**A Regio- and Stereoselective Route to Tetrasubstituted Olefins by
the Palladium-Catalyzed Three-Component-Coupling of Aryl
Iodides, Internal Alkynes and Arylboronic Acids**

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General

The ^1H and ^{13}C NMR spectra were recorded at 300 MHz or 400 MHz and 75 MHz or 100 MHz, respectively. The COESY and NOESY NMR spectra were recorded at 400 MHz. Thin layer chromatography was performed using commercially prepared 60-mesh silica gel plates, and visualization was effected with short wavelength UV light (254 nm). Low resolution mass spectra were recorded on a Finnigan TSQ700 triple quadrupole mass spectrometer. High resolution mass spectra were recorded on a Kratos MS50TC double focusing magnetic sector mass spectrometer using EI at 70 eV. All reagents were used as obtained commercially. Distilled water was used as the source of water in this chemistry. Anhydrous forms of K_2CO_3 , KHCO_3 , DMF, ethyl ether, hexanes, and ethyl acetate were purchased from Fisher Scientific Co. All palladium salts were donated by Johnson Matthey Inc. and Kawaken Fine Chemicals Co., Ltd. All arylboronic acids, except for 4-[2-(dimethylamino)ethoxy]phenylboronic acid (**34**), were donated by Frontier Scientific Co., Ltd. The product characterization data, ^1H and ^{13}C NMR spectra for compounds **1a**, **1b**, **5a+5b**, **6a+6b**, **15**, **16**, **20**, **24a**, **25a**, **25b** and **26a**, and H-H COESY/NOESY spectra for compounds **1a**, **24a**, **25a** and **26a** can be found in the "Supporting Information" from our previous communication.¹

General procedure for the synthesis of tetrasubstituted olefins at 100 °C (Tables 2-5)

For this experimental procedure, see the text.

General procedure for the synthesis of tetrasubstituted olefins at room temperature (Table 6).

For this experimental procedure, see the text.

Synthesis of 4-[2-(dimethylamino)ethoxy]phenylboronic acid (**34**) (eq. 11).

To a solution of *N,N*-dimethyl-2-(*p*-bromophenoxy)ethylamine (7.2 g, 30 mmol, 0.5M in dry THF) were added Mg ribbon (1.1 g, 45 mmol, cut in pieces). The contents were stirred and refluxed for 1 h. The resulted Grignard reagent was cooled to -78 °C and $\text{B}(\text{OMe})_3$ (4 mL, 36 mmol) was slowly added. The reaction mixture was stirred at a temperature between -60 to -78 °C for 2 h, and then warmed to room temperature. The resulting reaction mixture was quenched by adding 100 mL of 1N HCl solution and then washed with 50 mL of ethyl ether (Note: the arylboronic acid is in the aqueous layer as an ammonium salt). Triethylamine (10 mL each time) was added to the aqueous layer and the resulting mixture was extracted with ethyl ether (50 mL each time). This was repeated 3 times (Note: the arylboronic acid is now in the organic phase as the free amine). The combined organic layers were dried over anhydrous MgSO_4 and the solvents were evaporated under reduced pressure. The crude product was solidified by washing with a small amount (3 to 5 mL) of acetone. The final product was collected as a white solid in 70 % yield (4.2 g).

General procedure for the synthesis of tamoxifen and derivatives (eqs. 12 and 13).

For this experimental procedure, see the text.

Characterization data:

1,1,2-Triphenyl-1-hexene (3). White solid: mp 85-87 °C (lit.² mp 87-88 °C); ¹H NMR (300 MHz, CDCl₃) δ 0.81 (t, *J* = 7.2 Hz, 3H), 1.23-1.35 (m, 4H), 2.47 (q, *J* = 7.5 Hz, 2H), 6.90-7.04 (m, 5H), 7.12-7.18 (m, 5H), 7.26-7.40 (m, 5H); ¹³C NMR (75 MHz, CDCl₃) δ 14.15, 23.05, 31.37, 35.89, 125.94, 126.35, 126.81, 127.59, 128.04, 128.35, 129.77, 129.84, 130.99, 139.27, 141.36, 142.77, 143.31, 143.76; IR (CDCl₃, cm⁻¹) 3057, 3022, 2958, 2927, 2860, 1598, 1491; MS (EI) *m/z* (rel intensity) 312 (M⁺, 61), 269 (60), 191 (100); HRMS (EI) calcd for C₂₄H₂₄ 312.1878, found: 312.1885.

2,3,3-Triphenyl-2-propen-1-ol (7). White solid: mp 129-131 °C (lit.³ mp 133.5-134 °C); ¹H NMR (300 MHz, CDCl₃) δ 1.80 (s, 1H), 4.49 (s, 2H), 6.95-6.96 (m, 2H), 7.06-7.08 (m, 3H), 7.21-7.25 (m, 5H), 7.36-7.39 (m, 5H); ¹³C NMR (75 MHz, CDCl₃) δ 65.33, 126.76, 127.14, 127.59, 127.82, 128.51, 128.54, 129.94, 130.19, 130.92, 138.70, 140.50, 142.41, 142.44, 143.08; IR (CDCl₃, cm⁻¹) 3602, 3060, 3026, 2955, 1578, 1491; MS (EI) *m/z* (rel intensity) 286 (M⁺, 22), 268 (16), 178 (47), 167 (100); HRMS (EI) calcd for C₂₁H₁₈O 286.1358, found: 286.1361.

Ethyl (*E*)-2,3-diphenyl-2-buten-1-olate (8).⁴ Colorless liquid: ¹H NMR (300 MHz, CDCl₃) δ 1.30 (t, *J* = 7.2 Hz, 3H), 2.35 (s, 3H), 4.28 (q, *J* = 7.2 Hz, 2H), 7.00-7.06 (m, 4H), 7.09-7.16 (m, 6H); ¹³C NMR (75 MHz, CDCl₃) δ 14.46, 23.32, 61.14, 127.01, 127.25, 127.99, 128.14, 128.75, 130.07, 132.31, 137.36, 142.09, 143.51, 169.86; IR (CDCl₃, cm⁻¹) 3060, 3022, 2983, 1709, 1490, 1444; MS (EI) *m/z* (rel intensity) 266 (M⁺, 31), 220 (48), 191 (82), 178 (48), 115 (100); HRMS (EI) calcd for C₁₈H₁₈O₂ 266.1307, found: 266.1311.

2,3,3-Triphenylpropenal (9). White solid: mp 176-178 °C (lit.⁵ mp 177-178 °C); ¹H NMR (300 MHz, CDCl₃) δ 6.98-7.01 (m, 2H), 7.08-7.24 (m, 8H), 7.32-7.34 (m, 2H), 7.43-7.46 (m, 3H), 9.75 (s, 1H); ¹³C NMR (75 MHz, CDCl₃) δ 127.71, 128.07, 128.30, 128.51, 128.95, 129.91, 131.31, 131.52, 131.89, 136.35, 139.31, 140.23, 141.06, 160.86, 193.83; IR (CDCl₃, cm⁻¹) 3060, 3025, 1664, 1492; MS (EI) m/z (rel intensity) 284 (M⁺, 43), 283 (27), 178 (100); HRMS (EI) calcd for C₂₁H₁₆O 284.1201, found: 284.1208.

Diethyl (Z)-2,3-diphenylmaleate (10).⁶ Colorless liquid: ¹H NMR (400 MHz, CDCl₃) δ 1.30 (t, *J* = 7.2 Hz, 6H), 4.30 (q, *J* = 7.2 Hz, 4H), 7.08-7.20 (m, 10H); ¹³C NMR (100 MHz, CDCl₃) δ 14.29, 61.96, 128.30, 128.43, 129.96, 134.83, 138.85, 168.20; IR (CDCl₃, cm⁻¹) 3058, 2983, 1716, 1492, 1444; MS (EI) m/z (rel intensity) 324 (M⁺, 35), 251 (45), 178 (100); HRMS (EI) calcd for C₂₀H₂₀O₄ 324.1362, found: 324.1369.

(Z)-4,5-Diphenyl-4-octene (11). White solid: mp 40-42 °C (lit.⁷ mp 42-43 °C); ¹H NMR (300 MHz, CDCl₃) δ 0.91 (t, *J* = 7.2 Hz, 6H), 1.30-1.38 (m, 4H), 2.53 (t, *J* = 7.5 Hz, 4H), 6.91-7.08 (m, 10H); ¹³C NMR (75 MHz, CDCl₃) δ 14.20, 21.77, 36.50, 125.59, 127.53, 130.00, 138.53, 143.71; IR (CDCl₃, cm⁻¹) 2958, 2868, 1491, 1468; MS (EI) m/z (rel intensity) 264 (M⁺, 79), 221 (35), 178 (37), 91 (100); HRMS (EI) calcd for C₂₀H₂₄ 264.1878, found: 264.1882.

(Z,Z)-4,7-Diphenyl-5,6-dipropyl-4,6-decadiene (12). White solid: mp 82-84 °C; ¹H NMR (300 MHz, CDCl₃) δ 0.75-0.85 (m, 12H), 1.14-1.23 (m, 8H), 1.61-1.63 (m, 2H), 2.01-2.07 (m, 2H), 2.20-2.28 (m, 4H), 7.08-7.23 (m, 10H); ¹³C NMR (75 MHz, CDCl₃) δ 14.36, 15.06, 21.66, 22.92, 36.25, 36.64, 125.85, 127.57, 128.87, 136.89, 139.43, 144.12; IR (CDCl₃, cm⁻¹) 2960, 2870, 1493, 1465; MS (EI) m/z (rel intensity) 374 (M⁺, 23), 331 (86), 289 (70), 247 (47), 91 (100); HRMS (EI) calcd for C₂₈H₃₈ 374.2974,

found: 374.2980. Anal. Calcd for $C_{28}H_{38}$: C, 89.78; H, 10.22. Found: C, 89.76; H, 10.18.

4-(Triphenylethenyl)phenol (19). White solid: mp 215-217 °C (decompose); 1H NMR (300 MHz, $CDCl_3$) δ 4.72 (s, 1H), 6.56 (d, J = 8.7 Hz, 2H), 6.90 (d, J = 8.7 Hz, 2H), 7.00-7.18 (m, 15H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 114.83, 126.51, 126.62, 127.85, 127.95, 131.57, 131.58, 131.61, 132.98, 136.61, 140.42, 140.66, 144.12, 144.13, 144.23, 154.23 (2 C are missing due to overlap); IR ($CDCl_3$, cm^{-1}) 3597, 3056, 3027, 2928, 1508, 1490, 1442; MS (EI) m/z (rel intensity) 348 (M^+ , 68), 252 (40), 170 (100; HRMS (EI) calcd for $C_{26}H_{20}O$ 348.1514, found: 348.1521. Anal. Calcd for $C_{26}H_{20}O$: C, 89.62; H, 5.78. Found: C, 89.78; H, 5.75.

1-[4-(Triphenylethenyl)phenyl]ethanone (21). Light yellow solid: mp 106-108 °C (lit.⁸ mp 111 °C); 1H NMR (400 MHz, $CDCl_3$) δ 2.53 (s, 3H), 7.01-7.05 (m, 6H), 7.10-7.16 (m, 11H), 7.70 (d, J = 8.4 Hz, 2H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 26.84, 127.00, 127.02, 127.16, 127.95, 128.04, 128.10, 128.12, 131.49, 131.51, 131.73, 135.13, 140.07, 142.80, 143.29, 143.35, 143.42, 149.28, 198.02; IR ($CDCl_3$, cm^{-1}) 3060, 3023, 1678, 1600, 1492, 1444; MS (EI) m/z (rel intensity) 374 (M^+ , 59), 359 (11), 252 (100); HRMS (EI) calcd for $C_{28}H_{22}O$ 374.1671, found: 374.1680.

1-(4-Nitrophenyl)-1,2,2-triphenylethene (22). Yellow solid: mp 75-78 °C; 1H NMR (400 MHz, $CDCl_3$) δ 7.03-7.07 (m, 6H), 7.13-7.22 (m, 11H), 7.97 (d, J = 8.4 Hz, 2H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 123.29, 127.35, 127.37, 127.61, 128.06, 128.35, 128.36, 131.44, 131.50, 131.51, 132.34, 139.06, 142.77, 142.91, 142.97, 144.11, 146.19, 151.29; IR ($CDCl_3$, cm^{-1}) 3056, 3023, 1598; MS (EI) m/z (rel intensity) 377 (M^+ , 32), 252 (66), 165 (100); HRMS (EI) calcd for $C_{26}H_{19}NO_2$ 377.1416, found: 377.1422.

4-(Triphenylethenyl)phenyl tetrahydropyranyl ether (23). Colorless liquid: ^1H NMR (400 MHz, CDCl_3) δ 1.62-1.71 (m, 3H), 1.81-1.87 (m, 2H), 1.96-2.05 (m, 1H), 3.56-3.63 (m, 1H), 3.88-3.98 (m, 1H), 5.33-5.36 (m, 1H), 6.81 (dd, $J = 9.2, 2.8$ Hz, 2H), 6.95 (dd, $J = 8.8, 2.8$ Hz, 2H), 7.02-7.14 (m, 15H); ^{13}C NMR (100 MHz, CDCl_3) δ 19.23, 25.45, 30.68, 62.51, 96.68, 115.76, 126.47, 126.50, 126.58, 127.83, 127.84, 127.96, 131.60, 131.63, 131.67, 132.70, 137.20, 140.40, 140.83, 144.22, 144.24, 144.26, 155.91; IR (CDCl_3 , cm^{-1}) 3058, 3026, 1491; MS (EI) m/z (rel intensity) 432 (M^+ , 11), 348 (100), 253 (20); HRMS (EI) calcd for $\text{C}_{31}\text{H}_{28}\text{O}_2$ 432.2089, found: 432.2099.

Methyl (Z)-4-(2-phenyl-1-propyl-1-pentenyl)benzoate (29). Colorless liquid: ^1H NMR (400 MHz, CDCl_3) δ 0.88-0.93 (m, 6H), 1.30-1.35 (m, 4H), 2.51-2.57 (m, 4H), 3.83 (s, 3H), 6.89-6.92 (m, 2H), 6.99-7.06 (m, 5H), 7.73 (d, $J = 8.4$ Hz, 2H); ^{13}C NMR (100 MHz, CDCl_3) δ 14.16, 14.21, 21.71, 21.78, 36.20, 36.60, 52.11, 126.00, 127.32, 127.74, 128.99, 129.88, 130.03, 137.75, 139.87, 143.10, 149.04, 167.36; IR (CDCl_3 , cm^{-1}) 3026, 2960, 2931, 2871, 1714, 1606, 1491, 1456; MS (EI) m/z (rel intensity) 322 (M^+ , 54), 293 (36), 279 (21), 205 (40), 191 (48), 91 (100); HRMS (EI) calcd for $\text{C}_{22}\text{H}_{26}\text{O}_2$ 322.1933, found: 322.1941.

Methyl (Z,Z)-4-[(4-phenyl-1,2,3-tripropyl)hepta-1,3-dienyl]benzoate (30). Colorless liquid: ^1H NMR (400 MHz, CDCl_3) δ 0.75-0.80 (m, 6H), 0.85-0.89 (m, 6H), 1.09-1.18 (m, 4H), 1.35-1.46 (m, 4H), 1.69-1.75 (m, 2H), 2.08-2.23 (m, 6H), 3.91 (s, 3H), 6.94-6.97 (m, 2H), 7.04-7.07 (m, 2H), 7.12-7.17 (m, 3H), 7.83 (d, $J = 8.4$ Hz, 2H); ^{13}C NMR (100 MHz, CDCl_3) δ 14.30, 14.40, 15.10, 15.12, 21.69, 21.71, 23.01, 23.08, 35.90, 36.20, 36.73, 36.80, 52.18, 117.65, 125.93, 127.40, 127.59, 128.78, 128.89, 136.25, 137.71, 138.68, 140.79, 143.71, 149.31, 167.56; IR (CDCl_3 , cm^{-1}) 3026, 2962, 2869, 1715, 1492, 1442; MS (EI) m/z (rel intensity) 432 (M^+ , 14), 389 (81), 346 (30), 91 (100); HRMS (EI) calcd for $\text{C}_{30}\text{H}_{40}\text{O}_2$ 432.3028, found: 432.3038.

(Z)-4,4-Dimethyl-2-(4-methylphenyl)-3-phenyl-2-pentene (31). Colorless liquid: ^1H NMR (400 MHz, CDCl_3) δ 0.86 (s, 9H), 1.53 (s, 3H), 2.36 (s, 3H), 7.12-7.15 (m, 6H), 7.24-7.35 (m, 3H); ^{13}C NMR (100 MHz, CDCl_3) δ 21.40, 27.71, 32.52, 36.74, 125.83, 127.90, 128.51, 128.73, 129.60, 133.81, 135.56, 143.72, 144.71, 145.48; IR (CDCl_3 , cm^{-1}) 3022, 2958, 2870, 1491; MS (EI) m/z (rel intensity) 264 (M^+ , 55), 249 (54), 171 (49), 157 (69), 115 (100), 91 (88); HRMS (EI) calcd for $\text{C}_{20}\text{H}_{24}$ 264.1878, found: 264.1884.

(Z)-1-(4-Methoxyphenyl)-1-(4-nitrophenyl)-2-phenyl-1-butene (32). Yellow solid: mp 79-82 $^{\circ}\text{C}$; ^1H NMR (400 MHz, CDCl_3) δ 0.96 (t, $J = 7.6$ Hz, 3H), 2.46 (q, $J = 7.6$ Hz, 2H), 3.69 (s, 3H), 6.58 (d, $J = 8.8$ Hz, 2H), 6.75 (d, $J = 8.8$ Hz, 2H), 7.12-7.21 (m, 5H), 7.42 (d, $J = 8.8$ Hz, 2H), 8.22 (d, $J = 8.8$ Hz, 2H); ^{13}C NMR (100 MHz, CDCl_3) δ 13.79, 29.31, 55.30, 113.35, 123.78, 126.84, 128.30, 129.72, 130.64, 132.15, 134.36, 136.64, 141.65, 143.71, 146.73, 151.11, 158.16; IR (CDCl_3 , cm^{-1}) 3058, 2967, 2935, 2838, 1604, 1511, 1463; MS (EI) m/z (rel intensity) 359 (M^+ , 21), 344 (10), 214 (100), 199 (71); HRMS (EI) calcd for $\text{C}_{23}\text{H}_{21}\text{NO}_3$ 359.1521, found: 359.1531.

(Z)-1-(4-Nitrophenyl)-2-phenyl-1-(4-tetrahydropyranyl-2-oxyphenyl)-1-butene (33). Yellow liquid: ^1H NMR (300 MHz, CDCl_3) δ 0.98 (t, $J = 7.2$ Hz, 3H), 1.50-2.18 (m, 6H), 2.46 (q, $J = 7.2$ Hz, 2H), 3.52-3.58 (m, 1H), 3.81-3.89 (m, 1H), 5.25-5.29 (m, 1H), 6.69-6.76 (m, 4H), 7.11-7.25 (m, 5H), 7.40 (d, $J = 8.8$ Hz, 2H), 8.22 (d, $J = 8.8$ Hz, 2H); ^{13}C NMR (75 MHz, CDCl_3) δ 13.74, 19.13, 25.38, 29.29, 30.59, 62.44, 96.58, 115.81, 123.75, 126.84, 128.29, 129.72, 130.67, 132.05, 135.19, 136.72, 141.61, 143.75, 146.74, 151.08, 155.76; IR (CDCl_3 , cm^{-1}) 3059, 2968, 2840, 1511; MS (EI) m/z (rel intensity) 429 (M^+ , 10), 344 (10), 214 (100), 199 (71); HRMS (EI) calcd for $\text{C}_{27}\text{H}_{27}\text{NO}_4$ 429.1940, found: 429.1948.

Tamoxifen (35). White solid: mp 95-97 °C (lit.^{9a} 96-98 °C); ¹H NMR (300 MHz, CDCl₃) δ 0.94 (t, *J* = 7.5 Hz, 3H), 2.29 (s, 6H), 2.46 (q, *J* = 7.5 Hz, 2H), 2.66 (t, *J* = 6.0 Hz, 2H), 3.94 (t, *J* = 6.0 Hz, 2H), 6.60 (d, *J* = 9.0 Hz, 2H), 6.80 (d, *J* = 8.7 Hz, 2H), 7.11-7.36 (m, 10H); ¹³C NMR (75 MHz, CDCl₃) δ 13.86, 29.25, 46.18, 58.57, 65.95, 113.63, 126.24, 126.75, 128.11, 128.34, 129.71, 129.94, 132.07, 135.75, 138.50, 141.53, 142.66, 144.07, 157.04; IR (CDCl₃, cm⁻¹) 3029, 2965, 2826, 1508; MS (EI) *m/z* (rel intensity) 371 (*M*⁺, 36), 252 (68), 58 (100); HRMS (EI) calcd for C₂₆H₂₉NO 371.2249, found: 371.2255.

(Z)-N,N-Dimethyl-2-[4-[2-(4-methylphenyl)-1-phenyl-1-butenyl]phenoxy]ethanamine (36). Colorless liquid: ¹H NMR (400 MHz, CDCl₃) δ 0.94 (t, *J* = 7.2 Hz, 3H), 2.30 (s, 3H), 2.31 (s, 6H), 2.46 (q, *J* = 7.2 Hz, 2H), 2.68 (t, *J* = 6.0 Hz, 2H), 3.96 (t, *J* = 6.0 Hz, 2H), 6.60 (d, *J* = 8.8 Hz, 2H), 6.80 (d, *J* = 8.8 Hz, 2H), 6.95-7.05 (m, 4H), 7.23-7.27 (m, 3H), 7.32-7.36 (m, 2H); ¹³C NMR (100 MHz, CDCl₃) δ 13.95, 21.43, 29.23, 46.22, 58.61, 65.97, 113.63, 126.67, 128.31, 128.85, 129.73, 129.79, 132.06, 135.71, 135.98, 138.15, 139.51, 141.43, 144.25, 156.95; IR (CDCl₃, cm⁻¹) 3020, 2955, 2829, 1509; MS (EI) *m/z* (rel intensity) 385 (*M*⁺, 61), 348 (100), 252 (82); HRMS (EI) calcd for C₂₇H₃₁NO 385.2406, found: 385.2414. Anal. Calcd for C₂₇H₃₁NO: C, 84.11; H, 8.10; N, 3.63. Found: C, 84.30; H, 8.05, N, 3.60.

(Z)-N,N-Dimethyl-2-[4-[2-(4-methoxyphenyl)-1-phenyl-1-butenyl]phenoxy]ethanamine (37). Light yellow liquid: ¹H NMR (300 MHz, CDCl₃) δ 0.94 (t, *J* = 7.5 Hz, 3H), 2.30 (s, 6H), 2.46 (t, *J* = 7.5 Hz, 2H), 2.67 (t, *J* = 5.7 Hz, 2H), 3.77 (s, 3H), 3.97 (t, *J* = 5.7 Hz, 2H), 6.60 (d, *J* = 9.0 Hz, 2H), 6.73 (d, *J* = 9.0 Hz, 2H), 6.80 (d, *J* = 9.0 Hz, 2H), 7.05 (d, *J* = 9.0 Hz, 2H), 7.25-7.35 (m, 5H); ¹³C NMR (75 MHz, CDCl₃) δ 13.92, 29.14,

46.03, 55.32, 58.47, 65.74, 113.53, 113.66, 126.65, 128.32, 129.72, 130.98, 132.11, 134.75, 136.12, 137.98, 141.03, 144.28, 156.80, 158.02; IR (CDCl₃, cm⁻¹) 3022, 2962, 2825, 1508; MS (EI) m/z (rel intensity) 401 (M⁺, 37), 252 (25), 58 (100); HRMS (EI) calcd for C₂₇H₃₁NO₂ 401.2355, found: 401.2365.

1-(4-Methylphenyl)-1-(4-nitrophenyl)-2,2-diphenylethene (38a) and E-1-(4-methylphenyl)-2-(4-nitrophenyl)-1,2-diphenylethene (38b). Yellow oil (mixture); ¹H NMR (300 MHz, CDCl₃) δ 2.29 (2 sets of singlets, 3H), 6.93-7.23 (m, 16H), 7.96 (2 sets of doublets, 2H); ¹³C NMR (75 MHz, CDCl₃) δ 21.49, 21.50, 123.21, 123.25, 127.26, 127.50, 127.55, 128.09, 128.29, 128.34, 128.38, 128.81, 129.09, 129.11, 131.36, 131.41, 131.44, 131.51, 131.55, 131.57, 131.60, 132.38, 137.13, 137.17, 138.59, 139.08, 139.84, 140.05, 143.04, 143.13, 143.17, 143.21, 143.63, 144.15, 146.14, 146.20, 151.53, 151.58 (2 sets of peaks); IR (CDCl₃, cm⁻¹) 3056, 3022, 1599, 1491, 1442; MS (EI) m/z (rel intensity) 391 (M⁺, 66), 252 (100); HRMS (EI) calcd for C₂₇H₂₁NO₂ 391.1572, found: 391.1579.

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