Supporting Information

Zinc-Mediated Chain Extension Reaction of 1,3-Diketones to 1,4-Diketones and Diastereoselective Synthesis of Trans-1,2-Disubstituted Cyclopropanols

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General

All reactions were conducted under nitrogen atmosphere in oven-dried glassware with magnetic stirring. Dichloromethane was dried and freshly distilled from calcium hydride under nitrogen atmosphere. Chromatographic purification was performed on silica gel (100~200 mesh) and analytical thin layer chromatography (TLC) on silica gel 60-F₂₅₄, which was detected by fluorescence. ¹H NMR (300 MHz) and ¹³C NMR (75 MHz) spectra were measured using TMS as an internal standard. Data are reported as follows: (s = singlet, br s = broad singlet, d = doublet, t = triplet, q = quartet, m = multiplet, dd = doublet of doublets, td = triplet of doublets). High resolution mass spectra were obtained with a Micromass GCT-TOF mass spectrometer. IR spectra were recorded as thin films or as solids in KBr pellets.

7-Phenyl-heptane-2,5-dione² (2a)

The title compound was prepared according to the General Procedure and purified by chromatography on silica gel (10:1 petroleum ether/EtOAc) to give an oil (44% yield); ¹H NMR (300MHz, CDCl₃), δ , ppm, 7.23-7.18 (m, 2H), 7.13-7.09 (m, 3H), 2.83 (m, 2H), 2.72 (m, 2H), 2.61 (m, 2H), 2.58 (m, 2H), 2.11 (s, 3H). ¹³C NMR (300MHz, CDCl₃) δ , ppm, 208.5, 207.3, 141.1, 128.5, 128.4, 126.2, 44.4, 37.0, 36.3, 30.0, 29.8. IR (neat) ν 3062, 3027, 2923, 1712, 1686, 1361, 1094 cm⁻¹.

Octane-3,6-dione¹ (2b)

The title compound was prepared according to the General Procedure, except that the reaction mixture was stirred for 5 h at 0°C, and then purified by chromatography on silica gel (10:1 petroleum ether/EtOAc) to give an oil (45% yield); ¹H NMR (300MHz, CDCl₃), δ , ppm, 2.68 (s, 4H), 2.50 (q, J = 7.2Hz, 4H), 1.06 (t, J = 7.2Hz, 6H). ¹³C NMR (400MHz, CDCl₃) δ , ppm, 210.2, 36.0, 35.7, 7.8. IR (neat) ν 2977, 2939, 1713 cm⁻¹.

Phenyl-pentane-1,4-dione¹ (2c)

The title compound was prepared according to the General Procedure and purified by chromatography on silica gel (10:1 petroleum ether/EtOAc) to give an oil (66% yield); ^1H NMR (300MHz, CDCl_3), δ , ppm, 7.89 (d, $J = 7.2\text{Hz}$, 2H), 7.49 (t, $J = 7.2\text{Hz}$, 1H), 7.38 (t, $J = 7.2\text{Hz}$, 2H), 3.21 (t, $J = 6.0\text{Hz}$, 2H), 2.81 (t, $J = 6.0\text{Hz}$, 2H), 2.19 (s, 3H). ^{13}C NMR (300MHz, CDCl_3) δ , ppm, 207.4, 198.6, 136.7, 133.2, 128.6, 128.1, 37.1, 32.5, 30.2. IR (neat) ν 2962, 2910, 1715, 1684, 1596, 1359, 1211, 1162 cm^{-1} .

5,5-Dimethyl-1-phenyl-hexane-1,4-dione³ (2e)

The title compound was prepared according to the General Procedure and purified by chromatography on silica gel (10:1 petroleum ether/EtOAc) to give a oil (40% yield); ^1H NMR (300MHz, CDCl_3), δ , ppm, 7.91(d, $J = 7.2\text{Hz}$, 2H), 7.47 (t, $J = 7.2\text{Hz}$, 1H), 7.36-7.41(t, $J = 7.2\text{Hz}$, 2H), 3.18 (t, $J = 6.3\text{Hz}$, 2H), 2.90 (t, $J = 6.3\text{Hz}$, 2H), 1.14 (s, 9H). ^{13}C NMR (300MHz, CDCl_3) δ , ppm, 214.8, 199.1, 136.9, 133.2, 128.7, 128.1, 44.7, 32.5, 30.9, 26.7. IR (neat) ν 2967, 1705, 1687, 1597, 1448, 1002 cm^{-1} .

1-(4-Methoxy-phenyl)-pentane-1,4-dione¹ (2f)

The title compound was prepared according to the General Procedure and purified by chromatography on silica gel (10:1 petroleum ether/EtOAc) to give a white solid (78% yield); mp 55-57 $^{\circ}\text{C}$. ^1H NMR (300MHz, CDCl_3), δ , ppm, 7.90 (d, $J = 6.9\text{Hz}$, 2H), 6.87 (d, $J = 6.9\text{Hz}$, 2H), 3.80 (s, 3H), 3.17 (t, $J = 6.3\text{Hz}$, 2H), 2.80 (t, $J = 6.3\text{Hz}$, 2H), 2.19 (s, 3H). ^{13}C NMR (300MHz, CDCl_3) δ , ppm, 207.7, 197.1, 163.6, 130.4, 129.8, 113.8, 55.6, 37.1, 32.2, 30.3. IR (neat) ν 2962, 2911, 1708, 1671, 1601 1360, 1246, 1176, 834, 768 cm^{-1} .

1-(4-Chloro-phenyl)-pentane-1,4-dione⁴ (2h)

The title compound was prepared according to the General Procedure and purified by chromatography on silica gel (10:1 petroleum ether/EtOAc) to give a white solid (57%);

mp 70-72 °C. ^1H NMR (300MHz, CDCl_3), δ , ppm, 7.86 (d, $J = 8.6\text{Hz}$, 2H), 7.37 (d, $J = 8.6\text{Hz}$, 2H), 3.17 (t, $J = 6.0\text{Hz}$, 2H), 2.82 (t, $J = 6.0\text{Hz}$, 2H), 2.19 (s, 3H). ^{13}C NMR (300MHz, CDCl_3) δ , ppm, 207.2, 197.4, 139.7, 135.1, 129.6, 129.0, 37.1, 32.4, 30.2. IR (neat) ν 2913, 2254, 1709, 1673, 1591, 1408, 1093, 910, 828 cm^{-1} .

(E)-7-Phenyl-hept-6-ene-2,5-dione¹ (2j)

The title compound was prepared according to the General Procedure and purified by chromatography on silica gel (10:1 petroleum ether/EtOAc) to give a light yellow oil (66% yield); ^1H NMR (300MHz, CDCl_3), δ , ppm, 7.54 (d, $J = 16.2\text{Hz}$, 1H), 7.48 (m, 2H), 7.35 (m, 3H), 6.71 (d, $J = 16.2\text{Hz}$, 1H), 2.93 (t, $J = 6.3\text{Hz}$, 2H), 2.75 (t, $J = 6.3\text{Hz}$, 2H), 2.16 (s, 3H). ^{13}C NMR (300MHz, CDCl_3) δ , ppm, 207.4, 198.6, 142.9, 134.5, 130.6, 129.0, 128.4, 126.1, 37.1, 34.3, 30.1. IR (neat) ν 2962, 2909, 1710, 1670, 1602, 1260, 198, 1043, 798, 690 cm^{-1} .

1,4-Diphenyl-butane-1,4-dione¹ (2l)

The title compound was prepared according to the General Procedure and purified by chromatography on silica gel (10:1 petroleum ether/EtOAc) to give a white solid (78% yield); mp 142-143 °C. ^1H NMR (300MHz, CDCl_3), δ , ppm 7.97 (d, $J = 7.0\text{Hz}$, 4H), 7.51 (t, $J = 7.0\text{Hz}$, 2H), 7.41 (t, $J = 7.04\text{Hz}$, 4H), 3.40 (s, 4H). ^{13}C NMR (300MHz, CDCl_3) δ , ppm, 198.8, 136.9, 133.3, 128.7, 128.2, 32.7. IR (neat) ν 2964, 2905, 1678, 1593, 1446, 1354, 1223, 990, 803, 775, 732, cm^{-1} .

1-(4-Chloro-phenyl)-4-phenyl-butane-1,4-dione³ (2m)

The title compound was prepared according to the General Procedure and purified by chromatography on silica gel (10:1 petroleum ether/EtOAc) to give a white solid (59% yield); mp 115-117 °C. ^1H NMR (300MHz, CDCl_3), δ , ppm, 7.99-7.90 (m, 4H), 7.52 (t, $J = 7.3\text{Hz}$, 1H), 7.44-7.37 (m, 4H), 3.38 (m, 4H). ^{13}C NMR (300MHz, CDCl_3) δ , ppm, 198.6, 197.6, 139.7, 136.8, 135.2, 133.4, 129.7, 129.1, 128.8, 128.2, 32.7, 32.6. IR (neat) ν 2920, 1675, 1587, 1327, 1190, 1006, 748, 688 cm^{-1} .

1-(4-Methoxy-phenyl)-4-phenyl-butane-1,4-dione³ (2n)

The title compound was prepared according to the General

Procedure and purified by chromatography on silica gel (10:1 petroleum ether/EtOAc) to give a white solid (82% yield); mp 58-60 °C. ¹H NMR (300MHz, CDCl₃), δ, ppm, 8.06 (m, 4H), 9.59 (t, *J* = 7.1Hz, 1H), 7.49 (t, *J* = 7.1Hz, 2H), 6.97 (d, *J* = 6.9Hz, 2H), 3.89 (s, 3H), 3.45 (m, 4H). ¹³C NMR (400MHz, CDCl₃) δ, ppm, 198.9, 197.2, 136.9, 133.2, 130.5, 130.0, 128.7, 128.2, 113.8, 55.6, 32.8, 32.3. IR (neat) ν 2934, 1680, 1602 cm⁻¹.

2-(2-Hydroxy-2-methyl-cyclopropyl)-1-phenyl-ethanone (7a)

The title compound was prepared according to the General Procedure and

purified by chromatography on silica gel (5:1 petroleum ether/EtOAc) to give a light yellow oil (93% yield); ¹H NMR (300MHz, CDCl₃), δ, ppm, 7.98 (d, *J* = 7.4Hz, 2H), 7.57 (t, *J* = 7.4Hz, 1H), 7.47 (t, *J* = 7.4Hz, 2H), 3.55 (dd, *J* = 17.2, 5.1Hz, 1H), 3.85 (dd, *J* = 17.2, 9.0Hz, 1H), 2.45 (br s, 1H), 1.50 (s, 3H), 1.25-0.97 (m, 1H), 0.76 (dd, *J* = 9.1, 5.8Hz, 1H), 0.56 (dd, *J* = 5.8Hz). ¹³C NMR (300MHz, CDCl₃) δ, ppm, 201.6, 137.0, 133.3, 128.8, 128.3, 54.7, 38.0, 25.9, 20.7, 19.9. IR (neat) ν 3428, 1681, 1264, 1215, 753 cm⁻¹. HRMS (EI) calcd for C₁₂H₁₄O₂ (M⁺): 190.0994; Found: 190.0988.

Proof of the *trans* disposition of alkyl substituents was obtained by 2D NOESY spectroscopy, which revealed no NOEs between the methyl group and H_c on the cyclopropanol ring. While positive NOEs between the methyl group and H_a, H_b showed clearly, respectively. The coupling constants between H_a and H_b, H_a and H_c (*J*_{ab} = 9.0Hz and *J*_{ac} = 5.8Hz) also confirmed this stereochemical assignment. ¹H NMR spectroscopy established that only isomer **7a** was formed, and isomer **8a** was not detected. It is easy to identify these two isomers by ¹H NMR spectroscopy. The hydrogen of methyl group at δ 1.5 ppm should be ascribed for isomer **7a**, and if about δ 2.2 ppm for isomer **8a**.

2-(2-Hydroxy-2-propyl-cyclopropyl)-1-phenyl-ethanone (7e)

The title compound was prepared according to the General Procedure

and purified by chromatography on silica gel (5:1 petroleum ether/EtOAc) to give a light yellow oil (45% yield); ^1H NMR (300MHz, CDCl_3) δ , ppm, 7.98 (d, $J = 7.2\text{Hz}$, 2H), 7.58 (t, $J = 7.2\text{Hz}$, 1H), 7.47 (t, $J = 7.2\text{Hz}$, 2H), 3.56 (dd, $J = 16.8, 5.1\text{Hz}$, 1H), 2.83 (dd, $J = 16.8, 9.0\text{Hz}$, 1H), 2.44 (br s, 1H), 1.61-1.53 (m, 4H), 0.99-0.93 (m, 4H), 0.76 (dd, $J = 9.0, 5.4\text{Hz}$, 1H), 0.56 (t, $J = 5.4\text{Hz}$, 1H). ^{13}C NMR (400MHz, CDCl_3) δ , ppm, 201.6, 136.9, 133.2, 128.6, 128.2, 57.9, 41.6, 37.7, 19.9, 19.2, 18.8, 14.2. IR (neat) ν 3428, 1687, 1274, 1109 cm^{-1} . HRMS (EI) calcd for $\text{C}_{14}\text{H}_{18}\text{O}_2$ (M^+): 218.1307; Found: 218.1310.

1-(2-Hydroxy-2-phenyl-cyclopropyl)-pentan-2-one (8e)

The title compound was prepared according to the General Procedure and purified by chromatography on silica gel (5:1 petroleum ether/EtOAc) to give a light yellow oil (12% yield); ^1H NMR (300MHz, CDCl_3) δ , ppm, 7.39-7.22 (m, 5H), 3.11 (br s, 1H), 3.03 (dd, $J = 16.8, 5.8\text{Hz}$, 1H), 2.55-2.46 (m, 3H), 1.66-1.58 (m, 2H), 1.33-1.25 (m, 2H), 0.97-0.89 (m, 4H). ^{13}C NMR (400MHz, CDCl_3) δ , ppm, 212.4, 144.5, 128.3, 126.6, 125.0, 58.6, 45.1, 41.9, 23.3, 22.4, 17.1, 13.7. IR (neat) ν 3424, 1717, 1261, 1027 cm^{-1} . HRMS (EI) calcd for $\text{C}_{14}\text{H}_{18}\text{O}_2$ (M^+): 218.1307; Found: 218.1314.

2-(2-Hydroxy-2-propyl-cyclopropyl)-1-(4-methoxy-phenyl)-ethanone (7f)

The title compound was prepared according to the General Procedure and purified by chromatography on silica gel (5:1 petroleum ether/EtOAc) to give a light yellow oil (93% yield); ^1H NMR (300MHz, CDCl_3) δ , ppm, 7.92 (d, $J = 9.7\text{Hz}$, 2H), 6.88 (d, $J = 9.7\text{Hz}$, 2H), 3.82 (s, 3H), 3.50 (dd, $J = 16.6, 5.0\text{Hz}$, 1H), 2.65 (dd, $J = 16.6, 9.0\text{Hz}$, 1H), 1.54-1.45 (m, 5H), 0.89 (m, 4H), 0.68 (dd, $J = 9.1, 5.4\text{Hz}$, 1H), 0.47 (t, $J = 5.4\text{Hz}$, 1H). ^{13}C NMR (300MHz, CDCl_3) δ , ppm, 200.4, 163.8, 130.7, 129.9, 113.9, 57.9, 55.6, 41.7, 37.4, 20.3, 19.5, 18.9, 14.3. IR (neat) ν 3435, 1673, 1261, 1172, 1029 cm^{-1} . HRMS (EI) calcd for $\text{C}_{15}\text{H}_{20}\text{O}_3$ (M^+): 248.1412; Found: 248.1409.

2-(2-Hydroxy-2-phenyl-cyclopropyl)-1-phenyl-ethanone (7g)

The title compound was prepared according to the General Procedure and purified by chromatography on silica gel (5:1 petroleum ether/EtOAc) to give a light yellow solid

(61% yield); mp 43-44 °C. ¹H NMR (300MHz, CDCl₃), δ, ppm, 8.02 (d, *J* = 7.2Hz, 2H), 7.58-7.25 (m, 8H), 3.72 (dd, *J* = 17.1, 5.1Hz, 1H), 3.07 (br s, 1H), 3.00 (dd, *J* = 17.1, 9.0Hz, 1H), 1.56 (m, 1H), 1.35 (dd, *J* = 9.4, 5.8Hz, 1H), 1.06 (dd, *J* = 6.3Hz, 1H). ¹³C NMR (300MHz, CDCl₃) δ, ppm, 201.3, 144.6, 136.9, 133.5, 128.8, 128.5, 128.4, 126.8, 125.3, 58.9, 37.9, 23.6, 22.4. IR (neat) ν 3426, 1682, 1217, 1020 cm⁻¹. HRMS (EI) calcd for C₁₇H₁₆O₂ (M⁺): 252.1150; Found: 252.1152.

2-(2-Hydroxy-2-phenyl-cyclopropyl)-1-(4-methoxy-phenyl)-ethanone (7h)

The title compound was prepared according to the General Procedure and purified by chromatography on silica gel (5:1 petroleum ether/EtOAc) to give a light yellow solid (73% yield); mp 75-77 °C. ¹H NMR (300MHz, CDCl₃), δ, ppm, 8.00 (dd, *J* = 6.9, 1.7Hz, 2H), 7.43-7.25 (m, 5H), 6.95 (dd, *J* = 6.9, 1.7Hz, 2H), 3.87 (s, 3H), 3.75 (dd, *J* = 16.7, 5.1Hz, 1H), 3.40 (br s, 1H), 2.88 (dd, *J* = 16.7, 9.0Hz, 1H), 1.52 (m, 1H), 1.35 (dd, *J* = 9.3, 5.7Hz, 1H), 1.07 (t, *J* = 6.3Hz, 1H). ¹³C NMR (300MHz, CDCl₃) δ, ppm, 199.9, 163.9, 144.8, 130.8, 129.9, 128.4, 126.6, 125.1, 113.9, 58.8, 55.6, 37.4, 24.1, 22.7. IR (neat) ν 3465, 1658, 1219, 1024 cm⁻¹. HRMS (EI) calcd for C₁₈H₁₈O₃ (M⁺): 282.1256; Found: 282.1248.

2-(2-Hydroxy-2-methyl-cyclopropyl)-1-thiophen-2-yl-ethanone (7j)

The title compound was prepared according to the General Procedure and purified by chromatography on silica gel (5:1 petroleum ether/EtOAc) to give a light yellow oil (60% yield); ¹H NMR (300MHz, CDCl₃), δ, ppm, 7.78 (dd, *J* = 3.8, 1.0Hz, 1H), 7.66 (dd, *J* = 5.0, 1.0Hz, 1H), 7.15 (dd, *J* = 4.9, 3.8Hz, 1H), 3.48 (dd, *J* = 16.5, 5.1Hz, 1H), 2.73 (dd, *J* = 16.5, 9.3Hz, 1H), 2.67 (br s, 1H), 1.48 (s, 3H), 0.98 (m, 1H), 0.76 (dd, *J* = 9.0, 5.7Hz, 1H), 0.59 (t, *J* = 5.7Hz, 1H). ¹³C NMR (300MHz, CDCl₃) δ, ppm, 194.4, 144.2, 134.2, 132.5, 128.3, 54.6, 38.7, 25.8, 21.1, 20.2. IR (neat) ν 3418, 1659, 1414, 1263, 1058 cm⁻¹. HRMS (EI) calcd for C₁₀H₁₂O₂S (M⁺): 196.0558; Found: 196.0551.

1-(2-Hydroxy-2-methyl-cyclopropyl)-4-phenyl-butan-2-one (7k)

The title compound was prepared according to the General Procedure

and purified by chromatography on silica gel (5:1 petroleum ether/EtOAc) to give an oil (43% yield); ^1H NMR (300MHz, CDCl_3), δ , ppm, 7.24-7.10 (m, 5H), 2.87-2.70 (m, 5H), 2.26 (dd, $J = 17.1$, 9.0Hz, 1H), 1.36 (s, 3H), 0.73 (m, 1H), 0.60 (dd, $J = 9.0$, 5.7Hz, 1H), 0.36 (t, $J = 5.7$ Hz, 1H). ^{13}C NMR (300MHz, CDCl_3) δ , ppm, 212.0, 141.7, 128.6, 128.4, 126.2, 54.5, 44.5, 42.4, 29.8, 25.8, 20.3, 19.9. IR (neat) ν 3423, 1712 cm^{-1} . HRMS (EI) calcd for $\text{C}_{14}\text{H}_{18}\text{O}_2$ (M^+): 218.1307; Found: 218.1299.

1-(2-Hydroxy-2-phenethyl-cyclopropyl)-propan-2-one (8k)

The title compound was prepared according to the General Procedure and purified by chromatography on silica gel (5:1 petroleum ether/EtOAc) to give a white oil (20% yield); ^1H NMR (300MHz, CDCl_3), δ , ppm, 7.23-7.08 (m, 5H), 2.86-2.78 (m, 3H), 2.29 (dd, $J = 17.1$, 5.7Hz, 1H), 2.28 (br s, 1H), 2.13 (s, 3H), 1.83-1.76 (m, 2H), 0.78 (m, 1H), 0.63 (dd, $J = 9.3$, 5.7Hz, 1H), 0.41 (t, $J = 5.7$ Hz, 1H). ^{13}C NMR (300MHz, CDCl_3) δ , ppm, 142.4, 128.5, 128.5, 125.9, 57.9, 42.9, 41.5, 32.2, 30.3, 19.8, 19.5. IR (neat) ν 3408, 1707, 1260, 1080 cm^{-1} . HRMS (EI) calcd for $\text{C}_{14}\text{H}_{18}\text{O}_2$ (M^+): 218.1307; Found: 218.1300.

1-(2-Ethyl-2-hydroxy-cyclopropyl)-butan-2-one (7l)

The title compound was prepared according to the General Procedure and purified by chromatography on silica gel (5:1 petroleum ether/EtOAc) to give a white oil (61% yield); ^1H NMR (300MHz, CDCl_3), δ , ppm, 2.90 (dd, $J = 16.8$, 5.2Hz, 1H), 2.50 (q, $J = 7.2$ Hz, 2H), 2.33 (dd, $J = 16.8$, 9.3Hz, 1H), 1.68-1.46 (m, 2H), 1.25 (br s, 1H), 1.05 (t, $J = 7.2$ Hz, 3H), 1.03 (t, $J = 7.2$ Hz, 3H), 0.83 (m, 1H), 0.68 (dd, $J = 9.0$, 5.7Hz, 1H), 0.43 (t, $J = 5.7$ Hz, 1H). ^{13}C NMR (300MHz, CDCl_3) δ , ppm, 213.3, 58.8, 41.7, 36.3, 32.2, 19.7, 19.1, 9.7, 7.8. IR (neat) ν 3424, 1708, 1461 cm^{-1} . HRMS (EI) calcd for $\text{C}_9\text{H}_{16}\text{O}_2$ (M^+): 156.1150; Found: 156.1151.

1-(2-Hydroxy-2-methyl-cyclopropyl)-propan-2-one (7m)

The title compound was prepared according to the General Procedure and purified by chromatography on silica gel (5:1 petroleum ether/EtOAc) to give a white oil (65% yield); ^1H NMR (300MHz, CDCl_3), δ , ppm, 2.89 (dd, $J = 17.3$, 5.4Hz, 1H), 2.41 (dd, $J = 17.3$, 9.0Hz, 1H), 2.19 (s, 3H), 1.45 (s, 3H), 1.25 (br s, 1H), 0.82 (m, 1H), 0.70 (dd, $J = 8.9$, 5.7Hz, 1H), 0.45 (dd, $J = 5.7$ Hz,

¹H). ¹³C NMR (300MHz, CDCl₃) δ, ppm, 212.0, 54.6, 43.0, 30.3, 25.8, 20.2, 19.9. IR (neat) ν 3491, 1714, 1363, 1223 cm⁻¹. HRMS (EI) calcd for C₇H₁₂O₂ (M⁺): 128.0837; Found: 128.0846.

References

- (1). Lu, X. Y.; Ji, J. G.; Ma, D. W.; Shen, W. *J. Org. Chem.* **1991**, 56, 5774.
- (2). Katritzky, A. R.; Zhang, G. F.; Jiang, J. L. *J. Org. Chem.* **1995**, 60, 7605.
- (3). Yasuda, M.; Tsuji, S.; Shigeyoshi, Y.; Baba, A. *J. Am. Chem. Soc.* **2002**, 124, 7440.
- (4). Matsumoto, S.; Okubo, Y.; Mikami, K. *J. Am. Chem. Soc.* **1998**, 120, 4015.