Supplementary Information

“Catalytic Enone Allylation via Concomitant Activation of Latent Nucleophilic and Electrophilic Partners: Merging Organic and Transition Metal Catalysis”

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Experimental Section

General. All reactions were run under an atmosphere of argon, unless otherwise indicated. Anhydrous solvents were transferred by an oven-dried syringe. Flasks were flame-dried and cooled under a stream of argon. *Tert*-Butanol was distilled before use.

Analytical thin-layer chromatography (TLC) was carried out using 0.2-mm commercial silica gel plates (DC-Fertigplatten Kieselgel 60 F₂₅₄). Preparative column chromatography employing silica gel was performed according to the method of Still.¹ Melting points were determined on a Thomas-Hoover melting point apparatus in sealed capillaries and are uncorrected. Infrared spectra were recorded on a Perkin-Elmer 1420 spectrometer. High-resolution mass spectra (HRMS) were obtained on a Karatos MS9 and are reported as m/e (relative intensity). Accurate masses are reported for the molecular ion (M+1). The Wittig reagent used in the synthesis of **6a** was prepared by a procedure analogous to that reported for AcOCH₂COCH=PPh₃.²

Proton nuclear magnetic resonance (¹H NMR) spectra were recorded with a Varian Gemini (300 MHz) spectrometer and a Mercury (400 MHz) spectrometer. Chemical shifts are reported in delta (δ) units, parts per million (ppm) downfield from trimethylsilane. Coupling constants are reported in Hertz (Hz). Carbon-13 nuclear magnetic resonance (¹³C NMR) spectra were recorded with a Varian Gemini 300 (75 MHz) spectrometer and a Mercury 400 (100 MHz) spectrometer. Chemical shifts are reported in delta (δ) units, parts per million (ppm) relative to the center of the triplet at 77.00 ppm for deuteriochloroform. ¹³C NMR spectra were routinely run with broad band decoupling. Phosphorous-31 nuclear magnetic resonance (³¹P NMR) spectra were recorded with a Varian Gemini 300 (121.5 MHz) spectrometer.

(1) Still, W. C.; Kahn, M; Mitra, A. *J. Org. Chem.* **1978**, *43*, 2923.

(2) Kim, K. W.; Szarek, W. A. *Can. J. Chem.* **1981**, *59*, 878.

This compound was isolated as a mixture of alkene isomers (4:1 – 10:1). Spectral data for the major isomer is reported.

¹H NMR (400 MHz, CDCl₃): 5.75 (dt, $J = 15.4, 6.7$ Hz, 1H), 5.54 (dt, $J = 15.4, 6.5, 1.5$ Hz, 1H), 4.49 (dd, $J = 1.0, 6.5$ Hz, 2H), 3.69 (s, 3H), 3.52 (q, $J = 5.9$ Hz, 2H), 2.51 (t, $J = 5.0$ Hz, 1H), 2.07 (q, $J = 7.2$ Hz, 2H), 1.57 (dt, $J = 14.7, 6.7$ Hz, 2H).

¹³C NMR (100 MHz, CDCl₃): 155.5, 136.3, 123.5, 68.3, 61.7, 54.5, 31.4, 28.3.

HRMS Calcd. for C₈H₁₄O₄ (M+1): 175.0970, Found: 175.0974.

FTIR (neat): 3375, 2941, 1747, 1445, 1259, 942, 793 cm⁻¹.

This compound was isolated as a 6:1 mixture of alkene isomers. Spectral data for the major isomer is reported.

¹H NMR (400 MHz, CDCl₃): 5.76 (dtd, $J = 15.4, 5.9, 1.0$ Hz, 1H), 5.55 (dtd, $J = 15.4, 6.5, 1.4$ Hz, 1H), 4.52 (d, $J = 6.5$ Hz, 2H), 3.73 (s, 3H), 3.57 (br s, 1H), 2.14-1.96 (m, 4H), 1.56-1.48 (m, 2H), 1.45-1.38 (m, 2H).

¹³C NMR (100 MHz, CDCl₃): 155.6, 136.8, 123.4, 68.5, 62.4, 54.6, 31.9, 31.8, 24.8.

HRMS Calcd. for C₉H₁₆O₄ (M+1): 189.1127, Found: 189.1127.

FTIR (neat): 3364, 2937, 2861, 1747, 1444, 1263, 942, 793 cm⁻¹.

This substrate was isolated as a 4:1 mixture of alkene isomers at the position of the allylic carbonate. Spectral data for the major isomer is reported.

¹H NMR (400 MHz, CDCl₃): 7.91 (dd, *J* = 8.2, 1.0 Hz, 2H), 7.54 (td, *J* = 7.4, 1.4 Hz, 1H), 7.46 (t, *J* = 7.7 Hz, 2H), 7.01 (dt, *J* = 15.4, 6.8 Hz, 1H), 6.88 (d, *J* = 15.4 Hz, 1H), 5.83 (dt, *J* = 15.4, 6.5 Hz, 1H), 5.66 (dt, *J* = 14.4, 6.3 Hz, 1H), 4.57 (d, *J* = 6.5 Hz, 2H), 3.75 (s, 3H), 2.42 (dt, *J* = 7.9, 6.7 Hz, 2H), 2.30 (dt, *J* = 7.2, 7.0 Hz, 2H).

¹³C NMR (100 MHz, CDCl₃): 190.9, 155.8, 148.5, 138.1, 135.4, 132.9, 128.8, 126.7, 124.8, 68.5, 63.6, 55.0, 32.6, 32.2, 30.9, 26.4.

HRMS Calcd. for C₁₆H₁₈O₄ (M+1): 275.1283, Found: 275.1271.

FTIR (neat): 3028, 2947, 1751, 1671, 1621, 1447, 1267, 974, 944 cm⁻¹.

This substrate was isolated as a 4:1 mixture of alkene isomers at the position of the allylic carbonate. Spectral data for the major isomer is reported.

¹H NMR (400 MHz, CDCl₃): 8.43 (s, 1H), 8.04-7.96 (m, 2H), 7.93-7.86 (m, 2H), 7.58 (dtd, $J = 19.3, 7.4, 1.4$ Hz, 2H), 7.07 (d, $J = 4.5$ Hz, 2H), 5.85 (dtt, $J = 15.4, 6.5, 1.0$ Hz, 1H), 5.70 (dtt, $J = 15.4, 6.3, 1.4$ Hz, 1H), 4.60 (dd, $J = 6.2, 1.0$ Hz, 2.0H), 3.76 (s, 3H), 2.47 (dtd, $J = 7.2, 5.6, 1.7$ Hz, 2H), 2.34 (dtd, $J = 7.2, 5.6, 1.7$ Hz, 2H).

¹³C NMR (100 MHz, CDCl₃): 190.3, 155.5, 148.4, 135.3, 135.1, 135.0, 132.4, 129.9, 129.4, 128.4, 128.2, 127.7, 126.6, 126.3, 124.45, 124.38, 68.1, 54.6, 31.9, 30.7.

HRMS Calcd. for C₂₀H₂₀O₄ (M+1): 325.1440, Found: 325.1444.

FTIR (neat): 3061, 2952, 1747, 1667, 1618, 1442 cm⁻¹.

This substrate was isolated in >95% alkene isomeric purity.

¹H NMR (400 MHz, CDCl₃): 8.08 (dd, $J = 7.9, 1.4$ Hz, 2H), 7.56 (t, $J = 7.5$ Hz, 1H), 7.43 (t, $J = 7.7$ Hz, 2H), 6.94 (td, $J = 16.1, 6.8$ Hz, 1H), 6.22 (d, $J = 16.1$ Hz, 1H), 5.76 (dt, $J = 15.4, 6.5$ Hz, 1H), 5.61 (dt, $J = 15.4, 6.3$ Hz, 1H), 5.03 (s, 2H), 4.54 (dd, $J = 6.5, 0.7$ Hz, 2H), 3.74 (s, 3H), 2.33 (dt, $J = 7.9, 6.7$ Hz, 2H), 2.22 (dt, $J = 7.5, 6.8$ Hz, 2H).

¹³C NMR (100 MHz, CDCl₃): 192.1, 155.4, 147.7, 134.6, 133.2, 129.7, 129.2, 128.3, 126.2, 124.6, 68.0, 67.3, 54.6, 31.7, 30.3.

HRMS Calcd. for C₁₈H₂₀O₆ (M+1): 333.1338, Found: 333.1340.

FTIR (neat): 3008, 2955, 1747, 1634, 1451, 1264, 1114, 943, 714 cm⁻¹.

This substrate was isolated as a 4:1 mixture of alkene isomers at the position of the allylic carbonate. Spectral data for the major isomer is reported.

¹H NMR (300 MHz, CDCl₃): 7.62 (dd, $J = 1.4, 0.6$ Hz, 1H), 7.24 (dd, $J = 3.5, 0.8$ Hz, 1H), 7.12 (dt, $J = 15.4, 6.7$ Hz, 1H), 6.81 (dt, $J = 15.4, 1.5$ Hz, 1H), 6.56 (dd, $J = 3.5, 1.7$ Hz, 1H), 5.83 (dtt, $J = 15.7, 6.2, 1.0$ Hz, 1H), 5.66 (dtt, $J = 15.6, 6.2, 1.1$ Hz, 1H), 4.58 (dd, $J = 5.9, 1.1$ Hz, 2H), 3.78 (s, 3H), 2.40 (dtd, $J = 14.3, 7.2, 1.4$ Hz, 2H), 2.31 (dtd, $J = 13.7, 7.0, 1.4$ Hz, 2H).

¹³C NMR (100 MHz, CDCl₃): 178.2, 155.8, 153.5, 147.7, 146.8, 135.4, 125.6, 124.8, 117.8, 112.6, 68.5, 55.0, 32.1, 30.9.

HRMS Calcd. for C₁₄H₁₆O₅ (M+1): 265.1076, Found: 265.1073.

FTIR (neat): 3024, 2955, 1651, 1597, 1578, 1383, 1351 cm⁻¹.

This substrate was isolated as a 61 mixture of alkene isomers at the position of the allylic carbonate. Spectral data for the major isomer is reported.

¹H NMR (300 MHz, CDCl₃): 6.68-6.59 (m, 1H), 5.96-5.90 (td, $J = 1.35, 16.2$ Hz, 1H), 5.54-5.47 (m, 1H), 4.43 (dd, $J = 0.9, 6.3$ Hz, 2H), 3.63 (s, 3H), 2.21-2.10 (m, 4H), 2.09 (s, 3H).

¹³C NMR (75 MHz, CDCl₃): 198.5, 155.7, 147.0, 135.1, 131.9, 124.8, 68.3, 54.8, 31.7, 30.7, 27.0.

HRMS: Calcd. for C₁₁H₁₆O₄(M+1): 213.1127, Found: 213.1125.

FTIR (neat): 2957, 2254, 1748, 1696, 1674, 1443 cm⁻¹.

This substrate was isolated as a 10:1 mixture of alkene isomers at the position of the allylic carbonate. Spectral data for the major isomer is reported.

¹H NMR (300 MHz, CDCl₃): 6.85-6.77 (m, 1H), 6.18 (td, *J* = 1.43, 15.6 Hz, 1H), 5.81-5.74 (m, 1H), 5.63-5.58 (m, 1H), 4.54 (dd, *J* = 0.75, 6.15 Hz, 2H), 3.74 (s, 3H), 2.32-2.21 (m, 4H), 2.10-2.05 (m, 1H), 1.10-1.01 (m, 2H), 0.89-0.83 (m, 2H).

¹³C NMR (75 MHz, CDCl₃): 200.0, 155.5, 145.2, 135.1, 130.8, 124.4, 68.2, 54.7, 31.5, 30.6, 18.7, 11.0.

HRMS: Calcd. for C₁₃H₁₈O₄ (M+1): 239.1283, Found: 239.1275.

FTIR (neat): 3009, 2956, 1749, 1683, 1663, 1626, 1443 cm⁻¹.

This substrate was isolated as a 9:1 mixture of alkene isomers at the position of the allylic carbonate. Spectral data for the major isomer is reported.

¹H NMR (300 MHz, CDCl₃): 6.88-6.81 (m, 1H), 5.78-5.71 (m, 2H), 5.58-5.53 (m, 1H), 4.50 (dd, *J* = 0.9, 6.3 Hz, 2H), 4.00 (q, *J* = 7.2 Hz, 2H), 3.70 (s, 3H), 2.25-2.15 (m, 4H), 1.21 (t, *J* = 7.1 Hz, 3H).

¹³C NMR (75 MHz, CDCl₃): 166.7, 155.8, 147.9, 135.3, 124.7, 122.1, 66.4, 60.4, 54.9, 31.5, 30.7, 14.4.

HRMS: Calcd. for C₁₂H₁₈O₄S(M+1): 259.1004, Found: 259.1009.

FTIR (neat): 3957, 1748, 1673, 1633, 1444 cm⁻¹.

This substrate was isolated as a 6:1 mixture of alkene isomers at the position of the allylic carbonate. Spectral data for the major isomer is reported.

¹H NMR (300 MHz, CDCl₃): 7.91-7.87 (m, 2H), 7.54-7.39 (m, 3H), 7.03-6.96 (m, 1H), 6.88-6.82 (m, 1H), 5.82-5.72 (m, 1H), 5.62-5.52 (m, 1H), 4.54 (dd, *J* = 0.75, 6.45 Hz, 2H), 3.73 (s, 3H), 2.32-2.25 (m, 2H), 2.19-2.04 (m, 2H), 1.64-1.54 (m, 2H).

¹³C NMR (75 MHz, CDCl₃): 190.6, 155.5, 149.0, 136.0, 132.5, 128.4, 128.4, 126.1, 126.1, 124.0, 68.3, 54.6, 40.0, 31.5, 27.1.

HRMS: Calcd. for C₁₇H₂₀O₄ (*M*+1): 289.1440, Found: 289.1431.

FTIR (neat): 2935, 1748, 1670, 1621, 1447 cm⁻¹.

This substrate was isolated as a 9:1 mixture of alkene isomers at the position of the allylic carbonate. Spectral data for the major isomer is reported.

¹H NMR (300 MHz, CDCl₃): 6.81 (dt, $J = 15.9, 6.6$ Hz, 1H), 6.16 (dt, $J = 15.6, 1.5$ Hz, 1H), 5.74 (dt, $J = 15.3, 6.9, 1.1$ Hz, 1H), 5.56 (dt, $J = 15.3, 6.3, 1.2$ Hz, 1H), 4.51 (dd, $J = 6.0, 0.9$ Hz, 2H), 3.69 (s, 3H), 2.18 (ddd, $J = 7.8, 7.1, 1.4$ Hz, 2H), 2.10-2.02 (m, 3H), 1.53 (p, $J = 7.4$ Hz, 2H), 1.03-0.98 (m, 2H), 0.86-0.80 (m, 2H).

¹³C NMR (75 MHz, CDCl₃): 200.0, 155.5, 146.0, 136.0, 130.6, 124.0, 68.3, 54.6, 31.6, 31.4, 27.0, 18.6, 10.9.

HRMS: Calcd. for C₁₄H₂₀O₄ (M+1): 253.1430, Found: 253.1440.

FTIR (neat): 2933, 1748, 1625, 1443, 1389, 1265 cm⁻¹.

¹H NMR (300 MHz, CDCl₃): 7.92-7.88 (m, 2H), 7.55-7.49 (m, 1H), 7.46-7.43 (m, 2H), 7.04 (dt, *J* = 15.0, 7.8 Hz, 1H), 6.84 (d, *J* = 15 Hz, 1H), 5.83 (dt, *J* = 15.3, 7.5 Hz, 1H), 5.58 (dt, *J* = 15.3, 6.0 Hz, 1H), 4.57 (dd, *J* = 6.6, 0.5 Hz, 2H), 3.74 (s, 3H), 2.17 (dd, *J* = 7.5, 1.1 Hz, 2H), 1.99 (d, *J* = 7.5 Hz, 2H), 0.92 (s, 6H).

¹³C NMR (75 MHz, CDCl₃): 190.6, 155.8, 146.8, 138.2, 133.3, 132.9, 128.8, 128.54, 128.47, 126.6, 68.6, 55.0, 45.4, 45.1, 34.7, 27.2.

HRMS: Calcd. for C₁₉H₂₄O₄ (M+1): 317.1748, Found: 317.1753.

FTIR (neat): 2958, 1748, 1619, 1447, 1266, 945 cm⁻¹.

This substrate was isolated in >95% alkene isomeric purity.

¹H NMR (300 MHz, CDCl₃): 6.88 (dt, $J = 15.6, 6.5$ Hz, 1H), 5.81-5.71 (m, 2H), 5.59 (dtt, $J = 15.6, 6.2, 1.3$ Hz, 1H), 4.52 (dd, $J = 6.3, 0.9$ Hz, 2H), 4.13 (q, $J = 7.2$ Hz, 2H), 3.73 (s, 3H), 2.29-2.18 (m, 4H), 1.23 (t, $J = 7.2$ Hz, 3H).

¹³C NMR (75 MHz, CDCl₃): 166.3, 155.5, 147.6, 134.9, 124.4, 121.8, 68.1, 60.1, 54.6, 31.2, 30.4, 14.1.

HRMS: Calcd. for C₁₂H₁₈O₅(M+1): 243.1232, Found: 243.1233.

FTIR (neat): 3957, 1748, 1673, 1633, 1444 cm⁻¹.

¹H NMR (300 MHz, CDCl₃): 7.79-7.75 (m, 2H), 7.56-7.49 (m, 1H), 7.46-7.40 (m, 2H), 6.51 (dt, *J* = 2.6, 1.7 Hz, 1H), 5.91 (ddd, *J* = 17.1, 10.1, 7.3 Hz, 1H), 5.10 (dd, *J* = 17.2, 1.4 Hz, 1H), 4.99 (ddd, *J* = 10.3, 1.5, 0.9 Hz, 1H), 3.87 (q, *J* = 6.7 Hz, 1H), 2.75-2.62 (m, 1H), 2.58-2.45 (m, 1H), 2.33-2.21 (m, 1H), 1.92-1.82 (m, 1H).

¹³C NMR (75 MHz, CDCl₃): 193.9, 146.3, 140.0, 139.1, 132.2, 129.2, 128.4, 114.4, 48.7, 32.9, 30.4.

HRMS Calcd. for C₁₄H₁₄O (*M*+1): 199.1123, Found: 199.1130.

FTIR (neat): 3061, 2930, 1642, 1353, 1288, 911, 760 cm⁻¹.

¹H NMR (400 MHz, CDCl₃): 8.28 (d, *J* = 0.7 Hz, 1H) 7.94 (dd, *J* = 8.2, 1.4 Hz, 1H), 7.91-7.86 (m, 3H), 7.56 (dtd, *J* = 18.0, 6.8, 1.5 Hz, 2H), 6.58 (dt, *J* = 2.6, 1.7 Hz, 1H), 5.15 (dt, *J* = 17.1, 1.4 Hz, 1H), 5.02 (dt, *J* = 10.3, 1.2 Hz, 1H), 3.94 (q, *J* = 7.2 Hz, 1H), 2.78-2.68 (m, 1H), 2.60-2.51 (m, 1H), 2.37-2.27 (m, 1H), 1.97-1.88 (m, 1H).

¹³C NMR (100 MHz, CDCl₃): 193.8, 146.5, 146.3, 140.0, 136.3, 135.4, 132.6, 130.6, 129.5, 128.4, 128.2, 128.0, 126.9, 125.4, 114.5, 48.9, 33.0, 30.4.

HRMS Calcd. for C₁₈H₁₆O (*M*+1): 249.1279, Found: 249.1269.

FTIR (neat): 3058, 2956, 2927, 2870, 1643, 1465, 1353, 1288 cm⁻¹.

¹H NMR (400 MHz, CDCl₃): 8.10 (dd, $J = 7.2, 0.7$ Hz, 2H), 7.57 (dt, $J = 7.4, 0.7$ Hz, 1H), 7.45 (t, $J = 7.7$ Hz, 1H), 6.92 (t, $J = 2.4$ Hz, 1H), 5.84 (ddd, $J = 17.1, 10.1, 7.5$ Hz, 1H), 5.21 (ddd, $J = 59.2, 15.9, 0.7$ Hz, 2H), 5.07 (d, $J = 17.1$ Hz, 1H), 5.00 (dt, $J = 10.3, 0.7$ Hz, 1H), 3.70 (q, $J = 1.4$ Hz, 1H), 2.70-2.59 (m, 1H), 2.58-2.49 (m, 1H), 2.24-2.13 (m, 1H), 1.88-1.80 (m, 1H).

¹³C NMR (100 MHz, CDCl₃): 190.0, 166.0, 144.9, 144.0, 139.3, 133.2, 129.9, 129.4, 128.4, 114.2, 66.4, 47.3, 32.4, 30.0.

HRMS Calcd. for C₁₆H₁₆O₃ (M+1): 257.1178, Found: 257.1181.

FTIR (neat): 3061, 2940, 1728, 1687, 1272, 1119, 709 cm⁻¹.

¹H NMR (400 MHz, CDCl₃): 7.58 (d, $J = 0.7$ Hz, 1H), 7.16 (dd, $J = 4.1, 0.7$ Hz, 1H), 7.00 (dd, $J = 4.1, 2.4$ Hz, 1H), 6.51 (dt, $J = 2.1, 1.7$ Hz, 1H), 5.86 (ddd, $J = 17.1, 10.1, 7.5$ Hz, 1H), 5.06 (dd, $J = 17.1, 1.4$ Hz, 1H), 4.95 (d, $J = 10.3$ Hz, 1H), 3.86 (q, $J = 6.2$ Hz, 1H), 2.72-2.62 (m, 1H), 2.59-2.49 (m, 1H), 2.26-2.16 (m, 1H), 1.86-1.77 (m, 1H).

¹³C NMR (100 MHz, CDCl₃): 179.5, 153.4, 146.3, 145.4, 145.3, 139.9, 118.3, 114.3, 112.2, 48.5, 33.0, 30.1.

HRMS Calcd. for C₁₂H₁₂O₂ (M+1): 189.0916, Found: 189.0910.

FTIR (neat): 3133, 2942, 1637, 1564, 1467, 1391, 1293 cm⁻¹.

¹H NMR (300 MHz, CDCl₃): 6.77-6.75 (m, 1H), 5.88-5.77 (m, 2H), 5.03-4.91 (m, 1H), 3.61-3.58 (m, 1H), 2.61-2.47 (m, 2H), 2.28 (s, 3H), 2.19-2.07 (m, 1H), 1.85-1.76 (m, 1H).

¹³C NMR (75 MHz, CDCl₃): 196.1, 147.4, 144.8, 139.8, 113.4, 46.7, 32.0, 30.4, 27.1.

HRMS: Calcd. for C₉H₁₂O (M+1): 137.0966, Found: 137.0968.

FTIR (neat): 2938, 1668, 1611, 1368 cm⁻¹.

¹H NMR (300 MHz, CDCl₃): 6.89-6.86 (m, 1H), 5.89-5.77 (m, 1H), 5.03-4.91 (m, 2H), 3.63-3.61 (m, 1H), 2.60-2.47 (m, 2H), 2.33-2.26 (m, 1H), 2.22-2.11 (m, 1H), 1.85-1.62 (m, 1H), 1.05-1.00 (m, 2H), 0.86-0.80 (m, 2H).

¹³C NMR (75 MHz, CDCl₃): 198.2, 147.7, 143.6, 140.1, 113.4, 47.3, 32.1, 30.4, 17.7, 10.9, 10.6.

HRMS: Calcd. for C₁₁H₁₄O (M+1): 163.1123, Found: 163.1122.

FTIR (neat): 3009, 2942, 1655, 1610, 1445, 1398 cm⁻¹.

¹H NMR (300 MHz, CDCl₃): 6.83-6.81 (m, 1H), 5.86-5.75 (m, 1H), 5.08-4.95 (m, 2H), 3.68-3.64 (m, 1H), 2.94-2.83 (m, 2H), 2.53-2.42 (m, 2H), 2.24-2.11 (m, 1H), 1.84-1.75 (m, 1H), 1.24 (t, *J* = 7.5 MHz, 3H).

¹³C NMR (75 MHz, CDCl₃): 188.8, 146.0, 142.6, 139.4, 114.2, 47.9, 31.7, 30.7, 22.9, 14.8.

HRMS: Calcd. for C₁₀H₁₄OS (M+1): 183.0844, Found: 184.0839.

FTIR (neat): 2967, 2931, 1659, 1612, 1452 cm⁻¹.

¹H NMR (300 MHz, CDCl₃): 7.69-7.66 (m, 2H), 7.51-7.36 (m, 3H), 6.5 (t, *J* = 4.05 Hz, 1H), 5.90-5.79 (m, 1H), 5.02-4.94 (m, 2H), 3.6 (s, 1H), 2.35-2.11 (m, 2H), 1.80-1.61 (m, 4H).

¹³C NMR (75 MHz, CDCl₃): 197.3, 143.51, 140.3, 140.1, 138.6, 131.6, 129.3, 128.0, 115.1, 36.3, 27.5, 26.1, 17.6.

HRMS: Calcd. for C₁₅H₁₆O (*M*+1): 213.1279, Found: 213.1276.

FTIR (neat): 2934, 1649, 1446, 1263 cm⁻¹.

¹H NMR (300 MHz, CDCl₃): 7.06 (t, $J = 4.1$ Hz, 1H), 5.80 (ddd, $J = 17.1, 10.7, 6.3$ Hz, 1H), 4.99 (dt, $J = 10.2, 1.4$ Hz, 1H), 4.83 (dt, $J = 17.4, 1.4$ Hz, 1H), 3.47 (br s, 1H), 2.35-2.18 (m, 3H), 1.74-1.55 (m, 4H), 1.04-0.94 (m, 2H), 0.84-0.78 (m, 2H).

¹³C NMR (75 MHz, CDCl₃): 200.7, 141.1, 140.7, 140.0, 114.9, 35.6, 27.4, 26.1, 17.0, 16.2, 10.8, 10.4.

HRMS: Calcd. for C₁₂H₁₆O (M+1): 177.1279, Found: 177.1279.

FTIR (neat): 2934, 1657, 1398, 1205, 992 cm⁻¹.

¹H NMR (300 MHz, CDCl₃): 7.75-7.71 (m, 2H), 7.52-7.46 (m, 1H), 7.42-7.37 (m, 2H), 6.33 (dt, *J* = 5.7, 2.1 Hz, 1H), 5.80-5.68 (m, 1H), 4.98 (dd, *J* = 31.4, 14.2 Hz, 2H), 3.49 (br s, 1H), 2.14 (dt, *J* = 18.6, 3.3 Hz, 1H), 1.92 (ddt, *J* = 15.3, 5.7, 2.1 Hz, 1H), 1.69-1.61 (m, 1H), 1.44-1.36 (m, 1H), 1.02 (s, 3H), 0.91 (s, 3H).

¹³C NMR (75 MHz, CDCl₃): 197.6, 140.3, 140.2, 139.3, 138.2, 132.0, 129.5, 128.1, 115.2, 42.5, 39.6, 37.9, 31.1, 29.3, 25.5.

HRMS: Calcd. for C₁₇H₂₀O (*M*+1): 241.1592, Found: 241.1583.

FTIR (neat): 2953, 1653, 1446, 1266, 707 cm⁻¹.

¹H NMR (400 MHz, CDCl₃): 8.15-8.13 (m, 2H), 7.68-7.63 (m, 6H), 7.58-7.53 (m 4H), 7.49-7.41 (m, 8H), 4.85 (s, 2H), 4.00 (d, *J* = 22.9 Hz, 1H).

¹³C NMR (125 MHz, CDCl₃): 186.2 (d, *J* = 3 Hz), 166.1, 133.0 (d, *J* = 10 Hz), 132.7, 132.2 (d, *J* = 3 Hz), 130.5, 129.7, 128.9 (d, *J* = 12 Hz), 128.2, 126.5 (d, *J* = 91 Hz), 68.0 (d, *J* = 15 Hz), 49.3 (d, *J* = 111 Hz).

³¹P NMR (121.5 MHz, CDCl₃): 17.2.

M.P. 166-168 °C (recrystallized from toluene/hexane).

HRMS Calcd. for C₂₈H₂₃O₃P (*M*+1): 439.1463, Found: 439.1471.

FTIR (neat): 3057, 2940, 1719, 1544, 1437, 1401, 1271, 1109 cm⁻¹.