

Superbase-catalyzed addition of ketones to propargyl and allenyl ethers in the KOH (KO^tBu)/DMSO system

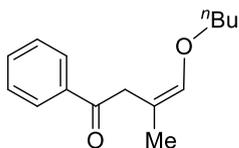
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and Boris A. Trofimov**

<i>General procedure</i>	1
<i>General information</i>	1
<i>(Z)</i> -4-Butoxy-3-methyl-1-phenyl-3-buten-1-one 3b	2
<i>(Z)</i> -1-[1,1'-Biphenyl]-4-yl-4-butoxy-3-methyl-3-buten-1-one 3c	2
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General procedure for the reaction of ketones **1** with propargyl (or allenyl ethers) **2** in the KOH/DMSO or KO^tBu/DMSO system. A mixture of ketone **1** (2 mmol), propargyl (or allenyl ethers) **2** (2 mmol), KOH·0.5H₂O (0.13 g, 2 mmol) or KO^tBu (0.22 g, 2 mmol) in DMSO (7 mL) was heated (100 °C) and stirred for 1 h. The reaction mixture, after cooling (20-25 °C), was diluted with H₂O (10 mL), neutralized with NH₄Cl and extracted with Et₂O (5 mL x 4). The organic extract was washed with H₂O (10 mL x 3) and dried (K₂CO₃). Column chromatography (SiO₂, eluent hexane-diethyl ether with gradient from 1:0 to 3:1) of a crude residue after removal of the solvent gave the pure adducts **3-6**.

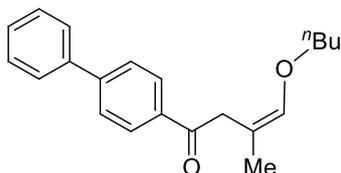
General information. ¹H and ¹³C NMR spectra were recorded on a Bruker AVANCE 400 instrument (400.13 and 100.61 MHz respectively) equipped with inverse gradient 5mm probe in CDCl₃ with HMDS as internal standard. All 2D NMR spectra were recorded using a standard gradient Bruker pulse programs. IR spectra were obtained on a “Bruker Vertex 70” spectrometer.

(Z)-4-Butoxy-3-methyl-1-phenyl-3-buten-1-one 3b: yield 0.06 g, 14%, yellow oil.



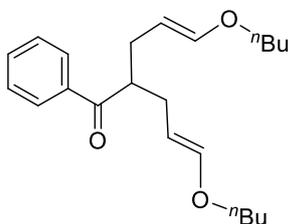
$^1\text{H NMR } \delta$: 7.92-7.90 (m, 2H, H_o), 7.52-7.49 (m, 2H, H_m), 7.41-7.38 (m, 1H, H_p), 5.91 (s, 1H, $\text{C}=\text{CH}-\text{O}^n\text{Bu}$), 3.66-3.62 (m, 2H, $\text{O}-\text{CH}_2-$), 3.45 (s, 2H, $\text{O}=\text{C}-\text{CH}_2-$), 1.60 (s, 3H, Me), 1.55-1.52 (m, 2H, $\text{O}-\text{CH}_2-\text{CH}_2-$), 1.34-1.31 (m, 2H, $-\text{CH}_2-\text{Me}$), 0.99-0.96 (m, 3H, $-\text{CH}_2-\text{Me}$). $^{13}\text{C NMR } \delta$: 198.1 ($\text{C}=\text{O}$), 144.1 ($\text{C}=\text{CH}-\text{O}^n\text{Bu}$), 137.1 (C_i), 132.7 (C_p), 128.6 (C_m), 128.4 (C_o), 107.9 ($\text{C}=\text{CH}-\text{O}^n\text{Bu}$), 71.8 ($\text{O}-\text{CH}_2-$), 43.7 ($\text{O}=\text{C}-\text{CH}_2-$), 32.0 ($\text{O}-\text{CH}_2-\text{CH}_2-$), 19.2 ($-\text{CH}_2-\text{Me}$), 14.0 ($-\text{CH}_2-\text{Me}$), 13.8 (Me). IR (film, $\nu_{\text{max}}/\text{cm}^{-1}$): 3086, 3061, 3029, 2960, 2931, 2873, 2734, 1960, 1726, 1679, 1652, 1600, 1583, 1450, 1379, 1234, 1203, 1071, 1002, 937, 755, 699. Found (%): C, 77.86; H, 8.81. Calc. for $\text{C}_{15}\text{H}_{20}\text{O}_2$ (%): C, 77.55; H, 8.68.

(Z)-1-[1,1'-Biphenyl]-4-yl-4-butoxy-3-methyl-3-buten-1-one 3c: yield 0.11 g, 18%, light yellow oil.



$^1\text{H NMR } \delta$: 8.02-7.98, 7.67-7.64, 7.50-7.30 (m, 9H, H_{Aryl}), 5.97 (s, 1H, $\text{C}=\text{CH}-\text{O}^n\text{Bu}$), 3.66-3.62 (m, 2H, $\text{O}-\text{CH}_2-$), 3.52 (s, 2H, $\text{O}=\text{C}-\text{CH}_2-$), 2.17 (s, 3H, Me), 1.55-1.52 (m, 2H, $\text{O}-\text{CH}_2-\text{CH}_2-$), 1.34-1.31 (m, 2H, $-\text{CH}_2-\text{Me}$), 0.99-0.96 (m, 3H, $-\text{CH}_2-\text{Me}$). $^{13}\text{C NMR } \delta$: 198.0 ($\text{C}=\text{O}$), 144.3 ($\text{C}=\text{CH}-\text{O}^n\text{Bu}$), 146.3, 140.0, 135.5, 129.6, 129.3, 128.5, 127.8, 127.2 (12C_{Aryl}), 108.0 ($\text{C}=\text{CH}-\text{O}^n\text{Bu}$), 72.0 ($\text{O}-\text{CH}_2-$), 43.9 ($\text{O}=\text{C}-\text{CH}_2-$), 31.8 ($\text{O}-\text{CH}_2-\text{CH}_2-$), 19.0 (CH_2-Me), 14.2 ($-\text{CH}_2-\text{Me}$), 13.8 (Me). IR (film, $\nu_{\text{max}}/\text{cm}^{-1}$): 3058, 3031, 2958, 2932, 2872, 1721, 1679, 1603, 1487, 1449, 1405, 1266, 1230, 1191, 1116, 1006, 910, 842, 765, 749, 748, 733, 697. Found (%): C, 81.72; H, 7.73. Calc. for $\text{C}_{21}\text{H}_{24}\text{O}_2$ (%): C, 81.78; H, 7.84.

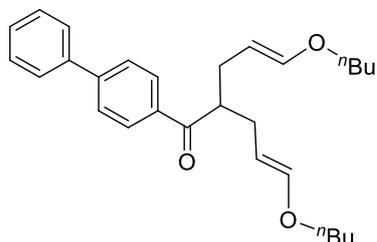
(E)-5-Butoxy-2-[(E)-3-butoxy-2-propenyl]-1-phenylpent-4-en-1-one 4b: yield 0.18 g, 26%, yellow oil.



$^1\text{H NMR } \delta$: 7.93-7.91 (m, 2H, H_o), 7.57-7.55 (m, 2H, H_m), 7.46-7.44 (m, 1H, H_p), 6.25 (d, 2H, $\text{CH}=\text{CH}-\text{O}^n\text{Bu}$, 3J 12.5 Hz), 4.66 (dt, 2H, $-\text{CH}=\text{CH}-\text{O}^n\text{Bu}$, 3J 12.5 Hz, 3J 7.7 Hz), 3.58-3.55 (m, 4H, $\text{O}-\text{CH}_2-$), 3.45-3.44 (m, 1H, $\text{O}=\text{C}-\text{CH}$), 2.37-2.33, 2.20-2.17 (m, 4H, $-\text{CH}_2-\text{CH}=\text{CH}-\text{O}^n\text{Bu}$), 1.57-1.55 (m, 4H, $\text{O}-\text{CH}_2-\text{CH}_2-$), 1.37-1.34 (m, 4H, $-\text{CH}_2-\text{Me}$), 0.94-0.92 (m, 6H, $-\text{CH}_2-\text{Me}$). $^{13}\text{C NMR } \delta$: 203.8 ($\text{C}=\text{O}$), 148.0 ($2\text{CH}=\text{CH}-\text{O}^n\text{Bu}$), 137.8 (C_i), 132.8 (C_p), 128.6 (C_m), 128.4 (C_o), 100.5 ($2\text{CH}=\text{CH}-\text{O}^n\text{Bu}$), 69.0 ($2\text{O}-\text{CH}_2-$), 48.6 ($\text{O}=\text{C}-\text{CH}$), 31.3 ($2\text{O}-\text{CH}_2-\text{CH}_2-$), 30.2 ($2\text{CH}_2-\text{CH}=\text{CH}-\text{O}^n\text{Bu}$), 19.2 ($2-\text{CH}_2-\text{Me}$), 13.9 ($2-\text{CH}_2-\text{Me}$). IR (film, $\nu_{\text{max}}/\text{cm}^{-1}$): 3086, 3060, 3028,

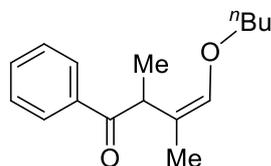
2959, 2934, 2872, 2735, 1960, 1725, 1681, 1652, 1597, 1581, 1449, 1378, 1233, 1203, 1162, 1129, 1072, 1002, 937, 757, 703. Found (%): C, 76.98; H, 9.54. Calc. for C₂₂H₃₂O₃ (%): C, 76.70; H, 9.36.

(E)-1-[1,1'-Biphenyl]-4-yl-5-butoxy-2-[(E)-3-butoxy-2-propenyl]-4-penten-1-one 4c: yield 0.21 g, 24%, yellow oil.



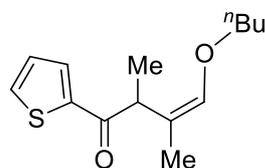
¹H NMR δ : 8.06-8.04, 7.66-7.63, 7.50-7.34 (m, 9H, H_{Aryl}), 6.22 (d, 2H, CH=CH-OⁿBu, ³J 12.7 Hz), 4.64 (dt, 2H, -CH=CH-OⁿBu, ³J 12.7 Hz, ³J 7.6 Hz), 3.57-3.54 (m, 4H, O-CH₂-), 3.45-3.43 (m, 1H, O=C-CH), 2.37-2.33, 2.20-2.17 (m, 4H, -CH₂-CH=CH-OⁿBu), 1.58-1.56 (m, 4H, O-CH₂-CH₂-), 1.42-1.38 (m, 4H, -CH₂-Me), 0.96-0.94 (m, 6H, -CH₂-Me). ¹³C NMR δ : 203.9 (C=O), 147.0 (2-CH=CH-OⁿBu), 146.2, 139.8, 135.2, 129.3, 129.1, 128.2, 127.5, 127.3 (12C_{Aryl}), 100.7 (2-CH=CH-OⁿBu), 70.1 (2O-CH₂-), 48.6 (O=C-CH), 31.3 (2O-CH₂-CH₂-), 30.4 (2CH₂-CH=CH-OⁿBu), 19.3 (2CH₂-Me), 14.0 (2-CH₂-Me). IR (film, $\nu_{\max}/\text{cm}^{-1}$): 3083, 3057, 3029, 2960, 2873, 2731, 1959, 1724, 1688, 1654, 1600, 1578, 1451, 1374, 1231, 1178, 1130, 1072, 1004, 935, 757. Found (%): C, 79.71; H, 8.86. Calc. for C₂₈H₃₆O₃ (%): C, 79.96; H, 8.63.

(Z)-4-Butoxy-2,3-dimethyl-1-phenyl-3-buten-1-one 5a: yield 0.04 g, 8%, light yellow oil.



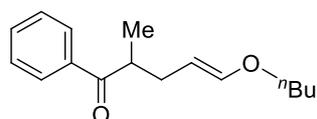
¹H NMR δ : 7.95-7.93 (m, 2H, H_o), 7.51-7.48 (m, 2H, H_m), 7.42-7.40 (m, 1H, H_p), 5.83 (q, 1H, C=CH-OⁿBu, ⁴J 1.6 Hz), 3.96 (q, 1H, O=C-CH(Me), ³J 6.9 Hz), 3.80-3.77 (m, 2H, O-CH₂-), 1.68-1.64 (m, 2H, O-CH₂-CH₂-), 1.39-1.37 (m, 2H, -CH₂-Me), 1.36 (d, 3H, Me-C=CH-OⁿBu, ⁴J 1.6 Hz), 1.32 (d, 3H, O=C-CH(Me), ³J 6.9 Hz), 0.94-0.92 (t, 3H, -CH₂-Me, ³J 7.5 Hz). ¹³C NMR δ : 201.6 (C=O), 143.9 (C=CH-OⁿBu), 136.5 (C_i), 132.5 (C_p), 128.5 (C_m), 128.4 (C_o), 112.8 (C=CH-OⁿBu), 71.9 (O-CH₂-), 40.7 [O=C-CH(Me)], 32.1 (O-CH₂-CH₂-), 19.2 (-CH₂-Me), 13.8 (-CH₂-Me), 13.7 [O=C-CH(Me)], 13.3 (Me-C=CH-OⁿBu). IR (film, $\nu_{\max}/\text{cm}^{-1}$): 3060, 3028, 2961, 2933, 2873, 1960, 1684, 1652, 1597, 1580, 1491, 1458, 1301, 1232, 1206, 1169, 1100, 1075, 1023, 1002, 956, 845, 742, 698. Found (%): C, 77.96; H, 8.89. Calc. for C₁₆H₂₂O₂ (%): C, 78.01; H, 9.00.

(Z)-4-Butoxy-2,3-dimethyl-1-(2-thienyl)-3-buten-1-one 5b: yield 0.05 g, 9%, deep yellow oil.



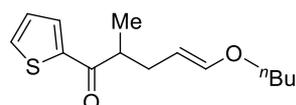
$^1\text{H NMR } \delta$: 7.87 (dd, 1H, H-3, 3J 3.9 Hz, 4J 1.2 Hz), 7.53 (dd, 1H, H-5, 3J 4.9 Hz, 4J 1.2 Hz), 7.02 (dd, 1H, H-4, 3J 4.9 Hz, 4J 3.9 Hz), 5.81 (q, 1H, C=CH-OⁿBu, 4J 1.5 Hz), 4.56 (q, 1H, O=C-CH(Me), 3J 6.9 Hz), 3.79-3.75 (m, 2H, O-CH₂-), 1.67-1.63 (m, 2H, O-CH₂-CH₂-), 1.47-1.44 (m, 2H, -CH₂-Me), 1.41 (d, 3H, Me-C=CH-OⁿBu, 4J 1.5 Hz), 1.20 (d, 3H, O=C-CH(Me), 3J 6.9 Hz), 0.99-0.96 (t, 3H, -CH₂-Me, 3J 7.5 Hz). $^{13}\text{C NMR } \delta$: 193.6 (C=O), 144.5 (C-2), 141.6 (C=CH-OⁿBu), 133.0 (C-5), 131.8 (C-3), 127.7 (C-4), 113.5 (C=CH-OⁿBu), 72.0 (O-CH₂-), 41.7 [O=C-CH(Me)], 32.2 (O-CH₂-CH₂-), 19.4 (-CH₂-Me), 14.1 (-CH₂-Me), 13.9 [O=C-CH(Me)], 13.3 (Me-C=CH-OⁿBu). IR (film, $\nu_{\text{max}}/\text{cm}^{-1}$): 3092, 2960, 2934, 2873, 2725, 1724, 1661, 1518, 1457, 1415, 1378, 1355, 1236, 1163, 1126, 1057, 856, 724. Found (%): C, 66.97; H, 7.81; S, 12.79. Calc. for C₁₄H₂₀O₂S (%): C, 66.63; H, 7.99; S, 12.71.

(E)-5-Butoxy-2-methyl-1-phenyl-4-penten-1-one 6a: yield 0.14 g, 28%, light yellow oil.



$^1\text{H NMR } \delta$: 7.97-7.94 (m, 2H, H_o), 7.54-7.49 (m, 2H, H_m), 7.44-7.39 (m, 1H, H_p), 6.26 (d, 1H, C=CH-OⁿBu, 3J 12.7 Hz), 4.72 (dt, 1H, CH=CH-OⁿBu, 3J 12.7 Hz, 3J 7.7 Hz), 3.60-3.58 (m, 2H, O-CH₂-), 3.48-3.45 [m, 1H, O=C-CH(Me)], 2.42-2.39, 2.09-2.07 (m, 2H, O=C-CH(Me)-CH₂), 1.57-1.56 (m, 2H, O-CH₂-CH₂-), 1.40-1.37 (m, 2H, -CH₂-Me), 1.20 (d, 3H, O=C-CH(Me), 3J 6.9 Hz), 0.91 (t, 3H, -CH₂-Me, 3J 7.5 Hz). $^{13}\text{C NMR } \delta$: 204.0 (C=O), 147.9 (C=CH-OⁿBu), 136.8 (C_i), 132.8 (C_p), 128.6 (C_m), 128.3 (C_o), 100.6 (C=CH-OⁿBu), 68.9 (O-CH₂-), 41.9 [O=C-CH(Me)], 32.0 (O-CH₂-CH₂-), 31.3 (O=C-CH(Me)-CH₂), 19.1 (-CH₂-Me), 16.9 [O=C-CH(Me)], 13.8 (-CH₂-Me). IR (film, $\nu_{\text{max}}/\text{cm}^{-1}$): 3060, 2961, 2933, 2873, 1684, 1652, 1597, 1580, 1449, 1376, 1222, 1206, 1167, 1131, 1075, 1023, 1002, 971, 935, 758, 703. Found (%): C, 77.96; H, 8.89. Calc. for C₁₆H₂₂O₂ (%): C, 78.01; H, 9.00.

(E)-5-Butoxy-2-methyl-1-(2-thienyl)-4-penten-1-one 6b: yield 0.14 g, 27%, yellow oil.



$^1\text{H NMR } \delta$: 7.66 (dd, 1H, H-3, 3J 3.9 Hz, 4J 1.2 Hz), 7.59 (dd, 1H, H-5, 3J 4.9 Hz, 4J 1.2 Hz), 7.09 (dd, 1H, H-4, 3J 4.9 Hz, 4J 3.9 Hz), 6.20 (d, 1H, C=CH-OⁿBu, 3J 12.5 Hz), 4.65 (dt, 1H, CH=CH-OⁿBu, 3J 12.5 Hz, 3J 7.8 Hz), 3.56-3.53 (m, 2H, O-CH₂-), 3.21 [m, 1H, O=C-CH(Me)], 2.38-2.35, 2.07-2.04 (m, 2H, O=C-CH(Me)-CH₂), 1.67-1.63 (m, 2H, O-CH₂-CH₂-), 1.47-1.44 (m, 2H, -CH₂-Me), 1.19 (d, 3H, O=C-CH(Me), 3J 6.9 Hz), 0.99-0.96 (t, 3H, -CH₂-Me). $^{13}\text{C NMR } \delta$: 195.1 (C=O), 147.0 (C=CH-OⁿBu), 144.8 (C-2), 133.8 (C-5), 131.2 (C-3), 128.0 (C-4), 100.7 (C=CH-OⁿBu), 71.9 (O-CH₂-), 42.8 [O=C-CH(Me)], 32.7 (O-CH₂-CH₂-), 31.4 (O=C-CH(Me)-CH₂), 19.3 (-CH₂-Me), 14.2 (-CH₂-Me), 13.6 [O=C-CH(Me)]. IR (film, $\nu_{\text{max}}/\text{cm}^{-1}$): 2960, 2932, 2872, 2733, 1723, 1656, 1518, 1457, 1415, 1376, 1355, 1238, 1205, 1168, 1130, 1057, 934, 850, 724. Found (%): C, 66.67; H, 7.91; S, 12.79. Calc. for C₁₄H₂₀O₂S (%): C, 66.63; H, 7.99; S, 12.71.