Electronic Supplementary Material (ESI) for Organic Chemistry Frontiers.

Nickel-Catalyzed Regioselective Alkenylboration of Alkenylarenes to Access Homoallyl Boronic Esters

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Supporting Information

1. General information S3
2. Synthesis of substrates S4
3. The effect of different reaction conditions S7
4. General procedure for the reaction S11
5. Analytical data for compounds S12
6. Further transformations of the product S30
7. Competition reaction of different Reactants. S33
8. Some failed reaction S34
9. Discussion on mechanism S35
10. References S36
11. NMR spectra of products S38

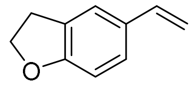
1. General Considerations

All manipulations were conducted with Schlenk tube. ^{1}H NMR spectra were recorded on JNM-ECZ400S/L1 and JNM-ECZ600R/S1 spectrometers. Chemical shifts (in ppm) were referenced to tetramethylsilane (δ = 0 ppm) in $CDCl_3$ as an internal standard. Data were reported as follows: chemical shift (ppm), multiplicity (s = singlet, d = doublet, t = triplet, q = quartet, dd = doublet of doublets, m = multiplet), coupling constants (Hz), integration and assignment. ^{13}C NMR spectra were obtained by using the same NMR spectrometers and were calibrated with $CDCl_3$ (δ = 77.00 ppm). ^{19}F NMR spectra were obtained by the same NMR and CF_3COOH was employed as external standard for the ^{19}F-NMR measurement. GC analysis was completed on an Agilent Technologies GC-7890B gas chromatograph, using ethyl acetate for sample preparation and nitrogen as a carrier gas. GC-MS analysis was completed on a Shimadzu GCMS-QP2010SE gas chromatograph mass spectrometer, using ethyl acetate for sample preparation and helium as a carrier gas. High resolution mass spectrometry (HRMS) data were obtained on a QTOF mass analyzer with electrospray ionization (ESI) through a Waters Acquity UPLC Class I/Xevo G2 Q-Tof. Substrates were purchased from Aldrich, TCI, Acros, Energy, Aladdin, or synthesized according to the procedures outlined below. Unless otherwise noted, materials obtained from commercial suppliers were used without further purification.

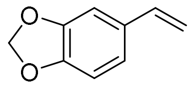
2. Synthesis of Substrates

2.1 Synthesis of alkenylarenes

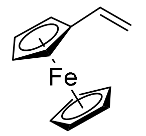
These substrates were prepared according to the corresponding literature reports. Analytical data (^{1}H NMR, ^{13}C NMR) matches with the literature.



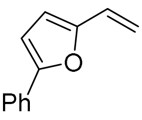
1n: 5-vinyl-2,3-dihydrobenzofuran [1]



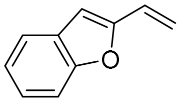
1o: 5-vinylbenzo[*d*][1,3]dioxole [2]



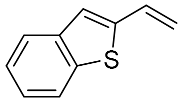
1p: Vinylferrocene [3]



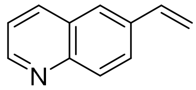
1q: 2-phenyl-5-vinylfuran [4]



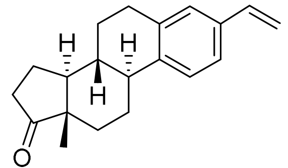
1s: 2-vinylbenzofuran [5]



1t: 2-vinylbenzo[*b*]thiophene [5]

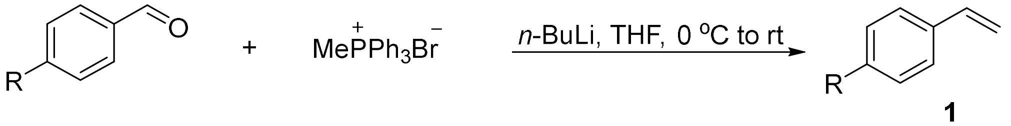


1u: 6-vinylquinoline [6]



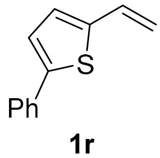
1w: (8*R*,9*S*,13*S*,14*S*)-13-methyl-3-vinyl-6,7,8,9,11,12,13,14,15,16-decahydro-17*H*-cyclopenta[*a*]phenanthren-17-one [3]

Representative procedure for preparing alkenylarenes via Wittig olefination



1

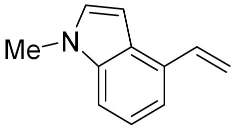
A suspension of methyltriphenylphosphonium bromide (2.9 g, 8.1 mmol) in dry THF (30 ml) under inert atmosphere was cooled at 0 ºC with an ice bath. Then *n*-BuLi (3.2 ml, 2.5 M in n-hexane, 8.1 mmol) was added dropwise. After stirring for 30 min, corresponding aldehyde (5.4 mmol) (dissolved in THF (20 ml)) was added dropwise and the reaction mixture was warmed to room temperature for an additional hour. Then the reaction mixture was quenched with sat. NH_4Cl aq. (20 mL) and extracted with EtOAc (20 mL × 3). The combined organic layers were dried over Na_2SO_4 and concentrated in vacuo. The residue was purified by silica-gel column chromatography to give the alkenylarenes **1**.



1r

2-phenyl-5-vinylthiophene (1r). The general procedure was followed using

5-phenylthiophene-2-carbaldehyde (1.02 g, 5.4 mmol), afforded product **1r** (663 mg, 66% yield). yellow solid. **^{1}H NMR** ($CDCl_3$, 600 MHz) δ: 7.60-7.59 (m, 2H), 7.37 (t, *J* = 7.8 Hz, 2H), 7.29-7.26 (m, 1H), 7.18 (d, *J* = 3.6 Hz, 1H), 6.94 (d, *J* = 3.6 Hz, 1H), 6.79 (dd, J_1 = 17.4, J_2 = 10.8 Hz, 1H), 5.58 (d, *J* = 17.4 Hz, 1H), 5.16 (d, *J* = 10.8 Hz, 1H); **^{13}C NMR** ($CDCl_3$, 150 MHz) δ: 143.0, 142.4, 134.2, 129.9, 128.9, 127.5, 127.0, 125.6, 123.2, 113.2 ppm; **HRMS** (ESI-TOF) *m/z* calcd for $C_{12}H_{11}S$ $(M + H)^+$: 187.0582, found 187.0585.

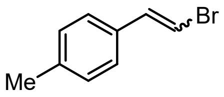


1v

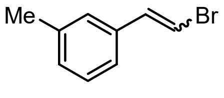
1-methyl-4-vinyl-1*H*-indole (1v). The general procedure was followed using 1-methyl-1H-indole-4-carbaldehyde (860 mg, 5.4 mmol), afforded product **1v** (593 mg, 70% yield) yellow oil. **^{1}H NMR** ($CDCl_3$, 600 MHz) δ: 7.25-7.22 (m, 1H), 7.18-7.15 (m, 2H), 7.12-7.05 (m, 1H), 6.97 (d, *J* = 3.6 Hz, 1H), 6.64 (d, *J* = 3.0 Hz, 1H), 5.89 (d, *J* = 18.0 Hz, 1H), 5.35 (d, *J* = 11.4 Hz, 1H), 3.63 (s, 3H); **^{13}C NMR** ($CDCl_3$, 150 MHz) δ: 137.0, 135.3, 129.9, 129.0, 126.5, 121.4, 116.8, 114.4, 108.7, 99.2, 32.8 ppm; **HRMS** (ESI-TOF) *m/z* calcd for $C_{11}H_{12}N$ $(M + H)^+$: 158.0970, found 158.0967.

2.2 Synthesis of Alkenyl Bromides

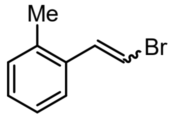
These substrates were prepared according to the corresponding literature reports. Analytical data (^{1}H NMR, ^{13}C NMR) matches with the literature.



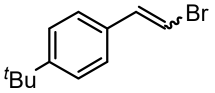
2b: (*E*,*Z*)-1-(2-bromovinyl)-4-methylbenzene [7]
E:*Z* = 93:7



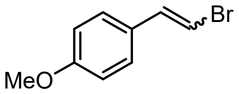
2c: (*E*,*Z*)-1-(2-bromovinyl)-3-methylbenzene [7]
E:*Z* = 95:5



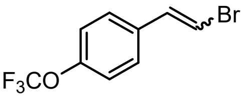
2d: (*E*,*Z*)-1-(2-bromovinyl)-2-methylbenzene [7]
E:*Z* = 90:10



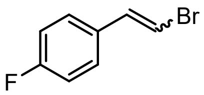
2e: (*E*,*Z*)-1-(2-bromovinyl)-4-(*tert*-butyl)benzene [8]
E:*Z* = 93:7



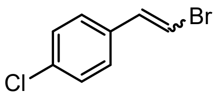
2f: (*E*,*Z*)-1-(2-bromovinyl)-4-methoxybenzene [8]
E:*Z* = 96:4



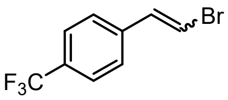
2g: (*E*,*Z*)-1-(2-bromovinyl)-4-(trifluoromethoxy)benzene [9]
E:*Z* = 92:8



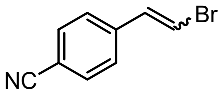
2h: (*E*,*Z*)-1-(2-bromovinyl)-4-fluorobenzene [7]
E:*Z* = 85:15



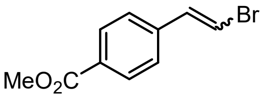
2i: (*E*,*Z*)-1-(2-bromovinyl)-4-chlorobenzene [7]
E:*Z* = 91:9



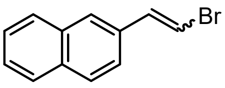
2j: (*E*,*Z*)-1-(2-bromovinyl)-4-fluorobenzene [7]
E:*Z* = 91:9



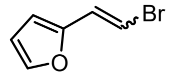
2k: (*E*,*Z*)-4-(2-bromovinyl)benzonitrile [10]
E:*Z* = 85:15



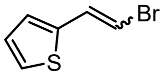
2l: (*E*,*Z*)-methyl 4-(2-bromovinyl)benzoate [8]
E:*Z* = 90:10



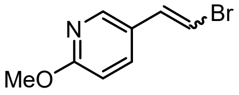
2m: (*E*,*Z*)-2-(2-bromovinyl)naphthalene [8]
E:*Z* = 95:5



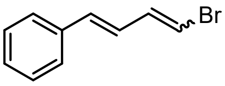
2n: (*E*,*Z*)-2-(2-bromovinyl)furan [11]
E:*Z* = 30:70



2o: (*E*,*Z*)-2-(2-bromovinyl)thiophene [12]
E:*Z* = 98:2



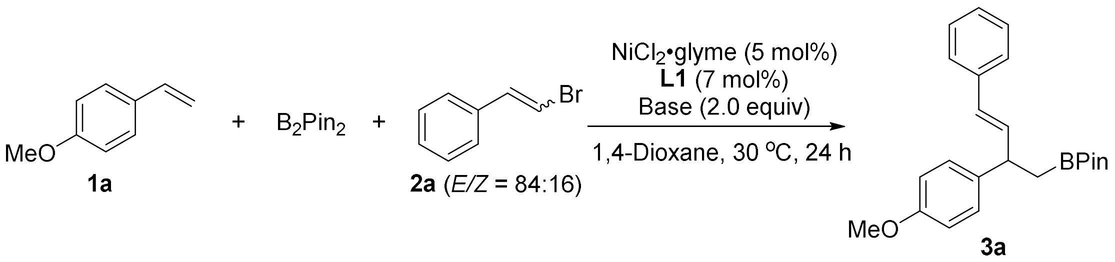
2p: (*E*,*Z*)-5-(2-bromovinyl)-2-methoxypyridine [10]
E:*Z* = 94:6



2q: (*E*,*Z*)-4-bromobuta-1,3-dien-1-yl)benzene [7]
E:*Z* = 61:39

3. The effect of different reaction conditions

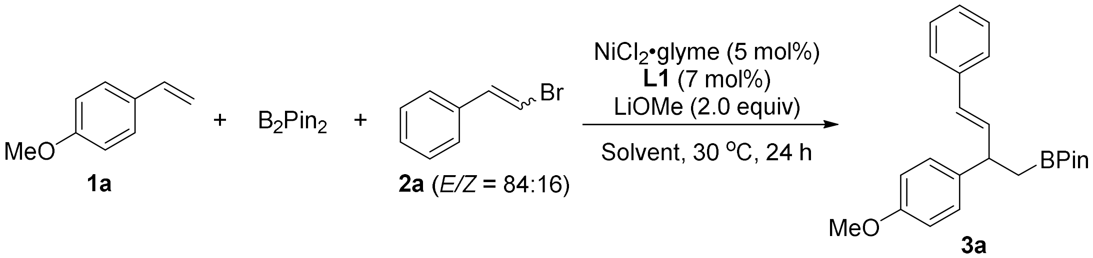
Table S1. The effect of different bases [a]



Entry	Bases	Yield (%)[b]
1	LiOMe	79
2	NaOMe	31
3	KOMe	26
4	LiO^{t}Bu	40
5	NaO^{t}Bu	26
6	K_3PO_4	38
7	Na_2CO_3	15
8	KF	0

[a] Standard conditions: **1a** (0.2 mmol), **2a** (0.4 mmol), B_2Pin_2 (0.4 mmol), $NiCl_2$•glyme (0.01 mmol), **L1** (0.014 mmol), Base (0.4 mmol), 1,4-Dioxane (2.0 mL), at 30 °C for 24 h. [b] Yields determined by GC using *n*-dodecane as the internal standard.

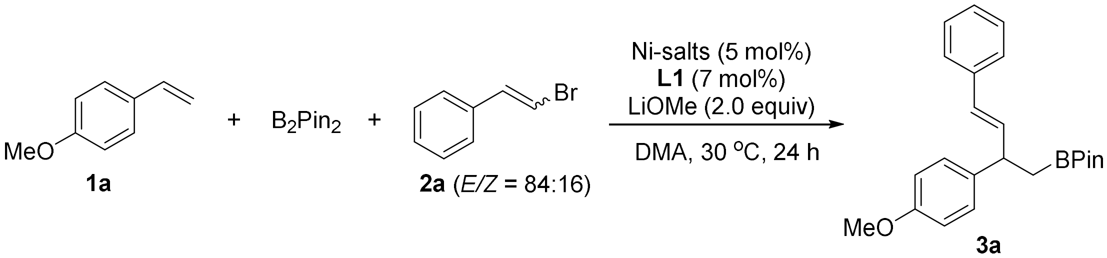
Table S2. The effect of different Solvents [a]



Entry	Solvents	Yield (%)[b]
1	DMA	80
2	DMF	65
3	DME	54
4	1,4-Dioxane	79
5	THF	68
6	CH_3CN	47
7	Toluene	22
8	EA	20

[a] Standard conditions: **1a** (0.2 mmol), **2a** (0.4 mmol), B_2Pin_2 (0.4 mmol), $NiCl_2$•glyme (0.01 mmol), **L1** (0.014 mmol), LiOMe (0.4 mmol), Solvent (2.0 mL), at 30 °C for 24 h. [b] Yields determined by GC using *n*-dodecane as the internal standard.

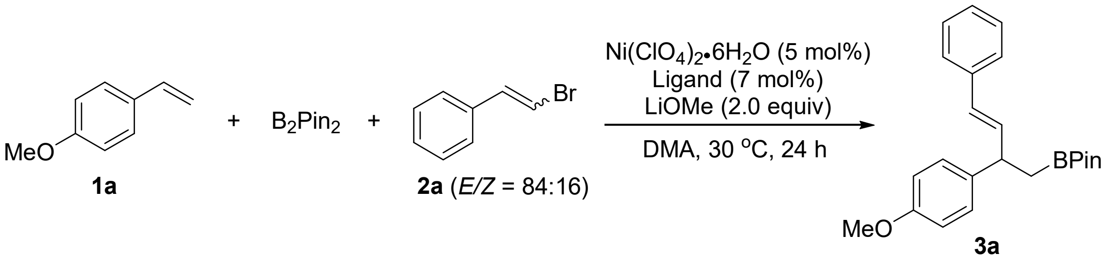
Table S3. The effect of different [Ni]-salts [a]



Entry	Ni-salts	Yield (%)[b]
1	$NiBr_2$•diglyme	88
2	$NiBr_2$	59
3	$NiCl_2$•glyme	80
4	$NiCl_2$	56
5	$Ni(PPh_3)_2Cl_2$	63
6	NiI_2	53
7	$Ni(acac)_2$	14
8	$Ni(OTf)_2$	69
9	$Ni(ClO_4)_2$•$6H_2O$	93% (88%) [c]
10	none	0

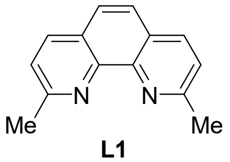
[a] Standard conditions: **1a** (0.2 mmol), **2a** (0.4 mmol), B_2Pin_2 (0.4 mmol), Ni-salt (0.01 mmol), **L1** (0.014 mmol), LiOMe (0.4 mmol), DMA (2.0 mL), at 30 °C for 24 h. [b] Yields determined by GC using *n*-dodecane as the internal standard. [c] Isolated yield.

Table S4. The effect of different ligands[a]

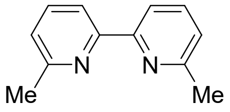


Entry	Ligands	Yield (%)[b]
1	**L1**	93
2	**L2**	76
3	**L3**	89
4	**L4**	0
5	**L5**	0
6	**L6**	0
7	**L7**	0
8	**L8**	0
9	**L9**	0
10	none	0

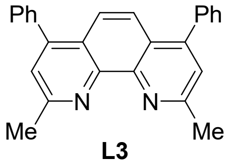
[a] Standard conditions: **1a** (0.2 mmol), **2a** (0.4 mmol), B_2Pin_2 (0.4 mmol), Ni(ClO$_4$)$_2$• 6H$_2$O (0.01 mmol), Ligand (0.014 mmol), LiOMe (0.4 mmol), DMA (2.0 mL), at 30 °C for 24 h. [b] Yields determined by GC using *n*-dodecane as the internal standard.



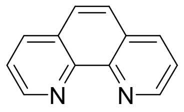
L1



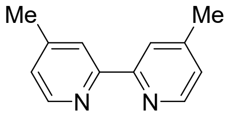
L2



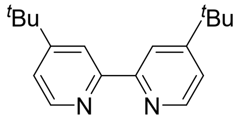
L3



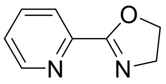
L4



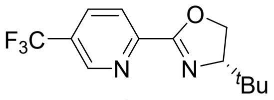
L5



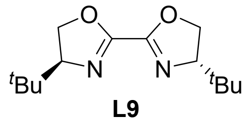
L6



L7



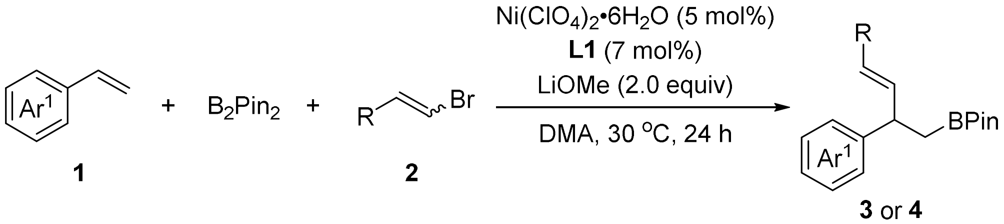
L8



L9

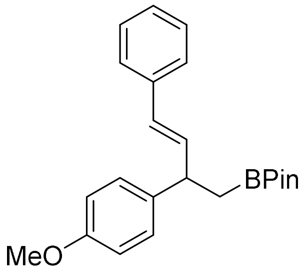
4. General procedure for the reaction

General procedure :



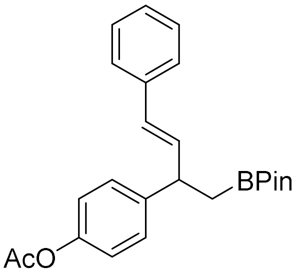
In an oven dried 25-ml Schlenk tube, which contained a stirring bar, was charged with $Ni(ClO_4)_2{\cdot}6H_2O$ (3.7 mg, 0.01 mmol, 5 mol%), **L1** (3.2 mg, 0.014 mmol, 7 mol%), B_2Pin_2 (102 mg, 0.4 mmol, 2.0 equiv), and LiOMe (15 mg, 0.4 mmol, 2.0 equiv). The tube was evacuated and back-filled under a N_2 flow (this sequence was repeated three times), then anhydrous DMA (2.0 ml) was added under N_2. After above, **1** (0.2 mmol, 1.0 equiv) and **2** (0.4 mmol, 2.0 equiv) was added subsequently under N_2, the tube was stirred at 30 ^{o}C for 24 h. *n*-Dodecane (23 μL) was added as an internal standard for GC analysis. The resulting mixture was diluted with EtOAc (2 mL) and quenched by H_2O (2 mL), then it was extracted with EtOAc (10 ml × 3), the organic layer was combined and dried over Na_2SO_4, filtered and concentrated by rotary evaporation. The residue was purified by silica gel column chromatography to afford the product **3** or **4**.

5. Analytical data for compounds



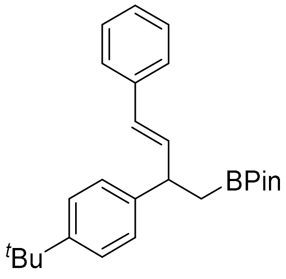
3a

(*E*)-2-(2-(4-methoxyphenyl)-4-phenylbut-3-en-1-yl)-4,4,5,5-tetramethyl-1,3,2-dioxaborolane (3a): The general procedure A was followed using 1-methoxy-4-vinylbenzene (**1a**, 27 mg, 0.20 mmol) and (2-bromovinyl)benzene (**2a**, 73 mg, 0.40 mmol). Purification of this material by chromatography on silica gel (EtOAc : petroleum ether = 1 : 20) afforded product **3a** as a yellow solid (64mg, 88% yield): Rf = 0.7 (EtOAc : petroleum ether = 1 : 10); **^{1}H NMR** (CDCl$_3$, 400 MHz) δ: 7.33-7.30 (m, 2H), 7.28-7.24 (m, 2H), 7.22-7.15 (m, 3H), 6.85-6.82 (m, 2H), 6.42-6.32 (m, 2H), 3.81-3.71 (m, 4H), 1.41-1.31 (m, 2H), 1.14 (s, 12H); **^{13}C NMR** (CDCl$_3$, 100 MHz) δ: 157.9, 137.9, 137.7, 136.0, 128.4, 128.0, 126.8, 126.1, 113.7, 83.1, 55.2, 43.5, 24.8, 24,7 ppm; **HRMS** (ESI-TOF) *m/z* calcd for $C_{23}H_{30}BO_3$ $(M + H)^+$: 364.2324, found 364.2333.



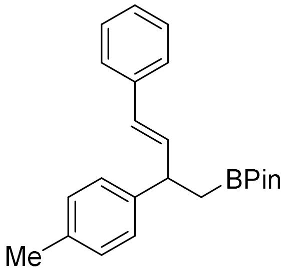
3b

(*E*)-4-(4-phenyl-1-(4,4,5,5-tetramethyl-1,3,2-dioxaborolan-2-yl)but-3-en-2-yl)phenyl acetate (3b): The general procedure A was followed using 4-vinylphenyl acetate (**1b**, 32 mg, 0.20 mmol) and (2-bromovinyl)benzene (**2a**, 73 mg, 0.40 mmol). Purification of this material by chromatography on silica gel (EtOAc : petroleum ether = 1 : 20) afforded product **3b** as a yellow solid (60 mg, 76% yield): Rf = 0.2 (EtOAc : petroleum ether = 1 : 10); **^{1}H NMR** (CDCl$_3$, 400 MHz) δ: 7.33-7.31 (m, 2H), 7.29-7.24 (m, 4H), 7.19-7.15 (m, 1H), 7.01-6.98 (m, 2H), 6.43-6.31 (m, 2H), 3.78 (q, *J* = 7.6 Hz, 1H), 2.27 (s, 3H), 1.42-1.32 (m, 2H), 1.14 (s, 12H); **^{13}C NMR** (CDCl$_3$, 100 MHz) δ: 169.5, 148.9, 143.3, 137.5, 135.3, 128.5, 128.42, 128.39, 127.0, 126.1, 121.3, 83.2, 43.8, 24.8, 24.7, 21.1 ppm; **HRMS** (ESI-TOF) *m/z* calcd for $C_{24}H_{28}BO_4$ $(M - H)^-$: 390.2117, found 390.2107.



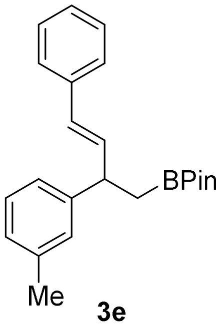
3c

(*E*)-2-(2-(4-(tert-butyl)phenyl)-4-phenylbut-3-en-1-yl)-4,4,5,5-tetramethyl-1,3,2-dioxaborolane (3c): The general procedure A was followed using 1-(tert-butyl)-4-vinylbenzene (**1c**, 32 mg, 0.20 mmol) and (2-bromovinyl)benzene (**2a**, 73 mg, 0.40 mmol). Purification of this material by chromatography on silica gel (EtOAc : petroleum ether = 1 : 20) afforded product **3c** as a yellow solid (66 mg, 84% yield): Rf = 0.7 (EtOAc : petroleum ether = 1 : 10); **^{1}H NMR** ($CDCl_3$, 400 MHz) δ: 7.34-7.25 (m, 6H), 7.24-7.20 (m, 2H), 7.19-7.14 (m, 1H), 6.46-6.34 (m, 2H), 3.76 (q, *J* = 7.6 Hz, 1H), 1.43-1.35 (m, 2H), 1.30 (s, 9H), 1.13 (s, 6H), 1.12 (s, 6H); **^{13}C NMR** ($CDCl_3$, 100 MHz) δ: 148.8, 142.7, 137.7, 135.7, 128.4, 128.1, 127.0, 126.8, 126.2, 125.2, 83.1, 43.9, 34.3, 31.4, 24.8, 24.6 ppm; **HRMS** (ESI-TOF) *m/z* calcd for $C_{26}H_{36}BO_2$ $(M + H)^+$: 390.2845, found 390.2850.



3d

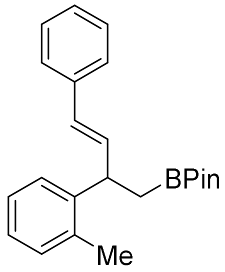
(*E*)-4,4,5,5-tetramethyl-2-(4-phenyl-2-(p-tolyl)but-3-en-1-yl)-1,3,2-dioxaborolane (3d): The general procedure A was followed using1-methyl-4-vinylbenzene (**1d**, 24 mg, 0.20 mmol) and (2-bromovinyl)benzene (**2a**, 73 mg, 0.40 mmol). Purification of this material by chromatography on silica gel (EtOAc : petroleum ether = 1 : 20) afforded product **3d** as a yellow solid (56 mg, 80% yield): Rf = 0.8 (EtOAc : petroleum ether = 1 : 10); **^{1}H NMR** ($CDCl_3$, 400 MHz) δ: 7.33-7.30 (m, 2H), 7.29-7.27 (m, 1H), 7.26-7.24 (m, 1H), 7.19-7.14 (m, 3H), 7.11-7.08 (m, 2H), 6.44-6.33 (m, 2H), 3.75 (q, *J* = 7.6 Hz, 1H), 2.31 (s, 3H), 1.43-1.31 (m, 2H), 1.15 (s, 12H); **^{13}C NMR** ($CDCl_3$, 100 MHz) δ: 142.8, 137.7, 135.8, 135.5, 129.0, 128.4, 128.1, 127.3, 126.8, 126.1, 83.1, 43.9, 24.8, 24.7, 21.0 ppm; **HRMS** (ESI-TOF) *m/z* calcd for $C_{23}H_{30}BO_2$ $(M + H)^+$: 348.2375, found 348.2371.



3e

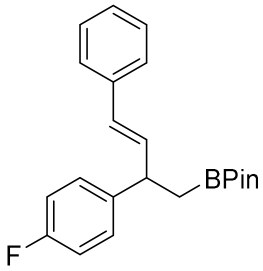
(*E*)-4,4,5,5-tetramethyl-2-(4-phenyl-2-(o-tolyl)but-3-en-1-yl)-1,3,2-dioxaborolane (3e): The general procedure A was followed using 1-methyl-3-vinylbenzene (**1e**, 24 mg, 0.20 mmol) and (2-bromovinyl)benzene (**2a**, 73 mg, 0.40 mmol). Purification of this material by chromatography on silica gel (EtOAc : petroleum ether = 1 : 20) afforded product **3e** as yellow solid (50 mg, 72% yield): Rf = 0.8 (EtOAc : petroleum ether = 1 : 10); **^{1}H NMR** ($CDCl_3$, 600 MHz) δ: 7.34-7.32 (m, 2H), 7.29-7.27 (m, 1H), 7.26-7.24 (m, 1H), 7.18-7.15 (m, 2H), 7.09-7.07 (m, 2H), 6.99-6.98 (m, 1H), 6.44-6.35 (m, 2H), 3.75 (q, *J* = 7.8 Hz, 1H), 2.32 (s, 3H), 1.41-1.33 (m, 2H), 1.14 (s, 12H);

^{13}C NMR (CDCl$_3$, 150 MHz) δ: 145.7, 137.8, 137.7, 135.7, 128.4, 128.23, 128.19, 126.9, 126.8, 126.2, 124.4, 83.1, 44.3, 24.8, 24.7, 21.4 ppm; **HRMS** (ESI-TOF) *m/z* calcd for $C_{23}H_{30}BO_2$ (M + H)$^+$: 348.2375, found 348.2377.



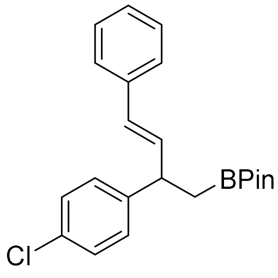
3f

(*E*)-4,4,5,5-tetramethyl-2-(4-phenyl-2-(o-tolyl)but-3-en-1-yl)-1,3,2-dioxaborolane (3f): The general procedure A was followed using 1-methyl-2-vinylbenzene (**1f**, 24 mg, 0.20 mmol) and (2-bromovinyl)benzene (**2a**, 73 mg, 0.40 mmol). Purification of this material by chromatography on silica gel (EtOAc : petroleum ether = 1 : 20) afforded product **3f** as yellow solid (48 mg, 69% yield): Rf = 0.8 (EtOAc : petroleum ether = 1 : 10); **^{1}H NMR** (CDCl$_3$, 400 MHz) δ: 7.31-7.27 (m, 3H), 7.26-7.22 (m, 2H), 7.19-7.12 (m, 2H), 7.11-7.05 (m, 2H), 6.40-6.32 (m, 2H), 4.03-3.98 (m, 1H), 2.40 (s, 3H), 1.39-1.36 (m, 2H), 1.11 (s, 6H), 1.09 (s, 6H); **^{13}C NMR** (CDCl$_3$, 100 MHz) δ: 143.5, 137.7, 135.8, 135.4, 130.2, 128.4, 128.1, 126.8, 126.5, 126.1, 125.9, 83.1, 39.8, 24.7, 24.6, 19.7 ppm; **HRMS** (ESI-TOF) *m/z* calcd for $C_{23}H_{30}BO_2$ (M + H)$^+$: 348.2375, found 348.2372.



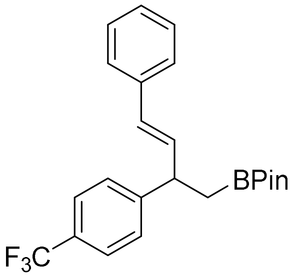
3g

(*E*)-2-(2-(4-fluorophenyl)-4-phenylbut-3-en-1-yl)-4,4,5,5-tetramethyl-1,3,2-dioxaborolane (3g): The general procedure A was followed using 1-fluoro-4-vinylbenzene (**1g**, 24 mg, 0.20 mmol) and (2-bromovinyl)benzene (**2a**, 73 mg, 0.40 mmol). Purification of this material by chromatography on silica gel (EtOAc : petroleum ether = 1 : 20) afforded product **3g** as a yellow solid (56 mg, 79% yield): Rf = 0.7 (EtOAc : petroleum ether = 1 : 10); **^{1}H NMR** (CDCl$_3$, 400 MHz) δ: 7.33-7.31 (m, 2H), 7.28-7.26 (m, 1H), 7.25-7.21 (m, 3H), 7.20-7.15 (m, 1H), 6.99-6.94 (m, 2H), 6.41-6.30 (m, 2H), 3.77 (q, *J* = 7.2 Hz, 1H), 1.41-1.31 (m, 2H), 1.13 (s, 12H); **^{13}C NMR** (CDCl$_3$, 100 MHz) δ: 161.3 (d, *J* = 242.6 Hz), 141.4 (d, *J* = 3.1 Hz), 137.4, 135.5, 128.9 (d, *J* = 7.7 Hz), 128.43, 128.38, 127.0, 126.1, 115.0 (d, *J* = 21.0 Hz), 83.2, 43.6, 24.8, 24.7 ppm; ^{19}F NMR (CDCl$_3$, 376 MHz) δ: -117.14 - -117.21 (m, 1F). **HRMS** (ESI-TOF) *m/z* calcd for $C_{22}H_{27}BFO_2$ (M + H)$^+$: 352.2124, found 352.2133.



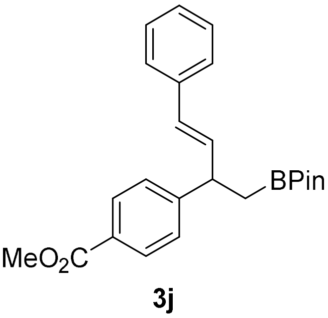
3h

(*E*)-2-(2-(4-chlorophenyl)-4-phenylbut-3-en-1-yl)-4,4,5,5-tetramethyl-1,3,2-dioxaborolane (3h): The general procedure A was followed using 1-chloro-4-vinylbenzene (**1h**, 28 mg, 0.20 mmol) and (2-bromovinyl)benzene (**2a**, 73 mg, 0.40 mmol). Purification of this material by chromatography on silica gel (EtOAc : petroleum ether = 1 : 20) afforded product **3h** as a yellow solid (58 mg, 78% yield): Rf = 0.7 (EtOAc : petroleum ether = 1 : 10); ^{1}**H NMR** (CDCl$_3$, 400 MHz) δ: 7.33-7.30 (m, 2H), 7.29-7.24 (m, 4H), 7.23-7.16 (m, 3H), 6.42-6.29 (m, 2H), 3.76 (q, *J* = 7.6 Hz, 1H), 1.41-1.30 (m, 2H), 1.14 (s, 12H); ^{13}**C NMR** (CDCl$_3$, 100 MHz) δ: 144.2, 137.4, 135.0, 131.7, 128.9, 128.7, 128.5, 128.4, 127.1, 126.2, 83.3, 43.7, 24.8, 24.7 ppm; **HRMS** (ESI-TOF) *m/z* calcd for $C_{22}H_{25}BClO_2$ $(M - H)^-$: 366.1672, found 366.1674.



3i

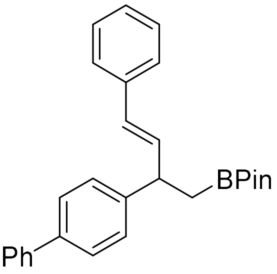
(*E*)-4,4,5,5-tetramethyl-2-(4-phenyl-2-(4-(trifluoromethyl)phenyl)but-3-en-1-yl)-1,3,2-dioxaborolane (3i): The general procedure A was followed using 1-(trifluoromethyl)-4-vinylbenzene (**1i**, 34 mg, 0.20 mmol) and (2-bromovinyl)benzene (**2a**, 73 mg, 0.40 mmol). Purification of this material by chromatography on silica gel (EtOAc : petroleum ether = 1 : 20) afforded product **3i** as a yellow solid (44 mg, 55% yield): Rf = 0.6 (EtOAc : petroleum ether = 1 : 10); ^{1}**H NMR** (CDCl$_3$, 400 MHz) δ: 7.55-7.53 (m, 2H), 7.40-7.38 (m, 2H), 7.33-7.25 (m, 4H), 7.21-7.16 (m, 1H), 6.45-6.30 (m, 2H), 3.84 (q, *J* = 7.6 Hz, 1H), 1.45-1.33 (m, 2H), 1.14 (s, 6H), 1.13 (s, 6H); ^{13}**C NMR** (CDCl$_3$, 100 MHz) δ: 149.9, 137.2, 134.4, 129.1, 128.5, 127.8, 127.2, 126.2, 125.3 (q, *J* = 3.7 Hz), 124.3 (q, *J* = 270.4 Hz), 83.3, 44.2, 24.8, 24.6 ppm; ^{19}F NMR (CDCl$_3$, 376 MHz) δ: -62.17; **HRMS** (ESI-TOF) *m/z* calcd for $C_{23}H_{27}BF_3O_2$ $(M + H)^+$: 402.2093, found 402.2088.



3j

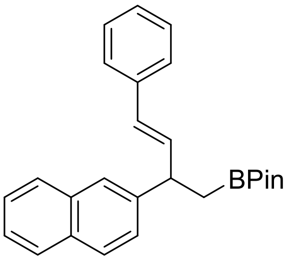
methyl(*E*)-4-(4-phenyl-1-(4,4,5,5-tetramethyl-1,3,2-dioxaborolan-2-yl)but-3-en-2-yl)benzoate

(3j): The general procedure A was followed using methyl 4-vinylbenzoate (**1j**, 32 mg, 0.20 mmol) and (2-bromovinyl)benzene (**2a**, 73 mg, 0.40 mmol). Purification of this material by chromatography on silica gel (EtOAc : petroleum ether = 1 : 20) afforded product **3j** as a yellow solid (41 mg, 52% yield): Rf = 0.3 (EtOAc : petroleum ether = 1 : 10); **^{1}H NMR** ($CDCl_3$, 400 MHz) δ: 7.96 (d, *J* = 8.4 Hz, 2H), 7.37-7.31 (m, 4H), 7.29-7.25 (m, 2H), 7.21-7.17 (m, 1H), 6.44-6.31 (m, 2H), 3.90 (s, 3H), 3.84 (q, *J* = 7.6 Hz, 1H), 1.45-1.34 (m, 2H), 1.14 (s, 6H), 1.13 (s, 6H); **^{13}C NMR** ($CDCl_3$, 100 MHz) δ: 167.1, 151.2, 137.3, 134.6, 129.8, 129.0, 128.5, 128.0, 127.5, 127.1, 126.2, 83.3, 52.0, 44.4, 24.8, 24.7 ppm; **HRMS** (ESI-TOF) *m/z* calcd for $C_{24}H_{30}BO_4$ $(M + H)^+$: 392.2274, found 392.2277.



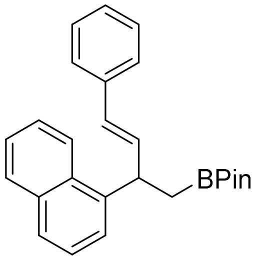
3k

(*E*)-2-(2-([1,1'-biphenyl]-4-yl)-4-phenylbut-3-en-1-yl)-4,4,5,5-tetramethyl-1,3,2-dioxaborolane (3k):The general procedure A was followed using 4-vinyl-1,1'-biphenyl (**1k**, 36 mg, 0.20 mmol) and (2-bromovinyl)benzene (**2a**, 73 mg, 0.40 mmol). Purification of this material by chromatography on silica gel (EtOAc : petroleum ether = 1 : 20) afforded product **3k** as a yellow solid (65 mg, 79% yield): Rf = 0.6 (EtOAc : petroleum ether = 1 : 10); **^{1}H NMR** ($CDCl_3$, 400 MHz) δ: 7.59-7.51 (m, 4H), 7.44-7.25 (m, 9H), 7.20-7.16 (m, 1H), 6.49-6.38 (m, 2H), 3.84 (q, *J* = 7.6 Hz, 1H), 1.47-1.38 (m, 2H), 1.15 (s, 12H); **^{13}C NMR** ($CDCl_3$, 100 MHz) δ: 144.9, 141.1, 139.0, 137.6, 135.4, 128.7, 128.5, 128.4, 127.9, 127.1, 126.99, 126.95, 126.2, 83.2, 44.1, 24.8, 24.7 ppm; **HRMS** (ESI-TOF) *m/z* calcd for $C_{28}H_{32}BO_2$ $(M + H)^+$: 410.2532, found 410.2527.



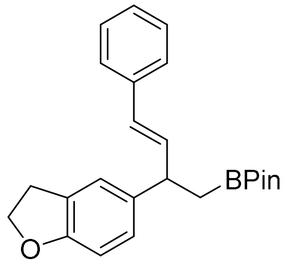
3l

(*E*)-4,4,5,5-tetramethyl-2-(2-(naphthalen-2-yl)-4-phenylbut-3-en-1-yl)-1,3,2-dioxaborolane (3l): The general procedure A was followed using 2-vinylnaphthalene (**1l**, 31 mg, 0.20 mmol) and (2-bromovinyl)benzene (**2a**, 73 mg, 0.40 mmol). Purification of this material by chromatography on silica gel (EtOAc : petroleum ether = 1 : 20) afforded product **3l** as a yellow solid (62 mg, 81% yield): Rf = 0.6 (EtOAc : petroleum ether = 1 : 10); **^{1}H NMR** ($CDCl_3$, 400 MHz) δ: 7.79-7.72 (m, 4H), 7.45-7.38 (m, 3H), 7.35-7.31 (m, 2H), 7.29-7.28 (m, 1H), 7.26-7.24 (m, 1H), 7.19-7.15 (m, 1H), 6.46-6.38 (m, 2H), 3.99-3.93 (m, 1H), 1.53-1.44 (m, 2H), 1.12 (s, 12H); **^{13}C NMR** ($CDCl_3$, 100 MHz) δ: 143.2, 137.6, 135.4, 133.6, 132.2, 128.6, 128.4, 127.9, 127.7, 127.5, 127.0, 126.5, 126.2, 125.8, 125.4, 125.2, 83.2, 44.4, 24.8, 24.7 ppm; **HRMS** (ESI-TOF) *m/z* calcd for $C_{26}H_{28}BO_2$ $(M - H)^-$: 382.2219, found 382.2224.



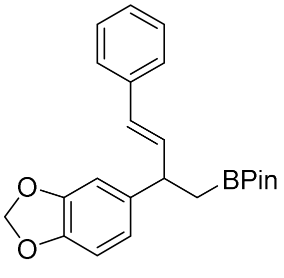
3m

(*E*)-4,4,5,5-tetramethyl-2-(2-(naphthalen-1-yl)-4-phenylbut-3-en-1-yl)-1,3,2-dioxaborolane (3m): The general procedure A was followed using 1-vinylnaphthalene (**1m**, 31 mg, 0.20 mmol) and (2-bromovinyl)benzene (**2a**, 73 mg, 0.40 mmol). Purification of this material by chromatography on silica gel (EtOAc : petroleum ether = 1 : 20) afforded product **3m** as yellow solid (57 mg, 74% yield): Rf = 0.6 (EtOAc : petroleum ether = 1 : 10); ^{1}**H NMR** (CDCl$_3$, 600 MHz) δ: 8.26 (d, *J* = 8.4 Hz, 1H), 7.84 (d, *J* = 8.4 Hz, 1H), 7.72 (d, *J* = 8.4 Hz, 1H), 7.52-7.43 (m, 4H), 7.32-7.31 (m, 2H), 7.26-7.23 (m, 2H), 7.18-7.15 (m, 1H), 6.53-6.46 (m, 2H), 4.63 (q, *J* = 7.2 Hz, 1H), 1.58-1.51 (m, 2H), 1.12 (s, 6H), 1.07(s, 6H); ^{13}**C NMR** (CDCl$_3$, 150 MHz) δ: δ 141.7, 137.5, 135.3, 133.9, 131.4, 128.7, 128.4, 126.9, 126.7, 126.1, 125.7, 125.5, 125.3, 123.93, 123.88, 83.2, 39.0, 24.8, 24.6. ppm; **HRMS** (ESI-TOF) *m/z* calcd for $C_{26}H_{30}BO_2$ $(M + H)^+$: 384.2375, found 384.2370.



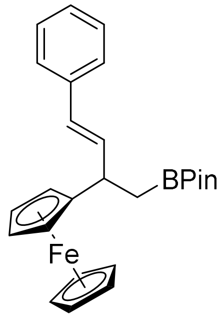
3n

(*E*)-2-(2-(2,3-dihydrobenzofuran-5-yl)-4-phenylbut-3-en-1-yl)-4,4,5,5-tetramethyl-1,3,2-dioxaborolane (3n): The general procedure A was followed using 5-vinyl-2,3-dihydrobenzofuran (**1n**, 29 mg, 0.20 mmol) and (2-bromovinyl)benzene (**2a**, 73 mg, 0.40 mmol). Purification of this material by chromatography on silica gel (EtOAc : petroleum ether = 1 : 10) afforded product **3n** as a yellow solid (57 mg, 76% yield): Rf = 0.4 (EtOAc : petroleum ether = 1 : 10); ^{1}**H NMR** (CDCl$_3$, 400 MHz) δ: 7.34-7.31 (m, 2H), 7.29-7.23 (m, 2H), 7.18-7.14 (m, 1H), 7.11-7.10 (m, 1H), 7.03-7.00 (m, 1H), 6.71-6.69 (d, *J* = 8.0 Hz, 1H), 6.42-6.32 (m, 2H), 4.52 (t, *J* = 8.8 Hz, 2H), 3.72 (q, *J* = 7.2 Hz, 1H), 3.15 (t, *J* = 8.8 Hz, 2H), 1.40-1.31 (m, 2H), 1.14 (s, 12H); ^{13}**C NMR** (CDCl$_3$, 100 MHz) δ: 158.4, 137.9, 137.7, 136.1, 128.4, 127.8, 126.92, 126.85, 126.8, 126.1, 123.9, 108.8, 83.1, 71.1, 43.7, 29.8, 24.8, 24.7 ppm; **HRMS** (ESI-TOF) *m/z* calcd for $C_{24}H_{28}BO_3$ $(M - H)^-$: 374.2168, found 374.2158.



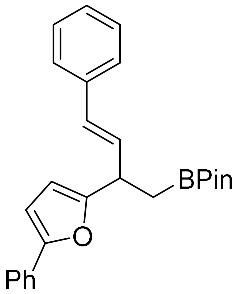
3o

(*E*)-2-(2-(benzo[*d*][1,3]dioxol-5-yl)-4-phenylbut-3-en-1-yl)-4,4,5,5-tetramethyl-1,3,2-dioxaborolane (3o): The general procedure A was followed using 5-vinylbenzo[*d*][1,3]dioxole (**1o**, 30 mg, 0.20 mmol) and (2-bromovinyl)benzene (**2a**, 73 mg, 0.40 mmol). Purification of this material by chromatography on silica gel (EtOAc : petroleum ether = 1 : 20) afforded product **3o** as a white solid (57 mg, 76% yield): Rf = 0.5 (EtOAc : petroleum ether = 1 : 10); **^{1}H NMR** ($CDCl_3$, 400 MHz) δ: 7.33-7.31 (m, 2H), 7.28-7.24 (m, 2H), 7.19-7.15 (m, 1H), 6.78-6.71 (m, 3H), 6.42-6.29 (m, 2H), 5.90 (s, 2H), 3.71 (q, *J* = 7.6 Hz, 1H), 1.35-1.30 (m, 2H), 1.16 (s, 12H); **^{13}C NMR** ($CDCl_3$, 100 MHz) δ: 147.5, 145.7, 139.8, 137.6, 135.6, 128.4, 128.2, 126.9, 126.1, 120.2, 108.0, 100.7, 83.2, 44.0, 24.8, 24.7 ppm; **HRMS** (ESI-TOF) *m/z* calcd for $C_{23}H_{28}BO_4$ $(M + H)^+$: 378.2117, found 378.2114.



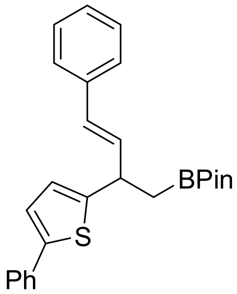
3p

(*E*)-(4-phenyl-1-(4,4,5,5-tetramethyl-1,3,2-dioxaborolan-2-yl)but-3-en-2-yl)-*ferrocene* (3p): The general procedure A was followed using vinylferrocene (**1p**, 42 mg, 0.20 mmol) and (2-bromovinyl)benzene (**2a**, 73 mg, 0.40 mmol). Purification of this material by chromatography on silica gel (EtOAc : petroleum ether = 1 : 20) afforded product **3p** as a red solid (59 mg, 67% yield): Rf = 0.7 (EtOAc : petroleum ether = 1 : 10); **^{1}H NMR** ($CDCl_3$, 400 MHz) δ: 7.38-7.36 (m, 2H), 7.32-7.27 (m, 2H), 7.21-7.17 (m, 1H), 6.45-6.32 (m, 2H), 4.14 (s, 5H), 4.11-4.09 (m, 1H), 4.08-4.06 (m, 3H), 3.49-3.43 (m, 1H), 1.38-1.30 (m, 2H), 1.20 (s, 12H); **^{13}C NMR** ($CDCl_3$, 100 MHz) δ: 137.8, 135.2, 128.5, 128.3, 126.8, 126.1, 94.9, 83.1, 68.4, 67.2, 67.0, 66.9, 66.6, 38.2, 25.1, 24.7 ppm; **HRMS** (ESI-TOF) *m/z* calcd for $C_{26}H_{32}BO_2Fe$ $(M + H)^+$: 441.1896, found 441.1903.



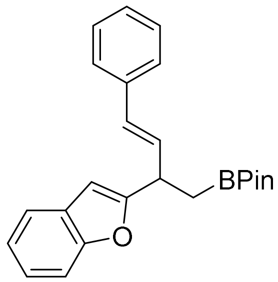
3q

(*E*)-4,4,5,5-tetramethyl-2-(4-phenyl-2-(5-phenylfuran-2-yl)but-3-en-1-yl)-1,3,2-dioxaborolane (3q): The general procedure A was followed using 2-phenyl-5-vinylfuran (**1q**, 34 mg, 0.20 mmol) , and (2-bromovinyl)benzene (**2a**, 73 mg, 0.40 mmol). Purification of this material by chromatography on silica gel (EtOAc : petroleum ether = 1 : 20) afforded product **3q** as a yellow solid (57 mg, 71% yield): Rf = 0.7 (EtOAc : petroleum ether = 1 : 10); **^{1}H NMR** ($CDCl_3$, 600 MHz) δ: 7.64-7.63 (m, 2H), 7.37-7.33 (m, 4H), 7.29 (t, *J* = 7.8 Hz, 2H), 7.22-7.19 (m, 2H), 6.56 (d, *J* = 3.6 Hz, 1H), 6.50 (d, *J* = 15.6 Hz, 1H), 6.34 (dd, J_1 = 15.6, J_2 = 7.8 Hz, 1H), 6.14 (dd, J_1 = 3.3, J_2 = 0.9 Hz, 1H), 3.90 (q, *J* = 7.8 Hz, 1H), 1.50-1.46 (m, 1H), 1.37-1.33 (m, 1H), 1.20 (s, 6H), 1.18 (s, 6H); **^{13}C NMR** ($CDCl_3$, 150 MHz) δ: 158.3, 152.4, 137.4, 132.4, 131.2, 129.7, 128.5, 128.4, 127.1, 126.8, 126.2, 123.4, 106.5, 105.6, 83.3, 38.4, 24.8, 24.7 ppm; **HRMS** (ESI-TOF) *m/z* calcd for $C_{26}H_{30}BO_3$ $(M + H)^+$: 400.2324, found 400.2329.



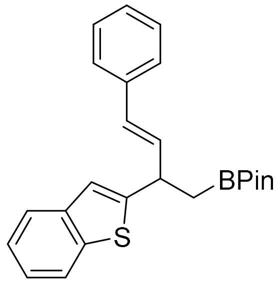
3r

(*E*)-4,4,5,5-tetramethyl-2-(4-phenyl-2-(5-phenylthiophen-2-yl)but-3-en-1-yl)-1,3,2-dioxaborolane (3r): The general procedure A was followed using 2-phenyl-5-vinylthiophene (**1r**, 37 mg, 0.20 mmol) and (2-bromovinyl)benzene (**2a**, 73 mg, 0.40 mmol). Purification of this material by chromatography on silica gel (EtOAc : petroleum ether = 1 : 20) afforded product **3r** as a yellow solid (51 mg, 62% yield): Rf = 0.7 (EtOAc : petroleum ether = 1 : 10); **^{1}H NMR** ($CDCl_3$, 400 MHz) δ: 7.56-7.54 (m, 2H), 7.37-7.26 (m, 6H), 7.24-7.18 (m, 2H), 7.14 (d, *J* = 3.6 Hz, 1H), 6.84 (d, *J* = 3.6, 1H), 6.50 (d, *J* = 7.6 Hz, 1H), 6.35 (dd, J_1 = 16.0, J_2 = 8.0 Hz, 1H), 4.03 (q, *J* = 7.6 Hz, 1H), 1.53-1.37 (m, 2H), 1.18 (s, 12H); **^{13}C NMR** ($CDCl_3$, 100 MHz) δ: 149.9, 142.1, 137.3, 134.7, 134.5, 129.1, 128.8, 128.5, 127.2, 127.0, 126.3, 125.5, 124.2, 122.6, 83.3, 40.2, 24.9, 24.7 ppm; **HRMS** (ESI-TOF) *m/z* calcd for $C_{26}H_{28}BO_2S$ $(M - H)^-$: 414.1939, found 414.1937.



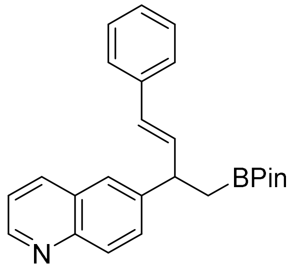
3s

(*E*)-2-(2-(benzofuran-2-yl)-4-phenylbut-3-en-1-yl)-4,4,5,5-tetramethyl-1,3,2-dioxaborolane (3s): The general procedure A was followed using 2-vinylbenzofuran (**1s**, 29 mg, 0.20 mmol), and (2-bromovinyl)benzene (**2a**, 73 mg, 0.40 mmol). Purification of this material by chromatography on silica gel (EtOAc : petroleum ether = 1 : 20) afforded product **3s** as a yellow solid (56 mg, 74% yield): Rf = 0.8 (EtOAc : petroleum ether = 1 : 10); **^{1}H NMR** ($CDCl_3$, 400 MHz) δ: 7.49-7.46 (m, 1H), 7.42-7.35 (m, 3H), 7.31-7.26 (m, 2H), 7.21-7.14 (m, 3H), 6.54 (d, J = 16.0 Hz, 1H), 6.45 (s, 1H), 6.37 (dd, J_1 = 16.0, J_2 = 8.0 Hz, 1H), 3.98 (q, J = 8.4 Hz, 1H), 1.54-1.48 (m, 1H), 1.42-1.36 (m, 1H),1.20 (s, 6H), 1.19 (s, 6H); **^{13}C NMR** ($CDCl_3$, 100 MHz) δ: 161.9, 154.8, 137.2, 131.6, 130.3, 128.8, 128.5, 127.3, 126.3, 123.2, 122.4, 120.4, 110.9, 101.4, 83.4, 38.6, 24.9, 24.7 ppm; **HRMS** (ESI-TOF) *m/z* calcd for $C_{24}H_{28}BO_3$ $(M + H)^+$: 374.2168, found 374.2169.



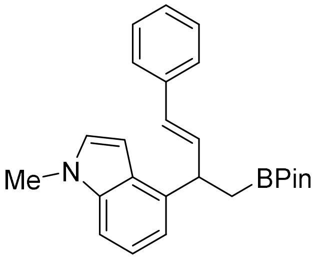
3t

(*E*)-2-(2-(benzo[*b*]thiophen-2-yl)-4-phenylbut-3-en-1-yl)-4,4,5,5-tetramethyl-1,3,2-dioxaborolane (3t): The general procedure A was followed using 2-vinylbenzo[*b*]thiophene (**1t**, 32 mg, 0.20 mmol) and (2-bromovinyl)benzene (**2a**, 73 mg, 0.40 mmol). Purification of this material by chromatography on silica gel (EtOAc : petroleum ether = 1 : 20) afforded product **3t** as a yellow solid (39 mg, 51% yield): Rf = 0.8 (EtOAc : petroleum ether = 1 : 20); **^{1}H NMR** ($CDCl_3$, 400 MHz) δ: 7.75 (d, J = 8.0 Hz, 1H), 7.66 (d, J = 7.6 Hz, 1H), 7.37-7.34 (m, 2H), 7.31-7.26 (m, 3H), 7.24-7.18 (m, 2H), 7.09 (s, 1H), 6.53 (d, J = 16.0 Hz, 1H), 6.38 (dd, J_1 = 16.0, J_2 = 8.0 Hz, 1H), 4.10 (q, J = 7.6 Hz, 1H), 1.53-1.44 (m, 2H), 1.17 (s, 12H); **^{13}C NMR** ($CDCl_3$, 100 MHz) δ: 151.2, 140.0, 139.4, 137.2, 134.0, 129.6, 128.5, 127.2, 126.3, 124.0, 123.5, 122.9, 122.2, 119.6, 83.4, 40.6, 24.9, 24.7 ppm; **HRMS** (ESI-TOF) *m/z* calcd for $C_{24}H_{26}BO_2S$ $(M - H)^-$: 390.1783, found 390.1786.



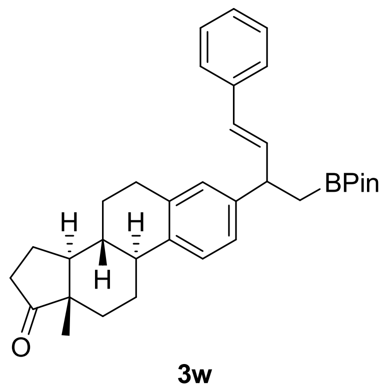
3u

(*E*)-6-(4-phenyl-1-(4,4,5,5-tetramethyl-1,3,2-dioxaborolan-2-yl)but-3-en-2-yl)quinoline (3u): The general procedure B was followed using 6-vinylquinoline (**1u**, 31 mg, 0.20 mmol) and (2-bromovinyl)benzene (**2a**, 73 mg, 0.40 mmol). Purification of this material by chromatography on silica gel (EtOAc : petroleum ether = 1 : 10) afforded product **3u** as a white solid (60 mg, 78% yield): Rf = 0.4 (EtOAc : petroleum ether = 1 : 5); **^{1}H NMR** (CDCl$_3$, 400 MHz) δ: 8.86 (dd, J_1 = 4.0, J_2 = 1.6 Hz, 1H), 8.12-8.03 (m, 2H), 7.70-7.67 (m, 2H), 7.38-7.33 (m, 3H), 7.29-7.25 (m, 2H), 7.20-7.16 (m, 1H), 6.50-6.40 (m, 2H), 4.02-3.97 (m, 1H), 1.54-1.43 (m, 2H), 1.12 (s, 6H), 1.11 (s, 6H); **^{13}C NMR** (CDCl$_3$, 100 MHz) δ: 149.8, 147.3, 144.1, 137.3, 135.8, 134.9, 130.2, 129.3, 129.0, 128.4, 128.3, 127.1, 126.2, 125.2, 121.0, 83.2, 44.2, 24.74, 24.65 ppm; **HRMS** (ESI-TOF) *m/z* calcd for $C_{25}H_{27}BNO_2$ $(M + H)^+$: 383.2328, found 383.2315.



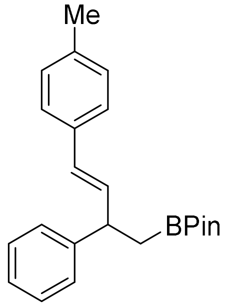
3v

(*E*)-1-methyl-4-(4-phenyl-1-(4,4,5,5-tetramethyl-1,3,2-dioxaborolan-2-yl)but-3-en-2-yl)-1H-indole (3v): The general procedure A was followed using 1-methyl-4-vinyl-1H-indole (**1v**, 31 mg, 0.20 mmol) and (2-bromovinyl)benzene (**2a**, 73 mg, 0.40 mmol). Purification of this material by chromatography on silica gel (EtOAc : petroleum ether = 1 : 10) afforded product **3v** as a yellow solid (60 mg, 78% yield): Rf = 0.4 (EtOAc : petroleum ether = 1 : 10); **^{1}H NMR** (CDCl$_3$, 600 MHz) δ: 7.32-7.30 (m, 2H), 7.24-7.21 (m, 2H), 7.19-7.12 (m, 3H), 7.04 (dd, J_1 = 5.4, J_2 = 2.5 Hz, 1H), 7.01 (d, J = 3.6 Hz, 1H), 6.66 (d, J = 3.0 Hz, 1H), 6.54-6.48 (m, 2H), 4.23-4.20 (m, 1H), 3.75 (s, 3H), 1.58-1.48 (m, 2H), 1.13 (s, 6H), 1.12 (s, 6H); **^{13}C NMR** (CDCl$_3$, 150 MHz) δ: 138.1, 137.9, 136.8, 135.4, 128.3, 128.2, 128.0, 127.1, 126.7, 126.1, 121.7, 116.8, 107.3, 99.9, 83.1, 42.0, 32.9, 24.8, 24.6 ppm; **HRMS** (ESI-TOF) *m/z* calcd for $C_{25}H_{29}BNO_2$ $(M - H)^-$: 385.2328, found 385.2327.



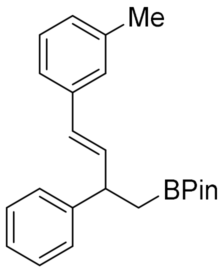
3w

(8*R*,9*S*,13*S*,14*S*)-13-methyl-3-((*E*)-4-phenyl-1-(4,4,5,5-tetramethyl-1,3,2-dioxaborolan-2-yl)but-3-en-2-yl)-6,7,8,9,11,12,13,14,15,16-decahydro-17H-cyclopenta[*a*]phenanthren-17-one (3w): The general procedure A was followed using (8*R*,9*S*,13*S*,14*S*)-13-methyl-3-vinyl-6,7,8,9,11,12,13,14,15,16-decahydro-17H-cyclopenta[*a*]phenanthren-17-one (**1w**, 56 mg, 0.20 mmol) and (2-bromovinyl)benzene (**2a**, 73 mg, 0.40 mmol). Purification of this material by chromatography on silica gel (EtOAc : petroleum ether = 1 : 10) afforded product **3w** as a yellow solid (62 mg, 61% yield): Rf = 0.2 (EtOAc : petroleum ether = 1 : 10); **^{1}H NMR** ($CDCl_3$, 600 MHz) δ: 7.34-7.32 (m, 2H), 7.27-7.25 (m, 2H), 7.22-7.21 (m, 1H), 7.18-7.16 (m, 1H), 7.09-7.07 (m, 1H), 7.01 (s, 1H), 6.45 (d, *J* = 15.6 Hz, 1H), 6.38-6.34 (m, 1H), 3.73 (q, *J* = 7.8 Hz, 1H), 2.89-2.87 (m, 2H), 2.52-2.47 (m, 1H), 2.42-2.39 (m, 1H), 2.30-2.25 (m, 1H), 2.17-2.10 (m, 1H), 2.07-1.98 (m, 2H), 1.96-1.93 (m, 1H), 1.65-1.61 (m, 1H), 1.53-1.47 (m, 3H), 1.43-1.36 (m, 2H), 1.33-1.30 (m, 2H), 1.16 (s, 12H), 0.9 (s, 3H); **^{13}C NMR** ($CDCl_3$, 150 MHz) δ: 221.0, 143.5, 137.7, 137.5, 136.3, 135.4, 128.4, 128.3, 128.0, 127.9, 126.9, 126.2, 125.4, 124.9, 124.7, 83.2, 50.5, 48.0, 44.3, 43.9, 38.2, 35.9, 31.6, 29.5, 26.6, 25.7, 24.9, 24.7, 21.6, 13.8 ppm; **HRMS** (ESI-TOF) *m/z* calcd for $C_{34}H_{44}BO_3$ $(M + H)^+$: 510.3420, found 510.3415.



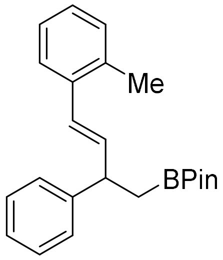
4b

(*E*)-4,4,5,5-tetramethyl-2-(2-phenyl-4-(*p*-tolyl)but-3-en-1-yl)-1,3,2-dioxaborolane (4b): The general procedure A was followed using styrene (**1x**, 21 mg, 0.20 mmol) and 1-(2-bromovinyl)-4-methylbenzene (**2b**, 79 mg, 0.40 mmol). Purification of this material by chromatography on silica gel (EtOAc : petroleum ether = 1 : 20) afforded product **4b** as a yellow solid (65 mg, 93% yield): Rf = 0.7 (EtOAc : petroleum ether = 1 : 10); **^{1}H NMR** ($CDCl_3$, 400 MHz) δ: 7.28-7.27 (m, 3H), 7.24-7.14 (m, 4H), 7.07-7.06 (m, 2H), 6.41-6.26 (m, 2H), 3.76 (q, *J* = 7.6 Hz, 1H), 2.30 (s, 3H), 1.43-1.33 (m, 2H), 1.13 (s, 12H); **^{13}C NMR** ($CDCl_3$, 100 MHz) δ: 145.9, 136.6, 134.8, 134.6, 129.1, 128.3, 128.1, 127.4, 126.0, 83.1, 44.4, 24.8, 24.7, 21.1 ppm; **HRMS** (ESI-TOF) *m/z* calcd for $C_{23}H_{30}BO_2$ $(M + H)^+$: 348.2375, found 348.2371.



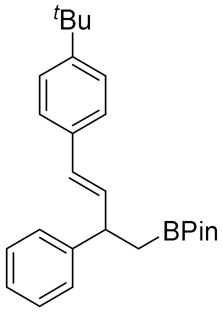
4c

(*E*)-4,4,5,5-tetramethyl-2-(2-phenyl-4-(*m*-tolyl)but-3-en-1-yl)-1,3,2-dioxaborolane (4c): The general procedure A was followed using styrene (**1x**, 21 mg, 0.20 mmol) and 1-(2-bromovinyl)-3-methylbenzene (**2c**, 79 mg, 0.40 mmol). Purification of this material by chromatography on silica gel (EtOAc : petroleum ether = 1 : 20) afforded product **4c** as a yellow solid (63mg, 90% yield): Rf = 0.8 (EtOAc : petroleum ether = 1 : 10); **^{1}H NMR** ($CDCl_3$, 600 MHz) δ: 7.28-7.25 (m, 4H), 7.18-7.11 (m, 4H), 7.00-6.98 (m, 1H), 6.40-6.34 (m, 2H), 3.79-3.75 (m, 1H), 2.30 (s, 3H), 1.42-1.33 (m, 2H), 1.14 (s, 12H); **^{13}C NMR** ($CDCl_3$, 150 MHz) δ: 145.8, 137.9, 137.6, 135.5, 128.31, 128.29, 127.7, 127.5, 126.8, 126.1, 123.4, 83.1, 44.4, 24.8, 24.7, 21.4 ppm; **HRMS** (ESI-TOF) *m/z* calcd for $C_{23}H_{30}BO_2$ $(M + H)^+$: 348.2375, found 348.2373.



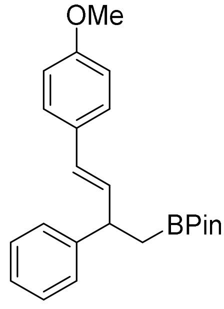
4d

(*E*)-4,4,5,5-tetramethyl-2-(2-phenyl-4-(*o*-tolyl)but-3-en-1-yl)-1,3,2-dioxaborolane (4d): The general procedure A was followed using styrene (**1x**, 21 mg, 0.20 mmol) and 1-(2-bromovinyl)-2-methylbenzene1 (**2d**, 79 mg, 0.40 mmol). Purification of this material by chromatography on silica gel (EtOAc : petroleum ether = 1 : 20) afforded product **4d** as a yellow solid (61 mg, 87% yield): Rf = 0.8 (EtOAc : petroleum ether = 1 : 10); **^{1}H NMR** ($CDCl_3$, 600 MHz) δ: 7.40-7.38 (m, 1H), 7.30-7.26 (m, 4H), 7.18-7.15 (m, 1H), 7.11-7.08 (m, 3H), 6.63 (dd, J_1 = 15.6, J_2 = 1.2 Hz, 1H), 6.24 (dd, J_1 = 15.6, J_2 = 7.8 Hz, 1H), 3.82-3.78 (m, 1H), 2.31 (s, 3H), 1.43-1.35 (m, 2H), 1.13 (s, 12H); **^{13}C NMR** ($CDCl_3$, 150 MHz) δ: 145.8, 137.0, 136.7, 135.1, 130.1, 128.3, 127. 5, 126.8, 126.1, 126.0, 125.9, 125.6, 83.1, 44.6, 24.8, 24.7, 19.8 ppm; **HRMS** (ESI-TOF) *m/z* calcd for $C_{23}H_{30}BO_2$ $(M + H)^+$: 348.2375, found 348.2369.



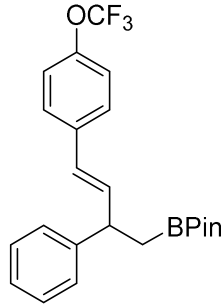
4e

(*E*)-2-(4-(4-(tert-butyl)phenyl)-2-phenylbut-3-en-1-yl)-4,4,5,5-tetramethyl-1,3,2-dioxaborolane (4e): The general procedure A was followed using styrene (**1x**, 21 mg, 0.20 mmol) and 1-(2-bromovinyl)-4-(tert-butyl)benzene (**2e**, 96 mg, 0.40 mmol). Purification of this material by chromatography on silica gel (EtOAc : petroleum ether = 1 : 20) afforded product **4e** as a yellow solid (73 mg, 94% yield): Rf = 0.8 (EtOAc : petroleum ether = 1 : 10); **^{1}H NMR** ($CDCl_3$, 400 MHz) δ: 7.30-7.25 (m, 8H), 7.19-7.14 (m, 1H), 6.42-6.30 (m, 2H), 3.77 (q, *J* = 7.6 Hz, 1H 1.40-1.35 (m, 2H), 1.29 (s, 9H), 1.14 (s, 12H); **^{13}C NMR** ($CDCl_3$, 100 MHz) δ: 149.9, 145.9, 134.93, 134.85, 128.3, 128.0, 127.5, 126.0, 125.8, 125.3, 83.1, 44.3, 34.5, 31.3, 24.8, 24.7 ppm; **HRMS** (ESI-TOF) *m/z* calcd for $C_{26}H_{36}BO_2$ $(M + H)^+$: 390.2845, found 390.2846.



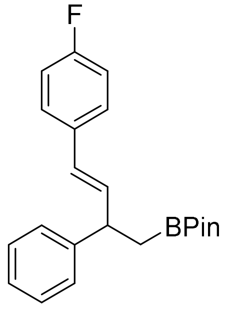
4f

(*E*)-2-(4-(4-methoxyphenyl)-2-phenylbut-3-en-1-yl)-4,4,5,5-tetramethyl-1,3,2-dioxaborolane (4f): The general procedure A was followed using styrene (**1x**, 21 mg, 0.20 mmol) and 1-(2-bromovinyl)-4-methoxybenzene (**2f**, 85 mg, 0.40 mmol). Purification of this material by chromatography on silica gel (EtOAc : petroleum ether = 1 : 20) afforded product **4f** as a yellow solid (57 mg, 78% yield): Rf = 0.5 (EtOAc : petroleum ether = 1 : 10); **^{1}H NMR** ($CDCl_3$, 400 MHz) δ: 7.28-7.24 (m, 6H), 7.20-7.14 (m, 1H), 6.81-6.79 (m, 2H), 6.36 (d, *J* = 15.6 Hz, 1H), 6.21 (dd, J_1 = 15.6, J_2 = 7.2 Hz, 1H), 3.81-3.73 (m, 4H), 1. 42-1.33 (m, 2H), 1.13 (s, 12H); **^{13}C NMR** ($CDCl_3$, 100 MHz) δ: 158.6, 146.0, 133.4, 130.4, 128.3, 127.6, 127.4, 127.2, 126.0, 113.8, 83.1, 55.2, 44.3, 24.8, 24.6 ppm; **HRMS** (ESI-TOF) *m/z* calcd for $C_{23}H_{30}BO_3$ $(M + H)^+$: 364.2324, found 364.2327.



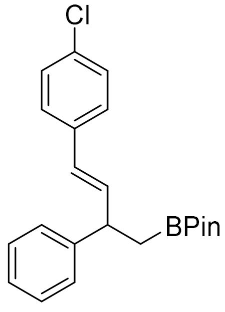
4g

(*E*)-4,4,5,5-tetramethyl-2-(2-phenyl-4-(4-(trifluoromethoxy)phenyl)but-3-en-1-yl)-1,3,2-dioxaborolane (4g): The general procedure A was followed using styrene (**1x**, 21 mg, 0.20 mmol) and 1-(2-bromovinyl)-4-(trifluoromethoxy)benzene (**2g**, 107 mg, 0.40 mmol). Purification of this material by chromatography on silica gel (EtOAc : petroleum ether = 1 : 20) afforded product **4g** as a yellow solid (69 mg, 83% yield): Rf = 0.5 (EtOAc : petroleum ether = 1 : 10); **^{1}H NMR** ($CDCl_3$, 400 MHz) δ: 7.33-7.27 (m, 6H), 7.20-7.16 (m, 1H), 7.13-7.09 (m, 2H), 6.42-6.32 (m, 2H), 3.80-3.75 (m, 1H), 1.41-1.36 (m, 2H), 1.13 (s, 12H); **^{13}C NMR** ($CDCl_3$, 100 MHz) δ: 148.0, 145.4, 136.8, 136.4, 128.4, 127.4, 127.3, 126.8, 126.2, 121.0, 120.4 (q, *J* = 255.4 Hz), 83.2, 44.3, 24.8, 24.7 ppm; ^{19}**F NMR** ($CDCl_3$, 376 MHz) δ: -57.77. **HRMS** (ESI-TOF) *m/z* calcd for $C_{23}H_{27}BF_3O_3$ $(M + H)^+$: 418.2042, found 418.2045.



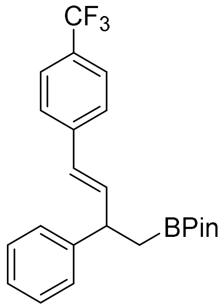
4h

(*E*)-2-(4-(4-fluorophenyl)-2-phenylbut-3-en-1-yl)-4,4,5,5-tetramethyl-1,3,2-dioxaborolane (4h): The general procedure A was followed using styrene (**1x**, 21 mg, 0.20 mmol) and 1-(2-bromovinyl)-4-fluorobenzene (**2h**, 80 mg, 0.40 mmol). Purification of this material by chromatography on silica gel (EtOAc : petroleum ether = 1 : 20) afforded product **4h** as a yellow solid (64 mg, 91% yield): Rf = 0.8 (EtOAc : petroleum ether = 1 : 10); ^{1}**H NMR** ($CDCl_3$, 400 MHz) δ: 7.29-7.25 (m, 6H), 7.19-7.15 (m, 1H), 6.97-6.92 (m, 2H), 6.39-6.25 (m, 2H), 3.76 (q, *J* = 7.6 Hz, 1H), 1.42-1.35 (m, 2H), 1.13 (s, 12H); ^{13}**C NMR** ($CDCl_3$, 100 MHz) δ: 161.9 (d, *J* = 244.5 Hz), 145.6, 135.4 (d, *J* = 2.3 Hz), 133.7 (d, *J* = 3.2 Hz), 128.4, 127.5 (d, *J* = 7.9 Hz), 127.4, 127.1, 126.1, 115.2 (d, *J* = 21.3 Hz), 83.2, 44.3, 24.8, 24.6 ppm; ^{19}**F NMR** ($CDCl_3$, 376 MHz) δ: -115.41- -115.49 (m, 1F). **HRMS** (ESI-TOF) *m/z* calcd for $C_{22}H_{27}BFO_2$ $(M + H)^+$: 352.2124, found 352.2118.



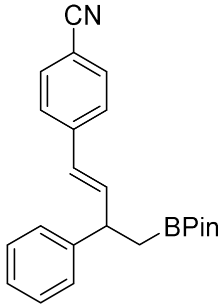
4i

(*E*)-2-(4-(4-chlorophenyl)-2-phenylbut-3-en-1-yl)-4,4,5,5-tetramethyl-1,3,2-dioxaborolane (4i): The general procedure A was followed using styrene (**1x**, 21 mg, 0.20 mmol) and 1-(2-bromovinyl)-4-chlorobenzene (**2i**, 87 mg, 0.40 mmol). Purification of this material by chromatography on silica gel (EtOAc : petroleum ether = 1 : 20) afforded product **4i** as a yellow solid (63 mg, 85% yield): Rf = 0.8 (EtOAc : petroleum ether = 1 : 10); ^{1}**H NMR** ($CDCl_3$, 400 MHz) δ: 7.31-7.26 (m, 4H), 7.24-7.16 (m, 5H), 6.39-6.30 (m, 2H), 3.79-3.74 (m, 1H), 1.40-1.33 (m, 2H), 1.13 (s, 12H); ^{13}**C NMR** ($CDCl_3$, 100 MHz) δ: 145.5, 136.4, 136.1, 132.5, 128.5, 128.4, 127.4, 127.3, 127.1, 126.2, 83.2, 44.4, 24.8, 24.7 ppm; **HRMS** (ESI-TOF) *m/z* calcd for $C_{22}H_{27}BClO_2$ $(M + H)^+$: 368.1829, found 368.1828.



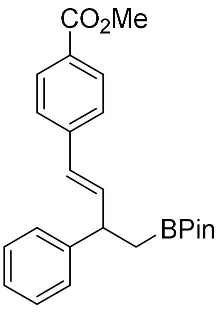
4j

(E)-4,4,5,5-tetramethyl-2-(2-phenyl-4-(4-(trifluoromethyl)phenyl)but-3-en-1-yl)-1,3,2-dioxaborolane (4j): The general procedure A was followed using styrene (**1x**, 21 mg, 0.20 mmol) and 1-(2-bromovinyl)-4-fluorobenzene (**2j**, 100 mg, 0.40 mmol). Purification of this material by chromatography on silica gel (EtOAc : petroleum ether = 1 : 20) afforded product **4j** as a yellow solid (58 mg, 72% yield): Rf = 0.8 (EtOAc : petroleum ether = 1 : 10); **^{1}H NMR** ($CDCl_3$, 400 MHz) δ: 7.52-7.50 (m, 2H), 7.42-7.40 (m, 2H), 7.32-7.26 (m, 4H), 7.21-7.17 (m, 1H), 6.52-6.41 (m, 2H), 3.80 (q, J = 7.6 Hz, 1H), 1.44-1.35 (m, 2H), 1.14 (s, 12H); **^{13}C NMR** ($CDCl_3$, 100 MHz) δ: 145.1, 141.1, 138.4, 128.4, 127.4, 127.1, 126.3, 126.2, 125.4 (q, J = 3.8 Hz), 124.2 (q, J = 270.3 Hz), 83.2, 44.4, 24.8, 24.6 ppm; ^{19}F NMR ($CDCl_3$, 376 MHz) δ: -62.25; **HRMS** (ESI-TOF) *m/z* calcd for $C_{23}H_{27}BF_3O_2$ $(M + H)^+$: 402.2093, found 402.2086.



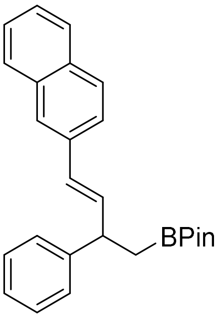
4k

(E)-4-(3-phenyl-4-(4,4,5,5-tetramethyl-1,3,2-dioxaborolan-2-yl)but-1-en-1-yl)benzonitrile (4k): The general procedure A was followed using styrene (**1x**, 21 mg, 0.20 mmol) and 4-(2-bromovinyl)benzonitrile (**2k**, 83 mg, 0.40 mmol). Purification of this material by chromatography on silica gel (EtOAc : petroleum ether = 1 : 10) afforded product **4k** as a yellow solid (54 mg, 75% yield): Rf = 0.2 (EtOAc : petroleum ether = 1 : 10); **^{1}H NMR** ($CDCl_3$, 400 MHz) δ: 7.56-7.53 (m, 2H), 7.40-7.37 (m, 2H), 7.32-7.26 (m, 4H), 7.22-7.17 (m, 1H), 6.55-6.38 (m, 2H), 3.80 (q, J = 7.6 Hz, 1H), 1.42-1.35 (m, 2H), 1.13 (s, 12H); **^{13}C NMR** ($CDCl_3$, 100 MHz) δ: 144.8, 142.1, 139.9, 132.3, 128.5, 127.4, 126.9, 126.6, 126.4, 119.1, 110.1, 83.2, 44.5, 24.7, 24.6 ppm; **HRMS** (ESI-TOF) *m/z* calcd for $C_{23}H_{27}BNO_2$ $(M + H)^+$: 359.2171, found 359.2178.



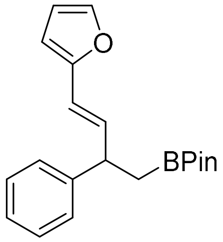
4l

Methyl(*E*)-4-(3-phenyl-4-(4,4,5,5-tetramethyl-1,3,2-dioxaborolan-2-yl)but-1-en-1-yl)benzoate (4l): The general procedure A was followed using styrene (**1x**, 21 mg, 0.20 mmol) and methyl 4-(2-bromovinyl)benzoate (**2l**, 96 mg, 0.40 mmol). Purification of this material by chromatography on silica gel (EtOAc : petroleum ether = 1 : 10) afforded product **4l** as a yellow solid (73 mg, 93% yield): Rf = 0.2 (EtOAc : petroleum ether = 1 : 10); **^{1}H NMR** (CDCl$_3$, 400 MHz) δ: 7.95-7.92 (m, 2H), 7.38-7.36 (m, 2H), 7.32-7.25 (m, 4H), 7.21-7.16 (m, 1H), 6.54-6.42 (m, 2H), 3.89 (s, 3H), 3.80 (q, *J* = 7.6 Hz, 1H), 1.44-1.34 (m, 2H), 1.13 (s, 12H); **^{13}C NMR** (CDCl$_3$, 100 MHz) δ: 166.9, 145.2, 142.2, 138.5, 129.8, 128.4, 127.5, 127.4, 126.3, 126.0, 83.2, 51.9, 44.5, 24.8, 24.6 ppm; **HRMS** (ESI-TOF) *m/z* calcd for $C_{24}H_{30}BO_4$ $(M + H)^+$: 392.2274, found 392.2282.



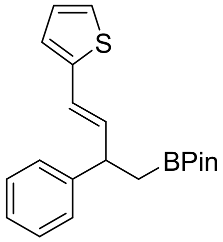
4m

(*E*)-4,4,5,5-tetramethyl-2-(4-(naphthalen-2-yl)-2-phenylbut-3-en-1-yl)-1,3,2-dioxaborolane (4m): The general procedure A was followed using styrene (**1x**, 21 mg, 0.20 mmol) and 2-(2-bromovinyl)naphthalene (**2m**, 93 mg, 0.30 mmol). Purification of this material by chromatography on silica gel (EtOAc : petroleum ether = 1 : 20) afforded product **4m** as a yellow solid (66 mg, 86% yield): Rf = 0.6 (EtOAc : petroleum ether = 1 : 10); **^{1}H NMR** (CDCl$_3$, 400 MHz) δ: 7.77-7.67 (m, 4H), 7.57-7.54 (m, 1H), 7.45-7.37 (m, 2H), 7.34-7.28 (m, 4H), 7.21-7.17 (m, 1H), 6.61-6.48 (m, 2H), 3.84 (q, *J* = 7.6 Hz, 1H), 1.48-1.37 (m, 2H), 1.14 (s, 12H); **^{13}C NMR** (CDCl$_3$, 100 MHz) δ: 145.7, 136.1, 135.1, 133.7, 132.7, 128.5, 128.4, 128.0, 127.8, 127.6, 127.5, 126.2, 126.1, 125.7, 125.5, 123.7, 83.2, 44.5, 24.8, 24.7 ppm; **HRMS** (ESI-TOF) *m/z* calcd for $C_{26}H_{30}BO_2$ $(M + H)^+$: 384.2375, found 384.2376.



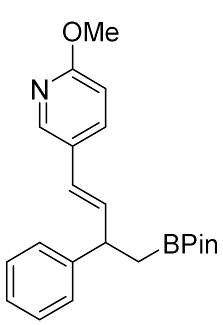
4n

(*E*)-2-(4-(furan-2-yl)-2-phenylbut-3-en-1-yl)-4,4,5,5-tetramethyl-1,3,2-dioxaborolane (4n): The general procedure A was followed using styrene (**1x**, 21 mg, 0.20 mmol) and 2-(2-bromovinyl)furan (**2n**, 69 mg, 0.40 mmol). Purification of this material by chromatography on silica gel (EtOAc : petroleum ether = 1 : 20) afforded product **4n** as a yellow solid (55 mg, 84% yield): Rf = 0.6 (EtOAc : petroleum ether = 1 : 10); ^{1}**H NMR** ($CDCl_3$, 400 MHz) δ: 7.30-7.26 (m, 5H), 7.19-7.15 (m, 1H), 6.37-6.31 (m, 2H), 6.19 (dd, J_1 = 15.6 Hz, J_2 = 1.2 Hz, 1H), 6.12 (d, J = 3.6 Hz, 1H), 3.77-3.71 (m, 1H), 1.37-1.34 (m, 2H), 1.13 (s, 6H), 1.12 (s, 6H); ^{13}**C NMR** ($CDCl_3$, 100 MHz) δ: 153.2, 145.4, 141.3, 134.7, 128.3, 127.5, 126.2, 117.1, 111.1, 106.5, 83.2, 44.1, 24.72, 24.65 ppm; **HRMS** (ESI-TOF) *m/z* calcd for $C_{20}H_{24}BO_3$ $(M - H)^-$: 322.1855, found 322.1852.



4o

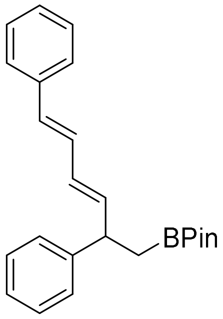
(*E*)-4,4,5,5-tetramethyl-2-(2-phenyl-4-(thiophen-2-yl)but-3-en-1-yl)-1,3,2-dioxaborolane (4o): The general procedure A was followed using styrene (**1x**, 21 mg, 0.20 mmol) and 2-(2-bromovinyl)thiophene (**2o**, 76 mg, 0.40 mmol). Purification of this material by chromatography on silica gel (EtOAc : petroleum ether = 1 : 20) afforded product **4o** as a yellow solid (53 mg, 78% yield): Rf = 0.6 (EtOAc : petroleum ether = 1 : 10); ^{1}**H NMR** ($CDCl_3$, 400 MHz) δ: 7.30-7.25 (m, 4H), 7.19-7.15 (m, 1H), 7.07-7.05 (m, 1H), 6.91-6.89 (m, 1H), 6.86-6.84 (m, 1H), 6.51 (dd, J_1 = 15.6 Hz, J_2 = 1.2 Hz, 1H), 6.23 (dd, J_1 = 15.6 Hz, J_2 = 6.8 Hz, 1H), 3.77-3.71 (m, 1H), 1.39-1.32 (m, 2H), 1.14 (s, 12H); ^{13}**C NMR** ($CDCl_3$, 100 MHz) δ: 145.4, 142.8, 135.5, 128.3, 127.5, 127.1, 126.1, 124.6, 123.3, 121.7, 83.2, 44.1, 24.8, 24.7 ppm; **HRMS** (ESI-TOF) *m/z* calcd for $C_{20}H_{24}BO_2S$ $(M - H)^-$: 338.1626, found 338.1620.



4p

(*E*)-2-methoxy-5-(3-phenyl-4-(4,4,5,5-tetramethyl-1,3,2-dioxaborolan-2-yl)but-1-en-1-yl)pyridine (4p): The general procedure A was followed using styrene (**1x**, 21 mg, 0.20 mmol) and

5-(2-bromovinyl)-2-methoxypyridine (**2p**, 85 mg, 0.40 mmol). Purification of this material by chromatography on silica gel (EtOAc : petroleum ether = 1 : 10) afforded product **4p** as a yellow solid (55 mg, 76% yield): Rf = 0.3 (EtOAc : petroleum ether = 1 : 10); **^{1}H NMR** ($CDCl_3$, 400 MHz) δ: 8.04 (d, *J* = 2.4 Hz, 1H), 7.61 (dd, J_1 = 8.8Hz, J_2 = 2.4 Hz, 1H), 7.31-7.26 (m, 4H), 7.20-7.16 (m, 1H), 6.66 (d, *J* = 8.8 Hz, 1H), 6.37-6.23 (m, 2H), 3.91 (s, 3H), 3.80-3.73 (m, 1H), 1.43-1.31 (m, 2H), 1.14 (s, 12H); **^{13}C NMR** ($CDCl_3$, 100 MHz) δ: 163.2, 145.6, 145.1, 135.4, 135.0, 128.4, 127.4, 126.7, 126.2, 124.4, 110.7, 83.2, 53.4, 44.4, 24.8, 24.7 ppm; **HRMS** (ESI-TOF) *m/z* calcd for $C_{22}H_{29}BNO_3$ $(M + H)^+$: 365.2277, found 365.2287.

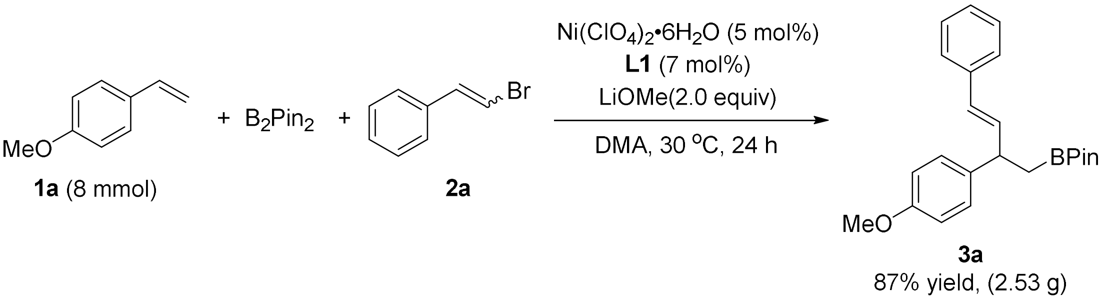


4q

2-((3*E*,5*E*)-2,6-diphenylhexa-3,5-dien-1-yl)-4,4,5,5-tetramethyl-1,3,2-dioxaborolane (4q): The general procedure A was followed using styrene (**1x**, 21 mg, 0.20 mmol) and ((1E)-4-bromobuta-1,3-dien-1-yl)benzene (**2a**, 84 mg, 0.40 mmol). Purification of this material by chromatography on silica gel (EtOAc : petroleum ether = 1 : 20) afforded product **4q** as a yellow solid (56 mg, 78% yield, >20:1 dr): Rf = 0.5 (EtOAc : petroleum ether = 1 : 10); **^{1}H NMR** ($CDCl_3$, 400 MHz) δ: 7.36-7.33 (m, 2H), 7.31-7.25 (m, 5H), 7.24-7.23 (m, 1H), 7.20-7.15 (m, 2H), 6.75 (dd, J_1 = 15.6 Hz, J_2 = 10.0 Hz, 1H), 6.44 (d, *J* = 15.6 Hz, 1H), 6.22 (dd, J_1 = 15.2Hz, J_2 = 10.4 Hz, 1H), 5.99 (dd, J_1 = 15.2 Hz, J_2 = 7.2 Hz, 1H), 3.71 (q, *J* = 7.6 Hz, 1H), 1.35-1.32 (m, 2H), 1.14 (s, 12H); **^{13}C NMR** ($CDCl_3$, 100 MHz) δ: 145.7, 140.3, 137.6, 133.5, 132.6, 130.7, 129.2, 129.0, 128.5, 128.3, 127.4, 127.1, 126.13, 126.09, 83.2, 44.3, 24.8, 24.7 ppm; **HRMS** (ESI-TOF) *m/z* calcd for $C_{24}H_{30}BO_2$ $(M + H)^+$: 360.2375, found 360.2383.

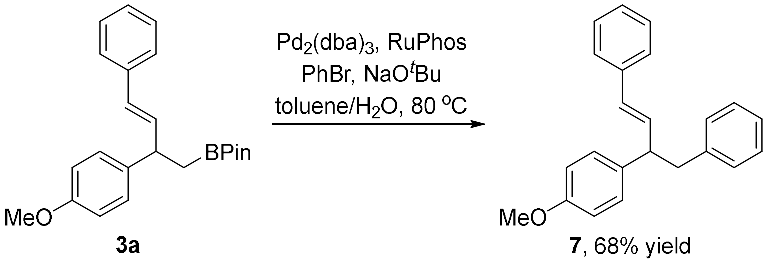
6. Further transformations for the product

6-1 Gram scale reaction



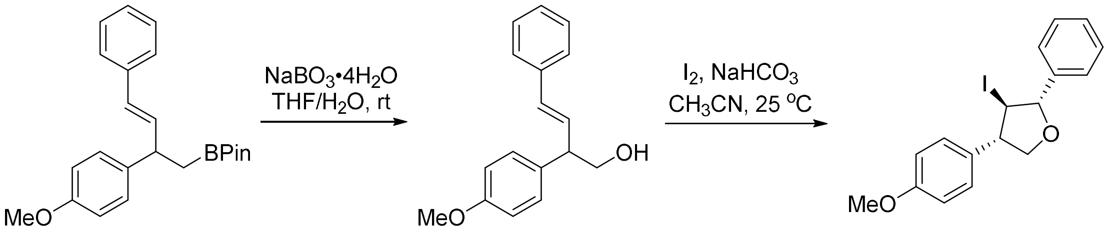
In an oven dried 250-ml Schlenk tube, which contained a stirring bar, was charged with $Ni(ClO_4)_2{\cdot}6H_2O$ (146 mg, 0.4 mmol), **L1** (127 mg, 0.56 mmol), B_2Pin_2 (4.06 g, 16.0 mmol), and LiOMe (608 mg, 16.0 mmol). The tube was then evacuated and back-filled under a N_2 flow (this sequence was repeated three times). Anhydrous DMA (80 ml) was added under N_2, then 1-methoxy-4-vinylbenzene (**1a**, 1.07 g, 8.0 mmol) and (2-bromovinyl)benzene (**2a**, 2.93 g, 16.0 mmol) was added subsequently under N_2, the tube was stirred at 30 °C for 24 h. The resulting mixture was diluted with EtOAc (80 mL) and quenched by H_2O (80 mL). Then it was extracted with EtOAc (100 ml × 3). The organic layer was combined and dried over Na_2SO_4, filtered and concentrated by rotary evaporation. The residue was purified by chromatography on silica gel (EtOAc : petroleum ether = 1 : 50) afforded product **3a** as a yellow solid (2.53 g, 87% yield).

6-2 Procedure for synthesis of **7** [13]



In an oven dried 10-ml Schlenk tube, which contained a stirring bar, was charged with **3a** (73 mg, 0.2 mmol), $Pd_2(dba)_3$ (3.7 mg, 0.004 mmol), NaO^{t}Bu (77 mg, 0.8 mmol), and Ruphos (3.7 mg, 0.008 mmol) the tube was then evacuated and back-filled under a N_2 flow (this sequence was repeated three times). Anhydrous toluene (1.0 mL), H_2O (60 ul) and bromobenzene (94 mg, 0.6 mmol) was added subsequently under N_2, the resulting mixture was allowed to stir at 80 °C for 24 hours. The reaction mixture diluted with EtOAc (5.0 ml) and H_2O (5.0 ml). Then it was extracted with EtOAc (5.0 ml × 3). The organic layer was combined and dried over Na_2SO_4, filtered and concentrated by rotary evaporation. The residue was purified by silica gel chromatography (EtOAc : petroleum ether = 1 : 40) to afford the product **7** as a colorless oil (43 mg, 68% yield): R_f = 0.6 (EtOAc : petroleum ether = 1 : 20); **^{1}H NMR** ($CDCl_3$, 600 MHz) δ: 7.29-7.14 (m, 4H), 7.22-7.10 (m, 6H), 7.07 (d, *J* = 8.4 Hz, 2H), 6.82 (d, *J* = 8.4 Hz, 2H), 6.39 (dd, J_1 = 15.6 Hz, J_2 = 7.2 Hz, 1H), 6.27 (d, *J* = 15.6 Hz, 1H), 3.76 (s, 3H), 3.68 (q, *J* = 7.8 Hz, 1H), 3.12-3.03 (m, 2H); **^{13}C NMR** ($CDCl_3$, 150 MHz) δ: 158.0, 140.0, 137.5, 135.7, 133.6, 129.6, 129.2, 128.8, 128.4, 128.1, 127.0, 126.1, 125.9, 113.8, 55.2, 49.9, 42.7 ppm; **HRMS** (ESI-TOF) *m/z* calcd for $C_{23}H_{23}O$ $(M + H)^+$: 315.1749, found 315.1757.

6-3 Procedure for synthesis of **8** [14]

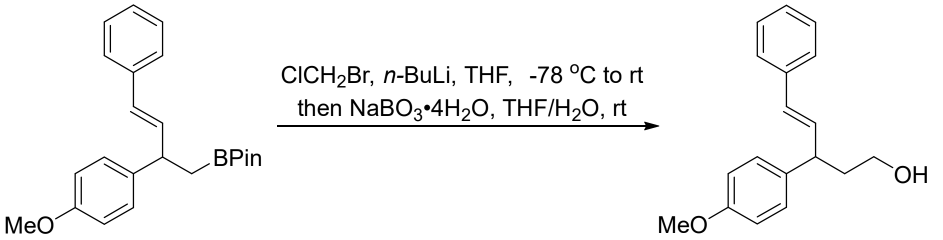


3a **3a-OH,** 92% yield **8**, 79% yield

In an oven dried 10-ml Schlenk tube, which contained a stirring bar, was charged with the solution of **3a** (73 mg, 0.2 mmol, THF 2 ml), $NaBO_3•4H_2O$ (154 mg, 1.0 mmol) and H_2O (2.0 mL) were added. The resulting mixture was allowed to stir at 25 °C for three hours. The reaction mixture diluted with EtOAc (5.0 ml) and H_2O (5.0 ml). Then it was extracted with EtOAc (5.0 ml × 3). The organic layer was combined and dried over Na_2SO_4, filtered and concentrated by rotary evaporation. The residue was purified by silica gel chromatography (EtOAc : petroleum ether = 1 : 5) to afford the product **3a-OH** as a white solid (47 mg, 92% yield): $R_f = 0.2$ (EtOAc : petroleum ether = 1 : 5); **^{1}H NMR** ($CDCl_3$, 400 MHz) δ: 7.38-7.35 (m, 2H), 7.31-7.27 (m, 2H), 7.23-7.19 (m, 3H), 6.91-6.88 (m, 2H), 6.52-6.32 (m, 2H), 3.88 (d, $J = 6.8$ Hz, 2H), 3.80 (s, 3H), 3.65 (q, $J = 7.2$ Hz, 1H), 1.61 (s, 1H); **^{13}C NMR** ($CDCl_3$, 100 MHz) δ: 158.6, 137.0, 132.7, 131.8, 130.0, 129.0, 128.5, 127.4, 126.2, 114.2, 66.4, 55.3, 50.9 ppm; **HRMS** (ESI-TOF) *m/z* calcd for $C_{17}H_{19}O_2$ $(M + H)^+$: 255.1385, found 255.1382.

In an oven dried 10-ml Schlenk tube, which contained a stirring bar, was charged with **3a-OH** (51 mg, 0.2 mmol), $NaHCO_3$ (50 mg, 0.6 mmol, 3.0 equiv.), I_2 (102 mg, 0.4 mmol, 2.0 equiv.), then CH_3CN (4 mL) were added under N_2. The resulting mixture was allowed to stir at 25 °C for 12 hours. A saturated solution of $Na_2S_2O_3$ (2 mL) was added, the reaction mixture diluted with EtOAc (5 ml) and H_2O (5 ml). Then it was extracted with EtOAc (5 ml × 3). The organic layer was combined and dried over Na_2SO_4, filtered and concentrated by rotary evaporation. The residue was purified by silica gel chromatography (EtOAc : petroleum ether = 1 : 20) to afford the product **8** as a white solid (60 mg, 79% yield): $R_f = 0.6$ (EtOAc : petroleum ether = 1 : 10); **^{1}H NMR** ($CDCl_3$, 600 MHz) δ: 7.54-7.51 (m, 2H), 7.41-7.32 (m, 3H), 7.26-7.22 (m, 2H), 6.91-6.89 (m, 2H), 5.16 (d, $J = 13.8$ Hz, 1H), 4.34 (t, $J = 13.2$ Hz, 1H), 4.11 (t, $J = 13.2$ Hz, 1H), 3.92 (t, $J = 14.4$ Hz, 1H), 3.80-3.73 (m, 4H); **^{13}C NMR** ($CDCl_3$, 150 MHz) δ: 159.0, 138.4, 130.2, 128.5, 128.5, 128.3, 126.6, 114.3, 89.6, 74.0, 56.5, 55.2, 36.9 ppm; **HRMS** (ESI-TOF) *m/z* calcd for $C_{17}H_{16}IO_2$ $(M - H)^-$: 379.0195, found 379.0199.

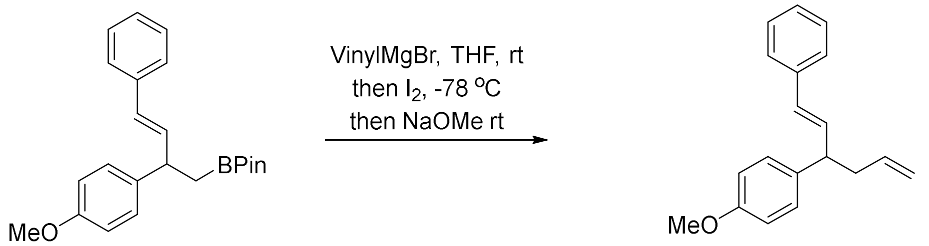
6-4 Procedure for synthesis of **9** [15]



3a **9**, 78% yield

In an oven dried 10-ml Schlenk tube, which contained a stirring bar, was charged with **3a** (73 mg, 0.2 mmol), the tube was then evacuated and back-filled under a N_2 flow (this sequence was repeated three times). Then THF (2.0 mL) and bromochloromethane (78 mg, 129 mmol) was added and the reaction was cooled to -78 ºC, followed by the dropwise addition of *n*-BuLi (0.24 mL, 2.5 M in hexanes, 0.6 mmol) at -78 ºC. The reaction stirred at -78 ºC for 10 minutes, then warmed to 25 °C and stirred for 12 h. The reaction mixture was quenched by H_2O (10 mL), then it was extracted with EtOAc (10 ml × 3). The organic layer was combined and dried over Na_2SO_4, filtered and concentrated by rotary evaporation. The residue was dissolved in THF (2.0 mL). $NaBO_3{\cdot}4H_2O$ (154 mg, 1.0 mmol,) and H_2O (2.0 mL) were added, the resulting mixture was allowed to stir at 25 °C for three hours. The reaction mixture diluted with EtOAc (5.0 ml) and H_2O (5.0 ml), then it was extracted with EtOAc (5.0 ml × 3). The organic layer was combined and dried over Na_2SO_4, filtered and concentrated by rotary evaporation. The residue was purified by silica gel chromatography (EtOAc: petroleum ether = 1:5) to afford the product **9** as a colorless oil (42 mg, 78% yield): R_f = 0.3 (EtOAc: petroleum ether = 1:5); **^{1}H NMR** ($CDCl_3$, 600 MHz) δ: 7.34-7.33 (m, 2H), 7.29-7.24 (m, 2H), 7.20-7.17 (m, 3H), 6.87-6.86 (m, 2H), 6.41 (d, *J* = 16.2 Hz, 1H), 6.31 (dd, J_1 = 16.2 Hz, J_2 = 7.8 Hz, 1H), 3.79 (s, 3H), 3.69-3.58 (m, 3H), 2.10-1.99 (m, 2H), 1.41 (s, 1H); **^{13}C NMR** ($CDCl_3$, 150 MHz) δ: 158.1, 137.3, 135.7, 133.8, 129.3, 128.51, 128.45, 127.1, 126.1, 114.0, 60.9, 55.2, 44.5, 38.4 ppm; **HRMS** (ESI-TOF) *m/z* calcd for $C_{18}H_{21}BO_2$ $(M + H)^+$: 269.1541, found 269.1548.

6-5 Procedure for synthesis of **10** [16]

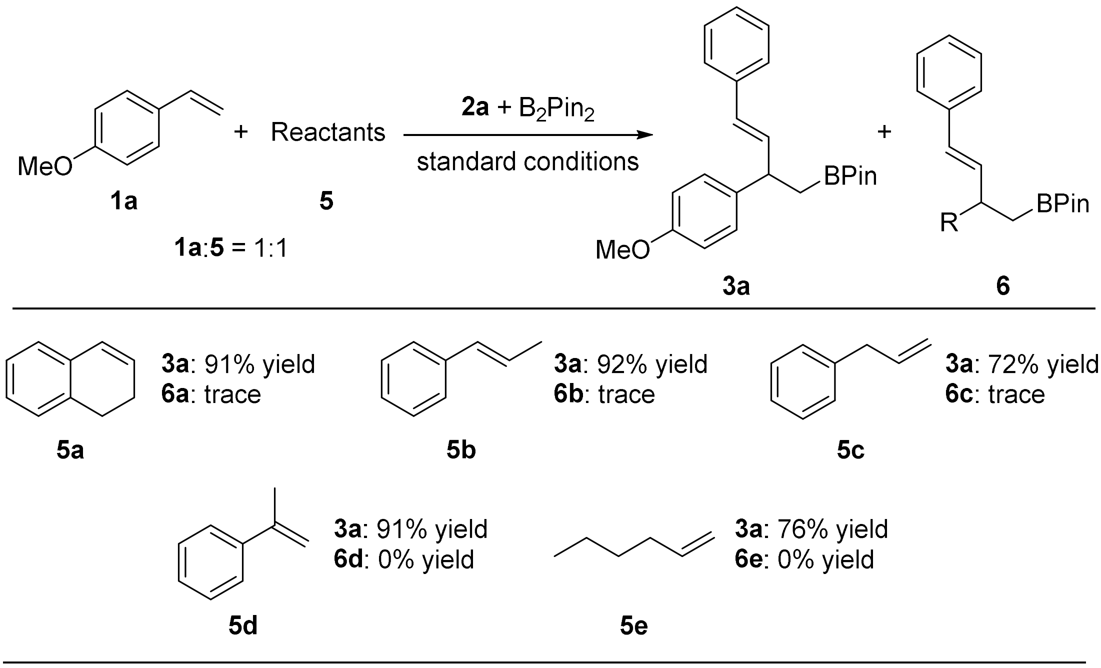


3a, 87% yield

10, 88% yield

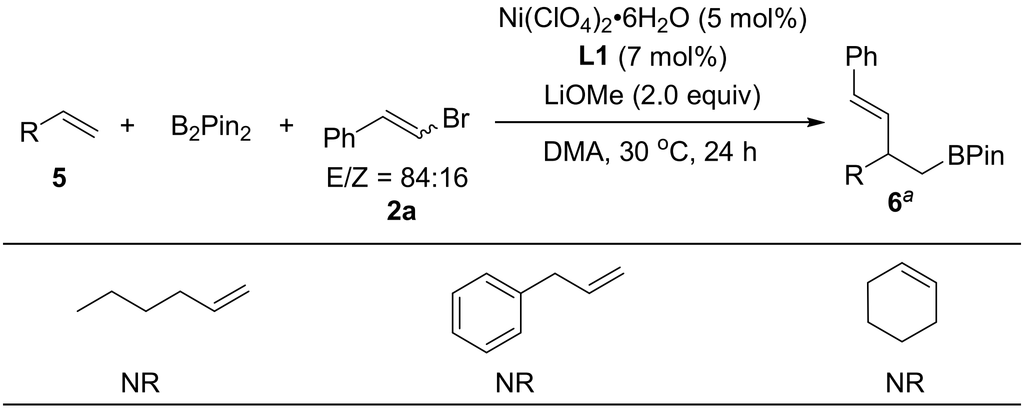
In an oven dried 10-ml Schlenk tube, which contained a stirring bar, was charged with **3a** (73 mg, 0.2 mmol), the tube was then evacuated and back-filled under a N_2 flow (this sequence was repeated three times). Then THF (2.0 mL) and vinylMgBr (0.80 mL, 1 M in THF, 0. 80 mmol) was added at 25 ºC, The resulting mixture was allowed to stir at same temperature for 0.5 h. A solution of I_2 (203 mg, 0.8 mmol, 2 mL MeOH) was then slowly added to the reaction mixture at -78 °C and stirred for 0.5 h. Then a solution of NaOMe (130 mg, 2.4 mmol, 2.4 mL MeOH) was added slowly at -78 °C. The resulting mixture was then warmed to 25 °C and stirred for 1 h. The reaction mixture was quenched by saturated aqueous $Na_2S_2O_3$ (5 mL), then it was extracted with EtOAc (10 ml × 3). The organic layer was combined and dried over Na_2SO_4, filtered and concentrated by rotary evaporation. The residue was purified by silica gel chromatography ((EtOAc : petroleum ether = 1 : 20) to afford the product **10** as a yellow oil (47 mg, 88% yield): R_f = 0.8 ((EtOAc : petroleum ether = 1 : 10); **^{1}H NMR** ($CDCl_3$, 600 MHz) δ: 7.34-7.32 (m, 2H), 7.28-7.25 (m, 2H), 7.21-7.15 (m, 3H), 6.87-6.84 (m, 2H), 6.38-6.31 (m, 2H), 5.79-5.72 (m, 1H), 5.06-4.97 (m, 2H), 3.78 (s, 3H), 3.48 (q, *J* = 7.2 Hz, 1H), 2.59-2.51 (m, 2H); **^{13}C NMR** ($CDCl_3$, 150 MHz) δ: 158.0, 137.4, 136.6, 135.8, 133.8, 129.4, 128.6, 128.4, 127.0, 126.1, 116.2, 113.8, 55.2, 48.0, 40.2 ppm; **HRMS** (ESI-TOF) *m/z* calcd for $C_{19}H_{19}O$ $(M - H)^-$: 263.1436, found 263.1439.

7. Competition reaction of different Reactants.



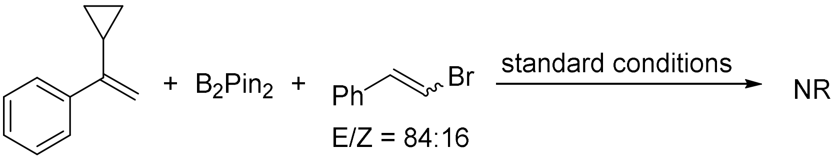
In an oven dried 25-ml Schlenk tube, which contained a stirring bar, was charged with $Ni(ClO_4)_2 \cdot 6H_2O$ (3.7 mg, 0.01 mmol), **L1** (3.2 mg, 0.014 mmol), B_2Pin_2 (102 mg, 0.4 mmol), and LiOMe (15 mg, 0.4 mmol). The tube was then evacuated and back-filled under a N_2 flow (this sequence was repeated three times), anhydrous DMA (2.0 ml) was added under N_2. then **1a** (27 mg, 0.2 mmol), **5** (0.2 mmol) and **2a** (73 mg, 0.4 mmol) was added subsequently under N_2, the tube was stirred at 30 °C for 24 h. The resulting mixture was diluted with EtOAc (2 mL) and quenched by H_2O (2 mL), then it was extracted with EtOAc (10 ml × 3), the organic layer was combined and dried over Na_2SO_4, filtered and concentrated by rotary evaporation give the crude product. *n*-Dodecane (23 μL) was added as an internal standard for GC-MS and GC analysis.

8. Some failed reaction



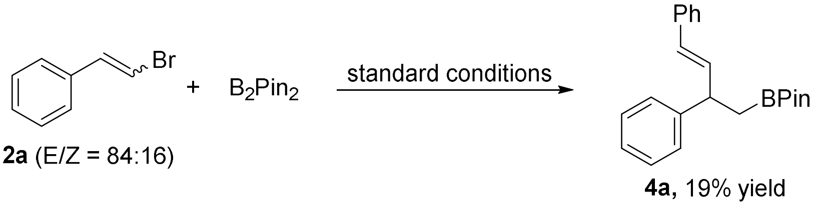
[a] Standard conditions: **5** (0.2 mmol), **2a** (0.4 mmol), $Ni(ClO_4)_2 \cdot 6H_2O$ (0.01 mmol), **L1** (0.014 mmol), LiOMe (0.4 mmol), DMA (2.0 mL), at 30 °C for 24 h.

9. discussion on mechanism



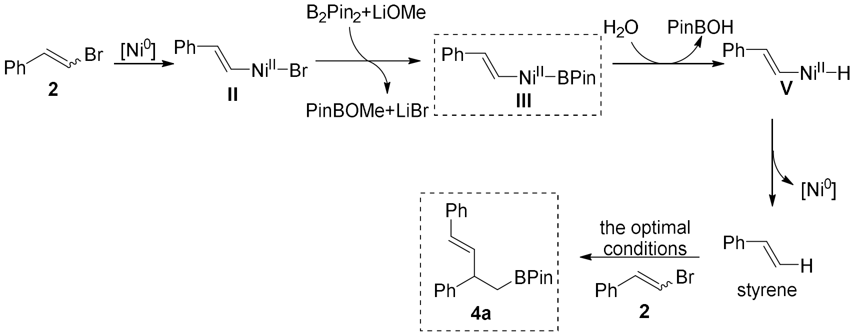
(eq. 9-1)

As shown at eq. 9-1, radical clock experiment was carried, but this chemistry did not work with this kind of substrate.



(eq. 9-2)

When this reaction was carried without alkene substrate, the product **4a** could be isolated with 19% yield (eq. 9-2). This data indicated that styrene should be produced in the reaction system. Based on the above result and the literatures, the proposed mechanism for the formation of **4a** was shown as Scheme S9-1. Notably, the compound **III** should be generated as key intermediate in this transformation. [17] The above information could verify the rationality of the proposed reaction mechanism in the text.



Scheme S9-1. The mechanism for the formation of **4a**

10. References

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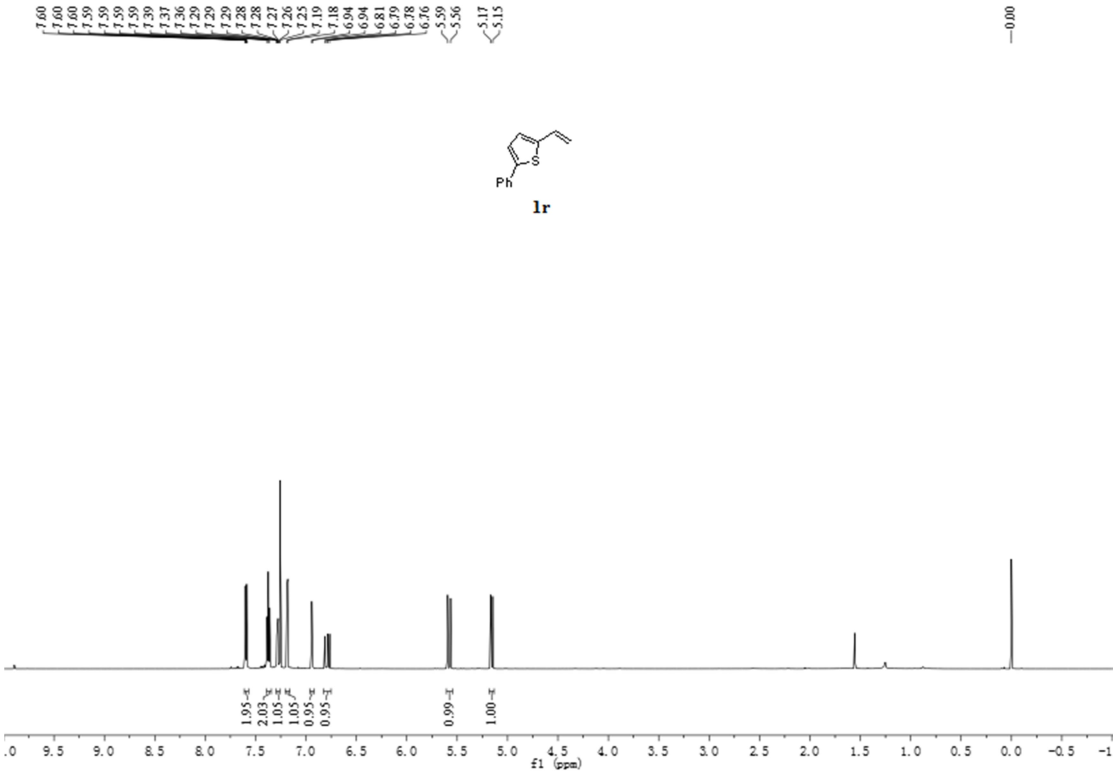
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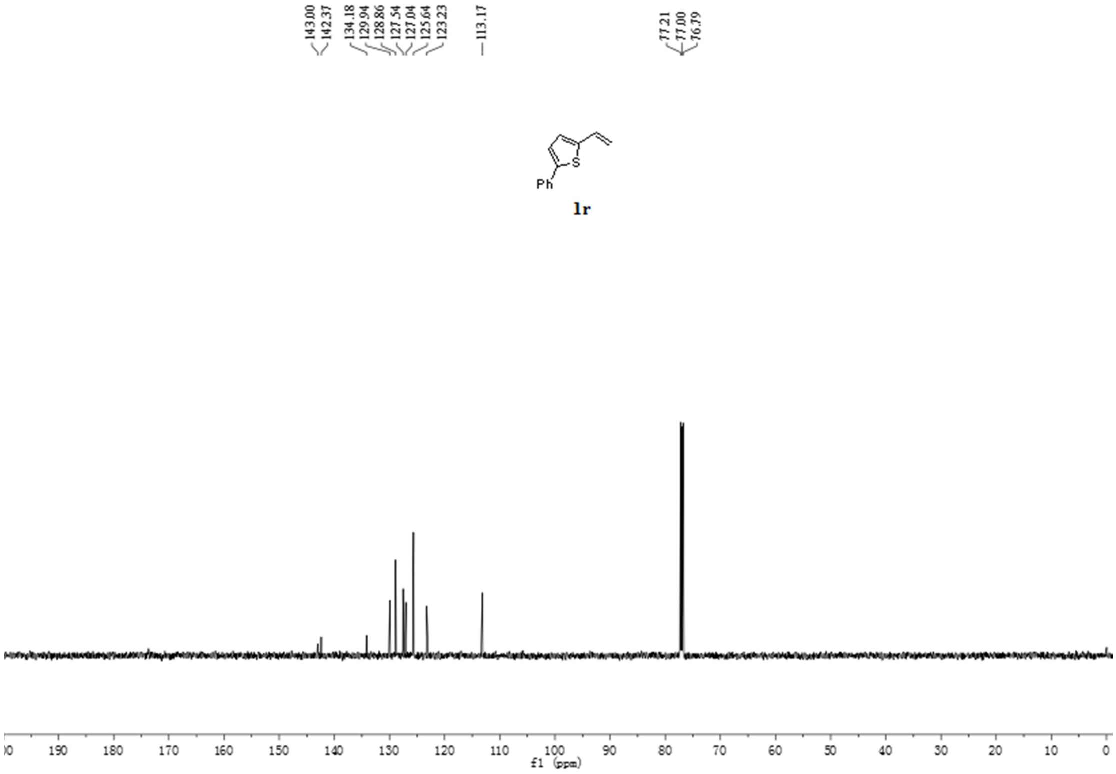
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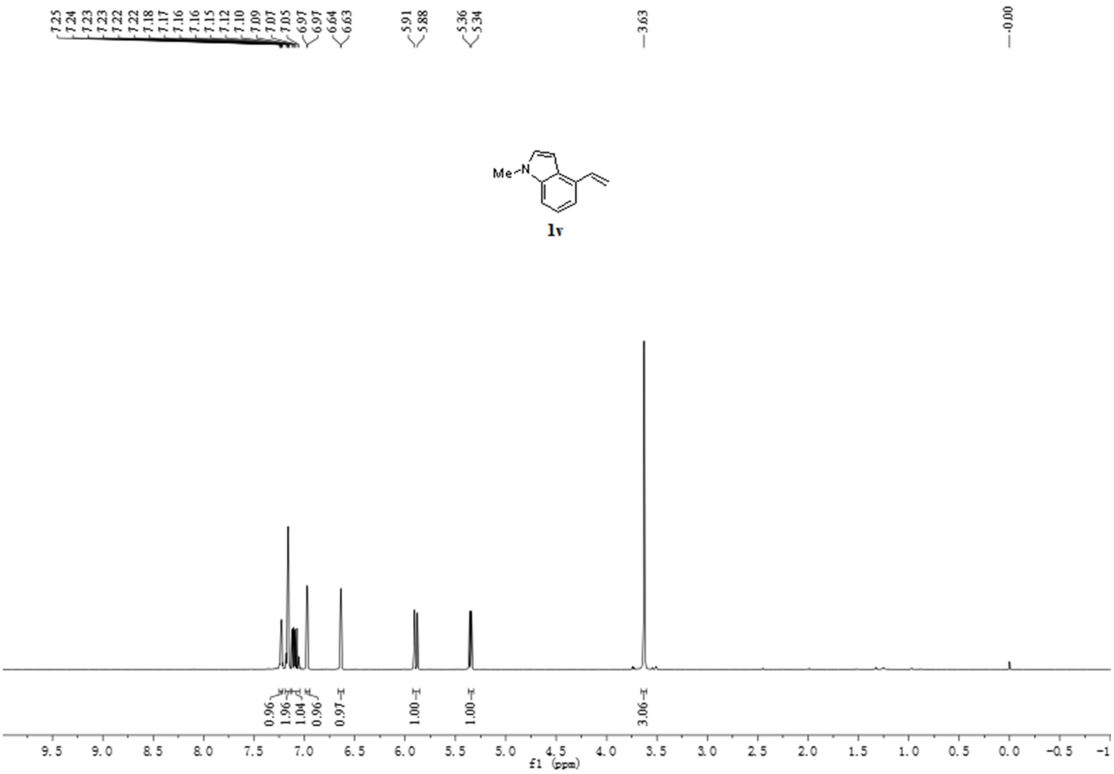
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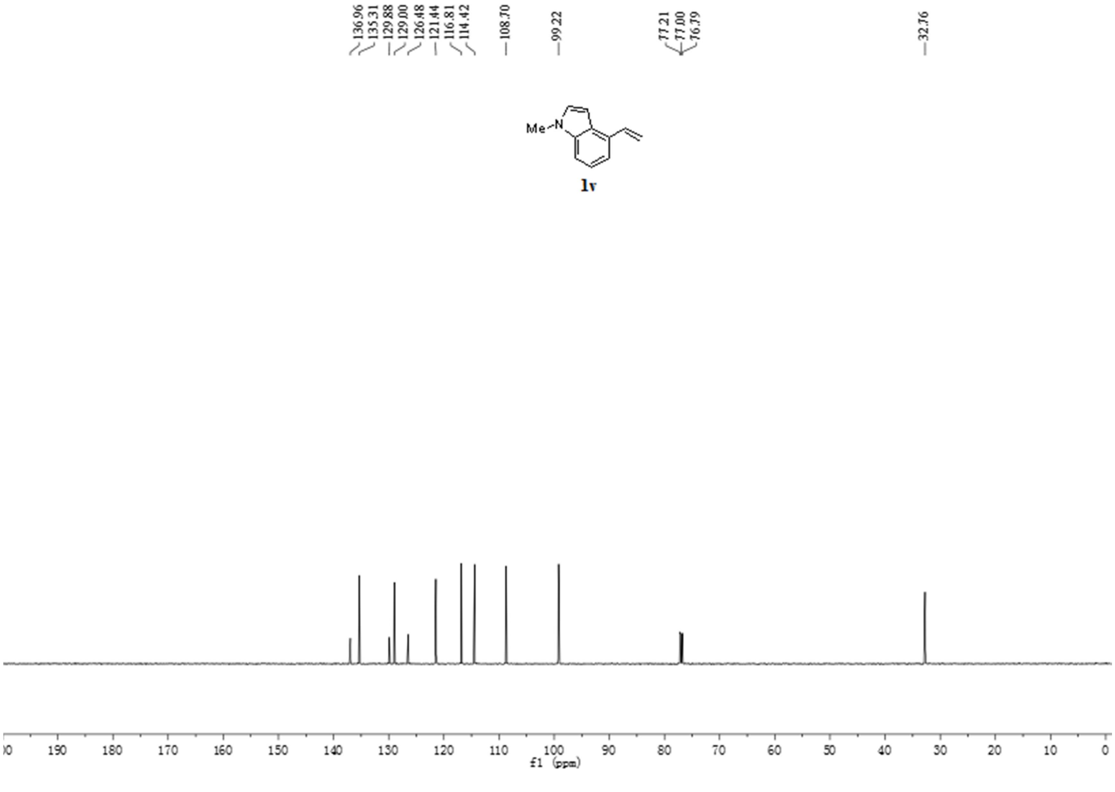
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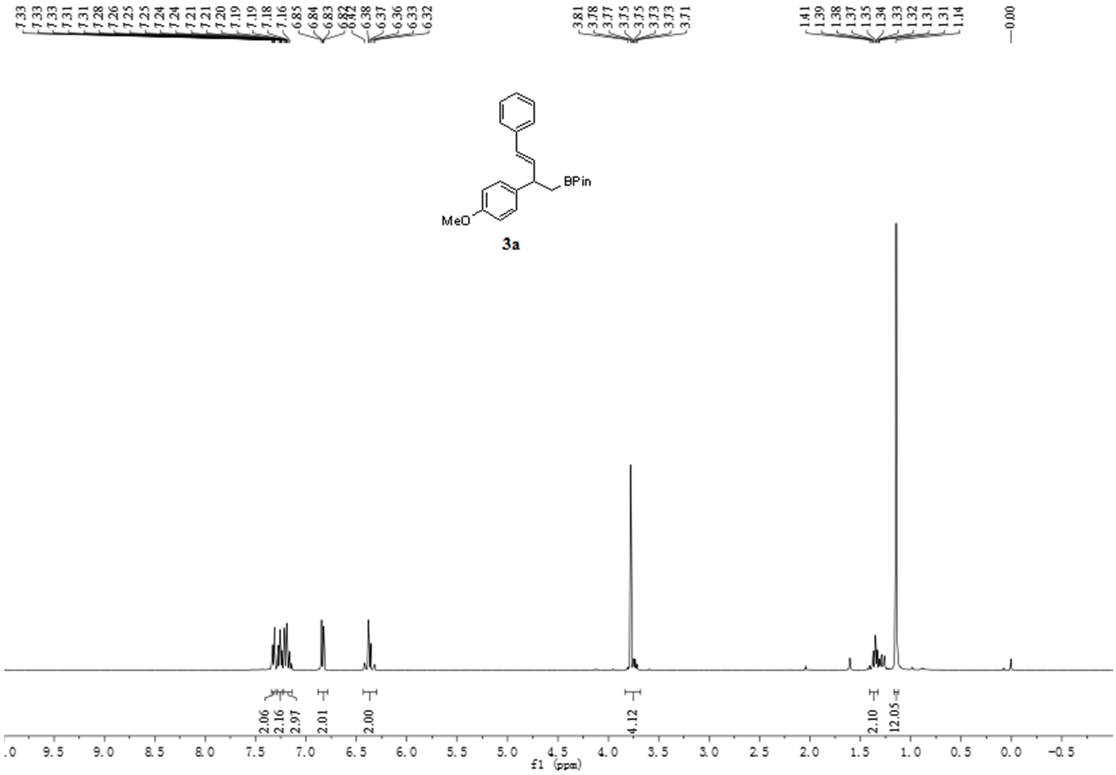
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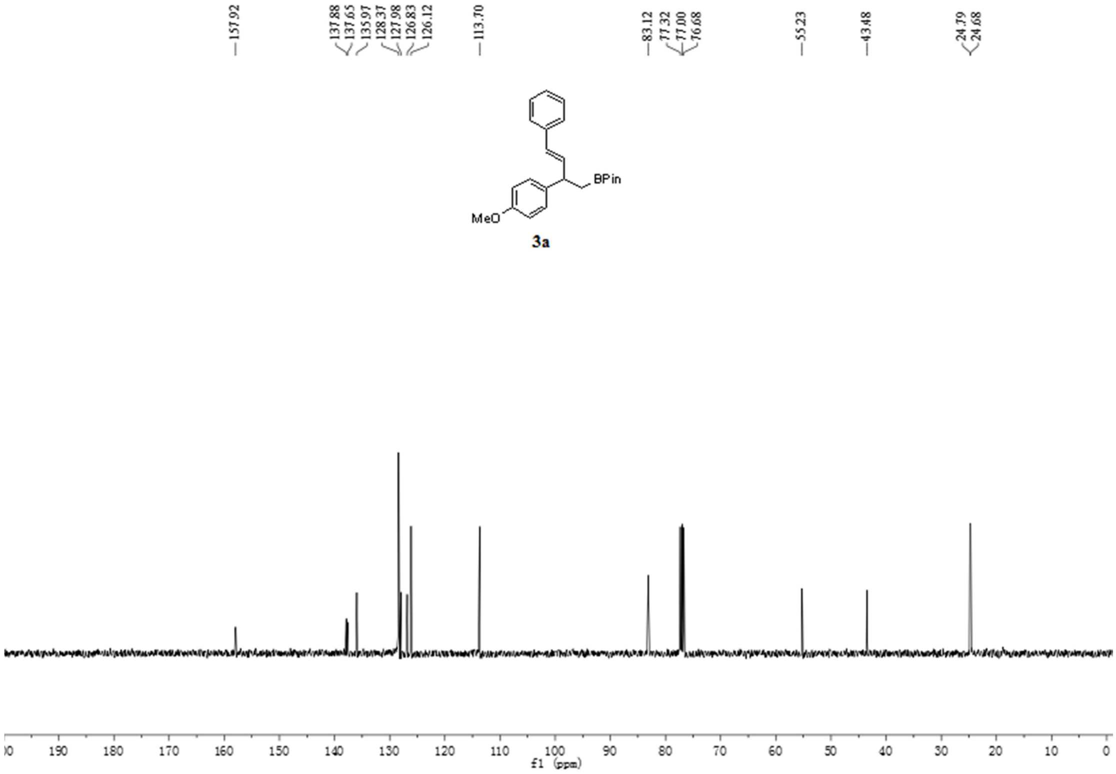
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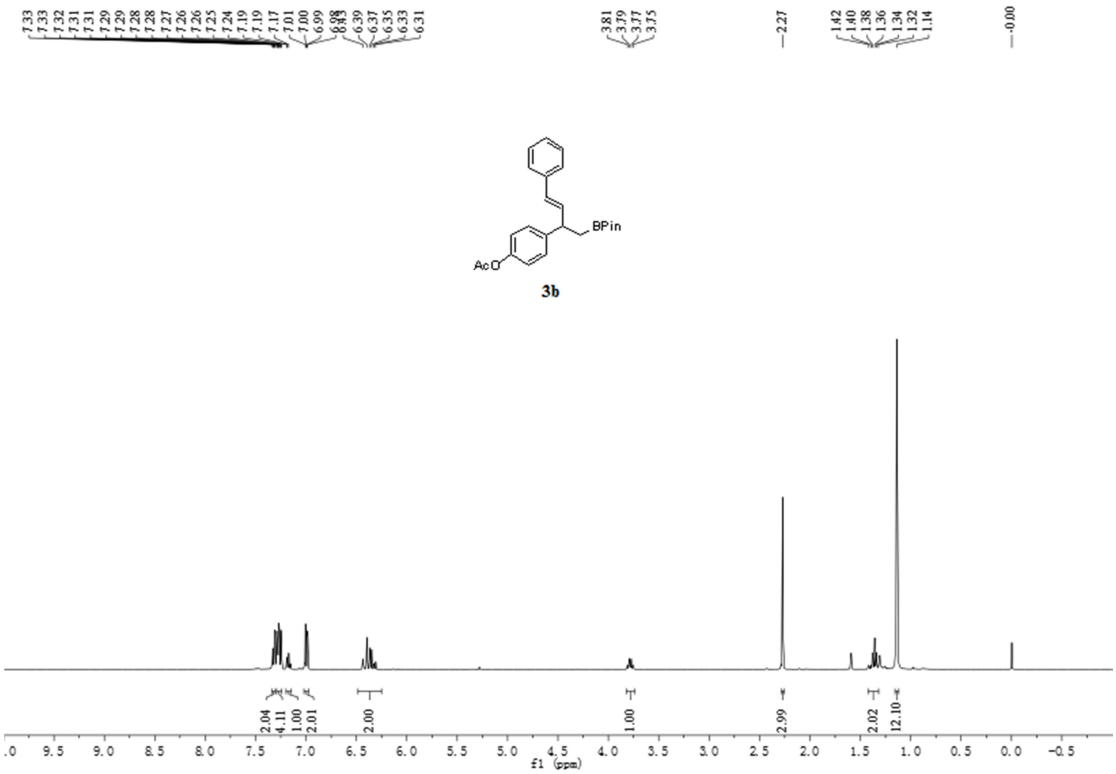
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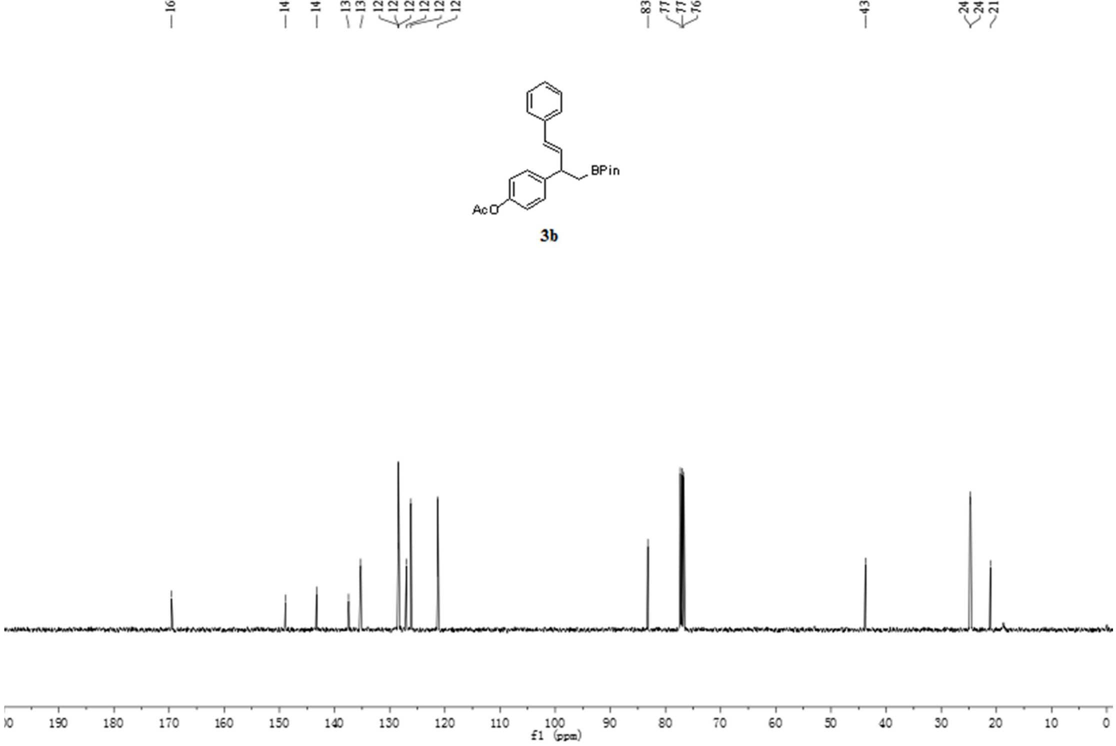
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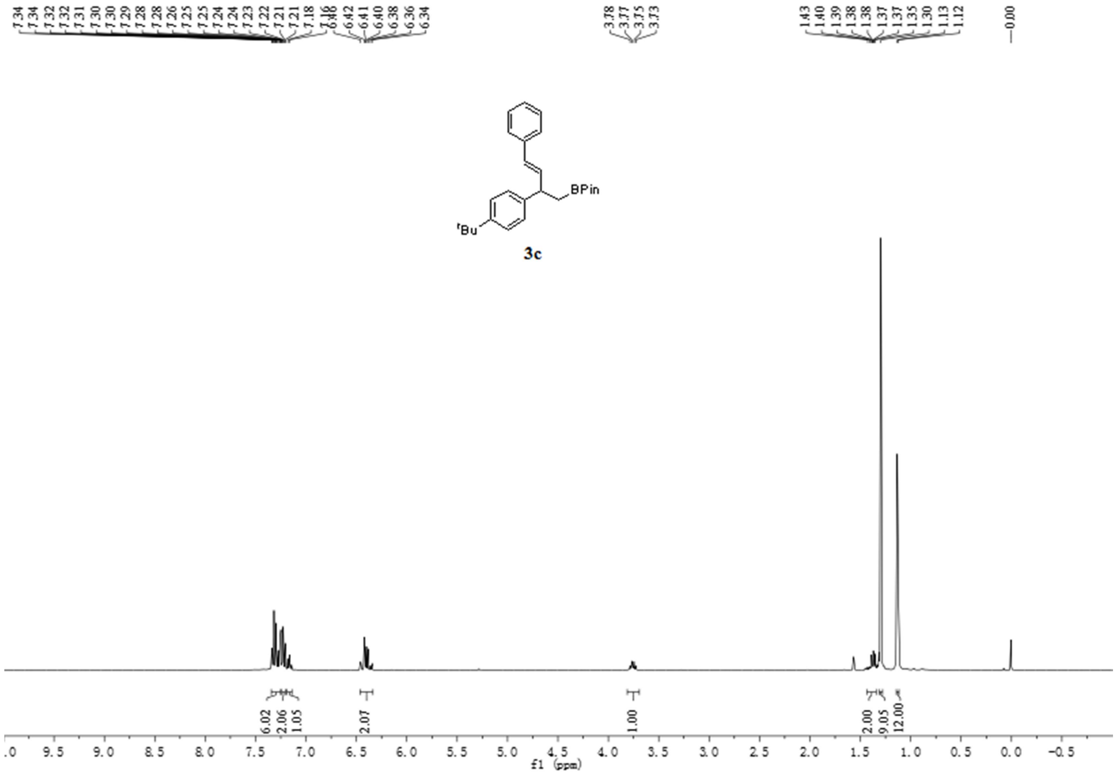
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3.77
3.75
3.73
1.43
1.40
1.39
1.38
1.38
1.37
1.37
1.35
1.30
1.13
1.12
0.00
BPin
ᵗBu
6.02
2.06
1.05
2.07
1.00
2.00
9.05
12.00
.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
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2.5
2.0
1.5
1.0
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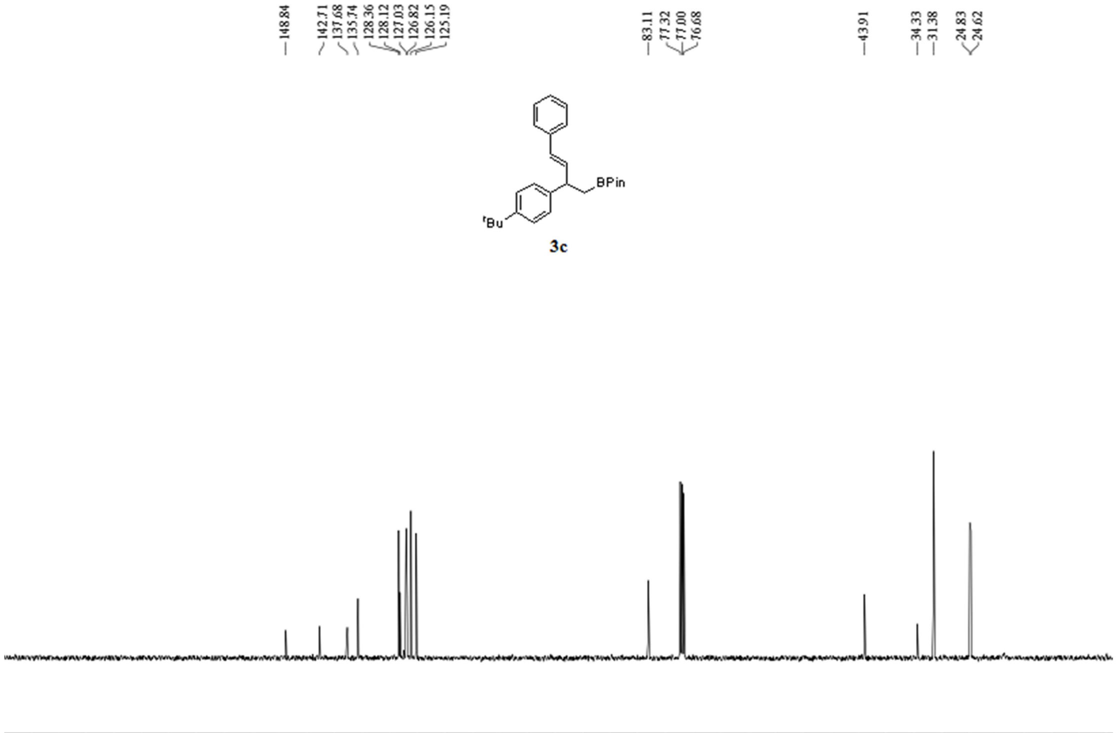
0.0
-0.5
f1 (ppm)

3c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125.19
83.11
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77.00
76.68
43.91
34.33
31.38
24.83
24.62
BPin
ᵗBu
190
180
170
160
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100
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80
70
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30
20
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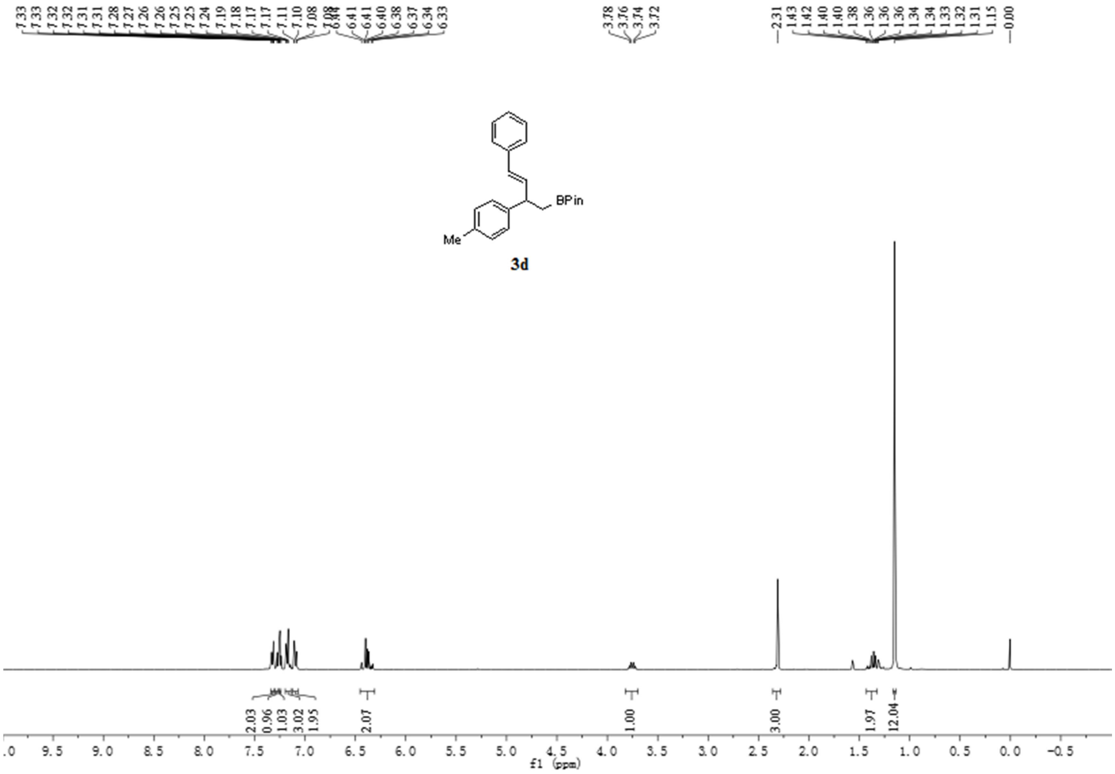
f1 (ppm)

3c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7.19
7.18
7.17
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7.11
7.10
7.08
7.08
6.44
6.41
6.41
6.40
6.38
6.37
6.34
6.33
3.78
3.76
3.74
3.72
2.31
1.43
1.42
1.40
1.40
1.38
1.36
1.36
1.36
1.34
1.34
1.33
1.32
1.31
1.15
0.00
BPin
Me
3d
2.03
0.96
1.03
3.02
1.95
2.07
1.00
3.00
1.97
12.04
.0
9.5
9.0
8.5
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6.5
6.0
5.5
5.0
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2.0
1.5
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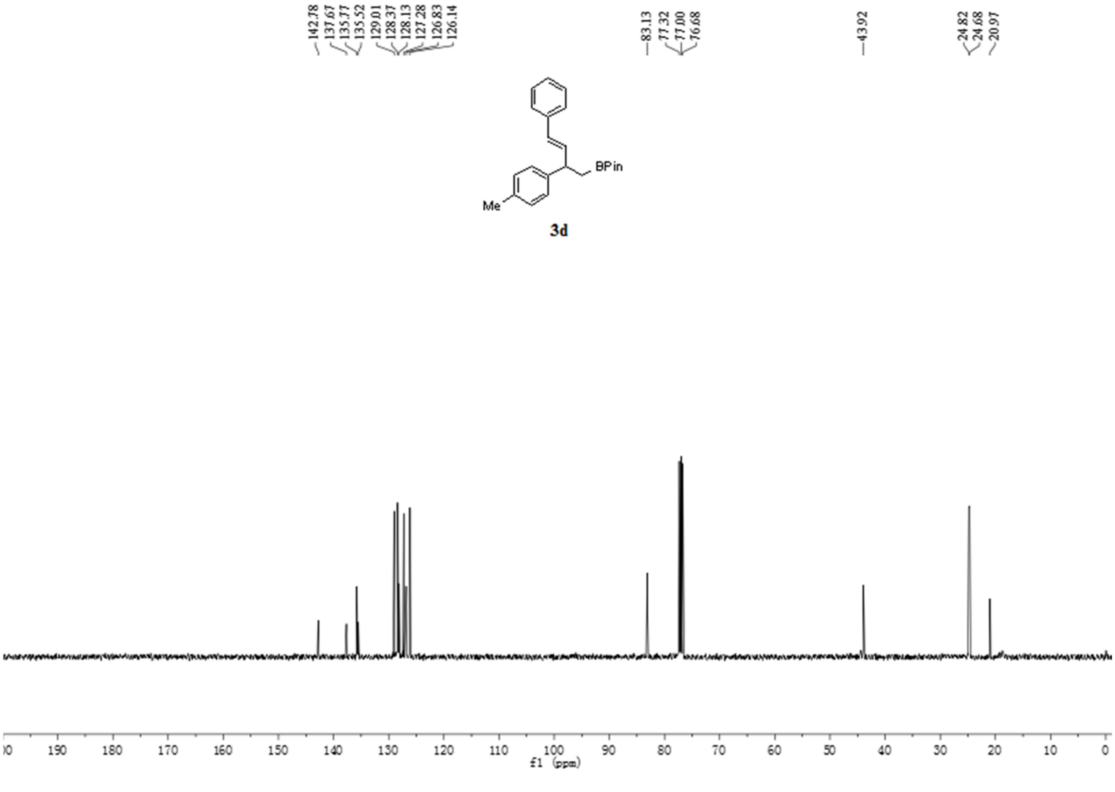
-0.5
f1 (ppm)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126.14
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77.00
76.68
43.92
24.82
24.68
20.97
BPin
Me
3d
00
190
180
170
160
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130
120
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50
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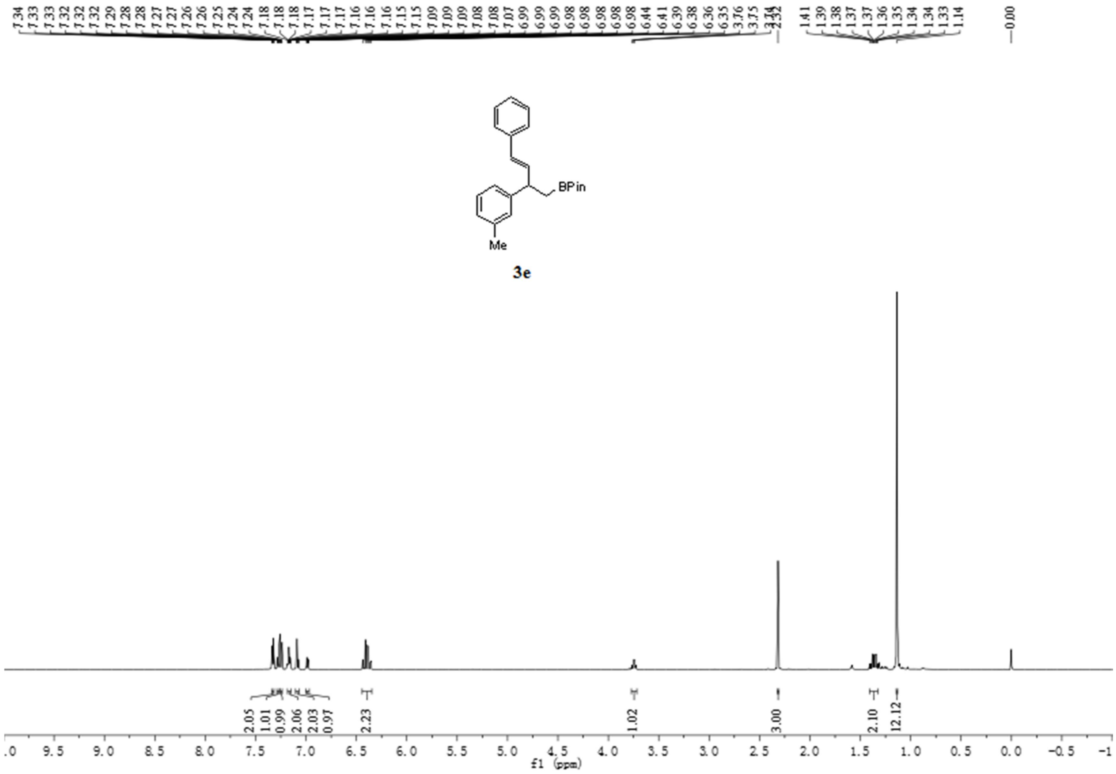
f1 (ppm)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7.25
7.24
7.24
7.18
7.18
7.18
7.17
7.17
7.17
7.16
7.16
7.16
7.15
7.15
7.09
7.09
7.09
7.08
7.08
7.07
6.99
6.99
6.99
6.98
6.98
6.98
6.98
6.98
6.44
6.41
6.39
6.38
6.36
6.35
3.76
3.75
3.74
2.32
1.41
1.39
1.38
1.37
1.37
1.36
1.35
1.34
1.34
1.33
1.14
0.00
BPin
Me
2.05
1.01
0.99
2.06
2.03
0.97
2.23
1.02
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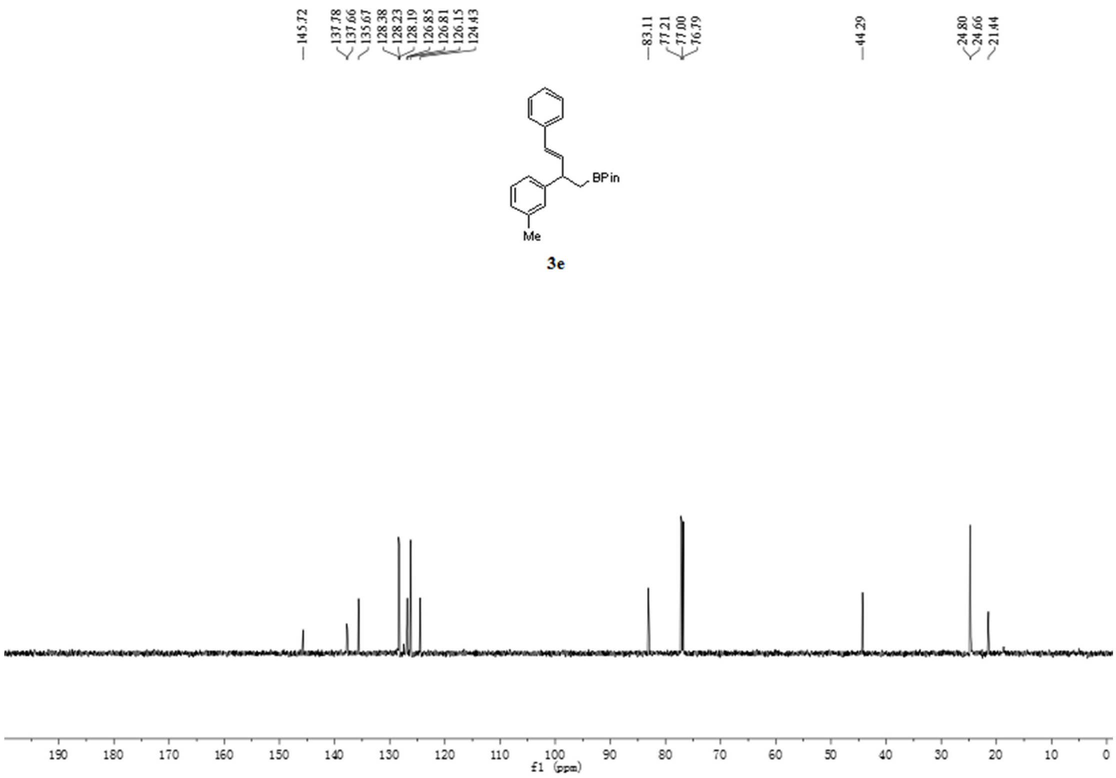
2.10
12.12
f1 (ppm)

3e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124.43
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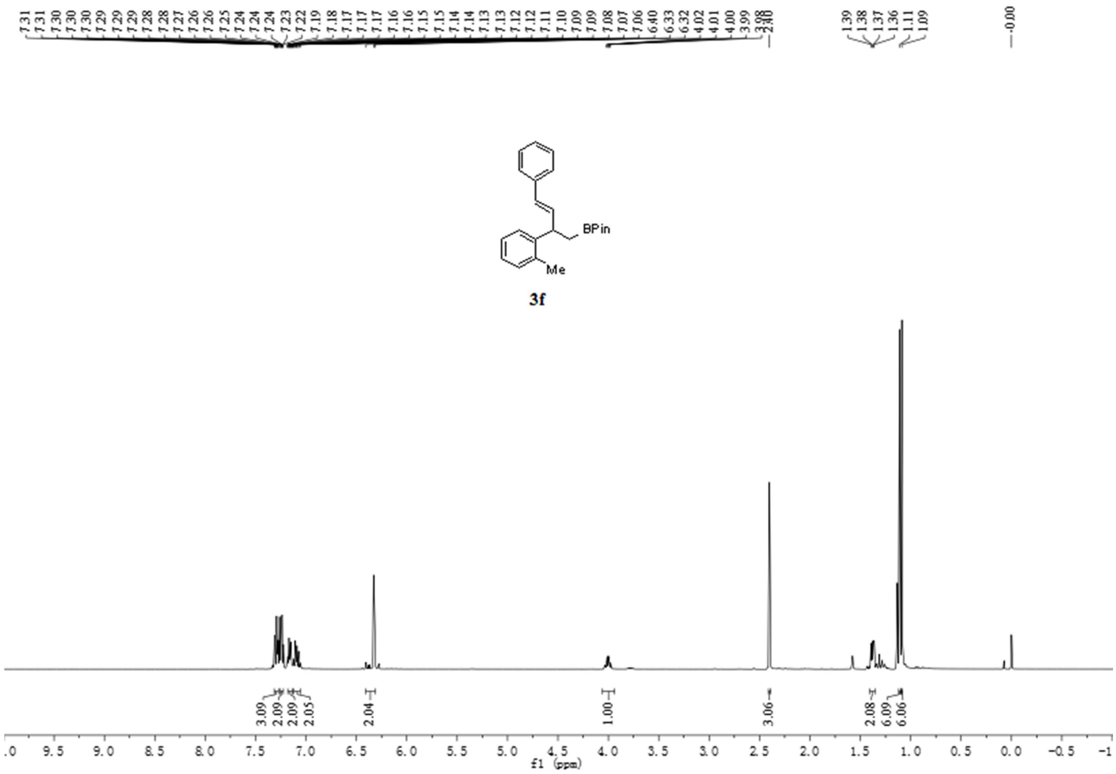
77.21
77.00
76.79
44.29
24.80
24.66
21.44
BPin
Me
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

3e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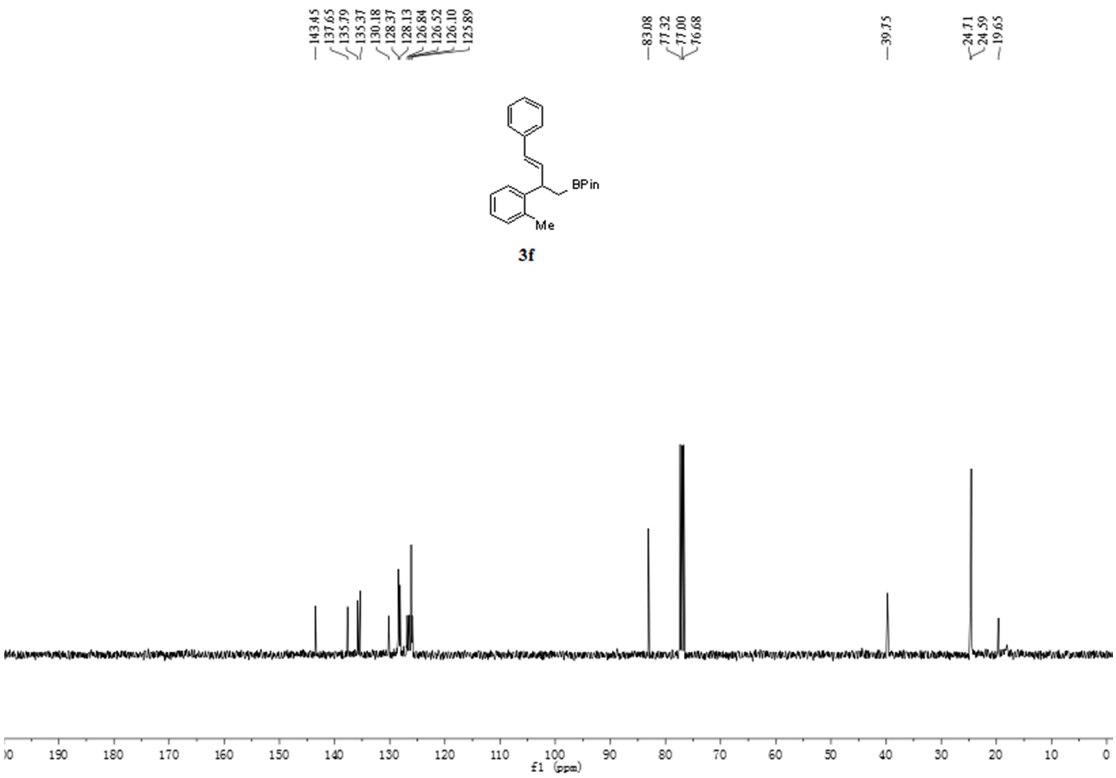
7.24
7.24
7.24
7.23
7.22
7.19
7.18
7.17
7.17
7.17
7.16
7.16
7.15
7.15
7.14
7.14
7.13
7.13
7.12
7.12
7.11
7.10
7.09
7.09
7.08
7.07
7.06
6.40
6.33
6.32
4.02
4.01
4.00
3.99
3.98
2.40
1.39
1.38
1.37
1.36
1.11
1.09
-0.00
BPin
Me
3.09
2.09
2.09
2.05
2.04
1.00
3.06
2.08
6.09
6.06
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
-1
f1 (ppm)

3f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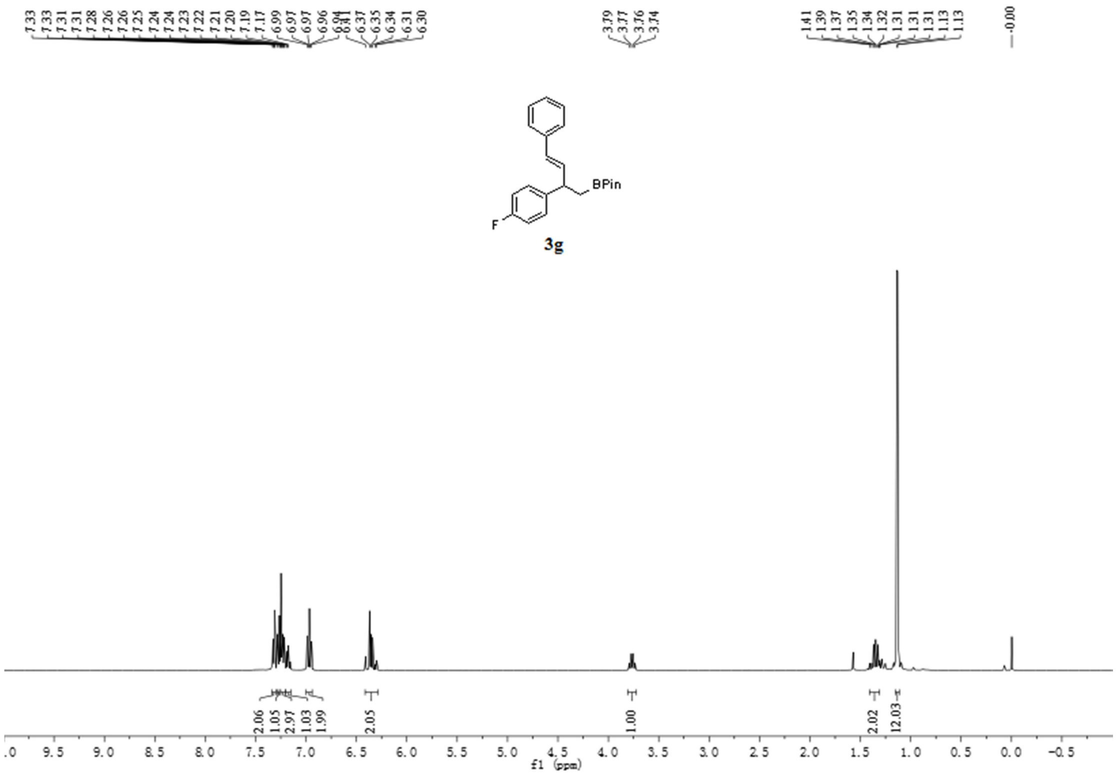
128.37
128.13
126.84
126.52
126.10
125.89
83.08
77.32
77.00
76.68
39.75
24.71
24.59
19.65
BPin
Me
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

3f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7.26
7.26
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7.24
7.24
7.23
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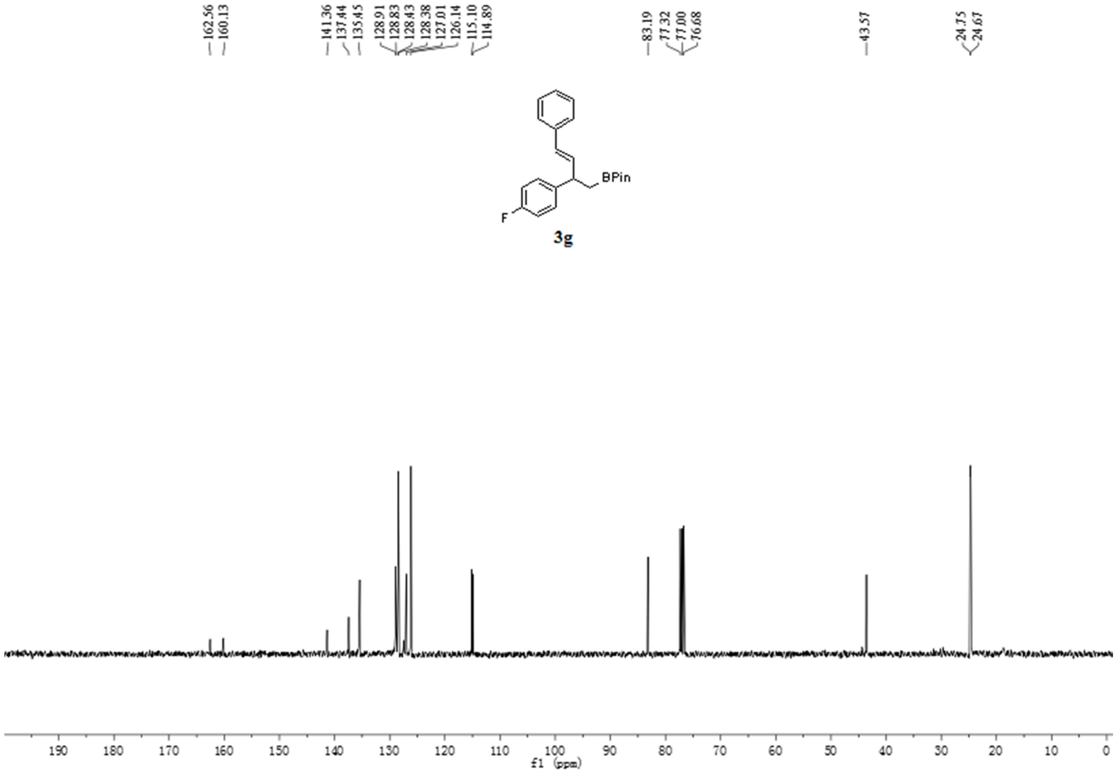
7.21
7.20
7.19
7.17
6.99
6.97
6.97
6.96
6.94
6.41
6.37
6.35
6.34
6.31
6.30
3.79
3.77
3.76
3.74
1.41
1.39
1.37
1.35
1.34
1.32
1.31
1.31
1.31
1.13
1.13
0.00
BPin
F
3g
2.06
1.05
2.97
1.03
1.99
2.05
1.00
2.02
12.03
.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
f1 (ppm)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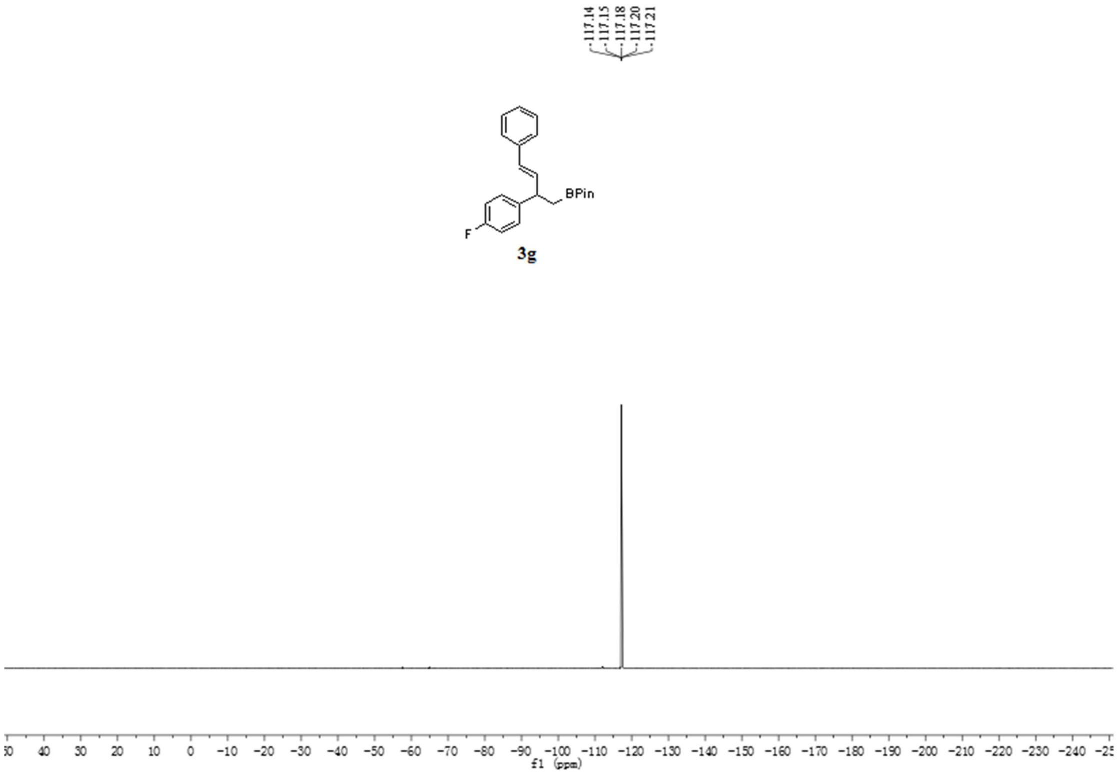
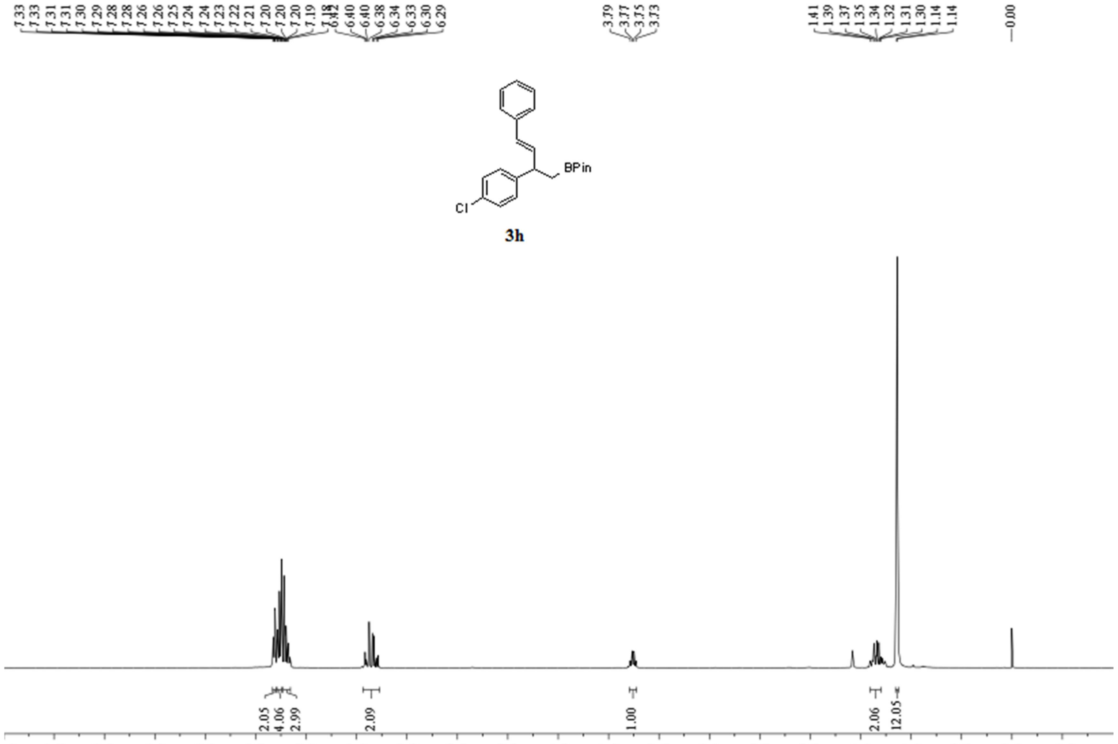
160.13
141.36
137.44
135.45
128.91
128.83
128.43
128.38
127.01
126.14
115.10
114.89
83.19
77.32
77.00
76.68
43.57
24.75
24.67
BPin
F
3g
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)


-117.14
-117.15
-117.18
-117.20
-117.21
F
BPin
50 40 30 20 10 0 −10 −20 −30 −40 −50 −60 −70 −80 −90 −100 −110 −120 −130 −140 −150 −160 −170 −180 −190 −200 −210 −220 −230 −240 −250
f1 (ppm)

3g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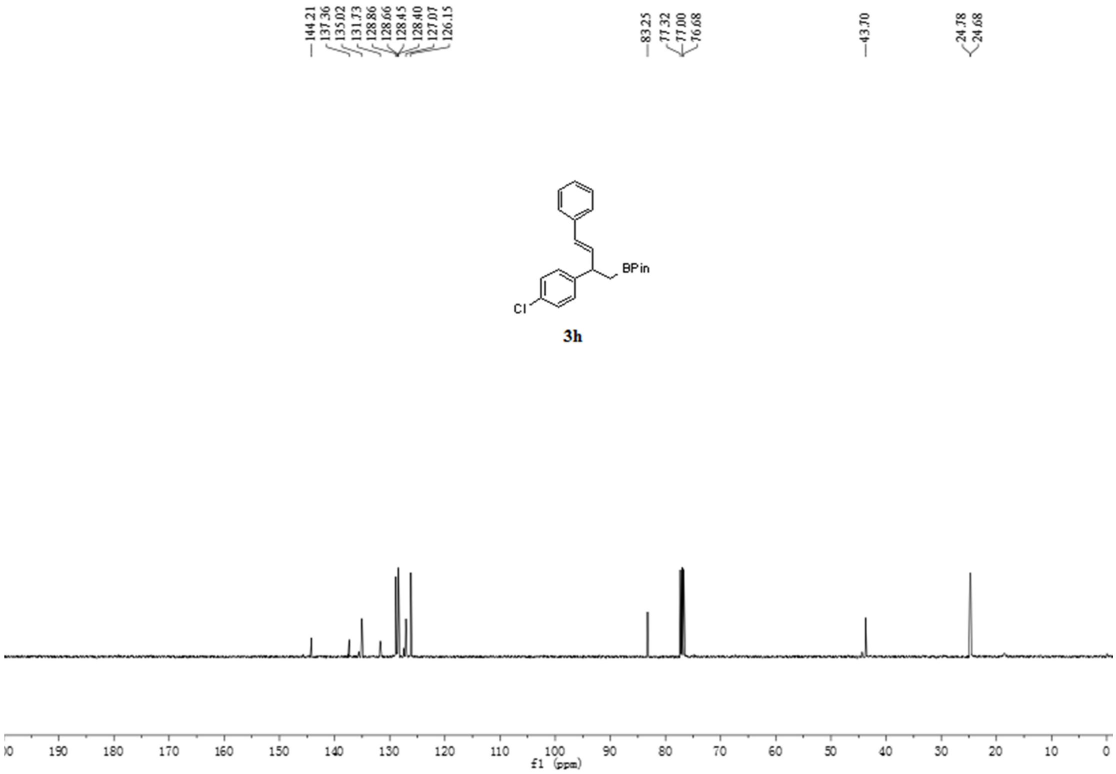
7.29
7.28
7.28
7.26
7.25
7.24
7.24
7.23
7.22
7.21
7.20
7.20
7.20
7.19
7.18
6.42
6.40
6.40
6.38
6.34
6.33
6.30
6.29
3.79
3.77
3.75
3.73
1.41
1.39
1.37
1.35
1.34
1.32
1.31
1.30
1.14
1.14
0.00
Cl
BPin
2.05
4.06
2.99
2.09
1.00
2.06
12.05
10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 −0.5
f1 (ppm)

3h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137.36
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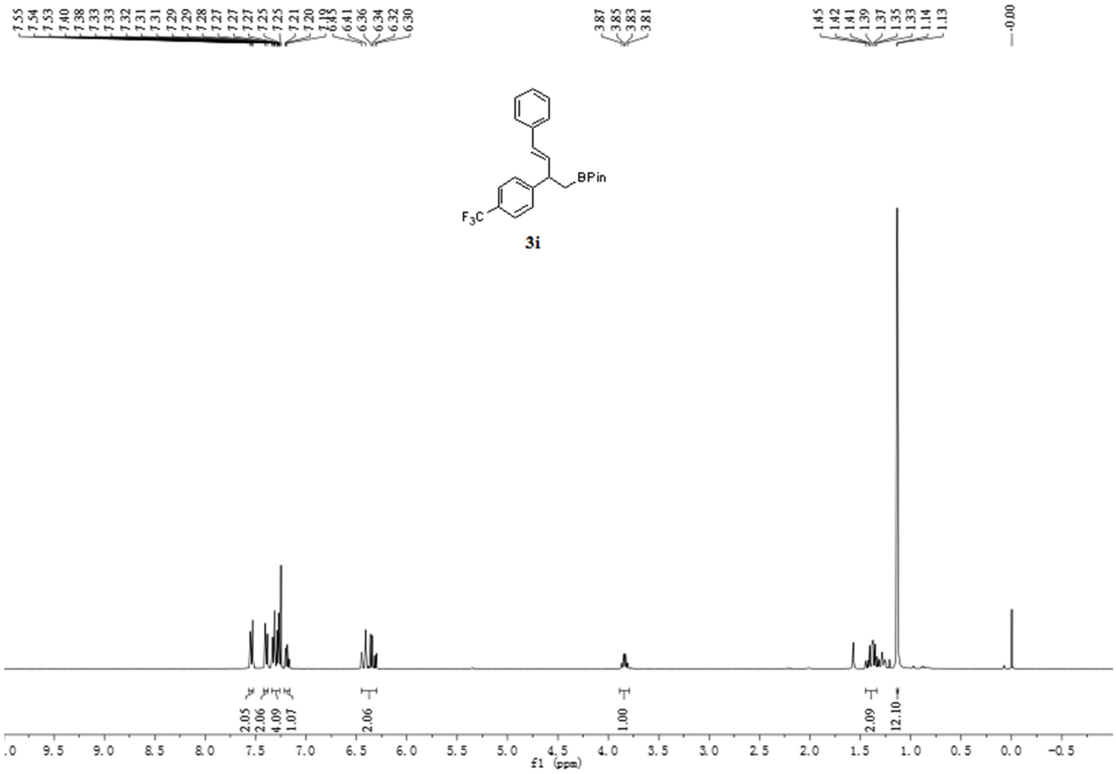
128.86
128.66
128.45
128.40
127.07
126.15
83.25
77.32
77.00
76.68
43.70
24.78
24.68
BPin
Cl
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

3h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7.54
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7.33
7.33
7.32
7.31
7.31
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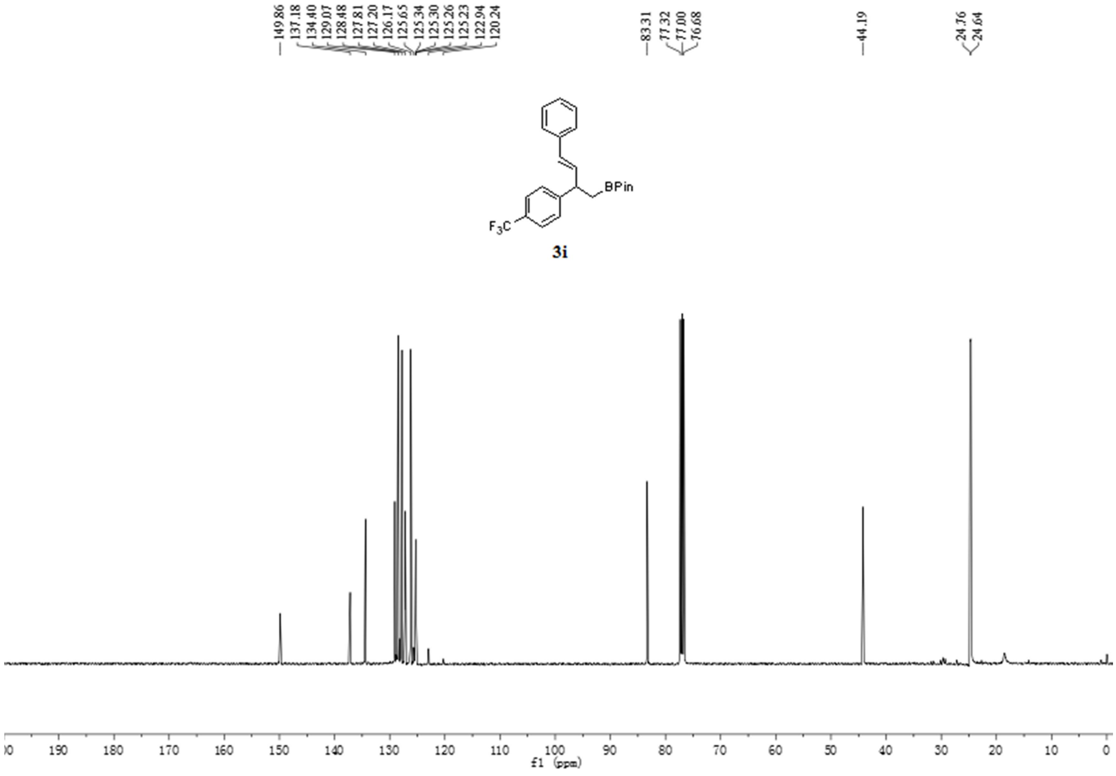
7.29
7.28
7.27
7.27
7.27
7.25
7.25
7.21
7.20
7.19
6.43
6.41
6.36
6.34
6.32
6.30
3.87
3.85
3.83
3.81
1.45
1.42
1.41
1.39
1.37
1.35
1.33
1.14
1.13
0.00
BPin
F3C
2.05
2.06
4.09
1.07
2.06
1.00
2.09
12.10
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
f1 (ppm)

3i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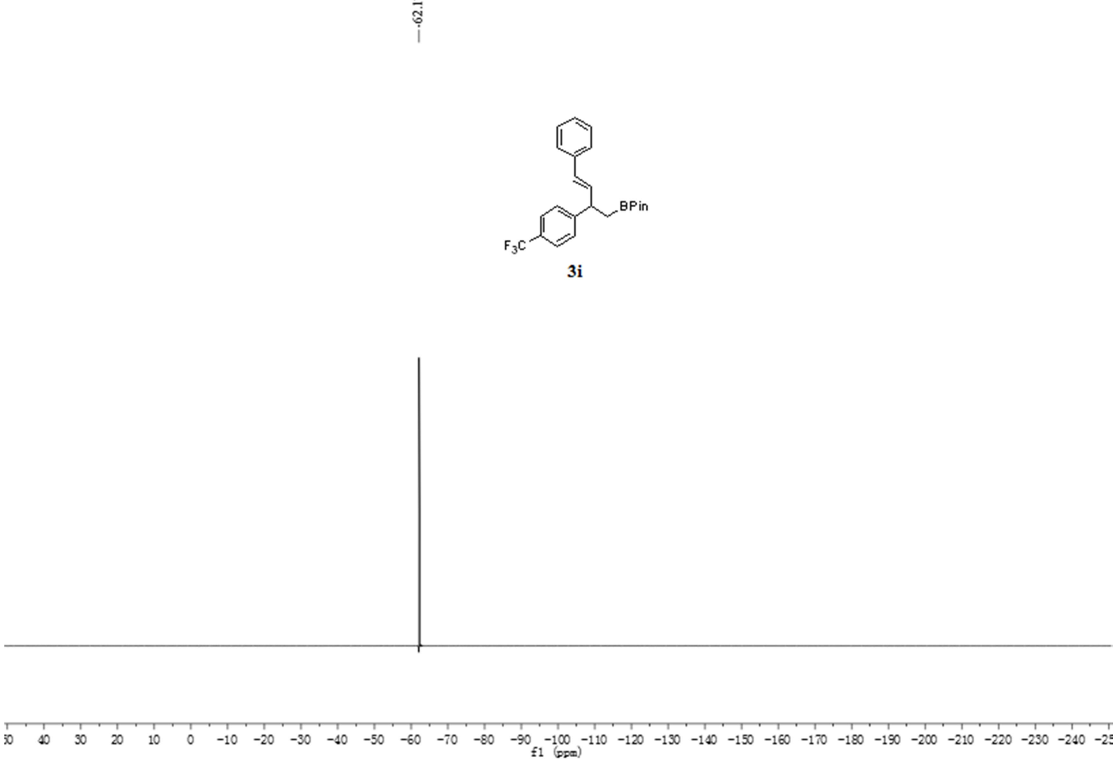
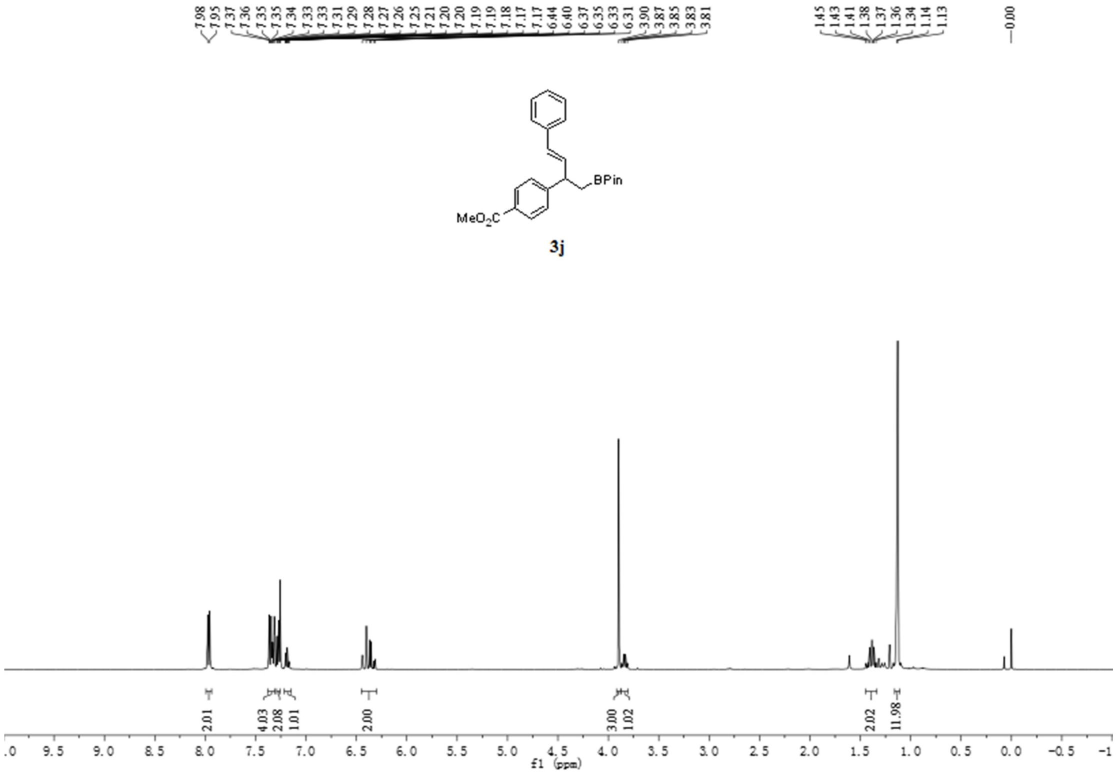
129.07
128.48
127.81
127.20
126.17
125.65
125.34
125.30
125.26
125.23
122.94
120.24
83.31
77.32
77.00
76.68
44.19
24.76
24.64
BPin
F_3C
3i
0
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)


-62.17
BPin
F_3C
3i
50
40
30
20
10
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
-110
-120
-130
-140
-150
-160
-170
-180
-190
-200
-210
-220
-230
-240
-25
f1 (ppm)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7.33
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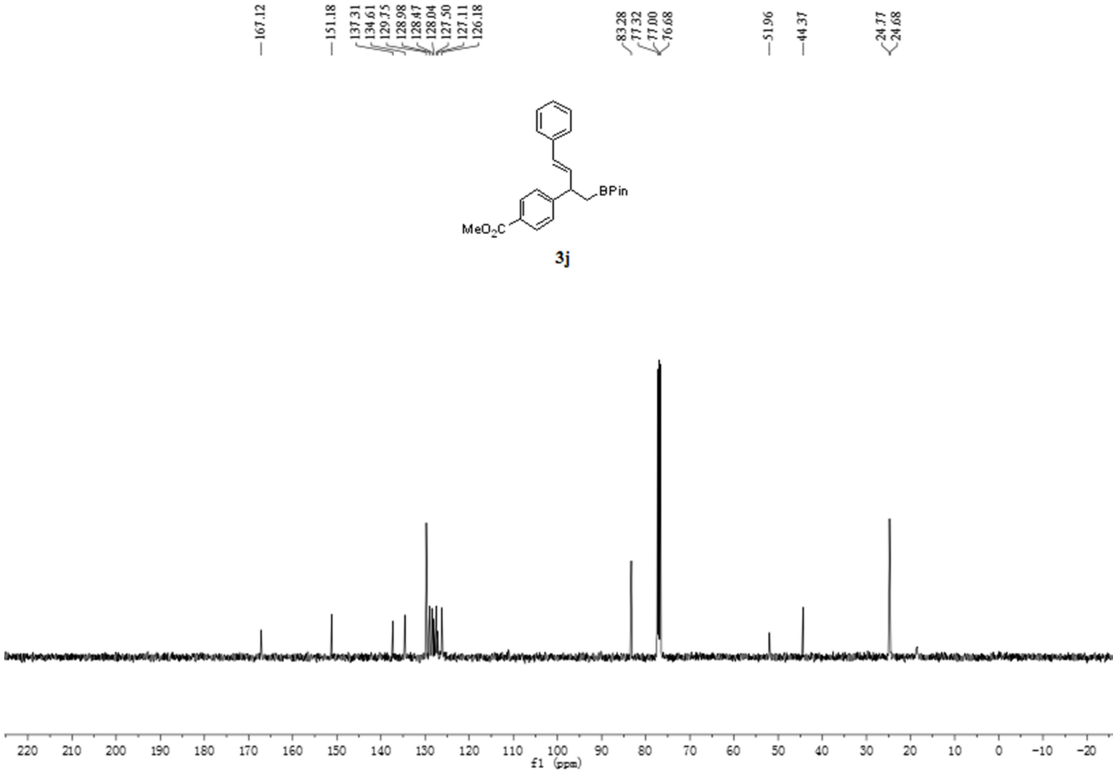
7.28
7.27
7.26
7.25
7.21
7.20
7.20
7.19
7.19
7.18
7.17
7.17
6.44
6.40
6.37
6.35
6.33
6.31
3.90
3.87
3.85
3.83
3.81
1.45
1.43
1.41
1.38
1.37
1.36
1.34
1.14
1.13
0.00
BPin
MeO$_2$C
3j
2.01
4.03
2.08
1.01
2.00
3.00
1.02
2.02
11.98
.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
-1
f1 (ppm)


167.12
151.18
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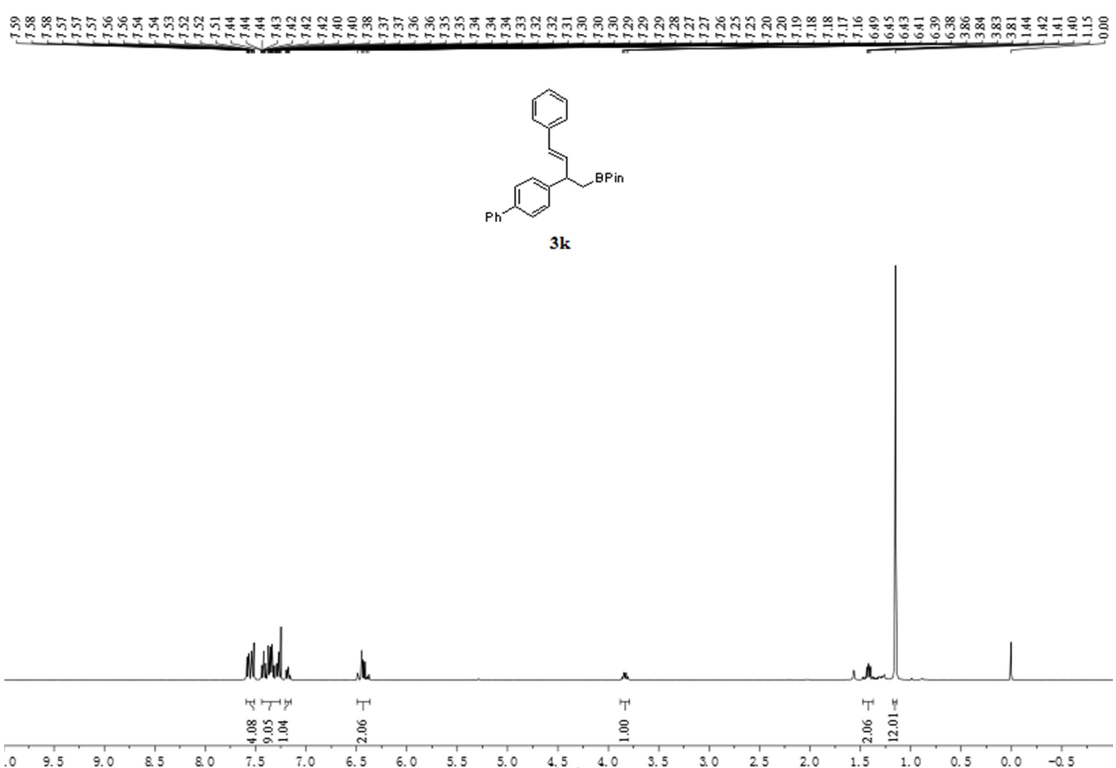
134.61
129.75
128.98
128.47
128.04
127.50
127.11
126.18
83.28
77.32
77.00
76.68
51.96
44.37
24.77
24.68
BPin
MeO$_2$C
3j
220
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
-10
-20
f1 (ppm)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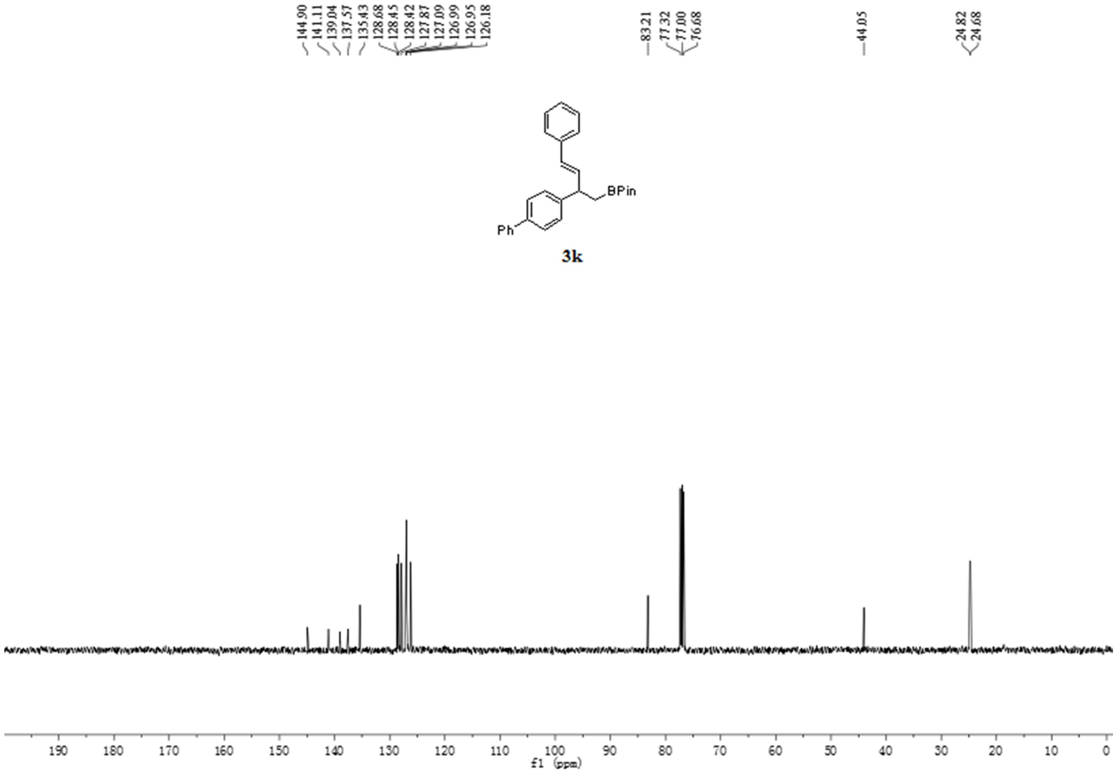
7.51
7.44
7.44
7.43
7.42
7.42
7.42
7.40
7.38
7.37
7.37
7.36
7.36
7.35
7.35
7.34
7.34
7.34
7.33
7.32
7.32
7.31
7.30
7.30
7.30
7.29
7.29
7.28
7.27
7.27
7.26
7.25
7.25
7.20
7.20
7.19
7.18
7.18
7.17
7.16
6.49
6.45
6.43
6.41
6.39
6.38
3.86
3.84
3.83
3.81
1.44
1.42
1.41
1.40
1.15
0.00
BPin
Ph
3k
4.08
9.05
1.04
2.06
1.00
2.06
12.01
.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5
f1 (ppm)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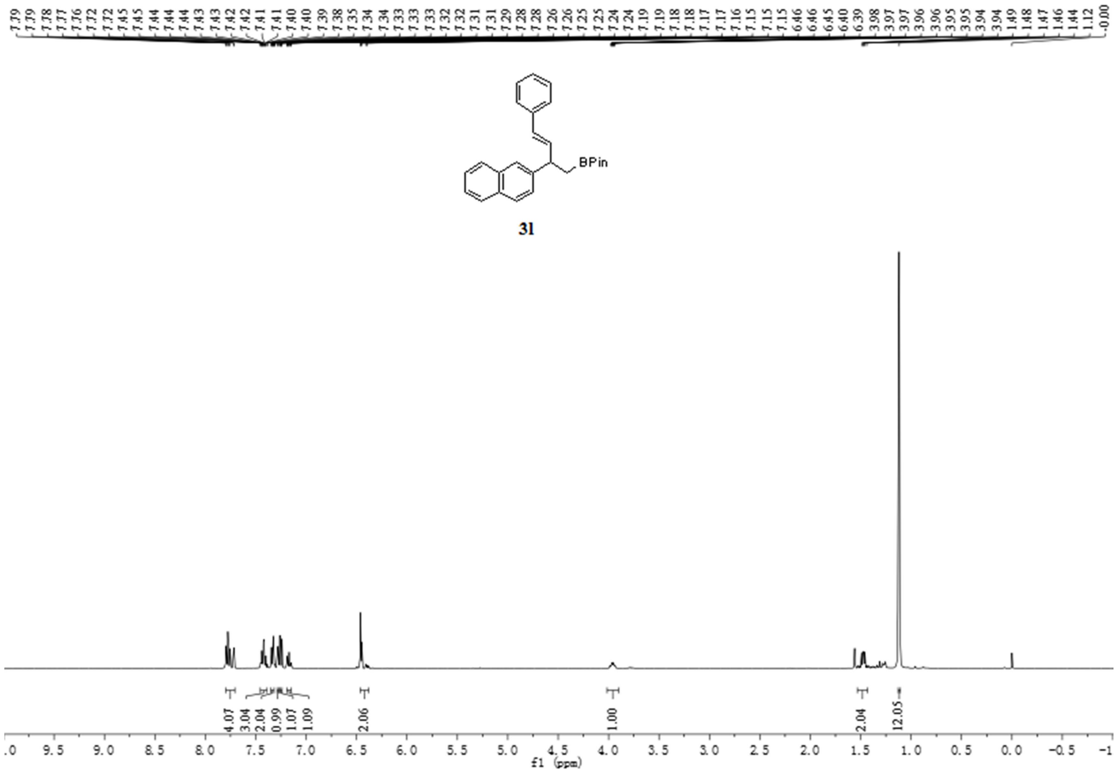
139.04
137.57
135.43
128.68
128.45
128.42
127.87
127.09
126.99
126.95
126.18
83.21
77.32
77.00
76.68
44.05
24.82
24.68
BPin
Ph
3k
190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)


7.79
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7.78
7.77
7.76
7.72
7.72
7.45
7.45
7.44
7.44
7.44
7.43
7.43
7.42
7.42
7.41
7.41
7.40
7.40
7.39
7.38
7.35
7.34
7.34
7.33
7.33
7.33
7.32
7.32
7.31
7.31
7.29
7.28
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7.25
7.25
7.24
7.24
7.19
7.19
7.18
7.18
7.17
7.17
7.16
7.15
7.15
7.15
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3.95
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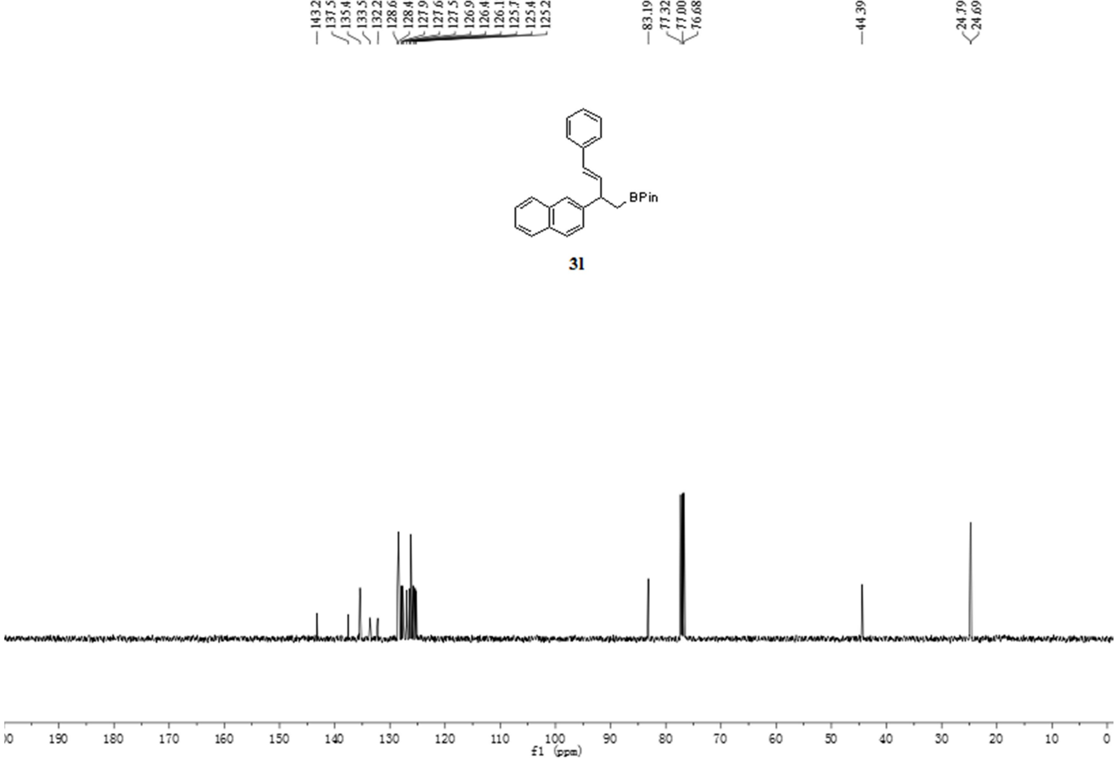
3.94
1.49
1.48
1.47
1.46
1.44
1.12
-0.00
BPin
31
4.07
3.04
2.04
0.99
1.07
1.09
2.06
1.00
2.04
12.05
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
-1
f1 (ppm)


143.20
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133.58
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127.54
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126.48
126.18
125.79
125.41
125.21
83.19
77.32
77.00
76.68
44.39
24.79
24.69
BPin
31
200
190
180
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120
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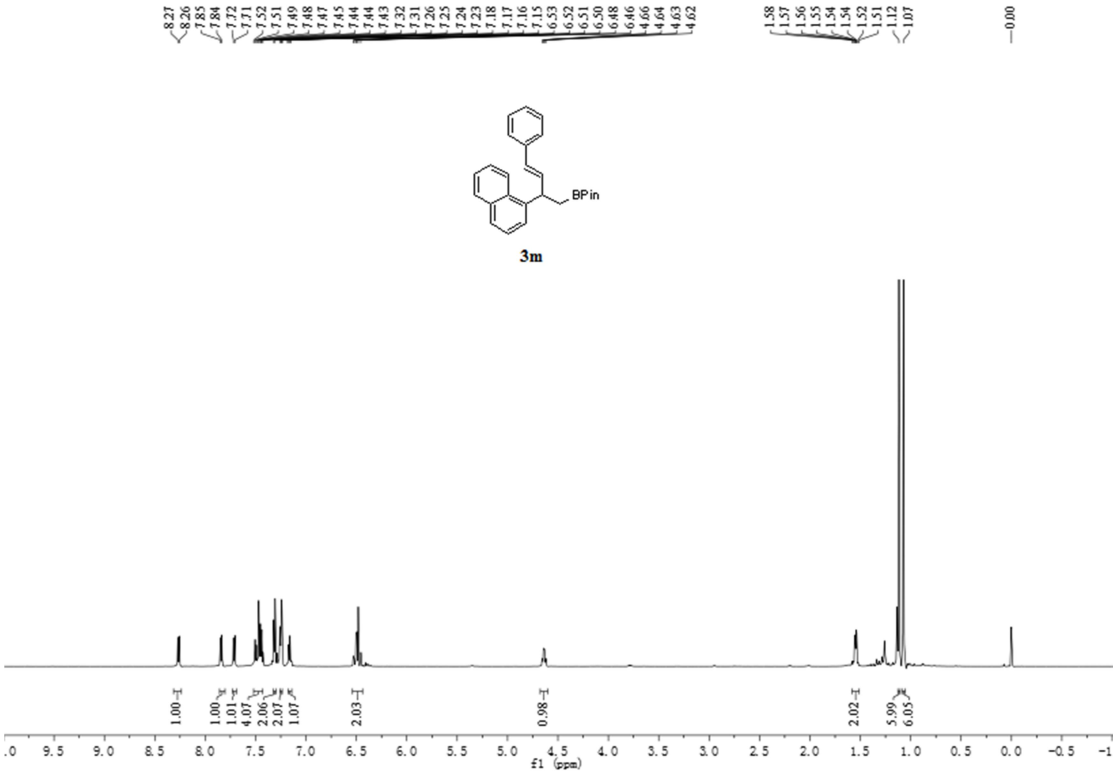
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7.44
7.43
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7.31
7.26
7.25
7.24
7.23
7.18
7.17
7.16
7.15
6.53
6.52
6.51
6.50
6.48
6.46
4.66
4.64
4.63
4.62
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1.57
1.56
1.55
1.54
1.54
1.52
1.51
1.12
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BPin
3m
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1.00
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2.06
2.07
1.07
2.03
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2.02
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6.05
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7.0
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6.0
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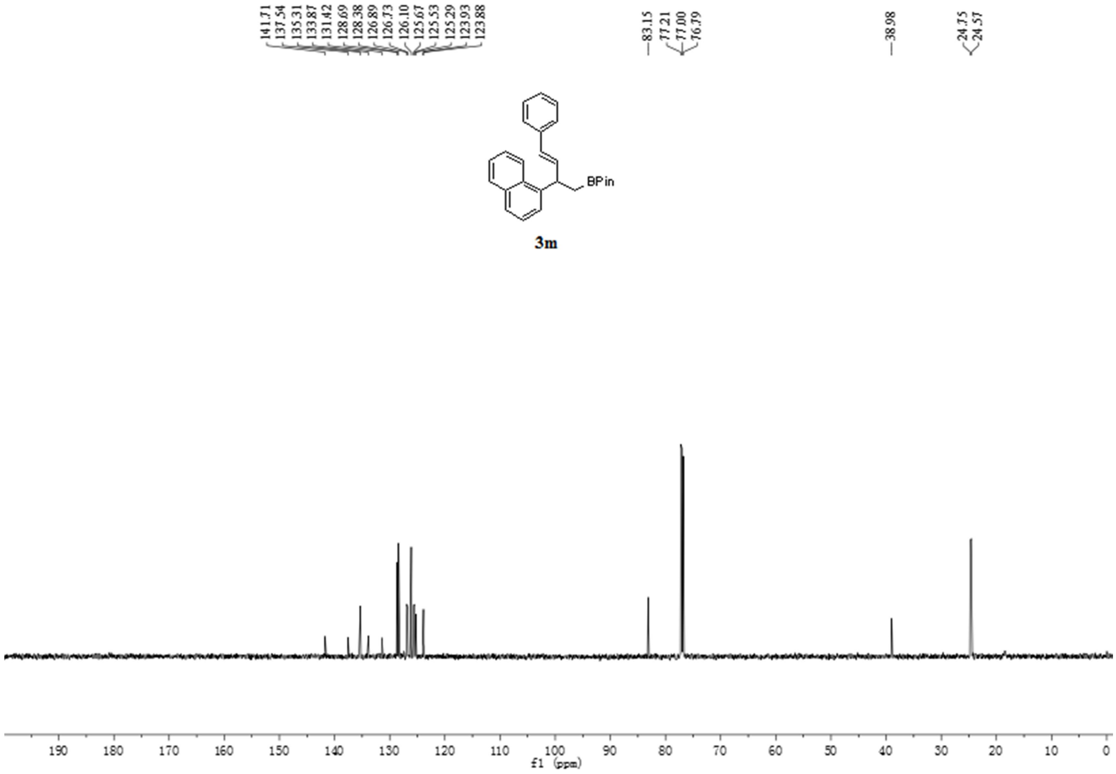
f1 (ppm)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125.29
123.93
123.88
83.15
77.21
77.00
76.79
38.98
24.75
24.57
BPin
3m
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180
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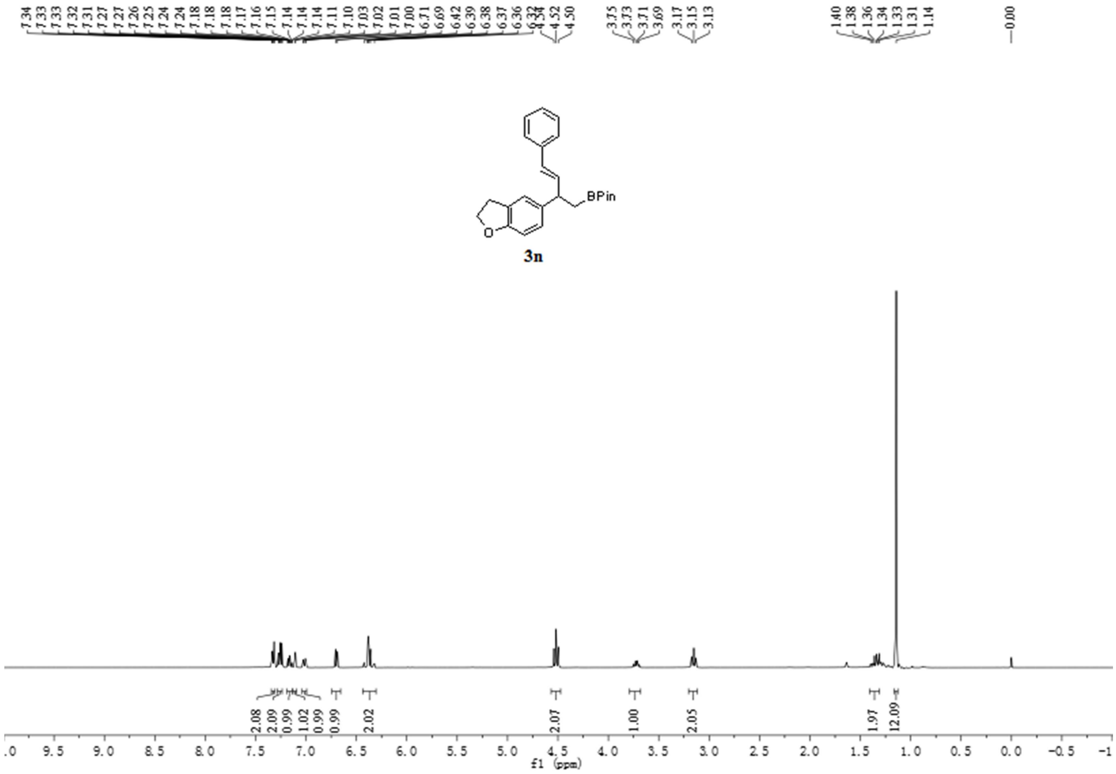
f1 (ppm)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7.18
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7.16
7.15
7.14
7.14
7.14
7.11
7.10
7.03
7.02
7.01
7.00
6.71
6.69
6.42
6.39
6.38
6.37
6.36
6.32
4.54
4.52
4.50
3.75
3.73
3.71
3.69
3.17
3.15
3.13
1.40
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1.36
1.34
1.33
1.31
1.14
0.00
BPin
O
3n
2.08
2.09
0.99
1.02
0.99
0.99
2.02
2.07
1.00
2.05
1.97
12.09
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
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2.0
1.5
1.0
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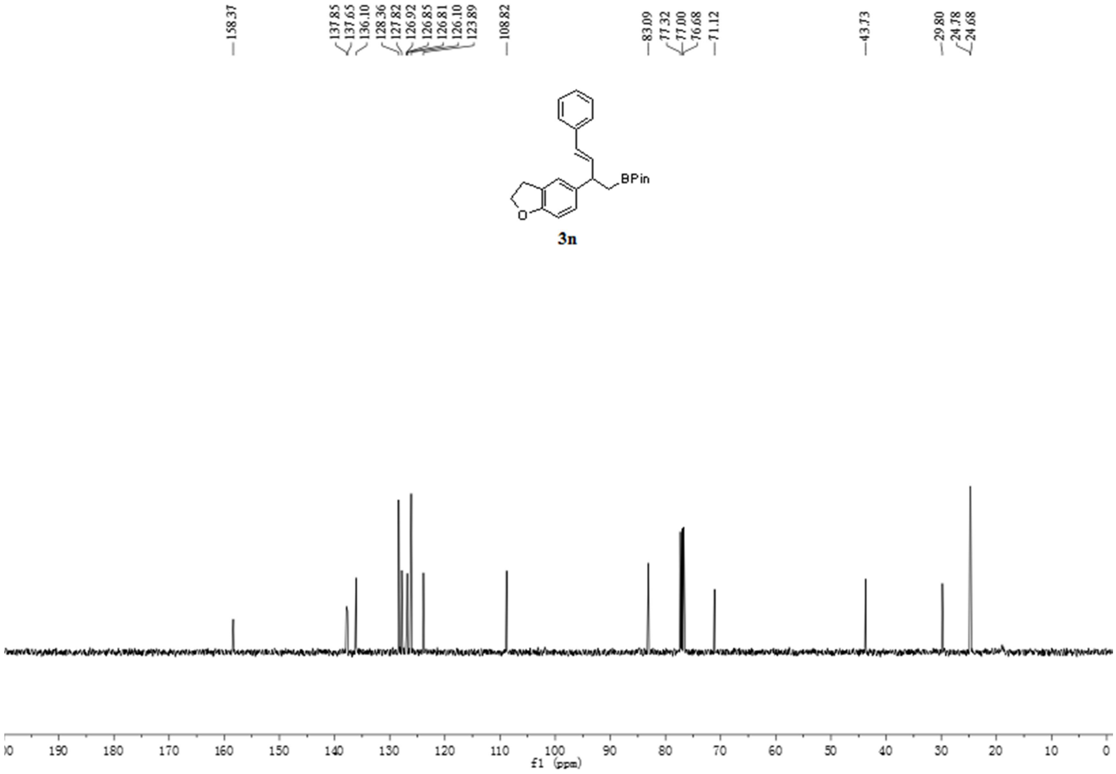
-1
f1 (ppm)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83.09
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77.00
76.68
71.12
43.73
29.80
24.78
24.68
BPin
O
3n
200
190
180
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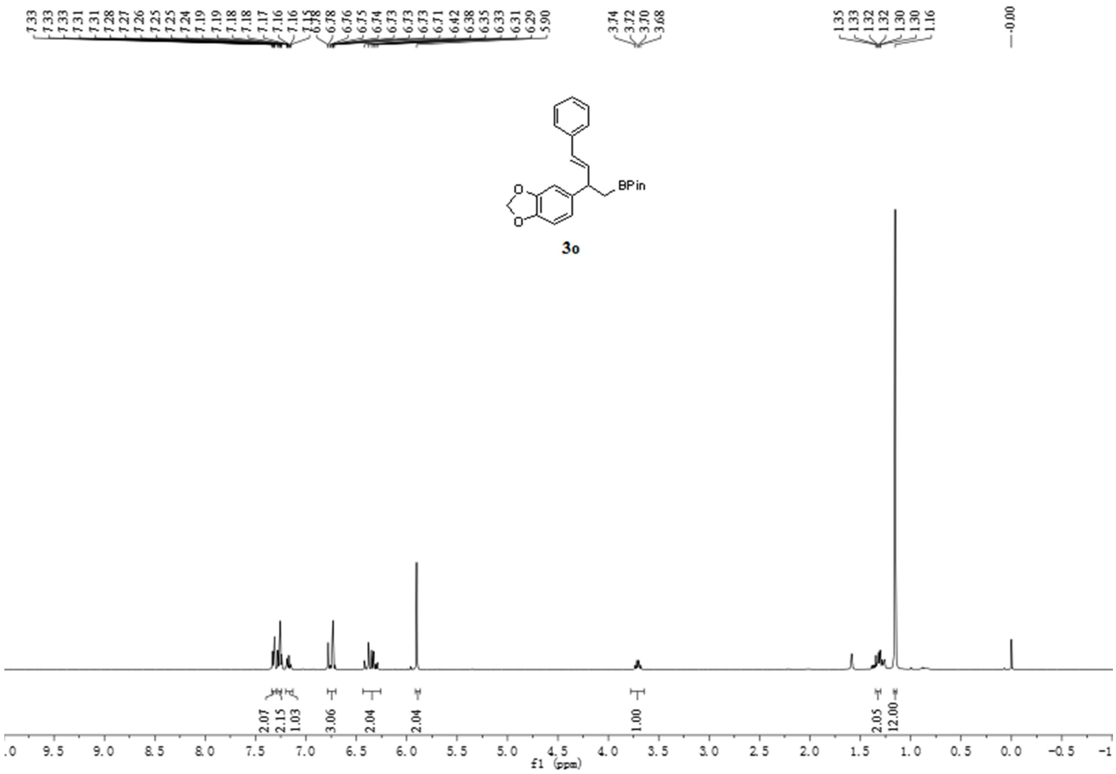
f1 (ppm)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7.18
7.18
7.17
7.16
7.16
7.15
6.78
6.78
6.76
6.75
6.74
6.73
6.73
6.73
6.71
6.42
6.38
6.35
6.33
6.31
6.29
5.90
3.74
3.72
3.70
3.68
1.35
1.33
1.32
1.32
1.30
1.30
1.16
-0.00
O
O
BPin
3o
2.07
2.15
1.03
3.06
2.04
2.04
1.00
2.05
12.00
10.0
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9.0
8.5
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6.5
6.0
5.5
5.0
4.5
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2.0
1.5
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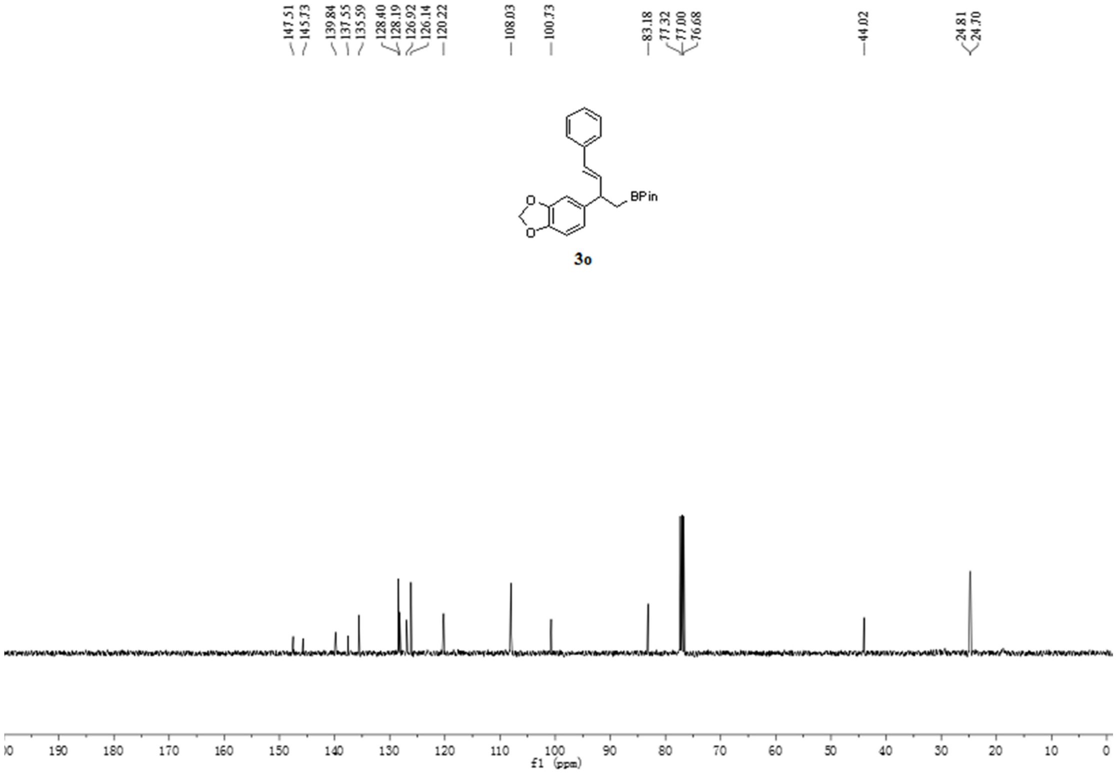
0.0
-0.5
-1
f1 (ppm)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120.22
108.03
100.73
83.18
77.32
77.00
76.68
44.02
24.81
24.70
O
O
BPin
3o
200
190
180
170
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150
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130
120
110
100
90
80
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40
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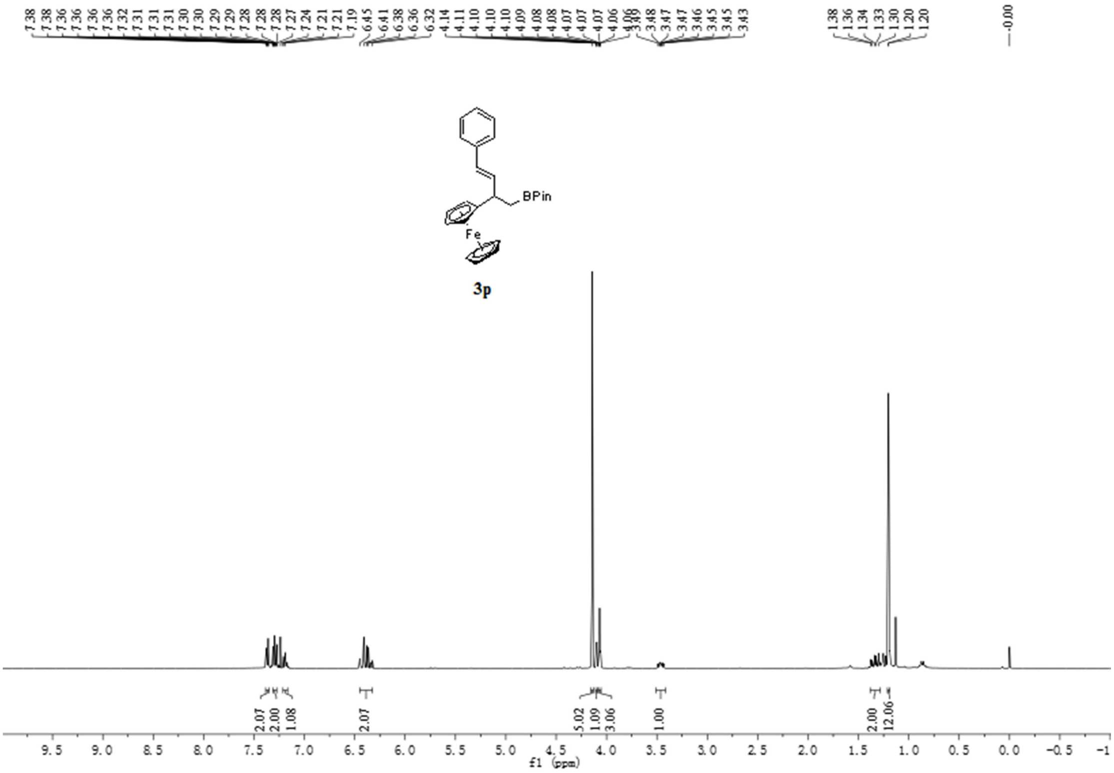
10
0
f1 (ppm)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7.28
7.28
7.28
7.27
7.24
7.21
7.21
7.19
6.45
6.41
6.38
6.36
6.32
4.14
4.11
4.10
4.10
4.09
4.08
4.08
4.07
4.07
4.07
4.06
4.06
3.49
3.48
3.47
3.47
3.46
3.45
3.45
3.43
1.38
1.36
1.34
1.33
1.30
1.20
1.20
-0.00
BPin
Fe
2.07
2.00
1.08
2.07
5.02
1.09
3.06
1.00
2.00
12.06
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
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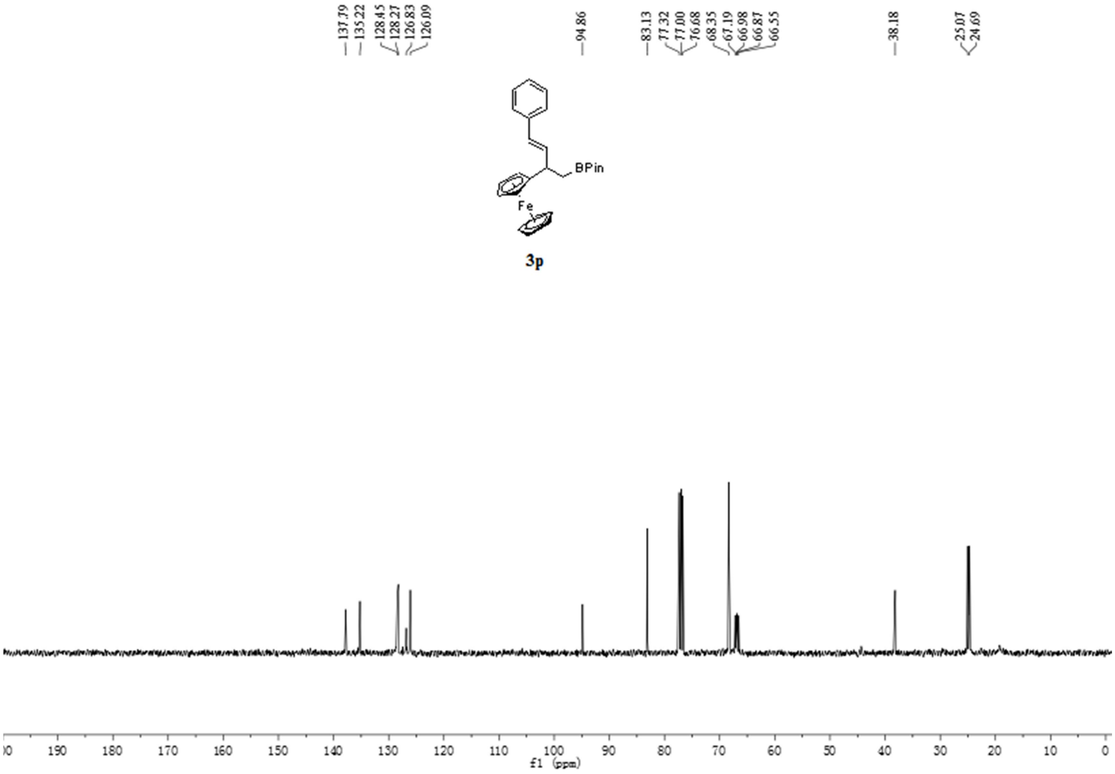
2.0
1.5
1.0
0.5
0.0
-0.5
-1
f1 (ppm)

3p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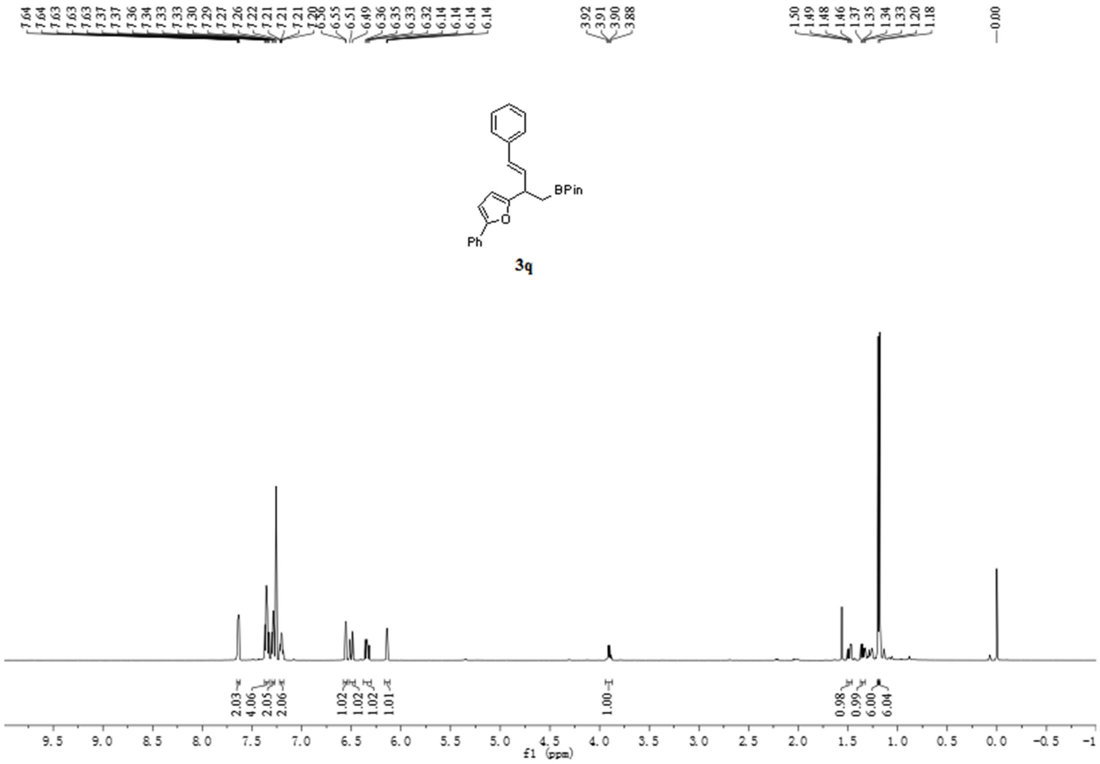
126.09
94.86
83.13
77.32
77.00
76.68
68.35
67.19
66.98
66.87
66.55
38.18
25.07
24.69
BPin
Fe
00
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

3p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7.27
7.26
7.22
7.21
7.21
7.21
7.20
6.56
6.55
6.51
6.49
6.36
6.35
6.33
6.32
6.14
6.14
6.14
6.14
3.92
3.91
3.90
3.88
1.50
1.49
1.48
1.46
1.37
1.35
1.34
1.33
1.20
1.18
0.00
BPin
O
Ph
2.03
4.06
2.05
2.06
1.02
1.02
1.02
1.01
1.00
0.98
0.99
6.00
6.04
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
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3.0
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2.0
1.5
1.0
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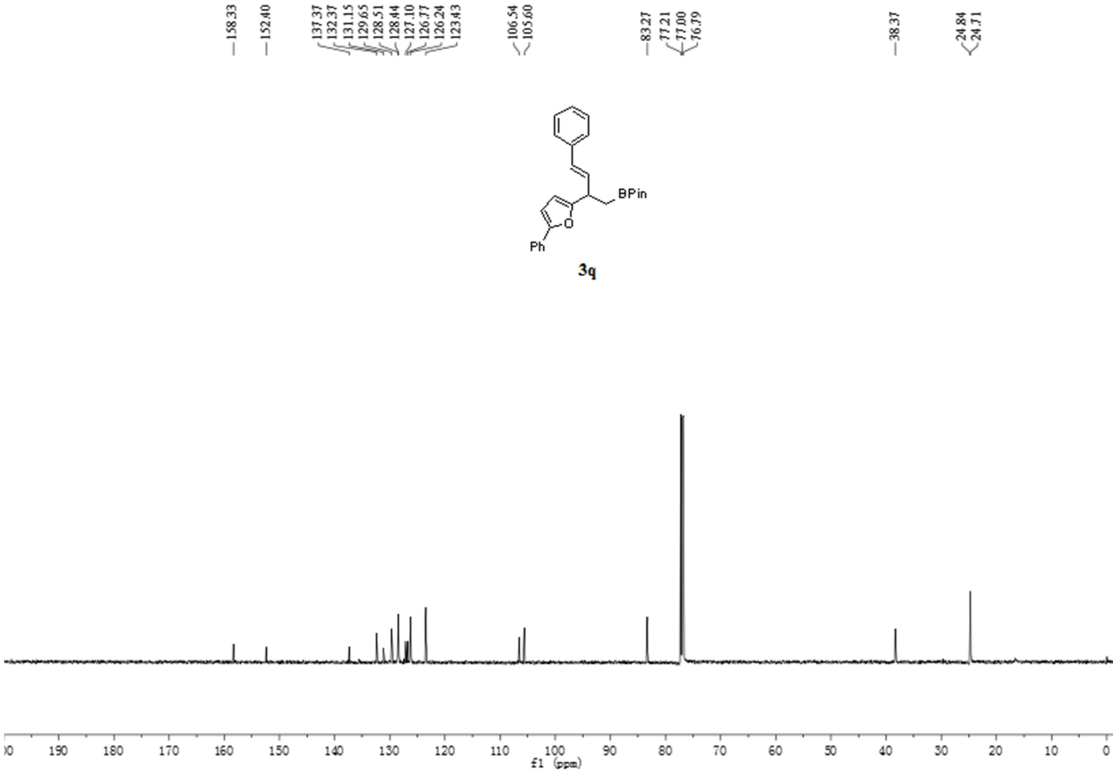
-0.5
-1
f1 (ppm)

3q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129.65
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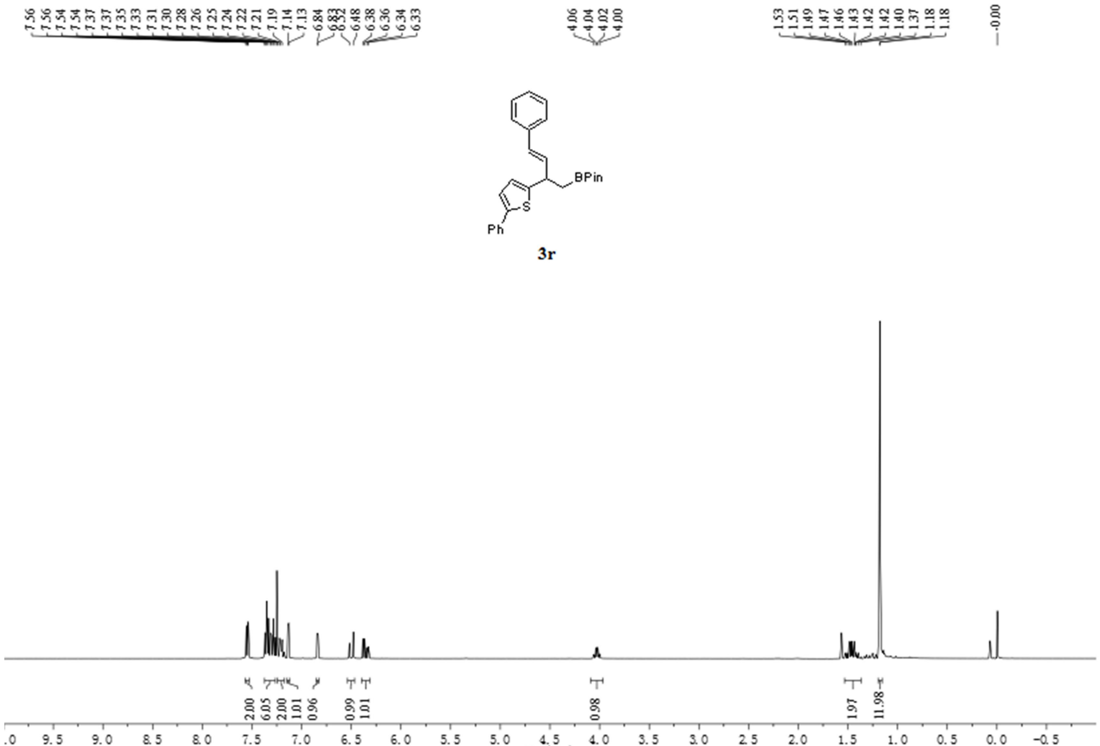
127.10
126.77
126.24
123.43
106.54
105.60
83.27
77.21
77.00
76.79
38.37
24.84
24.71
BPin
O
Ph
00
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

3q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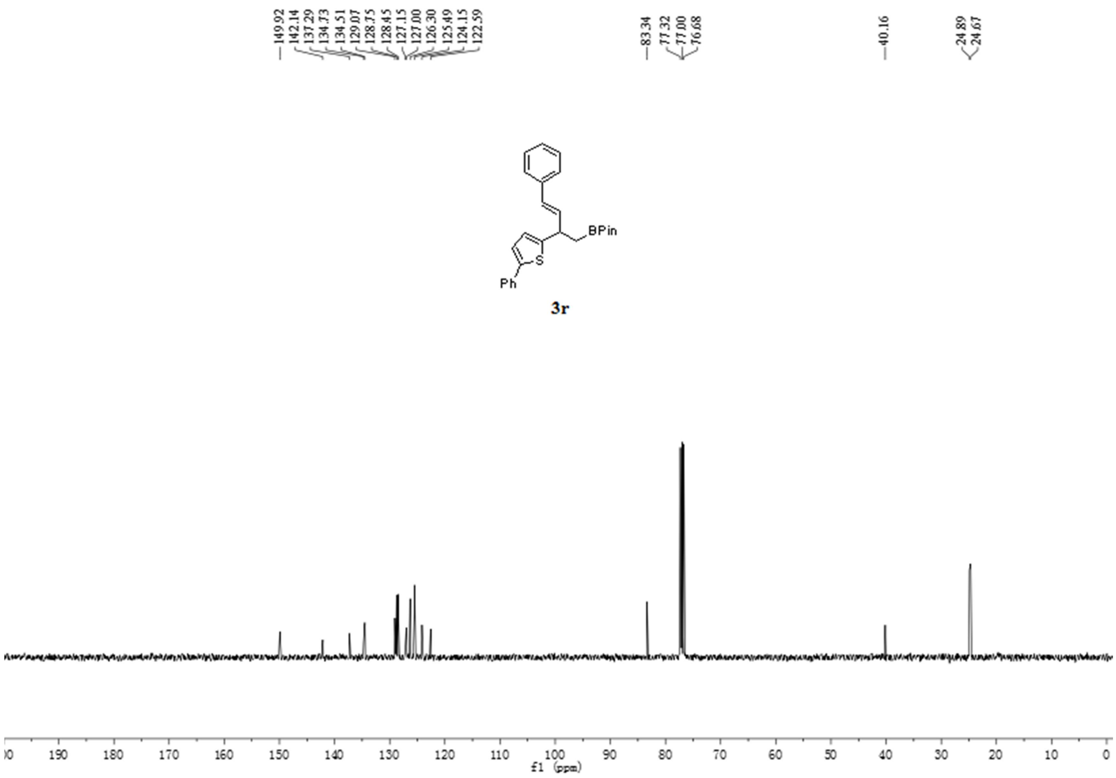
7.24
7.22
7.21
7.19
7.14
7.13
6.84
6.83
6.52
6.48
6.38
6.36
6.34
6.33
4.06
4.04
4.02
4.00
1.53
1.51
1.49
1.47
1.46
1.43
1.42
1.42
1.40
1.37
1.18
1.18
-0.00
BPin
S
Ph
2.00
6.05
2.00
1.01
0.96
0.99
1.01
0.98
1.97
11.98
f1 (ppm)

3r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125.49
124.15
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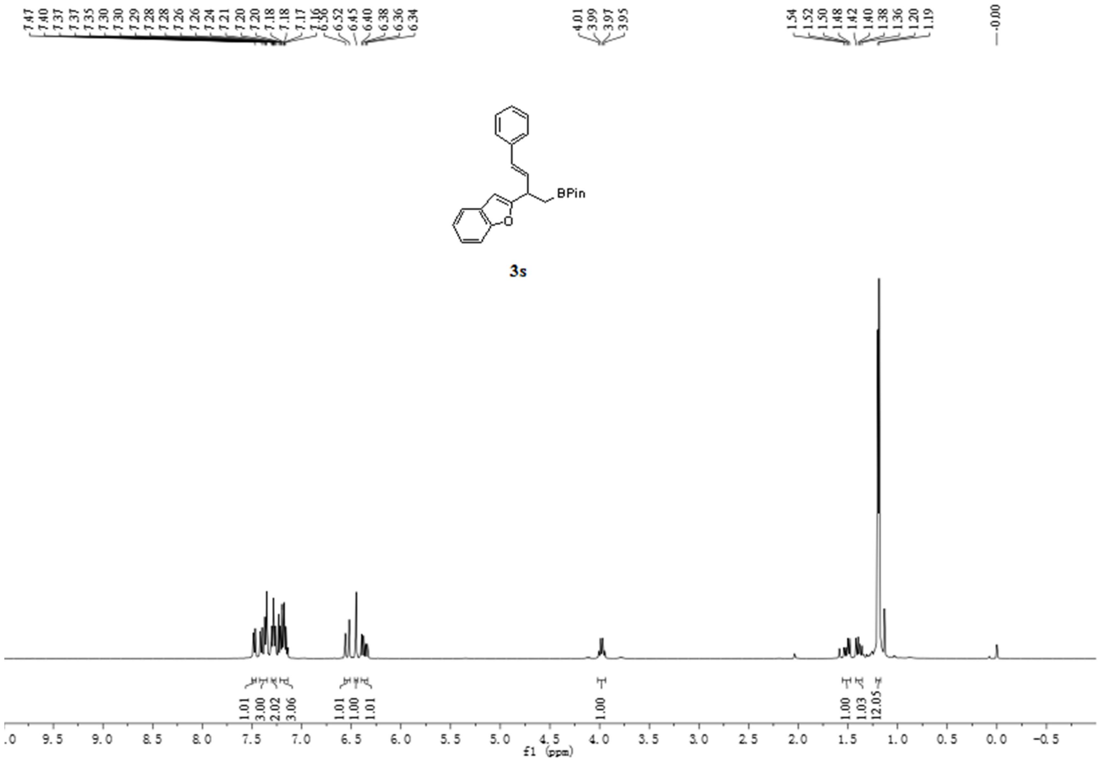
77.00
76.68
40.16
24.89
24.67
BPin
S
Ph
f1 (ppm)

3r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7.20
7.18
7.18
7.17
7.16
6.58
6.52
6.45
6.40
6.38
6.36
6.34
4.01
3.99
3.97
3.95
1.54
1.52
1.50
1.48
1.42
1.40
1.38
1.36
1.20
1.19
-0.00
BPin
O
3s
1.01
3.00
2.02
3.06
1.01
1.00
1.01
1.00
1.00
1.03
12.05
.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
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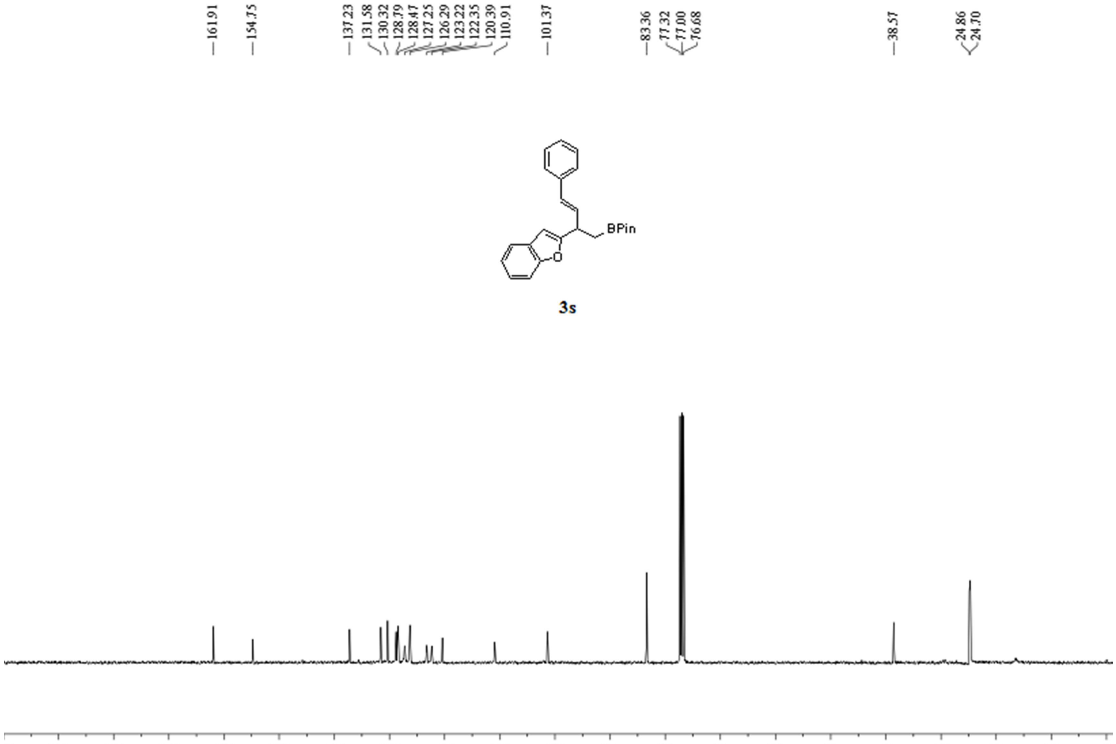
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
f1 (ppm)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123.22
122.35
120.39
110.91
101.37
83.36
77.32
77.00
76.68
38.57
24.86
24.70
BPin
O
3s
00
190
180
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120
110
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50
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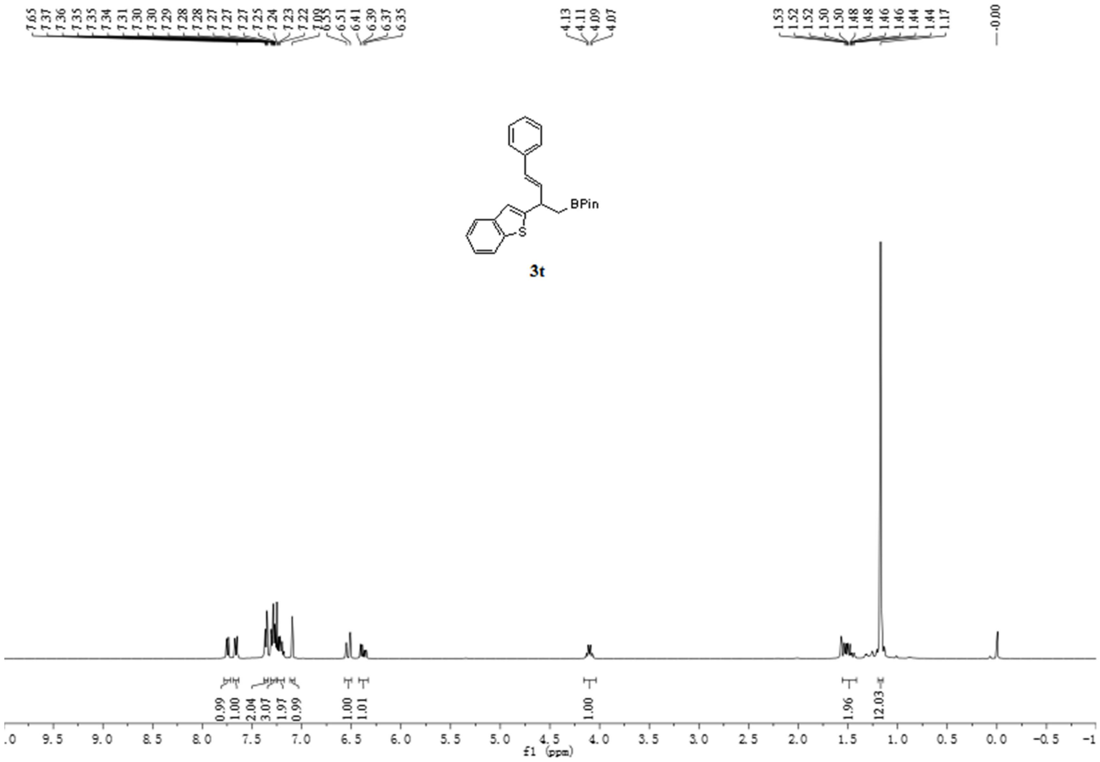
f1 (ppm)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7.27
7.27
7.25
7.24
7.23
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7.09
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6.51
6.41
6.39
6.37
6.35
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4.11
4.09
4.07
1.53
1.52
1.52
1.50
1.50
1.48
1.48
1.46
1.46
1.44
1.44
1.17
-0.00
BPin
S
3t
0.99
1.00
2.04
3.07
1.97
0.99
1.00
1.01
1.00
1.96
12.03
.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
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2.0
1.5
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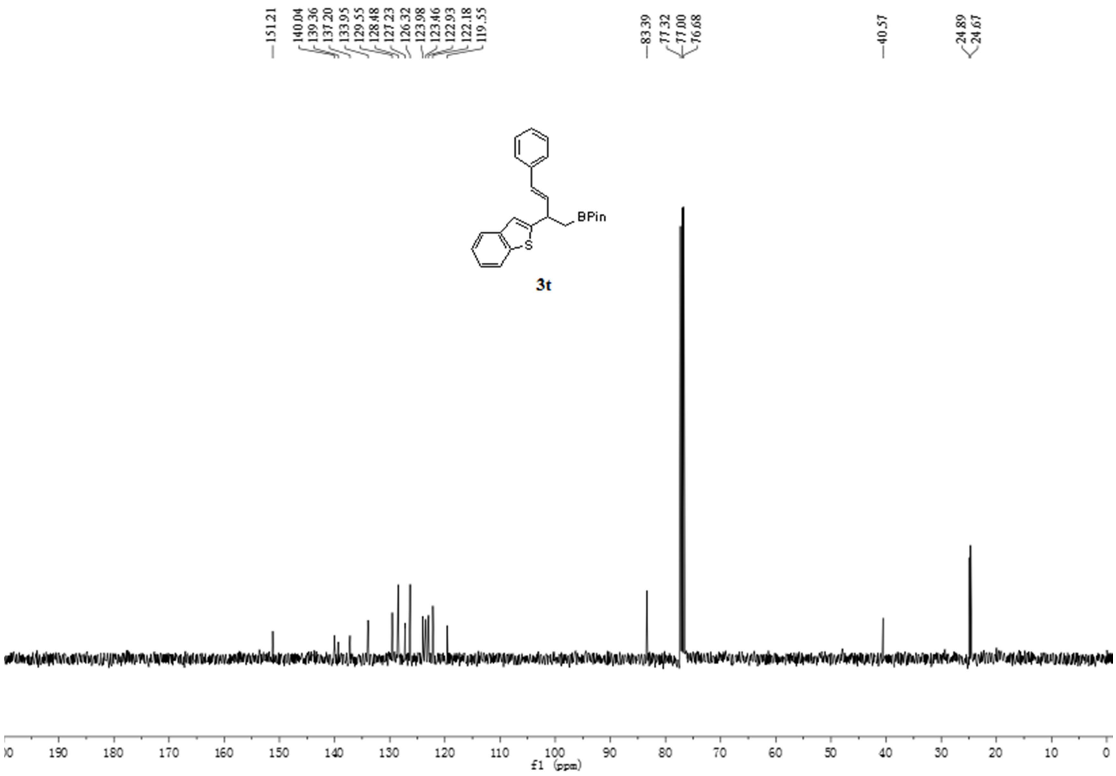
-1
f1 (ppm)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119.55
83.39
77.32
77.00
76.68
40.57
24.89
24.67
BPin
S
3t
00
190
180
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130
120
110
100
90
80
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50
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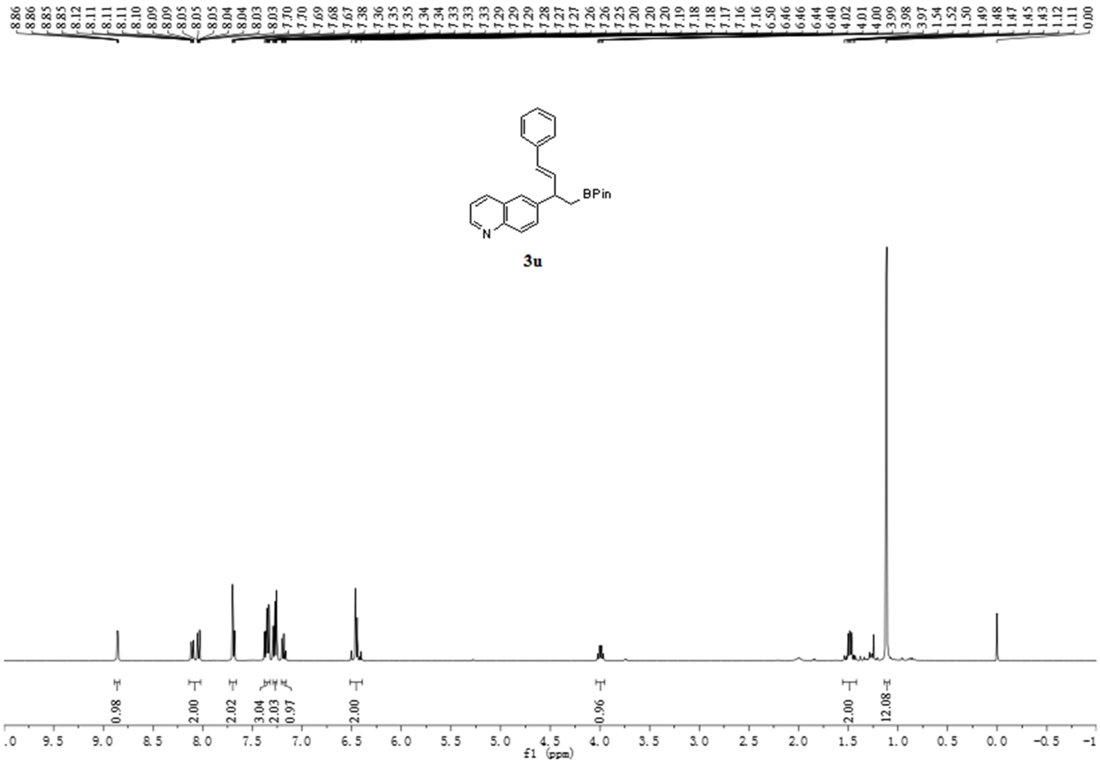
0
f1 (ppm)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8.11
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8.05
8.05
8.05
8.04
8.04
8.03
8.03
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7.20
7.20
7.20
7.19
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7.17
7.16
7.16
6.50
6.46
6.46
6.44
6.40
4.02
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1.54
1.52
1.50
1.49
1.48
1.47
1.45
1.43
1.12
1.11
0.00
BPin
N
0.98
2.00
2.02
3.04
2.03
0.97
2.00
0.96
2.00
12.08
.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
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3.0
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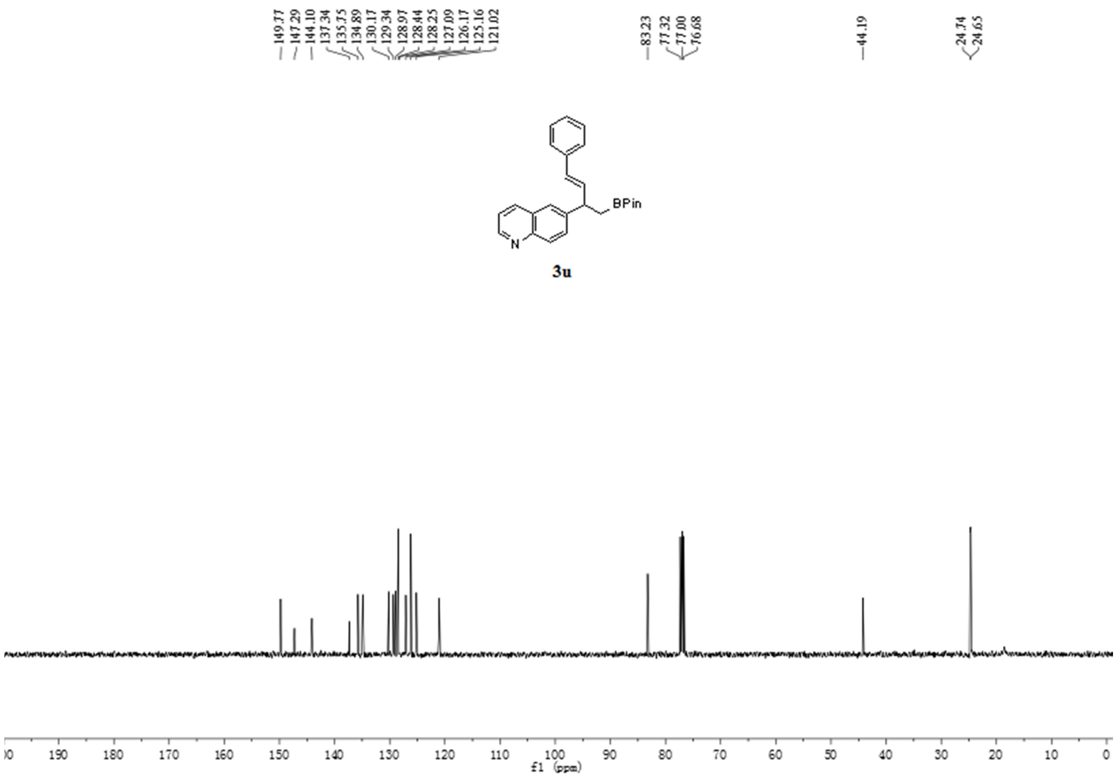
1.0
0.5
0.0
−0.5
−1
f1 (ppm)

3u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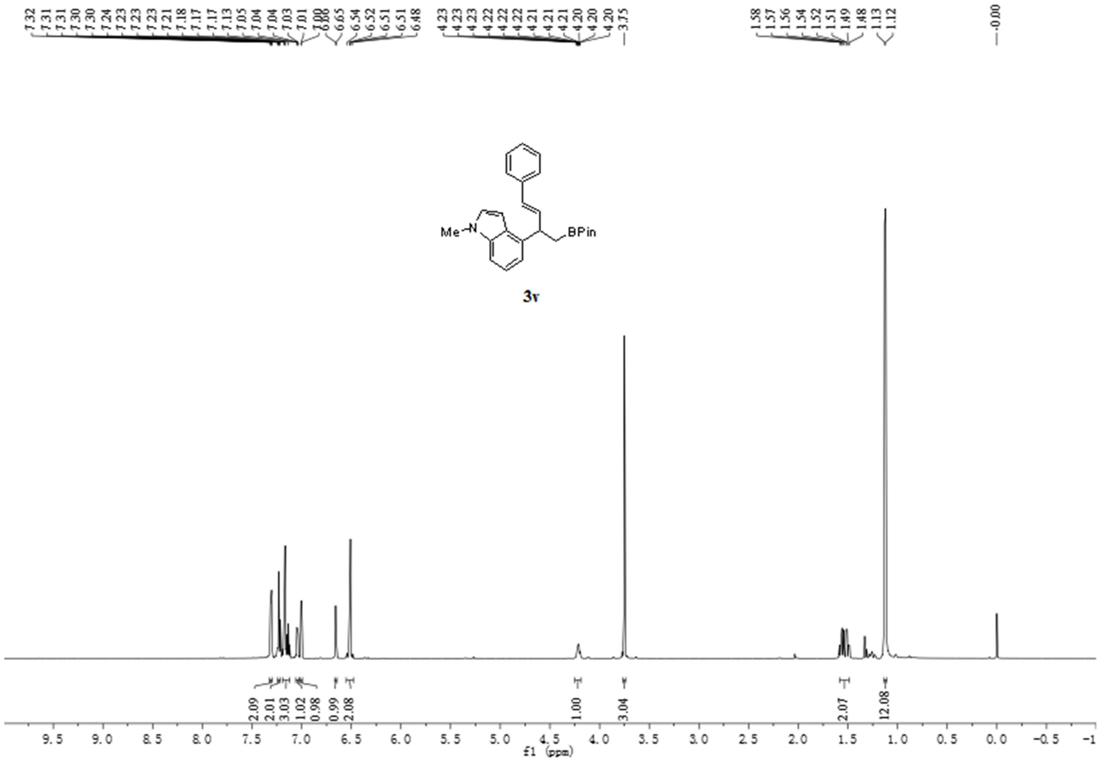
128.44
128.25
127.09
126.17
125.16
121.02
83.23
77.32
77.00
76.68
44.19
24.74
24.65
BPin
N
00
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

3u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7.13
7.05
7.04
7.04
7.03
7.01
7.00
6.98
6.65
6.54
6.52
6.51
6.48
4.23
4.23
4.23
4.22
4.22
4.22
4.21
4.21
4.21
4.20
4.20
4.20
3.75
1.58
1.57
1.56
1.54
1.52
1.51
1.49
1.48
1.13
1.12
-0.00
Me
N
BPin
2.09
2.01
3.03
1.02
0.98
0.99
2.08
1.00
3.04
2.07
12.08
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
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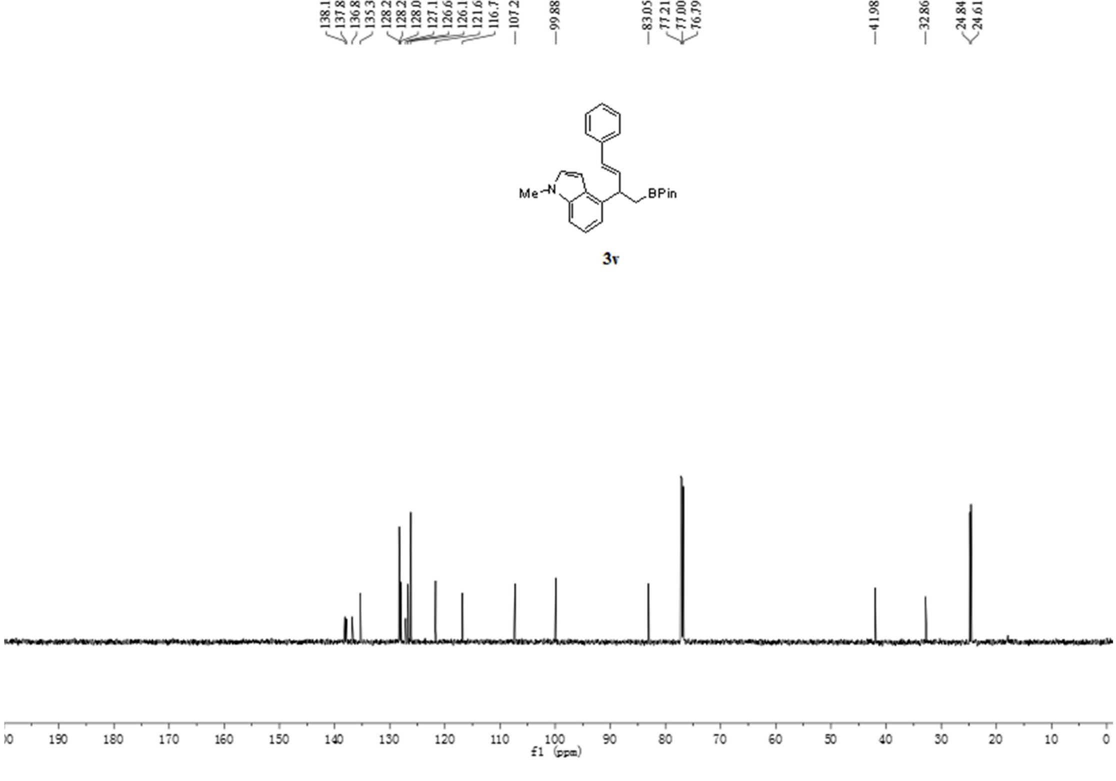
2.0
1.5
1.0
0.5
0.0
-0.5
-1
f1 (ppm)

3v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126.14
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107.28
99.88
83.05
77.21
77.00
76.79
41.98
32.86
24.84
24.61
Me
N
BPin
00
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180
170
160
150
140
130
120
110
100
90
80
70
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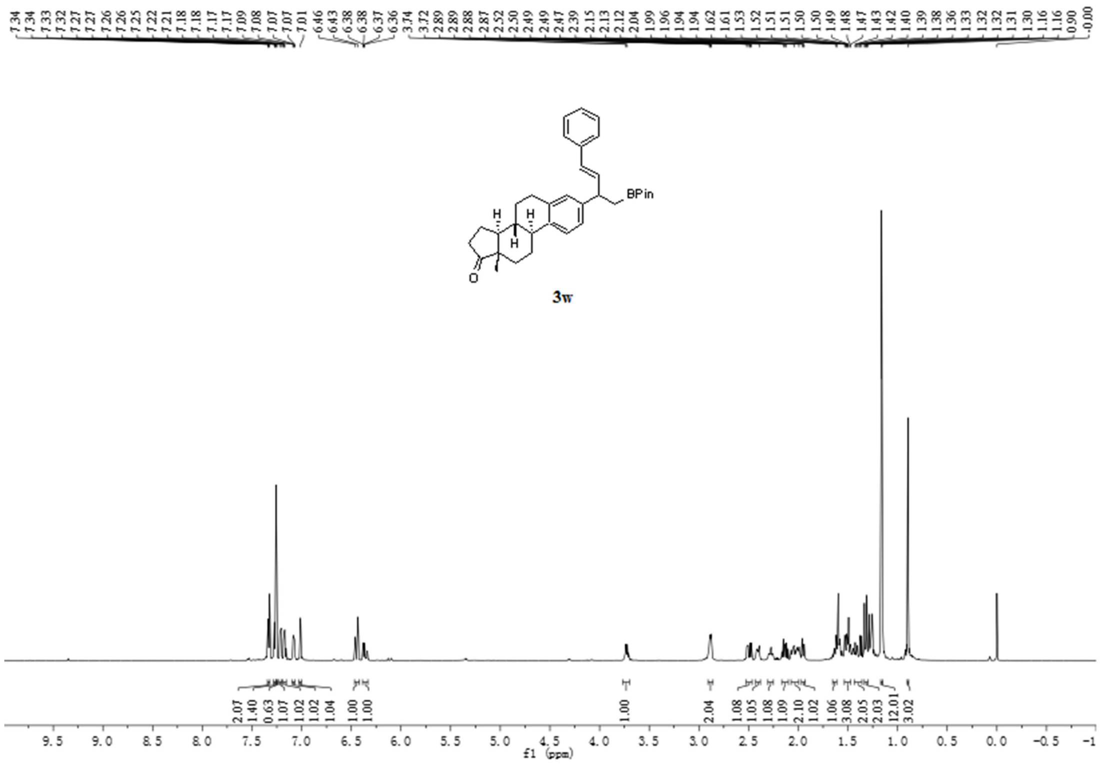
10
0
f1 (ppm)

3v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7.17
7.09
7.08
7.07
7.07
7.07
7.01
6.46
6.43
6.38
6.38
6.37
6.36
3.74
3.72
2.89
2.89
2.88
2.87
2.52
2.50
2.49
2.49
2.47
2.39
2.15
2.13
2.12
2.04
1.99
1.96
1.94
1.94
1.62
1.61
1.53
1.52
1.51
1.51
1.50
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1.49
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1.43
1.42
1.40
1.39
1.38
1.36
1.33
1.32
1.32
1.31
1.30
1.16
0.90
-0.00
BPin
H
H
H
O
3w
2.07
1.40
0.63
1.07
1.02
1.02
1.04
1.00
1.00
1.00
2.04
1.08
1.05
1.08
1.09
2.10
1.02
1.06
3.08
2.05
2.03
12.01
3.02
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
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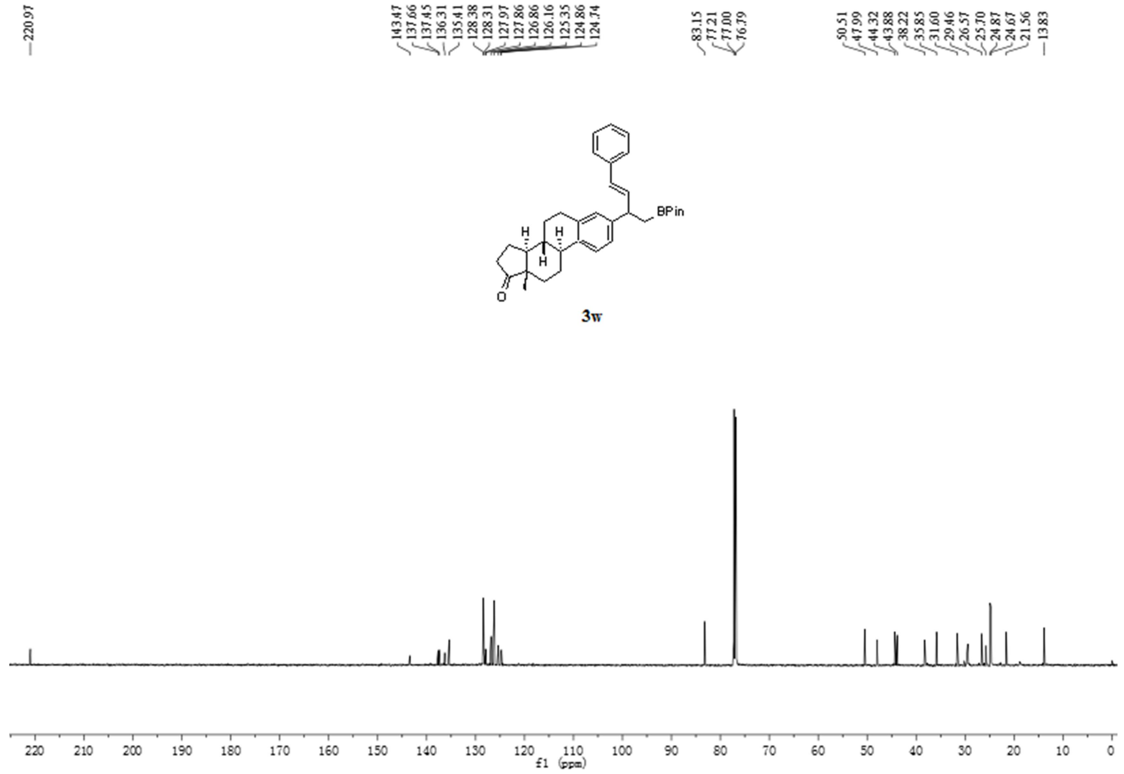
-1
f1 (ppm)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124.86
124.74
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77.21
77.00
76.79
50.51
47.99
44.32
43.88
38.22
35.85
31.60
29.46
26.57
25.70
24.87
24.67
21.56
13.83
BPin
H
H
H
O
3w
220
210
200
190
180
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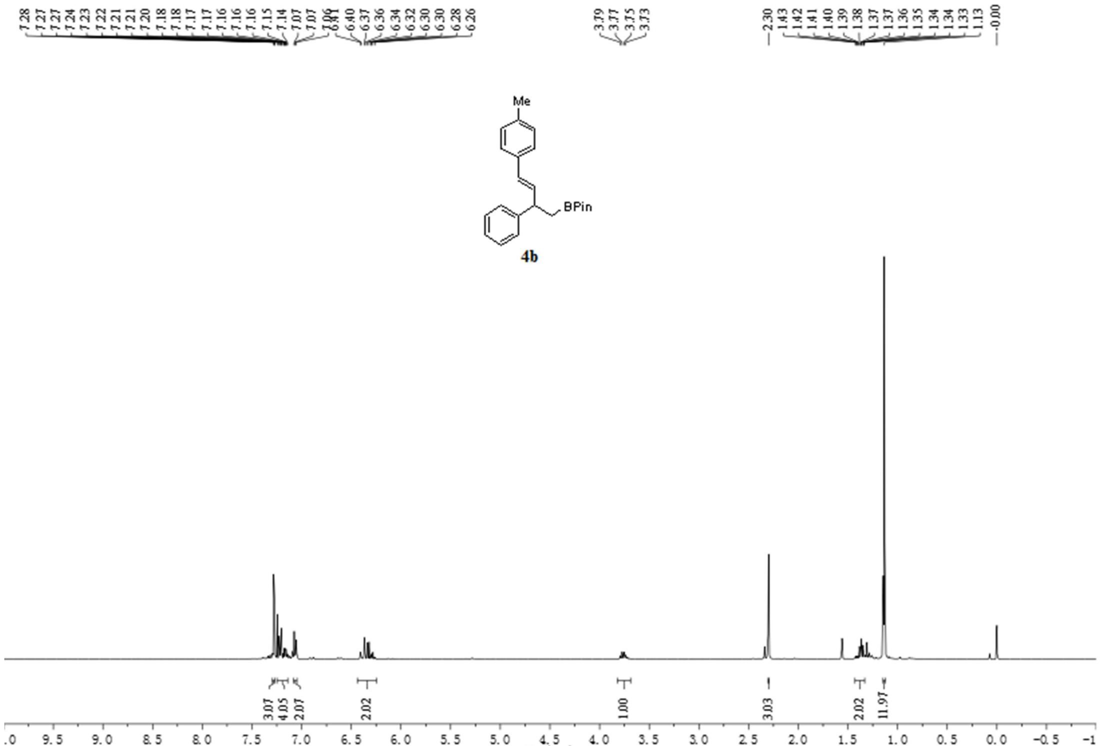
f1 (ppm)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7.16
7.15
7.14
7.07
7.07
7.06
6.41
6.40
6.37
6.36
6.34
6.32
6.30
6.30
6.30
6.28
6.26
3.79
3.77
3.75
3.73
2.30
1.43
1.42
1.41
1.40
1.39
1.38
1.37
1.37
1.36
1.35
1.34
1.34
1.33
1.13
-0.00
Me
BPin
4b
3.07
4.05
2.07
2.02
1.00
3.03
2.02
11.97
.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
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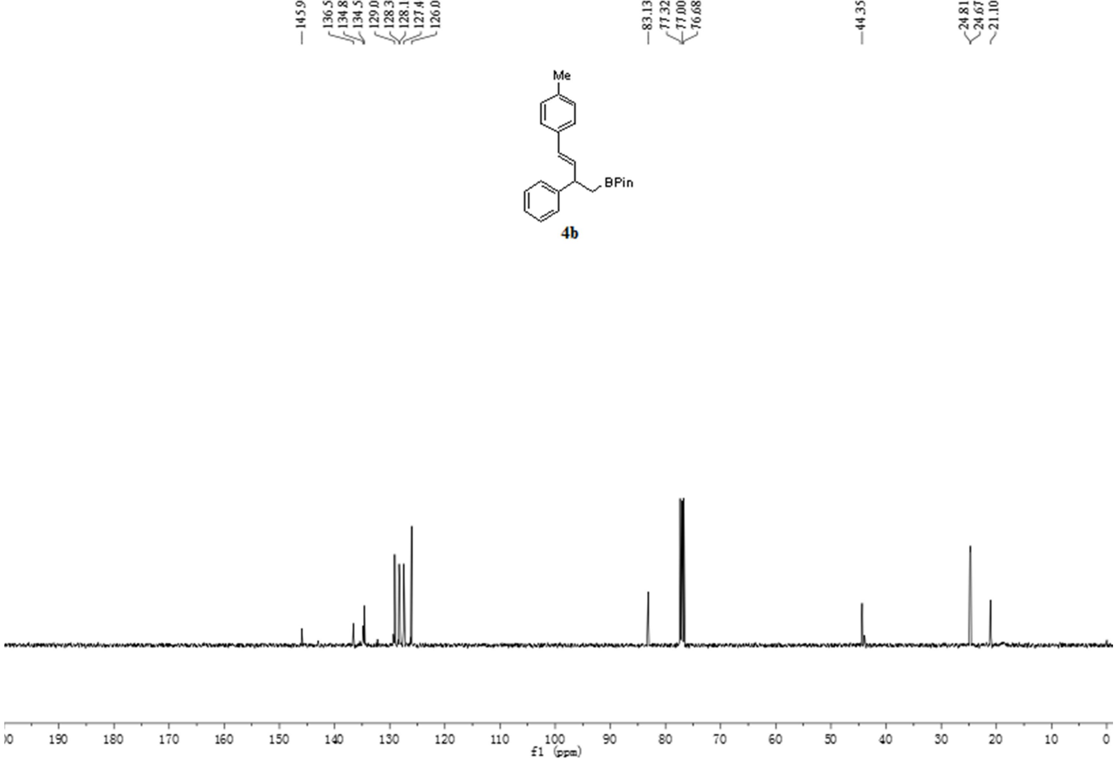
-1
f1 (ppm)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76.68
44.35
24.81
24.67
21.10
Me
BPin
4b
0
190
180
170
160
150
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130
120
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90
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50
40
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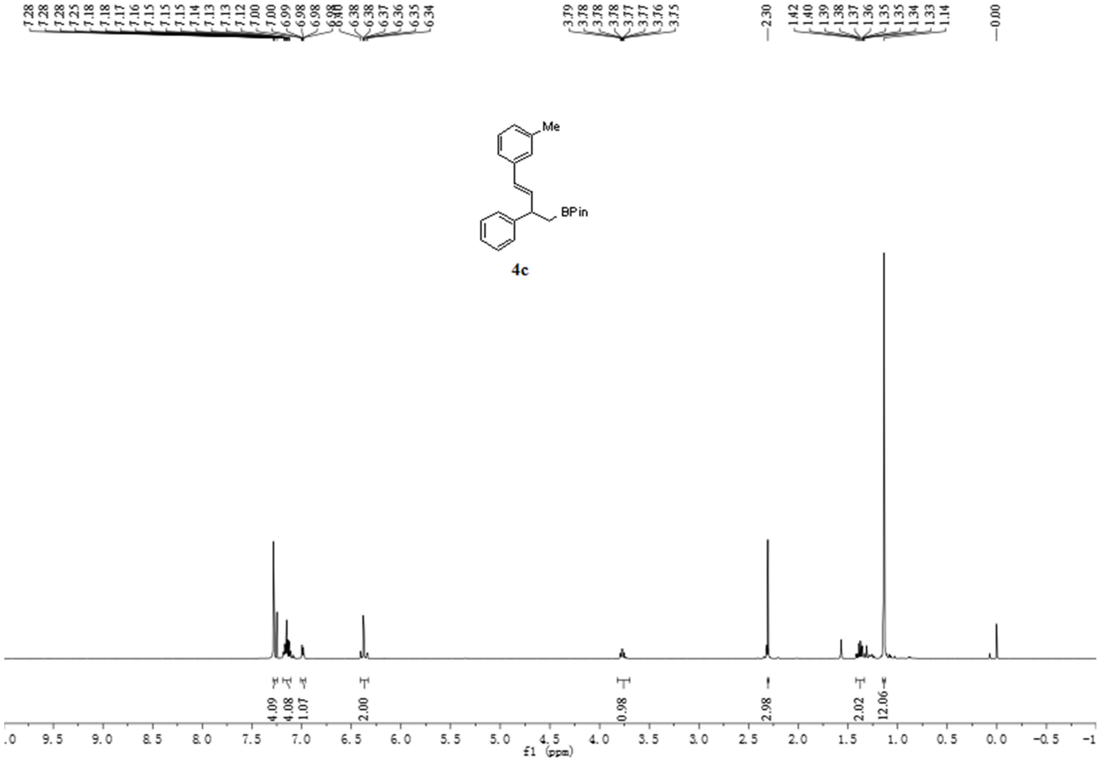
10
0
f1 (ppm)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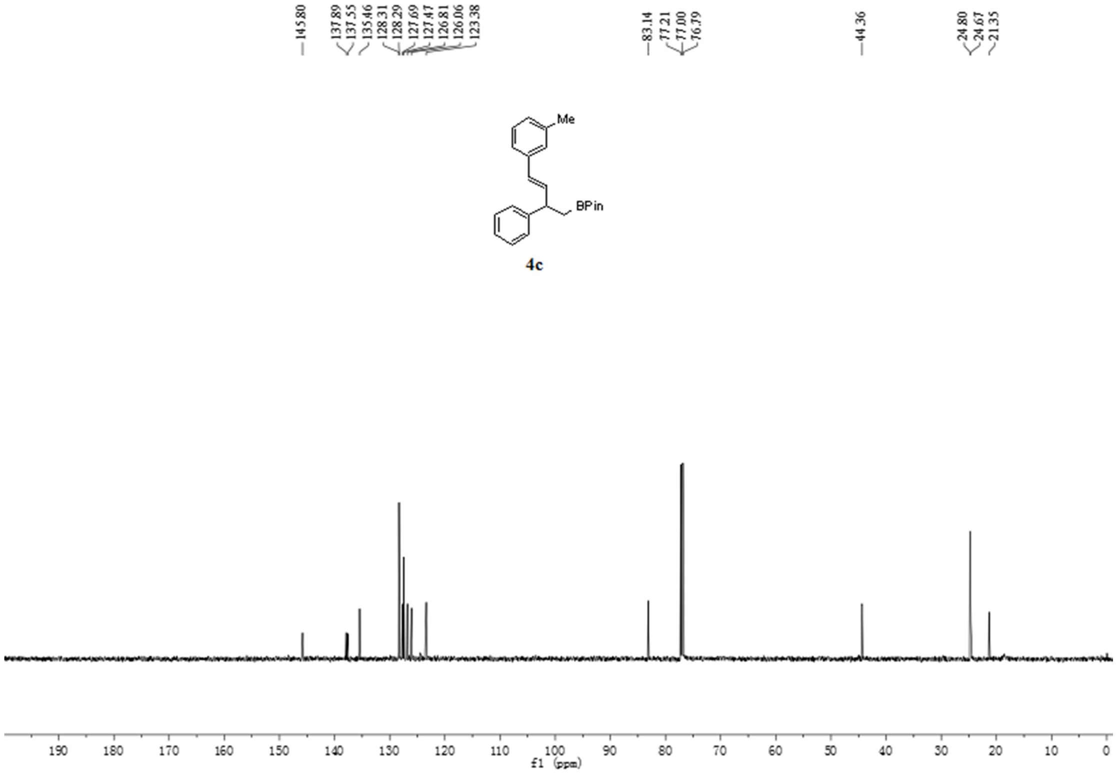
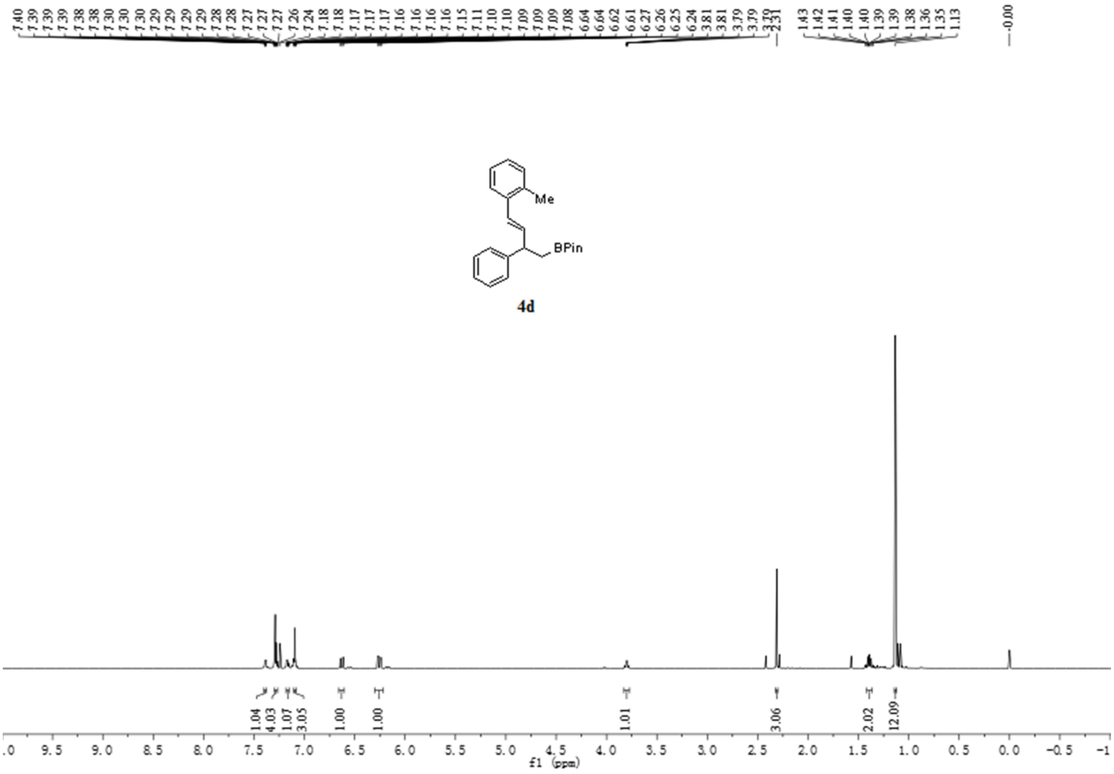
3.79 3.78 3.78 3.78 3.77 3.77 3.76 3.75
2.30
1.42 1.40 1.39 1.38 1.37 1.36 1.35 1.35 1.34 1.33 1.14
0.00
Me
BPin
4c
4.09
4.08
1.07
2.00
0.98
2.98
2.02
12.06
.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5 -1
f1 (ppm)


145.80
137.89 137.55 135.46 128.31 128.29 127.69 127.47 126.81 126.06 123.38
83.14
77.21 77.00 76.79
44.36
24.80 24.67 21.35
Me
BPin
4c
190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)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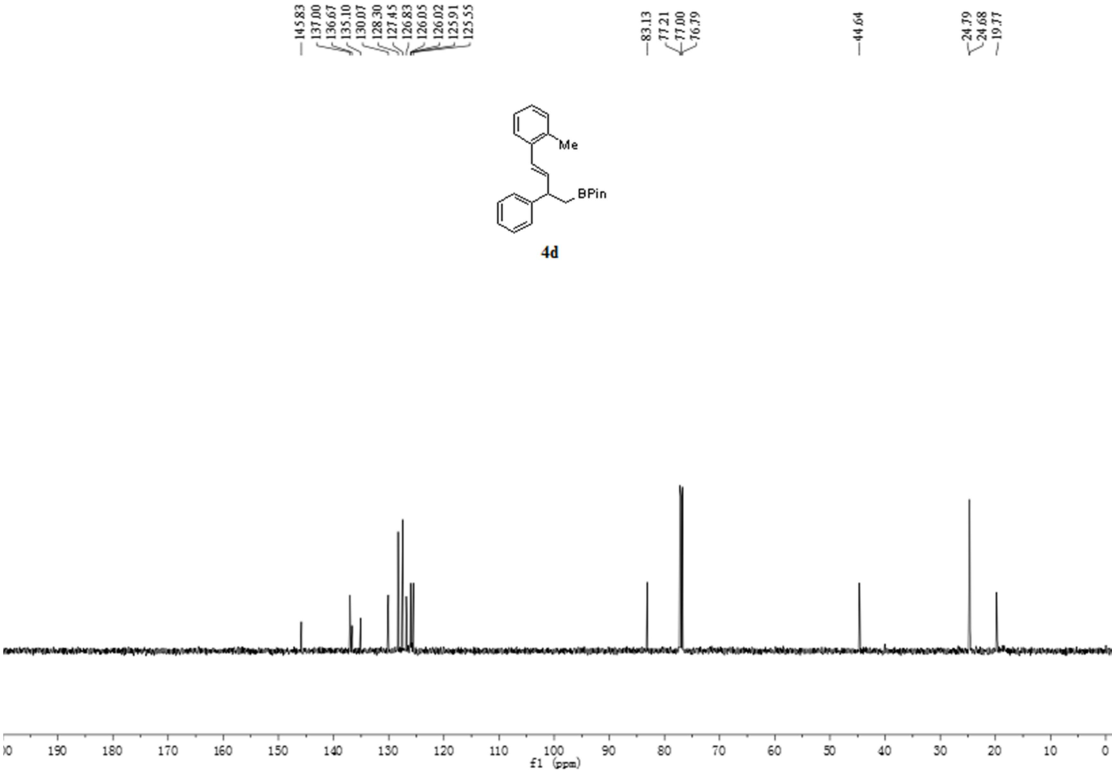
7.16
7.16
7.16
7.16
7.15
7.11
7.10
7.10
7.09
7.09
7.09
7.08
6.64
6.64
6.62
6.61
6.27
6.26
6.25
6.24
3.81
3.81
3.79
3.79
3.79
2.31
1.43
1.42
1.41
1.40
1.40
1.39
1.39
1.38
1.36
1.35
1.13
-0.00
Me
BPin
1.04
4.03
1.07
3.05
1.00
1.00
1.01
3.06
2.02
12.09
f1 (ppm)

4d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126.83
126.05
126.02
125.91
125.55
83.13
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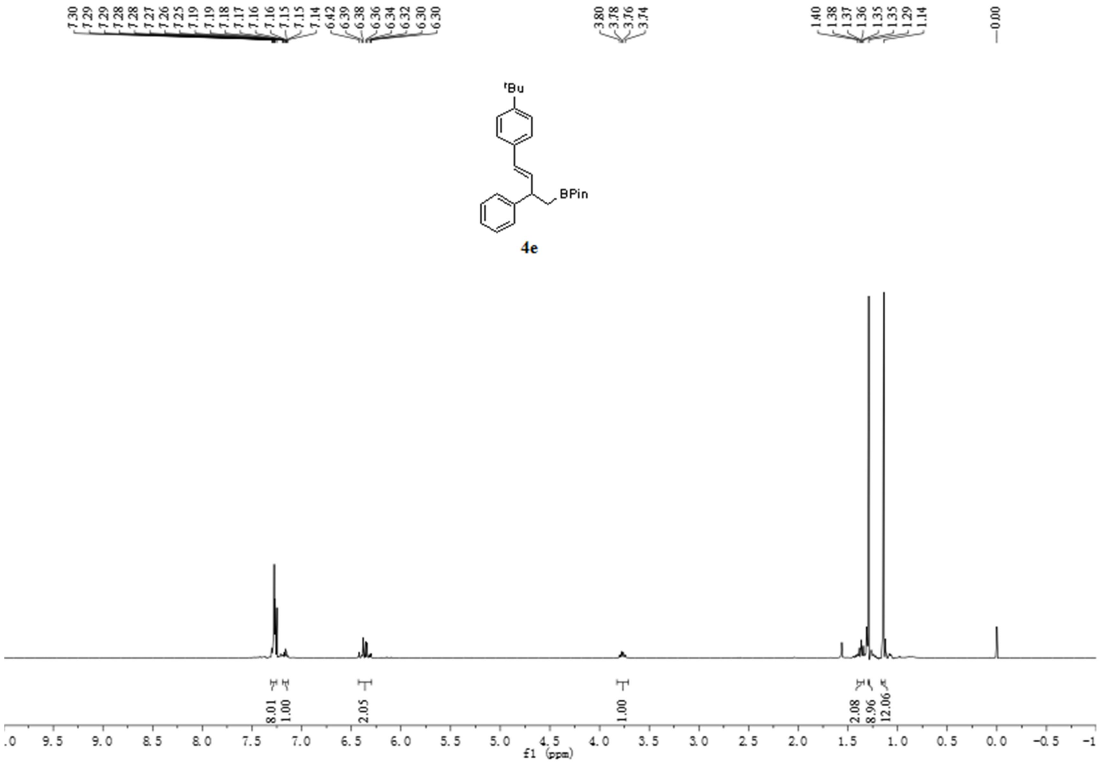
77.00
76.79
44.64
24.79
24.68
19.77
Me
BPin
f1 (ppm)

4d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7.18
7.17
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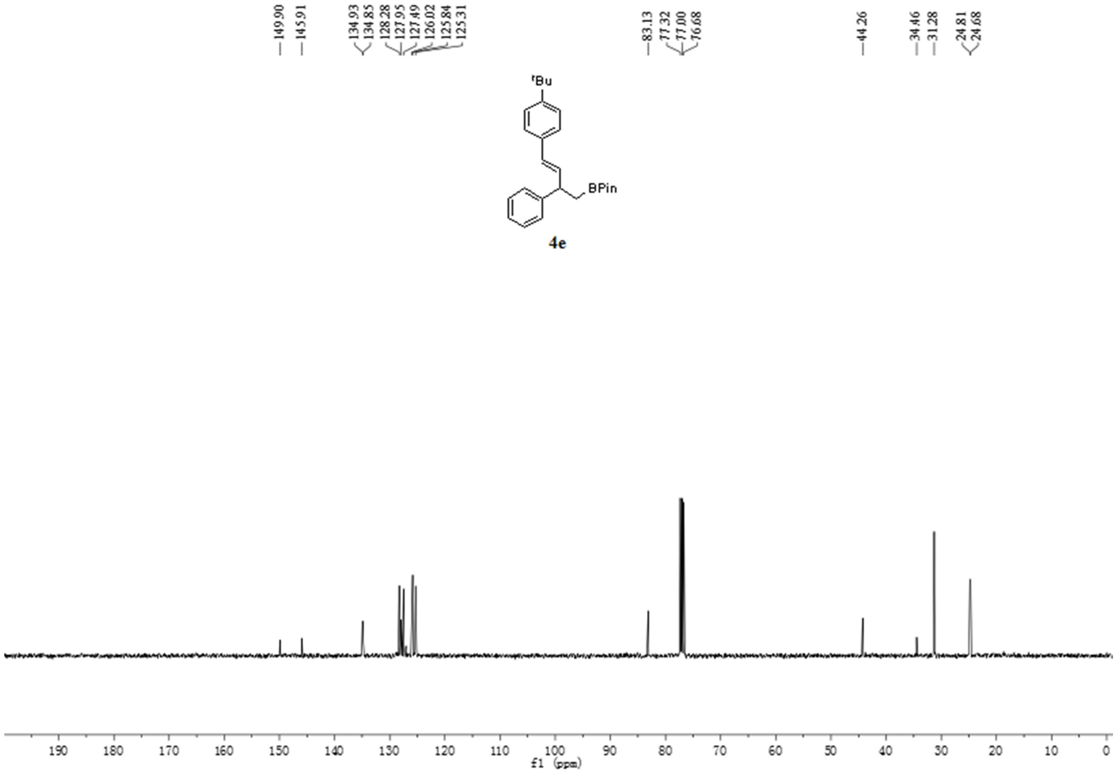
7.15
7.15
7.14
6.42
6.39
6.38
6.36
6.34
6.32
6.30
6.30
3.80
3.78
3.76
3.74
1.40
1.38
1.37
1.36
1.35
1.35
1.29
1.14
0.00
tBu
BPin
4e
8.01
1.00
2.05
1.00
2.08
8.96
12.06
.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
-1
f1 (ppm)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145.91
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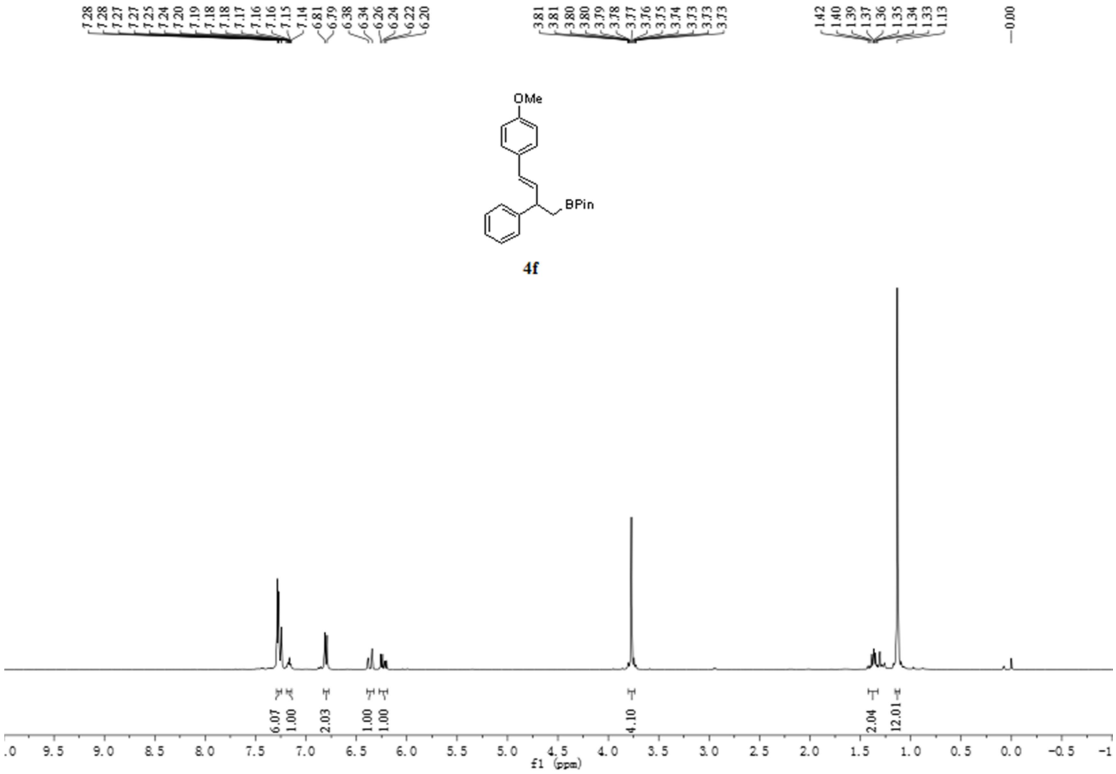
125.84
125.31
83.13
77.32
77.00
76.68
44.26
34.46
31.28
24.81
24.68
tBu
BPin
4e
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)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7.16
7.15
7.14
6.81
6.79
6.38
6.34
6.26
6.24
6.22
6.20
3.81
3.81
3.80
3.80
3.79
3.78
3.77
3.76
3.75
3.74
3.73
3.73
3.73
3.73
1.42
1.40
1.39
1.37
1.36
1.35
1.34
1.33
1.13
0.00
OMe
BPin
4f
6.07
1.00
2.03
1.00
1.00
4.10
2.04
12.01
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
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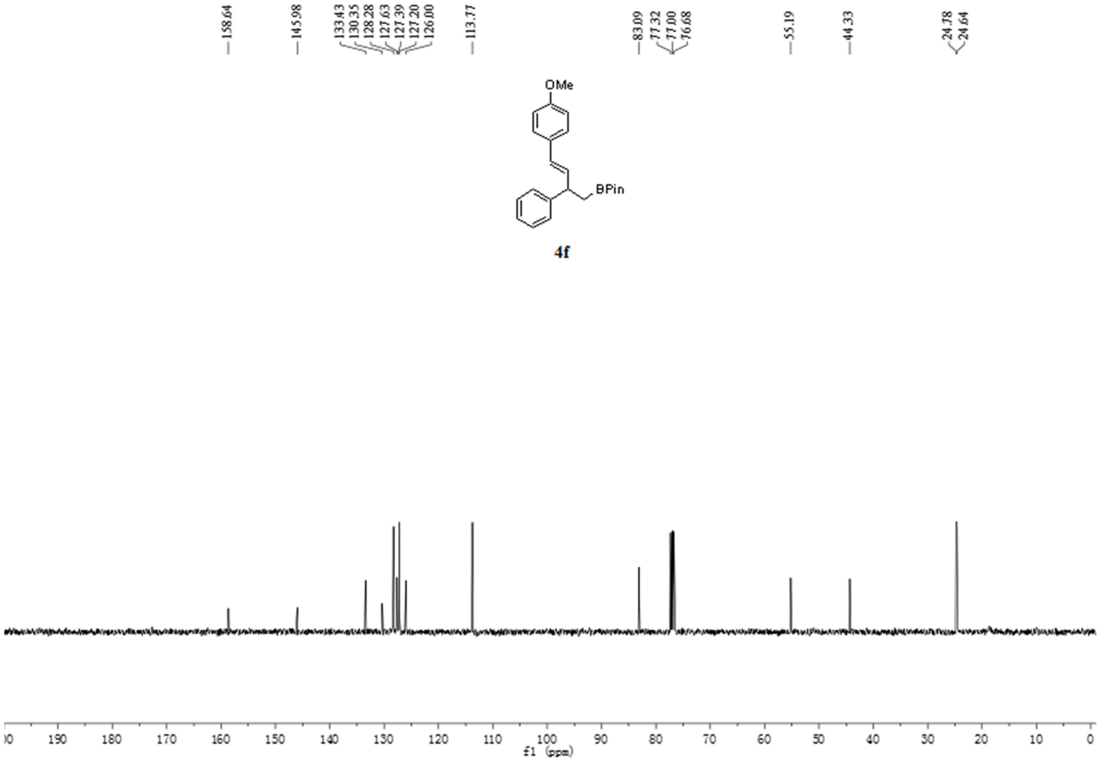
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
f1 (ppm)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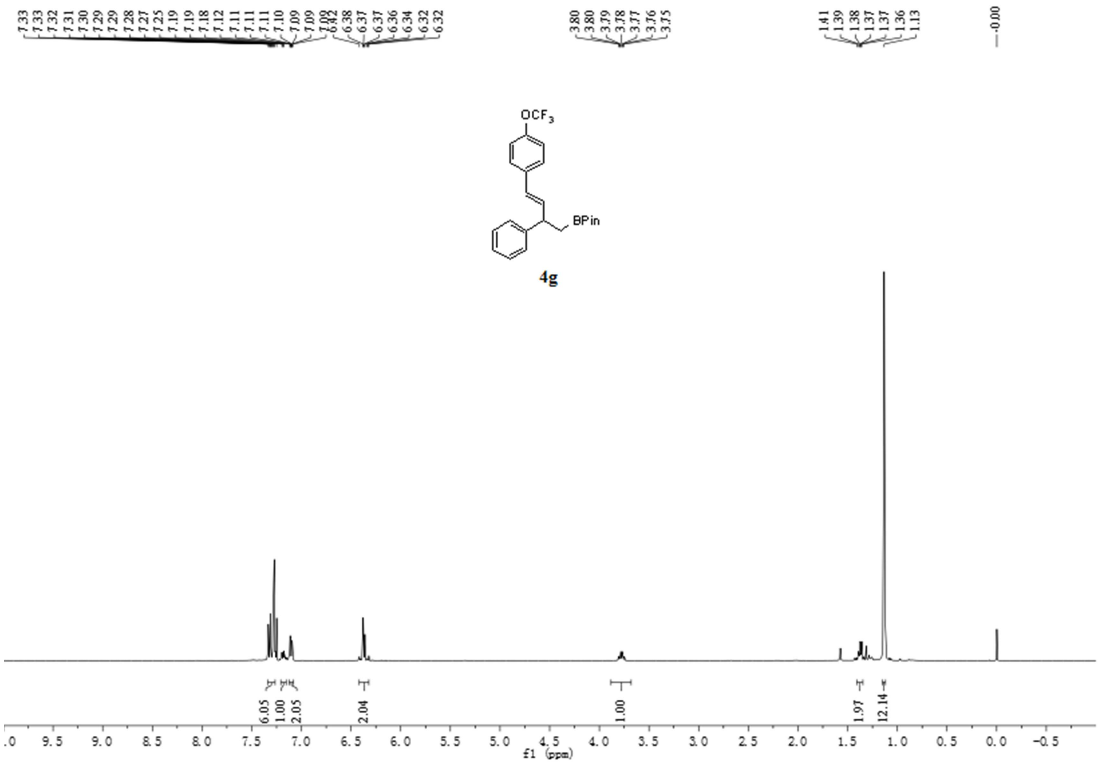
127.63
127.39
127.20
126.00
113.77
83.09
77.32
77.00
76.68
55.19
44.33
24.78
24.64
OMe
BPin
4f
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)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7.18
7.12
7.11
7.11
7.11
7.10
7.09
7.09
7.09
6.42
6.38
6.37
6.37
6.36
6.34
6.32
6.32
3.80
3.80
3.79
3.78
3.77
3.76
3.75
1.41
1.39
1.38
1.37
1.37
1.36
1.13
-0.00
OCF3
BPin
4g
6.05
1.00
2.05
2.04
1.00
1.97
12.14
.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
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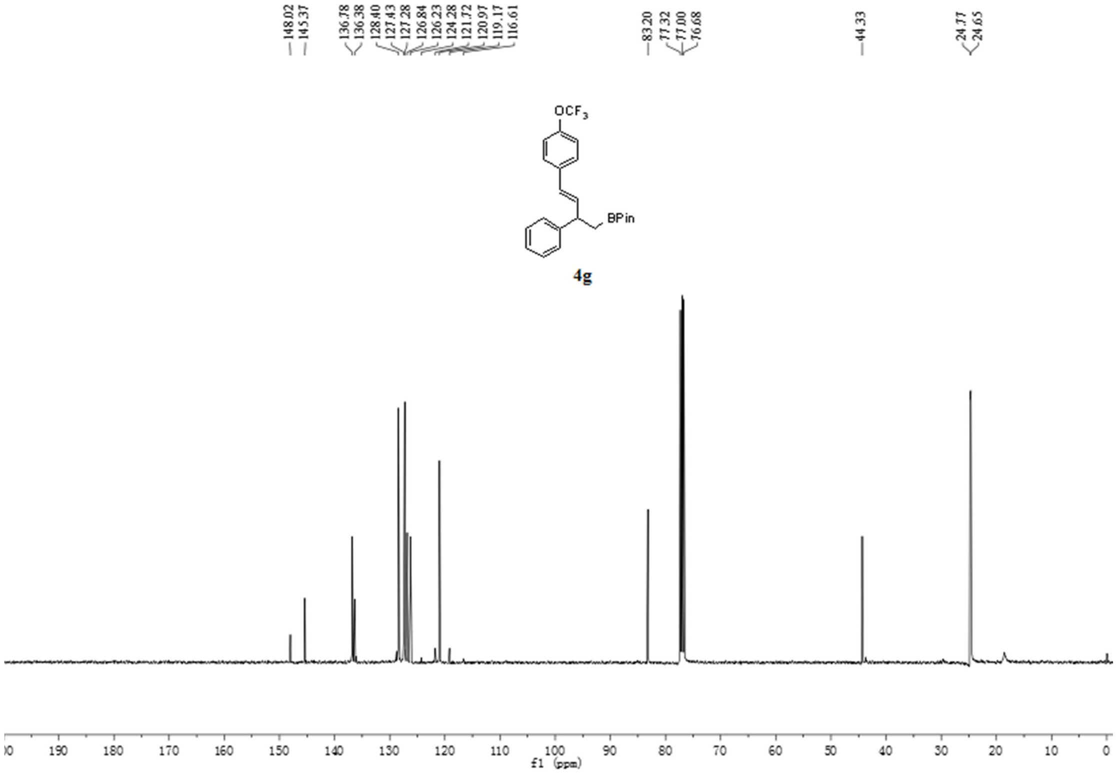
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
f1 (ppm)


148.02
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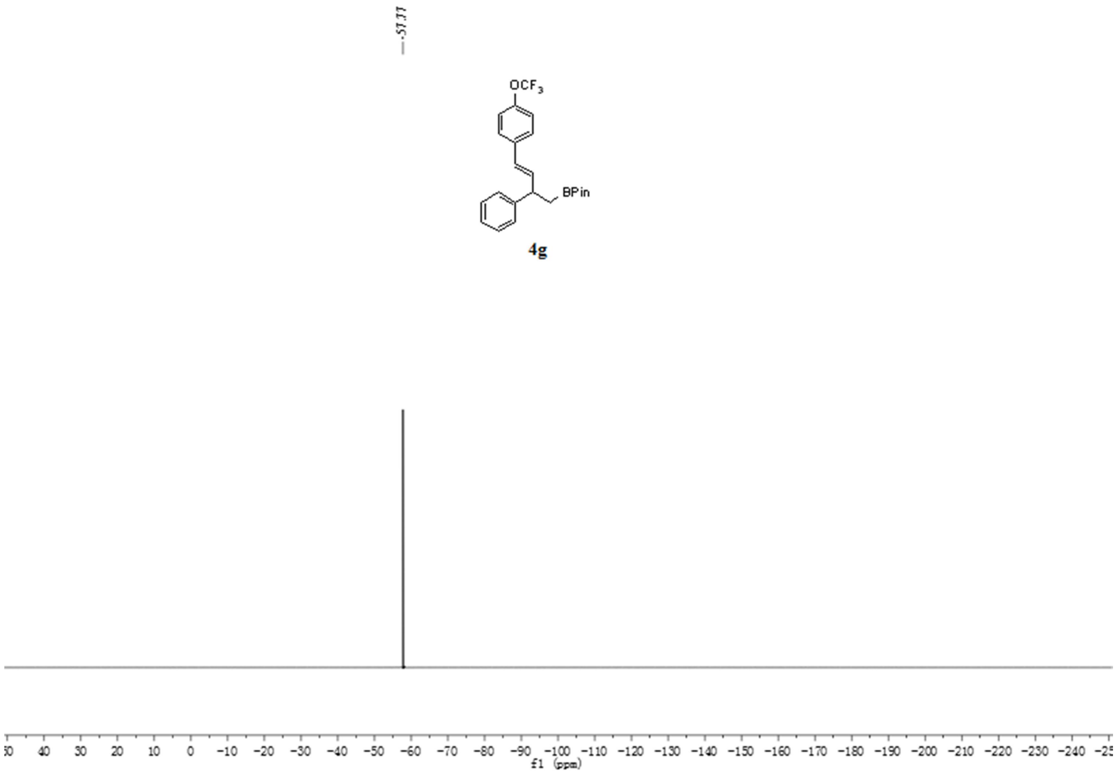
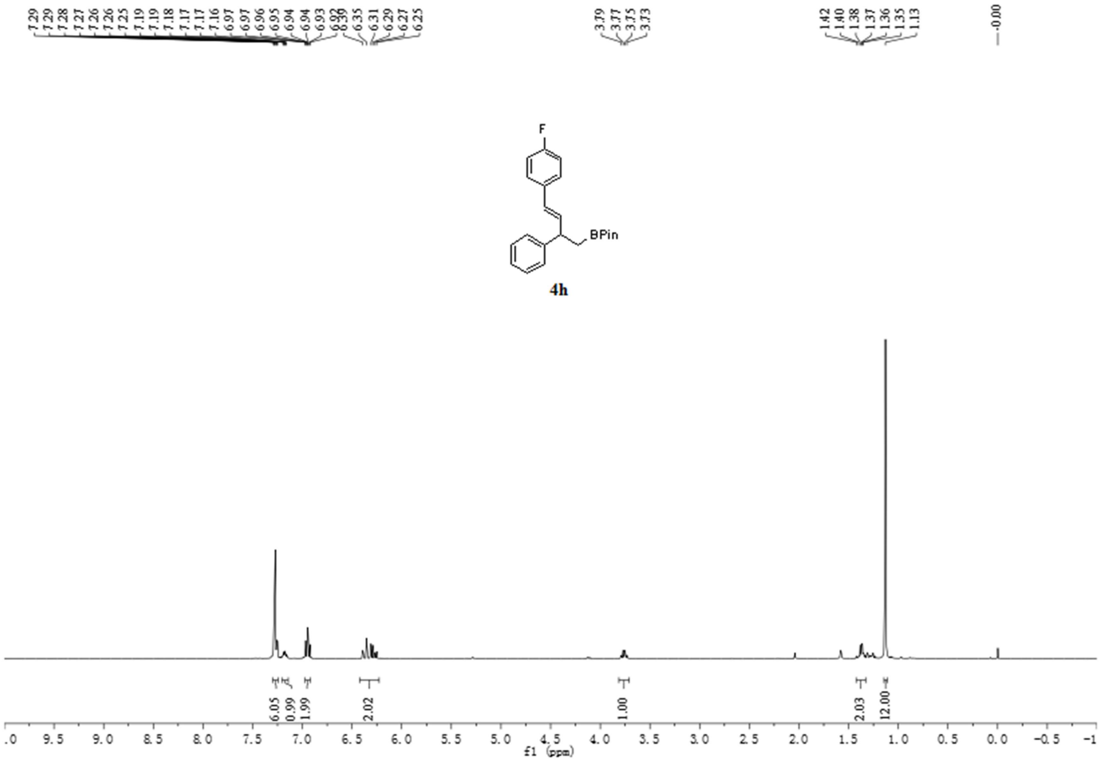
126.23
124.28
121.72
120.97
119.17
116.61
83.20
77.32
77.00
76.68
44.33
24.77
24.65
OCF3
BPin
4g
00
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)


-57.77
OCF₃
BPin
4g
50 40 30 20 10 0 −10 −20 −30 −40 −50 −60 −70 −80 −90 −100 −110 −120 −130 −140 −150 −160 −170 −180 −190 −200 −210 −220 −230 −240 −25
f1 (ppm)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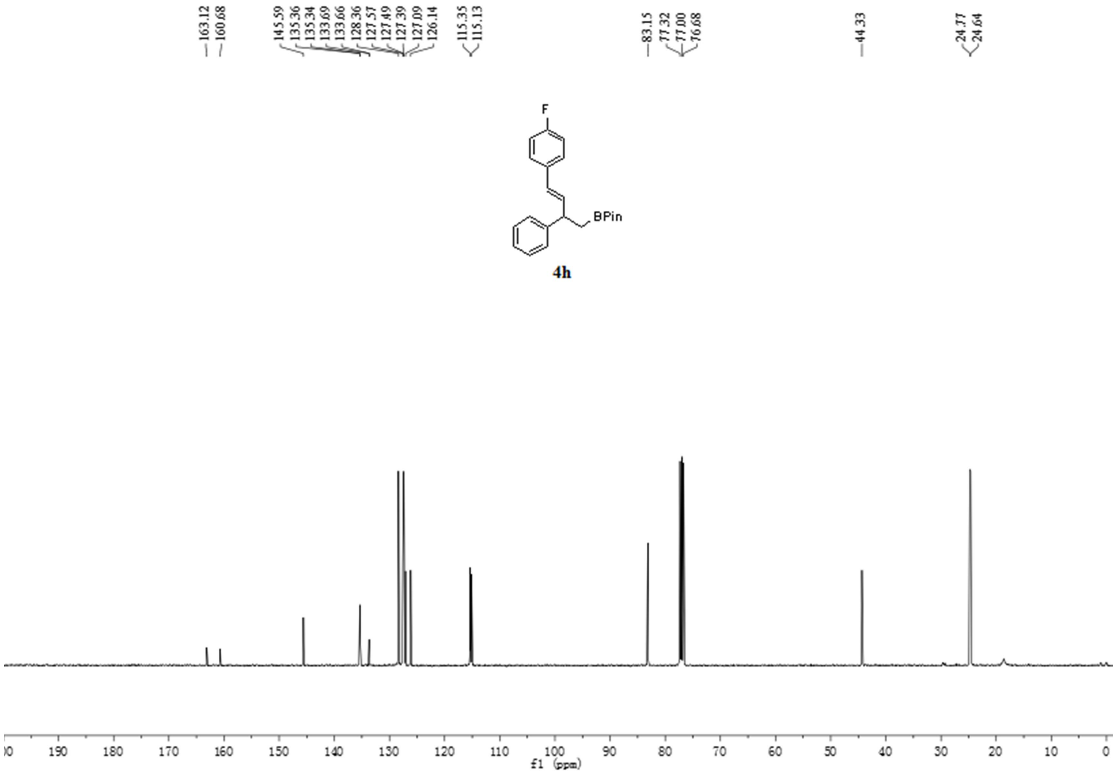
7.17
7.16
6.97
6.97
6.96
6.95
6.94
6.94
6.93
6.92
6.39
6.35
6.31
6.29
6.27
6.25
3.79
3.77
3.75
3.73
1.42
1.40
1.38
1.37
1.36
1.35
1.13
-0.00
F
BPin
4h
6.05
0.99
1.99
2.02
1.00
2.03
12.00
10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 −0.5 −1
f1 (ppm)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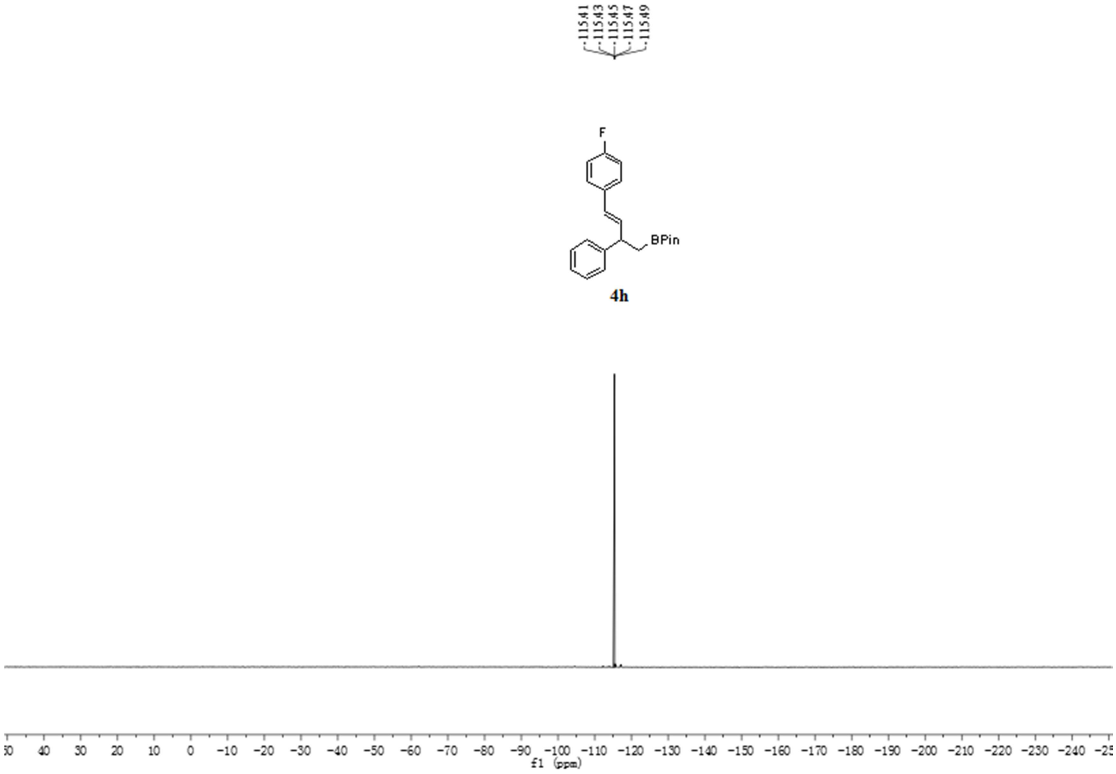
133.66
128.36
127.57
127.49
127.39
127.09
126.14
115.35
115.13
83.15
77.32
77.00
76.68
44.33
24.77
24.64
F
BPin
4h
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)


-115.41
-115.43
-115.45
-115.47
-115.49
F
BPin
4h
40
30
20
10
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
-110
-120
-130
-140
-150
-160
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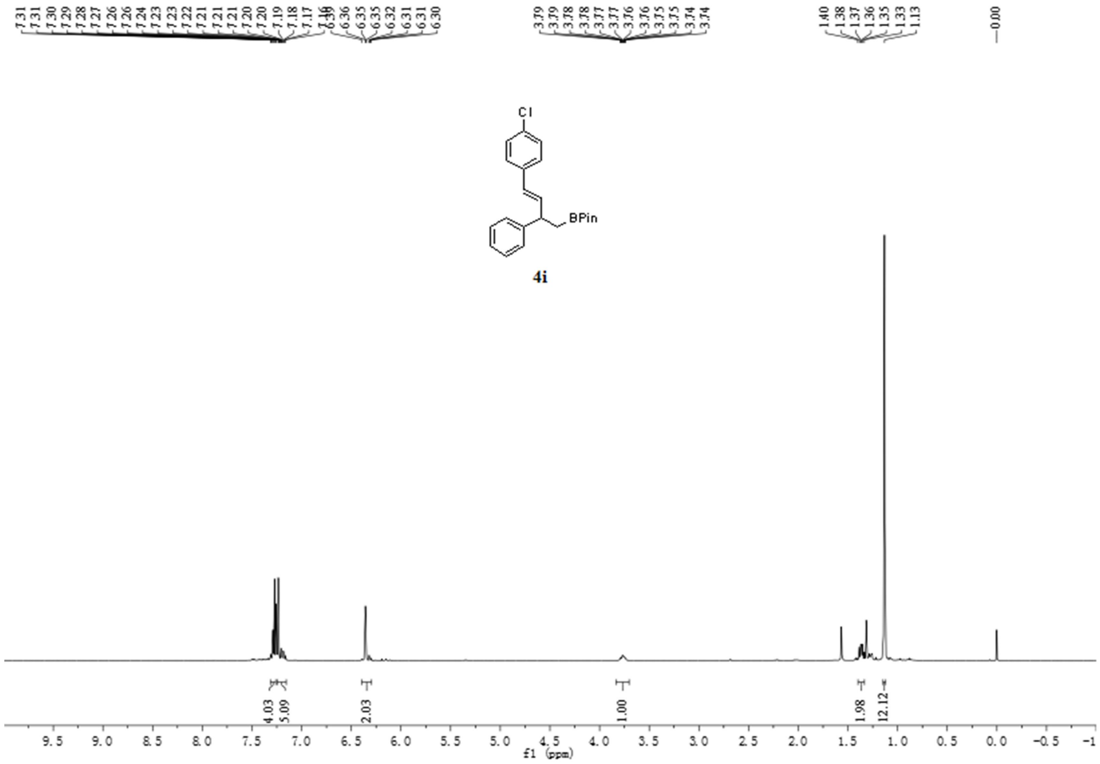
-220
-230
-240
f1 (ppm)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7.20
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7.19
7.18
7.17
7.16
6.39
6.36
6.35
6.35
6.32
6.31
6.31
6.30
3.79
3.79
3.78
3.78
3.77
3.77
3.76
3.76
3.75
3.75
3.74
3.74
1.40
1.38
1.37
1.36
1.35
1.33
1.13
0.00
Cl
BPin
4i
4.03
5.09
2.03
1.00
1.98
12.12
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
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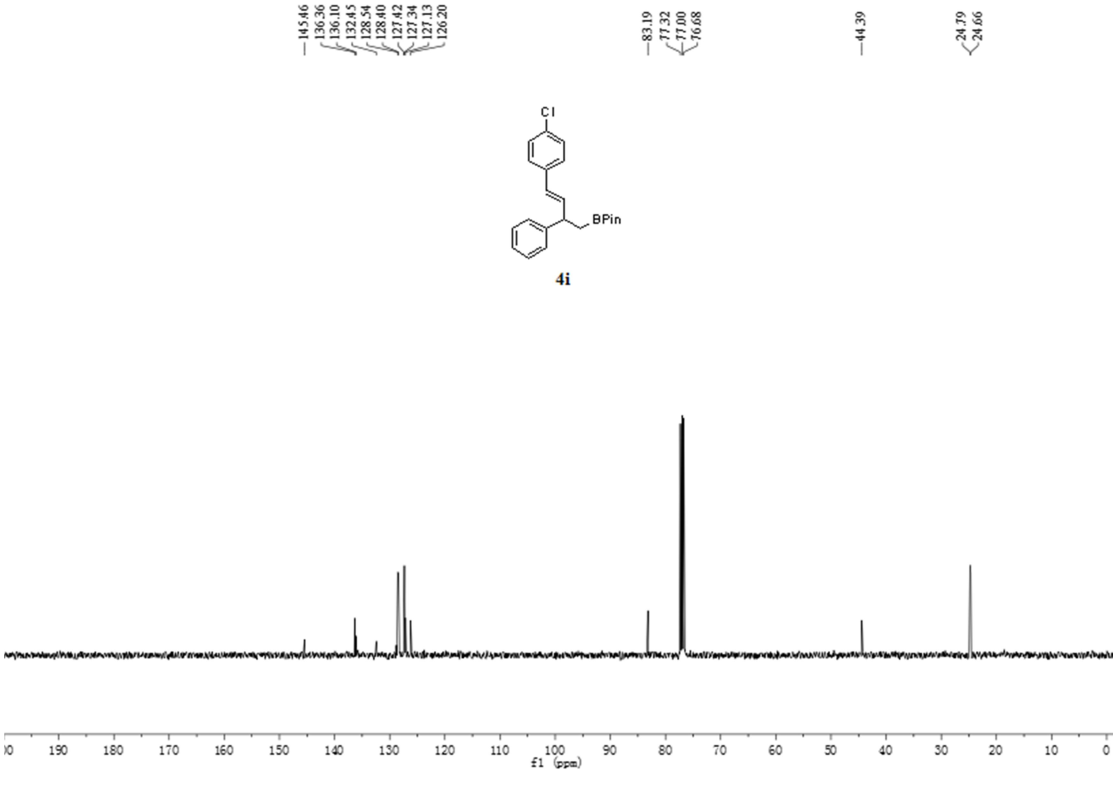
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
-1
f1 (ppm)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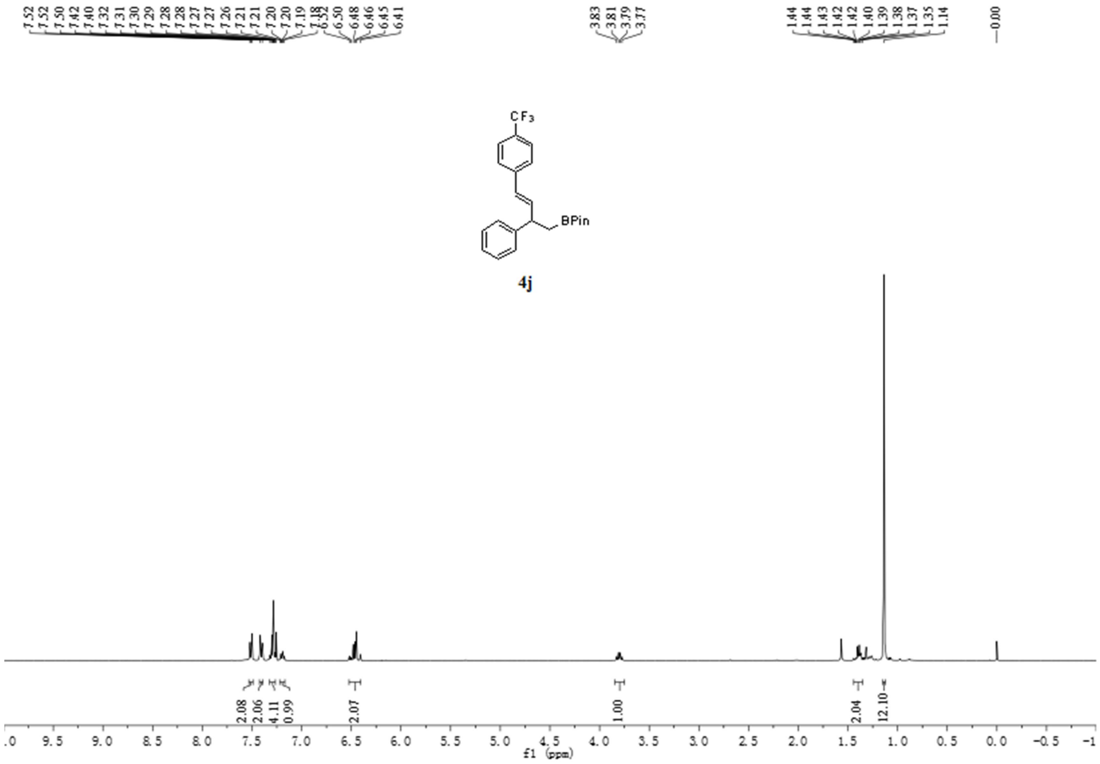
127.34
127.13
126.20
83.19
77.32
77.00
76.68
44.39
24.79
24.66
Cl
BPin
4i
00
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)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7.28
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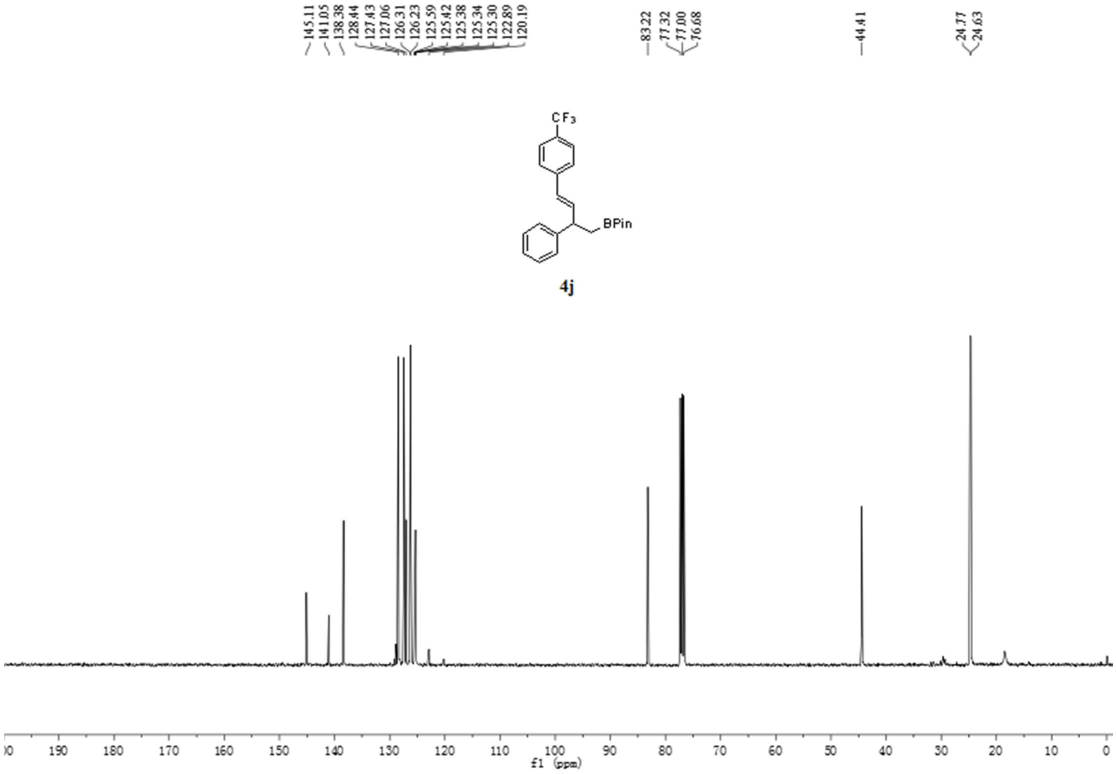
7.26
7.21
7.21
7.20
7.20
7.19
7.18
6.52
6.50
6.48
6.46
6.45
6.41
3.83
3.81
3.79
3.77
1.44
1.44
1.43
1.42
1.42
1.40
1.39
1.38
1.37
1.35
1.14
0.00
CF3
BPin
4j
2.08
2.06
4.11
0.99
2.07
1.00
2.04
12.10
.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5 -1
f1 (ppm)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138.38
128.44
127.43
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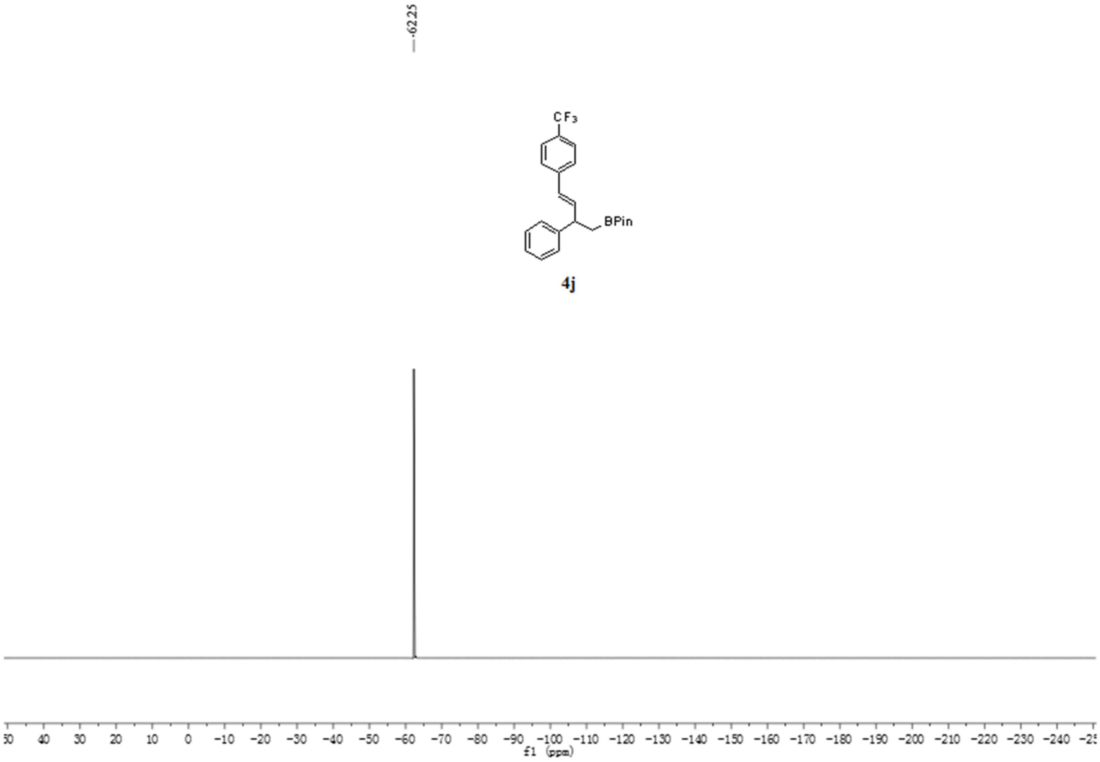
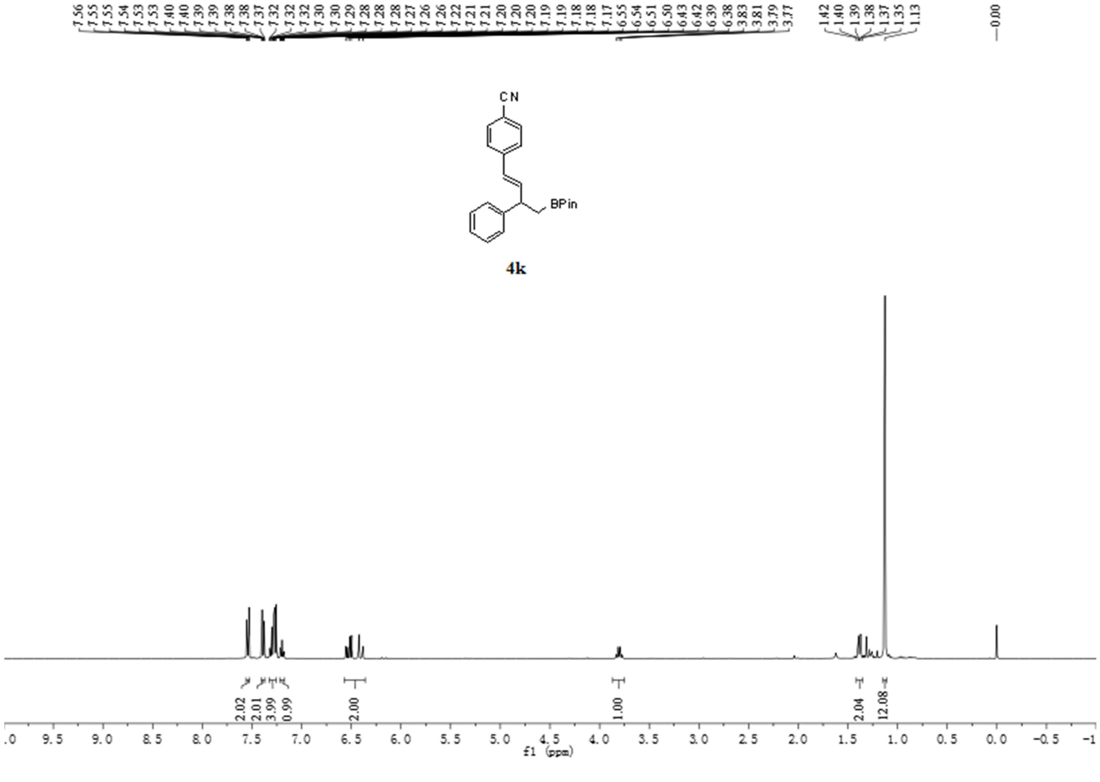
126.23
125.59
125.42
125.38
125.34
125.30
122.89
120.19
83.22
77.32
77.00
76.68
44.41
24.77
24.63
CF3
BPin
4j
)0 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)



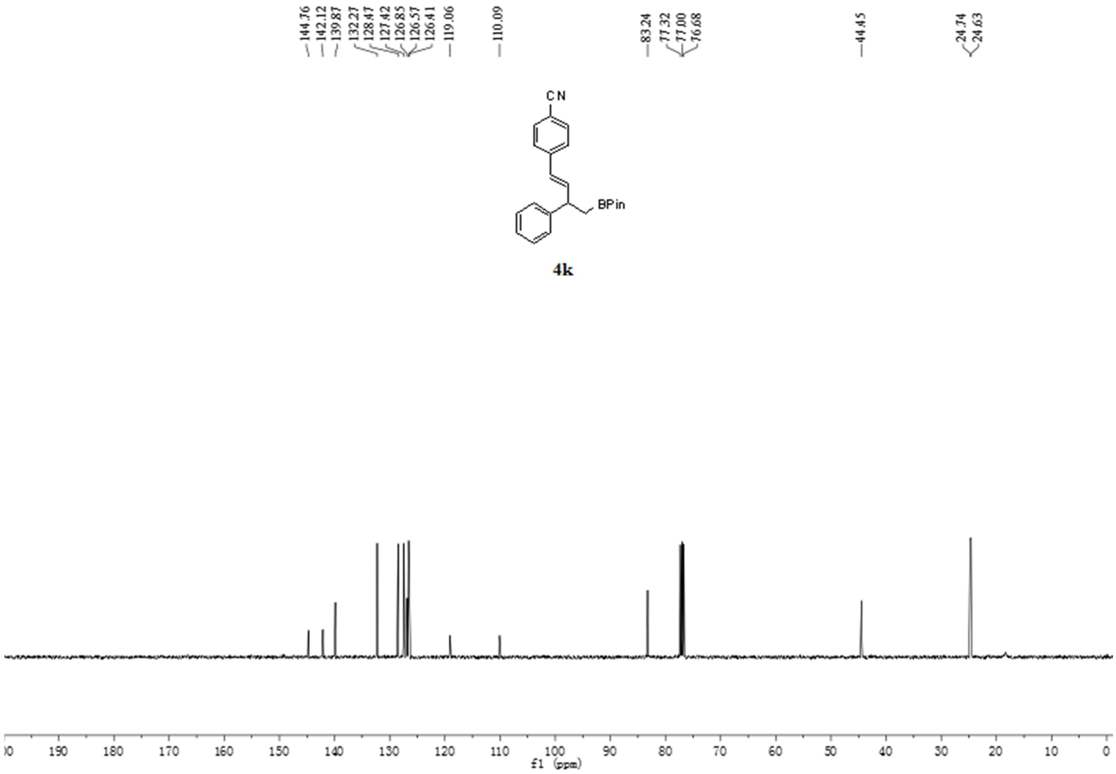
-62.25
CF3
BPin
50 40 30 20 10 0 −10 −20 −30 −40 −50 −60 −70 −80 −90 −100 −110 −120 −130 −140 −150 −160 −170 −180 −190 −200 −210 −220 −230 −240 −250
f1 (ppm)

4j

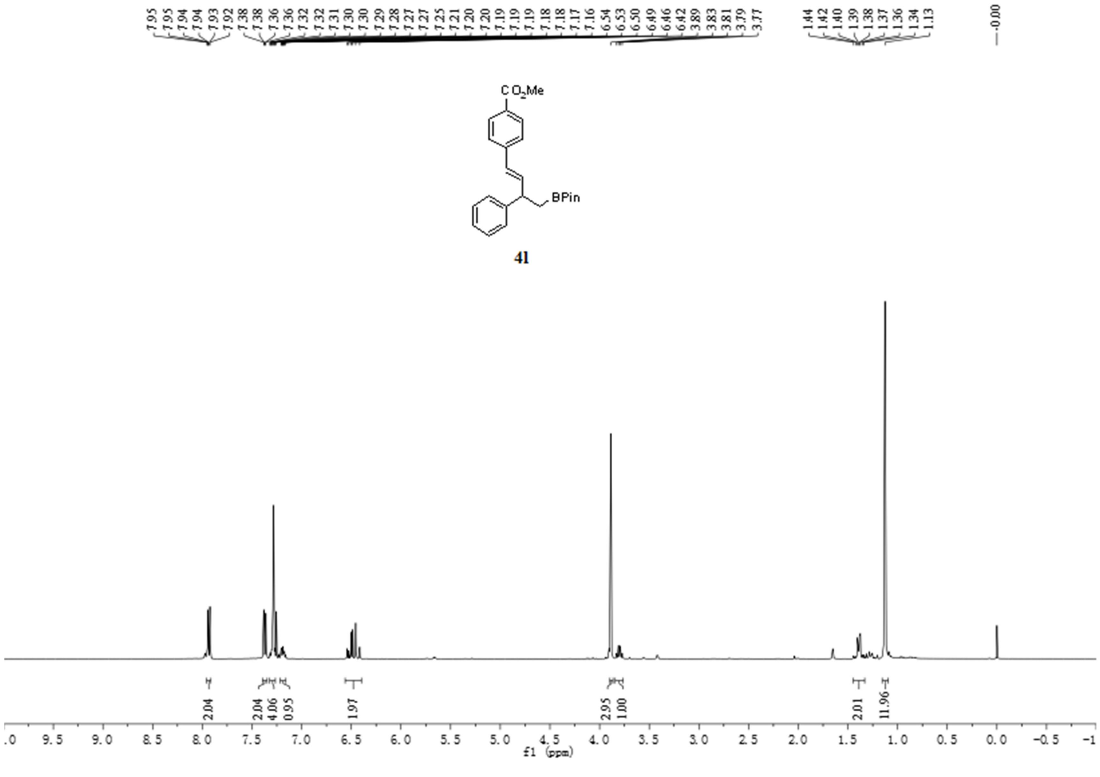


7.56 7.55 7.55 7.54 7.53 7.53 7.40 7.40 7.39 7.39 7.38 7.38 7.37 7.32 7.32 7.32 7.30 7.30 7.29 7.28 7.28 7.28 7.27 7.26 7.26 7.22 7.21 7.21 7.20 7.20 7.20 7.19 7.19 7.18 7.18 7.17 6.55 6.54 6.51 6.50 6.43 6.42 6.39 6.38 3.83 3.81 3.79 3.77
1.42 1.40 1.39 1.38 1.37 1.35 1.13
0.00
CN
BPin
2.02
2.01
3.99
0.99
2.00
1.00
2.04
12.08
10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 −0.5 −1
f1 (ppm)

4k


144.76
142.12
139.87
132.27
128.47
127.42
126.85
126.57
126.41
119.06
110.09
83.24
77.32
77.00
76.68
44.45
24.74
24.63
CN
BPin
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

4k


7.95
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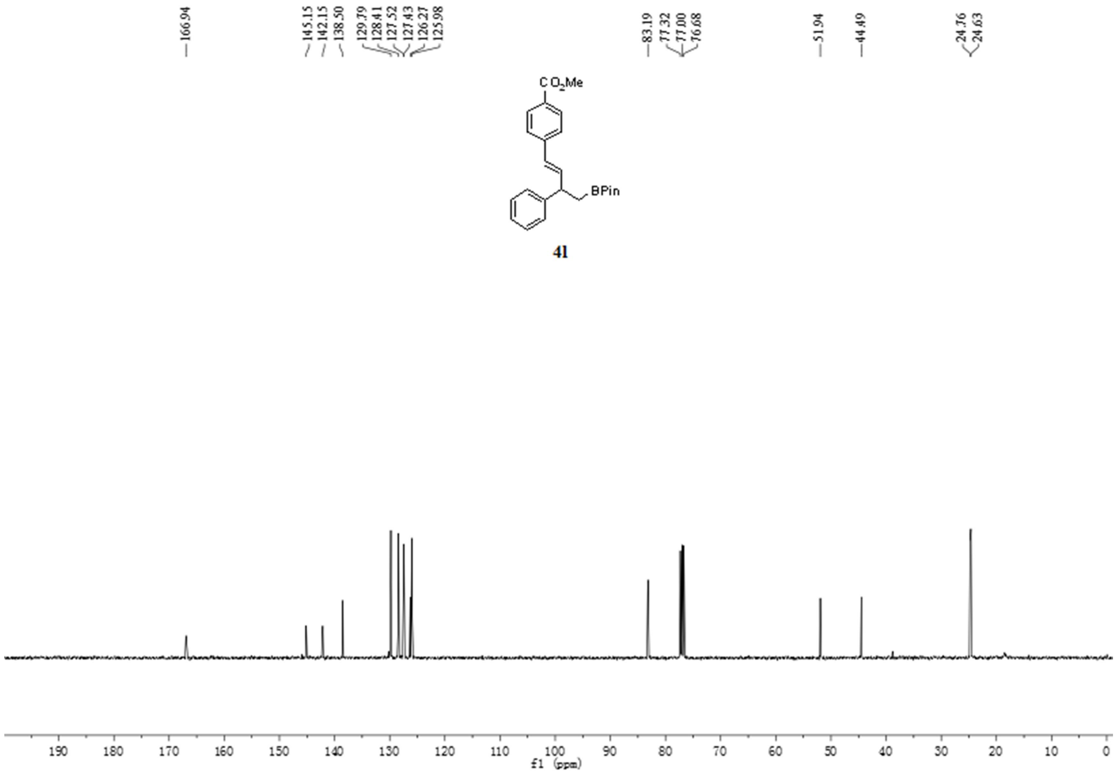
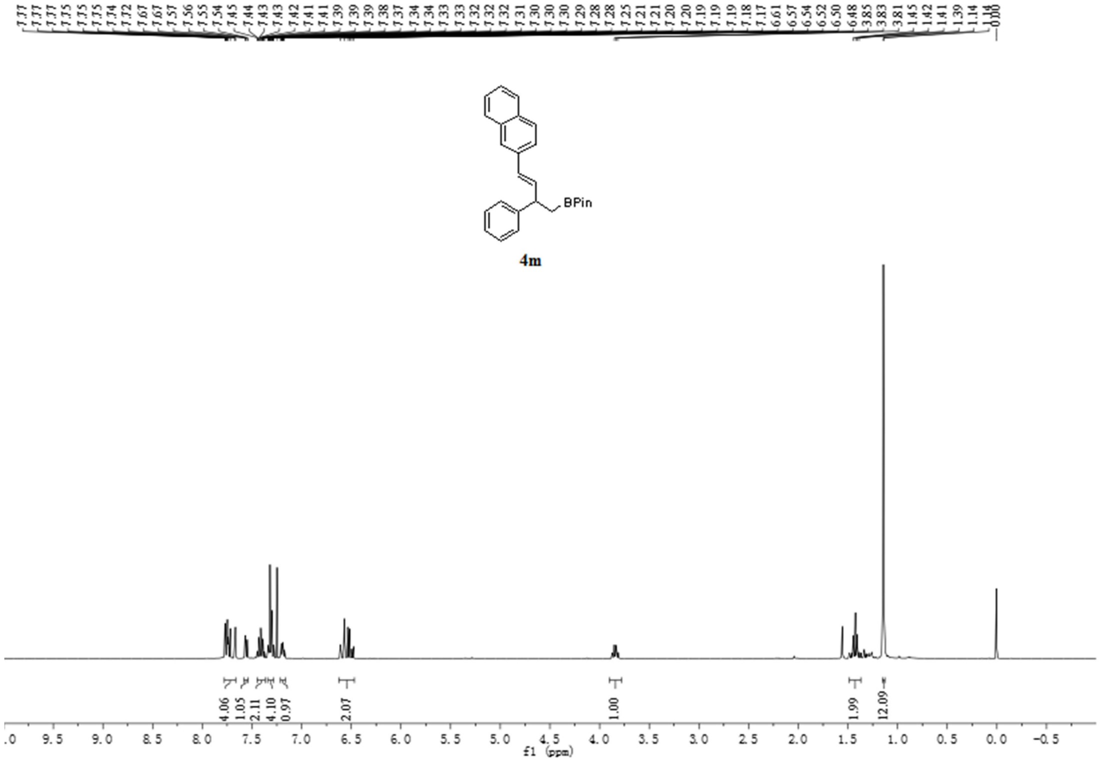
7.92
7.38
7.38
7.36
7.36
7.32
7.32
7.31
7.30
7.30
7.29
7.28
7.27
7.27
7.25
7.21
7.20
7.19
7.19
7.19
7.18
7.18
7.17
7.16
6.54
6.53
6.50
6.49
6.46
6.42
3.89
3.83
3.81
3.79
3.77
1.44
1.42
1.40
1.39
1.38
1.37
1.36
1.34
1.13
0.00
CO$_2$Me
BPin
2.04
2.04
4.06
0.95
1.97
2.95
1.00
2.01
11.96
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
f1 (ppm)

4l


166.94
145.15
142.15
138.50
129.79
128.41
127.52
127.43
126.27
125.98
83.19
77.32
77.00
76.68
51.94
44.49
24.76
24.63
CO2Me
BPin
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

4l


7.77
7.77
7.77
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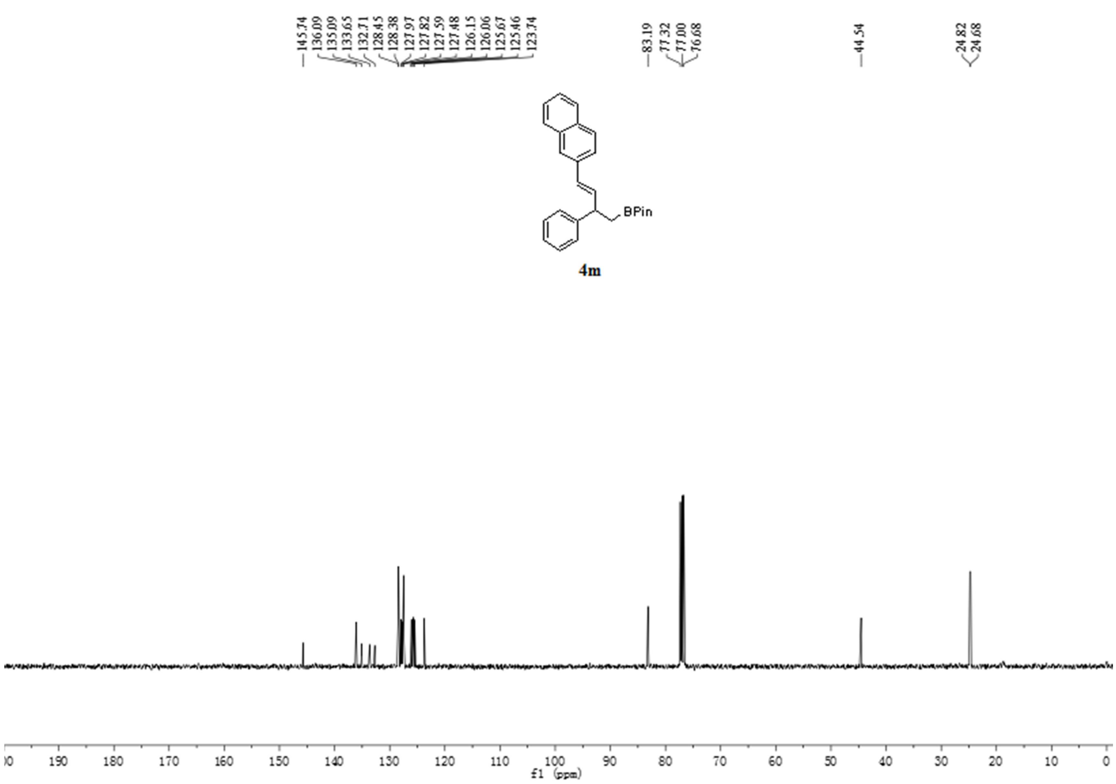
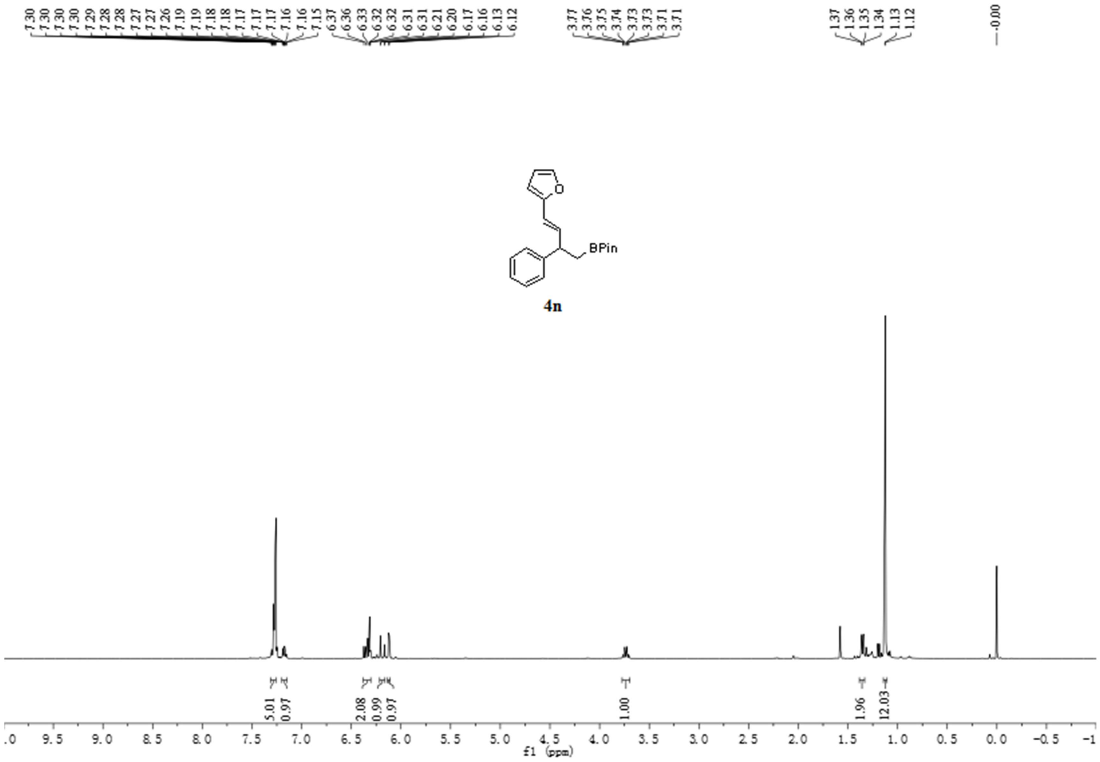
7.75
7.75
7.74
7.72
7.67
7.67
7.57
7.56
7.55
7.54
7.45
7.44
7.43
7.43
7.42
7.41
7.41
7.39
7.39
7.39
7.38
7.37
7.34
7.34
7.33
7.33
7.32
7.32
7.32
7.31
7.30
7.30
7.30
7.29
7.28
7.28
7.25
7.21
7.21
7.20
7.20
7.19
7.19
7.19
7.18
7.17
6.61
6.57
6.54
6.52
6.50
6.48
3.85
3.83
3.81
1.45
1.42
1.41
1.39
1.14
1.14
0.00
BPin
4.06
1.05
2.11
4.10
0.97
2.07
1.00
1.99
12.09
.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
f1 (ppm)

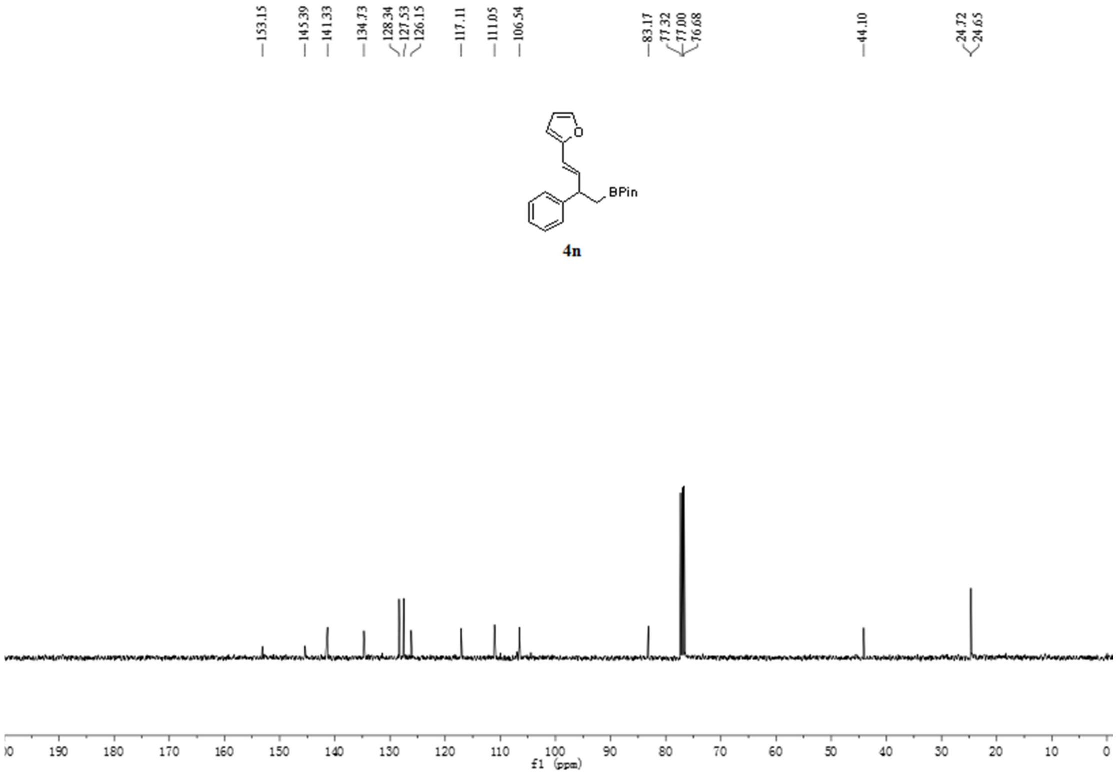
4m


145.74
136.09
135.09
133.65
132.71
128.45
128.38
127.97
127.82
127.59
127.48
126.15
126.06
125.67
125.46
123.74
83.19
77.32
77.00
76.68
44.54
24.82
24.68
BPin
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

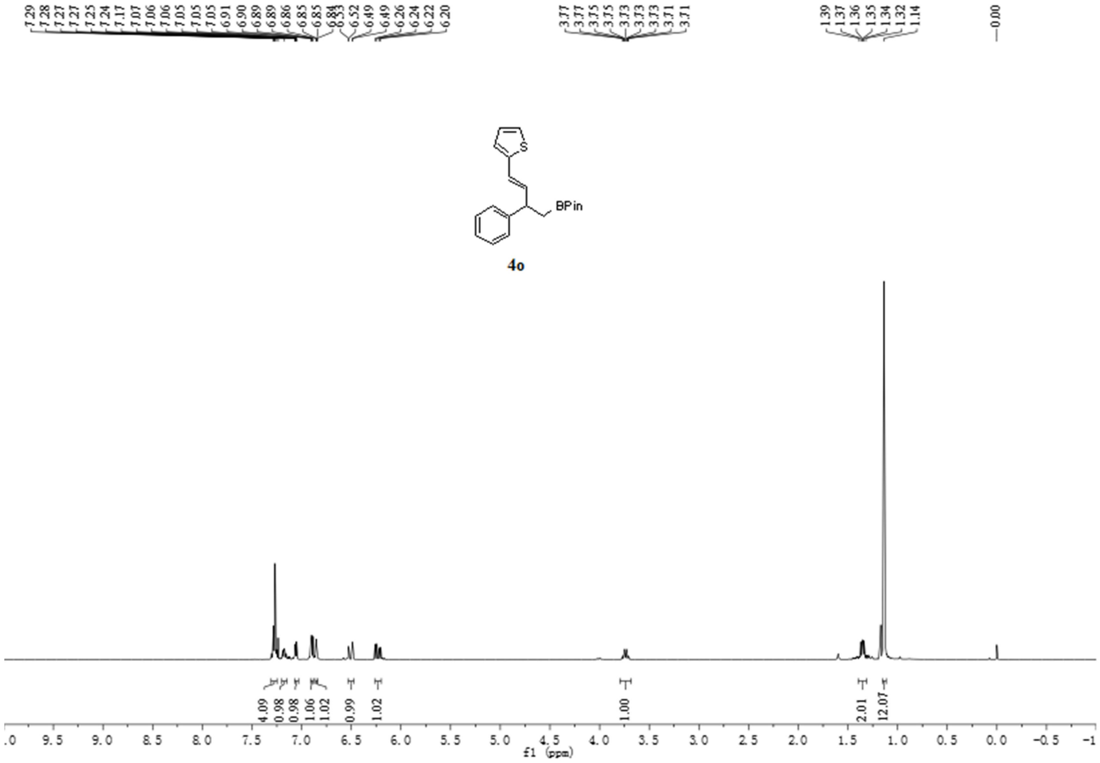
4m


7.30
7.30
7.30
7.30
7.29
7.28
7.28
7.27
7.26
7.19
7.18
7.18
7.17
7.17
7.17
7.16
7.15
6.37
6.36
6.33
6.32
6.32
6.31
6.31
6.21
6.20
6.17
6.16
6.13
6.12
3.77
3.76
3.75
3.74
3.73
3.73
3.71
3.71
1.37
1.36
1.35
1.34
1.13
1.12
0.00
O
BPin
5.01
0.97
2.08
0.99
0.97
1.00
1.96
12.03
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
f1 (ppm)

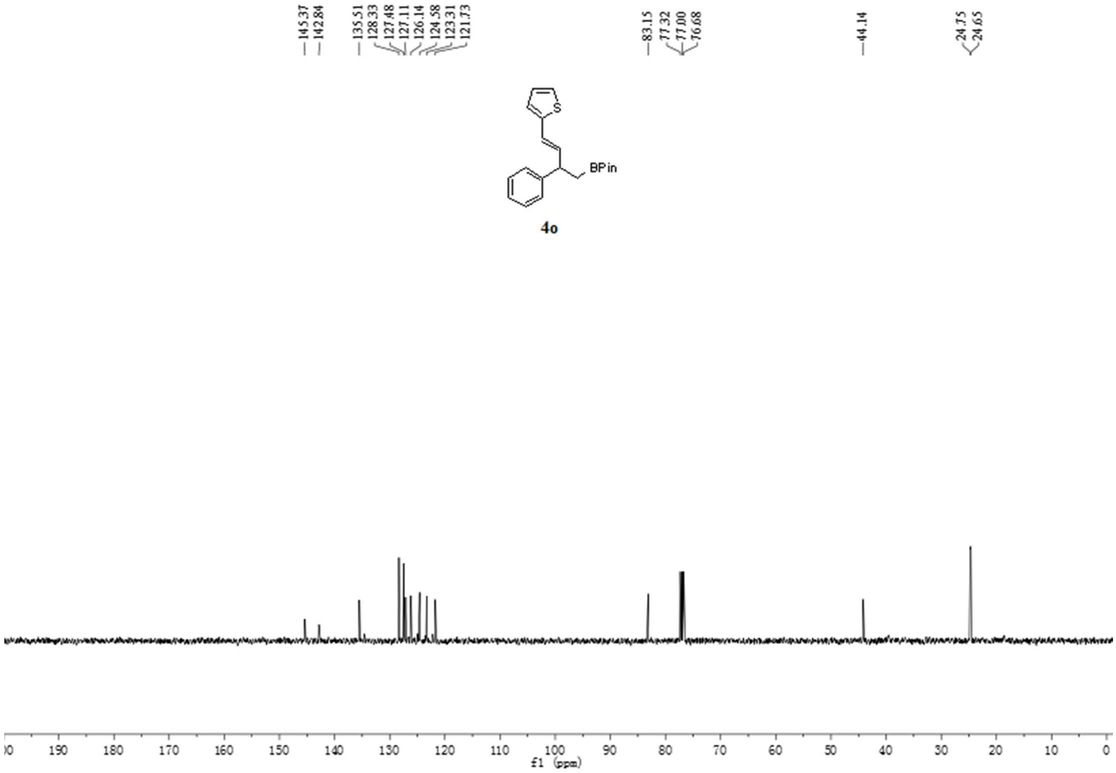
4n


153.15
145.39
141.33
134.73
128.34
127.53
126.15
117.11
111.05
106.54
83.17
77.32
77.00
76.68
44.10
24.72
24.65
O
BPin
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

4n


7.29
7.28
7.27
7.27
7.25
7.24
7.17
7.07
7.06
7.06
7.05
7.05
7.05
6.91
6.90
6.89
6.89
6.86
6.85
6.85
6.84
6.53
6.52
6.49
6.49
6.26
6.24
6.22
6.20
3.77
3.77
3.75
3.75
3.73
3.73
3.71
3.71
1.39
1.37
1.36
1.35
1.34
1.32
1.14
0.00
S
BPin
4.09
0.98
0.98
1.06
1.02
0.99
1.02
1.00
2.01
12.07
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
−0.5
−1
f1 (ppm)

4o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142.84
135.51
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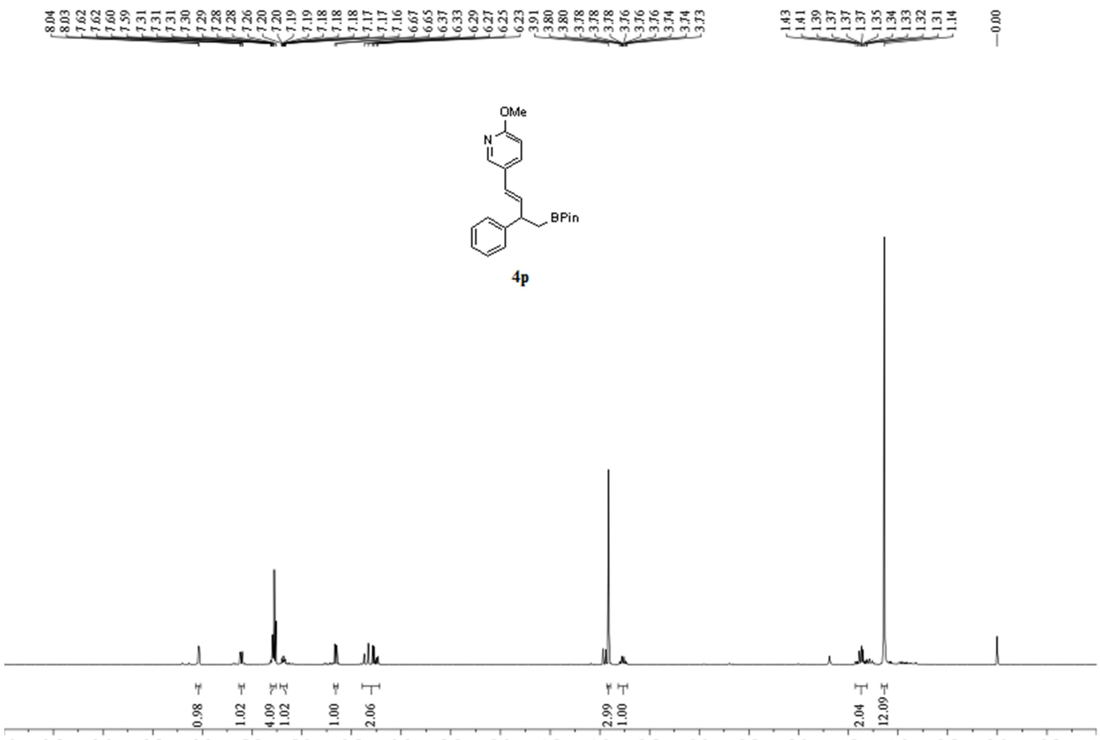
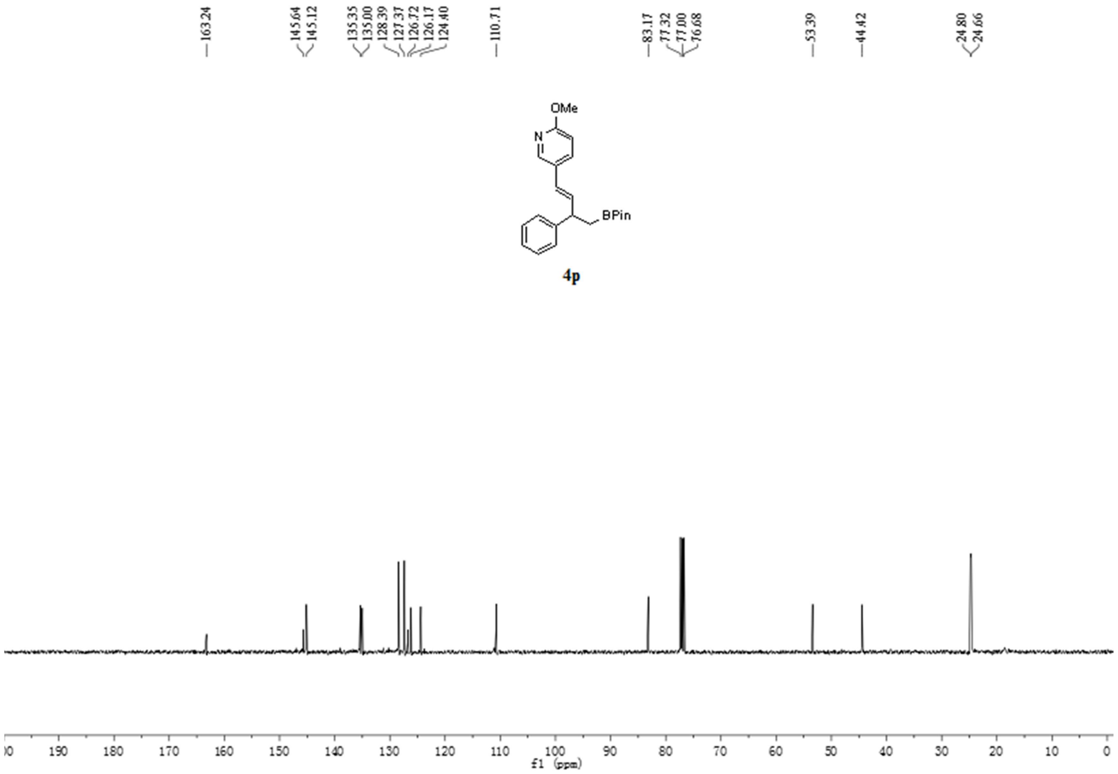
127.11
126.14
124.58
123.31
121.73
83.15
77.32
77.00
76.68
44.14
24.75
24.65
S
BPin
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

4o


8.04
8.03
7.62
7.62
7.60
7.59
7.31
7.31
7.31
7.30
7.29
7.28
7.28
7.26
7.20
7.20
7.19
7.19
7.18
7.18
7.18
7.17
7.17
7.16
6.67
6.65
6.37
6.33
6.29
6.27
6.25
6.23
3.91
3.80
3.80
3.78
3.78
3.78
3.76
3.76
3.74
3.74
3.73
1.43
1.41
1.39
1.37
1.37
1.37
1.35
1.34
1.33
1.32
1.31
1.14
0.00
OMe
N
BPin
0.98
1.02
4.09
1.02
1.00
2.06
2.99
1.00
2.04
12.09
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
-1
f1 (ppm)

4p


163.24
145.64
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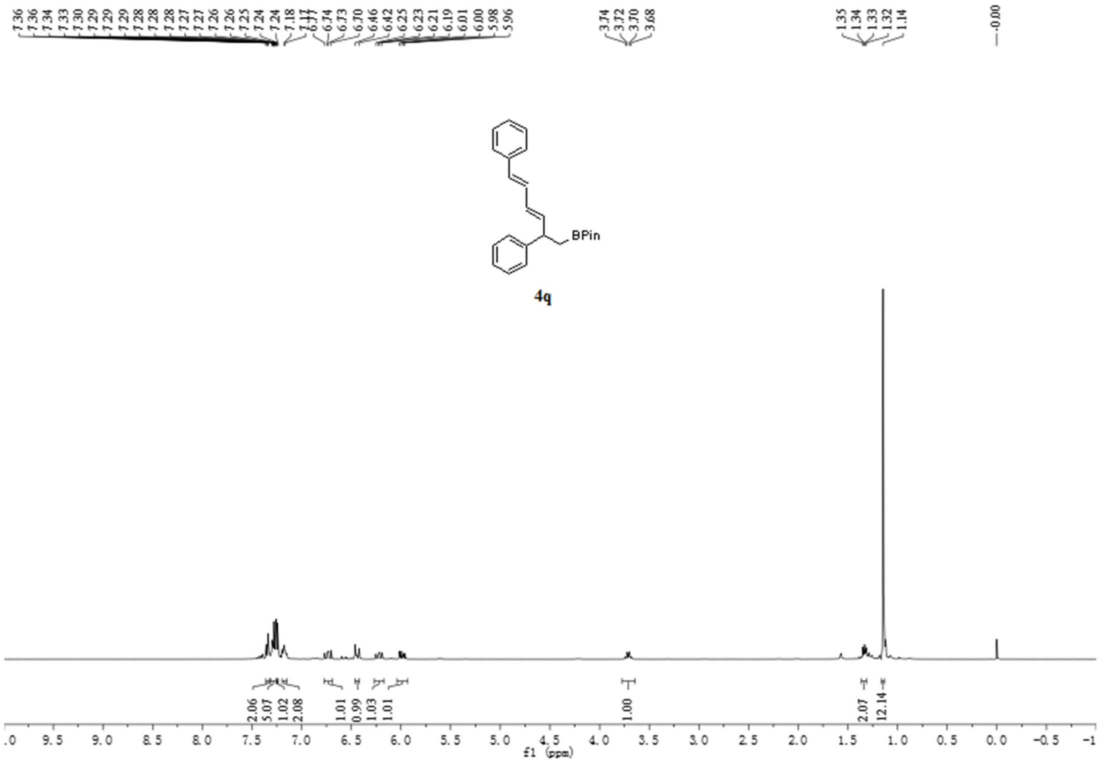
135.35
135.00
128.39
127.37
126.72
126.17
124.40
110.71
83.17
77.32
77.00
76.68
53.39
44.42
24.80
24.66
OMe
N
BPin
00
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

4p


7.36
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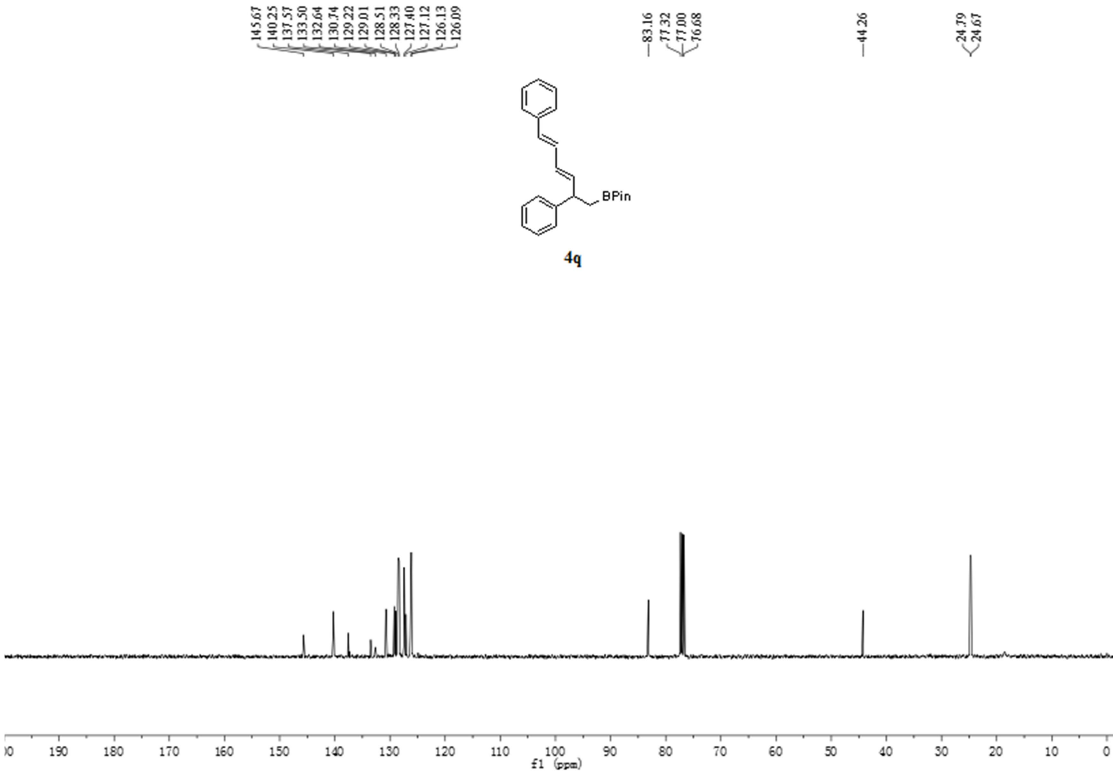
7.34
7.33
7.30
7.29
7.29
7.29
7.28
7.28
7.28
7.27
7.27
7.26
7.26
7.25
7.24
7.24
7.18
7.17
6.77
6.74
6.73
6.70
6.46
6.42
6.25
6.23
6.21
6.19
6.01
6.00
5.98
5.96
3.74
3.72
3.70
3.68
1.35
1.34
1.33
1.32
1.14
0.00
BPin
2.06
5.07
1.02
2.08
1.01
0.99
1.03
1.01
1.00
2.07
12.14
.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
-1
f1 (ppm)

4q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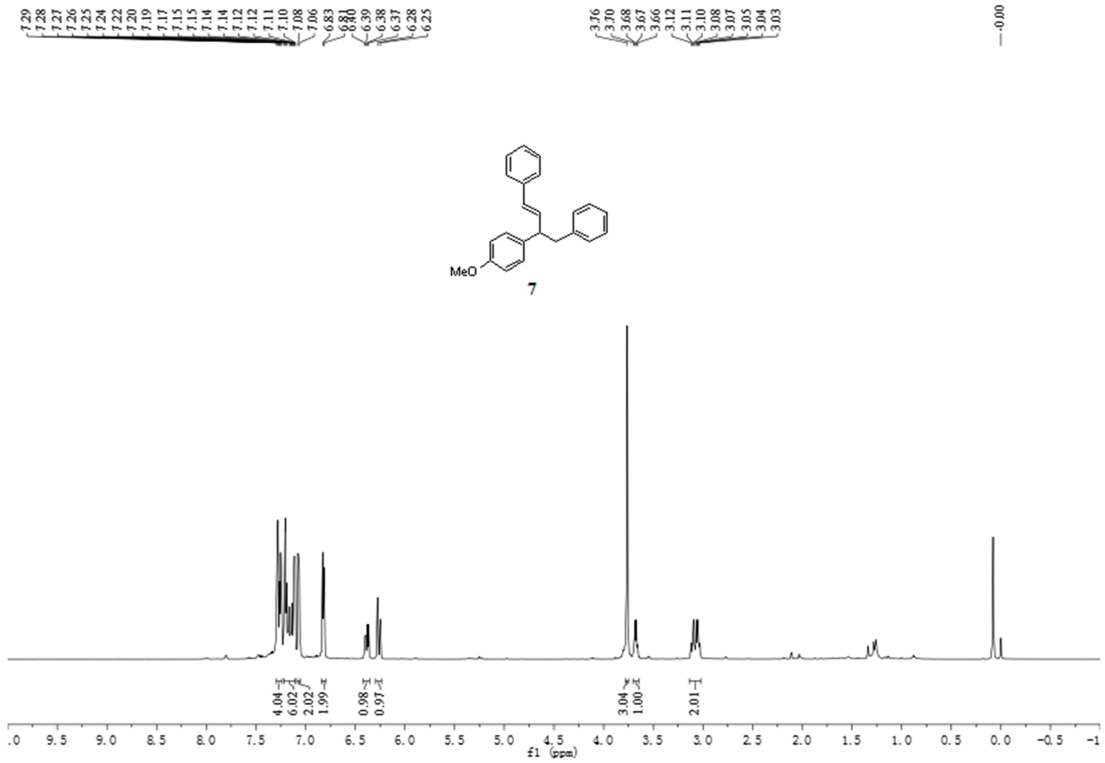
130.74
129.22
129.01
128.51
128.33
127.40
127.12
126.13
126.09
83.16
77.32
77.00
76.68
44.26
24.79
24.67
BPin
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

4q


7.29
7.28
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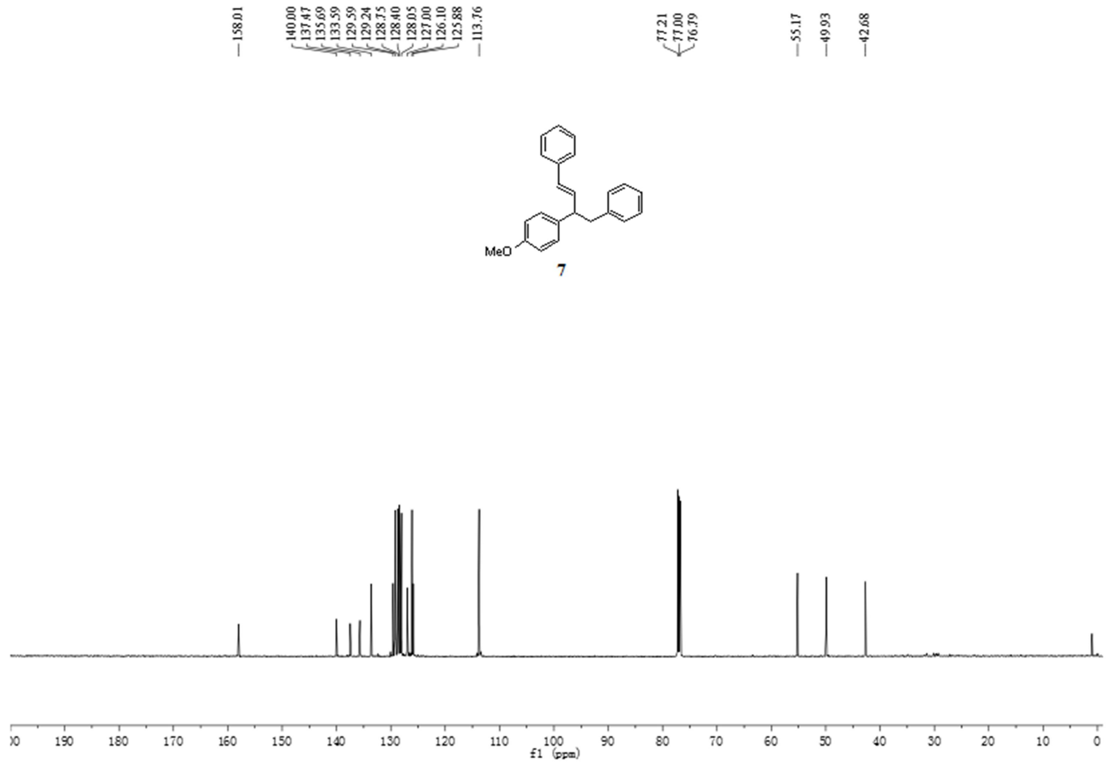
7.26
7.25
7.24
7.22
7.20
7.19
7.17
7.15
7.15
7.14
7.14
7.12
7.12
7.11
7.10
7.08
7.06
6.83
6.81
6.40
6.39
6.38
6.37
6.28
6.25
3.76
3.70
3.68
3.67
3.66
3.12
3.11
3.10
3.08
3.07
3.05
3.04
3.03
0.00
MeO
4.04
6.02
2.02
1.99
0.98
0.97
3.04
1.00
2.01
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
−0.5
−1
f1 (ppm)

7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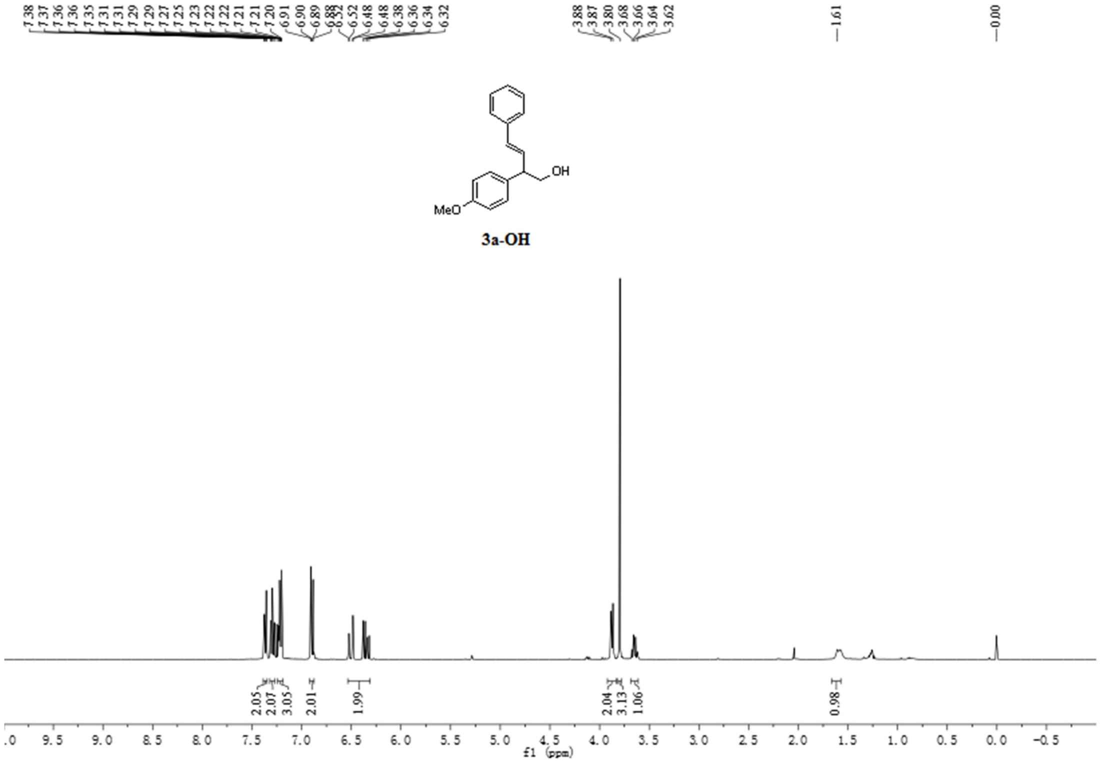
128.75
128.40
128.05
127.00
126.10
125.88
113.76
77.21
77.00
76.79
55.17
49.93
42.68
MeO
00
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

7


7.38
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7.36
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7.35
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7.31
7.29
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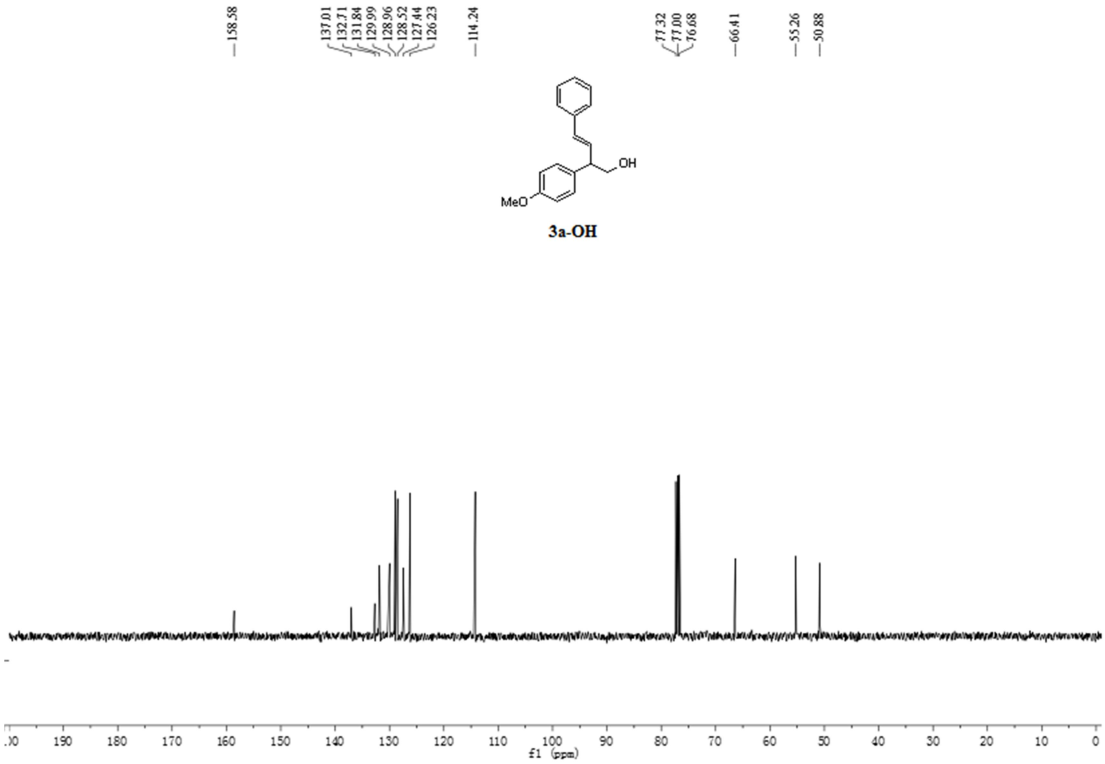
7.27
7.25
7.23
7.22
7.22
7.21
7.21
7.21
7.20
6.91
6.90
6.89
6.88
6.52
6.48
6.48
6.38
6.36
6.34
6.32
3.88
3.87
3.80
3.68
3.66
3.64
3.62
1.61
0.00
OH
MeO
2.05
2.07
3.05
2.01
1.99
2.04
3.13
1.06
0.98
.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
f1 (ppm)

3a-OH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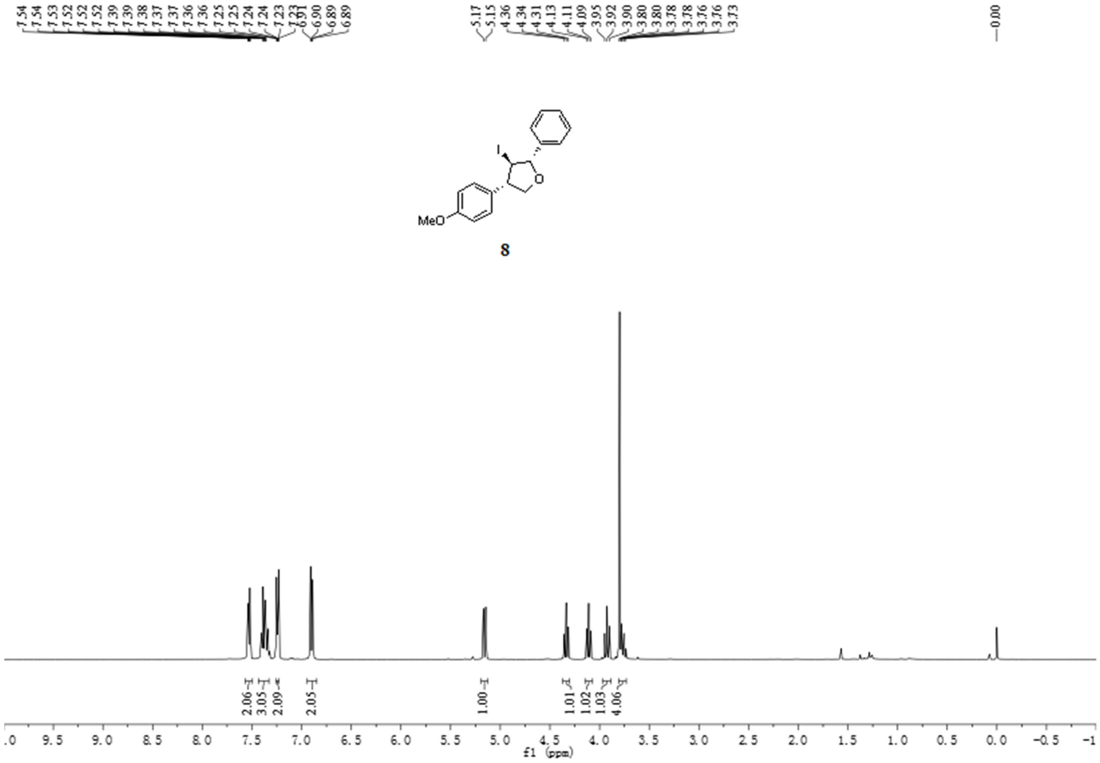
129.99
128.96
128.52
127.44
126.23
114.24
77.32
77.00
76.68
66.41
55.26
50.88
OH
MeO
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

3a-OH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7.52
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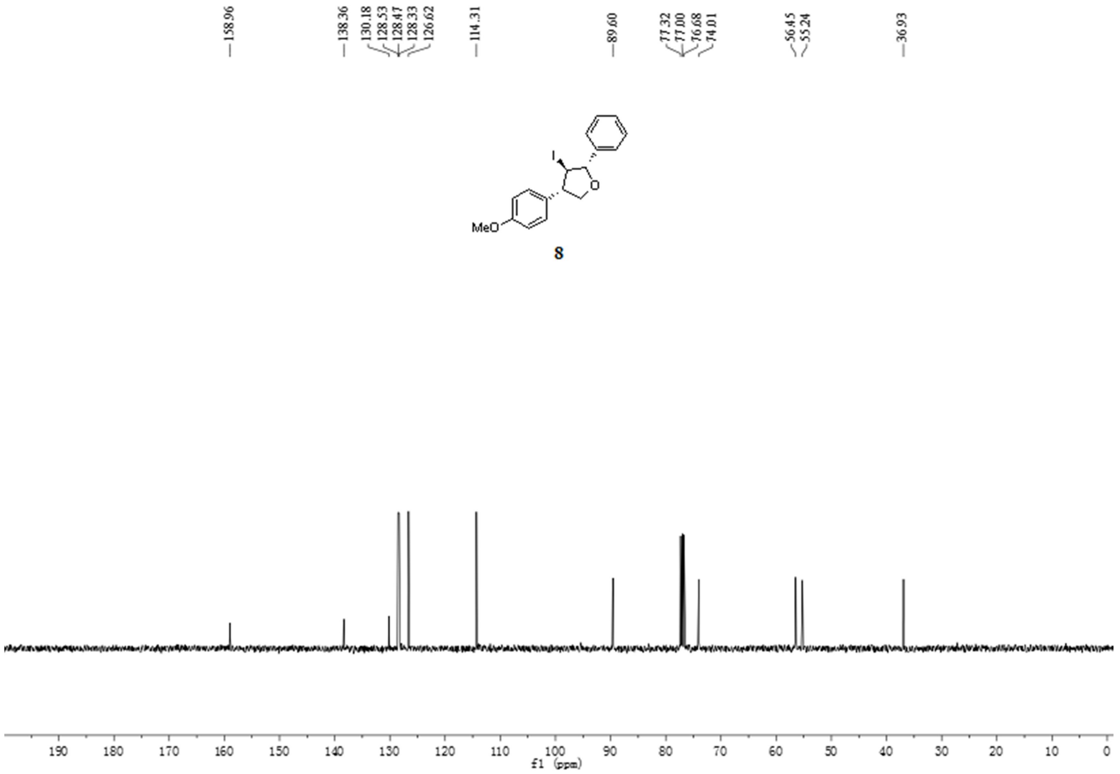
7.39
7.39
7.38
7.37
7.37
7.36
7.36
7.25
7.25
7.24
7.24
7.23
7.23
6.91
6.90
6.89
6.89
5.17
5.15
4.36
4.34
4.31
4.13
4.11
4.09
3.95
3.92
3.90
3.80
3.80
3.78
3.76
3.76
3.73
0.00
I
O
MeO
2.06
3.05
2.09
2.05
1.00
1.01
1.02
1.03
4.06
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
−0.5
−1
f1 (ppm)

8


158.96
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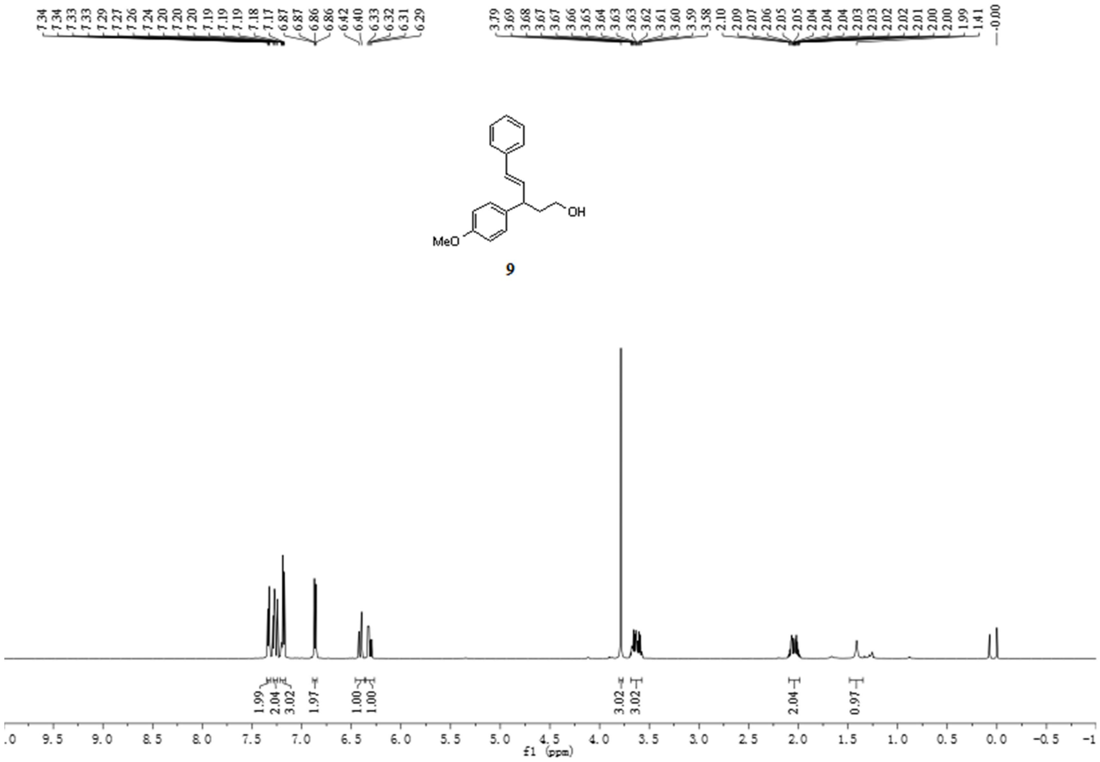
130.18
128.53
128.47
128.33
126.62
114.31
89.60
77.32
77.00
76.68
74.01
56.45
55.24
36.93
I
O
MeO
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

8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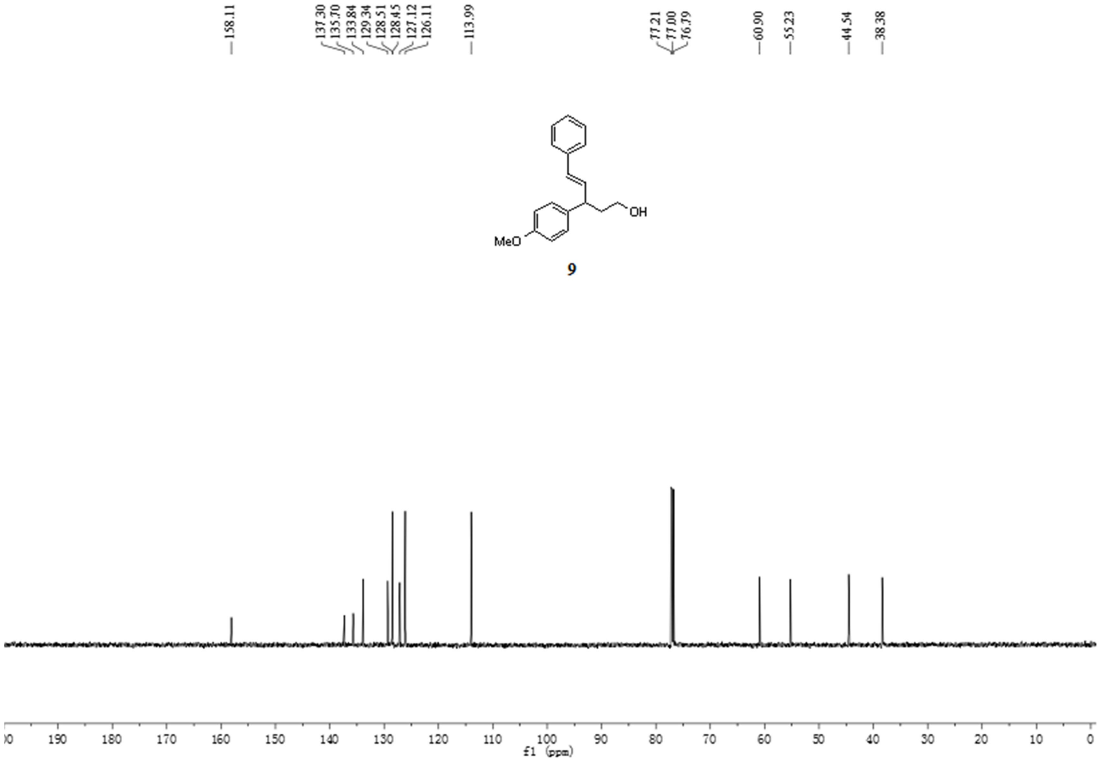
7.33
7.33
7.29
7.27
7.26
7.24
7.20
7.20
7.20
7.19
7.19
7.19
7.18
7.17
6.87
6.87
6.86
6.86
6.42
6.40
6.33
6.32
6.31
6.29
3.79
3.69
3.68
3.67
3.67
3.66
3.65
3.64
3.63
3.63
3.62
3.61
3.60
3.59
3.58
2.10
2.09
2.07
2.06
2.05
2.05
2.04
2.04
2.04
2.03
2.03
2.02
2.02
2.01
2.00
2.00
1.99
1.41
-0.00
OH
MeO
1.99
2.04
3.02
1.97
1.00
1.00
3.02
3.02
2.04
0.97
.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
-1
f1 (ppm)

9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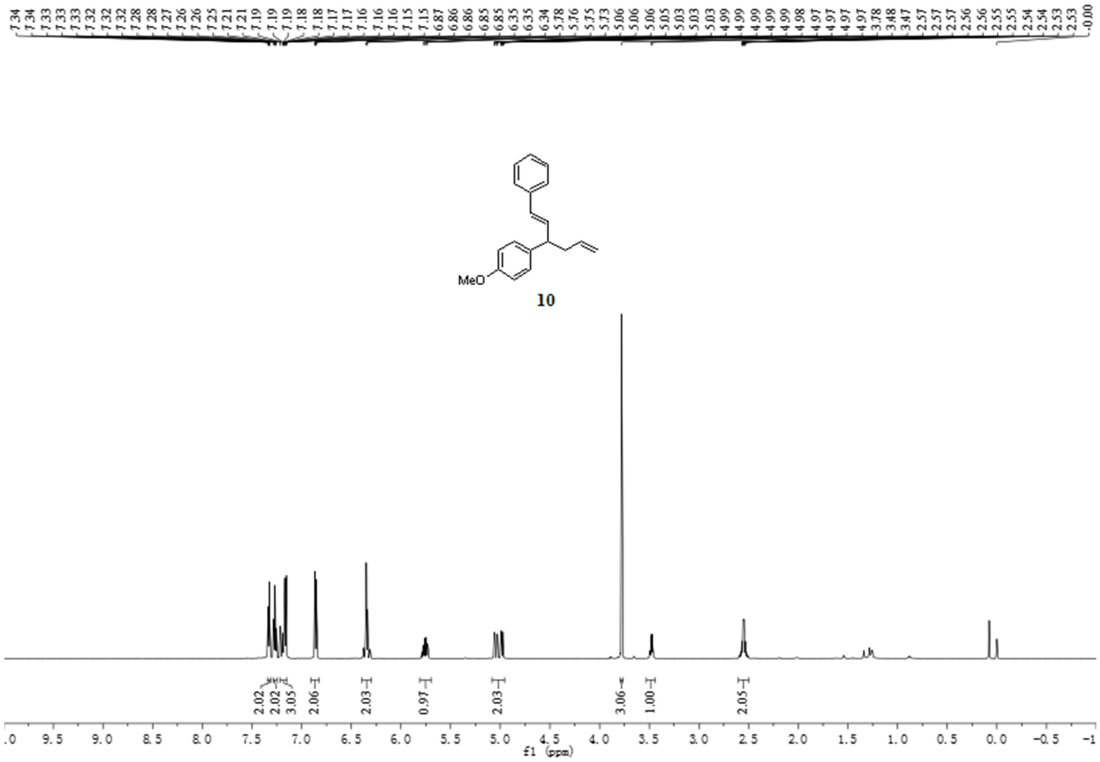
135.70
133.84
129.34
128.51
128.45
127.12
126.11
113.99
77.21
77.00
76.79
60.90
55.23
44.54
38.38
MeO
OH
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

9


7.34
7.34
7.33
7.33
7.33
7.32
7.32
7.32
7.28
7.28
7.27
7.26
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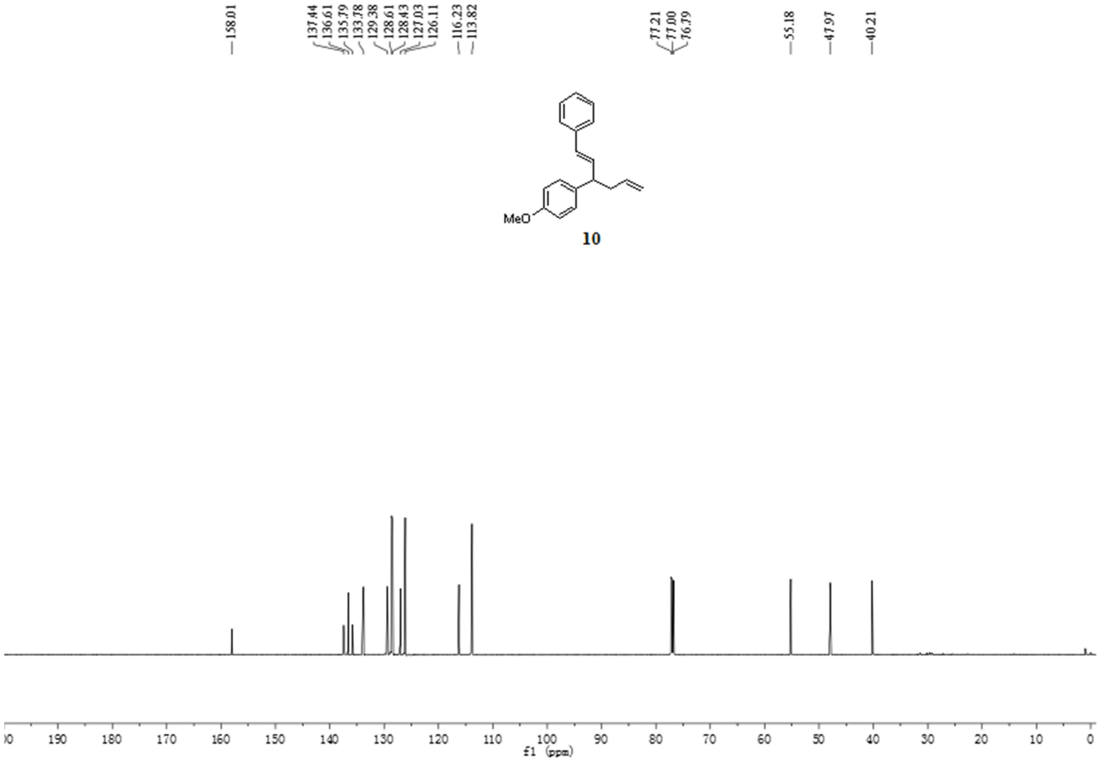
7.25
7.21
7.21
7.19
7.19
7.19
7.18
7.18
7.17
7.17
7.16
7.16
7.16
7.15
7.15
6.87
6.86
6.86
6.85
6.85
6.35
6.35
6.34
5.78
5.76
5.75
5.73
5.06
5.06
5.06
5.05
5.03
5.03
5.03
4.99
4.99
4.99
4.99
4.99
4.98
4.97
4.97
4.97
4.97
3.78
3.48
3.47
2.57
2.57
2.57
2.56
2.56
2.55
2.55
2.54
2.54
2.53
2.53
-0.00
MeO
2.02
2.02
3.05
2.06
2.03
0.97
2.03
3.06
1.00
2.05
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
-1
f1 (ppm)

10


158.01
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136.61
135.79
133.78
129.38
128.61
128.43
127.03
126.11
116.23
113.82
77.21
77.00
76.79
55.18
47.97
40.21
MeO
10
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)