Supporting material for:

Thermal Cyclization of (2-Ethynylphenyl)triazenes: Facile Synthesis of Substituted Cinnolines and Isoindazoles

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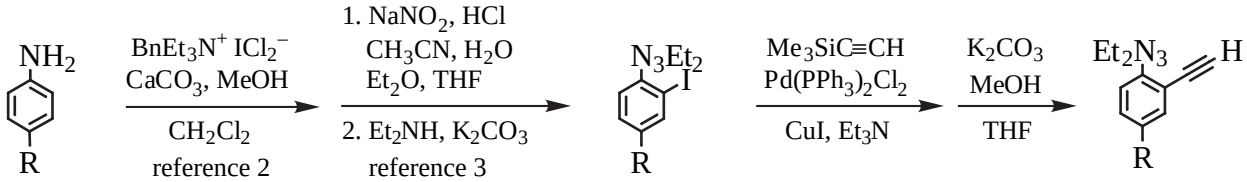
EXPERIMENTAL

General. ^{1}H and ^{13}C NMR spectra were recorded in $CDCl_3$ using a Varian Inova (^{1}H: 299.94 MHz, ^{13}C: 75.43 MHz) spectrometer. Chemical shifts (δ) are expressed in ppm downfield from tetramethylsilane using the residual chloroform as internal standard (^{1}H: 7.26 ppm, ^{13}C: 77.0 ppm). Coupling constants are expressed in hertz. IR spectra were recorded using a Nicolet Magna FTIR 550 spectrometer. MS spectra were recorded using a Kratos MS50 spectrometer. Melting points were determined on a Meltemp II apparatus and are uncorrected. EM Science pre-coated silica gel plates (20x20x0.1cm) were used for preparative thin layer chromatography. Eluting solvents were reagent quality and used as obtained from the manufacturers. *o*-Dichlorobenzene was purchased from Aldrich and distilled over CaH_2 prior to use. The 4-substituted *N,N*-dialkyl-*N'*-(2-ethynylphenyl)triazenes were prepared previously (entries a,c,j)[1] or via literature methods[2,3] from commercially available anilines (Aldrich) as illustrated below:[4]



General Cyclization Conditions. A solution of *N,N*-diethyl-*N'*-(4-substituted-2-ethynylphenyl)triazene in *o*-dichlorobenzene (4 mL, 0.035 M) was heated in a sealed glass pressure tube to 170 °C. After stirring 24 h, the tube was cooled and the solvent was evaporated. Preparative TLC (1:1:4 CH_2Cl_2, EtOAc, hexanes) provided the isoindazole (R_f = 0.50-0.65) and cinnoline (R_f = 0.10-0.20) products, respectively.

Cinnoline (2a): yield 35%, dark oil; ^{1}H NMR ($CDCl_3$) δ 9.33 (d, *J* = 5.9 Hz, 1H), 8.56 (dd, *J* = 8.5, 0.9 Hz, 1H), 7.90-7.84 (m, 3H), 7.80-7.74 (m, 1H); ^{13}C NMR ($CDCl_3$) δ 150.91, 145.05, 131.18, 130.67, 129.93, 126.61, 126.06, 122.54; IR (neat) 3059, 1621, 1580 cm^{-1}; FAB MS *m/z* (%): 131(50) [M^+].

2-Diethylamino-3-formyl-2H-indazole (3a): yield 55%, yellow oil; ^{1}H NMR ($CDCl_3$) δ 10.42 (s, 1H), 8.24-8.21 (m, 1H), 7.79-7.74 (m, 1H), 7.53-7.36 (m, 2H), 3.39 (br s, 4H), 0.89 (t, *J* = 7.2 Hz, 6H); ^{13}C NMR ($CDCl_3$) δ 181.42, 145.84, 132.81, 127.22, 126.40, 121.24, 119.85, 118.24, 52.68, 12.02; IR (neat) 3068, 2976, 2936, 2867, 1669, 1627 cm^{-1}; FAB MS *m/z* (%): 218(100) [M^+].

6-Methylcinnoline (2b): yield 51%, dark oil; ^{1}H NMR ($CDCl_3$) δ 9.23 (d, *J* = 5.9 Hz, 1H), 8.41 (d, *J* = 8.8 Hz, 1H), 7.75 (d, *J* = 5.9 Hz, 1H), 7.67 (dd, *J* = 8.8, 1.7 Hz, 1H), 7.57 (s, 1H), 2.58 (s,

3H); ^{13}C NMR ($CDCl_3$) δ 149.98, 145.04, 141.92, 133.22, 129.51, 126.32, 124.93, 121.99, 22.08; IR (neat) 3053, 2976, 2918, 2856, 1627 cm^{-1}; FAB MS *m/z* (%): 145(100) [M^+].

2-Diethylamino-3-formyl-5-methyl-2H-indazole (3b): yield 20%, tan solid; M.p. 27-28.5 °C; ^{1}H NMR ($CDCl_3$) δ 10.38 (s, 1H), 8.01 (s, 1H), 7.70 (d, *J* = 9.0 Hz, 1H), 7.28-7.26 (m, 1H), 3.43 (br s, 2H), 3.30 (br s, 2H), 2.49 (s, 3H), 0.88 (m, 6H); ^{13}C NMR ($CDCl_3$) δ 181.46, 144.63, 136.67, 132.28, 129.94, 120.24, 119.63, 117.90, 52.64, 21.98, 12.02; IR (KBr) 3061, 3028, 2976, 2935, 2857, 1671, 1631 cm^{-1}; FAB MS *m/z* (%): 232(100) [M^+].

6-*t*-Butylcinnoline (2c): yield 61%, dark oil; ^{1}H NMR ($CDCl_3$) δ 9.25 (d, *J* = 5.8 Hz, 1H), 8.45 (d, *J* = 9.1 Hz, 1H), 7.94 (dd, *J* = 9.1, 2.0 Hz, 1H), 7.82 (d, *J* = 5.8 Hz, 1H), 7.70 (d, *J* = 2.0 Hz, 1H), 1.43 (s, 9H); ^{13}C NMR ($CDCl_3$) δ 154.53, 149.91, 145.10, 130.05, 129.28, 126.13, 122.70, 121.10, 35.48, 30.79; IR (neat) 3062, 2964, 2908, 2871, 1623 cm^{-1}; FAB MS *m/z* (%): 187(100) [M^+].

5-*t*-Butyl-2-diethylamino-3-formyl-2H-indazole (3c): yield 22%, colorless oil that solidifies on standing; M.p. 79-81.5 °C; ^{1}H NMR ($CDCl_3$) δ 10.40 (s, 1H), 8.15 (d, *J* = 1.5 Hz, 1H), 7.74 (d, *J* = 9.1 Hz, 1H), 7.55 (dd, *J* = 9.1, 1.5 Hz, 1H), 3.37 (br s, 4H), 1.40 (s, 9H), 0.88 (t, *J* = 7.2 Hz, 6H); ^{13}C NMR ($CDCl_3$) δ 181.52, 149.77, 144.51, 132.79, 126.76, 119.97, 117.76, 115.71, 52.64, 35.27, 31.22, 12.02; IR (neat) 3071, 3034, 2966, 2937, 2906, 2876, 1669 cm^{-1}; FAB MS *m/z* (%): 274(100) [M^+].

6-Ethynylcinnoline (2d): yield 39%, tan solid; M.p. 145-146 °C; ^{1}H NMR ($CDCl_3$) δ 9.34 (d, *J* = 5.6 Hz, 1H), 8.50 (d, *J* = 8.9 Hz, 1H), 7.99 (d, *J* = 1.7 Hz, 1H), 7.87 (dd, *J* = 8.9, 1.7 Hz, 1H), 7.81 (d, *J* = 5.6 Hz, 1H), 3.34 (s, 1H); ^{13}C NMR ($CDCl_3$) δ 149.82, 145.66, 133.36, 130.68, 130.05, 125.65, 125.27, 121.94, 82.30, 81.17; IR (KBr) 3453, 3152, 3040, 2964, 2924, 2851, 2095, 1618 cm^{-1}; FAB MS *m/z* (%): 155(90) [M^+].

2-Diethylamino-5-ethynyl-3-formyl-2H-indazole (3d): yield 36%, orange solid; M.p. 97-98.2 °C; ^{1}H NMR ($CDCl_3$) δ 10.39 (s, 1H), 8.42 (s, 1H), 7.73 (d, *J* = 8.8 Hz, 1H), 7.48 (d, *J* = 8.8 Hz, 1H), 3.36 (br s, 4H), 3.15 (s, 1H), 0.89 (t, *J* = 7.0 Hz, 6H); ^{13}C NMR ($CDCl_3$) δ 181.17, 145.13, 132.85, 130.47, 125.94, 120.12, 119.40, 118.38, 83.82, 77.89, 52.69, 12.00; IR (KBr) 3253, 3074, 2983, 2938, 2855, 2103, 1672, 1620 cm^{-1}; FAB MS *m/z* (%): 242(100) [M^+].

6-Bromocinnoline (2e): yield 70%, yellow solid; M.p. 127-128.1 °C; ^{1}H NMR ($CDCl_3$) δ 9.31 (d, *J* = 6.1 Hz, 1H), 8.40 (d, *J* = 9.1 Hz, 1H), 8.02 (d, *J* = 2.1 Hz, 1H), 7.90 (dd, *J* = 9.1, 2.1 Hz, 1H), 7.77 (d, *J* = 6.1 Hz, 1H); ^{13}C NMR ($CDCl_3$) δ 149.33, 145.51, 134.49, 131.60, 128.71, 126.95, 126.13, 121.25; IR (KBr) 3071, 3057, 3028, 2925, 2852, 1606 cm^{-1}; FAB MS *m/z* (%): 209(66) [M^+].

5-Bromo-2-diethylamino-3-formyl-2H-indazole (3e): yield 15%, tan oil; ^{1}H NMR ($CDCl_3$) δ 10.37 (s, 1H), 8.42 (d, *J* = 1.9 Hz, 1H), 7.68 (d, *J* = 9.2 Hz, 1H), 7.51 (dd, *J* = 9.2, 1.9 Hz, 1H), 3.39 (br s, 4H), 0.88 (t, *J* = 7.5 Hz, 6H); ^{13}C NMR ($CDCl_3$) δ 181.09, 144.27, 132.30, 131.08,

123.62, 120.89, 120.55, 119.88, 52.72, 11.99 cm^{-1}; IR (neat) 3073, 2976, 2934, 2855, 1667, 1620; FAB MS *m/z* (%): 296(33) [M^+].

6-Chlorocinnoline (2f): yield 58%, yellow solid; M.p. 123.8-124.9 °C; ^1H NMR ($CDCl_3$) δ 9.30 (d, *J* = 6.2 Hz, 1H), 8.47 (dd, *J* = 9.1, 0.6 Hz, 1H), 7.82 (d, *J* = 2.1 Hz, 1H), 7.77 (d, *J* = 6.2 Hz, 1H), 7.76 (dd, *J* = 9.1, 2.1 Hz, 1H); ^{13}C NMR ($CDCl_3$) δ 149.16, 145.50, 137.45, 131.97, 131.66, 126.59, 125.21, 121.44; IR (KBr) 3061, 3034 cm^{-1}; FAB MS *m/z* (%): 165(100) [M^+].

5-Chloro-2-diethylamino-3-formyl-2H-indazole (3f): yield 14%, tan oil that solidifies slowly on standing; M.p. 92-93.5 °C; ^1H NMR ($CDCl_3$) δ 10.37 (s, 1H), 8.23 (d, *J* = 2.1 Hz, 1H), 7.73 (d, *J* = 9.2 Hz, 1H), 7.37 (dd, *J* = 9.2, 2.1 Hz, 1H), 3.39 (br s, 4H), 0.88 (t, *J* = 7.2 Hz, 6H); ^{13}C NMR ($CDCl_3$) δ 181.10, 144.15, 132.53, 128.72, 120.27, 119.73, 52.72, 12.00; IR (neat) 3086, 2975, 2934, 2846, 2803, 1671, 1624 cm^{-1}; FAB MS *m/z* (%): 252(100) [M^+].

6-Fluorocinnoline (2g): yield 35%, dark semi-solid oil; ^1H NMR ($CDCl_3$) δ 9.29 (d, *J* = 5.9 Hz, 1H), 8.59 (dd, *J* = 9.4, 5.3 Hz, 1H), 7.84 (d, *J* = 5.9 Hz, 1H), 7.64 (td, *J* = 8.6, 2.7 Hz, 1H), 7.44 (dd, *J* = 8.3, 2.6 Hz, 1H); ^{13}C NMR ($CDCl_3$) δ 162.90 (d, *J* = 255.5 Hz), 148.59, 145.16, 133.41 (d, *J* = 9.3 Hz), 122.11 (d, *J* = 5.6 Hz), 121.89 (d, *J* = 26.8 Hz), 109.31 (d, *J* = 22.2 Hz); IR (neat) 3044, 2975, 2928, 2855, 1626 cm^{-1}.

2-Diethylamino-5-fluoro-3-formyl-2H-indazole (3g): yield 25%, green oil; ^1H NMR ($CDCl_3$) δ 10.37 (s, 1H), 7.84-7.76 (m, 2H), 7.25-7.18 (m, 1H), 3.42 (br s, 4H), 0.89 (t, *J* = 6.9 Hz, 6H); IR (neat) 3083, 2976, 2928, 2856, 1734, 1670, 1633, 1524, 1459 cm^{-1}.

6-Carbomethoxycinnoline (2h): yield 28%, dark solid; M.p. 130.4-131.2 °C; ^1H NMR ($CDCl_3$) δ 9.41 (d, *J* = 5.9 Hz, 1H), 8.60 (d, *J* = 2.0 Hz, 1H), 8.59 (d, *J* = 9.1 Hz, 1H), 8.40 (dd, *J* = 9.1, 2.0 Hz, 1H), 7.96 (d, *J* = 5.9 Hz, 1H), 4.01 (s, 3H); ^{13}C NMR ($CDCl_3$) δ 165.64, 151.29, 145.73, 132.16, 130.32, 129.99, 129.94, 125.15, 123.41, 52.84; IR (KBr) 3063, 2957, 2926, 2852, 1716 cm^{-1}; FAB MS *m/z* (%): 189(100) [M^+].

5-Carbomethoxy-2-diethylamino-3-formyl-2H-indazole (3h): yield 63%, yellow solid; M.p. 90-90.8 °C; ^1H NMR ($CDCl_3$) δ 10.43 (s, 1H), 8.98-8.97 (m, 1H), 8.05 (dd, *J* = 9.1, 1.5 Hz, 1H), 7.80 (dd, *J* = 9.1, 0.9 Hz, 1H), 3.95 (s, 3H), 3.39 (br s, 4H), 0.89 (t, *J* = 7.2 Hz, 6H); ^{13}C NMR ($CDCl_3$) δ 181.17, 166.94, 147.22, 134.16, 128.05, 127.28, 125.07, 118.99, 118.20, 52.72, 52.25, 12.00; IR (KBr) 3067, 3036, 2974, 2944, 2868, 1719, 1665, 1629 cm^{-1}; FAB MS *m/z* (%): 276(100) [M^+], 244(12) [$M^+ - CH_3O$].

6-Cyanocinnoline (2i): yield 45%, light orange oil that slowly solidifies on standing; M.p. 129-131 °C; ^1H NMR ($CDCl_3$) δ 9.50 (d, *J* = 5.9 Hz, 1H), 8.70 (d, *J* = 8.8 Hz, 1H), 8.30 (d, *J* = 1.7 Hz, 1H), 7.99 (dd, *J* = 8.8, 1.7 Hz, 1H), 7.94 (dd, *J* = 5.9, 0.7 Hz, 1H); ^{13}C NMR ($CDCl_3$) δ 149.98, 146.29, 133.52, 131.70, 130.95, 125.05, 122.20, 117.40, 115.11; IR (neat) 3449, 3070, 3040, 2224 cm^{-1}; FAB MS *m/z* (%): 156(13) [M^+].

5-Cyano-2-diethylamino-3-formyl-2H-indazole (3i): yield 50%, tan solid; M.p. 165.8-167.2 °C; ^{1}H NMR ($CDCl_3$) δ 10.41 (s, 1H), 8.66 (m, 1H), 7.88 (dd, *J* = 8.7, 0.9 Hz, 1H), 7.56 (dd, *J* = 8.7, 1.5 Hz, 1H), 3.40 (br s, 4H), 0.90 (t, *J* = 7.2 Hz, 6H); ^{13}C NMR ($CDCl_3$) δ 180.99, 146.03, 133.62, 128.67, 128.22, 119.70, 118.75, 109.68, 52.81, 11.98; IR (KBr) 3077, 3026, 2975, 2924, 2878, 2853, 2227, 1670, 1627 cm^{-1}; FAB MS *m/z* (%): 243 (100) [M^+].

6-Nitrocinnoline (2j): yield 25%, tan powder; M.p. 174-175 °C; ^{1}H NMR ($CDCl_3$) δ 9.54 (d, *J* = 6.0 Hz, 1H), 8.84 (d, *J* = 2.3 Hz, 1H), 8.77 (d, *J* = 9.3 Hz, 1H), 8.60 (dd, *J* = 9.3, 2.3 Hz, 1H), 8.09 (d, *J* = 6.0 Hz, 1H); IR (KBr) 3439, 3101, 3034, 1627, 1526, 1481, 1347 cm^{-1}; FAB MS *m/z* (%): 176(100) [M^+].

3-Formyl-5-nitro-2-(*N*,*N*-pentamethyleneamino)-2H-indazole (3j): yield 60%, orange solid; M.p. 172.9-173.7 °C; ^{1}H NMR ($CDCl_3$) δ 10.44 (s, 1H), 9.11 (d, *J* = 1.8 Hz, 1H), 8.19 (dd, *J* = 9.3, 1.8 Hz, 1H), 7.86 (d, *J* = 9.3 Hz, 1H), 3.39 (t, *J* = 5.7 Hz, 4H), 1.95-1.87 (m, 4H), 1.69-1.65 (m, 2H); ^{13}C NMR ($CDCl_3$) δ 180.30, 146.53, 146.00, 131.45, 121.27, 119.44, 119.36, 118.49, 57.50, 25.70, 23.02; IR (KBr) 3099, 3084, 2945, 1668, 1624 cm^{-1}; FAB MS *m/z* (%): 275(65) [M^+].

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4. The spectral data of the intermediate species in the triazene syntheses will be reported in the full paper.