SUPPORTING INFORMATION

An uncatalyzed and solvent-free multicomponent process as a new approach for the synthesis of biphenyl-2-carbonitrile derivatives

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Experimental Section

All chemicals were purchased and used without any further purification. GC-EIMS analyses were carried out with 70 eV electron energy. All ^1H NMR and ^{13}C NMR spectra were recorded at 200 MHz or 400 MHz, and at 50.3 or 100.6 MHz respectively, using a convenient deuterated solvent (reported in the characterization charts) and the residual peak as internal standard, or TMS in the case of CDCl_3 . All melting points are uncorrected. IR spectra were recorded with FT-IR instrument, using CHCl_3 as solvent. Thin Layer Chromatography analyses were performed on silica gel on aluminum plates and UV and/or KMnO_4 were used as revealing systems. Column chromatographies were performed by using silica gel 230-400 mesh and eluting as reported below.

Knoevenagel adduct **3b-3o**¹ and biphenyl **6o**² are known compound.

Knoevenagel adduct **3a**, Diels-Alder cycloadducts **5a-o** and biphenyls **6a-n** are new compounds and their data (^1H NMR, ^{13}C NMR, IR, R_f , m.p., GC/EIMS) are reported below.

The (E)-geometry of adducts **3** was assigned by ^1H NMR chemical shift of the C-2 protons according to reported data.¹ C-2 protons in the (E)-compounds fall in the range 8.45-9.20 ppm, while in the (Z)-compounds the δ value is ca. 8 ppm.

¹ Amantini, D.; Fringuelli, F.; Pizzo, F.; Vaccaro, L.; *Green. Chem.* **2001**, 3, 229-232

² Carini, D. J.; Duncia, J. V.; Aldrich, P. E.; Chiu, A. T.; Johnson, A. L.; Pierce, M. E.; Price, W. A.; Santella, J. B., III; Wells, G. J.; Wexler, R. R.; Wong, P. C.; Yoo, S.-E.; Timmermans, P. B. M. W. M. *J. Med. Chem.* **1991**, 34, 2525

General Procedure for Knoevenagel adduct 3a, 3b. A screw-capped vial equipped with a magnetic stirrer was charged with benzaldehyde **1a-k** (1.0 mmol), nitroacetonitrile **2** (1.5 mmol). The resulting mixture was left under magnetic stirring for 3 hours at 30 °C. The reaction mixture was washed with water and filtered to obtain the desired adduct.

4-[(*E*)-2-cyano-2-nitrovinyl]benzonitrile (3a)

3a

yellow solid, washed with Et₂O, 75% yield; m.p. 119-121°C (MeOH/*n*-Hexane); ¹H NMR (400 MHz, CD₃COCD₃) δ: 8.07 (*d*, *J* = 8.4 Hz, 2H), 8.30 (*d*, *J* = 8.4 Hz, 2H), 9.03 (*s*, 1H); ¹³C NMR (100.6 MHz, CD₃COCD₃) δ: 111.6, 117.8, 118.31, 132.88, 132.98, 134.0, 147.6; FT-IR (CHCl₃, cm⁻¹) ν: 3035, 2236, 1631, 1550, 1329; anal. calcd. for C₁₀H₅N₃O₂: C, 60.31; H, 2.53; N, 21.10; found: C, 60.33; H, 2.50; N, 21.12.

(2*E*)-3-(4-methylphenyl)-2-nitroacrylonitrile (3o)

3o

yellow solid, 90% yield; m.p.: 92-93°C (lit., ¹ m.p.: 92-95°C); Tlc - R_f: 0.26 (8/2 Et_p/AcOEt); ¹H NMR (200 MHz, CDCl₃) δ: 2.49 (*s*, 3H), 7.39 (*d*, *J* = 8.1 Hz, 2H), 7.92 (*d*, *J* = 8.1 Hz, 2H), 8.62 (*s*, 1H); ¹³C NMR (50.3 MHz, CDCl₃) δ: 22.1, 111.2, 122.1, 124.5, 130.7, 132.4, 147.6, 148.5; FT-IR (CHCl₃, cm⁻¹) ν: 3010, 2925, 2857, 2233, 1624, 1603, 1539, 1328; anal. calcd. for C₁₀H₈N₂O₂: C, 63.82; H, 4.28; N, 14.89; found: C, 63.86; H, 4.24; N, 14.91.

General Procedure for multicomponent preparation of Diels-Alder-Adducts 5a-n. A screw-capped vial equipped with a magnetic stirrer was charged with benzaldehyde **1a-k** (1.0 mmol), nitroacetonitrile **2** (1.5 mmol) and diene **3a-c** (2.0 mmol). The resulting mixture was left under magnetic stirring for the time and at temperature reported in table 1 and 2 and in table 3. Cycloadducts **5a-n** were isolated after silica-gel column chromatography of the final mixture.

Rel (1*S*,6*R*)-4-(6-Cyano-3,4-dimethyl-6-nitro-cyclohex-3-enyl)-benzonitrile (5a)

5a

pale yellow, chromatography, eluent: Et_p/EtOAc, 9/1 gradient; 85% yield; m.p. 167-169 °C (AcOEt); Tlc - R_f: 0.35 (8/2 Et_p/AcOEt); ¹H NMR (400 MHz, CDCl₃) δ: 1.74 (*s*, 6H), 2.46 (*dd*, *J* = 5, 18 Hz, 1H), 2.74 (*m*, 1H), 2.85 (*d*, *J* = 16.6 Hz, 1H), 3.25 (*d*, *J* = 16.6 Hz, 1H), 3.72 (*dd*, *J* = 5.5, 11.8 Hz, 1H), 7.50 (*d*, *J* = 8.04 Hz, 2H), 7.63 (*d*, *J* = 8.5 Hz, 2H); ¹³C NMR (100.6 MHz, CDCl₃) δ: 18.3, 36.6, 42.2, 47.2, 89.3, 112.8, 113.2, 118.0, 120.3, 126.3, 128.9, 132.7, 140.8; FT-IR (CHCl₃,

cm⁻¹) ν : 3029, 2920, 2360, 2339, 1567, 1216, 736; anal. calcd. for C₁₆H₁₅N₃O₂: C, 68.31; H, 5.37; N, 14.94; found: C, 68.35; H, 5.41; N, 14.01.

Rel (1S,6R)-3,4-dimethyl-1-nitro-6-phenyl-3-cyclohexene-carbonitrile (5b)

5b

white solid, chromatography, eluent: Etp/ EtOAc, 9/1 gradient; 86%.yield; m.p.: 98-100 °C (Et₂O); Tlc - R_f: 0.49 (8/2 Etp/EtOAc); ¹H NMR (100.6 MHz, CDCl₃) δ : 1.76 (s, 6H), 2.46 (dd, J = 5.6, 18.2 Hz, 1H), 2.80 (*m*, 1H), 2.82 (*d*, J = 16.1 Hz, 1H), 3.28 (*d*, J = 16.1 Hz, 1H), 3.66 (dd, J = 5.6, 11.8 Hz, 1H), 7.3-7.4 (*m*, 5H); ¹³C NMR (100.6 MHz, CDCl₃) δ : 18.40, 18.43, 37.0, 42.5, 47.5, 90.1, 113.7, 120.0, 126.9, 128.0, 128.9, 129.0, 135.5; FT-IR (CHCl₃, cm⁻¹) ν : 3026, 1567, 1219, 1214; GC / EIMS (m/z) : 254 (1), 236 (23), 222 (28), 221 (100), 220 (33), 219 (91), 207 (22), 206 (28), 167 (20), 154 (12), 141 (12), 132 (15), 115 (22), 105 (23), 104 (24), 91 (100), 77 (17), 51 (10); anal. calcd. for C₁₅H₁₆N₂O₂: C, 70.29; H, 6.29; N, 10.93; found: C, 70.27; H, 6.26; N, 10.90.

Rel (1S,6R)-3,4-dimethyl-1-nitro-6-o-toluid-3-cyclohexene-carbonitrile (5c)

5c

pale yellow solid, chromatography, eluent: Etp/ EtOAc, 9/1 gradient; 85% yield; m.p.: 106-108 °C (Et₂O); Tlc - R_f: 0.53 (8/2 Etp/EtOAc); ¹H NMR (400 MHz, CD₃COCD₃) δ : 1.75 (s, 3H), 1.79 (s, 3H), 2.35 (s, 3H), 2.47-2.67 (*m*, 2H), 3.07 (*d*, J = 16.4 Hz, 1H), 3.40 (*d*, J = 16.4 Hz, 1H), 4.17 (dd, J = 6.0, 11.3 Hz, 1H), 7.15-7.30 (*m*, 3H), 7.75 (*d*, J = 7.6 Hz, 1H); ¹³C NMR (100.6 MHz, CD₃COCD₃) δ : 18.4, 18.6, 19.5, 39.0, 43.3, 44.0, 90.2, 115.3, 121.5, 126.3, 127.5, 127.9, 128.9, 132.0, 136.1, 137.8; FT-IR (CHCl₃, cm⁻¹) ν : 3029, 1561, 1355, 1326; GC / EIMS (m/z): 223 (66), 222 (14), 209 (16), 208 (100), 193 (17), 181 (20), 166 (12), 165 (15), 153 (8), 143 (21), 141 (10), 129 (10), 128 (13), 116 (10), 115 (15), 105 (23), 91 (14), 77 (7); anal. calcd. for C₁₆H₁₈N₂O₂: C, 71.09; H, 6.71; N, 10.36; found: C, 71.05; H, 6.69; N, 10.31.

Rel (1S,6R)-6-(2-methoxyphenyl)-3,4-dimethyl-1-nitro-3-cyclohexene-carbonitrile (5d)

5d

pale yellow solid; chromatography, eluent: Etp/ EtOAc, 9/1 gradient; 88% yield; m.p.: 110-112 °C (Et₂O). Tlc - R_f: 0.38 (8/2 Etp/EtOAc); ¹H NMR (400 MHz, CD₃COCD₃) δ: 1.75 (s, 3H), 1.79 (s, 3H), 2.45 (dd, *J* = 17.9; 5.7 Hz, 1H), 2.60 (*m*, 1H), 3.00 (*d*, *J* = 16.6 Hz, 1H), 3.36 (*d*, *J* = 16.6 Hz, 1H), 3.81 (s, 3H), 4.38 (dd, *J* = 11.6; 5.7 Hz, 1H), 6.95-7.05 (*m*, 2H), 7.31 (*m*, 1H), 7.60 (dd, *J* = 7.7; 0.7 Hz, 1H); ¹³C NMR (100.6 MHz, CD₃COCD₃) δ: 17.3, 17.4, 36.9, 39.1, 42.3, 54.9, 88.7, 111.1, 114.2, 120.3, 120.5, 124.7, 126.3, 126.5, 129.2, 157.1; FT-IR (CHCl₃, cm⁻¹) ν: 3028, 1566, 1495, 1464, 1359, 1210; GC / EIMS (*m/z*): 239 (50), 238 (29), 225 (18), 224 (100), 212 (14), 209 (25), 208 (41), 197 (9), 190 (10), 181 (14), 165 (10), 152 (7), 132 (8), 121 (9), 91 (12), 77 (8); anal. calcd. for C₁₆H₁₈N₂O₃: C, 58.82; H, 3.95; N, 13.72; found: C, 58.80; H, 3.90; N, 13.68.

Rel (1S,6R)-3,4-dimethyl-1-nitro-6-(2-nitrophenyl)-3-cyclohexene-carbonitrile (5e)

5e

pale yellow solid, chromatography, eluent: Etp/ EtOAc, 9/1 gradient; 78% yield; m.p.: 122-123 °C (Et₂O). Tlc - R_f: 0.37 (8/2 Etp/EtOAc); ¹H NMR (400 MHz, CD₃COCD₃) δ : 1.80 (s, 6H), 2.77 (*m*, 2H), 3.08 (*d*, *J* = 16.3 Hz, 1H), 3.33 (*d*, *J* = 16.3 Hz, 1H), 4.43 (dd, *J* = 10.9; 6.2, 1H), 7.65 (dd, *J* = 17.7 Hz, 1H), 7.84 (dd, *J* = 17.7 Hz, 1H), 7.90 (*d*, *J* = 8.1 Hz, 1H), 8.09 (*d*, *J* = 7.7 Hz, 1H); ¹³C NMR (100.6 MHz, CD₃COCD₃) δ: 18.5, 18.6, 38.4, 42.0, 44.1, 89.9, 115.0, 121.9, 126.0, 127.4, 128.6, 130.8, 131.1, 134.3, 152.0; FT-IR (CHCl₃, cm⁻¹) ν: 3028, 2337, 1607, 1529, 1565, 1345; GC / EIMS (*m/z*): 254 (1), 236 (23), 222 (28), 221 (100), 220 (33), 219 (91), 207 (22), 206 (28), 167 (20), 205 (29), 195 (10), 194 (14), 193 (23), 192 (30), 191 (32), 190 (34), 178 (18), 165 (23), 77(9); anal. calcd. for C₁₅H₁₅N₃O₄ : C, 59.79; H, 5.02; N, 13.95; found: C, 59.75; H, 5.00; N, 13.90.

Rel (1S,6R)-3,4-Dimethyl-1-nitro-6-(2-trifluoromethyl-phenyl)-cyclohex-3-enecarbonitrile (5f)

5f

white solid, chromatography, eluent: Etp/Et₂O, 9/1 gradient; 77% yield; Tlc - R_f: 0.43 (8/2 Etp/ Et₂O); m.p. 120-122 °C (Et₂O); ¹H NMR (400 MHz, CDCl₃) δ: 1.73 (s, 3H), 1.78 (s, 3H), 2.56 (*m*, 2H), 2.87 (*d*, *J* = 16.2 Hz, 1H), 3.54 (*d*, *J* = 16.2 Hz, 1H), 4.09 (dd, *J* = 5.9, 11.1 Hz, 1H), 7.42 (*t*, *J* = 7.6 Hz, 1H), 7.61 (*t*, *J* = 7.6 Hz, 1H), 7.67 (*d*, *J* = 7.9 Hz, 1H), 8.12 (*d*, *J* = 7.9 Hz, 1H); ¹³C NMR (100.6 MHz, CDCl₃) δ: 18.3, 18.6, 39.8, 43.4, 43.8, 87.7, 114.7, 120.5, 124.0, 126.8, 127.0, 127.3, 128.4, 129.0; 132.7, 135.5, FT-IR (CHCl₃, cm⁻¹) ν: 3029, 2920, 2862, 1609, 1569, 1356, 1312; anal. calcd. for C₁₆H₁₅F₃N₂O₂: C, 59.26; H, 4.66; N, 8.64; found: C, 59.28; H, 4.71; N, 8.68.

Rel (1S,6R)-6-(2,4-dimethoxyphenyl)-3,4-dimethyl-1-nitro-3-cyclohexene-carbonitrile (5g)

5g

white solid, chromatography, eluent: Etp/ EtOAc, 9/1 gradient; 80% yield; m.p.: 119-121 °C (Et₂O); Tlc - R_f : 0.43 (8/2 Etp/EtOAc); ¹H NMR (400 MHz, CD₃COCD₃) δ: 1.74 (s, 3H), 1.78 (s, 3H), 2.40 (dd, *J* = 17.9; 4.9 Hz, 1H), 2.59 (*m*, 1H), 2.97 (*d*, *J* = 16.6 Hz, 1H), 3.35 (*d*, 1H, *J* = 16.6 Hz), 3.79 (s, 3H), 3.80 (s, 3H), 4.26 (dd, 1H, *J* = 11.7, 5.6 Hz), 7.52 (dd, *J* = 2.2, 8.5 Hz, 1H), 7.56 (*d*, *J* = 2.2 Hz, 1H), 7.85 (*d*, *J* = 8.5 Hz, 1H); ¹³C NMR (100.6 MHz, CD₃COCD₃) δ: 18.4, 18.5, 38.1, 39.9, 43.3, 55.6, 56.0, 90.1, 99.4, 106.0, 115.4, 117.8, 121.3, 127.7, 128.4, 159.4, 161.8; FT-IR (CHCl₃, cm⁻¹) ν: 3028, 1615, 1588, 1565, 1508, 1465, 1211; GC / EIMS (*m/z*) : 270 (14), 269 (76), 268 (46), 255 (19), 242 (9), 239 (19), 238 (22), 211 (8), 189 (8), 178 (5), 152 (6), 151 (17), 138 (6), 121 (6), 115 (4), 77 (4); anal. calcd. for C₁₇H₂₀N₂O₄: C, 64.54; H, 6.37; N, 8.86; found: C, 64.50; H, 6.32; N, 8.82.

Rel (1S,6R)-6-(2-chloro-6-fluoro-phenyl)-3,4-dimethyl-1-nitro-3-cyclohexene-carbonitrile (5h)

5h

white solid; chromatography, eluent: Etp/ EtOAc, 95/5 gradient; 82% yield; m.p.: 93-95 °C (Et₂O). Tlc - R_f: 0.57 (9/1 Etp/EtOAc); ¹H NMR (400 MHz, CDCl₃) δ: 1.74 (s, 3H), 1.77 (s, 3H), 2.43 (dd, *J* = 17.7; 4.4 Hz, 1H), 2.89 (*d*, *J* = 16.1 Hz, 1H), 2.98 (*m*, 1H), 3.36 (*d*, *J* = 16.1 Hz, 1H), 4.49 (dd, *J* = 12.1, 4.9 Hz, 1H), 7.01-7.06 (*m*, 1H), 7.21 (*m*, 1H); ¹³C NMR (100.6 MHz, CD₃COCD₃) δ: 18.3, 18.6, 34.8, 43.9, 44.5, 87.1, 113.8, 115.6, 120.4, 121.2, 126.2, 127.1, 130.4, 135.9, 162.0; FT-IR (CHCl₃, cm⁻¹) ν: 3024, 2920, 1607, 1568, 1460 1208; GC / EIMS (*m/z*): 263 (33), 262 (18), 261 (92), 248 (36), 247 (17), 246 (100), 226 (16), 219 (11), 211 (23), 208 (13), 191 (17), 190 (15), 184 (13), 183 (21), 145 (24), 143 (64); anal. calcd. for C₁₅H₁₄ClFN₂O₂: C, 58.35; H, 4.57; N, 9.07; found: C, 58.40; H, 4.52; N, 9.09.

Rel (1S,6R)-6-(2,4-dichlorophenyl)-3,4-dimethyl-1-nitro-3-cyclohexene-carbonitrile (5i)

5i

white solid, chromatography, eluent: Etp/ EtOAc, 9/1 gradient; 84% yield; m.p.: 95-97 °C (Et₂O); Tlc - R_f : 0.43 (8/2 Etp/EtOAc). ¹H NMR (400 MHz, CD₃COCD₃) δ: 1.76 (s, 3H), 1.80 (s, 3H), 2.59 (*m*, 2H), 3.08 (*d*, *J* = 16.7 Hz, 1H), 3.43 (*d*, *J* = 16.6 Hz, 1H), 4.44 (dd, *J* = 8.8; 8.4 Hz, 1H), 7.51-7.56 (*m*, 2H), 7.85 (*d*, *J* = 8.5 Hz, 1H); ¹³C NMR (100.6 MHz,

CD₃COCD₃) δ : 18.3, 18.5, 38.2; 43.3; 43.4; 89.2, 114.8, 121.8, 127.2, 129.0, 129.4, 130.6, 134.2, 135.3, 136.0; FT-IR (CHCl₃, cm⁻¹) ν : 3024, 1590, 1568, 1478, 1210; GC / EIMS (m/z): 279 (50), 277 (85), 264 (56), 262 (95), 244 (12), 242 (35); 237 (12), 227 (32), 192 (11), 191 (26), 190 (33), 177 (11), 165 (15), 163 (13), 161 (45), 159 (65), 152 (8), 89 (10); anal. calcd. for C₁₅H₁₄Cl₂N₂O₂: C, 55.40; H, 4.34; N, 8.61; found: C, 55.35; H, 4.30; N, 8.56.

Rel (1S,6R)- 3,4-Dimethyl-1-nitro-6-(2,4,6-trimethyl-phenyl)-cyclohex-3-enecarbonitrile (5j)

5j

white solid, chromatography, eluent: Etp/ EtOAc, 9/1 gradient; 78% yield; m.p.: 140-142 °C (EtP/AcOEt). Tlc - R_f: 0.52 (8/2 Etp/EtOAc); ¹H NMR (400 MHz, CDCl₃) δ : 1.77 (s, 3H); 1.80 (s, 3H); 2.23 (s, 3H); 2.33 (s, 3H);, 2.36 (*m*, 1H), 2.68 (s, 3H), 2.86 (*d*, *J* = 16 Hz, 1H), 3.09 (*m*, 1H), 3.45 (*d*, *J* = 16 Hz, 1H), 4.33 (*dd*, *J* = 5.3, 12.1 Hz, 1H), 6.83 (s, 1H), 6.86 (s, 1H); ¹³C NMR (100.6 MHz, CDCl₃) δ : 18.5, 18.7, 20.5, 21.6, 22.9, 35.1, 45.3, 45.4, 88.1, 115.7, 120.5, 128.0, 128.9, 130.1, 131.9, 137.5, 137.6, 138.4; FT-IR (CHCl₃, cm⁻¹) ν : 3015, 2021, 1612, 1565, 1454, 1354, 1219; anal. calcd. for C₁₈H₂₂N₂O₂: C, 72.46; H, 7.43; N, 9.39; found: C, 72.48; H, 7.40; N, 9.42.

Rel (1S,6R)-6-(3,5-Dibromo-4-hydroxy-phenyl)-3,4-dimethyl-1-nitro-cyclohex-3-enecarbonitrile (5k)

5k

white solid, chromatography, eluent: Etp/EtOAc, 8/2 gradient; 75% yield; Tlc - R_f: 0.57 (6/4 Etp/AcOEt); m.p. 160-162 °C (Et₂O); ¹H NMR (400 MHz, CDCl₃) δ : 1.74 (s, 3H), 2.42 (*dd*, *J* = 4.8, 18.1 Hz, 1H), 2.67 (*m*, 1H), 2.83 (*d*, *J* = 16.7 Hz, 1H), 3.22 (*d*, *J* = 16.7 Hz, 1H), 3.54 (*dd*, *J* = 5.6, 11.8 Hz, 1H), 5.96 (s, 1H), 7.46 (s, 2H); ¹³C NMR (100.6 MHz, CDCl₃) δ : 18.40, 18.41, 37.0, 42.4, 46.0, 89.7, 110.2, 113.2, 120.2, 126.5, 130.0, 131.6, 150.0; FT-IR (CHCl₃, cm⁻¹) ν : 3505, 3205, 2919, 2396, 1567, 1474, 1325, 1221; anal. calcd. for C₁₅H₁₄Br₂N₂O₃: C, 41.89; H, 3.28; N, 6.51; found: C, 41.83; H, 3.22; N, 6.45.

Rel (1S,6R)-4-methyl-1-nitro-6-phenyl-3-cyclohexene-carbonitrile (5l)

5l

white solid, chromatography, eluent: Etp/ EtOAc, 9/1 gradient; 78% yield; m.p.: 78-81 °C (Et₂O); Tlc - R_f: 0.42 (8/2 EtOAc/Etp); ¹H NMR (400 MHz, CDCl₃) δ : 1.82 (s, 3H), 2.48 (*dd*, *J* = 5.5, 18.2 Hz, 1H), 2.78 (*m*, 1H), 2.97 (*dd*, *J* = 5.4,

16.6 Hz, 1H), 3.27 (*d*, *J* = 16.6 Hz, 1H), 3.70 (*dd*, *J* = 5.5, 11.8 Hz, 1H), 5.46 (*s*, 1H), 7.3-7.4 (*m*, 5H); ¹³C NMR (100.6 MHz, CDCl₃) δ: 22.6, 35.8, 37.2, 47.4, 89.6, 113.6, 114.4, 128.0, 128.9, 129.0, 135.4, 135.5; FT-IR (CHCl₃, cm⁻¹) ν: 3032, 1678, 1563; 1458, 1337; GC / EIMS (*m/z*): 196 (23), 195 (100), 194 (33), 180 (70), 169 (17), 154 (24), 128 (16), 116 (21), 115 (21), 104 (6), 91 (72), 77 (15), 65 (8), 51 (10); anal. calcd. for C₁₄H₁₄N₂O₂: C, 69.41; H, 5.82; N, 11.56; found: C, 69.39; H, 5.78; N, 11.51.

Rel (1S,2S,6R)-2-methyl-1-nitro-6-phenyl-3-cyclohexene-carbonitrile (5m)

5m

characterized in an enriched mixture with **5n**, white solid, chromatography, eluent: Etp/ EtOAc, 9/1 gradient (75/25 mixture of exo/endo diastereoisomers); 84% overall yield; m.p.: 109-111 °C (Et₂O); Tlc - R_f: 0.53 (8/2 Etp/EtOAc); ¹H NMR (400 MHz, CDCl₃) δ: 1.19 (*d*, *J* = 7.2 Hz, 3H), 2.62 (*d*, *J* = 18.7 Hz, 1H), 2.71 (*dd*, *J* = 10.8, 18.7 Hz, 1H), 3.28 (*m*, 1H), 3.70 (*dd*, *J* = 6.3, 10.8 Hz, 1H), 5.77 (*d*, *J* = 10.2, 1H), 5.90 (*d*, *J* = 10.2, 1H), 7.29-7.40 (*m*, 3H), 7.52 (*m*, 2H); ¹³C NMR (100.6 MHz, CDCl₃) δ: 17.0, 32.9, 40.9, 41.3, 91.6, 114.8, 126.3, 126.9, 128.4, 128.6, 128.8, 136.8; FT-IR (CHCl₃, cm⁻¹) ν: 3032, 1556, 1340, 1327; GC / EIMS (*m/z*) : 195 (91), 194 (25), 181 (24), 180 (24), 180 (59), 169 (23), 159 (24), 153 (18), 141 (15), 140 (17), 128 (17), 115 (28), 91 (100), 77 (18).

Rel (1S,2R,6R)-2-methyl-1-nitro-6-phenyl-3-cyclohexene-carbonitrile (5n)

5n

characterized in mixture with **5m**; white solid; chromatography, eluent: Etp/ EtOAc, 9/1 gradient (75/25 mixture of exo/endo diastereoisomers); 84% overall yield; Tlc - R_f: 0.53 (8/2 Etp/EtOAc); ¹H NMR (400 MHz, CDCl₃) δ: 1.26 (*d*, *J* = 7.1 Hz, 3H); 2.62 (*m*, 1H); 2.84 (*m*, 1H); 3.47 (*m*, 1H); 3.71 (*dd*, *J* = 6.2, 10.1 Hz, 1H); 5.55 (*d*, *J* = 10.1 Hz, 1H); 5.95 (*m*, 1H); 7.34 (*m*, 5H); ¹³C NMR (100.6 MHz, CDCl₃) δ : 15.9; 31.5; 41.3; 48.3; 95.9; 111.8; 126.8; 127.2; 128.0; 129.0; 135.3.

Procedure for preparation of Diels-Alder-Adducts 5o. A steel reactor equipped with a magnetic stirrer was charged with (2*E*)-3-(4-methylphenyl)-2-nitroacrylonitrile **3o** (1.0 mmol), and diene **3c** (3.0 mmol) and sealed. The resulting mixture was left under magnetic stirring for 12 h at 100°C. After silica-gel column chromatography of the final mixture cycloadduct **5o** was isolated in 75% yield.

Rel (1*S*,6*R*)-6-(4-methylphenyl)-1-nitrocyclohex-3-ene-1-carbonitrile (5o)

5o

white solid, chromatography, eluent: Etp/ EtOAc, 95/5 gradient; 75% yield; Tlc - R_f : 0.37 (8/2 EtOAc/Etp); ^1H NMR (400 MHz, CDCl_3) δ : 2.32 (s, 3H), 2.60 (*dt*, $J = 5.1, 18.6$, 1H), 2.81 (*m*, 1H), 2.99 (*dd*, $J = 5.3, 17$ Hz, 1H), 3.28 (*m*, 1H), 3.61 (*dd*, $J = 5.5, 11.6$ Hz, 1H), 5.75 (*m*, 1H), 5.97 (*m*, 1H), 7.15 (*d*, $J = 8.0$, 2H), 7.25 (*d*, $J = 8.0$, 2H); ^{13}C NMR (100.6 MHz, CDCl_3) δ : 21.0, 31.1, 37.1, 46.9, 89.6, 113.4, 120.2, 127.6, 127.9, 129.7, 132.3, 138.9; FT-IR (CHCl_3 , cm^{-1}) ν : 3023, 3015, 2927, 2863, 1597, 1353, 1226.

General Procedure for preparation of biphenyls 6a-o. A screw capped vial equipped with a magnetic stirrer was charged with cycloadduct **5a-o** (1.0 mmol), DBU (2.0 mmol) and O_2 at 0.5 bar. The resulting mixture was left under magnetic stirring for the time and at temperature reported in scheme 3 and 4, and in table 3. After silica-gel column chromatography of the final mixture cycloadducts **6a-n** were isolated.

4,5-Dimethyl-1,1'-biphenyl-2,4'-dicarbonitrile (6a)

6a

white solid; chromatography, eluent: Etp/AcOEt, 9/1 gradient; 77% yield; Tlc - R_f : 0.35 (8/2 Etp/AcOEt); m.p. 213-215 °C (AcOEt); ^1H NMR (400 MHz, CDCl_3) δ : 2.35 (s, 3H), 2.38 (s, 3H), 7.27 (s, 1H), 7.55 (s, 1H), 7.65 (*d*, $J = 8.5$ Hz, 2H), 7.77 (*d*, $J = 8.5$ Hz, 2H); ^{13}C NMR (100.6 MHz, CDCl_3) δ : 19.2, 20.2, 118.4, 118.5, 129.4, 131.0, 132.4, 134.6, 138.9, 140.7, 142.7, 143.0; FT-IR (CHCl_3 , cm^{-1}) ν : 3022, 2231, 1608, 1490, 1224; EIMS (m/z): 232 (M^+ , 100), 217 (39), 190 (20), 177 (5), 77 (2); anal. calcd. for $\text{C}_{16}\text{H}_{12}\text{N}_2$: C, 82.73; H, 5.21; N, 12.06; found: C, 82.70; H, 5.24; N, 12.11.

4,5-dimethyl-1,1'-biphenyl-2-carbonitrile (6b)

6b

white solid; chromatography, eluent: Etp/ EtOAc, 9/1 gradient; 75% yield; m.p.: 103-105 °C (Et₂O); Tlc - R_f: 0.42 (8/2 Etp/ EtOAc); ¹H NMR (400 MHz, CDCl₃) δ : 2.29 (s, 3H), 2.33 (s, 3H), 7.35-7.55 (*m*, 7H); ¹³C NMR (100.6 MHz, CDCl₃) δ: 19.0, 20.1, 108.2, 119.0, 128.2, 128.5, 128.6, 131.2, 134.3, 136.4, 138.2, 142.4, 142.9; FT-IR (CHCl₃, cm⁻¹) ν: 3020, 2225, 1610, 1486; GC / EIMS (*m/z*): 207 (100, M⁺), 206 (32), 192 (44), 191 (14), 190 (19), 178 (9), 165 (17), 152 (5), 140 (3), 102 (4), 89 (4), 63 (3); anal. calcd. for C₁₅H₁₃N: C, 86.92; H, 6.32; N, 6.76; found: C, 86.89; H, 6.29; N, 6.71.

4,5,2'-trimethyl-1,1'-biphenyl-2-carbonitrile (6c)

6c

white solid. chromatography, eluent: Etp/ EtOAc, 9/1 gradient; 57% yield; m.p.: 112-115 °C (Et₂O); Tlc - R_f: 0.51 (8/2 Etp/ EtOAc); ¹H NMR (400 MHz, CDCl₃) δ: 2.19 (s, 3H), 2.33 (s, 3H), 2.35 (s, 3H), 7.10-7.35 (*m*, 5H), 7.49 (s, 1H); ¹³C NMR (100.6 MHz, CDCl₃) δ: 19.1, 19.8, 20.1, 109.8, 118.5, 125.7, 128.4, 129.5, 130.2, 131.6, 133.4, 135.7, 136.3, 138.1, 142.1, 143.3; FT-IR (CHCl₃, cm⁻¹) ν: 3024, 2227, 1611, 1482, 1452; GC / EIMS (*m/z*): 221 (100, M⁺), 220 (26), 206 (32), 205 (9), 191 (10), 190 (17), 179 (22), 178 (13), 165 (5), 89 (5), 77 (2); anal. calcd. for C₁₆H₁₅N: C, 86.84; H, 6.83; N, 6.33; found: C, 86.81; H, 6.80; N, 6.30.

2'-Methoxy- 4,5-dimethyl-1,1'-biphenyl-2-carbonitrile (6d)

6d

pale yellow solid; chromatography, eluent: Etp/ EtOAc, 9/1 gradient; 60% yield; m.p.: 122-124 °C (Et₂O); Tlc - R_f: 0.55 (8/2 Etp/ EtOAc); ¹H NMR (400 MHz, CDCl₃) δ: 2.36 (s, 3H), 2.38 (s, 3H), 3.88 (s, 3H), 7.0-7.1 (*m*, 2H), 7.26 (s, 1H), 7.28 (*m*, 1H), 7.43 (*m*, 1H), 7.52 (s, 1H); ¹³C NMR (100.6 MHz, CDCl₃) δ : 19.1, 20.1, 55.4, 110.4, 111.2, 118.9, 120.6, 127.3, 129.9, 130.8, 132.0, 133.4, 136.2, 139.9, 141.9, 156.4; FT-IR (CHCl₃, cm⁻¹) ν: 3017, 2228, 1602, 1584, 1487; GC / EIMS (*m/z*): 237 (100, M⁺), 236 (35), 222 (27), 209 (33), 208 (25), 207 (31), 206 (28), 194 (15), 165 (11), 152 (7), 127 (3), 89 (3), 63 (3); anal. calcd. for C₁₆H₁₅NO: C, 80.98; H, 6.37; N, 5.90; found: C, 80.97; H, 6.35; N, 5.88.

4,5-Dimethyl-2'-nitro-1,1'-biphenyl-2-carbonitrile (6e)

6e

white solid; chromatography, eluent: Etp/ EtOAc, 7/3 gradient; 57% yield; m.p.: 154-155 °C (Et₂O); Tlc - R_f: 0.49 (1/1 Etp/ EtOAc); ¹H NMR (400 MHz, CDCl₃) δ: 2.33 (s, 6H), 7.10 (s, 1H), 7.42 (m, 1H), 7.51 (s, 1H), 7.59 (m, 1H), 7.69 (m, 1H), 8.10 (m, 1H); ¹³C NMR (100.6 MHz, CDCl₃) δ: 19.2, 20.1, 109.1, 117.8, 124.8, 129.5, 130.1, 132.3, 133.1, 133.3, 133.5, 137.5, 139.3, 142.5, 148.3; FT-IR (CHCl₃, cm⁻¹) ν: 3020, 2228, 1608, 1531, 1435; GC / EIMS (*m/z*): 252 (100, M⁺); 224 (38), 223 (41), 209 (37), 208 (20), 207 (98), 206 (35), 204 (21), 195 (78), 190 (99), 181 (46), 178 (32), 164 (21), 152 (20), 140 (16), 89 (11), 77 (11), 63 (10); anal. calcd. for C₁₅H₁₂N₂O₂: C, 71.42; H, 4.79; N, 11.10; found: C, 71.41; H, 4.74; N, 11.08.

4,5-Dimethyl-2'-trifluoromethyl-1,1'-biphenyl-2-carbonitrile (6f)

6f

white solid; chromatography, eluent: Etp/Et₂O, 8/2 gradient; 70% yield; m.p. 95-97 °C (*n*-Hexane); Tlc - R_f: 0.27 (8/2 Etp/ Et₂O); ¹H NMR (400 MHz, CDCl₃) δ: 2.346 (s, 3H), 2.348 (s, 3H), 7.18 (s, 1H), 7.33 (*d*, *J* = 7.5 Hz, 1H), 7.50 (s, 1H), 7.55 (*t*, *J* = 7.6 Hz, 1H), 7.61 (*t*, *J* = 7.5 Hz, 1H), 7.79 (*t*, *J* = 7.6 Hz, 1H); ¹³C NMR (100.6 MHz, CDCl₃) δ: 19.2, 20.0, 110.0, 117.9, 123.7, 126.1, 128.6, 128.9, 131.46, 131.51, 131.6, 133.0, 137.1, 137.2, 140.5, 141.5; FT-IR (CHCl₃, cm⁻¹) ν: 3022, 2228, 1605, 1484, 1448, 1316; GC / EIMS (*m/z*): 275 (M⁺, 100), 260 (23), 255 (5), 240 (30), 239 (6), 206 (11), 191 (6), 190 (12); anal. calcd. for C₁₆H₁₂F₃N: C, 69.81; H, 4.39; N, 5.09; found: C, 69.75; H, 4.43; N, 5.12.

2',4'-Dimethoxy-4,5-dimethyl-1,1'-biphenyl-2-carbonitrile (6g)

6g

white solid; chromatography, eluent: Etp/AcOEt, 9/1 gradient; 45% yield; m.p. 116-118 °C (Et₂O) ; Tlc - R_f: 0.4 (8/2 Etp/ AcOEt); ¹H NMR (400 MHz, CDCl₃) δ: 2.30 (s, 3H), 2.33 (s, 3H), 3.82 (s, 3H), 3.86 (s, 3H), 6.57 (m, 2H), 7.15 (*d*, *J* = 8.9 Hz, 1H), 7.19 (s, 1H), 7.47 (s, 1H); ¹³C NMR (100.6 MHz, CDCl₃) δ: 19.2, 20.1, 55.42, 55.48, 98.9, 104.8, 110.6, 119.2, 120.2, 131.4, 132.2, 133.5, 135.9, 139.9, 141.9, 157.6; FT-IR (CHCl₃, cm⁻¹) ν: 3014, 2965, 2840, 2228, 1613, 1582, 1490, 1309, 1207, 1161; GC / EIMS (*m/z*): 267 (M⁺, 100), 252 (11), 237 (13), 224 (9), 222 (8), 181 (5), 191 (6), 166 (6); anal. calcd. for C₁₇H₁₇NO₂: C, 76.38; H, 6.41; N, 5.24; found: C, 76.35; H, 6.44; N, 5.20.

6'-Chloro-2'-fluoro-4,5-dimethyl-1,1'-biphenyl-2-carbonitrile (6h)

6h

white solid; chromatography, eluent: Etp/AcOEt, 9/1 gradient; 70% yield; m.p. 125-127 °C (Et₂O) ; Tlc - R_f: 0.5 (8/2 Etp/AcOEt); ¹H NMR (400 MHz, CDCl₃) δ: 2.35 (s, 3H), 2.37 (s, 3H), 7.12 (*m*, 1H), 7.19 (s, 1H), 7.31-7.37 (*m*, 2H), 7.55 (s, 1H); ¹³C NMR (100.6 MHz, CDCl₃) δ: 19.4, 20.1, 110.8, 114.2, 114.5, 117.7, 125.4, 130.5, 132.2, 133.5, 134.0, 134.6, 137.9, 142.3, 160.1; FT-IR (CHCl₃, cm⁻¹) ν: 2229, 1569, 1462, 1440, 1207, 904; EIMS (*m/z*): 261.(41), 260 (21), 259 (M⁺, 100), 246 (10), 244 (30), 224 (37), 209 (18), 208 (30), 197 (6); anal. calcd. for C₁₅H₁₁ClFN: C, 69.37; H, 4.27; N, 5.39; found: C, 69.39; H, 4.32; N, 5.42.

2',4'-dichloro- 4,5-dimethyl-1,1'-biphenyl-2-carbonitrile (6i)

6i

yellow solid; chromatography, eluent: Etp/ EtOAc, 95/5 gradient; 70% yield; m.p.: 122-125 °C (Et₂O); Tlc - R_f: 0.4 (9/1 Etp/ EtOAc); ¹H NMR (400 MHz, CDCl₃) δ: 2.33 (s, 3H), 2.35 (s, 3H), 7.17 (s, 1H), 7.25 (*m*, 1H), 7.33 (*m*, 1H), 7.51 (s, 2H); ¹³C NMR (100.6 MHz, CDCl₃) δ : 19.3, 20.1, 109.9, 117.9, 127.2, 129.7, 131.7, 131.9, 133.5, 133.8, 135.1, 135.6, 137.6, 139.3, 142.3; FT-IR (CHCl₃, cm⁻¹) ν: 3028, 2228, 1478, 1451, 1598; GC / EIMS (*m/z*): 275 (100, M⁺); 260 (20), 240 (28), 224 (8), 205 (24), 204 (25), 203 (13), 190 (27), 177 (8), 88 (8); anal. calcd. for C₁₅H₁₁Cl₂N : C, 65.24; H, 4.01; N, 5.07; found: C, 65.20; H, 3.99; N, 5.03.

2',4,4',5,6'-pentamethyl-1,1'-biphenyl-2-carbonitrile (6j)

6j

pale yellow solid; chromatography, eluent: Etp/ EtOAc, 9/1 gradient; 62 % yield; m.p.: 134-137°C (Et₂O); Tlc - R_f: 0.52 (8/2 Etp/ EtOAc); ¹H NMR (400 MHz, CDCl₃) δ: 1.99 (s, 6H), 2.33 (s, 3H), 2.34 (s, 3H), 2.35 (s, 3H) 6.95 (s, 2H), 7.03 (s, 1H), 7.51 (s, 1H), ¹³C NMR (100.6 MHz, CDCl₃) δ: 19.2, 20.16, 20.22, 21.04, 110.3, 118.2, 128.3, 132.2, 131.5, 133.5, 135.7, 136.1, 137.6, 142.4, 142.8; GC / EIMS (*m/z*) : 249 (100, M⁺), 248 (16), 234 (46), 219 (12), 218 (11), 207 (25), 204 (13); FT-IR (CHCl₃, cm⁻¹) ν: 3028, 2948, 2924, 2857, 2227, 1593, 1495, 1212; anal. calcd. for C₁₈H₁₉N : C, 86.70; H, 7.68; N, 5.62; found: C, 86.75; H, 7.65; N, 5.60.

3',5'-Dibromo-4'-hydroxy-4,5-dimethyl-1,1'-biphenyl-2-carbonitrile (6k)

6k

pale yellow solid; chromatography, eluent: Etp/ EtOAc/AcOH (87/8/5), 9/1 gradient; 80% yield; m.p.: 225-228°C (AcOEt) dec. Tlc - R_f: 0.26 (8/2 Etp/ EtOAc). ¹H NMR (400 MHz, CDCl₃) δ: 2.32 (s, 3H), 2.35 (s, 3H), 5.99 (s, 1H), 7.21 (s, 1H), 7.46 (s, 1H), 7.63 (s, 2H), ¹³C NMR (100.6 MHz, CDCl₃) δ: 19.2, 20.2, 108.2, 110.0, 118.5, 131.0, 132.2, 133.0, 134.4, 137.2, 139.7, 142.8, 149.6; FT-IR (CHCl₃, cm⁻¹) ν: 3505, 3025, 2360, 2343, 2227, 1472, 1227; anal. calcd. for C₁₅H₁₁Br₂NO : C, 47.28; H, 2.91; N, 3.68; found: C, 47.31; H, 2.95; N, 3.71.

5-Methyl-1,1'-biphenyl-2-carbonitrile (6l)

6l

pale yellow oil; chromatography, eluent: Etp/ EtOAc, 9/1 gradient, 70% yield; Tlc - R_f: 0.42 (8:2 Etp/EtOAc); ¹H NMR (400 MHz, CDCl₃) δ: 2.43 (s, 3H); 7.20-7.65 (*m*, 8H); ¹³C NMR (100.6 MHz, CDCl₃) δ: 21.7, 108.2, 118.9, 128.3, 128.50, 128.57, 128.62, 130.7, 133.5, 138.2, 143.6, 145.3; FT-IR (CHCl₃, cm⁻¹) ν: 3016, 2226, 1711, 1607; GC / EIMS (*m/z*): 193 (100, M⁺), 192 (43), 190 (10), 166 (8), 165 (28), 164 (6); anal. calcd. for C₁₄H₁₁N: C, 87.01; H, 5.74; N, 7.25; found: C, 86.99; H, 5.71; N, 7.22.

3-Methyl-1,1'-biphenyl-2-carbonitrile (6m)

6m

colorless oil; chromatography, eluent: Etp/ EtOAc, 9/1 gradient; 65% overall yield of **6m** and **6n**; Tlc - R_f: 0.48 (8/2 Etp/ EtOAc); ¹H NMR (400 MHz, CDCl₃) δ: 2.64 (s, 3H), 7.31 (*d*, 2H, *J* = 7.7 Hz), 7.40-7.50 (*m*, 4H), 7.63 (*t*, 2H, *J* = 8.3 Hz); ¹³C NMR (100.6 MHz, CDCl₃) δ: 21.0, 111.8, 117.6, 127.3, 128.48, 128.53, 128.7, 132.1, 138.6, 143.0, 146.0; FT-IR (CHCl₃, cm⁻¹) ν: 3022, 2224, 1591, 1466; GC / EIMS (*m/z*): 193 (100, M⁺), 192 (83), 191 (10), 190 (10), 166 (8), 165 (34), 164 (9), 163 (6), 140 (4), 139 (5). anal. calcd. for C₁₄H₁₁N : C, 87.01; H, 5.74; N, 7.25; found: C, 86.99; H, 5.74; N, 7.24.

3-Methyl-2-nitro-1,1'-biphenyl (6n)

6n

colorless oil; chromatography, eluent: Etp/ EtOAc, 9/1 gradient; 65% overall yield of **6m** and **6n**; Tlc - R_f : 0.62 (98/2 Etp/EtOAc); ^1H NMR (400 MHz, CDCl_3) δ : 2.47 (s, 3H), 7.37 (m, 2H), 7.46 (m, 4H), 7.63 (d, $J = 8.3$ Hz, 2H); ^{13}C NMR (100.6 MHz, CDCl_3) δ : 21.5, 124.3, 127.2, 127.5, 128.0, 128.7, 129.0, 138.3, 141.2, 141.3; FT-IR (CHCl_3 , cm^{-1}) ν : 3013, 1946, 1601, 1482, 1216; GC / EIMS (m/z): 169 (19), 168 (100), 167 (57), 165 (27), 153 (17), 152 (24), 115 (7), 83 (5); anal. calcd. for $\text{C}_{13}\text{H}_{11}\text{NO}_2$: C, 73.23; H, 5.20; N, 6.57; found: C, 73.21; H, 5.24; N, 6.54.

4'-Methyl-1,1'-biphenyl-2-carbonitrile (6o)

6o

white solid; chromatography, eluent: Etp/AcOEt, 95/5 gradient; 62% yield; m.p: 47-48°C (Et_2O)(lit.,² mp: 48-49.5 °C); ; Tlc - R_f : 0.47 (8/2 Etp/ AcOEt); ^1H NMR (400 MHz, CDCl_3) δ : 2.35 (s, 3H), 2.37 (s, 3H), 7.12 (m, $J = 8.9$ Hz, 1H), 7.19 (s, 1H), 7.31-7.37 (m, 2H), 7.55 (s, 1H); ^{13}C NMR (100.6 MHz, CDCl_3) δ : 21.2, 111.1, 118.8, 127.2, 128.5, 129.4, 129.9, 132.7, 133.6, 135.2, 138.6, 145.4; FT-IR (CHCl_3 , cm^{-1}) ν : 2926, 2860, 2227, 1731, 1479; GC / EIMS (m/z): 193 (M^+ , 100), 192 (43), 190 (10), 177 (5), 165 (29), 82 (3), 77 (1); anal. calcd. for $\text{C}_{14}\text{H}_{11}\text{N}$: C, 87.01; H, 5.74; N, 7.25; found: C, 87.04; H, 5.70; N, 7.28.

Procedure for the one-pot multicomponent large scale synthesis of 4,5-Dimethyl-1,1'-biphenyl-2,4'-dicarbonitrile (6a). A metallic reactor equipped with a mechanical stirrer was charged with 4-cyano-benzaldehyde (**1a**) (5.240 g, 40 mmol), nitroacetonitrile (**2**) (3.440 g, 40 mmol) and diene **4a** (3.280 g, 40 mmol). The resulting mixture was left under mechanical stirring at 30°C and after 10 h, DBU (12.160 g, 80.0 mmol) was added at - 20°C. The reactor was then sealed and left under mechanical stirring for 12 h at 30 °C under O_2 atmosphere (0.5 bar). The reaction mixture was then dissolved in the minimal amount of DCM (25 mL) and mixed with 20 g of silica gel. After removing the organic solvent under reduced pressure, the solid mixture was charged on a silica gel pad (20 g, silica gel/ sample overall ratio 1/1) and was eluted with a 7:3 petroleum ether: ethyl acetate solution, yielding 9.300 g of the crude product (83% purity). Finally, 6.650 g (72 % yield) of the pure biphenyl **6a**, was obtained by re-crystallization from Acetone.

4-[(E)-2-cyano-2-nitrovinyl]-benzonitrile (3a)

3a**4-[(E)-2-cyano-2-nitrovinyl]benzonitrile (3a)**

3o

8.6240

7.4151
7.3747

7.9447
7.9038

0.0001

2.4891

(2E)-3-(4-methylphenyl)-2-nitroacrylonitrile (3o)

Rel(1*S*,6*R*)-4-(6-Cyano-3,4-dimethyl-6-nitro-cyclohex-3-enyl)-benzonitrile (5a)

5a

5b

Rel-(1S,6R)-3,4-dimethyl-1-nitro-6-phenyl-3-cyclohexene-carbonitrile (5b)

Rel (1S,6R)-3,4-dimethyl-1-nitro-6-o-toluid-3-cyclohexene-carbonitrile (5c)

Rel (1S,6R)-6-(2-methoxyphenyl)-3,4-dimethyl-1-nitro-3-cyclohexene-carbonitrile (5d)

Rel (1S,6R)-6-(2-methoxyphenyl)-3,4-dimethyl-1-nitro-3-cyclohexene-carbonitrile (5d)

Rel (1S,6R)-3,4-dimethyl-1-nitro-6-(2-nitrophenyl)-3-cyclohexene-carbonitrile (5e)

Rel (1S,6R)-3,4-dimethyl-1-nitro-6-(2-nitrophenyl)-3-cyclohexene-carbonitrile (5e)

5f

Rel (1S,6R)-3,4-Dimethyl-1-nitro-6-(2-trifluoromethyl-phenyl)-cyclohex-3-enecarbonitrile (5f)

8.133
8.113
7.684
7.664
7.629
7.610
7.591
7.445
7.426
7.407
7.260

4.113
4.098
4.085
4.070

3.367
3.327

2.890
2.850
2.605
2.570
2.555

1.778
1.728

Rel (1*S*,6*R*)-3,4-Dimethyl-1-nitro-6-(2-trifluoromethyl-phenyl)-cyclohex-3-enecarbonitrile (**5f**)

Rel (1S,6R)-6-(2,4-dimethoxyphenyl)-3,4-dimethyl-1-nitro-3-cyclohexene-carbonitrile (5g)

Rel (1S,6R)-6-(2-chloro-6-fluoro-phenyl)-3,4-dimethyl-1-nitro-3-cyclohexene-carbonitrile (5h)

5h

Rel (1S,6R)-6-(2-chloro-6-fluoro-phenyl)-3,4-dimethyl-1-nitro-3-cyclohexene-carbonitrile (5h)

Rel-(1*S*,6*R*)-6-(2-(2,4-dichlorophenyl)-3,4-dimethyl-1-nitro-3-cyclohexene-carbonitrile (5i)

7.846
7.867
7.563
7.557
7.539
7.533
7.517
7.512

4.466
4.445
4.423

3.453
3.450
3.447
3.411
3.409
3.406
3.111
3.070

2.600
2.579

2.061
2.055
2.050
2.045
2.039
1.804
1.763

5i

Rel-(1S,6R)-6-(2,4-dichlorophenyl)-3,4-dimethyl-1-nitro-3-cyclohexene-carbonitrile (5i)

Rel (1S,6R) 3,4 Dimethyl 1 nitro 6 (2,4,6 trimethyl phenyl) cyclohex 3 enecarbonitrile (5j)

Rel (1S,6R) 6 (3,5 Dibromo 4 hydroxy phenyl) 3,4 dimethyl 1 nitro cyclohex 3 enecarbonitrile (5k)

5k

Rel (1S,6R) 6 (3,5 Dibromo 4 hydroxy phenyl) 3,4 dimethyl 1 nitro cyclohex 3 enecarbonitrile (5k)

Rel-(1S,6R)-4-methyl-1-nitro-6-phenyl-3-cyclohexene-carbonitrile (**5l**)

Rel (1S,6R) 4 methyl 1 nitro 6 phenyl 3 cyclohexene carbonitrile (5l)

Rel (1S,2S,6R) 2 methyl 1 nitro 6 phenyl 3 cyclohexene carbonitrile (5m) + Rel (1S,2R,6R) 2 methyl 1 nitro 6 phenyl 3 cyclohexene carbonitrile (5n)

5m

5n

Rel (1S,2S,6R)-2-methyl-1-nitro-6-phenyl-3-cyclohexene-carbonitrile (5m) + Rel (1S,2R,6R)-2-methyl-1-nitro-6-phenyl-3-cyclohexene-carbonitrile (5n)

Rel (1S,2S,6R)-2-methyl-1-nitro-6-phenyl-3-cyclohexene-carbonitrile (5m) + Rel (1S,2R,6R)-2-methyl-1-nitro-6-phenyl-3-cyclohexene-carbonitrile (5n)

5m

5n

6a

6b4,5-dimethyl-biphenyl-2-carbonitrile (**6b**)

7.532
7.515
7.484
7.465
7.447
7.429
7.409
7.389
7.373

2.337
2.297

4,5,2'-Trimethyl-biphenyl-2-carbonitrile (6c)

6c

4,5,2' -Trimethylbiphenyl-2-carbonitrile (6c)

6d

2'-methoxy-4,5-dimethyl-biphenyl-2-carbonitrile (6d)

4,5 Dimethyl 2' nitro biphenyl 2 carbonitrile (6e)

6f

4,5 Dimethyl 2' trifluoromethyl biphenyl 2 carbonitrile (6f)

2,4'-Dimethoxy 4,5 dimethyl 1,1' biphenyl 2 carbonitrile (6g)

2,4'-Dimethoxy 4,5-dimethyl 1,1'-biphenyl 2 carbonitrile (6g)

6'-Chloro-2'-fluoro-4,5-dimethyl-biphenyl-2-carbonitrile (6h)

7.551
7.379
7.366
7.359
7.346
7.340
7.337
7.330
7.316
7.312
7.260
7.190
7.144
7.140
7.125
7.123
7.121
7.115
7.107
7.099

2.370
2.354

6h

6'-Chloro-2'-fluoro-4,5-dimethyl-biphenyl-2-carbonitrile (6h)

142.317
137.947
134.624
133.982
133.543
132.195
130.531
130.439
125.464
125.433
117.705
114.472
114.247
110.836

77.306
76.989
76.671

20.140
19.362

2',4'-dichloro-4,5-dimethylbiphenyl-2-carbonitrile (6i)

7.538
7.507
7.339
7.338
7.334
7.332
7.319
7.317
7.313
7.312
7.261
7.254
7.240
7.169

2.353
2.333

Integral

ppm

2',4,4',5,6'-pentamethyl-1,1'-biphenyl-2-carbonitrile (6j)

2,4,4',5,6'-Pentamethyl-1,1'-biphenyl-2-carbonitrile (6j)

3',5'-Dibromo-4'-hydroxy-4,5-dimethyl-1,1'-biphenyl-12carbonitrile (6k)

7.630
7.499
7.261
7.206

5.992

2.359
2.323

6k

3,5'-dibromo 4' hydroxy 4,5 dimethyl 1,1' biphenyl 2 carbonitrile (6k)

5 Methyl biphenyl 2 carbonitrile (6l)

145.286
143.620
138.216
133.543
130.749
128.624
128.573
128.503
128.284
118.913
108.187

77.329
77.011
76.693

21.724

165 160 155 150 145 140 135 130 125 120 115 110 105 100 95 90 85 80 75 70 65 60 55 50 45 40 35 30 25 20 15 10 5 0 ppm

3-Methyl-1,1'-biphenyl-2-carbonitrile (6m)

6m

7.506
7.505
7.500
7.492
7.492
7.490
7.488
7.484
7.483
7.473
7.470
7.470
7.468
7.463
7.461
7.457
7.453
7.447
7.441
7.440
7.431
7.425
7.422
7.418
7.324
7.322
7.321
7.305
7.304
7.302
7.275
7.260

2.637

6m

3-Methyl-1,1'-biphenyl-2-carbonitrile (6m)

3- Methyl- 2- nitro- 1,1'- biphenyl (6n)

6n

141.355
141.232
138.305

128.682
127.987
127.168
124.266

77.348
77.031
76.713

21.532

6o

4'-Methyl-biphenyl-2-carbonitrile (6o)

145.421
138.599
135.180
133.622
132.691
129.888
129.359
129.072
128.527
127.195
126.979
118.804
111.076

21.168