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New Synthesis of 3'-C-Substituted Nucleosides

Neeraj Garg, Janez Plavec and Jyoti Chattopadhyaya*

Department of Bioorganic Chemistry, Box 581, Biomedical Center,
University of Uppsala, S-751 23 Uppsala, Sweden

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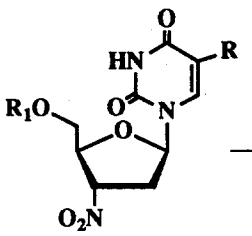
Abstract: *The base catalyzed addition reactions at C-3' of 2', 3'-dideoxy-3'-nitro-thymidine 1 or -uridine 2 with paraformaldehyde, methyl vinyl ketone, acrylonitrile and ethyl propiolate have produced various 1-(2',3'-dideoxy-3'-C-substituted-3'-nitro-β-D-pentofuranosyl)pyrimidine nucleosides 3 - 26 [α-substitution (major); β-substitution (minor)]. The stereochemistry of products formed in the reaction clearly suggest that the incipient carbanion at C3' preferentially attacks the electron-deficient reagent from the α-face of the sugar ring. Subsequently, the 3'-nitro group from 3, 14, 17, 22 and 25 was removed by the action of Bu_3SnH and AIBN to give 3'-C-substituted nucleosides 27 - 44 [threo (major) and erythro (minor)] which suggested that the intermediary 3'-carbon radical abstracted the hydrogen atom preferentially from the α-face. The stereochemistry of the products from the base-catalyzed addition reactions and free-radical promoted denitration reactions were ascertained by detailed structure analysis by NMR spectroscopy. The results presented in this paper is the first example of the preparation of C-branched nucleosides using the base catalyzed addition reaction at the α-carbon of a nitro function in the sugar moiety of nucleoside.*

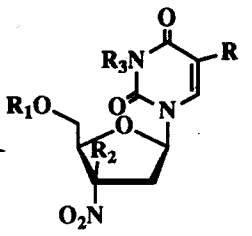
New stimulus for the synthesis of new types of nucleoside analogues with potential anti-HIV activities has grown from the fact that there are now three FDA approved nucleoside derivatives (AZT, ddI and ddC) available for the treatment of AIDS related syndromes and many are in the early or late phase of the human clinical trials. Our own interest in the design of suitable candidate drugs against AIDS is mainly concentrated in the development of new synthetic routes involving 2' or/and 3' modifications of the sugar residue of the nucleoside using both ionic and free-radical reactions. In this connection, we have developed several new routes[1a-k] leading to the introduction of the C-substituent at 2' or 3' in stereospecific manner. Procedures for the introduction of a C-substituent at 2' or 3' can be divided mainly into two types. In the first category, the C-substituent has been introduced at the sugar level[2a-j] followed by the glycosylation reaction to give the C-substituted nucleosides. The second category involves direct introduction of the C-substituent at the sugar moiety of the nucleoside, which poses considerable problem because of various steric and electronic reasons (*e.g.* dissimilar reactivities between the α and β-face of nucleosides, reactivity of 2'-carbon is much poorer than 3'-carbon, instabilities of the glycosidic bond, side reactions at the aglycone etc). Different chemical methodologies that have been developed for the chemoselective introduction of the C-substituent at the nucleoside level are as follows: (1) addition to 2'- and 3'-keto function,[1f-h,3a-q] (2) nucleophilic opening of 2',3'-epoxides,[4a-d] (3) intramolecular free-radical addition reaction,[1i-k,3l] (4) intermolecular free-radical addition reaction,[5a-c] (5) Michael addition reaction to 2',3'-unsaturated nucleosides,[1a-e] (6) ring contraction of 3-amino-glucopyanosyl nucleoside,[6] (7) Aldol condensation at the C3' of the enolate generated from the 2',3'-enol-ester of uridine,[7] and (8) the Pd catalyzed cross coupling or base catalyzed reactions of 2',3'-bromovinylnucleosides.[8]

The results described herein constitute the first report of the base-catalyzed addition reaction at the α-carbon of a nitro function in the sugar moiety of a nucleoside to introduce the C-substituent. This has been demonstrated through the reactions of 2',3'-dideoxy-3'-nitrothymidine[1e] **1** and 2',3'-dideoxy-3'-nitrouridine[1e] **2** with various reagents containing electron-deficient functions as in paraformaldehyde, methyl vinyl ketone, acrylonitrile and ethyl propiolate. Nitroaldol reactions[9a] as means to form a carbon-carbon bond have been explored extensively by Seebach and his co-workers on various simple acyclic or alicyclic systems.[9b,c] Subsequently, Vasella et al.[9d,e] performed base-catalyzed reaction of D-gluco-1-deoxy-1-nitroaldose with excess paraformaldehyde to give the anomeric mixture of D-gluco-2-deoxy-2-nitro-heptulopyranoses which were then denitrated under the influence of tributyltinhydride to give D-gulo-hepitol.

Reaction of 2',3'-dideoxy-3'-nitrothymidine 1 and 2',3'-dideoxy-3'-nitrouridine 2 with paraformaladehyde, acrylonitrile, ethyl propiolate and methyl vinyl ketone: Treatment of 5'-O-(4-monomethoxytrityl)-2',3'-dideoxy-3'-nitro-thymidine[1e] **1** with paraformaldehyde in THF in presence of tetrabutyl ammonium fluoride (0.2 equiv) for 30 min at room temperature gave a diastereomeric mixture which was separated to give pure 3'-(R)-hydroxymethyl-3'-nitro-thymidine **3** (34 %) and 3'-(S)-hydroxymethyl-3'-nitro-thymidine **14** (55 %). The chemical shifts of H-2', H-4' H5'/5" and *3'-CH_2*-OH were remarkably different in **3** and **14** [for **3**: H-2' (δ2.52 ppm), H-4' (δ4.67 ppm), H5'/5" (δ3.73 and 3.41 ppm), *3'-CH_2*-OH (δ4.04 ppm) and for **14**: H-2' (δ2.90 ppm), H-4' (δ3.96 ppm), H5'/5" (δ3.47 ppm), *3'-CH_2*-OH (δ4.26 and 3.91 ppm)]. The $\Delta J_{1'}$ (*i.e.* $J_{1'2'} - J_{1'2''}$) for **3** and **14** is 2.9 Hz and 0.8 Hz, respectively (see ^{1}H- and ^{13}C-NMR data in the experimental part). The presence of *3'-CH_2*OH group in **3** and **14** was also unequivocally proved *(vide infra)* by their straightforward conversions to the corresponding acetates **4** (85 %) and **15** (89 %), respectively. Similarly, the reaction of **1** with acrylonitrile for 20 min gave 3'-(R)-(β-cyanoethyl)-3'-nitro-thymidine **17** (83 %) as the major product (minor product was not isolable), whereas the treatment of **1** with ethyl propiolate for 10 min gave the diastereomeric mixture which was separated to give pure 3'-(R)-(ethoxycarbonylethylidene)-3'-nitro-thymidine **6** (18 %) and 3'-(S)-(ethoxycarbonylethylidene)-3'-nitro-thymidine **19** (69 %) [for **6**: H-2' (δ2.68 ppm) & H-4' (δ4.97 ppm), $\Delta J_{1'}$ = 4.6 Hz; for **19**: H-2' (δ2.89 ppm) & H-4' (δ4.05 ppm), $\Delta J_{1'}$ = 0.9 Hz]. In the similar manner, the reaction of **1** with methyl vinyl ketone for 5 min gave 3'-(S)-(3-oxobutyl)-3'-nitro-N-3-(3-oxobutyl)thymidine **8** (4 %), 3'-(R)-(3-oxobutyl)-3'-nitro-N-3-(3-oxobutyl)thymidine **21** (9 %), 3'-(S)-(3-oxobutyl)-3'-nitro-thymidine **9** (9 %) and 3'-(R)-(3-oxobutyl)-3'-nitro-thymidine **22** (62 %), [for **8**: H-4' (δ4.68 ppm), $\Delta J_{1'}$ = 4.1 Hz; for **21**: H-4' (δ4.01 ppm), $\Delta J_{1'}$ = 1.2 Hz; for **9**: H-4' (δ4.69 ppm), $\Delta J_{1'}$ = 4.2 Hz; for **22**: H-4' (δ4.00 ppm, $\Delta J_{1'}$ = 1.2 Hz;]. It is clear from the results of the above reactions that the incipient 3'-carbanion preferentially attacks the electron-deficient reagents from the α-face of the pentofuranose ring [**3** / **14** = 3:5; **6** / **19** = 1:3.8; **8** / **21** = 1:2.2; **9** / **22** = 1:6.9, *vide infra* for NMR arguments for the unequivocal assignment of the configuration at C3']. This is consistent with our earlier results of Michael addition reactions[1a-d] of 2',3'-enesulfone, 2',3'-eneselenone, 2',3'-enenitrile derivatives of nucleosides by various carbon or nitrogen nucleophiles in which it has been shown that 2',3'-trans-substituted nucleosides are by far the major products formed. These results suggested that the intermediary C3'-carbanion is asymmetric and preferentially orient itself away from the O4' and O5' lone-pairs presumably due to steric and electronic reasons. These results are consistent with the recent work by Miyasaka et al.[7] who have also shown that the aldol reaction at the C3' of the 2',3'-enol-ester of uridine exclusively took place from the α-face. It may also be noted that the nucleophilic addition reactions at 2'-keto[3a-l] and 3'-keto[1f-h,3m-q] nucleosides by carbon nucleophiles take place mainly from the α-face presumably due to both steric and electronic reasons. Subsequently, the 5'-O-MMTr group from **3**, **6**, **8**, **9**, **12**, **14**, **17**, **19**, **21**, **22** and **25** were

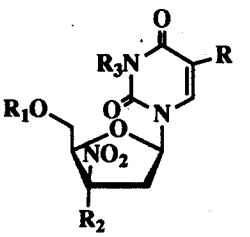


1: R = CH_3, R_1 = MMTr
2: R = H, R_1 = MMTr

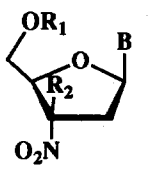


3: R = CH_3, R_1 = MMTr, R_2 = CH_2OH, R_3 = H
4: R = CH_3, R_1 = MMTr, R_2 = CH_2OAc, R_3 = H
5: R = CH_3, R_1 = H, R_2 = CH_2OH, R_3 = H
6: R = CH_3, R_1 = MMTr, R_2 = $CH{=}CHCO_2Et$, R_3 = H
7: R = CH_3, R_1 =H, R_2 = $CH{=}CHCO_2Et$, R_3 = H
8: R = CH_3, R_1 = MMTr, R_2 = R_3 = $CH_2CH_2COCH_3$
9: R = CH_3, R_1 = MMTr, R_2 = $CH_2CH_2COCH_3$, R_3 = H
10: R = CH_3, R_1 = H, R_2 = R_3 = $CH_2CH_2COCH_3$
11: R = CH_3, R_1 = H, R_2 = $CH_2CH_2COCH_3$, R_3 = H
12: R = H, R_1 = MMTr, R_2 = CH_2OH, R_3 = H
13: R = H, R_1 = H, R_2 = CH_2OH, R_3 = H

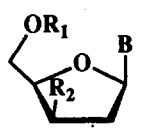
+



14: R = CH_3, R_1 = MMTr, R_2 = CH_2OH, R_3 = H
15: R = CH_3, R_1 = MMTr, R_2 = CH_2OAc, R_3 = H
16: R = CH_3, R_1 = H, R_2 = CH_2OH, R_3 = H
17: R = CH_3, R_1 = MMTr, R_2 = CH_2CH_2CN, R_3 = H
18: R = CH_3, R_1 = H, R_2 = CH_2CH_2CN, R_3 = H
19: R = CH_3, R_1 = MMTr, R_2 = $CH{=}CHCO_2Et$, R_3 = H
20: R = CH_3, R_1 = H, R_2 = $CH{=}CHCO_2Et$, R_3 = H
21: R = CH_3, R_1 = MMTr, R_2 = R_3 = $CH_2CH_2COCH_3$
22: R = CH_3, R_1 = MMTr, R_2 = $CH_2CH_2COCH_3$, R_3 = H
23: R = CH_3, R_1 = H, R_2 = R_3 = $CH_2CH_2COCH_3$
24: R = CH_3, R_1 = H, R_2 = $CH_2CH_2COCH_3$, R_3 = H
25: R = H, R_1 = MMTr, R_2 = CH_2OH, R_3 = H
26: R = H, R_1 = H, R_2 = CH_2OH, R_3 = H

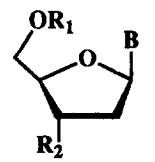


3: R_1 = MMTr, R_2 = CH_2OH, B = T

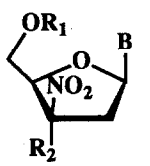


27: R_1 = MMTr, R_2 = CH_2OH, B = T
29: R_1 =H, R_2 = CH_2OH, B = T

+

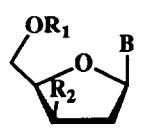


41: R_1 = MMTr, R_2 = CH_2OH, B = T



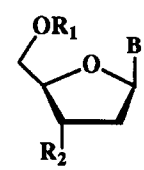
14: R_1 = MMTr, R_2 = CH_2OH, B = T
25: R_1 = MMTr, R_2 = CH_2OH, B = U
17: R_1 = MMTr, R_2 = CH_2CH_2CN, B = T
22: R_1 = MMTr, R_2 = $CH_2CH_2COCH_3$, B = T

B = Thymine-1-yl
B = Uracil-1-yl
B = Cytosine-1-yl



27: R_1 = MMTr, R_2 = CH_2OH, B = T
28: R_1 = MMTr, R_2 = CH_2OAc, B = T
29: R_1 = H, R_2 = CH_2OH, B = T
30: R_1 = H, R_2 = CH_2OAc, B = T
31: R_1 = MMTr, R_2 = CH_2OH, B = U
32: R_1 = MMTr, R_2 = CH_2OAc, B = U
33: R_1 = H, R_2 = CH_2OH, B = U
34: R_1 = MMTr, R_2 = CH_2OH, B = 4-(2-nitrophenyl)-2-pyrimidinone
35: R_1 = MMTr, R_2 = CH_2OAc, B = C
36: R_1 = H, R_2 = CH_2OH, B = C
37: R_1 = MMTr, R_2 = CH_2CH_2CN, B = T
38: R_1 = H, R_2 = CH_2CH_2CN, B = T
39: R_1 = MMTr, R_2 = $CH_2CH_2COCH_3$, B = T
40: R_1 = H, R_2 = $CH_2CH_2COCH_3$, , B = T

+



41: R_1 = MMTr, R_2 = CH_2OH, B = T
42: R_1 = MMTr, R_2 = CH_2OH, B = U
43: R_1 = MMTr, R_2 = CH_2CH_2CN, B = T
44: R_1 = MMTr, R_2 = $CH_2CH_2COCH_3$, B = T

removed by a brief treatment with 80% aqueous acetic acid at RT to give **5** (93 %), **7** (84 %), **10** (80 %), **11** (83 %), **13** (82 %), **16** (92 %), **18** (85 %), **20** (88 %), **23** (85 %), **24** (90 %) and **26** (86 %) respectively.

Assignment of configurations in compounds 3 - 26. The following trends of chemical shifts and J-couplings were observed in the ^{1}H-NMR spectra of **3 - 26**. (1) The H-2' was more shielded (0.11 - 0.50 ppm) in the case of **3 - 13** in comparison with their epimers **14 - 26**. (2) The difference in chemical shift of H2' and H2" in case of **3 - 13** was significantly larger (0.51 - 0.89 ppm) in comparison with their corresponding isomers **14 - 26**. (3) The H-4' in epimers **3 - 13** was more deshielded (0.47 - 0.92 ppm) than in their corresponding epimers **14 - 26**. (4) The difference in chemical shift of H-5' and H-5" in the case of **3 - 13** was larger (0.51 - 0.80 ppm) in comparison with their counterparts **14 - 26** (0.0 - 0.14 ppm). (5) The $J_{1'2'}$ in **3 - 13** were in the range of 8.2 - 9.5 Hz, whereas they were 6.7 - 7.6 Hz in **14 - 26**. (6) The difference between $J_{1'2'}$ and $J_{1'2''}$ in **3 - 13** was in the range of 2.1-4.2 Hz whereas in the case of **14 - 26** it was significantly smaller (0.1-1.2 Hz). Above spectroscopic characteristics clearly suggested two distinctly different trends of chemical shifts and J-couplings for the pair of 3'-epimers with C-substituent at the β-face (*i.e.* **3 - 13**) or at the α-face (*i.e.* **14 - 26**). At this point we have performed the NOE experiments on a pair of 3'-epimeric nucleosides **3** and **15** in order to assign the R or S configuration to the two groups of nucleosides (*i.e.* **3 - 13** versus **14 - 26**). The 3'-(R) configuration in **3** was confirmed by the following 1D difference NOE experiments: saturation of H5" showed NOE enhancements at H5' (14%), H4' (4%) and *3'-CH_2*-OH (5%) and the saturation of H2' showed NOE enhancements at H6 (5%), *3'-CH_2*-OH (2%) and H2" (19%) whereas the saturation of H2" gave NOE enhancements at H1' (7%), H4' (1%) and H2' (18%). The key NOE contact between *3'-CH_2*-OH and H5" and H2' suggested that the 3'-CH_2-OH in **3** is at the β-face of the pentofuranose ring. Hence, the similarities in the chemical shifts and J-couplings in **3 - 13** and the unequivocal assignment of configuration by 1D difference NOE on **3** altogether suggest that all other compounds belonging to this series should have the 3'-C-substituent at the β-face. Similar 1D difference NOE experiments on **14** was not feasible because the absorptions for H2', H2" and H5'/5" were very close precluding any selective presaturation experiment. Therefore, we have performed 1D difference NOE experiments on its acetate (*i.e.* **15**). The 3'-(S) configuration in **15** was clear from the following 1D difference NOE experiments: saturation of H4' showed NOE enhancements at H1' (4%), H5' (2%), H5" (2%), *3'-CH_a*-OAc (1% at δ 4.77 ppm) and *3'-CH_b*-OAc (4% at δ4.34 ppm), saturation of H2' showed NOE enhancements at H6 (6%), H1' (1%) and H2" (19%) whereas a saturation of H2" gave NOE enhancements at H1' (9%), *3'-CH_a*-OAc (0.4% at δ 4.77 ppm) and *3'-CH_b*-OAc (11.8% at δ 4.34 ppm) and H2' (19%). The key NOE contact between *3'-CH_2*-OAc and H2" and H4' (i.e. the protons at α-face) suggested that the *3'-CH_2*-OAc in **15** is at the α-face of the pentofuranose ring. Hence, the similarities in the chemical shifts and J-couplings in **14 - 26** and the unequivocal assignment of configuration by 1D difference NOE on **15** altogether suggested that all other compounds belonging to this series should have the 3'-C-substituent at the α-face.

Removal of 3'-nitro group in 3'-substituted nucleosides. The free-radical promoted removal of the tertiary nitro group is well documented in the literature.[10a,b] Treatment of **14** with tributyltin hydride (3 equiv) and α, α'-azoisobutyronitrile (AIBN) (1 equiv) in dry benzene at 70 °C for 20 h gave an epimeric mixture of **27** and **41**, which were purified by preparative thin layer chromatography to give 3'-*threo*-hydroxymethylthymidine **27** (82 %) and 3'-*erythro*-hydroxymethylthymidine **41** (9 %). Similarly, the 3'-nitro group was removed from **3** to give pure **27** (75 %) and **41** (10 %) upon chromatographic purification. The percentage yield of isolated products show that the radical generated at C3' from either of the epimers **3** or **14** gave preferentially the *threo*

isomer **27** whereas the *erythro* isomer **41** was formed only as a minor component (**3** → **27** + **41** in 7.5 : 1 ratio & **14** → **27** + **41** in 9.1 : 1 ratio). Earlier De la Heras et al.[3p] performed the free-radical promoted deoxygenation of an epimeric mixture (6:1) of 3'-cyano-3'-O-(phenoxythiocarbonyl)thymidine with tributyltin hydride in the presence of AIBN to give 1-(3'-cyano-3'-deoxyxylofuranosyl)thymine (60%) in a stereoselective manner. Matsuda et al.[3c] reported the free-radical promoted deoxygenation reaction of 2'-C-ethynyl-2'-(methoxyallyl ester) of uridine to give 2'-deoxy-2'-C-ethynyl-1-β-D-arabinofuranosyl-uracil (68 %) along with a negligible amount of the ribo isomer. Similarly, an intermolecular carbon-carbon bond formation at C3' by the reaction of 3'-O-phenoxythiocarbonyl thymidine derivative with allyltributyltin gave the 3'-α-isomer[5a,b] exclusively. In all of the reactions of the 2'-[3c] or 3'-[3p] *tert-* or *sec*-radical, described above, show that they have a clear preference for the abstraction of the hydrogen atom from Bu_3SnH from the less hindered α-face of the sugar ring. Our result of radical promoted 3'-denitration (*i.e.* **3** → **27** + **41** in 7.5:1 ratio & **14** → **27** + **41** in 9.1:1 ratio, due to abstraction of hydrogen atom from the α- or the β-face, respectively) also suggest that the abstraction of hydrogen atom indeed takes place preferentially from the α-face irrespective of the structure of free-radical precursor. Further evidence in support of the preferential abstraction of hydrogen atom from the α-face has been shown by the following transformations: **25** → **31** + **42** in 4.8:1 ratio; **17** → **37** + **43** in 7.5:1 ratio (NMR); **22** → **39** + **44** in 4.5:1 ratio (NMR). Upon removal of 5'-O-MMTr group from the mixture **37** + **43** and **39** + **44**, only the major 5'-hydroxy isomer, **38** (78%) and **40** (67%), could be isolated as pure compounds (see experimental). Attempts to remove the tertiary 3'-nitro group in **19** by an identical free-radical promoted denitration protocol (*vide supra*) gave an intractable mixture of compounds, which could not be identified. Subsequently, the 5'-O-MMTr group from **27**, **28** and **31** was removed by a brief treatment of 80% aqueous acetic acid at RT to give **29** (84 %), **30** (93 %) and **33** (87 %), respectively.

Assignment of threo and erythro configuration. The assignment of *threo* and *erythro* configuration in **27** - **44** was based on the following ^{1}H-NMR observations: (1) H-2' was more shielded by 0.32 - 0.39 ppm in **27** and **31** in comparison with their corresponding epimers **41** and **42**. (2) H-2' and H-2" were more separated in **27** and **31** (0.54 - 0.68 ppm), whereas in the isomeric **41** and **42** the separation of these resonances was much smaller (~0.13 ppm). (3) The $J_{1'2'}$ was larger than $J_{1'2"}$ by 0.6 - 4.2 Hz in **27** - **40**, whereas $J_{1'2'}$ was smaller than $J_{1'2"}$ by 1.4 - 4.0 Hz in **41** - **44**. This means that the configuration at C3' was opposite in compounds **27** - **40** and **41** - **44**. The final assignment of configuration in these two groups of epimers has been based on 1D difference NOE experiments on a representative pair of C3'-epimers: **27** and **41**. The *threo* configuration in **27** was established by the following 1D difference NOE experiments: saturation of H1' showed NOE enhancements at H6 (1%), H4' (2%), H3' (3%) and H2" (6%), while saturation of H4' showed NOE enhancements at H1' (1%), *3'-CH_a*-OH & H5' (1%), H5" (2%), H3' (6%), *3'-CH_b*-OH & H2" (1%). The *erythro* configuration in **41** was confirmed by the following 1D difference NOE experiments: Saturation of H4' showed NOE enhancements at H1' (0.5%), *3'-CH_2*-OH (1.5%), H5' (1%) , H5" (1.5%) , H3' (1%) and H2" (0.5%). Saturation of H1' shows NOE enhancement at H6 (0.4%), H4' (0.3%), *3'-CH_2*-OH (0.3%) and H2" (2%). The key NOE contacts in **41** are between *3'-CH_2*-OH and H1' and H4' suggesting that *3'-CH_2*-OH is on the α-face of the pentofuranose ring. These NOE experiments suggest *threo* configuration in all compounds **27** - **40** and *erythro* configuration in **41** - **44**.

Finally, the application of our present strategy as the unique route for the preparation of 3'-C-branched-*threo*-nucleosides is evident from the synthesis of hithertofore unknown 2',3'-dideoxy-3'-C-*threo*-hydroxymethyl cytidine **36** [**31** → **32** (82%) → **34** (48 %) → **35** (40 %)→ **36** (56 %)] which is an epimer of 2',3'-

dideoxy-3'-C-*erythro*-hydroxymethyl cytidine[2f] that has shown some impressive biological activity against HIV-reverse transcriptase.[2k]

EXPERIMENTALS

^{1}H-NMR spectra were recorded (in δ scale) with Jeol GX-270 at 270 MHz, using TMS as internal reference (0.0 ppm). ^{13}C-NMR were recorded at 67.8 MHz using both ^{1}H-coupled and ^{1}H-decoupled or INEPT modes. The 1D difference ^{1}H-NMR NOE experiments were performed with Bruker AMX-500 spectrometer at 500 MHz. UV absorption spectra were recorded with Varian-Cary 2200 instrument. Jeol DX 303 instrument was used for recording mass spectra. TLC was carried out using Merck pre-coated silica gel F_{254} plates. The column chromatography were carried out using Merck G60 silica gel.

1-[5'-O-(MMTr)-2', 3'-dideoxy-3'-(R)-hydroxymethyl-3'-nitro-β-D-pentofuranosyl]thymine (3) & its epimer (14). *General procedure for base catalyzed addition* : To a cooled solution (0 °C) of **1** (544 mg, 1 mmol) and paraformaldehyde (250 mg) in THF (30 ml) was added tetrabutyl ammonium fluoride (52 mg, 0.2 mmol), and kept it standing at RT for 30 min. The reaction mixture was poured in saturated aqueous solution of NH_4Cl (100 ml) and was extracted with CH_2Cl_2 (3 x 75 ml). The organic phase was washed with water (2 x 50 ml), dried over $MgSO_4$. All volatile were removed and the residue was purified on a silica gel column to give **3** (195 mg, 34 %) and **14** (316 mg, 55 %). Compound **3**: ^{1}H-NMR ($CDCl_3$): 8.36 (br, 1H) NH; 7.61 (q, 1H) H-6; 7.47-7.24 (m, 12H) arom; 6.86-6.82 (d, 2H) arom; 6.37 (dd, $J_{1'2'}$ = 8.9 Hz, $J_{1'2''}$ = 6.0 Hz, 1H) H-1'; 4.67 (dd, $J_{4'5'}$ = 5.0 Hz, $J_{4'5''}$ = 2.4 Hz, 1H) H-4'; 4.04 (s, 2H) CH_2OH; 3.81 (s, 3H) OMe; 3.73 (dd, $J_{5'5''}$ = 11.1 Hz, 1H) H-5'; 3.41 (dd, 1H) H-5"; 3.21 (dd, $J_{2'2''}$ = 14.7 Hz, 1H) H-2"; 2.52 (dd, 1H) H-2'; 1.56 (d, $J_{6,CH3}$ = 1.1 Hz, 3H) 5-CH_3; ^{13}C-NMR ($CDCl_3$): 135.4 (d, J_{CH} = 176.0 Hz) C-6; 111.7 (s) C-5; 98.1 (s) C-3'; 87.9 (s) MMTr; 83.6 (d, J_{CH} = 169.5 Hz) C-1'; 81.8 (d, J_{CH} = 150.3 Hz) C-4'; 63.3 (t, J_{CH} = 148.0 Hz) CH_2OH; 61.5 (t, J_{CH} = 144.3 Hz) C-5'; 55.1 (q, J_{CH} = 143.9 Hz) OMe; 38.4 (t, J_{CH} = 136.6 Hz) C-2'; 11.7 (q, J_{CH} = 129.5 Hz) 5-CH_3. Compound **14**: ^{1}H-NMR ($CDCl_3$): 9.00 (br, 1H) NH; 7.86 (q, $J_{6,CH3}$ = 1.1 Hz, 1H) H-6; 7.49-7.26 (m, 12H) arom; 6.86-6.83 (d, 2H) arom; 6.29 (dd, 1H) H-1'; 4.26 (d, $J_{3"a3"b}$ = 12.4 Hz, 1H) H-3"a; 3.96 (t, $J_{4'5'}$ = 4.5 Hz, 1H) H-4'; 3.91 (d, 1H) H-3"b; 3.80 (s, 3H) OMe; 3.47 (m, 2H) H-5', H-5"; 2.98 (dd, $J_{1'2''}$ = 6.8 Hz, $J_{2'2''}$ = 14.7 Hz, 1H) H-2"; 2.90 (dd, $J_{1'2'}$ = 7.6 Hz, 1H) H-2'; 1.65 (d, 3H) 5-CH_3; ^{13}C-NMR ($CDCl_3$): 135.6 (d, J_{CH} = 182.4 Hz) C-6; 111.7 (s) C-5; 95.7 (s) C-3'; 87.6 (s) MMTr; 82.3 (d, J_{CH} = 170.5 Hz) C-1'; 80.1 (d, J_{CH} = 150.3 Hz) C-4'; 64.6 (t, J_{CH} = 147.6 Hz) CH_2OH; 61.9 (t, J_{CH} = 144.3 Hz) C-5'; 55.0 (q, J_{CH} = 143.9 Hz) OMe; 37.8 (t, J_{CH} = 137.5 Hz) C-2'; 11.6 (q, J_{CH} = 129.5 Hz) 5-CH_3.

1-[5'-O-(MMTr)-2',3'-dideoxy-3'-(R)-acetoxymethyl-3'-nitro-β-D-pentofuranosyl]thymine (4). **3** (114 mg, 0.2 mmol) was treated with acetic anhydride (0.2 ml) in dry pyridine (2 ml) at room temperature for 8 h. The solvent was removed in vacuo and residue was dissolved in CH_2Cl_2 (3 x 20 ml). The organic layer was washed with water (2 x 15 ml), dried over $MgSO_4$. The organic phase was evaporated and the residue was purified on a silica gel column to give **4** (104 mg, 85 %). ^{1}H-NMR ($CDCl_3$): 8.56 (br, 1H) NH; 7.75 (q, 1H) H-6; 7.39-7.25 (m, 12H) arom; 6.88-6.85 (d, 2H) arom; 6.42 (dd, $J_{1'2'}$ = 9.4 Hz, $J_{1'2''}$ = 5.3 Hz, 1H) H-1'; 4.87 (d, $J_{3"a3"b}$ = 12.2 Hz, 1H) H-3"a; 4.72 (dd, $J_{4'5'}$ = 3.5 Hz, 1H) H-4'; 4.37 (d, 1H) H-3"b; 3.81 (s, 3H) OMe; 3.81 (dd, 1H) H-5'; 3.31 (dd, $J_{4'5''}$ = 2.0 Hz, $J_{5'5''}$ = 11.4 Hz, 1H) H-5"; 3.27 (dd, $J_{2'2''}$ = 14.3 Hz, 1H) H-2"; 2.46 (dd, 1H) H-2'; 1.93 (s, 3H) OAc; 1.32 (d, 3H) 5-CH_3; ^{13}C-NMR ($CDCl_3$): 134.7 (d, J_{CH} = 181.5 Hz) C-6; 112.0 (s) C-5; 96.4 (s) C-3'; 88.2 (s) MMTr; 83.5 (d, J_{CH} = 171.4 Hz) C-1'; 82.0 (d, J_{CH} = 152.1Hz) C-4'; 64.0 (t, J_{CH} = 153.0 Hz) CH_2OAc; 61.7 (t, J_{CH} = 144.3 Hz) C-5'; 55.2 (q, J_{CH} = 143.9 Hz) OMe; 39.0 (t, J_{CH} = 137.0 Hz) C-2'; 20.2 (q, J_{CH} = 129.8 Hz) OAc; 11.4 (q, J_{CH} = 128.6 Hz) 5-CH_3.

1-[5'-O-(MMTr)-2',3'-dideoxy-3'-(S)-acetoxymethyl-3'-nitro-β-D-pentofuranosyl]thymine (15). **14** (114 mg, 0.2 mmol) gave **15** (108 mg, 89 %) using a condition described for **4**. ^{1}H-NMR ($CDCl_3$): 8.64 (br, 1H) NH; 7.61 (q, $J_{6,CH3}$ = 1.2 Hz, 1H) H-6; 7.41-7.26 (m, 12H) arom; 6.86-6.83 (d, 2H) arom; 6.24 (dd, 1H) H-1'; 4.77 (d, $J_{3"a3"b}$ = 12.1 Hz, 1H) H-3"a; ; 4.34 (d, 1H) H-3"b; 3.93 (dd, 1H) H-4'; 3.81 (s, 3H) OMe; 3.50 (dd, $J_{4'5'}$ = 4.8 Hz, $J_{5'5''}$ =11.1 Hz, 1H) H-5'; 3.39 (dd, $J_{4'5''}$ = 5.0 Hz, 1H) H-5"; 3.00 (dd, $J_{1'2''}$ = 7.0 Hz, $J_{2'2''}$ = 15.3 Hz, 1H) H-2"; 2.83 (dd, $J_{1'2'}$ = 7.1 Hz, 1H) H-2'; 2.05 (s, 3H) OAc; 1.78 (d, 3H) 5-CH_3; ^{13}C-NMR ($CDCl_3$): 135.0 (d, J_{CH} = 181.0 Hz) C-6; 111.6 (s) C-5; 93.7 (s) C-3'; 87.9 (s) MMTr; 82.4 (d, J_{CH} = 170.2 Hz) C-1'; 80.9 (d, J_{CH} = 148.7 Hz) C4'; 64.4 (t, J_{CH} = 151.6 Hz) CH_2OAc; 61.7 (t, J_{CH} = 145.3 Hz) C-5'; 55.1 (q, J_{CH} = 144.1 Hz) OMe; 39.5 (t, J_{CH} = 137.4 Hz) C-2'; 20.4 (q, J_{CH} = 130.1 Hz) OAc; 12.2 (q, J_{CH} = 130.0 Hz) 5-CH_3.

1-[2',3'-Dideoxy-3'-(R)-hydroxymethyl-3'-nitro-β-D-pentofuranosyl]thymine (5). *General procedure for*

removal of 4-monometoxytrityl group: **3** (114 mg, 0.2 mmol) was treated with 80 % aqueous acetic acid (5 ml) overnight at RT. The solvent was removed in vacuo and coevaporated with toluene and ethanol. The residue was purified on a silica gel column to give **5** (56 mg, 93 %). ^{1}H-NMR ($CDCl_3$ + CD_3OD): 7.75 (q, 1H) H-6; 6.11 (dd, $J_{1'2'}$ = 8.9 Hz, $J_{1'2''}$ = 5.7 Hz, 1H) H-1'; 4.57 (dd, 1H) H-4'; 4.21 (d, $J_{3''a3''b}$ = 12.0 Hz, 1H) H-3"a; 4.15 (d, 1H) H-3"b; 3.92 (dd, $J_{4'5'}$ = 3.4 Hz, $J_{5'5''}$ = 12.7 Hz, 1H) H-5'; 3.84 (dd, $J_{4'5''}$ = 2.1 Hz, 1H) H-5"; 3.12 (dd, $J_{2'2''}$ = 14.5 Hz, 1H) H-2"; 2.42 (dd, 1H) H-2'; 1.83 (d, $J_{6,CH3}$ = 1.0 Hz, 3H) 5-CH_3; ^{13}C-NMR ($CDCl_3$ + CD_3OD): 136.2 (d, J_{CH} = 181.5 Hz) C-6; 111.0 (s) C-5; 99.0 (s) C-3'; 84.4 (d, J_{CH} = 172.3 Hz) C-1'; 83.1 (d, J_{CH} = 150.3 Hz) C-4'; 62.8 (t, J_{CH} = 147.5 Hz) CH_2OH; 60.3 (t, J_{CH} = 143.4 Hz) C-5'; 37.8 (t, J_{CH} = 137.0 Hz) C-2'; 12.0 (q, J_{CH} = 128.9 Hz) 5-CH_3. UV (EtOH): λ_{max} 267 nm (ε = 10250) (pH 7); 264 nm (ε = 10500) (pH 2). MS (FAB^-): cal. for $(M-H)^-$ 300.0832, found 300.0820.

1-[2',3'-Dideoxy-3'-(S)-hydroxymethyl-3'-nitro-β-D-pentofuranosyl]thymine (16). 14 (114 mg, 0.2 mmol) gave **16** (55 mg, 92 %) using a condition described for **5**. ^{1}H-NMR ($CDCl_3$ + CD_3OD): 7.80 (q, 1H) H-6; 6.21 (t, $J_{1'2'}$ = 7.1 Hz, 1H) H-1'; 4.19 (d, $J_{3''a3''b}$ = 12.0 Hz, 1H) H-3"a; 4.10 (t, $J_{4'5'}$ = 4.4 Hz, 1H) H-4'; 3.97 (d, 1H) H-3"b; 3.80 (m, 2H) H-5', H-5"; 2.94 (d, 2H) H-2', H-2"; 1.95 (d, 3H) 5-CH_3; ^{13}C-NMR ($CDCl_3$ + CD_3OD): 135.7 (d, J_{CH} = 185.2 Hz) C-6; 111.3 (s) C-5; 95.9 (s) C-3'; 82.4 (d, J_{CH} = 169.5 Hz) C-1'; 81.4 (d, J_{CH} = 147.5 Hz) C-4'; 63.6 (t, J_{CH} = 147.6 Hz) CH_2OH; 60.5 (t, J_{CH} = 143.0 Hz) C-5'; 38.1 (t, J_{CH} = 137.0 Hz) C-2'; 12.2 (q, J_{CH} = 128.9 Hz) 5-CH_3. UV (EtOH): λ_{max} 266 nm (ε = 11310) (pH 7); 266 nm (ε = 11570) (pH 2). MS (FAB^+): cal. for $(M + H)^+$ 301.0910, found 301.0920.

1-[5'-O-(MMTr)-2',3'-dideoxy-3'-(R)-(β-cyanoethyl)-3'-nitro-β-D-pentofuranosyl]thymine (17). 1 (272 mg, 0.5 mmol) gave **17** (245 mg, 83 %) using a condition [acrylonitrile (130 µl, 2.0 mmol)] described for **3** & **14.** ^{1}H-NMR ($CDCl_3$): 7.56 (q, 1H) H-6; 7.40-7.21 (m, 12H) arom; 6.87-6.81 (d, 2H) arom; 6.22 (dd, 1H) H-1'; 3.86 (dd, 1H) H-4'; 3.81 (s, 3H) OMe; 3.49 (dd, $J_{4'5'}$ = 5.0 Hz, $J_{5'5''}$ = 11.2 Hz, 1H) H-5'; 3.36 (dd, $J_{4'5''}$ = 4.9 Hz, 1H) H-5"; 2.98 (dd, $J_{1'2''}$ = 6.2 Hz, $J_{2'2''}$ = 15.3 Hz, 1H) H-2"; 2.78 (dd, $J_{1'2'}$ = 7.3 Hz, 1H) H-2'; 2.9-2.7 (m, 1H) H-3"a; 2.5-2.3 (m, 2H) $\underline{CH_2}CN$; 2.1-1.9 (m, 1H) H-3"b; 1.83 (d, 3H) 5-CH_3; ^{13}C-NMR ($CDCl_3$): 134.9 (d, J_{CH} = 186.9 Hz) C-6; 111.4 (s) C-5; 94.7 (s) C-3'; 87.8 (s) MMTr; 84.2 (d, J_{CH} = 151.2 Hz) C-4'; 82.5 (d, J_{CH} = 171.4 Hz) C-1'; 61.5 (t, J_{CH} = 144.8 Hz) C-5'; 55.2 (q, J_{CH} = 143.9 Hz) OMe; 40.5 (t, J_{CH} = 136.6 Hz) C-2'; 31.7 (t, J_{CH} = 132.4 Hz) 3'-CH_2; 13.1 (t, J_{CH} = 135.6 Hz) $\underline{C}H_2CN$; 12.4 (q, J_{CH} = 128.3 Hz) 5-CH_3.

1-[2',3'-Dideoxy-3'-(R)-(β-cyanoethyl)-3'-nitro-β-D-pentofuranosyl]thymine (18). 17 (120 mg, 0.2 mmol) gave **18** (56 mg, 85 %) using a condition described for **5**. ^{1}H-NMR ($CDCl_3$ + CD_3OD): 7.72 (d, $J_{6,CH3}$ = 1.2 Hz, 1H) H-6; 6.22 (dd, $J_{1'2'}$ = 7.3 Hz, $J_{1'2''}$ = 6.3 Hz, 1H) H-1'; 4.16 (dd, 1H) H-4'; 3.79 (dd, $J_{4'5'}$ = 5.5 Hz, $J_{5'5'}$ = 11.8 Hz, 1H) H-5'; 3.73 (dd, $J_{4'5''}$ = 5.5 Hz, 1H) H-5"; 3.01 (dd, $J_{2'2''}$ = 15.1 Hz, 1H) H-2"; 2.93 (m, 1H) H-3"a; 2.85 (dd, 1H) H-2'; 2.55 (t, $J_{CH2,CH2}$ = 7.5 Hz, 2H) $\underline{CH_2}CN$; 2.29 (m, 1H)H-3"b; 1.94 (d, 3H) 5-CH_3; ^{13}C-NMR ($CDCl_3$ + CD3OD): 135.4 (d) C-6; 111.6 (s) C-5; 95.0 (s) C-3'; 85.5 (d, J_{CH} = 146.6 Hz) C-4'; 82.4 (d, J_{CH} = 164.1 Hz) C-1'; 59.6 (t, J_{CH} = 143.0 Hz) C-5'; 40.0 (t, J_{CH} = 137.0 Hz) C-2'; 31.3 (t, J_{CH} = 133.8 Hz) 3'-CH_2; 12.6 (t, J_{CH} = 135.6 Hz) $\underline{C}H_2CN$; 12.0 (q, J_{CH} = 128.9 Hz) 5-CH_3. UV (EtOH): λ_{max} 266 nm (ε = 9050) (pH 7); 266 nm (ε = 9050) (pH 2). MS (FAB^-): cal. for $(M-H)^-$ 324.1070 found 324.1085.

1-[5'-O-(MMTr)-2',3'-dideoxy-3'-(R)-(ethoxycarbonylethylidene)-3'-nitro-β-D-pentofuranosyl]thymine (6) & its epimer (19). 1 (554 mg, 1 mmol) gave **6** (117 mg, 18 %) and **19** (441 mg, 69 %) using a condition [ethyl propiolate(200 µl, 2 mmol)] described for **3** & **14.** Compound **6** : ^{1}H-NMR ($CDCl_3$): 8.47 (br, 1H) NH; 7.66 (q, $J_{6,CH3}$ = 1.1 Hz, 1H) H-6; 7.37-7.21 (m, 12H) arom; 7.07 (d, $J_{CH,CH}$ = 15.9 Hz, 1H) $CHCO_2$; 6.85-6.82 (d, 2H) arom; 6.34 (dd, $J_{1'2'}$ = 9.5 Hz, $J_{1'2''}$ = 4.9 Hz,1H) H-1'; 5.97 (d, 1H) 3'-CH; 4.97 (dd, 1H) H-4'; 4.15 (q, $J_{CH2,CH3}$ = 7.0 Hz, 2H) CO_2CH_2; 3.80 (s, 3H) OMe; 3.67 (dd, $J_{4'5'}$ = 4.1 Hz, $J_{5'5''}$ = 11.3 Hz, 1H) H-5'; 3.37 (dd, $J_{2'2''}$ = 14.2 Hz, 1H) H-2"; 3.27 (dd, $J_{4'5''}$ = 2.3 Hz, 1H) H-5"; 2.68 (dd, 1H) H-2'; 1.31 (d, 3H) 5-CH_3; 1.22 (t, 3H) $CO_2CH_2\underline{CH_3}$; ^{13}C-NMR ($CDCl_3$): 137.7 (d, J_{CH} = 168.6 Hz) $\underline{C}HCO_2$; 134.6 (d, J_{CH} = 182.2 Hz) C-6; 125.5 (d, J_{CH} = 164.2 Hz) 3'-CH; 112.0 (s) C-5; 97.9 (s) C-3'; 88.1 (s) MMTr; 83.6 (d, J_{CH} = 153.0 Hz) C-4'; 83.2 (d, J_{CH} = 170.0 Hz) C-1'; 62.7 (t, J_{CH} = 144.3 Hz) C5'; 61.1 (t, J_{CH} = 143.0 Hz) CO_2CH_2; 55.1 (q, J_{CH} = 143.8 Hz) OMe; 39.2 (t, J_{CH} = 137.0 Hz) C-2'; 13.9 (q, J_{CH} = 127.4 Hz) $CO_2CH_2\underline{C}H_3$; 11.4 (q, J_{CH} = 128.9 Hz) 5-CH_3. Compound **19**: ^{1}H-NMR ($CDCl_3$): 8.06 (br, 1H) NH; 7.56 (q, $J_{6,CH3}$ = 1.1 Hz, 1H) H-6; 7.38-7.26 (m, 13H) arom, $CHCO_2$; 6.86-6.82 (d, 2H) arom; 6.23 (dd, 1H) H-1'; 6.06 (d, $J_{CH,CH}$ = 16.0 Hz, 1H) 3'-CH; 4.25 (q, $J_{CH2,CH3}$ = 7.0 Hz, 2H) CO_2CH_2; 4.05 (dd, 1H) H-4' ; 3.80 (s, 3H) OMe; 3.55 (dd, $J_{4'5'}$ = 5.0 Hz, $J_{5'5''}$ = 11.1 Hz, 1H) H-5'; 3.45 (dd, $J_{4'5''}$ = 5.1 Hz, 1H) H-5"; 3.10 (dd, $J_{1'2''}$ = 6.4 Hz, $J_{2'2''}$ = 15.3 Hz, 1H) H-2"; 2.89 (dd, $J_{1'2'}$ = 7.3 Hz, 1H) H-2'; 1.81 (d, 3H) 5-CH_3; 1.30 (t, 3H) $CO_2CH_2\underline{CH_3}$; ^{13}C-NMR (CDCl3): 139.5 (d, J_{CH}

= 167.7 Hz) $\underline{C}HCO_2$; 134.9 (d, J_{CH} = 182.4 Hz) C-6; 125.5 (d, J_{CH} = 164.3 Hz) 3'-CH; 111.5 (s) C-5; 94.6 (s) C-3'; 87.7 (s) MMTr; 84.8 (d, J_{CH} = 152.1 Hz) C-4'; 82.6 (d, J_{CH} = 172.3 Hz) C-1'; 61.5 (t, J_{CH} = 145.0 Hz) C5'; 61.2 (t, J_{CH} = 156.3 Hz) $CO_2\underline{C}H_2$; 55.1 (q, J_{CH} = 143.9 Hz) OMe; 41.9 (t, J_{CH} = 137.5 Hz) C-2'; 14.0 (q, J_{CH} = 127.4 Hz) $CO_2CH_2\underline{C}H_3$; 12.3 (q, J_{CH} = 129.2 Hz) 5-CH_3.

1-[2',3'-Dideoxy-3'-(R)-(ethoxycarbonylethylidene)-3'-nitro-β-D-pentofuranosyl]thymine (7). **6** (64 mg, 0.1 mmol) gave **7** (31 mg, 84 %) using a condition described for **5**. ^{1}H-NMR ($CDCl_3$ + CD_3OD): 7.75 (q, $J_{6,CH3}$ = 1.2 Hz, 1H) H-6; 7.21 (d, $J_{CH,CH}$ = 16.0 Hz, 1H) $\underline{C}HCO_2$; 6.11 (dd, $J_{1'2'}$ = 9.5 Hz, $J_{1'2''}$ = 5.3 Hz, 1H) H-1'; 6.04 (d, 1H) 3'-CH; 4.96 (dd, 1H) H-4'; 4.24 (q, $J_{CH2,CH3}$ = 7.0 Hz, 2H) $CO_2\underline{C}H_2$; 4.00 (dd, $J_{4'5'}$ = 2.3 Hz, $J_{5'5''}$ = 12.5 Hz, 1H) H-5'; 3.84 (dd, $J_{4'5''}$ = 1.9 Hz, 1H) H-5''; 3.36 (dd, $J_{2'2''}$ = 14.2 Hz, 1H) H-2''; 2.85 (dd, 1H) H-2'; 1.93 (d, 3H) 5-CH_3; 1.31 (t, 3H) $CO_2CH_2\underline{C}H_3$; ^{13}C-NMR ($CDCl_3$ + CD_3OD): 137.9 (d, J_{CH} = 167.7 Hz) $\underline{C}HCO_2$; 136.4 (d, J_{CH} = 182.4 Hz) C-6; 125.5 (d, J_{CH} = 165.0 Hz) 3'-CH; 111.4 (s) C-5; 98.6 (s) C-3'; 85.5 (d, J_{CH} = 172.3 Hz) C-1'; 85.0 (d, J_{CH} = 152.1 Hz) C-4'; 61.4 (t, J_{CH} = 145.7 Hz) C5'; 61.4 (t) $CO_2\underline{C}H_2$; 38.8 (t, J_{CH} = 137.9 Hz) C-2'; 14.0 (q, J_{CH} = 127.4 Hz) $CO_2CH_2\underline{C}H_3$; 12.4 (q, J_{CH} = 129.5 Hz) 5-CH_3. UV (EtOH): λ_{max} 266 nm (ε = 10280) (pH 7); 266 nm (ε = 10280) (pH 2); 261 nm (ε = 13510) (pH 12). MS (FAB^-): cal. for $(M-H)^-$ 368.1094, found 368.1076.

1-[2',3'-Dideoxy-3'-(S)-(ethoxycarbonylethylidene)-3'-nitro-β-D-pentofuranosyl]thymine (20). **19** (128 mg, 0.2 mmol) gave **20** (65 mg, 88 %) using a condition described for **5**. ^{1}H-NMR ($CDCl_3$ + CD_3OD): 7.71 (q, $J_{6,CH3}$ = 1.2 Hz, 1H) H-6; 7.36(d, $J_{CH,CH}$ = 16.2 Hz, 1H) $CHCO_2$; 6.29 (dd, 1H) H-1'; 6.23 (d, 1H) 3'-CH; 4.29 (dd, 1H) H-4'; 4.26 (q, $J_{CH2,CH3}$ = 7.0 Hz, 2H) CO_2CH_2; 3.90 (dd, $J_{4'5'}$ = 3.8 Hz, $J_{5'5''}$ = 12.3 Hz, 1H) H-5'; '3.84 (dd, $J_{4'5''}$ = 5.1 Hz, 1H) H-5''; 3.18 (dd, $J_{1'2''}$ = 6.9 Hz, $J_{2'2''}$ = 15.3 Hz, 1H) H-2''; 2.94 (dd, $J_{1'2'}$ = 7.3 Hz, 1H) H-2'; 1.95 (d, 3H) 5-CH_3; 1.33 (t, 3H) $CO_2CH_2\underline{C}H_3$; ^{13}C-NMR ($CDCl_3$ + CD_3OD): 139.6 (d, J_{CH} = 167.7 Hz) $\underline{C}HCO_2$; 135.3 (d, J_{CH} = 186.0 Hz) C-6; 124.5 (d, J_{CH} = 163.1 Hz) 3'-CH; 111.3 (s) C-5; 94.3 (s) C-3'; 85.1 (d, J_{CH} = 152.1 Hz) C-4'; 82.5 (d, J_{CH} = 173.2 Hz) C-1'; 61.3 (t, J_{CH} = 148.5 Hz) $CO_2\underline{C}H_2$; 60.4 (t, J_{CH} = 143.9 Hz) C-5'; 41.3 (t, J_{CH} = 137.9 Hz) C-2'; 13.9 (q, J_{CH} = 127.1 Hz) $CO_2CH_2\underline{C}H_3$; 12.3 (q, J_{CH} = 129.2 Hz) 5-CH_3. UV (EtOH): λ_{max} 266 nm (ε = 10040) (pH 7); 265 nm (ε = 10200) (pH 2). MS (FAB^-): cal. for $(M-H)^-$ 368.1094, found 368.1097.

1-[5'-O-(MMTr)-2',3'-dideoxy-3'-(S)-(3-oxobutyl)-3'-nitro-β-D-pentofuranosyl]-N-3-(3-oxobutyl)-thymine (8) & its epimer (21), 1-[5'-O-(MMTr)-2',3'-dideoxy-3'-(S)-(3-oxobutyl)-3'-nitro-β-D-pentofuranosyl] thymine (9) & its epimer (22). **1** (554 mg, 1 mmol) gave **8** (26 mg, 4 %), **21** (59 mg, 9 %), **9** (52 mg, 9 %) and **22** (383 mg, 62 %) using a condition [methyl vinyl ketone (170 µl, 2 mmol)] described for **3** & **14.** Compound **8**: ^{1}H-NMR ($CDCl_3$): 7.26 (q, $J_{6,CH3}$ = 1.0 Hz, 1H) H-6; 7.43-7.26 (m, 12H) arom; 6.88-6.84 (d, 2H) arom; 6.30 (dd, $J_{1'2'}$ = 9.3 Hz, $J_{1'2''}$ = 5.2 Hz, 1H) H-1'; 4.68 (dd, 1H) H-4'; 4.20 (m, 2H) NCH_2; 3.80 (s, 3H) OMe; 3.76 (dd, $J_{4'5'}$ = 3.7 Hz, $J_{5'5''}$ = 11.2 Hz, 1H) H-5'; 3.31 (dd, $J_{4'5''}$ = 2.8 Hz, 1H) H-5''; 3.25 (dd, $J_{2'2''}$ = 14.5 Hz, 1H) H-2''; 2.77 (m, 2H) $NCH_2\ \underline{C}H_2$; 2.45- 2.10 (m, 5H) H-2', 3'-CH2, $\underline{C}H_2COCH_3$; 2.18 (s, 3H) $COCH_3$; 2.08 (s, 3H) $COCH_3$; 1.30 (d, 3H) 5-CH_3; ^{13}C-NMR ($CDCl_3$): 133.7 (d, J_{CH} = 176.0 Hz) C-6; 110.9 (s) C-5; 98.8 (s) C-3'; 87.8 (s) MMTr; 84.0 (d, J_{CH} = 172.3 Hz) C-1'; 83.6 (d, J_{CH} = 152.1 Hz) C-4'; 62.1 (t, J_{CH} = 143.4 Hz) C-5'; 55.2 (q, J_{CH} = 143.9 Hz) OMe; 41.1 (t, J_{CH} = 127.8 Hz) $NCH_2\underline{C}H_2$; 39.7 (t, J_{CH} = 135.6 Hz) C-2'; 38.3 (t, J_{CH} = 126.5 Hz) $CH_2\underline{C}H_2CO$; 36.6 (t, J_{CH} = 144.8 Hz) NCH_2; 29.8 (q, J_{CH} = 127.4 Hz) $COCH_3$; 29.8 (q, J_{CH} = 127.4 Hz) $COCH_3$; 26.8 (t, J_{CH} = 132.4 Hz) 3'-CH_2; 12.0 (q, J_{CH} = 129.2 Hz) 5-CH_3. Compound **21**: ^{1}H-NMR ($CDCl_3$): 7.54 (q, $J_{6,CH3}$ = 1.2 Hz, 1H) H-6; 7.43-7.27 (m, 12H) arom; 6.86-6.83 (d, 2H) arom; 6.18 (dd, $J_{1'2'}$ = 7.2 Hz, $J_{1'2''}$ = 6.0 Hz, 1H) H-1'; 4.22 (m, 2H) NCH_2; 4.01 (t, $J_{4'5'}$ = 4.5 Hz, 1H) H-4'; 3.80 (s, 3H) OMe; 3.40 (d, 2H) H-5', H-5''; 2.95 (dd, $J_{2'2''}$ = 15.2 Hz, 1H) H-2''; 2.79 (m, 2H) $NCH_2\underline{C}H_2$; 2.60 (dd, 1H) H-2'; 2.53-2.36 (m, 3H) H-3''a, $CH_2\underline{C}H_2COCH_3$; 2.18 (s, 3H) $COCH_3$; 2.12 (s, 3H) $COCH_3$; 2.07-1.94 (m, 1H) H-3''b; 1.30 (d, 3H) 5-CH_3; ^{13}C-NMR ($CDCl_3$): 134.4 (d, J_{CH} = 188.8 Hz) C-6; 110.1 (s) C-5; 95.3 (s) C-3'; 87.6 (s) MMTr; 84.8 (d, J_{CH} = 148.5 Hz) C-4'; 83.5 (d, J_{CH} = 173.2 Hz) C-1'; 61.7 (t, J_{CH} = 143.9 Hz) C5'; 55.1 (q, J_{CH} = 143.9 Hz) OMe; 41.1 (t, J_{CH} = 128.3 Hz) $NCH_2\underline{C}H_2$; 41.0 (t, J_{CH} = 136.5 Hz) C-2'; 38.2 (t, J_{CH} = 126.2 Hz) $CH_2\underline{C}H_2CO$; 36.5 (t, J_{CH} = 144.3 Hz) NCH_2; 29.8 (q, J_{CH} = 127.4 Hz) $COCH_3$; 29.8 (q, J_{CH} = 127.4 Hz) $COCH_3$; 29.8 (t, J_{CH} = 131.5 Hz) 3'-CH_2; 12.0 (q, J_{CH} = 129.2 Hz) 5-CH_3. Compound **9**: ^{1}H-NMR ($CDCl_3$): 8.06 (br, 1H) NH; 7.85 (q, 1H) H-6; 7.43-7.26 (m, 12H) arom; 6.89-6.85 (d, 2H) arom; 6.29 (dd, $J_{1'2'}$ = 9.3 Hz, $J_{1'2''}$ = 5.1 Hz, 1H) H-1'; 4.69 (dd, 1H) H-4'; 3.80 (s, 3H) OMe; 3.74 (dd, $J_{4'5'}$ = 3.7 Hz, $J_{5'5''}$ = 11.4 Hz, 1H) H-5'; 3.30 (dd, $J_{4'5''}$ = 2.6 Hz, 1H) H-5''; 3.24 (dd, $J_{2'2''}$ = 14.5 Hz, 1H) H-2''; 2.45- 2.25 (m, 5H) H-2', 3'-CH_2, $\underline{C}H_2COCH_3$; 2.08 (s, 3H) $COCH_3$; 1.26 (d, $J_{6,CH3}$ = 1.2 Hz, 3H) 5-CH_3; ^{13}C-NMR ($CDCl_3$): 135.1 (d, J_{CH} = 183.3 Hz) C-6; 111.7 (s) C-5; 98.8 (s) C-3'; 88.1 (s) MMTr; 83.5 (d, J_{CH} =

151.2 Hz) C-4'; 83.2 (d, J_{CH} = 176.0 Hz) C-1'; 62.2 (t, J_{CH} = 143.4 Hz) C5'; 55.2 (q, J_{CH} = 143.9 Hz) OMe; 39.6 (t, J_{CH} = 137.0 Hz) C-2'; 38.3 (t, J_{CH} = 126.5 Hz) $CH_2\underline{C}H_2CO$; 29.3 (q, J_{CH} = 127.4 Hz) $COCH_3$; 26.7 (t, J_{CH} = 132.0Hz) 3'-CH_2; 12.3 (q, J_{CH} = 129.2 Hz) 5-CH_3. Compound **22**: ^{1}H-NMR ($CDCl_3$): 8.60 (br, 1H) NH; 7.58 (q, $J_{6,CH3}$ = 1.2 Hz, 1H) H-6; 7.46-7.25 (m, 12H) arom; 6.86-6.83 (d, 2H) arom; 6.19 (dd, $J_{1'2'}$ = 7.3 Hz, $J_{1'2''}$ = 6.1 Hz,1H) H-1'; 4.00 (t , $J_{4'5'}$ = 4.5 Hz, 1H) H-4'; 3.81 (s, 3H) OMe; 3.42 (d, 2H) H-5', H-5"; 2.97 (dd, $J_{2'2''}$ = 15.0 Hz, 1H) H-2"; 2.60 (dd, 1H) H-2'; 2.55- 2.30 (m, 3H) H-3"a, $\underline{CH}_2COCH_3$; 2.13 (s, 3H) $COCH_3$; 2.05 (m, 1H) H-3"b; 1.77 (d, 3H) 5-CH_3; ^{13}C-NMR ($CDCl_3$): 135.1 (d, J_{CH} = 179.6 Hz) C-6; 111.0 (s) C-5; 95.3 (s) C-3'; 87.6 (s) MMTr; 84.8 (d, J_{CH} = 150.3 Hz) C-4'; 82.8 (d, J_{CH} = 170.5 Hz) C-1'; 61.7 (t, J_{CH} = 144.3 Hz) C5'; 55.1 (q, J_{CH} = 144.2 Hz) OMe; 40.7 (t, J_{CH} = 134.7 Hz) C-2'; 38.2 (t, J_{CH} = 127.4 Hz) $\underline{C}H_2CO$; 29.9 (q, J_{CH} = 127.4 Hz) $COCH_3$; 29.9 (t, J_{CH} = 129.2 Hz) 3'-CH_2; 12.2 (q, J_{CH} = 129.5 Hz) 5-CH_3.

1-[2',3'-Dideoxy-3'-(S)-(3-oxobutyl)-3'-nitro-β-D-pentofuranosyl]-N-3-(3-oxobutyl)-thymine (10). **8** (23 mg, 0.03 mmol) gave **10** (11 mg, 80 %) using a condition described for **5**. ^{1}H-NMR ($CDCl_3$ + CD_3OD): 7.86 (q, 1H) H-6; 6.16 (dd, $J_{1'2'}$ = 9.1 Hz, $J_{1'2''}$ = 5.4 Hz, 1H) H-1'; 4.64 (dd, 1H) H-4'; 4.2 (m, 2H) NCH_2; 4.00 (dd, $J_{4'5'}$ = 2.8 Hz, $J_{5'5''}$ = 12.4 Hz, 1H) H-5'; 3.59 (dd, $J_{4'5''}$ = 2.1 Hz, 1H) H-5"; 3.24 (dd, $J_{2'2''}$ = 14.0 Hz, 1H) H-2"; 2.78 (m, 2H) $NCH_2\underline{C}H_2$; 2.58-2.40 (m, 4H) 3'-CH_2, $\underline{C}H_2CO$; 2.35 (dd, 1H) H-2'; 2.19 (s, 3H) $COCH_3$; 2.17 (s, 3H) $COCH_3$; 1.92 (d, $J_{6,CH3}$ = 1.0 Hz, 3H) 5-CH_3; ^{13}C-NMR ($CDCl_3$ + CD_3OD): 134.6 (d, J_{CH} = 181.7 Hz) C-6; 110.0 (s) C-5; 99.1 (s) C-3'; 85.8 (d, J_{CH} = 166.8 Hz) C-1'; 85.1 (d, J_{CH} = 151.2 Hz) C-4'; 60.9 (t, J_{CH} = 143.0 Hz) C5'; 40.9 (t, J_{CH} = 128.3 Hz) $NCH_2\underline{C}H_2$; 38.8 (t, J_{CH} = 137.0 Hz) C-2'; 38.5 (t, J_{CH} = 124.2 Hz) $CH_2\underline{C}H_2CO$; 36.4 (t, J_{CH} = 144.8 Hz) NCH_2; 29.8 (q, J_{CH} = 130.4 Hz) $COCH_3$; 29.6 (q, J_{CH} = 127.4 Hz) $COCH_3$; 26.7 (t, J_{CH} = 132.1 Hz) 3'-CH_2; 12.0 (q, J_{CH} = 129.2 Hz) 5-CH_3. UV (EtOH): λ_{max} 267 nm (ε = 10150) (pH 7); 267 nm (ε = 10150) (pH 2); 265 nm (ε = 17400) (pH 12). MS (FAB$^+$): cal. for (M+ H)$^+$ 411.1642, found 411.1624.

1-[2',3'-Dideoxy-3'-(R)-(3-oxobutyl)-3'-nitro-β-D-pentofuranosyl]-N-3-(3-oxobutyl)-thymine (23). **21** (55 mg, 0.08 mmol) gave **23** (28 mg, 85 %) using a condition described for **5**. ^{1}H-NMR ($CDCl_3$ + CD_3OD): 7.64 (q, $J_{6,CH3}$ = 1.2 Hz, 1H) H-6; 6.20 (dd, 1H) H-1'; 4.21 (m, 2H) NCH_2; 4.09 (dd, 1H) H-4'; 3.86 (dd, $J_{4'5'}$ = 3.8 Hz, $J_{5'5''}$ = 12.3 Hz, 1H) H-5'; 3.79 (dd, $J_{4'5''}$ = 5.0 Hz, 1H) H-5"; 3.00 (dd, $J_{1'2''}$ = 6.6 Hz, $J_{2'2''}$ = 14.8 Hz, 1H) H-2"; 2.78 (m, 2H) $NCH_2\underline{C}H_2$; 2.68 (m, 1H) H-3"a; 2.63 (dd, $J_{1'2'}$ = 7.1 Hz, 1H) H-2'; 2.51 (m, 2H) $CH_2\underline{C}H_2COCH_3$; 2.19 (m, 1H) H-3"b; 2.19 (s, 3H) $COCH_3$; 2.18 (s, 3H) $COCH_3$; 1.95(d, 3H) 5-CH_3; ^{13}C-NMR ($CDCl_3$ + CD_3OD): 133.7 (d, J_{CH} = 182.4 Hz) C-6; 110.3 (s) C-5; 95.2 (s) C-3'; 85.3 (d, J_{CH} = 150.3 Hz) C-4'; 83.4 (d, J_{CH} = 175.0 Hz) C-1'; 60.6 (t, J_{CH} = 143.4 Hz) C5'; 41.0 (t, J_{CH} = 127.8 Hz) $NCH_2\underline{C}H_2$; 40.2 (t, J_{CH} = 138.8 Hz) C-2'; 38.0 (t, J_{CH} = 126.5 Hz) $CH_2\underline{C}H_2CO$; 36.5 (t, J_{CH} = 144.8 Hz) NCH_2; 30.1 (q, J_{CH} = 127.7 Hz) $COCH_3$; 29.7 (q, J_{CH} = 127.7 Hz) $COCH_3$; 29.7 (t, J_{CH} = 132.4 Hz) 3'-CH_2; 13.0 (q, J_{CH} = 129.2 Hz) 5-CH_3. UV (EtOH): λ_{max} 267 nm (ε = 11380) (pH 7); 267 nm (ε = 11380) (pH 2); 266 nm (ε = 12330) (pH 12). MS (FAB$^+$): cal. for (M +H)$^+$ 411.1642, found 411.1623.

1-[2',3'-Dideoxy-3'-(S)-(3-oxobutyl)-3'-nitro-β-D-pentofuranosyl]thymine (11). **9** (50 mg, 0.08 mmol) gave **11** (23 mg, 83 %) using a condition described for **5**. ^{1}H-NMR ($CDCl_3$ + CD_3OD): 8.00 (q, $J_{6,CH3}$ = 1.1 Hz, 1H) H-6; 6.20 (dd, $J_{1'2'}$ = 9.2 Hz, $J_{1'2''}$ = 5.5 Hz, 1H) H-1'; 4.63 (dd, 1H) H-4'; 4.00 (dd, $J_{4',5'}$ = 2.8 Hz, $J_{5'5''}$ = 12.4 Hz, 1H) H-5'; 3.90 (dd, $J_{4'5''}$ = 2.0 Hz, 1H) H-5"; 3.23 (dd, $J_{2'2''}$ = 14.1 Hz, 1H) H-2"; 2.47 (m, 4H) 3'-$\underline{CH}_2\underline{CH}_2COCH_3$; 2.34 (dd, 1H) H-2'; 2.17 (s, 3H) $COCH_3$; 1.90 (d, 3H) 5-CH_3; ^{13}C-NMR ($CDCl_3$ + CD_3OD): 136.4 (d, J_{CH} = 182.4 Hz) C-6; 110.7 (s) C-5; 99.1 (s) C-3'; 85.1 (d, J_{CH} = 150.3 Hz) C-4'; 84.5 (d, J_{CH} = 171.4 Hz) C-1'; 60.7 (t, J_{CH} = 143.0 Hz) C5'; 38.8 (t, J_{CH} = 136.6 Hz) C-2'; 38.4 (t, J_{CH} = 120.5 Hz) 3'-CH2$\underline{C}H_2$; 29.6(q, J_{CH} = 127.7 Hz) $COCH_3$; 26.6 (t, J_{CH} = 133.3 Hz) 3'-CH_2; 12.0 (q, J_{CH} = 128.9 Hz) 5-CH_3. UV (EtOH): λ_{max} 267 nm (ε = 9830) (pH 7); 266 nm (ε = 9830) (pH 2); 262 nm (ε = 10700) (pH 12). MS (FAB$^-$): cal. for (M-H)$^-$ 340.1145, found 340.1181.

1-[2',3'-Dideoxy-3'-(R)-(3-oxobutyl)-3'-nitro-β-D-pentofuranosyl]thymine (24). **22** (123 mg, 0.2 mmol) gave **24** (61 mg, 90 %) using a condition described for **5**. ^{1}H-NMR ($CDCl_3$ + CD_3OD): 7.70 (q, $J_{6,CH3}$ = 1.2 Hz, 1H) H-6; 6.20 (dd, 1H) H-1'; 4.10 (dd, 1H) H-4'; 3.84 (dd, $J_{4'5'}$ = 5.2 Hz, $J_{5'5''}$ = 12.2 Hz, 1H) H-5'; 3.76 (dd, $J_{4'5''}$ = 3.6 Hz, 1H) H-5"; 2.99 (dd, $J_{1'2''}$ = 6.6 Hz, $J_{2'2''}$ = 15.0 Hz, 1H) H-2"; 2.64 (dd, $J_{1'2'}$ = 7.4 Hz, 1H) H-2', 2.73-2.50 (m, 3H) H-3"a, $\underline{CH}_2COCH_3$; 2.19 (s, 3H) $COCH_3$; 2.14 (m, 1H) H-3"b; 1.94 (d, 3H) 5-CH_3; ^{13}C-NMR ($CDCl_3$ + CD_3OD): 135.5 (d, J_{CH} = 183.3 Hz) C-6; 111.0 (s) C-5; 95.2 (s) C-3'; 85.3 (d, J_{CH} = 150.3 Hz) C-4'; 82.6 (d, J_{CH} = 169.5 Hz) C-1'; 60.3 (t, J_{CH} = 143.4 Hz) C5'; 40.1 (t, J_{CH} = 136.6 Hz) C-2'; 38.0 (t, J_{CH} = 125.6 Hz) $\underline{C}H_2CO$; 29.6 (q, J_{CH} = 127.7 Hz) $COCH_3$; 29.6 (t, J_{CH} = 132.4 Hz) 3'-CH_2; 12.2 (q, J_{CH} = 129.2 Hz) 5-CH_3. UV (EtOH): λ_{max} 265 nm (ε = 8940) (pH 7); 265 nm (ε = 8940) (pH 2); 264 nm (ε =

9820) (pH 12). MS (FAB$^-$): cal. for (M-H)$^-$ 340.1145, found 340.1145.

1-[5'-O-(MMTr)-2',3'-dideoxy-3'-(R)-hydroxymethyl-3'-nitro-β-D-pentofuranosyl]uracil (12) & its epimer (25). **2** (528 mg, 1 mmol) gave **12** (206 mg, 37 %) and **25** (292 mg, 52 %) using a condition described for **3** & **14**. Compound **12**: ^{1}H-NMR ($CDCl_3$): 8.38 (br, 1H) NH; 7.68 (d, $J_{5,6}$ = 8.1 Hz, 1H) H-6; 7.35-7.24 (m, 12H) arom; 6.88-6.82 (d, 2H) arom; 6.30 (dd, $J_{1'2'}$ = 8.2 Hz, $J_{1'2''}$ = 6.1 Hz, 1H) H-1'; 5.50 (d, 1H) H-5; 4.67 (dd, 1H) H-4'; 4.10 (d, $J_{3''a3''b}$ = 12.3 Hz, 1H) H-3"a; 4.01 (d, 1H) H-3"b; 3.81 (s, 3H) OMe; 3.66 (dd, $J_{4'5'}$ = 5.4 Hz, $J_{5'5''}$ = 11.1 Hz, 1H) H-5'; 3.50 (dd, $J_{4'5''}$ = 2.9 Hz, 1H) H-5"; 3.24 (dd, $J_{2'2''}$ = 14.7 Hz, 1H) H-2"; 2.46 (dd, 1H) H-2'; ^{13}C-NMR ($CDCl_3$): 139.4 (d, J_{CH} = 181.6 Hz) C-6; 102.9 (d, J_{CH} = 177.8 Hz) C-5; 97.1 (s) C-3'; 88.4 (s) MMTr; 83.8 (d, J_{CH} = 173.2 Hz) C-1'; 81.9 (d, J_{CH} = 153.1 Hz) C-4'; 63.3 (t, J_{CH} = 148.0 Hz) CH_2OH; 61.4 (t, J_{CH} = 144.3 Hz) C-5'; 55.2 (q, J_{CH} = 144.2 Hz) OMe; 38.9 (t, J_{CH} = 136.6 Hz) C-2'. Compound **25**: ^{1}H-NMR ($CDCl_3$): 8.79 (br, 1H) NH; 7.76 (d, $J_{5,6}$ = 8.2 Hz, 1H) H-6; 7.36-7.24 (m, 12H) arom; 6.86-6.82 (d, 2H) arom; 6.20 (dd, 1H) H-1'; 5.64 (d, 1H) H-5; 4.29 (d, $J_{3''a3''b}$ = 12.0 Hz, 1H) H-3"a; 3.98 (dd, 1H) H-4'; 3.87 (d, 1H) H-3"b; 3.80 (s, 3H) OMe; 3.53 (dd, $J_{4'5'}$ = 4.8 Hz, $J_{5'5''}$ = 10.9 Hz, 1H) H-5'; 3.37 (dd, $J_{4'5''}$ = 5.1 Hz, 1H) H-5"; 3.00 (dd, $J_{1'2''}$ = 7.0 Hz, $J_{2'2''}$ = 15.2 Hz, 1H) H-2"; 2.83 (dd, $J_{1'2'}$ = 6.7 Hz, 1H) H-2'; ^{13}C-NMR ($CDCl_3$): 139.7 (d, J_{CH} = 185.1 Hz) C-6; 102.8 (d, J_{CH} = 176.9 Hz) C-5; 95.9 (s) C-3'; 87.9 (s) MMTr; 82.8 (d, J_{CH} = 170.5 Hz) C-1'; 80.7 (d, J_{CH} = 150.3 Hz) C-4'; 64.2 (t, J_{CH} = 146.6 Hz) CH_2OH; 61.9 (t, J_{CH} = 144.3 Hz) C-5'; 55.1 (q, J_{CH} = 143.9 Hz) OMe; 39.8 (t, J_{CH} = 137.0 Hz) C-2'.

1-[2',3'-Dideoxy-3'-(R)-hydroxymethyl-3'-nitro-β-D-pentofuranosyl]uracil (13). **12** (55 mg, 0.1 mmol) gave **13** (23 mg, 82 %) using a condition described for **5**. ^{1}H-NMR ($CDCl_3$ + CD_3OD): 8.12 (d, $J_{5,6}$ = 8.1 Hz, 1H) H-6; 6.22 (dd, $J_{1'2'}$= 8.7 Hz, $J_{1'2''}$ = 5.7 Hz, 1H) H-1'; 5.74 (d, 1H) H-5; 4.69 (dd, 1H) H-4'; 4.24 (m, 2H) 3'-CH_2; 3.97 (dd, $J_{4'5'}$ = 3.2 Hz, $J_{5'5''}$ = 12.4 Hz, 1H) H-5'; 3.88 (dd, $J_{4'5''}$ = 2.1 Hz, 1H) H-5"; 3.28 (dd, $J_{2'2''}$ = 14.3 Hz, 1H) H-2"; 2.43 (dd, 1H) H-2'. UV (EtOH): λ_{max} 260 nm (ε = 7630) (pH 7); 260 nm (ε = 7760) (pH 2).

1-[2',3'-Dideoxy-3'-(S)-hydroxymethyl-3'-nitro-β-D-pentofuranosyl]uracil (26). **25** (55 mg, 0.1 mmol) gave **23** (24 mg, 86 %) using a condition described for **5**. ^{1}H-NMR ($CDCl_3$ + CD_3OD): 7.99 (d, $J_{5,6}$ = 8.1 Hz, 1H) H-6; 6.20 (dd, 1H) H-1'; 5.79 (d, 1H) H-5; 4.20 (d, $J_{3''a3''b}$ = 12.2 Hz, 1H) H-3"a; 4.13 (t, $J_{4'5'}$ = 4.1 Hz, 1H) H-4'; 4.00 (d, 1H) H-3"b; 3.80 (m, 2H) H-5', H-5"; 3.00 (d, $J_{1'2''}$ = 7.1 Hz, $J_{2'2''}$ = 15.0 Hz, 1H) H-2", 2.92 (dd, $J_{1'2'}$ = 7.3 Hz, 1H) H-2'; ^{13}C-NMR ($CDCl_3$ + CD_3OD): 140.2 (d, J_{CH} = 182.4 Hz) C-6; 102.2 (d, J_{CH} = 177.8 Hz) C-5; 95.8 (s) C-3'; 82.8 (d, J_{CH} = 172.3 Hz) C-1'; 81.6 (d, J_{CH} = 150.3 Hz) C-4'; 63.5 (t, J_{CH} = 147.6 Hz) CH_2OH; 60.3 (t, J_{CH} = 143.4 Hz) C-5'; 38.3 (t, J_{CH} = 137.5 Hz) C-2'. UV (EtOH): λ_{max} 260 nm (ε = 9530) (pH 7); 260 nm (ε = 9530) (pH 2).

1-[5'-O-(MMTr)-2',3'-dideoxy-3'-C-hydroxymethyl-β-D-*threo*-pentofuranosyl]thymine (27) & its epimer (41). *General procedure for denitration*: A mixture of **14** (287 mg, 0.5 mmol) , Bu_3SnH (404 µl, 1.5 mmol) and AIBN (82 mg, 0.5 mmol) in benzene (40 ml) was heated at 75 °C for 20 h. The solvent was removed in vacuo and the residue was purified by preparative thin layer chromatography to give **27** (217 mg, 82 %) and **41** (23 mg, 9 %). Compound **27**: ^{1}H-NMR ($CDCl_3$): 8.22 (br, 1H) NH; 7.60 (q, 1H) H-6; 7.45-7.26 (m, 12H) arom; 6.88-6.85 (d, 2H) arom; 6.16 (dd, $J_{1'2'}$ = 8.1 Hz, $J_{1'2''}$ = 5.9 Hz, 1H) H-1'; 4.30 (ddd, $J_{4'5'}$ = 5.1 Hz, $J_{3'4'}$ = 7.3 Hz, 1H) H-4'; 3.80 (s, 3H) OMe; 3.60 (m, 2H) H-5' , H-3"a; 3.29 (dd, $J_{4'5''}$ = 2.8 Hz, $J_{5'5''}$ = 10.5 Hz, 1H) H-5"; 2.70 (m, 1H) H-3'; 2.46 (m, 1H) H-3"b; 2.42 (ddd, $J_{2''3'}$ = 7.8 Hz, $J_{2'2''}$ = 12.9 Hz, 1H) H-2"; 1.88 (ddd, $J_{2'3'}$ = 10.2 Hz, 1H) H-2'; 1.59 (d, $J_{6,CH3}$ = 1.1 Hz, 3H) 5-CH_3; ^{13}C-NMR ($CDCl_3$): 135.5 (d, J_{CH} = 179.6 Hz) C-6; 111.0 (s) C-5; 87.8 (s) MMTr; 83.9 (d, J_{CH} = 171.4 Hz) C-1'; 80.1 (d, J_{CH} = 151.2 Hz) C-4'; 62.7 (t, J_{CH} = 143.0 Hz) CH_2OH; 61.4 (t, J_{CH} = 142.5 Hz) C-5'; 55.1 (q, J_{CH} = 143.9 Hz) OMe; 42.2 (d, J_{CH} = 130.1 Hz) C-3'; 33.7 (t, J_{CH} = 132.0 Hz) C-2'; 11.8 (q, J_{CH} = 129.2 Hz) 5-CH_3. Compound **41**:^{1}H-NMR ($CDCl_3$): 8.85 (br, 1H) NH; 7.60 (q, $J_{6,CH3}$ = 1.1 Hz, 1H) H-6; 7.45-7.24 (m, 12H) arom; 6.86-6.83 (d, 2H) arom; 6.13 (dd, $J_{1'2'}$ = 5.0 Hz, $J_{1'2''}$ = 6.4 Hz, 1H) H-1'; 3.99 (ddd, $J_{3'4'}$ = 7.0 Hz, 1H) H-4'; 3.79 (s, 3H) OMe; 3.62 (d, $J_{3'3''}$ = 5.8 Hz, 2H) CH_2OH; 3.52 (dd, $J_{4'5'}$ = 3.3 Hz, $J_{5'5''}$ = 10.5 Hz, 1H) H-5'; 3.33 (dd, $J_{4'5''}$ = 3.4 Hz, 1H) H-5"; 2.61 (m, 1H) H-3'; 2.33 (ddd, $J_{2''3'}$ = 8.6 Hz, $J_{2'2''}$ = 13.7 Hz, 1H) H-2"; 2.20 (ddd, $J_{2'3'}$ = 7.6 Hz, 1H) H-2'; 1.52 (d, 3H) 5-CH_3; ^{13}C-NMR ($CDCl_3$): 135.6 (d, J_{CH} = 176.9 Hz) C-6; 110.6 (s) C-5; 87.0 (s) MMTr; 85.0 (d, J_{CH} = 173.2 Hz) C-1'; 82.1 (d, J_{CH} = 143.9 Hz) C-4'; 64.1 (t, J_{CH} = 142.7 Hz) CH_2OH; 63.0 (t, J_{CH} = 140.7 Hz) C-5'; 55.1 (q, J_{CH} = 143.6 Hz) OMe; 41.4 (d, J_{CH} = 132.0 Hz) C-3'; 35.7 (t, J_{CH} = 133.8 Hz) C-2'; 11.9 (q, J_{CH} = 129.2 Hz) 5-CH_3.

1-[5'-O-(MMTr)-2',3'-dideoxy-3'-C-acetoxymethyl-β-D-*threo*-pentofuranosyl]thymine (28). **27** (132 mg, 0.25 mmol) gave **28** (134 mg, 95 %) using a condition described for **4**. ^{1}H-NMR ($CDCl_3$): 8.56 (br, 1H) NH;

7.80 (q, $J_{6,CH3}$ = 1.1 Hz, 1H) H-6; 7.41-7.28(m, 12H) arom; 6.86-6.83 (d, 2H) arom; 6.22 (dd, $J_{1'2'}$ = 8.8 Hz, $J_{1'2''}$ = 5.4 Hz, 1H) H-1'; 4.30 (ddd, $J_{3'4'}$ = 8.4 Hz, 1H) H-4'; 4.20 (dd, $J_{3'3''a}$ = 6.9 Hz, $J_{3''a\ 3''b}$ = 11.0 Hz, 1H) H-3"a; 4.00 (dd, $J_{3'3''b}$ = 8.0 Hz, 1H) H-3"b; 3.80 (s, 3H) OMe; 3.62 (dd, $J_{4'5'}$ = 3.5 Hz, $J_{5'5''}$ = 10.8 Hz, 1H) H-5'; 3.17 (dd, $J_{4'5''}$ = 3.1 Hz, 1H) H-5"; 2.84 (m, 1H) H-3'; 2.46 (ddd, $J_{2''3'}$ = 7.2 Hz, $J_{2'2''}$ = 12.5 Hz, 1H) H-2"; 2.20 (ddd, $J_{2'3'}$ = 8.6 Hz, 1H) H-2'; 1.87 (s, 3H) $COCH_3$; 1.39 (d, 3H) 5-CH_3; ^{13}C-NMR ($CDCl_3$): 135.4 (d, J_{CH} = 179.6 Hz) C-6; 111.2 (s) C-5; 87.4 (s) MMTr; 84.1 (d, J_{CH} = 170.5 Hz) C-1'; 78.3 (d, J_{CH} = 146.6 Hz) C-4'; 63.2 (t, J_{CH} = 148.5 Hz) $\underline{C}H_2OAc$; 62.8 (t, J_{CH} = 143.0 Hz) C-5'; 55.0 (q, J_{CH} = 143.9 Hz) OMe; 40.0 (d, J_{CH} = 133.8 Hz) C-3'; 34.9 (t, J_{CH} = 133.8 Hz) C-2'; 20.4 (q, J_{CH} = 129.5 Hz) $CH_2O\underline{Ac}$; 11.5 (q, J_{CH} = 130.1 Hz) 5-CH_3.

1-[2',3'-Dideoxy-3'-$\underline{C}$-hydroxymethyl-β-D-*threo*-pentofuranosyl]thymine (29). **27** (132 mg, 0.25 mmol) gave **29** (54 mg, 84 %) using a condition described for **5**. ^{1}H-NMR ($CDCl_3$ + CD_3OD): 7.88 (q, $J_{6,CH3}$ = 1.2 Hz, 1H) H-6; 6.10 (dd, $J_{1'2'}$ = 8.2 Hz, $J_{1'2''}$ = 5.9 Hz, 1H) H-1'; 4.18 (ddd, $J_{4'5'}$ = $J_{4'5''}$ = 3.8 Hz, $J_{3'4'}$ = 7.9 Hz, 1H) H-4'; 3.90 (dd, $J_{5'5''}$ = 12.8 Hz, 1H) H-5' ; 3.80 (dd, 1H) H-5"; 3.79 (d, $J_{3'3''}$ = 5.2 Hz, 2H) CH_2OH; 2.74 (m, 1H) H-3'; 2.36 (ddd, $J_{2''3'}$ = 7.3 Hz, $J_{2'2''}$ = 12.9 Hz, 1H) H-2"; 1.97 (ddd, $J_{2'3'}$ = 10.2 Hz, 1H) H-2'; 1.92 (d, 3H) 5-CH_3; ^{13}C-NMR ($CDCl_3$ + CD_3OD): 136.3 (d, J_{CH} = 180.5 Hz) C-6; 110.4 (s) C-5; 84.3 (d, J_{CH} = 169.6 Hz) C-1'; 80.2 (d, J_{CH} = 148.5 Hz) C-4'; 61.5 (t, J_{CH} = 141.6 Hz) CH_2OH; 59.6 (t, J_{CH} = 142.5 Hz) C-5'; 41.7 (d, J_{CH} = 131.1 Hz) C-3'; 33.4 (t, J_{CH} = 133.8 Hz) C-2'; 11.9 (q, J_{CH} = 128.6 Hz) 5-CH_3. UV (EtOH): λ_{max} 267 nm (ε = 10620) (pH 7); 267 nm (ε = 10480) (pH 2); 265 nm (ε = 9920) (pH 12). MS (FAB$^-$): cal. for (M-H)$^-$ 255.0981 found 255.1001.

1-[2',3'-Dideoxy-3'-$\underline{C}$-acetoxymethyl-β-D-*threo*-pentofuranosyl]thymine (30). **28** (130 mg, 0.23 mmol) gave **30** (63 mg, 93 %) using a condition described for **5**. ^{1}H-NMR ($CDCl_3$ + CD_3OD): 7.82 (q, $J_{6,CH3}$ = 1.2 Hz, 1H) H-6; 6.10 (dd, $J_{1'2'}$ = 8.9 Hz, $J_{1'2''}$ = 5.6 Hz, 1H) H-1'; 4.32 (d, $J_{3'3''}$ = 7.5 Hz, 2H) $\underline{C}H_2OAc$; 4.21 (ddd, $J_{3'4'}$ = 8.2 Hz, 1H) H-4'; 3.91 (dd, $J_{4'5'}$ = 3.0 Hz, $J_{5'5''}$ = 12.0 Hz, 1H) H-5' ; 3.74 (dd, $J_{4'5''}$ = 3.3 Hz, 1H) H-5"; 2.86 (m, 1H) H-3'; 2.41 (ddd, $J_{2''3'}$ = 7.2 Hz, $J_{2'2''}$ = 12.6 Hz, 1H) H-2"; 2.04 (s, 3H) $CO\underline{C}H3$; 1.99 (ddd, $J_{2'3'}$ = 11.8 Hz, 1H) H-2'; 1.91 (d, 3H) 5-CH_3; ^{13}C-NMR ($CDCl_3$ + CD_3OD): 136.4 (d, J_{CH} = 187.0 Hz) C-6; 110.7 (s) C-5; 84.9 (d, J_{CH} = 169.5 Hz) C-1'; 79.5 (d, J_{CH} = 149.4 Hz) C-4'; 63.3 (t, J_{CH} = 148.5 Hz) $\underline{C}H_2OAc$; 61.8 (t, J_{CH} = 141.3 Hz) C-5'; 39.2 (d, J_{CH} = 132.9 Hz) C-3'; 34.6 (t, J_{CH} = 133.8 Hz) C-2'; 20.6 (q, J_{CH} = 129.5 Hz) CH2O$\underline{Ac}$; 12.1 (q, J $_{CH}$ = 128.9 Hz) 5 CH_3. UV (EtOH): λ_{max} 267 nm (ε = 9720) (pH 7); 267 nm (ε = 9900) (pH 2); 264 nm (ε = 9550) (pH 12). MS . (FAB$^-$): cal. for (M-H)$^-$ 297.1086 found 297.1067.

1-[5'-O-(MMTr)-2',3'-dideoxy-3'-$\underline{C}$-hydroxymethyl-β-D-*threo*-pentofuranosyl]uracil (31) & its epimer (42). **25** (278 mg, 0.5 mmol) gave **31** (172 mg, 67 %) and **42** (36 mg, 14 %) using a condition described for **27** & **41.** Compound **31**: ^{1}H-NMR ($CDCl_3$): 8.83 (br, 1H) NH; 7.69 (d, $J_{5,6}$ = 8.1 Hz, 1H) H-6; 7.43-7.26 (m, 12H) arom; 6.88-6.84 (d, 2H) arom; 6.07 (dd, $J_{1'2'}$ = 7.4 Hz, $J_{1'2''}$ = 6.3 Hz, 1H) H-1'; 5.52 (d, 1H) H-5; 4.32 (ddd, $J_{3'4'}$ = 8.3 Hz, 1H) H-4'; 3.80 (s, 3H) OMe; 3.60 (m, 1H) H-3"a; 3.53 (dd, $J_{4'5'}$ = 5.7 Hz, $J_{5'5''}$ = 10.4 Hz, 1H) H-5'; 3.35 (dd, $J_{4'5''}$ = 3.6 Hz, 1H) H-5"; 2.68 (m, 1H) H-3'; 2.54 (m, 1H) H-3"b; 2.48 (ddd, $J_{2''3'}$ = 7.9 Hz, $J_{2'2''}$ = 13.9 Hz, 1H) H-2"; 1.80 (ddd, $J_{2'3'}$ = 8.8 Hz, 1H) H-2'; ^{13}C-NMR ($CDCl_3$): 139.8 (d, J_{CH} = 182.4 Hz) C-6; 102.0 (d, J_{CH} = 177.8 Hz) C-5; 87.8 (s) MMTr; 84.6 (d, J_{CH} = 172.3 Hz) C-1'; 79.0 (d, J_{CH} = 147.6 Hz) C-4'; 62.4 (t, J_{CH} = 143.0 Hz) CH_2OH; 61.4 (t, J_{CH} = 141.6 Hz) C-5'; 55.1 (q, J_{CH} = 144.2 Hz) OMe; 42.1 (d, J_{CH} = 132.0 Hz) C-3'; 34.2 (t, J_{CH} = 134.3 Hz) C-2'. Compound **42**: ^{1}H-NMR ($CDCl_3$): 8.30 (br, 1H) NH; 7.97 (d, $J_{5,6}$ = 8.1 Hz, 1H) H-6; 7.44-7.27 (m, 12H) arom; 6.87-6.84 (d, 2H) arom; 6.09 (dd, $J_{1'2'}$ = 3.2 Hz, $J_{1'2''}$ = 6.7 Hz, 1H) H-1'; 5.36 (d, 1H) H-5; 3.98 (ddd, $J_{3'4'}$ = 8.3 Hz, 1H) H-4'; 3.80 (s, 3H) OMe; 3.63 (d, $J_{3'3''}$ = 4.9 Hz, 2H) CH_2OH; 3.57 (dd, $J_{4'5'}$ = 3.2 Hz, $J_{5'5''}$ = 10.8 Hz, 1H) H-5' ; 3.44 (dd, $J_{4'5''}$ = 3.3 Hz, 1H) H-5"; 2.64 (m, 1H) H-3'; 2.33 (ddd, $J_{2''3'}$ = 9.3 Hz, $J_{2'2''}$ = 13.5 Hz, 1H) H-2"; 2.19 (ddd, $J_{2'3'}$ = 8.0 Hz, 1H) H-2'; ^{13}C-NMR ($CDCl_3$): 140.2 (d, J_{CH} = 183.3 Hz) C-6; 101.6 (d, J_{CH} = 176.9 Hz) C-5; 87.2 (s) MMTr; 85.3 (d, J_{CH} = 172.3 Hz) C-1'; 82.9 (d, J_{CH} = 143.9 Hz) C-4'; 63.2 (t) CH_2OH; 62.6 (t) C-5'; 55.1 (q, J_{CH} = 142.5 Hz) OMe; 40.2 (d) C-3'; 35.7 (t, J_{CH} = 130.0 Hz) C-2'.

1-[5'-O-(MMTr)-2',3'-dideoxy-3'-$\underline{C}$-acetoxymethyl-β-D-*threo*-pentouranosyl]uracil (32). **31** (256 mg, 0.5 mmol) gave **32** (227 mg, 82 %) using a condition described for **4.** ^{1}H-NMR ($CDCl_3$): 9.38 (br, 1H) NH; 7.80 (d, $J_{5,6}$ = 8.1 Hz, 1H) H-6; 7.42-7.26 (m, 12H) arom; 6.86-6.83 (d, 2H) arom; 6.12 (dd, $J_{1'2'}$ = 7.7 Hz, $J_{1'2''}$ = 5.7 Hz, 1H) H-1'; 5.42 (d, 1H) H-5; 4.35 (ddd, $J_{3'4'}$ = 8.1 Hz, 1H) H-4'; 4.05 (m, 2H) 3'-CH_2; 3.80 (s, 3H) OMe; 3.50 (dd, $J_{4'5'}$ = 3.7 Hz, $J_{5'5''}$ = 10.7 Hz, 1H) H-5'; 3.25 (dd, $J_{4'5''}$ = 4.7 Hz, 1H) H-5"; 2.81 (m, 1H) H-3'; 2.54 (m, 1H) H-2"; 1.91 (s, 3H) OAc; 1.83 (m,1H) H-2'; ^{13}C-NMR ($CDCl_3$): 139.9 (d, J_{CH} = 185.1 Hz) C-6; 102.1 (d, J_{CH} = 176.0 Hz) C-5; 87.4 (s) MMTr; 84.9 (d, J_{CH} = 176.0 Hz) C-1'; 79.1 (d, J_{CH} = 152.1 Hz) C-4'; 63.1,

62.7 (2 x t) CH_2OH, C-5'; 55.1 (q, J_{CH} = 143.9 Hz) OMe; 39.0 (d, J_{CH} = 133.8 Hz) C-3'; 35.4 (t, J_{CH} = 134.7 Hz) C-2'; 20.6 (q, J_{CH} = 130.0 Hz) OAc.

1-[-2',3'-Dideoxy-3'-C-hydroxymethyl-β-D-*threo*-pentofuranosyl]uracil (33). **31** (128 mg, 0.25 mmol) gave **33** (52 mg, 87 %) using a condition described for **5**. ^{1}H-NMR ($CDCl_3$ + CD_3OD): 8.07 (d, $J_{5,6}$ = 8.1 Hz, 1H) H-6; 6.08 (dd, $J_{1'2'}$ = 8.1 Hz, $J_{1'2''}$ = 6.0 Hz, 1H) H-1'; 5.74 (d, 1H) H-5; 4.18 (ddd, $J_{3'4'}$ = 8.1 Hz, 1H) H-4'; 3.89 (dd, $J_{4'5'}$ = 3.8 Hz, $J_{5'5''}$ = 12.4 Hz, 1H) H-5' ; 3.80 (dd, $J_{4'5''}$ = 2.8 Hz, 1H) H-5''; 3.78 (d, $J_{3'3''}$ = 5.0 Hz, 2H) CH_2OH; 2.72 (m, 1H) H-3'; 2.40 (ddd, $J_{2''3'}$ = 7.6 Hz, $J_{2'2''}$ = 13.3 Hz, 1H) H-2''; 1.97 (ddd, $J_{2'3'}$ = 10.7 Hz, 1H) H-2'; ^{13}C-NMR ($CDCl_3$ + CD_3OD): 140.6 (d, J_{CH} = 183.3 Hz) C-6; 101.7 (d, J_{CH} = 176.9 Hz) C-5; 84.6 (d, J_{CH} = 171.4 Hz) C-1'; 80.4 (d, J_{CH} = 148.5 Hz) C-4'; 61.5 (t, J_{CH} = 141.1 Hz) CH_2OH; 59.5 (t, J_{CH} = 142.0 Hz) C-5'; 41.7 (d, J_{CH} = 131.1 Hz) C-3'; 33.7 (t, J_{CH} = 132.4 Hz) C-2'. UV (EtOH): λ_{max} 261 nm (ε = 9440) (pH 7); 261 nm (ε = 9620) (pH 2); 260 nm (ε = 8890) (pH 12). MS (FAB$^-$): cal. for (M-H)$^-$ 241.0825 found 241.0837.

1-[5'-O-(MMTr)-2',3'-dideoxy-3'-C-acetoxymethyl-β-D-*threo*-pentofuranosyl]-4-(2-nitrophenyl)-2-pyrimidinone (34). **32** (220 mg, 0.4 mmol) was dissolved in CH_2Cl_2 (20 ml) and triethylamine (558 µl, 4.0 mmol) , 2-mesitylenesulfonyl chloride (262 mg, 1.2 mmol) and N, N-dimethylamino pyridine (12 mg, 0.1 mmol) were added at 20 °C. After 2 h, 2-nitrophenol (167 mg, 1.2 mmol) and 1, 4-diazabicyclo[2, 2, 2] octane (11mg, 0.1 mmol) were added and stirred for 30 min. The reaction was poured in saturated aqueous solution of ammonium chloride (30 ml) and extracted by CH_2Cl_2 (50 ml). The aqueous layer was further washed with CH_2Cl_2 (3 x 20 ml). The organic layers were pooled and dried over $MgSO_4$ and evaporated to dryness. The residue was purified on silica gel column to give **34** (128 mg, 48 %). ^{1}H-NMR ($CDCl_3$): 8.23 (d, $J_{5,6}$ = 7.3 Hz, 1H) H-6; 8.14-7.63 (m, 2H) arom; 7.45-7.26 (m, 14H) arom; 6.88-6.85 (d, 2H) arom; 6.06 (dd, $J_{1'2'}$ = 8.9 Hz, $J_{1'2''}$ = 5.8 Hz, 1H) H-1'; 5.99 (d, 1H) H-5; 4.45 (ddd, $J_{3'4'}$ = 9.7 Hz, 1H) H-4'; 4.01 (m, 2H) 3'-CH_2; 3.82 (s, 3H) OMe; 3.50 (dd, $J_{4'5'}$ = 3.8 Hz, $J_{5'5''}$ = 10.5 Hz, 1H) H-5'; 3.26 (dd, $J_{4'5''}$ = 5.8 Hz, 1H) H-5''; 2.77 (m, 1H) H-3'; 2.34 (m, 1H) H-2''; 1.91 (s, 3H) OAc; 1.79 (m, 1H) H-2'; ^{13}C-NMR ($CDCl_3$): 141.5 (d, J_{CH} = 186.9 Hz) C-6; 94.4 (d, J_{CH} = 180.5 Hz) C-5; 87.0 (s) MMTr; 83.7 (d, J_{CH} = 175.0 Hz) C-1'; 80.0 (d, J_{CH} = 152.1 Hz) C-4'; 62.8, 62.6 (2 x t) CH_2OH, C-5'; 55.1 (q, J_{CH} = 143.9 Hz) OMe; 39.0 (d, J_{CH} = 137.5 Hz) C-3'; 36.1(t, J_{CH} = 135.6 Hz) C-2'; 20.6 (q, J_{CH} = 128.8 Hz) OAc.

1-[5'-O-(MMTr)-2',3'-dideoxy-3'-C-acetoxymethyl-β-D-*threo*-pentofuranosyl]cytosine (35). **34** (120 mg, 0.18 mmol) was dissolved in THF (10 ml) and treated with liquid ammonia (3 ml) in a steel bomb for 48 h. The reaction mixture was poured in saturated aqueous solution of ammonium chloride (20 ml). The aqueous layer was washed with CH_2Cl_2 (3 x 30 ml). The organic layer was dried over $MgSO_4$ and evaporated to dryness. The residue was purified on silica gel column to give **35** (39 mg, 40 %). ^{1}H-NMR ($CDCl_3$): 7.88 (d, $J_{5,6}$ = 7.3 Hz, 1H) H-6; 7.45-7.24 (m, 12H) arom; 6.86-6.82 (d, 2H) arom; 6.10 (dd, $J_{1'2'}$ = 6.6 Hz, $J_{1'2''}$ = 5.9 Hz, 1H) H-1'; 5.49 (d, 1H) H-5; 4.38 (ddd, $J_{3'4'}$ = 8.2 Hz, 1H) H-4'; 3.97 (m, 2H) CH_2OH; 3.80 (s, 3H) OMe; 3.46 (dd, $J_{4'5'}$ = 3.9 Hz, $J_{5'5''}$ = 10.4 Hz, 1H) H-5'; 3.24 (dd, $J_{4'5''}$ = 5.5 Hz, 1H) H-5''; 2.77 (m, 1H) H-3'; 2.69 (ddd, $J_{2''3'}$ = 7.6 Hz, $J_{2'2''}$ = 13.4 Hz, 1H) H-2''; 1.88 (s, 3H) OAc; 1.79 (m, 1H) H-2'; ^{13}C-NMR ($CDCl_3$): 141.1 (d, J_{CH} = 179.6 Hz) C-6; 93.3 (d, J_{CH} = 172.3 Hz) C-5; 87.0 (s) MMTr; 86.3 (d, J_{CH} = 174.1 Hz) C-1'; 79.5 (d, J_{CH} = 148.5 Hz) C-4'; 63.2 (t) CH_2OH; 62.8 (t, J_{CH} = 142.5 Hz) C-5'; 55.1 (q, J_{CH} = 143.9 Hz) OMe; 39.0 (d, J_{CH} = 134.7 Hz) C-3'; 36.1 (t, J_{CH} = 135.6 Hz) C-2'; 20.6 (q, J_{CH} = 129.5 Hz) OAc.

1-[2',3'-Dideoxy-3'-C-hydroxymethyl-β-D-*threo*-pentofuranosyl]cytosine(36). **35** (37 mg, 0.07 mmol) was treated with methanolic ammonia (3 ml) overnight. The solvent was removed in vacuo, and coevaporated with toluene. The crude product was treated with 80 % aqueous acetic acid (4 ml) overnight at RT. The solvent was removed in vacuo and coevaporated with toluene and ethanol. The residue was purified on a silica gel column to give **36** (9 mg, 56 %). ^{1}H-NMR ($CDCl_3$ + CD_3OD): 8.03 (d, $J_{5,6}$ = 7.5 Hz, 1H) H-6; 6.04 (dd, $J_{1'2'}$ = 7.5 Hz, $J_{1'2''}$ = 6.1 Hz, 1H) H-1'; 5.85 (d, 1H) H-5; 4.21 (ddd, $J_{3'4'}$ = 8.1 Hz, 1H) H-4'; 3.89 (dd, $J_{4'5'}$ = 4.0 Hz, $J_{5'5''}$ = 12.3 Hz, 1H) H-5'; 3.79 (dd, $J_{4'5''}$ = 3.4 Hz, 1H) H-5''; 3.73 (d, $J_{3'3''}$ = 5.5 Hz, 2H) CH_2OH; 2.71 (m, 1H) H-3'; 2.50 (ddd, $J_{2''3'}$ = 7.8 Hz, $J_{2'2''}$ = 13.1 Hz, 1H) H-2''; 1.79 (ddd, $J_{2'3'}$ = 9.9 Hz, 1H) H-2'; ^{13}C-NMR ($CDCl_3$ + CD_3OD): 141.1 (d, J_{CH} = 183.3 Hz) C-6; 94.4 (d, J_{CH} = 175.0 Hz) C-5; 85.9 (d, J_{CH} = 173.2 Hz) C-1'; 80.7 (d, J_{CH} = 146.6 Hz) C-4'; 61.4 (t, J_{CH} = 142.0 Hz) CH_2OH; 59.6 (t, J_{CH} = 143.0 Hz) C-5'; 41.8 (d, J_{CH} = 132.0 Hz) C-3'; 34.4 (t, J_{CH} = 133.3 Hz) C-2'. UV (EtOH): λ_{max} 272 nm (ε = 9730) (pH 7); 283 nm (ε = 14600) (pH 2); 272 nm (ε = 11870) (pH 12). MS (FAB$^-$): cal. for (M-H)$^-$ 240.0984, found 240.0974.

1-[5'-O-(MMTr)-2',3'-dideoxy-3'-C-(β-cyanoethyl)-β-D-*threo*-pentofuranosyl]thymine (37) & its epimer (43). **17** (149 mg, 0.25 mmol) gave an inseparable mixture of **37** & **43** (117 mg, 85 %) in the ratio of 7.5 : 1

(^{1}H-NMR) using a condition described for **27** & **41**. Compound **37**: ^{1}H-NMR ($CDCl_3$): 7.78 (q, $J_{6,CH3}$ = 1.2 Hz, 1H) H-6; 7.40-7.26 (m, 12H) arom; 6.87-6.81 (d, 2H) arom; 6.20 (dd, $J_{1'2'}$ = 9.2 Hz, $J_{1'2''}$ = 5.0 Hz, 1H) H-1'; 4.28 (ddd, $J_{3'4'}$ = 8.1 Hz, 1H) H-4'; 3.81 (s, 3H) OMe; 3.65 (dd, $J_{4'5'}$ = 3.7 Hz, $J_{5'5''}$ = 10.9 Hz, 1H) H-5'; 3.10 (dd, $J_{4'5''}$ = 2.7 Hz, 1H) H-5"; 2.62 (m, 1H) H-3'; 2.52 (ddd, $J_{2''3'}$ = 6.7 Hz, $J_{2'2''}$ = 11.6 Hz, 1H) H-2"; 2.56 (m, 3H) H-3"a, $\underline{CH}_2CN$; 1.93 (ddd, $J_{2'3'}$ = 11.6 Hz, 1H) H-2'; 1.70 (m, 1H) H-3"b; 1.38 (d, 3H) 5-CH_3; ^{13}C-NMR ($CDCl_3$): 135.6 (d, J_{CH} = 184.2 Hz) C-6; 111.2 (s) C-5; 87.7 (s) MMTr; 84.2 (d, J_{CH} = 170.5 Hz) C-1';79.0 (d, J_{CH} = 145.7 Hz) C-4'; 63.0 (t, J_{CH} = 142.1 Hz) C-5'; 55.1 (q, J_{CH} = 143.9 Hz) OMe; 39.4 (d, J_{CH} 132.0 Hz) C-3'; 36.7(t, J_{CH} = 133.8 Hz) C-2'; 24.6 (t, J_{CH} = 132.4 Hz) 3'-CH_2; 16.4 (t) $\underline{C}H_2CN$; 11.5 (q, J_{CH} = 129.2 Hz) 5-CH_3; Compound **43**: ^{1}H-NMR ($CDCl_3$): 7.66 (q, $J_{6,CH3}$ = 1.2 Hz, 1H) H-6; 7.40-7.21 (m, 12H) arom; 6.87-6.81 (d, 2H) arom; 6.11 (dd, $J_{1'2'}$ = 3.4 Hz, $J_{1'2''}$ = 6.9 Hz, 1H) H-1'; 3.81 (s, 3H) OMe; 3.59 (dd, $J_{4'5'}$ = 2.6 Hz, 1H) H-5'; 3.26 (dd, $J_{4'5''}$ = 3.6 Hz, $J_{5'5''}$ = 11.1 Hz, 1H) H-5"; 2.90-1.50 (m, 7H) H-3', H-2', H-2"; 3'-CH_2, $\underline{CH}_2CN$; 1.54 (d, 3H) 5-CH_3.

1-[-2',3'-Dideoxy-3'-$\underline{C}$-(β-cyanoethyl)-β-D-*threo*-pentofuranosyl]thymine (38). **37** + **43** (110 mg, 0.2 mmol) gave **38** (43 mg, 78 %) using a condition described for **5**. ^{1}H-NMR ($CDCl_3$ + CD_3OD): 7.33 (q, $J_{6,CH3}$ = 1.1 Hz, 1H) H-6; 6.03 (dd, $J_{1'2'}$ = 9.3 Hz, $J_{1'2''}$ = 5.3 Hz, 1H) H-1'; 4.19 (ddd, $J_{3'4'}$ = 8.4 Hz, 1H) H-4'; 3.92 (dd, $J_{4'5'}$ = 3.0 Hz, $J_{5'5''}$ = 12.1 Hz, 1H) H-5'; 3.70 (dd, $J_{4'5''}$ = 2.7 Hz, 1H) H-5"; 2.65 (m, 1H) H-3'; 2.50-1.90 (m, 6H) H-2', H-2", 3'-CH_2, $\underline{CH}_2CN$; 1.91 (d, 3H) 5-CH_3; ^{13}C-NMR ($CDCl_3$ + CD_3OD): 136.7 (d, J_{CH} = 176.0 Hz) C-6; 110.7 (s) C-5; 85.8 (d, J_{CH} = 173.2 Hz) C-1'; 80.2 (d, J_{CH} = 146.6 Hz) C-4'; 62.2 (t, J_{CH} = 140.7 Hz) C-5'; 39.5 (d, J_{CH} = 127.4 Hz) C-3'; 35.8 (t, J_{CH} = 133.3 Hz) C-2'; 24.6 (t, J_{CH} = 131.1 Hz) 3'-CH_2; 16.4 (t, J_{CH} = 133.8 Hz) $\underline{C}H_2CN$; 12.3 (q, J_{CH} = 129.2 Hz) 5-CH_3. UV (EtOH): λ_{max} 267 nm (ε = 8340) (pH 7); 266 nm (ε = 8340) (pH 2); 264 nm (ε = 8140) (pH 12). MS (FAB^-): cal. for $(M-H)^-$ 278.1141, found 278.1143.

1-[5'-O-(MMTr)-2',3'-dideoxy-3'-$\underline{C}$-(3-oxobutyl)-β-D-*threo*-pentofuranosyl]thymine (39) & its epimer (44). **22** (307 mg, 0.5 mmol) gave an inseparable mixture of **39** & **44** (234 mg, 82 %) in the ratio of 4.5 : 1 (^{1}H-NMR) using a condition described for **27** & **41**. Compound **39**: ^{1}H-NMR ($CDCl_3$): 8.47 (br, 1H) NH; 7.79 (q, 1H) H-6; 7.45-7.29 (m, 12H) arom; 6.86-6.83 (d, 2H) arom; 6.14 (dd, $J_{1'2'}$ = 8.9 Hz, $J_{1'2''}$ = 4.7 Hz, 1H) H-1'; 4.32 (ddd, $J_{3'4'}$ = 7.7 Hz, 1H) H-4'; 3.80 (s, 3H) OMe; 3.59 (dd, $J_{4'5'}$ = 3.3 Hz, $J_{5'5''}$ = 10.7 Hz, 1H) H-5', 3.11 (dd, $J_{4'5''}$ = 3.4 Hz, 1H) H-5"; 2.50-2.35 (m, 4H) H-2", H-3', $\underline{CH}_2COCH_3$; 2.31 (dd, $J_{3'3''a}$ = 6.7 Hz, $J_{3''a3''b}$ = 14.3 Hz, 1H) H-3"a; 2.04 (s, 3H) $COCH_3$; 1.86 (ddd, 1H) H-2'; 1.60 (dd, $J_{3'3''b}$ = 6.8 Hz, 1H) H-3"b;1.35 (d, 3H) 5-CH_3; ^{13}C-NMR ($CDCl_3$): 134.4 (d, J_{CH} = 189.7 Hz) C-6; 110.9 (s) C-5; 87.4 (s) MMTr; 84.3 (d, J_{CH} = 170.5 Hz) C-1'; 79.7 (d, J_{CH} = 146.6 Hz) C-4'; 63.7 (t, J_{CH} = 142.1 Hz) C5'; 55.6 (q, J_{CH} = 143.9 Hz) OMe; 42.5 (t, J_{CH} = 124.6 Hz) CH_2CO; 40.3 (d, J_{CH} = 132.9Hz) C-3'; 37.7 (t, J_{CH} = 131.5 Hz) C-2'; 30.2 (q, J_{CH} = 127.1 Hz) $CO\underline{C}H_3$; 22.8 (t, J_{CH} = 127.8 Hz)3'-CH_2; 12.2 (q, J_{CH} = 129.5 Hz) 5-CH_3; Compound **41**: ^{1}H-NMR ($CDCl_3$): 7.70 (d, $J_{6,CH3}$ = 1.0 Hz, 1H) H-6; 7.45-7.29 (m, 12H) arom; 6.86-6.83 (d, 2H) arom; 6.07 (dd, $J_{1'2'}$ = 2.9 Hz, $J_{1'2''}$ = 6.9 Hz, 1H) H-1'; 3.80 (s, 3H) OMe; 3.26 (dd, $J_{4'5''}$ = 3.5 Hz, $J_{5'5''}$ = 10.8 Hz, 1H) H-5"; 2.60-1.20 (m, 13H) H-2', H-2", H-3', 3'-CH_2, $\underline{CH}_2CO\underline{CH}_3$, 5-$CH_3$.

1-[2',3'-Dideoxy-3'-$\underline{C}$-(3-oxobutyl)-β-D-*threo*-pentofuranosyl]thymine (40). **39** + **44** (227 mg, 0.4 mmol) gave **40** (79 mg, 67 %) using a condition described for **5**. ^{1}H-NMR ($CDCl_3$ + CD_3OD): 7.81 (q, $J_{6,CH3}$ = 1.1 Hz, 1H) H-6; 6.05 (dd, $J_{1'2'}$ = 9.1 Hz, $J_{1'2''}$ = 5.3 Hz, 1H) H-1'; 4.15 (ddd, $J_{3'4'}$ = 8.0 Hz, 1H) H-4'; 3.87 (dd, $J_{4'5'}$ = 3.0 Hz, $J_{5'5''}$ = 11.9 Hz, 1H) H-5'; 3.74 (dd, $J_{4'5''}$ = 3.7 Hz, 1H) H-5"; 2.50 (m, 4H) H-3', H-3"a, $\underline{CH}_2COCH_3$; 2.32 (ddd, $J_{2''3'}$ = 6.7 Hz, $J_{2'2''}$ = 12.1 Hz, 1H) H-2"; 2.18 (s, 3H) $COCH_3$; 2.13-1.73 (m, 2H) H-2', H-3"-b; 1.90 (d, 3H) 5-CH_3; ^{13}C-NMR ($CDCl_3$ + CD_3OD): 136.5(d, J_{CH} = 179.6 Hz) C-6; 110.5 (s) C-5; 85.2 (d, J_{CH} = 174.1 Hz) C-1'; 80.9 (d, J_{CH} = 147.5 Hz) C-4'; 62.1 (t, J_{CH} = 142.0 Hz) C5'; 42.1 (t, J_{CH} = 124.6 Hz) $\underline{C}H_2COCH3$; 39.7 (d, J_{CH} = 130.1 Hz) C-3'; 36.6 (t, J_{CH} = 132.4 Hz) C-2'; 29.8 (q, J_{CH} = 127.4 Hz) $COCH_3$; 22.2 (t, J_{CH} = 128.8 Hz) 3'-CH_2; 12.2 (q, J_{CH} = 129.2 Hz) 5-CH3. UV (EtOH): λ_{max} 267 nm (ε = 8700) (pH 7); 267 nm (ε = 8700) (pH 2); 264 nm (ε = 9590) (pH 12). MS (FAB^-): cal. for $(M-H)^-$ 295.1294, found 295.1281.

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