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Asymmetric Synthesis of 3,3,5,5-Tetrasubstituted 1,2-Dioxolanes: Total Synthesis of Epiplakinic Acid F

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The first enantioselective total synthesis of epiplakinic acid F (**1**) was achieved through a pivotal step involving a radical-mediated asymmetric peroxidation of vinylcyclopropanes with molecular oxygen to construct highly substituted 1,2-dioxolanes. Subsequent conversions of the chiral 1,2-dioxolanes led to total synthesis of epiplakinic acid F (**1**) and the confirmation of its absolute configuration. The enantiomer of epiplakinic acid F methyl ester (**2**) was also prepared.

Introduction

Studies of five-membered cyclic peroxides, isolated from terrestrial or marine sources, had been rejuvenated in last decades because many of them exhibit antifungal,[1a-1c,1e] antimalarial,[1c,1e,1f] antiviral,[1c,1d] antitumour,[1c,1e] and cytotoxic[1c,1e,1f] properties. Epiplakinic acid F (**1**), isolated from *Plakinastrella* sponge species collected from Félicité Island of Seychelles in 2001[2] as well as from *Plakortishalichondrioides* collected from Puerto Rico in 2010[3] (Figure 1), contains a 3,3,5,5-tetrasubstituted 1,2-dioxolane ring and a relatively unstable conjugated triene species. Epiplakinic acid F (**1**) exhibits potent cytotoxicity against DU-145 prostate cancer cells (IC_{50} = 1 μg/mL)[2] and moderate antifungal activity against *Candida albicans* with minimum inhibitory concentrations of 25 μg/mL (SDB) and 6.25 μg/mL (RPMI-1640).[3] The absolute configuration of epiplakinic acid F (**1**) was determined from its methyl ester (**2**).[3] Plakortide E (**3**), isolated from the Jamaican marine sponge *Plakortis halichondrioides*, shows a structural similarity with epiplakinic acid F (**1**), although it contains a *cis*-1,2-dioxolane ring.[1b,1d]

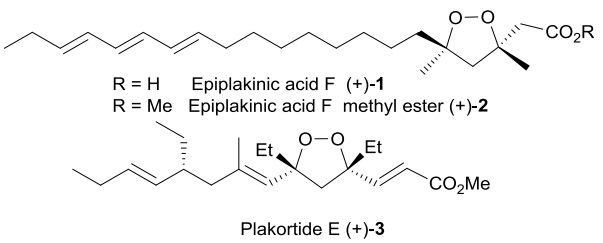
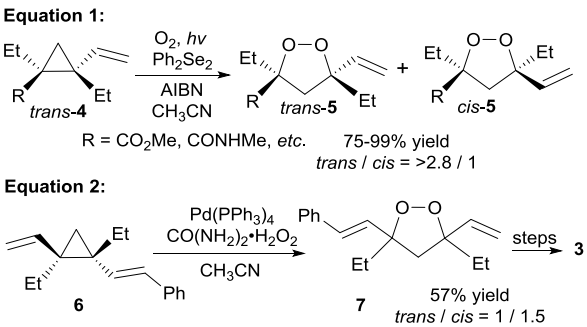


Figure 1 Structures of epiplakinic acid F (**1**) and its methyl ester (**2**), and plakortide E (**3**).

The development of an efficient method for the synthesis of five-membered cyclic peroxides is particularly difficult because of the low O-O bond dissociation energy (37±1 kcal/mol).[4] Moreover, in plakortide E (**3**) and epiplakinic acid F (**1**), the presence of two tertiary stereogenic centres in their cyclic peroxide central cores poses also a synthetic challenging issue. Although many methods have been developed in past decades to construct these peroxide rings,[4-5] only very few enantioselective syntheses of five-membered cyclic peroxides have been reported.[6] In 2006, Dussault, employing a Lewis acid-mediated annulation reaction of alkenes with peroxycarbenium ions, pioneered the synthesis of plakinic acid A.[6b] Vatèle and co-workers synthesized andavadoic acid in 2013, a base-catalyzed cyclization of a β-hydroperoxy epoxide as the key step for the construction of the 1,2-dioxolane framework.[6c] Our own preliminary synthetic efforts towards five-membered cyclic peroxides featuring the peroxide core **5** of plakortide E utilizing a Feldman reaction on vinylcyclopropanes **4**, was recorded in 2007, as shown in Equation 1.[7] The total synthesis of plakortide E (**3**) was eventually accomplished in 2011, albeit by a palladium-catalysed approach as depicted in Equation 2.[8] Feldman reaction is known to furnish favorable *anti*-3,3,5,5-tetrasubstituted 1,2-dioxolanes *via* a radical-mediated reaction between vinylcyclopropanes and molecular oxygen. Notwithstanding, Feldman reaction has not yet been used in a stereo- and enantio-selective manner because radicals, as highly reactive short-lived species,[9] are still difficult to tame, despite



the fact that asymmetric [3+2] cycloaddition has been a rather active research area.[10] Herein, we would like to report an asymmetric radical-mediated intermolecular Feldman reaction in the quest for 3,3,5,5-tetrasubstituted 1,2-dioxolanes between vinylcyclopropanes and molecular oxygen, as well as the use of this approach to achieve the first total synthesis of epiplakinic acid F (**1**) and its methyl ester (**2**).

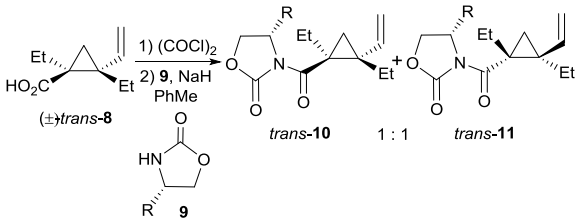
Results and discussion

Asymmetric Synthesis of 3,3,5,5-Tetrasubstituted 1,2-Dioxolanes.

In previous studies, we have established a Feldman reaction protocol to construct multi-substituted 1,2-dioxolane rings in a single step from vinylcyclopropanes under an atmosphere of molecular oxygen.[7] It was examined that the stereochemical outcome of radical [3+2] oxygenation reaction depends upon the nature of substituents of vinylcyclopropanes.[11] Therefore, incorporating chiral auxiliaries into vinylcyclopropanes as substituents may provide a promising strategy to achieve the enantioselective version of Feldman reaction. On this basis, various Evans oxazolidinone auxiliaries **9** were adopted in the preparation of substituted vinylcyclopropanes. As shown in Table 1, a series of 1:1 diastereomeric vinylcyclopropanes (*trans*-**10** and *trans*-**11**) were obtained by an amidation reaction of oxazolidinones with *trans*-2-vinylcyclopropane acyl chlorides,[12] which, in turn, were prepared from *trans*-2-vinylcyclopropane carboxylic acid [(±)-*trans*-**8**][7-8] and oxalyl chloride in quantitative yields. In general, vinylcyclopropane derivatives (*trans*-**10** and *trans*-**11**) were synthesized in overall yields of 55%-80%.

With *trans*-**10** and *trans*-**11** in hand, the peroxidation reaction was commenced under an atmosphere of molecular oxygen at room temperature by employing Ph_2Se_2 and AIBN as catalysts under sunlamp irradiation. The results were summarized in Table 2. As can be seen, the desired 1,2-dioxolanes as a mixture of three isomers were formed in quantitative yield, with the exception of *trans*-**10e/11e**, which

Table 1 Synthesis of vinylcyclopropane derivatives[a]



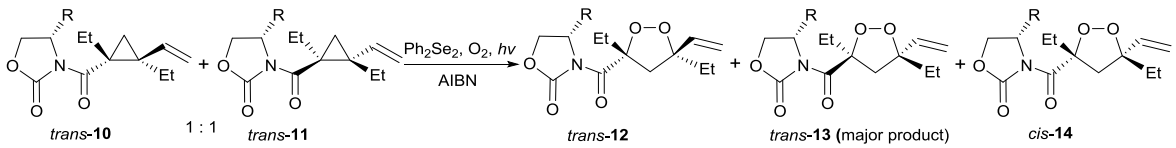
Entry	R	9	Yield (%)[b]
1[c]	*i*-Pr	**9a**	74
2	Bn	**9b**	67
3	Ph	**9c**	75
4	4-NO_2Bn	**9d**	55
5	*t*-Bu	**9e**	80

[a]Reaction conditions: ($(COCl)_2$ 3 equiv.), **9** (1.2 equiv.), NaH (1.5 equiv.) 80 ℃. [b]Isolated yields. [c]The structure of diastereomer *trans*-**10a** was confirmed by an X-ray crystallographic study (CCDC 978791), see Supporting Information.

provided a slightly diminished yield of 93% (Table 2, entry 5). Among them, the vinylcyclopropane *trans*-**10a/11a** (Table 2, entry 1, *cis*/*trans* = 9/91, *trans*-**13/12** = 67/23) and *trans*-**10c/11c** (Table 2, entry 3, *cis*/*trans* = 9/91, *trans*-**13/12** = 69/22) gave the best results. However, three isomers of the peroxidation products starting from *trans*-**10c/11c** were inseparable (Table 2, entry 3). Therefore, the vinylcyclopropanes *trans*-**10a** and **11a** as a mixture were chosen as starting materials for the optimisation of reaction conditions in our peroxidation procedure.

In an effort to increase the yield of *trans*-**13**, the mechanism of peroxidation reaction was studied. According to the studies on the radical addition to α-methacrylates by Sibi and Sausker,[13] a radical transition state stereoselective model based on chiral *N*-acyl oxazolidinones **10** and **11** was proposed as shown in Figure 2, which indicated that the transition state might proceed through a preferred conformation **A** rather than the sterically

Table 2 Radical peroxidation approach towards 1,2-dioxolanes[a]



entry	R	*trans*-**10** and *trans*-**11**	Additive (1 equiv.)	Yield (%)[d]	*cis*/*trans*[e]	*tran*-**13**/**12**[f]
1[b]	*i*-Pr	**10a** + **11a**	none	quant	9/91	67/23
2[b]	Bn	**10b** + **11b**	none	quant	7/93	53/40
3[b]	Ph	**10c** + **11c**	none	quant	9/91	69/22
4[b]	4-NO_2Bn	**10d** + **11d**	none	quant	15/85	49/37
5[b]	*t*-Bu	**10e** + **11e**	none	93	16/84	55/29
6[c]	*i*-Pr	**10a** + **11a**	LiCl	85	10/90	67/23
7[c]	*i*-Pr	**10a** + **11a**	$Mg(ClO_4)_2$	96	15/85	63/22
8[c]	*i*-Pr	**10a** + **11a**	Ti(*i*-PrO)$_4$	96	11/89	66/23
9[c]	*i*-Pr	**10a** + **11a**	$Yb(OTf)_3$	86	12/88	67/21
10[c]	*i*-Pr	**10a** + **11a**	$La(OTf)_3$	82	11/89	67/22
11[c]	*i*-Pr	**10a** + **11a**	$Sc(OTf)_3$	92	8/92	76/16

[a]Reaction conditions: Ph_2Se_2 (0.2 equiv.), AIBN (0.4 equiv.), 300 W sunlamp, r.t. [b]CH_3CN (1 mL). [c]diethyl ether (1 mL). [d]Isolated yields of all diastereomers. [e]Determined by HPLC analysis. [f]The structure of diastereomer *trans*-**12a** was confirmed by an X-ray crystallographic study (CCDC 978789), see Supporting Information.

hindered conformation **B**. The reaction course then goes via the lowest energy chair like conformation **C** to give *trans*-**13** as the major product.[11d] Recent studies also suggest that the use of Lewis acids as catalysts offers a possibility to improve the selectivity of free radical reactions of *N*-acyl-2-oxazolidinones *via* an interaction of the metal centre with substrates.[13-14] Therefore, various Lewis acids were surveyed, it was found that, in the presence of $Sc(OTf)_3$, a 76/16 ratio value of *trans*-**13**/**12** was realized (Table 2, entry 11). However, other metal salts (LiCl, $Mg(ClO_4)_2$, $Ti(i\text{-}PrO)_4$, $Yb(OTf)_3$, $La(OTf)_3$) did not improve the yield of the desired *trans*-**13** (Table 2, entries 6-10). Further screening of other reaction parameters including solvents and reaction temperatures did not show significant improvement (see Supporting Information).

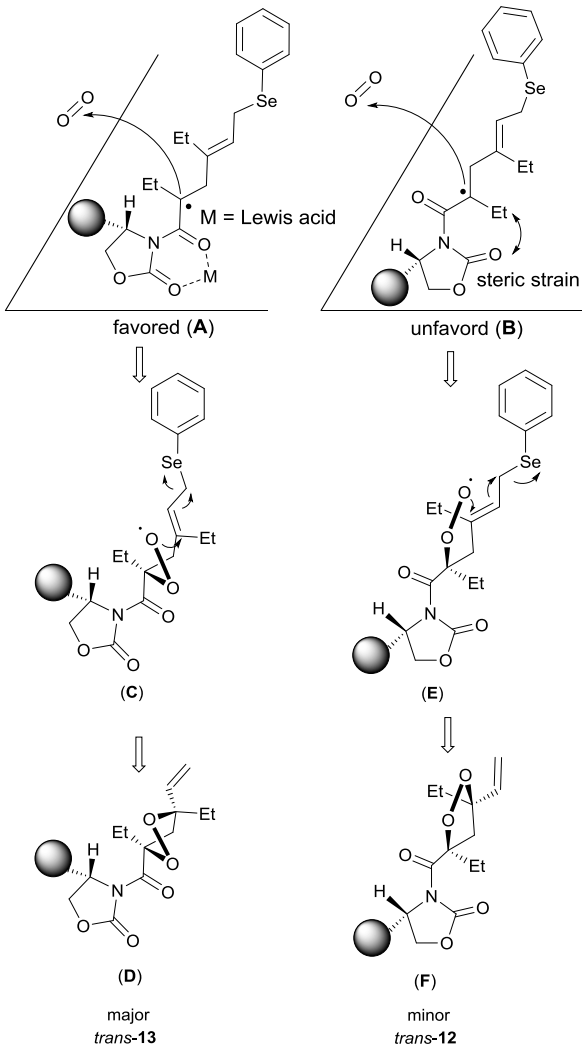
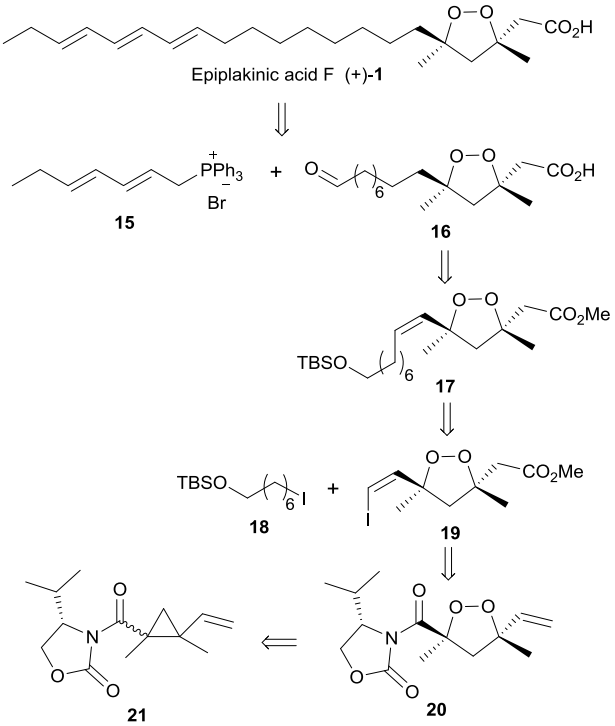


Figure 2 Radical transition state model of intermediates.

Retrosynthetic analysis.

After establishment of optimized conditions for peroxidation, we conceived that the synthesis of epiplakinic acid F (**1**) could be accomplished by a stereoselective radical-mediated intermolecular Feldman reaction as the key step. Our retrosynthetic plan is illustrated in Scheme 1. While there were

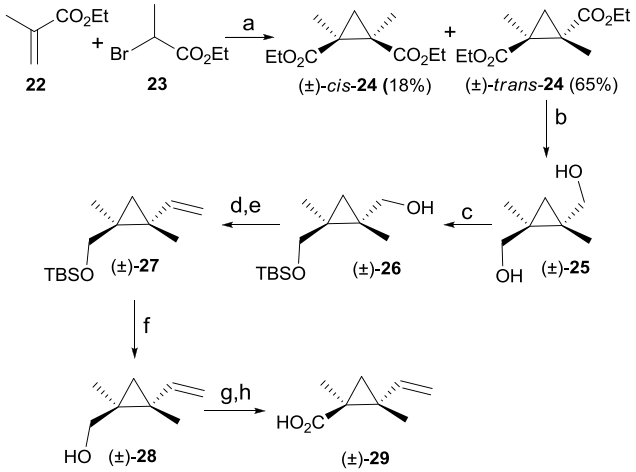


Scheme 1 Retrosynthetic analysis of epiplakinic acid F.

concerns on the presence of the side chain containing a conjugate triene that is a likely very sensitive scaffold due to the possible polymerization and oxidation in the presence of air and light, we decided to install this conjugate triene in the final step, making use of a Wittig reaction between aldehyde **16** and phosphonium salt **15**.[15] In turn, aldehyde **16** can be synthesized from central core **19** by a Negishi coupling reaction with the side chain **18**[8] followed by a reduction reaction and an Dess-Martin oxidation of the hydroxyl group of 1,2-dioxolane **17**. Furthermore, The central core **19** would be derived from the highly substituted 1,2-dioxolane **20**, which can be produced from vinylcyclopropanes **21** *via* an asymmetric Feldman reaction.

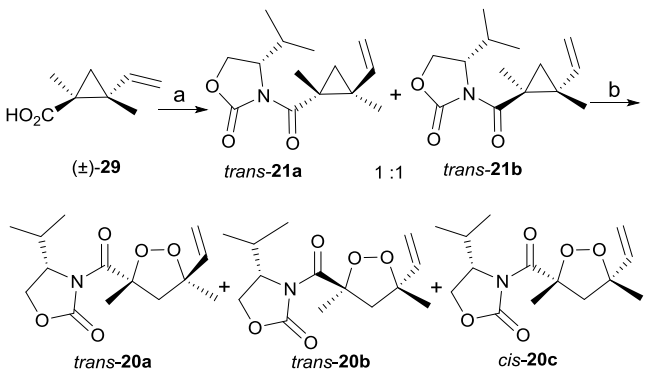
Total synthesis of epiplakinic acid F.

The key intermediate *trans*-1,2-methyl-2-vinyl-1,2-cyclopropane carboxylic acid (±)-**29** was prepared according to McCoy's procedure,[16] starting from ethyl α-methacrylate **22** and ethyl 2-bromopropionate **23**. The cyclopropanation reaction afforded (±)-*trans*-**24** in 65% yield, together with 18% yield of a *cis*-isomer. Sequential reduction of (±)-*trans*-**24** with $LiAlH_4$ followed by mono-protection with *tert*-$BuMe_2SiCl$ afforded alcohol (±)-**26** in good yields. Swern oxidation of (±)-**26**, and subsequent Horner–Emmons olefination reaction[17] with triphenylmethylphosphonium iodide led to the unsaturated ester (±)-**27** in 90% yield over two steps. Then, deprotection of (±)-**27** with *p*-TsOH provided (±)-**28** in 98% yield, which was again subjected to Swern oxidation and subsequent Pinnick oxidation, leading to acid (±)-**29** in 75% yield over two steps (Scheme 2).



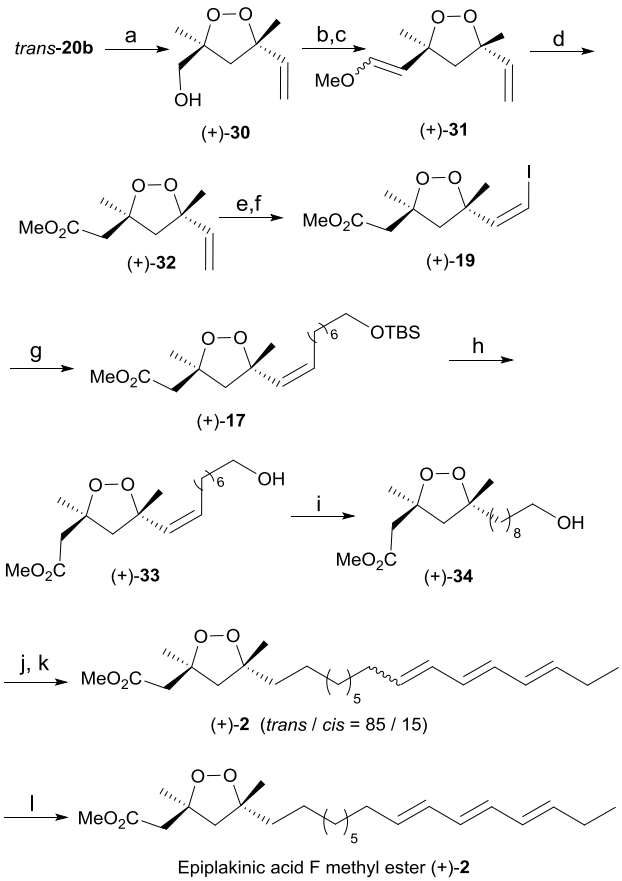
Scheme 2 Synthesis of acid (±)-**29.** Reagents and conditions: (a) NaH (1.05 equiv.), DMF, r.t., 24 h, 83%; (b) $LiAlH_4$, Et_2O, 0 ℃, 97%; (c) TBSCl, Et_3N, CH_2Cl_2, 0 ℃, 98%; (d) $(COCl)_2$, DMSO, Et_3N, CH_2Cl_2, -78 °C; (e) Ph_3PCH_3I (1.2 equiv.), *n*-BuLi (1.2 equiv.), THF, 0 ℃, 90% (2 steps); (f) *p*-TsOH, MeOH/CH_2Cl_2, 98%; (g) $(COCl)_2$, DMSO, Et_3N, CH_2Cl_2, -78 ℃; (h) $NaClO_2$, KH_2PO_4, resorcinol, *t*-BuOH/H_2O, 75% (2 steps).

With (±)-29 in hand, we synthesized N-acyl-2-oxazolidinones trans-21 in 76% yield as a 1:1 mixture of diastereomers with Evans chiral auxiliary. Compound 21 was then irradiated using a 300 W sunlamp at room temperature under an atmosphere of molecular oxygen and in the presence of Sc(OTf)3, providing the key 1,2-dioxolane 20 in 90% yield of trans-20a/trans-20b/cis-20c in a ratio of 11/80/9. Separation of this mixture of 1,2-dioxolanes gave the major product trans-20b in 74% yield and the minor product trans-20a (X-ray diffraction study CCDC 978792) in 10% yield, respectively (Scheme 3).



Scheme 3 Synthesis of 1,2-dioxolane **20**. Reagents and conditions: (a) $(COCl)_2$, **9a**, NaH, 80 ℃, toluene, 76%; (b) Ph_2Se_2 (0.2 equiv.), AIBN (0.4 equiv.), CH_3CN, 300 W sunlamp, r.t., 90% (**20a/20b/20c** = 11/80/9).

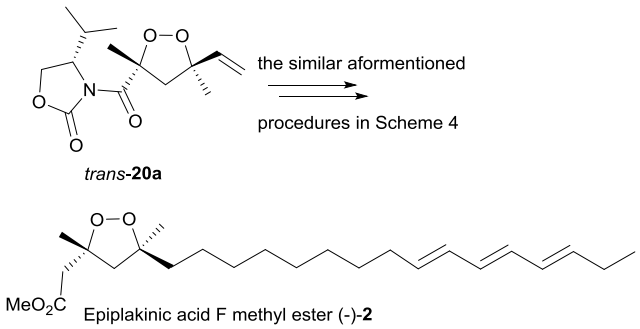
As shown in Scheme 4, enantiopure *trans*-**20b** was transformed to (+)-**30** in 90% yield by cleavage of the chiral auxiliary using $LiBH_4$.[18] It is worth mentioning that $LiAlH_4$ and DIBAL-H are able to cleave the O-O bond of the 1,2-dioxolane ring. In the next step involving oxidation of alcohol to aldehyde, Dess-Martin or Swern oxidation proved to be unsuccessful. Gratifyingly, oxidation of (+)-**30** with pyridinium chlorochromate (PCC) and subsequent Wittig olefination with



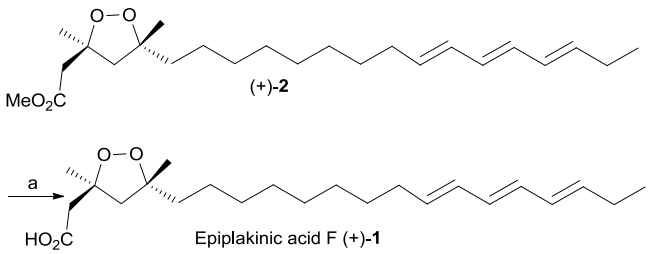
Scheme 4 Synthesis of methyl ester of epiplakinic acid F (+)-**2**. Reagents and conditions: (a) $LiBH_4$ (1.05 equiv.), THF, r.t., 0.5 h, 90%; (b) PCC (2.5 equiv.), CH_2Cl_2, r.t., 24 h; (c) NaHMDS (4.8 equiv.), $MeOCH_2PPh_3Cl$ (5.0 equiv.), -78 to 0 ℃, 60% (2 steps); (d) PCC (2.5 equiv.), CH_2Cl_2, r.t., 24 h, 60%; (e) O_3, 2 min, -78 ℃, then PPh_3 (5 equiv.), CH_2Cl_2, -78 to 0 ℃; (f) ICH_2PPh_3I (5.0 equiv.), NaHMDS (4.8 equiv.), THF, -78 to -20 ℃, 70% (2 steps); (g) **18** (2 equiv.), $ZnCl_2$ (2 equiv.), *t*-BuLi (6.0 equiv.), Et_2O/THF, -78 ℃ to r.t.; $[Pd(PPh_3)_4]$ (10 mol%), THF, 16 h, 77%; (h) *p*-TsOH, MeOH/CH_2Cl_2, 89%; (i) $KO_2CN{=}NCO_2K$ (10.0 equiv.), AcOH (15.0 equiv.), CH_2Cl_2, 0 ℃, three cycles, 85%; (j) Dess-Martin periodinane (1.5 equiv.), CH_2Cl_2; (k) **15** (5.0.equiv.), NaHMDS (4.8 equiv.), THF, -78 ℃, 64% (2 steps); (l) I_2 (5 mol%), sunlamp (visible light), CH_2Cl_2, 0 to -30 to -78 ℃ (*E* : *Z* = ca. 95 : 5), 77%.

NaHMDS-$MeOCH_2PPh_3Cl$ afforded vinyl ether (+)-**31** as a mixture of *E*/*Z* (2/1) isomers in 60% yield over two steps,[19] which was then converted to the desired ester (+)-**32** in 60% yield.[20] Ester (+)-**32** was subjected to ozonolysis. Reductive work-up with PPh_3 gave the aldehyde, and then Wittig olefination with excess NaHMDS-ICH_2PPh_3I afforded the key central core (+)-**19** as a single *Z*-isomer in 70% yield over two steps.[21] With the central core (+)-**19** and side chain (+)-**18** in hand, a modified Negishi reaction afforded the desired (+)-**17** in 77% yield. Then, desilylation using *p*-TsOH furnished alcohol (+)-**33** in 89% yield. To avoid the reduction of the 1,2-dioxolane

ring, the double bond in **33** was selectively reduced by diimide reduction in the presence of the peroxide unit. In this way, (+)-**34** was obtained in 85% yield. A straightforward oxidation of (+)-**34** afforded an aldehyde, which subsequently underwent a Wittig olefination using phosphonium salt in the presence of NaHMDS, providing *trans*-(+)-**2** in 64% overall yield as a mixture of *E*/*Z* isomers and an *E*/*Z* ratio of 85/15. Photo-induced isomerisation of this mixture with a catalytic amount of molecular iodine produced epiplakinic acid F methyl ester (+)-**2** in 77% yield with a better *E*/*Z* ratio of 95/5 (Scheme 4).[22] The structure of methyl ester (+)-**2** was confirmed by ^{1}H- and ^{13}C-NMR spectroscopic analyses, as well as by a HR-MS measurement. The NMR spectra fit well with those of the natural epiplakinic acid F methyl ester (**2**).[3] Moreover, the enantiomer of methyl ester, namely (-)-**2**, was also synthesized from the minor peroxidation product *trans*-**20a** (Scheme 5).



Scheme 5 Synthesis of methyl ester of epiplakinic acid F (-)-**2**.



Scheme 6 Synthesis of epiplakinic acid F (+)-**1**. Reagents and conditions: (a) LiOH (20 equiv.), MeOH/THF/H_2O = 1/1/0.1, r.t., 6 h, 70%.

Ultimately, ester (+)-**2** underwent saponification to provide epiplakinic acid F (**1**) in 70% yield as illustrated in Scheme 6. Comparisons of the chemical shifts and coupling constants of the synthetic compound with the literature values of natural epiplakinic acid F (**1**) are summarized in Supporting Information. The values are consistent with those reported in the literature.[3]

Conclusions

We report herein the first enantioselective total synthesis of epiplakinic acid F (**1**) in 22 steps and 0.4% overall yield from commercially available materials. The focus of our synthetic strategy is the construction of the 1,2-dioxolanes by a radical-mediated asymmetric peroxidation of vinylcyclopropanes with Evans' oxazolidinone auxiliaries in the presence of molecular oxygen, which provided a rapid access to the synthetically challenging chiral tetrasubstituted 1,2-dioxolanes. The bio-evaluation of chiral epiplakinic acid F (**1**) and its derivatives is underway.

Experimental section

General experimental methods

All non-aqueous reactions were carried out using oven-dried glassware under a positive pressure of dry nitrogen unless otherwise noted. Solvents were predried over activated 4Å molecular sieves and were refluxed over magnesium (methanol), sodium (toluene, THF, Et_2O, benzene, dioxane, cyclohexane), or calcium hydride (DCM, DCE, EtOAc, CH_3CN) under an argon atmosphere and collected by distillation. All evaporation of organic solvents was carried out with a rotary evaporator. Column chromatography was performed on silica gel 60 (Huanghai, 300-400 mesh). Yields refer to chromatographically and spectroscopically pure compounds, unless otherwise stated. ^{1}H and ^{13}C NMR spectra were recorded on a Varian Mercury 300 (300 MHz) or Bruker AM 400 (400 MHz) spectrometer.^{1}H and ^{13}C NMR spectra were referenced internally to residual protio-solvent (^{1}H) or solvent (^{13}C) resonances and are reported relative to tetramethylsilane. Data are reported as follows: brs = broad singlet, s = singlet, d = doublet, t = triplet, q = quartet, m = multiplet; coupling constants in Hz. HPLC analyses were on an Agilent 1100 Series chromatograph. Infrared spectra were prepared as KBr pellets and were recorded on a Bio-Rad FTS-185 FT-IR spectrometer. Optical rotations were measured with a Perkin Elmer 241 polarimeter in a 1 dm cuvette. Mass spectra were recorded by the mass spectrometry service of Shanghai Institute of Organic Chemistry.

General procedure for the preparation of *N*-acyl-2-oxazolidinones (*trans*-10 and *trans*-11).

Oxalyl chloride (0.262 mL, 3 mmol, 3 equiv.) was added dropwise to a solution of *trans*-(±)-**8** (0.168 g, 1 mmol) in dry CH_2Cl_2 (15 mL). The resulting mixture was stirred for 3 h, and then evaporated *in vacuo*. Repeated evaporation from dry CH_2Cl_2 afforded the crude acid chloride. Then the compound **9** (1.2 mmol) was added to the suspension of sodium hydride in dry toluene (15 mL). The mixture was stirred at 80 ℃ for 1 h and then cooled to room temperature prior to its addition over 5 min to a solution of the acid chloride obtained above in dry toluene (5 mL) at 0 ℃. The mixture was then allowed to warm to room temperature and stirred for 1 h. The residue was quenched with saturated aqueous NH_4Cl (15 mL), extracted with EtOAc (15 mL ×3) and the combined organic extracts were washed with water (20 mL), brine (20 mL), dried over Na_2SO_4, and concentrated. The residue was purified by flash chromatography to afford *trans*-**10** and *trans*-**11** as a 1:1 mixture.

(*S*)-3-((1*R*,2*S*)-1,2-Diethyl-2-vinylcyclopropanecarbonyl)-4-isopropyloxazolidin-2-one (*trans*-10a) and (*S*)-3-((1*S*, 2*R*)-1,2-diethyl-2-vinylcyclopropanecarbonyl)-4-isopropyl-oxazolidin-2-one (*trans*-11a). Prepared from 1.2 mmol of oxazolidinone **9a** using the general procedure. The *N*-acyl-2-oxazolidinones product was purified by flash chromatography (Hexanes/EtOAc, 10/1→5/1) to give *trans*-**10a** (pale yellow solid, 100 mg) and *trans*-**11a** (colourless oil, 107 mg) in a total 74% yield.

trans-**10a:** $[\alpha]_D^{25}$= -27.5 (*c*, 1.0, $CHCl_3$); IR (Film): 3080, 2965, 2932, 2875, 1787, 1686, 1490, 1388, 1363, 1257, 1227, 1101, 1078, 1002, 916, 797 cm^{-1}; ^1H NMR (300 MHz, $CDCl_3$): δ (ppm) 5.95 (dd, *J* = 10.5, 17.1 Hz, 1H), 5.15 (dd, *J* = 2.1, 10.5 Hz, 1H), 4.93 (dd, *J* = 2.1, 17.1 Hz, 1H), 4.49-4.55 (m, 1H), 4.15-4.29 (m, 2H), 2.10-2.31 (m, 2H), 1.64-1.76 (m, 1H), 1.15-1.25 (m, 2H), 1.03 (d, *J* = 5.4 Hz, 1H), 0.80-0.92 (m, 12H), 0.71 (d, *J* = 5.4 Hz, 1H); ^{13}C NMR (100 MHz, $CDCl_3$): δ (ppm) 173.3, 153.0, 138.3, 117.5, 63.3, 60.0, 40.7, 37.8, 28.4, 27.6, 24.0, 18.5, 14.6, 12.3, 11.6; MS (EI): *m/z* (relative intensity) 121(100), 150(67), 93(49), 122(49), 135(47), 107(30), 41(30), 279(M^+, 6); HRMS (EI): Calculated for $C_{16}H_{25}NO_3$ $[M]^+$: 279.1834, found: 279.1833; Anal. Calculated for $C_{16}H_{25}NO_3$: C, 68.79; H, 9.02; N, 5.01, found: C, 68.74; H, 9.29; N, 4.81.

trans-**11a:** $[\alpha]_D^{25}$ = 142.4 (*c*, 1.0, $CHCl_3$); IR (Film): 3073, 2965, 2929, 2875, 2855, 1789, 1686, 1464, 1385, 1371, 1363, 1229, 1080, 1015, 915 cm^{-1}; ^1H NMR (300 MHz, $CDCl_3$): δ (ppm) 5.99 (dd, *J* = 10.2, 17.1 Hz, 1H), 5.23 (dd, *J* = 1.8, 10.5 Hz, 1H), 5.00 (dd, *J* = 1.8, 17.1 Hz, 1H), 4.20-4.37 (m, 3H), 2.48-2.56 (m, 1H), 1.87-2.10 (m, 2H), 1.05-1.29 (m, 2H), 1.01 (d, *J* = 5.4 Hz, 1H), 0.75-0.94 (m, 12H), 0.73 (d, *J* = 5.4 Hz, 1H); ^{13}C NMR (100 MHz, $CDCl_3$): δ (ppm) 173.7, 153.0, 138.4, 117.6, 63.2, 58.4, 41.0, 38.2, 28.7, 27.2, 24.1, 18.2, 14.8, 12.3, 11.5; MS (ESI): *m/z* (relative intensity) 280 $[M+H]^+$; HRMS (EI): Calculated for $C_{16}H_{25}NO_3$ $[M]^+$: 279.1834, found: 279.1837.

(*S*)-4-Benzyl-3-((1*R*, 2*S*)-1,2-diethyl-2-vinylcyclopropane carbonyl) oxazolidin-2-one (*trans*-10b) and (*S*)-4-benzyl-3-((1*S*, 2*R*)-1,2-diethyl-2-vinylcyclopropanecarbonyl) oxazolidin-2-one (*trans*-11b). Prepared from 1.2 mmol of oxazolidinone **9b** using the general procedure. The *N*-acyl-2-oxazolidinones product was purified by flash chromatography (Hexanes/EtOAc, 10/1→5/1) to give *trans*-**10b** and *trans*-**11b** as a 1:1 mixture (220 mg, pale yellow solid) in a total 67% yield. The mixture was then separated by preparative HPLC to give *trans*-**10b** (pale yellow oil, 110 mg) and *trans*-**11b** (white solid, 110 mg).

trans-**10b:** $[\alpha]_D^{25}$ = -37.8 (*c*, 1.0, $CHCl_3$); IR (Film): 3029, 2966, 2931, 2874, 1789, 1687, 1455, 1379, 1350, 1257, 1213, 1107, 1053, 916, 762, 702 cm^{-1}; ^1H NMR (400 MHz, $CDCl_3$): δ (ppm) 7.20-7.33 (m, 5H), 5.97 (dd, *J* = 10.4, 17.2 Hz, 1H), 5.20 (d, *J* =10.0 Hz, 1H), 4.97 (d, *J* = 17.2 Hz, 1H), 4.70-4.76 (m, 1H), 4.11-4.20 (m, 2H), 3.40 (dd, *J* = 3.2, 13.2 Hz, 1H), 2.65 (dt, *J* = 2.4, 14.4 Hz, 1H), 2.15-2.20 (m, 1H), 1.68-1.76 (m, 1H), 1.19-1.25 (m, 1H), 1.12 (d, *J* = 5.2 Hz, 1H), 0.90 (t, *J* = 8.0 Hz, 3H); 0.84 (t, *J* = 7.2 Hz, 3H); 0.78 (d, *J* = 5.6 Hz, 1H); 0.70-0.74 (m,1H); ^{13}C NMR (100 MHz, $CDCl_3$): δ (ppm) 173.5, 152.3, 138.0, 135.3, 129.2, 128.5, 127.3, 117.4, 66.3, 55.1, 40.6, 38.6, 38.0, 27.0, 23.7, 17.3, 12.1, 11.2; MS (ESI): *m/z* (relative intensity): 328 $[M+H]^+$; HRMS (ESI): Calculated for $C_{20}H_{26}NO_3$ $[M+H]^+$: 328.1907, found: 328.1905.

trans-**11b**: M.p.: 84 ℃; $[\alpha]_D^{25}$ = 107.2 (*c*, 1.0, $CHCl_3$); IR (Film): 3029, 2966, 2931, 2874, 1799, 1686, 1485, 1378, 1349, 1259, 1194, 1104, 1014, 916, 736, 701 cm^{-1}; ^1H NMR (400 MHz, $CDCl_3$): δ (ppm) 7.22-7.33 (m, 5H), 6.00 (dd, *J* = 10.4, 17.2 Hz, 1H), 5.20 (d, *J* =10.0 Hz, 1H), 4.97 (d, *J* = 17.2 Hz, 1H), 4.51-4.56 (m, 1H), 4.11-4.17 (m, 2H), 3.45 (dd, *J* = 2.8, 13.2 Hz, 1H), 2.50 (dd, *J* = 11.2, 13.2 Hz, 1H), 1.93-1.98 (m, 1H), 1.82-1.87 (m, 1H), 1.16-1.23 (m, 1H), 1.11 (d, *J* = 5.2 Hz, 1H), 0.88 (t, *J* = 7.6 Hz, 3H); 0.86 (t, *J* = 7.2 Hz, 3H); 0.82 (d, *J* =5.6 Hz, 1H); 0.74-0.78 (m, 1H); ^{13}C NMR (100 MHz, $CDCl_3$): δ (ppm) 173.1, 15.0, 137.9, 135.7, 129.4, 128.9, 127.2, 117.3, 66.0, 56.7, 40.2, 37.6, 37.6, 27.0, 23.7, 17.6, 12.0, 11.3; MS (ESI): *m/z* (relative intensity): 328 $[M+H]^+$; HRMS (ESI): Calculated for $C_{20}H_{26}NO_3$ $[M+H]^+$: 328.1907, found: 328.1908.

(*S*)-3-((1*R*, 2*S*)-1,2-Diethyl-2-vinylcyclopropanecarbonyl)-4-phenyloxazolidin-2-one (*trans*-10c) and (*S*)-3-((1*S*, 2*R*)-1,2-diethyl-2-vinylcyclopropanecarbonyl)-4-phenyloxazolidin-2-one (*trans*-11c). Prepared from 1.2 mmol of oxazolidinone **9c** using the general procedure. The *N*-acyl-2-oxazolidinones product was purified by flash chromatography (Hexanes/EtOAc, 10/1→5/1) to *trans*-**10c** and *trans*-**11c** as a 1:1 mixture (238 mg, pale yellow oil) in a total 76% yield. The mixture was then separated by preparative HPLC to give *trans*-**10c** (white solid, 119 mg) and *trans*-**11c** (colorless oil, 119 mg).

trans-**10c**: M.p.: 93-94 ℃; $[\alpha]_D^{25}$= -37.8 (*c*, 1.0, $CHCl_3$); IR (Film): 3069, 2966, 2931, 2874, 1789, 1690, 1457, 1380, 1316, 1196, 1104, 1049, 1001, 915, 756, 709 cm^{-1}; ^1H NMR (400MHz, $CDCl_3$): δ (ppm) 7.31-7.41 (m, 5H), 5.96-6.03 (dd, *J* = 10.4, 17.2 Hz, 1H), 5.46-5.49 (dd, *J* =6.0, 9.2 Hz, 1H), 5.20 (dd, *J* =1.6, 10.4 Hz, 1H), 4.97 (dd, *J* =2.4, 17.2 Hz, 1H), 4.69 (t, *J* = 9.2 Hz, 1H), 4.28-4.32 (dd, *J* =6.0, 9.2 Hz, 1H), 2.12-2.18 (m, 1H), 1.72-1.78 (m, 1H), 1.14-1.20 (m, 1H), 1.05 (d, *J* = 9.2 Hz, 1H), 0.84 (t, *J* = 7.6 Hz, 3H); 0.73-0.77 (m, 1H); 0.69 (d, *J* = 5.2 Hz, 1H); 0.55 (t, *J* = 7.6 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$): δ (ppm) 172.7, 152.7, 139.9, 138.2, 129.2, 128.8, 126.2, 117.5, 70.3, 59.0, 40.3, 38.1, 27.3, 23.9, 17.8, 12.3, 11.5; MS (EI): *m/z* (relative intensity): 121 (100), 150 (82), 135 (59), 122 (58), 93 (54), 104 (47), 91 (40), 41 (39), 77 (39), 313 (M^+, 5); HRMS (EI): Calculated for $C_{19}H_{23}NO_3$ $[M]^+$: 313.1678, found: 313.1674.

trans-**11c:** $[\alpha]_D^{25}$ = 96.3 (*c*, 1.0, $CHCl_3$); IR (Film): 2963, 2920, 3874, 1786, 1686, 1457, 1383, 1313, 1201, 1104, 1055, 967, 759, 699 cm^{-1}; ^1H NMR (400 MHz, $CDCl_3$): δ (ppm) 7.28-7.38 (m, 5H), 5.97-6.04 (dd, *J* = 10.4, 17.6 Hz, 1H), 5.30 (dd, *J* =2.0, 7.6 Hz, 1H), 5.20 (dd, *J* = 2.0, 10.4 Hz, 1H), 4.97 (dd, *J* =2.0, 17.2 Hz, 1H), 4.69 (t, *J* = 7.6 Hz, 1H), 4.24-4.27 (dd, *J* = 2.0, 8.8 Hz, 1H,), 1.99-2.06 (m, 1H), 1.78-1.85 (m, 1H), 1.15-1.27 (m, 1H), 0.93 (d, *J* = 5.6 Hz, 1H), 0.88 (t, *J* = 7.6 Hz, 3H); 0.74 (t, *J* = 7.2 Hz, 3H); 0.71 (d, *J* = 5.2 Hz, 1H); 0.43-0.50

(m,1H); ^{13}C NMR (100 MHz, $CDCl_3$): δ (ppm) 172.5, 152.5, 139.7, 138.0, 129.0, 128.6, 125.9, 117.2, 70.1, 58.7, 40.0, 37.8, 27.0, 23.6, 17.5, 12.1, 11.3; MS (EI): *m/z* (relative intensity): 121(100), 150 (72), 93 (58), 104 (58), 135 (54), 122 (53), 77 (45), 91 (43), 41 (34), 313 (M^+, 2); HRMS (ESI): Calculated for $C_{19}H_{23}NO_3$ $[M]^+$: 313.1678, found: 313.1682.

(*S*)-3-((1*R*, 2*S*)-1,2-Diethyl-2-vinylcyclopropanecarbonyl)-4-(4-nitrobenzyl)oxazolidin-2-one (*trans*-10d) and (*S*)-3-((1*S*, 2*R*)-1,2-diethyl-2-vinylcyclopropanecarbonyl)-4-(4-nitrobenzyl)oxazolidin-2-one (*trans*-11d). Prepared from 1.2 mmol of oxazolidinone **9d** using the general procedure. The *N*-acyl-2-oxazolidinones product was purified by flash chromatography (Hexanes/EtOAc, 10/1→2/1) to give *trans*-**10d** and *trans*-**11d** as a 1:1 mixture (pale yellow solid, 200 mg) in a total 56% yield.

Mixture of *trans*-**10d** and *trans*-**11d**: M.p.: 105 ℃; IR (Film): 3073, 2966, 2931, 2873, 1786, 1687, 1638, 1600, 1525, 1453, 1349, 1293, 1201, 1109, 1016, 977, 910, 737 cm^{-1}; ^{1}H NMR (300 MHz, $CDCl_3$): δ (ppm) 8.18 (d, *J* = 7.5 Hz, 2H), 7.44 (dd, *J* = 6.0, 7.8 Hz, 2H), 5.9 (m, 1H), 5.20 (d, *J* = 10.5 Hz, 1H), 4.96-5.01 (dd, *J* = 1.2, 17.1 Hz, 1H), 4.76-4.85 (m, 0.5H), 4.58-4.63 (m, 0.5H), 4.26 (t, *J* = 8.4 Hz, 1H), 4.12 (t, *J* = 6.3 Hz, 1H), 3.47-3.56 (td, *J* = 2.4, 14.7 Hz, 1H), 2.78-2.89 (dd, *J* = 14.7, 23.4 Hz, 1H), 2.10-2.20 (m, 0.5H), 1.92-1.99 (m, 0.5H), 1.80-1.89 (m, 0.5H), 1.65-1.74 (m, 0.5H), 1.20-1.30 (m, 1H), 1.11 (t, *J* = 4.8 Hz, 1H), 0.68-0.93 (m, 8H); ^{13}C NMR (100 MHz, $CDCl_3$): δ (ppm) 173.5 (173.2), 151.9 (151.6), 147.2 (147.2), 143.3 (143.0), 137.7 (137.6), 130.3 (130.1), 124.0 (124.0), 117.5 (117.5), 66.1 (65.9), 56.2, 54.6, 40.4 (40.1), 38.5, 37.9 (37.7), 37.5, 26.9, 23.6 (23.6), 12.1 (12.0), 11.3 (11.2); MS (ESI): *m/z* (relative intensity) 373.1 $[M+H]^+$; HRMS (ESI): Calculated for $C_{20}H_{24}N_2O_5Na$ $[M+Na]^+$: 395.1577, found: 395.1579; Anal. Calculated for $C_{20}H_{24}N_2O_5$: C, 64.50; H, 6.50; N, 7.52, found: C, 64.56; H, 6.66; N, 7.32.

(*S*)-4-(*tert*-Butyl)-3-((1*R*, 2*S*)-1,2-diethyl-2-vinylcyclopropane-carbonyl)oxazolidin-2-one (*trans*-10e) and (*S*)-4-(*tert*-butyl)-3-((1*S*, 2*R*)-1,2-diethyl-2-vinyl-cyclopropane carbonyl)oxazolidin-2-one (*trans*-11e). Prepared from 1.2 mmol of oxazolidinone **9e** using the general procedure. The *N*-acyl-2-oxazolidinones product was purified by flash chromatography (Hexanes/EtOAc, 10/1→5/1) to give *trans*-**10e** (white solid, 117 mg) and *trans*-**11e** (colorless oil, 116 mg) in a total 80% yield.

trans-**10e:** M.p.: 83-86 ℃; $[\alpha]_D^{25}$ = -48.0 (*c*, 1.0, $CHCl_3$); IR (Film): 3078, 2966, 2934, 2875, 1789, 1693, 1478, 1368, 1322, 1254, 1221, 1185, 1107, 1062, 1000, 915, 801, 760cm^{-1}; ^{1}H NMR (300 MHz, $CDCl_3$): δ (ppm) 5.93 (dd, *J* = 10.8, 17.4 Hz, 1H), 5.24 (dd, *J* = 1.8, 10.2 Hz, 1H), 4.99 (dd, *J* = 1.2, 17.4 Hz, 1H), 4.52 (dd, *J* = 1.8, 8.1 Hz, 1H), 4.30 (dd, *J* = 1.5, 9.0 Hz, 1H), 4.18 (dd, *J* = 7.8, 9.0 Hz, 1H), 2.28-2.36 (m, 1H), 1.59-1.70 (m, 1H), 1.25-1.38 (m, 1H), 1.05 (d, *J* = 5.4 Hz, 1H), 0.95 (s, 9H); 0.93 (t, *J* = 7.2 Hz, 3H); 0.81 (t, *J* = 7.5 Hz, 3H); 0.80 (d, *J* = 4.2 Hz, 1H); 0.62-0.74 (m, 1H); ^{13}C NMR (100 MHz, $CDCl_3$): δ (ppm) 173.8, 153.4, 138.1, 117.4, 64.9, 60.9, 40.8, 38.2, 35.6, 26.5, 25.6, 23.8, 16.9, 12.3, 11.3; MS (EI): *m/z* (relative intensity): 121 (100), 41 (62), 150 (53), 93 (49), 122 (47), 135 (46), 57 (44), 55 (38), 10 (30), 293 (M^+, 4); HRMS (EI): Calculated for $C_{17}H_{27}NO_3$ $[M]^+$: 293.1991. found: 293.1989; Anal. Calculated for $C_{17}H_{27}NO_3$: C, 69.59; H, 9.28; N, 4.77, found: C, 69.65; H, 9.36; N, 4.65.

trans-**11e:** $[\alpha]_D^{25}$ = 108.0 (*c*, 1.0, $CHCl_3$); IR (Film): 3078, 2966, 2933, 2875, 1789, 1693, 1477, 1368, 1320, 1256, 1220, 1185, 1104, 1057, 1007, 916, 801, 761cm^{-1}; ^{1}H NMR (300 MHz, $CDCl_3$): δ (ppm) 6.00 (dd, *J* = 10.5, 17.4 Hz, 1H), 5.22 (dd, *J* = 1.8, 10.2 Hz, 1H), 5.00 (dd, *J* = 1.8, 17.1 Hz, 1H), 4.20-4.32 (m, 3H), 2.00-2.06 (m, 1H), 1.74-1.81(m, 1H), 1.08-1.20 (m, 1H), 1.00 (d, *J* = 5.1 Hz, 1H), 0.96 (s, 9H); 0.82-0.92 (m, 7H); 0.75-0.80 (m, 1H); ^{13}C NMR (100 MHz, $CDCl_3$): δ (ppm) 172.6, 153.6, 137.9, 117.1, 65.5, 62.8, 40.1, 37.4, 36.0, 28.1, 26.2, 23.9, 18.0, 11.9, 11.4; MS (EI): *m/z* (relative intensity): 121 (100), 150 (65), 135 (52), 122 (48), 93 (42), 57 (37), 41 (37), 107 (29), 293 (M^+, 6); HRMS (EI): Calculated for $C_{17}H_{27}NO_3$ $[M]^+$: 293.1991, found: 293.1994.

General procedure for the preparation of 3,3,5,5-Tetrasubstituted 1,2-Dioxolanes (*trans*-12, *trans*-13 and *cis*-14).

To a stirring solution of the mixture of *trans*-**10** and *trans*-**11** (1.0 equiv.) in CH_3CN (30 mL per 1 mmol) was added diphenyl diselenide (0.2 equiv.) and AIBN (0.4 equiv.). The mixture was placed under a balloon of oxygen and irradiated with a 300 W sunlamp. When starting material was consumed as shown by TLC, the reaction mixture was concentrated *in vacuo*, and the residue was purified by flash chromatography (Hexane/EtOAc, 10/1) to afford *trans*-**12,** *trans*-**13** and *cis*-**14** as a mixture. The mixture was then detected by chiral HPLC.

(*S*)-3-((3*R*, 5*R*)-3,5-Diethyl-5-vinyl-1,2-dioxolane-3-carbonyl)-4-isopropyloxazolidin-2-one (*trans*-12a), (*S*)-3-((3*S*, 5*S*)-3,5-diethyl-5-vinyl-1,2-dioxolane-3-carbonyl)-4-isopropyloxazolidin-2-one (*trans*-13a) and (*S*)-3-((3*R*, 5*S*)-3,5-diethyl-5-vinyl-1,2-dioxolane-3-carbonyl)-4-isopropyloxazolidin-2-one (*cis*-14a). Prepared from 20 mg of 1:1 mixture of *trans*-**10a** and *trans*-**11a** using the general procedure. The 1,2-dioxolanes was carefully separated by flash chromatography (Hexane/EtOAc, 20/1→3/1) to *trans*-**13a** (pale yellow oil, 14 mg), *trans*-**12a** and *cis*-**14a** (white solid, 8 mg) in a total 100% yield. The mixture of *trans*-**12a** and *cis*-**14a** was recrystallized from 1mL Hexanes/EtOAc (10/1) to give pure *trans*-**12a** as a white solid (3.5 mg, 16%). HPLC (Chiralcel AD-H colum, 214 nm, hexane/2-propanol＝98/2, Flow rate ＝ 0.7 mL/min), t_R = 20.852, 22.688, 24.952, 25.352 min.

trans-**13a:** $[\alpha]_D^{25}$ = 97.8 (*c*, 1.0, $CHCl_3$); IR (Film): 2969, 2939, 2878, 1781, 1695, 1507, 1464, 1386, 1354, 1302, 1205, 1153, 1057, 1014, 990, 923, 773, 754, 725 cm^{-1}; ^{1}H NMR (300 MHz, $CDCl_3$): δ (ppm) 5.86 (dd, *J* = 10.8, 17.1 Hz, 1H), 5.33 (d, *J* =17.1 Hz, 1H), 5.22 (d, *J* = 10.8 Hz, 1H), 4.56-4.61 (m, 1H), 4.31-4.37 (t, *J* = 8.7 Hz, 1H), 4.16-4.26 (m, 1H), 2.81 (s, 2H), 2.37-2.44 (m, 1H), 2.24-2.34 (m, 1H), 2.08-2.18 (m, 1H), 1.58-1.66 (m, 2H), 0.83-0.94 (m, 12H); ^{13}C NMR (100 MHz,

$CDCl_3$): δ (ppm) 172.5, 153.0, 140.7, 114.9, 91.8, 88.6, 63.7, 59.7, 52.0, 30.2, 28.1, 26.8, 18.3, 14.6, 8.9, 8.8; MS (ESI): *m/z* (relative intensity): 312 $[M+H]^+$; HRMS (ESI): Calculated for $C_{16}H_{25}NO_5Na$ $[M+Na]^+$: 334.1628, found: 334.1625; Anal. Calculated for $C_{16}H_{25}NO_5$: C, 61.72; H, 8.09; N, 4.50, found: C, 62.03; H, 8.12; N, 4.48.

trans-**12a:** M.p.: 61-62 ℃; $[\alpha]_D^{25}$ = -23.4 (*c*, 0.5, $CHCl_3$); IR (Film): 2968, 2939, 2880, 1782, 1709, 1488, 1464, 1387, 1364, 1301, 1257, 1205, 1145, 1058, 990, 927, 774, 722 cm^{-1}; ^1H NMR (300 MHz, $CDCl_3$): δ (ppm) 5.86 (dd, *J* = 10.8, 17.1 Hz, 1H), 5.31 (d, *J* = 17.1 Hz, 1H), 5.20 (d, *J* = 6.9 Hz, 1H), 4.48-5.23 (m, 1H), 4.33-4.38 (t, *J* = 8.7 Hz, 1H), 4.39-2.47 (m, 1H), 3.02 (d, *J* = 13.2 Hz, 1H), 2.76 (d, *J* = 13.2 Hz, 1H), 2.39-2.47 (m, 1H), 2.10-2.18 (m, 2H), 1.58-1.68 (m, 2H), 0.83-0.94 (m, 12H); ^{13}C NMR (100 MHz, $CDCl_3$): δ (ppm) 172.3, 153.1, 140.8, 114.7, 92.2, 88.6, 64.0, 60.3, 51.5, 30.2, 28.9, 26.5, 18.3, 15.1, 9.0, 8.9; MS (ESI): *m/z* (relative intensity): 312 $[M+H]^+$; HRMS (EI): Calculated for $C_{16}H_{25}NO_5$ $[M]^+$: 311.1733, found: 311.1729.

(*S*)-4-Benzyl-3-((3*R*, 5*R*)-3,5-diethyl-5-vinyl-1,2-dioxolane-3-carbonyl)oxazolidin-2-one (*trans*-12b), (*S*)-4-benzyl-3-((3*S*, 5*S*)-3,5-diethyl-5-vinyl-1,2-dioxolane-3-carbonyl)oxazolidin-2-one (*trans*-13b) and (*S*)-4-benzyl-3-((3*R*, 5*S*)-3,5-diethyl-5-vinyl-1,2-dioxolane-3-carbonyl)oxazolidin-2-one (*cis*-14b). Prepared from 145 mg of 1:1 mixture of *trans*-**10b** and *trans*-**11b** using the general procedure. The 1,2-dioxolanes product was carefully purified by flash chromatography (Hexanes/EtOAc, 20/1→5/1) to *trans*-**12b,** *trans*-**13b** and *cis*-**14b** (160 mg, pale yellow oil) as a mixture in a total 100% yield. The mixture then was separated by preparative HPLC to give *trans*-**13b** (pale yellow oil, 80 mg) and *trans*-**12b** (pale yellow oil, 50 mg). HPLC (Chiralcel OD-H colum, 214 nm, hexane/2-propanol ＝80/20, Flow rate ＝ 0.7 mL/min), t_R = 20.55, 26.41, 29.78 min.

trans-**13b:** $[\alpha]_D^{25}$ = 119.1 (*c*, 1.0, $CHCl_3$); IR (Film): 2971, 2938, 2881, 1785, 1706, 1456, 1378, 1351, 1257, 1212, 1110, 1076, 1015, 925, 762, 703 cm^{-1}; ^1H NMR (400 MHz, $CDCl_3$): δ (ppm) 7.22-7.34 (m, 5H), 5.86 (dd, *J* = 11.2, 17.6 Hz, 1H), 5.33 (d, *J* =17.6 Hz, 1H), 5.22 (d, *J* = 10.8 Hz, 1H), 4.76-4.79 (m, 1H), 4.18-4.23 (m, 2H), 3.56 (dd, *J* = 2.0, 13.2 Hz, 1H), 2.81 (s, 2H), 2.68 (dd, *J* = 10.4, 13.2 Hz, 1H), 2.26-2.32 (m, 1H), 2.06-2.13 (m, 1H), 1.59-1.65 (m, 2H), 0.91 (t, *J* = 7.6 Hz, 3H), 0.85 (t, *J* = 7.6 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$): δ (ppm) 172.2, 152.3, 140.4, 135.2, 129.4, 129.0, 127.4, 114.7, 91.5, 88.5, 66.7, 56.5, 51.5, 37.8, 29.9, 26.5, 8.7; MS (ESI): *m/z* (relative intensity): 360.2 $[M+H]^+$; HRMS (ESI): Calculated for $C_{20}H_{26}NO_5$ $[M+H]^+$: 360.1805, found: 360.1801.

trans-**12b:** $[\alpha]_D^{25}$ = -56.5 (*c*, 0.5, $CHCl_3$); IR (Film): 2970, 2926, 2881, 1785, 1706, 1456, 1386, 1351, 1259, 1211, 1107, 1012, 926, 761, 703 cm^{-1}; ^1H NMR (400 MHz, $CDCl_3$): δ (ppm) 7.24-7.36 (m, 5H), 5.88 (dd, *J* = 10.8, 17.6 Hz, 1H), 5.35 (dd, *J* = 0.8, 17.2 Hz, 1H), 5.22 (dd, *J* = 0.8, 11.2 Hz, 1H), 4.67-4.72 (m, 1H), 4.24-4.28 (m, 1H), 4.21 (dd, *J* = 2.0, 9.2 Hz, 1H), 3.36 (dd, *J* =3.2, 13.2 Hz, 1H), 3.05 (d, *J* = 13.2 Hz, 1H), 2.81 (dd, *J* = 10.0, 13.2 Hz, 1H), 2.72 (d, *J* = 13.2 Hz, 1H), 2.11-2.17 (m, 2H), 1.61-1.69 (m, 2H), 0.92 (t, *J* = 7.6 Hz, 3H), 0.88 (t, *J* = 7.6 Hz, 3 H); ^{13}C NMR (100 MHz, $CDCl_3$): δ (ppm) 172.2, 152.1, 140.5, 135.2, 129.5, 129.0, 127.4, 114.5, 91.8, 88.5, 66.5, 57.0, 51.0, 37.9, 29.9, 26.2, 8.8; MS (ESI): *m/z* (relative intensity): 360.1 $[M+H]^+$; HRMS (ESI): Calculated for $C_{20}H_{29}N_2O_5$ $[M+NH_4]^+$: 377.2071, found: 377.2066.

(*S*)-3-((3*R*, 5*R*)-3,5-Diethyl-5-vinyl-1,2-dioxolane-3-carbonyl)-4-phenyloxazolidin-2-one (*trans*-12c), (*S*)-3-((3*S*, 5*S*)-3,5-diethyl-5-vinyl-1,2-dioxolane-3-carbonyl)-4-phenyl oxazolidin-2-one (*trans*-13c) and (*S*)-3-((3*R*, 5*S*)-3,5-diethyl-5-vinyl-1,2-dioxolane-3-carbonyl)-4-phenyloxazolidin-2-one (*cis*-14c). Prepared from 76 mg of 1:1 mixture of *trans*-**10c** and *trans*-**11c** using the general procedure. The 1,2-dioxolanes product was carefully purified by flash chromatography (Hexanes/EtOAc, 20/1→3/1) to give *trans*-**12c,** *trans*-**13c** and *cis*-**14c** (colorless oil, 84 mg) in a total 100% yield. HPLC (Chiralcel IC colum, 214 nm, hexane/2-propanol ＝ 80/20, Flow rate＝0.7 mL/min), t_R=23.72, 37.85, 44.72 min.

trans-**12c,** *trans*-**13c** and *cis*-**14c**: IR (Film): 3032, 2975, 2938, 2881, 1785, 1709, 1444, 1382, 1316, 1256, 1199, 1111, 1043, 980, 905, 757, 705 cm^{-1}; ^1H NMR (300 MHz, $CDCl_3$): δ (ppm) 7.32-7.41 (m, 5H), 5.38 (dd, *J* = 10.8, 17.4 Hz, 1H), 5.52-5.57 (m, 1H), 5.30 (d, *J* = 17.4 Hz, 1H), 5.22 (d, *J* = 11.4 Hz, 1H), 4.70-4.80 (m, 1H), 4.29-4.34 (m, 1H), 2.89-3.08 (m, 1H), 2.69 (d, *J* = 13.2 Hz, 1H), 2.05-2.18 (m, 2H), 1.38-1.45 (m, 2H), 0.67-0.88 (m, 6H); ^{13}C NMR (100 MHz, $CDCl_3$): δ (ppm) 173.5, 152.5, 140.3, 138.1, 129.2 (129.0), 129.0 (128.8), 126.6 (125.9), 114.5, 91.8, 88.3 (88.3), 70.2, 59.2, 52.2, 29.8, 26.1, 8.8, 8.3; MS (ESI): *m/z* (relative intensity): 346.2 $[M+H]^+$; HRMS (ESI): Clculated for $[C_{19}H_{23}NO_5Na$ $[M+Na]^+$: 368.1468, found: 368.1474; Anal. Calculated for $C_{19}H_{23}NO_5$: C, 66.07; H, 6.71; N, 4.06, found: C, 65.89; H, 6.76; N, 3.97.

(*S*)-3-((3*R*, 5*R*)-3,5-Diethyl-5-vinyl-1,2-dioxolane-3-carbonyl)-4-(4-nitrobenzyl)oxazolidin-2-one (*trans*-12d), (*S*)-3-((3*S*, 5*S*)-3,5-diethyl-5-vinyl-1,2-dioxolane-3-carbonyl)-4-(4-nitrobenzyl)oxazolidin-2-one (*trans*-13d) and (*S*)-3-((3*R*, 5*S*)-3,5-diethyl-5-vinyl-1,2-dioxolane-3-carbonyl)-4-(4-nitrobenzyl)oxazolidin-2-one (*cis*-14d). Prepared from 67 mg of 1:1 mixture of *trans*-**10d** and *trans*-**11d** using the general procedure. The 1,2-dioxolanes product was carefully purified by flash chromatography (Hexanes/EtOAc, 10/1→1/1) to give *trans*-**12d**, *trans*-**13d** and *cis*-**14**d (pale yellow solid, 73 mg) in a total 100% yield. HPLC (Chiralcel IC colum, 214 nm, hexane/2-propanol ＝ 50/50, Flow rate ＝ 0.5 mL/min), t_R = 24.31, 31.56 min.

trans-**12d,** *trans*-**13d** and *cis*-**14d**: M.p.: 104 ℃; IR (Film): 3083, 2974, 2938, 2881, 1789, 1703, 1645, 1605, 1518, 1482, 1462, 1387, 1349, 1317, 1257, 1211, 1110, 923, 860, 832, 765cm^{-1}; ^1H NMR (300 MHz, $CDCl_3$): δ (ppm) 8.21-8.23 (d, *J* = 8.7 Hz, 2H), 7.45-7.48 (d, *J* = 8.7 Hz, 2H), 5.74-5.94 (m, 1H), 5.14-5.38 (m, 2H), 4.70-4.89 (m, 1H), 4.30-4.36 (m, 1H), 4.15-4.19 (dd, *J* = 9.6, 3.0 Hz, 1H), 3.43-3.48 (dd, *J* = 13.5, 3.0 Hz, 1H), 2.95-3.05 (m, 0.5H), 2.71-2.95 (m, 2H), 2.23-2.36 (m, 0.5H), 2.10-2.18 (m, 2H), 1.61-1.68 (m, 2H), 0.85-0.96 (m,

6H); ^{13}C NMR (100 MHz, $CDCl_3$): δ (ppm) 172.4, 151.8 (151.7), 147.3, 142.8, 140.3 (140.2), 130.3 (130.2), 124.1 (124.1), 114.8 (114.6), 91.9 (91.5), 88.5 (88.5), 66.5 (66.5), 56.7 (56.0), 51.4 (51.0), 37.9 (37.7), 29.9, 26.3 (26.2), 8.73 (8.70), 8.66 (8.65); MS (ESI): *m/z* (relative intensity), 405 $[M+H]^+$; HRMS (ESI): Calculated for $C_{20}H_{24}N_2O_7Na$ $[M+Na]^+$: 427.1481, found: 427.1476; Anal. Calculated for $C_{20}H_{24}N_2O_7$: C, 59.40; H, 5.98; N, 6.93, found: C, 59.58; H, 6.11; N, 6.74.

(*S*)-4-(*tert*-Butyl)-3-((3*R*, 5*R*)-3,5-diethyl-5-vinyl-1,2-dioxolane-3-carbonyl)oxazolidin-2-one (*trans*-12e), (*S*)-4-(*tert*-butyl)-3-((3*S*, 5*S*)-3,5-diethyl-5-vinyl-1,2-dioxolane-3-carbonyl)oxazolidin-2-one (*trans*-13e) and (*S*)-4-(*tert*-butyl)-3-((3*R*, 5*S*)-3,5-diethyl-5-vinyl-1,2-dioxolane-3-carbonyl) oxazolidin-2-one (*cis*-14e). Prepared from 54 mg of 1:1 mixture of *trans*-**10e** and *trans*-**11e** using the general procedure. The 1,2-dioxolanes product was carefully purified by flash chromatography (Hexanes/EtOAc, 20/1→3/1) to *trans*-**12e**, *trans*-**13e** and *cis*-**14e** (56 mg, pale yellow solid) as a mixture in a total 93% yield. The mixture then was separated by preparative HPLC to give *trans*-**13e** (pale yellow oil, 35 mg) and *trans*-**12e** (white solid, 15 mg). HPLC (Chiralcel AD-H colum, 214 nm, hexane/2-propanol = 80/20, Flow rate = 0.7 mL/min), t_R = 24.98, 25.88, 27.88 min.

trans-**13e:** $[\alpha]_D^{25}$ = 151.9 (*c*, 0.5, $CHCl_3$); IR (Film): 2967, 2880, 1780, 1702, 1464, 1386, 1369, 1278, 1186, 1056, 909, 813, 760 cm^{-1}; ^{1}H NMR (400 MHz, $CDCl_3$): δ (ppm) 5.86 (dd, *J* = 10.8, 17.6 Hz, 1H), 5.34 (dd, *J* = 1.2, 17.1Hz, 1H), 5.22 (dd, *J* = 1.2, 10.8 Hz, 1H), 4.56 (dt, *J* = 2.0, 7.2 Hz, 1H), 4.26-4.34 (m, 2H), 2.80 (dd, *J* = 1.2, 13.6 Hz, 1H), 2.70 (d, *J* = 13.2 Hz, 1H), 2.16-2.26(m, 2H), 1.58-1.63 (m, 2H), 0.95 (s, 9H), 0.93 (t, *J* = 7.6 Hz, 3H), 0.84 (t, *J* = 7.6 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$): δ (ppm) 172.7, 153.2, 140.4, 114.7, 91.5, 88.4, 65.5, 62.1, 51.8, 35.9, 30.0, 29.6, 25.7, 8.7, 8.7; MS (ESI): *m/z* (relative intensity): 326 $[M+H]^+$; HRMS (ESI): Calculated for $C_{17}H_{28}NO_5$ $[M+H]^+$: 326.1962, found: 326.1960.

trans-**12e**: M.p.: 99-101 ℃; $[\alpha]_D^{25}$= -57.5 (*c*, 0.5, $CHCl_3$); IR (Film): 2968, 2940, 2881, 1782, 1717, 1696, 1461, 1383, 1369, 1322, 1256, 1188, 1108, 1067, 980, 926, 759 cm^{-1}; ^{1}H NMR (400 MHz, $CDCl_3$): δ (ppm) 5.82 (dd, *J* = 10.8, 17.6 Hz, 1H), 5.30 (d, *J* =17.2 Hz, 1H), 5.20 (d, *J* = 10.8 Hz, 1H), 4.46 (t, *J* = 3.6 Hz, 1H), 4.29 (d, *J* = 4.0 Hz, 2H), 3.05 (d, *J* = 13.2 Hz, 1H), 2.75 (d, *J* = 13.6 Hz, 1H), 2.06-2.15 (m, 2H), 1.59-1.63 (m, 2H), 0.95 (s, 9H), 0.83-0.91 (m, 6H); ^{13}C NMR (100 MHz, $CDCl_3$): δ (ppm) 172.5, 153.6, 140.3, 114.6, 92.2, 88.5, 65.6, 62.7, 51.5, 35.8, 30.1, 26.3, 25.8, 8.9, 8.8 ppm; MS (ESI): *m/z* (relative intensity): 326 $[M+H]^+$; HRMS (ESI): Calculated For $C_{17}H_{28}NO_5$ $[M+H]^+$: 326.1962, found: 326.1961.

Procedures for the total synthesis of Epiplakinic acid F

(1*R*, 2*S*)-Diethyl 1,2-dimethylcyclopropane-1,2-dicarboxylate (*cis*-24) and *trans*-Diethyl 1,2-dimethyl cyclopropane-1,2-dicarboxylate ((±)-*trans*-24). McCoy's procedure was ultilised for the cyclopropanation of commercially available materials α-methacrylate **22** and ethyl 2-bromopropionate **23**. α-Methacrylate **22** (114 g, 1.0 mol) and ethyl 2-bromopropionate **23** (180 g, 1.0 mol) in 100 mL dry DMF were added dropwise with stirring to sodium hydride (60% suspension in mineral oil, 52 g, 1.3 mol) in dry DMF (300 mL) and maintaining temperature at 0℃. After the addition, the reaction was stirred for overnight at room temperature. At the end, residual sodium hydride was destroyed by addition of a small amount of ethanol. Water (500 mL) was added to dissolve the sodium halide, and the mixture was extracted with ester (200 mL × 3), washed with water (100 mL × 3) and brine (100 mL), dried over Na_2SO_4, and concentrated. The residual oil was purified by flash chromatography (Hexane/EtOAc, 20/1) to give *cis*-**24** (colorless oil, 38 g, 18%) and (±)-*trans*-**24** (colorless oil, 140 g, 65%).

(±)-*trans*-**24**: IR (Film): 2981, 2940, 1724, 1460, 1385, 1307, 1262, 1184, 1138, 1083, 1027, 863 cm^{-1}; ^{1}H NMR (300 MHz, $CDCl_3$): δ (ppm) 4.16 (q, *J* = 7.2 Hz, 4H), 1.43 (s, 2H), 1.31 (s, 6H), 1.26 (t, *J* = 7.5 Hz, 6H); ^{13}C NMR (100 MHz, $CDCl_3$): δ (ppm) 172.1, 61.0, 31.3, 23.9, 15.6, 14.3; MS (EI): *m/z* (relative intensity): 112(100), 140(86), 169(70), 111(64), 113(54), 43(35), 67(32), 214 (M^+, 5); HRMS (EI): Calculated for $C_{11}H_{18}O_4$ $[M]^+$: 214.1205, found: 214.1206.

cis-**24**: IR (Film): 2983, 2939, 2907, 1724, 1471, 1447, 1369, 1314, 1259, 1196, 1146, 1029, 862, 764 cm^{-1}; ^{1}H NMR (300 MHz, $CDCl_3$): δ (ppm) 4.16 (dq, *J* =1.8, 7.2 Hz, 4H), 1.95 (d, *J* = 4.8 Hz, 2H), 1.31 (s, 6H), 1.23 (t, *J* = 7.5 Hz, 6H), 0.68 (d, *J* = 4.8 Hz, 1H); ^{13}C NMR (100 MHz, $CDCl_3$): δ (ppm) 172.8, 60.8, 31.4, 25.8, 16.2, 14.1; MS (EI): *m/z* (relative intensity): 112 (100), 140 (61), 141 (52), 169 (50), 43 (36), 69 (30), 111 (29), 214 (M^+, 6); HRMS (EI): Calculated For $C_{11}H_{18}O_4$ $[M]^+$: 214.1205, found: 214.1207.

***trans*-1,2-Dimethyl-1,2-bis(hydroxymethyl)cyclopropane (±)-25.** To a stirred suspension of lithium aluminumhydride (11.7 g, 0.31 mol) in Et_2O (400 mL) at 0 °C was added a solution of (±)-*trans*-**24** (30 g, 140 mmol) in Et_2O (100 mL). Upon complete disappearance of (±)-*trans*-**24** by TLC, the reaction mixture was quenched with 20% potassium hydroxide (30 mL). The mixture was filtered through Florisil and the filter cake was washed with Et_2O (100 mL×5). The filtrate was washed with water (100 mL) and brine (100 mL), dried over Na_2SO_4 and evaporated by rotary evaporation. Further purification by flash chromatography (Hexane/EtOAc, 4/1) gave (±)-**25** as a white solid (17.5 g, 97%).

(±)-**25**: IR (Film): 3288, 2986, 2958, 2924, 2880, 1480, 1383, 1095, 1033, 941, 694 cm^{-1}; ^{1}H NMR (300 MHz, $CDCl_3$): δ (ppm) 3.75 (d, *J* = 11.1 Hz, 2H), 3.44(d, *J* = 11.1 Hz, 2H), 3.0 (br, 2H), 1.31 (s, 6H), 0.34 (s, 2H); ^{13}C NMR (100 MHz, $CDCl_3$): δ (ppm) 68.5, 26.4, 23.0, 17.4; MS (ESI): *m/z* (relative intensity): 153.1 $[M+Na]^+$; HRMS (ESI): Calculated for $C_7H_{14}O_2Na$ $[M+Na]^+$: 153.0886, found: 153.0889.

***trans*-1,2-Dimethyl-2-(hydroxymethyl)-[(*tert*-butyldimethyl-siloxy)-methyl]cyclopropane (±)-26.** To a solution of *trans*-(±)-**25** (14.3 g, 0.11 mol) and triethylamine (33.6 mL, 0.24 mol) in CH_2Cl_2 (200 mL) at 0 °C was added *tert*-butyl-dimethylsilyl

chloride (18.4 g, 0.12 mol) in CH_2Cl_2 (50 mL). After 12 h at room temperature, a white precipitate formed. The reaction mixture was washed with H_2O (100 mL), 1% HCl (100 mL), H_2O (100 mL), saturated $NaHCO_3$ (100 mL), and brine (100 mL), dried over Na_2SO_4, filtered, and concentrated to give a yellow oil, which was purified by flash chromatography (Hexane/EtOAc, 40/1) to give (±)-**26** as a colorless oil (26.3 g, 98%).

(±)-**26**: IR (Film): 3382 (br, OH), 2956, 2929, 2857, 1472, 1463, 1379, 1256, 1077, 1034, 1010, 940, 774, 667 cm^{-1}; ^1H NMR (300 MHz, $CDCl_3$): δ (ppm) 3.58 (d, J = 10.8 Hz, 2H), 3.40 (dd, J = 11.1, 16.8 Hz, 2H), 1.53 (s, 1H), 1.20 (s, 3H), 1.18 (s, 3H), 0.86 (s, 9H), 0.30 (s, 2H), 0.00 (s, 6H); ^{13}C NMR (75 MHz, $CDCl_3$): δ (ppm) 68.8, 68.5, 26.2, 26.1, 25.8, 22.7, 17.2, 17.2, 17.0, -5.5; MS (ESI): *m/z* (relative intensity) 267.2 $[M+Na]^+$; HRMS (ESI): Calculated For $C_{13}H_{28}O_2SiNa$ $[M+Na]^+$: 267.1757, found: 267.1751.

***trans*-1,2-Dimethyl-1-(*tert*-butyldimethylsiloxymethyl)-2-vinyl-cyclopropane (±)-27.** (1) A solution of DMSO (23 mL, 0.32 mol) in CH_2Cl_2 (250 mL) was added to a solution of oxalyl chloride (14.0 mL, 0.16 mol) in CH_2Cl_2 (50 mL) at -78 ^oC over 30 min, followed by a solution of (±)-**26** (26.2 g, 0.11 mol) in CH_2Cl_2 (25 mL). The resulting mixture was stirred at the same temperature for 30 min, and then Et_3N (89 mL, 0.64 mol) was added. After another 20 min, water (300 mL) and CH_2Cl_2 (100 mL) were added, and the whole was partitioned. The aqueous layer was extracted with CH_2Cl_2 (200 mL×3). The combined organic layers were successively washed with 1% HCl (300 mL), H_2O (100 mL), saturated $NaHCO_3$ (100 mL), and brine (100 mL), and dried over Na_2SO_4. After removal ofthe solvents, the crude product was used without purification in the next step. (2) To a stirred suspension of methyltriphenyl-phosphonium bromide (60.4 g, 0.15 mol) in THF (300 mL) at 0 ^oC was added *n*-BuLi (2.5 M in hexane, 60 mL, 0.15 mol). After 0.5 h, a solution of the crude product (26 g, 0.11 mol) in THF (100 mL) was added in one portion. The reaction mixture was allowed to warm to room temperature, stirred overnight, and poured into saturated aqueous NH_4Cl (200 mL), extracted with Et_2O (100 mL×2), dried over Na_2SO_4, filtered, and concentrated. The residue was purified by flash chromatography (Hexane/EtOAc, 40/1) to give (±)-**27** as a colorless oil (24 g, 90% yield).

(±)-**27**: IR (Film): 2986, 2956, 2929, 2857, 1633, 1472, 1463, 1256, 1096, 1006, 897, 840, 774, 667 cm^{-1}; ^1H NMR (300 MHz, $CDCl_3$): δ (ppm) 5.76 (dd, J = 10.2, 18.0 Hz, 1H), 4.98 (dd, J = 1.8, 3.9 Hz, 1H), 4.94 (dd, J = 1.8, 3.6 Hz, 1H), 3.61 (d, J = 10.2 Hz, 1H), 3.45 (d, J = 10.2 Hz, 1H), 1.20 (s, 3H), 1.08 (s, 3H), 0.86 (s, 9H), 0.57 (d, J = 4.8 Hz, 1H), 0.49 (d, J = 4.8 Hz, 1H), 0.00 (s, 6H); ^{13}C NMR (100 MHz, $CDCl_3$): δ (ppm) 143.8, 112.1, 68.3, 28.1, 26.7, 25.9, 25.1, 18.3, 18.2, 17.6, -5.4; MS (EI): *m/z* (relative intensity) 157 (100), 129 (460, 105 (32), 159 (30), 131 (15), 109 (13), 77 (13), 240 (26, M^+); HRMS (EI): Calculated for $C_{14}H_{28}OSi$ $[M]^+$: 240.1909, found: 240.1915.

***trans*-1,2-Dimethyl-1-(hydroxymethyl)-2-vinylcyclopropane (±)-28.** To a solution of (±)-**27** (24 g, 0.1 mol) in CH_2Cl_2/MeOH (100/100 mL) was added *p*-TsOH (0.9 g, 0.01 mol). The reaction was stirred at room temperature until no starting material remained (TLC). After removal of the solvents, the crude product was purified by column chromatography (Hexane/EtOAc, 5/1) to give (±)-**28** as a colorless oil (12.3 g, 98%).

(±)-**28**: IR (Film): 3382 (br, OH), 2987, 2930, 1876, 1631, 1446, 1379, 1035, 1015, 964, 898 cm^{-1}; ^1H NMR (400 MHz, $CDCl_3$): δ (ppm) 5.77 (dd, J = 10.0, 13.6 Hz, 1H), 5.03 (dd, J = 1.2, 4.0 Hz, 1H), 4.99 (dd, J = 1.6, 3.2 Hz, 1H), 3.70 (d, J = 11.2 Hz , 1H), 3.54 (d, J = 11.2 Hz, 1H), 1.71 (s, 1H), 1.27 (s, 3H), 1.17 (s, 3H), 0.63 (d, J = 5.2 Hz, 1H), 0.55 (d, J = 4.8 Hz, 1H); ^{13}C NMR (100 MHz, $CDCl_3$): δ (ppm) 143.4, 113.0, 69.0, 28.6, 27.2, 25.7, 18.3, 17.9; MS (EI): *m/z* (relative intensity) 95 (100), 67 (90), 93 (54), 69 (52), 58 (46), 57 (39), 71 (29), 68 (28), 126 (M^+, 2); HRMS (EI): Calculated for $C_8H_{14}O$ $[M]^+$: 126.1045, found: 126.1043.

***trans*-1,2-Dimethyl-2-vinylcyclopropanecarboxylic acid (±)-29.** (1) A solution of DMSO (11.6 g, 148 mmol) in CH_2Cl_2 (200 mL) was added to a solution of oxalyl chloride (9.4 g, 74 mmol) in CH_2Cl_2 (50 mL) at -78 ^oC over 30 min, followed by a solution of (±)-**28** (6.2 g, 49 mmol) in CH_2Cl_2 (50 mL). The resulting mixture was stirred at the same temperature for 30 min, and then Et_3N (40 mL, 295 mmol) was added. After another 20 min, water (100 mL) and CH_2Cl_2 (100 mL) were added, and the whole was partitioned. The aqueous layer was extracted with CH_2Cl_2 (100 mL×3). The combined organic layers were successively washed with 1% HCl (100 mL), H_2O (100 mL), saturated $NaHCO_3$ (100 mL), and brine (100 mL), and dried over Na_2SO_4, filtered, and concentrated to give the crude aldehyde. (2) To a solution of the crude aldehyde (6 g, 48 mmol) in *t*-BuOH/H_2O (100/40 mL) was added KH_2PO_4 (9.9 g, 73 mmol), resorcinol (8.27 g, 73 mmol), and $NaClO_2$ (6.6 g, 73 mmol). The mixture was stirred at room temperature until all aldehyde was consumed. The aqueous layer was saturated with NH_4Cl and extracted with EtOAc (100 mL×2). The aqueous layer was adjusted to pH 4-5 with 10% HCl, and again extracted with EtOAc (100 mL×2). The combined organic extracts were dried over Na_2SO_4, filtered, and concentrated. The residue was purified by flash chromatography (Hexane/EtOAc, 10/1) to give (±)-**29** as a colorless oil (5.1 g, 75%).

(±)-**29**: IR (Film): 3000 (br, OH), 2937, 1686, 1462, 1417, 1320, 1252, 1181, 1081, 907, 829 cm^{-1}; ^1H NMR (300 MHz, $CDCl_3$): δ (ppm) 10.71 (br, 1H), 5.77 (dd, J = 11.1, 17.4 Hz, 1H), 5.14 (dd, J = 5.7, 9.3 Hz, 2H), 1.52 (d, J = 5.1 Hz, 1H), 1.33 (s, 3H), 1.30 (s, 3H), 0.93 (d, J = 5.1 Hz, 1H); ^{13}C NMR (100 MHz, $CDCl_3$): δ (ppm) 180.9, 140.2, 115.5, 31.6, 30.0, 26.1, 17.2, 16.7; MS (EI): *m/z* (relative intensity) 95 (100), 125 (87), 67 (42), 79 (42), 55 (32), 41 (31), 53 (22), 77 (18), 140 (M^+, 5); HRMS (EI): Calculated for $C_8H_{12}O_2$ $[M]^+$: 140.0837, found: 140.0840.

(*S*)-3-((1*R*, 2*S*)-1,2-Dimethyl-2-vinylcyclopropanecarbonyl)-4-isopropyloxazolidin-2-one (*trans*-21a) and (*S*)-3-((1*S*, 2*R*)-1,2-Dimethyl-2-vinylcyclopropanecarbonyl)-4-isopropyl oxazolidin-2-one (*trans*-21b). Oxalyl chloride (0.262 mL, 3 mmol, 3 equiv.) was added dropwise to a solution of (±)-**29** (0.14 g, 1 mmol) in dry CH_2Cl_2 (15 mL). The resulting mixture was stirred for 3 h, and then evaporated *in vacuo*. Repeated evaporation from dry CH_2Cl_2 afforded the crude acid chloride. Then the compound **9a** (0.15 g, 1.2 mmol) was added to the suspension of sodium hydride in dry toluene (15 mL). The mixture was stirred at 80 °C for 1 h and then allowed to cool to room temperature prior to its addition over 5 min to a solution of the acid chloride obtained above in dry toluene (5 mL) at 0 °C. The mixture was then allowed to warm to room temperature and stirred for 1 h. The residue was quenched with saturated aqueous NH_4Cl (15 mL), extracted with EtOAc (15 mL ×3) and the combined extracts were washed with water (20 mL), brine (20 mL), dried over Na_2SO_4, and concentrated. The residue was purified by flash chromatography (Hexanes/EtOAc, 10/1→5/1) to *trans*-**21a** (colourless oil, 95 mg) and *trans*-**21b** (white solid, 95 mg) in a total 76% yield.

trans-**21a:** $[\alpha]_D^{25}$ = 59.0 (*c*, 1.0, $CHCl_3$); IR (Film): 2965, 2929, 2876, 1787, 1692, 1387, 1364, 1302, 1208, 1101, 998, 910 cm^{-1}; ^1H NMR (300 MHz, $CDCl_3$): δ (ppm) 5.95 (dd, *J* = 10.5, 17.4 Hz, 1H), 5.14 (dd, *J* = 1.2, 10.5 Hz, 1H), 5.09 (dd, *J* = 1.2, 17.1 Hz, 1H), 4.50-4.56 (m, 1H), 4.28 (t, *J* = 9.3 Hz, 1H), 4.18 (dd, *J* = 4.2, 8.7 Hz, 1H), 2.29-2.35 (m, 1H), 1.39 (s, 3H), 1.31 (d, *J* = 5.4 Hz, 1H), 1.09 (s, 3H); 0.89-0.93 (m, 6H), 0.80 (d, *J* = 5.1 Hz, 1H); ^{13}C NMR (100 MHz, $CDCl_3$): δ (ppm) 173.9, 152.6, 139.8, 115.2, 63.2, 58.1, 33.7, 30.7, 28.3, 22.4, 19.7, 17.8, 17.1, 14.8; MS (ESI): *m/z* (relative intensity): 252.2 $[M+H]^+$; HRMS (ESI): Calculated for $C_{14}H_{21}NO_3Na$, $[M+Na]^+$: 274.1414, found: 274.1422.

trans-**21b:** M.p.: 66-68 ℃; $[\alpha]_D^{25}$ = 93.0 (*c*, 1.0, $CHCl_3$); IR (Film): 2967, 2874, 1778, 1682, 1488, 1388, 1361, 1256, 1138, 1100, 1077, 993, 900 cm^{-1}; ^1H NMR (300 MHz, $CDCl_3$): δ (ppm) 5.99 (dd, *J* = 11.4, 17.4 Hz, 1H), 5.17 (dd, *J* = 1.5, 10.5 Hz, 1H), 5.10 (d, *J* = 17.1 Hz, 1H), 4.21-4.36 (m, 3H), 2.47-2.52 (m, 1H), 1.30 (s, 3H), 1.27 (d, *J* = 5.1 Hz, 1H), 1.17 (s, 3H); 0.93 (d, *J* = 7.2 Hz, 3H), 0.89 (d, *J* = 6.6 Hz, 3H), 0.80 (d, *J* = 5.1 Hz, 1H); ^{13}C NMR (100 MHz, $CDCl_3$): δ (ppm) 173.5, 152.6, 139.8, 115.1, 63.1, 59.8, 33.5, 30.1, 28.1, 22.7, 20.3, 18.2, 16.9, 14.3; MS (ESI): *m/z* (relative intensity): 252.2 $[M+H]^+$; HRMS (ESI): Calculated for $C_{14}H_{21}NO_3Na$ $[M+Na]^+$: 274.1414, found: 274.1427.

(*S*)-3-((3*R*,5*R*)-3,5-Dimethyl-5-vinyl-1,2-dioxolane-3-carbonyl)-4-isopropyloxazolidin-2-one (*trans*-20a), (*S*)-3-((3*S*, 5*S*)-3,5-dimethyl-5-vinyl-1,2-dioxolane-3-carbonyl)-4-isopropyloxazolidin-2-one (*trans*-20b) and (*S*)-3-((3*R*, 5*S*)-3,5-dimethyl-5-vinyl-1,2-dioxolane-3-carbonyl)-4-isopropyloxazolidin-2-one (*cis*-20c). To a stirring solution of the mixture of *trans*-**21a** and *trans*-**21b** (160 mg，0.63 mmol) in ether (20 mL) was added diphenyl diselenide (39 mg，0.12 mmol，0.2 equiv), $Sc(OTf)_3$ (310 mg，0.63 mmol, 1 equiv) and AIBN (41 mg，0.25 mmol, 0.4 equiv). The mixture was placed under a balloon of oxygen and irradiated with a 300 W sunlamp. When starting material was consumed as shown by TLC, the reaction mixture was concentrated *in vacuo*, and the residue was purified by flash chromatography (Hexanes/EtOAc, 20/1→5/1) to *trans*-**20b** (pale yellow oil, 125 mg), *trans*-**20a** and *cis*-**20c** (white solid, 28 mg) in a total 90% yield. The mixture of *trans*-**20a** and *cis*-**20c** was recrystallized from 5 mL 10/1 Hexanes/EtOAc to give pure *trans*-**20a** as a white solid (17 mg, 10% yield). HPLC (Chiralcel AD-H colum, 214 nm, hexane/2-propanol ＝ 98/2, Flow rate ＝ 0.7 mL/min), t_R = 32.052, 40.218, 43.752 min.

trans-**20b:** $[\alpha]_D^{25}$ = 99.4 (*c*, 1.0, $CHCl_3$); IR (Film): 2966, 2935, 2877, 1784, 1706, 1388, 1373, 1302, 1209, 1106, 1056, 991, 927 cm^{-1}; ^1H NMR (400 MHz, $CDCl_3$): δ (ppm) 5.99 (dd, *J* = 10.8, 17.2 Hz, 1H), 5.23 (d, *J* = 17.6 Hz, 1H), 5.08 (dd, *J* = 1.2, 10.8 Hz, 1H), 4.50-4.54 (m, 1H), 4.31 (t, *J* = 9.2 Hz, 1H), 4.20 (dd, *J* = 4.0, 9.6 Hz, 1H), 2.86 (d, *J* = 13.2 Hz, 1H), 2.77 (d, *J* = 13.2 Hz, 1H), 2.31-2.35 (m, 1H), 1.66 (s, 3H), 1.27 (s, 3H), 0.84-0.92 (m, 6H); ^{13}C NMR (100 MHz, $CDCl_3$): δ (ppm) 172.7, 152.7, 141.8, 113.5, 88.4, 85.5, 63.6, 59.2, 55.4, 27.7, 22.6, 20.4, 17.9, 14.4; MS (ESI): *m/z* (relative intensity): 284.0 $[M+H]^+$; HRMS (ESI): Anal. Calculated for $C_{14}H_{21}NO_5Na$ $[M+Na]^+$: 306.1312, found: 306.1317.

trans-**20a:** M.p.: 113-115 ℃; $[\alpha]_D^{25}$ = -60.8 (*c*, 1.0, $CHCl_3$); IR (Film): 2966, 2936, 2877, 1782, 1711, 1388, 1373, 1302, 1209, 1106, 1056, 991, 927 cm^{-1}; ^1H NMR (400 MHz, $CDCl_3$): δ (ppm) 6.02 (dd, *J* = 10.8, 17.2 Hz, 1H), 5.26 (d, *J* = 17.6 Hz, 1H), 5.13 (d, *J* = 10.4 Hz, 1H), 4.45-4.48 (m, 1H), 4.35 (t, *J* = 8.8 Hz, 1H), 4.25 (dd, *J* = 2.0, 8.8 Hz, 1H), 3.05 (d, *J* = 13.2Hz, 1H), 2.76 (d, *J* = 13.2 Hz, 1H), 2.40-2.47 (m, 1H), 1.71 (s, 3H), 1.31 (s, 3H), 0.92-0.94 (m, 6H); ^{13}C NMR (100 MHz, $CDCl_3$): δ (ppm) 172.2, 152.6, 141.6, 113.1, 88.4, 85.3, 63.6, 59.6, 55.0, 28.3, 22.5, 19.9, 17.7, 14.6; MS (ESI): *m/z* (relative intensity): 284.0 $[M+H]^+$; HRMS (ESI): Calculated for $C_{14}H_{21}NO_5Na$ $[M+Na]^+$: 306.1312, found: 306.1316.

((3*S*, 5*S*)-3,5-Dimethyl-5-vinyl-1,2-dioxolan-3-yl)methanol (+)-30. To a stirred solution of *trans*-**20a** (116 mg, 0.4 mmol) in THF (10 mL) at 0 ℃ was added $LiBH_4$ (2.0 M solution in THF, 0.21 mL, 0.42 mmol). After 10 min, the reaction mixture was quenched by saturated aqueous NH_4Cl (10 mL). Then the mixture was allowed to warm to room temperature and stirred for 0.5 h. Then the mixture was extracted with EtOAc (10 mL ×3), dried over Na_2SO_4, filtered, and concentrated. The residue was purified by flash chromatography (Hexane/EtOAc, 5/1) to give (+)-**30** as a colorless oil (57 mg, 90% yield).

(+)-**30:** $[\alpha]_D^{25}$ = 140.4 (*c*, 1.0, $CHCl_3$); IR (Film): 3418 (br, OH), 2976, 2932, 1738, 1455, 1416, 1372, 1300, 1051, 925, 797 cm^{-1}; ^1H NMR (400 MHz, $CDCl_3$): δ (ppm) 6.00 (dd, *J* = 10.8, 17.6 Hz, 1H), 5.26 (d, *J* = 17.6 Hz, 1H), 5.13 (d, *J* = 10.4 Hz, 1H), 3.62 (d, *J* = 11.6 Hz, 1H), 3.42 (d, *J* = 11.6 Hz, 1H), 2.35 (s, 2H), 1.37 (s, 3H), 1.27 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$): δ (ppm) 141.6, 113.2, 86.3, 85.7, 67.1, 52.2, 22.7, 20.0; MS (EI): *m/z* (relative intensity) 43 (100), 55 (15), 41 (6), 85 (6), 71 (5), 53 (5), 127 (5), 58 (4), 158 (M^+, 2); HRMS (EI): Calculated for $C_8H_{14}O_3$ $[M]^+$: 158.0943, found: 158.0947.

Compound (-)-**30** was prepared from *trans*-**20a** by a similar procedure. [α] = -145.7 (*c*, 1.0, $CHCl_3$).

(*E*)- or (*Z*)-(3*S*, 5*S*)-3-(2-Methoxyvinyl)-3,5-dimethyl-5-vinyl-1,2-dioxolane (+)-31. (1) To a stirred solution of (+)-**30** (100 mg, 0.63 mmol) in CH_2Cl_2 (20 mL) was added PCC (341 mg, 1.58 mmol) and NaOAc (13 mg, 0.16 mmol). Then the mixture was stirred overnight. Then the mixture was filtered through the celatom and concentrated to give the crude aldehyde. (2) To a stirred suspension of (Methoxymethyl)triphenylphosphonium Chloride (1.08 g, 3.15 mmol) in THF (20 mL) at 0 ℃ was added NaHMDS (2M solution in THF, 1.57 mL, 3.15 mmol) dropwise via syringe. After stirred for 0.5 h at 0 ℃, a solution of the crude product (0.63 mmol) in THF (2 mL) was added in one portion. The reaction mixture was allowed to warm to room temperature and stirred for 2 h, and the mixture was quenched by saturated aqueous NH_4Cl (10 mL), extracted with EtOAc (20 mL×3), dried over Na_2SO_4, filtered, and concentrated. The residue was purified by flash chromatography (Hexane/EtOAc, 20/1) to give *trans*-(+)-**31** (colourless oil, 46 mg) and *cis*-(+)-**31** (colourless oil, 23 mg) in a total 60% yield.

trans-(+)-**31:** $[\alpha]_D^{25}$ = 15.7 (*c*, 1.0, $CHCl_3$); IR (Film): 2959, 2929, 2856, 1727, 1654, 1453, 1371, 1262, 1220, 1124, 941, 802 cm^{-1}; ^1H NMR (300 MHz, $CDCl_3$): δ (ppm) 6.56 (d, *J* = 12.9 Hz, 1H), 6.03 (dd, *J* = 10.8, 17.6 Hz, 1H), 5.23 (d, *J* = 17.4 Hz, 1H), 5.10 (d, *J* = 10.8 Hz, 1H), 4.90 (d, *J* = 12.9 Hz, 1H), 3.53 (s, 3H), 2.40 (m, 2H), 1.43 (s, 6H); ^{13}C NMR (75 MHz, $CDCl_3$): δ (ppm) 149.0, 140.8, 114.0, 106.0, 85.8, 84.5, 58.1, 55.9, 24.7, 24.2; MS (ESI): *m/z* (relative intensity) 206.9 $[M+Na]^+$; HRMS (ESI): Calculated for $C_{10}H_{16}O_3Na$, $[M+Na]^+$: 207.0992, found: 207.0993.

Compound *trans*-(-)-**31** was prepared from (-)-**30** by a similar procedure. $[\alpha]_D^{25}$ = -14.9 (*c*, 1.0, $CHCl_3$).

cis-(+)-**31:** $[\alpha]_D^{25}$ = 17.2 (*c*, 1.0, $CHCl_3$); IR (Film): 2977, 2933, 2854, 1724, 1663, 1452, 1368, 1261, 1103, 1019, 923, 799 cm^{-1}; ^1H NMR (300 MHz, $CDCl_3$): δ (ppm) 6.00 (dd, *J* = 10.8, 17.6 Hz, 1H), 5.82 (d, *J* = 6.6 Hz, 1H), 5.26 (dd, *J* = 0.9, 17.4 Hz, 1H), 5.09 (dd, *J* = 1.2, 10.8 Hz, 1H), 4.70 (d, *J* = 6.6 Hz, 1H), 3.58 (s, 3H), 2.70 (d, *J* = 12.3 Hz, 1H), 2.44 (d, *J* = 12.0 Hz, 1H), 1.44 (s, 3H), 1.39 (s, 3H); ^{13}C NMR (100MHz, $CDCl_3$): δ (ppm) 146.2, 141.8, 113.1, 111.5, 85.4, 85.0, 60.0, 57.8, 24.4, 23.8; MS (ESI): *m/z* (relative intensity) 206.9 $[M+Na]^+$; HRMS (ESI): Calculated for $C_{10}H_{16}O_3Na$ $[M+Na]^+$: 207.0992, found: 207.0995.

Compound *cis*-(-)-**31** was prepared from (-)-**30** by a similar procedure. $[\alpha]_D^{25}$ = -15.4 (*c*, 1.0, $CHCl_3$).

Methyl 2-((3*S*, 5*S*)-3,5-dimethyl-5-vinyl-1,2-dioxolan-3-yl) acetate (+)-32. To a stirred solution of (+)-**31** (240 mg, 1.3 mmol) in CH_2Cl_2 (20 mL) was added PCC (562 mg, 2.6 mmol). The mixture was stirred for overnight and then filtered through the celatom and concentrated. The residue was purified by flash chromatography (Hexane/EtOAc, 20/1 to 10/1) to give (+)-**32** (colourless oil, 156 mg, 60% yield).

(+)-**32:** $[\alpha]_D^{25}$ = 60.7 (*c*, 1.0, $CHCl_3$); IR (Film): 2982, 2955, 1739, 1438, 1374, 1348, 1309, 1209, 1148, 1013, 925 cm^{-1}; ^1H NMR (300 MHz, $CDCl_3$): δ (ppm) 6.00 (dd, *J* = 10.8, 17.6 Hz, 1H), 5.26 (d, *J* = 17.4 Hz, 1H), 5.07 (d, *J* = 10.8 Hz, 1H), 3.65 (s, 3H), 2.75 (d, *J* = 14.4 Hz, 1H), 2.65 (d, *J* = 14.7 Hz, 1H), 2.60 (d, *J* = 12.6 Hz, 1H), 2.41 (d, *J* = 12.3 Hz, 1H), 1.39 (s, 3H), 1.37 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$): δ (ppm) 170.9, 141.5, 113.3, 85.8, 84.2, 55.2, 51.6, 44.2, 23.5, 23.4; MS (ESI): *m/z* (relative intensity) 222.9 $[M+Na]^+$; HRMS (ESI): Calculated for $C_{10}H_{16}O_4Na$ $[M+Na]^+$: 223.0941, found: 223.0941.

Compound (-)-**32** was prepared from (-)-**31** by a similar procedure. $[\alpha]_D^{25}$ = -65.9 (*c*, 1.0, $CHCl_3$).

(2*E*,4*E*)-Hepta-2,4-dien-1-yltriphenyl phosphonium bromide 15. (1) To a stirred solution of (2*E*,4*E*)-hepta-2,4-dienal (5 g, 45.5 mmol) in EtOH (100 mL) at 0 ℃ was added sodium borohydride (2.19 g, 47.7 mmol) and the mixture was stirred for 30 min. The solution was concentrated and the residue was purified by flash chromatography (Hexane/EtOAc, 10/1) to obtain a clear liquid. (2) To a stirred solution of (2*E*, 4*E*)-hepta-2,4-dien-1-ol (4.5 g, 40 mmol) in dry ether (200 mL) was added calcium hydride (1.57 g, 37.5 mmol) and the mixture was stirred for 1 h. The reaction mixture was then cooled to 0 ℃ and phosphorous tribromide (4.0 g, 15 mmol,) in dry ether (50 mL) was added. After 1 h the reaction was allowed to warm to room temperature and then quenched by addition of methanol (0.3 mL, 7.4 mmol). The mixture was filtered through celite followed by ether washing and concentrated. The residue was purified by flash chromatography (Hexane/EtOAc, 50/1 to 20/1) to give a mixture of bromides (6.1 g, colourless oil, 89% yield) as a mixture. (3) To a stirred solution of triphenyl phosphine (8.75 g, 33.4 mmol) in dry dichloromethane (100 mL) and a mixture of bromides (6.1 g, 35 mmol) was added. The mixture was then stirred for 20 h at room temperature and concentrated. The residue was purified by flash chromatography (EtOAc/MeOH, 5/1 to 1/1) to give **15** (14 g, white foam, 94% yield).

15: IR (Film): 3405, 3054, 3018, 2964, 2872, 2178, 1651, 1621, 1587, 1485, 1438, 1112, 996, 923, 723, 690 cm^{-1}; ^1H NMR (300 MHz, $CDCl_3$): δ (ppm) 7.63-7.86 (m, 15H), 6.33 (ddd, *J* = 5.1, 10.2, 15.3 Hz, 1H); 5.87 (dd, *J* = 10.8, 15.6 Hz, 1H), 5.64-5.71 (m, 1H), 5.26-5.33 (m, 1H), 4.70 (dd, *J* = 7.5, 15.0 Hz, 1H), 2.18-2.02 (m, 2H), 0.91 (t, *J* = 7.5 Hz, 3H); MS (ESI): *m/z* (relative intensity) 357.2 $[M-Br]^+$; HRMS (ESI): Calculated for $C_{25}H_{26}P$ $[M-Br]^+$: 357.1767, found: 357.1767.

***tert*-Butyl((7-iodoheptyl)oxy)dimethylsilane 18.** (1) To a solution of 1,8-octanediol (2 g, 15.2 mmol) in THF (30 mL) was added NaH (664 mg, 16.6 mmol) at room temperature. The mixture was stirred for 2 h and a solution of *tert*-butyl-dimethylsilyl chloride (2.52 g, 16.6 mmol) in THF (10 mL) was added. The mixture was then stirred overnight and quenched by water (100 mL).The aqueous phase was extracted with EtOAc (50 mL×3). The combined organic extracts were washed with water (50 mL), and brine (50 mL), dried over Na_2SO_4, filtered,

and concentrated to give a yellow oil, which was purified by flash chromatography (Hexane/EtOAc, 10/1) to obtain the alcohol as a colorless oil (3.4 g, 90%). (2) Triphenylphosphine (4.1 g, 15.6 mmol) and imidazole (2.6 g, 14.3 mmol) was dissolved in THF (50 mL) and cooled to 0 ℃. Iodine (3.6 g, 14.3 mmol) was added and then a solution of the alcohol intermediate (3.2 g，13 mmol) in THF (10 mL) was added. The mixture was allowed to warm to room temperature and stirred overnight. The solution was concentrated and purified by flash chromatography (Hexane/EtOAc, 50/1) to obtain **18** as a colorless oil (3.4 g, 90%).

18: IR (Film): 2930, 2856, 1471, 1463, 1387, 1255, 1103, 1006, 836, 775 cm^{-1}; ^1H NMR (300 MHz, $CDCl_3$): δ (ppm) 3.58 (t, J = 7.5 Hz, 2H), 3.17 (t, J = 7.2 Hz, 2H), 1.75-1.83 (m, 2H), 1.46-1.52 (m, 2H), 1.30-1.40 (m, 6H), 0.87 (s, 9H), 0.02 (s, 6H); ^{13}C NMR (100 MHz, $CDCl_3$): δ (ppm) 63.1, 33.4, 32.7, 30.4, 28.3, 25.9, 25.5, 18.3, 7.2, -5.3; MS (ESI): *m/z* (relative intensity) 357.1 $[M+H]^+$; HRMS (ESI): Calculated for $C_{13}H_{30}IOSi$ $[M+H]^+$: 357.1105, found: 357.1104.

Methyl 2-((3*S*, 5*S*)-5-((*Z*)-2-iodovinyl)-3,5-dimethyl-1,2-dioxolan-3-yl)acetate (+)-19. (1) To a -78 ℃ solution of (+)-**32** (200 mg, 1 mmol) in CH_2Cl_2 (20 mL) was bubbled O_3. After the mixture turned into the color of light blue and TLC analysis displayed that starting material was disappeared, ozonolysis was stopped and the ozone was removed by passage of N_2 through the solution. Triphenylphosphine (1.3 g, 5 mmol) was added to the reaction mixture at the same temperature. The mixture was allowed to warm to room temperature and stirred for 3 h. Then the solution was concentrated and purified by flash chromatography (Hexane/EtOAc, 5/1) to obtain the aldehyde as a colorless oil (180mg); (2) To a stirred suspension of $Ph_3P^+ICH_2I^-$ (2.65 g, 5 mol) in THF (40 mL) at 0 ℃ was added NaHMDS (2M solution in THF, 2.4 mL, 4.8 mmol) dropwise via syringe. After stirred for 0.5 h at 0 ℃, the mixture was cooled to -78 ℃ and a solution of the aldehyde (0.9 mmol) in THF (10 mL) was added. The reaction mixture was stirred for 10 min and then quenched by saturated aqueous NH_4Cl (50 mL). The aqueous phase was extracted with EtOAc (50 mL ×3). The combined organic extracts were washed with water (50 mL), brine (50 mL), and dried over Na_2SO_4, filtered, and concentrated to give a yellow oil, which was purified by flash chromatography (Hexane/EtOAc, 10/1) to obtain (+)-**19** as a colorless oil (230 mg, 70 % yield for 2 steps).

(+)-**19:** $[\alpha]_D^{25}$ = 10.9 (*c*, 1.0, $CHCl_3$); IR (Film): 2979, 2952, 2934, 1736, 1607, 1437, 1372, 1347, 1292, 1205, 1012, 809, 703 cm^{-1}; ^1H NMR (300 MHz, $CDCl_3$): δ (ppm) 6.90 (d, J = 8.4 Hz, 1H), 6.32 (d, J = 9.0 Hz, 1H), 3.70 (s, 3H), 2.85 (d, J = 12.9 Hz, 1H), 2.78 (d, J = 14.4 Hz, 1H), 2.63-2.69 (m, 2H), 1.54 (s, 3H), 1.38 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$): δ (ppm) 170.9, 147.7, 87.7, 84.3, 78.6, 55.7, 51.7, 44.6, 23.4, 21.2; MS (ESI): *m/z* (relative intensity) 344.0 $[M+NH_4]^+$; HRMS (ESI): Calculated for $C_{10}H_{15}IO_4Na$ $[M+Na]^+$: 348.9907, found: 348.9910.

Compound (-)-**19** was prepared from (-)-**32** by a similar procedure. $[\alpha]_D^{25}$ = -10.6 (*c*, 1.0, $CHCl_3$).

Methyl 2-((3S, 5*S*)-5-((*Z*)-9-((*tert*-butyldimethylsilyl)oxy)non-1-en-1-yl)-3,5-dimethyl-1,2-dioxolan-3-yl)acetate (+)-17. To a solution of **18** (140 mg, 0.4 mmol) in Et_2O (5 mL) was added $ZnCl_2$ (1 M solution in Et_2O, 0.8 mL, 0.4 mmol). The mixture was cooled to -78 ℃ and *t*-butyllithium (1.6 M solution in hexanes, 0.75 mL, 1.2 mmol) was added dropwise via syringe. The mixture was stirred at -78 ℃ for 30 min and the temperature was allowed to warm to room temperature. A solution of (+)-**19** (60 mg, 0.2 mmol) and $Pd(PPh_3)_4$ (46.2 mg, 0.04 mmol) in THF (5 mL) was added *via* syringe. The mixture was stirred for 3 h in the absence of light and then quenched by saturated aqueous NH_4Cl (10 mL). The aqueous phase was extracted with EtOAc (20 mL×3). The combined organic extracts were washed with water (20 mL), brine (20 mL), and dried over Na_2SO_4, filtered, and concentrated. Purified by flash chromatography (Hexane/EtOAc, 20/1) to obtain (+)-**17** as a colorless oil (65 mg, 77 %).

(+)-**17:** $[\alpha]_D^{25}$ = 21.2 (*c*, 1.0, $CHCl_3$); IR (Film): 2930, 2856, 1741, 1463, 1437, 1346, 1257, 1012, 836, 776 cm^{-1}; ^1H NMR (400 MHz, $CDCl_3$): δ (ppm) 5.62 (dt, J = 2.0, 12.0 Hz, 1H), 5.29-5.36 (m, 1H), 3.70 (s, 3H), 3.61 (t, J = 6.8 Hz, 2H), 2.75 (d, J = 14.4 Hz, 1H), 2.67 (d, J = 5.2 Hz, 1H), 2.65 (d, J = 7.6 Hz, 1H), 2.49 (d, J = 12.0 Hz, 1H), 2.08-2.13 (m, 2H), 1.45-1.54 (m, 2H), 1.42 (s, 3H), 1.40 (s, 3H), 1.24-1.38 (m, 8H), 0.89 (s, 9H), 0.04 (s, 6H); ^{13}C NMR (100 MHz, $CDCl_3$): δ (ppm) 171.1, 134.8, 130.8, 86.3, 83.8, 63.3, 57.6, 51.7, 44.3, 32.8, 29.6, 29.3, 29.3, 28.5, 25.9, 25.7, 25.0, 23.9, 18.3, -5.3; MS (ESI): *m/z* (relative intensity) 446.3 $[M+NH_4]^+$; HRMS (ESI): Calculated for $C_{23}H_{44}O_5Si$ $[M]^+$: 428.2958, found: 428.2961.

Compound (-)-**17** was prepared from (-)-**19** by a similar procedure. $[\alpha]_D^{25}$ = -22.8 (*c*, 1.0, $CHCl_3$).

Methyl 2-((3*S*,5*S*)-5-((*Z*)-9-hydroxynon-1-en-1-yl)-3,5-dimethyl-1,2-dioxolan-3-yl)acetate (+)-33. To a solution of (+)-**17** (43 mg, 0.1 mmol) in CH_2Cl_2/MeOH (0.7/1.4 mL) was added *p*-TsOH (1.9 mg, 0.01 mmol). The reaction was stirred at room temperature until no starting material remained (TLC). After removal of the solvents, the crude product was purified by column chromatography (Hexane/EtOAc, 3/1) to give (+)-**33** as a colorless oil (27 mg, 89 %).

(+)-**33:** $[\alpha]_D^{25}$= 37.08 (*c*, 1.0, $CHCl_3$); IR (Film): 3383(br, OH), 2928, 2855, 1738, 1436, 1347, 1260, 1208, 1074, 1014, 801, 725 cm^{-1}; ^1H NMR (400MHz, $CDCl_3$): δ (ppm) 5.61 (dt, J = 2.0, 11.6 Hz, 1H), 5.29-5.36 (m, 1H), 3.69 (s, 3H), 3.63 (t, 2H, J = 6.8 Hz), 2.75 (d, J = 14.8 Hz, 1H), 2.67 (d, J = 3.6 Hz, 1H), 2.65 (d, J = 8.4 Hz, 1H), 2.49 (d, J = 12.4 Hz, 1H), 2.08-2.13 (m, 2H), 1.45-1.57 (m, 2H), 1.40 (s, 3H), 1.38 (s, 3H), 1.32-1.38 (m, 8H); ^{13}C NMR (100 MHz, $CDCl_3$): δ (ppm) 171.1, 134.8, 130.9, 86.3, 83.8, 62.9, 57.6, 51.7, 44.3, 32.7, 29.5, 29.3, 29.2, 28.4, 25.6, 24.8, 23.9; MS (ESI): *m/z* (relative intensity) 332.2 $[M+NH_4]^+$; HRMS (ESI): Calculated for $C_{17}H_{30}O_5$ $[M]^+$: 314.2093, found: 314.2096.

Compound (-)-**33** was prepared from (-)-**17** by a similar procedure. $[\alpha]_D^{25}$ = -35.5 (*c*, 1.0, $CHCl_3$).

Methyl 2-((3*S*, 5*R*)-5-(9-hydroxynonyl)-3,5-dimethyl-1,2-dioxolan-3-yl) acetate (+)-34. (1) To a solution of (+)-**33** (28 mg, 0.089 mmol) in CH_2Cl_2 (5 mL) was added potassium azodicarboxylate (353 mg, 1.78 mmol). Then the mixture was vigorously stirred at 0 ℃ while a solution of acetic acid (0.21 mL, 3.6 mmol) in CH_2Cl_2 (1 mL) is added dropwise over a 2 h period. After decoloration of the yellow suspension, the solids were removed by filtration and another potassium azodicarboxylate (353 mg, 1.78 mmol) was added and the reduction process was repeated 3 times. Then the solids were removed by filtration and the solvent was concentrated *in vacuo* to give the crude product. The residue was purified by flash chromatography (Hexane/EtOAc, 3/1) to afford (+)-**34** as a colorless oil (24 mg, 85 %).

(+)-**34:** $[\alpha]_D^{25}$ = 34.9 (*c*, 1.0, $CHCl_3$); IR (Film): 3419 (br, OH), 2930, 2855, 1739, 1456, 1438, 1375, 1210, 1074, 1014, 804 cm^{-1}; ^1H NMR (400 MHz, $CDCl_3$): δ (ppm) 3.72 (s, 3H), 3.65 (t, *J* = 5.1 Hz, 2H), 2.76 (d, *J* = 14.4 Hz, 1H), 2.65 (d, *J* = 14.4 Hz, 1H), 2.47 (d, *J* = 12.0 Hz, 1H), 2.22 (d, *J* = 12.4 Hz, 1H), 1.68-1.74 (m, 1H), 1.54-1.60 (m, 3H), 1.45 (s, 3H), 1.26-1.36 (m, 16H); ^{13}C NMR (100 MHz, $CDCl_3$): δ (ppm) 171.1, 86.5, 83.9, 63.0, 55.3, 51.7, 44.0, 39.6, 32.7, 30.0, 29.5, 29.4, 29.3, 25.7, 24.5, 24.1, 23.2; MS (ESI): *m/z* (relative intensity): 317.1 $[M+H]^+$; HRMS (ESI): Calculated for $C_{17}H_{32}O_5Na$ $[M+Na]^+$: 339.2142, found: 339.2150.

Compound (-)-**34** was prepared from (-)-**33** by a similar procedure. $[\alpha]_D^{25}$ = -35.5 (*c*, 1.0, $CHCl_3$).

Epiplakinic acid F methyl ester (+)-2. (1) To a 0 ℃ solution of (+)-**34** (20 mg, 0.063 mmol) in CH_2Cl_2 (1 mL) was added DMP (40 mg, 0.095 mmol). The reaction mixture was stirred at the same temperature for 0.5 h. Then saturated aqueous $NaHCO_3$ (10 mL) was added and the mixture was extracted with CH_2Cl_2 (20 mL×3). The combined organic extracts were washed with brine (20 mL), and dried over Na_2SO_4, filtered, and concentrated. The residue was purified by flash chromatography (Hexane/EtOAc, 10/1) to afford the desired aldehyde. (2) To a stirred suspension of **15** (138.9 mg, 0.32 mol) in THF (5 mL) at -30 ℃ was added *n*-BuLi (2.4M solution in hexane, 0.13 mL, 0.32 mmol) dropwise via syringe. After stirred for 1 h at the same temperature, a solution of the aldehyde in THF (2 mL) was added dropwise via syringe. The reaction mixture was stirred for 1 h at the same temperature and then quenched by saturated aqueous NH_4Cl (10 mL). The aqueous phase was extracted with EtOAc (20 mL×3). The combined organic extracts were washed with water (20 mL), brine (20 mL), and dried over Na_2SO_4, filtered, and concentrated, which was purified by flash chromatography (Hexane/EtOAc, 20/1) to obtain (+)-**2** (16 mg, 64 % yield for 2 steps) in 85/15 (*E:Z*) ratio as a colorless oil. (3) To a 0 ° C solution of (+)-**2** (16 mg, 0.04 mmol) in CH_2Cl_2 (2 mL) was added iodine (catalytic amount). The mixture was stirred at the same temperature for 0.5 h under the sunlamp. Then the mixture was cooled to -30 ℃ and stirred for 0.5 h, followed by cooled to -78 ℃ and stirred for another 1 h. Then quenched by $NaBH_4$ (0.01 M solution in MeOH, 0.1 mL), the reaction was allowed to warm to room temperature and concentrated. The residue was purified by flash chromatography (Hexane/EtOAc, 20/1) to obtain (+)-**2** (12 mg, 77 %) in 95/5 (*E:Z*) ratio as a colorless oil.

(+)-**2:** $[\alpha]_D^{25}$ = 32.4 (*c*, 0.5, $CHCl_3$); [Lit[3]: $[\alpha]_D^{25}$= 32.3 (*c*, 1.6, $CHCl_3$)]; IR (Film): 3012, 2962, 2929, 2854, 1739, 1456, 1437, 1374, 1261, 1094, 1016, 801 cm^{-1}; ^1H NMR (500 MHz, $CDCl_3$): δ (ppm) 6.01-6.10 (m, 4H), 5.62-5.73 (m, 2H), 3.69 (s, 3H), 2.76 (d, *J* = 14.5 Hz, 1H), 2.64 (d, *J* = 14.5 Hz, 1H), 2.46 (d, *J* = 12.5 Hz, 1H), 2.22 (d, *J* = 12.5 Hz, 1H), 2.05-2.10 (m, 4H), 1.65-1.69 (m, 1H), 1.53 (t, *J* = 12.0 Hz, 1H), 1.44 (s, 3H), 1.35-1.40 (m, 3H), 1.27-1.30 (m, 12H), 1.00 (t, *J* = 7.5Hz, 3H); ^{13}C NMR (125 MHz, $CDCl_3$): δ (ppm) 171.3, 136.1, 134.7, 131.1, 131.0, 130.7, 129.7, 86.7, 84.2, 55.6, 51.9, 44.2, 39.9, 33.0, 30.2, 29.7, 29.6, 29.6, 29.4, 26.0, 24.8, 24.4, 23.5, 13.8; MS (ESI): *m/z* (relative intensity): 393.3 $[M+H]^+$; HRMS (ESI): Calculated for $C_{24}H_{40}O_4$ $[M]^+$: 392.2927, found: 392.2911.

Compound (-)-**2** was prepared from (-)-**34** by a similar procedure. $[\alpha]_D^{25}$ = -32.9 (*c*, 0.5, $CHCl_3$).

Epiplakinic acid F (+)-1. To a 0 ℃ solution of (+)-**2** (15 mg, 0.038 mmol) in H_2O/MeOH/THF (1/10/10, 1 mL) was added LiOH (18 mg, 0.76 mmol). The reaction was allowed to warm to room temperature and stirred for 6 h in the absence of light. Then water (10 mL) and AcOH (0.1 mL) was added and the mixture was extracted with CH_2Cl_2 (10 mL×3). The combined organic extracts washed with brine (10 mL), and dried over Na_2SO_4, filtered, and concentrated. The residue was purified by flash chromatography (Hexane/EtOAc, 5/1) to afford (+)-**1** (10 mg, 70 %) as a colorless oil.

(+)-**1:** $[\alpha]_D^{25}$ = 31.21 (*c*, 0.5, $CHCl_3$); IR (Film): (2800-3500, br, OH), 2925, 2852, 1710, 1457, 1376, 1261, 1082, 995, 803, 738 cm^{-1}; ^1H NMR (500 MHz, $CDCl_3$): δ (ppm) 6.01-6.20 (m, 4H), 5.65-5.77 (m, 2H), 2.79 (dd, *J* = 14.5, 23.5 Hz, 2H), 2.46 (d, *J* = 12.5 Hz, 1H), 2.28 (d, *J* = 12.5 Hz, 1H), 2.10-2.15 (m, 4H), 1.70-1.77 (m, 1H), 1.55-1.60 (m, 1H), 1.50 (s, 3H), 1.38-1.43 (m, 3H), 1.29-1.34 (m, 12H), 1.03 (t, *J* = 7.5 Hz, 3H); ^{13}C NMR (125 MHz, $CDCl_3$): δ (ppm) 173.3, 135.4, 133.9, 130.4, 130.3, 130.0, 129.0, 86.2, 83.4, 55.2, 43.1, 39.3, 32.3, 29.5, 29.0, 29.0, 28.8, 28.7, 25.3, 24.0, 23.2, 22.6, 13.1; MS (ESI): *m/z* (relative intensity): 396.3 $[M+NH_4]^+$; HRMS (ESI): Calculated for $C_{23}H_{42}O_4N$ $[M+NH_4]^+$: 396.3108, found: 396.3102.

Compound (-)-**1** was prepared from (-)-**2** by a similar procedure. $[\alpha]_D^{25}$ = -29.3 (*c*, 0.5, $CHCl_3$); IR (Film): 2968, 2940, 2881, 1782, 1717, 1696, 1461, 1383, 1369, 1322, 1256, 1188, 1108, 1067, 980, 926, 759 cm^{-1}.

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Notes and references

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1 (a) D.-C. Oh, J. J. Scott, C. R. Currie and J. Clardy, *Org. Lett.*, 2009, **11**, 633; (b) Y. Chen, P. J. McCarthy, D. K. Harmody, R. Schimoler-O'Rourke, K. Chilson, C. Selitrennikoff, S. A. Pomponi and A. E. Wright, *J. Nat. Prod.*, 2002, **65**, 1509; (c) D. A. Casteel, *Nat. Prod. Rep.*, 1999, **16**, 55; (d) A. D. Patil, A. J. Freyer, M. F. Bean, B. K. Carte, J. W. Westley and R. K. Johnson, *Tetrahedron*, 1996, **52**, 377; (e) T. R. Thomas, D. P. Kavlekar and P. A. LokaBharathi, *Mar. Drugs*, 2010, **8**, 1417; (f) M. H. Kossuga, A. M. Nascimento, J. Q. Reimão, A. G. Tempone, N. N. Taniwaki, K. Veloso, A. G. Ferreira, B. C. Cavalcanti, C. Pessoa, M. O. Moraes, A. M. S. Mayer, E. Hajdu and R. G. S. Berlinck, *J. Nat. Prod.*, 2008, **71**, 334.

2 Y. Chen, K. B. Killday, P. J. McCarthy, R. Schimoler, K. Chilson, C. Selitrennikoff, S. A. Pomponi and A. E. Wright, *J. Nat. Prod.*, 2001, **64**, 262.

3 C. Jiménez-Romero, I. Ortiz, J. Vicente, B. Vera, A. D. Rodriguez, S. Nam and R. Jove, *J. Nat. Prod.*, 2010, **73**, 1694.

4 A. C. Baldwin in *The Chemistry of Peroxides*(Ed.: S. Patai), Wiley, New York, 1983, pp. 94-104.

5 (a) A. L. J. Beckwith and R. D. Wagner, *J. Chem. Soc., Chem. Commun.*, 1980, 485; (b) E. N. Frankel, D. Weisleder and W. E. Neff, *J. Chem. Soc., Chem. Commun.*, 1981, 766; (c) H. Kropf and H. von Wallis, *Synthesis*, 1981, 237; (d) M. Miura, M. Yoshida, M. Nojima and S. Kusabayashi, *J. Chem. Soc., Chem. Commun.*, 1982, 397; (e) M. Yoshida, M. Miura, M. Nojima and S. Kusabayashi, *J. Am. Chem. Soc.*, 1983, **105**, 6279; (f) A. L. Baumstark and P. C. Vasquez, *J. Org. Chem.*, 1992, **57**, 393; (g) J. L. Courtneidge, *J. Chem. Soc., Chem. Commun.*, 1992, 1270; (h) M. R. Iesce, F. Cermola, A. Guitto, R. Scarpati and M. L. Graziano, *J. Org. Chem.*, 1995, **60**, 5324; (i) H. Shimizu, S. Miyazaki and T. Kataoka, *J. Chem. Soc., Perkin Trans. 1*, 1996, 2227; (j) T. Ito, T.Tokuyasu, A. Masuyama, M. Nojimaa and K. J. McCullough, *Tetrahedron*, 2003, **59**, 525; (k) I. Gbara-Haj-Yahia, G. Zvilichovsky and N. Seri, *J. Org. Chem.*, 2004, **69**, 4135; (l) T. Tokuyasu, S. Kunikawa, K. J. McCullough, A. Masuyama and M. Nojima, *J. Org. Chem.*, 2004, **70**, 251; (m) C. E. Schiaffo, M. Rottman, S. Wittlin and P. H. Dussault, *ACS Med. Chem. Lett.*, 2011, **2**, 316; (n) H. Yin, L. Xu and N. A. Porter, *Chem. Rev.*, 2011, **111**, 5944; (o) B. Barnych and J.-M. Vatèle, *Tetrahedron*, 2012, **68**, 3717.

6 (a) L. Cointeaux, J.-F. Berrien and J. Mayrargue, *Tetrahedron Lett.*, 2002, **43**, 6275; (b) P. Dai, T. K. Trullinger, X. Liu and P. H. Dussault, *J. Org. Chem.*, 2006, **71**, 2283; (c) B. Barnych, B. Fenet and J.-M. Vatèle, *Tetrahedron*, 2013, **69**, 334; (d) O. Lifchits, M. Mahlau, C. M. Reisinger, A. Lee, C. Farès, I. Polyak, G. Gopakumar, W. Thiel and B. List, *J. Am. Chem. Soc.*, 2013, **135**, 6677.

7 Q. Zhao and H. N. C. Wong, *Tetrahedron*, 2007, **63**, 6296.

8 X.-Y. Sun, X.-Y. Tian, Z.-W. Li, X.-S. Peng and H. N. C. Wong, *Chem. Eur. J.*, 2011, **17**, 5874.

9 M. P. Sibi, S. Manyem and J. Zimmerman, *Chem. Rev.*, 2003, **103**, 3263.

10 (a) A. T. Parsons and J. S. Johnson, *J. Am. Chem. Soc.*, 2009, **131**, 3122; (b) F. de Nanteuil and J. Waser, *Angew. Chem. Int. Ed.*, 2011, **50**, 12075; (c) B. M. Trost, P. J. Morris and S. J. Sprague, *J. Am. Chem. Soc.*, 2012, **134**, 17823; (d) S. M. Wales, M. M. Walker and J. S. Johnson, *Org. Lett.*, 2013, **15**, 2558; (e) H. Xu, J. P. Qu, S. Liao, H. Xiong and Y. Tang, *Angew. Chem. Int. Ed.*, 2013, **52**, 4004; (f) Z. Lu, M. Shen and T. P. Yoon, *J. Am. Chem. Soc.*, 2011, **133**, 1162; (g) Z. Luo, B. Zhou and Y. Li, *Org. Lett.*, 2012, **14**, 2540.

11 (a) K. S. Feldman and M. Parvez, *J. Am. Chem. Soc.*, 1986, **108**, 1328; (b) K. S. Feldman and R. E. Simpson, *J. Am. Chem. Soc.*, 1989, **111**, 4878; (c) K. S. Feldman and C. M. Kraebel, *J. Org. Chem.*, 1992, **57**, 4574; (d) C. K. Weinreb,D. Hartsough and K. S. Feldman, *Tetrahedron Lett.*, 1995, **36**, 6859.

12 B. Lagu, R. Lebedev, B. Pio, M. Yang and P. D. Pelton, *Bioorg. Med. Chem. Lett.*, 2007, **17**, 3491.

13 M. P. Sibi and J. B. Sausker, *J. Am. Chem. Soc.*, 2002, **124**, 984.

14 (a) P. Renaudand M. Gerster, *Angew. Chem. Int. Ed.*, 1998, **37**, 2562; (b) C. L. Mero and N. A. Porter, *J. Am. Chem. Soc.*, 1999, **121**, 5155; (c) D. Yang, S. Gu, Y.-L. Yan, N.-Y. Zhu and K.-K. Cheung, *J. Am. Chem. Soc.*, 2001, **123**, 8612; (d) R. H. Taaning, L. Thim, J. Karaffa, A. G. Campaña, A.-M. Hansen and T. Skrydstrup, *Tetrahedron*, 2008, **64**, 11884.

15 E. T. T. Kumpulainen, A. M. P. Koskinen and K. Rissanen, *Org. Lett.*, 2007, **9**, 5043.

16 (a) L. L. McCoy, *J. Am. Chem. Soc.*, 1958, **80**, 6568; (b) L. L. McCoy, *J. Org. Chem.*, 1960, **25**, 2078; (c) L. L. McCoy, *J. Am. Chem. Soc.*, 1962, **84**, 2246.

17 (a) K. C. Nicolaou, K. Namoto, A. Ritzén, T. Ulven, M. Shoji, J. Li, G. D'Amico, D. Liotta, C. T. French, M. Wartmann, K.-H. Altmann and P. Giannakakou, *J. Am. Chem. Soc.*, 2001, **123**, 9313; (b) A.-Y. Park, H. R. Moon, K. R. Kim, M. W. Chun and L. S. Jeong, *Org. Biomol. Chem.*, 2006, **4**, 4065; (c) J.-L. Ko, S.-H. Ueng, C.-W. Chiu, C.-C. Lai, Y.-H. Liu, S.-M. Peng and S.-H. Chiu, *Chem. Eur. J.*, 2010, **16**, 6950.

18 (a) M. Perez, C. del Pozo, F. Reyes, A. Rodriguez, A. Francesch, A. M. Echavarren and C. Cuevas, *Angew. Chem. Int. Ed.*, 2004, **43**, 1724; (b) B. O. Ashburn, R. G. Carter and L. N. Zakharov, *J. Am.*

Chem. Soc., 2007, **129**, 9109; (c) X. Guo, T. Liu, C. R. Valenzano, Z. Deng and D. E. Cane, *J. Am. Chem. Soc.*, 2010, **132**, 14694.

19 (a) P. Magnus, F. Tavares and N. Westwood, *Tetrahedron Lett.*, 1997, **38**, 1341; (b) B. M. Trost and F. D. Toste, *J. Am. Chem. Soc*., 2000, **122**, 11262; (c) K. C. Nicolaou, A. Ritzén, K. Namoto, R. M. Buey, J. F. Dıíaz, J. Andreu, M. Wartmann, K.-H. Altmann, A. O'Brate and P. Giannakakou, *Tetrahedron*, 2002, **58**, 6413.

20 (a) H. Nemoto, H. Kurobe, K. Fukumoto and T. Kametani, *J. Org. Chem*., 1986, **51**, 5311; (b) A. Corbu, M. Perez, M. Aquino, P. Retailleau and S. Arseniyadis, *Org. Lett.*, 2008, **10**, 2853.

21 B. Gebhardt, C. M. Konig, C. Schleth, M. Dauber and U. Koert, *Chem. Eur. J*., 2010, **16**, 5934.

22 (a) J. Xu, E. J. E. Caro-Diaz, M. H. Lacoske, C.-I. Hung, C. Jamora and E. A. Theodorakis, *Chem. Sci*., 2012, **3**, 3378; (b) C. I. Turner, R. M. Williamson, P. Turner and M. S. Sherburn, *Chem. Commun.*, 2003, 1610.

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Asymmetric Synthesis of 3,3,5,5-Tetrasubstituted 1,2-Dioxolanes: Total Synthesis of Epiplakinic Acid F

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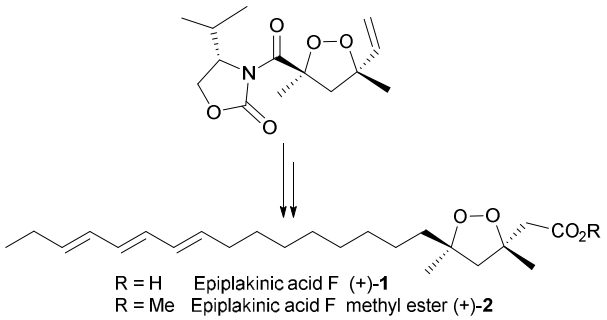

R = H Epiplakinic acid F (+)-**1**
R = Me Epiplakinic acid F methyl ester (+)-**2**