Supporting Information

Synthesis of *N*-Vinylcarbazoles via Dehydrogenative Coupling of *N*-H Carbazoles with Alkenes under Palladium Catalysis

Daisuke Takeda,[†] Koji Hirano,[†] Tetsuya Satoh,*,[†,‡] and Masahiro Miura*,[†]

† Department of Applied Chemistry, Faculty of Engineering, Osaka University, Suita, Osaka 565-0871, Japan

‡ JST, ACT-C, 4-1-8 Honcho, Kawaguchi, Saitama 332-0012, Japan

e-mail: satoh@chem.eng.osaka-u.ac.jp; miura@chem.eng.osaka-u.ac.jp

List of Contents for Experimental Section

Experimental Section

General. ^{1}H and ^{13}C NMR spectra were recorded at 400 and 100 MHz for $CDCl_3$ solutions. HRMS data were obtained by EI using a double focusing mass spectrometer, unless noted. GC analysis was carried out using a silicon OV-17 column (i. d. 2.6 mm x 1.5 m). GC-MS analysis was carried out using a CBP-1 capillary column (i. d. 0.25 mm x 25 m). The structures of all products listed below were unambiguously determined by ^{1}H and ^{13}C NMR.

Compound **7** was prepared according to a published procedure.[10] Other starting materials and reagents were commercially available.

The following experimental procedures may be regarded as typical in methodology and scale.

Procedure for the Preparation of 3a (entry 7, Table 1): To a 20 mL two-necked flask with a reflux condenser, a balloon, and a rubber cup were added 9*H*-carbazole (**1a**) (0.2 mmol, 33 mg), styrene (**2a**) (1.0 mmol, 104 mg), $Pd(OAc)_2$ (0.02 mmol, 4.5 mg), Ag_2CO_3 (0.2 mmol, 55 mg), *n*-hexadecane (ca. 30 mg) as internal standard, and MeCN (2 mL). Then, the resulting mixture was stirred under nitrogen at 100 ^{o}C for 6 h. After cooling, the reaction mixture was poured into ethyl acetate (100 mL). The organic layer was washed by water (100 mL, three times), and dried over Na_2SO_4. After evaporation of the solvent under vacuum, the product **3a** (46 mg, 85%) was isolated by column chromatography on silica gel using hexane-ethyl acetate (40:1, v/v) as eluant and thin-layer chromatography using hexane.

Characterization Data of Products.

9-(1-Phenylvinyl)-9*H*-carbazole (3a):[3a] oil; ^{1}H NMR (400 MHz, $CDCl_3$) δ 5.59 (s, 1H), 6.08 (s, 1H), 7.23-7.36 (m, 11H), 8.12 (d, J = 8.7 Hz, 2H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 110.8, 112.9, 119.8, 120.2, 123.4, 125.8, 126.2, 128.7, 129.1, 136.3, 140.8, 142.7; HRMS *m/z* calcd for $C_{20}H_{15}N$ (M^+) 269.1204, found 269.1203.

9-[1-(4-Methylphenyl)vinyl]-9*H*-carbazole (3b): oil; ^{1}H NMR (400 MHz, $CDCl_3$) δ 2.33 (s, 3H), 5.53 (s, 1H), 6.03 (s, 1H), 7.08 (d, J = 8.3 Hz, 2H), 7.14 (d, J = 8.2 Hz, 2H), 7.23-7.26 (m, 4H), 7.32-7.36 (m, 2H), 8.12 (d, J = 8.2 Hz, 2H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 21.2, 110.9, 112.0, 119.7, 120.1, 123.3, 125.8, 126.1, 129.4, 133.5, 139.1, 140.8, 142.6; HRMS *m/z* calcd for $C_{21}H_{17}N$ (M^+) 283.1361, found 283.1357.

9-[1-(4-Methoxyphenyl)vinyl]-9*H*-carbazole (3c): oil; ^{1}H NMR (400 MHz, $CDCl_3$) δ 3.77 (s, 3H), 5.47 (s, 1H), 5.95 (s, 1H), 6.78-6.80 (m, 2H), 7.16-7.18 (m, 2H), 7.22-7.26 (m, 4H), 7.32-7.36 (m, 2H), 8.11 (d, J = 6.9 Hz, 2H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 55.3, 110.86, 110.92, 114.1, 119.7, 120.1, 123.3, 125.8, 127.6, 128.8, 140.8, 142.2, 160.3; HRMS *m/z* calcd for $C_{21}H_{17}NO$ (M^+) 299.1310, found 299.1316.

9-[1-(4-Chlorophenyl)vinyl]-9*H*-carbazole (3d): mp 104-106 ^{o}C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 5.61 (s, 1H), 6.06 (s, 1H), 7.16-7.28 (m, 8H), 7.33-7.37 (m, 2H), 8.12 (d, J = 7.8 Hz, 2H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 110.7, 113.3, 120.0, 120.2, 123.4, 125.9, 127.5, 129.0, 134.8, 135.0, 140.6, 141.7; HRMS *m/z* calcd for $C_{20}H_{14}ClN$ (M^+) 303.0815, found 303.0816.

9-[1-(Naphthalen-2-yl)vinyl]-9*H*-carbazole (3e): oil; ^{1}H NMR (400 MHz, $CDCl_3$) δ 5.67 (s, 1H), 6.19 (s, 1H), 7.24-7.35 (m, 6H), 7.39-7.50 (m, 3H), 7.65-7.66 (m, 2H), 7.76-7.81 (m, 2H), 8.14-8.16 (m, 2H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 110.9, 113.4, 119.8, 120.2, 123.5, 123.8, 125.7, 125.9,126.4, 126.6, 127.6, 128.5, 128.6, 133.2, 133.6, 133.8, 140.9, 142.8; HRMS *m/z* calcd for $C_{24}H_{17}N$ (M^+) 319.1361, found 319.1360.

3,6-Di-*tert*-butyl-9-(1-phenylvinyl)-9*H*-carbazole (3f): oil; ^{1}H NMR (400 MHz, $CDCl_3$) δ 1.44 (s, 18H), 5.52 (s, 1H), 5.96 (s, 1H), 7.12 (d, J = 8.7 Hz, 2H), 7.28-7.39 (m, 7H), 8.11 (s, 2H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 32.0, 34.7, 110.4, 111.9, 116.0, 123.4, 123.5, 126.4, 128.6, 128.9, 136.8, 139.3, 142.6, 143.1; HRMS *m/z* calcd for $C_{28}H_{31}N$ (M^+) 381.2457, found 381.2458.

3,6-Dichloro-9-(1-phenylvinyl)-9*H*-carbazole (3g): mp 120-122 ^{o}C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 5.57 (s, 1H), 6.08 (s, 1H), 7.14 (d, J = 8.7 Hz, 2H), 7.17-7.20 (m, 2H), 7.25-7.37 (m, 5H), 8.015-8.020 (m, 2H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 112.1, 113.3, 120.1, 123.5, 125.7, 126.1, 126.7, 128.9, 129.4, 135.6, 139.5, 142.2; HRMS *m/z* calcd for $C_{20}H_{13}Cl_2N$ (M^+) 337.0425, found 337.0424.

3,6-Dibromo-9-(1-phenylvinyl)-9*H*-carbazole (3h): mp 97-99 ^{o}C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 5.57 (s, 1H), 6.09 (s, 1H), 7.10 (d, J = 8.8 Hz, 2H), 7.17-7.20 (m, 2H), 7.27-7.37 (m, 3H), 7.43 (d, J = 2.3 Hz, 1H), 7.45 (d, J = 2.3 Hz, 1H), 8.18 (d, J = 1.8 Hz, 2H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 112.5, 113.1, 113.4, 123.1, 124.0, 126.1, 128.9, 129.35, 129.44, 135.6, 139.7, 142.1; HRMS *m/z* calcd for $C_{20}H_{13}Br_2N$ (M^+) 424.9415, found 424.9418.

3-Bromo-9-(1-phenylvinyl)-9*H*-carbazole (3i): oil; ^{1}H NMR (400 MHz, $CDCl_3$)

δ 5.58 (s, 1H), 6.08 (s, 1H), 7.09 (d, *J* = 8.7 Hz, 1H), 7.20-7.42 (m, 9H), 8.06-8.08 (m, 1H), 8.23 (d, *J* = 1.4 Hz, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 111.0, 112.3, 112.7, 113.2, 120.2, 120.4, 122.3, 122.9, 125.1, 126.1, 126.6, 128.5, 128.8, 129.3, 135.9, 139.4, 141.1, 142.4; HRMS *m/z* calcd for $C_{20}H_{14}BrN$ (M^+) 347.0310, found 347.0308.

9'-(1-Phenylvinyl)-9'*H*-9,3':6',9''-tercarbazole (4): oil; ^{1}H NMR (400 MHz, $CDCl_3$) δ 5.78 (s, 1H), 6.22 (s, 1H), 7.25-7.30 (m, 4H), 7.36-7.56 (m, 17H), 8.15 (d, *J* = 33.4 Hz, 4H), 8.24 (d, *J* = 1.8 Hz, 2H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 109.7, 112.3, 113.7, 119.5, 119.7, 120.3, 123.1, 124.0, 125.9, 126.2, 126.3, 129.1, 129.6, 130.3, 135.9, 140.5, 141.7, 142.6; HRMS *m/z* calcd for $C_{44}H_{29}N_3$ (M^+) 599.2361, found 599.2366.

(*E*)-Butyl 3-(9*H*-Carbazol-9-yl)acrylate (6a): mp 62-64 ^{o}C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 1.00 (t, *J* = 7.3 Hz, 3H), 1.44-1.53 (m, 2H), 1.70-1.77 (m, 2H), 4.27 (t, *J* = 6.7 Hz, 2H), 6.33 (d, *J* = 14.7 Hz, 1H), 7.37 (t, *J* = 7.3 Hz, 2H), 7.52 (t, *J* = 7.8 Hz, 2H), 7.76 (d, *J* = 8.2 Hz, 2H), 8.04 (d, *J* = 7.8 Hz, 2H), 8.53 (d, *J* = 14.2 Hz, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 13.8, 19.2, 30.9, 64.3, 101.7, 111.8, 120.4, 122.7, 125.5, 127.0, 137.1, 139.1, 168.2; HRMS *m/z* calcd for $C_{19}H_{19}NO_2$ (M^+) 293.1416, found 293.1417.

(*E*)-Isobutyl 3-(9*H*-Carbazol-9-yl)acrylate (6b): mp 59-61 ^{o}C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 1.03 (d, *J* = 6.9 Hz, 6H), 2.06 (qq, *J* = 6.7, 6.7 Hz, 1H), 4.05 (d, *J* = 6.4 Hz, 2H), 6.37 (d, *J* = 14.2 Hz, 1H), 7.37 (t, *J* = 7.2 Hz, 2H), 7.52 (t, *J* = 7.7 Hz, 2H), 7.76 (d, *J* = 8.2 Hz, 2H), 8.04 (d, *J* = 7.8 Hz, 2H), 8.53 (d, *J* = 14.7 Hz, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 19.2, 27.9, 70.6, 101.7, 111.8, 120.4, 122.7, 125.5, 127.0, 137.1, 139.1, 168.2; HRMS *m/z* calcd for $C_{19}H_{19}NO_2$ (M^+) 293.1416, found 293.1414.

(*E*)-Cyclohexyl 3-(9*H*-Carbazol-9-yl)acrylate (6c): mp 125-127 ^{o}C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 1.27-1.62 (m, 6H), 1.79-1.83 (m, 2H), 1.96-2.00 (m, 2H), 4.92-4.99 (m, 1H), 6.33 (d, *J* = 14.2 Hz, 1H), 7.37 (t, *J* = 7.3 Hz, 2H), 7.49-7.54 (m, 2H), 7.77 (d, *J* = 8.2 Hz, 2H), 8.04 (d, *J* = 7.8 Hz, 2H), 8.52 (d, *J* = 14.2 Hz, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 23.9, 25.4, 31.9, 72.6, 102.3, 111.8, 120.4, 122.6, 125.4, 126.9, 136.9, 139.1, 167.5; HRMS *m/z* calcd for $C_{21}H_{21}NO_2$ (M^+) 319.1572, found 319.1574.

(*E*)-3-(9*H*-Carbazol-9-yl)-*N*,*N*-dimethylacrylamide (6d): mp 96-98 ^{o}C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 3.14 (s, 3H), 3.22 (s, 3H), 6.78 (d, *J* = 13.7 Hz, 1H), 7.36 (t, *J* = 7.6 Hz, 2H), 7.49-7.54 (m, 2H), 7.75 (d, *J* = 8.7 Hz, 2H), 8.06 (d, *J* = 7.8 Hz, 2H), 8.56 (d, *J* = 13.7 Hz, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 35.9, 37.5, 101.9, 111.5, 120.4,

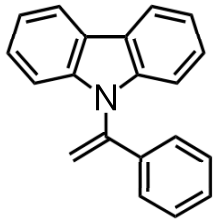
122.2, 125.2, 126.8, 136.0, 139.3, 167.3; HRMS *m/z* calcd for $C_{17}H_{16}N_2O$ (M^+) 264.1263, found 264.1264.

(*E*)-*N*-(*tert*-Butyl)-3-(9*H*-carbazol-9-yl)acrylamide (6e): mp 271-273 ^oC; ^1H NMR (400 MHz, $CDCl_3$) δ 1.48 (s, 9H), 5.44 (s, 1H), 6.26 (d, J = 13.7 Hz, 1H), 7.32-7.36 (m, 2H), 7.47-7.51 (m, 2H), 7.75 (d, J = 8.2 Hz, 2H), 8.04 (d, J = 7.8 Hz, 2H), 8.48 (d, J = 13.7 Hz, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 29.1, 51.6, 105.8, 111.6, 120.3, 122.1, 125.1, 126.7, 134.2, 139.3, 165.9; HRMS *m/z* calcd for $C_{19}H_{20}N_2O$ (M^+) 292.1576, found 292.1577.

References

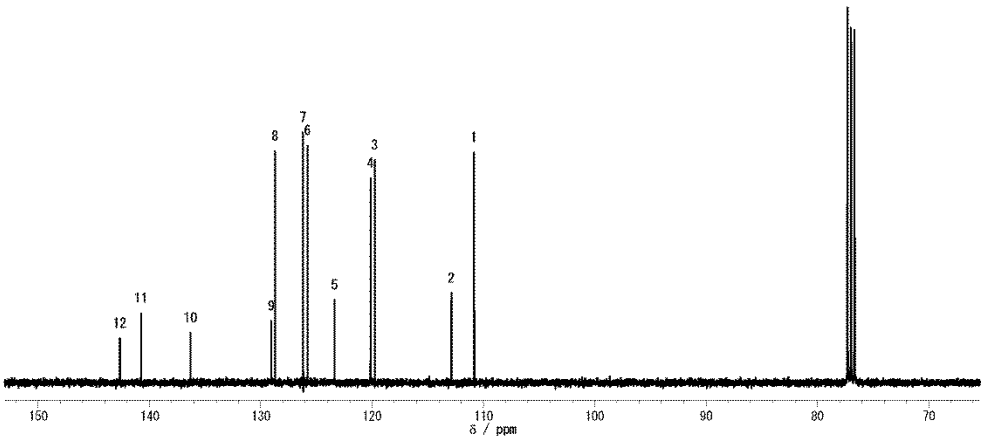
(3) (a) Liao, Q.; Wang, Y.; Zhang, L.; Xi, C. *J. Org. Chem.* **2009**, *74*, 6371.

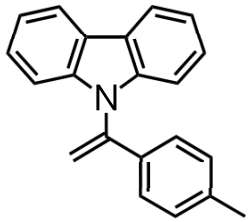
(10) Ferorelli, S.; Abate, C.; Colabufo, N. A.; Niso, M.; Inglese, C.; Berardi, F.; Perrone, R. *J. Med. Chem.* **2007**, *50*, 4648.



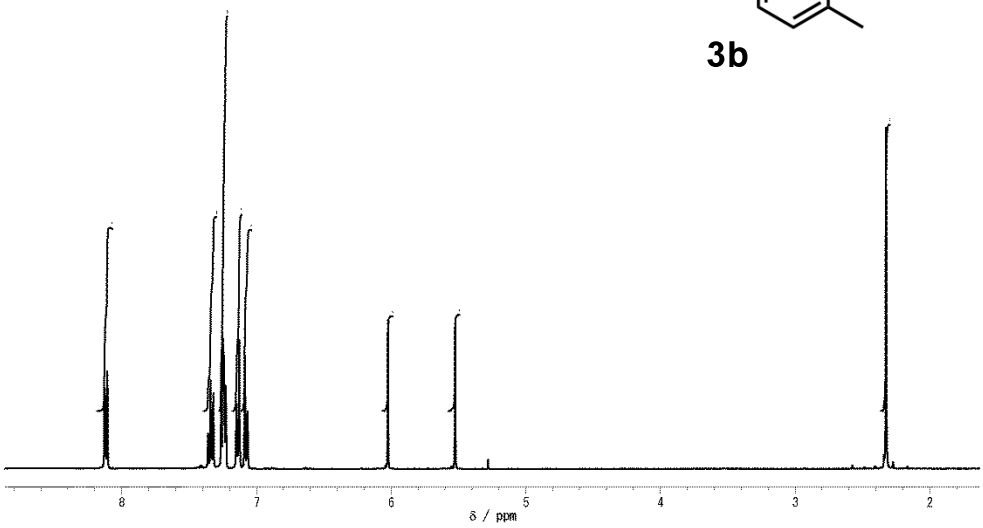
3a

No.	ppm	Hz	Amp.	Height
1	110.84	11141.3	40490	61.40
2	112.89	11347.3	15739	23.87
3	119.77	12038.4	39150	59.37
4	120.15	12076.7	35999	54.59
5	123.37	12400.7	14568	22.09
6	125.81	12646.1	41703	63.24
7	126.21	12686.3	44016	66.75
8	128.72	12938.4	40715	61.74
9	129.05	12971.9	10852	16.46
10	136.33	13703.3	8753	13.27
11	140.77	14149.9	12186	18.48
12	142.67	14340.6	7848	11.90

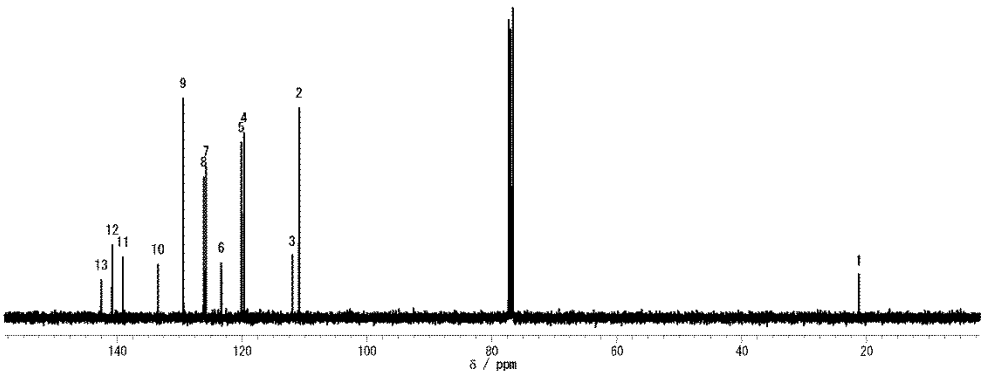


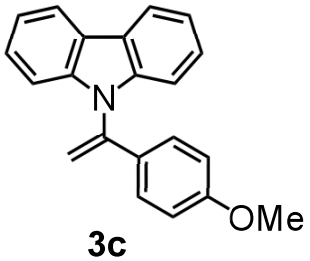


3b

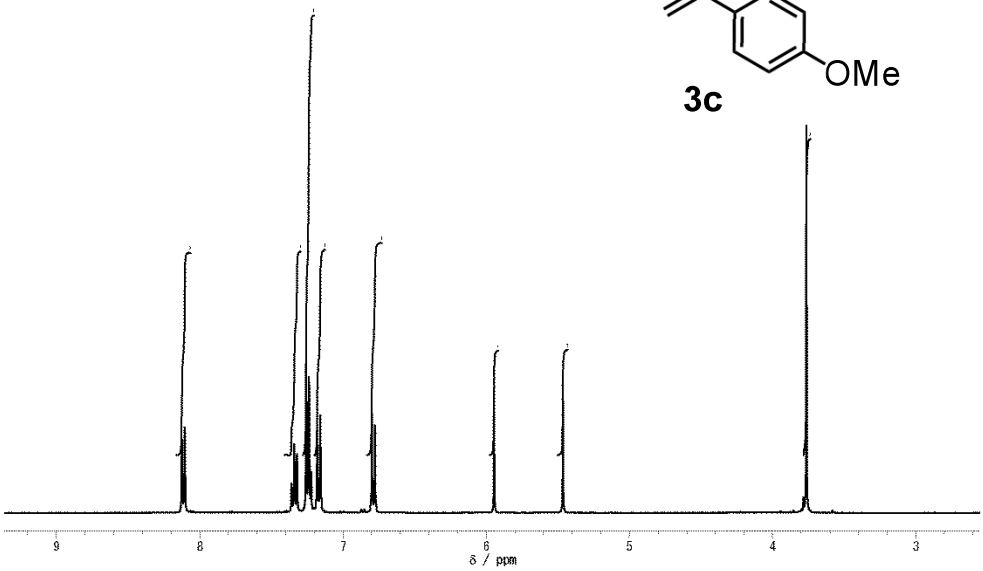


No.	ppm	Hz	Amp.	Height
1	21.23	2133.6	8785	13.49
2	110.88	11145.1	44024	67.58
3	111.98	11255.3	12864	19.75
4	119.69	12030.7	38851	59.64
5	120.12	12073.9	36829	56.53
6	123.32	12395.9	11492	17.64
7	125.77	12642.2	31748	48.73
8	126.12	12676.7	29516	45.31
9	129.42	13008.4	46063	70.71
10	133.48	13416.7	11128	17.08
11	139.10	13982.2	12675	19.46
12	140.81	14153.7	15237	23.39
13	142.58	14331.1	7858	12.06

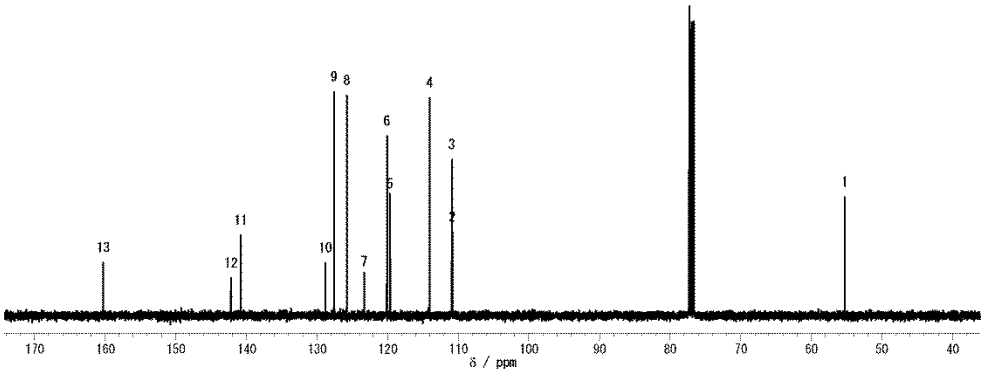


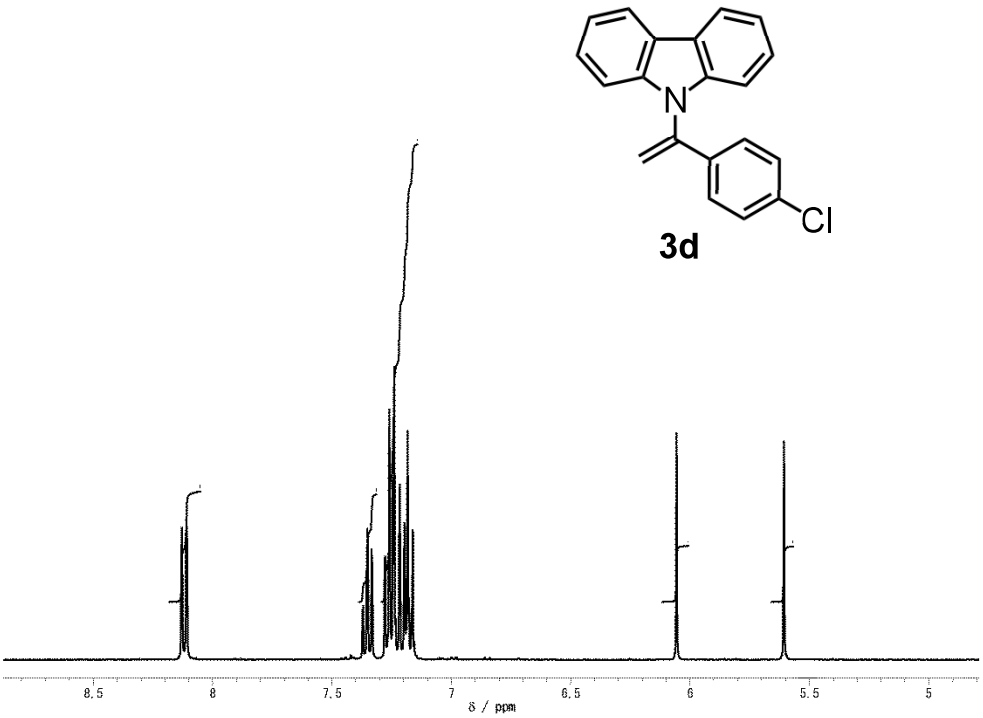


3c

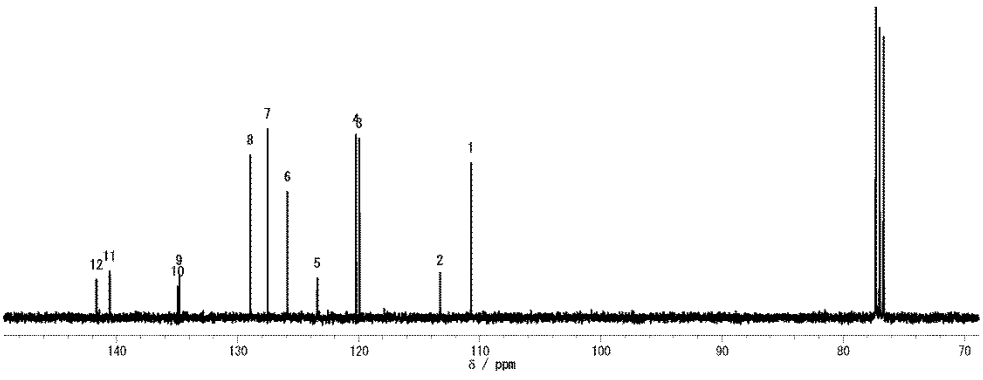


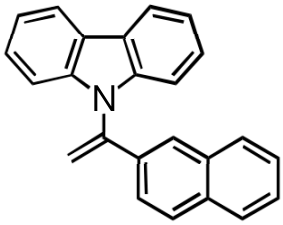
No.	ppm	Hz	Amp.	Height
1	55.27	5555.3	24258	38.26
2	110.86	11143.2	17131	27.02
3	110.92	11148.9	31933	50.37
4	114.05	11463.3	44579	70.31
5	119.69	12030.7	23873	37.66
6	120.12	12073.9	36733	57.94
7	123.32	12395.9	8000	12.62
8	125.77	12642.2	45022	71.01
9	127.59	12824.3	45795	72.23
10	128.82	12948.0	10793	17.02
11	140.80	14152.8	16440	25.93
12	142.18	14291.8	7691	12.13
13	160.27	16110.0	10853	17.12



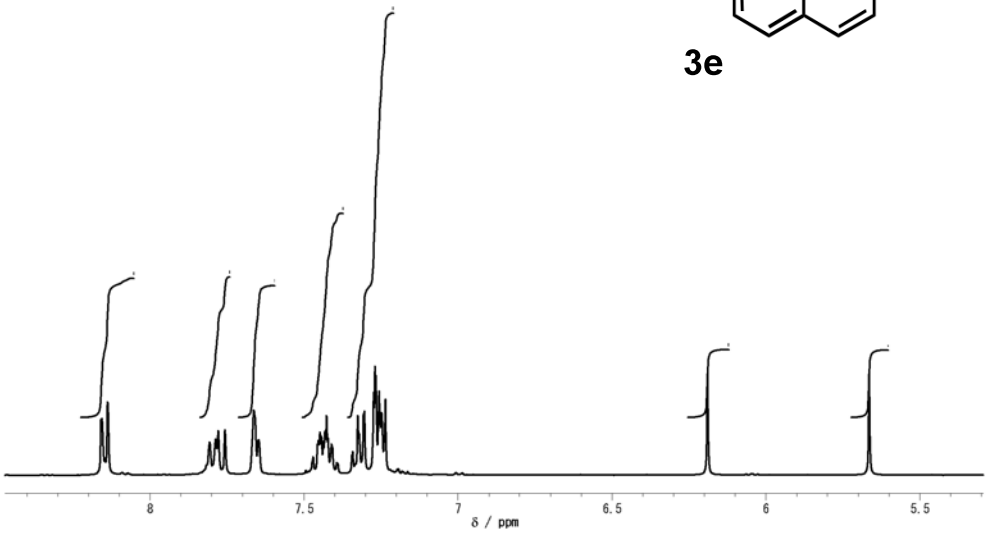


No.	ppm	Hz	Amp.	Height
1	110.73	11129.8	34385	49.91
2	113.30	11388.6	9404	13.65
3	119.97	12058.5	39857	57.85
4	120.23	12085.4	40691	59.06
5	123.43	12406.4	8747	12.70
6	125.91	12655.7	27910	40.51
7	127.54	12819.5	41980	60.94
8	128.97	12963.3	36127	52.44
9	134.82	13551.8	9412	13.66
10	134.97	13566.2	6873	9.98
11	140.58	14130.7	10253	14.88
12	141.68	14241.0	8394	12.18

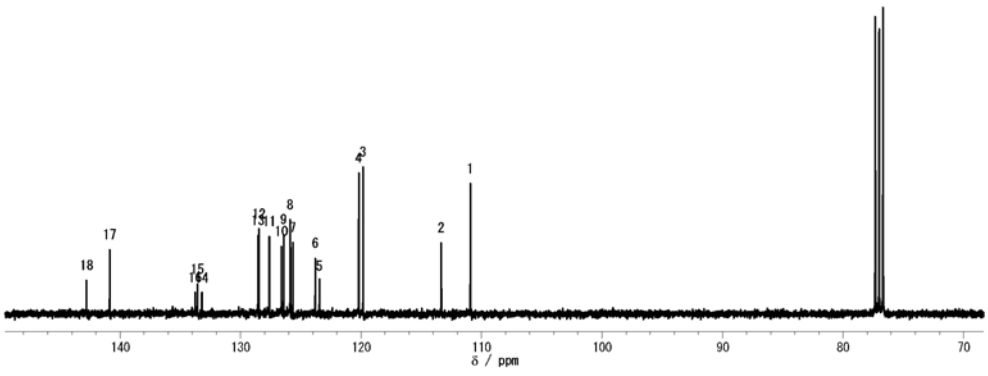


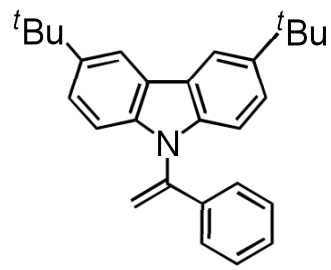


3e

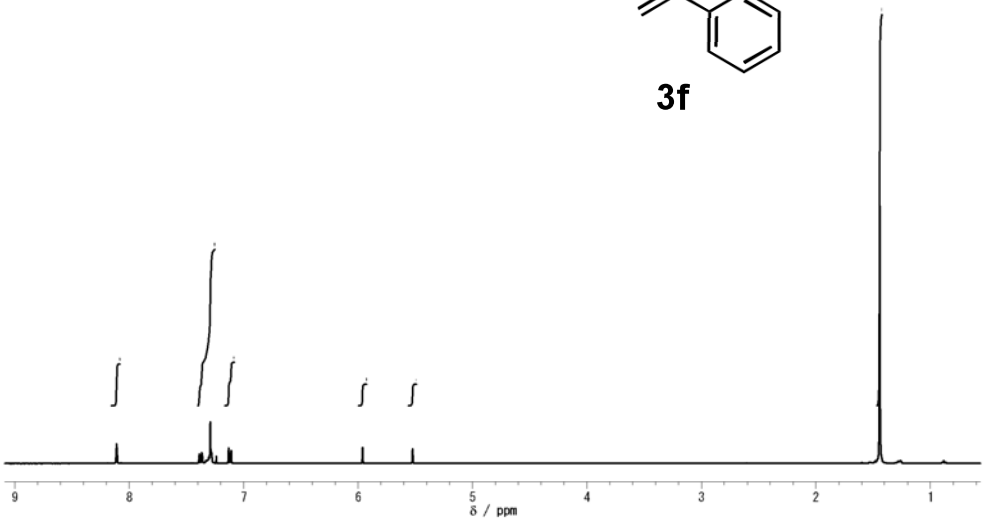


No.	ppm	Hz	Amp.	Height
1	110.94	11150.9	25813	41.99
2	113.36	11394.3	14087	22.92
3	119.83	12045.1	29131	47.39
4	120.20	12081.5	27966	45.49
5	123.46	12409.3	6470	10.52
6	123.80	12443.8	11015	17.92
7	125.67	12631.7	14133	22.99
8	125.89	12653.7	18636	30.32
9	126.42	12707.4	15734	25.59
10	126.61	12726.6	13367	21.74
11	127.62	12828.2	15364	24.99
12	128.48	12914.4	16833	27.38
13	128.56	12922.1	15550	25.29
14	133.22	13390.8	4100	6.67
15	133.59	13428.2	5851	9.52
16	133.77	13446.4	4215	6.86
17	140.87	14159.5	12732	20.71
18	142.79	14352.1	6620	10.77

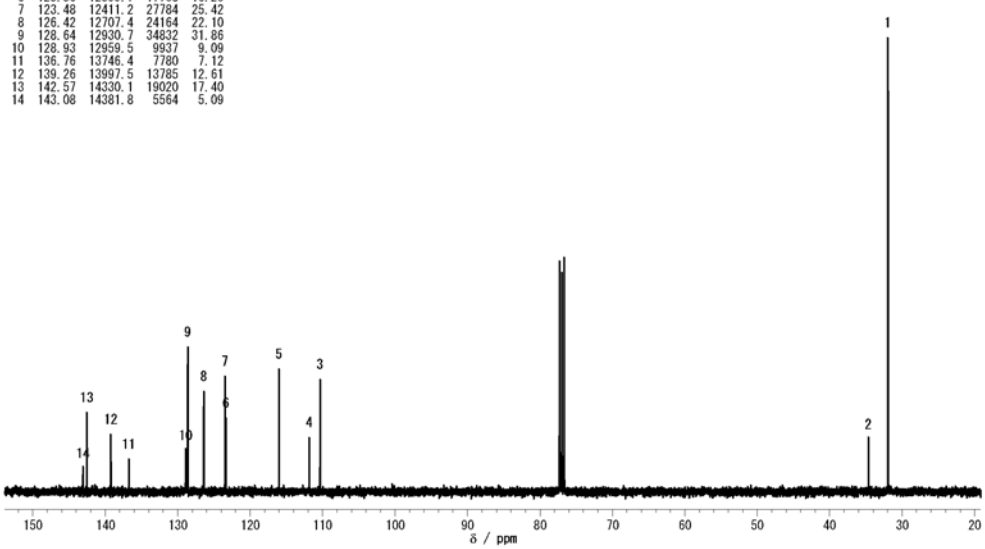


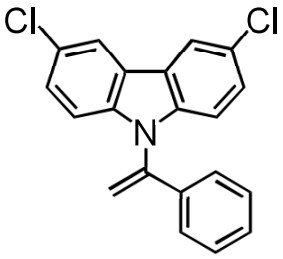


3f

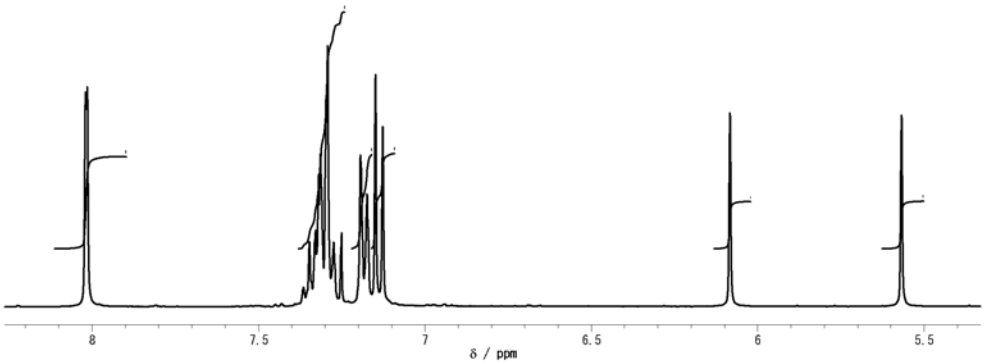


No.	ppm	Hz	Amp.	Height
1	31.99	3215.7	109318	100
2	34.68	3486.0	12571	11.50
3	110.36	11093.3	27022	24.72
4	111.85	11242.9	13057	11.94
5	116.03	11662.7	29520	27.01
6	123.36	12399.7	17708	16.20
7	123.48	12411.2	27784	25.42
8	126.42	12707.4	24164	22.10
9	128.64	12930.7	34832	31.86
10	128.93	12959.5	9937	9.09
11	136.76	13746.4	7780	7.12
12	139.26	13997.5	13785	12.61
13	142.57	14330.1	19020	17.40
14	143.08	14381.8	5564	5.09

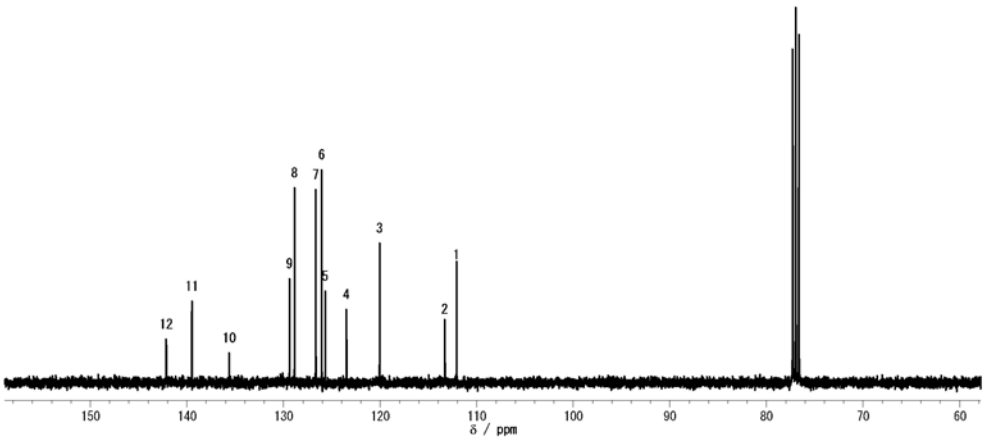


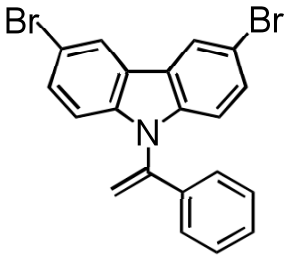


3g

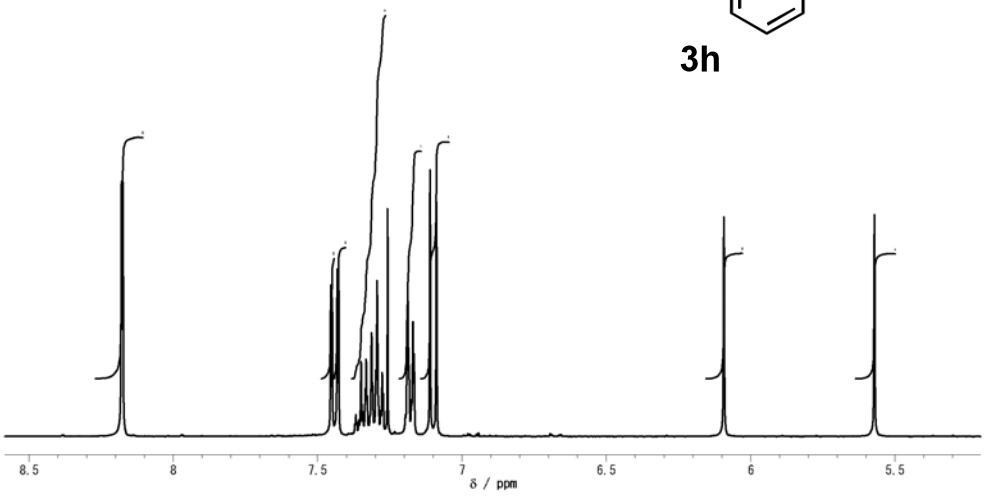


No.	ppm	Hz	Amp.	Height
1	112.10	11267.8	18017	30.06
2	113.32	11390.5	9355	15.61
3	120.05	12067.2	22268	37.15
4	123.50	12414.1	11682	19.49
5	125.70	12634.6	14613	24.38
6	126.06	12671.0	33997	56.72
7	126.68	12733.3	30855	51.48
8	128.87	12953.7	31129	51.94
9	129.41	13007.4	16615	27.72
10	135.63	13633.3	4728	7.89
11	139.52	14023.4	13013	21.71
12	142.17	14289.8	6949	11.59

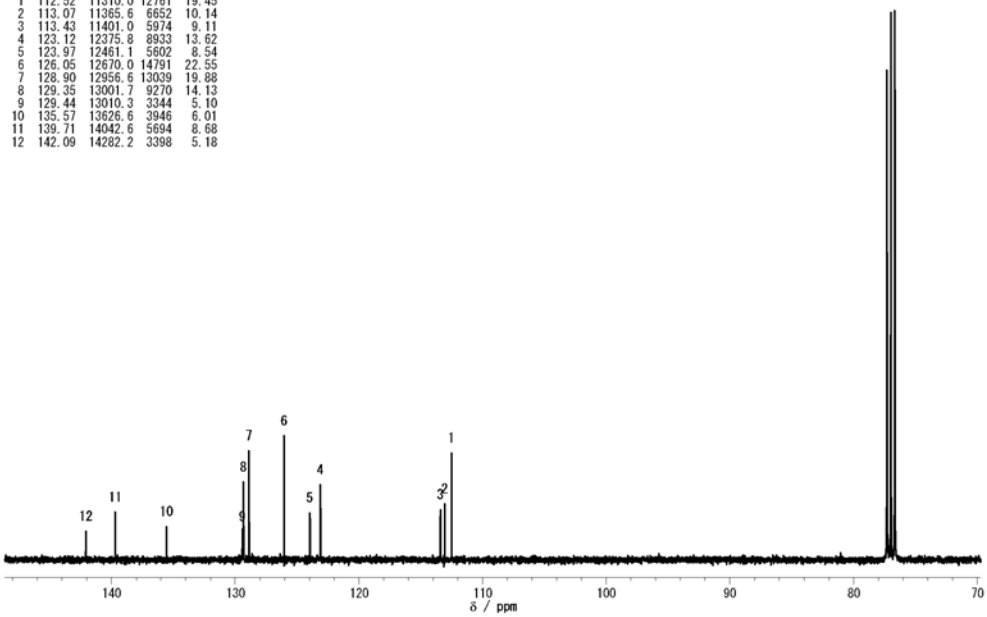


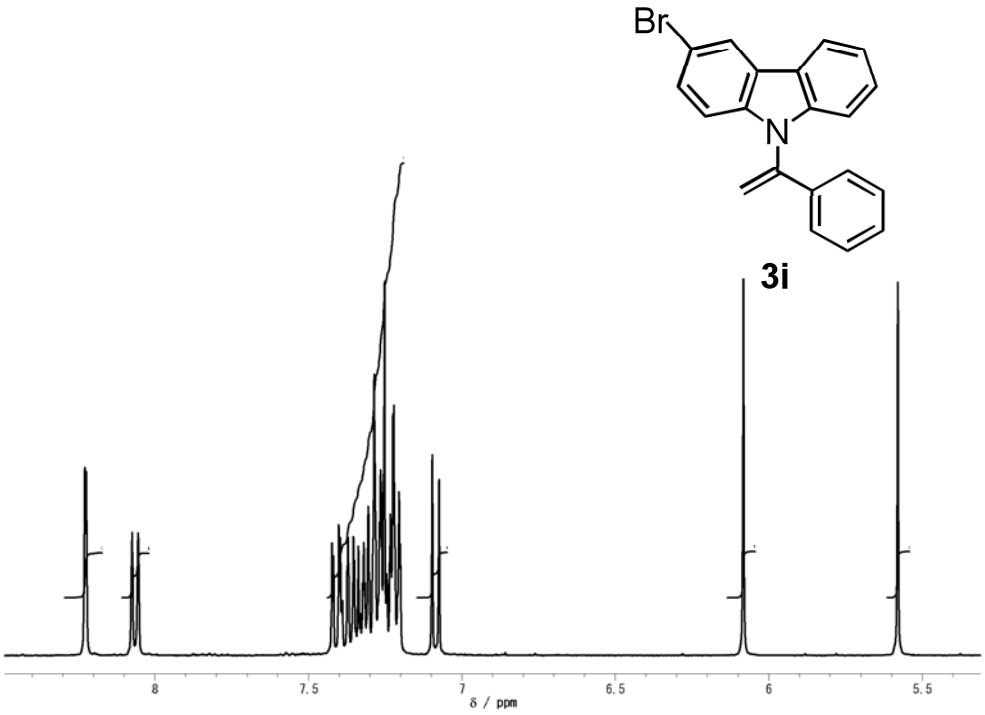


3h

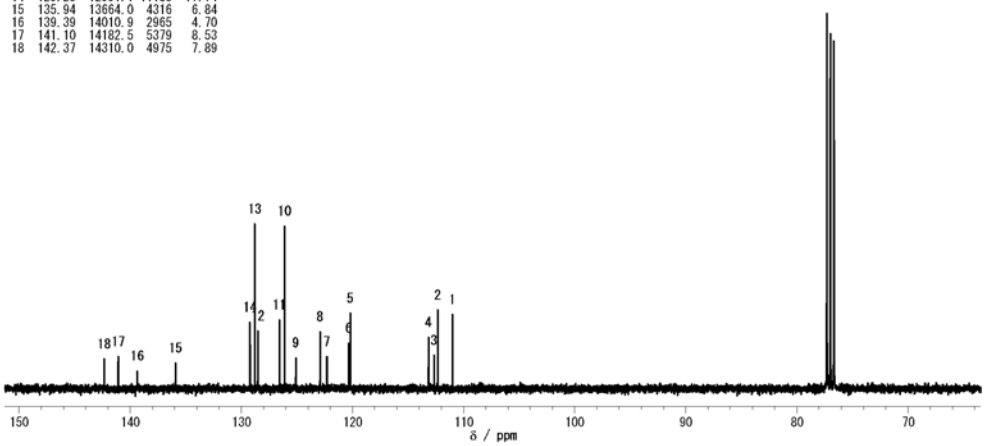


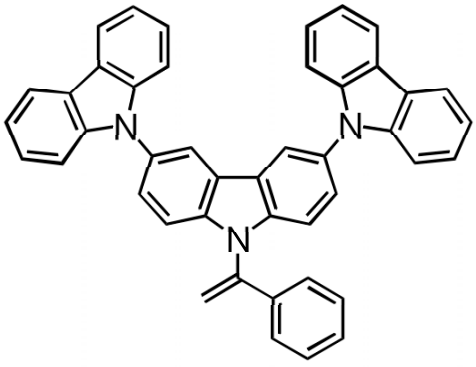
No.	ppm	Hz	Amp.	Height
1	112.52	11310.0	12761	19.45
2	113.07	11365.6	6652	10.14
3	113.43	11401.0	5974	9.11
4	123.12	12375.8	8933	13.62
5	123.97	12461.1	5602	8.54
6	126.05	12670.0	14791	22.55
7	128.90	12956.6	13039	19.88
8	129.35	13001.7	9270	14.13
9	129.44	13010.3	3344	5.10
10	135.57	13626.6	3946	6.01
11	139.71	14042.6	5694	8.68
12	142.09	14282.2	3398	5.18



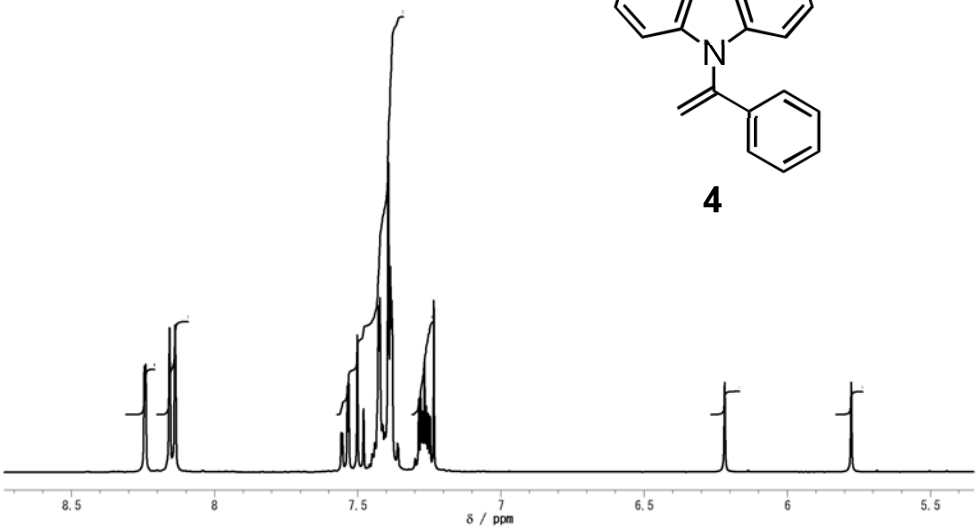


No.	ppm	Hz	Amp.	Height
1	111.01	11158.5	12453	19.75
2	112.34	11291.8	13201	20.93
3	112.66	11324.3	5589	8.86
4	113.16	11374.2	8636	13.69
5	120.22	12083.4	12671	20.09
6	120.35	12096.9	7640	12.12
7	122.31	12294.3	5379	8.53
8	122.92	12355.7	9578	15.19
9	125.12	12576.1	5181	8.22
10	126.13	12677.7	27333	43.34
11	126.58	12723.7	11563	18.34
12	128.53	12919.2	9715	15.41
13	128.81	12947.0	27674	43.89
14	129.25	12991.1	11185	17.74
15	135.94	13664.0	4316	6.84
16	139.39	14010.9	2965	4.70
17	141.10	14182.5	5379	8.53
18	142.37	14310.0	4975	7.89

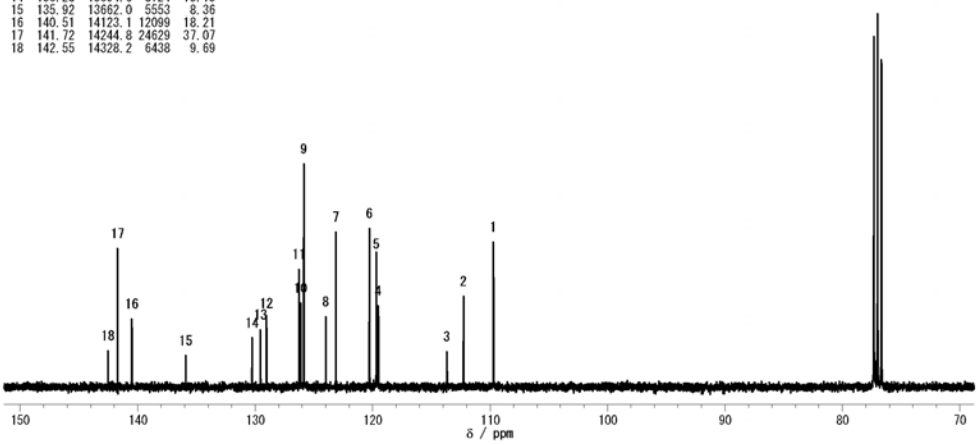


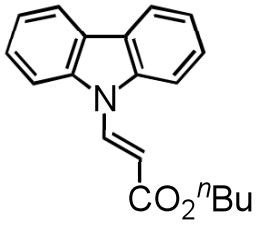


4

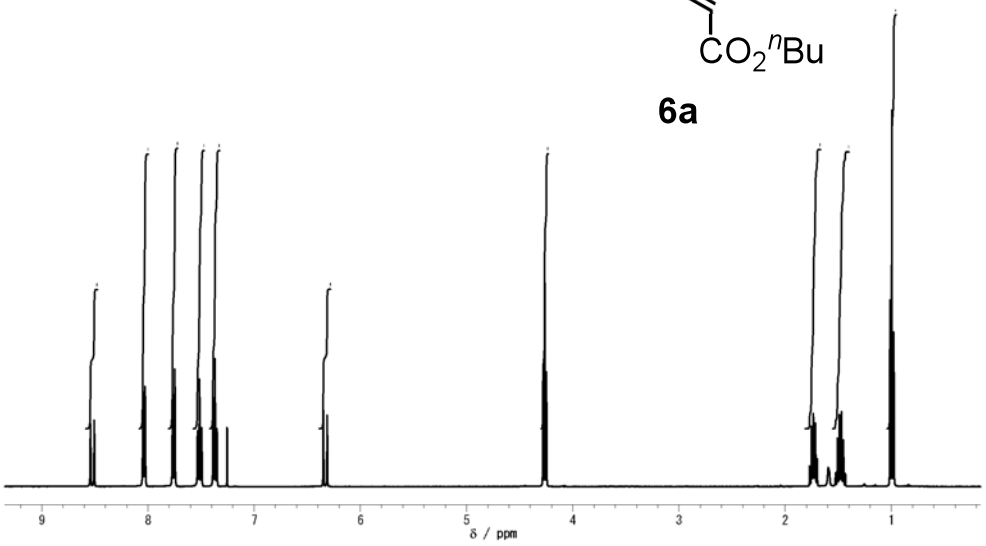


No.	ppm	Hz	Amp.	Height
1	109.74	11030.1	25804	38.83
2	112.27	11285.0	16128	24.27
3	113.69	11427.9	6270	9.44
4	119.52	12013.5	14418	21.70
5	119.68	12029.8	22753	34.24
6	120.28	12090.2	28198	42.44
7	123.14	12377.7	27577	41.50
8	123.99	12463.0	12485	18.79
9	125.87	12651.8	39685	59.72
10	126.15	12679.6	14880	22.39
11	126.28	12693.0	20924	31.49
12	129.05	12971.9	12180	18.33
13	129.56	13022.7	10137	15.26
14	130.28	13094.6	8724	13.13
15	135.92	13662.0	5553	8.36
16	140.51	14123.1	12099	18.21
17	141.72	14244.8	24629	37.07
18	142.55	14328.2	6438	9.69

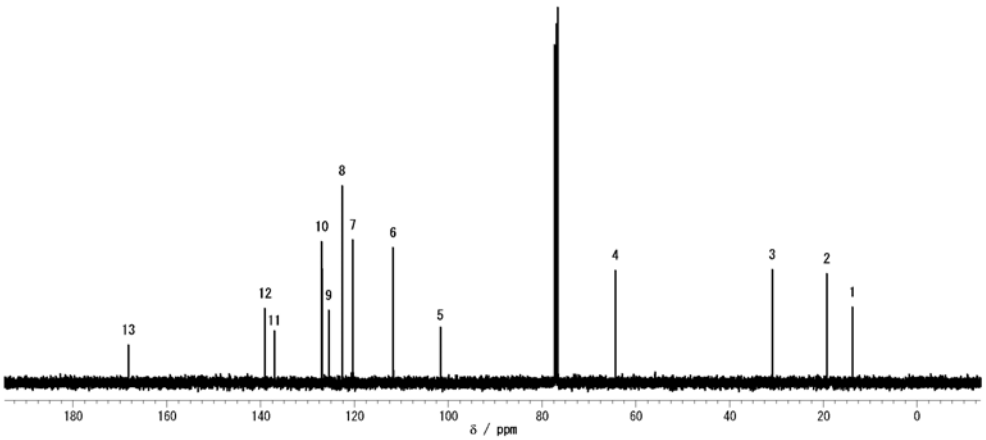


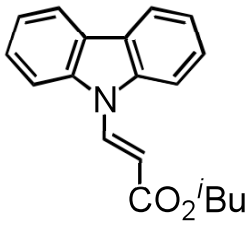


6a

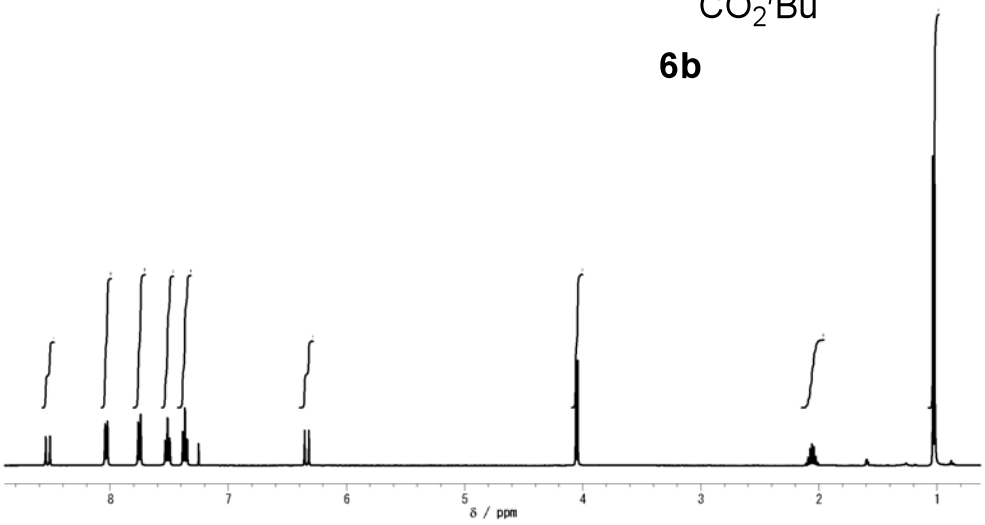


No.	ppm	Hz	Amp.	Height
1	13.79	1386.0	12839	20.09
2	19.24	1934.2	18601	29.10
3	30.88	3103.6	19248	30.11
4	64.33	6465.9	19154	29.96
5	101.70	10222.1	8940	13.99
6	111.78	11235.2	22995	35.97
7	120.38	12099.7	24308	38.03
8	122.65	12327.9	33564	52.51
9	125.46	12610.6	12320	19.27
10	126.98	12763.0	24034	37.60
11	137.09	13779.9	8047	12.59
12	139.10	13981.2	12659	19.80
13	168.20	16906.5	6431	10.06

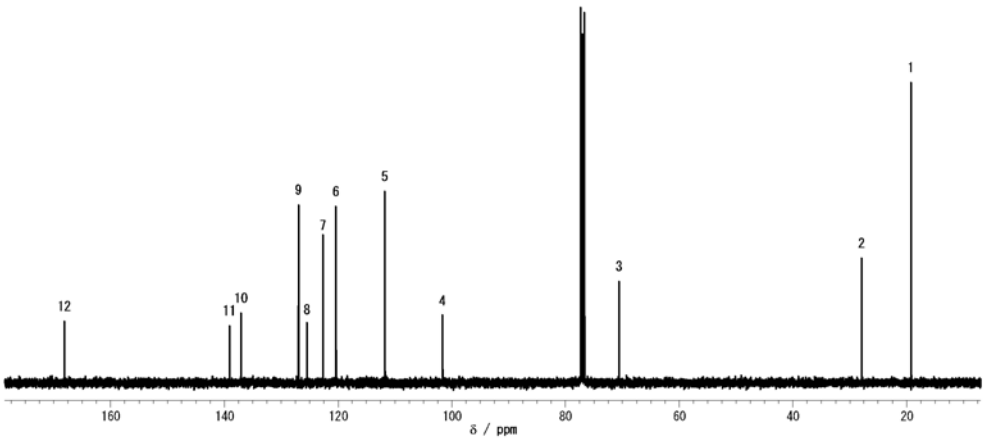


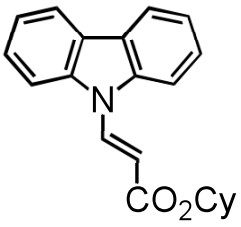


6b

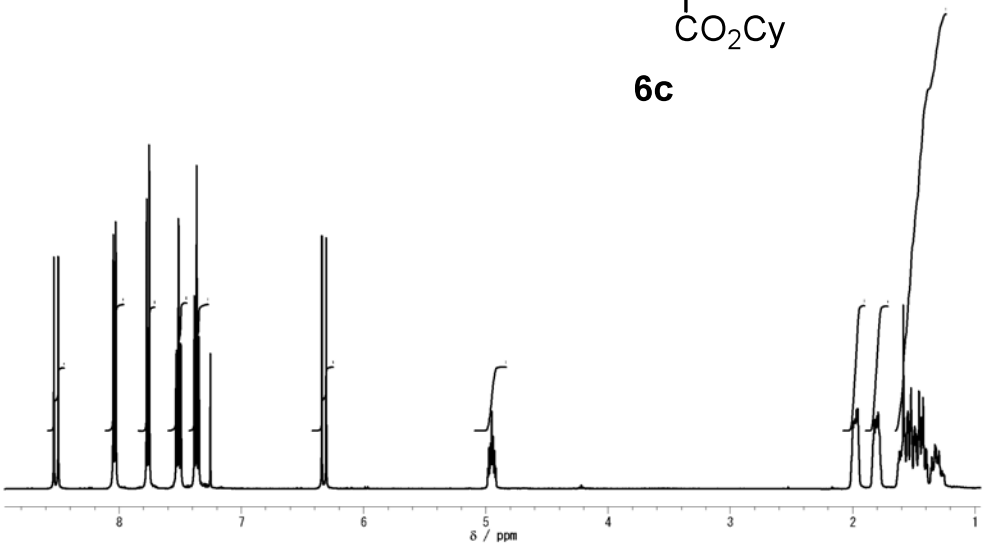


No.	ppm	Hz	Amp.	Height
1	19.23	1933.3	49868	79.99
2	27.93	2807.4	20666	33.15
3	70.57	7093.7	16816	26.97
4	101.65	10217.3	11066	17.75
5	111.78	11235.2	31762	50.94
6	120.39	12100.7	29240	46.90
7	122.67	12329.8	23646	37.93
8	125.48	12612.5	9614	15.42
9	126.99	12764.0	29537	47.37
10	137.10	13780.9	11541	18.51
11	139.10	13982.2	9458	15.17
12	168.18	16904.5	10187	16.34

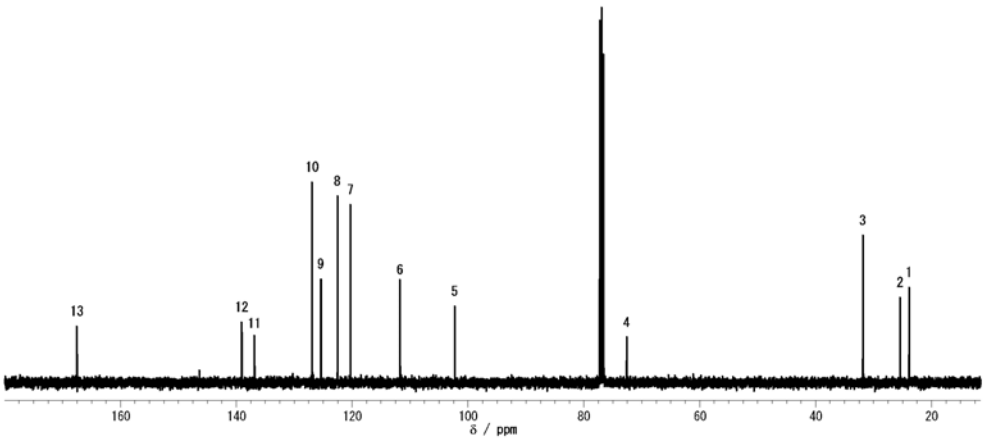


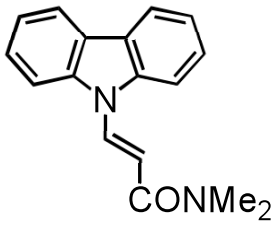


6c

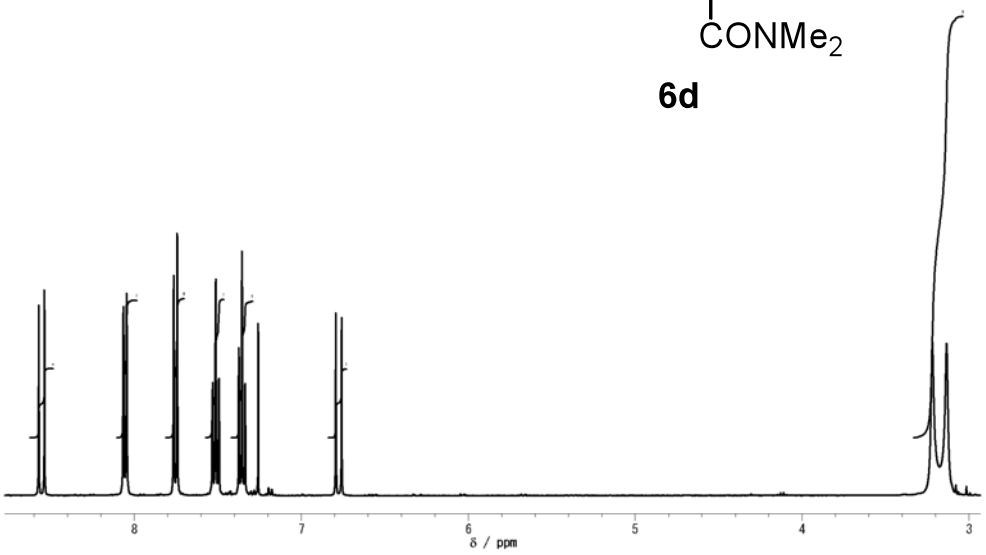


No.	ppm	Hz	Amp.	Height
1	23.90	2402.0	16265	25.43
2	25.44	2557.2	14550	22.75
3	31.88	3204.2	25108	39.25
4	72.63	7300.7	7702	12.04
5	102.32	10284.4	13001	20.32
6	111.78	11235.2	16695	26.10
7	120.35	12096.9	30360	47.46
8	122.58	12321.1	31804	49.72
9	125.42	12606.8	17681	27.64
10	126.94	12759.2	34215	53.49
11	136.89	13759.8	7553	11.81
12	139.10	13982.2	10310	16.12
13	167.53	16839.4	9625	15.05

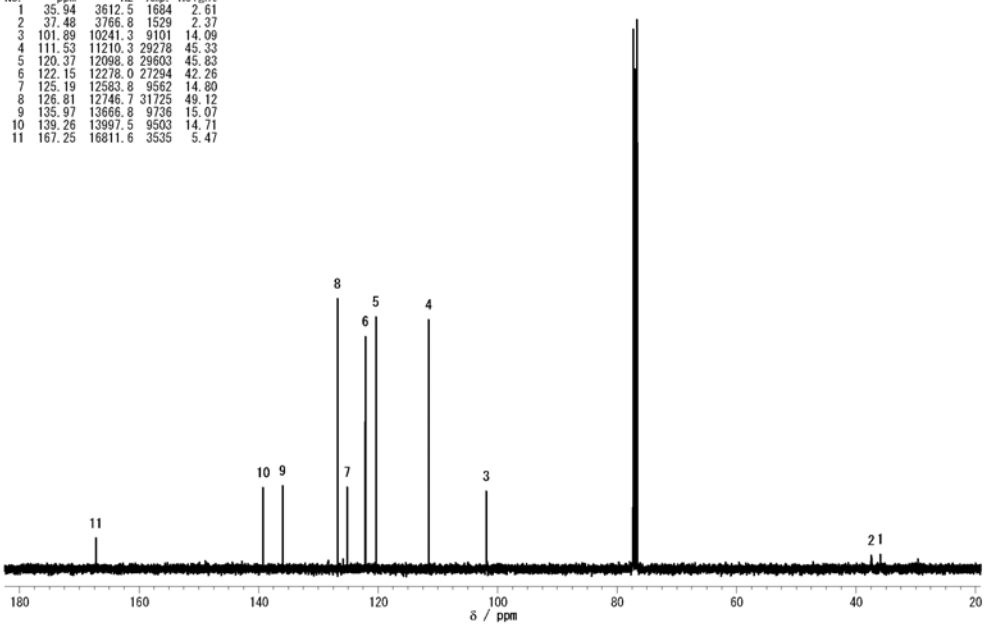


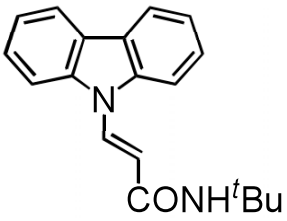


6d

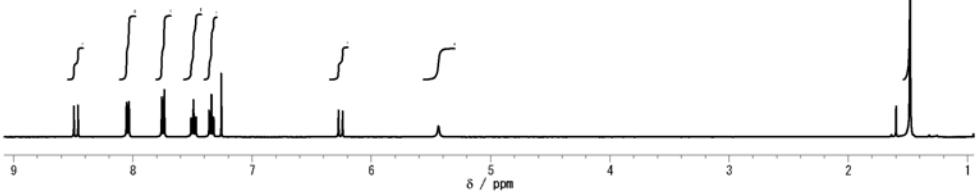


No.	ppm	Hz	Amp.	Height
1	35.94	3612.5	1684	2.61
2	37.48	3766.8	1529	2.37
3	101.89	10241.3	9101	14.09
4	111.53	11210.3	29278	45.33
5	120.37	12098.8	29603	45.83
6	122.15	12278.0	27294	42.26
7	125.19	12583.8	9562	14.80
8	126.81	12746.7	31725	49.12
9	135.97	13666.8	9736	15.07
10	139.26	13997.5	9503	14.71
11	167.25	16811.6	3535	5.47





6e



No.	ppm	Hz	Amp.	Height
1	29.06	2920.5	37720	54.79
2	51.62	5188.2	12552	18.23
3	105.83	10637.1	8989	13.06
4	111.54	11211.2	28436	41.30
5	120.30	12092.1	30615	44.47
6	122.05	12267.5	23518	34.16
7	125.12	12576.1	12900	18.74
8	126.73	12738.1	34823	50.58
9	134.15	13483.8	9842	14.30
10	139.27	13998.5	12061	17.52
11	165.93	16678.3	5329	7.74