Expanding the Chemical Space of Peptides via Biocompatible Tryptophan C7-Arylation

Lei Liu [a,b], Yanyang Zhao[a], Yiming Su[a], Boning Wang[a], Yue Xiong[b], Tianhang Wang[a], Xiude Hua[b,c], Yonghao Ye[b,c]*, Zhuangzhi Shi[a]* and Huan Wang[a]*

[a]*State Key Laboratory of Coordination Chemistry, Chemistry and Biomedicine Innovation Center of Nanjing University, Jiangsu Key Laboratory of Advanced Organic Materials, School of Chemistry and Chemical Engineering, Nanjing University, Nanjing, 210093, China*

[b]*State Key Laboratory of Agricultural and Forestry Biosecurity, State & Local Joint Engineering Research Center of Green Pesticide Invention and Application, College of Plant Protection, Nanjing Agricultural University, Nanjing 210095, PR China*

[c]*Key Laboratory of Integrated Management of Crop Diseases and Pests, Ministry of Education, Nanjing 210095, PR China*

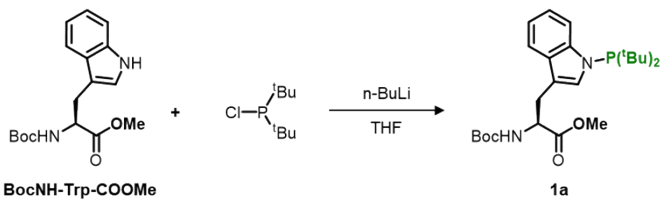
E-mail: wanghuan@nju.edu.cn; shiz@nju.edu.cn; yeyh@njau.edu.cn

1. General Information.

All the solvents were obtained from Sigma-Aldrich, Alfa-Aesar and Acros, and were dried and preserved over molecular sieves. Amino acids, EDCI, Ligand and $Rh(PPh_3)_3Cl$ were commercially available and used without purification. Rink Amide Resin (0.38 mmol/g) were purchased from Hecheng Technology (Tianjin, China) and GL Biochem (Shanghai, China). All reactions were carried out in inert atmosphere using flame-dried glassware. NMR spectra were recorded on a Bruker AVANCE III 400 MHz/500 MHz spectrometer. All NMR experiments were reported in units, parts per million (ppm), using residual solvent peaks as internal reference. ^{1}H NMR coupling constants were reported in Hz, and multiplicities are recorded as: s (singlet); d (doublet); t (triplet); q (quartet); m (multiplet); dd (doublet of doublets); ddd (doublet of doublet of doublets); dt (doublet of triplets); td (triplet of doublets); br (broad). Linear isomer is represented as 'l' and branch isomer is represented as 'b'. Mass spectra were collected at a Micromass Q-Tof instrument (ESI) and Agilent Technologies 5973N (EI). HPLC was performed with Agilent1260 Series chromatographs using daicel chiralcel columns (254 mm) and reverse-phase columns (254 mm). The solution was concentrated using Labconco CentriVap centrifugal concentrator instrument. Unless otherwise noted, linear peptides were synthesized by the Liberty Lite microwave peptide synthesizer (CEM Corporation).

2. Experimental Section

A. Install the *N*-P^{t}Bu$_2$ group in peptide substrates

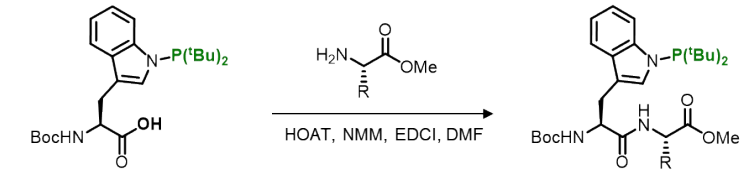


BocNH-Trp-COOMe **1a**

To a solution of BocNH-Trp-COOMe (5.0 mmol, 1.0 equiv) in 10 mL anhydrous THF

at 0°C was added a solution of *n*-BuLi in 6.0 mL hexanes (6.0 mmol, 1.2 equiv) dropwise with injection pump over 1 h. After stirring for 15 min, di-*tert*-butylchlorophosphine (6.0 mmol, 1.2 equiv) was added dropwise. The mixture was warmed to room temperature gradually. Upon completion, the reaction was quenched with ammonium chloride solution. The reaction mixture was extracted with EtOAc and washed with brine. The solvent was removed under reduced pressure. The resulting residue was purified by flash chromatography (petroleum ether/ethyl acetate) to yield the product **1a** in 79% yield.

B. General procedure for the synthesis of dipeptide substrates



BocNH-(*N*-P^{t}Bu$_2$) Trp-CO_2H **1x**

Typically, A solution of BocNH-(*N*-P^{t}Bu$_2$) Trp-CO_2H (5.0 mmol) and 4-methylmorpholine (NMM, 8.5 mmol) in DMF was treated with amino acid methyl ester hydrochloride (5.0 mmol) and 1-hydroxy-7-azabenzotriazole (HOAt, 5.2 mmol). The mixture was cooled in an ice bath, and 1-ethyl-3-(3-(dimethylamino)propyl)carbodiimide hydrochloride (EDCI, 6.0 mmol) was added in one portion. After stirring for 1.5 h at 0 °C followed by 6 h at room temperature, the reaction mixture was diluted with H_2O and extracted with EtOAc. The combined organic extracts were washed sequentially with H_2O, 1.0 M HCl, saturated aqueous $NaHCO_3$, and brine, then dried over anhydrous Na_2SO_4. Filtration and concentration afforded dipeptide substrates **1x** in pure form.

C. General procedure for Trp(C7) arylation of peptide substrates

To a flame dried Schlenk tube was added peptide substrate **1a/1x** (0.1 mmol), $Rh(PPh_3)_3Cl$ (10 mol%) K_2CO_3 (3.0 e.q) and **L12** (0-20 mol%) in a glove box. Dry toluene (1.0 mL, 1.0 M) was added to the Schlenk under Ar atmosphere along with aryl bromide **2x/2z** (3.0 equiv). The reaction mixture was stirred at 120-130 °C for 48 h.

Upon completion, the reaction mixture was cooled to room temperature and passed through a pad of silica. The solvent was removed under vacuum, and the resulting residue was purified by silica gel flash chromatography to afford product **3ax/3xz**.

D. General procedure for homo-ligation of dipeptides and tripeptides.

To a flame dried Schlenk tube was added peptide substrate **1a** (0.1 mmol), $Rh(PPh_3)_3Cl$ (15 mol%) K_2CO_3 (3.0 equiv) and **L12** (20 mol%) in a glove box. Dry toluene (1.0 mL, 1.0 M) was added to the Schlenk under Ar atmosphere along with aryl bromide **3x** (3.0-9.0 equiv). The reaction mixture was stirred at 130 ℃ for 48 h. Upon completion, the reaction mixture was cooled to room temperature and passed through a pad of silica. The solvent was removed under vacuum, and the resulting residue was purified by silica gel flash chromatography to afford product **4ax**.

E. Removal of the di-*tert*-butylphosphine group.

Removal of the di-*tert*-butylphosphine group with TBAF. In a 25 mL Schlenk tube, peptide substrate (0.2 mmol) was dissolved in anhydrous THF (4.0 mL), followed by addition of TBAF (1.6 mmol, 8.0 equiv, 1.0 M in THF). The reaction mixture was stirred at 80°C for 12 h, then quenched with H_2O and extracted with EtOAc. The organic phase was washed sequentially with H_2O, saturated aqueous $NaHCO_3$, and brine, dried over anhydrous Na_2SO_4, and concentrated under reduced pressure. Purification by flash chromatography on silica gel afforded the desired product.

Removal of the di-*tert*-butylphosphine group with TFA. The peptide substrate (0.01 mmol) was treated with TFA cleavage cocktail (1.0 mL, TFA/TIPS/H_2O= 95/2.5/2.5, v/v/v) for 3 hours at 30 ℃. TFA solutions were concentrated by nitrogen blow-down and then precipitated with chilled diethyl ether. The crude peptides were isolated by centrifugation. The crude product was purified by reversed-phase HPLC (Welch C18: 4.6 × 250 mm, 5 μm particle size, acetonitrile/water gradient elution) and characterized by low-resolution mass spectrometry (LRMS), ultimately affording the target peptide after lyophilization.

F. General procedure for solid phase peptide synthesis (SPPS)

The peptide synthesis was assembled on an automated microwave peptide synthesizer (Liberty LiteTM, CEM) using Rink Amide Resin (0.02 mmol), with the following reagent stoichiometry: Fmoc-amino acids (5.0 equiv), DIC (5.0 equiv), Oxyma (5.0 equiv) in DMF as solvent under nitrogen atmosphere. After synthesis, the crude peptide was cleaved from the resin by treatment with TFA cleavage cocktail (TFA/water/TIPS = 95:2.5:2.5, v/v/v) at 30°C with agitation for 2 h. The cleavage solution was concentrated to one-fifth of its original volume via nitrogen blow-down, followed by precipitation with 10 volumes of diethyl ether; the pellet was isolated by centrifugation (5,000 rpm, 4°C, 10 min). The crude product was purified by reversed-phase HPLC (Welch C18: 4.6 × 250 mm, 5 μm particle size, acetonitrile/water gradient elution) and characterized by low-resolution mass spectrometry (LRMS), ultimately affording the target peptide after lyophilization.

G. Flow cytometry

A 1 mL aliquot of logarithmic-phase *E. coli* was first centrifuged (6000 × g, 1 min), and the supernatant was carefully removed. Subsequently, the pellet was resuspended in 200 μL of PBS (20 mM, pH 7.4), centrifuged again under identical conditions, and this washing procedure was rigorously repeated twice to ensure complete elimination of residual medium. Subsequently, the purified bacterial pellet was co-incubated with the peptide dye (**5h**) (concentration gradient: 0, 25, 50, 100 μM) at 37°C with 220 rpm shaking for 3 hours to facilitate staining. Following incubation, the cell suspension was carefully diluted with PBS to a standardized concentration of 1×10^6 cells/mL. Finally, the samples were subjected to flow cytometric analysis using a NovoCyte Flow Cytometer (excitation at 488 nm), with data acquisition parameters optimized for fluorescent signal resolution.

H. Wash-Free Imaging of CPP Trafficking in Live Cells.

A 1 mL aliquot of logarithmic-phase *E. coli* was first centrifuged (6000 × g, 1 min), and the supernatant was carefully removed. Subsequently, the pellet was resuspended

in 200 μL of PBS (20 mM, pH 7.4), centrifuged again under identical conditions, and this washing procedure was rigorously repeated twice to ensure complete elimination of residual medium. Following purification, the cells were incubated with the peptide dye (**5h**) (25 μM) at 37 °C under constant shaking (220 rpm) for 3 h to facilitate uniform staining. For confocal microscopy analysis, a 1% agarose gel pad (1 mm thickness) was initially prepared on a glass slide, onto which 1 μL of the stained bacterial suspension was precisely spotted. After allowing 5 min for incubation in the dark at room temperature, 10 μL of glycerol was strategically applied around the sample periphery to prevent dehydration prior to coverslip placement. Finally, high-resolution images were systematically acquired using a laser confocal microscope (Olympus SpinSR) equipped with a 100× oil-immersion objective, employing optimized Z-stack scanning (step size: 0.5 μm) with 488 nm excitation. All acquired images were then quantitatively analyzed using OLY-VIA-31689 v4.2 software to ensure accurate data interpretation.

I. General procedure for broth microdilution antimicrobial susceptibility testing

On a 96-well microtiter plate, add 40 μL of *Aspergillus fumigatus* spore suspension (1×10^6 CFU/mL) prepared with PDA (200 g potato, 20 g anhydrous glucose, 1L water) and 40 μL of serially diluted antimicrobial peptide solution (diluted with PDB) to each well. The final concentration gradient is 512, 256, 128, 64, 32, 16, and 8 μM, with three biological replicates per concentration level. Following incubation at 25°C for 40 hours, fungal growth was quantitatively assessed by measuring the absorbance at 492 nm (A_{492}) using a microplate reader (SpectraMax M5, Molecular Devices). The IC_{50} value (defined as the peptide concentration required for 50% inhibition of fungal growth) was calculated via Probit regression analysis in SPSS Statistics, utilizing inhibition rates across concentrations and growth data from the control group at 50% saturation as computational inputs.

J. General procedure for fluorescence measurement of Trp derivatives

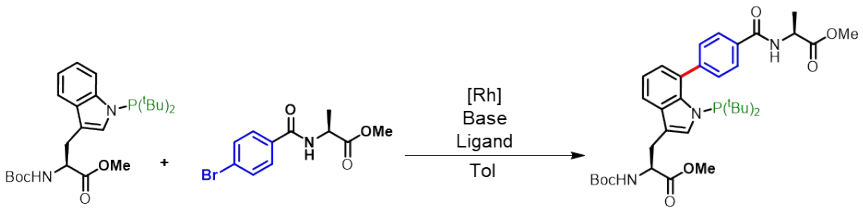
1. A stock solution of the test molecule (10 mM in acetonitrile (MeCN)) was prepared. An aliquot (3.0 μL) of this stock solution was transferred to a 10 mL centrifuge tube

and diluted with MeCN to a final volume of 3.0 mL (resulting in a final concentration of 10 μM). The solution was vortex-mixed thoroughly for 30 seconds to ensure homogeneity. Fluorescence spectra were acquired using a fluorescence spectrophotometer with an excitation wavelength set at 295 nm (or the predetermined λ_{ex} for the specific derivative). Emission spectra were recorded from 310 to 500 nm.

2. To investigate solvent polarity effects, the test molecule was dissolved in H_2O/1,4-dioxane mixtures with varying water fractions (fw = 0 to 99%, v/v). Specifically, an aliquot (3.0 μL) of the stock solution (10 mM in MeCN) was added to a 10 mL centrifuge tube. The solution was then diluted to a final volume of 3.0 mL with the appropriate H_2O/1,4-dioxane co-solvent mixture (pre-mixed to the desired v/v ratio), yielding a final analyte concentration of 10 μM. The solution was vortex-mixed thoroughly for 30 seconds. Fluorescence emission spectra were immediately recorded under identical instrumental conditions as described in Section 1.

3. Supplementary tables and figures

Table S1. Optimization of reaction conditions.

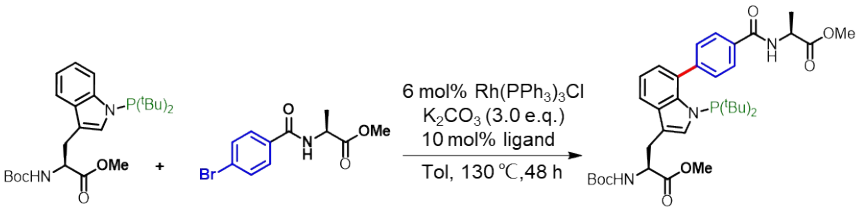


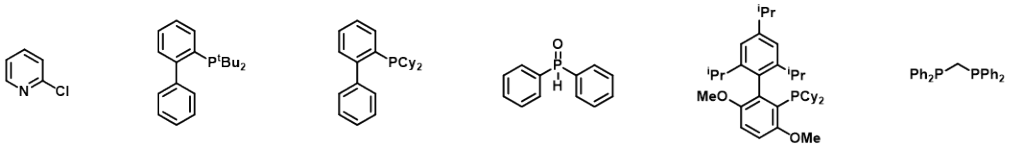
1a 2a 3aa

Entry	[Ru] (mol %)	Base	Ligand (mol %)	T (°C)	Sol	t(h)	Yield of 2ab[b]
1	$Rh(PPh_3)_3Cl$ (6.0)	K_2CO_3	None	120	Tol	24	6
2	$Rh(PPh_3)_3Cl$ (6.0)	LiO^tBu	None	120	Tol	24	0
3	$Rh(PPh_3)_3Cl$ (6.0)	NaOAc	None	120	Tol	24	3
4	$Rh(PPh_3)_3Cl$ (6.0)	K_2CO_3	None	130	Tol	24	9
5	$Rh(PPh_3)_3Cl$ (6.0)	K_2CO_3	None	130	Tol	48	12
6	$[Rh(cod)Cl]_2$ (6.0)	K_2CO_3	None	130	Tol	48	5
7	$[Rh(coe)_2Cl]_2$ (6.0)	K_2CO_3	None	130	Tol	48	3
8	None	K_2CO_3	None	130	Tol	48	0
9	$Rh(PPh_3)_3Cl$ (6.0)	K_2CO_3	L12 (10)	130	Tol	48	30
10	$Rh(PPh_3)_3Cl$ (6.0)	K_2CO_3	L12 (20)	130	Tol	48	65
11	$Rh(PPh_3)_3Cl$ (6.0)	K_2CO_3	L12 (30)	130	Tol	48	67
12	$Rh(PPh_3)_3Cl$ (10)	K_2CO_3	L12 (20)	130	Tol	48	80
13	$Rh(PPh_3)_3Cl$ (15)	K_2CO_3	L12 (20)	130	Tol	48	82
14	$Rh(PPh_3)_3Cl$ (10)	K_2CO_3	L12 (20)	130	Tol	24	40
15	$Rh(PPh_3)_3Cl$ (10)	K_2CO_3	L12 (20)	120	Tol	48	32
16	$Rh(PPh_3)_3Cl$ (10)	K_2CO_3	L12 (20)	130	DME	48	57
17	$Rh(PPh_3)_3Cl$ (10)	K_2CO_3	L12 (20)	130	DMF	48	43
18	$Rh(PPh_3)_3Cl$ (10)	K_2CO_3	L12 (20)	130	PhCl	48	73
19	$Rh(PPh_3)_3Cl$ (10)	K_2CO_3	L12 (20)	130	DMSO	48	35

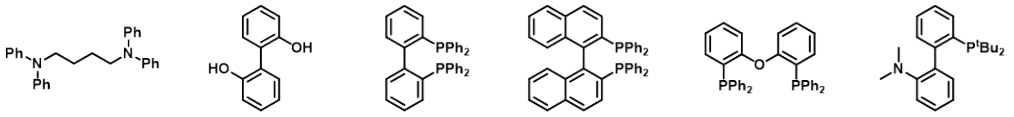
Reaction conditions: [a] **1a** (0.10 mmol), **2a** (0.60 mmol), Rh catalyst, K_2CO_3 (3.0 e.q.), **L12** (20 mol%), solvent (1.0 mL) at 130°C for 48 h, under Ar. [b] Isolated yields are reported.

Table S2. Screening of ligands.





L1 5% | L2 trace | L3 trace | L4 trace | L5 5% | L6 5%



L7 trace | L8 8% | L9 trace | L10 17% | L11 trace | L12 30%

Reaction conditions: **1a** (0.10 mmol), **2a** (0.60 mmol), $Rh(PPh_3)_3Cl$ (6 mol%), K_2CO_3 (3.0 e.q.), ligand (10 mol%), Sol (1 mL) at 130 °C for 48 h, under Ar. Isolated yields are reported.

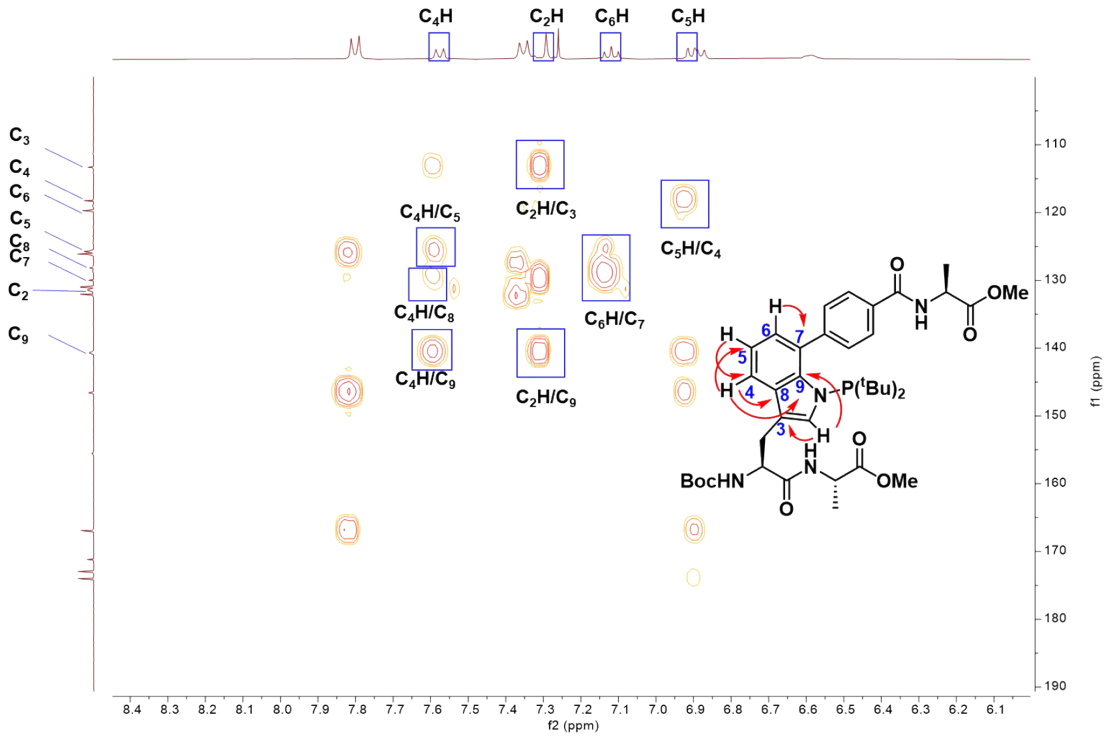


Figure S1. Determination of the arylation site on the Trp residue in product **3aa** by HMBC.

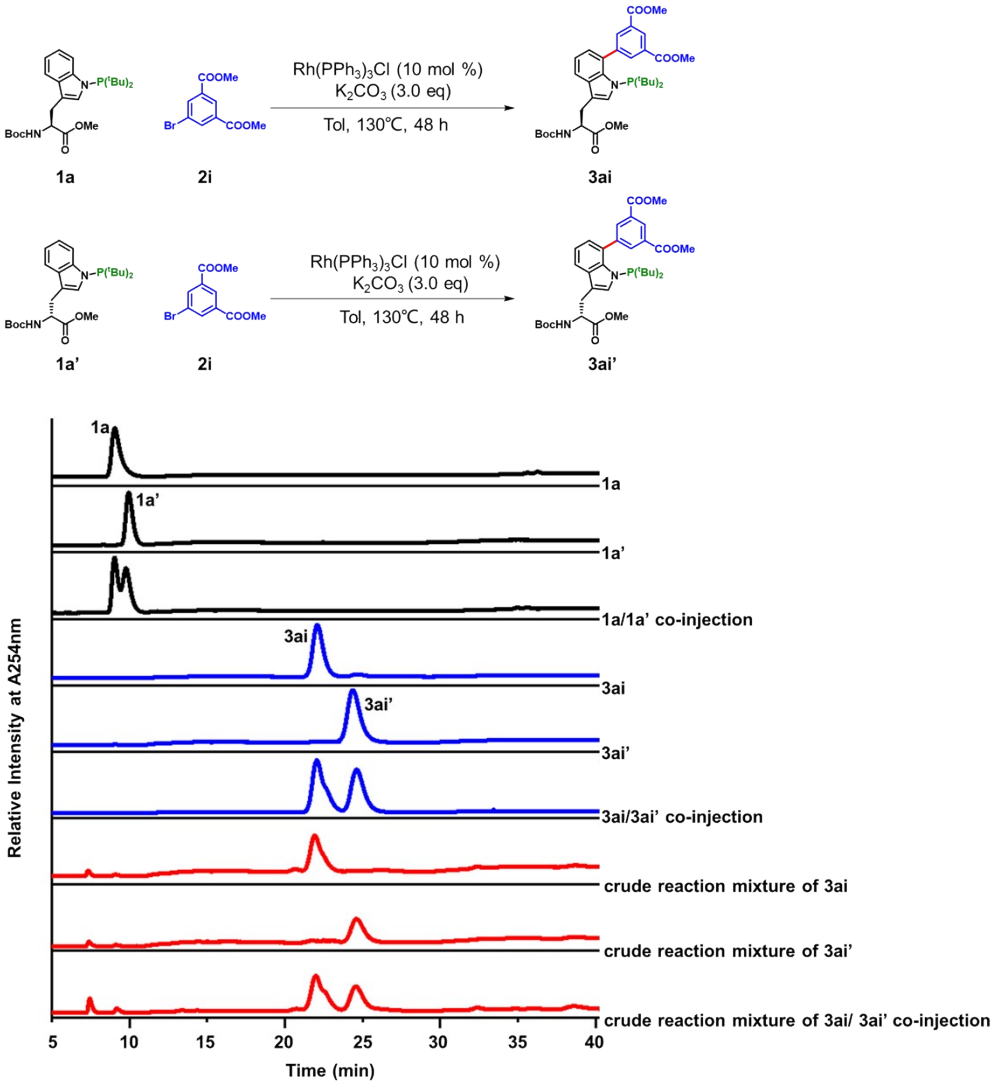


Figure S2. The reaction condition for Trp(C7) arylation is epimerization-free. HPLC analysis were performed on a CHIRALPAK® AD-H column with mobile phase of ^{i}PrOH-*n*-hexane at a flow rate of 1.0 mL/min. Gradient conditions: isocratic 1 % ^{i}PrOH for 5 min, 1-8 % ^{i}PrOH in 25 min, isocratic 8 % for 5 min, 8-20 % ^{i}PrOH in 55 min, isocratic 20 % ^{i}PrOH for 5 min. Signal was monitored at 254 nm UV.

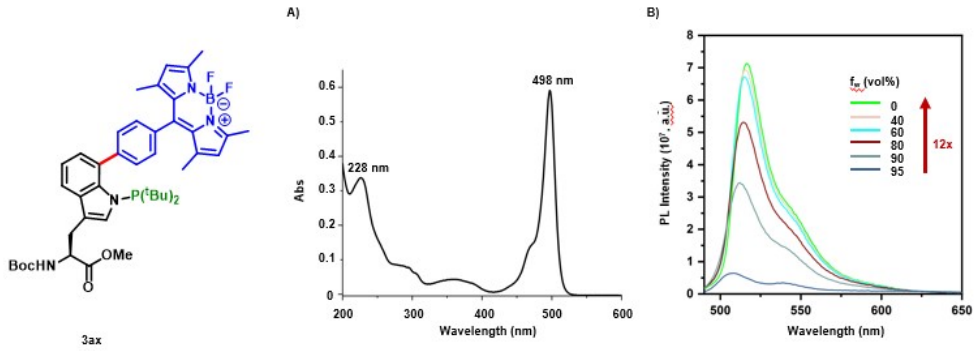


Figure S3. UV-Vis absorption spectra and solvent-sensitive fluorescent emission of **3ax**. A) UV-Vis absorption spectra of **3ax** (10 μM) in MeCN; B) Fluorescent emission of **3ax** (10 μM) in mixed solvents of dioxane/water. The excitation wavelength was 490 nm.

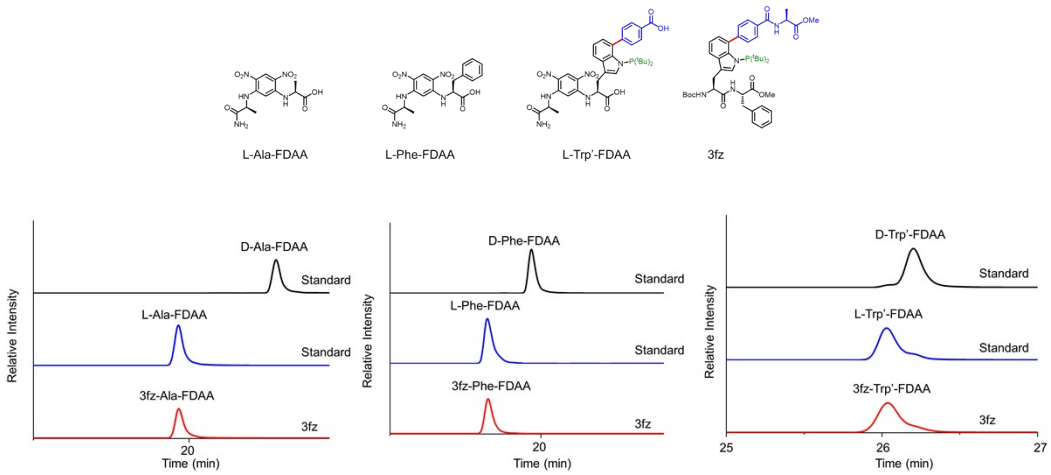
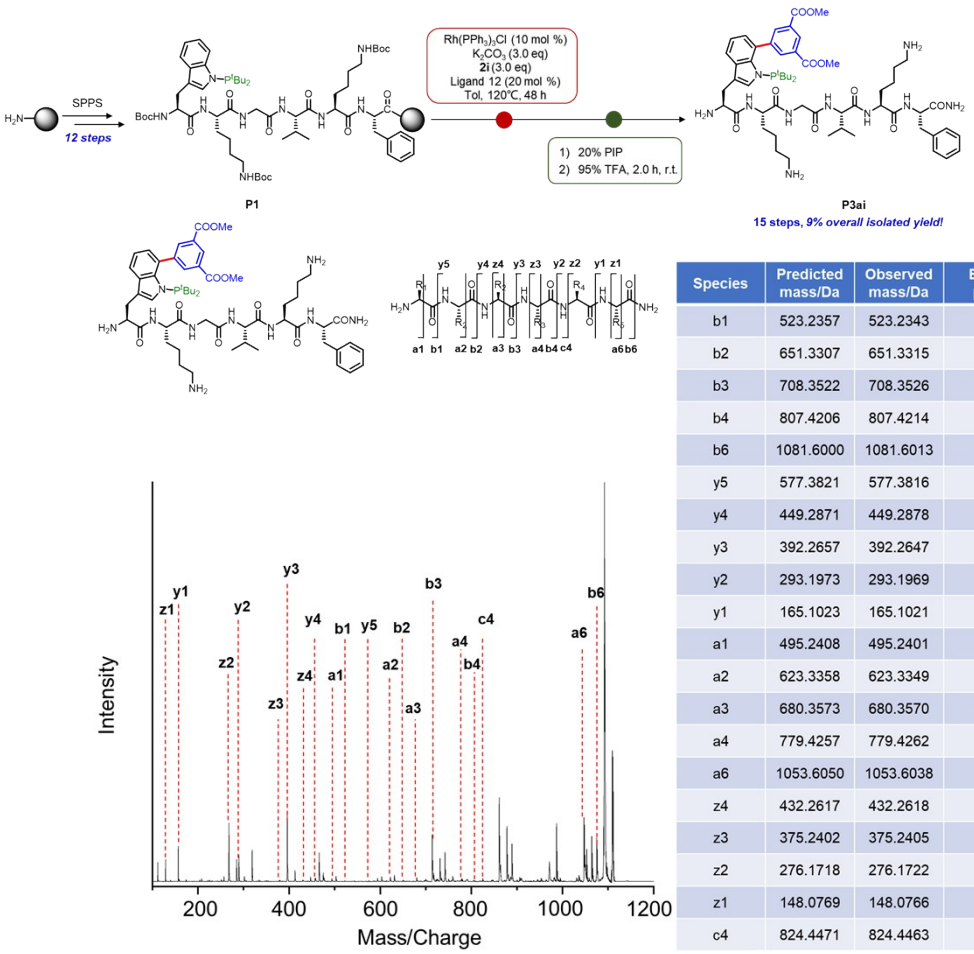


Figure S4. LC-MS analysis of sample **3fz** after derivatization with Marfey's reagent (FDLA).



Species	Predicted mass/Da	Observed mass/Da	Error/ ppm
b1	523.2357	523.2343	2.7
b2	651.3307	651.3315	1.2
b3	708.3522	708.3526	0.6
b4	807.4206	807.4214	1.0
b6	1081.6000	1081.6013	0.4
y5	577.3821	577.3816	0.9
y4	449.2871	449.2878	1.6
y3	392.2657	392.2647	2.5
y2	293.1973	293.1969	1.3
y1	165.1023	165.1021	1.2
a1	495.2408	495.2401	1.4
a2	623.3358	623.3349	1.4
a3	680.3573	680.3570	0.4
a4	779.4257	779.4262	0.6
a6	1053.6050	1053.6038	1.1
z4	432.2617	432.2618	0.2
z3	375.2402	375.2405	0.8
z2	276.1718	276.1722	1.4
z1	148.0769	148.0766	2.0
c4	824.4471	824.4463	1.0

Figure S5. On-resin Trp(C7) arylation of peptide **P1**. Product **P3ai** was purified by a Welch C18 reverse-phase column with mobile phase of water-acetonitrile-(0.1% formic acid) at a flow rate of 4.0 mL/min. Gradient conditions: isocratic 2% acetonitrile for 5 min, 2-90% acetonitrile in 35 min, isocratic 90% for 15 min, then 90-2% acetonitrile in 5 min). Signal was monitored at 254 nm UV.

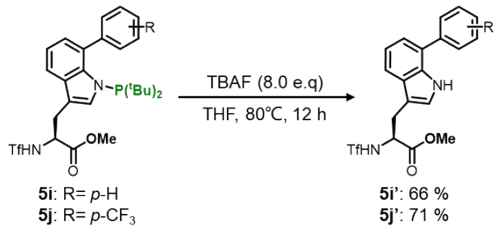


Figure S6. Removal of the di-*tert*-butylphosphine group with TBAF. Conditions: **5i**/**5j** (0.2 mmol), TBAF (1.2 mL, 1.2 mmol, 1.0 M in THF), anhydrous THF (4.0 mL), at 80 °C under Ar atmosphere for 12 h. Isolated yields are reported.

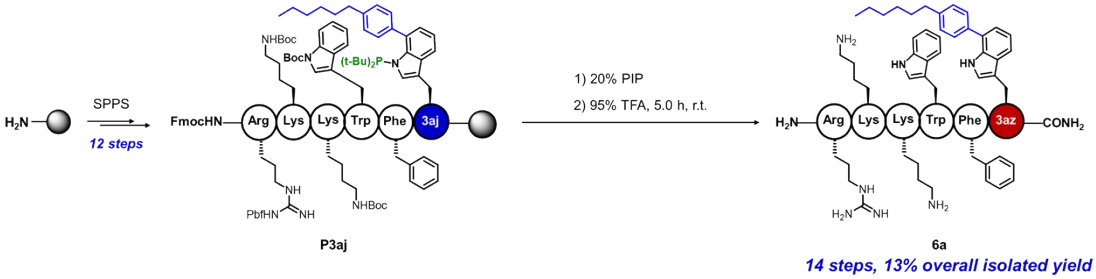


Figure S7. Removal of the di-*tert*-butylphosphine group with TFA. Conditions: **P3aj** (0.02 mmol), TFA cleavage cocktail (TFA/TIPS/H_2O= 95/2.5/2.5, v/v/v), at 30 °C for 5 h. Isolated yields are reported. The crude residue was purified by a Welch C18 reverse-phase column to compound **6a** (2.9 mg, 13%) as a white solid powder after lyophilization. Gradient conditions: isocratic 2% acetonitrile for 5 min, 2-90% acetonitrile in 30 min, isocratic 90% for 5 min, then 90-2% acetonitrile in 5 min.

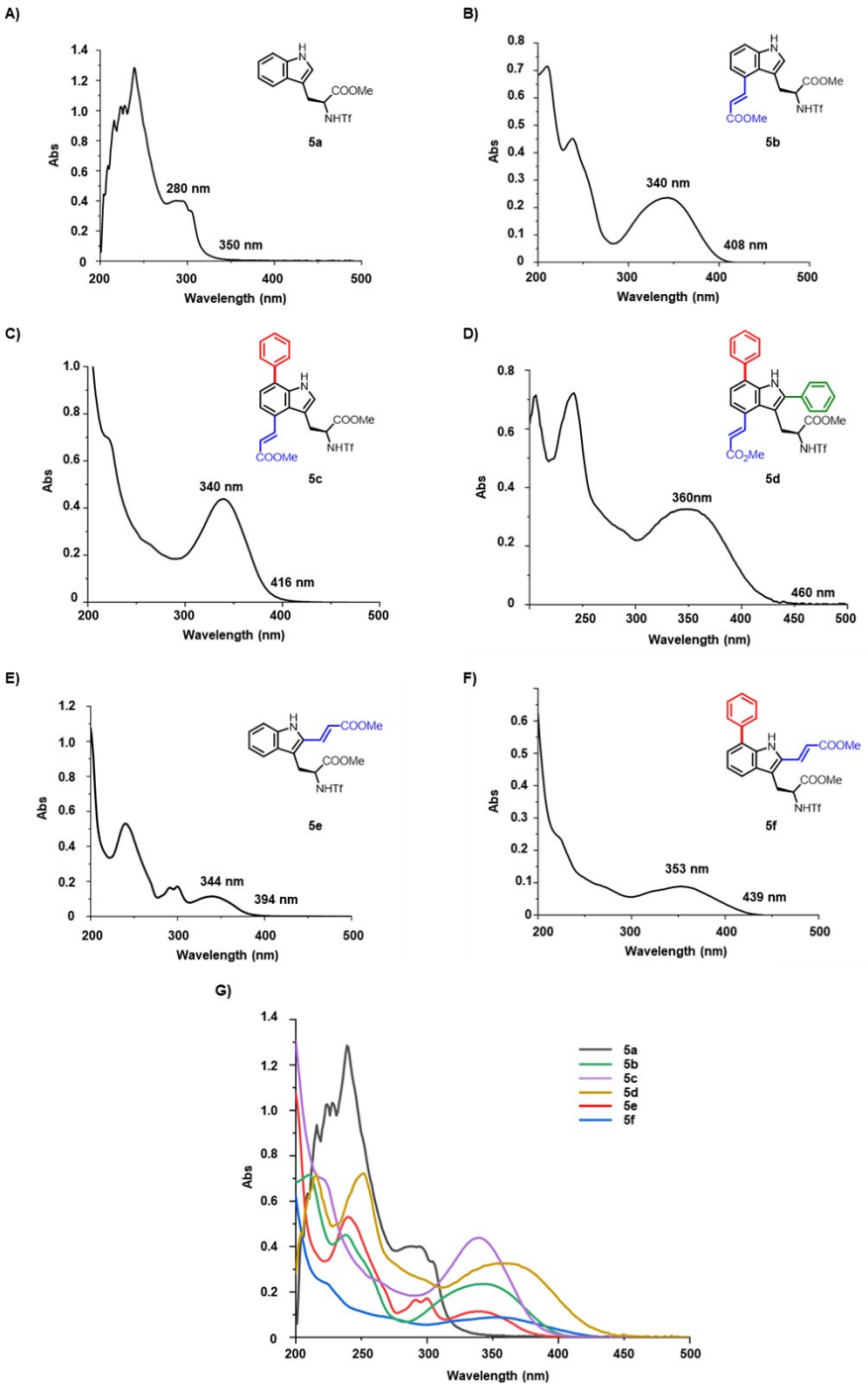


Figure S8. UV-Vis absorption spectra of **5a**- **5f**. A) UV-Vis absorption spectra of **5a** (10 μM) in MeCN; B) UV-Vis absorption spectra of **5b** (10 μM) in MeCN; C) UV-Vis absorption spectra of **5c** (10 μM) in MeCN; D) UV-Vis absorption spectra of **5d** (5 μM) in MeCN; E) UV-Vis absorption spectra of **5e** (10 μM) in MeCN; F) UV-Vis absorption spectra of **5f** (10 μM) in MeCN; G) Overlapped UV-Vis absorption spectra of **5a**- **5f**.

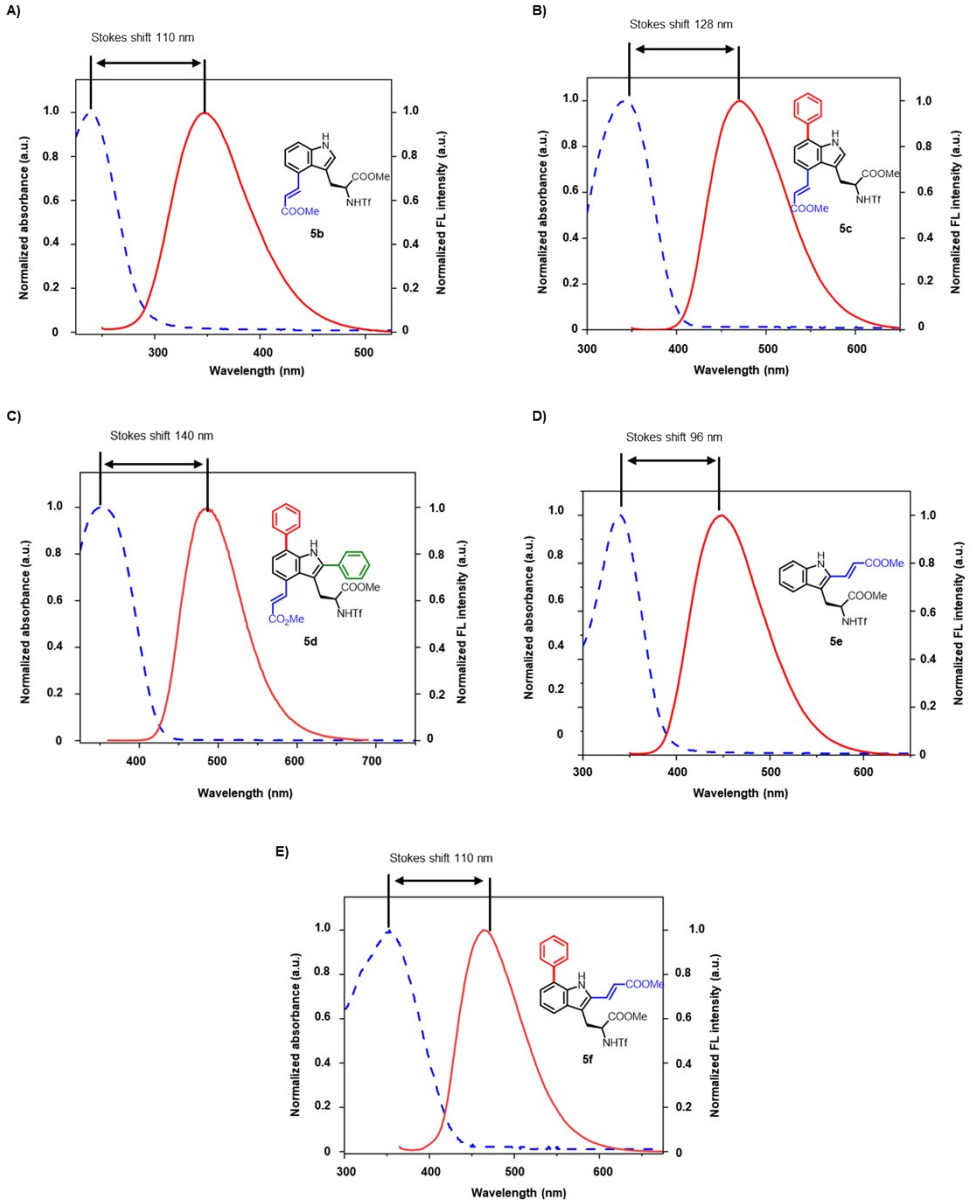


Figure S9. UV-Vis absorption spectra (blue line) and fluorescence emission spectra (red line) of **5b**–**5f** in MeCN. Fluorescence measurements were performed at 10 μM for **5b**, **5c**, **5e**, and **5f** (excitation at 350 nm) and 5 μM for **5d** (excitation at 375 nm).

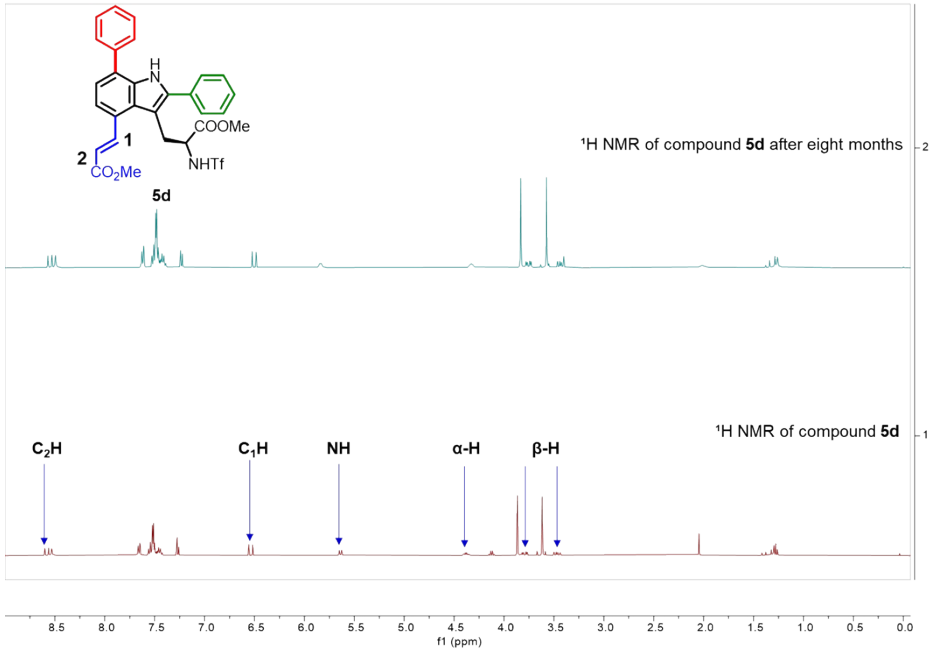


Figure S10. Comparison of the ^{1}H NMR spectra of compound **5d** before and after eight months of storage at room temperature.

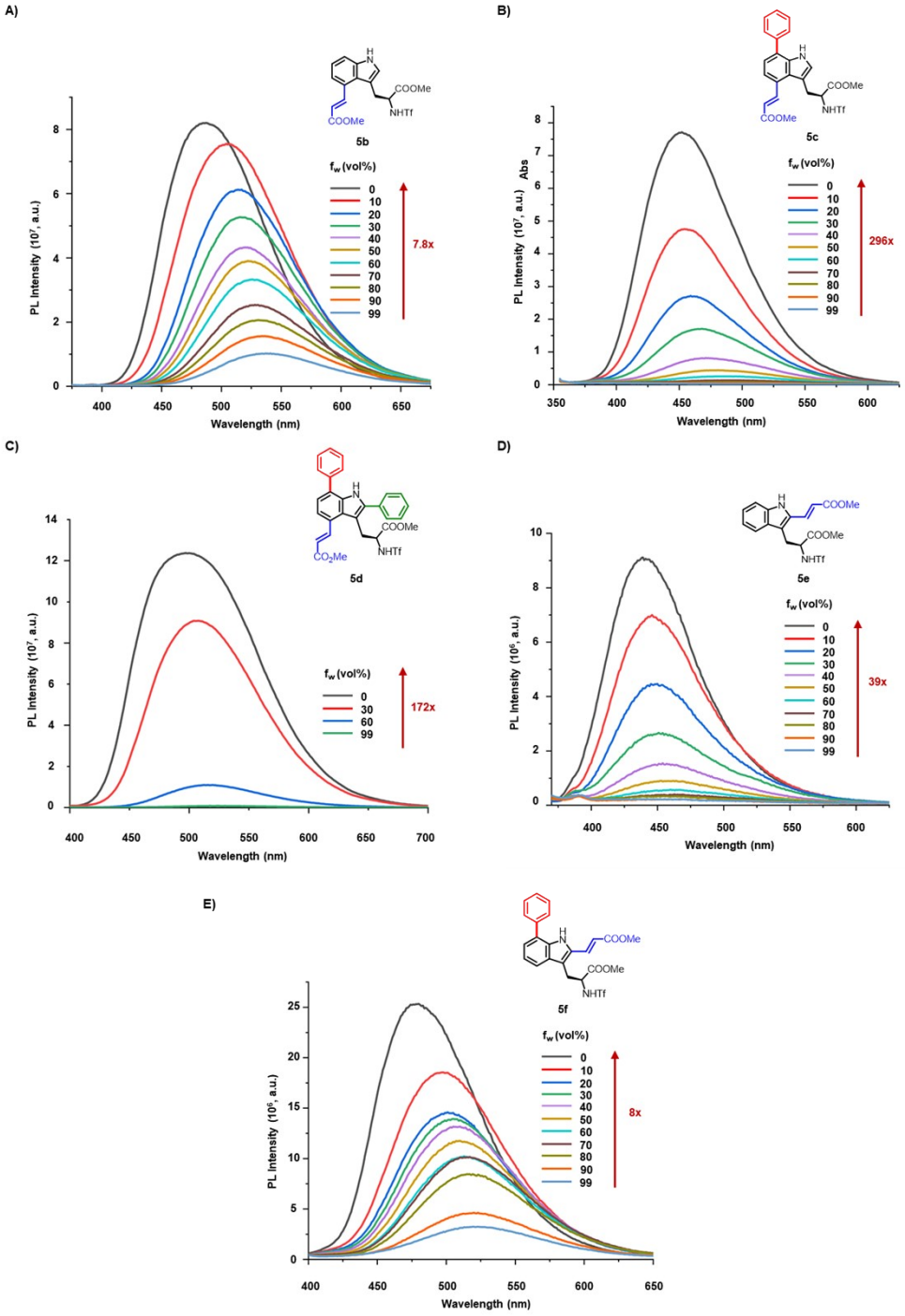


Figure S11. Fluorescence-fold increase ratios of **5b**–**5f** in H_2O/ dioxane mixtures (ranging from 9.9/0.1 to 0:10, v/v). Measurements were performed at 10 μM for **5b**, **5c**, **5e**, and **5f** (excitation at 350 nm) and 5 μM for **5d** (excitation at 375 nm).

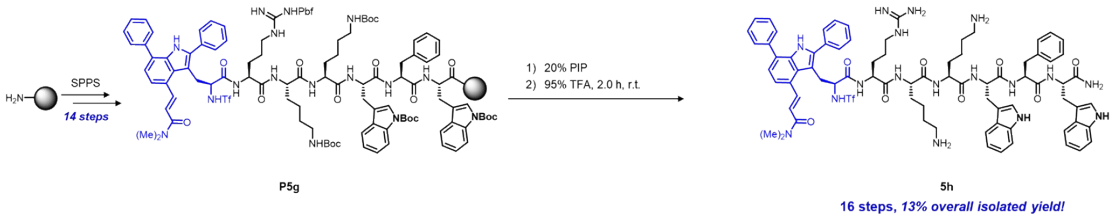


Figure S12. Synthetic the peptide dye **5h**. Product **5h** was purified by a Welch C18 reverse-phase column to compound **5h** (3.9 mg, 13%) as a yellow solid powder after lyophilization. Gradient conditions: isocratic 2% acetonitrile for 5 min, 2-90% acetonitrile in 30 min, isocratic 90% for 5 min, then 90-2% acetonitrile in 5 min. HPLC-MS: t_R: 13.8 min (>99% purity). LRMS (ESI+) m/z calcd. for $C_{78}H_{92}F_3N_{17}O_{10}S$, $[M+H]^+$: 1517.77; found: 1517.30. $[M+2H]^{2+}$: 759.39; found: 759.05. $[M+3H]^{3+}$: 506.59; found: 506.64.

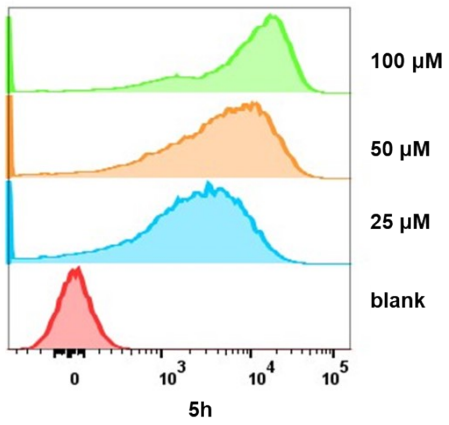
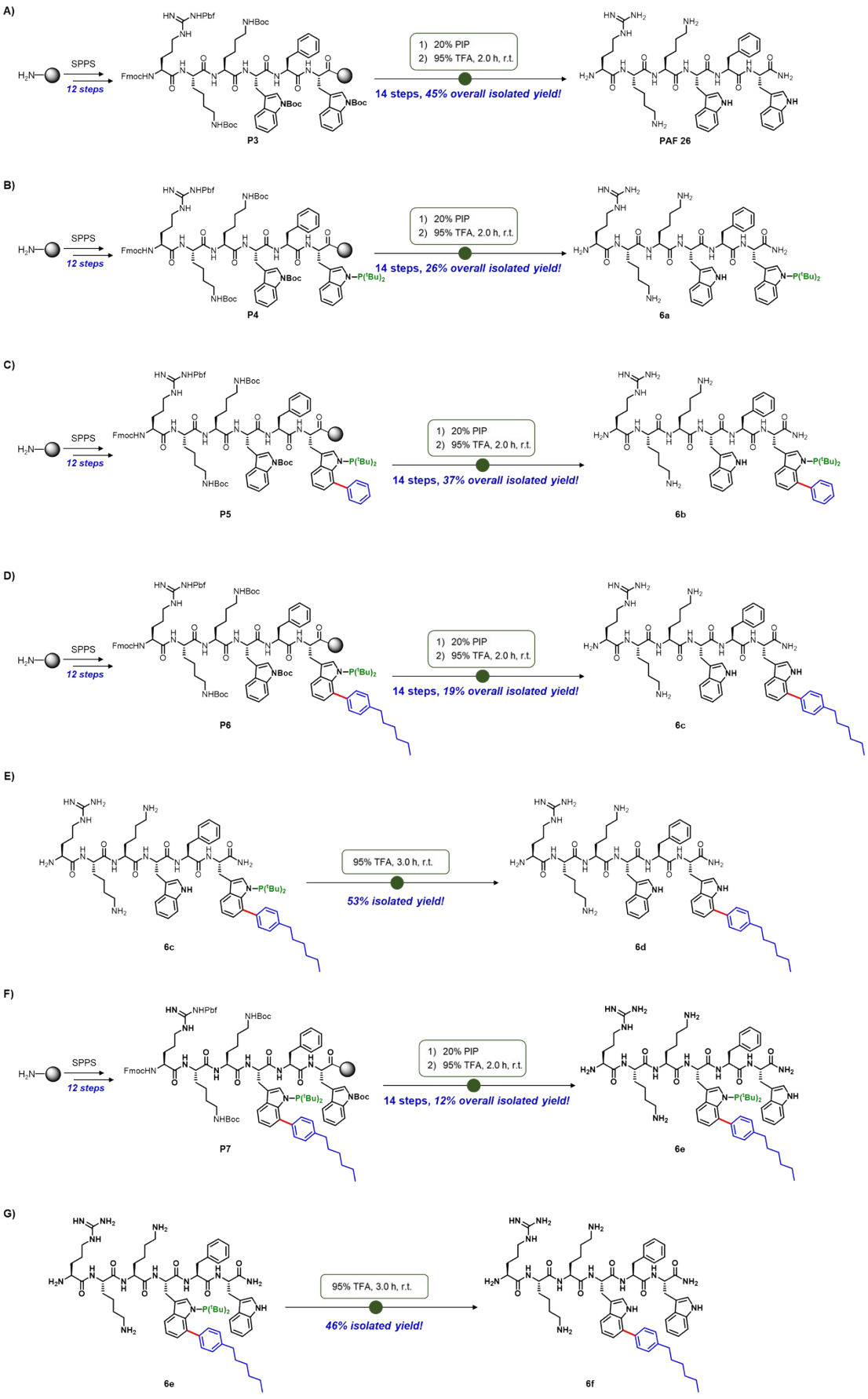
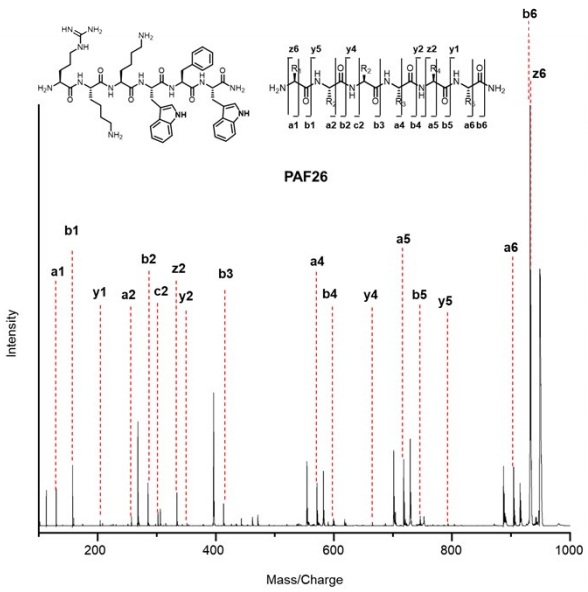


Figure S13. Flow cytometry analysis of *E. coli* treated with the peptide **5h** at concentrations of 0, 25, 50, and 100 μM.

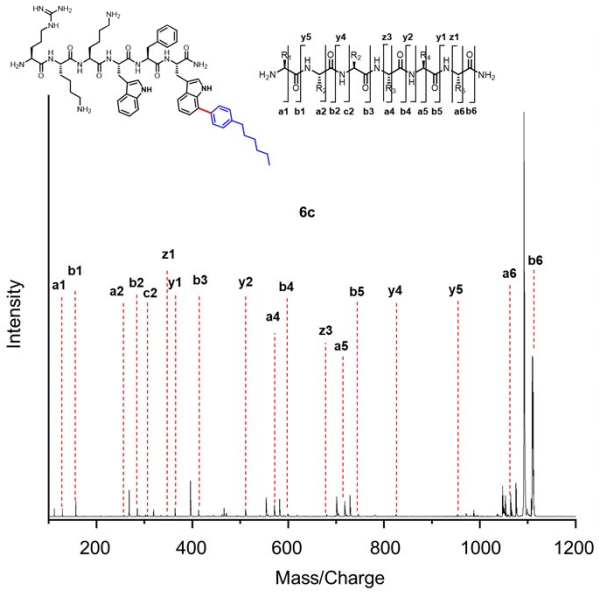

A)
SPPS
12 steps
P3
1) 20% PIP
2) 95% TFA, 2.0 h, r.t.
14 steps, 45% overall isolated yield!
PAF 26
B)
SPPS
12 steps
P4
1) 20% PIP
2) 95% TFA, 2.0 h, r.t.
14 steps, 26% overall isolated yield!
6a
C)
SPPS
12 steps
P5
1) 20% PIP
2) 95% TFA, 2.0 h, r.t.
14 steps, 37% overall isolated yield!
6b
D)
SPPS
12 steps
P6
1) 20% PIP
2) 95% TFA, 2.0 h, r.t.
14 steps, 19% overall isolated yield!
6c
E)
6c
95% TFA, 3.0 h, r.t.
53% isolated yield!
6d
F)
SPPS
12 steps
P7
1) 20% PIP
2) 95% TFA, 2.0 h, r.t.
14 steps, 12% overall isolated yield!
6e
G)
6e
95% TFA, 3.0 h, r.t.
46% isolated yield!
6f

H)



Species	Predicted mass/Da	Observed mass/Da	Error/ ppm
b1	157.1084	157.1085	0.6
b2	285.2034	285.2038	1.4
b3	413.2984	413.2983	0.2
b4	599.3777	599.3771	1.0
b5	746.4461	746.4459	0.3
b6	931.5414	931.5410	0.4
y5	793.4509	793.4517	1.0
y4	665.3559	665.3567	1.2
y2	351.1816	351.1829	3.7
y1	204.1132	204.1134	1.0
a1	129.1135	129.1134	0.8
a2	257.2085	257.2081	1.6
a4	571.3828	571.3819	1.6
a5	718.4512	718.4501	1.5
a6	903.5465	903.5460	0.6
z6	932.5266	932.5261	0.5
z2	334.1562	334.1566	1.2
c2	302.2300	302.2304	1.3

I)

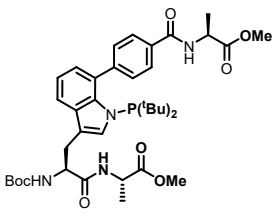


Species	Predicted mass/Da	Observed mass/Da	Error/ ppm
b1	157.1084	157.1082	1.2
b2	285.2034	285.2031	1.1
b3	413.2984	413.2991	1.7
b4	599.3777	599.3774	0.5
b5	746.4461	746.4465	0.5
b6	1091.6666	1091.6657	0.8
y5	953.5761	953.5755	0.6
y4	825.4811	825.4826	1.8
y2	511.3068	511.3062	1.2
y1	364.2384	364.2384	0
a1	129.1135	129.1132	2.3
a2	257.2085	257.2084	0.4
a4	571.3828	571.3824	0.7
a5	718.4512	718.4501	1.5
a6	1063.6717	1063.6719	0.2
Z3	680.3607	680.3594	1.9
z1	347.2130	347.2125	1.4
c2	302.2299	302.2287	4.0

Figure S14. The peptide **PAF26** and its derivatives (**6a**–**6f**) were synthesized and purified using a Welch C18 reverse-phase column to yield white solid powders after lyophilization. Gradient conditions: isocratic 2% acetonitrile for 5 min, 2-90% acetonitrile in 30 min, isocratic 90% for 5 min, then 90-2% acetonitrile in 5 min. A) **PAF26** was obtained in 31% yield (5.8 mg), HPLC-MS: t_R: 12.5 min (>99% purity). LR-MS (ESI+) m/z calcd. for $C_{49}H_{68}N_{14}O_6P$, $[M+H]^+$: 949.55; found: 949.80. $[M-H]^-$: 947.54; found: 947.75. B) **6a** was obtained in 26% yield (5.7 mg), HPLC-MS: t_R: 20.5 min (>99% purity). LR-MS (ESI+) m/z calcd. for $C_{57}H_{85}N_{14}O_6P$, $[M+H]^+$: 1093.66; found: 1093.72. $[M+2H]^{2+}$: 547.33; found: 547.43. $[M+3H]^{3+}$: 365.22; found: 365.30. C) **6b** was obtained in 37% yield (8.6 mg), HPLC-MS: t_R: 21.1 min (>99% purity). LR-MS (ESI+) m/z calcd. for $C_{63}H_{89}N_{14}O_6P$, $[M+H]^+$: 1169.69; found: 1169.82. $[M+2H]^{2+}$: 585.35; found: 585.46. $[M+3H]^{3+}$: 390.57; found: 390.71. D) **6c** was obtained in 13% yield (2.9 mg), HPLC-MS: t_R: 21.9 min (>99% purity). LR-MS (ESI+) m/z calcd. for $C_{61}H_{84}N_{14}O_6$, $[M+H]^+$: 1109.68; found: 1109.95. $[M+2H]^{2+}$: 555.35; found: 555.80. $[M+3H]^{3+}$: 370.56; found: 370.80. E) **6d** was obtained in 28% yield (7.0 mg), HPLC-MS: t_R: 23.8 min (>99% purity). LR-MS (ESI+) m/z calcd. for $C_{69}H_{101}N_{14}O_6P$, $[M+H]^+$: 1253.78; found: 1254.20. $[M+2H]^{2+}$: 627.40; found: 627.95; $[M+3H]^{3+}$: 418.60; found: 418.90. F) **6e** was obtained in 8% yield (1.8 mg), HPLC-MS: t_R: 20.0 min (>99% purity). LR-MS (ESI+) m/z calcd. for $C_{61}H_{84}N_{14}O_6$, $[M+H]^+$: 1109.68; found: 1110.00. $[M+2H]^{2+}$: 555.35; found: 555.75. $[M+3H]^{3+}$: 370.56; found: 370.85. G) **6f** was obtained in 25% yield (6.2 mg), HPLC-MS: t_R: 30.1 min (>99% purity). LR-MS (ESI+) m/z calcd. for $C_{69}H_{101}N_{14}O_6P$, $[M+H]^+$: 1253.78; found: 1254.20. $[M+2H]^{2+}$: 626.90; found: 627.90. $[M+3H]^{3+}$: 418.60; found: 418.95. H) MS/MS analysis of **PAF26**. I) MS/MS analysis of **6c**.

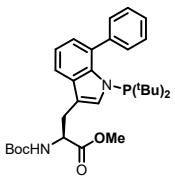
4. Spectra data

Compound 3**aa**



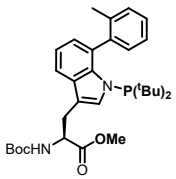
According to the general procedure C, the crude residue was purified by flash column chromatography on silica gel (petroleum ether: ethyl acetate =2:1; R_f = 0.25) to compound **3aa** ^{1}H NMR (400 MHz, Chloroform-*d*) δ 7.80 (d, *J* = 8.3 Hz, 2H), 7.58 (dt, *J* = 7.9, 1.4 Hz, 1H), 7.35 (d, *J* = 8.1 Hz, 2H), 7.29 (s, 1H), 7.12 (t, *J* = 7.5 Hz, 1H), 6.94 – 6.84 (m, 2H), 6.63 – 6.53 (m, 1H), 5.15 (s, 1H), 4.85 (p, *J* = 7.2 Hz, 1H), 4.46 (p, *J* = 7.0 Hz, 2H), 3.80 (s, 3H), 3.67 (s, 3H), 3.27 (d, *J* = 6.5 Hz, 2H), 1.55 (d, *J* = 7.2 Hz, 3H), 1.41 (s, 9H), 1.31 (d, *J* = 7.1 Hz, 3H), 0.98 (dd, *J* = 12.4, 10.9 Hz, 18H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 174.0, 173.0, 171.2, 166.9, 155.5, 146.6, 140.7, 132.1, 131.5, 131.0, 130.0, 128.1, 126.1, 125.7, 119.7, 118.3, 113.3, 113.3, 80.2, 55.0, 52.7, 52.5, 48.6, 48.2, 36.02, 35.99, 35.70, 35.67, 29.6, 29.5, 29.44, 29.36, 28.4, 18.8, 18.5. ^{31}P NMR (162 MHz, $CDCl_3$) δ 73.9. HRMS (ESI) $[M+Na]^+$ m/z calcd for $C_{39}H_{55}N_4O_8PNa$ 761.3655, found 761.3658.

Compound **3ab**



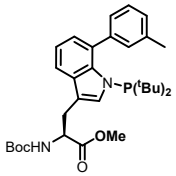
According to the general procedure C, the crude residue was purified by flash column chromatography on silica gel (petroleum ether: ethyl acetate = 10:1; R_f = 0.25) to compound **3ab**. ^{1}H NMR (500 MHz, Chloroform-*d*) δ 7.55 (d, *J* = 7.6 Hz, 1H), 7.36 – 7.35 (m, 3H), 7.29 – 7.17 (m, 3H), 7.26 (s, 1H), 7.17 (t, *J* = 7.5 Hz, 1H), 7.03 (d, *J* = 7.1 Hz, 1H), 5.15 (d, *J* = 8.1 Hz, 1H), 4.73 – 4.70 (m, 1H), 3.70 (s, 3H), 3.38 (dd, *J* = 14.7, 5.6 Hz, 1H), 3.32 (dd, *J* = 14.8, 5.5 Hz, 1H), 1.47 (s, 9H), 1.04 (d, *J* = 5.0 Hz, 9H), 1.02 (d, *J* = 4.9 Hz, 9H). ^{13}C NMR (126 MHz, $CDCl_3$) δ 172.8, 155.2, 142.4, 140.9, 131.2, 130.9, 130.8, 129.9, 129.4, 127.3, 126.9, 125.8, 119.6, 117.7, 112.7, 79.9, 54.1, 52.4, 35.6, 31.6, 29.6, 29.4, 28.5. ^{31}P NMR (202 MHz, $CDCl_3$) δ 71.4. HRMS (ESI) $[M+Na]^+$ m/z calcd for $C_{31}H_{43}N_2O_4PNa$ 561.2858, found 561.2859.

Compound **3ac**



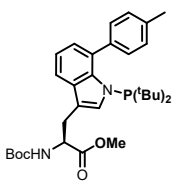
According to the general procedure C, the crude residue was purified by flash column chromatography on silica gel (petroleum ether: ethyl acetate = 10:1; R_f = 0.25) to compound **3ac**. ^{1}H NMR (500 MHz, Chloroform-*d*) δ 7.60 (d, *J* = 7.5 Hz, 1H), 7.33 – 7.27 (m, 2H), 7.20 (t, *J* = 7.4 Hz, 1H), 7.18 – 7.14 (m, 2H), 7.00 (d, *J* = 7.9 Hz, 1H), 7.00 – 6.96 (m, 1H), 5.10 (d, *J* = 8.1 Hz, 1H), 4.69 – 4.54 (m, 1H), 3.63 (s, 3H), 3.33 (dd, *J* = 14.7, 5.8 Hz, 1H), 3.26 (dd, *J* = 14.7, 5.5 Hz, 1H), 2.82 (s, 3H), 1.43 (s, 9H), 0.93 (d, *J* = 4.6 Hz, 9H), 0.90 (d, *J* = 4.6 Hz, 9H). ^{13}C NMR (126 MHz, $CDCl_3$) δ 172.7, 155.2, 140.4, 139.4, 132.4, 132.0, 131.6, 130.02, 129.95, 125.3, 123.2, 119.8, 119.8, 114.0, 80.0, 54.0, 52.4, 31.7, 29.1, 29.0, 28.5, 22.3. ^{31}P NMR (162 MHz, $CDCl_3$) δ 74.6. HRMS (ESI) $[M+Na]^+$ m/z calcd for $C_{32}H_{45}N_2O_4PNa$ 575.3015, found 575.3014.

Compound **3ad**



According to the general procedure C, the crude residue was purified by flash column chromatography on silica gel (petroleum ether: ethyl acetate = 10:1; R_f = 0.25) to compound **3ad**. ^{1}H NMR (500 MHz, Chloroform-*d*) δ 7.83 (dd, *J* = 8.4, 2.5 Hz, 1H), 7.76 – 7.69 (m, 1H), 7.50 (d, *J* = 7.9 Hz, 1H), 7.42 – 7.34 (m, 2H), 7.24 (s, 1H), 7.21 – 7.18 (m, 1H), 7.09 – 7.07 (t, *J* = 7.4 Hz, 1H), 5.09 (d, *J* = 8.3 Hz, 1H), 4.71 – 4.67 (m, 1H), 3.64 (s, 3H), 3.38 – 3.28 (m, 2H), 1.43 (s, 9H), 1.22 (s, 9H), 1.18 (s, 9H). ^{13}C NMR (126 MHz, $CDCl_3$) δ 172.7, 155.2, 144.3, 134.9, 130.2, 129.4, 129.3, 128.7, 128.3, 122.2, 120.1, 118.4, 113.3, 113.4, 113.0, 79.9, 54.2, 52.4, 29.4, 35.1, 29.2, 28.5. ^{31}P NMR (162 MHz, $CDCl_3$) δ 71.0. HRMS (ESI) $[M+Na]^+$ m/z calcd for $C_{32}H_{45}N_2O_4PNa$ 575.3015, found 575.3012.

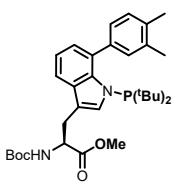
Compound **3ae**



According to the general procedure C, the crude residue was purified by flash column chromatography on silica gel (petroleum ether: ethyl

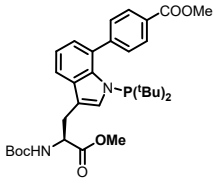
acetate = 10:1; R_f = 0.25) to compound **3ae**. ^{1}H NMR (400 MHz, Chloroform-*d*) δ 7.51 (d, *J* = 7.8 Hz, 1H), 7.23 (s, 1H), 7.23 – 7.13 (m, 5H), 6.99 (d, *J* = 6.7 Hz, 1H), 5.12 (d, *J* = 8.1 Hz, 1H), 3.38 – 3.26 (m, 1H), 3.68 (s, 3H), 3.35 (dd, *J* = 14.7, 5.6 Hz, 1H), 3.29 (dd, *J* = 14.7, 5.4 Hz, 1H), 2.43 (s, 3H), 1.44 (s, 9H), 1.03 (d, *J* = 4.3 Hz, 9H), 1.00 (d, *J* = 4.3 Hz, 9H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 172.8, 155.2, 139.4, 136.4, 133.4, 131.2, 130.7, 130.6, 130.0, 128.4, 128.0, 126.4, 126.0, 119.6, 117.6, 112.6, 79.9, 54.1, 52.4, 35.9, 35.7, 29.6, 29.4, 28.5, 21.5. ^{31}P NMR (162 MHz, $CDCl_3$) δ 74.0. HRMS (ESI) $[M+Na]^+$ m/z calcd for $C_{32}H_{45}N_2O_4PNa$ 575.3015, found 575.3012.

Compound **3af**



According to the general procedure C, the crude residue was purified by flash column chromatography on silica gel (petroleum ether: ethyl acetate = 10:1; R_f = 0.25) to compound **3af**. ^{1}H NMR (400 MHz, Chloroform-*d*) δ 7.50 (d, *J* = 7.6 Hz, 1H), 7.23 (s, 1H), 7.17 – 7.10 (m, 2H), 7.05 (s, 1H), 7.02 – 6.96 (m, 2H), 5.12 (d, *J* = 8.2 Hz, 1H), 4.71 – 4.65 (m, 1H), 3.68 (s, 3H), 3.37 – 3.26 (m, 2H), 2.35 (s, 3H), 2.28 (s, 3H), 1.44 (s, 9H), 1.05 – 0.94 (m, 18H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 172.8, 155.2, 139.7, 139.6, 135.0, 134.9, 132.5, 132.4, 131.2, 131.1, 128.8, 127.92, 127.86, 125.8, 119.6, 117.5, 112.6, 79.9, 54.1, 52.4, 35.9, 35.6, 29.6, 29.5, 28.5, 19.8, 19.7. ^{31}P NMR (162 MHz, $CDCl_3$) δ 74.3. HRMS (ESI) $[M+Na]^+$ m/z calcd for $C_{33}H_{47}N_2O_4PNa$ 589.3171, found 589.3173.

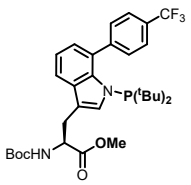
Compound **3ag**



According to the general procedure C, the crude residue was purified by flash column chromatography on silica gel (petroleum ether: ethyl acetate = 6:1; R_f = 0.3) to compound **3ag**. ^{1}H NMR (400 MHz, Chloroform-*d*) δ 7 8.03 (d, *J* = 8.2 Hz, 2H), 7.54 (d, *J* = 7.8 Hz, 1H), 7.35 (d, *J* = 8.0 Hz, 2H), 7.24 (s, 1H), 7.15 (t, *J* = 7.5 Hz, 1H), 6.95 (dd, *J* = 7.3, 1.2 Hz, 1H), 5.13 (d, *J* = 8.1 Hz, 1H), 4.74 – 4.63 (m, 1H), 3.96 (s, 3H), 3.68 (s, 3H), 3.36 (dd, *J* = 14.7, 5.6 Hz, 1H), 3.29 (dd, *J* = 14.7, 5.5 Hz, 1H), 1.44 (s, 9H), 1.02 (d, *J* = 4.1 Hz, 9H), 0.99 (d, *J* = 4.1 Hz, 9H). ^{13}C NMR (126 MHz, $CDCl_3$) δ 172.7, 167.6, 155.2, 147.8, 140.5, 131.3, 131.2, 130.91, 130.85, 130.1, 128.7, 128.5, 128.3, 125.5, 119.7,

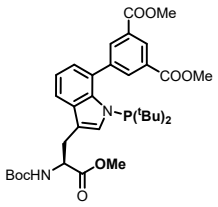
118.3, 112.9, 80.0, 54.1, 52.4, 52.2, 36.0, 35.7, 29.6, 29.4, 28.5. ^{31}P NMR (162 MHz, $CDCl_3$) δ 74.6. HRMS (ESI) $[M+H]^+$ m/z calcd for $C_{33}H_{46}N_2O_6P$ 597.3093, found 597.3095.

Compound **3ah**



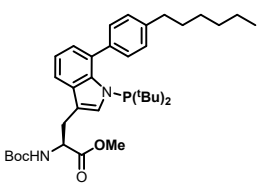
According to the general procedure C, the crude residue was purified by flash column chromatography on silica gel (petroleum ether: ethyl acetate = 10:1; R_f = 0.25) to compound **3ah**. ^{1}H NMR (400 MHz, Chloroform-*d*) δ 7.61 (d, *J* = 8.0 Hz, 2H), 7.56 (d, *J* = 7.9 Hz, 1H), 7.39 (d, *J* = 8.0 Hz, 3H), 7.24 (s, 1H), 7.17 (t, *J* = 7.6 Hz, 1H), 6.98 (d, *J* = 7.0 Hz, 1H), 5.13 (d, *J* = 8.0 Hz, 1H), 4.70 (dt, *J* = 8.2, 5.5 Hz, 1H), 3.68 (s, 3H), 3.37 (dd, *J* = 14.8, 5.6 Hz, 1H), 3.31 (dd, *J* = 14.8, 5.6 Hz, 1H), 1.44 (s, 9H), 1.02 (d, *J* = 3.7 Hz, 9H), 0.99 (d, *J* = 3.7 Hz, 9H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 172.7, 155.2, 146.4, 140.6, 131.2, 131.10, 130.09, 129.7, 129.4, 129.1, 127.8, 125.4, 124.3, 119.7, 118.4, 113.0, 80.0, 54.1, 52.4, 36.0, 35.6, 29.6, 29.4, 28.5. ^{31}P NMR (162 MHz, $CDCl_3$) δ 74.0. HRMS (ESI) $[M+Na]^+$ m/z calcd for $C_{32}H_{42}F_3N_2O_4PNa$ 629.2732, found 629.2733.

Compound **3ai**



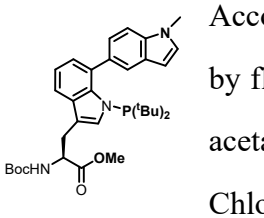
According to the general procedure C, the crude residue was purified by flash column chromatography on silica gel (petroleum ether: ethyl acetate = 5:1; R_f = 0.3) to compound **3ai**. ^{1}H NMR (400 MHz, Chloroform-*d*) δ 8.69 (t, *J* = 1.7 Hz, 1H), 8.17 (t, *J* = 1.3 Hz, 2H), 7.57 (d, *J* = 7.7 Hz, 1H), 7.23 (s, 1H), 7.17 (t, *J* = 7.6 Hz, 1H), 6.99 (d, *J* = 7.0 Hz, 1H), 5.14 – 5.12 (m, 1H), 4.71 – 4.66 (m, 1H), 3.93 (s, 6H), 3.67 (s, 3H), 3.36 (dd, *J* = 14.7, 5.6 Hz, 1H), 3.29 (dd, *J* = 14.7, 5.4 Hz, 1H), 1.43 (s, 9H), 0.98 (dd, *J* = 12.6, 3.8 Hz, 18H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 172.7, 166.6, 155.2, 143.0, 140.6, 136.4, 136.3, 132.4, 131.3, 130.2, 129.5, 129.3, 127.0, 125.9, 119.9, 118.6, 112.9, 79.9, 54.1, 52.4, 52.3, 36.0, 35.7, 29.5, 28.5. ^{31}P NMR (162 MHz, $CDCl_3$) δ 73.7. HRMS (ESI) $[M+H]^+$ m/z calcd for $C_{35}H_{48}N_2O_8P$ 655.3148, found 655.3139.

Compound **3aj**



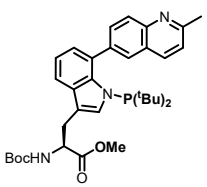
According to the general procedure C, the crude residue was purified by flash column chromatography on silica gel (petroleum ether: ethyl acetate = 10:1; R_f = 0.25) to compound **3aj**. ^{1}H NMR (500 MHz, Chloroform-*d*) 7.51 (d, *J* = 7.7 Hz, 1H), 7.22 (s, 1H), 7.16 – 7.12 (m, 5H), 7.02 (d, *J* = 7.2 Hz, 1H), 5.12 (d, *J* = 8.1 Hz, 1H), 4.71 – 4.66 (m, 1H), 3.68 (s, 3H), 3.35 (dd, *J* = 14.6, 5.4 Hz, 1H), 3.28 (dd, *J* = 15.0, 5.4 Hz, 1H), 2.68 (t, *J* = 7.4 Hz, 2H), 1.71 – 1.63 (m, *J* = 7.0 Hz, 2), 1.44 (s, 9H), 1.41 – 1.23 (m, 9H), 1.02 (d, *J* = 4.1 Hz, 9H), 0.99 (d, *J* = 4.1 Hz, 9H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 172.8, 155.2, 141.6, 141.2, 139.5, 131.14, 131.08, 130.7, 130.6, 129.8, 129.5, 127.5, 125.7, 119.6, 117.6, 112.6, 79.9, 54.1, 52.4, 36.0, 35.8, 35.6, 32.0, 29.6, 29.5, 28.8, 28.5, 22.8, 14.3. ^{31}P NMR (162 MHz, $CDCl_3$) δ 71.4. HRMS (ESI) $[M+Na]^+$ m/z calcd for $C_{37}H_{55}N_2O_4PNa$ 645.3797, found 645.3792.

Compound **3ak**



According to the general procedure C, the crude residue was purified by flash column chromatography on silica gel (petroleum ether: ethyl acetate = 8:1; R_f = 0.3) to compound **3ak**. ^{1}H NMR (500 MHz, Chloroform-*d*) δ 7.58 (d, *J* = 8.0 Hz, 1H), 7.53 (d, *J* = 7.7 Hz, 1H), 7.25 (s, 1H), 7.22 (s, 1H), 7.17 (t, *J* = 7.5 Hz, 1H), 7.10 (m, 1H), 7.07 (d, *J* = 3.1 Hz, 1H), 7.06 – 7.02 (m, 1H), 6.53 (dd, *J* = 3.2, 0.8 Hz, 1H), 5.15 (d, *J* = 8.1 Hz, 1H), 4.73 – 4.69 (m, 1H), 3.76 (s, 3H), 3.70 (s, 3H), 3.35 (qd, *J* = 14.7, 5.5 Hz, 2H), 1.46 (s, 9H), 1.03 – 0.93 (m, 18H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 172.8, 155.2, 141.3, 136.7, 135.7, 131.3, 131.2, 130.5, 129.9, 128.7, 127.6, 126.3, 123.1, 119.6, 117.4, 112.6, 111.5, 100.9, 79.9, 54.1, 52.4, 35.9, 35.5, 32.9, 29.6, 29.4, 28.5. ^{31}P NMR (162 MHz, $CDCl_3$) δ 74.3. HRMS (ESI) $[M+H]^+$ m/z calcd for $C_{34}H_{47}N_3O_4P$ 592.3304, found 592.3297.

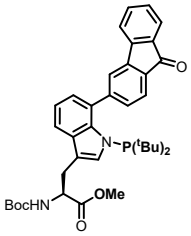
Compound **3al**



According to the general procedure C, the crude residue was purified by flash column chromatography on silica gel (petroleum ether: ethyl acetate = 4:1; R_f = 0.25) to compound **3al**. ^{1}H NMR (500 MHz, Chloroform-*d*) δ 8.00 (m, 2H), 7.64 (m, 2H), 7.57 (d, *J* = 7.9 Hz, 1H),

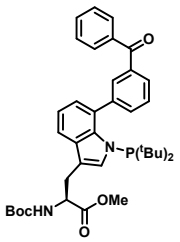
7.30 (d, *J* = 8.4 Hz, 1H), 7.26 (d, *J* = 6.8 Hz, 1H), 7.18 (t, *J* = 7.5 Hz, 1H), 7.06 (d, *J* = 7.2 Hz, 1H), 5.15 (d, *J* = 8.1 Hz, 1H), 4.73 – 4.68 (m, 1H), 3.69 (s, 3H), 3.38 (dd, *J* = 14.7, 5.6 Hz, 1H), 3.31 (dd, *J* = 14.7, 5.4 Hz, 1H), 2.79 (s, 3H), 1.44 (s, 9H), 1.06 – 0.86 (m, 18H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 172.7, 158.6, 155.2, 147.3, 140.9, 140.1, 136.2, 133.6, 133.5, 131.3, 131.2, 130.0, 128.5, 128.4, 127.0, 126.1, 122.2, 119.7, 118.1, 112.8, 79.9, 54.0, 52.4,35.9, 35.6, 29.4, 28.5, 25.5. ^{31}P NMR (162 MHz, $CDCl_3$) δ 73.5. HRMS (ESI) $[M+H]^+$ m/z calcd for $C_{35}H_{47}N_3O_4P$ 604.3304, found 604.3308.

Compound **3am**



According to the general procedure C, the crude residue was purified by flash column chromatography on silica gel (petroleum ether: ethyl acetate = 6:1; R_f = 0.3) to compound **3am**. ^{1}H NMR (400 MHz, Chloroform-*d*) δ 7.67 (d, *J* = 7.3 Hz, 0.5H), 7.61 – 7.58 (m, 2.5H), 7.57 – 7.48 (m, 5.5H), 7.38 – 7.36 (m, 1H), 7.37 (dd, *J* = 7.5, 1.6 Hz, 0.5H), 7.31 (t, *J* = 7.4 Hz, 0.5H), 7.26 – 7.20 (m, 4H), 7.16 (t, *J* = 7.6 Hz, 0.5H), 7.12 (d, *J* = 7.2 Hz, 1H), 6.99 (d, *J* = 7.5 Hz, 0.5H), 5.19 – 5.13 (m, 1.5H), 4.74 – 4.68 (m, 1.5H), 3.71 (s, 3H), 3.67 (s, 1.5H), 3.40 – 3.19 (m, 3H), 1.44 (d, *J* = 2.5 Hz, 13H), 1.16 – 1.13 (m, 18H), 1.03 – 0.96 (m, 9H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 194.2, 172.7, 155.2, 144.9, 143.8, 143.0, 136.6, 134.7, 133.3, 131.33, 131.27, 130.2, 128.9, 127.9, 127.43, 127.36, 125.7, 124.4, 120.4, 119.9, 119.4, 118.4, 113.0, 80.0, 54.1, 52.4, 36.1, 35.8, 29.6, 29.4, 28.5. ^{31}P NMR (162 MHz, $CDCl_3$) δ 74.1, 63.6. HRMS (ESI) $[M+H]^+$ m/z calcd for $C_{38}H_{46}N_2O_5P$ 641.3144, found 641.3138.

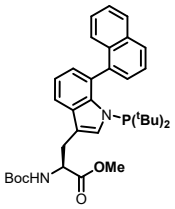
Compound **3an**



According to the general procedure C, the crude residue was purified by flash column chromatography on silica gel (petroleum ether: ethyl acetate = 10:1; R_f = 0.25) to compound **3an**. ^{1}H NMR (400 MHz, Chloroform-*d*) δ 7.88 – 7.82 (m, 2H), 7.81 – 7.78 (m, 1H), 7.75 (s, 1H), 7.57 – 7.53 (m, 2H), 7.51 – 7.42 (m, 4H), 7.24 (s, 1H), 7.17 (t, *J* = 7.5 Hz, 1H), 7.04 (dd, *J* = 7.1, 1.3 Hz, 1H), 5.14 (d, *J* = 8.1 Hz, 1H), 4.71 – 4.67 (m, 1H),

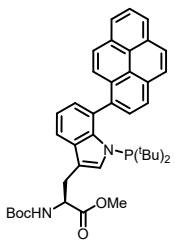
3.67 (s, 3H), 3.36 (dd, *J* = 14.8, 5.6 Hz, 1H), 3.29 (dd, *J* = 14.8, 5.5 Hz, 1H), 1.44 (s, 9H), 0.99 (d, *J* = 12.0 Hz, 18H). ^{13}C NMR (126 MHz, $CDCl_3$) δ 197.1, 172.7, 155.2, 142.6, 140.6, 138.0, 136.8, 134.7, 132.7, 132.3, 131.2, 130.1, 128.7, 128.3, 128.1, 127.3, 125.8, 119.7, 118.2, 112.9, 79.9, 54.0, 52.4, 36.0, 35.7, 29.5, 29.4, 28.5. ^{31}P NMR (162 MHz, $CDCl_3$) δ 74.0. HRMS (ESI) $[M+H]^+$ m/z calcd for $C_{38}H_{48}N_2O_5P$ 643.3301, found 643.3309.

Compound **3ao**



According to the general procedure C, the crude residue was purified by flash column chromatography on silica gel (petroleum ether: ethyl acetate = 8:1; R_f = 0.25) to compound **3ao**. ^{1}H NMR (500 MHz, Chloroform-*d*) δ 9.16 (d, *J* = 8.6 Hz, 1H), 7.91 (d, *J* = 8.1 Hz, 1H), 7.86 (d, *J* = 8.2 Hz, 1H), 7.71 (ddd, *J* = 8.5, 6.8, 1.3 Hz, 1H), 7.64 (d, *J* = 7.7 Hz, 1H), 7.56 (ddd, *J* = 8.1, 6.8, 1.1 Hz, 1H), 7.35 (d, *J* = 7.1 Hz, 1H), 7.30 (dd, *J* = 7.2, 1.3 Hz, 1H), 7.25 – 7.19 (m, 2H), 7.13 (s, 1H), 5.10 (d, *J* = 8.1 Hz, 1H), 4.67 (d, *J* = 7.0 Hz, 1H), 3.63 (s, 3H), 3.34 (dd, *J* = 14.6, 5.8 Hz, 1H), 3.27 (dd, *J* = 14.7, 5.4 Hz, 1H), 1.43 (s, 9H), 0.73 (t, *J* = 11.8 Hz, 18H). ^{13}C NMR (126 MHz, $CDCl_3$) δ 172.6, 155.2, 137.5, 137.4, 134.1, 133.1, 131.4, 131.3, 130.0, 129.7, 128.2, 128.0, 127.79, 127.76, 126.5, 124.2, 123.6, 120.1, 119.8, 114.1, 80.0, 54.0, 52.4, 35.6, 28.9, 28.8, 28.5. ^{31}P NMR (202 MHz, $CDCl_3$) δ 71.4. HRMS (ESI) $[M+Na]^+$ m/z calcd for $C_{35}H_{45}N_2O_4PNa$ 611.3015, found 611.3023.

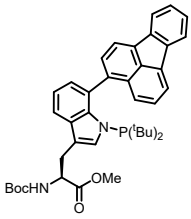
Compound **3ap**



According to the general procedure C, the crude residue was purified by flash column chromatography on silica gel (petroleum ether: ethyl acetate = 6:1; R_f = 0.25) to compound **3ap**. ^{1}H NMR (500 MHz, Chloroform-*d*) δ 8.22 – 8.08 (m, 5H), 7.99 (t, *J* = 7.6 Hz, 1H), 7.94 – 7.86 (m, 2H), 7.70– 7.66 (m, 2H), 7.29 (d, *J* = 7.5 Hz, 1H), 7.22 (d, *J* = 2.5 Hz, 1H), 7.18 – 7.16 (m, 1H), 5.20 – 5.19 (m, 1H), 4.78 – 4.72 (m, 1H), 3.72 (d, *J* = 3.8 Hz, 3H), 3.46– 3.29 (m, 2H), 1.47 (d, *J* = 1.5 Hz, 9H), 0.94 (d, *J* = 12.2 Hz, 9H), 0.58 (dd, *J* =

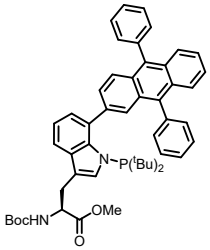
12.5, 1.6 Hz, 9H). ^{13}C NMR (126 MHz, $CDCl_3$) δ 172.9, 155.3, 142.0, 137.7, 131.6, 131.2, 130.7, 130.4, 130.0, 129.5, 129.4, 127.8, 127.1, 127.0, 126.8, 125.8, 125.0, 124.8, 123.9, 119.8, 118.2, 112.8, 80.0, 54.0, 52.5, 35.9, 34.8, 29.4, 29.2, 28.5. ^{31}P NMR (162 MHz, $CDCl_3$) δ 74.40, 74.37. HRMS (ESI) $[M+Na]^+$ m/z calcd for $C_{41}H_{47}N_2O_4PNa$ 685.3137, found 685.3130.

Compound **3aq**



According to the general procedure C, the crude residue was purified by flash column chromatography on silica gel (petroleum ether: ethyl acetate = 6:1; R_f = 0.25) to compound **3aq**. ^{1}H NMR (400 MHz, Chloroform-*d*) δ 7.99 – 7.89 (m, 4H), 7.64 (d, *J* = 7.8 Hz, 1H), 7.50 – 7.34 (m, 6H), 7.25 – 7.20 (m, 2H), 7.17 – 7.15 (dd, *J* = 7.2, 1.3 Hz, 1H), 5.24 – 5.12 (m, 1H), 4.74 (d, *J* = 7.0 Hz, 1H), 3.71 (d, *J* = 1.9 Hz, 3H), 3.46 – 3.25 (m, 2H), 1.47 (s, 9H), 0.98 (d, *J* = 12.2 Hz, 9H), 0.68 (d, *J* = 12.5 Hz, 9H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 172.8, 155.2, 142.2, 140.5, 140.0, 139.8, 136.7, 136.3, 132.5, 131.14, 131.08, 130.1, 130.0, 127.4, 127.3, 126.9, 126.8, 125.7, 121.6, 121.5, 119.8, 119.5, 118.2, 112.8, 79.94 54.1, 52.5, 36.2, 34.9, 29.5, 29.3, 28.5. ^{31}P NMR (162 MHz, $CDCl_3$) δ 74.61, 74.51. HRMS (ESI) $[M+H]^+$ m/z calcd for $C_{41}H_{48}N_2O_4P$ 663.3352, found 663.3344.

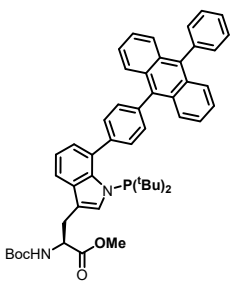
Compound **3ar**



According to the general procedure C, the crude residue was purified by flash column chromatography on silica gel (petroleum ether: ethyl acetate = 9:1; R_f = 0.25) to compound **3ar**. ^{1}H NMR (400 MHz, Chloroform-*d*) δ 7.78 – 7.72 (m, 1H), 7.70 – 7.61 (m, 4H), 7.61 – 7.48 (m, 7H), 7.47 – 7.40 (m, 3H), 7.38 – 7.26 (m, 3H), 7.20 (s, 1H), 7.13 (t, *J* = 7.5 Hz, 1H), 7.01 (d, *J* = 7.0 Hz, 1H), 5.12 (d, *J* = 8.0 Hz, 1H), 4.69 (m, 1H), 3.69 (d, *J* = 4.0 Hz, 3H), 3.41 – 3.21 (m, 2H), 1.44 (d, *J* = 3.4 Hz, 9H), 1.05 (dd, *J* = 12.5, 2.6 Hz, 9H), 0.84 (dd, *J* = 12.3, 2.0 Hz, 9H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 172.7, 155.2, 140.8, 139.6, 139.2, 137.2, 137.0, 131.6, 131.5, 131.4, 131.4, 131.01,

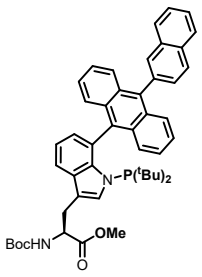
130.95, 130.3, 130.1, 129.8, 129.4, 129.3, 128.63, 128.59, 128.5, 128.2, 127.5, 127.12, 127.07, 126.7, 126.0, 125.2, 124.9, 124.9, 119.6, 117.9, 112.8, 79.9, 54.0, 52.4, 36.3, 35.5, 29.8, 29.4, 28.5. ^{31}P NMR (162 MHz, $CDCl_3$) δ 73.87, 73.82. HRMS (ESI) $[M+Na]^+$ m/z calcd for $C_{51}H_{55}N_2O_4PNa$ 813.3797, found 813.3796.

Compound **3as**



According to the general procedure C, the crude residue was purified by flash column chromatography on silica gel (petroleum ether: ethyl acetate = 9:1; R_f = 0.25) to compound **3as**. ^{1}H NMR (400 MHz, Chloroform-*d*) δ 8.18 – 7.89 (m, 2H), 7.77 – 7.68 (m, 2H), 7.64 – 7.55 (m, 4H), 7.54 – 7.45 (m, 6H), 7.39 – 7.31 (m, 4H), 7.28 – 7.21 (m, 3H), 5.18 (d, *J* = 8.1 Hz, 1H), 4.75 – 4.71 (m, 1H), 3.71 (s, 3H), 3.40 (dd, *J* = 14.7, 5.5 Hz, 1H), 3.34 (dd, *J* = 14.9, 5.5 Hz, 1H), 1.46 (s, 9H), 1.17 (d, *J* = 2.9 Hz, 9H), 1.14 (d, *J* = 2.9 Hz, 9H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 172.8, 155.3, 141.5, 141.0, 140.5, 139.3, 137.8, 137.5, 137.1, 131.5, 131.3, 130.9, 130.4, 130.0, 129.2, 128.6, 127.6, 127.1, 125.6, 125.1, 124.7, 123.6, 120.0, 117.9, 112.8, 80.0, 54.1, 52.5, 36.2, 36.0, 35.9, 29.83, 29.76, 29.6, 28.5. ^{31}P NMR (162 MHz, $CDCl_3$) δ 73.3. HRMS (ESI) $[M+Na]^+$ m/z calcd for $C_{51}H_{55}N_2O_4PNa$ 813.3797, found 813.3794.

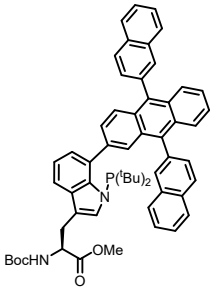
Compound **3at**



According to the general procedure C, the crude residue was purified by flash column chromatography on silica gel (petroleum ether: ethyl acetate = 6:1; R_f = 0.25) to compound **3at**. ^{1}H NMR (400 MHz, Chloroform-*d*) δ 8.11 – 8.00 (m, 3H), 7.98 – 7.87 (m, 2H), 7.74 – 7.67 (m, 3H), 7.63 – 7.59 (m, 2H), 7.56 – 7.51 (m, 2H)), 7.43 – 7.36 (m, 2H), 7.25 (s, 1H), 7.25 – 7.17 (m, 4H), 7.11 (d, *J* = 3.0 Hz, 1H), 5.19 (d, *J* = 8.1 Hz, 1H), 4.76 – 4.71 (m, 1H), 3.71 (s, 3H), 3.41 (dd, *J* = 14.9, 5.7 Hz, 1H), 3.34 (dd, *J* = 14.8, 5.5 Hz, 1H), 1.46 (s, 9H), 0.56 (m, 18H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 172.9, 155.3, 143.1, 137.4, 137.2, 136.7, 133.60, 132.8, 131.2, 131.13, 130.95, 130.6, 130.5, 130.4, 130.3, 130.14 129.9, 128.3, 128.2, 128.1, 128.0, 126.9, 126.8, 126.6, 126.5, 126.3, 126.2, 125.0, 124.6, 120.2, 118.4, 112.9, 80.0, 54.0, 52.5, 34.6, 34.3, 29.2, 29.0,

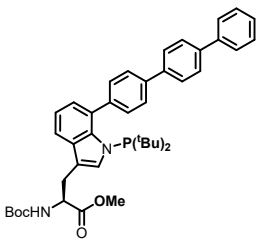
28.5. ^{31}P NMR (162 MHz, $CDCl_3$) δ 74.61, 74.51. HRMS (ESI) $[M+H]^+$ m/z calcd for $C_{31}H_{43}N_2O_4PNa$ 765.3821, found 765.3818.

Compound **3au**



According to the general procedure C, the crude residue was purified by flash column chromatography on silica gel (petroleum ether: ethyl acetate = 6:1; R_f = 0.25) to compound **3au**. ^{1}H NMR (400 MHz, Chloroform-*d*) δ 8.15 – 8.12 (m, 1H), 8.11 – 8.02 (m, 3H), 7.99 – 7.92 (m, 3H), 7.83 – 7.45 (m, 12H), 7.37 – 7.27 (m, 3H), 7.20 – 7.15 (m, 1H), 7.12 – 7.05 (m, 1H), 6.98 (d, *J* = 7.2 Hz, 1H), 5.09 (t, *J* = 7.7 Hz, 1H), 4.68 – 4.64 (m, 1H), 4.66 – 4.64 (m, 3H), 3.35 – 3.21 (m, 2H), 1.44 – 1.37 (m, 9H), 1.09 – 1.04 (m, 9H), 0.86 (dd, *J* = 12.4, 3.5 Hz, 9H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 172.7, 155.2, 140.8, 139.7, 137.1, 136.9, 133.6, 133.4, 132.9, 132.8, 130.9, 130.5, 130.3, 130.0, 129.9, 129.8, 129.6, 129.1, 128.8, 128.3, 128.2, 128.1, 128.0, 127.9, 127.8, 127.2, 126.60, 126.56, 126.5, 126.4, 126.3, 126.2, 125.9, 125.3, 125.1, 125.0, 123.6, 119.6, 117.9, 112.8, 79.9, 54.1, 54.0, 52.4, 36.4, 35.5, 35.2, 31.7, 29.8, 29.2. ^{31}P NMR (162 MHz, $CDCl_3$) δ 73.9. HRMS (ESI) $[M+Na]^+$ m/z calcd for $C_{59}H_{59}N_2O_4PNa$ 913.4110, found 913.4121.

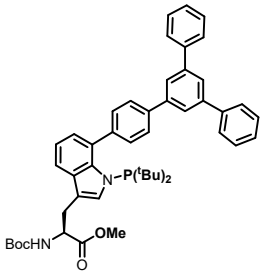
Compound **3av**



According to the general procedure C, the crude residue was purified by flash column chromatography on silica gel (petroleum ether: ethyl acetate = 6:1; R_f = 0.25) to compound **3av**. ^{1}H NMR (400 MHz, Chloroform-*d*) δ 7.75 – 7.71 (m, 2H), 7.75 – 7.71 (m, 2H), 7.70 – 7.66 (m, 4H), 7.57 (d, *J* = 7.8 Hz, 1H), 7.49 (t, *J* = 7.6 Hz, 2H), 7.441 – 7.37 (m, 3H), 7.28 (s, 1H), 7.20 (t, *J* = 7.5 Hz, 1H), 7.10 – 7.08 (m, 1H), 5.17 (d, *J* = 8.0 Hz, 1H), 4.75 – 4.70 (m, 1H), 3.71 (s, 3H), 3.39 (dd, *J* = 14.7, 5.6 Hz, 1H), 3.32 (dd, *J* = 14.8, 5.5 Hz, 1H), 1.47 (s, 9H), 1.06 (d, *J* = 4.2 Hz, 9H), 1.03 (d, *J* = 4.2 Hz, 9H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 172.8, 155.2, 141.63, 141.59, 140.9, 140.4, 140.1, 139.3, 131.4, 131.3, 131.2, 130.0, 129.0, 127.7, 127.6, 127.4, 127.18, 127.1, 126.0, 125.7, 119.7, 117.9, 112.7, 79.9, 54.1, 52.4, 36.0,

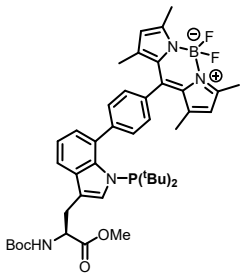
35.7, 31.6, 29.7, 29.5, 28.5. ^{31}P NMR (162 MHz, $CDCl_3$) δ 74.0. HRMS (ESI) $[M+Na]^+$ m/z calcd for $C_{43}H_{51}N_2O_4PNa$ 713.3484, 713.3491.

Compound **3aw**



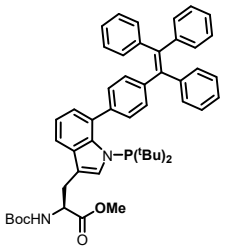
According to the general procedure C, the crude residue was purified by flash column chromatography on silica gel (petroleum ether: ethyl acetate = 6:1; R_f = 0.3) to compound **3aw**. ^{1}H NMR (400 MHz, Chloroform-*d*) δ 7.92 (d, *J* = 1.7 Hz, 2H), 7.83 (t, *J* = 1.7 Hz, 1H), 7.77 – 7.75 (m, 6H), 7.58 (d, *J* = 7.8 Hz, 1H), 5.54 – 5.51 (m, 4H), 7.46 – 7.38 (m, 4H), 7.29 (s, 1H), 7.21 (t, *J* = 7.5 Hz, 1H), 7.10 (d, *J* = 7.2 Hz, 1H), 5.18 (d, *J* = 8.1 Hz, 1H), 4.76 – 4.71 m, 1H), 3.72 (s, 3H), 3.40 (dd, *J* = 14.7, 5.5 Hz, 1H), 3.33 (dd, *J* = 14.8, 5.5 Hz, 1H), 1.47 (s, 9H), 1.07 (d, *J* = 4.3 Hz, 9H), 1.04 (d, *J* = 4.3 Hz, 9H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 172.8, 155.2, 142.5, 141.9, 141.8, 141.4, 139.6, 131.4, 131.2, 130.0, 129.0, 127.7, 127.5, 127.4, 126.2, 125.8, 125.21, 125.17, 119.7, 117.9, 112.7, 50.0, 54.1, 52.5, 36.1, 35.7, 29.7, 29.5, 28.5.^{31}P NMR (162 MHz, $CDCl_3$) δ 74.0. HRMS (ESI) $[M+Na]^+$ m/z calcd for $C_{49}H_{55}N_2O_4PNa$ 789.3797, found 789.3792.

Compound **3ax**



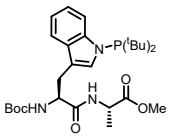
According to the general procedure C, the crude residue was purified by flash column chromatography on silica gel (petroleum ether: ethyl acetate = 8:1; R_f = 0.3) to compound **3ax**. ^{1}H NMR (400 MHz, Chloroform-*d*) δ 7.56 (d, *J* = 7.8 Hz, 1H), 7.47 (d, *J* = 7.9 Hz, 2H), 7.31 – 7.27 (m, 3H), 7.16 (t, *J* = 7.5 Hz, 1H), 6.90 (dd, *J* = 7.2, 1.2 Hz, 1H), 6.01 (s, 2H), 5.14 (d, *J* = 8.1 Hz, 1H), 4.70 (q, *J* = 6.2 Hz, 1H), 3.69 (s, 3H), 3.38 (dd, *J* = 14.8, 5.6 Hz, 1H), 3.30 (dd, *J* = 15.1, 5.4 Hz, 1H), 2.58 (s, 6H), 1.44 (s, 9H), 1.27 (d, *J* = 11.6 Hz, 6H), 1.08 (d, *J* = 5.3 Hz, 9H), 1.05 (d, *J* = 5.3 Hz, 9H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 173.1, 155.8, 144.59, 144.56, 143.8, 142.7, 140.6, 133.6, 131.9, 130.7, 128.6, 127.5, 127.4, 121.6, 120.1, 118.5, 113.3, 80.3, 60.8, 54.3, 52.8, 36.7, 36.3, 30.1, 30.0, 29.8, 28.8, 15.0.^{31}P NMR (162 MHz, $CDCl_3$) δ 71.5. HRMS (ESI) $[M+H]^+$ m/z calcd for $C_{44}H_{57}BF_2N_4O_4P$ 785.4179, found 785.4168.

Compound **3ay**



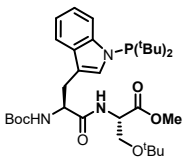
According to the general procedure C, the crude residue was purified by flash column chromatography on silica gel (petroleum ether: ethyl acetate = 5:1; R_f = 0.3) to compound **3ay**. ^{1}H NMR (400 MHz, Chloroform-*d*) δ 7.09 – 7.01 (m, 17H), 6.91 – 6.85 (m, 3H), 6.63 – 6.54 (m, 2H), 5.11 – 5.09 (m, 1H), 4.70 – 4.63 (m, 1H), 3.65 (s, 2H), 3.52 (d, *J* = 10.6 Hz, 1H), 3.35 – 3.23 (m, 2H), 1.44 – 1.42 (m, 9H), 1.07 – 1.01 (m, 14H), 0.87 – 0.78 (m, 4H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 172.7, 155.2, 144.3, 144.2, 144.1, 143.8, 143.7, 142.5, 141.4, 141.2, 140.9, 140.8, 140.7, 140.6, 140.4, 139.6, 137.9, 133.6, 132.9, 131.8, 131.5, 131.4, 131.1, 130.6, 130.5, 130.2, 129.2, 128.8, 128.2, 127.9, 127.8, 127.7, 127.6, 126.5, 126.4, 125.9, 119.6, 117.6, 112.7, 79.9, 54.0, 52.4, 36.0, 35.8, 29.8, 29.7, 29.5, 28.5. ^{31}P NMR (162 MHz, $CDCl_3$) δ 74.44, 74.42, 73.0. HRMS (ESI) $[M+H]^+$ m/z calcd for $C_{51}H_{58}N_2O_4P$ 793.4134, found 793.4139.

Compound **1a**



According to the general procedure B, the crude residue was purified by flash column chromatography on silica gel (petroleum ether: ethyl acetate = 4:1; R_f = 0.3) to compound **1a**. ^{1}H NMR (400 MHz, Chloroform-*d*) δ 7.82 (dd, *J* = 8.3, 2.5 Hz, 1H), 7.55 (d, *J* = 7.8 Hz, 1H), 7.31 (s, 1H), 7.20 (t, *J* = 7.6 Hz, 1H), 7.11 (t, *J* = 7.4 Hz, 1H), 6.54 (d, *J* = 7.2 Hz, 1H), 5.09 (s, 1H), 4.50-4.43 (m, 2H), 3.65 (s, 3H), 3.31-3.21 (m, 2H), 1.41 (s, 9H), 1.29 (d, *J* = 7.1 Hz, 3H), 1.20 (d, *J* = 4.4 Hz, 9H), 1.17 (d, *J* = 4.4 Hz, 9H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 172.9, 171.2, 155.5, 144.3, 144.1, 129.6, 129.5, 129.3, 128.6, 122.2, 120.2, 120.1, 118.4, 118.3, 113.3, 113.1, 80.2, 55.0, 52.5, 48.2, 48.1, 35.30, 35.26, 35.0, 29.7, 29.34, 29.32, 29.2, 29.1, 28.4, 28.0, 18.5. ^{31}P NMR (162 MHz, $CDCl_3$) δ 71.3. HRMS (ESI) $[M+Na]^+$ m/z calcd for $C_{28}H_{44}N_3O_5PNa$ 556.2916, found 556.2917.

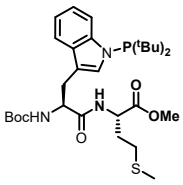
Compound **1b**



According to the general procedure B, the crude residue was purified by flash column chromatography on silica gel (petroleum ether: ethyl

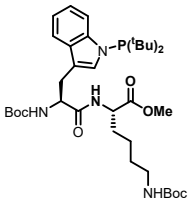
acetate = 4:1; R_f = 0.35) to compound **1b**. ^{1}H NMR (400 MHz, Chloroform-*d*) δ 7.81 (dd, *J* = 8.3, 2.5 Hz, 1H), 7.55 (d, *J* = 7.8 Hz, 1H), 7.31 (s, 1H), 7.18 (t, *J* = 7.5 Hz, 1H), 7.10 (t, *J* = 7.3 Hz, 1H), 6.73 (d, *J* = 8.2 Hz, 1H), 5.14 – 4.98 (m, 1H), 4.63 – 4.60 (m, 1H), 4.58 – 4.46 (m, 1H), 3.73 (dd, *J* = 9.1, 2.9 Hz, 1H), 3.67 (s, 3H), 3.42 (dd, *J* = 9.3, 3.3 Hz, 1H), 3.34 – 3.22 (m, 2H), 1.39 (s, 9H), 1.18 (dd, *J* = 12.7, 2.0 Hz, 18H), 1.04 (s, 9H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 171.4, 170.6, 155.3, 144.3, 144.1, 129.5, 129.4, 128.7, 122.1, 120.0, 118.4, 113.3, 113.2, 113.0, 79.9, 73.4, 61.9, 54.8, 53.0, 52.3, 35.3, 35.2, 35.04, 34.97, 29.3, 29.1, 28.4, 28.1, 27.3. ^{31}P NMR (162 MHz, $CDCl_3$) δ 71.0. HRMS (ESI) $[M+Na]^+$ m/z calcd for $C_{32}H_{52}N_3O_6PNa$ 628.3491, found 628.3493.

Compound **1c**



According to the general procedure B, the crude residue was purified by flash column chromatography on silica gel (petroleum ether: ethyl acetate = 4:1; R_f = 0.3) to compound **1c**. ^{1}H NMR (400 MHz, Chloroform-*d*) δ 7.81 (dd, *J* = 8.3, 2.4 Hz, 1H), 7.54 (d, *J* = 7.9 Hz, 1H), 7.30 (s, 1H), 7.21 – 7.09 (m, 1H), 7.10 (t, *J* = 7.4 Hz, 1H), 6.68 (d, *J* = 7.7 Hz, 1H), 5.09 (d, *J* = 7.5 Hz, 1H), 4.61 – 4.42 (m, 1H), 4.48 – 4.42 (m, 1H), 3.64 (s, 3H), 3.30 – 3.20 (m, 2H), 2.43 – 2.28 (m, 2H), 2.10 – 2.04 (m, 1H), 2.00 (s, 3H), 1.95 – 1.84 (m, 1H), 1.40 (s, 9H), 1.20 (d, *J* = 6.2 Hz, 9H), 1.17 (d, *J* = 6.1 Hz, 9H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 171.8, 155.5, 144.29, 144.26, 144.13, 144.09, 129.4, 129.33, 129.27, 128.48, 128.45, 124.4, 122.3, 122.23, 120.18, 120.1, 118.4, 118.3, 113.31, 113.29, 113.24, 113.15, 113.1, 80.2, 54.9, 52.5, 51.64, 51.55, 35.3, 35.2, 35.1, 35.0, 31.7, 29.7, 29.3, 29.2, 28.3, 28.3, 27.7, 15.4. ^{31}P NMR (162 MHz, $CDCl_3$) δ 71.2. HRMS (ESI) $[M+Na]^+$ m/z calcd for $C_{30}H_{48}N_3O_5PSNa$ 616.2950, found 616.2945.

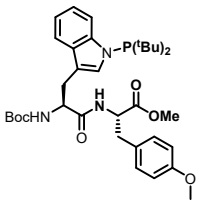
Compound **1d**



According to the general procedure B, the crude residue was purified by flash column chromatography on silica gel (petroleum ether: ethyl acetate = 3:1; R_f = 0.3) to compound **1d**. ^{1}H NMR (400 MHz, Chloroform-*d*) δ 7.77 (dd, *J* = 8.1, 2.7 Hz, 1H), 7.51 (d, *J* = 7.8 Hz, 1H), 7.22 – 7.09 (m, 3H), 7.06 (t, *J* = 7.4 Hz, 1H), 6.58 (d, *J* = 8.0 Hz, 1H), 4.66 (s,

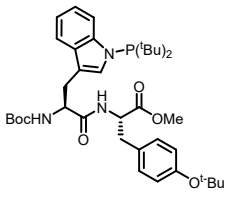
1H), 4.50 – 4.33 (m, 2H), 3.59 (s, 3H), 3.24 (dd, *J* = 14.9, 6.4 Hz, 1H), 3.16 (dd, *J* = 14.8, 7.0 Hz, 1H), 2.98 (d, *J* = 6.8 Hz, 2H), 2.30 (s, 2H), 1.78 – 1.67 (m, 1H), 1.61 – 1.49 (m, 1H), 1.38 (s, 9H), 1.35 (d, *J* = 2.6 Hz, 9H), 1.30 – 1.20 (m, 2H), 1.14 (dd, *J* = 12.7, 6.5 Hz, 18H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 172.4, 172.3, 171.6, 156.1, 155.6, 144.30, 144.27, 144.1, 137.9, 129.4, 129.3, 129.1, 128.53, 128.49, 128.3, 125.4, 124.6, 122.2, 120.2, 120.1, 118.4, 118.3, 113.43, 113.41, 113.3, 113.2, 113.1, 113.0, 80.1, 79.1, 68.9, 54.9, 52.41, 52.35, 52.1, 51.9, 40.2, 35.29, 35.26, 35.04, 35.01, 32.2, 29.32, 29.29, 29.24, 29.16, 29.1, 28.5, 28.4, 28.3, 27.7, 26.8, 26.3, 22.2, 21.5. ^{31}P NMR (162 MHz, $CDCl_3$) δ 71.2. HRMS (ESI) $[M+Na]^+$ m/z calcd for $C_{36}H_{59}N_4O_7PNa$ 713.4019, found 713.4022.

Compound **1e**



According to the general procedure B, the crude residue was purified by flash column chromatography on silica gel (petroleum ether: ethyl acetate = 4:1; R_f = 0.3) to compound **1e**. ^{1}H NMR (400 MHz, Chloroform-*d*) δ 7.83 (dd, *J* = 8.3, 2.6 Hz, 1H), 7.56 (d, *J* = 7.8 Hz, 1H), 7.30 (s, 1H), 7.20 (ddd, *J* = 8.3, 7.0, 1.3 Hz, 1H), 7.12 (t, *J* = 7.5 Hz, 1H), 6.81 (d, *J* = 8.6 Hz, 2H), 6.71 (d, *J* = 8.7 Hz, 2H), 6.41 (d, *J* = 7.6 Hz, 1H), 5.01 (s, 1H), 4.75 – 4.69 (m, 1H), 4.47 – 4.42 (m, 1H), 3.74 (s, 3H), 3.62 (s, 3H), 3.23 (d, *J* = 6.5 Hz, 2H), 2.96 (d, *J* = 5.6 Hz, 2H), 1.40 (s, 9H), 1.19 (dd, *J* = 12.7, 1.5 Hz, 18H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 171.5, 171.2, 158.7, 155.4, 144.4, 144.2, 130.4, 129.6, 129.5, 128.5, 127.7, 122.3, 120.2, 118.5, 118.4, 114.1, 114.0, 113.44, 113.35, 113.2, 80.2, 55.3, 54.9, 53.5, 53.4, 52.3, 37.2, 35.4, 35.3, 35.11, 35.06, 29.4, 29.2, 28.4, 28.0.^{31}P NMR (162 MHz, $CDCl_3$) δ 71.3. HRMS (ESI) $[M+Na]^+$ m/z calcd for $C_{35}H_{50}N_3O_6PNa$ 662.3335, found 662.3331.

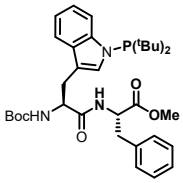
Compound **1e'**



According to the general procedure B, the crude residue was purified by flash column chromatography on silica gel (petroleum ether: ethyl acetate =5:1; R_f = 0.3) to compound **1e'**. ^{1}H NMR (400 MHz, Chloroform-*d*) 7.81 (dd, *J* =

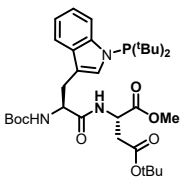
8.3, 2.5 Hz, 1H), 7.34 (d, *J* = 7.8 Hz, 1H), 7.22 – 7.16 (m, 2H), 7.07 (m, 3H), 6.91 – 6.85 (m, 2H), 6.47 (d, *J* = 7.9 Hz, 1H), 4.92 (dt, *J* = 7.7, 5.4 Hz, 2H), 4.38 – 4.23 (m, 1H), 3.56 (s, 3H), 3.29 – 3.20 (m, 2H), 3.02 – 2.95 (m, 2H), 1.33 (s, 9H), 1.29 (s, 9H), 1.19 (s, 9H), 1.16 (s, 9H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 171.7, 170.8, 155.1, 154.4, 144.1, 143.9, 131.3, 129.8, 129.0, 128.9, 128.6, 128.5, 124.2, 122.2, 120.1, 118.1, 113.3, 113.1, 112.7, 79.9, 78.3, 55.8, 53.1, 52.3, 37.8, 35.20, 35.18, 35.0, 34.9, 29.2, 29.0, 28.8, 28.2, 28.1.^{31}P NMR (162 MHz, $CDCl_3$) δ 71.22. HRMS (ESI) $[M+Na]^+$ m/z calcd for $C_{38}H_{56}N_3O_6PNa$ 704.3804, found 704.3812.

Compound **1f**



According to the general procedure B, the crude residue was purified by flash column chromatography on silica gel (petroleum ether: ethyl acetate = 5:1; R_f = 0.3) to compound **1f**. ^{1}H NMR (400 MHz, Chloroform-*d*) δ 7.83 (dd, *J* = 8.3, 2.6 Hz, 1H), 7.56 (d, *J* = 7.6 Hz, 1H), 7.30 (s, 1H), 7.23 – 7.17 (m, 4H), 7.12 (t, *J* = 7.4 Hz, 1H), 6.97 – 6.89 (m, 2H), 6.46 (d, *J* = 7.6 Hz, 1H), 5.10 – 4.93 (m, 1H), 4.80 – 4.75 (m, 1H), 4.48 – 4.42 (m, 1H), 3.61 (d, *J* = 1.4 Hz, 3H), 3.24 (d, *J* = 6.4 Hz, 2H), 3.02 (d, *J* = 5.7 Hz, 2H), 1.40 (s, 9H), 1.21 (d, *J* = 1.9 Hz, 9H), 1.18 (d, *J* = 1.9 Hz, 9H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 171.4, 171.3, 155.4, 144.4, 144.2, 135.7, 129.5, 129.4, 129.3, 128.7, 128.6, 128.5, 127.1, 122.3, 120.2, 118.5, 118.4, 113.3, 113.1, 80.2, 68.2, 54.9, 53.4, 53.3, 52.3, 38.0, 35.33, 35.28, 35.1, 35.0, 29.3, 29.2, 28.4, 28.0.^{31}P NMR (162 MHz, $CDCl_3$) δ 71.3. HRMS (ESI) $[M+H]^+$ m/z calcd for $C_{34}H_{49}N_3O_5P$ 610.3410, found 610.3405.

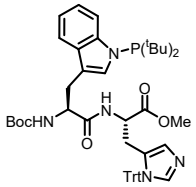
Compound **1g**



According to the general procedure B, the crude residue was purified by flash column chromatography on silica gel (petroleum ether: ethyl acetate = 5:1; R_f = 0.2) to compound **1g**. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.82 (dd, *J* = 8.2, 2.4 Hz, 1H), 7.54 (d, *J* = 7.7 Hz, 1H), 7.31 (s, 1H), 7.26 (s, 1H), 7.22 – 7.15 (m, 1H), 7.11 (t, *J* = 7.4 Hz, 1H), 6.94 (d, *J* = 8.1 Hz, 1H), 5.01 (s, 1H), 4.80 – 4.68 (m, 1H), 4.59 – 4.42 (m, 1H), 3.67 (s, 3H), 3.27 (qd, *J* = 14.8, 6.1 Hz, 2H), 2.86 (dd, *J* = 16.9, 4.3 Hz, 1H), 2.62 (dd, *J* = 16.9, 4.7 Hz, 1H), 1.38 (d, *J* = 4.7 Hz, 18H), 1.20 (s, 9H), 1.17 (s, 9H). ^{13}C NMR (101 MHz, $CDCl^3$) δ 171.44,

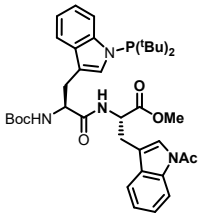
171.05, 169.90, 155.38, 144.33, 144.12, 129.57, 129.48, 128.65, 122.22, 120.12, 118.42, 113.29, 113.21, 113.09, 81.84, 80.10, 54.89, 52.69, 48.79, 37.56, 35.34, 35.30, 35.09, 35.05, 29.35, 29.19, 28.37, 28.08. ^{31}P NMR (162 MHz, $CDCl_3$) δ 71.13. HRMS (ESI) $[M+H]^+$ m/z calcd for $C_{33}H_{53}N_3O_7P$ 634.3621, found 634.3593.

Compound **1h**



According to the general procedure B, the crude residue was purified by flash column chromatography on silica gel (petroleum ether: ethyl acetate = 1:1; R_f = 0.3) to compound **1h**. ^{1}H NMR (400 MHz, Chloroform-*d*) δ 7.85 – 7.73 (m, 2H), 7.54 (d, *J* = 7.9 Hz, 1H), 7.33 (s, 1H), 7.32 – 7.28 (m, 10H), 7.17 (t, *J* = 7.6 Hz, 1H), 7.10 – 7.05 (m, 7H), 6.51 (d, *J* = 1.4 Hz, 1H), 5.19 (d, *J* = 7.6 Hz, 1H), 4.78 – 4.73 (m, 1H), 4.64 – 4.48 (m, 1H), 3.55 (s, 3H), 3.35 (dd, *J* = 14.9, 5.0 Hz, 1H), 3.23 – 3.18 (m, 1H), 3.00 (dd, *J* = 14.6, 4.7 Hz, 1H), 2.85 – 2.77 (m, 1H), 1.32 (s, 9H), 1.20 (d, *J* = 4.7 Hz, 9H), 1.17 (d, *J* = 4.7 Hz, 9H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 171.4, 171.3, 162.5, 155.2, 144.1, 143.9, 142.3, 142.2, 138.64, 138.56, 136.3, 129.7, 129.5, 129.4, 128.07, 128.05, 121.9, 119.8, 119.6, 118.4, 113.48, 113.46, 113.1, 112.8, 79.4, 75.2, 54.9, 52.6, 52.5, 52.0, 36.4, 35.2, 35.19, 35.15, 35.0, 34.94, 34.90, 31.5, 30.2, 29.8, 29.7, 29.3, 29.1, 28.3, 27.9. ^{31}P NMR (162 MHz, $CDCl_3$) δ 70.8. HRMS (ESI) $[M+Na]^+$ m/z calcd for $C_{50}H_{60}N_5O_5PNa$ 864.4230, found 864.4224.

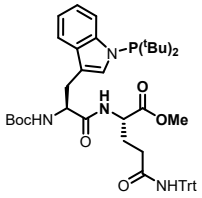
Compound **1i**



According to the general procedure B, the crude residue was purified by flash column chromatography on silica gel (petroleum ether: ethyl acetate = 2:1; R_f = 0.3) to compound **1i**. ^{1}H NMR (400 MHz, Chloroform-*d*) δ 8.40 (d, *J* = 8.3 Hz, 1H), 7.85 – 7.82 (m, 1H), 7.56 – 7.53 (m, 1H), 7.37 (d, *J* = 7.8 Hz, 1H), 7.33 – 7.29 (m, 3H), 7.26 – 7.16 (m, 3H), 7.14 – 7.10 (m, 1H), 6.63 (d, *J* = 7.5 Hz, 1H), 5.09 – 4.97 (m, 1H), 4.87 – 4.83 (m, 1H), 4.42 (q, *J* = 7.0 Hz, 1H), 3.54 (s, 3H), 3.31 – 3.17 (m, 4H), 2.55 (s, 3H), 1.36 (s, 9H), 1.20 (d, *J* = 1.8 Hz, 9H), 1.17 (d, *J* = 1.8 Hz, 9H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 171.6, 171.3, 168.7, 155.6, 144.4, 144.2, 135.8, 130.4, 129.6, 129.5, 129.1, 128.40, 128.37,

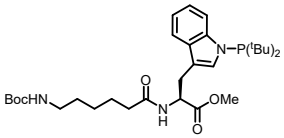
128.3, 125.44, 125.39, 124.1, 123.6, 122.33, 122.32, 120.2, 118.7, 118.6, 118.3, 116.8, 116.5, 113.4, 113.23, 113.19, 80.2, 55.3, 52.5, 52.3, 35.32, 35.27, 35.1, 35.0, 29.3, 29.17, 29.16, 29.1, 28.3, 28.2, 27.9, 27.6, 24.0. ^{31}P NMR (162 MHz, $CDCl_3$) δ 71.4. HRMS (ESI) $[M+H]^+$ m/z calcd for $C_{38}H_{52}N_4O_6P$ 691.3624, found 691.3620.

Compound **1j**



According to the general procedure B, the crude residue was purified by flash column chromatography on silica gel (petroleum ether: ethyl acetate = 1:1; R_f = 0.35) to compound **1j**. ^{1}H NMR (400 MHz, Chloroform-*d*) δ ^{1}H NMR (400 MHz, Chloroform-*d*) δ 7.84 – 7.77 (m, 1H), 7.49 (d, *J* = 7.7 Hz, 1H), 7.29 – 7.19 (m, 15H), 7.15 – 7.11 (m, 1H), 7.10 – 7.01 (m, 2H), 6.72 (d, *J* = 7.7 Hz, 1H), 5.07 (d, *J* = 7.7 Hz, 1H), 4.50 – 4.36 (m, 1H), 4.38 (q, *J* = 6.9 Hz, 1H), 3.60 (s, 3H), 3.22 (qd, *J* = 14.7, 6.7 Hz, 2H), 2.32 – 2.08 (m, 3H), 1.87 – 1.76 (m, 1H), 1.37 (s, 9H), 1.20 (d, *J* = 6.8 Hz, 9H), 1.17 (d, *J* = 6.8 Hz, 9H). ^{13}C NMR (101 MHz, $CDCl_3$) δ ^{13}C NMR (101 MHz, $CDCl_3$) δ 174.4, 172.0, 171.9, 171.0, 155.5, 144.8, 144.4, 144.2, 129.5, 129.4, 128.92, 128.88, 128.6, 128.0, 127.1, 122.3, 122.2, 120.1, 118.5, 113.4, 113.3, 113.1, 80.2, 70.7, 55.2, 52.6, 51.9, 35.4, 35.3, 35.10, 35.07, 33.3, 29.4, 29.3, 29.20, 29.18, 29.0, 28.4, 28.0, 20.7. ^{31}P NMR (162 MHz, $CDCl_3$) δ 71.4. HRMS (ESI) $[M+Na]^+$ m/z calcd for $C_{49}H_{61}N_4O_6PNa$ 855.4226, found 855.4232.

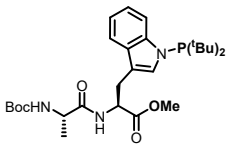
Compound **1k**



According to the general procedure B, the crude residue was purified by flash column chromatography on silica gel (petroleum ether: ethyl acetate = 3:1; R_f = 0.3) to compound **1k**. ^{1}H NMR (400 MHz, Chloroform-*d*) δ 7.79 (dd, *J* = 8.2, 2.6 Hz, 1H), 7.44 (d, *J* = 7.8 Hz, 1H), 7.20 (s, 1H), 7.09 – 7.05 (m, 1H), 7.10 – 7.04 (m, 1H), 6.28 (d, *J* = 7.9 Hz, 1H), 4.96 – 4.91 (m, 1H), 4.75 (s, 1H), 3.61 (s, 3H), 3.35 – 3.20 (m, 2H), 3.04 – 3.01 (m, 2H), 2.11 (t, *J* = 7.5 Hz, 2H), 1.59 – 1.50 (m, 2H), 1.43 – 1.35 (m, 11H), 1.27 – 1.22 (m, 2H), 1.17 (d, *J* = 2.2 Hz, 9H), 1.13 (d, *J* = 2.2 Hz, 9H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 174.03, 172.7, 172.5, 144.1, 143.9, 129.0, 128.9, 128.6, 128.5, 122.13,

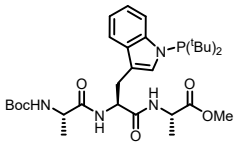
122.11, 120.0, 118.0, 113.2, 113.0, 112.84, 112.81, 78.9, 52.8, 52.3, 40.2, 36.2, 35.2, 34.9, 29.6, 29.13, 29.10, 29.0, 28.9, 28.4, 27.7, 26.2, 25.0. ^{31}P NMR (162 MHz, $CDCl_3$) δ 71.2. HRMS (ESI) $[M+H]^+$ m/z calcd for $C_{31}H_{51}N_3O_5P$ 576.3566, found 576.3568.

Compound **1l**



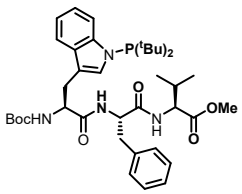
According to the general procedure B, the crude residue was purified by flash column chromatography on silica gel (petroleum ether: ethyl acetate = 4:1; R_f = 0.3) to compound **1l**. ^{1}H NMR (400 MHz, Chloroform-*d*) δ 7.81 (dd, *J* = 8.3, 2.5 Hz, 1H), 7.48 (d, *J* = 7.8 Hz, 1H), 7.26 (s, 1H), 7.20 – 7.16 (m, 1H), 7.10 (t, *J* = 7.3 Hz, 1H), 6.71 (d, *J* = 8.0 Hz, 1H), 5.02 (d, *J* = 7.5 Hz, 1H), 4.94 (dt, *J* = 8.1, 5.6 Hz, 1H), 4.17 – 4.03 (m, 1H), 3.59 (s, 3H), 3.30 (d, *J* = 5.7 Hz, 2H), 1.38 (s, 9H), 1.28 (d, *J* = 6.8 Hz, 3H), 1.19 (s, 9H), 1.16 (s, 9H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 172.3, 172.0, 155.2, 144.1, 143.9, 129.0, 128.9, 128.63, 128.60, 122.2, 120.0, 118.1, 113.3, 113.1, 112.8, 79.8, 53.0, 52.3, 50.2, 35.2, 35.0, 34.9, 29.2, 29.0, 28.3, 27.9, 18.5. ^{31}P NMR (162 MHz, $CDCl_3$) δ 71.2. HRMS (ESI) $[M+Na]^+$ m/z calcd for $C_{28}H_{44}N_3O_5PNa$ 556.2916, found 556.2926.

Compound **1m**



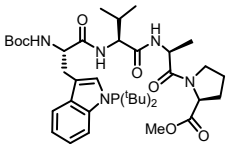
According to the general procedure B, the crude residue was purified by flash column chromatography on silica gel (petroleum ether: ethyl acetate = 2:1; R_f = 0.2) to compound **1m**. ^{1}H NMR (500 MHz, Chloroform-*d*) δ 7.82 (dd, *J* = 8.2, 2.6 Hz, 1H), 7.49 (d, *J* = 7.9 Hz, 1H), 7.28 (s, 1H), 7.19 (t, *J* = 7.7 Hz, 1H), 7.11 (t, *J* = 8.0 Hz, 2H), 5.50 – 5.39 (m, 1H), 4.92 (q, *J* = 6.5 Hz, 1H), 4.52 (p, *J* = 7.1 Hz, 1H), 4.22 – 4.10 (m, 1H), 3.59 (s, 3H), 3.30 (d, *J* = 6.1 Hz, 2H), 1.42 (s, 9H), 1.34 (d, *J* = 7.0 Hz, 3H), 1.23 (d, *J* = 7.1 Hz, 3H), 1.18 (d, *J* = 12.9 Hz, 18H). ^{13}C NMR (126 MHz, $CDCl_3$) δ 175.5, 172.8, 172.7, 172.11, 172.06, 172.0, 155.5, 155.3, 144.1, 143.9, 141.2, 129.9, 129.1, 129.0, 128.9, 128.52, 128.49, 128.4, 126.7, 125.8, 122.2, 120.1, 118.1, 117.7, 113.3, 113.2, 113.1, 112.78, 112.77, 110.8, 79.9, 53.3, 52.3, 50.0, 48.9, 35.2, 35.1, 35.0, 34.9, 29.2, 29.1, 29.02, 29.00, 28.3, 27.7, 18.51, 18.45. ^{31}P NMR (202 MHz, $CDCl_3$) δ 71.2. HRMS (ESI) $[M+Na]^+$ m/z calcd for $C_{31}H_{49}N_4O_6PNa$ 627.3287, found 627.3290.

Compound **1n**



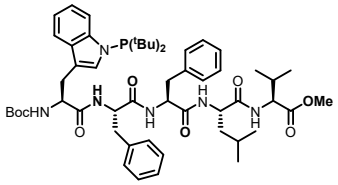
According to the general procedure B, the crude residue was purified by flash column chromatography on silica gel (petroleum ether: ethyl acetate = 2:1; R_f = 0.25) to compound **1n**. ^{1}H NMR (400 MHz, Chloroform-*d*) δ 7.84 (dd, *J* = 8.3, 2.5 Hz, 1H), 7.54 (d, *J* = 7.8 Hz, 1H), 7.30 (s, 1H), 7.25 – 7.16 (m, 4H), 7.15 – 7.11 (m, 1H), 7.05 – 6.98 (m, 2H), 6.67 (d, *J* = 7.8 Hz, 1H), 6.37 (d, *J* = 8.5 Hz, 1H), 4.89 – 4.81 (m, 1H), 4.67 – 4.62 (m, 1H), 4.44 – 4.35 (m, 2H), 3.69 (s, 3H), 3.23 (d, *J* = 5.8 Hz, 2H), 3.12 – 3.08 (m, 1H), 2.79 (dd, *J* = 13.6, 7.6 Hz, 1H), 2.09 – 2.01 (m, 1H), 1.30 (s, 9H), 1.21 (dd, *J* = 12.7, 7.8 Hz, 18H), 0.82 (dd, *J* = 11.0, 6.9 Hz, 6H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 171.8, 171.7, 170.5, 155.5, 144.5, 144.3, 136.3, 129.5, 129.4, 128.8, 128.4, 127.1, 122.6, 120.3, 118.6, 113.4, 113.3, 113.2, 80.4, 57.7, 54.9, 54.3, 52.2, 37.6, 35.4, 35.1, 31.1, 29.42, 29.37, 29.3, 29.2, 28.3, 27.6, 19.0, 18.0. ^{31}P NMR (162 MHz, $CDCl_3$) δ 71.4. HRMS (ESI) $[M+H]^+$ m/z calcd for $C_{39}H_{58}N_4O_6P$ 709.4094, found 709.4082.

Compound **1o**



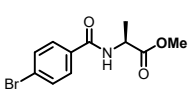
According to the general procedure B, the crude residue was purified by flash column chromatography on silica gel (petroleum ether: ethyl acetate = 1:1.5; R_f = 0.2) to compound **1o**. ^{1}H NMR (400 MHz, Chloroform-*d*) δ 7.79 (dd, *J* = 8.2, 2.6 Hz, 1H), 7.52 (d, *J* = 7.7 Hz, 1H), 7.29 (s, 1H), 7.18 – 7.12 (m, 1H), 7.11 – 7.02 (m, 2H), 6.94 (d, *J* = 8.6 Hz, 1H), 5.15 (d, *J* = 7.6 Hz, 1H), 4.68 (p, *J* = 6.9 Hz, 1H), 4.54 – 4.42 (m, 2H), 4.33 (dd, *J* = 8.5, 5.7 Hz, 1H), 3.71 – 3.65 (m, 4H), 3.60 – 3.55 (m, 1H), 3.30 – 3.15 (m, 2H), 2.27 – 2.11 (m, 1H), 2.11 – 1.86 (m, 4H), 1.34 (d, *J* = 7.1 Hz, 12H), 1.17 (dd, *J* = 12.7, 4.1 Hz, 18H), 0.82 (dd, *J* = 6.8, 1.8 Hz, 6H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 172.4, 171.9, 171.8, 171.6, 170.9, 170.2, 169.8, 155.8, 144.2, 144.0, 129.1, 129.0, 128.6, 122.1, 120.0, 118.4, 113.6, 113.1, 112.9, 80.0, 59.1, 58.8, 58.2, 58.0, 54.8, 52.9, 52.3, 46.8, 46.5, 35.3, 35.0, 31.3, 29.3, 29.1, 28.9, 28.3, 27.2, 25.0, 19.1, 17.8. ^{31}P NMR (162 MHz, $CDCl_3$) δ 71.0. HRMS (ESI) $[M+Na]^+$ m/z calcd for $C_{38}H_{60}N_5O_7PNa$ 752.4128, found 752.4129.

Compound **1p**



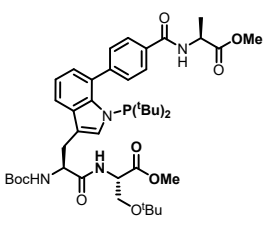
According to the general procedure B, the crude residue was purified by flash column chromatography on silica gel (petroleum ether: ethyl acetate = 1:1.5; R_f = 0.3) to compound **1p**. ^{1}H NMR (400 MHz, Chloroform-*d*) δ 7.86 (dd, *J* = 8.3, 2.5 Hz, 1H), 7.45 (d, *J* = 7.9 Hz, 1H), 7.31 – 7.20 (m, 6H), 7.18 – 7.01 (m, 9H), 6.82 (d, *J* = 7.0 Hz, 2H), 5.09 – 4.87 (m, 2H), 4.69 – 4.47 (m, 3H), 4.30 – 4.19 (m, 1H), 3.73 (s, 3H), 3.26 – 3.13 (m, 3H), 3.00 – 2.74 (m, 3H), 2.26 – 2.18 (m, 1H), 1.83 – 1.55 (m, 3H), 1.25 (d, *J* = 2.1 Hz, 9H), 1.22 (d, *J* = 3.9 Hz, 9H), 1.19 (d, *J* = 4.0 Hz, 9H), 0.99 (d, *J* = 6.8 Hz, 7H), 0.90 (d, *J* = 6.5 Hz, 6H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 173.0, 172.23, 172.20, 172.15, 171.2, 171.0, 156.1, 144.5, 144.3, 137.0, 135.4, 129.3, 129.2, 129.0, 128.9, 128.8, 128.7, 128.6, 128.5, 128.04, 128.00, 127.97, 127.2, 126.7, 122.6, 120.3, 118.3, 113.4, 113.2, 112.7, 80.7, 57.5, 55.2, 54.8, 54.2, 52.13, 52.07, 40.6, 37.3, 36.8, 35.33, 35.25, 35.1, 35.0, 31.1, 29.32, 29.27, 29.2, 29.1, 28.2, 27.3, 24.7, 23.2, 21.8, 19.1, 18.19, 18.17. ^{31}P NMR (162 MHz, $CDCl_3$) δ 71.5. HRMS (ESI) $[M+Na]^+$ m/z calcd for $C_{54}H_{77}N_6O_8PNa$ 991.5438, found 991.5432.

Compound **2z**



According to the general procedure B, the crude residue was purified by flash column chromatography on silica gel (petroleum ether: ethyl acetate = 4:1; R_f = 0.2) to compound **2z**. ^{1}H NMR (400 MHz, Chloroform-*d*) δ 7.67 – 7.64 (m, 2H), 7.56 – 7.53 (m, 2H), 6.86 – 6.77 (m, 1H), 4.79 – 4.73 (m, 1H), 3.78 (s, 3H), 1.50 (d, *J* = 7.2 Hz, 3H). ^{13}C NMR (126 MHz, $CDCl_3$) δ 173.73, 173.70, 166.0, 132.8, 131.9, 128.81, 128.80, 126.6, 52.7, 48.7, 18.60, 18.59. HRMS (ESI) $[M+Na]^+$ m/z calcd for $C_{11}H_{12}BrNO_3$ 307.9898, found 307.9886.

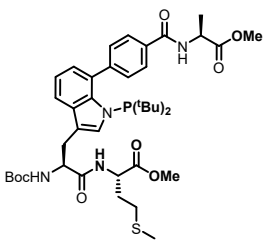
Compound **3bz**



According to the general procedure C, the crude residue was purified by flash column chromatography on silica gel (petroleum ether: ethyl acetate =2:1; R_f = 0.3) to compound **3bz**. ^{1}H NMR (400 MHz, Chloroform-*d*) δ 7.80 (d, *J* = 8.0 Hz, 2H),

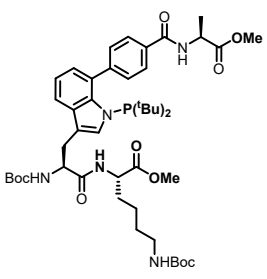
7.61 – 7.55 (m, 1H), 7.35 – 7.29 (m, 2H), 7.29 (s, 1H), 7.14 – 7.09 (m, 1H), 6.94 – 6.88 (m, 3H), 5.13 – 5.08 (m, 1H), 4.89 – 4.80 (m, 1H), 4.65 – 4.48 (m, 2H), 3.79 (s, 3H), 3.76 – 3.72 (m, 1H), 3.68 (d, J = 2.6 Hz, 3H), 3.52 – 3.14 (m, 3H), 1.54 (d, J = 7.2 Hz, 3H), 1.39 (d, J = 6.7 Hz, 9H), 1.07 (d, J = 3.8 Hz, 9H), 1.01 – 0.95 (m, 18H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 173.9, 171.6, 170.8, 170.6, 166.9, 155.3, 146.6, 146.5, 140.7, 140.5, 132.0, 132.0, 131.4, 131.0, 130.9, 130.1, 128.1, 126.1, 125.7, 125.6, 119.6, 118.3, 113.5, 113.3, 80.0, 73.4, 61.9, 61.8, 54.8, 53.0, 52.9, 52.6, 52.4, 48.6, 36.0, 35.7, 31.6, 30.3, 29.7, 29.38, 28.36, 28.1, 27.3, 18.8. ^{31}P NMR (162 MHz, $CDCl_3$) δ 74.0. HRMS (ESI) $[M+Na]^+$ m/z calcd for $C_{43}H_{63}N_4O_9PNa$ 833.4230, found 833.4238.

Compound **3cz**



According to the general procedure C, the crude residue was purified by flash column chromatography on silica gel (petroleum ether: ethyl acetate =1.5:1; R_f = 0.3) to compound **3cz**. ^{1}H NMR (400 MHz, Chloroform-*d*) δ 7.80 (d, J = 8.1 Hz, 2H), 7.59 – 7.56 (m, 1H), 7.37 – 7.33 (m, 2H), 7.30 (d, J = 3.2 Hz, 1H), 7.16 – 7.10 (m, 1H), 6.93 – 6.90 (m, 1H), 6.87 – 6.84 (m, 1H), 6.81 – 6.79 (m, 0.5H), 6.68 (d, J = 7.6 Hz, 0.5H), 5.13 – 4.99 (m, 1H), 4.85 (p, J = 7.1 Hz, 1H), 4.65 – 4.57 (m, 1H), 4.52 – 4.42 (m, 1H), 3.80 (s, 3H), 3.68 (d, J = 8.9 Hz, 3H), 3.35 – 3.21 (m, 2H), 2.45 – 2.27 (m, 2H), 2.12 – 1.84 (m, 5H), 1.55 (d, J = 7.1 Hz, 3H), 1.41 (d, J = 6.0 Hz, 9H), 1.02 – 0.96 (m, 18H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 178.0, 172.1, 171.9, 171.5, 166.9, 155.6, 146.6, 146.5, 140.8, 140.6, 132.1, 131.4, 131.03, 130.97, 129.9, 128.3, 128.2, 126.1, 125.9, 125.8, 119.7, 118.2, 113.3, 80.3, 55.0, 52.7, 52.6, 51.7, 51.6, 48.6, 36.04, 36.01, 35.72, 35.69, 31.8, 31.6, 31.6, 30.2, 29.8, 29.7, 29.70 29.61, 29.56, 29.43, 29.38, 28.39, 28.37, 18.9, 15.6. ^{31}P NMR (162 MHz, $CDCl_3$) δ 73.93. HRMS (ESI) $[M+Na]^+$ m/z calcd for $C_{41}H_{59}N_4O_8PSNa$ 821.3689, found 821.3676.

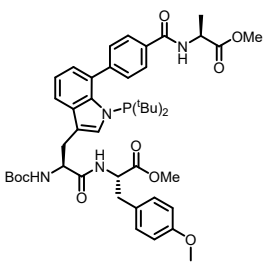
Compound **3dz**



According to the general procedure C, the crude residue was purified by flash column chromatography on silica gel

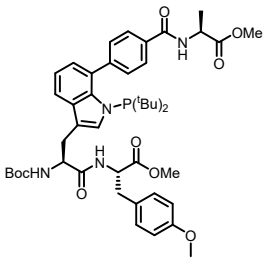
(petroleum ether: ethyl acetate =2:1; R_f = 0.25) to compound **3dz**. ^{1}H NMR (400 MHz, Chloroform-*d*) δ 7.80 (d, *J* = 8.5 Hz, 2H), 7.58 (d, *J* = 7.9 Hz, 1H), 7.37 – 7.33 (m, 2H), 7.29 (s, 1H), 7.13 (t, *J* = 7.5 Hz, 1H), 6.94 – 6.92 (m, 1H), 6.85 (d, *J* = 7.3 Hz, 1H), 6.59 (d, *J* = 7.9 Hz, 1H), 5.37 – 5.19 (m, 1H), 4.85 (p, *J* = 7.1 Hz, 1H), 4.67 (s, 1H), 4.56 – 4.38 (m, 2H), 3.80 (s, 3H), 3.67 (d, *J* = 9.2 Hz, 3H), 3.35 – 3.14 (m, 2H), 3.08 – 3.03 (m,, 2H), 2.02 – 1.73 (m, 2H), 1.64 – 1.61 (m, 5H), 1.47 – 1.40 (m, 20H), 1.03 – 0.95 (m, 18H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 174.0, 172.3, 171.6, 166.9, 156.01 155.7, 146.6, 140.6, 132.1, 131.3, 131.04, 130.98, 130.0, 128.2, 126.1, 125.9, 125.7, 124.5, 124.1, 123.6, 119.8, 119.7, 119.2, 118.2, 113.5, 80.3, 79.2, 55.0, 52.7, 52.5, 52.1, 51.9, 48.6, 40.3, 36.0, 35.7, 32.3, 31.6, 31.5, 30.3, 30.2, 29.8, 29.7, 29.59, 29.55, 29.5, 29.42, 29.37, 29.3, 28.6, 28.41, 28.38, 22.2, 18.9. ^{31}P NMR (162 MHz, $CDCl_3$) δ 73.9. HRMS (ESI) $[M+Na]^+$ m/z calcd for $C_{47}H_{70}N_5O_{10}PNa$ 918.4758, found 918.4762.

Compound **3ez**



According to the general procedure C, the crude residue was purified by flash column chromatography on silica gel (petroleum ether: ethyl acetate = 2:1; R_f = 0.3) to compound **3ez**. ^{1}H NMR (400 MHz, Chloroform-*d*) δ 7.81 – 7.78 (m, 2H), 7.59 – 7.56 (m, 1H), 7.36 – 7.27 (m, 3H), 7.16 – 7.08 (m, 1H), 6.94 – 6.91 (m, 2H), 6.87 – 6.79 (m, 2H), 6.73 – 6.65 (m, 2H), 6.48 (d, *J* = 7.6 Hz, 1H), 5.18 – 5.01 (m, 1H), 4.87 – 4.80 (m, 1H), 4.77 – 4.69 (m, 1H), 4.51 – 4.43 (m, 1H), 3.78 (s, 3H), 3.71 (d, *J* = 8.5 Hz, 3H), 3.62 (s, 3H), 3.29 – 3.22 (m, 2H), 2.96 (d, *J* = 5.7 Hz, 2H), 1.54 (d, *J* = 7.4 Hz, 3H), 1.38 (d, *J* = 8.4 Hz, 9H), 1.00 – 0.94 (m, 18H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 173.9, 171.6, 171.4, 171.1, 166.9, 158.7, 155.4, 146.5, 140.7, 132.0, 131.5, 130.9, 130.3, 129.9, 128.6, 128.5, 128.1, 127.6, 127.4, 126.1, 125.7, 119.7, 118.2, 114.0, 113.9, 113.3, 80.1, 55.2, 53.4, 52.6, 52.2, 48.6, 37.1, 36.0, 35.7, 29.54, 29.48, 29.4, 29.3, 28.3, 18.7. ^{31}P NMR (162 MHz, $CDCl_3$) δ 74.0. HRMS (ESI) $[M+Na]^+$ m/z calcd for $C_{46}H_{61}N_4O_9PNa$ 867.4074, found 867.4077.

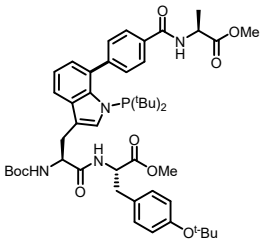
Compound **3ez**



According to the general procedure C, the crude residue was

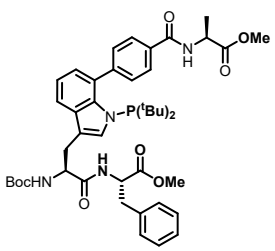
purified by flash column chromatography on silica gel (petroleum ether: ethyl acetate = 2:1; R_f = 0.3) to compound **3ez**. ^{1}H NMR (400 MHz, Chloroform-*d*) δ 7.81 – 7.78 (m, 2H), 7.59 – 7.56 (m, 1H), 7.36 – 7.27 (m, 3H), 7.16 – 7.08 (m, 1H), 6.94 – 6.91 (m, 2H), 6.87 – 6.79 (m, 2H), 6.73 – 6.65 (m, 2H), 6.48 (d, *J* = 7.6 Hz, 1H), 5.18 – 5.01 (m, 1H), 4.87 – 4.80 (m, 1H), 4.77 – 4.69 (m, 1H), 4.51 – 4.43 (m, 1H), 3.78 (s, 3H), 3.71 (d, *J* = 8.5 Hz, 3H), 3.62 (s, 3H), 3.29 – 3.22 (m, 2H), 2.96 (d, *J* = 5.7 Hz, 2H), 1.54 (d, *J* = 7.4 Hz, 3H), 1.38 (d, *J* = 8.4 Hz, 9H), 1.00 – 0.94 (m, 18H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 173.9, 171.6, 171.4, 171.1, 166.9, 158.7, 155.4, 146.5, 140.7, 132.0, 131.5, 130.9, 130.3, 129.9, 128.6, 128.5, 128.1, 127.6, 127.4, 126.1, 125.7, 119.7, 118.2, 114.0, 113.9, 113.3, 80.1, 55.2, 53.4, 52.6, 52.2, 48.6, 37.1, 36.0, 35.7, 29.54, 29.48, 29.4, 29.3, 28.3, 18.7. ^{31}P NMR (162 MHz, $CDCl_3$) δ 74.0. HRMS (ESI) $[M+Na]^+$ m/z calcd for $C_{46}H_{61}N_4O_9PNa$ 867.4074, found 867.4077.

Compound **3ez'**



According to the general procedure C, the crude residue was purified by flash column chromatography on silica gel (petroleum ether: ethyl acetate =2:1; R_f = 0.3) to compound **3ez'**. ^{1}H NMR (400 MHz, Chloroform-*d*) δ 7.80 (d, *J* = 8.2 Hz, 2H), 7.43 (d, *J* = 7.6 Hz, 1H), 7.34 (d, *J* = 7.9 Hz, 1H), 7.19 (s, 1H), 7.06 (t, *J* = 8.1 Hz, 4H), 6.93 – 6.85 (m, 5H), 6.49 (d, *J* = 7.8 Hz, 1H), 4.94 (dd, *J* = 11.8, 7.7 Hz, 2H), 4.85 (t, *J* = 7.2 Hz, 1H), 3.80 (s, 3H), 3.61 (s, 3H), 3.27 (d, *J* = 5.7 Hz, 2H), 3.02 – 2.95 (m, 2H), 1.56 (d, *J* = 7.1 Hz, 3H), 1.36 (s, 10H), 1.31 (s, 10H), 0.99 (d, *J* = 2.1 Hz, 9H), 0.96 (d, *J* = 2.1 Hz, 9H).^{13}C NMR (101 MHz, $CDCl_3$) δ 174.7, 174.0, 171.8, 171.1, 167.0, 155.3, 154.5, 146.6, 140.6, 132.0, 131.3, 131.1, 131.0, 130.04, 130.0, 129.9, 128.9, 128.2, 126.1, 125.9, 124.4, 124.2, 119.8, 118.1, 112.7, 80.0, 78.5, 77.5, 68.3, 55.9, 54.4, 53.1, 52.7, 52.5, 48.7, 38.8, 38.0, 37.4, 36.0, 35.7, 29.5, 29.4, 28.9, 28.3, 18.9. ^{31}P NMR (162 MHz, $CDCl_3$) δ 73.84. HRMS (ESI) $[M+Na]^+$ m/z calcd for $C_{49}H_{67}N_4O_9PNa$ 909.4543, found 909.4534.

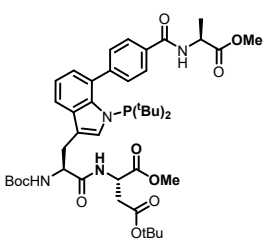
Compound **3fz**



According to the general procedure C, the crude residue was purified by flash column chromatography on silica gel

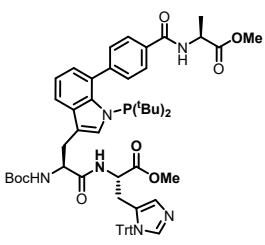
(petroleum ether: ethyl acetate = 2:1; R_f = 0.3) to compound **3fz**. ^{1}H NMR (400 MHz, Chloroform-*d*) δ 7.80 (dd, *J* = 8.3, 3.1 Hz, 2H), 7.58 (d, *J* = 8.1 Hz, 1H), 7.38 – 7.27 (m, 3H), 7.22 – 7.11 (m, 4H), 6.99 – 6.85 (m, 4H), 6.47 (d, *J* = 7.6 Hz, 1H), 5.15 – 4.95 (m, 1H), 4.91 – 4.71 (m, 2H), 4.53 – 4.51 (m, 1H), 3.80 (s, 3H), 3.63 (d, *J* = 1.7 Hz, 3H), 3.30 – 3.22 (m, 2H), 3.07 – 2.92 (m, 2H), 1.55 (d, *J* = 7.2 Hz, 3H), 1.42 – 1.37 (m, 9H), 1.01 – 0.94 (m, 18H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 173.9, 171.5, 171.3, 171.3, 171.1, 166.8, 155.3, 146.5, 140.7, 135.7, 135.5, 132.0, 131.4, 130.9, 130.9, 129.9, 129.3, 129.2, 128.6, 128.5, 127.1, 126.1, 125.7, 119.7, 118.2, 113.3, 80.1, 77.4, 68.2, 54.8, 53.3, 53.2, 52.6, 52.21, 48.5, 38.7, 38.0, 36.0, 35.6, 31.5, 30.1, 29.7, 29.50, 29.45, 29.33, 29.28, 28.3, 18.7. ^{31}P NMR (162 MHz, $CDCl_3$) δ 74.0. HRMS (ESI) $[M+Na]^+$ m/z calcd for $C_{45}H_{59}N_4O_8PNa$ 837.3968, found 837.3964.

Compound **3gz**



According to the general procedure C, the crude residue was purified by flash column chromatography on silica gel (petroleum ether: ethyl acetate =1.5:1; R_f = 0.3) to compound **3gz**. ^{1}H NMR (400 MHz, Chloroform-*d*) δ 7.79 (d, *J* = 7.8 Hz, 2H), 7.56 (d, *J* = 7.7 Hz, 1H), 7.36 – 7.29 (m, 3H), 7.20 (d, *J* = 7.6 Hz, 1H), 7.12 (t, *J* = 7.6 Hz, 1H), 6.92 (d, *J* = 7.3 Hz, 1H), 6.89 (d, *J* = 7.0 Hz, 1H), 5.62 (d, *J* = 8.7 Hz, 1H), 4.94 – 4.89 (m, 1H), 4.83 (p, *J* = 7.2 Hz, 1H), 4.44 (q, *J* = 5.2 Hz, 1H), 3.77 (s, 3H), 3.57 (s, 3H), 3.34 – 3.22 (m, 2H), 2.96 – 2.86 (m, 1H), 2.56 (dd, *J* = 17.1, 6.1 Hz, 1H), 1.53 (d, *J* = 7.2 Hz, 3H), 1.40 (s, 9H), 1.37 (s, 9H), 0.99 (dd, *J* = 12.4, 2.0 Hz, 18H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 173.9, 171.8, 171.4, 170.7, 166.9, 155.3, 146.6, 140.56, 132.0, 131.1, 131.0, 129.9, 128.1, 126.1, 125.7, 119.6, 118.2, 112.7, 81.7, 80.3, 67.2, 60.7, 53.1, 52.6, 52.3, 50.7, 48.6, 37.6, 35.9, 35.6, 29.5, 29.3, 28.3, 28.0, 18.7. ^{31}P NMR (162 MHz, $CDCl_3$) δ 73.4. HRMS (ESI) $[M+Na]^+$ m/z calcd for $C_{44}H_{63}N_4O_{10}PNa$ 861.4180, found 861.4182.

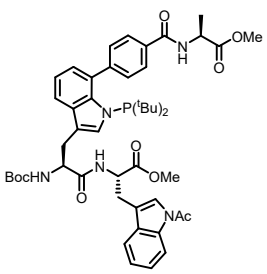
Compound **3hz**



According to the general procedure C, the crude residue was purified by flash column chromatography on silica gel

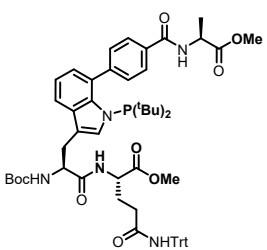
(petroleum ether: ethyl acetate: methanol =2:2:0.1; R_f = 0.35) to compound **3hz**. ^{1}H NMR (400 MHz, Chloroform-*d*) δ 7.81 (d, *J* = 7.9 Hz, 2H), 7.71 (d, *J* = 7.8 Hz, 1H), 7.53 (d, *J* = 8.0 Hz, 1H), 7.36 – 7.27 (m, 13H), 7.14 – 7.07 (m, 7H), 6.93 – 6.82 (m, 2H), 6.67 (s, 1H), 6.25 – 6.15 (m, 1H), 4.93 (dt, *J* = 7.9, 6.1 Hz, 1H), 4.87 (p, *J* = 7.2 Hz, 1H), 4.51 – 4.41 (m, 1H), 3.81 (s, 3H), 3.54 (s, 3H), 3.27 (dd, *J* = 14.6, 5.7 Hz, 1H), 3.17 (dd, *J* = 14.7, 6.5 Hz, 1H), 2.98 (td, *J* = 14.1, 5.4 Hz, 2H), 1.57 (d, *J* = 7.1 Hz, 3H), 1.39 (s, 9H), 0.99 (dd, *J* = 12.4, 6.4 Hz, 18H). ^{13}C NMR (126 MHz, $CDCl_3$) δ 174.5, 174.0, 172.2, 171.6, 166.9, 155.7, 146.7, 146.6, 142.4, 140.6, 140.4, 138.5, 136.9, 132.0, 131.03, 130.98, 123.0, 129.9, 129.8, 128.2, 128.1, 128.02, 127.98, 126.1, 125.7, 119.71, 119.66, 118.3, 113.2, 113.1, 79.7, 75.4, 54.6, 53.2, 52.7, 52.3, 48.6, 36.0, 35.6, 29.5, 29.3, 28.4, 28.3, 18.8. ^{31}P NMR (162 MHz, $CDCl_3$) δ 73.6. HRMS (ESI) $[M+Na]^+$ m/z calcd for $C_{61}H_{71}N_6O_8PNa$ 1069.4969, found 1069.4956.

Compound **3iz**



According to the general procedure C, the crude residue was purified by flash column chromatography on silica gel (petroleum ether: ethyl acetate = 1.5:1; R_f = 0.25) to compound **3iz**. ^{1}H NMR (400 MHz, Chloroform-*d*) δ 8.12 (d, *J* = 8.3 Hz, 1H), 7.79 (d, *J* = 7.9 Hz, 2H), 7.62 (d, *J* = 7.7 Hz, 1H), 7.50 (s, 1H), 7.30 (d, *J* = 7.9 Hz, 2H), 7.27 – 7.21 (m, 3H), 7.12 (s, 1H), 6.95 (t, *J* = 7.5 Hz, 1H), 6.87 (d, *J* = 7.2 Hz, 2H), 6.28 (d, *J* = 7.0 Hz, 2H), 4.92 – 4.78 (m, 2H), 4.71 – 4.66 (m, 1H), 3.81 (s, 3H), 3.58 (s, 3H), 3.22 (d, *J* = 5.7 Hz, 3H), 3.07 (dd, *J* = 14.4, 7.9 Hz, 1H), 1.86 (s, 3H), 1.65 (s, 9H), 1.56 (d, *J* = 7.1 Hz, 3H), 1.26 (s, 3H), 0.92 (d, *J* = 12.4 Hz, 18H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 174.0, 171.5, 170.6, 170.0, 167.0, 149.7, 146.4, 141.4, 140.6, 135.6, 132.1, 131.1, 131.0, 130.4, 130.0, 128.3, 126.7, 126.2, 125.9, 124.8, 122.9, 119.7, 119.2, 117.9, 115.4, 112.5, 111.0, 83.8, 53.5, 53.3, 52.7, 52.6, 48.7, 36.0, 35.7, 29.4, 29.3, 28.3, 27.7, 23.2, 18.9. ^{31}P NMR (162 MHz, $CDCl_3$) δ 74.1. HRMS (ESI) $[M+H]^+$ m/z calcd for $C_{49}H_{63}N_5O_9P$ 896.4363, found 896.4370.

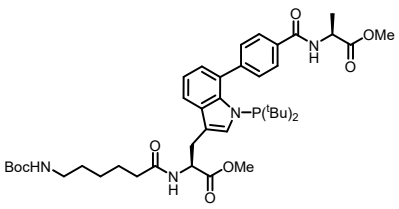
Compound **3jz**



According to the general procedure C, the crude residue was

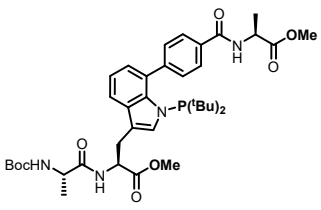
purified by flash column chromatography on silica gel (petroleum ether: ethyl acetate =1:1; R_f = 0.3) to compound **3jz**. ^{1}H NMR (400 MHz, Chloroform-*d*) δ 7.80 (d, *J* = 8.0 Hz, 2H), 7.50 (dt, *J* = 7.9, 1.4 Hz, 1H), 7.40 (s, 1H), 7.34 (d, *J* = 8.1 Hz, 2H), 7.26 (s, 1H), 7.24 – 7.17 (m, 15H), 7.10 (t, *J* = 7.5 Hz, 1H), 7.00 (d, *J* = 7.9 Hz, 1H), 6.92 – 6.85 (m, 2H), 5.54 – 5.42 (m, 1H), 4.92 – 4.82 (m, 2H), 4..10 – 4.04 (m, 1H), 3.81 (s, 3H), 3.64 (s, 3H), 3.32 (dd, *J* = 14.9, 5.7 Hz, 1H), 3.12 (dd, *J* = 14.9, 6.9 Hz, 1H), 2.43 (d, *J* = 6.9 Hz, 2H), 1.90 (d, *J* = 15.5 Hz, 2H), 1.56 (d, *J* = 7.1 Hz, 3H), 1.41 (s, 9H), 0.97 (t, *J* = 12.9 Hz, 18H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 174.0, 172.2, 172.0, 171.5, 166.9, 155.8, 146.6, 144.7, 140.5, 132.0, 131.0, 131.0, 130.93, 130.87, 129.9, 128.8, 128.1, 128.0, 127.0, 126.1, 125.9, 119.8, 118.0, 113.1, 79.9, 70.7, 53.4, 53.0, 52.7, 52.5, 48.6, 36.0, 35.6, 33.6, 30.3, 29.5, 29.44, 29.36, 29.3, 28.4, 27.8, 18.8. ^{31}P NMR (162 MHz, $CDCl_3$) δ 74.1. HRMS (ESI) $[M+Na]^+$ m/z calcd for $C_{60}H_{72}N_5O_9PNa$ 1060.4965, found 1060.4971.

Compound **3kz**



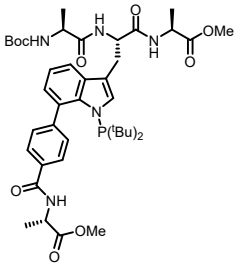
According to the general procedure C, the crude residue was purified by flash column chromatography on silica gel (petroleum ether: ethyl acetate =1:1; R_f = 0.3) to compound **3kz**. ^{1}H NMR (400 MHz, Chloroform-*d*) δ 7.80 (d, *J* = 8.3 Hz, 2H), 7.51 (dt, *J* = 7.9, 1.3 Hz, 1H), 7.33 (d, *J* = 8.3 Hz, 2H), 7.20 (s, 1H), 7.12 (t, *J* = 7.6 Hz, 1H), 6.92 – 6.89 (m, 2H), 6.10 (d, *J* = 7.8 Hz, 1H), 4.98 (dt, *J* = 7.9, 5.6 Hz, 1H), 4.83 (p, *J* = 7.1 Hz, 1H), 4.62 (s, 1H), 3.78 (s, 3H), 3.67 (s, 3H), 3.38 – 3.31 (m, 1H), 3.29 (dd, *J* = 14.9, 5.5 Hz, 1H), 3.08 – 3.26 (m, 2H), 2.14 (t, *J* = 7.5 Hz, 2H), 1.64 – 1.57 (m, 2H), 1.54 (d, *J* = 7.1 Hz, 3H), 1.48 – 1.40 (m, 11H), 1.35 – 1.26 (m, 2H), 0.99 (d, *J* = 7.0 Hz, 9H), 0.96 (d, *J* = 7.0 Hz, 9H). ^{13}C NMR (126 MHz, $CDCl_3$) δ 173.9, 172.6, 172.5, 166.8, 156.0, 146.40, 146.36, 140.6, 140.4, 132.1, 130.99, 130.95, 130.9, 130.1, 128.19, 128.15, 126.1, 125.8, 119.7, 118.1, 112.88, 112.85, 79.0, 52.8, 52.6, 52.4, 48.6, 40.4, 36.3, 36.0, 35.6, 29.8, 29.7, 29.51, 29.45, 29.34, 29.27, 28.5, 27.7, 26.4, 25.1, 18.7. ^{31}P NMR (162 MHz, $CDCl_3$) δ 73.8. HRMS (ESI) $[M+Na]^+$ m/z calcd for $C_{42}H_{61}N_4O_8PNa$ 803.4125, found 803.4126.

Compound **3lz**



According to the general procedure C, the crude residue was purified by flash column chromatography on silica gel (petroleum ether: ethyl acetate =2:1; R_f = 0.3) to compound **3lz**. ^{1}H NMR (400 MHz, Chloroform-*d*) δ 7.80 (d, *J* = 8.2 Hz, 2H), 7.56 – 7.52 (m, 1H), 7.35 (d, *J* = 8.0 Hz, 2H), 7.24 (d, *J* = 2.6 Hz, 1H), 7.14 (t, *J* = 7.5 Hz, 1H), 6.92 (dd, *J* = 7.1, 1.2 Hz, 1H), 6.86 (dd, *J* = 7.3, 4.7 Hz, 1H), 6.62 (d, *J* = 7.9 Hz, 1H), 5.05 – 4.82 (m, 2H), 4.85 (p, *J* = 7.1 Hz, 1H), 4.17 – 4.06 (m, 1H), 3.80 (s, 3H), 3.65 (d, *J* = 3.0 Hz, 3H), 3..39 – 3.26 (m, 2H), 1.56 (d, *J* = 7.2 Hz, 3H), 1.41 (d, *J* = 2.9 Hz, 9H), 1.26 (d, *J* = 11.7 Hz, 3H), 1.01 (d, *J* = 3.6 Hz, 9H), 0.98 (d, *J* = 3.5 Hz, 9H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 173.9, 172.3, 172.2, 172.0, 166.8, 155.2, 146.5, 140.5, 132.0, 130.94, 130.88, 130.0, 128.1, 126.0, 125.8, 119.6, 118.1, 112.7, 80.1, 52.9, 52.6, 52.4, 48.5, 35.9, 35.6, 29.5, 29.4, 29.3, 29.2, 28.3, 27.8, 18.8, 18.6. ^{31}P NMR (162 MHz, $CDCl_3$) δ 73.9. HRMS (ESI) $[M+H]^+$ m/z calcd for $C_{39}H_{56}N_4O_8P$ 739.3836, found 739.3831.

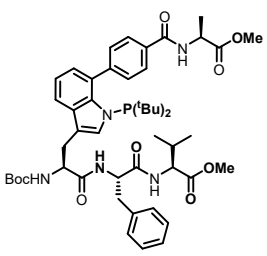
Compound **3mz**



According to the general procedure C, the crude residue was purified by flash column chromatography on silica gel (petroleum ether: ethyl acetate = 1:1; R_f = 0.3) to compound **3mz**. ^{1}H NMR (400 MHz, Chloroform-*d*) δ 7.81 (d, *J* = 8.4 Hz, 2H), 7.64 – 7.60 (m, 1H), 7.39 – 7.30 (m, 3H), 7.17 (q, *J* = 7.3 Hz, 1H), 6.96 – 6.92 (m, 1H), 6.83 (d, *J* = 7.2 Hz, 1H), 6.78 – 6.68 (m, 1H), 6.59 – 6.51 (m, 1H), 4.92 – 4.73 (m, 3H), 4.46 – 4.39 (m, 2H), 4.14 – 4.06 (m, 1H), 3.82 (s, 3H), 3.68 (d, *J* = 9.2 Hz, 3H), 3.44 – 3.19 (m, 2H), 1.57 (d, *J* = 7.1 Hz, 3H), 1.40 (d, *J* = 20.4 Hz, 9H), 1.32 (d, *J* = 7.6 Hz, 3H), 1.05 – 0.93 (m, 18H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 174.0, 173.0, 172.6, 172.4, 170.5, 166.9, 146.6, 140.8, 132.2, 131.7, 131.3, 131.04, 130.98, 130.1, 128.4, 127.9, 127.5, 126.2, 126.0, 125.8, 124.6, 124.1, 119.91, 119.85, 118.1, 113.5, 113.2, 80.7, 53.9, 52.7, 52.54, 52.49, 50.9, 48.7, 48.4, 48.3, 36.0, 35.8, 31.6, 30.3, 29.8, 29.63, 29.56, 29.5, 29.39, 28.41, 28.35, 22.8, 19.0, 18.2, 17.8. ^{31}P NMR (162 MHz,

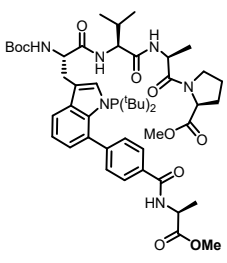
$CDCl_3$) δ 74.3, 74.2. HRMS (ESI) $[M+H]^+$ m/z calcd for $C_{42}H_{61}N_5O_9P$ 810.4207, found 810.42011.

Compound **3nz**



According to the general procedure C, the crude residue was purified by flash column chromatography on silica gel (petroleum ether: ethyl acetate: methanol =2:2:0.08; R_f = 0.4) to compound **3nz**. ^{1}H NMR (400 MHz, Chloroform-*d*) δ 7.80 (d, *J* = 8.3 Hz, 2H), 7.57 (d, *J* = 7.9 Hz, 1H), 7.34 (d, *J* = 8.2 Hz, 2H), 7.29 (s, 1H), 7.24 – 7.17 (m, 3H), 7.14 (t, *J* = 7.5 Hz, 1H), 7.10 – 7.02 (m, 2H), 6.64 – 6.92 (m, 2H), 6.89 (d, *J* = 7.2 Hz, 1H), 6.79 (d, *J* = 7.8 Hz, 1H), 6.45 (d, *J* = 8.4 Hz, 1H), 4.95 (d, *J* = 6.5 Hz, 1H), 4.84 (p, *J* = 7.1 Hz, 1H), 4.68 (td, *J* = 7.6, 5.5 Hz, 1H), 4.43 (q, *J* = 6.6 Hz, 1H), 4.37 (dd, *J* = 8.4, 5.3 Hz, 1H), 3.79 (s, 3H), 3.68 (s, 3H), 3.28 – 3.24 (m, 1H), 3.13 – 3.09 (m, 1H), 2.86 – 2.81 (m, 1H), 2.63 – 2.56 (m, 1H), 2.08 – 2.01 (m, 1H), 1.55 (d, *J* = 7.2 Hz, 3H), 1.31 (s, 9H), 1.02 – 0.98 (m, 18H), 0.82 (dd, *J* = 14.6, 6.9 Hz, 6H). ^{13}C NMR (126 MHz, $CDCl_3$) δ 174.0, 171.8, 171.7, 170.5, 166.9, 155.5, 146.5, 140.8, 140.7, 136.3, 132.1, 131.4, 131.3, 131.0, 130.9, 129.8, 129.4, 128.7, 128.2, 127.1, 126.2, 125.9, 119.8, 118.4, 113.3, 80.3, 57.7, 54.3, 52.7, 52.1, 48.6, 37.8, 36.0, 35.8, 31.0, 29.6, 29.54, 29.45, 29.4, 28.3, 18.9, 18.8, 18.0. ^{31}P NMR (162 MHz, $CDCl_3$) δ 74.1. HRMS (ESI) $[M+Na]^+$ m/z calcd for $C_{50}H_{68}N_5O_9PNa$ 936.4652, found 936.4664.

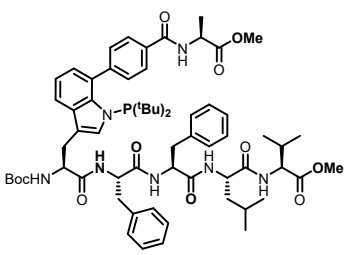
Compound **3oz**



According to the general procedure C, the crude residue was purified by flash column chromatography on silica gel (petroleum ether: ethyl acetate: methanol =2:2:0.1; R_f = 0.35) to compound **3oz**. ^{1}H NMR (400 MHz, Chloroform-*d*) δ 7.80 (d, *J* = 8.1 Hz, 2H), 7.59 (d, *J* = 7.7 Hz, 1H), 7.34 (d, *J* = 8.1 Hz, 2H), 7.30 (s, 1H), 7.13 (t, *J* = 7.5 Hz, 1H), 6.93 – 6.82 (m, 4H), 5.07 (s, 1H), 4.85 (p, *J* = 7.2 Hz, 1H), 4.69 (p, *J* = 6.9 Hz, 1H), 4.56 – 4.40 (m, 2H), 4.29 (dd, *J* = 8.4, 5.5 Hz, 1H), 3.80 (s, 3H), 3.70 (s,

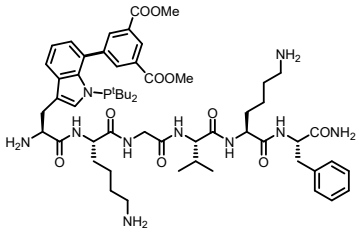
3H), 3.36 – 3.14 (m, 2H), 2.28 – 1.88 (m, 7H), 1.55 (d, *J* = 7.1 Hz, 3H), 1.37 (d, *J* = 5.7 Hz, 12H), 0.99 (dd, *J* = 12.4, 5.7 Hz, 18H), 0.85 (d, *J* = 6.8 Hz, 6H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 174.0, 172.4, 171.8, 170.9, 170.1, 166.9, 155.9, 146.64, 146.60, 140.7, 141.6, 132.1, 131.1, 131.0, 130.0, 128.13, 128.09, 126.1, 125.8, 119.7, 118.3, 113.5, 80.4, 58.9, 58.4, 54.8, 52.7, 52.4, 48.6, 46.9, 36.1, 35.7, 31.3, 29.8, 29.6, 29.5, 29.0, 28.4, 27.0, 25.1, 19.1, 18.9, 18.0, 17.8. ^{31}P NMR (162 MHz, $CDCl_3$) δ 73.8. HRMS (ESI) $[M+Na]^+$ m/z calcd for $C_{49}H_{71}N_6O_{10}PNa$ 957.4867, found 957.4865.

Compound **3pz**



According to the general procedure C, the crude residue was purified by flash column chromatography on silica gel (petroleum ether: ethyl acetate: methanol =2:3:0.1; R_f = 0.3) to compound **3pz**. ^{1}H NMR (400 MHz, Chloroform-*d*) δ 7.85 – 7.81 (m, 2H), 7.53 – 7.47 (m, 1H), 7.40 – 7.30 (m, 3H), 7.28 – 7.10 (m, 10H), 7.06 – 6.95 (m, 2H), 6.91 (d, *J* = 7.4 Hz, 2H), 6.83 (d, *J* = 8.1 Hz, 1H), 6.73 – 6.61 (m, 1H), 4.92 – 4.79 (m, 2H), 4.58 – 4.41 (m, 3H), 4.27 – 3.90 (m, 3H), 3.84 (s, 3H), 3.78 – 3.74 (m, 3H), 3.37 – 2.76 (m, 6H), 2.29 – 2.18 (m, 1H), 1.85 – 1.64 (m, 2H), 1.59 (d, *J* = 7.1 Hz, 3H), 1.28 (d, *J* = 3.1 Hz, 9H), 1.07 – 0.88 (m, 31H). ^{13}C NMR (126 MHz, $CDCl_3$) δ 174.0, 173.2, 172.3, 172.2, 171.3, 171.1, 167.0, 156.3, 146.2, 140.9, 140.8, 137.0, 135.5, 132.2, 131.2, 130.97, 130.04, 129.60, 129.6, 129.4, 129.3, 129.1, 129.0, 128.8, 128.7, 128.48, 128.45, 127.5, 126.9, 126.31, 126.27, 120.1, 118.1, 112.6, 81.2, 57.6, 55.2, 54.3, 52.8, 52.3, 48.7, 40.2, 36.6, 36.0, 31.1, 29.8, 29.63, 29.56, 29.5, 29.4, 28.3, 28.2, 27.1, 24.8, 23.4, 21.6, 19.2, 18.9, 18.1. ^{31}P NMR (162 MHz, $CDCl_3$) δ 74.4. HRMS (ESI) $[M+Na]^+$ m/z calcd for $C_{65}H_{88}N_7O_{11}PNa$ 1196.6177, found 1196.6184.

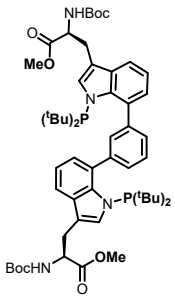
Compound **P3ai**



According to the general procedure C, the crude residue was purified by a Welch C18 reverse-phase column (4.6 × 250 mm, 5 μm particle size) to compound **P3ai** with mobile phase of water-acetonitrile-(0.1% formic acid) at

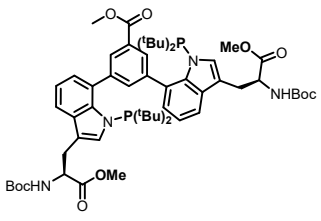
a flow rate of 4.0 mL/min. ^{1}H NMR (400 MHz, Acetic Acid-d_4) δ 8.85 (t, J = 1.7 Hz, 1H), 8.38 – 8.34 (m, 2H), 8.27 (d, J = 3.3 Hz, 2H), 7.93 (d, J = 7.8 Hz, 1H), 7.74 (s, 1H), 7.48 – 7.37 (m, 6H), 7.25 (dd, J = 7.2, 1.2 Hz, 1H), 5.00 (dd, J = 8.4, 5.9 Hz, 1H), 4.88 – 4.77 (m, 2H), 4.73 (t, J = 7.1 Hz, 1H), 4.59 (d, J = 7.3 Hz, 1H), 4.26 (d, J = 16.7 Hz, 1H), 4.14 (s, 7H), 3.73 (dd, J = 14.9, 5.9 Hz, 1H), 3.60 (dd, J = 14.7, 8.3 Hz, 1H), 3.35 (dd, J = 13.9, 5.9 Hz, 1H), 3.24 – 3.15 (m, 4H), 2.07 – 1.82 (m, 8H), 1.61 (d, J = 14.9 Hz, 4H), 1.47 (s, 3H), 1.44 (s, 2H), 1.18 (dd, J = 21.7, 12.6 Hz, 18H), 1.09 (d, J = 6.7 Hz, 6H). ^{13}C NMR (101 MHz, Acetic) δ 177.7, 174.8, 174., 174.1, 172.0, 171.1, 168.4, 167.0, 144.9, 142.8, 138.1, 131.5, 131.0, 130.9, 130.6, 130.2, 128.7, 128.6, 127.5, 121.8, 121.6, 120.4, 116.7, 112.5, 56.2, 55.2, 54.9, 53.8, 44.0, 41.3, 39.4, 37.3, 37.2, 37.0, 36.9, 33.8, 32.7, 32.6, 30.43, 30.35, 30.3, 30.2, 28.3, 28.1, 26.4, 24.1, 23.5, 19.2. ^{31}P NMR (162 MHz, Acetic) δ 75.3. HRMS (ESI) $[M+H]^+$ m/z calcd for $C_{57}H_{84}N_{10}O_{10}P$ 1099.6110, found 1099.6122.

Compound **4aa**



According to the general procedure D, the crude residue was purified by flash column chromatography on silica gel (petroleum ether: ethyl acetate = 5:1; R_f = 0.3) to compound **4aa**. ^{1}H NMR (400 MHz, Chloroform-*d*) δ 7.50 (d, J = 7.6 Hz, 2H), 7.29 (t, J = 7.5 Hz, 1H), 7.25 (s, 2H), 7.21 – 7.06 (m, 7H), 5.11 (d, J = 8.1 Hz, 2H), 4.69 – 4.64 (dt, J = 9.2, 4.6 Hz, 2H), 3.65 (s, 6H), 3.36 – 3.25 (td, J = 14.9, 12.4, 5.6 Hz, 4H), 1.43 (s, 18H), 1.12 – 0.86 (m, 36H). ^{13}C NMR (101 MHz, $CDCl_3$) 172.8, 155.2, 141.0, 133.3, 131.11, 131.05, 129.8, 129.1, 126.3, 126.1, 119.5, 117.5, 112.5, 79.9, 77.5, 54.0, 52.4, 36.1, 35.6, 29.6, 29.5, 28.5. ^{31}P NMR (162 MHz, $CDCl_3$) δ 73.4. HRMS (ESI) $[M+Na]^+$ m/z calcd for $C_{56}H_{80}N_4O_8P_2Na$ 1021.5349, found 1021.5357.

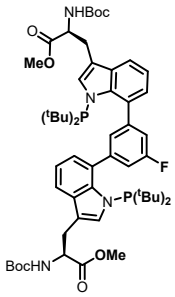
Compound **4ab**



According to the general procedure D, the crude residue was purified by flash column chromatography on silica gel (petroleum ether: ethyl acetate = 4:1; R_f = 0.25) to compound **4ab**. ^{1}H NMR (400 MHz, Chloroform-*d*) δ 7.94

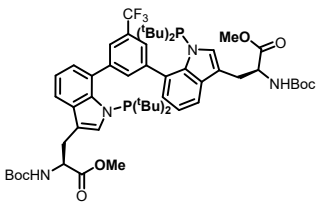
(s, 2H), 7.53 (d, *J* = 7.8 Hz, 2H), 7.41 (s, 1H), 7.14 (t, *J* = 7.5 Hz, 2H), 7.26 (s, 2H), 7.08 (d, *J* = 7.0 Hz, 2H), 5.13 – 5.11 (m, 2H), 4.70 – 4.65 (m, 2H), 3.87 (s, 3H), 3.66 (s, 6H), 3.40 – 3.21 (m, *J* = 5.3 Hz, 4H), 1.43 (s, 18H), 1.10 – 0.99 (m, 36H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 172.79, 172.75, 167.7, 155.2, 141.5, 140.8, 140.7, 137.2, 131.2, 130.9, 130.2, 130.0, 128.5, 128.3, 127.9, 126.0, 119.6, 118.0, 112.7, 79.9, 54.1, 52.4, 51.9, 36.0, 35.6, 29.7, 29.5, 28.5.^{31}P NMR (162 MHz, $CDCl_3$) δ 73.8. HRMS (ESI) $[M+Na]^+$ m/z calcd for $C_{58}H_{82}N_4O_{10}P_2Na$ 1079.5404, found 1079.5420.

Compound **4ac**



According to the general procedure D, the crude residue was purified by flash column chromatography on silica gel (petroleum ether: ethyl acetate = 5:1; R_f = 0.3) to compound **4ac**. ^{1}H NMR (400 MHz, Chloroform-*d*) δ 7.58 (d, *J* = 7.8 Hz, 2H), 7.30 (s, 3H), 7.26 (s, 2H), 7.22 (t, *J* = 7.5 Hz, 2H), 7.11 (d, *J* = 7.0 Hz, 2H), 5.18 (d, *J* = 8.1 Hz, 2H), 4.76 – 4.72 (m, 2H), 3.73 (s, 6H), 3.43 – 3.32 (m, 4H), 1.49 (s, 18H), 1.11 (d, *J* = 3.4 Hz, 18H), 1.08 (d, *J* = 3.5 Hz, 18H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 172.8, 155.3, 141.1, 141.1, 131.3, 131.2, 129.9, 129.7, 129.7, 126.2, 119.6, 117.6, 112.6, 79.9, 54.1, 52.5, 36.0, 35.7, 29.7, 29.5, 28.5.^{31}P NMR (162 MHz, $CDCl_3$) δ 74.3. HRMS (ESI) $[M+Na]^+$ m/z calcd for $C_{56}H_{79}FN_4O_8P_2Na$ 1039.5255, found 1039.5241.

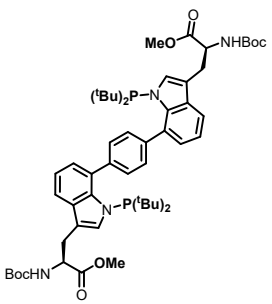
Compound **4ad**



According to the general procedure D, the crude residue was purified by flash column chromatography on silica gel (petroleum ether: ethyl acetate = 4:1; R_f = 0.3) to compound **4ad**. ^{1}H NMR (400 MHz, Chloroform-*d*) δ 7.55 (d, *J* = 7.8 Hz, 2H), 7.50 (s, 2H), 7.38 (s, 1H), 7.26 (s, 2H), 7.15 (t, *J* = 7.5 Hz, 2H), 7.07 (d, *J* = 7.0 Hz, 2H), 5.12 (d, *J* = 8.1 Hz, 2H), 4.70 – 4.65 (m, 2H), 3.66 (s, 6H), 3.38 – 3.26 (m, 4H), 1.43 (s, 18H), 1.17 – 0.96 (m, 36H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 172.6, 155.1, 141.9, 140.6, 135.8, 131.1, 130.0, 127.8, 126.2, 126.0, 125.6, 124.5, 124.4, 124.0, 119.4, 118.1, 114.1, 112.7, 79.8, 53.9, 52.30, 36.2, 35.8, 29.7, 29.4, 29.3, 28.4.^{31}P NMR (162 MHz, $CDCl_3$) δ 73.9. HRMS (ESI) $[M+H]^+$ m/z calcd for $C_{57}H_{80}F_3N_4O_8P_2$

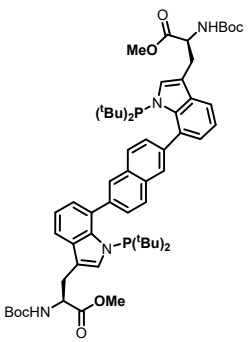
1067.5403, found 1067.5411.

Compound **4ae**



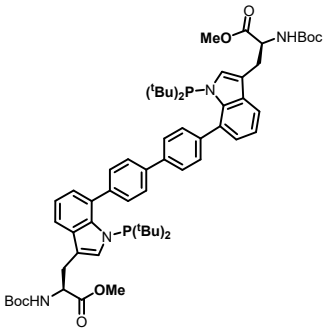
According to the general procedure D, the crude residue was purified by flash column chromatography on silica gel (petroleum ether: ethyl acetate = 5:1; R_f = 0.25) to compound **4ae**. ^{1}H NMR (400 MHz, Chloroform-*d*) δ 7.58 (d, *J* = 7.8 Hz, 2H), 7.30 (s, 3H), 7.26 (s, 3H), 7.22 (t, *J* = 7.5 Hz, 2H), 7.11 (d, *J* = 6.9 Hz, 2H), 5.19 – 5.17 (d, *J* = 8.0 Hz, 2H), 4.76 – 4.72 (m, 2H), 3.73 (s, 6H), 3.41 (dd, *J* = 14.7, 5.6 Hz, 2H), 3.34 (dd, *J* = 14.8, 5.5 Hz, 2H), 1.49 (s, 18H), 1.11 (d, *J* = 3.4 Hz, 18H), 1.08 (d, *J* = 3.5 Hz, 18H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 172.8, 155.3, 141.13, 141.08, 131.3, 129.9, 129.73, 129.67, 126.2, 119.6, 117.6, 112.6, 79.9, 54.1, 52.5, 36.0, 35.6, 29.7, 29.5, 28.5.^{31}P NMR (162 MHz, $CDCl_3$) δ 74.3. HRMS (ESI) $[M+Na]^+$ m/z calcd for $C_{56}H_{80}N_4O_8P_2Na$ 1021.5349, found 1021.5352.

Compound **4af**



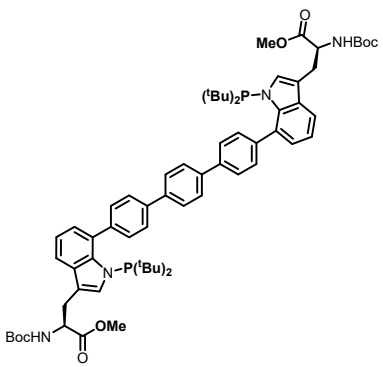
According to the general procedure D, the crude residue was purified by flash column chromatography on silica gel (petroleum ether: ethyl acetate = 5:1; R_f = 0.3) to compound **4af**. ^{1}H NMR (400 MHz, Chloroform-*d*) δ 7.78 – 7.76 (m, 4H), 7.57 (d, *J* = 7.8 Hz, 2H), 7.45 (d, *J* = 8.3 Hz, 2H), 7.28 (s, 2H), 7.23 – 7.16 (m, 2H), 7.22 – 7.07 (m, 2H), 5.17 (d, *J* = 8.1 Hz, 2H), 4.77 – 4.66 (m, 2H), 3.70 (s, 6H), 3.39 (dd, *J* = 14.6, 5.6 Hz, 2H), 3.33 (dd, *J* = 14.8, 5.5 Hz, 2H), 1.46 (s, 18H), 1.06 – 0.93 (m, 36H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 172.8, 155.2, 141.1, 140.9, 139.7, 132.2, 131.1, 130.0, 129.8, 129.5, 128.9, 126.4, 119.7, 117.8, 112.8, 79.9, 54.1, 52.5, 35.9, 35.6, 29.7, 29.5, 28.5.^{31}P NMR (162 MHz, $CDCl_3$) δ 74.3. HRMS (ESI) $[M+Na]^+$ m/z calcd for $C_{60}H_{82}N_4O_8P_2Na$ 1071.5506, found 1071.5525.

Compound **4ag**



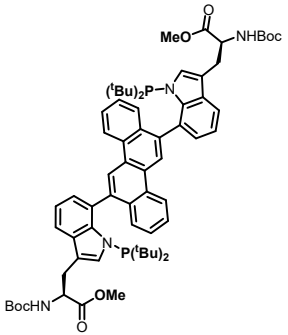
According to the general procedure D, the crude residue was purified by flash column chromatography on silica gel (petroleum ether: ethyl acetate = 5:1; R_f = 0.3) to compound **4ag**. ^{1}H NMR (400 MHz, Chloroform-*d*) δ 7.70 (d, *J* = 8.3 Hz, 4H), 7.55 (d, *J* = 8.0 Hz, 2H), 7.36 (d, *J* = 8.1 Hz, 4H), 7.25 (s, 2H), 7.19 (t, *J* = 7.5 Hz, 2H), 7.09 (d, *J* = 6.8 Hz, 2H), 5.14 (d, *J* = 8.1 Hz, 2H), 4.73 – 4.68 (m, 2H), 3.69 (s, 6H), 3.37 (dd, *J* = 14.7, 5.6 Hz, 2H), 3.30 (dd, *J* = 14.7, 5.5 Hz, 2H), 1.45 (s, 19H), 1.04 – 1.00 (m, 36H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 172.8, 155.2, 141.3, 140.1, 131.3, 131.2, 130.0, 129.1, 127.7, 127.6, 126.1, 125.6, 124.5, 119.7, 117.9, 112.8, 80.0, 54.1, 52.5, 36.0, 35.9, 35.7, 35.6, 29.6, 29.5, 28.5.^{31}P NMR (162 MHz, $CDCl_3$) δ 74.1. HRMS (ESI) $[M+Na]^+$ m/z calcd for $C_{62}H_{84}N_4O_8P_2Na$ 1097.5662, found 1097.5668.

Compound **4ah**



According to the general procedure D, the crude residue was purified by flash column chromatography on silica gel (petroleum ether: ethyl acetate = 4:1; R_f = 0.3) to compound **4ah**. ^{1}H NMR (400 MHz, Chloroform-*d*) δ 7.51 (t, *J* = 8.3 Hz, 3H), 7.37 (s, 2H), 7.25 (s, 1H), 7.20 – 7.03 (m, 9H), 5.12 (d, *J* = 8.1 Hz, 3H), 4.67 (t, *J* = 6.5 Hz, 3H), 3.66 (d, *J* = 2.1 Hz, 9H), 3.40 – 3.23 (m, 6H), 1.43 – 1.42 (m, 27H), 1.18 – 0.99 (m, 54H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 172.8, 155.2, 141.6, 141.6, 141.0, 140.3, 139.4, 131.4, 131.3, 131.2, 131.2, 130.0, 129.0, 127.6, 126.0, 125.7, 119.7, 117.9, 112.8, 79.9, 54.1, 52.5, 36.0, 35.6, 29.7, 29.5, 28.5. ^{31}P NMR (162 MHz, $CDCl_3$) δ 74.0. HRMS (ESI) $[M+H]^+$ m/z calcd for $C_{68}H_{89}N_4O_8P_2$ 1151.6156, found 1151.6149.

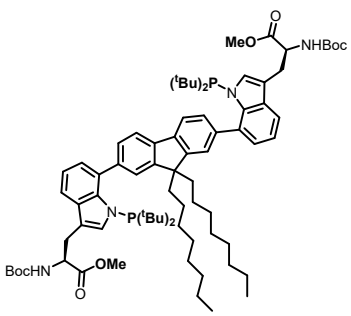
Compound **4ai**



According to the general procedure D, the crude residue was

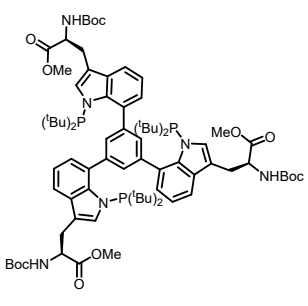
purified by flash column chromatography on silica gel (petroleum ether: ethyl acetate = 4:1; R_f = 0.3) to compound **4ai**. ^{1}H NMR (400 MHz, Chloroform-*d*) δ 8.72 – 8.62 (m, 4H), 7.72 – 7.64 (m, 2H), 7.59 – 7.50 (m, 4H), 7.42 – 7.38 (m, 2H), 7.33 – 7.27 (m, 3H), 7.25 (s, 1H), 7.22 – 7.15 (m, 2H), 5.24 – 5.19 (m, 2H), 4.82 – 4.67 (m, 2H), 3.76 – 3.70 (m, 6H), 3.74 – 3.37 (m, 4H), 1.48 – 1.47 (m, 18H), 0.90 (d, *J* = 12.2 Hz, 9H), 0.80 (d, *J* = 12.2 Hz, 9H), 0.68 (dd, *J* = 19.4, 12.5 Hz, 18H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 172.9, 172.8, 155.3, 142.0, 138.8, 138.3, 133.5, 131.1, 130.6, 130.0, 128.4, 128.2, 127.6, 127.4, 127.0, 126.5, 126.1, 125.9, 125.8, 125.7, 123.6, 123.5, 123.1, 122.9, 120.0, 119.8, 118.2, 112.74, 112.73, 80.0, 54.2, 52.5, 36.3, 36.0, 34.7, 34.4, 29.5, 29.4, 28.5. ^{31}P NMR (162 MHz, $CDCl_3$) δ 74.9. HRMS (ESI) $[M+Na]^+$ m/z calcd for $C_{68}H_{86}N_4O_8P_2Na$ 1171.5819, found 1171.5822.

Compound **4aj**



According to the general procedure D, the crude residue was purified by flash column chromatography on silica gel (petroleum ether: ethyl acetate = 4:1; R_f = 0.3) to compound **4aj**. ^{1}H NMR (400 MHz, Chloroform-*d*) δ 7.67 (d, *J* = 7.7 Hz, 2H), 7.54 (d, *J* = 8.1 Hz, 2H), 7.32 – 7.26 (m, 5H), 7.24 (s, 1H), 7.16 (t, *J* = 8.3 Hz, 2H), 7.00 – 6.97 (m, 2H), 5.15 (d, *J* = 8.1 Hz, 2H), 4.71 (s, 2H), 3.70 (s, 6H), 3.41 – 3.28 (m, 4H), 2.06 – 1.91 (m, 4H), 1.61 – 1.58 (m, 2H), 1.45 – 1.41 (m, 20H), 1.24 – 1.06 (m, 34H), 0.95 – 0.81 (m, 34H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 172.7, 155.1, 150.6, 141.1, 139.7, 131.2, 130.4, 129.9, 128.2, 126.6, 124.5, 119.6, 117.8, 117.5, 112.6, 79.8, 55.0, 54.0, 52.3, 40.3, 36.3, 31.9, 31.5, 29.7, 29.2, 28.4, 24.0, 22.7, 14.1.^{31}P NMR (162 MHz, $CDCl_3$) δ 73.3. HRMS (ESI) $[M+H]^+$ m/z calcd for $C_{79}H_{117}N_4O_8P_2$ 1311.8347, found 1311.8341.

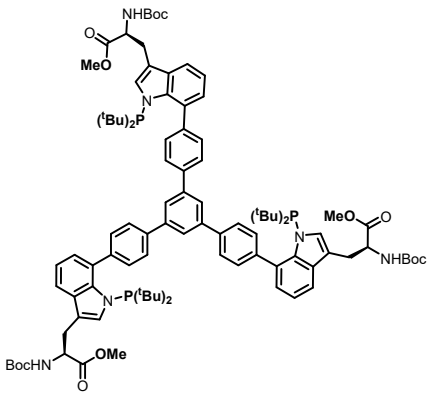
Compound **4ak**



According to the general procedure D, the crude residue was purified by flash column chromatography on silica gel

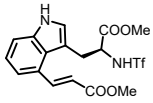
(petroleum ether: ethyl acetate = 4:1; R_f = 0.3) to compound **4ak**. ^{1}H NMR (400 MHz, Chloroform-*d*) δ 7.51 (t, *J* = 8.3 Hz, 3H), 7.37 (s, 2H), 7.25 (s, 1H), 7.20 – 7.03 (m, 9H), 5.12 (d, *J* = 8.1 Hz, 3H), 4.67 (t, *J* = 6.5 Hz, 3H), 3.66 (d, *J* = 2.1 Hz, 9H), 3.40 – 3.23 (m, 6H), 1.43 – 1.42 (m, 27H), 1.18 – 0.99 (m, 54H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 172.8, 155.2, 143.2, 141.0, 140.8, 133.3, 132.4, 131.2, 130.0, 129.8, 129.1, 128.0, 126.3, 126.1, 125.6, 120.2, 119.5, 119.4, 118.1, 117.5, 112.7, 112.5, 79.9, 54.0, 52.4, 36.3, 35.9, 29.7, 29.5, 28.5. ^{31}P NMR (162 MHz, $CDCl_3$) δ 74.2. HRMS (ESI) $[M+Na]^+$ m/z calcd for $C_{81}H_{117}N_6O_{12}P_3Na$ 1481.7840, found 1481.7846.

Compound **4al**



According to the general procedure D, the crude residue was purified by flash column chromatography on silica gel (petroleum ether: ethyl acetate = 4:1; R_f = 0.3) to compound **4al**. ^{1}H NMR (400 MHz, Chloroform-*d*) δ 8.00 (s, 3H), 7.78 (d, *J* = 8.1 Hz, 6H), 7.55 (d, *J* = 7.9 Hz, 3H), 7.42 (d, *J* = 7.9 Hz, 6H), 7.26– 7.25 (d, *J* = 3.2 Hz, 5H), 7.19 (t, *J* = 7.5 Hz, 3H), 7.09 (d, *J* = 7.2 Hz, 3H), 5.14 (d, *J* = 8.1 Hz, 3H), 4.73 – 4.68 (m, 3H), 3.69 (s, 9H), 3.37 (dd, *J* = 14.7, 5.5 Hz, 3H), 3.31 (dd, *J* = 14.7, 5.4 Hz, 3H), 1.45 (s, 28H), 1.05 (d, *J* = 4.3 Hz, 27H), 1.02 (d, *J* = 4.4 Hz, 27H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 172.8, 155.2, 142.7, 141.9, 141.8, 141.0, 140.0, 131.5, 131.4, 131.3, 130.0, 128.9, 126.4, 125.8, 125.1, 119.7, 117.9, 112.8, 80.0, 54.1, 52.5, 36.0, 35.7, 29.7, 29.5, 28.5. ^{31}P NMR (162 MHz, $CDCl_3$) δ 74.0. HRMS (ESI) $[M+Na]^+$ m/z calcd for $C_{99}H_{129}N_6O_{12}P_3Na$ 1709.8779, found 1709.8787.

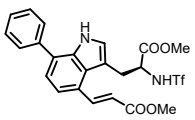
Compound **5b**



TfNH-(N-TIPS)Trp-CO_2Me (99 mg, 0.2 mmol), $Pd(OAc)_2$ (4.5 mg, 0.02 mmol), AgOAc (83 mg, 0.5 mmol) and methyl acrylate (45 uL, 0.5 mmol) were dissolved in 5 mL of dry toulene under Ar. The tube was sealed and the reaction mixture was stirred at 100 °C for 24 h. The reaction mixture was filtered with

celite and the filtrate was concentrated under vacuum. To crude product in 25 mL Schlenk tube was added anhydrous THF (4.0 mL), and then TBAF (0.8 mL, 0.8 mmol, 1 M in THF) was added, the mixture was stirred under 30℃ for 12 h. The reaction mixture was quenched and partitioned between H_2O and EtOAc. The organic phase was washed successively with H_2O, saturated aqueous $NaHCO_3$ solution and brine, and dried over anhydrous Na_2SO_4. The solvent was evaporated under reduced pressure, and the resulting residue was purified by flash column chromatography on silica gel (petroleum ether: ethyl acetate = 3:1; R_f = 0.3) to afford product **5b** (56 mg, 65%). ^{1}H NMR (400 MHz, Chloroform-*d*) 8.54 (d, *J* = 2.6 Hz, 1H), 8.45 (d, *J* = 15.6 Hz, 1H), 7.37 (t, *J* = 7.7 Hz, 2H), 7.18 (t, *J* = 7.8 Hz, 1H), 7.13 (d, *J* = 2.7 Hz, 1H), 6.46 (d, *J* = 15.6 Hz, 1H), 6.31 (s, 1H), 4.53 – 4.46 (m, 1H), 3.84 (s, 3H), 3.73 (s, 3H), 3.60 (dd, *J* = 15.2, 5.2 Hz, 1H), 3.33 (dd, *J* = 15.2, 7.8 Hz, 1H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 171.2, 167.8, 143.1, 137.3, 127.9, 125.9, 125.0, 122.5, 119.5, 119.3, 113.6, 109.0, 58.0, 53.1, 51.9, 31.4. HRMS (ESI) $[M+Na]^+$ m/z calcd for $C_{17}H_{17}F_3N_2O_6SNa$ 457.0657, found 457.0652.

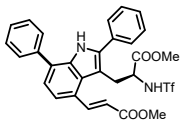
Compound **5c**



5i (114 mg, 0.2 mmol), $Pd(OAc)_2$ (4.5 mg, 0.02 mmol), AgOAc (83 mg, 0.5 mmol) and methyl methyl acrylate (45 uL, 0.5 mmol) were dissolved in 5 mL of dry toulene under Ar. The tube was sealed and the reaction mixture was stirred at 100 °C for 24 h. The reaction mixture was filtered with celite and the filtrate was concentrated under vacuum. The residue was purified by flash column chromatography on silica gel (petroleum ether: ethyl acetate = 3:1; R_f = 0.3) to compound **5c** (51 mg, 50%). ^{1}H NMR (400 MHz, Chloroform-*d*) δ 8.52 (d, *J* = 15.6 Hz, 1H), 8.38 (s, 1H), 7.55 – 7.47 (m, 5H), 7.44 – 7.37 (m, 2H), 7.22 (t, *J* = 7.8 Hz, 1H), 6.47 (d, *J* = 15.6 Hz, 1H), 5.52 (d, *J* = 9.8 Hz, 1H), 4.36 – 4.25 (m, 1H), 3.84 (s, 3H), 3.72 (dd, *J* = 15.1, 5.0 Hz, 1H), 3.58 (s, 3H), 3.44 (dd, *J* = 15.1, 5.0 Hz, 1H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 170.9, 167.6, 143.2, 139.4, 136.6, 132.1, 129.6, 129.4, 129.3, 129.0, 128.6, 128.1, 126.3, 122.8, 120.9, 119.9, 119.9, 117.7, 113.1, 106.1, 58.0, 53.0, 51.8, 30.1. HRMS (ESI) $[M+Na]^+$ m/z calcd for $C_{23}H_{21}F_3N_2O_6SNa$ 533.0970,

found 533.0971.

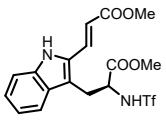
Compound **5d**



To a flame dried Schlenk tube was added **5i'** (426 mg, 1 mmol), $[Ir(OMe)(cod)]_2$ (8.5 mg, 1.3 mol%), dtbpy (6.7 mg, 2.5 mol%), and B_2pin_2 (330 mg, 1.3 e.q.) in a glove box. Dry THF (3.0 mL) was added to the Schlenk under Ar atmosphere. The reaction mixture was stirred at 60 ℃ for 12 h. After the reaction is complete, cool the reaction mixture to room temperature, quench with methanol (5.0 mL), and then filter through a silica gel pad. The solvent was removed under vacuum, and the resulting residue was purified by silica gel flash chromatography (petroleum ether: ethyl acetate = 6:1; R_f = 0.25) to afford product **5d'** (306 mg, 56%).
To a flame dried Schlenk tube was added **5d'** (270 mg, 0.5 mmol), $Pd_2(dba)_3$ (23 mg, 5.0 mol%), Sphos (20.5 mg, 10 mol%), PhBr (63 uL, 1.2 e.q.) mol%) and K_3PO_4 (212 mg, 2.0 e.q.) in a glove box. Dry toulene (8 mL) was added to the Schlenk under Ar atmosphere. The reaction mixture was stirred at 80 ℃ for 12 h. Upon completion, the reaction mixture was cooled to room temperature and passed through a pad of silica. The solvent was removed under vacuum, and the resulting residue was purified by silica gel flash chromatography (petroleum ether: ethyl acetate = 5:1; R_f = 0.3) to afford product **5d''** (198 mg, 81 %).
5d''(104 mg, 0.2 mmol), $Pd(OAc)_2$ (4.5 mg, 0.02 mmol), AgOAc (83 mg, 0.5 mmol) and N,N-Dimethylacrylamide (52 uL, 0.5 mmol) were dissolved in 5 mL of dry toulene under Ar atmosphere. The tube was sealed and the reaction mixture was stirred at 100 °C for 24 h. The reaction mixture was filtered with celite and the filtrate was concentrated under vacuum. The residue was purified by flash column chromatography on silica gel (petroleum ether: ethyl acetate = 2:1; R_f = 0.2) to compound **5d** (86 mg, 73%).^{1}H NMR (500 MHz, Chloroform-*d*) δ 8.58 (d, *J* = 15.7 Hz, 1H), 8.53 (s, 1H), 7.69 – 7.63 (m, 2H), 7.57 – 7.50 (m, 7H), 7.49 – 7.42 (m, 2H), 7.28 (d, *J* = 1.5 Hz, 1H), 6.54 (d, *J* = 15.5 Hz, 1H), 5.64 (d, *J* = 9.7 Hz, 1H), 4.38 (td, *J* = 9.4, 5.0 Hz, 1H), 3.87 (s, 3H), 3.79 (dd, *J* = 15.1, 5.1 Hz, 1H), 3.62 (s, 3H), 3.47 (dd, *J* = 15.2, 9.2 Hz, 1H). ^{13}C NMR (126 MHz, $CDCl_3$) δ 170.8, 167.5, 142.9, 139.7, 138.3, 134.3, 132.0, 129.5,

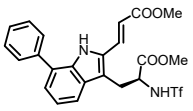
129.4, 129.3, 129.0, 128.4, 128.1, 127.5, 127.3, 126.6, 122.9, 120.4, 119.7, 106.6, 58.0, 53.0, 51.8, 30.0. HRMS (ESI) $[M+Na]^+$ m/z calcd for $C_{29}H_{25}F_3N_2O_6SNa$ 609.1283, found 609.1291

Compound **5e**



5a (70 mg, 0.2 mmol), $Pd(OAc)_2$ (4.5 mg, 0.02 mmol), AgOAc (83 mg, 0.5 mmol) and methyl acrylate (45 uL, 0.5 mmol) were dissolved in 5 mL of dry toulene under Ar. The tube was sealed and the reaction mixture was stirred at 100 °C for 24 h. The reaction mixture was filtered with celite and the filtrate was concentrated under vacuum. The residue was purified by flash column chromatography on silica gel (petroleum ether: ethyl acetate = 3:1; R_f = 0.3) to compound **5e** (56 mg, 65%). ^{1}H NMR (500 MHz, Chloroform-*d*) δ 8.66 (s, 1H), 7.66 (d, *J* = 15.9 Hz, 1H), 7.58 (d, *J* = 8.0 Hz, 1H), 7.35 – 7.26 (m, 2H), 7.15 (t, *J* = 7.4 Hz, 1H), 6.21 (d, *J* = 15.9 Hz, 1H), 4.59 (t, *J* = 5.5 Hz, 1H), 3.80 (s, 3H), 3.68 (s, 3H), 3.50 (dd, *J* = 5.5, 1.5 Hz, 2H). ^{13}C NMR (126 MHz, $CDCl_3$) δ 170.7, 167.5, 137.5, 131.63, 131.55, 128.4, 125.7, 121.1, 121.1, 119.7, 118.0, 115.3, 114.5, 111.6, 57.6, 53.5, 52.0, 29.8, 28.6. HRMS (ESI) $[M+Na]^+$ m/z calcd for $C_{17}H_{17}F_3N_2O_6SNa$ 457.0657, found 457.0650.

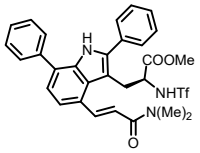
Compound **5f**



5i' (85 mg, 0.2 mmol), $Pd(OAc)_2$ (4.5 mg, 0.02 mmol), AgOAc (83 mg, 0.5 mmol) and methyl acrylate (45 uL, 0.5 mmol) were dissolved in 5 mL of dry toulene under Ar. The tube was sealed and the reaction mixture was stirred at 100 °C for 24 h. The reaction mixture was filtered with celite and the filtrate was concentrated under vacuum. The residue was purified by flash column chromatography on silica gel (petroleum ether: ethyl acetate = 3:1; R_f = 0.3) to compound **5f** (77 mg, 75%). ^{1}H NMR (500 MHz, Chloroform-*d*) δ 8.68 (s, 1H), 7.68 (d, *J* = 15.9 Hz, 1H), 7.66 – 7.61 (m, 3H), 7.55 (t, *J* = 7.5 Hz, 2H), 7.48 – 7.44 (m, 1H), 7.33 (dd, *J* = 7.3, 1.2 Hz, 1H), 7.29 – 7.26 (m, 1H), 6.55 (d, *J* = 8.4 Hz, 1H), 6.21 (d, *J* = 16.0 Hz, 1H), 4.64 – 4.60 (m, 1H), 3.76 (s, 3H), 3.71 (s, 3H), 3.59 – 3.48 (m, 2H).

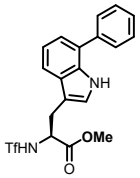
^{13}C NMR (126 MHz, $CDCl_3$) δ 170.6, 167.4, 138.3, 135.3, 131.9, 131.5, 129.5, 128.9, 128.3, 128.0, 126.0, 125.5, 121.6, 118.8, 115.4, 115.1, 57.6, 53.4, 52.0, 28.6. HRMS (ESI) $[M+Na]^+$ m/z calcd for $C_{23}H_{21}F_3N_2O_6SNa$ 533.0970, found 533.0971.

Compound **5g**



According to the general procedure for the synthesis of **5d**, the crude residue was purified by flash column chromatography on silica gel (petroleum ether: ethyl acetate = 1:1; R_f = 0.3) to compound **5g**.^{1}H NMR (500 MHz, Chloroform-*d*) δ 8.48 (d, *J* = 14.9 Hz, 2H), 7.86 (d, *J* = 9.7 Hz, 1H), 7.66 – 7.61 (m, 2H), 7.55 – 7.48 (m, 6H), 7.47 – 7.40 (m, 3H), 7.22 (d, *J* = 7.6 Hz, 1H), 6.86 (d, *J* = 15.1 Hz, 1H), 4.34 (td, *J* = 9.7, 4.9 Hz, 1H), 3.71 – 3.65 (m, 1H), 3.59 (s, 3H), 3.58 – 3.51 (m, 1H), 3.22 (s, 3H), 3.12 (s, 3H). ^{13}C NMR (126 MHz, $CDCl_3$) δ 170.8, 168.0, 141.8, 139.1, 138.6, 134.1, 132.2, 129.5, 129.4, 129.22, 129.17, 128.9, 128.7, 128.5, 128.4, 128.0, 126.9, 126.8, 122.6, 120.8, 119.8, 119.5, 118.2, 107.7, 59.0, 52.8, 37.8, 37.6, 36.1, 31.6, 30.3, 29.8. HRMS (ESI) $[M+H]^+$ m/z calcd for $C_{29}H_{27}F_3N_3O_5S$ 586.1624, found 586.1622.

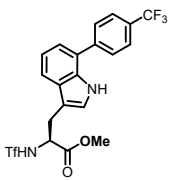
Compound **5i'**



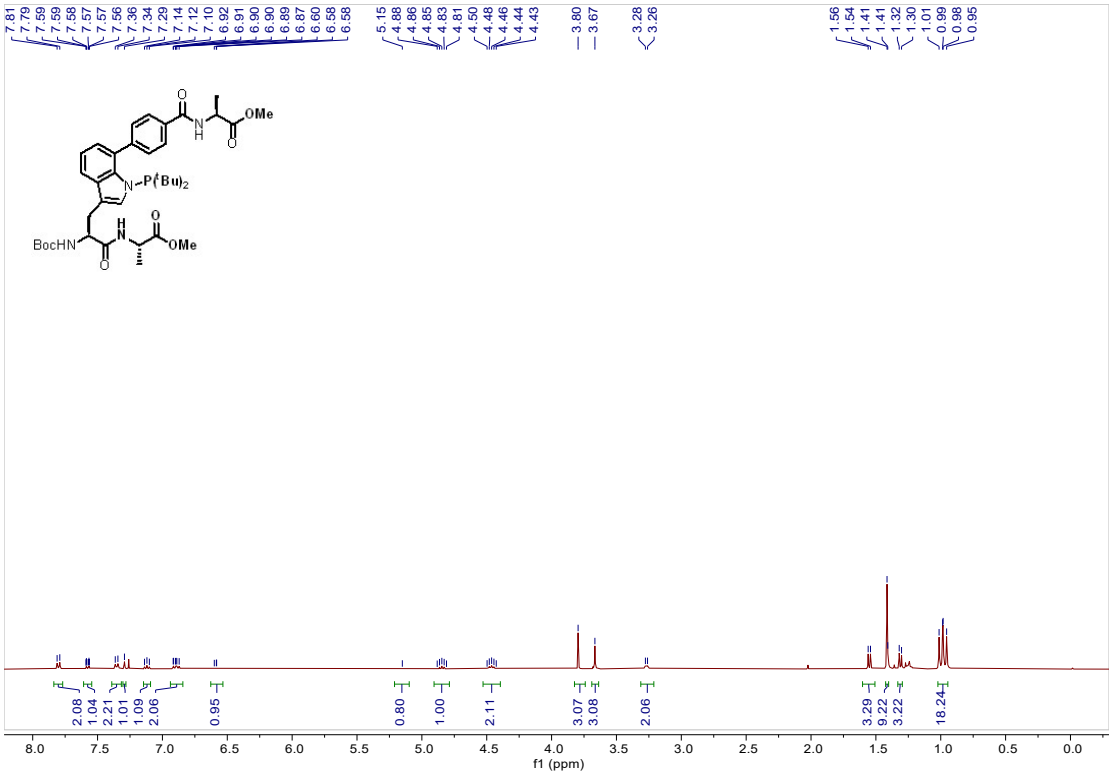
To **5i** (0.2 mmol) in 25 mL Schlenk tube was added anhydrous THF (4.0 mL), and then TBAF (1.2 mL, 1.2 mmol, 1 M in THF) was added, the mixture was stirred under 80 ℃ for 12 h. The reaction mixture was quenched and partitioned between H_2O and EtOAc. The organic phase was washed successively with H_2O, saturated aqueous $NaHCO_3$ solution and brine, and dried over anhydrous Na_2SO_4. The solvent was evaporated under reduced pressure, and the resulting residue was purified by silica gel flash chromatography (petroleum ether: ethyl acetate = 3:1; R_f = 0.3) to product **5i'**. ^{1}H NMR (400 MHz, Chloroform-*d*) δ 7.96 (s, 1H), 7.34 (d, *J* = 7.2 Hz, 1H), 7.30 – 7.20 (m, 4H), 7.18 – 7.13 (m, 2H), 6.99 – 6.90 (m, 2H), 5.17 (d, *J* = 9.6 Hz, 1H), 4.19 (dt, *J* = 9.6, 5.9 Hz, 1H), 3.37 – 3.23 (m, 2H), 3.10 (s, 3H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 170.8, 136.8, 135.8, 132.6, 129.4, 129.3, 128.9, 128.6, 128.5, 123.0, 121.0, 120.6, 118.8, 117.8, 111.2, 105.0, 57.4, 52.8, 28.7.

HRMS (ESI) $[M+Na]^+$ m/z calcd for $C_{19}H_{17}F_3N_2O_4SNa$ 449.0759, found 449.0761.

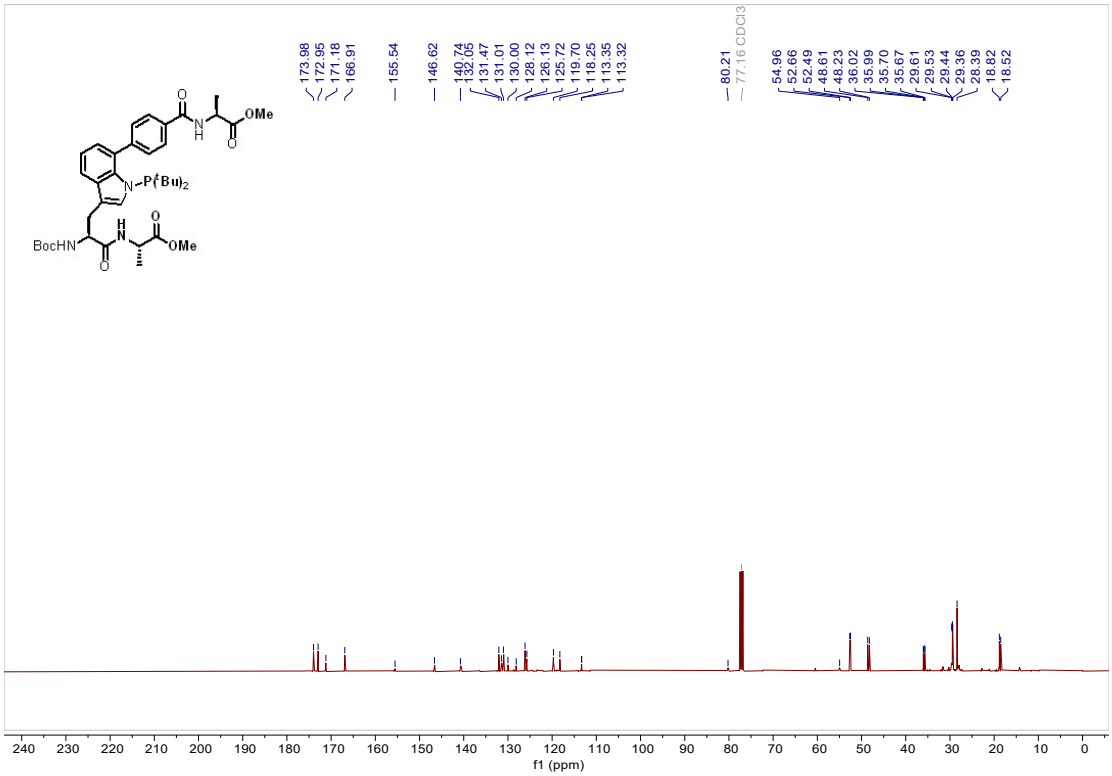
Compound **5j'**



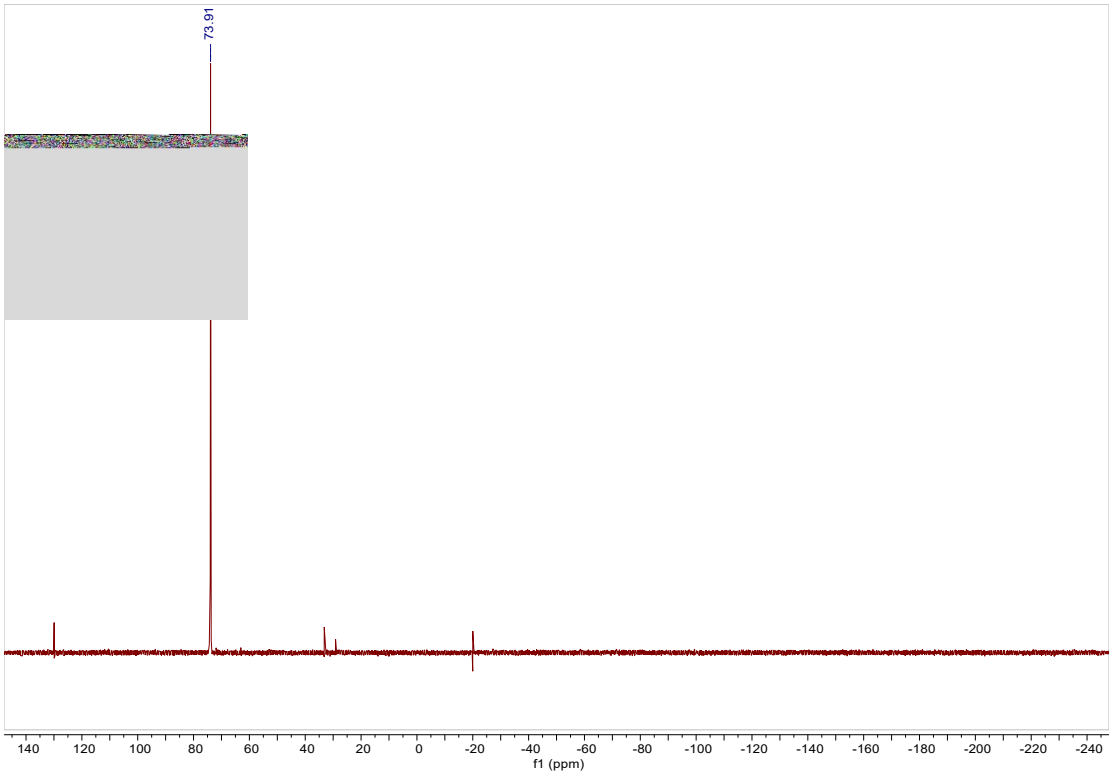
To **5j** (0.2 mmol) in 25 mL Schlenk tube was added anhydrous THF (4.0 mL), and then TBAF (1.2 mL, 1.2 mmol, 1 M in THF) was added, the mixture was stirred under 80 ℃ for 12 h. The reaction mixture was quenched and partitioned between H_2O and EtOAc. The organic phase was washed successively with H_2O, saturated aqueous $NaHCO_3$ solution and brine, and dried over anhydrous Na_2SO_4. The solvent was evaporated under reduced pressure, and the resulting residue was purified by silica gel flash chromatography (petroleum ether: ethyl acetate = 3:1; R_f = 0.3) to compound **5j'**. ^{1}H NMR (400 MHz, Chloroform-*d*) δ 7 8.34 (s, 1H), 7.75 (d, *J* = 8.3 Hz, 2H), 7.69 (d, *J* = 8.2 Hz, 2H), 7.55 (dd, *J* = 6.9, 2.1 Hz, 1H), 7.26 – 7.19 (m, 2H), 7.06 (d, *J* = 2.5 Hz, 1H), 5.66 (d, *J* = 6.6 Hz, 1H), 4.59 (q, *J* = 5.4 Hz, 1H), 3.73 (s, 3H), 3.45 (dd, *J* = 14.9, 4.7 Hz, 1H), 3.34 (dd, *J* = 14.9, 5.6 Hz, 1H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 170.7, 142.6, 134.0, 128.7, 128.0, 126.31, 126.27, 124.6, 124.1, 122.9, 120.8, 118.7, 118.0, 108.9, 57.5, 53.2, 29.6. HRMS (ESI) $[M+Na]^+$ m/z calcd for $C_{28}H_{16}F_6N_2O_4SNa$ 517.0633, found 517.0643.



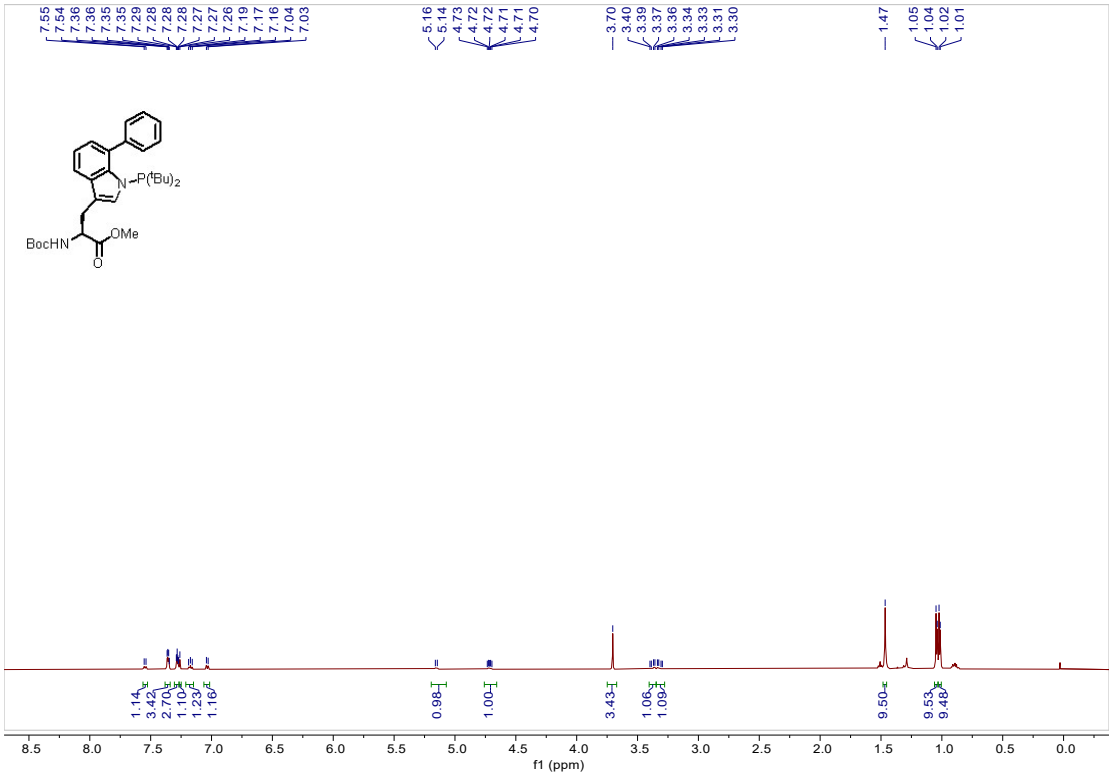
^{1}H NMR (400 MHz, $CDCl_3$) spectrum of **3aa**



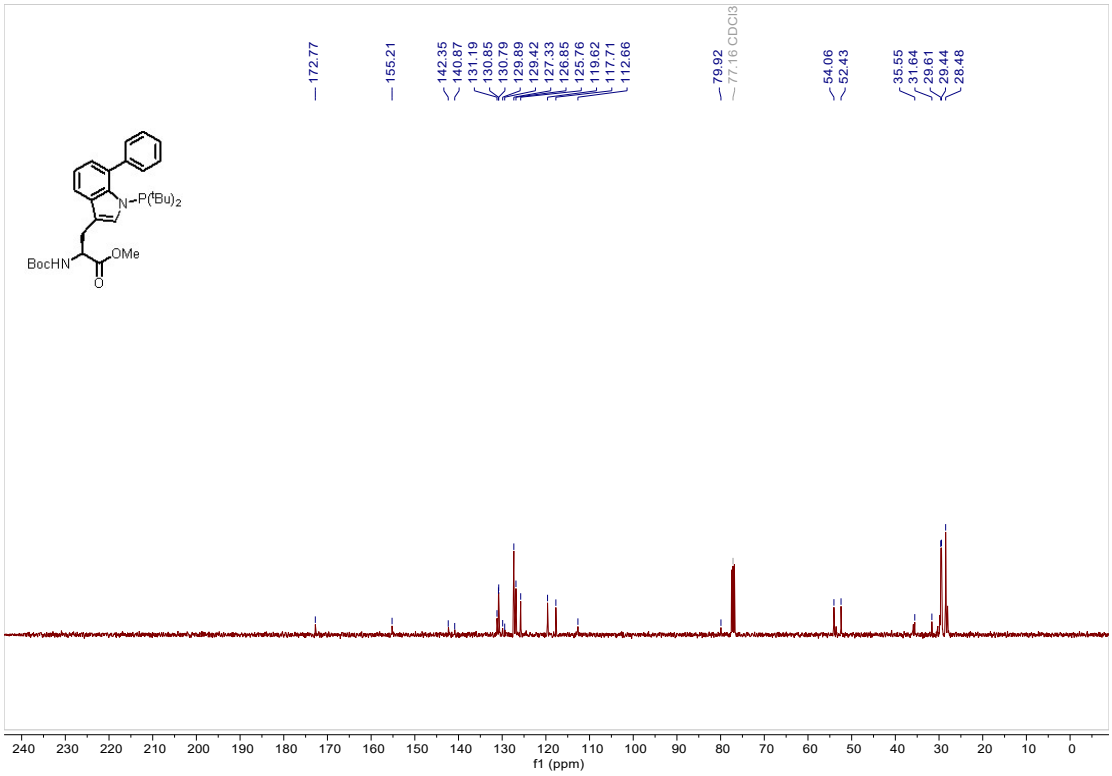
^{13}C NMR (101 MHz, $CDCl_3$) spectrum of **3aa**



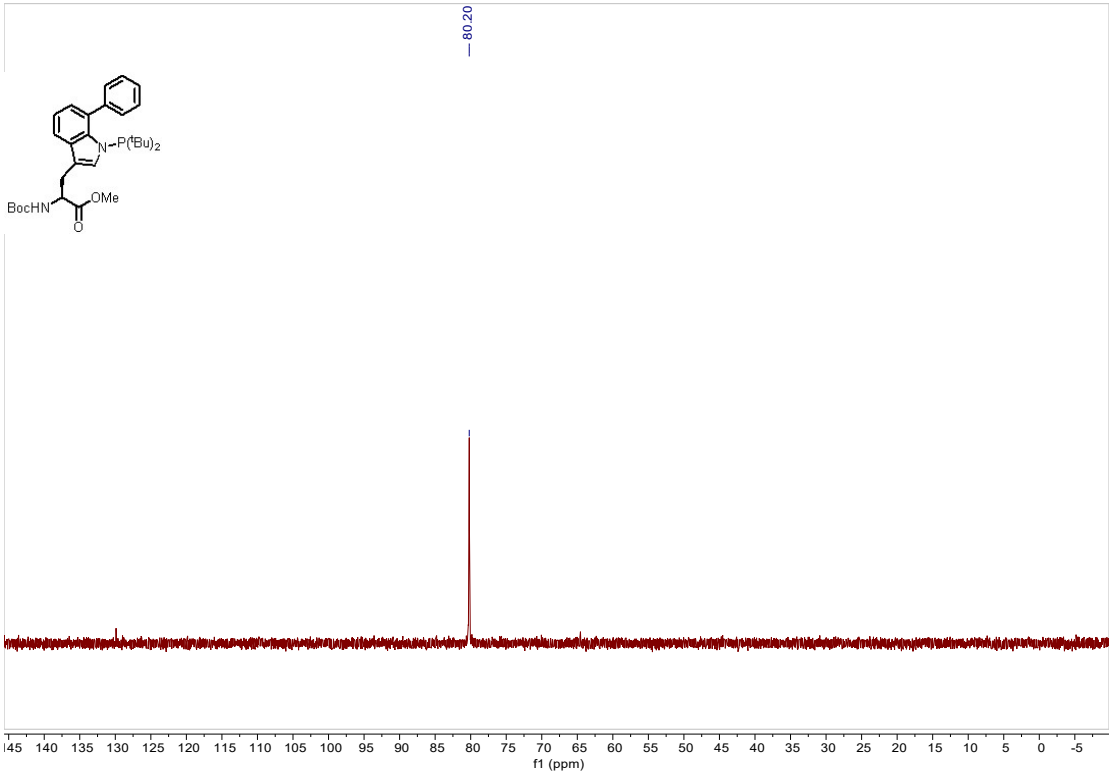
^{31}P NMR (162 MHz, $CDCl_3$) of **3aa**



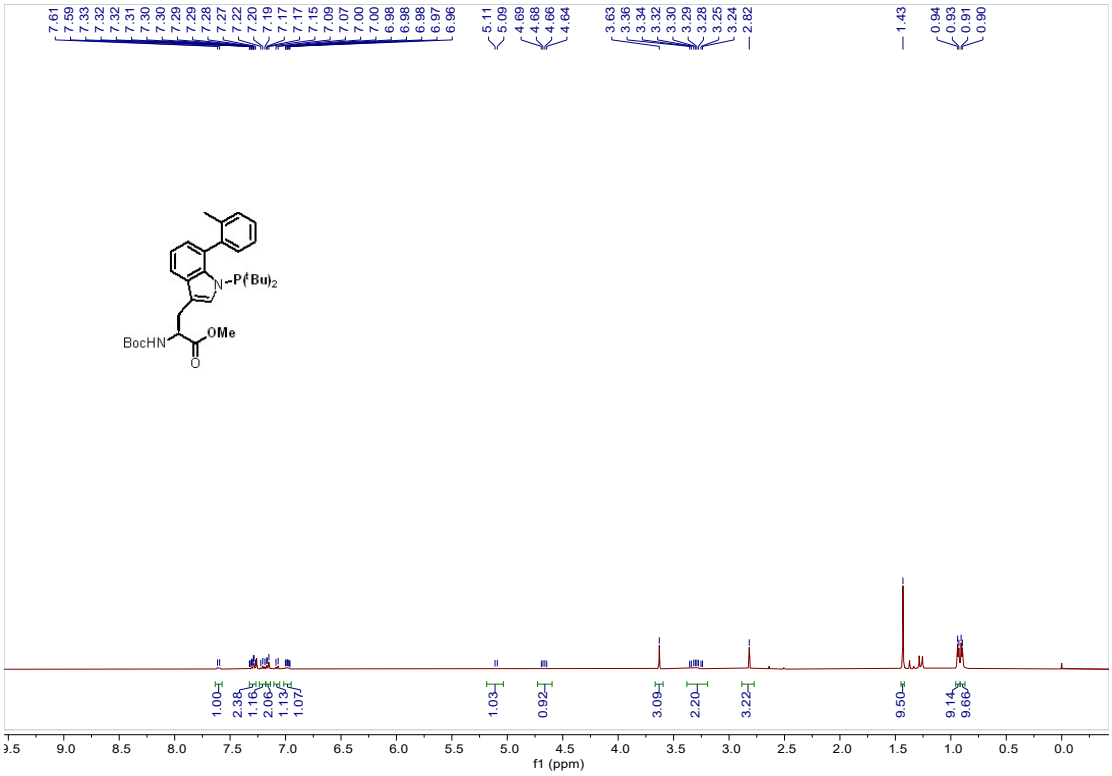
^{1}H NMR (500 MHz, $CDCl_3$) spectrum of **3ab**



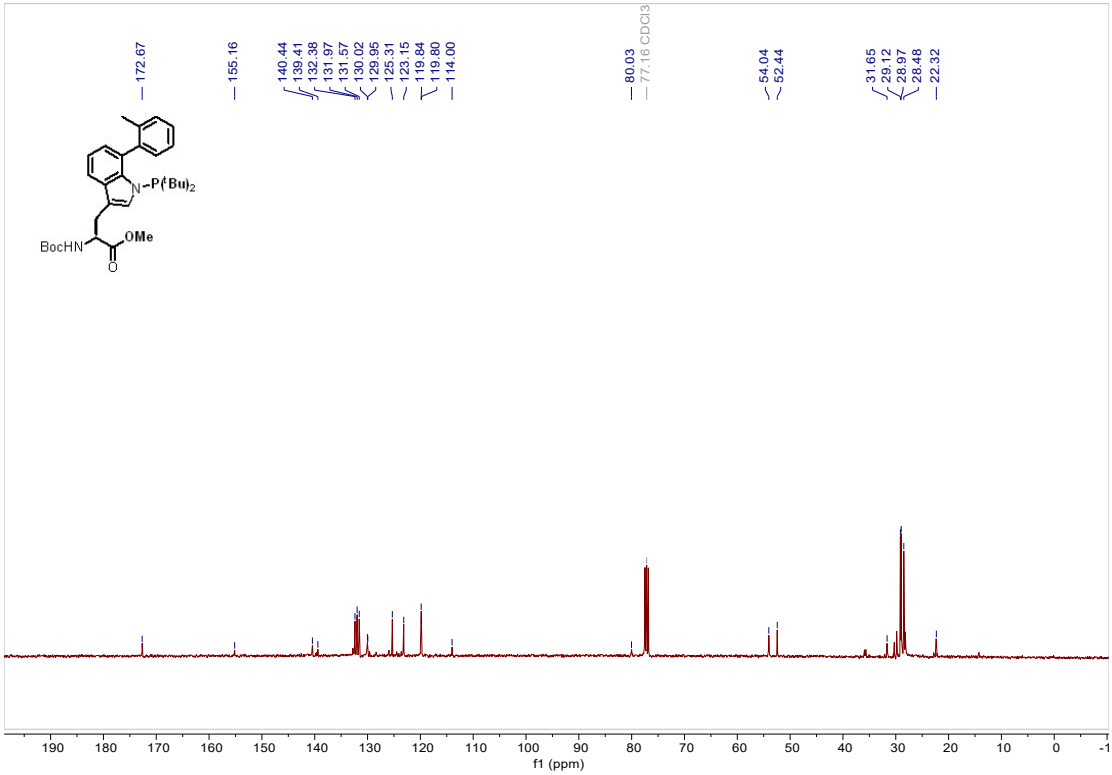
^{13}C NMR (126 MHz, $CDCl_3$) spectrum of **3ab**



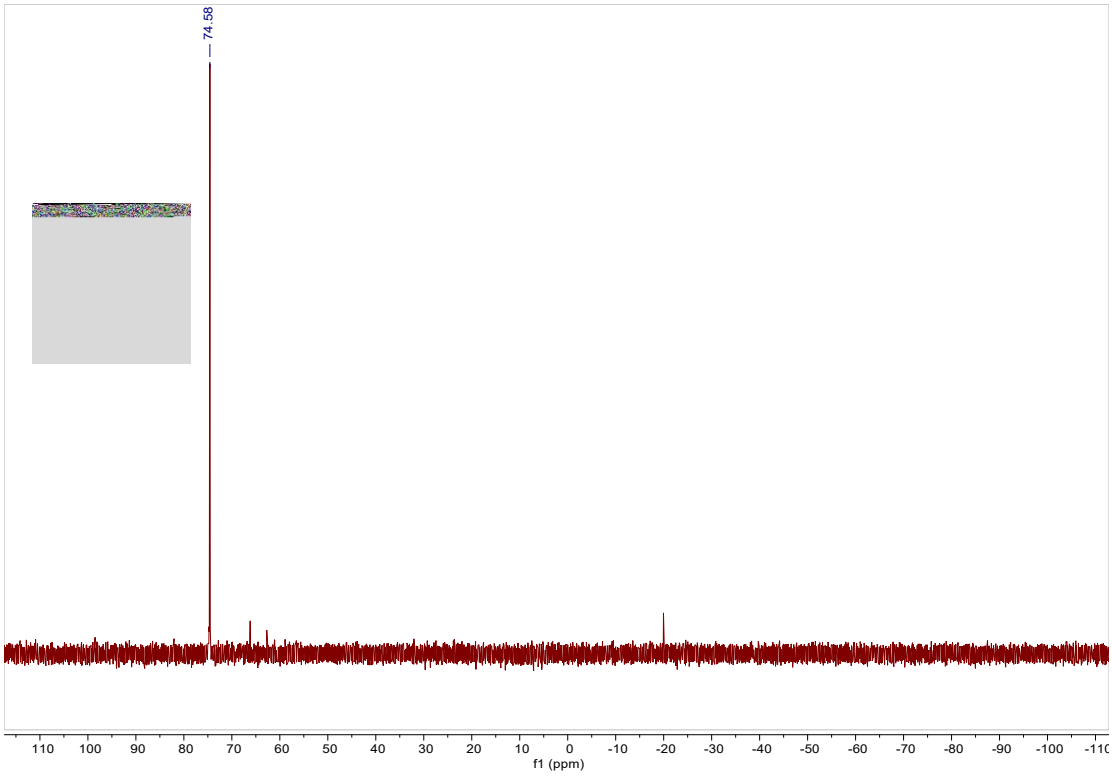
^{31}P NMR (202 MHz, $CDCl_3$) of **3ab**



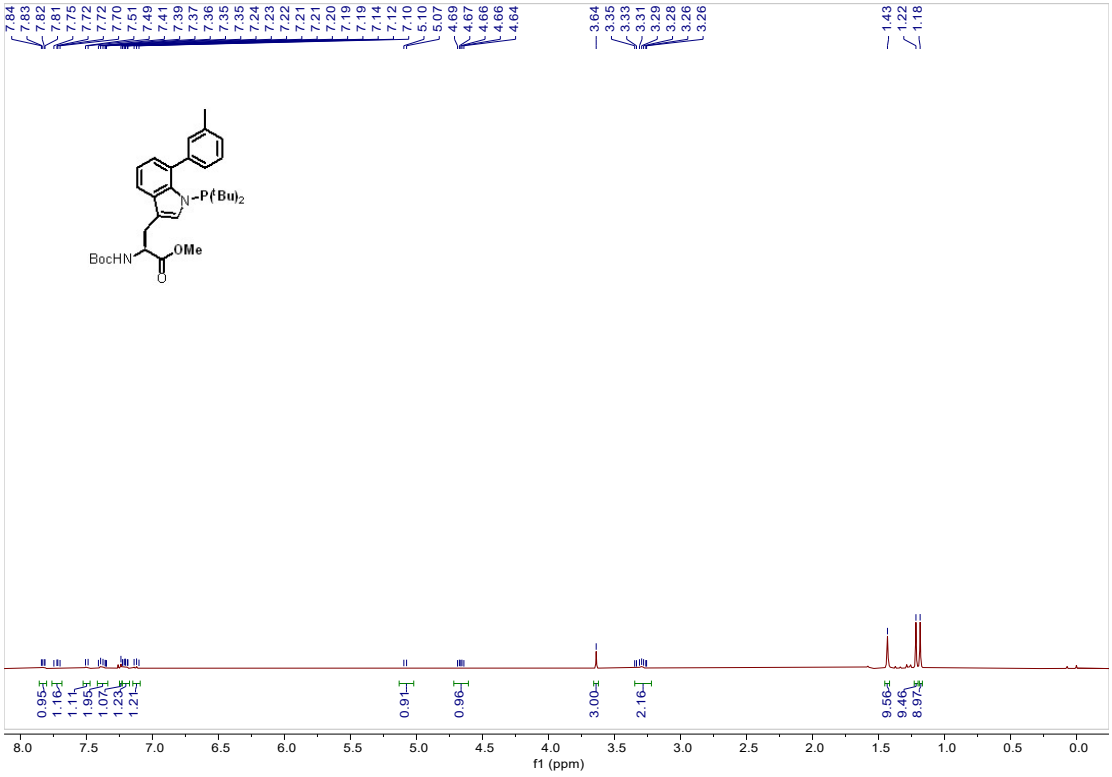
^{1}H NMR (400 MHz, $CDCl_3$) spectrum of **3ac**



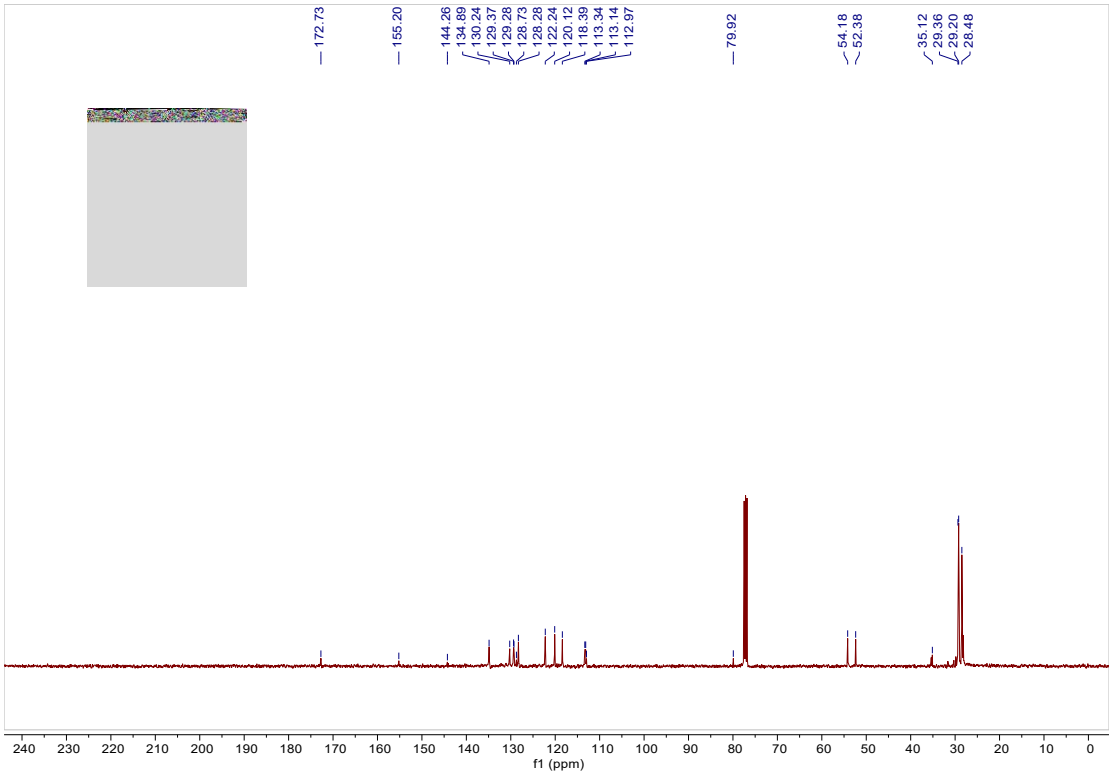
^{13}C NMR (101 MHz, $CDCl_3$) spectrum of **3ac**



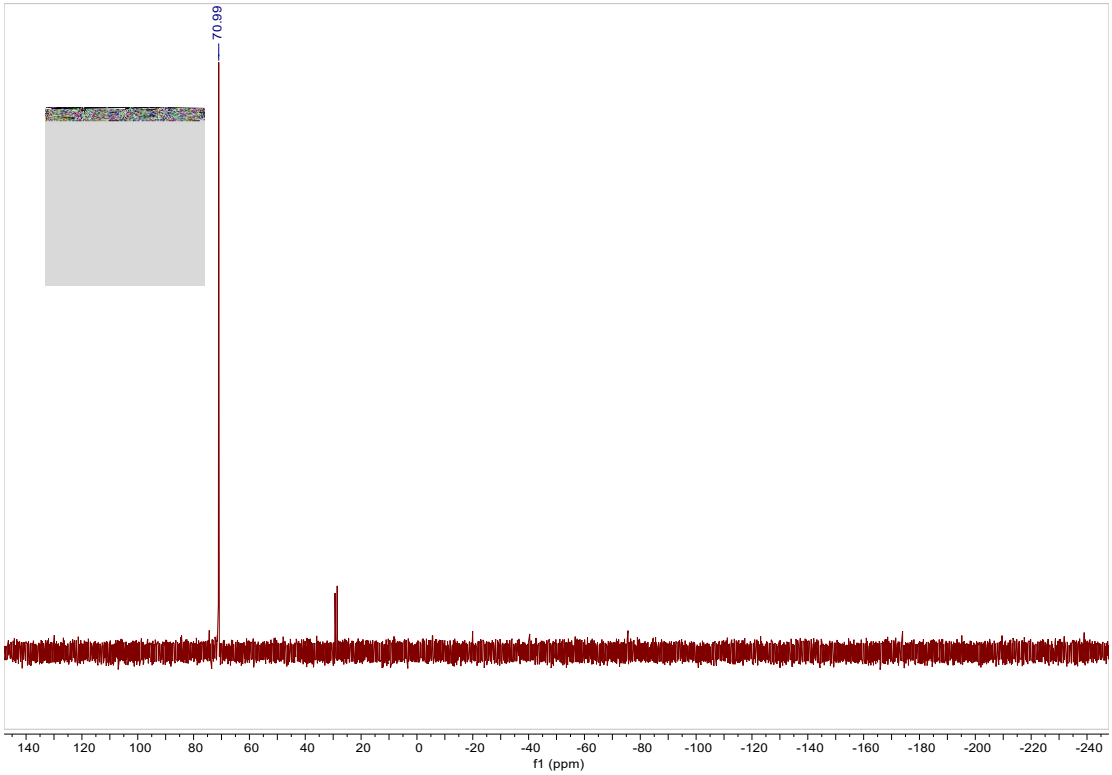
^{31}P NMR (162 MHz, $CDCl_3$) of **3ac**



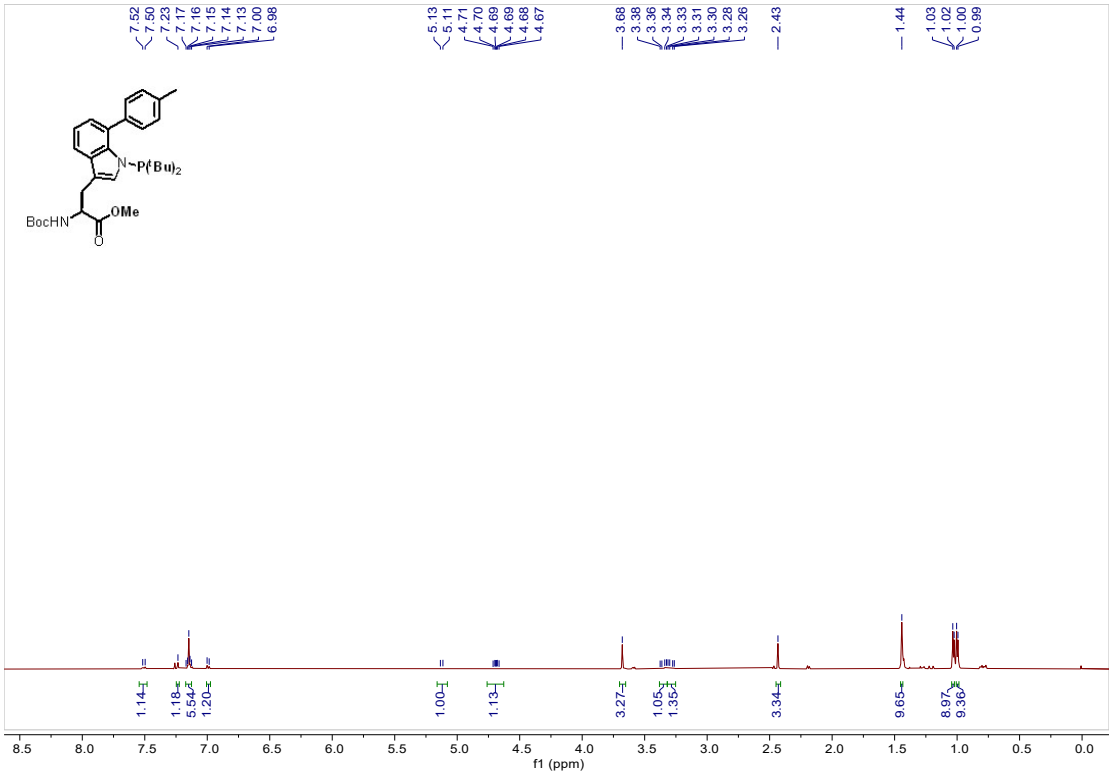
^{1}H NMR (400 MHz, $CDCl_3$) spectrum of **3ad**



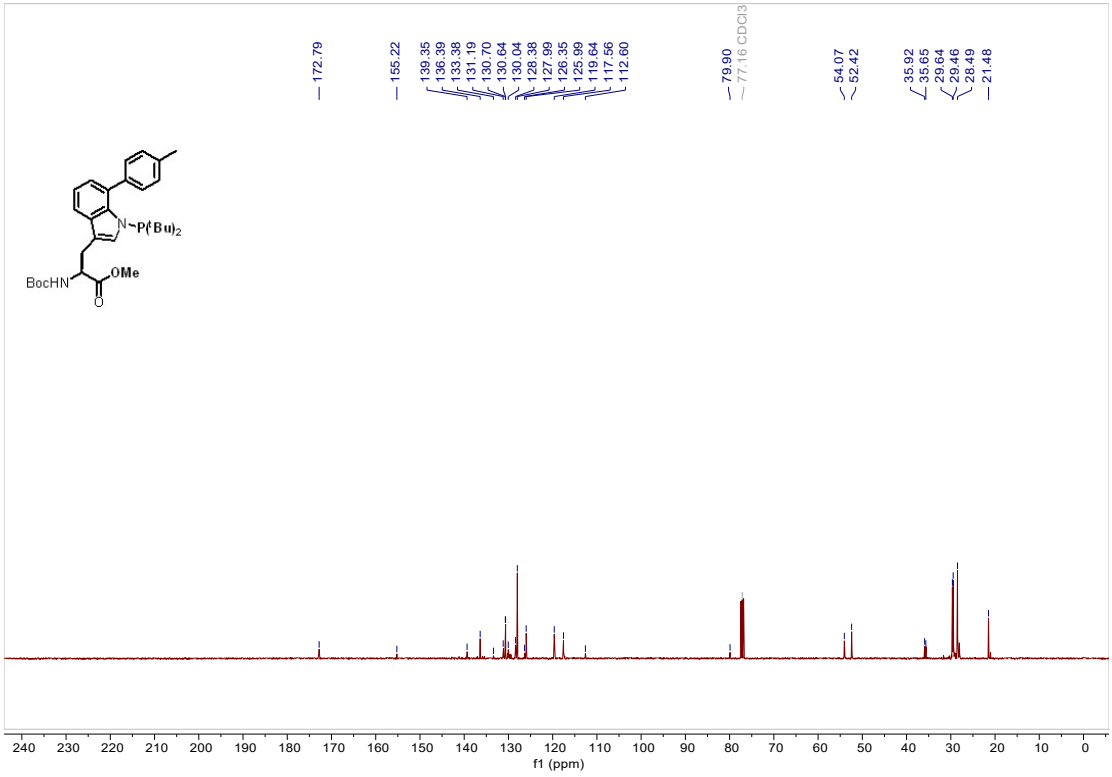
^{13}C NMR (101 MHz, $CDCl_3$) spectrum of **3ad**



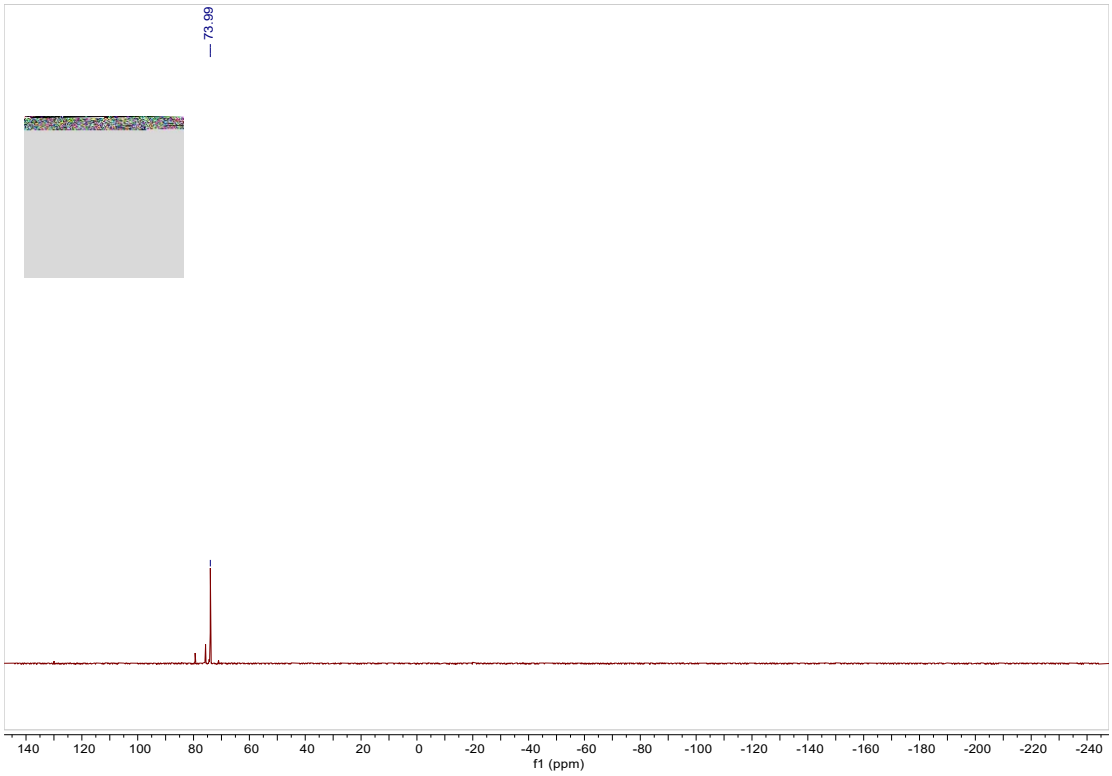
^{31}P NMR (162 MHz, $CDCl_3$) of **3ad**



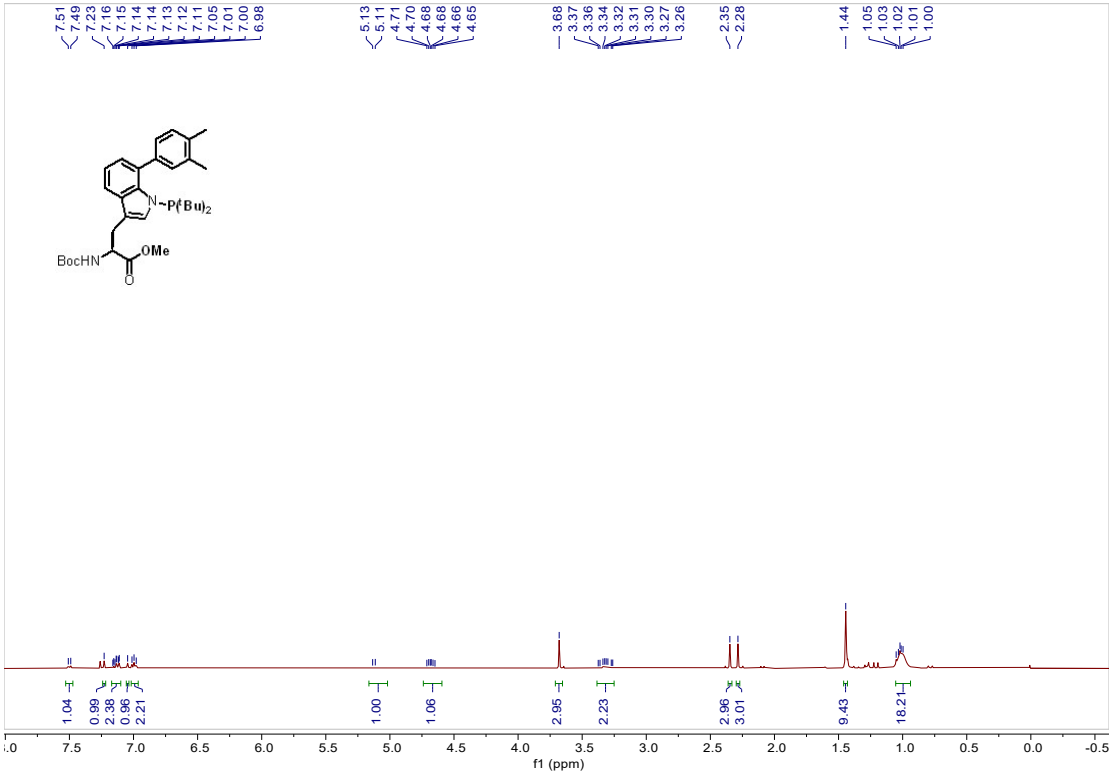
^{1}H NMR (400 MHz, $CDCl_3$) spectrum of **3ae**



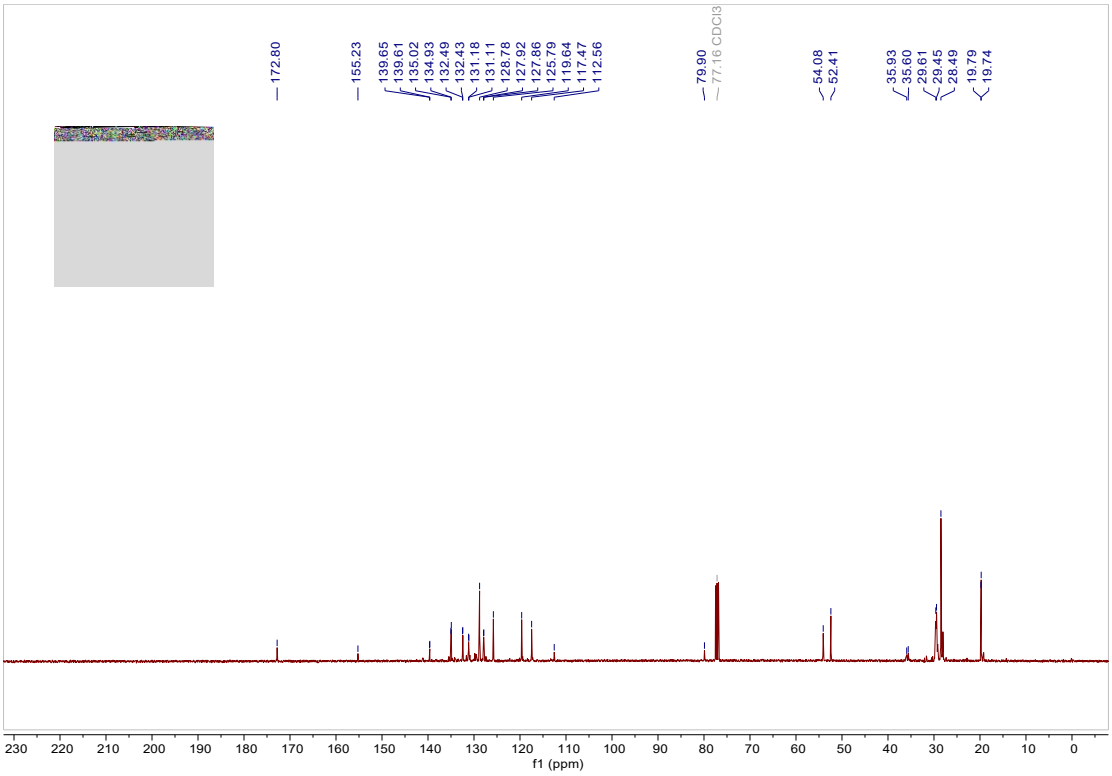
^{13}C NMR (101 MHz, $CDCl_3$) spectrum of **3ae**



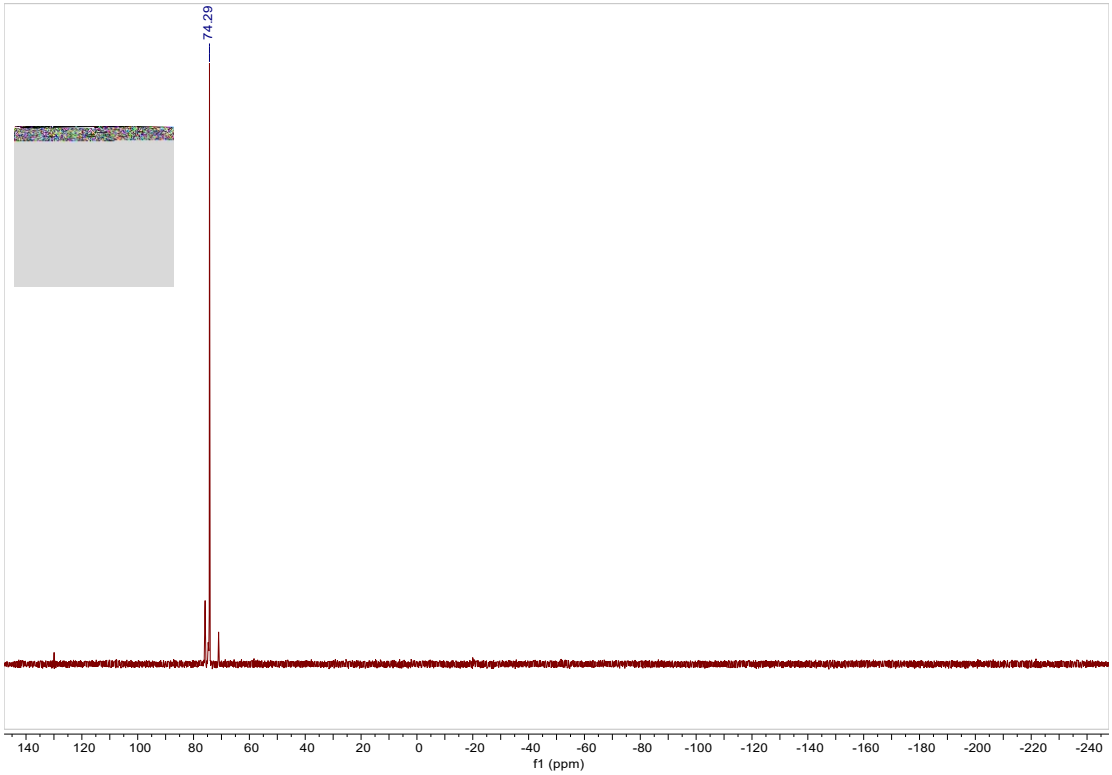
^{31}P NMR (162 MHz, $CDCl_3$) of **3ae**



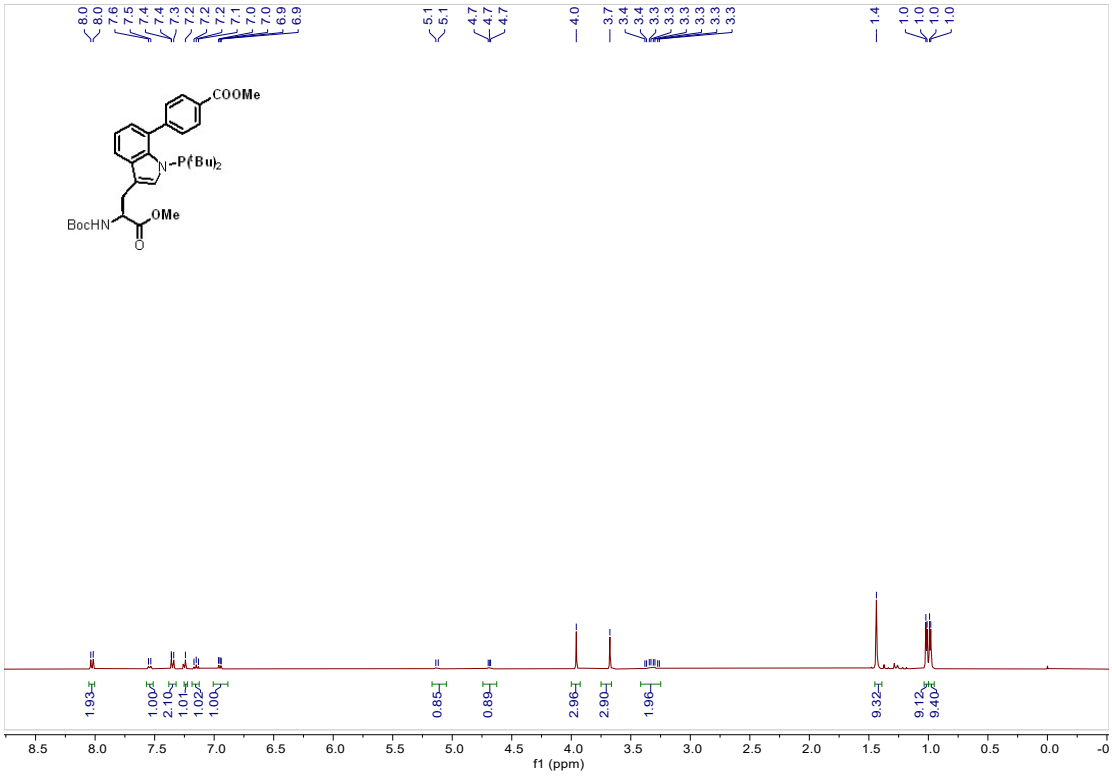
^{1}H NMR (400 MHz, $CDCl_3$) spectrum of **3af**



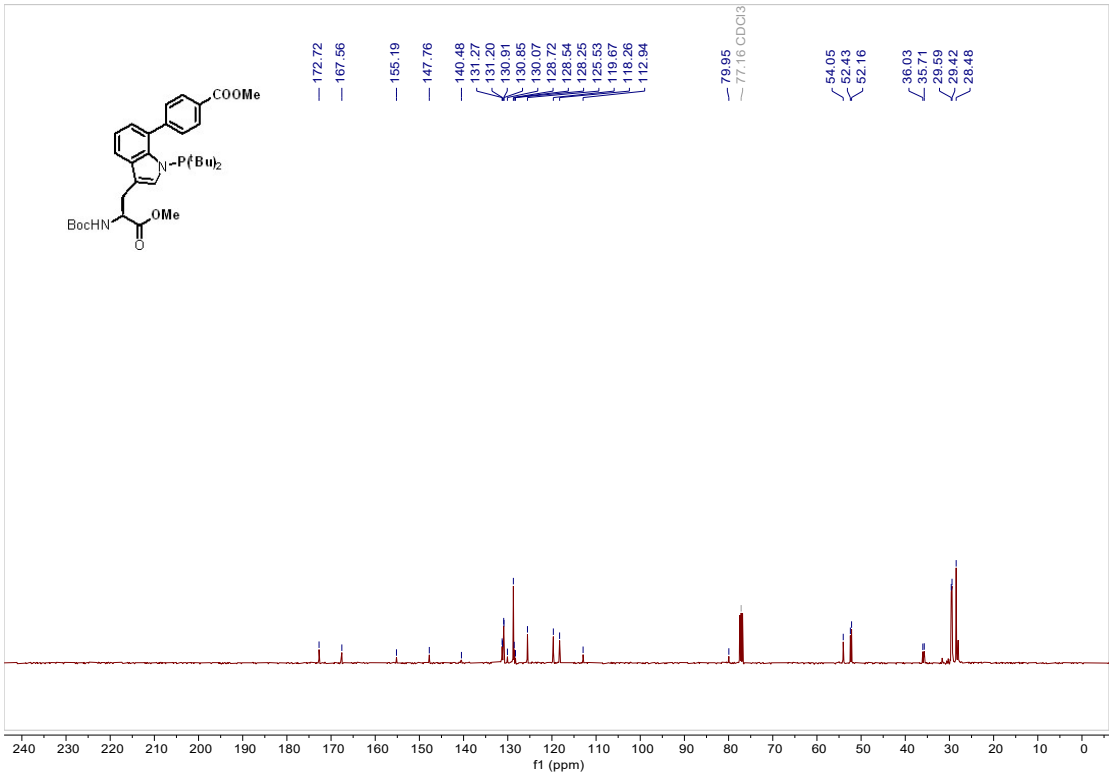
^{13}C NMR (101 MHz, $CDCl_3$) spectrum of **3af**



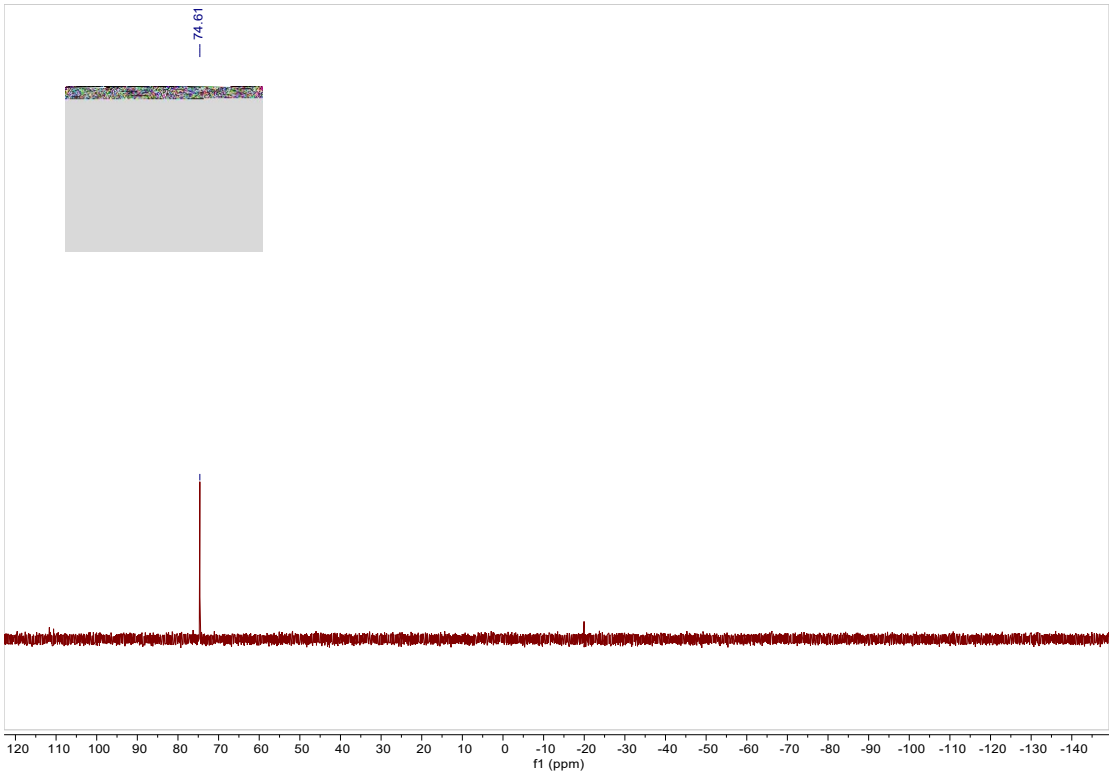
^{31}P NMR (162 MHz, $CDCl_3$) of **3af**



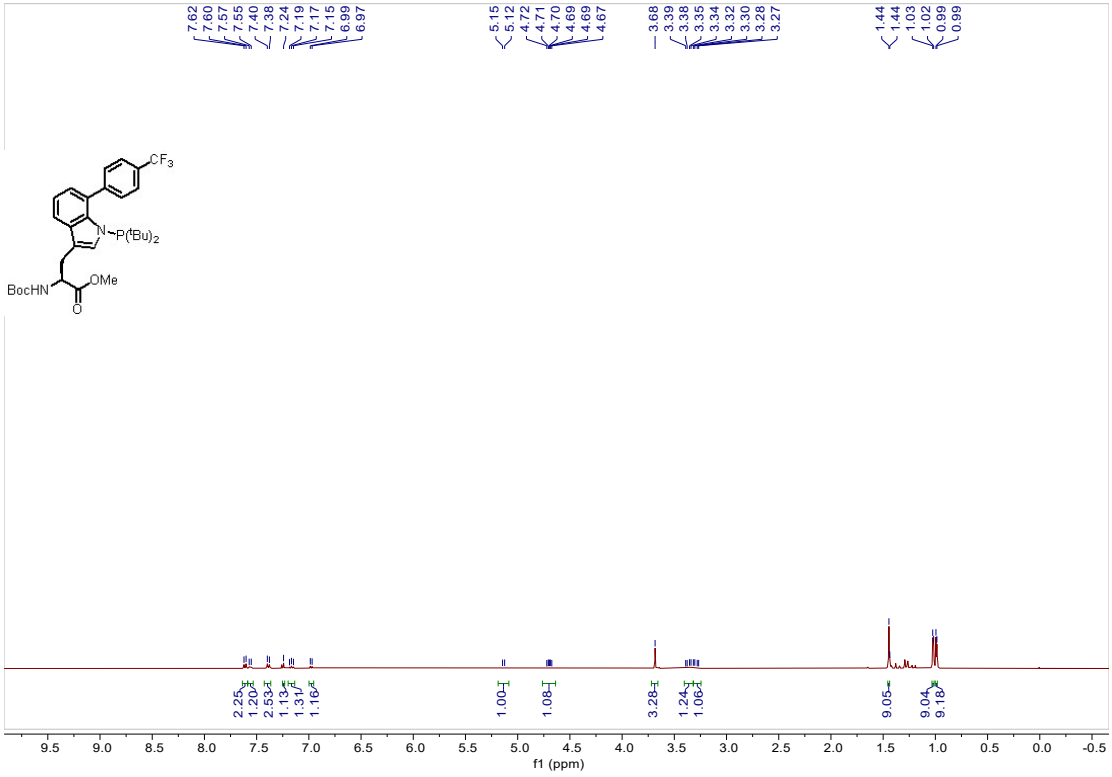
^{1}H NMR (400 MHz, $CDCl_3$) spectrum of **3ag**



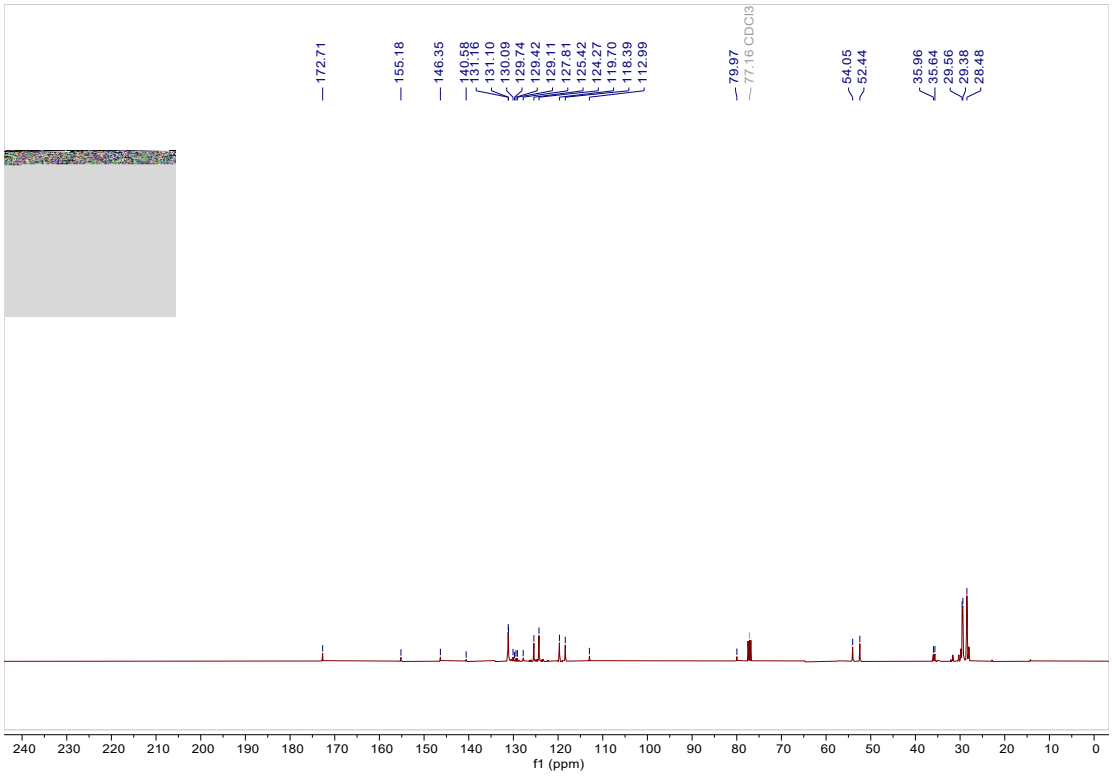
^{13}C NMR (101 MHz, $CDCl_3$) spectrum of **3ag**



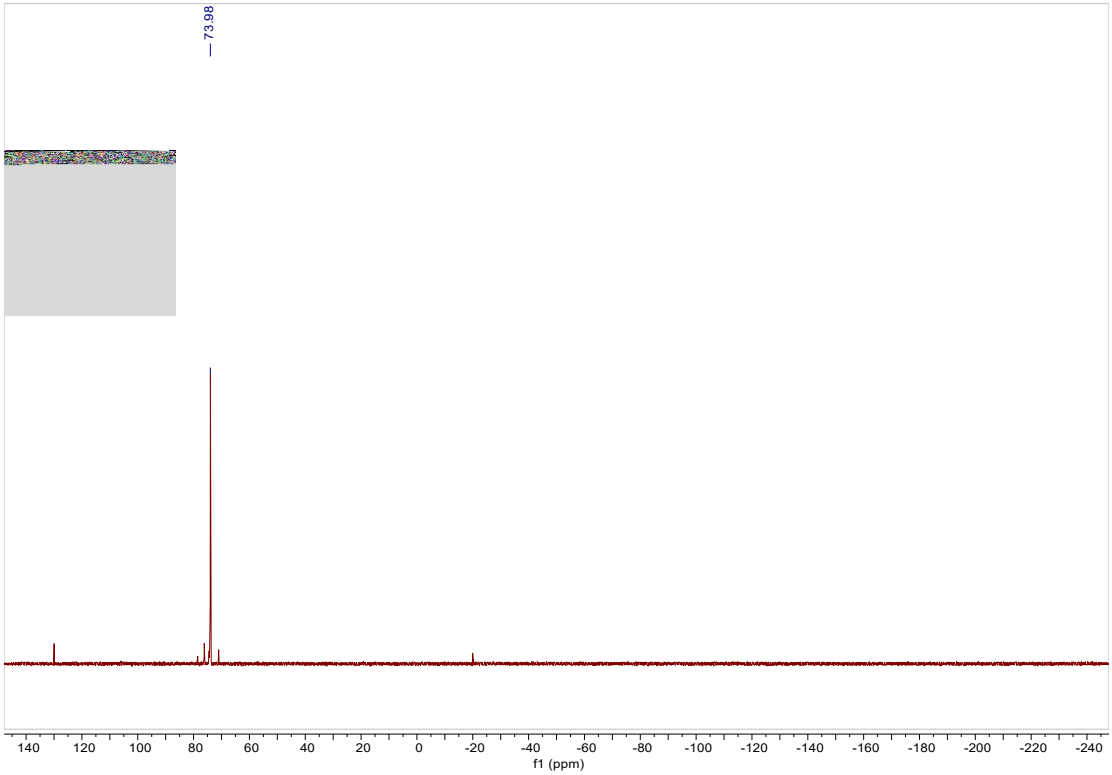
^{31}P NMR (162 MHz, $CDCl_3$) of **3ag**



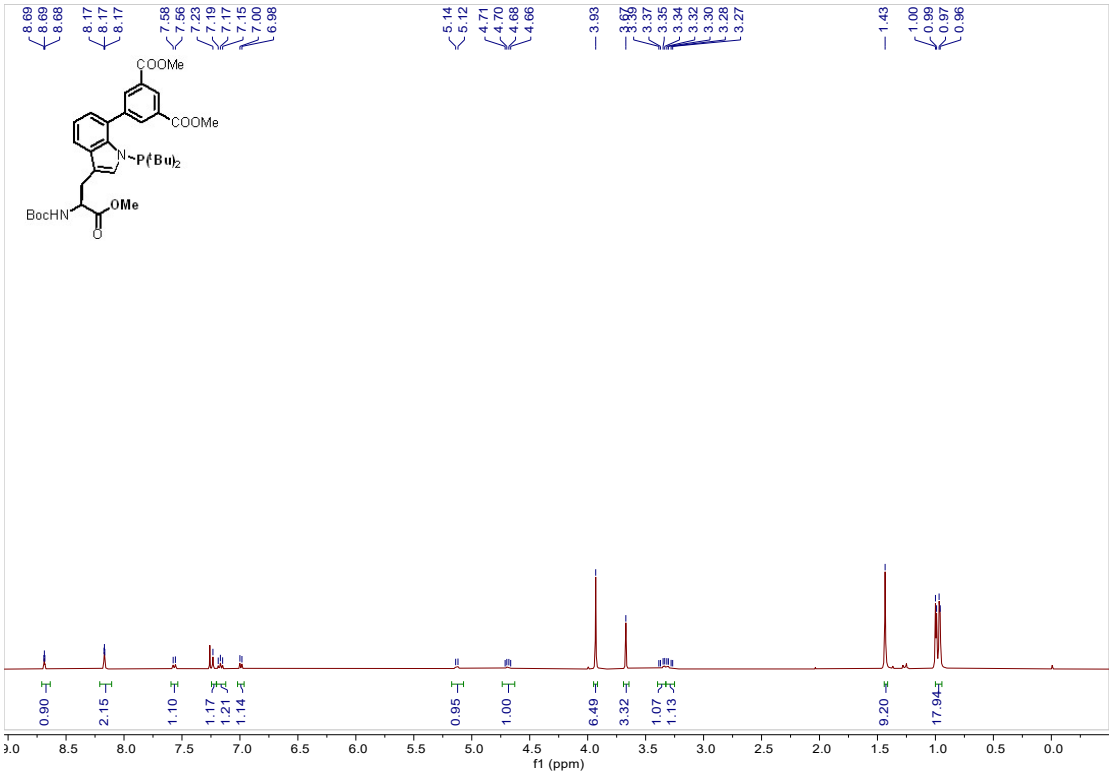
^{1}H NMR (400 MHz, $CDCl_3$) spectrum of **3ah**



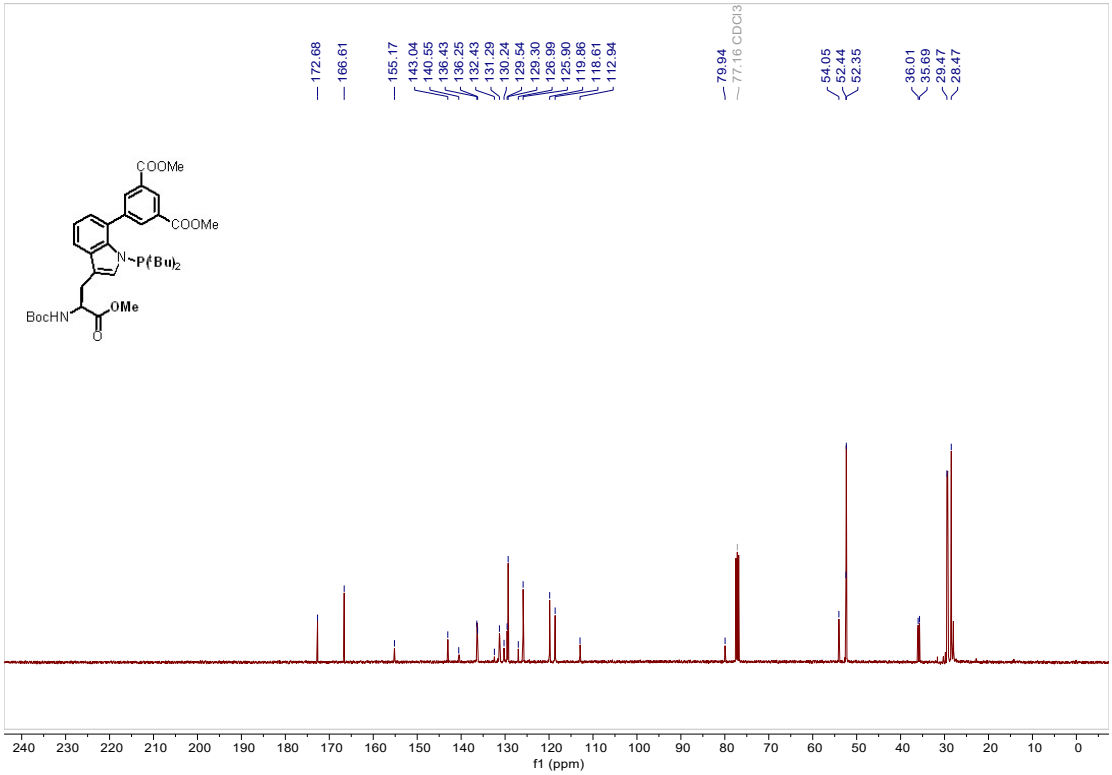
^{13}C NMR (101 MHz, $CDCl_3$) spectrum of **3ah**



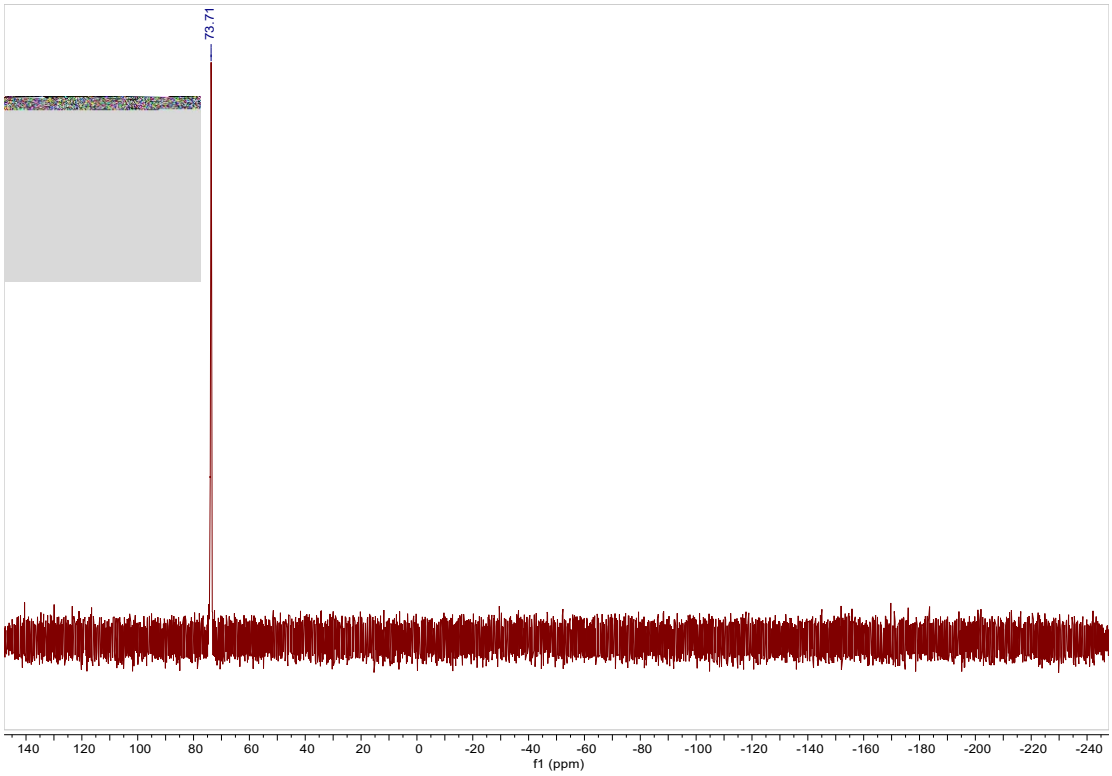
^{31}P NMR (162 MHz, $CDCl_3$) of **3ah**



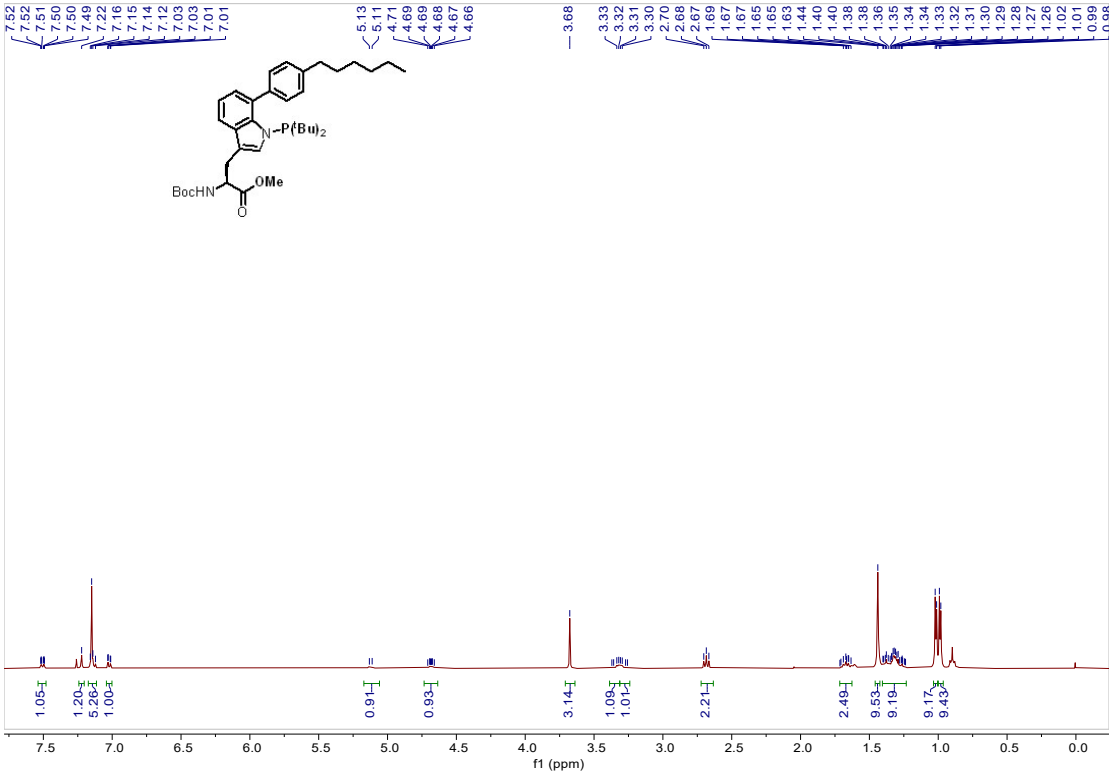
^{1}H NMR (400 MHz, $CDCl_3$) spectrum of **3ai**



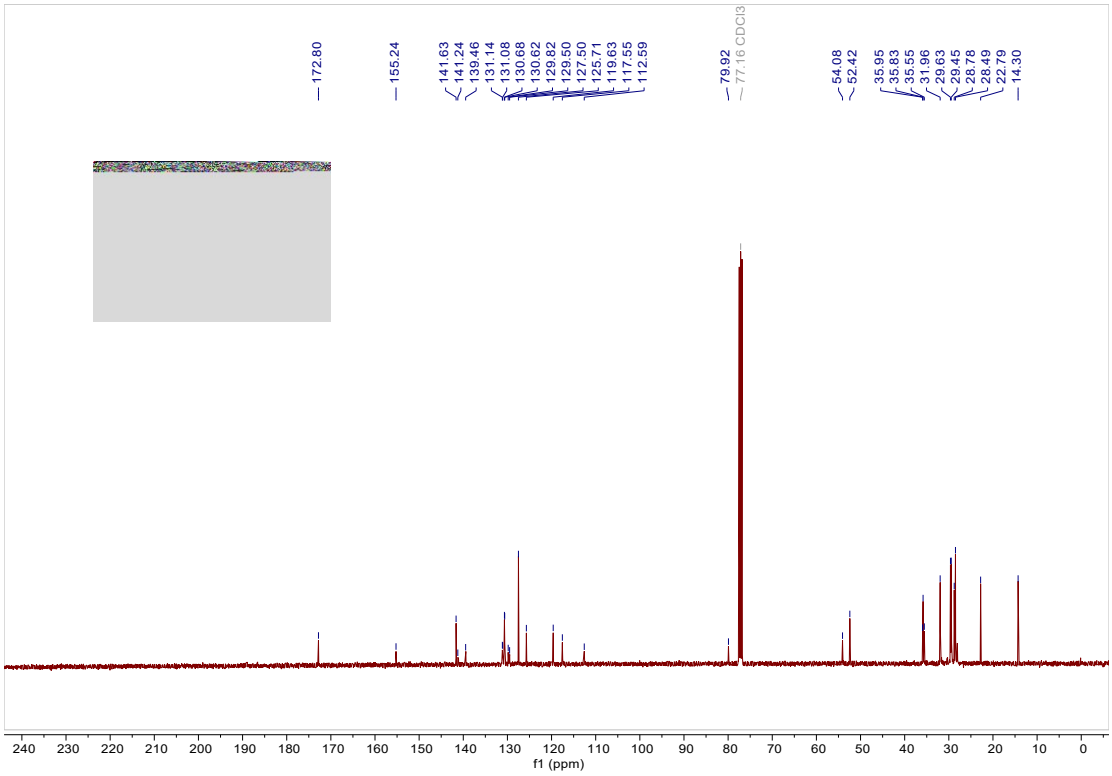
^{13}C NMR (101 MHz, $CDCl_3$) spectrum of **3ai**



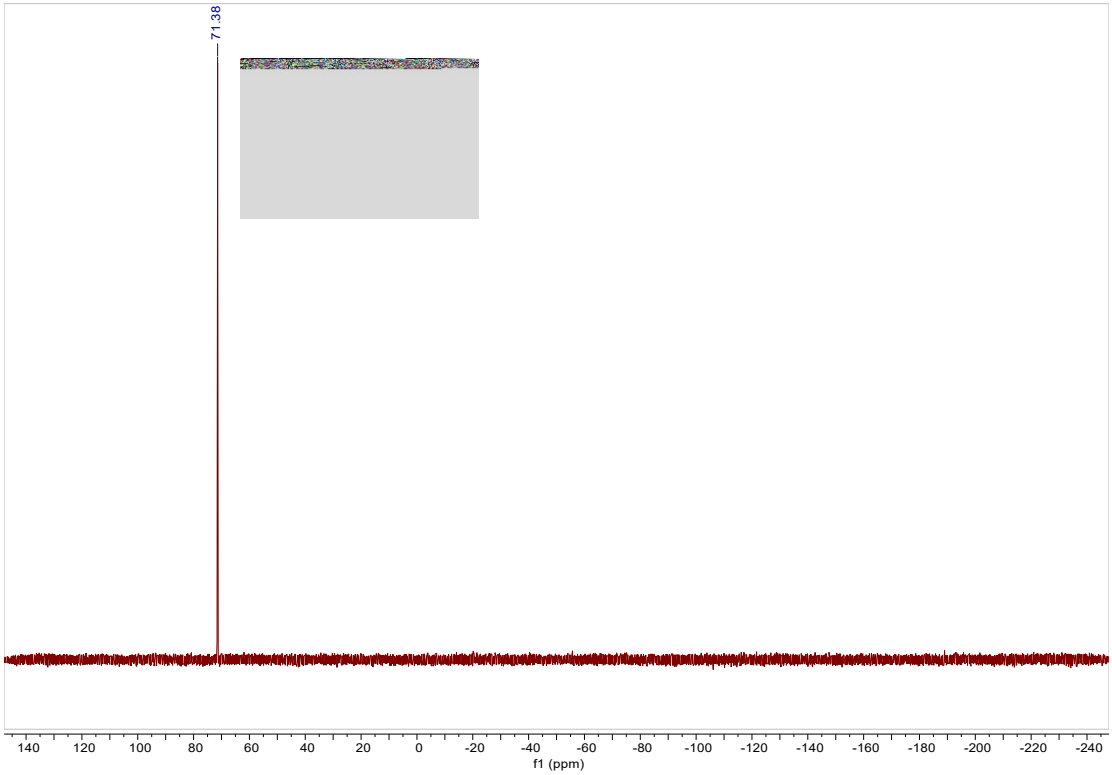
^{31}P NMR (162 MHz, $CDCl_3$) of **3ai**



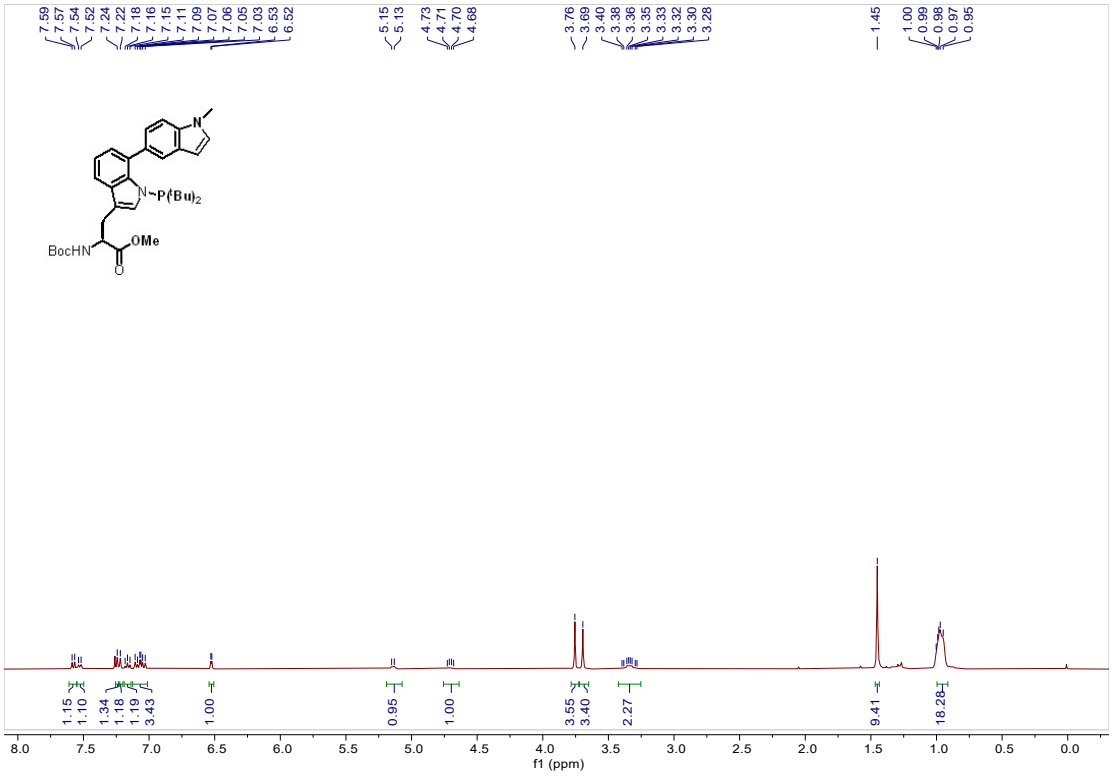
^{1}H NMR (400 MHz, $CDCl_3$) spectrum of **3aj**



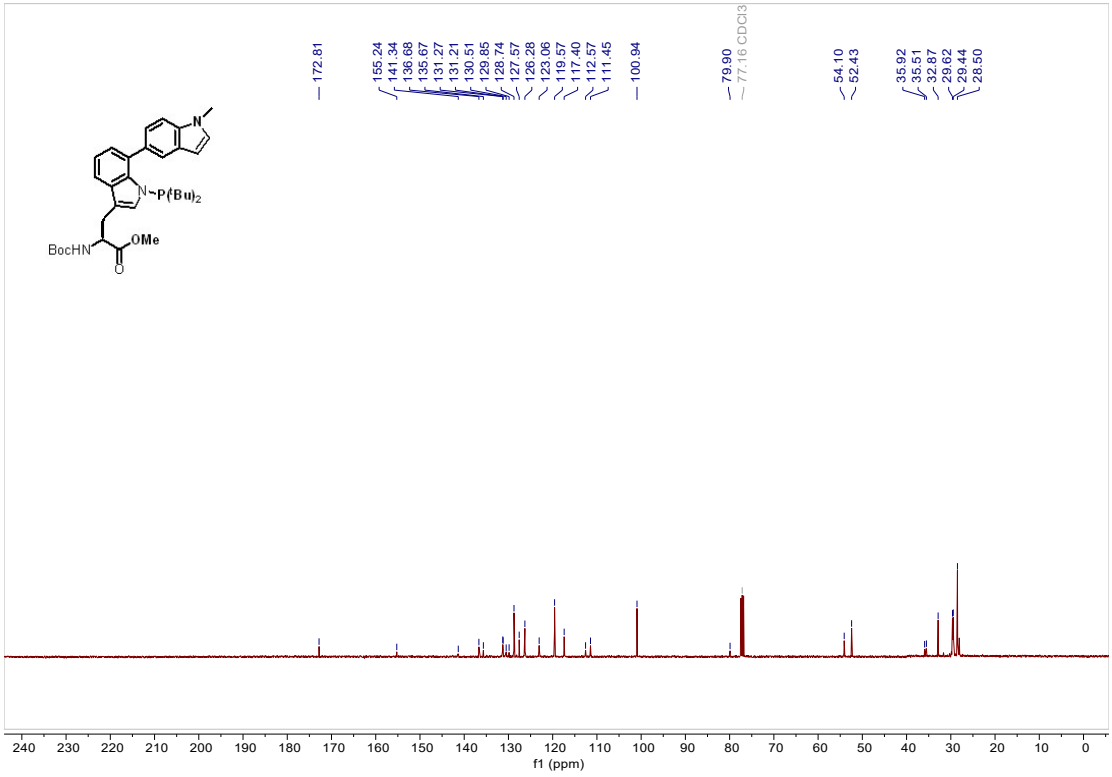
^{13}C NMR (101 MHz, $CDCl_3$) spectrum of **3aj**



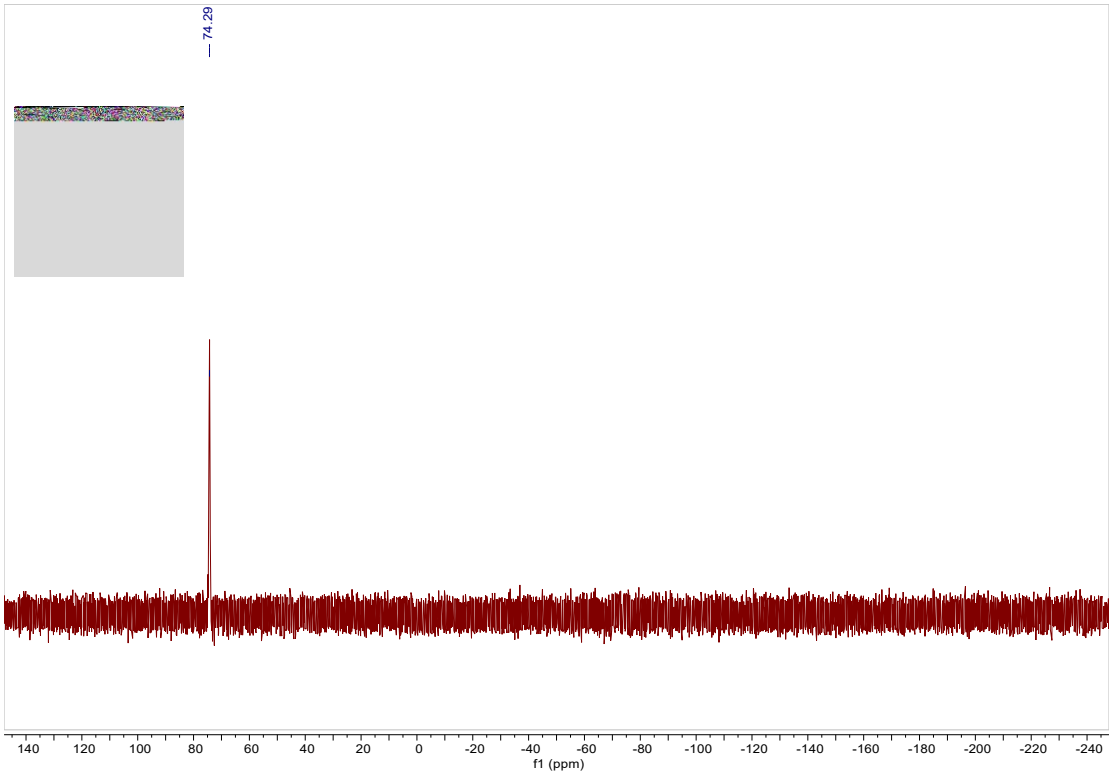
^{31}P NMR (162 MHz, $CDCl_3$) of **3aj**



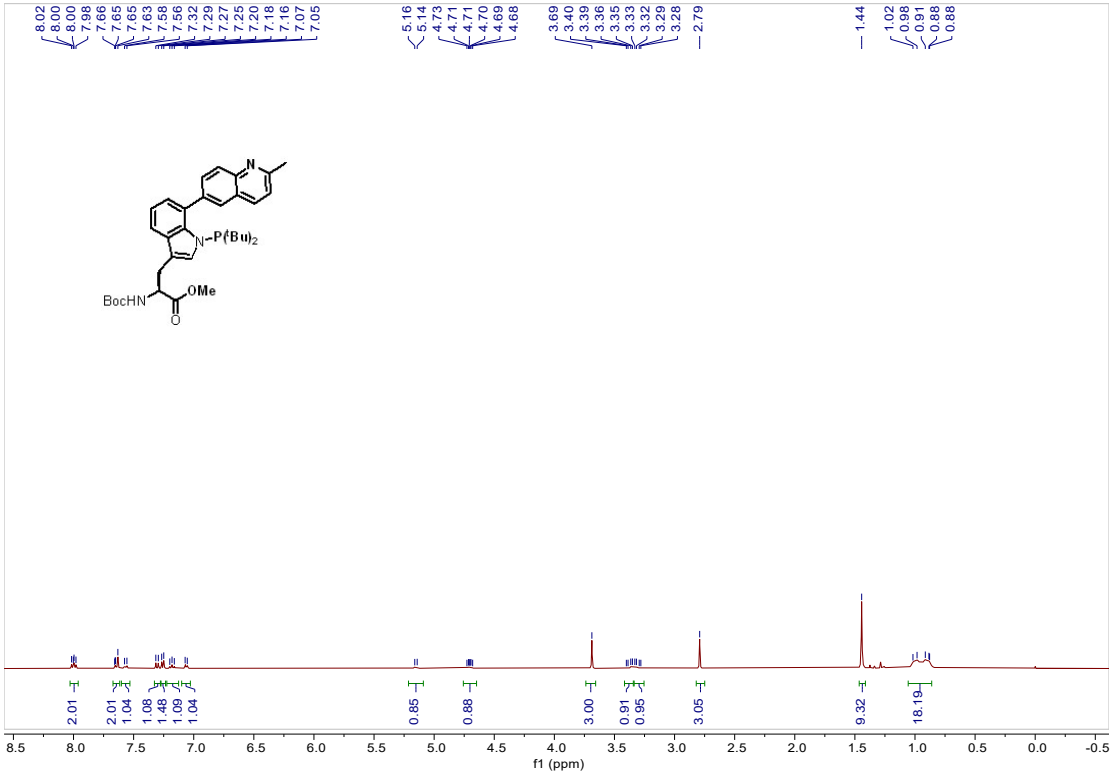
^{1}H NMR (400 MHz, $CDCl_3$) spectrum of **3ak**



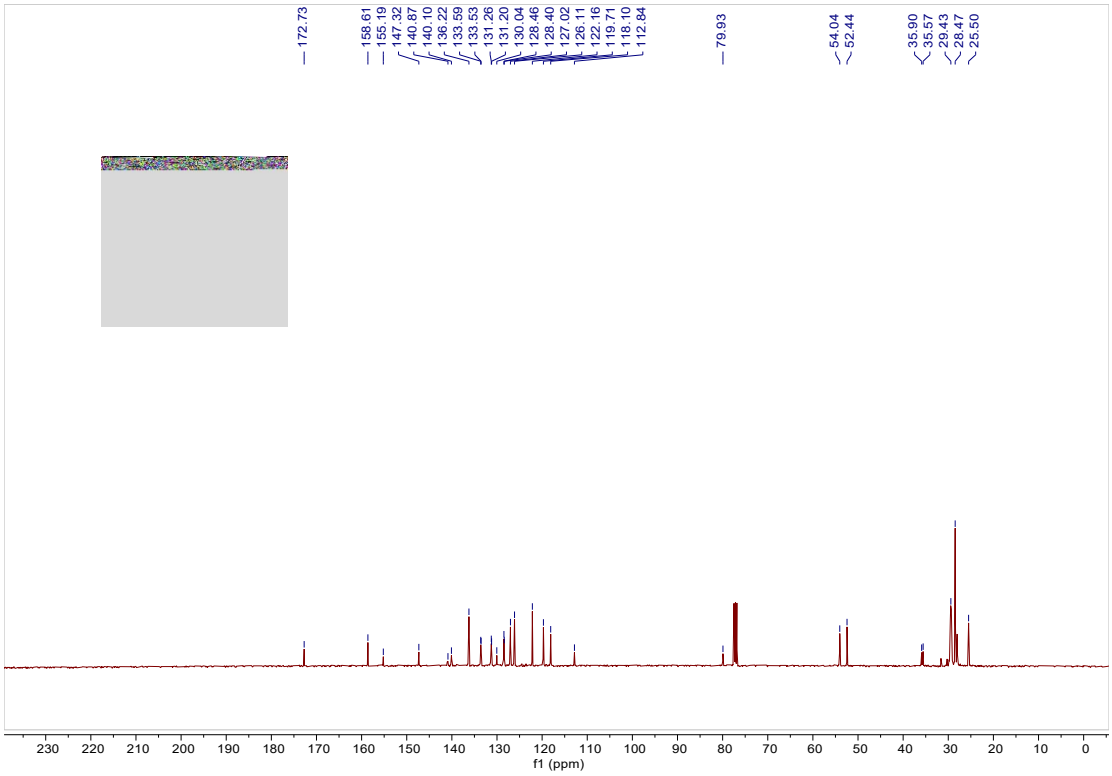
^{13}C NMR (101 MHz, $CDCl_3$) spectrum of **3ak**



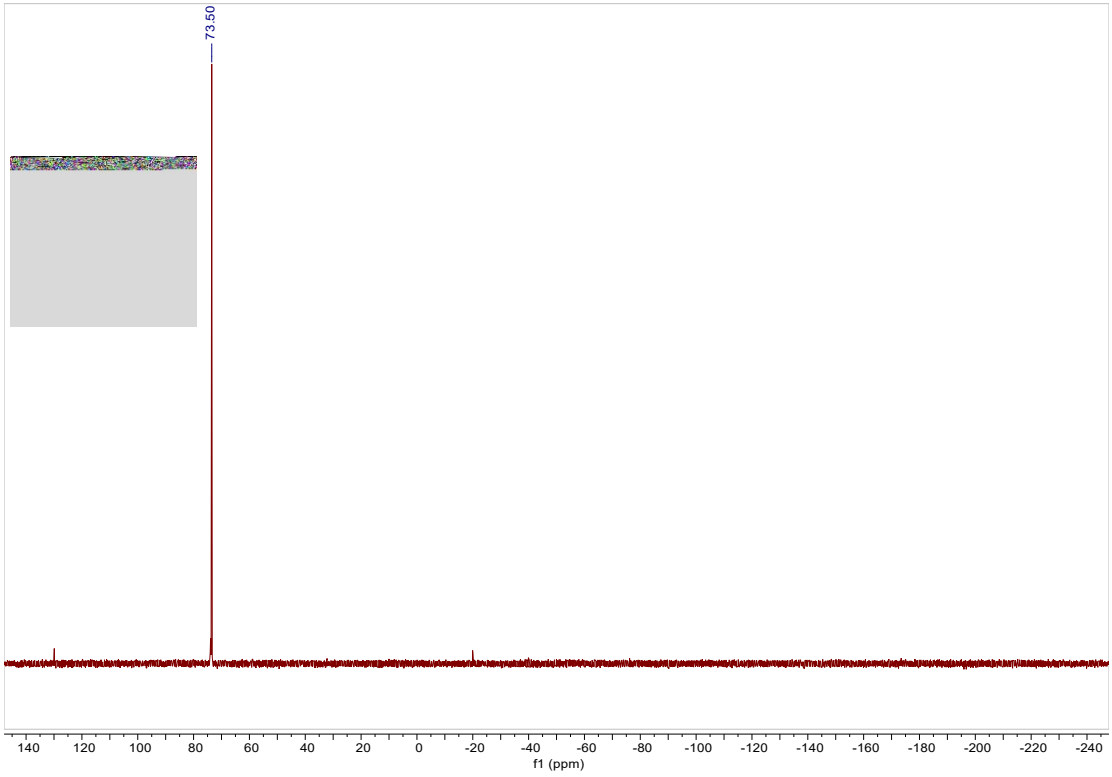
^{31}P NMR (162 MHz, $CDCl_3$) of **3ak**



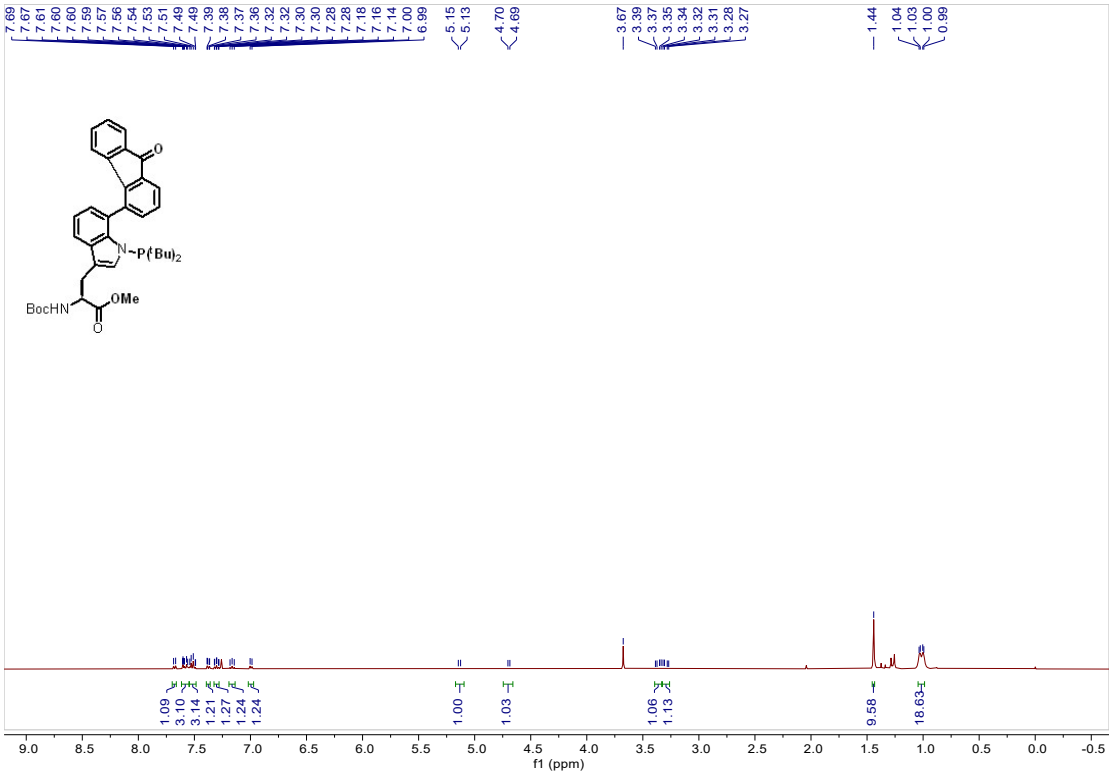
^{1}H NMR (400 MHz, $CDCl_3$) spectrum of **3al**



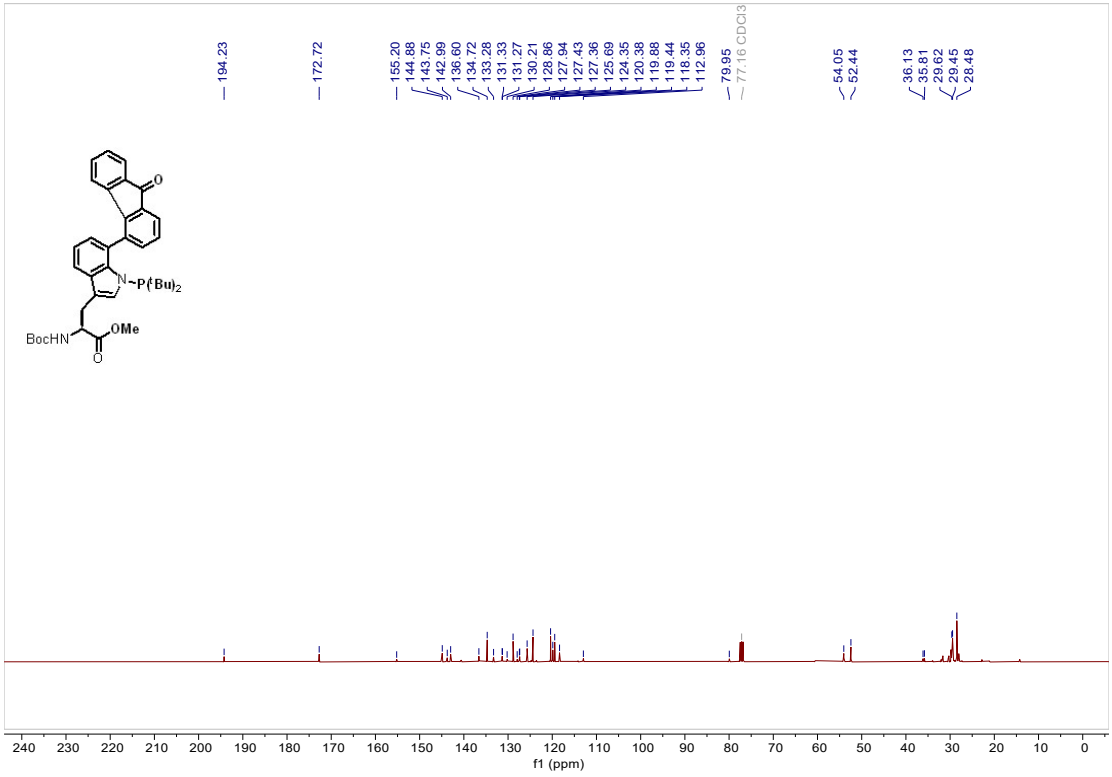
^{13}C NMR (101 MHz, $CDCl_3$) spectrum of **3al**



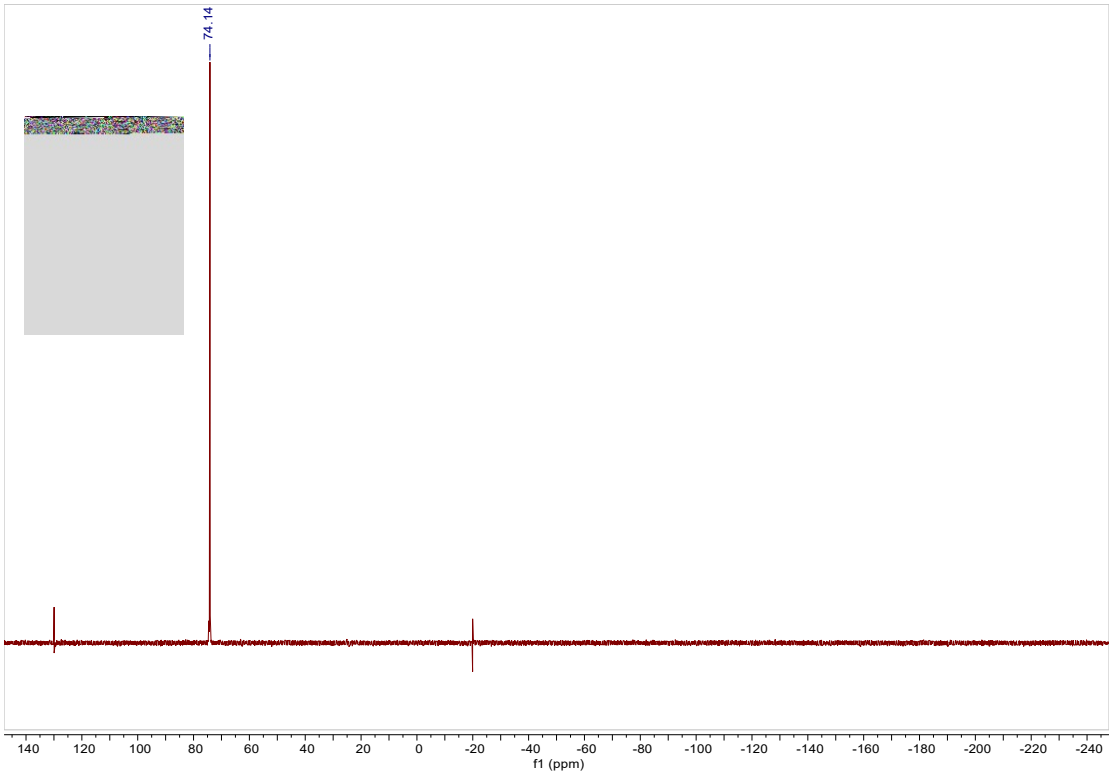
^{31}P NMR (162 MHz, $CDCl_3$) of **3al**



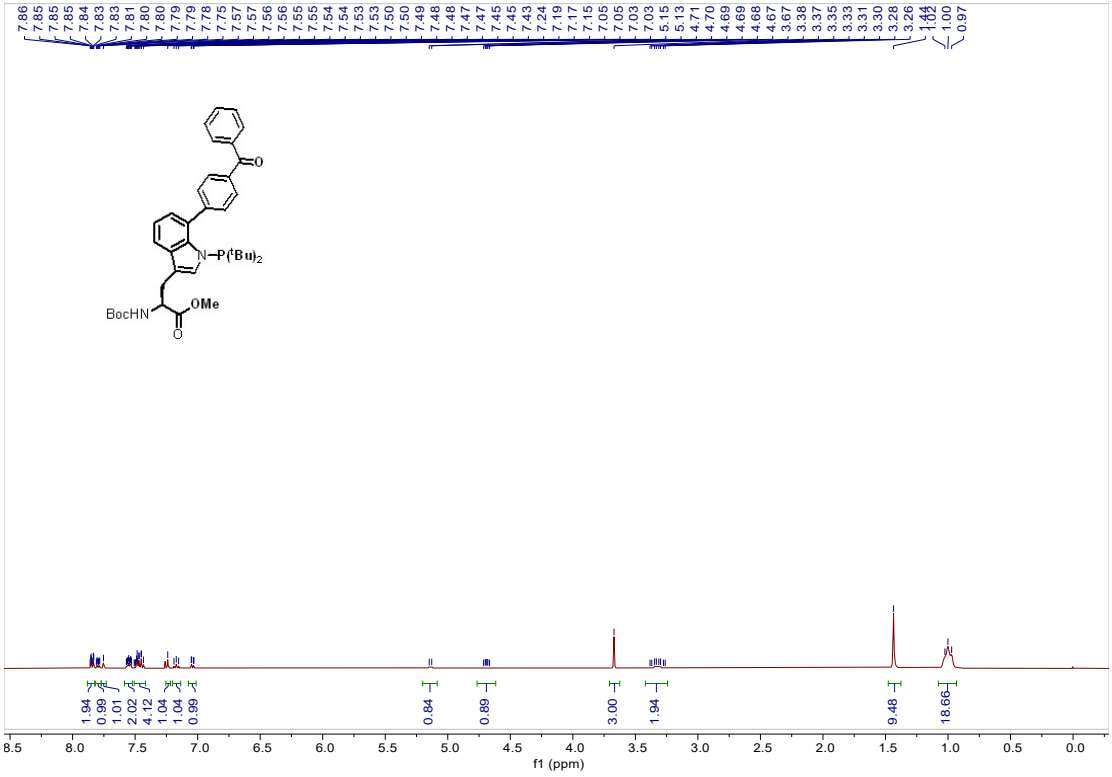
^{1}H NMR (400 MHz, $CDCl_3$) spectrum of **3am**



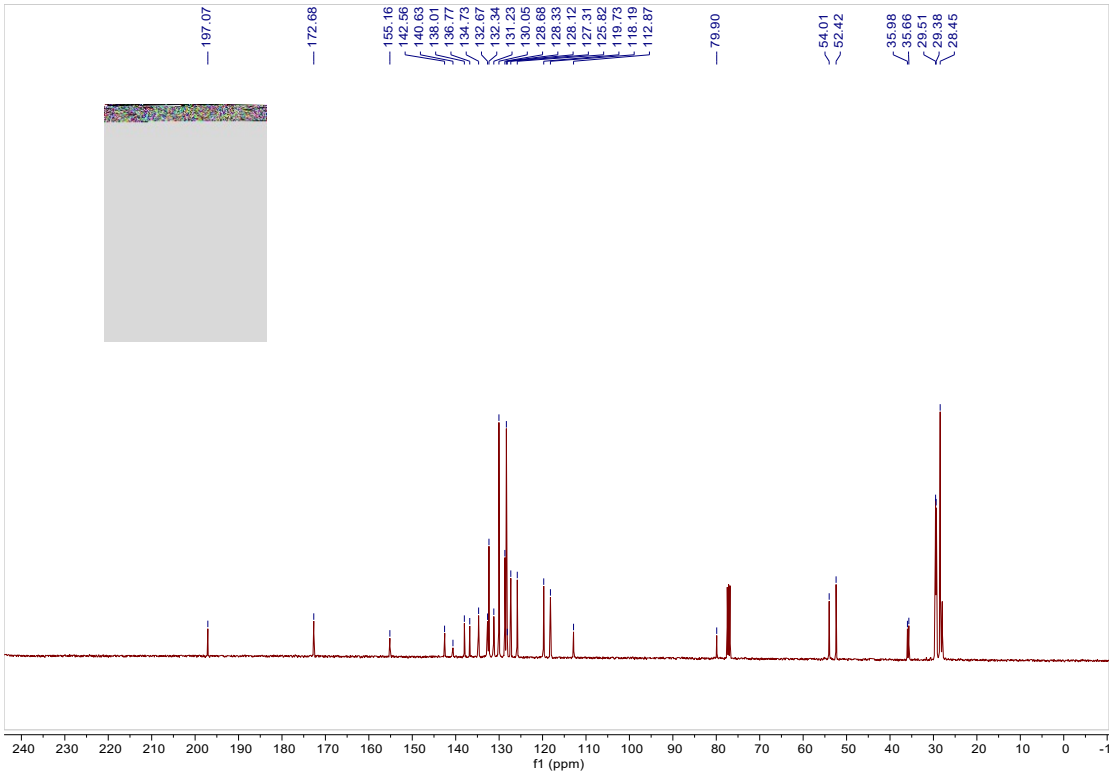
^{13}C NMR (101 MHz, $CDCl_3$) spectrum of **3am**



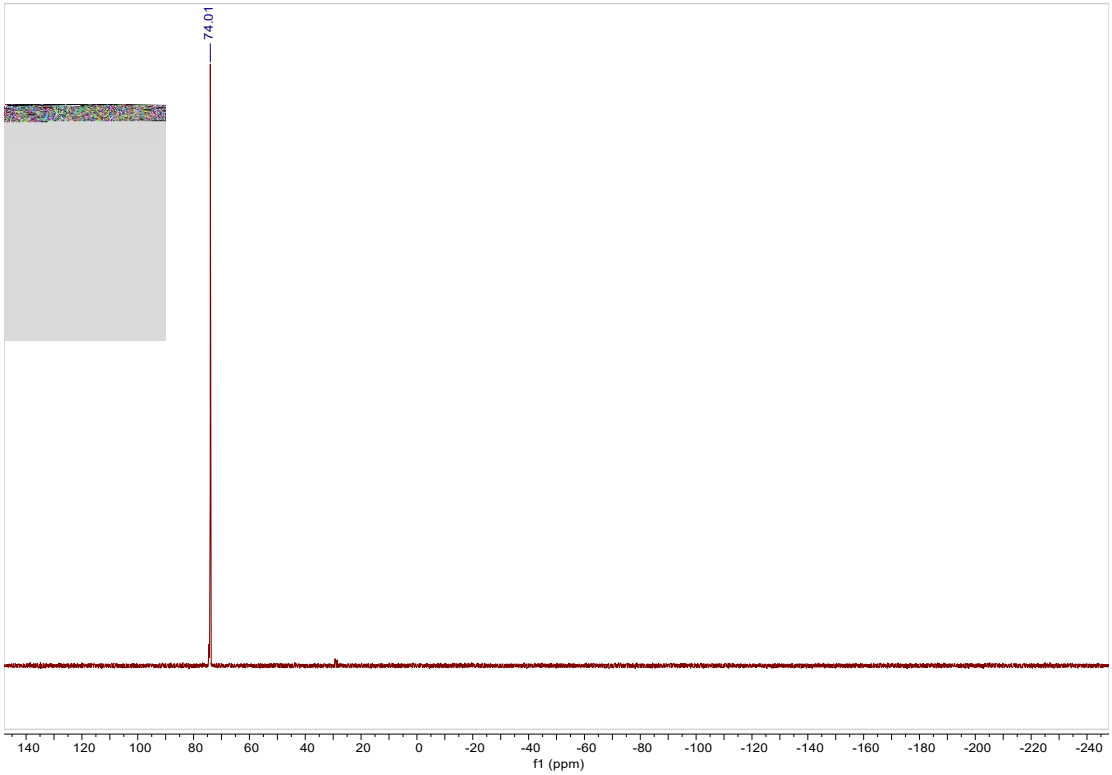
^{31}P NMR (162 MHz, $CDCl_3$) of **3am**



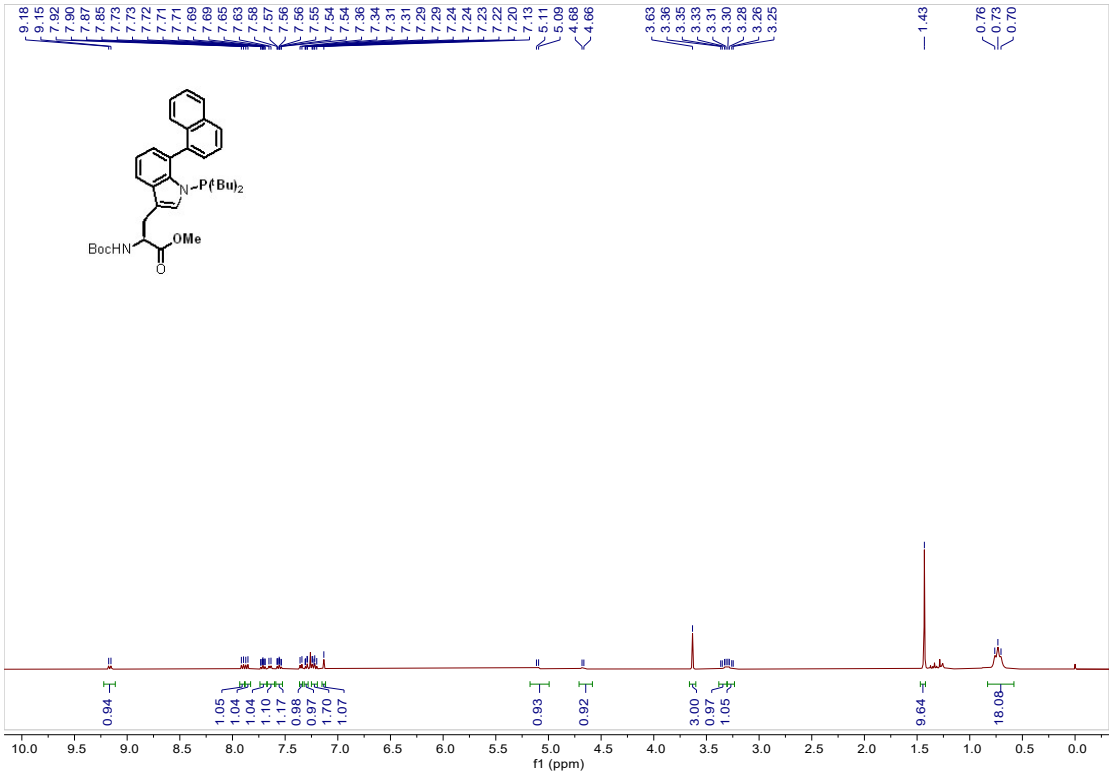
^{1}H NMR (400 MHz, $CDCl_3$) spectrum of **3an**



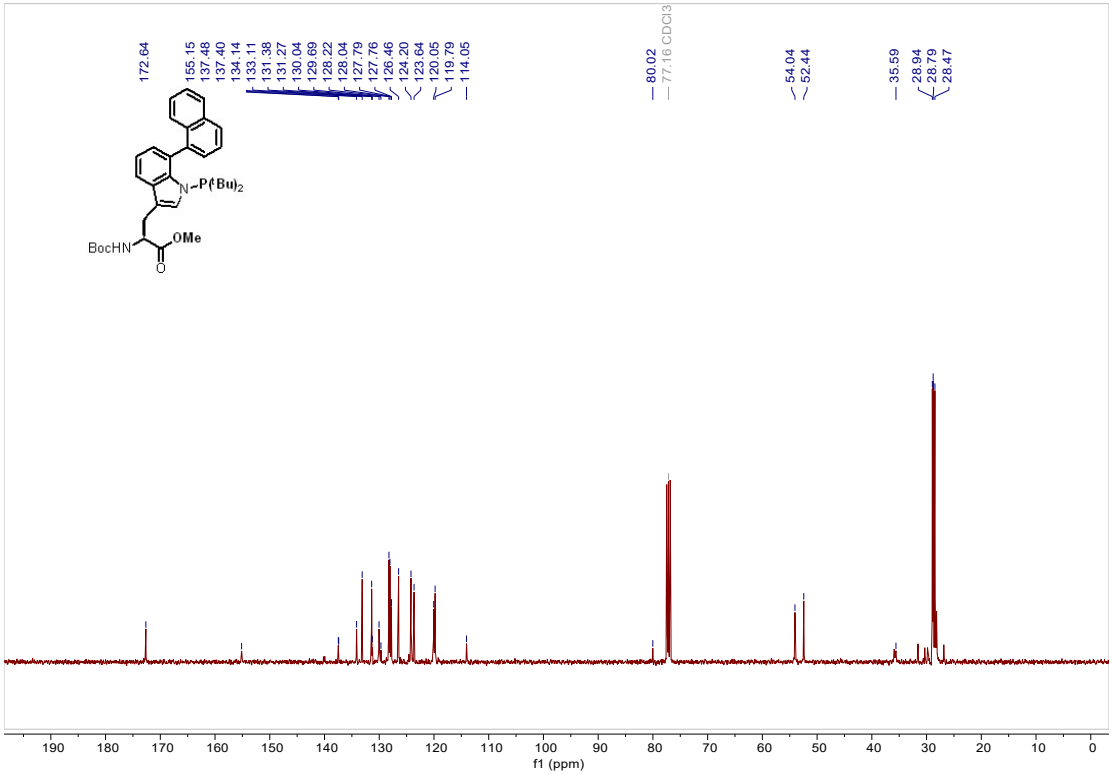
^{13}C NMR (101 MHz, $CDCl_3$) spectrum of **3an**



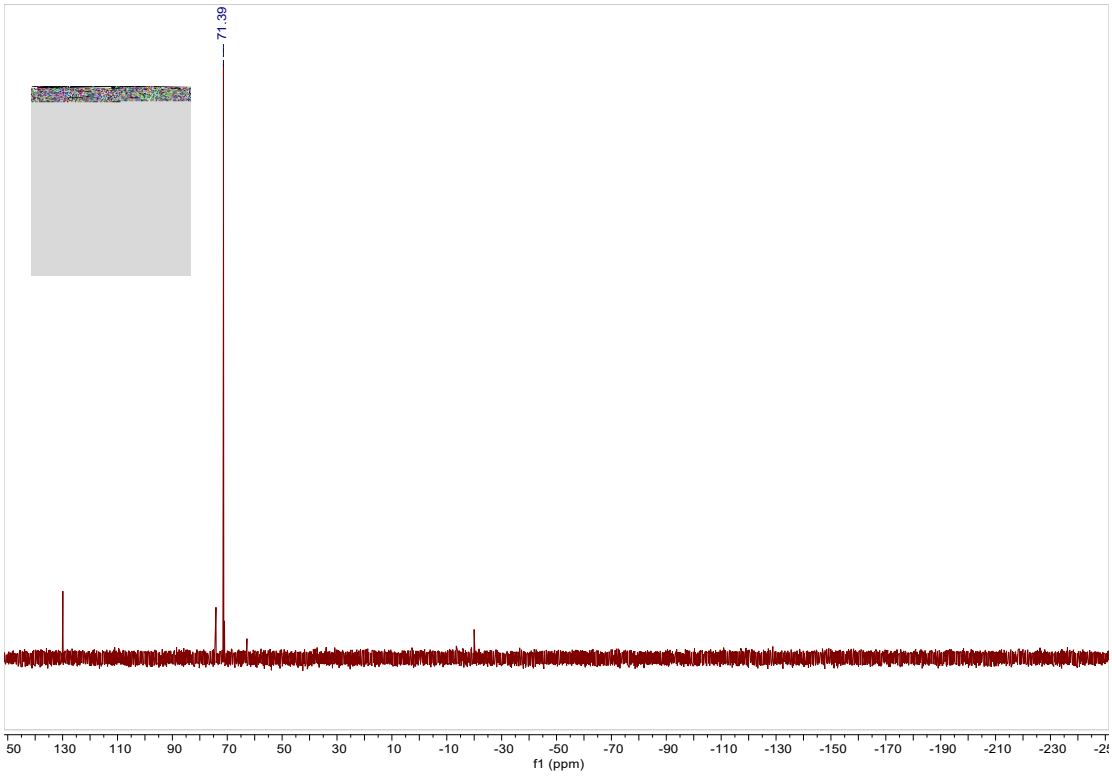
^{31}P NMR (162 MHz, $CDCl_3$) of **3an**



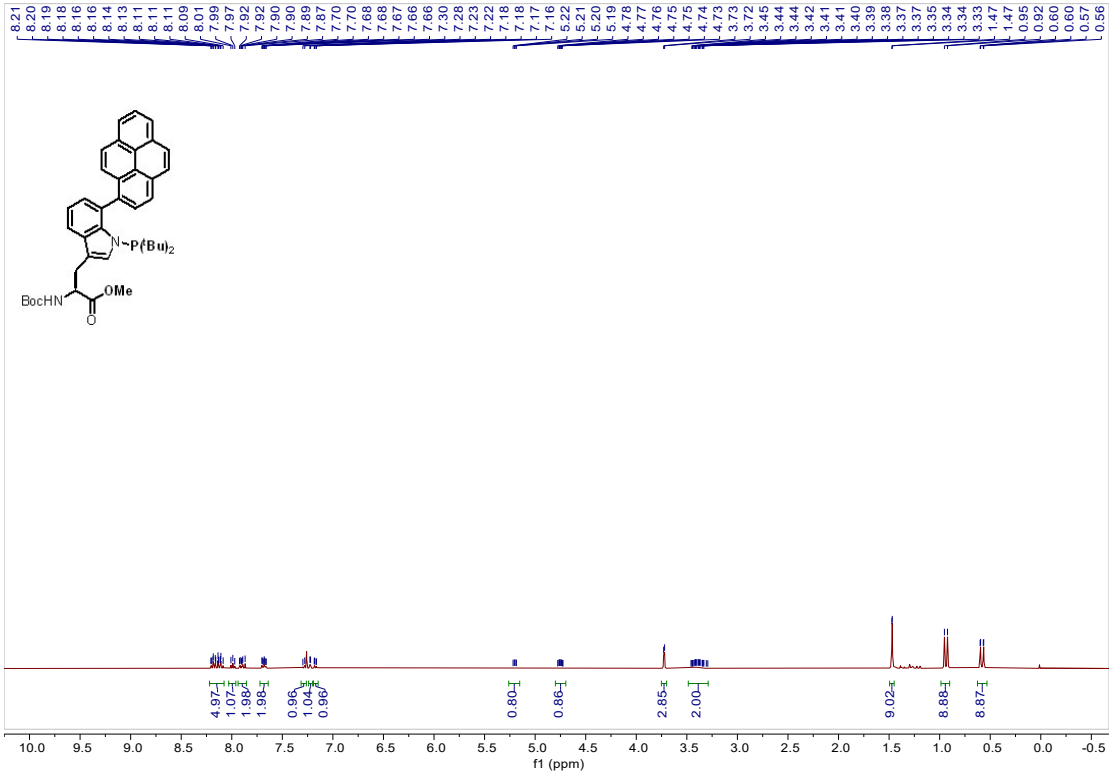
^{1}H NMR (400 MHz, $CDCl_3$) spectrum of **3ao**



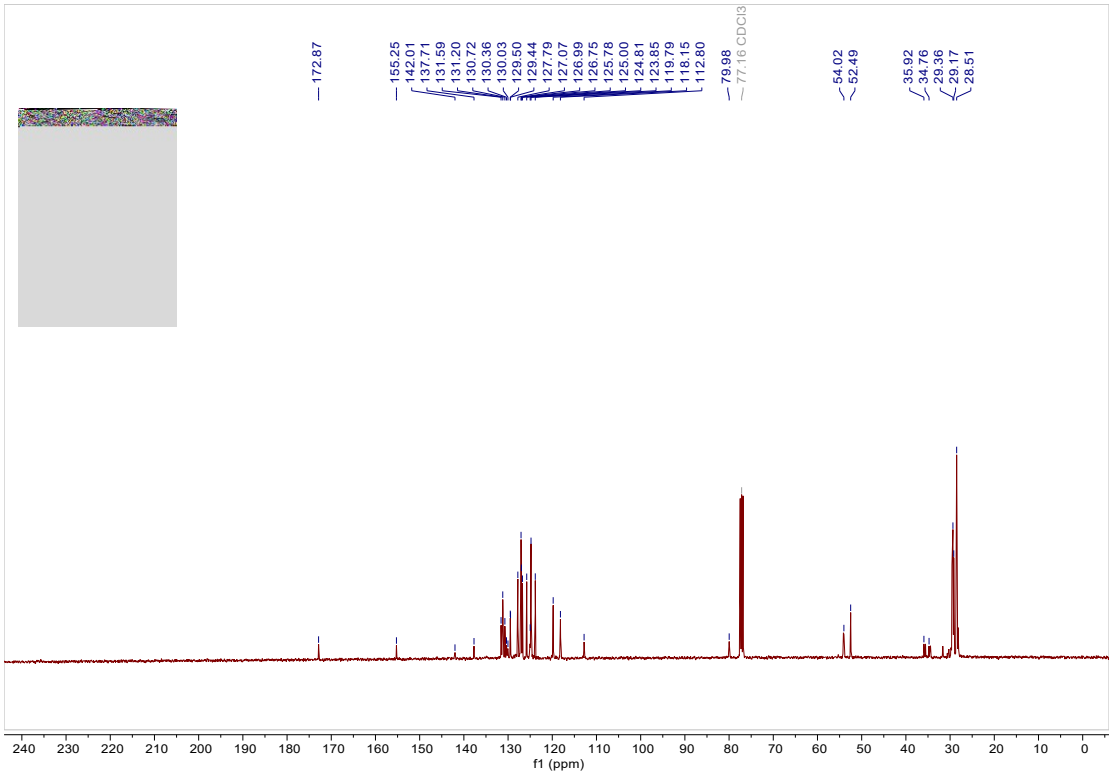
^{13}C NMR (101 MHz, $CDCl_3$) spectrum of **3ao**



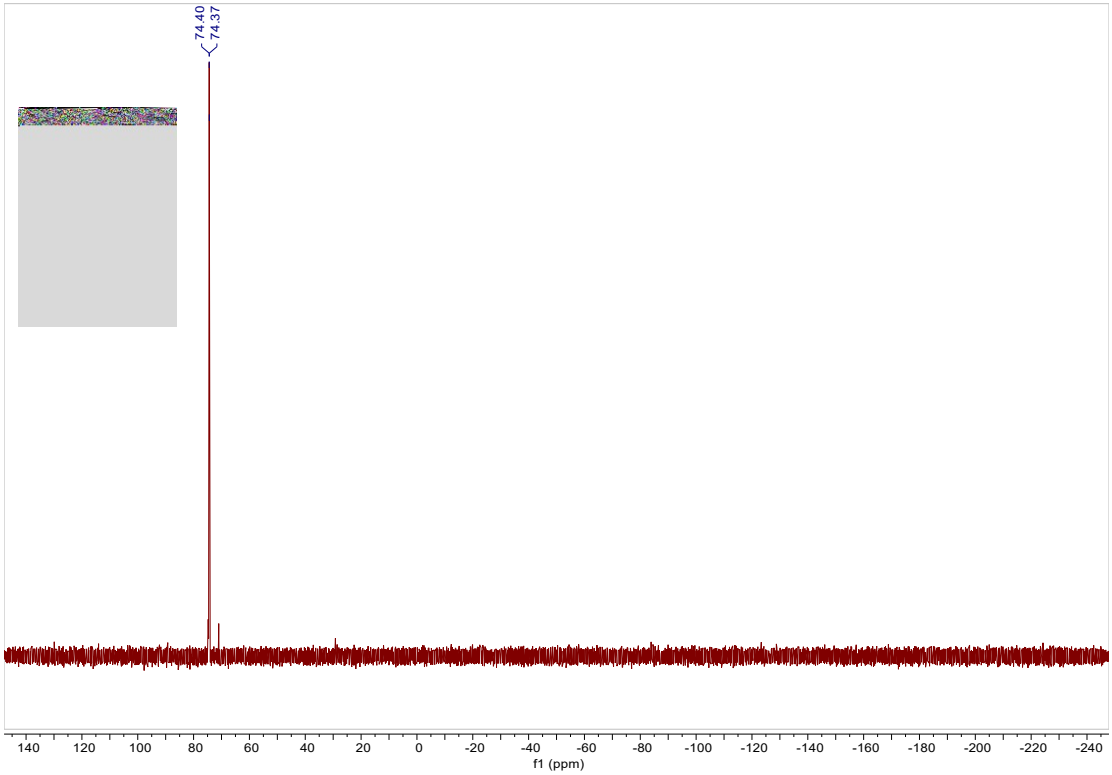
^{31}P NMR (162 MHz, $CDCl_3$) of **3ao**



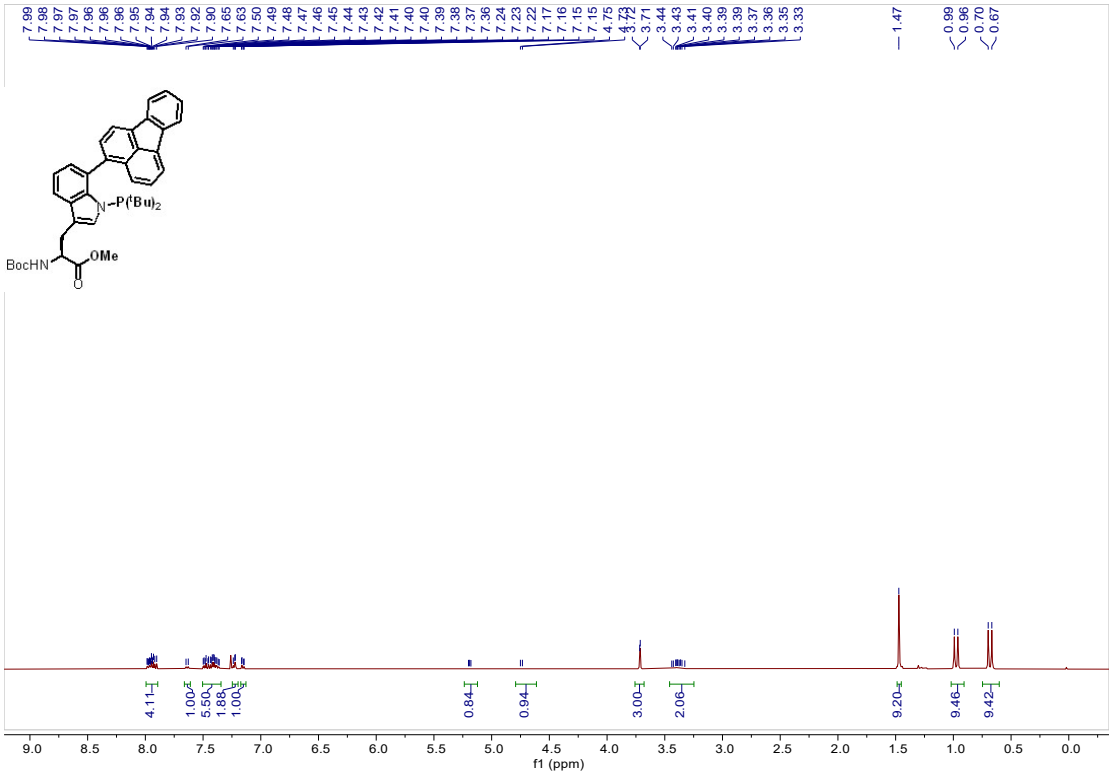
^{1}H NMR (400 MHz, $CDCl_3$) spectrum of **3ap**



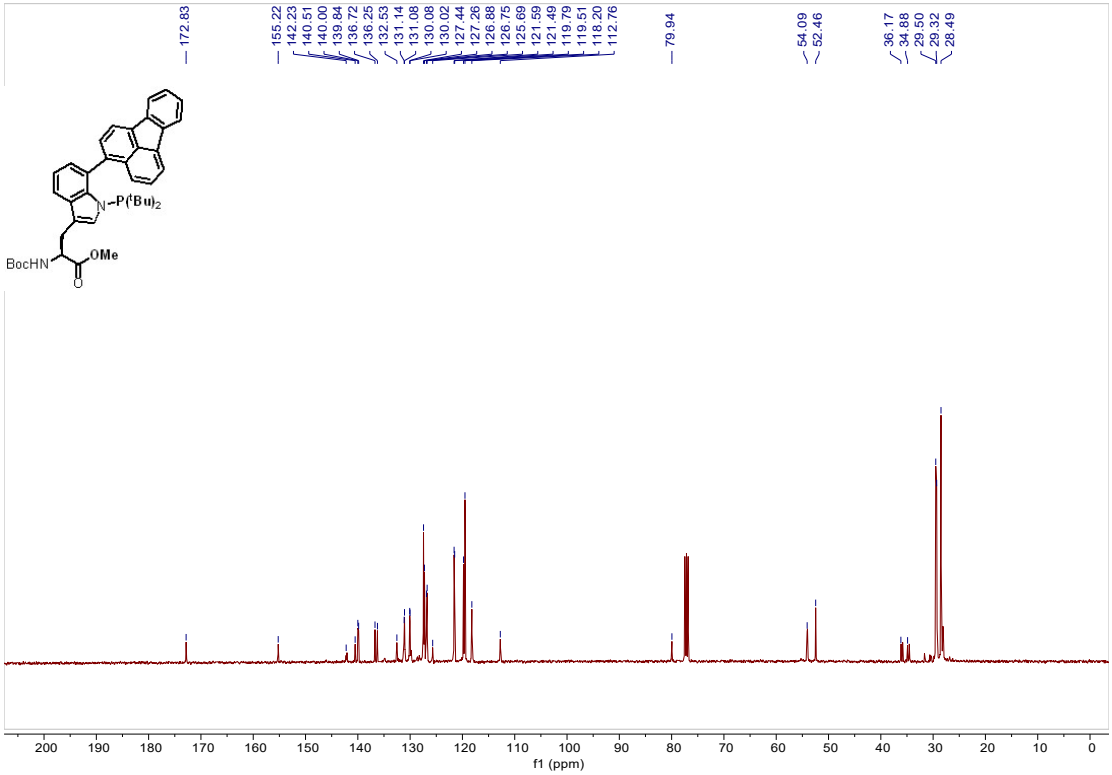
^{13}C NMR (101 MHz, $CDCl_3$) spectrum of **3ap**



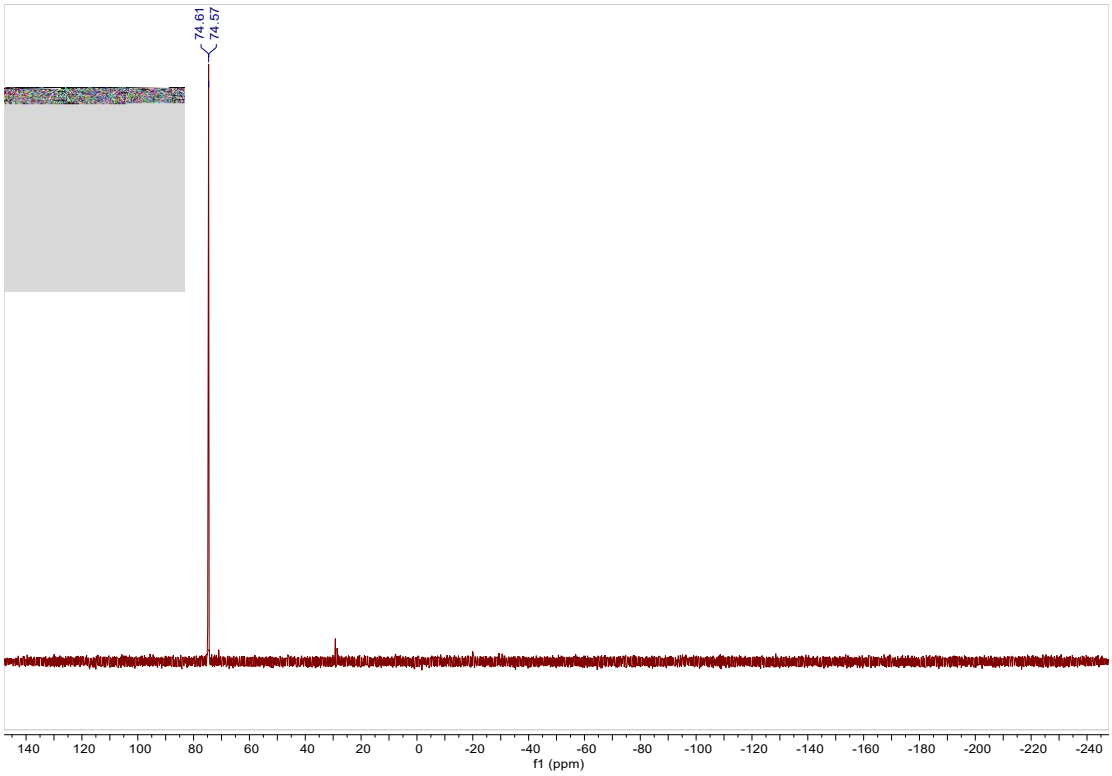
^{31}P NMR (162 MHz, $CDCl_3$) of **3ap**



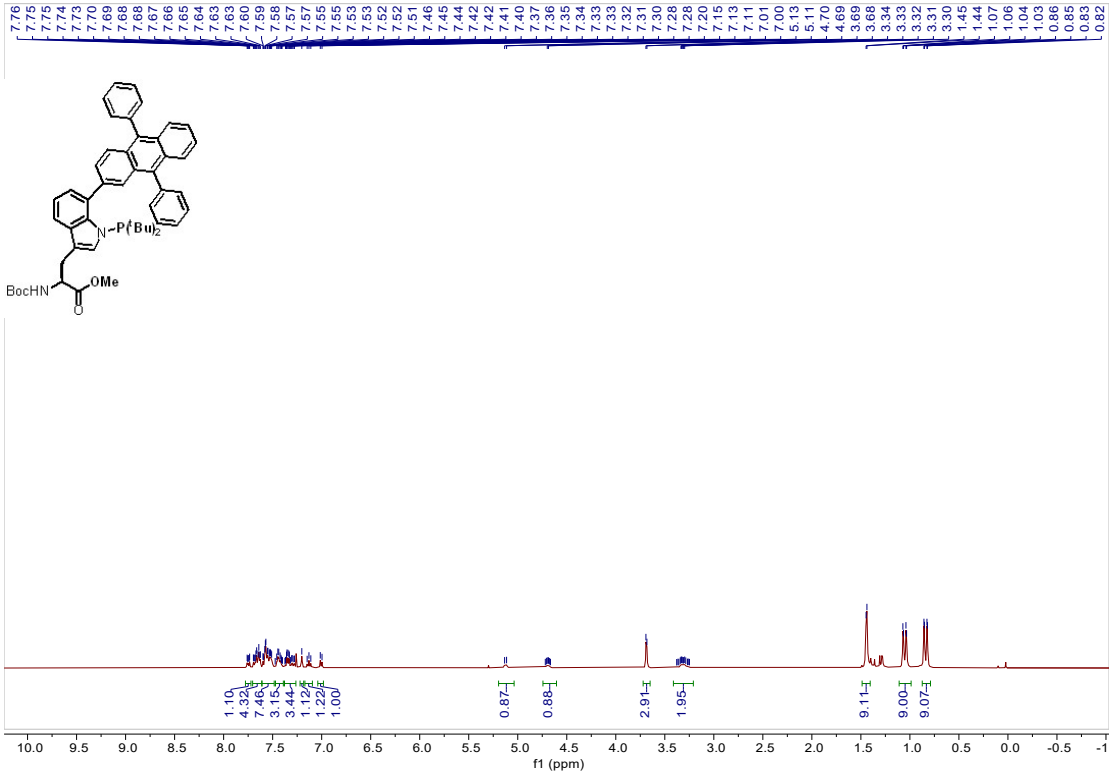
^{1}H NMR (400 MHz, $CDCl_3$) spectrum of **3aq**



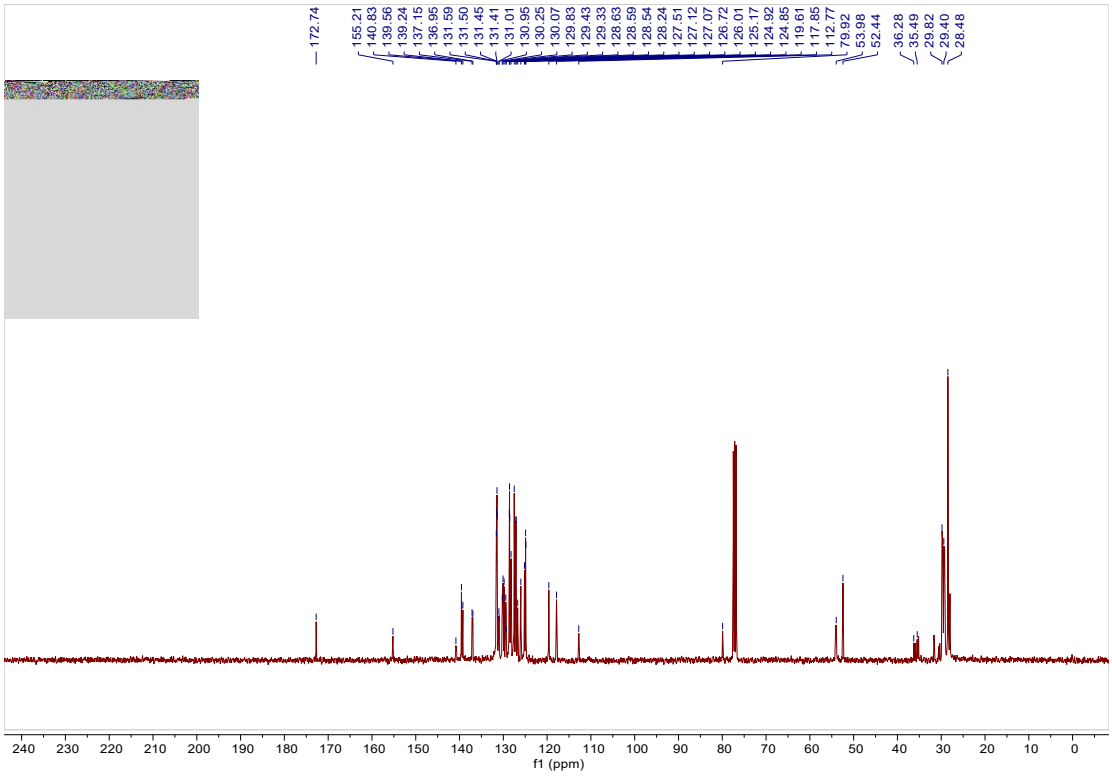
^{13}C NMR (101 MHz, $CDCl_3$) spectrum of **3aq**



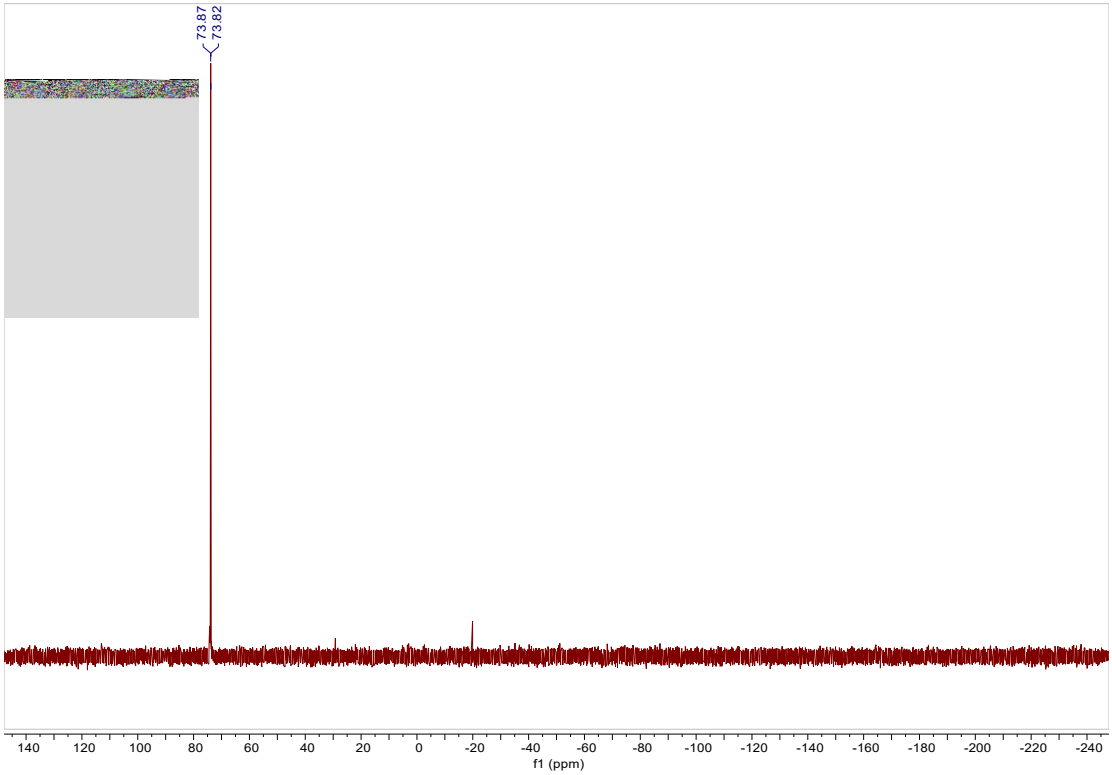
^{31}P NMR (162 MHz, $CDCl_3$) of **3aq**



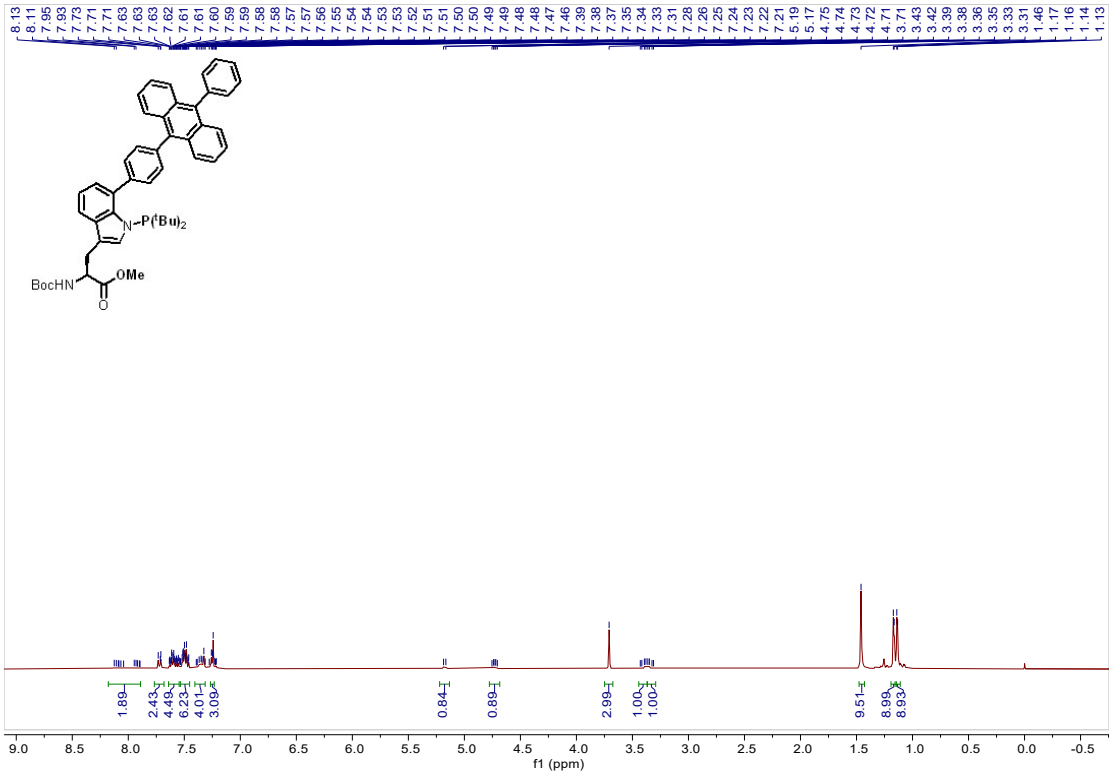
^{1}H NMR (400 MHz, $CDCl_3$) spectrum of **3ar**



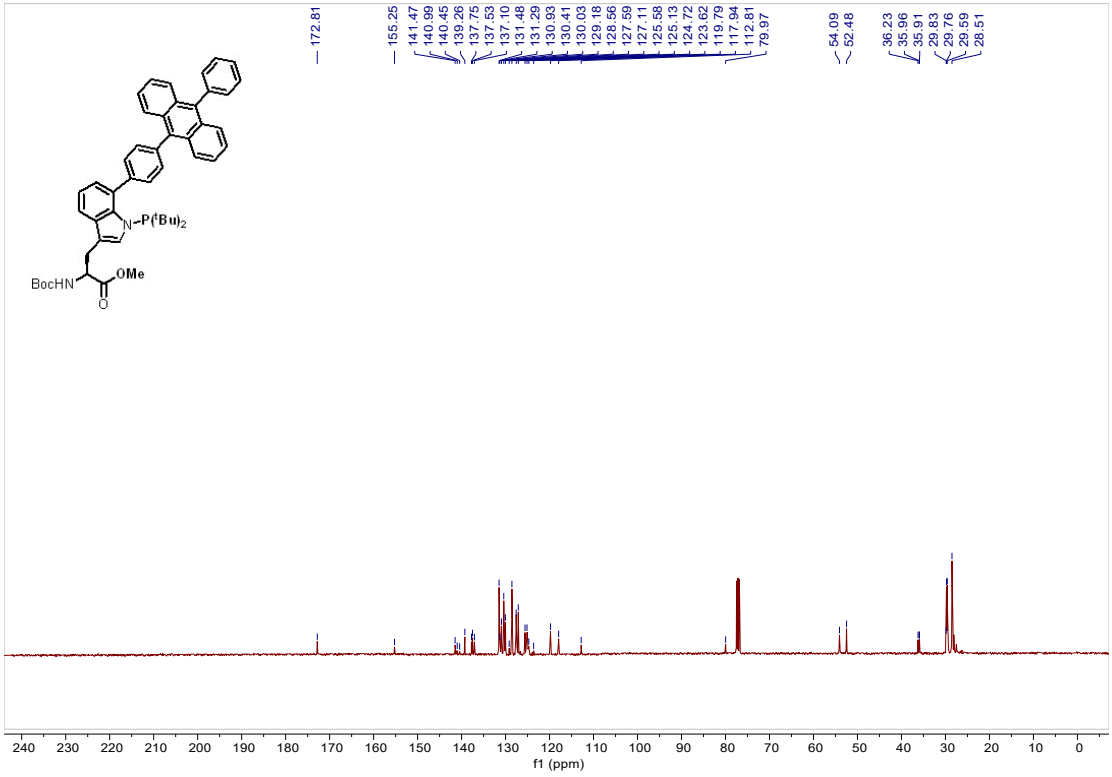
^{13}C NMR (101 MHz, $CDCl_3$) spectrum of **3ar**



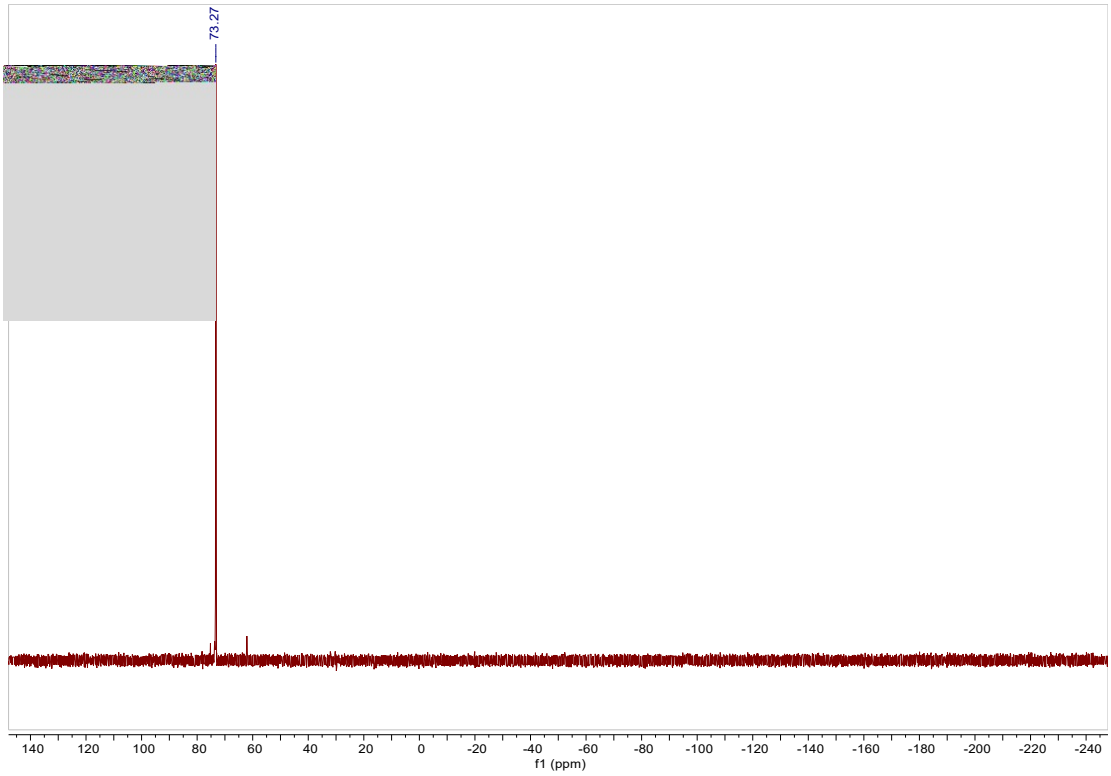
^{31}P NMR (162 MHz, $CDCl_3$) of **3ar**



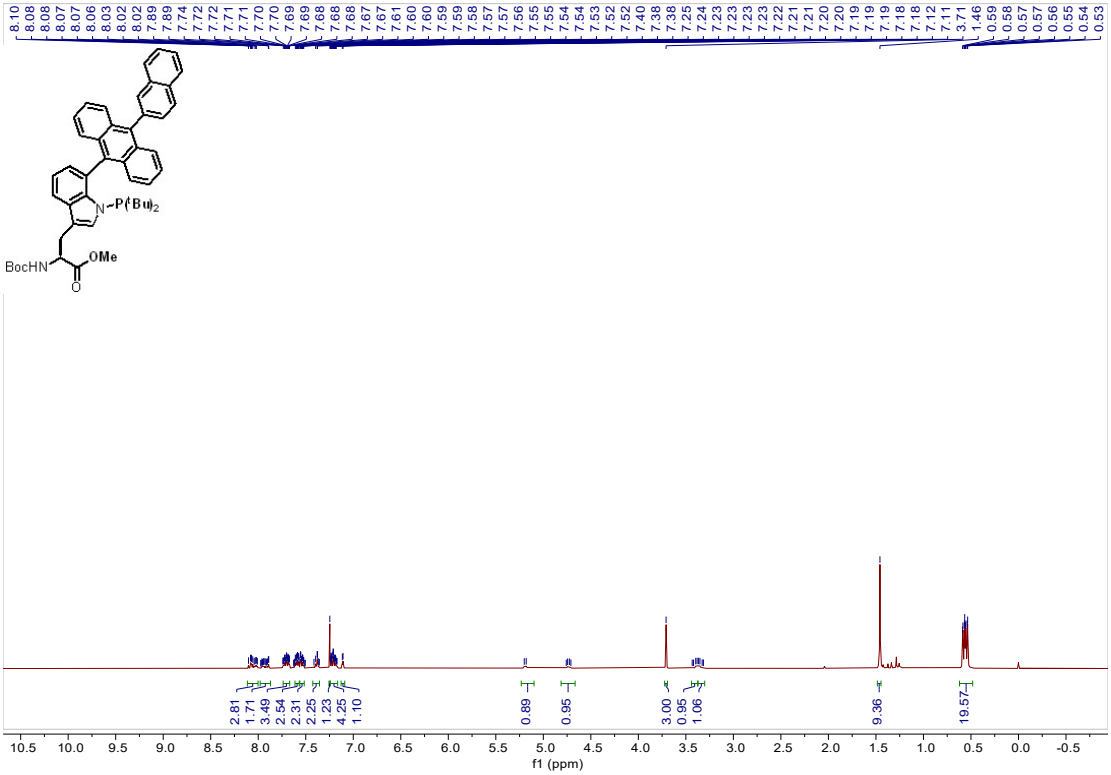
^{1}H NMR (400 MHz, $CDCl_3$) spectrum of **3as**



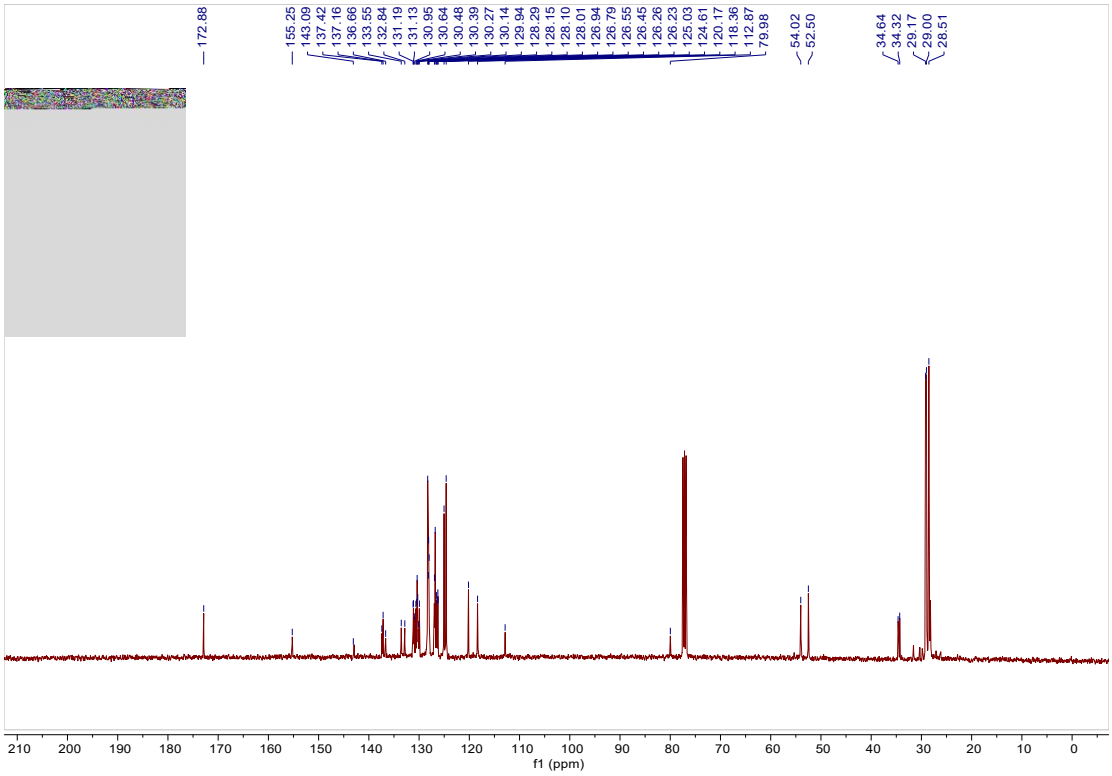
^{13}C NMR (101 MHz, $CDCl_3$) spectrum of **3as**



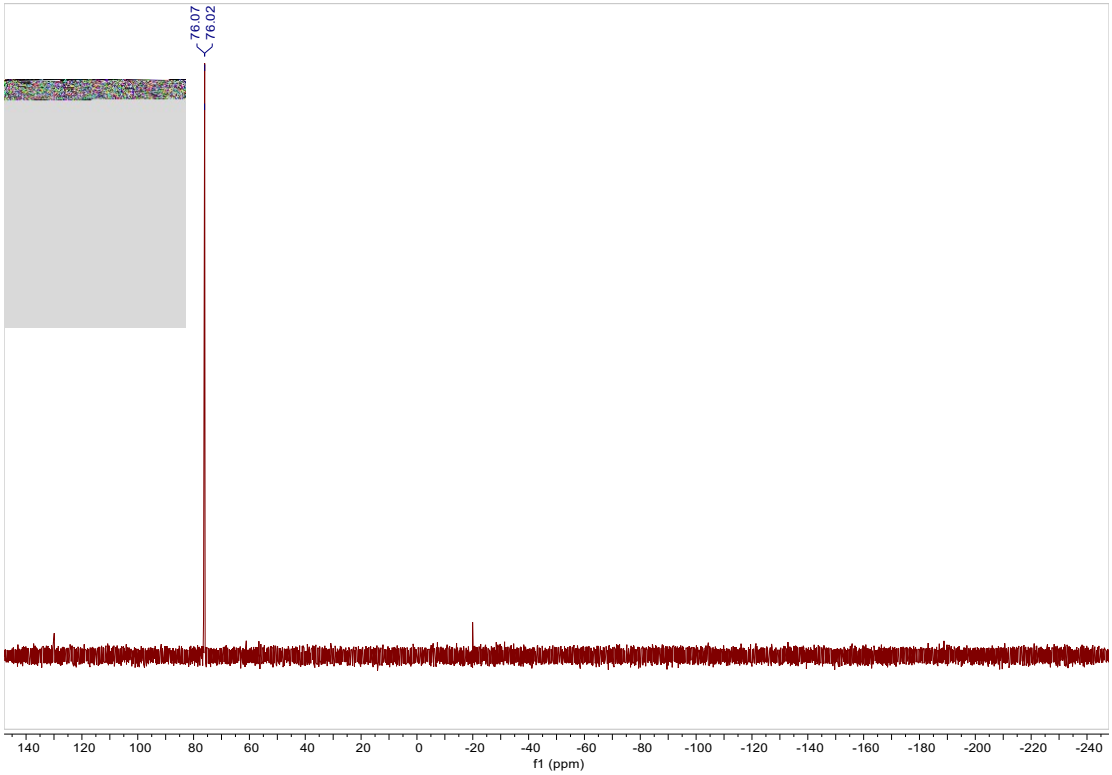
^{31}P NMR (162 MHz, $CDCl_3$) of **3as**



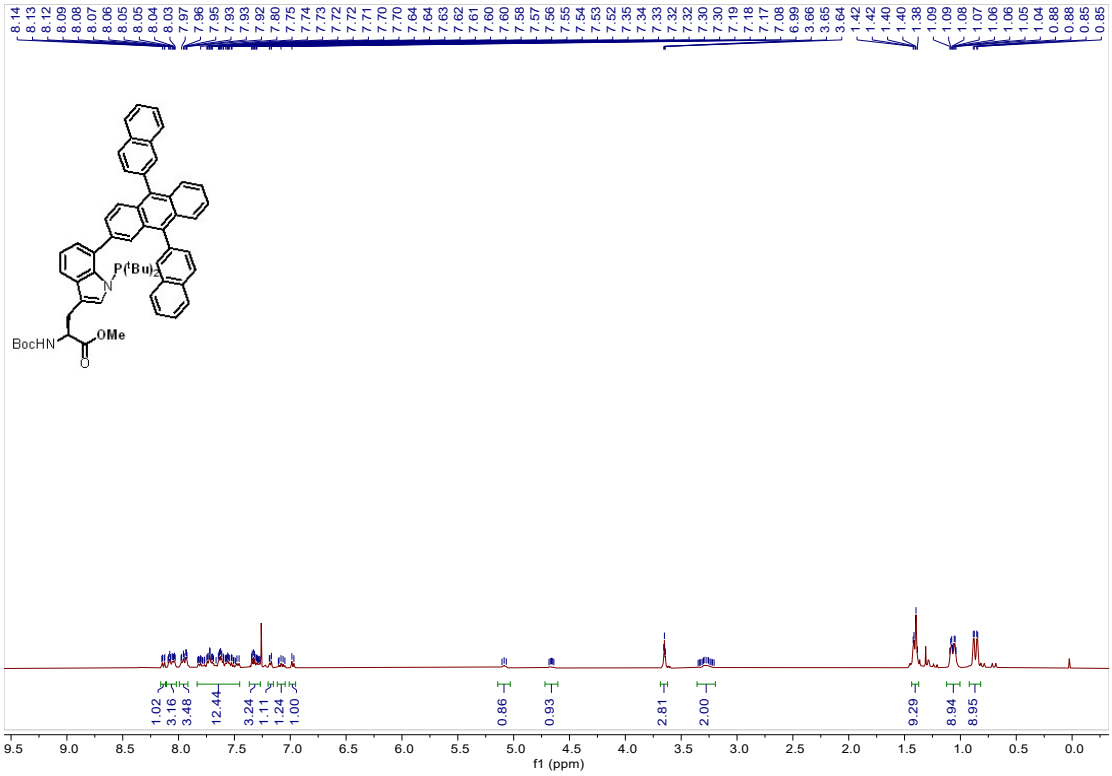
^{1}H NMR (400 MHz, $CDCl_3$) spectrum of **3at**



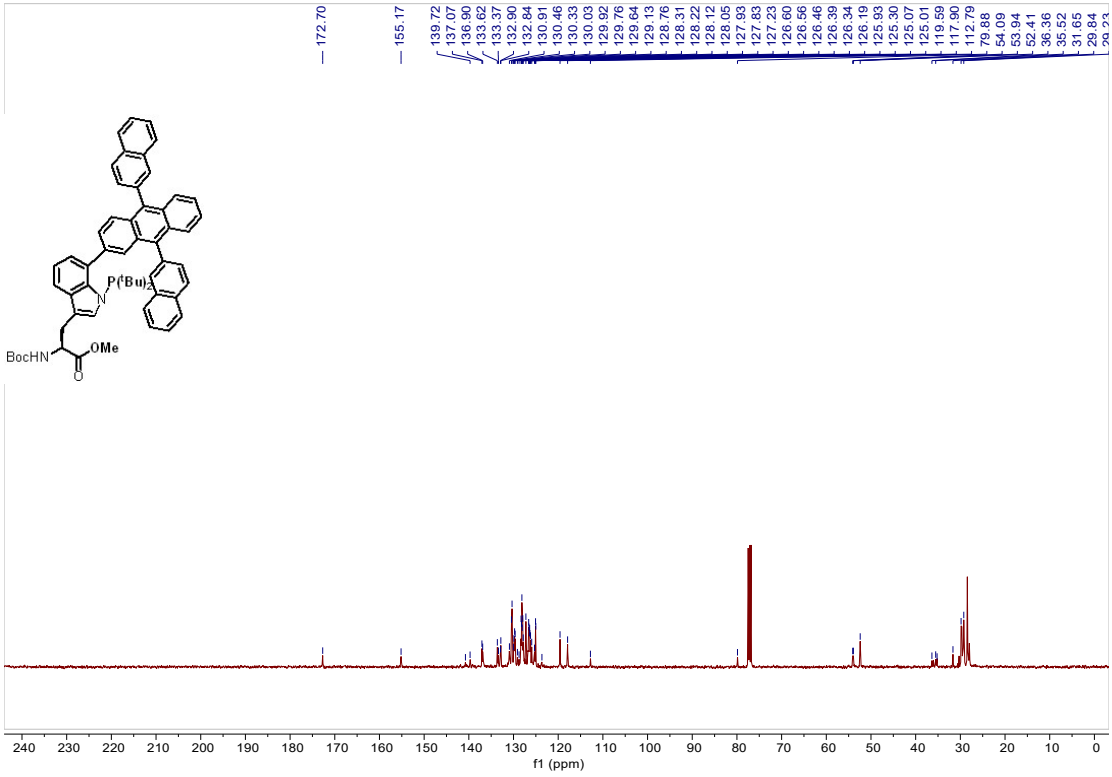
^{13}C NMR (101 MHz, $CDCl_3$) spectrum of **3at**



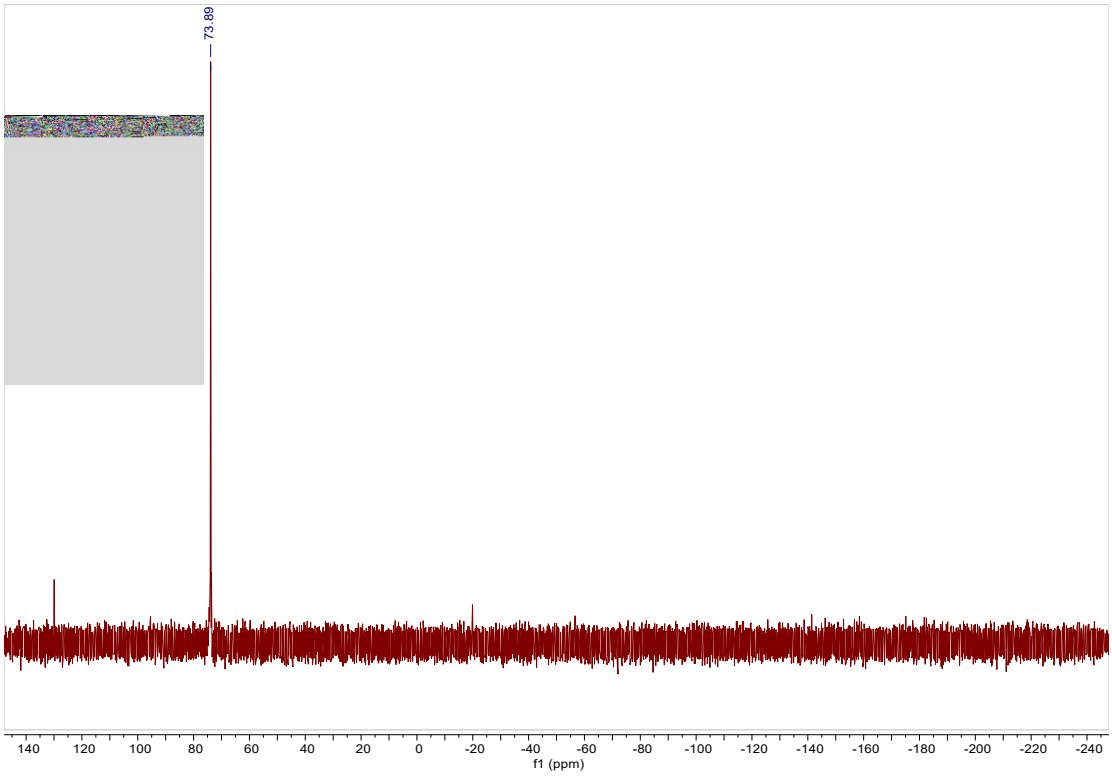
^{31}P NMR (162 MHz, $CDCl_3$) of **3at**



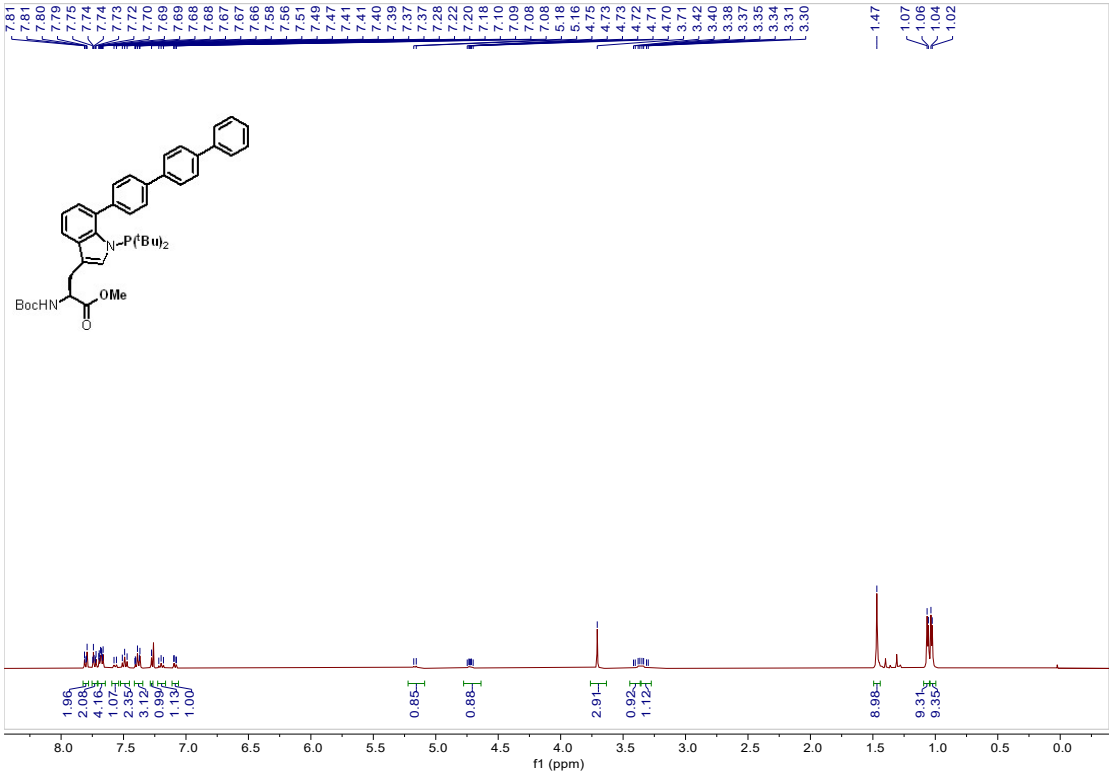
^{1}H NMR (400 MHz, $CDCl_3$) spectrum of **3au**



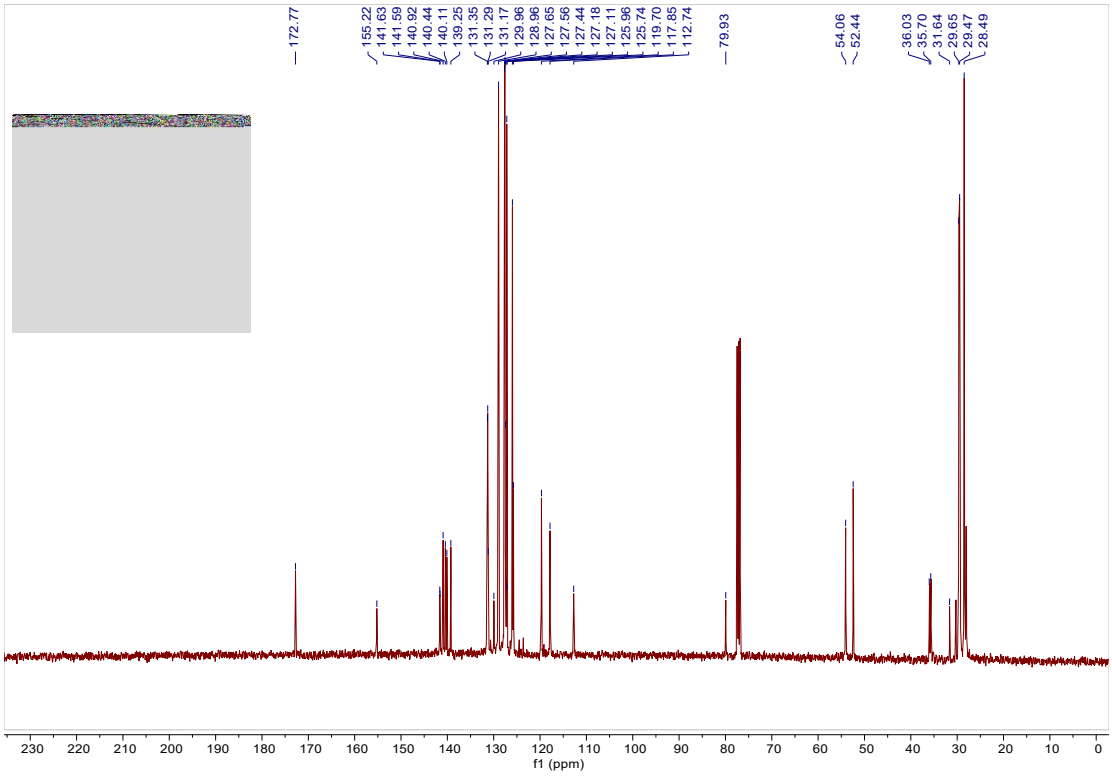
^{13}C NMR (101 MHz, $CDCl_3$) spectrum of **3au**



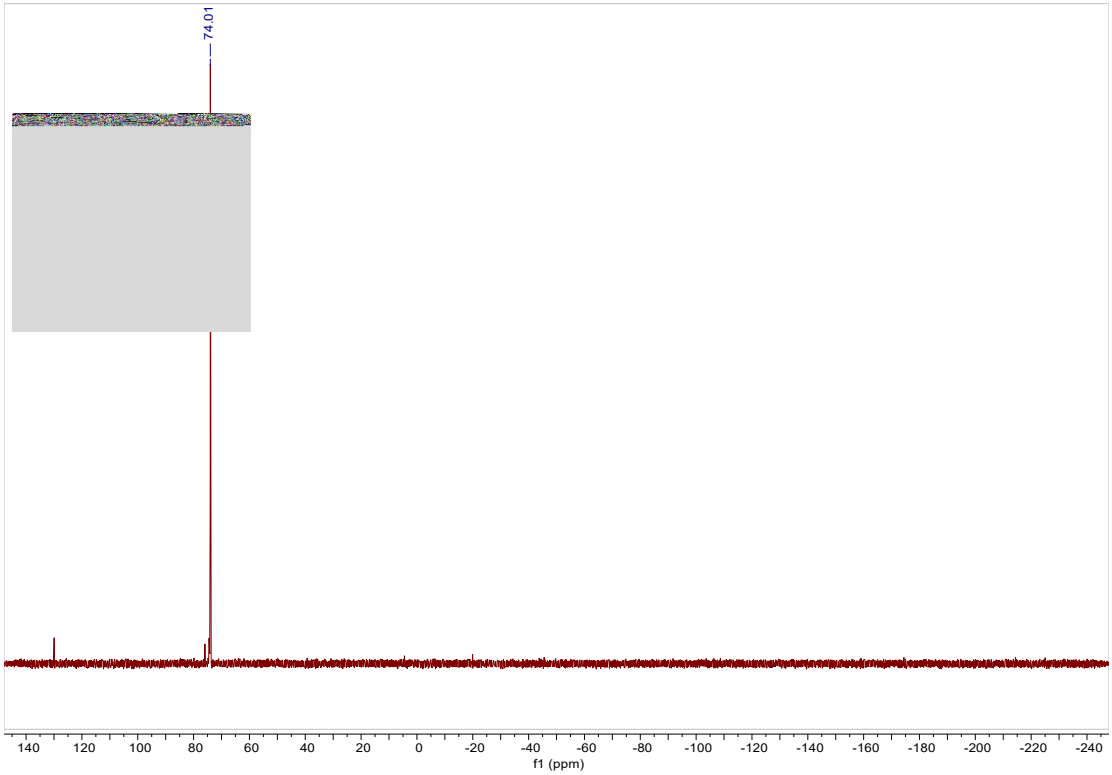
^{31}P NMR (162 MHz, $CDCl_3$) of **3au**



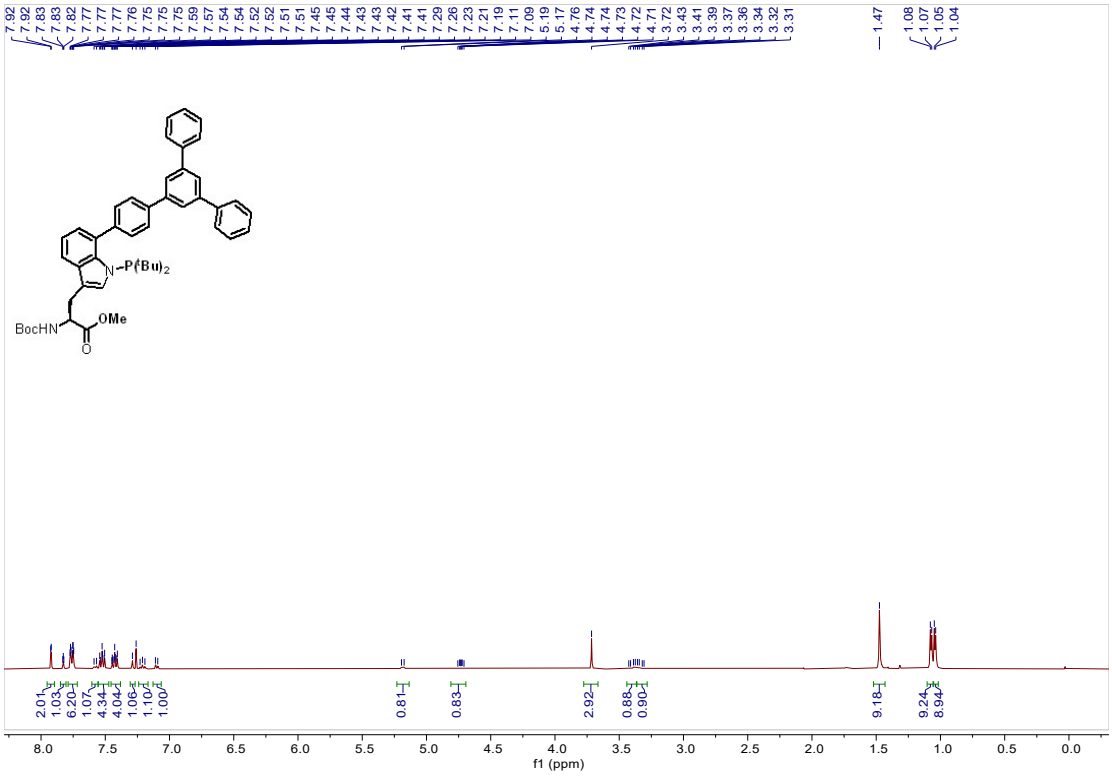
^{1}H NMR (400 MHz, $CDCl_3$) spectrum of **3av**



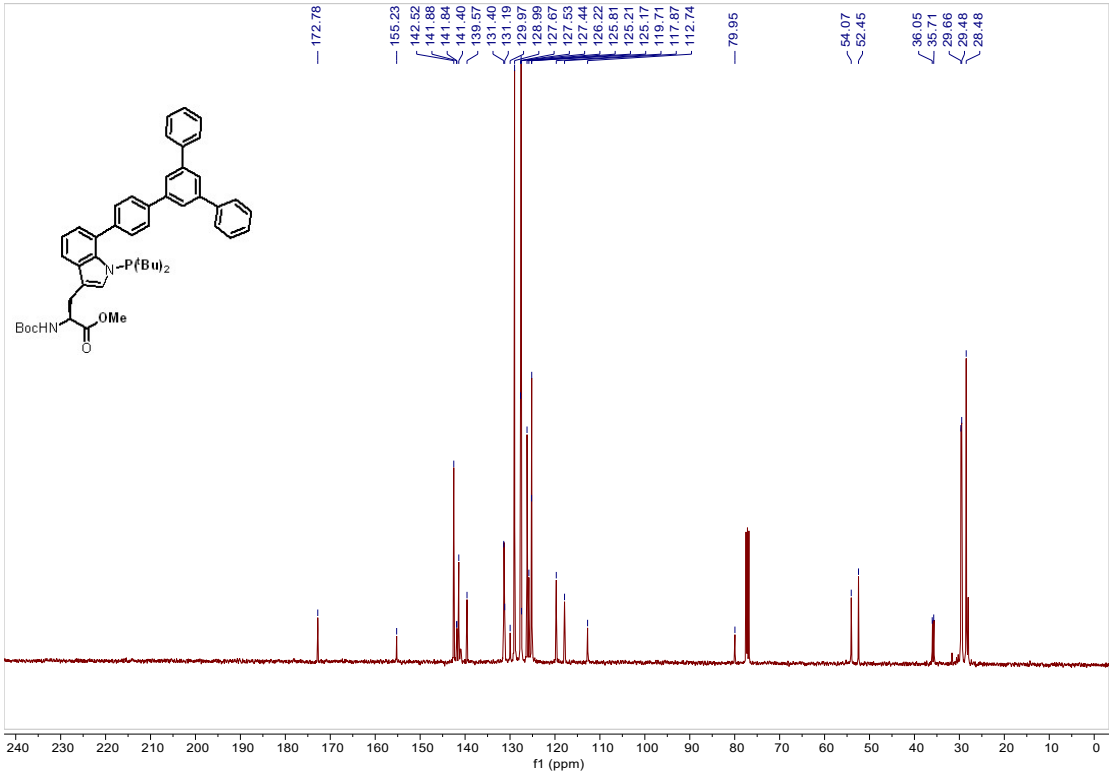
^{13}C NMR (101 MHz, $CDCl_3$) spectrum of **3av**



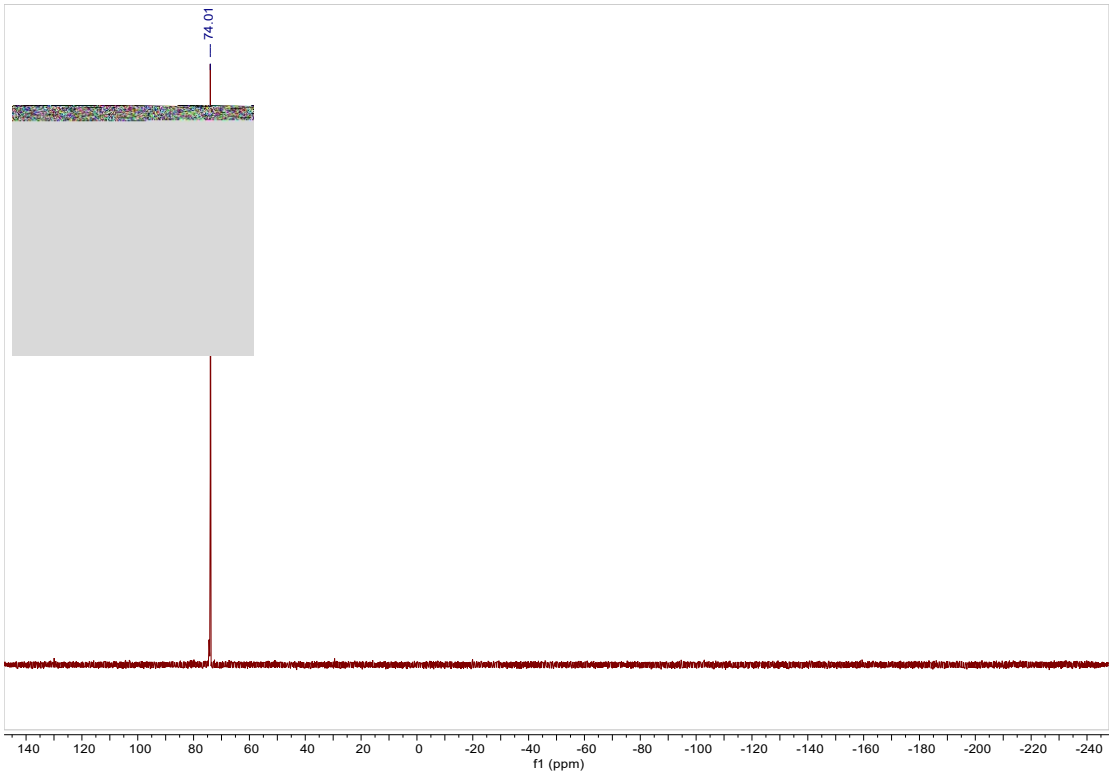
^{31}P NMR (162 MHz, $CDCl_3$) of **3av**



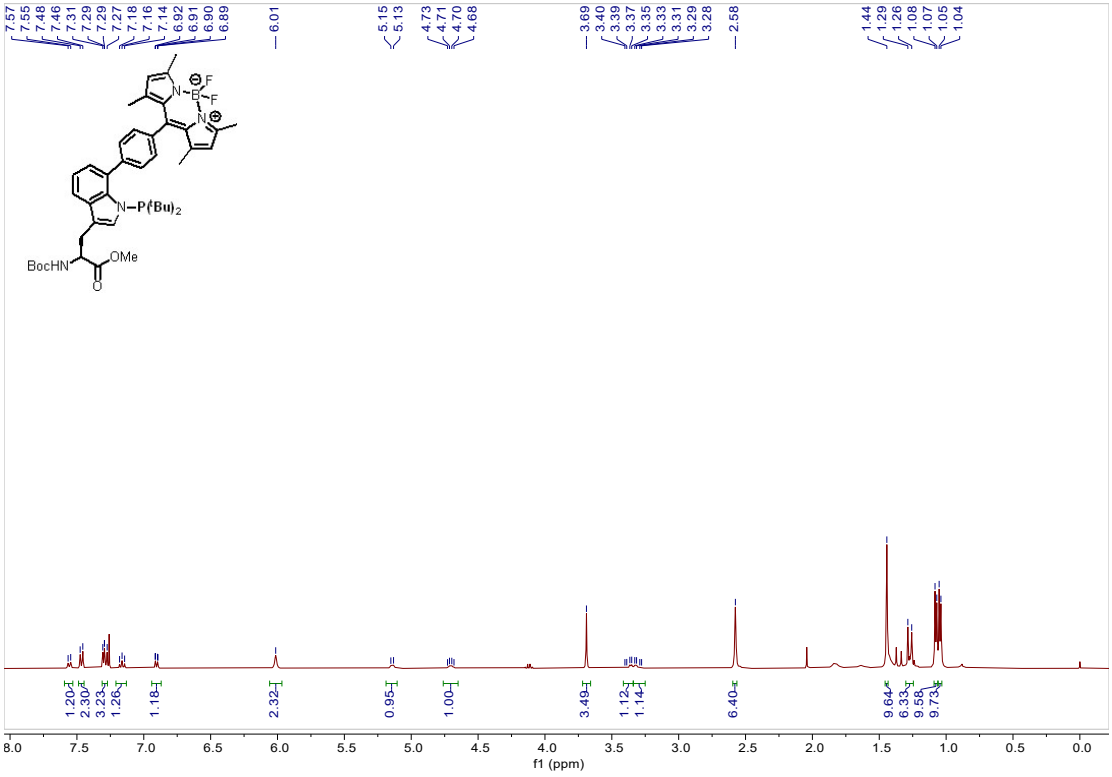
^{1}H NMR (400 MHz, $CDCl_3$) spectrum of **3aw**



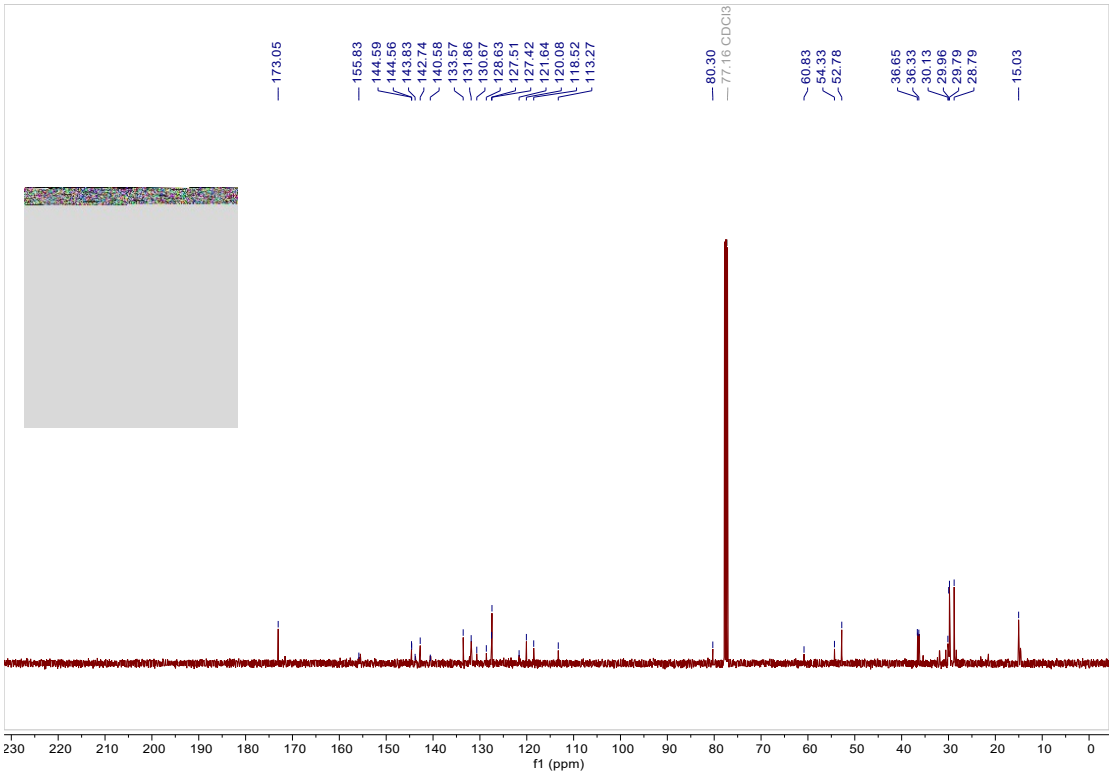
^{13}C NMR (101 MHz, $CDCl_3$) spectrum of **3aw**



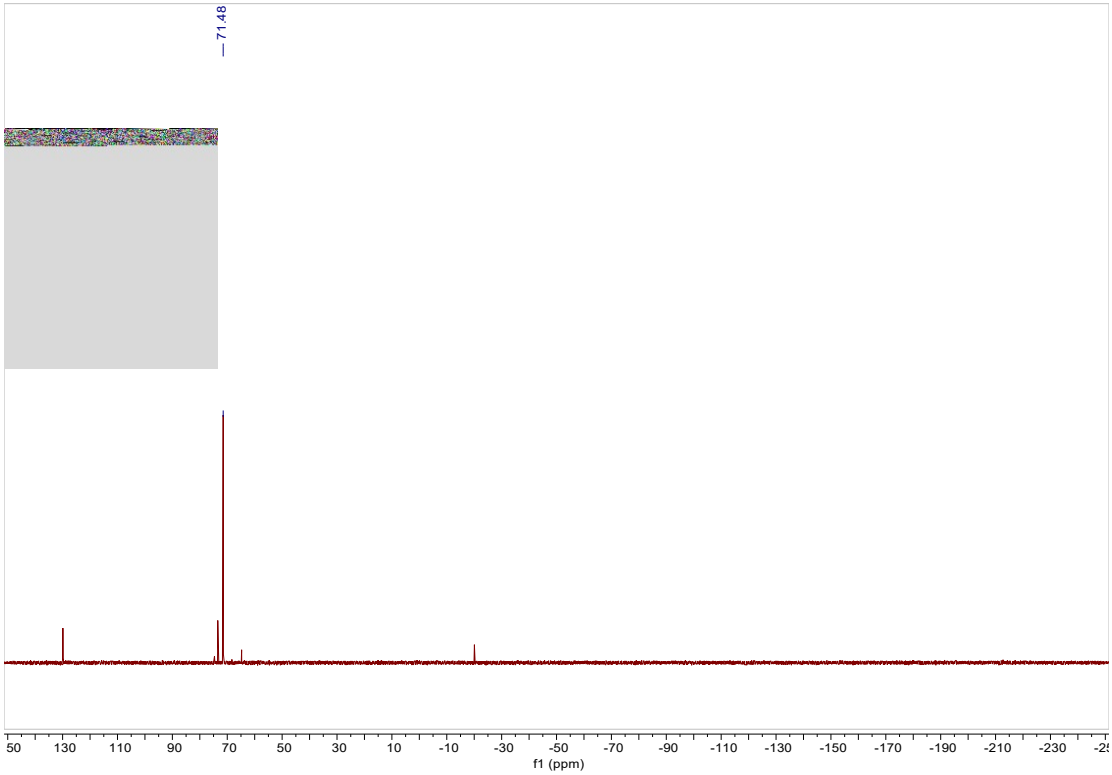
^{31}P NMR (162 MHz, $CDCl_3$) of **3aw**



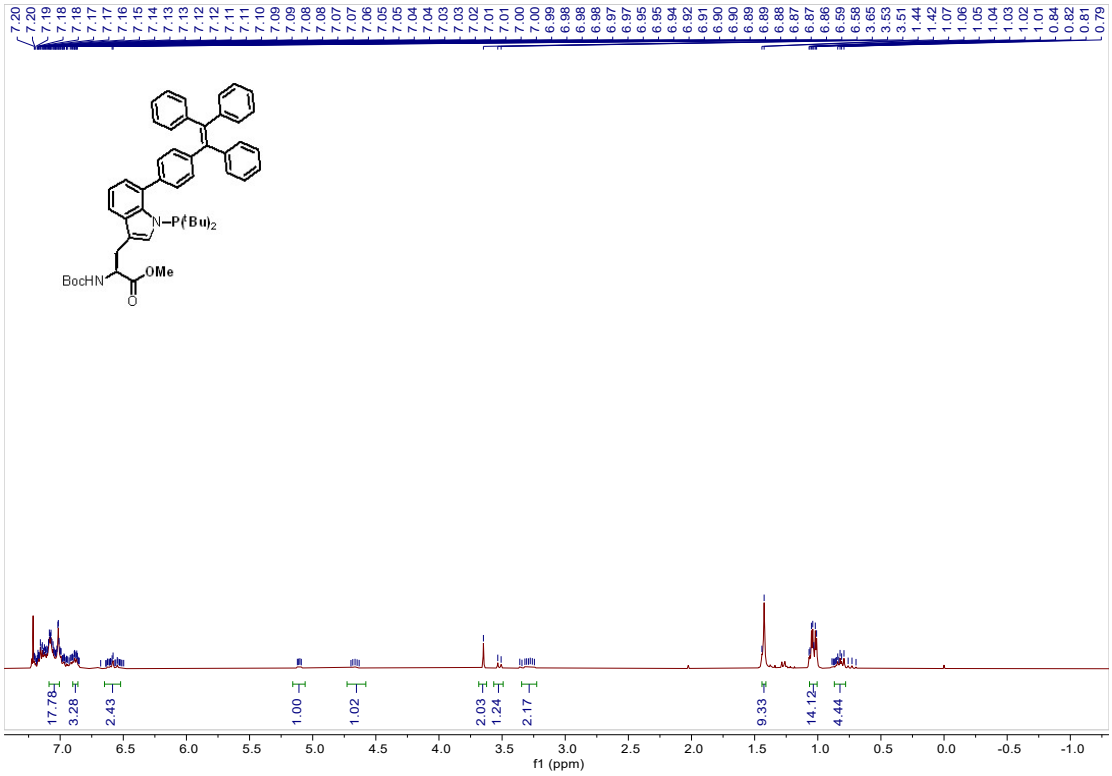
^{1}H NMR (400 MHz, $CDCl_3$) spectrum of **3ax**



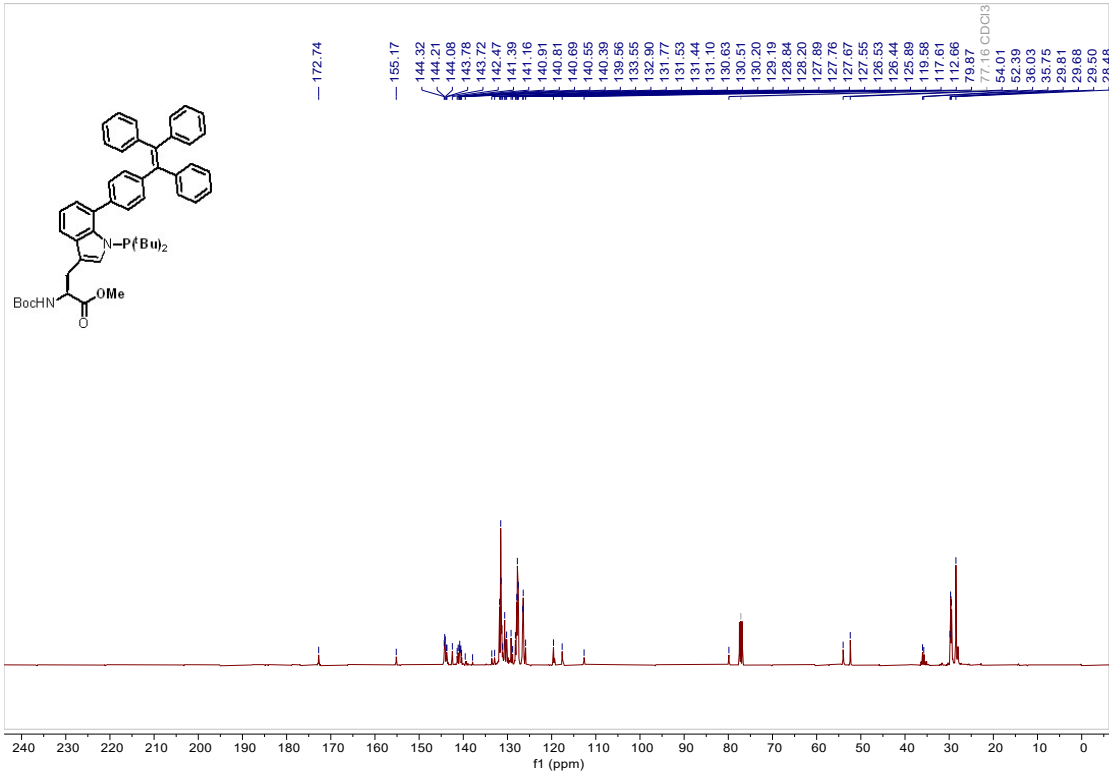
^{13}C NMR (101 MHz, $CDCl_3$) spectrum of **3ax**



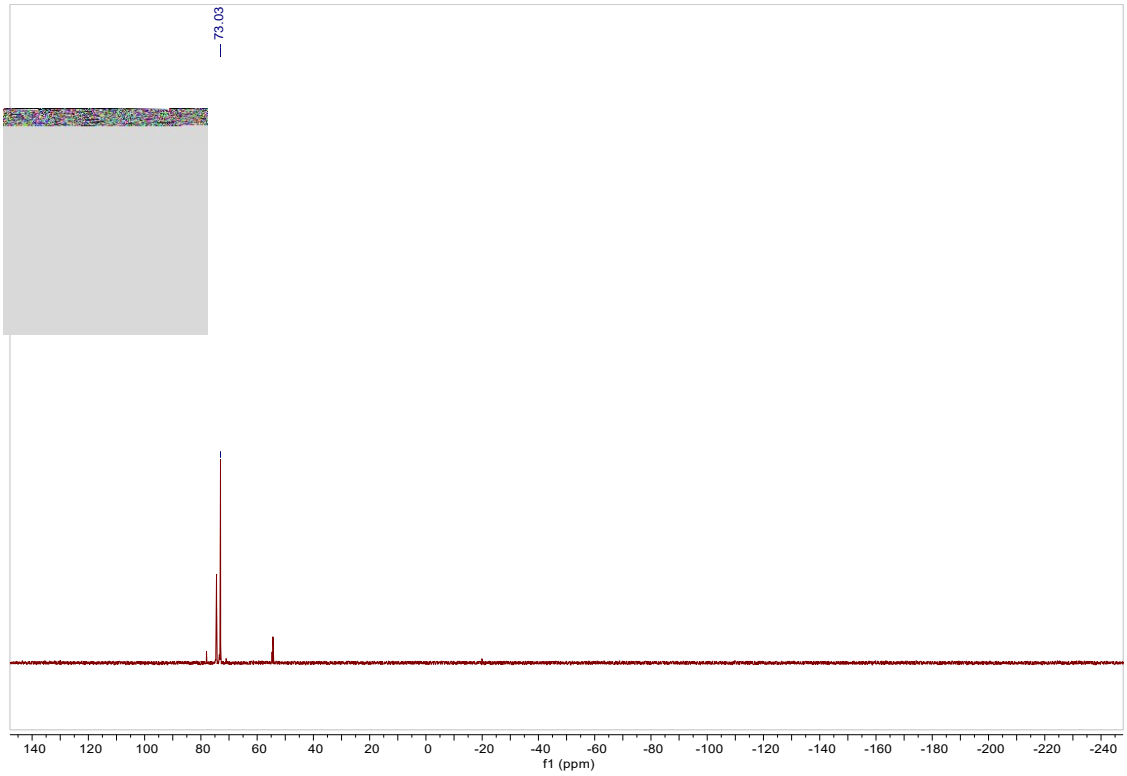
^{31}P NMR (162 MHz, $CDCl_3$) of **3ax**



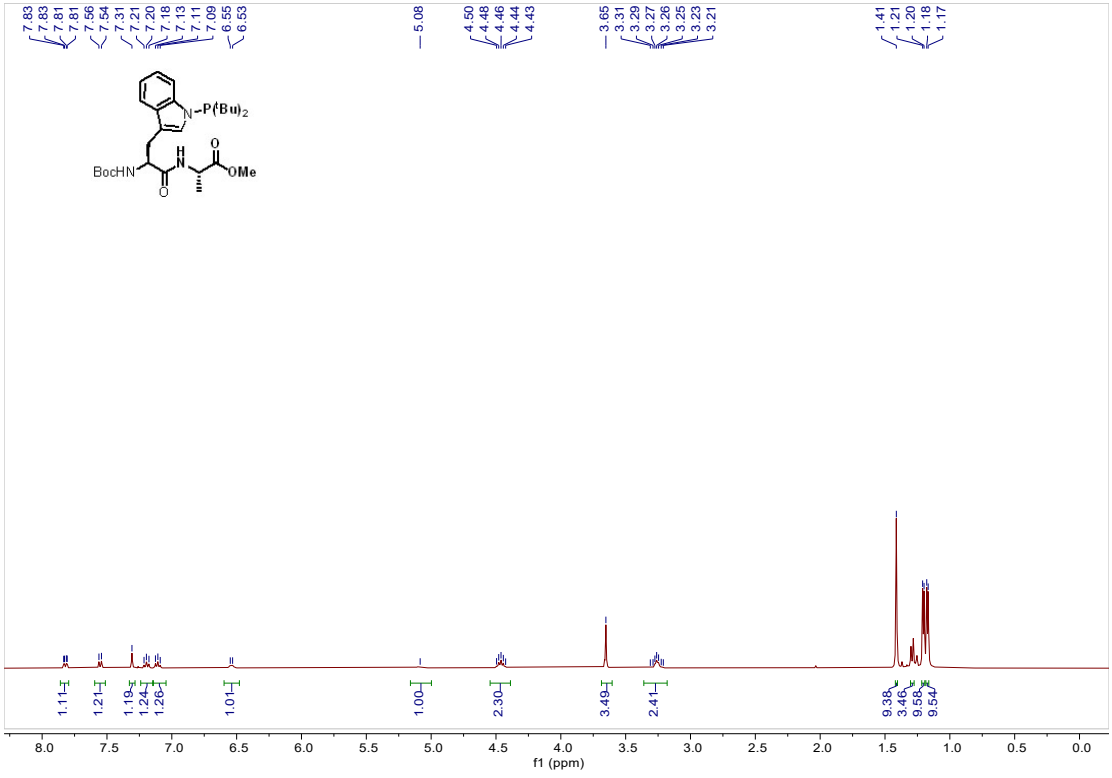
^{1}H NMR (400 MHz, $CDCl_3$) spectrum of **3ay**



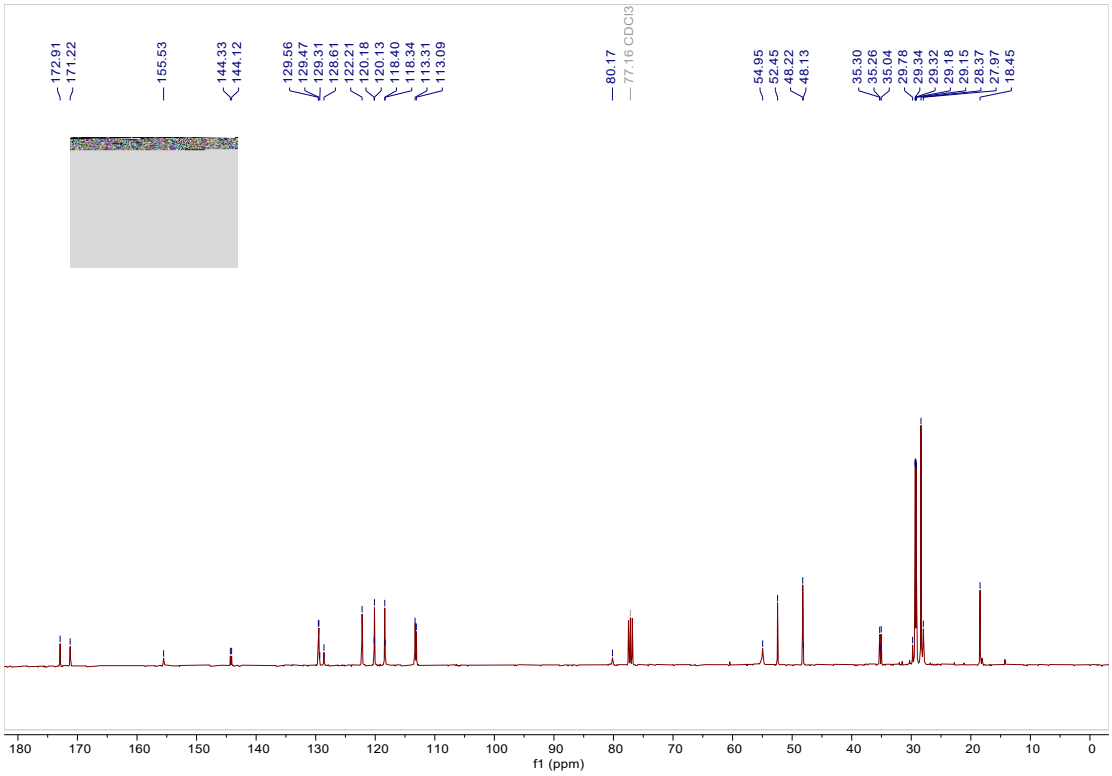
^{13}C NMR (101 MHz, $CDCl_3$) spectrum of **3ay**



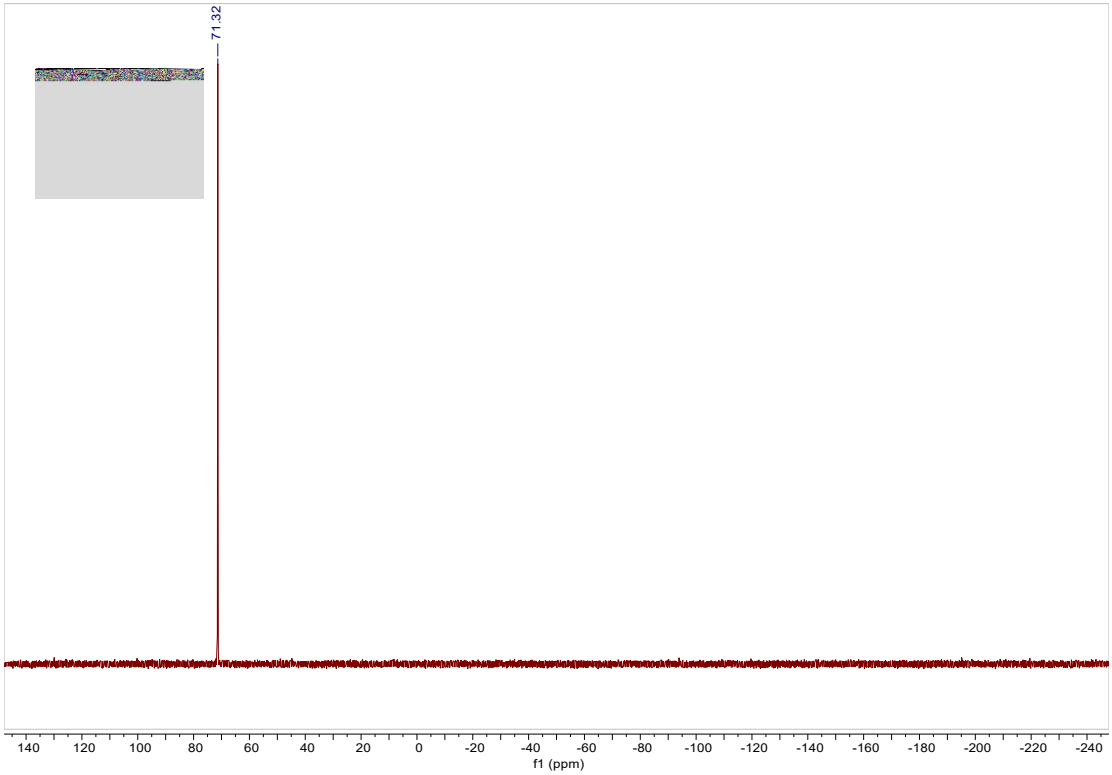
^{31}P NMR (162 MHz, $CDCl_3$) of **3ay**



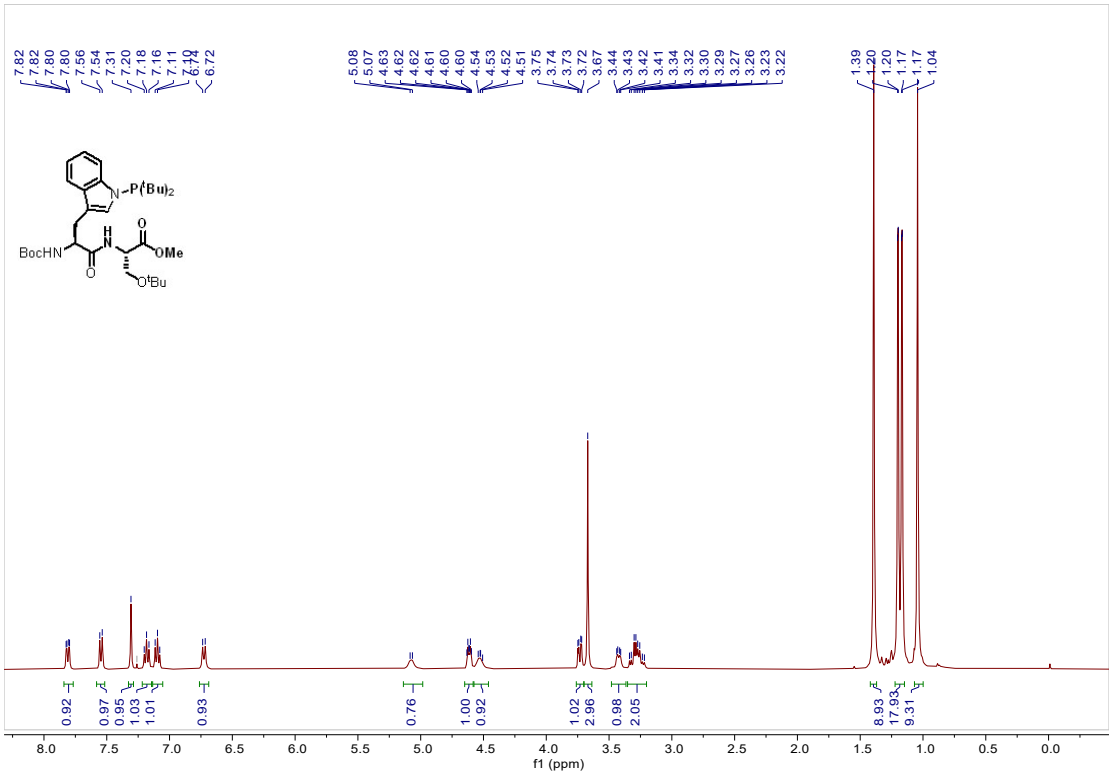
^{1}H NMR (400 MHz, $CDCl_3$) spectrum of **1a**



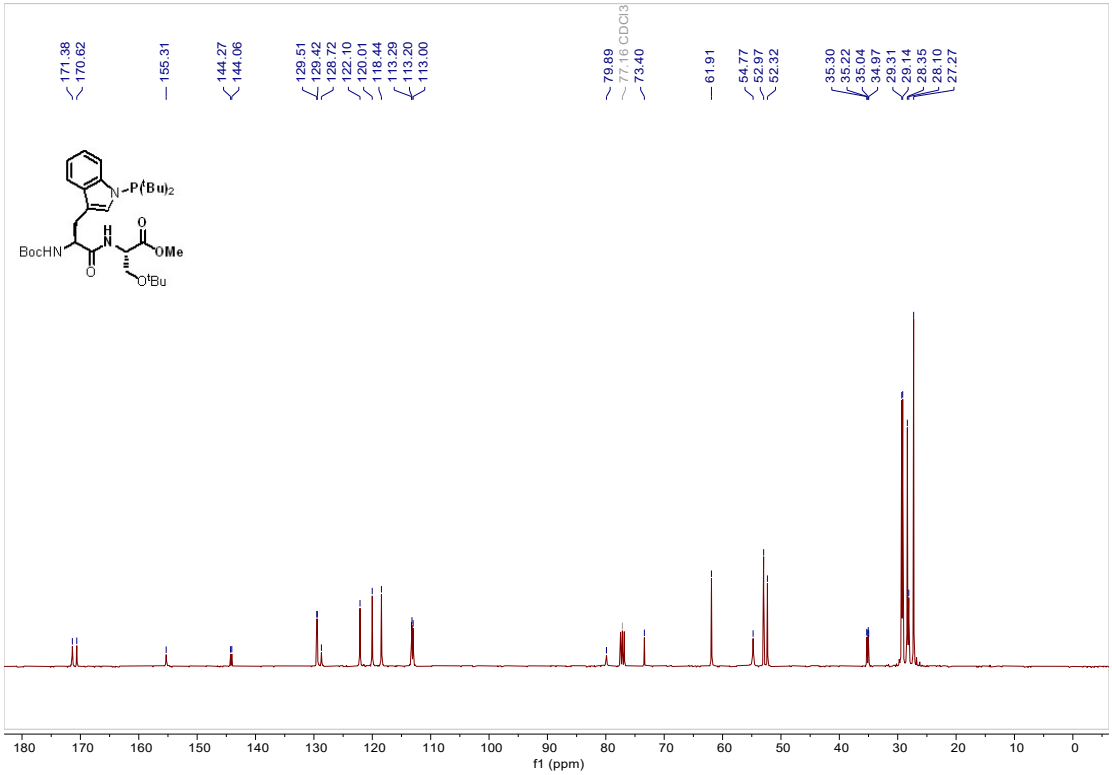
^{13}C NMR (101 MHz, $CDCl_3$) spectrum of **1a**



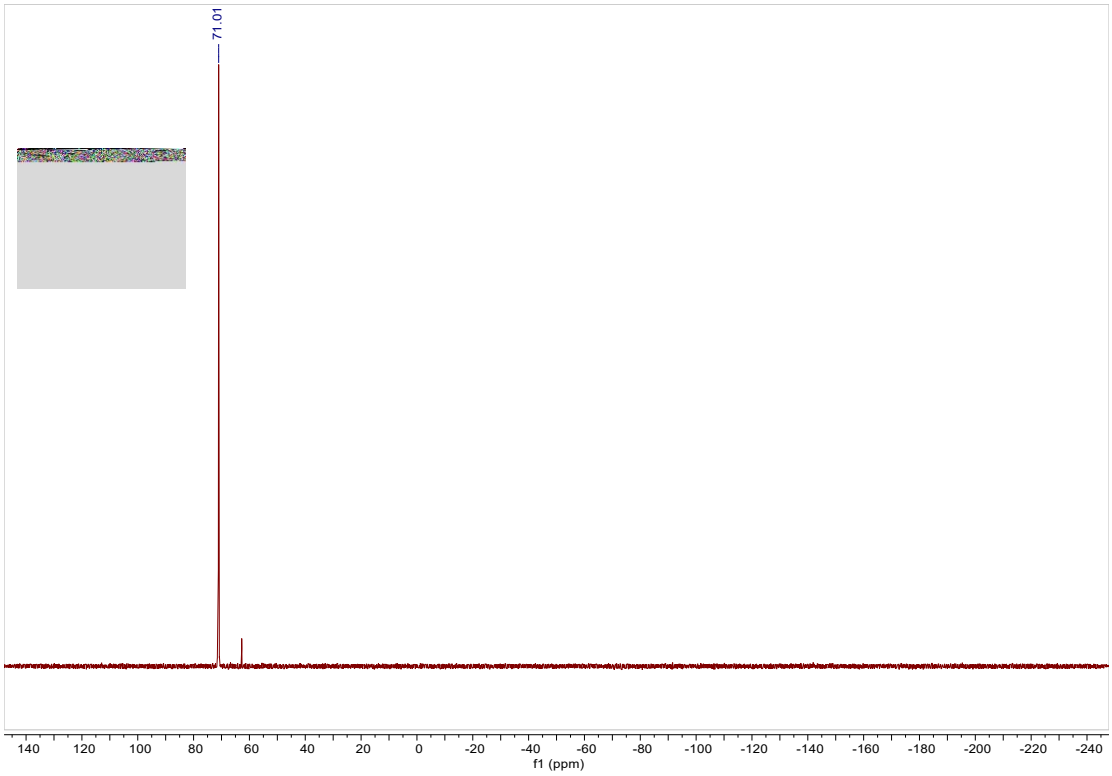
^{31}P NMR (162 MHz, $CDCl_3$) of **1a**



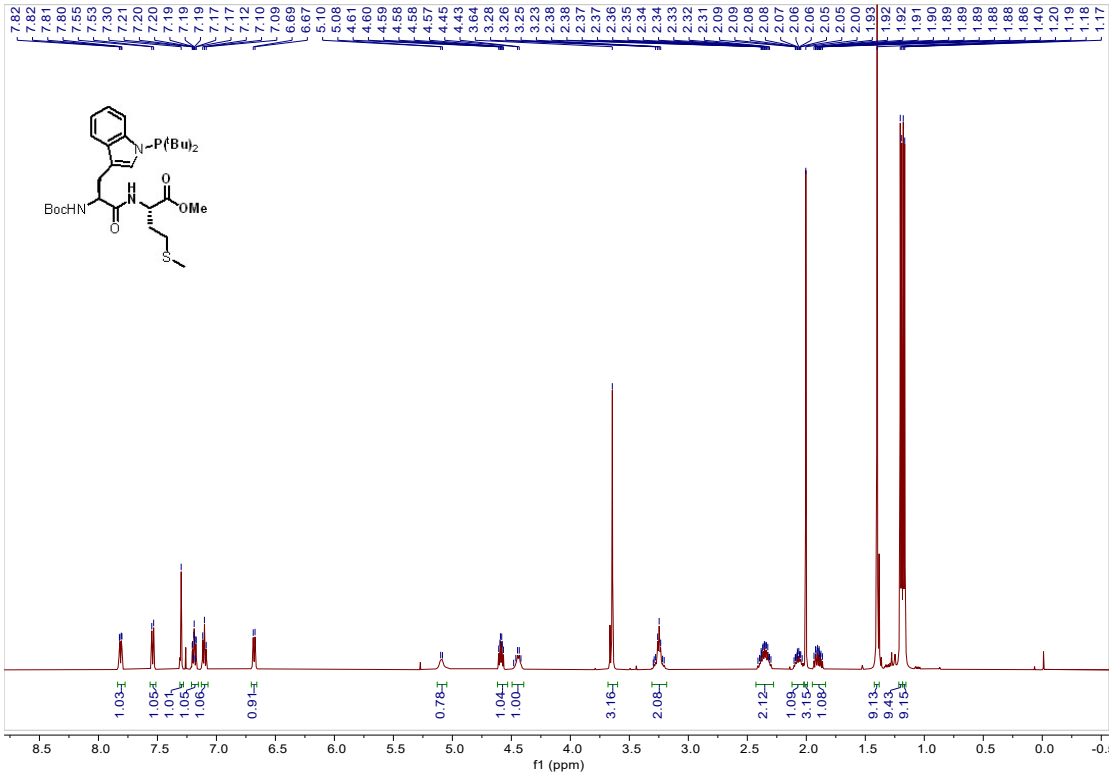
^{1}H NMR (400 MHz, $CDCl_3$) spectrum of **1b**



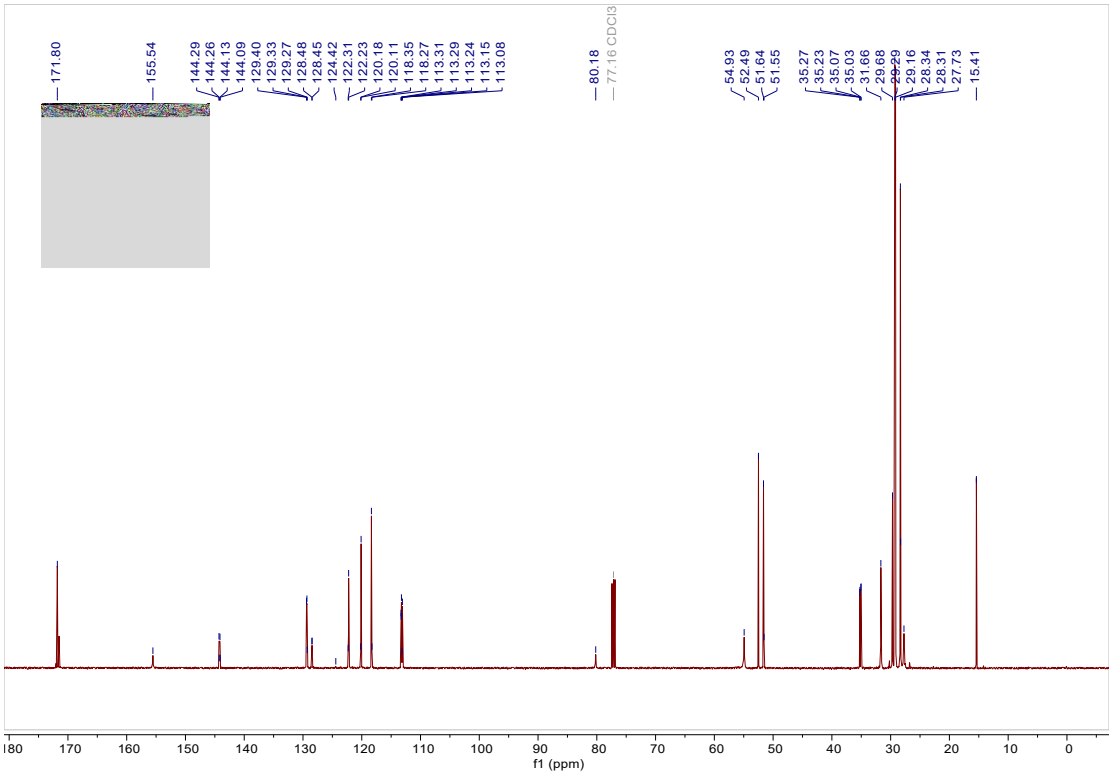
^{13}C NMR (101 MHz, $CDCl_3$) spectrum of **1b**



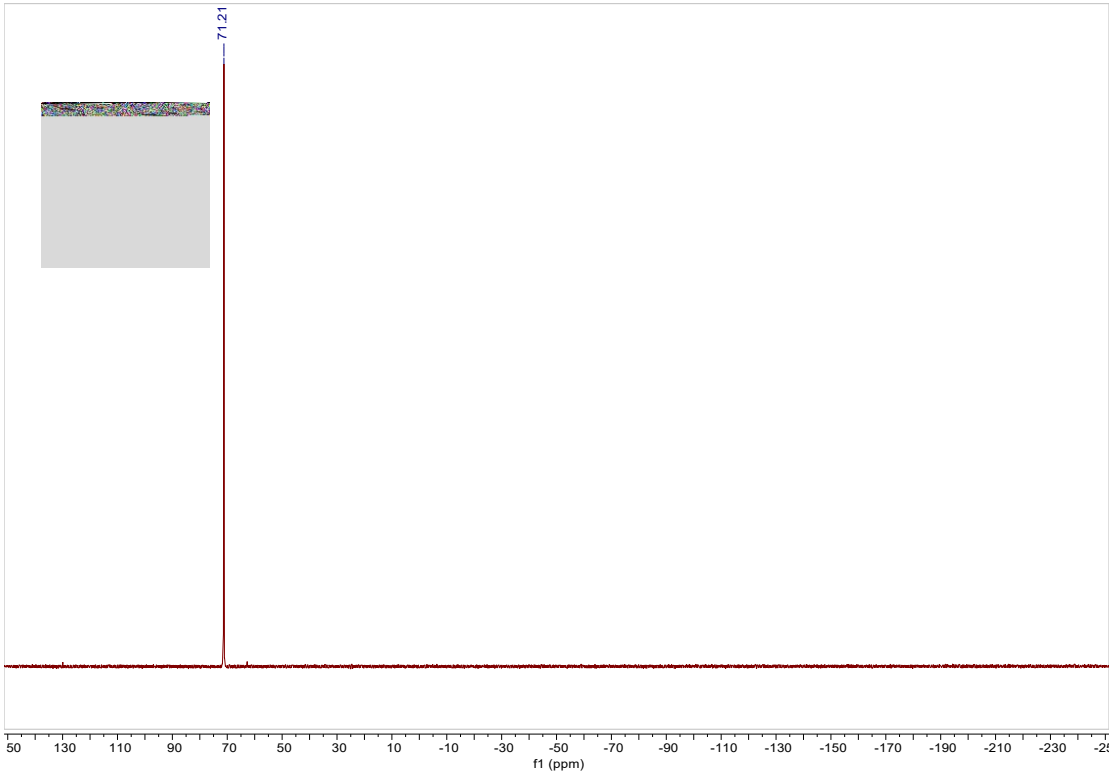
^{31}P NMR (162 MHz, $CDCl_3$) of **1b**



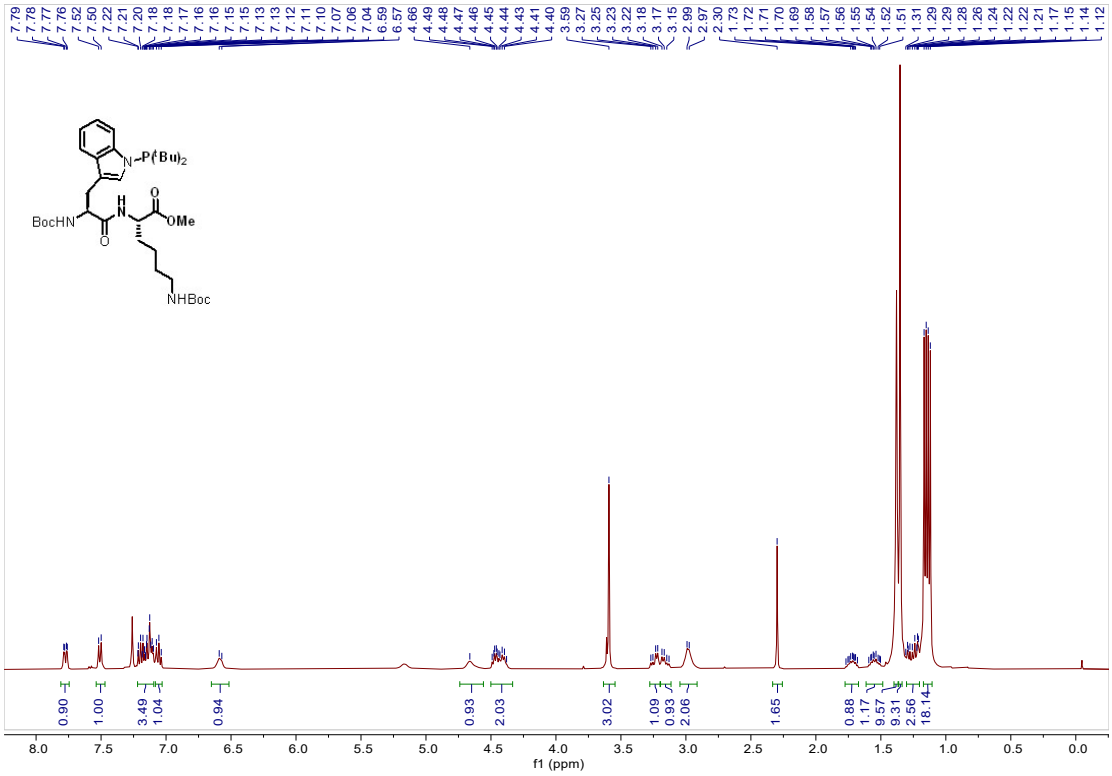
^{1}H NMR (400 MHz, $CDCl_3$) spectrum of **1c**



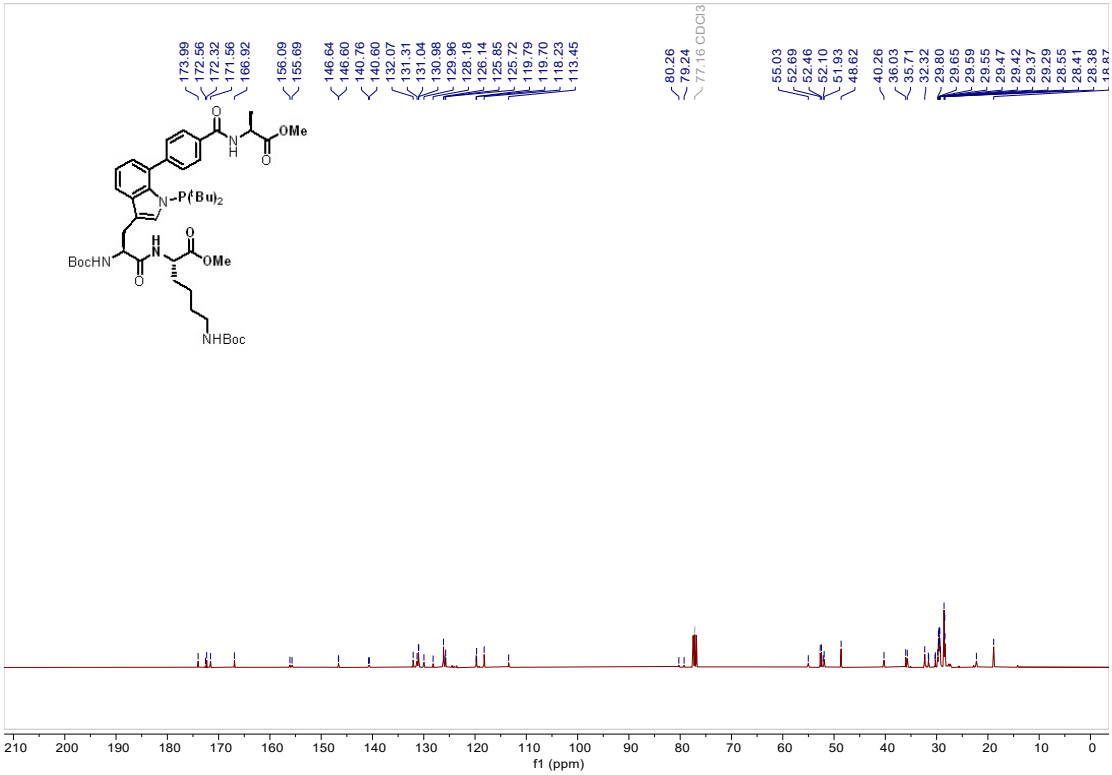
^{13}C NMR (101 MHz, $CDCl_3$) spectrum of **1c**



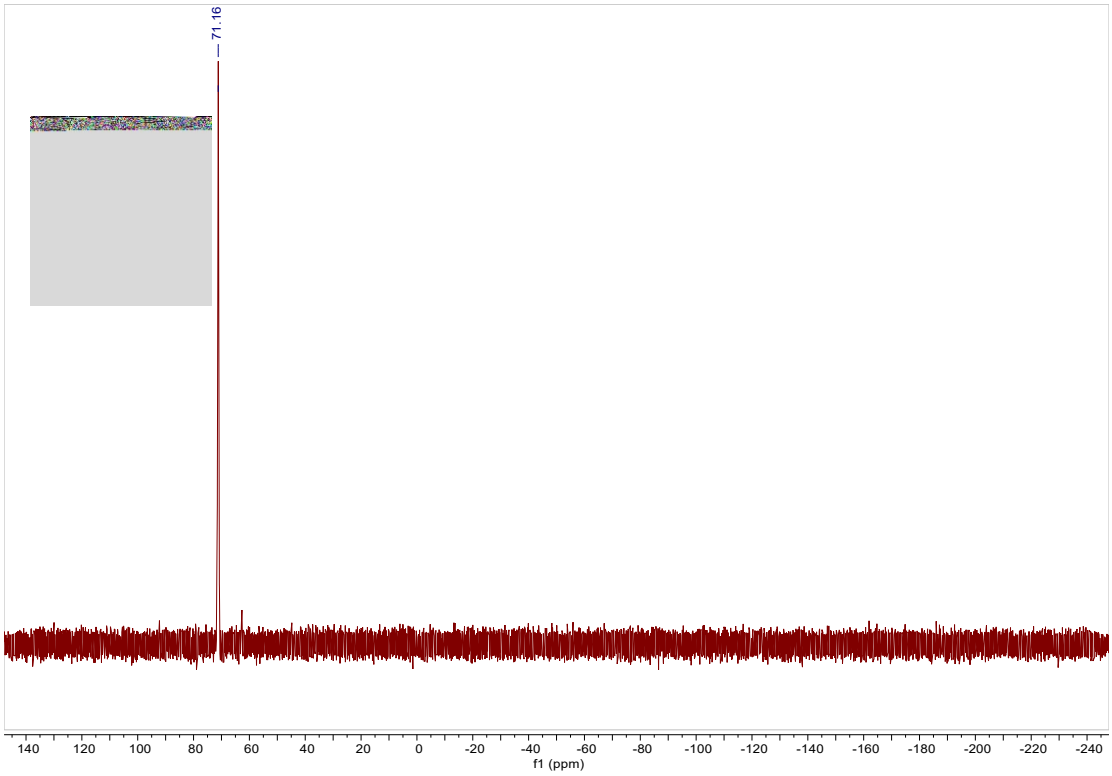
^{31}P NMR (162 MHz, $CDCl_3$) of **1c**



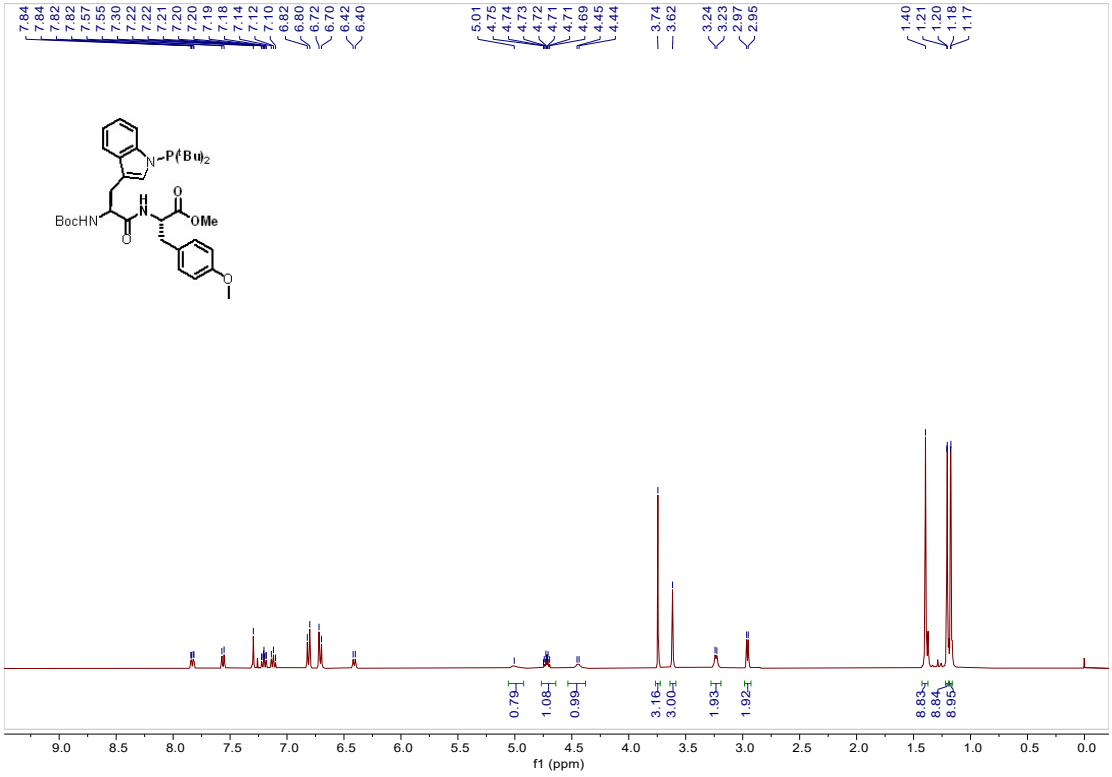
^{1}H NMR (400 MHz, $CDCl_3$) spectrum of **1d**



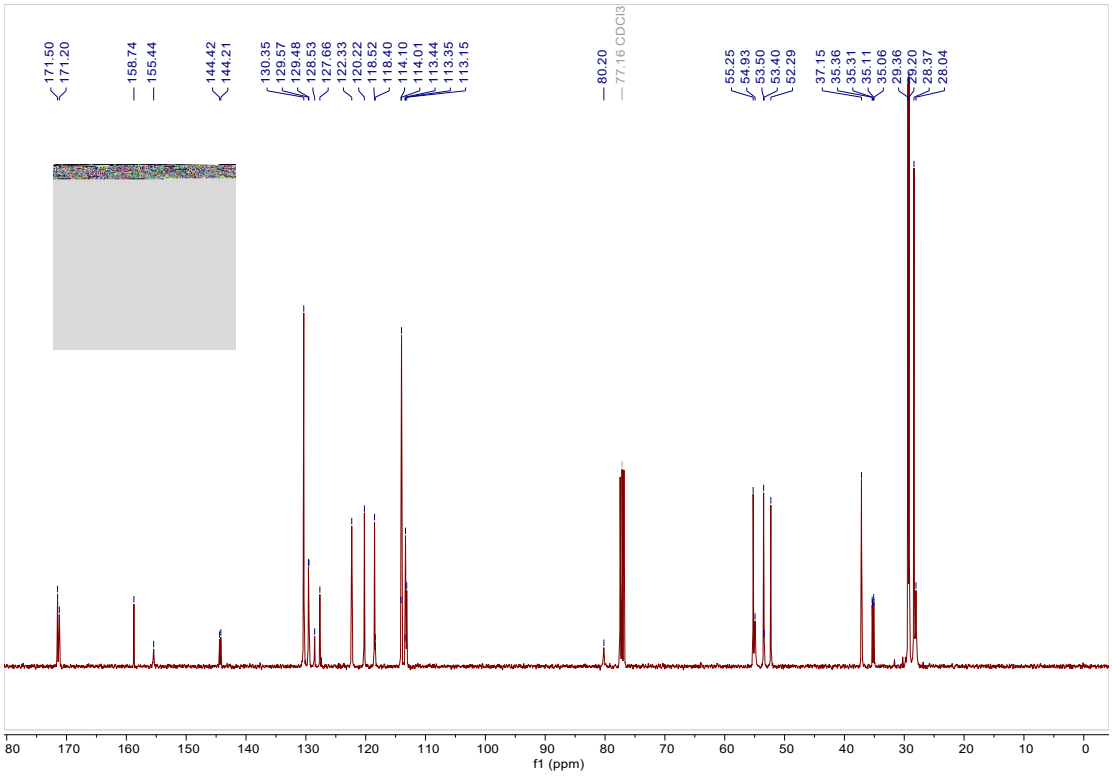
^{13}C NMR (101 MHz, $CDCl_3$) spectrum of **1d**



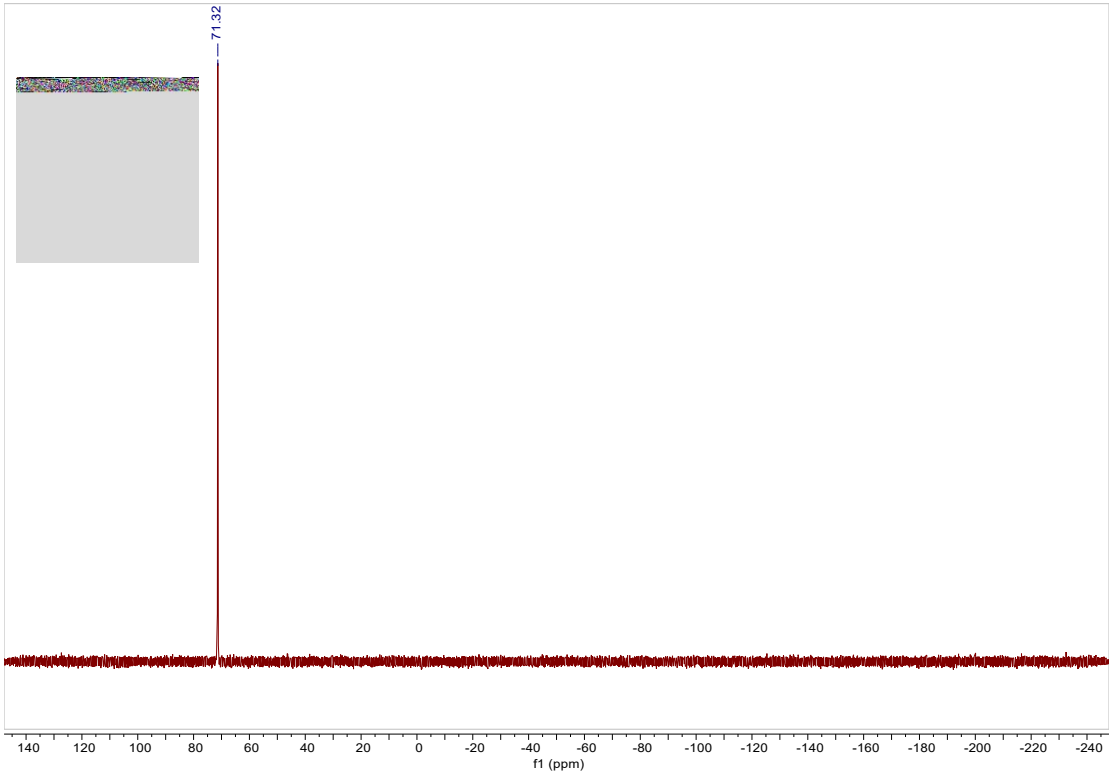
^{31}P NMR (162 MHz, $CDCl_3$) of **1d**



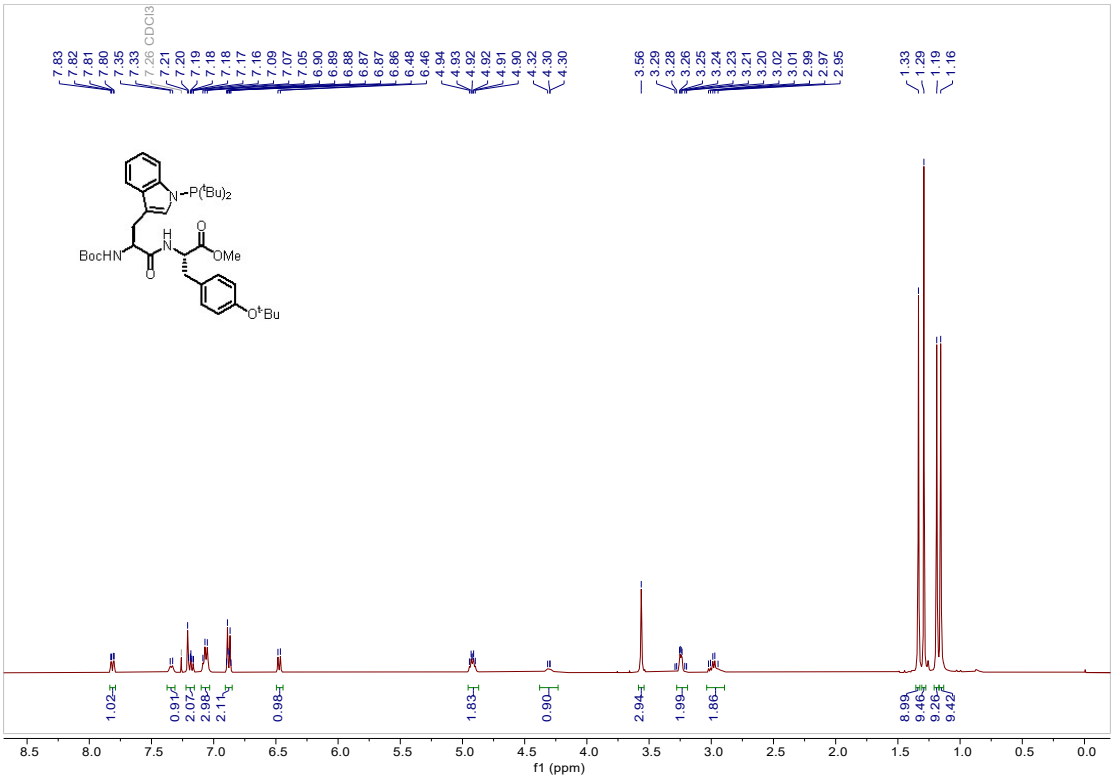
^{1}H NMR (400 MHz, $CDCl_3$) spectrum of **1e**



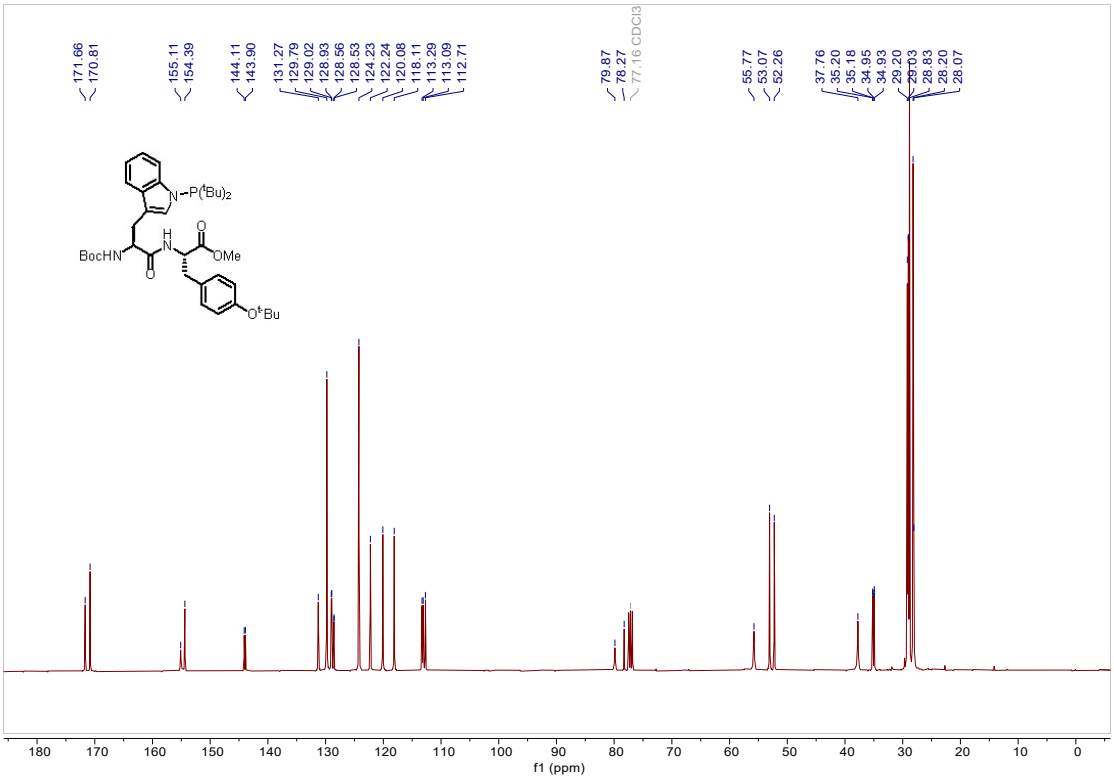
^{13}C NMR (101 MHz, $CDCl_3$) spectrum of **1e**



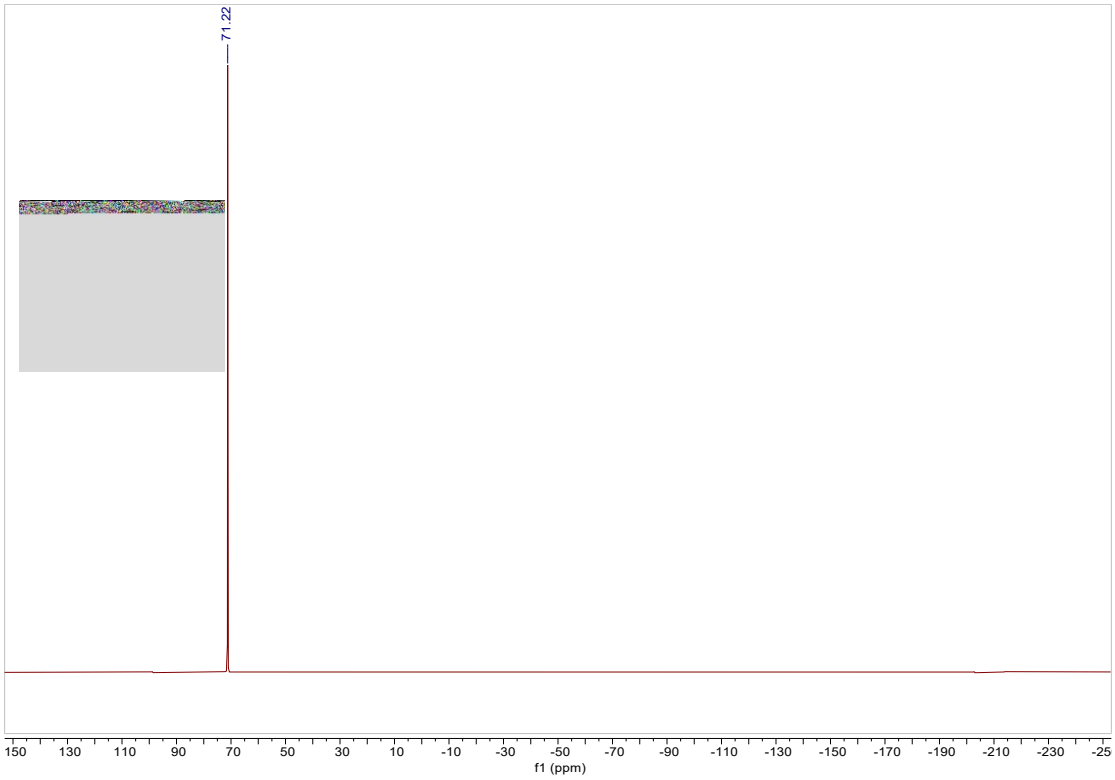
^{31}P NMR (162 MHz, $CDCl_3$) of **1e**



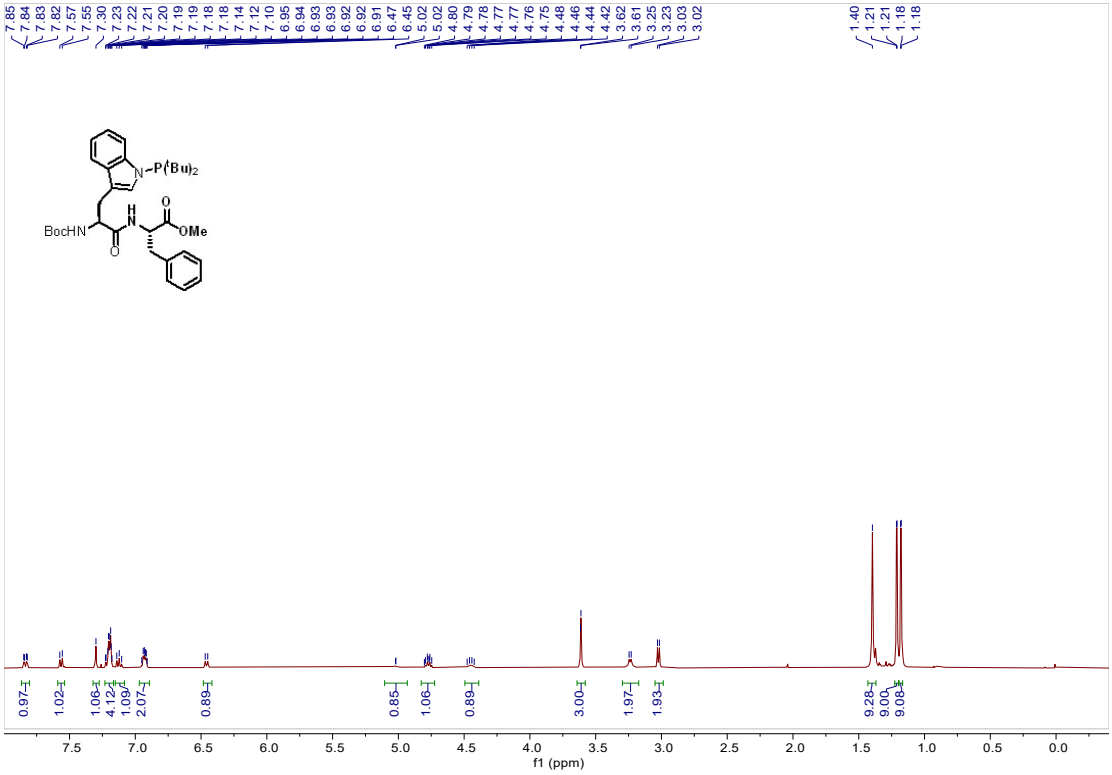
^{1}H NMR (400 MHz, $CDCl_3$) spectrum of **1e'**



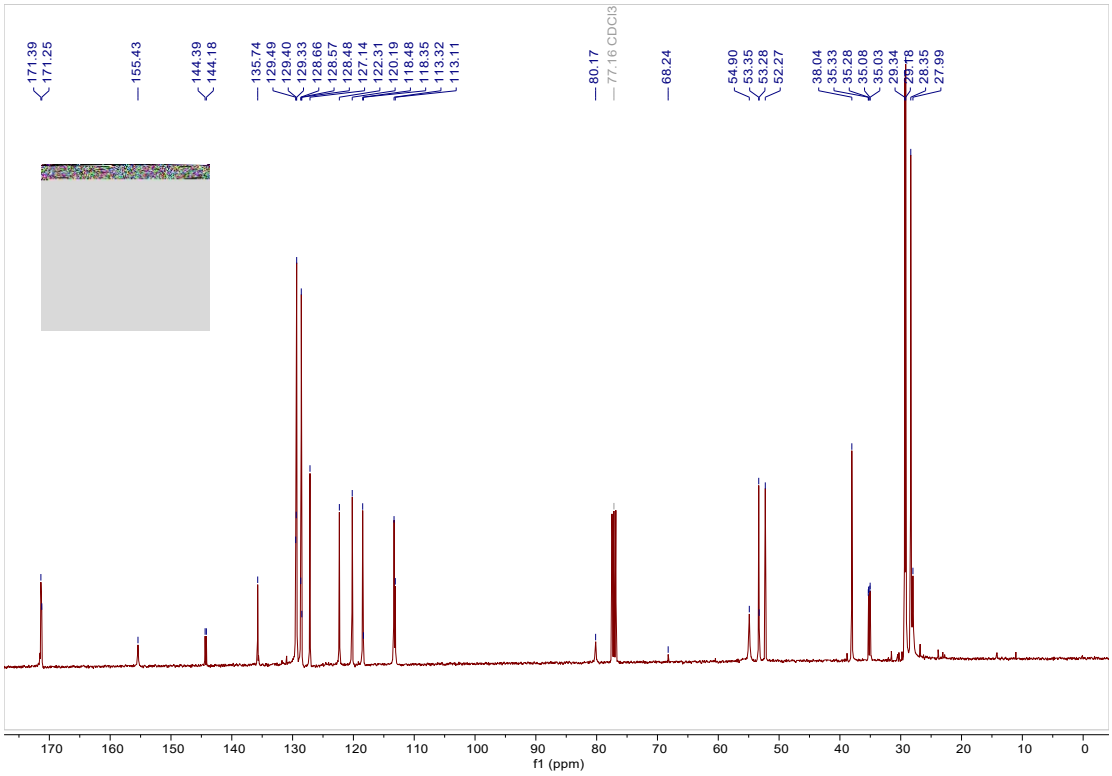
^{13}C NMR (101 MHz, $CDCl_3$) spectrum of **1e'**



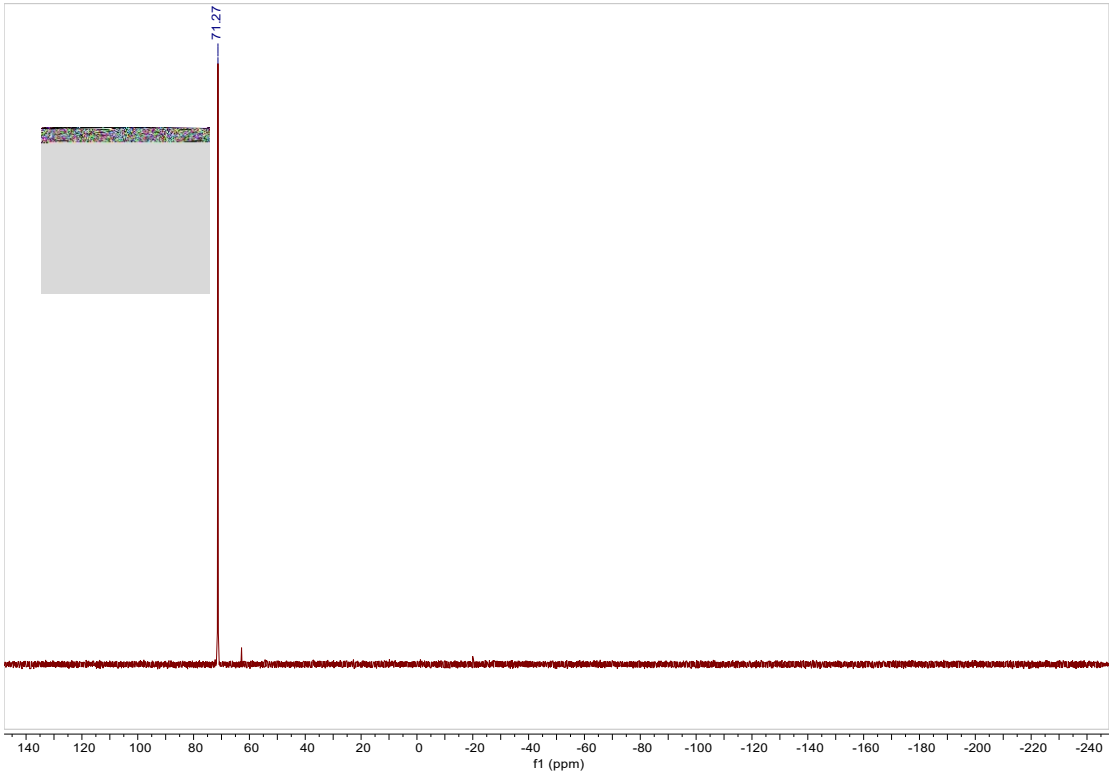
^{31}P NMR (162 MHz, $CDCl_3$) of **1e'**



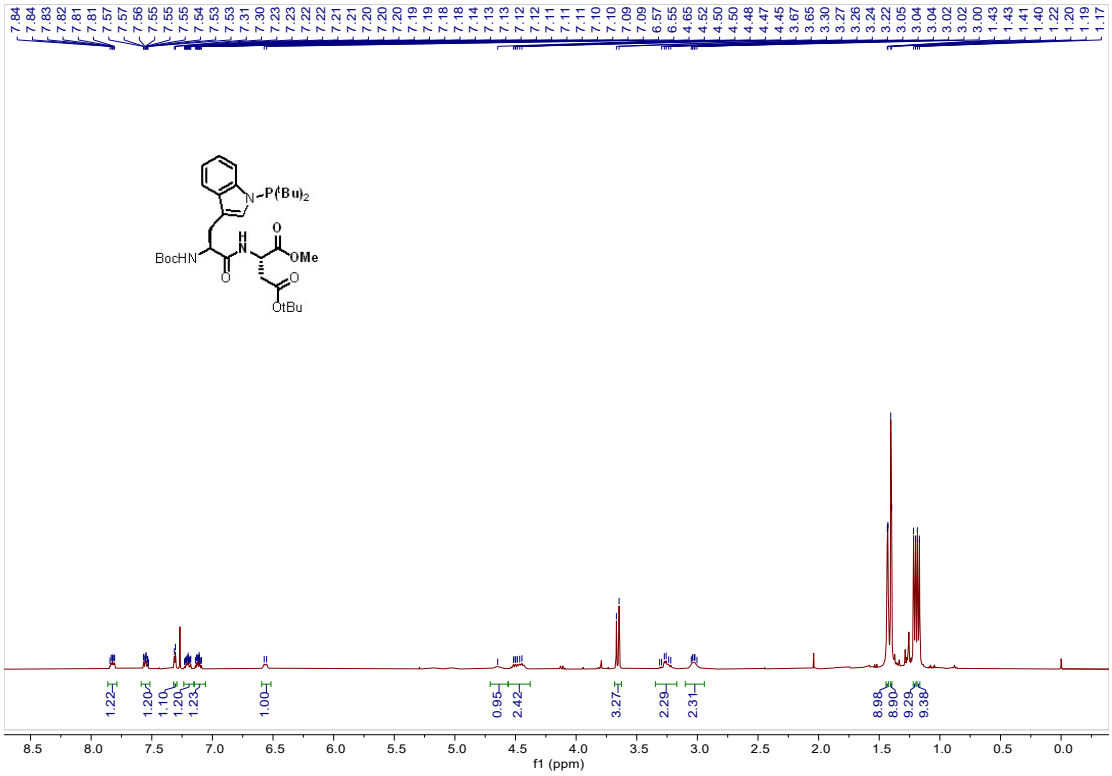
^{1}H NMR (400 MHz, $CDCl_3$) spectrum of **1f**



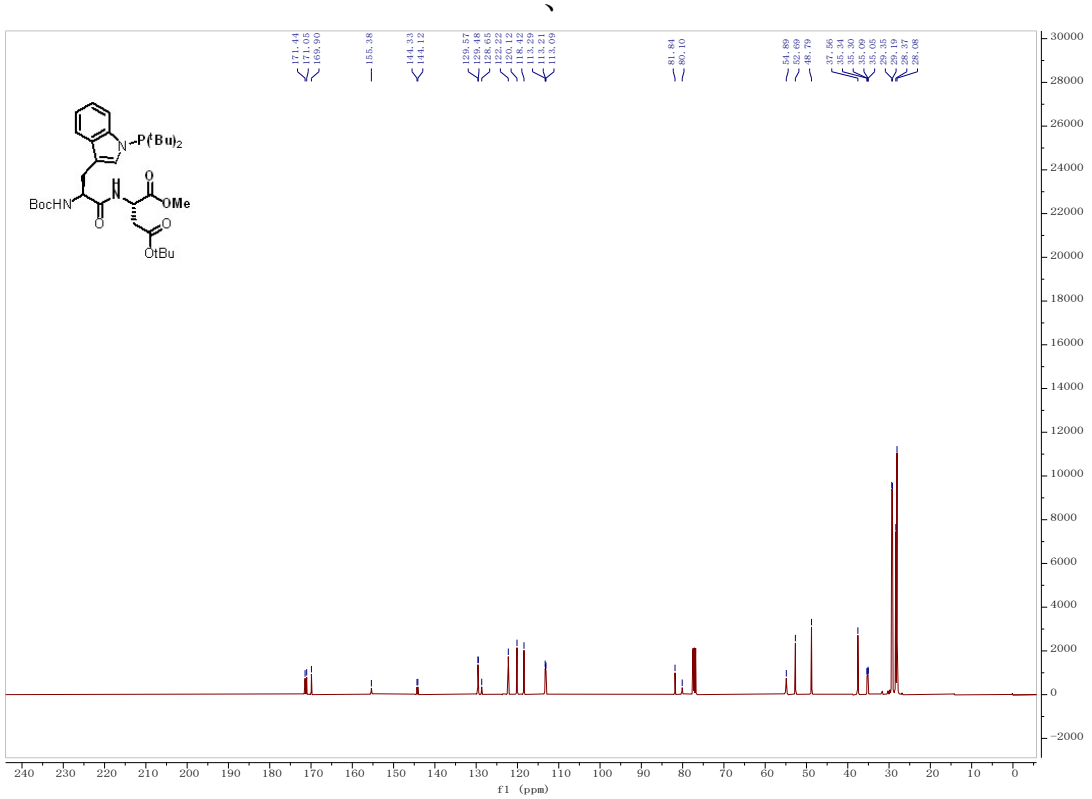
^{13}C NMR (101 MHz, $CDCl_3$) spectrum of **1f**



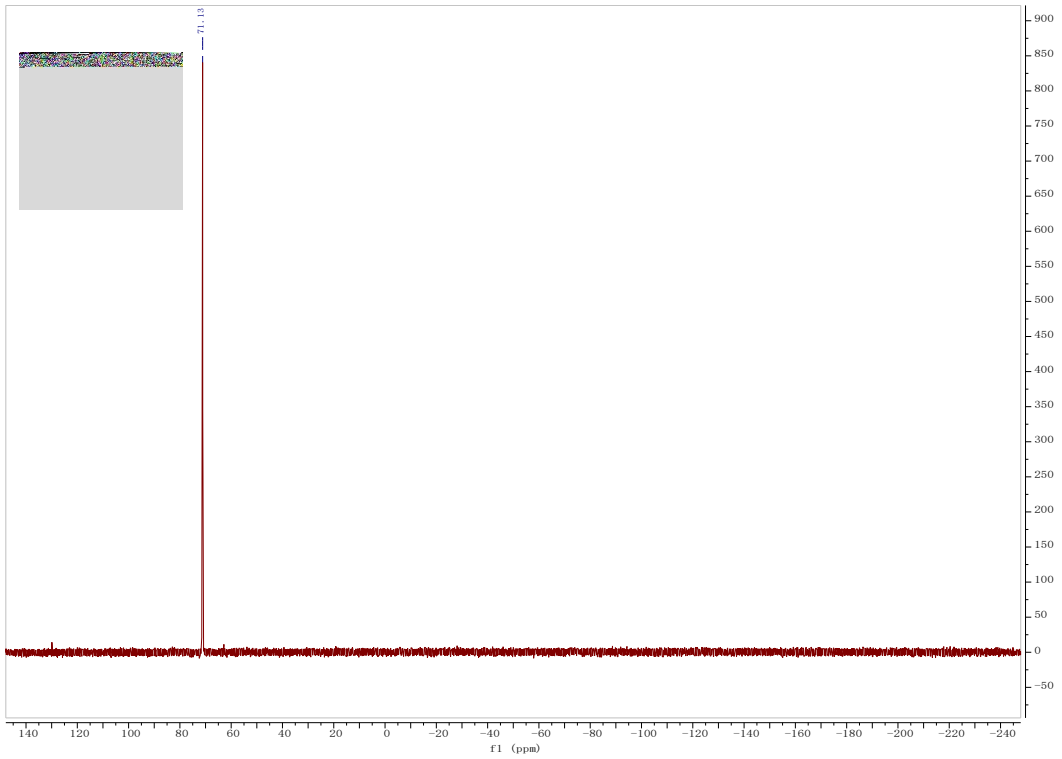
^{31}P NMR (162 MHz, $CDCl_3$) of **1f**



^{1}H NMR (400 MHz, $CDCl_3$) spectrum of **1g**



^{13}C NMR (101 MHz, $CDCl_3$) spectrum of **1g**



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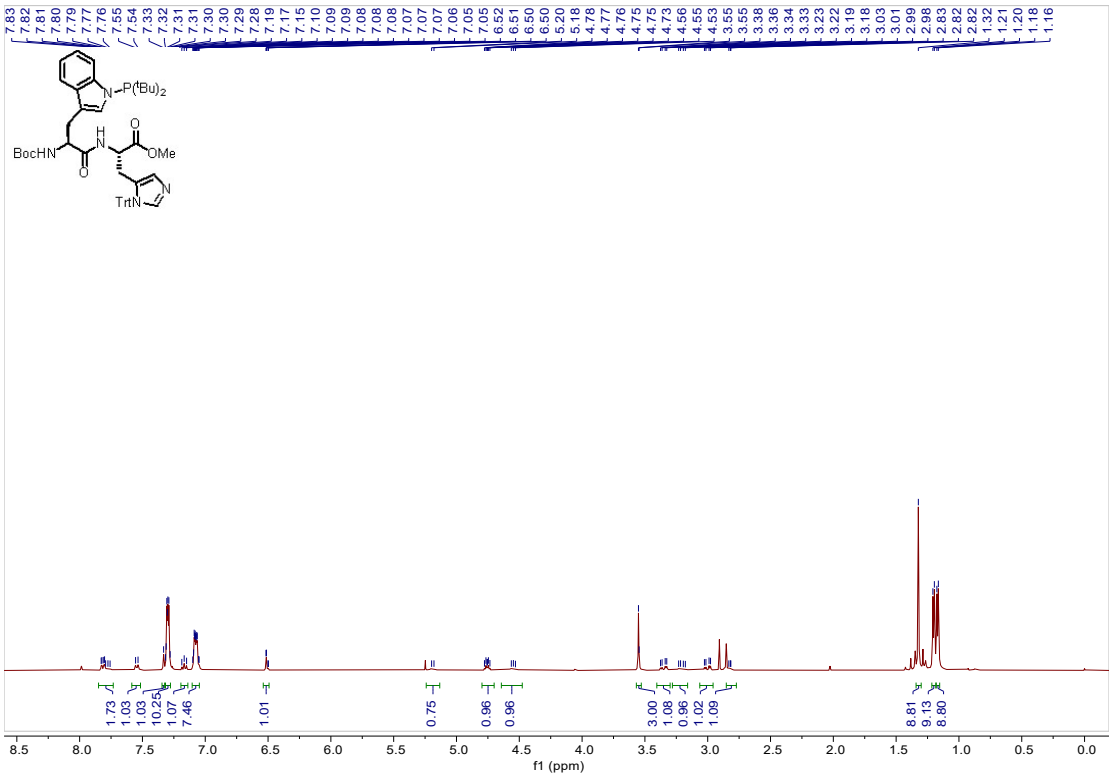
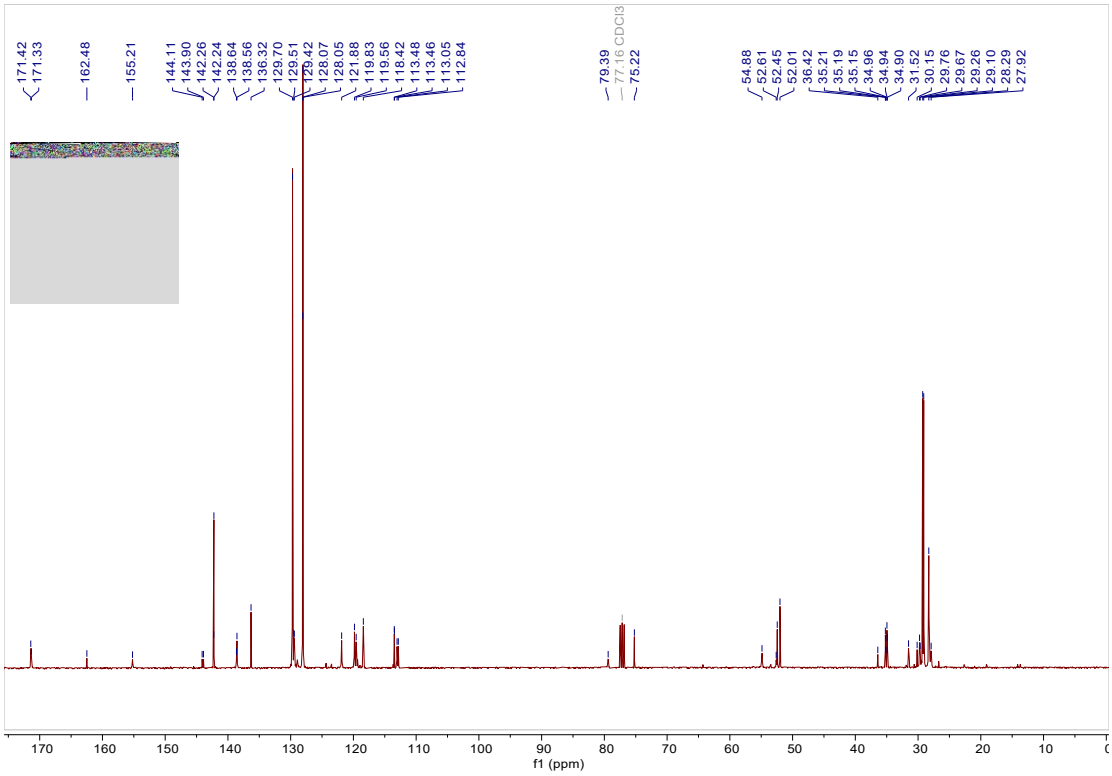
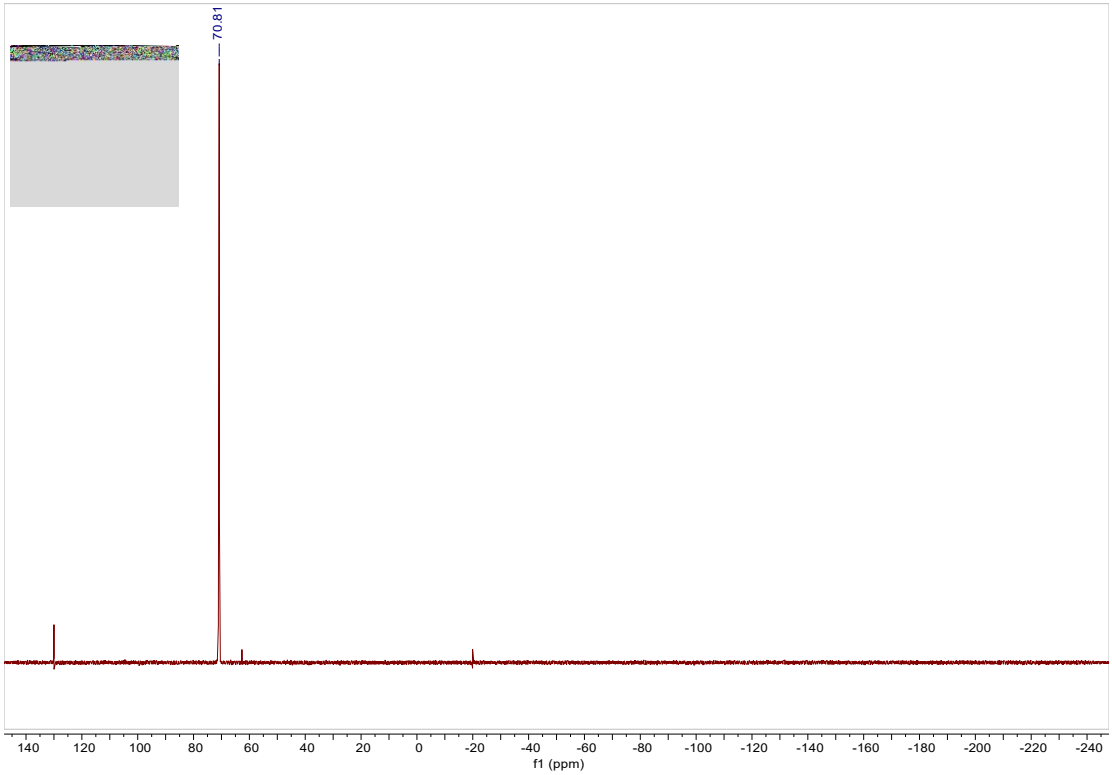
^{1}P NMR (162 MHz, $CDCl_3$) of **1g**



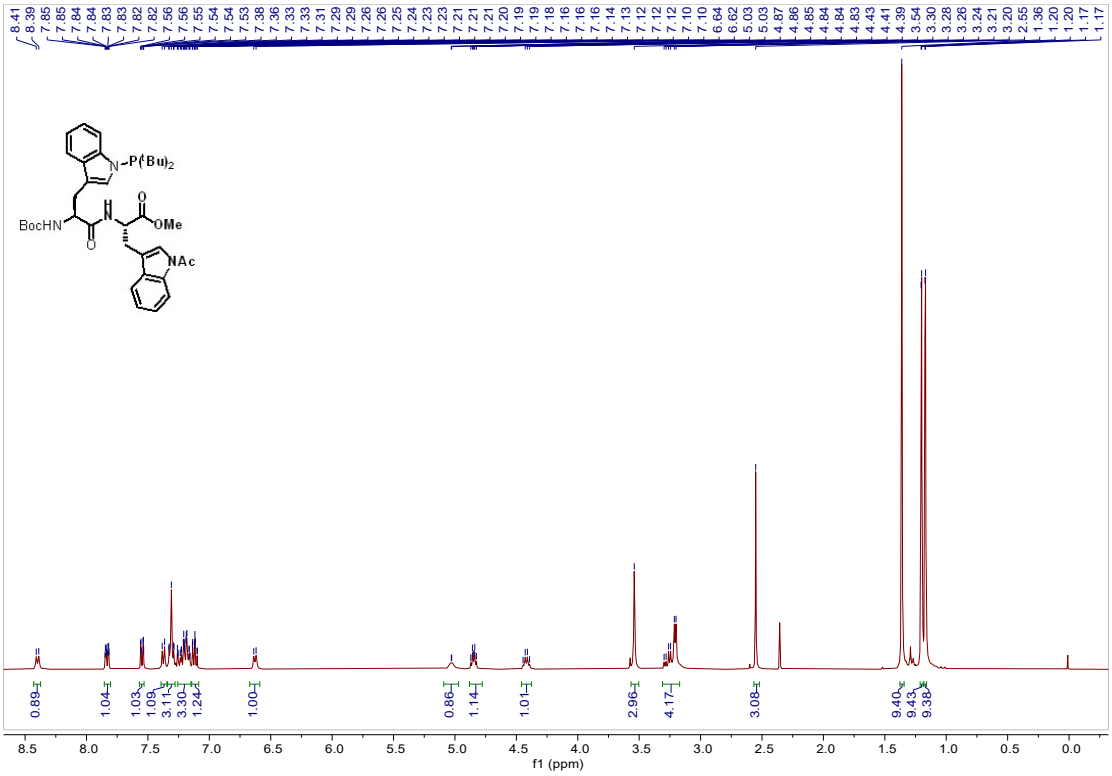
^{1}H NMR (400 MHz, $CDCl_3$) spectrum of **1h**



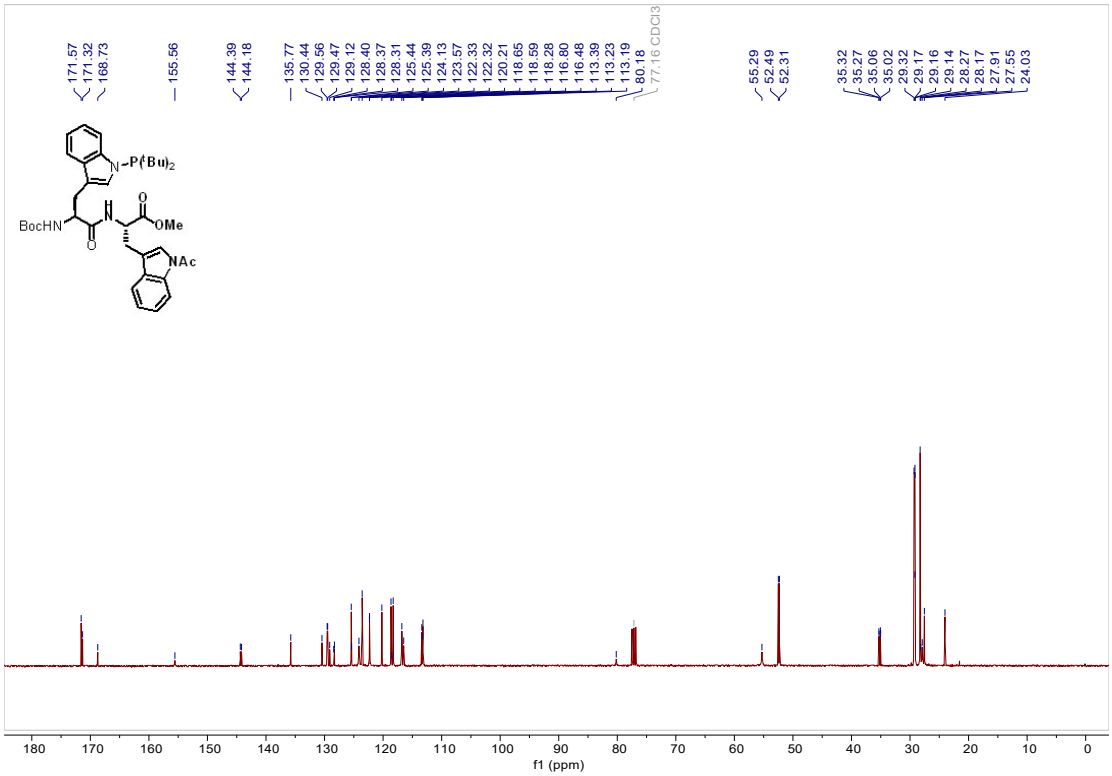
^{13}C NMR (101 MHz, $CDCl_3$) spectrum of **1h**



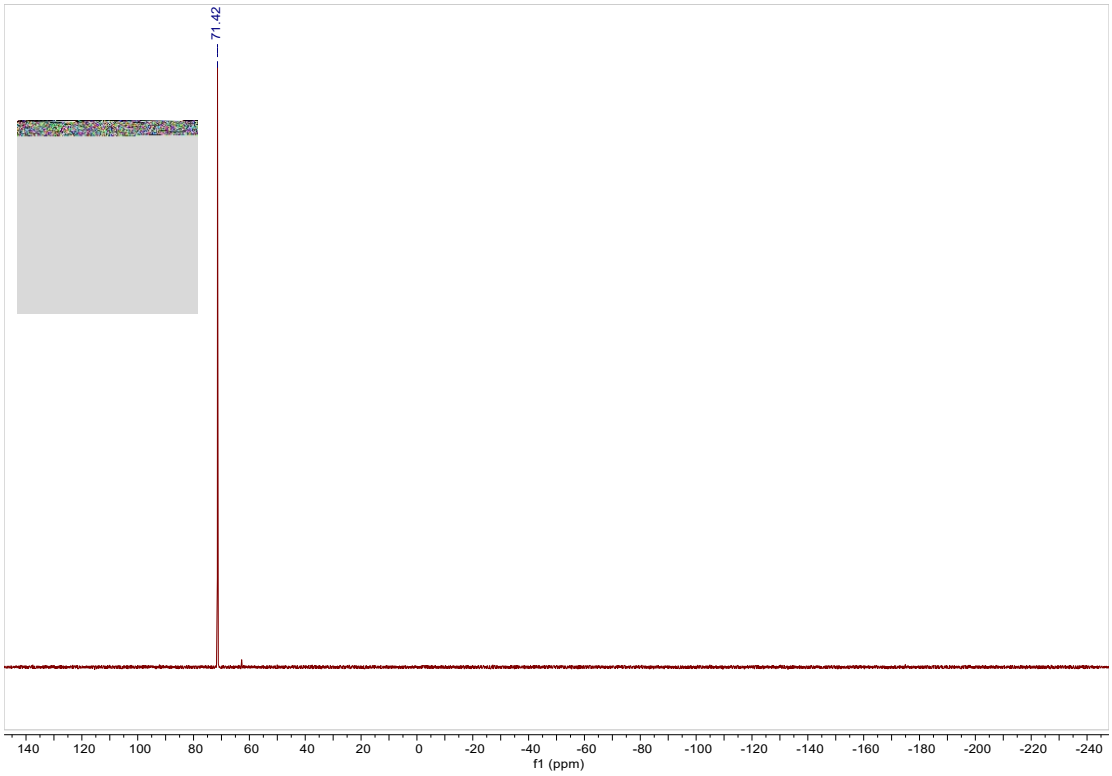
^{31}P NMR (162 MHz, $CDCl_3$) of **1h**



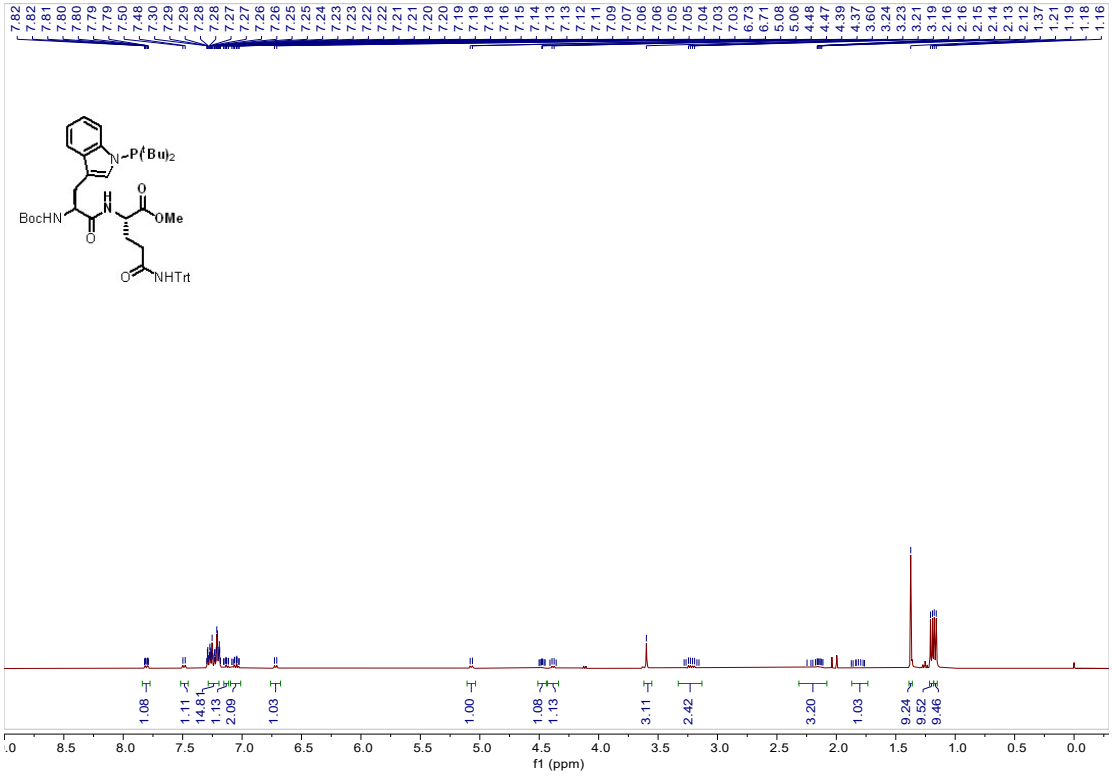
^{1}H NMR (400 MHz, $CDCl_3$) spectrum of **1i**



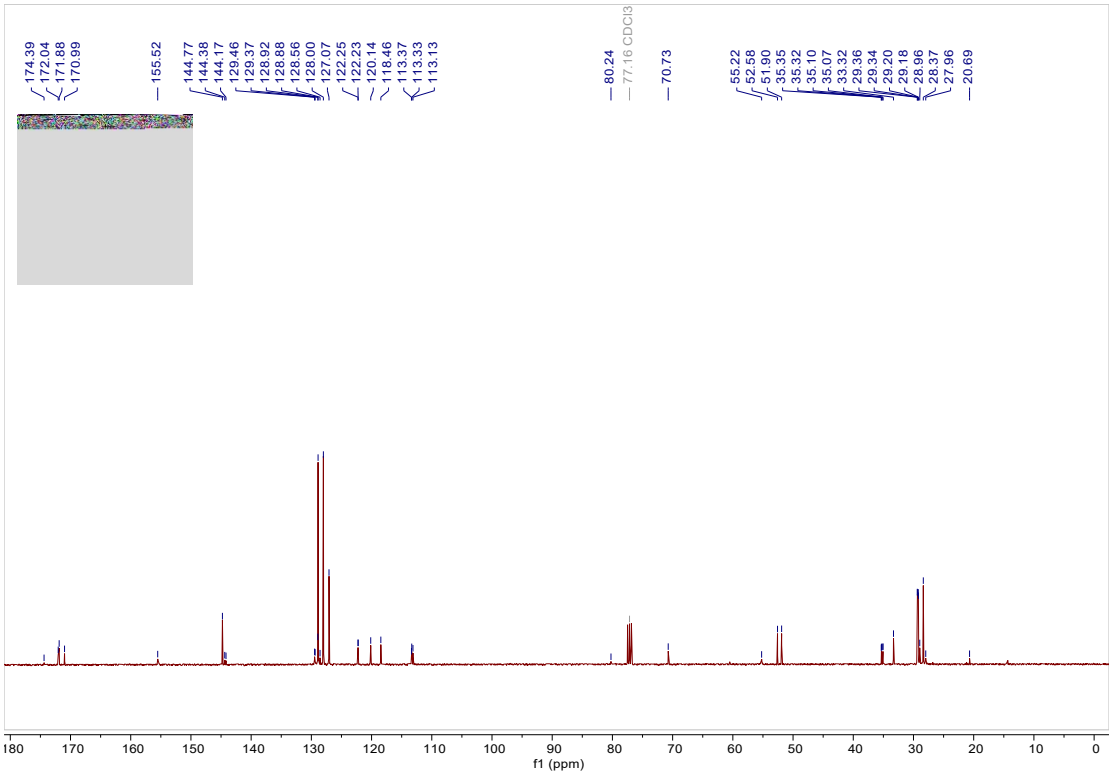
^{13}C NMR (101 MHz, $CDCl_3$) spectrum of **1i**



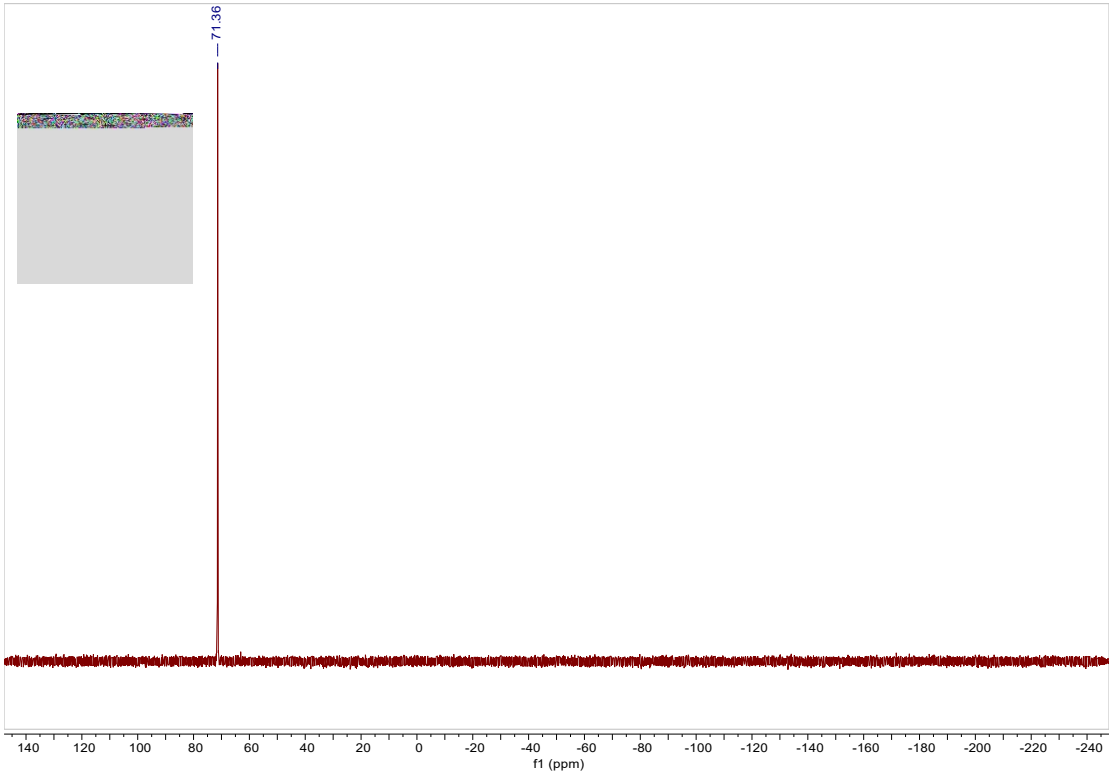
^{31}P NMR (162 MHz, $CDCl_3$) of **1i**



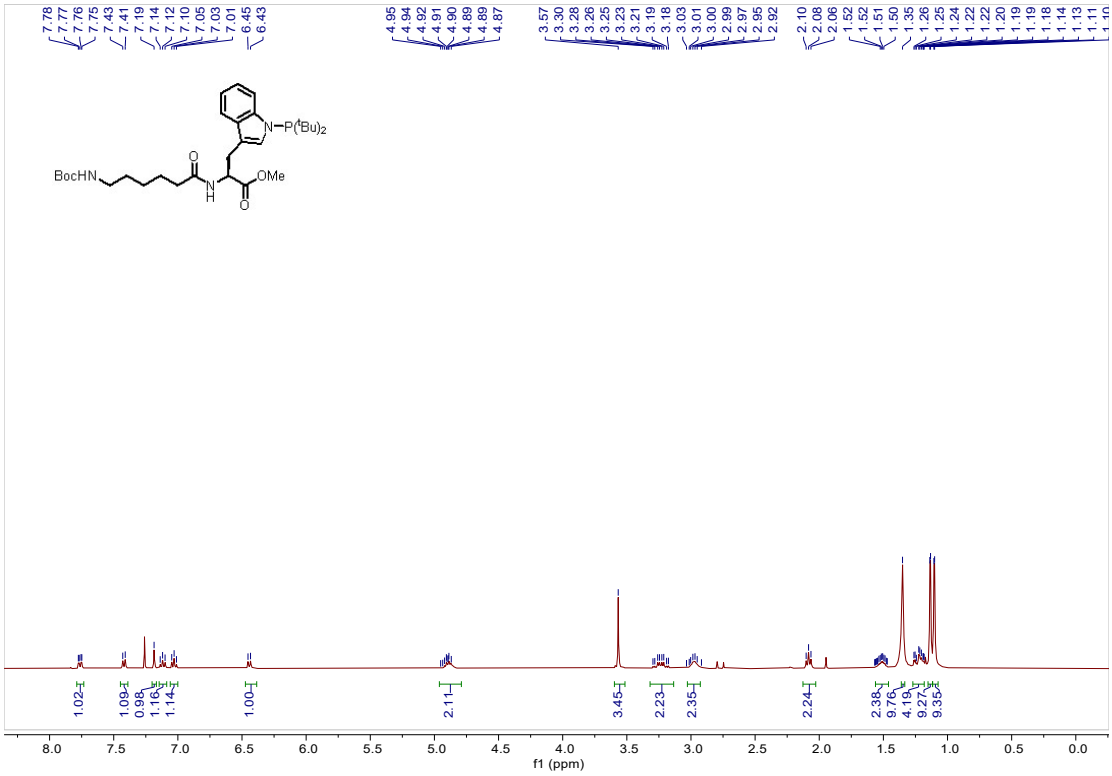
^{1}H NMR (400 MHz, $CDCl_3$) spectrum of **1j**



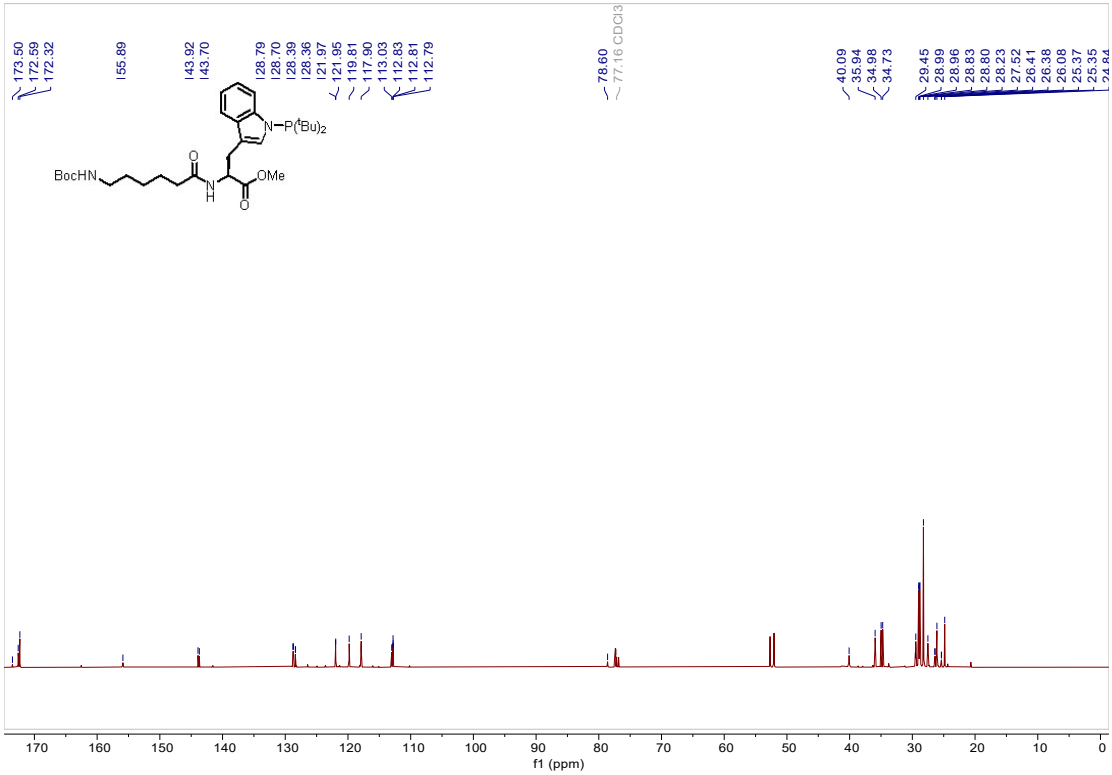
^{13}C NMR (101 MHz, $CDCl_3$) spectrum of **1j**



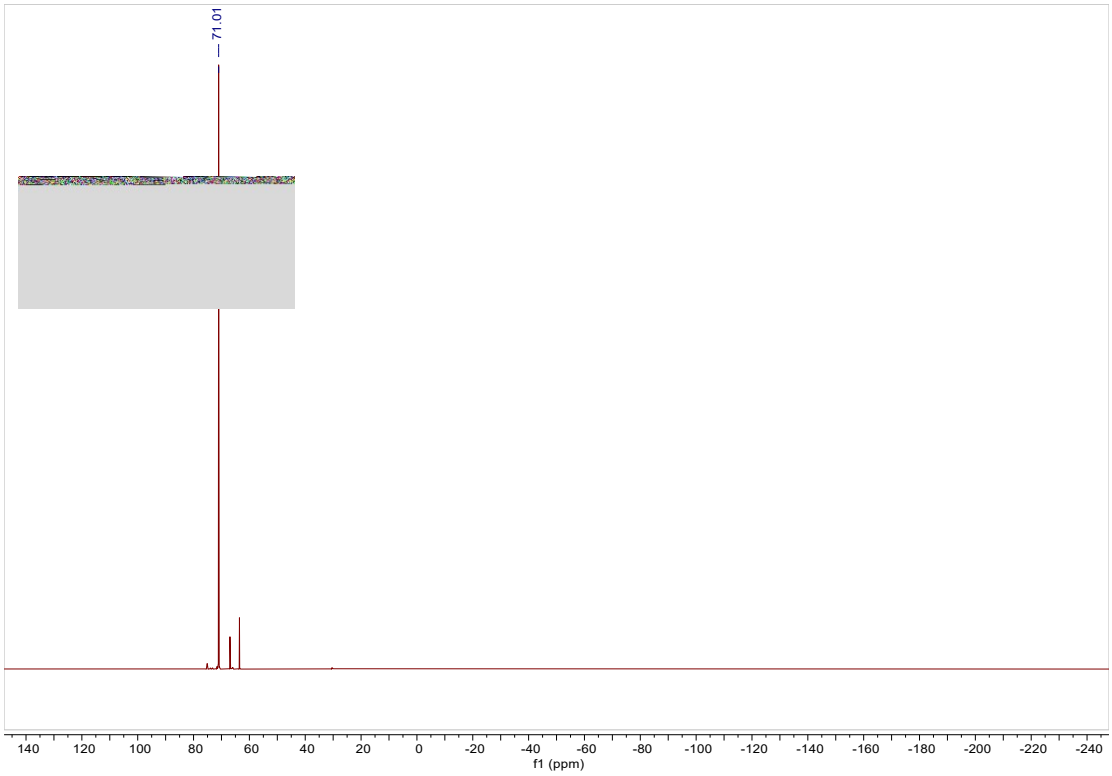
^{31}P NMR (162 MHz, $CDCl_3$) of **1j**



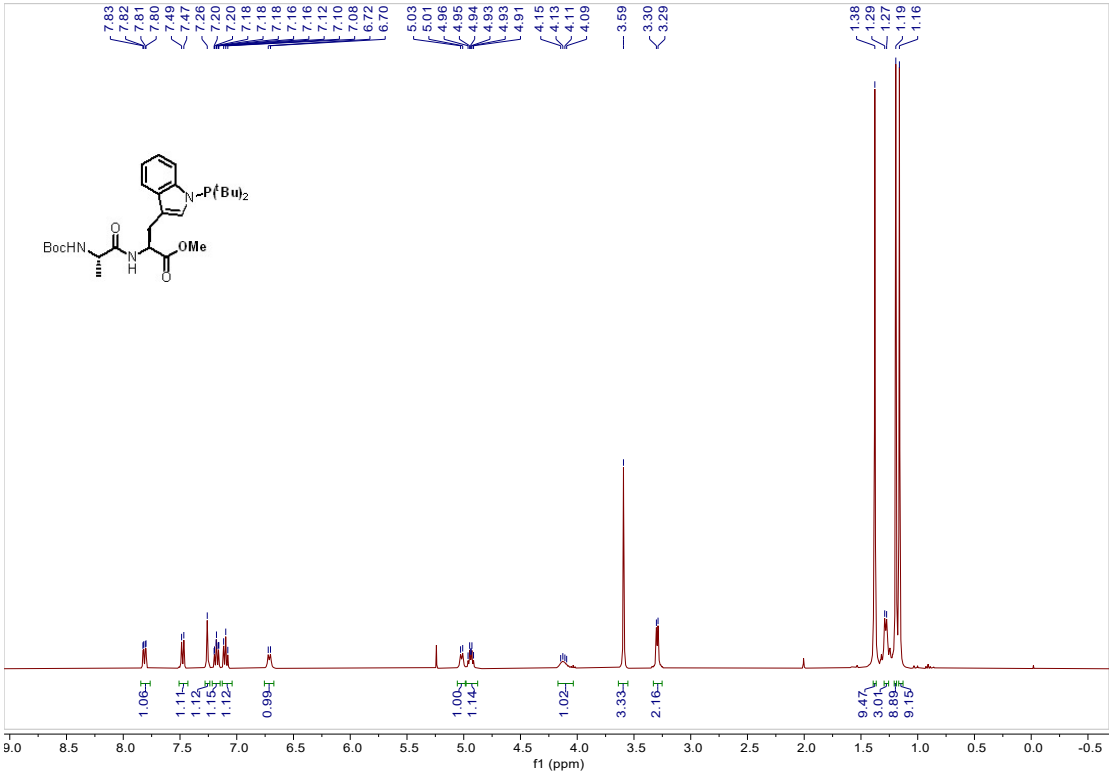
^{1}H NMR (400 MHz, $CDCl_3$) spectrum of **1k**



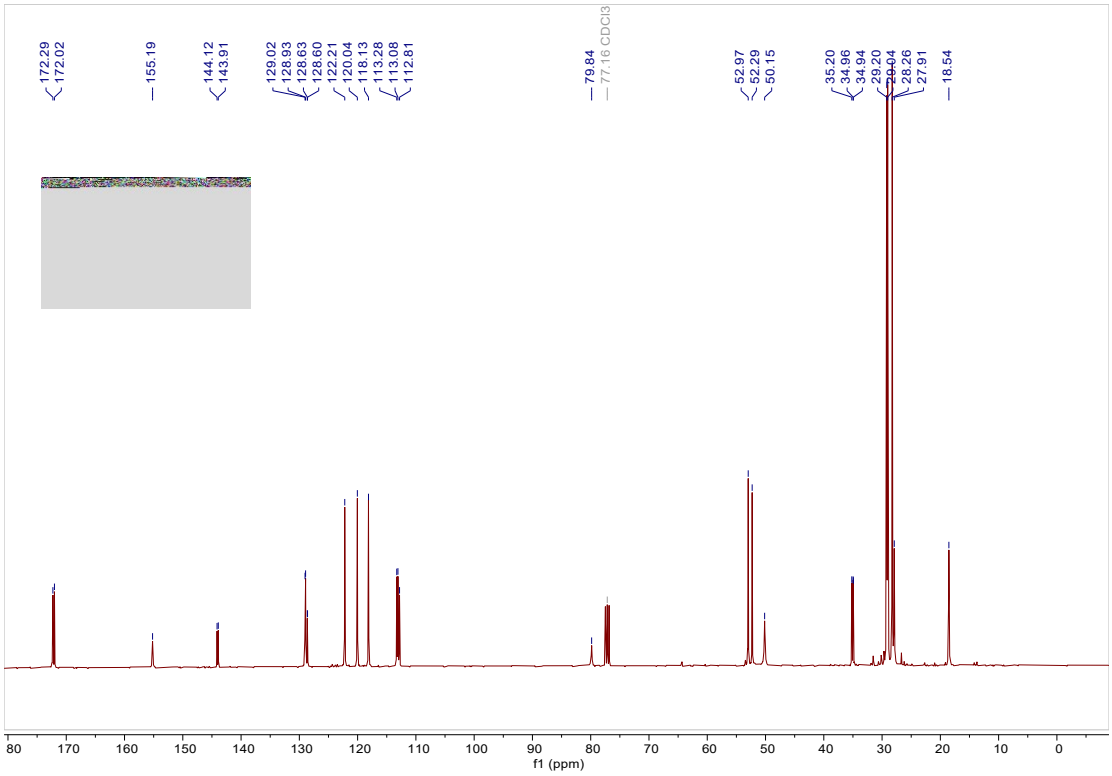
^{13}C NMR (101 MHz, $CDCl_3$) spectrum of **1k**



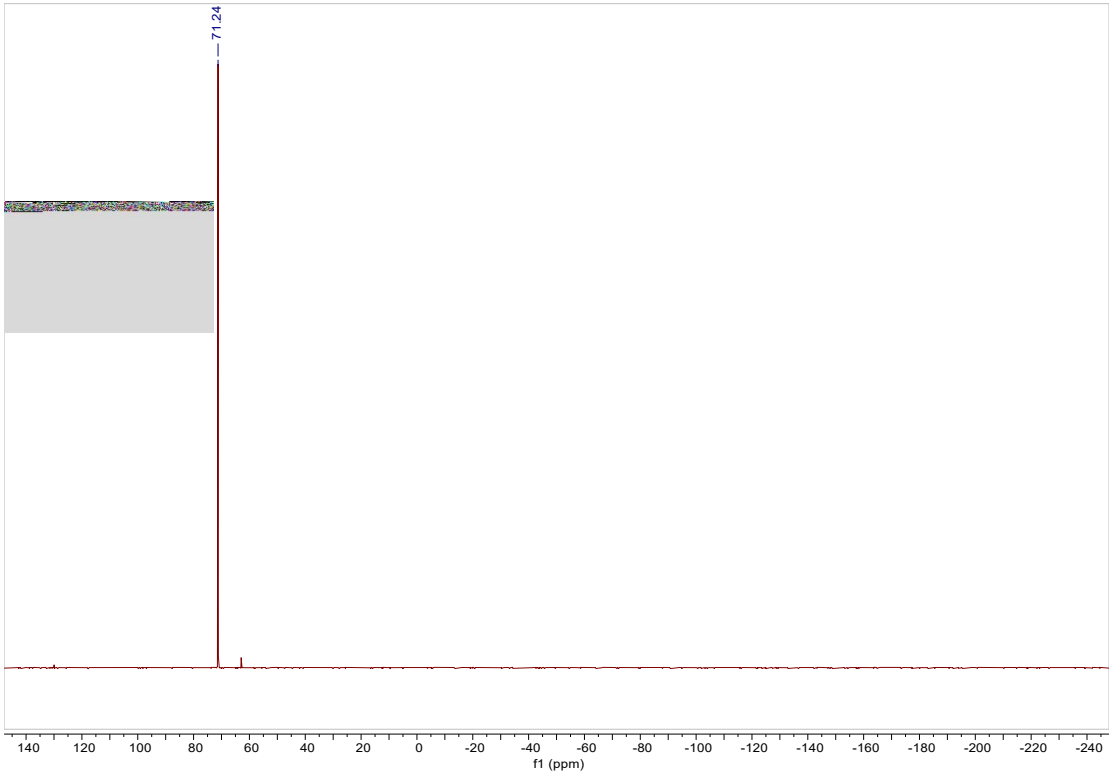
^{31}P NMR (162 MHz, $CDCl_3$) of **1k**



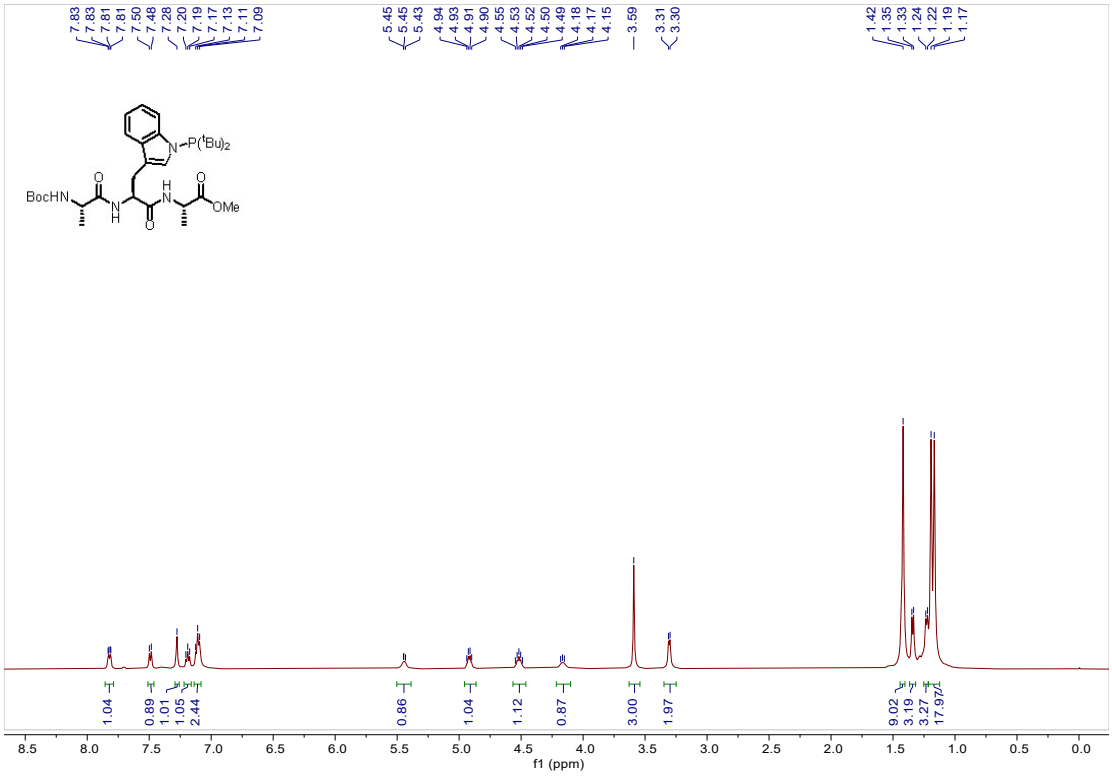
^{1}H NMR (400 MHz, $CDCl_3$) spectrum of **1l**



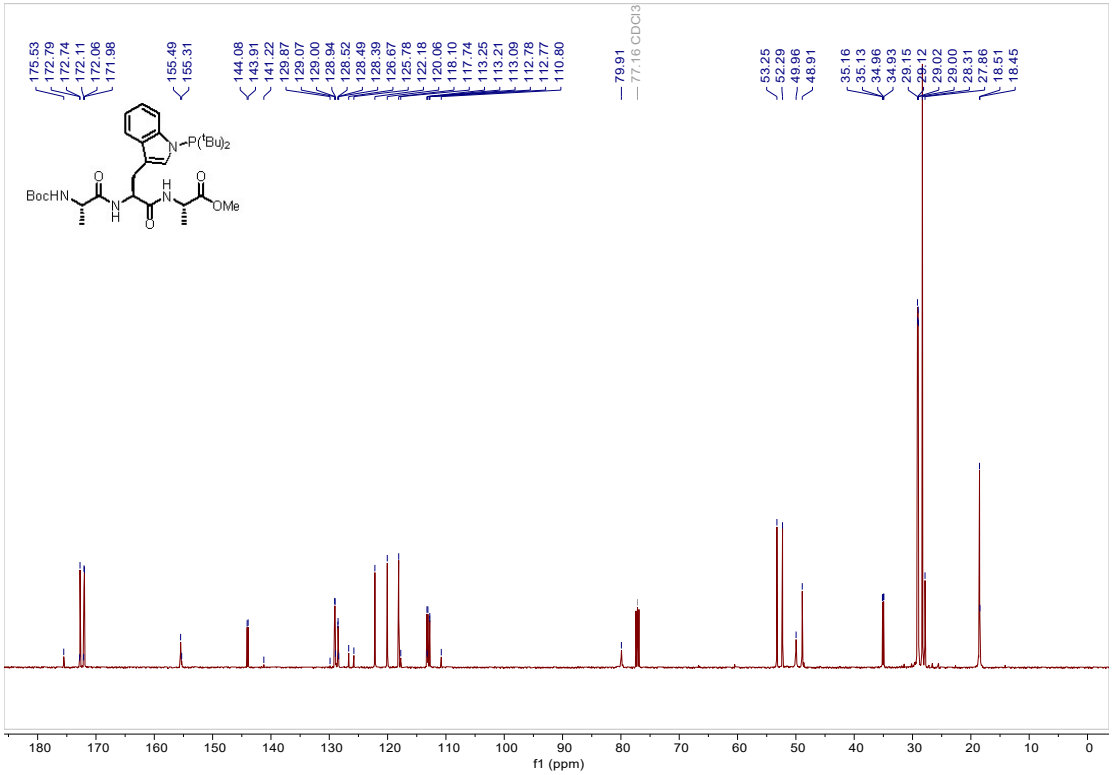
^{13}C NMR (101 MHz, $CDCl_3$) spectrum of **1l**



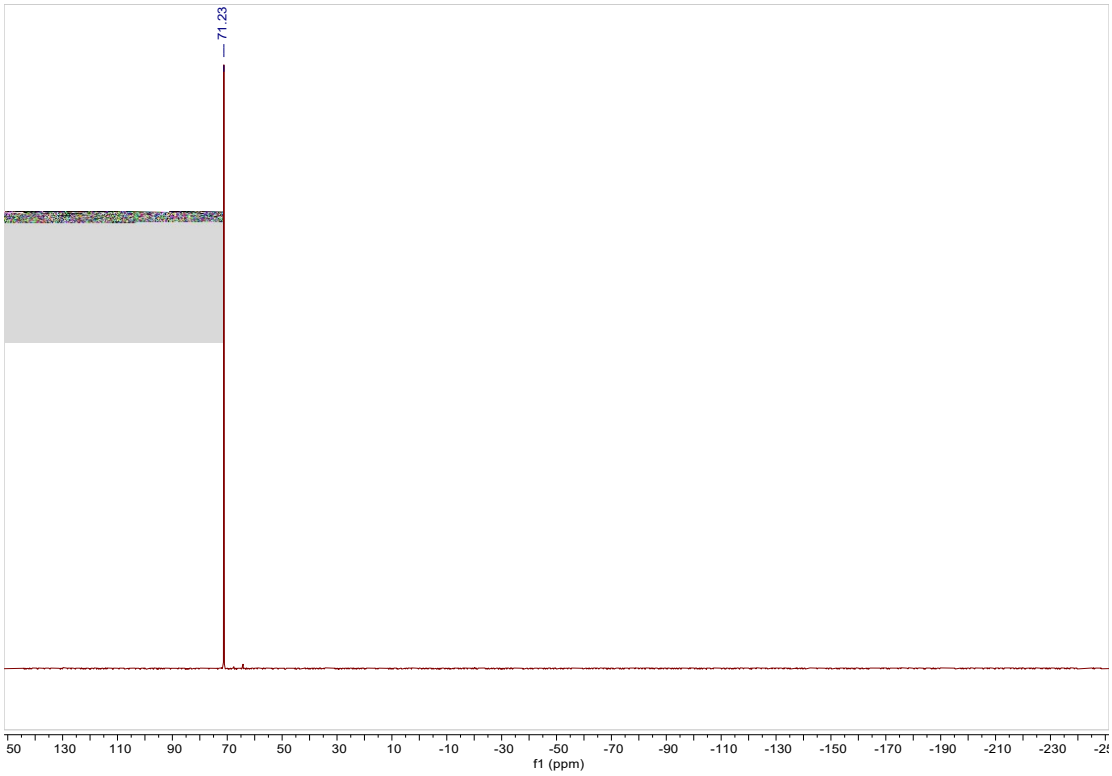
^{31}P NMR (162 MHz, $CDCl_3$) of **1l**



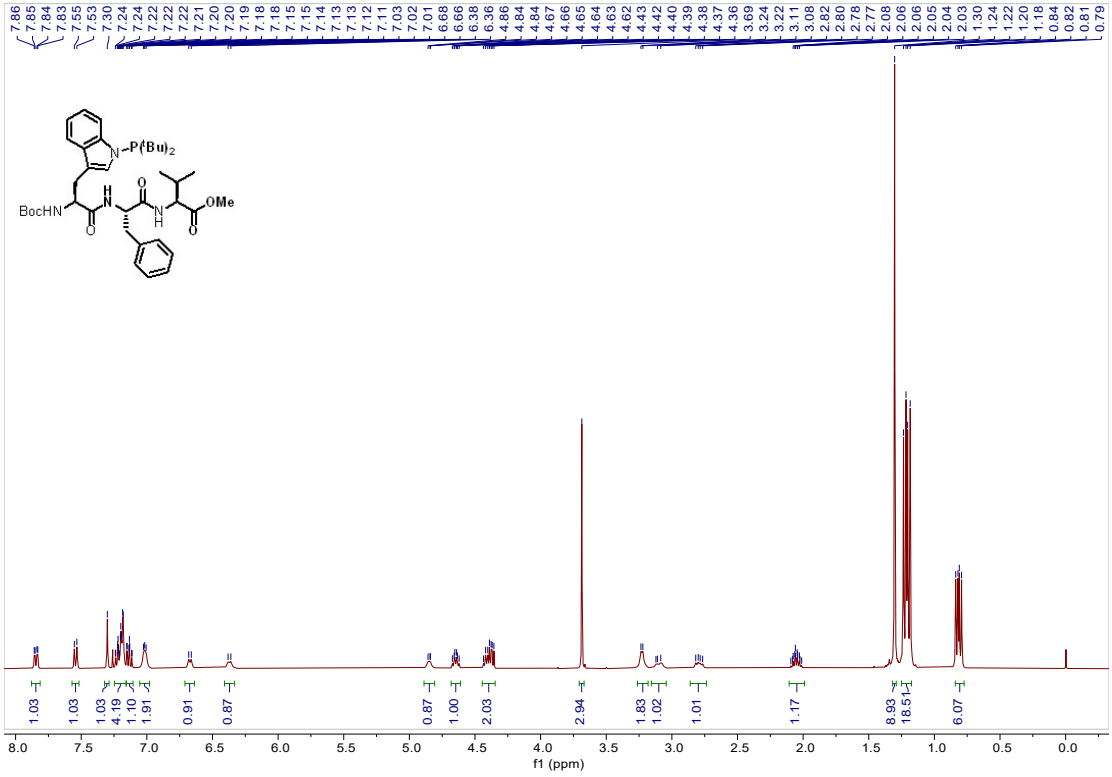
^{1}H NMR (500 MHz, $CDCl_3$) spectrum of **1m**



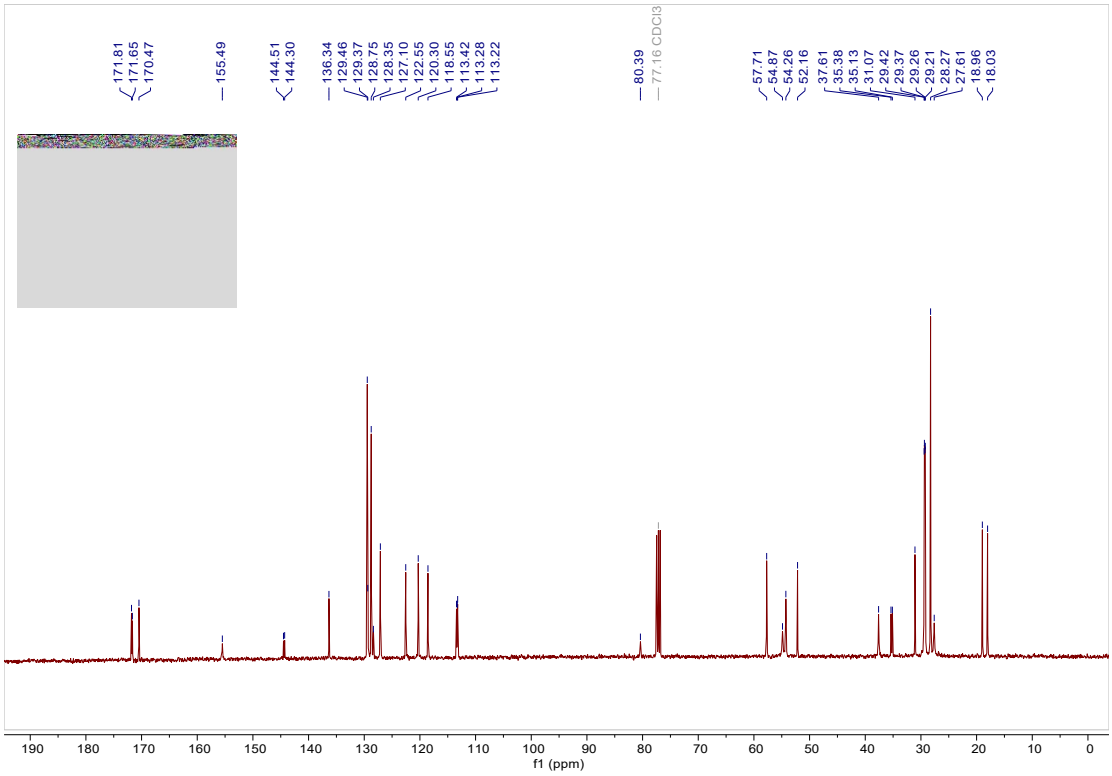
^{13}C NMR (126 MHz, $CDCl_3$) spectrum of **1m**



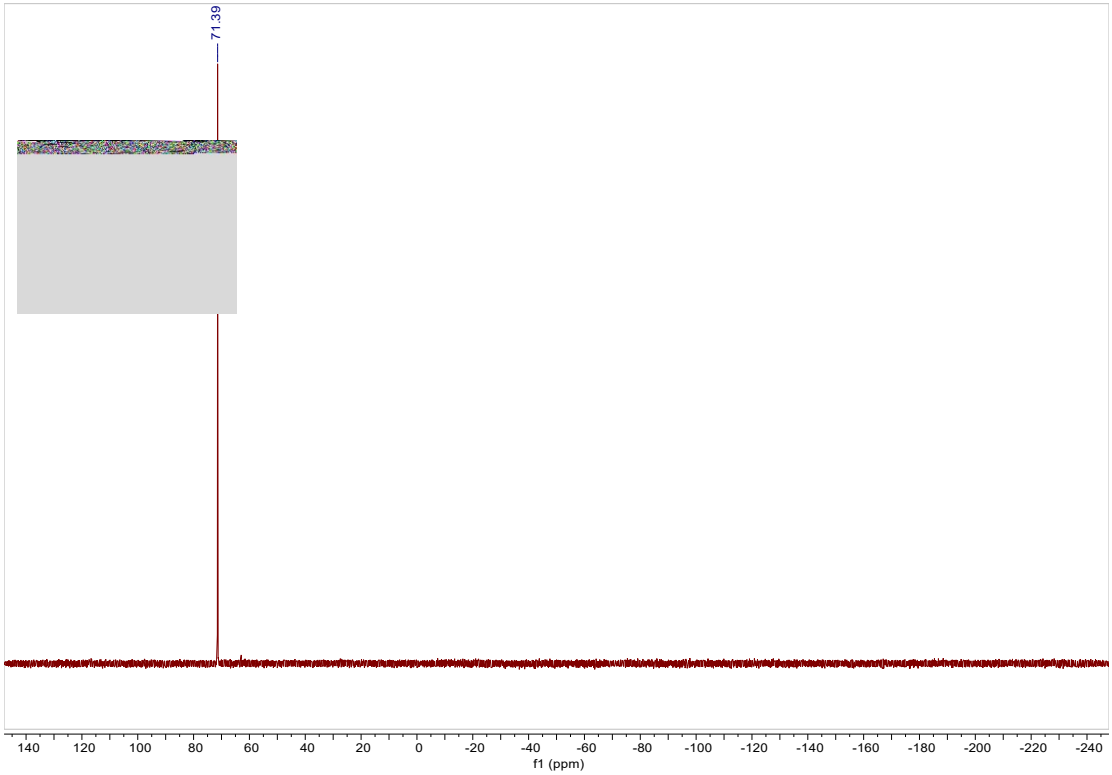
^{31}P NMR (202 MHz, $CDCl_3$) of **1m**



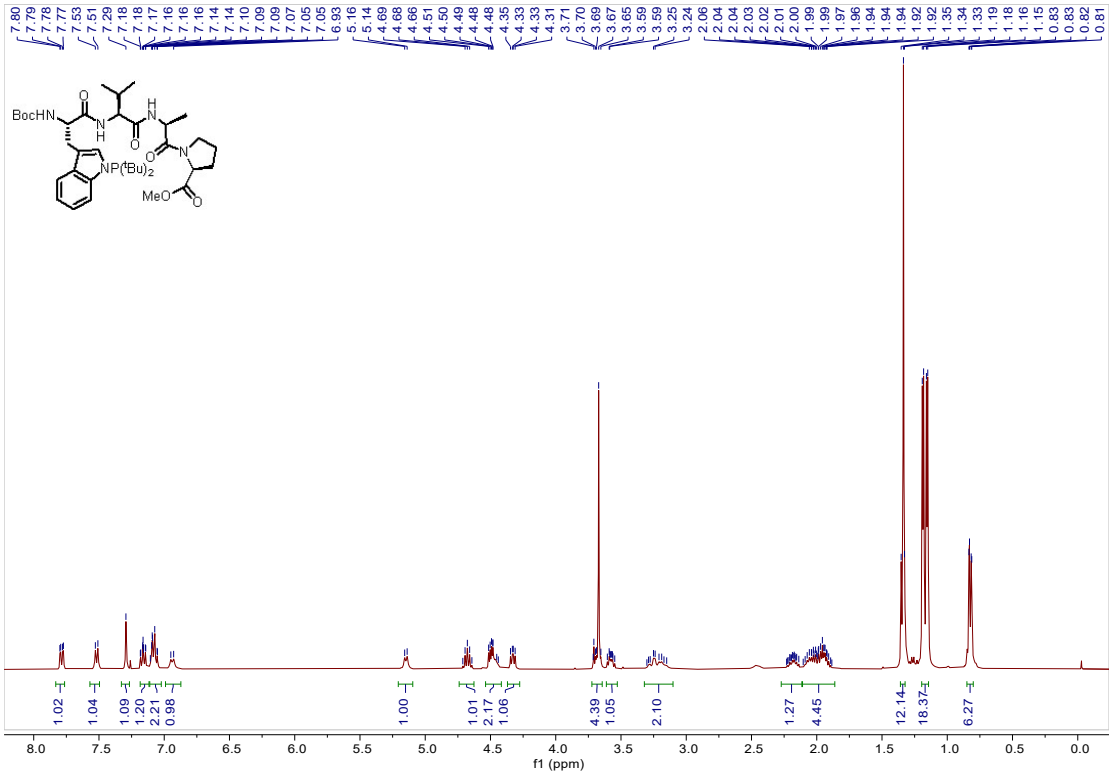
^{1}H NMR (400 MHz, $CDCl_3$) spectrum of **1n**



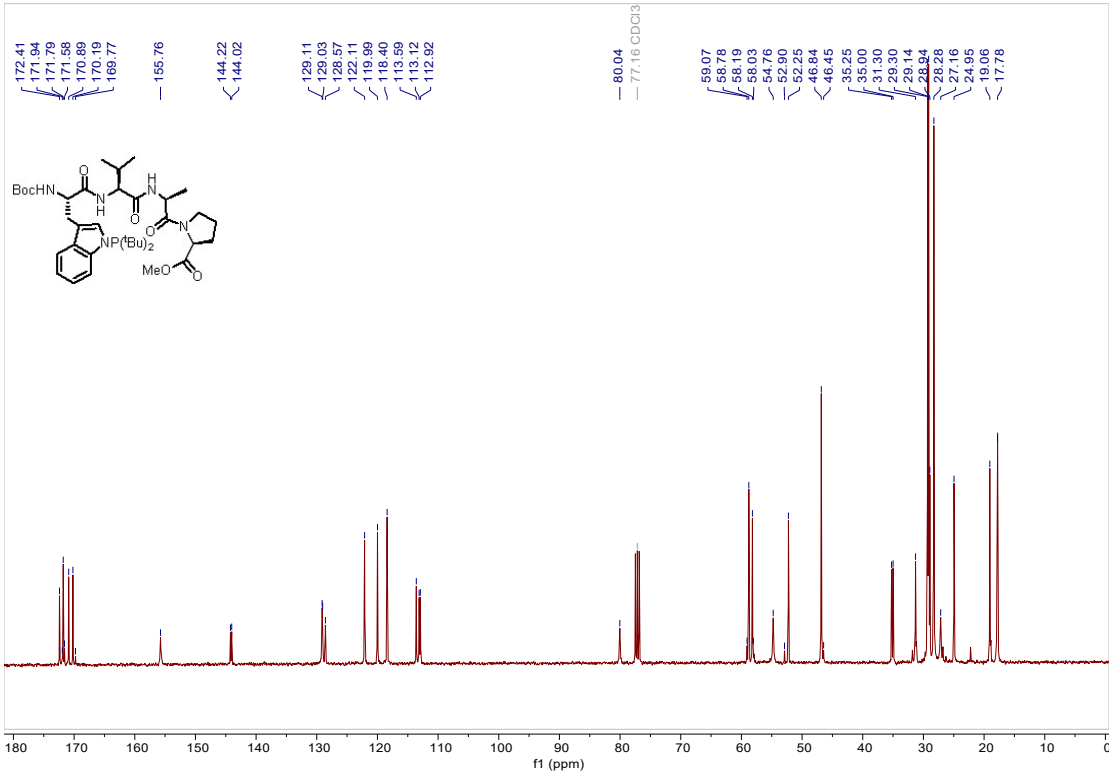
^{13}C NMR (101 MHz, $CDCl_3$) spectrum of **1n**



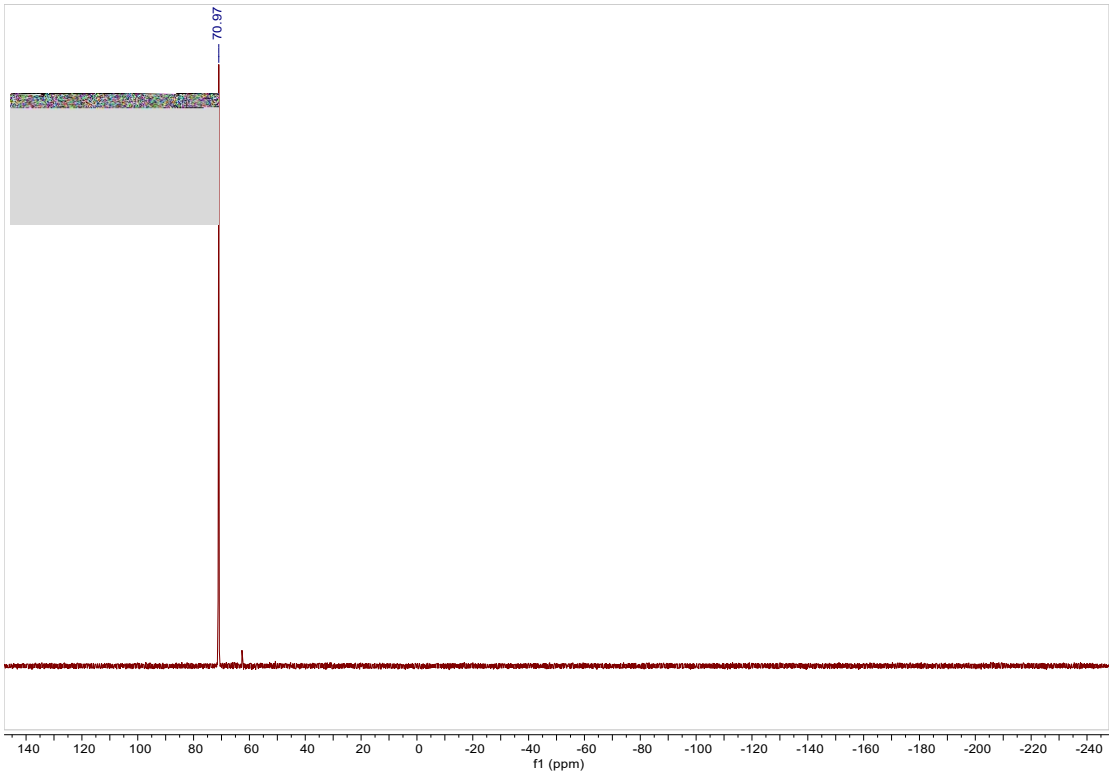
^{31}P NMR (162 MHz, $CDCl_3$) of **1n**



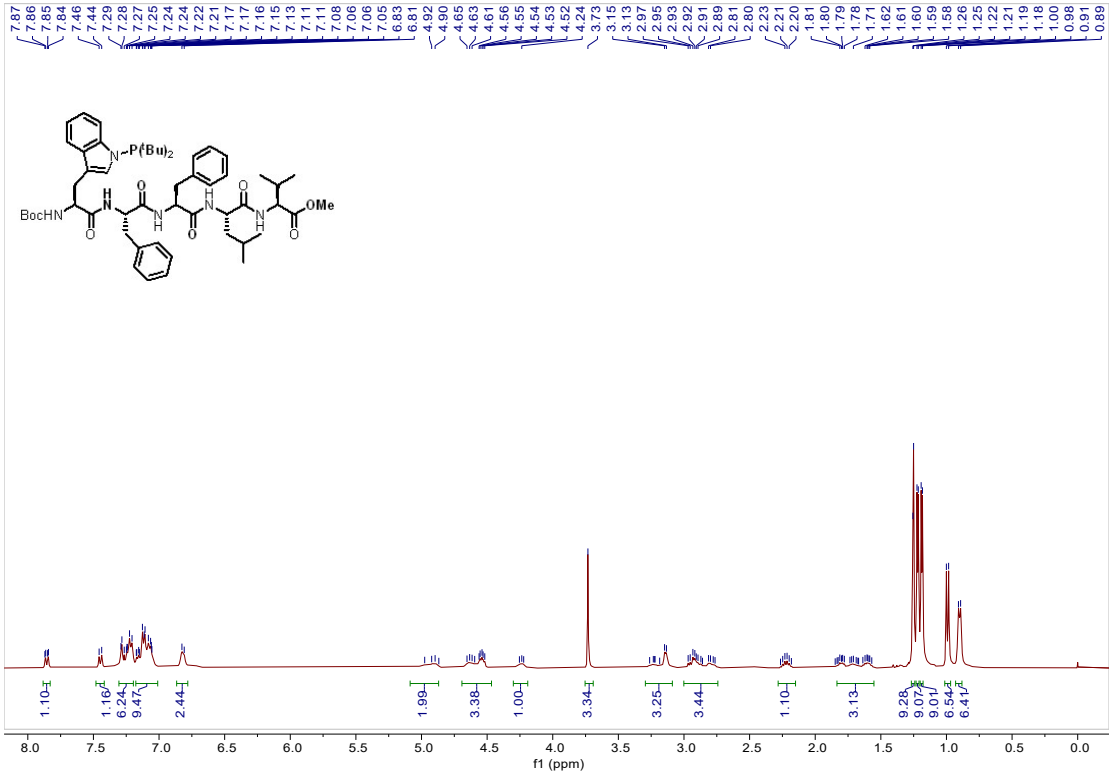
^{1}H NMR (400 MHz, $CDCl_3$) spectrum of **1o**



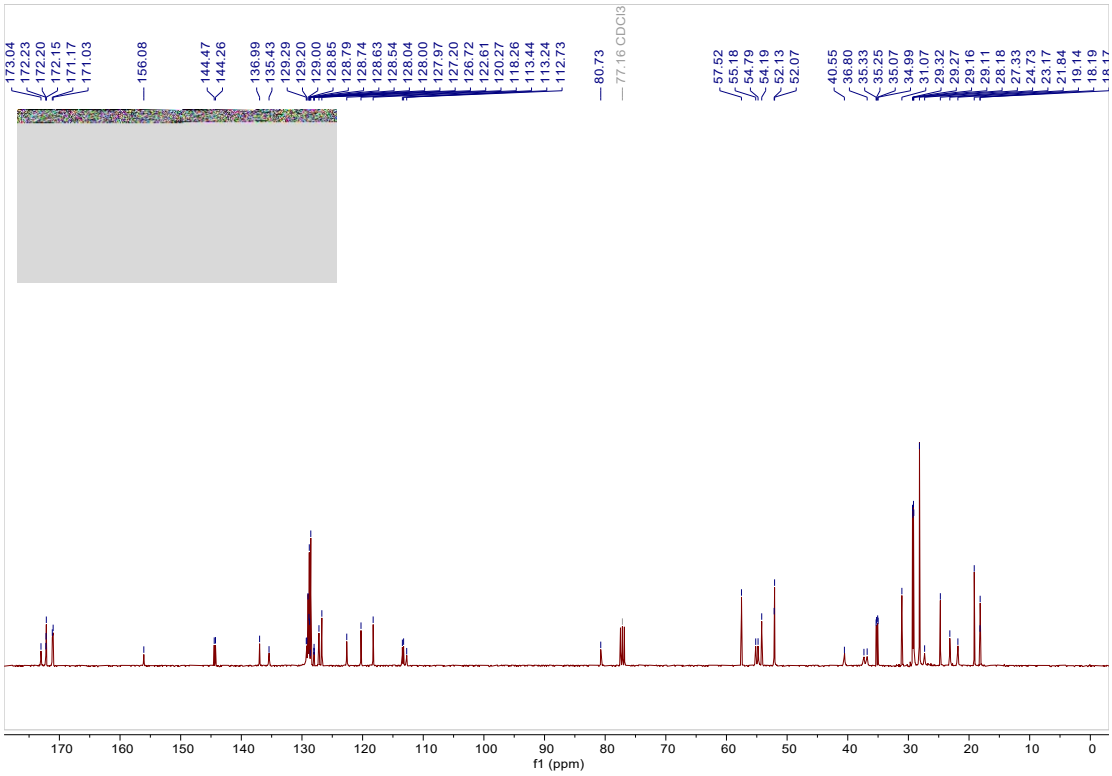
^{13}C NMR (101 MHz, $CDCl_3$) spectrum of **1o**



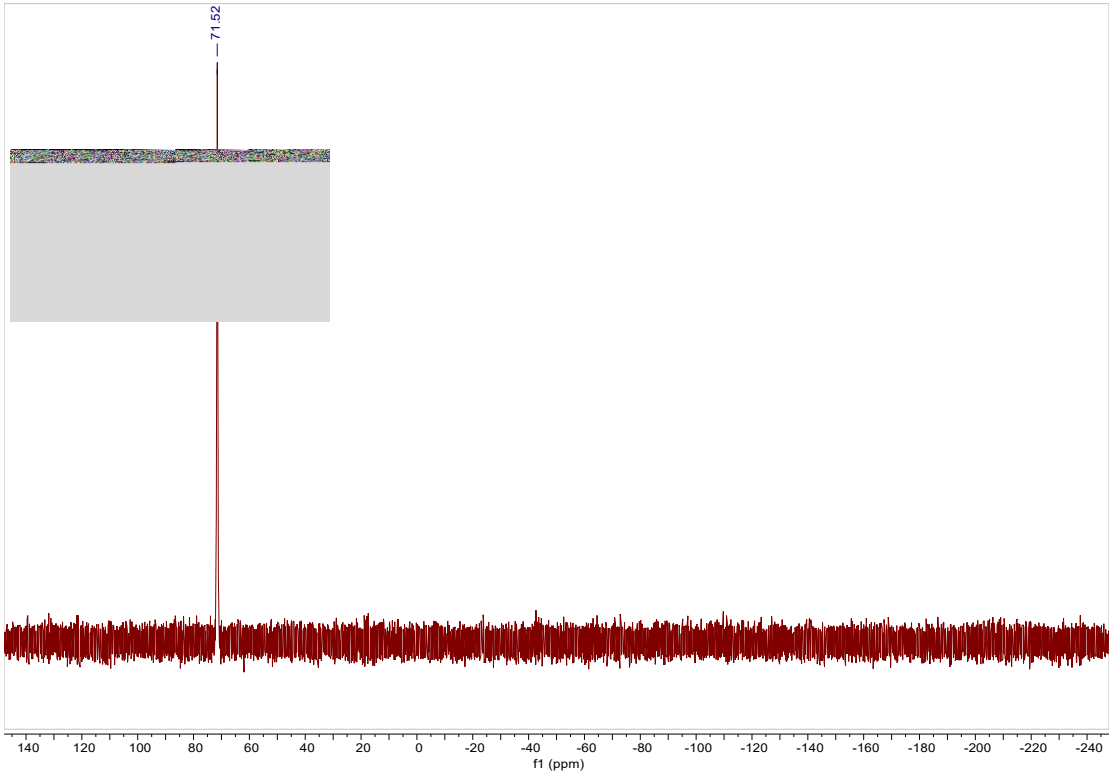
^{31}P NMR (162 MHz, $CDCl_3$) of **1o**



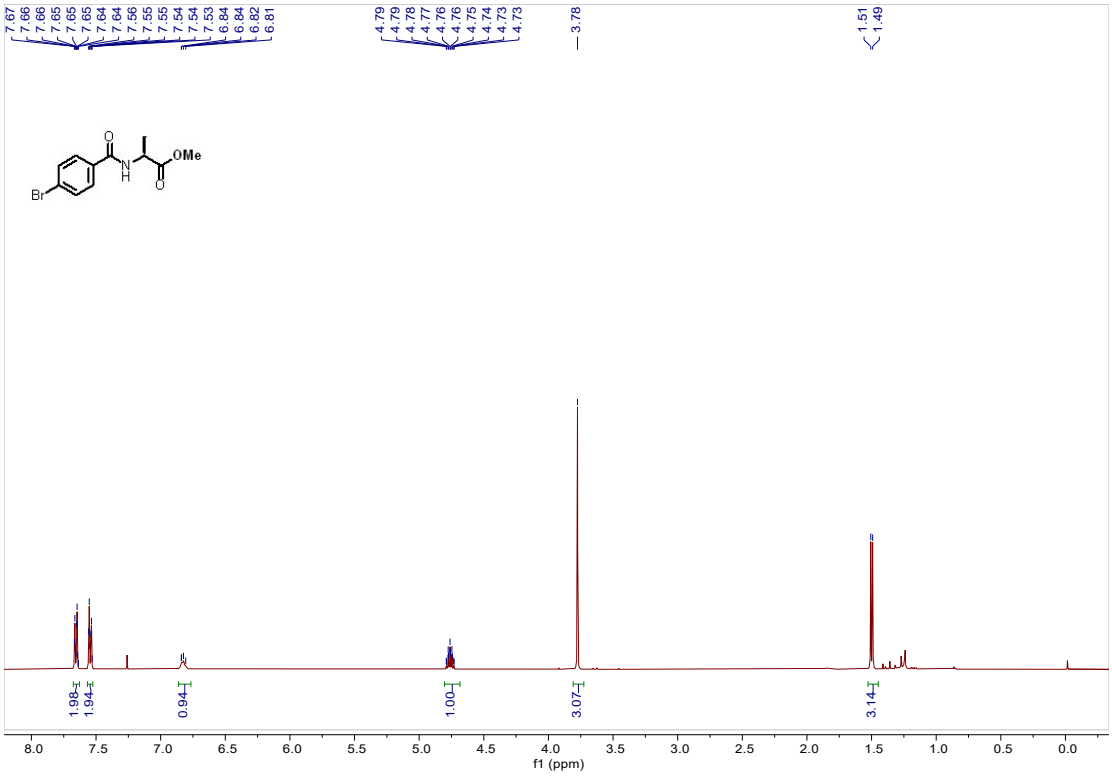
^{1}H NMR (400 MHz, $CDCl_3$) spectrum of **1p**



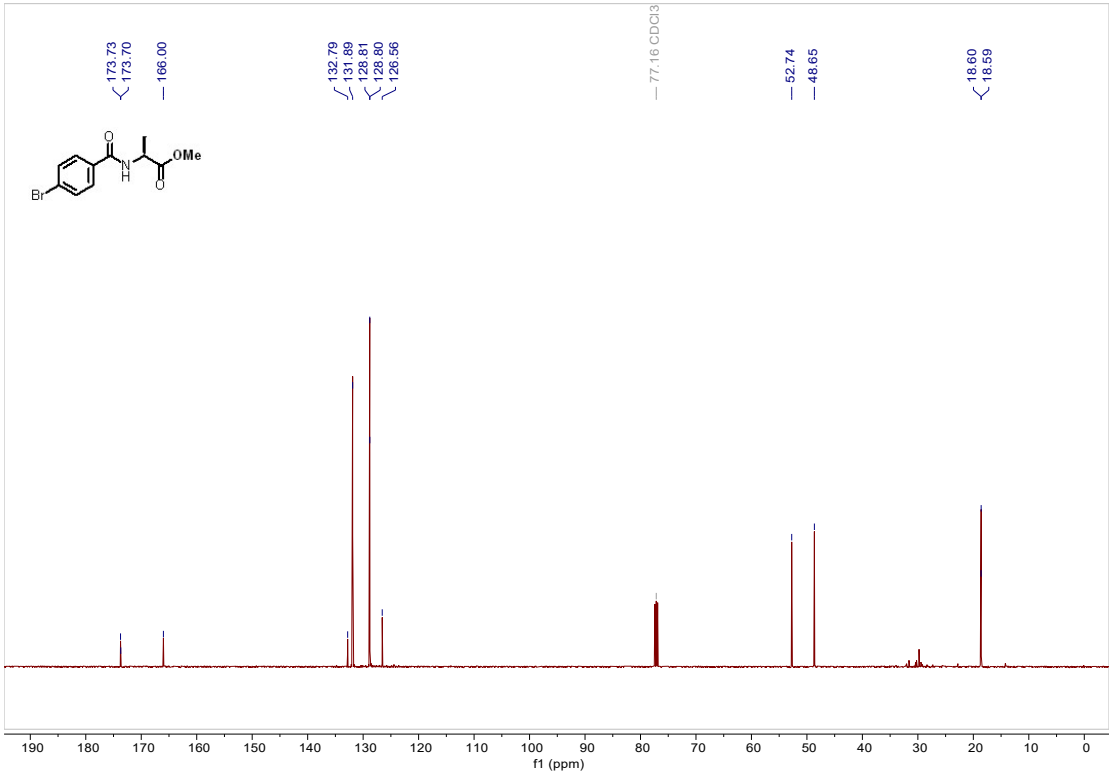
^{13}C NMR (101 MHz, $CDCl_3$) spectrum of **1p**



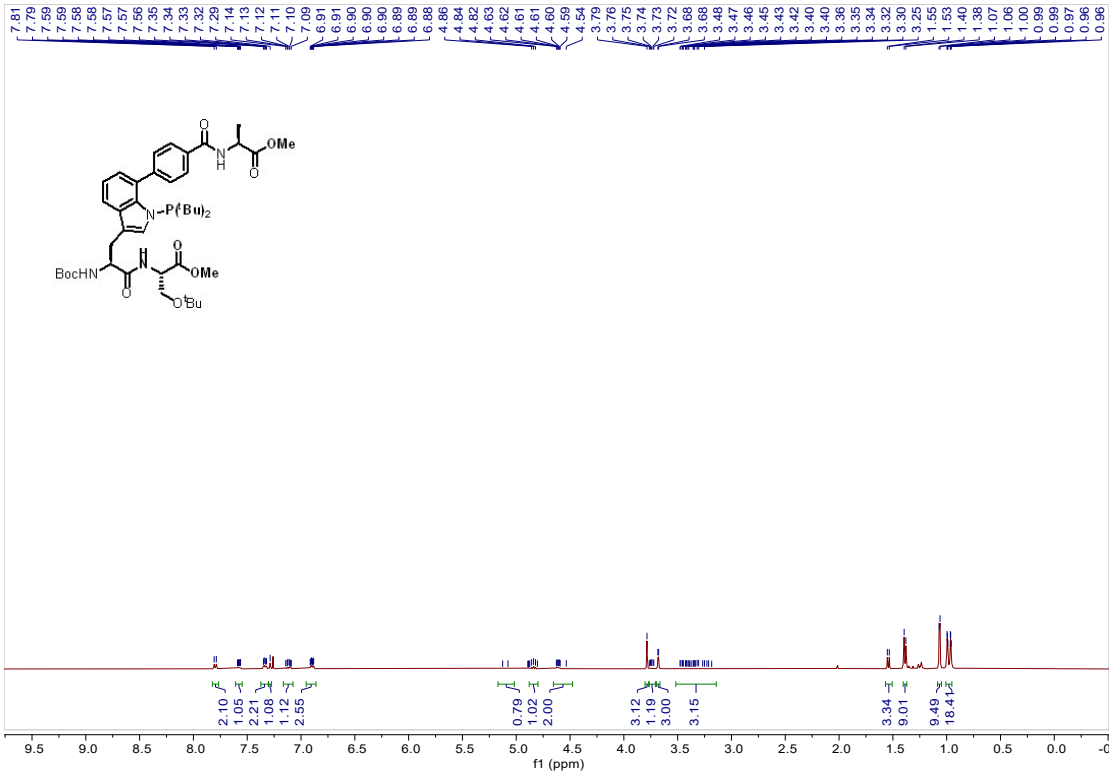
^{31}P NMR (162 MHz, $CDCl_3$) of **1p**



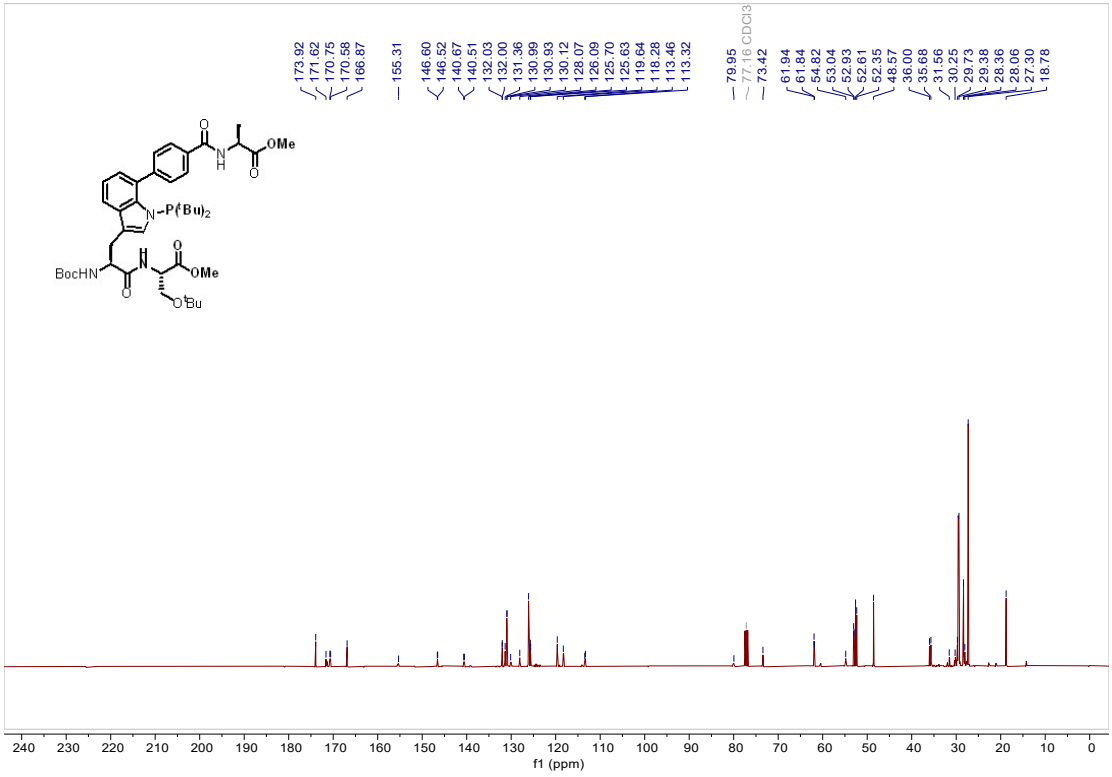
^{1}H NMR (400 MHz, $CDCl_3$) spectrum of **2z**



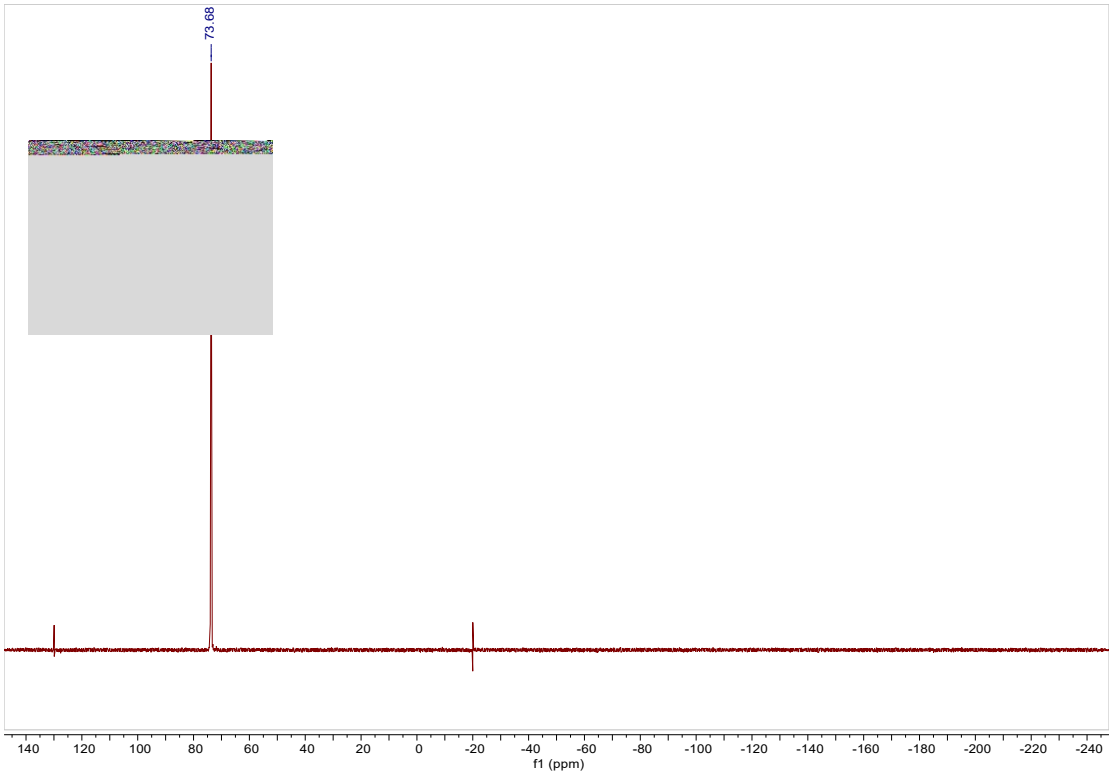
^{13}C NMR (101 MHz, $CDCl_3$) spectrum of **2z**



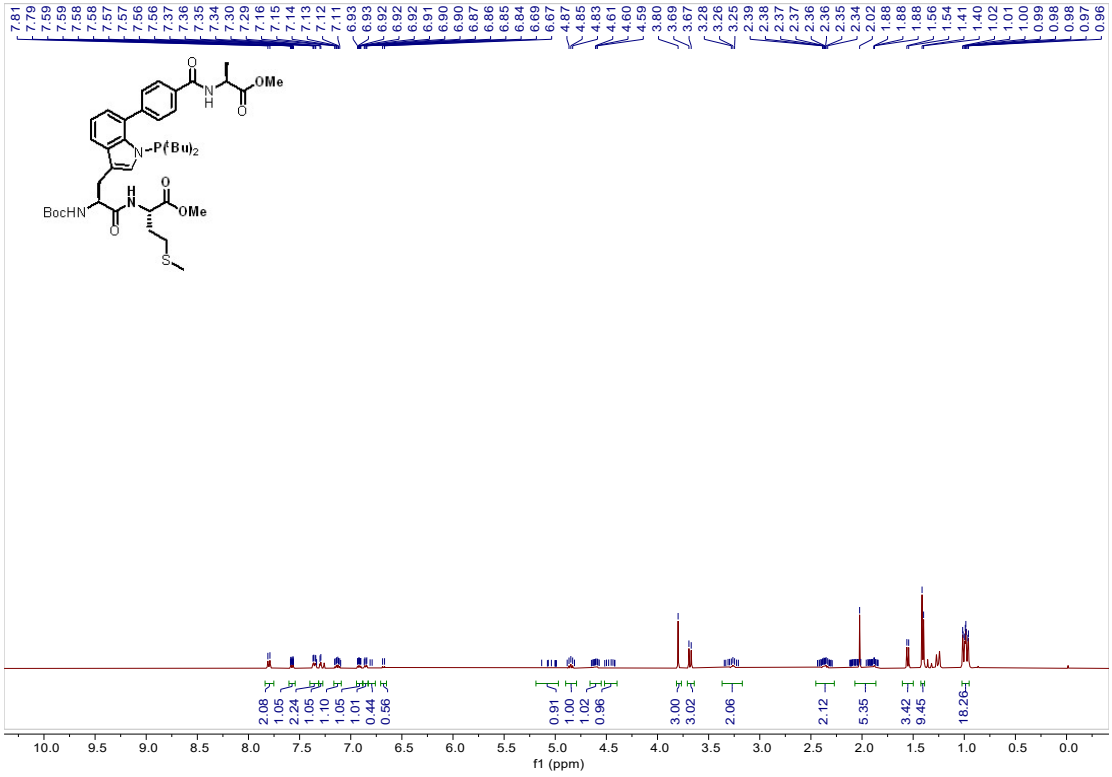
^{1}H NMR (400 MHz, $CDCl_3$) spectrum of **3bz**



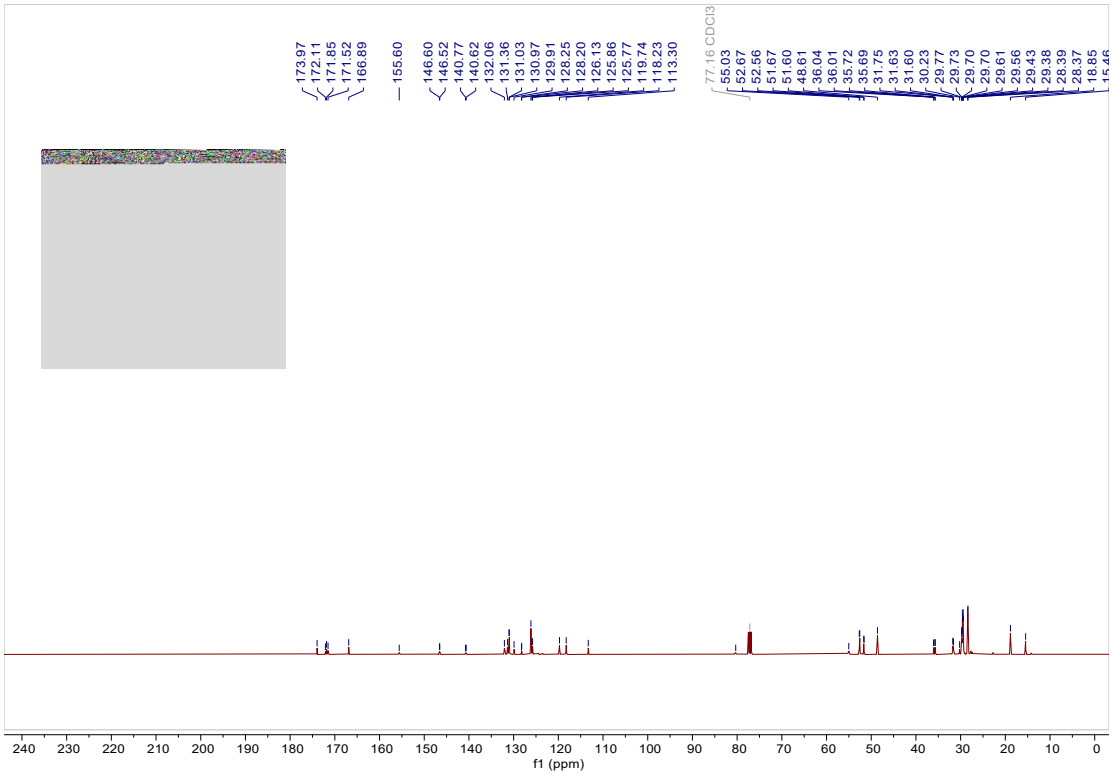
^{13}C NMR (101 MHz, $CDCl_3$) spectrum of **3bz**



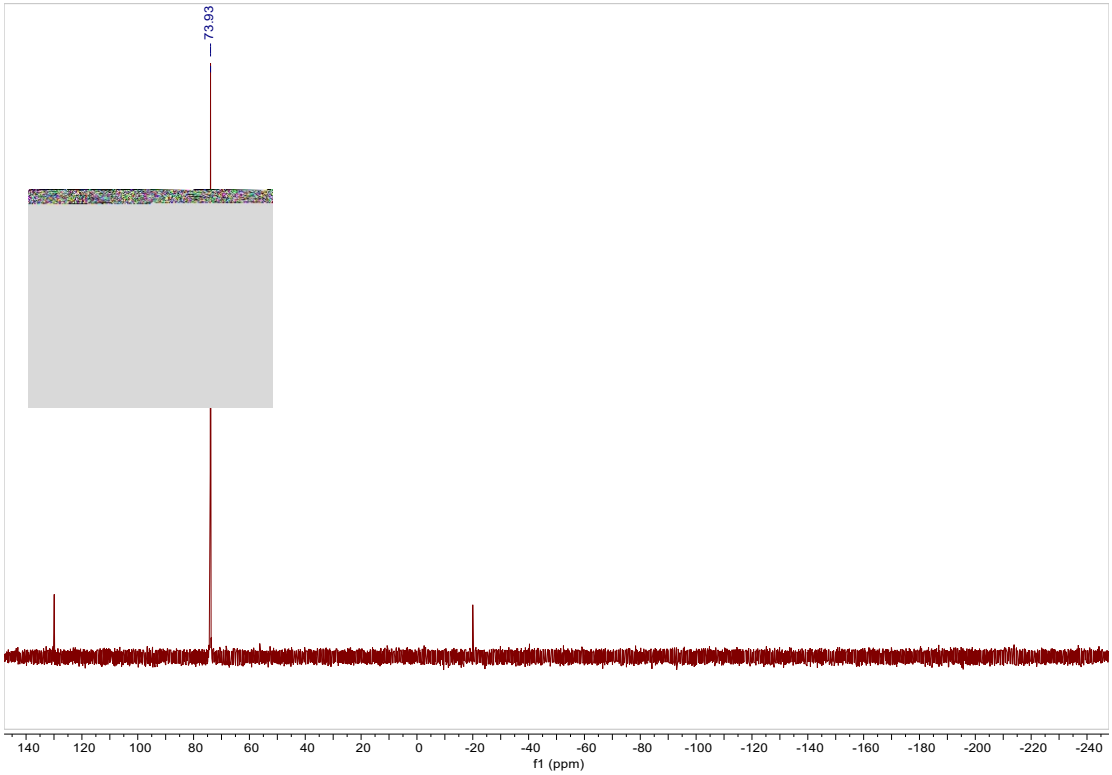
^{31}P NMR (162 MHz, $CDCl_3$) of **3bz**



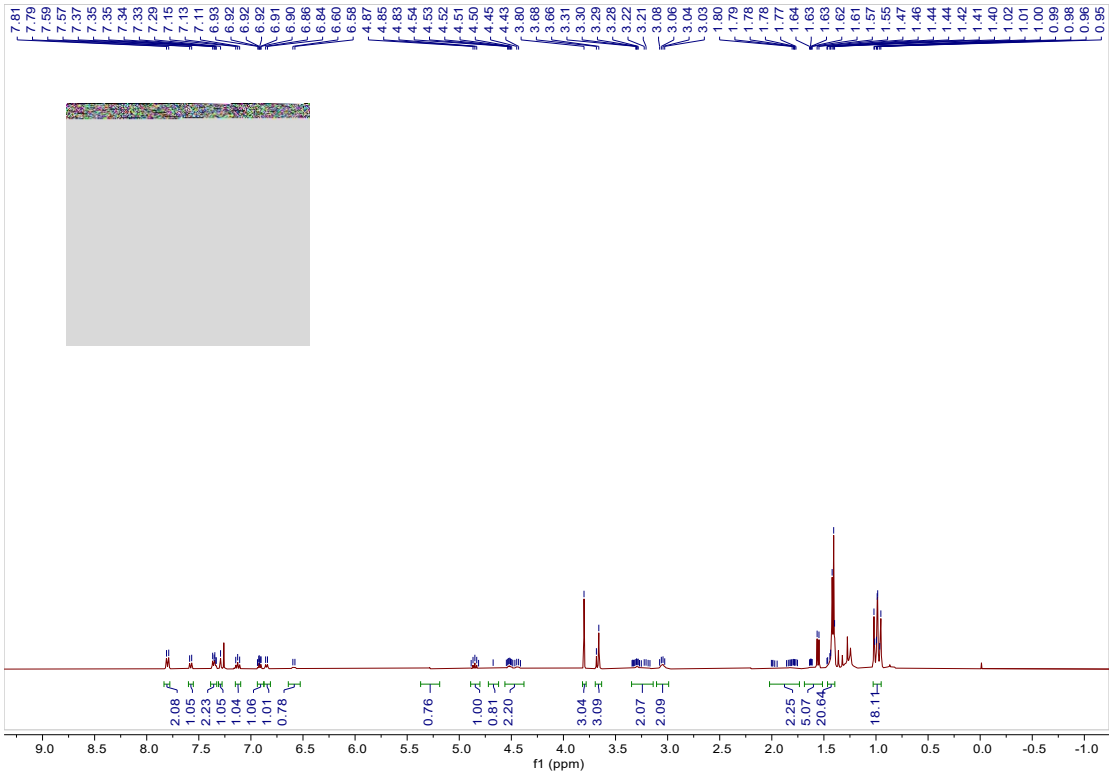
^{1}H NMR (400 MHz, $CDCl_3$) spectrum of **3cz**



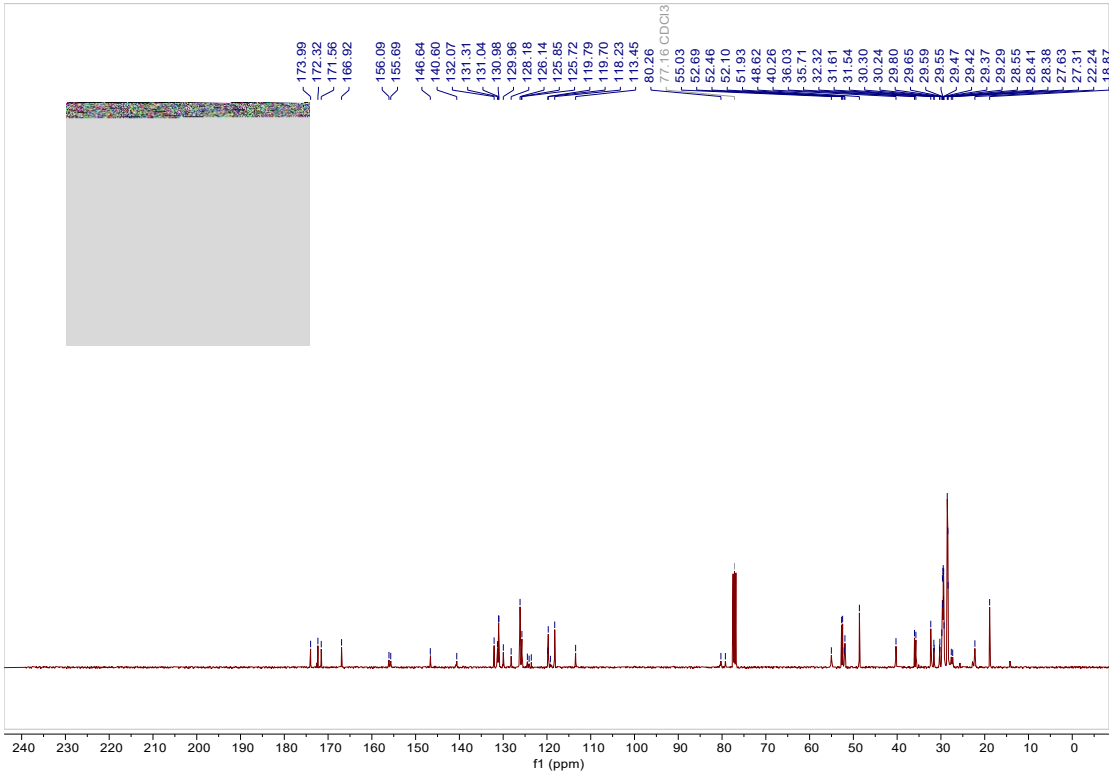
^{13}C NMR (101 MHz, $CDCl_3$) spectrum of **3cz**



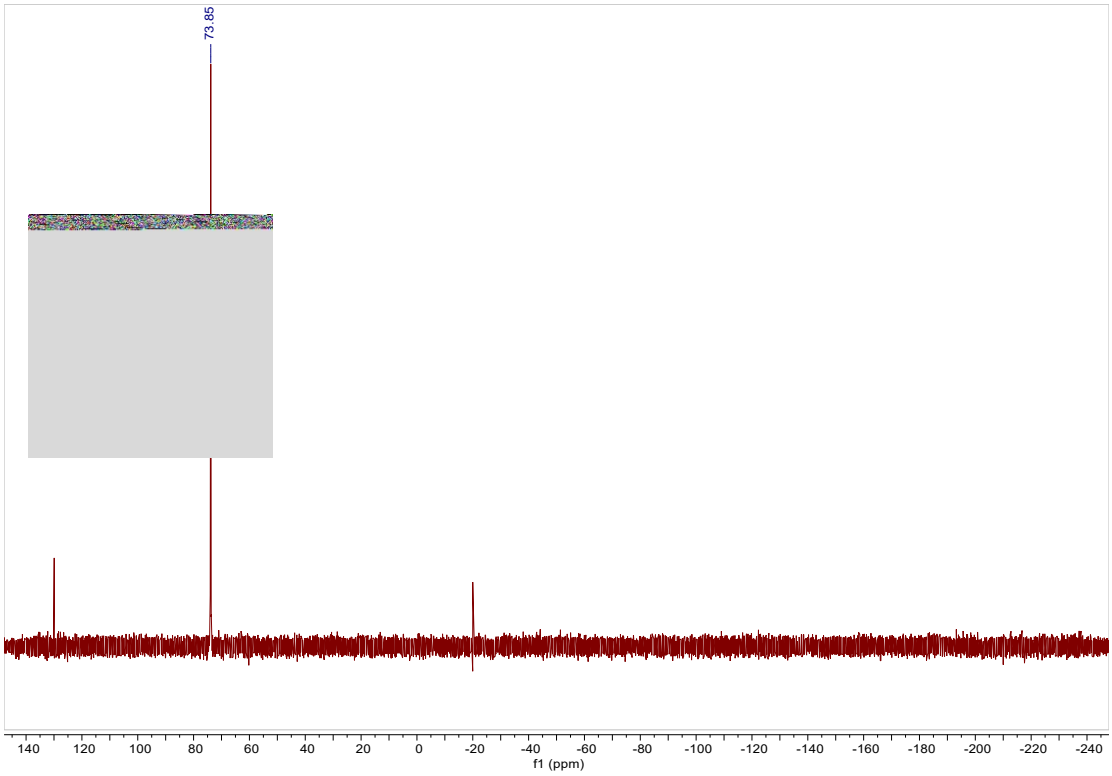
^{31}P NMR (162 MHz, $CDCl_3$) of **3cz**



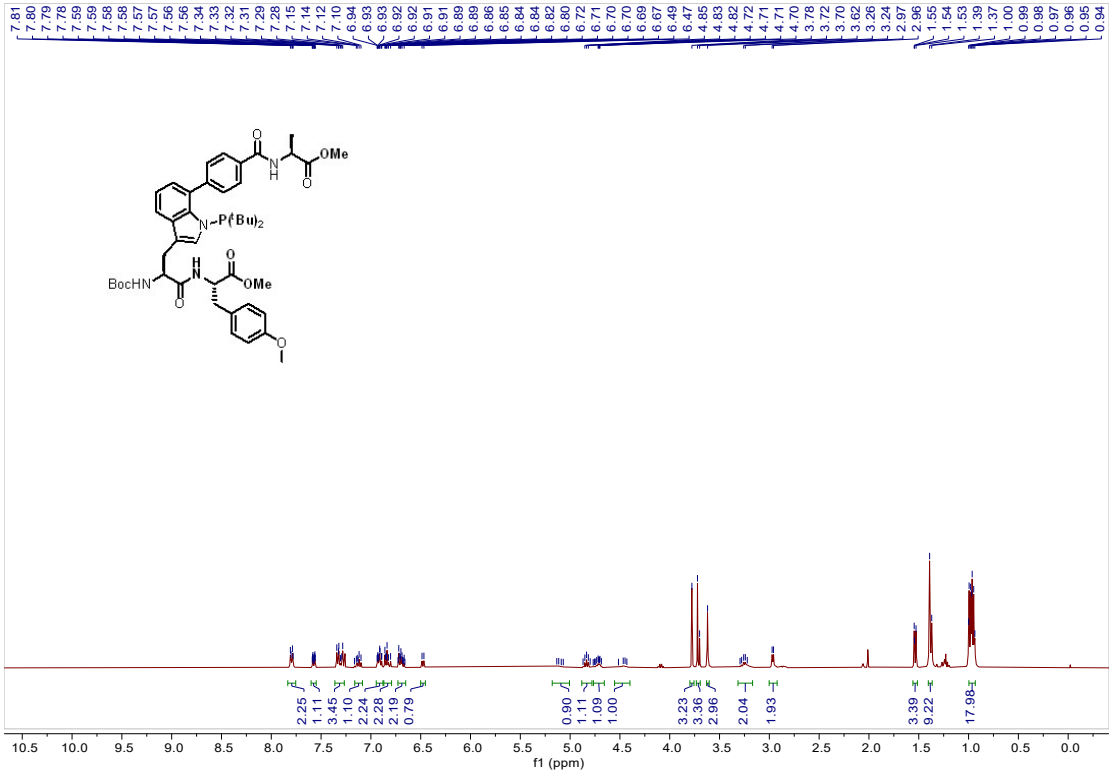
^{1}H NMR (400 MHz, $CDCl_3$) spectrum of **3dz**



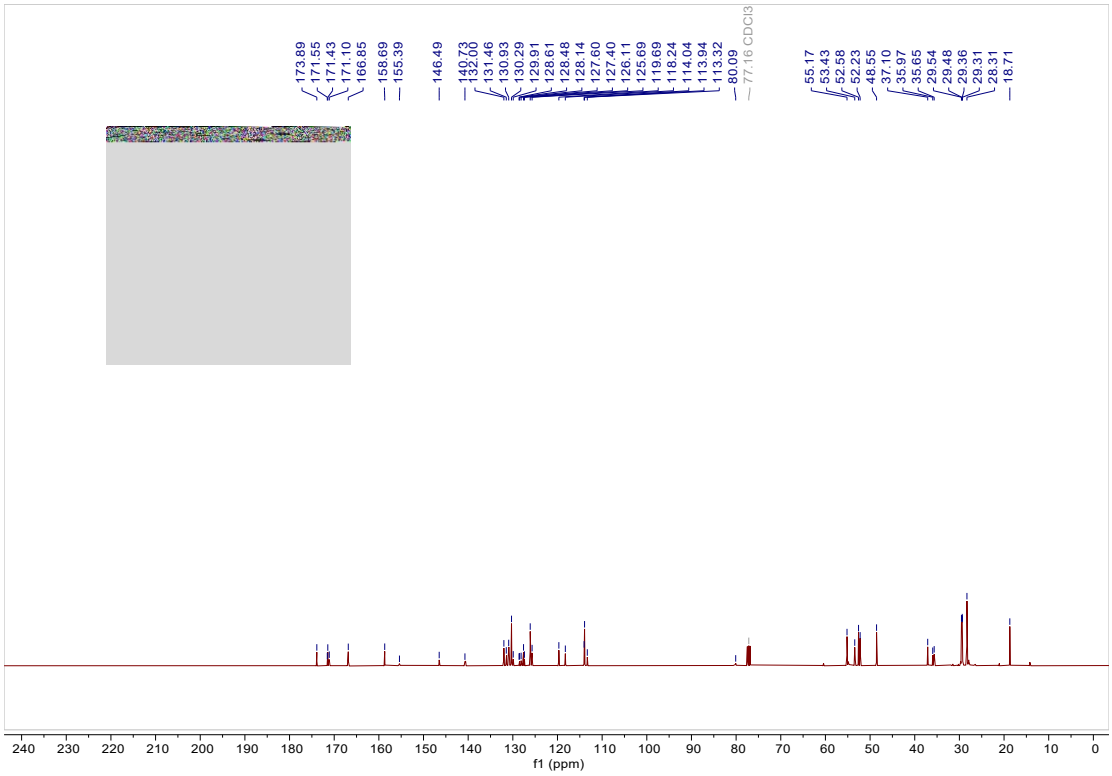
^{13}C NMR (101 MHz, $CDCl_3$) spectrum of **3dz**



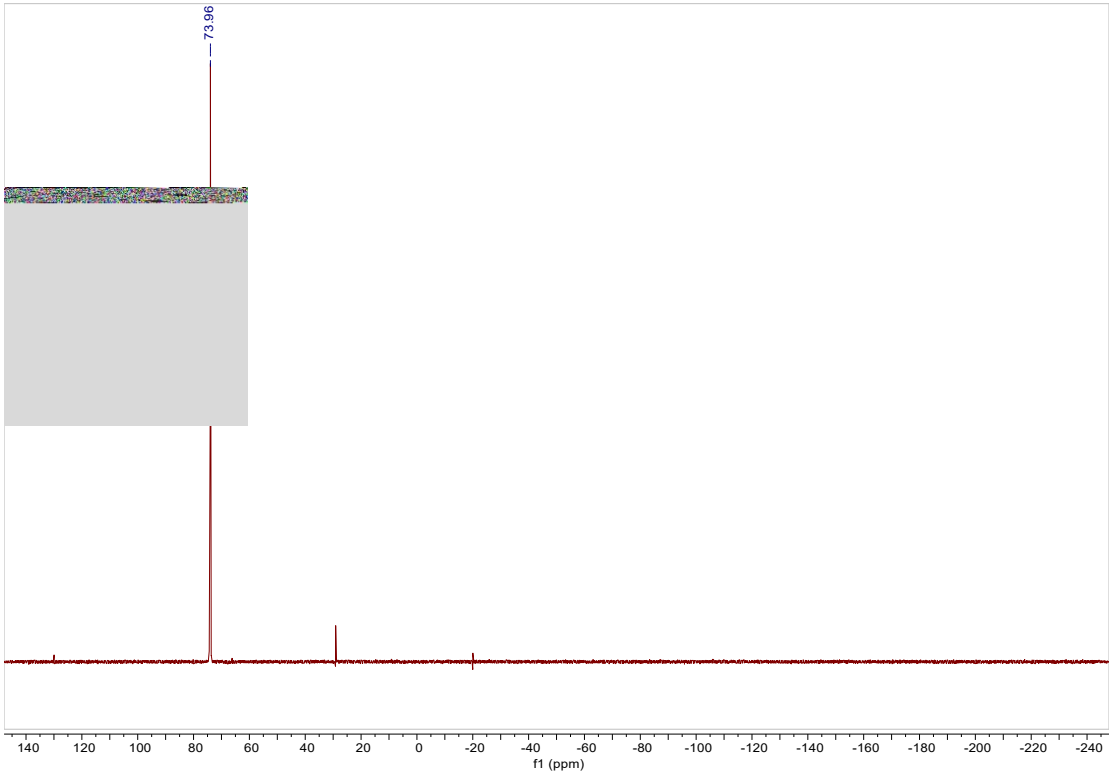
^{31}P NMR (162 MHz, $CDCl_3$) of **3dz**



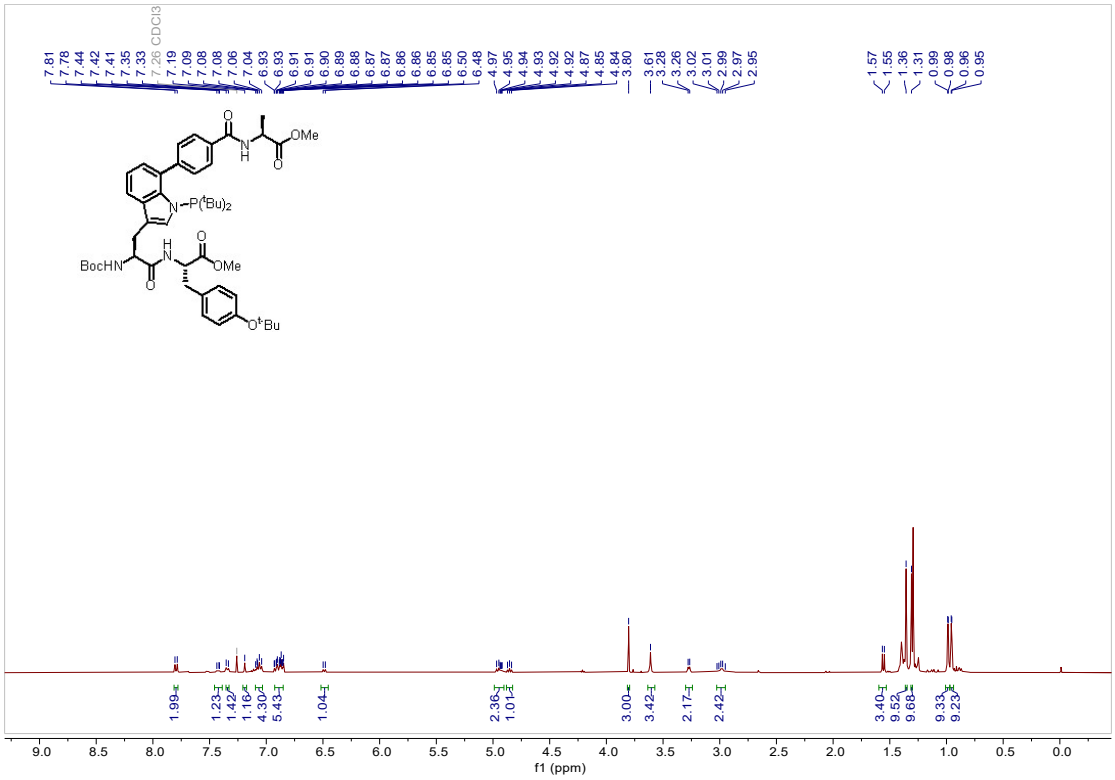
^{1}H NMR (400 MHz, $CDCl_3$) spectrum of **3ez**



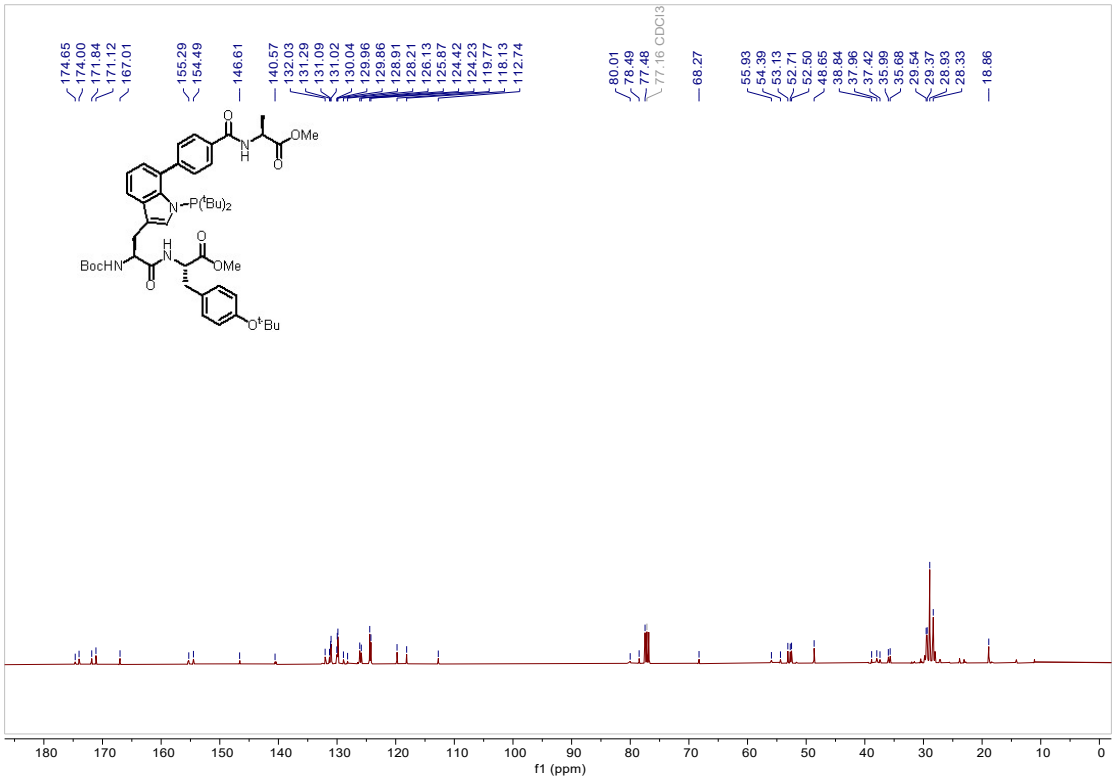
^{13}C NMR (101 MHz, $CDCl_3$) spectrum of **3ez**



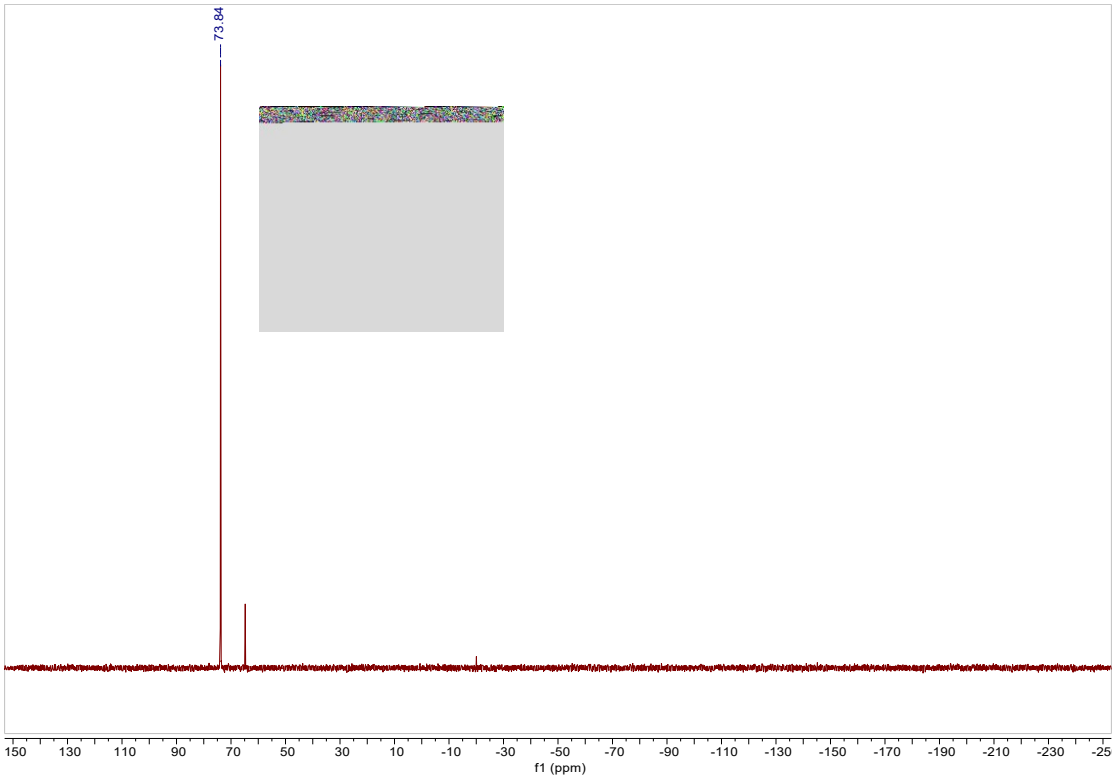
^{31}P NMR (162 MHz, $CDCl_3$) of **3ez**



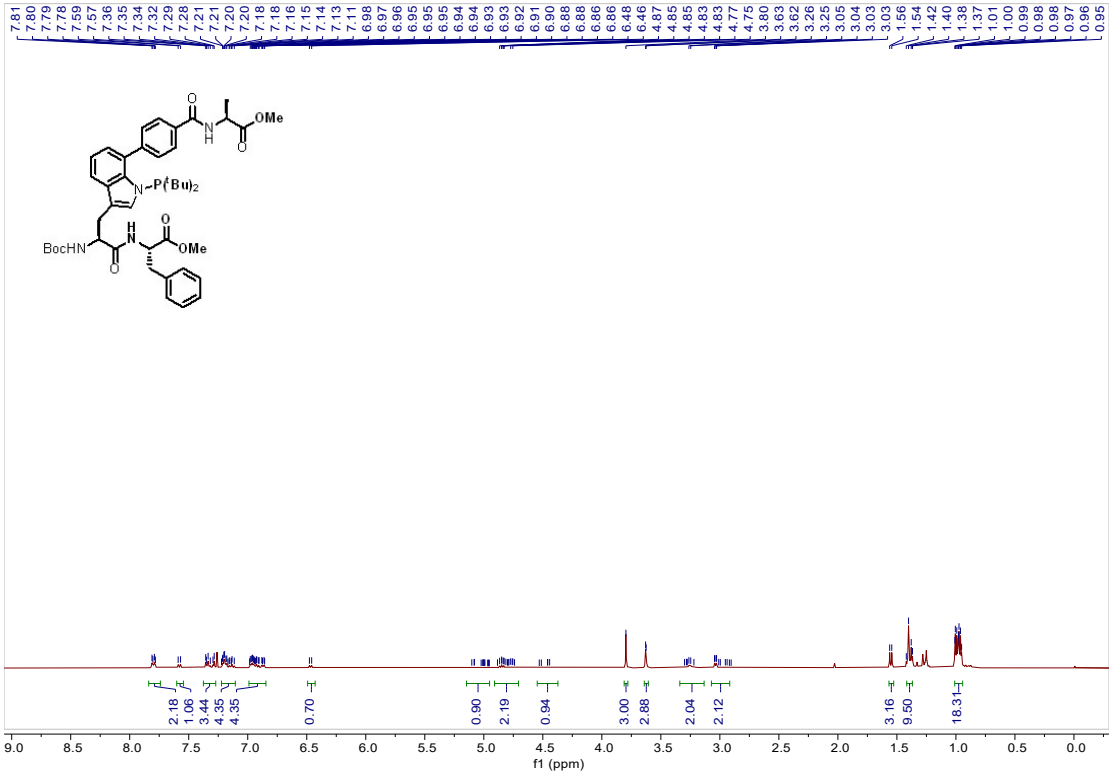
^{1}H NMR (400 MHz, $CDCl_3$) spectrum of **3ez'**



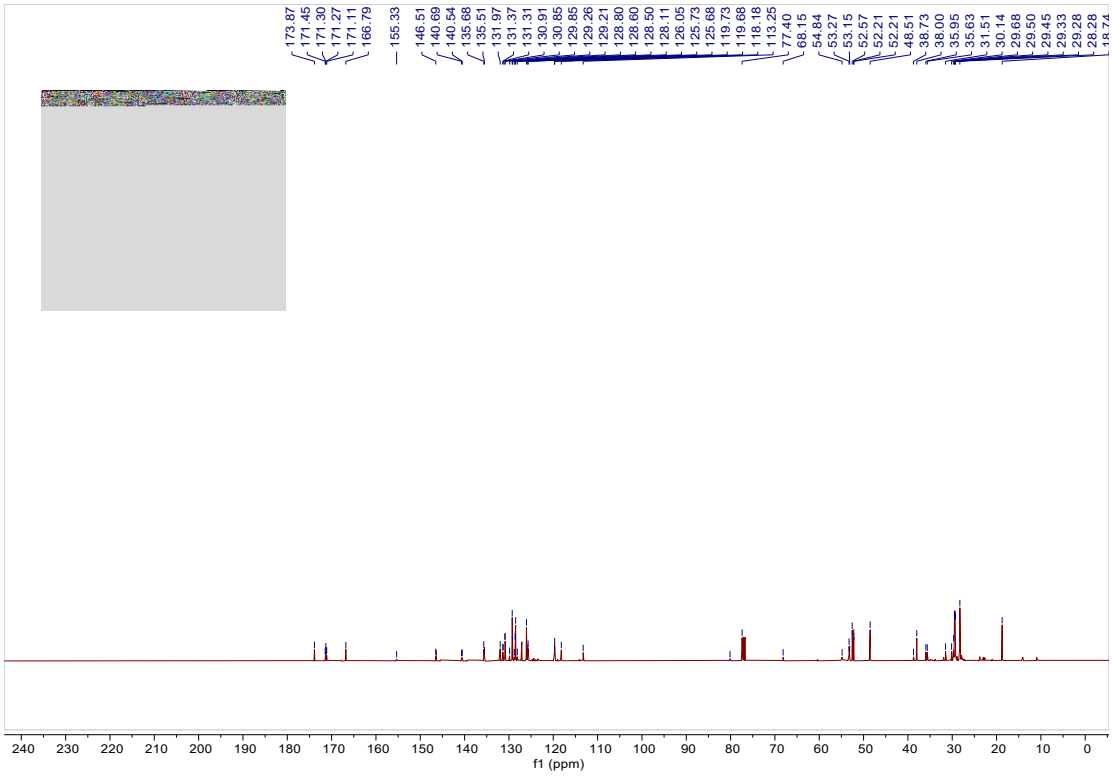
^{13}C NMR (101 MHz, $CDCl_3$) spectrum of **3ez'**



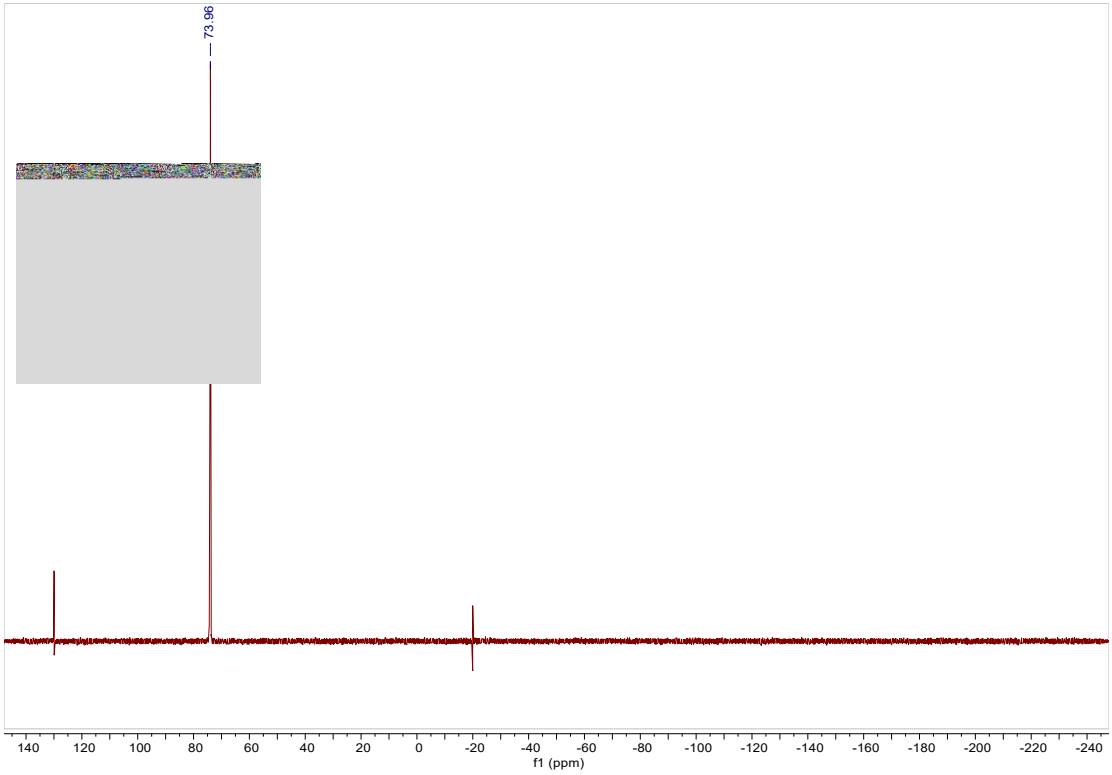
^{31}P NMR (162 MHz, $CDCl_3$) of **3ez'**



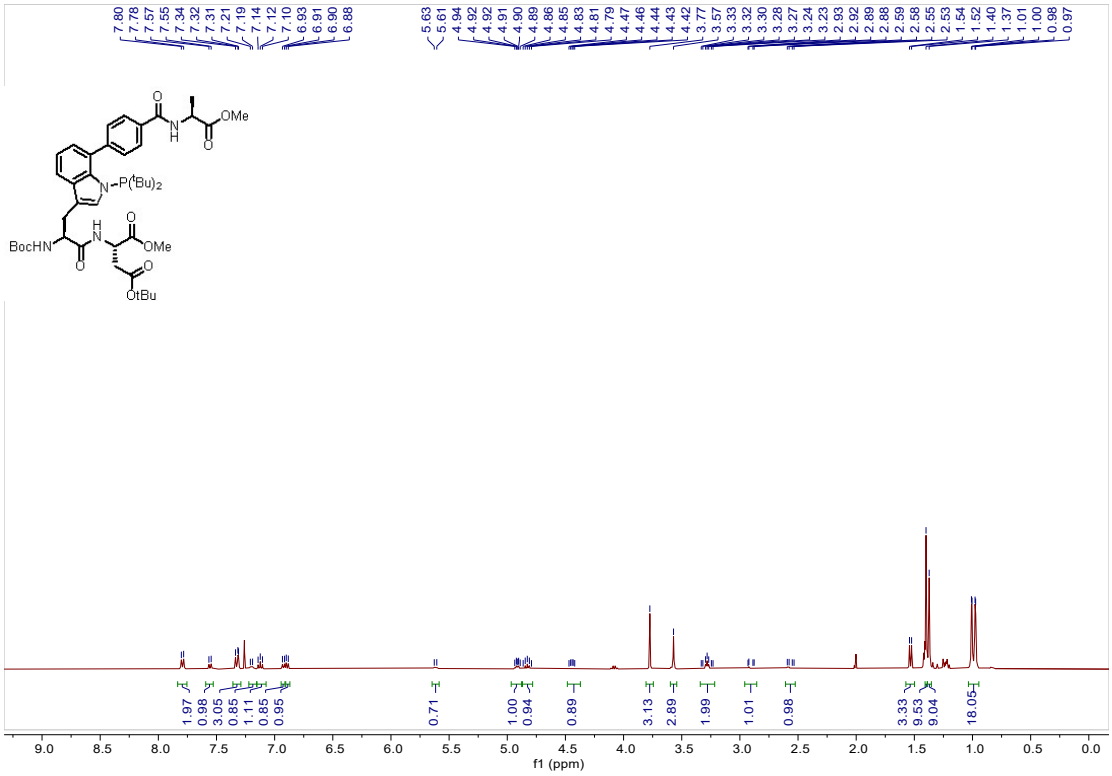
^{1}H NMR (400 MHz, $CDCl_3$) spectrum of **3fz**



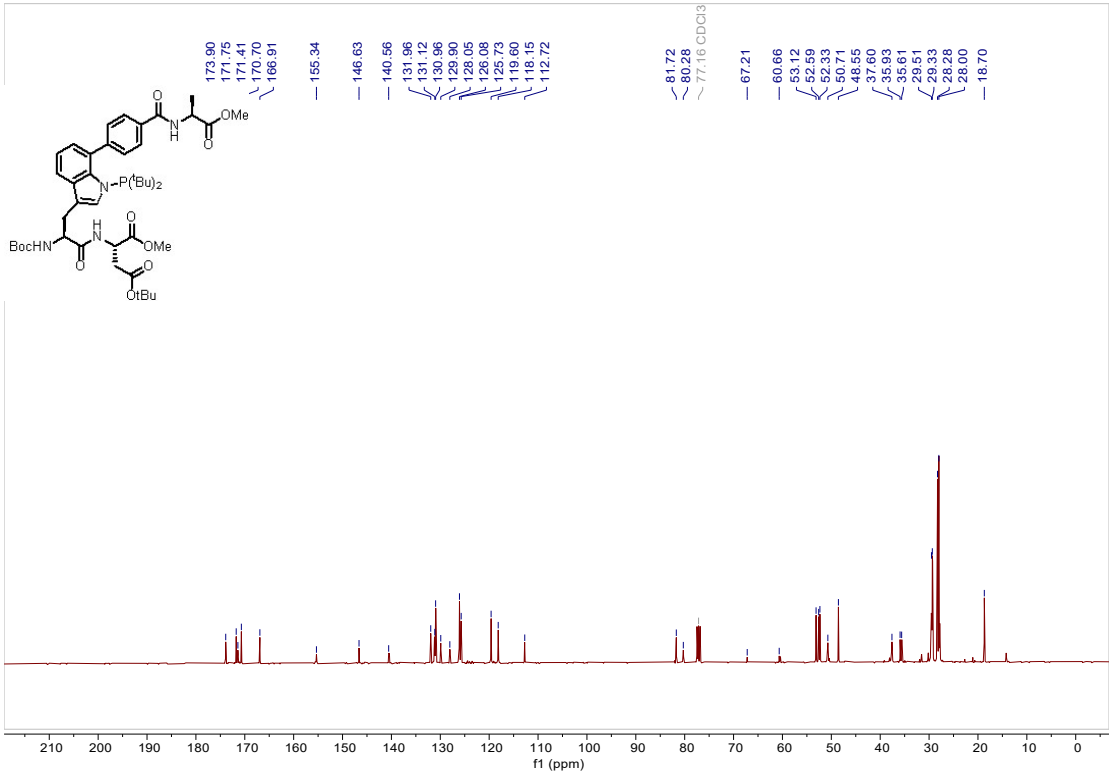
^{13}C NMR (101 MHz, $CDCl_3$) spectrum of **3fz**



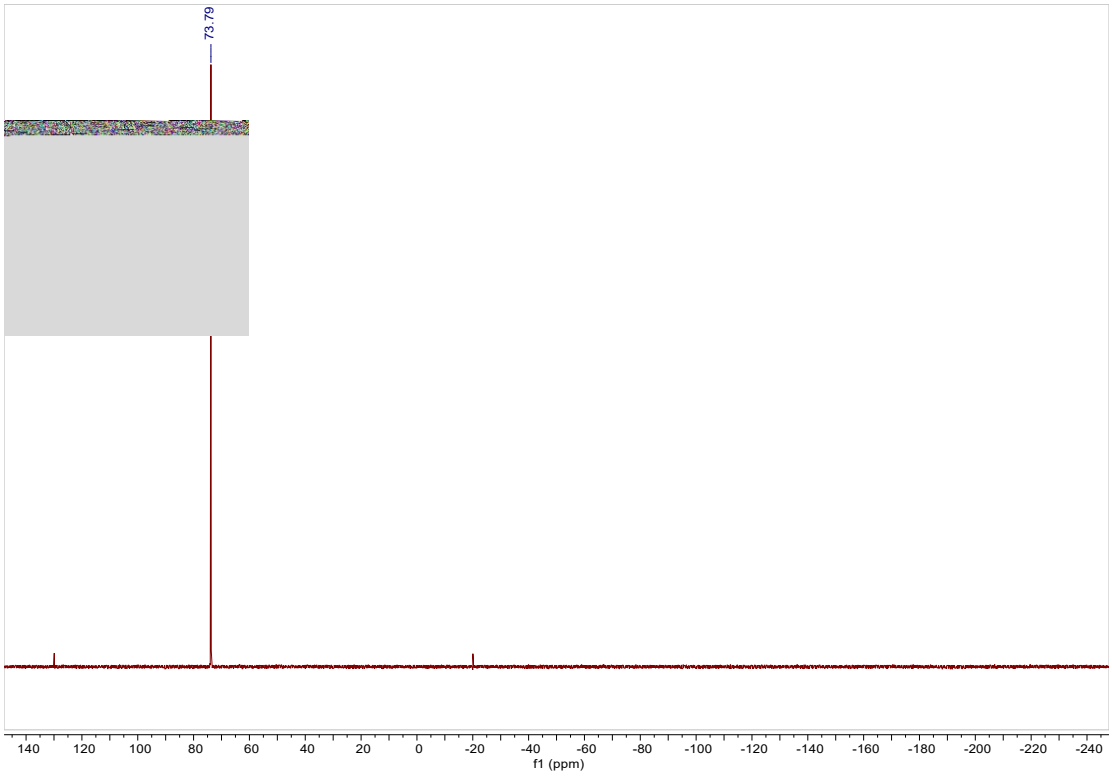
^{31}P NMR (162 MHz, $CDCl_3$) of **3fz**



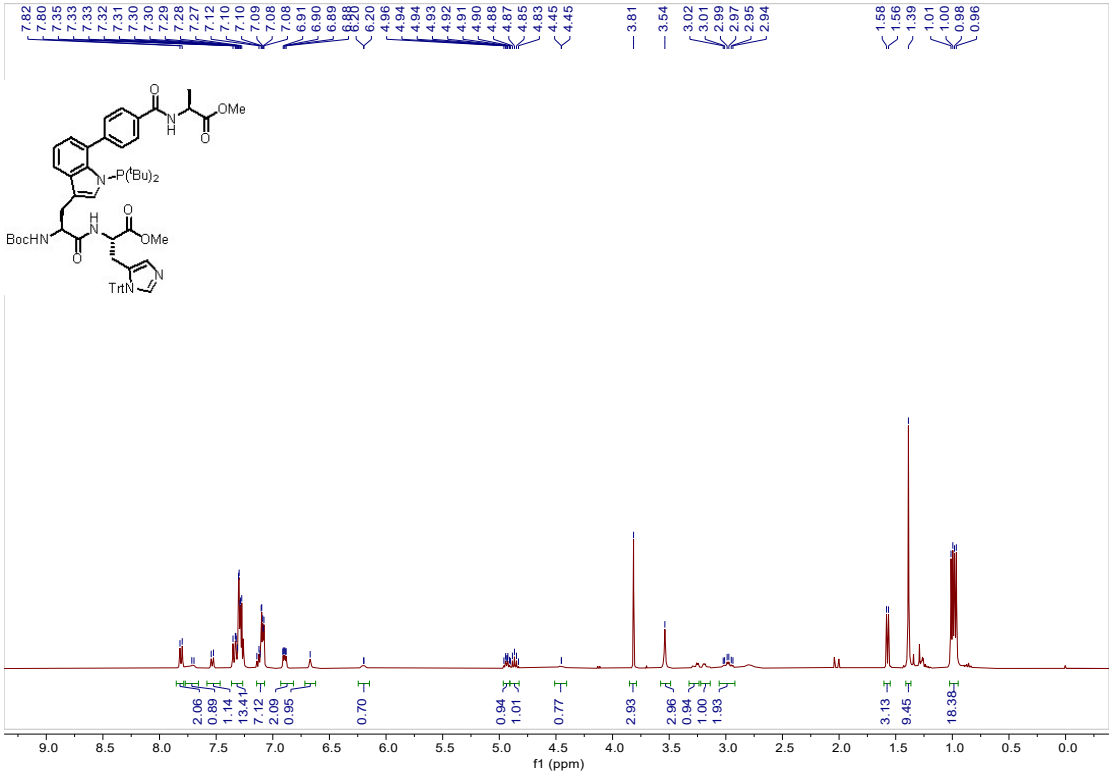
^{1}H NMR (400 MHz, $CDCl_3$) spectrum of **3gz**



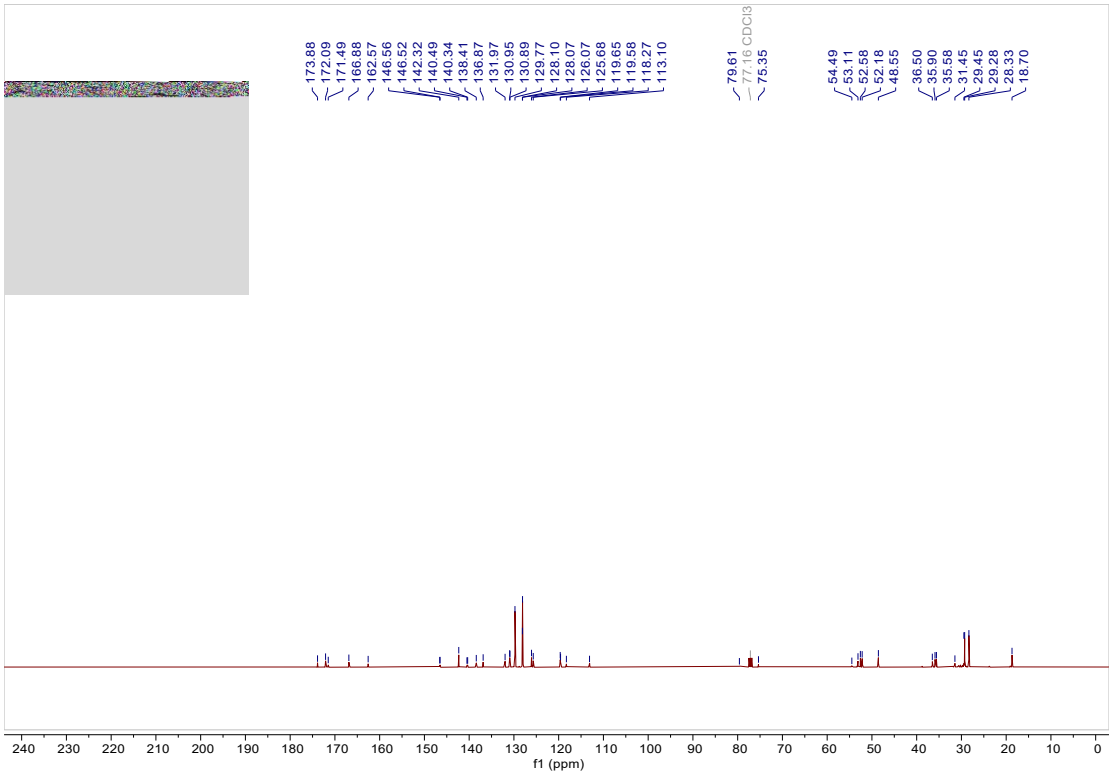
^{13}C NMR (101 MHz, $CDCl_3$) spectrum of **3gz**



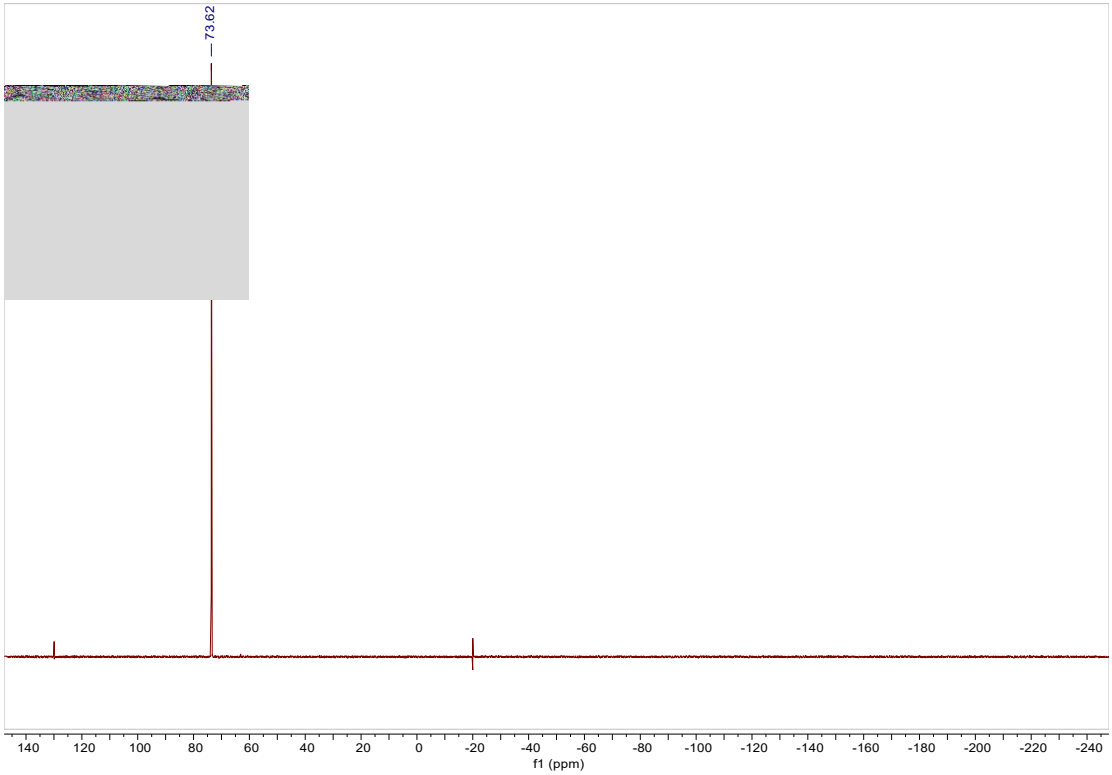
^{31}P NMR (162 MHz, $CDCl_3$) of **3gz**



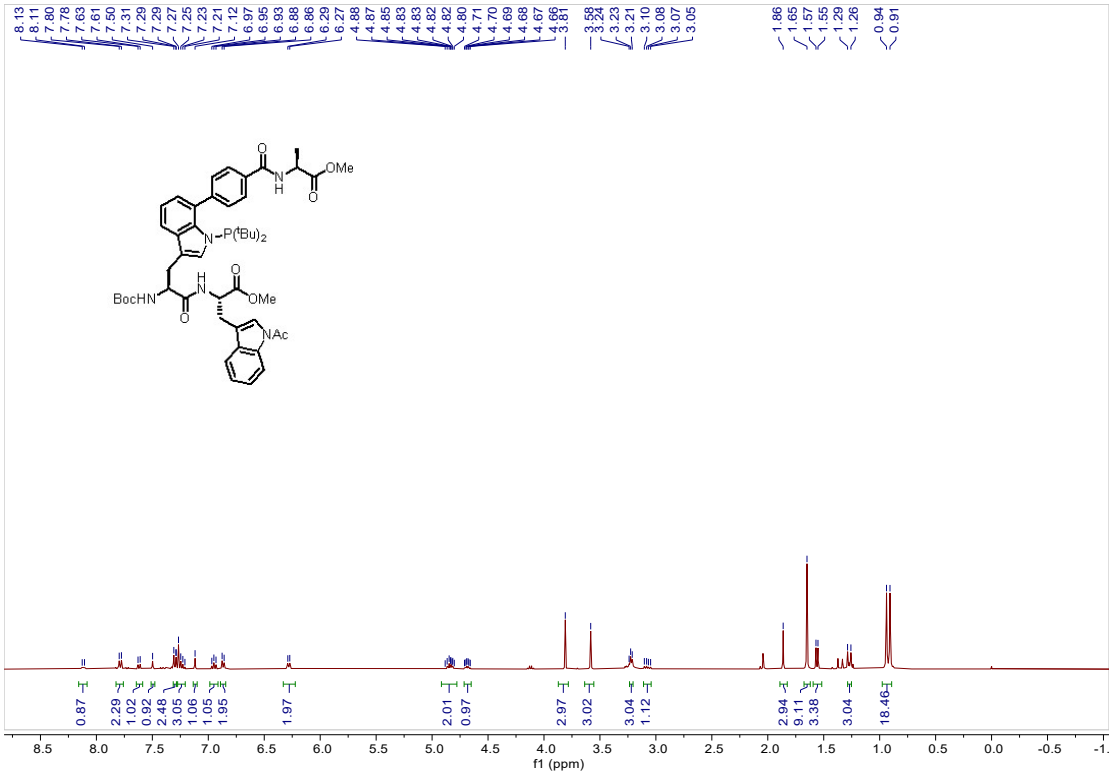
^{1}H NMR (400 MHz, $CDCl_3$) spectrum of **3hz**



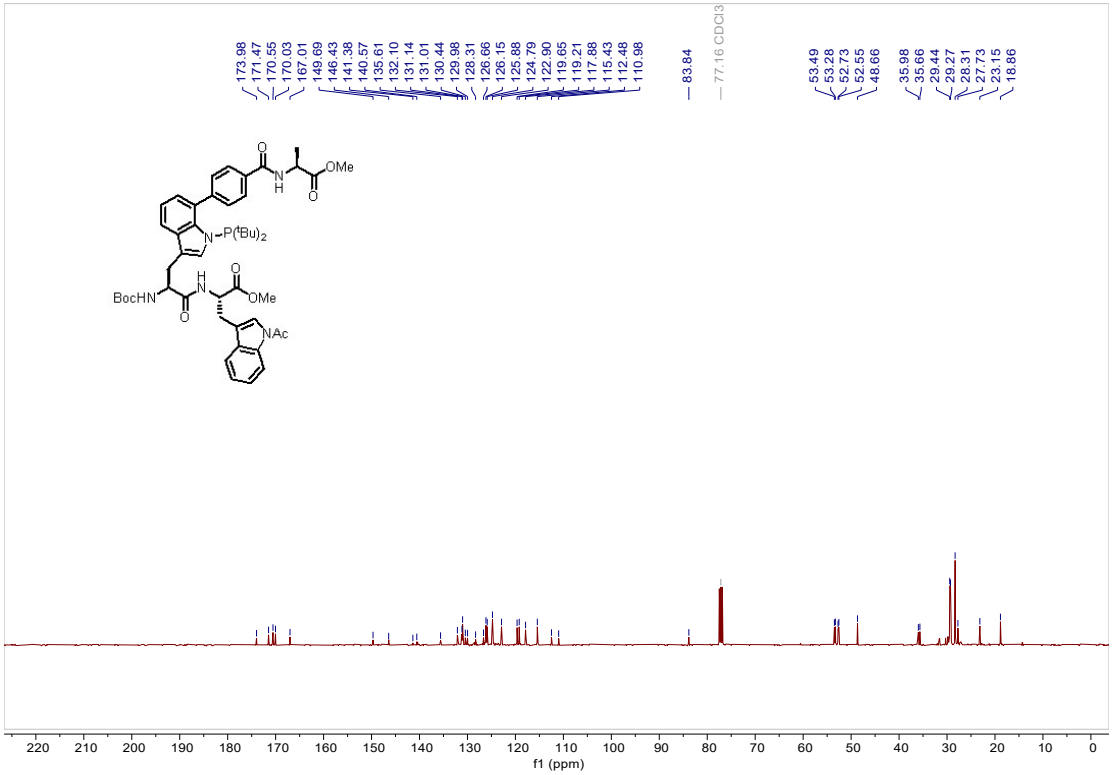
^{13}C NMR (101 MHz, $CDCl_3$) spectrum of **3hz**



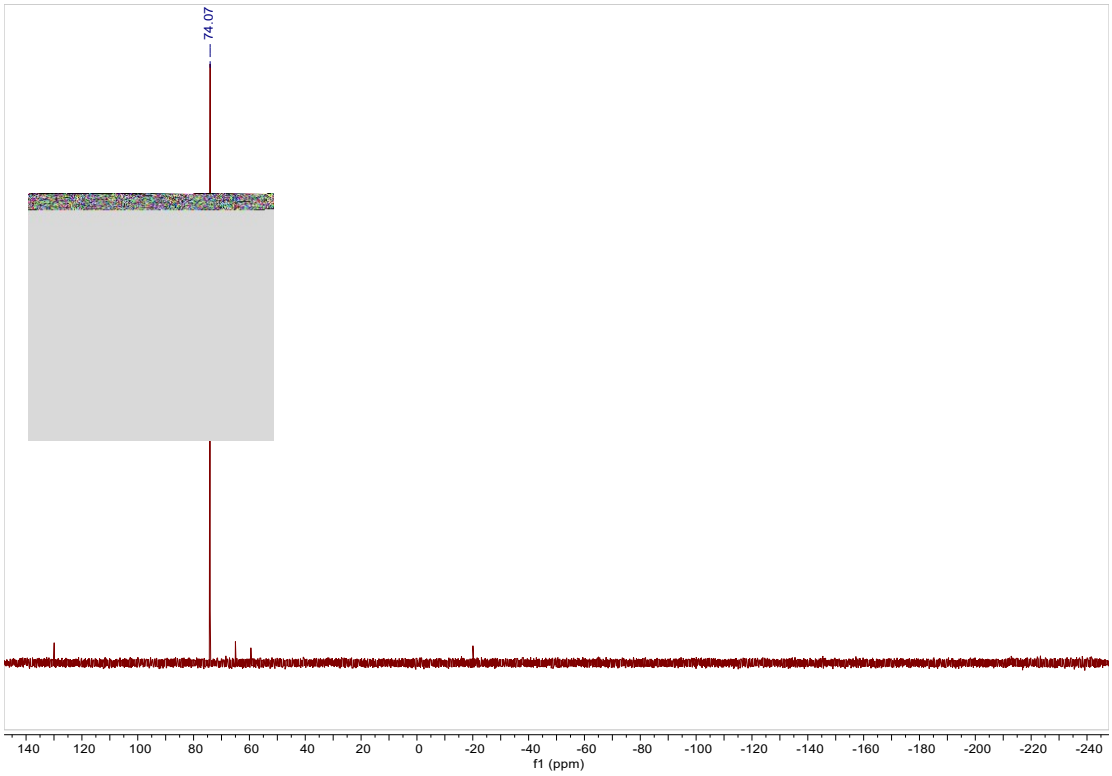
^{31}P NMR (162 MHz, $CDCl_3$) of **3hz**



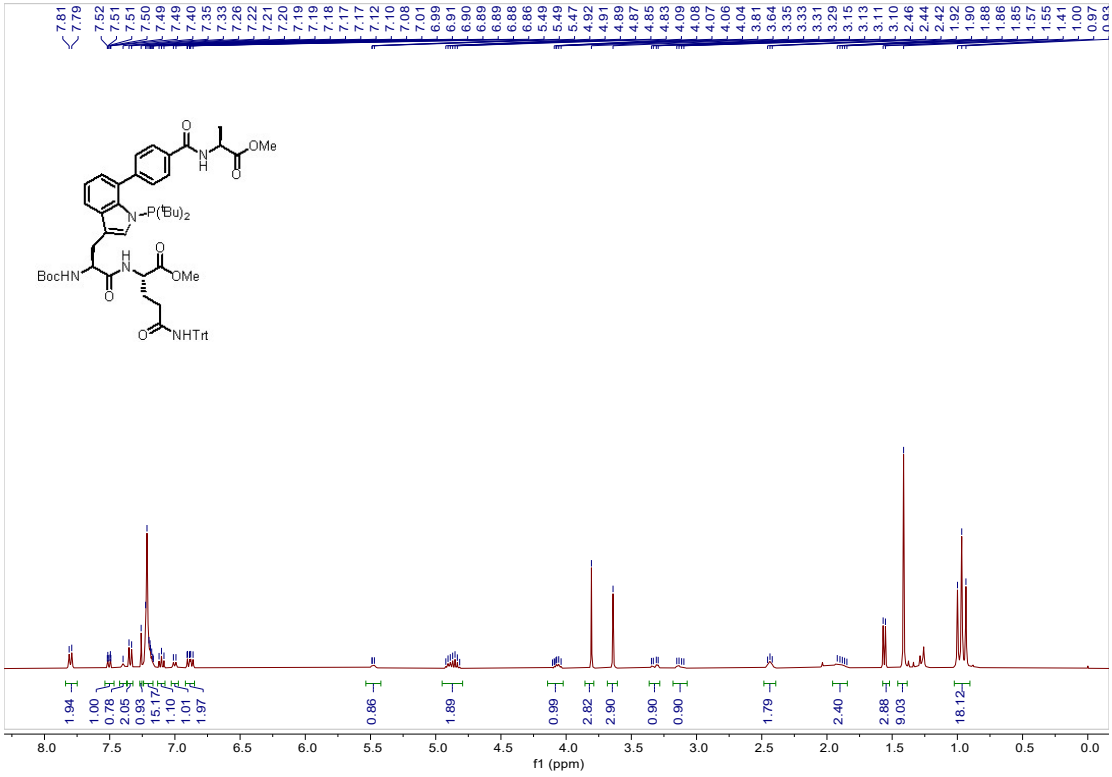
^{1}H NMR (400 MHz, $CDCl_3$) spectrum of **3iz**



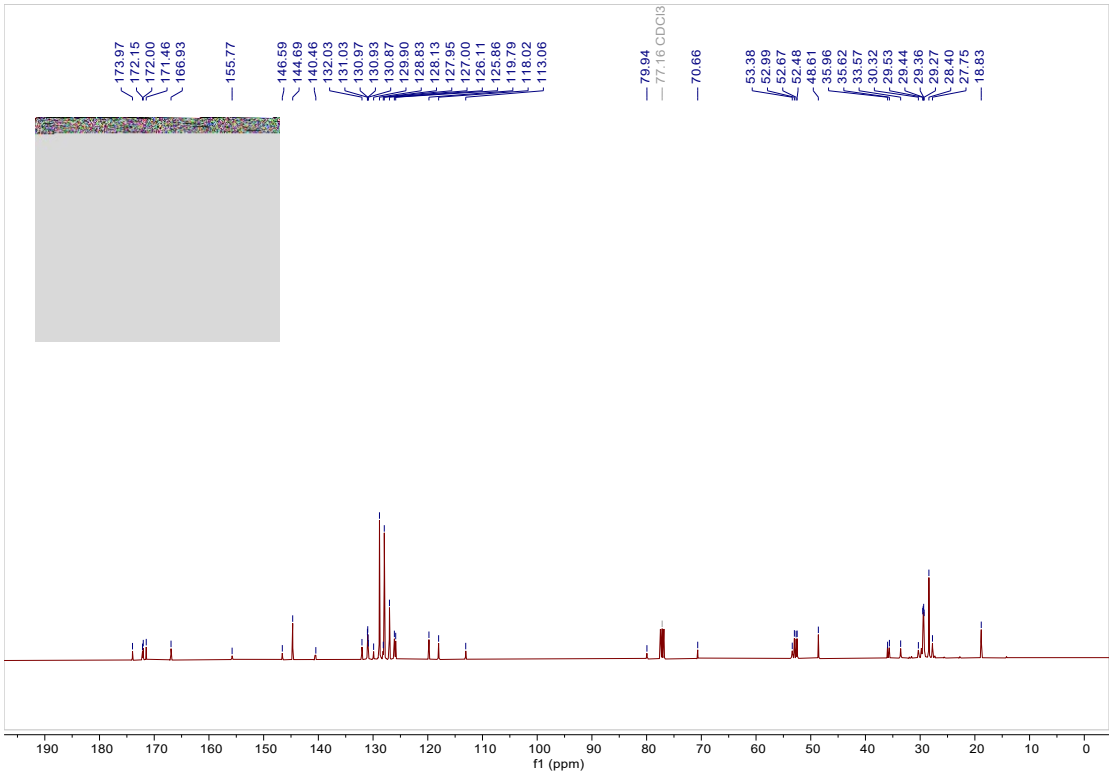
^{13}C NMR (101 MHz, $CDCl_3$) spectrum of **3iz**



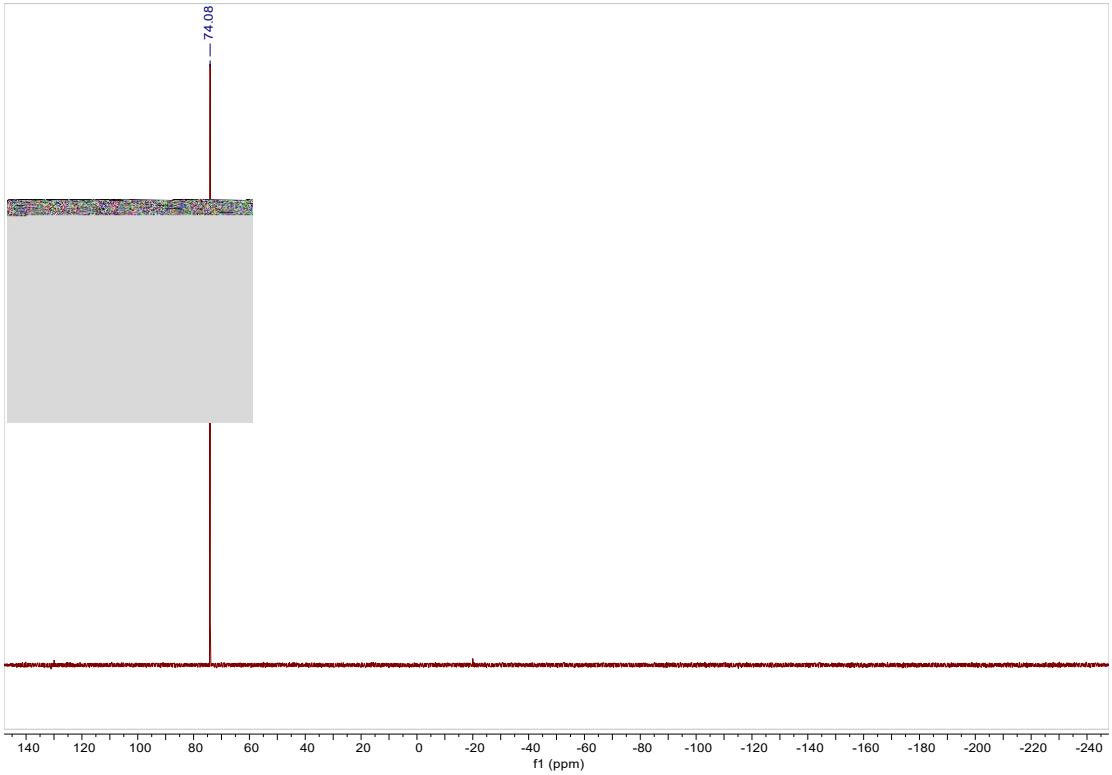
^{31}P NMR (162 MHz, $CDCl_3$) of **3iz**



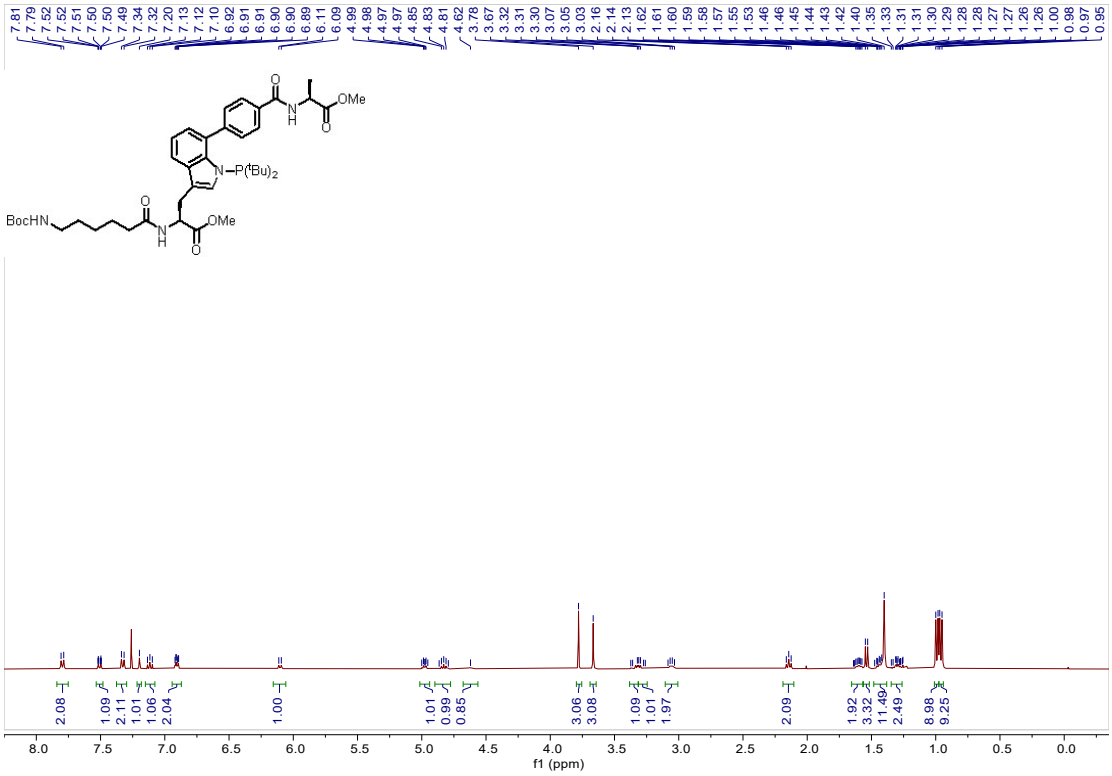
^{1}H NMR (400 MHz, $CDCl_3$) spectrum of **3jz**



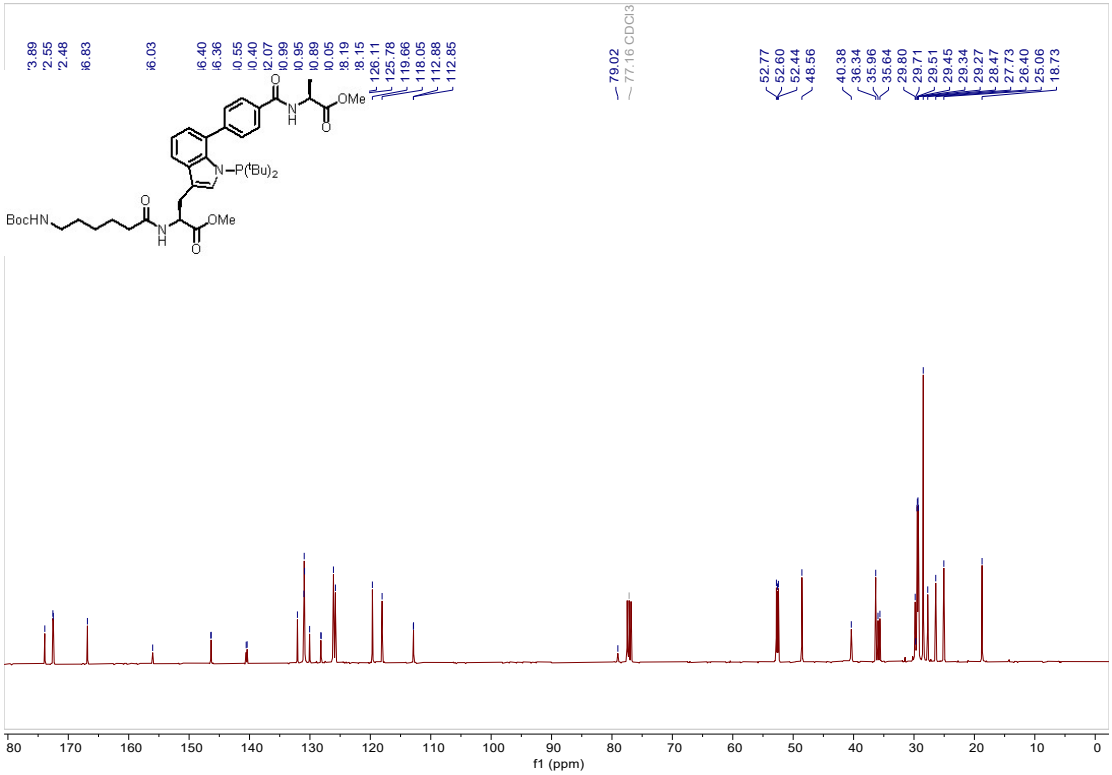
^{13}C NMR (101 MHz, $CDCl_3$) spectrum of **3jz**



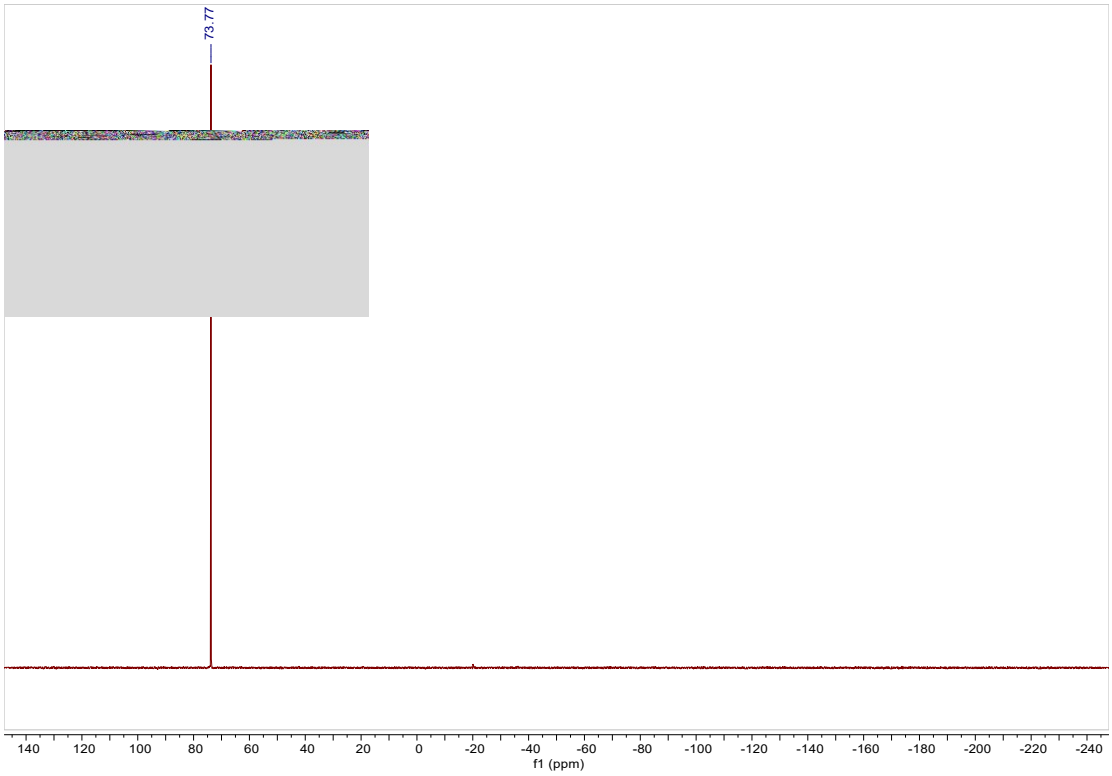
^{31}P NMR (162 MHz, $CDCl_3$) of **3jz**



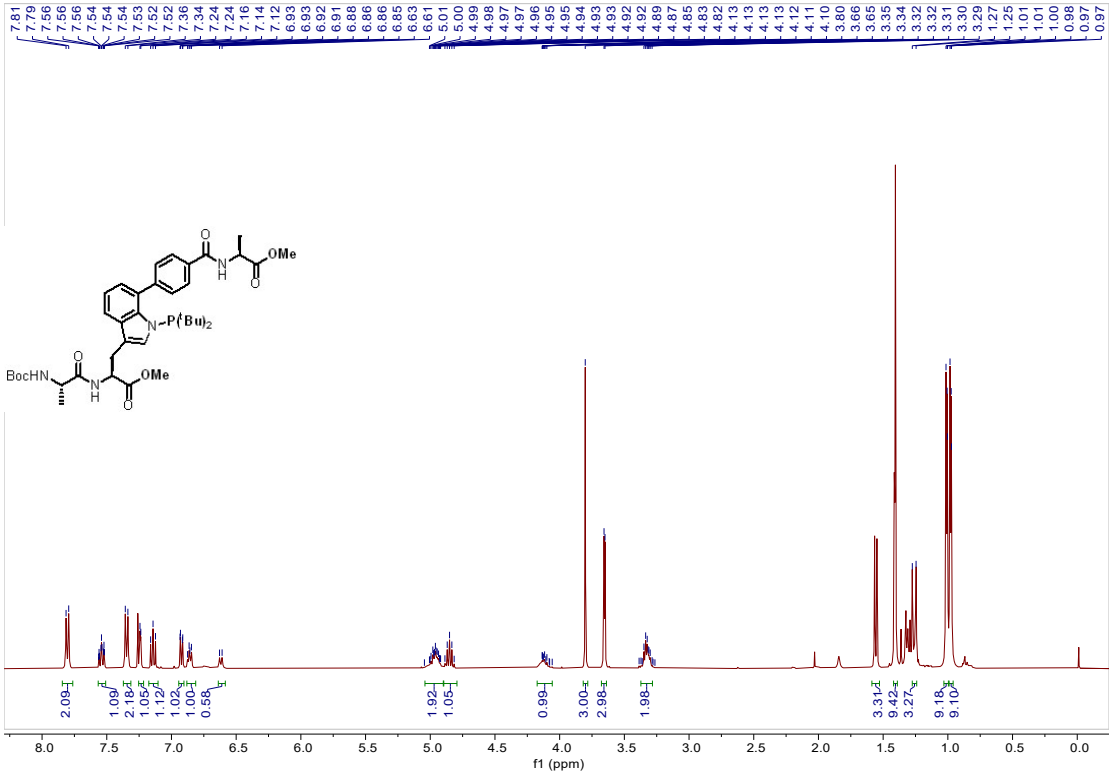
^{1}H NMR (400 MHz, $CDCl_3$) spectrum of **3kz**



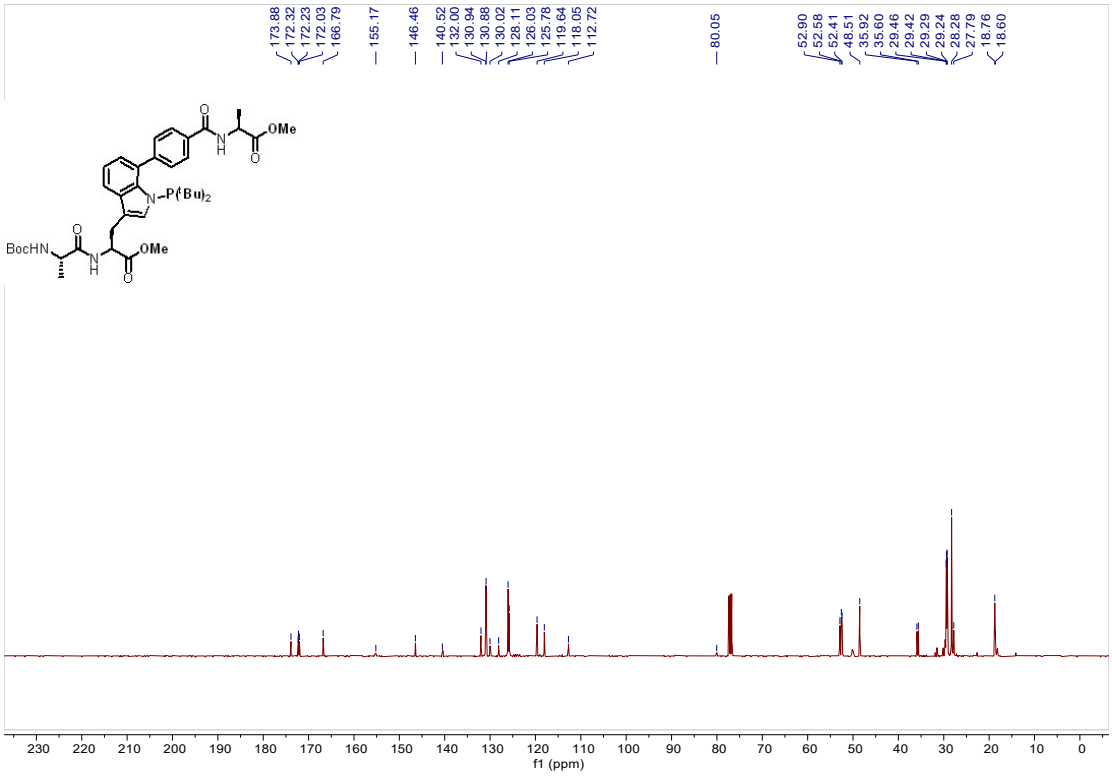
^{13}C NMR (101 MHz, $CDCl_3$) spectrum of **3kz**



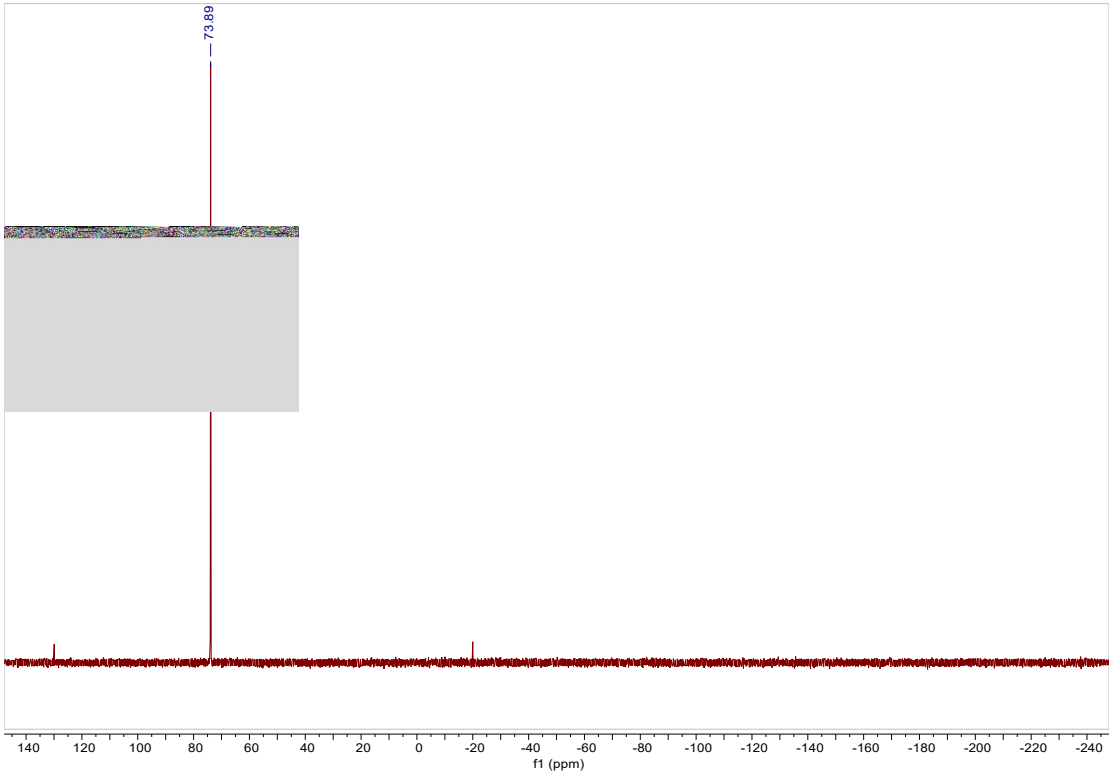
^{31}P NMR (162 MHz, $CDCl_3$) of **3kz**



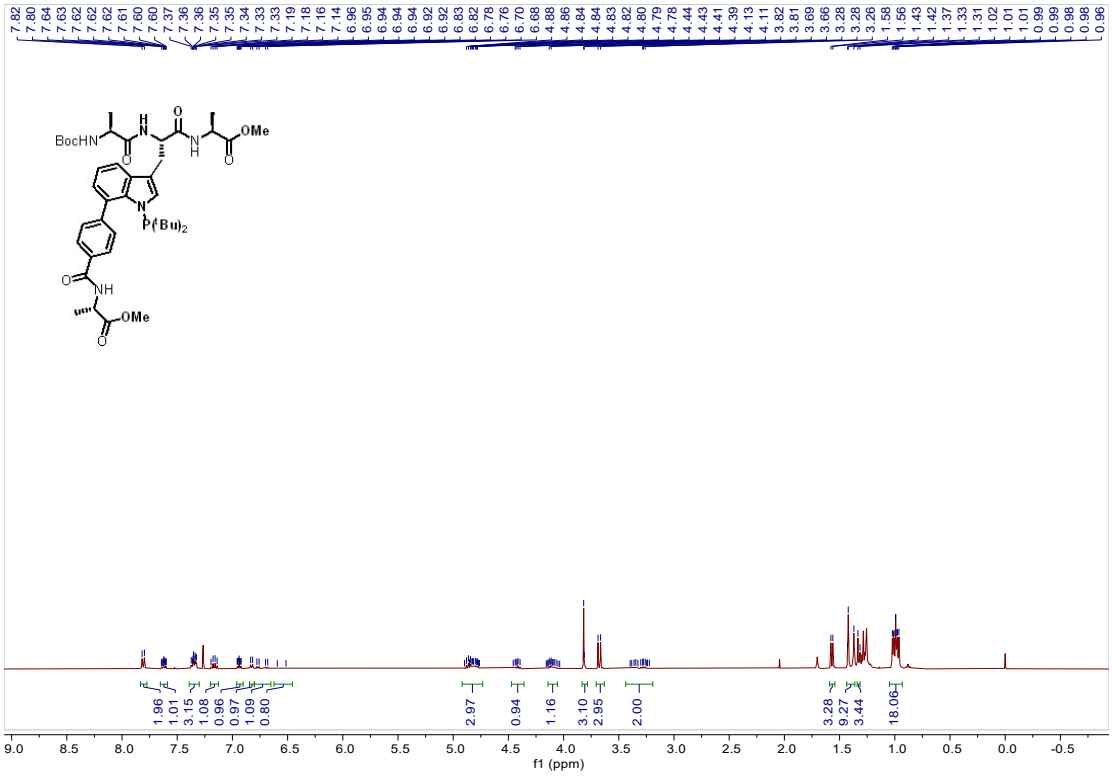
^{1}H NMR (400 MHz, $CDCl_3$) spectrum of **3lz**



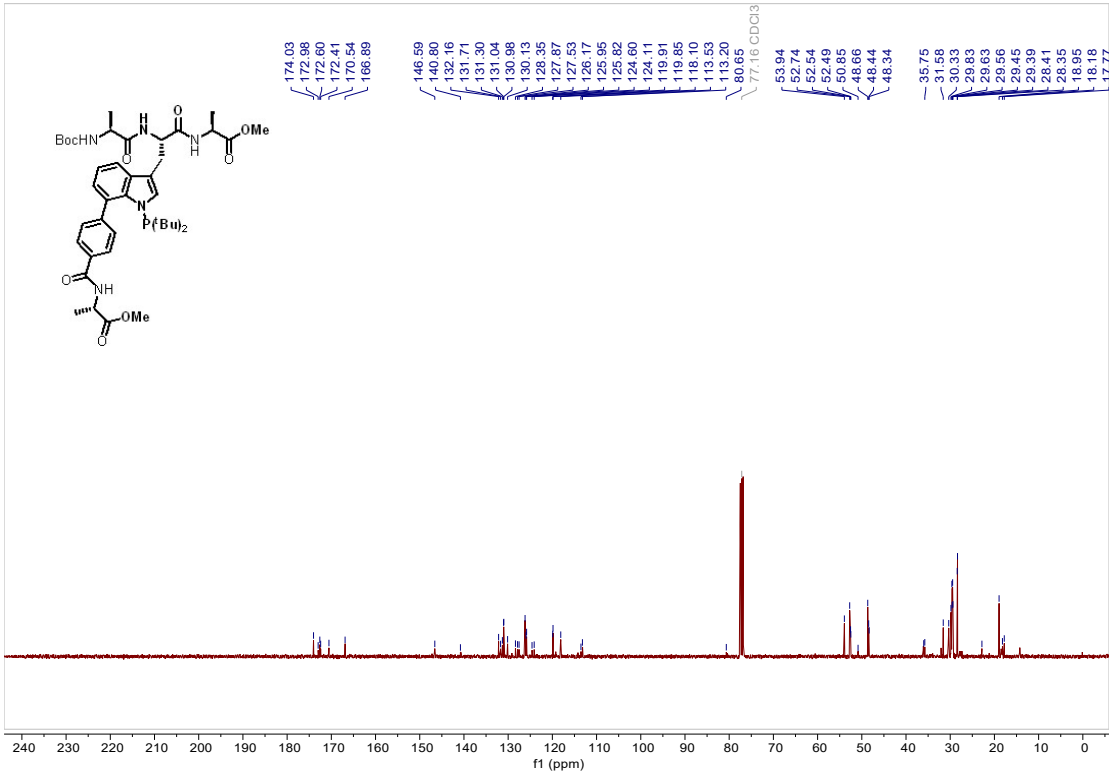
^{13}C NMR (101 MHz, $CDCl_3$) spectrum of **3ly**



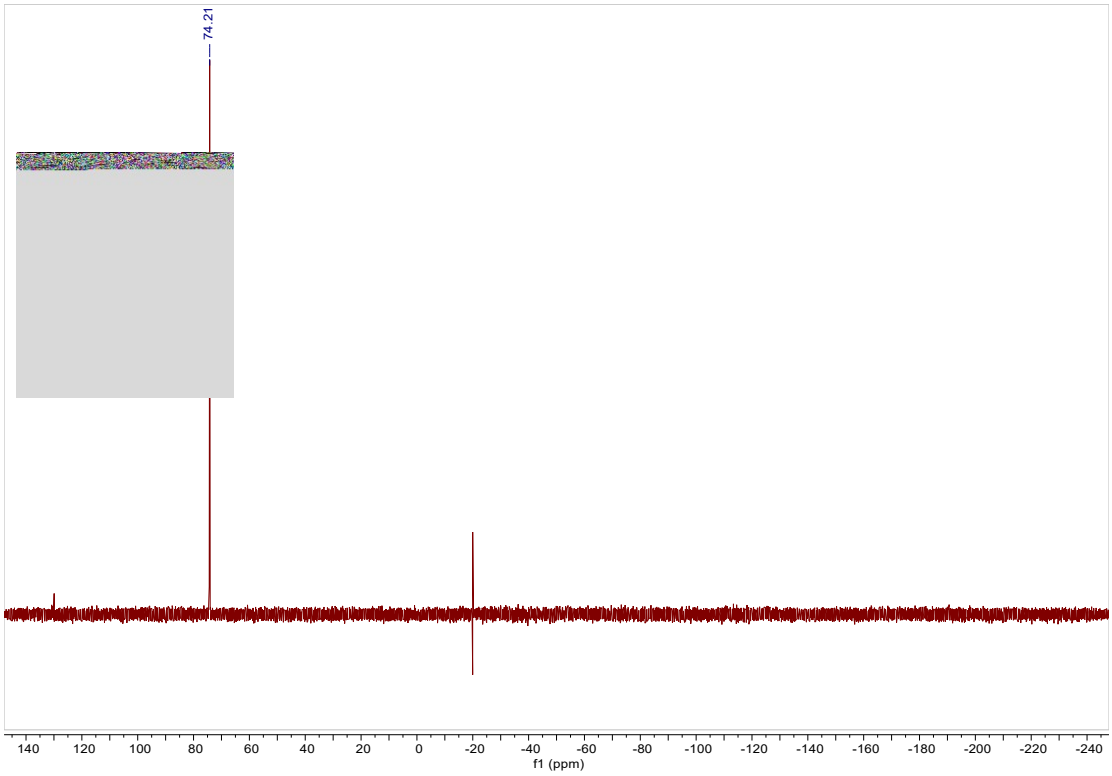
^{31}P NMR (162 MHz, $CDCl_3$) of **3lz**



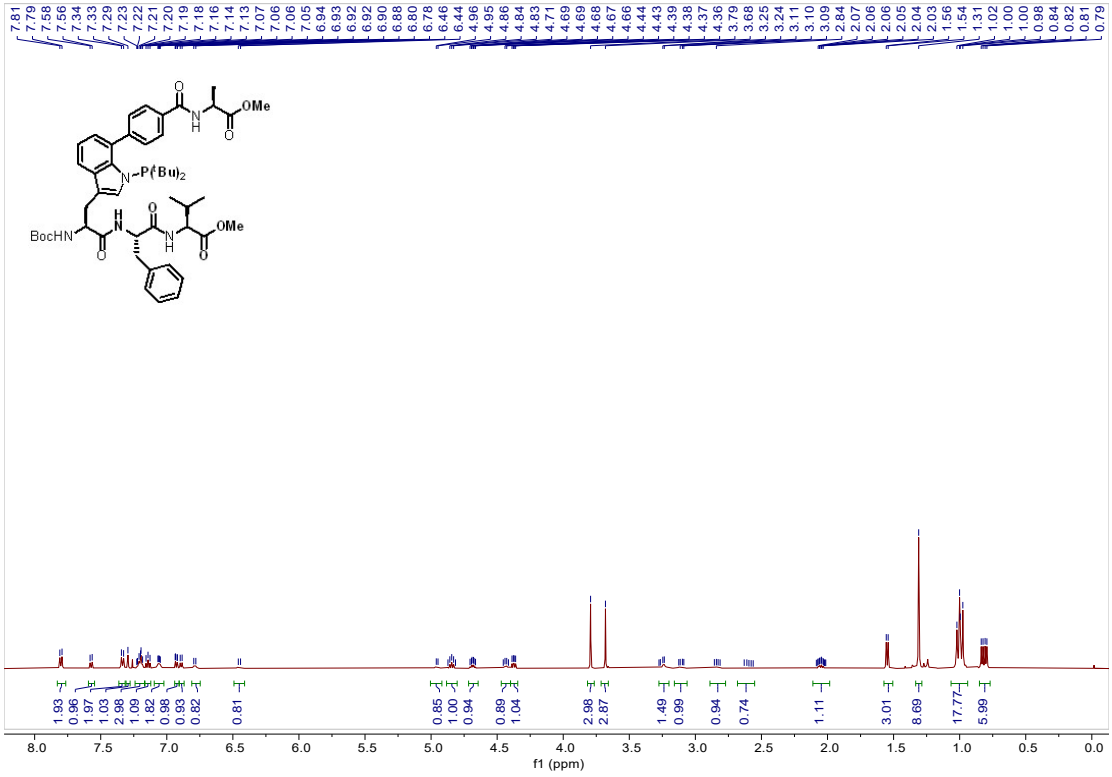
^{1}H NMR (400 MHz, $CDCl_3$) spectrum of **3mz**



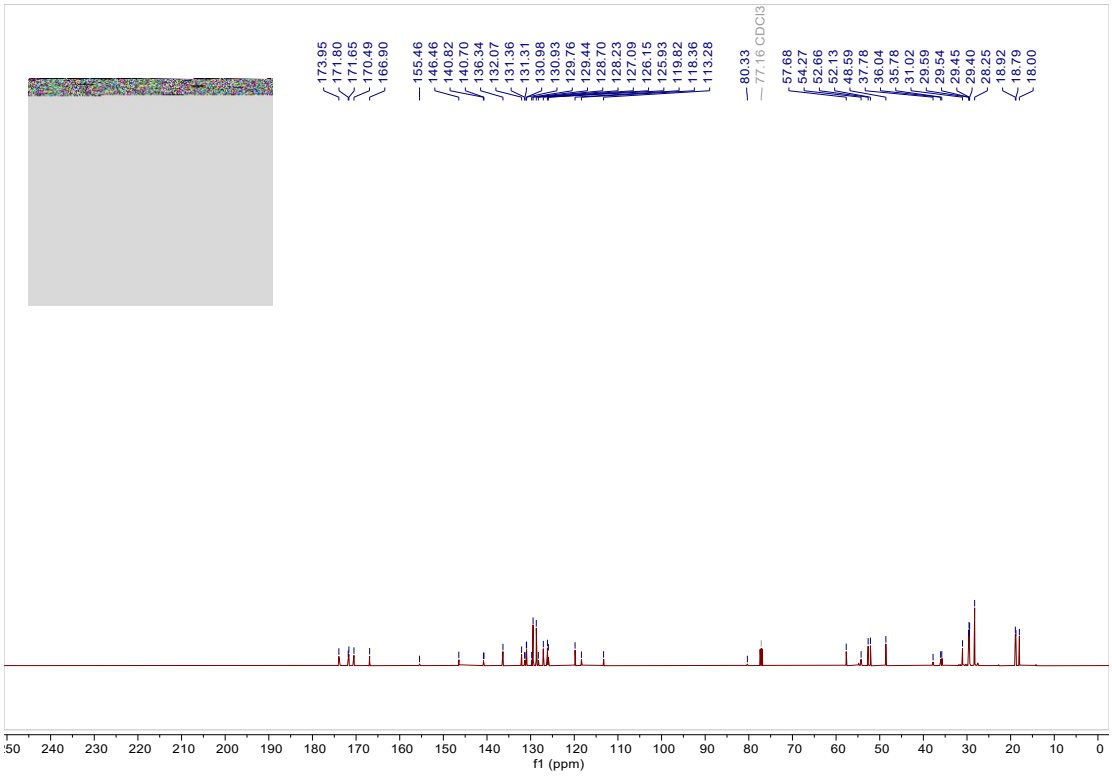
^{13}C NMR (101 MHz, $CDCl_3$) spectrum of **3mz**



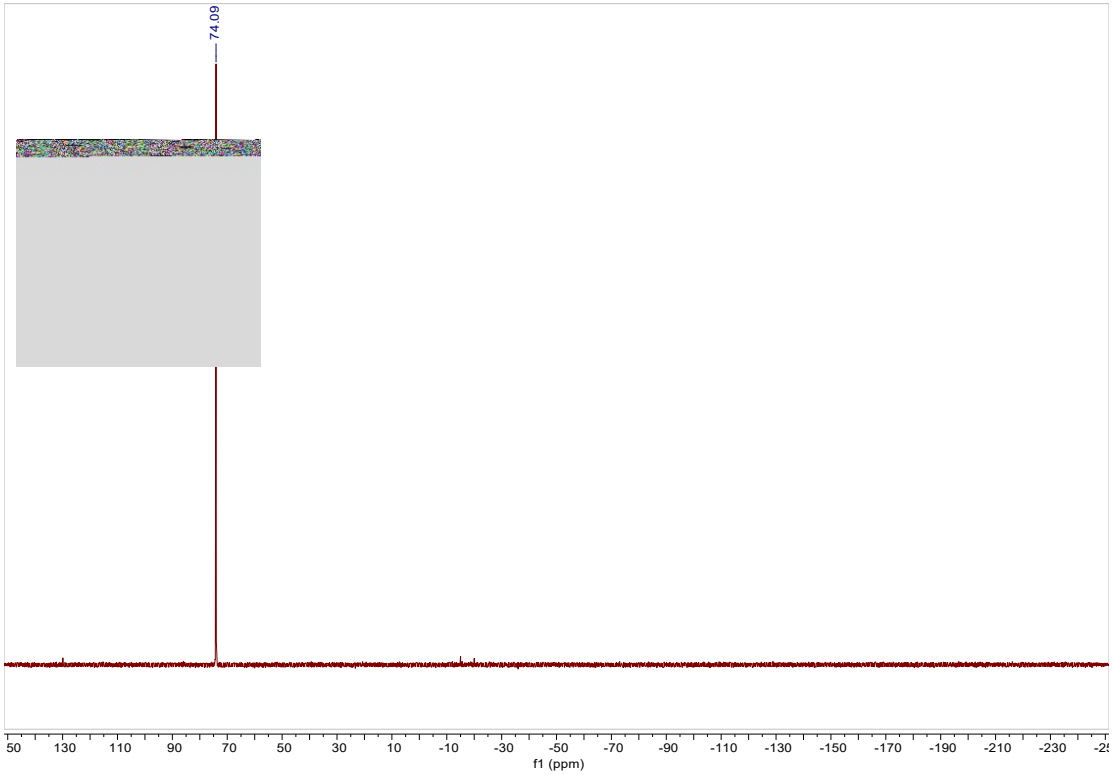
^{31}P NMR (162 MHz, $CDCl_3$) of **3mz**



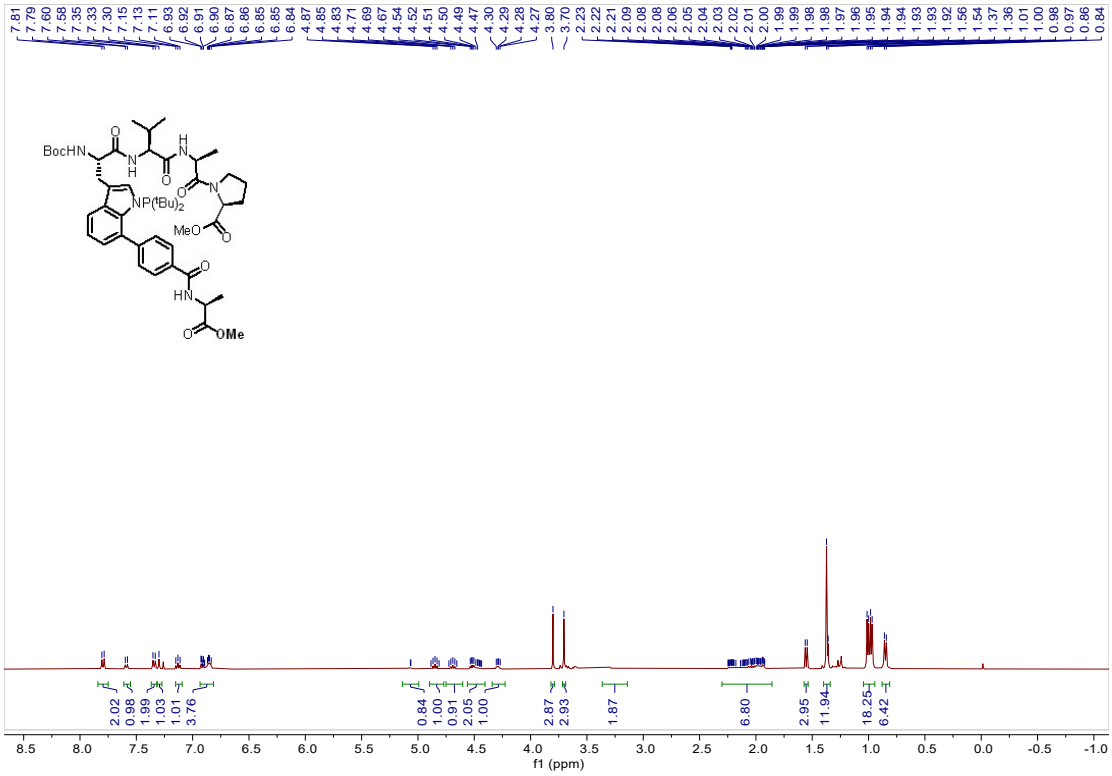
^{1}H NMR (400 MHz, $CDCl_3$) spectrum of **3nz**



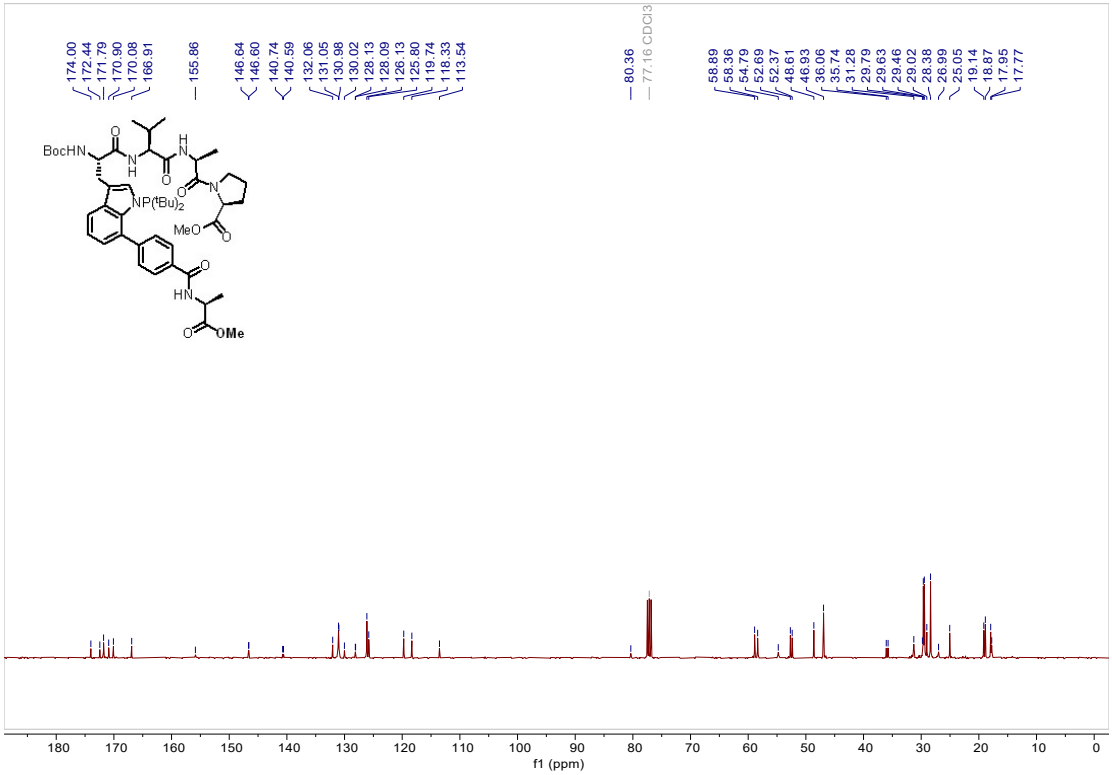
^{13}C NMR (101 MHz, $CDCl_3$) spectrum of **3nz**



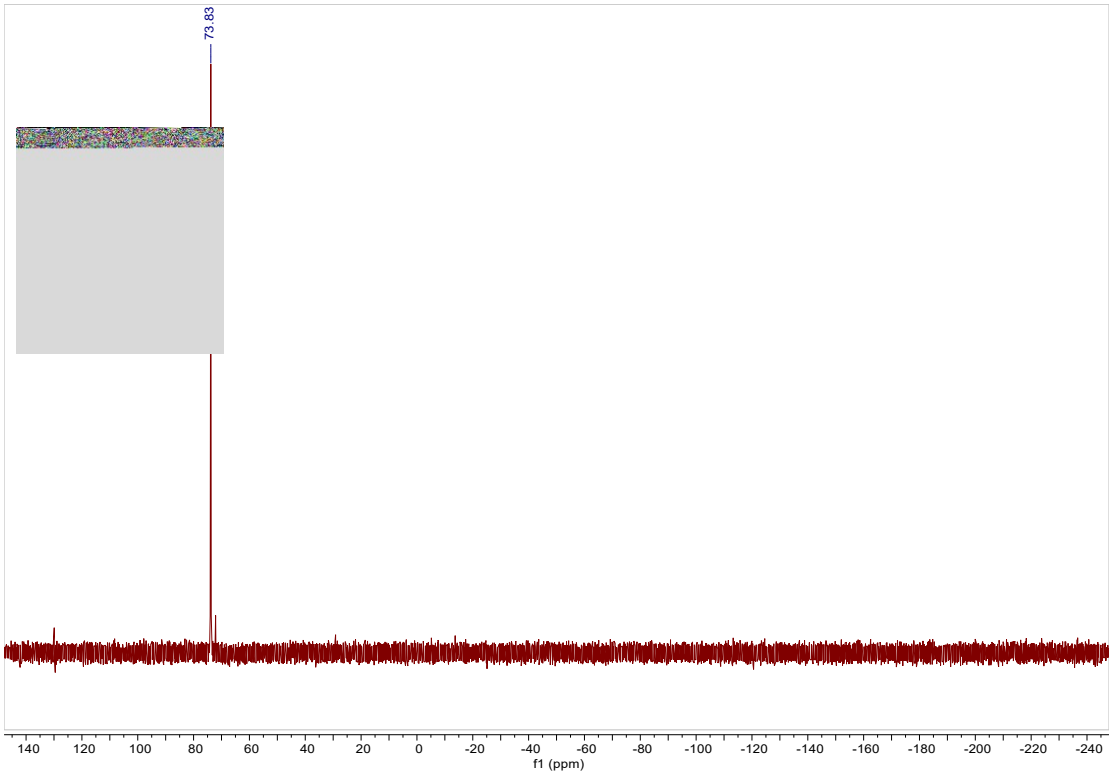
^{31}P NMR (162 MHz, $CDCl_3$) of **3nz**



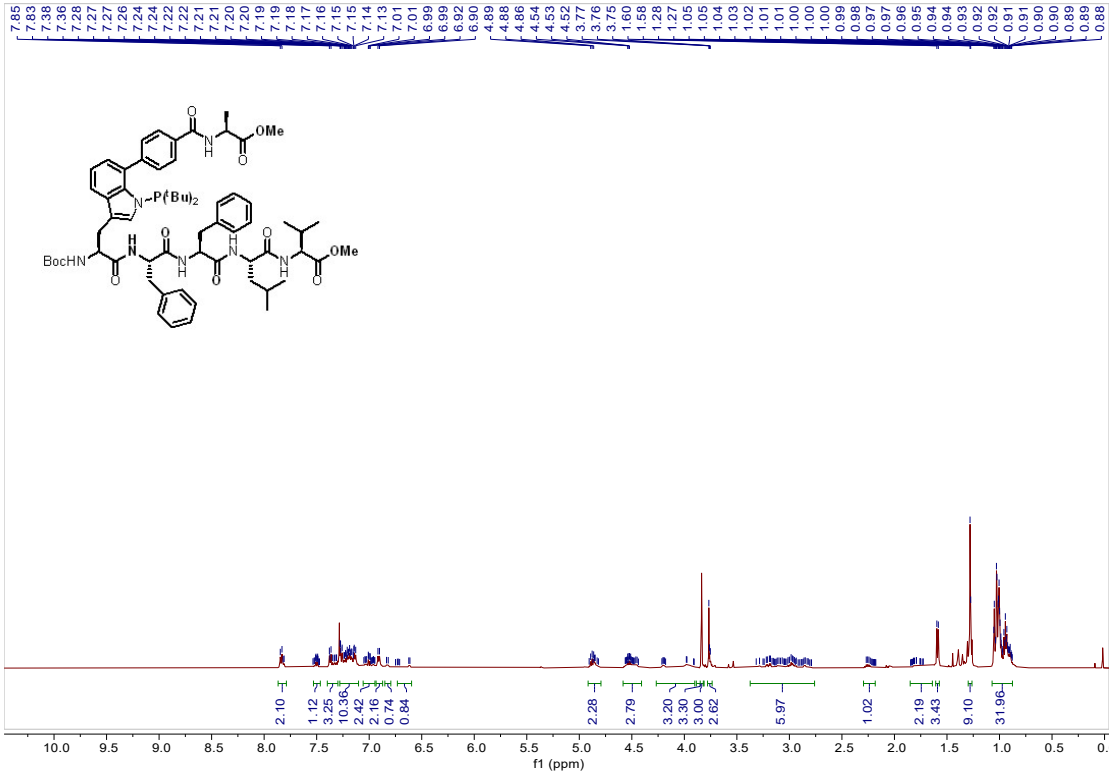
^{1}H NMR (400 MHz, $CDCl_3$) spectrum of **3oz**



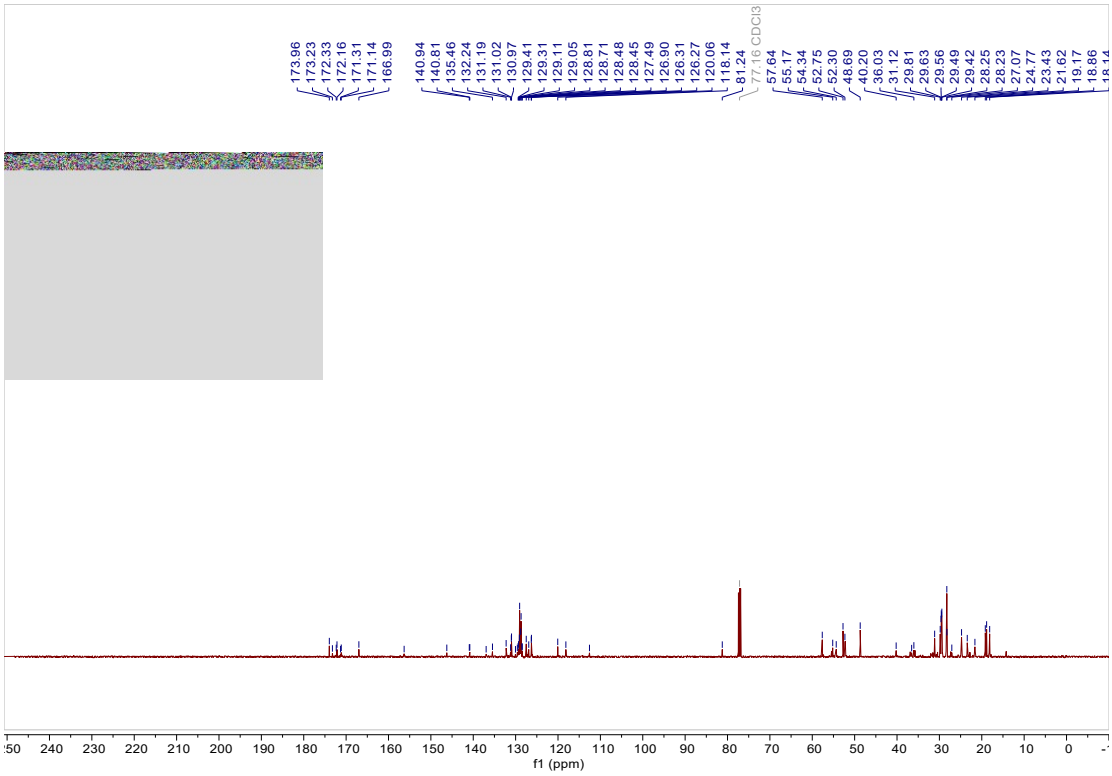
^{13}C NMR (101 MHz, $CDCl_3$) spectrum of **3oz**



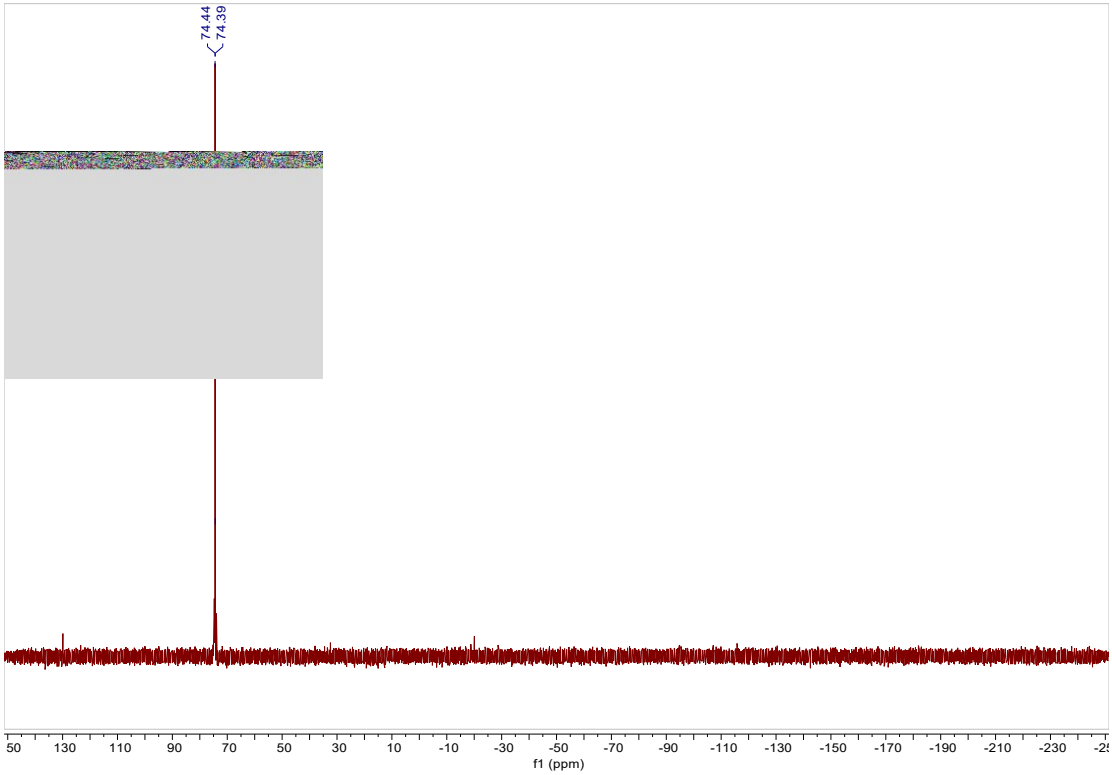
^{31}P NMR (162 MHz, $CDCl_3$) of **3oz**



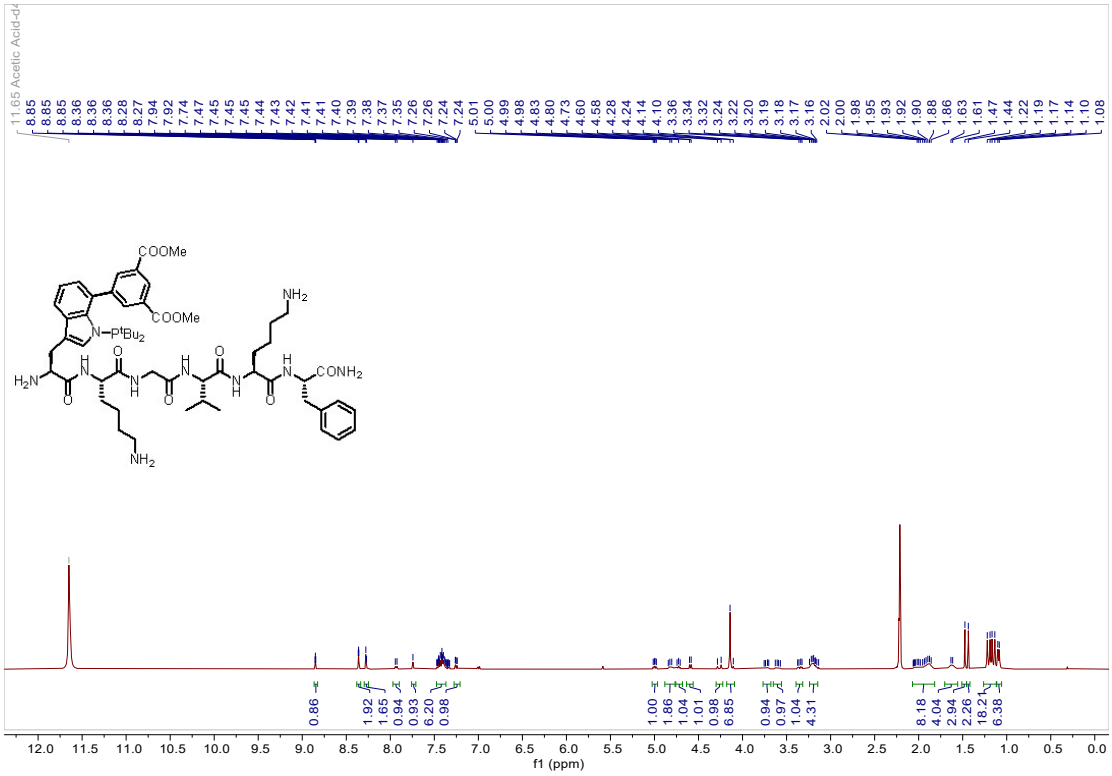
^{1}H NMR (400 MHz, $CDCl_3$) spectrum of **3pz**



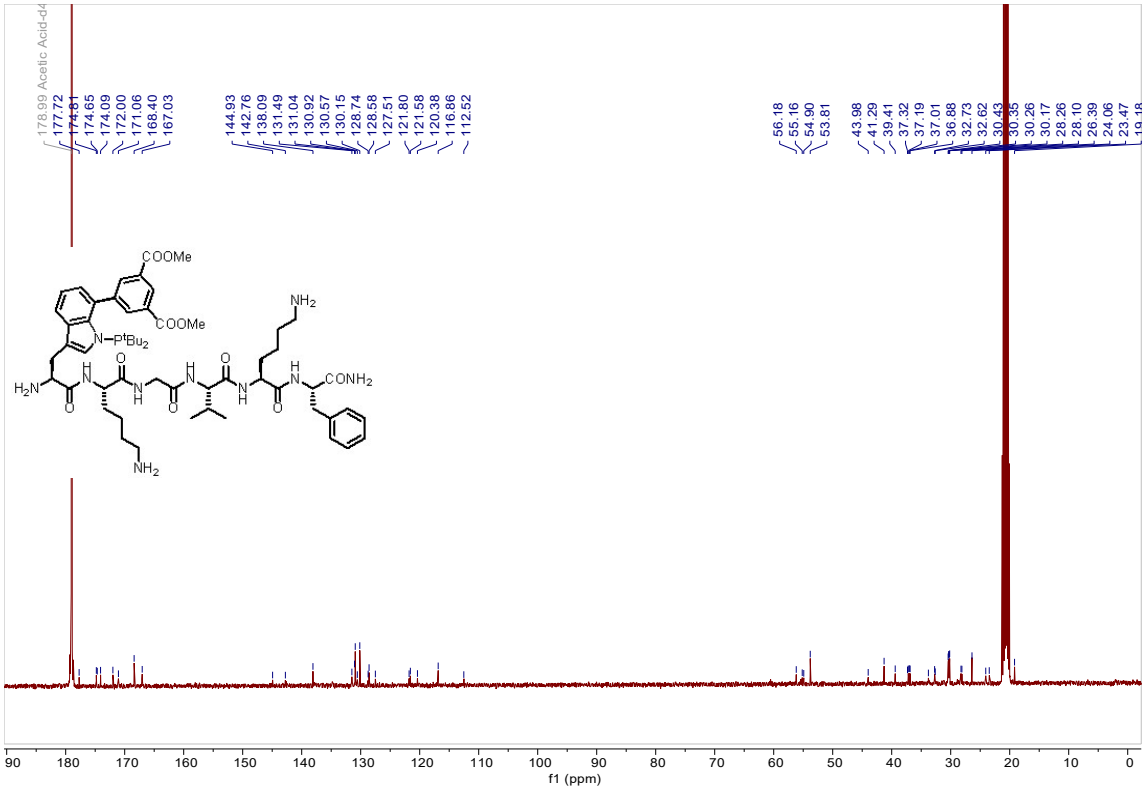
^{13}C NMR (101 MHz, $CDCl_3$) spectrum of **3pz**



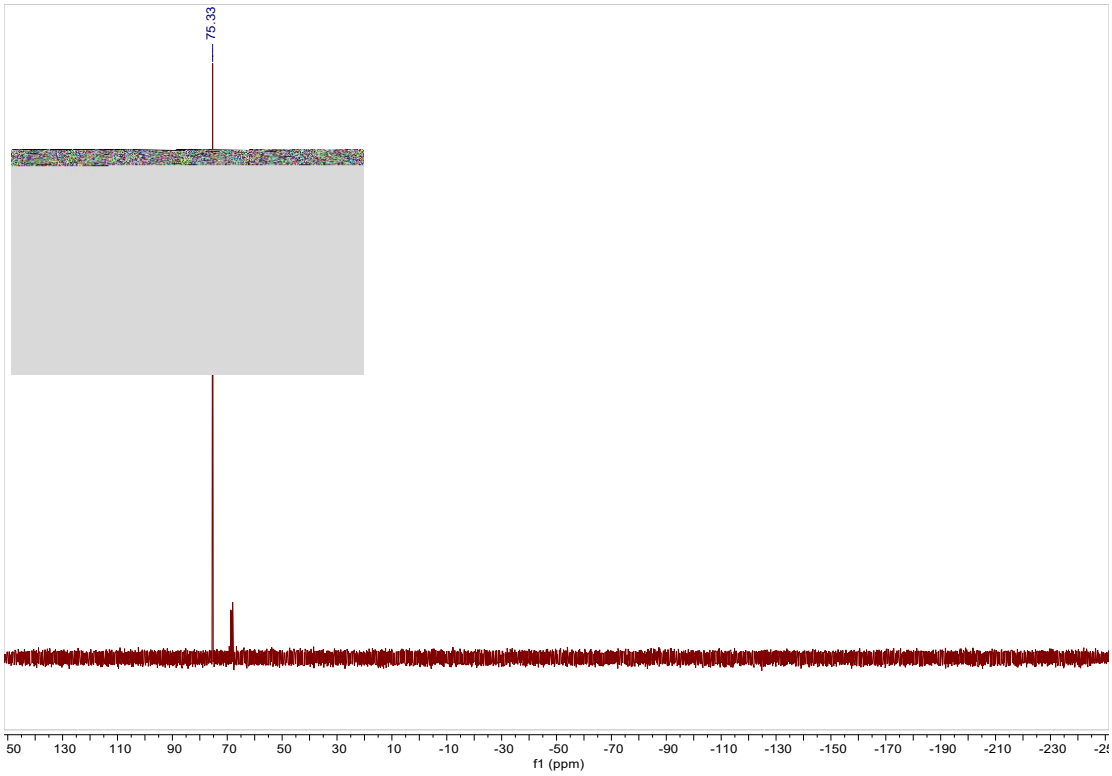
^{31}P NMR (162 MHz, $CDCl_3$) of **3pz**



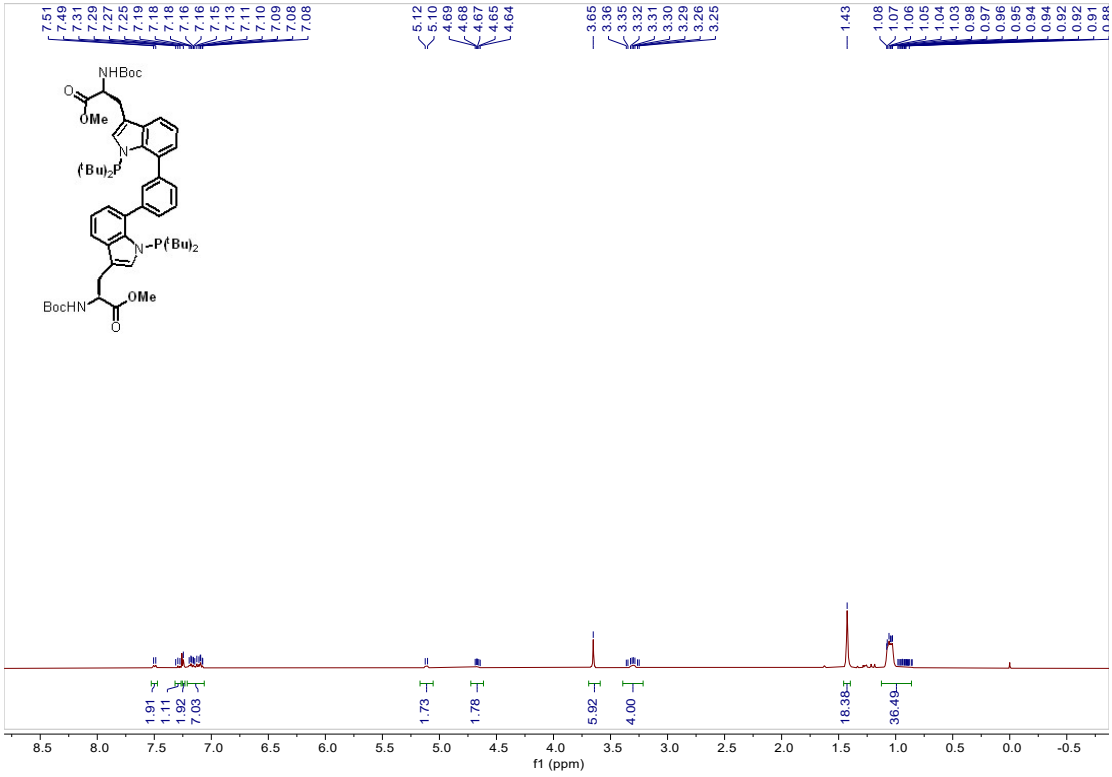
^{1}H NMR (400 MHz, Acetic Acid-d_4) spectrum of **P3ai**



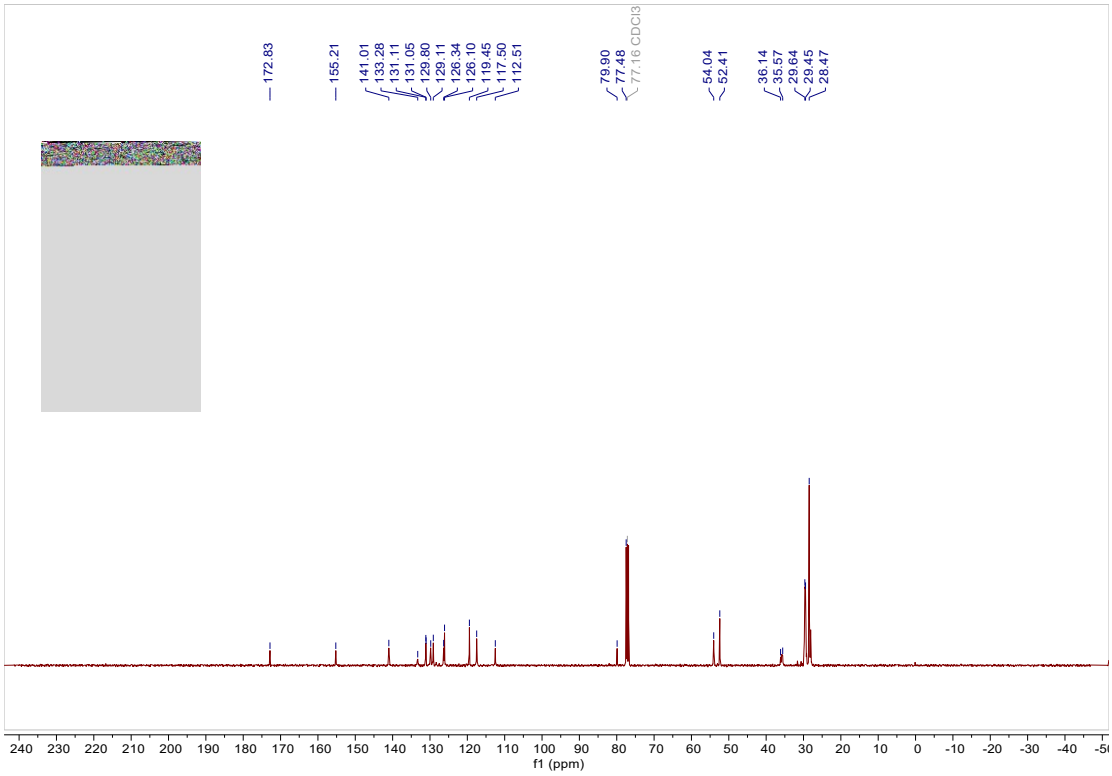
^{13}C NMR (101 MHz, Acetic Acid-d_4) spectrum of **P3ai**



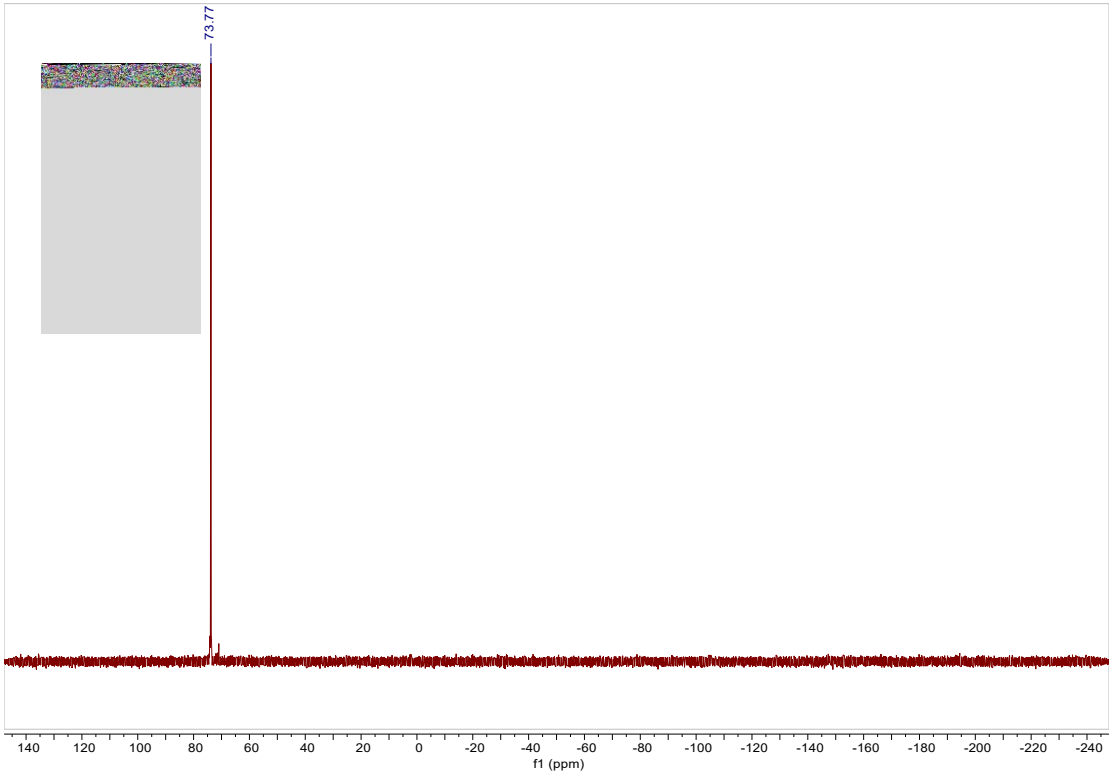
^{31}P NMR (162 MHz, Acetic Acid-d_4) of **P3ai**



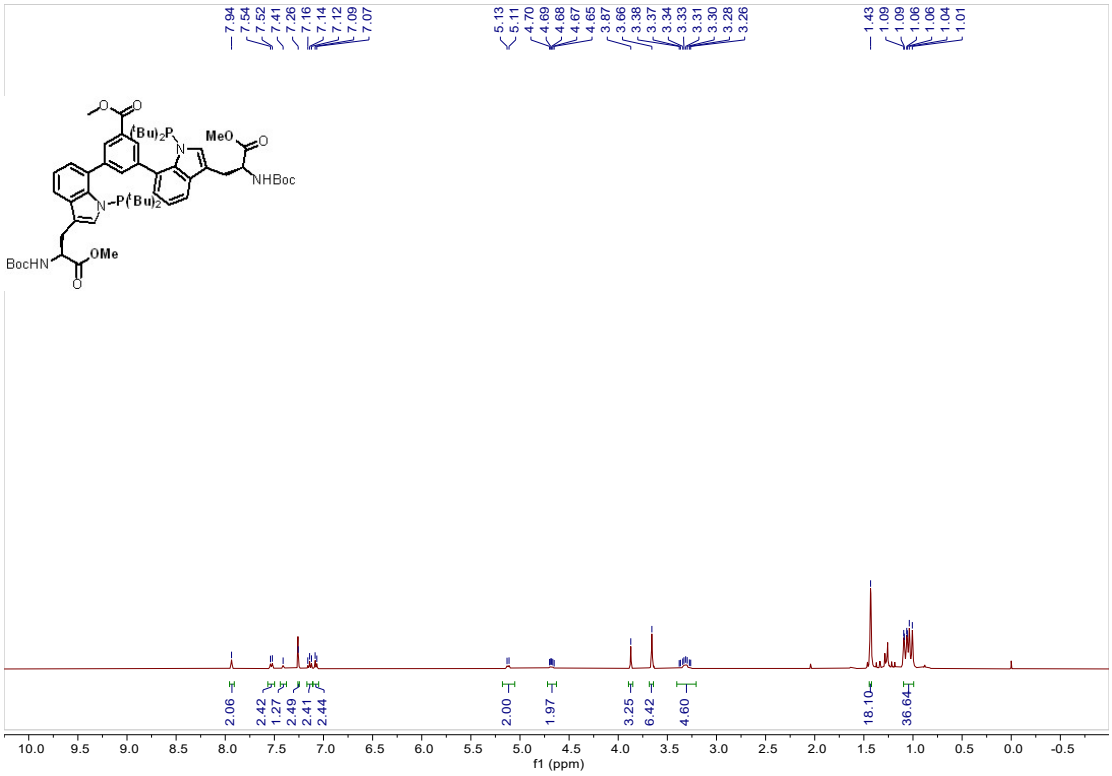
^{1}H NMR (400 MHz, $CDCl_3$) spectrum of **4aa**



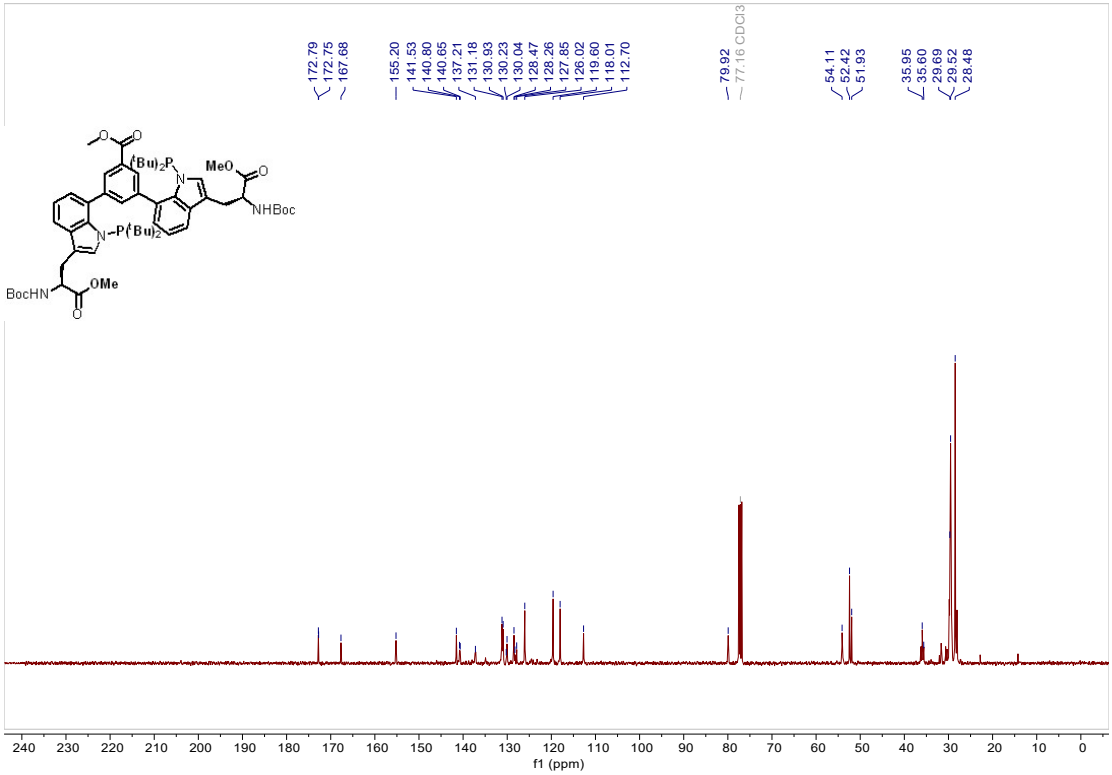
^{13}C NMR (101 MHz, $CDCl_3$) spectrum of **4aa**



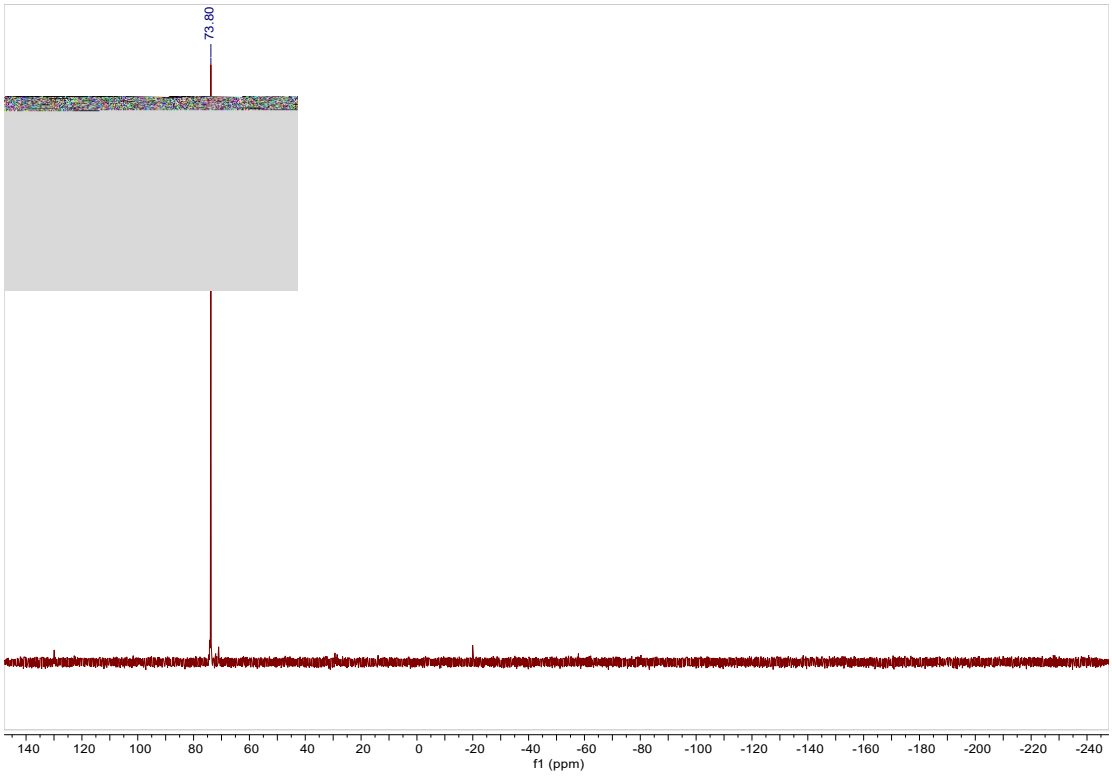
^{31}P NMR (162 MHz, $CDCl_3$) of **4aa**



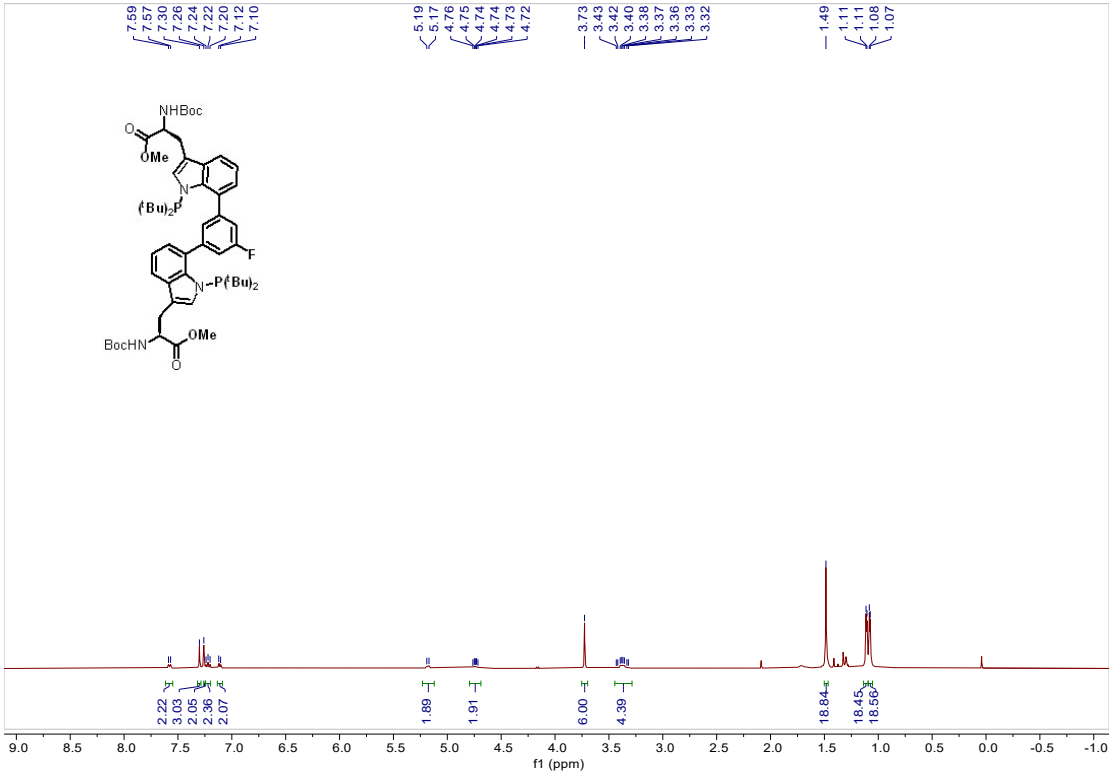
^{1}H NMR (400 MHz, $CDCl_3$) spectrum of **4ab**



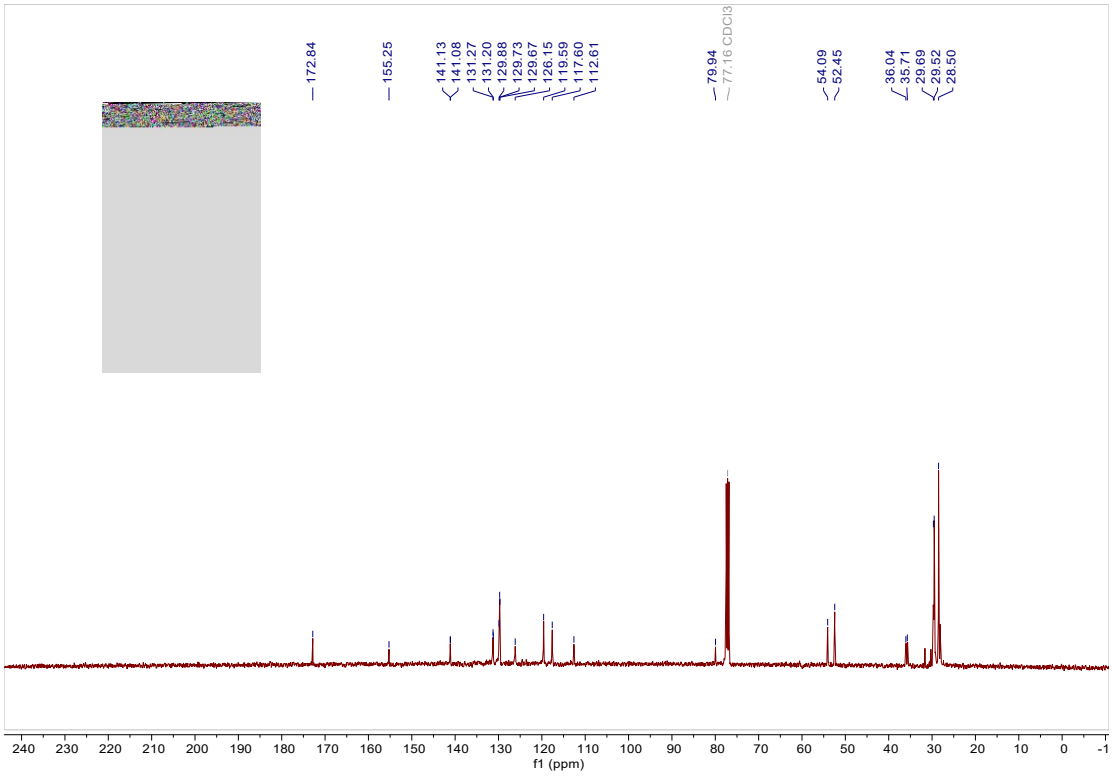
^{13}C NMR (101 MHz, $CDCl_3$) spectrum of **4ab**



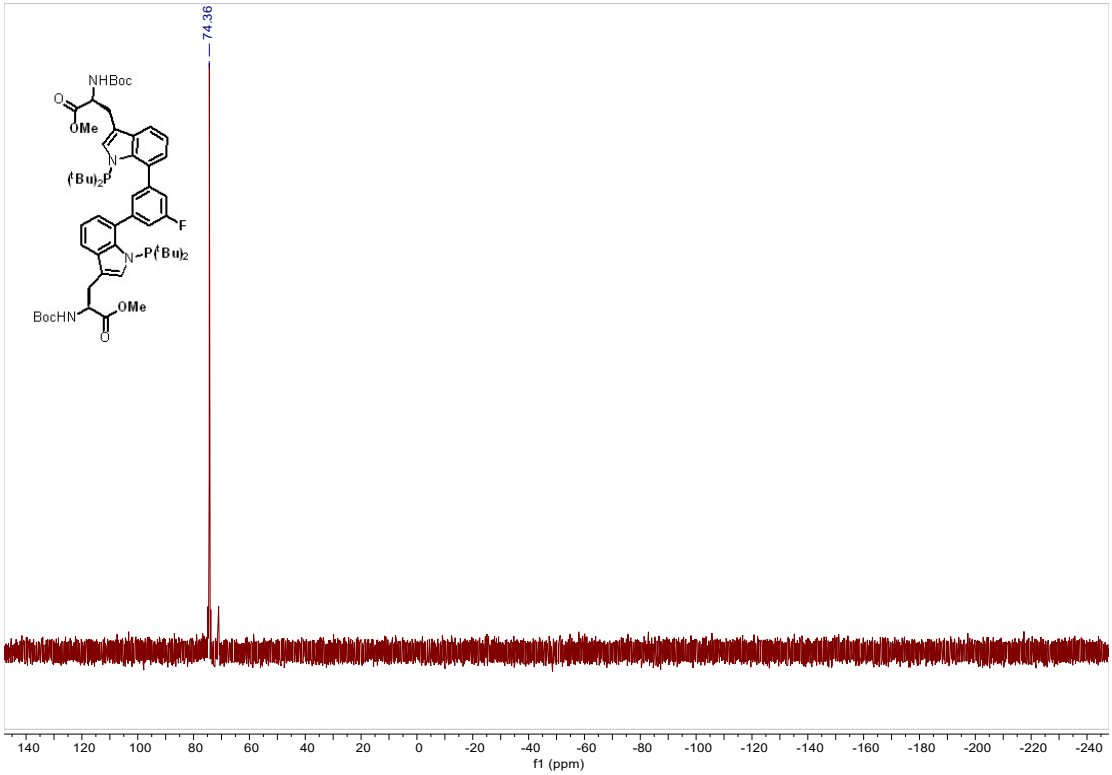
^{31}P NMR (162 MHz, $CDCl_3$) of **4ab**



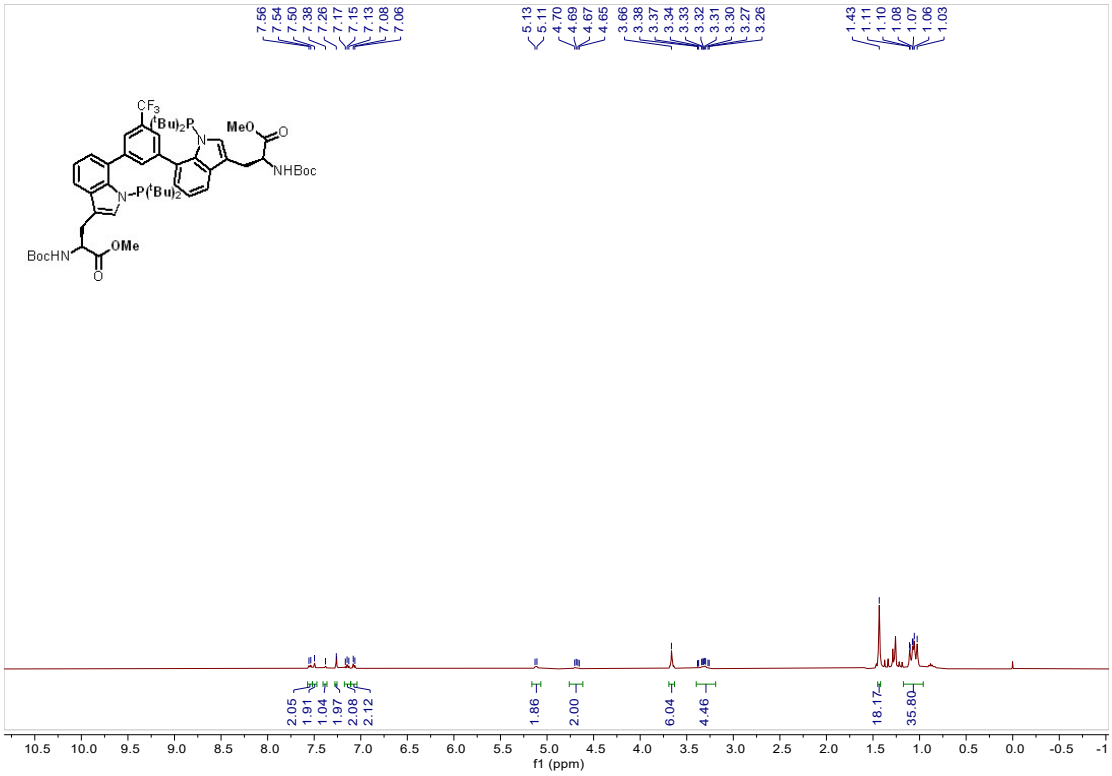
^{1}H NMR (400 MHz, $CDCl_3$) spectrum of **4ac**



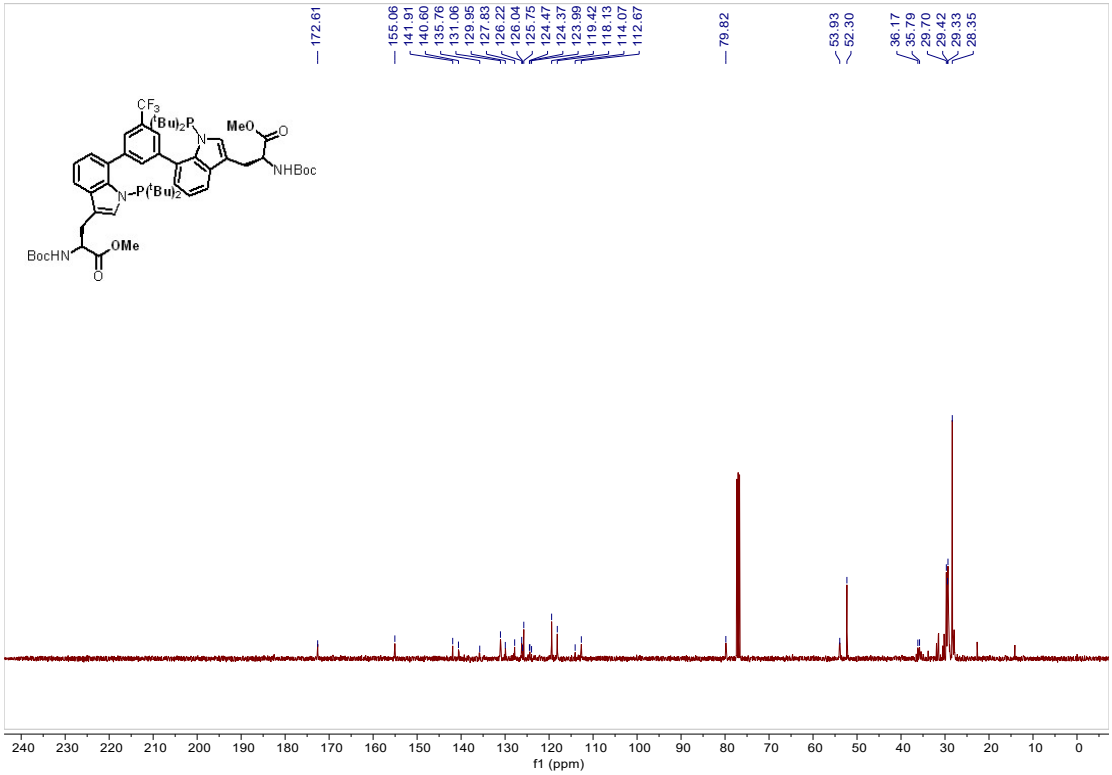
^{13}C NMR (101 MHz, $CDCl_3$) spectrum of **4ac**



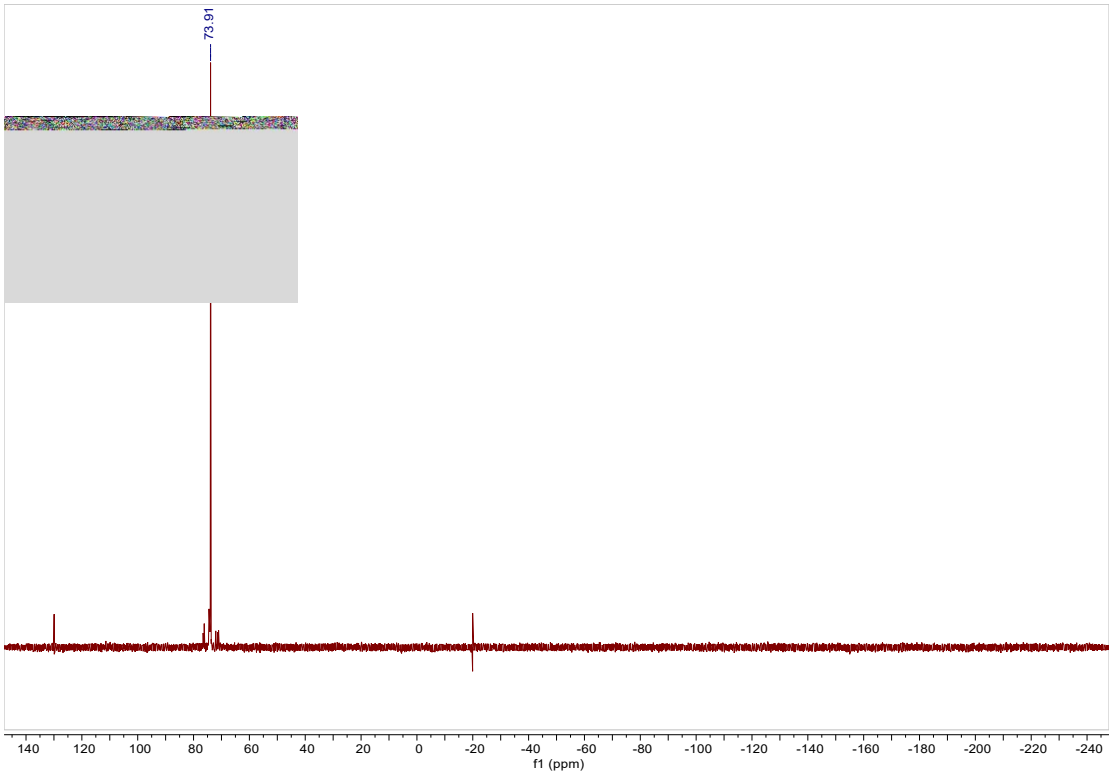
^{31}P NMR (162 MHz, $CDCl_3$) of **4ac**



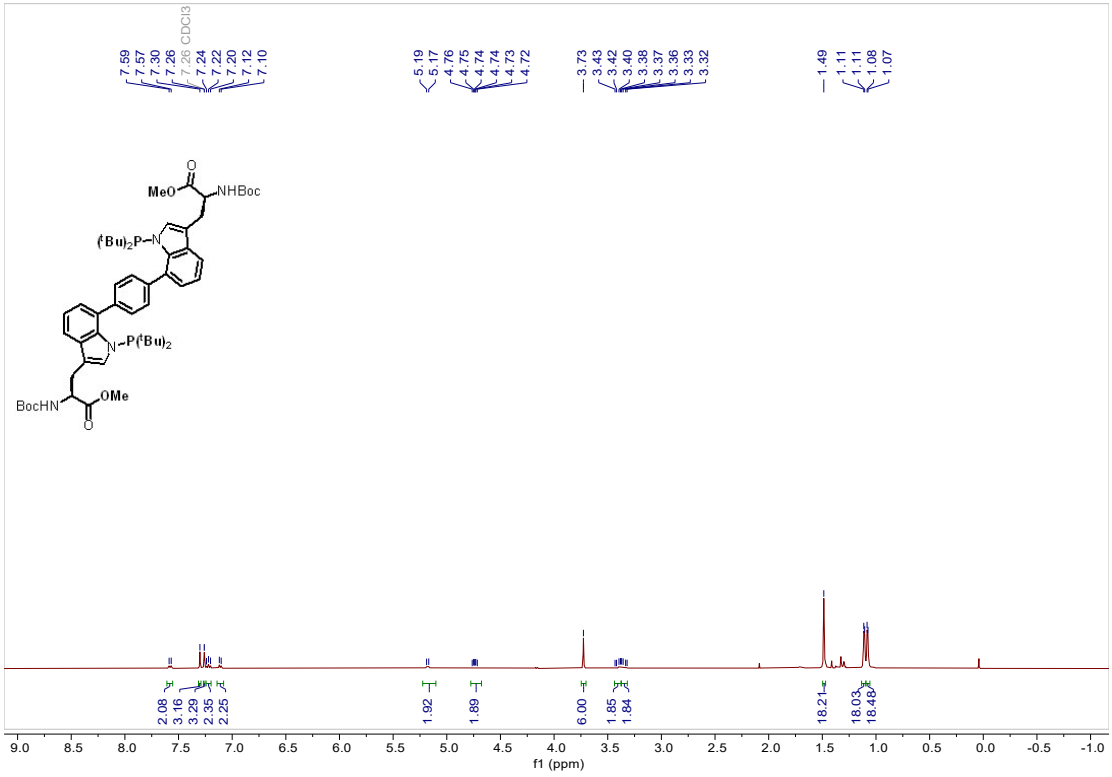
^{1}H NMR (400 MHz, $CDCl_3$) spectrum of **4ad**



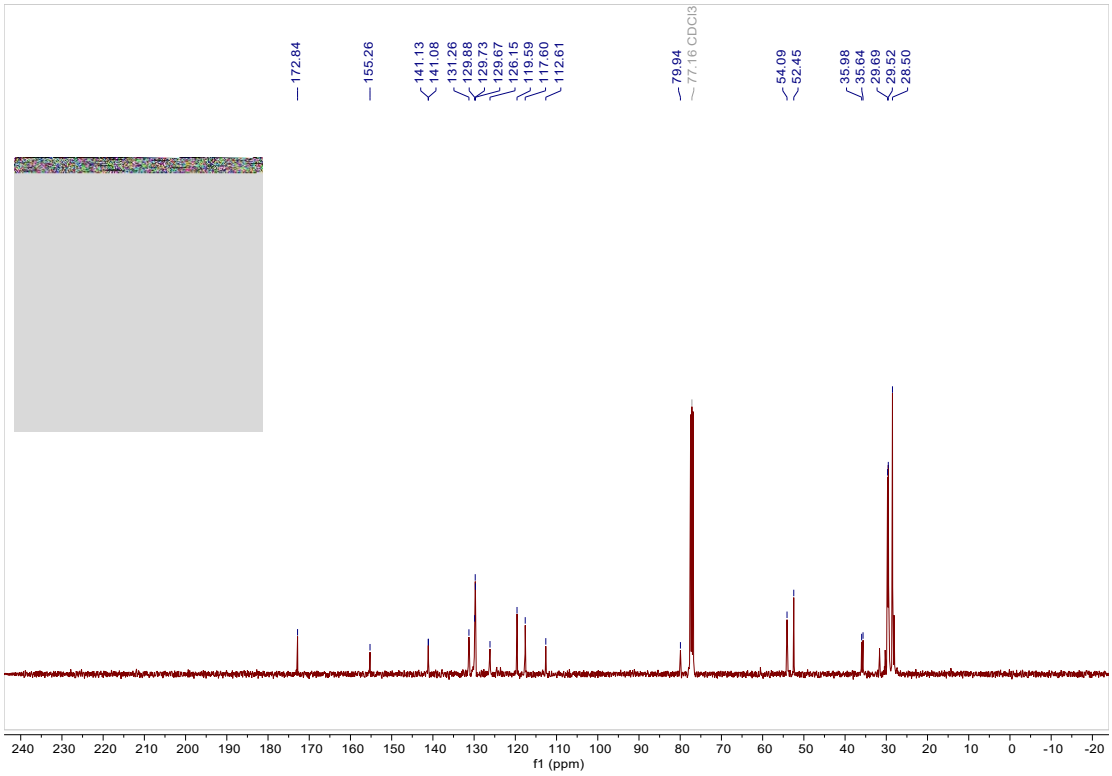
^{13}C NMR (101 MHz, $CDCl_3$) spectrum of **4ad**



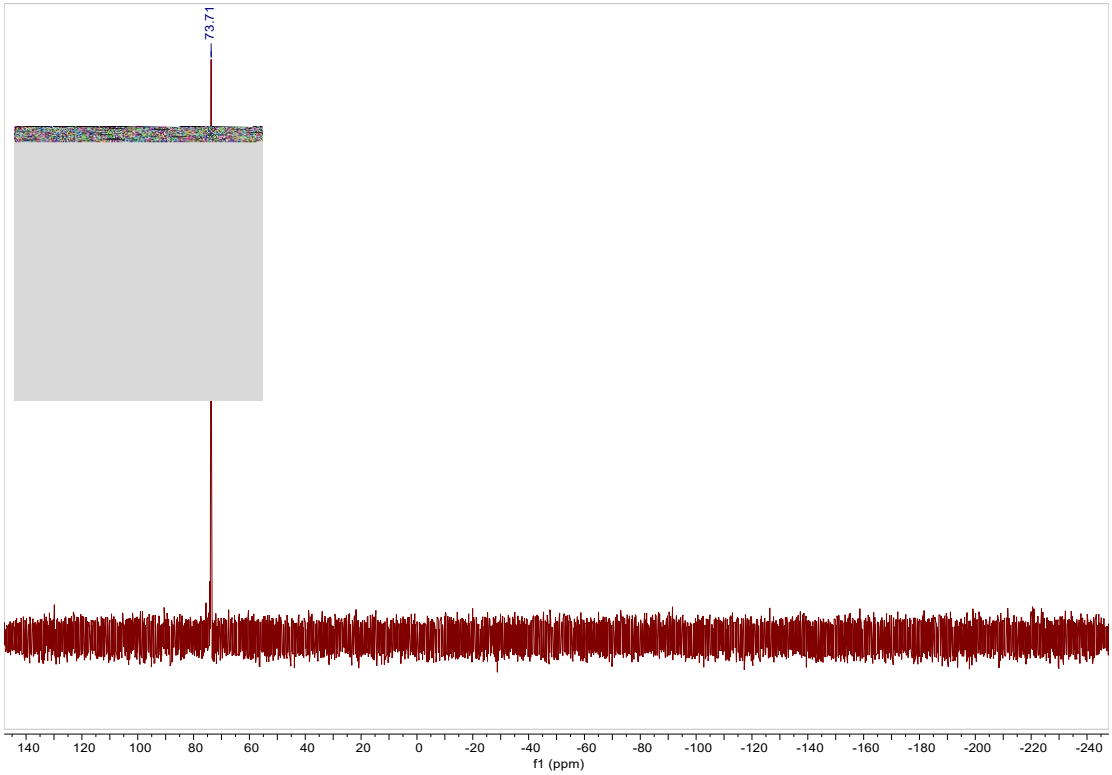
^{31}P NMR (162 MHz, $CDCl_3$) of **4ad**



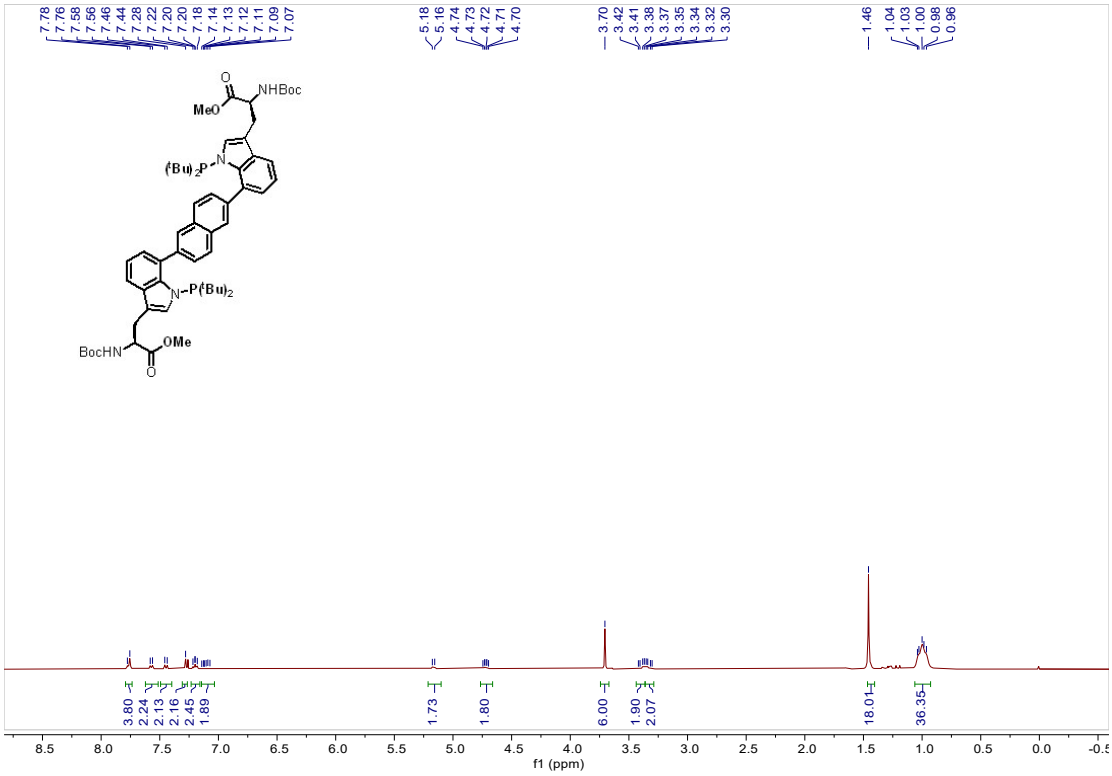
^{1}H NMR (400 MHz, $CDCl_3$) spectrum of **4ae**



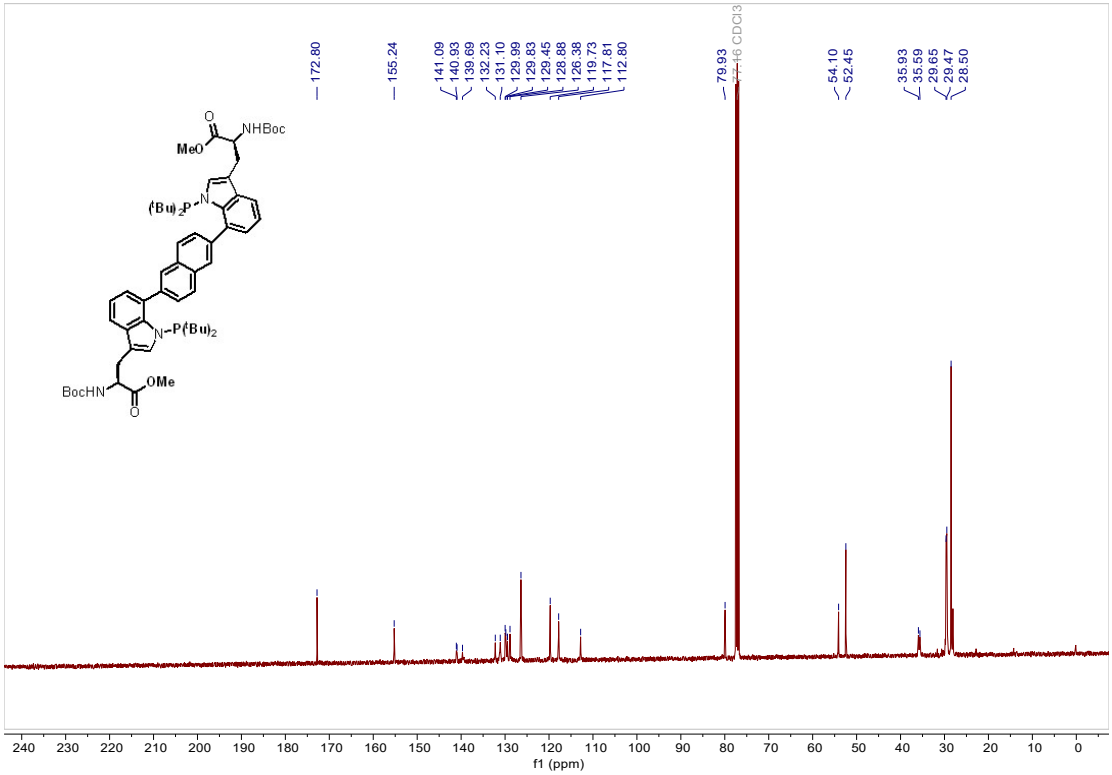
^{13}C NMR (101 MHz, $CDCl_3$) spectrum of **4ae**



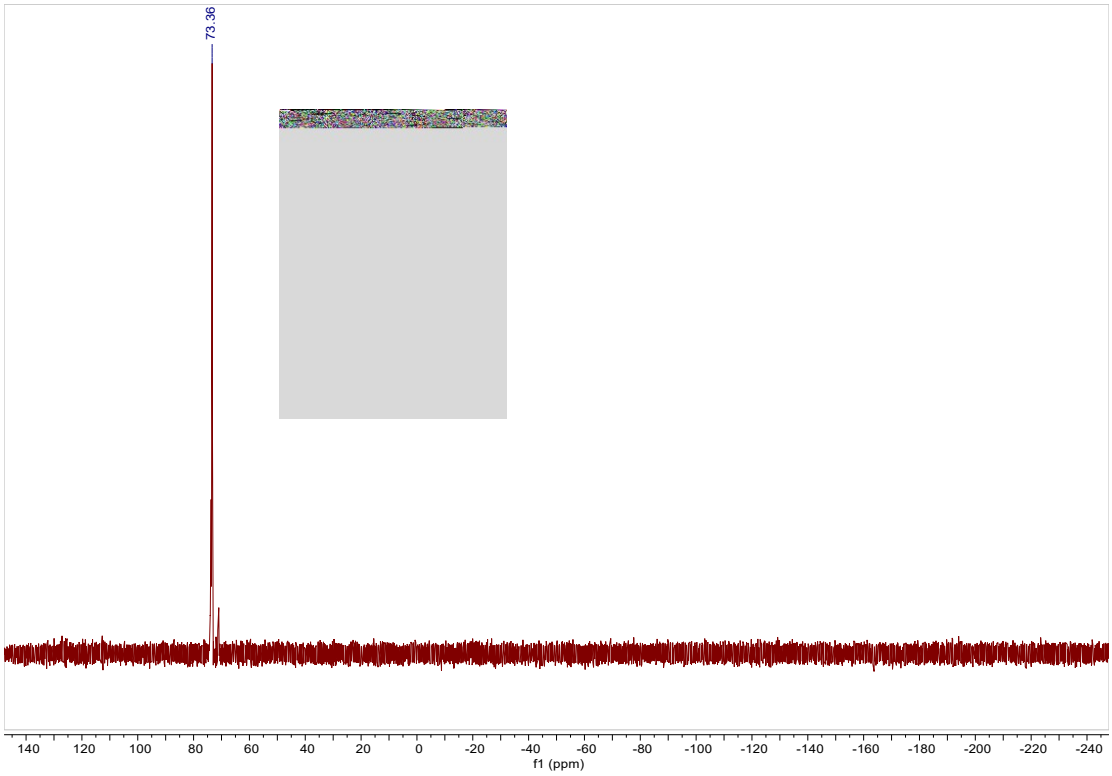
^{31}P NMR (162 MHz, $CDCl_3$) of **4ae**



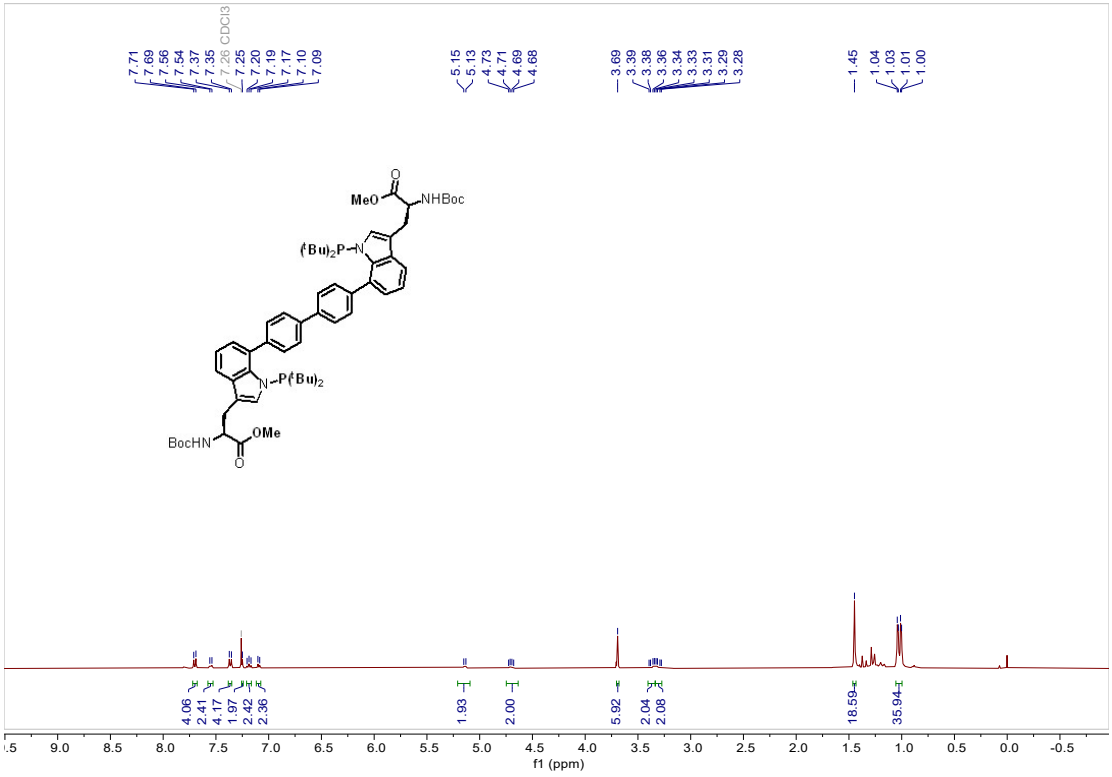
^{1}H NMR (400 MHz, $CDCl_3$) spectrum of **4af**



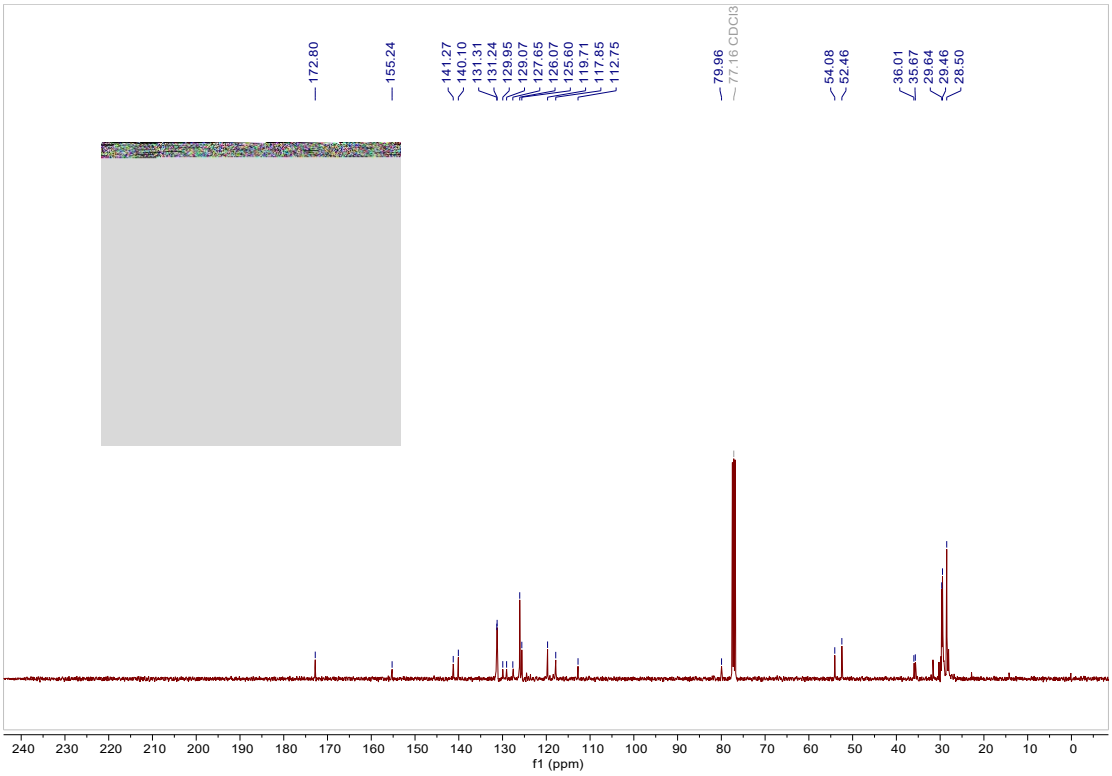
^{13}C NMR (101 MHz, $CDCl_3$) spectrum of **4af**



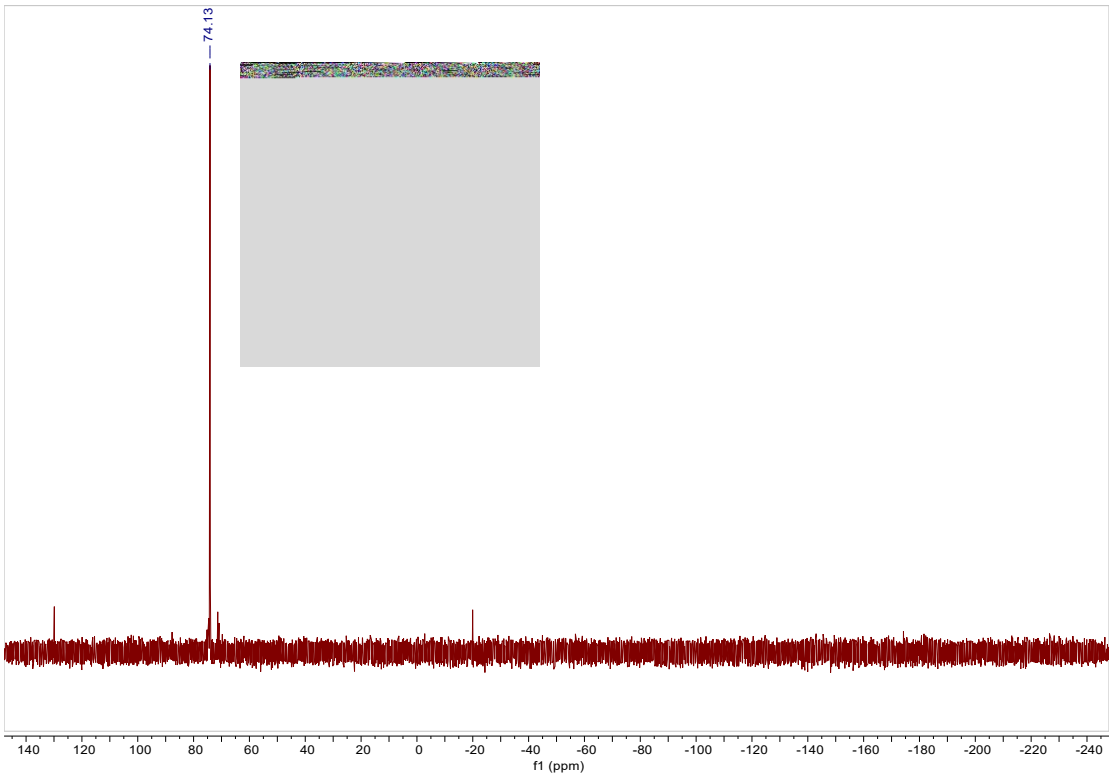
^{31}P NMR (162 MHz, $CDCl_3$) of **4af**



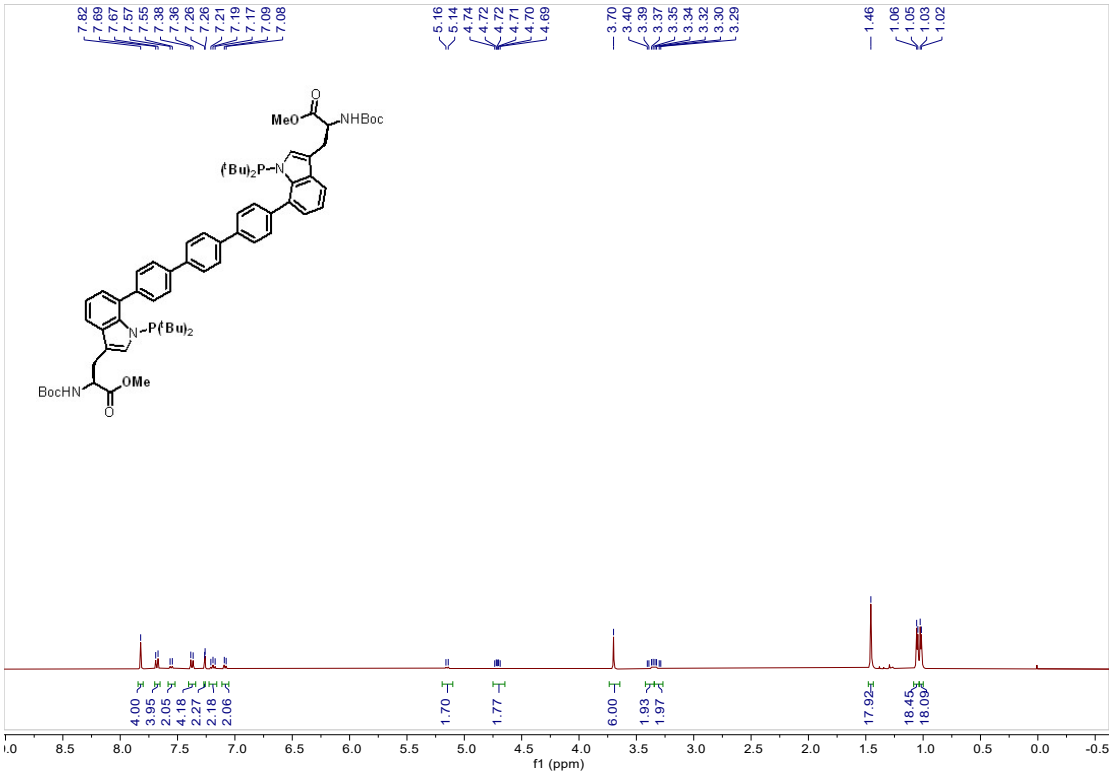
^{1}H NMR (400 MHz, $CDCl_3$) spectrum of **4ag**



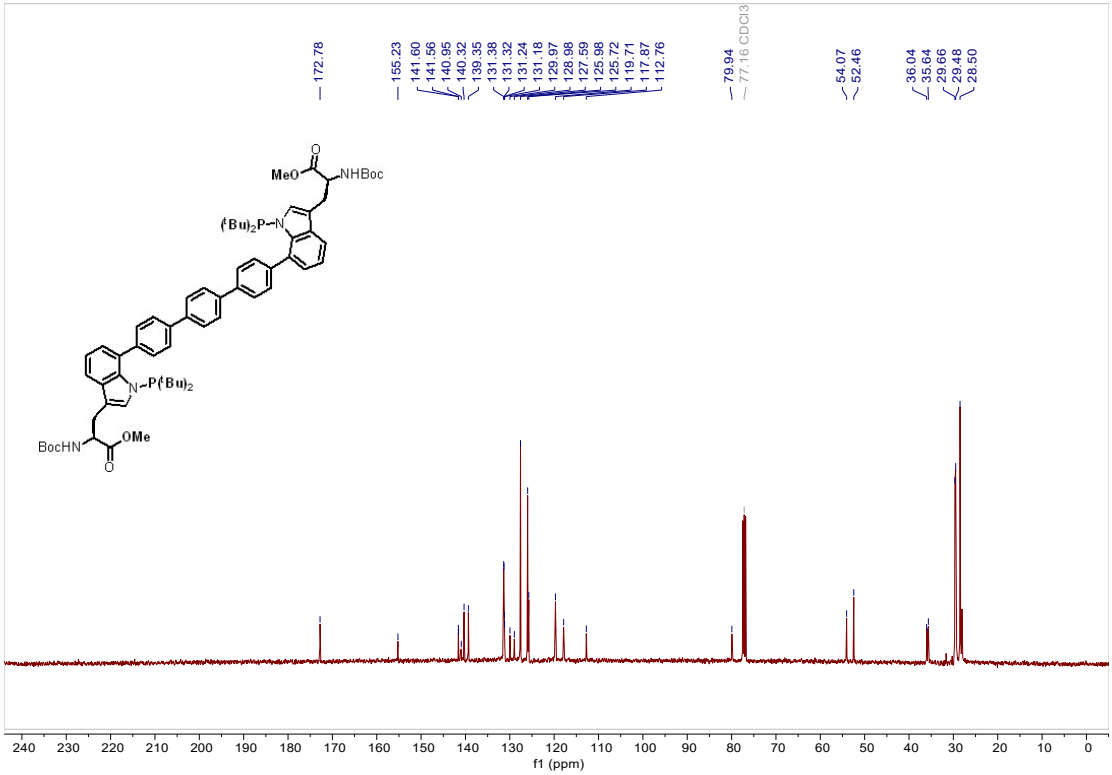
^{13}C NMR (101 MHz, $CDCl_3$) spectrum of **4ag**



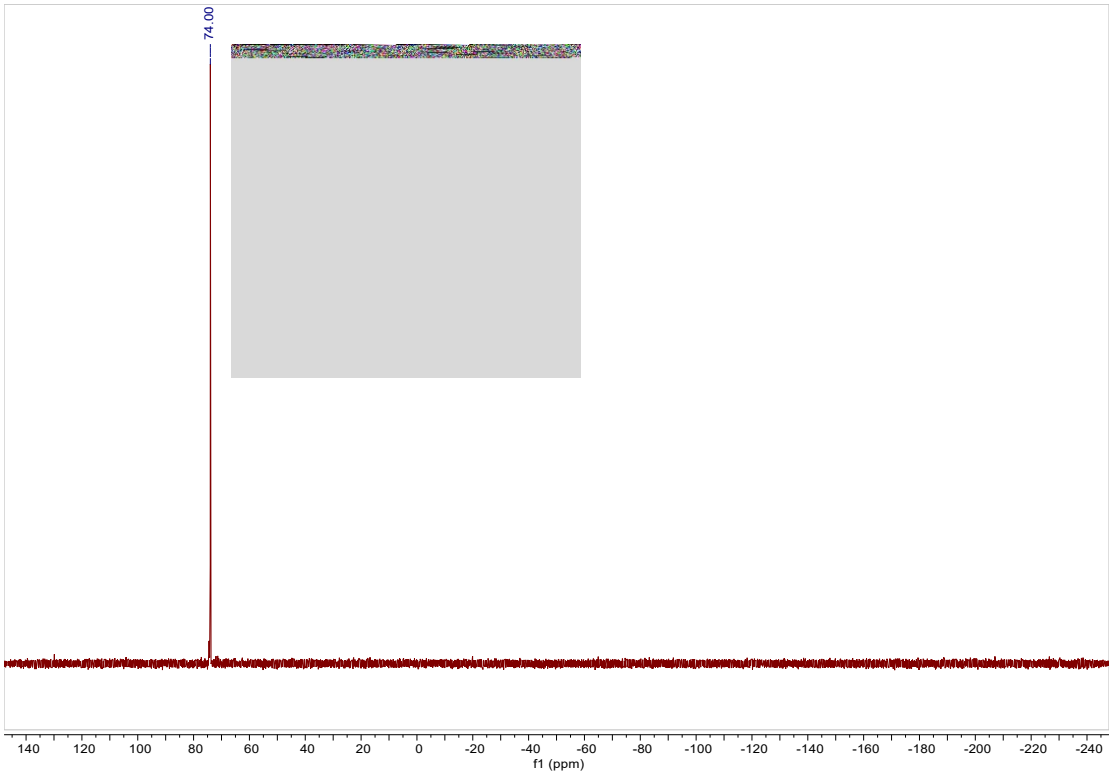
^{31}P NMR (162 MHz, $CDCl_3$) of **4ag**



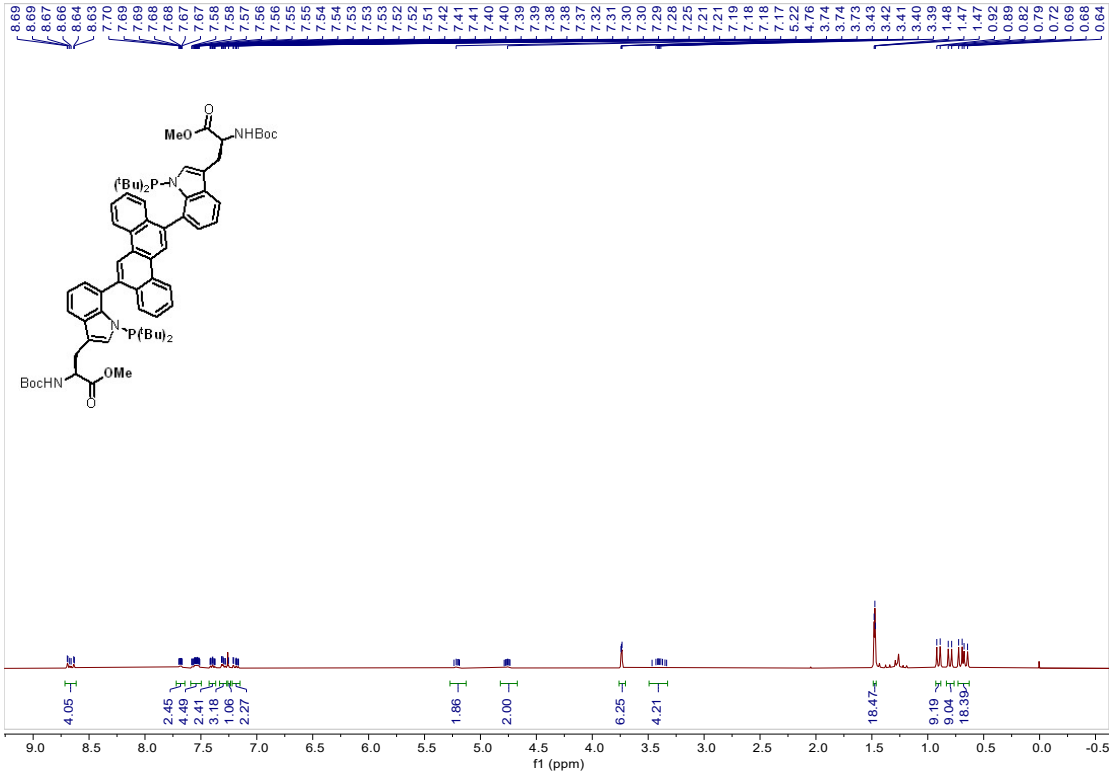
^{1}H NMR (400 MHz, $CDCl_3$) spectrum of **4ah**



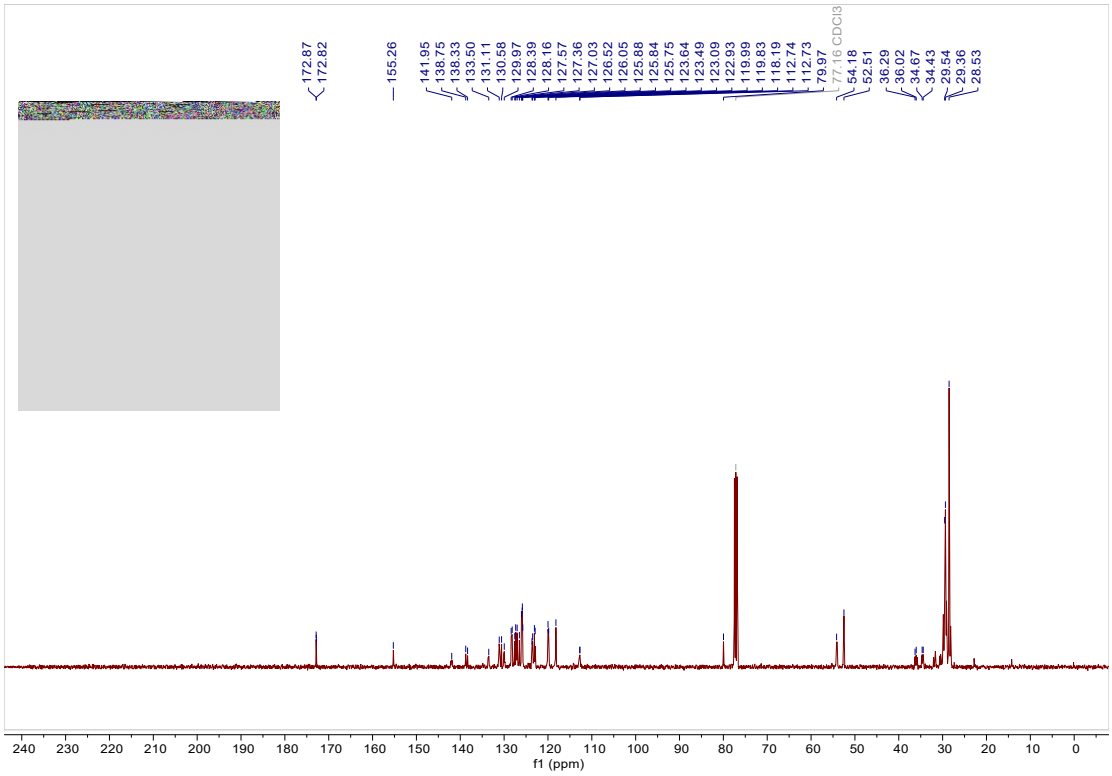
^{13}C NMR (101 MHz, $CDCl_3$) spectrum of **4ah**



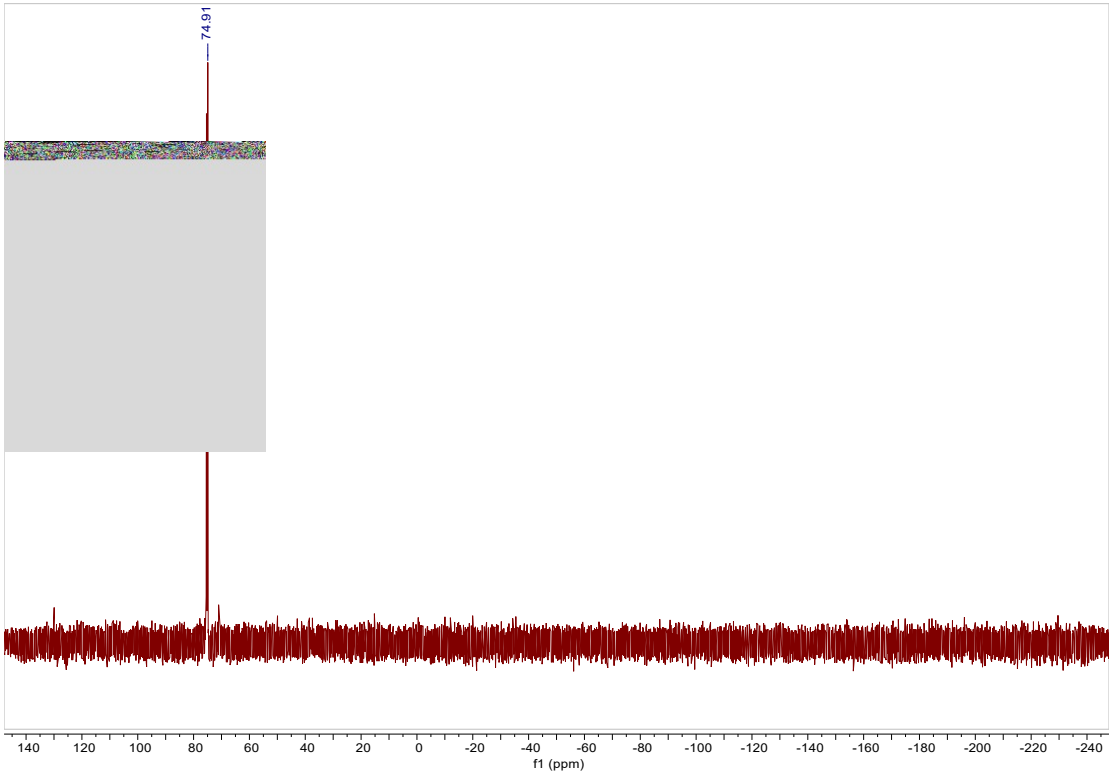
^{31}P NMR (162 MHz, $CDCl_3$) of **4ah**



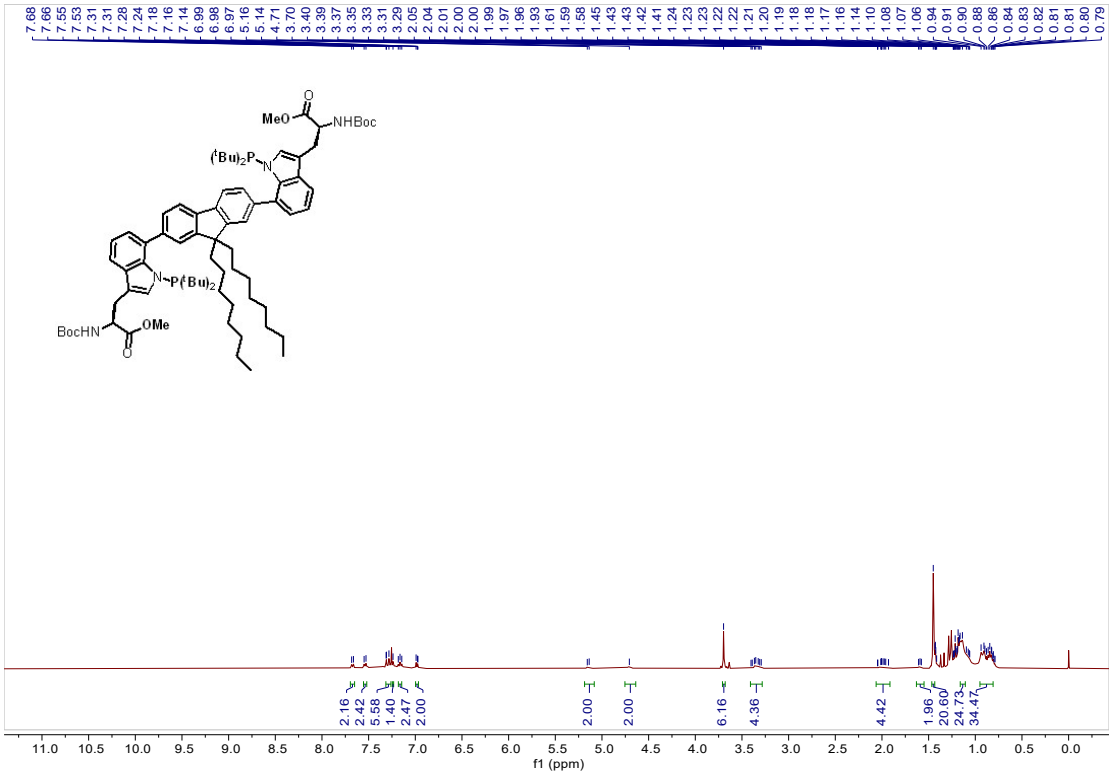
^{1}H NMR (400 MHz, $CDCl_3$) spectrum of **4ai**



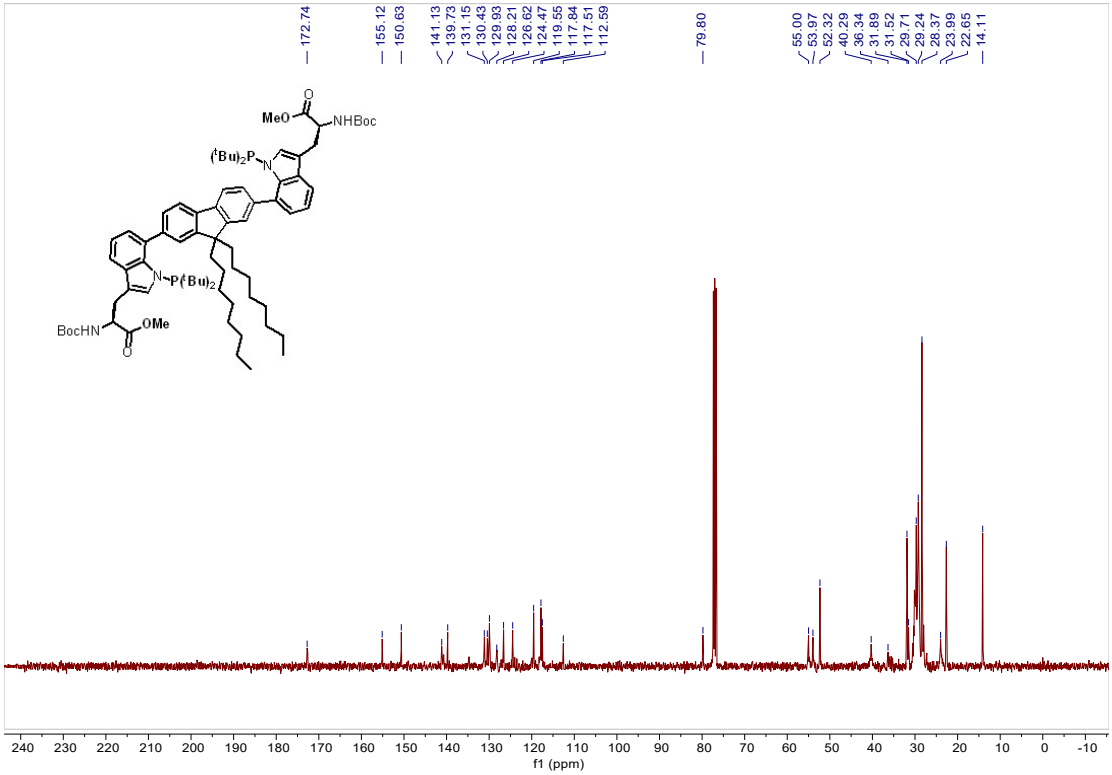
^{13}C NMR (101 MHz, $CDCl_3$) spectrum of **4ai**



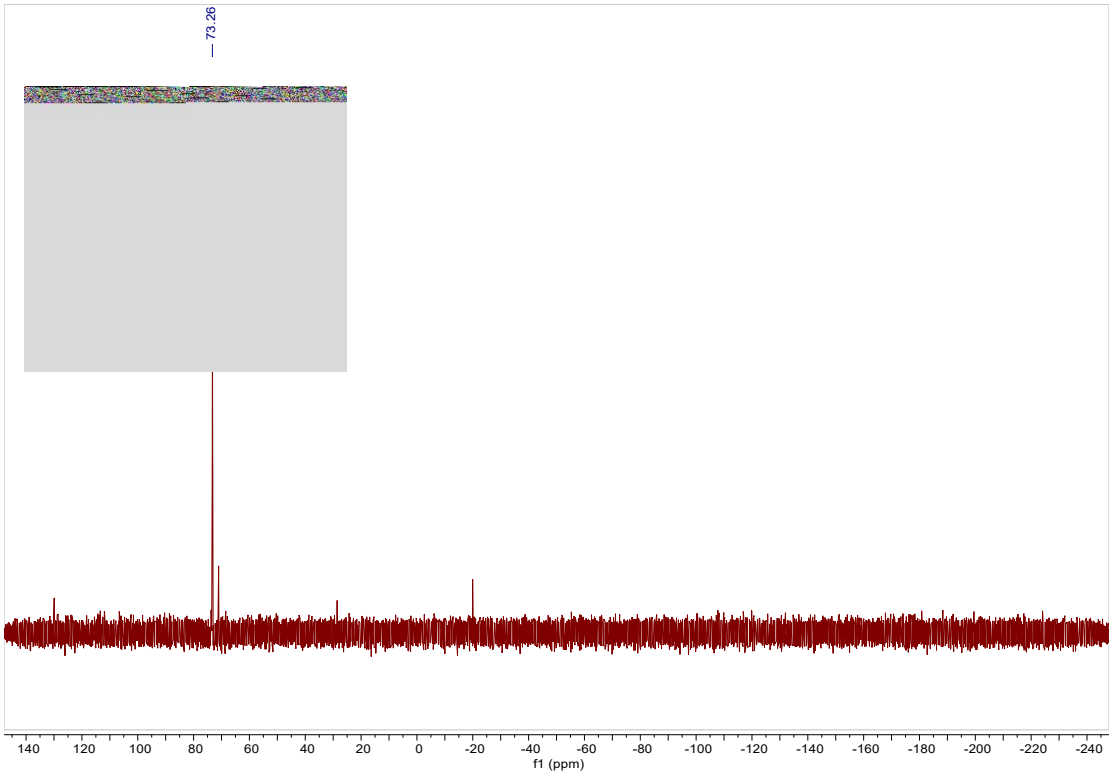
^{31}P NMR (162 MHz, $CDCl_3$) of **4ai**



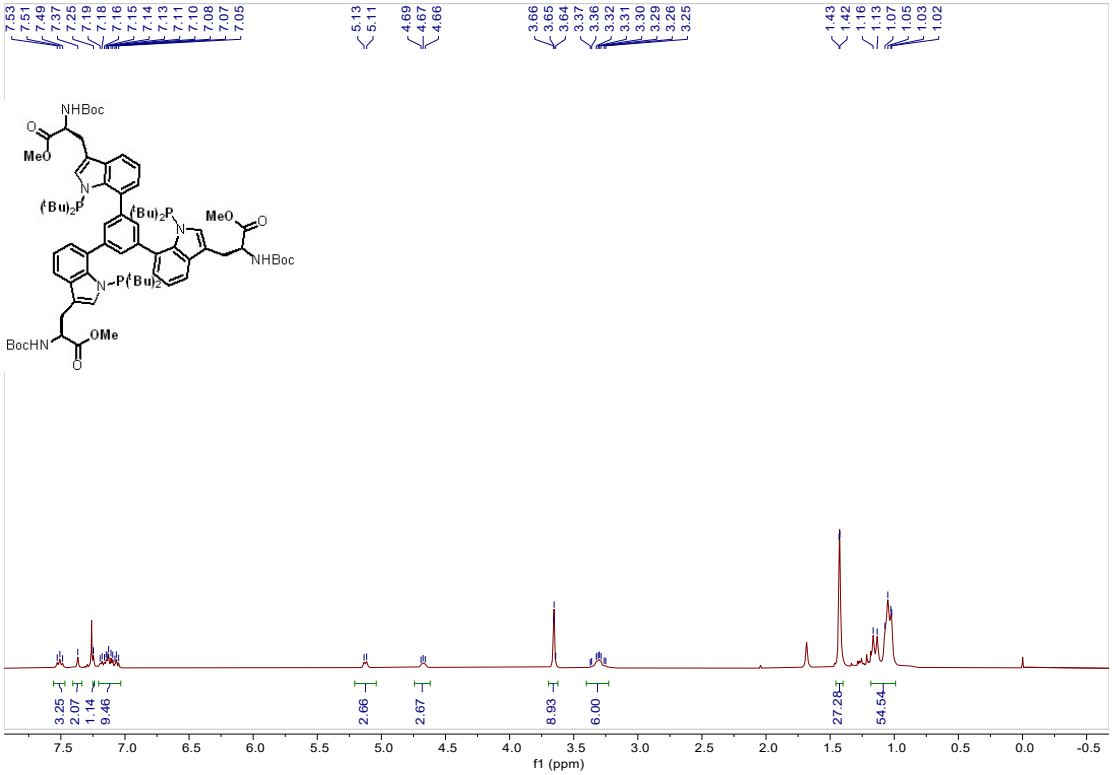
^{1}H NMR (400 MHz, $CDCl_3$) spectrum of **4aj**



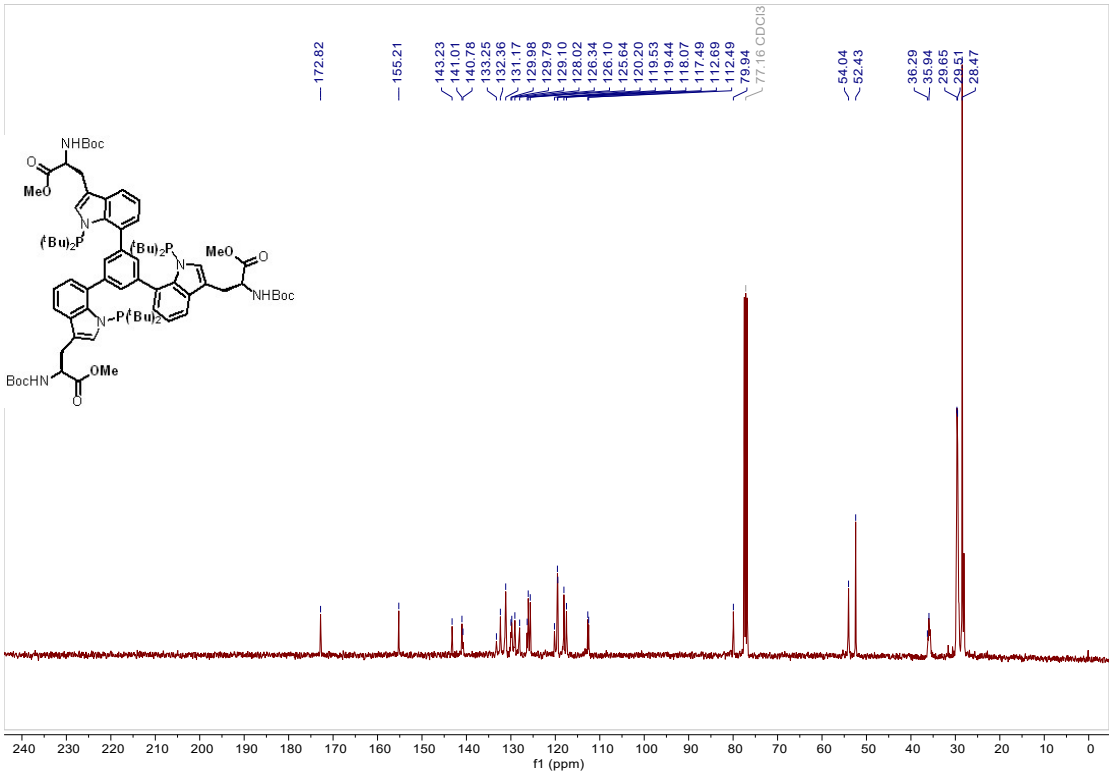
^{13}C NMR (101 MHz, $CDCl_3$) spectrum of **4aj**



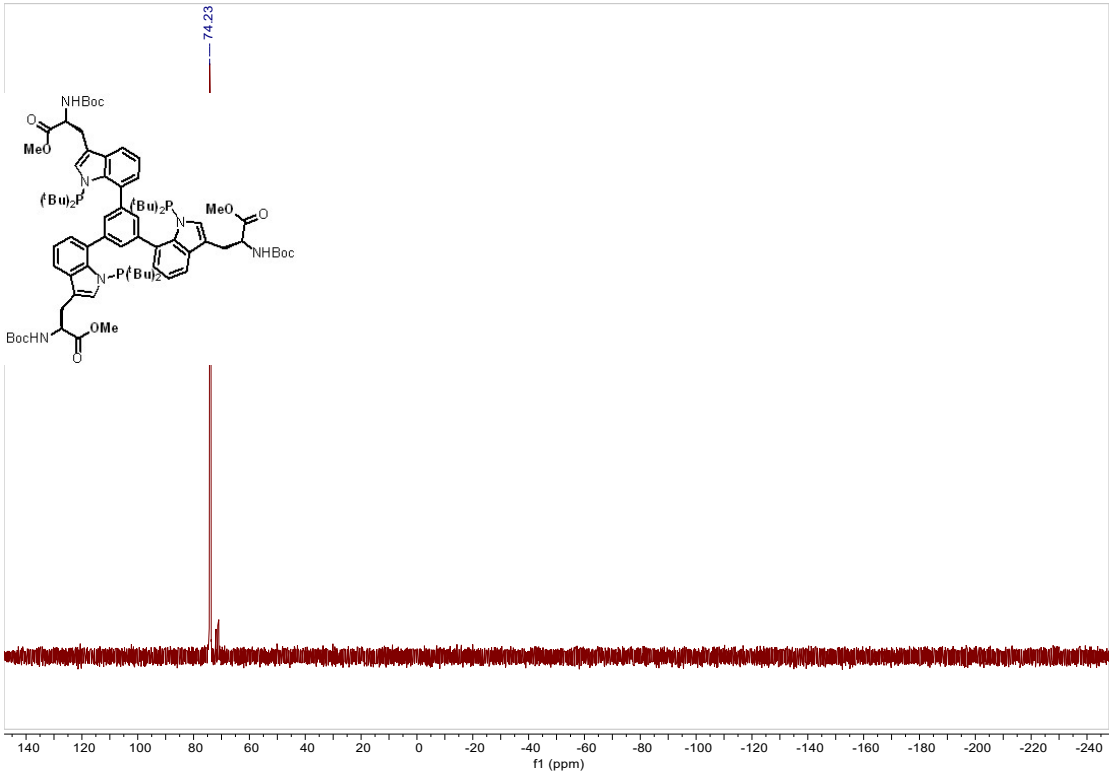
^{31}P NMR (162 MHz, $CDCl_3$) of **4aj**



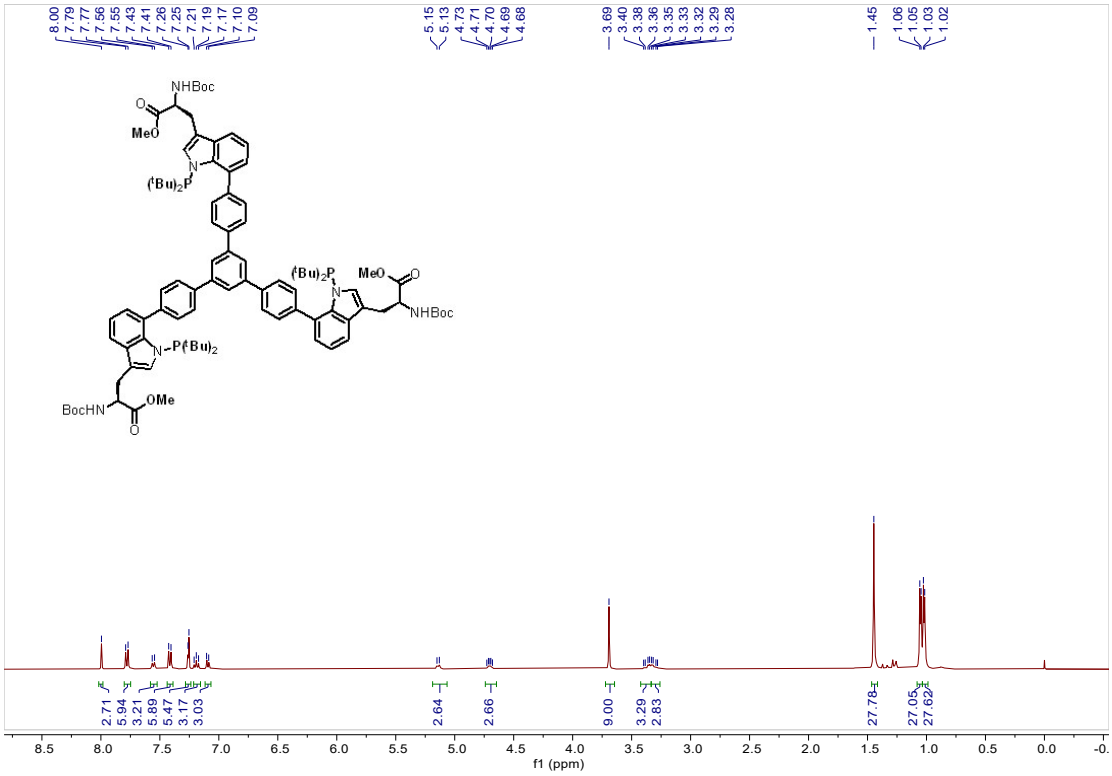
^{1}H NMR (400 MHz, $CDCl_3$) spectrum of **4ak**



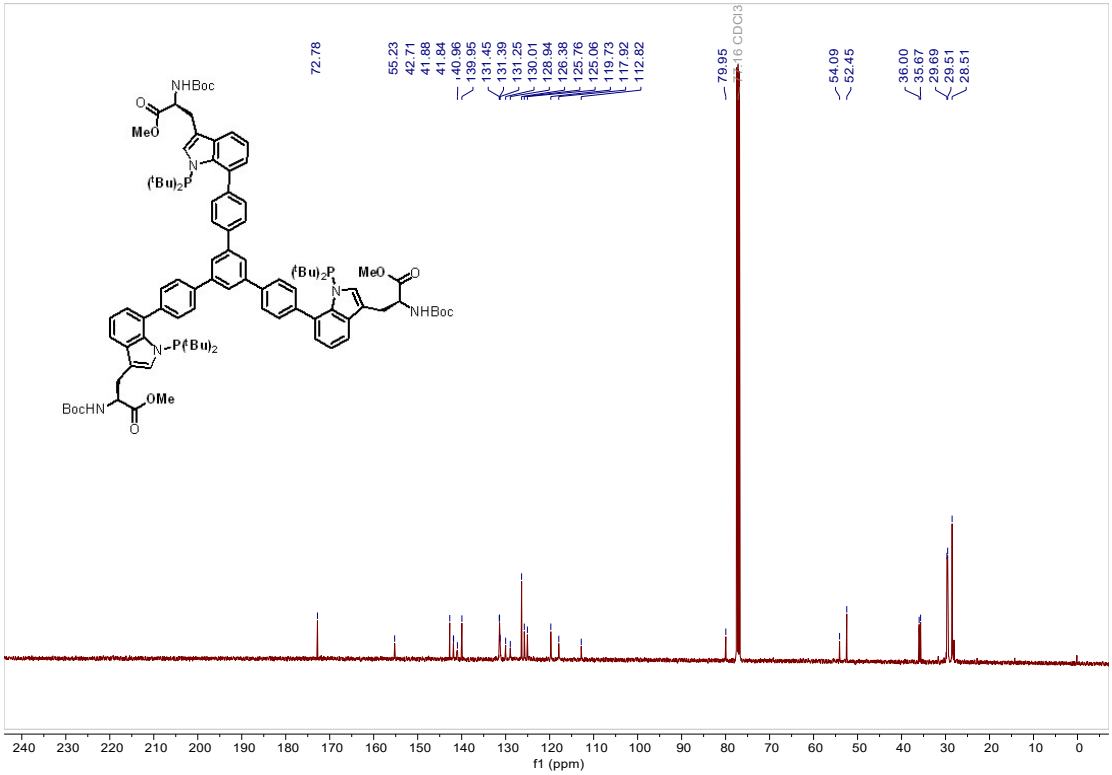
^{13}C NMR (101 MHz, $CDCl_3$) spectrum of **4ak**



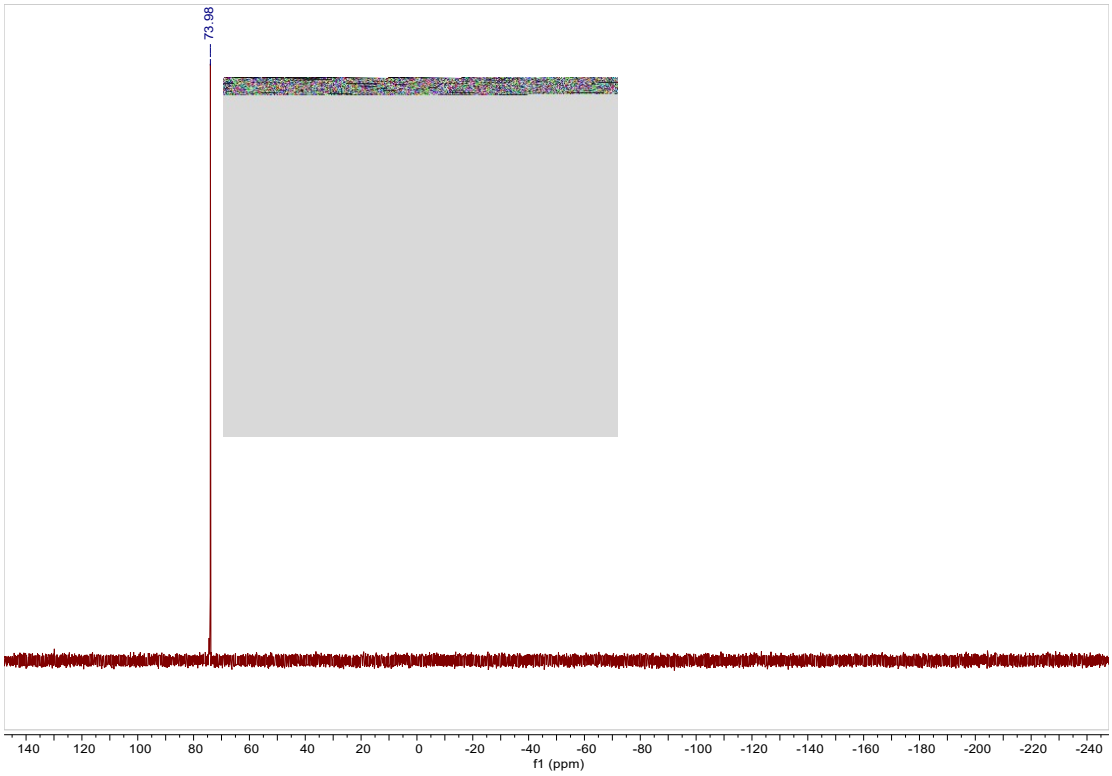
^{31}P NMR (162 MHz, $CDCl_3$) of **4ak**



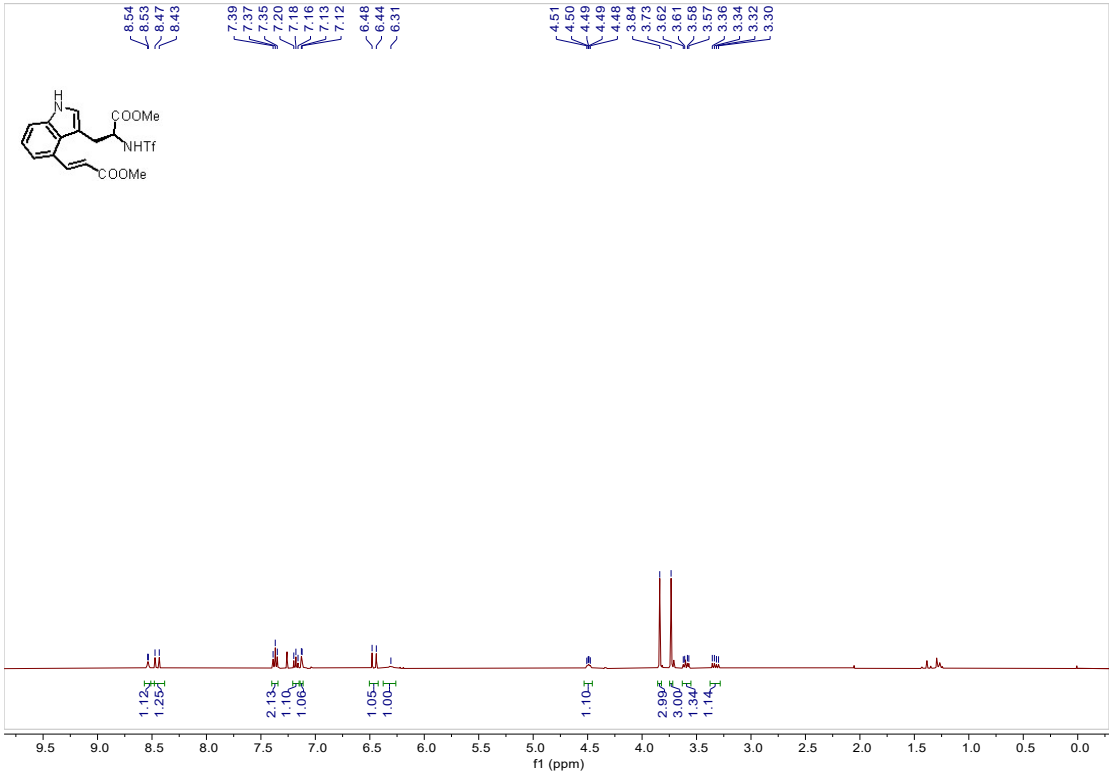
^{1}H NMR (400 MHz, $CDCl_3$) spectrum of **4al**



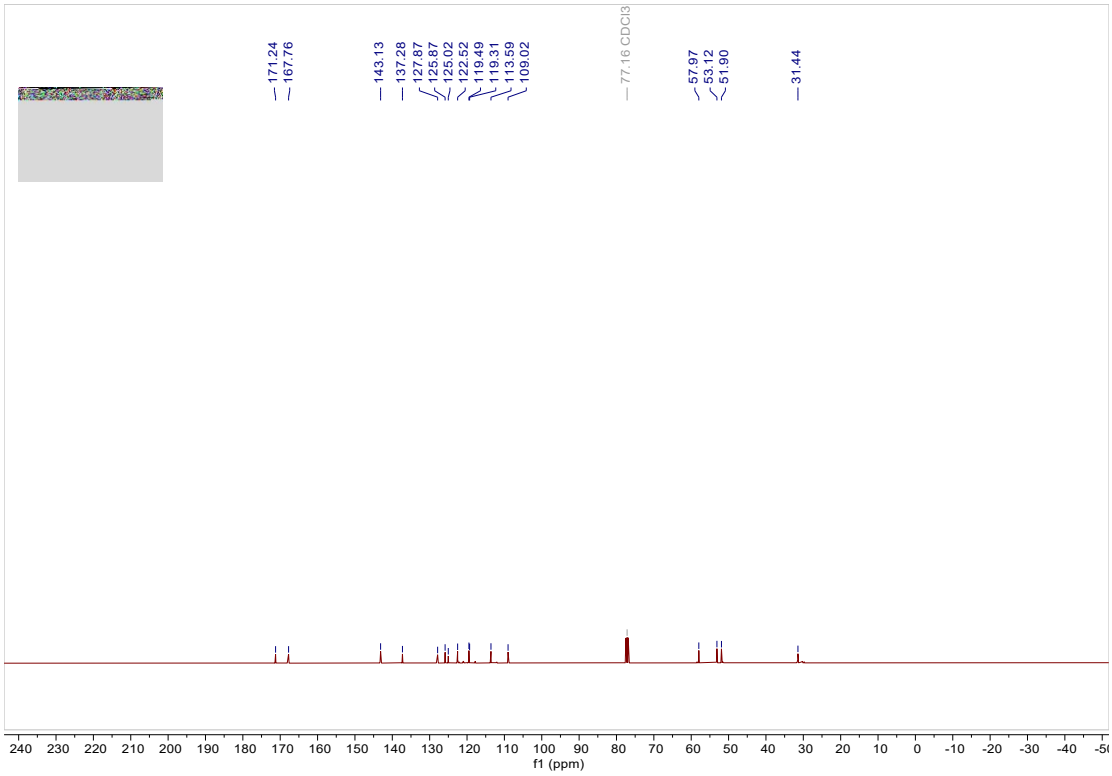
^{13}C NMR (101 MHz, $CDCl_3$) spectrum of **4al**



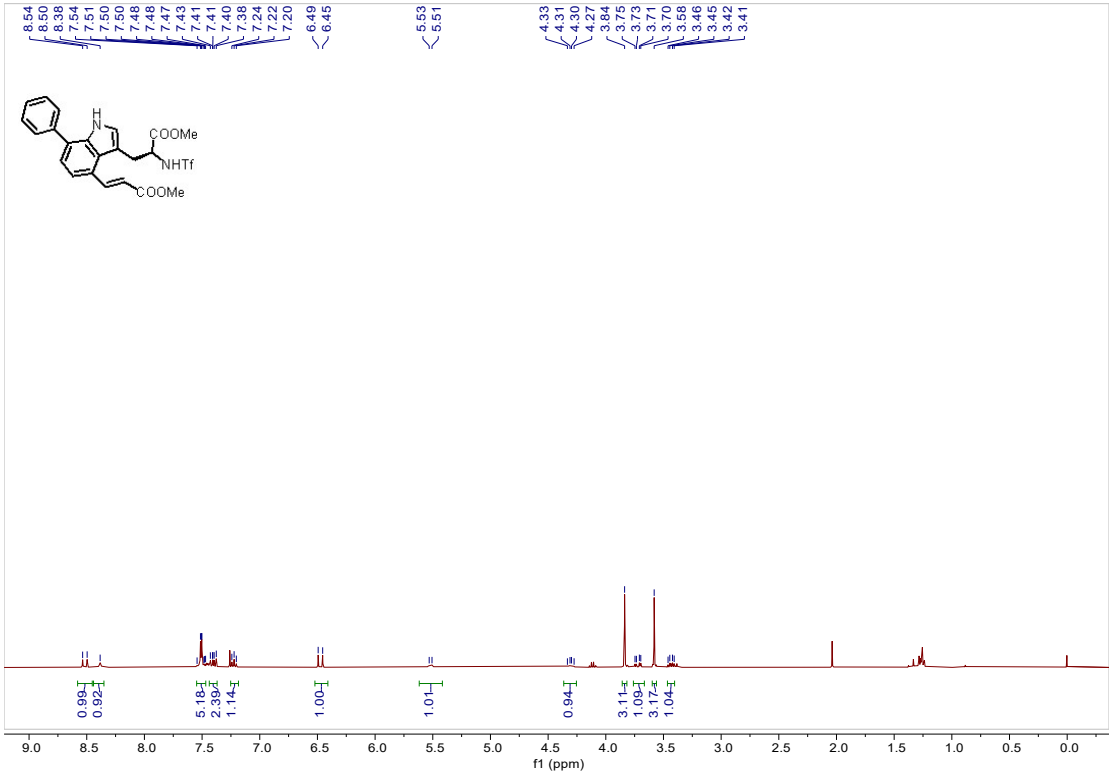
^{31}P NMR (162 MHz, $CDCl_3$) of **4al**



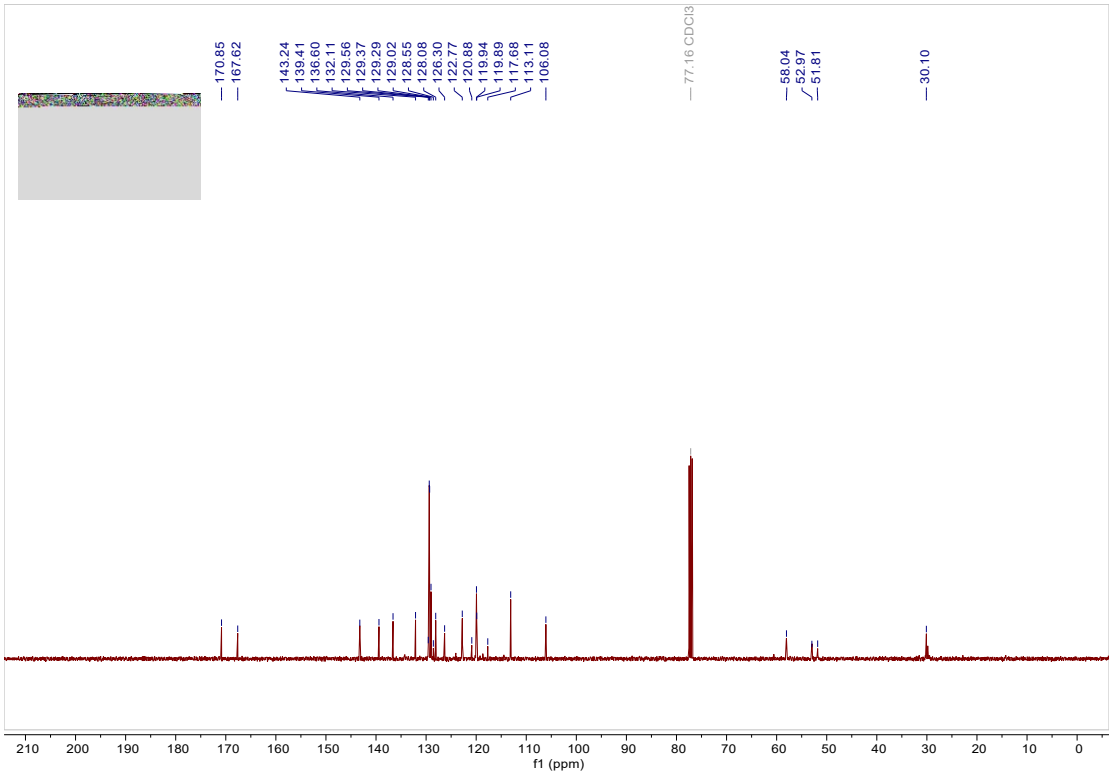
^{1}H NMR (400 MHz, $CDCl_3$) spectrum of **5b**



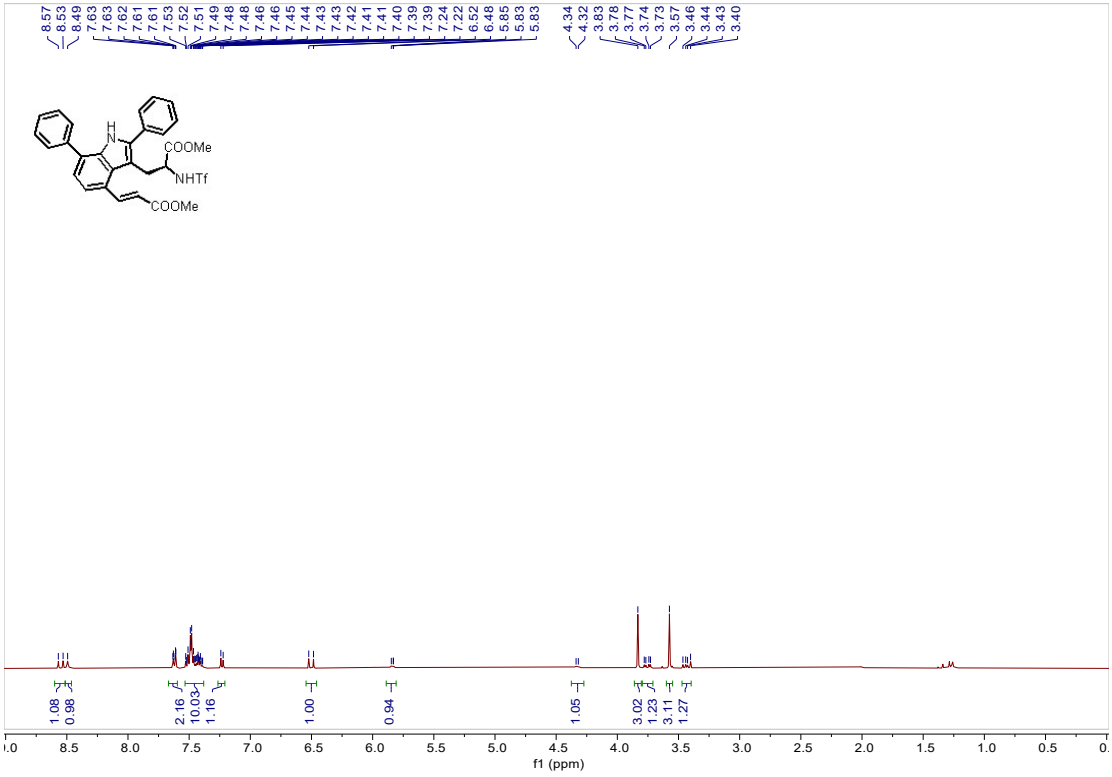
^{13}C NMR (101 MHz, $CDCl_3$) spectrum of **5b**



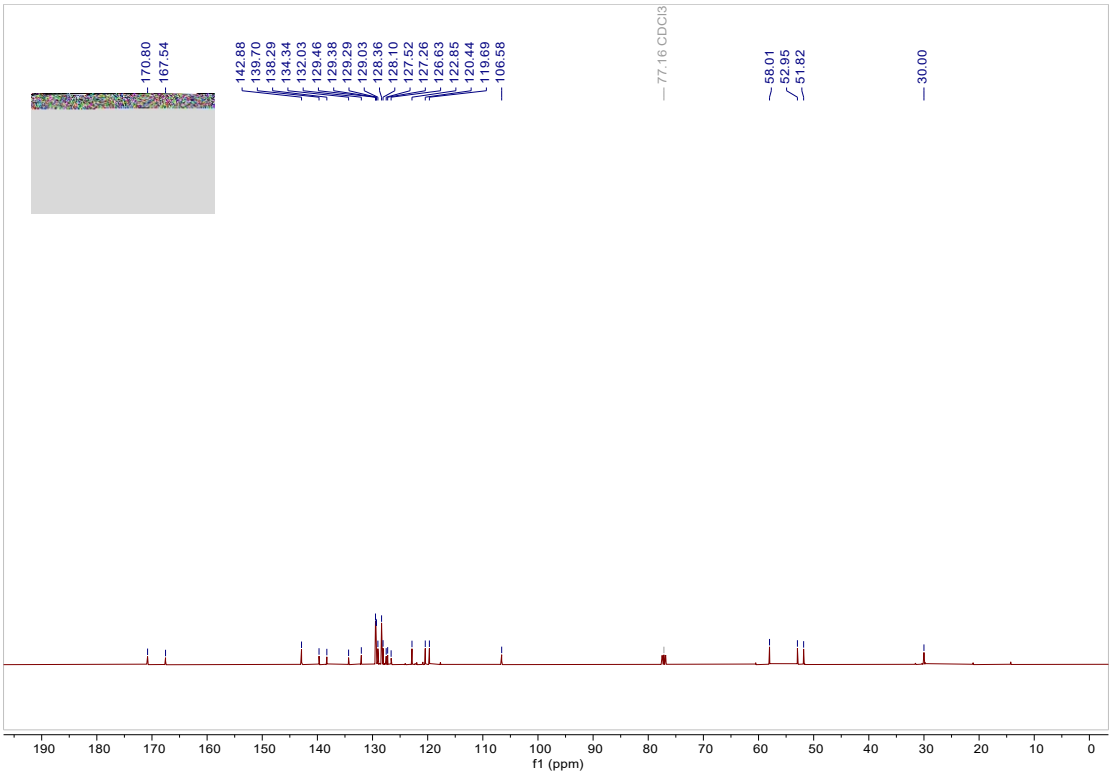
^{1}H NMR (400 MHz, $CDCl_3$) spectrum of **5c**



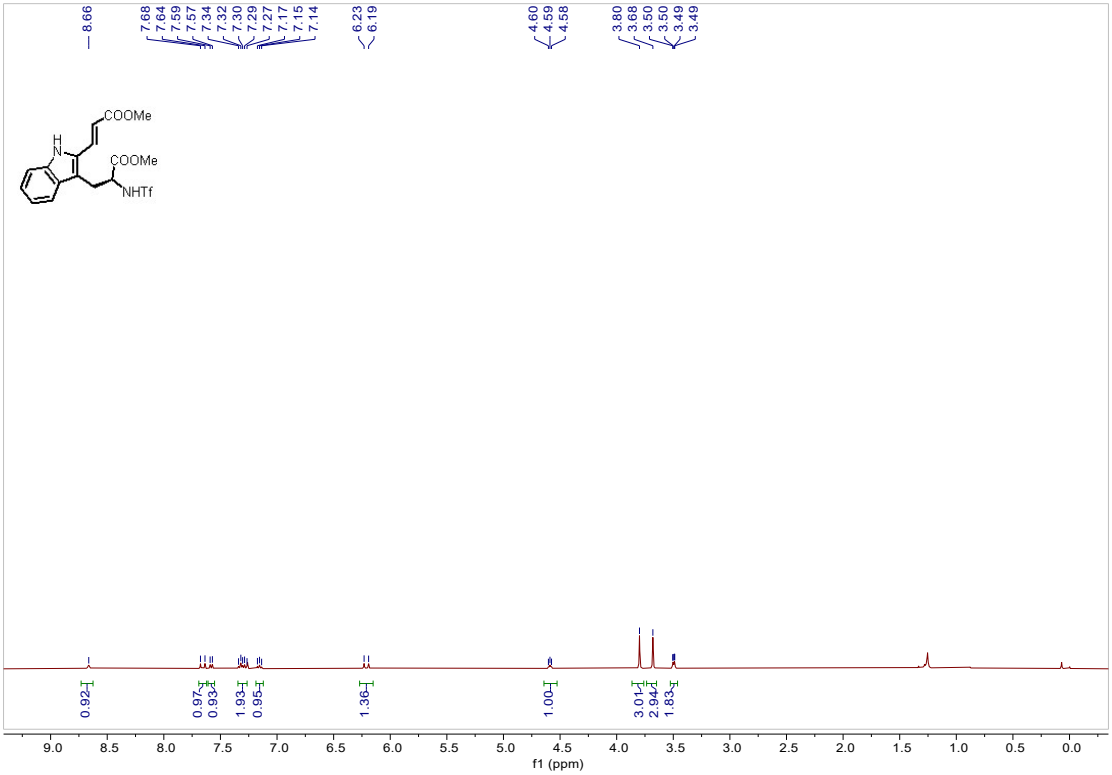
^{13}C NMR (101 MHz, $CDCl_3$) spectrum of **5c**



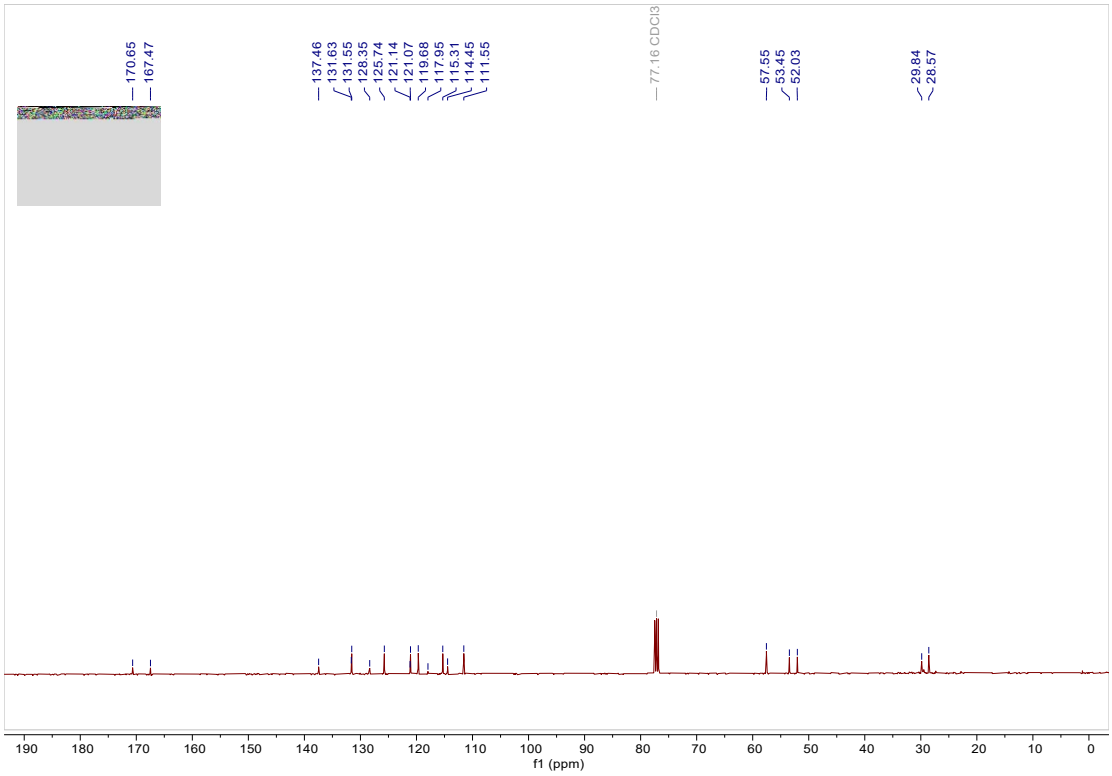
^{1}H NMR (400 MHz, $CDCl_3$) spectrum of **5d**



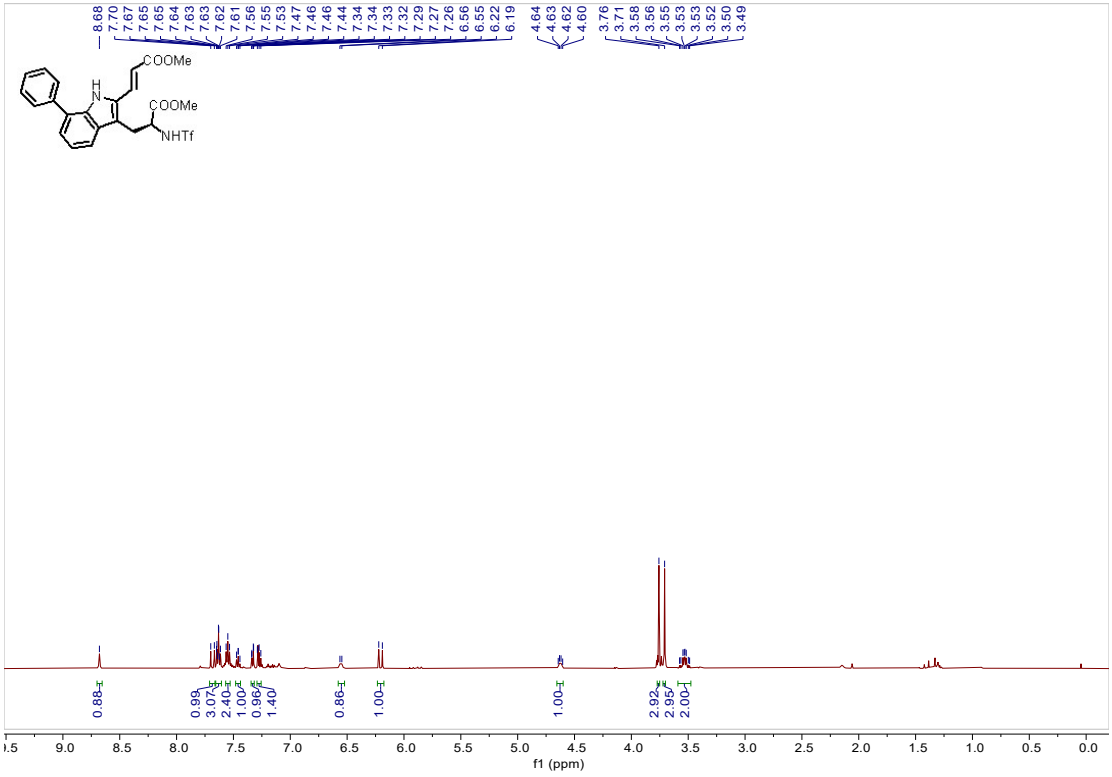
^{13}C NMR (101 MHz, $CDCl_3$) spectrum of **5d**



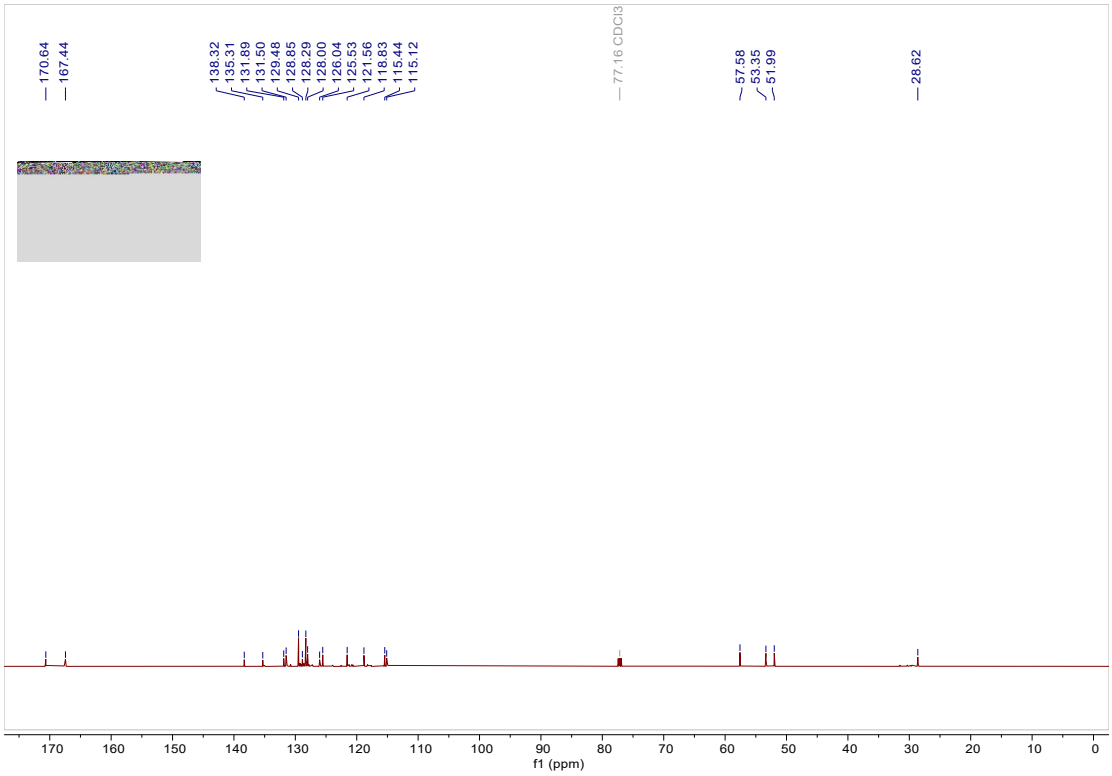
^{1}H NMR (400 MHz, $CDCl_3$) spectrum of **5e**



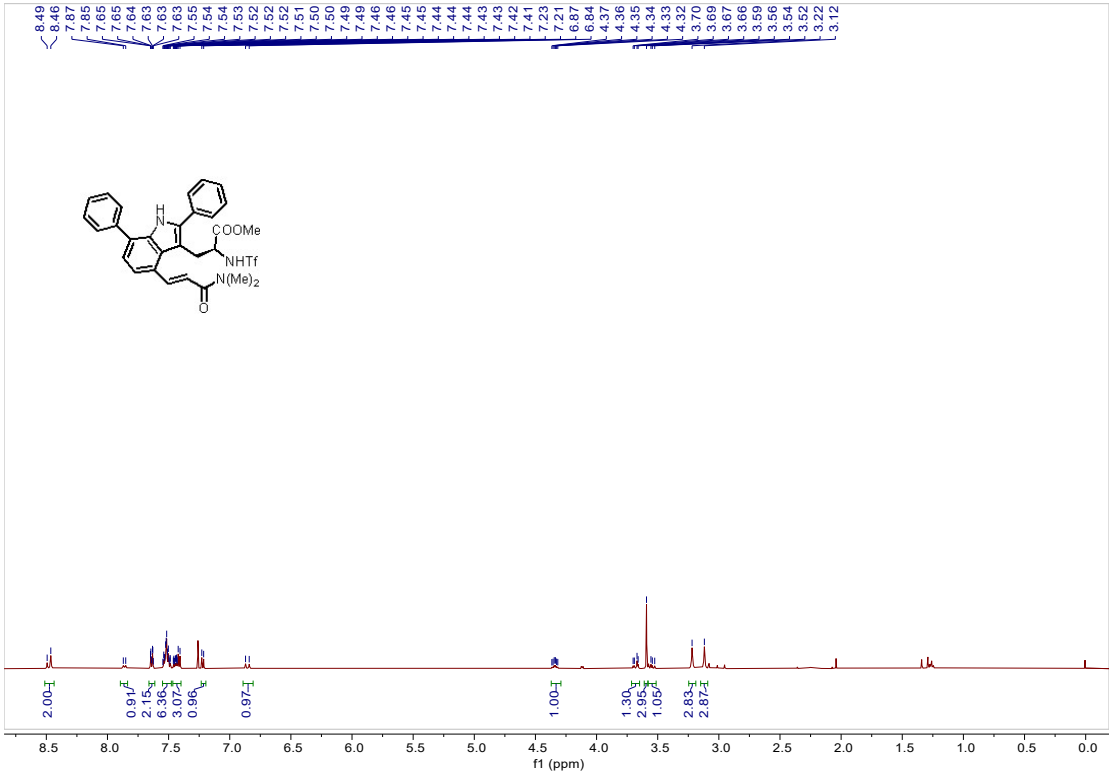
^{13}C NMR (101 MHz, $CDCl_3$) spectrum of **5e**



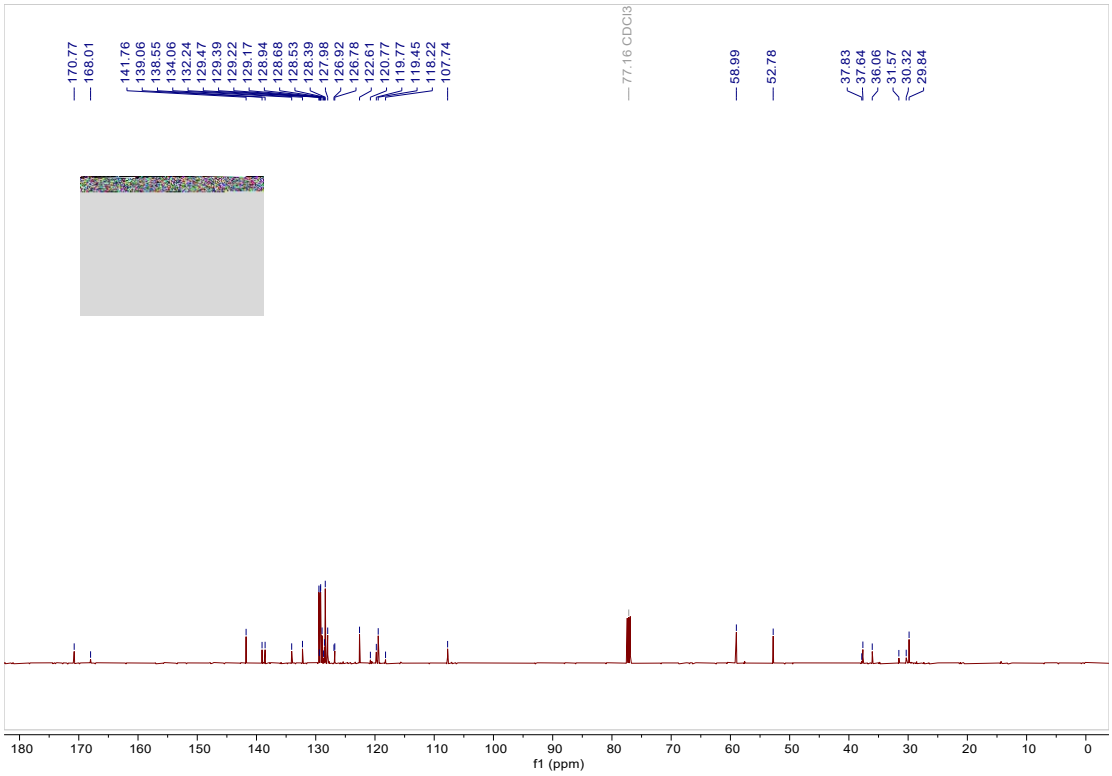
^{1}H NMR (500 MHz, $CDCl_3$) spectrum of **5f**



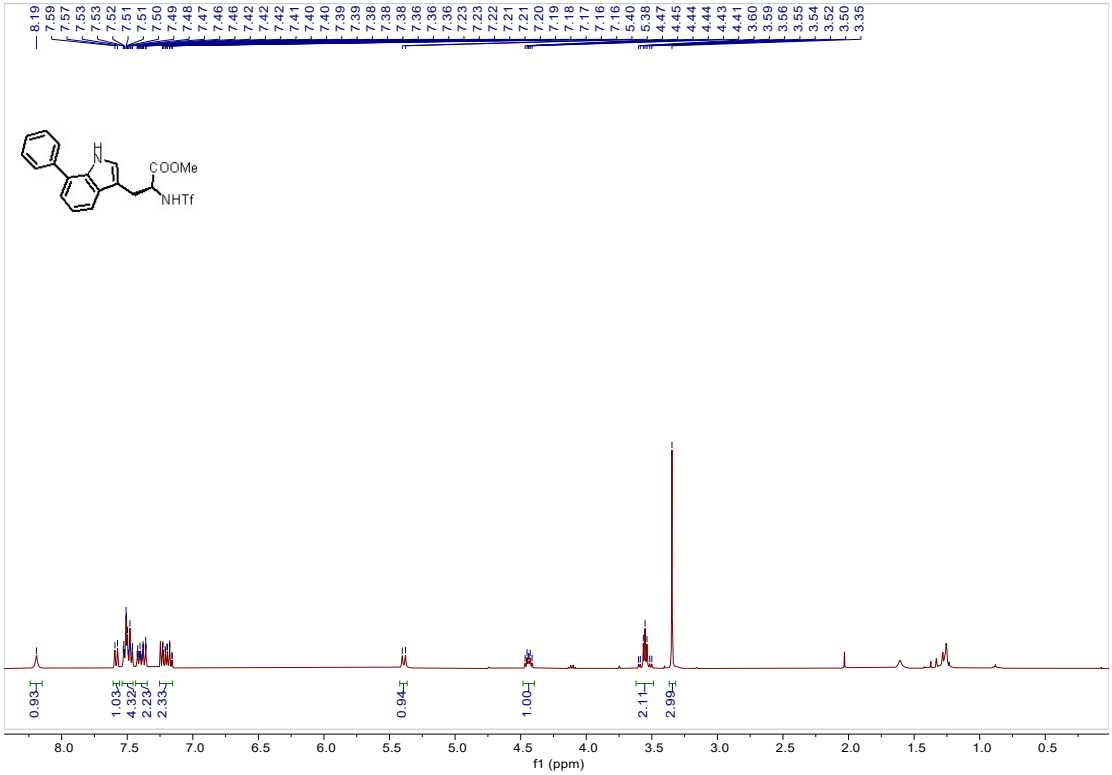
^{13}C NMR (126 MHz, $CDCl_3$) spectrum of **5f**



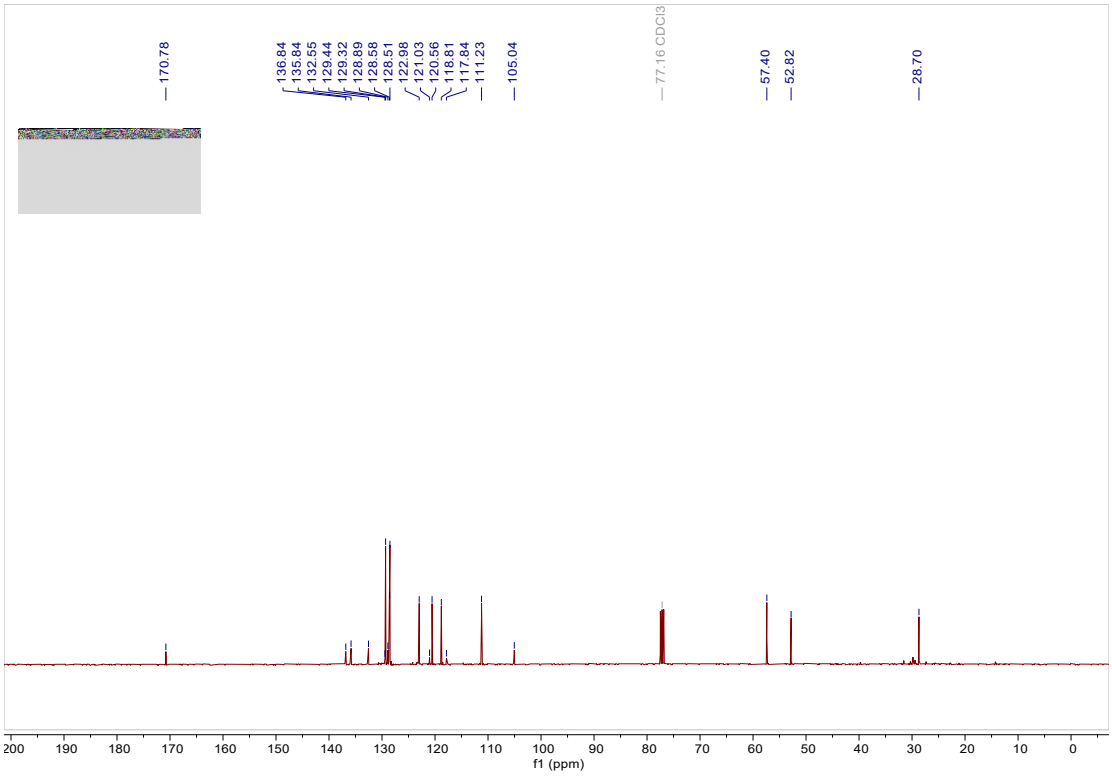
^{1}H NMR (500 MHz, $CDCl_3$) spectrum of **5g**



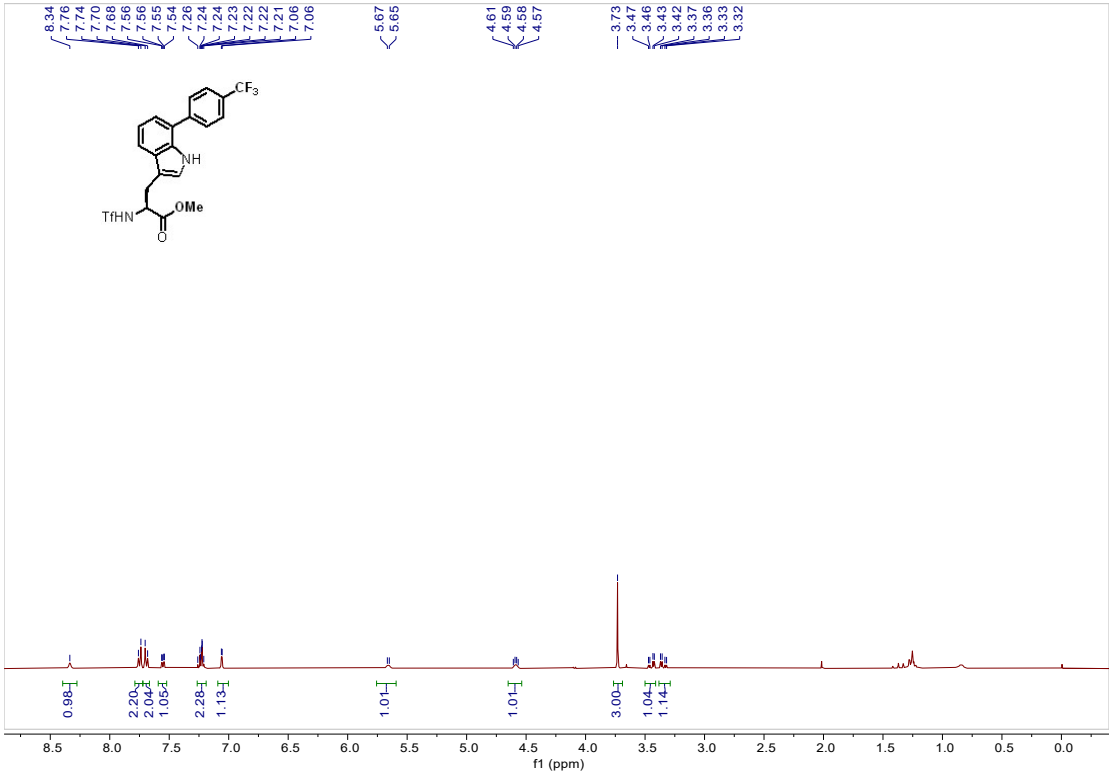
^{13}C NMR (126 MHz, $CDCl_3$) spectrum of **5g**



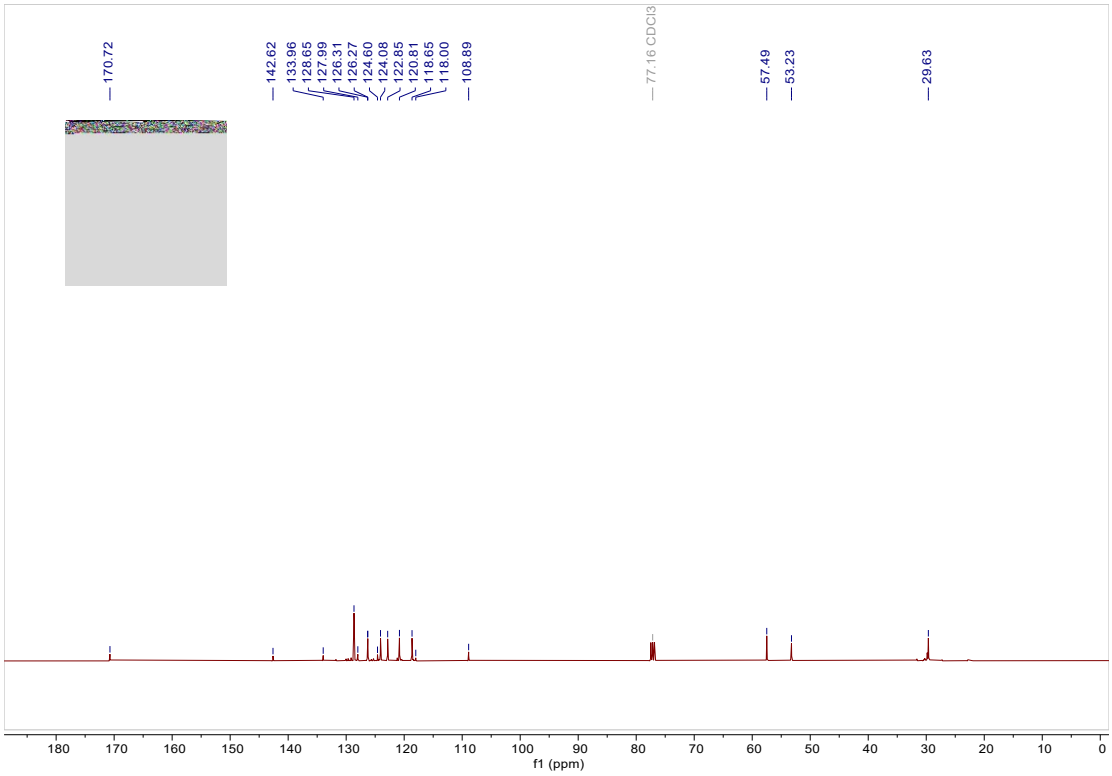
^{1}H NMR (400 MHz, $CDCl_3$) spectrum of **5i'**



^{13}C NMR (101 MHz, $CDCl_3$) spectrum of **5i'**



^{1}H NMR (400 MHz, $CDCl_3$) spectrum of **5j'**



^{13}C NMR (101 MHz, $CDCl_3$) spectrum of **5j'**