Aminocyclitols. 33. Synthesis of Diaminocyclopentanetriols[1]

Kinnichi TADANO, Yasufumi EMORI, Mitsukuni AYABE, and Tetsuo SUAMI

Department of Applied Chemistry, Faculty of Engineering, Keio University, Hiyoshi, Yokohama 223

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Three hitherto unknown 2,5-diamino-1,3,4-cyclopentanetriols have been prepared. Their structures were established by chemical evidence.

We have been studying a synthesis of carbocyclic nucleoside analogs[2] and during the course of this study, we needed 2,5-diamino-1,3,4-cyclopentanetriols with analogous configurations as those of the pentose moiety of naturally occurring nucleoside antibiotics, such as puromycin[3] and 3′-amino-3′-deoxyadenosine.[4]

In the first attempt for this aim, 5-acetamido-1-*O*-benzoyl-1,2,3,4-cyclopentanetetrol (**2**) seemed to be an adequate starting material, which was obtained by mono-*O*-benzoylation of 2,3-*O*-cyclohexylidene-(1,4/2,3,5)-5-acetamido-1,2,3,4-cyclopentanetetrol (**1**),[5] followed by mild acid hydrolysis. Sodium metaperiodate oxidation of **2** afforded the corresponding dialdehyde (**3**) and then **3** was cyclized with nitromethane in the presence of sodium ethoxide. The product was catalytically hydrogenated and subsequently acetylated. The product was purified on a silica gel column to give penta-*N,O*-acetyl-2,5-diamino-1,3,4-cyclopentanetriol (**4**) as a main product in 11% yield. A few minor products were detectable on TLC, but they were not isolated in a crystalline state.

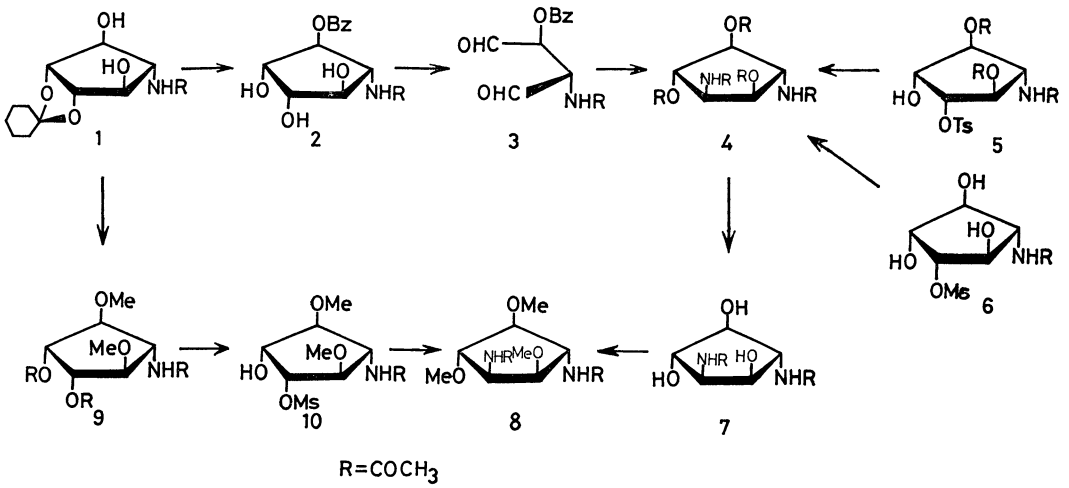
There are ten theoretically possible stereoisomers (A—J) in 2,5-diamino-1,3,4-cyclopentanetriols. In the present reaction, three new chiral centers are introduced in the product and therefore, seven stereoisomers are possible for **4**. Since the PMR spectrum of **4** indicated a lack of a molecular symmetry, five stereoisomers: E, F, G, H and J are possible. On the other hand, when 2-*O*-tosyl- (**5**)[8] or 2-*O*-mesyl-DL-(1,4/2,3,5)-5-acetamido-1,2,3,4-cyclopentanetetrol (**6**)[8] was heated with sodium azide in *N,N*-dimethylformamide (DMF), an azido derivative was obtained. The product was hydrogenated and subsequently acetylated to give the same compound **4**.

Considering from the reaction employed, the configurations on C-3, 4 and 5 are not changed. Therefore, three stereoisomers: F, G and H are possible for **4**. To distinguish these three, following reactions have been attempted.

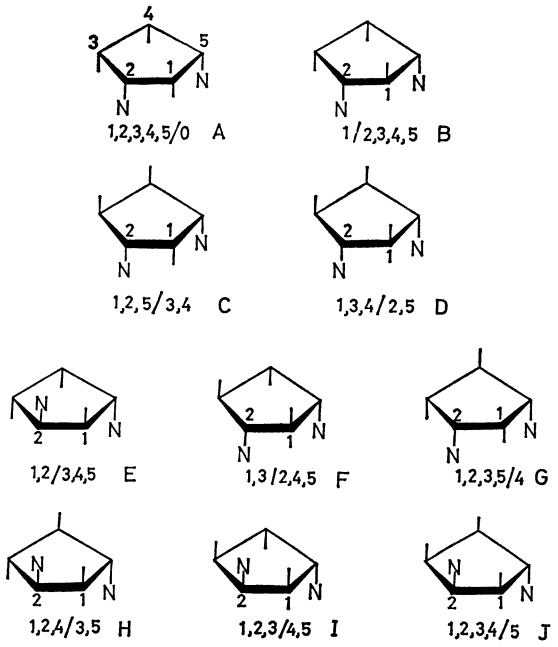
Since a possibility of neighboring group participation on the azidolysis of **6** is avoided by methylating the hydroxyl groups on C-1 and 4, 1,4-di-*O*-methyl derivative of **6** (**10**) has been submitted to the azidolysis. The azide derivative thus obtained was hydrogenated and *N*-acetylated to give 2,5-diacetamido-1,4-di-*O*-methyl-1,3,4-cyclopentanetriol. The product was further *O*-methylated to give 2,5-diacetamido-1,3,4-tri-*O*-methyl-1,3,4-cyclopentanetriol (**8**), which was identified with the compound derived from **4** *via* **7**. This fact indicated that the displacement of the mesyloxy group by a highly nucleophilic azide ion occurred in a direct S_N2 mechanism with a Walden inversion of the configuration on C-2.[6,7] Therefore, the configuration of **4** was established to be H.

In the second attempt, two other stereoisomers of 2,5-diamino-1,3,4-cyclopentanetriols (**14** and **15**) were prepared by azidolysis of 2,3-di-*O*-mesyl-(1,4/2,3,5)-5-acetamido-1,2,3,4-cyclopentanetetrol[8] (**11**). Azidolysis of **11**, followed by acetylation afforded two diastereomers of 1,3,4-tri-*O*-acetyl-5-acetamido-2-azido-1,3,4-cyclopentanetriols (**12** and **13**) in 32 and 7% yield respectively. The corresponding penta-*N,O*-acetyl-2,5-diamino-1,3,4-cyclopentanetriols (**14** and **15**) were prepared from **12** and **13**.

The configurations of **14** and **15** were established to be those of I and F respectively by the following evidence. (1) Both diacetamido-cyclopentanetriols (**16** and **17**) which were prepared from **14** and **15** respectively,



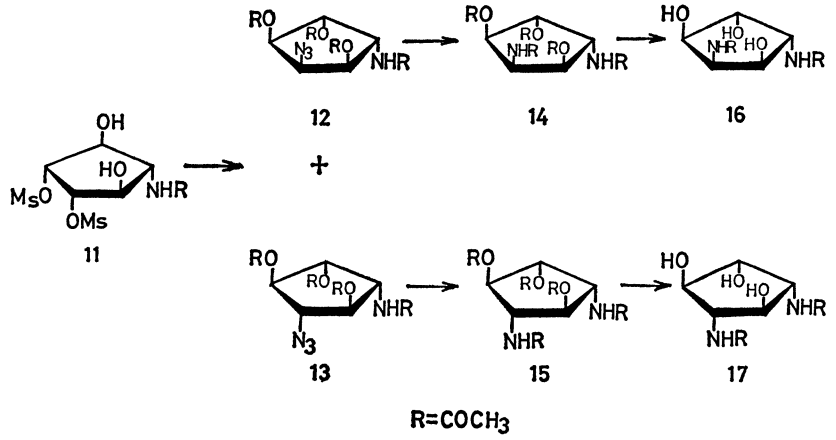
Scheme 1.



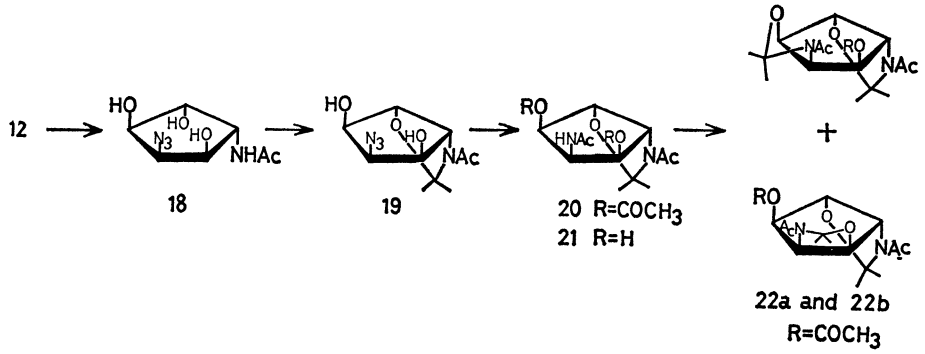
Scheme 2. 2,5-Diaminocyclopentanetriols.

consumed one molar equivalent of periodate respectively, and this fact indicated that they had two acetamido groups on C-2 and 5 (not on C-1 and 5). (2) Displacement of the mesyloxy group on C-3 of **11** proceeded *via* an intermediary epoxide with a participation of the hydroxyl group on C-4 and the epoxide was attacked by a hydroxide ion to give *trans*-3,4-diol.[8] Therefore, four stereoisomers: F, G, H and I are likely for **14** and **15**, but none of them is identical with **4** (H-configuration). Also a formation of a compound with G-configuration is hardly explained without a big contradiction of *cis*-opening of an intermediary epoxide between C-1 and C-2 by an azide ion. (3) When the azido-acetates (**12** and **13**) were catalytically hydrogenated, **12** gave a ninhydrin negative product and **13** gave a ninhydrin positive product. This fact suggested that the former had an acetyl group migration from O to N between a vicinal *cis*-located amino-acetate and I-configuration was given to **12**. Accordingly, F-configuration was given to **13**. (4) This was further confirmed by a formation of di-*N*,*O*-isopropylidene derivatives in the case of **16** and a formation of mono-*N*,*O*-isopropylidene derivative in the case of **17**.[10]

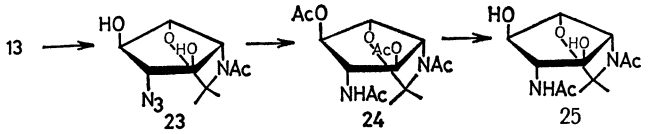
A direct S_N2 mechanism is proposed to the displace-



Scheme 3.



Scheme 4.



Scheme 5.

ment of the mesyloxy group on C-2 of **11** by an azide ion in a formation of **12**, and an anchimeric reaction mechanism is proposed in a formation of **13**.

Experimental

Mps were measured in capillary tubes and are uncorrected. Acetylation was carried out in the usual manner with acetic anhydride in pyridine. De-*O*-acetylation was performed in methanolic ammonia. Hydrogenation was carried out with Raney nickel in a hydrogen atmosphere (3.4 kg/cm^2) in Parr shaker apparatus. Silica gel (Wakogel C-200, Wako Pure Chemical Ind. Ltd.) was used for column chromatography and TLC was performed on a Wakogel B-10 plate in benzene–ethanol (5 : 1, v/v) solvent system. PMR spectrum was measured at 60 MHz on a Varian A-60D spectrometer in $CDCl_3$ with reference to tetramethylsilane as an internal standard and the peak positions are given in τ values. Elemental analyses were performed by Mr. Saburo Nakada, to whom our thanks are due.

*2,3-O-Cyclohexylidene-(1,4/2,3,5)-5-acetamido-1,2,3,4-cyclopentanetetrol (**1**).* The compound was prepared by the method described in the previous paper.[5]

*1-O-Benzoyl-*DL*-(1,4/2,3,5)-5-acetamido-1,2,3,4-cyclopentanetetrol (**2**).* Compound **1** (5.0 g) was dissolved in dry pyridine (50 ml), and benzoyl chloride (3.5 ml) was added to the solution drop by drop under ice cooling with mechanical agitation. After settled overnight at room temperature, the reaction solution was poured into ice cold water to give crystalline precipitates (7.97 g) which consisted of two components of R_f 0.7 and 0.5 on TLC. The precipitate was heated in 50% aqueous acetic acid for 2 h under reflux and then evaporated. The residue was dissolved in cold water (150 ml) and the solution was extracted with chloroform repeatedly. From the combined chloroform layers, 1,4-di-*O*-benzoyl derivative[9] was obtained in 31% yield.

The aqueous layer was evaporated and the residue was recrystallized from ethanol to give 1.84 g (34%) of **2**, mp 163—165 °C.

Found: C, 56.66; H, 5.88; N, 4.58%. Calcd for $C_{14}H_{17}NO_6$: C, 56.94; H, 5.80; N, 4.74%.

*Periodate Oxidation of **2**.* Sodium metaperiodate (675 mg) was dissolved in ice cold water (35 ml) and **2** (775 mg) was added to the solution under ice cooling with agitation. After 1 h another crop of sodium metaperiodate (576 mg) was added to the solution and the reaction solution was settled overnight in a refrigerator. Crystalline products which appeared in the solution were collected by filtration to give 546 mg (79%) of the dialdehyde (**3**), mp 138—142 °C. The product was used for the successive reaction without any purification.

*Nitromethane Cyclization of **3**.* Compound **3** (546 mg) was dissolved in methanol (10 ml) and nitromethane (0.7 ml) was added to the solution in the presence of 0.9 M methanolic sodium methoxide (7 ml) under ice cooling with agitation. After settled overnight in a refrigerator, the solution was adjusted to pH 5 with glacial acetic acid and then catalytically hydrogenated for 18 hr. After the catalyst was filtered off, the solution was evaporated and the residue was acetylated. The product was fractionated on a silica gel column. Fractions which showed a single spot at R_f 0.4 on TLC were combined and evaporated to give a crystalline residue (100 mg). Recrystallization from ether afforded 80 mg (11%) of 1,3,4-tri-*O*-acetyl-DL-(1,2,4/3,5)-2,5-diacetamido-1,3,4-cyclopentanetriol (**4**), mp 191—193 °C; PMR: τ 8.04 (s, 6, 2NAc), 7.95 (s, 3, OAc), 7.93 (s, 3, OAc), 7.90 (s, 3, OAc), 3.48 (d, 1, J=8 Hz, NH), 2.67 (d, 1, J=8 Hz, NH).

Found: C, 50.58; H, 6.13; N, 7.54%. Calcd for $C_{15}H_{22}N_2O_8$: C, 50.28; H, 6.19; N, 7.82%.

*Azidolysis of 1,4-Di-O-acetyl-2-O-tosyl-*DL*-(1,4/2,3,5)-5-acetamido-1,2,3,4-cyclopentanetetrol (**5**).* Compound **5**[8] (0.50 g) was heated with sodium azide (0.76 g) in DMF (10 ml) at 120 °C for 10 h with agitation. The reaction mixture was filtered and the filtrate was evaporated. The residue was extracted with warm ethyl acetate and the ethyl acetate solution was catalytically hydrogenated for 40 h. After the catalyst was removed by filtration, the filtrate was settled in a refrigerator to give 28 mg (9%) of crystalline product, mp 226—228 °C. The product was acetylated and then recrystallized from ether to give 30 mg (7%) of **4**, which was identified with an authentic sample.

The ethyl acetate mother liquor was evaporated and the residue was acetylated. The product was fractionated on a silica gel column to give 109 mg (26%) of 1,2,3,4-tetra-*O*-acetyl-DL-(1,2,4/3,5)-5-acetamido-1,2,3,4-cyclopentanetetrol, mp 110—111 °C, which was identified with an authentic sample.[8]

*Azidolysis of 2-O-Mesyl-*DL*-(1,4/2,3,5)-5-acetamido-1,2,3,4-cyclopentanetetraol (**6**).* Compound **6**[8] (0.65 g) was heated in DMF (20 ml) at 115 °C with sodium azide (1.57 g) for 10 h with agitation. The mixture was filtered and the filtrate was evaporated. The residue was acetylated overnight and the reaction solution was poured into ice cold water. The mixture was extracted with chloroform repeatedly and the combined chloroform layer was evaporated. The residue was hydrogenated in ethanol (12 ml) and the product was acetylated to give 0.59 g (68%) of **4**, 189—191 °C, which was identified with an authentic sample.

*DL-(1,2,4/3,5)-2,5-Diacetamido-1,3,4-cyclopentanetriol (**7**).* Compound **4** (188 mg) was de-*O*-acetylated and the product was recrystallized from ethanol to give 84 mg (69%) of **7** as hygroscopic crystals, mp 171—172 °C.

*1,3,4-Tri-O-methyl-*DL*-(1,2,4/3,5)-2,5-diacetamido-1,3,4-cyclopentanetriol (**8**).* Compound **7** (99 mg) was treated with methyl iodide (0.17 ml) in DMF (2 ml) in the presence of silver oxide (0.44 g) for 70 h with agitation. The reaction mixture was filtered and the filtrate was evaporated. The residue was extracted with warm ethanol and the alcoholic solution was evaporated. The residue was recrystallized from ethyl acetate–petroleum ether to give 40 mg (34%) of **8**, mp 193—194 °C; PMR: τ 8.00 (s, 3, NAc), 7.97 (s, 3, NAc), 6.60 (s, 3, OCH_3), 6.58 (s, 6, $2OCH_3$), 3.73 (d, 1, J=8 Hz, NH), 2.92 (d, 1, J=9 Hz, NH).

Found: C, 52.43; H, 7.83; N, 10.27%. Calcd for $C_{12}H_{22}N_2O_5$: C, 52.54; H, 8.09; N, 10.21%.

*2,3-Di-O-acetyl-1,4-di-O-methyl-(1,4/2,3,5)-5-acetamido-1,2,3,4-cyclopentanetetrol (**9**).* Compound **1** (2.81 g) was methylated analogously as described in the preparation of **8**. The product was hydrolyzed in 0.1 M hydrochloric acid for 2 h under reflux, and then the solution was evaporated. The residue was acetylated and the product was purified on a silica gel column. The product was recrystallized from benzene to give 1.72 g (55%) of **9**, mp 98—99 °C; PMR τ 7.99 (s, 3, NAc), 7.95 (s, 6, 2OAc), 6.62 (s, 6, $2OCH_3$), 3.74 (d, 1, J=9 Hz, NH).

Found: C, 51.76; H, 7.13; N, 4.51%. Calcd for $C_{13}H_{21}NO_7$: C, 51.48; H, 6.98; N, 4.62%.

*2-O-Mesyl-1,4-di-O-methyl-*DL*-(1,4/2,3,5)-5-acetamido-1,2,3,4-cyclopentanetetrol (**10**).* Compound **9** (2.63 g) was de-*O*-acetylated to give 2.36 g of syrup. The syrup was *O*-mesylated with mesyl chloride (1.5 ml) in pyridine (8 ml) overnight with agitation. After an excess of mesyl chloride was decomposed by adding cold water (4 ml), the reaction solution was evaporated. The residue was extracted with

chloroform, and the extract was purified on a silica gel column. Fractions which showed a single spot at R_f 0.37 on TLC were combined and evaporated to give crystals. Recrystallization from ethyl acetate afforded 1.37 g (53%) of **10**, mp 115—116 °C; PMR ($CDCl_3$–pyridine-d_5 3 : 1, v/v): τ 7.95 (s, 3, NAc), 6.82 (s, 3, OSO_2CH_3), 6.51 (s, 3, OCH_3), 6.47 (s, 3, OCH_3), 2.00 (d, 1, J=8 Hz, NH).

Found: C, 40.58; H, 6.32; N, 4.56; S, 10.67%. Calcd for $C_{10}H_{19}NO_7S$: C, 40.40; H, 6.44; N, 4.71; S, 10.78%.

Acetylation of **10** (30 mg) yielded 29 mg (85%) of the corresponding mono-*O*-acetyl derivative, mp 79—80 °C; PMR τ 7.98 (s, 3, NAc), 7.87 (s, 3, OAc), 6.95 (s, 3, OSO_2CH_3), 6.57 (s, 3, OCH_3), 6.53 (s, 3, OCH_3), 3.84 (d, 1, J= 9 Hz, NH).

Found: C, 42.71; H, 6.11; N, 4.01; S, 9.27%. Calcd for $C_{12}H_{21}NO_8S$: C, 42.47; H, 6.24; N, 4.13; S, 9.45%.

From the fractions (R_f 0.57), 0.29 g (9%) of 2,3-di-*O*-mesyl derivative, mp 132—133 °C, was obtained. PMR ($CDCl_3$–pyridine-d_5 1 : 1, v/v): τ 7.96 (s, 3, NAc), 6.80 (s, 6, $2OSO_2CH_3$), 6.48 (s, 6, $2OCH_3$), 2.15 (d, 1, J=12 Hz, NH).

Found: C, 35.21; H, 5.49; N, 3.65; S, 16.88%. Calcd for $C_{11}H_{21}NO_9S_2$: C, 35.19; H, 5.64; N, 3.73; S, 17.08%.

Azidolysis of ***10***. Compound **10** (1.00 g) was heated with sodium azide (2.2 g) in DMF (10 ml) at 95 °C for 42 h, and the product was treated analogously as described in the azidolysis of **6**. The product was purified on a silica gel column to give 123 mg (14%) of 1,4-di-*O*-methyl-DL-(1,2,4/3,5)-2,5-diacetamido-1,3,4-cyclopentanetriol, mp 179—180 °C.

Found: C, 50.69; H, 7.60; N, 10.60%. Calcd for $C_{11}H_{20}N_2O_5$: C, 50.76; H, 7.75; N, 10.76%. A 376 mg portion of the starting material **10** was recovered from the column.

The above mentioned diacetamido derivative (120 mg) was further *O*-methylated and then purified on a silica gel column to give 58 mg (46%) of **8**, 191—192 °C, which was identified with an authentic sample.

*Azidolysis of 2,3-Di-*O*-mesyl-(1,4/2,3,5)-5-acetamido-1,2,3,4-cyclopentanetetrol (**11**).* Compound **11**[8] (3.00 g) was heated with sodium azide (5.67 g) in DMF (25 ml) at 125 °C for 3 hr, and the product was acetylated. The acetylated product was recrystallized from ethyl acetate to give 692 mg (23%) of 1,3,4-tri-*O*-acetyl-DL-(1,2,3/4,5)-5-acetamido-2-azido-1,3,4-cyclopentanetriol (**12**), mp 163—164 °C; PMR τ 8.04 (s, 3, NAc), 7.92 (s, 3, OAc), 7.88 (s, 6, 2OAc), 3.71 (d, 1, J=8 Hz, NH).

Found: C, 45.49; H, 5.19; N, 16.55%. Calcd for $C_{13}H_{18}N_4O_7$: C, 45.61; H, 5.30; N, 16.37%. The mother liquor was evaporated and the residue was fractionated on a silica gel column to give 240 mg (8%) of **12** (Rf 0.3 on TLC) and 216 mg (7%) of 1,3,4-tri-*O*-acetyl-DL-(1,3/2,4,5)-5-acetamido-2-azido-1,3,4-cyclopentanetriol (**13**), mp 110—112 °C (recrystallized from ether); R_f 0.4 on TLC; PMR: τ 8.06 (s, 3, NAc), 7.90 (s, 9, 3OAc), 3.84 (d, 1, J=8 Hz, NH).

Found: C, 45.51; H, 5.23; N, 16.54%. Calcd for $C_{13}H_{18}N_4O_7$: C, 45.61; H, 5.30; N, 16.37%.

*1,3,4-Tri-*O*-acetyl-*DL*-(1,2,3/4,5)-2,5-diacetamido-1,3,4-cyclopentanetriol (**14**).* Compound **12** (921 mg) was catalytically hydrogenated in ethanol (15 ml) for 5 hr, and subsequently acetylated. The product was recrystallized from ethanol to give 651 mg (68%) of **14**, mp 205—206 °C; PMR (pyridine-d_5) τ 8.19 (s, 3, NAc), 8.06 (s, 3, NAc), 8.04 (s, 3, OAc), 8.01 (s, 3, OAc), 7.98 (s, 3, OAc), 1.93 (d, 1, J=9 Hz, NH), 0.61 (d, 1, J=9 Hz, NH).

Found: C, 50.48; H, 6.31; N, 7.65%. Calcd for $C_{15}H_{22}N_2O_8$: C, 50.28; H, 6.19; N, 7.82%.

*1,3,4-Tri-*O*-acetyl-*DL*-(1,3/2,4,5)-2,5-diacetamido-1,3,4-cyclopentanetriol (**15**)* Compound **13** (534 mg) was hydrogenated analogously as described in the preparation of **14** to give 232 mg (41%) of **15**, mp 206—207 °C; PMR (pyridine-d_5): τ 8.14 (s, 3, NAc), 8.07 (s, 3, NAc), 8.04 (s, 3, OAc), 7.95 (s, 3, OAc), 7.89 (s, 3, OAc), 1.26 (d, 1, J=8 Hz, NH), 0.85 (d, 1, J=8 Hz, NH).

Found: C, 50.17; H, 6.27; N, 7.58%. Calcd for $C_{15}H_{22}N_2O_8$: C, 50.28; H, 6.19; N, 7.82%.

*DL-(1,2,3/4,5)-2,5-Diacetamido-1,3,4-cyclopentanetriol (**16**).* Compound **14** (0.70 g) was de-*O*-acetylated and the product was recrystallized from ethanol to give 395 mg (87%) of **16**, mp 193—194 °C.

Found: C, 46.46; H, 7.05; N, 12.08%. Calcd for $C_9H_{16}N_2O_5$: C, 46.54; H, 6.96; N, 12.06%. Compound **16** consumed 0.9 molar equivalent of periodate in 0.05 M sodium metaperiodate solution for 2 h at room temperature.

*DL-(1,3/2,4,5)-2,5-Diacetamido-1,3,4-cyclopentanetriol (**17**).* Compound **15** (216 mg) was de-*O*-acetylated and the product was recrystallized from ethanol to give 93 mg (66%) of **17**, mp 180—181 °C.

Found: C, 46.86; H, 6.96; N, 11.73%. Calcd for $C_9H_{16}N_2O_5$: C, 46.54; H, 6.96; N, 12.06%. Compound **17** consumed 0.9 molar equivalent of periodate in the same conditions as described above.

*Structural Determinations of **12** and **13** by Acetyl Migration.* Compound **12** (33 mg) was hydrogenated in the presence of platinum oxide in ethanol (5 ml) overnight to give a practically ninhydrin negative product (28 mg). The product was de-*O*-acetylated and subsequently treated with Amberlite IR-120 (H^+) to give 19 mg (85%) of a ninhydrin negative product, mp 193—194 °C, which was identified as **16** by a comparison with an authentic sample.

Compound **13** (22 mg) was hydrogenated analogously as described above to give 15 mg (74%) of a ninhydrin positive product as a syrup.

*DL-(1,2,3/4,5)-5-Acetamido-2-azido-1,3,4-cyclopentanetriol (**18**).* Compound **12** (707 mg) was de-*O*-acetylated to give 340 mg (76%) of **18**, mp 168—169 °C.

Found: C, 38.77; H, 5.74; N, 25.60%. Calcd for $C_7H_{12}N_4O_4$: C, 38.89; H, 5.60; N, 25.92%.

*4,5-*N,O*-Isopropylidene-*DL*-(1,2,3/4,5)-5-acetamido-2-azido-1,-3,4-cyclopentanetriol (**19**).* Compound **18** (280 mg) was treated with 2,2-dimethoxypropane (0.7 ml) in DMF (12 ml) at room temperature in the presence of *p*-toluenesulfonic acid (3 mg) for 46 h. After neutralized with Amberlite IRA-400 (OH^-), the reaction solution was evaporated and the residue was recrystallized from ethyl acetate to give 228 mg (69%) of **19**, mp 131—133 °C.

Found: C, 46.70; H, 6.23; N, 22.06%. Calcd for $C_{10}H_{16}N_4O_4$: C, 46.87; H, 6.29; N, 21.86%.

*1,3-Di-*O*-acetyl-4,5-*N,O*-isopropylidene-*DL*-(1,2,3/4,5)-2,5-diacetamido-1,3,4-cyclopentanetriol (**20**).* Compound **19** (396 mg) was hydrogenated in hydrogen atomosphere (3.4 kg/cm^2) in the presence of Raney nickel in ethanol (24 ml) overnight. The hydrogenation product was acetylated and the product was recrystallized from ethyl acetate to give 363 mg (66%) of **20**, mp 167—168 °C; PMR: τ 8.49 and 8.31 (each 3, CMe_2), 8.01 (s, 3, NAc), 7.93 (s, 3, NAc), 7.85 (s, 6, 2OAc), 4.21 (d, 1, J=9 Hz, NH).

Found: C, 53.76; H, 6.76; N, 7.94%. Calcd for $C_{16}H_{24}N_2O_7$: C, 53.93; H, 6.79; N, 7.86%.

*4,5-*N,O*-Isopropylidene-*DL*-(1,2,3/4,5)-2,5-diacetamido-1,3,4-cyclopentanetriol (**21**).* Compound **20** (323 mg) was de-*O*-acetylated and the product was recrystallized from ethyl acetate to give 229 mg (93%) of **21**, mp 163—164 °C.

Found: C, 52.65; H, 7.27; N, 10.29%. Calcd for $C_{12}H_{20}N_2O_5$: C, 52.93; H, 7.40; N, 10.29%.

O-*Acetyl-di*-N,O-*isopropylidene*-DL-*(1,2,3/4,5)-2,5-diacetamido-1,3,4-cyclopentanetriols (**22a** and **b**).* Compound **21** (149 mg) was treated with 2,2-dimethoxypropane (0.3 ml) in DMF (10 ml) in the presence of *p*-toluenesulfonic acid (3 mg) at room temperature for 21 h. After neutralized with Amberlite IRA-400 (OH^-), the reaction solution was evaporated to give 168 mg of a crystalline residue. The residue was fractionated on a silica gel column with benzene–ethanol as an eluate to give 119 mg of a main product and 30 mg of a minor product. The main product showed a single spot of R_f 0.5 and the minor one showed a single spot of R_f 0.4 on TLC in benzene–ethanol (5 : 1, v/v).

A 50 mg portion of the main product was acetylated to give 40 mg (70%) of **22a**, mp 197—198 °C (recryst. from ether); PMR: τ 8.50, 8.47, 8.38 and 8.32 (each 3, $2CMe_2$), 7.90 (s, 3, 2NAc), 7.85 (s, 3, OAc).

Found: C, 57.79; H, 7.33; N, 7.85%. Calcd for $C_{17}H_{26}N_2O_6$: C, 57.61; H, 7.40; N, 7.90%.

A 30 mg portion of the minor product was acetylated to give 20 mg (57%) of **22b**, mp 135—136 °C (recryst. from ether); PMR: τ 8.46, 8.43, 8.34 and 8.30 (each 3, $2CMe_2$), 8.00 (s, 6, 2NAc), 7.88 (s, 3, OAc).

Found: C, 57.39; H, 7.28; N, 7.72%. Calcd for $C_{17}H_{26}N_2O_6$: C, 57.61; H, 7.40; N, 7.90%.

4,5-N,O-*Isopropylidene*-DL-*(1,3/2,4,5)-5-acetamido-2-azido-1,3,4-cyclopentanetriol (**23**).* Compound **13** (293 mg) was de-*O*-acetylated to give 243 mg of colorless syrup. The syrup was treated with 2,2-dimethoxypropane (0.6 ml) in DMF (8 ml) in the presence of a catalytic amount of *p*-toluenesulfonic acid (3 mg) for 49 h at room temperature. After neutralized with Amberlite IRA-400 (OH^-), the solution was evaporated. The residue was recrystallized from ethyl acetate–petroleum ether to give 55 mg (25%) of **23**, mp 111—112 °C.

Found: C, 46.83; H, 6.33; N, 21.91%. Calcd for $C_{10}H_{16}N_4O_4$: C, 46.87; H, 6.29; N, 21.86%.

1,3-Di-O-*acetyl-4,5*-N,O-*isopropylidene*-DL-*(1,3/2,4,5)-2,5-diacetamido-1,3,4-cyclopentanetriol (**24**).* Compound **23** (36 mg) was acetylated and subsequently hydrogenated in the presence of Raney nickel in ethanol (2 ml) in hydrogen atmosphere (3.4 kg/cm^2) for 5 h. The product was acetylated to give 27 mg (54%) of **24** as a syrup; PMR: τ 8.45 and 8.25 (each 3, CMe_2), 8.03 (s, 3, NAc), 7.88 (s, 9, NAc and 2OAc), 3.63 (d, 1, J=9 Hz, NH).

Found: C, 53.71; H, 6.70; N, 7.93%. Calcd for $C_{16}H_{24}N_2O_7$: C, 53.93; H, 6.79; N, 7.86%.

A 72 mg portion of **24** was de-*O*-acetylated give to 58 mg of 4,5-*N,O*-isopropylidene-DL-(1,3/2,4,5)-2,5-diacetamido-1,3,-4-cyclopentanetriol (**25**) as a syrup.

Compound **25** (58 mg) was treated with 2,2-dimethoxypropane as described in the preparation of **22a** and **b**, but only **24** was recovered in 88% yield (67 mg).

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