Tetrahedron Vol. 49, No. 35, pp. 7701-7722, 1993
Printed in Great Britain

0040-4020/93 $6.00+.00

Efficient Routes to Pyranosidic Homologated Conjugated Enals and Dienes from Monosaccharides

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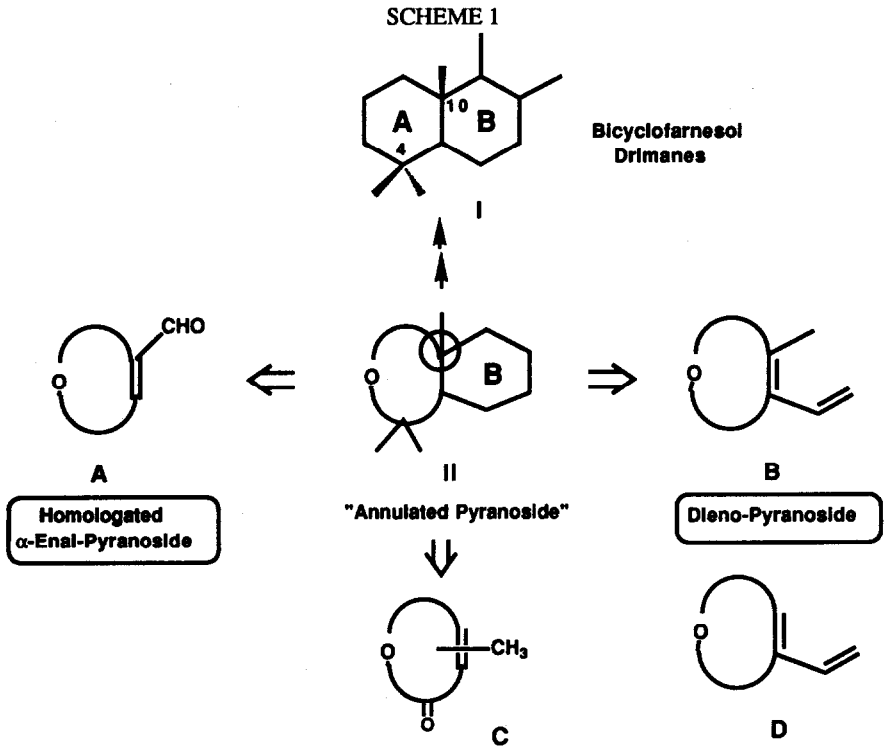
(*Received in Belgium* 26 *February* 1993; *accepted* 21 *June* 1993)

Abstract : Three new processes for the obtention of pyranosidic dienes type **B**, and **D** and homologated conjugated enals **A**, have been designed in the context of the preparation of useful chiral building blocks from monosaccharides. Addition of vinylmagnesium bromide onto ulose **1**, followed by acetal ring opening; benzoate protection at C-4 and C-6; and dehydration of the tertiary hydroxyl group, mediated by thionyl chloride, reveals to be a straightforward route to diene **11**. Analogous dehydration on conformationally rigid **2** was not regioselective and afforded isomeric dienes **3** and **6** in a 1:1 ratio. Addition of 2-lithio-1,3 dithiane onto locked 2,3-anhydropyranoses **21** and **22** followed by unravelling of the S,S-acetal moiety led efficiently to homologated α-enals **26**, **27**, **31**, and **30** and hence to dienes **34**, **14**, **20** and **13** through Wittig methylenation. Finally α-alkoxyvinyl ethers, prepared either by Wittig-Horner reaction of α-alkoxy-uloses, or by hetero Diels-Alder reaction of conjugated-enals, afforded in good to excellent yields pyranosidic α-enals **37**, **42**, **43**, **44**, **50** and **51** on treatment with pyridinium hydrochloride in pyridine or a mixture acetic acid-water (4:1).

INTRODUCTION

Over the last few years carbohydrates have become the natural products most commonly incorporated in synthetic schemes leading to optically active substances[4-8]. Some time ago, we decided to explore the feasibility of a carbohydrate based approach to bicyclofarnesol type structures **I** starting from previously unreported pyranose building blocks **A** or **B**. In our retrosynthetic approach, outlined in Scheme 1, a Diels-Alder cycloaddition on a carbohydrate derivative was envisaged as the key step, with the sugar functioning as a diene **B** or as a dienophile **A**. The formyl group in the dienophilic structure **A** and the methyl group in dienic **B**, will provide different alternatives for the retrosynthetic origin of the quaternary carbon in the annulated pyranoside[9] **II**, and therefore for the methyl group at C-10 in structure **I**. The use of α or β methyl pyranoside-enones type **C** in a similar approach had already been suggested by Fraser-Reid and Anderson[5]. The intermediate annulated pyranoside[9] **II** is to be transformed into a carbobicyclic structure **I** by means of a Ferrier type pyranoside-carbocycle transformation[10] on an annulated pyranoside.

SCHEME 1

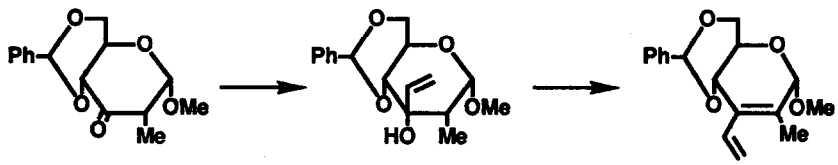


METHODS AND RESULTS

Our first objective was thus to develop efficient routes for gaining access to homologated conjugated enals **A**, and closely related pyranosidic dienes **B** and **D**. Pyranosido-dienes **D** were chosen as model compounds for dienes **B** in cycloaddition reactions, on the basis of a supposed similar stereoselectivity and an expected higher reactivity[11]. We have already disclosed preliminary accounts of our work concerning synthetic schemes to compounds type **A**[12,13] and **D**[12], as well as their behaviour in cycloaddition reactions[12,14]. Methodology for the construction of the gem-dimethyl system (at C-4 in generic structure **I**) has also been reported[15]. In this manuscript we describe in detail our work on straightforward routes to **A** and **D**, and previously unreported access to structures **B**. When the present investigation was initiated, Giuliano and Buzby[16] published the first example of a pyranosidic diene (type **D**) and more recently Lipshutz et al.[17] reported on a further example.

It seemed to us that a logical synthetic entry to diene **3** (as generic representant for **B** type dienes) would be vinyl magnesium bromide (VMB) addition onto a carbonyl group in ulose **1**[18] followed by dehydration of the tertiary hydroxyl group created in **2** to furnish the above mentioned compound (scheme 2).

SCHEME 2

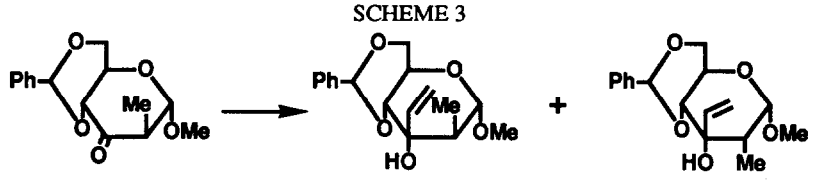


1 2 3

Extensive studies on the introduction of a vinyl branch into a carbohydrate ulose had been carried out by Horton et al[19] with the conclusion that a two step route involving ethynilation, and lithium aluminium hydride reduction of the corresponding ethylene compound was superior to direct vinylation. Nevertheless, we were tempted to search for optimal conditions in order to achieve such transformations in one step and in acceptable yields. Extensive experimentation taught us that direct vinylation was sensitive to a) temperature; b) order of addition of the reagents; and c) quenching conditions. As a result, addition of fresh vinyl magnesium bromide solution (5 equiv.) to ulose **1** in tetrahydrofuran at -50°C followed by quenching at the same temperature afforded vinyl derivative **2** in yields ranging from 85 to 95% in multigram scale reactions.

We decided to study also the VMB addition to ulose **4**[18d] with an axially oriented C-2 methyl group. In fact when ulose **4** was reacted with VMB, a completely selective attack was observed at C-3 to afford the equatorially disposed vinyl branch, the direction of attack being dictated by the axial anomeric substituent. However, two isomeric compounds at C-2 were obtained indicating that epimerisation prior to nucleophilic attack was taking place[20] (scheme 3). When the reaction was carried out at -15°C a mixture (**5**:**2** ; 0.9:1 ; 73%) was obtained. By lowering the reaction temperature to -50°C the epimerisation rate at C-2 was decreased so that the axial methyl containing sugar **5** (54%) was the major isomer (**5**:**2** ; 2.6:1).

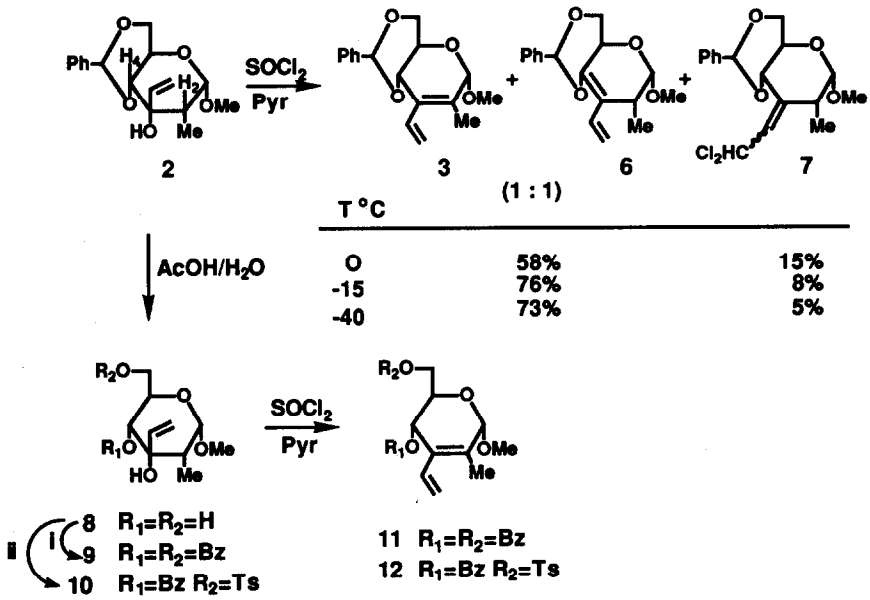
SCHEME 3



4 5 2

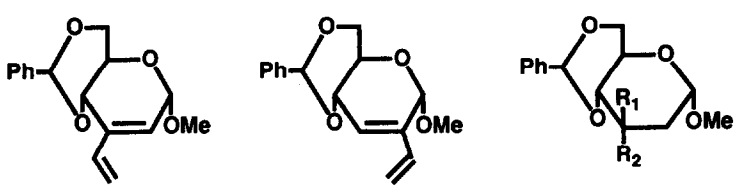
With compound **2** in hand our attention was then turned to the finding of appropriate dehydration conditions for access to diene **3** (Scheme 2). Treatment of **2** with phosphorous oxychloride left the product unchanged. Treatment of **2** with thionyl chloride in dry pyridine yielded a mixture of three compounds (scheme 4). The dienic derivatives **3** and **6**, originating from a trans-elimination of an alkyl chlorosulphite intermediate, with either of the vicinal hydrogens H-2 and H-4 respectively, were accompanied by the allylic chloride rearrangement compound **7**. The amount of chlorinated **7** could be reduced to a third by lowering the temperature (see Scheme 4). Unfortunately, the 1:1 ratio of compounds **3**:**6** remained constant regardless of the temperature. Although, separation of the isomeric dienic compounds **3** and **6** could be readily achieved by chromatography we decided to seek for a more practically useful route to diene **3**.

SCHEME 4



i. BzCl/Pyr 80%; ii. a) TsCl/Pyr -15°C, b) BzCl/Pyr

In the hypothesis that torsional factors in the trans-decaline type skeleton could be playing an important role in the regiochemistry of elimination, and based on previous results from our laboratory[21], we decided to carry out the elimination in a monocyclic pyranoside system. In fact, when dibenzoate **9** was treated with thionyl chloride in pyridine at -40°C, diene **11** was obtained as the sole product in 77% yield, thus providing an efficient route to **11** from D-glucose. To our surprise when structurally similar **10** was subjected to identical reaction conditions diene **12** was obtained as major product (50% isolated yield) but two other compounds were also present in the reaction mixture (t.l.c. ^{1}H NMR). The structures of the latter were tentatively assigned on the basis of the analogous reaction with **2** and confirmed by ^{1}H NMR analysis of the crude reaction mixture (scheme 4). According to these observations we planned to extend the methodology to the synthesis of dienes **13** and **14**. Reaction of ulose **15**[18b] with VMB in tetrahydrofuran afforded vinyl compound **16** (90%) with complete stereoselectivity. Thionyl chloride mediated dehydration of this allylic alcohol did afford a mixture of reaction products which were not separated.



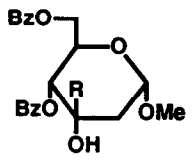
13 14

15 R_1=R_2=O

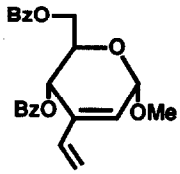
16 R_1=(CH=CH_2); R_2=OH

The difference of behaviour, from the point of view of regioselectivity in the elimination, of the hydroxyl group in rigid bicyclic **2** and monocyclic **9** (vide supra) appeared promising towards the finding of a satisfactory synthetic route to **18** from **17**. However, when subjected to thionyl chloride treatment compound **17** afforded a complex mixture in which the desired diene **18** was only a minor constituent as estimated from high field ^1H NMR of the crude reaction mixture. This disappointing result led us to attempt the elimination from the acetylenic alcohol **19**, however and as in the previous case a complex reaction mixture arose on treatment with thionyl chloride.

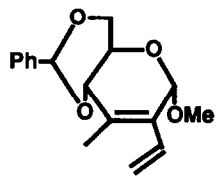
The capricious nature of the dehydration pattern of the tertiary hydroxyl group in the different examples studied led us to consider the development of alternative synthetic routes to dienes **13**, **14** and **20**.



17 R=(CH=CH$_2$)
19 R=(C≡CH)



18

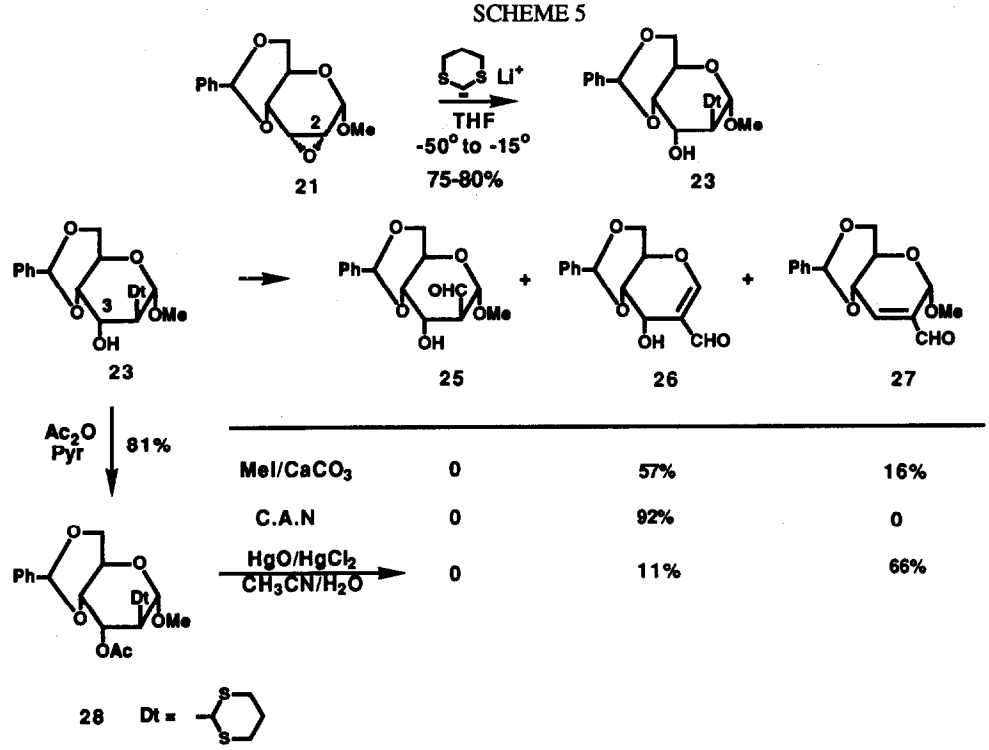


20

In the search for a different retrosynthetic scheme we imagined a plan involving two important features: a) the scheme would be common for conjugated enals and dienes, and b) a rational choice of the leaving group would preclude the complications due to regioisomeric elimination mentioned above. In the synthetic plan a dithiane was visualized as an aldehyde equivalent and the leaving group would be an activated hydroxyl function. Both functionalities could then originate from an epoxide via dithiane ring opening. This retrosynthetic plan seemed also attractive when considering that an oxirane is easily correlated with vicinal trans diol systems present in carbohydrates.The 1,3 dithiane procedure of Corey and Seebach[22] was brought to the carbohydrate field due to independent pioneering efforts by Gero's[23] and Paulsen's[24] groups. The easiness for nucleophilic attack onto carbonyl groups by 2-lithio-1,3-dithiane[22] contrasts with its usually sluggish reaction with epoxides[25]. Therefore, it was not surprising that only moderate to low yields had been reported for products resulting of 2-lithio-1,3-dithiane opening of epoxides **21** and **22**[26]. Modification of the reaction conditions (see experimental section) allowed us to obtain compounds **23**[23c] and **24**[23c] in yields ranging from 75-80% and 65-70% respectively in multigram scale operations.

When according to our plan, deprotection of the dithiane ring[27] on **23** was attempted (MeI, $CaCO_3$, CH_3CN, H_2O, 55°C)[28] only traces of the expected aldehydo alcohol **25** was observed and instead two olefinic compounds **26** and **27** were obtained in 57 and 16% yield respectively, both compounds appeared to originate via an spontaneous β-elimination process. As a consequence, an enhancement of the migratory properties of the hydroxyl group in **23** seemed appealing in order to reverse the direction of the elimination. In fact, when acetyl derivative **28** was subjected to hydrolytic conditions (HgO, $HgCl_2$, H_2O/CH_3CN 1:4)[29] aldehyde **27**[42] was obtained along with **26**, the former being the major (66% yield) and the latter the minor product of the reaction (11% yield).

SCHEME 5

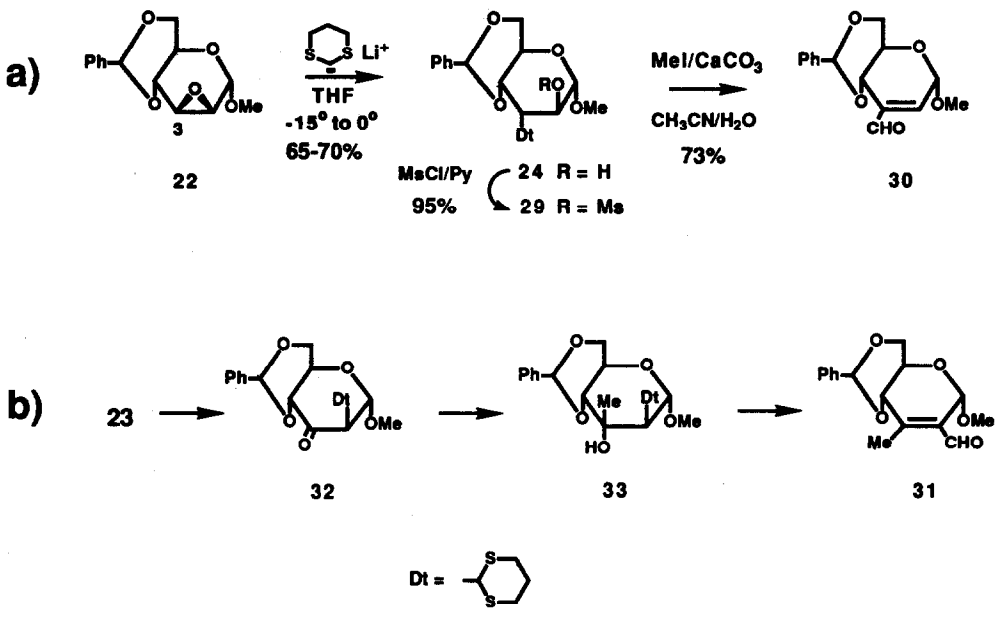


Treatment of compound **28** under oxidative S,S-acetal removal conditions (cerium ammoniun nitrate, 25°C, 2 min)[30], followed by flash chromatography furnished exclusively conjugated enal **26** in 92% yield (scheme 5).

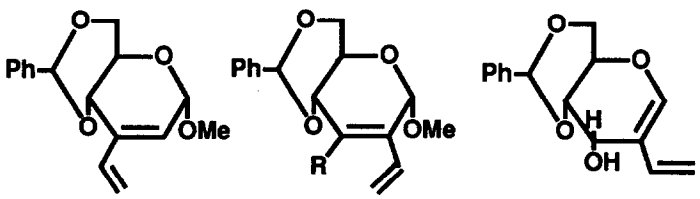
Further assumption on the spontaneity of the β-elimination accompanying deprotection of the S,S-acetal was confirmed when mesylate **29** was subjected to alkylative hydrolytic conditions, as described above, to yield conjugated enal **30** as the sole product (73% yield) (scheme 6a).

The preparation of β-methyl-α-enal **31** would require a β-elimination process with a tertiary hydroxyl leaving group (scheme 6b). Swern oxidation[31] on hydroxy dithiane[32] **23** gave unstable ketone **32** which was treated without further purification with methyl lithium to afford tertiary alcohol **33** (77% yield from **23**). Application of the conditions for dithiane deprotection in **33** (HgO, $HgCl_2$, H_2O/CH_3CN 1:4) furnished α-enal **31** in 63% yield. The dithiane approach presents a practical value for the synthesis of pyranosidic homologated conjugated enals[12,13], the transformation of such systems to their diene homologs is straightforward. Thus α-enal **27** afforded diene **14** (methyl triphenyl phosphonium bromide, 7 equiv. BuLi, 68% yield).

SCHEME 6

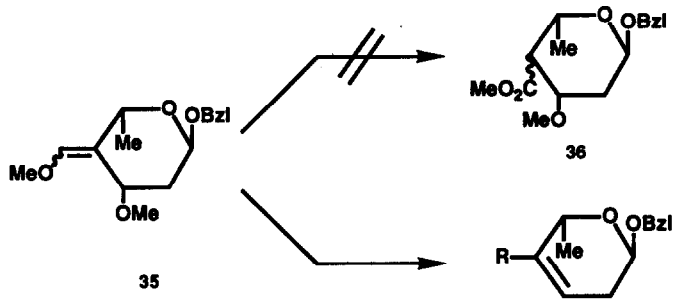


Under similar experimental conditions, but using lithium hexamethyldisilazide (LiHMDS), dienes **13** and **20** were obtained (73% and 66% yields) from, respectively, **30** and **31**. The preparation of diene **34** from **26** appeared to be specially sensitive to the base employed, change from butyl lithium, to LiHMDS, and to KHMDS resulted in yields of 21, 50, and 70% respectively.



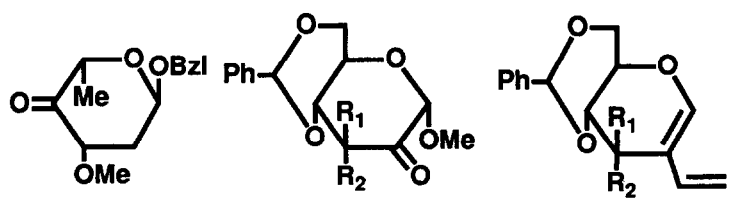
The strategy mentioned above provides efficient access to homologated pyranosidic conjugated α-enals **26**, **27**, **30** and **31** and to dienes **13**, **14**, **20**, and **34** via epoxide intermediates. Although, in our opinion, the described methodology would provide access to a variety of conjugated α-enals, we were concerned by the fact that our strategy was actually taking advantage of the well documented, completely stereoselective, pattern in the oxirane ring opening of locked 2,3-anhydropyranosides[33] and might not work as efficiently in monocyclic pyranosides where stereorandom regioselectivity in the oxirane ring opening might happen.[34]

SCHEME 7



In this context, and in relation with another project underway in our laboratory, we observed that the, well precedented, pyridinium chlorochromate oxidation of enol ethers to esters[35] when applied to compound **35** did not afford the expected saturated ester **36** but a mixture of unsaturated compounds **37** and **38** (scheme 7). It was our feeling that **37** might have originated from traces of pyridinium hydrochloride present in the reaction mixture, thus inducing enol-ether hydrolysis and subsequent β-elimination. To verify this hypothesis compound **35** was treated with pyridinium hydrochloride in pyridine[36], and as predicted conjugated enal **37** was obtained as the sole product in 71% yield. This observation followed a logical pattern when compared to the first report on pyranosidic conjugated α-enal synthons and our dithiane approach to such compounds[37], in the sense that generation of a carboxaldehyde group in a pyranose ring with a vicinal activated hydroxyl group, prone to elimination, would likely result in the formation of pyranosidic α-enals. We were then persuaded of the generality of an alkoxy enol-ether based entry to α-enals and carried out a series of experiments to explore the scope of this route.

Table 1 lists the conjugated α-enals which we have prepared applying this method. Treatment with acetic acid-water (4:1) is the condition of choice when the alkoxy group is part of a benzylidene ring (entries 2 and 6). Pyridinium hydrochloride 1M in pyridine induced α-enal formation in case of monocyclic systems (entry 1).



45

46 R_1=R_2=H

47 R_1=OMe; R_2=H

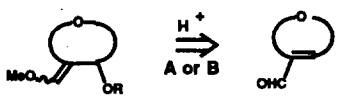
52 R_1=R_2=H

53 R_1=OMe; R_2=H

TABLE 1

Route Enol-Ether

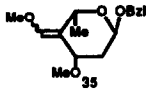
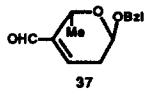
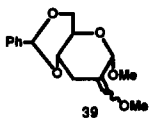
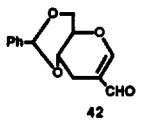
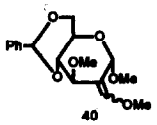
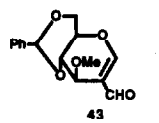
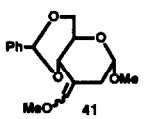
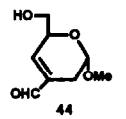
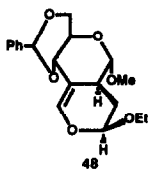
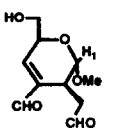
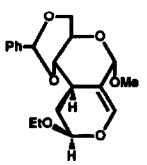
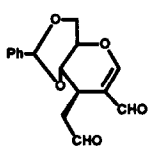
Regioselective Obtention of Homologated α-Enal-Pyranosides



Conditions

A 1M HCl.Pyridine

B AcOH/H_2O (4:1)

Entry	Enol-ether	α-Enal	Yield (%)	Conditions
1	 35	 37	71	A
2	 39	 42	76	A
3	 40	 43	89	A
4	 41	 44	88	B
5	 48	 50	91	B
6	 49	 51	93	A

Access to such pyranosidic α-alkoxy vinyl ethers **35**, **39**, **40** and **41** is provided by Wittig Horner reaction[34] of the corresponding α-alkoxy uloses **45**, **46**[38], **47**[39], and **15**[18b] respectively, or by hetero Diels-Alder reaction of former α-enal systems with ethyl vinyl ether (**30** ⇒ **48** and **27** ⇒ **49**)[14]. Aldehydes **42** and **43** were readily transformed into, respectively, dienes **52** (98% yield) and **53** (79% yield).

CONCLUSIONS.

Vinyl magnesium bromide addition onto pyranoside-uloses followed by tertiary hydroxyl elimination is of limited value for access to pyranosidic dienes. The latter could be better synthesized by exploiting synthetic schemes leading to homologated conjugated enals, followed by Wittig methylenation reaction. Methods for the preparation of α-enals developed in this work took advantage of the spontaneous β-elimination process accompanying the unveiling of a carboxaldehyde group by hydrolyzing either a S,S-acetal or a enol-ether moiety. Evidence for the synthetic potential of the conjugated enals and dienes described here to annulated pyranosides or to homologated pyranosidic structures has already been furnished[12,14].

EXPERIMENTAL PART :

General procedures. A Perkin-Elmer Model 141 MC polarimeter and 1-dm tubes were used for measurement of specific rotations. ^1H NMR spectra were recorded in chloroform-d solution at 200 MHz and 400 MHz. The ^{13}C NMR spectra were measured in chloroform-d solution at 50.31 MHz with a Bruker WP-200 spectrometer. Chemical shifts are given in parts per million, and tetramethylsilane was the internal standard (δ 0.000). Carbon-13 chemical shifts for aromatic carbons are not given. Microanalyses were performed by the Service Central de Microanalyse du CNRS. Silica gel 60 PF_{254} (Merck) activated at 120°C was the support for TLC and for column chromatography.

General Procedure a. for the Preparation of C-Vinyl Branched-Chain Sugars. To a solution of ketone (19.8 mmol.) in tetrahydrofuran (250 mL) was added dropwise at -78°C, in an argon atmosphere, a solution of vinylmagnesium bromide in tetrahydrofuran (18 mmol, 18 mL, 5 eq.). After stirring at -50°C for 4h, an aqueous solution of saturated ammonium chloride was added (40 mL). Further stirring at room temperature for 1 h was followed by CH_2Cl_2 extraction, extensive washing of the organic layer with water, drying over Na_2SO_4, filtration, concentration and chromatography of the residue.

General Procedure b. for Thionyl Chloride Mediated Dehydration. To a solution of alcohol (3.3 mmol) in dry pyridine (100 mL) was added dropwise at -78°C, in an argon atmosphere, thionyl chloride (16.3 mmol, 5 eq.). After stirring at -40°C for 2h, the solution was poored into ice-water, and extracted with ether. The organic layer was washed with an aqueous solution of 2N hydrochloric acid, with water, dried over Na_2SO_4, filtered, concentrated and chromatographed.

General Procedure c. for Wittig Methylenation of α,β-Unsaturated Aldehydes. To a solution of methyltriphenylphosphonium bromide (1.68 g, 4.7 mmol.) in dry tetrahydrofuran (20 mL)was added dropwise at 0°C, in an argon atmosphere the base [procedure **c1** : 1.6 M butyl lithium in hexane (18.8 mL, 4.7 mmol.); procedure **c2** : 1.0 M lithium bis(trimethylsilyl) amide (LiHMDS) in tetrahydrofuran (18.8 mL, 4.7 mmol.); procedure **c3** : 0.5 M potassium bis(trimethylsilyl) amide (KHMDS) in toluene (9.4 mL, 4.7 mmol.)] and the mixture was stirred for 1h at 0°C. Then a solution of aldehyde (1.18 mmol) in tetrahydrofuran (10 mL) was added rapidly and the mixture was left to warm up to room for 1h. A saturated

aqueous solution of NH_4Cl was added and the mixture extracted with CH_2Cl_2. The organic layer was dried over Na_2SO_4, filtered, concentrated and chromatographed.

General Procedure d. for the Preparation of enol-ethers from ketones. To a solution of methoxymethyldiphenylphosphine oxide (4.3 mmol) in tetrahydrofuran (10 mL) was added, in a nitrogene atmosphere at 0°C, a solution of diisopropylamide in tetrahydrofuran (7.1 mL). This solution was prepared from diisopropylamine (790 µL, 5.7 mmol), butyl lithium (3.6 mL, 5.7 mmol) and tetrahydrofuran (5 mL). The reaction mixture was cooled to-78°C and the ketone (1.08 mmol) in tetrahydrofuran (2 mL) was added to it.The temperature was allowed to raise slowly and the reaction was monitored by TLC. After consumption of the starting ketone, a saturated solution of ammonium chloride was added and the mixture was extracted with CH_2Cl_2.The organic layer was dried over Na_2SO_4, filtered and concentrated and the residue dissolved in N,N'-dimethylformamide (20 mL). To this solution was added potassium hydride (10 eq.). After stirring for 1h. the excess of potassium hydride was distroyed by adding ethyl acetate and water. A solution of ammonium chloride was added and the mixture extracted with toluene. The organic layer was dried over Na_2SO_4, filtered and concentrated and the residue chromatographed giving a mixture of enol-ethers.

Methyl 4,6-O-benzylidene-2-deoxy-2-C-methyl-3-C-vinyl-α-D-allo-hexopyranoside (2). Prepared from 1[18d] by general procedure **a.** as crystals (92%), m.p. 163-167°C, $[\alpha]_D$ +114.2° (c O.73, $CHCl_3$), mass spectrum : m/z 307 (M^+ + H), ^1H NMR (400 MHz, $CDCl_3$) δ 7.65-7.33 (m, 5H, Ph), 5.72 (dd, 1H, $J_{8,9}$ = 9.5 Hz, $J_{8,10}$ = 17.5 Hz, H-8), 5.62 (s, 1H, H-7), 5.50 (dd, 1H, $J_{9,10}$ = 2 Hz, $J_{8,10}$ = 17.5 Hz, H-10), 5.34 (dd, 1H, $J_{8,9}$ = 9.5 Hz, $J_{9,10}$ = 2 Hz, H-9), 4.64 (d, 1H, $J_{1,2}$ = 3 Hz, H-1), 4.38 (dd, 1H, $J_{5,6eq}$ = 5 Hz, J_{gem} = 10 Hz, H-6eq), 4.16 (m, 1H, H-5), 3.80 (t, 1H, $J_{5,6ax}$ = J_{gem} = 10 Hz, H-6ax), 3.53 (d, 1H, $J_{4,5}$ = 10 Hz, H-4), 3.44 (s, 3H, OMe), 1.92 (m, 1H, H-2), 0.97 (d, 3H, $J_{2,Me}$ = 7 Hz, Me); ^{13}C NMR (50.33 MHz, $CDCl_3$) δ 139.1 (C-8), 116.3 (C-9), 102.0 and 101.9 (C-7 and C-1), 82.7 (C-4), 74.0 (C-3), 69.4 (C-6), 59.5 (C-5), 55.8 (OMe), 41.3 (C-2), 9.2 (Me). Anal. Calcd for $C_{17}H_{22}O_5$: C, 66.64; H, 7.23. Found : C,66.90; H, 7.29.

Methyl 4,6-O-benzylidene-2,3-dideoxy-2-C-methyl-3-C-vinyl-α-D-erythro-hex-2-enopyranoside (3). Prepared from 2 by general procedure **b.** Chromatography of the reaction mixture using hexane-ethyl acetate; 95 : 5 gave 3 (36%), 6 (37%) and 7 (5%), each as a syrup. 3 $[\alpha]_D$ + 13° (c 1.3, $CHCl_3$), mass spectrum : m/z 289 (M^+ + H) ^1H NMR (200 MHz, $CDCl_3$) δ 7.68-7.35 (m, 5H, Ph), 6.50 (dd, 1H, $J_{8,9}$ = 18 Hz, $J_{8,10}$ = 10 Hz, H-8), 5.63 (s, 1H, H-7), 5.56 (d, 1H, $J_{8,9}$ = 18 Hz, H-9), 5.31 (d, 1H, $J_{8,10}$ = 10 Hz, H-10), 4.67 (s, 1H, H-1), 4.37 (bd, 1H, $J_{4,5}$ = 10 Hz, H-4), 4.32 (dd, 1H, $J_{5,6eq}$ = 5 Hz, J_{gem} = 10 Hz, H-6eq), 4.05 (m, 1H, H-5), 3.85 (t, 1H, $J_{5,6ax}$ = J_{gem} = 10 Hz, H-6ax), 3.46 (s, 3H, OMe), 1.83 (3H, s, Me); ^{13}C NMR (50.33 MHz, $CDCl_3$) δ 137.9 (C-8), 131.7 and 129.8 (C-2 and C-3), 112.9 (C-9), 101.9 (C-7), 100.2 (C-1), 76.6 (C-4), 69.5 (C-6), 63.9 (C-5), 53.2 (OMe), 15.2 (Me). Anal. Calcd for $C_{17}H_{20}O_4$: C, 70.81; H, 6.99. Found : C,71.07; H, 7.05.

Methyl 4,6-O-benzylidene-2-deoxy-2-C-methyl-3-C-vinyl-α-D-altro-hexopyranoside (5). Prepared from 4 by general procedure **a.** as crystals (54%), m.p. 157-160°C, $[\alpha]_D$

+79.4° (c 0.60, $CHCl_3$), mass spectrum : m/z 307 ($M^+ + H$), ^1H NMR (400 MHz, $CDCl_3$) δ 7.66-7.31 (m, 5H, Ph), 5.93 (dd, 1H, $J_{8,9}$ = 18 Hz, $J_{8,10}$ = 10 Hz, H-8), 5.64 (s, 1H, H-7), 5.57 (dd, 1H, $J_{8,9}$ = 18 Hz, $J_{9,10}$ = 2 Hz, H-9), 5.32 (dd, 1H, $J_{8,10}$ = 10 Hz, $J_{9,10}$ = 2 Hz, H-10), 4.58 (s, 1H, H-1), 4.37 (m, 1H, H-5), 4.22 (dd, 1H, $J_{5,6eq}$ = 5 Hz, J_{gem} = 10 Hz, H-6eq), 3.84 (d, 1H, $J_{4,5}$ = 10 Hz, H-4), 3.83 (t, 1H, $J_{5,6ax} = J_{gem}$ = 10 Hz, H-6ax), 3.45 (s, 3H, OMe), 2.05 (q, 1H, $J_{2,Me}$ = 8 Hz, H-2), 1.12 (d, 3H, $J_{2,Me}$ = 8 Hz, Me). Anal. Calcd for $C_{17}H_{22}O_5$: C,66.64; H, 7.23. Found : C,66.87; H, 7.12.

Methyl 4,6-O-benzylidene-2,3-dideoxy-2-C-methyl-3-C-vinyl-α-D-erythro-hex-3-enopyranoside (6). Prepared from 2 by general procedure **b**. Chromatography of the reaction mixture using hexane-ethyl acetate; 95 : 5 gave 3 (36%), 6 (37%) and 7 (5%), each as a syrup. 6 $[\alpha]_D$ + 16.4° (c 0.78, $CHCl_3$), mass spectrum : m/z 289 ($M^+ + H$), ^1H NMR (200 MHz, $CDCl_3$) δ 7.72-7.31 (m, 5H, Ph), 6.87 (dd, 1H, $J_{8,9}$ = 18 Hz, $J_{8,10}$ = 11 Hz, H-8), 5.57 (s, 1H, H-7), 5.26 (d, 1H, $J_{8,9}$ = 18 Hz, H-9), 5.15 (d, 1H, $J_{8,10}$ = 11 Hz, H-10), 4.63 (d, 1H, $J_{1,2}$ = 3 Hz, H-1), 4.58 (dd, 1H, $J_{5,6eq}$ = 6 Hz, $J_{5,6ax}$ = 11 Hz, H-5), 4.37 (dd, 1H, $J_{5,6eq}$ = 6 Hz, J_{gem} = 11 Hz, H-6eq), 3.85 (t, 1H, $J_{5,6ax} = J_{gem}$ = 11 Hz, H-6ax), 3.53 (s, 3H, OMe), 2.86 (m, 1H, H-2), 1.13 (d, 3H, $J_{2,Me}$ = 7 Hz, Me). Anal. Calcd for $C_{17}H_{20}O_4$: C, 70.81; H, 6.99. Found : C,70.53; H, 7.23.

Methyl 4,6-O-benzylidene-2,3-dideoxy-2-C-methyl-3-C-(2-chloroethylene)-α-D-ribo-hexopyranoside (7). Prepared from 2 by general procedure **b**. Chromatography of the reaction mixture using hexane-ethyl acetate; 95 : 5 gave 3 (36%), 6 (37%) and 7 (5%), each as a syrup.7 $[\alpha]_D$ + 51° (c 2.3, $CHCl_3$), mass spectrum : m/z 325 and 327 ($M^+ + H$), ^1H NMR (200 MHz, $CDCl_3$) δ 7.65-7.33 (m, 5H, Ph), 5.88 (t, 1H, $J_{8,9} = J_{8,9'}$ = 8 Hz, H-8), 5.62 (s, 1H, H-7), 4.51 (d, 1H, $J_{1,2}$ = 3 Hz, H-1), 4.42 (m, 3H, H-4, 5, 6eq), 4.38 (m, 2H, H-9, 9'), 3.78 (t, 1H, $J_{5,6ax} = J_{gem}$ = 10 Hz, H-6ax), 3.33 (s, 3H, OMe), 3.02 (m, 1H, H-2), 1.28 (d, 3H, $J_{2,Me}$ = 7 Hz, Me). Anal. Calcd for $C_{17}H_{21}O_4Cl$: C, 62.86; H, 6.51; Cl, 10.88. Found : C,62.64; H, 6.59; Cl, 10.82.

Methyl 2-deoxy-2-C-methyl-3-C-vinyl-α-D-allo-hexopyranoside (8). To a solution of aqueous acetic acid (80%), (630 mL), was added alcohol 2 (5.3 g, 17.3 mmol) and the mixture was stirred at room temperature for 30 h. After concentration of the solution and chromatography of the residue using ethyl acetate, pure syrupy 8 (3.3 g, 87%) was obtained; $[\alpha]_D$ + 86.8° (c 0.56, $CHCl_3$), mass spectrum : m/z 219 ($M^+ + H$), ^1H NMR (200 MHz, $CDCl_3$) δ 5.97-5.47 (m, 3H, H-8, 9, 10), 4.83 (d, 1H, $J_{1,2}$ = 3.5, Hz, H-1), 4.07 (bs, 2H, H-6, 6'), 3.83 (m, 2H, H-4, 5), 3.57 (s, 3H, OMe), 1.90 (m, 1H, H-2), 1.00 (d, 3H, $J_{2,Me}$ = 7 Hz, Me); ^{13}C NMR (50.33 MHz, $CDCl_3$) δ 139.1 (C-8), 116.1 (C-9), 101.9 (C-1), 75.6 (C-3), 70.3 and 69.2 (C-4 and C-5), 62.8 (C-6), 55.4 (OMe), 40.1 (C-2), 9.1 (Me). Anal. Calcd for $C_{10}H_{18}O_5$: C, 55.03; H, 8.31. Found : C,55.22; H, 8.03.

Methyl 4,6-di-O-benzoyl-2-deoxy-2-C-methyl-3-C-vinyl-α-D-allo-hexopyranoside (9). To a solution of 8 (500 mg, 2.30 mmol) in dry pyridine (30 mL) was added benzoyl chloride (1.07 mL, 9.2 mmol) in pyridine (10 mL) at 0°C. Stirring was maintained overnight at room temperature and after CH_2Cl_2 extraction, pure syrupy 9 (784 mg,80%) was obtained; $[\alpha]_D$ + 154.9° (c 1.20, $CHCl_3$), mass spectrum : m/z 427 ($M^+ + H$), ^1H NMR (200 MHz, $CDCl_3$) δ 7.06-8.00 (m, 10H, 2Ph), 5.80 (dd, 1H,

$J_{8,9}$ = 18 Hz, $J_{8,10}$ = 10 Hz, H-8), 5.50 (d, 1H, $J_{4,5}$ = 11, Hz, H-4), 5.33 (m, 2H, H-9, 10), 4.93 (d, 1H, $J_{1,2}$ = 3 Hz, H-1), 4.70 (m, 3H, H-5, 6, 6'), 4.00 (s, 1H, OH), 3.63 (s, 3H, OMe), 2.13 (m, 1H, H-2), 0.96 (d, 3H, $J_{2,Me}$ = 7 Hz, Me). Anal. Calcd for $C_{24}H_{26}O_7$: C, 67.59; H, 6.14. Found : C,67.37; H, 6.22.

Methyl 4-O-benzoyl-2-deoxy-2-C-methyl-6-O-p.toluene-sulfonyl-3-C-vinyl-α-D-allo-hexopyranoside (10). To a solution of 8 (3.8 g, 17.4 mmol) in dry pyridine (100 mL) was added, in an argon atmosphere, at -20°C, tosyl chloride (3.9 g, 20.9 mmol) and the mixture was stirred at -15°C for 20 h. Then, benzoyl chloride (4.05 mL, 34.8 mmol) in pyridine (20 mL) was added and the mixture stirred at room temperature for 15 h. The solution was poored into ice-water, extracted with CH_2Cl_2 and the organic layer washed with 2N hydrochloric acid then with water, dried over Na_2SO_4 and concentrated. The residue was chromatographed affording pure syrupy 10 (6.3 g, 76%); $[\alpha]_D$ + 59.3° (c 1.25, $CHCl_3$), mass spectrum : m/z 477 (M^+ + H), ^1H NMR (400 MHz, $CDCl_3$) δ 6.80-8.30 (m, 9H, 2Ph), 5.77 (dd, 1H, $J_{8,9}$ = 18 Hz, $J_{8,10}$ = 10 Hz, H-8), 5.59 (dd, 1H, $J_{8,9}$ = 18 Hz, $J_{9,10}$ = 3 Hz, H-9), 5.34 (dd, 1H, $J_{8,10}$ = 10 Hz, $J_{9,10}$ = 3 Hz, H-10), 5.26 (d, 1H, $J_{4,5}$ = 11 Hz, H-4), 4.86 (d, 1H, $J_{1,2}$ = 3.5 Hz, H-1), 4.47 (m, 1H, H-6), 4.30 (m, 2H, H-5, 6'), 3.93 (bs, 1H, OH), 3.59 (s, 3H, s, OMe), 2.43 (bs, 3H, bs, Me), 2.04 (m, 1H, H-2), 0.98 (d, 3H, $J_{2,Me}$ = 7 Hz, Me). Anal. Calcd for $C_{24}H_{28}O_8S$: C, 60.49; H, 5.92. Found : C, 60.57; H, 5.11.

Methyl 4,6-di-O-benzoyl-2,3-dideoxy-2-C-methyl-3-C-vinyl-α-D-erythro-hex-2-enopyranoside (11). Prepared from 9 by general procedure **b**. as a syrup (77%), $[\alpha]_D$ + 21.3° (c 0.31, $CHCl_3$), mass spectrum : m/z 409 (M^+ + H), ^1H NMR (400 MHz, $CDCl_3$) δ 7.03-8.08 (m, 10H, 2Ph), 6.73 (dd, 1H, $J_{8,9}$ = 19 Hz, $J_{8,10}$ = 13 Hz, H-8), 6.33 (dd, 1H, $J_{8,10}$ = 13 Hz, $J_{9,10}$ = 1 Hz, H-10), 5.60 (d, 1H, $J_{4,5}$ = 9 Hz, H-4), 5.42 (d, 1H, $J_{8,9}$ = 19 Hz, H-9), 5.03 (s, 1H, H-1), 4.67 (m, 3H, H-5, 6, 6'), 3.65 (s, 3H, OMe), 1.95 (s, 3H, Me). Anal. Calcd for $C_{24}H_{24}O_6$: C, 70.57; H, 5.92. Found : C,70.43; H, 6.22.

Methyl 4-O-benzoyl-2,3-dideoxy-2-C-methyl-6-O-p.toluene-sulfonyl-3-C-vinyl-α-D-erythro-hex-2-enopyranoside (12). Prepared from 10 by general procedure **b**. as a syrup (50%), $[\alpha]_D$ + 12.3° (c 0.21, $CHCl_3$), mass spectrum : m/z 459 (M^+ + H), ^1H NMR (400 MHz, $CDCl_3$) δ 6.78-8.32 (m, 9H, 2Ph), 6.70 (dd, 1H, $J_{8,9}$ = 18.5 Hz, $J_{8,10}$ = 12 Hz, H-8), 6.07 (bd, 1H, $J_{4,5}$ = 9 Hz, H-4), 5.40 (d, 1H, $J_{8,10}$ = 12 Hz, H-10), 5.30 (d, 1H, $J_{8,9}$ = 18.5 Hz, H-9), 4.41 (m, 3H, H-5, 6, 6'), 3.63 (s, 3H, OMe), 2.47 (s, 3H, Me). 1.91 (s, 3H, Me). Anal. Calcd for $C_{24}H_{26}O_7S$: C, 62.89; H, 5.68, S 6.99. Found : C, 62.81; H, 5.74 ,S 7.15.

Methyl 4,6-O-benzylidene-2,3-dideoxy-3-C-vinyl-α-D-erythro-hex-2-enopyranoside (13). Prepared from 30 by general procedure **c2** as crystals (73%), m.p. 119-121°C, $[\alpha]_D$ - 1.2° (c 1.1, $CHCl_3$), mass spectrum : m/z 275 (M^+ + H) ^1H NMR (400 MHz, $CDCl_3$) δ 7.66-7.35 (m, 5H, Ph), 6.28 (dd, 1H, $J_{8,9}$ = 18 Hz, $J_{8,9'}$ = 11 Hz, H-8), 5.72 (bs, 1H, H-2), 5.68 (d, 1H, $J_{8,9}$ = 18 Hz, H-9), 5.64 (s, 1H, H-7), 5.22 (d, 1H, $J_{8,9'}$ = 11 Hz, H-9'), 4.95 (bs, 1H, H-1), 4.37 (d, 1H, $J_{4,5}$ = 10 Hz, H-4), 4.34 (dd, 1H, $J_{5,6eq}$ = 4.5 Hz, J_{gem} = 10 Hz, H-6eq), 3.99 (m, 1H, H-5), 3.86 (t,

1H, $J_{5,6ax} = J_{gem}$ = 10 Hz, H-6ax), 3.62 (s, 3H, OMe); ^{13}C NMR (50.33 MHz, $CDCl_3$) δ 138.9 (C-3), 132.8 (C-8), 128.7 (C-2), 118.4 (C-9), 102.0 (C-7), 95.6 (C-1), 76.4 (C-4), 69.5 (C-6), 65.6 (C-5), 55.8 (OMe). Anal. Calcd for $C_{16}H_{18}O_4$: C, 70.05; H, 6.61. Found : C,70.45; H, 6.93.

Methyl 4,6-O-benzylidene-2,3-dideoxy-2-C-vinyl-α-D-erythro-hex-2-enopyranoside (14). Prepared from 27 by general procedure **c1** as crystals (82%), m.p. 138-140°C, $[\alpha]_D$ + 127° (c 1.8, $CHCl_3$), mass spectrum : m/z 275 (M^+ + H) ^1H NMR (400 MHz, $CDCl_3$) δ 7.62-7.29 (m, 5H, Ph), 6.24 (dd, 1H, $J_{8,9}$ = 18 Hz, $J_{8,9'}$ = 11 Hz, H-8), 6.03 (bs, 1H, H-2), 5.28 (d, 1H, $J_{8,9}$ = 18 Hz, H-9), 5.61 (s, 1H, H-7), 5.18 (d, 1H, $J_{8,9'}$ = 11 Hz, H-9'), 5.05 (s, 1H, H-1), 4.33 (dd, 1H, $J_{5,6eq}$ = 4.5 Hz, J_{gem} = 10 Hz, H-6eq), 4.25 (dd, 1H, $J_{3,4}$ = 2 Hz, $J_{4,5}$ = 10 Hz, H-4), 4.02 (m, 1H, H-5), 3.84 (t, 1H, $J_{5,6ax} = J_{gem}$ = 10 Hz, H-6ax), 3.50 (s, 3H, OMe); ^{13}C NMR (50.33 MHz, $CDCl_3$) δ 136.5 (C-2), 134.4 (C-8), 129.2 (C-3), 115.5 (C-9), 102.3 (C-7), 96.9 (C-1), 76.0 (C-4), 69.4 (C-6), 64.2 (C-5), 55.8 (OMe). Anal. Calcd for $C_{16}H_{18}O_4$: C, 70.05; H, 6.61. Found : C,70.11; H, 6.73.

Methyl 4,6-O-benzylidene-2-deoxy-3-C-vinyl-α-D-ribo-hexopyranoside (16). Prepared from 15 by general procedure **a**. as crystals (90%), m.p. 136-139°C, $[\alpha]_D$ +111° (c O.70, $CHCl_3$), mass spectrum : m/z 293 (M^+ + H), ^1H NMR (400 MHz, $CDCl_3$) δ 7.68-7.35 (m, 5H, Ph), 5.92 (dd, 1H, $J_{8,9}$ = 17.5 Hz, $J_{8,10}$ = 11 Hz, H-8), 5.60 (s, 1H, H-7), 5.47 (d, 1H, $J_{8,9}$ = 17.5 Hz, H-9), 5.22 (d, 1H, $J_{8,10}$ = 11 Hz, H-10),4.78 (s, 1H, H-1), 4.35 (dd, 1H, $J_{5,6eq}$ = 5 Hz, J_{gem} = 10 Hz, H-6eq), 4.20 (m, 1H, H-5), 3.77 (t, 1H, $J_{5,6ax} = J_{gem}$ = 10 Hz, H-6ax), 3.55 (d, 1H, $J_{4,5}$ = 10 Hz, H-4), 3.38 (s, 3H, OMe), 1.96 (m, 2H, H-2ax, 2eq); ^{13}C NMR (50.33 MHz, $CDCl_3$) δ 140.5 (C-8), 114.7 (C-9), 101.6 (C-7), 98.2 (C-1), 81.9 (C-4), 70.7 (C-3), 69.0 (C-6), 59.3 (C-5), 55.1 (OMe), 40.0 (C-2). Anal. Calcd for $C_{16}H_{20}O_5$: C, 65.73; H, 6.89. Found : C,65.71; H, 7.03.

Methyl 4,6-di-O-benzoyl-2-deoxy-3-C-vinyl-α-D-ribo-hexopyranoside (17). To a solution of aqueous acetic acid (80%) (100 mL), was added alcohol 16 (1 g, 3.4 mmol) and the mixture was stirred at room temperature for 30 h. After concentration of the solution, the crude residue was dissolved in dry pyridine (10 mL) and benzoyl chloride (1 mL, 8.2 mmol) in pyridine (5 mL) was added to it at 0°C. Stirring was maintained overnight at room temperature and CH_2Cl_2 extraction followed by chromatography gave pure syrupy 17 (1.15 g, 82%), $[\alpha]_D$ +146° (c O.80, $CHCl_3$), mass spectrum : m/z 413 (M^+ + H), ^1H NMR (400 MHz, $CDCl_3$) δ 8.50-7.50 (m, 10H, 2 Ph), 5.70 (dd, 1H, $J_{8,9}$ = 18 Hz, $J_{8,9'}$ = 11 Hz, H-8), 5.08 (dd, 1H, $J_{8,9'}$ = 11 Hz, J_{gem} = 1.5 Hz, H-9'), 4.98 (d, 1H, $J_{1,2ax}$ = 3 Hz, H-1), 4.37 (m, 3H, H-5, 6, 6'), 4.20 (d, 1H, $J_{4,5}$ = 10 Hz, H-4), 3.47 (s, 3H, OMe), 2.03 (m, 2H, H-2ax, 2eq). Anal. Calcd for $C_{23}H_{24}O_7$: C, 66.99; H, 5.82. Found : C,67.21; H, 5.65.

Methyl 4,6-di-O-benzoyl-2-deoxy-3-C-ethynyl-α-D-ribo-hexopyranoside (19). To a solution of aqueous acetic acid (80%) (100 mL), was added methyl 4,6-O-benzylidene-2-deoxy-3-C-ethynyl-α-D-ribo-hexopyranoside[40] (6.82 g, 23.52 mmol) and the mixture was stirred at room temperature for 30 h. After concentration of the solution, the crude residue was dissolved in dry pyridine (50 mL) and benzoyl chloride (7 mL, 56.72 mmol) in pyridine (15 mL) was added to it at 0°C. Stirring was maintained overnight at room temperature and CH_2Cl_2 extraction followed by chromatography gave pure syrupy 19

(7.04 g, 73%), $[\alpha]_D$ +127.4° (c 0.80, $CHCl_3$), mass spectrum : m/z 411 ($M^+ + H$), ^1H NMR (400 MHz, $CDCl_3$) δ 8.50-7.50 (m, 10H, 2 Ph), 5.53 (d, 1H, $J_{4,5}$ = 10 Hz, H-4), 4.97 (d, 1H, $J_{1,2ax}$ = 4 Hz, H-1), 4.65-4.40 (m, 3 H, H-5, 6, 6'), 3.47 (s, 3H, OMe), 2.49 (d, 1 H, J_{gem} = 10 Hz, H-2eq), 2.46 (s, 1 H, H-8), 2.32 (dd, 1H, $J_{1,2ax}$ = 4 Hz, J_{gem} = 10 Hz, H-2ax). Anal. Calcd for $C_{23}H_{22}O_7$: C, 67.32; H, 5.37. Found : C,67.21; H, 5.45.

Methyl 4,6-O-benzylidene-2,3-dideoxy-3-C-methyl-2-C-vinyl-α-D-erythro-hex-2-enopyranoside (20). Prepared from 31 by general procedure c2 as a syrup (66%), $[\alpha]_D$ + 49.3° (c 1.7, $CHCl_3$), mass spectrum : m/z 289 ($M^+ + H$) ^1H NMR (400 MHz, $CDCl_3$) δ 7.64-7.31 (m, 5H, Ph), 6.60 (dd, 1H, $J_{8,9}$ = 16 Hz, $J_{8,9'}$ = 12 Hz, H-8), 5.60 (s, 1H, H-7), 5.24 (d, 1H, $J_{8,9}$ = 16 Hz, H-9), 5.21 (d, 1H, $J_{8,9'}$ = 12 Hz, H-9'), 5.02 (s, 1H, H-1), 4.32 (d, 1H, $J_{4,5}$ = 10 Hz, H-4), 4.09 (m, 2H, H-5, 6eq), 3.79 (t, 1H, $J_{5,6ax} = J_{gem}$ = 10 Hz, H-6ax), 3.50 (s, 3H, OMe), 1.89 (3H, s, Me); Anal. Calcd for $C_{17}H_{20}O_4$: C, 70.81; H, 6.99. Found : C,71.07; H, 7.05.

Methyl 4,6-O-benzylidene-2-deoxy-2-C-dithianyl-α-D-altro-hexopyranoside (23).[23c] To a solution of 1,3-dithiane (14 g, 121.6 mmol) in dry tetrahydrofuran (600 mL) was added at -78°C butyl lithium (71.2 mL, 114 mmol) and the mixture was stirred for 1 h. at -40°C in a nitrogen atmosphere. The temperature was cooled to -78°C and crystalline epoxide 21 (9.5 g, 36 mmol) was added. Stirring was maintained for 1 h. at -78°C and then for 70 h. while the temperature was left to raise slowly from -50°C to -15°C. The solution was washed with water (3 x 300 mL), the organic layer dried over Na_2SO_4, concentrated and the residue chromatographed giving pure syrupy 23[23c] (10.8 g, 77%).

Methyl 4,6-O-benzylidene-3-deoxy-3-C-dithianyl-α-D-altro-hexopyranoside (24).[23c] To a solution of 1,3-dithiane (7 g, 60.8 mmol) in dry tetrahydrofuran (300 mL) was added at -78°C butyl lithium (35.6 mL, 57 mmol) and the mixture was stirred for 1 h. at -40°C in a nitrogen atmosphere. Then, HMPT (15 mL, 183 mmol) was added dropwise to the solution at -78°C and the mixture was stirred at -40°C for another 30 min. The temperature was cooled to -78°C and crystalline epoxide 22 (5.02 g, 19 mmol) was added. Stirring was maintained for 1 h. at -78°C and then for 60 h. while the temperature was left to raise slowly from -15°C to 0°C. The solution was washed with water (3 x 150 mL), the organic layer dried over Na_2SO_4, concentrated and the residue chromatographed giving pure crystalline 24[23c] (4.88 g, 67%).

4,6-O-benzylidene-1,2-dideoxy-2-C-formyl-α-D-ribo-hex-1-enopyranose (26). To a solution of 23 (1 g, 2.60 mmol) in a mixture (50 mL) of acetonitrile : water, 8 : 2 was added rapidly cerium ammonium nitrate (5.71 g, 10.41 mmol). After 3 min the mixture was diluted with water and extracted with ether. The organic layer was washed with water, dried over Na_2SO_4, evaporated and chromatographed giving pure sirupy 30 (630 mg, 92%), $[\alpha]_D$ +213.9° (c 0.62, $CHCl_3$), mass spectrum : m/z 263 ($M^+ + H$), ^1H NMR (400 MHz, $CO(CD_3)_2$) δ 8.30 (s, 1H, CHO), 7.81-7.36 (m, 5H, Ph), 7.50 (s, 1H, H-1), 5.71 (s, 1H, H-7), 4.67 (bd, 1H, $J_{3,4}$ = 3 Hz, H-3), 4.45 (m, 2H, H-5, 6eq), 3.88 (t, 1H, $J_{5,6ax} = J_{gem}$ = 10 Hz, H-6ax), 3.75 (dd, 1H, $J_{3,4}$ = 3 Hz, $J_{4,5}$ = 10 Hz, H-4); ^{13}C NMR (50.33 MHz, $CDCl_3$) δ 189.4

(CHO), 164.9 (C-1), 122.5 (C-2), 102.3 (C-7), 77.9 (C-4), 68.7 (C-6), 66.9 (C-3), 52.1 (C-5). Anal. Calcd for $C_{15}H_{16}O_5$: C, 65.20; H, 5.83. Found : C,65.33; H, 5.73.

Methyl 4,6-O-benzylidene-2,3-dideoxy-2-C-formyl-α-D-erythro-hex-2-enopyranoside (27). A mixture of HgO (610 mg, 282 mmol) and $HgCl_2$ (1.53 g, 5.6 mmol) in acetonitrile : water, 8 : 2, (100 mL) was heated to 80°C for 30 min. To this mixture was added 28 (1 g, 2.3 mmol) and heating was maintained at 80°C for 2 h and then at 120°C for 4 h. After cooling and filtration, extraction with CH_2Cl_2 the organic layer was dried, evaporated and chromatographed affording 26 (68 mg, 11%) and 27 (428 mg, 66%), as crystals, [From 23 using MeI + $CaCO_3$, as described for the preparation of 30 from 29, 27 was obtained (16%) accompanied by 30 (57%)], m.p. 190-192°C, $[\alpha]_D$ +100.4° (c 0.25, $CHCl_3$), mass spectrum : m/z 277 (M^+ + H), ^1H NMR (400 MHz, $CDCl_3$) δ 8.60 (s, 1H, CHO), 7.85-7.40 (m, 5H, Ph), 6.97 (s, 1H, H-3), 5.65 (s, 1H, H-7), 5.22 (s, 1H, H-1), 4.38 (m, 2H, H-4, 6eq), 4.05 (m, 1H, H-5), 3.87 (t, 1H, $J_{5,6ax} = J_{gem}$ = 10 Hz, H-6ax), 3.53 (s, 3H, OMe); ^{13}C NMR (50.33 MHz, $CDCl_3$) δ 190.0 (CHO), 146.7 (C-3), 139.8 (C-2), 102.9 (C-7), 94.8 (C-1), 75.6 (C-4), 69.5 (C-6), 63.5 (C-5), 56.8 (OMe). Anal. Calcd for $C_{15}H_{16}O_5$: C, 65.20; H, 5.83. Found : C,65.33; H, 5.73.

Methyl 4,6-O-benzylidene-3-deoxy-3-C-dithianyl-2-O-methanesulfonyl-α-D-altro-hexopyranoside (29). To a solution of 24 (3 g, 7.81 mmol) in dry pyridine (100 mL) was added at 0°C methanesulphonyl chloride (2.5 mL, 31.24 mmol) in pyridine (20 mL). The mixture was stirred over night at room temperature, poored into ice-water and extrated with CH_2Cl_2. The organic layer was washed with 0.5 N hydrochloric acid, water, dried over Na_2SO_4, evaporated and chromatographed affording pure 29 (3.43g, 95%) as crystals, m.p. 122-125°C, $[\alpha]_D$ +57.3° (c 1.30, $CHCl_3$), mass spectrum : m/z 463 (M^+ + H), ^1H NMR (200 MHz, $CDCl_3$) δ 7.68-7.33 (m, 5H, Ph), 5.60 (s, 1H, H-7), 4.88 (d, 1H, $J_{3,8}$ = 10 Hz, H-8), 4.83 (s, 1H, H-1), 4.37 (dd, 1H, $J_{5,6eq}$ = 5 Hz, J_{gem} = 10 Hz, H-6eq), 4.23 (m, 3H, H-2, 4, 6ax), 3.78 (m, 1H, H-5), 3.50 (s, 3H, OMe), 3.16 (s, 3H, Me), 2.97 (m, 2H, H-9eq, 11eq), 2.90 (m, 2H, H-9ax, 11ax), 2.76 (bd, 1H, $J_{3,8}$ = 10 Hz, H-3), 1.95 (m, 2H, H-10ax, 11ax). Anal. Calcd for $C_{19}H_{26}O_7S_3$: C, 49.33; H, 5.66. Found : C,49.54; H, 5.55.

Methyl 4,6-O-benzylidene-2,3-dideoxy-3-C-formyl-α-D-erythro-hex-2-enopyranoside (30). To a solution of acetonitrile : water, 8 : 2 (200 mL) containing $CaCO_3$ (18.4 g, 184 mmol), was added 29 (4.31 g, 10.82 mmol). To this mixture methyl iodide (10.1 mL, 162 mmol) was added dropwise and then the temperature was brought to 120°C for 24 h. After filtration, extraction with CH_2Cl_2, the organic layer was dried over Na_2SO_4, concentrated and chromatographed, giving 30 (2.18 g, 73%) as crystals, m.p. 155-158°C, $[\alpha]_D$ +61° (c 0.80, $CHCl_3$), mass spectrum : m/z 277 (M^+ + H), ^1H NMR (400 MHz, $CDCl_3$) δ 9.33 (s, 1H, CHO), 7.88-7.36 (m, 5H, Ph), 6.57 (t, 1H, $J_{1,2} = J_{2,4}$ = 1 Hz, H-2), 5.70 (s, 1H, H-7), 5.08 (d, 1H, $J_{1,2}$ = 1 Hz, H-1), 4.48 (bd, 1H, $J_{4,5}$ = 8 Hz, H-4), 4.35 (dd, 1H, $J_{5,6eq}$ = 4 Hz, J_{gem} = 10 Hz, H-6eq), 3.90 (m, 1H, H-5), 3.86 (t, 1H, $J_{5,6ax} = J_{gem}$ = 10 Hz, H-6ax), 3.48 (s, 3H, OMe). Anal. Calcd for $C_{15}H_{16}O_5$: C, 65.20; H, 5.83. Found : C,65.27; H, 5.61.

Methyl 4,6-O-benzylidene-2,3-dideoxy-2-C-formyl-3-C-methyl-α-D-erythro-hex-2-enopyranoside (31). A suspension of HgO (34 mg, 0.15 mmol) in a mixture of acetonitrile : water (8 :

2), (10 mL), was heated to 80°C for 30 min. Alcohol 33 (50 mg, 0.125 mmol) was then added and the mixture was heated to 80°C for 2 h. and then to 120°C for 4 h. After cooling filtration and CH_2Cl_2 extraction the organic layer was dried over Na_2SO_4, concentrated and chromatographed giving pure syrupy 31 (23 mg, 63%), $[\alpha]_D$ +95.3° (c O.17, $CHCl_3$), mass spectrum : m/z 291 (M^+ + H), 1H NMR (400 MHz, $CDCl_3$) δ 10.0 (s, 1H, CHO), 7.73-7.36 (m, 5H, Ph), 5.63 (s, 1H, H-7), 5.07 (bs, 1H, H-1),4.37 (dd, 1H, $J_{5,6eq}$ = 5 Hz, J_{gem} = 10 Hz, H-6eq), 4.13 (m, 2H, H-4, 5), 3.83 (t, 1H, $J_{5,6ax} = J_{gem}$ = 10 Hz, H-6ax), 3.50 (s, 3H, OMe), 2.27 (s, 3H, Me), Anal. Calcd for $C_{16}H_{18}O_5$: C, 66.19; H, 6.24. Found : C,66.38; H, 5.96.

Methyl 4,6-O-benzylidene-2-deoxy-2-C-dithianyl-3-C-methyl-α-D-altro-hexopyranoside (33). To a solution of oxalyl chloride (5.5 mmol, 2.75 mL) in dry CH_2Cl_2 (25 mL) was added at -60°C dimethylsulfoxide (5.5 mmol, 4.25 mL) and the mixture was stirred for 3 min. Then alcohol 23 (960 mg, 2.5 mmol) in CH_2Cl_2 (2.5 mL) was added and the mixture was stirred at -60°C for an additional 15 min. Then triethylamine (12.5 mmol, 1.75 mL) was added dropwise and stirring was continued until the temperature rose to +20°C. Water (15 mL) and then CH_2Cl_2 (15 mL) were then added and the organic layer was washed with an aqueous solution of sodium chloride (2 x 20 mL),then with 1% HCl (3 x 20 mL) and finaly with 5% sodium carbonate (3 x 20 mL) and water.After concentration the crude ketone 32 (800 mg, 2.1 mmol) was dissolved in tetrahydrofuran (30 mL) and a solution of methyl lithium (2.1 mmol, 2mL) in hexane was added at -60°C dropwise to this mixture. After stirring at -40°C for 30 min., the mixture was diluted with an aqueous solution of ammonium chloride (50 mL). Extraction with CH_2Cl_2 drying over Na_2SO_4 filtration, concentration and chromatography of the residue gave 33 (766 mg, 77%) as a syrup, $[\alpha]_D$ +92.3° (c O.56, $CHCl_3$), mass spectrum : m/z 399 (M^+ + H), 1H NMR (400 MHz, $CDCl_3$) δ 7.68-7.35 (m, 5H, Ph), 5.60 (s, 1H, H-7), 4.89 (s, 1H, H-1), 4.25 (m, 2H, H-5, 6eq), 3.70 (m, 2H, H-4, 6ax), 4.12 (bs, 1H, H-8), 3.39 (s, 3H, OMe), 2.83 (m, 4H, H-9, 9', 11, 11'), 2.12 (m, 2H, H-10, 10'), 1.38 (s, 3H, Me); 13C NMR (50.33 MHz, $CDCl_3$) δ 102.1 (C-7), 99.7 (C-1), 80.4 (C-4), 71.2 (C-3), 69.3 (C-6), 59.3 (C-5), 56.0 (OMe), (55.4 (C-8), 47.6 (C-2), 31.6 (C-9, 11), 25.3 (C-10), 22.5 (Me). Anal. Calcd for $C_{19}H_{26}O_5S_2$: C, 57.26; H, 6.57; S, 16.08. Found : C,57.05; H, 6.58; S, 15.91.

4,6-O-benzylidene-1,2-dideoxy-2-C-vinyl-α-D-ribo-hex-1-enopyranose (34). Prepared from 26 by general procedure **c1**; **c2** or **c3** as crystals (21%; 50% and 70% respectively), m.p. 123-125°C, $[\alpha]_D$ +148.1° (c 1.02, $CHCl_3$), mass spectrum : m/z 261 (M^+ + H), 1H NMR (400 MHz, $CDCl_3$) δ 7.75-7.40 (m, 5H, Ph), 6.53 (s, 1H, H-1), 6.21 (dd, 1H, $J_{8,9}$ = 17 Hz, $J_{8,10}$ = 11 Hz, H-8), 5.64 (s, 1H, H-7), 5.32 (d, 1H, $J_{8,9}$ = 17 Hz, H-9), 4.97 (d, 1H, $J_{8,10}$ = 11 Hz, H-10), 4.57 (d, 1H, $J_{3,4}$ = 3 Hz, H-3), 4.47 (dd, 1H, $J_{5,6eq}$ = 5 Hz, J_{gem} = 10 Hz, H-6eq), 4.27 (m, 1H, H-5), 3.82 (t, 1H, $J_{5,6ax} = J_{gem}$ = 10 Hz, H-6ax), 3.78 (dd, 1H, $J_{3,4}$ = 3 Hz, $J_{4,5}$ = 10 Hz, H-4). Anal. Calcd for $C_{15}H_{16}O_4$: C,69.21; H, 6.19. Found : C,69.36; H, 6.34.

Benzyl 2,4,6-trideoxy-3-O-methyl-4-C-methoxymethylene-α-L-threo-hexopyranoside (Z+E) (35). Prepared from 45 by general procedure **d**. as a mixture of enol ethers (Z+E) 35 (43%) in a 2 : 1 ratio, mass spectrum : m/z 279 (M^+ + H) 1H NMR (400 MHz, $CDCl_3$) δ (major isomer) 7.37 (m, 5H, Ph),6.10 (s, 1H, H-7), 4.83 (d, 1H, J_{gem} = 12 Hz, CHPh)., 4.53 (d, 1H, J_{gem} =

12 Hz, CH'Ph), 3.60 (s, 3H, s, OMe), 3.25 (s, 3H, s, OMe), 2.40 (d, 3H, $J_{5,Me}$ = 7 Hz, Me), (minor isomer) 7.37 (m, 5H, Ph),5.90 (s, 1H, H-7), 4.80 (d, 1H, J_{gem} = 12 Hz, CHPh), 4.60 (d, 1H, J_{gem} = 12 Hz, CH'Ph), 3.63 (s, 3H, s, OMe), 3.18 (s, 3H, s, OMe), 2.45 (d, 3H, $J_{5,Me}$ = 7 Hz, Me).

Benzyl 2,3,4,6-tetradeoxy-4-C-formyl-α-L-glycero-hex-3-enopyranoside (37). A solution of 35 (20 mg, 0.07 mmol) in pyridine containing hydrochloric acid (1 mL) [prepared from pyridine (10 mL) + hydrochloric acid (83 µL) (12 M)] was stirred at room temperature for 12 h. The solution was concentrated and the residue purified by T.L.C. giving pure syrupy 37 (11.8 mg, 71%); $[\alpha]_D$ - 101° (c 0.60, $CHCl_3$), mass spectrum : m/z 233 (M^+ + H), ^1H NMR (400 MHz, $CDCl_3$) δ 9.46 (bs, 1H, CHO), 7.35 (m, 5H, Ph), 6.78 (d, 1H, $J_{2ax,3}$ = 8 Hz, H-3), 5.10 (dd, 1H, $J_{1,2ax}$ = 4 Hz, $J_{1,2eq}$ = 1 Hz, H-1), 4.80 (d, 1H, J_{gem} = 12 Hz, CHPh), 4.67 (m, 1H, H-5), 4.57 (d, 1H, J_{gem} = 12 Hz, CH'Ph), 2.68 (m, 1H, H-2ax), 2.47 (m, 1H, H-2eq), 1.47 (d, 3H, $J_{5,Me}$ = 7 Hz, Me); ^{13}C NMR (50.33 MHz, $CDCl_3$) δ 191.7 (CHO), 144.8 (C-3), 143.5 (C-4), 93.4 (C-1), 69.5 (CH_2Ph), 64.5 (C-5), 31.6 (C-2), 19.1 (Me). Anal. Calcd for $C_{14}H_{16}O_3$: C, 72.39; H, 6.94. Found : C,72.30; H, 7.23.

Benzyl 4-carboxymethyl-2,3,4,6-tetradeoxy-α-L-glycero-hex-3-enopyranoside (38). To a solution of pyridinium chlorochromate (32.3 mg, 0.15 mmol) in dichloromethane (1 mL) was added a solution of 35 (20 mg, 0.072 mmol) in dichloromethane (150 µL).The mixture was stirred at room temperature in an argon atmosphere until disappearance of 35 as shown by T.L.C. The mixture was diluted with ether (5 mL), filtered and after concentration the residue was purified by preparative thin layer chromatography giving 37 (5 mg, 30%) and 38 (6 mg, 32%) as a syrup, $[\alpha]_D$ - 80° (c 0.43, $CHCl_3$), mass spectrum : m/z 263 (M^+ + H), ^1H NMR (200 MHz, $CDCl_3$) δ 7.43 (m, 5H, Ph), 6.93 (d, 1H, $J_{2ax,3}$ = 8 Hz, H-3), 5.10 (bs, 1H, H-1), 4.87 (d, 1H, J_{gem} = 12 Hz, CHPh)., 4.73 (m, 1H, H-5), 4.60 (d, 1H, J_{gem} = 12 Hz, CH'Ph), 3.77 (s, 3H, s, OMe), 2.43 (m, 2H, H-2ax, H-2eq), 1.47 (d, 3H, $J_{5,Me}$ = 7 Hz, Me); ^{13}C NMR (50.33 MHz, $CDCl_3$) δ 165.9 (CO), 134 0 (C-3), 133.5 (C-4), 93.4 (C-1), 69.4 (CH_2Ph), 65.7 (C-5), 51.6 (CO_2Me), 31.0 (C-2), 19.9 (Me). Anal. Calcd for $C_{15}H_{18}O_4$: C, 68.68; H, 6.92. Found : C,68.47; H, 7.02.

4,6-O-Benzylidene-1,2,3-trideoxy-2-C-formyl-D-erythro-hex-1-enopyranose (42). Enol ether (Z+E) 41 were prepared from 46 by general procedure **d**. From ketone 46 (500 mg) crude enol ethers 39 were obtained.The mixture of enol ethers 39 in $CDCl_3$ solution was monitored by ^1H NMR spectroscopy.It underwent transformation into aldehyde 42 (356 mg, 76%) m.p. 110-112°C, $[\alpha]_D$ +185° (c 0.82, $CHCl_3$), mass spectrum : m/z 247 (M^+ + H), ^1H NMR (200 MHz, $CDCl_3$) δ 9.35 (s, 1H, CHO), 7.40 (m, 5H, Ph),7.25 (s, 1H, H-1), 5.63 (s, 1H, H-7), 4.48 (dd, 1H, $J_{5,6eq}$ = 3 Hz, J_{gem} = 10 Hz, H-6eq), 3.90 (m, 3H, H-4, 5,6ax), 2.83 (dd, 1H, $J_{3eq,4}$ = 5 Hz, J_{gem} = 16 Hz, H-3eq), 2.25 (dd, 1H, $J_{3ax,4}$ =10 Hz,J_{gem} = 16 Hz, H-3ax), ^{13}C NMR (50.33 MHz, $CDCl_3$) δ 189.4 (CHO), 162.8 (C-1), 118.3 (C-2), 101.8 (C-7), 73.5 (C-4), 72.0 (C-5), 68.1 (C-6), 23.7 (C-3). Anal. Calcd for $C_{14}H_{14}O_4$: C, 66.28; H, 5.73. Found : C,68.34; H, 5.85.

4,6-O-benzylidene-1,2-dideoxy-2-C-formyl-3-O-methyl-D-arabino-hex-1-enopyranose (43). Enol ethers (Z+E) 40 were prepared from 47 by general procedure d. From ketone 47

(200 mg) crude enol ethers 40 and aldehyde 43 (61 mg, 34%), were obtained after chromatography.The mixture of enol ethers 40 (132 mg, 0.41 mmol) in pyridine containing hydrochloric acid (3 mL) [prepared from pyridine (10 mL) + hydrochloric acid (83 µL) (12 M)] was stirred at room temperature for 5 h. The solution was concentrated and the residue purified by T.L.C. giving pure crystalline 43 (99 mg, total yield 89%), m.p. 75-78°C, $[\alpha]_D$ +93° (c 0.44, $CHCl_3$), mass spectrum : m/z 277 (M^+ + H), ^1H NMR (200 MHz, $CDCl_3$) δ 9.43 (s, 1H, CHO), 7.47 (m, 5H, Ph),7.30 (s, 1H, H-1), 5.67 (s, 1H, H-7), 4.43 (m, 2H, H-3, 4), 4.00 (m, 3H, H-5, 6ax, 6eq), 3.70 (s, 3H, OMe); ^{13}C NMR (50.33 MHz, $CDCl_3$) δ 188.5 (CHO), 162.3 (C-1), 120.7 (C-2), 101.5 (C-7), 79.9 (C-3), 73.8 (C-4), 70.4 (C-5), 67.7 (C-6), 55.0 (OMe). Anal. Calcd for $C_{15}H_{16}O_5$: C, 65 21; H, 5.84. Found : C,65.05; H, 5.79.

Methyl 2,3,4-trideoxy-3-C-formyl-α-D-glycero-hex-3-enopyranoside (44). Enol ethers (Z+E) 41 were prepared from 15 by general procedure d. From ketone 15 (100 mg) enol ethers 41 (42 mg,40 %) were obtained after chromatography. The mixture of enol ethers 41 (42 mg, 0.14 mmol) was dissolved in acetic acid (2 mL) containing 20% water and the solution was stirred at room temperature for 2h., concentrated and the residue purified by preparative TLC to afford pure syrupy 44 (27 mg, 88%), $[\alpha]_D$ +32° (c 0.23, $CHCl_3$), mass spectrum : m/z 173 (M^+ + H), ^1H NMR (200 MHz, $CDCl_3$) δ 9.57 (s, 1H, CHO), 6.78 (bs, 1H, H-4), 5.10 (bs, 1H, H-1), 4.50 (m, 1H, H-5), 3.93 (m, 2H, CH_2OH), 3.47 (s, 3H, s, OMe), 2.57 (m, 2H, H-2, 2'); ^{13}C NMR (50.33 MHz, $CDCl_3$) δ 192.1 (CHO), 145.7 (C-4), 137.3 (C-3), 97.2 (C-1), 68.7 (C-5), 64.7 (C-6), 55.3 (OMe), 27.0 (C-2),. Anal. Calcd for $C_8H_{12}O_4$: C, 55 81; H, 7.02. Found : C,55.87; H, 6.80.

Benzyl 2,6-dideoxy-3-O-methyl-α-L-threo-hexopyranoside-4-ulose (45). To a solution of oleandomycin hydrochloride[41] (3 g, 4.14 mmol) in water (15 mL) and $CHCl_3$ (6 mL) was added 20% NaOH until the pH of the solution was raised to 9. The organic layer was extracted with CH_2Cl_2 and oleandomycin base was crystallized (2.8 g) by addition of hexane. To a solution of benzylic alcohol (50 mL) containing 1% hydrochloric acid was added oleandomycin base (2.8 g, 4.07 mmol) and the mixture was stirred at room temperature for 48 h. Then an aqueous solution of sodium carbonate was added to bring the pH to 8, the mixture was evaporated and extracted with ether and ethyl acetate.The organic layer was dried over Na_2SO_4, filtered, evaporated and chromatographed giving a mixture of benzyl α-and β-L-oleandroside (0.84 g, 82%). Molecular sieves 3Å (0.7 g) were added to dry CH_2Cl_2 (18 mL) and the mixture was stirred in an argon atmosphere for 10 min. at room temperature. Then pyridinium chlorochromate (2.5 g, 12 mmol) was added to the mixture and stirring was continued for an additional 10 min. To this mixture was added benzyl α and β-L-oleandroside (0.74 g, 3 mmol) in tetrahydrofurane (5 mL). The reaction was monitored by thin layer chromatography. After consumption of the starting sugar, the mixture was diluted with ether and filtered through florisil before silicagel chromatography. Pure syrupy ketone 45 (0.39 g, 62%) was obtained, $[\alpha]_D$ -193° (c 1.30, $CHCl_3$), mass spectrum : m/z 251 (M^+ + H), ^1H NMR (200 MHz, $CDCl_3$) δ 7.38 (m, 5H, Ph), 5.12 (s, 1H, H-1), 4.80 (d, 1H, J_{gem} = 12 Hz, CHPh), 4.62 (d, 1H, J_{gem} = 12 Hz, CH'Ph), 4.35 (m, 2H, H-3,5), 3.50 (s, 3H, OMe), 2.63 (dd, 1H, $J_{1,2ax}$ = 4 Hz, J_{gem} = 13 Hz, H-2ax), 2.08 (dd, 1H, $J_{1,2eq}$ = 4 Hz, J_{gem} = 13 Hz, H-2eq), 1.32 (d, 3H, $J_{5,Me}$ = 7 Hz, Me). ^{13}C NMR (50.33 MHz, $CDCl_3$) δ 205.1 (C-4), 96.0 (C-1), 77.9 (C-3), 70.1 (CH_2Ph), 69.5 (C-

5), 58.0 (OMe), 39.2 (C-2), 13.6 (Me). Anal. Calcd for $C_{14}H_{18}O_4$: C, 67.18; H, 7.25. Found : C,66.96; H, 7.32

Hetero Diels-Alder adduct (48). A mixture of α,β-unsaturated aldehyde 30 (100 mg, 0.36 mmol) and Eu(Fod)$_3$ (5 mg), in ethyl vinyl ether (20 mL) was refluxed for 10h. The solution was concentrated and the residue purified by preparative TLC giving pure crystalline 48 (89 mg, 71%), m.p. 175-177°C, $[\alpha]_D$ +12.3° (c 0.35, $CHCl_3$), mass spectrum : m/z 349 (M^+ + H), ^{1}H NMR (200 MHz, $CDCl_3$) δ 7.65-7.33 (m, 5H, Ph), 6.63 (bs, 1H, H-8), 5.61 (s, 1H, H-7), 4.97 (dd, 1H, $J_{1',2'ax}$ = 9 Hz, $J_{1',2'eq}$ = 1 Hz, H-1'), 4.46 (d, 1H, $J_{1,2}$ = 8 Hz, H-1), 4.36 (dd, 1H, $J_{5,6eq}$ = 5 Hz, J_{gem} = 10 Hz, H-6eq), 4.22 (d, 1H, $J_{4,5}$ = 10 Hz, H-4), 4.05 (m, 1H, H-5), 3.90 (m, 1H, OCH_2Me), 3.76 (t, 1H, $J_{5,6ax}$ = J_{gem} = 10 Hz, H-6ax), 3.56 (m, 1H, OCH_2Me), 4.40 (s, 3H, OMe), 2.97 (m, 1H, H-2), 2.25 (m, 1H, H-2'eq), 1.67 (m, 1H, H-2'ax), 1.23 (t, 3H, $J_{CH2,Me}$ = 5Hz, Me); ^{13}C NMR (50.33 MHz, $CDCl_3$) δ 143.8 (C-3), 106.3 (C-3), 104.6 (C-1'), 101.6 (C-7), 99.4 (C-1), 76.4 (C-4), 70.2 (C-5), 64.7 (C-6), 55.6 (OMe), 34.8 (C-2), 31.8 (C-2'), 15.2 (Me). Anal. Calcd for $C_{19}H_{24}O_6$: C, 65.50; H, 6.94. Found : C,65.51; H, 6.76.

Methyl 2,3,4-trideoxy-3-C-formyl-2-C-methylformyl-α-D-threo-hex-3-enopyranoside (50). A solution of 48 (22 mg, 0.063 mmol) in acetic acid (1 mL) containing 20% water was stirred at room temperature for 2h., concentrated and the residue purified by preparative TLC furnishing pure syrupy 50 (12.3 mg, 91%), $[\alpha]_D$ + 111° (c 0.26, $CHCl_3$), mass spectrum : m/z 215 (M^+ + H), ^{1}H NMR (200 MHz, $CDCl_3$) δ 9.91 (s, 1H, CHO), 9.56 (s, 1H, CHO), 6.90 (bs, 1H, H-4), 4.86 (s, 1H, H-1), 4.50 (m, 1H, H-5), 3.93 (m, 2H, H-6,6'), 3.46 (s, 3H, OMe), 2.60 (m, 3H, H-2, CH_2CHO); ^{13}C NMR (50.33 MHz, $CDCl_3$) δ 200.0 (CHO), 191.7 (CHO), 146.1 (C-4), 139.5 (C-3), 100.2 (C-1), 69.3 (C-5), 64.0 (C-6), 55.7 (OMe), 45.7 (C-8), 31.4 (C-2). Anal. Calcd for $C_{10}H_{14}O_5$: C, 56.06; H, 6.58. Found : C,55.78; H, 6.60.

Hetero Diels-Alder adduct (49). A mixture of α,β-unsaturated aldehyde 27 (100 mg, 0.36 mmol) and Eu(Fod)$_3$ (5 mg), in ethyl vinyl ether (20 mL) was refluxed for 10h. The solution was concentrated and the residue purified by preparative TLC giving pure syrupy 49 (91 mg, 72%), $[\alpha]_D$ +52.1° (c 1.23, $CHCl_3$), mass spectrum : m/z 349 (M^+ + H), ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.67-7.37 (m, 5H, Ph), 6.58 (bs, 1H, H-8), 5.52 (s, 1H, H-7), 4.88 (dd, 1H, $J_{1',2'ax}$ = 9 Hz, $J_{1',2'eq}$ = 2 Hz, H-1'), 4.67 (s, 1H, H-1), 4.27 (dd, 1H, $J_{5,6eq}$ = 5 Hz, J_{gem} = 10 Hz, H-6eq), 3.97 (m, 1H, H-5), 3.90 (m, 3H, H-4, OCH_2Me), 3.70 (t, 1H, $J_{5,6ax}$ = J_{gem} = 10 Hz, H-6ax), 3.37 (s, 3H, OMe), 2.83 (m, 1H, H-2'eq), 2.38 (m, 1H, H-2'ax), 2.09 (m, 1H, H-3), 1.25 (t, 3H, $J_{CH2,Me}$ = 5Hz, Me). Anal. Calcd for $C_{19}H_{24}O_6$: C, 65.50; H, 6.94. Found : C,65.27; H, 6.99.

4,6-O-Benzylidene-1,2,3-trideoxy-2-C-formyl-3-C-methylformyl-D-arabino-hex-1-enopyranose (51). A solution of 49 (35 mg, 0.1 mmol) in pyridine (1 mL) containing hydrochloric acid (0.1 M) (10%) was stirred at room temperature overnight. After concentration the residue was purified by preparative TLC giving pure syrupy 51 (27 mg, 93%), $[\alpha]_D$ + 106° (c 0.6, $CHCl_3$), mass spectrum : m/z 289 (M^+ + H), ^{1}H NMR (200 MHz, $CDCl_3$) δ 9.80 (s, 1H, CHO), 9.41 (s, 1H, CHO), 7.62-7.40 (m,

1H, Ph), 7.30 (s, 1H, H-1), 5.63 (s, 1H, H-7), 4.57 (dd, 1H, $J_{5,6eq}$ = 5 Hz, J_{gem} = 10 Hz, H-6eq), 4.10 (m, 2H, H-3,5), 3.90 (t, 1H, $J_{5,6ax} = J_{gem}$ = 10 Hz, H-6ax), 3.73 (dd, 1H, $J_{3,4}$ = 6 Hz, $J_{4,5}$ = 10 Hz, H-4), 2.63 (m, 2H, CH_2CHO). Anal. Calcd for $C_{16}H_{16}O_5$: C, 66.65; H, 5.59. Found : C,66.77; H, 5.41.

4,6-O-Benzylidene-1,2,3-trideoxy-2-C-vinyl-D-erythro-hex-1-enopyranose (52). Prepared from 42 by general procedure **c3** as crystals (98%), m.p. 89-91°C, $[\alpha]_D$ +107° (c 1.4, $CHCl_3$), mass spectrum : m/z 245 (M^+ + H), ^1H NMR (200 MHz, $CDCl_3$) δ 7.62-7.36 (m, 5H, Ph), 6.56 (s, 1H, H-1), 6.30 (dd, 1H, J_{trans} = 17 Hz, J_{cis} = 11 Hz, H-8), 5.63 (s, 1H, H-7), 4.96 (d, 1H, J_{trans} = 17 Hz, H-9), 4.90 (d, 1H, J_{cis} = 11 Hz, H-9'),4.43-3.70 (m, 4H, H-4,5,6ax,6eq), 2.60 (dd, 1H, $J_{3eq,4}$ = 5 Hz, J_{gem} = 11 Hz, H-3eq), 2.33 (dd, 1H, $J_{3ax,4}$ = 9 Hz, J_{gem} = 11 Hz, H-3ax); ^{13}C NMR (50.33 MHz, $CDCl_3$) δ 144.4 (C-1), 134.4 (C-8), 112.7 (C-2), 108.8 (C-9), 101.7 (C-7), 74.7 (C-4), 70.5 (C-5), 68.8 (C-6), 26.4 (C-3). Anal. Calcd for $C_{15}H_{16}O_3$: C, 73.75; H, 6.60. Found : C,73.70; H, 6.77.

4,6-O-Benzylidene-1,2-dideoxy-3-O-methyl-2-C-vinyl-D-arabino-hex-1-enopyranose (53). Prepared from 43 by general procedure **c3** as crystals (79%), m.p. 115-117°C, $[\alpha]_D$ +51° (c 0.15, $CHCl_3$), mass spectrum : m/z 275 (M^+ + H), ^1H NMR (200 MHz, $CDCl_3$) δ 7.64-7.33 (m, 5H, Ph), 6.58 (s, 1H, H-1), 6.18 (dd, 1H, J_{trans} = 17 Hz, J_{cis} = 11 Hz, H-8), 5.67 (s, 1H, H-7), 5.23 (dd, 1H, J_{trans} = 17 Hz, J_{gem} = 1 Hz, H-9), 5.03 (dd, 1H, J_{cis} = 11 Hz, J_{gem} = 1 Hz, H-9'), 4.50 (m, 2H, H-3,4), 4.10 (dd, 1H, $J_{5,6eq}$ = 7 Hz, J_{gem} = 10 Hz, H-6eq), 3.80 (m, 2H, H-5,6ax), 3.50 (s, 3H, OMe). ^{13}C NMR (50.33 MHz, $CDCl_3$) δ 146.2 (C-1), 131.7 (C-8), 115.7 (C-2), 112.2 (C-9), 101.4 (C-7), 80.6 (C-4), 75.2 (C-3), 69.0 (C-5), 68.5 (C-6) 57.5 (OMe). Anal. Calcd for $C_{16}H_{18}O_4$: C, 70.05; H, 6.61. Found : C,69.97; H, 6.34.

REFERENCES

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(4) (a) Inch, T. D. in *Advances in Carbohydrates Chemistry and Biochemistry*, **1972**, 27, 191-225. (b) Vasella, A.in R. Scheffold : *Modern Synthetic Methods*, Vol 2. 1980, pp 173-267. (c) Inch, T. D.*Tetrahedron*, **1984**, *40*, 3161-3213.
(5) Fraser-Reid, B.; Anderson, R. C. in *Fortschr. Chem. Org. Naturst.* **1980**, *39*, 1-61.
(6) Hanessian, S. *"Total Synthesis of Natural Products, The Chiron Approach"* Pergamon Press, Oxford, **1983**.
(7) Seebach, D.; Hungerbühler, E. in R. Scheffold: *Modern Synthetic Methods*, Vol 2. **1980**, p 93-171.
(8) Brehm, M.; Dauben, W. G.; Köhler, P.; Lichtenthaler, F. W. *Angew. Chem. Int. Ed. Eng.* **1987**, *26*, 1271-1273.
(9) (a) Fitzsimmons, B. J.; Fraser-Reid, B.; *J. Am. Chem. Soc.* **1979**, *101*, 6123-6125. (b) idem, *Tetrahedron*, **1984**, 1279-1287.
(10) Ferrier, R. J. *Chem. Soc., Perkin I*, **1979**, 1455-1458.
(11) Bonnert, R. V. ; Jenkins, P. R. *Tetrahedron Lett.*, **1987**, *28*, 697-700. and references therein.
(12) López, J. C.; Lameignère, E.; Lukacs, G. *J. Chem. Soc., Chem. Commun.*, **1988**, 514-515; see also López, J. C.; Lukacs, G.in R. M. Giuliano *Cycloaddition Reactions in Carbohydrate Chemistry*, A C S Symposium Series 494, **1992** pp. 33-49.
(13) Burnouf, C.; López, J. C.; Laborde, M. A.; Olesker, A.; Lukacs, G. *Tetrahedron Lett.*, **1988**, 5533-5534.

(14) López, J. C.; Lameignère, E.; Lukacs, G. *J. Chem. Soc., Chem. Commun,* **1988**, 706-707.
(15) a) Rocherolle, V.; López, J. C.; Olesker, A.; Lukacs, G. *J. Chem. Soc., Chem. Commun,* **1988**, 513-514. b) Idem, *J. Carbohydrate Chem,* **1989**, *8*,429-441.
(16) Giuliano, R. M.; Buzby, J. H. *Carbohydrate Res.* **1986**, *158*, C1. See also Giuliano, R. M.; Buzby, J. H.; Marcopulos, N.; Springer, J. P. *J. Org. Chem.* **1990**, *55*, 3555-3562.
(17) Lipshutz, B. H., Nguyen, S. L.; Elworthy, T. R.; *Tetrahedron*, **1988**, *44*, 3335-3364.
(18) a) Chapleur, Y. *J. Chem. Soc., Chem. Commun.* **1983**, 141-142. b) Klemer, A.; Rodemeyer, G. *Chem. Ber.* **1974**, *107*, 2612-2614. c) Hanessian, S ; Pougny, J-R. Boessenkool, I. K. *Tetrahedron*, **1984**, *40*, 1289-1301. d) Hanessian, S ; Rancourt, G. *Can. J. Chem.* **1977**, *55*, 1111-1113.
(19) Baker, D. C.; Brown, D. K.; Horton, D.; Nickol, R. G. *Carbohydrate Res.* **1974**, *32*, 299-319. See also Horton, D.; Just, E. K. *Carbohydrate Res.* **1971**, *18*, 81-94.
(20) Compare with a) Brandänge, S.; Dahlman, O.; *J. Chem. Soc., Chem. Commun.*, **1983**, 1324-1325. b) Brandänge, S.; Dahlman, O.; Lindquist, B.; Mahlen, A.; Mörch, L. *Acta Chem. Scand. B*; **1984**, *38*, 837-844. where no epimerization at C-2 occurs and attack at C-3 is only stereoselective.
(21) Lagrange, A.; Olesker, A.; Lukacs, G.; Thang, T. T. *Carbohydrate Res.* **1982**, *110*, 165-169.
(22) Corey, E. J.; Seebach, D. *Angew. Chem. Int. Ed.* **1965**, *4*, 1075-1077.
(23) Opening of carbohydrate epoxides: a) Sepulchre, A. M.; Lukacs, G.; Vass, G.; Gero, *S. D. C. R. Acad. Sc. Serie C*, **1971**, 1180-1182. b) Idem, *Angew. Chem. Int. Ed.* **1972**, *11*, 148. c) Idem, *Bull. Soc. Chim. Fr.* **1972**, 4000-4007. Nucleophilic displacement on carbohydrate halides: d) Sepulchre, A. M.; Vass, G.; Gero, S. D. *Tetrahedron Lett* **1973**, 3619-3620. Nucleophilic addition on carbohydrate-uloses e) Gateau-Olesker, A.; Gero, S. D.; Pascard-Billy, C.; Riche, C.; Hughes, N. A. Sepulchre, A. M.; Vass, G.; *J. Chem. Soc., Chem. Commun.* **1974**, 811-812.
(24) a) Paulsen, H.; Sinwell, V.; Stadler, P. *Angew. Chem. Int. Ed.* **1972**, *11*, 149-150. b) Paulsen, H.; Redlich H. ibid, **1972**, *11*, 1021-1023. For an interesting survey see: c) Paulsen, H.; Sinnwell, V.; Thiem, J. *Methods in Carbohydrate Chemistry* Vol VIII **1980** 185-194.
(25) a) Corey, E. J.; Crousie, D. *J. Org. Chem.* **1968**, *33*, 298-300. b) Seebach, D.; Corey, E. J.; *J. Org. Chem.* **1975**, *40*, 231-237.
(26) Szeja, W., *Carbohydrate Res.* **1986**, *158*, 245-248.
(27) For an excellent review on hydrolysis of S,S acetals see: Gröbel, B.-T, Seebach, D. *Synthesis* **1977**, 357-402.
(28) Dahlman, O.; Garegg, P. J.; Mayer, H.; Schramek, S.; *Acta Chem. Scand.* B. **1986**, *40*, 15-20.
(29) a) Corey, E. J.; Erickson, B. W.; *J. Org. Chem.* **1971**, *36*, 3553-3560. b) Tamaka, H. Torii, S. *J. Org. Chem.* **1975**, *40*, 462-465.
(30) Ho, T.-L. Ho, H. C.; Wong, C. M. *J. Chem. Soc., Chem. Commun.* **1972**, 791.
(31) Omura, K.; Sharma, A. K.; Swern, D. *J. Org. Chem.* **1976**, *41*, 957-962.
(32) Barton and coworkers have shown that 1,3-dithiolanes are stable to Swern oxidative conditions: Barton, D. H. R.; Gero, S. D.; Maycock, C. D. *J. Chem. Soc. Perkin Trans. 1*, **1982**, 1541-1551.
(33) a) Guthrie, R. D. in "*The Carbohydrates, Chemistry and Biochemistry*" (2nd Ed.) Pigman, W.; Horton, D. Eds. Academic Press. New York **1972**, Vol. 1A, pp 423-478; b) Buchanan, J. G.; Sable, H. Z. in "*Selective Organic Transformations*" Thyagarajan, B. S. Eds. Wiley-Interscience, New York **1972**, Vol. 2 pp 1-95.
(34) Asano, T.; Yokota, S.; Mitsunobu, O. *Chem. Lett.* **1983**, 343-346.
(35) a) Piancatelli, G.; Scettri, A.; D'Auria, M. *Tetrahedron Lett.* **1977**, 3483-3484. b) Idem, *Synthesis*, **1982**, 245-258. See also c) Baskaran, S.; Islam, I.; Raghavan, M.; Chandrasekaran, S. *Chem. Lett.*; **1987**, 1175-1178.
(36) Beynou, P. J.; Collins, P. M.; Doganges, P. T.; Overend, W. G. *J Chem. Soc. Perkin (C)* **1966**, 1131-1136.
(37) Cree, G. M.; Mackie, D. W.; Perlin, A. S. *Can. J. Chem.* **1969**, *47*, 511-512. See also Vatele, J. M. *Tetrahedron* , **1986**, *24*, 4443-4450.
(38) Rosenthal, A.; Catsoulacos, P. *Can. J. Chem.* **1968**, *46*, 2868-2872.
(39) Krasso, A.; Weiss, E.; Reichstein, T. *Helv. Chim; Acta* **1963**, *46*, 2538-2543.
(40) Krohn, K.; Broser, E.; Heins, H. *Carbohydrate Res.* **1987**, *164*, 59-69.
(41) Celmer, W. D. *J. Am. Chem. Soc.* **1965**, *87*, 1797-1799.
(42) The preparation of C-2-formyl glycals was reported recently using Vilsmeier-Haack reaction of glycals : Ramesh, N. G.; Balasubramanian, K. K. *Tetrahedron Lett.* **1991**, 3875-3878.