure (SI 3.1), and it was purified by column chromatography on silica gel (PE:EA = 30:1, 64% yield, 39.0 mg, yellow oil).

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.31-7.20 (m, 2H), 7.20-7.11 (m, 3H), 4.12-3.96 (m, 1H), 3.39 (t, *J* = 7.1 Hz, 2H), 2.93-2.84 (m, 2H), 2.84-2.71 (m, 2H), 2.02-1.87 (m, 1H), 1.86-1.75 (m, 1H), 1.37 (t, *J* = 7.0 Hz, 6H), 1.15 (d, *J* = 6.7 Hz, 3H), 1.06 (d, *J* = 6.6 Hz, 3H), 0.87 (t, *J* = 7.4 Hz, 3H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 206.5, 167.6, 141.0, 128.38, 128.36, 126.0, 61.1, 48.7, 46.2, 40.6, 29.5, 22.5, 20.9, 20.59, 20.55, 20.3, 12.1.

HRMS (ESI) m/z: $[M+H]^+$ calcd. for $C_{19}H_{30}NO_2$: 304.2271, found: 304.2264.



47

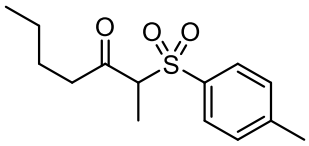
The title compound **47** was synthesized according to General Procedure (SI 3.1), and it was purified by column chromatography on silica gel (PE:EA = 15:1, 57% yield, 40.5 mg, yellow oil).

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.34-7.28 (m, 2H), 7.27-7.20 (m, 1H), 7.18-7.11 (m,

2H), 4.03 (dd, *J* = 10.4, 3.4 Hz, 1H), 3.73-3.60 (m, 4H), 3.36-3.21 (m, 4H), 2.82 (dt, *J* = 18.4, 7.4 Hz, 1H), 2.72-2.59 (m, 1H), 2.58-2.38 (m, 3H), 2.31-2.18 (m, 1H), 1.58-1.48 (m, 2H), 1.36-1.29 (m, 2H), 0.91 (t, *J* = 7.3 Hz, 3H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 203.35, 139.44, 128.75, 128.42, 126.70, 72.03, 66.87, 46.84, 44.04, 32.88, 28.56, 25.23, 22.02, 13.80.

HRMS (ESI) m/z: $[M+CH_3CN+Na]^+$ calcd. for $C_{20}H_{30}N_2NaO_4S$: 417.1818, found: 417.1818.



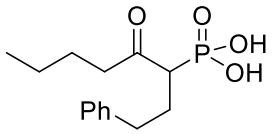
49

The title compound **49** was synthesized according to General Procedure (SI 3.1), and it was purified by column chromatography on silica gel (PE:EA = 30:1, 41% yield, 22.1 mg, yellow oil).

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.66 (d, *J* = 8.1 Hz, 2H), 7.35 (d, *J* = 8.0 Hz, 2H), 4.16 (q, *J* = 7.1 Hz, 1H), 2.89 (dt, *J* = 18.1, 7.3 Hz, 1H), 2.64 (dt, *J* = 18.1, 7.1 Hz, 1H), 2.45 (s, 3H), 1.55 (q, *J* = 7.5 Hz, 2H), 1.38 (d, *J* = 7.1 Hz, 3H), 1.36-1.22 (m, 2H), 0.91 (t, *J* = 7.3 Hz, 3H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 202.6, 145.4, 133.3, 129.7, 129.4, 70.0, 43.5, 25.4, 22.0, 21.6, 13.7, 12.0.

HRMS (ESI) m/z: $[M+K]^+$ calcd. for $C_{14}H_{20}KO_3S$: 307.0765, found: 307.0735.



50

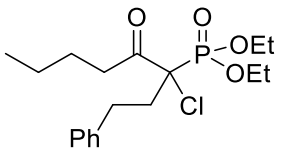
The title compound **50** was synthesized according to General Procedure (SI 3.3) without purified (95% yield, 27.0 mg, yellow solid).

^{1}H NMR (400 MHz, CD_3OD_SPE) δ 7.31-7.24 (m, 2H), 7.22-7.15 (m, 3H), 3.20 (ddd, *J* = 24.5, 10.5, 3.4 Hz, 1H), 2.77 (dt, *J* = 17.9, 7.4 Hz, 1H), 2.67-2.51 (m, 2H), 2.50-2.30 (m, 2H), 2.17-2.01 (m, 1H), 1.58-1.47 (m, 2H), 1.37-1.31 (m, 2H), 0.92 (t, *J* = 7.3 Hz, 3H).

^{13}C NMR (101 MHz, CD_3OD_SPE) δ 207.6 (d, *J* = 4.4 Hz), 140.9, 128.2, 128.1, 125.8, 52.8 (d, *J* = 122.1 Hz), 43.6, 33.9 (d, *J* = 14.7 Hz), 28.1 (d, *J* = 4.4 Hz), 25.2 (d, *J* = 2.2 Hz), 21.8, 12.8.

^{31}P NMR (162 MHz, CD_3OD_SPE) δ 19.59.

HRMS (ESI) m/z: $[M+H]^+$ calcd. for $C_{14}H_{22}O_4P$: 285.1250, found: 285.1250.



51

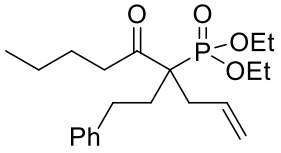
The title compound **51** was synthesized according to General Procedure (SI 3.3), and it was purified by column chromatography on silica gel (PE:EA = 8:1, 96% yield, 35.8 mg, colorless oil).

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.33-7.24 (m, 2H), 7.24-7.15 (m, 3H), 4.30-4.15 (m, 4H), 2.96-2.69 (m, 4H), 2.49 (td, *J* = 12.0, 4.0 Hz, 1H), 2.35-2.20 (m, 1H), 1.63-1.52 (m, 2H), 1.34 (t, *J* = 7.0 Hz, 8H), 0.92 (t, *J* = 7.3 Hz, 3H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 203.7, 140.60 128.6, 128.5, 126.2, 74.9 (d, *J* = 142.0 Hz), 64.7 (d, *J* = 7.3 Hz), 64.6 (d, *J* = 7.3 Hz), 40.1, 37.7, 37.6, 30.6 (d, *J* = 10.6 Hz), 26.0, 22.0, 16.39 (d, *J* = 5.5 Hz), 16.35 (d, *J* = 5.9 Hz), 13.8.

^{31}P NMR (162 MHz, $CDCl_3$) δ 15.31.

HRMS (ESI) m/z: $[M+H]^+$ calcd. for $C_{18}H_{29}ClO_4P$: 375.1487, found: 375.1487.



52

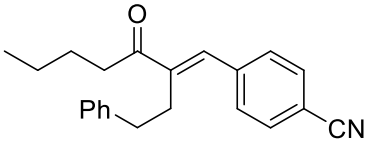
The title compound **52** was synthesized according to General Procedure (SI 3.3), and it was purified by column chromatography on silica gel (PE:EA = 6:1, 48% yield, 18.4 mg, yellow oil).

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.31-7.25 (m, 2H), 7.23-7.15 (m, 3H), 5.92-5.75 (m, 1H), 5.27-5.11 (m, 2H), 4.15 (p, *J* = 7.2 Hz, 4H), 2.90-2.56 (m, 5H), 2.52 (td, *J* = 12.8, 4.6 Hz, 1H), 2.30-2.09 (m, 2H), 1.62-1.53 (m, 2H), 1.37-1.29 (m, 8H), 0.91 (t, *J* = 7.4 Hz, 3H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 207.2, 142.1, 133.3 (d, *J* = 9.2 Hz), 128.42, 128.36, 126.0, 118.6, 62.6 (d, *J* = 7.3 Hz), 62.5 (d, *J* = 7.4 Hz), 58.1 (d, *J* = 127.3 Hz), 39.6, 35.1 (d, *J* = 3.3 Hz), 33.2, 30.7 (d, *J* = 8.1 Hz), 25.9, 22.2, 16.4 (d, *J* = 5.9 Hz), 13.9.

^{31}P NMR (162 MHz, $CDCl_3$) δ 25.77.

HRMS (ESI) m/z: $[M+H]^+$ calcd. for $C_{21}H_{34}O_4P$: 381.2189, found: 381.2156.



53

The title compound **53** was synthesized according to General Procedure (SI 3.3), and it was purified by column chromatography on silica gel (PE:EA = 50:1, 86% yield, 54.9 mg, E/Z = 6.7:1, determined by HNMR, colorless oil).

^{1}H NMR (400 MHz, CDCl3) δ 7.62 (d, *J* = 8.3 Hz, 2H), 7.44 (s, 1H), 7.29–7.19 (ovrlp, 5H), 7.11–7.05 (m, 2H), 2.81–2.69 (ovrlp, 6H), 1.68 (p, *J* = 7.6 Hz, 2H), 1.43–1.36 (m, 2H), 0.96 (t, *J* = 7.3 Hz, 3H).
^{13}C NMR (101 MHz, CDCl3) δ 202.0, 143.8, 141.0, 140.4, 136.5, 132.1, 129.3, 128.39, 128.38, 126.1, 118.4, 111.7, 37.6, 34.8, 28.6, 26.8, 22.4, 13.9.
HRMS (ESI) m/z: $[M+H]^+$ calcd. for $C_{22}H_{24}NO_4$: 318.1852, found: 318.1852.

5. Supplimentary References

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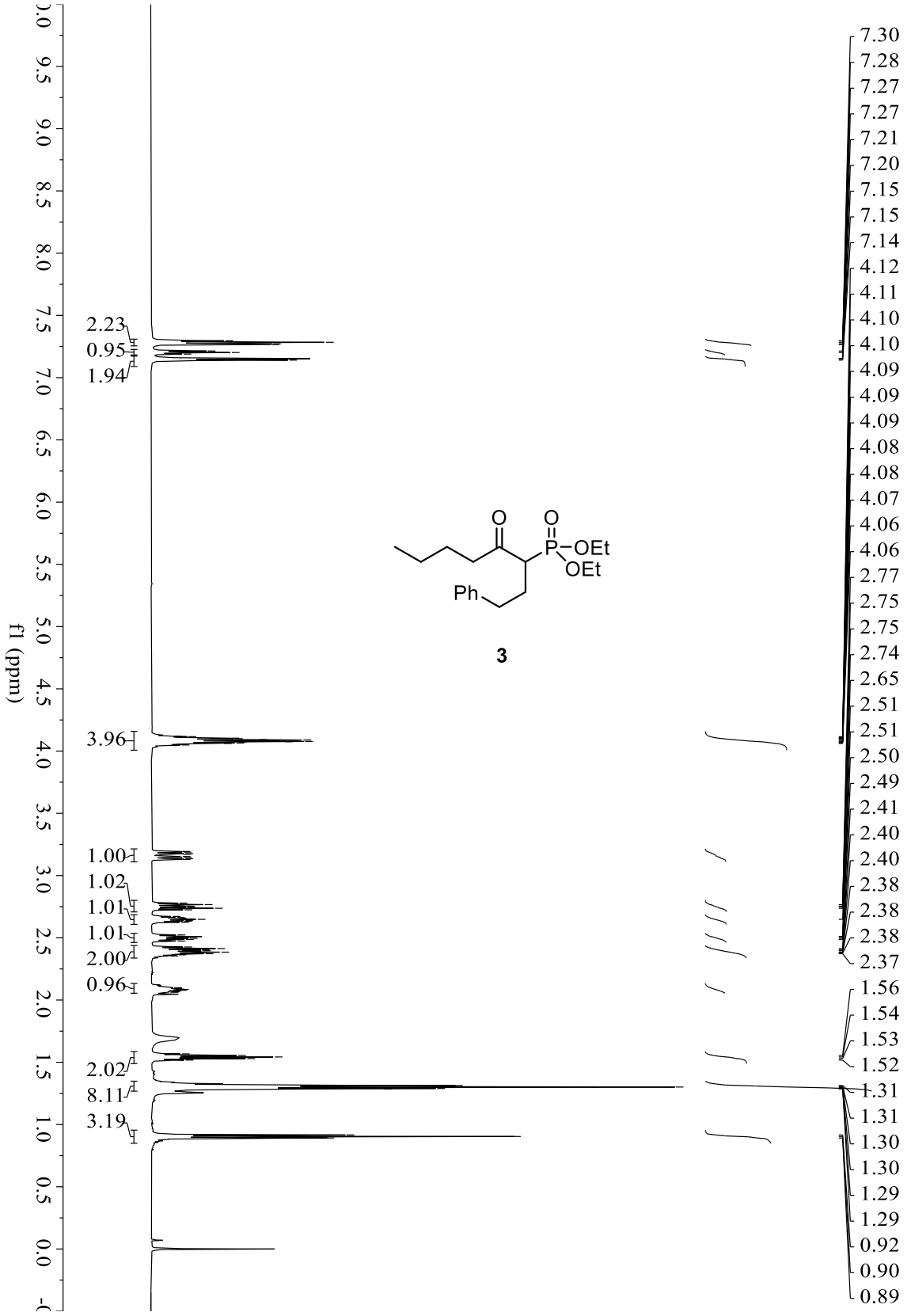
[S6] Perry, I. B.; Brewer, T. F.; Sarver, P. J.; Schultz, D. M.; DiRocco, D. A.; MacMillan, D. W. C. Direct arylation of strong aliphatic C–H bonds. *Nature* **2018,** *560*, 70-75.

[S7] He, S.-J.; Wang, J.-W.; Li, Y.; Xu, Z.-Y.; Wang, X.-X.; Lu, X.; Fu, Y., Nickel-Catalyzed Enantioconvergent Reductive Hydroalkylation of Olefins with α-Heteroatom Phosphorus or Sulfur Alkyl Electrophiles. *Journal of the American Chemical Society* **2020,** *142*, 214-221.

[S8] Choi, J.; Martín-Gago, P.; Fu, G. C. Stereoconvergent Arylations and Alkenylations of Unactivated Alkyl Electrophiles: Catalytic Enantioselective Synthesis of Secondary Sulfonamides and Sulfones. *Journal of the American Chemical Society* **2014,** *136*, 12161-12165.

[S9] Wang, H.; Zheng, P.; Wu, X.; Li, Y.; XU, T. Modular and Facile Access to Chiral α-Aryl Phosphates via Dual Nickel- and Photoredox-Catalyzed Reductive Cross-Coupling. *Journal of the American Chemical Society* **2022,** *144*, 3989-3997.

6. Spectra data for the compounds



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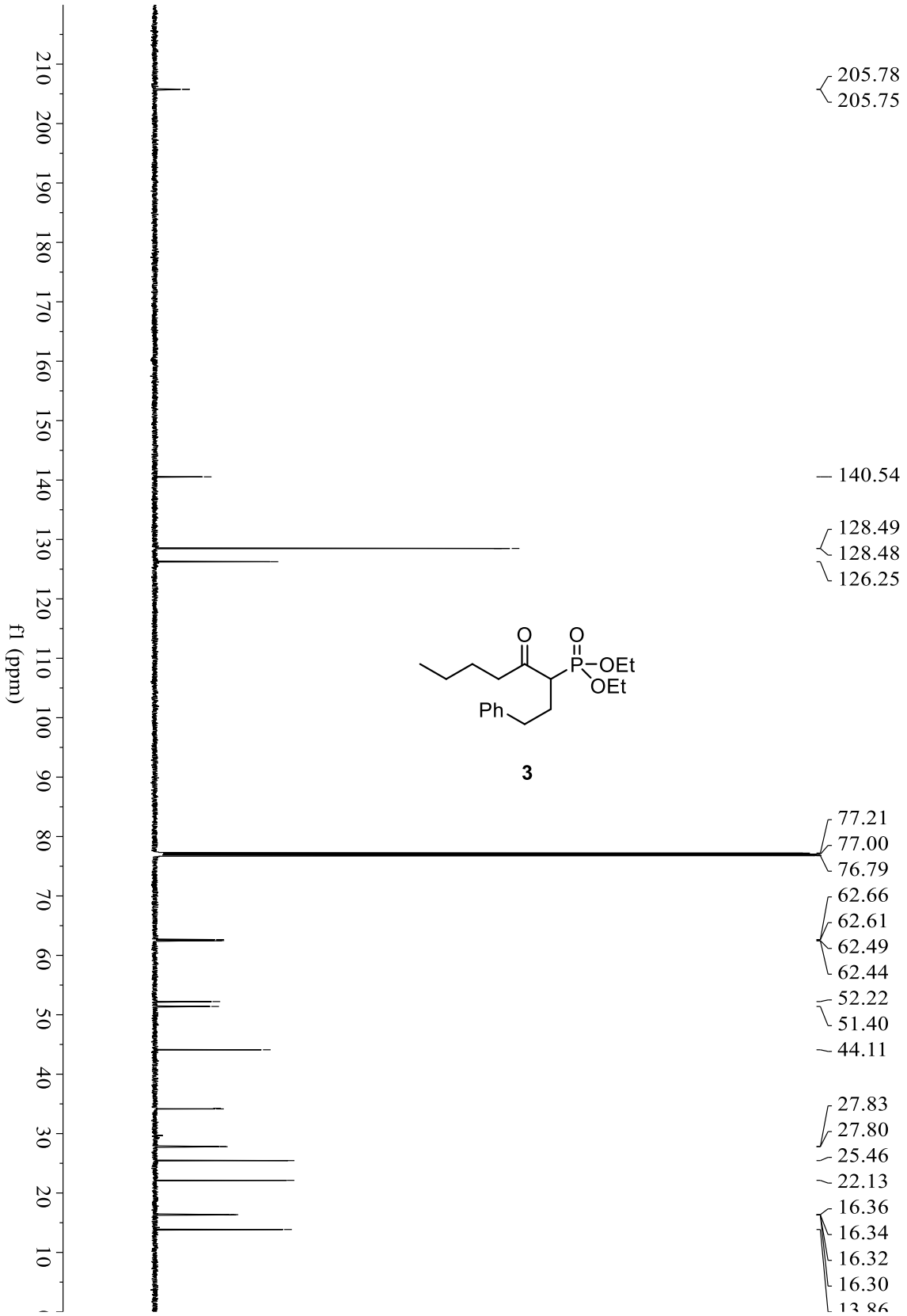
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44.11
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27.80
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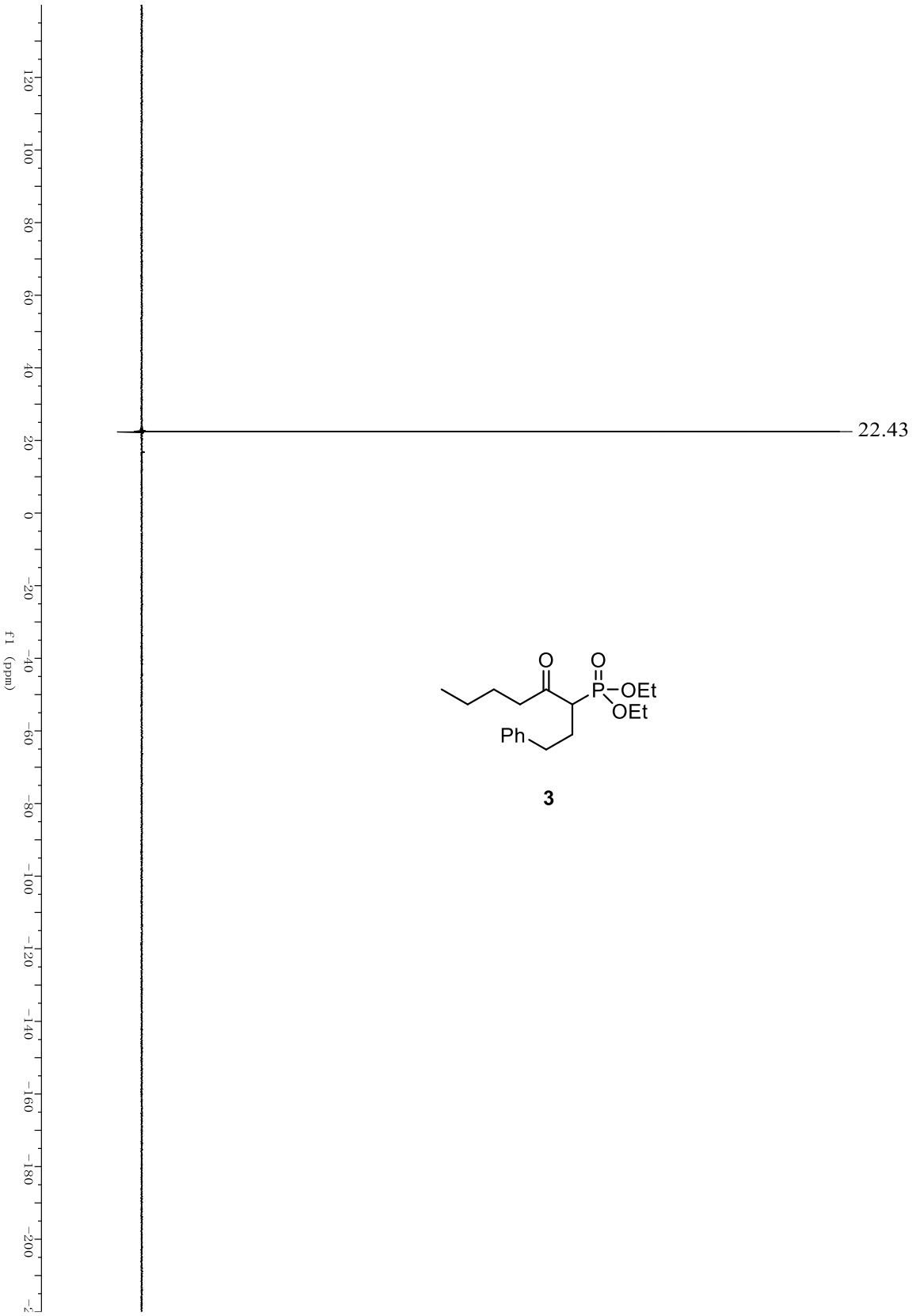
OEt
OEt
Ph

3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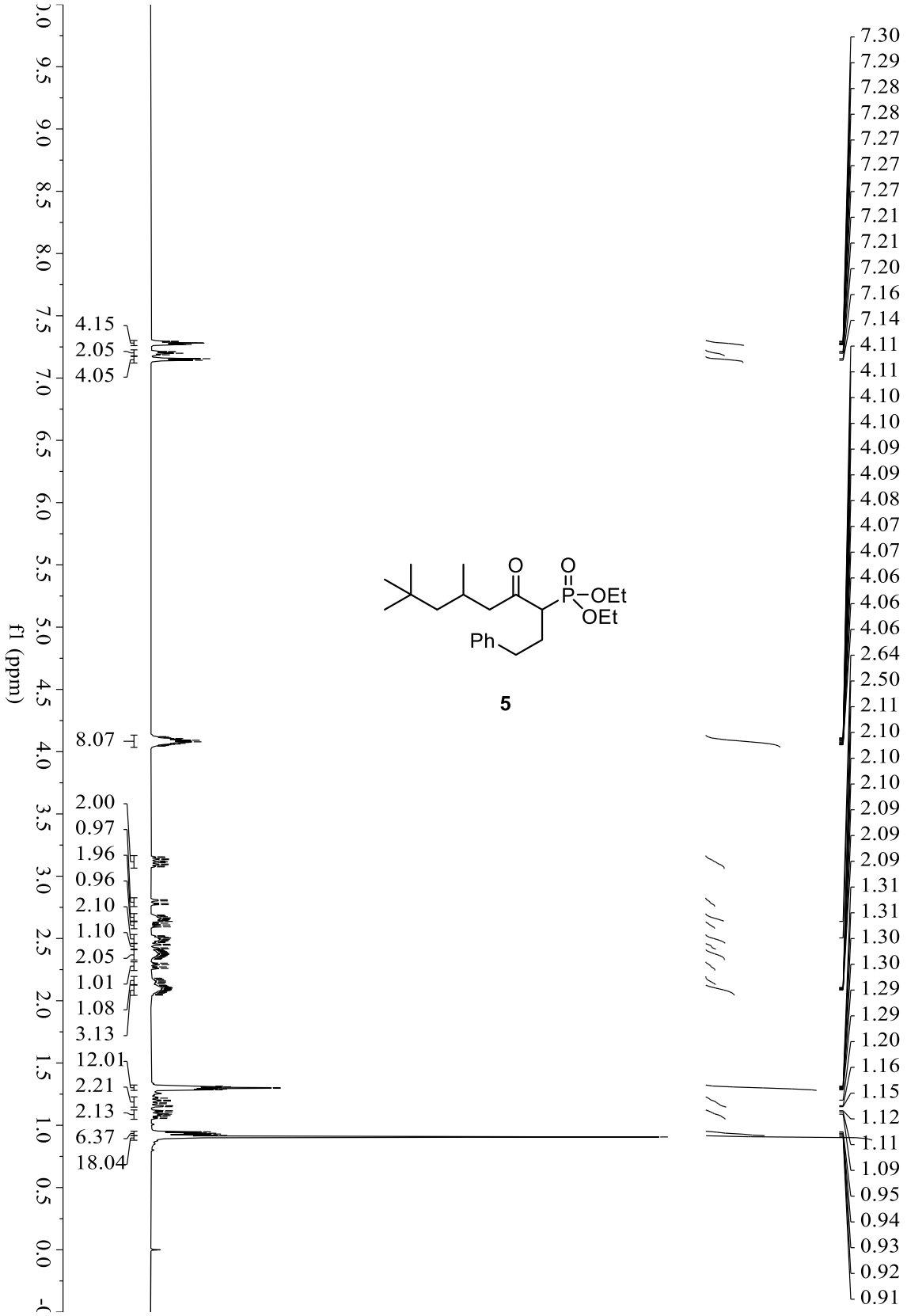
P
OEt
OEt
Ph

3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1.08
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12.01
2.21
2.13
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7.27
7.27
7.27
7.21
7.21
7.20
7.16
7.14
4.11
4.11
4.10
4.10
4.09
4.09
4.08
4.07
4.07
4.06
4.06
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Ph

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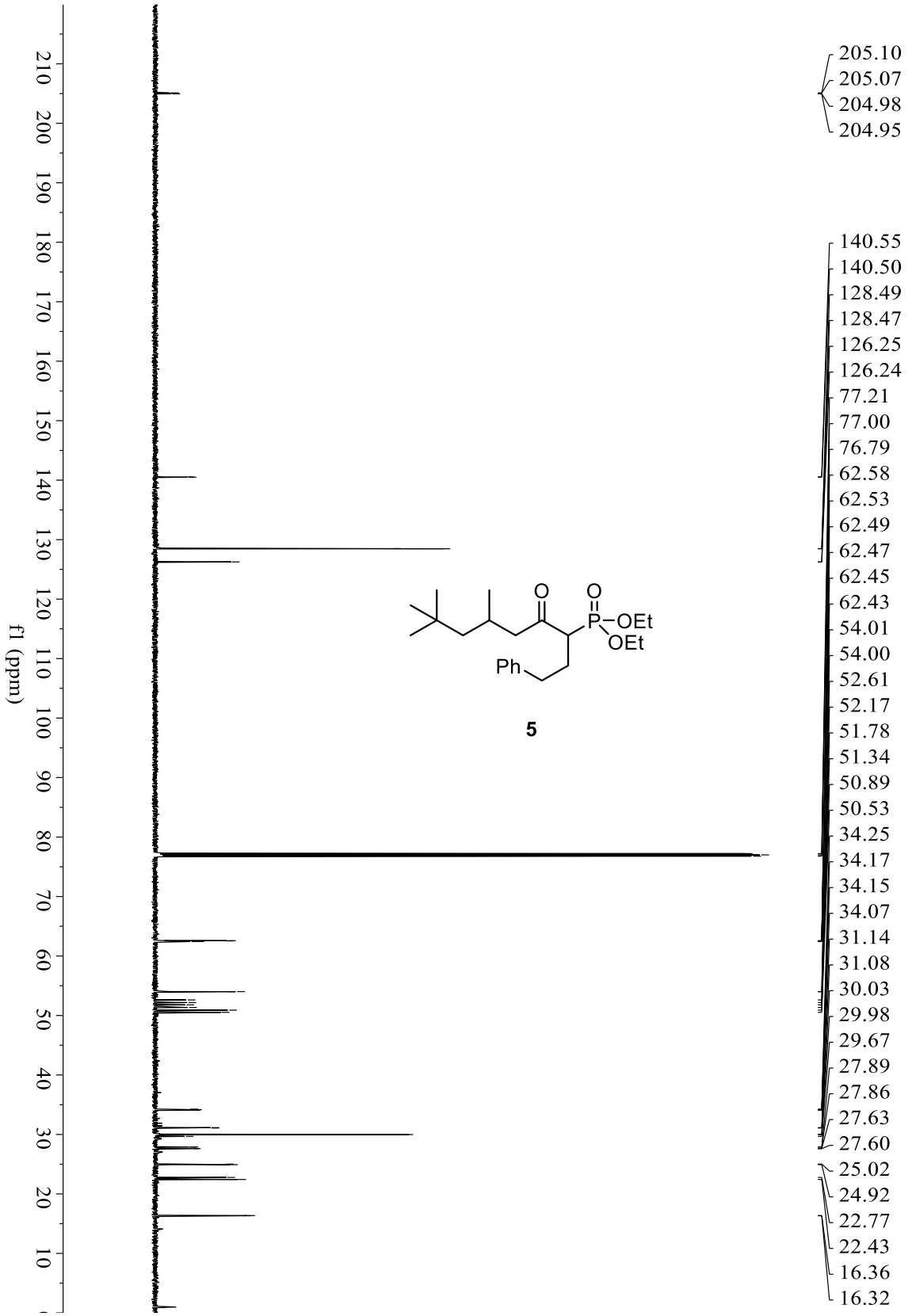
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34.25
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34.15
34.07
31.14
31.08
30.03
29.98
29.67
27.89
27.86
27.63
27.60
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P
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OEt
Ph
f1 (ppm)

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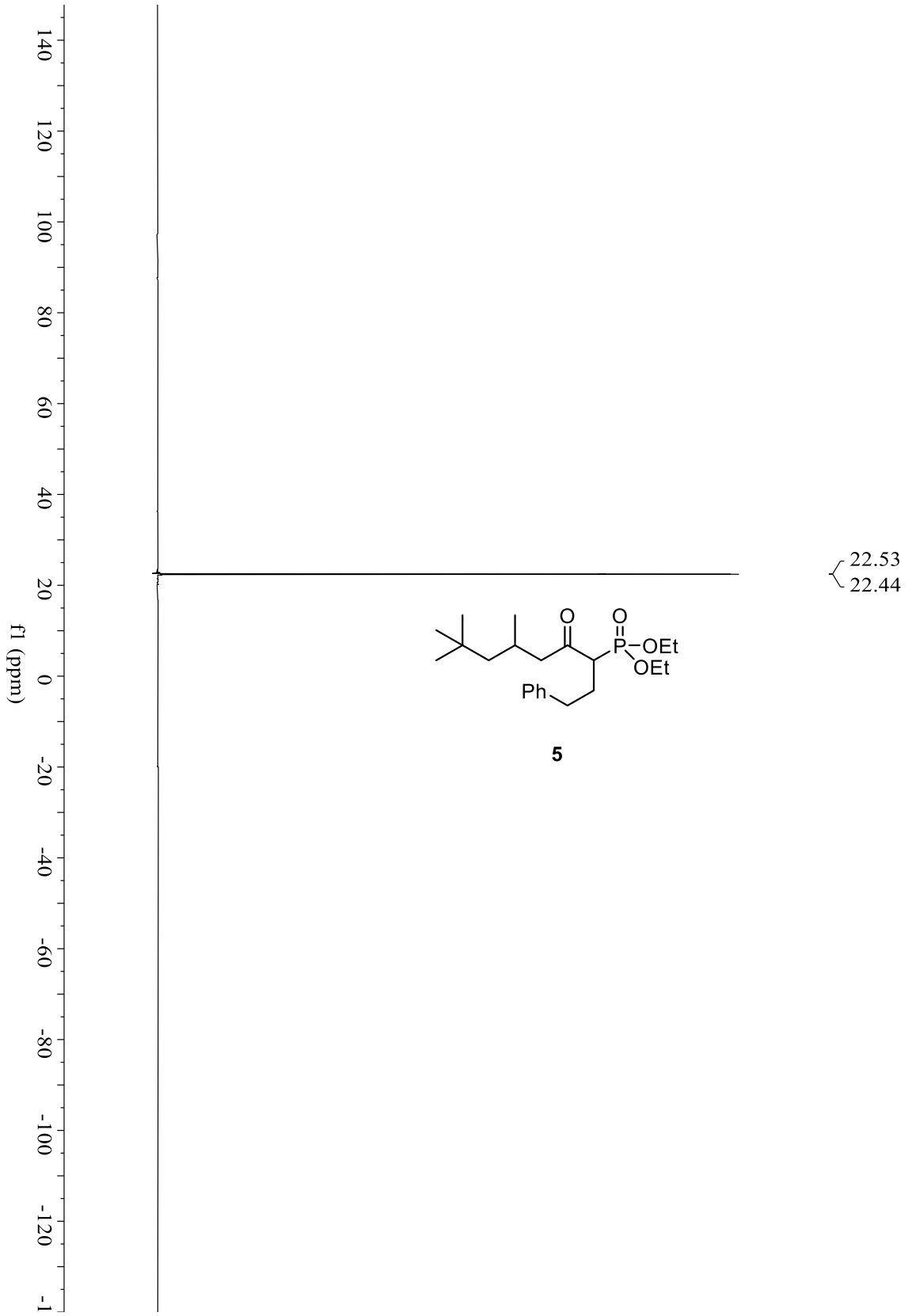
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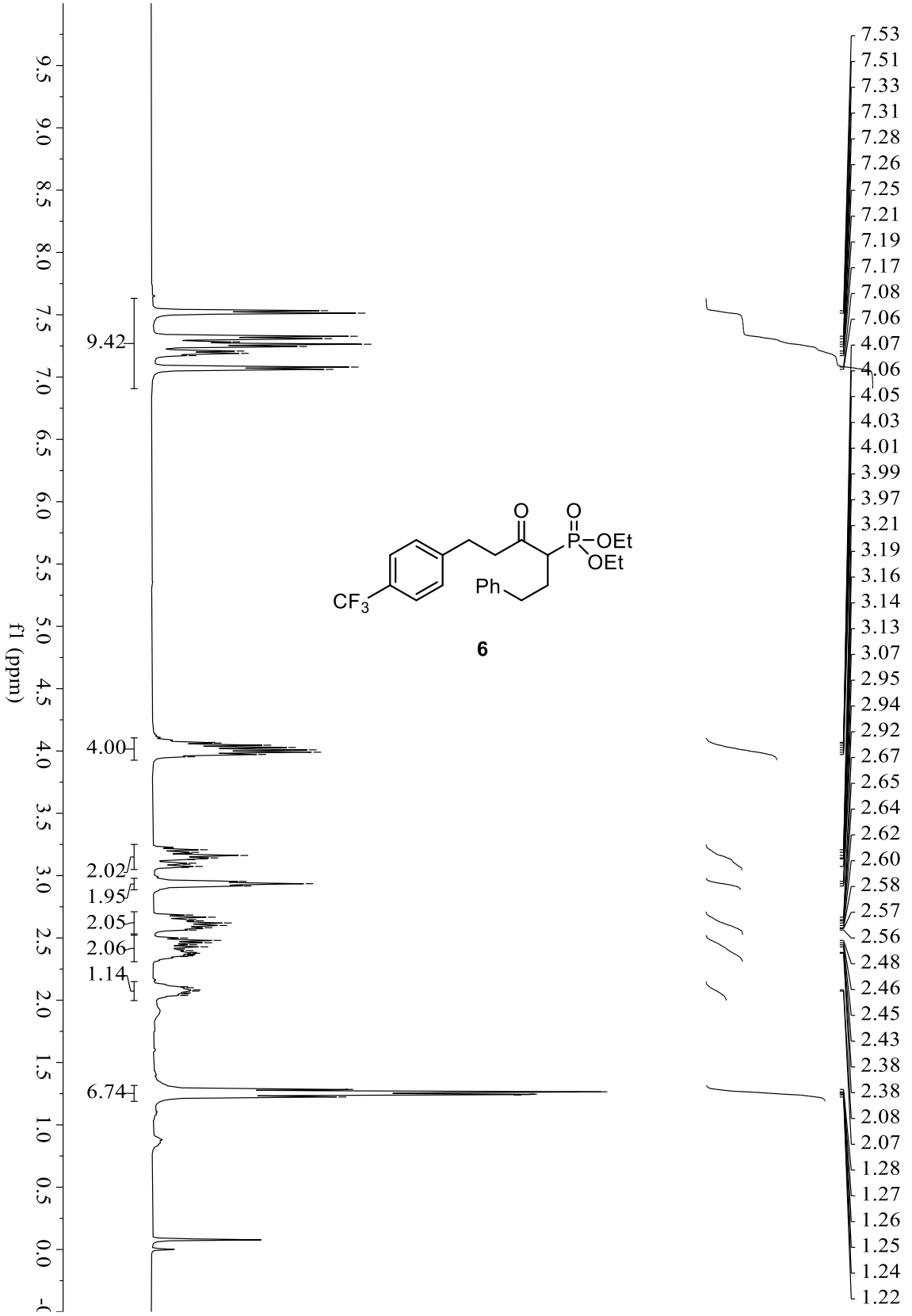
5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7.51
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7.19
7.17
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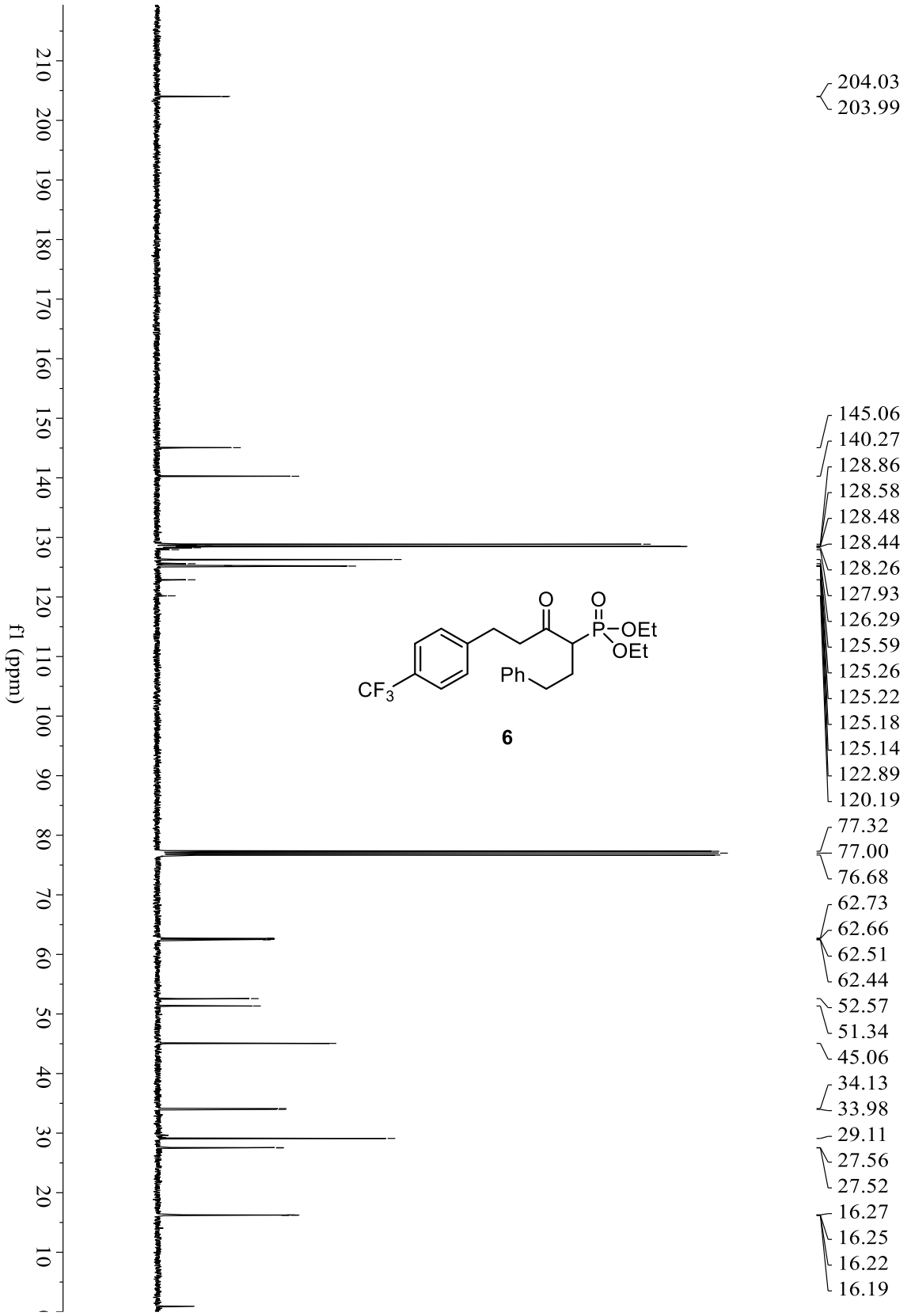
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CF3
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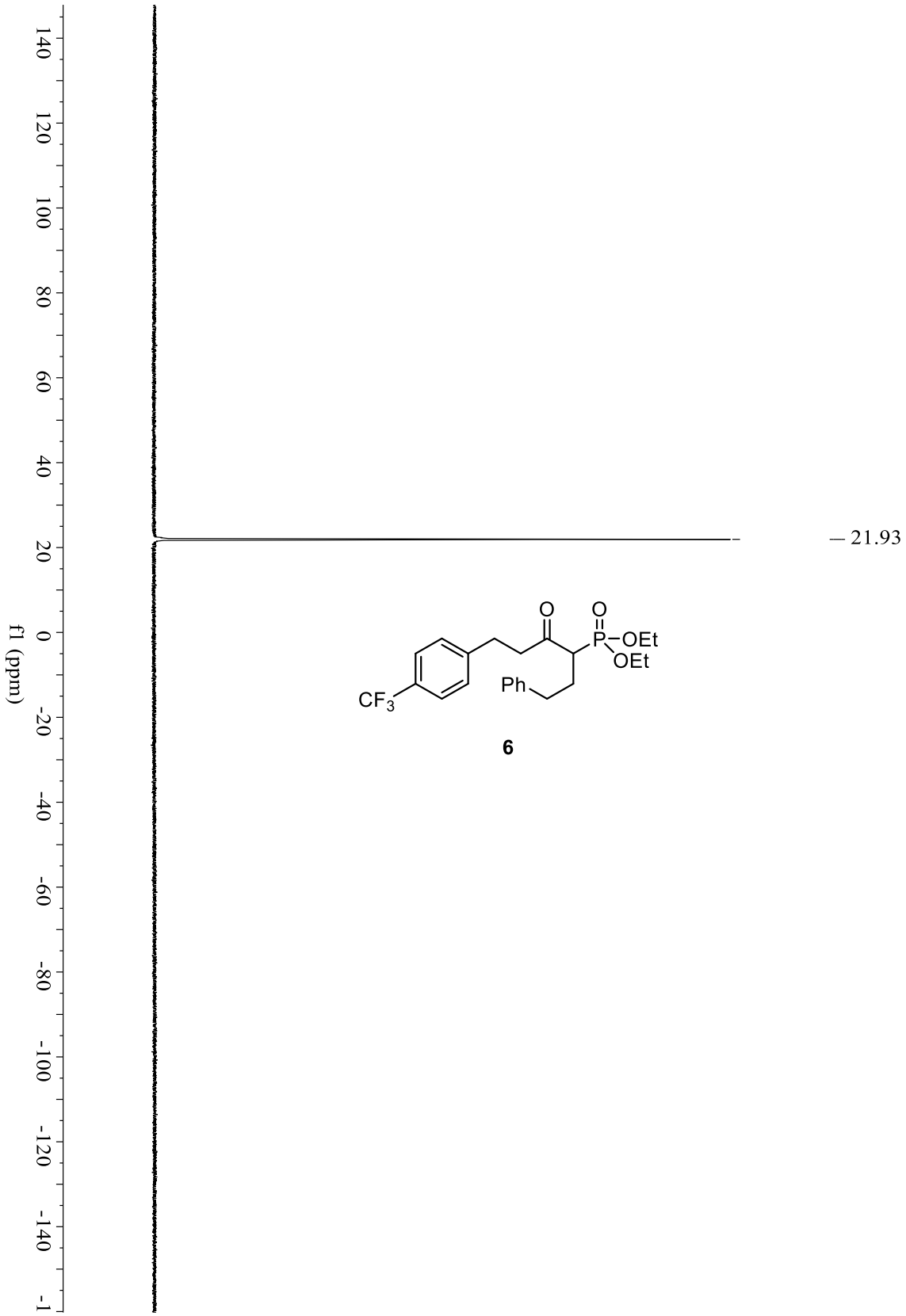
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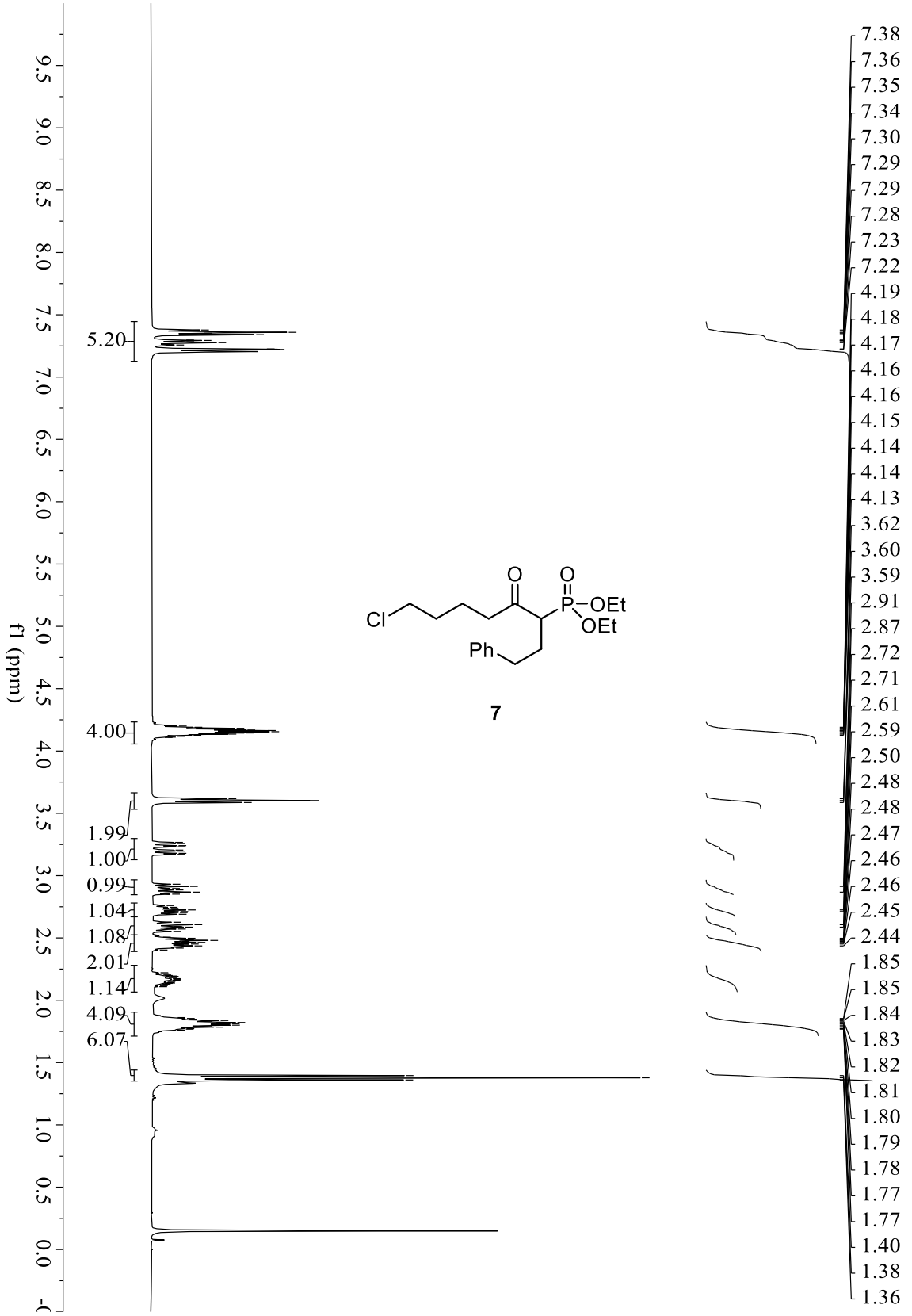
CF3

6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2.01
1.14
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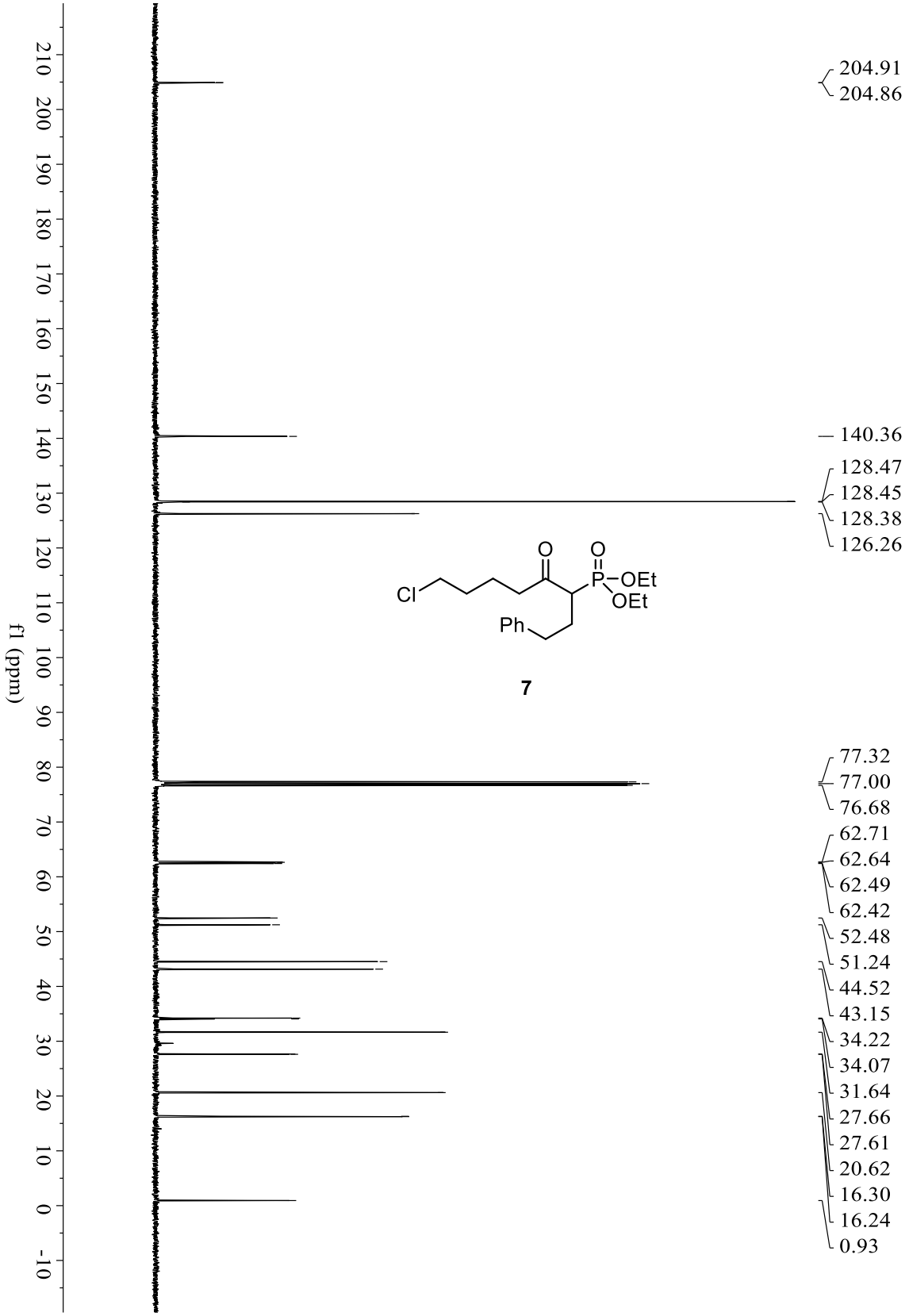
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OEt
Cl
Ph

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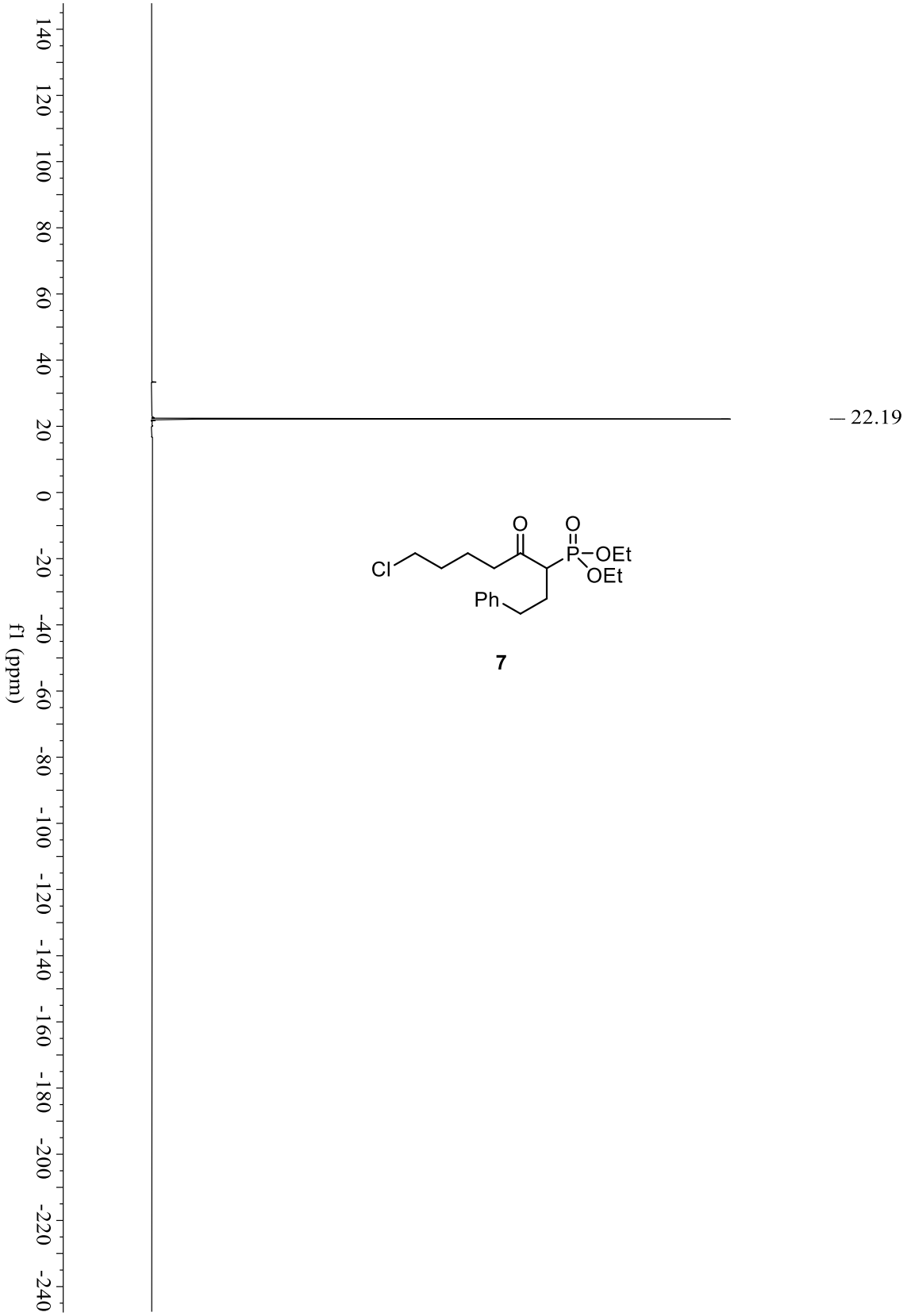
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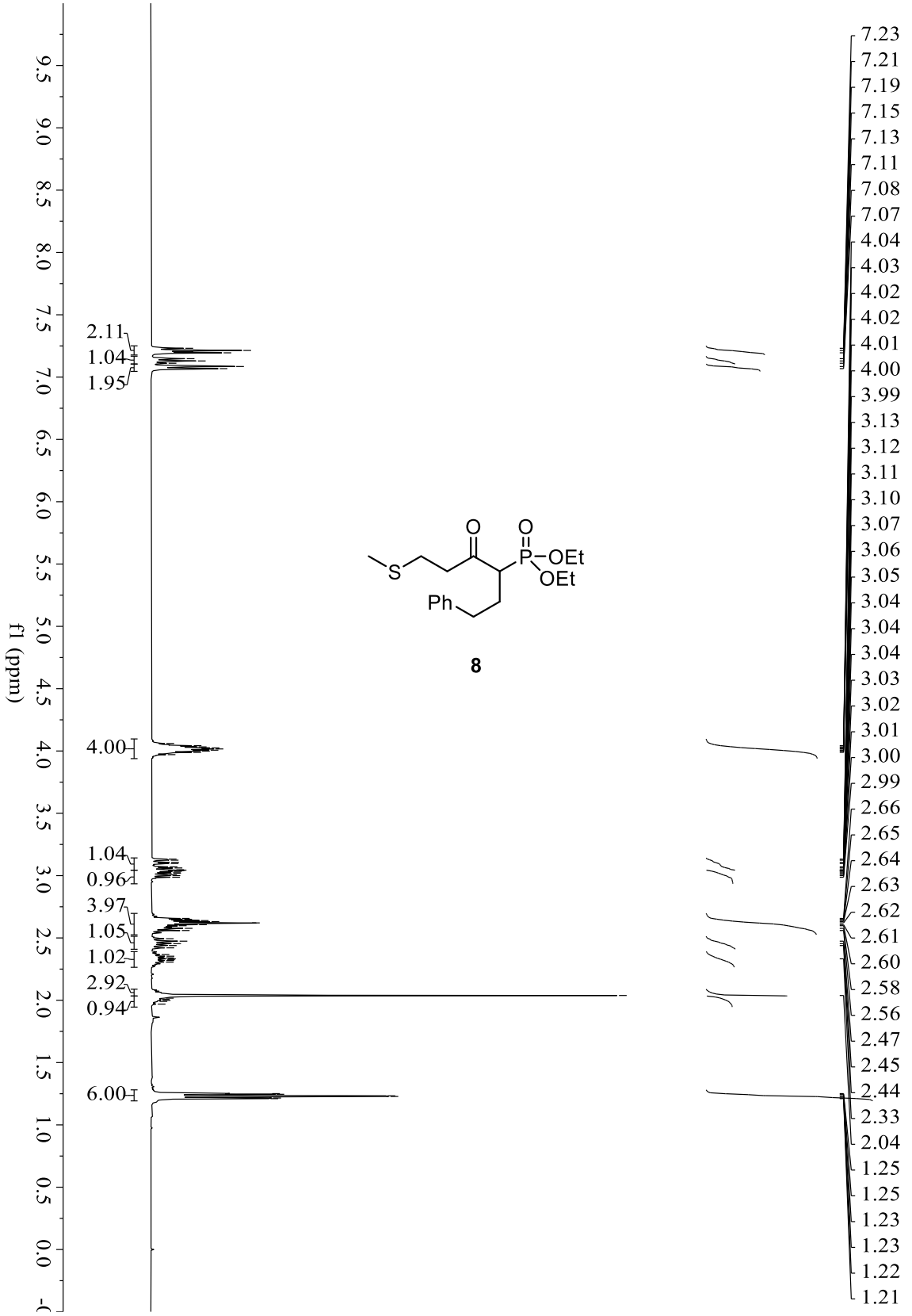
OEt
Cl
Ph

7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2.11
1.04
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0.96
3.97
1.05
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2.92
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S
Ph
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7.21
7.19
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7.13
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7.08
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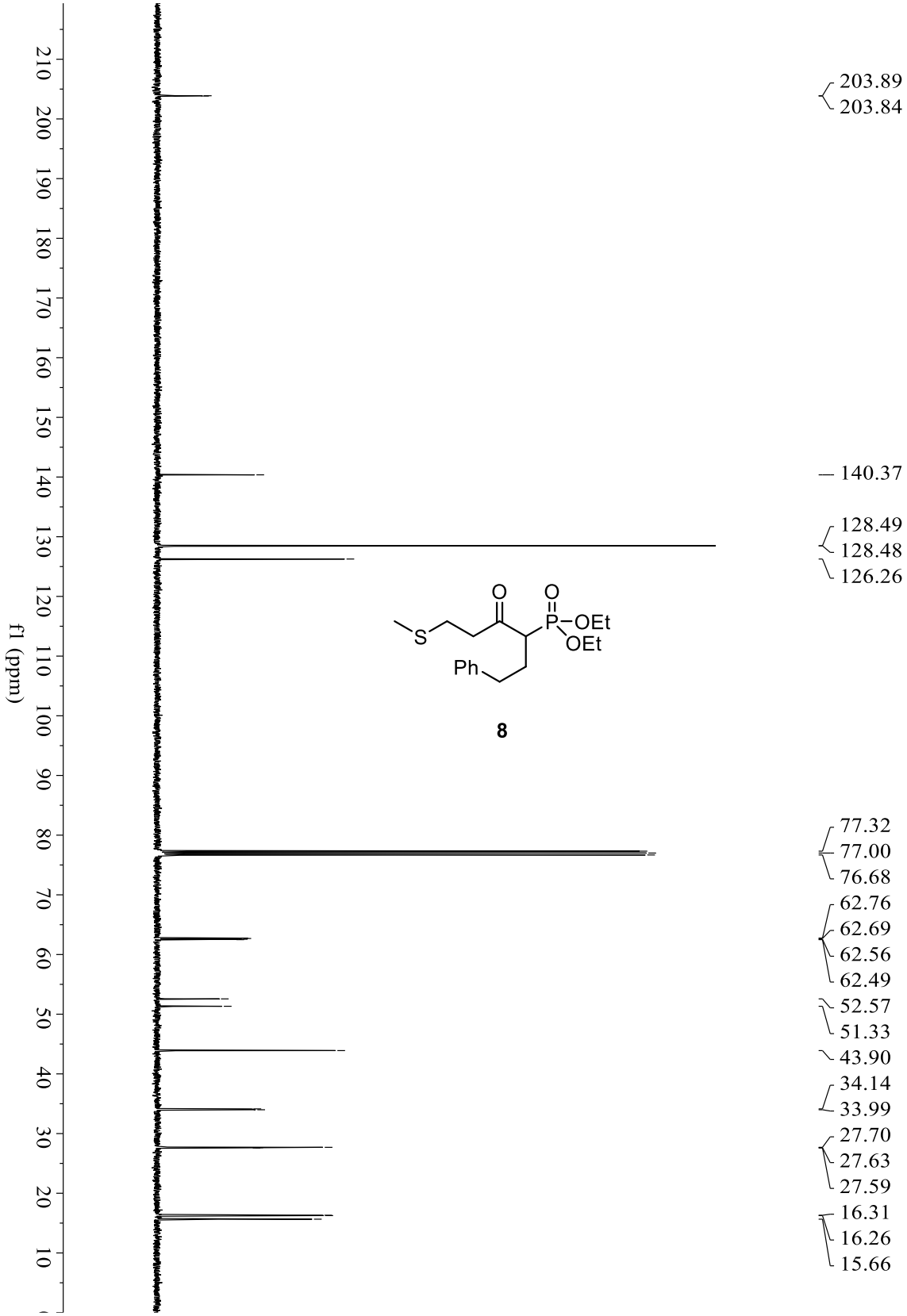
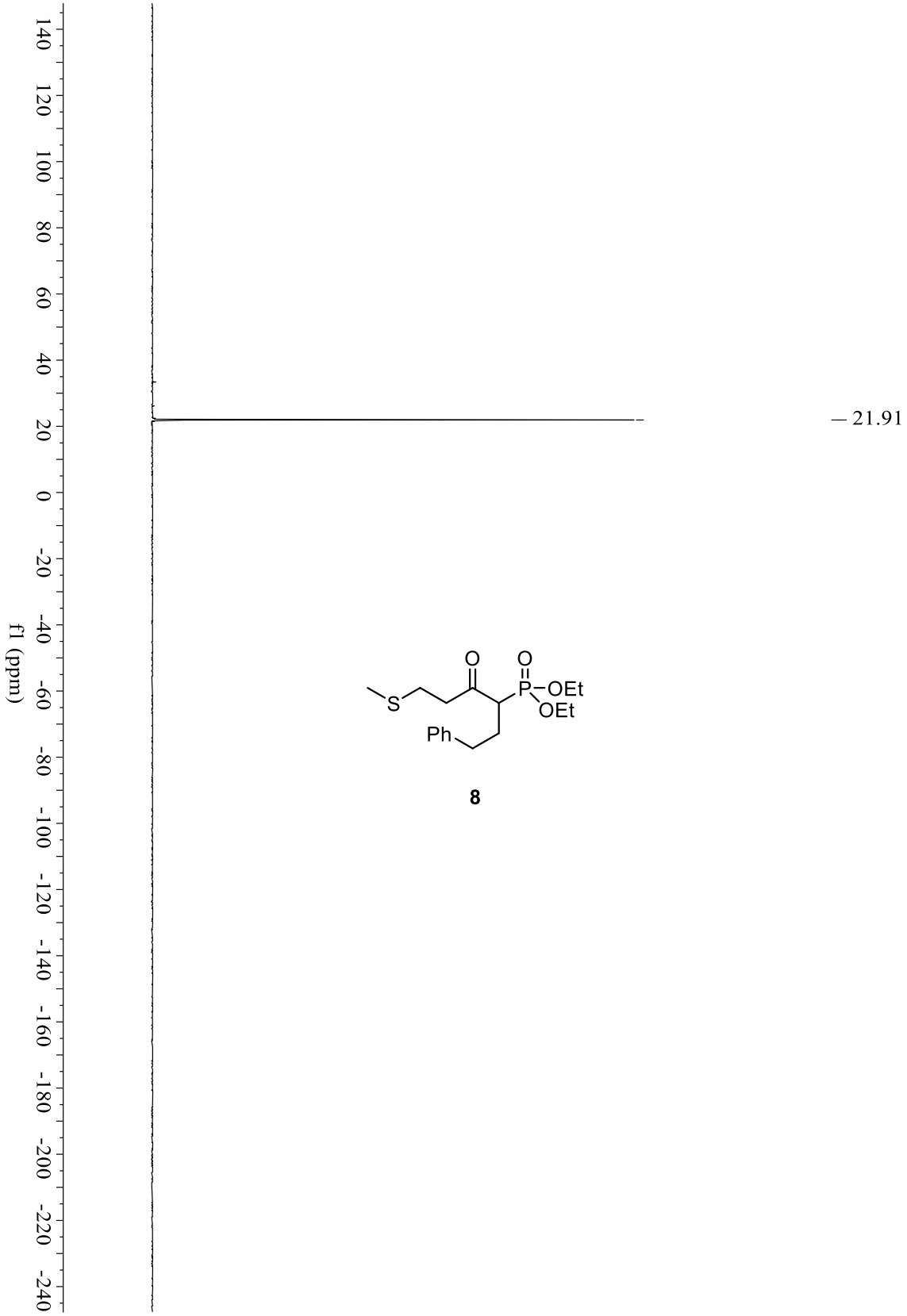
4.03
4.02
4.02
4.01
4.00
3.99
3.13
3.12
3.11
3.10
3.07
3.06
3.05
3.04
3.04
3.04
3.03
3.02
3.01
3.00
2.99
2.66
2.65
2.64
2.63
2.62
2.61
2.60
2.58
2.56
2.47
2.45
2.44
2.33
2.04
1.25
1.25
1.23
1.23
1.22
1.21

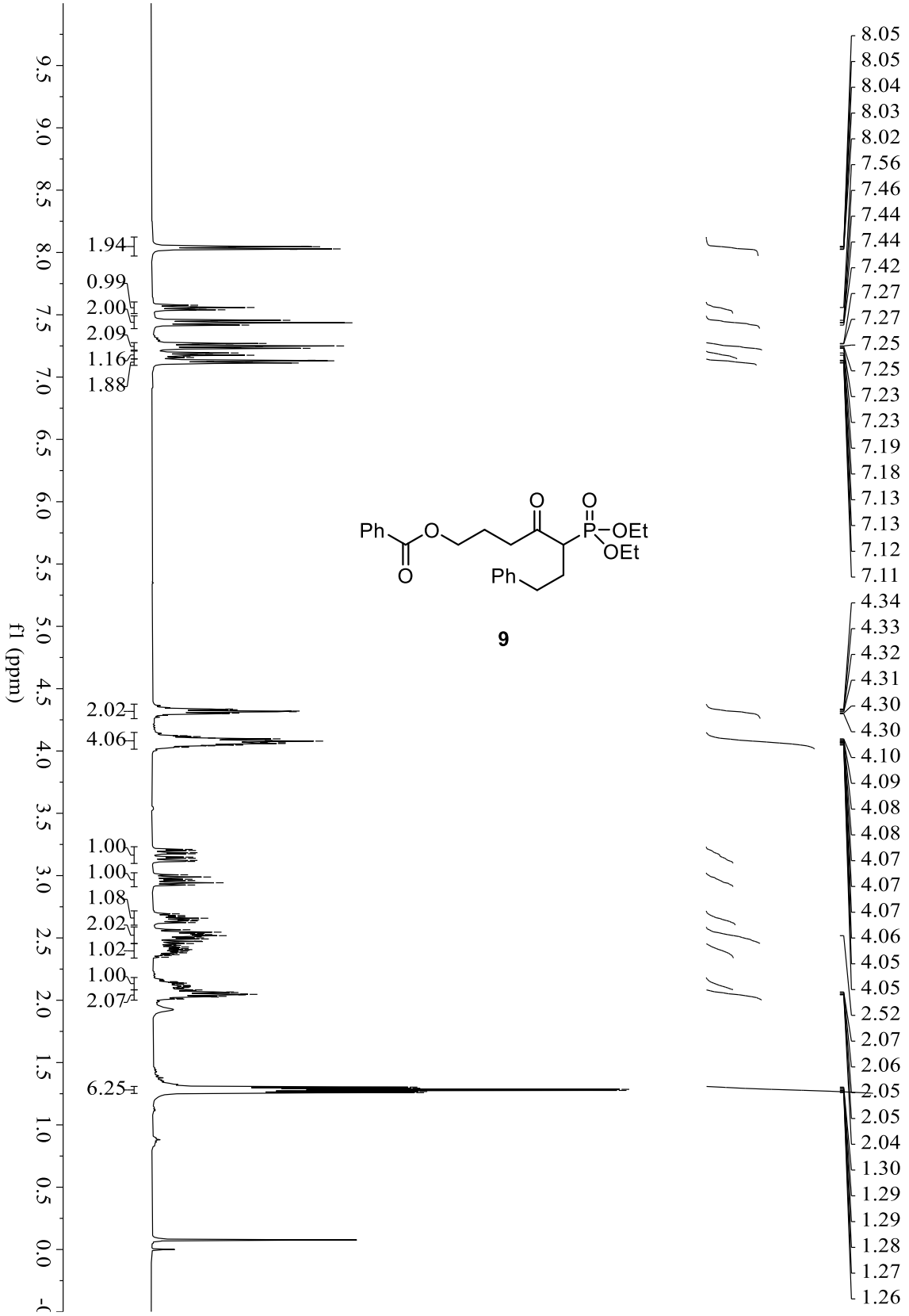
8

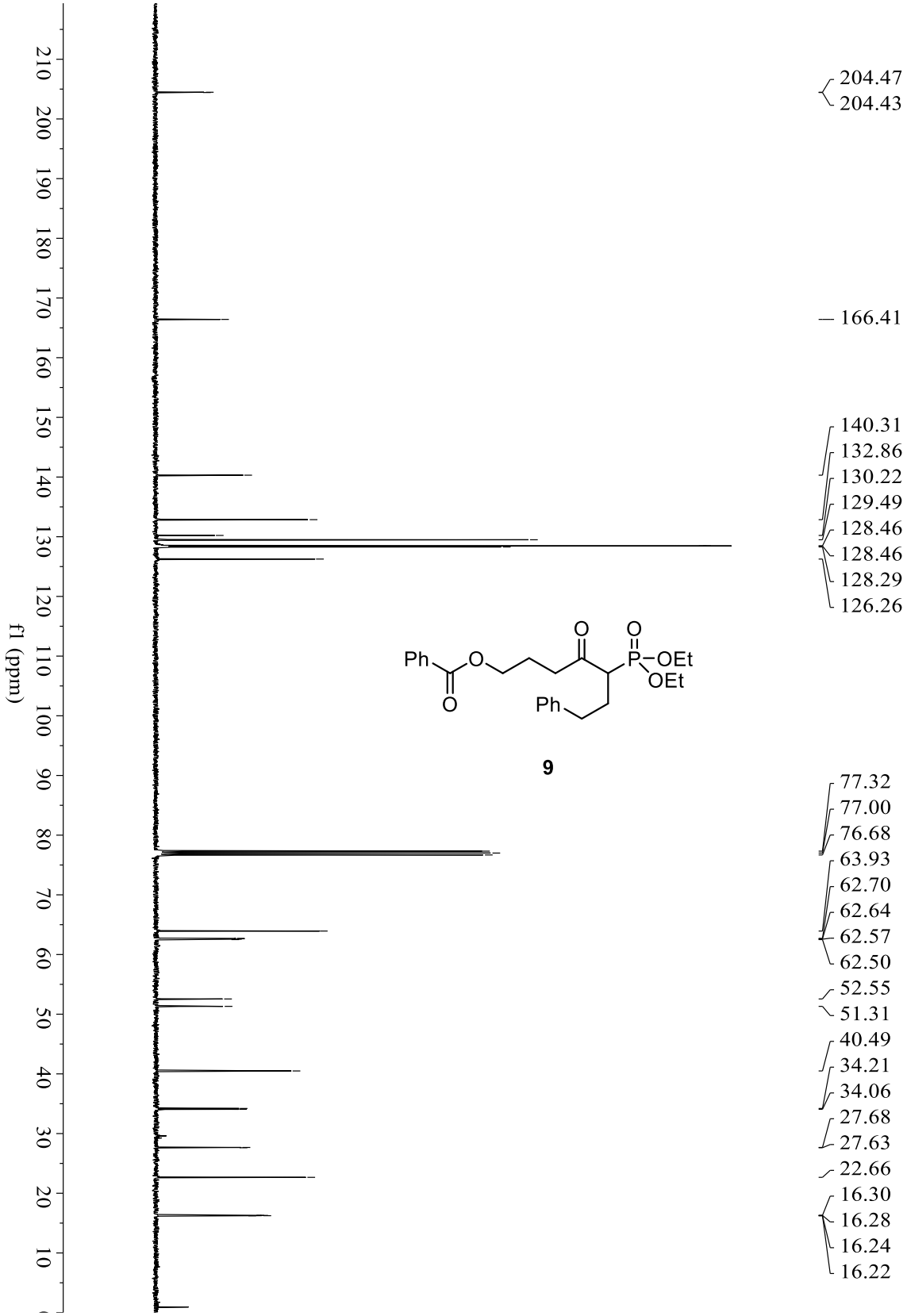

f1 (ppm)
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
203.89
203.84
140.37
128.49
128.48
126.26
77.32
77.00
76.68
62.76
62.69
62.56
62.49
52.57
51.33
43.90
34.14
33.99
27.70
27.63
27.59
16.31
16.26
15.66
O
O
P
OEt
OEt
S
Ph

8

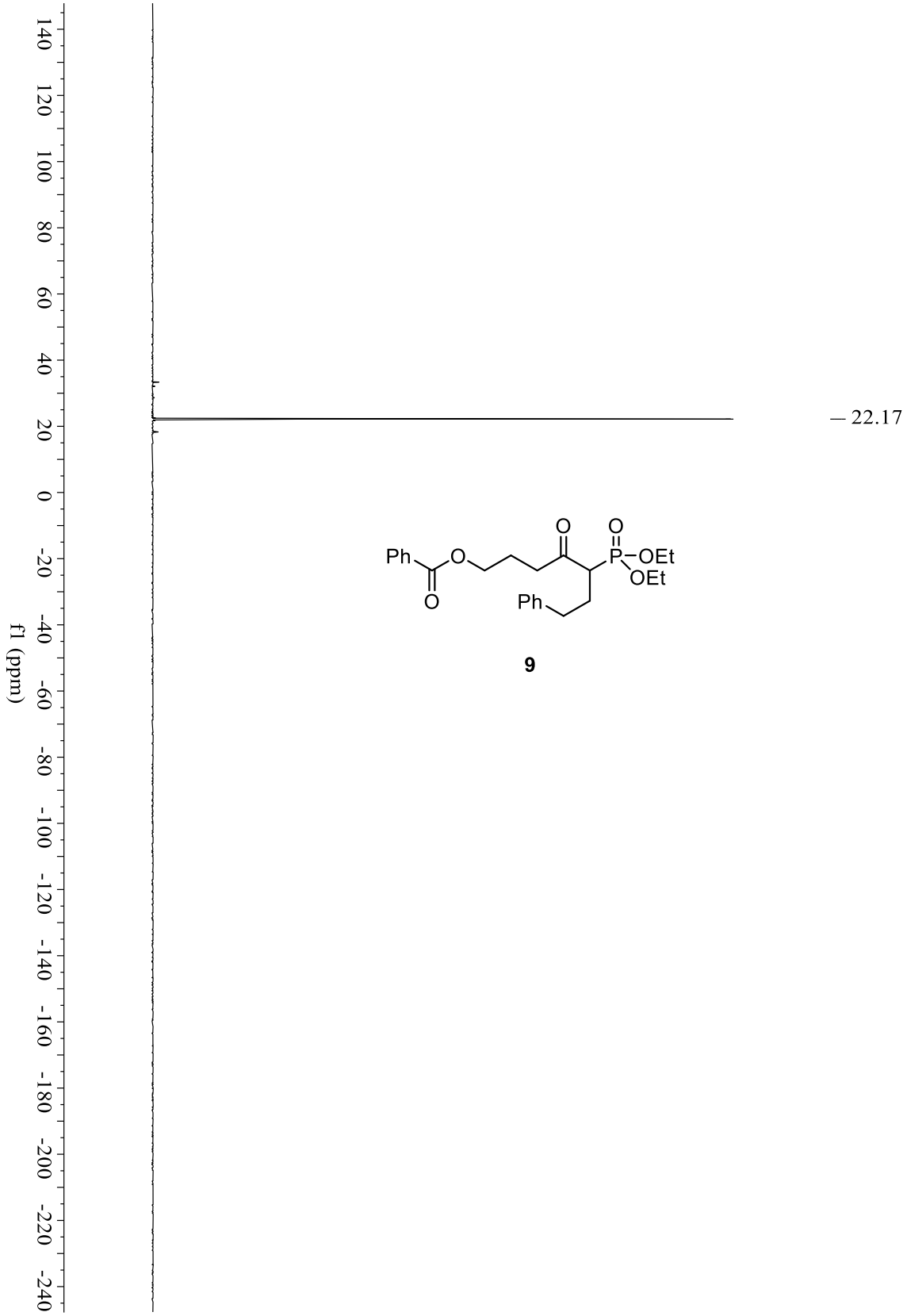

21.91
140
120
100
80
60
40
20
0
-20
-40
-60
-80
-100
-120
-140
-160
-180
-200
-220
-240
f1 (ppm)
O
O
P
OEt
OEt
S
Ph

8

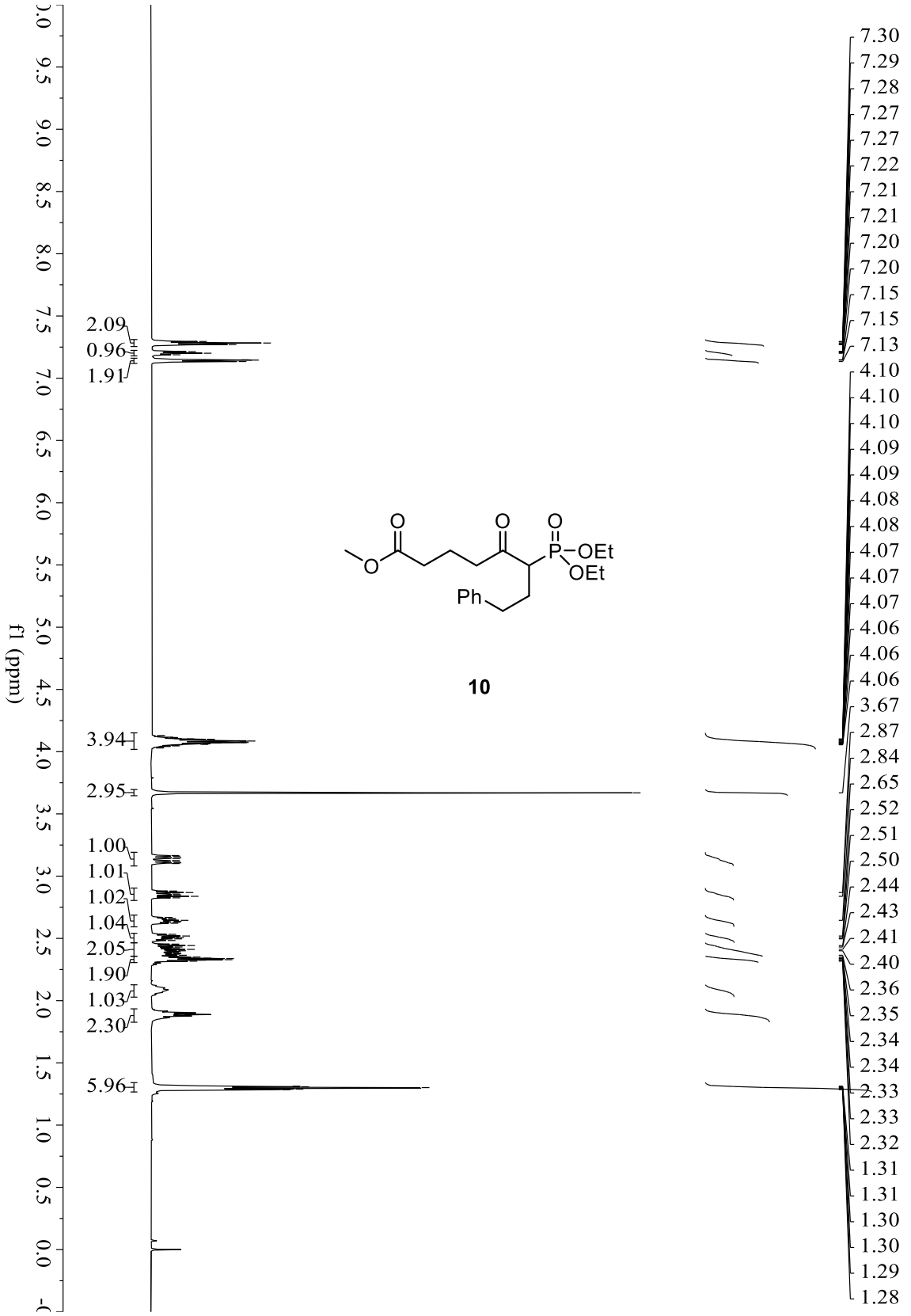

f1 (ppm)
1.94
0.99
2.00
2.09
1.16
1.88
2.02
4.06
1.00
1.00
1.08
2.02
1.02
1.00
2.07
6.25
Ph
O
O
O
O
P
OEt
OEt
Ph
9
8.05
8.05
8.04
8.03
8.02
7.56
7.46
7.44
7.44
7.42
7.27
7.27
7.25
7.25
7.23
7.23
7.19
7.18
7.13
7.13
7.12
7.11
4.34
4.33
4.32
4.31
4.30
4.30
4.10
4.09
4.08
4.08
4.07
4.07
4.07
4.06
4.05
4.05
2.52
2.07
2.06
2.05
2.05
2.04
1.30
1.29
1.29
1.28
1.27
1.26

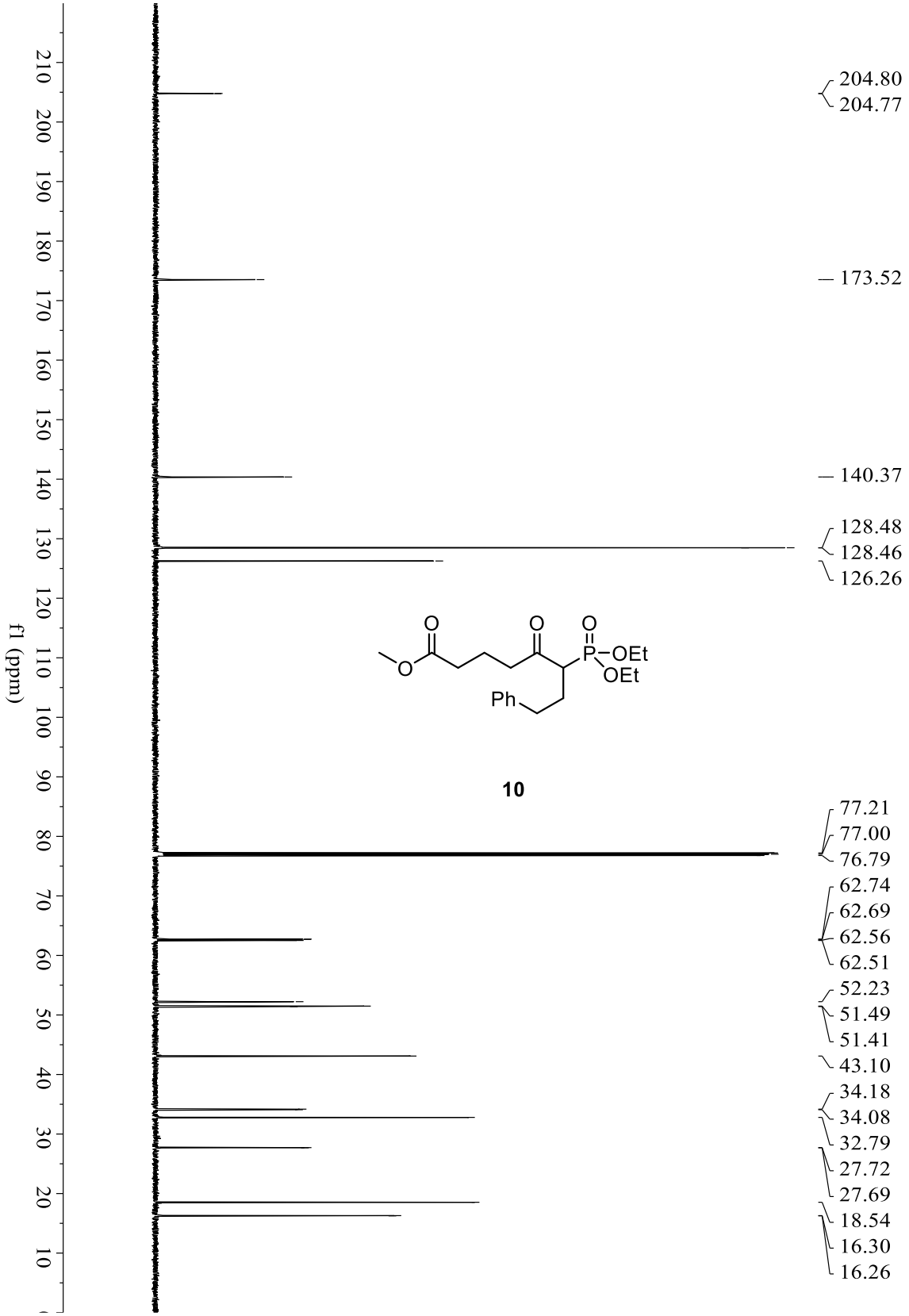

f1 (ppm)
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
204.47
204.43
166.41
140.31
132.86
130.22
129.49
128.46
128.46
128.29
126.26
77.32
77.00
76.68
63.93
62.70
62.64
62.57
62.50
52.55
51.31
40.49
34.21
34.06
27.68
27.63
22.66
16.30
16.28
16.24
16.22
Ph
O
O
O
O
P
OEt
OEt
Ph

9

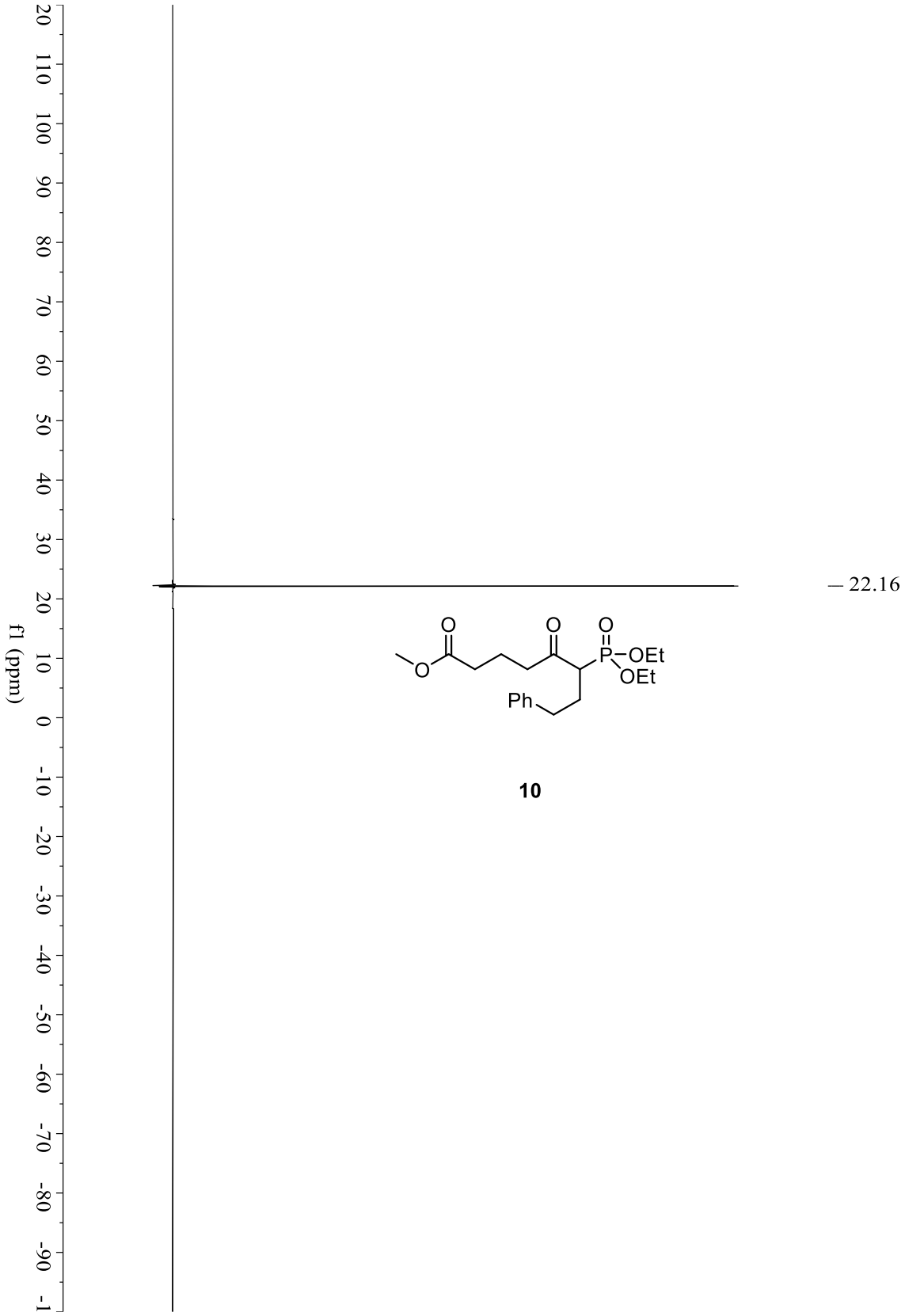

22.17
f1 (ppm)
140
120
100
80
60
40
20
0
-20
-40
-60
-80
-100
-120
-140
-160
-180
-200
-220
-240
Ph
O
O
O
O
P
OEt
OEt
Ph

9

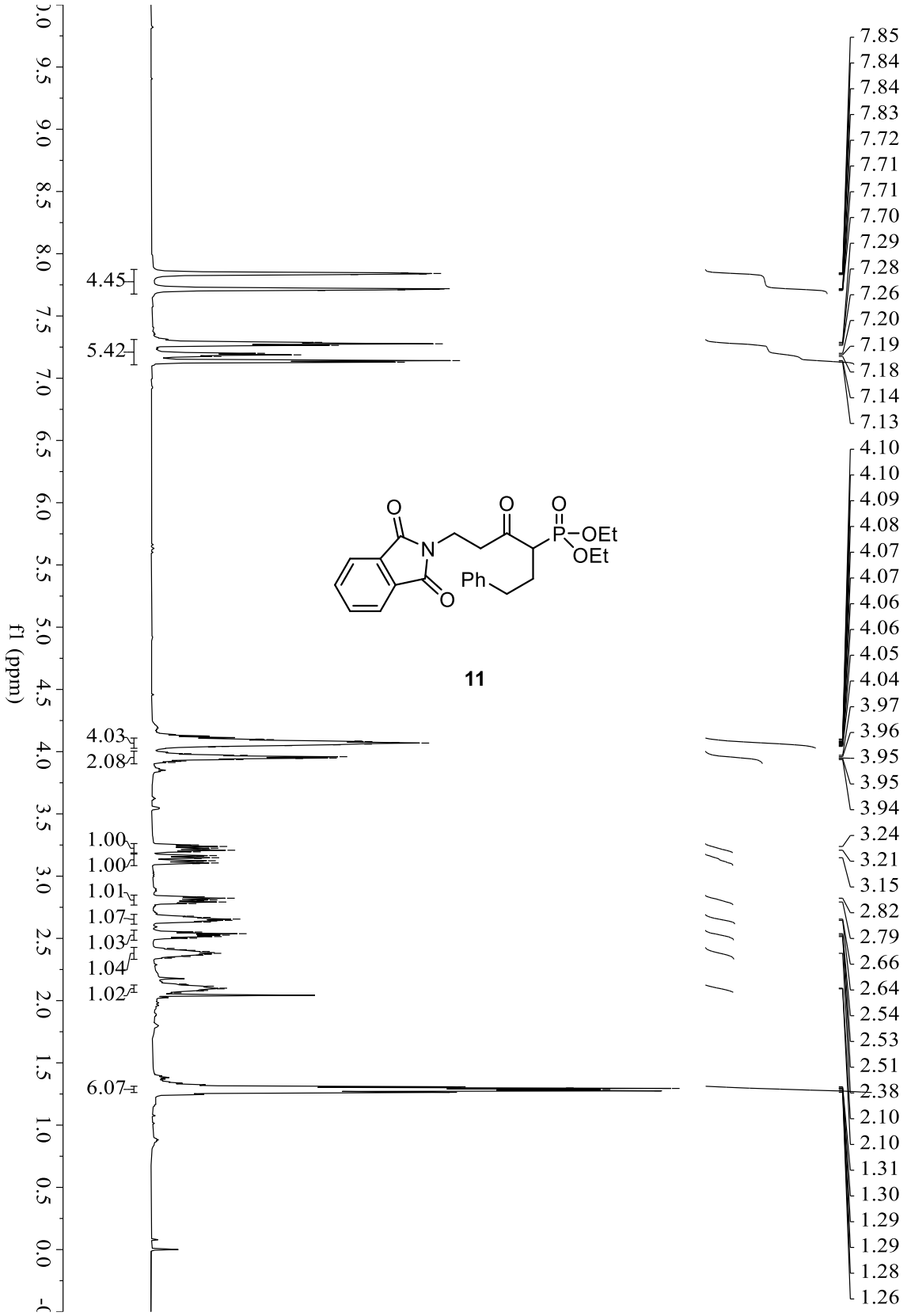

f1 (ppm)
2.09
0.96
1.91
3.94
2.95
1.00
1.01
1.02
1.04
2.05
1.90
1.03
2.30
5.96
O
O
O
O
P
OEt
OEt
Ph
10
7.30
7.29
7.28
7.27
7.27
7.22
7.21
7.21
7.20
7.20
7.15
7.15
7.13
4.10
4.10
4.10
4.09
4.09
4.08
4.08
4.07
4.07
4.07
4.06
4.06
4.06
3.67
2.87
2.84
2.65
2.52
2.51
2.50
2.44
2.43
2.41
2.40
2.36
2.35
2.34
2.34
2.33
2.33
2.32
1.31
1.31
1.30
1.30
1.29
1.28


f1 (ppm)
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
204.80
204.77
173.52
140.37
128.48
128.46
126.26
77.21
77.00
76.79
62.74
62.69
62.56
62.51
52.23
51.49
51.41
43.10
34.18
34.08
32.79
27.72
27.69
18.54
16.30
16.26
O
O
O
O
P
OEt
OEt
Ph

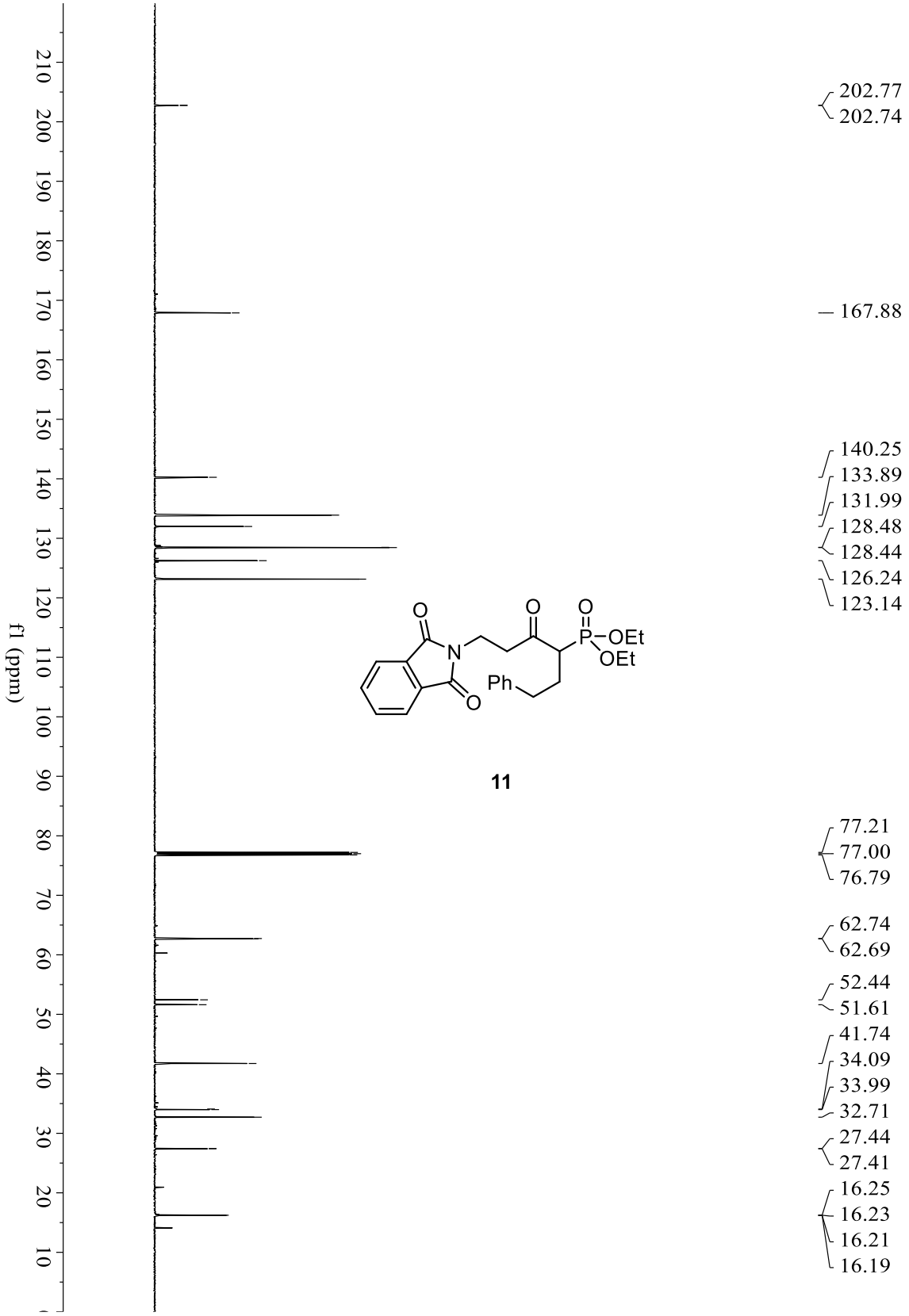
10


20
110
100
90
80
70
60
50
40
30
20
10
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-1
f1 (ppm)
22.16
O
O
O
P
OEt
OEt
O
Ph

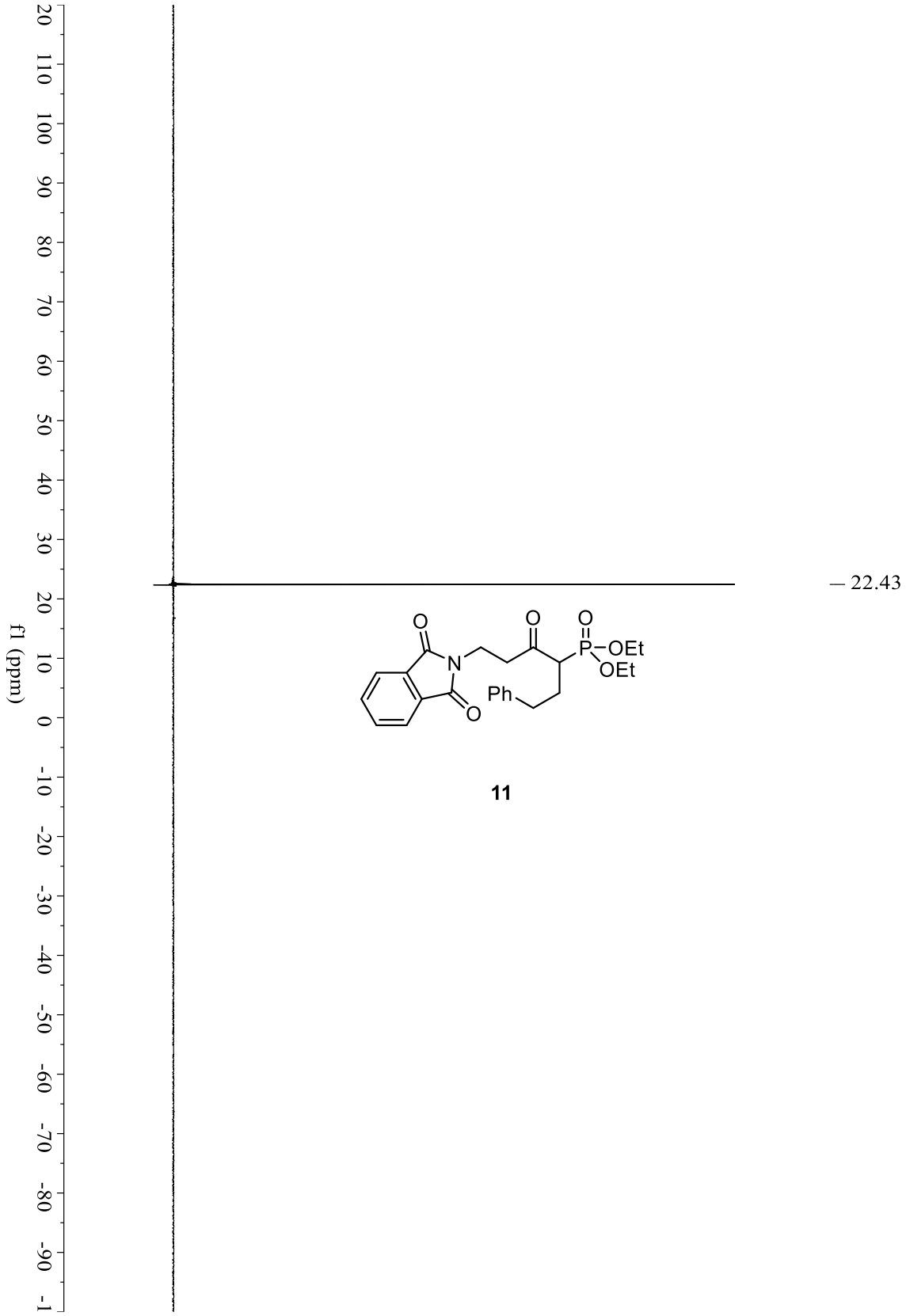
10


f1 (ppm)
4.45
5.42
4.03
2.08
1.00
1.00
1.01
1.07
1.03
1.04
1.02
6.07
7.85
7.84
7.84
7.83
7.72
7.71
7.71
7.70
7.29
7.28
7.26
7.20
7.19
7.18
7.14
7.13
4.10
4.10
4.09
4.08
4.07
4.07
4.06
4.06
4.05
4.04
3.97
3.96
3.95
3.95
3.94
3.24
3.21
3.15
2.82
2.79
2.66
2.64
2.54
2.53
2.51
2.38
2.10
2.10
1.31
1.30
1.29
1.29
1.28
1.26
O
O
O
N
P
OEt
OEt
Ph
O

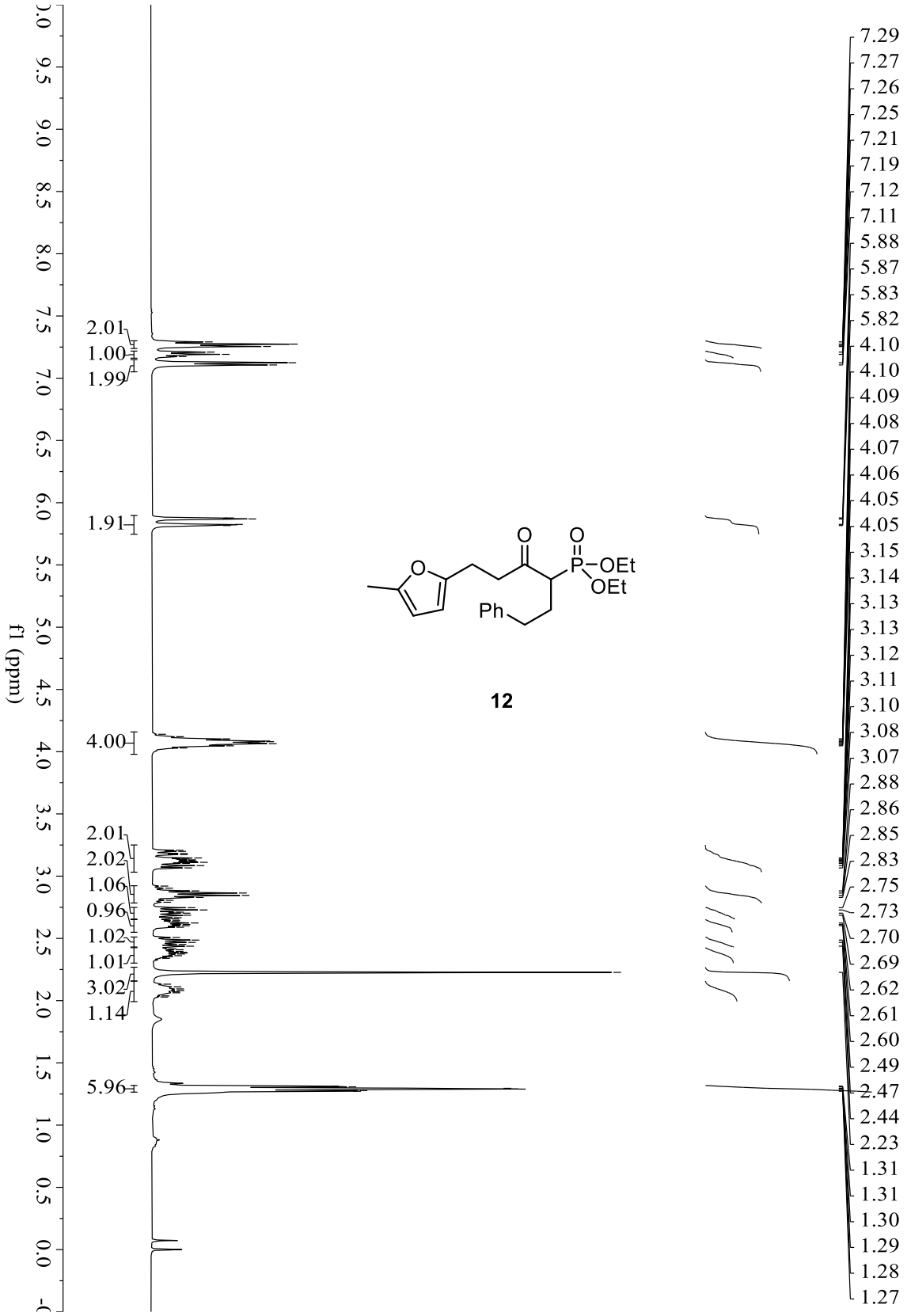
11

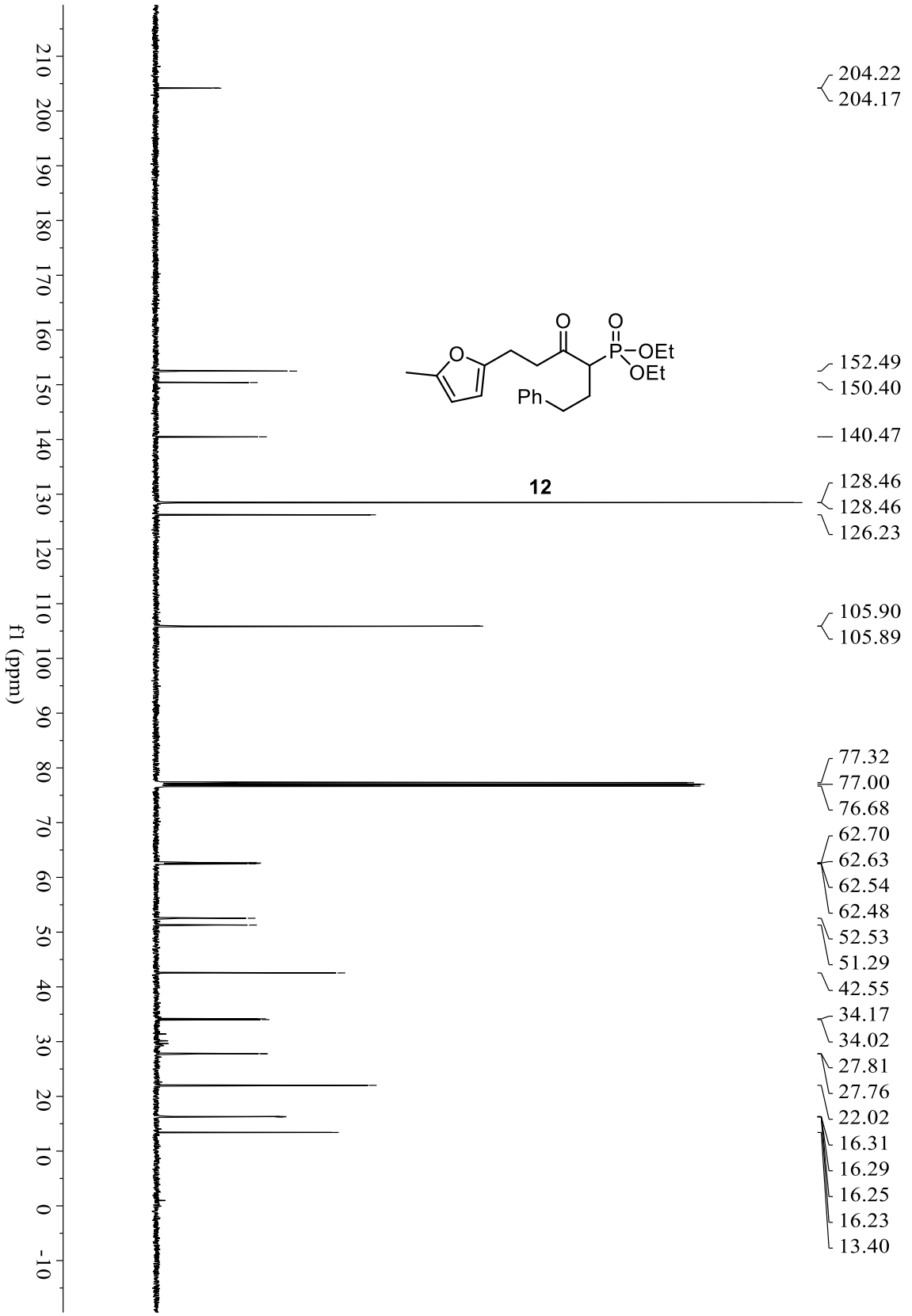

f1 (ppm)
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
202.77
202.74
167.88
140.25
133.89
131.99
128.48
128.44
126.24
123.14
77.21
77.00
76.79
62.74
62.69
52.44
51.61
41.74
34.09
33.99
32.71
27.44
27.41
16.25
16.23
16.21
16.19
O
O
O
P
OEt
OEt
N
Ph
O

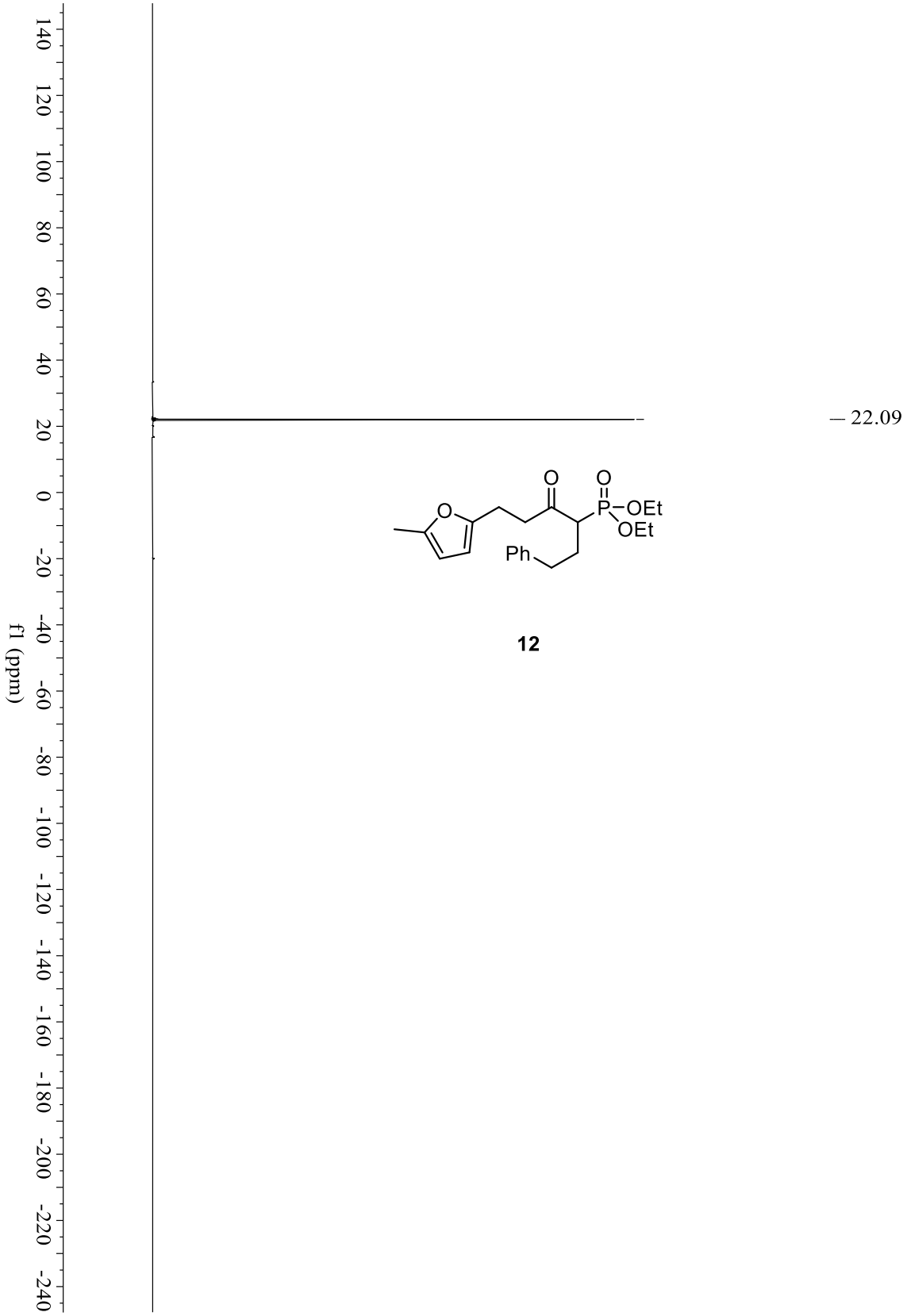
11

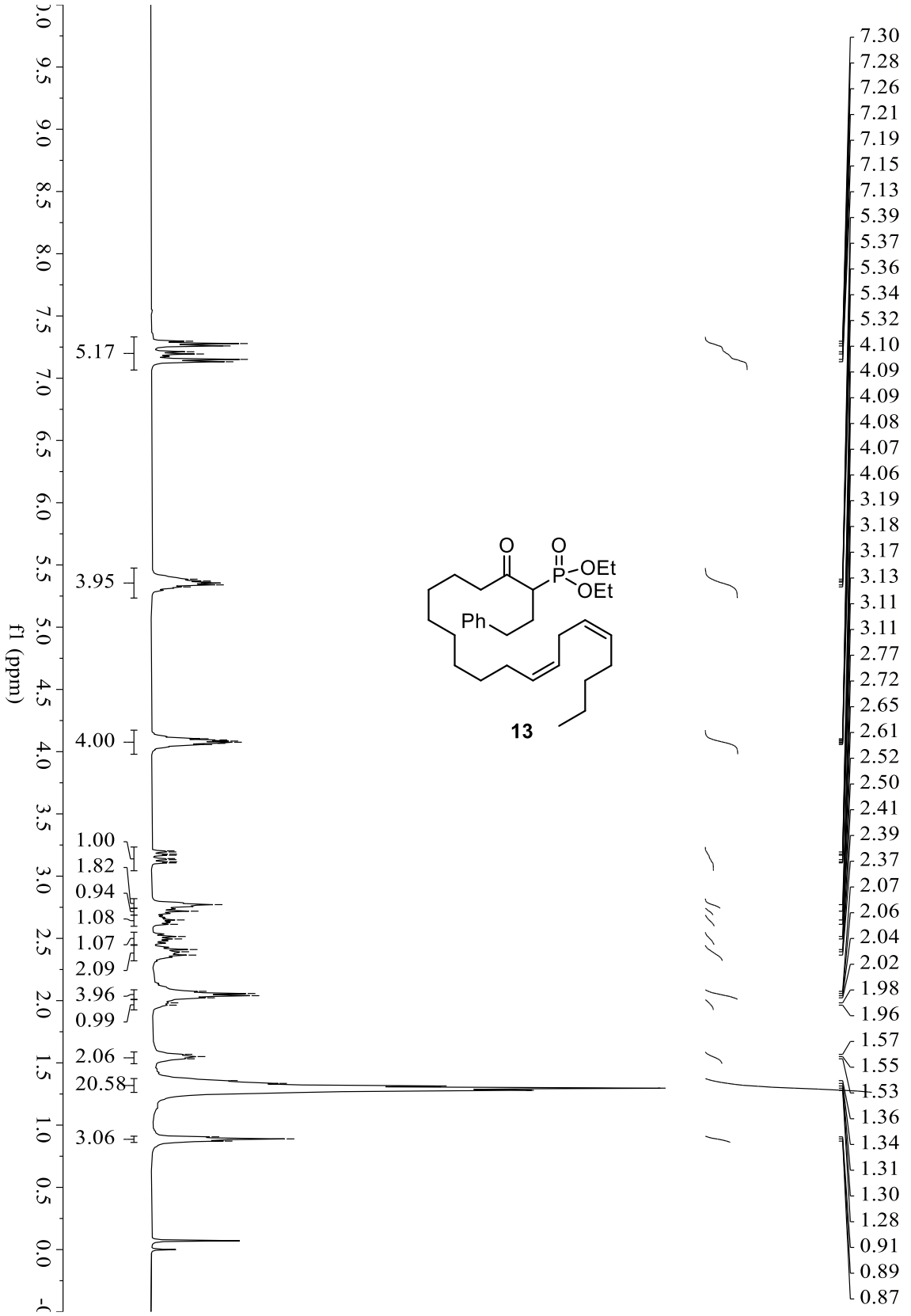

22.43
f1 (ppm)
20
110
100
90
80
70
60
50
40
30
20
10
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-1
O
O
O
N
P
OEt
OEt
Ph
O

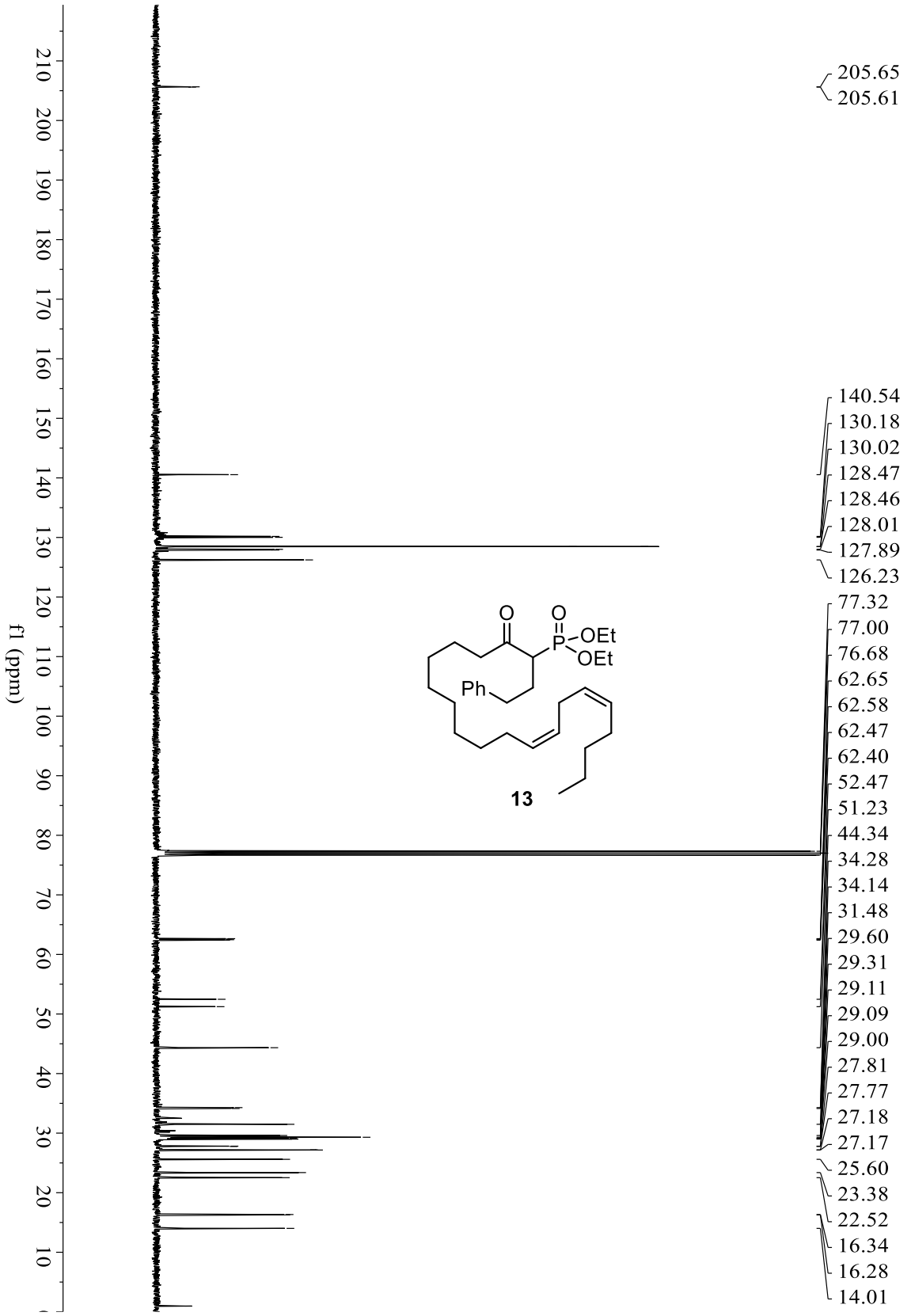
11

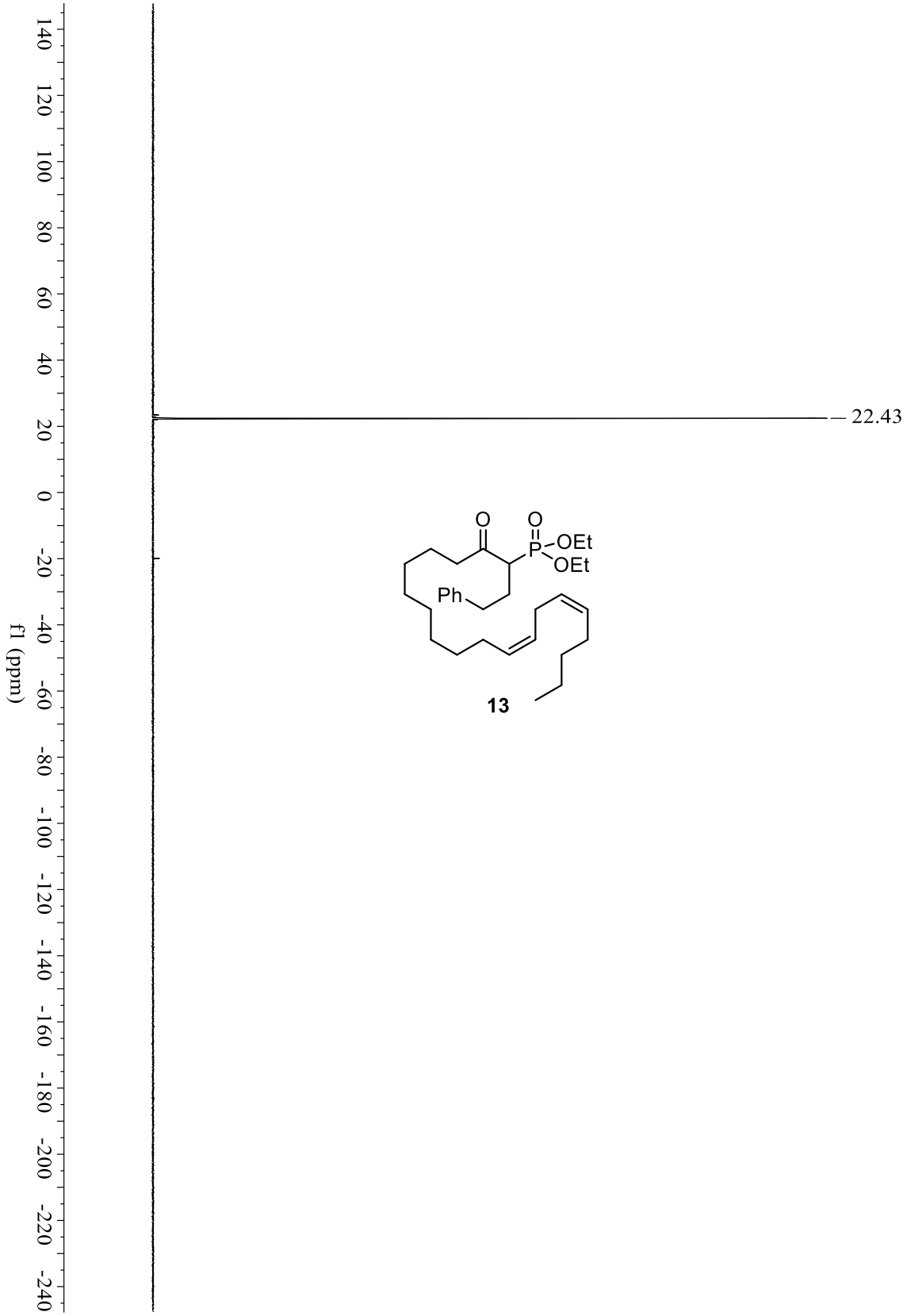

f1 (ppm)
2.01
1.00
1.99
1.91
4.00
2.01
2.02
1.06
0.96
1.02
1.01
3.02
1.14
5.96
O
O
O
P
OEt
OEt
Ph
12
7.29
7.27
7.26
7.25
7.21
7.19
7.12
7.11
5.88
5.87
5.83
5.82
4.10
4.10
4.09
4.08
4.07
4.06
4.05
4.05
3.15
3.14
3.13
3.13
3.12
3.11
3.10
3.08
3.07
2.88
2.86
2.85
2.83
2.75
2.73
2.70
2.69
2.62
2.61
2.60
2.49
2.47
2.44
2.23
1.31
1.31
1.30
1.29
1.28
1.27

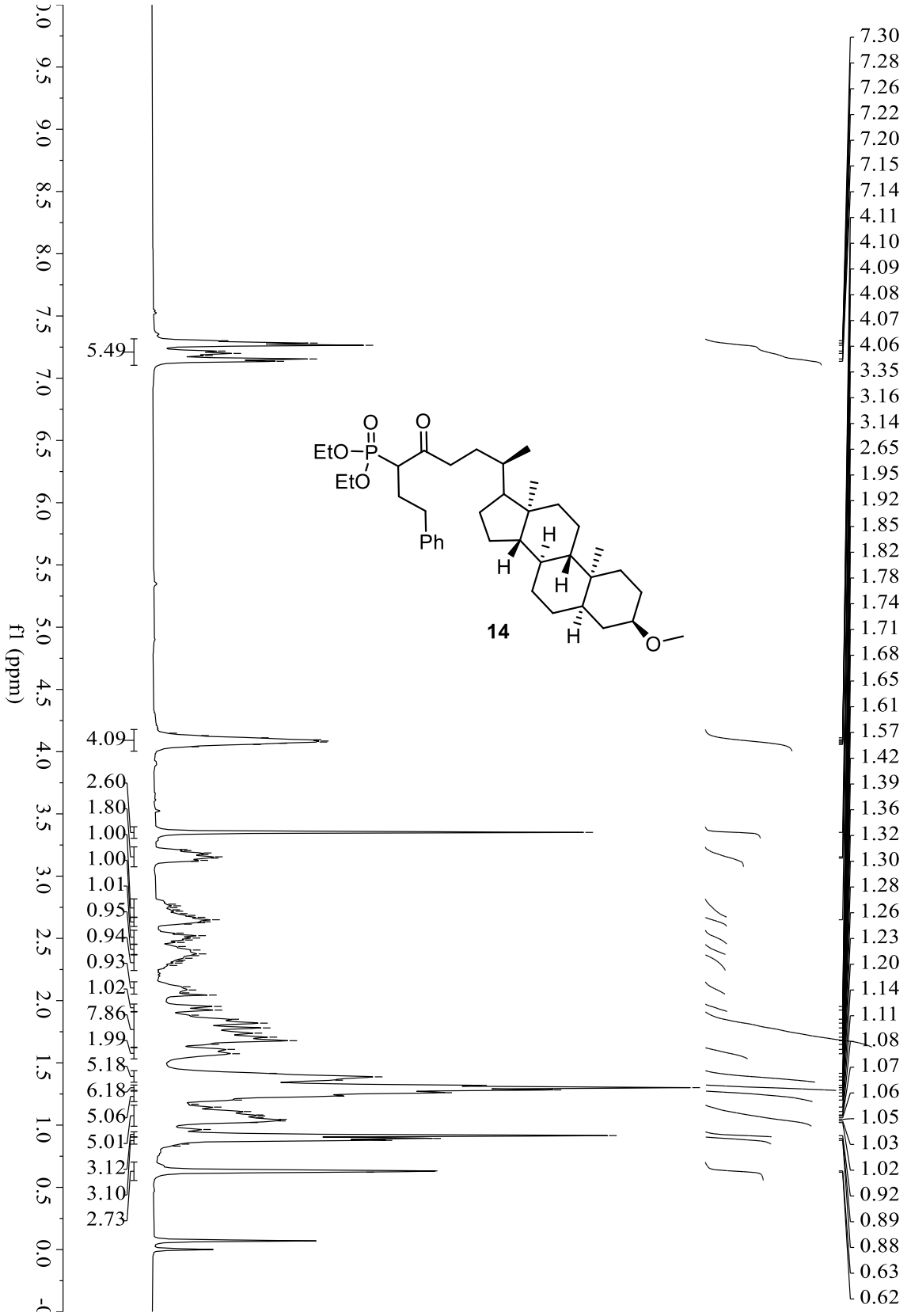

204.22
204.17
152.49
150.40
140.47
128.46
128.46
126.23
105.90
105.89
77.32
77.00
76.68
62.70
62.63
62.54
62.48
52.53
51.29
42.55
34.17
34.02
27.81
27.76
22.02
16.31
16.29
16.25
16.23
13.40
O
O
P
OEt
OEt
O
Ph
12
f1 (ppm)
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
-10

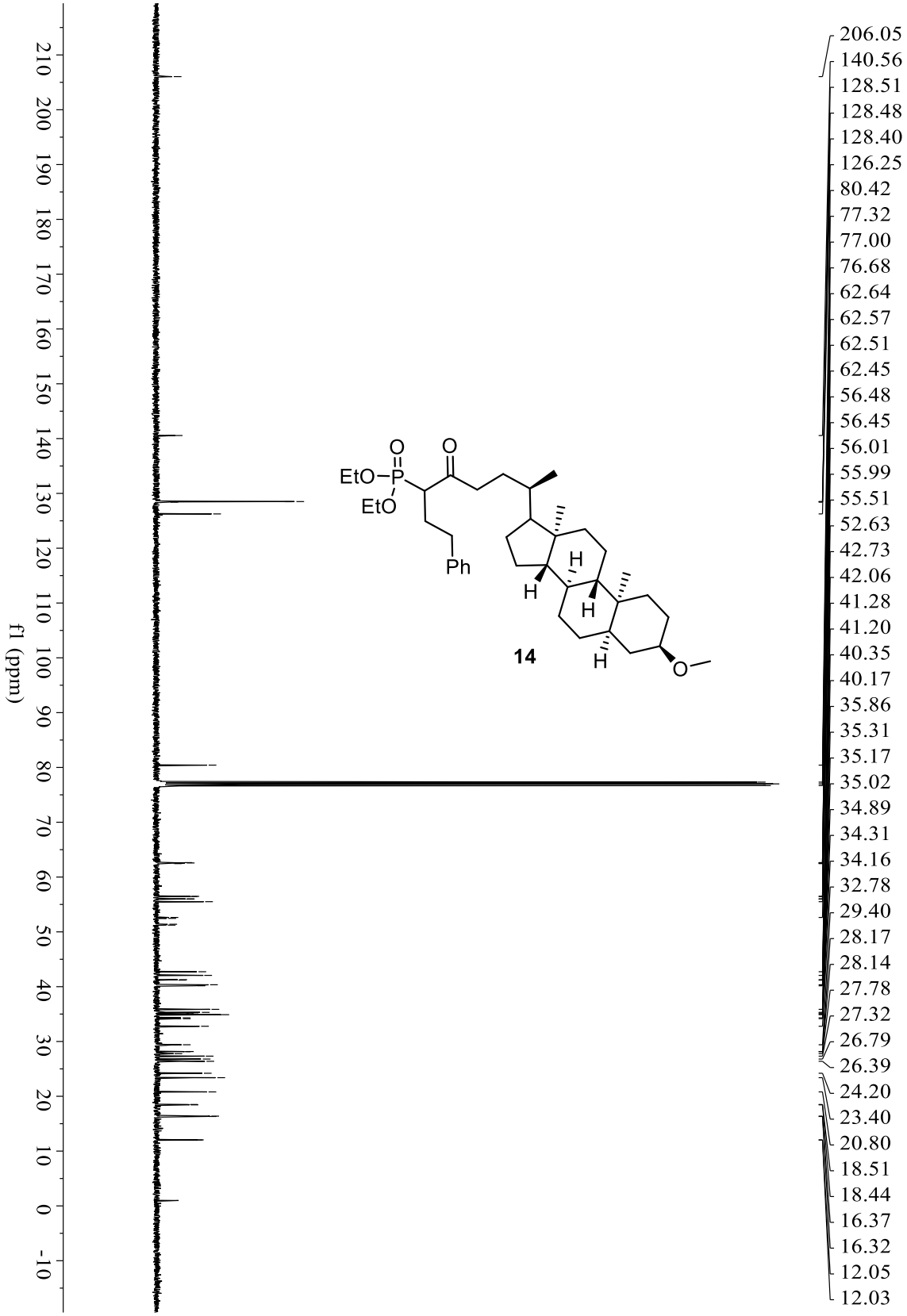

22.09
O
O
P
OEt
OEt
O
Ph
12
140 120 100 80 60 40 20 0 -20 -40 -60 -80 -100 -120 -140 -160 -180 -200 -220 -240
f1 (ppm)

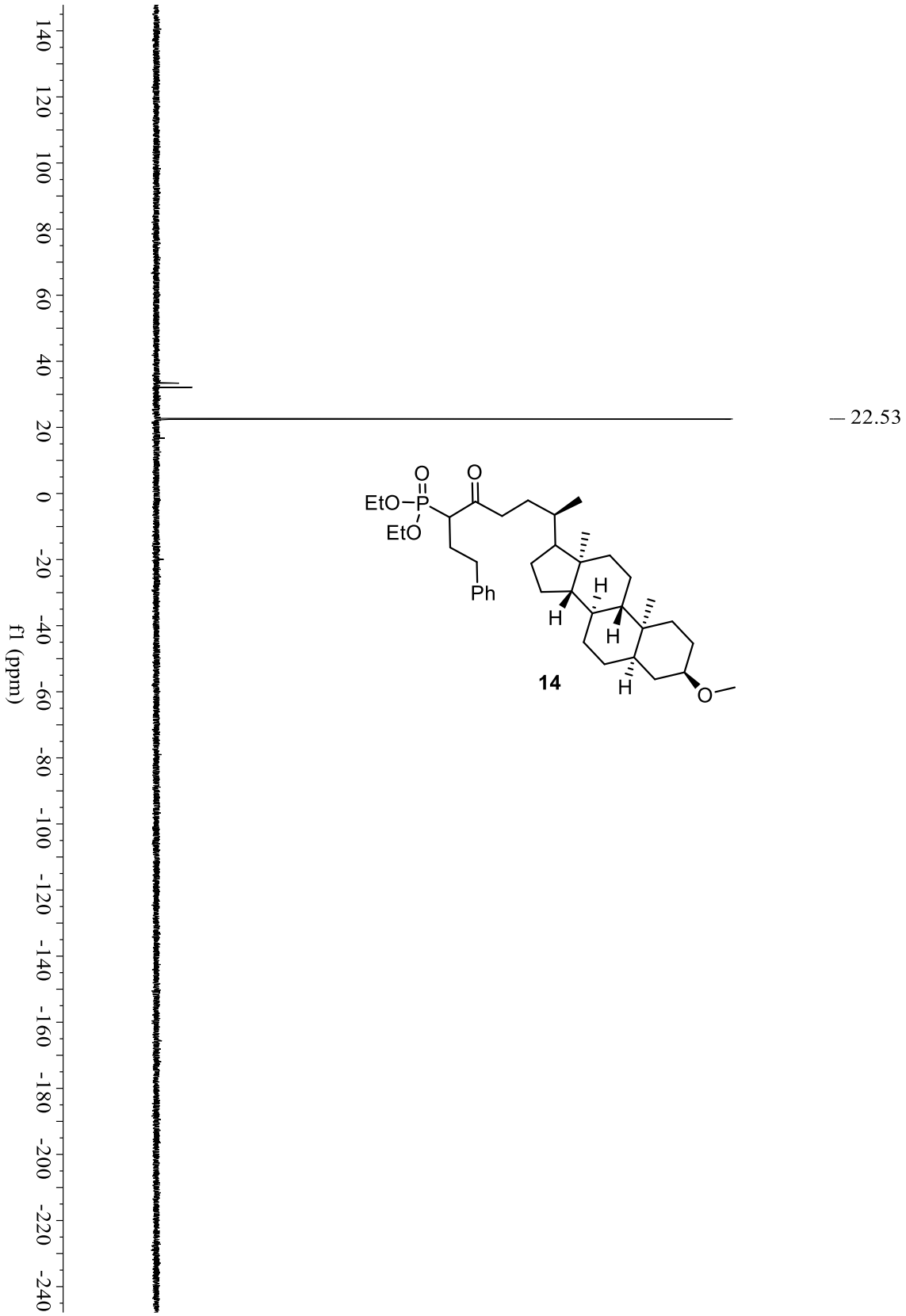

f1 (ppm)
5.17
3.95
4.00
1.00
1.82
0.94
1.08
1.07
2.09
3.96
0.99
2.06
20.58
3.06
O
O
P
OEt
OEt
Ph
13
7.30
7.28
7.26
7.21
7.19
7.15
7.13
5.39
5.37
5.36
5.34
5.32
4.10
4.09
4.09
4.08
4.07
4.06
3.19
3.18
3.17
3.13
3.11
3.11
2.77
2.72
2.65
2.61
2.52
2.50
2.41
2.39
2.37
2.07
2.06
2.04
2.02
1.98
1.96
1.57
1.55
1.53
1.36
1.34
1.31
1.30
1.28
0.91
0.89
0.87

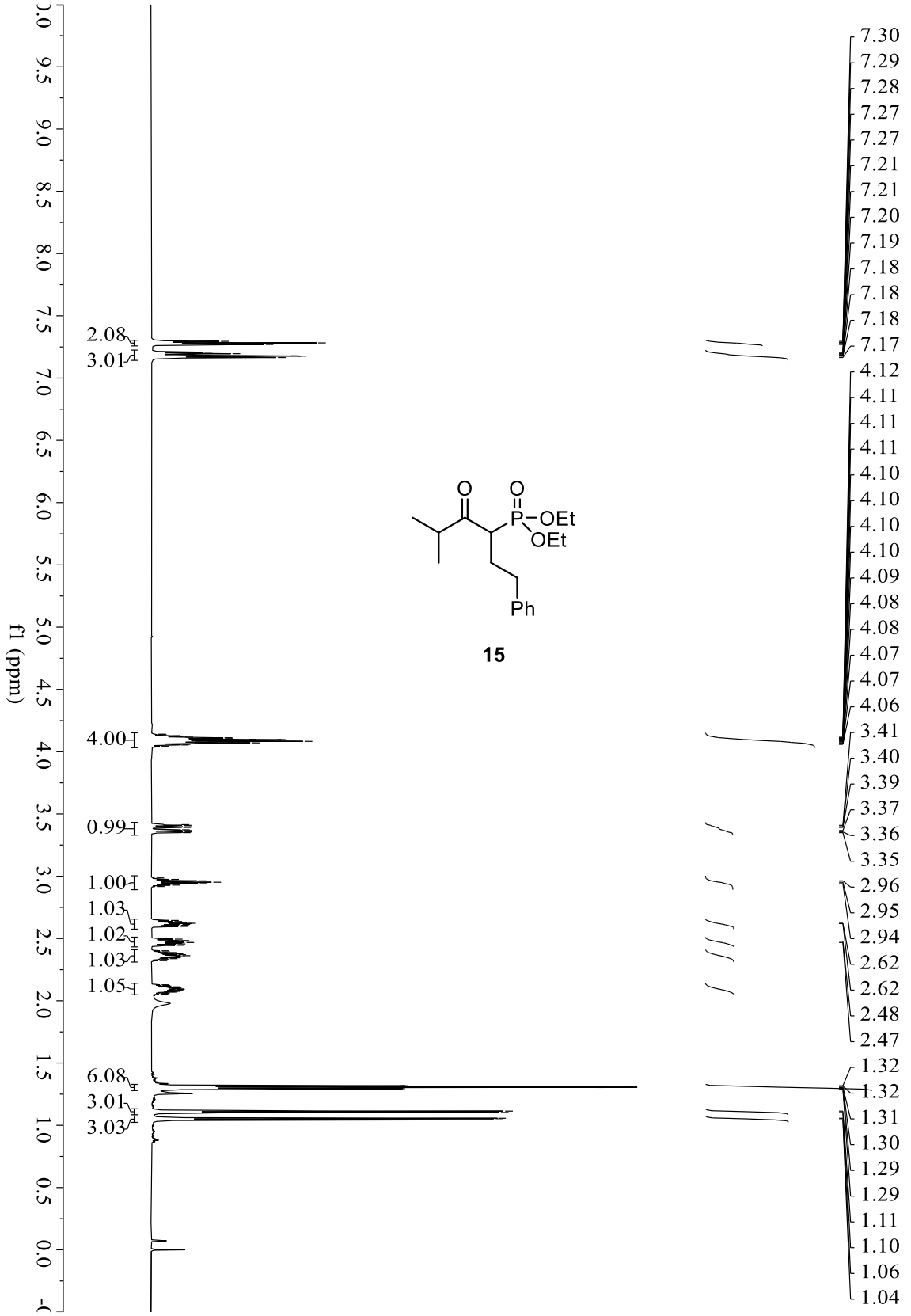

205.65
205.61
140.54
130.18
130.02
128.47
128.46
128.01
127.89
126.23
77.32
77.00
76.68
62.65
62.58
62.47
62.40
52.47
51.23
44.34
34.28
34.14
31.48
29.60
29.31
29.11
29.09
29.00
27.81
27.77
27.18
27.17
25.60
23.38
22.52
16.34
16.28
14.01
O
O
P
OEt
OEt
Ph
13
f1 (ppm)
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10

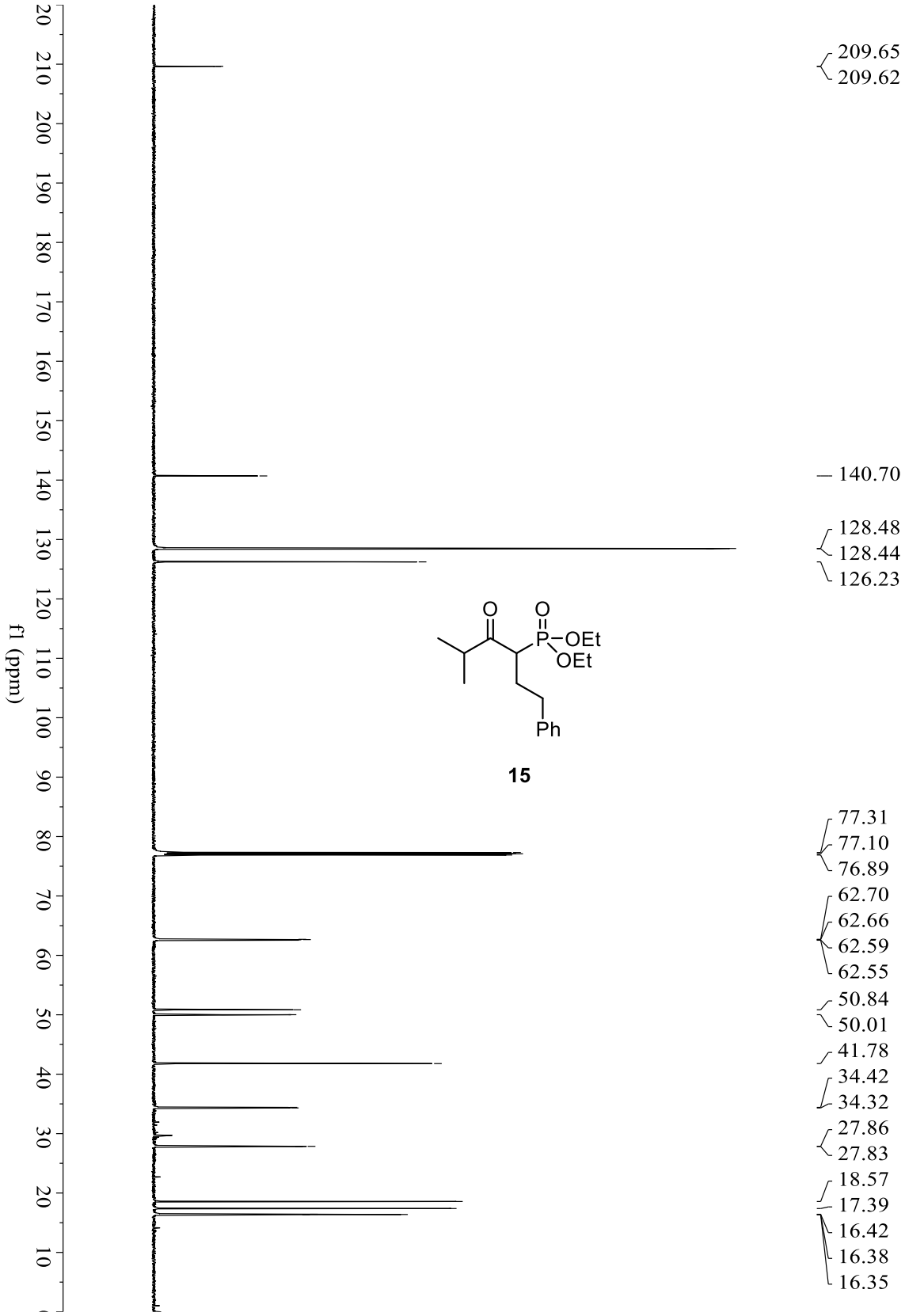

22.43
O
O
P
OEt
OEt
Ph
13
140 120 100 80 60 40 20 0 -20 -40 -60 -80 -100 -120 -140 -160 -180 -200 -220 -240
f1 (ppm)


f1 (ppm)
5.49
4.09
2.60
1.80
1.00
1.00
1.01
0.95
0.94
0.93
1.02
7.86
1.99
5.18
6.18
5.06
5.01
3.12
3.10
2.73
7.30
7.28
7.26
7.22
7.20
7.15
7.14
4.11
4.10
4.09
4.08
4.07
4.06
3.35
3.16
3.14
2.65
1.95
1.92
1.85
1.82
1.78
1.74
1.71
1.68
1.65
1.61
1.57
1.42
1.39
1.36
1.32
1.30
1.28
1.26
1.23
1.20
1.14
1.11
1.08
1.07
1.06
1.05
1.03
1.02
0.92
0.89
0.88
0.63
0.62
EtO
P
EtO
Ph
H
H
H
H
O
14

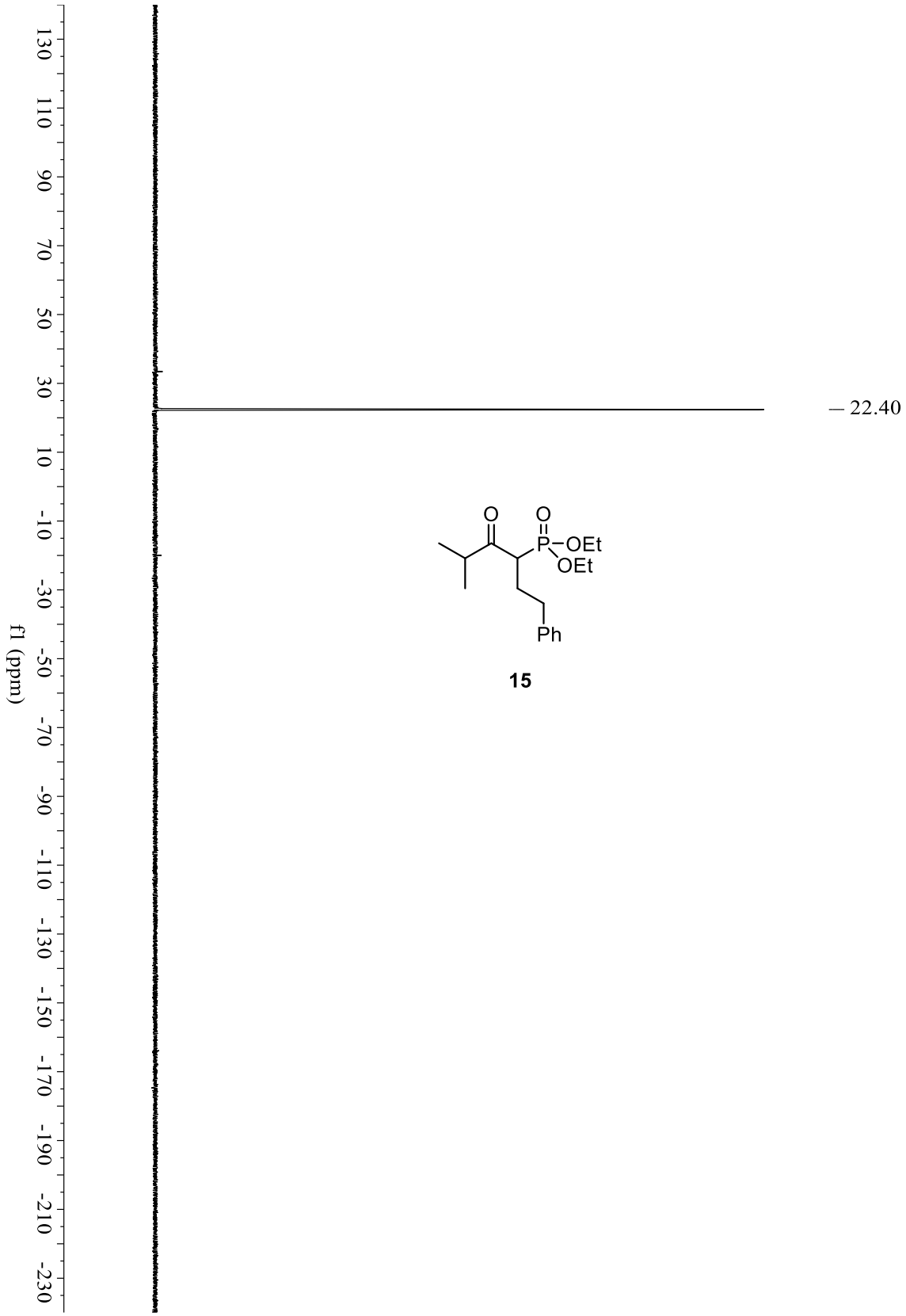

f1 (ppm)
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
-10
206.05
140.56
128.51
128.48
128.40
126.25
80.42
77.32
77.00
76.68
62.64
62.57
62.51
62.45
56.48
56.45
56.01
55.99
55.51
52.63
42.73
42.06
41.28
41.20
40.35
40.17
35.86
35.31
35.17
35.02
34.89
34.31
34.16
32.78
29.40
28.17
28.14
27.78
27.32
26.79
26.39
24.20
23.40
20.80
18.51
18.44
16.37
16.32
12.05
12.03
O
O
EtO
P
EtO
Ph
H
H
H
H
O
14


22.53
f1 (ppm)
140
120
100
80
60
40
20
0
-20
-40
-60
-80
-100
-120
-140
-160
-180
-200
-220
-240
EtO
P
O
EtO
O
Ph
H
H
H
O
14

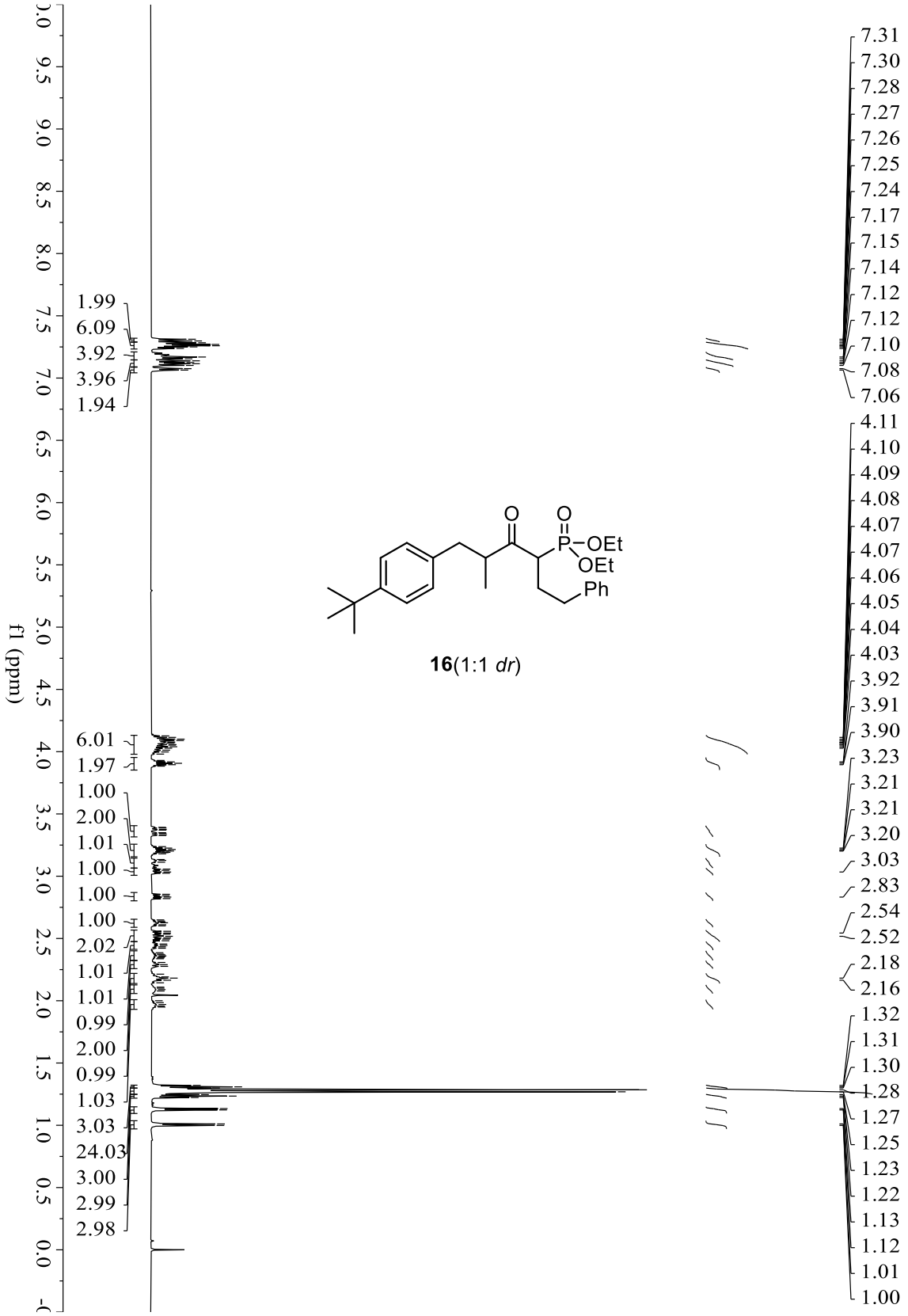

f1 (ppm)
2.08
3.01
4.00
0.99
1.00
1.03
1.02
1.03
1.05
6.08
3.01
3.03
O
O
P–OEt
OEt
Ph
15
7.30
7.29
7.28
7.27
7.27
7.21
7.21
7.20
7.19
7.18
7.18
7.18
7.17
4.12
4.11
4.11
4.11
4.10
4.10
4.10
4.10
4.09
4.08
4.08
4.07
4.07
4.06
3.41
3.40
3.39
3.37
3.36
3.35
2.96
2.95
2.94
2.62
2.62
2.48
2.47
1.32
1.32
1.31
1.30
1.29
1.29
1.11
1.10
1.06
1.04


209.65
209.62
140.70
128.48
128.44
126.23
77.31
77.10
76.89
62.70
62.66
62.59
62.55
50.84
50.01
41.78
34.42
34.32
27.86
27.83
18.57
17.39
16.42
16.38
16.35
f1 (ppm)
O
O
P
OEt
OEt
Ph

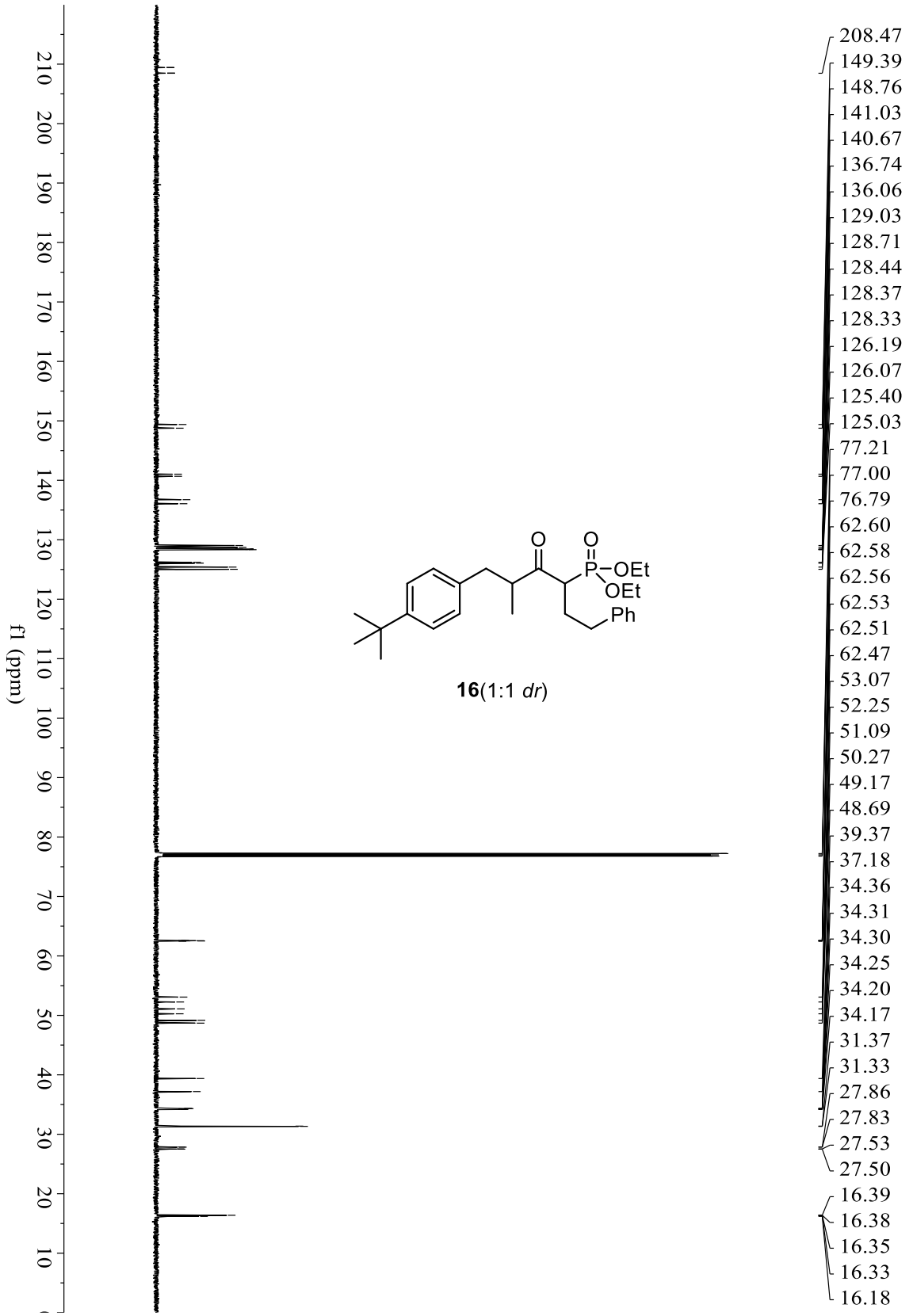
15


22.40
130
110
90
70
50
30
10
-10
-30
-50
-70
-90
-110
-130
-150
-170
-190
-210
-230
f1 (ppm)
O
O
P
OEt
OEt
Ph

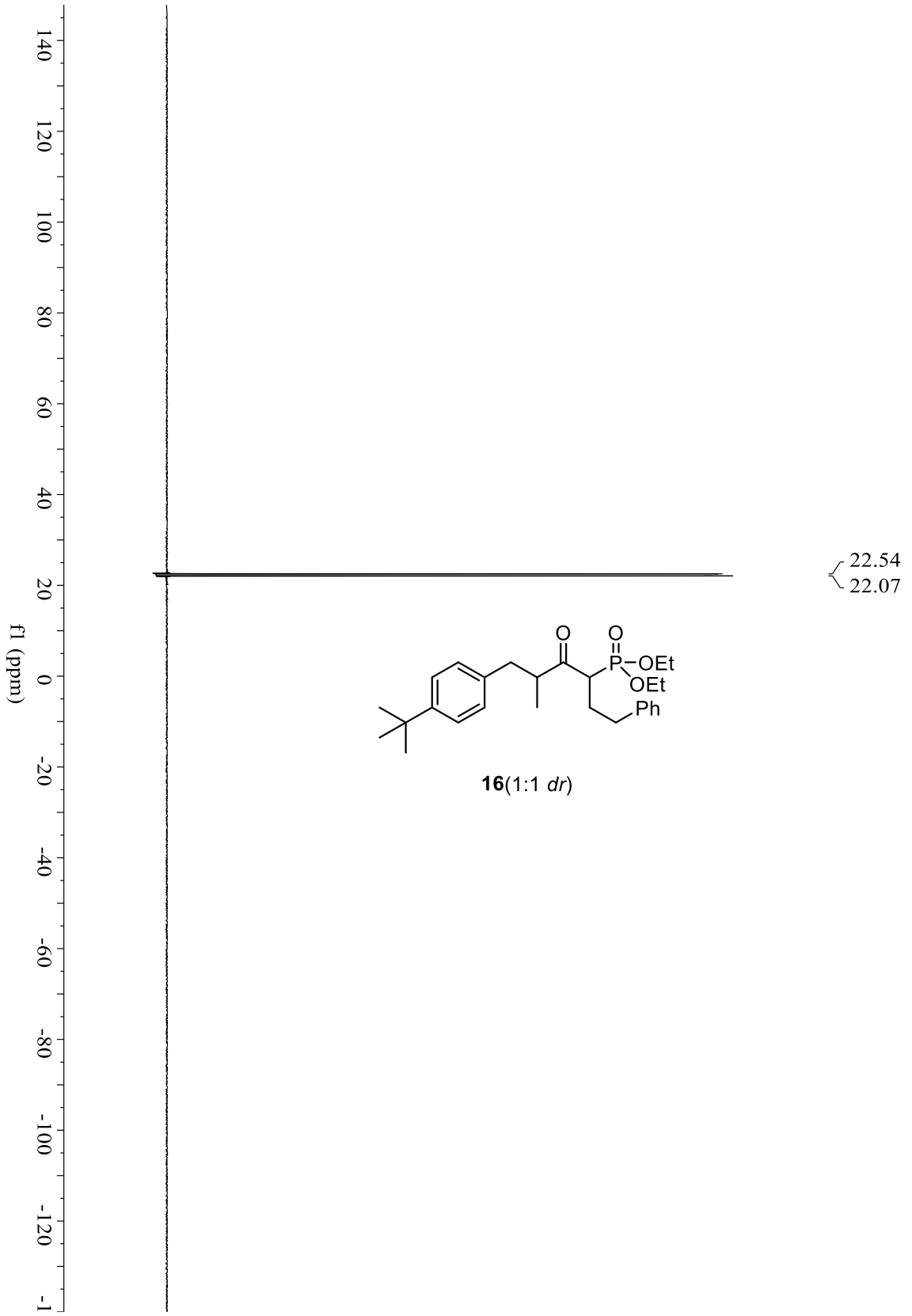
15


f1 (ppm)
1.99
6.09
3.92
3.96
1.94
6.01
1.97
1.00
2.00
1.01
1.00
1.00
1.00
2.02
1.01
1.01
0.99
2.00
0.99
1.03
3.03
24.03
3.00
2.99
2.98
7.31
7.30
7.28
7.27
7.26
7.25
7.24
7.17
7.15
7.14
7.12
7.12
7.10
7.08
7.06
4.11
4.10
4.09
4.08
4.07
4.07
4.06
4.05
4.04
4.03
3.92
3.91
3.90
3.23
3.21
3.21
3.20
3.03
2.83
2.54
2.52
2.18
2.16
1.32
1.31
1.30
1.28
1.27
1.25
1.23
1.22
1.13
1.12
1.01
1.00
O
O
P–OEt
OEt
Ph

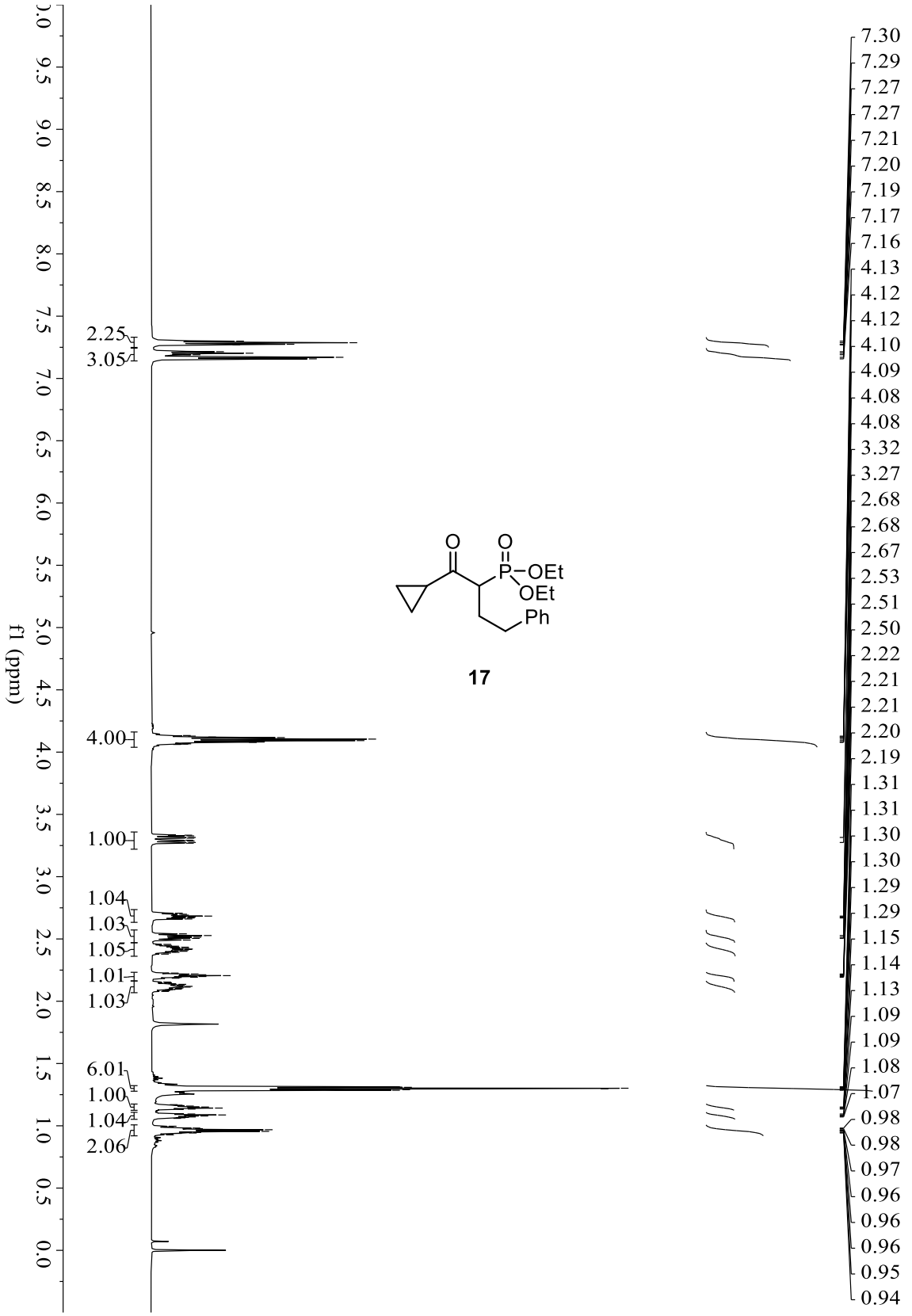
16(1:1 *dr*)

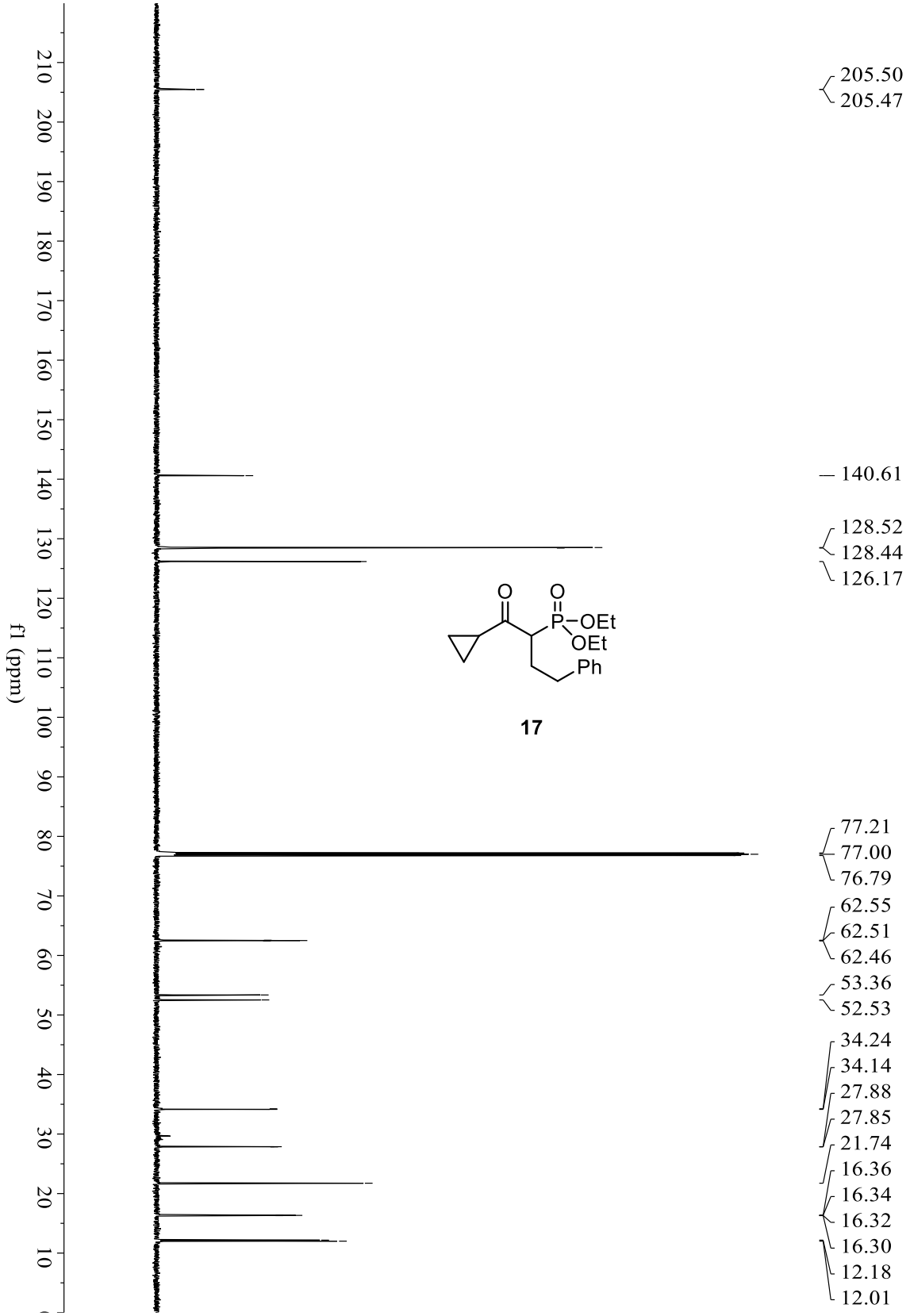

f1 (ppm)
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
O
O
P
OEt
OEt
Ph
208.47
149.39
148.76
141.03
140.67
136.74
136.06
129.03
128.71
128.44
128.37
128.33
126.19
126.07
125.40
125.03
77.21
77.00
76.79
62.60
62.58
62.56
62.53
62.51
62.47
53.07
52.25
51.09
50.27
49.17
48.69
39.37
37.18
34.36
34.31
34.30
34.25
34.20
34.17
31.37
31.33
27.86
27.83
27.53
27.50
16.39
16.38
16.35
16.33
16.18

16(1:1 *dr*)

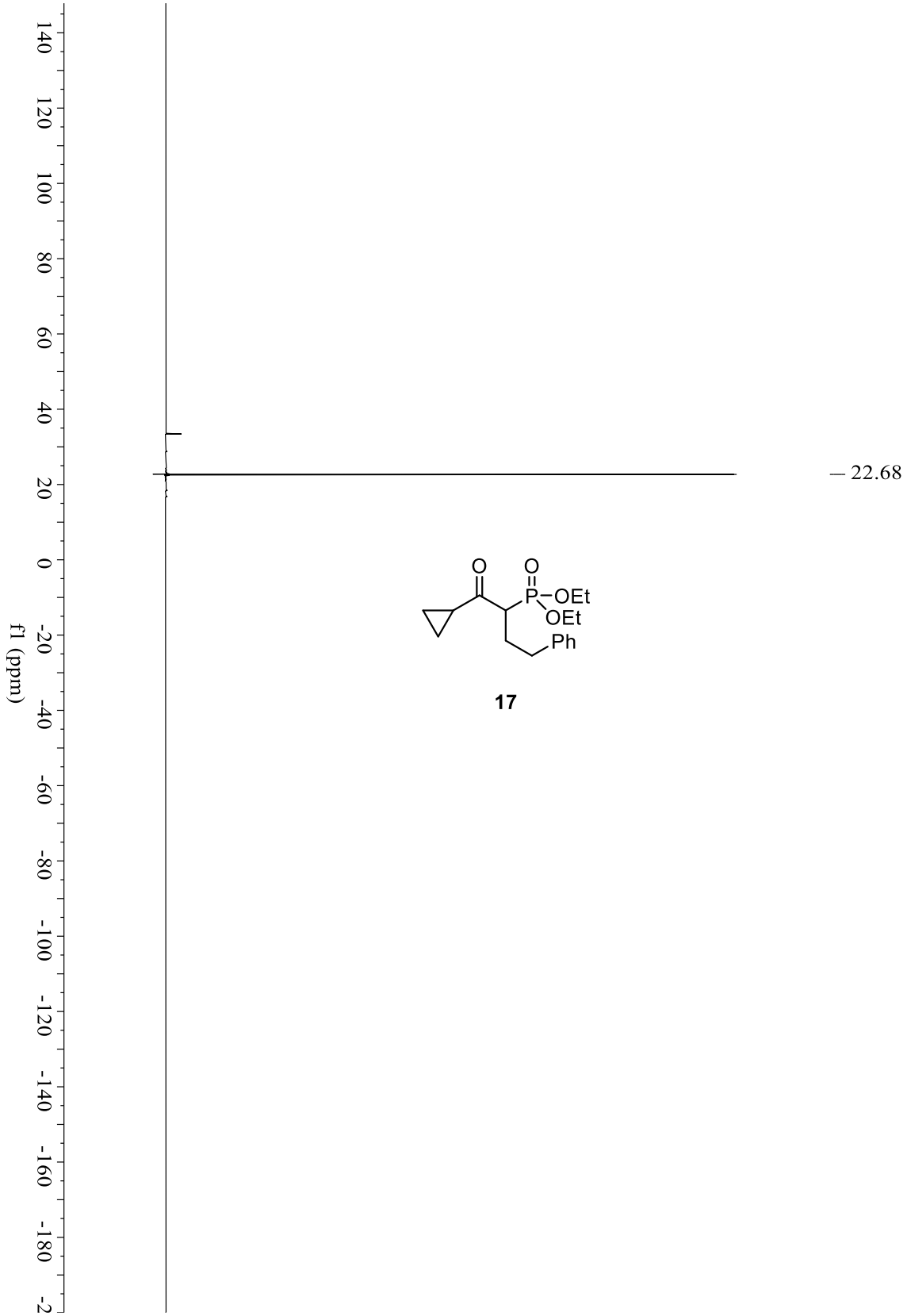

140
120
100
80
60
40
20
0
-20
-40
-60
-80
-100
-120
-1
f1 (ppm)
22.54
22.07
O
O
P
OEt
OEt
Ph

16(1:1 *dr*)

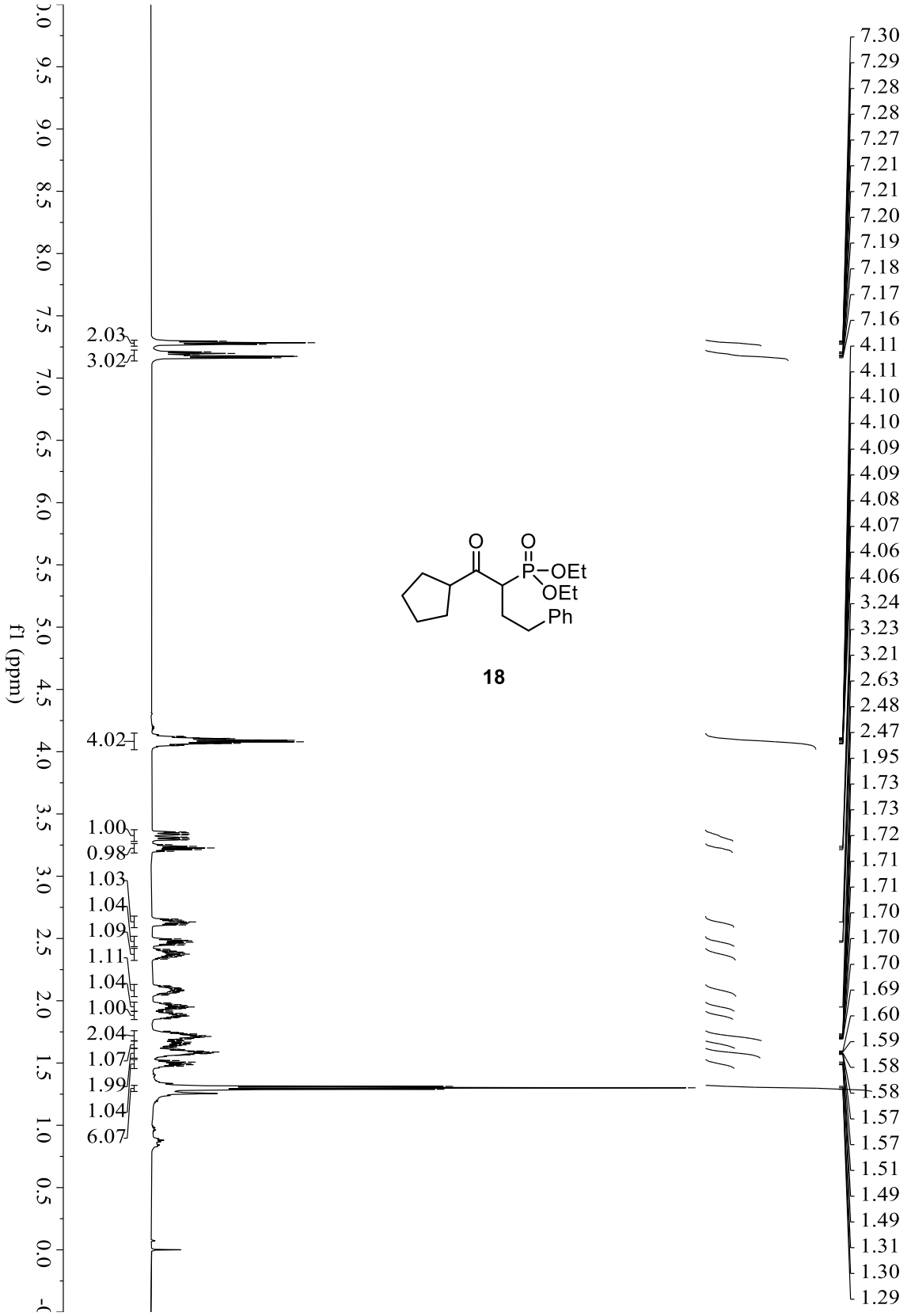

f1 (ppm)
2.25
3.05
4.00
1.00
1.04
1.03
1.05
1.01
1.03
6.01
1.00
1.04
2.06
O
O
P
OEt
OEt
Ph
17
7.30
7.29
7.27
7.27
7.21
7.20
7.19
7.17
7.16
4.13
4.12
4.12
4.10
4.09
4.08
4.08
3.32
3.27
2.68
2.68
2.67
2.53
2.51
2.50
2.22
2.21
2.21
2.20
2.19
1.31
1.31
1.30
1.30
1.29
1.29
1.15
1.14
1.13
1.09
1.09
1.08
1.07
0.98
0.98
0.97
0.96
0.96
0.96
0.95
0.94

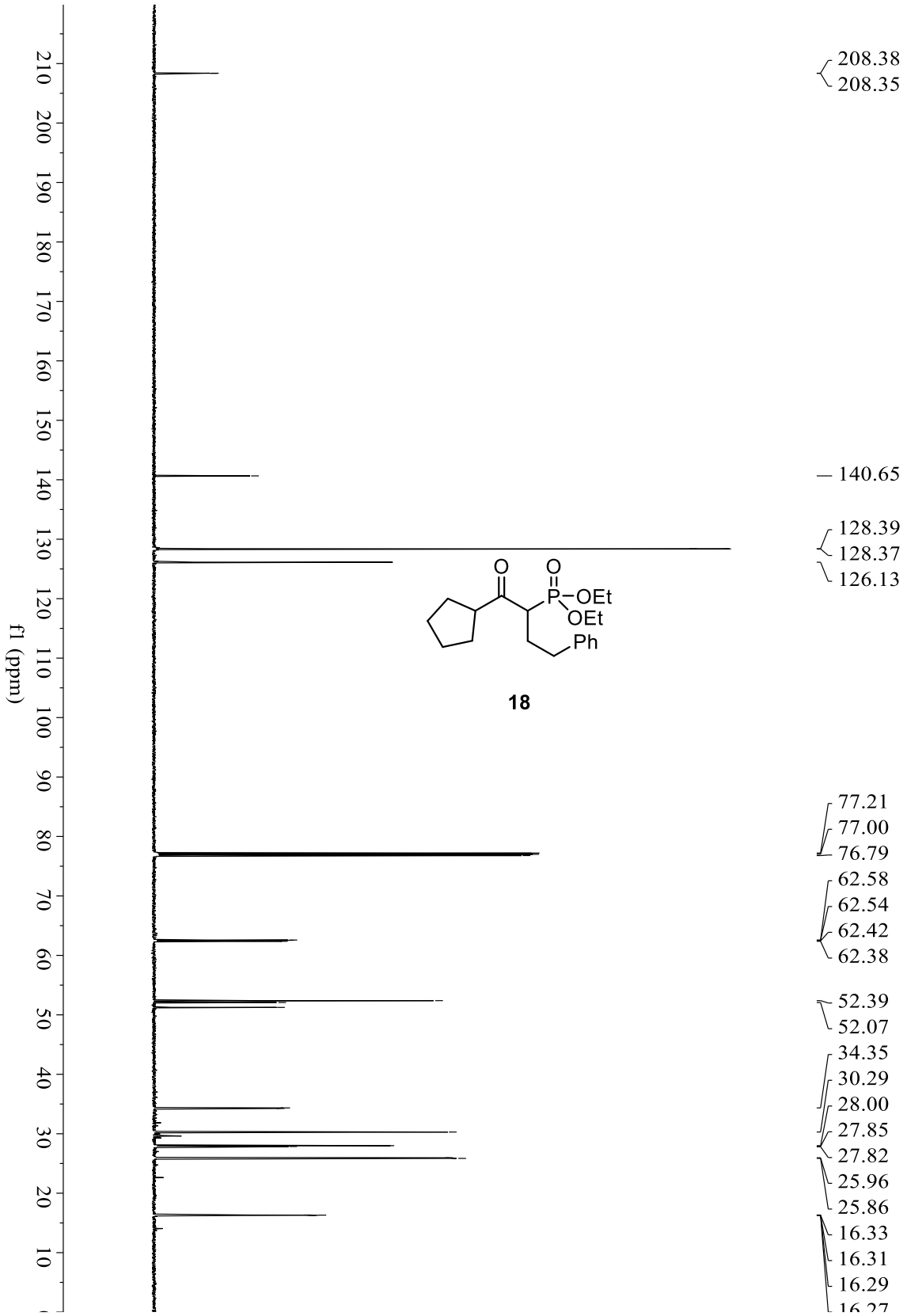

205.50
205.47
140.61
128.52
128.44
126.17
77.21
77.00
76.79
62.55
62.51
62.46
53.36
52.53
34.24
34.14
27.88
27.85
21.74
16.36
16.34
16.32
16.30
12.18
12.01
f1 (ppm)
O
O
P
OEt
OEt
Ph

17

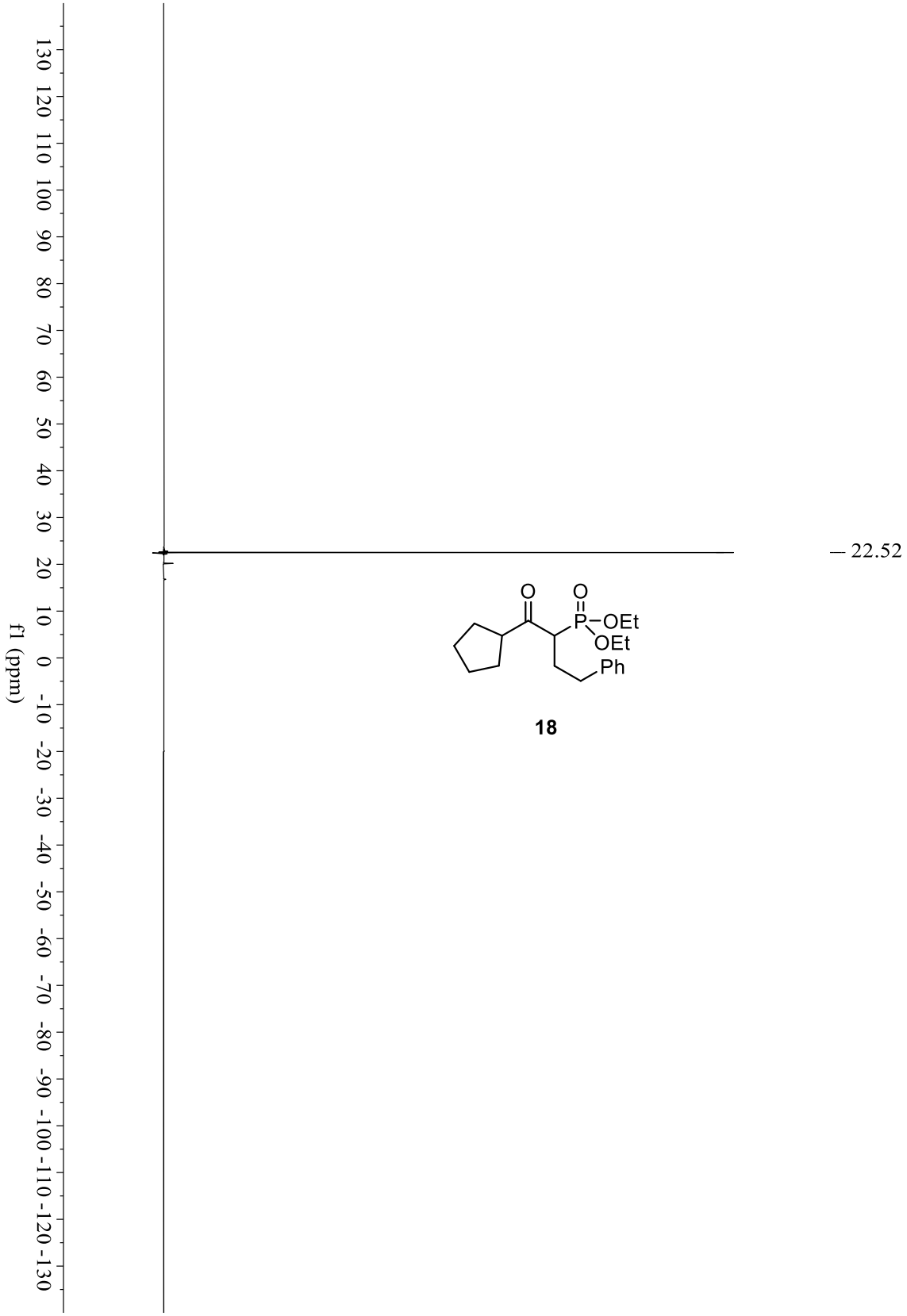

140
120
100
80
60
40
20
0
-20
-40
-60
-80
-100
-120
-140
-160
-180
-2
f1 (ppm)
22.68
O
O
P
OEt
OEt
Ph

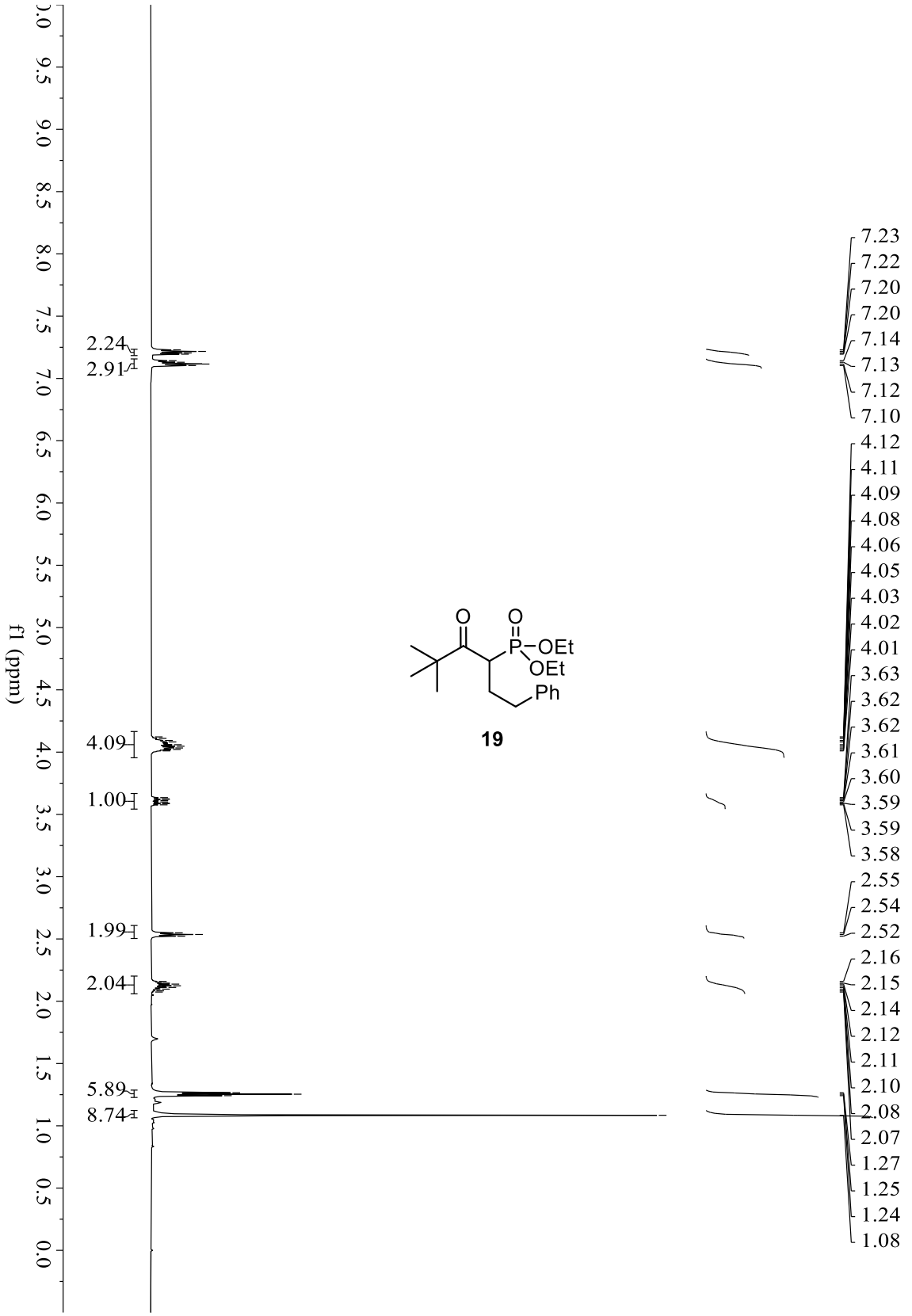
17

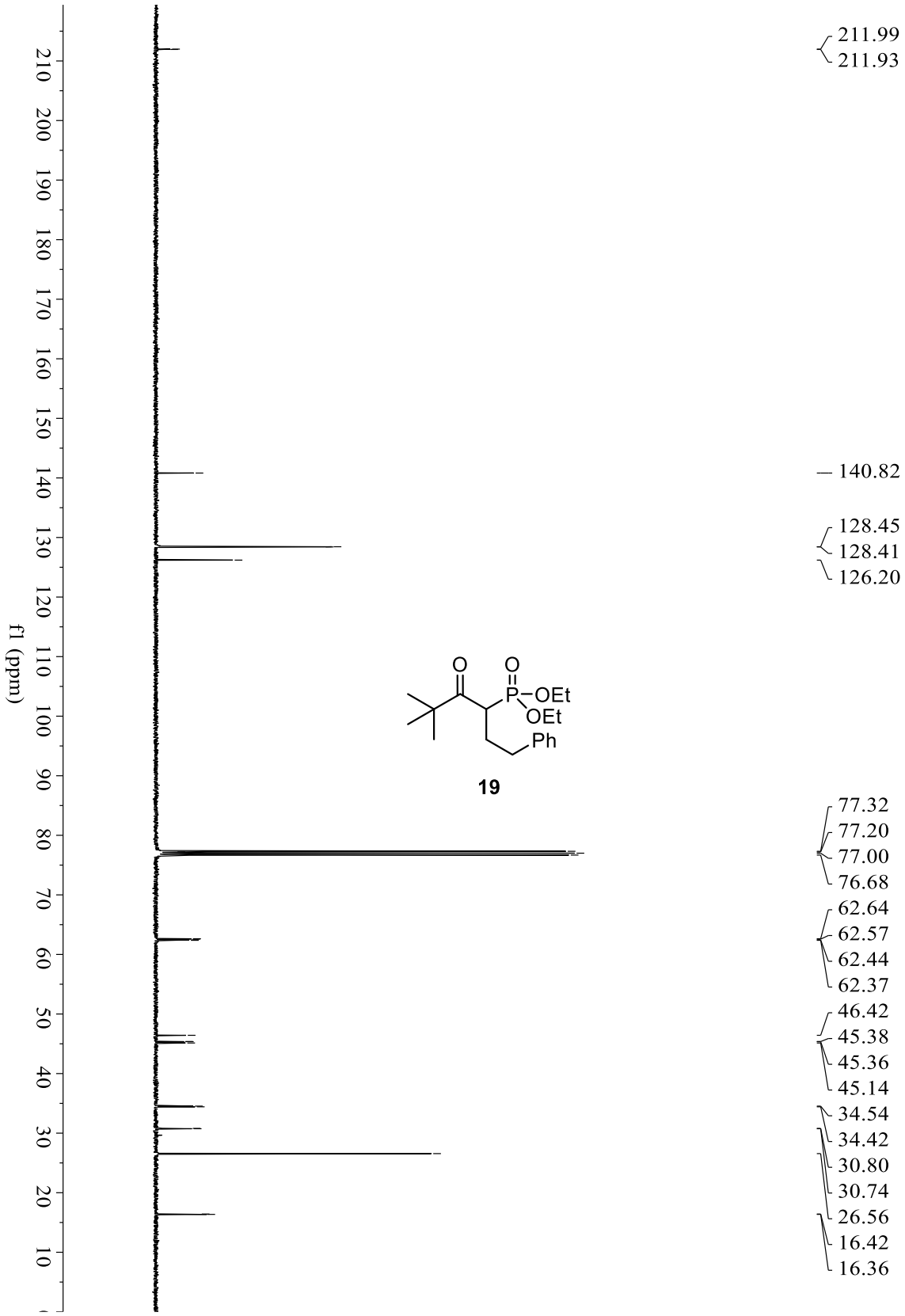

f1 (ppm)
2.03
3.02
4.02
1.00
0.98
1.03
1.04
1.09
1.11
1.04
1.00
2.04
1.07
1.99
1.04
6.07
O
O
P
OEt
OEt
Ph
18
7.30
7.29
7.28
7.28
7.27
7.21
7.21
7.20
7.19
7.18
7.17
7.16
4.11
4.11
4.10
4.10
4.09
4.09
4.08
4.07
4.06
4.06
3.24
3.23
3.21
2.63
2.48
2.47
1.95
1.73
1.73
1.72
1.71
1.71
1.70
1.70
1.70
1.69
1.60
1.59
1.58
1.58
1.57
1.57
1.51
1.49
1.49
1.31
1.30
1.29


208.38
208.35
140.65
128.39
128.37
126.13
77.21
77.00
76.79
62.58
62.54
62.42
62.38
52.39
52.07
34.35
30.29
28.00
27.85
27.82
25.96
25.86
16.33
16.31
16.29
f1 (ppm)
O
O
P
OEt
OEt
Ph

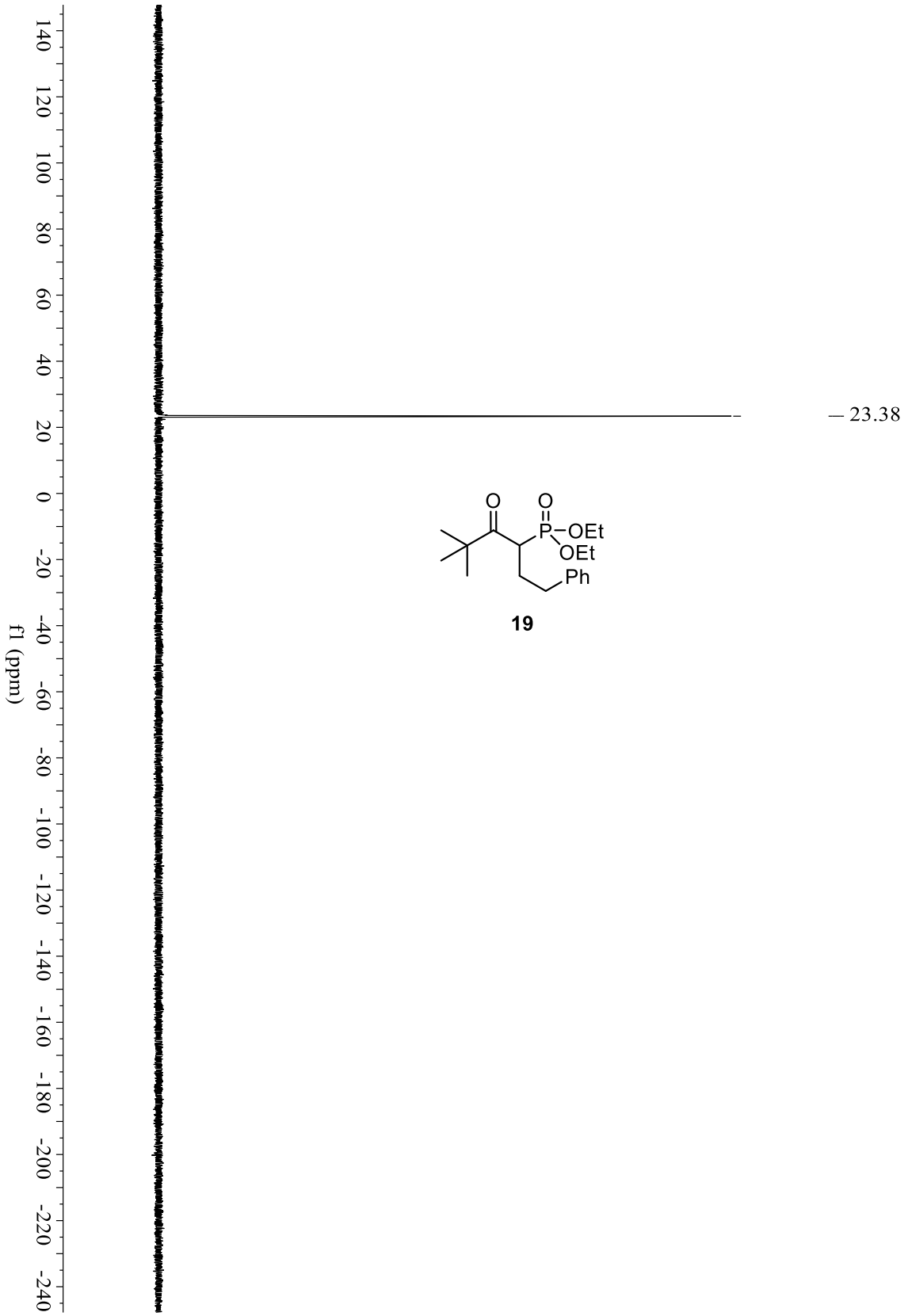
18


22.52
O
O
P
OEt
OEt
Ph
18
f1 (ppm)
130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10 -20 -30 -40 -50 -60 -70 -80 -90 -100 -110 -120 -130

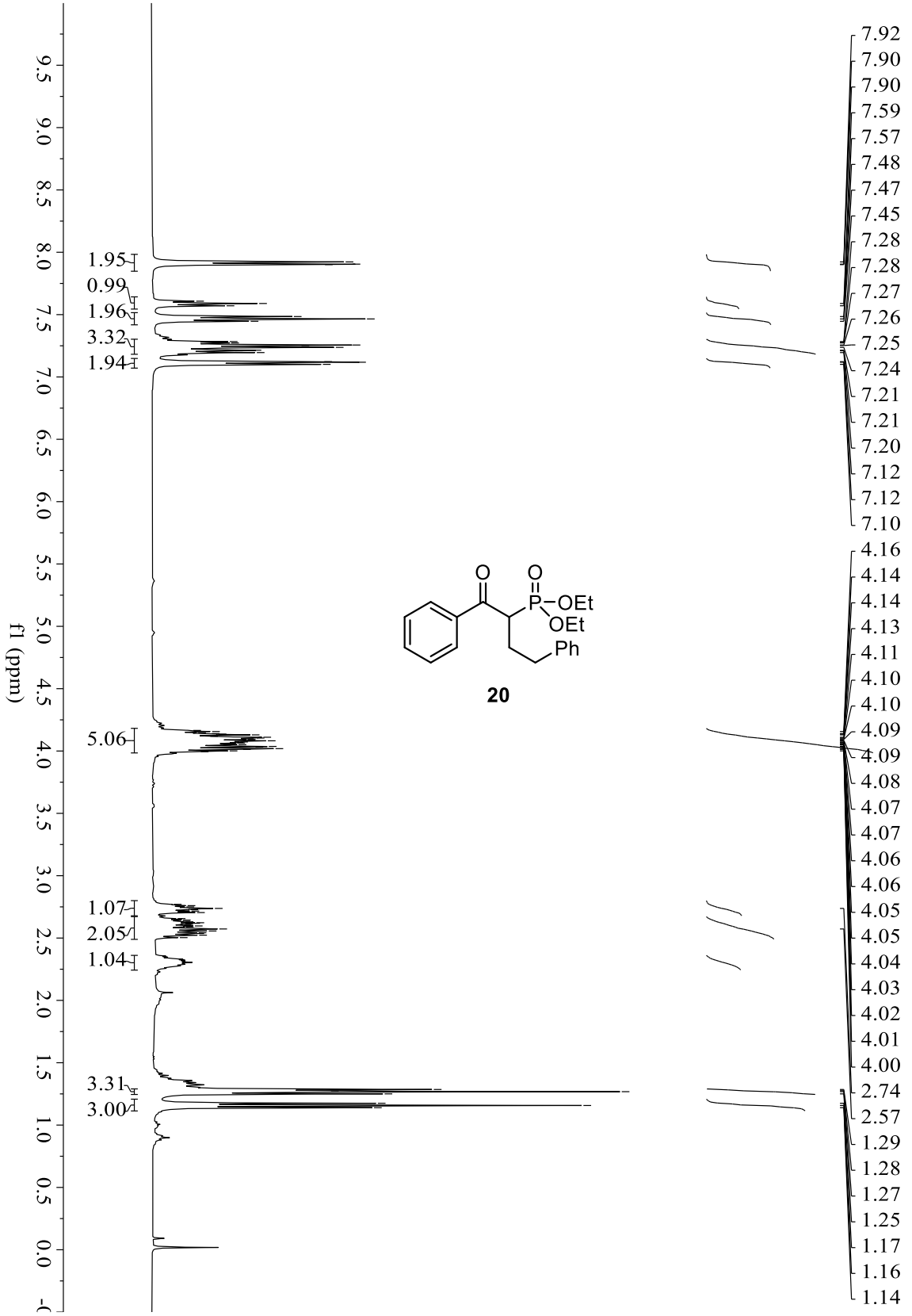

f1 (ppm)
2.24
2.91
4.09
1.00
1.99
2.04
5.89
8.74
O
O
P
OEt
OEt
Ph
19
7.23
7.22
7.20
7.20
7.14
7.13
7.12
7.10
4.12
4.11
4.09
4.08
4.06
4.05
4.03
4.02
4.01
3.63
3.62
3.62
3.61
3.60
3.59
3.59
3.58
2.55
2.54
2.52
2.16
2.15
2.14
2.12
2.11
2.10
2.08
2.07
1.27
1.25
1.24
1.08

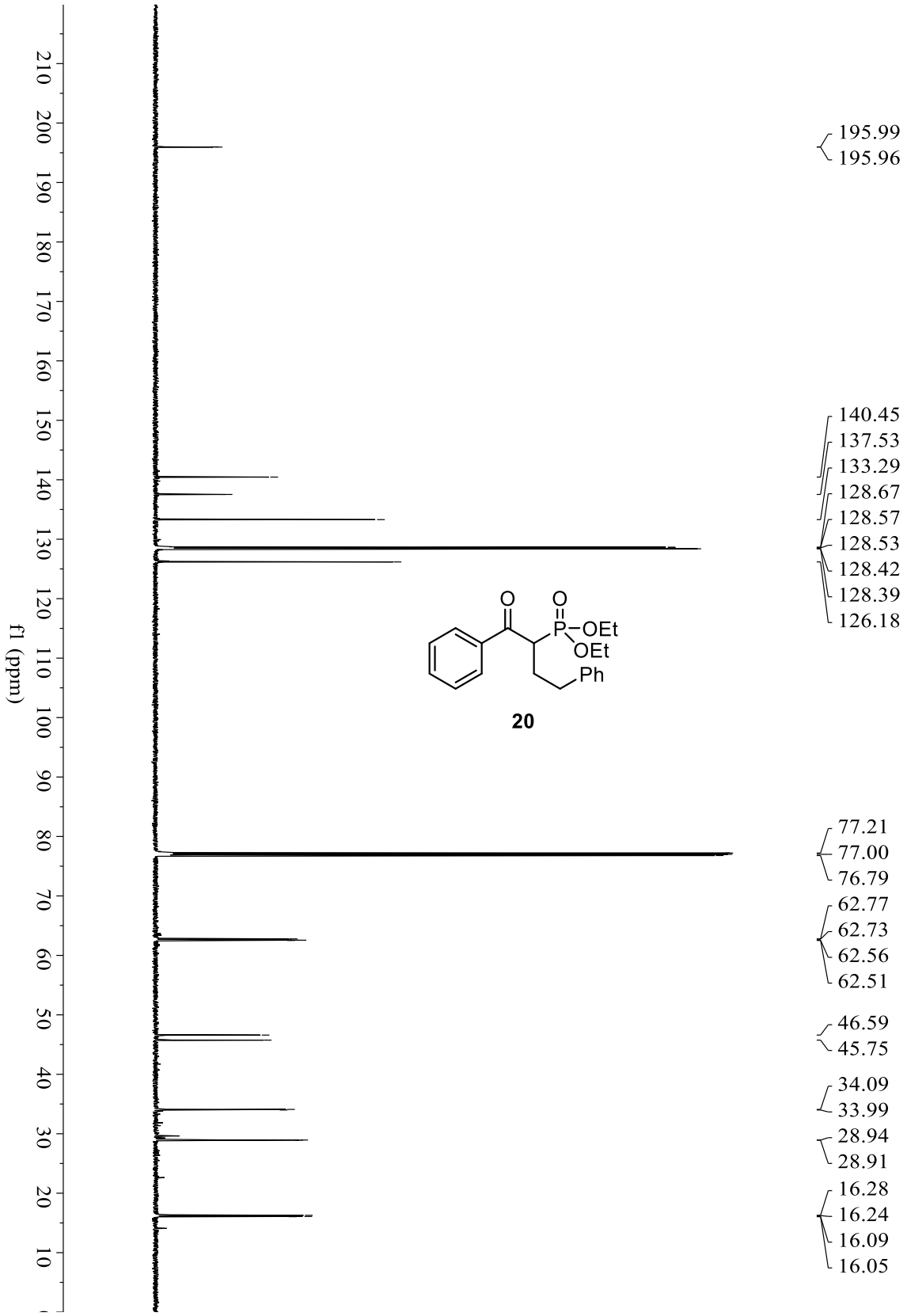

211.99
211.93
140.82
128.45
128.41
126.20
77.32
77.20
77.00
76.68
62.64
62.57
62.44
62.37
46.42
45.38
45.36
45.14
34.54
34.42
30.80
30.74
26.56
16.42
16.36
f1 (ppm)
O
O
P
OEt
OEt
Ph

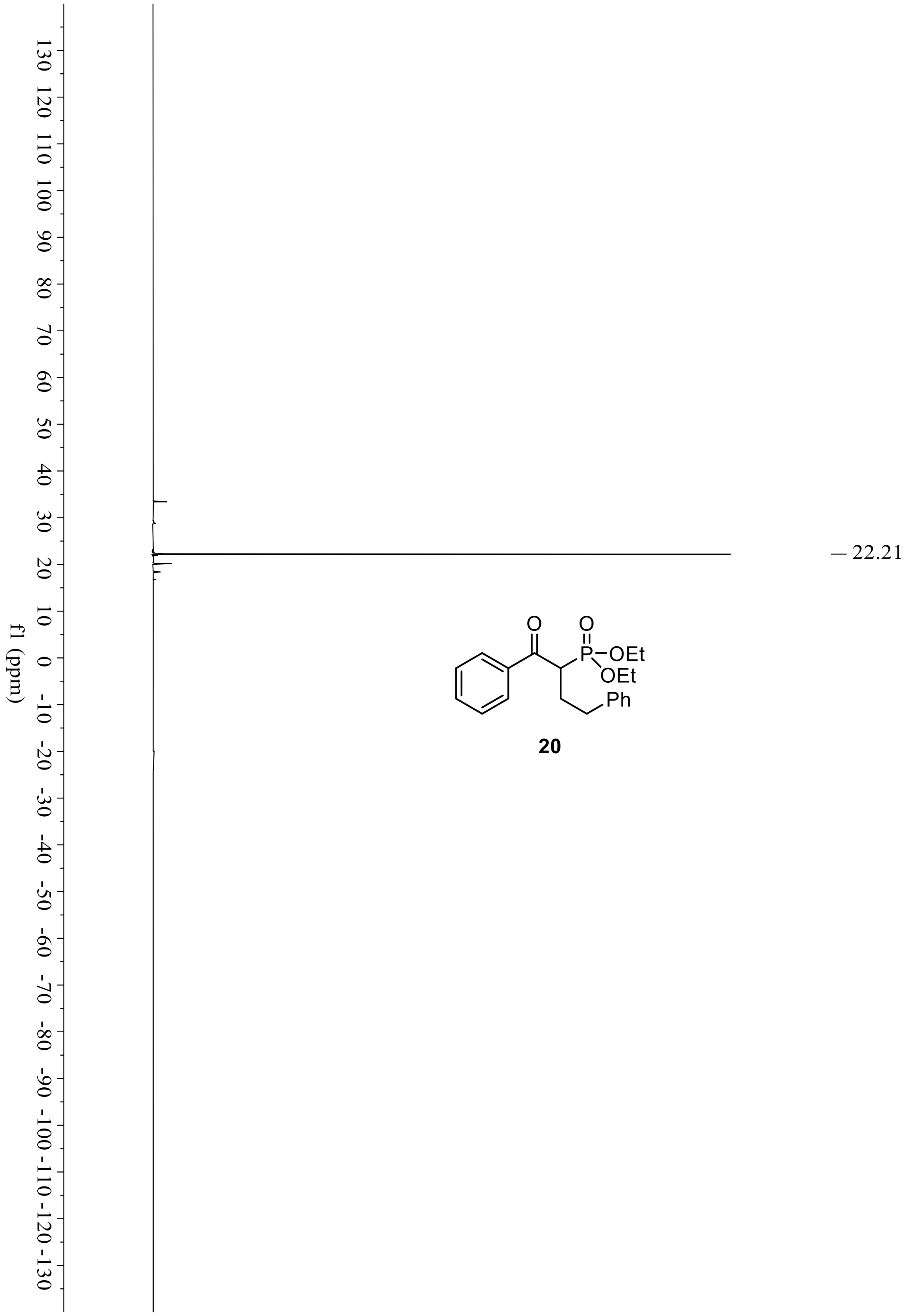
19

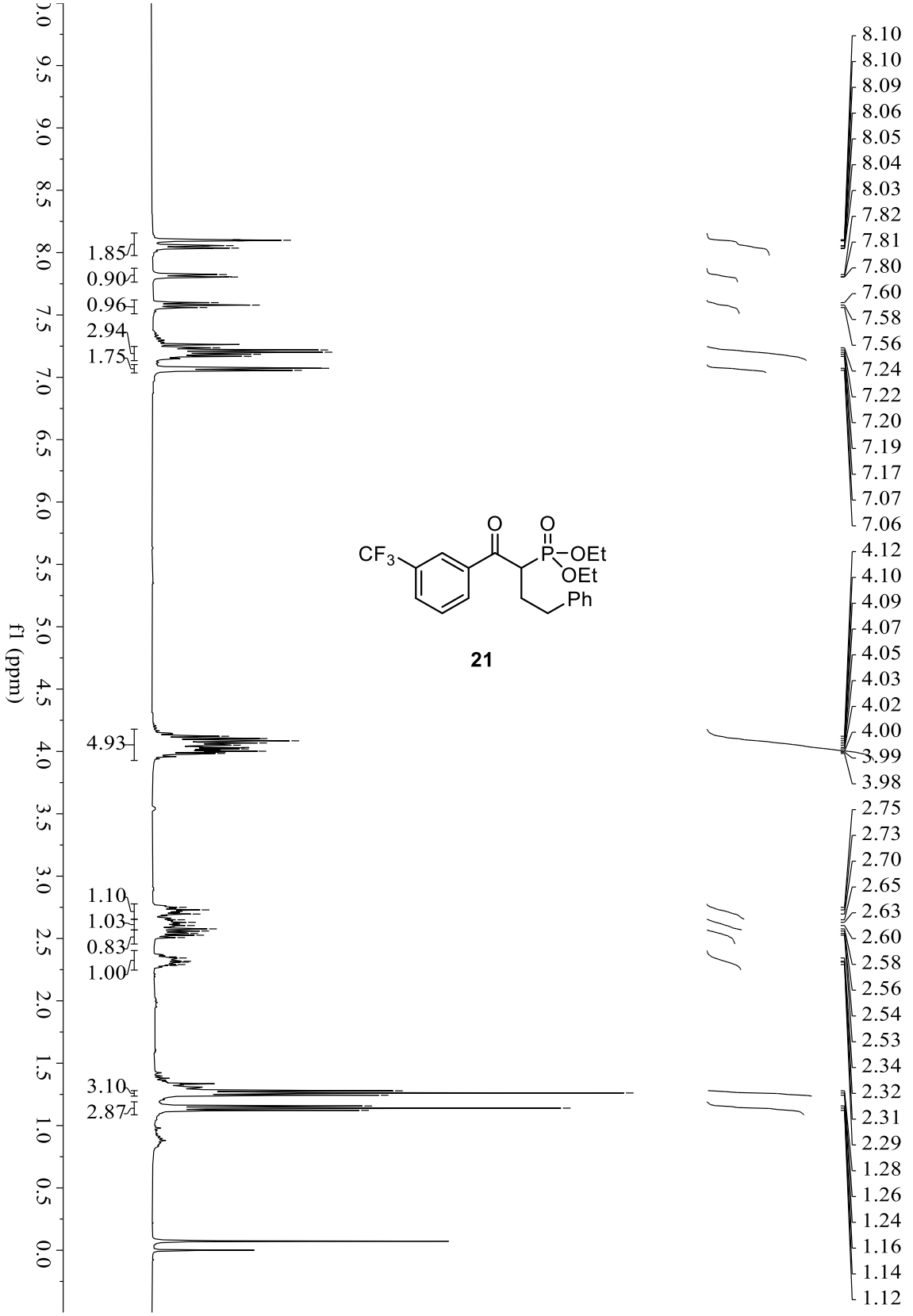

23.38
140
120
100
80
60
40
20
0
-20
-40
-60
-80
-100
-120
-140
-160
-180
-200
-220
-240
f1 (ppm)
O
O
P
OEt
OEt
Ph

19

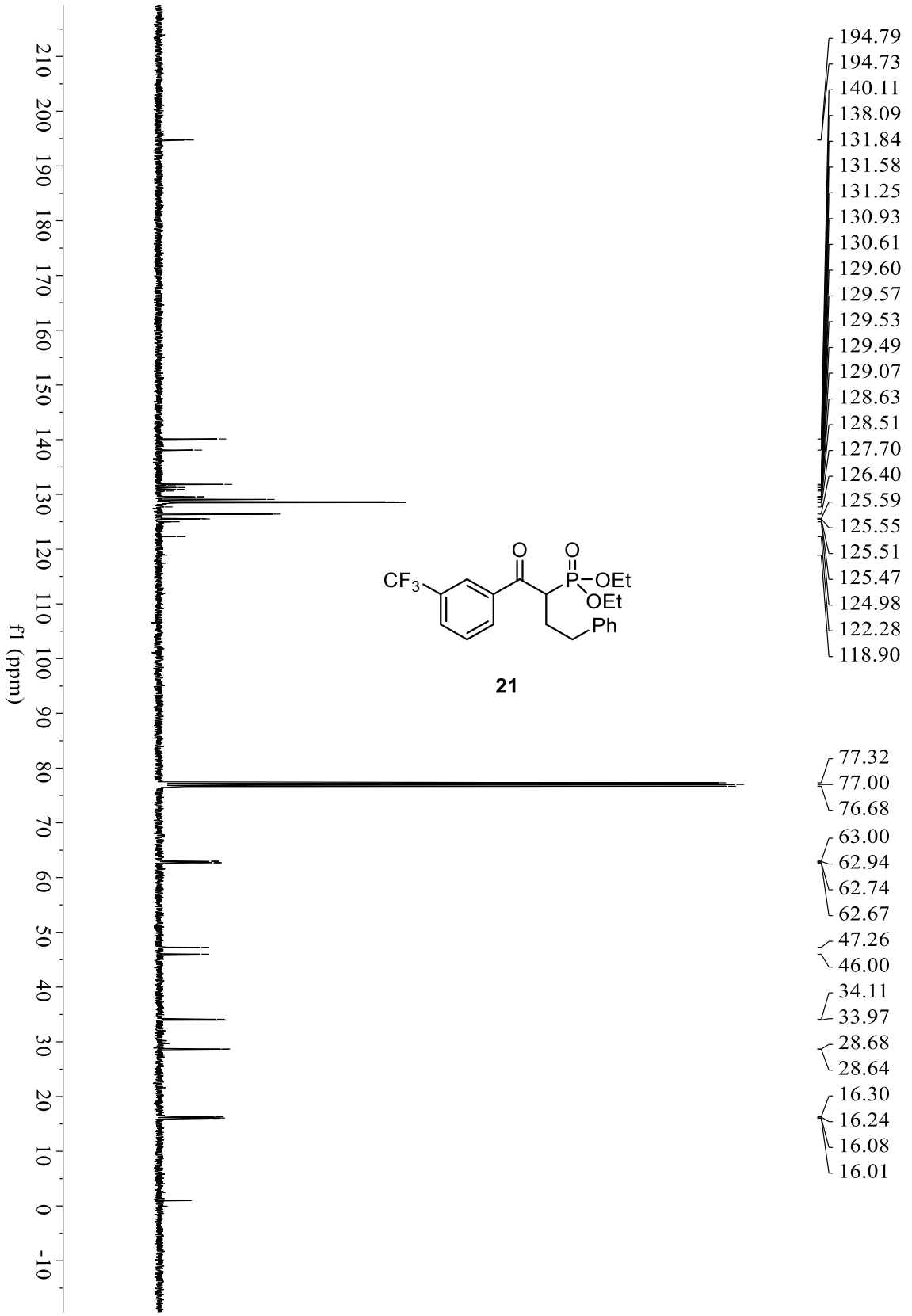

f1 (ppm)
1.95
0.99
1.96
3.32
1.94
5.06
1.07
2.05
1.04
3.31
3.00
O
O
P
OEt
OEt
Ph
20
7.92
7.90
7.90
7.59
7.57
7.48
7.47
7.45
7.28
7.28
7.27
7.26
7.25
7.24
7.21
7.21
7.20
7.12
7.12
7.10
4.16
4.14
4.14
4.13
4.11
4.10
4.10
4.09
4.09
4.08
4.07
4.07
4.06
4.06
4.05
4.05
4.04
4.03
4.02
4.01
4.00
2.74
2.57
1.29
1.28
1.27
1.25
1.17
1.16
1.14

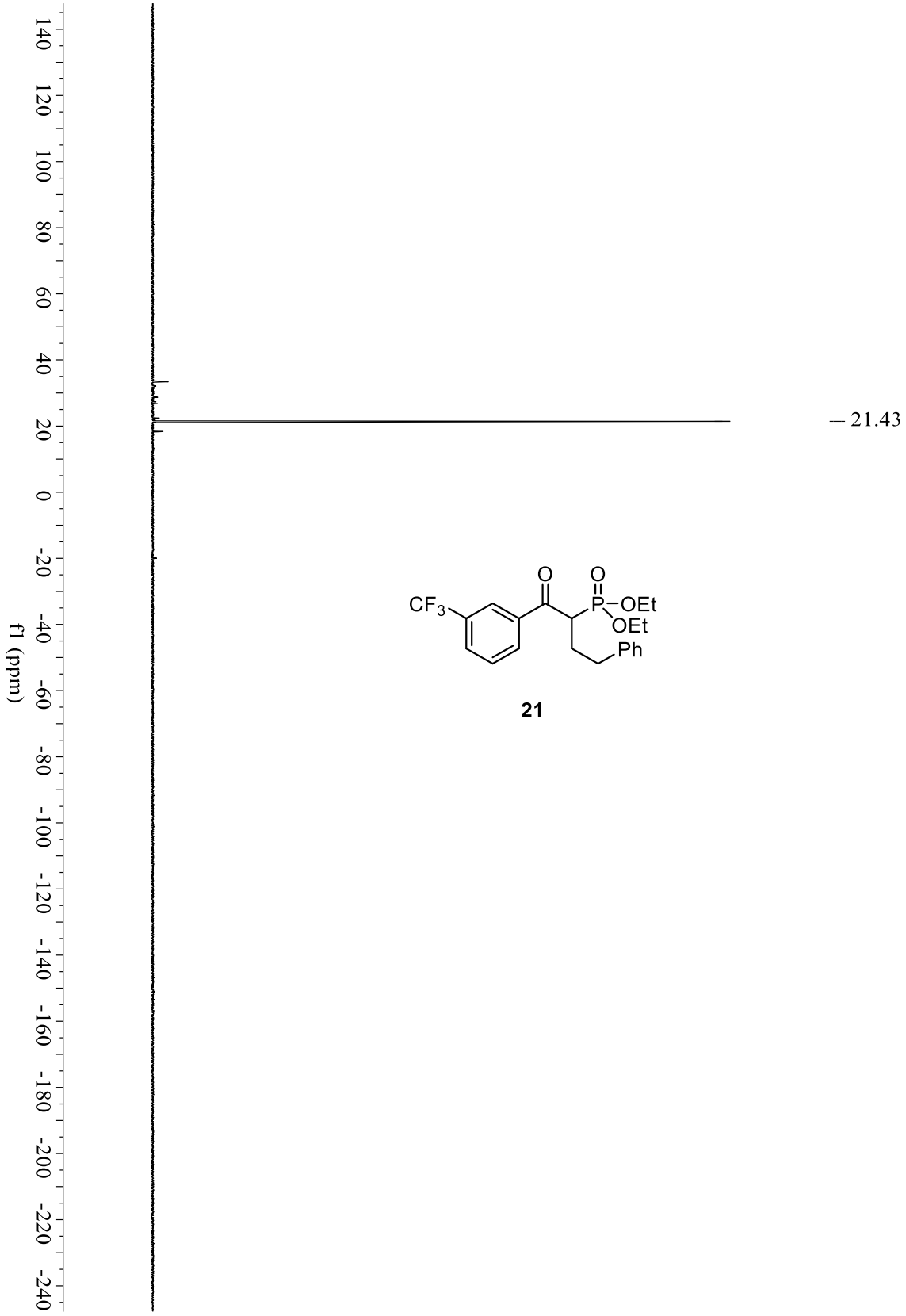

195.99
195.96
140.45
137.53
133.29
128.67
128.57
128.53
128.42
128.39
126.18
77.21
77.00
76.79
62.77
62.73
62.56
62.51
46.59
45.75
34.09
33.99
28.94
28.91
16.28
16.24
16.09
16.05
O
O
P
OEt
OEt
Ph
20
f1 (ppm)
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10


f1 (ppm)
22.21
OEt
OEt
Ph
20

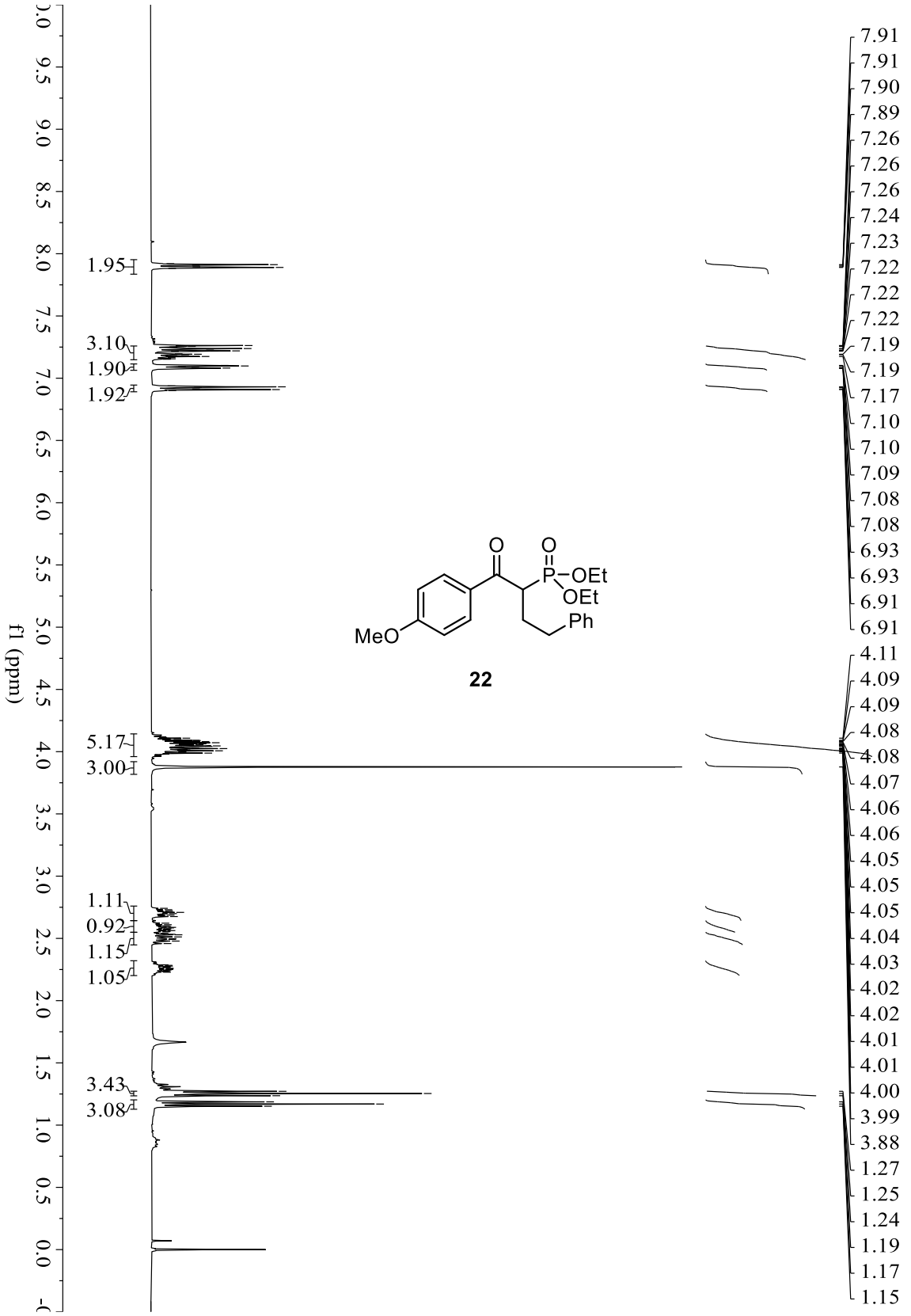

f1 (ppm)
1.85
0.90
0.96
2.94
1.75
4.93
1.10
1.03
0.83
1.00
3.10
2.87
8.10
8.10
8.09
8.06
8.05
8.04
8.03
7.82
7.81
7.80
7.60
7.58
7.56
7.24
7.22
7.20
7.19
7.17
7.07
7.06
4.12
4.10
4.09
4.07
4.05
4.03
4.02
4.00
3.99
3.98
2.75
2.73
2.70
2.65
2.63
2.60
2.58
2.56
2.54
2.53
2.34
2.32
2.31
2.29
1.28
1.26
1.24
1.16
1.14
1.12
CF3
O
O
P
OEt
OEt
Ph

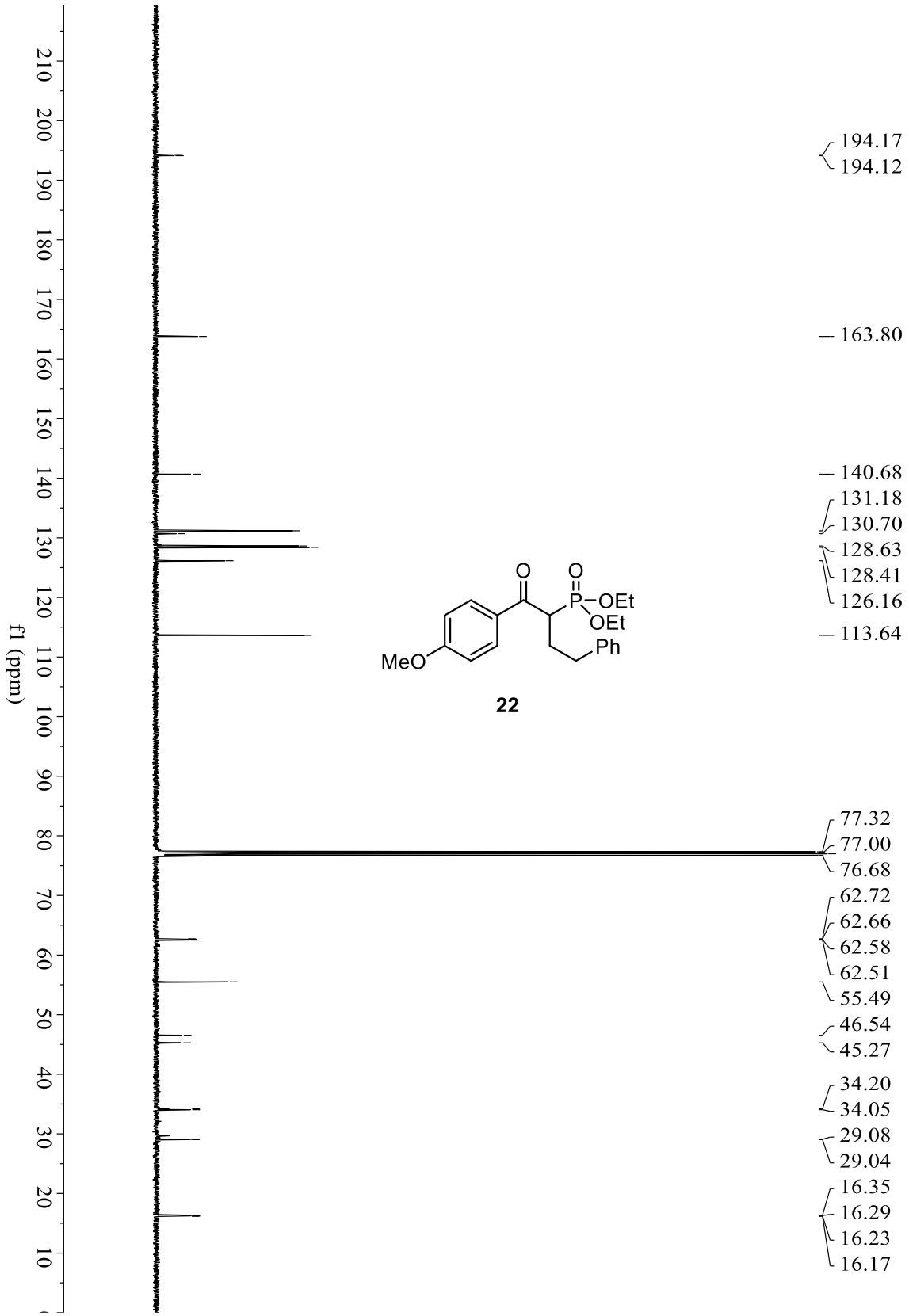
21


194.79
194.73
140.11
138.09
131.84
131.58
131.25
130.93
130.61
129.60
129.57
129.53
129.49
129.07
128.63
128.51
127.70
126.40
125.59
125.55
125.51
125.47
124.98
122.28
118.90
77.32
77.00
76.68
63.00
62.94
62.74
62.67
47.26
46.00
34.11
33.97
28.68
28.64
16.30
16.24
16.08
16.01
O
O
CF3
P
OEt
OEt
Ph
21
f1 (ppm)
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
-10

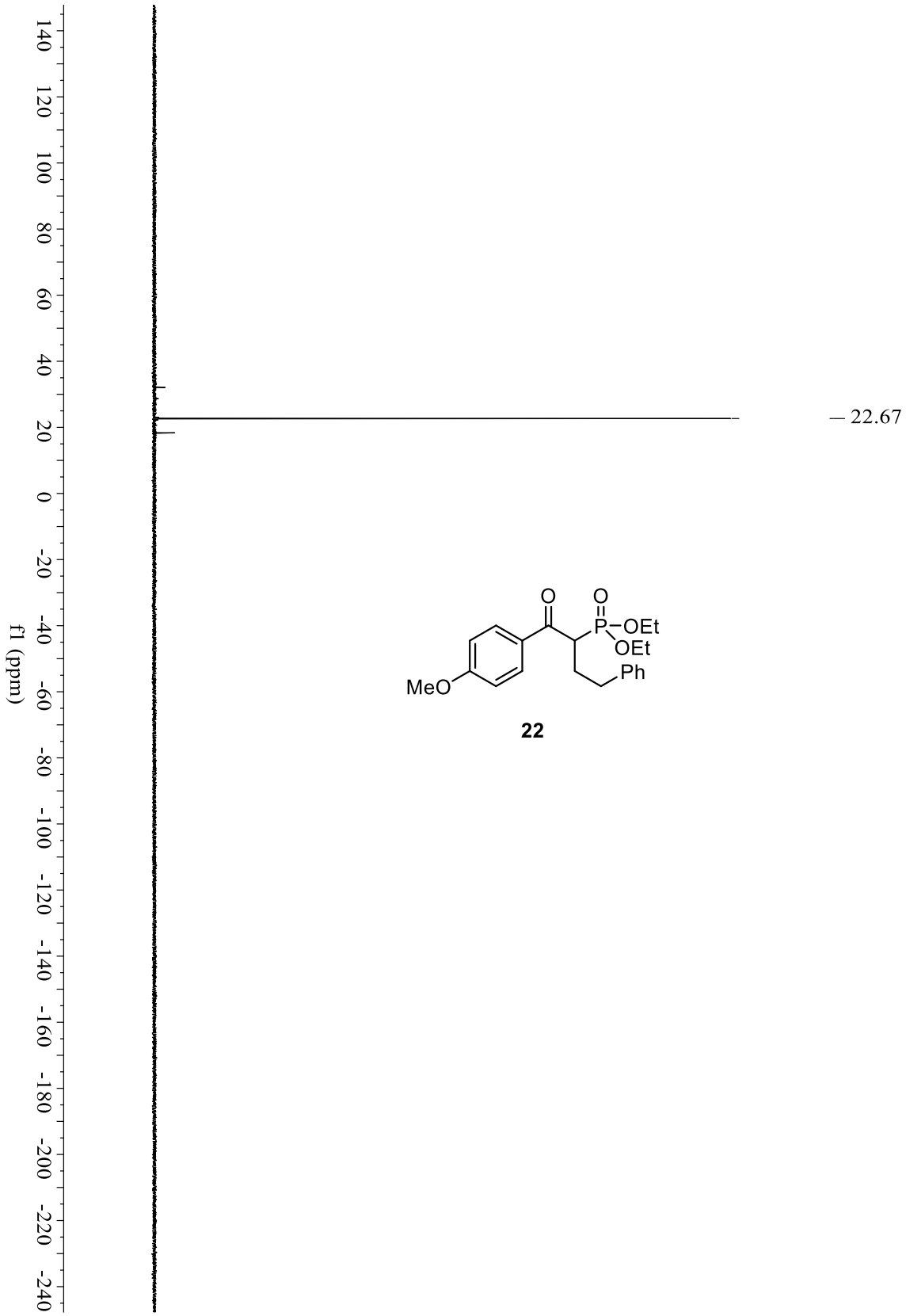

140
120
100
80
60
40
20
0
-20
-40
-60
-80
-100
-120
-140
-160
-180
-200
-220
-240
f1 (ppm)
21.43
O
O
CF3
P
OEt
OEt
Ph

21

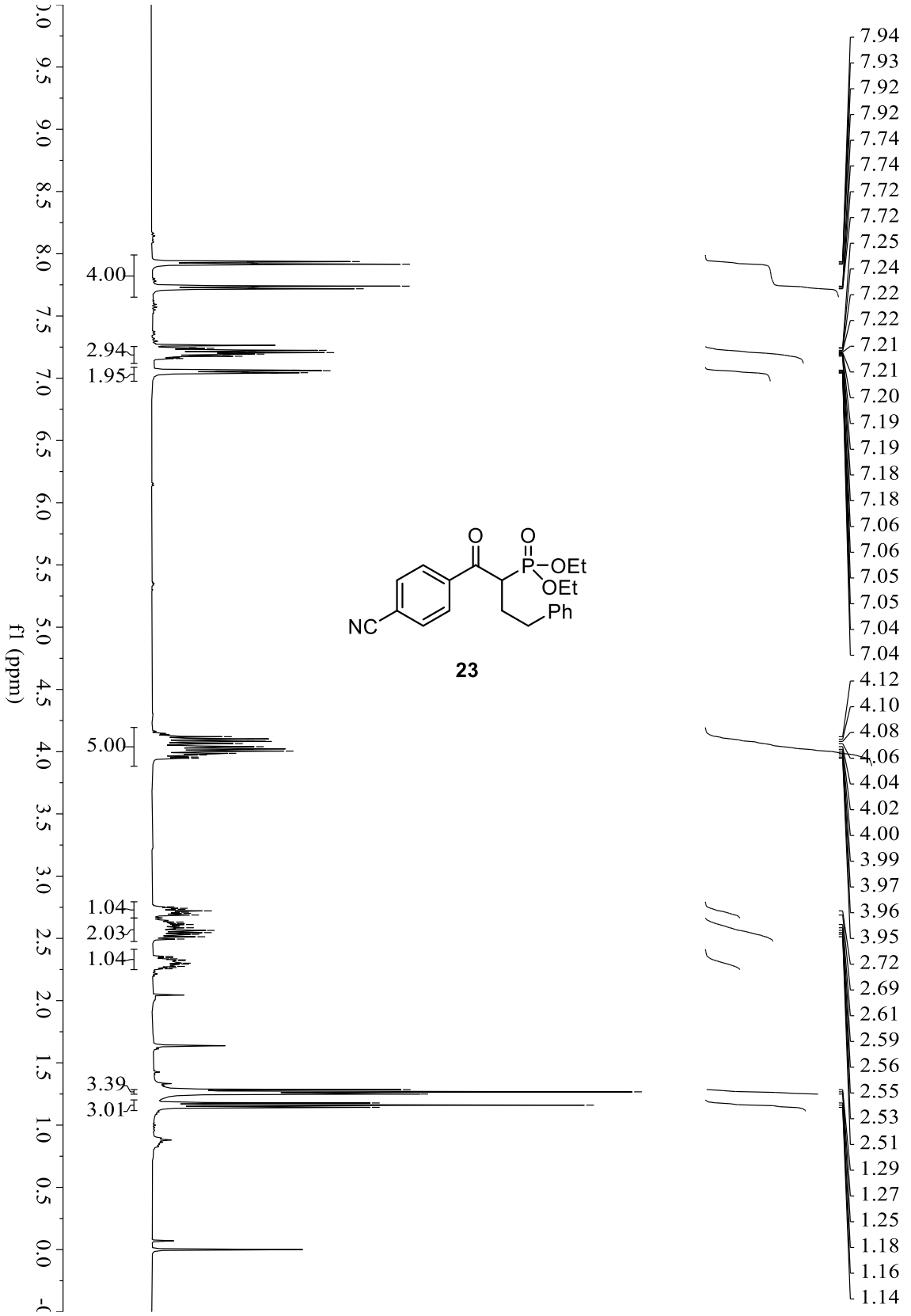

f1 (ppm)
1.95
3.10
1.90
1.92
5.17
3.00
1.11
0.92
1.15
1.05
3.43
3.08
MeO
O
O
P
OEt
OEt
Ph
22
7.91
7.91
7.90
7.89
7.26
7.26
7.26
7.24
7.23
7.22
7.22
7.22
7.19
7.19
7.17
7.10
7.10
7.09
7.08
7.08
6.93
6.93
6.91
6.91
4.11
4.09
4.09
4.08
4.08
4.07
4.06
4.06
4.05
4.05
4.05
4.04
4.03
4.02
4.02
4.01
4.01
4.00
3.99
3.88
1.27
1.25
1.24
1.19
1.17
1.15

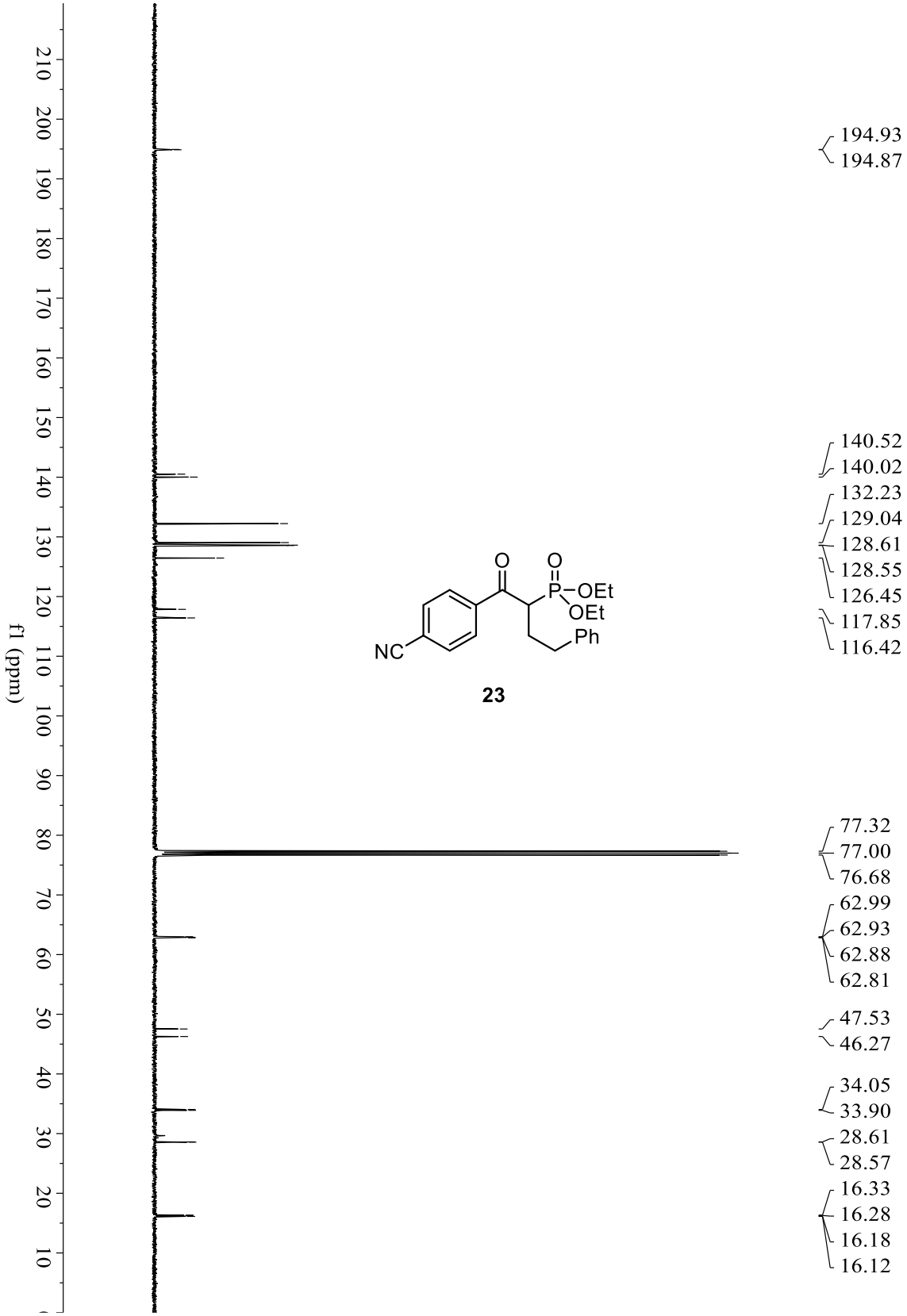

194.17
194.12
163.80
140.68
131.18
130.70
128.63
128.41
126.16
113.64
77.32
77.00
76.68
62.72
62.66
62.58
62.51
55.49
46.54
45.27
34.20
34.05
29.08
29.04
16.35
16.29
16.23
16.17
f1 (ppm)
O
O
P
OEt
OEt
Ph
MeO

22

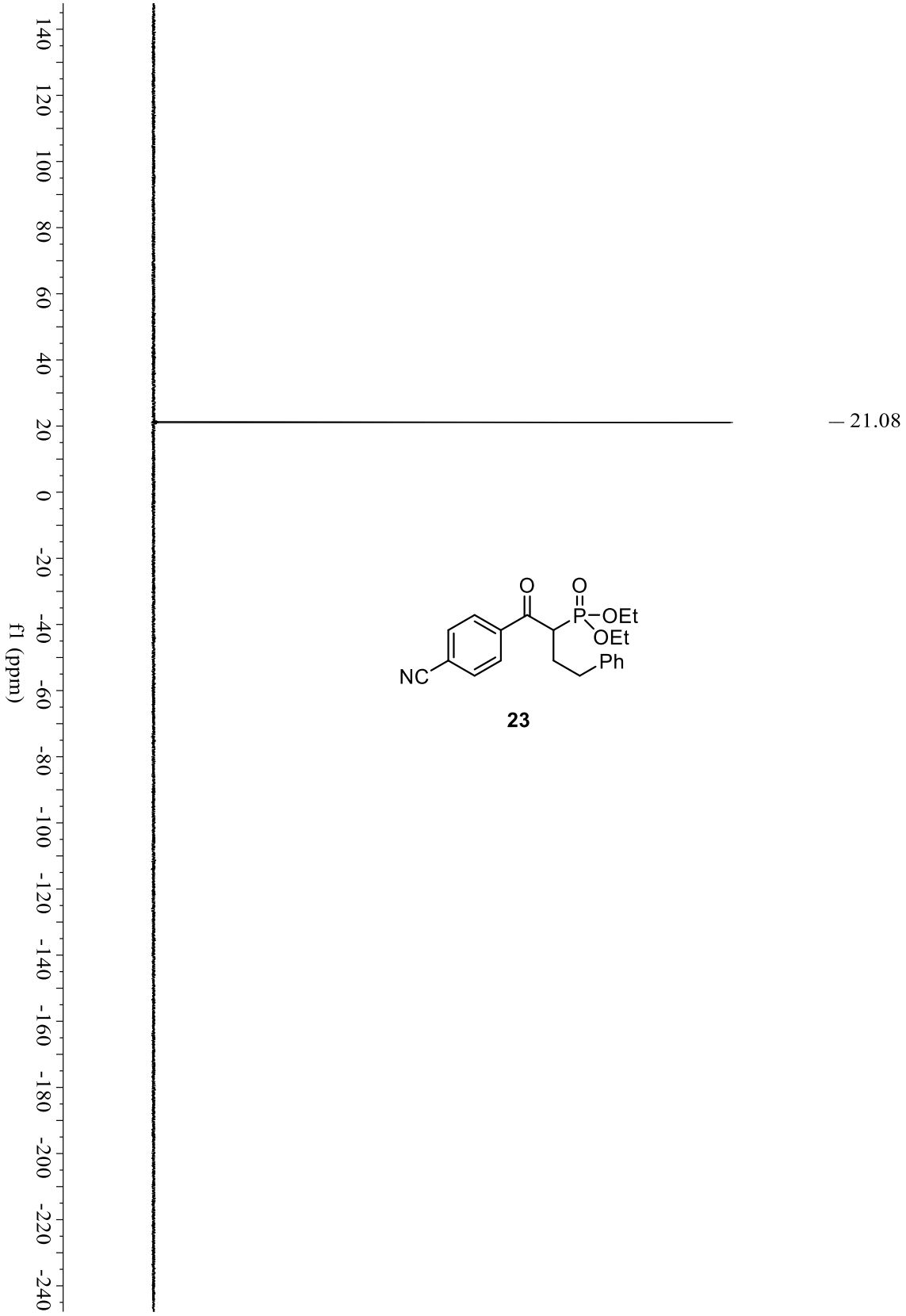

22.67
140
120
100
80
60
40
20
0
-20
-40
-60
-80
-100
-120
-140
-160
-180
-200
-220
-240
f1 (ppm)
O
O
P
OEt
OEt
Ph
MeO

22

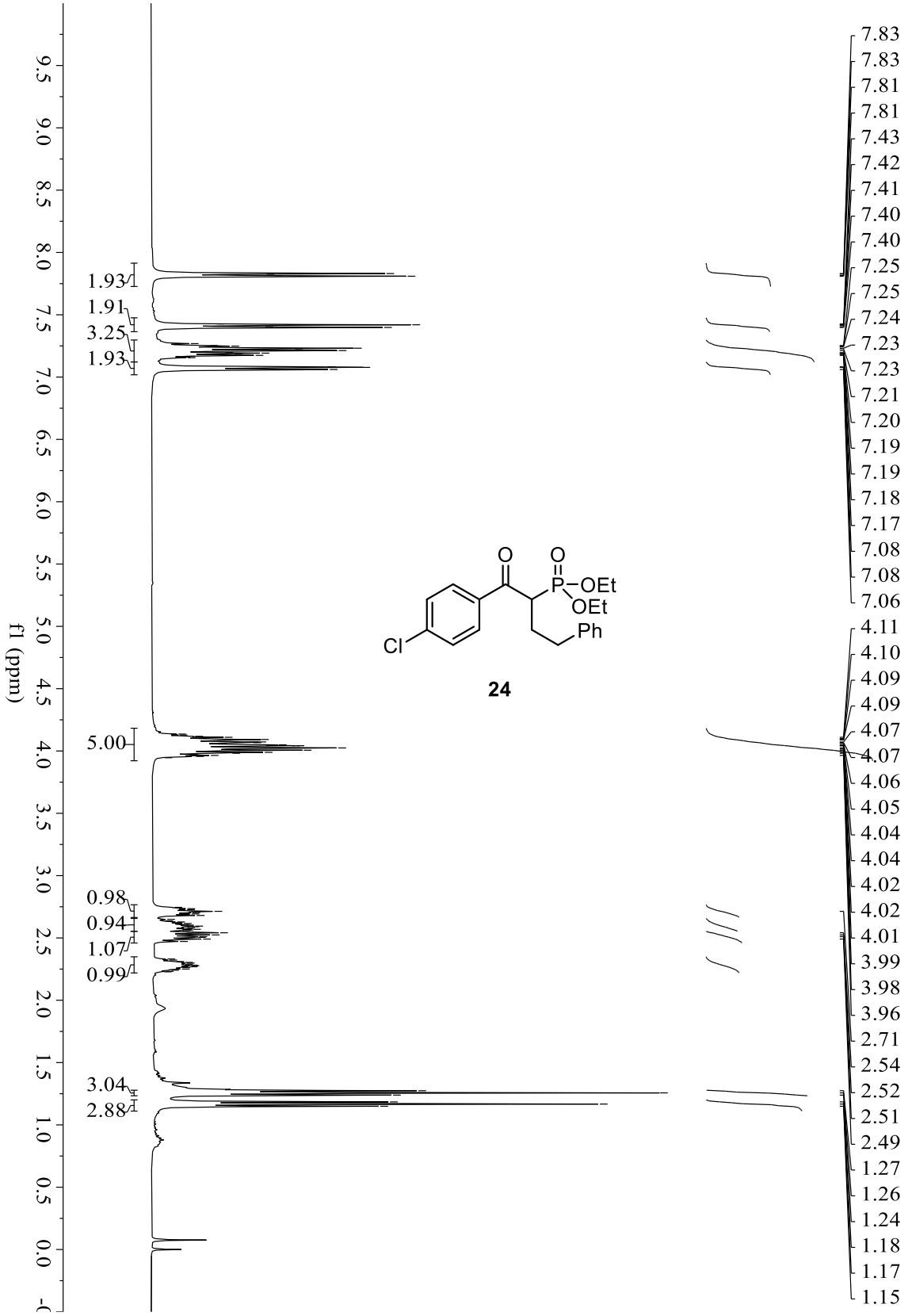

f1 (ppm)
4.00
2.94
1.95
5.00
1.04
2.03
1.04
3.39
3.01
NC
O
O
P
OEt
OEt
Ph
23
7.94
7.93
7.92
7.92
7.74
7.74
7.72
7.72
7.25
7.24
7.22
7.22
7.21
7.21
7.20
7.19
7.19
7.18
7.18
7.06
7.06
7.05
7.05
7.04
7.04
4.12
4.10
4.08
4.06
4.04
4.02
4.00
3.99
3.97
3.96
3.95
2.72
2.69
2.61
2.59
2.56
2.55
2.53
2.51
1.29
1.27
1.25
1.18
1.16
1.14

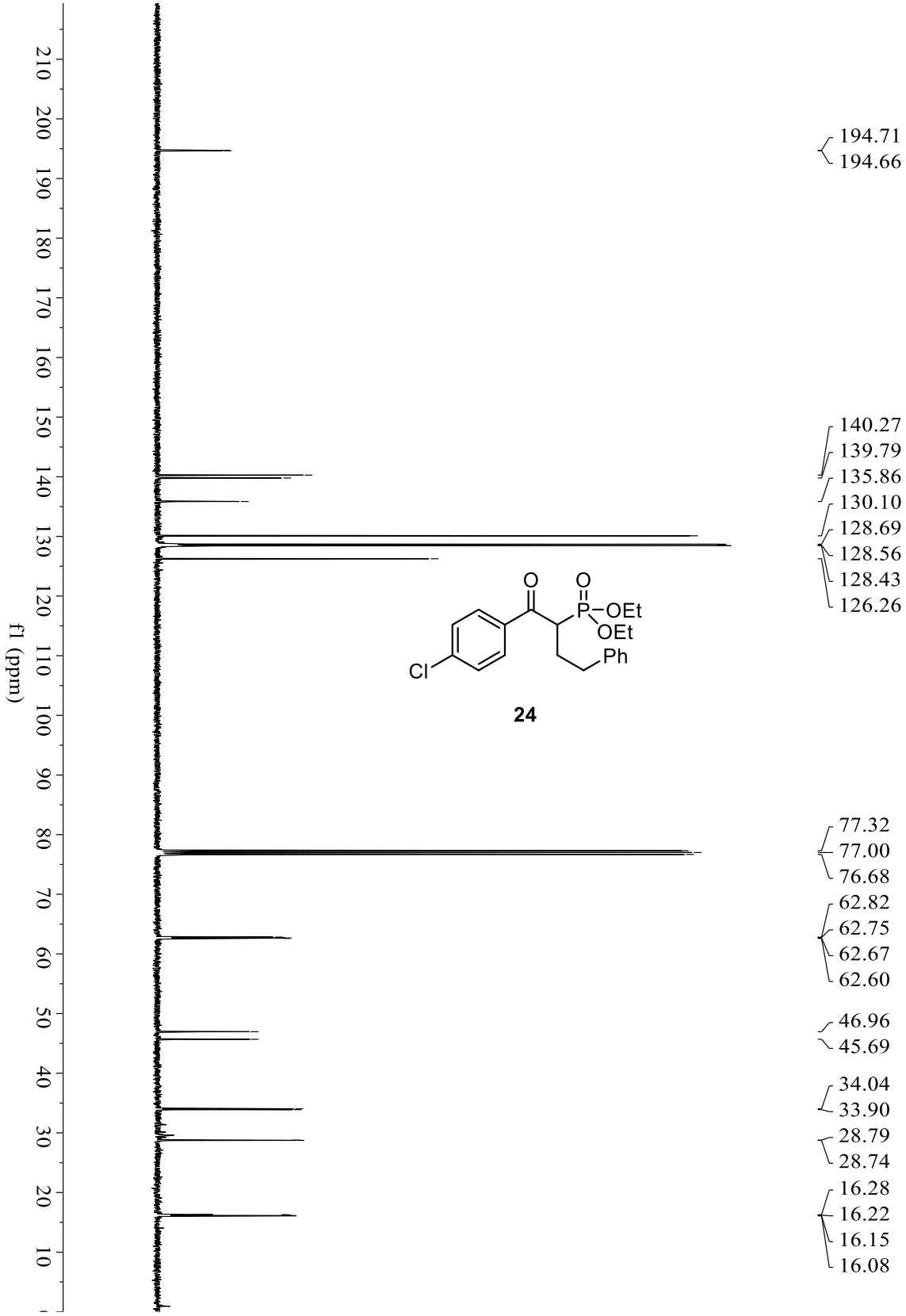

194.93
194.87
140.52
140.02
132.23
129.04
128.61
128.55
126.45
117.85
116.42
77.32
77.00
76.68
62.99
62.93
62.88
62.81
47.53
46.27
34.05
33.90
28.61
28.57
16.33
16.28
16.18
16.12
f1 (ppm)
NC
O
O
P
OEt
OEt
Ph

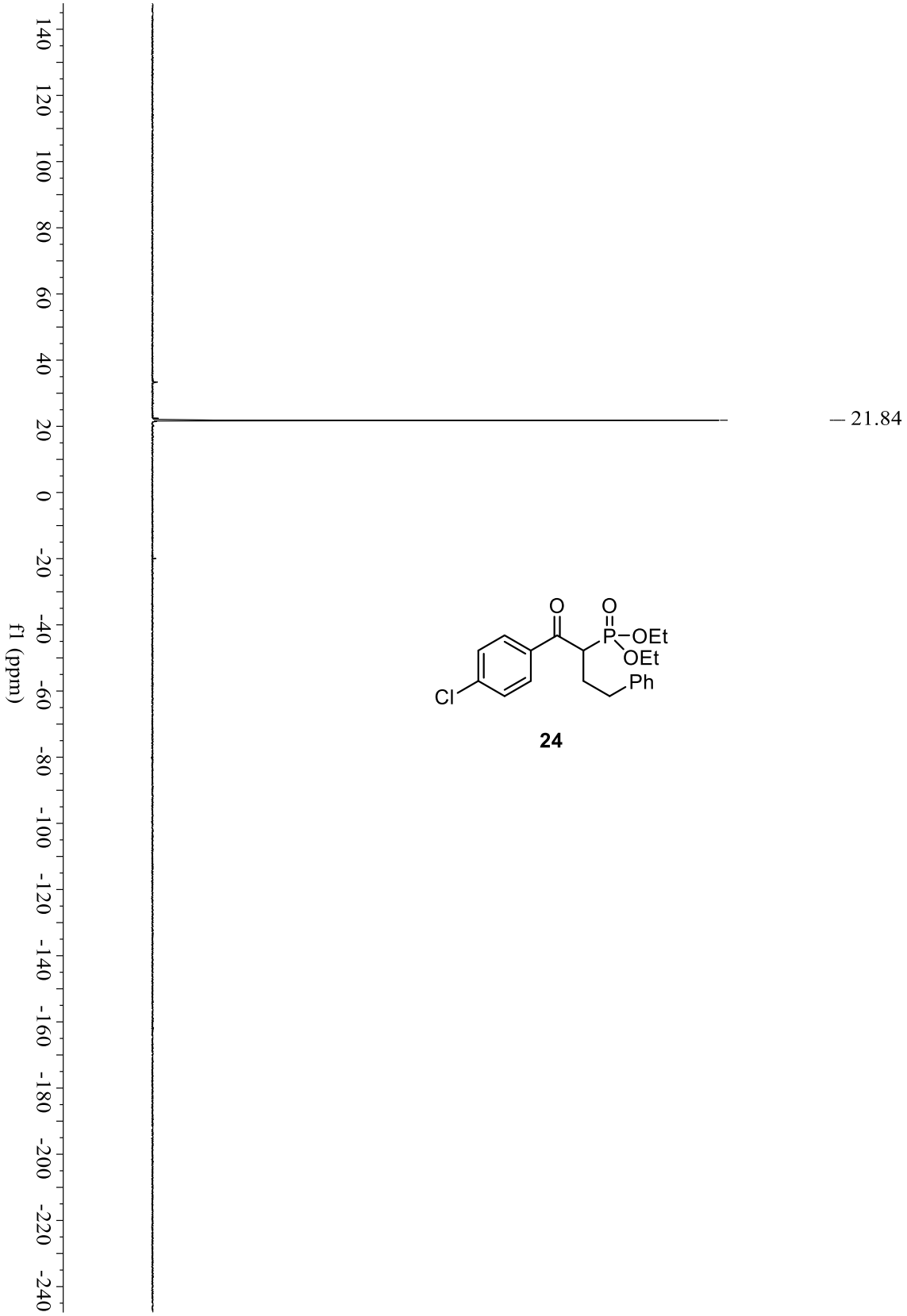
23


140
120
100
80
60
40
20
0
-20
-40
-60
-80
-100
-120
-140
-160
-180
-200
-220
-240
f1 (ppm)
21.08
O
O
P
OEt
OEt
Ph
NC

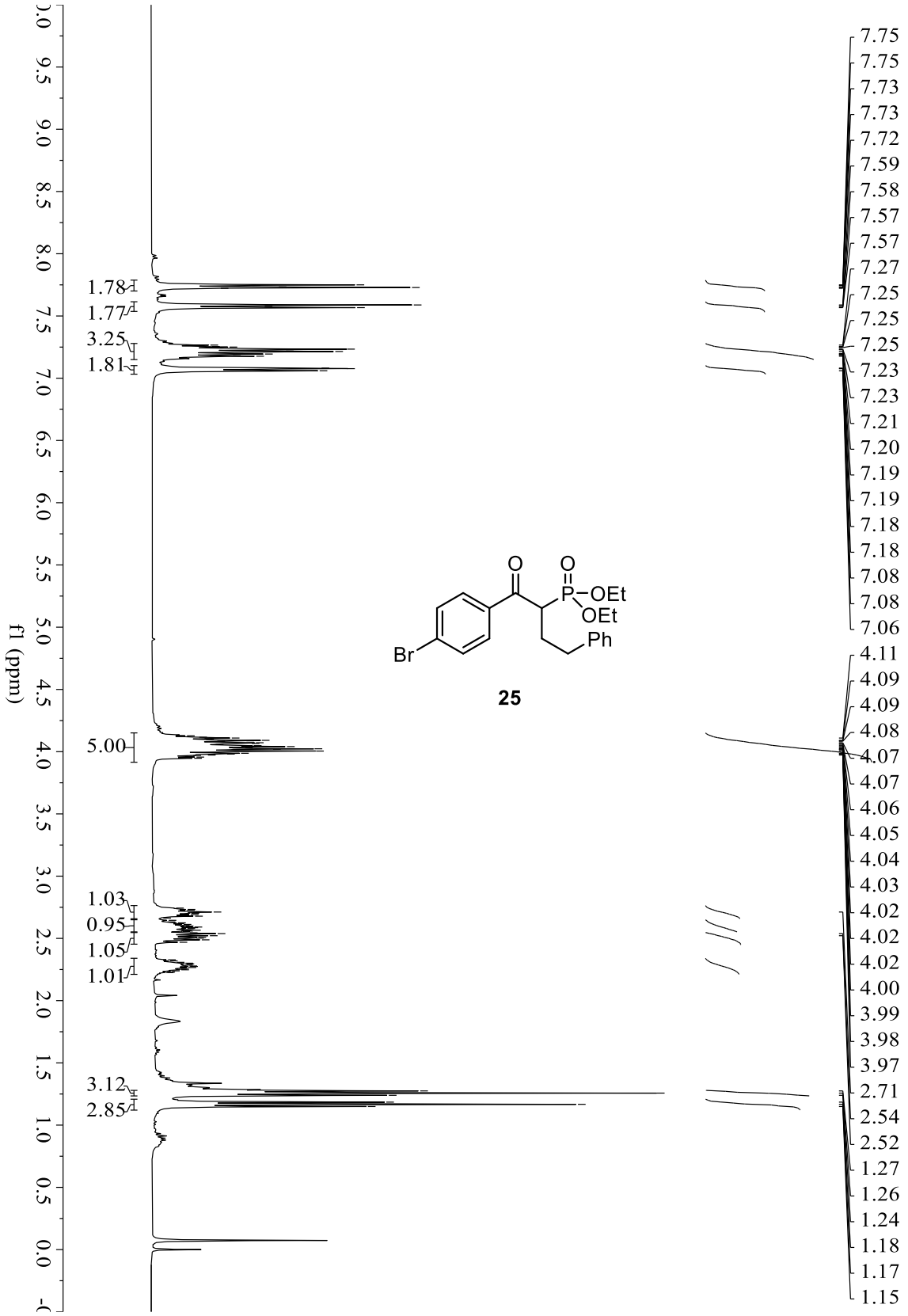
23

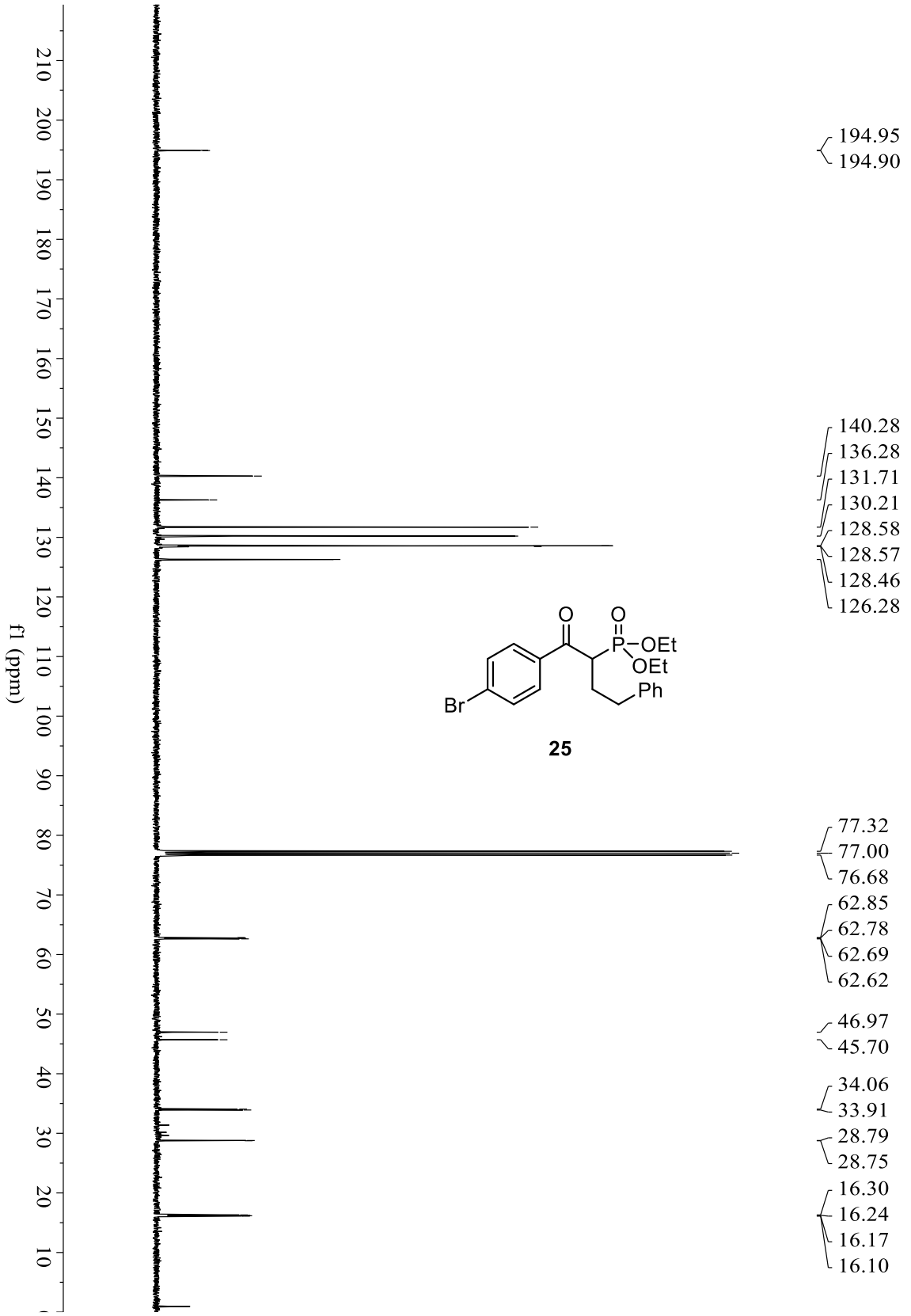

f1 (ppm)
1.93
1.91
3.25
1.93
5.00
0.98
0.94
1.07
0.99
3.04
2.88
O
O
P
OEt
OEt
Ph
Cl
24
7.83
7.83
7.81
7.81
7.43
7.42
7.41
7.40
7.40
7.25
7.25
7.24
7.23
7.23
7.21
7.20
7.19
7.19
7.18
7.17
7.08
7.08
7.06
4.11
4.10
4.09
4.09
4.07
4.07
4.06
4.05
4.04
4.04
4.02
4.02
4.01
3.99
3.98
3.96
2.71
2.54
2.52
2.51
2.49
1.27
1.26
1.24
1.18
1.17
1.15


194.71
194.66
140.27
139.79
135.86
130.10
128.69
128.56
128.43
126.26
77.32
77.00
76.68
62.82
62.75
62.67
62.60
46.96
45.69
34.04
33.90
28.79
28.74
16.28
16.22
16.15
16.08
f1 (ppm)
O
O
P–OEt
OEt
Cl
Ph
24

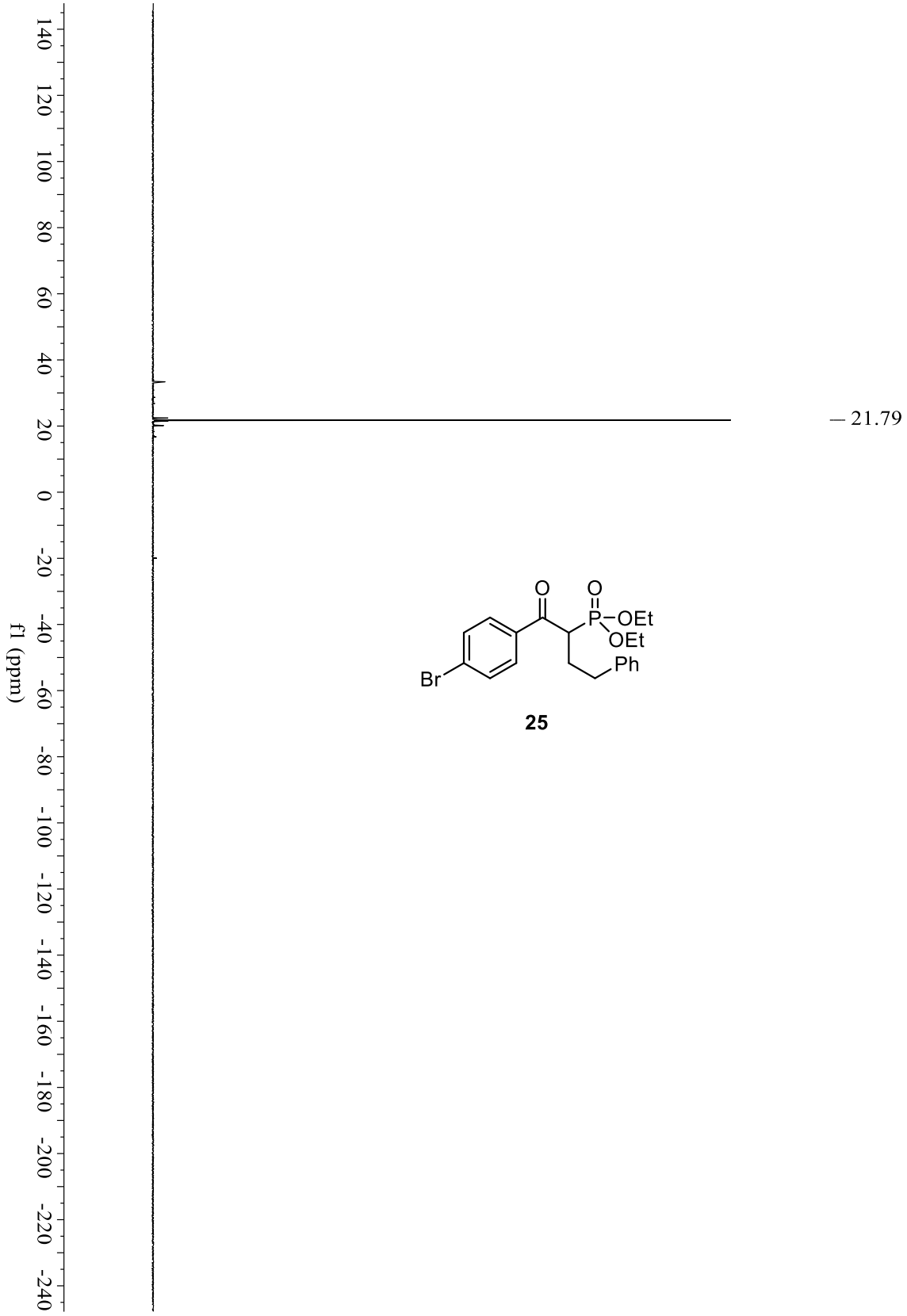

21.84
140
120
100
80
60
40
20
0
-20
-40
-60
-80
-100
-120
-140
-160
-180
-200
-220
-240
f1 (ppm)
O
O
P
OEt
OEt
Ph
Cl

24

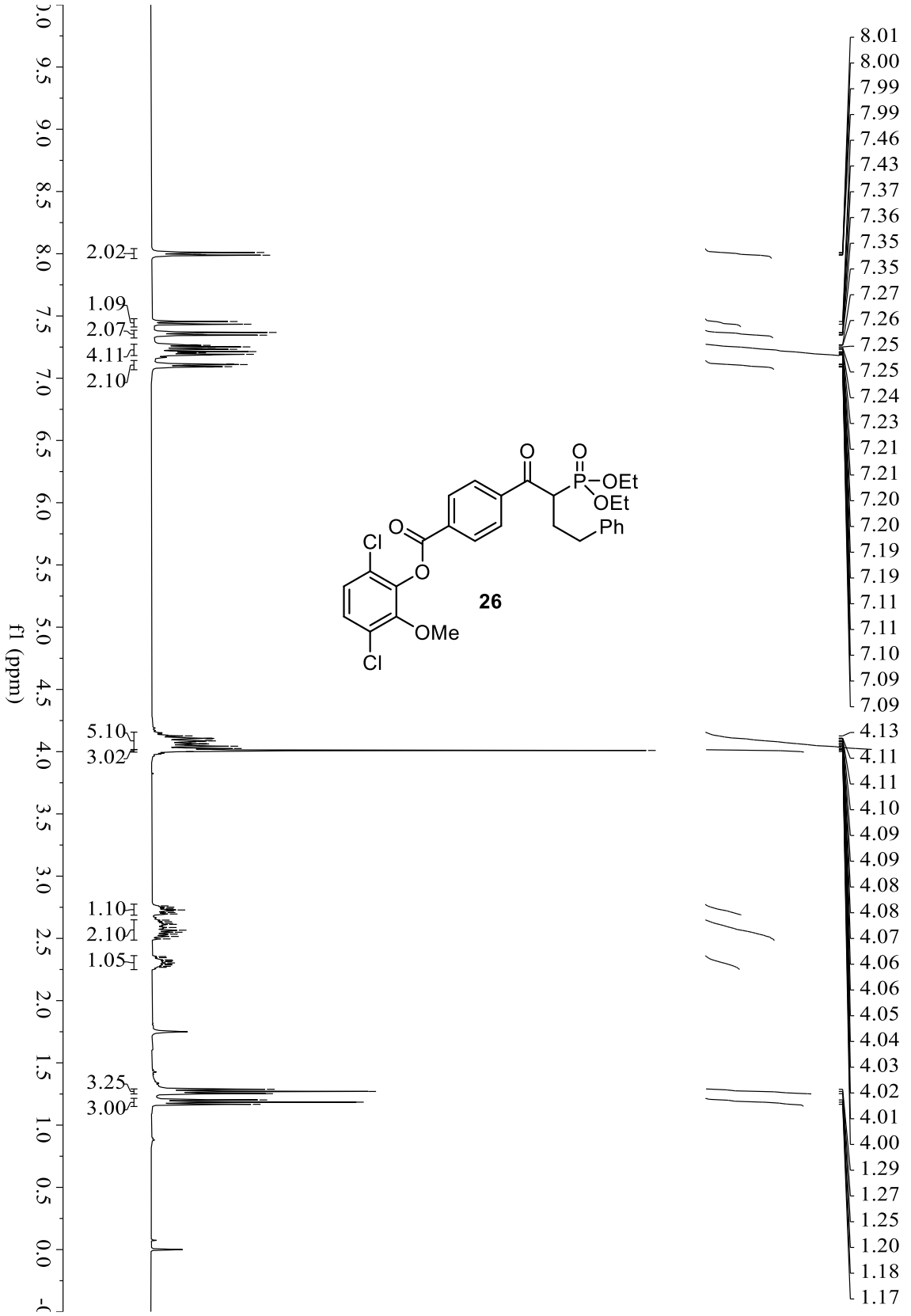

f1 (ppm)
1.78
1.77
3.25
1.81
5.00
1.03
0.95
1.05
1.01
3.12
2.85
O
O
P
OEt
OEt
Ph
Br
25
7.75
7.75
7.73
7.73
7.72
7.59
7.58
7.57
7.57
7.27
7.25
7.25
7.25
7.23
7.23
7.21
7.20
7.19
7.19
7.18
7.18
7.08
7.08
7.06
4.11
4.09
4.09
4.08
4.07
4.07
4.06
4.05
4.04
4.03
4.02
4.02
4.02
4.00
3.99
3.98
3.97
2.71
2.54
2.52
1.27
1.26
1.24
1.18
1.17
1.15

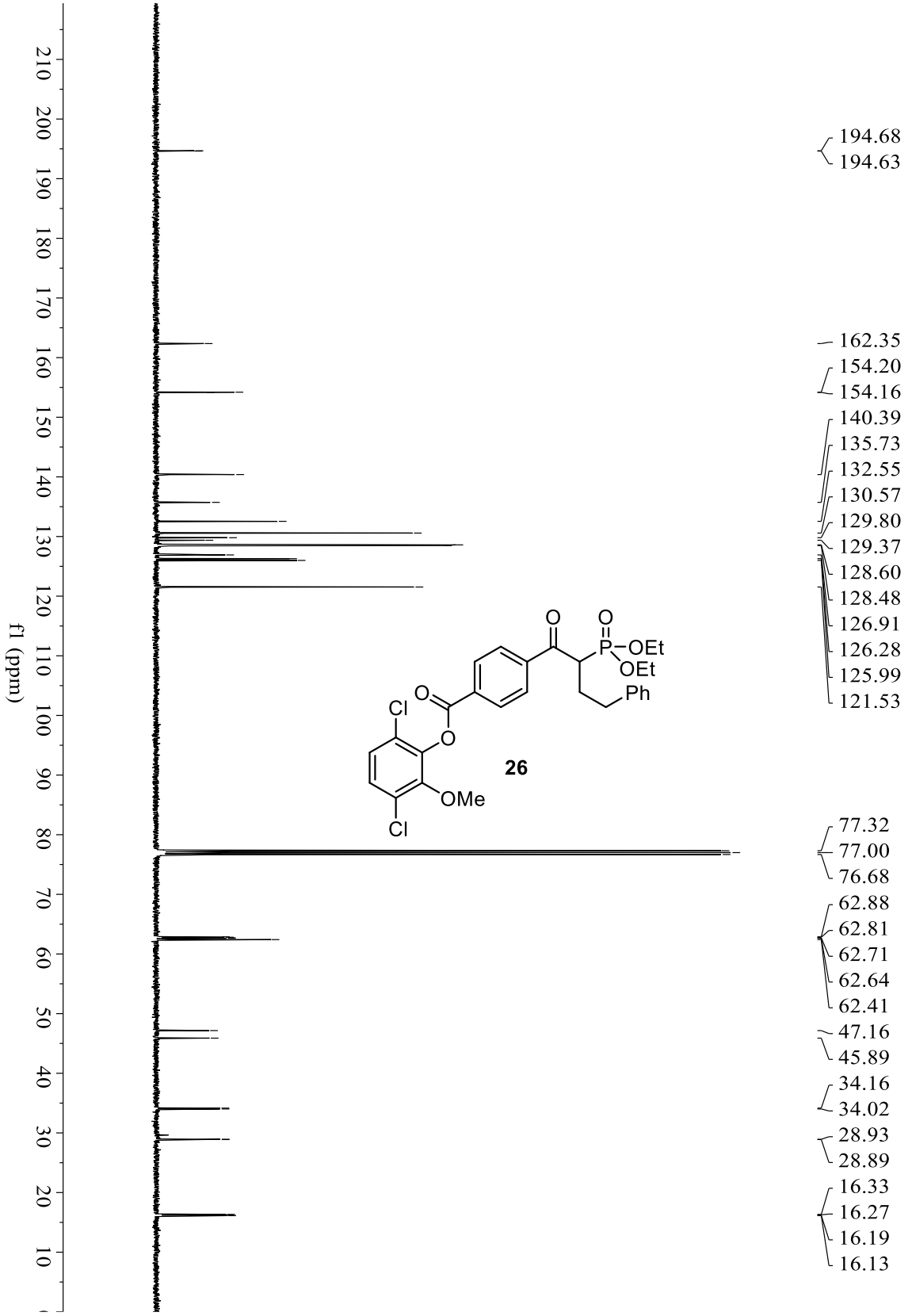

194.95
194.90
140.28
136.28
131.71
130.21
128.58
128.57
128.46
126.28
77.32
77.00
76.68
62.85
62.78
62.69
62.62
46.97
45.70
34.06
33.91
28.79
28.75
16.30
16.24
16.17
16.10
f1 (ppm)
O
O
P
OEt
OEt
Ph
Br

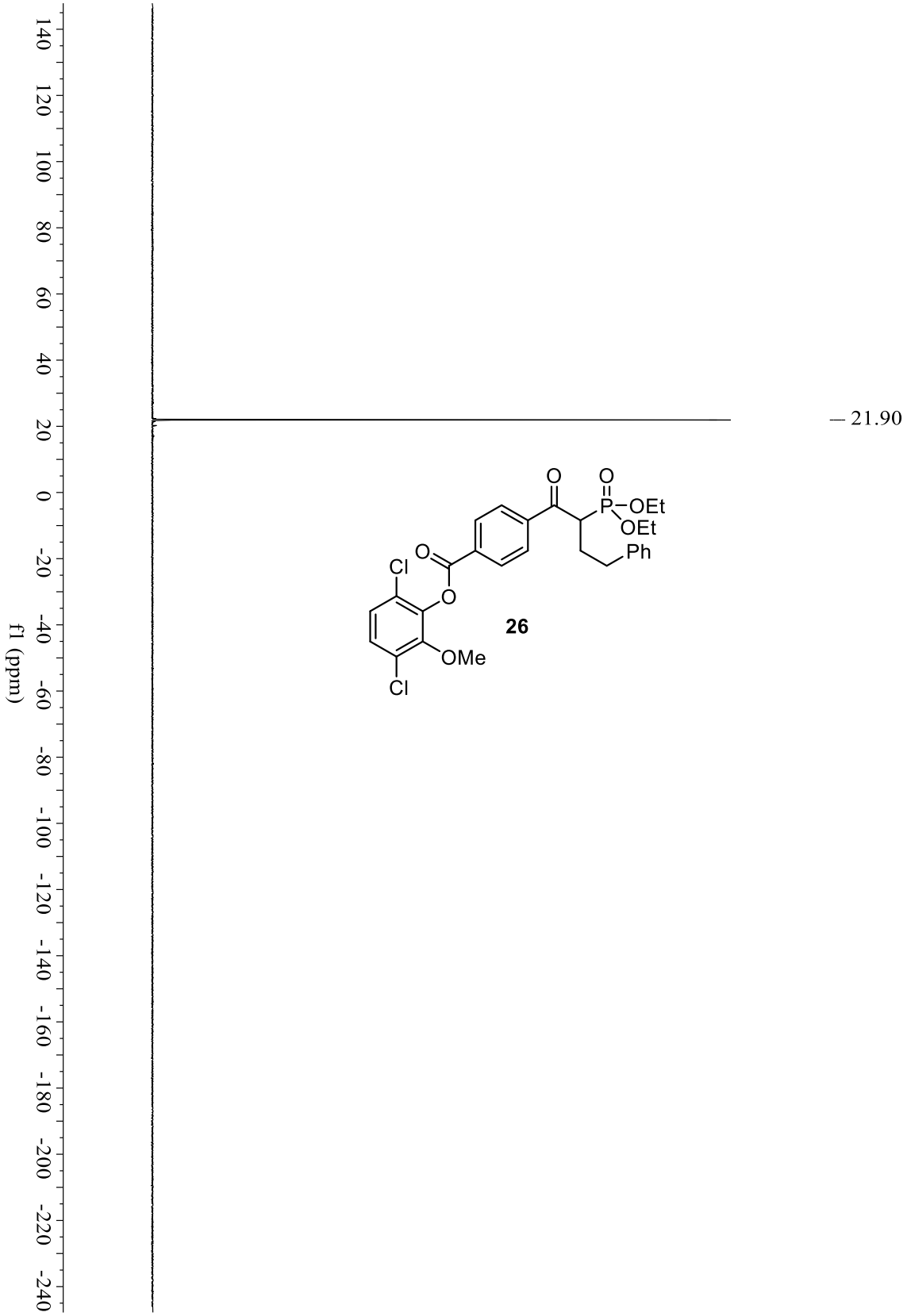
25

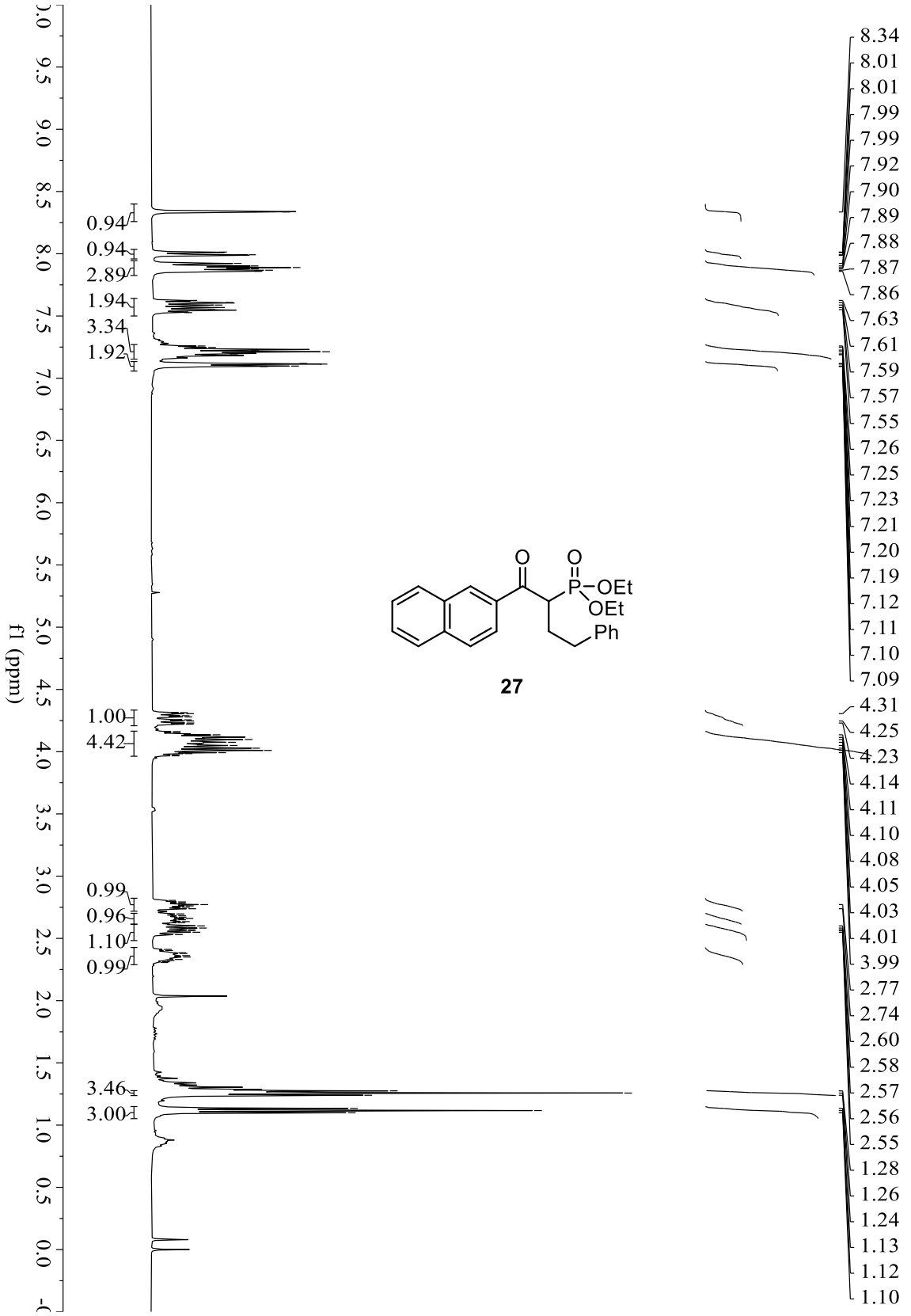

21.79
140
120
100
80
60
40
20
0
-20
-40
-60
-80
-100
-120
-140
-160
-180
-200
-220
-240
f1 (ppm)
O
O
P
OEt
OEt
Ph
Br

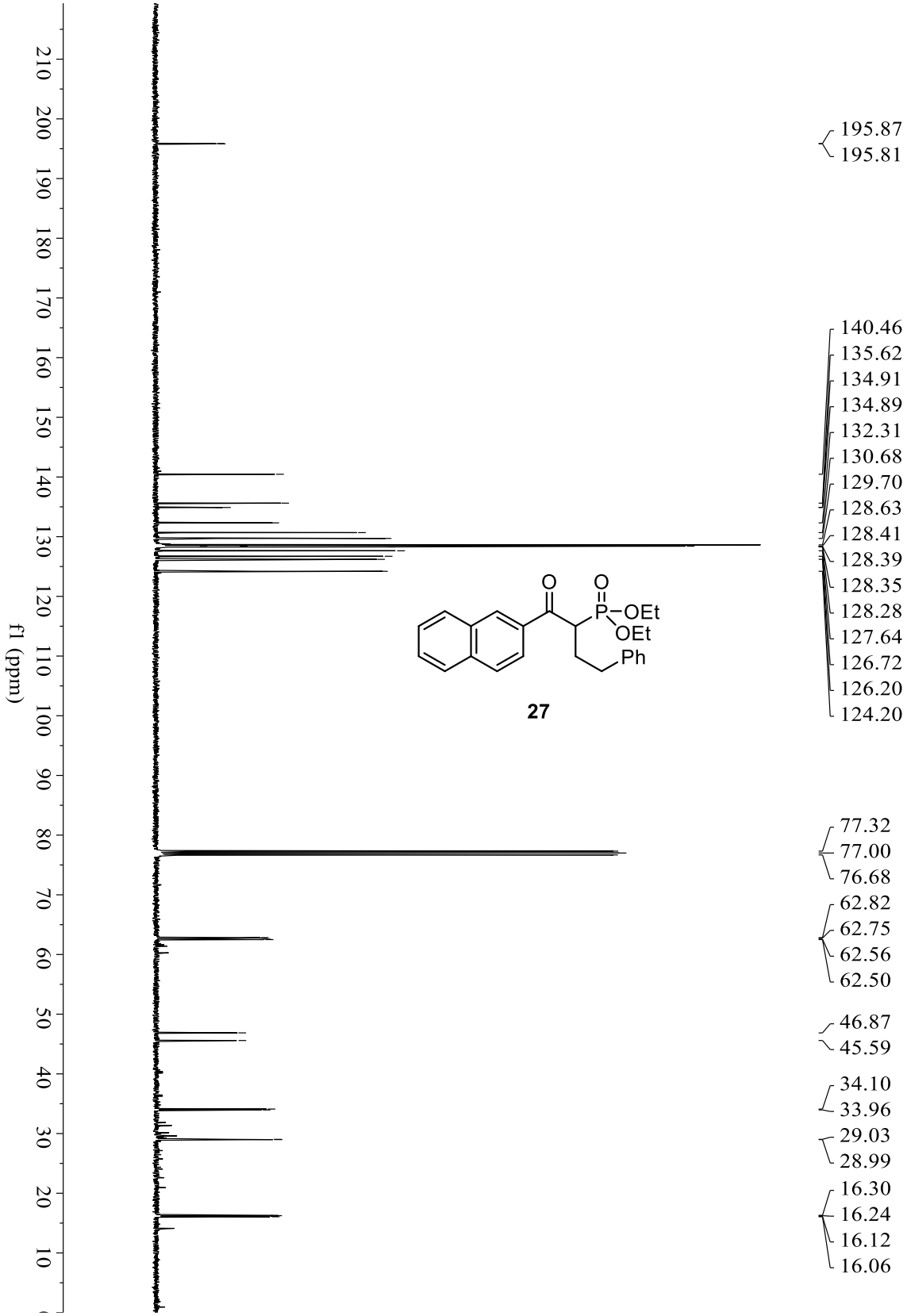
25

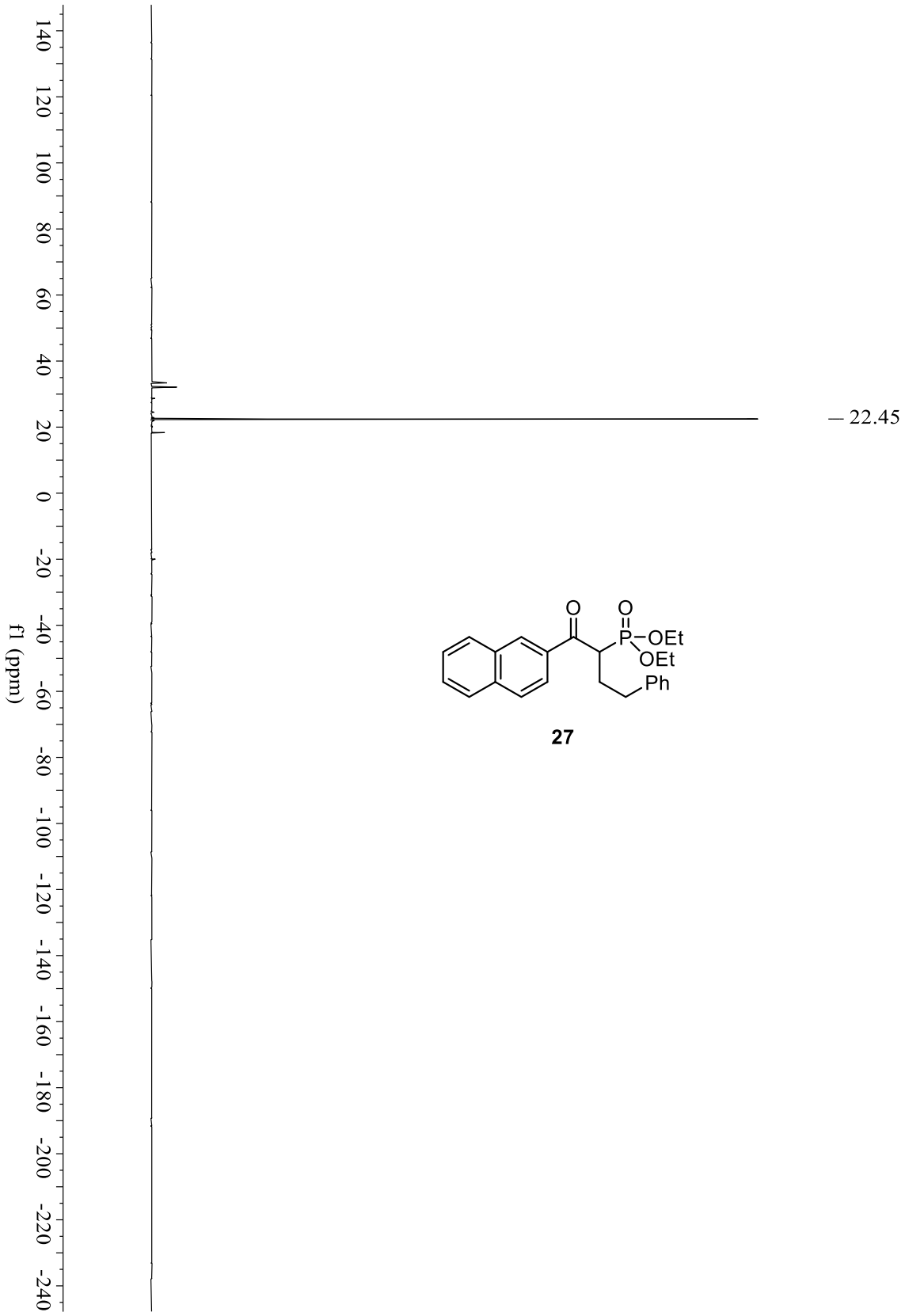

f1 (ppm)
2.02
1.09
2.07
4.11
2.10
5.10
3.02
1.10
2.10
1.05
3.25
3.00
O
O
P
OEt
OEt
Ph
O
Cl
O
OMe
Cl
26
8.01
8.00
7.99
7.99
7.46
7.43
7.37
7.36
7.35
7.35
7.27
7.26
7.25
7.25
7.24
7.23
7.21
7.21
7.20
7.20
7.19
7.19
7.11
7.11
7.10
7.09
7.09
4.13
4.11
4.11
4.10
4.09
4.09
4.08
4.08
4.07
4.06
4.06
4.05
4.04
4.03
4.02
4.01
4.00
1.29
1.27
1.25
1.20
1.18
1.17


194.68
194.63
162.35
154.20
154.16
140.39
135.73
132.55
130.57
129.80
129.37
128.60
128.48
126.91
126.28
125.99
121.53
77.32
77.00
76.68
62.88
62.81
62.71
62.64
62.41
47.16
45.89
34.16
34.02
28.93
28.89
16.33
16.27
16.19
16.13
f1 (ppm)
26

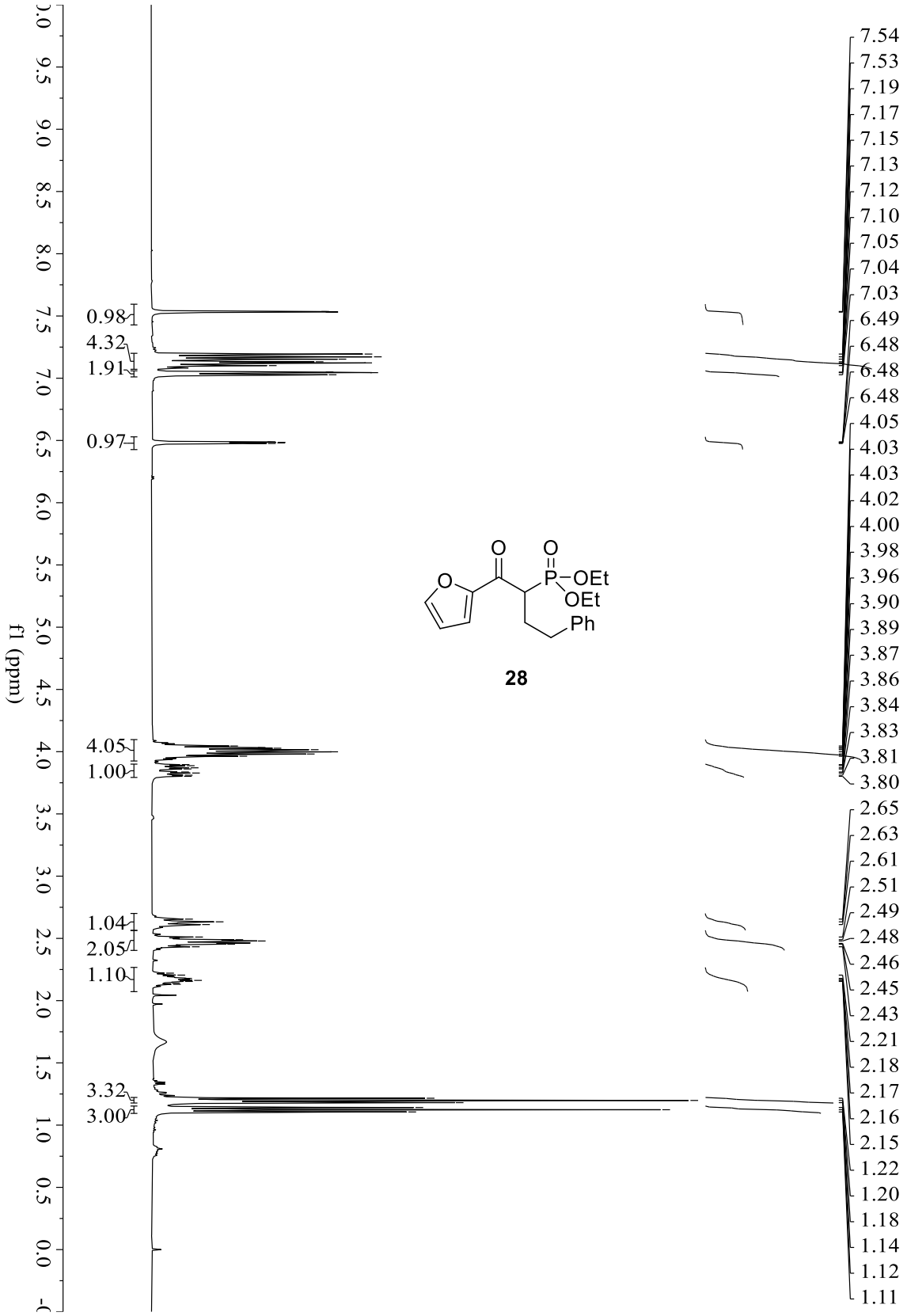

140 120 100 80 60 40 20 0 -20 -40 -60 -80 -100 -120 -140 -160 -180 -200 -220 -240
f1 (ppm)
21.90
O
O
P
OEt
OEt
Ph
O
Cl
O
OMe
Cl
26

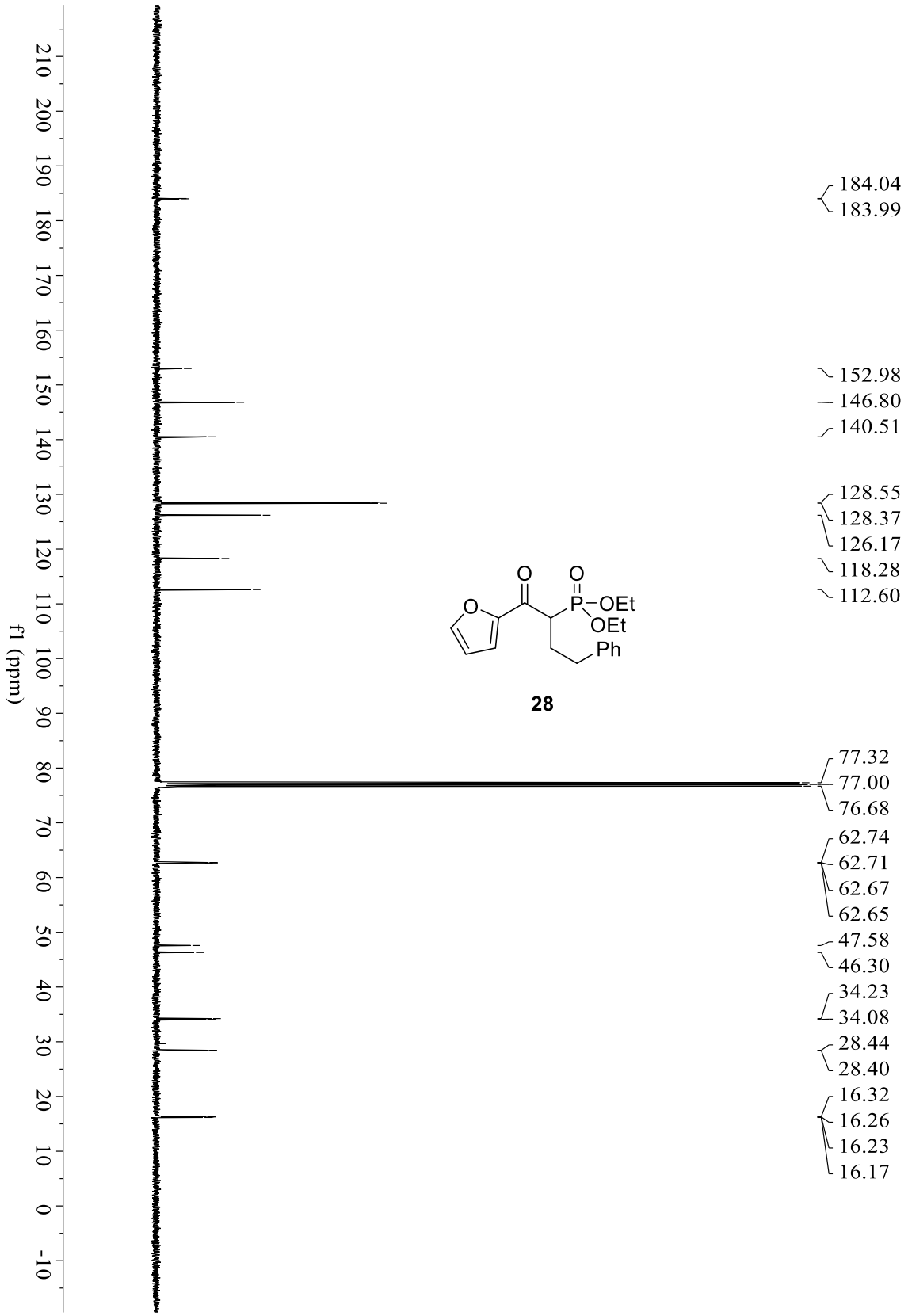

f1 (ppm)
0.94
0.94
2.89
1.94
3.34
1.92
1.00
4.42
0.99
0.96
1.10
0.99
3.46
3.00
O
O
P
OEt
OEt
Ph
27
8.34
8.01
8.01
7.99
7.99
7.92
7.90
7.89
7.88
7.87
7.86
7.63
7.61
7.59
7.57
7.55
7.26
7.25
7.23
7.21
7.20
7.19
7.12
7.11
7.10
7.09
4.31
4.25
4.23
4.14
4.11
4.10
4.08
4.05
4.03
4.01
3.99
2.77
2.74
2.60
2.58
2.57
2.56
2.55
1.28
1.26
1.24
1.13
1.12
1.10


195.87
195.81
140.46
135.62
134.91
134.89
132.31
130.68
129.70
128.63
128.41
128.39
128.35
128.28
127.64
126.72
126.20
124.20
77.32
77.00
76.68
62.82
62.75
62.56
62.50
46.87
45.59
34.10
33.96
29.03
28.99
16.30
16.24
16.12
16.06
O
O
P
OEt
OEt
Ph
27
f1 (ppm)
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10

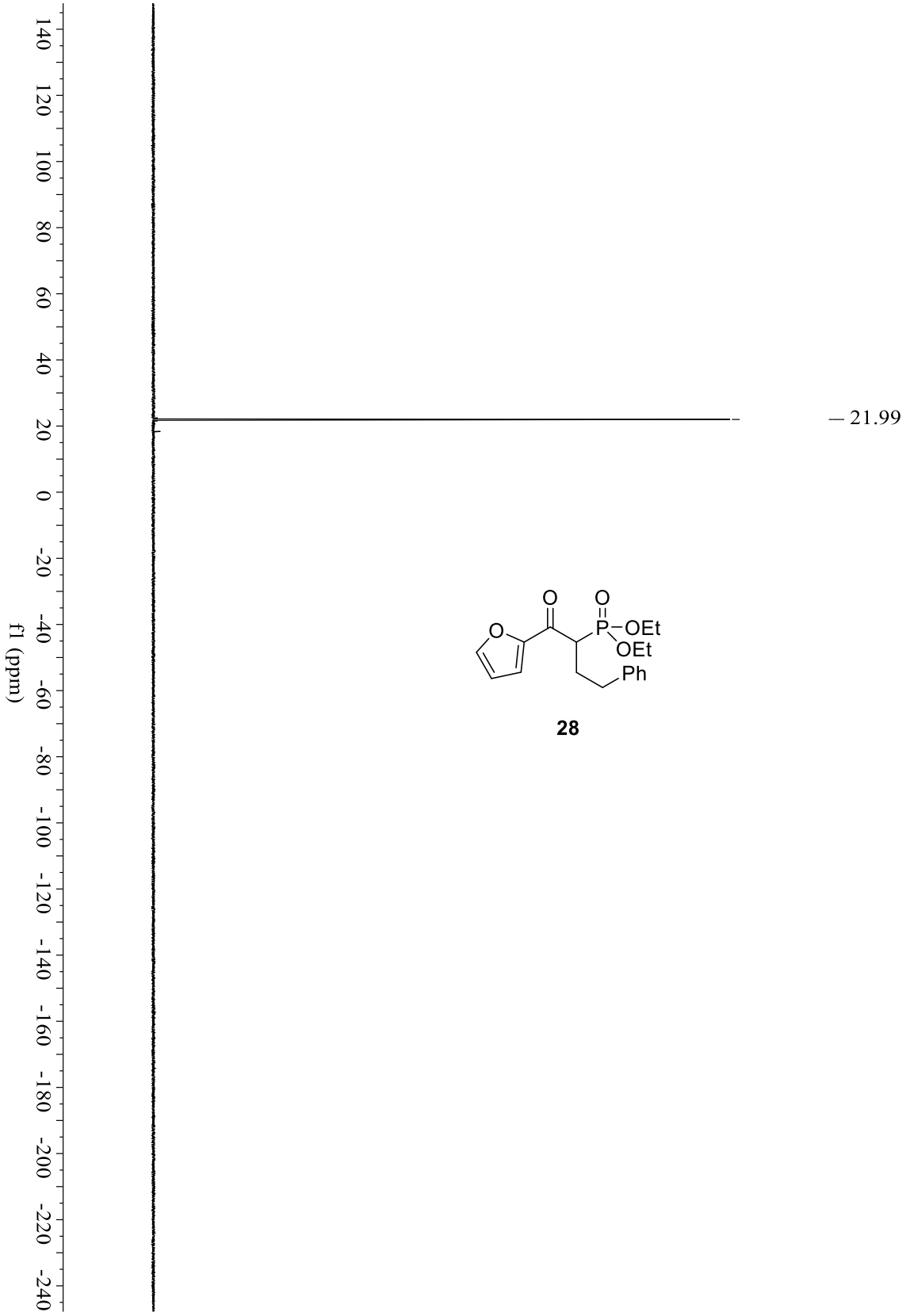

22.45
140
120
100
80
60
40
20
0
-20
-40
-60
-80
-100
-120
-140
-160
-180
-200
-220
-240
f1 (ppm)
O
O
P
OEt
OEt
Ph

27

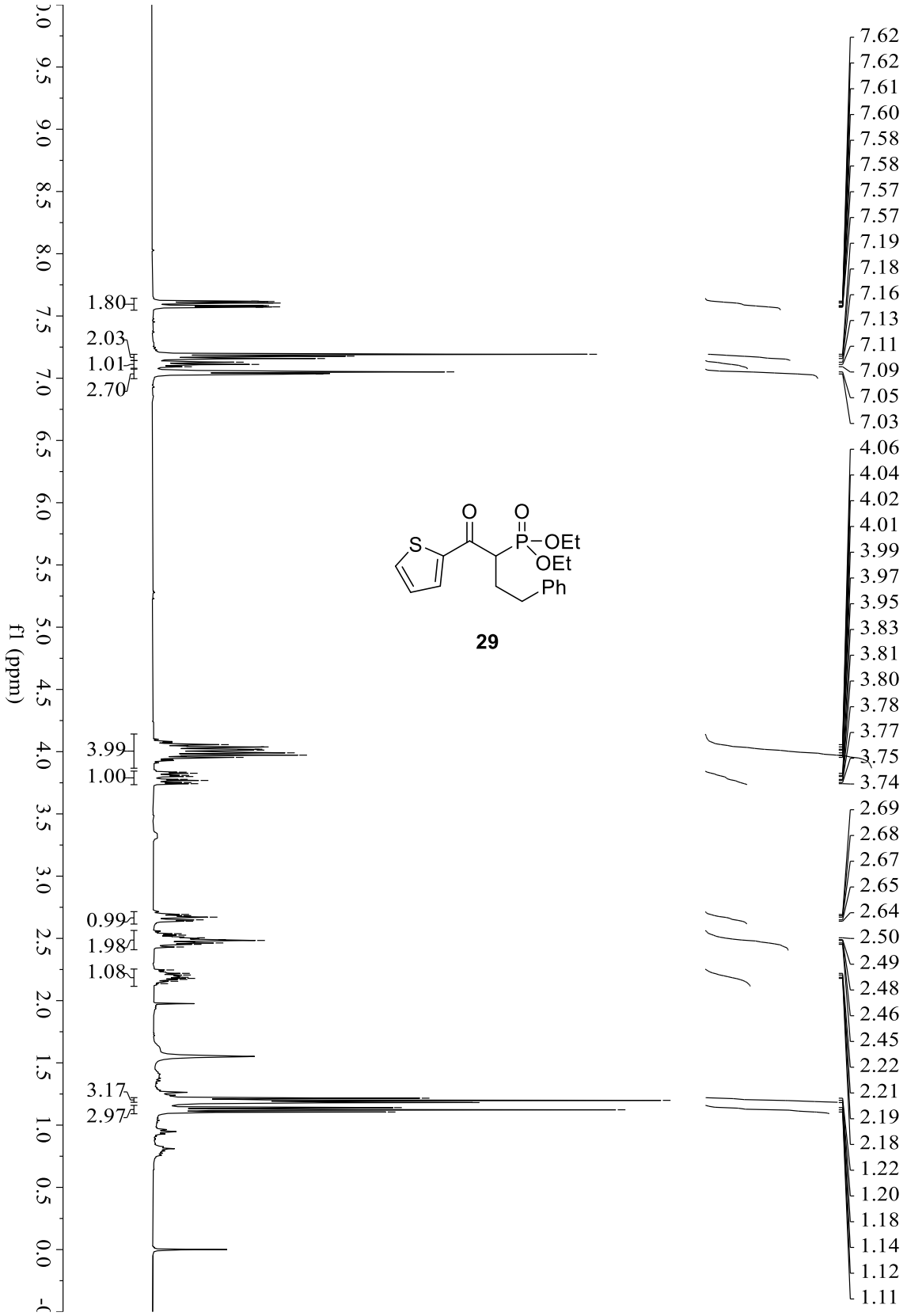

f1 (ppm)
0.98
4.32
1.91
0.97
4.05
1.00
1.04
2.05
1.10
3.32
3.00
O
O
O
P–OEt
OEt
Ph
28
7.54
7.53
7.19
7.17
7.15
7.13
7.12
7.10
7.05
7.04
7.03
6.49
6.48
6.48
6.48
4.05
4.03
4.03
4.02
4.00
3.98
3.96
3.90
3.89
3.87
3.86
3.84
3.83
3.81
3.80
2.65
2.63
2.61
2.51
2.49
2.48
2.46
2.45
2.43
2.21
2.18
2.17
2.16
2.15
1.22
1.20
1.18
1.14
1.12
1.11


f1 (ppm)
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
184.04
183.99
152.98
146.80
140.51
128.55
128.37
126.17
118.28
112.60
77.32
77.00
76.68
62.74
62.71
62.67
62.65
47.58
46.30
34.23
34.08
28.44
28.40
16.32
16.26
16.23
16.17
O
O
O
P
OEt
OEt
Ph

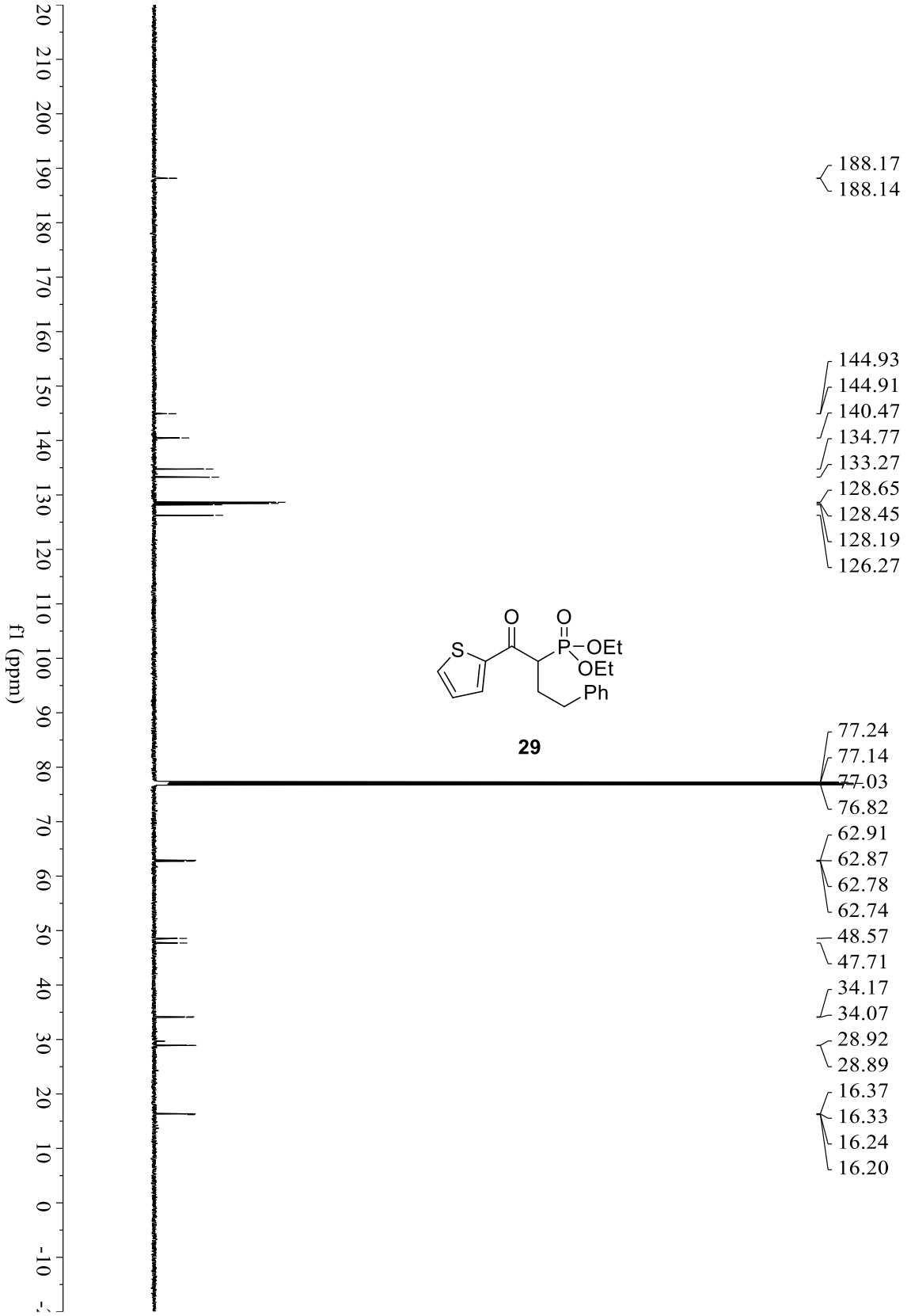
28


140
120
100
80
60
40
20
0
-20
-40
-60
-80
-100
-120
-140
-160
-180
-200
-220
-240
f1 (ppm)
21.99
O
O
O
P
OEt
OEt
Ph

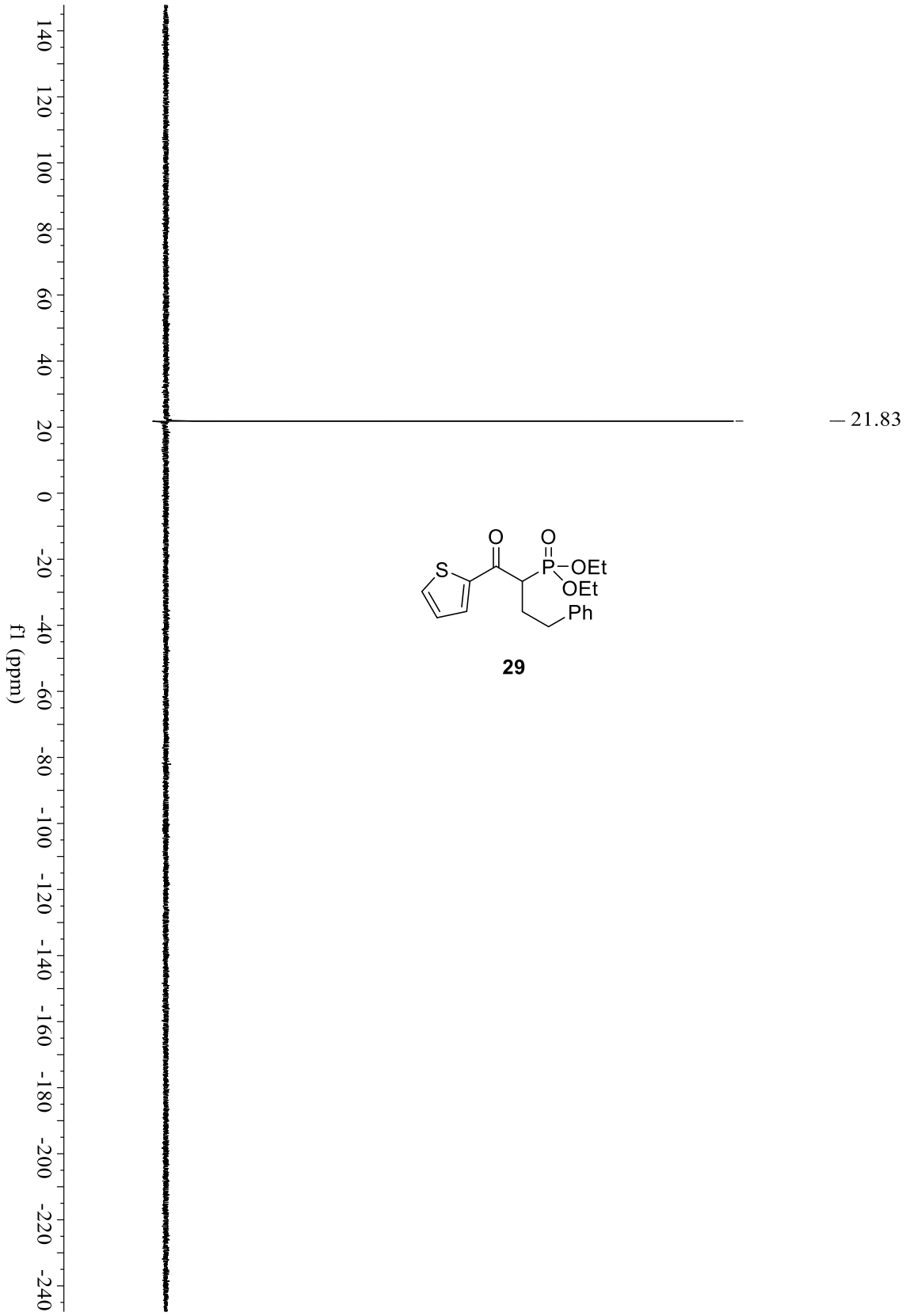
28


f1 (ppm)
1.80
2.03
1.01
2.70
3.99
1.00
0.99
1.98
1.08
3.17
2.97
7.62
7.62
7.61
7.60
7.58
7.58
7.57
7.57
7.19
7.18
7.16
7.13
7.11
7.09
7.05
7.03
4.06
4.04
4.02
4.01
3.99
3.97
3.95
3.83
3.81
3.80
3.78
3.77
3.75
3.74
2.69
2.68
2.67
2.65
2.64
2.50
2.49
2.48
2.46
2.45
2.22
2.21
2.19
2.18
1.22
1.20
1.18
1.14
1.12
1.11
O
O
S
P
OEt
OEt
Ph

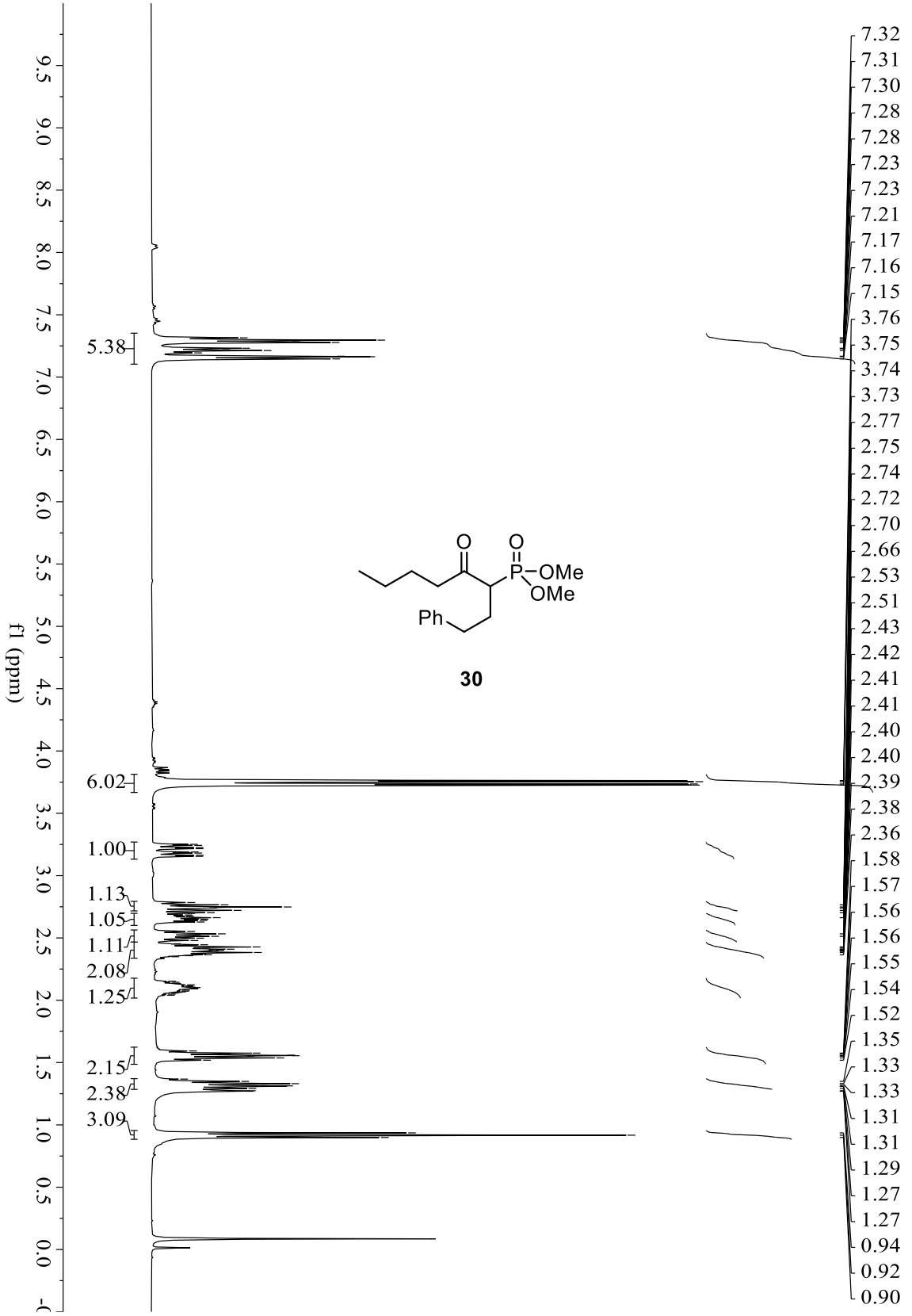
29

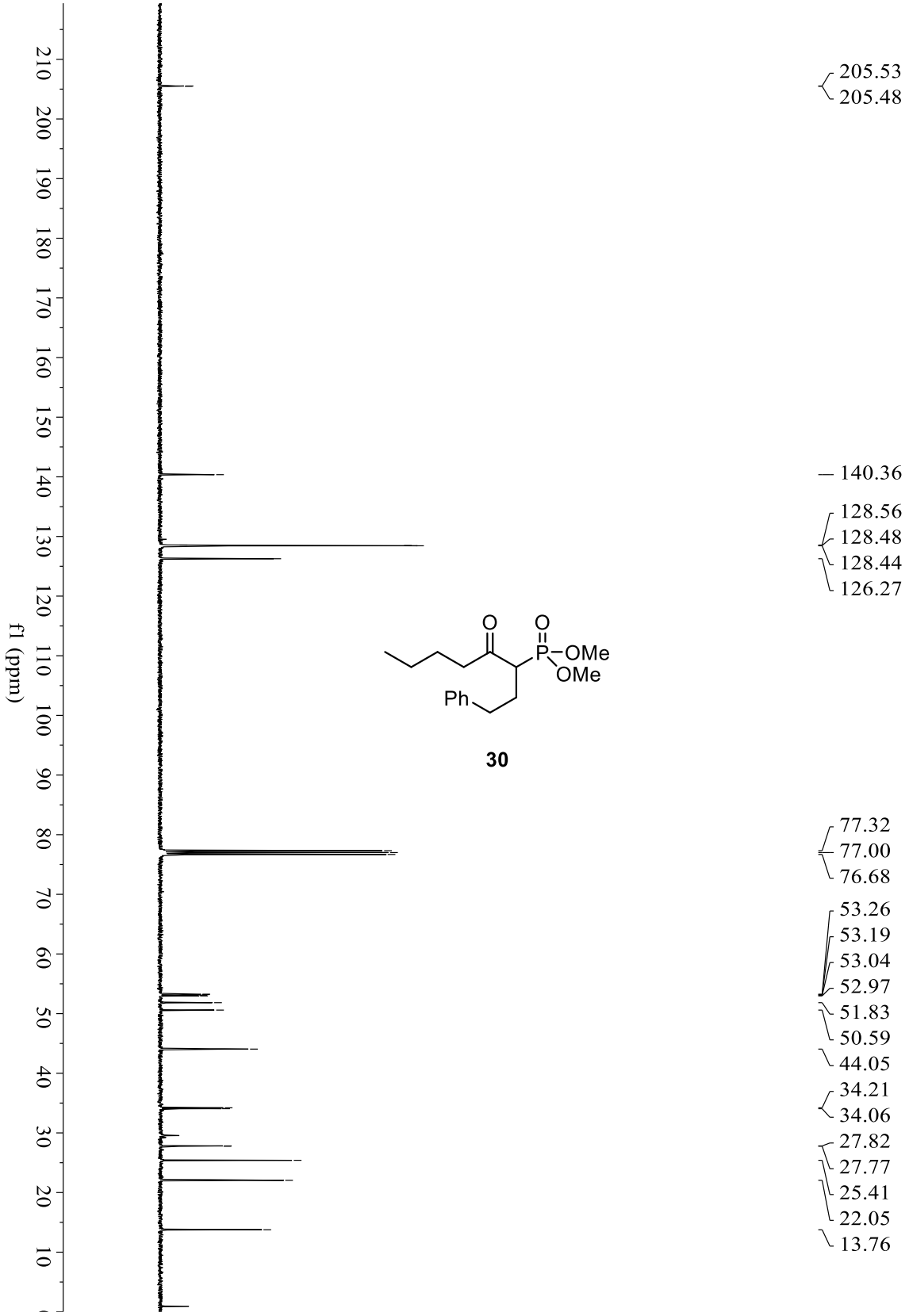

188.17
188.14
144.93
144.91
140.47
134.77
133.27
128.65
128.45
128.19
126.27
77.24
77.14
77.03
76.82
62.91
62.87
62.78
62.74
48.57
47.71
34.17
34.07
28.92
28.89
16.37
16.33
16.24
16.20
f1 (ppm)
O
O
S
P
OEt
OEt
Ph

29

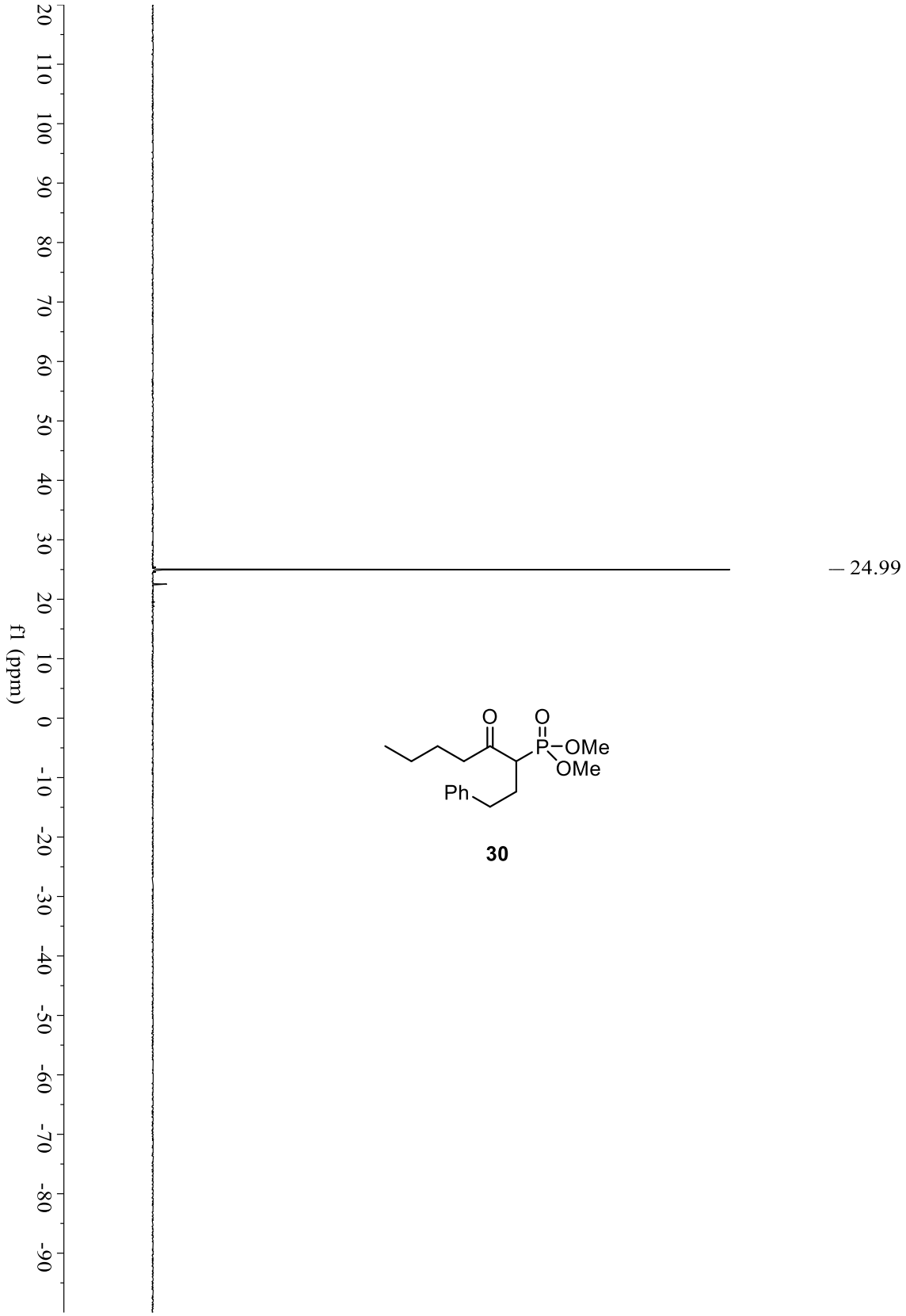

21.83
f1 (ppm)
140
120
100
80
60
40
20
0
-20
-40
-60
-80
-100
-120
-140
-160
-180
-200
-220
-240
O
O
S
P
OEt
OEt
Ph

29

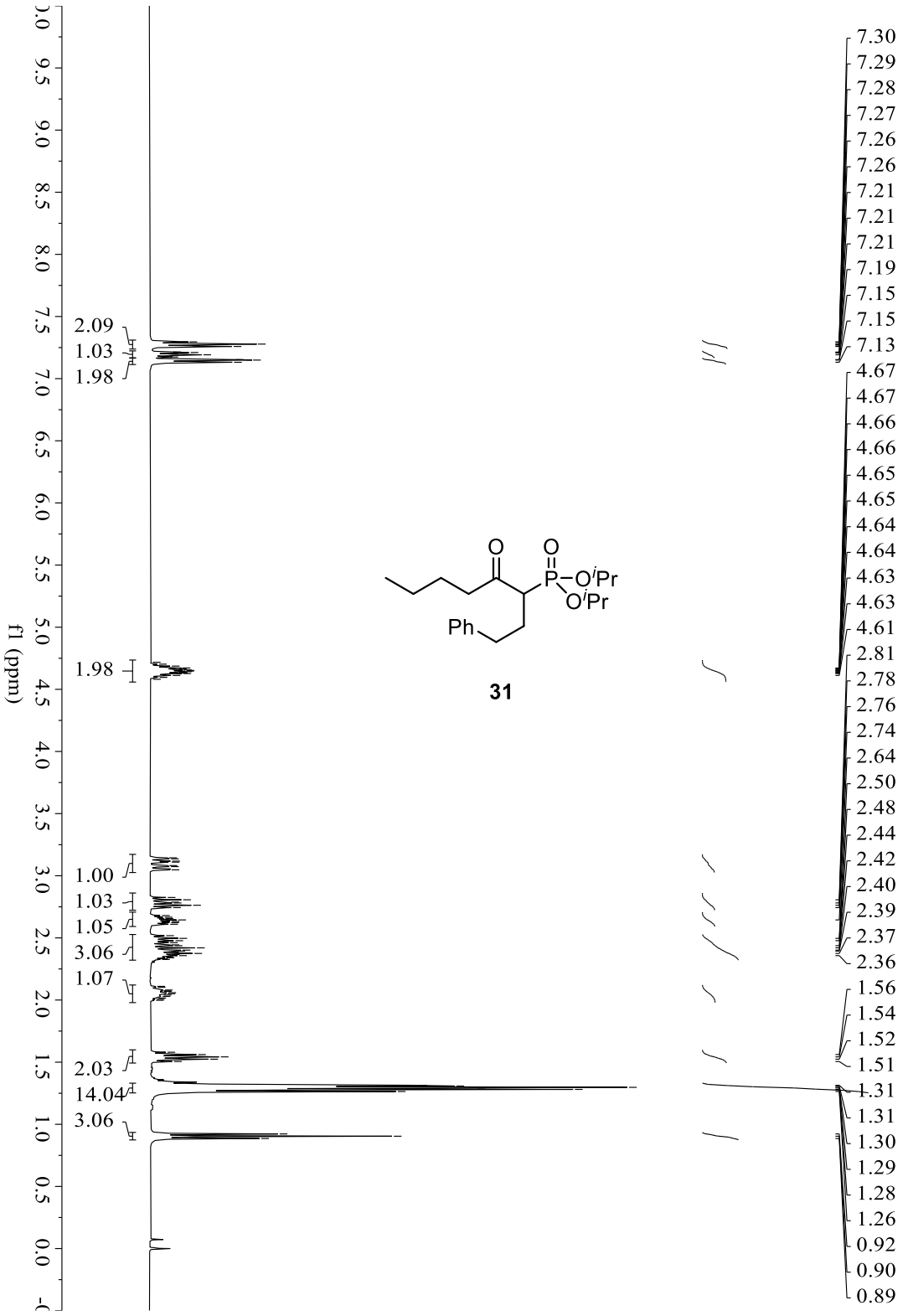

f1 (ppm)
5.38
6.02
1.00
1.13
1.05
1.11
2.08
1.25
2.15
2.38
3.09
O
O
P–OMe
OMe
Ph
30
7.32
7.31
7.30
7.28
7.28
7.23
7.23
7.21
7.17
7.16
7.15
3.76
3.75
3.74
3.73
2.77
2.75
2.74
2.72
2.70
2.66
2.53
2.51
2.43
2.42
2.41
2.41
2.40
2.40
2.39
2.38
2.36
1.58
1.57
1.56
1.56
1.55
1.54
1.52
1.35
1.33
1.33
1.31
1.31
1.29
1.27
1.27
0.94
0.92
0.90

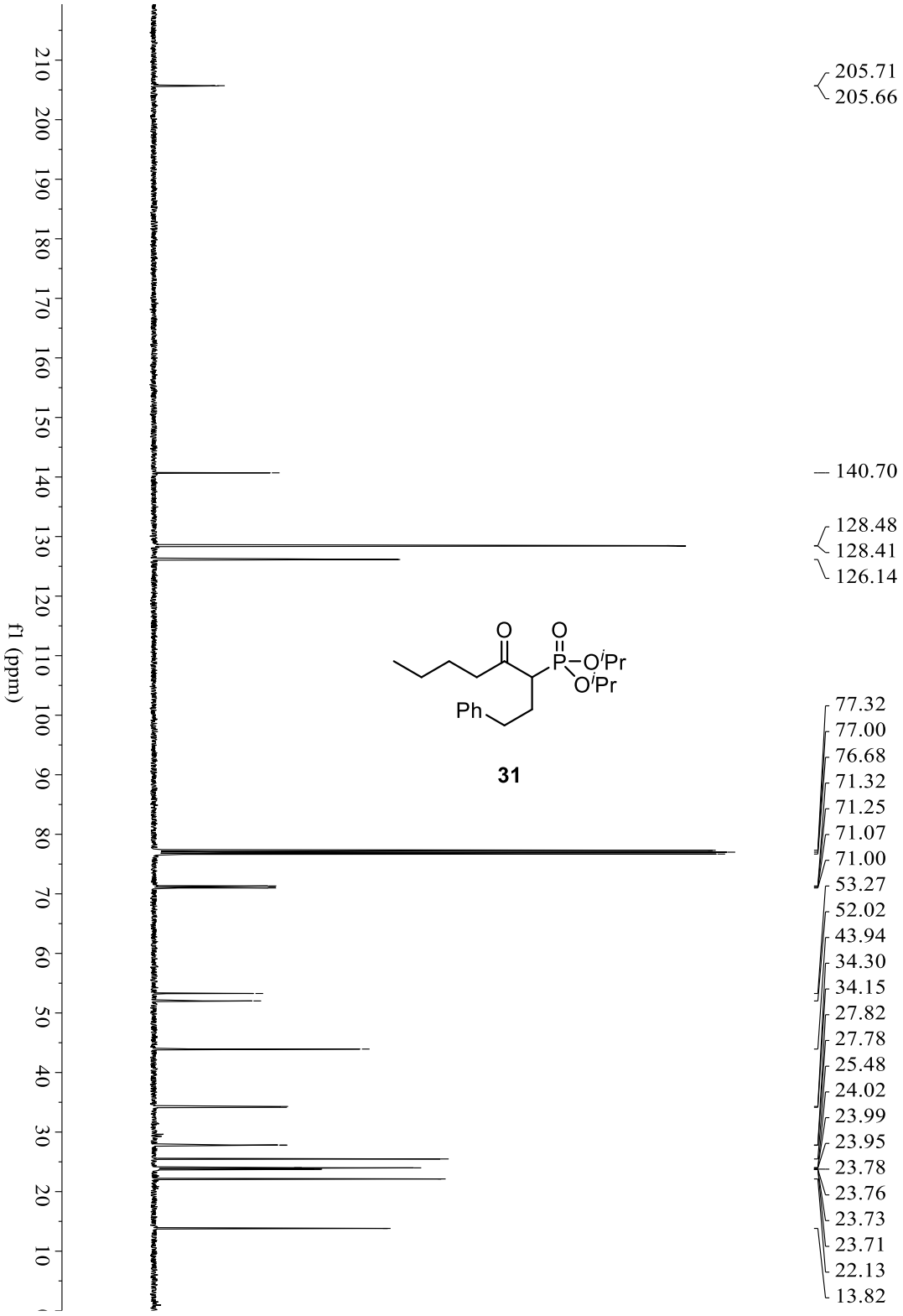

205.53
205.48
140.36
128.56
128.48
128.44
126.27
77.32
77.00
76.68
53.26
53.19
53.04
52.97
51.83
50.59
44.05
34.21
34.06
27.82
27.77
25.41
22.05
13.76
f1 (ppm)
O
O
P
OMe
OMe
Ph

30

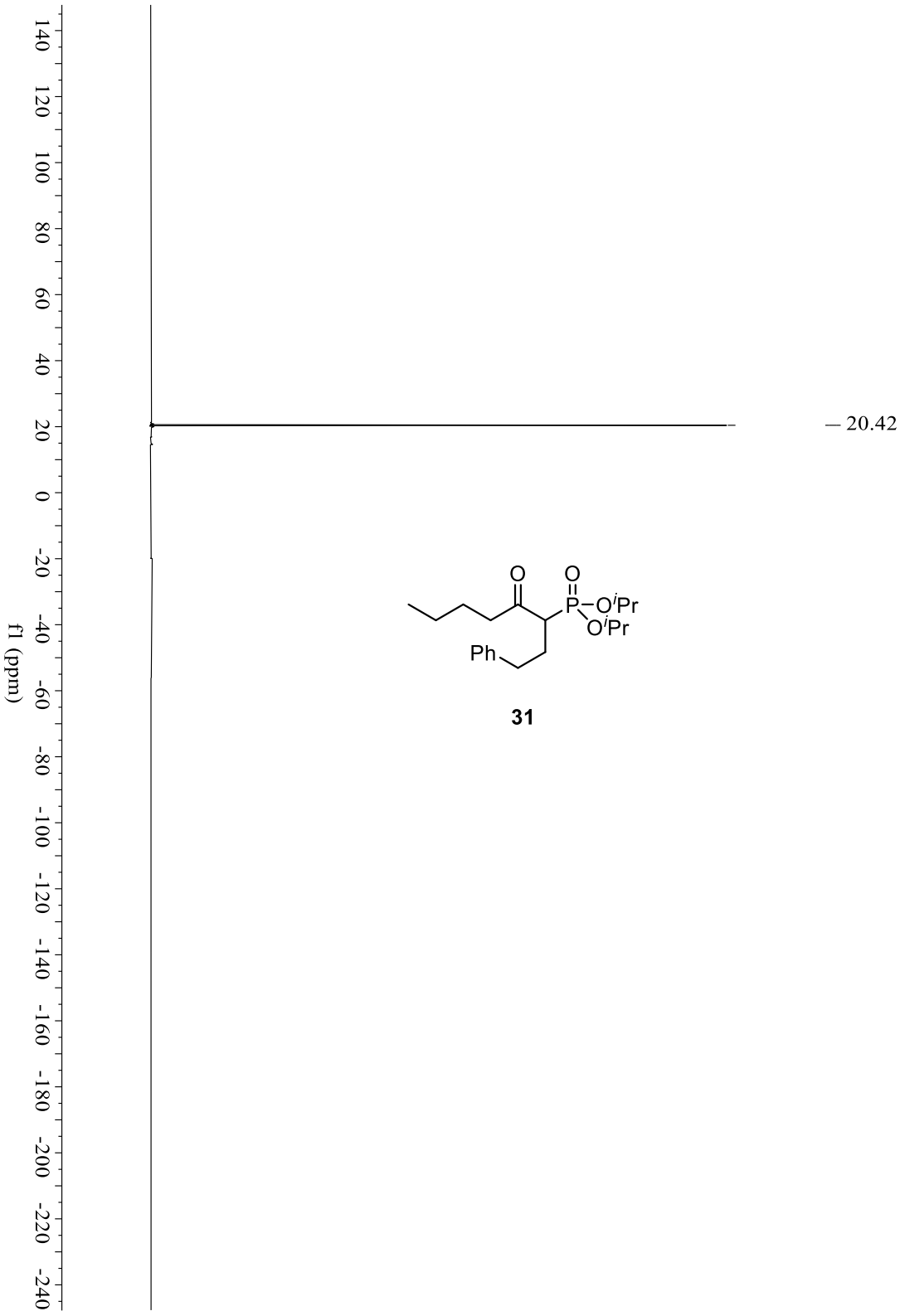

24.99
f1 (ppm)
20
110
100
90
80
70
60
50
40
30
20
10
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
O
O
P
OMe
OMe
Ph

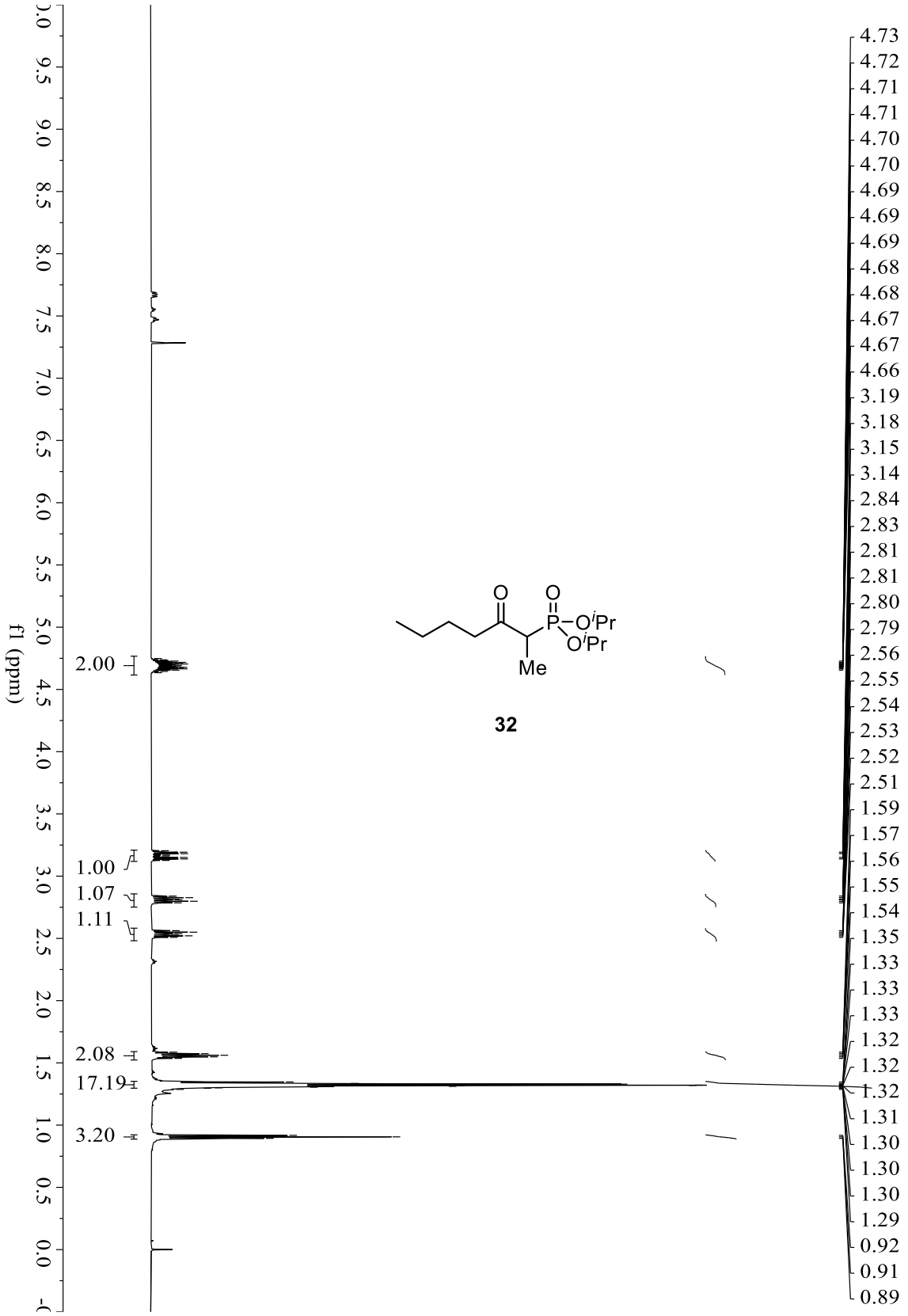
30

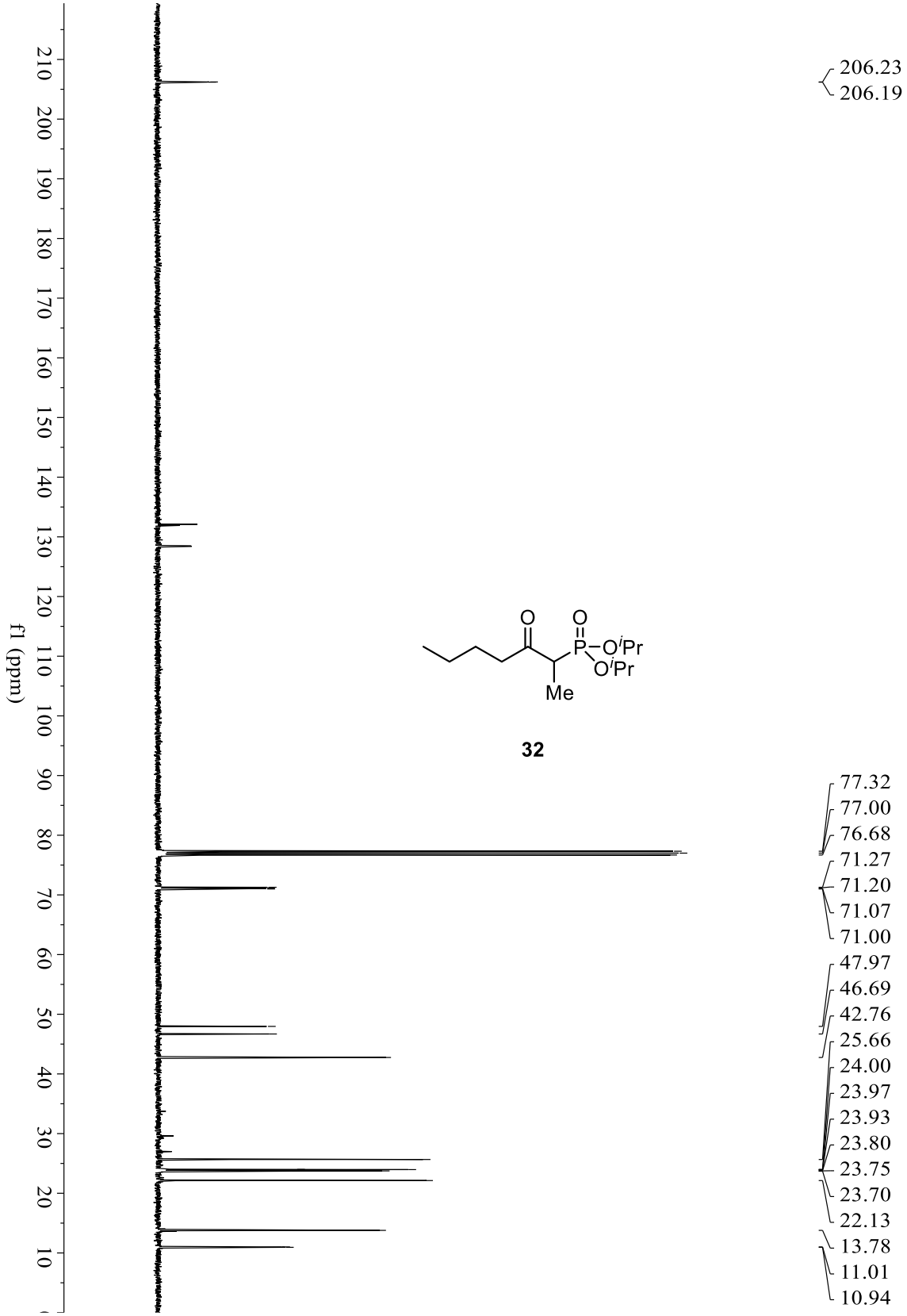

f1 (ppm)
2.09
1.03
1.98
1.98
1.00
1.03
1.05
3.06
1.07
2.03
14.04
3.06
O
O
P–O^{i}Pr
O^{i}Pr
Ph
31
7.30
7.29
7.28
7.27
7.26
7.26
7.21
7.21
7.21
7.19
7.15
7.15
7.13
4.67
4.67
4.66
4.66
4.65
4.65
4.64
4.64
4.63
4.63
4.61
2.81
2.78
2.76
2.74
2.64
2.50
2.48
2.44
2.42
2.40
2.39
2.37
2.36
1.56
1.54
1.52
1.51
1.31
1.31
1.30
1.29
1.28
1.26
0.92
0.90
0.89


f1 (ppm)
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
205.71
205.66
140.70
128.48
128.41
126.14
77.32
77.00
76.68
71.32
71.25
71.07
71.00
53.27
52.02
43.94
34.30
34.15
27.82
27.78
25.48
24.02
23.99
23.95
23.78
23.76
23.73
23.71
22.13
13.82
O
O
P
O^{i}Pr
O^{i}Pr
Ph

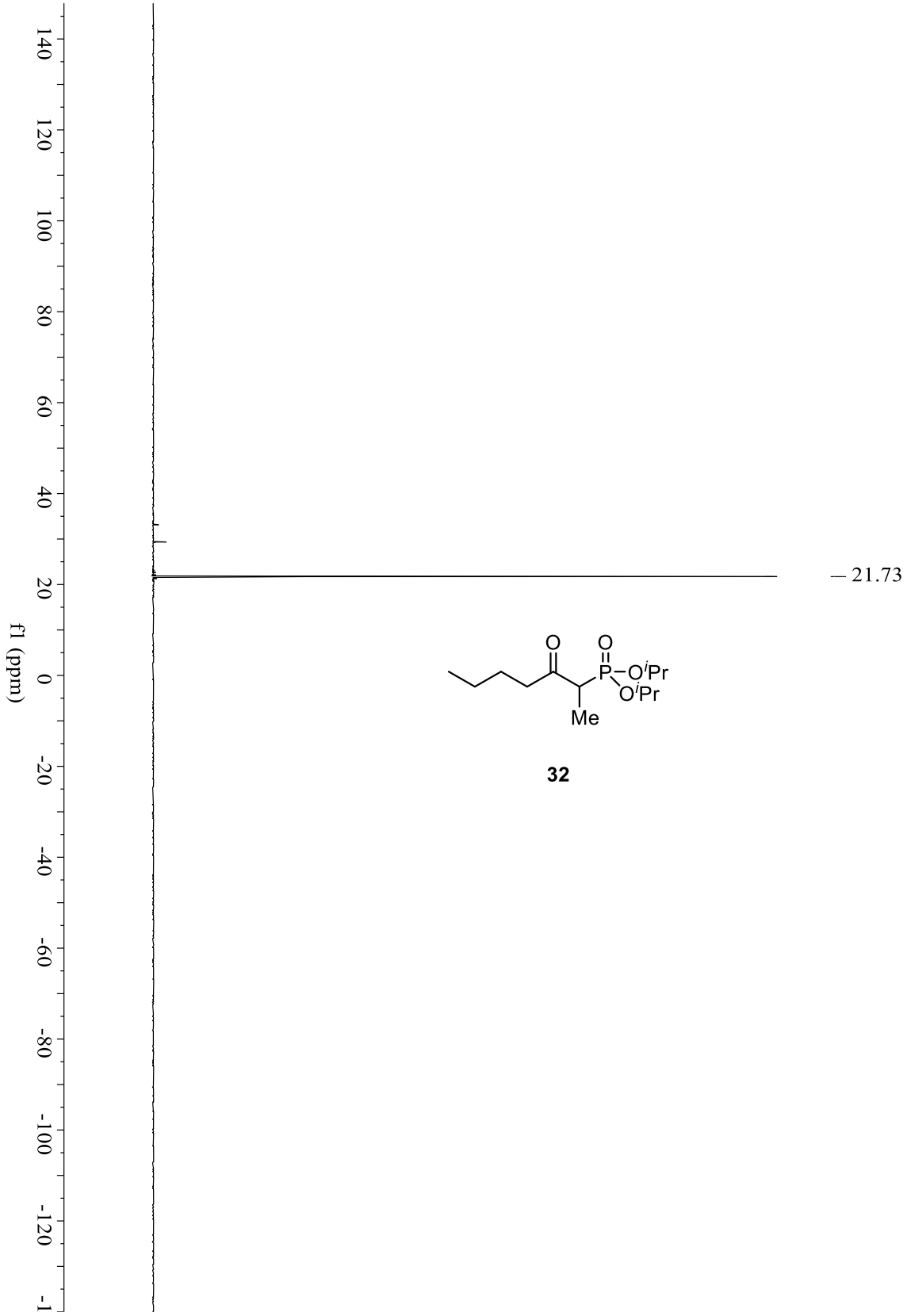
31


20.42
O
O
P–O^{i}Pr
O^{i}Pr
Ph
31
f1 (ppm)
140
120
100
80
60
40
20
0
-20
-40
-60
-80
-100
-120
-140
-160
-180
-200
-220
-240

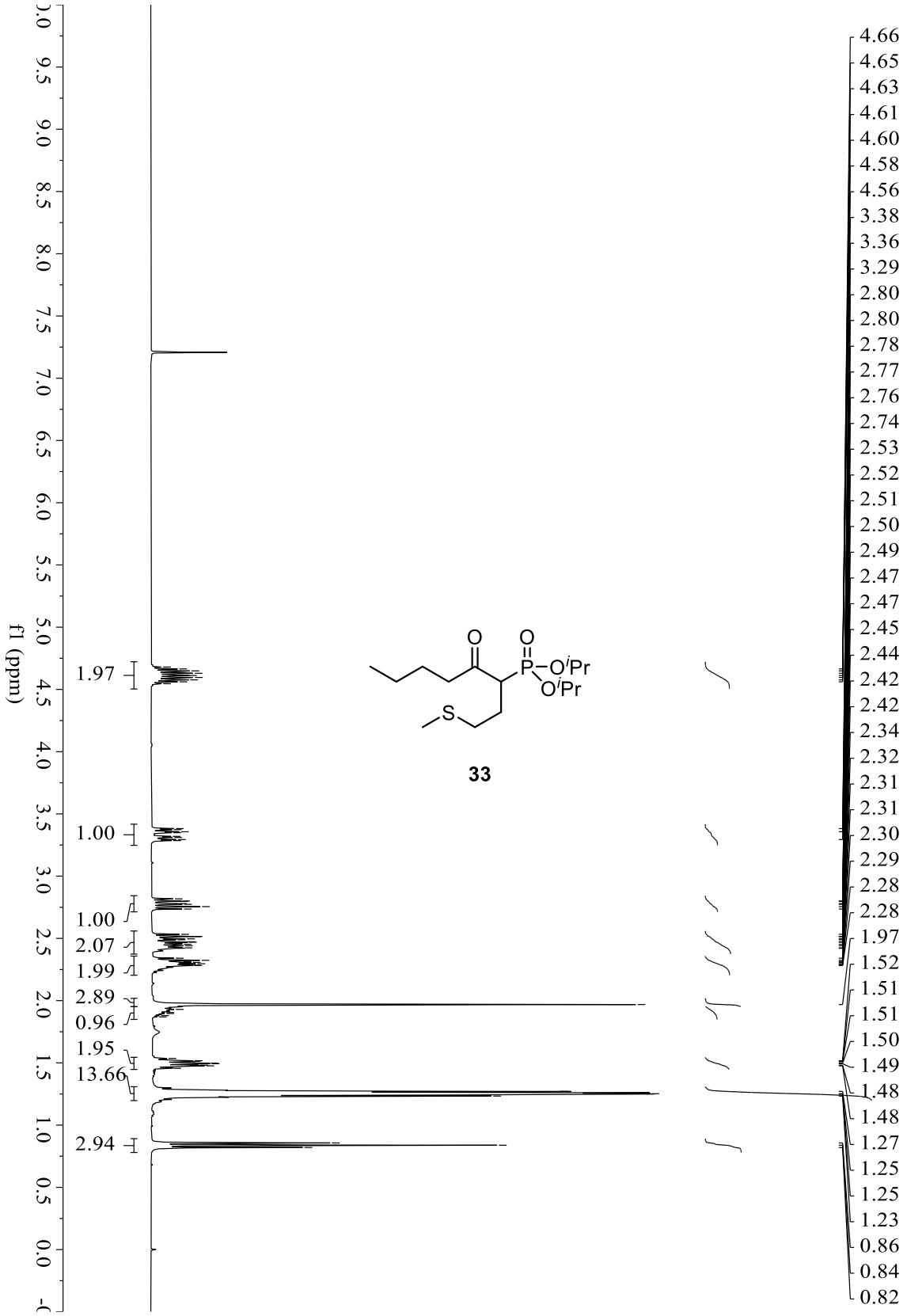

f1 (ppm)
2.00
1.00
1.07
1.11
2.08
17.19
3.20
O
O
P
O^{i}Pr
O^{i}Pr
Me
32

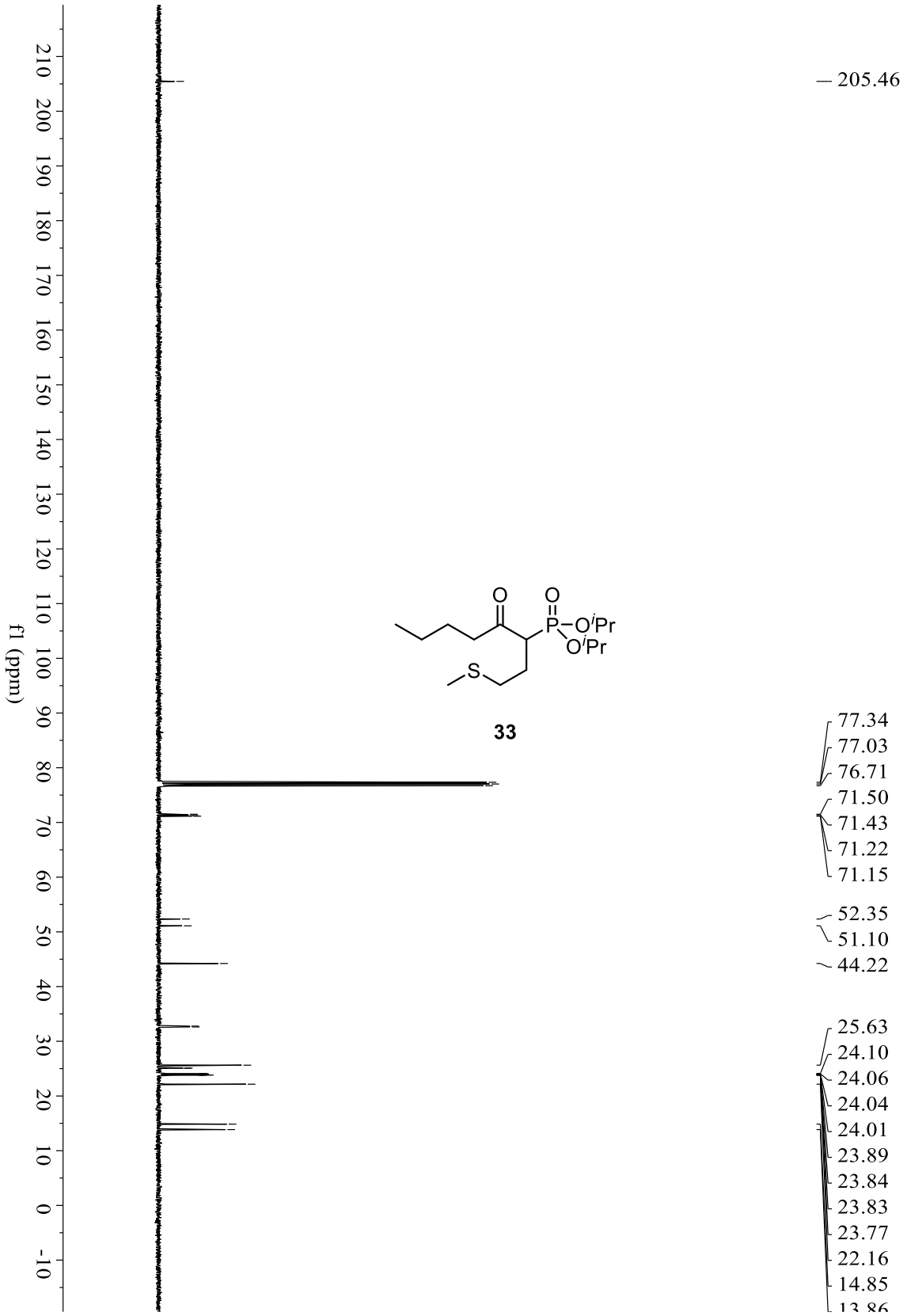

206.23
206.19
77.32
77.00
76.68
71.27
71.20
71.07
71.00
47.97
46.69
42.76
25.66
24.00
23.97
23.93
23.80
23.75
23.70
22.13
13.78
11.01
10.94
f1 (ppm)
O
O
P
O
iPr
O
iPr
Me

32

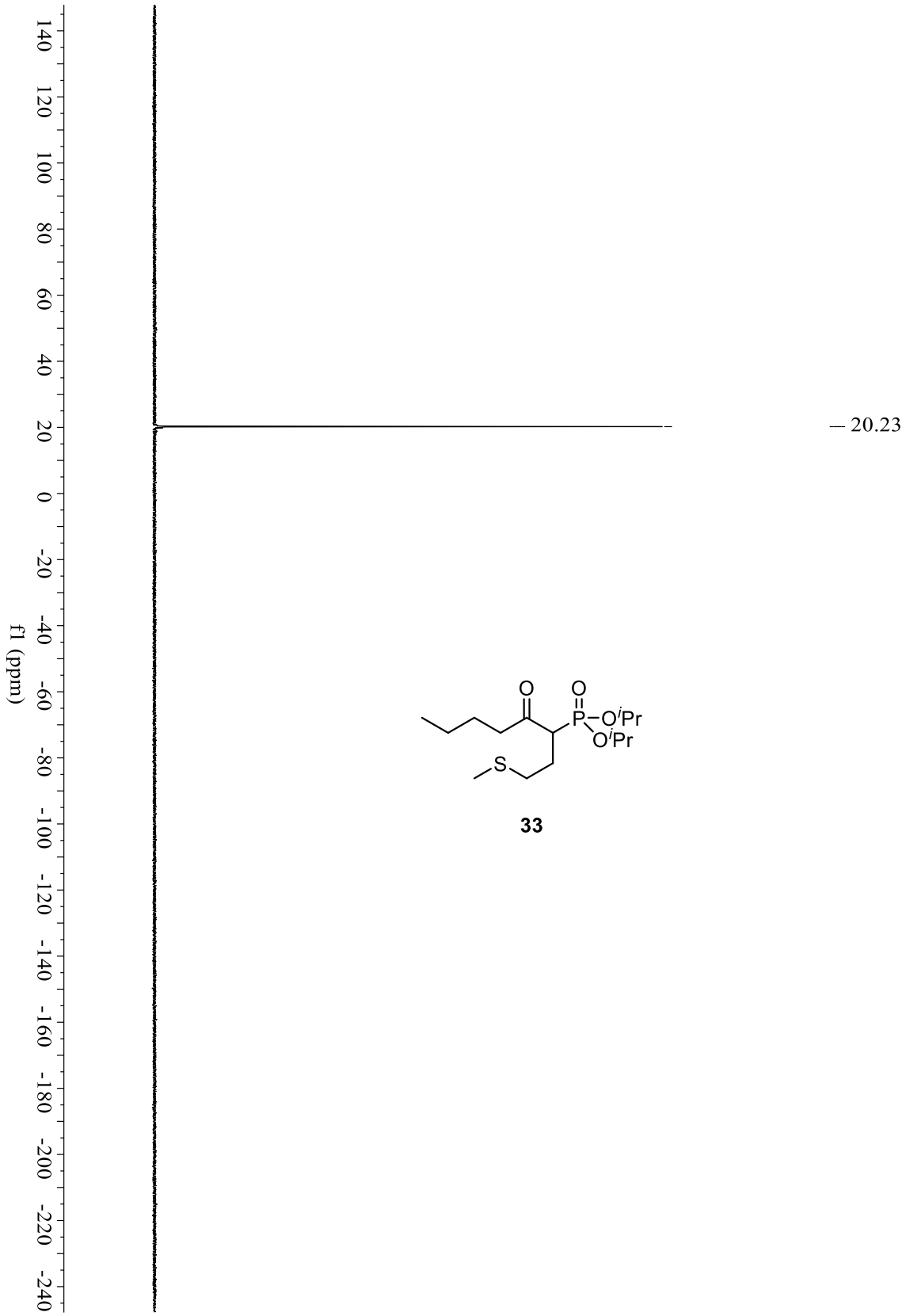

140
120
100
80
60
40
20
0
-20
-40
-60
-80
-100
-120
-1
f1 (ppm)
21.73
O
O
P
O
iPr
O
iPr
Me

32

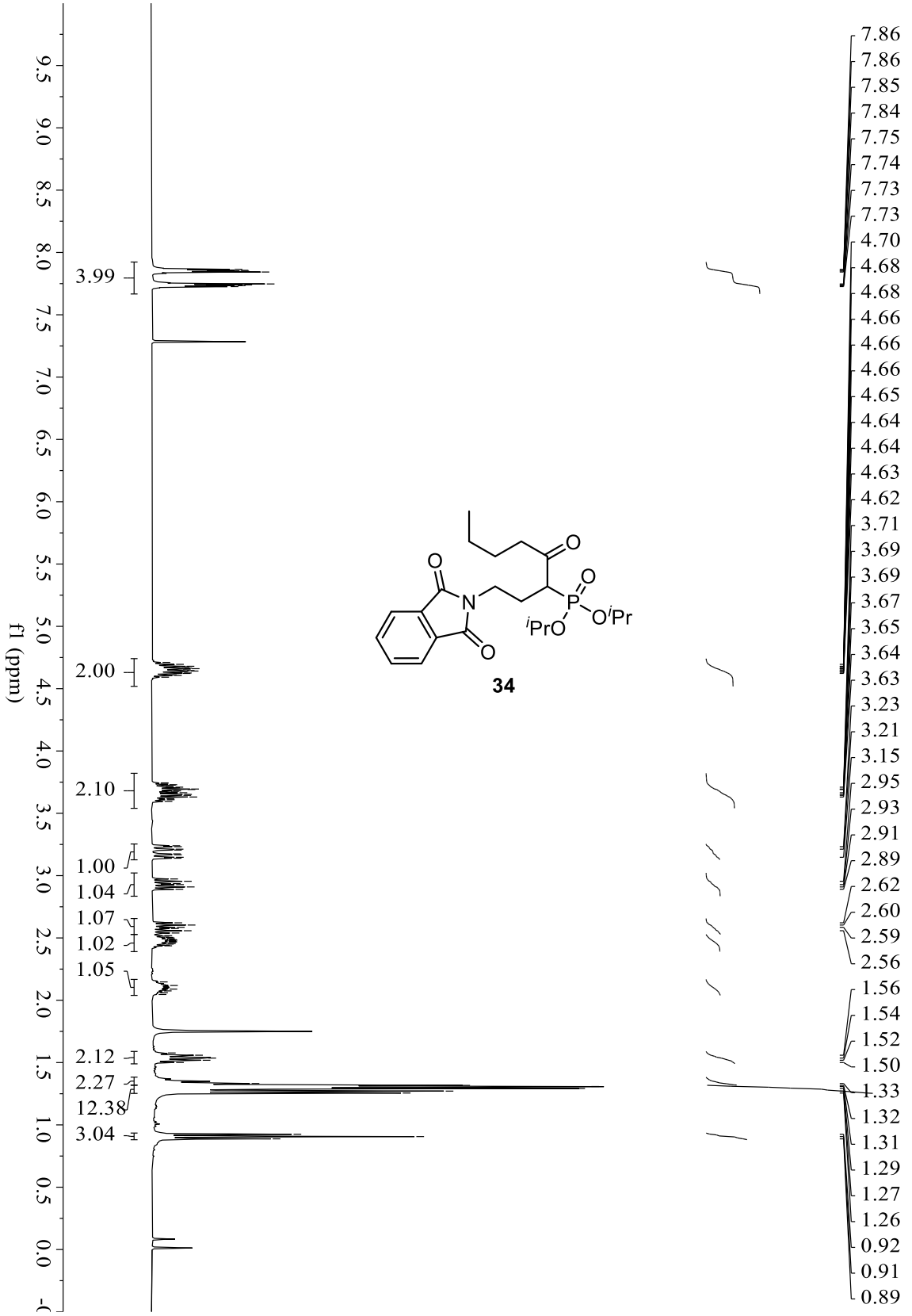

f1 (ppm)
1.97
1.00
1.00
2.07
1.99
2.89
0.96
1.95
13.66
2.94
O
O
P
O^{i}Pr
O^{i}Pr
S
33


205.46
77.34
77.03
76.71
71.50
71.43
71.22
71.15
52.35
51.10
44.22
25.63
24.10
24.06
24.04
24.01
23.89
23.84
23.83
23.77
22.16
14.85
13.86
f1 (ppm)
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
O
O
P
O^{i}Pr
O^{i}Pr
S

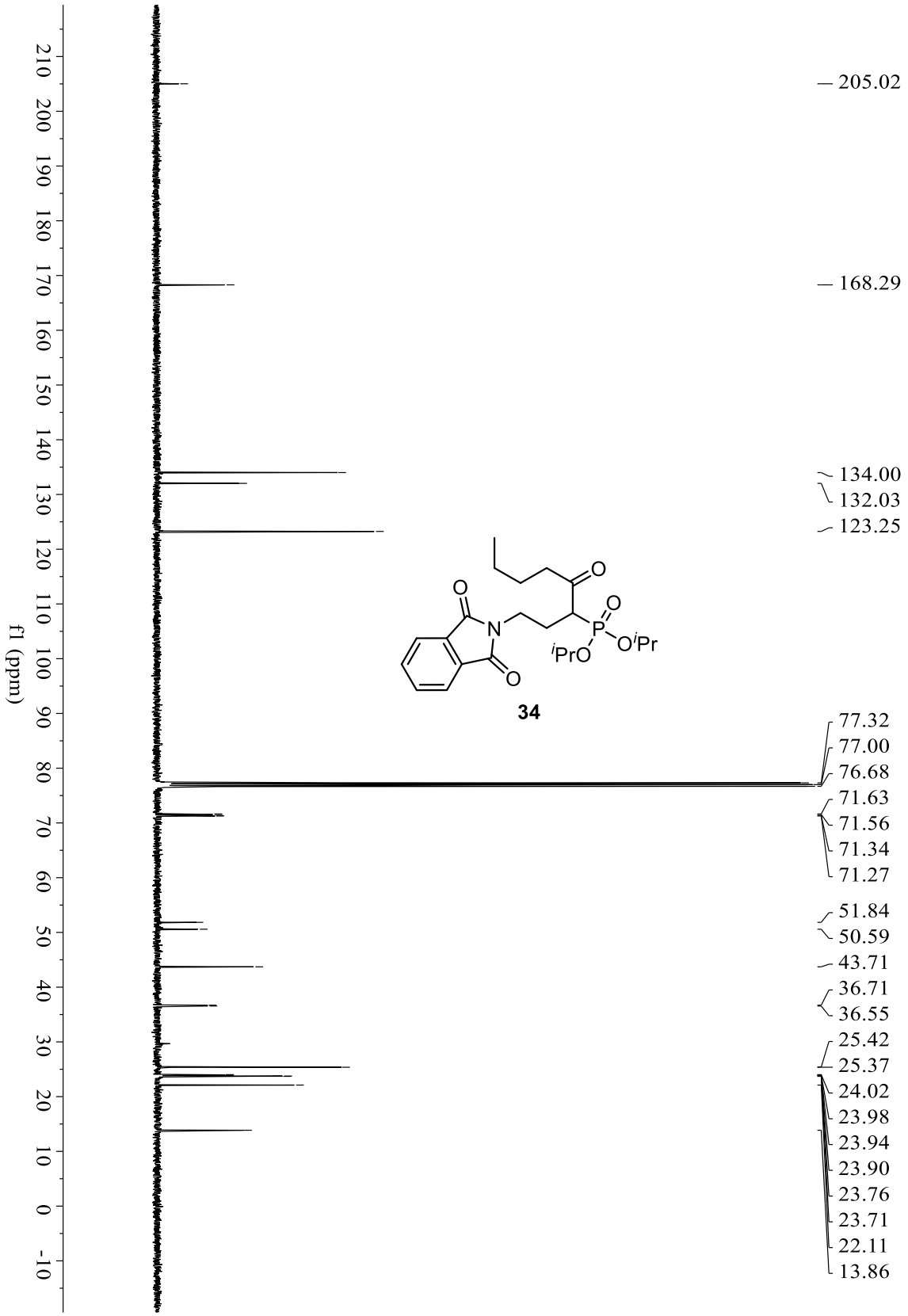
33

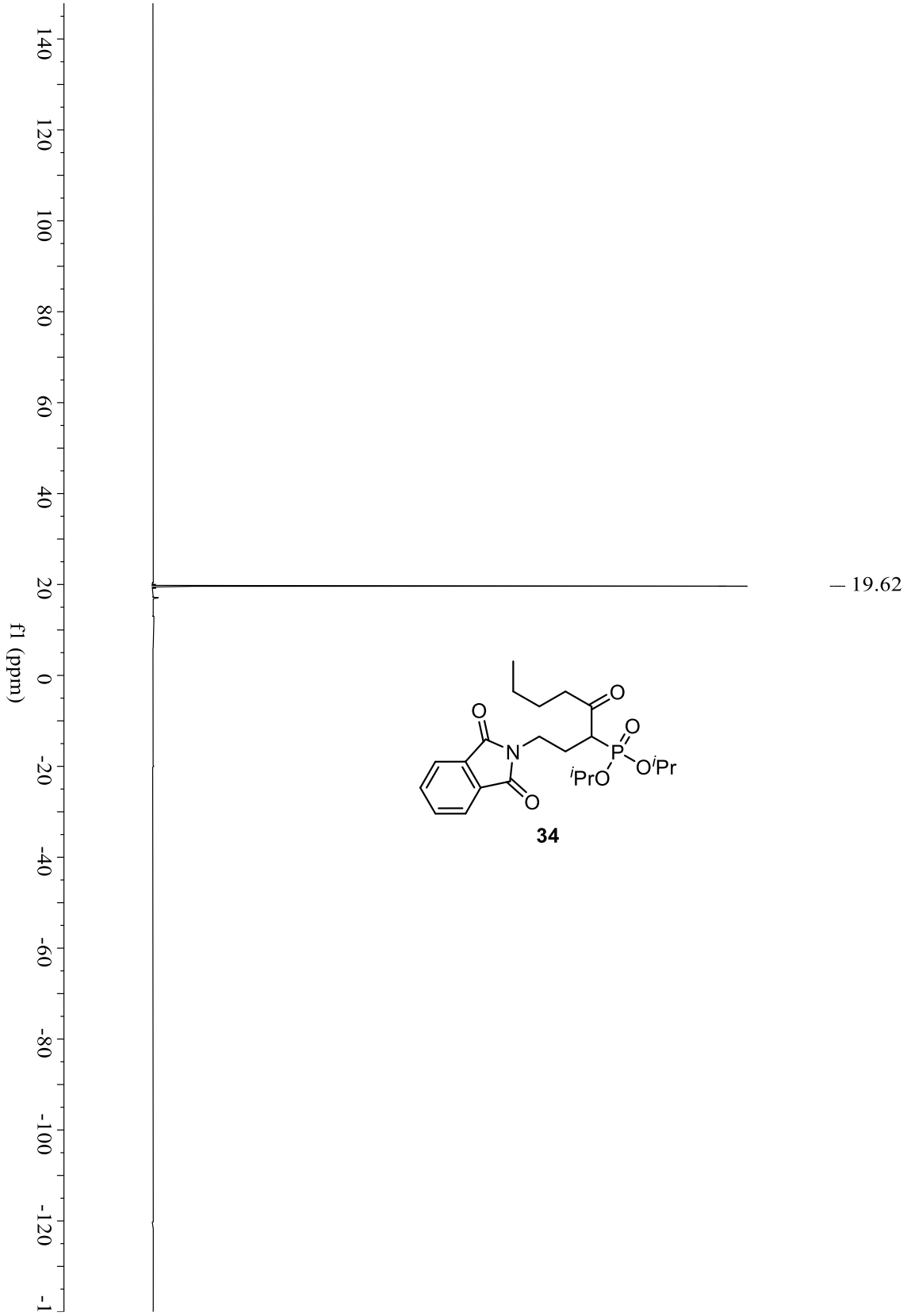

20.23
140
120
100
80
60
40
20
0
-20
-40
-60
-80
-100
-120
-140
-160
-180
-200
-220
-240
f1 (ppm)
O
O
P
O^{i}Pr
O^{i}Pr
S

33

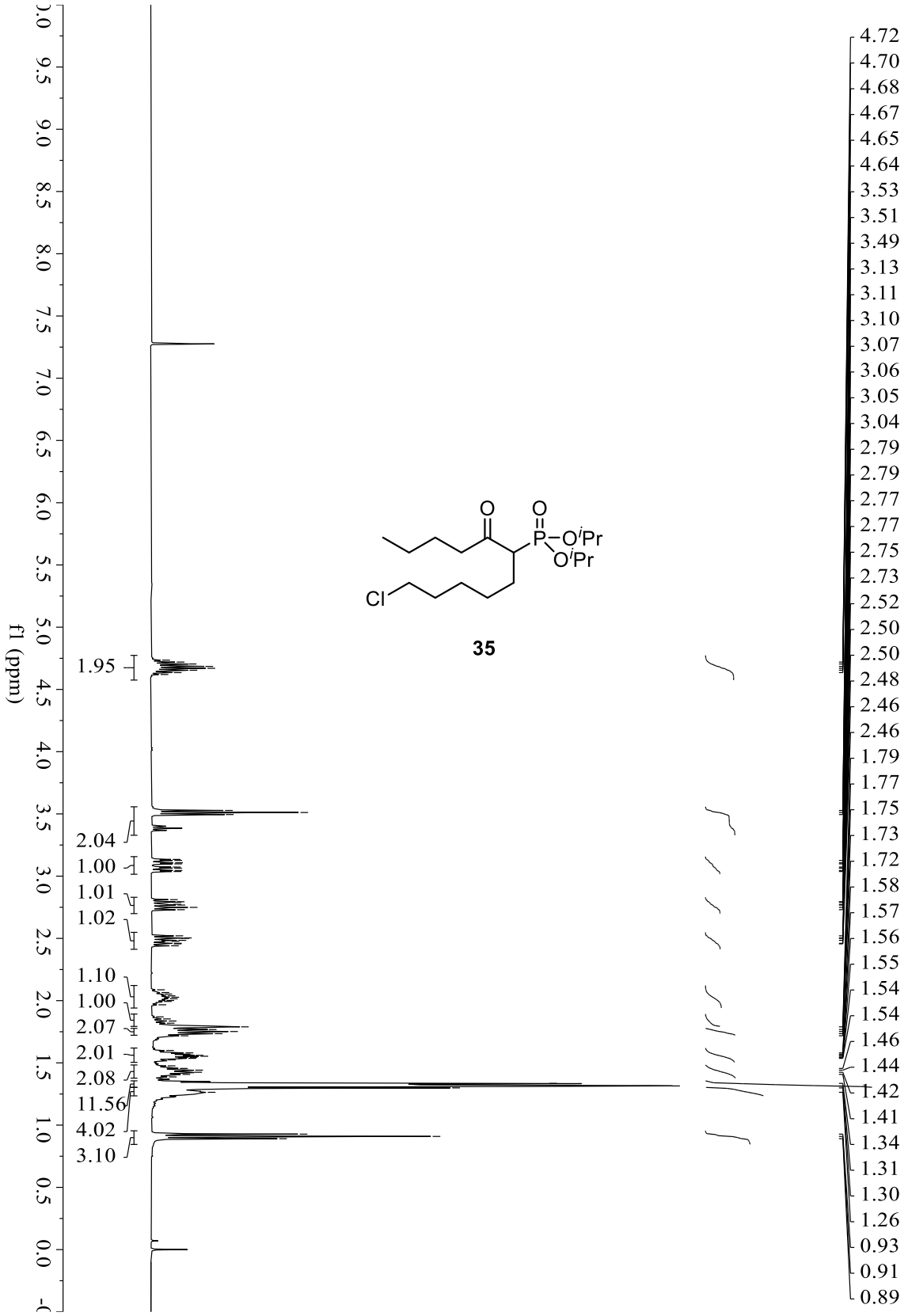

f1 (ppm)
3.99
2.00
2.10
1.00
1.04
1.07
1.02
1.05
2.12
2.27
12.38
3.04
7.86
7.86
7.85
7.84
7.75
7.74
7.73
7.73
4.70
4.68
4.68
4.66
4.66
4.66
4.65
4.64
4.64
4.63
4.62
3.71
3.69
3.69
3.67
3.65
3.64
3.63
3.23
3.21
3.15
2.95
2.93
2.91
2.89
2.62
2.60
2.59
2.56
1.56
1.54
1.52
1.50
1.33
1.32
1.31
1.29
1.27
1.26
0.92
0.91
0.89

34


205.02
168.29
134.00
132.03
123.25
77.32
77.00
76.68
71.63
71.56
71.34
71.27
51.84
50.59
43.71
36.71
36.55
25.42
25.37
24.02
23.98
23.94
23.90
23.76
23.71
22.11
13.86
f1 (ppm)
34

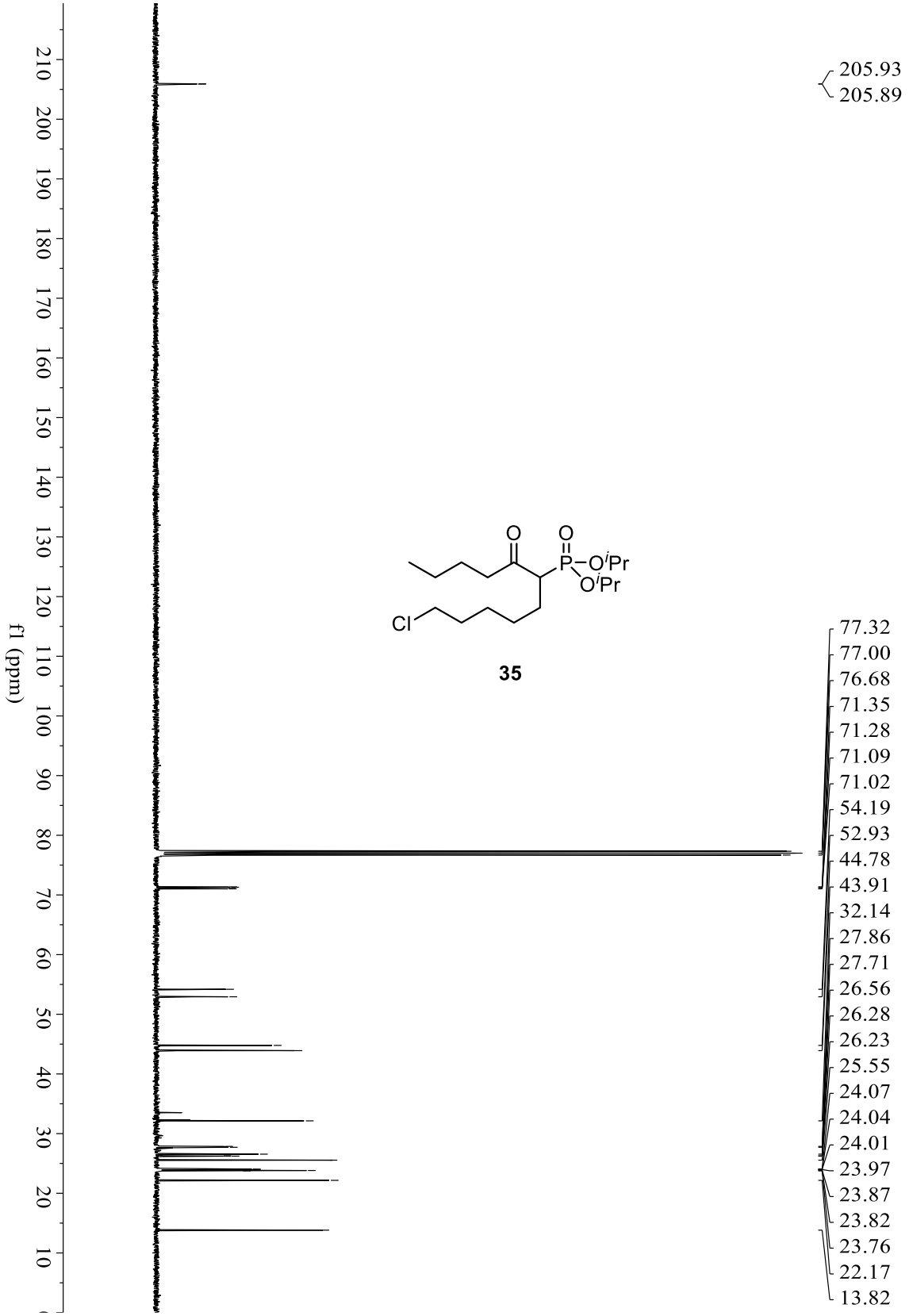

19.62
f1 (ppm)
140
120
100
80
60
40
20
0
-20
-40
-60
-80
-100
-120
-1
O
O
N
O
P
O
iPrO
OiPr
O

34

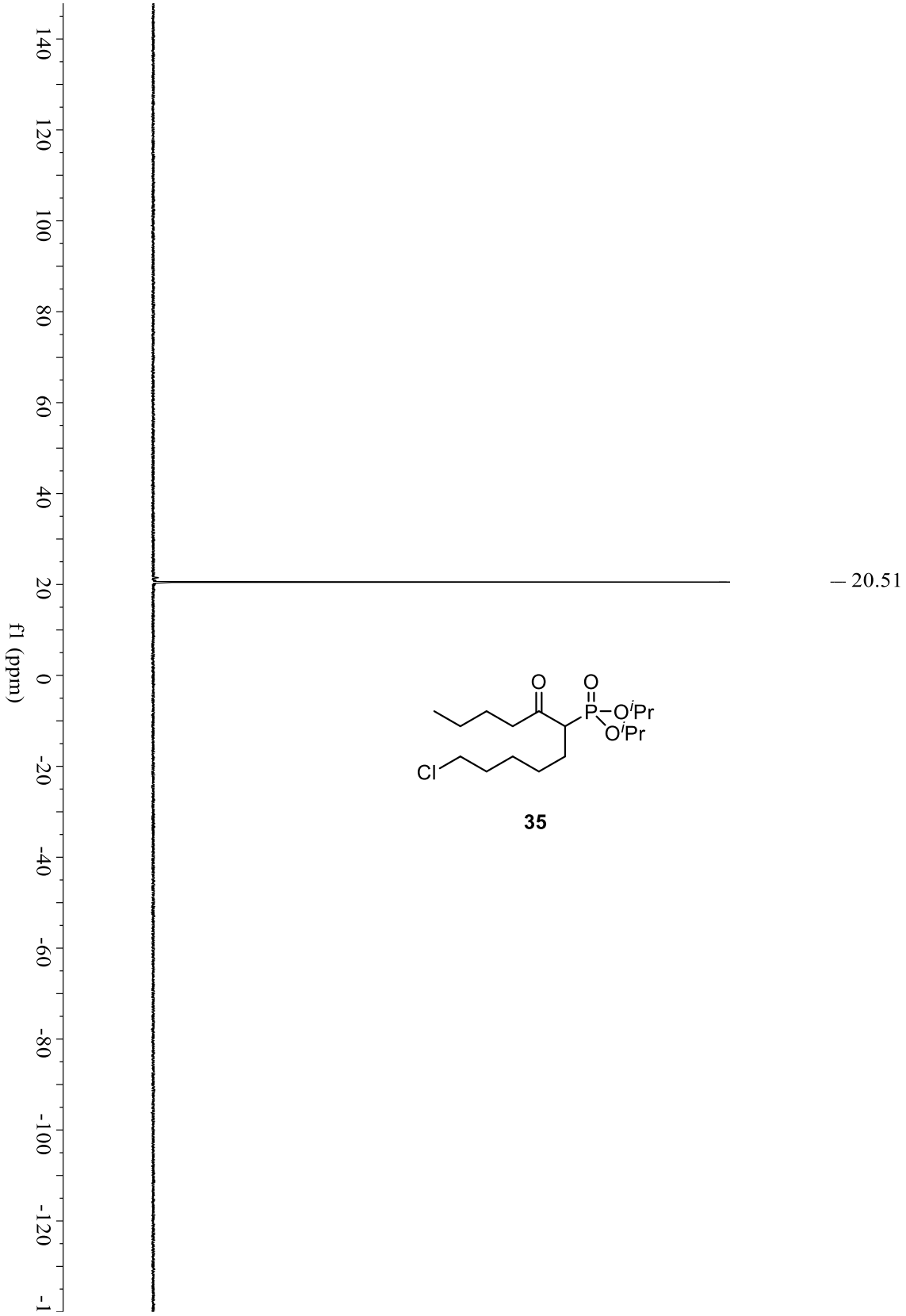

f1 (ppm)
1.95
2.04
1.00
1.01
1.02
1.10
1.00
2.07
2.01
2.08
11.56
4.02
3.10
4.72
4.70
4.68
4.67
4.65
4.64
3.53
3.51
3.49
3.13
3.11
3.10
3.07
3.06
3.05
3.04
2.79
2.79
2.77
2.77
2.75
2.73
2.52
2.50
2.50
2.48
2.46
2.46
1.79
1.77
1.75
1.73
1.72
1.58
1.57
1.56
1.55
1.54
1.54
1.46
1.44
1.42
1.41
1.34
1.31
1.30
1.26
0.93
0.91
0.89

O
O
P
O^{i}Pr
O^{i}Pr
Cl

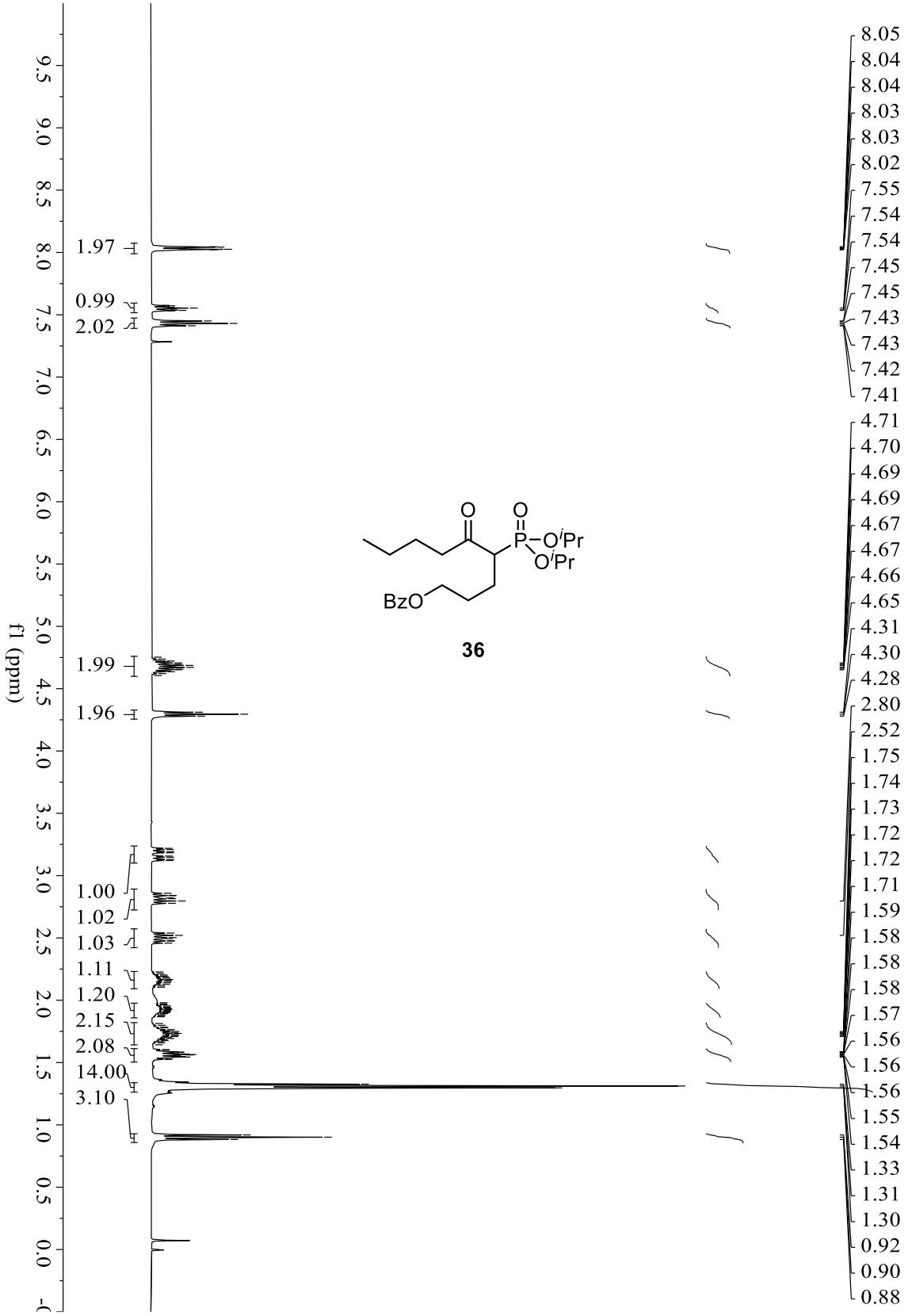
35


205.93
205.89
77.32
77.00
76.68
71.35
71.28
71.09
71.02
54.19
52.93
44.78
43.91
32.14
27.86
27.71
26.56
26.28
26.23
25.55
24.07
24.04
24.01
23.97
23.87
23.82
23.76
22.17
13.82
O
O
P
O
O
Cl
f1 (ppm)

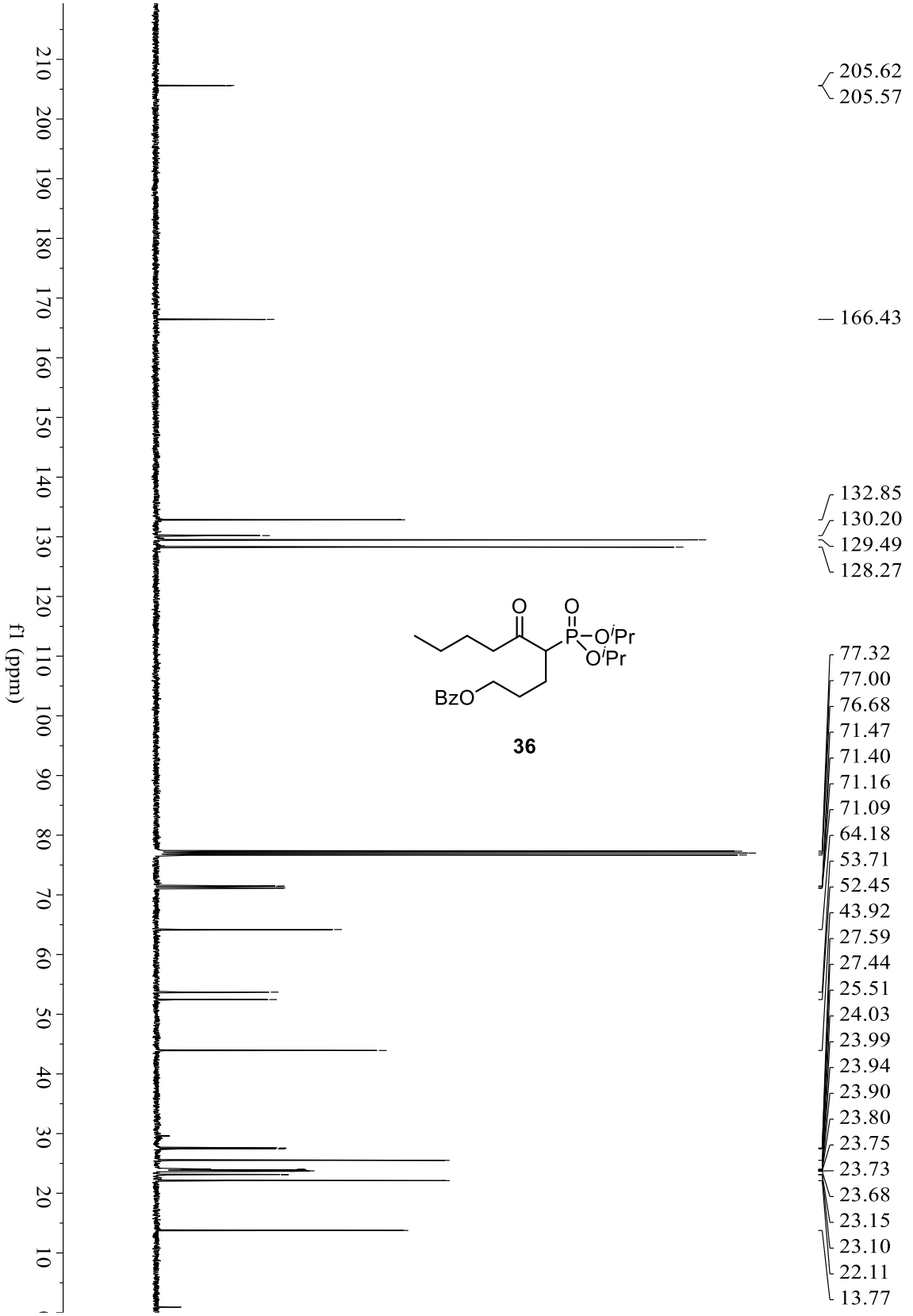
35


140
120
100
80
60
40
20
0
-20
-40
-60
-80
-100
-120
-1
f1 (ppm)
20.51
O
O
P
O
iPr
O
iPr
Cl

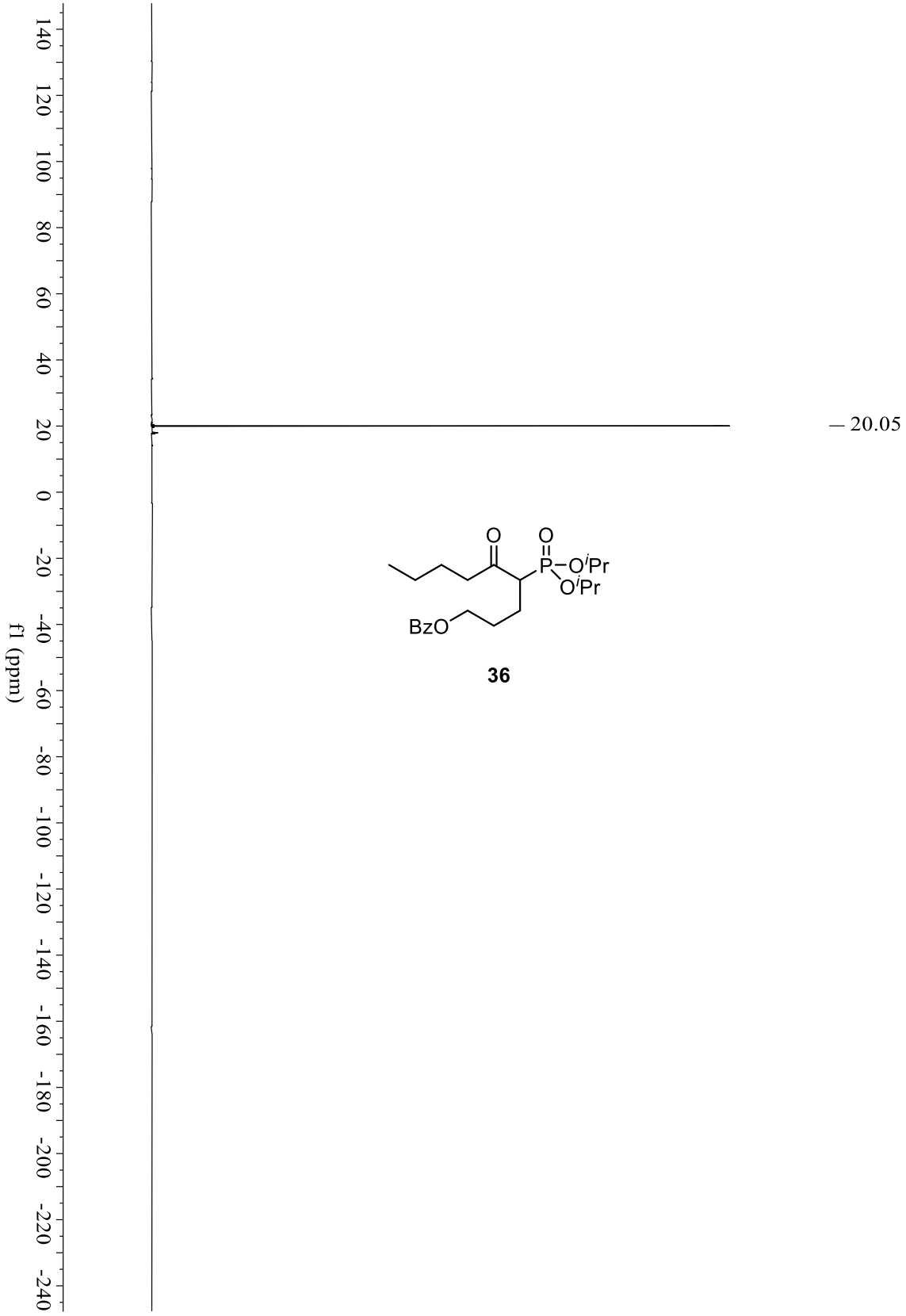
35


f1 (ppm)
1.97
0.99
2.02
1.99
1.96
1.00
1.02
1.03
1.11
1.20
2.15
2.08
14.00
3.10
O
O
P
O^{i}Pr
O^{i}Pr
BzO
8.05
8.04
8.04
8.03
8.03
8.02
7.55
7.54
7.54
7.45
7.45
7.43
7.43
7.42
7.41
4.71
4.70
4.69
4.69
4.67
4.67
4.66
4.65
4.31
4.30
4.28
2.80
2.52
1.75
1.74
1.73
1.72
1.72
1.71
1.59
1.58
1.58
1.58
1.57
1.56
1.56
1.56
1.55
1.54
1.33
1.31
1.30
0.92
0.90
0.88

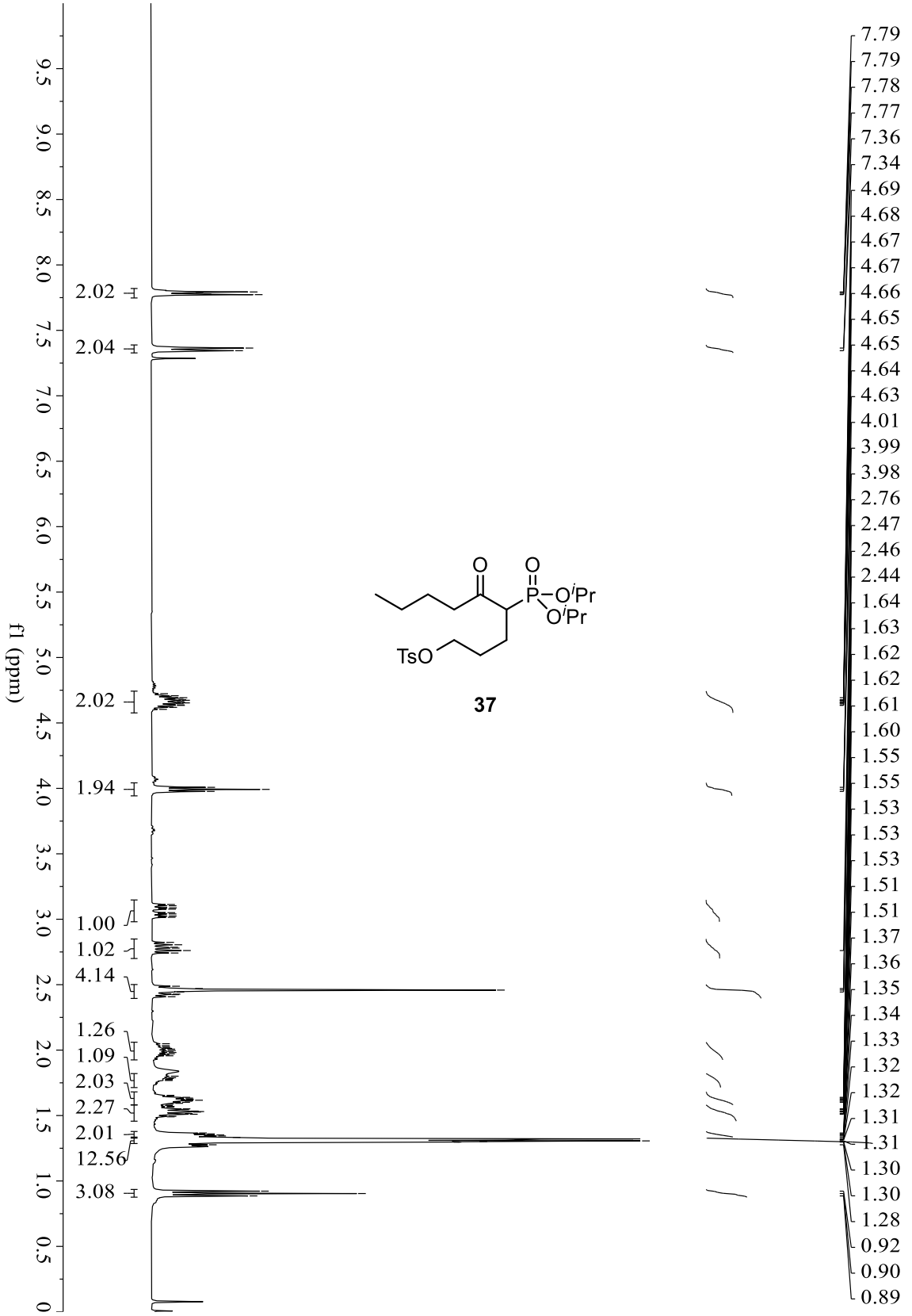
36


205.62
205.57
166.43
132.85
130.20
129.49
128.27
77.32
77.00
76.68
71.47
71.40
71.16
71.09
64.18
53.71
52.45
43.92
27.59
27.44
25.51
24.03
23.99
23.94
23.90
23.80
23.75
23.73
23.68
23.15
23.10
22.11
13.77
O
O
P
O^{i}Pr
O^{i}Pr
BzO
f1 (ppm)

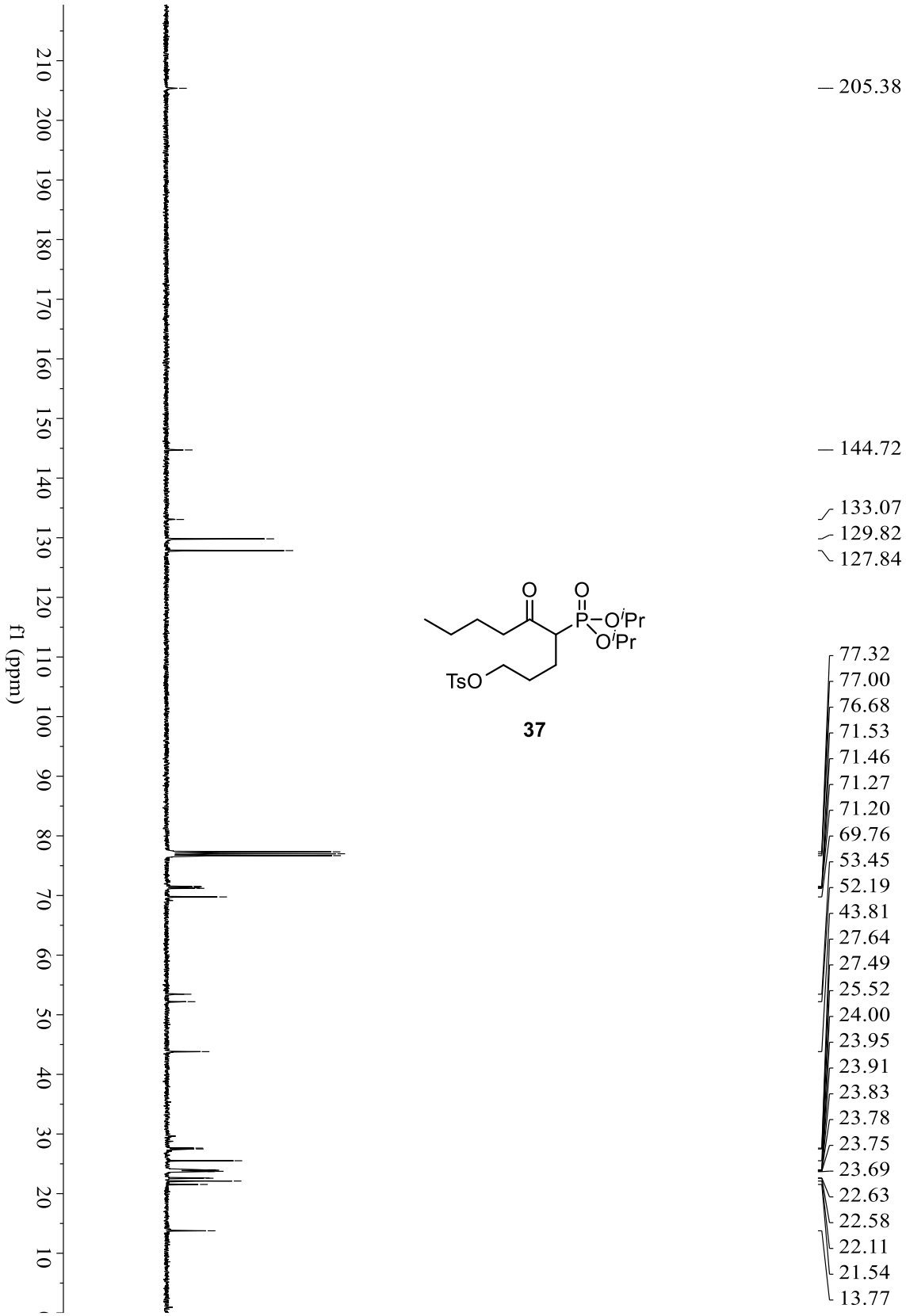
36


20.05
f1 (ppm)
140 120 100 80 60 40 20 0 -20 -40 -60 -80 -100 -120 -140 -160 -180 -200 -220 -240
O
O
P–O^{i}Pr
O^{i}Pr
BzO

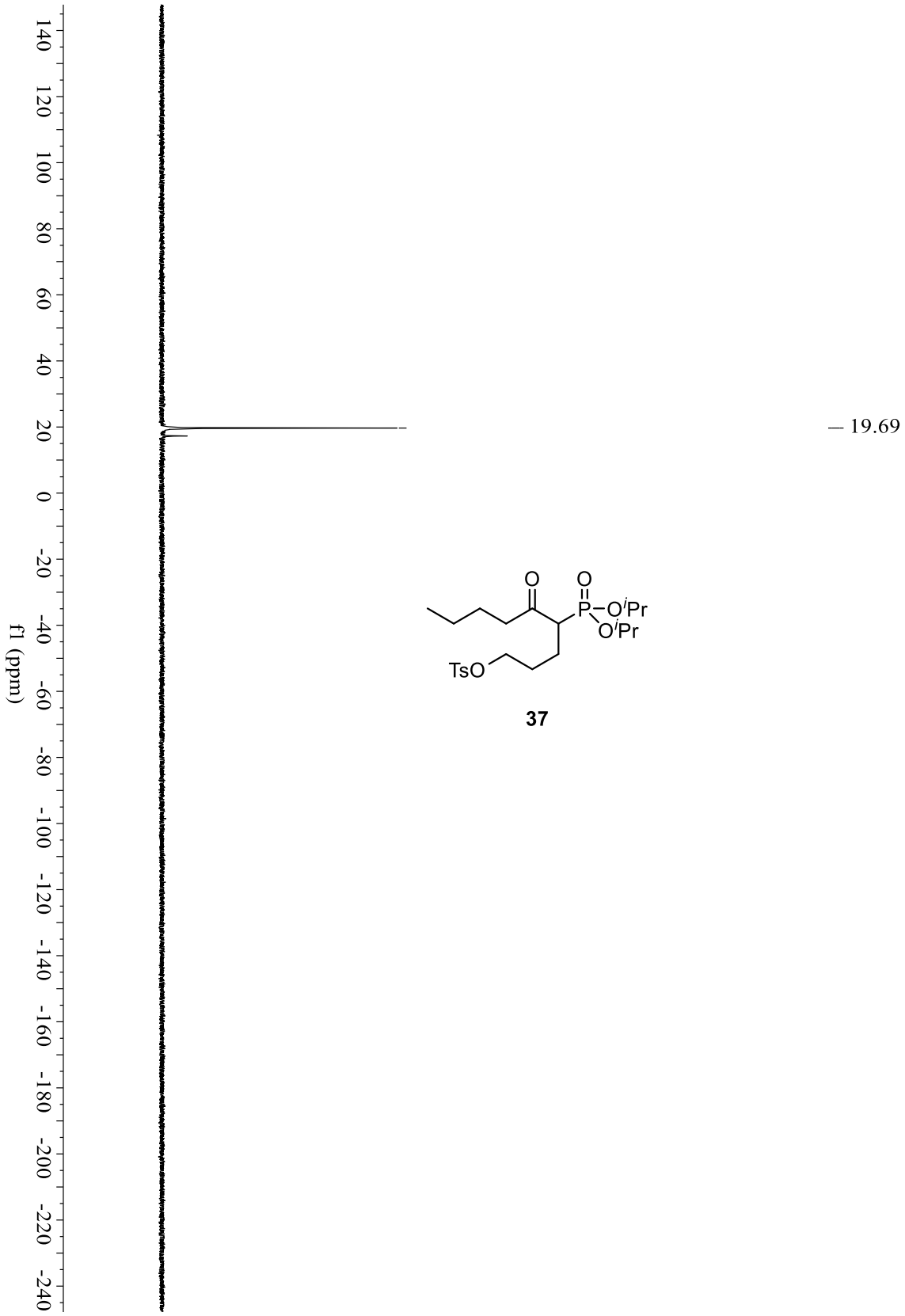
36


f1 (ppm)
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0
2.02
2.04
2.02
1.94
1.00
1.02
4.14
1.26
1.09
2.03
2.27
2.01
12.56
3.08
O
O
P–O^{i}Pr
O^{i}Pr
TsO
7.79
7.79
7.78
7.77
7.36
7.34
4.69
4.68
4.67
4.67
4.66
4.65
4.65
4.64
4.63
4.01
3.99
3.98
2.76
2.47
2.46
2.44
1.64
1.63
1.62
1.62
1.61
1.60
1.55
1.55
1.53
1.53
1.53
1.51
1.51
1.37
1.36
1.35
1.34
1.33
1.32
1.32
1.31
1.31
1.30
1.30
1.28
0.92
0.90
0.89

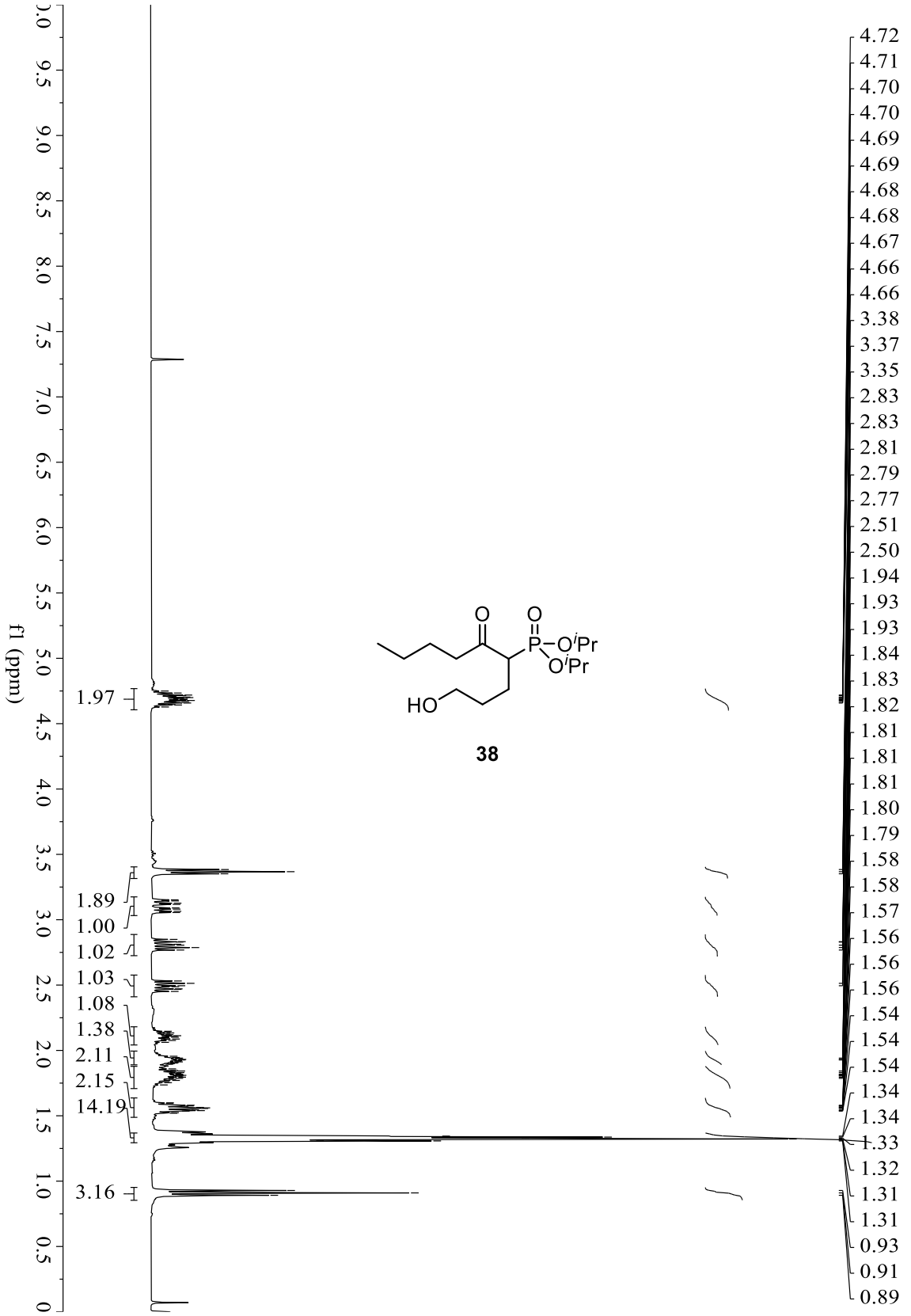
37


f1 (ppm)
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
205.38
144.72
133.07
129.82
127.84
77.32
77.00
76.68
71.53
71.46
71.27
71.20
69.76
53.45
52.19
43.81
27.64
27.49
25.52
24.00
23.95
23.91
23.83
23.78
23.75
23.69
22.63
22.58
22.11
21.54
13.77
O
O
P
O^{i}Pr
O^{i}Pr
TsO

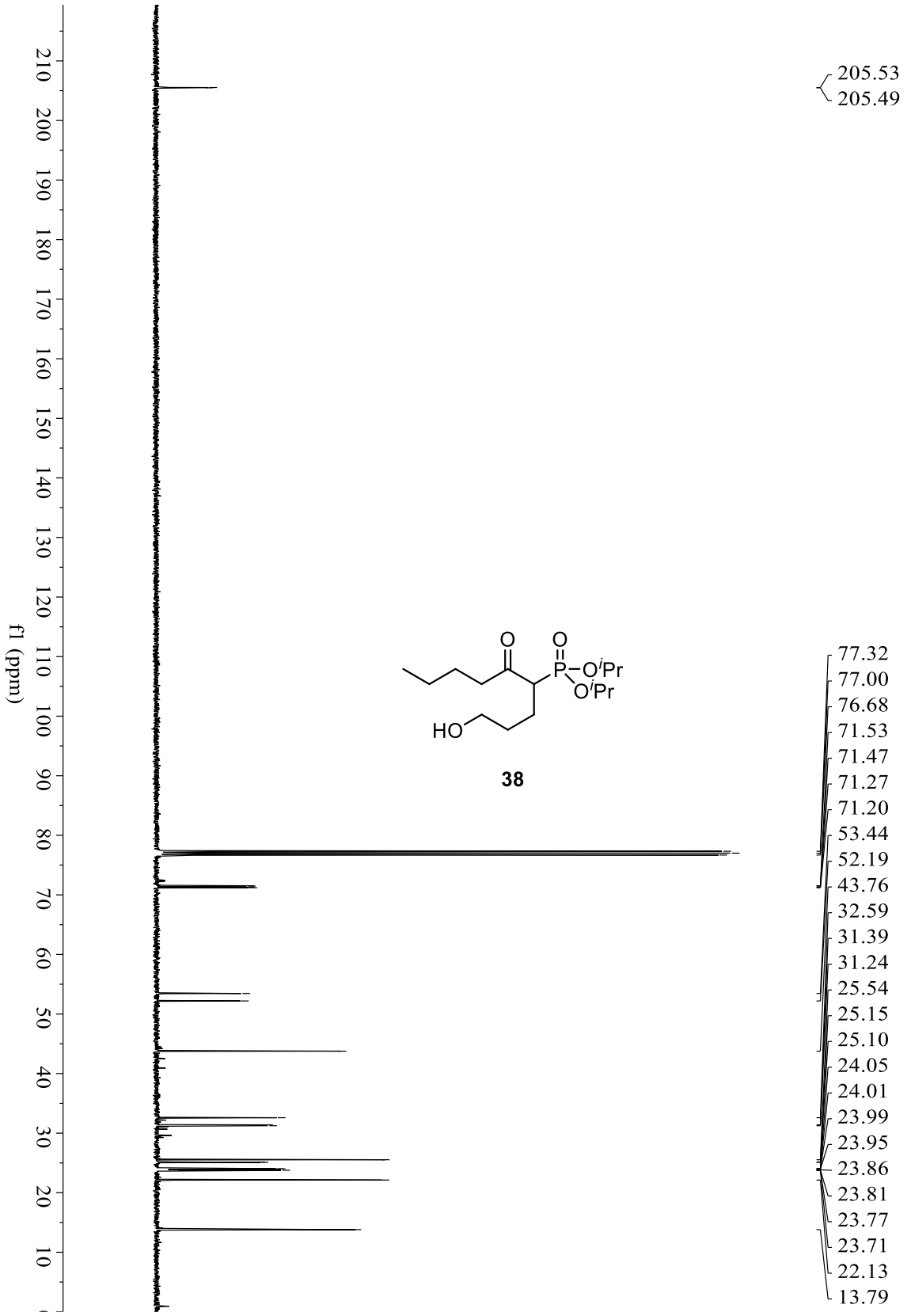
37


140
120
100
80
60
40
20
0
-20
-40
-60
-80
-100
-120
-140
-160
-180
-200
-220
-240
f1 (ppm)
19.69
O
O
P
O
iPr
O
iPr
TsO

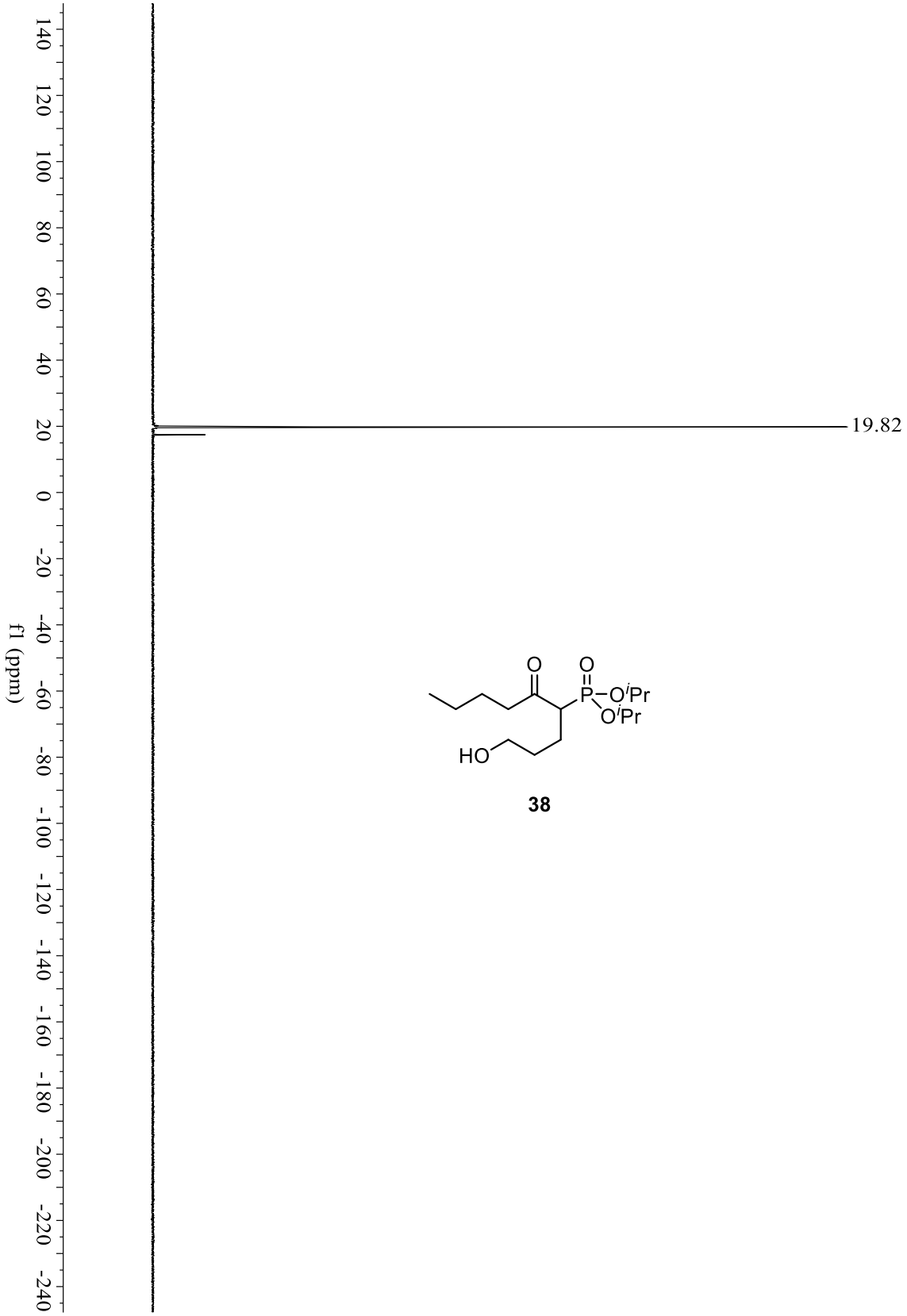
37


f1 (ppm)
1.97
1.89
1.00
1.02
1.03
1.08
1.38
2.11
2.15
14.19
3.16
HO
O
O
P–O^{i}Pr
O^{i}Pr
4.72
4.71
4.70
4.70
4.69
4.69
4.68
4.68
4.67
4.66
4.66
3.38
3.37
3.35
2.83
2.83
2.81
2.79
2.77
2.51
2.50
1.94
1.93
1.93
1.84
1.83
1.82
1.81
1.81
1.81
1.80
1.79
1.58
1.58
1.57
1.56
1.56
1.56
1.54
1.54
1.54
1.34
1.34
1.33
1.32
1.31
1.31
0.93
0.91
0.89

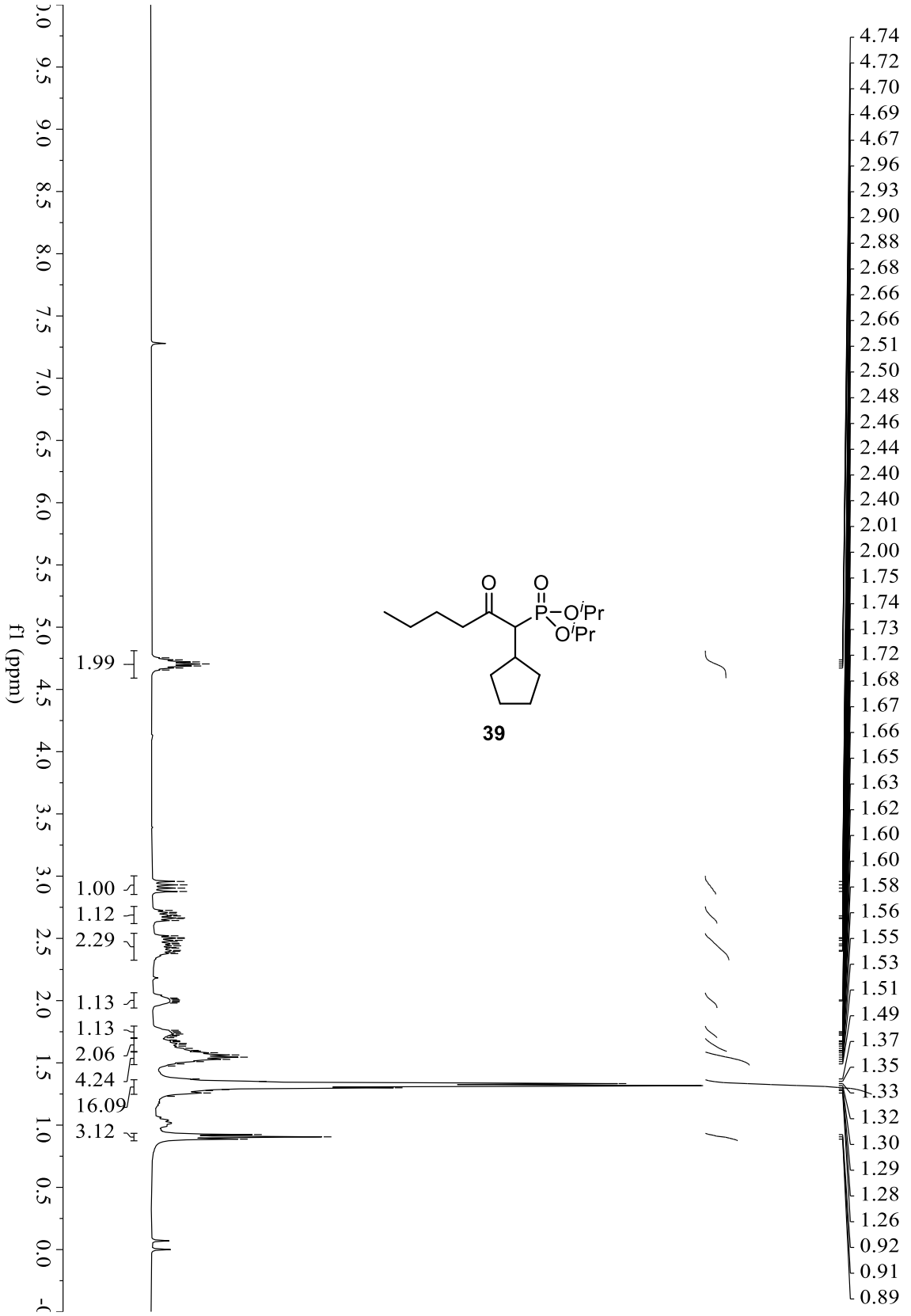
38

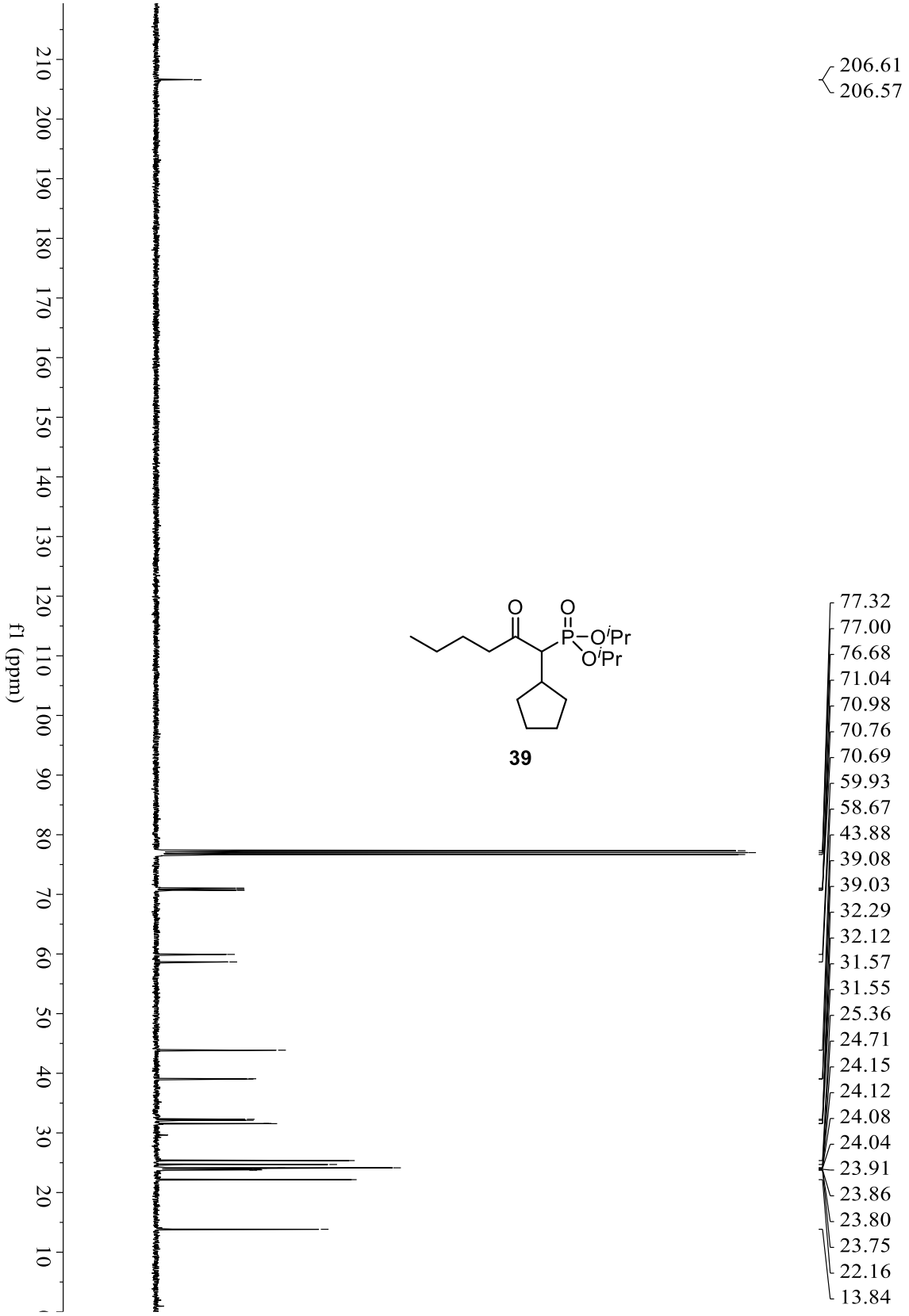

205.53
205.49
77.32
77.00
76.68
71.53
71.47
71.27
71.20
53.44
52.19
43.76
32.59
31.39
31.24
25.54
25.15
25.10
24.05
24.01
23.99
23.95
23.86
23.81
23.77
23.71
22.13
13.79
f1 (ppm)
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
O
O
P
O^{i}Pr
O^{i}Pr
HO

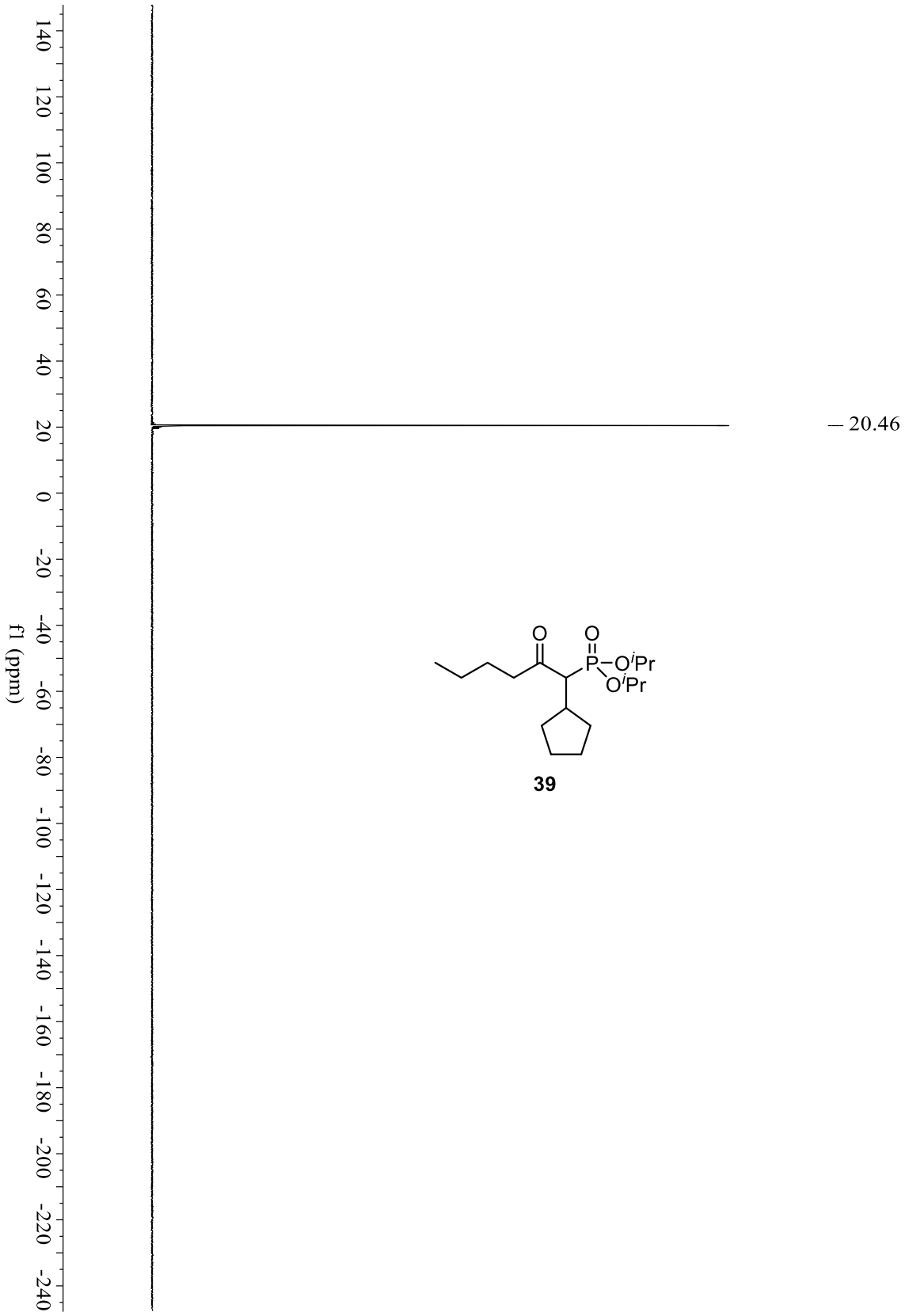
38


19.82
140 120 100 80 60 40 20 0 -20 -40 -60 -80 -100 -120 -140 -160 -180 -200 -220 -240
f1 (ppm)
O
O
P
O^{i}Pr
O^{i}Pr
HO

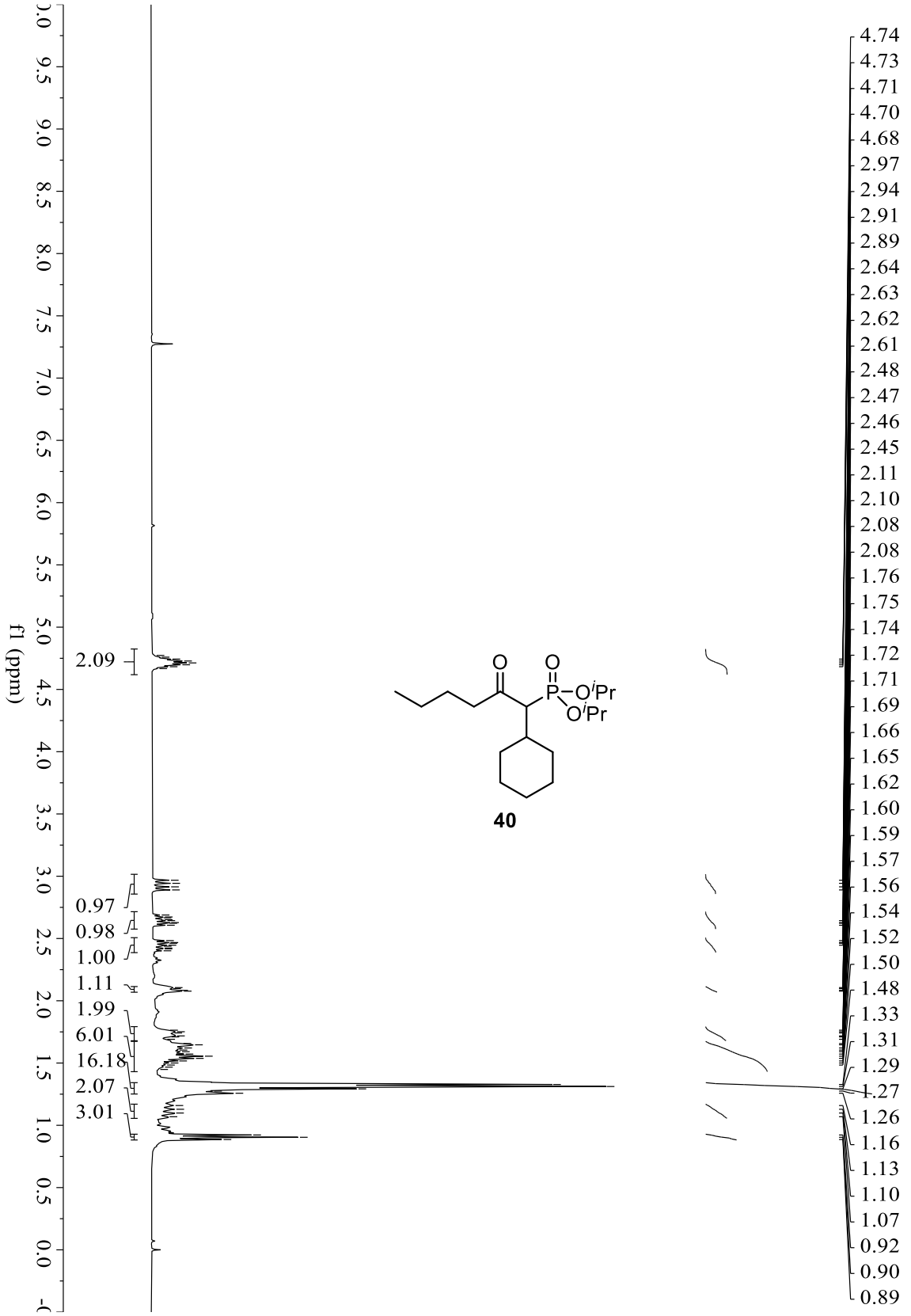
38

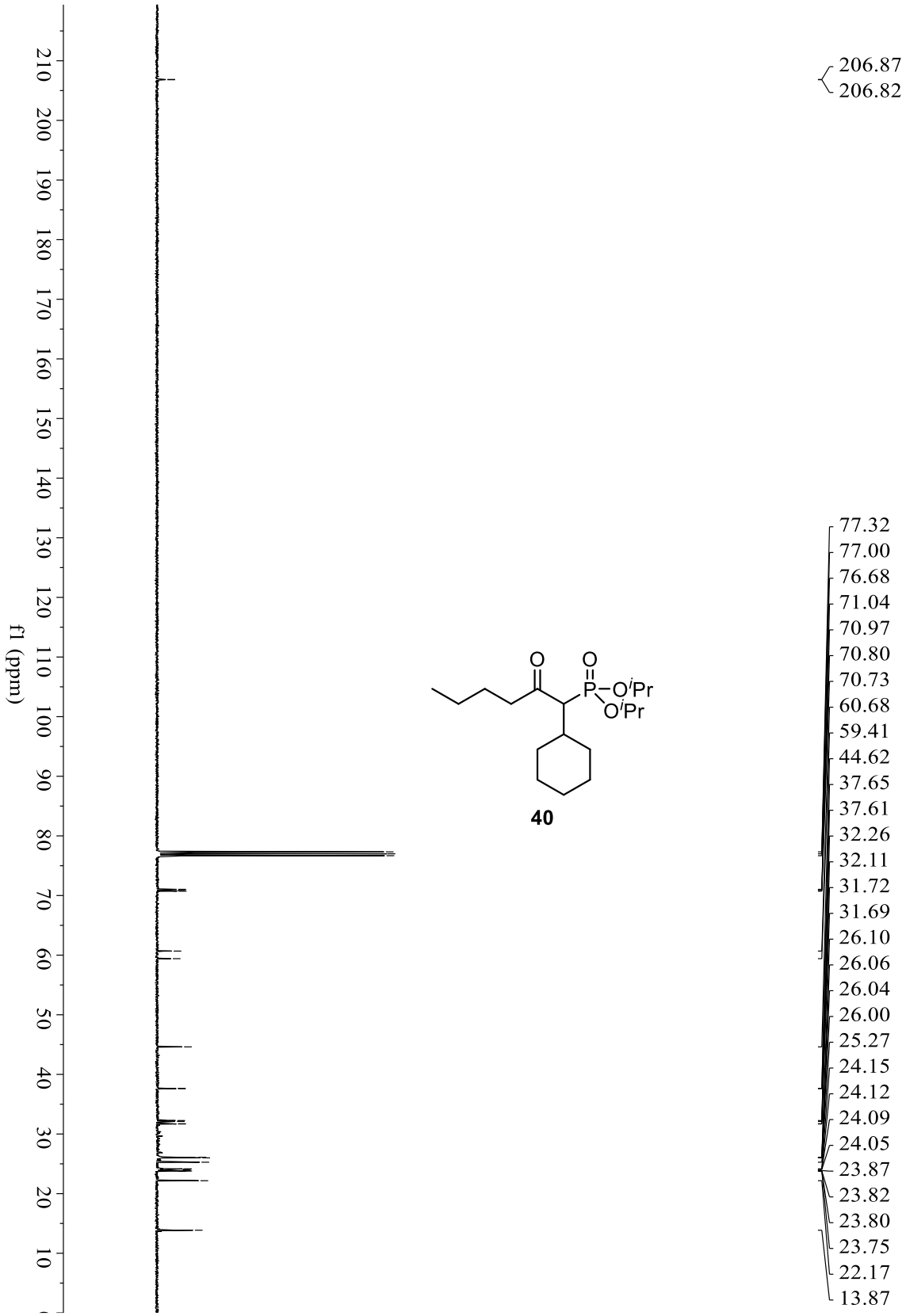

f1 (ppm)
1.99
1.00
1.12
2.29
1.13
1.13
2.06
4.24
16.09
3.12
O
O
P
O^{i}Pr
O^{i}Pr
39
4.74
4.72
4.70
4.69
4.67
2.96
2.93
2.90
2.88
2.68
2.66
2.66
2.51
2.50
2.48
2.46
2.44
2.40
2.40
2.01
2.00
1.75
1.74
1.73
1.72
1.68
1.67
1.66
1.65
1.63
1.62
1.60
1.60
1.58
1.56
1.55
1.53
1.51
1.49
1.37
1.35
1.33
1.32
1.30
1.29
1.28
1.26
0.92
0.91
0.89

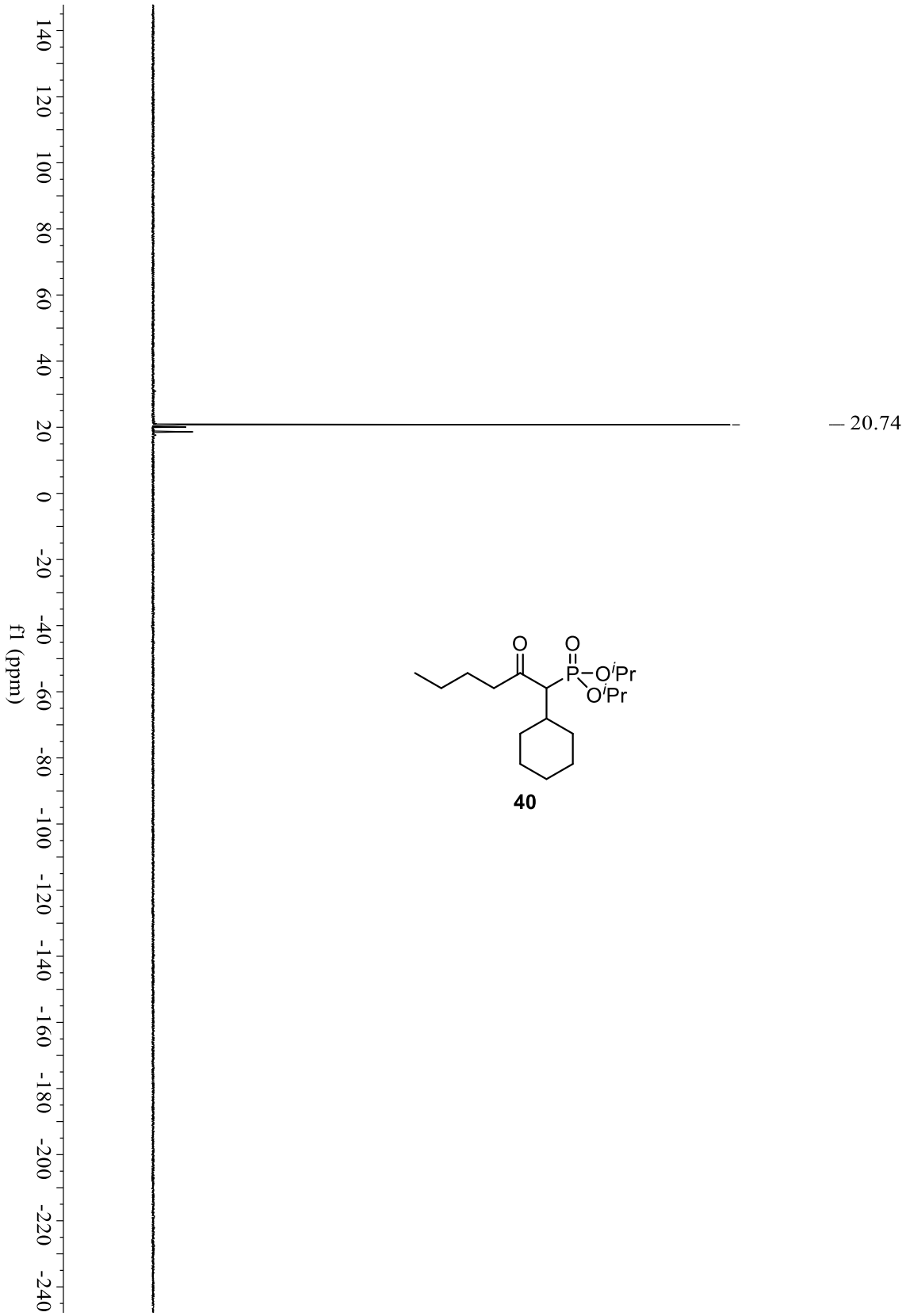

206.61
206.57
77.32
77.00
76.68
71.04
70.98
70.76
70.69
59.93
58.67
43.88
39.08
39.03
32.29
32.12
31.57
31.55
25.36
24.71
24.15
24.12
24.08
24.04
23.91
23.86
23.80
23.75
22.16
13.84
O
O
P
O^{i}Pr
O^{i}Pr
39
f1 (ppm)
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10


140
120
100
80
60
40
20
0
-20
-40
-60
-80
-100
-120
-140
-160
-180
-200
-220
-240
f1 (ppm)
20.46
O
O
P
O
iPr
O
iPr

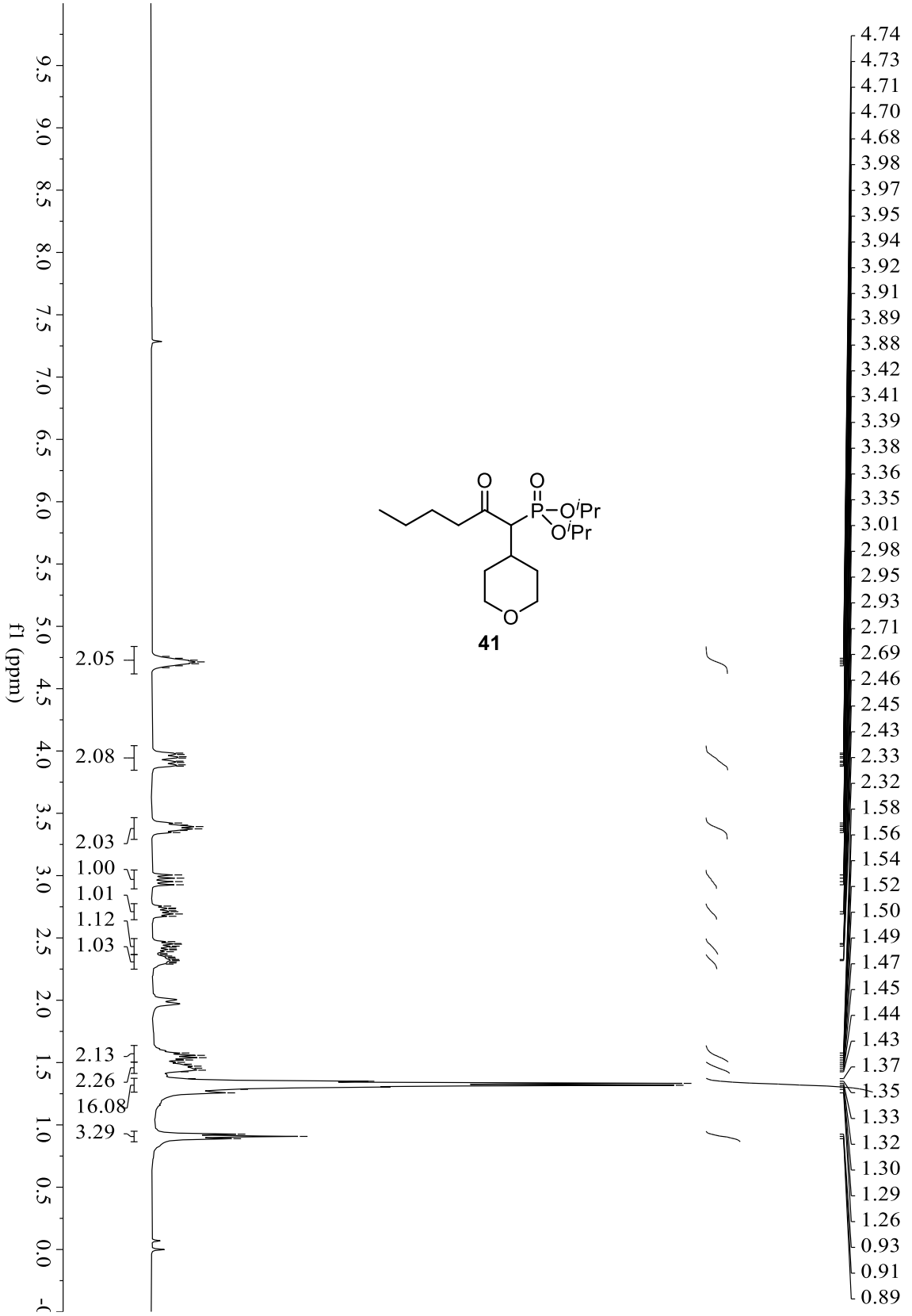
39

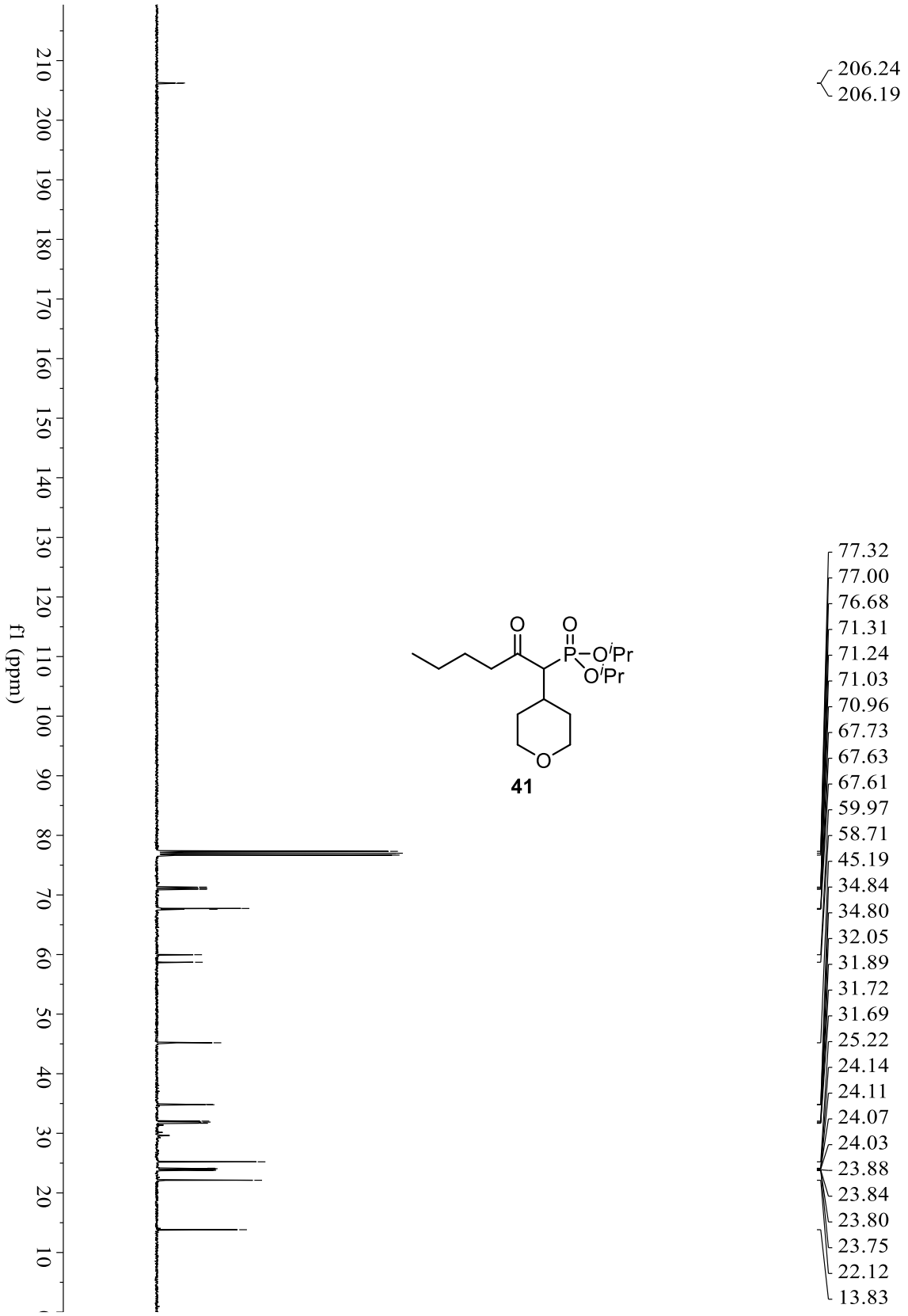

f1 (ppm)
2.09
0.97
0.98
1.00
1.11
1.99
6.01
16.18
2.07
3.01
O
O
P
O
iPr
O
iPr
40
4.74
4.73
4.71
4.70
4.68
2.97
2.94
2.91
2.89
2.64
2.63
2.62
2.61
2.48
2.47
2.46
2.45
2.11
2.10
2.08
2.08
1.76
1.75
1.74
1.72
1.71
1.69
1.66
1.65
1.62
1.60
1.59
1.57
1.56
1.54
1.52
1.50
1.48
1.33
1.31
1.29
1.27
1.26
1.16
1.13
1.10
1.07
0.92
0.90
0.89

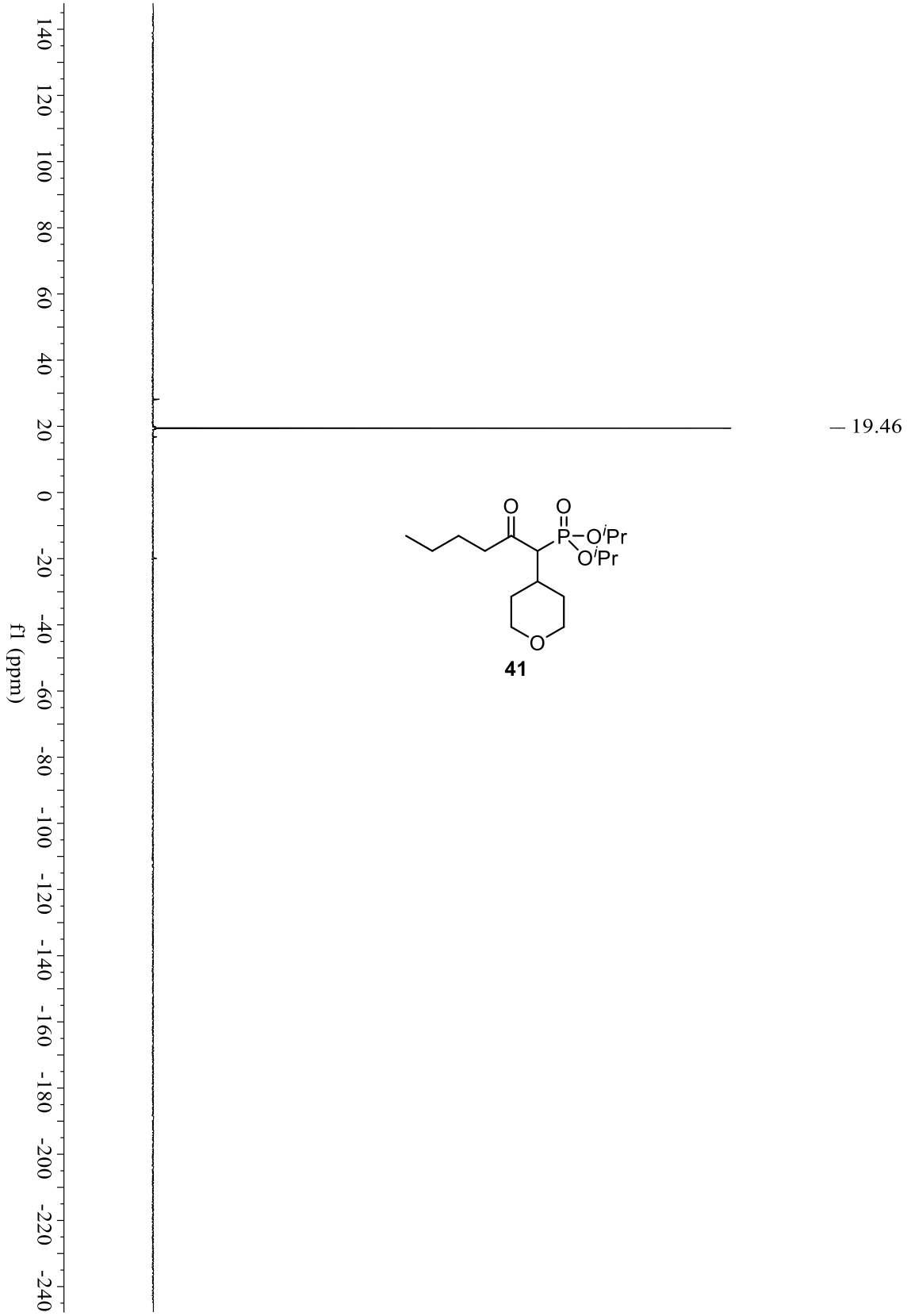

206.87
206.82
77.32
77.00
76.68
71.04
70.97
70.80
70.73
60.68
59.41
44.62
37.65
37.61
32.26
32.11
31.72
31.69
26.10
26.06
26.04
26.00
25.27
24.15
24.12
24.09
24.05
23.87
23.82
23.80
23.75
22.17
13.87
O
O
P
O
iPr
O
iPr
40
f1 (ppm)
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10

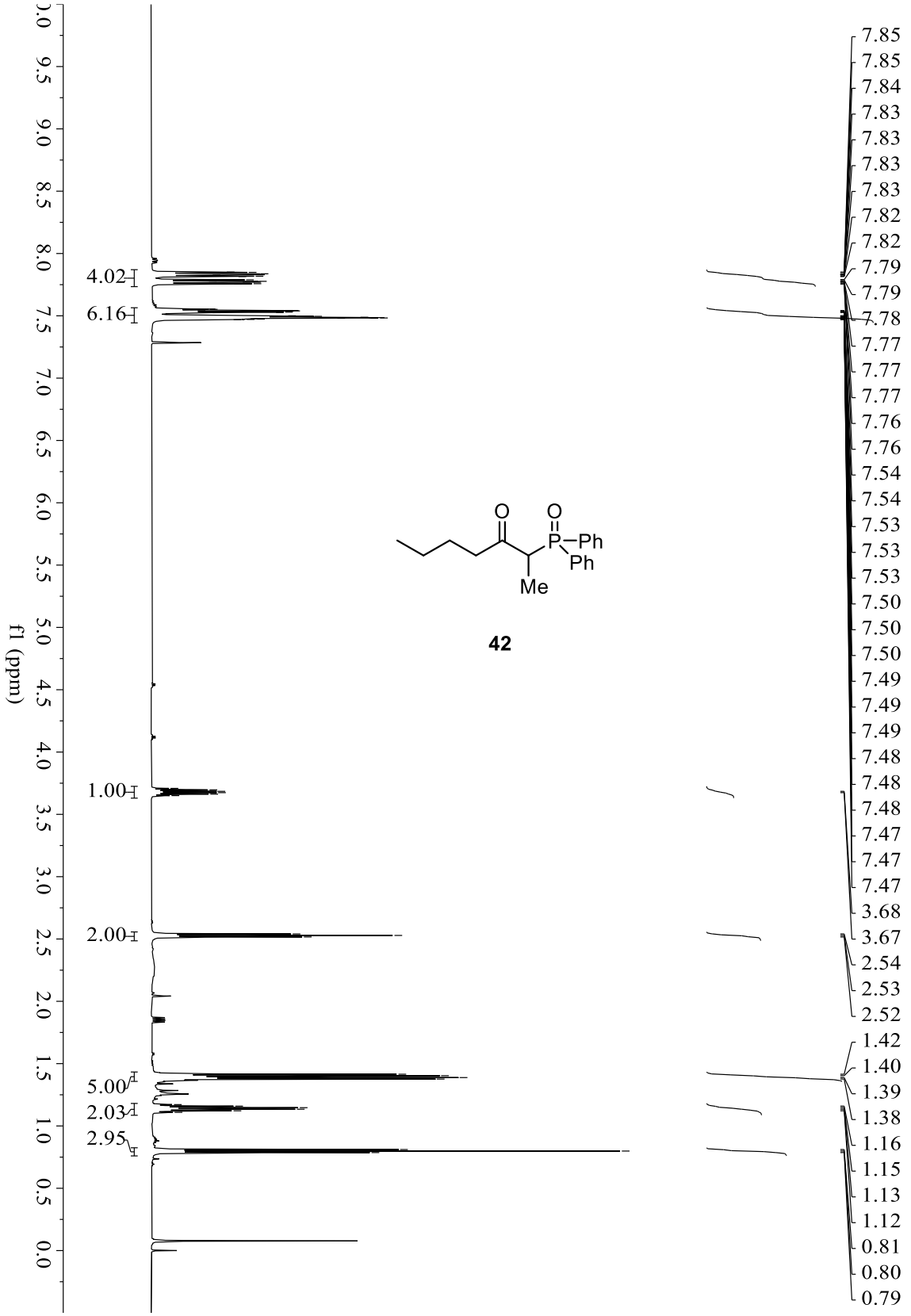

140
120
100
80
60
40
20
0
-20
-40
-60
-80
-100
-120
-140
-160
-180
-200
-220
-240
f1 (ppm)
20.74
O
O
P
O
iPr
O
iPr

40

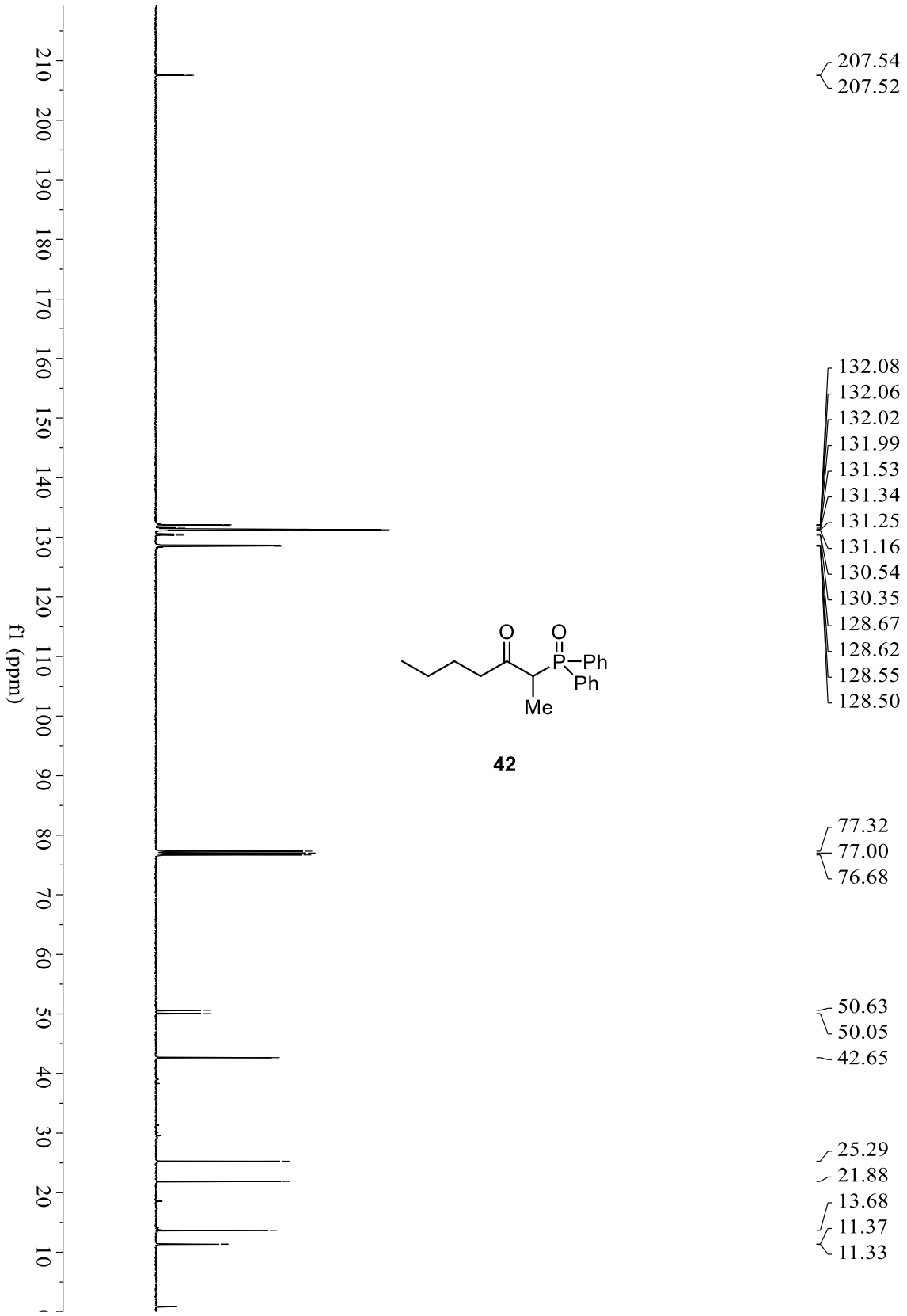

f1 (ppm)
9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0
2.05
2.08
2.03
1.00
1.01
1.12
1.03
2.13
2.26
16.08
3.29
O
O
P–O^{i}Pr
O^{i}Pr
O
41
4.74
4.73
4.71
4.70
4.68
3.98
3.97
3.95
3.94
3.92
3.91
3.89
3.88
3.42
3.41
3.39
3.38
3.36
3.35
3.01
2.98
2.95
2.93
2.71
2.69
2.46
2.45
2.43
2.33
2.32
1.58
1.56
1.54
1.52
1.50
1.49
1.47
1.45
1.44
1.43
1.37
1.35
1.33
1.32
1.30
1.29
1.26
0.93
0.91
0.89


206.24
206.19
77.32
77.00
76.68
71.31
71.24
71.03
70.96
67.73
67.63
67.61
59.97
58.71
45.19
34.84
34.80
32.05
31.89
31.72
31.69
25.22
24.14
24.11
24.07
24.03
23.88
23.84
23.80
23.75
22.12
13.83
O
O
P
O
iPr
O
iPr
O
41
f1 (ppm)
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10

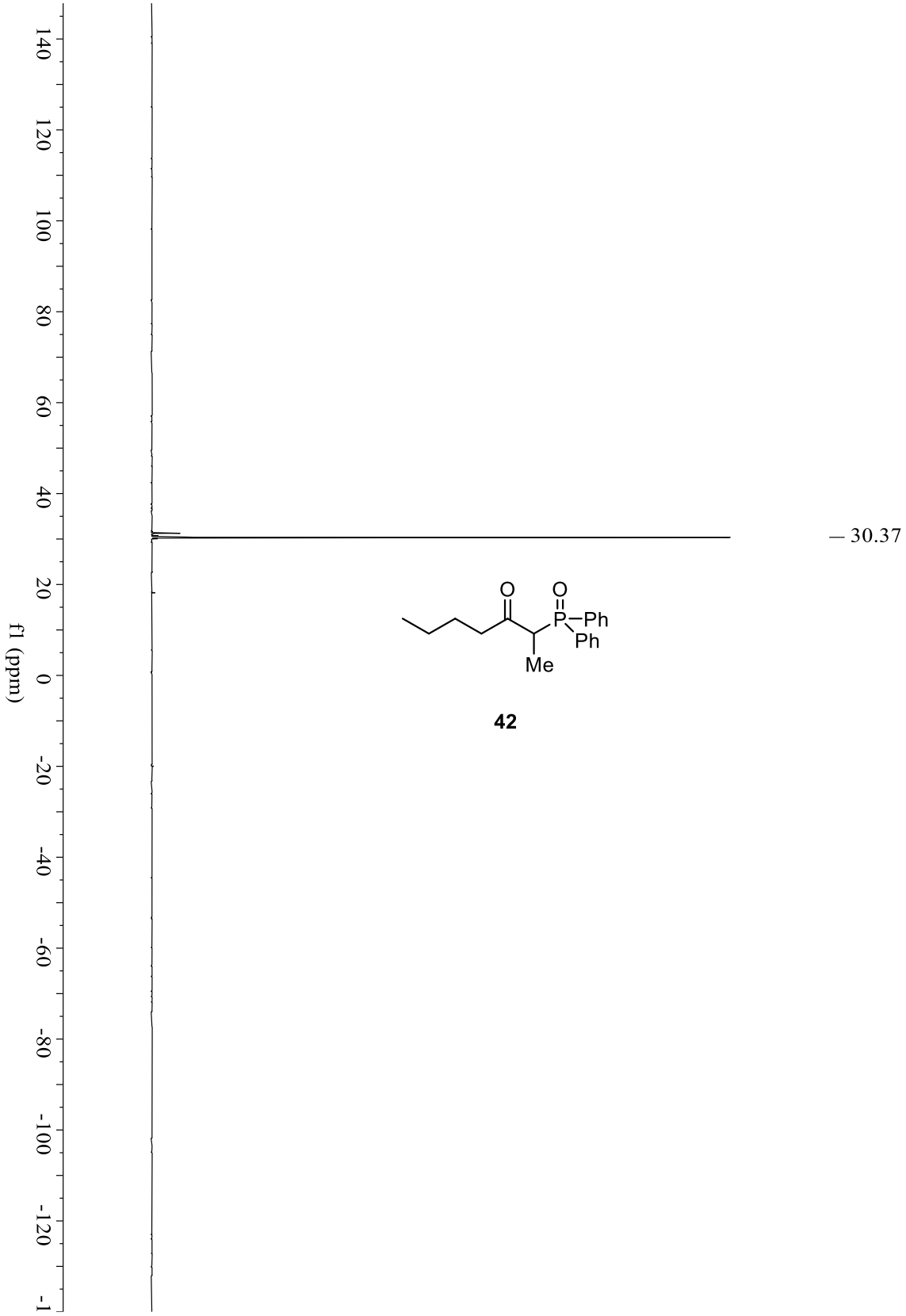

19.46
O
O
P
O^{i}Pr
O^{i}Pr
O
41
140 120 100 80 60 40 20 0 -20 -40 -60 -80 -100 -120 -140 -160 -180 -200 -220 -240
f1 (ppm)


f1 (ppm)
4.02
6.16
1.00
2.00
5.00
2.03
2.95
O
O
P–Ph
Ph
Me
7.85
7.85
7.84
7.83
7.83
7.83
7.83
7.82
7.82
7.79
7.79
7.78
7.77
7.77
7.77
7.76
7.76
7.54
7.54
7.53
7.53
7.53
7.50
7.50
7.50
7.49
7.49
7.49
7.48
7.48
7.48
7.47
7.47
7.47
3.68
3.67
2.54
2.53
2.52
1.42
1.40
1.39
1.38
1.16
1.15
1.13
1.12
0.81
0.80
0.79

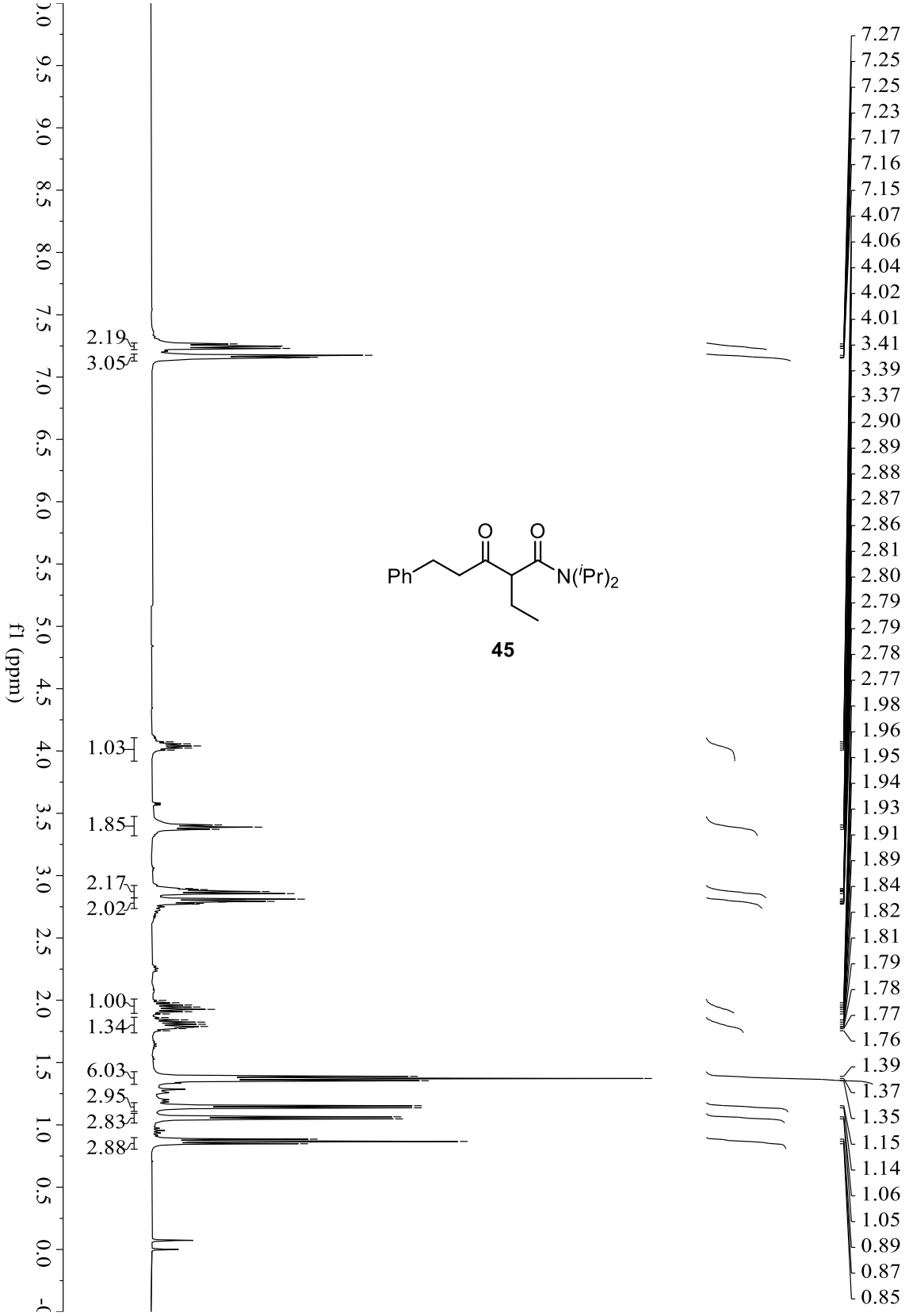
42

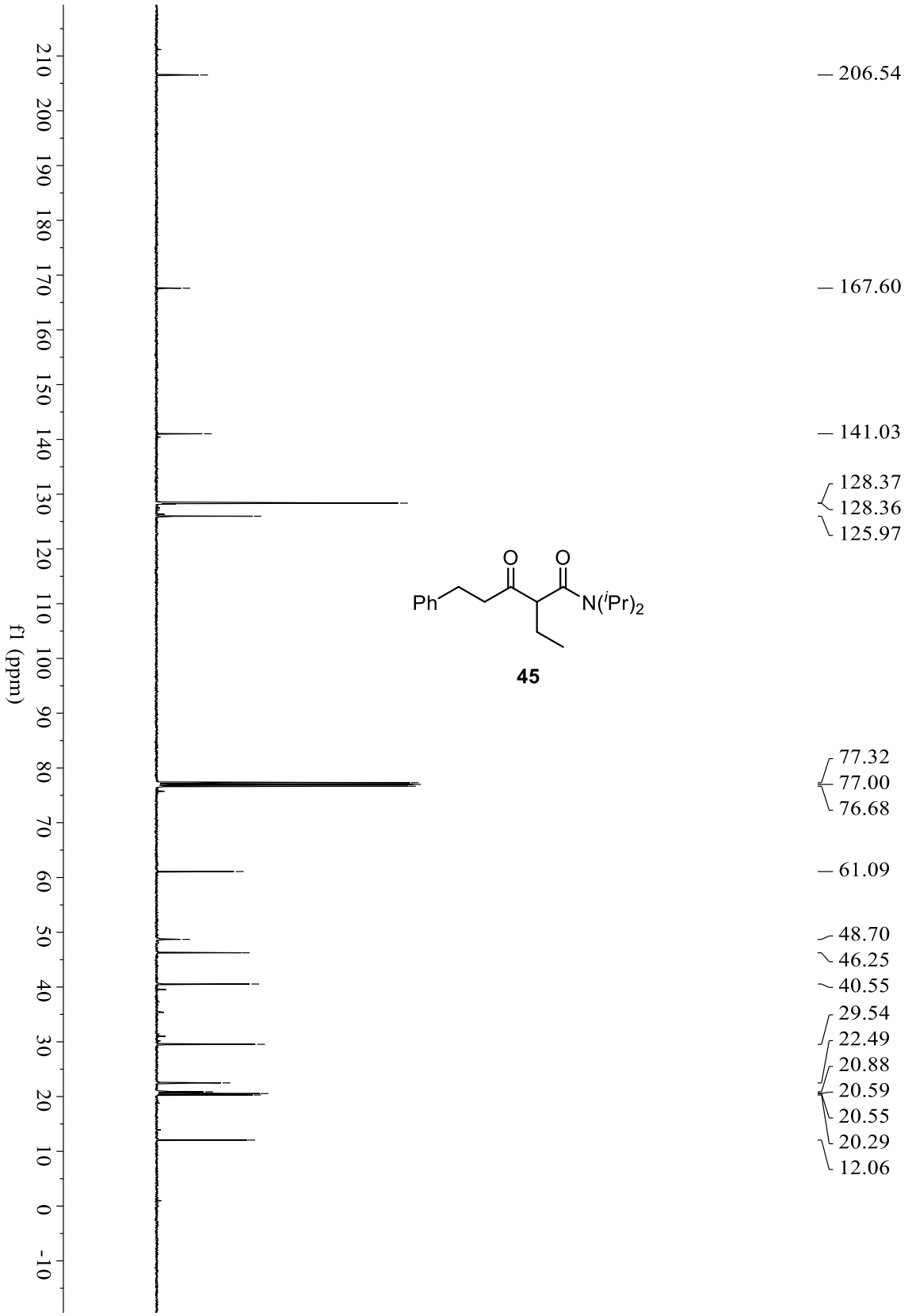

f1 (ppm)
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
207.54
207.52
132.08
132.06
132.02
131.99
131.53
131.34
131.25
131.16
130.54
130.35
128.67
128.62
128.55
128.50
77.32
77.00
76.68
50.63
50.05
42.65
25.29
21.88
13.68
11.37
11.33
O
O
P
Ph
Ph
Me

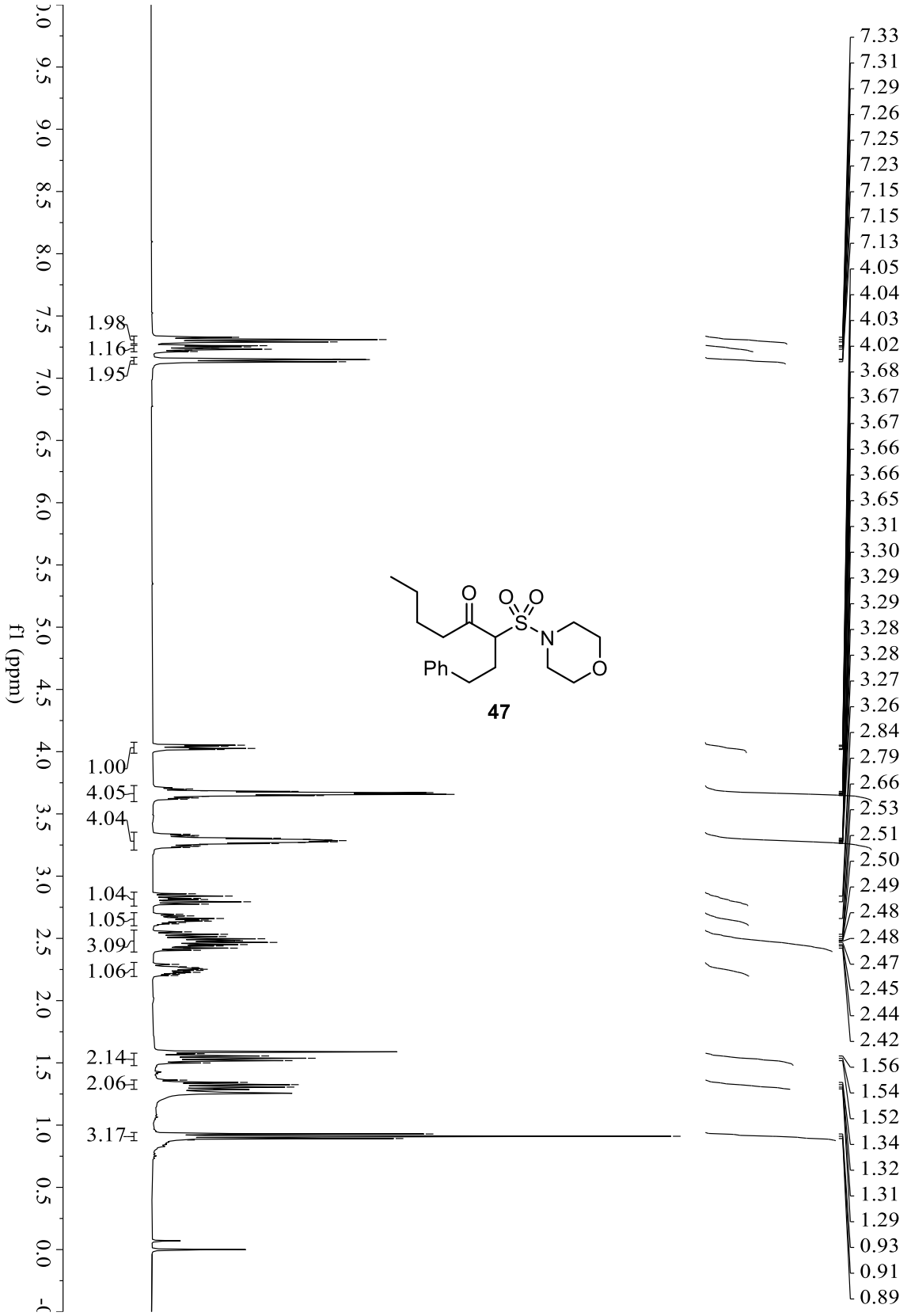
42


140
120
100
80
60
40
20
0
-20
-40
-60
-80
-100
-120
-1
f1 (ppm)
30.37
O
O
P
Ph
Ph
Me

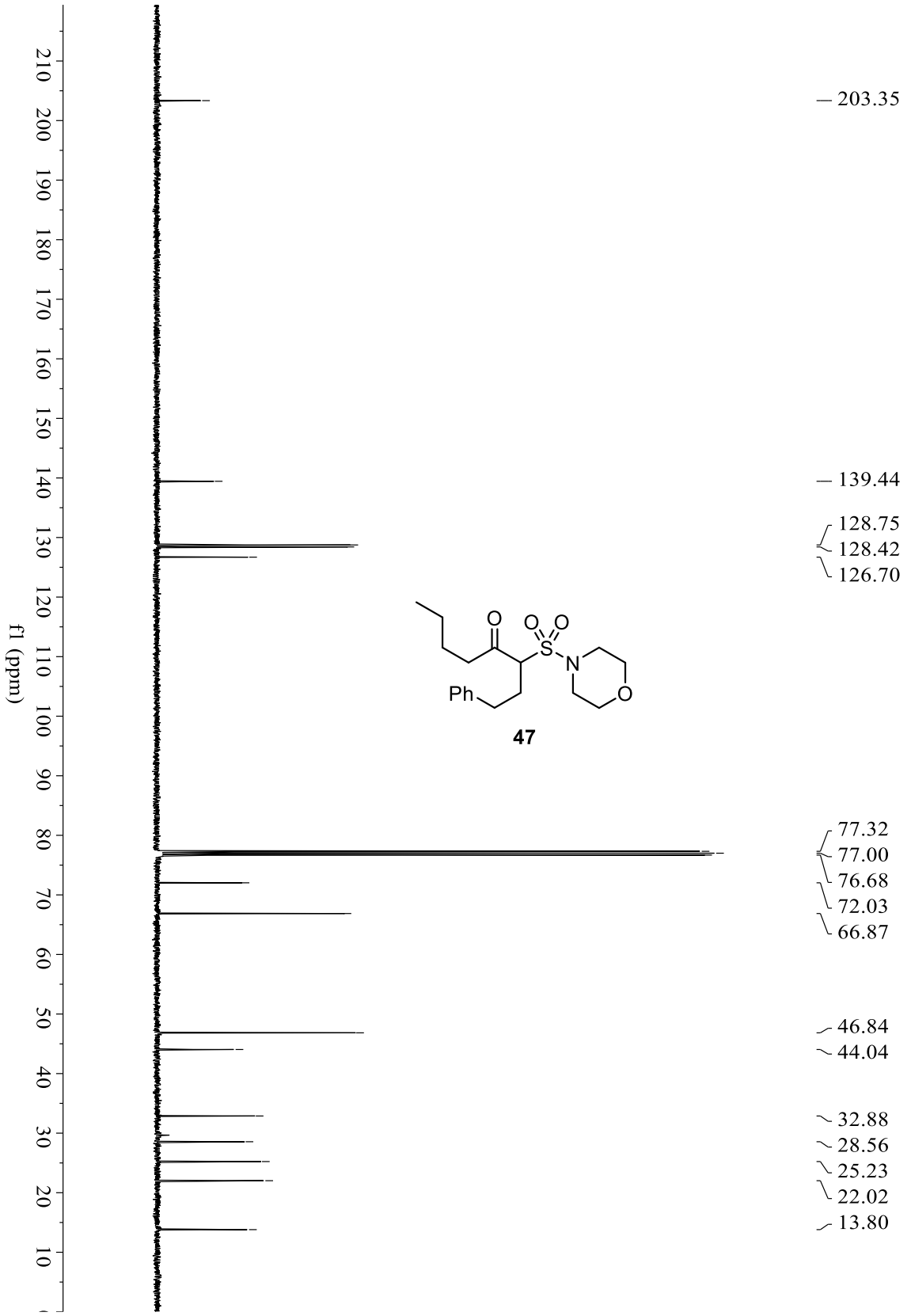
42

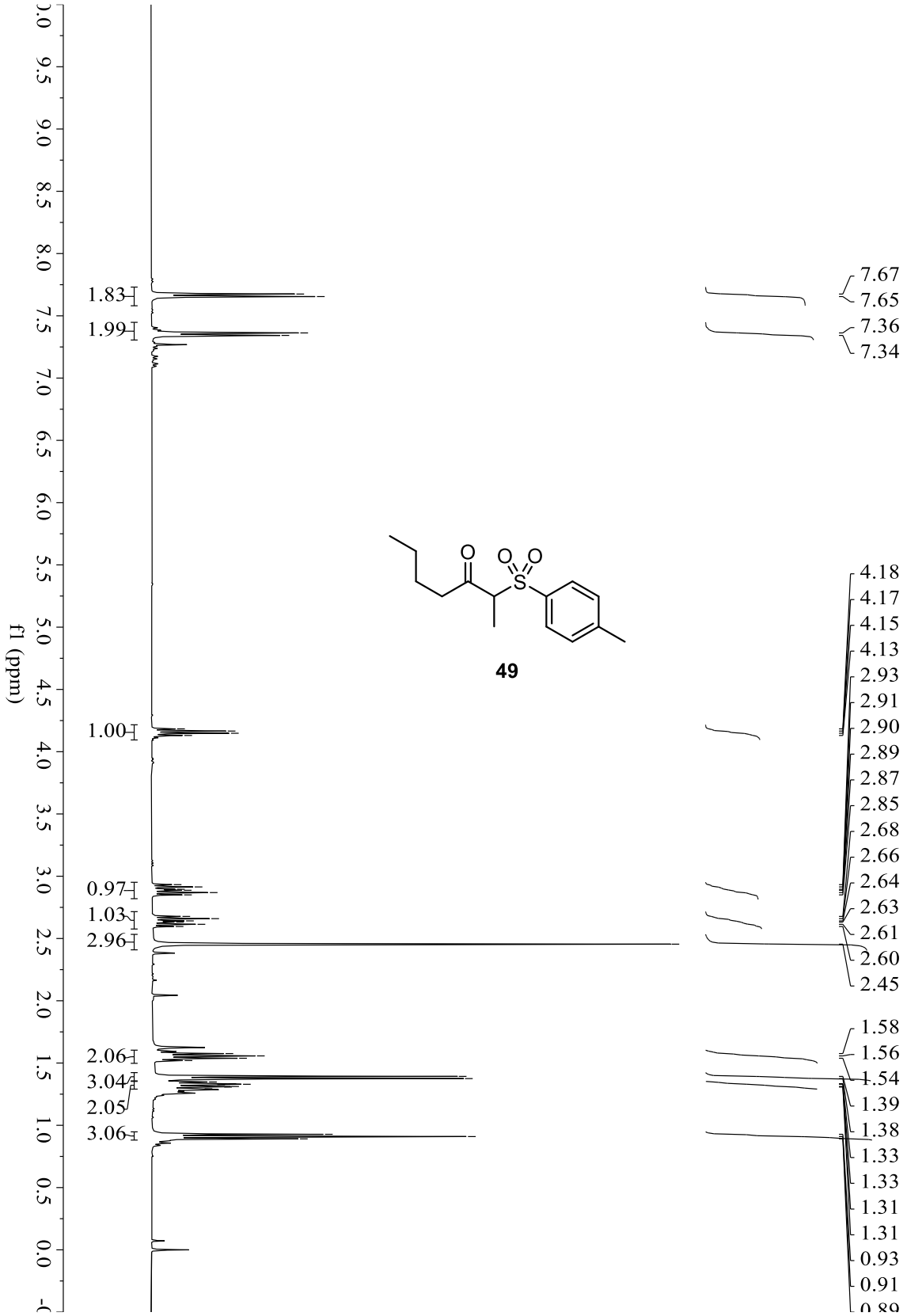

f1 (ppm)
2.19
3.05
1.03
1.85
2.17
2.02
1.00
1.34
6.03
2.95
2.83
2.88
Ph
O
O
N(iPr)2
45
7.27
7.25
7.25
7.23
7.17
7.16
7.15
4.07
4.06
4.04
4.02
4.01
3.41
3.39
3.37
2.90
2.89
2.88
2.87
2.86
2.81
2.80
2.79
2.79
2.78
2.77
1.98
1.96
1.95
1.94
1.93
1.91
1.89
1.84
1.82
1.81
1.79
1.78
1.77
1.76
1.39
1.37
1.35
1.15
1.14
1.06
1.05
0.89
0.87
0.85


f1 (ppm)
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
-10
206.54
167.60
141.03
128.37
128.36
125.97
77.32
77.00
76.68
61.09
48.70
46.25
40.55
29.54
22.49
20.88
20.59
20.55
20.29
12.06
O
O
Ph
N(iPr)2
45

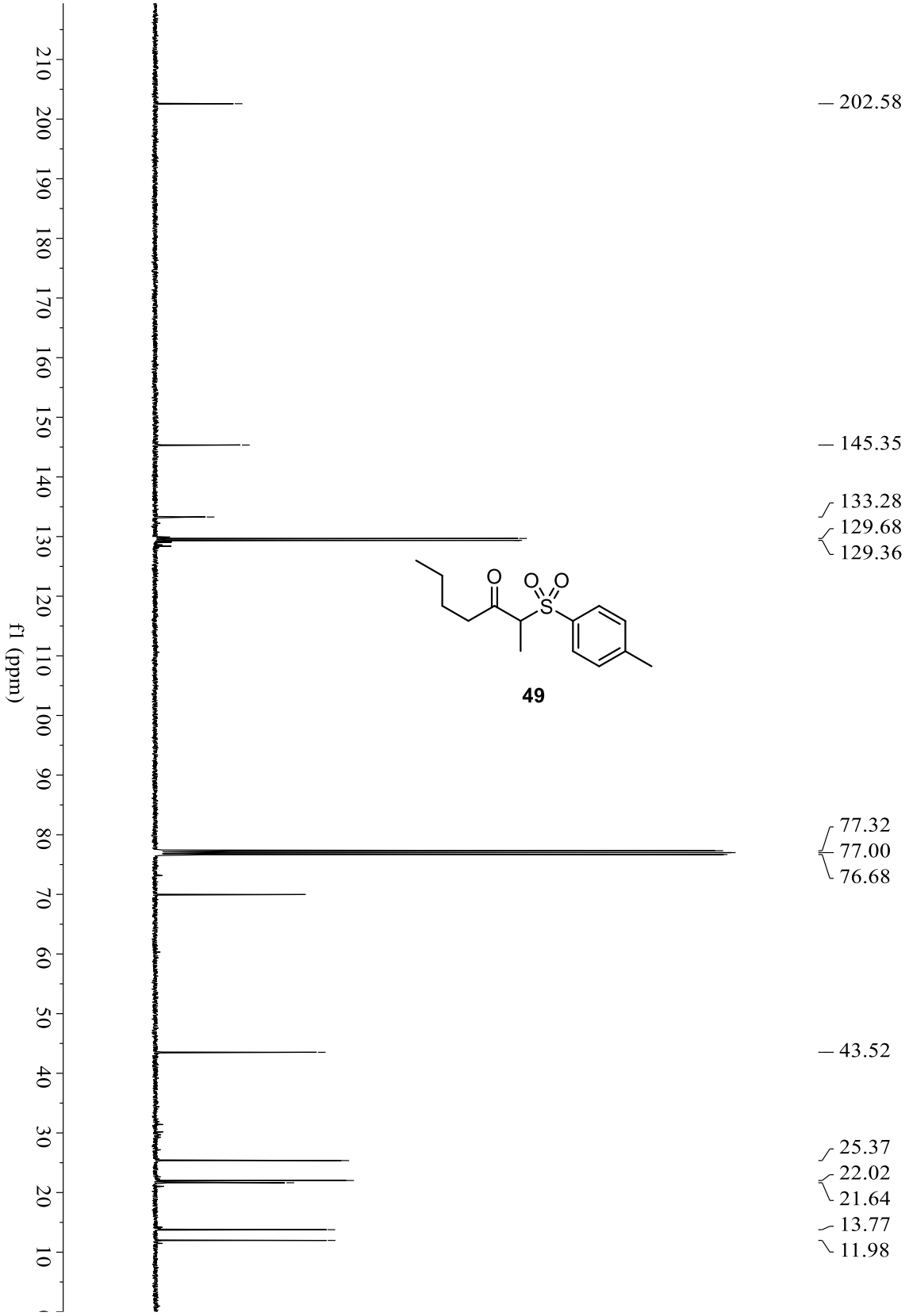

f1 (ppm)
1.98
1.16
1.95
1.00
4.05
4.04
1.04
1.05
3.09
1.06
2.14
2.06
3.17
7.33
7.31
7.29
7.26
7.25
7.23
7.15
7.15
7.13
4.05
4.04
4.03
4.02
3.68
3.67
3.67
3.66
3.66
3.65
3.31
3.30
3.29
3.29
3.28
3.28
3.27
3.26
2.84
2.79
2.66
2.53
2.51
2.50
2.49
2.48
2.48
2.47
2.45
2.44
2.42
1.56
1.54
1.52
1.34
1.32
1.31
1.29
0.93
0.91
0.89
O
O
O
S
N
O
Ph

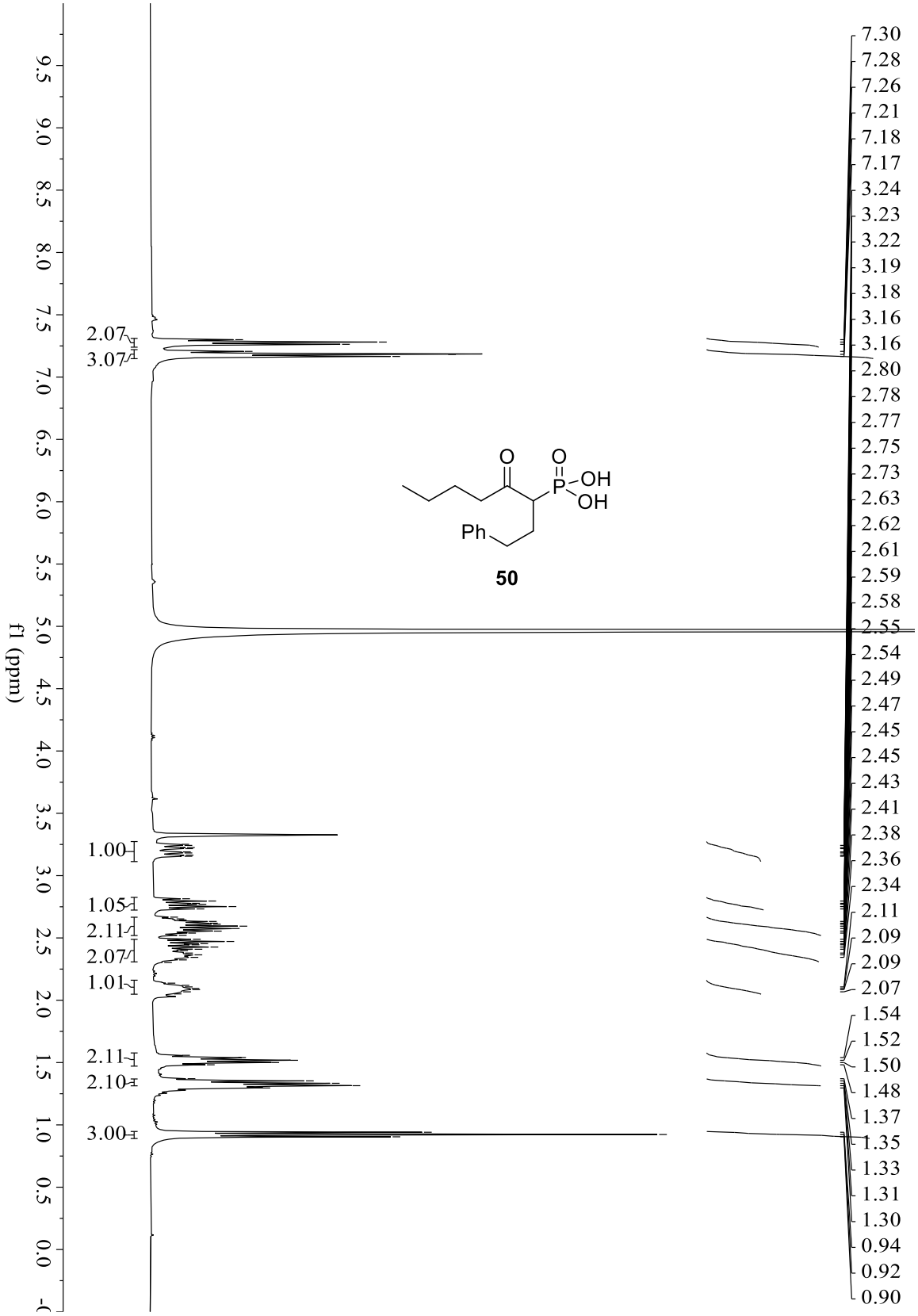
47

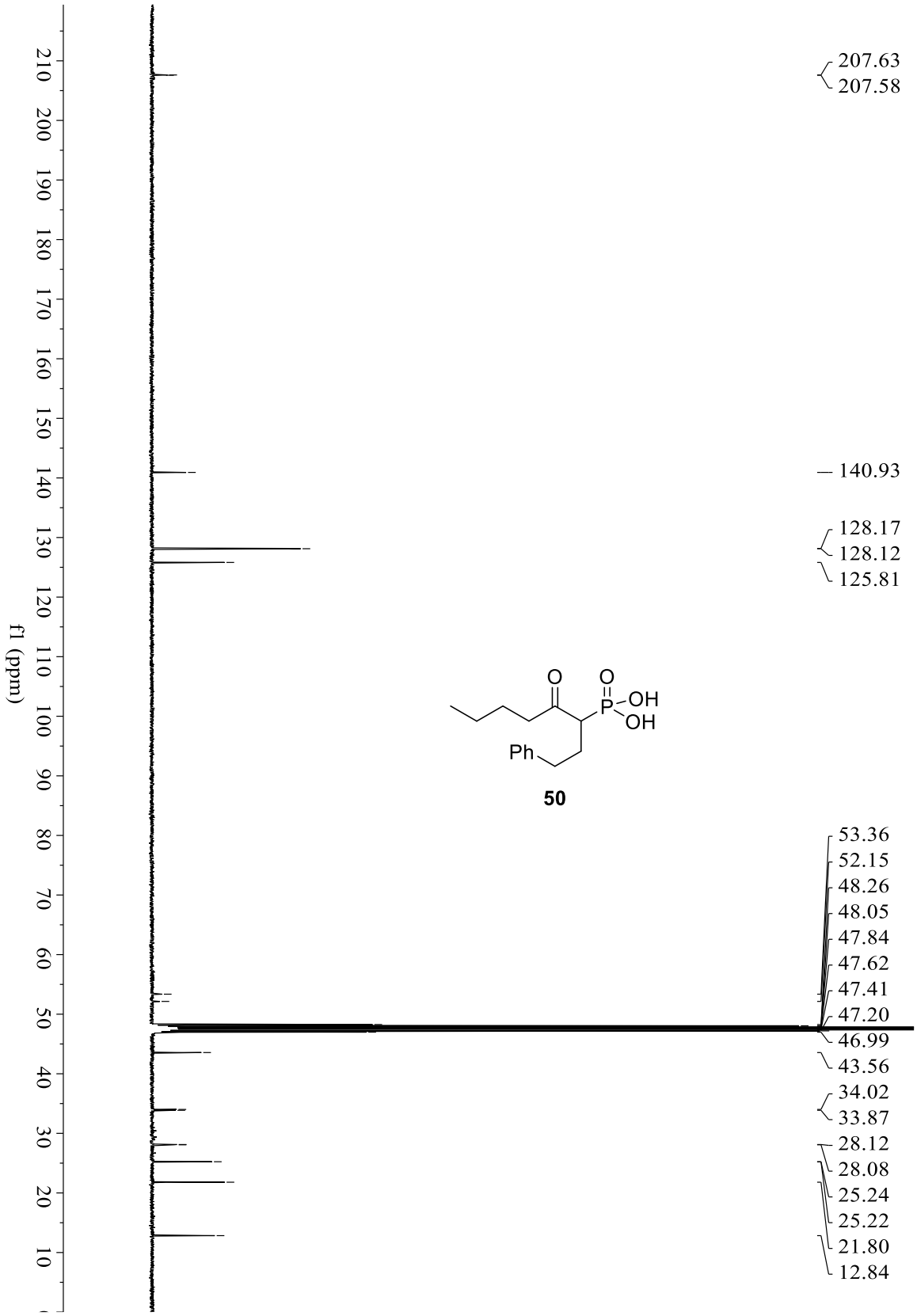

203.35
139.44
128.75
128.42
126.70
77.32
77.00
76.68
72.03
66.87
46.84
44.04
32.88
28.56
25.23
22.02
13.80
f1 (ppm)
O
O
O
S
N
O
Ph
47


f1 (ppm)
1.83
1.99
1.00
0.97
1.03
2.96
2.06
3.04
2.05
3.06
7.67
7.65
7.36
7.34
4.18
4.17
4.15
4.13
2.93
2.91
2.90
2.89
2.87
2.85
2.68
2.66
2.64
2.63
2.61
2.60
2.45
1.58
1.56
1.54
1.39
1.38
1.33
1.33
1.31
1.31
0.93
0.91
0.89
O
O
O
S

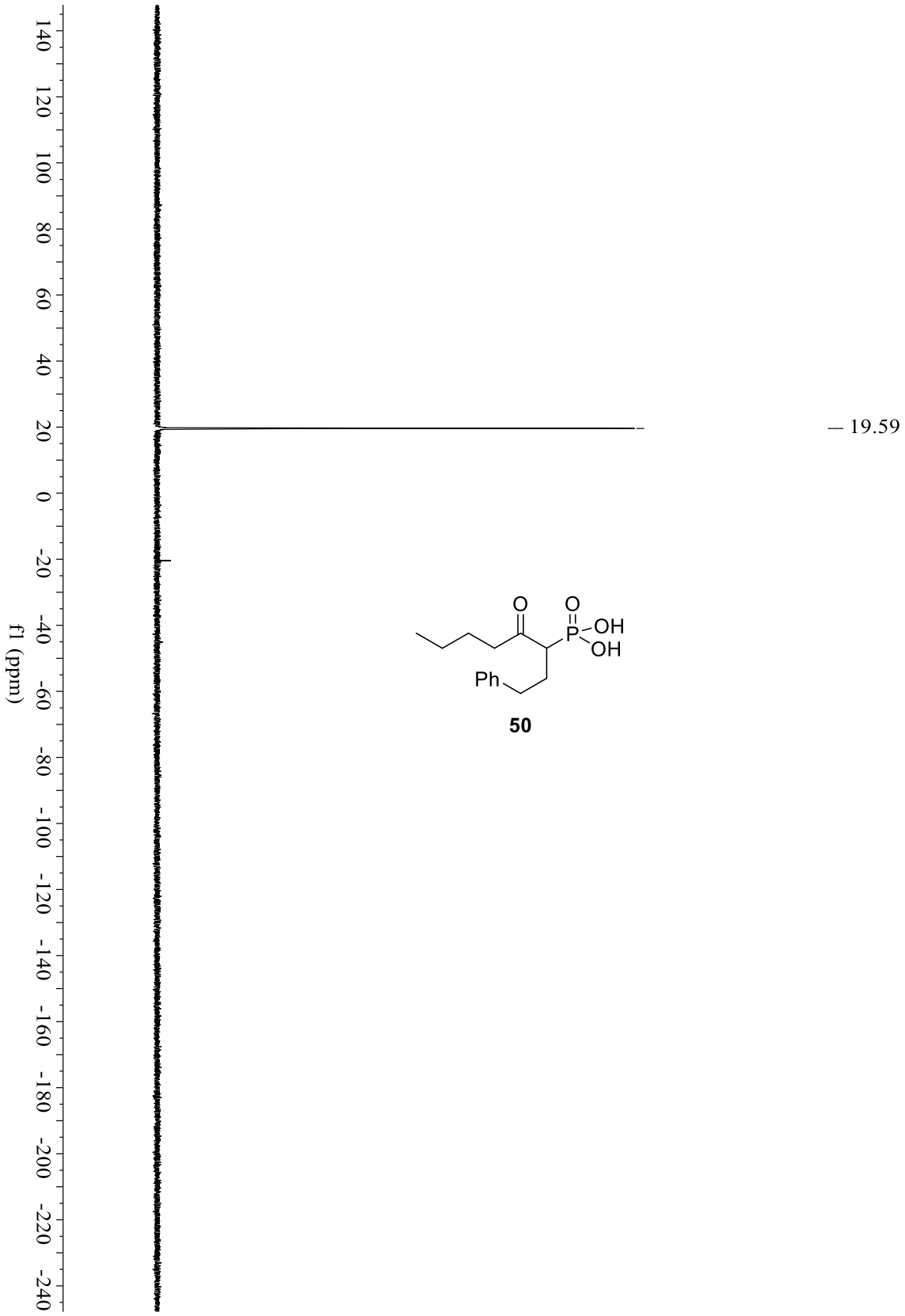
49

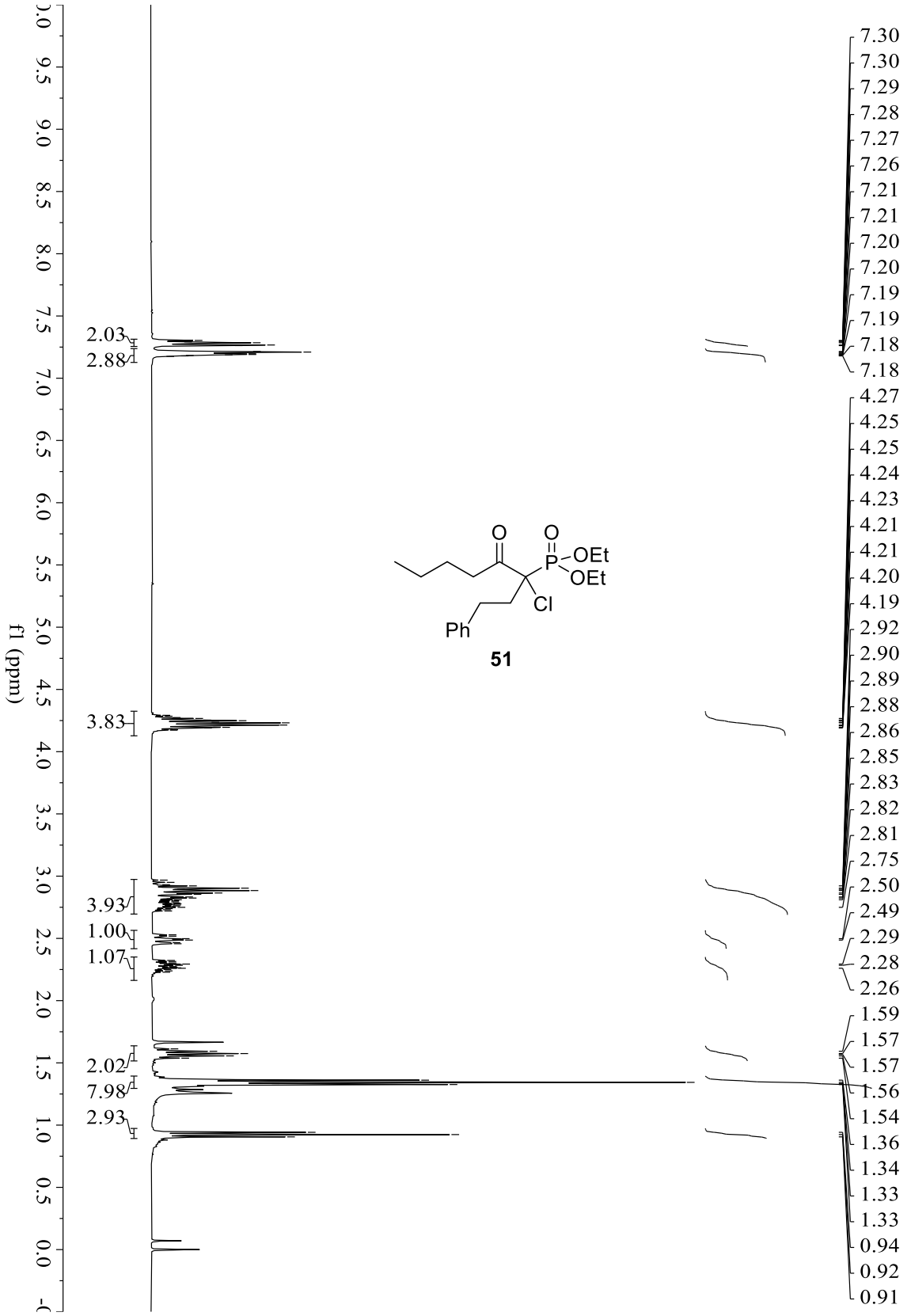

f1 (ppm)
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
202.58
145.35
133.28
129.68
129.36
77.32
77.00
76.68
43.52
25.37
22.02
21.64
13.77
11.98
O
O
O
S
49

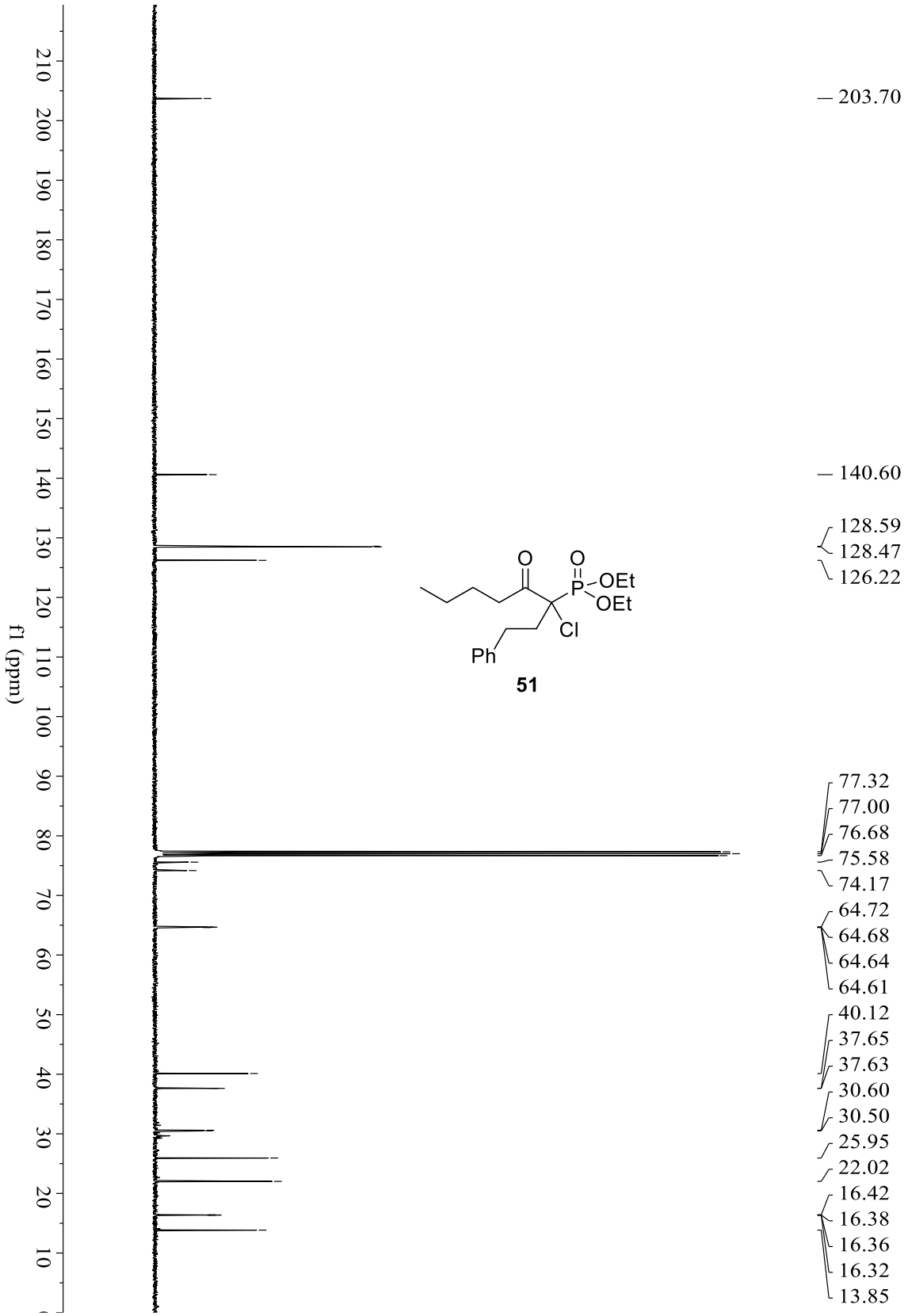

f1 (ppm)
9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0
2.07
3.07
1.00
1.05
2.11
2.07
1.01
2.11
2.10
3.00
O
O
P
OH
OH
Ph
50
7.30
7.28
7.26
7.21
7.18
7.17
3.24
3.23
3.22
3.19
3.18
3.16
3.16
2.80
2.78
2.77
2.75
2.73
2.63
2.62
2.61
2.59
2.58
2.55
2.54
2.49
2.47
2.45
2.45
2.43
2.41
2.38
2.36
2.34
2.11
2.09
2.09
2.07
1.54
1.52
1.50
1.48
1.37
1.35
1.33
1.31
1.30
0.94
0.92
0.90

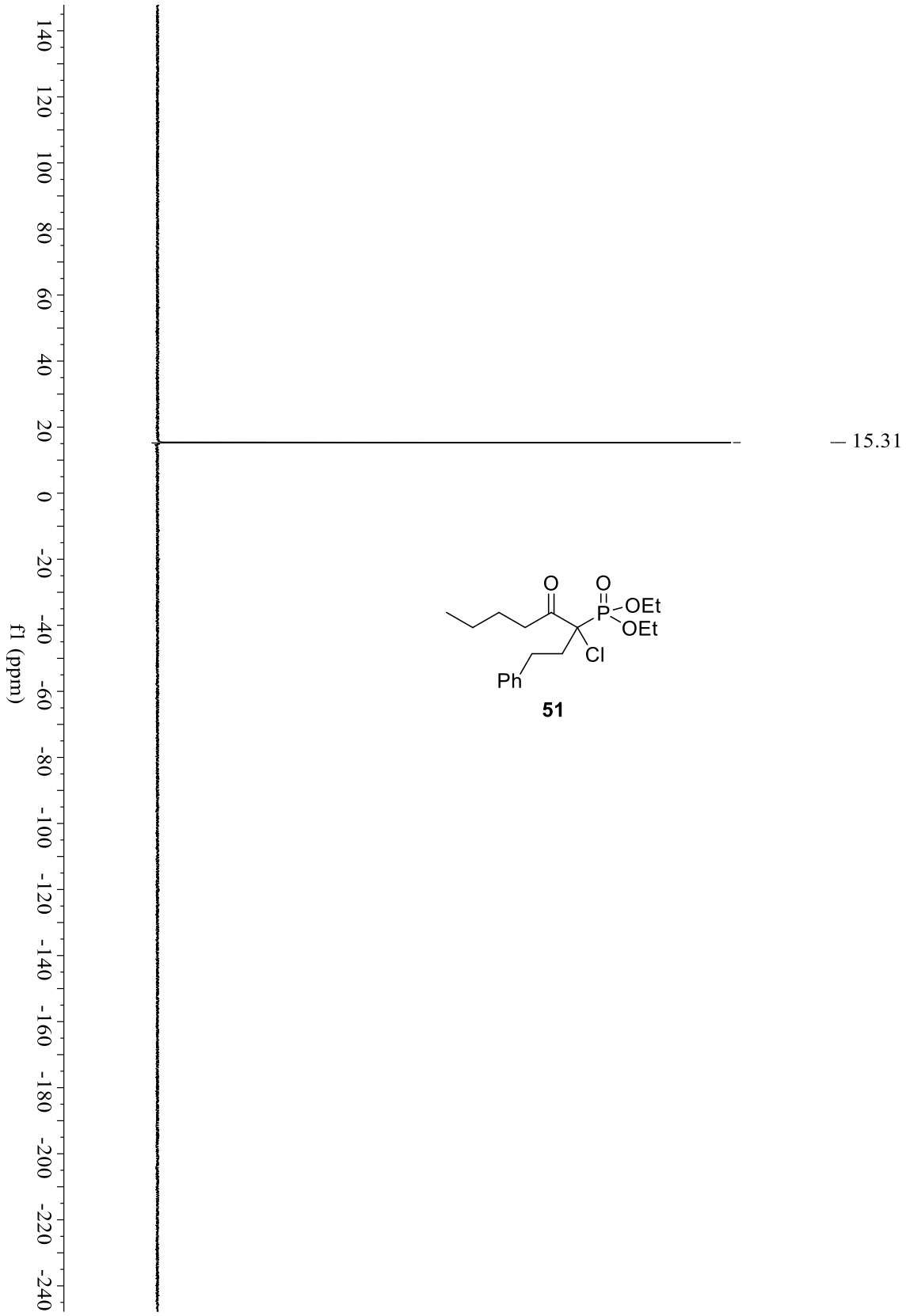

207.63
207.58
140.93
128.17
128.12
125.81
53.36
52.15
48.26
48.05
47.84
47.62
47.41
47.20
46.99
43.56
34.02
33.87
28.12
28.08
25.24
25.22
21.80
12.84
f1 (ppm)
O
O
P
OH
OH
Ph

50

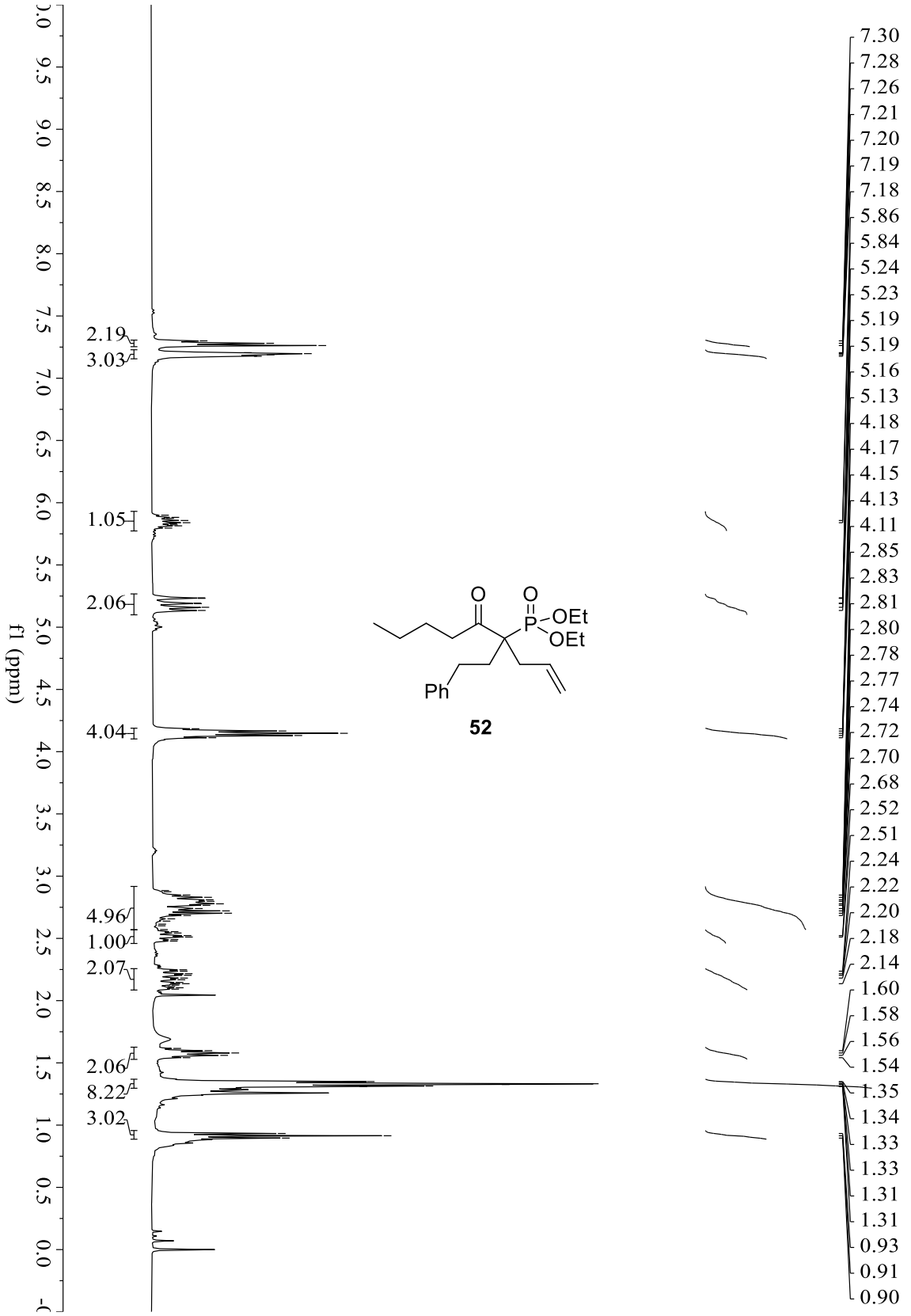

19.59
O
O
P
OH
OH
Ph
50
f1 (ppm)
140
120
100
80
60
40
20
0
-20
-40
-60
-80
-100
-120
-140
-160
-180
-200
-220
-240

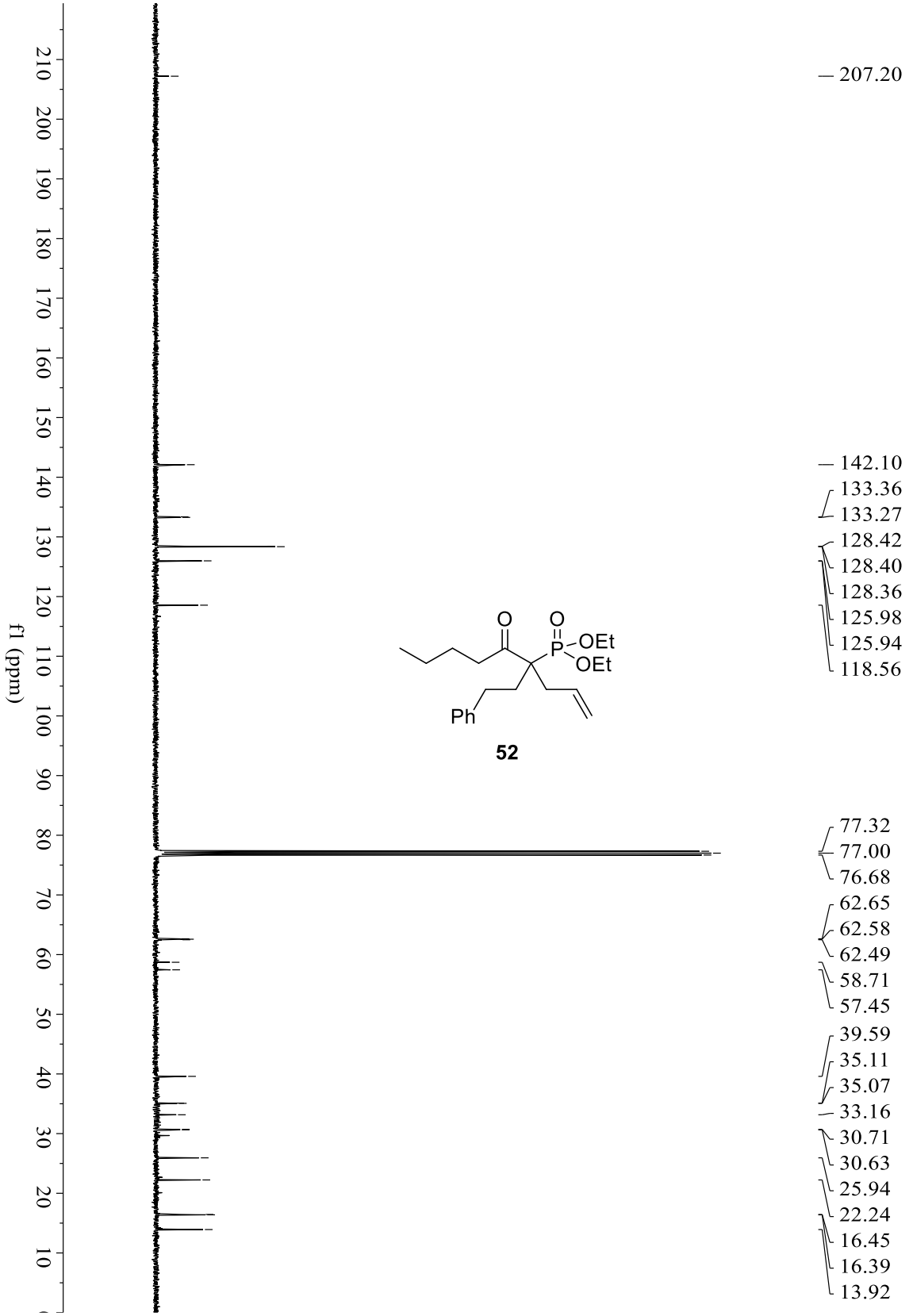

f1 (ppm)
2.03
2.88
3.83
3.93
1.00
1.07
2.02
7.98
2.93
O
O
P
OEt
OEt
Cl
Ph
51
7.30
7.30
7.29
7.28
7.27
7.26
7.21
7.21
7.20
7.20
7.19
7.19
7.18
7.18
4.27
4.25
4.25
4.24
4.23
4.21
4.21
4.20
4.19
2.92
2.90
2.89
2.88
2.86
2.85
2.83
2.82
2.81
2.75
2.50
2.49
2.29
2.28
2.26
1.59
1.57
1.57
1.56
1.54
1.36
1.34
1.33
1.33
0.94
0.92
0.91

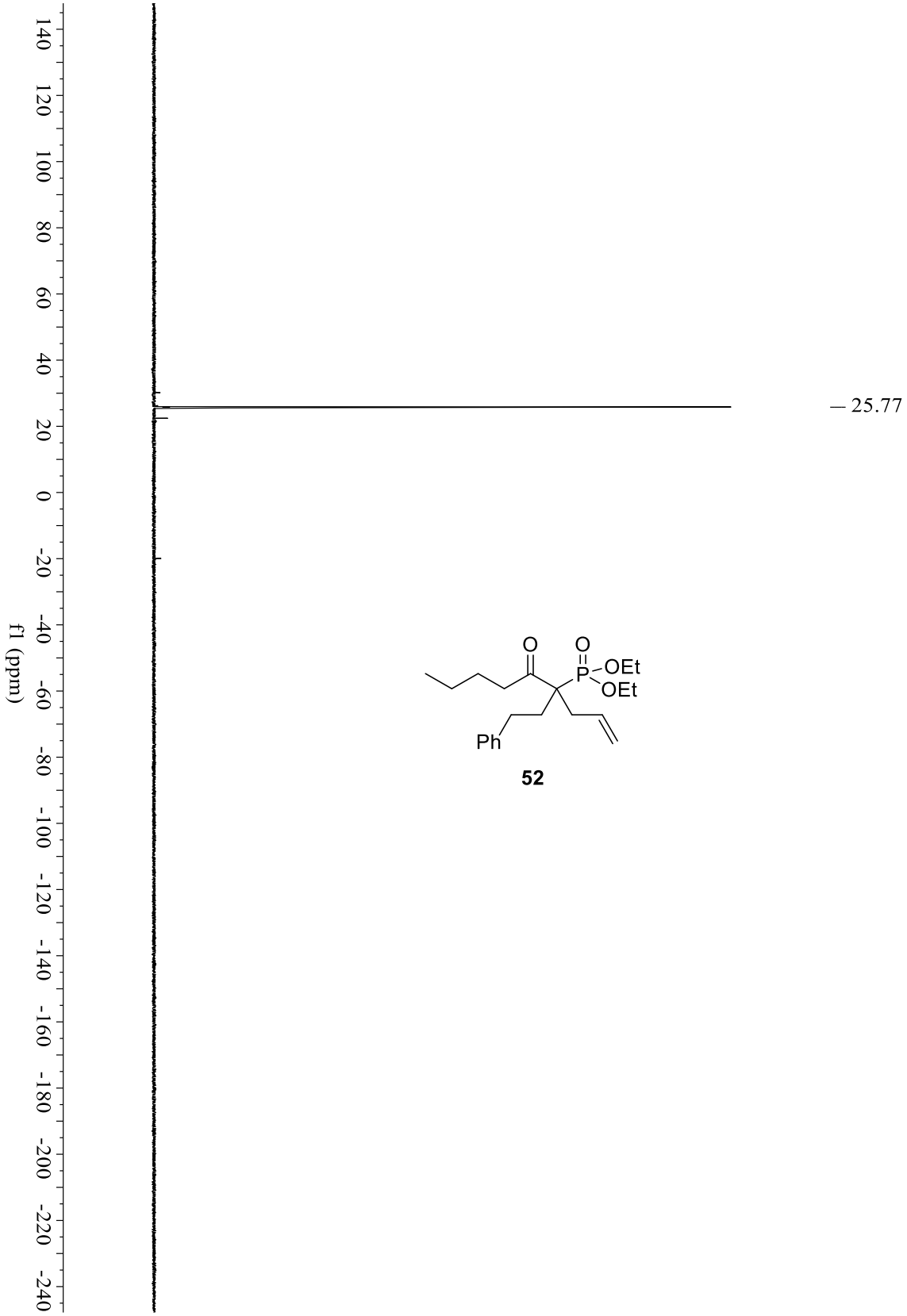

203.70
140.60
128.59
128.47
126.22
77.32
77.00
76.68
75.58
74.17
64.72
64.68
64.64
64.61
40.12
37.65
37.63
30.60
30.50
25.95
22.02
16.42
16.38
16.36
16.32
13.85
O
O
P
OEt
OEt
Cl
Ph
51
f1 (ppm)


15.31
140
120
100
80
60
40
20
0
-20
-40
-60
-80
-100
-120
-140
-160
-180
-200
-220
-240
f1 (ppm)
O
O
P
OEt
OEt
Cl
Ph

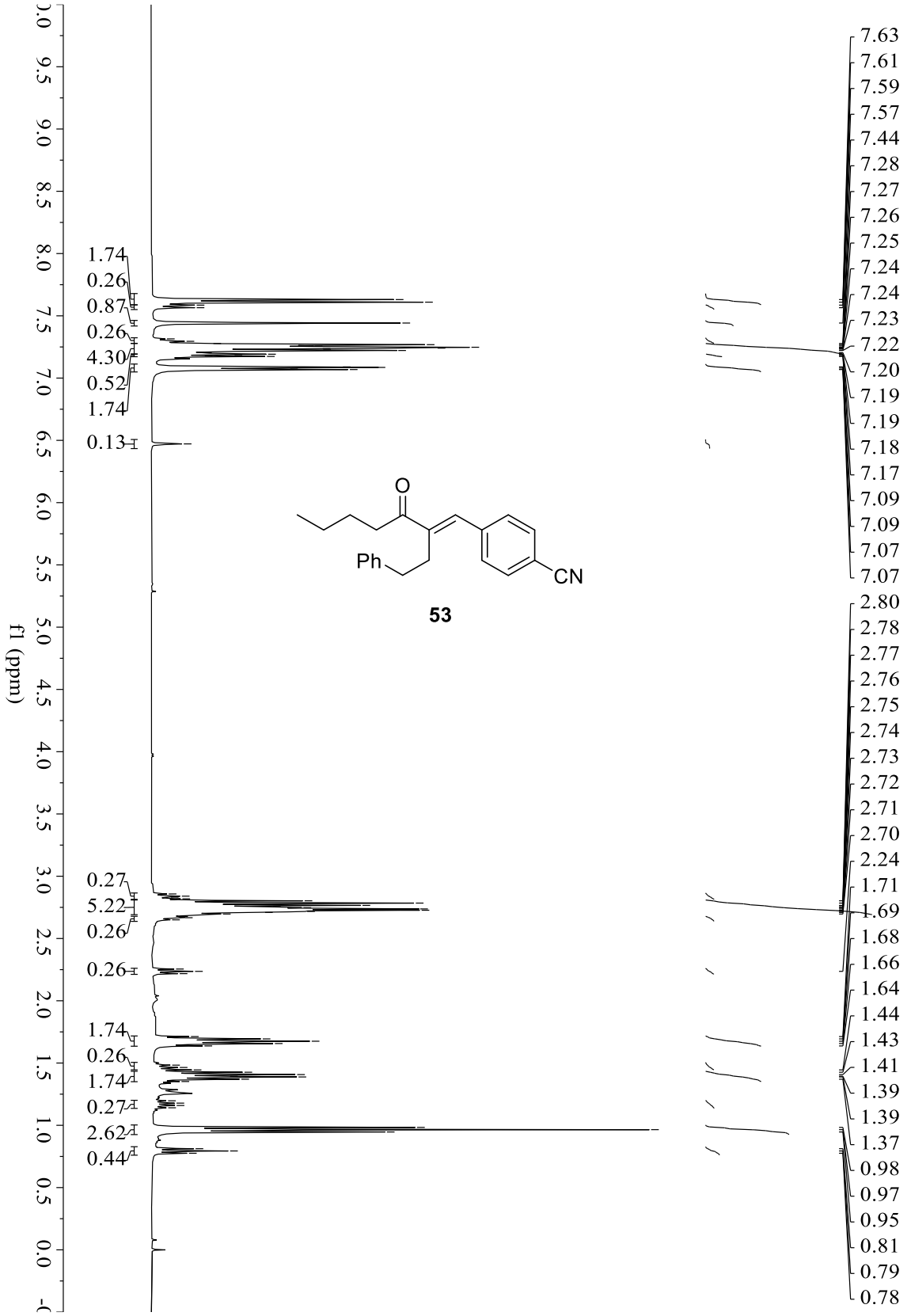
51


f1 (ppm)
2.19
3.03
1.05
2.06
4.04
4.96
1.00
2.07
2.06
8.22
3.02
O
O
P
OEt
OEt
Ph
52
7.30
7.28
7.26
7.21
7.20
7.19
7.18
5.86
5.84
5.24
5.23
5.19
5.19
5.16
5.13
4.18
4.17
4.15
4.13
4.11
2.85
2.83
2.81
2.80
2.78
2.77
2.74
2.72
2.70
2.68
2.52
2.51
2.24
2.22
2.20
2.18
2.14
1.60
1.58
1.56
1.54
1.35
1.34
1.33
1.33
1.31
1.31
0.93
0.91
0.90

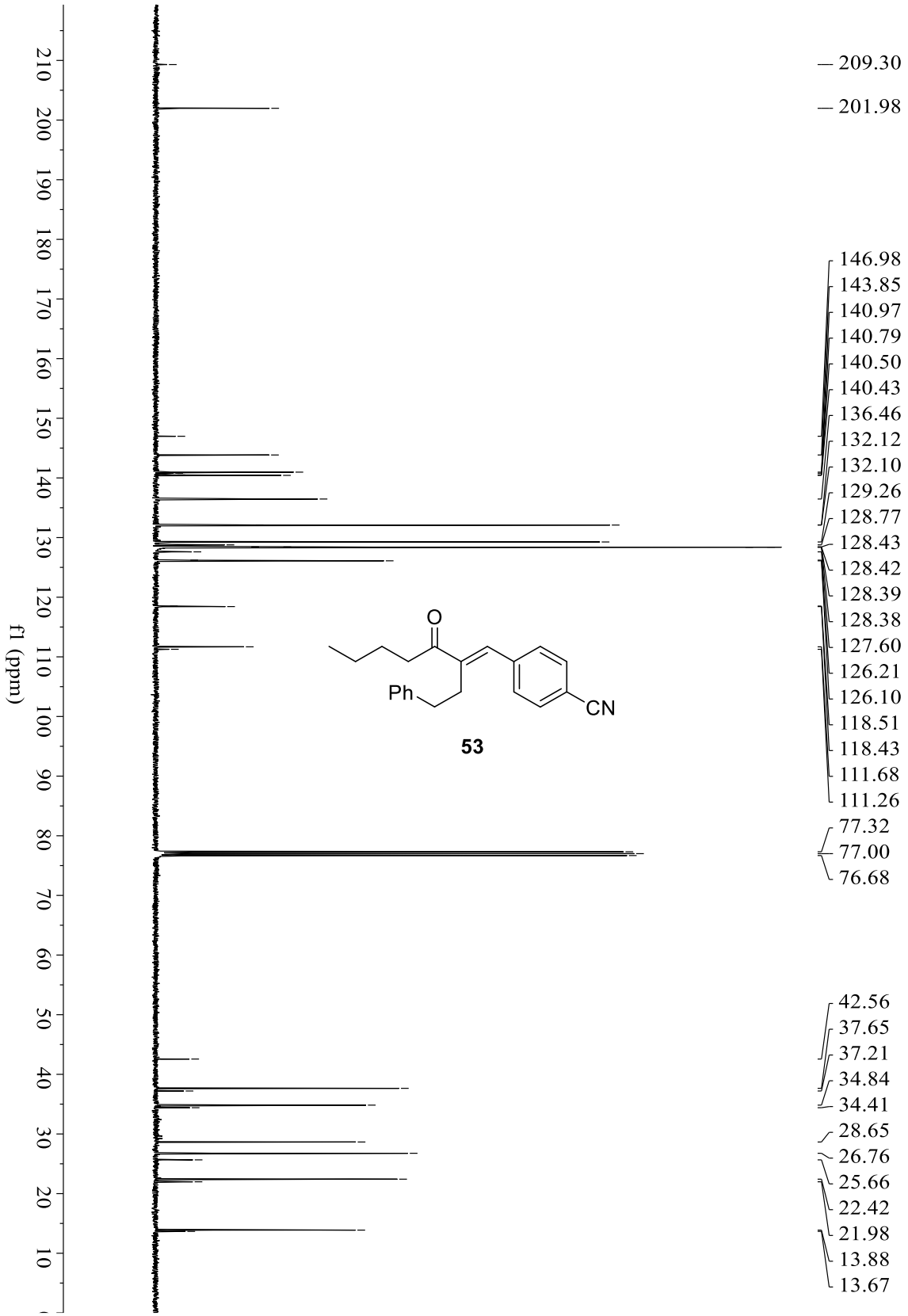

207.20
142.10
133.36
133.27
128.42
128.40
128.36
125.98
125.94
118.56
77.32
77.00
76.68
62.65
62.58
62.49
58.71
57.45
39.59
35.11
35.07
33.16
30.71
30.63
25.94
22.24
16.45
16.39
13.92
O
O
P
OEt
OEt
Ph
52
f1 (ppm)
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10


25.77
f1 (ppm)
140
120
100
80
60
40
20
0
-20
-40
-60
-80
-100
-120
-140
-160
-180
-200
-220
-240
O
O
P
OEt
OEt
Ph

52


f1 (ppm)
1.74
0.26
0.87
0.26
4.30
0.52
1.74
0.13
0.27
5.22
0.26
0.26
1.74
0.26
1.74
0.27
2.62
0.44
O
Ph
CN
7.63
7.61
7.59
7.57
7.44
7.28
7.27
7.26
7.25
7.24
7.24
7.23
7.22
7.20
7.19
7.19
7.18
7.17
7.09
7.09
7.07
7.07
2.80
2.78
2.77
2.76
2.75
2.74
2.73
2.72
2.71
2.70
2.24
1.71
1.69
1.68
1.66
1.64
1.44
1.43
1.41
1.39
1.39
1.37
0.98
0.97
0.95
0.81
0.79
0.78

53


209.30
201.98
146.98
143.85
140.97
140.79
140.50
140.43
136.46
132.12
132.10
129.26
128.77
128.43
128.42
128.39
128.38
127.60
126.21
126.10
118.51
118.43
111.68
111.26
77.32
77.00
76.68
42.56
37.65
37.21
34.84
34.41
28.65
26.76
25.66
22.42
21.98
13.88
13.67
f1 (ppm)
O
Ph
CN

53