Supplementary Material for:

Asymmetric Syntheses of Fused Bicyclic Compounds by Conjugate Additions of Allylic Organolithium Species to Activated Olefins and Subsequent Cyclizations

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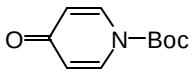
Experimental

General. All air-sensitive reactions were performed in oven or flame dried glassware under nitrogen with freshly distilled solvents. Toluene was distilled over CaH_2, and diethyl ether, tetrahydrofuran (THF) and methyl *tert*-butyl ether (MTBE) were distilled from sodium and benzophenone. Commercial (–)-sparteine (Aldrich) was distilled and stored under nitrogen. Commercially available TMEDA was used to obtain racemic product and used without purification. *n*-BuLi solution in hexanes (1.6M) was titrated prior to use against *N*-pivaloyl-*o*-toluidine. All other commercial reagents were used without further purification, unless otherwise indicated.

Preparative high-pressure liquid chromatography (HPLC) was performed using Rainin SD 200 pump system equipped with Dynamax-60-A 8 μm silica column (Rainin Instrument Co., 25 cm x 21.4 mm i.d.) and Knauer UV detector (254 nm). Analytical chiral stationary phase HPLC was performed using Rainin HPXL pump systems. Either Whelk-O (Regis Chemical Co., 25 cm x 4.6 mm i.d.) or Chiralpak AD (Chiral Technologies Inc. 25 cm x 4.6 mm i.d.) was used to obtain product enantiomeric purity. Analytical thin layer chromatography (TLC) was done on Merck silica plates (0.25 mm) with QF-254 indicator. Either UV light or alkaline $KMnO_4$ was used for TLC visualization. Flash chromatography was performed suing 230-400 mesh silica gel.
^1H and ^{13}C NMR spectra were acquired using either a Varian U400 (400 MHz ^1H, 100.6 MHz ^{13}C) or U500 (500 MHz ^1H, 125.7 MHz ^{13}C) spectrometer using $CDCl_3$, acetone-d_6 or DMSO as a solvent. Chemical shifts are reported in ppm relative to the solvent. Mass spectral data was obtained at the University of Illinois Mass Spectrometry Laboratory. GC/MS was performed on a HP 5809 gas chromatograph coupled to a HP 5970B EI mass detector. Thomas-Hoover capillary melting point apparatus was used to determine uncorrected melting points. Purity of the sample is established to be >95% based on ^{13}C NMR spectra. Elemental analyses were carried out by the University of Illinois Microanalytical Service Laboratory. Melting points were acquired on a Thomas-Hoover melting point apparatus and are uncorrected. Diastereomeric purity was determined by ^1H NMR integration or gas chromatographic analysis.

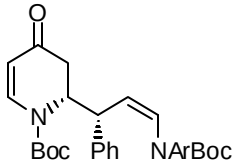
"Standard workup" refers to dilution with diethyl ether, addition of H_2O, separation of phases, extraction of the aqueous layer with ether (3x), combination of the organic phases, drying with $MgSO_4$ and concentration by rotary evaporation.



9a

***N-Boc*-Pyridin-4-one (6a)**

To a stirring solution of (4H)-pyridone (3.00 g, 31.5 mmol) in *t*-BuOH(1M) NaH (1.60 g, 40.1 mmol washed with hexanes) was added and the resulting mixture was heated to 50 °C. The reaction mixture turned to a slurry and BocOBoc(9.2 mL, 40.1 mmol) in *t*-BuOH was added dropwise over 1 h. The reaction mixture was cooled to room temperature and stirred overnight when it was quenched with water (25 mL). The solution was acidified to pH=7 with 5% H_3PO_4 and the aqueous portion was extracted with ether (4 x 10mL). The ether layers were combined, dried over $MgSO_4$, concentrated and purified by flash chromatography(19/1 CH_2Cl_2/MeOH) providing 3.88 g(65%) of **9a** as a white solid. m.p. 89 °C. **^{1}H-NMR** ($CDCl_3$, 400 MHz) δ 1.56 (s, 9H, C(C$\underline{H}_3$)$_3$), 6.2 (m, 2H, 2(C$\underline{H}$=CHN), 8.0 (m, 2H, 2(C$\underline{H}$=CHN). **^{13}C-NMR** ($CDCl_3$, 100 MHz) δ 27.7, 87.3, 118.2, 134.9, 147.9, 180.6. Anal. Calcd. C: 61.53%, H: 6.71%, N: 7.18%. Found C: 61.45%, H: 6.73%, N: 7.10%.



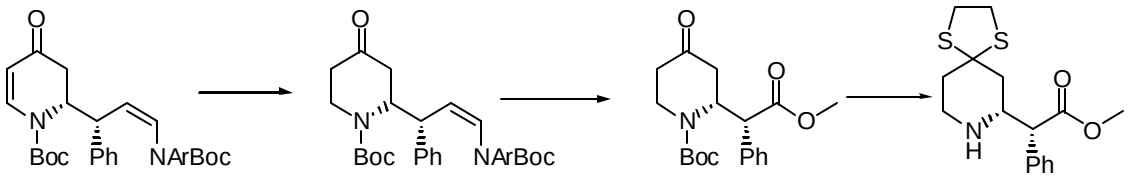
9

2-{3-[tert-Butoxycarbonyl-(4-methoxy-phenyl)-amino]-1-phenyl-allyl}-4-oxo-3,4-dihydro-2H-pyridine-1-carboxylic acid tert-butyl ester (9)

To a solution of *N*-Boc-*N*-(*p*-methoxyphenyl)cinnamyl amine (0.600 g, 1.76 mmol) in toluene (0.05 M) was added 1.1 equiv of (–)-sparteine (1.94 mmol, 0.44 mL). The solution was precooled to –78 °C when 1.1 equiv of *n*-BuLi (1.21 mL, 1.94 mmol). was added dropwise. The solution was stirred at –78 °C for 1h, when 1.5 equiv of **9a** (0.52g, 2.64 mmol) and 3 equiv of TMSCl (0.67ml, 5.28 mmol) in 3 mL of toluene were added to the reaction mixture dropwise via syringe pump (2 mL/hr). After addition was

complete, the reaction was quenched with MeOH and warmed to room temperature. At room temperature excess TBAF (1 M in THF) was added and the reaction stirred for 15 min and worked up in the usual manner. Separation of the diastereomers **9** was accomplished by flash chromatography (30% EtOAc/hexanes) providing the major, less retained, diastereomer as a white foamy solid (0.712g, 75%). m.p.145-146 °C. **^{1}H-NMR** (d^6-DMSO, *VT = 100 °C*, 400 MHz) δ 1.37 (s, 9H, C(C$\underline{H}_3$)$_3$), 1.57 (s, 9H, C(C$\underline{H}_3$)$_3$), 1.70 (d, *J* = 16.5 Hz, 1H, C$\underline{H}_2$C=O), 2.50 (dd, *J* = 16.5, 6.22 Hz, 1H, C$\underline{H}_2$C=O), 3.54 (dd, *J* = 10.8, 10.6 Hz, 1H, C$\underline{H}$Ph), 3.79 (s, 3H, OC$\underline{H}_3$), 4.61 (dd, *J* = 10.2, 6.3 Hz, 1H, *ring*-C$\underline{H}$NBoc), 5.18 (d, *J* = 8.2 Hz, 1H, HC=C$\underline{H}$C=O), 5.23 (dd, *J* = 10.8, 8.9 Hz, 1H, PhCHC$\underline{H}$=CH), 6.5 (d, *J* = 8.9 Hz, 1H, PhCHCH=C$\underline{H}$), 6.62 (m, 2H, Ar$\underline{H}$), 6.81 (m, 2H, Ar$\underline{H}$), 6.95 (m, 2H, Ph$\underline{H}$), 7.16(m, 3H, Ph$\underline{H}$), 7.6 (d, *J* = 8.2 Hz, 1H, NC$\underline{H}$=CHC=O). **^{13}C-NMR** (d^6-DMSO, *VT=100 °C*, 100 MHz) δ 28.1, 28.2, 38.1, 42.8, 55.9, 56.9, 80.9, 83.2, 106.9, 114.6, 119.8, 127.1, 127.9, 128.1, 128.6, 130.0, 135.3, 139.6, 141.9, 151.4, 153.1, 191.4. Anal. Calcd. C: 69.64%, H: 7.16%, N: 5.24%, Found C: 69.55%, H: 7.18%, N: 5.26%. The enantiomeric ratio of the major diastereomer **6** was determined by CSP HPLC on a Chiral Pak AD column with 2.5% IPA/hexanes mobile phase. (R_t 9.6 and 10.6 min). The minor, more retained diastereomer was isolated as a clear oil in 5.5% yield (0.052 g). **^{1}H-NMR** (d^6-DMSO, *VT = 60°C*, 400 MHz) δ 1.10 (s, 9H, C(C$\underline{H}_3$)$_3$), 1.39 (s, 9H, C(C$\underline{H}_3$)$_3$), 2.42 (m, 1H, C$\underline{H}_2$C=O), 2.70 (dd, *J* = 16.9, 6.3 Hz, 1H, C$\underline{H}_2$C=O), 3.40 (dd, *J* = 11.0, 10.4 Hz, 1H, C$\underline{H}$Ph), 3.72 (s, 3H, OC$\underline{H}_3$), 4.44 (bs, 1H, *ring*-C$\underline{H}$NBoc), 5.18 (dd, *J* = 10.8, 9.3 Hz, 1H, PhCHC$\underline{H}$=CH), 5.22 (d, *J* = 8.1 Hz, 1H, HC=C$\underline{H}$C=O), 6.6 (m, 2H, PhCHCH=C$\underline{H}$+ArH), 6.7 (m, 3H, PhH, 6.79 (m, 2H, PhH), 7.08 (m, 3H, PhH), 7.53 (bd, *J* = 8.0 Hz, NC$\underline{H}$=CHC=O). **^{13}C-NMR** (d^6-DMSO, *VT = 100 °C*, 100 MHz) δ 27.9, 28.5, 39.2, 41.9, 56.1, 57.7, 81.3, 82.8, 108.0, 114.8, 116.3, 126.9, 128.0, 128.5, 128.9, 130.6, 134.9, 140.2, 142.4, 150.9, 153.3, 158.2, 192.2. Anal. Calcd. C: 69.64%, H: 7.16%, N: 5.24%, Found C: 69.43%, H: 7.31%, N: 4.97%. The enantiomeric ratio of the minor diastereomer **9** was determined by CSP HPLC on a Chiral Pak AD column with 2.5% IPA/hexanes mobile phase.(R_t 25.6 and 39.6 min).

Determination of the Absolute Configuration of 9 by Derivatization and X-ray Crystallography:



9 **9a** **9b** **9c**

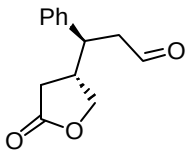
2-{3-[tert-Butoxycarbonyl-(4-methoxy-phenyl)-amino]-1-phenyl-allyl}-4-oxo-piperidine-1-carboxylic acid tert-butyl ester (9a)

To a stirring solution of **9** (0.456 g, 0.85 mmol) under a N_2 atmosphere in THF (0.13 M) cooled to -25 °C was added L-selectride (0.95 mL, 0.94 mmol, 1M in THF) dropwise. The reaction mixture was stirred at -25 °C for 2h and then warmed to room temperature and quenched with cold saturated $NaHCO_3$(10mL). The aqueous portion of the reaction was extracted with ether(3 x 10 mL), dried over $MgSO_4$, concentrated, and purified by flash chromatography (30% EtOAc/hexanes) providing **9a** as a clear oil (0.355g, 82%). **^{1}H-NMR** (*d*^{6}-DMSO, *VT = 100°C*, 500 MHz) δ 1.35 (s, 9H, C(C$\underline{H}_3$)$_3$), 1.50 (s, 9H, C(C$\underline{H}_3$)$_3$), 1.78 (d, *J* = 14.6 Hz, 1H, O=CC$\underline{H}_2$CHNBoc), 2.10 (d, *J* = 15.2 Hz, 1H, O=CC$\underline{H}_2$CH$_2$NBoc), 2.28 (dd, *J* = 14.6, 6.8 Hz, 1H, O=CC$\underline{H}_2$CHNBoc), 2.39 (ddd, *J* = 15.2, 11.8, 7.5 Hz, 1H, O=CC$\underline{H}_2$CH$_2$NBoc), 2.94 (m, 1H), 3.22 (t, *J* = 10.4Hz, PhC$\underline{H}$), 3.78 (s, 3H, OC$\underline{H}_3$), 4.13 (m, 1H), 4.55 (m, 1H), 5.23 (dd, *J* = 10.1, 9.0 Hz, 1H, PhCHC$\underline{H}$=CHNBoc), 6.46 (d, *J* = 9.0 Hz, PhCHCH=C$\underline{H}$NBoc), 6.70 (m, 2H, Ar$\underline{H}$), 6.8 (m, 2H, Ar$\underline{H}$), 6.90 (m, 2H, Ph$\underline{H}$), 7.15 (m, 3H, Ph$\underline{H}$). The material was carried forward to the subsequent hydrolysis step without further characterization due to concerns of decomposition of **9a**.

2-(Methoxycarbonyl-phenyl-methyl)-4-oxo-piperidine-1-carboxylic acid tert-butyl ester (9b). A stirring solution of **9a** (0.956 g, 1.78 mmol) in dry CH_2Cl_2 (32 mL) at – 78 °C was treated with O_3 for 20 min. The resulting lavender solution was purged with O_2 until colorless (~ 10 min). Dimethylsulfide (6 mL) was added and the solution was allowed to slowly warm to room temperature overnight and concentrated. The residue was dissolved in *t*-BuOH (41 mL) and 2-methyl-2-butene (9.50 ml) and then a solution of

$NaClO_2$ (1.57 g) and NaH_2PO_4 (1.57 g) in H_2O (15.8 mL) was added. The resulting yellow solution was stirred for 30 min at room temperature and poured into CH_2Cl_2 (70 mL) and 2.5 % HCl (50 mL). The organics were separated and the aqueous was back extracted with CH_2Cl_2 (3 x 50 mL). The combined organics were dried over $MgSO_4$ and concentrated. The crude acid was purified by column chromatography (20 % EtOAc/pet ether, then 5% AcOH/EtOAc). Esterification of the acid with an ether solution of CH_2N_2 (~5 equiv) and purification by column chromatography (30 % EtOAc/pet ether) gave the title compound (0.321 g, 52 %) as a colorless oil. **^{1}H NMR** ($CDCl_3$, 500 MHz) δ 1.53 (br s, 9H, $C(CH_3)_3$), 2.08 (br d, *J* = 14.4 Hz, 1H, CHC=O), 2.31 (br d, *J* = 14.0 Hz, 1H, CHC=O), 2.42 (br m, 2H, CHC=O), 3.26 (br m, 1H, CHN), 3.63 (s, 3H, OMe), 3.78 (d, *J* = 11.1 Hz, 1H, PhCH), 4.40 (m, 1 H, CHN), 5.12 (m, 1 H, CHN), 7.33 (m, 5H, PhH). **^{13}C NMR** ($CDCl_3$, 125.6 MHz) δ 28.2 (CH_3), 40.7 (CH_2), 42.1 (CH_2), 52.1 (CH_3), 53.6 (CH), 80.9 (C), 128.2 (CH), 128.9 (CH), 134.5 (C), 154.1 (C), 171.3 (C), 207.4 (C). HRMS-FAB (M+1) Calcd for $C_{19}H_{26}NO_5$: 348.1811; Found: 348.1811.

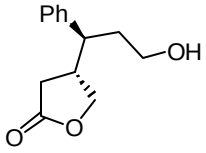
(1,4-Dithia-8-aza-spiro[4.5]dec-7-yl)-phenyl-acetic acid methyl ester (9c). A stirring solution of **9b** (0.173 g, 0.498 mmol) in dry CH_2Cl_2 (4 mL) at rt was treated with ethanedithiol (0.209 mL, 2.49 mmol) and BF_3OEt (0.315 mL, 2.49 mmol). The solution was stirred for 2 h at room temperature and poured into sat. $NaHCO_3$ (25 mL). The organics were separated and the aqueous was back extracted with CH_2Cl_2 (3 x 20 mL). The combined organics were dried over Na_2SO_4 and concentrated. Purification of the residue by column chromatography (20 % EtOAc/pet ether then 3% MeOH/EtOAc) gave the title compound (0.123 g, 76 %) as colorless crystals which were suitable for X-ray analysis. **^{1}H NMR** ($CDCl_3$, 400 MHz) δ 1.58?(t, *J* = 12.7 Hz, 1H, ring-CH), 1.75 (d, *J* = 13.1 Hz, 1H, ring-CH), 1.98 (m, 2H, ring-CH), 2.95 (td, *J* = 12.7, 3.1 Hz, 1H, ring-CH), 3.16 (m, 5H, CH_2S, CHPh), 3.41 (m, 2H, CHN), 3.65 (s, 3H, OMe), 7.30 (m, 5H, PhH). **^{13}C NMR** ($CDCl_3$, 100.6 MHz) δ 37.8 (CH_2), 38.7 (CH_2), 42.4 (CH_2), 45.9 (CH_2), 46.0 (CH_2), 52.1 (CH_3), 58.0 (CH), 58.1 (CH), 66.4 (C), 127.6 (CH), 128.4 (CH), 128.7 (CH), 135.5 (C), 173.2 (C). HRMS-FAB (M+1) Calcd for $C_{16}H_{22}NO_2S_2$: 324.1092; Found: 324.1093. Melting point: 120-126 °C



10

3-(4'-furanone)benzenepropanal (10)

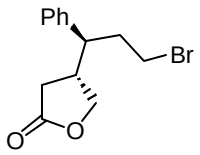
To a solution of **6** (302 mg, 0.71 mmol) in 6 mL of $CHCl_3$, 2 mL of 6M HCl was added. The reaction mixture was stirred for 2 h, and standard workup and flash chromatography (35% EtOAc/hexane) provided the aldehyde **10** in 81% yield as a viscous oil (125 mg, 0.58 mmol): **^{1}H NMR** ($CDCl_3$, 500 MHz) δ 2.21 (m, 2H, OCC$\underline{H}_2$), 2.72 (dd, *J* = 16.5, 6.0 Hz, 1H, PhCHC$\underline{H}$), 2.82 (m, 2H, CHOC$\underline{H}_2$), 3.21 (m, 1H, PhC$\underline{H}$), 4.02 (t, *J* = 8.9 Hz, 1H, C$\underline{H}_2$O), 4.41 (t, *J* = 8.2 Hz, 1H, C$\underline{H}_2$O), 7.11 (m, 5H, PhH), 9.59 (bs, 1H, C$\underline{H}$O). **^{13}C NMR** ($CDCl_3$, 125 MHz) δ 33.0, 41.4, 42.5, 47.8, 71.5, 127.6, 129.2, 140.5, 176.1, 200.3. HRMS: Calcd for $C_{13}H_{14}O_3$: 218.0943; found: 218.0942.



11

4-(3-Hydroxy-1-phenyl-propyl)-dihydro-furan-2-one (11)

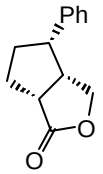
To a solution of **10** (102 mg, 0.47 mmol) in 5 mL of ethanol, 8.9 mg of $NaBH_4$ (0.24 mmol, 0.5 equiv) was added. After stirring at room temperature for 5 min, the reaction mixture was quenched with acetone. Addition of H_2O, ether extraction, drying with $NaSO_4$ and concentration by rotary evaporation afford crude **11** in quantitative yield. No purification was necessary. **^{1}H NMR** ($CDCl_3$, 500 Mhz) δ 1.80 (m, 2H, C$\underline{H}_2$CH$_2$OH), 2.06 (dd, *J* = 17.7, 9.4 Hz, 1H, OCC$\underline{H}_2$), 2.13 (bs, 1H, O$\underline{H}$), 2.20 (dd, *J* = 17.7, 8.2 Hz, 1H, OCC$\underline{H}_2$), 2.72 (td, *J* = 10.5, 3.9 Hz, 1H, PhC$\underline{H}$), 2.82 (m, 1H, OCH$_2$C$\underline{H}$), 3.28 (ddd, *J* = 10.7, 8.6, 6.1Hz, 1H, C$\underline{H}_2$OH), 3.43 (ddd, *J* = 10.7, 6.4, 4.6 Hz, 1H, C$\underline{H}_2$OH), 4.08 (dd, *J* = 9.0, 8.1 Hz, 1H, COC$\underline{H}_2$), 4.50 (dd, 1H, *J* = 9.0, 7.6Hz, COC$\underline{H}_2$), 7.17 (m, 2H, PhH), 7.25 (m, 1H, PhH), 7.33 (m, 2H, PhH). **^{13}C NMR** ($CDCl_3$) δ 30.89, 33.29, 36.61, 41.10, 47.32, 71.82, 127.45, 127.51, 129.02, 139.96, 176.16. HRMS: Calcd for $C_{13}H_{16}O_3$: 220.1099; found: 220.1096.



12

4-(3-Bromo-1-phenyl-propyl)-dihydro-furan-2-one (12)

To a solution of **11** (0.22 g, 0.98 mmol) and CBr_4 (0.41 g, 1.22 mmol, 1.25 equiv) in CH_2Cl_2 was cooled to 0 °C, PPh_3 (0.39 g, 1.47 mmol, 1.5 equiv) was added over 20 min. After stirring for additional 1 hr, the solution was warmed to room temperature. The solvent was exchanged with ether, and the resulting white precipitates were filtered. The crude product was purified by column chromatography (30% EtOAc/hexane) to afford **12** (0.14 g, 1.45 mmol, 49%). **^{1}H NMR** ($CDCl_3$, 500 Mhz) δ 2.10 (m, C$\underline{H}_2$CH$_2$OH, OCC$\underline{H}_2$, 3H), 2.19 (td, *J* = 17.6, 8.1 Hz, OCC$\underline{H}_2$, 1H), 2.80 (m, 2H, PhC$\underline{H}$, OCH$_2$C$\underline{H}$), 2.96 (td, *J* = 10.0, 5.9 Hz, 1H, C$\underline{H}_2$Br), 3.27 (ddd, *J* = 10.26, 6.35, 4.2 Hz, 1H, C$\underline{H}_2$Br), 4.08 (dd, *J* = 8.1, 7.6 Hz, 1H, COC$\underline{H}_2$), 4.52 (dd, *J* = 9.0, 7.3 Hz, 1H, COC$\underline{H}_2$), 7.17 (m, 2H, PhH), 7.25 (m, 1H, PhH), 7.33 (m, 2H, PhH). **^{13}C NMR** ($CDCl_3$, 125 MHz) δ 30.89, 33.29, 36.61, 41.10, 47.32, 71.82, 127.45, 127.51, 129.02, 139.96, 176.16.

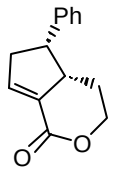


13

4-Phenyl-hexahydro-cyclopentafuran-1-one (13)

A solution of the **12** (110 mg, 0.39 mmol) in 4 mL of THF was cooled to -78 °C, and LDA (0.25 mL, 0.47 mmol, 1.2 equiv) was added. After stirring for 1 hr, the solution was warmed to room temperature. Standard workup and purification by column chromatography (30% EtOAc/hexane) to afford **13** (47 mg, 0.23 mmol, 60%). **^{1}H NMR** ($CDCl_3$, 500 Mhz) δ 1.78 (m, 1H, C$\underline{H}_2$CHPh), 2.05 (m, 2H, C$\underline{H}_2$C$\underline{H}_2$CHPh), 2.29(m, 1H, C$\underline{H}_2$CH$_2$CHPh), 3.17 (t, *J* = 9.0 Hz, 1H, OCC$\underline{H}$), 3.34 (dq, *J* = 8.79, 4.76 Hz, 1H, C$\underline{H}$CHPh), 3.43 (m, 1H, C$\underline{H}$Ph), 3.73 (dd, *J* = 10.01, 4.76 Hz, 1H, OC$\underline{H}_2$), 4.07 (dd, *J* = 10.0, 9.0 Hz, 1H, OC$\underline{H}_2$), **7**.17 (m, 2H, PhH), 7.25 (m, 1H, PhH), 7.33 (m, 2H, PhH). **^{13}C NMR** ($CDCl_3$, 125 MHz) δ 28.12, 30.57, 42.08, 44.18, 48.90, 68.99, 126.64, 127.71,

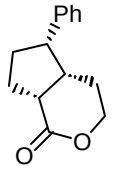
128.52, 139.07, 180.91. Anal. Calcd for $C_{13}H_{14}O_2$: C, 77.20 %; H, 6.98 % Found: C, 77.41%; H, 7.03%. Melting point: 89-90 °C.



15

5-Phenyl-4,4',5,6-tetrahydro-3H-cyclopentapyran-1-one (15)

To a solution of **14** (180 mg, 0.77 mmol) in 10 mL of toluene, 1.0 equiv TFA was added, and the reaction mixture was refluxed overnight. Standard workup and flash chromatography (35% EtOAc/hexane) provided **15** as white crystals (135 mg, 0.63 mmol, 81%). **^{1}H NMR** ($CDCl_3$, 400 Mhz) δ1.10 (tdd, *J* = 13.9, 12.2, 5.2 Hz, 1H, $OCH_2C\underline{H}_2CH$), 1.52 (dm, *J* = 13.7 Hz, 1H, $OCH_2C\underline{H}_2$), 2.77 (dddd, *J* = 19.1, 3.5, 2.3 Hz, 1.4Hz,1H, $PhCHC\underline{H}_2$), 3.06 (dddd, *J* = 19.1, 8.2, 3.6, 2.3 Hz, 1H, $PhCHC\underline{H}_2$), 3.3 (m, 1H, $PhCHC\underline{H}$), 3.80 (td, *J* = 8.7, 0.9 Hz, 1H, $PhC\underline{H}$), 4.29 (m, 2H, $OC\underline{H}_2$), 7.06 (dm, *J* = 7.06 Hz, 1H, $C{=}C\underline{H}$), 7.25 (m, 5H, PhH). **^{13}C NMR** ($CDCl_3$ 100 Mhz) δ25.9, 39.3, 46.3, 47.2, 69.5, 126.8, 127.6, 128.3, 144.7, 163.69. Anal. Calcd for $C_{14}H_{14}O_2$: C, 78.48%; H, 6.59% Found: C, 78.25%; H, 6.61%. Melting point: 124-125 °C.

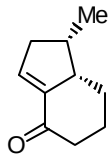


16

5-Phenyl-hexahydro-cyclopenta[c]pyran-1-one (16)

To a solution of **15** (118 mg, 0.55 mmol) in 4 mL of methanol, 10 mol% of dichloro[(*S*)-(–)-2,2'-bis(diphenylphosphino)-1,1'-binapthyl]ruthenium (II) (44 mg, 0.06 mmol) was added, and the heterogeneous mixture was hydrogenated for 8 h at room temperature. The solvent was removed under vacuum, and flash chromatography (35% EtOAc/hexane) afforded **16** as white crystals (90 mg, 0.42 mmol, 76%) which were suitable for X-ray analysis. **^{1}H NMR** ($CDCl_3$, 500 Mhz) δ 1.30 (m, 2H, $PhCHC\underline{H}_2$), 2.01 (m, 2H, $OCH_2C\underline{H}_2$), 2.28 (m,1H, $PhCHCH_2C\underline{H}_2$), 2.36 (m, 1H, $PhCHCH_2C\underline{H}_2$), 2.77 (m,

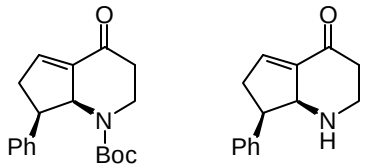
1H, PhCHC<u>H</u>), 3.17 (ddd, *J* = 13.8, 8.7, 5.1 Hz, 1H, OCC<u>H</u>), 3.36 (td, *J* = 9.4, 8.0 Hz, 1H, PhC<u>H</u>), 4.13 (td, *J* = 11.2, 3.1 Hz, 1H, OC<u>H</u>$_2$), 4.31 (dt, *J* = 11.2, 3.6 Hz, 1H, OC<u>H</u>$_2$), 7.21 (d, *J* = 8.0 Hz, 2H, PhH), 7.25 (d, *J* = 7.6Hz, 1H, PhH), 7.34 (t, *J* = 7.6 Hz, 2H, PhH). **^{13}C NMR** ($CDCl_3$) δ 24.05, 27.15, 29.56, 41.95, 43.58, 49.22, 68.74, 126.76, 128.17, 128.65, 140.37. Anal. Calcd for $C_{14}H_{16}O_2$: C, 77.75%; H, 7.46% Found: C, 77.57%; H, 7.28%. Melting point: 82-83 °C.



17

1-Methyl-1,2,5,6,7,7'-hexahydro-inden-4-one (17)

To a stirring solution of **8** (421 mg, 1.16 mmol) in 30 mL of toluene, 1 mL of H_2O and TFA (0.1 mL, 1.3 mmol) was added. The reaction mixture was refluxed for 4 h, and the standard workup afforded the crude product as a dark oil, which was purified by column chromatography (20% EtOAc/hexane) to give the product as a clear oil with 83:17 dr (134 mg, 0.89 mmol, 77%). Major diastereomer: **^{1}H NMR** (CDCl3, 500 Mhz) δ 1.16 (d, 3H, *J* = 6.4 Hz, C<u>H</u>$_3$), 1.74 (m, 1H), 2.03 (m, 3H), 2.10 (m, 1H), 2.21 (m, 1H), 2.40 (m, 1H), 2.52 (m, 2H), 6.60 (m, 1H, C=C<u>H</u>). **^{13}C NMR** ($CDCl_3$, 125 MHz) δ 16.58, 18.28, 24.06, 25.37, 30.14, 36.25, 40.23, 40.35, 40.64, 44.12, 48.68, 52.86, 138.36, 144.91, 199.57. HRMS: Calcd for $C_{10}H_{14}O_1$: 150.1045; found: 150.1049.

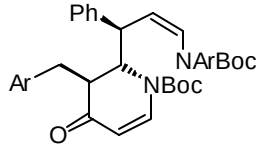


18 **18a**

4-Oxo-7-phenyl-2,3,4,6,7,7a-hexahydro-[1]pyrindine-1-carboxylic acid tert-butyl ester (18):

To a stirring solution of **9a** (0.338 g, 0.63 mmol) in $CHCl_3$ (0.1M) at room temperature, was added approximately 1 mL of 6M HCl. The reaction mixture was stirred for 1h when water (10mL) was added and the aqueous portion separated and extracted with CH_2Cl_2 (3x10mL). The organic portions were combined, dried over

MgSO4, and filtered. Purification of **18** by flash chromatography (30% EtOAc/hexanes) provided a yellow solid (0.140g, 85%). **^{1}H-NMR** (d^6-DMSO, *VT = 100 °C*, 400 MHz) δ 1.40 (s, 9H, C(C$\underline{H}_3$)$_3$), 2.20 (m, 2H), 2.35 (m,1H), 2.67 (m, 1H), 2.96 (m, 1H), 3.80 (m, 1H), 3.96 (t, *J* = 7.2 Hz, 1H, PhC$\underline{H}$), 5.13 (m, 1H), 6.96 (dd, *J* = 5.4, 3.2 Hz, 1H), 7.18 (m, 5H, PhH). In addition, to further confirm the identity of **18**, the compound was Boc deprotected by treating it with excess TFA in CH_2Cl_2 to provide 80% of the deprotected aminoketone **18a**. **^{1}H-NMR** ($CDCl_3$, 400 MHz) δ 2.10 (ddd, *J* = 17.8, 12.1, 7.0 Hz, 1H), 2.38 (ddd, *J* = 17.8, 3.7, 1.3 Hz, 1H), 2.70 (dpentets, *J* = 18.8, 1.7 Hz,1H), 3.0 (m, 2H), 3.24 (ddd, 1H, *J* = 13.9, 7.1, 1.1 Hz), 3.90 (t, 1H, *J*= 7.7 Hz), 4.30 (m, 1H), 6.88 (dt, *J* = 3.5, 2.0 Hz, 1H, C$\underline{H}$=C), 7.20 (m, 5H, Ph$\underline{H}$). **^{13}C-NMR** ($CDCl_3$, 100 MHz) δ 38.3, 41.2, 44.4, 48.1, 67.0, 127.2, 128.2, 128.2, 128.5, 137.4, 140.6, 142.2, 197.5.

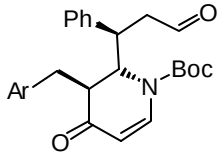


19a

3-(4-Bromo-benzyl)-2-{3-[tert-butoxycarbonyl-(4-methoxy-phenyl)-amino]-1-phenyl-allyl}-4-oxo-3,4-dihydro-2H-pyridine-1-carboxylic acid tert-butyl ester (19a):

To a precooled (–78 °C) solution of the major diastereomer **9** (0.149 g, 0.278 mmol) in THF (0.2 M) was added LDA (2 equiv. 0.556 mmol, 0.29 mL) dropwise. The solution was stirred at –78 °C for 0.5 h when a solution of *p*-bromobenzyl bromide (0.139g, 0.56mmol) in THF (0.5 M) was added dropwise. The reaction was stirred at –78 °C for 0.5 h and warmed to room temperature and quenched with MeOH. Following the standard workup, the reaction mixture was purified by flash chromatography (30%EtOAc/hexanes) providing diastereomerically pure **19a** (0.183 g, 91%) as a white solid. **^{1}H-NMR** (d^6-DMSO, *VT = 100 °C*, 400 MHz) δ 1.38 (s, 9H, C(C$\underline{H}_3$)$_3$), 1.54 (s, 9H, C(C$\underline{H}_3$)$_3$), 1.86 (dd, 1H, *J* = 10.3, 5.3 Hz), 2.41 (dd, 1H, *J* = 13.7, 10.7 Hz), 2.54 (dd, 1H, *J* = 13.9, 5.3 Hz), 3.44 (t, 1H, *J* = 11.0Hz, =CHC$\underline{H}$(PhH)), 3.79 (s, 3H, OC$\underline{H}$3), 4.18 (bs, 1H, ring-CHC$\underline{H}$N(Boc)), 5.11 (dd, *J* = 11.0, 8.8 Hz, 1H, PhCHC$\underline{H}$=CHN), 5.24 (d,

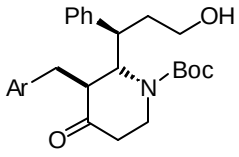
1H, *J* = 8.0, ring-=CHC=O), 6.31 (m, 2H, ArH), 6.49 (d, 1H, *J*=8.8 Hz, PhCHCH=CHN), 6.72 (m, 2H, ArH), 6.83 (m, 2H, ArH), 6.94 (m, 2H, ArH), 7.11 (m, 3H, ArH), 7.35 (m, 2H, ArH), 7.71 (bs, 1H, ring-NCH=CHC=O). **^{13}C-NMR** (*d*^{6}-DMSO, *VT = 100°C*, 100 MHz) δ 28.3, 28.5, 35.8, 42.8, 48.3, 56.3, 59.0, 81.3, 83.6, 105.8, 114.9, 119.8, 120.2, 127.5, 128.2, 128.3, 129.0, 130.5, 131.5, 131.7, 135.6, 137.6, 139.3, 141.8, 151.9, 153.4, 158.2, 194.3. Anal. Calcd. C: 64.86%, H: 6.16%, N: 3.98%, Found C: 64.89%, H: 6.34%, N: 3.99%.



19

3-(4-Bromo-benzyl)-4-oxo-2-(3-oxo-1-phenyl-propyl)-3,4-dihydro-2H-pyridine-1-carboxylic acid tert-butyl ester (19)

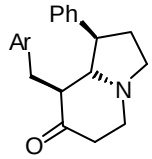
To a solution of **19a** (0.476 g, 0.676 mmol) in $CHCl_3$ (0.1 M) at room temperature was added excess 6M HCl (4 mL) and the reaction stirred over 5h. The progress of the reaction was monitored by TLC(30% EtOAc/Hex, R_f=0.25). Following completion of the reaction water was added and the aqueous portion was extracted with ether(3 x 10mL). The organic portions were combined, dried over $MgSO_4$, and filtered. The crude product was purified by flash chromatography(30% EtOAc/ Hex) to provide 0.285g of **19**, 85% yield, as a clear viscous oil. **^{1}H-NMR** ($CDCl_3$, 400 MHz, sample rotameric at room temperature) δ 1,56 (s, 9H, C(CH$_3$)$_3$), 2.31 (bs, 1H), 2.21 (dd, *J* = 13.7, 11.5 Hz,1H), 2.61 (m, 3H), 3.60 (dt, *J* = 11.0, 7.3 Hz, 1H), 4.30 (bd, 1H), 5.38 (bs, 1H), 6.68 (m, 2H), 6.91 (m, 2H), 7.24 (m, 5H), 7.74 (bd, 1H), 9.44 (bs, 1H, CHO). Anal. Calcd. C: 62.66%, H: 6.16%, N: 3.98%, Found C: 64.89%, H: 6.34%, N: 3.99%.



20

3-(4-Bromo-benzyl)-2-(3-hydroxy-1-phenyl-propyl)-4-oxo-3,4-dihydro-2H-pyridine-1-carboxylic acid tert-butyl ester (20)

To a stirring solution of **19** (0.285 g, 0.59 mmol) under a N_2 atmosphere in THF (0.13 M) cooled to -25 °C was added L-selectride (1.30 mL, 1.30 mmol, 1M in THF) dropwise. The reaction mixture was stirred at -25 °C for 2 h and then warmed to room temperature and quenched with cold saturated $NaHCO_3$ (10 mL). The aqueous portion of the reaction was extracted with ether(3 x 10 mL), dried over $MgSO_4$, concentrated, and purified by flash chromatography (50%EtOAc/hexanes) providing **20** as a clear oil (0.171 g, 57%). **^{1}H-NMR** ($CDCl_3$, 500 MHz, sample rotameric at room temperature) δ 1.50 (d, rotamer, 9H, $C(C\underline{H}_3)_3$), 1.71 (m, 1H), 2.38 (m, 2H), 2.60 (m, 3H), 2.81 (m, 3H), 3.35 (m, 2H), 3.38 (m, 1H), 4.41 (m, 2H, rotamers centered about 4.41), 6.70 (m, 4H), 7.19 (m, 5H). **^{13}H-NMR** (CDCl3, 125 MHz, (sample rotameric at room temperature)) δ 28.6 (28.7), 34.5 (34.7), 36.4 (36.8), 37.9 (38.2), 38.4 (39.1), 43.5 (43.9), 53.3 (54.4), 58.0 (58.8), 60.2, 80.9 (81.2), 120.5 (120.6), 127.2 (127.4), 129.0 (129.2), 130.8 (131.0), 131.6 (131.7), 136.8 (136.9), 140.4 (140.5), 155.8 (155.9), 210.7 (210.8). **IR** (film evaporated from CH_2Cl_2) bs 3450 cm^{-1} (OH), 2950 cm^{-1} (CH_2), 1690 cm^{-1} (C=O). HRMS (FAB) M+1 Calcd: 502.1592 Found: 502.1592.

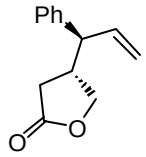


21

8-(4-Bromo-benzyl)-1-phenyl-hexahydro-indolizin-7-one (21):

The alcohol **20** (0.165 g, 0.338 mmol) was converted to the mesylate under standard conditions (MsCl, pyridine, CH_2Cl_2, 36 h, RT) in 85% yield (0.165 g). **^{1}H-NMR** (CDCl3, 500 MHz, sample rotameric at room temperature) δ 1.55(d, rotamer, 9H, $C(C\underline{H}_3)_3$), 1.78 (m, 1H), 2.37 (m, 2H), 2.65 (m, 3H), 2.80 (m, 4H), 3.18 (m, 1H), 3.63 (m, 1H), 4.0 (m, 1H), 4.42 (m, 2H), 6.71 (m, 4H), 7.21 (m, 5H). **IR** (film evaporated from CH_2Cl_2) 2975 cm^{-1} (CH2), 1692 cm^{-1} (C=O) 1363 and 1173 cm^{-1} (RSO2(OR)). The mesylate was cyclized immediately out of concern of product decomposition. To a solution of the mesylate (0.112g, 0.192 mmol) in CH_2Cl_2 (0.05M) was added excess TFA

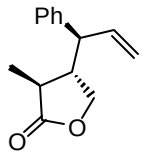
(~1 mL). The reaction was stirred at room temperature until completion as indicated by TLC (EtOAc). Upon completion, the reaction mixture was concentrated, basified, and extracted with ether(3 x 10mL). The combined extracts were dried over $MgSO_4$ and concentrated. The crude product was purified by flash chromatography(5% MeOH, EtOAc, 1% Et_3N) to give 0.056 g of a clear oil(90% yield). **^{1}H-NMR** ($CDCl_3$, 500 MHz) δ 1.82 (m, 1H,), 2.25 (dd, *J* = 14.3, 2.2 Hz, 1H), 2.37 (ddd, *J*=13.7, 3.1, 2.0 Hz, 1H), 2.62 (m, 6H), 2.82 (td, *J*=9.4, 1.6 Hz, 1H), 3.25 (m, 2H), 3.38 (ddd, *J*=10.9, 6.7, 2.0 Hz, 1H), 6.76 (m, 2H, Ar<u>H</u>), 7.56 (m, 7H, Ar<u>H</u>, Ph<u>H</u>). **^{13}C-NMR** (CDCl3, 125 MHz) δ 30.4, 35.9, 41.2, 50.7, 52.3, 53.3, 58.8, 75.0, 119.7, 126.9, 128.0, 129.1, 131.1, 131.3, 140.1, 145.3, 209.6. HRMS (FAB) M+1 Calcd: 384.0963 Found: 384.0956.



23

Representative Ozonolysis and Subsequent Olefination of the Enecarbamates: Preparation of 4-(1-Phenyl-allyl)-dihydro-furan-2-one (23)

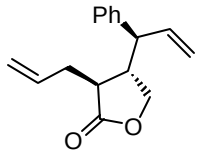
To a solution of **6** (952 mg, 2.28 mmol) in 50 mL of CH_2Cl_2 ozone was bubbled at –78 °C until color of the solution changed to light purple. DMS (1 mL) was added to quench the reaction, and the reaction mixture was stirred overnight at room temperature. The solvent was removed under vacuum, and the aldehydes in 5 mL of THF was slowly added to the ylide generated from Ph_3PCH_3Br (1.79 g, 5.01 mmol, 2.2 equiv) and *n*-BuLi (3.14 mL, 5.01 mL) in 100 mL of THF. After the reaction mixture was stirred for 2 h, standard workup and column chromatography provided **23** as a colorless oil (245 mg, 1.21 mmol, 53%). **^{1}H NMR** ($CDCl_3$, 500 MHz) δ 2.17 (dd, *J* = 17.5, 8.3 Hz, 1H, OCC<u>H</u>$_2$), 2.39 (dd, *J* = 18.0, 8.8 Hz, 2H, OCC<u>H</u>$_2$), 2.96(m, 1H, OCH$_2$C<u>H</u>), 3.24 (t, *J* = 9.3 Hz, 1H, PhC<u>H</u>), 4.16 (dd, *J* = 9.4, 7.2 Hz, 1H, OC<u>H</u>$_2$), 4.44(dd, *J* = 9.4, 7.2 Hz, 1H, OC<u>H</u>$_2$), 5.15 (dm, *J* = 9.4 Hz, 1H, CH=C<u>H</u>$_2$), 5.17 (dm, *J* = 16.3 Hz, 1H, CH=C<u>H</u>$_2$), 5.93 (ddd, *J* = 17.2, 10.0, 8.7 Hz, 1H, C<u>H</u>=CH$_2$), 7.19 (m, 2H, PhH), 7.27(m, 1H, PhH), 7.35(m, 2H, PhH). **^{13}C NMR** ($CDCl_3$, 125 MHz) δ 33.39, 39.95, 54.02, 72.03, 117.02, 128.42, 127.75, 129.27, 138.64, 141.48, 176.95. HRMS: Calcd for $C_{13}H_{14}O_2$: 202.0994; found: 202.0990.



24

3-Methyl-4-(1-phenyl-allyl)-dihydro-furan-2-one (24)

The general ozonolysis and subsequent olefination procedure was followed using **22** (82 mg, 0.19 mmol) to afford **24** (24 mg, 0.11 mmol, 58%). **^{1}H NMR** ($CDCl_3$, 500 MHz) δ0.80 (d, *J* = 7.2 Hz, 3H, C$\underline{H}_3$), 2.30 (dq, *J* = 9.3, 7.2 Hz, 1H, C$\underline{H}$CH$_3$), 2.55 (m, *J* = 9.3 Hz, 1H, PhCHC$\underline{H}$), 3.27, (t, *J* = 9.2 Hz, 1H, PhC$\underline{H}$), 4.00 (t, *J* = 9.0 Hz, 1H, C$\underline{H}_2$O), 4.41 (dd, *J* = 9.4, 7.8 Hz, 1H, C$\underline{H}_2$O), 5.17 (ddd, *J* = 10.2, 1.4, 0.4 Hz, 1H, CH=C$\underline{H}_2$), 5.18 (dt, *J* = 17.1, 1.3 Hz, 1H, CH=C$\underline{H}_2$), 5.99 (ddd, *J* = 17.1, 10.3, 8.9 Hz, 1H, C$\underline{H}$=CH$_2$), 7.20-7.40 (m, 5H, PhH) ^{13}C NMR ($CDCl_3$, 125 MHz) δ 15.24, 39.53, 47.77, 54.29, 70.27, 116.99, 127.46, 127.87, 129.29, 138.26, 141.37, 180.09. HRMS: Calcd for $C_{14}H_{16}O_2$: 216.1150; found: 216.1145.

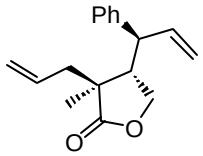


25

Representative Enolization-Alkylation of Michael adducts: Preparation of 3-Allyl-4-(1-phenyl-allyl)-dihydro-furan-2-one (25)

A solution of the enecarbamate **23** (88 mg, 0.44 mmol) in 30 mL THF was cooled to –78 °C and LDA (0.27 mL, 0.53 mmol, 1.2 equiv) was added. After stirring for 1 hr, allyl bromide (0.06 mL, 0.66 mmol, 1.5 equiv) was added. The mixture was stirred an additional 2 h and slowly warmed to room temperature. Standard workup and purification of the crude product by column chromatography afforded **25** (73 mg, 0.30 mmol, 69%). **^{1}H NMR** ($CDCl_3$, 500 MHz) δ1.74 (m, 1H, H$_2$C=CHC$\underline{H}_2$), 2.27 (m, 1H, H$_2$C=CHC$\underline{H}_2$), 2.42 (m, 1H, OCC$\underline{H}$), 2.71 (m, 1H, OCH$_2$C$\underline{H}$), 3.27 (t, *J* = 9.5 Hz, 1H, PhC$\underline{H}$), 4.09 (ddd, *J* = 9.6, 7.2, 1.5 Hz, 1H, OC$\underline{H}_2$), 4.35 (ddd, 1H, *J* = 9.4, 7.8, 1.5 Hz, OC$\underline{H}_2$), 4.92 (dm, *J* = 17.0 Hz, 1H, C$\underline{H}_2$=CH), 5.06 (d, *J* = 10.4 Hz, 1H, C$\underline{H}_2$=CH), 5.17 (m, 1H, C$\underline{H}_2$=CH), 5.20 (dm, *J* = 5.0 Hz, 1H, C$\underline{H}_2$=CH), 5.54 (m, 1H, CH$_2$=C$\underline{H}$), 5.90 (m, 1H, CH$_2$=C$\underline{H}$), 7.19 (m, 2H, PhH), 7.27 (m, 1H, PhH), 7.36 (m, 2H, PhH). **^{13}C**

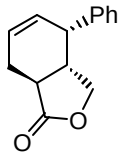
NMR ($CDCl_3$, 125 MHz) δ 33.39, 43.00, 44.03, 54.22, 70.22, 117.41, 118.97, 127.54, 127.98, 129.20, 133.83, 128.08, 141.21, 178.88. HRMS: Calcd for $C_{16}H_{18}O_2$: 242.1307; found: 242.1314.



26

3-Allyl-3-methyl-4-(1-phenyl-allyl)-dihydro-furan-2-one (26)

The general enolization and subsequent alkylation procedure was followed using **24** (150 mg, 0.69 mmol) to afford **26** (133 mg, 0.52 mmol, 75%). **^{1}H NMR** ($CDCl_3$, 500 MHz) δ 1.20 (s, 3H, CH_3), 1.25 (dd, *J* = 14.3, 9.2 Hz, 1H, CH_3CCH_2), 2.20 (ddt, *J* = 14.1, 5.0, 1.7 Hz, 1H, CH_3CCH_2), 2.94 (dt, *J* = 11.0, 8.3 Hz, 1H, PhCHCH), 3.34 (dd, *J* = 11.0, 9.3, 1H, PhCH), 3.89 (dd, *J* = 11.0, 9.3Hz, 1H, OCH_2), 4.35 (dd, *J* = 9.5, 7.8 Hz, 1H, OCH_2), 4.83 (dm, *J* = 17.3 Hz, 1H, CH_2=CH), 5.03 (dd, *J* = 10.1, 1.2 Hz, 1H, CH_2=CH), 5.08 (dt, *J* = 10.3, 1.7 Hz, 1H, CH_2=CH), 5.13 (dm, *J* = 17.0 Hz, 1H, CH_2=CH), 5.54 (m, 1H, , CH_2=CH), 5.87 (ddd, *J* = 17.0, 10.1, 9.3 Hz, 1H, CH_2=CH), 7.24 (m, 2H, PhH), 7.29 (m, 1H, PhH), 7.36 (m, 2H, PhH). **^{13}C NMR** ($CDCl_3$, 125 MHz) δ 18.77, 40.27, 43.18, 45.85, 50.83, 69.47, 116.01, 119.72, 127.49, 128.22, 129.03, 133.54, 139.12, 141.04, 181.74. HRMS: Calcd for $C_{17}H_{22}O_2$: 256.1463; found: 256.1457.

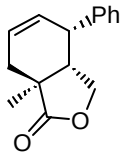


28

4-Phenyl-3',4,7,7'-tetrahydro-3H-isobenzofuran-1-one (28)

To a solution of **25** (21 mg, 0.086 mmol) in 10 mL of CH_2Cl_2, 5 mol% of the Grubbs catalyst (4 mg, 4 μmol) was added. The solution was refluxed overnight. The solvent was removed under vacuum and the purification by chromatography (15% EtOAc/hexane) afforded **28** (18 mg, 0.084 mmol, 98%). **^{1}H NMR** ($CDCl_3$, 500 MHz) δ2.24 (m, 1H, OCCH), 2.37 (ddd, *J* = 14.2, 11.4, 5.4 Hz, 1H, PhCHCH), 2.65 (m, 2H,

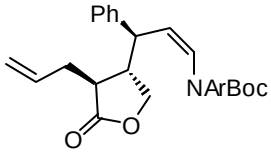
CH=CHC$\underline{H}_2$), 3.44 (dd, *J* = 11.4, 8.4 Hz, 1H, PhC$\underline{H}$), 3.83 (m, 1H, OC$\underline{H}_2$), 4.37 (dd, *J* = 8.7, 7.0 Hz, 1H, OC$\underline{H}_2$), 5.85 (m, 1H, CH=C$\underline{H}$), 6.11(m, 1H, C$\underline{H}$=CH), 7.12 (m, 2H, PhH), 7.30 (m, 1H, PhH), 7.37 (m, 2H, PhH). **^{13}C NMR** ($CDCl_3$, 125 MHz) δ 25.62, 34.93, 42.41, 43.09, 70.35, 127.71, 128.22, 128.69, 128.91, 129.67, 138.29, 177.54 HRMS: Calcd for $C_{14}H_{14}O_2$: 214.0994; found: 214.0988.



29

7'-Methyl-4-phenyl-3',4,7,7'-tetrahydro-3H-isobenzofuran-1-one

To a solution of **26** (70 mg, 0.27 mmol) in 20 mL of CH_2Cl_2, 5 mol% of the Grubbs catalyst (11.3 mg, 14 μmol) was added. The solution was refluxed for 24 h. The solvent was removed under vacuum and the purification by chromatography (15% EtOAc/hexane) afforded **29** (52 mg, 0.23 mmol, 83%). **^{1}H NMR** ($CDCl_3$, 500 MHz) δ 0.88 (s, 3H, C$\underline{H}_3$), 2.35 (m, 2H, CH=CHC$\underline{H}_2$), 2.75 (dt, *J* = 12.2, 7.2 Hz, 1H, PhCHC$\underline{H}$), 3.93 (bs, 1H, PhC$\underline{H}$), 4.07 (dd, *J* = 12.2, 8.7 Hz, 1H, OC$\underline{H}_2$), 4.57 (dd, *J* = 8.7, 7.0Hz, 1H, OC$\underline{H}_2$), 6.06 (m, 2H, C$\underline{H}$=C$\underline{H}$), 7.16 (m, 2H, PhH), 7.26 (m, 1H, PhH), 7.34 (m, 2H, PhH). **^{13}C NMR** ($CDCl_3$, 125 MHz) δ 16.30, 33.86, 40.00, 40.92, 44.90, 69.58, 127.05, 127.82, 127.88, 128.65, 129.20, 138.79, 180.94. HRMS: Calcd for $C_{15}H_{16}O_2$: 228.1150; found: 228.1151.

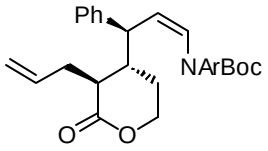


30

[3-(4-Allyl-5-oxo-tetrahydro-furan-3-yl)-3-phenyl-propenyl]-(4-methoxy-phenyl)-carbamic acid tert-butyl ester (30)

The general enolization and subsequent alkylation procedure was followed using **6** (320 mg, 0.76 mmol) to afford **30** (280 mg, 60 mmol, 79%). **^{1}H NMR** ($CDCl_3$, 500 MHz) δ1.43 (bs, 9H, C(CH_3)$_3$), 1.68 (m, 1H, C$\underline{H}_2$CH=CH_2), 2.22 (m, 2H, C$\underline{H}_2$CH=CH_2, C$\underline{H}$CO), 2.40 (m, 1H, C$\underline{H}CH_2$O), 2.92 (bs, 1H, C$\underline{H}$Ph), 3.83 (s, 3H, OC$\underline{H}_3$), 3.99 (dd, *J* =

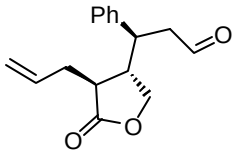
9.5, 6.9 Hz, 1H, OC$\underline{H}_2$), 4.23 (dd, *J* = 9.5, 7.9 Hz, 1H, OC$\underline{H}_2$), 4.82 (dm, *J* = 17.2Hz, 1H, C$\underline{H}$=CHN), 4.97 (m, 2H, HC=C$\underline{H}_2$), 5.40 (m, 1H, C$\underline{H}$=CH$_2$), 6.69 (m, 2H, CH=C$\underline{H}$N, ArH), 6.83 (m, 3H, ArH), 7.02 (bd, 2H, *J* = 7.9 Hz, PhH), 7.18 (m, 3H, PhH). **^{13}C NMR** ($CDCl_3$, 125 MHz) δ 28.35, 33.43, 43.70, 44.70, 44.82, 55.78, 69.85, 114.53, 118.70, 127.13, 127.80, 128.67, 133.84, 134.47, 153.74, 178.88. HRMS: Calcd for $C_{28}H_{33}N_1O_5$: 463.2359; found: 463.2356.



31

[3-(3-Allyl-2-oxo-tetrahydro-pyran-4-yl)-3-phenyl-propenyl]-(4-methoxy-phenyl)-carbamic acid tert-butyl ester (31)

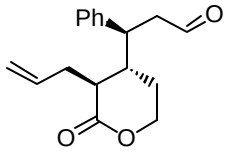
31 was obtained using **7** (731 mg, 1.67 mmol) as the starting material following a procedure similar to that reported for the preparation of **30**. Standard workup and separation of the diastereomers by preparative HPLC (20% EtOAc/hexane) provided 460 mg (0.96 mmol, 58%) of the major diastereomer and 105 mg (0.22 mmol, 13%) of the minor diastereomer. **^{1}H NMR** ($CDCl_3$, 500 MHz) δ 1.41 (s, 9H, C(C$\underline{H}_3$)$_3$), 1.60 (m, 1H, OCH$_2$C$\underline{H}_2$), 1.68 (m, 1H, OCH$_2$C$\underline{H}_2$), 1.92 (m, 1H, OCCHC$\underline{H}_2$), 2.05 (m, 1H, OCCHC$\underline{H}_2$), 2.43 (dt, *J* = 8.9, 4.6 Hz, 1H, OCCHC$\underline{H}$), 2.55 (dt, *J* = 14.1, 5.2 Hz, 1H, OCC$\underline{H}$), 3.12 (bs, 1H, PhC$\underline{H}$), 3.73 (s, 3H, OC$\underline{H}_3$), 4.04 (ddd, *J* = 12.3, 8.6, 3.8 Hz, 1H, OC$\underline{H}_2$), 4.23 (ddd, *J* = 11.2, 5.9, 4.0Hz, 1H, OC$\underline{H}_2$), 4.98 (dm, 1H, *J* = 17.1 Hz, C$\underline{H}$=CHN), 5.04 (m, 2H, C$\underline{H}_2$=CH), 5.59 (m, 1H, CH$_2$=C$\underline{H}$), 6.62 (m, 2H, ArH, HC=C$\underline{H}$N), 6.72 (m, 2H, ArH), 6.88 (m, 3H, PhH, ArH), 7.13 (m, 3H, PhH). **^{13}C NMR** ($CDCl_3$, 125 MHz) δ 23.90, 28.33, 34.11, 40.46, 43.11, 43.51, 55.62, 67.72, 114.08, 118.28, 126.60, 128.01, 128.28, 134.32, 134.77, 141.48, 153.72, 157.93, 173.70. HRMS: Calcd for $C_{29}H_{35}N_1O_5$: 477.2515; found: 477.2517.



32

Representative Hydrolysis of the Enecarmates: Preparation of 3-(4-Allyl-5-oxo-tetrahydro-furan-3-yl)-3-phenyl-propionaldehyde (32)

To a solution of the enecarbamate **30** (96 mg, 0.24 mmol) in 25 mL of $CHCl_3$, 2 mL of 6M HCl was added. The heterogeneous mixture was stirred vigorously for 3 h, diluted with water, and extracted with CH_2Cl_2. The organic layer was dried with $MgSO_4$, and concentrated in vacuum. Chromatography of the crude product (15% EtOAc/pet ether) afforded **32** (53 mg, 0.21 mmol, 91%). as a colorless oil. **^{1}H NMR** ($CDCl_3$, 500 Mhz) δ 1.54 (m, 1H, OCCHC$\underline{H}_2$), δ 2.25 (m, 1H, OCCHC$\underline{H}_2$), 2.40 (dt, *J* = 9.2, 3.8 Hz, 1H, OCC$\underline{H}$), 2.63 (m, 1H, PhCHC$\underline{H}$), 2.69 (ddd, *J* = 17.1, 4.4, 1.3 Hz, 1H, CHOC$\underline{H}_2$), 2.93 (ddd, *J* = 17.1, 10.1, 1.8 Hz, 1H, CHOC$\underline{H}_2$), 3.26 (td, *J* = 9.8, 4.4 Hz, 1H, PhC$\underline{H}$), 4.02 (dd, *J* = 9.2, 8.2 Hz, 1H, OC$\underline{H}_2$), 4.40 (dd, *J* = 9.2, 8.1 Hz, 1H, OC$\underline{H}_2$), 4.64 (dm, *J* = 17.1 Hz, 1H, C$\underline{H}_2$=CH), 5.05 (dm, *J* = 10.2Hz, 1H, C$\underline{H}_2$=CH), 5.50 (m, 1H, CH_2=C$\underline{H}$), 7.20 (m, 2H, PhH), 7.30 (m, 1H, PhH), 7.36 (m, 2H, PhH), 9.60 (dd, *J* = 2.0, 1.4 Hz, 1H, C$\underline{H}$O). **^{13}C NMR** ($CDCl_3$, 125 Mhz) δ 32.97, 43.48, 43.67, 43.99, 47.30, 70.03, 119.29, 128.09, 128.20, 129.38, 133.52, 140.42, 178.31, 200.21. HRMS: Calcd for $C_{16}H_{18}O_3$: 258.1256; found: 258.1252.

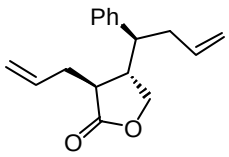


33

3-(3-Allyl-2-oxo-tetrahydro-pyran-4-yl)-3-phenyl-propionaldehyde (33)

The general hydrolysis procedure was followed using **31** (350 mg, 0.71 mmol) to afford **33** (190 mg, 0.70 mmol, 97%). **^{1}H NMR** ($CDCl_3$, 500 Mhz) δ 1.69 (m, 1H, $OCH_2C\underline{H}_2$), 1.91 (m, 1H, $OCH_2C\underline{H}_2$), 2.20 (m, 2H, OCHC$\underline{H}_2$), 2.52 (m, 2H, CHOC$\underline{H}_2$), 2.74 (ddd, *J* = 16.9, 4.4, 1.3 Hz, 1H, PhCHC$\underline{H}$), 2.90 (ddd, *J*=16.9, 10.5, 2.7Hz, 1H, PhC$\underline{H}$), 3.34 (ddd, *J*=10.5, 7.0, 4.4Hz, 1H, , OC$\underline{H}_2$), 4.35 (dd, *J*=11.4, 5.1, 4.2 Hz, 1H, OC$\underline{H}_2$), 5.10 (m, 2H, CH=C$\underline{H}_2$), 5.60 (m, 1H, C$\underline{H}$=CH_2), 7.18 (m, 2H, PhH), 7.26 (m, 1H, PhH), 7.36 (m, 2H, PhH), 9.62 (dd, *J* = 2.4, 1.2 Hz, 1H, C$\underline{H}$O). **^{13}C NMR** ($CDCl_3$, 125 Mhz) δ 25.14, 36.28, 40.65, 42.40, 44.25, 44.69, 67.20, 118.95, 127.67, 128.37,

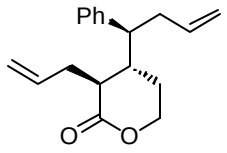
129.21, 134.35, 137.37, 141.08, 173.23, 200.92. HRMS: Calcd for $C_{17}H_{20}O_3$: 272.1412; found: 272.1415.



34

Representative Procedure for the Wittig Reaction: Preparation of 3-Allyl-4-(1-phenyl-but-3-enyl)-dihydro-furan-2-one (34)

To a suspension of Ph_3PCH_3Br (70.7 mg, 0.20 mmol, 1.1 equiv) in 15 mL of THF *n*-BuLi (0.12 mL, 0.20 mmol, 1.1 equiv) was added at –78 °C, and stirred for 1 hr. After slowly warming the solution to room temperature, it was cooled down to –78 °C. A solution of **32** (46 mg, 0.18 mmol) in 5 mL of THF was slowly added to the ylide. The reaction mixture was slowly warmed to room temperature after stir for 2 h. Standard workup and purification by column chromatography (10% EtOAc/hexane) afforded **34** as a colorless oil (32 mg, 0.15 mmol, 67%). **^{1}H NMR** ($CDCl_3$, 500 Mhz) δ 1.48 (m, 1H, C<u>H</u>$_2$CH=CH$_2$), 2.22 (m, 1H, C<u>H</u>$_2$CH=CH$_2$), 2.41 (m, 3H, C<u>H</u>$_2$CH=CH$_2$, OCC<u>H</u>), 2.64 (m, 2H, PhC<u>H</u>, PhCHC<u>H</u>), 4.08 (dd, *J* = 9.1, 8.0 Hz, 1H, OC<u>H</u>$_2$), 4.48 (dd, *J* = 9.3, 7.9 Hz, 1H, OC<u>H</u>$_2$), 4.86 (dm, *J* = 17.2 Hz, 1H, CH=C<u>H</u>$_2$), 4.93 (dm, *J* = 10.3 Hz, 1H, CH=C<u>H</u>$_2$), 4.99 (dm, 1H, *J* = 17.5 Hz, CH=C<u>H</u>$_2$), 5.04 (dm, *J* = 10.1 Hz, 1H, CH=C<u>H</u>$_2$), 5.54 (m, 2H, C<u>H</u>=CH$_2$), 7.15 (m, 2H, PhH), 7.30 (m, 1H, PhH), 7.35 (tm, *J* = 7.6 Hz, 2H, PhH). **^{13}C NMR** ($CDCl_3$, 125 Mhz) δ 10.0, 32.96, 37.97, 43.88, 44.28, 50.39, 70.73, 117.19, 119.04, 127.53, 128.41, 129.00, 133.72, 135.58, 141.38. HRMS: Calcd for $C_{17}H_{20}O_2$: 256.1463; found: 256.1469.

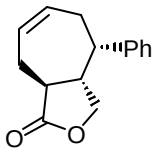


35

3-Allyl-4-(1-phenyl-but-3-enyl)-tetrahydro-pyran-2-one (35)

The general Wittig reaction procedure was followed using **33** (205 mg, 0.75 mmol) to afford **35** (150 mg, 0.56 mmol, 74%). **^{1}H NMR** ($CDCl_3$, 500 Mhz) δ 1.79 (m,

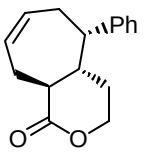
1H, $OCH_2C\underline{H}_2$), 1.96 (m, 1H, $OCH_2C\underline{H}_2$), 2.12 (m, 1H, $PhCHC\underline{H}_2$), 2.24 (m, 1H, $PhCHC\underline{H}_2$), 2.50 (m, 3H, PhCHC<u>H</u>, $OCCHC\underline{H}_2$), 2.59 (q, *J* = 6.2 Hz, 1H, OCC<u>H</u>), 2.77 (ddd, *J* = 9.6, 7.1, 5.4 Hz, 1H, PhC<u>H</u>), 4.19 (ddd, *J* = 11.3, 9.4, 3.3 Hz, 1H, $OC\underline{H}_2$), 4.37 (ddd, *J* = 11.3, 5.6, 4.1 Hz, 1H, $OC\underline{H}_2$), 4.92 (dm, *J* = 10.4 Hz, 1H, $CH=C\underline{H}_2$), 5.00 (dq, *J* = 17.1, 1.8 Hz, 1H, $CH=C\underline{H}_2$), 5.09 (m, 2H, $CH=C\underline{H}_2$), 5.59 (m, 2H, C<u>H</u>=CH_2), 7.15 (m, 2H, PhH), 7.24 (m, 1H, PhH), 7.33 (t, *J* = 7.6 Hz, 2H, PhH). **^{13}C NMR** ($CDCl_3$, 125 Mhz) δ 24.86, 34.57, 36.40, 40.78, 44.49, 48.37, 67.42, 116.83, 118.60, 127.06, 128.73, 128.79, 134.66, 136.31, 142.05, 173.79. HRMS: Calcd for $C_{18}H_{22}O_2$: 270.1620; found: 270.1621.



36

4-Phenyl-3,3',4,5,8,8'-hexahydro-cyclohepta[c]furan-1-one (36)

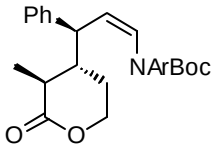
To a solution of **34** (15 mg, 0.07 mmol) in 15 mL of CH_2Cl_2, 5 mol% of the Grubbs catalyst (3 mg, 4 μmol) was added. The solution was stirred overnight at room temperature. The solvent was removed under vacuum and the purification by chromatography (15% EtOAc/hexane) afforded **36** (13 mg, 0.06 mmol, 83%). **^{1}H NMR** ($CDCl_3$, 500 Mhz) δ 2.23 (m, 1H, $PhCHC\underline{H}_2$), 2.57 (m, 2H, $PhCHC\underline{H}_2$, OCC<u>H</u>), 2.73 (ddd, *J* = 16.3, 7.8, 4.1Hz, 1H, $OCCHC\underline{H}_2$), 2.83 (m, 1H, $OCH_2C\underline{H}$), 2.90 (ddd, *J* = 16.7, 7.4, 3.5 Hz, 1H, $OCCHC\underline{H}_2$), 3.26 (q, *J* = 4.2 Hz, 1H, PhC<u>H</u>), 3.64 (dd, *J* = 11.6, 8.8 Hz, 1H, $OC\underline{H}_2$), 4.29 (dd, *J* = 8.8, 7.7 Hz, 1H, $OC\underline{H}_2$), 5.97 (m, 2H, C<u>H</u>=C<u>H</u>), 7.31 (m, 5H, PhH). **^{13}C NMR** ($CDCl_3$, 125 Mhz) δ 30.19, 34.07, 38.30, 41.13, 49.76, 68.88, 127.43, 128.67, 128.69, 130.08, 130.83, 140.65, 179.77. HRMS: Calcd for $C_{15}H_{16}O_2$: 228.1150; found: 228.1148.



37

5-Phenyl-4,4a,5,6,9,9a-hexahydro-3H-cyclohepta[c]pyran-1-one (37)

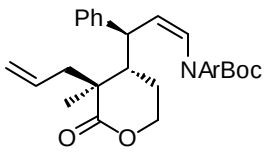
The general ring closing metathesis procedure was followed using **35** (60 mg, 0.22 mmol) to afford **37** as colorless crystals (52 mg, 0.21 mmol, 96%) which were suitable for X-ray analysis. **^{1}H NMR** ($CDCl_3$, 500 Mhz) δ 1.47 (m, 1H, OCH_2CH_2), 1.59 (m, 1H, OCH_2CH_2), 2.31 (m, 1H, PhCHCH), 2.41 (m, 2H, PhCHCH_2), 2.74 (m, 2H, OCCHCH_2), 3.03 (dd, *J* = 17.7, 7.2 Hz, 1H, OCCH), 3.44 (ddd, *J* = 10.1, 5.9, 1.3 Hz, 1H, PhCH), 4.19 (t, *J* = 6.9 Hz, 2H, OCH_2), 5.85 (m, 2H, CH=CH), 7.23 (m, 5H, PhH). **^{13}C NMR** ($CDCl_3$, 125 Mhz) δ 26.10, 28.41, 29.39, 42.35, 43.66, 45.36, 67.08, 126.78, 128.35, 128.64, 129.72, 130.73, 143.10, 175.13. Anal. Calcd for $C_{16}H_{18}O_2$: C, 79.31%; H, 7.49% Found: C, 79.01%; H, 7.43%. Melting point: 126-128 °C.



38

(4-Methoxy-phenyl)-[3-(3-methyl-2-oxo-tetrahydro-pyran-4-yl)-3-phenyl-propenyl]-carbamic acid tert-butyl ester (38)

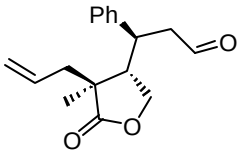
Following a representative enolization-alkylation procedure with **7** (473 mg, 1.08 mmol) and methyl iodide (0.10 mL, 1.62 mmol, 1.5 equiv) as an electrophile provided **38** (351 mg, 0.78 mmol, 72%). Diastereomers were separated on preparative HPLC (25% ethyl aceatate/hexane). **^{1}H NMR** ($CDCl_3$, 400 MHz) δ 1.12 (d, *J* = 6.9 Hz, 3H, CH_3) 1.43 (s, 9H, $C(CH_3)_3$), 1.69 (m, 3H, OCH_2CH_2, CH_3CH), 2.40 (m, 1H, PhCHCH), 3.23(bs, 1H, PhCH), 3.74 (s, 3H, OCH_3), 4.12 (m, 1H, OCH_2), 4.26 (m, 1H, OCH_2), 5.05 (t, *J* = 9.9 Hz, 1H, CH=CHN), 6.60 (dm, *J* = 9.0 Hz, 2H, CH=CHN, ArH), 6.77 (m, 2H, ArH), 6.90 (m, 3H, ArH, PhH), 7.12 (m, 3H, PhH). **^{13}C NMR** ($CDCl_3$, 125 MHz) δ 16.10, 24.10, 28.35, 38.71, 43.39, 44.45, 55.64, 67.45, 114.05, 126.58, 127.99, 128.29, 134.33, 153.80, 157.91, 175.32. HRMS: Calcd for $C_{27}H_{33}N_1O_5$: 451.2359; found: 451.2350.



40

[3-(3-Allyl-3-methyl-2-oxo-tetrahydro-pyran-4-yl)-3-phenyl-propenyl]-(4-methoxy-phenyl)-carbamic acid tert-butyl ester (40)

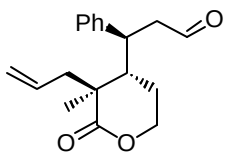
Following a representative enolization-alkylation procedure with **38** (203 mg, 0.45 mmol) and allyl bromide (0.06 mL, 0.68 mmol, 1.5 equiv) as an electrophile provided **40** (178 mg, 0.36 mmol, 81%). **^{1}H NMR** ($CDCl_3$, 500 MHz) δ 1.20 (s, 3H, CH_3), 1.41 (s, 9H, $C(CH_3)_3$), 1.76 (m, 2H, OCH_2CH_2), 1.89 (m, 1H, CH_3CCH_2), 2.03 (m, 1H, CH_3CCH_2), 2.58 (dd, *J* = 14.1, 4.8 Hz, 1H, PhCHCH), 3.25 (bs, 1H, PhCH), 3.79 (s, 3H, OCH_3), 3.99 (dt, *J* = 11.4, 2.9 Hz, 1H, OCH_2), 4.31 (ddd, *J* = 11.8, 5.0, 1.8 Hz, 1H, OCH_2), 4.97 (dm, *J* = 16.8Hz, 1H, $CH=CH_2$), 5.09 (dm, *J* = 10.2 Hz, 1H, $CH=CH_2$), 5.15 (m, 1H, CH=CHN), 5.56 (m, 1H, , $CH=CH_2$), 6.73 (m, 3H, CH=CHN, ArH), 6.83 (m, 2H, ArH), 6.93 (m, 2H, ArH), 7.16(m, 3H, PhH). **^{13}C NMR** ($CDCl_3$, 125 MHz) δ 21.88, 28.34, 40.52, 42.39, 43.85, 55.71, 69.26, 114.16, 119.20, 126.46, 128.14, 128.29, 134.23, 183.02. HRMS: Calcd for $C_{30}H_{37}N_1O_5$: 491.2671; found: 491.2682.



41

3-(4-Allyl-4-methyl-5-oxo-tetrahydro-furan-3-yl)-3-phenyl-propionaldehyde (41)

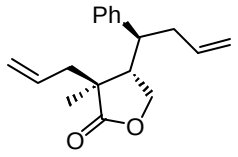
The general hydrolysis procedure was followed using **39** (334 mg, 0.68 mmol) to afford **41** (140 mg, 0.52 mmol, 77%). **^{1}H NMR** ($CDCl_3$, 500 MHz) δ 1.09 (dd, *J* = 14.3, 9.4 Hz, 1H, CH_3CCH_2), 1.20 (s, 3H, CH_3), 2.14 (ddt, *J* = 14.2, 5.1, 1.7 Hz, 1H, CH_3CCH_2), 2.53 (ddd, *J* = 16.5, 4.4, 1.4 Hz, 1H, $CHOCH_2$), 2.80 (m, 2H, PhCHCH, $CHOCH_2$), 3.35 (dt, *J* = 10.7, 4.4 Hz, 1H, PhCH), 3.93 (dd, *J* = 11.0, 9.0 Hz, 1H, OCH_2), 4.39(dd, *J* = 8.8, 8.0 Hz, 1H, OCH_2), 4.76 (dt, *J* = 17.1, 1.7 Hz, 1H, $CH_2=CH$), 5.04 (dt, *J* = 10.2, 1.7 Hz, 1H, $CH_2=CH$), 5.47 (m, 1H, $CH_2=CH$), 7.29 (m, 5H, PhH) 9.52 (t, *J* = 1.7 Hz, 1H, CHO). **^{13}C NMR** ($CDCl_3$, 125 MHz) δ 18.63, 39.49, 39.95, 44.24, 46.09, 48.42, 68.75, 119.87, 127.99, 128.58, 129.09, 133.34, 181.25, 200.36. HRMS: Calcd for $C_{17}H_{20}O_3$: 272.1412; found: 272.1414.



42

3-(3-Allyl-3-methyl-2-oxo-tetrahydro-pyran-4-yl)-3-phenyl-propionaldehyde (42)

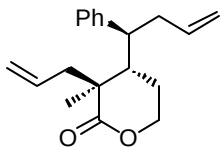
The general hydrolysis procedure was followed using **40** (106 mg, 0.24 mmol) to afford **42** (53 mg, 0.19 mmol, 79%). **^{1}H NMR** ($CDCl_3$, 500 MHz) δ 1.40 (s, 3H, $C\underline{H}_3$), 1.92 (m, 2H, $OCH_2C\underline{H}_2$), 2.13 (dd, *J* = 14.3, 8.6 Hz, 1H, $CH_3CC\underline{H}_2$), 2.34 (m, 1H, $CHOC\underline{H}_2$), 2.65 (ddt, *J* = 14.1, 6.0, 1.7 Hz, 1H, $CH_3CC\underline{H}_2$), 2.77 (ddd, *J* = 17.0, 4.0, 1.0 Hz, $CHOC\underline{H}_2$), 2.93 (dd, 1H, *J* = 10.9, 3.8 Hz, $PhCHC\underline{H}$), 3.52 (dt, 1H, *J* = 10.9, 4.0 Hz, $PhC\underline{H}$, 1H), 4.14 (m, 1H, $OC\underline{H}_2$), 4.40 (dt, *J* = 17.0, 4.0 Hz, 1H, $OC\underline{H}_2$), 4.98 (dm, *J* = 16.9 Hz, $CH=C\underline{H}_2$, 1H), 5.07 (dm, *J* = 10.3 Hz, 1H, $CH=C\underline{H}_2$), 5.59 (m, 1H, $C\underline{H}=CH_2$), 7.30 (m, 5H, PhH), 9.60 (m, 1H, $C\underline{H}O$). **^{13}C NMR** ($CDCl_3$, 125 MHz) δ 22.47, 23.01, 38.59, 42.56, 42.89, 46.52, 49.50, 68.63, 120.05, 127.47, 127.83, 129.29, 133.47, 143.95, 176.03, 200.85. HRMS: Calcd for $C_{18}H_{22}O_3$: 286.1569; found: 286.1563.



43

3-Allyl-3-methyl-4-(1-phenyl-but-3-enyl)-dihydro-furan-2-one (43)

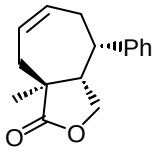
The general Wittig reaction procedure was followed using **41** (38 mg, 0.14 mmol) to afford **43** (28 mg, 0.10 mmol, 73%). **^{1}H NMR** ($CDCl_3$, 500 MHz) δ 1.14 (dd, *J* = 14.5, 9.2 Hz, 1H, $CH_3CC\underline{H}_2$), 1.17 (s, 3H, $C\underline{H}_3$) 2.15 (ddt, *J* = 14.1, 5.3, 1.7 Hz, 1H, $CH_3CC\underline{H}_2$), 2.29 (m, 2H, $PhCHC\underline{H}_2$), 2.76 (ddd, *J* = 11.0, 9.3, 5.5Hz, 1H, $PhCHC\underline{H}$), 2.85 (dt, *J* = 11.0, 8.0 Hz, 1H, $PhC\underline{H}$) 4.00 (dd, *J* = 10.8, 9.0 Hz, 1H, $OC\underline{H}_2$) 4.53(dd, *J* = 9.0, 8.0 Hz, 1H, $OC\underline{H}_2$), 4.82 (dm, *J* = 16.5 Hz, 1H, $CH=C\underline{H}_2$), 4.89 (dm, *J* = 11.2 Hz, 1H, $CH=C\underline{H}_2$), 4.93 (dd, *J* = 17.0, 1.9 Hz, 1H, $CH=C\underline{H}_2$), 5.06 (dt, *J* = 10.4, 1.9 Hz, 1H, $CH=C\underline{H}_2$), 5.48 (m, 2H, $C\underline{H}=CH_2$), 7.18(m, 2H, PhH), 7.28 (m, 1H, PhH), 7.34 (m, 2H, PhH). **^{13}C NMR** ($CDCl_3$, 125 MHz) δ 18.78, 39.08, 39.98, 44.38, 45.82, 46.05, 69.37, 117.20, 119.63, 127.40, 128.66, 128.78, 133.59, 135.33, 141.21, 181.75. HRMS: Calcd for $C_{18}H_{22}O_2$: 270.1620; found: 270.1621.



44

3-Allyl-3-methyl-4-(1-phenyl-but-3-enyl)-tetrahydro-pyran-2-one (44)

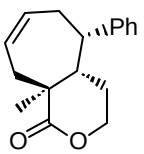
The general Wittig reaction procedure was followed using **42** (75 mg, 0.26 mmol) to afford **44** (62 mg, 0.22 mmol, 86%). **^{1}H NMR** ($CDCl_3$, 500 MHz) δ 1.39 (s, 3H, C$\underline{H}_3$), 1.99 (m, 2H, OCH$_2$C$\underline{H}_2$), 2.13 (dd, *J* = 14.1, 8.7 Hz, 1H, CC$\underline{H}_2$CH=CH$_2$), 2.28 (dt, 1H, *J* = 12.1, 4.3 Hz, PhCHC$\underline{H}$), 2.46 (m, 2H, PhCHC$\underline{H}_2$), 2.60 (ddt, *J* = 13.9, 6.0, 1.4 Hz, 1H, CC$\underline{H}_2$CH=CH$_2$), 2.83 (dt, *J* = 10.7, 4.0 Hz, 1H, PhC$\underline{H}$), 4.13(td, *J* = 11.5, 4.0 Hz, 1H, OC$\underline{H}_2$), 4.40 (ddd, *J* = 11.2, 4.7, 2.4 Hz, 1H, OC$\underline{H}_2$), 4.86 (dm, *J* = 10.3 Hz, 1H, CH=C$\underline{H}_2$), 4.92 (dm, *J* = 16.9 Hz, 1H, CH=C$\underline{H}_2$), 4.94 (dm, *J* = 17.1 Hz, 1H, CH=C$\underline{H}_2$), 5.06 (dt, *J* = 10.4, 1.7 Hz, 1H, CH=C$\underline{H}_2$), 5.53 (m, 2H, , C$\underline{H}$=CH$_2$), 7.18 (m, 2H, PhH), 7.23 (m, 1H, PhH), 7.31 (m, 2H, PhH). **^{13}C NMR** ($CDCl_3$, 125 MHz) δ 22.60, 22.67, 36.34, 42.58, 43.15, 44.71, 49.59, 68.96, 116.51, 119.80, 126.84, 128.11, 128.86, 133.65, 136.53, 144.86, 176.46. HRMS: Calcd for $C_{19}H_{24}O_2$: 284.1776; found: 284.1784.



45

8'-Methyl-4-phenyl-3,3',4,5,8,8'-hexahydro-cycloheptafuran-1-one (45)

To a solution of **43** (25 mg, 0.092 mmol) in 20 mL of CH_2Cl_2, 5 mol% of the Grubbs catalyst (4 mg, 5 μmol) was added. The solution was refluxed overnight. The solvent was removed under vacuum and the purification by chromatography (5% EtOAc/hexane) afforded **45** (20 mg, 0.083 mmol, 89%). **^{1}H NMR** ($CDCl_3$, 500 MHz) δ 0.78 (s, 3H, C$\underline{H}_3$), 2.32 (dm, *J* = 16.2 Hz, 1H, PhCHC$\underline{H}$), 2.61 (m, 2H, CH=CHC$\underline{H}_2$CH), 2.82 (m, C$\underline{H}_2$CH=CHCH), 3.39 (q, *J* = 4.8 Hz, 1H, C$\underline{H}$Ph), 4.24 (dd, *J* = 12.7, 8.8 Hz, 1H, OC$\underline{H}_2$), 4.40 (dd, *J* = 8.5, 7.0 Hz, 1H, OC$\underline{H}_2$), 5.91 (m, 1H, CH=C$\underline{H}$), 6.23 (m, 1H, C$\underline{H}$=CH), 7.28 (m, 5H, PhH). **^{13}C NMR** ($CDCl_3$, 125 MHz) δ 16.82, 33.37, 37.13, 41.13, 44.03, 52.63, 68.54, 126.95, 128.38, 128.82, 129.43, 131.13, 141.19. HRMS: Calcd for $C_{16}H_{18}O_2$: 242.1307; found: 242.1308.



46

9'-Methyl-5-phenyl-4,4',5,6,9,9'-hexahydro-3H-cycloheptapyran-1-one (46)

The general ring closing metathesis procedure was followed using **44** (52 mg, 0.18 mmol) to afford **46** (41 mg, 0.16 mmol, 89%). **^{1}H NMR** ($CDCl_3$, 500 MHz) δ 1.23 (s, 3H, CH_3), 1.43 (m, 1H, OCH_2CH_2), 1.87 (m, 1H, OCH_2CH_2), 2.39 (ddd, *J* = 14.0, 6.5, 4.0 Hz, 1H, PhCHCH), 2.50 (m, 1H, PHCHCH_2), 2.63 (bd, *J* = 16.9 Hz, 1H, CH_3CCH_2), 2.71 (m, 1H, PHCHCH_2), 2.99 (dd, *J* = 16.7, 8.4 Hz, 1H, CH_3CCH_2), 3.40 (ddd, *J* = 9.2, 6.3, 2.5 Hz, 1H, PhCH), 4.26 (ddd, *J* = 11.8, 9.3, 7.7 Hz, 1H, OCH_2), 4.43 (ddd, *J* = 11.6, 8.3, 3.0 Hz, OCH_2) , 1H, 5.82 (m, 1H, CH=CH), 6.00 (m, 1H, CH=CH) 7.30 (m, 5H, PhH). **^{13}C NMR** ($CDCl_3$, 125 MHz) δ 18.62, 23.78, 31.24, 35.53, 44.91, 45.82, 46.02, 68.02, 126.72, 127.87, 128.44, 128.71, 131.71, 143.44, 177.44. HRMS: Calcd for $C_{17}H_{20}O_2$: 256.1463; found: 256.1459.