[Chem. Pharm. Bull. 29(9)2571—2581(1981)]

Chemical Transformation of Uronic Acids leading to Aminocyclitols. III.[1] Syntheses of Aminocyclitols and Aminocyclitol-oligoglycosides from Uronic Acids and Glucuronide-saponins by Means of Electrolytic Decarboxylation

Isao Kitagawa,* Masayuki Yoshikawa, Toshiyuki Kamigauchi, Kiyoharu Shirakawa, and Yoshiharu Ikeda

Faculty of Pharmaceutical Sciences, Osaka University, 1-6, Yamada-oka, Suita, Osaka 565, Japan

(Received March 20, 1981)

Conversions of uronic acids [*e.g.* methyl 2,3,4-tri-O-methyl-β-D-glucopyranosiduronic acid (**1**), D-glucuronic acid (**9**), and D-galacturonic acid (**17**)] into the corresponding aminocyclitols [*e.g.* **6b**, **7b**, **8b**; **14b,c**, **15b,c**, **16b,c**; **18b**] have been accomplished by means of initial electrolytic decarboxylation and subsequent treatment with alkaline nitromethane, followed by catalytic reduction, and acetylation. The conversion method has also been applied to neutral sugar [*e.g.* D-mannose (**19**)] to affording L-*neo*-aminocyclitol hexaacetate (**22b**) and also to two glucuronide-saponins [sakuraso-saponin (**23**) and desacyl-jegosaponin (**27**)] to afford aminocyclitol-oligoglycosides (**26a**, **28a**). The present electrolytic conversion is noteworthy since prior protection of hydroxyl groups in the starting uronic acids is not necessary.

Keywords——anodic oxidation; D-glucuronic acid; D-galacturonic acid; D-mannose; sakuraso-saponin; desacyl-jegosaponin; aminocyclitol; aminocyclitol-oligoglycoside; nitromethane cyclization; catalytic oxidation

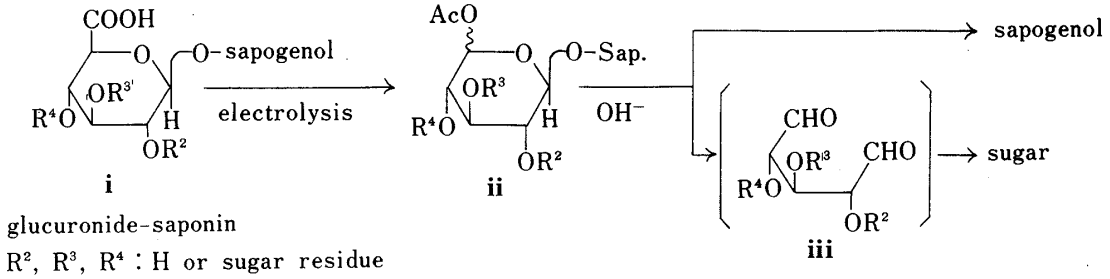
Recently, we reported a new selective cleavage method for the glucuronide linkage in oligoglycosides.[2] The method was initiated by anodic oxidation, in which the fundamental reaction was electrolytic decarboxylation. The reaction pathway has been presumed to be as shown in Chart 1 and is essentially similar to that inferred for the lead tetraacetate degradation method[3] which is a selective cleavage method for the glucuronide linkage.[4] Thus, electrolytic decarboxylation of a glucuronide-saponin (**i**)[4] in acetic acid is followed by introduction of an acetoxyl group at the position of the carboxylic moiety to yield C_5-acetoxylated derivatives (**ii**). Subsequent alkaline treatment liberates a sapogenol and sugar residue (s) *via* elimination from a presumed dialdehydic intermediate (**iii**).

In the case of the lead tetraacetate degradation method, the participation of this dialdehydic intermediate (**iii**) has been demonstrated by its conversion into nitrocyclitols,[3c] and furthermore this reaction sequence has been utilized for the conversion from N-acetyl-D-glucosamine to hexaacetyl-streptamine.[1] On the other hand, in the case of anodic oxidation, our initial attempt to isolate the dialdehydic intermediate (**iii**) was unsuccessful. However, we have succeeded in the conversion of this dialdehyde into aminocyclitol derivatives, which simultaneously constitutes successful transformation of a uronic acid to aminocyclitols. This paper deals in detail with the conversions of uronic acids and glucuronide-saponins into aminocyclitols and aminocyclitol-oligoglycosides by means of electrolytic decarboxylation.[5]

Aminocyclitols from D-Glucuronic Acid

In our previous paper,[2] we reported the electrochemical conversion of methyl 2,3,4-tri-O-methyl-β-D-glucopyranosiduronic acid (**1**) to two pairs of C_5-methoxylated products (**2**, **3**) and C_5-acetoxylated products (**4**, **5**). With regard to these C_5-functionalized compounds, an attempt to isolate a corresponding dialdehydic derivative or its equivalent (**ib** or **ia**) was unsuccessful. However, as in the case of the lead tetraacetate degradation method,[3c] the

dialdehydic intermediate has been successfully converted to aminocyclitol derivatives. Thus, three nitrocyclitols [*myo* (**6**), *scyllo* (**7**), and *muco* (**8**)], which were obtained from the C_5-methoxylated compound (**2** or **3**) *via* aqueous hydrochloric acid treatment followed by nitromethane cyclization under alkaline conditions,[2] were subjected to catalytic reduction over Raney Ni (T-4)[6] and subsequent acetylation to afford three aminocyclitols (**6b**, **7b**, and **8b**, respectively). Since conversions from the C_5-acetoxylated compound (**4** or **5**) to three nitrocyclitols (**6**, **7**, and **8**) have already been accomplished,[3c] here again, the participation of a dialdehydic intermediate has been confirmed by the conversion of **4** or **5** into aminocyclitols. It has become apparent that electrolytic decarboxylation may be a useful initial reaction for synthesizing aminocyclitols from various types of uronic acids.



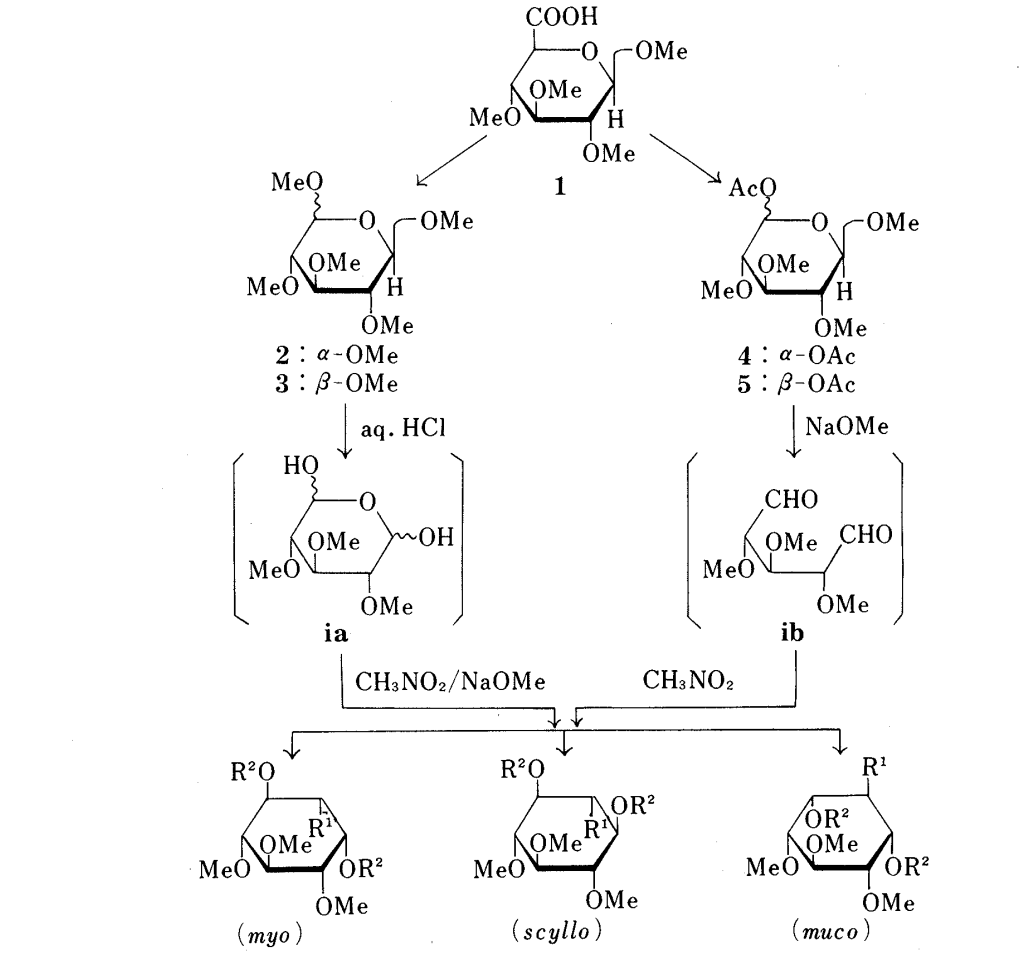
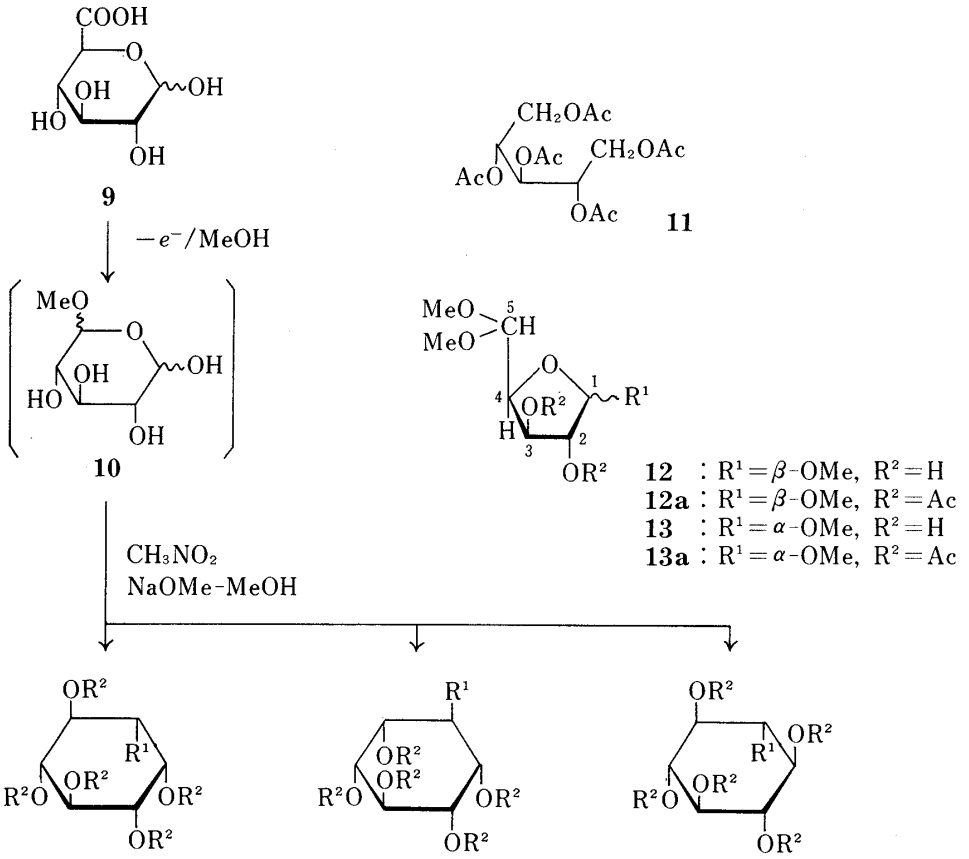


Chart 1

As was mentioned in our previous paper,[2] previous protection of hydroxyl groups or acetal functions in the starting material is unnecessary in the electrolytic decarboxylation reaction. We next examined the behavior of D-glucuronic acid (**9**) itself in the anodic oxidation. When **9** was subjected to constant current electrolysis in methanol containing diethylamine, a decarboxylation product (**10**) was formed. Since this product was too unstable to be readily isolated in a pure form, its formation was substantiated by its conversion either to xylitol pentaacetate (**11**) *via* sodium borohydride reduction followed by acetylation or to two methyl furanosides (**12, 13**) *via* methanolysis by heating under reflux in an acetyl chloride-methanol mixture.

The structures of the two furanosides (**12, 13**) have been elucidated on the basis of spectral properties of their acetylated derivatives (**12a, 13a**). The infrared (IR) spectrum of **12a** lacks the hydroxyl absorption band but shows strong acetoxyl absorption bands (1760, 1240 cm^{-1}). The proton nuclear magnetic resonance (^1H NMR) spectrum taken in pentadeutero-(d_5-)pyridine supports the β-furanoside structure, showing signals due to two acetoxyl groups at C-2 and C-3 (δ 2.02, 2.05, 3H both s; δ 5.26, 1H br.s, $W_{h/2}$=3 Hz, 2β-H; δ 5.61, 1H br d, J=*ca.* 5.5 Hz, 3α-H), three methoxyl groups (δ 3.34, 3.42, 3.45, 3H each, all s), 4α-H (δ 4.54, 1H d.d, J=5.5, 8 Hz), 5-H (δ 4.75, 1H d, J=8 Hz), and 1α-H (δ 5.04, 1H s).[7] The mass spectrum of **12a** also shows a fragmentation pattern which is reasonable for the furanoside structure.[8] Physical data for **13a** suggest its structure to be epimeric to **12a** at C-1. A doublet at δ 4.98 (in carbon tetrachloride, 1H, J=4.5 Hz) assignable to 1β-H confirmed the α-



14 : R^1=NO_2, R^2=H
14a : R^1=NO_2, R^2=Ac
14b : R^1=NHAc, R^2=H
14c : R^1=NHAc, R^2=Ac

15 : R^1=NO_2, R^2=H
15a : R^1=NO_2, R^2=Ac
15b : R^1=NHAc, R^2=H
15c : R^1=NHAc, R^2=Ac

16 : R^1=NO_2, R^2=H
16a : R^1=NO_2, R^2=Ac
16b : R^1=NHAc, R^2=H
16c : R^1=NHAc, R^2=Ac

Chart 2

furanoside structure.

The structure **10** corresponds to a cyclic acetal of a dialdehyde, initiated by participation of methanol. Formation of this unstable product shows that a decarboxylation reaction predominates over oxidation of hydroxyl groups or an acetal moiety under electrolytic conditions. The cyclic acetal (**10**) is considered to be readily convertible to nitrocyclitols as described above. Electrolysis under constant current conditions of **9**, followed by alkaline nitromethane treatment of the product under an argon atmosphere, afforded three nitrocyclitols: **14** (*myo*, 37%), **15** (*muco*, 8%), and **16** (*scyllo*, 6%). The structures of these products were confirmed by conversion to the corresponding pentaacetates (**14a**, **15a**, and **16a**) with acetic anhydride and boron trifluoride (BF_3) etherate (see "Experimental" for the ^1H NMR data). In practice, three N-acetyl-aminocyclitols (**14b**, **15b**, and **16b**) and their pentaacetates (**14c**, **15c**, and **16c**) were prepared from D-glucuronic acid *via* a series of reactions without isolation of each intermediary product: constant current electrolysis, alkaline nitromethane treatment, catalytic Raney Ni (T-4) reduction, and acetylation. Among the three aminocyclitols, *scyllo*-inosamine (**16b** without the N-acetyl group) is a constituent of aminoglycoside antibiotics: glebomycin[9] (bluensomycin[10]).

It should be pointed out that the configurations at C-2, C-3, and C-4 of the starting D-glucuronic acid (**9**) are retained in the final aminocyclitols. In other words, it should be possible to synthesize various types of aminocyclitols from a variety of uronic acid derivatives through analogous reactions. We next carried out these reactions on D-galacturonic acid (**17**).

Aminocyclitols from D-Galacturonic Acid

When D-galacturonic acid (**17**) was subjected to electrolysis under constant current conditions and subsequent treatment with alkaline nitromethane, an optically active nitrocyclitol (**18**, D-*neo*) was obtained in 18% yield. The structure **18** was deduced on the basis of the ^1H NMR analysis of its pentaacetate (**18a**) by using a shift reagent Eu $(fod)_3$ (**18a**: reagent=6.5: 1) and undertaking detailed spin-decoupling experiments (Table I). Thus, signals attributable to axial protons at C-1, C-3, C-4, and C-6 in **18a** are observed at δ 5.44, 6.13, 6.45, and 6.66 as a doublet of doublets (1H each, J=3, 11 Hz), while signals due to equatorial protons at C-2 and C-5 are observed at δ 6.89 and 7.18 as a triplet (1H both, J=3 Hz). This seems to be the first example of a synthesis of an optically active *neo*-nitrocyclitol. Catalytic reduction of **18** over Raney Ni (T-4) followed by acetylation afforded D-*neo*-aminocyclitol hexaacetate (**18b**).

Table I. Spin-Decoupling Experiments on **18a**

Decoupled proton (δ)	Irradiated at δ					
	5.44 (1-H)	6.89 (2-H)	6.13 (3-H)	6.45 (4-H)	7.18 (5-H)	6.66 (6-H)
1-H (5.44, d.d, J=3, 11)	—	Doublet (J=11)				Doublet (J=3)
2-H (6.89, t, J=3)	Doublet (J=3)	—	Doublet (J=3)			
3-H (6.13, d.d, J=3, 11)		Doublet (J=11)	—	Doublet (J=3)		
4-H (6.45, d.d, J=3, 11)			Doublet (J=3)	—	Doublet (J=11)	
5-H (7.18, t, J=3)				Doublet (J=3)	—	Doublet (J=3)
6-H (6.66, d.d, J=3, 11)	Doublet (J=3)				Doublet (J=11)	—

Aminocyclitol from D-Mannose

If uronic acids can be readily prepared from neutral sugars, the present conversion method may be applicable to conversions from ordinary sugars to aminocyclitols. D-Mannose was

chosen as an example the key step in this case was conversion of the C_5-carbinol moiety into a carboxylic function. The object was attained by catalytic oxidation of methyl D-mannopyranoside over platinum to afford methyl α-D-mannopyranosiduronic acid (**20**).[11] Electrolysis of **20** under constant current conditions in acetic acid containing triethylamine furnished an epimeric mixture of C_5-acetoxylated products (**21**) in 48% yield. Treatment of **21** with alkaline nitromethane yielded a nitrocyclitol (**22**, L-*neo*) which was identical with the above-described D-*neo*-nitrocyclitol (**18**) in all respects except the sign of the optical rotation, thus indicating that the nitrocyclitol prepared from **20** is an optical antipode of the nitrocyclitol (**18**) prepared above from D-galacturonic acid (**17**). Catalytic reduction followed by acetylation of **22** accomplished the final conversion to D-*neo*-aminocyclitol hexaacetate (**22b**).

It has been shown that not only uronic acids but also neutral sugars are convertible to the corresponding aminocyclitols if their primary carbinol moieties can be converted to carboxylic functions, *e.g.* by catalytic oxidation.

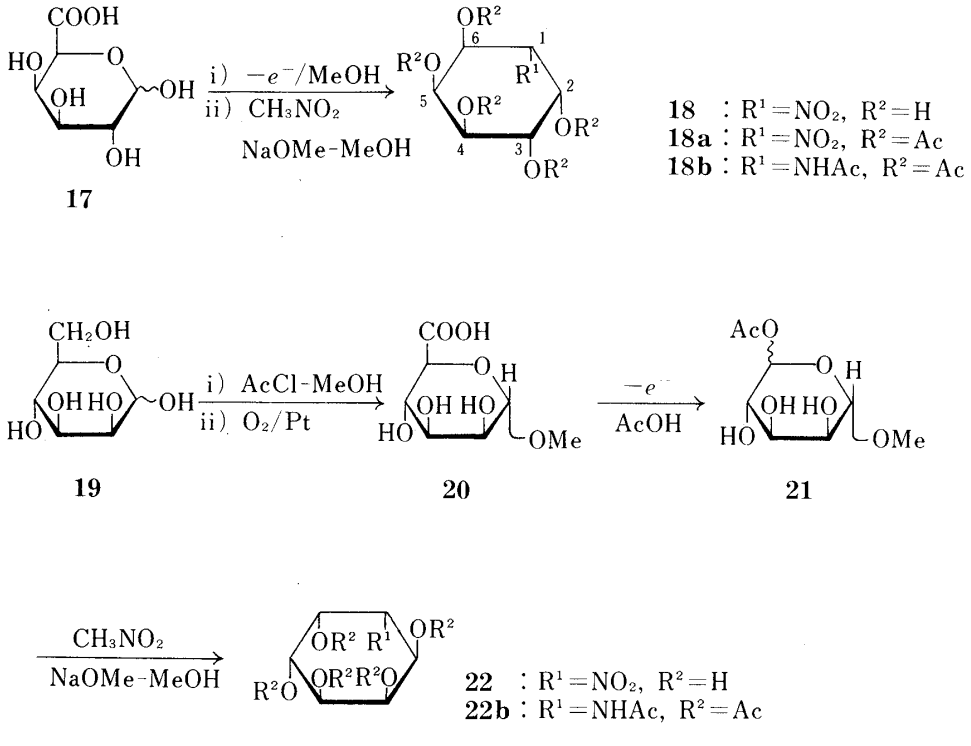


Chart 3

Aminocyclitol-oligoglycosides from Sakuraso-saponin and Desacyl-jegosaponin

One of characteristics of the above-mentioned conversions from uronic acids to aminocyclitols is the retention of configurations at C-2, C-3, and C-4 during the procedure. If a starting uronic acid possesses one or more glycosidic linkages at these positions, the ultimate product is expected to be an aminocyclitol-(oligo)glycoside. We next attempted the conversion of two glucuronide-saponins: sakuraso-saponin (**23**)[12] and desacyl-jegosaponin (**27**).[12]

Electrolysis of **23** under constant current conditions in acetic acid containing triethylamine for 10 h afforded a product which was subsequently treated with alkaline nitromethane to liberate protoprimulagenin A (**24**, 22%),[2,13] aegicerin (**25**, 16%),[2,13] and a mixture of nitrocyclitol-oligoglycosides (58%). Characterization of the latter was carried out by converting one of the constituents to an N-acetylaminocyclitol-oligoglycoside (**26a**, *myo*).

The IR spectrum of **26a** shows a strong hydroxyl absorption band (3376 (br) cm^{-1}) together with amide bands (1640, 1563 cm^{-1}). The ^1H NMR spectrum taken in a $CDCl_3$–CD_3OD–D_2O mixture[14] shows signals due to two rhamnose-methyls (δ 1.30, 6H br d, $J=ca.$ 5 Hz), and an

N-acetyl group (δ 2.03, 3H s), and anomeric protons of two rhamnoside moieties (δ 5.28, 2H br.s, $W_{h/2}$=5 Hz). The field-desorption mass spectrum (FD–MS) of **26a** gives ion peaks at m/z 838 ($M^+ +1$) and m/z 860 ($M^+ +Na$), supporting the oligoglycosidic nature of the product. Methanolysis of **26a** followed by trimethylsilylation liberated methyl pyranosides of rhamnose, glucose, and galactose together with N-acetyl-*myo*-inosamine. Based on these findings and the structure of the starting saponin (**23**), the structure of **26a** has become unequivocal except for the configurations in its aminocyclitol moiety. Although the *myo* configuration has been clarified, the configurations at C-2 and C-6 in **26a** have not yet been determined whether (which one is axial). In any case, the liberation of the oligosaccharide moiety in sakuraso-saponin (**23**) in the form of an aminocyclitol-oligoglycoside has been effected in a short reaction sequence.

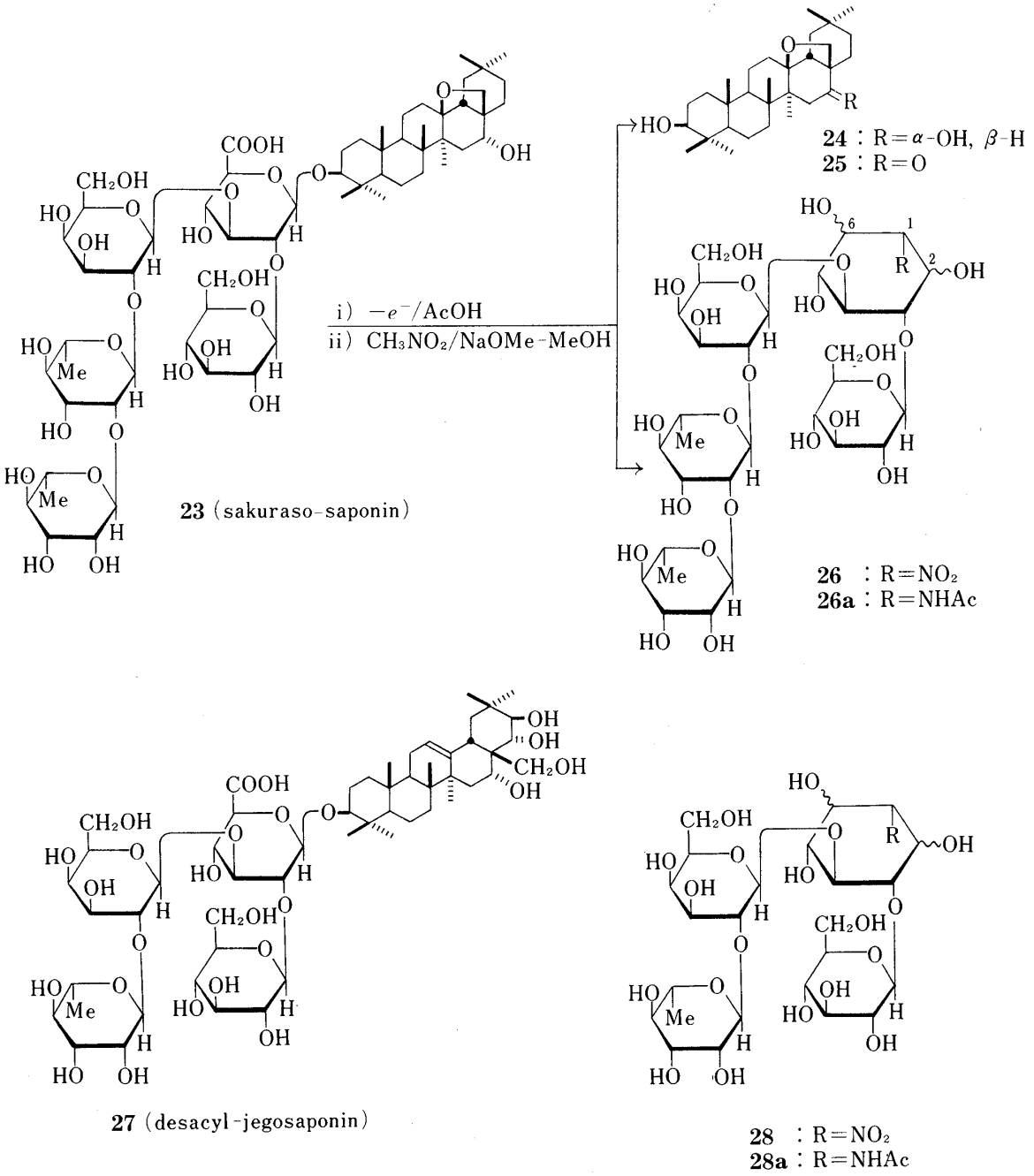


Chart 4

In the case of desacyl-jegosaponin (**27**), electrolytic decarboxylation followed by treatment with alkaline nitromethane yielded a complicated mixture from the sapogenol portion as was experienced before.[2] However, a product derived from the oligoglycosidic moiety was isolated as an N-acetylaminocyclitol-oligoglycoside (**28a**) in the manner described for the preparation of **26a**. The structure of **28a** was elucidated on the basis of its physical properties (IR, ^{1}H NMR, FD-MS) in the same way as described for **26a** (see Experimental) and the results of methanolysis, which liberated methyl pyranosides of rhamnose, glucose, and galactose, and N-acetyl-*myo*-inosamine. Here again, the configurations at C-2 and C-6 in the *myo*-inosamine moiety of **28a** have not yet been determined.

Electrolytic decarboxylation has been shown to be a useful initial reaction for the degradation of glucuronide-saponins (*e.g.* **23**, **27**) to liberate their oligosaccharide moieties and to convert them into aminocyclitol-oligoglycosides (*e.g.* **26a**, **28a**). It is noteworthy in these degradations that no previous protection of hydroxyl groups in the starting glucuronide-saponins is necessary.

In order to clarify the scope and limitations of the present electrolytic conversion method, further studies are in progress.

Experimental

The instruments used to obtain physical data and the experimental conditions for chromatography were the same as in our previous paper.[2] The electrolytic reactions were carried out in a beaker with stirring using a potentiostat/galvanostat apparatus (Hokuto Denko Co., model HA-105).

Acidic Hydrolysis followed by Nitromethane Treatment of 2 and 3——A mixture of **2** and **3** (400 mg) was dissolved in aq. 5% HCl–acetone (1: 1, 10 ml) and the solution was heated under reflux for 4 h. After neutralization with aq. 10% NaOH, the whole mixture was evaporated to dryness under reduced pressure and the residue was treated with dioxane and filtered. Removal of the solvent from the filtrate under reduced pressure gave a residue which was dissolved in nitromethane (5 ml). The solution was treated with 10% NaOMe–MeOH (1 ml) and stirred at 10°C for 12 h. The reaction mixture was neutralized with aq. 10% HCl and acidified with AcOH. The whole mixture was then evaporated to dryness under reduced pressure and the residue was purified by preparative TLC (*n*-hexane–AcOEt=1: 5) to furnish **6** (*myo*, 112 mg, 31%), **7** (*scyllo*, 80 mg, 22%), and **8** (*muco*, 29 mg, 8%), all of which were identical with corresponding authentic samples[3c] as judged by mixed mp determination and TLC comparisons (*n*-hexane–AcOEt=1: 5).

Reduction followed by Acetylation of 6, 7, or 8——A solution of **6**, **7**, or **8** (each 30 mg) in EtOH (5 ml) was treated with a suspension of Raney Ni (T-4)[6] in EtOH (5 ml) and the whole was shaken at 12°C under a hydrogen atmosphere for 6 h. After filtration, the filtrate was evaporated to dryness under reduced pressure to give a residue which was acetylated with Ac_2O–pyridine (1: 1, 4 ml) at 35°C for 12 h. The reaction mixture was poured into ice-water and the whole was extracted with AcOEt. Work-up of the AcOEt extract in the usual manner and removal of the solvent under reduced pressure furnished **6b** (30 mg), **7b** (31 mg), or **8b** (28 mg).

6b, mp 154—156°C (colorless needles from EtOH), $[\alpha]_D^{22}$ 0° (c=1.0, $CHCl_3$). *Anal.* Calcd for $C_{15}H_{25}O_8N$: C, 51.86; H, 7.25; N, 4.03. Found: C, 51.44; H, 7.32; N, 4.03. IR $\nu_{max}^{CHCl_3}$ cm^{-1}: 3430, 1750, 1659, 1512, 1236. ^{1}H NMR ($CDCl_3$, δ): 1.92 (3H, s, >NAc), 2.11, 2.17 (3H each, both s, OAc×2), 3.43, 3.58, 3.62 (3H each, all s, OMe×3), 4.44 (1H, d d d, J=3, 9, 11, 1-H), 5.05 (1H, d d, J=11, 11, 6-H), 5.54 (1H, d d, J=3, 3, 2-H), 5.84 (1H, d, J=9, exchangeable with D_2O, >N<u>H</u>).

7b, mp 145—147°C (colorless needles from EtOH), $[\alpha]_D^{22}$ 0° (c=1.0, $CHCl_3$). *Anal.* Calcd for $C_{15}H_{25}O_8N$: C, 51.86; H, 7.25; N, 4.03. Found: C, 51.75; H, 7.35; N, 4.00. IR $\nu_{max}^{CHCl_3}$ cm^{-1}: 3425, 1745, 1677, 1520, 1240. ^{1}H NMR ($CDCl_3$, δ): 1.86 (3H, s, >NAc), 2.05 (6H, s, OAc×2), 3.51 (6H, s), 3.60 (3H, s) (OMe×3), 4.14 (1H, d t, J=10, 10, 1-H), 4.83 (2H, t-like, 2-H, 6-H), 5.94 (1H, d, J=10, exchangeable with D_2O, >N<u>H</u>).

8b, mp 153—156°C (colorless needles from EtOH), $[\alpha]_D^{22}$ 0° (c=1.0, $CHCl_3$). *Anal.* Calcd for $C_{15}H_{25}O_8N$: C, 51.86; H, 7.25; N, 4.03. Found: C, 51.48; H, 7.36; N, 4.02. IR $\nu_{max}^{CHCl_3}$ cm^{-1}: 3435, 1740, 1685, 1524, 1245. ^{1}H NMR ($CDCl_3$, δ): 1.91 (3H, s, >NAc), 2.07 (6H, s, OAc×2), 3.44 (9H, s, OMe×3), 4.72 (1H, d t, J=9, 9, 1-H), 5.06 (2H, d.d-like, J=*ca.* 3, 9, 2-H, 3-H), 5.94 (1H, d, J=9, exchangeable with D_2O, >N<u>H</u>).

Electrolysis followed by Reduction and Acetylation of D-Glucuronic Acid (9)——A solution of **9** (500 mg) in MeOH (100 ml) containing Et_2NH (0.2 ml) was subjected to constant current electrolysis for 3 h [glassy carbon electrode; 200 mA (8 mA/cm^2); 0—5°C]. After neutralization with Dowex 50 W×8 (H^+), the reaction mixture was filtered. The filtrate was concentrated under reduced pressure to *ca.* 50 ml, then the solution was treated with $NaBH_4$ (1 g) and stirred at 24°C for 2 h. The reaction mixture was again neutralized with Dowex 50 W×8 (H^+) and treated with Amberlite IRA-400 (OH^-). The product obtained upon removal of the solvent under reduced pressure was acetylated with Ac_2O–pyridine (1: 1, 10 ml) at 35°C for 24 h.

Work-up of the reaction mixture in the usual manner yielded a product; this was purified by preparative TLC ($CHCl_3$–MeOH=50: 1) to furnish **11** (510 mg, 55%) which was identical with an authentic sample as judged by TLC ($CHCl_3$–MeOH=50: 1), IR (CCl_4), and ^1H NMR (CCl_4) comparisons.

Electrolysis followed by Acid Treatment and Acetylation of D-Glucuronic Acid (9)——Areaction mixture which was obtained by electrolysis of **9** (500 mg) as described above was neutralized with Dowex 50 W×8 (H^+) and the filtrate was evaporated to dryness under reduced pressure. The dried product was dissolved in AcCl-dry MeOH (3: 40, 10 ml) and the solution was heated under reflux for 10 min. The reaction mixture was neutralized with 10% NaOMe–MeOH and the product obtained upon removal of the solvent was purified by preparative TLC ($CHCl_3$–MeOH=10: 1) to furnish **12** (143 mg) and **13** (77 mg). Acetylation of **12** or **13** with Ac_2O–pyridine (1: 1, 2 ml) at 30°C for 12 h and subsequent work-up in the usual manner furnished **12a** (145 mg, 19%) or **13a** (80 mg, 11%). **12a**, colorless oil, $[\alpha]_D^{22}$ 0° (c=3.9, $CHCl_3$). IR $\nu_{max}^{CCl_4}$ cm^{-1}: 1760, 1225. ^1H NMR (CCl_4, δ): 1.99, 2.02 (3H each, both s, OAc×2), 3.26 (3H, s), 3.31 (6H, s) (OMe×3), 4.09 (1H, d.d, J=6, 6, 4-H), 4.31 (1H, d, J=6, 5-H), 4.76 (1H, d d, J=4.5, 4.5, 2-H), 4.98 (1H, d, J=4.5, 1-H), 5.33 (1H, d d, J=4.5, 6, 3-H). MS m/z(%): 292 (3, M^+), 261 (22), 159 (44), 126 (31), 75 (100). High resolution MS (m/z): Calcd for $C_{12}H_{20}O_8$ (M^+) 292.116; $C_{11}H_{17}O_7$ 261.097; $C_7H_{11}O_4$ 159.065; $C_6H_6O_3$ 126.031; $C_3H_7O_2$ 75.044. Found: 292.116, 261.098, 159.065, 126.032, 75.045. **13a**, colorless oil, $[\alpha]_D^{22}$ 0° (c=4.4, $CHCl_3$). IR $\nu_{max}^{CCl_4}$ cm^{-1}: 1760, 1240, 1220. ^1H NMR (CCl_4, δ): 2.02, 2.05 (3H each, both s, OAc×2), 3.25, 3.31, 3.33 (3H each, all s, OMe×3), 4.10, 4.50 (2H, AB in ABX, J_{AB}=8, J_{AX}=6, J_{BX}=0, 4-H, 5-H), 4.70 (1H, s, 1-H), 4.82 (1H, br s, $W_{h/2}$=4, 2-H), 5.19 (1H, X in ABX, J_{AX}=6, J_{BX}=0, 3-H). MS m/z(%): 292 (2, M^+), 261 (5), 159 (14), 126 (6), 75 (100). High resolution MS (m/z): Calcd for $C_{12}H_{20}O_8$ (M^+) 292.116; $C_{11}H_{17}O_7$ 261.097; $C_7H_{11}O_4$ 159.065; $C_6H_6O_3$ 126.031; $C_3H_7O_2$ 75.044. Found: 292.116, 261.096, 159.066, 126.032, 75.044.

Electrolysis followed by Nitromethane Cyclization of D-Glucuronic Acid (9)——A reaction mixture which was obtained by electrolysis of **9** (500 mg) as described above was evaporated to dryness below 20°C under reduced pressure to remove MeOH. The residual mixture was mixed with water (10 ml) and washed with AcOEt. The aqueous phase was then treated with MeOH (10 ml) and nitromethane (5 ml) and the whole mixture was stirred under an argon atmosphere for 10 min. After addition of 10% NaOMe–MeOH (1 ml), the whole was stirred under an argon atmosphere for 18 h. The reaction mixture was neutralized with Dowex 50 W×8 (H^+) and the solvent was evaporated off under reduced pressure. The product was mixed with SiO_2 (2 g) with the aid of a small amount of MeOH and then dried. The mixture was put on a column of SiO_2 (50 g) and the column was developed with $CHCl_3$–MeOH (5: 1) to furnish **14** (*myo*, 198 mg, 37%), **15** (*muco*, 47 mg, 8%), and **16** (*scyllo*, 33 mg, 6%). **14**, mp 142—146°C (colorless fine crystals from dioxane) [lit.[15]: mp 145—147°C (dioxane)], IR ν_{max}^{KBr} cm^{-1}: 3365, 1567, 1377. **15**, mp 180—182°C (colorless fine crystals from EtOH) [lit.[16]: mp 185—186°C (EtOH–ether)], IR ν_{max}^{KBr} cm^{-1}: 3380, 1555, 1385. **16**, mp 210—215°C (colorless fine crystals from dioxane) [lit.[15]: mp 216—217°C (dioxane)], IR ν_{max}^{KBr} cm^{-1}: 3325, 1565, 1376.

Acetylation of 14——A mixture of **14** (20 mg) and 1 ml of Ac_2O–BF_3–etherate (2 ml: 1 drop) was stirred at 18°C for 30 min. The reaction mixture was poured into ice-water and the precipitate was collected by filtration to furnish **14a** (15 mg). **14a**, mp 158—162°C (colorless fine crystals from EtOH). IR ν_{max}^{KBr} cm^{-1}: 1767, 1565, 1375, 1220. ^1H NMR ($CDCl_3$, δ): 2.01 (12H, s, eq. OAc×4), 2.15 (3H, s, ax. OAc), 4.97 (1H, d.d, J=3, 11, 1-H), 6.05 (1H, d d, J=3, 3, 2-H). **14a**[15,17]: ^1H NMR ($CDCl_3$, δ): 1.98 (12H, s, eq. OAc×4), 2.13 (3H, s, ax. OAc), 5.10—5.50 (5H, ax. ring proton×5), 6.06 (1H, eq. ring proton).

Acetylation of 15——Acetylation of **15** (18 mg) as described above furnished **15a** (22 mg), mp 198—200°C (colorless fine crystals from dioxane). IR ν_{max}^{KBr} cm^{-1}: 1760, 1563, 1372, 1220. ^1H NMR ($CDCl_3$, δ): 2.01 (6H, s, eq. OAc×2), 2.15 (6H, s), 2.22 (3H, s) (ax. OAc×3), 5.00—5.80 (6H). **15a**[15,17]: ^1H NMR ($CDCl_3$, δ): 2.04 (6H, s, eq. OAc×2), 2.17 (6H, s), 2.25 (3H, s) (ax. OAc×3), 5.10—5.50 (3H, ax. ring proton×3), 5.80 (3H, eq. ring proton×3).

Acetylation of 16——Acetylation of **16** (20 mg) as described above furnished **16a** (16 mg), mp 238—245°C (colorless fine crystals from dioxane). IR ν_{max}^{KBr} cm^{-1}: 1758, 1567, 1373, 1220. ^1H NMR ($CDCl_3$, δ): 2.01 (15H, s, eq. OAc×5), 4.83 (1H, d.d, J=10, 10, 1-H). **16a**:[15,17] ^1H NMR ($CDCl_3$, δ): 2.01 (15H, s, eq. OAc×5), 5.35 (ax. ring proton).

Electrolysis followed by Nitromethane Cyclization, Reduction, and Acetylation——A reaction mixture of nitrocyclitols, which was obtained by constant current electrolysis and subsequent nitromethane cyclization of **9** (500 mg) as described above, was dissolved in water (30 ml) and treated with a suspension of Raney Ni (T-4) in EtOH (15 ml). The whole mixture was shaken at 11°C under a hydrogen atmosphere for 15 h. Removal of the solvent from the filtrate under reduced pressure gave a product which was acetylated with Ac_2O (5 ml) in MeOH (50 ml) under stirring at 18°C for 5 h. MeOH was evaporated off under reduced pressure; the resulting precipitate was collected by filtration and crystallized from MeOH to furnish **14b** (*myo*, 102 mg, 18%). The mother liquor was mixed with silica gel (1 g) and dried. The mixture was then put on a silica gel (20 g) column and chromatographed with $CHCl_3$–MeOH–H_2O=65: 35: 10 (lower phase) to furnish an additional crop of **14b** (53 mg, 9%) together with **15b** (*muco*, 37 mg, 6%), and **16b** (*scyllo*, 18 mg, 3%). **14b**, mp 230—235°C (colorless fine crystals from MeOH–EtOH). IR ν_{max}^{KBr} cm^{-1}: 3400 (br), 1635, 1573. [**14b**:[15] mp 238—239°C (MeOH–EtOH)]. **15b**, mp 241—243°C (colorless fine crystals from EtOH). IR ν_{max}^{KBr} cm^{-1}: 3330 (br), 1635, 1550. [**15b**:[15] mp 243—244°C (EtOH)]. **16b**, mp 285—288°C (colorless fine crystals from EtOH). IR ν_{max}^{KBr} cm^{-1}: 3400 (br), 1630, 1562. [**16b**:[18] mp 288—290°C (EtOH)].

Acetylation of 14b——A solution of **14b** (30 mg) in Ac_2O–pyridine (1: 1, 1 ml) was stirred at 30°C for 15 h and poured into ice–water. The whole mixture was extracted with AcOEt and the AcOEt extract was worked up in the usual manner to furnish **14c** (35 mg), mp 240—245°C (colorless needles from $CHCl_3$–EtOH). IR $\nu_{max}^{CHCl_3}$ cm^{-1}: 3440, 1762, 1691, 1513, 1244. ^1H NMR ($CDCl_3$, δ): 1.90 (3H, s, eq. NAc), 1.95 (3H, s), 2.00 (6H, s), 2.03 (3H, s) (eq. OAc×4), 2.19 (3H, s, ax. OAc), 4.50 (1H, br t, J=9, 1-H), 5.47 (1H, d d, J=3, 3,2-H), 5.99 (1H, d, J=9, disappeared on D_2O addition, >NH). [**14c**:[17] ^1H NMR ($CDCl_3$, δ): 1.92 (3H, s, eq. NAc), 1.97 (3H, s), 2.02 (6H, s), 2.05 (3H, s) (eq. OAc×4), 2.22 (3H, s, ax. OAc)].

Acetylation of 15b——Acetylation of **15b** (20 mg) as described above for **14b** furnished **15c** (12 mg), mp 168—172°C (colorless fine crystals from EtOH). IR $\nu_{max}^{CHCl_3}$ cm^{-1}: 3423, 1742, 1683, 1511, 1218. ^1H NMR ($CDCl_3$, δ): 1.91 (3H, s, eq. NAc), 2.02 (6H, s, eq. OAc×2), 2.11 (9H, s, ax. OAc×3), 5.60 (1H, d, J=9, disappeared on D_2O addition, >NH). [**15c**:[15] ^1H NMR ($CDCl_3$, δ): 1.93 (3H, s, eq. NAc), 2.04 (6H, s, eq. OAc×2), 2.13 (9H, s, ax. OAc×3)].

Acetylation of 16b——Acetylation of **16b** (13 mg) as described above for **14b** furnished **16c** (9 mg), mp 278—282°C (colorless fine crystals from EtOH). IR $\nu_{max}^{CHCl_3}$ cm^{-1}: 3384, 1757, 1685, 1514, 1226. ^1H NMR ($CDCl_3$, δ): 1.90 (3H, s, eq. NAc), 2.01 (9H, s), 2.04 (6H, s) (eq. OAc×5), 5.64 (1H, d, J=10, disappeared on D_2O addition, >NH). [**16c**:[17] ^1H NMR ($CDCl_3$, δ): 1.92 (3H, s, eq. NAc), 2.03 (9H, s), 2.06 (6H, s) (eq. OAc×5)].

Electrolysis followed by Nitromethane Cyclization of D-Galacturonic Acid (17)——A solution of **17** (500 mg) in MeOH (100 ml) containing Et_2NH (1 ml) was subjected to constant current electrolysis [glassy carbon electrode; 450 mA (23 mA/cm^2); 0—5°C] for 5 h. Removal of MeOH below 20°C under reduced pressure gave a residue which was treated with water (10 ml) and extracted with AcOEt. The aqueous phase was mixed with MeOH (15 ml) and nitromethane (5 ml) and the whole was stirred at room temp. (10°C) under an argon atmosphere for 10 h. After neutralization with Dowex 50 W×8 (H^+ form), the filtrate was evaporated to dryness under reduced pressure to give a product. Crystallization of the product from MeOH furnished **18** (D-*neo*, 50 mg, 8%) as colorless plates. The residue obtained by evaporation of the mother liquor was mixed with silica gel (2 g) with the aid of $CHCl_3$–MeOH and dried. The silica gel mixture was then put on a column of silica gel (200 mg) and chromatographed with $CHCl_3$–MeOH–H_2O (6: 4: 1) to furnish another crop of **18** (60 mg, 10%). **18**, mp 208—210°C (colorless plates from MeOH), $[\alpha]_D^{24}$ −31.8° (c=1.0, H_2O). *Anal.* Calcd for $C_6H_{11}O_7N$: C, 34.45; H, 5.26; N, 6.70. Found: C, 34.40; H, 5.25; N, 6.66. IR ν_{max}^{KBr} cm^{-1}: 3500, 3405, 3225, 1541, 1386, 1126. MS m/z(%): 210 (1, M^++1), 109 (16), 85 (100).

Acetylation of 18——An ice-cooled mixture of **18** (40 mg) and Ac_2O (2 ml) was treated with BF_3–etherate (1 drop). The mixture was stirred for 5 min, then poured into ice-water and a white precipitate (**18a**, 40 mg) was collected by filtration. **18a**, white powder (an attempt at crystallization was unsuccessful), $[\alpha]_D^{14}$ −1.5° (c=0.9, $CHCl_3$). IR $\nu_{max}^{CCl_4}$ cm^{-1}: 1770, 1568, 1374, 1216. ^1H NMR ($CDCl_3$, δ): 2.01 (9H, s, eq. OAc×3), 2.13, 2.17 (3H, each, both s, ax. OAc×2), 4.99 (1H, d d, J=3, 11, 1-H), 5.32 (center, 2H, m), 5.75 (center, 2H, m), 6.06 (1H, d d, J=3, 3, 5-H). ^1H NMR [**18a** (22 mg, 0.065 mmol), Eu(fod)$_3$ (10 mg, 0.01 mmol), $CDCl_3$ (0.4 ml), δ]: 2.22, 2.25, 2.28, 2.32, 2.35 (3H each, all s, OAc×5), 5.44 (1H, d d, J=3, 11, 1-H), 6.13 (1H, d d, J=3, 11, 3-H), 6.45 (1H, d d, J=3, 11, 4-H), 6.66 (1H, d d, J=3, 11, 6-H), 6.89 (1H, t, J=3, 2-H), 7.18 (1H, t, J=3, 5-H). High resolution MS (m/z): Calcd for $C_{16}H_{22}O_{12}N$ (M^++1) 420.114. Found: 420.114.

Reduction followed by Acetylation of 18——A suspension of Raney Ni (T-4) in EtOH (10 ml) was added to a solution of **18** (20 mg) in H_2O (20 ml) and the mixture was shaken under a hydrogen atmosphere for 8 h. Removal of the solvent from the filtrate under reduced pressure yielded a product which was acetylated with Ac_2O–pyridine (1: 1, 2 ml) at room temperature (10°C) with stirring for 12 h. The reaction mixture was poured into ice–water and extracted with AcOEt. Work-up of the AcOEt extract in the usual manner and crystallization of the product from EtOH furnished **18b** (18 mg), mp 281—282°C (colorless needles from EtOH), $[\alpha]_D^{25}$ −9.4° (c=1.0, MeOH). *Anal.* Calcd for $C_{18}H_{25}O_{11}N$: C, 50.12; H, 5.80; N, 3.25. Found: C, 49.83; H, 5.75; N, 3.39. IR $\nu_{max}^{CCl_4}$ cm^{-1}: 3435, 1757, 1689, 1512, 1213. ^1H NMR ($CDCl_3$, δ): 1.91 (3H, s, eq. NAc), 1.96, 2.00, 2.03 (3H, each, all s, eq. OAc×3), 2.21 (6H, s, ax. OAc×2), 4.71 (1H, m, 1-H), 5.15—5.65 (5H, m). MS m/z(%): 432 (3, M^++1), 209 (83), 167 (100).

Methanolysis followed by Catalytic Oxidation of D-Mannose (19)——A solution of **19** (5 g) in MeOH (15 ml) was treated with AcCl–MeOH (3: 20, 5 ml) and the whole mixture was heated under reflux for 1.5 h. After neutralization with Amberlite IRA-400 (OH^- form), the solvent was removed from the filtrate under reduced pressure. The product was mixed with silica gel (5 g) with the aid of MeOH and dried. The silica gel mixture was then put on a column of silica gel (100 g) and chromatographed with $CHCl_3$–MeOH (3: 1) to furnish the α-anomer (3.4 g) and a mixture of α- and β-anomers (1.6 g). The α-anomer was identical with authentic methyl α-D-mannopyranoside as judged by mixed mp determination and TLC ($CHCl_3$–MeOH= 3: 1) comparison.

A solution of the α-anomer (1 g) in H_2O (60 ml) and a platinum catalyst (prepared from $PtO_2 \cdot 1$—3 H_2O, 1 g) were put in a four-necked round-bottomed flask which was equipped with a stirrer, a gas-inlet, a reflux condenser, and a dropping-funnel. With vigorous stirring, the whole mixture was heated at 70—80°C and a stream of oxygen was introduced. During this period, the reaction mixture was kept at pH 7—8 by occasional additions of aq. $NaHCO_3$. After 8 h, the mixture was filtered and the filtrate was neutralized with Dowex 50 W×8 (H^+ form). The product obtained upon removal of the solvent from the filtrate under

reduced pressure was treated with acetone to furnish **20** (800 mg, 77%) as a precipitate. The $[\alpha]_D$ and mp of **20** were identical with reported values ($[\alpha]_D$ +62°, mp 106—107°C (EtOH–ether)).[11]

Electrolysis followed by Nitromethane Cyclization of 20——A solution of **20** (500 mg) in AcOH (20 ml) containing Et_3N (0.4 ml) was subjected to constant current electrolysis [Pt electrode; 100 mA (20 mA/cm²); 5—7°C] for 7 h. Removal of the solvent by freeze-drying and purification by preparative TLC ($CHCl_3$–MeOH=4:1) furnished **21** (240 mg, 48%). IR ν_{max}^{KBr} cm^{-1}: 3360, 1746, 1240. ^1H NMR ($CDCl_3$, δ): 2.00, 2.10 (total 3H, OAc), 3.50 (3H, s, OMe), 4.45 (1H, d, J=3, 1-H). A solution of **21** (250 mg) in MeOH (5 ml) and nitromethane (10 ml) was stirred at room temperature (12°C) for 10 min, then 10% NaOMe–MeOH (1 ml) was added and the whole was stirred at room temp. under an argon atmosphere for 12 h. After neutralization with Dowex 50 W×8 (H^+ form), the filtrate was evaporated to dryness under reduced pressure. The product thus obtained was mixed with silica gel (0.5 g) with the aid of MeOH and dried. The silica gel mixture was put on a column of silica gel (25 g) and the column was eluted with $CHCl_3$–MeOH–H_2O=65:35:10 (lower phase). The eluate was evaporated to dryness and the residue was crystallized from MeOH to furnish **22** (L-*neo*, 24 mg, 12% from **20**), mp 209—210.5°C (colorless needles from MeOH), $[\alpha]_D^{14}$ +30.2° (c=0.54, H_2O). *Anal.* Calcd for $C_6H_{11}O_7N$: C, 34.45; H, 5.26; N, 6.70. Found: C, 34.31; H, 5.24; N, 6.74. IR ν_{max}^{KBr} cm^{-1}: 3500, 3405, 3225, 1541, 1386, 1126.

Reduction followed by Acetylation of 22——Reduction followed by acetylation of **22** (16 mg) as described above for **18** furnished **22b** (27 mg), mp 281—282°C (colorless needles from EtOH), $[\alpha]_D^{25}$ +8.9° (c=1.0, MeOH). *Anal.* Calcd for $C_{18}H_{25}O_{11}N$: C, 50.12; H, 5.80; N, 3.25. Found: C, 49.83; H, 5.76; N, 3.40.

Electrolysis followed by Nitromethane Cyclization of Sakuraso-saponin (23)——A solution of **23** (500 mg) in AcOH (20 ml) containing Et_3N (1 ml) was subjected to constant current electrolysis [Pt electrode; 100 mA (4 mA/cm²); 5—7°C] for 10 h. The reaction mixture was neutralized with aq. sat. $NaHCO_3$ and extracted with *n*-BuOH. The *n*-BuOH extract was washed with water and the solvent was evaporated off under reduced pressure. The product was dissolved in MeOH (10 ml) and nitromethane (5 ml) and the solution was stirred under an argon atmosphere for 10 min. The reaction mixture was then treated with 10% NaOMe–MeOH (0.5 ml) and the whole was stirred at 30°C under an argon atmosphere for 7 h. After neutralization with Dowex 50 W×8 (H^+ form), the filtrate was evaporated to dryness under reduced pressure. The residue was then partitioned into a *n*-BuOH–H_2O mixture. Concentration of the *n*-BuOH phase under reduced pressure gave a product which was treated with acetone and filtered. The acetone–insoluble portion was mixed with silica gel (0.5 g) with the aid of MeOH and dried. The silica gel mixture was put on a column of silica gel (10 g) and the column was eluted with $CHCl_3$–MeOH–H_2O=6:4:1 to furnish **23** (173 mg, recovered). The acetone–soluble portion was purified by preparative TLC ($CHCl_3$–MeOH=50:1) to furnish protoprimulagenin A (**24**, 25 mg, 22%) and aegicerin (**25**, 18 mg, 16%). **24** and **25** were identical with authentic samples[13] as judged by mixed mp, TLC ($CHCl_3$–MeOH=50:1), and IR (KBr) comparisons. Concentration of the aqueous phase under reduced pressure furnished a mixture of nitrocyclitol-oligoglycosides (**26**, 119 mg, 58%).

N-Acetylaminocyclitol-oligoglycoside (26a) from 26——A suspension of Raney Ni (T-4) in EtOH (2 ml) was added to a solution of **26** (77 mg) in H_2O (10 ml) and the mixture was shaken at room temperature (11°C) under a hydrogen atmosphere for 6 h. Removal of the solvent from the filtrate under reduced pressure gave a product which was acetylated with Ac_2O (2 ml) and MeOH (20 ml) at room temp. (17°C) under stirring for 3 h. Removal of MeOH from the mixture by evaporation under reduced pressure gave a product which was treated with acetone to yield a precipitate The precipitate was mixed with silica gel (0.5 g) with the aid of MeOH as above and put on a column of silica gel (10 g). Elution with $CHCl_3$–MeOH–H_2O=6:4:1 furnished highly hygroscopic **26a** (27 mg, 35%), mp 212—215°C (colorless fine crystals from MeOH), $[\alpha]_D^{16}$ −55.9° (c=0.59, MeOH). *Anal.* Calcd for $C_{32}H_{55}O_{24}N \cdot H_2O$: C, 44.91; H, 6.71; N, 1.64. Found: C, 44.68; H, 6.46; N, 1.79. IR ν_{max}^{KBr} cm^{-1}: 3376 (br), 1640, 1563. ^1H NMR ($CDCl_3$: CD_3OD: D_2O=2:3:1, δ): 1.30 (6H, br d, J=*ca.* 5, *sec.* Me in rhamnose×2), 2.03 (3H, s, >NAc), 5.28 (2H, br s, $W_{h/2}$=5, anomeric H of rhamnose×2). FD-MS m/z(%): 838 (100, M^++1), 860 (8, M^++Na).

Methanolysis of 26a——A solution of **26a** (5 mg) in AcCl–anhydrous MeOH (3:20, 1 ml) was heated under reflux for 3 h. After neutralization with Ag_2CO_3, the filtrate was evaporated to dryness under reduced pressure. The product was dissolved in pyridine (0.1 ml) and treated with N,O-bis(trimethylsilyl)trifluoroacetamide (BSTFA, 0.2 ml). L-Rhamnose, D-glucose, and D-galactose were treated in a similar manner to prepare standard samples. TLC [$CHCl_3$: MeOH: H_2O=7:3:1 (lower phase), double development] and GLC [2% silicone SE-52 on Chromosorb WAWDMCS (80—100 mesh); column 3 mm×2 m; column temp. 138°C; N_2 flow rate 45 ml/min] of the product resulted in the identification of methyl L-rhamnoside [Rf=0.65; t_R=2′48″], methyl D-glucoside [Rf=0.38;[19] t_R=6′25″, 12′12″ (major), 13′25″], and methyl D-galactoside [Rf=0.38;[19] t_R=8′10″, 9′24″ (major), 11′05″]. In regard to the cyclitol portion, N-acetyl-*myo*-inosamine (**14b**) was dissolved in pyridine (0.1 ml) and treated with BSTFA (0.2 ml) to prepare a standard sample for GLC. TLC [$CHCl_3$: MeOH=1:1, silica gel (Camag D-5)] and GLC [2% silicone SE-52 on Chromosorb WAWDMCS (80—100 mesh); column 3 mm×2 m; column temp. 180°C; N_2 flow rate 40 ml/min] of the product resulted in the identification of **14b** [Rf=0.57; t_R=4′12″].

Electrolysis followed by Nitromethane Cyclization of Desacyl-jegosaponin (27)——Electrolysis under constant current conditions followed by CH_3NO_2–NaOMe treatment of **27** (500 mg) as described above for

sakuraso-saponin (**23**) gave a product, which was partitioned into a *n*-BuOH–H_2O mixture. Concentration of the *n*-BuOH phase under reduced pressure gave a residue which was treated with acetone and filtered. Chromatography of the acetone-insoluble portion as described for **23** (SiO_2=0.5 g+10 g) with $CHCl_3$–MeOH–H_2O(6: 4: 1) furnished **27** (82 mg recovered). The acetone-soluble portion gave a sapogenol mixture (138 mg, not analyzed further). The aqueous phase gave a mixture of nitrocyclitol-oligoglycosides (**28**, 48%) upon removal of the solvent under reduced pressure.

N-Acetylaminocyclitol-oligoglycoside (28a) from 28——A suspension of Raney Ni (T-4) in EtOH (10 ml) was added to a solution of **28** (200 mg) in H_2O (20 ml) and the mixture was shaken at room temp. (10°C) under a hydrogen atmosphere for 5 h. Removal of the solvent from the filtrate under reduced pressure gave a product which was treated with Ac_2O (5 ml) and MeOH (50 ml), and the mixture was stirred at room temp. (17°C) for 4 h. Removal of the solvent from the reaction mixture by evaporation gave a product which was treated with acetone to yield a precipitate. Chromatography of the precipitate as described above for **26a** (SiO_2=1 g+10 g) with $CHCl_3$: MeOH: H_2O=6: 4: 1 furnished highly hygroscopic **28a** (47 mg, 23%), white powder (an attempt at crystallization was unsuccessful), $[\alpha]_D^{16}$ −54.7° (c=0.68, MeOH). *Anal.* Calcd for $C_{26}H_{45}O_{20}N$: C, 45.15; H, 6.56; N, 2.03. Found: C, 44.89; H, 6.23; N, 1.93. IR ν_{max}^{KBr} cm^{-1}: 3365 (br), 1640, 1562. ^1H NMR ($CDCl_3$: CD_3OD: D_2O=2: 3: 1, δ): 1.31 (3H, d, J=6, *sec.* Me in rhamnose), 2.04 (3H, s, >NAc), 5.16 (1H, br s, $W_{h/2}$=5, anomeric H of rhamnose). FD-MS m/z(%): 714 (100, M^++Na), 730 (4, M^++K).

Methanolysis of 28a——Methanolysis of **28a** as described above for **26a** gave a product which was mixed with pyridine (0.1 ml)–BSTFA (0.2 ml) and subjected to GLC analysis as described above. The methanolysis product and its TMS derivatives were analyzed by TLC and GLC, and methyl L-rhamnoside, methyl D-glucoside, methyl D-galactoside and N-acetyl-*myo*-inosamine (**14b**) were identified.

Acknowledgement The authors are grateful to the Research Laboratories of Dainippon Pharm. Co. for elemental analyses and to Dr. H. Ohmori of this Faculty for discussions. They are also indebted to Hōansha and to the Ministry of Education, Science and Culture (Grant No. 357605) for financial support.

References and Notes

1) I. Kitagawa, A. Kadota, and M. Yoshikawa, *Chem. Pharm. Bull.*, **26**, 3825 (1978).
2) I. Kitagawa, T. Kamigauchi, H. Ohmori, and M. Yoshikawa, *Chem. Pharm. Bull.*, **28**, 3078 (1980).
3) *a*) I. Kitagawa, M. Yoshikawa, Y. Ikenishi, K.S. Im, and I. Yosioka, *Tetrahedron Lett.*, **1976**, 549; *b*) I. Kitagawa, M. Yoshikawa, K.S. Im, and Y. Ikenishi, *Chem. Pharm. Bull.*, **25**, 657 (1977); *c*) I. Kitagawa, M. Yoshikawa, and A. Kadota, *ibid.*, **26**, 484 (1978).
4) I. Kitagawa and M. Yoshikawa, *Heterocycles*, **8**, 783 (1977).
5) Preliminary communication: I. Kitagawa, T. Kamigauchi, K. Shirakawa, Y. Ikeda, H. Ohmori, and M. Yoshikawa, *Heterocycles*, **15**, 349 (1981).
6) S. Nishimura, *Bull. Chem. Soc. Japan*, **32**, 61 (1959).
7) E.G. de Jong, W. Heerma, B. Dujardin, J. Haverkamp, J.F.G. Vliegenthart, *Carbohyd. Res.*, **60**, 229 (1978).
8) J. Alföldi, C. Peciar, R. Palovcik, and P. Kovac, *Carbohyd. Res.*, **25**, 249 (1972).
9) T. Naito, *J. Antibiotics*, **15B**, 373 (1962).
10) B. Bannister and A.D. Argoudelis, *J. Am. Chem. Soc.*, **85**, 119 (1963).
11) C.A. Marsh, *J. Chem. Soc.*, **1952**, 1578.
12) I. Kitagawa, M. Yoshikawa, K. Kobayashi, Y. Imakura, K.S. Im, and Y. Ikenishi, *Chem. Pharm. Bull.*, **28**, 296 (1980).
13) I. Kitagawa, A. Matsuda, and I. Yosioka, *Chem. Pharm. Bull.*, **20**, 2226 (1972).
14) K. Miyahara and T. Kawasaki, *Chem. Pharm. Bull.*, **22**, 1407 (1974).
15) F.W. Lichtenthaler, *Chem. Ber.*, **94**, 3071 (1961).
16) J.M. Grosheitz and H.O.L. Fisher, *J. Am. Chem. Soc.*, **70**, 1479 (1948).
17) F.W. Lichtenthaler and P. Emig, *Carbohyd. Res.*, **7**, 121 (1968).
18) L. Anderson and H.A. Lardy, *J. Am. Chem. Soc.*, **72**, 3141 (1950).
19) Methyl D-glucoside and methyl D-galactoside could not be differentiated on TLC under these conditions.