Applications of Organo Selenides in the Suzuki, Negishi, Sonogashira and Kumada Cross-Coupling Reactions

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SUPPORTING INFORMATION

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Materials and Methods

Proton nuclear magnetic resonance spectra (\( ^1\)H NMR) were obtained on a NMR spectrometer at 400 MHz. Spectra were recorded in CDCl\(_3\) solutions. Chemical shifts are reported in ppm, referenced to the solvent peak of CDCl\(_3\) or tetramethylsilane (TMS) as the external reference. Data are reported as follows: chemical shift (\( \delta \)), multiplicity, coupling constant (\( J \)) in Hertz and integrated intensity. Carbon-13 nuclear magnetic resonance spectra (\( ^{13}\)C NMR) were obtained on a 400 NMR spectrometer at 100 MHz. Spectra were recorded in CDCl\(_3\) solutions. Chemical shifts are reported in ppm, referenced to the solvent peak of CDCl\(_3\). Abbreviations to denote the multiplicity of a particular signal are s (singlet), d (doublet), t (triplet), q (quartet), quint (quintet), sex (sextet), dt (double triplet), td (triple doublet) and m (multiplet). High resolution mass spectra were recorded on a mass spectrometer using electrospray ionization (ESI). Column chromatography was performed using Silica Gel (230-400 mesh) following the methods described by Still. Thin layer chromatography (TLC) was performed using Gel GF\(_{254}\), 0.25 mm thickness. For visualization, TLC plates were either placed under ultraviolet light, or stained with iodine vapor, or acidic vanillin. Most reactions were monitored by TLC for disappearance of starting material. The following solvents were dried and purified by distillation from the reagents indicated: tetrahydrofuran from sodium with a benzophenone ketyl indicator. All other solvents were ACS or HPLC grade unless otherwise noted. Air- and moisture-sensitive reactions were conducted in flame-dried or oven dried glassware equipped with tightly fitted rubber septa and under a positive atmosphere of dry nitrogen or argon. Reagents and solvents were handled using standard syringe techniques.

Table S1:

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<th>entry</th>
<th>palladium (mol%)</th>
<th>Cu(OAc)(_2),H(_2)O (equiv)</th>
<th>solvent</th>
<th>temperature (^{\circ})C</th>
<th>time</th>
<th>Yield(^a) (%)</th>
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<td>45 min</td>
<td>93(^{b})</td>
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<td>45 min</td>
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<td>45 min</td>
<td>94</td>
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<td>45 min</td>
<td>76</td>
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<td>50</td>
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<td>15 h</td>
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<td>1 h</td>
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<td>DMF</td>
<td>80</td>
<td>45 min</td>
<td>-c, d</td>
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</table>

[a] The reactions were performed by using organo selenides 1 (0.25 mmol), boronic acid (1.2 equiv), palladium salt, copper salt, in solvent (3 mL) at 80 °C for 45 min. [b] Boronic acid (2 equiv) was used. [c] The starting material was recovered. [d] The reaction was carried out in the presence of K₂CO₃ (2 equiv) and H₂O (1mL).
General Experimental Procedures

**General procedure for Suzuki cross-coupling reaction of organo selenides with boronic acids:** A mixture of organo selenide (0.25 mmol), Pd(PPh₃)₄ (0.1 equiv) and boronic acid (1.2 equiv) were dissolved in DMF (3 mL). After this, the Cu(OAc)₂·H₂O (1.2 equiv) were added. This mixture was then heated in oil bath for 1h at 80 °C. After the reaction was cooled to ambient temperature, diluted with ethyl acetate (3 mL) and then washed with saturated solution of NH₄Cl (20 mL). The organic phase was separated, dried over MgSO₄ and concentrated under vacuum. The residue was purified by flash chromatography and eluted with hexane.

**General procedure for Negishi cross-coupling reaction of organo selenides with organo zinc reagents:** A mixture of organo selenide (0.25 mmol) and Pd(PPh₃)₄ (0.1 equiv) were dissolved in THF (3 mL). After this, the organo zinc reagent (2 equiv) were added. The mixture was then heated in oil bath for 3h at 60 °C. After the reaction was cooled to ambient temperature, the crude reaction mixture was diluted with ethyl acetate (3 mL) and then washed with saturated solution of NH₄Cl (20 mL). The organic phase was separated, dried over MgSO₄ and concentrated under vacuum. The residue was purified by flash chromatography and eluted with hexane.

**General procedure for Kumada cross-coupling reaction of organo selenides with organo magnesium reagents:** A mixture of organo selenide (0.25 mmol) and Pd(PPh₃)₄ (0.1 equiv) were dissolved in THF (3 mL). After this, the organo magnesium reagent (2 equiv) were added. The mixture was then heated in oil bath for 2h at 60 °C. After the reaction was cooled to ambient temperature, the crude reaction mixture was diluted with ethyl acetate (3 mL) and then washed with saturated solution of NH₄Cl (20 mL). The organic phase was separated, dried over MgSO₄ and concentrated under vacuum. The residue was purified by flash chromatography and eluted with hexane.

![Chemical Structure](image)

1-methoxy-4-(phenylethynyl)benzene (C₁₅H₁₂O)  3a.

Yield: 0.049g (94%). ¹H NMR (CDCl₃, 400 MHz): δ 7.55-7.49 (m, 4H), 7.39-7.32 (m,
3H), 6.91 (d, \( J = 8.8 \) Hz, 2H), 3.91 (s, 3H). \(^{13}\)C NMR (CDCl\(_3\), 100 MHz): \( \delta \) 159.6, 133.1, 128.3, 127.9, 123.6, 115.4, 114.0, 89.4, 88.1, 55.3. MS (EI, 70 eV; m/z (relative intensity)): 208 (100), 193 (54), 165 (66), 63 (6).

![1-methyl-4-(phenylethynyl)benzene](image)

**1-methyl-4-(phenylethynyl)benzene\(^1\) (C\(_{15}\)H\(_{12}\)) 3b.** Yield: 0.039g (81\%). \(^1\)H NMR (CDCl\(_3\), 400 MHz): \( \delta \) 7.56-7.54 (m, 2H), 7.46 (d, \( J = 8.2 \) Hz, 2H), 7.37-7.35 (m, 3H), 7.19 (d, \( J = 8.2 \) Hz, 2H), 2.40 (s, 3H). \(^{13}\)C NMR (CDCl\(_3\), 100 MHz): \( \delta \) 138.4, 131.5, 131.4, 129.1, 128.3, 128.1, 123.5, 120.2, 89.6, 88.7, 21.5. MS (EI, 70 eV; m/z (relative intensity)): 192 (100), 165 (24), 64 (11), 51 (4).

![1,2-diphenylethyne](image)

**1,2-diphenylethyne\(^1\) (C\(_{14}\)H\(_{10}\)) 3c.** Yield: 0.039g (89\%). \(^1\)H NMR (CDCl\(_3\), 400 MHz): \( \delta \) 7.55-7.49 (m, 4H), 7.64-7.58 (m, 4H), 7.44-7.37 (m, 6H). \(^{13}\)C NMR (CDCl\(_3\), 100 MHz): \( \delta \) 131.7, 128.4, 128.3, 123.4, 89.5. MS (EI, 70 eV; m/z (relative intensity)): 178 (100), 152 (18), 89 (10), 76 (15).

![1-chloro-4-(phenylethynyl)benzene](image)

**1-chloro-4-(phenylethynyl)benzene\(^1\) (C\(_{14}\)H\(_9\)Cl) 3d.** Yield: 0.043g (81\%). \(^1\)H NMR (CDCl\(_3\), 400 MHz): \( \delta \) 7.57-7.54 (m, 2H), 7.50-7.47 (m, 2H), 7.40-7.37 (m, 5H). \(^{13}\)C NMR (CDCl\(_3\), 100 MHz): \( \delta \) 134.3, 132.8, 131.6, 129.7, 128.5, 128.4, 122.9, 121.8, 90.3, 88.3. MS (EI, 70 eV; m/z (relative intensity)): 212 (100), 176 (59), 151 (16), 88 (12), 75 (10).

![1-fluoro-4-(phenylethynyl)benzene](image)

**1-fluoro-4-(phenylethynyl)benzene\(^1\) (C\(_{14}\)H\(_9\)F) 3e.** Yield: 0.035g (72\%). \(^1\)H NMR (CDCl\(_3\), 400 MHz): \( \delta \) 7.58-7.52 (m, 4H), 7.41-7.36 (m, 3H), 7.10-7.04 (m, 2H). \(^{13}\)C NMR (CDCl\(_3\), 100 MHz): \( \delta \) 162.5 (d, \( J = 249.6 \) Hz), 133.5 (d, \( J = 8.1 \) Hz), 131.6, 128.3, 128.2, 1213.2, 119.5 (d, \( J = 3.6 \) Hz), 115.6 (d, \( J = 22.1 \) Hz), 89.1, 88.3. MS (EI, 70 eV; m/z (relative intensity)): 196 (100), 170 (22), 98 (15), 85 (11).

![1-nitro-3-(phenylethynyl)benzene](image)

**1-nitro-3-(phenylethynyl)benzene\(^1\) (C\(_{14}\)H\(_9\)NO) 3f.** Yield: 0.030g (54\%). \(^1\)H NMR (CDCl\(_3\), 400 MHz): \( \delta \) 8.40-8.39 (m, 1H), 8.20 (ddd, \( J = 8.3, 2.3, 1.1 \) Hz, 2H), 3.91 (s, 3H). \(^{13}\)C NMR (CDCl\(_3\), 100 MHz): \( \delta \) 137.2, 131.8, 129.3,
129.0, 128.5, 126.4, 125.2, 122.9, 122.2, 91.9, 86.9. MS (EI, 70 eV; m/z (relative intensity)): 223 (100), 176 (98), 151 (38), 88 (15).

![1-methoxy-2-(phenylethynyl)benzene](C15H12O) 3g. Yield: 0.034g (65%). ^1H NMR (CDCl₃, 400 MHz): δ 7.60-7.52 (m, 3H), 7.39-7.31 (m, 4H), 6.96 (ddd, J = 10.9, 8.7, 4.7 Hz, 1H), 3.95 (s, 3H). ^13C NMR (CDCl₃, 100 MHz): δ 160.1, 133.6, 131.7, 129.7, 128.2, 128.0, 123.7, 120.5, 112.7, 110.9, 93.4, 85.8, 55.9. MS (EI, 70 eV; m/z (relative intensity)): 208 (100), 165 (28), 131 (20), 73 (15).

![1-methoxy-4-(tolylethynyl)benzene](C16H14O) 3h. Yield: 0.041g (73%). ^1H NMR (CDCl₃, 400 MHz): δ 7.51-7.44 (m, 4H), 7.18 (d, J = 7.9 Hz, 2H), 6.91 (d, J = 8.8 Hz, 2H), 3.85 (s, 3H), 2.40 (s, 3H). ^13C NMR (CDCl₃, 100 MHz): δ 159.6, 138.0, 133.0, 131.3, 129.0, 120.6, 115.7, 114.0, 88.7, 88.2, 55.3, 21.4. MS (EI, 70 eV; m/z (relative intensity)): 222(39), 207 (100), 178 (26), 133 (16), 77 (14).

![1,2-bis(4-metoxyphenyl)ethyne](C16H14O2) 3i. Yield: 0.050g (84%). ^1H NMR (CDCl₃, 400 MHz): δ 7.49-7.46 (m, 4H), 6.91-6.87 (m, 4H), 3.85 (s, 6H). ^13C NMR (CDCl₃, 100 MHz): δ 159.4, 132.9, 115.8, 114.0, 88.0, 55.3. MS (EI, 70 eV; m/z (relative intensity)): 238 (100), 223 (92), 152 (47), 119 (15), 63 (28).

![1-choro-4-((4-methoxyphenyl)ethynyl)benzene](C12H11ClO) 3j. Yield: 0.043g (71%). ^1H NMR (CDCl₃, 400 MHz): δ 7.50-7.44 (m, 4H), 7.35-7.31 (m, 2H), 6.92-6.89 (m, 2H), 3.85 (s, 3H). ^13C NMR (CDCl₃, 100 MHz): δ 159.9, 133.9, 133.1, 132.6, 128.6, 122.2, 115.1, 114.1, 90.4, 87.0, 55.3. MS (EI, 70 eV; m/z (relative intensity)): 243 (70), 206 (100), 192 (13), 76 (8).

![1-bromo-4-((4-methoxyphenyl)ethynyl)benzene](C12H11BrO) 3k. Yield: 0.022g (77%). ^1H NMR (CDCl₃, 400 MHz): δ 7.55-7.48 (m, 4H), 7.36-7.34 (m, 2H), 6.93-6.89 (m, 2H), 3.86 (s, 3H). ^13C NMR (CDCl₃, 100 MHz):
δ 159.7, 135.4, 133.0, 131.4, 128.3, 127.9, 123.7, 114.0, 89.4, 88.1, 55.3. MS (EI, 70 eV; m/z (relative intensity)): 287 (70), 207 (100), 198 (68), 165 (50), 63 (5).

1-(hex-1-ynyl)-4-methoxybenzene$^1$ (C$_{13}$H$_{16}$O) 3I. Yield: 0.080g (77%). $^1$H NMR (CDCl$_3$, 400 MHz): δ 7.35 (d, J = 8.8 Hz, 2H), 6.84 (d, J = 8.8 Hz, 2H), 3.82 (s, 3H), 2.42 (t, J = 7.2 Hz, 2H), 1.63-1.43 (m, 4H), 0.93 (t, J = 7.2 Hz, 3H). $^{13}$C NMR (CDCl$_3$, 100 MHz): δ 159.0, 132.8, 116.4, 113.8, 88.7, 80.2, 55.2, 30.9, 22.0, 13.6. MS (EI, 70 eV; m/z (relative intensity)): 188 (13), 159 (9), 149 (47), 145 (100).

3-(4-methoxyphenyl)prop-2-yn-1-ol$^1$ (C$_{10}$H$_{10}$O$_2$) 3m. Yield: 0.021g (53%). $^1$H NMR (CDCl$_3$, 400 MHz): δ 7.41-7.36 (m, 2H), 6.86-6.84 (m, 2H), 4.49 (s, 2H), 3.82 (s, 3H), 1.96 (s, 1H). $^{13}$C NMR (CDCl$_3$, 100 MHz): δ 159.8, 133.2, 129.9, 113.9, 86.0, 85.7, 55.3, 51.7. MS (EI, 70 eV; m/z (relative intensity)): 162 (59), 148 (100), 131 (34), 91 (33), 65 (28).

(Z)-1-methoxy-4-styrylbenzene$^2$ (C$_{15}$H$_{14}$O) 3n. Yield: 0.040g (77%). $^1$H NMR (CDCl$_3$, 400 MHz): δ 7.30-7.21 (m, 6H), 6.79 (d, J = 8.8 Hz, 2H), 6.56-6.55 (m, 2H), 3.81 (s, 3H). $^{13}$C NMR (CDCl$_3$, 100 MHz): δ 158.7, 137.6, 130.2, 129.8, 129.7, 128.8, 128.7, 128.2, 126.9, 113.6, 55.2. MS (EI, 70 eV; m/z (relative intensity)): 210 (100), 16.5 (60), 152 (47), 63 (10).

2-(4-methoxyphenyl)pyridine$^3$ (C$_{12}$H$_{11}$NO) 3o. Yield: 0.033g (72%). $^1$H NMR (CDCl$_3$, 400 MHz): δ 8.67 (dd, J = 4.8, 0.7 Hz, 1H), 7.97 (d, J = 8.8 Hz, 2H), 7.75-7.67 (m, 2H), 7.19 (ddd, J = 7.0, 4.8, 1.4 Hz, 1H), 7.02 (d, J = 8.8 Hz, 2H), 3.88 (s, 3H). $^{13}$C NMR (CDCl$_3$, 100 MHz): δ 160.6, 157.2, 149.5, 136.6, 132.1, 128.3, 119.7, 114.2, 55.3. MS (EI, 70 eV; m/z (relative intensity)): 185 (100), 170 (51), 142 (47), 51 (4).
3-(4-methoxyphenyl)-2,5-diphenylselenophene\(^d\) (C\(_{23}\)H\(_{18}\)OSe) 3p. Yield: 0.052g (54%). \(^1\)H NMR (CDCl\(_3\), 400 MHz): \(\delta\) 7.63-7.60 (m, 3H), 7.43-7.39 (m, 2H), 7.34-7.25 (m, 8H), 6.86 (d, \(J = 8.8\) Hz, 2H), 3.84 (s, 3H). \(^1\)C NMR (CDCl\(_3\), 100 MHz): \(\delta\) 158.6, 148.2, 143.2, 140.5, 136.4, 136.2, 130.3, 130.2, 129.6, 129.2, 128.9, 128.4, 127.7, 127.2, 126.1, 113.8, 55.2. MS (EI, 70 eV; \(m/z\) (relative intensity)): 389 (5), 281 (36), 207 (100), 191 (20), 73 (43).

2-(4-methoxyphenyl)thiophene\(^5\) (C\(_{11}\)H\(_{10}\)OS) 3q. Yield: 0.028g (58%). \(^1\)H NMR (CDCl\(_3\), 400 MHz): \(\delta\) 7.56 (d, \(J = 8.8\) Hz, 2H), 7.24-7.22 (m, 2H), 7.08-7.06 (m, 1H), 6.94 (d, \(J = 8.8\) Hz, 2H), 3.86 (s, 3H). \(^1\)C NMR (CDCl\(_3\), 100 MHz): \(\delta\) 159.2, 144.3, 127.9, 1127.3, 127.2, 123.8, 122.1, 114.3, 55.4. MS (EI, 70 eV; \(m/z\) (relative intensity)): 190 (77), 175 (100), 115 (12), 77 (10).

2-(4-methoxyphenyl)benzo[\(d\)]thiazole\(^6\) (C\(_{14}\)H\(_{11}\)NOS) 3r. Yield: 0.020g (32%). \(^1\)H NMR (CDCl\(_3\), 400 MHz): \(\delta\) 8.08-8.04 (m, 3H), 7.89 (ddd, \(J = 8.0, 1.3, 0.6\) Hz, 1H), 7.51-7.47 (m, 1H), 7.37 (ddd, \(J = 8.0, 7.2, 1.2\) Hz, 1H), 7.02 (d, \(J = 8.8\) Hz, 2H), 3.90 (s, 3H). \(^1\)C NMR (CDCl\(_3\), 100 MHz): \(\delta\) 167.8, 161.9, 154.3, 134.9, 129.1, 126.6, 126.2, 124.8, 122.9, 121.5, 114.4, 55.4. MS (EI, 70 eV; \(m/z\) (relative intensity)): 245 (100), 225 (46), 198 (59), 73 (43).

2-(phenylethynyl)thiophene\(^4\) (C\(_{12}\)H\(_8\)S) 4a. Yield: 0.038g (82%). \(^1\)H NMR (CDCl\(_3\), 400 MHz): \(\delta\) 7.57-7.53 (m, 2H), 7.39-7.36 (m, 3H), 7.32-7.30 (m, 2H), 7.05-7.03 (m, 1H). \(^1\)C NMR (CDCl\(_3\), 100 MHz): \(\delta\) 132.5, 131.8, 131.4, 129.2, 128.3, 127.2, 127.1, 123.0, 93.0, 82.6. MS (EI, 70 eV; \(m/z\) (relative intensity)): 184 (100), 152 (24), 139 (23), 51 (2).
2-(phenylethynyl)furan	extsuperscript{1} (C\textsubscript{12}H\textsubscript{8}O) 4b. Yield: 0.024g (58%). \textsuperscript{1}H NMR (CDCl\textsubscript{3}, 400 MHz): δ 7.56-7.54 (m, 2H), 7.45-7.44 (m, 1H), 7.38-7.35 (m, 3H), 6.68-6.67 (m, 1H), 6.46-6.44 (m, 1H). \textsuperscript{13}C NMR (CDCl\textsubscript{3}, 100 MHz): δ 143.6, 137.3, 131.4, 128.6, 128.3, 122.4, 115.1, 110.9, 93.2, 74.4. MS (EI, 70 eV; m/z (relative intensity)): 168 (75), 139 (100), 113 (13), 63 (10).

2-(thiophen-2-yl)pyridine	extsuperscript{3} (C\textsubscript{9}H\textsubscript{7}NS) 4c. Yield: 0.033g (82%). \textsuperscript{1}H NMR (CDCl\textsubscript{3}, 400 MHz): δ 8.59 (ddd, J = 4.9, 1.7, 1.1 Hz, 1H), 7.72-7.61 (m, 3H), 7.41 (dd, J = 5.1, 1.1 Hz, 1H), 7.17-7.12 (m, 2H). \textsuperscript{13}C NMR (CDCl\textsubscript{3}, 100 MHz): δ 152.6, 149.5, 141.2, 136.6, 128.0, 127.5, 124.6, 121.8, 118.8. MS (EI, 70 eV; m/z (relative intensity)): 161 (100), 117 (26), 89 (13), 51 (8).

**General procedure for Sonogashira cross-coupling reaction of organo selenides with terminal alkynes:** A mixture of organo selenide (0.25 mmol), PdCl\textsubscript{2}(PPh\textsubscript{3})\textsubscript{2} (0.1 equiv), terminal alkyne (4 equiv) and Et\textsubscript{3}N (1.0 equiv) were dissolved in DMF (3 mL). After this, the Cu(OAc)\textsubscript{2}.H\textsubscript{2}O (0.2 equiv) were added. The Schlenk was then heated in oil bath for 24h at 80 °C. After the reaction was cooled to ambient temperature, the crude reaction mixture was diluted with ethyl acetate (3 mL) and then washed with saturated solution of NH\textsubscript{4}Cl (20 mL). The organic phase was separated, dried over MgSO\textsubscript{4} and concentrated under vacuum. The residue was purified by flash chromatography and eluted with a mixture of hexane/acetate (9:1).

2-methyl-6-phenylhexa-3,5-diyn-2-ol\textsuperscript{7} (C\textsubscript{13}H\textsubscript{12}O) 5a. Yield: 0.042g (93%). \textsuperscript{1}H NMR (CDCl\textsubscript{3}, 400 MHz): δ 7.49-7.26 (m, 5H), 2.09 (sl, 1H), 1.58 (s, 6H). \textsuperscript{13}C NMR (CDCl\textsubscript{3}, 100 MHz): δ 132.5, 129.2, 128.4, 121.5, 86.7, 78.8, 73.1, 67.0, 65.7, 31.1. MS (EI, 70 eV; m/z (relative intensity)): 184 (42), 169 (100), 141 (57), 115 (48), 75 (9).

1-(phenylbuta-1,3-diynyl)cyclohexanol\textsuperscript{7} (C\textsubscript{16}H\textsubscript{16}O) 5b. Yield: 0.035g (63%). \textsuperscript{1}H NMR (CDCl\textsubscript{3}, 400 MHz): δ 7.53-7.50 (m, 2H), 7.40-7.32 (m,
3H), 2.07-1.98 (m, 3H), 1.77-1.57 (m, 8H). $^{13}$C NMR (CDCl$_3$, 100 MHz): $\delta$ 132.5, 129.2, 128.4, 121.7, 86.2, 78.5, 73.4, 69.3, 68.9, 39.7, 25.1, 23.1. MS (EI, 70 eV; m/z (relative intensity)): 224 (65), 181 (100), 167 (87), 126 (67), 55 (57).

**6-(4-chlorophenyl)-2-methylhexa-3,5-diyn-2-ol**\(^7\) (C$_{13}$H$_{11}$ClO) 5c. Yield: 0.042g (88%). $^1$H NMR (CDCl$_3$, 400 MHz): $\delta$ 7.42-7.27 (m, 4H), 2.34 (sl, 1H), 1.58 (s, 6H). $^{13}$C NMR (CDCl$_3$, 100 MHz): $\delta$ 135.4, 133.7, 128.8, 120.0, 87.3, 74.1, 69.0, 66.8, 65.7, 31.1. MS (EI, 70 eV; m/z (relative intensity)): 184 (42), 169 (100), 141 (57), 115 (48), 75 (9).

**2-methyl-6-p-tolylhexa-3,5-diyn-2-ol**\(^7\) (C$_{14}$H$_{14}$O) 5d. Yield: 0.044g (88%). $^1$H NMR (CDCl$_3$, 400 MHz): $\delta$ 7.25 (d, $J$ = 7.9 Hz, 2H), 7.00 (d, $J$ = 7.9 Hz, 2H), 2.23-2.13 (m, 4H), 1.42 (s, 6H). $^{13}$C NMR (CDCl$_3$, 100 MHz): $\delta$ 139.6, 132.4, 129.2, 118.5, 86.5, 79.1, 72.6, 67.2, 65.7, 31.2, 21.5. MS (EI, 70 eV; m/z (relative intensity)): 198 (75), 139 (100), 113 (13), 63 (10).

**1,4-diphenylbuta-1,3-diyne**\(^7\) (C$_{16}$H$_{10}$) 5e. Yield: 0.047g (93%). $^1$H NMR (CDCl$_3$, 400 MHz): $\delta$ 7.58-7.55 (m, 4H), 7.42-7.34 (m, 6H). $^{13}$C NMR (CDCl$_3$, 100 MHz): $\delta$ 132.5, 129.2, 128.4, 121.9, 81.6, 74.0. MS (EI, 70 eV; m/z (relative intensity)): 202 (100), 150 (13), 133 (12), 101 (12), 73 (18).

**References**


SELECTED SPECTRA

3a
\[
\begin{align*}
\text{Cl} & \quad \equiv & \quad \text{OMe} \\
\end{align*}
\]
Me

5d

OH

δ (ppm)