SmI_2-Promoted Reformatsky-Type Reaction and Acylation of Alkyl 1-Chlorocyclopropanecarboxylates

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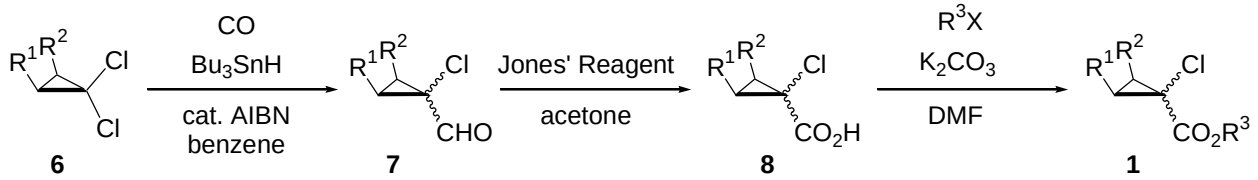
Supporting Information

General: All reactions were carried out in oven-dried glassware under an argon atmosphere. Tetrahydrofuran (THF) was distilled from sodium benzophenone ketyl. Column chromatography was performed with silica gel Merck 60 (70-230 mesh ASTM). TLC analysis was performed on 0.25 mm Silicagel Merck 60 F_{254} plates. NMR spectra were recorded on 400 MHz spectrometer, operating at 400 MHz for ^{1}H NMR and 100 MHz for ^{13}C NMR. Chemical shifts (δ ppm) in $CDCl_3$ were reported downfield from TMS (= 0) for ^{1}H NMR. For ^{13}C NMR, chemical shifts were reported in the scale relative to $CDCl_3$ (77.00 ppm) as an internal reference. Mass spectra were obtained by electron ionization (EI).

Preparation of alkyl 1-chlorocyclopropanecarboxylates.

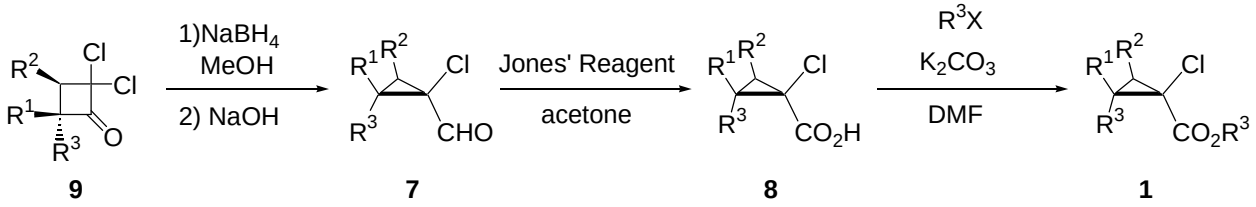
Method A: Alkyl 1-chrorocyclopropanecarboxylates **1a-1j** were derived from *gem*-dichlorocuclopropanes in three steps: (i) radical-type carbonylation (formylation)[1], (ii) Jones oxidation, and (iii) alkylation of carboxylic acid. Using R^1-monosubstituted subsutrate **6a,** and **b**,



the preparative method afforded only the *cis*-isomer **1a**, and **b**, respectively (*cis*/*trans* = 3/1). In the case of 2,3-*cis*-disubstituted cyclic substrates **6c**, **d**, and **h-j**, the preparative method afforded only the *cis*-isomer **1c**, **d**, and **h-j**, respectively (*cis*/*trans* = > 99/1).

1) Nishii, Y.; Nagano, T.; Gotoh, H.; Nagase, R.; Motoyoshiya, J.; Aoyama, H.; Tanabe, Y. *Org. Lett.* **2007**, *9*, 563.

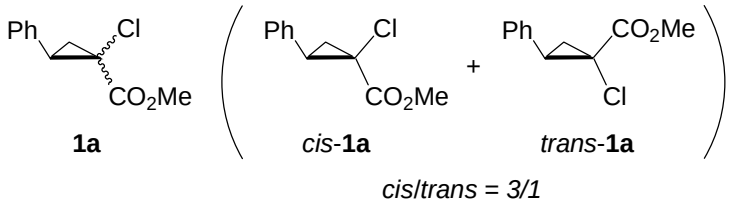
Method B: Methyl 1-chrorocyclopropanecarboxylates **1e-g**, **1k** and **1l** were prepared from 2,2-dichlorocyclobutanones **9** in 3 steps: (i) reduction with $NaBH_4$, and sequential treatment with NaOH (rearrangement of 2,2-dichlorocyclobutanols) (ii) Jones oxidation (iii) alkylation of carboxylic acid.[2]



2) Verniest, G.; Bombeke, F.; Kulinkovich, O. G.; Kimpe, N. D. *Tetaahedron Lett.* **2002**, *43*, 559.

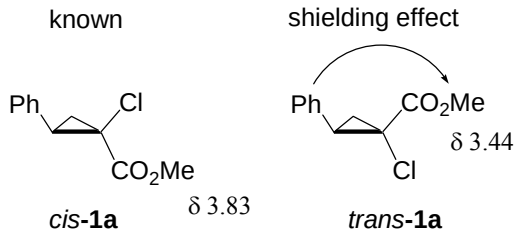
Methyl (1*R,2*R**)-** and **(1*S**,2*R**)-1-chloro-2-phenylcyclopropanecarboxylate** (**1a**)

(A mixture of diasteroisomers: *cis*/*trans* = 3/1)



Jones reagent (9.0 ml) was added to a stirred solution of (1*R**,2*R**)- and (1*S**,2*R**)-1-chloro-2–phenylcyclopropa necarbaldehyde[1] (**7a**) (*cis*/*trans* = 3/1, 1.50 g, 8.30 mmol) in acetone (13 ml) at 0-5˚C, followed by being stirred at the same temp for 2 h. 2-Propanol (10 ml) was added to the mixture, and followed by being stirred at the same temp for 15 min, which was concentrated. Water was added to the mixture, which was extracted three times with Et_2O (10 ml). The combined organic phase was washed with water, brine, dried (Na_2SO_4), and concentrated. The obtained crude carboxylic acid (1.62 g, 8.24 mmol) was used for the next step without purification. Methyl iodide (1.19 ml, 19.1 mmol) was added to a stirred solution of K_2CO_3 (2.64 g, 19.1 mmol) and carboxylic acid (1.60 g, 8.14 mmol) in DMF (15 ml) at 0-5˚C, followed by being stirred at the same temperature for 2 h. The reaction was quenched with 1M-HCl aqueous solution (10 ml) and extracted with Et_2O (20 ml x 2). The organic phase was washed with water and brine, dried (Na_2SO_4), and concentrated. The obtained crude oil was purified by column chromatography (SiO_2, hexane/AcOEt = 30/1) to give the product **1a** (3/1 mixture of diastereoisomers, 1.51 g, 86%). Based on the shielding effect[3] (up field shift) of phenyl group, the chemical shift (OMe 3.44 ppm) of a minor product was assigned to *trans*-isomer *trans*-**1a**. This shielding effect is consistent with that of aldehyde **7a**, see supporting information of previous report.[1]

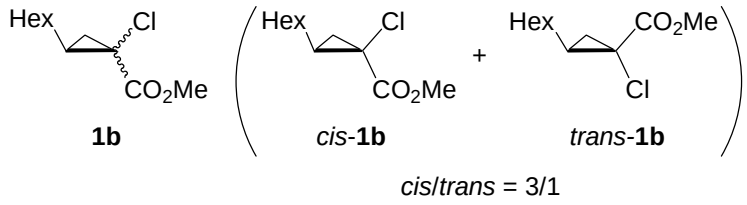
1a: colorless oil; ^{1}H NMR (400 MHz, $CDCl_3$) δ 1.76 (dd, *J* = 6.0, 8.8 Hz, 1H x 3/4), 2.15 (dd, *J* = 6.0, 10.0 Hz, 1H x 3/4), 3.08 (dd, *J* = 8.8, 10.0 Hz, 1H x 3/4), 3. 44 (s, 3H x 1/4), 3.83 (s, 3H x 3/4), 7.23-7.25 (m, 2H), 7.30-7.37 (m, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 23.5, 33.8, 44.6, 53.5, 127.6, 128.1, 129.4, 134.3, 170.7; IR (neat) 3032, 2955, 1724, 1716, 1434, 1281 cm^{-1}; HRMS (EI) calcd for $C_{11}H_{11}ClO_2$ (M^+) 210.0448, found 210.0449.



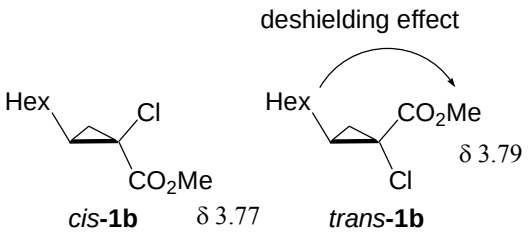
3) (a) Gaunder, A. *Stereochemistry*; Kagan, H. B., Ed., Georg Thieme Verlag: Stuttgart, 1977, 1, 77. (b) Harada, T.; Katsuhira, T.; Hattori, K.; Oku, A. *J.Org. Chem.* **1993**, *58*, 2958.

Methyl (1*R,2*S**)-** and **(1*S**,2*S**)-1-chloro-2-hexylcyclopropanecarbaldehyde** (**1b**)

(A mixture of diasteroisomers: *cis*/*trans* = 3/1)

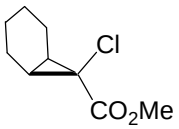


Following the procedure for the preparation of **1a**, the reaction of (1*R**,2*S**)- and (1*S**,2*S**)-1-chloro-2-hexylcyclopropane carbaldehyde[1] (**7b**) (1.00 g, 5.30mmol) with Jones reagent (5 ml) gave the crude solid (0.98 g, 5.12 mmol). The reaction of crude solid with K_2CO_3 (1.83 g, 12.8 mmol) and methyl iodide (1.85 g, 12.8 mmol) gave the product **1b** (3/1 mixture of diastereoisomers, 1.11 g, 96%). Based on the deshielding effect (down field shift) of hexyl group, the chemical shift (OMe 3.79 ppm) of minor product was assigned to that of *trans*-isomer *trans*-**1b**. This shielding effect is consistent with that of aldehyde **7b**, see supporting information of previous report.[1]



cis-and *trans*-**1b**: colorless oil; ^{1}H NMR (400 MHz, $CDCl_3$) δ 0.87-0.91 (m, 3H and 1H x 1/4), 0.99 (dd, *J* = 5.1, 7.6 Hz, 1H x 3/4), 1.27-1.37 (m, 6H x 3/4 and 8H x 1/4), 1.45-1.53 (m, 2H), 1.54-1.64 (m, 2H x 3/4 and 1H x 1/4), 1.69-1.75 (m, 1H), 1.77-1.81 (m, 1H x 3/4), 3.77 (s, 3H x 3/4), 3.79 (s, 3H x 1/4); ^{13}C NMR (100 MHz, $CDCl_3$) δ 14.0, 14.1, 22.6, 24.7, 25.7, 27.3, 28.7, 28.8, 28.8, 28.9, 29.0, 31.7, 34.2, 44.2, 53.0, 53.2, 169.7, 171.6; IR (neat) 2957, 2927, 1731, 1726, 1113 cm^{-1}; HRMS (EI) calcd for $C_{11}H_{19}ClO_2$ (M^+) 218.1074, found 218.1080.

Methyl *endo*-7-chlorobicyclo[4.1.0]heptane-7-carboxylate (1c)

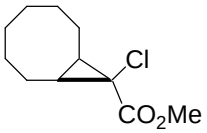


1c

Following the procedure for the preparation of **1a**, the reaction of *endo*-7-chloro-bicyclo[4.1.0]heptane-7-carbaldehyde[1] (**7c**) (2.90 g, 18.2 mmol) with Jones reagent (18 ml) gave the crude solid (3.03g, 17.2 mmol). The reaction of crude solid with K_2CO_3 (5.94 g, 43.0 mmol) and methyl iodide (6.10 g, 43.0 mmol) gave the product **1c** (2.71 g, 79%).

1c: colorless oil; ^{1}H NMR (400 MHz, $CDCl_3$) δ 1.23-1.31 (m, 2H), 1.35-1.44 (m, 2H), 1.61-1.67(m, 2H), 1.90-2.02 (m, 4H), 3.74 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 18.6, 20.7, 24.8, 49.8, 53.1, 172.0; IR (neat) 2947, 2858, 1720, 1439, 1265, 1165 cm^{-1}; HRMS (EI) calcd for $C_9H_{13}ClO_2$ (M^+) 188.0604, found 188.0612.

Methyl *endo*-9-chlorobicyclo[6.1.0]nonane-9-carboxylate (1d)

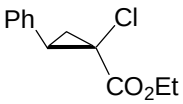


1d

Following the procedure for the preparation of **1a**, the reaction of *endo*-9-chlorobicyclo[6.1.0]nonane-9-carbaldehyde[1] (**7d**) (2.50 g, 13.4 mmol) with Jones reagent (14 ml) gave the crude solid (2.32 g, 11.4 mmol). The reaction of crude solid with K_2CO_3 (3.96 g, 28.5 mmol) and methyl iodide (4.07 g, 28.5 mmol) gave the product **1d** (2.35 g, 81%).

1d: colorless oil; ^{1}H NMR (400 MHz, $CDCl_3$) δ 1.32-1.51 (m, 6H), 1.59-1.70 (m, 6H), 1.84-1.89 (m, 2H), 3.76 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 22.6, 26.4, 28.2, 31.1, 48.3, 53.1, 172.0; IR (neat) 2923, 2854, 1713 cm^{-1}; HRMS (EI) calcd for $C_{11}H_{17}ClO_2$ (M^+) 216.0917, found 216.0911.

Ethyl (1*R,2*R**)-1-chloro-2-phenylcyclopropanecarboxylate (1e)**

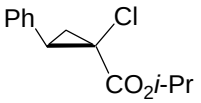


1e

Following the procedure for the preparation of **1a**, the reaction of (1*R**,2*R**)-1-chloro-2-phenylcyclopropanecarbaldehyde[2] (**7a**) (642 mg, 3.56 mmol) with Jones reagent (4 ml)gave the crude solid (698 mg, 3.55 mmol). The reaction of crude solid with K_2CO_3 (1.23 g, 8.90 mmol) and bromoethane (970 mg, 8.90 mmol) gave the product **1e** (735 mg, 92%).

1e: colorless oil; ^{1}H NMR (400 MHz, $CDCl_3$) δ 1.34 (t, *J* = 7.1 Hz, 3H), 1.75 (dd, *J* = 6.1, 8.6 Hz, 1H), 2.14 (dd, *J* = 6.1, 10.1 Hz, 1H), 3.07 (t, *J* = 9.6 Hz, 1H), 4,28 (q, *J* = 7.1 Hz, 2H), 7.25 (d, *J* = 7.2 Hz, 2H), 7.29-7.36 (m, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 14.1, 23.4, 33.6, 44.8, 62.6, 127.5, 128.1, 129.4, 134.4, 170.2; IR (neat) 2843, 1716, 1497 cm^{-1}; HRMS (EI) calcd for $C_{12}H_{13}ClO_2$ (M^+) 224.0604, found 224.0609.

Isopropyl (1*R,2*R**)-1-chloro-2-phenylcyclopropanecarboxylate (1f)**

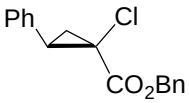


1f

Following the procedure for the preparation of **1a**, the reaction of ($1R^*,2R^*$)-1-chloro-2-phenylcyclopropanecarbaldehyde[2] (**7a**) (921 g, 5.24 mmol) with Jones reagent (5 ml) gave the crude solid (1.00 g, 5.10 mmol). The reaction of crude solid with K_2CO_3 (1.75 g, 12.8 mmol) and isopropyl bromide (1.56 g, 12.8 mmol) gave the product **1f** (1.15 g, 93%).

1f: colorless oil; ^{1}H NMR (400 MHz, $CDCl_3$) δ 1.31 (d, J = 6.0 Hz, 3H), 1.32 (d, J = 6.0 Hz, 3H), 1.72(dd, J = 6.0, 8.8 Hz, 1H), 2.12 (dd, J = 6.0, 9.6 Hz, 1H), 3.05 (t, J = 8.8 Hz, 1H), 5.10 (sep, J = 6.0 Hz, 1H), 7.23-7.24 (m, 1H), 7.28-7.37 m, 4H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 21.7, 23.3, 33.4, 45.0, 70.4, 127.5, 128.1, 129.4, 134.6, 169.6; IR (neat) 3032, 2955, 1724 cm^{-1}; HRMS (EI) calcd for $C_{13}H_{15}ClO_2$ (M^+) 238.0761, found 238.0768.

Benzyl ($1R^*,2R^*$)-1-chloro-2-phenylcyclopropanecarboxylate (1g)

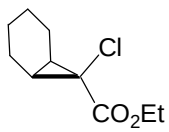


1g

Following the procedure for the preparation of **1a**, the reaction of ($1R^*,2R^*$)-1-chloro-2-phenylcyclopropanecarbaldehyde[2] (**7a**) (1.39 g, 7.68 mmol) with Jones reagent (8 ml)gave the crude solid (1.51 g, 7.63 mmol). The reaction of crude solid with K_2CO_3 (2.64 g, 19.1 mmol) and benzyl bromide (3.26 g, 19.1 mmol) gave the product **1g** (1.93 g, 88%).

1g: colorless oil; ^{1}H NMR (400 MHz, $CDCl_3$) δ 1.76 (dd, J = 6.0, 8.8 Hz, 1H), 2.16 (dd, J = 6.0, 10.0 Hz, 1H), 3.09 (dd, J = 8.8, 10.0 Hz, 1H), 5.25 (s, 2H), 7.23-7.25 (m, 2H), 7.30-7.37 (m, 3H), 7.31-7.42 (m, 5H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 23.5, 33.8, 44.8, 68.0, 127.6, 128.0, 128.2, 128.4, 128.6, 129.4, 134.3, 135.3, 170.1; IR (neat) 3021, 2948, 1719 cm^{-1}; HRMS (EI) calcd for $C_{17}H_{17}ClO_2$ (M^+) 286.0761, found 286.0763.

Ethyl *endo*-7-chlorobicyclo[4.1.0]heptane-7-carboxylate (1h)

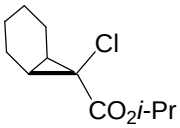


1h

Following the procedure for the preparation of **1a**, the reaction of *endo*-7-chlorobicyclo[4.1.0]heptane-7-carbaldehyde[1] (**7c**) (430 mg, 2.71 mmol) with Jones reagent (3 ml) gave the crude solid (503 mg, 2.65 mmol). The reaction of crude solid with K_2CO_3 (915 mg, 6.57 mmol) and bromoethane (722 mg, 6.57 mmol) gave the product **1h** (478 mg, 88%).

1h: colorless oil; ^{1}H NMR (400 MHz, $CDCl_3$) δ 1.21-1.30 (m, 5H), 1.35-1.43 (m, 2H), 1.61-1.68 (m, 2H), 1.89-2.01 (m, 4H), 4.18 (q, J = 7.3 Hz, 2H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 14.1, 18.6, 20.7, 24.6, 50.0, 62.1, 171.4; IR (neat) 2947, 2853, 1726 cm^{-1}; HRMS (EI) calcd for $C_{10}H_{15}ClO_2$ (M^+) 202.0761, found 202.0760.

Isopropyl *endo*-7-chlorobicyclo[4.1.0]heptane-7-carboxylate (1i)

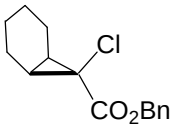


1i

Following the procedure for the preparation of **1a**, the reaction of *endo*-7-chlorobicyclo[4.1.0]heptane-7-carbaldehyde[1] (**7c**) (430 mg, 2.71 mmol) with Jones reagent (3 ml) gave the crude solid (501 g, 2.65 mmol). The reaction of crude solid with K_2CO_3 (915 mg, 6.57 mmol) and isopropyl bromide (815 mg, 6.57 mmol) gave the product **1i** (540 mg, 93%).

1i: colorless oil; ^{1}H NMR (400 MHz, $CDCl_3$) δ 1.22-1.30 (m, 5H), 1.35-1.43 (m, 2H), 1.59-1.68(m, 2H), 1.87-1.89 (m, 4H), 1.92-2.00 (m, 2H), 4.99 (sep, J = 6.0 Hz); ^{13}C NMR (100 MHz, $CDCl_3$) δ 18.6, 20.8, 21.7, 24.2, 26.6, 50.3, 69.7, 170.8; IR (neat) 2951, 2872, 1720 cm^{-1}; HRMS (EI) calcd for $C_{11}H_{17}ClO_2$ (M^+) 216.0917, found 216.0916.

Benzyl *endo*-7-chlorobicyclo[4.1.0]heptane-7-carboxylate (**1j**)

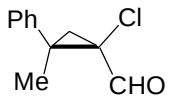


1j

Following the procedure for the preparation of **1a**, the reaction of *endo*-7-chloro-bicyclo[4.1.0]heptane-7-carbaldehyde[1] (**7c**) (430 mg, 2.71 mmol) with Jones reagent (3 ml) gave the crude solid (505 g, 2.66 mmol). The reaction of crude solid with K_2CO_3 (915 mg, 6.57 mmol) and benzylbromide (1.13 g, 6.57 mmol) gave the product **1j** (610 mg, 87%).

1j: colorless oil; ^{1}H NMR (400 MHz, $CDCl_3$) δ 1.20-1.29(m, 2H), 1.35-1.44 (m, 2H), 1.60-1.67(m, 2H), 1.90-1.99 (m, 4H), 5.15 (s, 2H), 7.31-7.37 (m, 5H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 18.6, 20.8, 24.7, 50.0, 67.6, 128.0, 128.3, 128.6, 135.5, 171.3; IR (neat) 2944, 2863, 1718 cm^{-1}; HRMS (EI) calcd for $C_{15}H_{17}ClO_2$ (M^+) 264.0917, found 264.0911.

(1*R,2*R**)-1-Chloro-2-methyl-2-phenylcyclopropanecarbaldehyde** (**7k**)



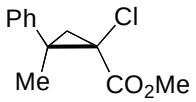
7k

$NaBH_4$ (180 mg, 4.65 mmol) was added to a stirred solution of 2,2-dichloro-3-methyl-3- phenylcyclobutanone[4] (**9k**) (1.07 g, 4.65 mmol) in MeOH (10 ml) at 0-5˚C, followed by being stirred at the same temp for 2 h. 1M-NaOH aqueous solution was added to the reaction mixture at room temperature, which was stirred for 15 min. Water was added to the mixture, which was extracted three times with $CHCl_3$ (10 ml). The combined organic phase was washed with water, brine, dried (Na_2SO_4), and concentrated. The obtained crude oil was purified by column chromatography (SiO_2, hexane/AcOEt = 30/1) to give the product **7k** (787 mg, 87%).

7k: colorless oil; ^{1}H NMR (400 MHz, $CDCl_3$) δ 1.54 (s, 3H), 1.91 (d, J = 6.3 Hz, 1H), 2.14 (d, J = 6.3 Hz, 1H), 7.25-7.32 (m, 3H), 7.36-7.40 (m, 2H), 9.76 (s, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 21.4, 28.8, 41.4, 55.7, 127.5, 128.5, 128.9, 140.6 196.5; IR (neat) 2843, 1716, 1497 cm^{-1}; HRMS (EI) calcd for $C_{11}H_{11}ClO$ (M^+) 194.0498, found 194.0493.

4) Weiguo, C.; Ihsan, E.; Richard H. G.; James, R. K.; Jiangao, S.; Mary, B. T.; Teri, L. W.; Fu-Pei, X.; Ji-Bin, Z. *Can. J. Chem.* **1997**, *77*, 1009

Methyl (1*R,2*R**)-1-chloro-2-methyl-2-phenylcyclopropanecarboxylate** (**1k**)

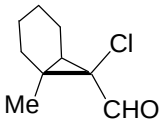


1k

Following the procedure for the preparation of **1a**, the reaction of aldehyde **7k** (1.00 g, 5.14 mmol) with Jones reagent (5.0 ml) gave the crude solid (1.08 g, 5.03 mmol). The reaction of crude solid with K_2CO_3 (1.43 g, 10.3 mmol) and methyl iodide (1.86 g, 10.3 mmol) gave the product **1k** (1.11 g, 96%).

1k: colorless oil; ^{1}H NMR (400 MHz, $CDCl_3$) δ 1.50 (s, 3H), 1.73 (d, *J* = 6.3 Hz, 1H), 2.06 (d, *J* = 6.3 Hz, 1H), 3.86 (s, 3H), 7.16-7.22 (m, 1H), 7.28-7.30 (m, 2H), 7.34-7.38 (m, 2H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 22.3,27.6, 37.0, 47.8, 53.2, 127.2, 128.4, 128.9, 141.2, 169.4; IR (neat) 3032, 2955, 1724, 1434, 1281 cm^{-1}; HRMS (EI) calcd for $C_{12}H_{13}ClO_2$ (M^+) 224.0604, found 224.0600.

***endo*-7-Chloro-1-methylbicyclo[4.1.0]heptane-7-carbaldehyde** (**7l**)



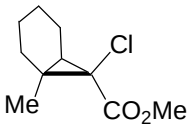
7l

Following the procedure for the preparation of **7k**, the reaction of 8,8-dichloro-1-methylbicyclo[4,2,0]octan-7-on[5] (**9k**) (4.00 g, 21.2 mmol) with $NaBH_4$ gave the product **7l** (4.33 g, 21.2 mmol).

7l: colorless oil; ^{1}H NMR (400 MHz, $CDCl_3$) δ 1.26 (s, 3H), 1.27-1.35 (m, 2H), 1.37-1.43 (m, 1H), 1.48-1.54 (m, 1H), 1.58-1.65 (m, 1H), 1.69-1.76 (m, 1H), 1.88-2.03 (m, 3H), 9.57 (s, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 18.9, 20.6, 21.2, 21.7, 28.4, 30.8, 33.0, 62.8, 197.7; IR (neat) 2939, 2858, 1709, 1447 cm^{-1}; HRMS (EI) calcd for $C_9H_{13}ClO$ (M^+) 172.0655, found 172.0649.

5) Back, D. V.; Brady, W. T. *J. Org. Chem*. **1979, *44,*** 107

Methyl *endo*-7-chloro-1-methylbicyclo[4.1.0]heptane-7-carboxylate (**1l**)



1l

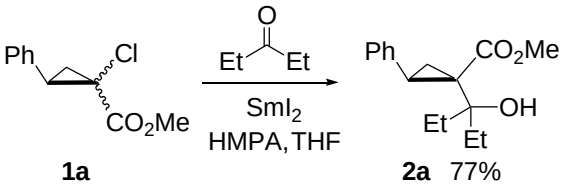
Following the procedure for the preparation of **1a**, the reaction of aldehyde **7l** (2.00 g, 11.6 mmol) with Jones reagent (12 ml) gave the crude solid (2.04 g, 10.8 mmol). The reaction of crude solid with K_2CO_3 (3.67 g, 26.5 mmol) and methyl iodide (3.76 g, 26.5 mmol) gave the product **1l** (2.05 g, 87%).

1l: colorless oil; ^{1}H NMR (400 MHz, $CDCl_3$) δ 1.18 (s, 3H), 1.24-1.31 (m, 2H), 1.35-1.50 (m, 2H), 1.58-1.65 (m, 1H), 1.68-1.71 (m, 1H), 1.85-1.99(m, 3H), 3.77 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 18.5, 20.5, 21.3, 22.4, 27.4, 27.6, 52.9, 54.3, 170.3; IR (neat) 2944, 2853, 1716, 1447 cm^{-1}; HRMS (EI) calcd for $C_{10}H_{15}ClO_2$ (M^+) 202.0761, found 202.0766.

Initial investigation

SmI_2-promoted Reformatsky-type reaction of methyl 2-phenylcyclopropanecarboxylate with diethyl ketone.

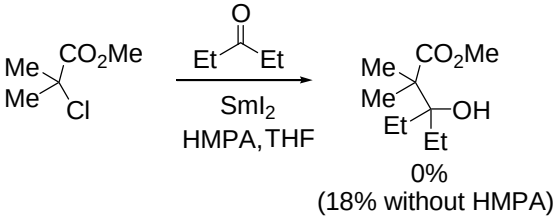
Methyl (1*R,2*R**)-1-(1-ethyl-1-hydroxypropyl)-2-phenylcyclopropanecarboxylate (2a)**



(**Method I**) A typical procedure: A solution of CH_2I_2 (115 μl, 1.42 mmol) in THF (14 ml) was added to Sm (286 mg, 1.90 mmol) at 0˚C under an Ar atmosphere, followed by being stirred at room temp for 2 h. HMPA (996 μl, 5.70 mmol) was added to the mixture at the same temp, which was stirred for 15 min. A solution of ester **1a** (100 mg, 0.48 mmol) and diethyl ketone (49 mg, 0.57 mmol) in THF (1.0 ml) was added to the mixture at the same temp, which was stirred for 2 h. The reaction was quenched with sat. NH_4Cl aqueous solution (10 ml). Water was added to the mixture, which was extracted with Et_2O (20 ml x 5). The organic phase was washed with water and brine, dried (Na_2SO_4), and concentrated. The obtained crude oil was purified by column chromatography (SiO_2, hexane/AcOEt = 7/1) to give the product **2a** (96 mg, 77%) (*trans*-add/*cis*-add = > 99/1). Without using HMPA, a similar reaction gave the product **2a** (17 mg, 14%) and pinacol (31 mg, 75%). Based on the analogy of spectra data of **2b**, the relative configuration of **2a** was determined as *trans*-adduct.

2a: colorless oil; ^{1}H NMR (400 MHz, $CDCl_3$) δ 0.94-1.00 (m, 6H), 1.44 (dd, *J* = 5.6, 9.1 Hz, 1H), 1.49-1.51 (m, 1H), 1.53-1.61 (m, 1H), 1.92-1.98 (m, 3H), 2.57 (s, 1H), 2.63 (dd, *J* = 7.8, 9.1 Hz, 1H), 3.19 (s, 3H), 7.16-7.24 (m, 5H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 7.4, 8.7, 13.7, 25.5, 28.4, 31.8, 40.2, 51.1, 74.0, 126.4, 127.9, 128.6, 137.4, 171.9; IR (neat) 3453, 2876, 1729 cm^{-1}; HRMS (EI) calcd for $C_{16}H_{22}O_3$ (M^+) 262.1569, found 262.1574.

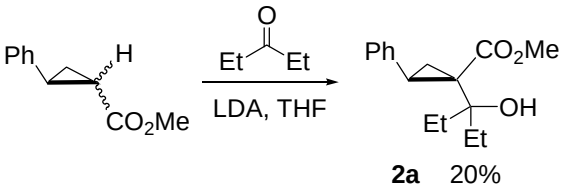
SmI_2-promoted Reformatsky-type reaction of methyl α-chloroisobutyrate with diethyl ketone.



A solution of CH_2I_2 (121 μl, 1.50 mmol) in THF (15 ml) was added to Sm (301 mg, 2.00 mmol) at 0˚C under an Ar atmosphere, followed by being stirred at room temp for 2 h. A solution of methyl α-chloroisobutyrate (68 mg, 0.50 mmol) and diethyl ketone (52 mg, 0.60 mmol) in THF (1.0 ml) was added to the mixture at the same temp, which was stirred for 2 h. The reaction was quenched with sat. NH_4Cl aqueous solution (10 ml). Water was added to the mixture, which was extracted with Et_2O (20 ml x 5). The organic phase was washed with water and brine, dried (Na_2SO_4), and concentrated. The obtained crude oil was purified by column chromatography (SiO_2, hexane/AcOEt = 10/1) to give methyl 3-ethyl-3-hydroxy-2,2-dimethylpentanoate[6] (17 mg, 18%) and pinacol (38 mg, 73%). In the presence of HMPA in THF, a similar reaction gave none of β-hydroxy ester.

6) Wenke, G.; Jacobsen, E. N.; Totten, G. E.; Karydas, A. C.; Rhodes, Y. E. *Synthetic Commun.* **1983**, *13*, 449

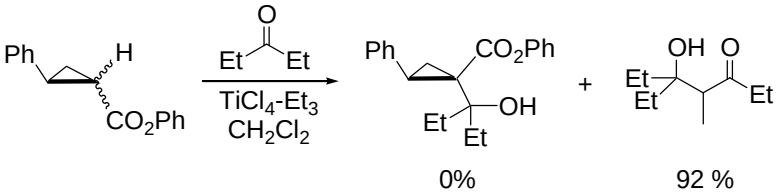
Aldol-type reaction of methyl 2-phenylcyclopropanecarboxylate with diethyl ketone using LDA.



2a 20%

BuLi (1.59 M in hexane, 430 μl, 0.68 mmol) was added to a stirred solution of diisopropylamine (96 μl, 0.68 mmol) in THF (1.42 ml) at -78 ˚C under an Ar atmosphere, and the mixture was stirred at the same temperature for 30 min. A solution of methyl 2-phenylcyclopropanecarboxylate (100 mg, 0.57 mmol) in THF (1.42 ml) was added to the mixture at the same temp. After being stirred for 30 min, a solution of diethyl ketone (58 mg, 0.68 mmol) in THF (1.42 ml) was added to the mixture, followed by being stirred at the same temp for 2h and then warmed up to room temp during about 1h. The reaction was quenched with sat. NH_4Cl aqueous solution (10 ml). Water was added to the mixture, which was extracted with Et_2O (20 ml x 5). The organic phase was washed with water and brine, dried (Na_2SO_4), and concentrated. The obtained crude oil was purified by column chromatography (SiO_2, hexane/AcOEt = 7/1) to give the product **2a** (30 mg, 20%) (*trans*-add/*cis*-add = > 99/1) and inseparable complex mixture.

Investigation for the alternative hydroxyalkylation of phenyl 2-phenylcyclopropane -carboxylate using $TiCl_4$-Et_3N.



0% 92 %

Following the Tanabe's report,[7] $TiCl_4$ (76 μl, 0.63 mmol) was added to a stirred solution of phenyl 2-phenylcyclopropanecarboxylate[8] (100 mg, 0.42 mmol) and Et_3N (85 mg, 0.84 mmol) in CH_2Cl_2 (630 μl) at 0-5 ˚C under an Ar atmosphere. After stirring at the same temp for 30 min, diethyl ketone (43 mg, 0.50 mmol) was added to the mixture, followed by being stirred at same temp for 2h. The mixture was poured into ice water, wich was extracted with Et_2O (10 ml x 2). The organic phase was washed with water and brine, dried (Na_2SO_4), and concentrated. The obtained crude oil was purified by column chromatography (SiO_2, hexane/AcOEt = 10/1) to give β-hydroxy ester (0%) and self-aldol product of diethyl ketone[9] (40 mg, 92%). Most of the starting material was recovered.

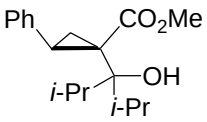
7) Nagase, R.; Matsumoto, R.; Hosomi, K.; Higashi, T.; Funakoshi, S.; Misaki, T.; Tanabe, Y. *Org. Biomol. Chem.* **2007**, *5*, 151

8) Hirao, T.; Harano, Y.; Yamana, Y.; Hamada, Y.; Nagata, S.; Agawa, T. *Bull. Chem. Soc. Jpn.* **1986**, *59*, 1341

9) Simpura, I.; Nevalainen, V. *Tetrahedron* **2003**, *59*, 7535

Methyl (1*R,2*R**)-1-(1-hydroxy-1-isopropyl-2-methylpropyl)**

-2-phenylcyclopropanecarboxylate (2b)

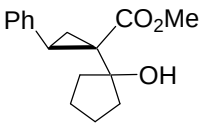


2b

Following the procedure of method I, ester **1a** (100 mg, 0.48 mmol) with Sm (286 mg, 1.90 mmol), CH_2I_2 (115 μl, 1.42 mmol) and 2,4-dimethylpentanone (65 mg, 0.57 mmol) gave the product **2b** (131 mg, 95%) (*trans*-add/*cis*-add = > 99/1). The ratio was determined by using ^{1}H NMR spectroscopy. The relative configuration was determined by X-ray crystallographic analysis of **2b** (recrystallized from EtOH).

2b: colorless crystals; mp 62˚C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 0.87 (d, *J* = 7.1 Hz, 3H), 0.96 (d, *J* = 7.1 Hz, 3H), 1.11 (d, *J* = 6.8 Hz, 3H), 1.17 (s, 1H), 1.19(d, *J* = 6.8 Hz, 3H), 1.57 (dd, *J* = 5.6, 9.1 Hz, 1H), 1.81 (dd, *J* = 5.6, 7.1 Hz, 1H), 2.04 (sep, *J* = 7.1 Hz, 1H), 2.48 (dd, *J* = 7.1, 9.1 Hz, 1H), 2.73 (sep, *J* = 6.8 Hz, 1H), 3.31 (s, 3H), 7.12-7.18 (m, 3H), 7.21-7.25 (m, 2H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 13.6, 16.9, 17.8, 18.8, 25.3, 32.5, 38.0, 38.2, 51.1, 126.2, 127.7, 127.9, 137.6, 170.7; IR ($CHCl_3$) 3457, 2876, 1726 cm^{-1}; HRMS (EI) calcd for $C_{18}H_{26}O_3$ (M^+) 290.1882, found 290.1883.

Methyl (1*R,2*R**)-1-(1-hydroxycyclopentyl)-2-phenylcyclopropanecarboxylate (2c)**



2c

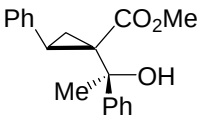
Following the procedure of method I, ester **1a** (100 mg, 0.48 mmol) with Sm (286 mg, 1.90 mmol), CH_2I_2 (115 μl, 1.42 mmol) and cyclopentanone (48 mg, 0.57 mmol) gave the product **2c** (102 mg, 82%) (*trans*-add/*cis*-add = > 99/1). Based on the analogy of spectra data of **2b**, the relative configuration of **2c** was determined as *trans*-adduct.

2c: colorless oil; ^{1}H NMR (400 MHz, $CDCl_3$) δ 1.34 (dd, *J* = 5.6, 8.8 Hz, 1H), 1.43-1.50 (m, 1H), 1.57-1.74 (m, 5H), 1.84-1.95 (m, 2H), 2.00 (dd, *J* = 5.6, 7.6 Hz), 2.65 (t, *J* = 8.8 Hz), 3.18(s, 3H), 4.00 (s,1H), 7.15-7.20 (m, 1H), 7.21-7.25 (m, 4H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 15.0, 23.7, 24.0, 29.4, 35.6, 39.3, 39.6, 51.1, 82.8, 126.5, 127.9, 128.9, 136.9, 173.4; IR (neat) 3459, 2879, 1723 cm^{-1}; HRMS (EI) calcd for $C_{16}H_{20}O_3$ (M^+) 260.1412, found 260.1414.

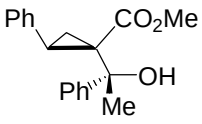
Methyl (1*R,2*R**)-1-[(*S**)-1-hydroxy-1-phenylethyl]-2-phenylcyclopropanecarboxylate (2d)**

Methyl (1*R,2*R**)-1-[(*R**)-1-hydroxy-1-phenylethyl]-2-phenylcyclopropanecarboxylate (3d)**

(A mixture of diastereoisomers: **2d**/**3d** = 67/33)



2d



3d

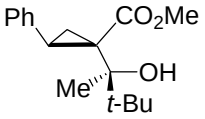
Following the procedure of method I, ester **1a** (100 mg, 0.48 mmol) with Sm (286 mg, 1.90 mmol), CH_2I_2 (115 μl, 1.42 mmol) and acetophenone (68 mg, 0.57 mmol) gave an inseparable mixture of **2d** and **3d** (117 mg, 82%, **2d**/**3d** =

67/33). Based on the analogy of spectra data of **2b**, the relative configuration at the α-position of ester **2d** and **3d** was determined as *trans*-adduct. The major product was assigned to *re*-face-adduct, based on the typical selectivity of SmI_2-promoted Reformatsky reaction.

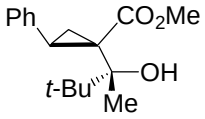
2d and **3d**: colorless oil; ^{1}H NMR (400 MHz, $CDCl_3$) δ 1.15 (dd, *J* = 5.6, 9.2 Hz, 1H x 1/3), 1.29 (s, 3H x 2/3), 1.66 (dd, *J* = 5.6, 9.2 Hz, 1H x 2/3), 1.87 (s, 3H x 1/3), 1.91 (dd, *J* = 5.6, 7.2 Hz, 1H x 1/3), 2.32-2.38 (m, 1H), 2.91-2.95 (m, 4H x 2/3), 3.16 (s, 3H x 2/3), 7.15-7.36 (m, 7H x 2/3 and 8H x 1/3), 7.44-7.47 (m, 1H x 1/3), 7.54-7.61 (m, 3H x 2/3), 7.94-7.97 (m, 1H x 1/3); ^{13}C NMR (100 MHz, $CDCl_3$) δ 13.8, 15.8, 26.5, 26.6, 26.7, 27.8, 28.1, 41.4, 41.6, 51.1, 51.2, 74.6, 75.3, 124.5, 126.5, 126.7, 126.9, 127.3, 127.7, 127.9, 128.0, 128.2, 128.5, 128.8, 129.9, 133.0, 136.4, 136.8, 143.2, 149.1, 172.6, 173.0; IR (neat) 3502, 2879, 1727, 1716 cm^{-1}; HRMS (EI) calcd for $C_{19}H_{20}O_3$ (M^+) 296.1412, found 296.1409.

Methyl (1*R,2*R**)-1-[(*S**)-1-hydroxy-1,2,2-trimethylpropyl]**
-2-phenylcyclopropanecarboxylate (2e)
Methyl (1*R,2*R**)-1-[(*R**)-1-hydroxy-1,2,2-trimethylpropyl]**
-2-phenylcyclopropanecarboxylate (3e)

(A mixture of diastereoisomes: **2e**/**3e** = 75/25)



2e



3e

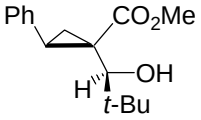
Following the procedure of method I, eater **1a** (100 mg, 0.48 mmol) with Sm (286 mg, 1.90 mmol), CH_2I_2 (115 μl, 1.42 mmol) and 3,3-dimethyl-2-butanone (65 mg, 0.57 mmol) gave an inseparable mixture of **2e** and **3e** (123 mg, 93%, **2e/3e** = 75/25). Based on the analogy of spectra data of **2b**, the relative configuration at the α-position of ester **2e** and **3e** was determined as *trans*-adduct. The major product was assigned to *re*-face-adduct, based on the typical selectivity of SmI_2-promoted Reformatsky reaction.

2e and **3e**: colorless oil; ^{1}H NMR (400 MHz, $CDCl_3$) δ 0.99 (s, 9H x 3/4), 1.00 (s, 9H x 1/4), 1.21 (s, 3H x 1/4), 1.26 (dd, *J* = 6.4, 8.8 Hz, 1H x 1/4), 1.57 (dd, *J* = 5.6, 8.8 Hz, 1H x 3/4), 1.67 (s, 3H x 3/4), 1.94 (dd, *J* = 5.6, 7.6 Hz, 1H x 3/4), 2.14 (t, *J* = 6.6 Hz, 1H x 1/4), 2.54 (dd, *J* = 7.6, 8.8 Hz, 1H x 3/4), 2.78 (dd, *J* = 7.2, 8.8 Hz, 1H x 1/4), 3.07 (s, 3H x 1/4), 3.15 (s, 3H x 3/4), 7.13-7.25 (m, 5H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 14.4, 24.2, 25.6, 26.2, 40.2, 41.1, 51.0, 76.0, 126.2, 126.6, 127.8, 128.3, 129.1, 137.5, 171.2, 172.2; IR (neat) 3502, 2879, 1733, 1727 cm^{-1}; HRMS (EI) calcd for $C_{17}H_{22}O_3$ (M^+) 276.1725, found 276.1731.

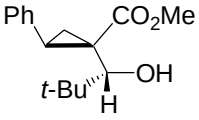
Methyl (1*R,2*R**)-1-[(*S**)-1-hydroxy-2,2-dimethylpropyl]**
-2-phenylcyclopropanecarboxylate (2f)
Methyl (1*R,2*R**)-1-[(*R**)-1-hydroxy-2,2-dimethylpropyl]**

-2-phenylcyclopropanecarboxylate (3f)

(A ratio of diastereoisomes: **2f**/**3f** = 75/25)



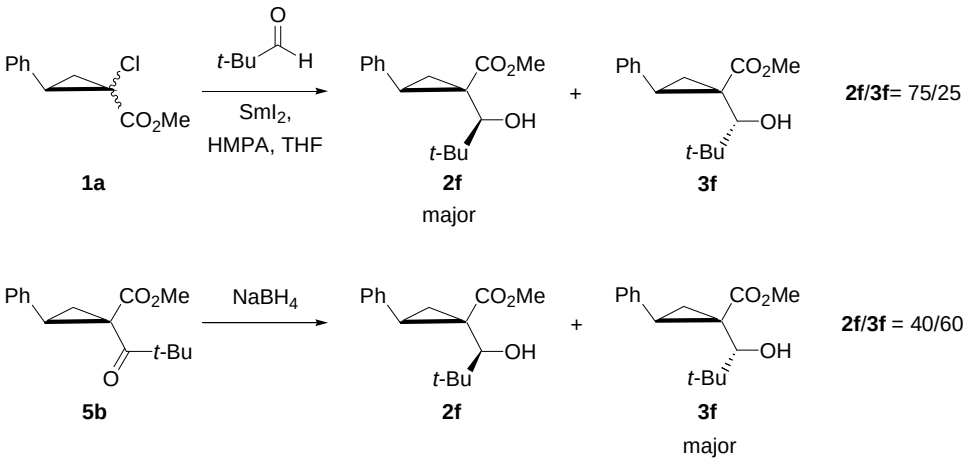
2f



3f

(**Method II**) A typical procedure: A solution of CH_2I_2 (115 μl, 1.42 mmol) in THF (14 ml) was added to Sm (286 mg, 1.90 mmol) at 0˚C under an Ar atmosphere, followed by being stirred at room temp for 2 h. HMPA (996 μl, 5.70 mmol) was added to the mixture at the same temp, which was stirred for 15 min. A solution of ester **1a** (100 mg, 0.48 mmol) and pivalaldehyde (49 mg, 0.57 mmol) in THF (1.0 ml) was added to the mixture at -78˚C, which was stirred for 2 h. The reaction was quenched with sat. NH_4Cl aqueous solution (10 ml). Water was added to the mixture, which was extracted with Et_2O (20 ml x 5). The organic phase was washed with water and brine, dried (Na_2SO_4), and concentrated. The obtained crude oil was purified by column chromatography (SiO_2, hexane/AcOEt = 5/1) to give the separable product **2f** (77 mg, 61%) and **3f** (26 mg, 21%) (**2f**/**3f** = 75/25). Based on the analogy of spectra data of **2b**, the relative configuration at the α-position of ester **2f** and **3f** was determined as *trans*-adduct. The major product was assigned to *re*-face-adduct, based on the typical selectivity of SmI_2-promoted Reformatsky reaction and supporting experiments as described below.

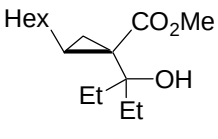
2f: colorless oil; ^{1}H NMR (400 MHz, $CDCl_3$) δ 0.97 (s, 9H), 1.39 (dd, *J* = 5.6, 8.8 Hz, 1H), 1.94 (dd, *J* = 5.6, 6.8 Hz, 2H), 2.72 (t, *J* = 8.8 Hz, 1H), 3.20 (s, 3H), 4.14 (d, *J* = 4.3 Hz, 1H), 7.14-7.25 (m, 5H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 11.8, 25.8, 26.7, 36.1, 37.7, 51.1, 76.1, 126.3, 127.7, 128.8, 136.9, 171.7; IR (neat) 3453, 2876, 1721 cm^{-1}; HRMS (EI) calcd for $C_{16}H_{22}O_3$ (M^+) 262.1569, found 262.1564. **3f**: colorless oil; ^{1}H NMR (400 MHz, $CDCl_3$) δ 0.97 (s, 9H), 1.27 (dd, *J* = 6.1, 8.8 Hz, 1H), 2.17 (dd, *J* = 6.1, 7.3 Hz, 1H), 2.54 (t, *J* = 8.1 Hz, 1H), 2.72 (d, *J* = 10.1 Hz, 1H), 3.20 (s, 3H), 4.14 (d, *J* = 10.1 Hz, 1H), 7.18-7.25 (m, 5H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 11.8, 16.4, 27.0, 35.2, 37.8, 51.2, 86.5, 126.8, 128.0, 128.7, 135.8, 172.1; IR (neat) 3444, 2873, 1726 cm^{-1}; HRMS (EI) calcd for $C_{16}H_{22}O_3$ (M^+) 262.1569, found 262.1562.



Treatment of ketone **5b** (the product of acylation**,** Table 3, entry 2) with $NaBH_4$ gave β-hydroxy esters **2f** and **3f** (**2f**/**3f** = 40/60). Spectral data of the product was consistent with **2f** and **3f** with the switch of stereoselectivity. Based on Shuto's report, the major product of the reduction was determined as **3f**.[10] Thus, the major product of the Reformatsky-type reaction was assigned to **2f**.

10) Kazuta, Y.; Abe, H.; Yamamoto, T.; Matsuda, A.; Shuto, S. *J. Org. Chem.* **2003**, *68*, 3511-3521.

Methyl (1*S,2*R**)-1-(1-ethyl-1-hydroxypropyl)-2-hexylcyclopropanecarboxylate (2g)**

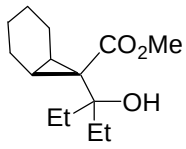


2g

Following the procedure of method I, ester **1b** (100 mg, 0.46 mmol) with Sm (275 mg, 1.64 mmol), CH_2I_2 (367 mg, 1.38 mmol) and diethyl ketone (47 mg, 0.55 mmol) gave the product **2g** (111 mg, 90%). Based on the analogy of spectra data of **2b**, the relative configuration of **2g** was determined as *trans*-adduct.

2g: colorless oil; ^{1}H NMR (400 MHz, $CDCl_3$) δ 0.87 (t, *J* = 6.4 Hz, 3H), 0.97 (dd, *J* = 4.5, 8.3 Hz, 1H), 1.19-1.38 (m, 14H), 1.44-1.64 (m, 5H), 1.74-1.84 (m, 3H), 3.69 (brs, 1H), 3.71 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 14.0, 17.0, 22.6, 23.6, 25.6, 28.4, 29.0, 29.3, 31.7, 35.8, 36.6, 39.0, 51.6, 83.0, 174.8; IR (neat) 3451, 2843, 1716 cm^{-1}; HRMS (EI) calcd for $C_{16}H_{30}O_3$ (M^+) 270.2195, found 270.2186.

Methyl *endo*-7-(1-ethyl-1-hydroxypropyl)bicyclo[4.1.0]heptane-7-carboxylate (2h)

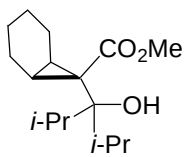


2h

Following the procedure of method I, ester **1c** (100 mg, 0.53 mmol) with Sm (319 mg, 2.12 mmol), CH_2I_2 (426 mg, 1.59 mmol) and diethyl ketone (55 mg, 0.64 mmol) gave the product **2h** (106 mg, 83%). Based on the analogy of spectra data of **2b**, the relative configuration of **2h** was determined as *trans*-adduct.

2h: colorless crystals; mp 46°C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 0.92-1.00 (m, 8H), 1.18-1.27 (m, 4H), 1.53 (q, *J* = 7.3 Hz, 4H), 1.55 (s, 1H), 1.73-1.90 (m, 4H), 3.69 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 7.9, 14.9, 19.8, 21.2, 31.5, 51.2, 74.1, 171.6; IR ($CHCl_3$) 3503, 2939, 2858, 1709 cm^{-1}; HRMS (EI) calcd for $C_{14}H_{22}O_3$ (M^+) 240.1725, found 240.1722.

Methyl *endo*-7-(1-hydroxy-1-isopropyl-2-methylpropyl)bicyclo[4.1.0]heptane -7-carboxylate (2i)



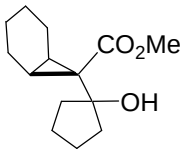
2i

Following the procedure of method I, ester **1c** (100 mg, 0.53 mmol) with Sm (319 mg, 2.12 mmol), CH_2I_2 (426 mg, 1.59 mmol) and 2,4-dimethyl-diethyl ketone (91 mg, 0.64 mmol) gave the product **2i** (96 mg, 68%). Based on the analogy of spectra data of **2b**, the relative configuration of **2i** was determined as *trans*-adduct.

2i: colorless crystal; mp 68°C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 0.94-1.01 (m, 15H), 1.18-1.25 (m, 2H), 1.30-1.32 (m, 2H), 1.70-1.87 (m, 4H), 2.13 (sep, *J* = 6.8 Hz, 2H), 3.63 (s, 3H); ^{13}C NMR (100

MHz, $CDCl_3$) δ 15.8, 17.2, 17.8, 19.6, 21.3, 34.0, 35.9, 50.8, 171.5; IR ($CHCl_3$) 3478, 2919, 2858, 1714 cm^{-1}; HRMS (EI) calcd for $C_{16}H_{28}O_3$ (M^+) 268.2038, found 268.2042.

Methyl *endo*-7-(1-hydroxycyclopentyl)bicyclo[4.1.0]heptane-7-carboxylate (2j)

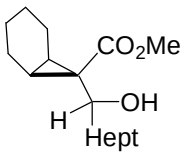


2j

Following the procedure of method I, ester **1c** (100 mg, 0.53 mmol) with Sm (319 mg, 2.12 mmol), CH_2I_2 (426 mg, 1.59 mmol) and cyclopentanone (54 mg, 64 mmol) gave the product **2j** (98 mg, 71%). Based on the analogy of spectra data of **2b**, the relative configuration of **2j** was determined as *trans*-adduct.

2j: colorless oil; ^{1}H NMR (400 MHz, $CDCl_3$) δ 0.95- 1.04 (m, 2H), 1.19-1.26 (m, 4H), 1.51-1.58 (m, 5H), 1.76-1.91 (m, 6H), 3.73 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 17.6, 20.1, 21.0, 23.3, 36.9, 39.0, 51.4, 83.9, 172.1; IR (neat) 3478, 2919, 2858, 1714 cm^{-1}; HRMS (EI) calcd for $C_{14}H_{22}O_3$ (M^+) 238.1569, found 238.1572.

Methyl *endo*-7-(1-hydroxyoctyl)bicyclo[4.1.0]heptane-7-carboxylate (2k)

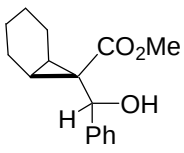


2k

Following the procedure of method II, ester **1c** (100 mg, 0.53 mmol) with Sm (319 mg, 2.12 mmol), CH_2I_2 (426 mg, 1.59 mmol) and octanal (82 mg, 64 mmol) gave the product **2k** (117 mg, 78%). Based on the analogy of spectra data of **2b**, the relative configuration of **2k** was determined as *trans*-adduct.

2k: colorless oil; ^{1}H NMR (400 MHz, $CDCl_3$) δ 0.88 (t, J = 6.0 Hz, 3H), 1.01-1.11 (m, 4H), 1.23-1.35 (m, 12H), 1.48-1.58 (m, 4H), 1.79-2.00 (m,4H), 2.78 (dd, J = 5.3, 8.1 Hz, 1H), 3.74 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 14.1, 19.3, 19.5, 20.0, 20.4, 21.0, 21.2, 22.6, 26.2, 29.2, 29.5, 31.8, 35.6, 37.6, 51.4, 79.6, 171.4; IR (neat) 3478, 2919, 2858, 1714 cm^{-1}; HRMS (EI) calcd for $C_{17}H_{30}O_3$ (M^+) 282.2195, found 282.2202.

Methyl *endo*-7-(1-hydroxybenzyl)bicyclo[4.1.0]heptane-7-carboxylate (2l)

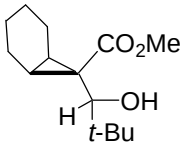


2l

Following the procedure of method II, ester **1c** (100 mg, 0.53 mmol) with Sm (319 mg, 2.12 mmol), CH_2I_2 (426 mg, 1.59 mmol) and benzaldehyde (68 mg, 64 mmol) gave the product **2l** (112 mg, 81%). Based on the analogy of spectra data of **2b**, the relative configuration of **2l** was determined as *trans*-adduct.

2l: colorless oil; ^{1}H NMR (400 MHz, $CDCl_3$) δ 1.03-1.14 (m, 3H), 1.18-1.23 (m, 1H), 1.29-1.35(m, 2H), 1.40-1.50 (m, 1H), 1.77-1.96 (m, 3H), 3.16 (brs, 1H), 3.48 (s, 3H), 4.20 (s, 1H), 7.17 (t, J = 6.8 Hz, 1H), 7.24 (t, J = 7.2 Hz, 2H), 7.29 (d, J = 6.8 Hz, 2H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 19.0, 19.7, 20.0, 20.1, 20.9, 21.0, 38.4, 51.3, 79.2, 125.9, 127.4, 128.0, 141.6, 171.8; IR (neat) 3482, 2919, 1711 cm^{-1}; HRMS (EI) calcd for $C_{16}H_{20}O_3$ (M^+) 260.1412, found 260.1419.

Methyl *endo*-7-(1-hydroxy-2,2-dimethylpropyl)bicyclo[4.1.0]heptane-7-carboxylate (2m)

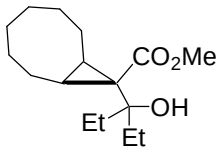


2m

Following the procedure of method II, ester **1c** (100 mg, 0.53 mmol) with Sm (319 mg, 2.12 mmol), CH_2I_2 (426 mg, 1.59 mmol) and pivalaldehyde (55 mg, 64 mmol) gave the product **2m** (104 mg, 82%). Based on the analogy of spectra data of **2b**, the relative configuration of **2m** was determined as *trans*-adduct.

2m: colorless oil; ^{1}H NMR (400 MHz, $CDCl_3$) δ 0.93 (s, 9H), 1.02-1.16 (m, 4H), 1.24-1.34 (m, 4H), 1.77-1.86 (m, 1H), 1.93-2.01 (m, 1H), 2.15-2.22 (m, 1H), 2.38 (s, 1H), 3.06 (brs, 1H), 3.71 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 18.6, 20.6, 20.7, 20.8, 21.2, 21.6, 26.3, 34.3, 37.6, 51.4, 88.3, 172.4; IR (neat) 3477, 2921, 1714 cm^{-1}; HRMS (EI) calcd for $C_{14}H_{24}O_3$ (M^+) 240.1725, found 240.1722.

Methyl *endo*-9-(1-ethyl-1-hydroxypropyl)bicyclo[6.1.0]nonane-9-carboxylate (2n)

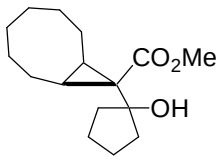


2n

Following the procedure of method I, ester **1d** (100 mg, 0.44 mmol) with Sm (263 mg, 1.75 mmol), CH_2I_2 (351 mg, 1.31 mmol) and diethyl ketone (45 mg, 0.52 mmol) gave the product **2n** (101 mg, 86%). Based on the analogy of spectra data of **2b**, the relative configuration of **2n** was determined as *trans*-adduct.

2n: colorless oil; ^{1}H NMR (400 MHz, $CDCl_3$) δ 0.94 (t, J = 7.6 Hz, 6H), 0.97-1.06 (m, 4H), 1.32-1.41 (m, 4H), 1.53 (q, J = 7.6 Hz, 2H), 1.54 (q, J = 7.6Hz, 2H), 1.59-1.63 (m, 4H), 1.88 (brs, 1H), 1.92-1.96 (m, 2H), 3.66 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 7.8, 22.1, 24.2, 26.4, 29.4, 31.2, 39.0, 51.1, 74.1, 171.7; IR (neat) 3462, 2923, 2854, 1713 cm^{-1}; HRMS (EI) calcd for $C_{16}H_{28}O_3$ (M^+) 268.2038, found 268.2043.

Methyl *endo*-9-(1-hydroxycyclopenthyl)bicyclo[6.1.0]nonane-9-carboxylate (2o)

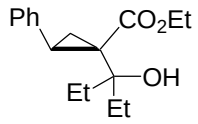


2o

Following the procedure of method I, ester **1d** (100 mg, 0.44 mmol) with Sm (263 mg, 1.75 mmol), CH_2I_2 (351 mg, 1.31 mmol) and cyclopentanone (45 mg, 0.52 mmol) gave the product **2o** (101 mg, 87%). Based on the analogy of spectra data of **2b**, the relative configuration of **2o** was determined as *trans*-adduct.

2o: colorless oil; ^{1}H NMR (400 MHz, $CDCl_3$) δ 1.00-1.06 (m, 2H), 1.10-1.21 (m, 2H), 1.33-1.42 (m, 4H), 1.51-1.63 (m, 10H), 1.78-1.80 (m, 2H), 1.93-1.96 (m, 2H), 3.71 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 23.5, 23.9, 25.3, 26.3, 29.3, 37.3, 39.6, 51.3, 83.6, 172.7; IR (neat) 3448, 2893, 2854, 1723 cm^{-1}; HRMS (EI) calcd for $C_{16}H_{28}O_3$ (M^+) 266.1882, found 266.1881.

Ethyl (1*R,2*R**)-1-(1-ethyl-1-hydroxypropyl)-2-phenylcyclopropanecarboxylate (2p)**

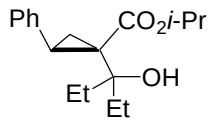


2p

Following the procedure of method I, ester **1e** (100 mg, 0.44 mmol) with Sm (263 mg, 1.75 mmol), CH_2I_2 (351 mg, 1.31 mmol) and diethyl ketone (45 mg, 0.52 mmol) gave the product **2p** (111 mg, 91%). Based on the analogy of spectra data of **2b**, the relative configuration of **2p** was determined as *trans*-adduct.

2p: colorless oil; ^{1}H NMR (400 MHz, $CDCl_3$) δ 0.78 (t, *J* = 6.4 Hz, 3H), 0.94-1.00 (m, 6H), 0.94-1.00 (m, 6H), 1.44 (dd, *J* = 5.6, 9.1 Hz, 1H), 1.46-1.63 (m, 3H), 1.91-1.98 (m, 3H), 2.63 (t, *J* = 7.8 Hz, 1H), 2.72 (s, 1H), 3.55-3.63 (m, 1H), 3.69-3.77 (m, 1H), 7.16-7.24 (m, 5H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 7.4, 8.7, 13.4, 13.6, 25.4, 28.3, 31.7, 39.8, 60.2, 73.9, 126.3, 127.8, 128.8, 137.4, 171.4; IR (neat) 3505, 2865, 1716 cm^{-1}; HRMS (EI) calcd for $C_{17}H_{24}O_3$ (M^+) 276.1725, found 276.1725.

Isopropyl (1*R,2*R**)-1-(1-ethyl-1-hydroxypropyl)-2-phenylcyclopropanecarboxylate (2q)**

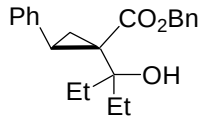


2q

Following the procedure of method I, ester **1f** (100 mg, 0.41 mmol) with Sm (252 mg, 1.64 mmol), CH_2I_2 (337 mg, 1.23 mmol) and diethyl ketone (43 mg, 0.49 mmol) gave the product **2q** (98 mg, 83%). Based on the analogy of spectra data of **2b**, the relative configuration of **2q** was determined as *trans*-adduct.

2q: colorless oil; ^{1}H NMR (400 MHz, $CDCl_3$) δ 0.74 (d, *J* = 6.3 Hz, 3H), 0.84 (d, *J* = 6.3 Hz, 3H), 0.95-1.00 (m, 6H), 1.39 (dd, *J* = 5.6, 9.1 Hz, 1H), 1.44-1.63 (m, 3H), 1.89-1.99 (m, 3H), 2.61 (dd, *J* = 7.8, 8.6 Hz, 1H), 4.58 (sep, *J* = 6.3 Hz, 1H), 7.12-7.18 (m, 1H), 7.21-7.25 (m, 4H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 7.4, 8.7, 13.4, 21.0, 21.4, 25.2, 28.1, 31.8, 40.0, 74.1, 104.9, 126.4, 127.9, 128.9, 137.4, 170.8; IR (neat) 3502, 2879, 1722 cm^{-1}; HRMS (EI) calcd for $C_{18}H_{26}O_3$ (M^+) 290.1882, found 290.1886.

Benzyl (1*R,2*R**)-1-(1-ethyl-1-hydroxypropyl)-2-phenylcyclopropanecarboxylate (2r)**

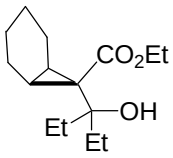


2r

Following the procedure of method I, ester **1g** (100 mg, 0.35 mmol) with Sm (210 mg, 1.75 mmol), CH_2I_2 (280 mg, 1.31 mmol) and diethyl ketone (36 mg, 0.42 mmol) gave the product **2r** (94 mg, 80%). Based on the analogy of spectra data of **2b**, the relative configuration of **2r** was determined as *trans*-adduct.

2r: colorless oil; ^{1}H NMR (400 MHz, $CDCl_3$) δ 0.93-0.99 (m, 6H), 1.44 (dd, *J* = 5.6, 9.1 Hz, 1H), 1.49-1.62 (m, 2H), 1.92-1.98 (m, 3H), 2.51 (s, 1H), 2.64 (dd, *J* = 7.8, 8.6 Hz, 1H), 4.45 (d, *J* = 12.0 Hz, 1H), 7.76 (d, *J* = 12.0 Hz, 1H), 6.94-6.96 (m, 2H), 7.14-7.20 (m, 5H), 7.23-7.26 (m, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 7.5, 8.7, 13.8, 25.7, 28.7, 31.8, 40.1, 66.3, 74.0, 126.4, 127.9, 128.1, 128.3, 128.6, 128.7, 135.3, 137.3, 171.3; IR (neat) 3492, 2869, 1710 cm^{-1}; HRMS (EI) calcd for $C_{22}H_{26}O_3$ (M^+) 338.1882, found 338.1886.

Ethyl *endo*-7-(1-ethyl-1-hydroxypropyl)bicyclo[4.1.0]heptane-7-carboxylate (2s)

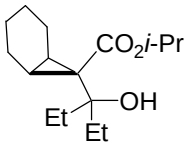


2s

Following the procedure of method I, ester **1h** (100 mg, 0.50 mmol) with Sm (298 mg, 1.98 mmol), CH_2I_2 (398 mg, 1.48 mmol) and diethyl ketone (51 mg, 0.59 mmol) gave the product **2s** (118 mg, 86%). Based on the analogy of spectra data of **2b**, the relative configuration of **2s** was determined as *trans*-adduct.

2s: colorless crystal; mp 55°C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 0.92-0.98 (m, 6H), 1.10-1.17 (m, 2H), 1.25-1.27 (m, 4H), 1.29-1.31 (m, 3H), 1.51-1.53 (m, 4H), 4.12-4.18 (m, 2H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 7.9, 14.0, 19.8, 21.2, 31.3, 37.7, 60.1, 74.2, 171.1; IR ($CHCl_3$) 3462, 2881, 1727 cm^{-1}; HRMS (EI) calcd for $C_{15}H_{26}O_3$ (M^+) 254.1882, found 254.1881.

Isopropyl *endo*-7-(1-ethyl-1-hydroxypropyl)bicyclo[4.1.0]heptane-7-carboxylate (2t)

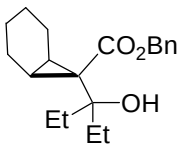


2t

Following the procedure of method I, ester **1i** (100 mg, 0.46 mmol) with Sm (268 mg, 1.84 mmol), CH_2I_2 (333 mg, 1.38 mmol) and diethyl ketone (48 mg, 0.55 mmol) gave the product **2t** (95 mg, 77%). Based on the analogy of spectra data of **2b**, the relative configuration of **2t** was determined as *trans*-adduct.

2t: colorless oil; ^{1}H NMR (400 MHz, $CDCl_3$) δ 0.94 (t, J = 7.3 Hz, 6H), 1.00-1.07 (m, 2H), 1.19-1.24 (m, 4H), 1.27 (d, J = 6.3 Hz, 6H), 1.51-1.58 (m, 4H), 1.80-1.87 (m, 4H), 5.04 (sep, J = 6.3 Hz, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 7.9, 14.0, 14.9, 19.8, 21.3, 31.4, 37.7, 60.1, 74.2, 171.1; IR (neat) 3462, 2881 , 1727 cm^{-1}; HRMS (EI) calcd for $C_{16}H_{28}O_3$ (M^+) 268.2038, found 268.2038.

Benzyl *endo*-7-(1-ethyl-1-hydroxypropyl)bicyclo[4.1.0]heptane-7-carboxylate (2u)

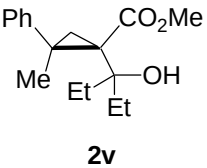


2u

Following the procedure of method I, ester **1j** (100 mg, 0.38 mmol) with Sm (228 mg, 1.52 mmol), CH_2I_2 (304 mg, 1.14 mmol) and diethyl ketone (39 mg, 0.46 mmol) gave the product **2u** (95 mg, 79%). Based on the analogy of spectra data of **2b**, the relative configuration of **2u** was determined as *trans*-adduct.

2u: colorless oil; ^{1}H NMR (400 MHz, $CDCl_3$) δ 0.90-0.944 (m, 7H), 1.14-1.23 (m, 4H), 1.43-1.53 (m, 6H), 1.78-1.86 (m, 4H), 5.11 (s, 2H), 7.21-7.39 (m, 5H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 7.9, 7.9, 14.9, 19.8, 21.2, 31.5, 37.7, 66.5, 74.2, 128.2, 128.5, 128.5, 135.6, 170.9; IR (neat) 3461, 2881, 1721 cm^{-1}; HRMS (EI) calcd for $C_{20}H_{28}O_3$ (M^+) 316.2038, found 316.2044.

Methyl (1*R,2*R**)-1-(1-ethyl-1-hydroxypropyl)-2-methyl-2-phenylcyclopropanecarboxylate (2v)**



2v

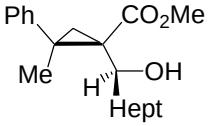
Following the procedure of method I, ester **1k** (100 mg, 0.44 mmol) with Sm (263 mg, 1.75 mmol), CH_2I_2 (351 mg, 1.31 mmol) and diethyl ketone (45 mg, 0.52 mmol) gave the product **2v** (97 mg, 79%). Based on the analogy of spectra data of **2b**, the relative configuration of **2v** was determined as *trans*-adduct.

2v: colorless oil; ^{1}H NMR (400 MHz, $CDCl_3$) δ 0.95 (t, *J* = 7.2 Hz, 6H), 1.36 (d, *J* = 6.4 Hz, 1H), 1.39-1.46 (m, 2H), 1.46-1.49 (m, 2H), 1.68 (s, 3H), 2.44 (d, *J* = 6.4 Hz,1H), 3.32 (s, 3H), 3.46 (brs, 1H), 7.20-7.23 (m, 2H), 7.27-7.31 (m, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 9.8, 22.3, 25.0, 27.4, 29.5, 36.8, 49.9, 52.6, 74.6, 127.8, 128.3, 128.9, 141.1, 168.5; IR (neat) 3514, 2877, 1722 cm^{-1}; HRMS (EI) calcd for $C_{17}H_{24}O_3$ (M^+) 276.1725, found 276.1723.

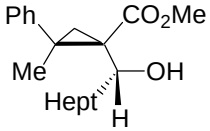
Methyl (1*R, 2*R**)-1-[(*S**)-1-ethyl-1-hydroxyoctyl]-2-methyl -2-phenylcyclopropanecarboxylate (2w)**

Methyl (1*R, 2*R**)-1-[(*R**)-1-ethyl-1-hydroxyoctyl]-2-methyl -2-phenylcyclopropanecarboxylate (3w)**

(A mixture of diastereoisomers: **2w**/**3w** = 75/25)



2w



3w

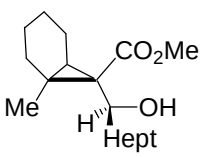
Following the procedure of method I, eater **1k** (100 mg, 0.44 mmol) with Sm (263 mg, 1.75 mmol), CH_2I_2 (351 mg, 1.31 mmol) and octanal (69 mg, 0.52 mmol) gave an inseparable mixture of **2w** and **3w** (125 mg, 88%). Based on the analogy of spectra data of **2b**, the relative configuration of **2w** and **3w** was determined as *trans*-adduct. The major product was assigned to *re*-face-adduct, based on the typical selectivity of SmI_2-promoted Reformatsky reaction.

2w and **3w**: colorless oil; ^{1}H NMR (400 MHz, $CDCl_3$) δ 0.83-0.90 (m, 3H), 1.09-1.15 (m, 3H x 3/4 and 1H x 1/4), 1.25-1.31 (m, 7H), 1.40 (s, 3H x 1/4), 1.42-1.44 (m, 2H x 1/4), 1.48 (s 3H x 3/4), 1.62-1.67 (m, 2H), 180-1.88 (m, 1H x 3/4 and 2H x 1/4), 2.12 (d, *J* = 4.8 Hz, 1H x 3/4), 3.11(s, 3H), 3.25 (dd, *J* = 2.3, 9.3 Hz, 1H x 1/4), 3.46 (dd, *J* = 2.3, 10.3 Hz, 1H x 3/4), 7.16-7.21 (m, 2H), 7.24-7.27 (m, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 14.1, 22.6, 24.4, 25.1, 25.6, 27.2, 29.2, 29.4, 29.5, 29.6, 31.2, 31.8, 31.9, 33.6, 35.2, 36.4, 40.1, 50.9, 74.5, 75.9, 126.4, 126.6, 127.3, 128.1, 128.2, 128.5, 143.9, 172.3; IR (neat) 3502, 2879, 1727, 1712 cm^{-1}; HRMS (EI) calcd for $C_{20}H_{30}O_3$ (M^+) 318.2195, found 318.2195.

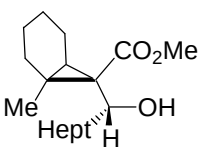
Methyl *endo*-7-[(*S)-1-hydroxyoctyl]-1-methylbicyclo[4.1.0]heptane-7-carboxylate (2x)**

Methyl *endo*-7-[(*R)-1-hydroxyoctyl]-1-methylbicyclo[4.1.0]heptane-7-carboxylate (3x)**

(A mixture of diastereoisomers: **2x**/**3x** = 60/40)



2x



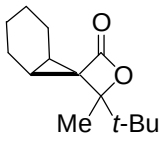
3x

Following the procedure of method II, ester **1l** (100 mg, 0.49 mmol) with Sm (319 mg, 2.12 mmol), CH_2I_2 (426 mg, 1.59 mmol) and octanal (76 mg, 0.59 mmol) gave gave an inseparable mixture of **2x** and **3x** (102 mg, 72%). Based on the analogy of spectra data of **2b**, the relative configuration of **2x** and **3x** was determined as

trans-adduct. The major product was assigned to *re*-face-adduct, based on the typical selectivity of SmI_2-promoted Reformatsky reaction.

2x and **3x**: colorless oil; ^{1}H NMR (400 MHz, $CDCl_3$) δ 0.88 (t, J = 6.0 Hz, 3H), 0.99-1.03 (m, 1H), 1.16 (s, 3H), 1.22-1.35 (m, 13H), 1.72-1.79 (m, 1H), 1.89-1.97 (m, 1H), 2.02-2.08 (m, 1H), 3.26-3.29 (m, 1H), 3.72 (s, 3H x 2/5), 3.72 (s, 3H x 3/5); ^{13}C NMR (100 MHz, $CDCl_3$) δ 14.1, 20.4, 21.1, 22.6, 23.3, 23.6, 26.4, 27.6, 29.2, 29.5, 29.6, 29.7, 30.4, 31.8, 36.2, 41.2, 41.2, 51.2, 51.3, 75.9, 76.3, 171.1, 171.9, ; IR (neat) 3478, 2919, 2858, 1714 cm^{-1}; HRMS (EI) calcd for $C_{18}H_{32}O_3$ (M^+) 296.2351, found 296.2351.

4'-*tert*-Butyl-4'-methylspiro{bicyclo[4.1.0]heptene[2,3']oxetane}-2'-one (4y)



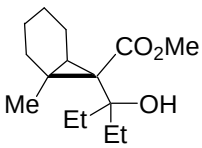
4y

Following the procedure of method I, ester **1c** (100 mg, 0.53 mmol) with Sm (319 mg, 2.12 mmol), CH_2I_2 (426 mg, 1.59 mmol) and 2,4-dimethylpentanone (73 mg, 0.64 mmol) gave the product **4y** (96 mg, 80%).

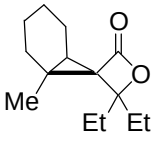
4y: colorless oil; ^{1}H NMR (400 MHz, $CDCl_3$) δ 1.00 (s, 9H), 1.21-1.31 (m, 2H), 1.42 (s, 3H), 1.47-1.52 (m, 1H), 1.61-1.80 (m, 3H), 1.83-1.97 (m, 4H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 19.4, 19.6, 19.9, 20.6, 20.9, 23.2, 23.6, 25.1, 36.8, 46.6, 87.0, 173.5; IR (neat) 2939, 2877, 1797, 1265 cm^{-1}; HRMS (EI) calcd for 222.1620, found 222.1621.

Methyl *endo*-7-(1-ethyl-1-hydroxypropyl)-1-methylbycyclo[4.1.0]heptane-7-carboxylate (2z)

4',4'-Diethyl-1-methylspiro{bicyclo[4.1.0]heptene[2,3']oxetane}-2'-one (4z)



2z

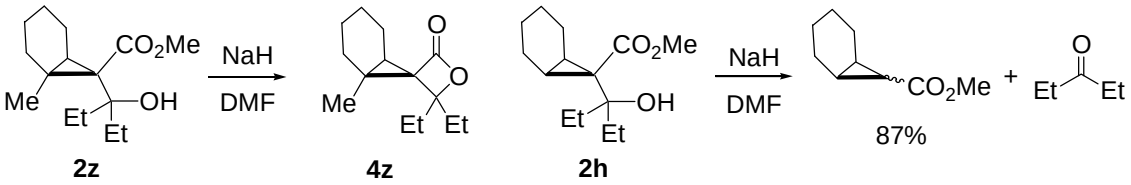


4z

Following the procedure of method I, ester **1c** (100 mg, 0.49 mmol) with Sm (319 mg, 2.12 mmol), CH_2I_2 (426 mg, 1.59 mmol) and diethyl ketone (51 mg, 0.59 mmol) gave the product **2z** (31 mg, 25%) and **4z** (69 mg, 63%). Following the procedure of method II, ester **1c** (100 mg, 0.53 mmol) with Sm (319 mg, 2.12 mmol), CH_2I_2 (426 mg, 1.59 mmol) and diethyl ketone (51 mg, 0.59 mmol) gave the product **4z** (92 mg, 84%).

2z: colorless oil; ^{1}H NMR (400 MHz, $CDCl_3$) δ 0.92-1.00 (m, 8H), 1.15 (s, 3H), 1.18-1.27 (m, 4H), 1.53 (q, J = 7.3 Hz, 4H), 1.62 (s, 1H), 1.73-1.90 (m, 3H), 3.66 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 7.9, 11.3, 14.7, 19.3, 21.8, 33.2, 50.8, 73.2, 173.3; IR (neat) 3517, 2876, 1716 cm^{-1}; HRMS (EI) calcd for $C_{15}H_{26}O_3$ (M^+) 254.1882, found 254.1882. **4z**: colorless oil; ^{1}H NMR (400 MHz, $CDCl_3$) δ 0.97-1.04 (m, 6H), 1.15 (s, 3H), 1.21-1.30 (m, 3H), 1.54-1.63 (m, 2H), 1.65-1.72 (m, 2H), 1.74-1.85 (m, 3H), 1.88-2.01 (m, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 7.5, 20.1, 24.1, 27.6, 28.1, 29.2, 29.6, 48.2, 86.3, 172.9; IR (neat) 2941, 2886, 1798, 1270 cm^{-1}; HRMS (EI) calcd for $C_{14}H_{22}O_2$ (M^+) 222.1620, found 222.1621.

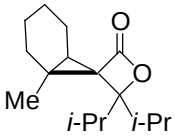
Treatment of β-hydroxyester **2z** with NaH in DMF gave β-lactone **4z** in quantitative yield. (In contrast, in a similar treatment of **2h** with NaH, retro-aldol reaction occurred to give methyl bicycle[4.1.0]heptane-7-carboxylate[11] in 87%.)



2z **4z** **2h**

11) Krabbenhoft, H. O. *J. Org. Chem.* **1979, *44,*** 4285

4',4'-Diisoprpyl-1-methylspiro{bicyclo[4.1.0]heptene[2,3']oxetane}-2'-one (4α)

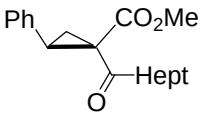


4α

Following the procedure of method II, ester **1c** (100 mg, 0.49 mmol) with Sm (297 mg, 2.12 mmol), CH_2I_2 (426 mg, 1.47 mmol) and 2,4-dimethylpentanone (68 mg, 0.59 mmol) gave the product **4α** (90 mg, 73%).

4α: colorless oil; ^{1}H NMR (400 MHz, $CDCl_3$) δ 0.86 (d, *J* = 7.3 Hz, 3H), 0.93 (d, *J* = 6.8 Hz, 3H), 0.98 (d, *J* = 6.8 Hz, 3H), 1.04 (d, *J* = 7.3 Hz, 3H), 1.13 (s, 3H), 1.17-1.22 (m, 2H), 1.46-1.50 (m, 1H), 1.57-1.76 (m, 4H), 1.80-1.92 (m, 2H), 2.03-2.14 (m, 1H), 2.28-2.38 (m, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 15.9, 16.7, 16.8, 17.2, 19.5, 20.5, 20.8, 24.0, 26.8, 27.2, 28.8, 30.3, 31.7, 46.4, 89.8, 173.1; IR (neat) 2939, 1796, 1265 cm^{-1}; HRMS (EI) calcd for $C_{16}H_{26}O_2$ (M^+) 250.1933, found 250.1940.

Methyl (1*R,2*R**)-1-octanoyl-2-phenylcyclopropanecarboxylate (5a)**



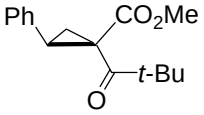
5a

(**Method III**) A typical procedure: A solution of CH_2I_2 (115 μl, 1.42 mmol) in THF (4.0 ml) was added to Sm (286 mg, 1.90 mmol) at 0˚C under an Ar atmosphere, followed by being stirred at room temp for 2 h. HMPA (996 μl, 5.70 mmol) was added to the mixture at the same temp, which was stirred for 15 min. A solution of ester **1a** (100 mg, 0.48 mmol) in THF (1.0 ml) was added to the mixture at -78˚C, which was stirred for 15 min. Octanoyl chloride (93 mg, 0.57 mmol) was added to the mixture at the same temp, which was stirred for 2h. The reaction was quenched with sat. NH_4Cl aqueous solution (10 ml). Water was added to the mixture, which was extracted with Et_2O (20 ml x 5). The organic phase was washed with water and brine, dried (Na_2SO_4), and concentrated. The obtained crude oil was purified by column chromatography (SiO_2, hexane/AcOEt = 15/1) to give the product **5a** (96 mg, 88%). Based on the analogy of spectra data of **5b** (described below), the relative configuration of **5a** was determined as *trans*-adduct.

5a: colorless oil; ^{1}H NMR (400 MHz, $CDCl_3$) δ 0.88 (t, *J* = 6.0 Hz, 3H), 1.73 (dd, *J* = 7.0 Hz, *J* = 10.1 Hz, 1H), 2.21 (dd, *J* = 7.0 Hz, *J* = 10.1 Hz 1H), 2.52 (t, *J* = 7.3 Hz, 2H), 3.01 (dd, *J* = 7.0, 10.1

Hz, 1H) 3.19 (s, 3H), 7.20-7.24 (m, 2H), 7.29-7.37 (m, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 25.0, 36.3, 44.8, 52.5, 119.0, 127.6, 128.1, 129.3, 130.2, 134.6, 171.8, 204.5; IR (neat) 2843, 1725, 1716, 1497 cm^{-1}; HRMS (EI) calcd for $C_{16}H_{22}O_3$ (M^+) 302.1882, found 302.1881.

Methyl (1*R,2*R**)-1-pivaloyl-2-phenylcyclopropanecarboxylate (5b)**

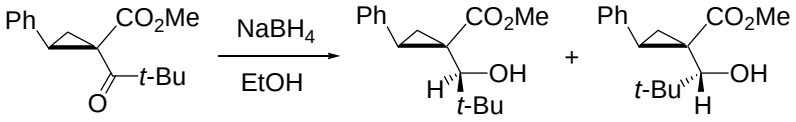


5b

Following the procedure of method III, ester **1a** (100 mg, 0.48 mmol) with Sm (319 mg, 2.12 mmol), CH_2I_2 (426 mg, 1.59 mmol) and pivaloyl chloride (69 mg, 0.57 mmol) gave the product **5b** (107 mg, 89%).

5b: colorless oil; ^{1}H NMR (400 MHz, $CDCl_3$) δ 1.25 (s, 9H), 1.37 (dd, *J* = 4.8, 9.2 Hz, 1H), 2.19 (dd, *J* = 4.8, 8.0 Hz, 1H), 3.27 (t, *J* = 8.8 Hz, 1H), 3.37 (s, 3H), 7.20-7.28 (m, 5H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 18.1, 28.0, 29.3, 42.7, 45.3, 51.9, 127.0, 128.0, 129.0, 135.0, 168.3, 203.2; IR (neat) 2876, 1729, 1711 cm^{-1}; HRMS (EI) calcd for $C_{17}H_{28}O_3$ (M^+) 280.2038, found 280.2039.

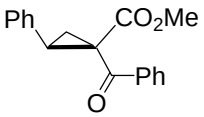
In order to determine the relative configuration (*trans*-adduct), β-keto ester **5b** converted into β-hydroxy esters **2f** and **3f**. Spectral data of the product was consistent with that of the products **2f** and **3f** of the aforementioned method II. Thus, the relative configuration of **5b** was determined as *trans*-adduct.



5b **2f** **3f**

98%, **2f**/**3f** = 40/60

Methyl (1*R,2*R**)-1-benzoyl-2-phenylcyclopropanecarboxylate (5c)**

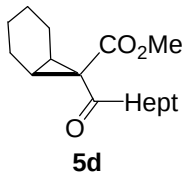


5c

Following the procedure of method III, ester **1a** (100 mg, 0.48 mmol) with Sm (319 mg, 2.12 mmol), CH_2I_2 (426 mg, 1.59 mmol) and benzoyl chloride (80 mg, 0.57 mmol) gave the product **5c** (111 mg, 92%). Based on the analogy of spectral data of **5b**, the relative configuration of **5c** was determined as *trans*-adduct.

5c: colorless oil; ^{1}H NMR (400 MHz, $CDCl_3$) δ 1.68 (dd, *J* = 5.6, 9.1 Hz, 1H), 2.45 (dd, *J* = 7.8, 9.1 Hz, 1H), 3.24 (s, 3H), 3.56 (t, *J* = 8.8 Hz, 1H), 7.23-7.28 (m, 1H), 7.30-7.31 (m, 3H), 7.37-7.48 (m, 3H), 7.54-7.57 (m, 1H), 7.91-7.93 (m, 2H) ; ^{13}C NMR (100 MHz, $CDCl_3$) δ 20.1, 20.1, 42.3, 52.1, 127.2, 128.0, 128.2, 128.6, 129.0, 132.0, 124.8, 137.0, 168.9, 194.5; IR (neat) 2916, 1722 , 1695 cm^{-1}; HRMS (EI) calcd for $C_{18}H_{16}O_3$ (M^+) 280.1099, found 280.1095.

Methyl *endo*-7-octanoylbicyclo[4.1.0]-7-carboxylate (5d)

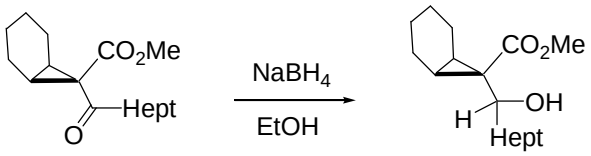


5d

Following the procedure of method III, ester **1c** (100 mg, 0.53 mmol) with Sm (319 mg, 2.12 mmol), CH_2I_2 (426 mg, 1.59 mmol) and octanoyl chloride (103 mg, 0.64 mmol) gave the product **5d** (106 mg, 89%).

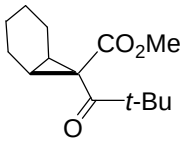
5d: colorless oil; ^{1}H NMR (400 MHz, $CDCl_3$) δ 0.87 (t, *J* = 7.2 Hz, 3H), 0.99-1.06 (m, 2H), 1.26-1.29 (m, 10H), 1.50-1.57 (m, 2H), 1.81-1.82 (m, 2H), 1.84-1.95 (m, 4H), 2.52 (t, *J* = 7.2 Hz, 2H) 3.81 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 14.0, 20.0, 20.8, 22.6, 23.7, 27.8, 29.1, 31.6, 40.4, 44.1, 52.1, 81.9, 170.1, 204.5; IR (neat) 2896, 1733, 1711 cm^{-1}; HRMS (EI) calcd for $C_{16}H_{20}O_3$ (M^+) 280.2038, found 280.2043.

In order to determine the relative configuration (*trans*-adduct), β-keto ester **5d** converted into β-hydroxy ester **2k**. Spectral data of the product was consistent with that of the product **2k** of aforementioned method II. Thus, the relative configuration of **5d** was determined as *trans*-adduct.



5d **2k** 99%

Methyl *endo*-7-pivaloylbicyclo[4.1.0]-7-carboxylate (5e)

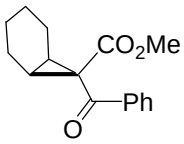


5e

Following the procedure of method III, ester **1c** (100 mg, 0.53 mmol) with Sm (319 mg, 2.12 mmol), CH_2I_2 (426 mg, 1.59 mmol) and pivaloyl chloride (77 mg, 0.64 mmol) gave the product **5e** (96 mg, 78%). Based on the analogy of spectra data of **5d**, the relative configuration of **5e** was determined as *trans*-adduct.

5e: colorless oil; ^{1}H NMR (400 MHz, $CDCl_3$) δ 1.19 (s, 9H), 1.24-1.28 (m, 4H), 1.69-1.78 (m, 4H), 1.89-1.97 (m, 2H), 3.73 (s, 3H) ; ^{13}C NMR (100 MHz, $CDCl_3$) δ 18.8, 20.7, 24.0, 27.7, 42.0, 45.6, 51.6, 169.6, 208.9; IR (neat) 2936, 1711, 1702 cm^{-1}; HRMS (EI) calcd for $C_{14}H_{22}O_3$ (M^+) 238.1569, found 238.1574.

Methyl *endo*-7-benzoylbicyclo[4.1.0]-7-carboxylate (5f)



5f

Following the procedure of method III, ester **1c** (100 mg, 0.53 mmol) with Sm (319 mg, 2.12 mmol), CH_2I_2 (426 mg, 1.59 mmol) and benzoyl chloride (89 mg, 0.64 mmol) gave the product **5f** (96 mg, 82%). Based on the analogy of spectra data of **5d**, the relative configuration of **5f** was determined as *trans*-adduct.

5f: colorless oil; ^{1}H NMR (400 MHz, $CDCl_3$) δ 1.26-1.43 (m, 4H), 1.86-1.91 (m, 2H), 2.03-2.11 (m, 4H), 3.49 (s, 3H), 7.42 (t, *J* = 7.8 Hz, 2H), 7.51 (t, *J* =7.8 Hz, 1H), 7.83 (d, *J* = 8.4 Hz); ^{13}C NMR (100 MHz, $CDCl_3$) δ 19.0, 20.8, 25.9, 42.6, 51.9, 127.8, 128.4, 132.3, 137.9, 170.2, 196.3; IR (neat) 2876, 1729, 1705, 1620 cm^{-1}; HRMS (EI) calcd for $C_{16}H_{18}O_3$ (M^+) 258.1256, found 258.1264.