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Zinc Mediated Deoxygenation of 4-Hydroxy-2-Butenoic Acid Moiety. An Application for the Synthesis of Multifunctional chiral synthon.

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Abstract: *A facile and practical method for the deoxygenation of 4-alkoxy- 2-butenoic acid moiety mediated by zinc is described to prepare multifunctional chiral building blocks from carbohydrates and tartaric acid.*

INTRODUCTION

Though asymmetric synthesis began its domination in natural product synthesis, the relentless persuit of organic chemist for preparing optically pure building blocks via 'Chiron approach'[1,2] still continues especially if these building blocks are obtained from naturally available carbohydrates, tartaric acid, amino acids, lactic acid etc., owing to abundance and cost efficiency. Our continued interest in the total synthesis of arachidonic acid lipoxygenation products such as leukotrienes[3,4], lipoxins[3,4], 5-HETE[5], pheromones[6] and others[7,8] prompted us to study zinc mediated reductive deoxygenation of 4-alkoxy-2-butenoic acid moiety of the type **1a** to yield deconjugated chiral allyl alcohol of the type **2a**. A similar transformation was achieved by Kang *et al.*[9] using more expensive and hazardous samarium diiodide, whereas a closely related work was also reported earlier using same reagent by Molander *et al*[10]. The details of our findings are presented herein.

RESULTS AND DISCUSSION

At the first glance we intended to prepare a desired precursor starting from D-ribose. Accordingly D-ribose on treatment with (carbethoxy methylene) triphenyl phosphorane in THF at reflux followed by acetonation ($CuSO_4$, H_2SO_4, Acetone) yielded the prerequisite γ-oxy, α,β unsaturated ester **1a** (scheme 1). This substrate underwent a very facile reductive elimination process (REP) in refluxing ethanolic Zn dust

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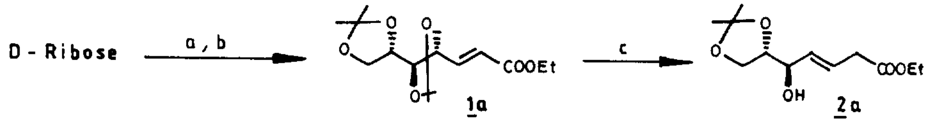
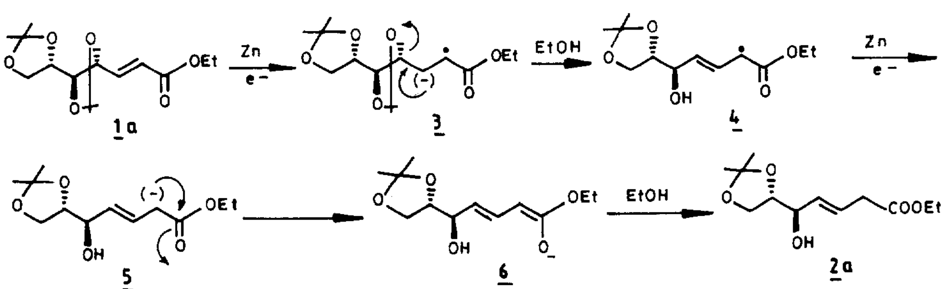
(activated)[11] producing δ-hydroxy, β,γ unsaturated ester **2a** in 85% yield. The newly positioned olefin was found to have E-geometry based on ^{1}H NMR and ^{13}C analysis (See experimental).



Reagents : (a) Ph_3P = CH-COOEt, C_6H_5COOH, THF, reflux[12]; (b) Acetone, $CuSO_4$, H_2SO_4; (c) Zn dust, EtOH, reflux.

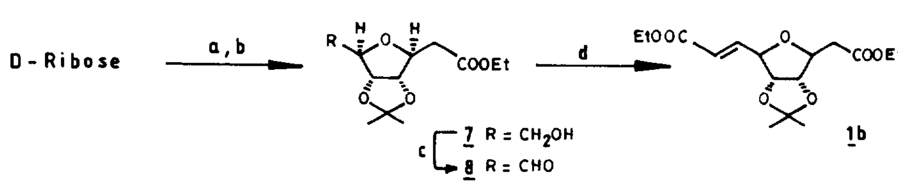
SCHEME 1

A plausible mechanism for the above reaction is shown in scheme 2. Accordingly[10,13] metal (Zn) initially involves the supply of an electron to the double bond to generate radical anion which then undergoes concomitant reductive elimination of γ-oxy group via olefin migration. This then accepts another electron from Zn to give rise to enolate **6** which ultimately leads to desired product **2a**.



SCHEME 2

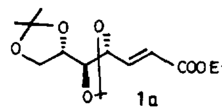
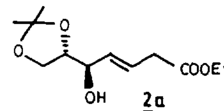
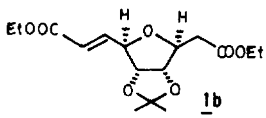
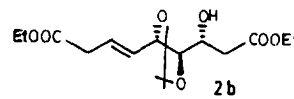
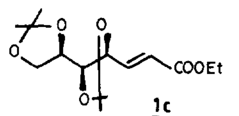
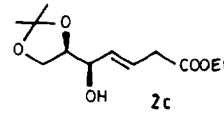
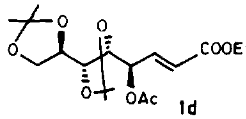
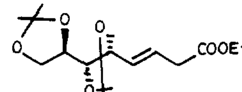
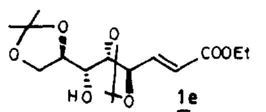
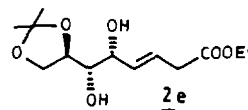
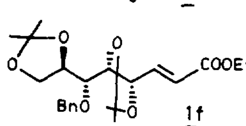
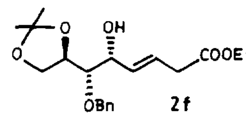
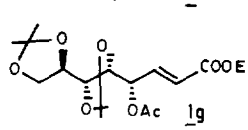
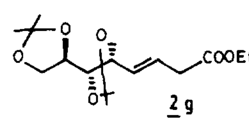
Taking advantage of the ready availability of sugars commercially, several substrates having γ,δ dioxy-α,β unsaturated esters were prepared using acetonation and Wittig olefination as primary reactions and subjected to the described transformation as shown in Table 1. The substrate **1c** was prepared from D-xylose following the sequence described for D-ribose and **1b** was prepared as delineated in Scheme 3.



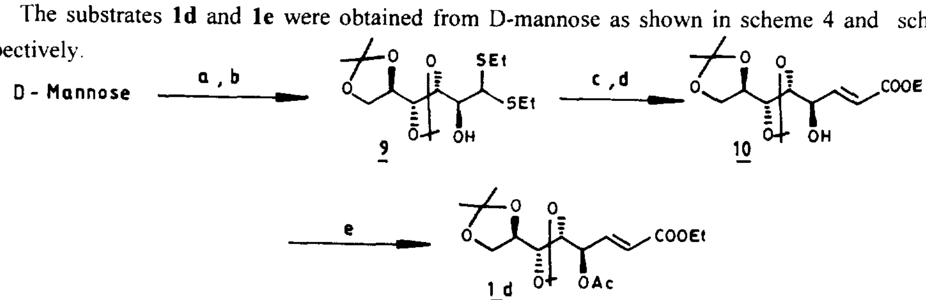
Reagents : (a) Acetone, $CuSO_4$, H_2SO_4[14]; (b) Ph_3P = CH-COOEt, CH_3CN, reflux[15]; (c) $(COCl)_2$, DMSO, Et_3N, -78°c ; (d) Ph_3P = CH-COOEt, C_6H_6 room temperature.

SCHEME 3

Table 1. Zinc mediated deoxygenation of γ-oxy, α, β unsaturated esters.

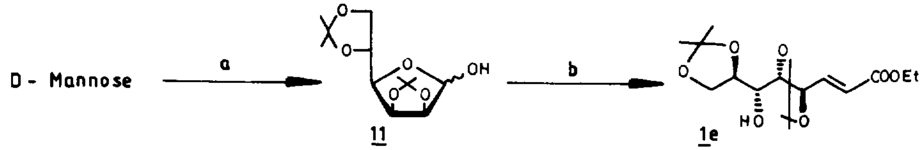
Entry	Starting materials	Reactants	Products
1	D - Ribose	 1a	 2a
2	D - Ribose	 1b	 2b
3	D - Xylose	 1c	 2c
4	D-Mannose	 1d	 2d
5	D - Mannose	 1e	 2e
6	D - Glucose	 1f	 2f
7	δ - D - Gluconolactone	 1g	 2g

The substrates **1d** and **1e** were obtained from D-mannose as shown in scheme 4 and scheme 5 respectively.



Reagents : (a) HCl. EtSH[16] ; (b) Acetone, $CuSO_4$, H_2SO_4 ; (c) $HgCl_2$, HgO, H_2O, Acetone[17] ; (d) Ph_3 P = CH-COOEt, C_6H_6 room temperature ; (e) Ac_2O, Et_3N, DMAP, DCM.

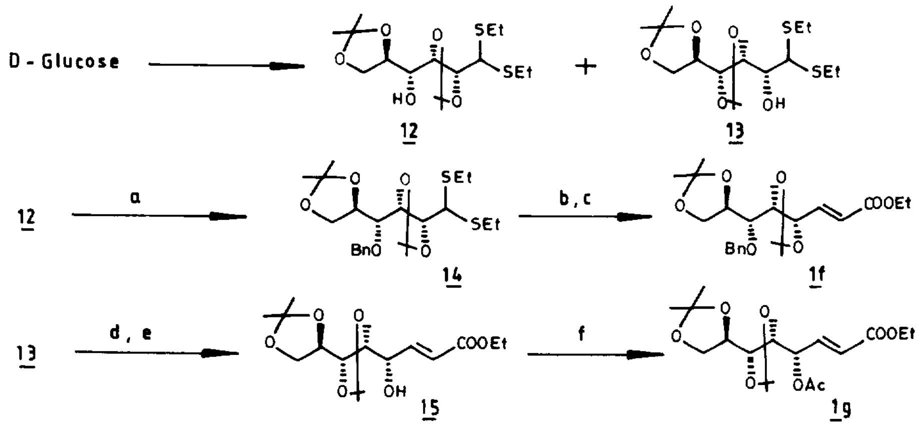
SCHEME 4



Reagents : (a) Acetone, $CuSO_4$, H_2SO_4; (b) $Ph_3P = CH\text{-}COOEt$, C_6H_5COOH, THF, reflux.

SCHEME 5

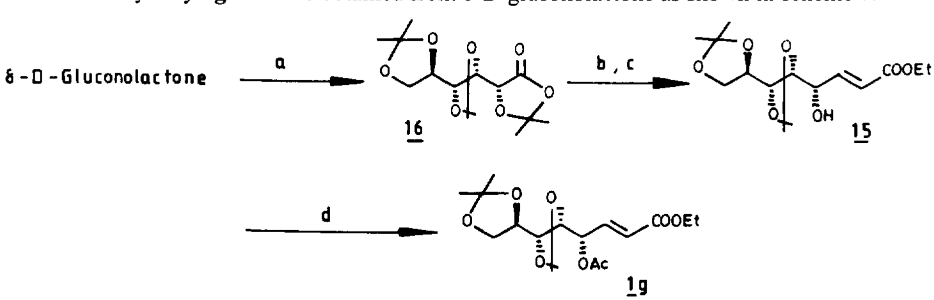
D-Glucose, the cheapest but the most important sugar, following literature procedure[19] produced mixture of two compounds **12** and **13** which on separation followed by simple chemical transformations as represented in scheme 6 furnished **1f** and **1g** respectively.



Reagents : (a) $HgCl_2$, HgO, Acetone, H_2O ; (b) $Ph_3P = CH\text{-}COOEt$, C_6H_6, room temperature ; (c) Ac_2O, DMAP, Et_3N, DCM ; (d) NaH, $C_6H_5CH_2Br$, THF ; (e) $HgCl_2$, HgO, Acetone, H_2O ; (f) $Ph_3P = CH\text{-}COOEt$, C_6H_6, room temperature.

SCHEME 6

Alternatively only **1g** could be obtained from δ-D-gluconolactone as shown in scheme 7.



Reagents : (a) Acetone, $CuSO_4$, H_2SO_4 ; (b) DIBAL, DCM, -78°; (c) $Ph_3P = CH - COOEt$, THF, reflux ; (d) Ac_2O, Et_3N, DMAP, DCM.

SCHEME 7

All these chemodifferential substrates **(1b-1g)** under the described reaction conditions i.e.. refluxing in ethanolic Zn conveniently yielded the deconjugated allyl alcohols **(2b-2g)** in excellent isolated yields (Table 1). In all the cases, a single olefinic isomer was isolated from the reaction mixture. The key feature of this transformation is furanosoid **(1b)** and acetoxy **(1d)** group behaved identically like a dioxolane derivatives.

CONCLUSION

We have demonstrated that reduction of a variety of functionalised α,β unsaturated γ,δ dioxy carboxylates with Zn provides a highly efficient route to substituted allyl alcohols. The mild and almost neutral reaction conditions allows no isomerisation of olefinic protons. The ready availability of substrates in large quantities makes it an interesting source for the synthesis of biologically important natural products having allylic alcohol functionality.

EXPERIMENTAL SECTION

IR spectrum were recorded as neat film on Perkin-Elmer 683 on 1310 spectrometers. ^{1}H NMR spectra were recorded by Varian Gemini spectrometer 200 MHz with $CDCl_3$ as solvent and TMS as internal standard. Mass spectra were recorded on either Micromass 7070 H or Finnigan Mat 1020 B mass spectrometer operating at 70 eV. molecular weights determined by CI technique. optical rotations were recorded by Jasco Dip-370 polarimeter and substrates were prepared by the literature procedures.

General procedure for the Deoxygenation of 4,5; 6,7-di-O-isopropylidene α,β unsaturated esters with Zn dust

Ethyl (E)-5-hydroxy-0-isopropylidene-3-heptenoate (2a)

To a stirred suspension of activated Zn dust (16.6 mmol. 5 eqv.) in dry ethanol (10 ml) under N_2 atmosphere, a solution of 4,5; 6,7-di-O-isopropyldene α,β unsaturated ester **1a** (0.47 g. 1.56 mmol) in dry ethanol (2 ml) was added and reflux for 12 h. After cooling it was filtered, solvent was removed under reduced pressure, the crude product was purified by SiO_2 column chromatography (eluent 20% ethyl acetate in hexane) to afford **2a** as a liquid product (0.347 g) in 91% yield. ^{1}H NMR ($CDCl_3$, 200 MHz): δ 1.25 (t, 3H, J = 4.4 Hz); 1.35 (s, 3H); 1.45 (s, 3H); 3.0-3.1 (d, 2H, J=8.33 Hz); 3.85-4.3 (m, 6H); 5.5-5.65 (dd, 1H, J=6.25. 14.58 Hz); 5.8-6.0 (m, 1H, J=6.2. 8.9 MHz); IR (neat): 3480, 2990, 1730, 1670 cm^{-1} ; MS : m/z 224 (M^+) ; $[\alpha]_D^{28}$ -15.5° (c 2.05, MeOH); Anal. calcd. for $C_{12}H_{20}O_5$: C, 59.00; H, 8.25. Found : C, 58.9; H, 8.24.

Ethyl (E)-3-Hydroxy-4,5-O-isopropylidene-9-carbethoxy-6-noneoate (2b)

With the general procedure above **1b** (0.250g, 0.762 mmol) was deoxygenated to provide 0.238 g (95%) of ethyl (E)-3-hydroxy-4,5-O-isopropylidene-9-carbethoxy-6-noneoate **(2b)** as a liquid product after column chromatography (20% ethyl acetate in hexane). ^{1}H NMR ($CDCl_3$, 200 MHz) : δ 1.2-1.35 (m, 9H); 1.4(s, 3H); 2.35-2.5 (m, 1H); 2.65-2.8 (m, 1H); 3.05-3.1 (d, 1H, J=6.01 Hz); 3.3-3.5 (m, 1H); 3.9-4.2 (m, 7H); 4.65,4.90 (m, 1H); 5.65-6.91 (m, 2H); IR (neat): 3980, 2990, 1730, 1670 cm^{-1} ; MS : m/z 300 (M^+) ; $[\alpha]_D^{28}$ -15.43 (c 1.27, MeOH); Anal. calcd. for $C_{16}H_{26}O_7$: C, 58.17 ; H, 7.93. Found : C, 58.15 ; H, 7.92.

Ethyl (E)-5-hydroxy-6,7-O-isopropylidene-3-heptenoate (2c)

With the general procedure above, substrate **1c** (0.200 g, 0.81 mmol) was deoxygenated to provide 0.146 g (90%) of ethyl (E)-5-hydroxy-6-7-0-isopropylidene-3-heptenoate **(2c)** as a liquid product after column chromatography (20% ethyl acetate in hexane). ^{1}H NMR ($CDCl_3$, 200 MHz) : δ 1.3 (t, 3H, J=5.41); 1.33 -1.4 (s, 3H); 1.45 -1.5 (s, 3H); 3.05-3.19 (d, 2H, J = 8.3 Hz); 3.79-3.85 (m,1H); 3.94-4.36(m, 5H); 5.5-5.67 (dd , 1H, J=7.08, 16.66 Hz); 5.8 - 6.03 (m, 1H); IR (neat) : 3480, 2990, 1730, 1670 cm^{-1} ; MS m/z 244 (M^+); $[\alpha]_D^{28}$ + 28.17 (c 3.9, MeOH); Anal. Calcd. for $C_{12}H_{20}O_5$: C, 59.00; H,8.25. Found : C, 58.95; H, 8.19.

Ethyl (E)-5,6; 7,8-di-O-isopropylidene-3-octenoate (2d)

With the general procedure above, the substrate **1d** (0.300g, 0.806 mmol) was deoxygenated to provide 0.24g (95%) of ethyl (E)-5,6; 7,8 di-O-isopropylidene-3-octenoate **(2d)** as a liquid product after column chromatography (10% ethyl acetate in hexane). ^{1}H NMR ($CDCl_3$, 200 MHz): δ 1.12-1.38 (m, 15H); 2.95-3.05 (d, 2 H, J=8.3 Hz); 3.58 (t, 1H, J=5.4 Hz); 3.78-3.89 (m, 1H); 3.92-4.1 (m, 4H); 4.25 (t,1H, J=4.16 Hz); 5.5-5.62 (dd, 1H, J=6.25, 12.5 Hz); IR (neat) : 2990, 1730, 1670 cm^{-1} ; MS m/z 314 (M^+); $[\alpha]_D^{28}$ -6.10 (c 2.86, $CHCl_3$). Anal. caled for $C_{16}H_{26}O_6$: C, 61.13; H, 8.34. Found : C, 61.10; H, 8.29.

Ethyl (E)-5.6-dihydroxy-7,8-O-isopropylidene-3-octenoate (2e).

With the general procedure above, the substrate **1e** (0.250 g, 0.75 mmol) was deoxygenated to provide 0.101 g (49%) of ethyl (E)-5,6-dihydroxy-7,8-O-isoprohyledene-3-octenoate **(2e)** as a liquid product after column chromatography (15% ethyl acetate in hexane). ^{1}H NMR ($CDCl_3$, 200 MHz) : δ 1-2-1.5 (m, 9H); 3.0-3.1 (d, 2H, J=7.48 Hz); 3.45-3.52 (m,1H); 3.85-4.25 (m, 6H); 5.6-5.75 (dd, 1H, J=6.23, 16.74 Hz); 5.75-8.95 (m, 1H); IR (neat) : 3480, 2990, 1730, 1670 cm^{-1} ; MS m/z 274 (M^+); $[\alpha]_D^{28}$ + 10.26 (c 1.14 MeOH); Anal. Calcd. for $C_{13}H_{22}O_6$: C, 56.92; H, 8.08. Found : C, 56.87; H, 8.1.

Ethyl (E) - 6-benzyloxy-5-hydroxy-7,8-0-isopropylidene - 3-octenoate (2f)

With the general procedure above, the intermediate **1f** (0.250 g, 0.595 mmol) was deoxygenated to provide 0.184 g (85%) of ethyl (E)-6-benzyloxy-5-hydroxy-7,8-0-isopropyledene-3-octenoate **(2f)** as a liquid product after column chromatography (20% ethylacetate in hexane). ^{1}H NMR ($CDCl_3$, 200 MHz): δ 1.2-1.5 (m, 9H); 3.05 - 3.15 (d, 2H, J=6.97 Hz); 3.52-3.63 (m, 1H); 3.8-3.92 (m, 1H); 4.0-4.22 (m, 5H); 4.7 (d, 2H, J=4.65 Hz); 5.63-5.65 (dd, 1H, J=6.7 Hz); 5.8-6.0 (m, 1H); 7.2-7.4 (m, 5H); IR (neat): 3480, 2990, 1730, 1670 cm^{-1} ; MS m/z 364 (M^+); $[\alpha]_D^{28}$ +10.52 (c 0.56, $CHCl_3$); Anal. Calcd. for $C_{20}H_{28}O_6$: C, 65.91; H, 7.74. Found : C, 65.82; H, 7.59.

Ethyl (E) - 5,6; 7,8 - di-O-isopropylidene-3-octenoate (2g)

With the general procedure above, the intermediate **1g** (0.300 g, 0.806 mmol) was deoxygenated to provide 0.230 g (94%) of ethyl (E)-5,6; 7,8-di-O-isopropylidene-3-octenoate **2g** which is same as **2d**.

Ethyl (E) -4,5; 6,7-di-O-isopropylidene-2-heptenoate (1a).

A stirred mixture of D-ribose (5 g, 33.30 mmol), (carbethoxymethylene) triphenyl phosphorane (13.92 g, 39.96 mmol) and catalytic amount of benzoic acid in THF (100 ml) under N_2 atmosphere was heated under reflux for overnight. The solvent was removed, 60 ml water was added to the syrup which precipitated triphenyl phosphine oxide. The precipitated was filtered and filtrate was washed with $CHCl_3$ (2 x 20 ml). The aq. layer was evaporated to give a syrup, the syrup was disolved in dry acetone (100 ml) containing 0.2% H_2SO_4, anhydrous $CuSO_4$ (5 g) was added and stirred at room temperature for 20 h. The $CuSO_4$ was filtered off, washed thoroughly with small quantities of dry acetone and the filtrate rendered neutral by shaking with $Ca(OH)_2$ for 1h. The inorganic salts were removed by filtration and thoroughly washed with acetone. The combined filtrate was then evaporated to dryness under reduced pressure at a temperature not exceeding 40°c and residue was subjected to chromatographic purification (silica gel, 5% ethyl acetate in hexane) to afford **1a** (9.43 g) in 95% yield as denser liquid. ^1H NMR ($CDCl_3$, 200 MHz) : δ 1.25 (t, 3H, J=6.38 Hz); 1.33-1.4 (m, 6H); 1.45-1.5 (s, 3H); 3.8-4.29 (m, 6H); 4.79-4.87 (m, 1H); 6.05-6.18 (d, 1H, J = 14.79 Hz); 6.9-7.50 (dd, 1H, J=6.34,14.73); IR (neat) : 2990, 1760, 1670 cm^{-1}; MS m/z 300 (M^+); $[\alpha]_D^{28}$ -23.40 (c 3.22, $CHCl_3$); Anal.calcd. for $C_{15}H_{24}O_6$; C, 59.98; H, 8.05. Found : C, 59.8; H, 8.03.

Ethyl 3,6-anhydro-2-deoxy-4,5-O-isopropylidene-7,8-dideoxy-8-carbethoxy-D-allo-7-octenoate (1b)

The compound **7** under Swern oxidation to provide the aldehyde compound **8**, (1.5 g, 4.57 mmol) which on treated with (carbethoxy methylene) triphenyl phosphorane (2.22 g, 6.39 mmol) to get the intermediate **1b** (1.75 gm) in 92% yield as a liquid product. ^1H NMR ($CDCl_3$, 200 MHz) : δ 1.2-1.3 (m, 9H); 1.5-1.51 (s, 3H); 2.6 (d, 2H, J = 6.01 Hz); 4.1-4.6 (m, 8H); 6.0-6.1 (d, 1H, J =16.03 Hz); 6.88-7.02 (dd, 1H, J = 6.01, 16.03 Hz); IR (neat): 2990, 1730, 1670 cm^{-1}; MS m/z 328 (M^+); $[\alpha]_D^{28}$ +11.27 (c 3.82, $CHCl_3$); Anal. Calcd. for $C_{16}H_{24}O_7$: C, 58.52; H, 7.37. Found : C, 58.51; H, 7.35.

Ethyl (E) -4,5; 6,7-di-O-isopropylidene-2-heptenoate (1c)

With the procedure above **1a**, D-xylose (4.5 g, 29.97 mmol) was treated with ylide, Ph_3P =CH-COOEt (11.13 g, 31.97 mmol) and then was treated with dry acetone (75 ml) containing 0.2% H_2SO_4, 4 g anhydrous $CuSO_4$ to provide 8.36 g (93%) of ethyl (E)-4,5: 6,7-di-O-isopropylidene-2-heptenoate **(1c)** as a liquid product after column chromatography (5% ethyl acetate in hexane). ^1H NMR ($CDCl_3$, 200 MHz) : δ 1.25-1.5 (m, 15 H); 3.73-3.9 (m, 2H); 3.95-4.08 (t, 1H, J = 7.64 Hz); 4.1-4.26 (m, 3H); 4.45-4.6 (m, 1H); 6.04-6.2 (d. 1H, J=15.28 Hz); 6.8-6.95 (dd, 1H, J = 5.84, 15.73 Hz); IR (neat) : 2990, 1730, 1670 cm^{-1}; MS m/z 300 (M^+); $[\alpha]_D^{28}$ -22.01 (c 0.98, $CHCl_3$); Anal. Calcd. for $C_{15}H_{24}O_6$: C, 59.98; H, 8.05. Found : C, 59.85; H, 8.04.

Ethyl (E)-4-acetoxy-5,6; 7,8-di-O-isopropylidene-2-octenoate (1d)

According to the literature procedure, D-mannose was converted to the compound **6** (0.300 g, 0.909 mmol) followed by acetylation with Ac_2O, Et_3N, DMAP to provide 0.334 g. (99%) of ethyl (E)-4-acetoxy-5,6; 7,8-di-O-isopropylidene-2-octenoate **(1d)** as a liquid product after column chromatography (5% ethyl acetate in hexane). ^1H NMR ($CDCl_3$, 200 MHz) : δ 1.2-1.4 (m, 15H); 2.15 (s, 3H); 3.69 (t, 1H, J=7.11 Hz); 3.87-4.25 (m, 6H); 5.5-5.6 (m, 1H); 5.9-6.05 (d, 1H, J = 15.5 Hz); 6.8-6.98 (dd, 1H, J=6.6, 15.5 Hz); IR (neat): 2990, 1730, 1670 cm^{-1}; MS m/z 372 (M^+); $[\alpha]_D^{28}$ +18.22 (c 1.96, $CHCl_3$); Anal. calcd. for $C_{18}H_{28}O_8$: C, 58.05; H, 7.58. Found : C, 58.04; H, 7.53.

Ethyl (E)-6-hydroxy-4,5; 7,8-di-O-isopropylidene-2-octenoate (1e)

Finely powdered D-mannose (2 g, 11.1 mmol) was suspended in dry acetone (70 ml) containing 0.2% H_2SO_4, anhydrous $CuSO_4$, (2 g) was added and the mixture was shaken at 37°c for 20 h, after completion of the reaction, $CuSO_4$ was filtered off, washed thoroughly with small quantities of dry acetone, and filtrate was neutralised by shaking with $Ca(OH)_2$ for 1 h. The $CaSO_4$ and excess $Ca(OH)_2$ were removed by filtration and thoroughly washed with small quantities of acetone. The combined filtrate was evaporated under reduced pressure and residue was purified by column chromatography (Silica gel : 10% ethyl acetate in hexane) gave acetonide product 2.59g (90%), which on treatment with ylide, Ph_3P =CH-COO Et (3.18 g, 10.95 mmol) in THF to provide 2.95 g (90%) of **1e** as a liquid product after column chromatography (20% ethyl acetate in hexane). ^{1}H NMR ($CDCl_3$, 200 MHz) : δ 1.25-1.45 (m, 9H); 1.5-1.58 (s, 3H); 3.9-4.3 (m, 6H); 4.38-4.49 (m, 1H); 4.78-4.9 (m, 1H); 6.0-6.12 (d, 1H, J=16.35 Hz); 6.95-7.1 (dd, 1H, J=6.54, 15.88 Hz); ^{13}C ($CDCl_3$, 200 MHz) d 166.1, 143.8, 123.8, 116.5, 109.8, 78.1, 76.8, 76.5, 70.8, 67.6, 60.9, 31.2, 27.1, 25.6, 25.5, 14.5; IR (neat) : 3480, 2990, 1760, 1670 cm^{-1}; MS m/z 330 (M$^+$); $[\alpha]_D^{28}$ +11.72 (c 7.82, $CHCl_3$); Anal. Calcd. for $C_{16}H_{26}O_7$: C, 58.17; H,7.93. Found : C, 58.12; H,7.88.

Ethyl (E)-6-benzyloxy-4,5;7,8 di-O-isopropylidene-2-octenoate (1f)

The compound **14** (0.250 g, 0.58 mmol) was treated with $HgCl_2$, HgO, Acetone, H_2O to get the aldehyde (0.225 g), which was treated with Ph_3P=CH-COOEt to provide 0.235 g (95%) of ethyl (E)-6-benzyloxy -4,5; 7,8 di-O-isopropylidene **(1f)** as a liquid product after column chromatography (5% ethyl acetate in hexane). ^{1}H NMR ($CDCl_3$, 200 MHz) : δ 1.2-1.5 (m, 15H); 3.6-3.7 (m, 1H); 3.7-3.8 (m, 1H); 3.95-4.25 (m, 7H); 4.4-4.55 (m, 1H); 4.65-4.7 (dd, 2H, J = 12.5, 32.5 Hz); 5.8-5.92 (d, 1H, J=15 Hz); 6.64-6.79 (dd, 1H, J=6.25, 16.1 Hz); 7.25-7.4 (m, 5H); IR (neat) : 2990, 1730, 1670 cm^{-1} ; MS m/z 420 (M$^+$); $[\alpha]_D^{28}$ -34.63 (c 1.22, $CHCl_3$); Anal. Calcd. for $C_{23}H_{32}O_7$: C, 65.69; H, 7.69. Found : C, 65.70; H,7.62.

Ethyl (E)-4-acetoxy-5,6; 7,8-di-O-isopropylidene-2-octenoate (1g)

According to the literature procedure, D-glucose was converted to the compound **15** (0.300 g, 0.909 mmol) followed by acetylation with Ac_2O, DMAP, Et_3N to provide 0.334 g (99%) of ethyl (E)-4-acetoxy-5,6; 7,8 di-O-isopropylidene-2-octenoate **(1g)** as a liquid product after column chromatography (5% ethyl acetate in hexane). ^{1}H NMR ($CDCl_3$, 200 MHz) : δ 1.2-1.4 (m, 15H); 2.05 (s, 3H); 3.69 (t, 3H, J=7.11 Hz); 3.88-4.25 (m, 6H); 5.5-5.6 (m, 1H); 5.9-6.05 (d, 1H, J = 15.55 Hz); 6.82-6.90 (dd 1H, J = 6.6, 15.5 Hz); IR (neat) : 2990, 1730, 1670 cm^{-1} ; MS m/z 372 (M$^+$); $[\alpha]_D^{28}$ +15.06 (c 1.68, $CHCl_3$); Anal. Calcd. for $C_{18}H_{28}O_8$: C, 58.05; H,7.85. Found : C, 58.04; H,7.40.

Ethyl (E)-4-hydroxy-5,6; 7,8 di-O-isopropylidene-2-octenoate (10)

According to the literature procedure, compound **9** (0.250 g, 0.748 mmol) was refluxed with $HgCl_2$, HgO, acetone, H_2O to provide 0.186 g (85%) of aldehyde, which on treated with Ph_3P = CH-COOEt (0.265 gm, 0.76, mmol) to get **10** (0.205 g) in 98% yield as a liquid product. ^{1}H NMR ($CDCl_3$, 200 MHz) : δ 1.2-1.5 (m, 15 H); 3.6-3.7.3 (m, 3H); 3.9-4.25 (m, 5H); 6.05-6.15 (d, 1H, J=15.62 Hz); 6.9-7.03 (dd, 1H, J=6.01, 15.62 Hz); IR (neat) : 3480, 2990, 1730, 1670 cm^{-1} ; MS m/z 330 (M$^+$); Anal. Calcd. for $C_{16}H_{26}O_7$: C, 58.18; H, 7.87. Found : C, 58.15; H,7.85 .

Ethyl (E)-4-hydroxy-5,6; 7,8-di-O-isopropylidene-2-octenoate (15)

The compound **15** was prepared same way as compound **10** but from D-glucose. [1]HNMR ($CDCl_3$, 200 MHz) : δ 1.2-1.45 (m, 15H); 2.78-2.90 (d, 1H, J=10 Hz); 3.65-3.76 (m, 1H); 3.87-4.23 (m, 6H); 4.36-4.5 (m, 1H); 6.0-6.15 (d, 1H, J=17.5 Hz); 6.94-7.09 (dd, 1H, J=6.01, 17.4 Hz); IR (neat) : 3480, 2990, 1760, 1670 cm^{-1} ; MS m/z 330 (M^+); $[\alpha]_D^{28}$ -17.84 (c 3.206, $CHCl_3$). Anal. calcd. for $C_{16}H_{26}O_7$: C, 58.17; H, 7.93. Found : C, 58.16: H, 7.85.

1,2; 3,4; 5,6 Tri-O-isopropylidene gluconoate (16)

Finely powered δ -D-gluconolactone (3 g., 16.85 mmol) was suspended in dry acetone (80 ml) containing 0.2% H_2SO_4, anhydrous $CuSO_4$ (3 g) was added and the mixture was shaken for 20 h at room temperature. After completion of the reaction, $CuSO_4$ was filtered off and filterate was neutralised by shaking with $Ca(OH)_2$ for 1 h. The $CaSO_4$ and excess $Ca(OH)_2$ were removed by filtration, the filtrate was evaporated under reduced pressure and residue was purified by column chromatography (silica gel; 10% ethyl acetate in hexane) gave acetonide product 4.79 gm (90%) of compound **16** as a crystalline solid m.p. 115°c. [1]HNMR ($CDCl_3$, 200 MHz) : δ 1.33 (s, 3H); 1.35-1.45 (m, 9H); 1.59 (s, 3H); 1.65 (s, 3H); 3.85-4.3 (m. 5H); 4.55-4.60 (m, 1H); IR (neat) : 2990, 1760 cm^{-1}; MS m/z 316 (M^+); $[\alpha]_D^{28}$ +34.76 (c 2.34, $CHCl_3$); Anal. Calcd. for $C_{15}H_{24}O_7$: C, 56.95; H,7.65. Found : C, 56.95; H,7.55.

Ethyl (E)-4-hydroxy-5,6; 7,8-di-O-isopropylidene-2-octenoate (15).

A solution of DIBAL-H (0.74 g, 5.21 mmol) was added dropwise over 30 min to a solution of **16** (1.5 g, 4.74 mmol) in dry DCM (50 ml) at -78°c under an argon atmosphere. After 30 min. resultant solution was quenched with saturated sodium potassium tartarate and was extracted with ether. The solvent was removed by reduced pressure to afford 1.28 g (85%) of alcohol compound, which on treated with Ph_3P =CH-COOEt (1.68 g, 4.83 mmol) to provide **15** (1.26 g) in 95% yield as a liquid product.

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