Chem. Pharm. Bull. 25(2) 239—245 (1977)

UDC 541.64.04 : 547.361.2-11.04

Studies on Telomers and Oligomers of Vinylene Carbonate. VII.[1] Facile Synthesis of Trihalogenomethyl-containing Aldo-sugars and Polyalcohols

Tsutomu Matsuura, Takehisa Kunieda, and Takeo Takizawa

Faculty of Pharmaceutical Sciences, University of Tokyo[2]

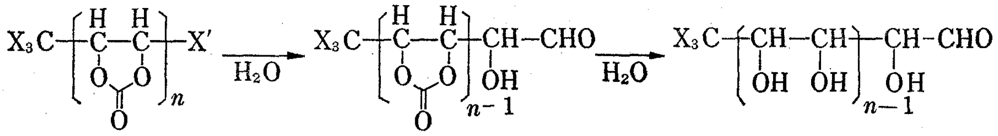
(Received May 20, 1976)

Facile routes to trichloromethyl-containing aldoses and polyalcohols from low telomers of vinylenecarbonate with carbon tetrachloride are described. 3,3,3-Trichloro-3-deoxyglyceraldehyde derived from $n=1$ adduct was dimerized to five-membered 1,3-dioxolane derivative preferentially, in contrast to the corresponding 3,3-dichloro compound which gave the dimer in 1,4-dioxane structure. Three-step procedure involving acetalization followed by removal of cyclic carbonate groups and subsequent deacetalization was mild and selective enough to permit the hydrolysis of $n=2$ telomers to 5,5,5-trichloro-5-dioxy-DL-lyxose and -xylose in excellent yields, while acid hydrolysis under more drastic conditions (at 100—110°) gave the rearranged 5,5,5-trichloro-3,5-dideoxy-pentosulose in dimeric form exclusively. Reduction of telomers ($n=1$ and 2) and the derivatives with sodium borohydride gave polyalcohols of the type $Cl_3C-(CHOH)_n-H$ ($n=2$, 3, and 4), among which some compounds showed considerable sedative activities.

Keywords——telomer; trihalogenomethyl-aldoses; trihalogenomethyl-polyalcohols; vinylene carbonate; 3-deoxy-pentosone; acetalization

In connection with our research programs on the novel synthesis of carbohydrates by telomerization of vinylene carbonate,[3] the present paper describes the convenient synthetic routes to polyalcohols including aldo-sugars which contain tri- (or di-) chloromethyl group at the terminal position from the low telomers of vinylene carbonate with carbon tetrachloride previously isolated[4] and the preliminary results pharmacologically evaluated with some of the polyalcohols thus obtained.

Re-examination of the reported hydrolysis (with sulfuric acid[4] or sodium alkoxides[4a]) of the type **1** telomers, quite sensitive towards nucleophiles, into aldose derivatives revealed the formation of the complicating mixture of little preparative value as a consequence of the undesirable side reactions (epimerization, degradation and condensation) and showed the need for the mild and selective hydrolytic method to α-hydroxy-aldehydes, which would permit an efficient conversion from vinylene carbonate telomers to carbohydrates.



1 (X, X'=Cl, Br) **2** **3**

Trichloromethyl-aldoses

Chloro-substituted ethylenecarbonate rings underwent the smooth and selective ring-opening merely by standing the aqueous solutions at room temperature to afford the excellent

---

[1] Part VI: N. Mitsuo, T. Kunieda, and T. Takizawa, *Chem. Pharm. Bull.* (Tokyo), 25, 231 (1977).

[2] Location: *Hongo, Bunkyo-ku, Tokyo.*

[3] H. Takahata, T. Kunieda, and T. Takizawa, *Chem. Pharm. Bull.* (Tokyo), 23, 3017 (1975); for a review, T. Kunieda and T. Takizawa, *J. Syn. Org.* (Japan), 33, 560 (1975).

[4] T. Tamura, T. Kunieda, and T. Takizawa, *J. Org. Chem.*, 39, 38 (1974); *a*) T. Tamura, Ph. D. dissertation (1972), University of Tokyo.

yields of crystalline α-hydroxy-aldehydes (**2**) in dimeric forms. Thus, $n=1$ compound (**4**) gave dimeric five membered ring product (**9**) (80%) selectively, and the acetonide (**12**) as a major product in the presence of large excess of acetone, while dichloromethyl compound (**5**) prepared from **4**[5a,b] and the stereoisomeric **13a** (*trans*-"*syn*"-*trans*)[3] and **13b** (*trans*-"*anti*"-*trans*)[3] preferentially formed six-membered ring dimers (**10** (70%), **16a** (87%) and **16b**) (90%), respectively.[6]

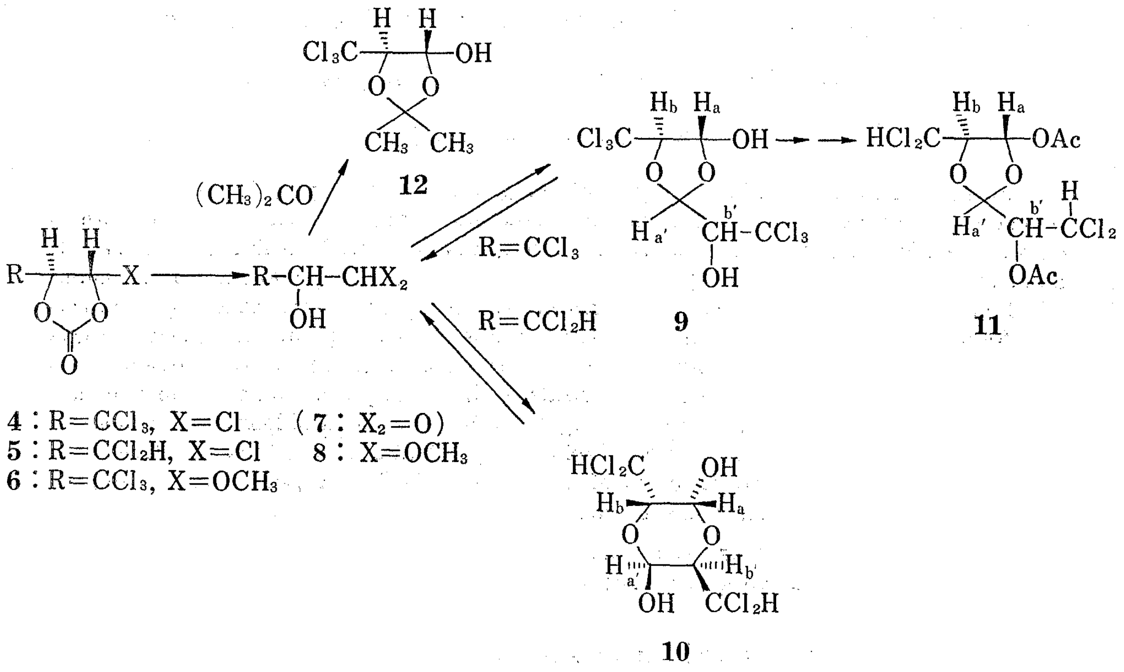


Chart 1

Structures of the dimers as well as their diacetates including stereochemistry were established as shown in the Charts on the basis of the nuclear magnetic resonance (NMR) spectral data (Table I). Five-membered ring structure of **9** was further demonstrated by reductive photolysis[5b] of the diacetate of **9** to give **11** which was distinctly different from the diacetate of **10** directly derived from **5**. Diacetates of the dimers (**10**, **16a**, and **16b**) showed in each case the identical signals due to H_a and $H_{a'}$ as well as those of H_b and $H_{b'}$ in the NMR spectra, indicative of the high symmetry in the 1,4-dioxane structures.

Complete hydrolysis of the $n=2$ telomers (**13a** and **13b**) or of the remaining cyclic carbonates of **16a** and **16b** under more drastic conditions (dilute hydrochloric acid at 100—110° in a sealed

Table I. NMR Spectral Data for Dimer Derivatives

Compound	H_a ($H_{a'}$) (δ)	H_b ($H_{b'}$) (δ)	$J_{a,b}$ ($J_{a',b'}$) (Hz)
9 diacetate[a]	6.55(5.82)	4.75(5.82)	2.0(0)
9 bis-methyl formate[a]	6.44(5.94)	4.75(5.64)	1.6(3.6)
10 diacetate[b]	6.47	4.35	1.5
11[a]	6.46(5.60)	4.46(5.46)	1.5(3.8)
16a diacetate[c]	6.24	4.37	9.0
16b diacetate[b]	6.13	4.34	9.0

a) $CDCl_3$, *b)* CF_3COOH, *c)* CH_3CN at 60 MHz

---

5) *a)* T. Kunieda, T. Tamura, and T. Takizawa, *J. Chem. Soc., Chem. Commun.*, **1972**, 885; *b)* N. Mitsuo, T. Kunieda, and T. Takizawa, *J. Org. Chem.*, **38**, 2255 (1973).

6) *cf.* Dimer of glycolaldehyde has been reported to consist of six- and five-membered ring compounds. E. Späth and L. Raschik, *Monatsh.*, **76**, 65 (1946); R. Jacquier, *Bull. Soc. Chim. Fr.*, **1950**, D 83.

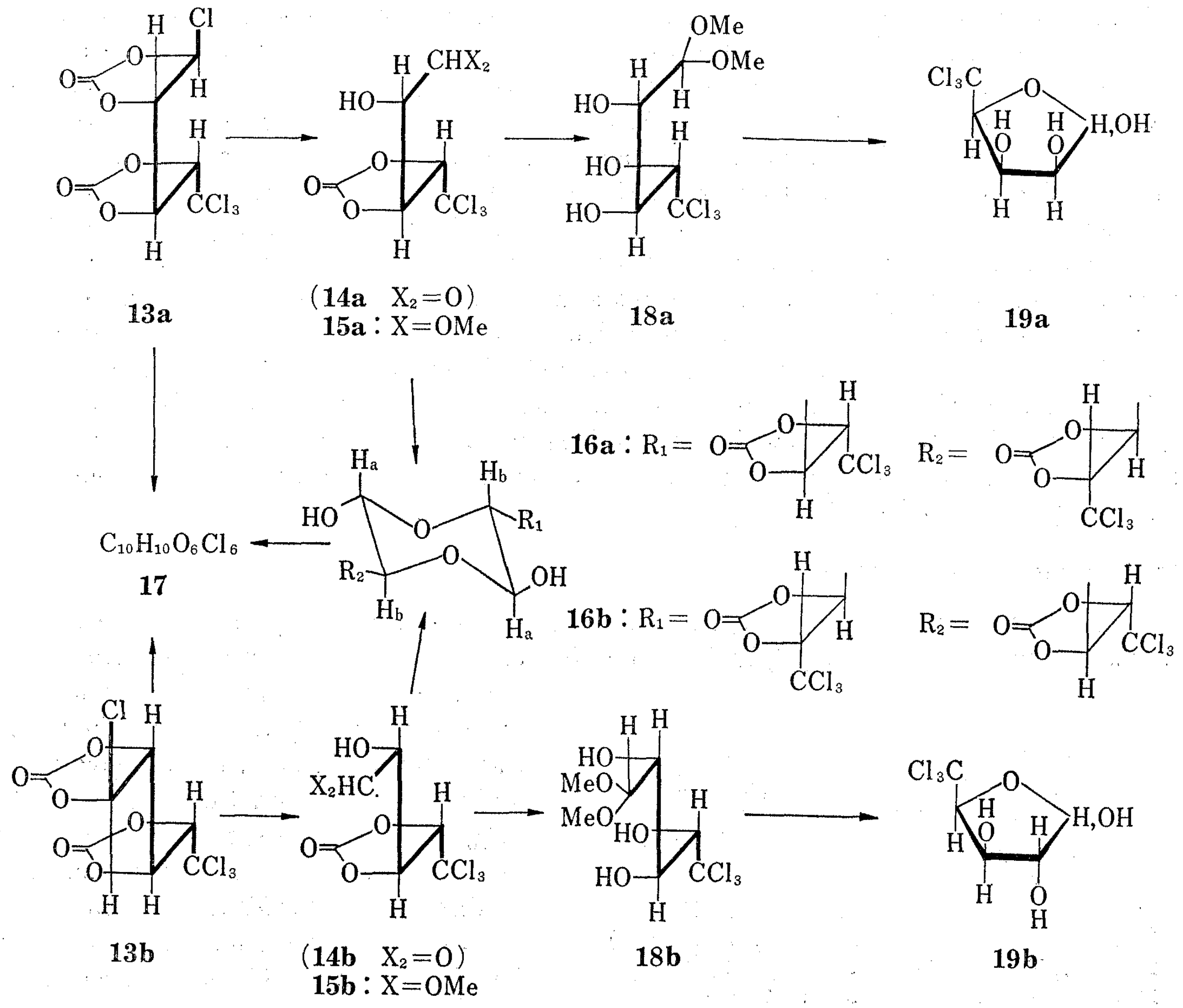
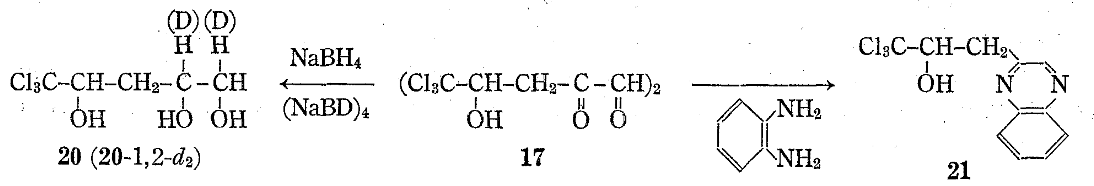


Chart 2

tube) resulted in the exclusive formation of unexpected compound (**17**) as colorless prisms (mp 138°, $C_{10}H_{10}O_6Cl_6$) (96%) which gave a diacetate and was assigned as the dimer of 5,5,5-trichloro-3,5-dideoxy-pentosulose[7] based on the spectral data and the following reactions. Treatment of **17** with sodium borohydride and borodeuteride gave high yields of **20** and **20**-1, 2-d_2 (in a diastereomeric mixture), respectively, proving during the hydrolysis the rearrangement to 3-deoxy-pentosone by the Lobry de Bruyn-Alberda van Ekenstein isomerization[8] of the primary products, lyxose and xylose derivatives. This monomeric structure was further confirmed by the isolation of quinoxaline derivative(**21**) arising from the reaction with *o*-phenylenediamine as well as by the reddish purple coloration of the di-oxime with nickel acetate,[9] though the dimeric actual structure still remains equivocal.



---

[7] *cf.* E.F.L.J. Anet, *Advan. Carbohydrate Chem.*, **19**, 181 (1964).

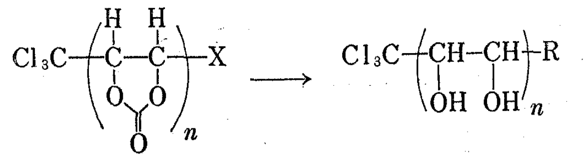
[8] *cf.* S. Coffey, Ed., "Rodd's Chemistry of Carbon Compounds," Vol. I, Part F, Elsevier, New York, N.Y. 1967, p. 262.

[9] M. Ishidate, *Mikrochim. Acta*, **3**, 283 (1938).

Efficient method for the conversion of the telomers to the aldoses involves selective protection of the aldehyde groups followed by hydrolysis with bases and subsequent deacetalization with acids. Thus, $n=2$ telomers (**13a** and **13b**) were heated in methanol to give quantitative yields of dimethyl acetals (**15a** and **15b**,) characterized as *p*-nitrobenzoates. On the same treatment, the $n=1$ adduct (**4**) afforded the acetal (**8**) in high yield *via* the primary substitution product (**6**) whose intermediacy in this reaction could be shown by the exclusive conversion to **8** under the identical conditions and the isolation of both products (**6** and **8**) depending on the duration. Sodium borohydride or triethylamine was satisfactory for the cleavage of the remaining carbonate rings of **15a,b** to give **18a** and **18b**, which, on subsequent treatment with a cation exchange resin (IR-120 H$^+$), gave 5-deoxy-5,5,5-trichloro-DL-lyxose (**19a**) and -xylose (**19b**) in 83% and 96% overall yields from **13a** and **13b**, respectively. Acetylation of **19a** and **19b** with acetic anhydride catalyzed by sulfuric acid resulted in the preferential formation of "β-anomers" which was shown by vicinal coupling constants ($J_{1,2}$) of 3.5 Hz and <0.5 Hz, respectively.[10] This mild method would provide the routes to heptoses and nonoses from higher telomers ($n=3$ and 4) which were previously isolated.[4]

Trichloromethyl-polyalcohols

Direct action of sodium borohydride on the telomers (**4**, **13a** and **b**) afforded high yields of trichloromethyl-propanediol (**23**) and trichloro-5-deoxy-lyxitol and -xylitol (**25a** and **b**) in a single step. On the similar treatment, *trans* cyano compound (**26**) derived from **4**[3] and *trans* ester (**22**)[3] gave *threo*-cyanohydrin (**27**) and trichloro-4-deoxy-threitol (**24**) in 73—82% and 58% yields, respectively. Convenient and high-yield preparation of **23** in this route provides a potential source for carbonyl protection as an ethylene ketal[11] which could be cleaved under neutral conditions by the familiar β,β,β-trichloro ether reductive elimination.[12]



4
13a, b
22 ($n=1$, X=COOMe)
26 ($n=1$, X=CN)

23 ($n=1$, R=H)
24 ($n=1$, R=CH_2OH)
25a, b ($n=2$, R=H)
27 ($n=1$, R=CN)

Preliminary Pharmacological Assays[13]

Some of the above polyalcohols containing trichloromethyl group which was known to show sedative actions in many compounds[14] were examined for the effects on the central nervous system of the mice. Compounds, (**9**, **23**, **24**, **25a**, and **25b**), had low oral toxicity ($LD_{50}>1000$ mg/kg) to ICR-JCL mice (male),[15] nearly comparable to that of ethylene-carbon tetrachloride telomers.[16] Among the compounds evaluated, **23** (100 mg/kg) showed the most promising properties as a hypnotic agent. In oral administration at the level of 100 mg/kg, **25a** showed significant analgesic and little hypnotic activities, while the stereoisomer (**25b**) was much more active in hypnotic action than analgesic. Compounds (**9** and **24**) showed little biological activity in this screening tests.

---

[10] J.D. Stevens and H.G. Fletcher, Jr., *J. Org. Chem.*, **33**, 1799 (1968).

[11] T. Kunieda and T. Takizawa, unpublished observations.

[12] *cf.* E.J. Corey and R.A. Ruder, *J. Org. Chem.*, **38**, 834 (1973); M.F. Semmelhack and G.E. Heinsohn, *J. Am. Chem. Soc.*, **94**, 5140 (1972).

[13] For these preliminary tests, we are much indebted to Drs. T. Kobayashi and M. Mori, The Mitsubishi-Yukayakuhin Research Laboratories.

[14] R.E. Bowman and W.R.N. Williamson, *J. Chem. Soc. (C)*, **1970**, 101 and the preceding papers in the series.

[15] Similar compound, 3,3-dichloro-2-hydroxy-2-propenal prepared from 4-dichloromethylene-5-chloro-1,3-dioxolan-2-one, showed the LD_{50} value 300 mg/kg.

[16] C.M. Starks, "Free Radical Telomerization," Academic Press, New York, N. Y. 1974, p. 109.

Experimental

All melting points (Yanaco micro melting point apparatus) are uncorrected. Infrared (IR) spectra were recorded on a JASCO-IR-S infrared spectrophotometer or JASCO-IRA-1 Grating infrared spectrophotometer, absorptions given in cm^{-1}. NMR spectra were recorded on a Hitachi R-24 spectrometer (60 MHz) using tetramethylsilane (TMS) as an internal standard. Telomers used were prepared from vinylene carbonate and carbon tetrachloride in the presence of benzoyl peroxide.[4]

3-Deoxy-3,3,3-trichloro-DL-glyceraldehyde, Dimer (9)——The solution of **4** (2.4 g, 0.01 mole) in a mixture (50 ml) of acetone and water (1: 1) or tetrahydrofuran (THF) and water (1: 1) was stirred at room temperature for 40 hr. The organic solvent was removed under reduced pressure, and the crystalline material precipitated was collected by filtration and washed with water to give the dimer (**9**) (1.42 g, 80%), which was recrystallized from MeOH–CH_2Cl_2 to afford colorless prisms, mp 173—178° (partly sublimed). IR (Nujol) 3440, NMR (CH_3CN, 100 MHz) δ 4.25 (1H, d, $J=4$ Hz), 4.46 (1H, d, $J=2$ Hz), 4.65 (1H, s, OH), 5.44 (1H, s, OH), 5.64 (1H, d, $J=2$ Hz), 5.66 (1H, d, 4 Hz). *Anal.* Calcd. for $C_6H_6O_4Cl_6$: C, 20.28; H, 1.69. Found: C, 20.32; H, 1.62.

Diacetate: mp 109—110° (from *n*-hexane–benzene), IR (Nujol) 1770, NMR ($CDCl_3$) δ 2.18 (3H, s), 2.20 (3H, s), 4.75 (1H, d, $J=2$ Hz), 5.82 (2H, s), 6.55 (1H, d, $J=2$ Hz). *Anal.* Calcd. for $C_{10}H_{10}O_6Cl_6$: C, 27.54; H, 2.15. Found: C, 27.33; H, 2.27.

Bis-methyl formate: mp 77—78° (from *n*-hexane–ether), IR (Nujol) 1767, NMR ($CDCl_3$) δ 3.87 (6H, s), 4.75 (1H, d, $J=1.6$ Hz), 5.64 (1H, d, $J=3.6$ Hz), 5.94 (1H, d, $J=3.6$ Hz), 6.44 (1H, d, $J=1.6$ Hz). Mass Spectrum *m/e*: 467 (M^+-1), 469, 471, 473, 475, and 395 (base). *Anal.* Calcd. for $C_{10}H_{10}O_8Cl_6$: C, 25.49; H, 2.14. Found: C, 26.23; H, 2.27.[17]

2-(1-Acetoxy-2,2-dichloroethyl)-5-dichloromethyl-1,3-dioxolan-4-yl Acetate (11)——Diacetate of **9** (170 mg, 0.387 mmole) was dissolved in THF (15 ml) and irradiated in a pyrex tube with a high pressure mercury lamp for 10 hr. The solvent was evaporated *in vacuo* and chromatography on silica-gel (CH_2Cl_2) followed by recrystallization from *n*-hexane–benzene gave **11** (106 mg, 74%), mp 87—88°, IR (Nujol) 1770, NMR ($CDCl_3$) δ 2.16 (3H, s), 2.19 (3H, s), 4.46 (1H, d.d, $J=1.5$ and 5.4 Hz), 6.46 (1H, d, $J=1.5$ Hz), 5.60 (1H, d, $J=3.8$ Hz), 5.46 (1H, d.d, $J=3.8$ and 5.4 Hz), 5.69 (1H, d, $J=5.4$ Hz), 5.90 (1H, d, $J=5.4$ Hz). *Anal.* Calcd. for $C_{10}H_{12}O_6Cl_4$: C, 32.46; H, 3.27. Found: C, 32.74; H, 3.34.

2,2-Dimethyl-5-trichloromethyl-1,3-dioxolan-4-ol (12)——Adduct (**4**) was dissolved in a 10% aqueous acetone and worked up in the analogous manner as described for **7**. Acetonide (**12**) was obtained as an oily substance in addition to **7** and the spectral properties follow: IR(neat) 3440, NMR ($CDCl_3$) δ 1.56 (6H, s), 4.60 (1H, d, $J=2$ Hz), 5.58 (1H, d, $J=2$ Hz).

Acetate: mp 48—48.5° (from *n*-hexane–CH_2Cl_2), IR (Nujol) 1759, NMR ($CDCl_3$) δ 1.59 (3H, s), 1.60 (3H, s), 2.14 (3H, s), 4.76 (1H, d, $J=2$ Hz), 6.45 (1H, d, $J=2$ Hz). *Anal.* Calcd. for $C_8H_{11}O_4Cl_3$: C, 34.59; H, 3.96. Found: C, 34.31; H, 3.93.

3-Deoxy-3,3-dichloro-DL-glyceraldehyde, Dimer (10)——Compound (**5**) (2.0 g, 0.01 mole) prepared from **4**[5b] was dissolved in 50% aqueous THF (50 ml) and kept at room temperature for 40 hr. The solution was concentrated *in vacuo* and the precipitates were collected and washed with water to give the dimer (**10**) as colorless crystals (1.0 g, 70%). Pure sample was obtained by recrystallization from MeOH, mp 180—185° (partly sublimed), IR (Nujol) 3395, *Anal.* Calcd. for $C_6H_8O_4Cl_4$: C, 25.17; H, 2.80. Found: C, 25.14; H, 2.68.

The acetate was recrystallized from THF to give colorless crystals, mp 243—245° (partly sublimed), IR (nujol) 1760, NMR (CF_3COOH) δ 2.35 (6H, s), 4.35 (2H, d.d, $J=1.5$ and 8 Hz), 5.54 (2H, d, $J=8$ Hz), 6.47 (2H, d, $J=1.5$ Hz). *Anal.* Calcd for $C_{10}H_{12}O_6Cl_4$: C, 32.46; H, 3.27. Found: C, 32.59; H, 3.20.

3,6-Bis(2-oxo-5-trichloromethyl-1,3-dioxolan-4-yl)-1,4-dioxane-2,5-diol (16a) and (16b)——a) To a solution of telomer (**13a**) (300 mg, 0.92 mmole) in THF (10 ml) was added 2N HCl (10 ml) and the mixture was stirred at room temperature for 40 hr. The solvent was removed *in vacuo*, and the resulting solid was washed with water to leave a colorless solid. Recrystallization from MeOH–acetone gave **16a** as colorless prisms, mp 174—175°, IR (Nujol) 3480 and 1790, *Anal.* Calcd. for $C_{12}H_{10}O_{10}Cl_6$: C, 27.53; H, 1.90. Found: C, 27.23; H, 1.78.

Diacetate: mp over 300° (from CH_2Cl_2–benzene), IR (Nujol) 1809, 1801 and 1770, NMR (CH_3CN) δ 4.37 (2H, d.d, $J=9$ and 1 Hz), 5.19 (2H, d.d, $J=4$ and 1 Hz), 5.42 (2H, d, $J=4$ Hz), 6.24 (2H, d, $J=9$ Hz). *Anal.* Calcd for $C_{16}H_{14}O_{12}Cl_6$: C, 31.42; H, 2.29. Found: C, 31.60; H, 2.18.

b) In the same way as above, telomer **13b** gave **16b** (384 mg, 90%) which was recrystallized from MeOH–acetone to afford colorless crystals, mp 184—185°, IR (nujol) 3490 and 1815, *Anal.* Calcd. for $C_{12}H_{10}O_{10}Cl_6$: C, 27.53; H, 1.90. Found: C, 27.23; H, 1.78.

Diacetate: mp over 300° (from CH_2Cl_2), IR (Nujol) 1822 and 1763 NMR (CF_3COOH) δ 2.36 (6H, s), 4.34 (2H, d.d, $J=9$ and 1 Hz), 5.08 (2H, d.d, $J=4$ and 1 Hz), 5.30 (2H, d, $J=4$ Hz), 6.13 (2H, d, $J=9$ Hz). *Anal.* Calcd. for $C_{16}H_{14}O_{12}Cl_6$: C, 31.42; H, 2.29. Found: C, 31.66; H, 2.34.

5,5,5-Trichloro-3,5-dideoxy-pentosulose, Dimer (17)——The solution of **13a** (2.0 g, 6 mmole) in 50% aqueous dioxane (8 ml) was heated at 100—110° in a sealed tube for 10 hr. The solvent was removed *in vacuo*

---

[17] In spite of extensive purification procedures and acceptable spectral data, elementary analyses showed the unsatisfactory results, which were reproducible on repeated runs.

and purification of an oily residue by chromatography on silica gel (CH_2Cl_2) gave **17** (1.32 g, 96%), which was recrystallized from ether–CH_2Cl_2 to afford colorless prisms, mp 136—138°, IR (Nujol) 3495 and 3380, NMR (CH_3CN) δ 3.50 (1H, m), 4.90 (2H, m), 5.27 (1H, s), 5.78 (1H, s). *Anal.* Calcd. for $C_{10}H_{10}O_6Cl_6$: C, 27.33; H, 2.27. Found: C, 27.45; H, 2.27.

Diacetate: mp 187—188° (from *n*-hexane–ether), IR (Nujol) 1758, NMR ($CDCl_3$) δ 2.15 (6H, s), 2.50 (3H, m), 3.32 (1H, q, J=14 and 6 Hz), 4.90 (2H, m), 6.02 (1H, s), 6.37 (1H, s). *Anal.* Calcd. for $C_{14}H_{14}O_8Cl_6$: C, 32.12; H, 2.68. Found: C, 31.93; H, 2.66.

17 was also obtained from **13b** and therefore the mixture of **13a** and **13b** was routinely used for the preparation.

5,5,5-Trichloro-1,2,4-pentanetriol (20)——To a cooled solution of **17** (100 mg, 0.23 mmole) in 85% aqueous MeOH (10 ml) was added $NaBH_4$ (40 mg, 1.03 mmole) and the mixture was refluxed for 3 hr. The solution was neutrallized with an ion exchange resin (Amberlite IR-120 H^+) and the resin was filtered off. Removal of the solvent followed by flash evaporation with MeOH (3 times) gave a colorless solid which was recrystallized from MeOH–acetone to give **20** as colorless needles (70 mg, 67%), mp 132—134°, IR (Nujol) 3320 and 3185, NMR (D_2O) δ 1.80 (2H, m), 3.40 (2H, t), 3.75 (1H, m), 4.30 (1H, d.d, J=9 and 2 Hz). *Anal.* Calcd. for $C_5H_9O_3Cl_3$: C, 26.87; H, 4.06. Found: C, 27.14; H, 4.09.

5,5,5-Trichloro-1,2,4-pentanetriol-1,2-d_2 (20-d_2)——In the same procedure as described for **20**, reduction of **17** (60 mg, 0.14 mmole) with $NaBD_4$ (0.2 g, 4.9 mmole) gave **20-d_2** (41 mg, 66%), which was recrystallized from MeOH–CH_2Cl_2 to afford colorless prisms, mp 128—130°, IR (Nujol) 3360, NMR (D_2O) δ 1.80 (2H, m), 3.50 (1H, d, J=7 Hz), 4.30 (1H, d.d, J=9 and 2 Hz).

α-Trichloromethyl-2-quinoxalineethanol (21)——The mixture of **17** (1.0 g, 2.27 mmole) and *o*-phenylenediamine (0.49 g, 4.54 mmole) in 30 ml of ethanol was refluxed for 4 hr and the solvent was removed *in vacuo*. Purification of the product by chromatography on silica gel (CH_2Cl_2) followed by recrystallization from CCl_4 gave **21** (0.7 g, 53%) as colorless needles, mp 108—109°, IR (Nujol) 3160 and 1560. NMR ($CDCl_3$) δ 3.53 (2H, m), 4.76 (1H, d.d, J=3 and 9 Hz), 7.57—8.09 (4H, m), 8.71 (1H, s). *Anal.* Calcd. for $C_{11}H_9ON_2Cl_3$: C, 45.28; H, 3.09; N, 9.61. Found: C, 45.35; H, 3.04; N, 9.71.

4-(1-Hydroxy-2,2-dimethoxyethyl)-5-trichloromethyl-1,3-dioxolan-2-one (15a) and (15b)——a) A methanolic solution (50 ml) of **13a** (2.5 g, 7.8 mmole) was refluxed in the presence of catalytic amount of *p*-toluenesulfonic acid for 65 hr. The solvent was removed *in vacuo* and the residue was chromatographed on silica-gel (CH_2Cl_2) to give **15a** (2.37 g, quantitatively) as a colorless viscous oil. IR (neat) 3480 and 1822.

p-Nitrobenzoate: mp 107—108° (from *n*-hexane–ether), IR (nujol) 1822, 1740, and 1603. NMR ($CDCl_3$) δ 3.51 (6H, s), 4.78 (1H, d, J=5.5 Hz; acetal proton), 5.15 (1H, m), 5.41—5.51 (2H, m), 8.25 (4H, s). *Anal.* Calcd. for $C_{15}H_{14}O_9NCl_3$: C, 39.28; H, 3.07; N, 3.05. Found: C, 39.35; H, 3.00; N, 2.96.

b) In the same procedure as described for the methanolysis to **15a**, telomer (**13b**) (1.42 g, 4.36 mmole) gave the acetal (**15b**) (1.345 g, quantitatively) as a colorless viscous oil. IR (neat) 3480 and 1820.

p-Nitrobenzoate: mp 127—128° (from *n*-hexane–ether), IR (Nujol) 1819, 1745, and 1607. NMR ($CDCl_3$) δ 3.40 (3H, s), 3.55 (3H, s), 4.75 (1H, d, J=6.5 Hz; acetal proton), 4.85 (1H, d, J=4 Hz), 5.22 (1H, d.d, J=4 and 1.8 Hz), 5.50 (1H, d.d, J=6.5 and 1.8 Hz), 8.31 (4H, s). *Anal.* Calcd for $C_{15}H_{14}O_9NCl_3$: C, 39.28; H, 3.07; N, 3.05. Found: C, 39.39; H, 3.13; N, 3.13.

5-Deoxy-5,5,5-trichloro-DL-lyxose (19a)——The mixture of **15a** (2.62 g, 8.4 mmole) and $NaBH_4$ (1.08 g, 28 mmole) in 80% aqueous MeOH (50 ml) was refluxed for 10 hr and neutrallized with a cation exchange resin (Amberlite IR 120 H^+). Another portion of the resin was added and the mixture was stirred at room temperature overnight. Removal of the solvent followed by flash evaporation with MeOH (3 times) gave crude lyxose (**19a**) (1.5 g, 82%) as an oil, whose IR spectrum (neat) showed band at 3400 and no absorption in the carbonyl region.

Triacetate (1,2-*cis* Isomer): mp 105—106° (from *n*-hexane–ether), IR (Nujol) 1765, NMR ($CDCl_3$) ρ 2.08 (3H, s), 2.10 (3H, s), 2.12 (3H, s), 4.86 (1H, d, J=5 Hz), 5.95 (1H, d.d, J=5 and 5 Hz), 5.35 (1H, d.d, J=3.5 and 5 Hz), 6.44 (1H, d, J=3.5 Hz). *Anal.* Calcd. for $C_{11}H_{13}O_7Cl_3$: C, 36.32; H, 3.61. Found: C, 36.47; H, 3.44.

5-Deoxy-5,5,5-trichloro-DL-xylose (19b)——The acetal (**15b**) (0.93 g, 3 mmole) in the same manner as described for **19a** gave crude product of **19b** (0.68 g, 96%) as viscous oil, which showed the absence of carbonyl functions in the IR spectrum. IR (neat) 3360.

Triacetate (1,2-*trans* Isomer): mp 92—93° (from *n*-hexane–CH_2Cl_2), IR (Nujol) 1757, NMR ($CDCl_3$) δ 2.08 (3H, s), 2.12 (6H, s), 4.94 (1H, d, J=7.3 Hz), 5.19 (1H, d.d, J=2 and 0.5 Hz), 5.64 (1H, d.d, J=2 and 7.3 Hz), 6.20 (1H, d, J=0.5 Hz). *Anal.* Calcd. for $C_{11}H_{13}O_7Cl_3$: C, 36.32; H, 3.61. Found: C, 36.40; H, 3.56.

1,1-Dimethoxy-3,3,3-trichloro-2-propanol (8)——a) Adduct (**4**) (1.2 g, 5 mmole) was dissolved in 25 ml of absolute MeOH and it was refluxed in the presence of catalytic amount of TsOH for 50 hr. Removal of the solvent followed by chromatography on silica-gel (CH_2Cl_2) gave **8** (1.11 g, 99%) as an oil. Further purification by distillation gave a viscous oil, bp 72—73°/1 mm, IR (neat) 3480, NMR ($CDCl_3$) δ 3.40 (3H, s), 3.53 (3H, s), 4.08 (1H, d, J=2 Hz), 4.75 (1H, d, J=2 Hz). *Anal.* Calcd. for $C_5H_9O_3Cl_3$: C, 26.84; H, 4.03. Found: C, 26.94; H, 4.20.

b) A methanolic solution (50 ml) of **4** (7 g, 29 mmole) and TsOH (catalytic amounts) was refluxed for 10 hr. Working up as above gave **6** (2 g, 29%) and **8** (2.5 g, 38%) as oily products which were identical with the authentic samples.

c) A methanolic solution (15 ml) of **6** (1.13 g, 4.8 mmole) was treated in the same way as above to give **8** (1.1 g, quantitatively), whose IR and NMR spectra were identical with those of **8** prepared from **4**.

4-Methoxy-5-trichloromethyl-1,3-dioxolan-2-one (6)——Compound **4** (6.0 g, 0.025 mole) was treated with NaOH (1.0 g, 0.025 mole) in absolute MeOH (60 ml) under ice-cooling for 7 hr. The methanol was removed *in vacuo* and acetone was added. Precipitates were filtered off. Evaporation of the filtrate followed by chromatography on silica gel (benzene) gave **6** (2.9 g, 50%) in addition to **7** (0.1 g, 2.2%). Spectral data were following: IR (neat) 1828, NMR ($CDCl_3$) δ 3.60 (3H, s), 4.75 (1H, d, $J=2$ Hz), 5.50 (1H, d, $J=2$ Hz).

Reduction to *gem*-Trichloro Polyalcohols (23, 24, 25a, 25b)——3,3,3-Trichloro-1,2-propanediol (**23**) provides the typical procedure as follows. To an aqueous methanolic solution of **4** (2.6 g, 10.8 mmole) was added $NaBH_4$ (0.5 g, 13.2 mmole) underi ce-cooling and the mixture was stirred during the first 30 min and then refluxed for 45 min. After the neutralization with an ion exchange resin (Amberlite IR 120 H^+) followed by removal of the precipitates with the aid of acetone, flash evaporation of the residue with MeOH (3 times) gave **23** (1.62 g, 83.5%), mp 83—84° (from CH_2Cl_2–acetone) (lit.,[18] mp 83°), IR (Nujol) 3440, NMR (D_2O) δ 3.75 (1H, d.d), 4.20 (1H, m), 4.20 (1H, m). *Anal.* Calcd. for $C_3H_5O_2Cl_3$: C, 20.07; H, 2.81. Found: C, 20.41; H, 2.81.

4-Deoxy-4,4,4-trichloro-DL-threitol (**24**) was analogously prepared from *trans*-ester (**22**) (3.6 g, 13.6 mmole) in 58% yield and recrystallized from CH_2Cl_2–acetone as colorless crystals, mp 103—104°, IR (Nujol) 3440 and 3280. *Anal.* Calcd. for $C_4H_7O_3Cl_3$: C, 22.92; H, 3.37. Found: C, 22.84; H, 3.28.

5-Deoxy-5,5,5-trichloro-DL-lyxitol (**25a**) was similarly prepared by reduction of telomer (**13a**) (0.652 g, 2 mmole) in 78% yield (0.374 g). Recrystallization from MeOH–CH_2Cl_2 gave **25a** as colorless needles, mp 151—152°, IR (Nujol) 3380, 3280, and 3180. *Anal.* Calcd. for $C_5H_9O_4Cl_3$: C, 25.05; H, 3.76. Found: C, 24.87; H, 3.72.

5-Deoxy-5,5,5-trichloro-DL-xylitol (**25b**) was obtained in 85% yield (0.325 g) from telomer (**13b**) (0.52 g, 1.6 mmole) in the same procedure as for **25a**, mp 125—126° (from MeOH–acetone), IR (Nujol) 3380. 3300, and 3240. *Anal.* Calcd. for $C_5H_9O_4Cl_3$: C, 25.05; H, 3.76. Found: C, 25.33; H, 3.79.

4,4,4-Trichloro-2,3-dihydroxybutyronitrile (27)——a) *trans*-Nitrile (**26**) (1.5 g, 6.5 mmole)[3] was treated with $NaBH_4$ (0.6 g, 0.015 mole) in 90% aqueous MeOH (30 ml) at room temperature for 1 hr. The reaction mixture was worked up in the usual way to give a mixture of the products as a solid. Separation by chromatography on silica gel (CH_2Cl_2–acetone 10%) gave cyanohydrin (**27**) (0.97 g, 73%) in addition to **23** (0.3 g, 25%). Recrystallization of **27** from CH_2Cl_2 gave an analytical sample of mp 80°, IR (Nujol) 3380, NMR (CH_3CN) δ 4.42 (1H, d, $J=2.8$ Hz), 5.14 (1H, d, $J=2.8$ Hz). *Anal.* Calcd. for $C_4H_4O_2NCl_3$: C, 23.49; H, 1.97; N, 6.85. Found: C, 23.63; H, 2.03; N, 6.84.

b) A solution of **26** (0.5 g, 2.16 mmole) in acetone (3 ml) and water (10 ml) was refluxed in the presence of a catalytic amount of conc. HCl for 3 hr. Removal of the solvent followed by chromatography on silica, gel (CH_2Cl_2–acetone 10%) gave **27** (0.364 g, 82%) which was identical with the compound prepared above.

---

[18] J. Colonge and G. Lartigau, *Bull. Soc. Chim. France*, **10**, 2436 (1964).