Supporting Information
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Silver-Catalyzed Efficient Synthesis of Vinylene Carbonate Derivatives from Carbon Dioxide

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1. General

The $^1$H and $^{13}$C NMR spectra were recorded with a JEOL model AL-400, alpha-400 or ECX-400 spectrometer using CDCl$_3$ as the solvent. The IR spectra were measured with a Thermo Electron Corporation model NICOLET 6700 FT-IR spectrometer. The melting points were measured with a Stanford Research Systems MPA100. The ESI high resolution mass spectra were obtained using a Waters LCT Premier XE mass spectrometer. Column chromatography was conducted on silica gel (Kanto 60 N). The dehydrated THF and CH$_2$Cl$_2$ were purchased from Kanto Chemical Co., Inc., and used without further purification. All other solvents, such as toluene, benzene, etc., were distilled before use. AgOAc was purchased from Kanto Chemical Co., Inc., and Ag(II) picolinate was purchased from Tokyo Chemical Industry Co., Ltd., and used without further purification. DBU was purchased from Wako Pure Chemical Industries, Ltd., and used without further purification.
2. Supporting Tables

Table S1 The investigation of silver salts

<table>
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<th>Entry</th>
<th>Ag Salt</th>
<th>Yield / %</th>
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<tr>
<td>1</td>
<td>AgOAc</td>
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<tr>
<td>2</td>
<td>AgOBz</td>
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<tr>
<td>3</td>
<td>AgOCOCF₃</td>
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<tr>
<td>4</td>
<td>AgOTs</td>
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</tr>
<tr>
<td>5</td>
<td>AgOTf</td>
<td>85</td>
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<tr>
<td>6</td>
<td>AgSCN</td>
<td>NR⁸</td>
</tr>
<tr>
<td>7</td>
<td>Ag(picolinate)₂</td>
<td>NDᵇ</td>
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</tbody>
</table>

<sup>⁸ No reaction. ⁰ No desired product was detected.</sup>

Table S2 The investigation of bases

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<th>Yield / %</th>
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<tr>
<td>2</td>
<td>DBN</td>
<td>53</td>
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<tr>
<td>3</td>
<td>TBD</td>
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<td>Pyridine</td>
<td>NR&lt;sup&gt;a&lt;/sup&gt;</td>
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<tr>
<td>6</td>
<td>tPr₂NEt</td>
<td>NR&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

<sup>a No reaction.</sup>
Table S3 The investigation of solvents

\[
\begin{align*}
\text{1a} + \text{CO}_2 \xrightarrow{40 \text{ mol}\% \text{ DBU}} \xrightarrow{10 \text{ mol}\% \text{ AgOAc}} & \text{Solvent, 30 °C} \\
& (1.5 \text{ MPa}) 24 \text{ h} \\
\end{align*}
\]

<table>
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<th>Entry</th>
<th>Solvent</th>
<th>Yield / %</th>
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<td>Benzene</td>
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<td>3</td>
<td>CH(_2)Cl(_2)</td>
<td>59</td>
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<tr>
<td>4</td>
<td>THF</td>
<td>89</td>
</tr>
<tr>
<td>6</td>
<td>1,4-Dioxane</td>
<td>- (^a)</td>
</tr>
<tr>
<td>7</td>
<td>CH(_3)CN</td>
<td>- (^a)</td>
</tr>
<tr>
<td>8</td>
<td>DMF</td>
<td>32</td>
</tr>
</tbody>
</table>

\(^a\) Complex mixture

Table S4 The examination of reaction time.

The isomerization would be too fast to isolate the cyclic carbonate 3 having exo-olefin. So, for the reaction mechanism, the reaction of propargylic alcohol 1 was stopped in 0.5 h, 8 h and 18 h and the yields of the cyclic carbonate 2 and vinylene carbonate 2 were determined by \(^1\)H-NMR (2-Methoxynaphtalene was used as an internal standard) after the silver metal residue was removed by the flash silica-gel column chromatography (SiO\(_2\)). Base on NMR analysis, it was found that the yield of the desired product 2 was increased with decreasing of the cyclic carbonate.

\[
\begin{align*}
\text{CO}_2 (1.5 \text{ MPa}) & \xrightarrow{40 \text{ mol}\% \text{ DBU}} \xrightarrow{10 \text{ mol}\% \text{ AgOAc}} \\
& \text{Toluene, 30 °C} \\
\text{1} & \text{2} & \text{3} \\
\end{align*}
\]

<table>
<thead>
<tr>
<th>Entry</th>
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<th>2</th>
<th>3</th>
</tr>
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<td>66</td>
<td>-</td>
<td>-</td>
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<tr>
<td>2</td>
<td>8</td>
<td>3</td>
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<td>9</td>
</tr>
<tr>
<td>3</td>
<td>18</td>
<td>-</td>
<td>81</td>
<td>5</td>
</tr>
<tr>
<td>4</td>
<td>24</td>
<td>-</td>
<td>94</td>
<td>-</td>
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</table>
3. Methods

**General Procedure for the synthesis of the starting materials.**

To a solution of alkyne (6 mmol) in THF (6 mL) at -78 °C was added dropwise \( n \)-BuLi (1.6 M in hexane, 3.1 mL, 5 mmol). After stirring for 30 min, aldehyde (5 mmol) was added and the solution warmed to 0 °C. After 6 h, the solution was quenched with sat. aq. NH\(_4\)Cl, the mixture was extracted with Et\(_2\)O, dried over Na\(_2\)SO\(_4\), filtered, and concentrated under reduced pressure. The crude product was purified by column chromatography (SiO\(_2\), eluted with hexane/EtOAc) to afford the desired propargylic alcohol \( \mathbf{1} \).

**General Procedure for the Synthesis of Vinylene Carbonate**

The reaction was performed using pressure test-tube equipped with a stirring bar in a 50 mL autoclave. To a solution of propargyl alcohol \( \mathbf{1} \) (0.30 mmol) and silver acetate (0.030 mmol) in toluene (2.0 mL) was added DBU (0.12 mmol) under an inert gas. Immediately, CO\(_2\) gas was purged and the reaction mixture was stirred at 30°C under 1.5 MPa CO\(_2\) pressure. After the reaction was completed, the purification by column chromatography gave the corresponding carbonate \( \mathbf{2} \).
4. Material Data

1-Phenyl-2-heptyn-1-ol (1a):

Colorless oil; $^1$H NMR (400 MHz, CDCl$_3$): $\delta=0.92$ (t, $J=7.3$ Hz, 3H), 1.39-1.56 (m, 4H), 2.10 (d, $J=5.9$ Hz, 1H), 2.28 (t, $J=7.1$ Hz, 2H), 5.45 (d, $J=5.9$ Hz, 1H), 7.32-7.40 (m, 3H), 7.54 (d, $J=6.8$ Hz, 2H); $^{13}$C NMR (100 MHz, CDCl$_3$): $\delta=13.6$, 18.5, 21.9, 30.6, 64.8, 79.9, 87.7, 126.6, 128.2, 128.5, 141.2.

1-$p$-Tolyl-2-heptyn-1-ol (1b):

Colorless oil; $^1$H NMR (400 MHz, CDCl$_3$): $\delta=0.92$ (t, $J=7.3$ Hz, 3H), 1.39-1.55 (m, 4H), 2.07 (d, $J=5.9$ Hz, 1H), 2.27 (t, $J=7.0$ Hz, 2H), 2.36 (s, 3H), 5.42 (d, $J=5.9$ Hz, 1H), 7.18 (d, $J=8.3$ Hz, 3H), 7.43 (d, $J=8.3$ Hz, 2H); $^{13}$C NMR (100 MHz, CDCl$_3$): $\delta=13.6$, 18.4, 21.9, 30.5, 64.1, 79.4, 88.1, 122.1, 128.3, 131.6, 140.2.

1-(4-Bromophenyl)-2-heptyn-1-ol (1c):

Colorless oil; $^1$H NMR (400 MHz, CDCl$_3$): $\delta=0.92$ (t, $J=7.3$ Hz, 3H), 1.39-1.56 (m, 4H), 2.22-2.29 (m, 3H), 5.40 (s, 1H), 7.41 (d, $J=8.3$ Hz, 2H), 7.49 (d, $J=8.3$ Hz, 2H); $^{13}$C NMR (100 MHz, CDCl$_3$): $\delta=13.6$, 18.5, 21.1, 22.0, 64.7, 80.0, 87.5, 126.6, 129.2, 138.0, 138.4.

1-(2-Naphthyl)-2-heptyn-1-ol (1d):

White solid; m.p.: 44.3 °C; $^1$H NMR (400 MHz, CDCl$_3$): $\delta=0.93$ (t, $J=7.3$ Hz, 3H), 1.42-1.57 (m, 4H), 2.24 (d, $J=5.9$ Hz, 1H), 2.31 (t, $J=7.0$ Hz, 2H), 5.62 (d, $J=5.9$ Hz, 1H), 7.48-7.50 (m, 2H), 7.64-7.67 (m, 1H), 7.83-7.87 (m, 3H), 7.98 (s, 1H); $^{13}$C NMR (100 MHz, CDCl$_3$): $\delta=13.6$, 18.5, 21.2, 30.6, 65.0, 79.9, 88.0, 124.7, 125.3, 126.2, 126.2, 127.6, 128.2, 128.4, 133.1, 133.2, 138.6; IR (KBr): 3186, 2952, 2943, 2859, 1508, 1427, 1366, 1286, 1173, 1121, 1004, 951, 862, 833, 764, 750; HRMS(ESI): [M+H]$^+$ calculated for C$_{17}$H$_{19}$O$^+$, 239.1430; found, 239.1432.

1-Phenyl-2-hexyn-1-ol (1e):

Colorless oil; $^1$H NMR (400 MHz, CDCl$_3$): $\delta=1.00$ (t, $J=7.3$ Hz, 3H), 1.55-1.60 (m, 2H), 2.15 (d, $J=6.3$ Hz, 1H), 2.26 (t, $J=7.1$ Hz, 2H), 5.46 (d, $J=6.3$ Hz, 1H), 7.32-7.40 (m, 3H), 7.55 (d, $J=6.8$ Hz,
2H); $^{13}$C NMR (100 MHz, CDCl$_3$): $\delta$ 13.5, 20.8, 22.0, 64.8, 80.0, 87.5, 126.6, 128.2, 128.5, 141.2; IR (KBr): 3364, 2964, 2934, 2873, 1493, 1455, 1380, 1277, 1134, 1033, 994, 761, 727, 698, 635; HRMS(ESI): [M+H]$^+$ calculated for C$_{12}$H$_{15}$O$^+$, 175.1117; found, 175.1115.

1,6-Diphenyl-2-hexyn-1-ol (1f):

[Chemical structure]

Colorless oil; $^1$H NMR (400 MHz, CDCl$_3$): $\delta$=1.83-1.91 (m, 2H), 2.14 (d, $J$ = 5.9, 1H), 2.73 (t, $J$ = 7.6, 2H), 5.46 (d, $J$ = 5.9 Hz, 1H), 7.17-7.40 (m, 8H), 7.55 (d, $J$ = 7.3 Hz, 2H); $^{13}$C NMR (100 MHz, CDCl$_3$): $\delta$ 18.3, 30.1, 34.8, 64.8, 80.5, 87.2, 125.9, 126.6, 128.2, 128.3, 128.5, 141.2, 141.5; IR (KBr): 3372, 3062, 3027, 2941, 2860, 1495, 1454, 1430, 1274, 1131, 1030, 1002, 746, 699, 635; HRMS(ESI): [M+H]$^+$ calculated for C$_{18}$H$_{19}$O$^+$, 251.1430; found, 251.1671.

4-Methyl-1-phenyl-2-heptyn-1-ol (1g):

[Chemical structure]

Colorless oil; $^1$H NMR (400 MHz, CDCl$_3$): $\delta$=0.92 (t, $J$ = 7.1 Hz, 3H), 1.19 (s, 3H), 1.39-1.52 (m, 4H), 2.13 (d, $J$ = 6.3 Hz, 1H), 2.51-2.56 (m, 1H), 5.46 (d, $J$ = 6.3 Hz, 1H), 7.30-7.40 (m, 3H), 7.55 (d, $J$ = 7.3 Hz, 2H); $^{13}$C NMR (100 MHz, CDCl$_3$): $\delta$ 13.9, 20.5, 20.9, 25.7, 38.9, 64.8, 79.9, 92.1, 126.7, 128.2, 128.5, 141.3; IR (KBr): 3356, 3087, 3032, 2961, 2932, 2873, 1493, 1455, 1378, 1332, 1275, 1193, 1167, 1001, 979, 917, 759, 697, 634; HRMS(ESI): [M+H]$^+$ calculated for C$_{14}$H$_{19}$O$^+$, 203.1430; found, 203.1427.

4,4-Dimethyl-1-phenyl-2-pentyn-1-ol (1h):

[Chemical structure]

Colorless oil; $^1$H NMR (400 MHz, CDCl$_3$): $\delta$=1.27 (s, 9H), 2.10 (d, $J$ = 6.0 Hz, 2H), 5.45 (d, $J$ = 6.0 Hz, 2H), 7.31-7.40 (m, 3H), 7.55 (d, $J$ = 7.2 Hz, 2H); $^{13}$C NMR (100 MHz, CDCl$_3$): $\delta$ 27.5, 30.9, 64.7, 78.3, 95.8, 126.7, 128.1, 128.5, 141.2.

4-Methoxy-1-phenyl-2-butyn-1-ol (1i):

[Chemical structure]

Colorless oil; $^1$H NMR (400 MHz, CDCl$_3$): $\delta$=3.39 (s, 3H), 4.18 (s, 2H), 5.51 (s, 1H), 7.33-7.41 (m, 3H), 7.54 (d, $J$ = 7.8 Hz, 2H); $^{13}$C NMR (100 MHz, CDCl$_3$): $\delta$ 57.7, 59.9, 64.5, 82.4, 86.2, 126.6, 128.4, 128.6, 141.3; IR (KBr): 3387, 2936, 2892, 2826, 1494, 1453, 1377, 1359, 1280, 1189, 1120, 1094, 1003, 904, 761, 734, 700, 643; HRMS(ESI): [M+H]$^+$ calculated for
C_{11}H_{13}O^+, 177.0910; found, 177.0960.

6-\{(tert-Butyldimethylsilyl)oxy\}-1-phenyl-2-hexyn-1-ol (1j):
Colorless oil; \textsuperscript{1}H NMR (400 MHz, CDCl\textsubscript{3}): \(\delta=0.05\) (s, 6H), 0.89 (s, 9H), 1.71-1.78 (m, 2H), 2.14 (d, \(J=5.9\) Hz, 1H), 2.37 (t, \(J=7.1\) Hz, 2H), 3.69 (t, \(J=5.9\) Hz, 2H), 5.45 (d, \(J=5.9\) Hz, 1H), 7.32-7.40 (m, 3H), 7.54 (d, \(J=7.3\) Hz, 2H); \textsuperscript{13}C NMR (100 MHz, CDCl\textsubscript{3}): \(\delta=-5.36, 15.2, 18.3, 25.9, 31.5, 61.6, 64.8, 80.0, 87.2, 126.6, 128.2, 128.5, 141.2\); IR (KBr): 3405, 3064, 3032, 2954, 2930, 2885, 2857, 1463, 1453, 1389, 1361, 1256, 1104, 1006, 974, 836, 777, 698; HRMS(ESI): [M+H]\(^+\) calculated for C\textsubscript{18}H\textsubscript{29}O\(^+\), 305.1931; found, 305.1920.

1-Styryl-2-propyn-1-ol (1l):
White solid; \textsuperscript{1}H NMR (400 MHz, CDCl\textsubscript{3}): \(\delta=1.98\) (d, \(J=6.3\) Hz, 1H), 2.65 (d, \(J=2.2\) Hz, 1H), 5.06-5.09 (m, 1H), 6.31 (dd, \(J=5.9\) Hz, \(J=16\) Hz, 1H), 6.81 (d, \(J=16\) Hz, 1H), 7.26-7.36 (m, 3H), 7.42 (d, \(J=7.0\) Hz, 2H); \textsuperscript{13}C NMR (100 MHz, CDCl\textsubscript{3}): \(\delta\) 62.9, 74.8, 82.8, 126.9, 127.5, 128.3, 128.7, 132.4, 136.0.

4-Pentyl-5-phenyl-1,3-dioxol-2-one (2a):
Colorless oil; \textsuperscript{1}H NMR (400 MHz, CDCl\textsubscript{3}): \(\delta=0.91\) (t, \(J=7.1\) Hz, 3H), 1.37 (m, 4H), 1.71 (m, 2H), 2.69 (t, \(J=7.6\) Hz, 2H), 7.37-7.48 (m, 5H); \textsuperscript{13}C NMR (100 MHz, CDCl\textsubscript{3}): \(\delta=13.9, 22.3, 24.8, 26.5, 31.1, 125.2, 125.6, 128.9, 129.0, 137.2, 139.2, 152.4\); IR (KBr): 2958, 2932, 2862, 1821, 1449, 1248, 1188, 1098, 1057, 1026, 977, 760, 692; HRMS(ESI): [M+H]\(^+\) calculated for C\textsubscript{14}H\textsubscript{17}O\textsubscript{3}\(^+\), 233.1172; found, 233.1177.

4-Pentyl-5-p-Tolyl-1,3-dioxol-2-one (2b):
Colorless oil; \textsuperscript{1}H NMR (400 MHz, CDCl\textsubscript{3}): \(\delta=0.91\) (t, \(J=7.1\) Hz, 3H), 1.33-1.40 (m, 4H), 1.68-1.71 (m, 2H), 2.39 (s, 3H), 2.66 (t, \(J=7.6\) Hz, 2H), 7.25 (d, \(J=7.8\) Hz, 2H), 7.35 (d, \(J=7.8\) Hz, 2H); \textsuperscript{13}C NMR (100 MHz, CDCl\textsubscript{3}): \(\delta=13.9, 21.3, 22.3, 24.8, 26.5, 31.1, 125.2, 127.5, 129.6, 129.7, 138.6, 139.2, 152.5\); IR (KBr): 2958, 2931, 2862, 1822, 1516, 1458, 1248, 1185, 1098, 1053, 1018, 976, 818, 769; HRMS(ESI): [M+H]\(^+\) calculated for C\textsubscript{15}H\textsubscript{19}O\textsubscript{3}\(^+\), 247.1329; found, 247.1328.
4-(4-Bromophenyl)-5-pentyl-1,3-dioxol-2-one (2c):

Colorless oil; $^1$H NMR (400 MHz, CDCl$_3$): $\delta$=0.91 (t, $J$ = 7.1 Hz, 3H), 1.35-1.39 (m, 4H), 1.69-1.72 (m, 2H), 2.66 (t, $J$ = 7.6 Hz, 2H), 7.33 (d, $J$ = 8.8 Hz, 2H); $^{13}$C NMR (100 MHz, CDCl$_3$): $\delta$=13.9, 22.3, 24.9, 26.4, 31.1, 123.1, 124.5, 126.6, 132.2, 136.4, 139.6, 152.0; IR (KBr): 2958, 2932, 2862, 1824, 1490, 1400, 1248, 1188, 1074, 1051, 1008, 978, 826, 768; HRMS(ESI): [M+H]$^+$ calculated for C$_{14}$H$_{16}$BrO$_3$+, 311.0277; found, 311.0276.

4-(2-Naphthyl)-5-Pentyl-1,3-dioxol-2-one (2d):

White solid; m.p.: 55.5 °C; $^1$H NMR (400 MHz, CDCl$_3$): $\delta$=0.92 (t, $J$ = 7.1 Hz, 3H), 1.35-1.45 (m, 4H), 1.71-1.78 (m, 2H), 2.76 (t, $J$ = 7.6 Hz, 2H), 7.51-7.56 (m, 3H), 7.84-7.97 (m, 4H); $^{13}$C NMR (100 MHz, CDCl$_3$): $\delta$=13.9, 22.3, 25.0, 26.6, 31.1, 122.1, 122.9, 124.9, 127.0, 127.1, 127.8, 127.9, 128.3, 128.9, 133.0, 133.1, 139.5, 152.4; IR (KBr): 2956, 2933, 2857, 1800, 1689, 1466, 1230, 1187, 1060, 977, 818, 768, 749; HRMS(ESI): [M+H]$^+$ calculated for C$_{18}$H$_{19}$O$_3$+, 283.1329; found, 283.1346.

4-Butyl-5-phenyl-1,3-dioxol-2-one (2e):

Colorless oil; $^1$H NMR (400 MHz, CDCl$_3$): $\delta$=0.95 (t, $J$ = 7.4 Hz, 3H), 1.39-1.48 (m, 2H), 1.67-1.73 (m, 2H), 2.70 (t, $J$ = 7.5 Hz, 2H), 7.37-7.47 (m, 5H); $^{13}$C NMR (100 MHz, CDCl$_3$): $\delta$=13.8, 22.3, 24.7, 29.0, 125.3, 125.8, 129.1, 129.2, 137.4, 139.3, 152.5; IR (KBr): 2960, 2933, 2874, 1824, 1449, 1248, 1189, 1093, 1057, 1025, 979, 761, 693; HRMS(ESI): [M+H]$^+$ calculated for C$_{13}$H$_{15}$O$_3$+, 219.1016; found, 219.1031.

4-Phenyl-5-(4-phenylbutyl)-1,3-dioxol-2-one (2f):

Colorless oil; $^1$H NMR (400 MHz, CDCl$_3$): $\delta$=1.73-1.75 (m, 4H), 2.65-2.72 (m, 4H), 7.14-7.44 (m, 10H); $^{13}$C NMR (100 MHz, CDCl$_3$): $\delta$=24.7, 26.3, 30.6, 35.4, 125.2, 125.5, 125.9, 128.3, 128.4, 129.0, 129.1, 137.3, 138.8, 141.6, 152.3; IR (KBr): 3027, 2935, 2860, 1817, 1497, 1449, 1260, 1236, 1188, 1083, 1059, 1025, 979, 760, 694, 672; HRMS(ESI): [M+H]$^+$ calculated for C$_{19}$H$_{19}$O$_3$+, 295.1329; found, 295.1326.
4-(2-Methylpentyl)-5-phenyl-1,3-dioxol-2-one (2g):

Colorless oil; $^1$H NMR (400 MHz, CDCl$_3$): $\delta$=0.90 (t, $J$ = 6.7 Hz, 3H), 0.98 (d, $J$ = 6.7 Hz, 3H), 1.19-1.42 (m, 4H), 1.89-2.01 (m, 1H), 2.50 (dd, $J$ = 8.2 Hz, $J$ = 15.1 Hz, 1H), 2.68 (dd, $J$ = 6.2 Hz, $J$ = 15.1 Hz, 1H), 7.36-7.49 (m, 5H); $^{13}$C NMR (100 MHz, CDCl$_3$): $\delta$=14.2, 19.6, 20.1, 31.6, 32.4, 38.9, 125.3, 125.8, 129.1, 129.2, 138.2, 138.7, 152.5; IR (KBr): 2960, 2930, 2873, 1824, 1458, 1449, 1289, 1261, 1240, 1180, 1101, 1058, 1026, 980, 761, 693, 672; HRMS(ESI): [M+H]$^+$ calculated for C$_{15}$H$_{19}$O$_3$+, 247.1329; found, 247.1354.

4-(2,2-Dimethylpropyl)-5-phenyl-1,3-dioxol-2-one (2h):

Colorless oil; $^1$H NMR (400 MHz, CDCl$_3$): $\delta$=1.05 (s, 9H), 2.61 (s, 2H), 7.37-7.53 (m, 5H); $^{13}$C NMR (100 MHz, CDCl$_3$): $\delta$=29.8, 32.9, 38.5, 125.5, 125.8, 129.0, 129.3, 138.1, 139.0, 152.4; IR (KBr): 2959, 2907, 2871, 1820, 1476, 1448, 1369, 1306, 1244, 1184, 1140, 1059, 1024, 981, 763, 748, 693, 672; HRMS(ESI): [M+H]$^+$ calculated for C$_{14}$H$_{17}$O$_3$+, 233.1172; found, 233.1177.

4-(2-Methoxyethyl)-5-phenyl-1,3-dioxol-2-one (2i):

Colorless oil; $^1$H NMR (400 MHz, CDCl$_3$): $\delta$=2.94 (t, $J$ = 6.3 Hz, 2H), 3.38 (s, 3H), 3.69 (t, $J$ = 6.2 Hz, 2H), 7.39-7.46 (m, 3H), 7.55 (d, $J$ = 7.0 Hz, 2H); $^{13}$C NMR (100 MHz, CDCl$_3$): $\delta$=26.1, 59.1, 68.7, 125.4, 125.6, 129.0, 129.4, 136.3, 138.9, 152.4; IR (KBr): 2928, 2896, 1817, 1500, 1449, 1292, 1252, 1275, 1212, 1189, 1116, 1066, 1066, 1025, 995, 761, 695, 672; HRMS(ESI): [M+H]$^+$ calculated for C$_{12}$H$_{13}$O$_3$+, 221.0808; found, 221.0821.

4-[(4-(tert-Butyldimethylsilyl)oxy)butyl]-5-phenyl-1,3-dioxol-2-one (2j):

Colorless oil; $^1$H NMR (400 MHz, CDCl$_3$): $\delta$=0.043 (s, 6H), 0.89 (s, 9H), 1.58-1.64 (m, 2H), 1.77-1.81 (m, 2H), 2.73 (t, $J$ = 7.6 Hz, 2H), 3.65 (t, $J$ = 6.1 Hz, 2H), 7.38-7.48 (m, 5H); $^{13}$C NMR (100 MHz, CDCl$_3$): $\delta$=−5.2, 18.5, 23.6, 24.8, 26.1, 32.1, 62.5, 125.4, 125.8, 129.1, 129.2, 137.5, 139.2, 152.5; IR (KBr): 2954, 2930, 2885, 2858, 1825, 1472, 1449, 1254, 1188, 1103, 1057, 1026, 979, 837, 776, 761, 694; HRMS(ESI): [M+H]$^+$ calculated for C$_{19}$H$_{29}$O$_4$Si$,^+$, 349.1830; found, 349.1751.
4-Methyl-5-phenyl-1,3-dioxol-2-one (2k):

White solid; $^1$H NMR (400 MHz, CDCl$_3$): $\delta$=2.38 (s, 3H), 7.39-7.46 (m, 5H); $^{13}$C NMR (100 MHz, CDCl$_3$): $\delta$=10.9, 125.2, 125.7, 129.1, 129.1, 135.2, 137.5, 152.3.

4-Methyl-5-styryl-1,3-dioxol-2-one (2l):

Yellow solid; m.p.: 121.9 °C (decomposed); $^1$H NMR (400 MHz, CDCl$_3$): $\delta$=2.24 (s, 3H), 6.53 (d, $J$ = 16 Hz, 1H), 6.89 (d, $J$ = 16 Hz, 1H), 7.30-7.45 (m, 5H); $^{13}$C NMR (100 MHz, CDCl$_3$): $\delta$=9.62, 109.0, 126.6, 128.6, 128.8, 130.3, 135.6, 136.1, 137.2, 149.2; IR (KBr): 1800, 1702, 1397, 1234, 1190, 983, 955, 765, 749, 688, 606; HRMS(ESI): [M+H]$^+$ calculated for C$_{12}$H$_{11}$O$_3$, 203.0703; found, 203.0702.