

# Development of a Concise and Diversity-Oriented Approach for the Synthesis of Plecomacrolides via the Diene-ene RCM

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## Supporting Information

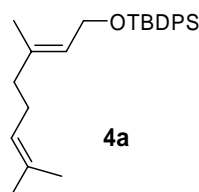
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for the syntheses of compounds **15** to **33**.

## General Information

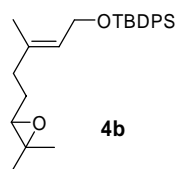
1,7-heptanediol, 1,8-octanediol, 18-crown-6, MeMgCl, n-BuLi, TBAF, Geraniol, TBDPSCl, 10% palladium on activated carbon, 3-buten-1,2-diol, and 3-butene-1-ol were purchased from Acros DIBAL-H, HMPA, EDC.HCl, TMSOK, KHMDS, DMAP, and allyldiphenylphosphine oxide were purchased from Aldrich. benzylidien-bis(tricyclohexylphosphine)dichlororuthenium (Grubbs' 1<sup>st</sup> generation catalyst) was purchased from Fluka and used without further purification. Imidazole, BiCl<sub>3</sub>, NaBH<sub>4</sub>, DMSO, oxalyl chloride, 95% ethanol, Hexane, dichloromethane, toluene, ethyl acetate, diethyl ether, petroleum ether and THF were purchase from Beijing Chemical Reagent Co. of China and used without further purification. Dry THF and toluene were distilled from sodium. Dry dichloromethane was distilled from calcium hydride. The boiling point of petroleum ether is between 60-90 °C. Silica gel (200-300 mesh) for purification was purchased from Qing Dao Hai Yang Chemical Industry Co. of China. <sup>1</sup>H-NMR was recorded at 200 MHz or 300 MHz with Varian Mercury 300 spectrometer and 400 MHz with Bruker Am-400 spectrometer. <sup>13</sup>C-NMR was recorded at 75 MHz with Varian Mercury 300 spectrometer. Mass spectrometric data were obtained using ZAB-HS mass spectrometer.

## Preparation of Compound 4a



To a solution of geraniol (14.7 g, 50 mmol) in dry THF (200 mL) were sequentially added imidazole (13.6 g, 200 mmol) and, TBDPSCl (30.2 g, 110 mmol) *via* syringe at 0 °C. After stirring for 9 h at room temperature, the reaction mixture was first quenched with water (100 mL), and then extracted with Et<sub>2</sub>O (3 x 100 mL). The combined organic layer was washed with brine and dried over Na<sub>2</sub>SO<sub>4</sub>. The solvent was removed under vacuum, and the residue was purified by flash chromatography (40/1 = petroleum ether/ethyl acetate) to give **1** as oil 37.2 g in 95% yield. <sup>1</sup>H NMR (300 MHz, CDCl<sub>3</sub>): δ 7.68-7.72 (m, 4H), 7.68-7.72 (m, 6H), 5.39 (t, *J* = 6.3 Hz, 1H), 5.09 (t, *J* = 5.4 Hz, 1H), 4.23 (d, *J* = 6.3 Hz, 2H), 1.96-2.08 (m, 4H), 1.64 (s, 3H), 1.60 (s, 3H), 1.43 (s, 3H), 1.06 (s, 9H); <sup>13</sup>C NMR (50 MHz, CDCl<sub>3</sub>): δ 136.9, 135.6, 134.0, 131.5, 129.5, 127.6, 124.1, 124.0, 61.1, 39.5, 26.8, 26.3, 25.7, 19.1, 17.7, 16.3.

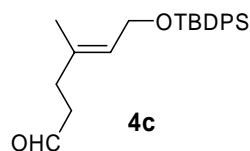
## Preparation of Compound 4b



To a solution of **4a** (37.2 g, 95 mmol) in CH<sub>2</sub>Cl<sub>2</sub> (300 mL) was added m-CPBA (25.8 g, 75%, 104.5 mmol) in CH<sub>2</sub>Cl<sub>2</sub> (50 mL) was added at °C in drop-wise, then the reaction mixture was warmed to room temperature, and stirred for 5 h. The reaction mixture was quenched by addition of a saturated NaHCO<sub>3</sub> solution (100 mL), and extracted with ether (3 x 100 mL). The organic layer was washed with brine and dried over Na<sub>2</sub>SO<sub>4</sub>. The solvent was removed under

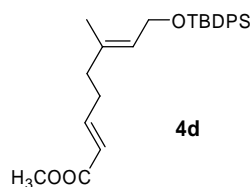
vacuum, and the residue was purified by flash chromatography (20/1 = petroleum ether/ethyl acetate) to give **2** as product **4b** 33.6 g in 87% yield.  $^1\text{H}$  NMR (300 MHz,  $\text{CDCl}_3$ ):  $\delta$  7.67-7.70 (m, 4H), 7.34-7.42 (m, 6H), 5.41 (t,  $J = 6.3$  Hz, 1H), 4.22 (d,  $J = 6.0$  Hz, 2H), 2.71 (t,  $J = 6.3$  Hz, 1H), 2.09-2.12 (m, 2H), 1.59-1.67 (m, 2H), 1.46 (s, 3H), 1.30 (s, 3H), 1.26 (s, 3H), 1.06 (s, 9H);  $^{13}\text{C}$  NMR (75 MHz,  $\text{CDCl}_3$ ):  $\delta$  136.1, 135.5, 135.4, 134.0, 129.4, 127.6, 127.5, 124.6, 63.9, 60.9, 58.2, 36.0, 27.1, 26.8, 24.8, 19.1, 18.7.

### Preparation of Compound 4c



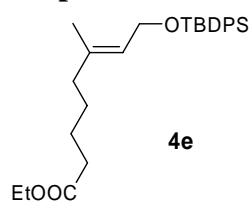
To a solution of **4b** (16.8 g, 41 mmol) in THF (200 mL) was added  $\text{HIO}_4 \cdot 2\text{H}_2\text{O}$  (20.9 g, 45 mmol) in water (30 mL) at  $0^\circ\text{C}$  in drop-wise, and the reaction mixture was stirred at same temperature for 4 hours. The reaction mixture was then quenched with brine and extracted with  $\text{Et}_2\text{O}$  (3 x 75 mL), and the organic layer was dried over  $\text{Na}_2\text{SO}_4$ . The solvent was removed under vacuum, and the residue was purified by flash chromatography (20/1 = petroleum ether/ethyl acetate) to give **3** 15.2 g in 95% yield;  $^1\text{H}$  NMR (200 MHz,  $\text{CDCl}_3$ ):  $\delta$  9.71 (t,  $J = 1.8$  Hz, 1H), 7.66-7.69 (m, 4H), 7.34-7.45 (m, 6H), 5.38-5.39 (m, 1H), 4.22 (d,  $J = 6.3$  Hz, 2H), 2.45-2.51 (m, 2H), 2.26 (t,  $J = 7.2$  Hz, 2H), 1.43 (s, 3H), 1.06 (s, 9H);  $^{13}\text{C}$  NMR (50 MHz,  $\text{CDCl}_3$ ):  $\delta$  202.0, 135.5, 134.8, 134.7, 133.8, 129.5, 127.5, 124.8, 60.8, 41.7, 31.3, 26.7, 26.5, 19.0, 16.3.

### Preparation of Compound 4d



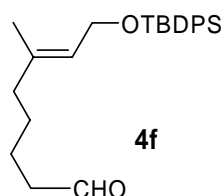
To a solution of aldehyde **4c** (7.33 g, 20 mmol) in dry toluene (100 mL) was added (carbmethoxymethylidene)triphenylphosphorane (20 g, 60 mmol) at room temperature, and the mixture was then stirred at  $80^\circ\text{C}$  for 4 hr. The mixture was then cooled to room temperature, and diluted with petroleum ether (100 mL). The precipitate was filtered off, and the filtrate was then concentrated. The residue was purified by flash chromatography (30/1 = petroleum ether/ethyl acetate) to give **4** 6.85 g in 81% yield;  $^1\text{H}$  NMR (300 MHz,  $\text{CDCl}_3$ ):  $\delta$  7.67-7.70 (m, 4H), 7.34-7.44 (m, 6H), 6.92-9.98 (m, 1H), 5.83 (d,  $J = 15.6$  Hz, 1H), 5.40 (t,  $J = 6.3$  Hz, 1H), 4.22 (d,  $J = 6.3$  Hz, 2H), 3.69 (s, 3H), 2.25-2.30 (m, 2H), 2.11 (t,  $J = 7.2$  Hz, 2H), 1.43 (s, 3H), 1.06 (s, 9H).

### Preparation of Compound 4e



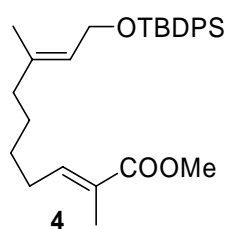
To a solution of **4d** (6.85 g, 16.2 mmol) in 95% EtOH (100 mL) was added BiCl<sub>3</sub> (5.10 g, 16.2 mmol), followed by addition of NaBH<sub>4</sub> (6.16 g, 162 mmol) in several portions over 20 min at room temperature. After stirring at room temperature for 4 hours, the reaction mixture was cooled to 0 °C, and then carefully quenched with water (50 mL). The mixture was filtered through celite, and the filtrate was concentrated under vacuum to remove ethanol, and the resulting solution was extracted with Et<sub>2</sub>O (3 x 75 mL). The combined organic layer was washed with brine and dried over Na<sub>2</sub>SO<sub>4</sub>. The solvent was removed under vacuum, and the residue was purified by flash chromatography (30/1 = petroleum ether/ethyl acetate) to give **5** 4.83 g in 68% yield; <sup>1</sup>H NMR (300 MHz, CDCl<sub>3</sub>): δ 7.68-7.71 (m, 4H), 7.33-7.43 (m, 6H), 5.38 (t, *J* = 6.3 Hz, 1H), 4.22 (d, *J* = 6.3 Hz, 2H), 4.12 (q, *J* = 7.2 Hz, 2H), 2.27-2.32 (m, 2H), 1.95 (t, *J* = 6.3 Hz, 2H), 1.52-1.68 (m, 2H), 1.35-1.45 (m, 5H), 1.22 (t, *J* = 7.2 Hz, 3H), 1.04 (s, 9H); <sup>13</sup>C NMR (75 MHz, CDCl<sub>3</sub>): δ 173.6, 136.6, 135.5, 133.9, 129.4, 127.5, 124.2, 61.0, 60.1, 38.9, 34.2, 26.9, 26.8, 24.5, 19.1, 16.0, 14.2.

### Preparation of Compound 4f



To a solution of **4e** (4.83 g, 11 mmol) in dry toluene (50 mL) was added DIBAL-H (1.0 M in toluene 22 mL, 22 mmol) at -78 °C in drop-wise over 20 min. and then the mixture was stirred at the same temperature for 3 hr. The reaction mixture was quenched by slowly adding EtOAc (10 mL) -78 °C, and continually stirred at the same temperature for another 20 min, and gradually warmed up to room temperature. The reaction mixture was then poured carefully into a rapid stirred mixture of saturated (Rochelle's salt solution (potassium sodium tartrate tetrahydrate, 100 mL), and the resultant cloudy mixture was stirred vigorously until the organic layer became clear. The aqueous phase was extracted with EtOAc (3 x 50 mL), and the combined organic layer was dried over Na<sub>2</sub>SO<sub>4</sub>. The solvent was removed under vacuum, and the residue was purified by flash chromatography (15/1 = petroleum ether/ethyl acetate) to give **6** 3.56g in 82% yield; <sup>1</sup>H NMR (300 MHz, CDCl<sub>3</sub>): δ 9.74 (t, *J* = 1.8 Hz, 1H), 7.65-7.71 (m, 4H), 7.34-7.44 (m, 6H), 5.37 (t, *J* = 6.3 Hz, 1H), 4.22 (d, *J* = 6.3 Hz, 2H), 2.39-2.44 (m, 2H), 1.98 (t, *J* = 7.2 Hz, 2H), 1.53-1.64 (m, 2H), 1.25-1.45 (m, 5H), 1.04 (s, 9H); <sup>13</sup>C NMR (75 MHz, CDCl<sub>3</sub>): δ 202.7, 136.4, 136.5, 133.9, 129.5, 127.5, 124.4, 60.9, 43.7, 39.0, 26.9, 26.8, 21.5, 19.1, 16.1.

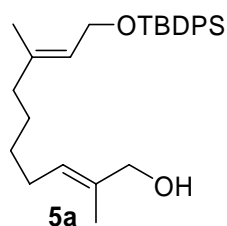
### Preparation of Compound 4



To a solution of aldehyde **4f** (3.56 g, 9 mmol) in dry toluene (50 mL) was added

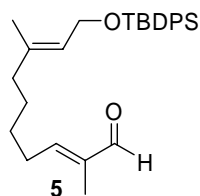
(carbomethoxyethylidene)triphenylphosphorane (9.0 g, 27 mmol) at room temperature, and the mixture was then stirred at 80 °C for 4 h. The reaction was then cooled to room temperature, followed by dilution with petroleum ether (100 mL). The formed precipitate was filtered off, and the filtrate was concentrated under vacuum, and the residue was purified by flash chromatography (30/1 = petroleum ether/ethyl acetate) to give **7** (3.55 g, 85% yield);  $^1\text{H}$  NMR (300 MHz,  $\text{CDCl}_3$ ):  $\delta$  7.68-7.72 (m, 4H), 7.31-7.43 (m, 6H), 6.73-6.81 (m, 1H), 5.38 (t,  $J$  = 5.8 Hz 1H), 4.23 (d,  $J$  = 5.8 Hz, 2H), 3.72 (s, 3H), 2.16 (m, 2H), 1.98 (m, 2H), 1.67 (s, 3H), 1.43 (s, 3H), 1.04 (s, 9H);  $^{13}\text{C}$  NMR (75 MHz,  $\text{CDCl}_3$ ):  $\delta$  168.6, 142.2, 136.7, 135.5, 134.0, 129.4, 127.5, 127.4, 124.3, 61.0, 51.5, 39.1, 29.4, 28.5, 28.0, 27.2, 26.8, 19.1, 16.1, 12.3.

### Preparation of Compound 5a



To a solution of **4** (3.55 g, 7.65 mmol) in dry toluene (50 mL) was added DIBAL-H (1.0 M in toluene 19.1 mL, 19.1 mmol) at – 78 °C in dropwise over 20 min. and the mixture was stirred at the same temperature for 3 hr. The reaction was quenched by slow addition of EtOAc (10 mL) at – 78 °C, and then gradually warmed up to room temperature. The reaction mixture was poured carefully into a rapid stirred mixture of saturated Rochelle's salt solution (potassium sodium tartrate tetrahydrate, 100 mL), and the resultant cloudy mixture was stirred vigorously until the organic layer became clear. The aqueous phase was extracted with EtOAc (3 x 50 mL), and the combined organic phase was dried over  $\text{Na}_2\text{SO}_4$ . The solvent was removed under vacuum, and the residue was purified by flash chromatography (4/1 = petroleum ether/ethyl acetate) to give **5a** (3.08 g in 92% yield);  $^1\text{H}$  NMR (300 MHz,  $\text{CDCl}_3$ ):  $\delta$  7.68-7.72 (m, 4H), 7.34-7.42 (m, 6H), 5.37-5.41 (m, 2H), 4.21 (d,  $J$  = 6.3 Hz, 2H), 4.00 (d,  $J$  = 5.7 Hz, 2H), 1.94-2.04 (m, 4H), 1.66 (s, 3H), 1.25-1.42 (m, 8H), 1.06 (s, 9H);  $^{13}\text{C}$  NMR (75 MHz,  $\text{CDCl}_3$ ):  $\delta$  137.1, 135.6, 134.6, 134.0, 129.5, 127.5, 126.4, 123.9, 69.0, 61.1, 39.3, 29.0, 27.4, 27.2, 26.8, 19.1, 16.1, 13.7.

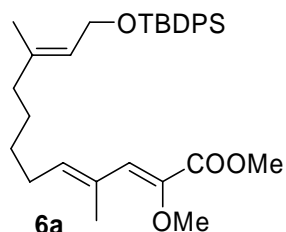
### Preparation of Compound 5



To a solution of **5a** (3.08 g, 7.04 mmol) in dry  $\text{CH}_2\text{Cl}_2$  (10 mL) was added Dess-Martin periodinane reagent (3.28 g, 7.74 mmol) at 0 °C in several portions during half hr. and the reaction mixture was stirred for additional 30 min at room temperature. To this solution was added petroleum ether (20 mL), and the formed precipitate was filtered off, and the filtrate was concentrated under vacuum. The residue was purified by flash chromatography (15/1 = petroleum ether/ethyl acetate) to give **5** (2.75 g, 90% yield).  $^1\text{H}$  NMR (300 MHz,  $\text{CDCl}_3$ ) for compound **5**:

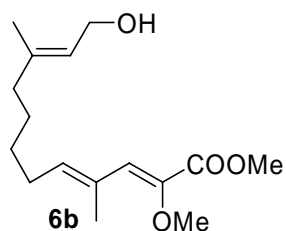
$\delta$  9.40 (s, 1H), 7.68-7.70 (m, 4H), 7.24-7.44 (m, 6H), 6.45-6.50 (m, 1H), 5.37-5.38 (m, 1H), 4.23 (d,  $J = 6.0$  Hz, 2H), 2.33-2.36 (m, 2H), 2.00-2.02 (m, 2H), 1.70 (s, 3H), 1.43-1.56 (m, 7H), 1.03 (s, 9H);  $^{13}\text{C}$  NMR (75 MHz,  $\text{CDCl}_3$ ):  $\delta$  195.3, 154.8, 139.3, 136.6, 135.5, 133.9, 129.5, 127.5, 124.4, 61.0, 39.0, 29.3, 28.8, 27.8, 27.2, 19.1, 16.1, 14.1.

### Preparation of Compound 6a



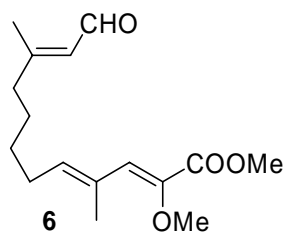
To a solution of methyl 2-methoxy-2-(diisopropoxyphosphoryl)acetate (2.14 g, 8.0 mmol) in dry THF (30 mL) was sequentially added 18-crown-6 (2.11 g, 8.0 mmol), and KHMDS (0.5 M in toluene 16 mL, 8 mmol) in dropwise, and the mixture was stirred for 30 min. To this solution was added aldehyde **9** (1.74 g, 4.0 mmol) in THF (10 mL) in dropwise at 0 °C, and the mixture was stirred for 0.5 hr, and then warmed up to warm. After stirring at room temperature for 10 h, the reaction mixture was quenched with saturated aqueous  $\text{NH}_4\text{Cl}$  (20 mL), and the mixture was extracted with  $\text{Et}_2\text{O}$  (3 x 20 mL), and the extracts were dried over  $\text{Na}_2\text{SO}_4$ . The solvent was removed under vacuum, and the residue was purified by flash chromatography (30/1 = petroleum ether/ethyl acetate) to give **6a** (1.87 g, 90% yield);  $^1\text{H}$  NMR (300 MHz,  $\text{CDCl}_3$ ):  $\delta$  7.68-7.71 (m, 4H), 7.34-7.41 (m, 6H), 6.62 (s, 1H), 5.81 (t,  $J = 7.5$  Hz, 1H), 5.37 (t,  $J = 6.3$  Hz, 1H), 4.22 (d,  $J = 6.3$  Hz, 2H), 3.77 (s, 3H), 3.68 (s, 3H), 1.95-1.98 (m, 2H), 1.75 (s, 3H), 1.26-1.42 (m, 9H), 1.03 (s, 9H);  $^{13}\text{C}$  NMR (75 MHz,  $\text{CDCl}_3$ ):  $\delta$  165.4, 139.5, 137.0, 135.6, 134.1, 131.5, 129.8, 129.8, 127.5, 124.2, 61.1, 60.2, 51.8, 39.2, 28.6, 28.2, 27.2, 26.8, 19.1, 16.1, 14.4.

### Preparation of Compound 6b



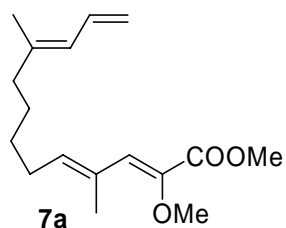
To a solution of **6a** (1.87 g, 3.6 mmol) in THF (12 mL) was added HOAc (216 mg, 3.6 mmol), followed by TBAF (1 M in THF 3.6 mL, 3.6 mmol), and the mixture was stirred at room temperature for 24 hr. The reaction mixture was quenched with saturated aqueous  $\text{NaHCO}_3$  (5 mL), and extracted with EtOAc (3 x 20 mL), and the combined organic layer was dried over  $\text{Na}_2\text{SO}_4$ . The solvent was removed under vacuum, and the residue was purified by flash chromatography (8/1 to 4/1 = petroleum ether/ethyl acetate) to give **6b** (863 mg, 85% yield).  $^1\text{H}$  NMR (300 MHz,  $\text{CDCl}_3$ ):  $\delta$  6.61 (s, 1H), 5.81 (t,  $J = 7.5$  Hz, 1H), 5.37-5.42 (m, 1H), 4.14 (d,  $J = 6.9$  Hz, 2H), 3.78 (s, 3H), 3.65 (s, 3H), 1.99-2.19 (m, 4H), 1.96 (s, 3H), 1.43 (s, 3H), 1.37-1.41 (m, 4H);  $^{13}\text{C}$  NMR (75 MHz,  $\text{CDCl}_3$ ):  $\delta$  165.3, 142.3, 139.2, 139.0, 131.4, 129.6, 123.5, 60.1, 59.0, 51.7, 39.2, 28.5, 27.1, 15.9, 14.3.

## Preparation of Compound 6



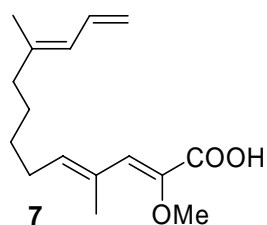
To a solution of **6b** (836 mg, 3.06 mmol) in dry CH<sub>2</sub>Cl<sub>2</sub> (10 mL) were sequentially added solid NaHCO<sub>3</sub> (514 mg, 6.12 mmol), and Dess-Martin periodinane reagent (1.43 g, 3.37 mmol) at 0 °C, and the mixture was stirred at room temperature for 30 min. The reaction mixture was then diluted with petroleum ether (20 mL), and the formed precipitate was filtered off. The filtrate was concentrated under vacuum, and the residue was purified by flash chromatography (15/1 = petroleum ether/ethyl acetate) to give **12** (557 mg, 65% yield).

### Preparation of Compound 7a



To a solution of methyltriphenyl phosphonium bromide (782 mg, 2.19 mmol) in dry THF (10 mL) was added NaHMDS (1.0 M in THF 2.19 mL, 2.19 mmol) at 0 °C in dropwise, and the mixture was stirred for 30 min. at the same temperature. To this solution was added aldehyde **6** (557 mg, 1.99 mmol) in THF (5 ml) *via* cannula, and the mixture was stirred at 0 °C for 3 hr. The reaction was quenched with saturated aqueous NH<sub>4</sub>Cl (10 mL), and extracted with Et<sub>2</sub>O (3 x 15 mL), and the organic layer was dried over Na<sub>2</sub>SO<sub>4</sub>. The solvent was removed under vacuum, and the residue was purified by flash chromatography (20/1 = petroleum ether/ethyl acetate) to give **7a** as an oil (232 mg, 42% yield).

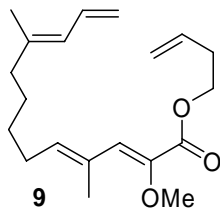
### Preparation of Compound 7



To a solution of **7a** (232 mg, 0.84 mmol) in dry THF (2 mL) was added potassium trimethylsilanolate (216 mg, 1.68 mmol) in one portion at room temperature, and the mixture was stirred at the same temperature for 24 h. The reaction was quenched with saturated aqueous NH<sub>4</sub>Cl (3 mL), and extracted with diluted with EtOAc (2 x 3 mL). The aqueous phase was then acidified to pH3 with aqueous HCl (2 N), and then extracted with EtOAc (3 x 15 mL), and the combined

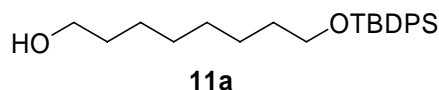
extracts were dried over Na<sub>2</sub>SO<sub>4</sub>. The solvent was removed under vacuum, and the residue was purified by flash chromatography (1/1 = petroleum ether/ethyl acetate) to give **7** (188 mg, 85% yield).

### Preparation of Compound 9



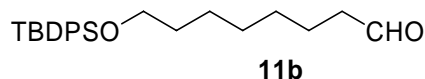
To a solution of **7** (188 mg, 0.71 mmol) and 3-butene-1-ol (0.091 mL, 1.07 mmol) in dry CH<sub>2</sub>Cl<sub>2</sub> (2 mL) were sequentially added DMAP (130 mg, 1.07 mmol), and EDC·HCl (205 mg, 1.07 mmol) at room temperature, and reaction mixture was stirred at the same temperature for 10 hr. The reaction mixture was then diluted with CH<sub>2</sub>Cl<sub>2</sub> (10 mL), and then washed with water (2 mL) and brine (2 mL), and the organic phase was dried over Na<sub>2</sub>SO<sub>4</sub>. The solvent was removed under vacuum, and the residue was purified by flash chromatography (40/1 = hexane/ethyl acetate) to give **15** (198 mg, 88% yield); <sup>1</sup>H NMR (400 MHz, CDCl<sub>3</sub>): δ 6.52-6.62 (m, 1H) 6.59 (s, 1H), 5.77-5.85 (m, 3H), 5.06-5.16 (m, 3H), 4.97 (dd, *J* = 10.8 Hz, *J* = 1.6 Hz, 1H), 4.24 (t, *J* = 6.6 Hz, 2H), 3.65 (s, 3H), 2.43-2.48 (m, 2H), 2.13-2.18 (m, 2H), 2.05 (t, *J* = 7.0 Hz, 2H), 1.96 (s, 3H), 1.74 (s, 3H), 1.36-1.47 (m, 4H); <sup>13</sup>C NMR (75 MHz, CDCl<sub>3</sub>): δ 164.9, 142.6, 139.4, 134.0, 133.2, 131.6, 125.5, 117.3, 114.5, 63.9, 60.2, 39.6, 33.1, 28.7, 28.1, 27.3, 16.5, 14.4.

### Preparation of Compound 11a



To a solution of 1,8-octanediol (5.84 g, 40 mmol) in dry THF (300 mL) were sequentially added imidazole (2.72 g, 40 mmol), and TBDPSCl (11.0 g, 40 mmol) *via* syringe at 0 °C, and the mixture was stirred at room temperature for 9 hr. The reaction was quenched with water (50 mL), and then extracted with Et<sub>2</sub>O (3 x 150 mL). The combined organic phase was washed with brine (2 x 20 mL) and dried over Na<sub>2</sub>SO<sub>4</sub>. The solvent was removed under vacuum, and the residue was purified by flash chromatography (from 10/1 to 4/1 = petroleum ether/ethyl acetate) to give **16** (8.92 g, 58% yield).

### Preparation of Compound 11b

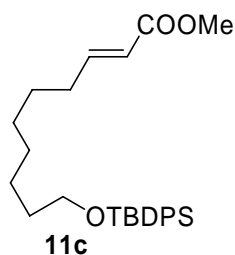


To a solution of oxalyl chloride (3.83 g, 30.2 mmol) in dry CH<sub>2</sub>Cl<sub>2</sub> (30 mL) was added a solution of dimethyl sulfoxide (2.36 g, 30.2 mmol) in dry CH<sub>2</sub>Cl<sub>2</sub> (20 mL) in dropwise at – 78 °C, and the mixture was stirred at the same temperature for 30 min. To this solution was added a solution of alcohol **16** (8.92 g, 23.2 mmol) in dry CH<sub>2</sub>Cl<sub>2</sub> (100 mL) in dropwise, and the resultant



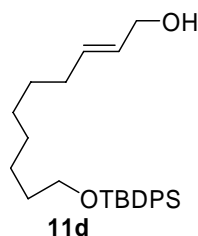
solution was stirred for 30 min at  $-78\text{ }^{\circ}\text{C}$ . After addition of triethylamine (6.10 g, 60.4 mmol), the reaction mixture was allowed to warm to  $0\text{ }^{\circ}\text{C}$ , and then stirred for additional 1 h before quenching with water (30 mL). The mixture was extracted with  $\text{CH}_2\text{Cl}_2$  (3 x 30 mL), and the combined organic phase was washed with brine (2 x 5 mL) and dried over  $\text{Na}_2\text{SO}_4$ . The solvent was removed under vacuum, and the residue was purified by flash chromatography (15/1 = petroleum ether/ethyl acetate) to give **11b** (8.08 g, 91% yield).

### Preparation of Compound 11c



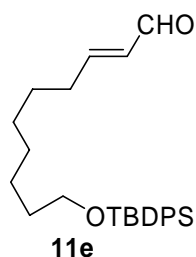
To a solution of aldehyde **11b** (8.08 g, 21.1 mmol) in dry toluene (100 mL) was added (carbmethoxymethylidene)triphenylphosphorane (21.1 g, 63.3 mmol) at room temperature and the mixture was stirred at  $80\text{ }^{\circ}\text{C}$  for 4 hr. The reaction mixture was then cooled to room temperature, and diluted with petroleum ether (200 mL). The formed precipitate was filtered off and the filtrate was concentrated under vacuum. The residue was purified by flash chromatography (30/1 petroleum ether/ethyl acetate) to give **11c** (8.15 g, 88% yield).

### Preparation of Compound 11d



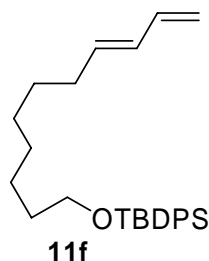
To a solution of **11c** (8.15 g, 18.5 mmol) in dry toluene (100 mL) was added DIBAL-H (1.0 M in toluene 46.3 mL, 46.3 mmol) at  $-78\text{ }^{\circ}\text{C}$  in dropwise over 20 min, and the mixture was stirred 4 hr at the same temperature. The reaction was quenched by slow addition of EtOAc (20 mL) at  $-78\text{ }^{\circ}\text{C}$ , and the mixture was stirred at the same temperature for 20 min. and then gradually warmed up to room temperature. The mixture was poured carefully into a rapid stirred mixture of saturated aqueous Rochelle's salt (potassium sodium tartrate tetrahydrate, 200 mL), and the resultant cloudy mixture was stirred vigorously until the organic layer became clear. The aqueous phase was extracted with EtOAc (3 x 100 mL), and combined organic phase was dried over  $\text{Na}_2\text{SO}_4$ . The solvent was removed under vacuum, and the residue was purified by flash chromatography (4/1 = petroleum ether/ethyl acetate) to give **11d** (6.84 g, 90% yield).  $^1\text{H}$  NMR (300 MHz,  $\text{CDCl}_3$ ):  $\delta$  7.64-7.69 (m, 4H), 7.32-7.45 (m, 6H), 5.62-5.69 (m, 2H), 4.07 (d,  $J = 4.2$  Hz, 2H), 3.65 (t,  $J = 6.6$  Hz, 2H), 1.98-2.04 (m, 2H), 1.49-1.59 (m, 2H), 1.26-1.34 (m, 8H), 1.05 (s, 9H);  $^{13}\text{C}$  NMR (75 MHz,  $\text{CDCl}_3$ ):  $\delta$  135.6, 134.2, 133.5, 129.5, 128.8, 127.5, 64.0, 63.8, 32.5, 32.2, 29.2, 29.1, 26.9, 25.7, 19.2.

### Preparation of Compound 11e



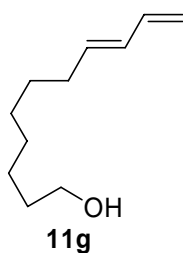
A solution of dimethyl sulfoxide (1.68 g, 21.6 mmol) in dry  $\text{CH}_2\text{Cl}_2$  (20 mL) was added to a solution of oxalyl chloride (2.74 g, 21.6 mmol) in dry  $\text{CH}_2\text{Cl}_2$  (30 mL) at  $-78^\circ\text{C}$  in dropwise, and the mixture was stirred at the same temperature for 30 min. To this solution was added a solution of alcohol **11d** (6.84 g, 16.6 mmol) in dry  $\text{CH}_2\text{Cl}_2$  (100 mL) in dropwise, and the reaction mixture was stirred at  $-78^\circ\text{C}$  for 30 min. After addition of triethylamine (4.36 g, 43.2 mmol), the reaction mixture was allowed to warm to  $0^\circ\text{C}$ , and stirred for 1 h before quenching with water (20 mL). The mixture was then extracted with  $\text{CH}_2\text{Cl}_2$  (3 x 30 mL), and the combined organic phase was washed with brine (2 x 15 mL), and dried over  $\text{Na}_2\text{SO}_4$ . The solvent was removed under vacuum, and the residue was purified by flash chromatography (15/1 = petroleum ether/ethyl acetate) to give **11e** (6.11 g, 90% yield).  $^1\text{H}$  NMR (300 MHz,  $\text{CDCl}_3$ ):  $\delta$  9.50 (d,  $J = 7.8\text{ Hz}$ , 1H), 7.62-7.70 (m, 4H), 7.34-7.46 (m, 6H), 6.76-6.91 (m, 1H), 6.15 (dd,  $J = 15.6\text{ Hz}$ ,  $J = 7.8\text{ Hz}$ , 2H), 3.66 (t,  $J = 6.4\text{ Hz}$ , 2H), 2.26-2.37 (m, 2H), 1.15-1.64 (m, 10H), 1.05 (s, 9H);  $^{13}\text{C}$  NMR (75 MHz,  $\text{CDCl}_3$ ):  $\delta$  194.1, 158.9, 135.5, 134.1, 133.0, 129.5, 127.5, 63.9, 32.7, 32.4, 29.0, 27.7, 26.8, 25.6, 19.2.

### Preparation of Compound 11f



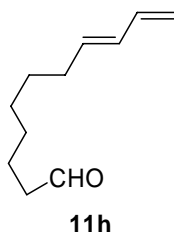
To a solution of methyltriphenyl phosphonium bromide (6.92 g, 19.4 mmol) in dry THF (10 mL) was added *n*-BuLi (2.5 M in hexane 7.15 mL, 17.9 mmol) at  $0^\circ\text{C}$  in dropwise, and the reaction mixture was stirred for 1 hr. To this solution was added a solution of aldehyde **11e** (6.11 g, 14.9 mmol) in THF *via* cannular at the same temperature, and the reaction mixture was stirred at  $50^\circ\text{C}$  for 3 hr. The reaction mixture was first cooled to room temperature, and then quenched with saturated aqueous  $\text{NH}_4\text{Cl}$  (15 mL). The mixture was extracted with  $\text{Et}_2\text{O}$  (3 x 30 mL), and the combined extracts were dried over  $\text{Na}_2\text{SO}_4$ . The solvent was removed under vacuum, and the residue was purified by flash chromatography (30/1 = petroleum ether/ethyl acetate) to give **11f** (4.97 g, 82% yield);  $^1\text{H}$  NMR (300 MHz,  $\text{CDCl}_3$ ):  $\delta$  7.65-7.70 (m, 4H), 7.31-7.39 (m, 6H), 6.21-6.35 (m, 1H), 5.98-6.10 (m, 1H), 5.65-5.76 (m, 1H), 4.92-5.12 (m, 2H), 3.65 (t,  $J = 6.4\text{ Hz}$ , 2H), 2.01-2.11 (m, 2H), 1.49-1.55 (m, 2H), 12.6-1.43 (m, 8H), 1.05 (s, 9H);  $^{13}\text{C}$  NMR (75 MHz,  $\text{CDCl}_3$ ):  $\delta$  137.3, 135.6, 134.2, 130.9, 129.5, 127.5, 114.6, 64.0, 32.5, 29.2, 29.1, 26.9, 25.7, 19.2.

### Preparation of Compound 11g



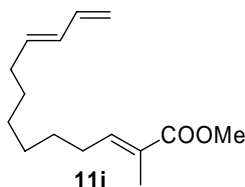
To a solution of **11f** (4.97 g, 12.2 mmol) in THF (20 mL) was added TBAF (7.70 g, 24.4 mmol) at room temperature, and the mixture was stirred at the same temperature for 4 hr. The reaction mixture diluted with water (20 mL), and then extracted with Et<sub>2</sub>O (3 x 20 mL). The combined organic phase was washed with brine (2 x 5 mL), and dried over Na<sub>2</sub>SO<sub>4</sub>. The solvent was removed under vacuum, and the residue was purified by flash chromatography (from 8/1 to 4/1 = petroleum ether/ethyl acetate) to give **11g** (1.95 g, 95% yield).

### Preparation of Compound 11h



To a solution of **11g** (1.95 g, 11.6 mmol) in dry CH<sub>2</sub>Cl<sub>2</sub> (20 mL) was added Dess-Martin periodinane reagent (5.41 g, 12.7 mmol) was added at 0 °C in several portions, and the reaction mixture was stirred at room temperature for 30 min. The mixture was diluted with petroleum ether (20 mL), and the formed precipitate was filtered off, and the filtrate was concentrated under vacuum at 0 °C, and the residue was purified by flash chromatography (20/1 = petroleum ether/Et<sub>2</sub>O) to give **23** (1.22 g, 63% yield): <sup>1</sup>H NMR (300 MHz, CDCl<sub>3</sub>): δ 9.77 (t, *J* = 1.8 Hz, 1H), 6.21-6.34 (m, 1H), 6.01-6.09 (m, 1H), 5.65-5.74 (m, 1H), 4.94-5.12 (m, 2H), 2.40-2.45 (m, 2H), 2.04-2.09 (m, 2H), 1.58-1.65 (m, 2H), 1.20-1.42 (m, 6H); <sup>13</sup>C NMR (75 MHz, CDCl<sub>3</sub>): δ 202.8, 137.2, 135.2, 131.0, 114.7, 43.8, 32.4, 28.9, 28.86, 28.81, 21.9.

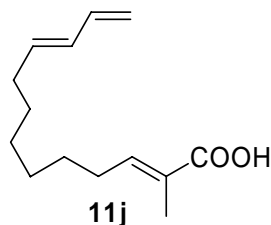
### Preparation of Compound 11i



To a solution of aldehyde **11h** (1.22 g, 7.31 mmol) in dry toluene (20 mL) was added (carbmethoxymethylidene)triphenylphosphorane (7.63 g, 21.9 mmol) at room temperature, and the reaction mixture was stirred at 80 °C for 4 hr. The reaction was first cooled to room temperature, and then diluted with petroleum ether (40 mL). The formed precipitate was filtered off, and the filtrate was concentrated under vacuum and the residue was purified by flash chromatography (20/1 = petroleum ether/ethyl acetate) to give **11i** (1.49 g, 86% yield): <sup>1</sup>H NMR

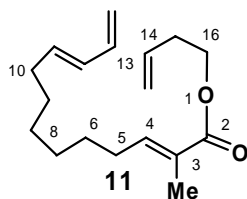
(300 MHz, CDCl<sub>3</sub>):  $\delta$  7.16-7.27 (m, 1H), 6.74-6.80 (m, 1H), 6.25-6.37 (m, 1H), 6.01-6.09 (m, 1H), 5.65-5.75 (m, 1H), 4.94-5.12 (m, 2H), 3.75 (s, 3H), 2.04-2.20 (m, 4H), 1.85 (s, 3H), 1.58-1.65 (m, 2H), 1.30-1.48 (m, 8H); <sup>13</sup>C NMR (75 MHz, CDCl<sub>3</sub>):  $\delta$  168.7, 142.7, 137.3, 135.3, 130.9, 127.4, 114.6, 51.6, 32.4, 29.1, 29.0, 28.9, 28.6, 28.4, 12.3.

### Preparation of Compound 11j



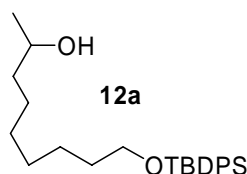
To a solution of **11i** (473 mg, 2 mmol) in dry THF (4 mL) was added potassium trimethylsilanolate (513 mg, 4 mmol) in one portion at room temperature, and the mixture was stirred at the same temperature for 24 hr. The reaction mixture was quenched with saturated aqueous NH<sub>4</sub>Cl (3 mL), and extracted with EtOAc (2 mL). The aqueous phase was acidified to pH3 with HCl (2 M), and extracted with EtOAc (3 x 15 mL), and the combined extracts were dried over Na<sub>2</sub>SO<sub>4</sub>. The solvent was removed under vacuum, and the residue was purified by flash chromatography (1/1 = petroleum ether/ethyl acetate) to give **11j** (369 mg, 83% yield).

### Preparation of Compound 11



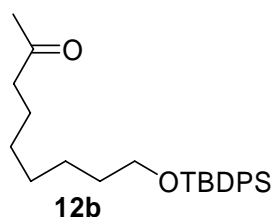
To a solution of **11j** (369 mg, 1.66 mmol) and 3-butene-1-ol (0.212 mL, 1.07 mmol) in dry CH<sub>2</sub>Cl<sub>2</sub> (2 mL) were sequentially added DMAP (304 mg, 2.49 mmol) and EDC·HCl (477 mg, 2.49 mmol), and the mixture was stirred for 10 hr. The reaction mixture was then diluted with CH<sub>2</sub>Cl<sub>2</sub> (5 mL), and washed with brine (2 mL), and the organic layer was dried over Na<sub>2</sub>SO<sub>4</sub>. The solvent was removed under vacuum, and the residue was purified by flash chromatography (40/1 = hexane/ethyl acetate) gave **11** (390 mg, 85% yield); <sup>1</sup>H NMR (300 MHz, CDCl<sub>3</sub>):  $\delta$  6.73-6.79 (m, 1H) 6.25-6.38 (m, 1H), 6.01-6.10 (m, 1H), 5.66-5.88 (m, 2H), 5.06-5.31 (m, 3H), 4.94-4.98 (m, 1H) 4.20 (t, *J* = 6.6 Hz, 2H), 2.39-2.47 (m, 2H), 2.05-2.20 (m, 4H), 1.82 (s, 3H), 1.30-1.46 (m, 8H); <sup>13</sup>C NMR (75 MHz, CDCl<sub>3</sub>):  $\delta$  168.2, 142.5, 137.3, 135.3, 134.2, 130.9, 127.6, 117.0, 114.6, 63.5, 33.1, 32.4, 29.2, 29.0, 28.9, 28.6, 28.5, 12.3.

### Preparation of Compound 12a



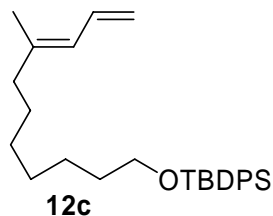
To a solution of methylmagnesium chloride (2.85 M in THF, 6.32 mL, 18 mmol) in dry THF (30 mL) was aldehyde **11b** (5.74 g, 15 mmol) in dry THF (20 mL) at 0 °C *via* cannular, and the mixture was stirred at the same temperature for 30 min. The reaction mixture was quenched with saturated aqueous NH<sub>4</sub>Cl (10 mL), and then extracted with Et<sub>2</sub>O (3 x 10 mL), and the combined extracts were dried over Na<sub>2</sub>SO<sub>4</sub>. The solvent was removed under vacuum, and the residue was purified by flash chromatography (6/1 = petroleum ether/ethyl acetate) to give **12a** (5.38 g, 90% yield); <sup>1</sup>H NMR (300 MHz, CDCl<sub>3</sub>): δ 7.64-7.71 (m, 4H), 7.35-7.46 (m, 6H), 3.75-3.81 (m, 1H), 3.66 (t, *J* = 6.6 Hz, 2H), 1.23-1.40 (m, 12H), 2.20 (d, *J* = 3.6 Hz, 3H), 1.05 (s, 9H); <sup>13</sup>C NMR (75 MHz, CDCl<sub>3</sub>): δ 135.5, 134.1, 129.4, 127.5, 68.1, 63.9, 39.3, 32.5, 29.6, 29.3, 26.8, 25.7, 23.5, 19.2.

### Preparation of Compound 12b



A solution of dimethyl sulfoxide (1.37 g, 17.6 mmol) in dry CH<sub>2</sub>Cl<sub>2</sub> (20 mL) was added to the solution of oxalyl chloride (2.23 g, 17.6 mmol) in dry CH<sub>2</sub>Cl<sub>2</sub> (30 mL) at – 78 °C in dropwise, and the mixture was stirred at the same temperature for 30 min. To this solution was added a solution of alcohol **12a** (5.38 g, 13.5 mmol) in dry CH<sub>2</sub>Cl<sub>2</sub> (50 mL) in dropwise, and the formed solution was stirred at – 78 °C for additional 30 min. After addition of triethylamine (3.56 g, 35.2 mmol), the reaction mixture was allowed to warm to 0 °C, and continually stirred for additional 1 hr. The reaction was first quenched with water (20 mL), and then extracted with CH<sub>2</sub>Cl<sub>2</sub> (3 x 20 mL). The combined organic phase was washed with brine (2 x 5 mL), and dried over Na<sub>2</sub>SO<sub>4</sub>. The solvent was removed under vacuum, and the residue was purified by flash chromatography (15/1 = petroleum ether/ethyl acetate) to give **12b** (4.71 g, 88% yield); <sup>1</sup>H NMR (300 MHz, CDCl<sub>3</sub>): δ 7.66-7.70 (m, 4H), 7.36-7.43 (m, 6H), 3.65 (t, *J* = 6.6 Hz, 2H), 2.41 (t, *J* = 7.5 Hz, 2H), 2.16 (s, 3H), 1.52-1.57 (m, 4H), 1.25-1.35 (m, 6H), 1.05 (s, 9H); <sup>13</sup>C NMR (75 MHz, CDCl<sub>3</sub>): δ 209.3, 135.5, 134.1, 129.5, 127.5, 63.9, 43.7, 32.5, 29.8, 29.1, 26.8, 25.6, 23.8, 19.2.

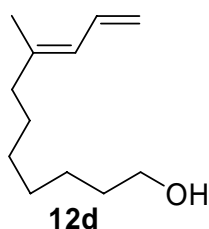
### Preparation of Compound 12c



*n*-BuLi (2.5 M in hexane 6.32 mL, 15.8 mmol) was added to a solution of allyldiphenylphosphine oxide (3.82 g, 15.8 mmol) and HMPA (5.66 g, 31.6 mmol) in dry THF (200 mL) at – 78 °C in dropwise, and the mixture was stirred at the same temperature. To this solution was added ketone **12b** (4.71 g, 11.9 mmol) in THF (30 mL) was added at the same

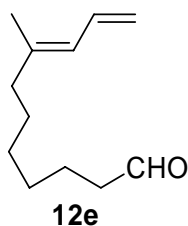
temperature during 15 min. The reaction mixture was first stirred at  $-78\text{ }^{\circ}\text{C}$  for 30 min. and then warmed to  $0\text{ }^{\circ}\text{C}$  for 10 min. and finally stirred at room temperature for 2 hr. The reaction mixture was quenched by addition of saturated aqueous  $\text{NH}_4\text{Cl}$  (20 mL), and extracted with  $\text{Et}_2\text{O}$  (3 x 50 mL), the combined extracts were dried over  $\text{Na}_2\text{SO}_4$ . The solvent was removed under vacuum and the residue was purified by flash chromatography (30/1 = petroleum ether/ethyl acetate) to give **12c** (3.50 g, 70% yield);  $^1\text{H}$  NMR (300 MHz,  $\text{CDCl}_3$ ):  $\delta$  7.67-7.70 (m, 4H), 7.35-7.45 (m, 6H), 6.52-6.65 (m, 1H), 5.85 (d,  $J = 11.7\text{ Hz}$ , 1H), 5.09 (dd,  $J = 16.8\text{ Hz}$ , 2.1 Hz, 1H), 4.97 (dd,  $J = 11.7\text{ Hz}$ , 2.1 Hz, 1H), 3.65 (t,  $J = 6.6\text{ Hz}$ , 2H), 2.03 (t,  $J = 7.5\text{ Hz}$ , 2H), 1.73 (s, 3H), 1.51-1.60 (m, 2H), 1.23-1.45 (m, 8H), 1.05 (s, 9H);  $^{13}\text{C}$  NMR (75 MHz,  $\text{CDCl}_3$ ):  $\delta$  140.0, 135.6, 124.1, 133.4, 129.5, 127.6, 125.2, 114.4, 64.0, 39.8, 32.5, 29.3, 29.2, 27.7, 26.9, 25.7, 19.2, 16.6.

### Preparation of Compound 12d



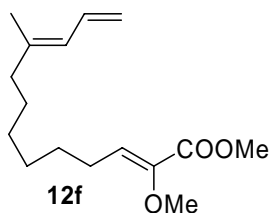
To a solution of **12c** (3.50 g, 8.33 mmol) in THF (20 mL) was added TBAF (5.27 g, 16.7 mmol) at room temperature, and the mixture was stirred at the same temperature for 4 hr. The reaction was quenched by addition of water (10 mL), and the mixture was extracted with  $\text{Et}_2\text{O}$  (3 x 20 mL). The combined organic phase was washed with brine, and dried over  $\text{Na}_2\text{SO}_4$ . The solvent was removed under vacuum, and the residue was purified by flash chromatography (from 8/1 to 4/1 = petroleum ether/ethyl acetate) to give **12d** (1.46 g, 96% yield);  $^1\text{H}$  NMR (300 MHz,  $\text{CDCl}_3$ ):  $\delta$  6.52-6.62 (m, 1H), 5.85 (d,  $J = 11.1\text{ Hz}$ , 1H), 5.09 (dd,  $J = 16.8\text{ Hz}$ , 2.1 Hz, 1H), 4.97 (dd,  $J = 11.7\text{ Hz}$ , 2.1 Hz, 1H), 3.64 (t,  $J = 6.3\text{ Hz}$ , 2H), 2.04 (t,  $J = 7.5\text{ Hz}$ , 2H), 1.77 (s, 3H), 1.23-1.60 (m, 10H);  $^{13}\text{C}$  NMR (75 MHz,  $\text{CDCl}_3$ ):  $\delta$  139.9, 133.4, 125.2, 114.4, 63.0, 39.7, 32.7, 29.3, 29.2, 27.6, 25.6, 16.5.

### Preparation of Compound 12e



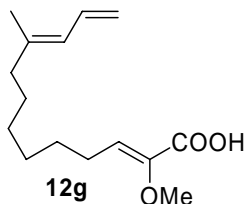
To a solution of **12d** (1.46 g, 8.0 mmol) in dry  $\text{CH}_2\text{Cl}_2$  (15 mL) was added Dess-Martin periodinane reagent (3.73 g, 8.8 mmol) at  $0\text{ }^{\circ}\text{C}$  in several portions during 20 min. and the reaction mixture was then stirred at room temperature for 30 min. The reaction mixture was diluted with petroleum ether (20 mL), and the formed precipitate was filtered off. The filtrate was concentrated under vacuum at  $0\text{ }^{\circ}\text{C}$ , and the residue was purified by flash chromatography (20/1 = petroleum ether /  $\text{Et}_2\text{O}$ ) to give **12e** (995 mg, 69% yield).

### Preparation of Compound 12f



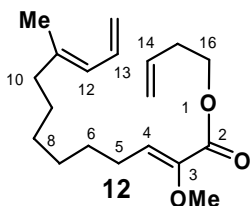
To a solution of methyl 2-methoxy-2-(diisopropoxyphosphoryl)acetate (536 mg, 2.0 mmol) in dry (10 mL) THF were sequentially added 18-crown-6 (528 mg, 2.0 mmol) and KHMDS (0.5 M in toluene 4 mL, 2.0 mmol) in dropwise at 0 °C, and the reaction mixture was stirred at the same temperature for 30 min. To this solution was added a solution of aldehyde **12e** (180 mg, 1.0 mmol) in THF at 0 °C in dropwise, and the mixture was stirred for another 30 min. The reaction mixture was then stirred at room temperature for 10 hr. and then quenched with a saturated aqueous solution of NH<sub>4</sub>Cl (10 mL). The mixture was first extracted with Et<sub>2</sub>O (3 x 20 mL), and then dried over Na<sub>2</sub>SO<sub>4</sub>. The solvent was removed under vacuum, and the residue was purified by flash chromatography (20/1 = petroleum ether/ethyl acetate) to give **12f** (192 mg, 72% yield); <sup>1</sup>H NMR (300 MHz, CDCl<sub>3</sub>): δ 6.52-6.61 (m, 1H), 5.85 (d, *J* = 10.8 Hz, 1H), 5.22 (t, *J* = 7.5 Hz, 1H), 5.09 (dd, *J* = 16.8 Hz, 1.8 Hz, 1H), 4.97 (d, *J* = 10.8 Hz, 1H), 3.83 (s, 3H), 3.65 (s, 3H), 2.43-2.51 (m, 2H), 2.04 (t, *J* = 7.5 Hz, 2H), 1.77 (s, 3H), 1.26-1.48 (m, 8H); <sup>13</sup>C NMR (75 MHz, CDCl<sub>3</sub>): δ 163.9, 145.1, 139.8, 133.4, 125.2, 115.1, 114.3, 55.5, 51.8, 39.7, 30.2, 29.1, 27.6, 26.5, 16.5.

### Preparation of Compound 12g



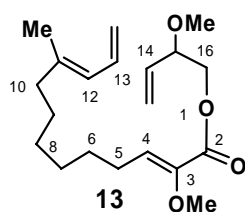
To a solution of **12f** (192 mg, 0.72 mmol) in dry THF (2 mL) was added potassium trimethylsilanolate (185 mg, 1.44 mmol) at room temperature in one portion, and the mixture was stirred at the same temperature for 24 hr. The reaction mixture was quenched with saturated aqueous NH<sub>4</sub>Cl (2 mL), and extracted with EtOAc (2 mL). The aqueous phase was first acidified to pH 3 with aqueous HCl (2 M), and extracted with EtOAc (3 x 10 mL), and the combined extracts were dried over Na<sub>2</sub>SO<sub>4</sub>. The solvent was removed under vacuum, and the residue was purified by flash chromatography (1/1 = petroleum ether/ethyl acetate) to give **12g** (144 mg, 79% yield).

### Preparation of Compound 12



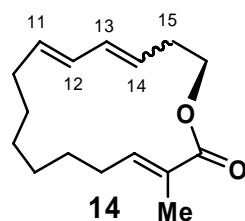
To a solution of **12g** (50 mg, 0.2 mmol) and 3-butene-1-ol (21.6 mg, 0.3 mmol) in dry  $\text{CH}_2\text{Cl}_2$  (1 mL) were sequentially added DMAP (36.7 mg, 0.3 mmol) and EDC·HCl (57 mg, 0.3 mmol) at room temperature, and the mixture was stirred at the same temperature for 10 hr. The reaction mixture was first diluted with  $\text{CH}_2\text{Cl}_2$  (20 mL), and then washed with brine (2 x 3 mL), and the organic phase was dried over  $\text{Na}_2\text{SO}_4$ . The solvent was removed under vacuum, and the residue was purified by flash chromatography (40/1 = hexane/ethyl acetate) to give **12** (46 mg, 74% yield);  $^1\text{H}$  NMR (300 MHz,  $\text{CDCl}_3$ ):  $\delta$  6.52-6.65 (m, 1H), 5.77-5.89 (m, 2H), 5.17-5.23 (m, 2H), 5.07-5.12 (m, 2H), 4.97 (d,  $J$  = 10.2 Hz, 1H), 4.28 (t,  $J$  = 6.6 Hz, 2H), 3.59 (s, 3H), 2.40-2.51 (m, 4H), 2.04 (t,  $J$  = 7.5 Hz, 2H), 1.75 (s, 3H), 1.20-1.42 (m, 8H);  $^{13}\text{C}$  NMR (75 MHz,  $\text{CDCl}_3$ ):  $\delta$  163.7, 145.4, 139.8, 133.8, 133.4, 125.2, 117.4, 114.9, 114.4, 64.0, 55.6, 39.7, 33.0, 30.2, 29.1, 27.7, 26.6, 16.5.

### Preparation of Compound 13



To a solution of **12g** (50 mg, 0.2 mmol) and 2-methoxybut-3-en-1-ol (30.6 mg, 0.3 mmol) in dry  $\text{CH}_2\text{Cl}_2$  (1 mL) were sequentially added DMAP (36.7 mg, 0.3 mmol) and EDC·HCl (57 mg, 0.3 mmol) at room temperature, and the mixture was stirred for 10 h at the same temperature. The reaction mixture was first diluted with  $\text{CH}_2\text{Cl}_2$  (10 mL), and then washed with brine (2 x 2 mL), and the combined organic layer was dried over  $\text{Na}_2\text{SO}_4$ . The solvent was removed under vacuum, and the residue was purified by flash chromatography (25/1 = hexane/ethyl acetate) to give **13** (51.8 mg, 77% yield);  $^1\text{H}$  NMR (300 MHz,  $\text{CDCl}_3$ ):  $\delta$  6.52-6.65 (m, 1H), 5.85(d,  $J$ =10.8Hz, 1H), 5.67-5.79 (m, 1H), 5.31-5.41 (m, 2H), 5.22 (t,  $J$  = 7.5 Hz, 1H), 5.09 (d,  $J$  = 16.8 Hz, 1H), 4.97(d,  $J$  = 13.8 Hz, 1H), 4.23 (d,  $J$  = 6.3 Hz, 2H), 3.89-3.96 (m, 1H), 3.58 (s, 3H), 3.36 (s, 3H), 2.42-2.49 (m, 2H), 2.04 (t,  $J$  = 7.5 Hz, 2H), 1.75 (s, 3H), 1.26-1.48 (m, 8H);  $^{13}\text{C}$  NMR (75 MHz,  $\text{CDCl}_3$ ):  $\delta$  163.6, 145.3, 139.9, 134.3, 133.4, 125.2, 119.4, 115.2, 114.4, 114.3, 80.2, 66.4, 56.6, 55.6, 39.7, 30.2, 29.1, 27.7, 26.6, 16.5.

### Preparation of Compound 14

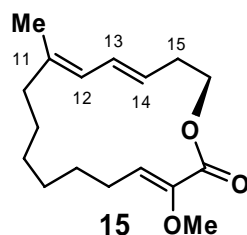


To a refluxing solution of benzyldien-bis(tricyclohexylphosphine)dichlororuthenium (Grubbs' 1<sup>st</sup> generation catalyst, 8.2 mg, 0.01 mmol) in dry  $\text{CH}_2\text{Cl}_2$  (90 mL) was added **11** (27.6 mg, 0.1 mmol) in dry  $\text{CH}_2\text{Cl}_2$  (10 mL) *via* cannular during 30 min. and the mixture was continually stirred at the same temperature for 5 hr. The reaction mixture was then cooled to room temperature and then concentrated under vacuum. The residue was purified by flash



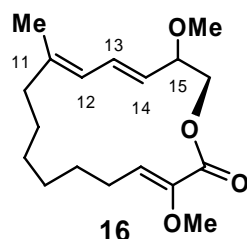
chromatography (25/1 = hexane/ethyl acetate) to give **14** (19.8 mg, 80% yield);  $^1\text{H}$  NMR (300 MHz,  $\text{CDCl}_3$ ):  $\delta$  6.66-6.86 (m, 1H) 6.18-6.45 (m, 1H), 5.94-6.14 (m, 1H), 5.21-5.68 (m, 2H), 4.18-4.28 (m, 2H), 2.36-2.54 (m, 2H), 2.11-2.26 (m, 4H), 1.84 (s, 3H), 1.19-1.64 (m, 8H);  $^{13}\text{C}$  NMR (75 MHz,  $\text{CDCl}_3$ ):  $\delta$  168.0, 167.7, 143.0, 141.7, 135.3, 134.9, 134.3, 131.7, 130.7, 129.7, 128.9, 128.7, 126.3, 125.1, 62.9, 62.2, 61.8, 33.5, 33.1, 32.7, 31.1, 29.5, 28.44, 28.37, 28.1, 27.9, 27.72, 27.67, 27.6, 27.4, 27.2, 26.6, 26.1, 26.0, 25.4, 25.0, 12.2; LRMS (EI) [ $\text{C}_{16}\text{H}_{24}\text{O}_2$ ],  $m/z$  ( $\text{M}^+$ ): calcd 248, found 248.

### Preparation of Compound 15



To a refluxing solution of benzyldien-bis(tricyclohexylphosphine)dichlororuthenium (Grubbs' 1<sup>st</sup> generation catalyst, 8.2mg, 0.01mmol) in dry  $\text{CH}_2\text{Cl}_2$  (90 mL) was added **12** (30.6 mg, 0.1 mmol) in dry  $\text{CH}_2\text{Cl}_2$  (10 mL) *via* cannular, and the mixture was continually stirred for 5 hr at the same temperature. The reaction mixture was then cooled to room temperature, and then concentrated under vacuum. The residue was purified by flash chromatography (20/1 = hexane/ethyl acetate) to give **36** (11.1 mg, 40% yield);  $^1\text{H}$  NMR (300 MHz,  $\text{CDCl}_3$ ):  $\delta$  6.23 (dd,  $J$  = 15.0 Hz, 10.8 Hz, 1H), 5.80 (d,  $J$  = 10.8 Hz, 1H), 5.47 (dt,  $J$  = 15.0 Hz, 7.5 Hz, 1H), 5.05 (t,  $J$  = 6.6 Hz, 1H), 4.42 (t,  $J$  = 6.6 Hz, 2H), 3.58 (s, 3H), 2.33-2.49 (m, 4H), 2.03-2.06 (m, 2H), 1.59 (s, 3H), 1.19-1.47 (m, 8H);  $^{13}\text{C}$  NMR (75 MHz,  $\text{CDCl}_3$ ):  $\delta$  163.6, 145.3, 136.1, 129.7, 127.1, 126.4, 115.4, 63.0, 55.7, 38.5, 33.3, 29.2, 27.3, 25.9, 25.6, 24.7, 15.9; LRMS (EI) [ $\text{C}_{17}\text{H}_{26}\text{O}_3$ ],  $m/z$  ( $\text{M}^+$ ): calcd 278, found 278.

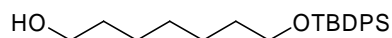
### Preparation of Compound 16



To a refluxing solution of benzyldien-bis(tricyclohexylphosphine)dichlororuthenium (Grubbs' 1<sup>st</sup> generation catalyst, 8.2mg, 0.01mmol) in dry  $\text{CH}_2\text{Cl}_2$  (90 mL) was added **13** (33.6 mg, 0.1 mmol) in dry  $\text{CH}_2\text{Cl}_2$  (10 mL) *via* cannular during 20 min. and the mixture was continually stirred at the same temperature for 6 hr. The reaction mixture was first cooled to room temperature, and then under vacuum. The residue was purified by flash chromatography (25/1 = hexane/ethyl acetate) to give **38** (24 mg, 78% yield);  $^1\text{H}$  NMR (300 MHz,  $\text{CDCl}_3$ ):  $\delta$  6.42 (ddd,  $J$  = 15.3 Hz, 10.8 Hz, 0.6 Hz, 1H), 5.85 (d,  $J$  = 11.1 Hz, 1H), 5.38 (dd,  $J$  = 15.3 Hz, 11.1 Hz, 1H), 5.05 (dd,  $J$  = 7.8 Hz, 5.4 Hz, 1H), 4.50 (dd,  $J$  = 10.8 Hz, 8.1 Hz, 1H), 4.27 (dd,  $J$  = 10.8 Hz, 4.5 Hz, 1H), 3.90-3.97 (m, 1H), 3.58 (s, 3H), 3.34 (s, 3H), 2.45-2.58 (m, 1H), 2.19-2.31 (m, 1H), 2.00-2.17 (m, 2H), 1.70 (s, 3H), 1.13-1.55 (m, 8H);  $^{13}\text{C}$  NMR (75 MHz,  $\text{CDCl}_3$ ):  $\delta$  163.1, 145.2, 138.8, 130.5,

128.1, 125.6, 115.8, 80.2, 64.3, 56.6, 55.7, 38.5, 29.1, 27.2, 25.8, 25.5, 24.7, 16.1. LRMS (EI) [C<sub>18</sub>H<sub>28</sub>O<sub>4</sub>], m/z (M<sup>+</sup>): calcd 308, found 308.

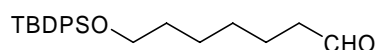
### Preparation of Compound 17a



**17a**

To solution of 1,7-heptanediol (7.92 g, 60 mmol) in dry THF(500 mL) were sequentially added imidazole (4.08 g, 60 mmol) and TBDPSCl (16.5 g, 60 mmol) *via* syringe at room temperature, and reaction mixture was stirred at the same temperature for 9 hr. The reaction mixture was then quenched with water (50 mL), and extracted with Et<sub>2</sub>O (3 x 150 mL), and the combined organic phase was washed with brine (2 x 30 mL) and dried over Na<sub>2</sub>SO<sub>4</sub>. The solvent was removed under vacuum, and the residue was purified by flash chromatography (from 10/1 to 4/1 = petroleum ether/ethyl acetate) to give **17a** (10.7 g, 48% yield); <sup>1</sup>H NMR (300 MHz, CDCl<sub>3</sub>): δ 7.65-7.69 (m, 4H), 7.34-7.41 (m, 6H), 3.58-3.68 (m, 4H), 1.51-1.58 (m, 4H), 1.31-1.35 (m, 6H), 1.05 (s, 9H); <sup>13</sup>C NMR (75MHz, CDCl<sub>3</sub>): δ 135.2, 134.1, 129.4, 127.5, 63.9, 62.9, 32.7, 32.4, 29.1, 26.8, 25.70, 25.66, 19.2.

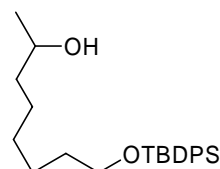
### Preparation of Compound 17b



**17b**

A solution of dimethyl sulfoxide (2.92 g, 37.4 mmol) in dry CH<sub>2</sub>Cl<sub>2</sub> (20 mL) was added to the solution of oxalyl chloride (4.75 g, 37.4 mmol) in dry CH<sub>2</sub>Cl<sub>2</sub> (30 mL) at -78 °C in dropwise, and the mixture was stirred for 30 min. at the same temperature. To this solution was added **17a** (10.7 g, 28.8 mmol) in dry CH<sub>2</sub>Cl<sub>2</sub> (100 mL) in dropwise at -78 °C, and the resultant solution was continually stirred for 30 min at the same temperature. After addition of triethylamine (7.55 g, 74.8 mmol), the reaction mixture was gradually warmed to 0 °C, and stirred for additional 1 hr before quenching with water (20 mL). The mixture was then extracted with CH<sub>2</sub>Cl<sub>2</sub> (3 x 30 mL), and the combined organic phase was washed with brine (2 x 10 mL), and dried over Na<sub>2</sub>SO<sub>4</sub>. The solvent was removed under vacuum, and the residue was purified by flash chromatography (10/1 petroleum ether/ethyl acetate) to give **40** (9.55 g, 90% yield).

### Preparation of Compound 17c

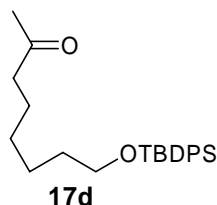


**17c**

To a solution of methylmagnesium chloride (2.85 M in THF, 6.32 mL, 18 mmol) in dry THF (30 mL) was added aldehyde **17b** (5.53 g, 15 mmol) in dry THF (20ml) was added at 0 °C *via* cannular, and the reaction mixture was stirred for 30 min. at the same temperature. The reaction mixture was quenched with saturated aqueous NH<sub>4</sub>Cl (15 mL), and extracted with Et<sub>2</sub>O (3 x 20 mL), and the combined extracts were dried over Na<sub>2</sub>SO<sub>4</sub>. The solvent was removed under

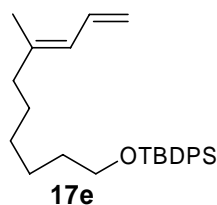
vacuum, and the residue was purified by a flash chromatography (6/1 = petroleum ether/ethyl acetate) to give **17c** (5.19 g, 90% yield).  $^1\text{H}$  NMR (300 MHz,  $\text{CDCl}_3$ ):  $\delta$  7.66-7.69 (m, 4H), 7.35-7.46 (m, 6H), 3.77-3.82 (m, 1H), 3.65 (t,  $J$  = 6.6 Hz, 2H), 1.51-1.62 (m, 2H), 1.28-1.44 (m, 8H), 1.18 (d,  $J$  = 6.3 Hz, 3H), 1.05 (s, 9H);  $^{13}\text{C}$  NMR (75 MHz,  $\text{CDCl}_3$ ):  $\delta$  135.6, 134.1, 129.5, 127.5, 68.2, 64.0, 39.3, 32.5, 29.6, 29.3, 26.8, 25.7, 23.4, 19.2.

### Preparation of Compound 17d



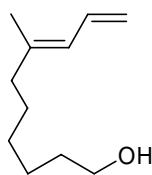
A solution of dimethyl sulfoxide (1.37 g, 17.6 mmol) in dry  $\text{CH}_2\text{Cl}_2$  (20 mL) was added to the solution of oxalyl chloride (2.23 g, 17.6 mmol) in dry  $\text{CH}_2\text{Cl}_2$  (30 mL) at  $-78^\circ\text{C}$  in dropwise, and the mixture was stirred for 30 min. at the same temperature. To this solution was added a solution of alcohol **17c** (5.19 g, 13.5 mmol) in dry  $\text{CH}_2\text{Cl}_2$  (100 mL) at  $-78^\circ\text{C}$  in dropwise, and the reaction mixture was stirred at the same temperature for additional 30 min. After addition of triethylamine (3.56 g, 35.2 mmol), the reaction mixture was gradually warmed to  $0^\circ\text{C}$ , and stirred for another 1 hr before quenching with water (15 mL). The mixture was extracted with  $\text{CH}_2\text{Cl}_2$  (3 x 20 mL), and the combined organic layer was washed with brine (2 x 5 mL), and dried over  $\text{Na}_2\text{SO}_4$ . The solvent was removed under vacuum, and the residue was purified by a flash chromatography (10/1 = petroleum ether/ethyl acetate) to give **17d** (4.60 g, 89% yield).

### Preparation of Compound 17e



$n\text{-BuLi}$  (2.5 M in hexane, 6.32 mL, 15.8 mmol) was added to a solution of allyldiphenylphosphine oxide (3.82 g, 15.8 mmol) and HMPA (5.66 g, 31.6 mmol) in dry THF (200 mL) at  $-78^\circ\text{C}$  in dropwise, and the solution was stirred at the same temperature for 30 min. To this solution was ketone **17d** (4.60 g, 12.0 mmol) in THF at  $-78^\circ\text{C}$  over a period of 15 min. The reaction mixture was first stirred at the same temperature for 30 min. and then warmed up to  $0^\circ\text{C}$  for 10 min. and finally stirred at room temperature for 2 hr. The reaction mixture was quenched by addition of a saturated aqueous solution of  $\text{NH}_4\text{Cl}$  (30 mL), and extracted with  $\text{Et}_2\text{O}$  (3 x 50 mL), and the extracts were dried over  $\text{Na}_2\text{SO}_4$ . The solvent was removed under vacuum, and the residue was purified by flash chromatography (20/1 = petroleum ether/ethyl acetate) to give **17e** (3.51 g, 72% yield).  $^1\text{H}$  NMR (300 MHz,  $\text{CDCl}_3$ ):  $\delta$  7.65-7.71 (m, 4H), 7.35-7.46 (m, 6H), 6.52-6.65 (m, 1H), 5.85 (d,  $J$ =11.1Hz, 1H), 5.09 (dd,  $J$ =16.8Hz, 2.1Hz, 1H), 4.97 (dd,  $J$ =11.1Hz, 2.1Hz, 1H), 3.65 (t,  $J$ =6.6Hz, 2H), 2.02 (t,  $J$ =7.2Hz, 2H), 1.75 (s, 3H), 1.51-1.60 (m, 2H), 1.19-1.46 (m, 6H), 1.05 (s, 9H);  $^{13}\text{C}$  NMR (75MHz,  $\text{CDCl}_3$ ):  $\delta$  139.8, 135.5, 134.1, 133.4, 129.5, 127.6, 125.3, 114.4, 63.9, 39.7, 32.5, 29.0, 27.7, 26.9, 25.6, 19.2, 16.5.

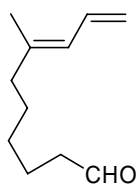
### Preparation of Compound 17f



**17f**

To a solution of **17e** (3.50 g, 8.64 mmol) in THF (20 mL) was added TBAF (5.45 g, 17.3 mmol) at room temperature, and the mixture was stirred at the same temperature for 4 hr. The reaction mixture was first diluted with water (15 mL), and then extracted with Et<sub>2</sub>O (3 x 20 mL). The combined organic phase was first washed with brine (2 x 5 mL), and then dried over Na<sub>2</sub>SO<sub>4</sub>. The solvent was removed under vacuum, and the residue was purified by a flash chromatography (8/1 to 4/1 = petroleum ether/ethyl acetate) to give **17f** (1.38 g, 95% yield). <sup>1</sup>H NMR (300 MHz, CDCl<sub>3</sub>): δ 6.52-6.65 (m, 1H), 5.85 (d, *J* = 11.1 Hz, 1H), 5.09 (d, *J* = 16.8 Hz, 1H), 4.97 (dd, *J* = 10.2 Hz, 1.5 Hz, 1H), 3.64 (t, *J* = 6.6 Hz, 2H), 2.05 (t, *J* = 7.5 Hz, 2H), 1.75 (s, 3H), 1.26-1.62 (m, 8H); <sup>13</sup>C NMR (75 MHz, CDCl<sub>3</sub>): δ 139.8, 133.4, 125.3, 114.4, 63.0, 39.7, 32.7, 29.0, 27.7, 25.6, 16.5.

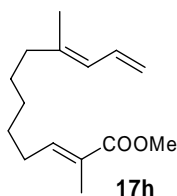
### Preparation of Compound 17g



**17g**

To a solution of **17f** (1.38 g, 8.21 mmol) in dry CH<sub>2</sub>Cl<sub>2</sub> (10 mL) was added Dess-Martin periodinane reagent (3.83 g, 9.03 mmol) in several portions at 0 °C, and the mixture was stirred for additional 30 min. at room temperature. The reaction mixture was first diluted with petroleum ether (30 mL), and the formed precipitate was filtered off, and the remained filtrate was concentrated under vacuum at 0 °C. The residue was purified by a flash chromatography (20/1 = petroleum ether/Et<sub>2</sub>O) to give **17g** (914 mg, 67% yield).

### Preparation of Compound 17h

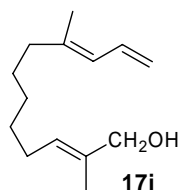


**17h**

To a solution of aldehyde **17g** (914 mg, 5.5 mmol) in dry toluene (15 mL) was added (carbmethoxymethylidene)triphenylphosphorane (5.74 g, 16.5 mmol) at room temperature, and the mixture was then stirred at 80 °C for 4 hr. The reaction mixture was first cooled to room temperature, and then diluted with petroleum ether (30 mL). The formed precipitate was filtered off, and the filtrate was concentrated. The residue was purified by flash chromatography (30/1 = petroleum ether/ethyl acetate) to give **17h** (1.10 g, 85% yield); <sup>1</sup>H NMR (300 MHz, CDCl<sub>3</sub>): δ 6.74-6.80 (m, 1H), 6.52-6.65 (m, 1H), 5.84 (dd, *J* = 10.8 Hz, 1.2 Hz, 1H), 5.09 (dd, *J* = 16.8 Hz, 1.8 Hz, 1H), 4.98 (dd, *J* = 10.2 Hz, 1.8 Hz, 1H), 3.73 (s, 3H), 2.02-2.08 (m, 2H), 2.13-2.20 (m,

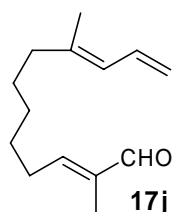
2H), 1.75 (s, 3H), 1.67 (s, 3H), 1.25-1.55 (m, 6H);  $^{13}\text{C}$  NMR (75 MHz,  $\text{CDCl}_3$ ):  $\delta$  168.7, 142.6, 139.6, 133.3, 127.4, 125.4, 114.5, 51.6, 39.6, 29.0, 28.5, 28.4, 27.5, 16.5, 12.3.

### Preparation of Compound 17i



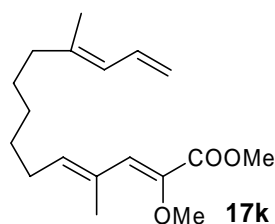
To a solution of **17h** (1.10 g, 4.68 mmol) in dry toluene (20 mL) was added DIBAL-H (1.0 M in toluene, 11.7 mL, 11.7 mmol) at  $-78\text{ }^\circ\text{C}$  in dropwise during 20 min. and the mixture was continually stirred for 4 hr at  $-78\text{ }^\circ\text{C}$ . The reaction mixture was quenched by slow addition of EtOAc (2 mL) at  $-78\text{ }^\circ\text{C}$ , and stirred for another 20 min. at the same temperature, and then gradually warmed up to room temperature. The mixture was poured carefully into a rapid stirred mixture of saturated aqueous Rochelle's salt solution (potassium sodium tartrate tetrahydrate, 40 mL), and the resultant cloudy mixture was stirred vigorously until the organic layer became clear. The aqueous phase was first extracted with EtOAc (3 x 40 mL), and the combined organic phase was then dried over  $\text{Na}_2\text{SO}_4$ . The solvent was removed under vacuum, and the residue was purified by a flash chromatography (4/1 = petroleum ether/ethyl acetate) to give **17i** (877 mg, 90% yield);  $^1\text{H}$  NMR (300 MHz,  $\text{CDCl}_3$ ):  $\delta$  6.52-6.65 (m, 1H), 5.85 (dd,  $J = 10.8\text{ Hz}$ , 1.2 Hz, 1H), 5.38-5.44 (m, 1H), 5.08 (dd,  $J = 16.8\text{ Hz}$ , 2.1 Hz, 1H), 4.98 (dd,  $J = 10.2\text{ Hz}$ , 2.1 Hz, 1H), 4.00 (s, 2H), 1.99-2.07 (m, 4H), 1.75 (s, 3H), 1.66 (s, 3H), 1.25-1.48 (m, 6H);  $^{13}\text{C}$  NMR (75 MHz,  $\text{CDCl}_3$ ):  $\delta$  139.8, 134.6, 133.4, 126.4, 125.3, 114.4, 68.9, 39.7, 29.3, 28.9, 27.6, 27.5, 16.5, 13.6.

### Preparation of Compound 17j



To a solution of **17i** (877 mg, 4.21 mmol) in dry  $\text{CH}_2\text{Cl}_2$  (5 mL) was added Dess-Martin periodinane reagent (1.96 g, 4.63 mmol) at  $0\text{ }^\circ\text{C}$  in several portions during 20 min and the mixture was stirred at the same temperature for 30 min. The reaction mixture was diluted with petroleum ether (20 mL), and the formed precipitate was filtered off, and filtrate was concentrated under vacuum. The residue was purified by a flash chromatography (10/1 = petroleum ether/ethyl acetate) to give **17j** (763 mg, 88% yield).

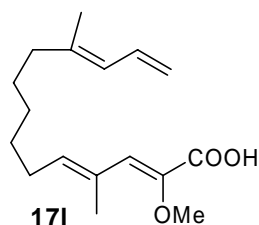
### Preparation of Compound 17k



To a solution of methyl 2-methoxy-2-(diisopropoxyphosphoryl)acetate (1.98 g, 7.4

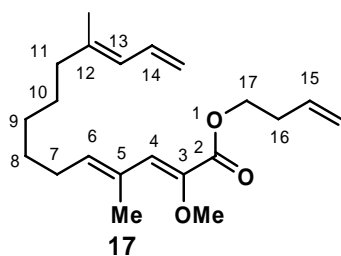
mmol) in dry THF (40 mL) were sequentially added 18-crown-6 (1.95g, 7.4mmol) and KHMDs (0.5 M in toluene, 14.8 mL, 7.4 mmol) in dropwise at 0 °C, and the mixture was stirred for additional 30 min. To this solution was added a solution of aldehyde **17j** (763 mg, 3.70 mmol) in THF at 0 °C in dropwise, and the mixture was stirred for 30 min. After stirring 10 hr at room temperature, the reaction mixture was quenched with a saturated aqueous solution of NH<sub>4</sub>Cl (20 mL), and extracted with Et<sub>2</sub>O (3 x 30 mL), and the extracts were dried over Na<sub>2</sub>SO<sub>4</sub>. The solvent was removed under vacuum, and the residue was purified by a flash chromatography (20/1 = petroleum ether/ethyl acetate) to give **17k** (886 mg, 82% yield). <sup>1</sup>H NMR (300 MHz, CDCl<sub>3</sub>): δ 6.52-6.62 (m, 2H), 5.81-5.87 (m, 2H), 5.08 (dd, *J* = 16.8 Hz, 2.1 Hz, 1H), 4.98 (dd, *J* = 10.2 Hz, 2.1 Hz, 1H), 3.80 (s, 3H), 3.67 (s, 3H), 2.11-2.18 (m, 2H), 2.05 (t, *J* = 7.5 Hz, 2H), 1.97 (s, 3H), 1.75 (s, 3H), 1.27-1.47 (m, 6H); <sup>13</sup>C NMR (75M Hz, CDCl<sub>3</sub>): δ 165.4, 142.4, 139.7, 133.3, 131.5, 129.7, 125.4, 114.4, 60.2, 51.9, 39.7, 28.9, 28.2, 27.6, 16.5, 14.4.

### Preparation of Compound 17i



To a solution of **17k** (886 mg, 3.03 mmol) in dry THF (5 mL) was added potassium trimethylsilanolate (777 mg, 6.06 mmol) in one portion at room temperature, and the reaction mixture was stirred at the same temperature for 24 hr. The reaction mixture was quenched with a saturated aqueous solution of NH<sub>4</sub>Cl (3 mL), and extracted with EtOAc (3 mL). The aqueous phase was first acidified to pH3 with HCl (2 M), and the extracted with EtOAc (3 x 15 mL), and the combined extracts were dried over Na<sub>2</sub>SO<sub>4</sub>. The solvent was removed under vacuum, and the residue was purified by a flash chromatography (1/1 = petroleum ether/ethyl acetate) to give **17l** (716 mg, 85% yield).

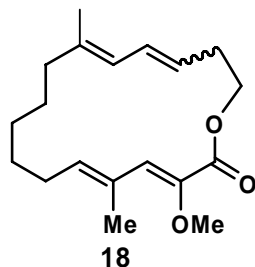
### Preparation of Compound 17



To a solution of **17k** (278 mg, 1 mmol) and 3-butene-1-ol (108 mg, 1.5 mmol) in dry CH<sub>2</sub>Cl<sub>2</sub> (1 mL) were added DMAP (183 mg, 1.5 mmol) and EDC•HCl (288 mg, 1.5 mmol) at room temperature, and the mixture was stirred at the same temperature for 10 hr. The reaction mixture was first diluted with CH<sub>2</sub>Cl<sub>2</sub> (10 mL), and then washed brine (3 mL), and the organic phase was dried over Na<sub>2</sub>SO<sub>4</sub>. The solvent was removed under vacuum, and the residue was purified by a flash chromatography (50/1 = hexane/ethyl acetate) to give **17** (262 mg, 79% yield). <sup>1</sup>H NMR (300 MHz, CDCl<sub>3</sub>): δ 6.52-6.65 (m, 1H), 6.59 (s, 1H), 5.79-5.88 (m, 3H), 5.07-5.19 (m, 3H), 4.98 (dd, *J* = 10.2 Hz, *J* = 1.8 Hz, 1H), 4.25 (t, *J* = 6.6Hz, 2H), 3.65 (s, 3H), 2.43-2.50 (m,

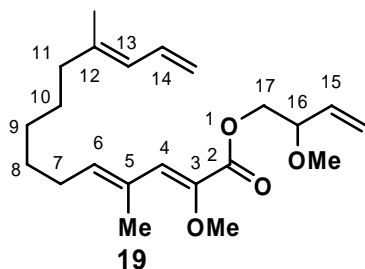
2H), 2.11-2.18 (m, 2H), 2.05 (t,  $J = 7.2$  Hz, 2H), 1.97 (s, 3H), 1.75 (s, 3H), 1.27-1.47 (m, 6H);  $^{13}\text{C}$  NMR (75 MHz,  $\text{CDCl}_3$ ):  $\delta$  165.0, 139.6, 134.0, 133.3, 131.5, 129.8, 125.3, 117.3, 114.5, 63.9, 60.3, 39.7, 33.1, 29.0, 28.2, 27.6, 16.5, 14.4.

### Preparation of Compound 18



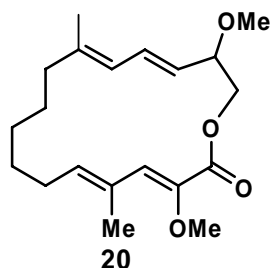
To a refluxing solution of benzyldien-bis(tricyclohexylphosphine)dichlororuthenium (Grubbs' 1<sup>st</sup> generation catalyst, 8.2 mg, 0.01 mmol) in dry  $\text{CH}_2\text{Cl}_2$  (90 mL) was added **17** (33.2 mg, 0.1 mmol) in dry  $\text{CH}_2\text{Cl}_2$  (10 mL) *via* cannular during 20 min. and the mixture was stirred at the same temperature for 20 hr. The reaction mixture was first cooled to room temperature, and then concentrated under vacuum. The residue was purified by a flash chromatography (25/1 = hexane/ethyl acetate) to give **18** (22.9 mg, 69% yield).  $^1\text{H}$  NMR (300 MHz,  $\text{CDCl}_3$ ):  $\delta$  6.63 (s, 1H) 6.35 (dd,  $J = 15.0$  Hz, 10.8 Hz, 1H), 5.89 (d,  $J = 10.8$  Hz, 1H), 5.49-5.59 (m, 2H), 4.25 (t,  $J = 6.0$  Hz, 2H), 3.66 (s, 3H), 2.48-2.54 (m, 2H), 2.09-2.14 (m, 4H), 1.92 (s, 3H), 1.68 (s, 3H), 1.35-1.50 (m, 4H), 1.16-1.26 (m, 2H);  $^{13}\text{C}$  NMR (75 MHz,  $\text{CDCl}_3$ ):  $\delta$  164.8, 141.7, 141.4, 137.1, 132.1, 132.0, 130.1, 127.3, 125.9, 63.0, 59.8, 37.6, 32.8, 26.7, 25.9, 23.8, 23.6, 15.6, 13.7; LRMS (EI) [ $\text{C}_{19}\text{H}_{28}\text{O}$ ],  $m/z$  ( $\text{M}^+$ ): calcd 304, found 304.

### Preparation of Compound 19



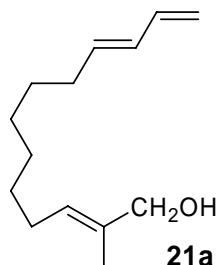
To a solution of **17k** (278 mg, 1 mmol) and 2-methoxybut-3-en-1-ol (30.6 mg, 1.5 mmol) in dry  $\text{CH}_2\text{Cl}_2$  (1 mL) were sequentially added DMAP (183 mg, 1.5 mmol) and EDC·HCl (288 mg, 1.5 mmol) at room temperature, and the mixture was stirred at the same temperature for 10 hr. The reaction mixture was diluted with  $\text{CH}_2\text{Cl}_2$  (10 mL), and then washed brine (2 mL), and the organic phase was dried over  $\text{Na}_2\text{SO}_4$ . The solvent was removed under vacuum, and the residue was purified by a flash chromatography (25/1 = hexane/ethyl acetate) to give **19** (293 mg, 81% yield).  $^1\text{H}$  NMR (300 MHz,  $\text{CDCl}_3$ ):  $\delta$  6.52-6.65 (m, 1H) 6.63 (s, 1H), 5.69-5.87 (m, 3H), 5.32-5.41 (m, 2H), 5.09 (dd,  $J = 16.8$  Hz,  $J = 1.8$  Hz, 1H), 4.98 (d,  $J = 10.2$  Hz, 1H), 4.16-4.27 (m, 2H), 3.89-3.95 (m, 1H), 3.66 (s, 3H), 3.35 (s, 3H), 2.07-2.18 (m, 2H), 2.05 (t,  $J = 7.5$  Hz, 2H), 1.97 (s, 3H), 1.75 (s, 3H), 1.26-1.55 (m, 6H);  $^{13}\text{C}$  NMR (75 MHz,  $\text{CDCl}_3$ ):  $\delta$  164.8, 142.3, 139.7, 138.6, 134.5, 133.3, 131.5, 130.0, 125.3, 119.2, 114.4, 80.3, 66.3, 60.2, 56.7, 39.8, 39.7, 28.9, 28.2, 27.6, 16.5, 14.4.

## Preparation of Compound 20



To a refluxing solution of benzyldien-bis(tricyclohexylphosphine)dichlororuthenium (Grubbs' 1<sup>st</sup> generation catalyst, 8.2mg, 0.01mmol) in dry CH<sub>2</sub>Cl<sub>2</sub> (90 mL) was added **19** (36.2 mg, 0.1 mmol) in dry CH<sub>2</sub>Cl<sub>2</sub> (10 mL) *via* cannular during 20 min. and the mixture was stirred at the same temperature for 40 hr. The reaction mixture was first cooled to room temperature, and then concentrated under vacuum. The residue was purified by a flash chromatography (25/1 = hexane/ethyl acetate) to give **20** (17.4 mg, 48% yield). <sup>1</sup>H NMR (300 MHz, CDCl<sub>3</sub>): δ 6.57 (s, 1H) 6.35 (dd, *J* = 15.0 Hz, 10.8 Hz, 1H), 5.96 (d, *J* = 10.8 Hz, 1H), 5.55 (t, *J* = 7.2 Hz, 1H), 5.43 (dd, *J* = 15.0 Hz, 7.8 Hz, 1H), 4.56 (dd, *J* = 9.9 Hz, 4.5 Hz, 1H), 3.85-3.98 (m, 2H), 3.66 (s, 3H), 3.35 (s, 3H), 2.10-2.17 (m, 4H), 1.91 (s, 3H), 1.72 (s, 3H), 1.48-1.60 (m, 2H), 1.37-1.46 (m, 4H); <sup>13</sup>C NMR (75 MHz, CDCl<sub>3</sub>): δ 164.3, 142.0, 141.2, 140.2, 132.4, 132.0, 131.8, 127.9, 125.4, 79.8, 64.2, 59.9, 56.3, 37.6, 26.6, 26.0, 23.8, 23.7, 15.7, 13.8; LRMS (EI) [C<sub>20</sub>H<sub>30</sub>O<sub>4</sub>], *m/z* (M<sup>+</sup>): calcd 334, found 334.

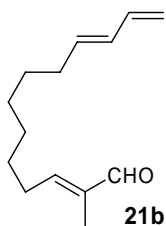
## Preparation of Compound 21a



To a solution of **11i** (1.18 g, 5 mmol) in dry toluene (30 mL) was added DIBAL-H (1.0 M in toluene, 12.5 mL, 12.5 mmol) at - 78 °C in dropwise over 20 min. and the mixture was stirred at the same temperature for 4 hr. The reaction was quenched by slow addition of EtOAc (5 mL) at - 78 °C, and then stirred at the same temperature for another 20 min. The mixture was gradually warmed up to room temperature, and then was poured carefully into a rapid stirred mixture a saturated aqueous solution of Rochelle's salt (potassium sodium tartrate tetrahydrate, 100 mL). The resultant cloudy mixture was stirred vigorously until the organic layer became clear, and the aqueous phase was extracted with EtOAc (3 x 50 mL), and the combined organic phase was dried over Na<sub>2</sub>SO<sub>4</sub>. The solvent was removed under vacuum, and the residue was purified by a flash chromatography (4/1 = petroleum ether/ethyl acetate) to give **21a** (936 mg, 90% yield).

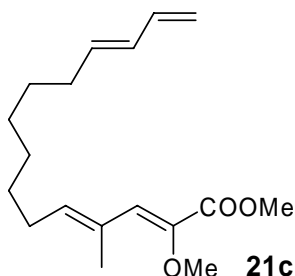
## Preparation of Compound 21b





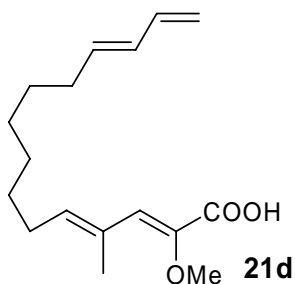
To a solution of **21a** (936 mg, 4.5 mmol) in dry  $\text{CH}_2\text{Cl}_2$  (5 mL) was added Dess-Martin periodinane reagent (2.10 g, 4.95 mmol) at 0 °C in several portions during 20 min. and the mixture was stirred at room temperature for 30 min. The reaction mixture was diluted petroleum ether (20ml), and the formed precipitate was filtered off, and the filtrate was concentrated under vacuum. The residue was purified by a flash chromatography (10/1 = petroleum ether/ethyl acetate) to give **21b** (834 mg, 90% yield).

### Preparation of Compound 21c



To a solution of methyl 2-methoxy-2-(diisopropoxyphosphoryl)acetate (1.07 g, 4 mmol) in dry THF (30 mL) were sequentially added 18-crown-6 (1.06 g, 4 mmol) and KHMDS (0.5 M in toluene, 8 mL, 4 mmol) in dropwise at 0 °C, and the mixture was stirred at the same temperature for 30 min. To this solution was added aldehyde **21b** (412 mg, 2 mmol) in THF at 0 °C in dropwise. After stirring at room temperature for 10 hr. the reaction mixture was quenched with a saturated aqueous solution of  $\text{NH}_4\text{Cl}$  (20 mL), and then extracted with  $\text{Et}_2\text{O}$  (3 x 30 mL), and the extracts were dried over  $\text{Na}_2\text{SO}_4$ . The solvent was removed under vacuum, and the residue was purified by a flash chromatography (20/1 = petroleum ether/ethyl acetate) to give **21c** (520 mg, 89% yield).

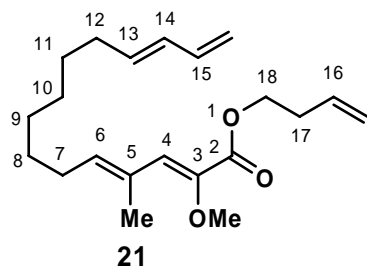
### Preparation of Compound 21d



To a solution of **21c** (520 mg, 1.78 mmol) in dry THF (2 mL) was added potassium trimethylsilanolate (457 mg, 3.56 mmol) at room temperature in one portion, and the mixture was stirred at the same temperature for 24 hr. The reaction was worked up by addition of a saturated aqueous solution of  $\text{NH}_4\text{Cl}$  (2 mL), and extracted with  $\text{EtOAc}$  (2 mL). The aqueous phase was

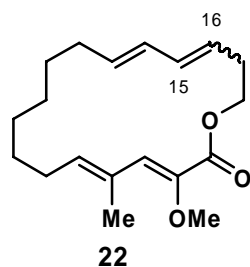
first acidified to pH3 with HCl (2 N), and then extracted with EtOAc (3 x 10 mL), and the combined extracts were dried over Na<sub>2</sub>SO<sub>4</sub>. The solvent was removed under vacuum, and the residue was purified by a flash chromatography (1/1 = petroleum ether/ethyl acetate) to give **21d** (347 mg, 70% yield).

### Preparation of Compound 21



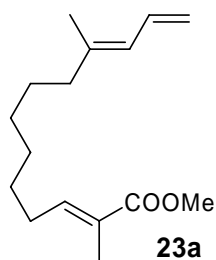
To a solution of **21d** (278 mg, 1 mmol) and 3-butene-1-ol (108 mg, 1.5 mmol) in dry CH<sub>2</sub>Cl<sub>2</sub> (1 mL) were added DMAP (183 mg, 1.5 mmol) and EDC•HCl (288 mg, 1.5 mmol) at room temperature, and the mixture was stirred at the same temperature for 10 hr. The reaction mixture was diluted with CH<sub>2</sub>Cl<sub>2</sub> (5 mL), and washed with brine (2 mL), and the organic phase was then dried over Na<sub>2</sub>SO<sub>4</sub>. The solvent was removed under vacuum, and the residue was purified by a flash chromatography (40/1 = hexane/ethyl acetate) to give **21** (266 mg, 80% yield). <sup>1</sup>H NMR (300 MHz, CDCl<sub>3</sub>): δ 6.61 (s, 1H), 6.32 (dt, *J* = 17.1 Hz, 10.2 Hz, 1H), 6.05 (dd, *J* = 15.3 Hz, 10.2 Hz, 1H), 5.66-5.90 (m, 3H), 5.06-5.19 (m, 3H), 5.08 (dd, *J* = 16.8 Hz, 2.1 Hz, 1H), 4.96 (dd, *J* = 10.2 Hz, 1.2 Hz, 1H), 4.23 (t, *J* = 6.6 Hz, 2H), 3.66 (s, 3H), 2.42-2.50 (m, 2H), 2.02-2.17 (m, 4H), 1.97 (s, 3H), 1.26-1.65 (m, 8H); <sup>13</sup>C NMR (75 MHz, CDCl<sub>3</sub>): δ 164.9, 142.6, 139.6, 137.3, 135.4, 134.0, 131.5, 130.9, 129.7, 117.3, 114.6, 63.9, 60.2, 33.1, 32.5, 29.1, 29.1, 29.0, 28.3, 14.4.

### Preparation of Compound 22



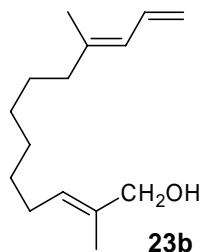
To a refluxing solution of benzylidien-bis(tricyclohexylphosphine)dichlororuthenium (Grubbs' 1<sup>st</sup> generation catalyst, 4.1 mg, 0.005 mmol) in dry CH<sub>2</sub>Cl<sub>2</sub> (90mL) was added **21** (33.2 mg, 0.1 mmol) in dry CH<sub>2</sub>Cl<sub>2</sub> (10 mL) *via* cannular in 20 min. and the mixture was stirred at the same temperature for 5 hr. The reaction mixture was then cooled to room temperature, and then concentrated under vacuum. The residue was purified by a flash chromatography (20/1 hexane/ethyl acetate) to give **22** (25.8 mg, 85% yield): <sup>1</sup>H NMR (300 MHz, CDCl<sub>3</sub>): δ 6.56 (s, 1H), 6.00-6.18 (m, 2H), 5.75-5.85 (m, 1H), 5.44-5.73 (m, 2H), 4.23 (t, *J* = 8.1 Hz, 2H), 3.66 (s, 3H), 2.37-2.55 (m, 2H), 2.10-2.24 (m, 4H), 2.00 (s, 3H), 1.26-1.52 (m, 8H); <sup>13</sup>C NMR (75 MHz, CDCl<sub>3</sub>): δ 164.5, 141.9, 140.4, 133.74, 133.67, 131.5, 130.8, 130.6, 127.0, 62.7, 59.9, 32.4, 32.0, 28.4, 28.3, 28.0, 27.8, 27.2, 13.9; LRMS (EI) [C<sub>19</sub>H<sub>28</sub>O<sub>3</sub>], *m/z* (M<sup>+</sup>): calcd 304, found 304.

### Preparation of Compound 23a



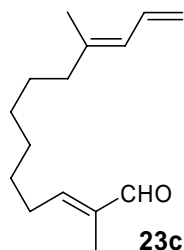
To a solution of aldehyde **12e** (900 mg, 5 mmol) in dry toluene (15 mL) was added (carbmethoxymethylidene)triphenylphosphorane (5.22 g, 15 mmol) at room temperature, and the reaction mixture was then stirred at 80 °C for 4 hr. The reaction mixture was then cooled to room temperature, and then diluted with petroleum ether (20 mL). The formed precipitate was filtered off, and the filtrate was concentrated. The residue was purified by a flash chromatography (30/1 = petroleum ether/ethyl acetate) to give **23a** (1.10 g, 88% yield).

### Preparation of Compound 23b



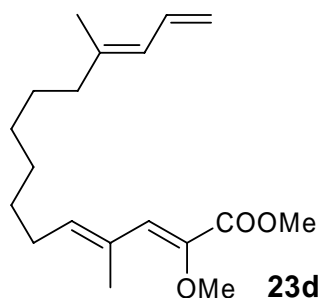
To a solution of **23a** (1.10 g, 4.4 mmol) in dry toluene (30 mL) was DIBAL-H (1.0 M in toluene 11 mL, 11 mmol) at – 78 °C in dropwise over 20 min. and the mixture was stirred at the same temperature for 4 hr. The reaction was quenched by slow addition of EtOAc (5 mL) at – 78 °C, and then stirred at the same temperature for 20 min. The reaction mixture was then gradually warmed up to room temperature, and the formed mixture was poured carefully into a rapid stirred mixture of a saturated aqueous solution of Rochelle's salt (potassium sodium tartrate tetrahydrate, 100 mL). The resultant cloudy mixture was stirred vigorously until the organic layer became clear, and the aqueous phase was extracted with EtOAc (3 x 50 mL), and the combined organic phase was dried over Na<sub>2</sub>SO<sub>4</sub>. The solvent was removed under vacuum, and the residue was purified by a flash chromatography (4/1 = petroleum ether/ethyl acetate) to give **23b** (869 mg, 89% yield); <sup>1</sup>H NMR (300 MHz, CDCl<sub>3</sub>): δ 6.52-6.61 (m, 1H), 5.85 (dd, *J* = 10.8 Hz, 1.2 Hz, 1H), 5.39-5.44 (m, 1H), 5.09 (dd, *J* = 16.8 Hz, 2.1 Hz, 1H), 4.98 (dd, *J* = 10.2 Hz, 2.1 Hz, 1H), 4.00 (s, 2H), 1.99-2.06 (m, 4H), 1.76 (s, 3H), 1.66 (s, 3H), 1.24-1.47 (m, 8H); <sup>13</sup>C NMR (75 MHz, CDCl<sub>3</sub>): δ 139.9, 134.5, 133.4, 126.5, 125.2, 114.4, 69.0, 39.8, 29.4, 29.2, 28.1, 27.7, 27.5, 16.5, 13.6.

### Preparation of Compound 23c



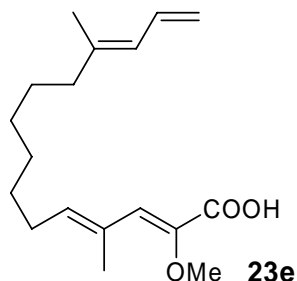
To a solution of **23b** (869 mg, 3.92 mmol) in dry CH<sub>2</sub>Cl<sub>2</sub> (5 mL) was added Dess-Martin periodinane reagent (1.83 g, 4.31 mmol) at 0 °C in several portions during 20 min. and the mixture was stirred at room temperature for 30 min. The reaction mixture was then diluted with petroleum ether (20 mL), and the formed precipitate was filtered off, and the filtrate was then concentrated under vacuum. The residue was purified by a flash chromatography (4/1 = petroleum ether/ethyl acetate) to give 716 mg **23c** (83% yield).

### Preparation of Compound 23d



To a solution of methyl 2-methoxy-2-(diisopropoxyphosphoryl)acetate (1.74 g, 6.5 mmol) in dry THF (40 mL) were sequentially added 18-crown-6 (1.72 g, 6.5 mmol) and KHMDs (0.5 M in toluene, 13 mL, 6.5 mmol) in dropwise at 0 °C, and the mixture was stirred at the same temperature for 30 min. To this solution was added aldehyde **23c** (716 mg, 3.25 mmol) in THF at 0 °C in dropwise, and the mixture was stirred at the same temperature for 30 min. After stirring at room temperature for 10 hr, the reaction mixture was quenched with a saturated aqueous solution of NH<sub>4</sub>Cl (20 mL), and extracted with Et<sub>2</sub>O (3 x 20 mL), and the combined extracts were then dried over Na<sub>2</sub>SO<sub>4</sub>. The solvent was removed under vacuum, and the residue was purified by a flash chromatography (20/1 = petroleum ether/ethyl acetate) to give **23d** (875 mg, 88% yield). <sup>1</sup>H NMR (300 MHz, CDCl<sub>3</sub>): δ 6.52-6.65 (m, 2H), 5.82-5.87 (m, 2H), 5.09 (dd, *J* = 16.8 Hz, 2.1 Hz, 1H), 4.98 (dd, *J* = 10.2 Hz, 2.1 Hz, 1H), 3.80 (s, 3H), 3.67 (s, 3H), 2.11-2.18 (m, 2H), 2.05 (t, *J* = 7.5 Hz, 2H), 1.97 (s, 3H), 1.75 (s, 3H), 1.28-1.47 (m, 8H); <sup>13</sup>C NMR (75 MHz, CDCl<sub>3</sub>): δ 165.4, 142.4, 139.7, 133.4, 131.4, 129.9, 125.3, 115.0, 114.4, 60.2, 51.9, 39.7, 29.2, 29.1, 29.0, 28.2, 27.6, 16.5, 14.4.

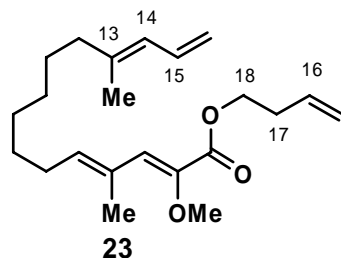
### Preparation of Compound 23e



To a solution of **23d** (875 mg, 2.86 mmol) in dry THF (3 mL) was added potassium trimethylsilanolate (734 mg, 5.72 mmol) at room temperature in one portion, and the mixture was stirred at the same temperature for 24 hr. The reaction mixture was quenched with a saturated aqueous solution of NH<sub>4</sub>Cl (3 mL), and extracted with EtOAc. The aqueous phase was first acidified to pH3 with HCl (2 N), and then extracted with EtOAc (3 x 10 mL), and the combined

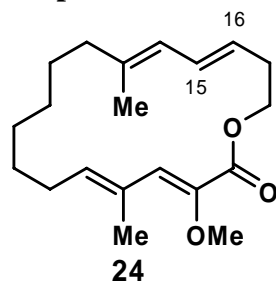
extracts were then dried over Na<sub>2</sub>SO<sub>4</sub>. The solvent was removed under vacuum, and the residue was purified by a flash chromatography (1/1 = petroleum ether/ethyl acetate) to give **23d** (727 mg, 87% yield).

### Preparation of Compound 23



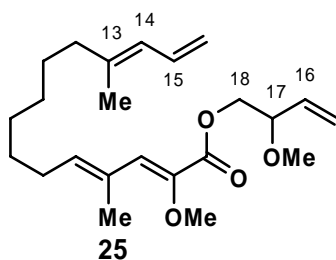
To a solution of **23e** (292 mg, 1 mmol) and 3-butene-1-ol (108 mg, 1.5 mmol) in dry CH<sub>2</sub>Cl<sub>2</sub> (1 mL) were added DMAP (183 mg, 1.5 mmol) and EDC•HCl (288 mg, 1.5 mmol) at room temperature, and the mixture was stirred at the same temperature for 10 hr. The mixture was diluted with CH<sub>2</sub>Cl<sub>2</sub> (5 mL), washed with brine (2 mL), and the organic phase was then dried over Na<sub>2</sub>SO<sub>4</sub>. The solvent was removed under vacuum, and the residue was purified by a flash chromatography (40/1 = hexane/ethyl acetate) to give **23** (249 mg, 72% yield). <sup>1</sup>H NMR (300 MHz, CDCl<sub>3</sub>): δ 6.52-6.65 (m, 1H), 6.60 (s, 1H), 5.77-5.90 (m, 3H), 5.06-5.19 (m, 3H), 4.98 (dd, *J* = 10.2 Hz, *J* = 2.1 Hz, 1H), 4.25 (t, *J* = 6.9 Hz, 2H), 3.65 (s, 3H), 2.43-2.50 (m, 2H), 2.10-2.18 (m, 2H), 2.04 (t, *J* = 7.2 Hz, 2H), 1.97 (s, 3H), 1.75 (s, 3H), 1.28-1.45 (m, 8H); <sup>13</sup>C NMR (75 MHz, CDCl<sub>3</sub>): δ 165.0, 142.5, 139.8, 139.7, 134.0, 133.4, 131.5, 129.8, 125.3, 117.3, 114.4, 63.9, 60.3, 39.7, 33.1, 29.2, 29.1, 29.0, 28.3, 27.6, 16.5, 14.4.

### Preparation of Compound 24



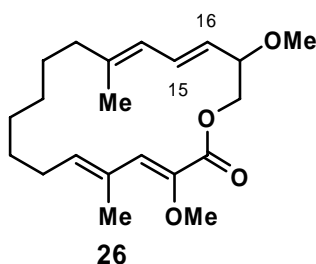
To a refluxing solution of benzyldien-bis(tricyclohexylphosphine)dichlororuthenium (Grubbs' 1<sup>st</sup> generation catalyst, 4.1mg, 0.005mmol) in dry CH<sub>2</sub>Cl<sub>2</sub> (90 mL) was added **23** (34.6 mg, 0.1 mmol) in dry CH<sub>2</sub>Cl<sub>2</sub> (10 mL) *via* cannular, and the mixture was stirred at the same temperature for 18 hr. The reaction mixture was first cooled to room temperature, and then concentrated under vacuum. The residue was purified by a flash chromatography (25/1 hexane/ethyl acetate) to give **24** (27.3 mg, 86% yield); <sup>1</sup>H NMR (300 MHz, CDCl<sub>3</sub>): δ 6.55 (s, 1H) 6.35 (dd, *J* = 15.0 Hz, 10.8 Hz, 1H), 5.87 (d, *J* = 10.8 Hz, 1H), 5.74 (t, *J* = 7.2 Hz, 1H), 5.44-5.54 (m, 1H), 4.26 (t, *J* = 5.7Hz, 2H), 3.66 (s, 3H), 2.47-2.51 (m, 2H), 2.10-2.22 (m, 4H), 1.95 (s, 3H), 1.66 (s, 3H), 1.21-1.54 (m, 6H), 1.12-1.18 (m, 2H); <sup>13</sup>C NMR (75 MHz, CDCl<sub>3</sub>): δ 164.6, 141.8, 140.8, 136.9, 131.2, 131.0, 129.8, 127.0, 125.4, 62.9, 59.9, 39.5, 29.0, 27.89, 27.87, 27.77, 26.5, 15.1, 13.8. LRMS (EI) [C<sub>20</sub>H<sub>30</sub>O<sub>3</sub>], *m/z* (M<sup>+</sup>): calcd 318, found 318.

## Preparation of Compound 25



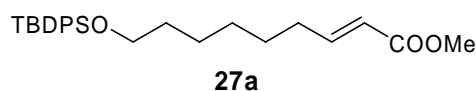
To a solution of **23e** (292 mg, 1 mmol) and 2-methoxybut-3-en-1-ol (30.6 mg, 1.5 mmol) in dry  $\text{CH}_2\text{Cl}_2$  (1 mL) were added DMAP (183 mg, 1.5 mmol) and EDC·HCl (288 mg, 1.5 mmol) at room temperature, and the mixture was stirred at the same temperature for 10 hr. The reaction mixture was then diluted with  $\text{CH}_2\text{Cl}_2$  (5 mL), and washed with brine (2 mL), and the organic layer was then dried over  $\text{Na}_2\text{SO}_4$ . The solvent was removed under vacuum, and the residue was purified by a flash chromatography (25/1 = hexane/ethyl acetate) to give **25** (308 mg, 82% yield).  $^1\text{H}$  NMR (300 MHz,  $\text{CDCl}_3$ ):  $\delta$  6.63 (s, 1H), 6.53-6.60 (m, 1H), 5.69-5.86 (m, 3H), 5.32-5.39 (m, 2H), 5.09 (dd,  $J = 16.8$  Hz,  $J = 1.6$  Hz, 1H), 4.97 (d,  $J = 10.2$  Hz, 1H), 4.16-4.25 (m, 2H), 3.89-3.93 (m, 1H), 3.66 (s, 3H), 3.35 (s, 3H), 2.11-2.17 (m, 2H), 2.04 (t,  $J = 7.2$  Hz, 2H), 1.97 (s, 3H), 1.75 (s, 3H), 1.38-1.43 (m, 4H), 1.28-1.32 (m, 4H);  $^{13}\text{C}$  NMR (75 MHz,  $\text{CDCl}_3$ ):  $\delta$  164.8, 142.3, 139.83, 139.80, 134.5, 133.4, 131.5, 130.1, 125.3, 119.3, 114.4, 80.4, 66.4, 60.2, 56.7, 39.7, 29.2, 29.1, 29.0, 28.3, 27.6, 16.5, 14.4.

## Preparation of Compound 26



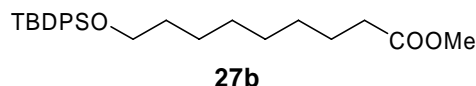
To a refluxing solution of benzyldien-bis(tricyclohexylphosphine)dichlororuthenium (Grubbs' 1<sup>st</sup> generation catalyst, 4.1 mg, 0.005 mmol) in dry  $\text{CH}_2\text{Cl}_2$  (90 mL) was added **25** (37.6 mg, 0.1 mmol) in dry  $\text{CH}_2\text{Cl}_2$  (10 mL) *via* a cannular, and the mixture was stirred at the same temperature for 28 hr. The mixture was then cooled to room temperature, and then concentrated under vacuum. The residue was purified by a flash chromatography (25/1 = hexane/ethyl acetate) to give **26** (22.6 mg, 65% yield).  $^1\text{H}$  NMR (300 MHz,  $\text{CDCl}_3$ ):  $\delta$  6.50 (s, 1H), 6.49 (dd,  $J = 15.3$  Hz, 10.8 Hz, 1H), 5.94 (d,  $J = 10.8$  Hz, 1H), 5.73 (t,  $J = 7.2$  Hz, 1H), 5.39 (dd,  $J = 15.3$  Hz, 7.8 Hz, 1H), 4.51-4.55 (m, 1H), 3.86-3.95 (m, 2H), 3.67 (s, 3H), 3.43 (s, 3H), 2.08-2.19 (m, 4H), 1.97 (s, 3H), 1.71 (s, 3H), 1.20-1.31 (m, 8H);  $^{13}\text{C}$  NMR (75 MHz,  $\text{CDCl}_3$ ):  $\delta$  164.2, 141.6, 141.0, 139.9, 131.4, 131.3, 131.2, 127.8, 124.9, 79.6, 64.1, 60.0, 56.4, 39.2, 29.1, 27.96, 27.95, 27.7, 26.5, 15.2, 13.8; LRMS (EI) [ $\text{C}_{21}\text{H}_{32}\text{O}_4$ ],  $m/z$  ( $\text{M}^+$ ): calcd 348, found 348.

## Preparation of Compound 27a



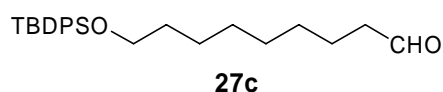
To a solution of aldehyde **17b** (7.36 g, 20 mmol) in dry toluene (100 mL) was added (carbmethoxymethylidene)triphenylphosphorane (20 g, 60 mmol) at room temperature, and the mixture was stirred at 80 °C for 4 hr. The reaction mixture was then cooled to room temperature and then diluted with petroleum ether (200 mL). The formed precipitate was filtered off, and the filtrate was concentrated. The residue was purified by a flash chromatography (20/1 = petroleum ether/ethyl acetate) to give **27a** (7.22 g, 85% yield).

### Preparation of Compound 27b



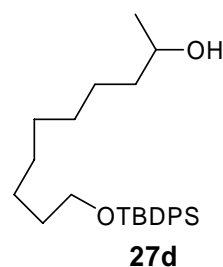
To a solution of **27a** (7.22 g, 17 mmol) in methanol (30 mL) was added the Pd-catalyst (10% palladium on activated carbon, 361 mg), and the reaction mixture was stirred under a balloon pressure of hydrogen for 30 min. The reaction mixture was first filtered through celite, and the filtrate was then concentrated. The residue was purified by a flash chromatography (20/1 petroleum ether/ethyl acetate) to give **27b** (5.81 g, 80% yield). <sup>1</sup>H NMR (300 MHz, CDCl<sub>3</sub>): δ 7.66-7.70 (m, 4H), 7.35-7.43 (m, 6H), 3.66 (s, 3H), 3.65 (t, *J* = 6.6 Hz, 2H), 1.53-1.64 (m, 4H), 1.28-1.36 (m, 10H), 1.05 (s, 9H); <sup>13</sup>C NMR (75 MHz, CDCl<sub>3</sub>): δ 174.3, 135.5, 134.1, 129.4, 127.5, 63.9, 51.4, 34.1, 32.5, 29.2, 29.1, 29.0, 26.8, 25.7, 24.9, 19.2.

### Preparation of Compound 27c



To a solution of **27b** (5.81 g, 13.6 mmol) in dry toluene (60 mL) was added DIBAL-H (1.0M in toluene 27.2 mL, 27.2 mmol) at – 78 °C in dropwise over 20 min. and the mixture was stirred at the same temperature for 4 hr. The reaction was carefully quenched by slow addition of EtOAc (15 mL), and mixture was stirred at – 78 °C for another 20 min. After warming up to room temperature gradually, the mixture was poured carefully into a rapid stirred mixture of a saturated aqueous solution of Rochelle's salt (potassium sodium tartrate tetrahydrate, 150 mL), and the resultant cloudy mixture was stirred vigorously until the organic layer became clear. The aqueous phase was extracted with EtOAc (3 x 50 mL), and the combined organic phase was then dried over Na<sub>2</sub>SO<sub>4</sub>. The solvent was removed under vacuum, and the residue was purified by a flash chromatography (20:1 petroleum ether/ethyl acetate) to give **27c** (4.47 g, 83% yield).

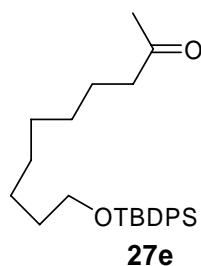
### Preparation of Compound 27d



To a solution of methylmagnesium chloride (2.85 M in THF, 4.77 mL, 13.6 mmol) in dry

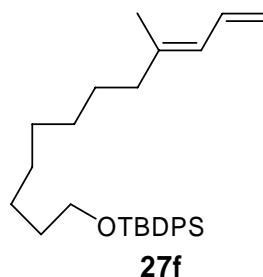
THF (30 mL) was added aldehyde **27c** (4.77 g, 11.3 mmol) in dry THF (20 mL) at 0 °C *via* a cannular, and the mixture was stirred at the same temperature for 30 min. The reaction mixture was first quenched with a saturated aqueous solution of NH<sub>4</sub>Cl (10 mL), and extracted with Et<sub>2</sub>O (3 x 20 mL), and combined extracts were then dried over Na<sub>2</sub>SO<sub>4</sub>. The solvent was removed under vacuum, and the residue was purified by a flash chromatography (6/1 = petroleum ether/ethyl acetate) gave **27d** (4.19 g, 90% yield); <sup>1</sup>H NMR (300 MHz, CDCl<sub>3</sub>): δ 7.66-7.70 (m, 4H), 7.35-7.46 (m, 6H), 3.77-3.81 (m, 1H), 3.65 (t, *J* = 6.6 Hz, 2H), 1.51-1.60 (m, 2H), 1.21-1.44 (m, 12H), 1.18 (d, *J* = 6.3 Hz, 3H), 1.05 (s, 9H); <sup>13</sup>C NMR (75 MHz, CDCl<sub>3</sub>): δ 135.5, 134.1, 129.4, 127.5, 68.2, 63.9, 39.3, 32.5, 29.5, 29.3, 26.8, 25.7, 23.4, 19.2.

### Preparation of Compound **27e**



A solution of dimethyl sulfoxide (1.04 g, 13.3 mmol) in dry CH<sub>2</sub>Cl<sub>2</sub> (20 mL) was slowly added to the solution of oxalyl chloride (1.69 g, 13.3 mmol) in dry CH<sub>2</sub>Cl<sub>2</sub> (20 mL) at -78 °C, and the mixture was stirred at the same temperature for 30 min. To this solution was alcohol **27d** (4.19 g, 10.2 mmol) in dry CH<sub>2</sub>Cl<sub>2</sub> (80 mL) at -78 °C in dropwise, and the resultant solution was stirred at the same temperature for 30 min. After addition of triethylamine (2.28 g, 26.6 mmol), the reaction was gradually warmed up 0 °C, and stirred for 1 h before quenching with water (15 mL). The mixture was extracted with CH<sub>2</sub>Cl<sub>2</sub> (3 x 20 mL), and the combined organic phase was washed with brine (2 x 5 mL), and then dried over Na<sub>2</sub>SO<sub>4</sub>. The solvent was removed under vacuum, and the residue was purified by a flash chromatography (10:1 petroleum ether/ethyl acetate) to give **27e** (3.72 g, 89% yield). <sup>1</sup>H NMR (300 MHz, CDCl<sub>3</sub>): δ 7.66-7.69 (m, 4H), 7.36-7.43 (m, 6H), 3.65 (t, *J* = 6.6 Hz, 2H), 2.41 (t, *J* = 7.5 Hz, 2H), 2.13 (s, 3H), 1.52-1.61 (m, 4H), 1.24-1.29 (m, 8H), 1.05 (s, 9H); <sup>13</sup>C NMR (75 MHz, CDCl<sub>3</sub>): δ 209.4, 135.6, 134.1, 129.5, 127.5, 63.9, 43.8, 32.5, 29.9, 29.3, 29.2, 29.1, 26.8, 25.7, 23.8, 19.2.

### Preparation of Compound **27f**

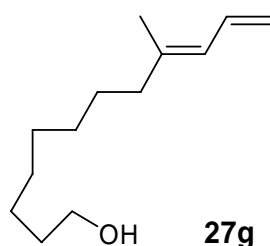


*n*-BuLi (2.5 M in hexane, 4.84 mL, 12.1 mmol) was added to a solution of allyldiphenylphosphine oxide (2.93 g, 12.1 mmol) and HMPA (4.33 g, 24.2 mmol) in dry THF (200 mL) at -78 °C in dropwise, and the mixture was stirred at the same temperature for 30 min. To this solution was added ketone **27e** (3.72 g, 9.08 mmol) in THF -78 °C within 15 min. The



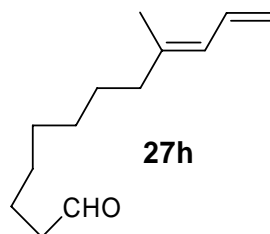
reaction mixture was stirred first at the same temperature for 30 min, and then at 0 °C for 10 min. and finally at room temperature for 2 hr. The reaction mixture was quenched with a saturated aqueous solution of NH<sub>4</sub>Cl (30 mL), and then extracted with Et<sub>2</sub>O (3 x 50 mL), and the combined extracts were then dried over Na<sub>2</sub>SO<sub>4</sub>. The solvent was removed under vacuum, and the residue was purified by a flash chromatography (20/1 = petroleum ether/ethyl acetate) to give **27f** (2.95 g, 75% yield). <sup>1</sup>H NMR (300 MHz, CDCl<sub>3</sub>): δ 7.67-7.70 (m, 4H), 7.35-7.46 (m, 6H), 6.53-6.65 (m, 1H), 5.85 (d, *J* = 11.1 Hz, 1H), 5.09 (dd, *J* = 16.8 Hz, 1.8 Hz, 1H), 4.97 (dd, *J* = 10.2 Hz, 1.8 Hz, 1H), 3.65 (t, *J* = 6.6 Hz, 2H), 2.03 (t, *J* = 7.2 Hz, 2H), 1.75 (s, 3H), 1.51-1.58 (m, 2H), 1.26-1.43 (m, 10H), 1.05 (s, 9H); <sup>13</sup>C NMR (75 MHz, CDCl<sub>3</sub>): δ 140.0, 135.6, 134.1, 133.4, 129.5, 127.5, 125.2, 114.4, 64.0, 39.8, 32.5, 29.5, 29.30, 29.28, 27.8, 26.9, 25.7, 19.2, 16.6.

### Preparation of Compound 27g



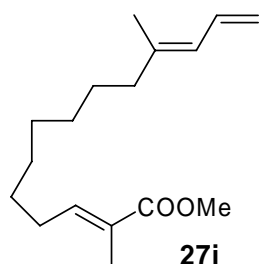
To a solution of **27f** (2.95 g, 6.81 mmol) in THF (15 mL) was added TBAF (4.29 g, 13.6 mmol) at room temperature, and the mixture was stirred at the same temperature for 4 hr. The reaction mixture was first diluted with water (10 mL), and then extracted with Et<sub>2</sub>O (3 x 20 mL). The combined organic phase was washed with brine (10 mL), and then dried over Na<sub>2</sub>SO<sub>4</sub>. The solvent was removed under vacuum, and the residue was purified by a flash chromatography (from 8/1 to 4/1 = petroleum ether/ethyl acetate) to give **27g** (1.28 g, 96% yield). <sup>1</sup>H NMR (300 MHz, CDCl<sub>3</sub>): δ 6.53-6.65 (m, 1H), 5.85 (d, *J* = 11.1 Hz, 1H), 5.09 (dd, *J* = 16.8 Hz, 1.8 Hz, 1H), 4.97 (d, *J* = 10.2 Hz, 1H), 3.64 (t, *J* = 6.6 Hz, 2H), 2.04 (t, *J* = 7.5 Hz, 2H), 1.75 (s, 3H), 1.31-1.59 (m, 12H); <sup>13</sup>C NMR (75 MHz, CDCl<sub>3</sub>): δ 139.9, 133.4, 125.2, 114.3, 63.0, 39.8, 32.7, 29.4, 29.3, 29.2, 27.7, 25.7, 16.5.

### Preparation of Compound 27h



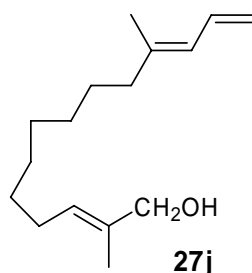
To a solution of **27g** (1.28 g, 6.54 mmol) in dry CH<sub>2</sub>Cl<sub>2</sub> (10 mL) was added Dess-Martin periodinane reagent (3.05 g, 7.19 mmol) at 0 °C in several portions during 20 min. and the mixture was stirred at the room temperature for 30 min. After addition of petroleum ether (20 mL), the formed precipitate was filtered off, and the filtrate was concentrated under vacuum at 0 °C. The residue was purified by a flash chromatography (20/1 = petroleum ether/Et<sub>2</sub>O) to give **27h** (901 mg, 71% yield).

## Preparation of Compound



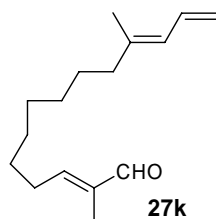
To a solution of aldehyde **27h** (901 mg, 4.64 mmol) in dry toluene (15 mL) was added (carbmethoxymethylidene)triphenylphosphorane (4.84 g, 13.9 mmol) at room temperature, and the reaction mixture was stirred at 80 °C for 4 hr. The reaction mixture was then cooled to room temperature, and then diluted with petroleum ether (20 mL). The formed precipitate was filtered off, and the filtrate was concentrated under vacuum. The residue was purified by a flash chromatography (30/1 = petroleum ether/ethyl acetate) to give **27i** (1.05 g, 86% yield). <sup>1</sup>H NMR (300 MHz, CDCl<sub>3</sub>): δ 6.75-6.80 (m, 1H), 6.53-6.62 (m, 1H), 5.85 (d, *J* = 10.5 Hz, 1H), 5.09 (dd, *J* = 16.8 Hz, 2.1 Hz, 1H), 4.97 (d, *J* = 9.9 Hz, 1H), 3.74 (s, 3H), 2.16 (t, *J* = 7.2 Hz, 2H), 2.04 (t, *J* = 7.5 Hz, 2H), 1.83 (s, 3H), 1.75 (s, 3H), 1.30-1.56 (m, 10H); <sup>13</sup>C NMR (75 MHz, CDCl<sub>3</sub>): δ 168.7, 142.8, 139.9, 133.4, 127.4, 125.2, 114.4, 51.6, 39.8, 29.31, 29.26, 29.19, 28.6, 28.5, 27.7, 16.5, 12.3.

## Preparation of Compound 27j



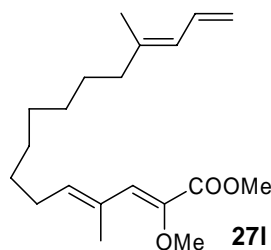
To a solution of **27i** (1.05 g, 3.99 mmol) in dry toluene (30 mL) was added DIBAL-H (1.0 M in toluene 9.98 mL, 9.98 mmol) at -78 °C in dropwise within 20 min. and the mixture was stirred at -78 °C for 4 hr. The reaction mixture was quenched by slow addition of EtOAc (5 mL) at -78 °C, and then stirred at the same temperature for another 20 min. After gradually warming up to room temperature, the mixture was poured carefully into a rapid stirred mixture of a saturated aqueous solution of Rochelle's salt (potassium sodium tartrate tetrahydrate, 80 mL), and the resultant cloudy mixture was stirred vigorously until the organic layer became clear. The aqueous phase was extracted with EtOAc (3 x 40 mL), and the combined organic phase was then dried over Na<sub>2</sub>SO<sub>4</sub>. The solvent was removed under vacuum, and the residue was purified by a flash chromatography (4/1 = petroleum ether/ethyl acetate) to give **27j** (857 mg, 91% yield). <sup>1</sup>H NMR (300 MHz, CDCl<sub>3</sub>): δ 6.53-6.65 (m, 1H), 5.85 (dd, *J* = 10.8 Hz, 1.2 Hz, 1H), 5.39-5.44 (m, 1H), 5.09 (dd, *J* = 16.8 Hz, 2.1 Hz, 1H), 4.97 (dd, *J* = 9.9 Hz, 2.1 Hz, 1H), 4.00 (s, 2H), 2.01 (t, *J* = 7.5 Hz, 2H), 1.75 (s, 3H), 1.66 (s, 3H), 1.26-1.47 (m, 12H); <sup>13</sup>C NMR (75 MHz, CDCl<sub>3</sub>): δ 140.0, 134.5, 133.4, 126.6, 125.2, 114.3, 69.0, 39.8, 29.5, 29.4, 29.3, 29.2, 27.7, 27.6, 16.5, 13.6.

### Preparation of Compound 27k



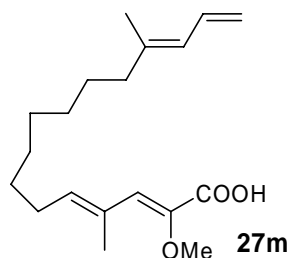
To a solution of **27j** (857 mg, 3.63 mmol) in dry  $\text{CH}_2\text{Cl}_2$  (5 mL) was added Dess-Martin periodinane reagent (1.69 g, 3.99 mmol) at 0 ° in several portions within 20 min, and the mixture was stirred at room temperature for 30 min. After addition of petroleum ether (20 mL) to the reaction mixture, the formed precipitate was filtered off, and the filtrate was concentrated under vacuum. The residue was purified by a flash chromatography (10/1 = petroleum ether/ethyl acetate) to give **27k** (756 mg, 89% yield).

### Preparation of Compound 27l



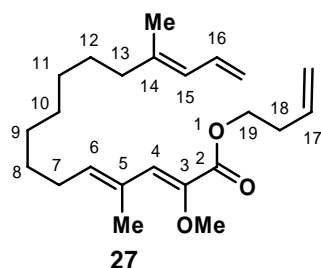
To a solution of methyl 2-methoxy-2-(diisopropoxyphosphoryl)acetate (1.73 g, 6.46 mmol) in dry THF (40 mL) were sequentially added 18-crown-6 (1.71 g, 6.46 mmol) and KHMDS (0.5 M in toluene, 12.9 mL, 6.46 mmol) in dropwise at 0 °C, and the mixture was stirred at the same temperature for 30 min. To this solution was added aldehyde **80** (716 mg, 3.23 mmol) in THF at 0 °C in dropwise, and the mixture was stirred at the same temperature for 30 min. After stirring at room temperature for 10 hr, the reaction mixture was quenched with a saturated aqueous solution of  $\text{NH}_4\text{Cl}$  (15 mL), and extracted with  $\text{Et}_2\text{O}$  (3 x 20 mL), the combined extracts were then dried over  $\text{Na}_2\text{SO}_4$ . The solvent was removed under vacuum, and the residue was purified by a flash chromatography (20/1 = petroleum ether/ethyl acetate) to give **27l** (838 mg, 81% yield).  $^1\text{H}$  NMR (300 MHz,  $\text{CDCl}_3$ ):  $\delta$  6.53-6.65 (m, 2H), 5.80-5.87 (m, 2H), 5.09 (dd,  $J$  = 16.8 Hz, 1.8 Hz, 1H), 4.98 (dd,  $J$  = 10.2 Hz, 1.8 Hz, 1H), 3.80 (s, 3H), 3.67 (s, 3H), 2.11-2.18 (m, 2H), 2.04 (t,  $J$  = 7.5 Hz, 2H), 1.97 (s, 3H), 1.75 (s, 3H), 1.24-1.47 (m, 10H);  $^{13}\text{C}$  NMR (75 MHz,  $\text{CDCl}_3$ ):  $\delta$  165.5, 142.5, 139.9, 133.4, 131.4, 129.9, 125.3, 114.4, 60.3, 51.9, 39.8, 29.4, 29.3, 29.1, 28.3, 27.7, 16.5, 14.4.

### Preparation of Compound 27m



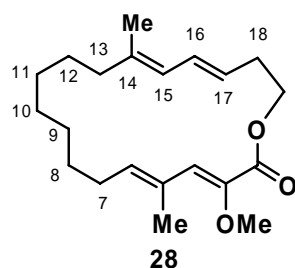
To a solution of **27i** (838 mg, 2.62 mmol) in dry THF (3 mL) was added potassium trimethylsilanolate (672 mg, 5.24 mmol) at room temperature in one portion, and the mixture was stirred at same temperature for 24 hr. The reaction mixture was quenched with a saturated aqueous solution of  $\text{NH}_4\text{Cl}$  (3 mL), and then extracted with EtOAc (2 mL). The aqueous phase was first acidified to pH3 with HCl (2 N), and extracted with EtOAc (3 x 10 mL), and the combined extracts were then dried over  $\text{Na}_2\text{SO}_4$ . The solvent was removed under vacuum, and the residue was purified by a flash chromatography (1/1 = petroleum ether/ethyl acetate) to give **27m** (665 mg, 83% yield).

### Preparation of Compound 27



To a solution of **27m** (306 mg, 1 mmol) and 3-butene-1-ol (108 mg, 1.5 mmol) in dry  $\text{CH}_2\text{Cl}_2$  (1 mL) were added DMAP (183 mg, 1.5 mmol) and EDC·HCl (288 mg, 1.5 mmol) at room temperature, and the mixture was stirred at same temperature for 10 hr. The reaction mixture was first diluted with  $\text{CH}_2\text{Cl}_2$  (5 mL), and washed with brine (2 mL), and then dried over  $\text{Na}_2\text{SO}_4$ . The solvent was removed under vacuum, and the residue was purified by a flash chromatography (40/1 = hexane/ethyl acetate) to give **27** (259 mg, 72% yield).  $^1\text{H}$  NMR (300 MHz,  $\text{CDCl}_3$ ):  $\delta$  6.53-6.65 (m, 1H), 6.61 (s, 1H), 5.79-5.88 (m, 3H), 5.06-5.19 (m, 3H), 4.98 (dd,  $J = 10.2$  Hz,  $J = 1.8$  Hz, 1H), 4.25 (t,  $J = 6.6$  Hz, 2H), 3.66 (s, 3H), 2.43-2.50 (m, 2H), 2.10-2.18 (m, 2H), 2.04 (t,  $J = 7.2$  Hz, 2H), 1.97 (s, 3H), 1.75 (s, 3H), 1.20-1.47 (m, 10H);  $^{13}\text{C}$  NMR (75 MHz,  $\text{CDCl}_3$ ):  $\delta$  165.0, 142.5, 139.8, 134.0, 133.4, 131.5, 129.8, 125.2, 117.3, 114.4, 63.9, 60.3, 39.8, 33.1, 29.4, 29.3, 29.2, 29.1, 28.3, 27.7, 16.5, 14.4.

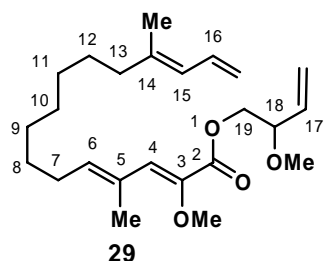
### Preparation of Compound 28



To a refluxing solution of Grubbs' 1<sup>st</sup> generation catalyst (benzylidien-bis-(tricyclohexylphosphine)dichlororuthenium, 4.1 mg, 0.005 mmol) in dry  $\text{CH}_2\text{Cl}_2$  (90 mL) was added **27** (36 mg, 0.1 mmol) in dry  $\text{CH}_2\text{Cl}_2$  (10 mL) *via* a cannular within 20 min, and the mixture was stirred at the same temperature for 10 hr. After cooling to room temperature, the reaction mixture was concentrated under vacuum, and the residue was purified by a flash chromatography (25/1 = hexane/ethyl acetate) to give **28** (27.9 mg, 84% yield);  $^1\text{H}$  NMR (300 MHz,  $\text{CDCl}_3$ ):

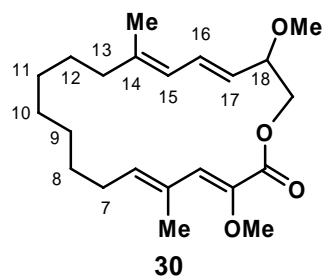
$\delta$  6.54 (s, 1H) 6.34 (dd,  $J$  = 15.0 Hz, 10.8 Hz, 1H), 5.84 (d,  $J$  = 10.8 Hz, 1H), 5.49-5.59 (m, 2H), 4.27 (t,  $J$  = 6.0 Hz, 2H), 3.67 (s, 3H), 2.47-2.53 (m, 2H), 2.10-2.16 (m, 2H), 2.56 (t,  $J$  = 6.3 Hz, 2H), 1.97 (s, 3H), 1.73 (s, 3H), 1.36-1.45 (m, 4H), 1.14-1.30 (m, 6H);  $^{13}\text{C}$  NMR (75 MHz,  $\text{CDCl}_3$ ):  $\delta$  164.6, 142.0, 140.8, 137.2, 132.4, 130.5, 129.4, 127.3, 125.2, 63.2, 60.0, 29.3, 32.3, 27.5, 27.2, 27.12, 27.11, 26.8, 16.0, 14.2; LRMS (EI) [ $\text{C}_{21}\text{H}_{32}\text{O}_3$ ],  $m/z$  ( $\text{M}^+$ ): calcd 332, found 332.

### Preparation of Compound 29



To a solution of **27m** (306 mg, 1 mmol) and 2-methoxybut-3-en-1-ol (30.6 mg, 1.5 mmol) in dry  $\text{CH}_2\text{Cl}_2$  (1 mL) were added DMAP (183 mg, 1.5 mmol) and EDC·HCl (288 mg, 1.5 mmol) at room temperature, and the mixture was stirred at the same temperature for 10 hr. After dilution with  $\text{CH}_2\text{Cl}_2$  (5 mL), the organic phase was washed with brine (2 mL), was then dried over  $\text{Na}_2\text{SO}_4$ . The solvent was removed under vacuum, and the residue was purified by a flash chromatography (25/1 = hexane/ethyl acetate) to give **29** (289 mg, 74% yield).  $^1\text{H}$  NMR (300 MHz,  $\text{CDCl}_3$ ):  $\delta$  6.53-6.65 (m, 1H), 6.63 (s, 1H), 5.69-5.87 (m, 3H), 5.32-5.41 (m, 2H), 5.09 (dd,  $J$  = 16.8 Hz,  $J$  = 1.8 Hz, 1H), 4.97 (dd,  $J$  = 10.2 Hz,  $J$  = 1.8 Hz, 1H), 4.16-4.27 (m, 2H), 3.89-3.95 (m, 1H), 3.67 (s, 3H), 3.36 (s, 3H), 2.10-2.18 (m, 2H), 2.04 (t,  $J$  = 7.5 Hz, 2H), 1.97 (s, 3H), 1.75 (s, 3H), 1.20-1.41 (m, 10H);  $^{13}\text{C}$  NMR (75 MHz,  $\text{CDCl}_3$ ):  $\delta$  164.8, 142.3, 140.0, 134.5, 133.4, 131.4, 130.1, 125.2, 119.3, 114.4, 80.4, 66.4, 60.2, 56.7, 39.8, 29.4, 29.3, 29.2, 29.1, 28.3, 27.7, 16.5, 14.4.

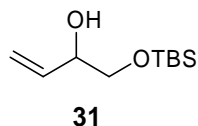
### Preparation of Compound 30



To a refluxing solution of Grubbs' 1<sup>st</sup> generation catalyst (benzylidien-bis-(tricyclohexylphosphine)dichlororuthenium, 4.1 mg, 0.005 mmol) in dry  $\text{CH}_2\text{Cl}_2$  (90 mL) was added **29** (39 mg, 0.1 mmol) in dry  $\text{CH}_2\text{Cl}_2$  (10 mL) *via* a cannular, and the mixture was stirred at the same temperature for 30 hr. After cooling to room temperature, the reaction mixture was concentrated under vacuum, and the residue was purified by a flash chromatography (25/1 = hexane/ethyl acetate) to give **30** (32.4 mg, 83% yield).  $^1\text{H}$  NMR (300MHz,  $\text{CDCl}_3$ ):  $\delta$  6.51(s, 1H) 6.50 (dd,  $J$ =15.0Hz, 11.1Hz, 1H), 5.91 (d,  $J$ =11.1Hz, 1H), 5.59 (t,  $J$ =7.2Hz, 1H), 5.44 (dd,  $J$ =15.0Hz, 7.8Hz, 1H), 4.46 (dd,  $J$ =10.2Hz, 4.2Hz, 1H), 3.91-4.05 (m, 2H), 3.66 (s, 3H), 3.34 (s, 3H), 2.04-2.16 (m, 4H), 1.95 (s, 3H), 1.75 (s, 3H), 1.22-1.47 (m, 10H);  $^{13}\text{C}$  NMR (75MHz,

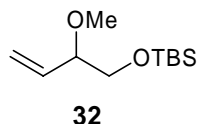
CDCl<sub>3</sub>):  $\delta$  164.2, 141.8, 140.8, 140.4, 132.3, 131.2, 130.7, 127.6, 124.4, 79.5, 64.8, 60.1, 56.3, 39.2, 27.33, 27.28, 26.9, 26.8, 26.74, 26.70, 16.3, 14.2. LRMS (EI) [C<sub>22</sub>H<sub>34</sub>O<sub>4</sub>], m/z (M<sup>+</sup>): calcd 362, found 362.

### Preparation of Compound 31



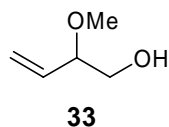
To a solution of 3-buten-1,2-diol (4.4 g, 50 mmol) in dry THF (150 mL) was added imidazole (13.6 g, 200 mmol) and TBSCl (7.93 g, 52.5mmol) in THF (50 mL) at room temperature *via* a cannular, and the mixture was stirred at the same temperature for 9 hr. After addition of water (100mL), the mixture was extracted with Et<sub>2</sub>O (3 x 100 mL), and the combined organic phase was washed with brine (2 x 30 mL), and then dried over Na<sub>2</sub>SO<sub>4</sub>. The solvent was removed under vacuum, and the residue was purified by a flash chromatography (6:1 petroleum ether/ethyl acetate) to give **31** (9.96 g, 95% yield).

### Preparation of Compound 32



To a solution of **31** (9.96 g, 47.5 mmol) in CH<sub>2</sub>Cl<sub>2</sub> (80 mL) were sequentially added fresh Ag<sub>2</sub>O (22 g, 95 mmol), iodomethane (67.5 g, 475mmol), and the reaction mixture was stirred under reflux for 48 hr. After cooling to room temperature, the formed precipitate was filtered, and the filtrate was concentrated and the residue was then purified by a flash chromatography (30/1 = petroleum ether/ethyl acetate) to give **32** (6.05 g, 59% yield).

### Preparation of Compound 33



To a solution of **32** (6.05 g, 28mmol) in THF (25 mL) was added TBAF (10.6 g, 33.6 mmol) at room temperature, and the mixture was stirred at same temperature for 4 hr. After addition of water (20 mL), the reaction mixture was extracted with Et<sub>2</sub>O (3 x 25 mL), and the combined organic phase was washed with brine (20 mL), and then dried over Na<sub>2</sub>SO<sub>4</sub>. The solvent was removed by distillation, and the residue was purified by a flash chromatography (5/1 = petroleum ether / Et<sub>2</sub>O). After distillation of the elution, compound **33** was obtained (1.83 g, 64% yield). <sup>1</sup>H NMR (300 MHz, CDCl<sub>3</sub>):  $\delta$  6.63-5.74 (m, 1H), 5.30-5.38 (m, 2H), 3.70-3.76 (m, 1H), 3.52-3.63 (m, 2H), 3.38(s, 3H); <sup>13</sup>C NMR (75 MHz, CDCl<sub>3</sub>):  $\delta$  134.7, 119.2, 83.4, 65.2, 56.5.