Electronic Supplementary Information

Rhodium(I) complexes with *N*-heterocyclic carbenes bearing a 2,3,4,5-tetraphenylphenyl and its higher dendritic frameworks

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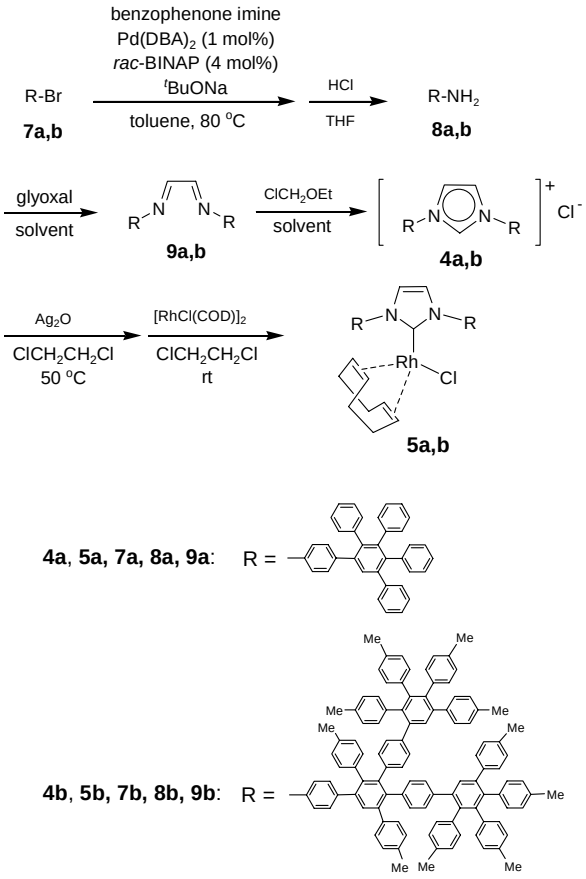
General procedure and materials.

All manipulations were performed under an argon atmosphere using standard Schlenk-type glasswares on a dual-manifold Schlenk line. The reagents and the solvents for catalytic reactions were dried and purified before use by usual procedures.[1] ^{1}H NMR and ^{13}C{^{1}H} NMR spectra were measured with a Bruker ARX-400, a JEOL ECX-400 or a JEOL ECA-600 spectrometers. MALDI-TOF mass spectra were measured with a Bruker Autoflex instrument. FD mass spectra were measured with a JEOL JMS-SX102A instrument at the GC-MS & NMR Laboratory of Faculty of Agriculture, Hokkaido University. ESI mass spectra were measured with a JEOL JMS-HX110 instrument at the Center for Instrumental Analysis, Hokkaido University. Elemental analyses were also carried out at the same center. Preparative recycling gel permeation chromatography (GPC) was performed with a JASCO LC9104. GC analysis was carried out using Shimadzu GC-17A

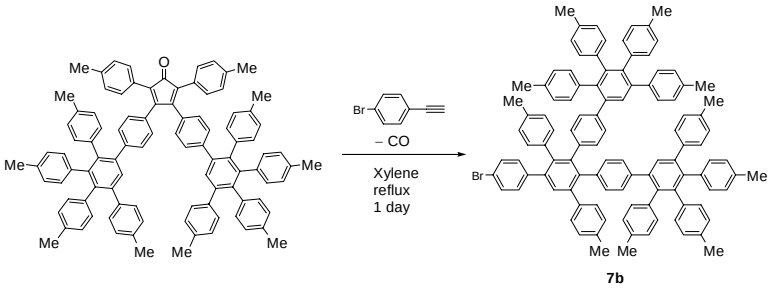
equipped with Shimadzu CPB1 (25 m length, 0.25 mm i.d.) or CPB10 (25 m length, 0.25 mm i.d.) columns.

Scheme 1S shows the preparation methods of **5a** and **5b**. **5c**,[2] **6a-d**[3] and 4-Bromo-(2′,3′,4′,5′-tetraphenylphenyl)biphenyl (**7a**)[4] were prepared according to the literatures.



Scheme 1S. Preparation of **5a** and **5b**

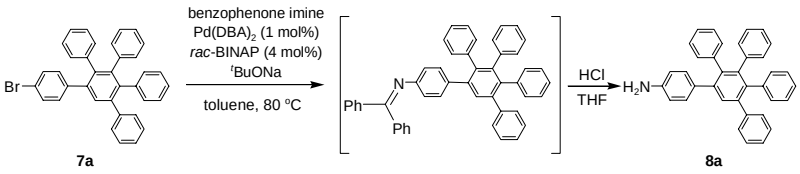
Synthesis of 7b:



In a 300−cm^3 flask under an argon atmosphere, a solution of 2,5-bis(*p*-tolyl)-3,4-bis{4-[2′,3′,4′,5′-tetra(*p*-tolyl)]biphenylyl}cyclopentadienone[5] (8.4 g, 6.5 mmol)

and 4-bromo-1-ethynylbenzene (1.5 g, 8.2 mmol) in degassed *o*-xylene (150 cm^3) was refluxed for 1 d. After a removal of the solvent, a residue was purified by silica gel chromatography using hexane/toluene (2/3) as an eluent. Removal of volatiles gave a white powder. Yield 5.3 g (57%). ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.444 (s, 1H, Ar_5C_6H), 7.436(s, 1H, Ar_5C_6H), 7.40 (s, 1H, Ar_5C_6H), 6.94-7.04 (m, 12H, Ph), 6.56-6.75 (m, 36H, Ph), 6.51 (d, 2H, J = 8.0 Hz, C_6H_4Br), 6.44 (d, 2H, J = 8.0 Hz, C_6H_4Br), 2.30 (s, 3H, Me), 2.26 (s, 6H, Me), 2.19 (s, 3H, Me), 2.15 (s, 6H, Me), 2.11 (s, 12H, Me). ^{13}C NMR (100 MHz, $CDCl_3$) δ 141.8, 141.5, 141.0, 140.7, 140.52, 140.50, 140.3, 139.5, 139.3, 139.21, 139.15, 139.12, 139.10, 139.0, 138.91, 138.86, 137.6, 137.2, 137.0, 135.5, 134.6, 134.3, 131.6, 131.55, 131.50, 131.3, 131.2, 131.03, 130.96, 130.7, 129.9, 129.8, 128.7, 128.5, 128.3, 128.2, 127.8, 127.6, 127.4, 127.3, 21.2, 21.13, 21.10, 21.05, 21.03. MALDI-TOF-MS (matrix: dithranol) *m/z* = 1437 $[M+H]^+$. Anal. Calcd. For $C_{106}H_{85}Br$: C, 88.49; H, 5.95. Found C, 88.40; H, 5.95.

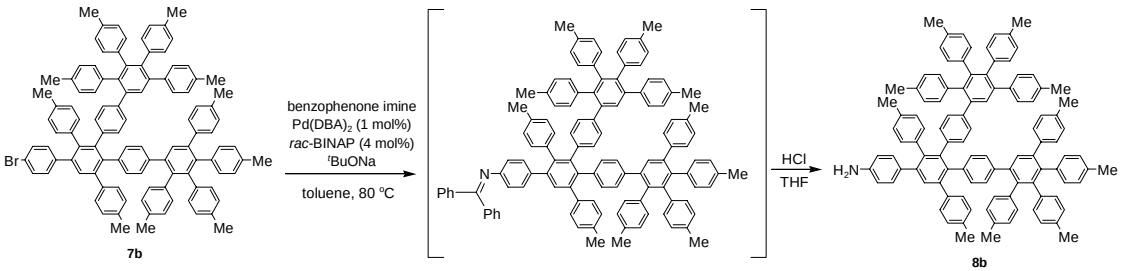
Synthesis of 8a:



In a 300−cm^3 two-neck flask under an argon atmosphere, benzophenone imine (3.5 cm^3, 21 mmol) was added to a suspension of **7a** (10 g, 18.7 mmol), *rac*-BINAP (466 mg, 0.75 mmol), $Pd(DBA)_2$ (95 mg, 0.19 mmol) and ^{t}BuONa (2.7 g, 28 mmol) in degassed toluene (100 cm^3) at 80 ºC. The mixture was stirred at 80 ºC under argon for 2 d. After removal of the solvent, a crude product was purified by silica gel column chromatography using CH_2Cl_2 as an eluent. Removal of volatiles gave the *N*-arylated imine as a yellow solid. It was dissolved in THF (500 cm^3) and 1N HCl aq. (150 cm^3) was added to the solution. The mixture was stirred at room temperature for 15 h. An aqueous saturated solution of $NaHCO_3$ (300 cm^3) was added to the reaction mixture and the organic layer was separated after vigorous shaking. The aqueous layer was extracted with AcOEt

(300 cm^3 × 2) and the washing liquid was combined with the organic layer, which was dried over anhydrous $MgSO_4$. After removal of volatiles, a crude product was obtained. It was dissolved in CH_2Cl_2 (20 cm^3) and the solution was poured into MeOH (600 cm^3). The product **8a** was collected by filtration as a white precipitate, washed with MeOH and dried *in vacuo*. Yield 7.9 g (96%). ^{1}H NMR (400 MHz, THF-d_8) δ 7.46 (s, 1H, Ar_5C_6H), 6.77-7.14 (m, 22H, Ph), 6.35 (d, 2H, J = 8.3 Hz, $C_6H_4NH_2$), 4.34 (s, 2H, NH_2). ^{13}C NMR (100 MHz, THF-d_8) δ 147.8, 143.1, 142.6, 142.2, 141.8, 141.7, 141.6, 141.4, 139.9, 139.2, 132.49, 132.47, 132.4, 132.1, 131.3, 130.73, 130.69, 128.23, 127.61, 127.56, 127.3, 126.7, 126.1. 126.0, 125.8. FD-MS m/z = 474 $[M]^+$. Anal. Calcd. For $C_{36}H_{27}N$: C, 91.30; H, 5.75; N, 2.96. Found: C, 91.44; H, 5.62; N, 2.95.

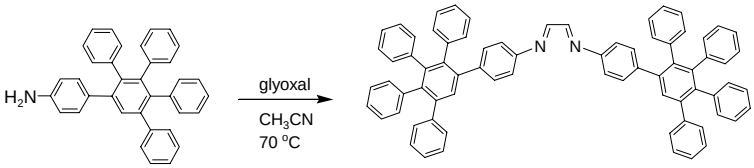
Synthesis of 8b:



In a 100−cm^3 two-neck flask under an argon atmosphere, benzophenone imine (0.42 cm^3, 2.5 mmol) was added to a suspension of **7b** (3.2 g, 2.2 mmol), *rac*-BINAP (55 mg, 89 μmol), ^{t}BuONa (327 mg, 3.4 mmol) and $Pd(DBA)_2$ (12 mg, 24 μmol) in degassed toluene (25 cm^3) at 80 ºC. The mixture was stirred at 80 ºC for 20 h. After removal of the solvent, a residue was purified by silica gel column chromatography using hexane/CH_2Cl_2 (from 2/1 to 1/1) as eluents. Removal of volatiles gave the *N*-arylated imine as a yellow solid. It was dissolved in THF (100 cm^3) and 1N HCl aq. (50 cm^3) was added to the solution. The mixture was stirred at room temperature for 1 h. An aqueous saturated solution of $NaHCO_3$ (100 cm^3) was added to the reaction mixture and the organic layer was separated after vigorous shaking. The aqueous layer was extracted with diethyl ether (100 cm^3 × 2) and the washing liquid was combined with the organic layer, which was dried over anhydrous $MgSO_4$. After removal of volatiles, a crude product was obtained. It was

dissolved in CH_2Cl_2 and the solution was poured into MeOH. The product **8b** was collected by filtration as a white powder, washed with MeOH and dried *in vacuo*. Yield 3.0 g (96%). ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.48 (s, 1H, Ar_5C_6H), 7.46 (s, 1H, Ar_5C_6H) 7.42 (s, 1H, Ar_5C_6H), 6.93-7.05 (m, 12H, Ph), 6.88 (d, 2H, J = 7.9 Hz, $C_6H_4NH_2$), 6.58-6.75 (m, 32H, Ph), 6.52 (d, 2H, J = 7.9 Hz, $C_6H_4NH_2$), 6.451 (d, 2H, J = 7.5 Hz, $Ar_2C_6H_4$), 6.450 (d, 2H, J = 7,5 Hz, $Ar_2C_6H_4$), 3.54 (br, 2H, NH_2), 2.29 (s, 3H, Me), 2.26 (s, 6H, Me), 2.18 (s, 3H, Me), 2.13 (s, 6H, Me), 2.11 (s, 12H, Me). ^{13}C NMR (100 MHz, $CDCl_3$) δ 144.5, 141.8, 141.2, 140.7, 140.5, 140.4, 139.2, 139.1, 139.0, 138.92, 138.86, 138.7, 138.3, 138.1, 137.7, 137.6, 137.2, 137.1, 137.0, 135.6, 135.5, 134.7, 134.6, 134.3, 132.4, 132.3, 131.6, 131.3, 131.15, 131.06, 130.8, 130.03, 129.98, 129.8, 128.7, 128.3, 128.2, 127.6, 127.4, 127.3, 21.2, 21.2, 21.0. MALDI-TOF-MS (matrix: dithranol) m/z = 1374 $[M+H]^+$. Anal. Calcd. For $C_{106}H_{87}N$: C, 92.60; H, 6.38; N, 1.02. Found C, 92.64; H, 6.55; N, 1.08.

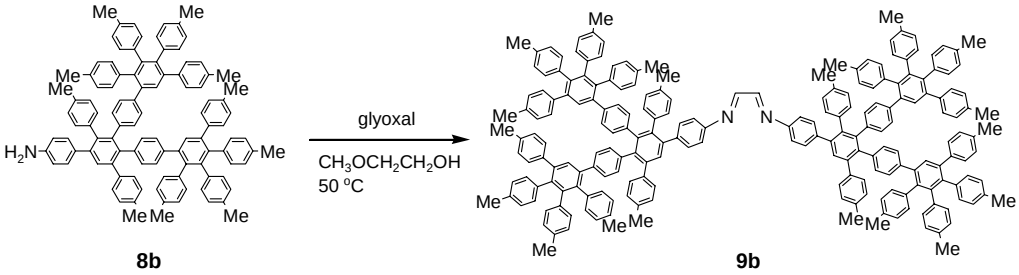
Synthesis of 9a:



8a **9a**

In a 100−cm^3 flask, glyoxal (40 wt% in water, 0.4 cm^3, 3.5 mmol) was added to a solution of **8a** (3.0 g, 6.3 mmol) in CH_3CN (45 cm^3) at 70 ºC. The mixture was stirred at 70 ºC for 6.5 h. A yellow solid formed and was collected by filtration, washed with CH_3CN and dried *in vacuo*. Yield 2.2 g (73%). ^{1}H NMR (400 MHz, THF-d_8) δ 8.32 (s, 2H, $C_2H_2N_2$), 7.55 (s, 2H, Ar_5C_6H), 7.21 (d, 4H, J = 8.7 Hz, C_6H_4N), 7.08-7.14 (m, 12H, Ph), 6.80-6.90 (m, 32H, Ph). ^{13}C NMR (100 MHz, CD_2Cl_2) δ 160.0, 142.2, 142.1, 141.9, 141.2, 140.8, 140.5, 140.4, 140.3, 139.9, 139.7, 131.87, 131.84, 131.78, 131.4, 131.3, 130.3, 127.9, 127.3, 127.2, 126.9, 126.7, 126.1, 126.0, 125.7, 121.0. FD-MS m/z = 968 $[M]^+$. Anal. Calcd. For $C_{74}H_{52}N_2$: C, 91.70; H, 5.41; N, 2.89. Found: C, 91.42; H, 5.55; N, 2.81.

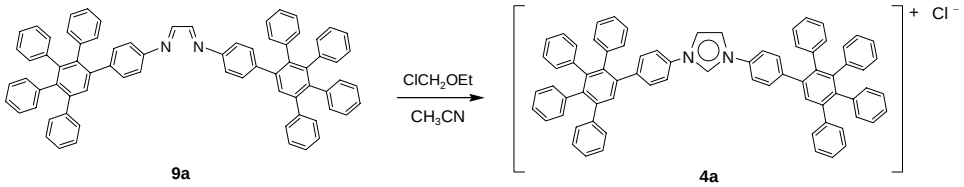
Synthesis of 9b:



8b **9b**

In a 30−cm^3 flask, a solution of glyoxal (40 wt% in water, 0.021 cm^3, 0.19 mmol) in 2-methoxyethanol (1 cm^3) was added to a solution of **8b** (512 mg, 0.37 mmol) in 2-methoxyethanol (4 cm^3) at 50 ºC. The mixture was stirred at 50 ºC for 17 h. After cooling with an ice bath, a yellow suspension was filtered on a Celite and washed with cold 2-methoxyethanol. The yellow material was dissolved in diethyl ether and evaporation of the solvent gave **9b** as a yellow powder. Yield 479 mg (93%). ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.33 (s, 2H, $C_2H_2N_2$), 7.45 (s, 4H, Ar_5C_6H), 7.41 (s, 2H, Ar_5C_6H), 6.84-7.16 (m, 28H, Ph), 6.44-6.73 (m, 76H, Ph), 2.30 (s, 6H, Me), 2.27 (s, 12H, Me), 2.18 (s, 6H, Me), 2.15 (s, 12H, Me), 2.12 (s, 24H, Me). ^{13}C NMR (100 MHz, $CDCl_3$) δ 141.8, 140.5, 140.4, 139.1, 138.92, 138.86, 137.6, 137.2, 137.1, 137.0, 136.7, 135.5, 134.7, 134.6, 134.3, 131.6, 131.3, 131.2, 131.1, 130.0, 129.8, 128.7, 128.4, 128.2, 127.6, 127.4, 127.3, 21.12, 21.09, 21.04, 21.02. MALDI-TOF-MS (matrix: dithranol) m/z = 2770 $[M+H]^+$. ESI-MS-HR Calcd. For $C_{214}H_{172}N_2Na$: 2792.3418, Found: m/z = 2792.3484.

Synthesis of 4a:

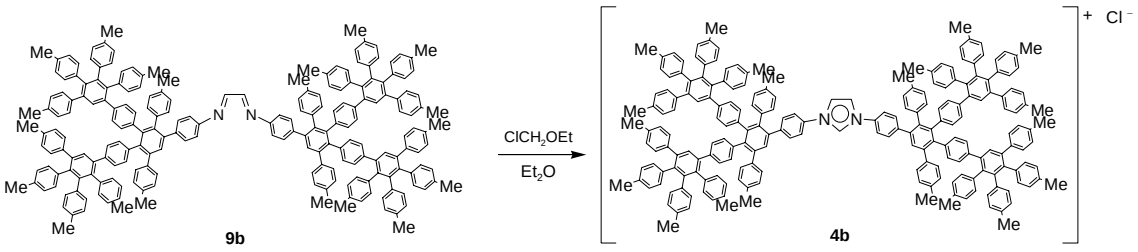


9a **4a**

In a 5−cm^3 flask, **9a** (1.0 g, 1.0 mmol) was added to $ClCH_2OEt$ (2 cm^3, 22 mmol) at room temperature with vigorous stirring. After **9a** was completely dissolved in $ClCH_2OEt$ (in ca. 1 min), CH_3CN (2.5 cm^3) was added and the mixture was stirred for 30 min. After removal of volatiles, a

residue was purified by silica gel column chromatography. Materials eluted with CH_2Cl_2 were discarded and a fraction eluted with MeOH/CH_2Cl_2 (1/9) was collected. Evaporation of the fraction *in vacuo* gave a crude product as a pale-brown solid. Further purification was performed with a preparative recycling GPC to afford a white powder. Yield 733 mg (69%). ^{1}H NMR (400 MHz, $CDCl_3$) δ 11.51 (s, 1H, NC*H*N), 7.90 (d, 4H, *J* = 8.7 Hz, C_6H_4Im), 7.69 (s, 2H, NC*H*=C*H*N), 7.50 (s, 2H, Ar_5C_6H), 7.37 (d, 4H, *J* = 8.7 Hz, C_6H_4Im), 6.78-6.93 (m, 40H, Ph). ^{13}C NMR (100 MHz, $CDCl_3$) δ 144.4, 142.1, 141.3, 141.1, 140.2, 139.9, 139.7, 139.4, 139.2, 138.6, 135.1, 132.4, 132.0, 131.43, 131.41, 131.36, 131.1, 129.9, 127.7, 127.3, 127.0, 126.7, 126.0, 125.8, 125.5, 121.1, 120.8. FD-MS *m/z* = 981 $[M\text{-}Cl]^+$. ESI-MS-HR Calcd. For $C_{75}H_{53}N_2$: 981.4209, Found: *m*/*z* = 981.4197.

Synthesis of 4b:

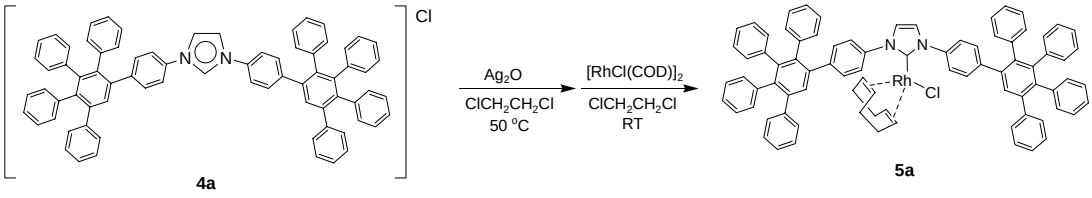


9b **4b**

In a 50−cm^3 flask under an argon atmosphere, a solution of $ClCH_2OEt$ (0.25 cm^3, 2.7 mmol) in degassed diethyl ether (5 cm^3) was added at –25 ºC to a solution of **9b** (502 mg, 0.18 mmol) in degassed diethyl ether (10 cm^3). The mixture was stirred at –25 ºC for 19 h. After removal of volatiles, a crude product was purified by silica gel column chromatography. Materials eluted with CH_2Cl_2, diethyl ether, and MeOH/diethyl ether (2/98) was discarded. A fraction eluted with MeOH/CH_2Cl_2 (1/9) was collected and evaporation gave a pale-brown powder. Yield 218 mg (43%). ^{1}H NMR (600 MHz, $CDCl_3$) δ 11.15 (s, 1H, NC*H*N), 7.81 (d, 4H, *J* = 7.2 Hz, C_6H_4Im), 7.66 (s, 2H, NC*H*=C*H*N), 7.45 (s, 2H, Ar_5C_6H), 7.44 (s, 2H, Ar_5C_6H), 7.41 (s, 2H, Ar_5C_6H), 7.32 (d, 4H, *J* = 7.2Hz, C_6H_4Im), 6.96-7.04 (m, 24H, Ph), 6.58-6.71 (m, 64H, Ph), 6.54 (d, 4H, *J* = 7.2 Hz, $Ar_2C_6H_4$), 6.46 (d, 4H, *J* = 7.2 Hz, $Ar_2C_6H_4$), 2.29 (s, 6H, Me), 2.27 (s, 12H, Me), 2.16 (s, 6H, Me),

2.15 (s, 12H, Me), 2.11 (s, 24H, Me). ^{13}C NMR (100 MHz, $CDCl_3$) δ 144.8, 141.8, 141.7, 140.9, 140.5, 140.3, 139.7, 139.25, 139.20, 138.92, 138.87, 138.7, 138.5, 137.6, 137.3, 137.2, 137.1, 137.0, 136.3, 135.9, 135.5, 135.3, 134.7, 134.6, 134.3, 132.3, 131.9, 131.6, 131.5, 131.3, 131.2, 131.0, 130.9, 129.9, 129.8, 128.8, 128.5, 128.3, 128.2, 128.0, 127.6, 127.4, 127.3, 121.3, 121.0, 21.19, 21.15, 21.11, 21.08, 21.06, 21.04. MALDI-TOF-MS (matrix: dithranol) *m*/*z* = 2782 $[M\text{-}Cl]^+$. ESI-MS-HR Calcd. For $C_{215}H_{173}N_2$: 2782.3599, Found: *m*/*z* = 2782.3599.

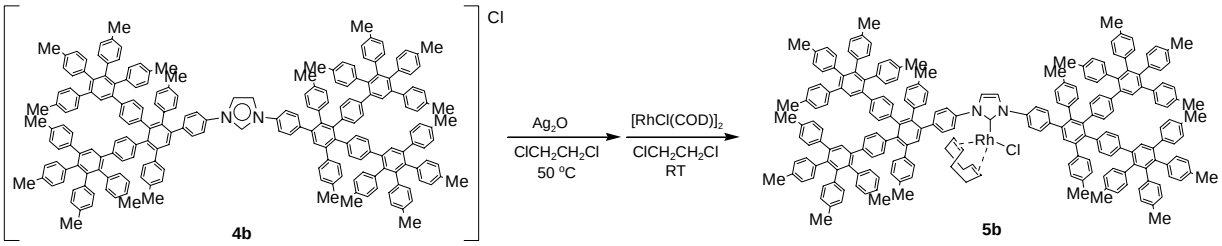
Synthesis of 5a:



4a **5a**

In a 100−cm^3 two-neck flask under argon atmosphere, a suspension of **4a** (329 mg, 0.32 mmol) and Ag_2O (46 mg, 0.20 mmol) in 1,2-dichloroethane (30 cm^3) was stirred at 50 °C for 1 d under Ar. At room temperature, $[RhCl(COD)]_2$ (96 mg, 0.20 mmol) was added to the solution and the whole mixture was stirred at room temperature under Ar for 8 h. After filtration through Celite to remove insoluble materials, a residue obtained by evaporation was purified by silica gel column chromatography using CH_2Cl_2/hexane (1/1) as an eluent. The crude product was recrystallized from CH_2Cl_2/diethyl ether. Yellow crystals were collected by filtration, washed with diethyl ether and dried *in vacuo*. Yield 274 mg (69%). ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.13 (d, 4H, *J* = 8.6 Hz, C_6H_4Im), 7.60 (s, 2H, Ar_5C_6H), 7.37 (d, 4H, *J* = 8.6 Hz, C_6H_4Im), 7.16-7.21 (m, 12H, Ph), 6.79-6.96 (m, 30H, Ph), 4.88 (m, 2H, COD), 2.58 (m, 2H, COD), 1.92 (m, 2H, COD), 1.49-1.59 (m. 6H, COD). ^{13}C NMR (100 MHz, $CDCl_3$) δ 184.4 (d, $J_{Rh\text{-}C}$ = 48.7 Hz, N*C*N), 142.1, 141.6, 141.5, 141.0, 140.2, 139.8, 139.7, 139.6, 139.3, 138.5, 131.54, 131.46, 131.38, 131.32, 130.4, 129.9, 127.7, 127.2, 127.1, 126.9, 126.67, 126.62, 126.4, 125.9, 125.7, 125.4, 124.2, 122.0, 97.3 (d, $J_{Rh\text{-}C}$ = 6.7 Hz), 68.0 (d, $J_{Rh\text{-}C}$ = 14.3 Hz), 32.3, 28.6. FD-MS *m/z* = 1227 $[M]^+$. Anal. Calcd. For $C_{83}H_{64}N_2ClRh$: C, 81.20; H, 5.25; N, 2.28. Found C, 81.26; H, 5.32; N, 2.33.

Synthesis of 5b:



In a 100−cm^3 two-necked flask under argon atmosphere, a solution of **4b** (652 mg, 0.23 mmol) and Ag_2O (33 mg, 0.14 mmol) in 1,2-dichloroethane (20 cm^3) was stirred at 50 ºC for 9 h under Ar. At room temperature, $[RhCl(COD)]_2$ (70 mg, 0.14 mmol) was added to the solution and the mixture was stirred at room temperature for 18 h. After filtration through Celite to remove insoluble materials, a residue obtained by evaporation was purified by silica gel column chromatography using CH_2Cl_2/hexane (3/7) as an eluent. Removal of volatiles gave a pale-orange solid. Yield 487 mg (70%). ^{1}H NMR (600 MHz, $CDCl_3$) δ 8.11 (d, 4H, J = 8.4 Hz, C_6H_4Im), 7.53 (s, 2H, NC*H*=C*H*N), 7.47 (s, 2H, Ar_5C_6H), 7.42 (s, 2H, Ar_5C_6H), 7.32 (d, 4H, J = 7.8 Hz, C_6H_4Im), 7.21 (s, 2H, Ar_5C_6H) 6.95-7.05 (m, 24H, Ph), 6.79-6.47 (m, 72H, Ph), 4.87 (br, 2H, COD), 2.60 (br, 2H, COD), 2.31, 2.27, 2.17, 2.16, 2.15, 2.13, 2.122, 2.119 (s, 60H, Me) 1.92 (br, 2H, COD), 1.66 (br, 2H, COD), 1.57 (br, 2H, COD), 1.52 (br, 2H, COD). ^{13}C NMR (150 MHz, $CDCl_3$) δ 184.3 (d, $J_{Rh\text{-}C}$ = 47.7 Hz, NCN), 141.9, 141.8, 141.7, 140.7, 140.53, 140.50, 140.3, 139.7, 139.25, 139.19, 139.10, 139.08, 138.96, 138.92, 138.87, 138.7, 138.6, 138.4, 137.8, 137.6, 137.5, 137.2, 137.1, 137.0, 136.8, 135.8, 135.5, 135.0, 134.7, 134.6, 134.3, 131.6, 131.3, 131.2, 131.0, 130.3, 129.9, 129.8, 128.7, 128.3, 128.2, 128.0, 127.6, 127.5, 127.3, 124.1, 121.9, 97.2 (br, COD), 68.0 (br, COD), 32.2, 28.5, 21.2, 21.14, 21.08, 21.06, 21.02. MALDI-TOF-MS *m/z* = 2992 $[M\text{-}Cl]^+$. Anal. Calcd. For $C_{223}H_{184}N_2ClRh$: C, 88.39; H, 6.12; N, 0.92. Found C, 88.59; H, 6.29; N, 1.01.

General procedure for the hydrosilylation (entry 1 in Table 1): A mixture of **5a** (0.01 mmol, 12 mg), CH_2Cl_2 (1 cm^3), 2-cyclohexen-1-one (1 mmol, 9.7×10^{-2} dm^3), and bibenzyl (0.25 mmol, 45.6 mg) as an internal standard was placed in a 10-cm^3 Schlenk tube under an Ar atmosphere and the

resulting solution was stirred for 5 min. Then, Ph_2SiH_2 (1.2 mmol, 0.22 dm^3) was added via a syringe and the reaction mixture was stirred at room temperature for 24 h. After removal of volatiles under vacuum at –30 ºC, a residue was dissolved in Et_2O (1 cm^3). The solution was further stirred for 1 h with K_2CO_3 (1 mg) and MeOH (1 cm^3). Total yield (77%) and a ratio (91/9) of cyclohexanone and 2-cyclohexen-1-ol were determined by a GC (Shimadzu CPB10 column, 25 m length, 0.25 mm i.d.).

X-ray Diffraction Study. Single crystals of **5a**·C_5H_{12} suitable for X-ray diffraction study were obtained by diffusion of *n*-pentane into **5a** in CH_2Cl_2. Data were collected on a Rigaku/Saturn70 CCD diffractometer using graphite-monochromated Mo Kα radiation (λ = 0.71070 Å) at 113 K, and processed using CrystalClear (Rigaku). The structures were solved by a direct method (SIR92) and refined by full-matrix least-square refinement on F^2. The non-hydrogen atoms except for solvated molecules were refined anisotropically. All hydrogen atoms were located on the calculated positions and not refined. All calculations were performed using the CrystalStructure software package. Crystal data for **5a**·C_5H_{12}: $C_{88}H_{76}ClN_2Rh$, M = 1299.9, T = 113 K, triclinic, space group $P\bar{1}$ (No. 2), a = 14.85(2), b = 20.51(2), c = 25.04(2) Å, α = 79.38(7), β = 71.05(9), γ = 81.10(10) °, U = 7054(1) $Å^3$, Z = 4, μ(Mo Kα) = 3.30 cm^{-1}, Unique reflections 31888, Observed reflections 16076 (I>3σ(I)), R1, wR2 = 0.056, 0.164, GOF = 1.01. CCDC Number 617650.

Calculation

An optimized structure of **5b** was obtained by ONIOM[6] calculations. In the ONIOM calculation, the molecular system of **5b** was divided into two layers. The high layer was assigned to **5b** with R = C_6H_4 for B3LYP[7]/LANL2DZ[8] calculation. The low layer contains the rest dendritic frameworks of **5b** for molecular mechanics calculation using UFF force field was carried out on the layer.[9] All calculations were performed with the Gaussian 03 program[10] on a HIT HPC-IA642/SS 1.3/3D-4G.

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