Supporting Information

Highly Regio-, and Stereoselective Markovnikov Hydrosilylation of Alkynes Catalyzed by High-nuclearity {Co_{14}} Clusters

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General Information

Reagents were purchased from commercial suppliers and used without further purification. THF, toluene, and hexane, ethyl ether were used after dried by molecular sieve. Column chromatography on silica gel (300-400 mesh) was carried out using technical grade 60-90℃ petroleum ether (distillated prior to use) and analytical grade EtOAc (without further purification). ^{1}H and ^{13}C spectra were recorded on a 400 MHz spectrometer. Chemical shifts were reported in ppm. ^{1}H NMR spectra were referenced to $CDCl_3$ (7.26 ppm) and DMSO-d_6 (2.5 ppm), and ^{13}C-NMR spectra were referenced to $CDCl_3$ (77.0 ppm) and DMSO-d_6 (40.0 ppm). Peak multiplicities were designated by the following abbreviations: s, singlet; d, doublet; t, triplet; m, multiplet; brs, broad singlet and *J*, coupling constant in Hz. The Glove Box & Gas Purification System is produced by Mikrouna; HRMS spectra were recorded with Aglient 7250& JEOL-JMS-T100LP AccuTOF and Micromass QTOF2 Quadrupole/Time-of-Flight Tandem mass spectrometer using electron spray ionization. The metal content passed the Inductively Coupled Plasma Mass (ICP-MS) spectrometry of FLexar-NexION300X of PekinElmer in the United States; inVia Raman microscope is produced by Renishaw; The reagents and solvents employed were commercially available and used as received without further purification. The C, H, and N microanalyses were carried out with a Perkin–Elmer PE 2400 II CHN elemental analyzer.

Experimental Details

1. **Synthesis of the Catalyst**

1.1 Hydrothermal Synthesis of $[Co_{14}(\mu_3\text{-}OCH_3)_4(\mathbf{L_1})_6Cl_{12}]\cdot 14CH_3OH$ (**C1**)

A mixture of 5,5-di(pyridin-2-yl)-3,3-bi(1,2,4-triazole) (**L1**) (0.087 g, 0.3 mmol), $CoCl_2\cdot 6H_2O$ (0.214 g, 0.9 mmol), and triethylamine (0.6 mmol, *ca.* 2 equiv per **L1**) in MeOH/EtOH (v/v = 10:1, 11 mL) was sealed in a 25 mL Teflon-lined autoclave and heated at 130 °C in an oven for 3 days. Then it was allowed to be cooled to ambient temperature over 24 h, giving blue-green strip crystals of **C1** in a yield of 26 % [base on **L1**]. Elemental analysis (%) calcd for $Co_{14}C_{102}H_{116}Cl_{12}N_{48}O_{18}$: C, 34.48; H, 3.29; N, 18.92. Found: C, 34.37; H, 3.08; N, 19.27. IR data for **C1** (KBr, cm^{-1}): 3412(s), 1620(m), 1478(m), 1448(m), 1418(m), 1310(m), 1272(m), 1033(m), 799(m), 724(m).

1.2 Hydrothermal Synthesis of $[Co_{14}(\mu_3\text{-}OCH_3)_4(\mathbf{L_2})_6Cl_{12}]\cdot 21CH_3OH$ (**C2**)

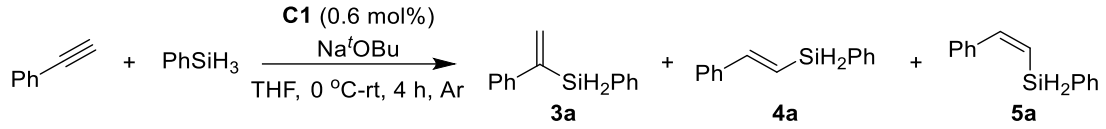
A mixture of 5,5'-di(4-methylpyridin-2-yl)-3,3'-bi(1,2,4-triazole) (**L2**) (0.095g, 0.3 mmol), $CoCl_2\cdot 6H_2O$ (0.214 g, 0.9 mmol), and triethylamine (0.6 mmol, *ca.* 2 equiv per **L2**) in MeOH (11 mL), was sealed in a 25 mL Teflon-lined autoclave and heated at 160 °C in an oven for 3 days. Then it was allowed to be cooled to ambient temperature over 24 h, giving blue-green strip crystals of **C2** in a yield of 31 % [base on **L2**]. Elemental analysis (%) calcd for $Co_{14}C_{121}H_{168}Cl_{12}N_{48}O_{25}$: C, 36.84; H, 4.29; N, 17.04; Found: C, 37.23; H, 4.01; N,17.66. IR data for **C2** (KBr, cm^{-1}): 3414(s), 1623(s), 1493(m), 1460(m), 1278(m), 1041(m), 1009(m), 769(m), 726 (m), 564(m)

1.3 Hydrothermal Synthesis of $[Co_{14}(\mu_3\text{-}OH)_4(\mathbf{L_3})_6Cl_{12}]\cdot 19CH_3CH_2OH$ (**C3**)

A mixture of 5,5'-di(5-methylpyridin-2-yl)-3,3'-bi(1,2,4-triazole) (**L3**) (0.095 g, 0.3 mmol), $CoCl_2\cdot 6H_2O$ (0.214 g, 0.9 mmol), and triethylamine (0.6 mmol, *ca.* 2 equiv per **L3**) in EtOH (11 mL) was sealed in a 25 mL Teflon-lined autoclave and heated at 160 °C in an oven for 3 days. Then it was allowed to be cooled to ambient temperature over 24 h, giving blue-green strip crystals of **C3** in a yield of 29% [base on **L3**]. Elemental analysis (%) calcd for $Co_{14}C_{134}H_{190}Cl_{12}N_{48}O_{23}$: C, 39.33; H, 4.68; N, 16.43; Found: C, 38.82; H, 4.23; N, 17.00. IR data for **C3** (KBr, cm^{-1}): 3363(s), 1614(s), 1478(m), 1458(s), 1261(m), 1037(m), 1011(m), 767(m), 726(s), 633(m).

2. **Optimization Studies**

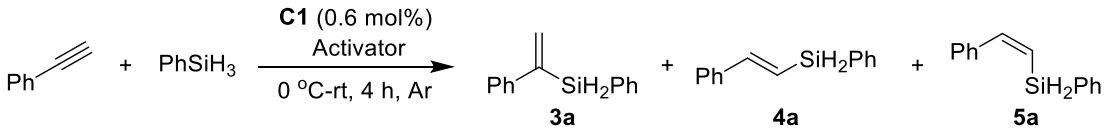
Table S1. Screening of the amount of silanes and additions.[a]



Entry	Catalyst	NaO^{t}Bu/%	$PhSiH_3$/eq.	Yield/%[b]	Ratio of **3a**:**4a**:**5a**[c]
1	**C1**	3	1.0	78	97:3:nd
2	**C1**	3	1.2	86	99:1:nd
3	**C1**	3	1.5	86	98:2:nd
4	**C1**	3	2.0	84	96:3:1
5	**C1**	4	1.2	82	98:2:nd
6	**C1**	5	1.2	78	95:5:nd
7	**C1**	6	1.2	75	97:3:nd
8	**C1**	2	1.2	81	97:3:nd

[a] Reaction conditions: phenylacetylene (0.5 mmol), $PhSiH_3$, **C1** (0.6 mol%), Na^{t}OBu, THF (2 mL), 0 ℃ to rt, 4 h. [b] Isolated yield. [c] Determined by ^{1}H NMR spectroscopy.

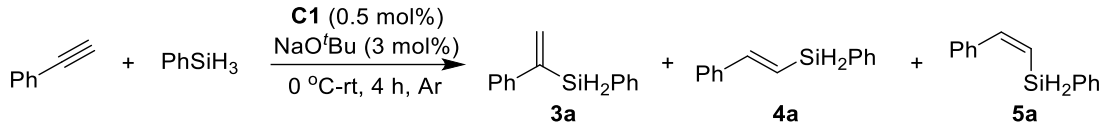
Table S2. Screening of addition and solvent.[a]



Entry	Solvent	Catalyst	Activator	Yield/%[b]	Ratio of **3a**:**4a**:**5a**[c]
1	THF	**C1**	none	trace	--
2	THF	**C1**	$NaBHEt_3$	82	89:8:3
3	THF	**C1**	*i*PrMgBr	trace	--
4	THF	**C1**	*n*-BuLi	68	96:2:2
5	THF	**C1**	$LiAlH_4$	72	96:2:2
6	*n*-hexane	**C1**	NaO^{t}Bu	64	83:15:2
7	Toluene	**C1**	NaO^{t}Bu	60	98:2:nd
8	Et_2O	**C1**	NaO^{t}Bu	77	96:4:nd
9	Dioxane	**C1**	NaO^{t}Bu	79	82:16:2
10	CH_3CN	**C1**	NaO^{t}Bu	62	88:10:2
11	THF	$CoCl_2$	NaO^{t}Bu	0	--

[a] Reaction conditions: phenylacetylene (0.5 mmol), $PhSiH_3$ (0.6 mmol), Catalyst (0.6 mol%), activator (3 mol%), THF (2 mL), 0 ℃ to rt, 4 h. [b] Isolated yield. [c] Determined by ^{1}H NMR spectroscopy.

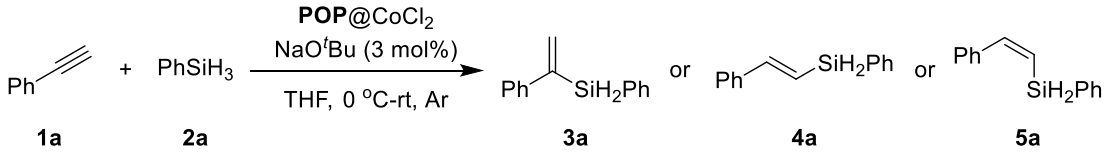
Table S3. Screening of catalyst loadings and reaction time.[a]

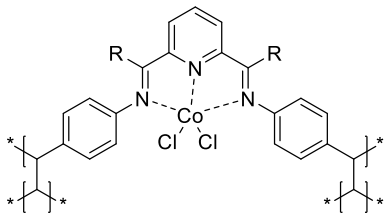


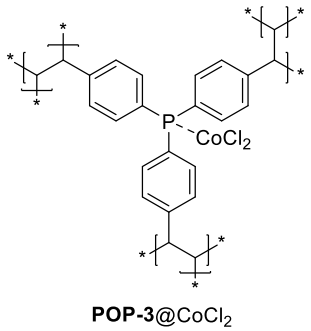
Entry	Solvent	**C1**/mol%	t/h	Yield/%[b]	Ratio of **3a**:**4a**:**5a**[c]
1	THF	0.6	2	78	98:2:nd
2	THF	0.6	4	86	99:1:nd
3	THF	0.6	5	85	99:1:nd
4	THF	0.5	4	78	96:4:nd
5	THF	0.4	4	76	98:2:nd
6	THF	0.7	4	85	97:3:nd

[a] Reaction conditions: phenylacetylene (0.5 mmol), $PhSiH_3$ (0.6 mmol), **C1**, Na^{t}OBu (3 mol%), THF (2 mL), 0 ℃ to rt. [b] Isolated yield. [c] Determined by ^{1}H NMR spectroscopy.

Table S4. Screening of **POP**@$CoCl_2$.[a]



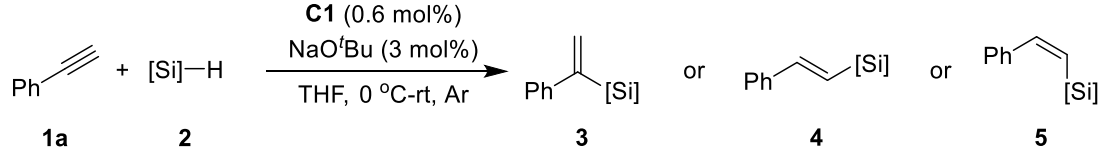


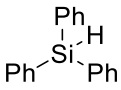


Entry	Catalyst	Yield/%[b]	Ratio (**3a**/**4a**/**5a**)[c]
1	**POP-1**@$CoCl_2$	62	65:29:6
2	**POP-2**@$CoCl_2$	64	70:26:4
3	**POP-3**@$CoCl_2$	trace	-

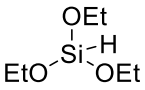
[a] Reaction conditions: phenylacetylene (0.5 mmol), $PhSiH_3$ (0.6 mmol), catalyst (0.6 mol%), Na^{t}OBu (3 mol%), solvent (2 mL), 0 °C to rt, 4 h. [b] Isolated yield. [c] Determined using ^{1}H NMR spectroscopy.

Table S5. Phenylacetylene reacts with tertiary hydrosilanes.[a]

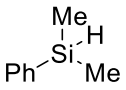




2c



2d



2e

Entry	[Si]—H	Yield/%[b]	Ratio (3/4/5)[c]
1	**2c**	0	-
2	**2d**	0	-
3	**2e**	trace	-

[a] Conditions: Phenylacetylyne (0.5 mmol), hydrosilanes (0.6 mmol), **C1** (0.6 mol%), Na^{t}OBu (3 mol%) in THF (0.25 M), 0 °C to rt, 4 h. [b] Isolated yield. [c] Determined using ^{1}H NMR spectroscopy.

3. **Hydrosilylation of Alkyness**

General Procedure for Hydrosilylation of Alkynes: In an Argon filled glovebox the cluster **C1** (0.6 mol%), alkynes (0.5 mmol), hydrosilanes (0.6 mmol), and anhydrous THF (2 mL) were added into a 25 mL Schlenk tube with a magnetic stirring bar. The reaction tube was cooled to 0 ℃. Then NaO^{t}Bu (3 mol%) was added to the reaction mixture and the reaction stirring at 0 ℃ to room temperature for 4 h. After 4 h of reaction, the solid catalyst was separated by centrifugation and washed with EA. Combine the organic phase and the solvent was removed by vacuum and the crude mixture was purified by flash column chromatography on silica gel using PE (PE/EA) as the eluent to give the corresponding product.

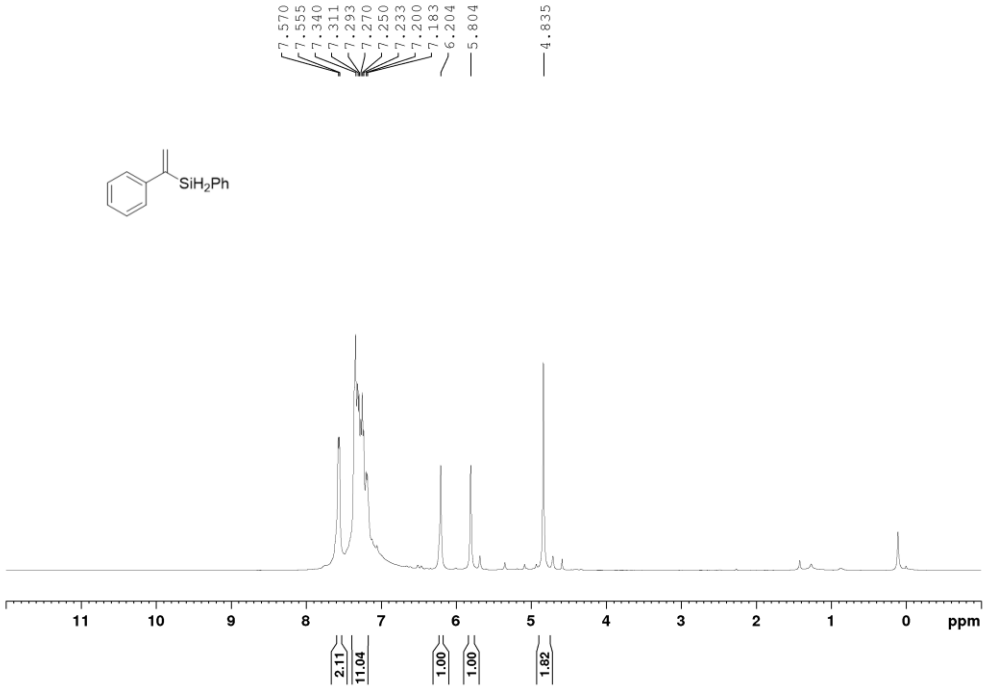
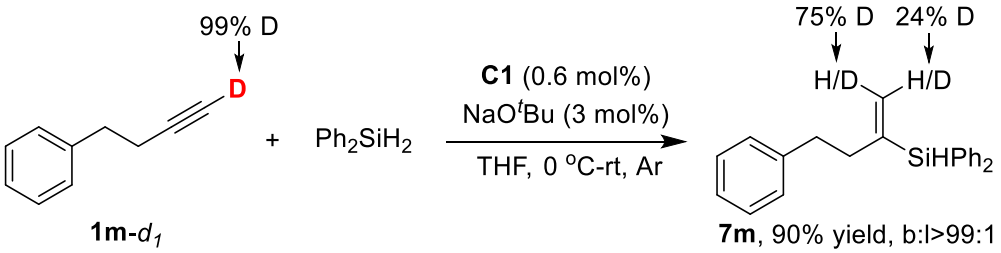


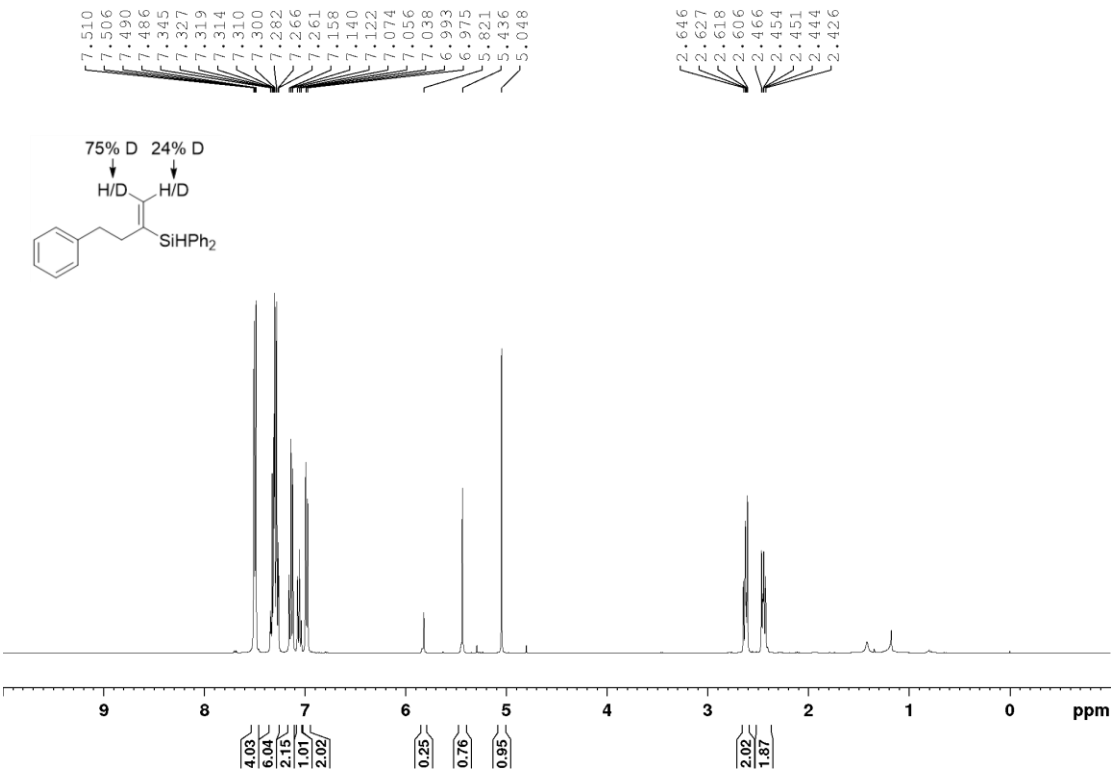
Figure S1. **3a** ^{1}H NMR spectrum of crude product

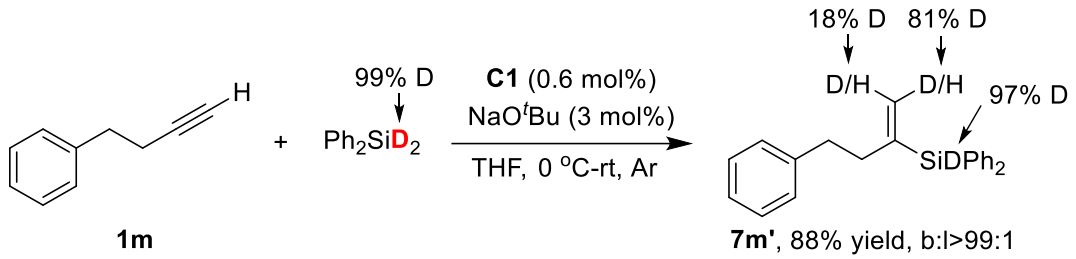
4. **Deuterium-Labeling Experiments**

Phenylacetylene-d_1[1], 4-phenyl-1-butyne-d_1[1] and Ph_2SiD_2[2] were synthesized based on previously reported procedures.

General Procedure for Deuterium-Labeling Experiments: In an Argon filled glovebox the cluster **C1** (0.6 mol %), alkynes-d_1 or alkynes (0.5 mmol), Ph_2SiH_2 or Ph_2SiD_2 (0.6 mmol), and anhydrous THF (2 mL) were added into a 25 mL Schlenk tube with a magnetic stirring bar. The reaction tube was cooled to 0 ℃. Then NaO^{t}Bu (3 mol%) was added to the reaction mixture and the reaction stirring at 0 ℃ to room temperature for 4 h. After 4 h of reaction, the solid catalyst was separated by centrifugation and washed with EA. Combine the organic phase and the solvent was removed by vacuum and the crude mixture was purified by flash column chromatography on silica gel using PE as the eluent to give the corresponding product. ^{1}H NMR detects the regioselectivity ratio and deuteration rate.

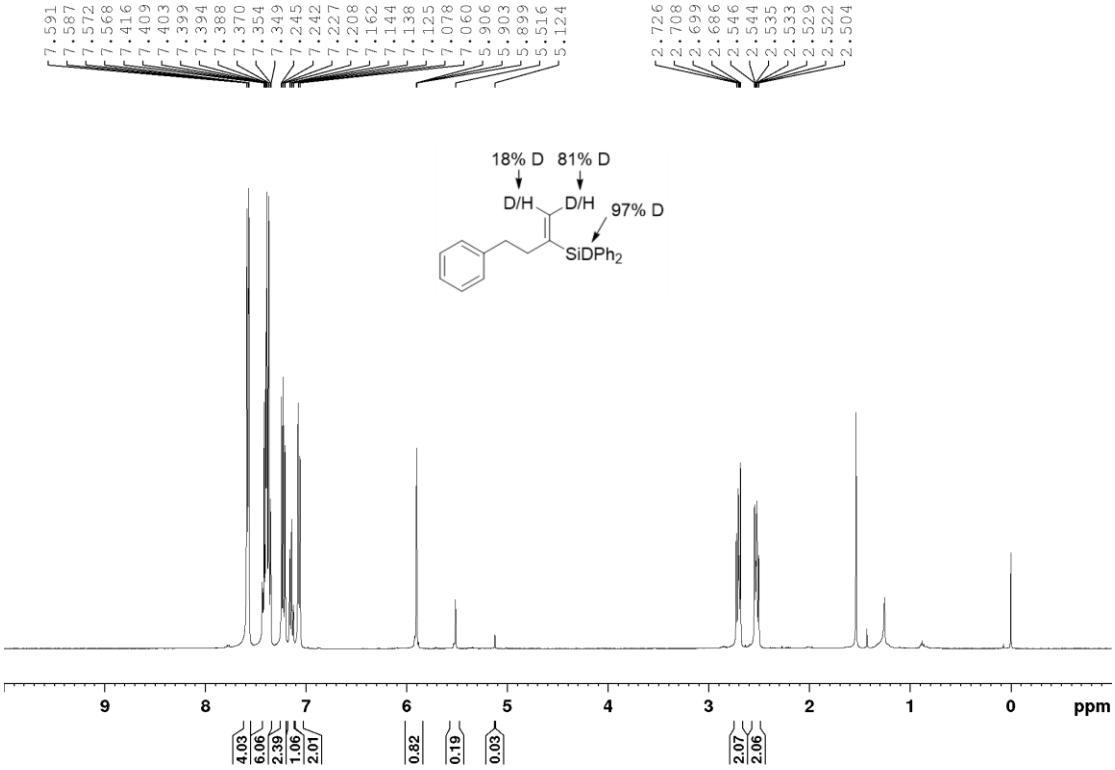


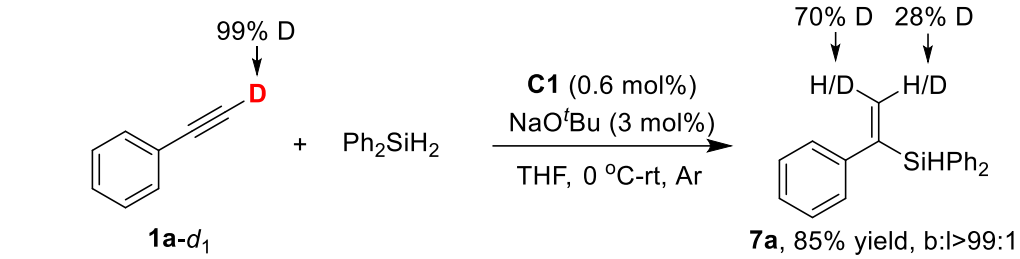


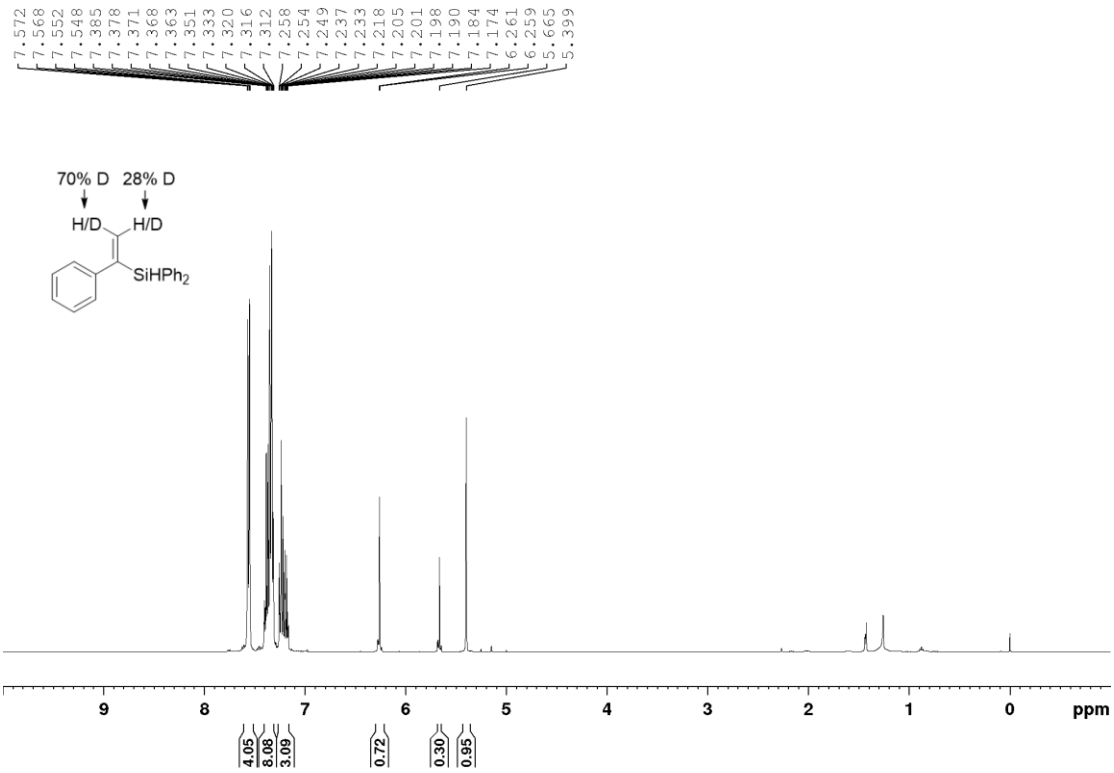


1m

7m', 88% yield, b:l>99:1




99% D
D
+ Ph2SiH2
C1 (0.6 mol%)
NaOtBu (3 mol%)
THF, 0 °C-rt, Ar
70% D 28% D
H/D H/D
SiHPh2
1a-d1
7a, 85% yield, b:l>99:1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7.312
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7.249
7.237
7.233
7.218
7.205
7.201
7.198
7.190
7.184
7.174
6.261
6.259
5.665
5.399
70% D 28% D
H/D H/D
SiHPh2
9
8
7
6
5
4
3
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1
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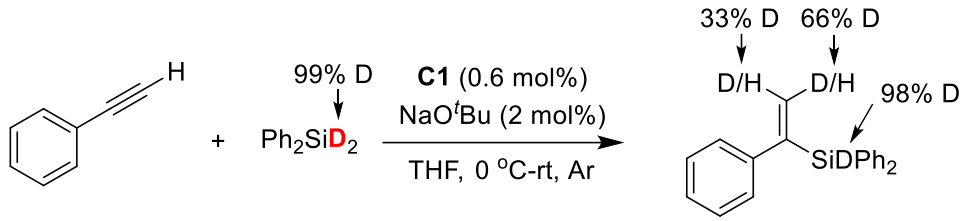
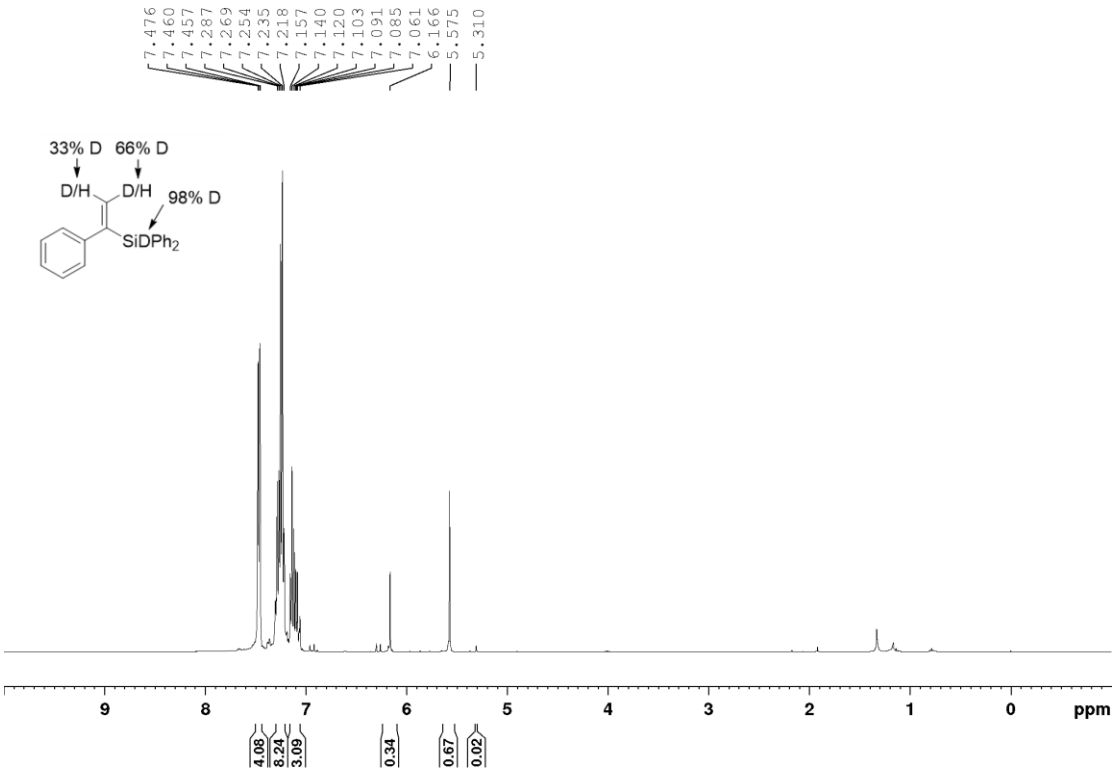
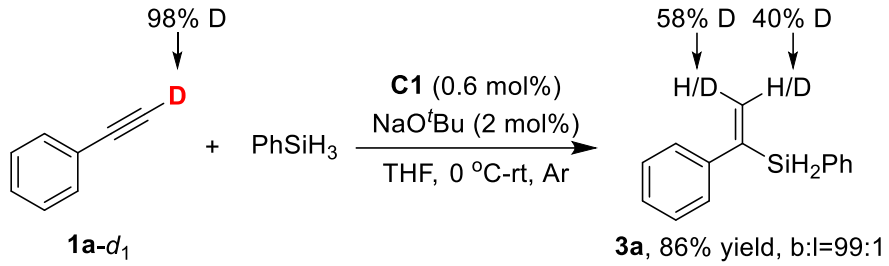
8.08
3.09
0.72
0.30
0.95

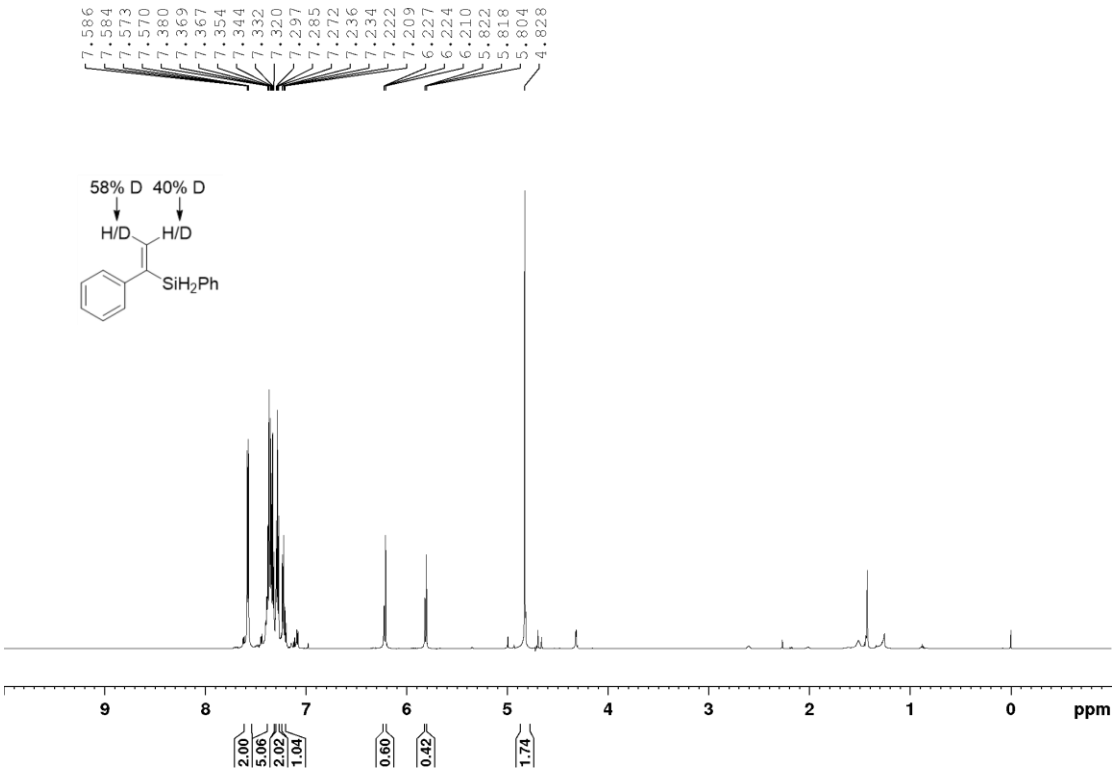


1a

7a', 86% yield, b:l>99:1




98% D
D
+ PhSiH3
C1 (0.6 mol%)
NaO^tBu (2 mol%)
THF, 0 °C-rt, Ar
58% D 40% D
H/D H/D
SiH2Ph
1a-d1
3a, 86% yield, b:l=99:1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7.272
7.236
7.234
7.222
7.209
6.227
6.224
6.210
5.822
5.818
5.804
4.828
58% D 40% D
H/D H/D
SiH2Ph
9
8
7
6
5
4
3
2
1
0
ppm
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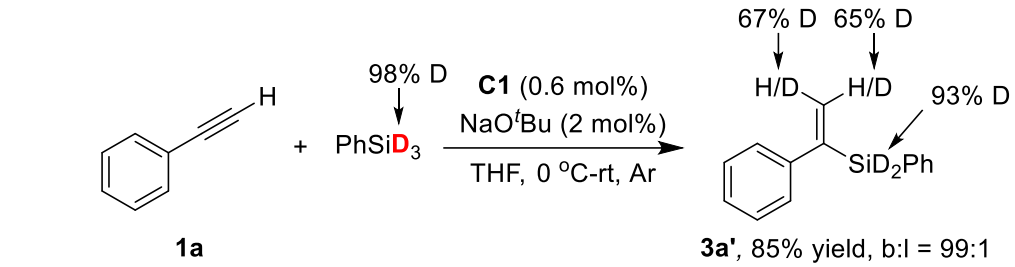
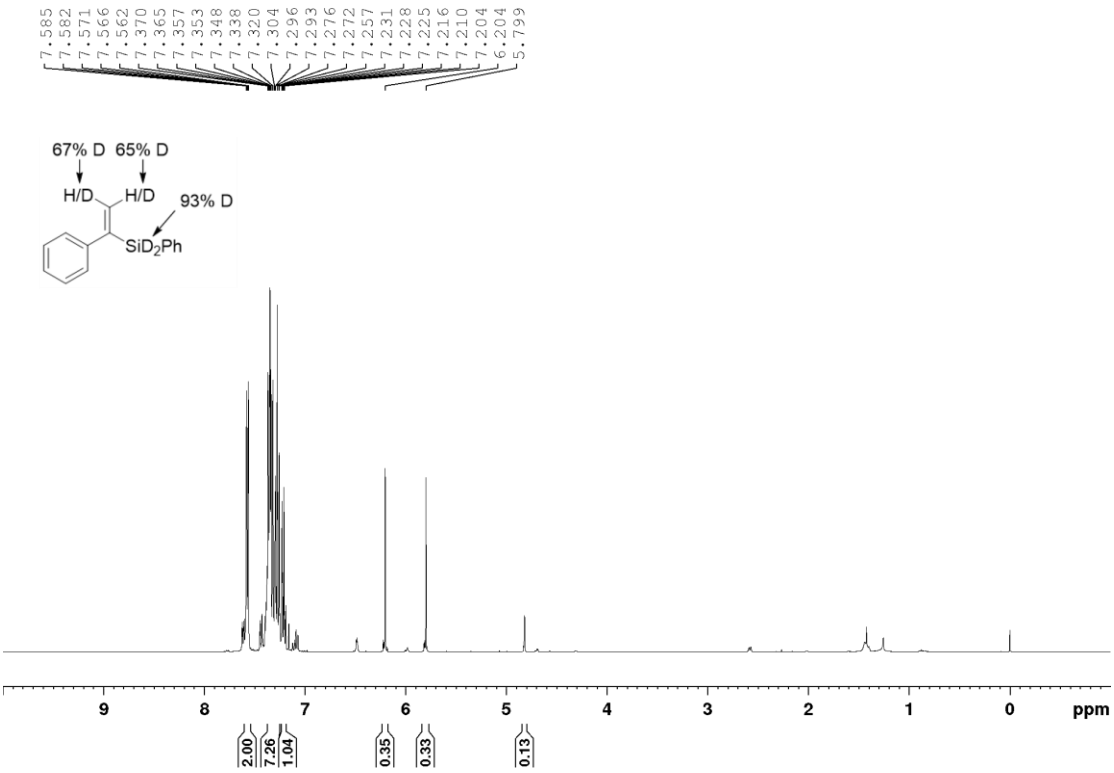
5.06
2.02
1.04
0.60
0.42
1.74



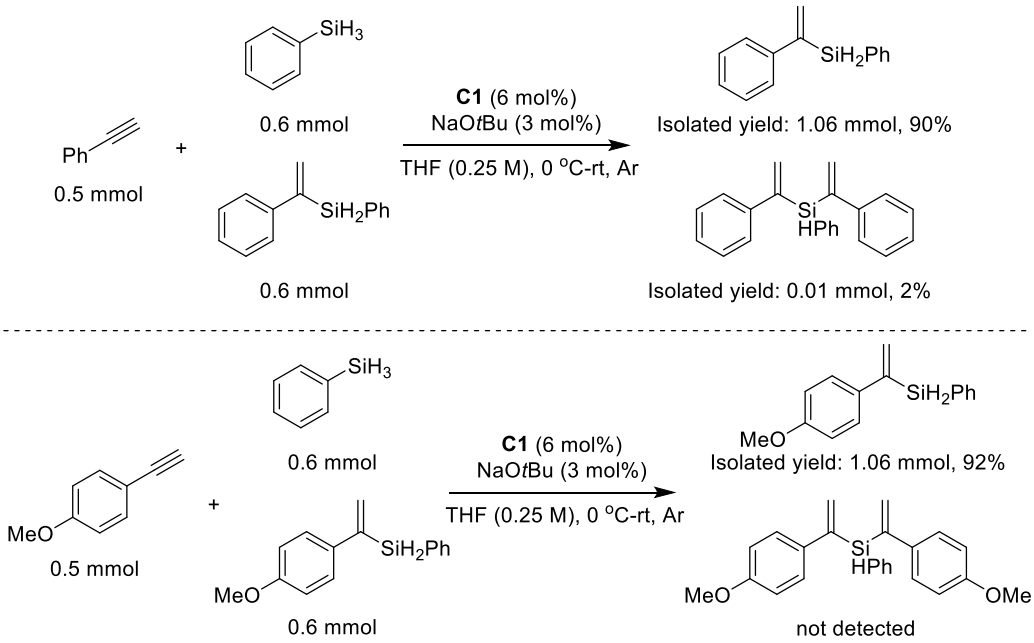
1a

3a', 85% yield, b:l = 99:1



5. **Competition Experiments**

In an Argon filled glovebox the cluster **C1** (0.6 mol %), phenylacetylyne (0.5 mmol), $PhSiH_3$ (0.6 mmol), **3a** (0.6 mmol), and anhydrous THF (2 mL) were added into a 25 mL Schlenk tube with a magnetic stirring bar. The reaction tube was cooled to 0 ℃. Then NaO^tBu (3 mol%) was added to the reaction mixture and the reaction stirring at 0 ℃ to room temperature for 4 h. After 4 h of reaction, the solid catalyst was separated by centrifugation and washed with EA. Combine the organic phase and the solvent was removed by vacuum and the crude mixture was purified by flash column chromatography on silica gel using PE as the eluent to give the corresponding product.



6. Post-treatment and activation of catalyst

After the cluster was used, we detected the concentration of Co in the reaction solution by Inductively Coupled Plasma Mass Spectrometry (ICP-MS) and found that a small amount of cobalt chloride fell off. We speculate that there may be the following equilibrium in the reaction process:

$$[Co_8]\cdot(CoCl_2)_6 \rightleftharpoons [Co_8]\cdot(CoCl_2)_{6-n} + n\ CoCl_2$$

The process of catalyst post-treatment and activation is as follows: after the catalysis is completed, the supernatant was carefully removed after the first catalytic run. The solid catalyst was washed with anhydrous methanol (5 × 5 mL) and dried under vacuum for 4 h to remove volatiles. The solid catalyst was then immersed in an alkaline

saturated $CoCl_2$ solution for 24 h. Then, the solid catalyst was then centrifuged and washed with anhydrous methanol. After drying, enter the next cycle.

X-ray Crystallography of Clusters and 7c

1. X-ray Crystallography of Clusters

1.1 X-ray Crystallography

Single-crystal X-ray diffraction data collection for **C1** was conducted on an Agilent Supernova diffractometer (Mo, λ= 0.71073 Å) and **C2-C3** were conducted on an Rigaku Oxford Diffraction diffractometer (Mo, λ= 0.71073 Å) at 100 K. The structures were solved by direct methods using ShelXS and refined using a full-matrix least-squares technique based on F^2 within ShelXL 2018 and OLEX-2.[3] Lattice solvent molecules in **C1-C3** are significantly disordered and could not be modeled properly due to the lack of well defined atomic positions, thus the SQUEEZE procedure implemented with the "solvent mask" method in OLEX2 was used to calculate the solvent disorder area and remove its contribution to the overall intensity data. The Squeeze (or Bypass) procedure is a widely used and accepted method that corrects diffraction data for structures affected by the presence of heavily disordered solvent. However, the use of Squeeze does not impact the framework atoms. For **C1**, SQUEEZE gives 492 electrons/unit cell for the voids. These electrons are all from CH_3OH (18 e^-), each unit cell has 14 (*ca.* 492/18) CH_3OH molecules, and each formula unit has 14 CH_3OH molecules (since Z = 2). So the suitable formula for this complex should be $[Co_{14}(\mu_3\text{-}OCH_3)_4(\mathbf{L_1})_6Cl_{12}]\cdot 14CH_3OH$. If other molecules (like Et_3N) are mixed in the structure, it maybe become more complicated and not easy to assign them. For **C2**, SQUEEZE gives 750 electrons/unit cell for the voids. If these electrons are all from CH_3OH (18 e^-), each unit cell has 42 (*ca.* 750/18) CH_3OH molecules, and each formula unit has 21 CH_3OH molecules (since Z = 2). So the suitable formula for this complex should be $[Co_{14}(\mu_3\text{-}OCH_3)_4(\mathbf{L_2})_6Cl_{12}]\cdot 21CH_3OH$ (**C2**). If other molecules (like EtOH or Et_3N) are mixed in the structure, it would become more complicated and not easy to assign them For **C3**, the contributions of some 907 electrons were removed from the formula unit. And as Z = 2 in this case, this might correspond with the removal of solvent such as 17 CH_3CH_2OH from the unit and 2 dissociative CH_3CH_2OH. Therefore, the suitable formula for this complex may be $[Co_{14}(\mu_3\text{-}OH)_4(\mathbf{L_3})_6Cl_{12}]\cdot 19CH_3CH_2OH$ (**C3**). Additionally, the elemental analysis for **C1-C3** approve the result. The crystallographic details are summarized in Table S1. Selected bond distances and bond angles arelisted in Tables **S2**. Crystallographic data for the structural analyses have been deposited at the Cambridge Crystallographic Data Centre, reference numbers 2074795 for **C1**, 2072970 for **C2** and 2072988 for **C3**, respectively.

1.2 **structural analyses**

Table S6. Crystal data and structure refinement for **C1-C3**.

Complex	**C1**	**C2**	**C3**
Empirical formula	$Co_{14}C_{88}H_{60}Cl_{12}N_{48}O_4$	$Co_{14}C_{100}H_{84}Cl_{12}N_{48}O_4$	$Co_{14}C_{100}H_{88}Cl_{12}N_{48}O_6$
Formula weight (M)	3104.26	3272.57	3308.60
Temp./K	100	100	100
Crystal system	triclinic	Triclinic	Triclinic
Space group	*P-1*	*P*-1	*P*-1
a (Å)	17.9279(2)	17.2316(4)	17.0354(2)
b (Å)	18.5845(2)	20.0133(3)	17.0429(2)
c (Å)	28.0387(3)	22.8085(6)	30.5086(3)
α (°)	74.8180(10)	84.523(2)	100.016(10)°
β (°)	87.5850(10)	81.462(2)	94.443(10)°
γ (°)	61.2650(10)	82.412(2)	100.929(10)°
V/(Å^3)	7866.81(17)	7687.4(3)	8508.4(17)
Z	2	2	2
D_c(Mg m^{-3})	1.311	1.414	1.291
F(000)	3076.0	3268.0	3308.0
θ range for data collection (°)	2.783- 29.293	2.0-26.4	1.9 -26.4
Reflections collected / unique	106205 / 37026 [R_{int}= 0.0353]	117553/ 31423 [R_{int} = 0.039]	138576/ 34753 [R_{int} = 0.039]
Goodness-of-fit on F^2	1.047	1.071	1.058
Final *R* indices [$I > 2\sigma(I)$]	R_1 = 0.0715 ωR_2 = 0.2048	R_1 = 0.0746 ωR_2= 0.2272	R_1 = 0.0698 ωR_2= 0.2037
R indices (all data)	R_1 = 0.0915 ωR_2= 0.2206	R_1 = 0.0983 ωR_2= 0.2513	R_1 = 0.0862 ωR_2= 0.2203

Table S7. Selected bond lengths (Å) and angles (°) for **C1 - C3**.

C1			
Co1—O1	2.157 (3)	Co6—N33	2.195 (5)
Co1—O2	2.081 (3)	Co6—N35	2.048 (4)
Co1—O3	2.112 (3)	Co7—N15	2.077 (4)

Co1—N6	2.259 (4)	Co7—N16	2.214 (4)
Co1—N12	2.177 (4)	Co7—N17	2.231 (5)
Co1—N44	2.179 (3)	Co7—N19	2.061 (4)
Co2—O2	2.106 (3)	Co7—N39	2.066 (4)
Co2—O3	2.135 (3)	Co7—N40	2.214 (4)
Co2—O4	2.100 (3)	Co8—N23	2.094 (4)
Co2—N4	2.215 (4)	Co8—N24	2.256 (5)
Co2—N30	2.187 (4)	Co8—N25	2.185 (5)
Co2—N36	2.215 (4)	Co8—N27	2.075 (4)
Co3—O1	2.131 (3)	Co8—N47	2.071 (4)
Co3—O2	2.127 (3)	Co8—N48	2.269 (4)
Co3—O4	2.111 (3)	Co9—Cl1	2.2137 (18)
Co3—N14	2.194 (4)	Co9—Cl2	2.220 (2)
Co3—N20	2.206 (4)	Co9—N2	2.034 (4)
Co3—N38	2.184 (3)	Co9—N5	2.028 (4)
Co4—O1	2.157 (3)	Co10—Cl3	2.2064 (14)
Co4—O3	2.098 (3)	Co10—Cl4	2.1994 (12)
Co4—O4	2.122 (3)	Co10—N42	2.040 (3)
Co4—N22	2.183 (4)	Co10—N45	2.037 (4)
Co4—N28	2.202 (4)	Cl12—Co11	2.133 (11)
Co4—N46	2.234 (3)	Cl9—Co11	2.356 (7)
Co5—N7	2.046 (4)	Co11—Cl14	1.925 (13)
Co5—N8	2.253 (4)	Co11—Cl16	2.184 (17)
Co5—N9	2.159 (4)	Co12—Cl	2.19 (3)
Co5—N11	2.079 (4)	Co12—Cl11	2.181 (5)
Co5—N41	2.229 (4)	Co12— N34	2.015 (5)
Co5—N43	2.071 (4)	Co12— N37	1.997 (4)
Co6—N1	2.231 (5)	Co13—Cl5	2.229 (3)
Co6—N3	2.078 (4)	Co13—Cl6	2.220 (3)
Co6—N31	2.065 (5)	Co13—N10	2.011 (4)
Co6—N32	2.187 (5)		

O1—Co1—N6	173.55 (14)	N11—Co5—N8	156.10 (15)
O1—Co1—N12	95.65 (13)	N11—Co5—N9	76.06 (15)
O1—Co1—N44	92.74 (13)	N11—Co5—N41	115.94 (14)
O2—Co1—O1	82.99 (12)	N41—Co5—N8	86.76 (15)
O2—Co1—O3	82.50 (12)	N43—Co5—N8	109.88 (15)
O2—Co1—N6	95.34 (12)	N43—Co5—N9	145.99 (15)
O2—Co1—N12	92.12 (12)	N43—Co5—N11	84.57 (14)
O2—Co1—N44	175.39 (13)	N43—Co5—N41	75.11 (14)
O3—Co1—O1	81.76 (13)	N3—Co6—N1	75.44 (16)
O3—Co1—N6	91.85 (13)	N3—Co6—N32	148.35 (19)
O3—Co1—N12	174.27 (13)	N3—Co6—N33	115.90 (18)
O3—Co1—N44	95.20 (13)	N31—Co6—N1	113.66 (18)

N12—Co1—N6	90.64 (13)	N35—Co6—N32	116.90 (19)
N12—Co1—N44	90.02 (13)	N35—Co6—N33	76.34 (16)
N44—Co1—N6	88.72 (13)	N15—Co7—N16	74.78 (15)
O2—Co2—O3	81.36 (12)	N15—Co7—N17	148.24 (15)
O2—Co2—N4	96.94 (13)	N15—Co7—N40	115.71 (16)
O2—Co2—N30	174.34 (14)	N16—Co7—N17	92.30 (17)
O2—Co2—N36	90.92 (13)	N19—Co7—N15	85.32 (15)
O3—Co2—N4	92.35 (13)	N19—Co7—N16	119.01 (15)
O3—Co2—N30	96.59 (14)	N19—Co7—N17	75.69 (16)
O3—Co2—N36	172.27 (14)	N19—Co7—N39	85.20 (16)
O4—Co2—O2	82.37 (12)	N19—Co7—N40	149.99 (17)
O4—Co2—O3	81.52 (12)	N39—Co7—N15	85.33 (15)
O4—Co2—N4	173.87 (13)	N39—Co7—N16	146.41 (17)
O4—Co2—N30	92.13 (14)	N39—Co7—N17	117.51 (17)
O4—Co2—N36	97.07 (13)	N39—Co7—N40	76.07 (15)
N30—Co2—N4	88.39 (15)	N40—Co7—N16	88.37 (15)
N30—Co2—N36	91.06 (15)	N40—Co7—N17	92.28 (16)
N36—Co2—N4	89.03 (14)	N23—Co8—N24	74.51 (15)
O1—Co3—N14	92.30 (13)	N23—Co8—N25	122.71 (18)
O1—Co3—N20	93.19 (13)	N23—Co8—N48	141.82 (17)
O1—Co3—N38	175.75 (14)	N24—Co8—N48	88.23 (16)
O2—Co3—O1	82.54 (12)	N25—Co8—N24	90.66 (18)
O2—Co3—N14	96.05 (13)	N25—Co8—N48	90.58 (17)
O2—Co3—N20	172.66 (13)	N27—Co8—N23	86.16 (16)
O2—Co3—N38	93.21 (13)	N27—Co8—N24	146.27 (17)
O4—Co3—O1	82.29 (13)	N27—Co8—N25	76.68 (17)
O4—Co3—O2	81.64 (12)	N27—Co8—N48	122.49 (18)
O4—Co3—N14	174.33 (13)	N47—Co8—N23	83.88 (15)
O4—Co3—N20	91.90 (13)	N47—Co8—N24	118.76 (16)
O4—Co3—N38	97.02 (13)	N47—Co8—N25	146.04 (18)
N14—Co3—N20	90.07 (14)	N47—Co8—N27	85.42 (15)
N38—Co3—N14	88.25 (14)	N47—Co8—N48	74.93 (15)
N38—Co3—N20	91.03 (14)	Cl1—Co9—Cl2	112.90 (7)
O1—Co4—N22	94.16 (14)	N2—Co9—Cl1	120.59 (13)
O1—Co4—N28	175.89 (14)	N2—Co9—Cl2	108.59 (15)
O1—Co4—N46	92.41 (13)	N5—Co9—Cl1	114.78 (14)
O3—Co4—O1	82.08 (13)	N5—Co9—Cl2	115.76 (14)
O3—Co4—O4	81.88 (12)	N5—Co9—N2	80.64 (17)
O3—Co4—N22	175.48 (14)	Cl4—Co10—Cl3	112.05 (6)
O3—Co4—N28	94.74 (14)	N42—Co10—Cl3	103.08 (11)
O3—Co4—N46	94.41 (13)	N42—Co10—Cl4	125.45 (11)
O4—Co4—O1	81.42 (13)	N45—Co10—Cl3	112.97 (12)
O4—Co4—N22	95.11 (13)	N45—Co10—Cl4	119.05 (11)
O4—Co4—N28	95.58 (13)	N45—Co10—N42	80.21 (14)

O4—Co4—N46	173.16 (13)	N18—Co14—N21	79.95 (16)
N22—Co4—N28	88.90 (15)	N18—Co14—Cl7	115.7 (2)
N22—Co4—N46	88.24 (13)	N18—Co14—Cl8	111.73 (18)
N28—Co4—N46	90.43 (14)	N18—Co14—Cl7A	85.9 (3)
N7—Co5—N8	76.02 (15)	N18—Co14—Cl8A	164.5 (2)
N7—Co5—N9	121.23 (15)	N21—Co14—Cl7	115.11 (17)
N7—Co5—N11	86.92 (15)	N21—Co14—Cl8	115.95 (16)
N7—Co5—N41	147.17 (15)	N21—Co14—Cl7A	100.8 (2)
N7—Co5—N43	84.65 (15)	N21—Co14—Cl8A	113.1 (2)
N9—Co5—N8	98.43 (15)	Cl7—Co14—Cl8	114.11 (18)
N9—Co5—N41	88.47 (14)	Cl8A—Co14—Cl7A	83.5 (3)

C2			
Co1—O1	2.117 (3)	Co7—N24	2.186 (6)
Co1—O3	2.101 (4)	Co7—N31	2.069 (6)
Co1—O4	2.100 (3)	Co7—N32	2.230 (7)
Co1—N28	2.214 (4)	Co8—N7	2.051 (5)
Co1—N36	2.226 (4)	Co8—N8	2.193 (5)
Co1—N46	2.170 (4)	Co8—N9	2.202 (4)
Co2—O1	2.121 (3)	Co8—N11	2.072 (5)
Co2—O2	2.086 (4)	Co8—N39	2.070 (4)
Co2—O4	2.087 (3)	Co8—N40	2.216 (5)
Co2—N6	2.222 (4)	Co10—Cl4A	2.487 (8)
Co2—N12	2.197 (4)	Co10—Cl3A	2.015 (8)
Co2—N38	2.209 (5)	Co11—N18	2.288 (8)
Co3—O1	2.090 (4)	Co11—N21	2.157 (7)
Co3—O2	2.137 (3)	Co11—Cl13	2.310 (13)
Co3—O3	2.090 (4)	Co11—Cl14	1.957 (7)
Co3—N14	2.209 (4)	Co12—Cl11	2.417 (17)
Co3—N20	2.169 (5)	Co12—Cl3	2.26 (3)
Co3—N44	2.239 (4)	Co12—Cl12	2.002 (9)
Co4—O2	2.092 (4)	Co12—N26	2.146 (8)
Co4—O3	2.111 (4)	Co12—N29	2.095 (9)
Co4—O4	2.120 (4)	Co12—Cl10	2.246 (19)
Co4—N4	2.251 (5)	Co13—N10	2.046 (5)
Co4—N22	2.191 (5)	Co13—N13	1.927 (5)
Co4—N30	2.177 (5)	Co13—Cl7	2.261 (8)
Co5—N25	2.195 (5)	Co13—Cl9	2.207 (6)
Co5—N27	2.070 (5)	Co14—N2	2.116 (5)
Co5—N33	2.243 (5)	Co14—N5	2.058 (5)
Co5—N35	2.063 (4)	Co14—Cl6	2.216 (3)
Co5—N47	2.096 (4)	Co14—Cl8	2.216 (2)
Co5—N48	2.199 (4)	Co15—N10	2.070 (5)
Co6—N15	2.070 (5)	Co15—N13	2.256 (6)

Co6—N16	2.242 (5)	Co15—Cl8A	2.236 (5)
Co6—N17	2.180 (6)	Co15—Cl7A	2.342 (10)
Co6—N19	2.093 (6)	Co16—N18	1.987 (7)
Co6—N41	2.217 (5)	Co16—N21	2.074 (6)
Co6—N43	2.074 (4)	Co16—Cl9A	2.130 (14)
Co7—N1	2.222 (6)	Co16—Cl16	2.315 (7)
Co7—N3	2.084 (5)	Co17—N2	1.996 (7)
Co7—N23	2.070 (5)	Co17—N5	2.265 (7)
Co9—Cl1	2.235 (2)	Co17—Cl6A	2.363 (13)
Co9—Cl2	2.2115 (19)	Co17—Cl5A	2.067 (17)
Co9—N42	2.027 (4)	Co18—Cl12	2.21 (5)
Co9—N45	2.043 (4)	Co18—Cl11	1.94 (5)
Co10—N34	2.038 (5)	Co18—Cl3	1.76 (5)
Co10—N37	2.041 (5)	Co18—N26	2.01 (2)
Co10—Cl4	2.099 (4)	Co18—N29	2.152 (17)
Co10—Cl5	2.300 (4)	Co18—Cl15	2.63 (7)
O1—Co1—N28	173.20 (16)	N31—Co7—N23	85.9 (2)
O1—Co1—N36	93.14 (15)	N31—Co7—N24	147.4 (2)
O1—Co1—N46	95.83 (14)	N31—Co7—N32	75.3 (2)
O3—Co1—O1	80.30 (14)	N7—Co8—N8	76.31 (18)
O3—Co1—N28	95.07 (15)	N7—Co8—N9	117.35 (18)
O3—Co1—N36	173.18 (14)	N7—Co8—N11	85.12 (18)
O3—Co1—N46	95.37 (15)	N7—Co8—N39	85.68 (17)
O4—Co1—O1	81.23 (13)	N7—Co8—N40	151.31 (18)
O4—Co1—O3	81.80 (14)	N8—Co8—N9	91.22 (17)
O4—Co1—N28	93.22 (15)	N8—Co8—N40	94.15 (18)
O4—Co1—N36	95.43 (14)	N9—Co8—N40	89.45 (17)
O4—Co1—N46	176.20 (14)	N11—Co8—N8	148.96 (19)
N28—Co1—N36	91.30 (15)	N11—Co8—N9	75.37 (17)
N46—Co1—N28	89.53 (16)	N11—Co8—N40	113.21 (18)
N46—Co1—N36	87.11 (16)	N39—Co8—N8	118.43 (17)
O1—Co2—N6	173.87 (15)	N39—Co8—N9	146.97 (17)
O1—Co2—N12	96.62 (14)	N39—Co8—N11	84.07 (17)
O1—Co2—N38	91.88 (15)	N39—Co8—N40	75.09 (17)
O2—Co2—O1	81.59 (14)	Cl2—Co9—Cl1	117.22 (9)
O2—Co2—O4	82.16 (14)	N42—Co9—Cl1	104.59 (15)
O2—Co2—N6	97.43 (16)	N42—Co9—Cl2	118.85 (15)
O2—Co2—N12	91.39 (16)	N42—Co9—N45	80.48 (17)
O2—Co2—N38	173.47 (14)	N45—Co9—Cl1	120.30 (15)
O4—Co2—O1	81.44 (13)	N45—Co9—Cl2	110.21 (14)
O4—Co2—N6	92.43 (14)	N34—Co10—N37	79.92 (18)
O4—Co2—N12	173.46 (16)	N34—Co10—Cl4	119.80 (18)
O4—Co2—N38	96.68 (14)	N34—Co10—Cl5	111.28 (17)

N12—Co2—N6	89.45 (16)	N34—Co10—Cl4A	151.31 (18)
N12—Co2—N38	89.61 (17)	N37—Co10—Cl4	91.22 (17)
N38—Co2—N6	89.03 (16)	N37—Co10—Cl5	94.15 (18)
O1—Co3—O2	81.11 (14)	N37—Co10—Cl4A	110.8 (2)
O1—Co3—N14	95.43 (16)	Cl4—Co10—Cl5	112.15 (16)
O1—Co3—N20	175.64 (16)	Cl3A—Co10—N34	127.2 (3)
O1—Co3—N44	92.91 (15)	Cl3A—Co10—N37	130.2 (3)
O2—Co3—N14	94.68 (15)	Cl3A—Co10—Cl4A	107.7 (4)
O2—Co3—N20	96.08 (16)	N18—Co11—Cl13	93.2 (5)
O2—Co3—N44	172.82 (14)	N21—Co11—N18	73.0 (2)
O3—Co3—O1	81.19 (14)	N21—Co11—Cl13	89.7 (7)
O3—Co3—O2	80.88 (14)	Cl14—Co11—N18	146.3 (4)
O3—Co3—N14	174.76 (15)	Cl14—Co11—N21	101.6 (3)
O3—Co3—N20	95.10 (17)	Cl14—Co11—Cl13	120.3 (5)
O3—Co3—N44	94.35 (15)	Cl12—Co12—Cl11	98.4 (6)
N14—Co3—N44	89.80 (16)	Cl12—Co12—Cl3	85.2 (7)
N20—Co3—N14	88.11 (18)	Cl12—Co12—N26	103.1 (4)
N20—Co3—N44	89.65 (17)	Cl12—Co12—N29	169.3 (10)
O2—Co4—O3	81.45 (14)	Cl12—Co12—Cl10	79.3 (7)
O2—Co4—O4	81.24 (14)	Cl3—Co12—Cl11	16.7 (3)
O2—Co4—N4	95.68 (16)	N26—Co12—Cl11	100.7 (6)
O2—Co4—N22	91.74 (16)	N26—Co12—Cl3	93.9 (8)
O2—Co4—N30	175.40 (16)	N26—Co12—Cl10	162.6 (10)
O3—Co4—O4	81.12 (14)	N29—Co12—Cl11	92.0 (4)
O3—Co4—N4	173.20 (16)	N29—Co12—Cl3	105.5 (6)
O3—Co4—N22	95.24 (16)	N29—Co12—N26	77.4 (2)
O3—Co4—N30	94.09 (16)	N29—Co12—Cl10	97.0 (8)
O4—Co4—N4	92.37 (15)	Cl10—Co12—Cl11	95.9 (5)
O4—Co4—N22	172.49 (16)	Cl10—Co12—Cl3	103.5 (8)
O4—Co4—N30	97.05 (15)	N10—Co13—Cl7	110.5 (3)
N22—Co4—N4	90.98 (18)	N10—Co13—Cl9	110.3 (2)
N30—Co4—N4	88.65 (18)	N13—Co13—N10	81.4 (2)
N30—Co4—N22	89.74 (17)	N13—Co13—Cl7	104.4 (3)
N25—Co5—N33	90.95 (18)	N13—Co13—Cl9	121.8 (3)
N25—Co5—N48	92.94 (17)	Cl9—Co13—Cl7	121.3 (3)
N27—Co5—N25	75.93 (18)	N2—Co14—Cl6	120.91 (18)
N27—Co5—N33	148.28 (17)	N2—Co14—Cl8	117.15 (16)
N27—Co5—N47	84.32 (18)	N5—Co14—N2	78.70 (19)
N27—Co5—N48	120.92 (19)	N5—Co14—Cl6	100.61 (15)
N35—Co5—N25	119.54 (17)	N5—Co14—Cl8	120.05 (18)
N35—Co5—N27	86.12 (18)	Cl6—Co14—Cl8	113.57 (12)
N35—Co5—N33	75.34 (17)	N10—Co15—N13	73.5 (2)
N35—Co5—N47	84.15 (16)	N10—Co15—Cl8A	105.1 (2)
N35—Co5—N48	143.08 (18)	N10—Co15—Cl7A	123.7 (3)

N47—Co5—N25	147.3 (2)	N13—Co15—Cl7A	91.7 (2)
N47—Co5—N33	118.29 (18)	Cl8A—Co15—N13	100.7 (2)
N47—Co5—N48	75.06 (16)	Cl8A—Co15—Cl7A	131.1 (3)
N48—Co5—N33	87.99 (17)	N18—Co16—N21	81.4 (2)
N15—Co6—N16	75.42 (19)	N18—Co16—Cl9A	117.7 (5)
N15—Co6—N17	145.5 (2)	N18—Co16—Cl16	110.4 (3)
N15—Co6—N19	85.2 (2)	N21—Co16—Cl9A	114.9 (7)
N15—Co6—N41	119.1 (2)	N21—Co16—Cl16	105.4 (3)
N15—Co6—N43	85.86 (18)	Cl9A—Co16—Cl16	120.0 (6)
N17—Co6—N16	89.5 (2)	N2—Co17—N5	76.5 (3)
N17—Co6—N41	91.1 (2)	N2—Co17—Cl6A	172.4 (6)
N19—Co6—N16	119.8 (2)	N2—Co17—Cl5A	95.3 (4)
N19—Co6—N17	75.7 (2)	N5—Co17—Cl6A	95.8 (5)
N19—Co6—N41	146.6 (2)	Cl5A—Co17—N5	165.3 (5)
N41—Co6—N16	90.00 (18)	Cl5A—Co17—Cl6A	92.2 (6)
N43—Co6—N16	147.0 (2)	Cl12—Co18—Cl15	62.3 (18)
N43—Co6—N17	119.8 (2)	Cl11—Co18—Cl12	107.7 (7)
N43—Co6—N19	84.63 (19)	Cl11—Co18—N26	126 (3)
N43—Co6—N41	75.52 (17)	Cl11—Co18—N29	105 (2)
N1—Co7—N32	87.7 (3)	Cl11—Co18—Cl15	125.8 (15)
N3—Co7—N1	75.3 (2)	Cl3—Co18—Cl12	92.8 (10)
N3—Co7—N24	121.7 (2)	Cl3—Co18—Cl11	20.9 (7)
N3—Co7—N32	143.7 (2)	Cl3—Co18—N26	117 (3)
N23—Co7—N1	149.3 (2)	Cl3—Co18—N29	125 (3)
N23—Co7—N3	86.2 (2)	Cl3—Co18—Cl15	132 (2)
N23—Co7—N24	76.2 (2)	N26—Co18—Cl12	100.7 (15)
N23—Co7—N32	120.4 (2)	N26—Co18—N29	79.2 (7)
N31—Co7—N1	92.8 (2)	N26—Co18—Cl15	108 (2)
N31—Co7—N3	90.5 (2)	N29—Co18—Cl12	139 (3)
		N29—Co18—Cl15	78.0 (15)
		C3	
Co1—O1	2.113 (4)	Co7—N24	2.202 (4)
Co1—O2	2.158 (4)	Co7—N47	2.061 (4)
Co1—O3	2.195 (4)	Co7—N48	2.198 (5)
Co1—N6	2.201 (5)	Co8—N31	2.067 (4)
Co1—N20	2.162 (4)	Co8—N32	2.250 (4)
Co1—N38	2.203 (4)	Co8—N33	2.241 (4)
Co2—O1	2.094 (4)	Co8—N35	2.067 (4)
Co2—O2	2.215 (4)	Co8—N41	2.222 (4)
Co2—O4	2.127 (4)	Co8—N43	2.085 (4)
Co2—N4	2.222 (4)	Co9—Cl1	2.1946 (18)
Co2—N14	2.233 (4)	Co9—Cl2	2.2217 (16)
Co2—N28	2.126 (4)	Co9—N2	2.036 (4)
Co3—O1	2.134 (4)	Co9—N5	2.030 (5)

Co3—O3	2.159 (3)	Co10—Cl3	2.2214 (15)
Co3—O4	2.113 (4)	Co10—Cl4	2.2227 (18)
Co3—N12	2.201 (4)	Co10—N10	2.024 (5)
Co3—N22	2.174 (4)	Co10—N13	2.048 (4)
Co3—N46	2.210 (4)	Co11—Cl9	2.268 (2)
Co4—O2	2.158 (4)	Co11—N26	2.133 (4)
Co4—O3	2.193 (3)	Co11—N29	2.099 (4)
Co4—O4	2.140 (4)	Co11—Cl10	2.13 (2)
Co4—N30	2.158 (4)	Co11—Cl13	2.333 (3)
Co4—N36	2.224 (4)	Co11—Cl14	2.215 (7)
Co4—N44	2.176 (4)	Co12—Cl5	2.2015 (19)
Co5—N7	2.069 (5)	Co12—Cl6	2.2130 (16)
Co5—N8	2.234 (6)	Co12—N34	2.038 (4)
Co5—N17	2.256 (5)	Co12—N37	2.038 (4)
Co5—N19	2.064 (5)	Co13—Cl7	2.209 (2)
Co5—N39	2.092 (4)	Co13—Cl8	2.208 (2)
Co5—N40	2.257 (5)	Co13—N18	2.035 (5)
Co6—N1	2.262 (4)	Co13—N21	2.050 (5)
Co6—N3	2.084 (4)	Co14—N42	2.067 (4)
Co6—N15	2.064 (4)	Co14—N45	2.058 (5)
Co6—N16	2.293 (4)	Co14—Cl00	2.136 (5)
Co6—N25	2.186 (4)	Co14—Cl01	2.169 (5)
Co6—N27	2.077 (4)	Co15—N42	2.175 (7)
Co7—N9	2.264 (4)	Co15—N45	2.144 (8)
Co7—N11	2.071 (5)	Co15—Cl11	2.259 (19)
Co7—N23	2.065 (4)	Co15—Cl12	2.053 (15)
O1—Co1—O2	84.09 (14)	N25—Co6—N16	97.67 (15)
O1—Co1—O3	83.40 (14)	N27—Co6—N1	115.51 (15)
O1—Co1—N6	98.86 (15)	N27—Co6—N3	83.09 (16)
O1—Co1—N20	91.13 (15)	N27—Co6—N16	153.10 (16)
O1—Co1—N38	171.58 (16)	N27—Co6—N25	75.54 (15)
O2—Co1—O3	85.56 (13)	N11—Co7—N9	74.68 (17)
O2—Co1—N6	87.89 (15)	N11—Co7—N24	146.76 (19)
O2—Co1—N20	174.83 (15)	N11—Co7—N48	111.97 (18)
O2—Co1—N38	97.28 (14)	N23—Co7—N9	111.34 (18)
O3—Co1—N6	172.82 (14)	N23—Co7—N11	83.95 (19)
O3—Co1—N38	88.42 (15)	N23—Co7—N24	75.53 (17)
N6—Co1—N38	89.50 (16)	N23—Co7—N48	155.6 (2)
N20—Co1—O3	95.85 (16)	N24—Co7—N9	88.64 (17)
N20—Co1—N6	90.92 (18)	N47—Co7—N9	150.66 (17)
N20—Co1—N38	87.74 (15)	N47—Co7—N11	85.10 (17)
O1—Co2—O2	83.14 (14)	N47—Co7—N23	86.85 (17)
O1—Co2—O4	82.66 (15)	N47—Co7—N24	118.93 (18)

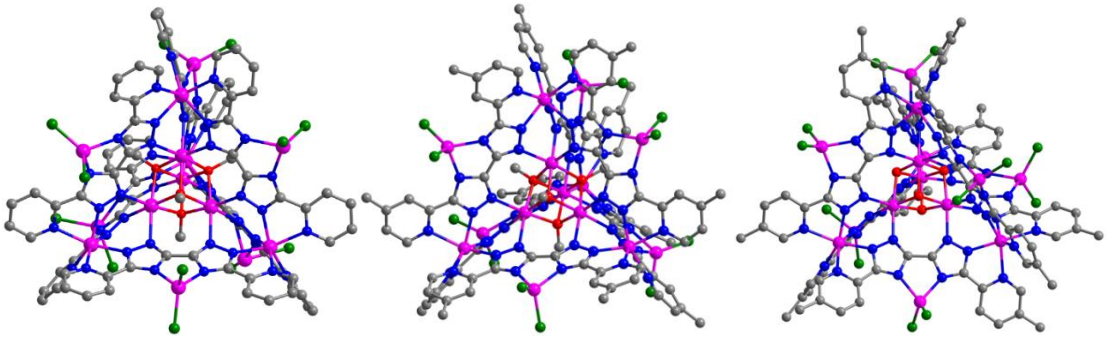
O1—Co2—N4	97.56 (15)	N47—Co7—N48	76.65 (16)
O1—Co2—N14	91.62 (14)	N48—Co7—N9	91.27 (18)
O1—Co2—N28	174.45 (15)	N48—Co7—N24	96.65 (18)
O2—Co2—N4	90.19 (14)	N31—Co8—N32	75.08 (14)
O2—Co2—N14	174.74 (14)	N31—Co8—N33	150.54 (16)
O4—Co2—O2	83.54 (14)	N31—Co8—N41	117.08 (16)
O4—Co2—N4	173.66 (14)	N31—Co8—N43	85.52 (16)
O4—Co2—N14	96.31 (15)	N33—Co8—N32	93.97 (14)
N4—Co2—N14	90.02 (15)	N35—Co8—N31	85.96 (15)
N28—Co2—O2	93.74 (14)	N35—Co8—N32	117.77 (15)
N28—Co2—O4	92.45 (15)	N35—Co8—N33	74.97 (15)
N28—Co2—N4	87.01 (15)	N35—Co8—N41	146.64 (16)
N28—Co2—N14	91.51 (14)	N35—Co8—N43	83.86 (15)
O1—Co3—O3	83.78 (14)	N41—Co8—N32	92.53 (14)
O1—Co3—N12	92.61 (16)	N41—Co8—N33	90.23 (15)
O1—Co3—N22	93.01 (17)	N43—Co8—N32	149.08 (15)
O1—Co3—N46	173.49 (14)	N43—Co8—N33	113.86 (15)
O3—Co3—N12	175.25 (15)	N43—Co8—N41	74.96 (15)
O3—Co3—N22	90.16 (14)	Cl1—Co9—Cl2	115.78 (8)
O3—Co3—N46	93.61 (14)	N2—Co9—Cl1	123.98 (13)
O4—Co3—O1	82.03 (15)	N2—Co9—Cl2	102.87 (12)
O4—Co3—O3	85.97 (14)	N5—Co9—Cl1	121.10 (14)
O4—Co3—N12	96.61 (14)	N5—Co9—Cl2	106.25 (13)
O4—Co3—N22	174.01 (16)	N5—Co9—N2	80.86 (18)
O4—Co3—N46	91.85 (14)	Cl3—Co10—Cl4	118.21 (6)
N12—Co3—N46	90.30 (15)	N10—Co10—Cl3	115.30 (14)
N22—Co3—N12	86.93 (15)	N10—Co10—Cl4	110.04 (15)
N22—Co3—N46	92.96 (17)	N10—Co10—N13	80.44 (18)
O2—Co4—O3	85.60 (14)	N13—Co10—Cl3	118.29 (13)
O2—Co4—N30	88.96 (15)	N13—Co10—Cl4	108.50 (14)
O2—Co4—N36	94.66 (14)	Cl9—Co11—Cl13	97.14 (10)
O2—Co4—N44	176.09 (14)	N26—Co11—Cl9	91.89 (14)
O3—Co4—N36	87.45 (13)	N26—Co11—Cl13	169.74 (16)
O4—Co4—O2	84.63 (14)	N26—Co11—Cl14	95.7 (2)
O4—Co4—O3	84.48 (14)	N29—Co11—Cl9	114.57 (14)
O4—Co4—N30	95.51 (14)	N29—Co11—N26	77.88 (15)
O4—Co4—N36	171.93 (14)	N29—Co11—Cl10	109.5 (5)
O4—Co4—N44	92.09 (14)	N29—Co11—Cl13	102.57 (12)
N30—Co4—O3	174.54 (15)	N29—Co11—Cl14	119.8 (2)
N30—Co4—N36	92.51 (14)	Cl10—Co11—Cl9	132.9 (5)
N30—Co4—N44	89.24 (15)	Cl10—Co11—N26	81.7 (5)
N44—Co4—O3	96.22 (14)	Cl10—Co11—Cl13	88.6 (5)
N44—Co4—N36	88.89 (14)	Cl14—Co11—Cl9	125.5 (2)
N7—Co5—N8	75.39 (19)	Cl5—Co12—Cl6	118.98 (9)

N7—Co5—N17	121.06 (17)	N34—Co12—Cl5	118.03 (14)
N7—Co5—N39	84.79 (17)	N34—Co12—Cl6	107.28 (12)
N7—Co5—N40	148.72 (16)	N34—Co12—N37	80.81 (16)
N8—Co5—N17	94.60 (19)	N37—Co12—Cl5	115.77 (13)
N8—Co5—N40	93.40 (19)	N37—Co12—Cl6	109.66 (14)
N17—Co5—N40	88.43 (16)	Cl8—Co13—Cl7	113.88 (8)
N19—Co5—N7	84.95 (19)	N18—Co13—Cl7	110.84 (17)
N19—Co5—N8	149.1 (2)	N18—Co13—Cl8	110.31 (16)
N19—Co5—N17	75.22 (17)	N18—Co13—N21	81.73 (19)
N19—Co5—N39	83.87 (16)	N21—Co13—Cl7	119.36 (16)
N19—Co5—N40	115.0 (2)	N21—Co13—Cl8	115.85 (18)
N39—Co5—N8	117.12 (17)	N42—Co14—Cl00	109.9 (2)
N39—Co5—N17	144.24 (19)	N42—Co14—Cl01	121.1 (2)
N39—Co5—N40	74.39 (16)	N45—Co14—N42	79.75 (17)
N1—Co6—N16	89.60 (15)	N45—Co14—Cl00	111.1 (2)
N3—Co6—N1	74.84 (17)	N45—Co14—Cl01	116.2 (2)
N3—Co6—N16	114.44 (15)	Cl00—Co14—Cl01	114.14 (19)
N3—Co6—N25	142.33 (15)	N42—Co15—Cl11	163.5 (7)
N15—Co6—N1	147.93 (16)	N45—Co15—N42	75.5 (3)
N15—Co6—N3	85.77 (16)	N45—Co15—Cl11	92.3 (5)
N15—Co6—N16	75.30 (15)	Cl12—Co15—N42	101.2 (6)
N15—Co6—N25	122.74 (16)	Cl12—Co15—N45	170.8 (7)
N15—Co6—N27	86.47 (16)	Cl12—Co15—Cl11	89.1 (7)
N25—Co6—N1	86.76 (16)		

1.3 **Structural Details**

L1 **L2** **L3**

Figure S2. coordination environment of cobalt ions in complexes **C1 - C3**. (The hydrogen atoms are omitted for clarity)



C1 **C2** **C3**

Figure S3. The coordination environments of the Co(II) ions and the structure of complexes **C1 – C3**.

2. **X-ray Crystallography of 7c**

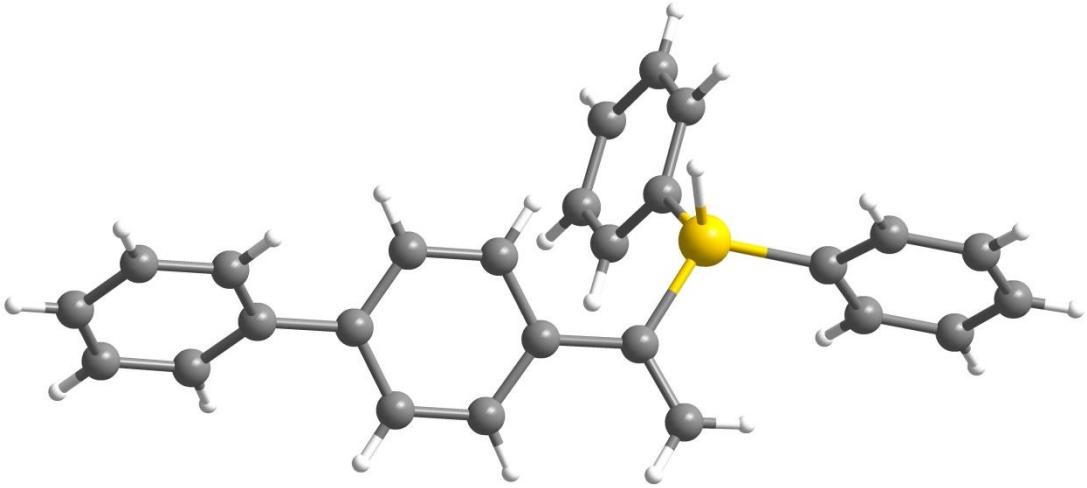


Table S8. Crystal data and structure refinement for **7c**.

CCDC	1972571
Empirical formula	$C_{26}H_{22}Si$
Formula weight	362.52
Temperature/K	293(2)
Crystal system	monoclinic
Space group	$P2_1/c$
a/Å	15.3385(15)
b/Å	5.8977(5)
c/Å	22.718(2)
α/°	90
β/°	101.633(9)
γ/°	90
Volume/Å^3	2012.9(3)
Z	4
ρ_{calc}g/cm^3	1.196
μ/mm^{-1}	0.124
F(000)	768.0
Crystal size/mm^3	0.410 × 0.230 × 0.120
Radiation	MoKα (λ = 0.71073)
2Θ range for data collection/°	7.132 to 52.744
Index ranges	$-19 \leq h \leq 19$, $-6 \leq k \leq 7$, $-28 \leq l \leq 23$

Reflections collected	11868
Independent reflections	4119 [R_{int} = 0.0539, R_{sigma} = 0.0760]
Data/restraints/parameters	4119/0/247
Goodness-of-fit on F^2	1.053
Final R indexes [I>=2σ (I)]	R_1 = 0.0594, wR_2 = 0.1168
Final R indexes [all data]	R_1 = 0.1178, wR_2 = 0.1484
Largest diff. peak/hole / e $Å^{-3}$	0.20/-0.26

Table S9. Fractional Atomic Coordinates ($\times 10^4$) and Equivalent Isotropic Displacement Parameters ($Å^2 \times 10^3$) for **7c**. U_{eq} is defined as 1/3 of of the trace of the orthogonalised U_{IJ} tensor.

Atom	***x***	***y***	***z***	***Uiso*/Ueq***
Si1	0.24398 (5)	0.41133 (14)	0.27891 (3)	0.0504 (3)
C1	0.08338 (16)	0.4080 (5)	0.16372 (11)	0.0474 (7)
C2	0.08556 (15)	0.2213 (4)	0.20082 (11)	0.0411 (6)
C3	-0.03661 (16)	0.2525 (5)	0.08952 (11)	0.0434 (6)
C4	0.14739 (16)	0.2122 (4)	0.26026 (11)	0.0437 (6)
C5	-0.10196 (17)	0.2709 (5)	0.03201 (12)	0.0469 (7)
C6	0.02337 (17)	0.4244 (5)	0.10936 (12)	0.0486 (7)
C7	0.1355 (2)	0.0635 (6)	0.30187 (14)	0.0582 (8)
C8	-0.03367 (18)	0.0633 (5)	0.12598 (12)	0.0528 (7)
C9	-0.11486 (18)	0.0944 (5)	-0.00888 (12)	0.0552 (7)
C10	0.02586 (18)	0.0476 (5)	0.17987 (12)	0.0534 (7)
C11	0.32408 (17)	0.3640 (5)	0.22850 (11)	0.0485 (7)
C12	0.30288 (17)	0.3790 (5)	0.35837 (12)	0.0535 (7)
C13	-0.15192 (19)	0.4661 (5)	0.01751 (13)	0.0583 (8)
C14	0.32543 (19)	0.1700 (5)	0.19461 (13)	0.0598 (8)
C15	-0.2129 (2)	0.4841 (6)	-0.03652 (14)	0.0676 (9)
C16	-0.1743 (2)	0.1130 (6)	-0.06287 (13)	0.0667 (9)
C17	0.4507 (2)	0.4971 (7)	0.18966 (16)	0.0796 (11)
C18	0.38852 (19)	0.5265 (6)	0.22494 (14)	0.0653 (9)
C19	-0.2234 (2)	0.3066 (6)	-0.07667 (14)	0.0702 (10)
C20	0.2956 (2)	0.5399 (6)	0.40110 (15)	0.0765 (10)
C21	0.3931 (3)	0.3362 (9)	0.47703 (16)	0.1016 (14)
C22	0.4504 (2)	0.3041 (7)	0.15703 (14)	0.0749 (10)
C23	0.4009 (3)	0.1700 (8)	0.43640 (16)	0.1011 (14)
C24	0.3563 (2)	0.1931 (6)	0.37805 (14)	0.0778 (10)
C25	0.3878 (2)	0.1399 (6)	0.15890 (14)	0.0740 (10)
C27	0.3400 (3)	0.5179 (8)	0.46011 (16)	0.0962 (13)

Table S10. Bond Lengths for **7c**.

Bond	Length/Å	Atom	Length/Å
Si1—C12	1.858 (3)	C11—C14	1.381 (4)
Si1—C11	1.862 (3)	C11—C18	1.391 (4)
Si1—C4	1.871 (3)	C12—C20	1.378 (4)
C1—C2	1.383 (3)	C12—C24	1.387 (4)
C1—C6	1.387 (3)	C13—C15	1.389 (4)
C2—C10	1.392 (3)	C14—C25	1.385 (4)
C2—C4	1.487 (3)	C15—C19	1.376 (4)
C3—C6	1.382 (3)	C16—C19	1.369 (4)
C3—C8	1.385 (3)	C17—C22	1.358 (5)
C3—C5	1.482 (3)	C17—C18	1.375 (4)
C4—C7	1.329 (4)	C20—C27	1.382 (4)
C5—C9	1.383 (4)	C21—C27	1.354 (5)
C5—C13	1.386 (4)	C21—C23	1.368 (5)
C8—C10	1.375 (3)	C22—C25	1.370 (4)
C9—C16	1.377 (4)	C23—C24	1.371 (4)

Table S11. Bond Angles for **7c**.

Angles	Angles/°	Angles	Angles/°
C12—Si1—C11	109.28 (12)	C14—C11—C18	116.6 (3)
C12—Si1—C4	111.30 (13)	C14—C11—Si1	123.6 (2)
C11—Si1—C4	110.93 (12)	C18—C11—Si1	119.8 (2)
C2—C1—C6	121.9 (2)	C20—C12—C24	116.3 (3)
C1—C2—C10	116.4 (2)	C20—C12—Si1	121.4 (2)
C1—C2—C4	121.0 (2)	C24—C12—Si1	122.3 (2)
C10—C2—C4	122.6 (2)	C5—C13—C15	121.0 (3)
C6—C3—C8	117.2 (2)	C11—C14—C25	121.5 (3)
C6—C3—C5	121.4 (2)	C19—C15—C13	119.7 (3)
C8—C3—C5	121.4 (2)	C19—C16—C9	120.4 (3)
C7—C4—C2	121.1 (3)	C22—C17—C18	119.8 (3)
C7—C4—Si1	118.0 (2)	C17—C18—C11	122.1 (3)
C2—C4—Si1	120.95 (19)	C16—C19—C15	119.8 (3)
C9—C5—C13	117.9 (3)	C12—C20—C27	121.6 (3)
C9—C5—C3	121.1 (3)	C27—C21—C23	120.3 (4)
C13—C5—C3	120.9 (3)	C17—C22—C25	120.0 (3)
C3—C6—C1	121.2 (2)	C21—C23—C24	119.1 (4)
C10—C8—C3	121.5 (3)	C23—C24—C12	122.5 (3)
C16—C9—C5	121.2 (3)	C22—C25—C14	119.9 (3)

C8—C10—C2	121.9 (3)	C21—C27—C20	120.0 (3)

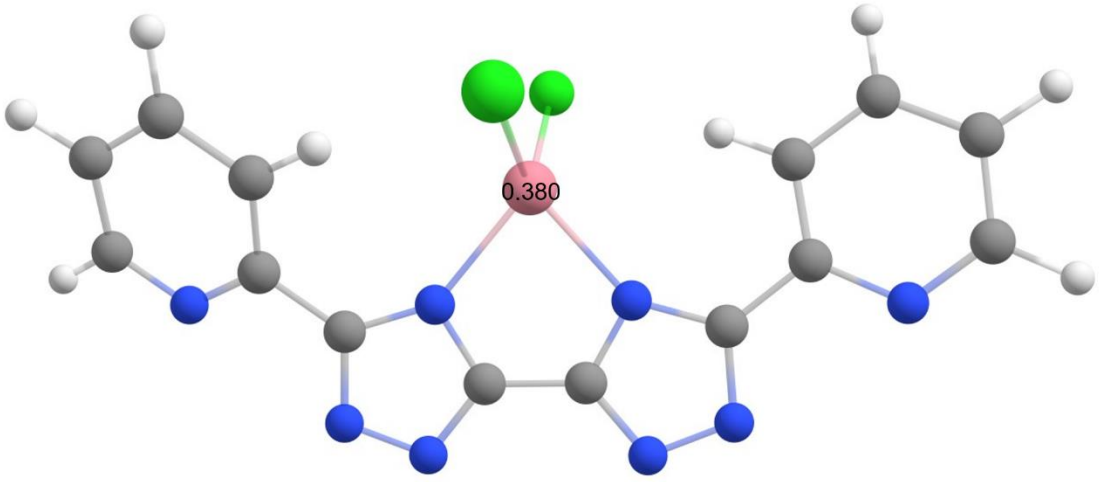
Computational Details

Density Function Theory (DFT) computation was performed to explore why **C1** exhibits superior selectivity over **C2** and **C3** in the reaction of hydrosilylation of alkynes. The spin-unrestricted hybrid density functional UB3LYP was used to optimize the geometries at pseudopotential basis set level, where the LACVP basis set is on cobalt and the 6-31G* basis set is on the remaining atoms. Natural Bond Orbitals calculations were also performed at the same level. Upon the optimized geometries, Mulliken charges and natural orbitals were analyzed.

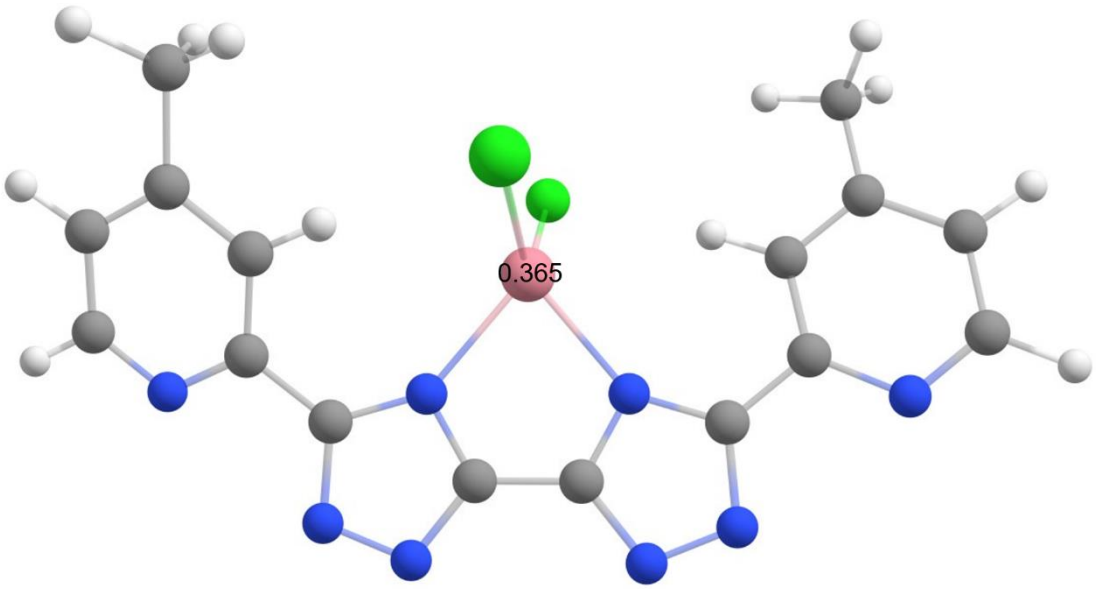
The adsorption energies (dE) between SiH_4 and the Catalysts **C1**, **C2** and **C3** were also calculated to find the reactivity of the three catalysts. The dE was computed as the difference of single molecule (SiH_4 and C_n) energy and the energy of the complex of SiH_4 and catalyst (SiH_4-C_n), as shown in Equation 1.

$$dE = E(SiH_4) + E(Cn(n=1,2,3)) - E(SiH_4\text{-}Cn) \quad \text{(Equation. 1)}$$

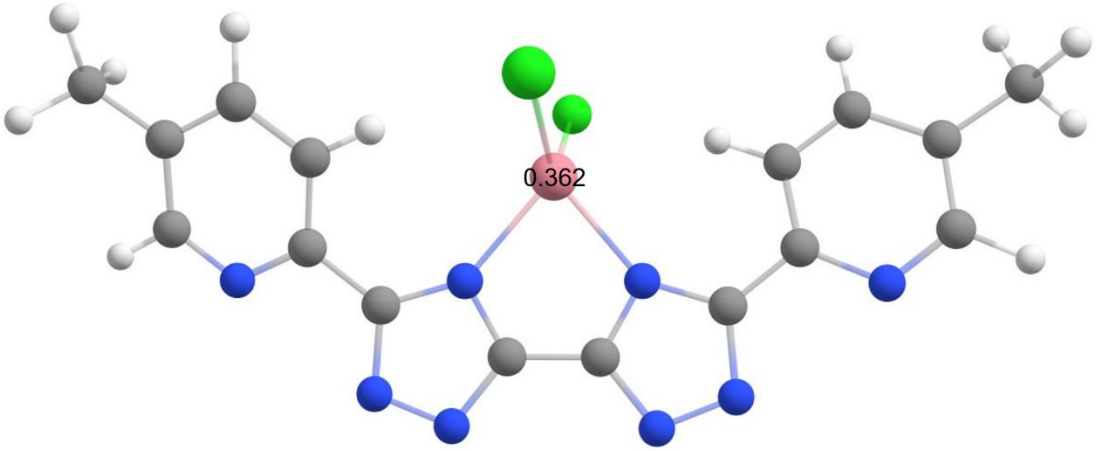
All the computations were performed with Gaussian 16 package. The 3D structures and orbital distributions were generated with Chemcraft software.



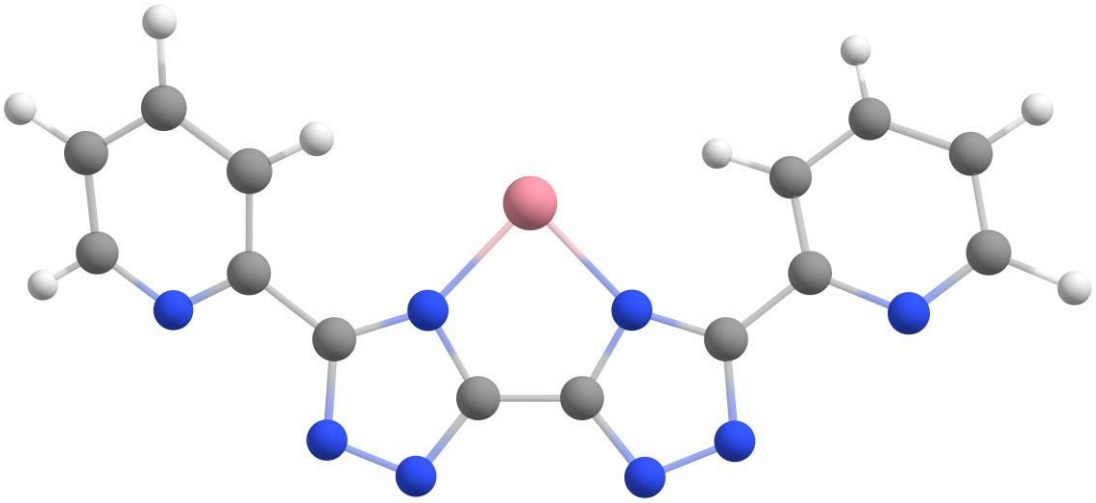
C1



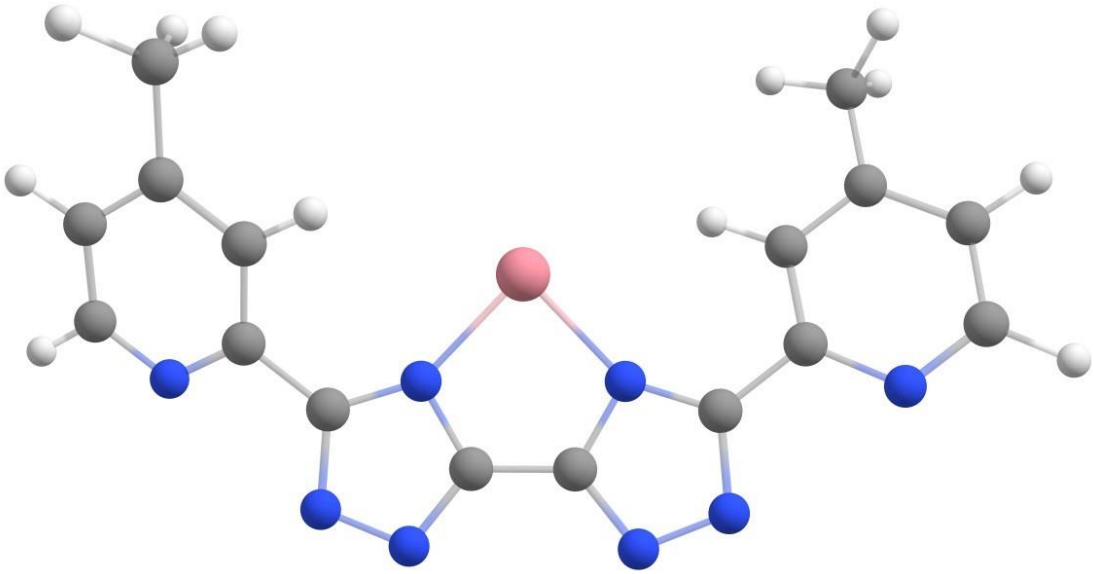
C2



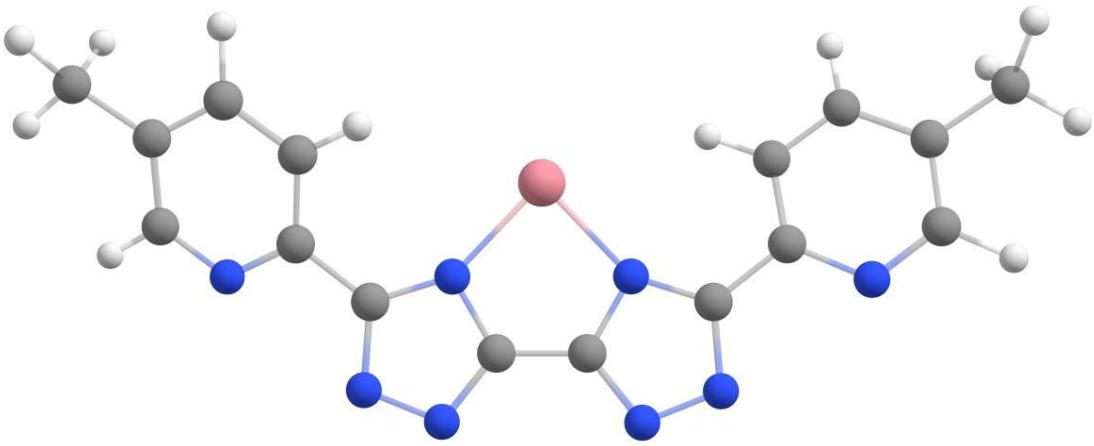
C3



C1′

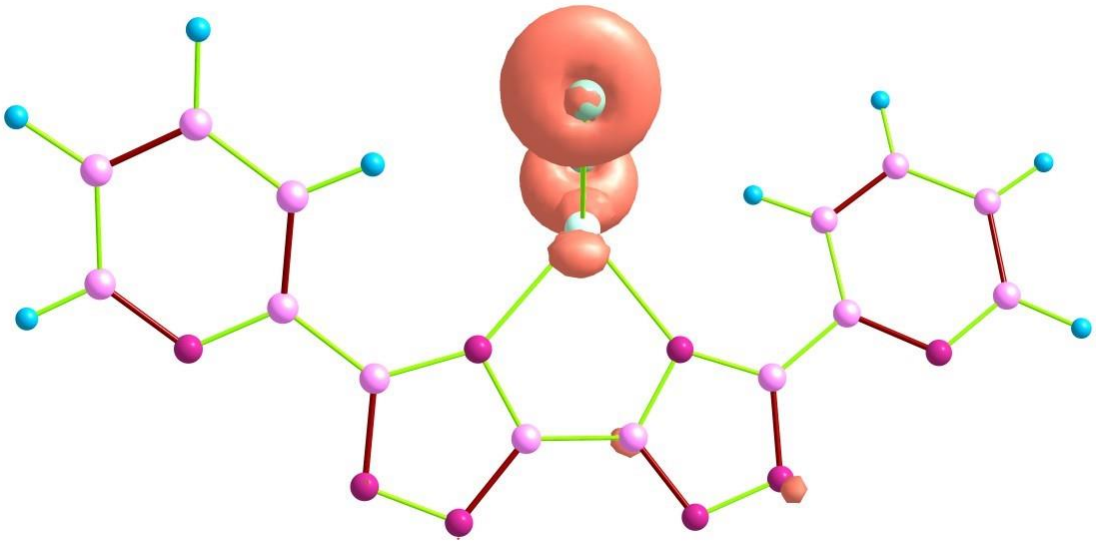


C2′

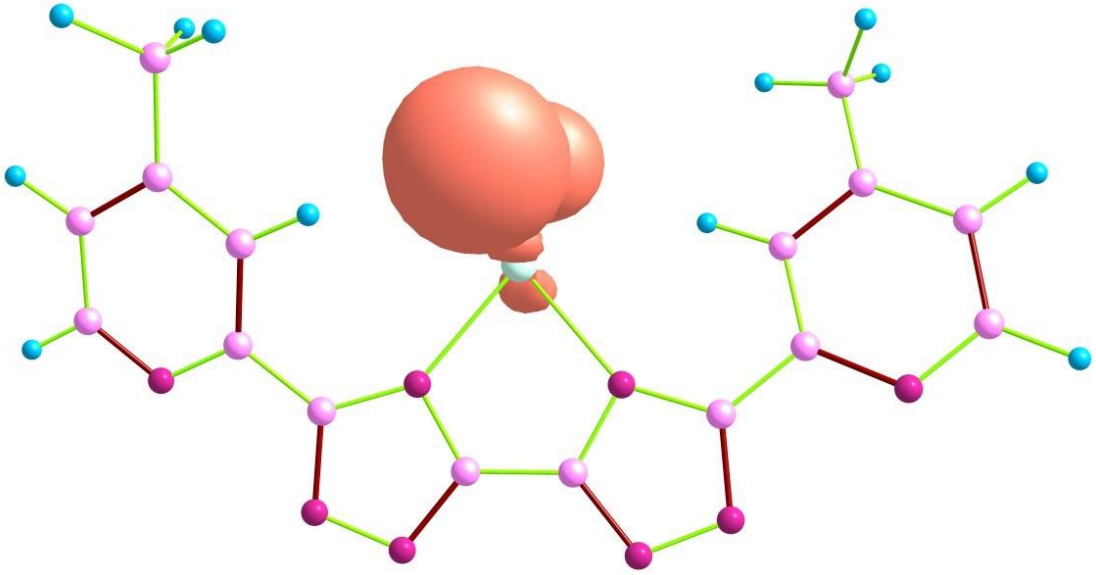


C3′

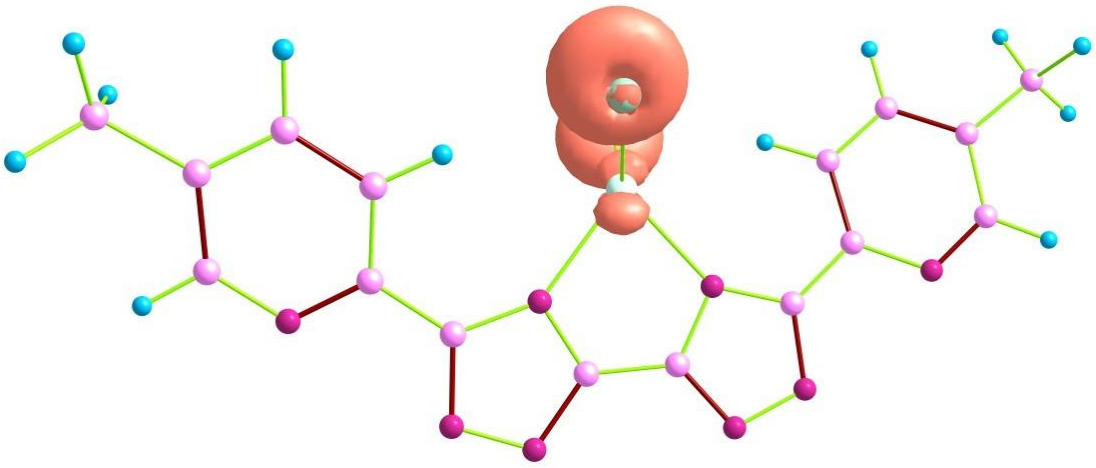
Figure S4. The Mulliken charge distribution on cobalt for catalysts **C1**, **C2** and **C3** as well as the the three catalysts loosing chlorine ligands, denoted as **C1'**, **C2'**, **C3'**.



C1

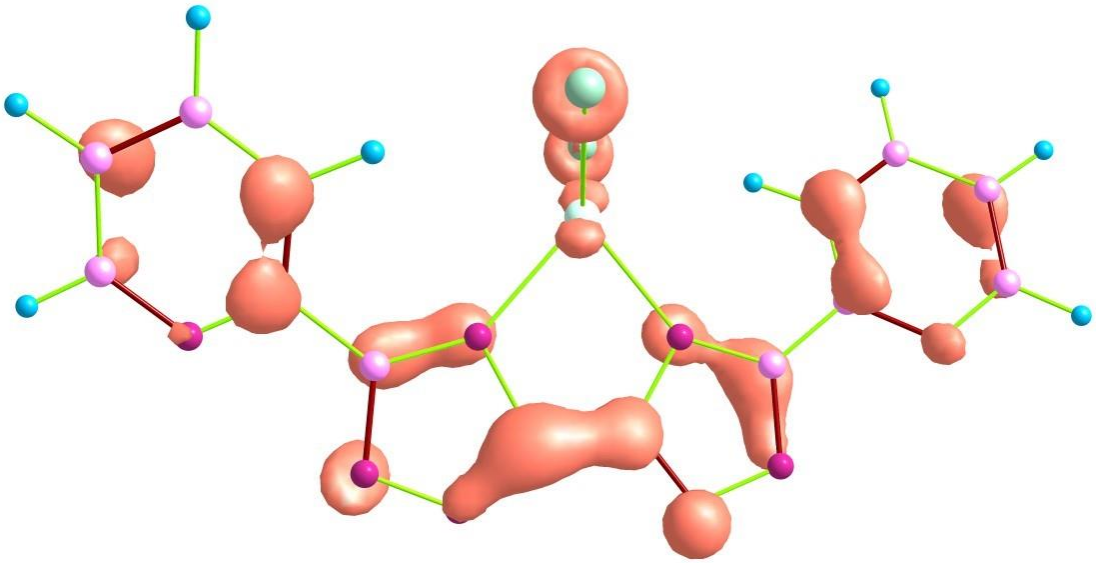


C2

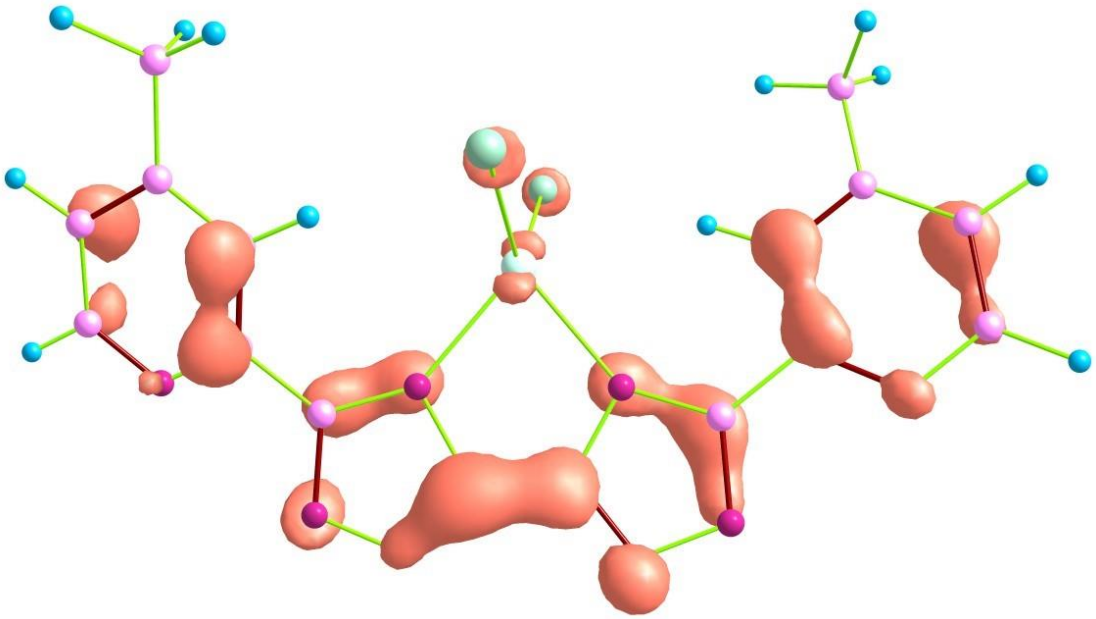


C3

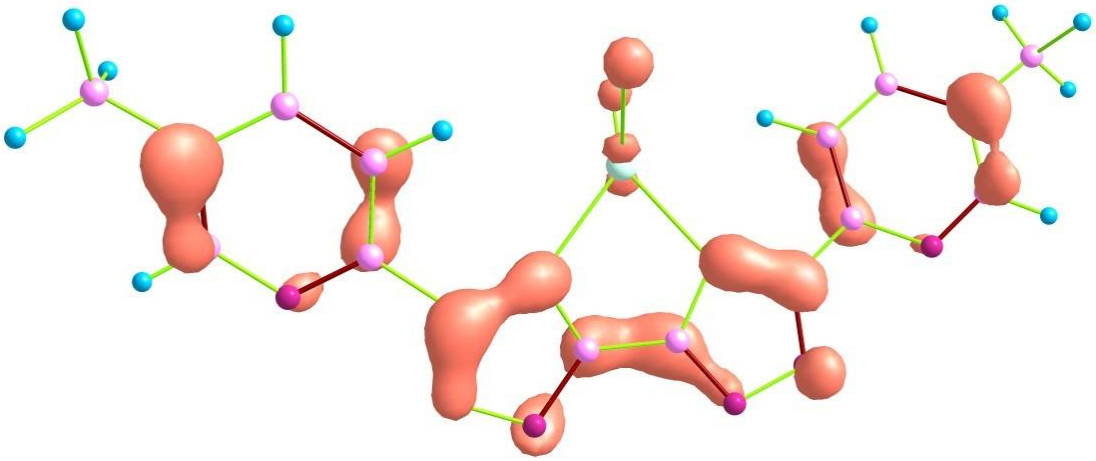
Figure S5. The configuration of the highest occupied molecular orbital (HOMO) for catalysts **C1**, **C2** and **C3**.



C1



C2



C3

Figure S6. The configuration of the lowest unoccupied molecular orbital (LUMO) for catalysts **C1**, **C2** and **C3**.

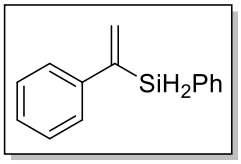
Table S12. The gap energy of the natural orbitals for the three catalysts.

Cat.	HOMO (a.u.)	LUMO (a.u.)	Gap (a.u.)	Gap(kJ·mol^{-1})	Natural electron configuration for cobalt
C1	-0.2645	-0.2367	0.0278	72.989039	Co 17 [core]4S(0.18)3d(4.96)4p(0.28)5p(0.01)
C2	-0.2614	-0.2323	0.0291	76.4021955	Co 17 [core]4S(0.35)3d(7.38)4p(0.54)4d(0.01)5p(0.01)
C3	-0.2561	-0.2268	0.0293	76.9272965	Co 17 [core]4S(0.35)3d(7.38)4p(0.54)4d(0.01)5p(0.01)

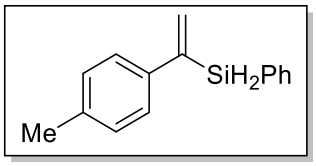
Table S13. The adsorption energy for the catalysts when they form complexes with SiH_4.

Catalysts	dE (a.u.)	dE(kJ·mol^{-1})
C1	0.2027055	532.2043038
C2	0.2797429	734.4663827
C3	0.2790184	732.5642043

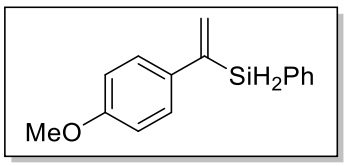
Characterization data



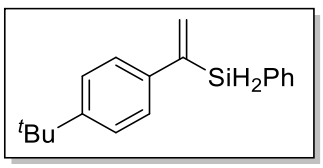
phenyl(1-phenylvinyl)silane[4] **(3a)** was isolated (90 mg, 0.43 mmol, 86%) as a colorless oil after chromatograph on silica with PE. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.51-7.45 (m, 2H), 7.41-7.24 (m, 7H), 7.24-7.18 (m, 1H), 6.13 (d, *J*=2.3 Hz, 1H), 5.72 (d, *J*=2.3 Hz, 1H), 4.74 (s, 2H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 144.2, 142.3, 135.6, 131.4, 131.2, 129.9, 128.5, 128.1, 127.3, 126.5.



phenyl(1-(*p*-tolyl)vinyl)silane[4] **(3b)** was isolated (99 mg, 0.44 mmol, 88%) as a colorless oil after chromatograph on silica with PE. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.79-7.75 (m, 2H), 7.58-7.43 (m, 5H), 7.31-7.24 (m, 2H), 6.40 (d, *J*=2.3 Hz, 1H), 5.97 (d, *J*=2.3 Hz, 1H), 5.03 (s, 2H), 2.48 (s, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 143.8, 139.3, 137.0, 135.5, 131.3, 130.4, 129.8, 129.2, 128.1, 126.3, 21.0.

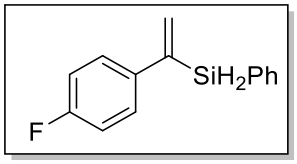


(1-(4-methoxyphenyl)vinyl)(phenyl)silane[4] **(3c)** was isolated (102 mg, 0.43 mmol, 85%) as a colorless oil after chromatograph on silica with PE. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.51-7.45 (m, 2H), 7.30-7.19 (m, 5H), 6.75-6.68 (m, 2H), 6.07 (d, *J*=2.2 Hz, 1H), 5.64 (d, *J*=2.2 Hz, 1H), 4.73 (s, 2H), 3.64(s, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 159.0, 143.1, 135.5, 134.6, 131.3, 129.8, 129.5, 128.1, 127.5, 113.9, 55.2.

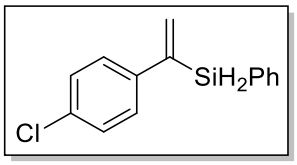


(1-(4-(*tert*-butyl)phenyl)vinyl)(phenyl)silane[5] **(3d)** was isolated (111 mg, 0.42 mmol, 83%) as a colorless oil after chromatograph on silica with PE. ^{1}H NMR (400 MHz,

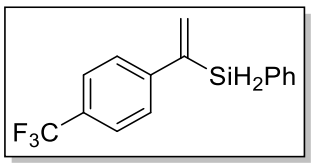
$CDCl_3$) δ 7.61-7.55 (m, 2H), 7.35-7.26 (m, 7H), 6.22 (d, *J*=2.1 Hz, 1H), 5.76 (d, *J*=2.1 Hz, 1H), 4.84 (s, 2H), 1.27 (s, 9H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 150.2, 143.5, 139.1, 135.6, 131.3, 130.5, 129.8, 128.1, 126.1, 125.4, 34.4, 31.3.



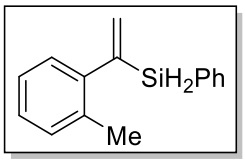
(1-(4-fluorophenyl)vinyl)(phenyl)silane[4] **(3e)** was isolated (95 mg, 0.42 mmol, 83%) as a colorless oil after chromatograph on silica with PE. ^1H NMR (400 MHz, $CDCl_3$) δ 7.59-7.54 (m, 2H), 7.41-7.28 (m, 5H), 7.00-6.94 (m, 2H), 6.17 (d, *J*=2.2 Hz, 1H), 5.83-5.79 (d, *J*=2.2 Hz, 1H), 4.81 (s, 2H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 162.2 (d, *J*=244.8 Hz), 143.2, 138.3 (d, *J*=3.1 Hz), 135.5, 131.2, 130.9, 130.0, 128.1, 128.0 (d, *J*=8.0 Hz), 115.3 (d, *J*=21.3 Hz). ^{19}F NMR (400 MHz, $CDCl_3$) δ -115.2 (s).



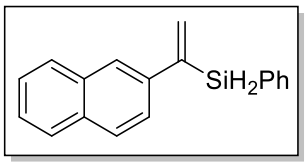
(1-(4-chlorophenyl)vinyl)(phenyl)silane[4] **(3f)** was isolated (97 mg, 0.40 mmol, 79%) as a colorless oil after chromatograph on silica with PE. ^1H NMR (400 MHz, $CDCl_3$) δ 7.60-7.53 (m, 2H), 7.41-7.31 (m, 3H), 7.30-7.22 (m, 4H), 6.19 (d, *J*=2.2 Hz, 1H), 5.83 (d, *J*=2.2 Hz, 1H), 4.80 (s, 2H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 143.2, 140.7, 135.5, 133.1, 131.7, 130.7, 130.0, 128.6, 128.2, 127.8.



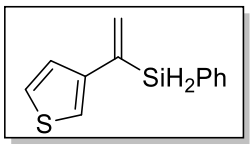
phenyl(1-(4-(trifluoromethyl)phenyl)vinyl)silane (3g) was isolated (106 mg, 0.38 mmol, 76%) as a colorless oil after chromatograph on silica with PE. ^1H NMR (400 MHz, $CDCl_3$) δ 7.60-7.50 (m, 4H), 7.45-7.31 (m, 5H), 6.24 (d, *J*=2.1 Hz, 1H), 5.92 (d, *J*=2.1 Hz, 1H), 4.83 (s, 2H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 146.0, 143.6, 135.5, 133.2, 130.4, 130.1, 129.2 (q, *J*=32.2 Hz), 128.2, 126.8, 125.4 (q, *J*=3.9 Hz), 124.2 (q, *J*=270.0 Hz). ^{19}F NMR (400 MHz, $CDCl_3$) δ -62.4 (s). HRMS-EI: *m*/*z* $[M]^+$ calcd for $C_{15}H_{13}F_3Si$: 278.0739, found 278.0732.



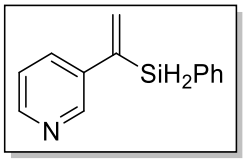
phenyl(1-(*o*-tolyl)vinyl)silane[4] **(3h)** was isolated (92 mg, 0.41 mmol, 82%) as a colorless oil after chromatograph on silica with PE. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.54-7.48 (m, 2H), 7.36-7.26 (m, 3H), 7.14-7.06 (m, 3H), 7.00-6.93 (m, 1H), 5.90 (d, *J*=3.06 Hz, 1H), 5.84 (d, *J*=3.06 Hz, 1H), 4.70 (s, 2H), 2.22 (s, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 146.5, 143.0, 135.6, 134.3, 133.0, 131.1, 130.1, 129.8, 128.0, 127.9, 126.6, 125.6, 20.2.



(1-(naphthalen-2-yl)vinyl)(phenyl)silane[4] **(3i)** was isolated (105 mg, 0.41 mmol, 81%) as a colorless oil after chromatograph on silica with PE. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.80-7.75 (m, 1H), 7.73-7.68 (m, 3H), 7.61-7.56 (m, 2H), 7.53-7.48 (m, 1H), 7.40-7.25 (m, 5H), 6.35-6.28 (d, *J*=2.2Hz, 1H), 5.92-5.85 (d, *J*=2.2Hz, 1H), 4.92 (s, 2H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 143.9, 139.5, 135.6, 133.4, 132.6, 131.6, 131.0, 129.9, 128.1, 128.1, 127.5, 126.1, 125.8, 125.6, 124.5.

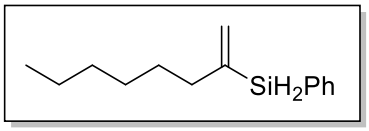


phenyl(1-(thiophen-3-yl)vinyl)silane[6] **(3j)** was isolated (94 mg, 0.44 mmol, 87%) as a colorless oil after chromatograph on silica with PE. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.62-7.55 (m, 2H), 7.40-7.29 (m, 3H), 7.22-7.17 (m, 2H), 7.16-7.11 (m, 1H), 6.24 (d, *J*=2.2 Hz, 1H), 5.74 (d, *J*=2.2 Hz, 1H), 4.80 (s, 2H). ^{13} NMR (100 MHz, $CDCl_3$) δ 143.1, 137.5, 135.5, 130.9, 129.9, 129.6, 128.1, 125.7, 125.3, 121.7.

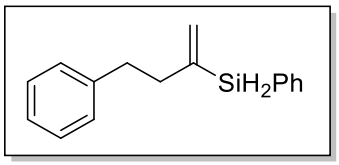


3-(1-(phenylsilyl)vinyl)pyridine[4] **(3k)** was isolated (79 mg, 0.38 mmol, 75%) as a colorless oil after chromatograph on silica with PE/EA (5:1). ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.52 (s, 1H), 8.39 (d, *J*=4.4 Hz, 1H), 7.58-7.46 (m, 3H), 7.36-7.24 (m, 3H), 7.16-7.10 (dd, *J*=4.8 Hz, 7.8 Hz, 1H), 6.18 (d, *J*=1.8 Hz, 1H), 5.85 (d, *J*=1.8 Hz, 1H), 4.76 (s, 2H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 148.3, 147.6, 141.3, 137.9, 135.5, 133.6,

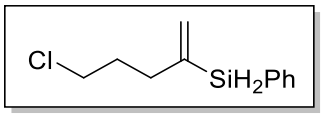
133.2, 130.2, 130.1, 128.2, 123.2.



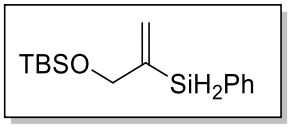
oct-1-en-2-yl(phenyl)silane[5] **(3l)** was isolated (98 mg, 0.45 mmol, 90%) as a colorless oil after chromatograph on silica with PE. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.65-7.60 (m, 2H), 7.44-7.38 (m, 3H), 5.86-5.79 (m, 1H), 5.64-5.53 (m, 1H), 4.59 (s, 2H), 2.29-2.21 (m, 2H), 1.50-1.43 (m, 2H), 1.33-1.24 (m, 6H), 0.91 (*t*, *J*=6.6 Hz, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 145.4, 135.5, 131.7, 129.6, 129.4, 128.0, 37.4, 31.6, 28.9, 28.8, 22.6, 14.1.



phenyl(4-phenylbut-1-en-2-yl)silane[5] **(3m)** was isolated (108 mg, 0.44 mmol, 91%) as a colorless oil after chromatograph on silica with PE. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.59-7.55 (m, 2H), 7.37-7.31 (m, 3H), 7.24-7.19 (m, 2H), 7.15-7.08 (m, 3H), 5.82-5.74 (m, 1H), 5.63-5.52 (m, 1H), 4.58 (s, 2H), 2.75-2.67 (m, 2H), 2.53-2.45 (m, 2H). ^{13}C NMR (100 MHz, CDCl3) δ 144.4, 141.7, 135.6, 131.6, 130.0, 129.8, 128.3, 128.2, 128.0, 125.8, 39.0, 35.3.

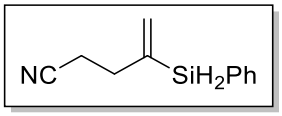


(5-chloropent-1-en-2-yl)(phenyl)silane (3n) was isolated (90 mg, 0.43 mmol, 85%) as a colorless oil after chromatograph on silica with PE. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.58-7.54 (m, 2H), 7.40-7.32 (m, 3H), 5.84-5.79 (m, 1H), 5.64-5.57 (m, 1H), 4.55 (s, 2H), 3.45 (t, *J*=6.6 Hz, 2H), 2.38-2.30 (m, 2H), 1.90-1.83 (m, 2H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 143.4, 135.5, 131.0, 130.7, 129.8, 128.1, 44.2, 34.1, 31.4. HRMS-EI: *m*/*z* $[M]^+$ calcd for $C_{11}H_{15}ClSi$: 209.0548, found 209.0548.

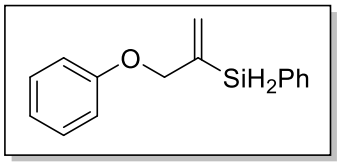


***tert*-butyldimethyl((2-(phenylsilyl)allyl)oxy)silane (3o)** was isolated (111 mg, 0.4 mmol, 80%) as a colorless oil after chromatograph on silica with PE. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.60-7.54 (m, 2H), 7.40-7.29 (m, 3H), 5.96 (d, *J*=2.2 Hz, 1H), 5.57 (d, *J*=2.2 Hz, 1H), 4.54 (s, 2H), 4.3-4.26 (m, 2H), 0.87 (s, 9H), 0.00 (s, 6H). ^{13}C NMR (100

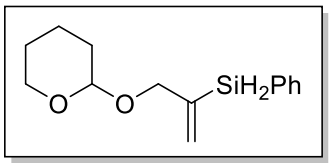
MHz, $CDCl_3$) δ 145.0, 135.6, 131.3, 129.7, 128.0, 127.4, 67.0, 26.0, 18.4, -5.4. HRMS-ESI : *m*/*z* $[M+Na]^+$ calcd for $C_{15}H_{26}OSi_2$: 301.1414, found 301.1409.



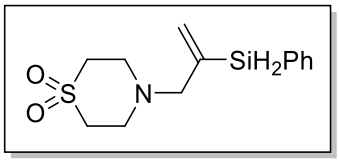
4-(phenylsilyl)pent-4-enenitrile (3p) was isolated (76 mg, 0.41 mmol, 81%) as a colorless oil after chromatograph on silica with PE. ^1H NMR (400 MHz, $CDCl_3$) δ 7.51-7.46 (m, 2H), 7.37-7.27 (m, 3H), 5.82 (s, 1H), 5.63 (s, 1H), 4.50 (s, 2H), 2.46-2.39 (m, 2H), 2.35-2.27 (m, 2H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 141.0, 135.4, 132.1, 130.1, 128.2, 119.0, 32.2, 29.6, 16.7. HRMS-ESI : *m*/*z* $[M+H]^+$ calcd for $C_{11}H_{13}NSi$: 188.0890, found 188.0886.



(3-phenoxyprop-1-en-2-yl)(phenyl)silane (3q) was isolated (96 mg, 0.4 mmol, 80%) as a colorless oil after chromatograph on silica with PE. ^1H NMR (400 MHz, $CDCl_3$) δ 7.69-7.56 (m, 2H), 7.44-7.32 (m, 3H), 7.29-7.19 (m, 2H), 6.95-6.89 (m, 1H), 6.88-6.81 (m, 2H), 6.08 (d, *J*=1.6 Hz, 1H), 5.76 (d, *J*=1.6 Hz, 1H), 4.66 (s, 2H), 4.63 (s, 2H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 158.5, 141.3, 135.6, 130.7, 130.2, 129.9, 129.3, 128.1, 120.8, 114.7, 71.7. HRMS-ESI : *m*/*z* $[M+Na]^+$ calcd for $C_{15}H_{16}OSi$: 263.0863, found 263.0855.

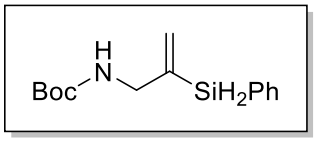


phenyl(3-((tetrahydro-2*H*-pyran-2-yl)oxy)prop-1-en-2-yl)silane (3r) was isolated (93 mg, 0.38 mmol, 75%) as a colorless oil after chromatograph on silica with PE/EA (8/1). ^1H NMR (400 MHz, $CDCl_3$) δ 7.64-7.55 (m, 2H), 7.41-7.31 (m, 3H), 6.02-5.95 (m, 1H), 5.71-5.63 (m, 1H), 4.59 (s, 2H), 4.58 (t, *J*=3.2 Hz, 1H), 4.45-4.36 (m, 1H), 4.13-4.05 (m, 1H), 3.80-3.72 (m, 1H), 3.48-3.40 (m, 1H), 1.68-1.41 (m, 6H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 142.5, 135.5, 131.1, 129.6, 129.6, 127.9, 97.6, 70.9, 61.6, 30.2, 25.4, 19.0. HRMS-ESI : *m*/*z* $[M+H]^+$ calcd for $C_{14}H_{20}O_2Si$: 249.1305, found 249.1304.

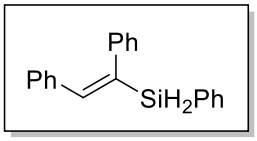


4-(2-(phenylsilyl)allyl)thiomorpholine 1,1-dioxide (3s) was isolated (110 mg, 0.39

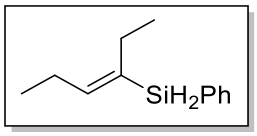
mmol, 78%) as a colorless oil after chromatograph on silica with PE/EA (8:1). ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.63-7.55 (m, 2H), 7.43-7.33 (m, 3H), 5.90 (s, 1H), 5.72 (s, 1H), 4.52 (m, 2H), 3.20 (s, 2H), 2.80 (s, 8H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 143.4, 135.2, 131.6, 131.5, 129.7, 127.9, 64.0, 51.0, 50.3. HRMS-ESI : *m*/*z* $[M+H]^+$ calcd for $C_{13}H_{19}NO_2SSi$: 282.0979, found 282.0973.



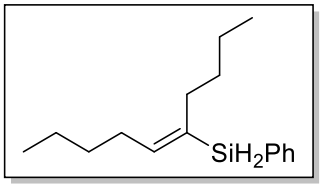
***tert*-butyl (2-(phenylsilyl)allyl)carbamate (3t)** was isolated (105 mg, 0.4 mmol, 80%) as a colorless oil after chromatograph on silica with PE/EA (10:1). ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.61-7.55 (m, 2H), 7.43-7.33 (m, 3H), 5.92-5.88 (m, 1H), 5.66-5.60 (m, 1H), 4.71 (s, 1H), 4.57 (s, 2H), 3.89 (d, *J*=5.6 Hz, 2H), 1.43 (s, 9H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 155.6, 142.3, 135.4, 130.6, 129.8, 129.3, 128.1, 79.2, 46.0, 28.3. HRMS-ESI : *m*/*z* $[M+Na]^+$ calcd for $C_{14}H_{21}NO_2Si$: 286.1234, found 286.1232.



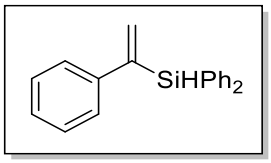
(*E*)-(1,2-diphenylvinyl)(phenyl)silane[5] **(3u)** was isolated (126 mg, 0.44 mmol, 88%) as a colorless oil after chromatograph on silica with PE. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.60-7.52 (m, 2H), 7.41-7.29 (m, 3H), 7.27-7.20 (m, 2H), 7.19-7.14 (m, 1H), 7.12-7.04 (m, 6H), 7.03-6.98 (m, 2H), 4.79 (s, 2H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 142.3, 141.3, 138.5, 136.8, 135.7, 131.3, 129.8, 129.5, 128.7, 128.0, 127.9, 127.7, 127.6, 126.3.



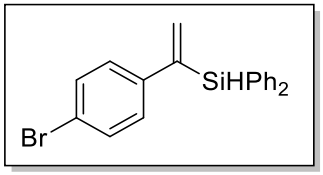
(*E*)-hex-3-en-3-yl(phenyl)silane (3v) was isolated (82 mg, 0.43 mmol, 86%) as a colorless oil after chromatograph on silica with PE. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.61-7.52 (m, 2H), 7.41-7.30 (m, 3H), 5.99 (t, *J*=6.6 Hz, 1H), 4.54 (s, 2H), 2.23-2.12 (m, 4H), 1.03-0.90 (m, 6H), ^{13}C NMR (100 MHz, $CDCl_3$) δ 147.3, 135.5, 134.9, 132.7, 129.5, 127.9, 23.3, 21.9, 14.3, 13.9. HRMS-ESI : *m*/*z* $[M+Na]^+$ calcd for $C_{12}H_{18}Si$: 213.1070, found 213.1060.



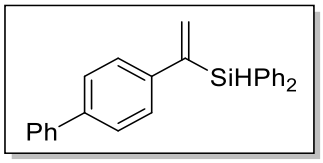
(*E*)-dec-5-en-5-yl(phenyl)silane (3w) was isolated (101 mg, 0.41 mmol, 82%) as a colorless oil after chromatograph on silica with PE. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.66-7.57 (m, 2H), 7.45-7.36 (m, 3H), 6.14-5.96 (t, *J*=7.0 Hz, 1H), 4.58 (s, 2H), 2.25-2.16 (m, 4H), 1.44-1.28 (m, 8H), 0.98-0.92 (t, *J*=7.0 Hz, 3H), 0.92-0.87 (t, *J*=7.1 Hz, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 146.2, 135.5, 134.0, 132.7, 129.4, 127.9, 31.7, 31.5, 30.0, 28.5, 22.7, 22.5, 14.0, 13.9. HRMS-ESI : *m*/*z* $[M+Na]^+$ calcd for $C_{16}H_{26}Si$: 269.1696, found 269.1691.



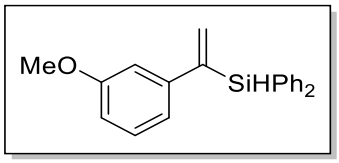
diphenyl(1-phenylvinyl)silane (7a) [7] was isolated (123 mg, 0.43 mmol, 86%) as a colorless oil after chromatograph on silica with PE. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.60-7.51 (m, 4H), 7.37-7.27 (m, 8H), 7.23-7.12 (m, 3H), 6.26 (d, *J*=2.3 Hz, 1H), 5.68 (d, *J*=2.4 Hz, 1H), 5.42 (s, 1H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 145.8, 142.8, 135.7, 133.0, 132.1, 129.8, 128.4, 128.0, 127.1, 126.7.



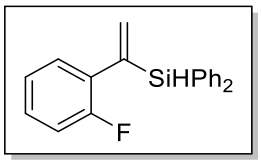
(1-(4-bromophenyl)vinyl)diphenylsilane[7] **(7b)** was isolated (153 mg, 0.42 mmol, 84%) as a white solid after chromatograph on silica with PE. ^{1}H NMR (400 MHz, DMSO-d_6) δ 7.53-7.49 (m, 4H), 7.46-7.35 (m, 8H), 7.29-7.23 (m, 2H), 6.32 (d, *J*=1.6 Hz, 1H), 5.65 (d, *J*=2.1 Hz, 1H), 5.33 (s, 1H). ^{13}C NMR (100 MHz, DMSO-d_6) δ 144.4, 141.7, 135.8, 133.4, 132.3, 131.9, 130.6, 128.9, 128.7, 121.1.



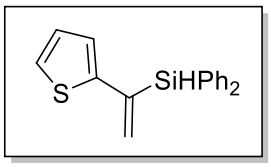
(1-([1,1'-biphenyl]-4-yl)vinyl)diphenylsilane[7] **(7c)** was isolated (163 mg, 0.45 mmol, 90%) as a white solid after chromatograph on silica with PE. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.61-7.56 (m, 4H), 7.55-7.51 (m, 2H), 7.48-7.40 (m, 4H), 7.39-7.31 (m, 8H), 7.30-7.25 (m, 1H), 6.33 (d, *J*=2.0 Hz, 1H), 5.70 (d, *J*=2.0 Hz, 1H), 5.44 (s, 1H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 145.2, 141.7, 140.6, 139.8, 135.8, 132.9, 132.0, 129.8, 128.7, 128.1, 127.2, 127.1, 127.1, 126.8.



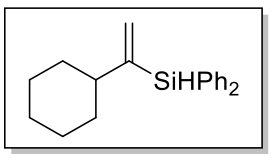
(1-(3-methoxyphenyl)vinyl)diphenylsilane (7d) was isolated (139 mg, 0.44 mmol, 88%) as a colorless oil after chromatograph on silica with PE. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.60-7.52 (m, 4H), 7.38-7.28 (m, 6H), 7.15-7.10 (m, 1H), 6.96-6.89 (m, 1H), 6.88-6.82 (m, 1H), 6.76-6.67 (m, 1H), 6.26 (d, *J*=2.3 Hz, 1H), 5.69 (d, *J*=2.3 Hz, 1H), 5.40 (s, 1H), 3.60 (s, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 159.5, 145.8, 144.3, 135.7, 133.0, 132.2, 129.8, 129.3, 128.0, 119.2, 122.8, 122.1, 54.9. HRMS-ESI : *m*/*z* $[M+H]^+$ calcd for $C_{21}H_{20}OSi$: 317.1356, found 317.1354.



(1-(2-fluorophenyl)vinyl)diphenylsilane[8] **(7e)** was isolated (119 mg, 0.39 mmol, 78%) as a colorless oil after chromatograph on silica with PE. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.51-7.44 (m, 4H), 7.28-7.19 (m, 6H), 7.12-7.07 (m, 1H), 7.04-7.6.98 (m, 1H), 6.92-6.81 (m, 2H), 6.15 (d, *J*=2.4 Hz, 1H), 5.74 (d, *J*=2.4 Hz, 1H), 5.24 (d, *J*=6.7 Hz, 1H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 160.6, 158.2, 141.1, 135.6, 135.2 (d, *J*=2.2 Hz), 133.0, 129.7, 129.4 (d, *J*=3.9 Hz), 128.4 (d, *J*=8.0 Hz), 127.9, 124.0 (d, *J*=3.5 Hz), 115.5 (d, *J*=22.3 Hz). ^{19}F NMR (400 MHz, $CDCl_3$) δ -113.6 (s).

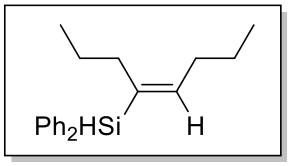


diphenyl(1-(thiophen-2-yl)vinyl)silane[7] **(7f)** was isolated (127 mg, 0.44 mmol, 87%) as a white solid after chromatograph on silica with PE. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.64-7.53 (m, 4H), 7.40-7.29 (m, 6H), 7.13-7.00 (m, 1H), 6.94-6.87 (m, 1H), 6.84-6.77 (dd, *J*=0.9 Hz, 1.3 Hz, 1H), 6.35-6.28 (s, 1H), 5.48 (d, *J*=1.8 Hz, 1H), 5.42 (s, 1H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 146.3, 137.9, 135.7, 132.3, 130.0, 129.5, 128.1, 127.5, 125.9, 124.1.

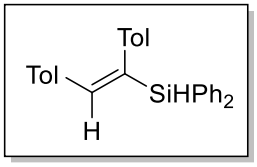


cyclohexylvinyl)(phenyl)silane[8] **(7g)** was isolated (132 mg, 0.45 mmol, 90%) as a colorless oil after chromatograph on silica with PE. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.60-

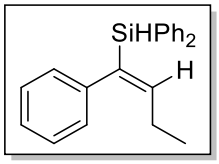
7.48 (m, 4H), 7.41-7.25 (m, 6H), 5.94-5.83 (m, 1H), 5.40 (d, *J*=2.4 Hz, 1H), 5.16 (s, 1H), 2.25-2.04 (m, 1H), 1.81-1.64 (m, 4H), 1.64-1.57 (m, 1H), 1.27-1.07 (m, 5H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 152.0, 135.7, 135.4, 133.8, 129.5, 128.0, 127.9, 45.1, 33.2, 26.7, 26.2.



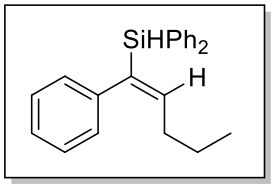
(*E*)-oct-4-en-4-yldiphenylsilane[7] **(7h)** was isolated (128 mg, 0.44 mmol, 87%) as a colorless oil after chromatograph on silica with PE. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.60-7.51 (m, 4H), 7.38-7.29 (m, 6H), 5.99-5.83 (m, 1H), 5.10 (s, 1H), 2.25-2.11 (m, 4H), 1.44-1.28 (m, 4H), 0.93-0.86 (m, 3H), 0.85-0.78 (m, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 146.6, 139.7, 135.2, 134.3, 129.4, 127.8, 32.6, 30.9, 23.0, 22.6, 14.3, 13.9.



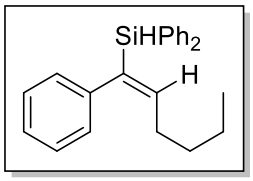
(*E*)-(1,2-di-*p*-tolylvinyl)diphenylsilane (7i) was isolated (176 mg, 0.45 mmol, 90%) as a colorless oil after chromatograph on silica with PE. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.61-7.54 (m, 4H), 7.32-7.24 (m, 6H), 6.99-6.89 (m, 7H), 6.85-6.81 (m, 2H), 5.31 (s, 1H), 2.20 (s, 3H), 2.14 (s, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 142.7, 138.8, 138.6, 137.3, 135.8, 135.5, 134.2, 133.2, 129.7, 129.6, 129.3, 128.6, 127.9, 127.9, 21.1. HRMS-ESI : *m*/*z* $[M+H]^+$ calcd for $C_{28}H_{26}Si$: 413.1696, found 413.1716.



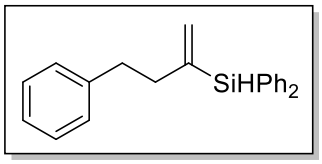
(*E*)-diphenyl(1-phenylbut-1-en-1-yl)silane[7] **(7j)** was isolated (137 mg, 0.44 mmol, 87%) as a colorless oil after chromatograph on silica with PE. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.56-7.48 (m, 4H), 7.33-7.26 (m, 6H), 7.20-7.15 (m, 2H), 7.11-7.06 (m, 1H), 7.01-7.69 (m, 2H), 6.20 (t, *J*=7.1 Hz, 1H), 5.22 (s, 1H), 2.16-2.01 (m, 2H), 0.92 (t, *J*=7.6 Hz, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 149.3, 141.2, 137.2, 135.7, 133.5, 129.5, 128.3, 128.0, 127.9, 125.8, 23.6, 14.0.



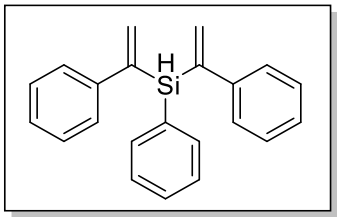
(*E*)-diphenyl(1-phenylpent-1-en-1-yl)silane[7] **(7k)** was isolated (140 mg, 0.43 mmol, 85%) as a colorless oil after chromatograph on silica with PE. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.55-7.45 (m, 4H), 7.37-7.27 (m, 6H), 7.23-7.15 (m, 2H), 7.14-7.07 (m, 1H), 7.03-6.91 (m, 2H), 6.20 (t, *J*=7.1 Hz, 1H), 5.20 (s, 1H), 2.15-1.97 (m, 2H), 1.42-1.31 (m, 2H), 0.82 (t, *J*=7.4 Hz, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 147.9, 141.3, 138.0, 135.7, 133.6, 129.5, 128.4, 128.0, 127.9, 125.7, 32.2, 22.6, 13.8.



(*E*)-diphenyl(1-phenylhex-1-en-1-yl)silane (7l) was isolated (137 mg, 0.40 mmol, 80%) as a colorless oil after chromatograph on silica with PE. ^{1}H NMR (600 MHz, $CDCl_3$) δ 7.56-7.48 (m, 4H), 7.35-7.28 (m, 6H), 7.20-7.17 (m, 2H), 7.12-7.08 (m, 1H), 7.02-6.96 (m, 2H), 6.20 (t, *J*=7.1 Hz, 1H), 5.20 (s, 1H), 2.10 (q, *J*=7.2 Hz, 14.6 Hz, 2H), 1.35-1.30 (m, 2H), 1.26-1.20 (m, 2H), 0.80 (t, *J*=7.3 Hz, 3H). ^{13}C NMR (125 MHz, $CDCl_3$) δ 148.0, 141.3, 137.8, 135.7, 133.6, 129.5, 128.3, 128.0, 127.8, 125.7, 31.6, 29.9, 22.3, 13.9. HRMS-ESI : *m*/*z* $[M+K]^+$ calcd for $C_{28}H_{26}Si$: 381.1435, found 381.1496.



Diphenyl(4-phenylbut-1-en-2-yl)silane (7m) was isolated (142 mg, 0.45 mmol, 90%) as a colorless oil after chromatograph on silica with PE. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.61-7.56 (m, 4H), 7.43-7.35 (m, 6H), 7.25-7.20 (m, 2H), 7.17-7.12 (m, 1H), 7.10-7.04 (m, 2H), 5.92 (d, *J*=1.4 Hz, 1H), 5.53 (d, *J*=1.6 Hz, 1H), 5.12 (s, 1H), 2.74-2.68 (m, 2H), 2.56-2.50 (m, 2H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 145.7, 142.0, 135.6, 133.1, 130.2, 129.7, 128.4, 128.2, 128.0, 125.7, 38.6, 35.4. HRMS-ESI : *m*/*z* $[M+Na]^+$ calcd for $C_{22}H_{22}Si$: 337.1383, found 337.1389.



phenylbis(1-phenylvinyl)silane[5] **(9)** was isolated (131 mg, 0.42 mmol, 84%) as a colorless oil after chromatograph on silica with PE. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.61-7.55 (m, 2H), 7.38-7.31 (m, 7H), 7.27-7.22 (m, 4H), 7.21-7.16 (m, 2H), 6.28-6.18 (m, 2H), 5.68 (d, *J*=2.4 Hz, 2H), 5.34 (s, 1H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 145.4, 142.8, 135.7, 132.7, 132.2, 129.8, 128.4, 128.0, 127.1, 126.7.

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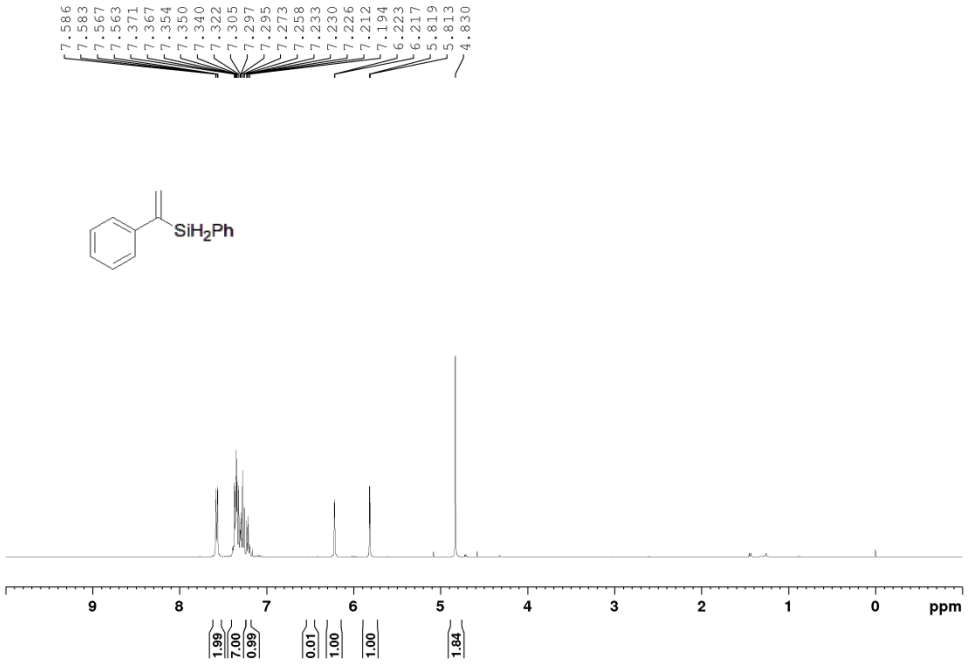
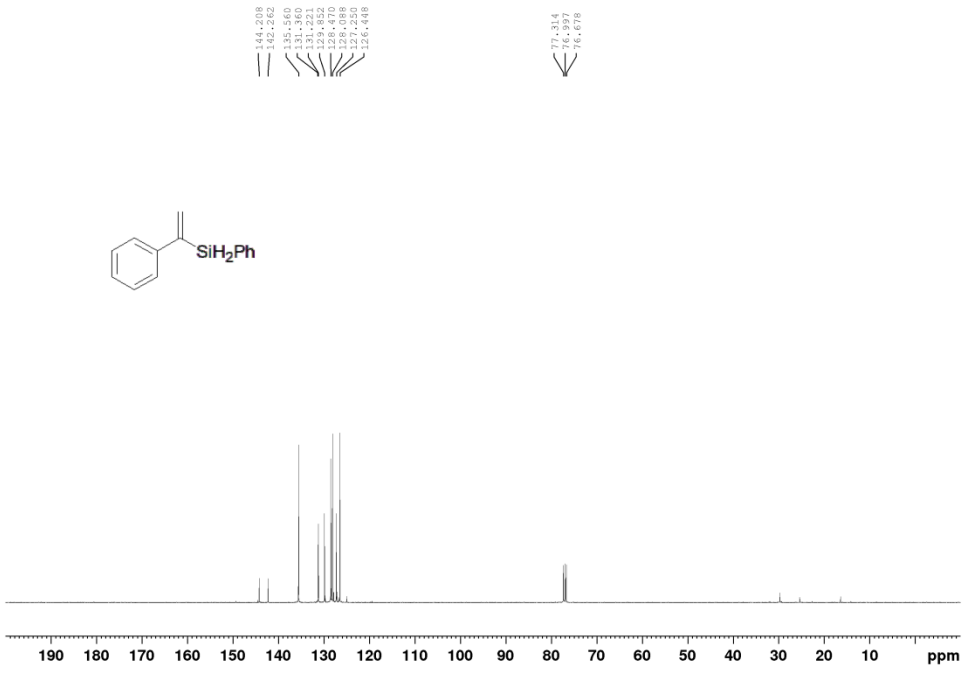
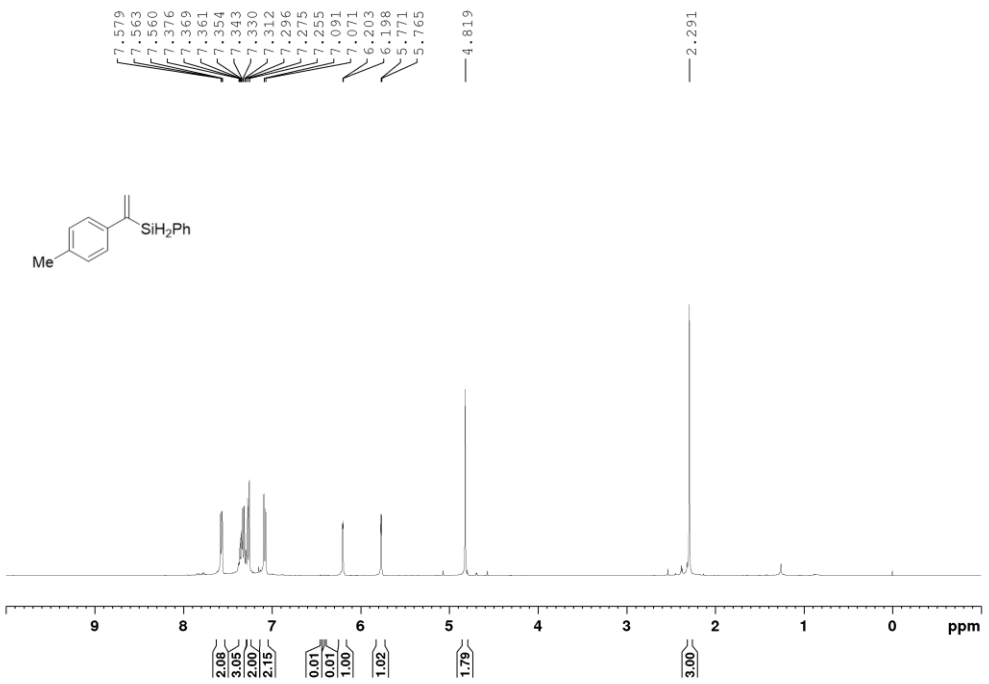
NMR Spectra



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



^{13}C NMR (100 M, $CDCl_3$) spectrum of **3a**



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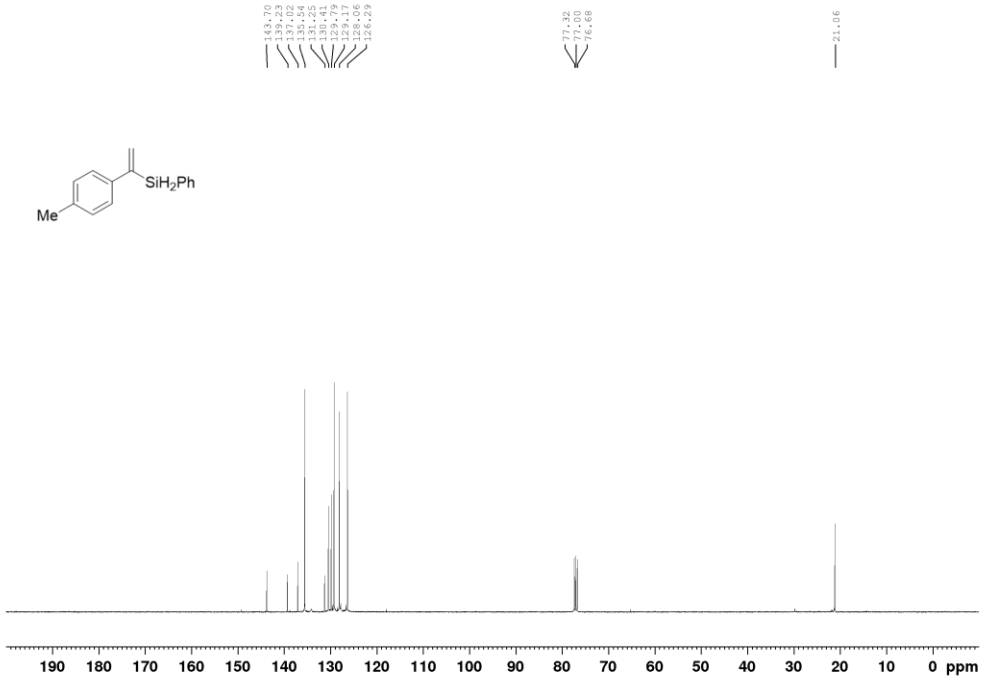
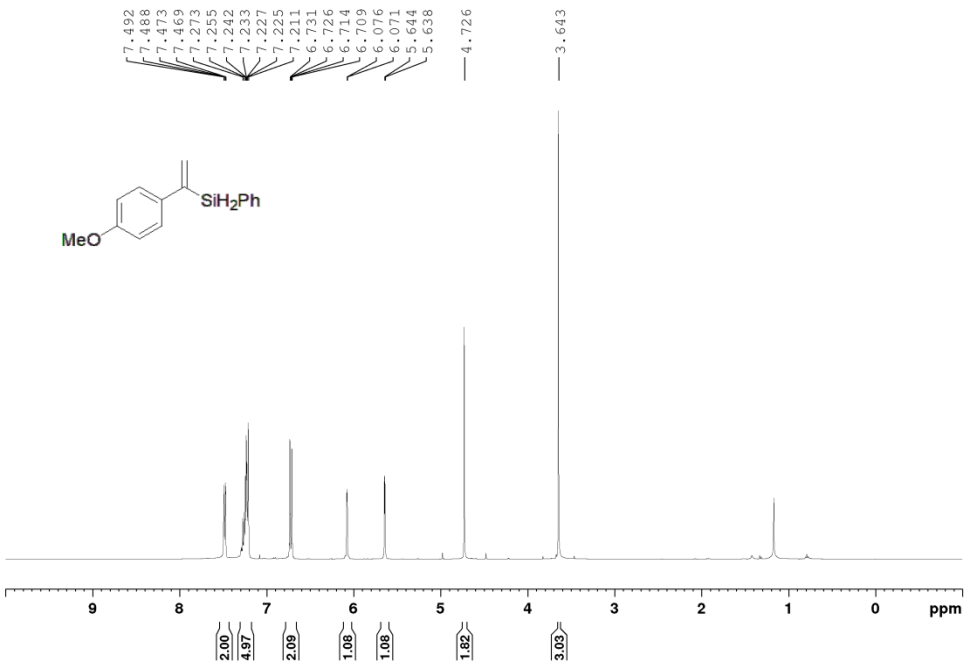
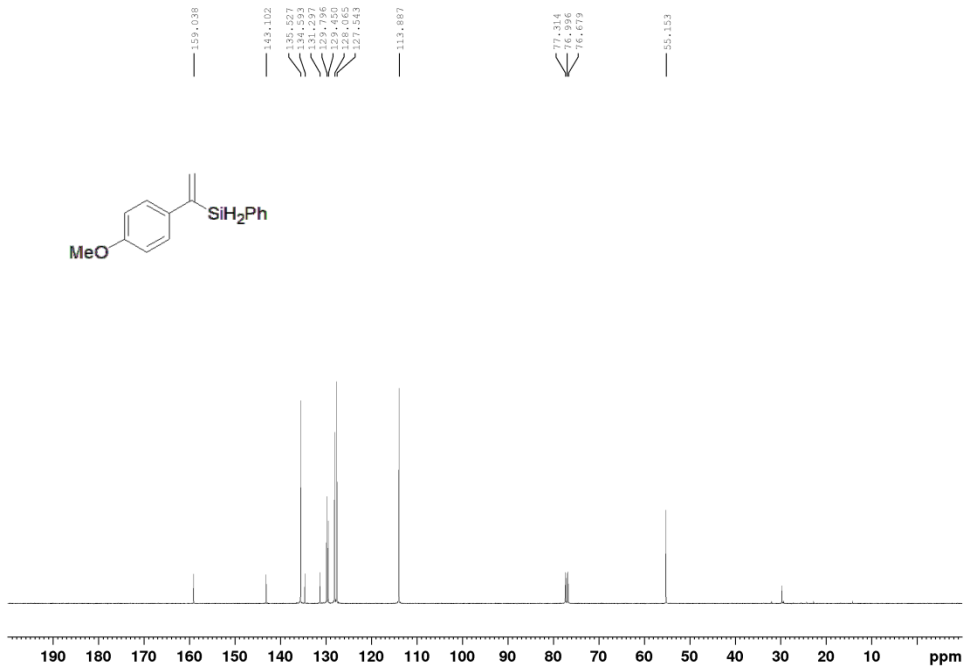


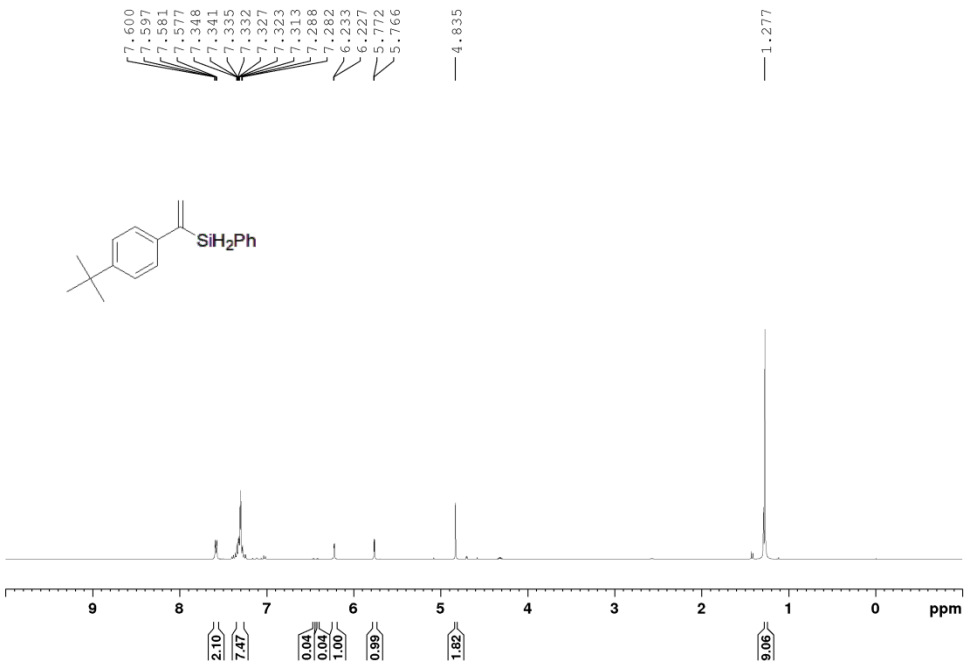
^{13}C NMR (100 M, $CDCl_3$) spectrum of **3b**



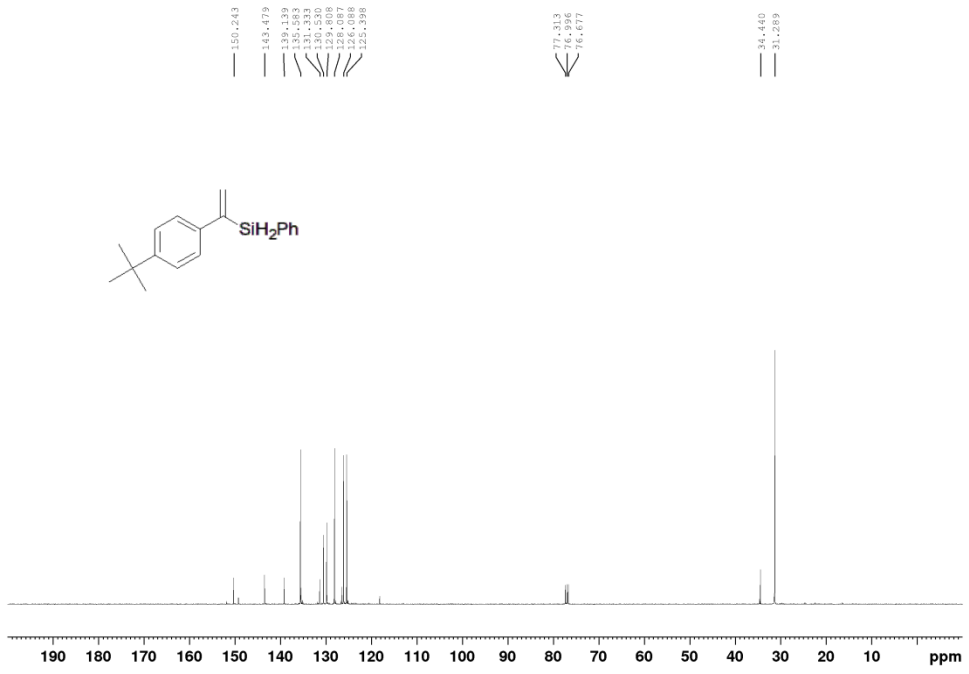
^{1}H NMR (400 M, $CDCl_3$) spectrum of **3c**



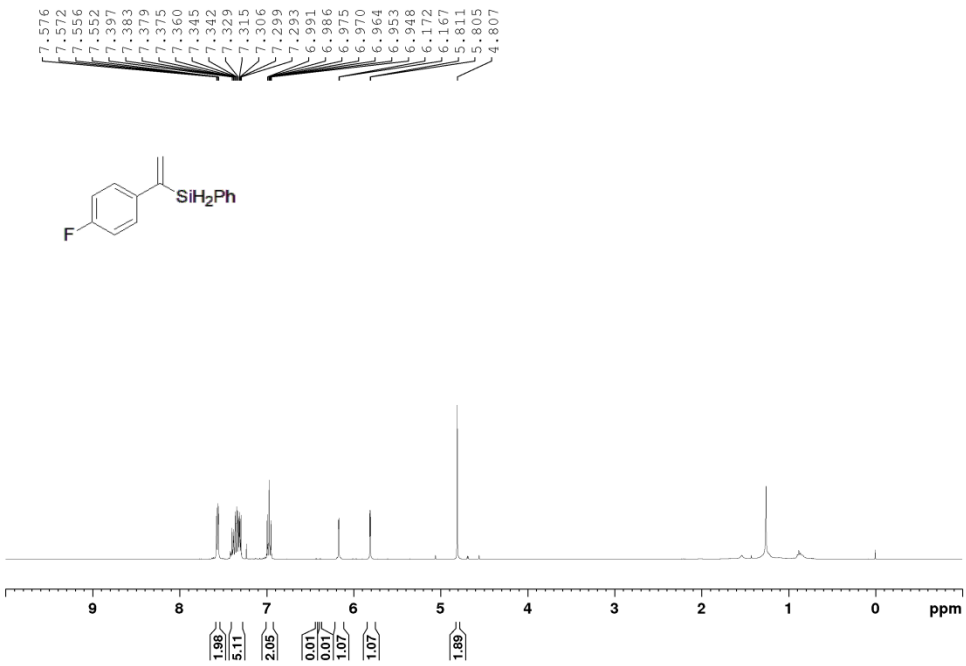
^{13}C NMR (100 M, $CDCl_3$) spectrum of **3c**



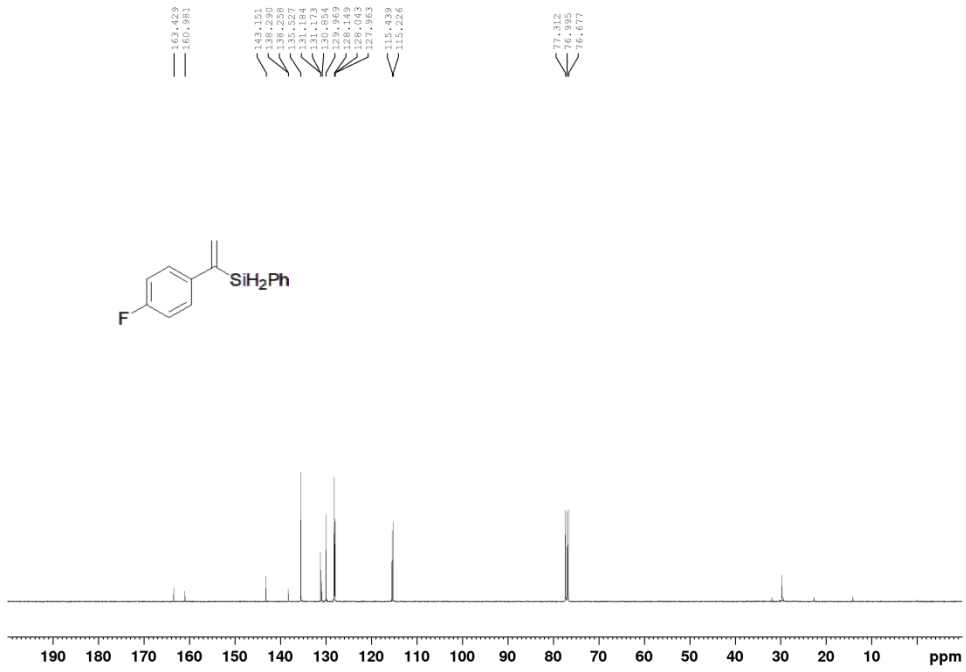
^{1}H NMR (400 M, $CDCl_3$) spectrum of **3d**



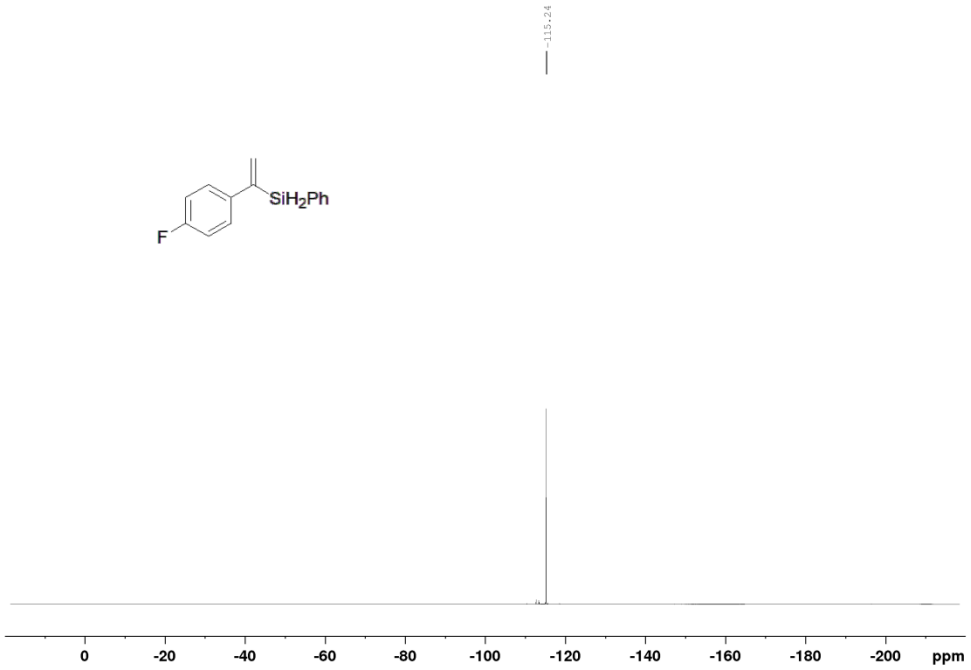
^{13}C NMR (100 M, $CDCl_3$) spectrum of **3d**



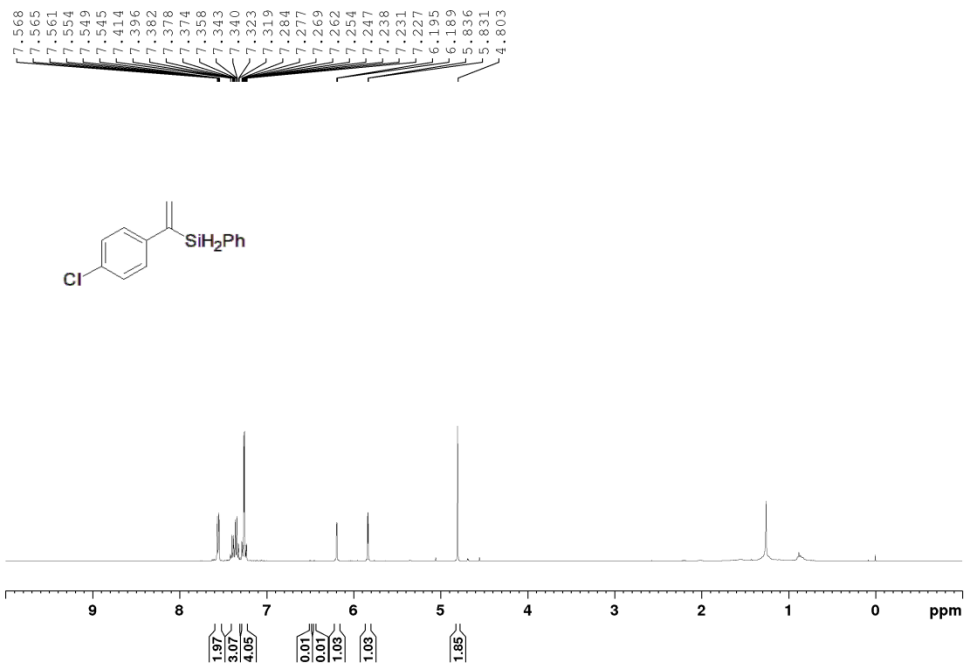
^{1}H NMR (400 M, $CDCl_3$) spectrum of **3e**



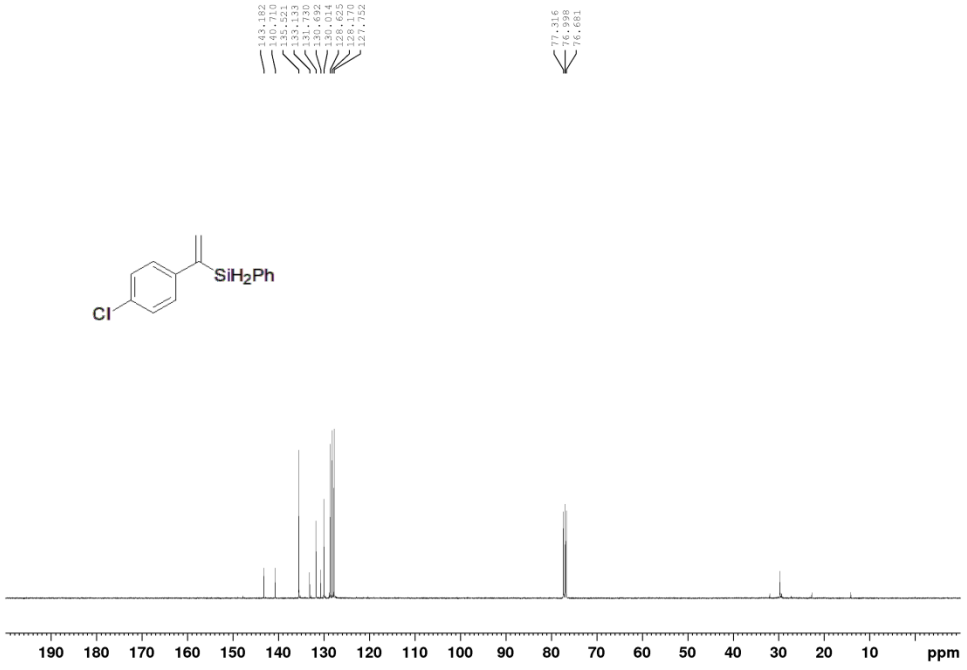
^{13}C NMR (100 M, $CDCl_3$) spectrum of **3e**



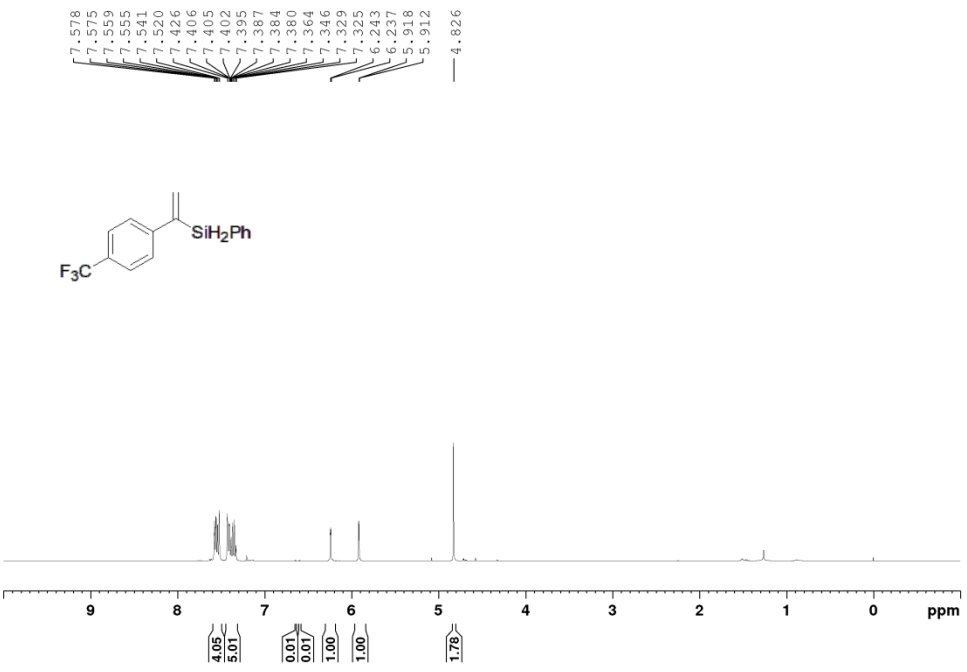
^{19}F NMR (400 M, $CDCl_3$) spectrum of **3e**



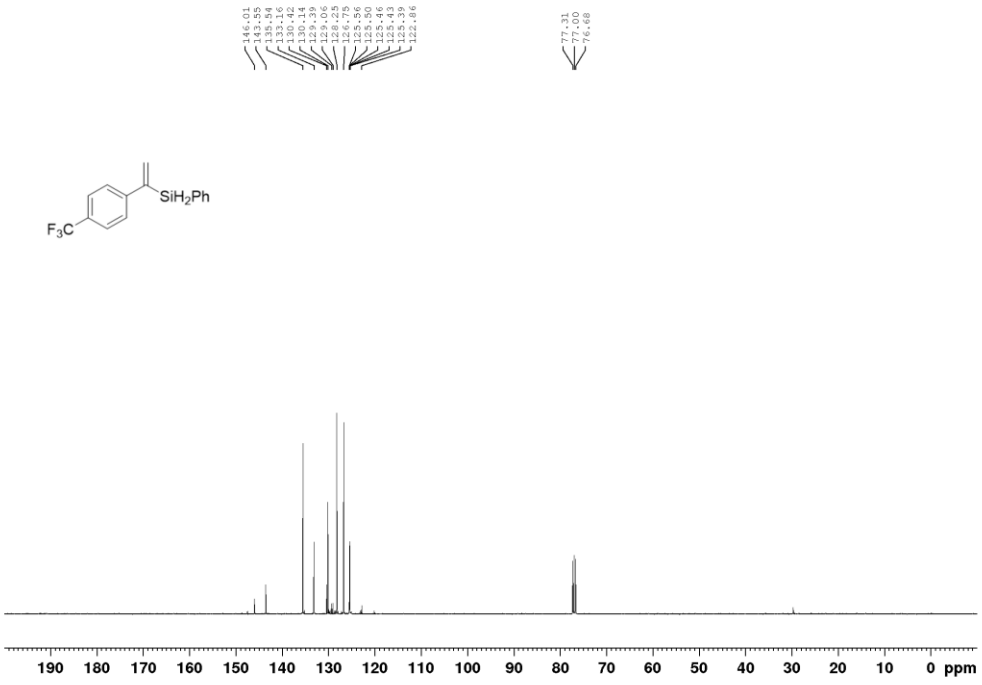
^{1}H NMR (400 M, $CDCl_3$) spectrum of **3f**



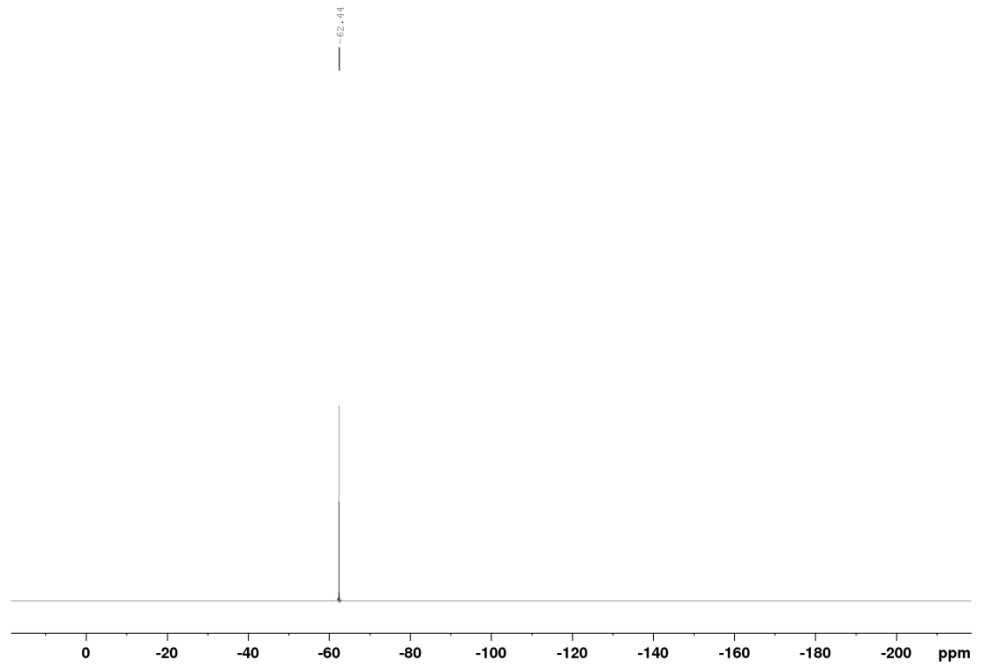
^{13}C NMR (100 M, $CDCl_3$) spectrum of **3f**



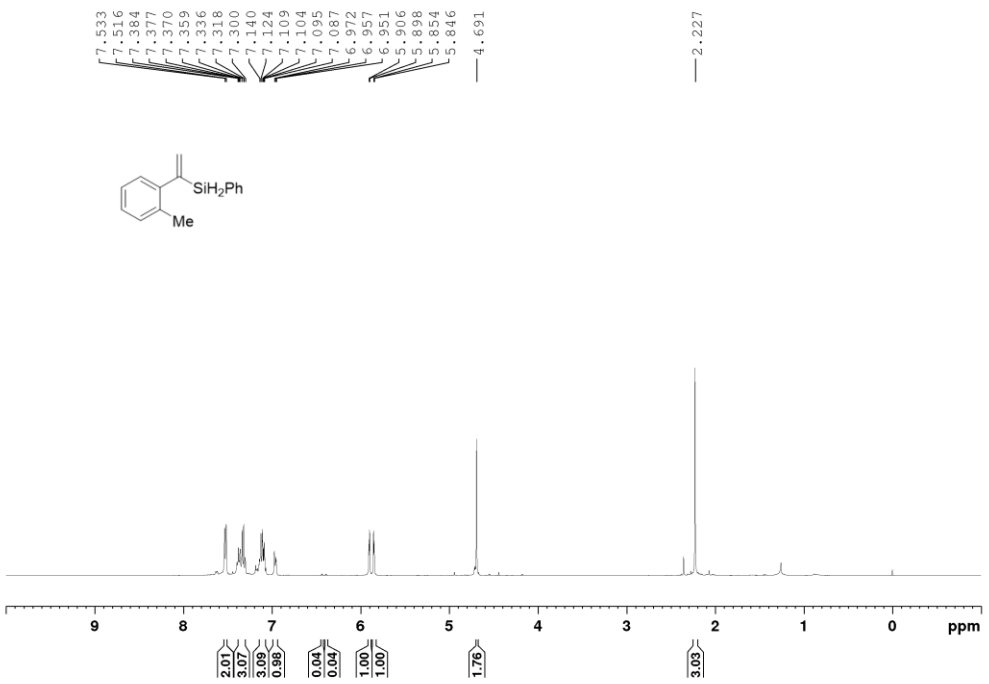
^{1}H NMR (400 M, $CDCl_3$) spectrum of **3g**



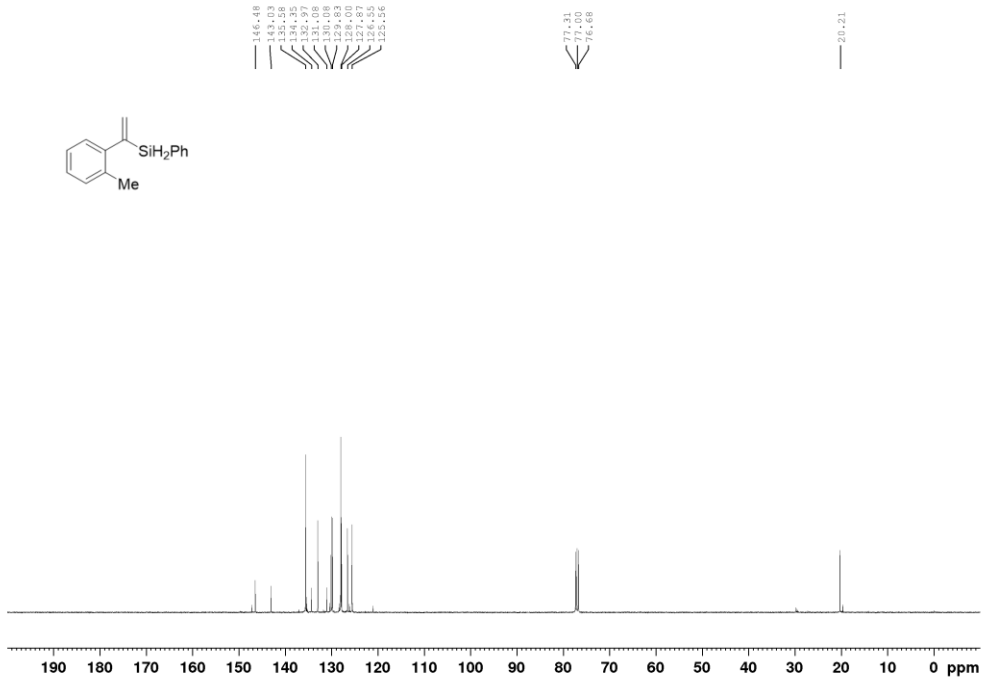
^{13}C NMR (100 M, $CDCl_3$) spectrum of **3g**



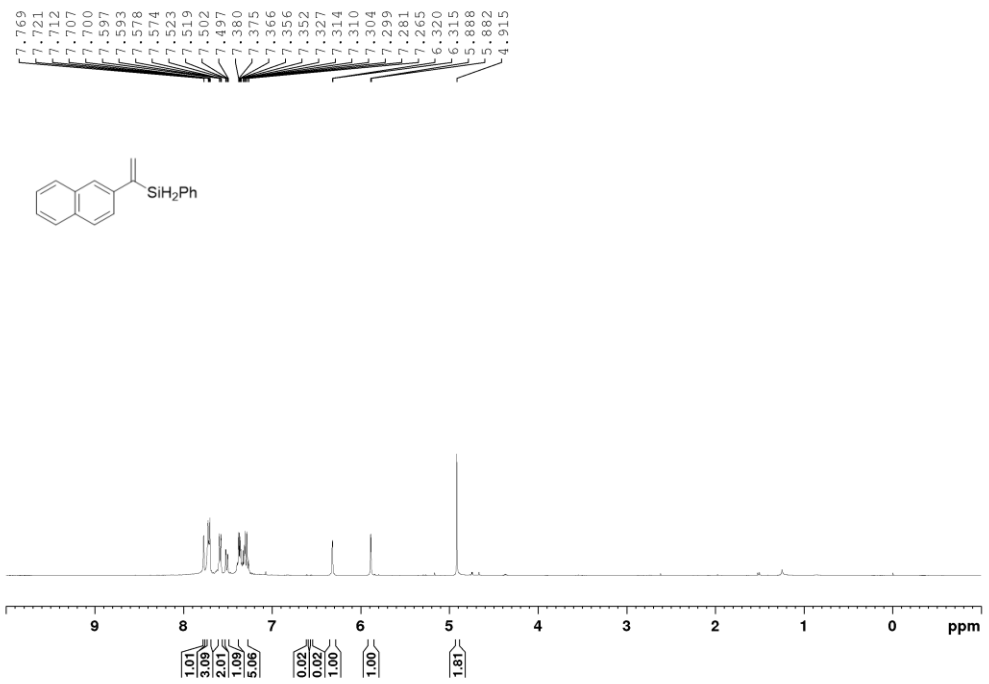
^{19}F NMR (400 M, $CDCl_3$) spectrum of **3g**



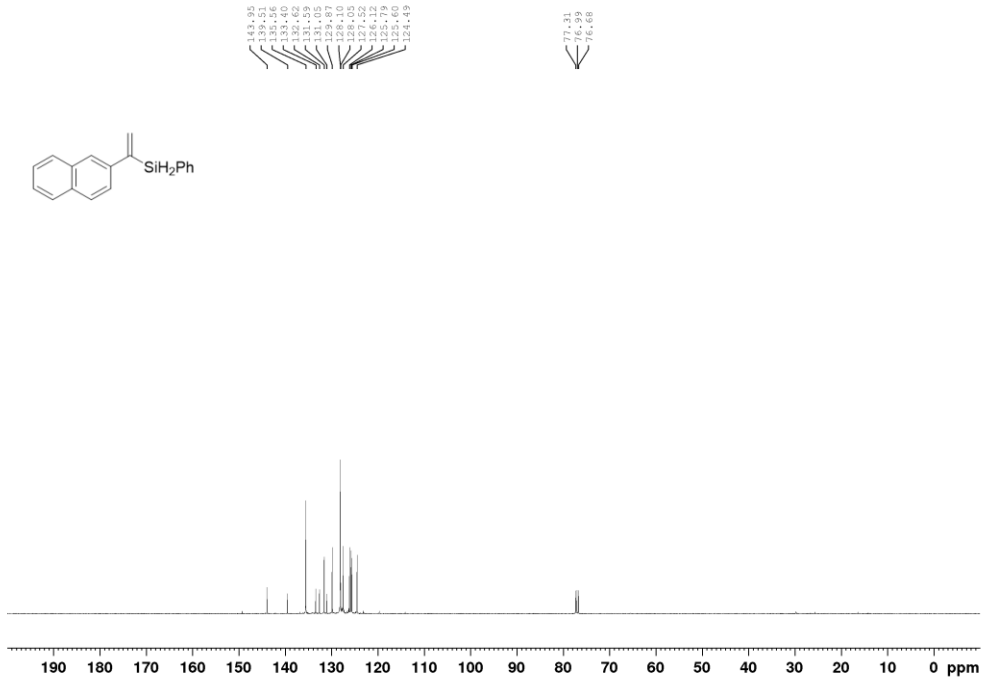
^{1}H NMR (400 M, $CDCl_3$) spectrum of **3h**



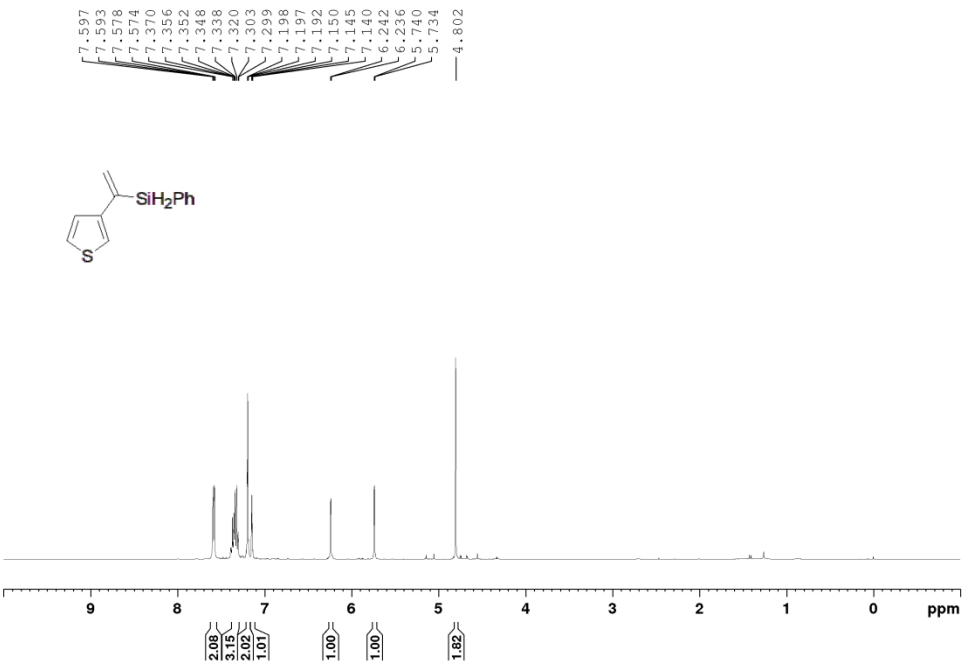
^{13}C NMR (100 M, $CDCl_3$) spectrum of **3h**



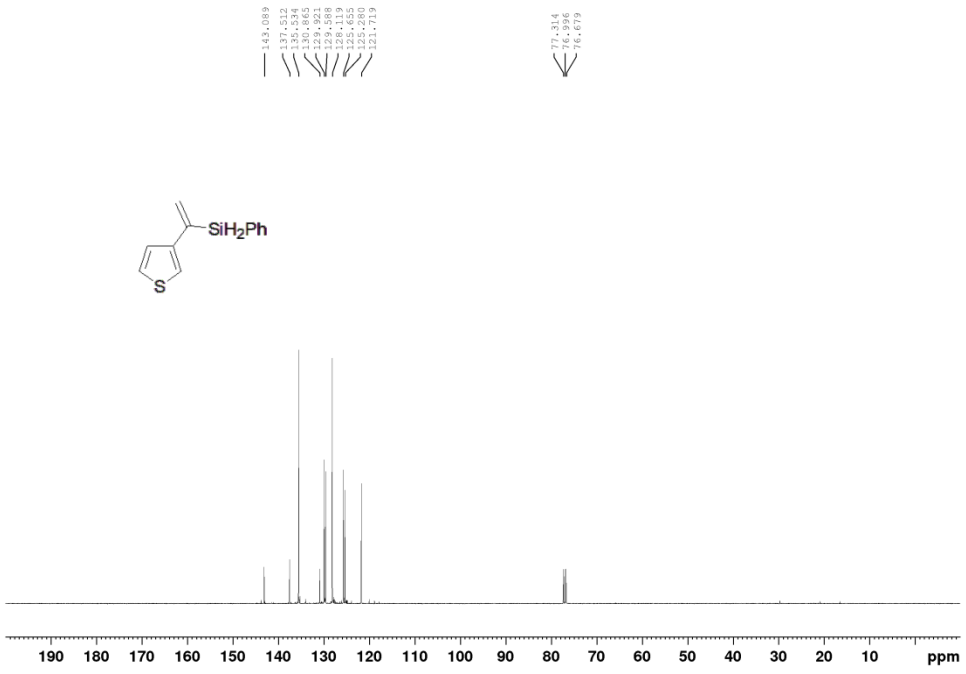
^{1}H NMR (400 M, $CDCl_3$) spectrum of **3i**



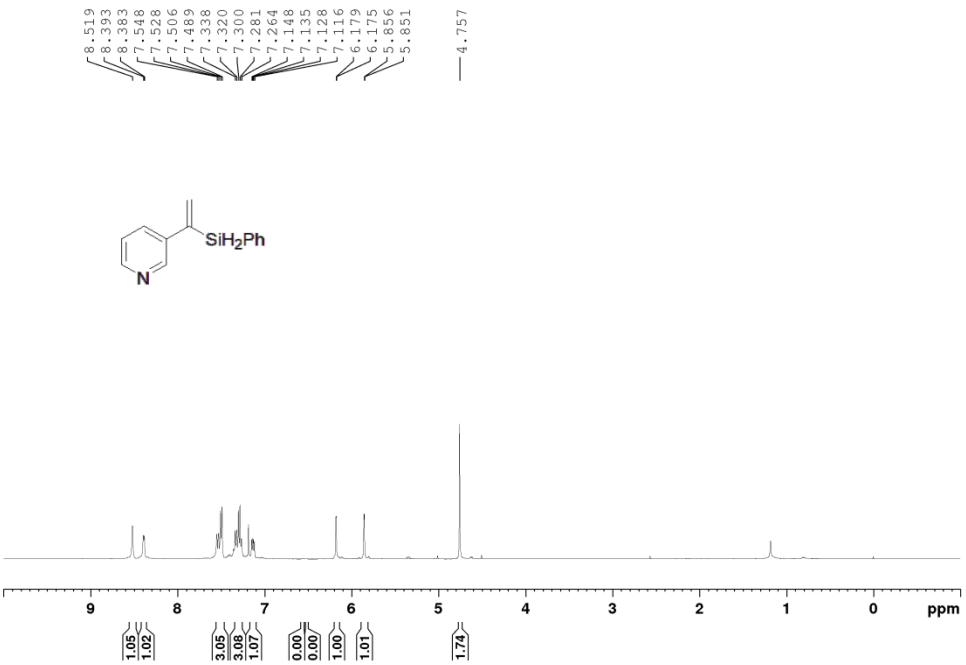
^{13}C NMR (100 M, $CDCl_3$) spectrum of **3i**



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



^{13}C NMR (100 M, $CDCl_3$) spectrum of **3j**



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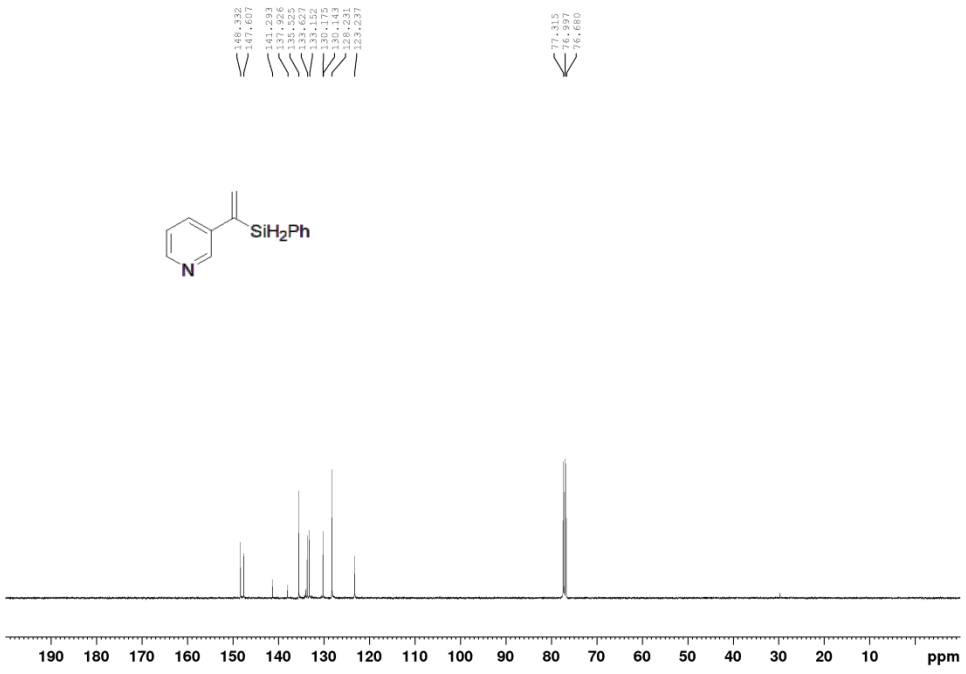
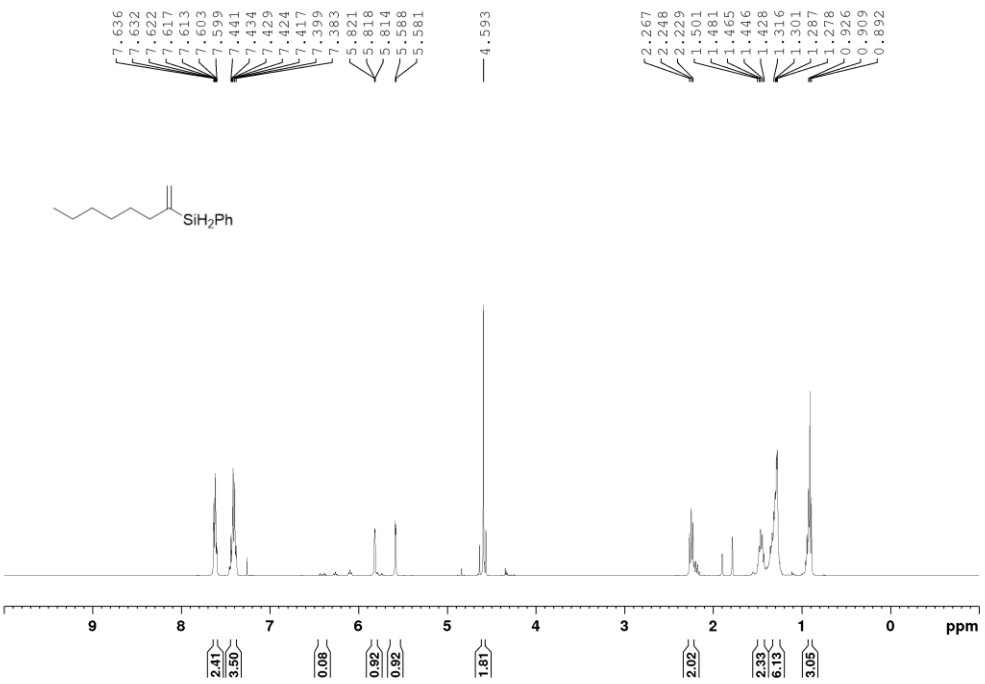
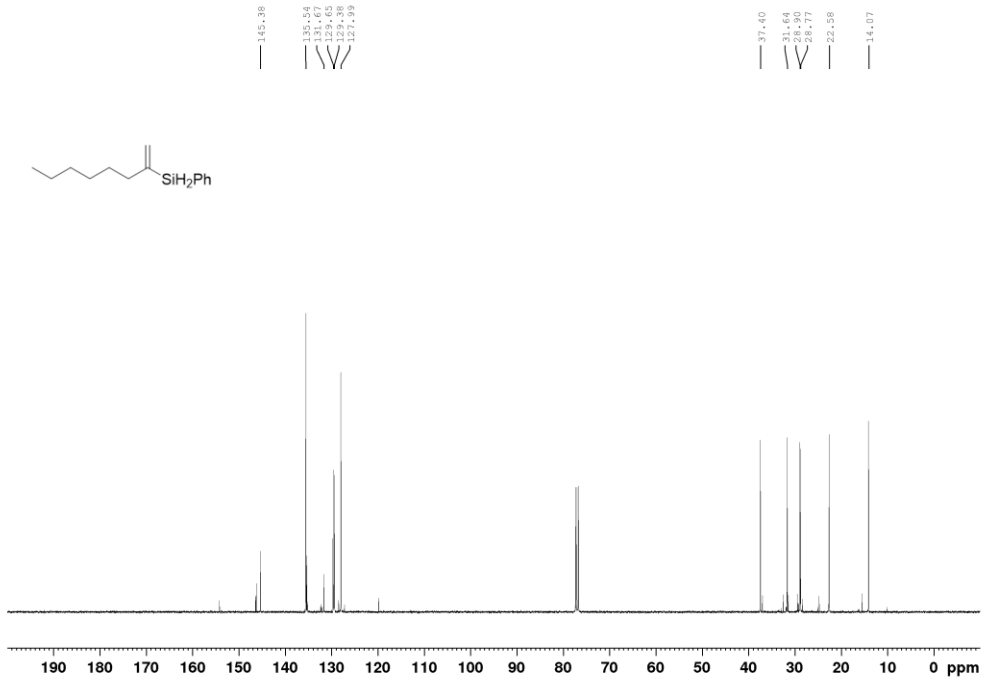


^{13}C NMR (100 M, $CDCl_3$) spectrum of **3k**



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



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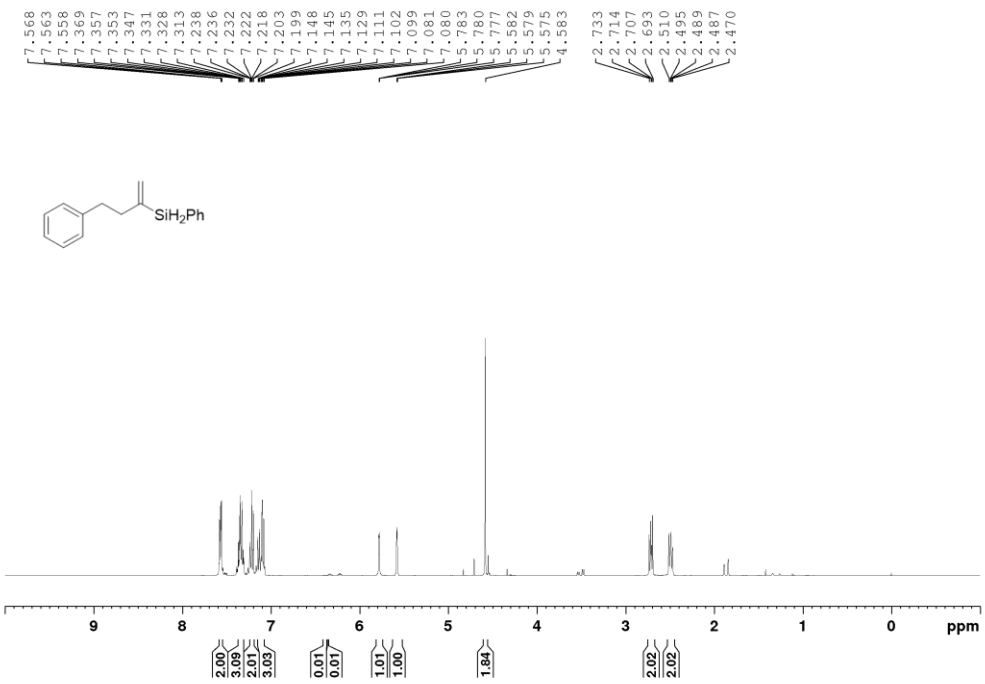

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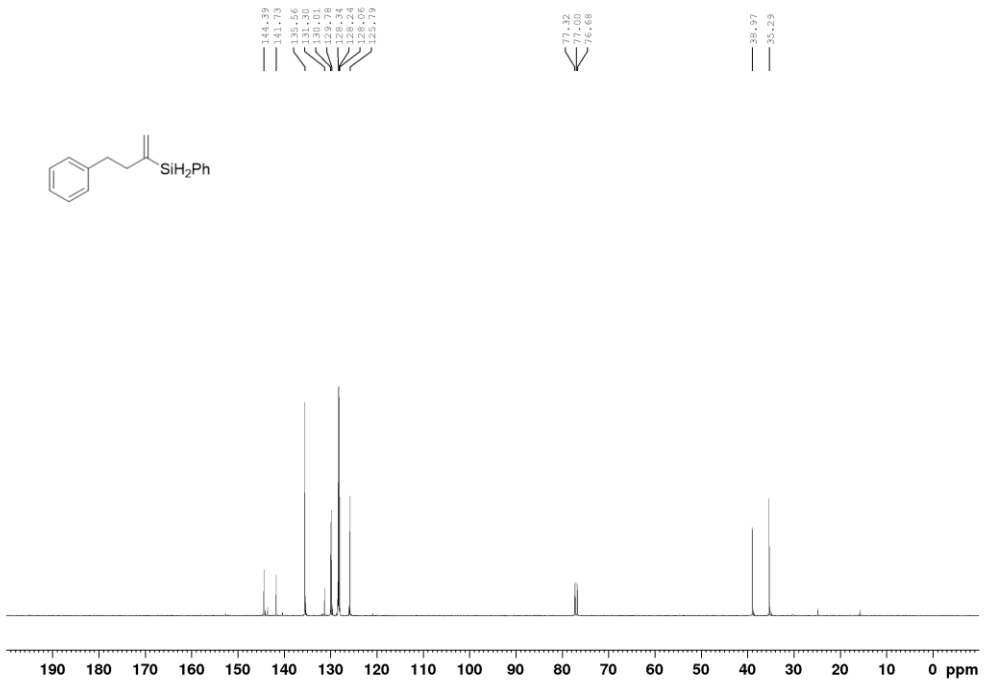
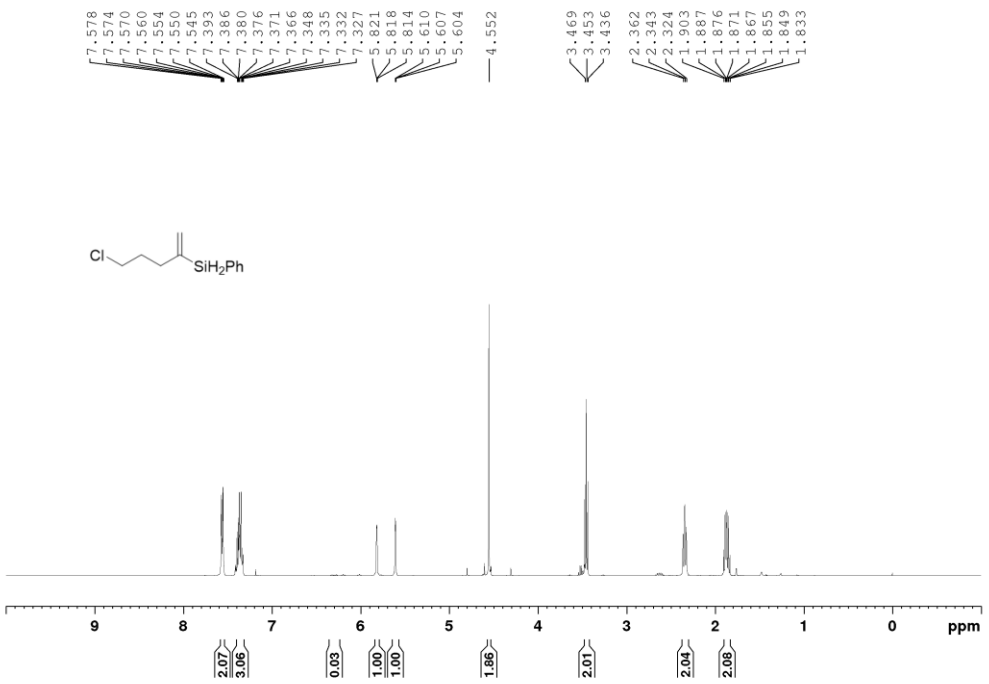


^{13}C NMR (100 M, $CDCl_3$) spectrum of **3m**



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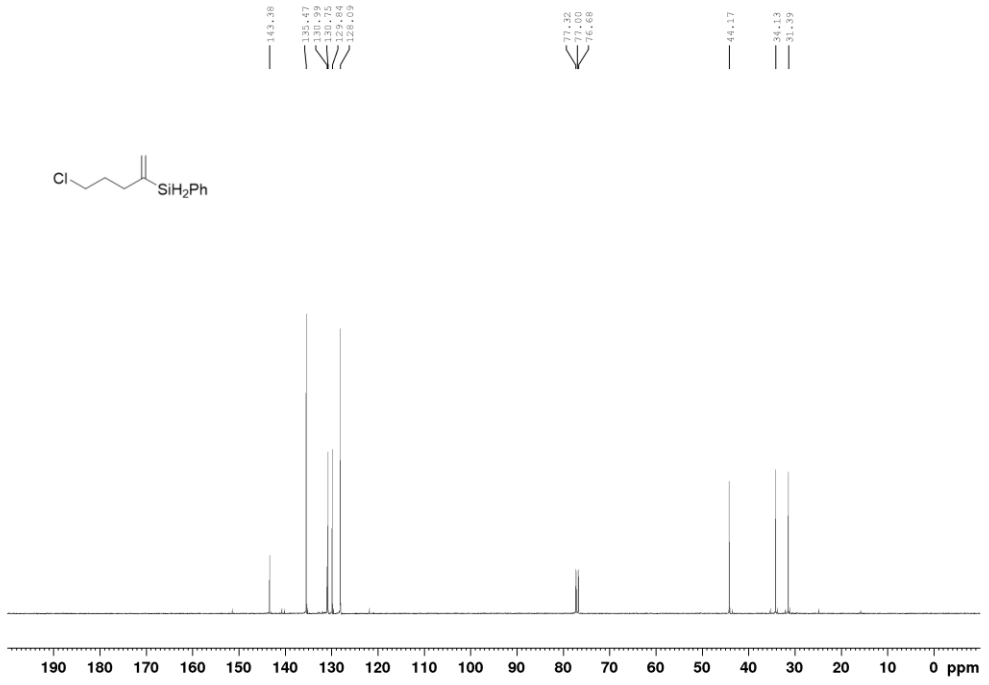

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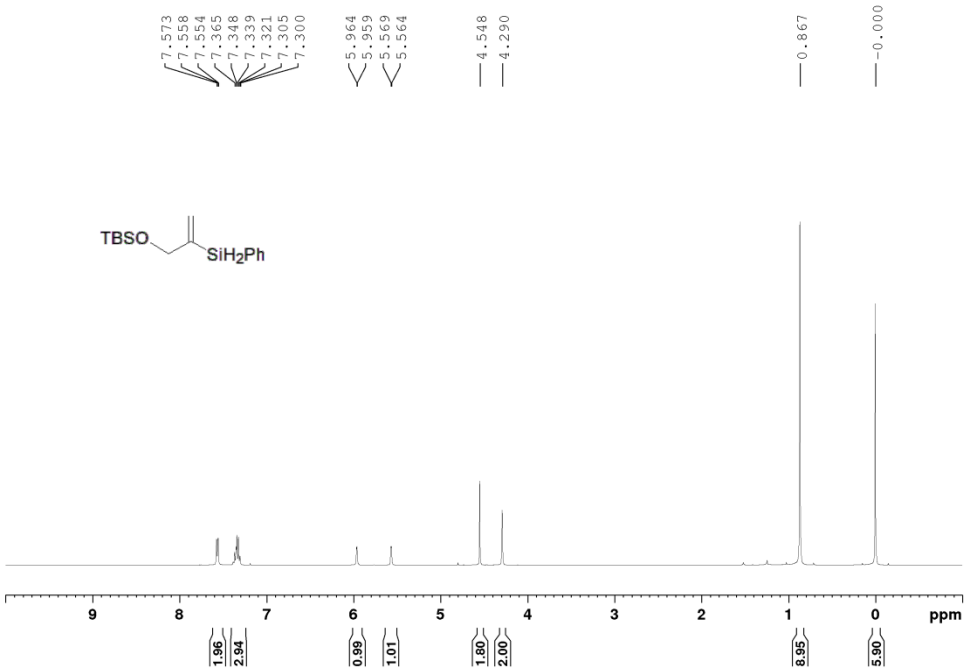

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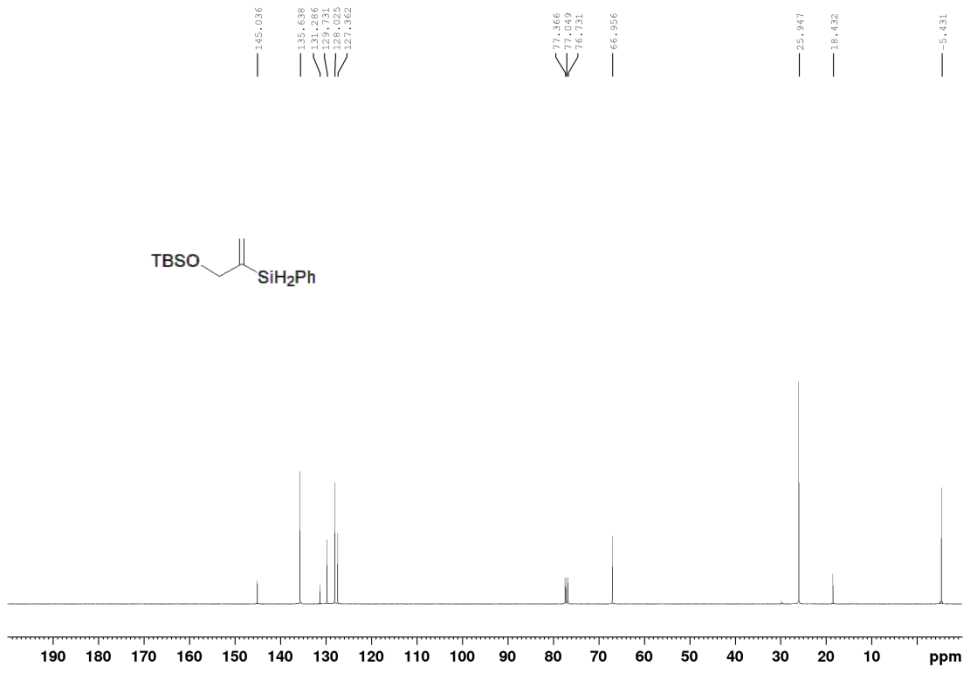

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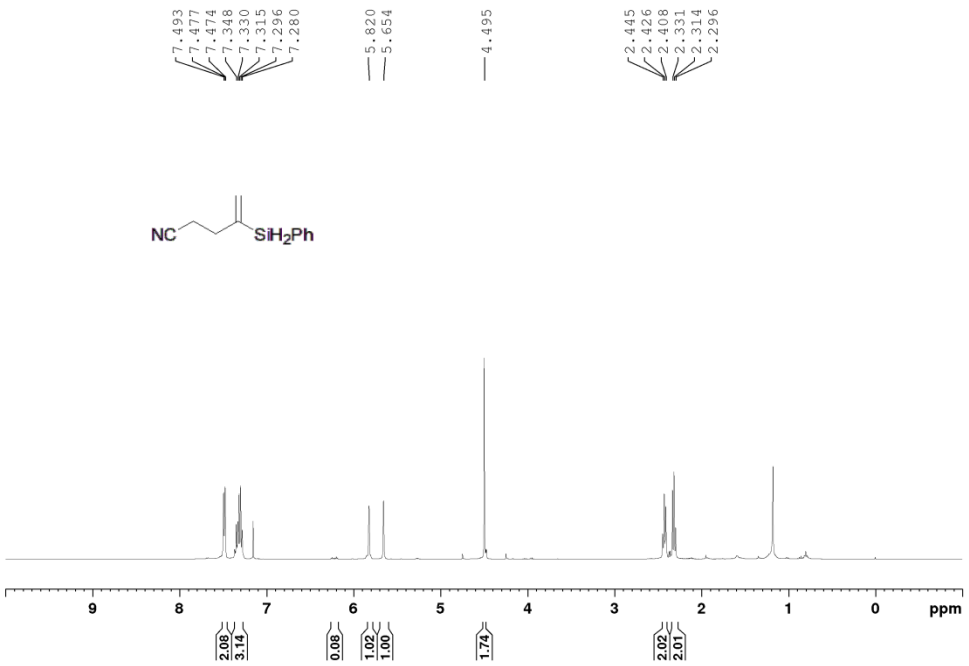

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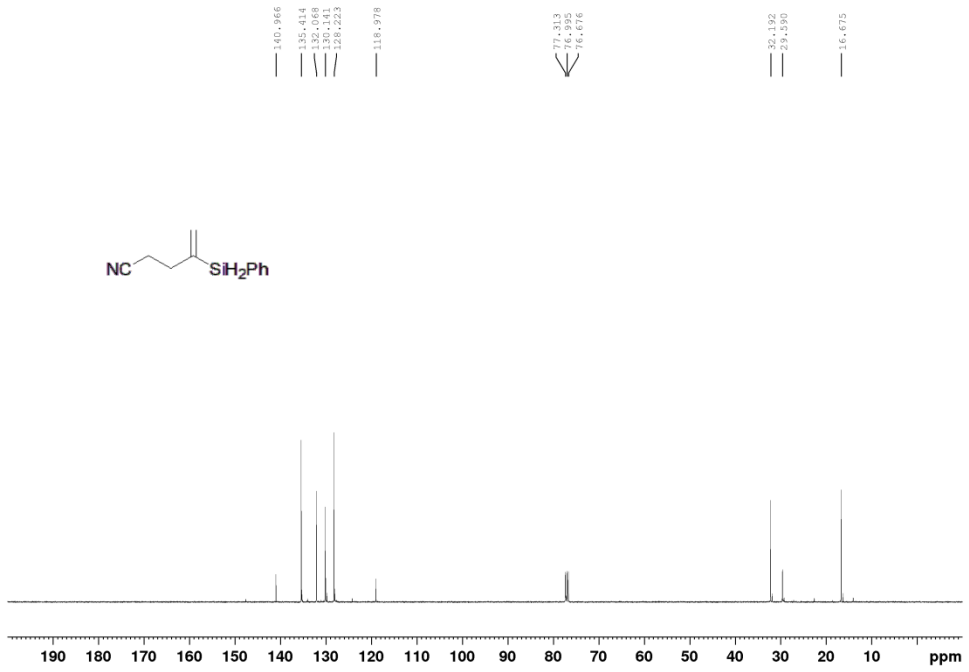

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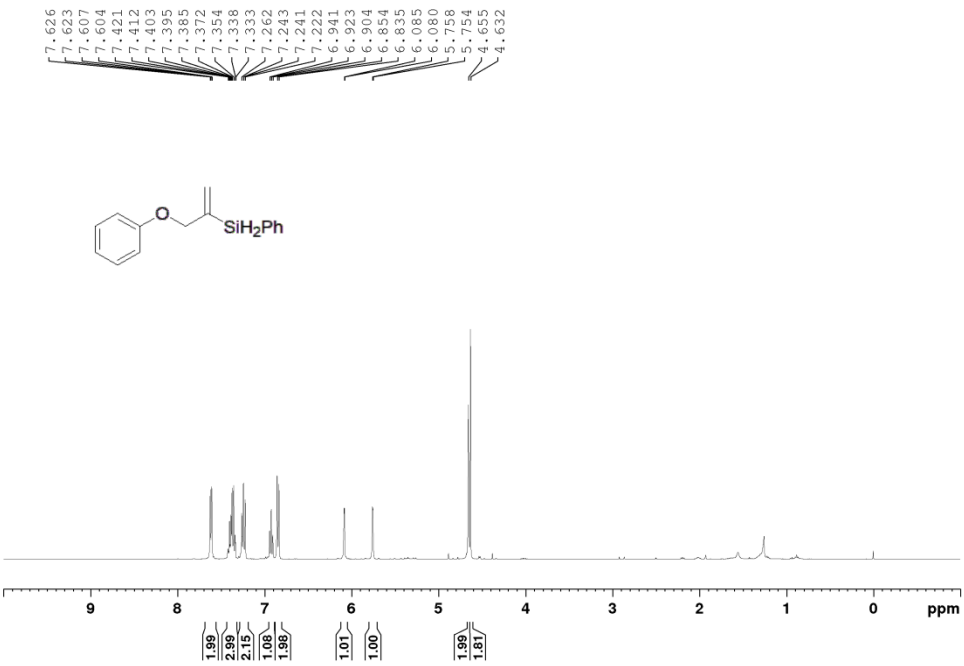
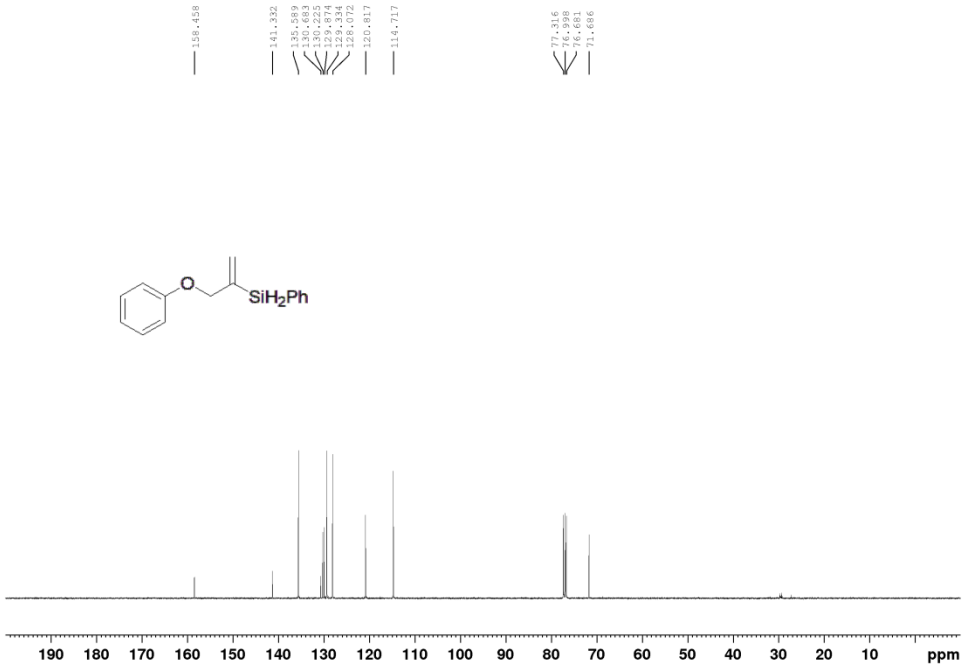


^{1}H NMR (400 M, $CDCl_3$) spectrum of **3q**



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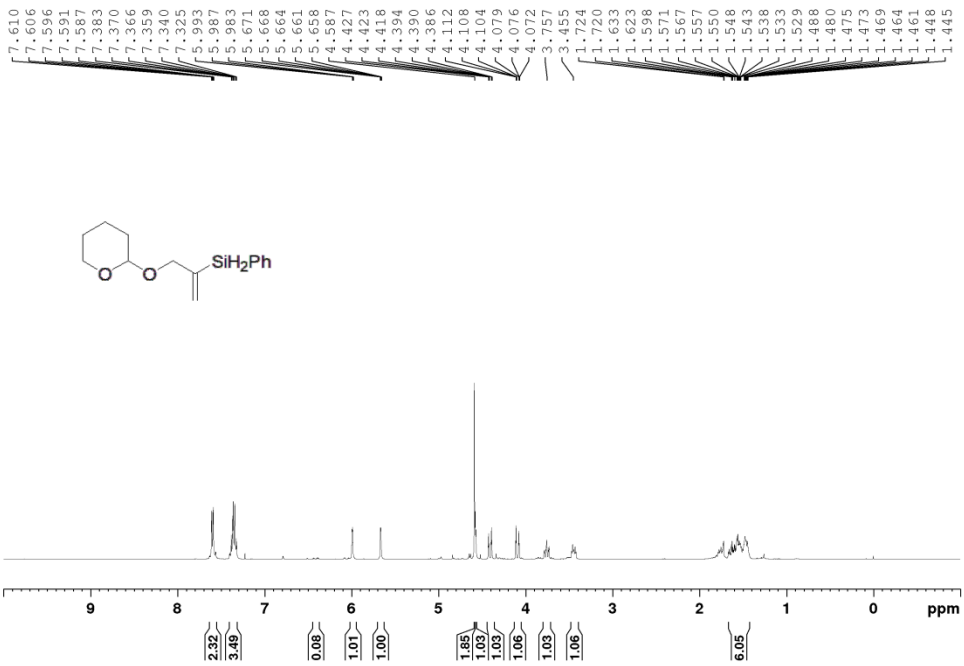
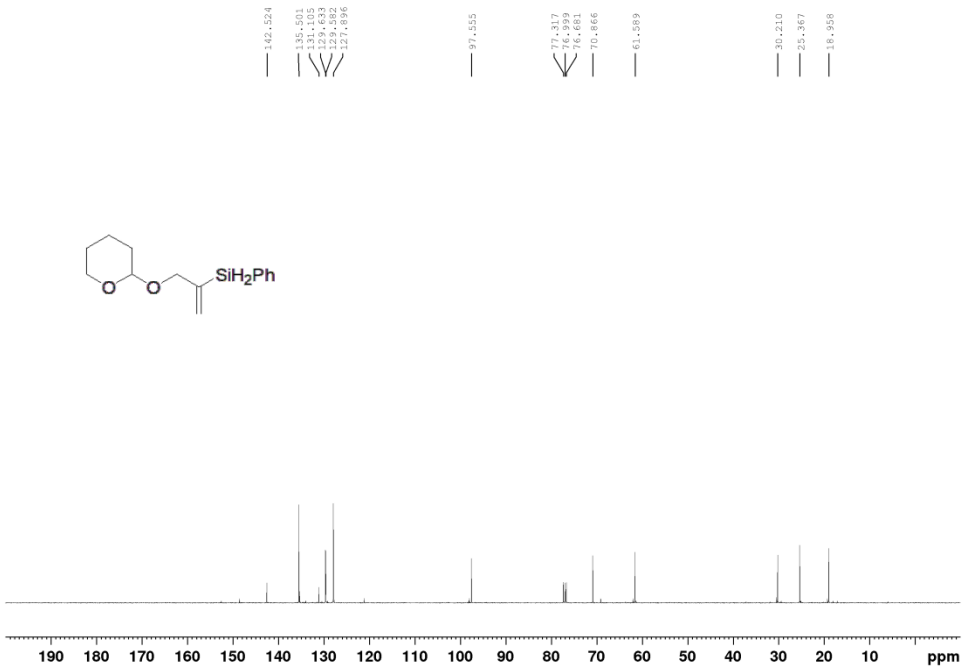


^{1}H NMR (400 M, $CDCl_3$) spectrum of **3r**



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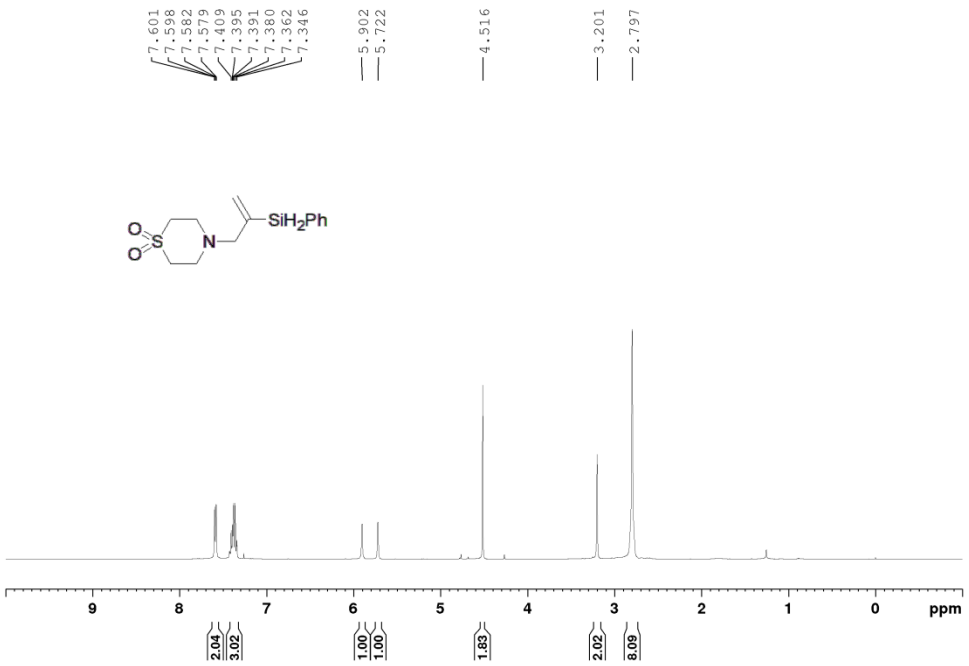

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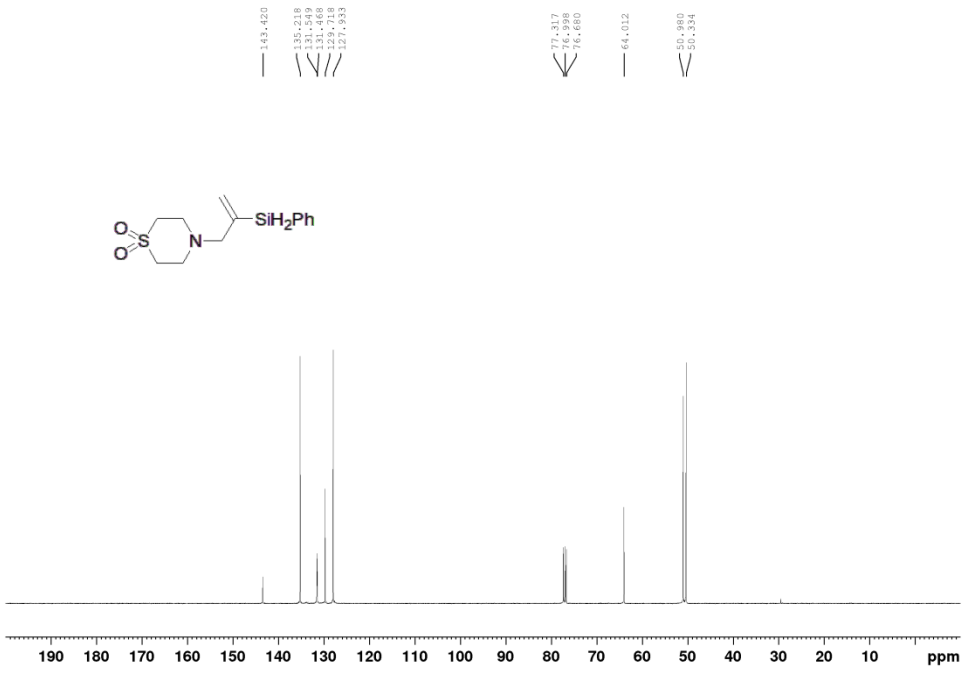

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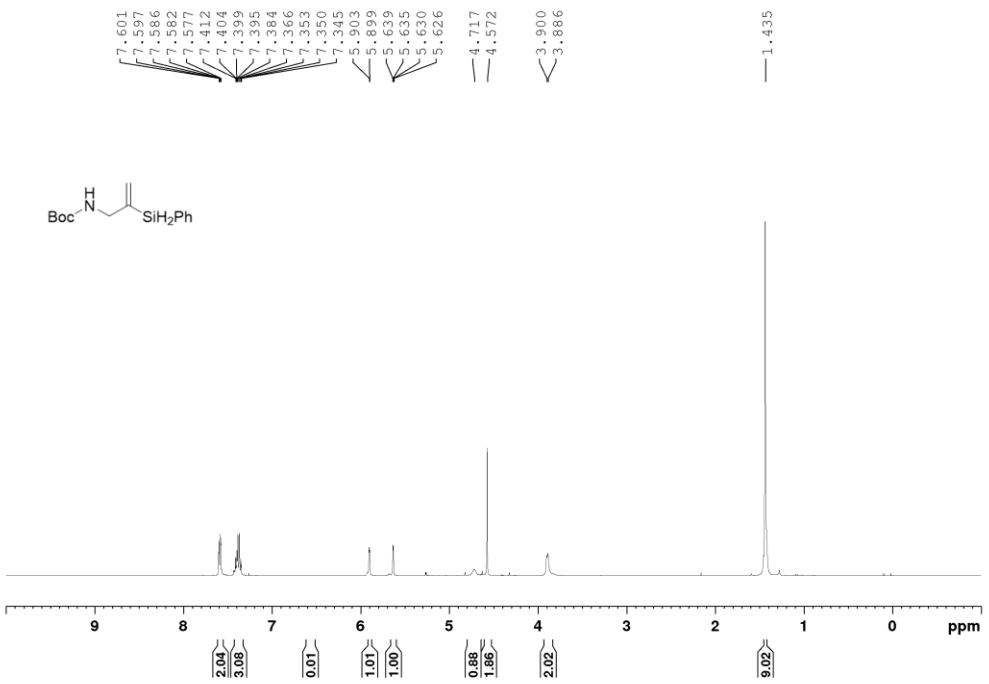
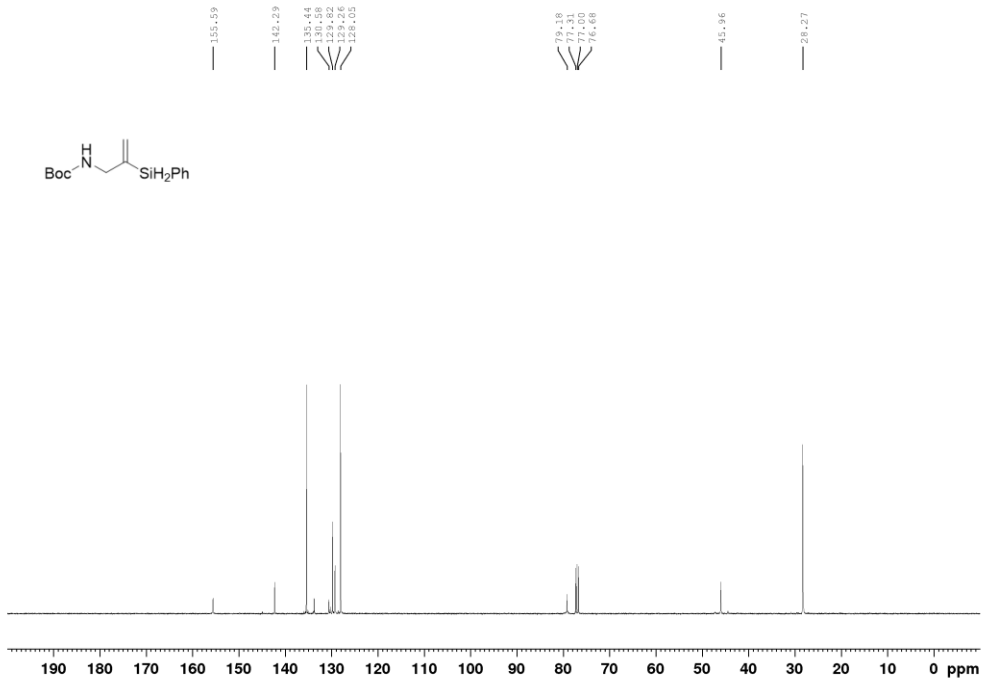
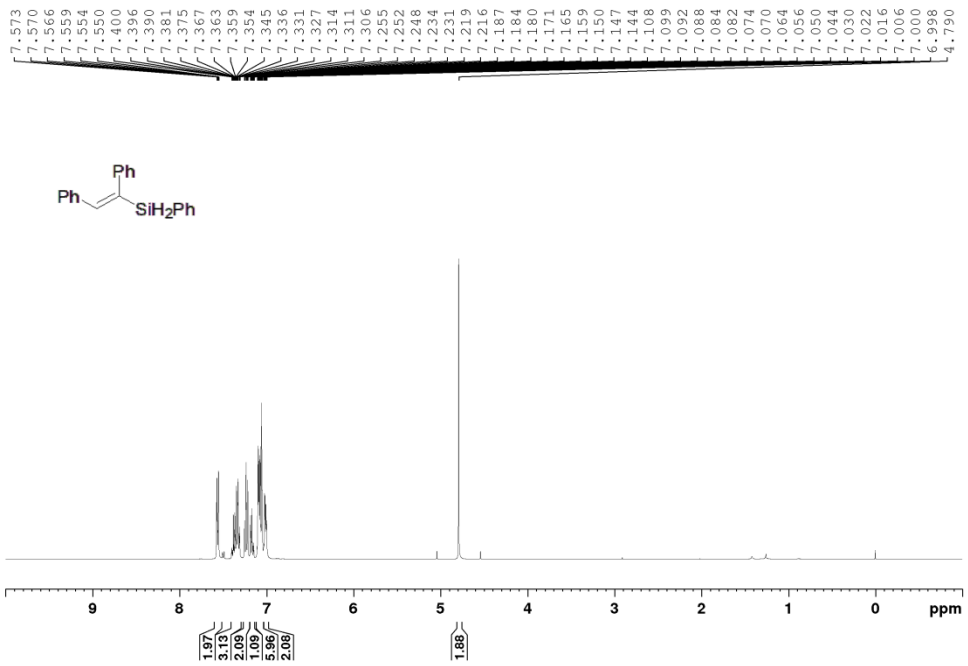


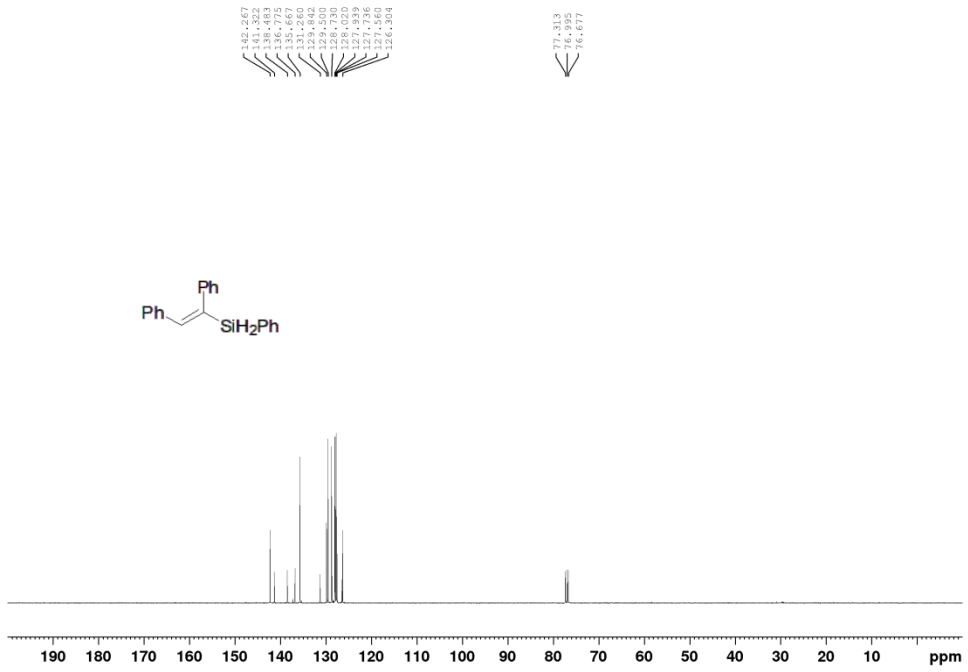
^{1}H NMR (400 M, $CDCl_3$) spectrum of **3t**



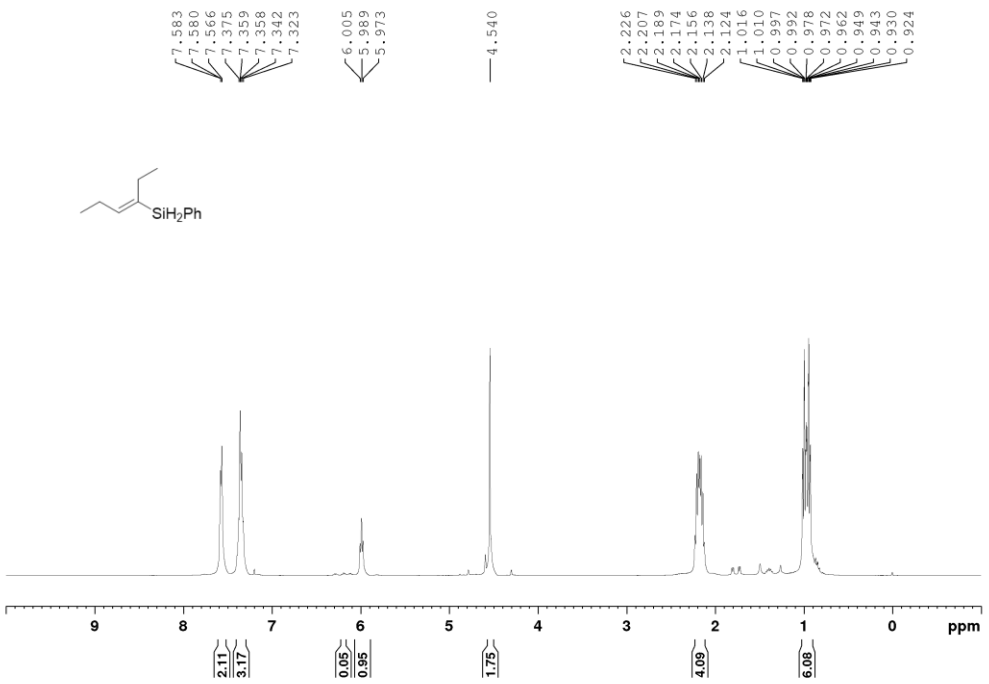
^{13}C NMR (100 M, $CDCl_3$) spectrum of **3t**



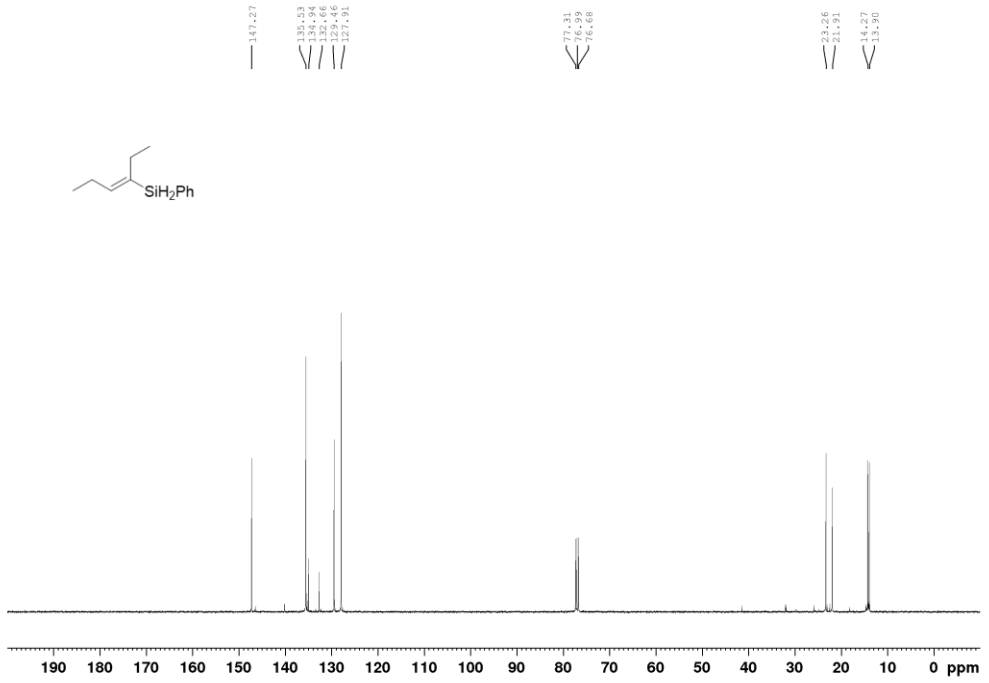
^{1}H NMR (400 M, $CDCl_3$) spectrum of **3u**



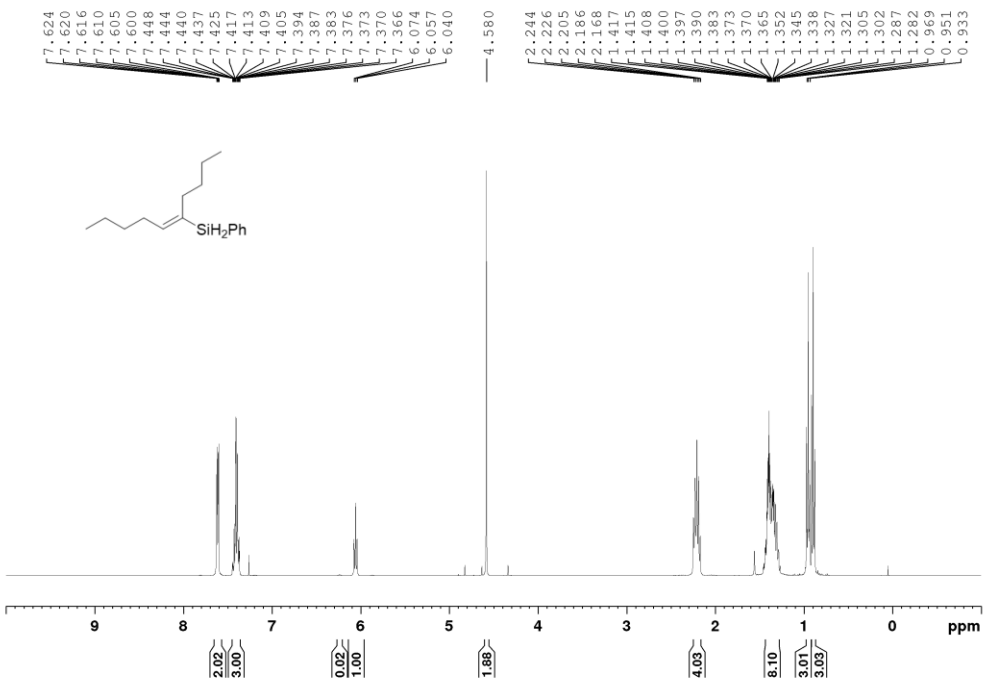
^{13}C NMR (100 M, $CDCl_3$) spectrum of **3u**



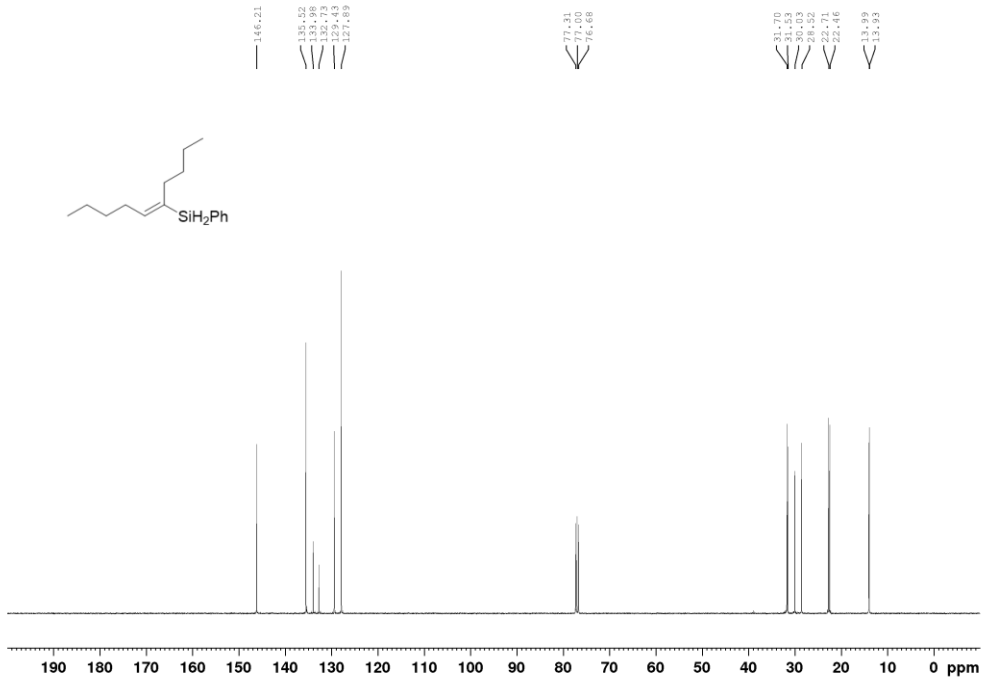
^{1}H NMR (400 M, $CDCl_3$) spectrum of **3v**



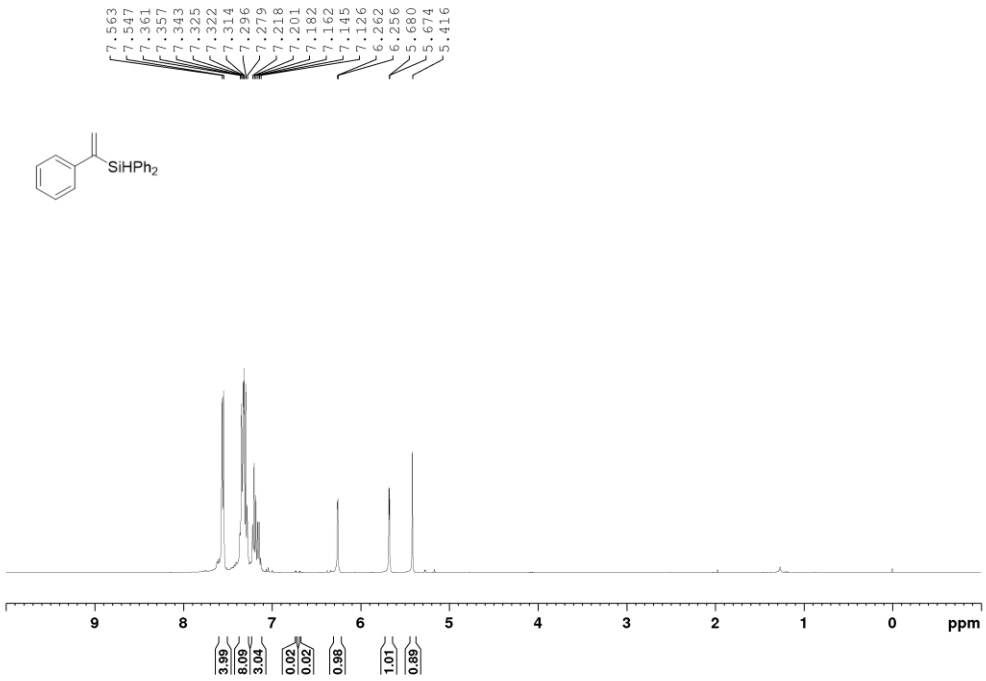
^{13}C NMR (100 M, $CDCl_3$) spectrum of **3v**



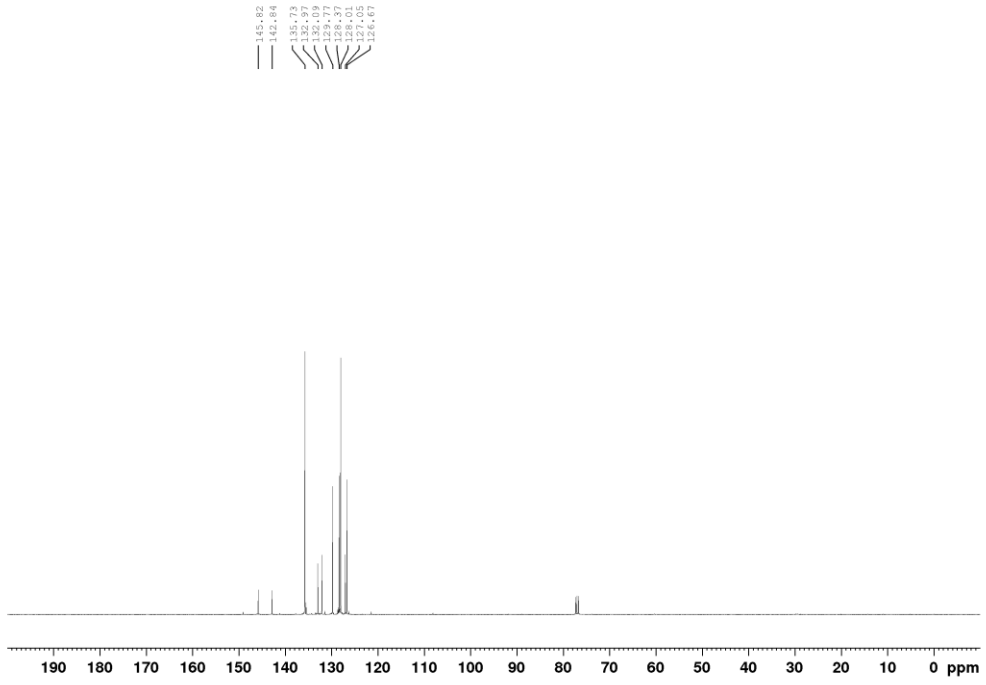
^{1}H NMR (400 M, $CDCl_3$) spectrum of **3w**



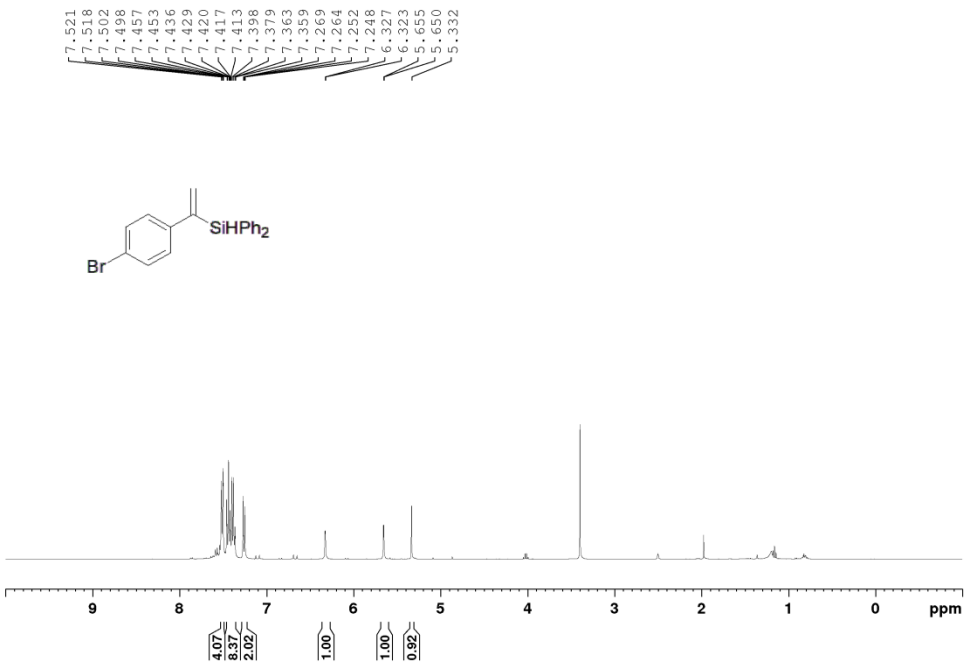
^{13}C NMR (100 M, $CDCl_3$) spectrum of **3w**



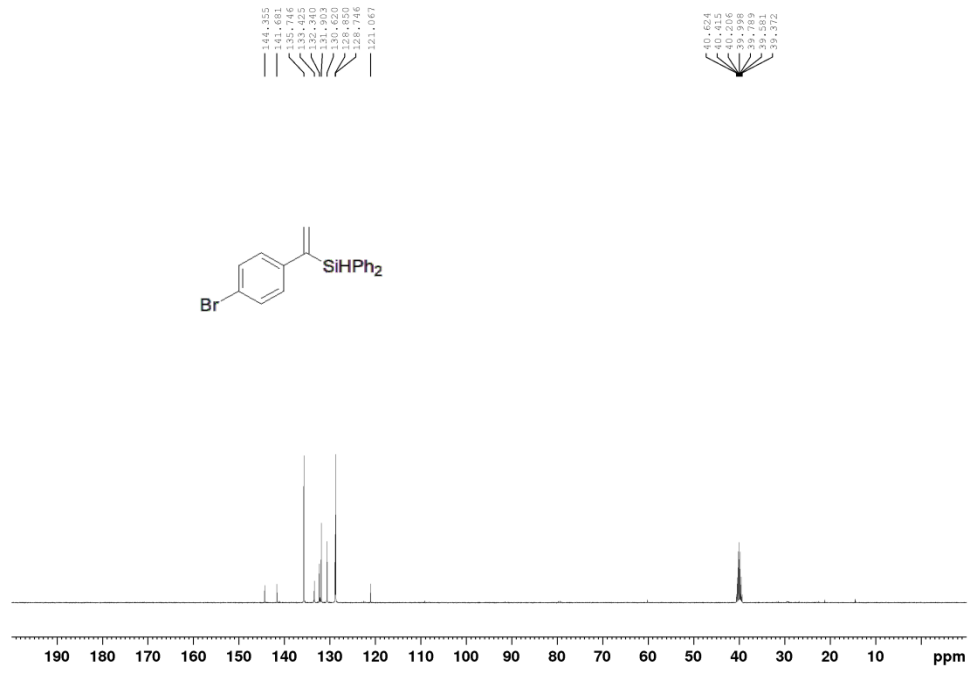
^{1}H NMR (400 M, $CDCl_3$) spectrum of **7a**



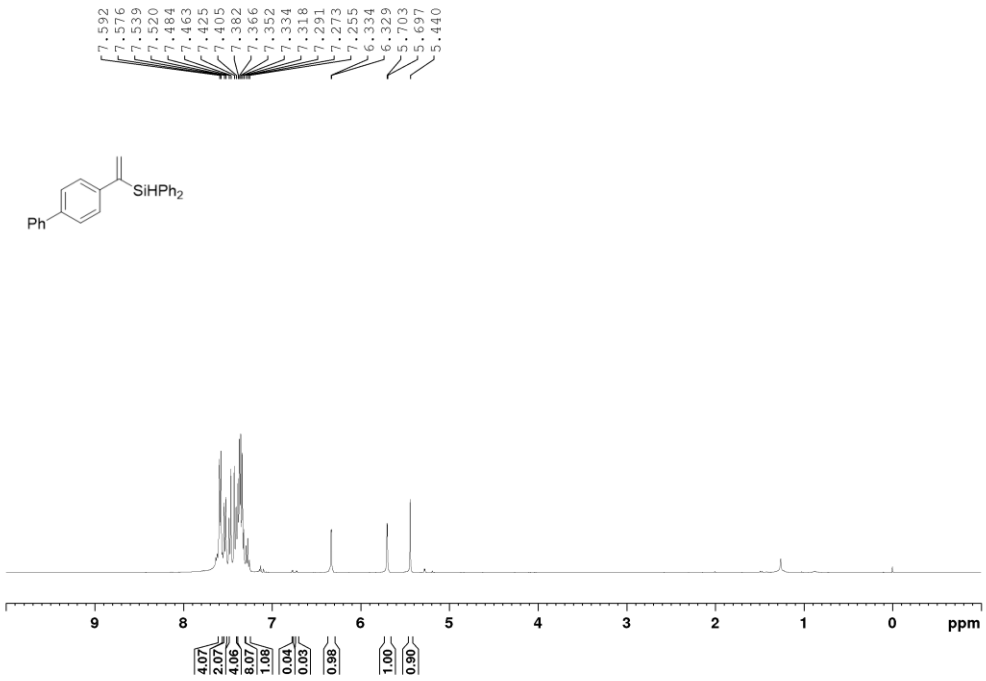
^{13}C NMR (100 M, $CDCl_3$) spectrum of **7a**



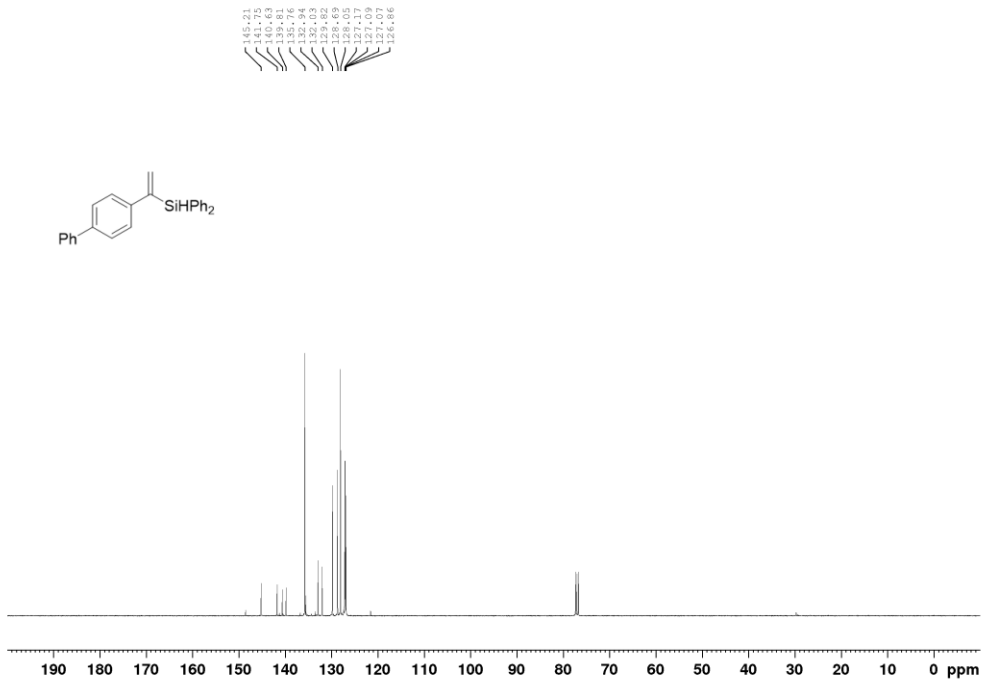
^{1}H NMR (400 M, DMSO-d_6) spectrum of **7b**



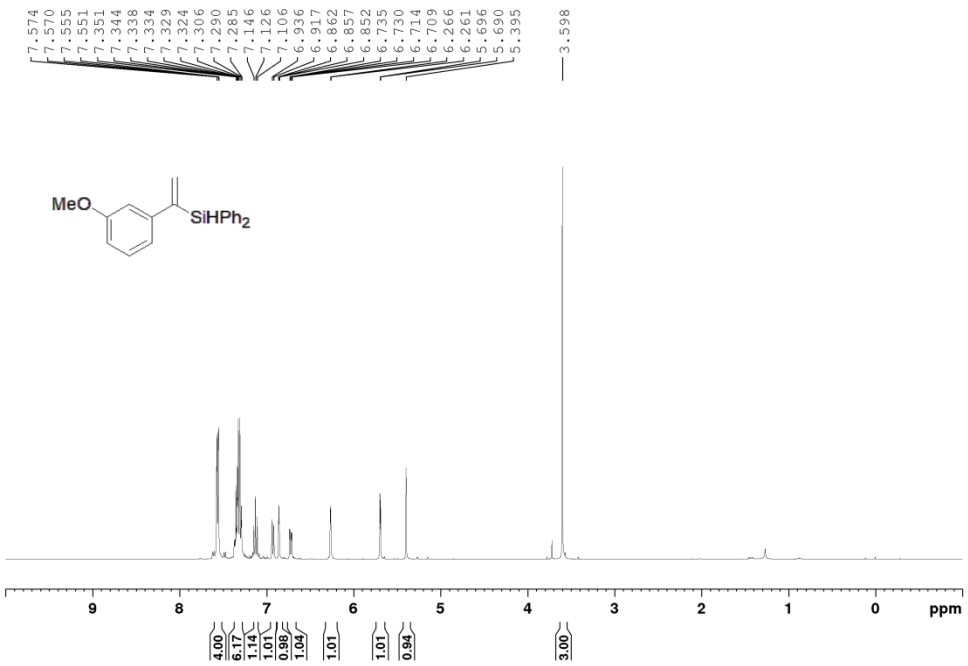
^{13}C NMR (100 M, DMSO-d_6) spectrum of **7b**



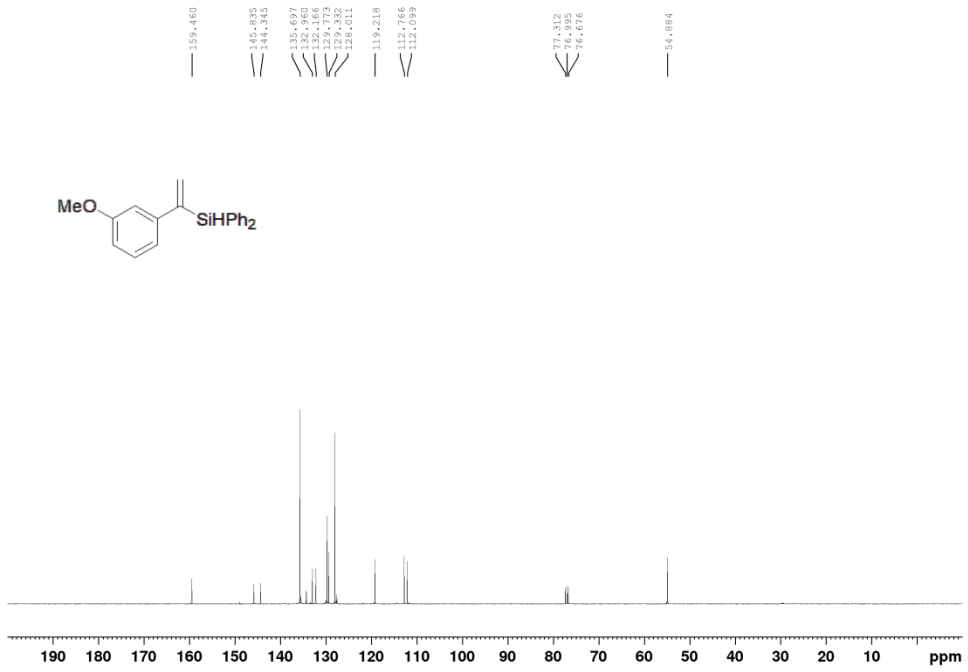
^{1}H NMR (400 M, $CDCl_3$) spectrum of **7c**



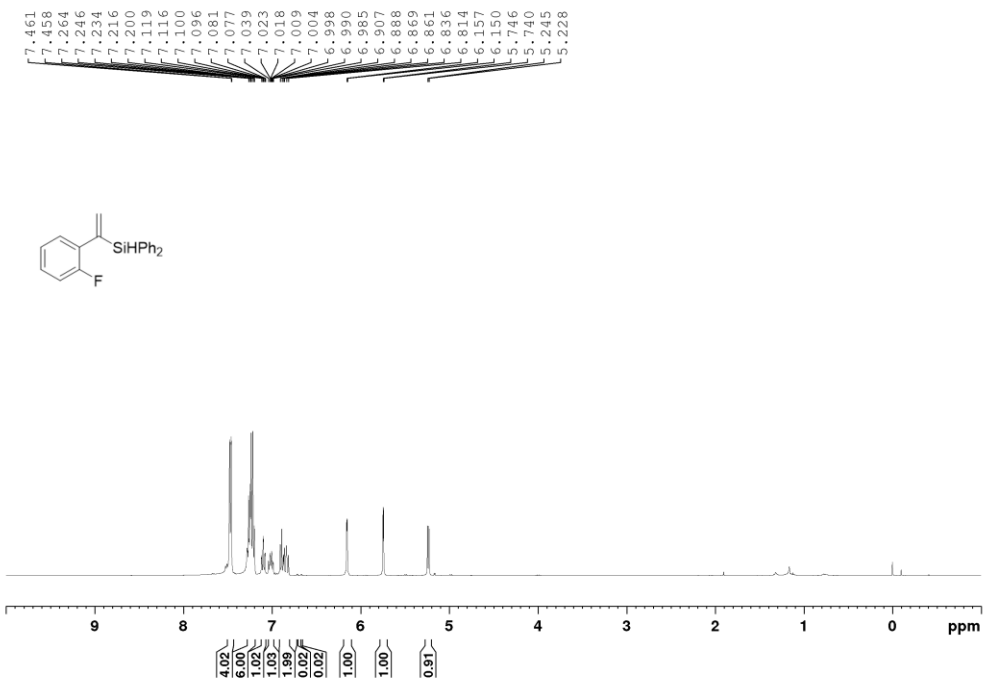
^{13}C NMR (100 M, $CDCl_3$) spectrum of **7c**



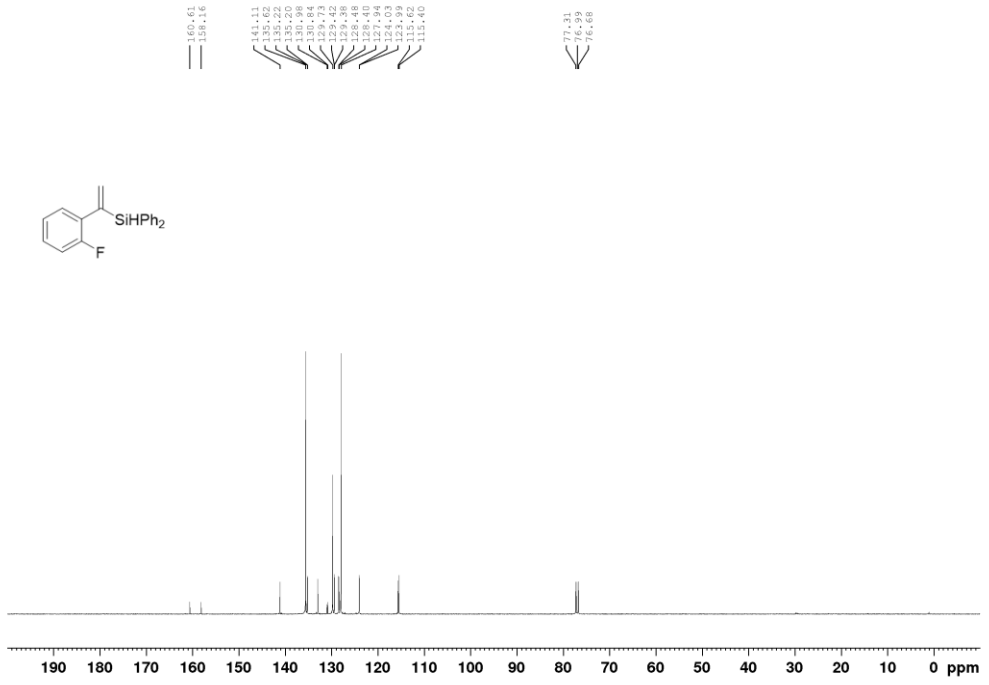
^{1}H NMR (400 M, $CDCl_3$) spectrum of **7d**



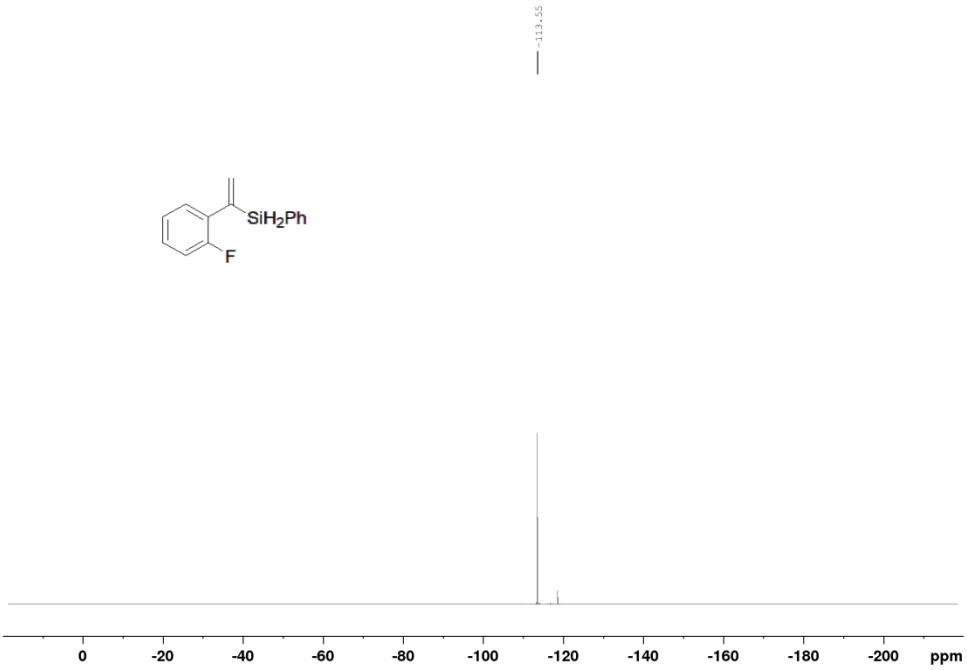
^{13}C NMR (100 M, $CDCl_3$) spectrum of **7d**



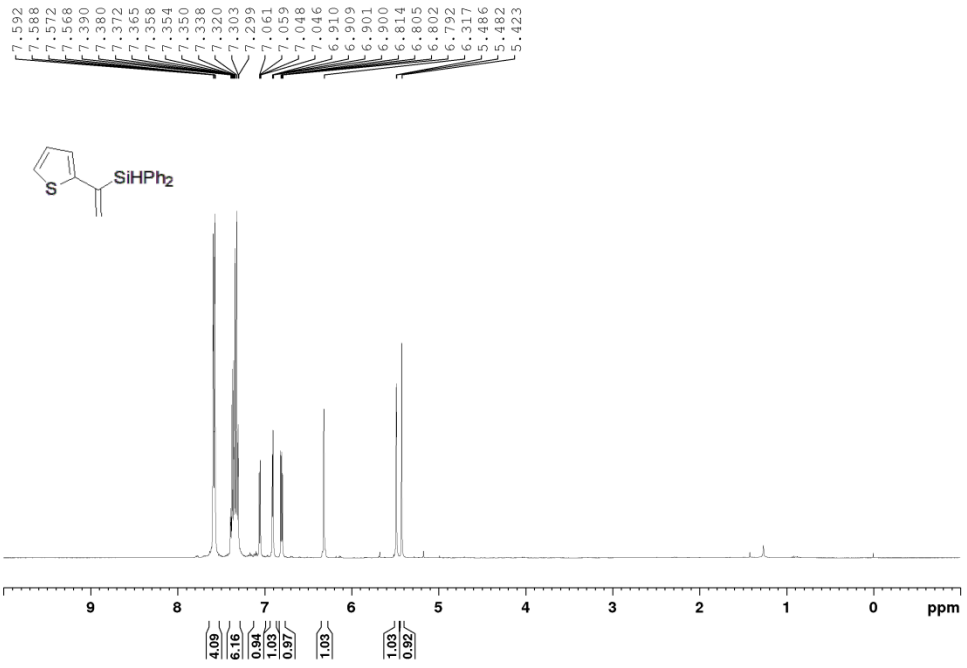
^{1}H NMR (400 M, $CDCl_3$) spectrum of **7e**



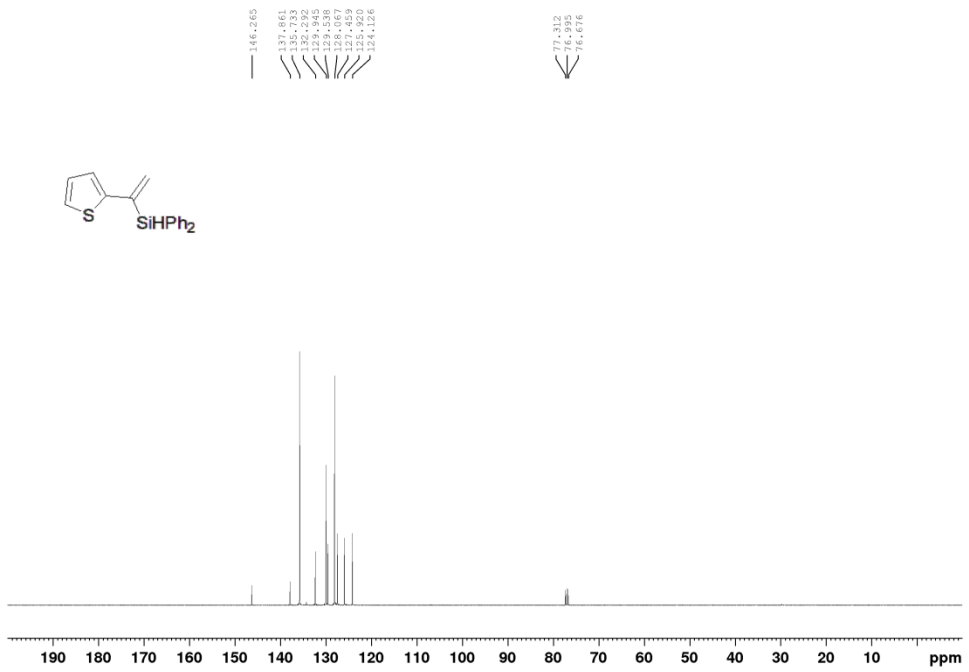
^{13}C NMR (100 M, $CDCl_3$) spectrum of **7e**



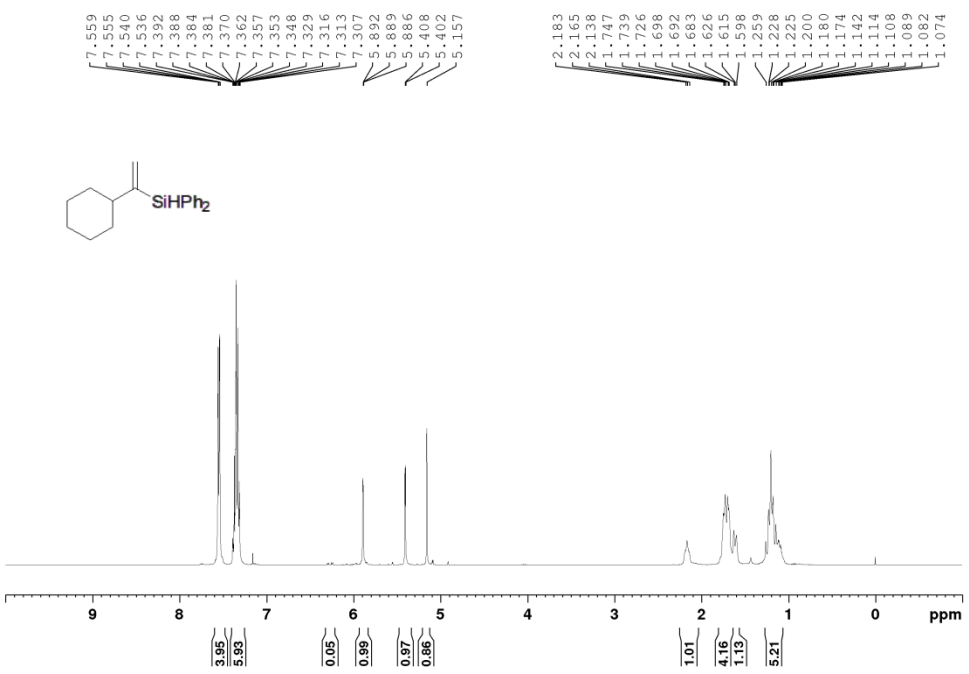
^{19}F NMR (400 M, $CDCl_3$) spectrum of **7e**



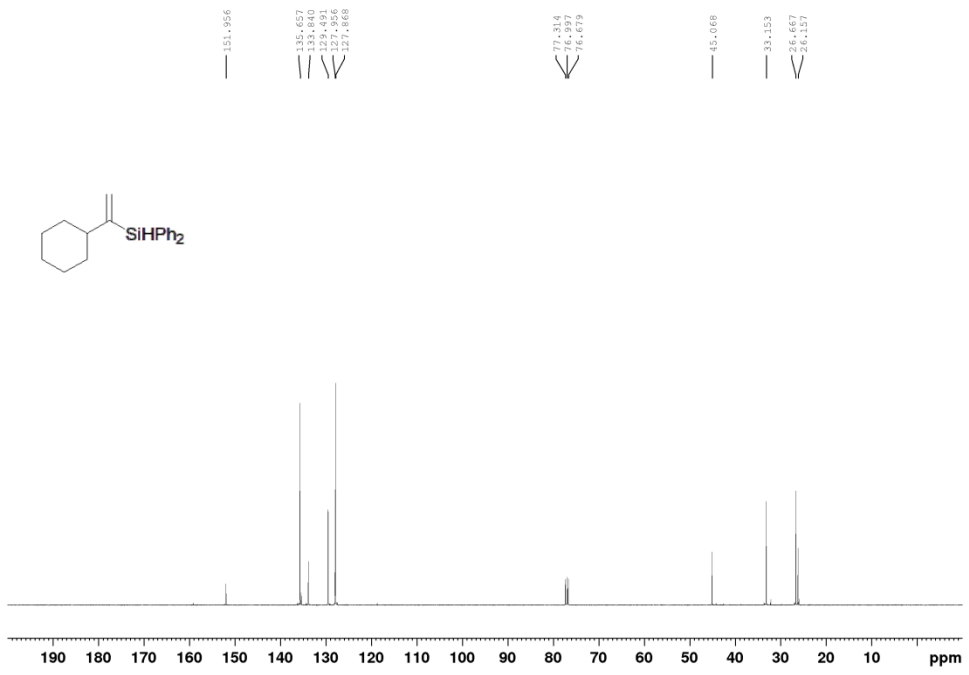
^{1}H NMR (400 M, $CDCl_3$) spectrum of **7f**



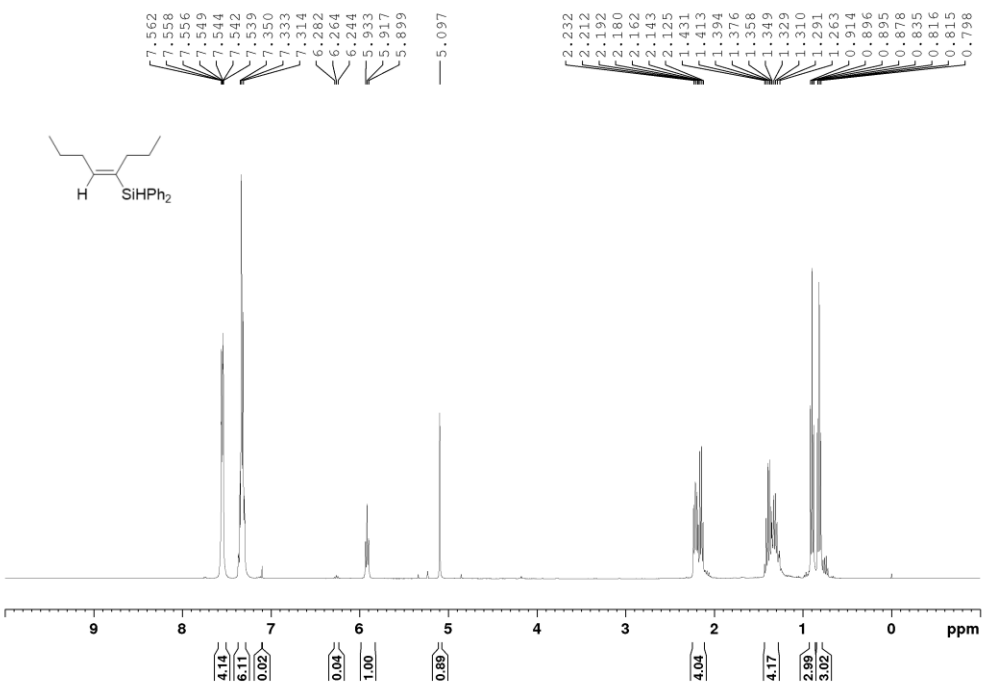
^{13}C NMR (100 M, $CDCl_3$) spectrum of **7f**



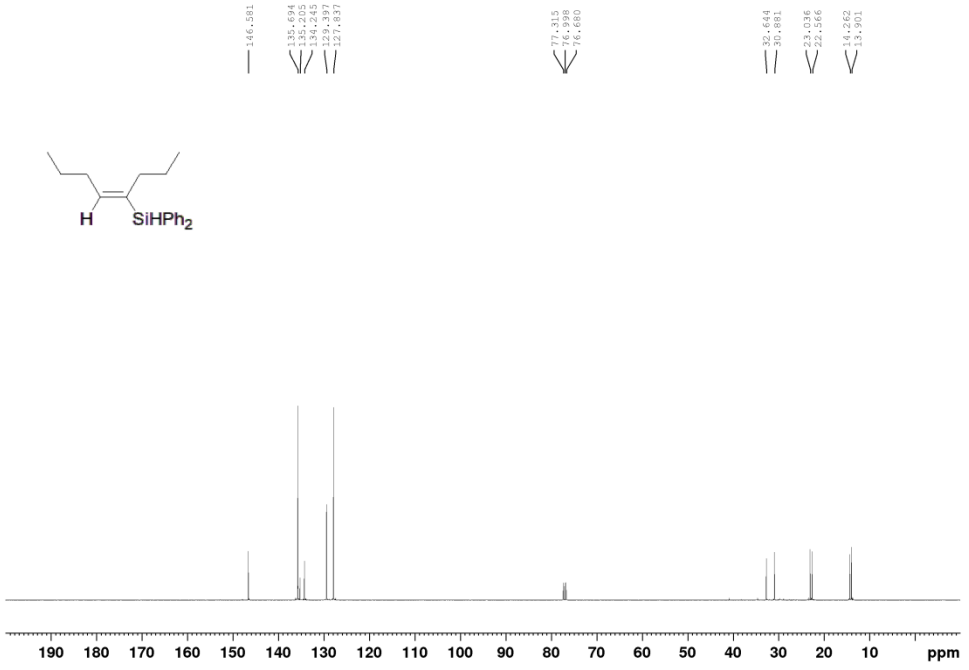
^{1}H NMR (400 M, $CDCl_3$) spectrum of **7g**



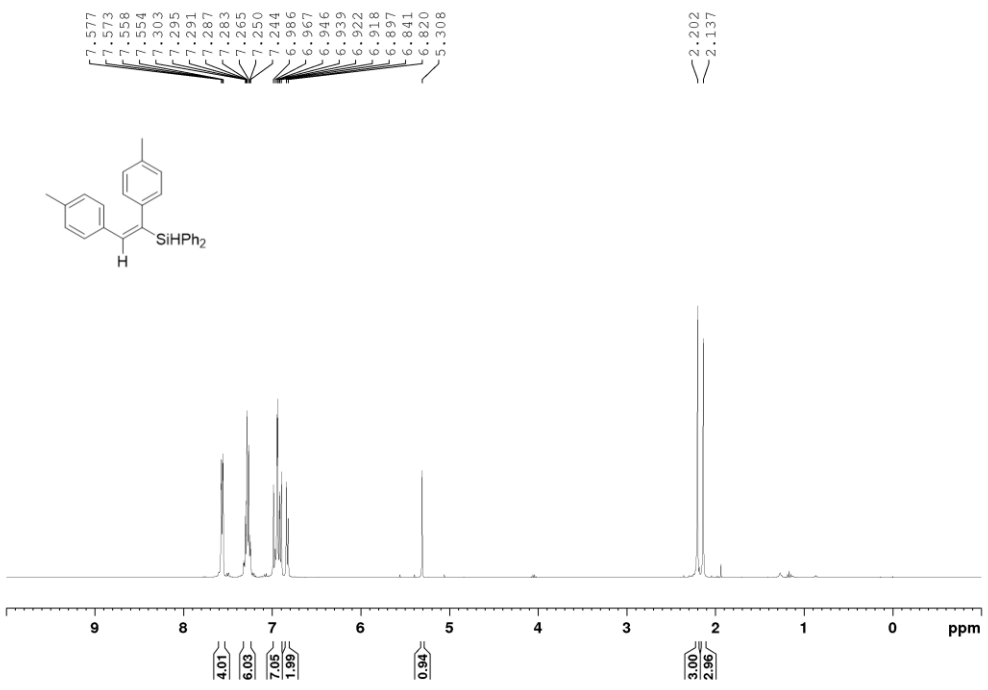
^{13}C NMR (100 M, $CDCl_3$) spectrum of **7g**



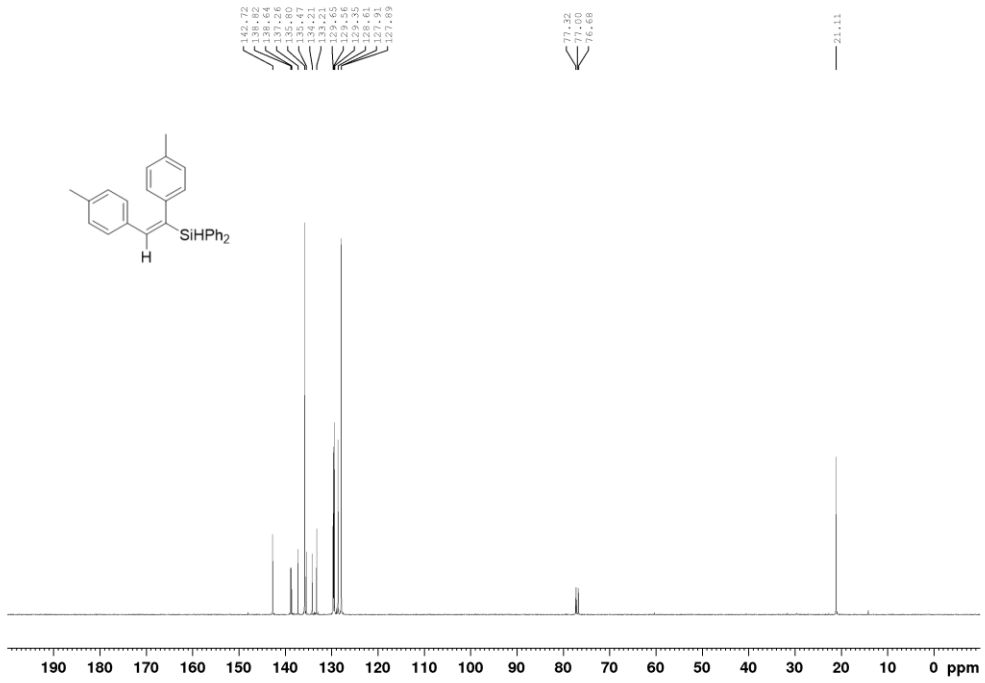
^{1}H NMR (400 M, $CDCl_3$) spectrum of **7h**



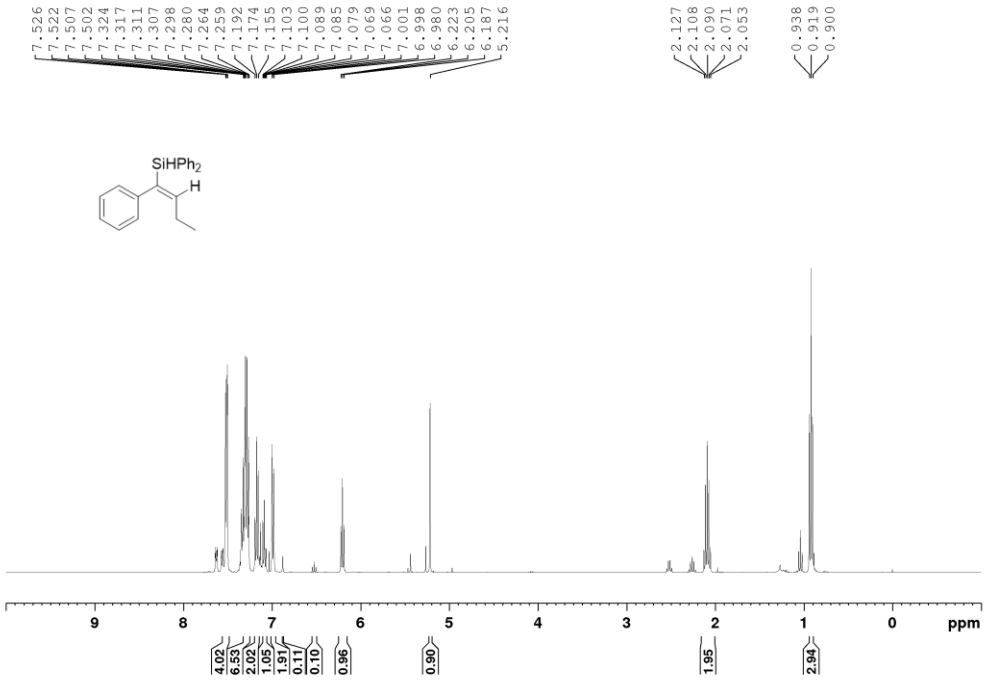
^{13}C NMR (100 M, $CDCl_3$) spectrum of **7h**



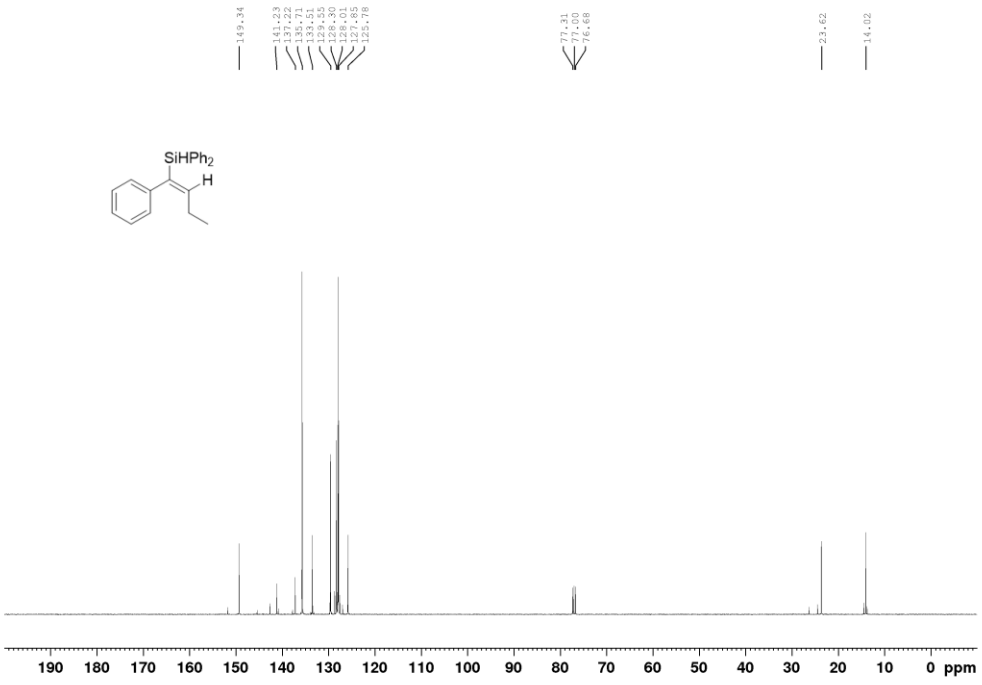
^{1}H NMR (400 M, $CDCl_3$) spectrum of **7i**



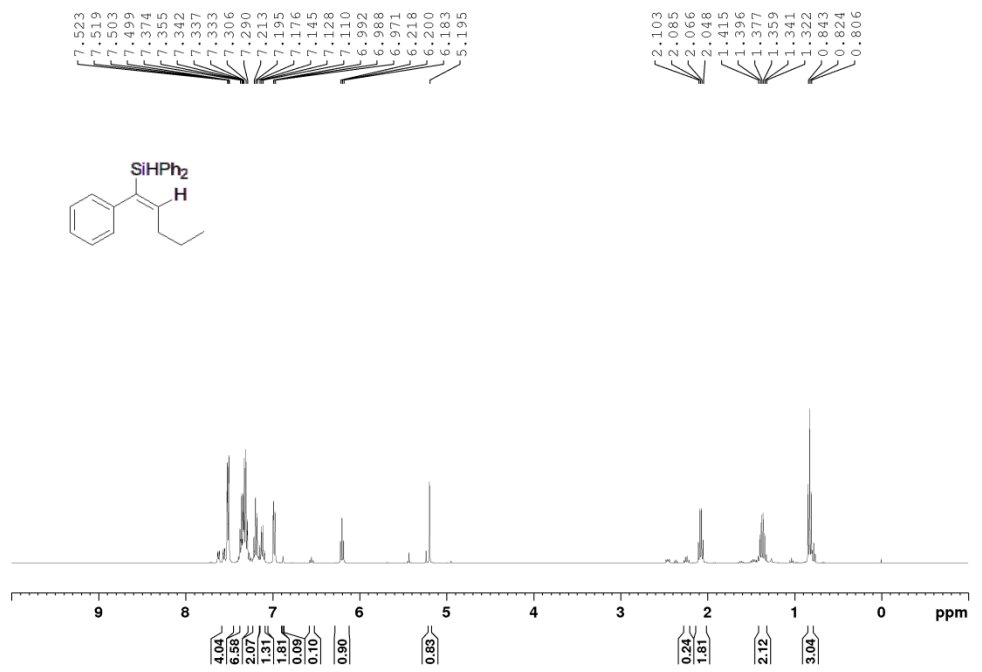
^{13}C NMR (100 M, $CDCl_3$) spectrum of **7i**



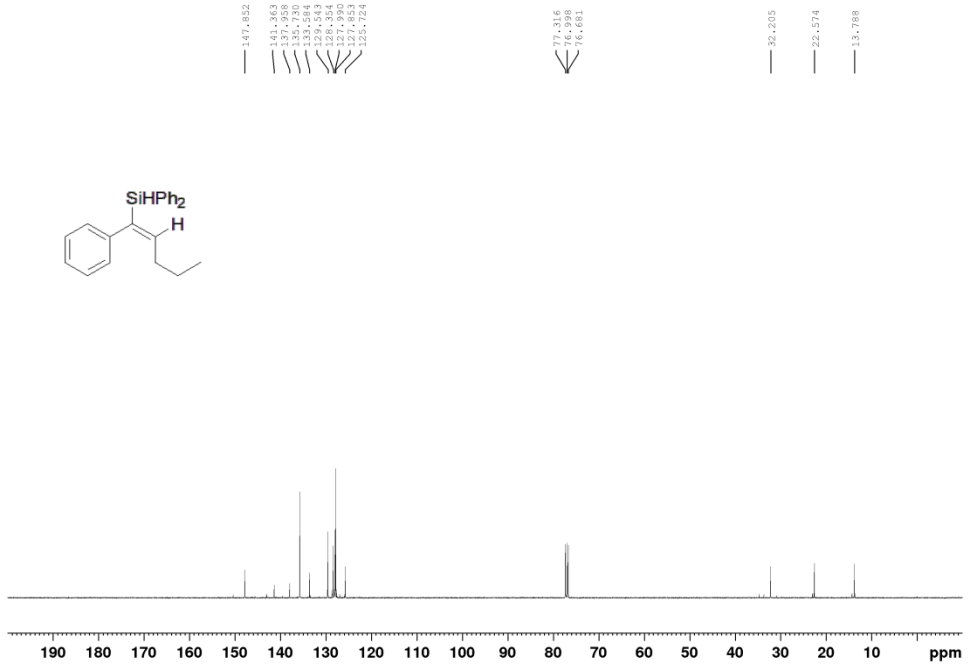
^{1}H NMR (400 M, $CDCl_3$) spectrum of **7j**



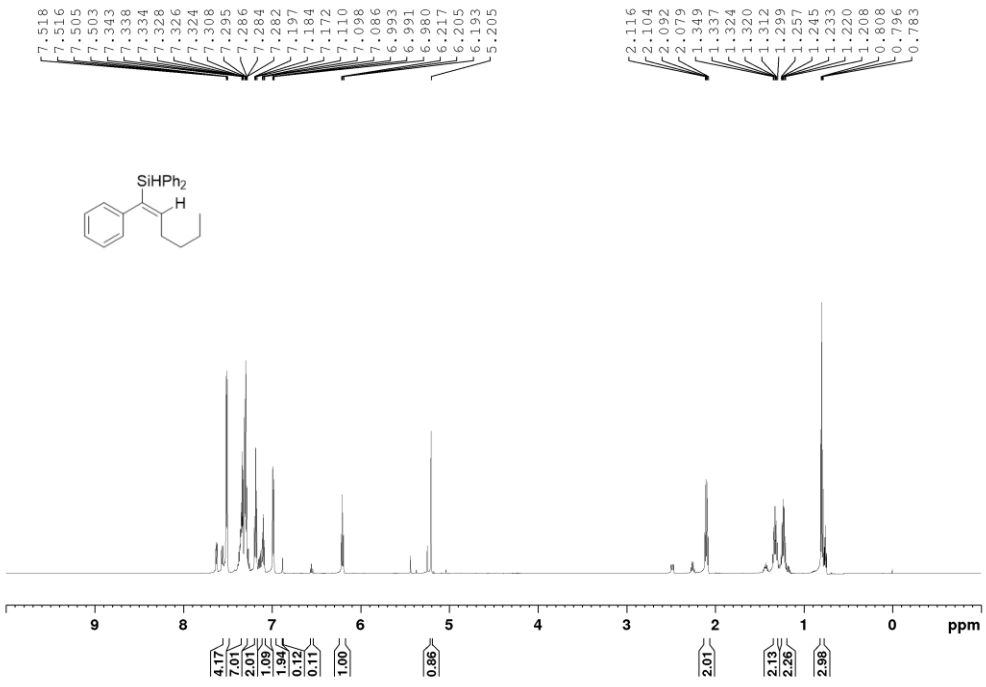
^{13}C NMR (100 M, $CDCl_3$) spectrum of **7j**



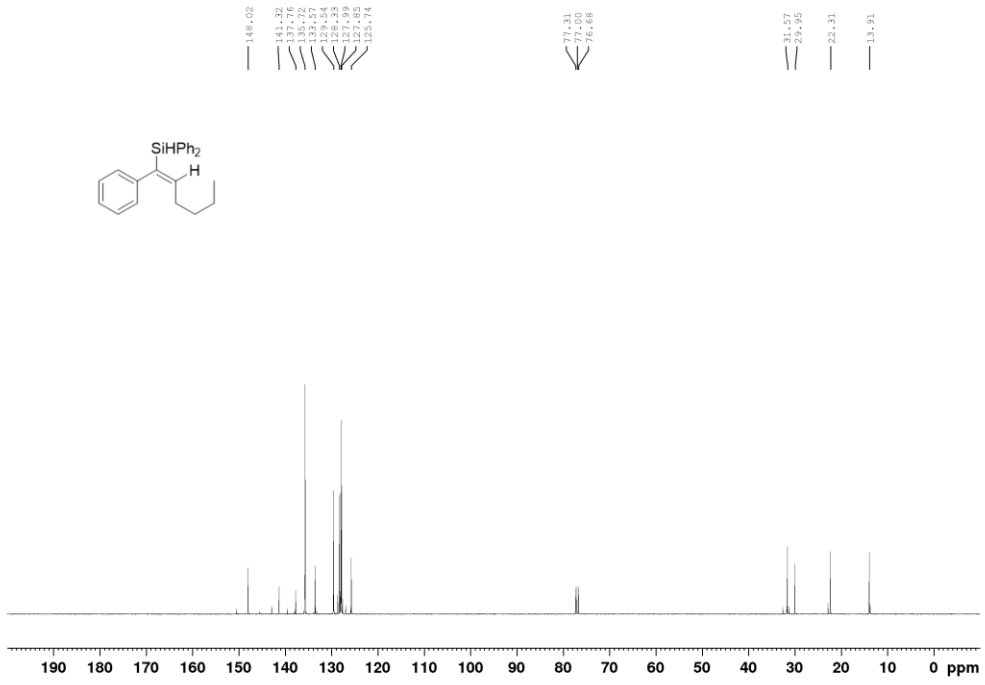
^{1}H NMR (400 M, $CDCl_3$) spectrum of **7k**



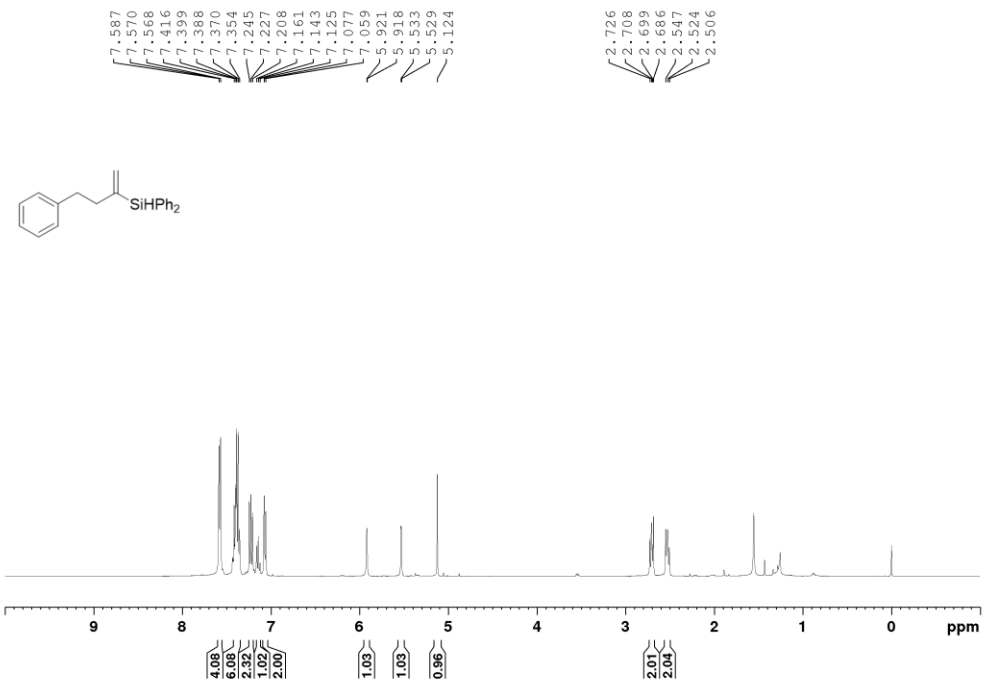
^{13}C NMR (100 M, $CDCl_3$) spectrum of **7k**



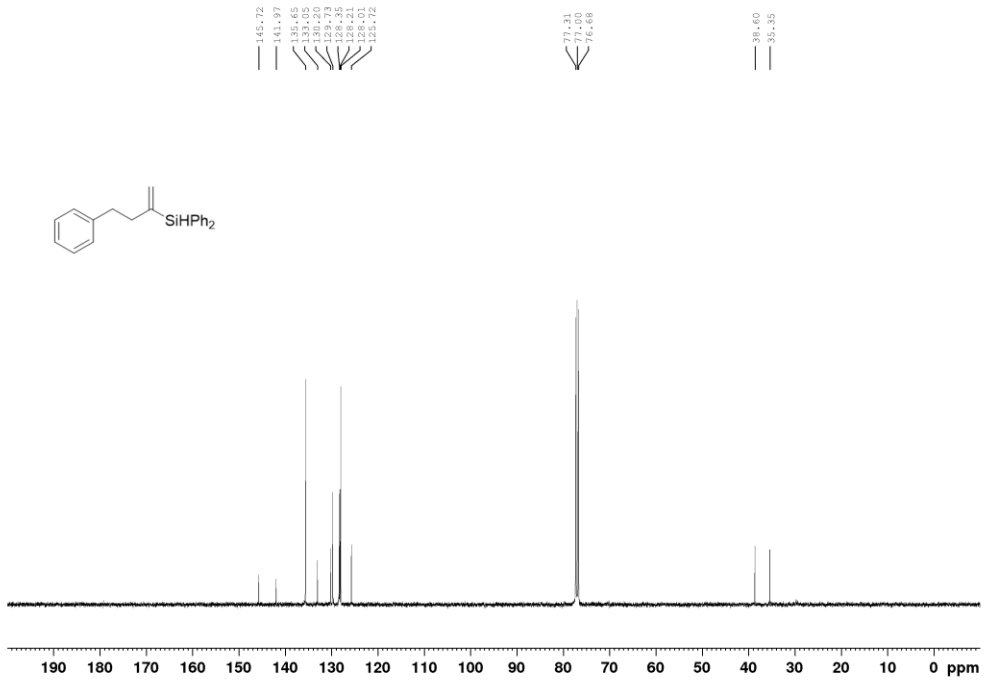
^{1}H NMR (600 M, $CDCl_3$) spectrum of **7l**



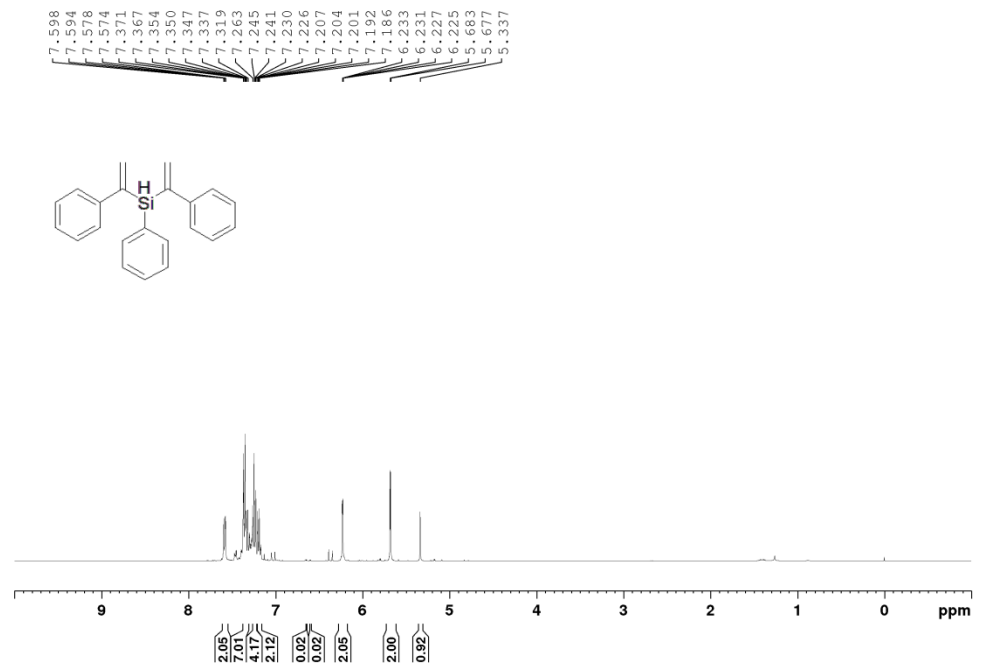
^{13}C NMR (125 M, $CDCl_3$) spectrum of **7l**



^{1}H NMR (400 M, $CDCl_3$) spectrum of **7m**



^{13}C NMR (100 M, $CDCl_3$) spectrum of **7m**



^{1}H NMR (400 M, $CDCl_3$) spectrum of **9**

^{13}C NMR (100 M, $CDCl_3$) spectrum of **9**