[Chem. Pharm. Bull. 24(11)2651—2656(1976)]

UDC 547.827.04 : 547.823.04

Synthetic Studies on Amino-sugars from Pyridines. II.[1] Synthesis of 5-Methoxycarbonylamino-5-deoxy-*dl*-xylopiperidinose Tetraacetate[2]

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(Received February 16, 1976)

Step-wise oxidation of the two double bonds in 1-alkoxycarbonyl-3-cyano-1,4- or -1,6-dihydropyridine (**6** or **5**) was found to be possible and 5-methoxycarbonyl-5-deoxy-*dl*-xylopiperidinose tetraacetate (**18a**) was synthesized *via* **5**, **12**, **13**, and **17** from nicotinonitrile.

N-Alkyldihydropyridines are generally unstable compounds and are readily oxidized to the corresponding pyridine derivatives by the action of various kinds of oxidizing agents.[4] Introduction of a cyano group at the β-position does not change their behavior to oxidation reaction and 5-cyano-1-methyl-2-pyridone (**2**) was the only detectable product, even when osmium tetroxide was used for the vicinal dihydroxylation of a dihydropyridine mixture mainly containing **1**.[5] In contrast, an N-acyldihydropyridine such as **3**[6] behaved in a different fashion and piperidine derivatives (**4**) having substituents on the ring were obtained by oxidation of **3** with potassium permanganate or with N-bromosuccinimide (NBS) in methanol or acetic acid. However, the stereochemical control seemed to be missing and the product in

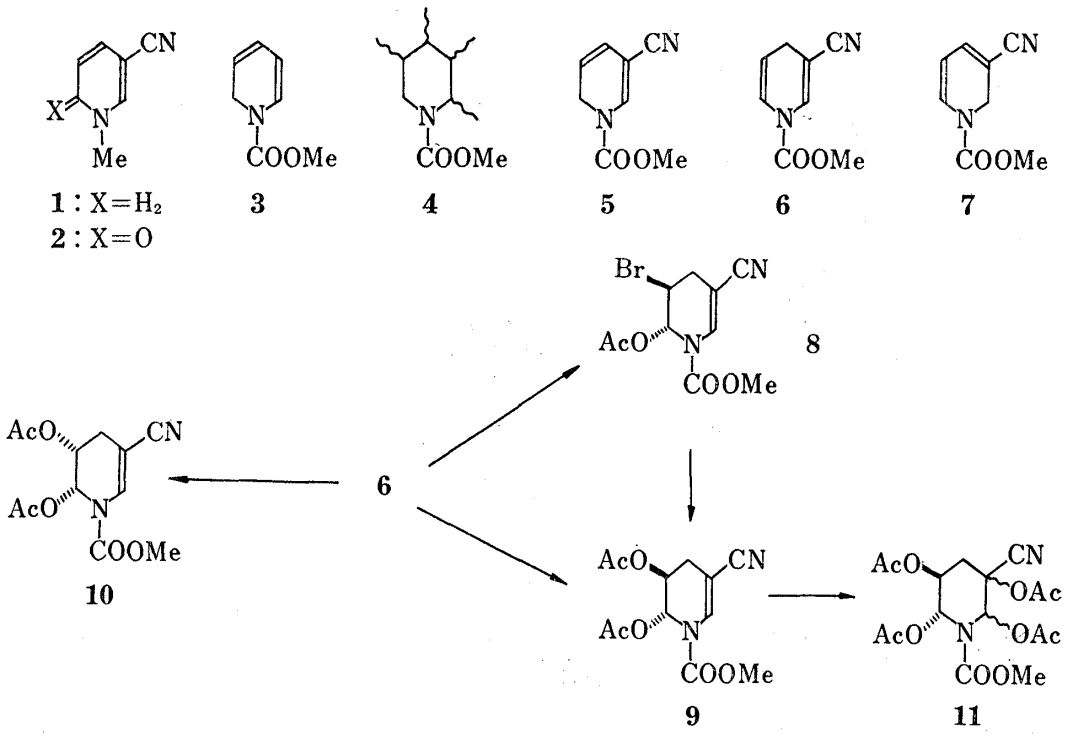

Chart 1

1) Part I: M. Natsume and M. Wada, *Chem. Pharm. Bull.* (Tokyo), **23**, 2567 (1975).
2) M. Natsume and M. Wada, Abstr. Papers, *6th Congr. Heterocycl. Chem.*, 187 (1973).
3) Location: *Tamagawa 2-28-10, Setagaya-ku, Tokyo, 158, Japan.*
4) U. Eisner and J. Kuthan, *Chem. Rev.*, **72**, 31 (1972).
5) N. Kinoshita and T. Kawasaki, *Yakugaku Zasshi*, **83**, 123 (1963).
6) F.W. Fowler, *J. Org. Chem.*, **37**, 1321 (1972).

either case was an unseparable mixture, which was composed of similar kinds of isomers possessing a different configuration of the substituents. For the synthesis of amino-sugars from pyridines, regio- and stereo-selective oxidation of the double bonds was necessary in the structure of 1,2-dihydropyridines and this was achieved by using **5** as a starting material.

Nicotinonitrile was reduced with sodium borohydride in the presence of methyl chlorocarbonate and, judging from the nuclear magnetic resonance (NMR) spectrum of the resulting mixture, the production of three possible dihydropyridine derivatives (**5**, **6**, and **7**) was recognized in the approximate ratio of 1:1:1, but only **6** was isolated in a pure state by chromatographic separation over silica gel. Oxidation of **6** was preliminarily carried out in order to ascertain that a dihydropyridine system, having both N-alkoxycarbonyl group and the electron-withdrawing group at the β-position with respect to the nitrogen, would resist various kinds of reactions for introducing the hydroxyl function into the double bonds. The 1,4-dihydropyridine derivative (**6**) was treated with NBS in acetic acid,[7] and a single product (**8**) was obtained in 49% yield. The orientation of the bromohydrin acetate grouping was determined as shown in the structure of **8**[8] because a proton signal involved in the coupling pattern with the methylene protons was shifted downfield by the change of the bromine to the acetoxyl function. The bromine atom in **8** was replaced by an acetoxyl group in 60% yield by the reaction of **8** with silver acetate in acetic acid with the retention of the configuration,[9] resulting in the formation of a *trans*-diol diacetate functionality. Woodward's dihydroxylation method

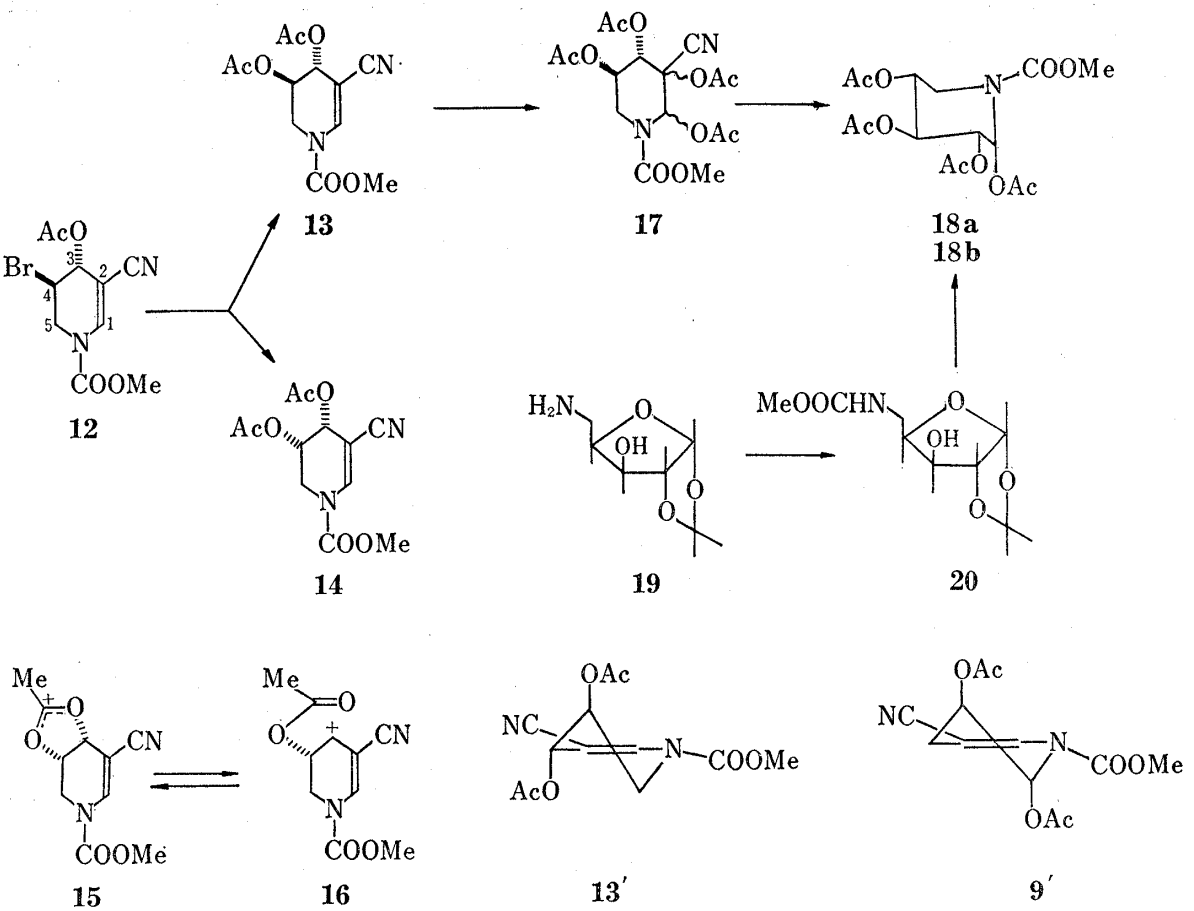

Chart 2

7) A. Iovchev, *J. Prakt. Chem.*, **28**, 186 (1965).
8) All formulae hereafter depict only one enantiomer of the respective racemates.
9) S. Winstein and R.E. Buckles, *J. Am. Chem. Soc.*, **64**, 2780 (1942).

using dry acetic acid as a solvent[10] gave the same diacetoxy derivative (**9**) in 34% yield, but the reaction was hardly reproducible and not so good as the above two-step procedure. Osmium tetroxide oxidation of **6** was carried out in benzene solution with the addition of a few drops of pyridine and, a *cis*-diol diacetate (**10**) was obtained in 22.5% yield after acetylation. Osmium tetroxide was reactive enough to oxidize the second double bond, which was a part of the vinylogous cyanamide function, and the reaction was much accelerated by the addition of an excess of pyridine and thus a tetraacetoxy derivative (**11**) with an unkown configuration of the newly introduced oxygen function was produced from **9** in 27% yield, implying that the two double bonds in dihydropyridine (**5** or **6**) behaved differently and the stepwise oxidation of each double bond became possible owing to the presence of the cyano group.

The dihydropyridine mixture (**5**, **6**, and **7**) stated above was subjected directly to the NBS oxidation in acetic acid, followed by the separation of the reaction mixture over silica gel, and another bromohydrin acetate (**12**) originating from **5** was obtained in 11.4% yield, in addition to the above-mentioned isomer (**8**) (10.4%). **12** differed from **8** in the chemical shift values both of methylene protons and of the proton signal adjacent to the acetoxyl group. Assignment of the coupling pattern (see Experimental part) revealed that the bromine and acetoxyl groups in **12** were located at C-4 and C-3 positions,[11] respectively, and this fact suggested that the dienamine character still existed in the structure of **5** and regulated the orientation of adding groups to produce a single derivative. Contrary to the model experiment using **8**, treatment of **12** with silver acetate in acetic acid afforded a mixture of *trans* (**13**) and *cis* (**14**) diol diacetates in the ratio of 2.4: 1, and the formation of **14** in this case was presumably considered to be derived from an allylic cation (**16**), which was equilibrated with the normal intermediate[9] (**15**). In order to improve the ratio for obtaining **13**, the reaction was carried out in a benzene-acetic acid mixture in the hope of less participation of **16** and a 6.6: 1 mixture of **13** and **14** was found to be produced in 42% yield. The structure of **14** was confirmed by identification with a sample isolated from the acetylated mixture of the osmium teroxide oxidation product of the dihydropyridine mixture (**5**, **6**, and **7**). The structure of **13** was deduced from the assignment of its NMR spectrum by the help of the spin decoupling study and the vicinal coupling constant of 3 Hz for either of J_{34}, J_{45a}, or J_{45e} suggested the possible conformation of **13** to be a half-chair form (**13'**) having two acetoxyl group in the *trans*-di*quasi*-axial configuration. A similar structure (**9'**) was also assumed for the corresponding isomeric diacetoxy derivative (**9**) and the repulsive interaction between two acetoxyl substituents seemed to be a predominant factor for fixing their conformation as **13'** and **9'**.

As in the case of the model experiment using **9**, the osmium tetroxide oxidation of **13**, followed by acetylation gave the expected tetraacetate (**17**) in 73% yield, but the configuration of newly formed acetoxyl functions remained unknown. The final step to convert the cyanohydrin acetate group at C-2 to the equatorial hydroxyl function proceeded smoothly by the treatment of **17** with sodium borohydride in methanol, and the desired 5-methoxycarbonylamino-5-deoxy-*dl*-xylopiperidinose tetraacetate (**18a**), mp 160—161°, was obtained after acetylation as a sole product in 71% yield. This compound possessed an empirical formula of $C_{15}H_{21}O_{10}N$ and the analysis of its NMR spectrum by the spin decoupling technique supported the structure (**18a**). The vicinal coupling constant of J_{23}, J_{34}, J_{45a}, and J_{45e} were 10, 10, 11, and 6 Hz, respectively, and these values suggested that all acetoxyl substituents on the piperidine ring from C-2 to C-4 were oriented in an equatorial manner and furthermore J_{12} of 3 Hz clearly indicated that the acetoxyl functions at C-1 and C-2 were in the *cis* relationship. The structure of the synthetic product was conclusively proved by comparison with the

10) R.B. Woodward and F.V. Brutcher, *J. Am. Chem. Soc.*, **80**, 209 (1958); L.F. Fieser and M. Fieser, "Reagents for Organic Synthesis," Vol. 1, John Wiley and Sons, Inc., New York, 1967, p. 1002.

11) Sugar numbering is used in this paper.

optically active sample derived from 5-amino-5-deoxy-1,2-O-isopropylidene-D-xylofuranose[12] (**19**). The amine (**19**) was submitted to the reaction with methyl chlorocarbonate in the presence of sodium methoxide in anhydrous methanol to yield methoxycarbonylamino derivative (**20**), mp 153—155.5°, and the protecting group was removed from **20** with aqueous acetic acid. The acetylation reaction of the resulting amino-sugar afforded 5-methoxycarbonylamino-5-deoxy-D-xylopiperidinose tetraacetate[13] (**18b**) as an oil, whose IR and NMR spectra were in complete agreement with those of the synthesized specimen (**18a**).

Experimental

All melting points were taken on Yanagimoto micro-melting point apparatus and are not corrected. IR spectra were recorded on Hitachi 215 spectrophotometer and NMR spectra were determined on Varian A-60 A instrument, using tetramethylsilane as an internal reference. Merck Silica Gel PF_{254} was used for preparative thin-layer chromatography (prep-TLC). Elemental analyses were performed by Mr. D. Ohata of this Laboratory.

Reduction of Nicotinonitrile with $NaBH_4$ in the Presence of Methyl Chlorocarbonate——$NaBH_4$ (883 mg) was suspended in a solution of nicotinonitrile (2.0 g) and methyl chlorocarbonate (3.0 g) in benzene (5 ml) and dimethylformamide (10 ml) was added under ice-cooling. Stirring was continued for 1 hr, the reaction mixture was diluted with H_2O and extracted with ether. The ether solution was washed with H_2O, dried over Na_2SO_4, and evaporated *in vacuo* to give a mixture of 1,6-, 1,4- and 1,2-dihydropyridine derivatives (**5**, **6**, and **7**) (2.128 g), whose ratio was determined to be approximately 1: 1: 1, judging from its NMR signals at δ 3.02 (m, $-CH_2-$ of **6**), 7.08 (d, $J=8$ Hz H_5 of **7**) and 7.44 (m, H_1 of **5** and **6**). This mixture was chromatographed over silica gel (65 g, CH_2Cl_2) to afford 1,4-dihydropyridine derivative (**6**) in the early fraction as yellow crystals, which was recrystallized from iso-PrOH to colorless prisms (315 mg), mp 83.5—84°. *Anal.* Calcd. for $C_8H_8O_2N_2$: C, 58.53; H, 4.91; N, 17.07. Found: C, 58.40; H, 4.97; N, 16.98. IR ν_{max}^{KBr} cm^{-1}: 2212, 1735, 1684, 1632. NMR δ ($CDCl_3$): 3.02 (2H, ddd, $J=3.5$, 2, 2 Hz, $-CH_2-$), 3.85 (3H, s, OMe), 4.98 (1H, ddd, $J=8.5$, 3.5, 3.5 Hz, H_4), 6.68 (1H, dddd, $J=8.5$, 2, 2, 2 Hz, H_5), 7.44 (1H, triple d, $J=2$ Hz, H_1).

NBS Oxidation of 6——A mixture of **6** (262 mg) and NBS (240 mg) in AcOH (5 ml) was kept to stand at room temperature for 2 days and AcOH was evaporated to dryness in a reduced pressure. The residue was dissolved in CH_2Cl_2, washed with sat. $NaHCO_3$–H_2O, and dried over Na_2SO_4. Evaporation of the solvent afforded a syrup, which was purified by prep-TLC (50% benzene–CH_2Cl_2) and recrystallization of the resulting crystals from iso-PrOH yielded 229 mg of **8** (40%) as colorless prisms, mp 119.5—120.5°. *Anal.* Calcd. for $C_{10}H_{11}O_4N_2Br$: C, 39.62; H, 3.66; N, 9.24. Found: C, 39.55; H, 3.74; N, 9.24. IR ν_{max}^{KBr} cm^{-1}: 2230, 1751—1740, 1642. NMR δ ($CDCl_3$): 2.08 (3H, s, OAc), 2.55 (1H, dddd, $J=18$, 2, 1, 1 Hz, H_{3e}), 3.07 (1H, ddd, $J=18$, 4.5, 2.5 Hz, H_{3a}), 4.35 (1H, ddd, $J=4.5$, 3.5, 2 Hz, H_4), 6.75 (1H, ddd, $J=3.5$, 1, 1 Hz, H_5), 7.64 (1H, ddd, $J=2.5$, 1, 1 Hz, H_1).

Conversion of 8 to 9——A mixture of **8** (1.818 g) and AcOAg (1.503 g) in AcOH (50 ml) was refluxed for 22.5 hr. When cooled, the solid was filtered off and the filtrate was evaporated *in vacuo*. The residue was dissolved in 10% MeOH–CH_2Cl_2, washed with sat. $NaHCO_3$–H_2O, and dried over Na_2SO_4. Evaporation of the solvent gave a mixture of mono- and di-acetates, and therefore, the mixture was acetylated with Ac_2O (5 ml) in pyridine (10 ml) at room temperature for 2 days, and treated in the usual way. A crystalline material thus produced was purified by recrystallization from iso-PrOH to give 837 mg of **9** as colorless prisms, mp 149—150°. Purification of the mother liquor by prep-TLC (CH_2Cl_2) afforded further 178 mg of **9**. Total yield of **9** was 1.015 g, 60%. An analytical sample was obtained by further recrystallization from iso-PrOH as colorless prisms, mp 150—151°. *Anal.* Calcd. for $C_{12}H_{14}O_6N_2$: C, 51.06; H, 5.00; N, 9.93. Found: C, 51.07; H, 5.00; N, 9.79. IR ν_{max}^{KBr} cm^{-1}: 2214, 1736, 1643. NMR δ ($CDCl_3$): 2.05 (3H, s, OAc), 2.08 (3H, s, OAc), 2.48 (1H, ddd, $J=2$, 1, 1 Hz, H_3), 2.53 (1H, dd, $J=3.5$, 2 Hz, H_3'), 3.90 (3H, s, OMe), 5.13 (1H, ddd, $J=3.5$, 3.5, 2 Hz, H_4), 6.67 (1H, ddd, $J=3.5$, 1, 1 Hz, H_5), 7.64 (1H, ddd, $J=2$, 1, 1 Hz, H_1).

Dihydroxylation of 6 with I_2 and AgOAc——A mixture of **6** (292 mg), I_2 (300 mg), and AgOAc (600 mg) in dry AcOH (8 ml) was refluxed for 3.5 hr. When cooled, the mixture was filtered and the filtrate was evaporated *in vacuo*. The residue was dissolved in CH_2Cl_2, washed with sat. $NaHCO_3$–H_2O, and dried over Na_2SO_4. Evaporation of the solvent gave a mixture of mono- and di-acetates, which was acetylated with Ac_2O (2 ml) in pyridine (3 ml) at room temperature overnight, followed by the usual treatment. The resulting yellow crystals were recrystallized from iso-PrOH to give 126 mg of **9** as colorless prisms, mp 146—147.5°. Purification of the mother liquor by prep-TLC (CH_2Cl_2) afforded 39 mg of the starting material and 20 mg of **9**. Total yield of **9** was 146 mg, 34%. This was identified as **9** by the comparison of IR and NMR spectra.

12) S. Akiya and T. Osawa, *Yakugaku Zasshi*, **76**, 1280 (1956).

13) H. Paulsen [*Ann, Chem.*, **670**, 121 (1963)] reported that the piperidinose form was favorable for 5-acetamido-5-deoxy-D-xylose.

OsO_4 Oxidation of 6——A mixture of **6** (150 mg) and OsO_4 (275 mg) in benzene (7 ml) containing 3 drops of pyridine was stirred at room temperature for 40 hr. It was diluted with CH_2Cl_2, H_2S gas was bubbled through the solution until the osmate was decomposed and the solvent was evaporated *in vacuo*. The residue was acetylated with Ac_2O (1.5 ml) in pyridine (3 ml) at room temperature for 5 hr. The product was purified by prep-TLC (CH_2Cl_2) and recrystallization of the product from iso-PrOH afforded 58 mg (22.5%) of **10** as colorless prisms, mp 139—140°. *Anal.* Calcd. for $C_{12}H_{14}O_6N_2$: C, 51.06; H, 5.00; N, 9.93. Found: C, 51.09; H, 5.13; N, 9.99. IR ν_{max}^{KBr} cm^{-1}: 2204, 1767, 1740, 1645. NMR δ ($CDCl_3$): 2.07 (3H, s, OAc), 2.13 (3H, s, OAc), 2.55 (2H, dd, J=9, 2 Hz, H_3), 3.88 (3H, s, OMe), 5.05 (1H, ddd, J=9, 9, 3 Hz, H_4), 6.98 (1H, d, J=3 Hz, H_5), 7.60 (1H, ddd, J=2, 2, 1 Hz, H_1).

OsO_4 Oxidation of 9——A mixture of **9** (101 mg) and OsO_4 (120 mg) in benzene (5 ml) containing 10 drops of pyridine was stirred at room temperature for 96 hr. It was diluted with CH_2Cl_2, H_2S gas was bubbled through the solution for 1 hr, and the solvent was evaporated in a reduced pressure. The residue was acetylated with Ac_2O (3 ml) and pyridine (3 ml) at room temperature for 44 hr. The resulting crude tetraacetate was purified by prep-TLC (1% MeOH–CH_2Cl_2) to afford 39 mg of **11** (27%). *Anal.* Calcd. for $C_{16}H_{20}O_{10}N_2$: C, 48.00; H, 5.04; N, 7.00. Found: C, 47.94; H, 5.02; N, 6.94. IR ν_{max}^{KBr} cm^{-1}: 1760. NMR δ ($CDCl_3$): 2.07 (3H, s, OAc), 2.10 (6H, s, OAc), 2.15 (3H, s, OAc), 2.45 (1H, dd, J=14.5, 3.5 Hz, H_3), 2.84 (1H, br d, J=14.5 Hz, H_3'), 4.03 (3H, s, OMe), 5.06 (1H, diffused q, J=*ca.* 2.5 Hz, H_4), 6.64 (1H, dd, J=2.5, 1 Hz, H_5), 7.30 (1H, diffused s, H_1).

NBS Oxidation of the Mixture of Dihydropyridines (5, 6, and 7)——A mixture of three dihydropyridine derivatives was obtained from nicotinonitrile (14.830 g), methyl chlorocarbonate (21.802 g), and $NaBH_4$ (5.984 g) as mentioned above. The mixture was dissolved in AcOH (70 ml), NBS (14.006 g) was added, and the whole was kept to stand at room temperature for 18.5 hr. The reaction mixture was evaporated *in vacuo*, and the residue, dissolved in CH_2Cl_2, was washed with sat. $NaHCO_3$–H_2O and dried over Na_2SO_4. Evaporation of the solvent afforded 21.1 g of a syrup, which was purified by repeated chromatography over silica gel to give 3.040 g of **8** (10.4%) and 3.338 g of **12** (11.4%). An analytical sample of **12** was obtained by recrystallization from iso-PrOH to colorless prisms, mp 139.5—141°. *Anal.* Calcd. for $C_{10}H_{11}O_4N_2Br$: C, 39.62; H, 3.66; N, 9.24. Found: C, 39.83; H, 3.75; N, 9.40. IR ν_{max}^{KBr} cm^{-1}: 2218, 1752, 1631. NMR δ ($CDCl_3$): 2.10 (3H, s, OAc), 3.69 (1H, dd, J=15, 3 Hz, H_5), 3.90 (3H, s, OMe), 4.27 (1H, triple d, J=3 Hz, H_4), 4.32 (1 H, diffused d, J=15 Hz, H_5'), 5.49 (1H, dd, J=3, 1.5 Hz, H_3), 7.88 (1H, diffused s, H_1).

Conversion of 12 to 13 and 14——i) A mixture of **12** (277 mg) and AcOAg (230 mg) in AcOH (10 ml) was refluxed for 8.5 hr. The solid material was filtered off and the filtrate was evaporated *in vacuo*. The residue, dissolved in CH_2Cl_2, was washed with sat. $NaHCO_3$–H_2O, and dried over Na_2SO_4. Evaporation of the solvent afforded a mixture of mono- and di-acetates, which was acetylated with Ac_2O (3 ml) in pyridine (5 ml) at room temperature for 2 days to give a mixture (166 mg) of *trans*- and *cis*-diacetates. The ratio of **13** and **14** was estimated to be 2.4: 1 from the integrated value of H_1 signals at δ 7.88 and 7.82 in the NMR spectrum of this mixture.

ii) A mixture of **12** (303 mg) and AcOAg (250 mg) in AcOH (5 ml) and benzene (10 ml) was refluxed for 87 hr, and treated as above. The oily material obtained was purified by prep-TLC to afford 34 mg of the starting material (11%) and a mixture of the two diacetates (105 mg, 42%). The ratio of **13** and 14 was determined to be 6.6: 1 by the same method as above. The mixture showed a single spot on the TLC plate and was hardly separable. Pure **13** and **14** were obtained after repeated chromatography over silica gel and prep-TLC. **13**: colorless prisms from ether–hexane, mp 91.5—93°. *Anal.* Calcd. for $C_{12}H_{14}O_6N_2$: C, 51.06; H, 5.00; N, 9.93. Found: C, 51.00; H, 5.04; N, 10.11. IR ν_{max}^{KBr} cm^{-1}: 2210, 1742, 1632. NMR δ ($CDCl_3$): 2.02 (3H, s, OAc), 2.07 (3H, s, OAc), 3.40 (1H, dd, J=15, 3 Hz, H_{5a}), 3.87 (3H, s, OMe), 4.22 (1H, dddd, J=15, 3, 1.5, 1 Hz, H_{5e}), 5.07 (1H, triple d, J=3 Hz, H_4), 5.30 (1H, dd, J=3, 1.5 Hz, H_3), 7.88 (1H, diffused s, H_1). **14**: syrup. *Anal.* Calcd. for $C_{12}H_{14}O_6N_2$: C, 51.06; H, 5.00; N, 9.93. Found: C, 50.96; H, 5.30; N, 9.35. IR ν_{max}^{KBr} cm^{-1}: 2224, 1751, 1633. NMR δ ($CDCl_3$): 2.10 (3H, s, OAc), 2.15 (3H, s, OAc), 3.68 (1H, dd, J=13, 8 Hz, H_{5a}), 3.92 (1H, ddd, J=13, 4, 1 Hz, H_{5e}), 3.95 (3H, s, OMe), 5.29 (1H, ddd, J=8, 4, 4 Hz, H_4), 5.20 (1H, ddd, J=4, 1, 1 Hz, H_3), 7.82 (1H, diffused s, H_1).

OsO_4 Oxidation of 13——A mixture of the crude **13** (295 mg) from the above experiment (ii) and OsO_4 (289 mg) in benzene (4 ml) and pyridine (2 ml) was kept to stand at room temperature for 39 hr, and the solvent was evaporated in a reduced pressure. The residue was dissolved in MeOH and CH_2Cl_2, and H_2S gas was introduced into the solution to give the desired diol (384 mg), 218 mg of which was acetylated with Ac_2O (1.5 ml) in pyridine (3 ml) at room temperature for 21 hr to give an only product. Purification of the oil by prep-TLC (1% MeOH–CH_2Cl_2) afforded 174 mg of **17** as colorless prisms, mp 147—147.5°, after recrystallization from iso-PrOH. *Anal.* Calcd. for $C_{16}H_{20}O_{10}N_2$: C, 48.00; H, 5.04; N, 7.00. Found: C, 47.71; H, 5.07; N, 7.08. IR ν_{max}^{KBr} cm^{-1}: 1765, 1733. NMR δ ($CDCl_3$): 2.05 (6H, s, OAc), 2.14 (6H, s, OAc), 3.01 (1H, dd, J=13, 10 Hz, H_{5a}), 3.81 (3H, s, OMe), 4.31 (1H, dd, J=13, 5.5 Hz, H_{5e}), 5.20 (1H, ddd, J=10, 10, 5.5 Hz, H_4), 5.61 (1H, d, J=10 Hz, H_3), 7.48 (1H, s, H_1).

5-Methoxycarbonylamino-5-deoxy-*dl*-xylopiperidinose Tetraacetate (18a)——$NaBH_4$ (9 mg) was added to a solution of **17** (72 mg) in MeOH (3 ml) under ice-cooling, and the resulting mixture was allowed to stand at room temperature for 39.5 hr. This mixture was neutralized with AcOH and the solvent was evaporated *in vacuo*. The residue was acetylated with Ac_2O (0.5 ml) in pyridine (1 ml) at room temperature for 3.25 hr to give a crystalline material, which was recrystallized from MeOH and **18a** (39 mg) was obtained as colorless prisms.

Purification of the mother liquor by prep-TLC (1% MeOH–CH_2Cl_2) afforded 9 mg of **18a**. Total yield of **18a** was 48 mg, 71%. An analytical sample, mp 160—161°, was obtained by further recrystallization from iso-PrOH. *Anal.* Calcd. for $C_{15}H_{21}O_{10}N$: C, 48.00; H, 5.64; N, 3.73. Found: C, 48.24; H, 5.70; N, 3.97. IR ν_{max}^{KBr} cm^{-1}: 1753. NMR (100 MHz) δ ($CDCl_3$): 1.99 (3H, s, OAc), 2.02 (3H, s, OAc), 2.04 (3H, s, OAc), 2.12 (3H, s, OAc), 3.07 (1H, dd, J=13, 11 Hz, H_{5a}), 3.76 (3H, s, OMe), 4.31 (1H, dd, J=13, 6 Hz, H_{5e}), 4.96 (1H, dd, J=10, 3 Hz, H_2), 4.96 (1H, ddd, J=11, 10, 6 Hz, H_4), 5.44 (1H, t, J=10 Hz, H_3), 6.94 (1H, d, J=3 Hz, H_1).

5-Methoxycarbonylamino-5-deoxy-D-xylopiperidinose Tetraacetate (18b)——The salt (50 mg) between 5-amino-5-deoxy-1,2-O-isopropylidene-D-xylofuranose and *p*-toluenesulfonic acid was stirred with the ion-exchanger resin, Amberlite IRA-400 (OH^- form, 2 ml) in MeOH (2 ml), the resin was filtered off, and the filtrate was evaporated *in vacuo* to yield the amine (**19**) as an oily product (27 mg). To the solution of this amine in anhyd. MeOH (1 ml) were added a solution (0.15 ml) of MeONa, prepared from Na (26 mg) and anhyd. MeOH (1 ml), and then a solution of methyl chlorocarbonate (33.5 mg) in anhyd. MeOH (1 ml). When the mixture was allowed to stand at room temperature for 1 hr, a solution of methyl chlorocarbonate (18 mg) in anhyd. MeOH (0.5 ml) was added to the reaction mixture, and it was continued to stand for further 1 hr. The solvent was evaporated and the residue dissolved in CH_2Cl_2 was washed with H_2O, and dried over Na_2SO_4. Evaporation of the solvent gave 20 mg of **20**, which was purified by recrystallization from ether–hexane to yield colorless needles, mp 119—120°. *Anal.* Calcd. for $C_{10}H_{17}O_6N$: C, 48.58; H, 6.93; N, 5.67. Found: C, 48.69; H, 7.02; N, 5.51. IR ν_{max}^{KBr} cm^{-1}: 3420, 1701. NMR δ ($CDCl_3$): 1.32 (3H, s, Me), 1.48 (3H, s, Me), 3.36 (2H, m, $-CH_2-$), 3.67 (3H, s, OMe), 4.10 (1H, d, J=2.5 Hz, H_3), 4.10 (1H, m, H_4), 4.55 (1H, d, J=3.5 Hz, H_2), 5.25 (1H, m, NH), 5.89 (1H, d, J=3.5 Hz, H_1). Mass Spectrum *m/e*: 232 (M^+-Me).

A solution of **20** (20 mg) in 20% AcOH solution (5 ml) was heated at 75° for 2 hr, refluxed for 45 min, and evaporated in a reduced pressure. The residue was acetylated with Ac_2O (1 ml) in pyridine (1.5 ml) at room temperature for 3 hr. The reaction mixture was evaporated *in vacuo*, diluted with H_2O, and extracted with CH_2Cl_2. The extract was washed with sat. $NaHCO_3$–H_2O, dried over Na_2SO_4, and evaporated to leave a yellow oily product. It was purified by prep-TLC to give a colorless syrup (**18b**, 16 mg, 30.8% from **19**-*p*-toluenesulfonate), whose IR (in $CHCl_3$, CS_2) and NMR spectra were identical with those of **18a**.

Acknowledgement The authors express their deep gratitude to the late Professor Emeritus E. Ochiai for his encouragement. The authors also thank Dr. S. Inoue of Meiji Seika Kaisha Ltd. for the sample of 5-amino-5-deoxy-1,2-O-isopropylidenexylofuranose *p*-toluenesulfonate. They are also indebted to the Faculty of Pharmaceutical Science, University of Tokyo, and Hitachi Ltd. for the determination of NMR spectra. A part of this work was supported by a Grant-in-Aid for Scientific Research from the Ministry of Education, Science and Culture, which is gratefully acknowledged.