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Partial Methylation with Diazomethane of the Sugar Moiety of Some C- and O-D-Glucopyranosides

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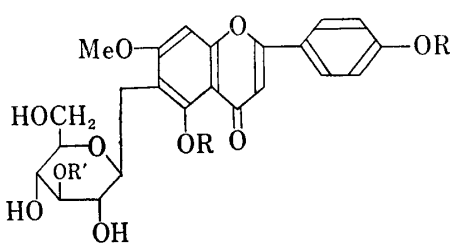
On treatment of some C- and O-D-glucopyranosides with diazomethane in methanol or in methanol-dimethylformamide mixture, a partial methylation of the sugar moiety took place, though to a slight extent, to give a mixture of methyl ethers, in which 3-methyl ether is the major. The reaction is much favored in the presence of a small amount of stannous chloride. A O-α-D-glucopyranoside gave almost exclusively the corresponding 3-methyl ether of the glucose residue, while the β-anomer provided, beside 3-methyl ether, 2,3-dimethyl ether nearly in equal amount. The benzylidene derivatives of O-α- and β-D-glucosides gave also the corresponding 3-methyl ether but 2,3-dimethyl ether was formed only in trace and, instead, 2-methyl ether was provided.

In the chemistry of phenolic C- and O-glycosides, diazomethane is conveniently used as a reagent to methylate exclusively the phenolic hydroxyl group of the aglycone. However, it has been reported that free monosaccharides,[2-4] methyl D-glucosides[2,5] and some polysaccharides[2,5,6] give, on treatment with diazomethane, respectively a small amount of unidentified product which is suspected to be a mixture of compounds where the alcoholic hydroxyl groups are partially methylated. According to Meerwein, *et al.*,[7] a certain kind of metal salts, such as zinc, ferric and magnesium chlorides, catalyze the methylation of *n*-butanol with diazomethane. During the course of studies on the structures of a flavonoid C-glycoside, swertisin,[8] and a xanthone C-glycoside, homomangiferin,[9] it was observed that their methylations with diazomethane in methanol or in a mixture of methanol and dimethylformamide to give the main product in which only the phenolic hydroxyl groups are methylated were always accompanied by formation of several less polar by-products, and that, in a series of incidental experiments using an aged methanol stored in a can, the yields of the by-products were much increased.

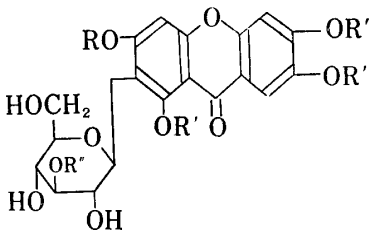
This paper is concerned with a study on methylation with diazomethane of some C- and O-D-glucopyranosides, which has led to the findings that a partial methylation in their sugar moieties takes place, though to a slight extent, to give the 3-methyl ether of the glucose residue as the major by-product, and that the reaction is much favored in the presence of a small amount of stannous chloride.

When swertisin (I) was methylated with diazomethane in distilled methanol, it gave 4',5-di-O-methylswertisin[8] (II) (*Rf* 0.09 on thin-layer chromatography (TLC)), but the mother liquor of its recrystallization contained II and several minor products showing *Rf* 0.22 (III),

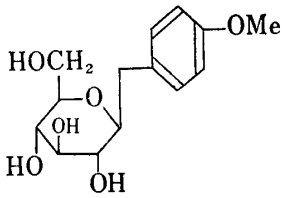
1) Location: *a*) *Kurokami-machi, Kumamoto*; *b*) *Katakasu, Fukuoka.*
2) L. Hough and R.S. Theobald, "Methods in Carbohydrate Chemistry," Vol. II, ed. by R.L. Whistler, M.L. Wolfrom and J.M. BeMiller, Academic Press Inc., New York, London, 1963, p. 162.
3) R. Kuhn and H.H. Baer, *Chem. Ber.*, **86**, 724 (1953).
4) E. Klajn and A. Damanski, *Bull. Soc. Chim. Biol.*, **49**, 521 (1967) [*C.A.*, **67**, 10283 (1967)].
5) L. Hough and J.K.N. Jones, *Chem. Ind.* (London), **1952**, 380.
6) *a*) L. Schmidt, *Chem. Ber.*, **58**, 1963 (1925); *b*) L. Schmidt and M. Zentner, *Monatsch.*, **49**, 111 (1928).
7) H. Meerwein and G. Hinz, *Ann.*, **484**, 1 (1930).
8) M. Aritomi and T. Kawasaki, *Chem. Pharm. Bull.* (Tokyo), **16**, 1842 (1968).
9) M. Aritomi and T. Kawasaki, *Chem. Pharm. Bull.* (Tokyo), **16**, 760 (1968).



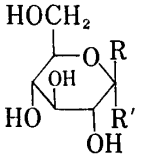
I : R=R′=H
II : R=Me, R′=H
III : R=R′=Me

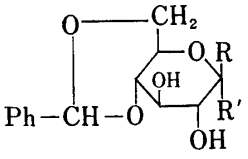


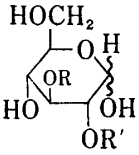
IV : R=R′=R″=H
V : R=Me, R′=R″=H
VI : R=R′=Me, R″=H
VII : R=R′=R″=Me



VIII







IX : R=H, R′=OPh
X : R=H, R′=OMe
XI : R=OPh, R′=H
XII : R=OMe, R′=H

XIII : R=H, R′=OMe
XIV : R=OMe, R′=H

XV : R=Me, R′=H
XVI : R=R′=Me

TABLE I. Effect of Metal Salts on Methylation with Diazomethane of C- and O-D-Glucopyranosides

Mole of salts (per mole of substrate)		10^{-1}			10^{-2}			10^{-3}			10^{-4}		
Salt	Substrate / Spots	A	B	C	A	B	C	A	B	C	A	B	C
C-D-Glucopyranoside													
without salt	I in MeOH	###	##	+	###	##	+	###	##	+	###	##	+
$AlCl_3 \cdot 6H_2O$	IV in DMF	###	##	+	###	##	+	###	##	+	###	##	+
$MgCl_2 \cdot 6H_2O$	VI in DMF	###	##	+	###	##	+	###	##	+	###	##	+
$ZnCl_2$	VI in MeOH	###	##	+	###	##	+	###	##	+	###	##	+
$Pb(OAc)_2 \cdot 3H_2O$	VIII in MeOH	###	##	+	###	##	+	###	##	+	###	##	+
$SnCl_2 \cdot 2H_2O$	I in MeOH	−	###	##	−	###	##	###	##	+	###	##	+
	IV in DMF	−	###	##	−	###	##	###	##	+	###	##	+
	VI in DMF	−	###	##	−	###	##	###	##	+−	###	##	+
	VI in MeOH	−	###	##	−	###	##	###	##	+	###	##	+
	VIII in MOeH	−	###	##	−	###	##	−	###	##	###	##	+
O-D-Glucopyranoside													
without salt	IX in MeOH	###	##	+	###	##	+	###	##	+	###	##	+
$AlCl_3 \cdot 6H_2O$	X in MeOH	###	##	+	###	##	+	###	##	+	###	##	+
$MgCl_2 \cdot 6H_2O$	XI in MeOH	###	##	+	###	##	+	###	##	+	###	##	+
$ZnCl_2$	XII in MeOH	###	##	+	###	##	+	###	##	+	###	##	+
$Pb(OAc)_2 \cdot 3H_2O$	XIII in MeOH	###	##	+	###	##	+	###	##	+	###	##	+
	XIV in MeOH	###	##	+	###	##	+	###	##	+	###	##	+
$SnCl_2 \cdot 2H_2O$	IX in MeOH	−	###	##	−	###	##	−	###	##	###	##	+
	X in MeOH	−	###	##	−	###	##	−	###	##	###	##	+
	XI in MeOH	−	###	##	−	###	##	−	###	##	###	##	+
	XII in MeOH	−	###	##	−	###	##	−	###	##	###	##	+
	XIII in MeOH	−	###	##	−	###	##	−	###	##	###	##	+
	XIV in MeOH	−	###	##	−	###	##	−	###	##	###	##	+

abbreviations A: spot corresponding to product without methoxyl groups on sugar moiety; B: spot of major by-product; C: spots of other by-products with heigher *Rf* values than A and B. Assessment of intensity of each spot is due to a visual comparison of area and degree of coloration and denoted by four symbols, ###: strong; ##: weak; +: very weak; −: not detectable. DMF: dimethylformamide.

0.36, 0.40, 0.50, 0.63 and 0.70. Similar reactions of mangiferin (IV) and of homomangiferin (V) in methanol–dimethylformamide (4:1, v/v) provided equally a mixture of compounds which showed on TLC a major spot at 0.56 and minor ones at 0.68, 0.74, 0.83, 0.87 and 0.91. The crude product gave, on repeated recrystallization, the compound of *Rf* 0.56 (VI) contaminated with that of 0.68 (VII) and, on chromatography over silica gel, afforded VI in an homogeneous state and a fraction consisting of the five less polar compounds. Recrystallization of the former provided pure 1,3,6,7-tetra-O-methylmangiferin[10] (VI), mp 231°, in 40% yield, and the latter gave, on further chromatography followed by recrystallization, a mixture of two compounds, VII (major) and that of *Rf* 0.74, in 5% yield. Meanwhile, in a series of experiments using, accidentally, an aged methanol stored in a can without distillation, it was found that I was methylated to give III, mp 253—254°, along with II and that IV as well as V afforded both VI and VII, mp 229—230°, the latter of which was the major. In consideration of the *Rf* values of III and VII comparing with those of II and VI, and taking into account the reported observations,[2-7] III and VII were assumed respectively to be a methyl ether where not only all the phenolic hydroxyl groups of the aglycone but a part of the sugar hydroxyl groups is also methylated, and their favored formation in a canned methanol was suspected to be due to a contaminant, possibly a metal salt, in the solvent.

Subsequently the methylation of four C-glycosides, I, IV, VI and 1-(*p*-methoxyphenyl)-1-deoxy-*β*-D-glucopyranose (VIII), was carried out in the presence of some kinds of metal salts in various concentrations and the respective product was examined by TLC. As shown in Table I, the result indicates that the presence of a small amount (10^{-1}—10^{-2} (for I, IV and VI) or 10^{-1}—10^{-3} (for VIII) mole per mole of substrate) of stannous chloride favored remarkably the formation of the "by-products", particularly the most polar one of them and the normal product was scarcely found on TLC. It is also noted that the *Rf* values of the major products from I and IV (and VI) agreed well respectively with those of III and VII. A large scale experiment was then carried out in order to isolate these products in a sufficient amount for identification (Table II).

Table II. Yields of Methyl Ethers on Methylations of C- and O-D-Glyucopyranosides in the Presence of Stannous Chloride

Starting material	$SnCl_2 \cdot 2H_2O$ (mole)	Methyl ether	Yield (%)
C-D-Glucoside I	6×10^{-2}	3″,4′,5-tri- (III)	29
IV	6×10^{-2}	1,3,3′,6,7-penta- (VII)	24
VIII	6×10^{-2}	3-mono-	54
O-D-Glucoside IX	2×10^{-3}	3-mono-	81
		2,3-di-	18
X	2×10^{-3}	3-mono-	74
		2,3-di-	17
XI	2×10^{-3}	3-mono-	47
		2,3-di-	44
XII	2×10^{-3}	3-mono-	54
		2,3-di-	48
XIII	2×10^{-3}	2-mono-	4
		3-mono-	97
		2,3-di-	trace
XIV	2×10^{-3}	2-mono-	34
		3-mono-	52
		2,3-di-	trace

Methylation of I in methanol containing 6×10^{-2} mole of stannous chloride per mole of I afforded a product consisting of III (major) and the compounds of *Rf* 0.36, 0.50, 0.63 and 0.70, recrystallization of which from ethyl acetate provided III in 29% yield as a sole isolable product. It had mp 253—255°, showed no melting point depression on admixture with the sample obtained on methylation in a canned methanol, analyzed for $C_{21}H_{16}O_6(OCH_3)_4\cdot1/2\ H_2O$ and showed $[\alpha]_D^8$ +55.6° (pyridine) and an ultraviolet (UV) spectrum hardly distinguishable from that of II. The nuclear magnetic resonance (NMR) spectrum of its acetate, mp 156—158°, indicated the presence of 4',5,6,7-tetra-substituted flavone nucleus,[11] three methoxyl groups on the aromatic ring,[11,12] one methoxyl[12] and three acetoxyl[12,13] groups in the sugar part. The chemical shifts of the three acetoxyl groups suggest[13] that the methoxyl group on the sugar moiety is located at C-3'' or C-4'', and no consumption of periodate in the oxidation of III excluded the location at C-4''. Therefore III is considered to be 3'',4',5-tri-O-methylswertisin. When IV was methylated with diazomethane in a mixture of dimethylformamide and methanol (1:4, v/v) containing stannous chloride (6×10^{-2} mole per mole of IV), it gave a mixture of VII (major) and the compounds of *Rf* 0.83, 0.87 and 0.91, from which VII, mp 229—230°, $[\alpha]_D^{17}$ +54.4° (pyridine), $C_{19}H_{13}O_6(OCH_3)_5\cdot H_2O$, was obtained in 24% yield through column chromatography and subsequent recrystallization. On admixture with the aforementioned specimen of VII, no melting point depression was observed. It showed an almost identical UV spectrum with that of VI and gave an acetate, mp 137—138°. The NMR spectrum of the acetate exhibited three protons and four methoxyl groups on the xanthone nucleus[12] and one methoxyl[12] and three acetoxyl[12,13] groups on the sugar moiety. The chemical shifts of the three acetoxyl groups[13] in the acetate and the fact that VII did not consume periodate indicate the structure of VII to be 1,3,3',6,7-penta-O-methylmangiferin. The reaction mixture yielded on treatment of VIII in a similar manner gave, on recrystallization from benzene, the corresponding monomethyl ether, mp 158—159°, $[\alpha]_D^8$ +7.0° (MeOH), $C_{12}H_{14}O_4(OCH_3)_2$, in 54% yield, which consumed no periodate indicating that the methoxyl group is located at C-3.

Accordingly it follows that, on treatment of these C-glucosides with diazomethane in methanol in the presence of stannous chloride (10^{-1}—10^{-2} mole), not only the phenolic hydroxyl groups but the alcoholic group(s), preferentially at C-3, of the sugar moiety is methylated, and that even without stannous chloride their sugar residues seem to be partially methylated to give a small amount of a mixture of methyl ethers in which 3-methyl ether is the major.[14]

It has been generally accepted[15,16] that the relative reactivities of the hydroxyl groups in glucopyranose derivatives are in an order of 6>2>3>4, though some exceptional results have also been reported on esterification,[17] etherification[18] and glycosydation.[19] In connec-

10) 1,3,6,7-Tetra-O-methylmangiferin, mp 185—186°, reported in a preliminary communication,[9] was later found to be somewhat inpure showing three spots on TLC at *Rf* 0.56 (main), 0.68 and 0.74 (trace). After purification through column chromatography over silica gel, it had mp 231°.

11) M. Komatsu, T. Tomimori and M. Ito, *Chem. Pharm. Bull.* (Tokyo), **15**, 263 (1967).

12) D. Billet, J. Massicot, C. Mercier, D. Anker, A. Matschenko, C. Mentzer, M. Chaigneau, G. Valdener and H. Pacheco, *Bull. Soc. Chim. France*, **1965**, 3006.

13) W.E. Hillis and D.H.S. Horn, *Australian J. Chem.*, **18**, 531 (1965).

14) According to Prox (A. Prox, *Tetrahedron* **24**, 3697 (1968)) tri-O-methylvitexin and tetra-O-methylorientin prepared from vitexin and scoparin (3'-O-methylorientin), respectively, with diazomethane in methanol were accompanied by a small amount (about 6%) of the corresponding homocompounds showing in their mass spectra the molecular ions of fourteen mass unit more than those of the main products.

15) J.M. Sugihara, "Advances in Carbohydrate Chemistry," Vol. 8, ed. by C.S. Hudson, M.L. Wolfrom, S. Peat, M. Stacey and E.L. Hirst, Academic Press Inc., Publishers, New York, N.Y., 1953, p. 1.

16) J.M. Williams and A.C. Richardson, *Tetrahedron*, **23**, 1369 (1967).

17) *a*) R.W. Jeanloz and D.A. Jeanloz, *J. Am. Chem. Soc.*, **79**, 2579 (1957); *b*) C.P.J. Glaudemans and H.G. Fletcher, Jr., *Carbohydrate Research*, **7**, 480 (1968); *c*) D. Horton and J.H. Lauterback, *J. Org. Chem.*, **34**, 86 (1969).

tion with these reported observations, the preferential methylation, catalyzed by stannous chloride, at C-3 of the sugar moiety in C-glucopyranosides is particularly of interest, and in order to know whether the reaction is indigenous to C-glucopyranosides having a phenolic aglycone, the same procedure was applied to methyl and phenyl O-glucopyranosides.

The result of a preliminary experiment shows, as summarized in Table I, that six compounds so far examined, phenyl (IX) and methyl (X) α-D-glucopyranosides, phenyl (XI) and methyl (XII) β-D-glucopyranosides, 4,6-O-benzylidene methyl α- (XIII) and β- (XIV) D-glucopyranosides, gave, on methylation in pure methanol, respectively a very small amount of mixture of a few products which are less polar than the starting material, while in the presence of 10^{-1}—10^{-3} mole of stannous chloride per mole of the substrate the yields of these products were much increased and the unchanged starting material was not detected on TLC. The reaction in a preparative scale and isolation and identification of the products were then tried (Table II). IX in methanol containing 2×10^{-3} mole of stannous chloride per mole of IX was treated with diazomethane and the products were separated by recrystallization and column chromatography on silica gel to give colorless needles (yield, 81%), *Rf* 0.35, mp 164°, $[\alpha]_D^{14}$ +109.2° (MeOH), and colorless syrup (18%), *Rf* 0.61, together with a trace amount of a compound of *Rf* 0.66. The crystal was characterized as phenyl 3-O-methyl-α-D-glucopyranoside on the basis of its analytical result and of the facts that it consumed no periodate and that acid hydrolysis gave 3-O-methyl-D-glucose (XV), mp 160—161° (phenylosazone, mp 174—175° (decomp.), identified with authentic samples[20]). The syrup gave, on acid hydrolysis, 2,3-di-O-methyl-D-glucose (XVI) identical with authentic specimen[21] on paper chromatogram, and on condensation[22] with benzaldehyde, phenyl 2,3-di-O-methyl-4,6-O-benzylidene-α-D-glucopyranoside, mp 144—145°, $[\alpha]_D^{9}$ +183.3° ($CHCl_3$), which was identified by mixed melting point determination with a sample, mp 146—147°, $[\alpha]_D^{14}$ +183.8° ($CHCl_3$), prepared by exhaustive methylation[23] by the Kuhn method[24] of phenyl 4,6-O-benzylidene-α-D-glucopyranoside. On methylations of X–XIV and subsequent separations of the products in the same way as above, X gave, in common with IX, predominantly (yield, 74%) the corresponding 3-methyl ether along with a minor amount (17%) of 2,3-dimethyl ether, while XI and XII afforded the two ethers in nearly equal amount (yield: 47% (3-ether) and 44% (2,3-diether) from XI; 54% (3-ether) and 48% (2,3-diether) from XII), and XIII and XIV yielded also the corresponding 3-methyl ether but 2,3-dimethyl ether was formed only in trace and, instead, 2-methyl ether was provided. It was noted that XIII gave, in the analogous manner to IX and X, solely (97%) 3-methyl ether, but that XIV afforded both 3- and 2-methyl ethers, in 52% and 34% yield respectively.

As observed in C-glucosides, one (major) of a few products from these O-glucosides on methylation with diazomethane in methanol without stannous chloride also showed the same *Rf* value with that of the corresponding 3-methyl ether suggesting their identity. In order to make a direct comparison of these compounds and to characterize other products, methylation of IX in pure methanol was conducted in a large scale and a mixture of several products (yield, 4%) was subjected to fractional recrystallization and column chromatography on silica gel. One (major) product was obtained as colorless needles, mp 163°, and was found to be

18) *a*) H.R. Bolliger and D.A. Prins, *Helv. Chim. Acta*, **28**, 465 (1945); *b*) I. Croon, *Acta Chem. Scand.*, **13**, 1235 (1959); *c*) R.W. Lenz, *J. Am. Chem. Soc.*, **82**, 182 (1960); *d*) E.J. Roberts and S.P. Rowland, *Can. J. Chem.*, **45**, 261 (1967); *e*) *Idem*, *Carbohydrate Research*, **4**, 509 (1967).
19) A.M. Bills and J.W. Green, *J. Chem. Soc.* **1967**, 716.
20) Prepared according to the method of Irvine and Scot (J.C. Irvine and J.P. Scott, *J. Chem. Soc.*, **103**, 564 (1913)).
21) Prepared according to the method of Irvine and Scot (J.C. Irvine and J.P. Scott, *J. Chem. Soc.*, **103**, 575 (1913)).
22) K. Freudenberg, H. Toepffer and C.C. Anderson, *Chem. Ber.*, **61**, 1750 (1928).
23) C.M. McCloskey and G.H. Coleman, *J. Org. Chem.*, **10**, 184 (1945).
24) R. Kuhn, H. Trischmann and I. Löw, *Angew. Chem.*, **67**, 32 (1955).

identical with the specimen of the corresponding 3-methyl ether. The others could not be isolated but two of them were regarded as 2- and 6-monomethyl ethers on the basis of their paper chromatographic behaviors (color tests with *p*-anisidine hydrochloride[25] and triphenyltetrazolium chloride[26] and *Rf* values) in comparison with those of the authentic samples run in parallel. A similar result was obtained with XI.

From the results described above it could be concluded that both in C- and O-D-glucopyranosides the sugar moiety is methylated with diazomethane, though partially and only to a small extent, to give some ethers, preferentially the 3-monomethyl ether, of the glucose residue, and that the reaction is much facilitated by adding a small amount of stannous chloride.

In order to account for the different reactivities of the hydroxyl groups of D-glucopyranosides, a steric effect,[16,18c-e,19,27] an intramolecular hydrogen bonding,[16,18b] the acidity of a hydroxyl group[16,18c] and others[16,17a,18a] have been taken into consideration, and the fact that partial esterification[16,18e] and etherification[28] of β-anomer proceed more randomly than those of the corresponding α-anomer has also been pointed out. The reaction reported here in this communication seems somewhat peculior and the mechanism can not be discussed until a further study will be completed, but the predominant formation of 3-methyl ether from α-D-glucopyranosides (IX, X, XIII) in contrast to the reaction of the corresponding β-anomers (XI, XII, XIV) seems to be of theoretical interest and may have a practical utility as a more simple and convenient method of preparation[29] of D-glucose 3-methyl ether.

Experimental[33]

Methylation of C-D-Glucopyraoside in Methanol——i) In Distilled Methanol: a) Swertisin (I): To a solution of I (500 mg) in distilled MeOH (30 ml) was added an ether solution (about 50 ml) of CH_2N_2 prepared from 5 g of nitrosomethylurea. After standing overnight at room temperature, the product separated out was collected by filtration and recrystallized from aqueous dioxane to give 4′,5-di-O-merthylswertisin (II) (yield: 220mg, 44%), mp 304—305° (decomp.), $[\alpha]_D^{18}$ +63.2° (c=1.02, pyridine), *Rf* 0.09. The filtrate showed several spots, *Rf* 0.09 (II), 0.22 (III), 0.36, 0.40, 0.50, 0.63 and 0.70, on TLC.

25) L. Hough, J.K.N. Jones and W.H. Wadman, *J. Chem. Soc.*, **1950**, 1702.
26) K. Wallenfels, *Naturwiss.*, **37**, 491 (1950).
27) *a*) G.O. Aspinall and G. Zweifel, *J. Chem. Soc.*, **1957**, 2271; *b*) H.M. Flowers and D. Shapiro, *J. Org. Chem.*, **30**, 2041 (1965).
28) J.J. Willard, J.S. Brimacombe and R.P. Brueton, *Can. J. Chem.*, **42**, 2560 (1964).
29) The methods so far reported[18a,30] for the synthesis of 3-O-methyl-D-glucopyranose and its methyl α-glucoside consist of several stages of reaction and the over-all yields are 10—80%. Recently Marvel, Sen, Berry and Deutschman Jr.[31] described two syntheses (10 and 50% yields) of methyl 3-O-ethyl-α-D-glucopyranoside by conventional methods. The same compound, mp 140—141°, $[\alpha]_D^{15}$ +151.1° (c=1.25, EtOH) (4,6-O-benzylidene derivative, mp 168°, $[\alpha]_D^{15}$ +111.0° (c=0.77, $CHCl_3$), phenylosazone of the parent sugar, mp 152—153°), was directly obtained in 92% yield from methyl α-D-glucopyranoside (4×10^{-3} mole) by the present procedure (stannous chloride, 8×10^{-6} mole) using diazoethane (prepared from 1-ethyl-1-nitroso-3-nitroguanidine[32]) in place of diazomethane.
30) *a*) J. Dewar and G. Fort, *J. Chem. Soc.*, **1944**, 496; *b*) E.J. Bourne, M. Stacey, C.E.M. Tatlow and J.C. Tatlow, *ibid.*, **1951**, 826; *c*) W.L. Glen, G.S. Myers and G.A. Grant, *ibid.*, **1951**, 2568; *d*) R.W. Jeanloz, A.M.C. Rapin and S. Hakomori, *J. Org. Chem.*, **26**, 3939 (1961).
31) J.T. Marvel, S.K. Sen, J.W. Berry and A.J. Deutschman, Jr., *Carbohydrate Research*, **8**, 148 (1968).
32) K. Makino, A. Watanabe and Y. Joh, *Seikagaku*, **32**, 788 (1960).
33) Melting points were measured in capirally and are uncorrected. NMR spectra were taken at 60 Mcps on JEOL-JNM-C-60H spectrometer using tetramethylsilane as internal reference and the chemical shifts are given in δ (ppm) values. Optical rotations were determined with a JASCO DIP-SL automatic polarimeter. TLC was carried out on silica gel (Kiesel gel G nach Stahl) using solvent systems i) $CHCl_3$–MeOH (9:1 v/v, for the derivatives of I, VIII, IX and XI), ii) $CHCl_3$–MeOH–H_2O (7:3:1, v/v, lower layer, for the derivatives of IV, X and XII) and iii) toluene–EtOAc–AcOH (5:4:1, v/v, for the derivatives of XIII and XIV). Reducing sugars were examined by paper chromatography (PC) on Toyo Roshi No. 50 using BuOH–pyridine–H_2O (3:2:1, v/v) and stained by heating with *p*-anisidine·HCl[25] and by warming with triphenyltetrazolium chloride.[26] In column chromatography, "Kanto" silica gel (100—200 mesh) was used.

b) Mangiferin (IV) and Homomangiferin (V): Using a mixture of dimethylformamide (25 ml) and MeOH (100 ml) as solvent, IV(500 mg) was methylated with CH_2N_2 (prepared from 10 g of nitrosomethylurea) in ether (about 100 ml). Solvent was evaporated (finally *in vacuo*) to yield a mixture of several products, *Rf* 0.56 (major) (VI), 0.68 (VII), 0.74 (trace), 0.83, 0.87 and 0.91. In one experiment, the mixture was dissolved in MeOH, ether added and the precipitates formed were collected and repeatedly recrystallized from MeOH–acetone (1:3, v/v) to give silky needles (yield: 140 mg, 28%), mp about 185°, which showed two spots at *Rf* 0.56 (major) (VI) and 0.68 (VII). In another experiment, the crude product was chromatographed over silica gel (50 g) using EtOAc–EtOH (9:1, v/v) as solvent to give two fractions: Fr. 1, 150 mg, *Rf* 0.68 (main) (VII), 0.74 (trace), 0.83, 0.87, 0.91; Fr. 2, 355 mg, *Rf* 0.56 (VI). Repeated recrystallization of Fr. 2 from MeOH gave pure VI[10] as colorless needles (yield: 200 mg, 40%), mp 231°, $[\alpha]_D^{17}$ +59.3° (c=1.08, pyridine). Fr. 1 was rechromatographed over silica gel (20 g) using the same solvent as above, and a fraction which showed two spots at *Rf* 0.68 (major) (VII) and 0.74 (trace) was recrystallized from MeOH or EtOAc to give colorless needles (yield: 25 mg, 5%), mp 166—167°, which were not homogeneous yet and an atttempted purification failed.

Treatment of V in the same way as above gave an almost similar result.

ii) In a Canned Methanol: a) Swertisin (I): In the same manner as above, a solution of I (1.0 g) in an aged canned MeOH (60 ml) was treated with CH_2N_2, and the crystals separated out were collected by filtration and recrystallized from aqueous dioxane to give II as colorless needles (yield: 320 mg, 32%), mp 304—305° (decomp.), undepressed on admixture with the sample obtained in i). The filtrate which revealed spots at *Rf* 0.09 (II), 0.22 (III, main), 0.36, 0.40, 0.50, 0.63 and 0.70 on TLC was concentrated, precipitated with ether to give a crystalline substance (yield: 150 mg, 15%). It was recrystallized from aqueous MeOH to colorless needles, mp 251—253°, which showed two spots at *Rf* 0.09 (II, trace) and 0.22 (III, main). Since further purification only by recrystallization failed, the mixture (150 mg) was subjected to column chromatography on silica gel (50 g) using EtOAc–EtOH (9:1, v/v) as solvent. A fraction (30 mg) showing only one spot at *Rf* 0.22 was recrystallized from EtOAc to give III as colorless needles, mp 253—254°.

b) Mangiferin (IV) and Homomangiferin (V): IV (500 mg) was methylated in the same manner as above using a canned MeOH. After removal of the solvent, the residue was dissolved in MeOH, ether added, the resulting precipitates were collected and washed with ether. They were crystallized from MeOH–acetone (1:3, v/v) to give colorless needles (120 mg), mp about 160°, which showed two spots, *Rf* 0.56 (VI) and 0.68 (VII, major) on TLC and *Rf* 0.65 and 0.83 (major) on PC (BuOH–AcOH–H_2O (4:2:1, v/v)). Separation of two compounds was achieved by preparative PC using the same solvent and VI was obtained as colorless needles (yield: 25% from crude crystals), mp 227—228° (from EtOH), undepressed on admixture with the sample obtained in i), and homogenous VII as colorless needles (yield: 48% from crude crystals), mp 229—230° (from EtOAc).

Duplication of the procedure with V resulted in the similar.

Effect of Metal Salts on Methylation of C-D-Glucopyranoside (Table I)——Stock solutions of substrates and metal salts are as follows: I, 2.5×10^{-3}M in MeOH; VI, 2.5×10^{-3}M in MeOH; VIII, 5×10^{-3}M in MeOH; $SnCl_2\cdot2H_2O$, $AlCl_3\cdot6H_2O$, $MgCl_2\cdot6H_2O$, $ZnCl_2$ and $Pb(OAc)_2\cdot3H_2O$, 10^{-2}, 10^{-3}, 10^{-4}, 10^{-5} and 10^{-6}M in MeOH. A mixture of a stock solution of substrate (I, VI (in MeOH), 4 ml; IV, VI (in dimethylformamide), 1 ml; VIII, 2 ml) and that of a salt (1 ml) was treated with an ether solution (about 10 ml) of CH_2N_2 prepared from nitrosomethylurea (1 g). The reaction mixture was left stand overnight and examined by TLC.

Methylation of C-D-Glucopyranoside in the Presence of Stannous Chloride (Preparative Experiment) (Table II)——i) Swertisin (I): A solution of I (446 mg, 10^{-3} mole) in 10^{-3}M methanolic solution of $SnCl_2\cdot2H_2O$ (60 ml: $SnCl_2$, 6×10^{-5} mole) was treated with an ether solution (about 50 ml) of CH_2N_2 prepared from nitrosomethylurea (5 g). The reaction mixture was left stand overnight and evaporated to dryness. The residue, which revealed five spots on TLC, *Rf* 0.22 (III, main), 0.36, 0.50, 0.63 and 0.70, was trituated with a small amount of H_2O to give III as a crystalline solid which was recrystallized from EtOAc to colorless needles (yield: 130 mg, 29%), mp 253—255°, either alone or on admixture with the aforementioned specimen of III. $[\alpha]_D^8$ +55.6° (c=0.86, pyridine). UV λ_{max}^{EtOH} mμ (log ε): 263 (4.27), 321 (4.44) (II: 264 (4.34), 321 (4.39)). *Anal.* Calcd. for $C_{21}H_{16}O_6(OCH_3)_4\cdot\frac{1}{2}H_2O$: C, 60.36; H, 5.88; OCH_3, 24.95; H_2O, 1.8. Found: C, 60.23; H, 5.59; OCH_3, 24.68; H_2O, 1.8. It consumed less than 0.2 mole of periodate after 24 hr while II uptook 2.3 moles of the oxidant.

III was acetylated overnight with Ac_2O and pyridine at room temperature, the reaction mixture was poured into ice-water, and the precipitates were collected and recrystallized from EtOAc–ligroin (bp 60—90°) (1:1, v/v) to give colorless needles, mp 156—158°. NMR ($CDCl_3$) δ: 7.79 (2H, doublet, J=9 cps, 2′,6′-H), 6.98 (2H, doublet, J=9 cps, 3′,5′-H), 6.75 (H, singlet, 8-H), 6.56 (H, singlet, 3-H), 3.99, 3.92, 3.88 (9H, singlets, OCH_3 on aromatic ring), 3.48 (3H, singlet, OCH_3 on sugar residue), 2.15, 2.04, 1.82 (9H, singlets, OAc on sugar residue).[11-13]

ii) Mangiferin (IV): A solution of IV (420 mg, 10^{-3} mole) in dimethylformamide (20 ml) was diluted with 10^{-3}M solution of $SnCl_2\cdot2H_2O$ in MeOH (60 ml: $SnCl_2$, 6×10^{-5} mole) and MeOH (20 ml) and to this mixture was added CH_2N_2 in ether (about 100 ml) prepared from nitrosomethylurea (10 g). After allowing to stand overnight, the solvent was removed(finally *in vacuo*) to give a mixture of four compounds, *Rf* 0.68

(VII, main), 0.83, 0.87 and 0.91, which was subjected to column chromatography on silica gel (50 g) using EtOAc–EtOH (9:1, v/v). The main fraction (yield: 120 mg) indicating only one spot at *Rf* 0.68 was recrystallized from EtOAc to give VII as colorless needles (yield: 100 mg, 24%), mp 229—230°, undepressed on admixture with VII mentioned above. $[\alpha]_D^{17}$ +54.4° (c=1.05, pyridine). *Anal.* Calcd. for $C_{19}H_{13}O_6(OCH_3)_5 \cdot H_2O$: C, 56.47; H, 5.92; OCH_3, 30.40; H_2O, 3.5. Found: C, 56.11; H, 5.99; OCH_3, 30.70; H_2O, 3.5. UV λ_{max}^{EtOH} mμ (log ε): 254 (4.56), 274 (4.05), 310 (4.27), 342 (4.05)(VI: 253 (4.54), 272 (4.04), 310 (4.22), 343 (3.96)). No periodate was consumed after 24 hr (VI consumed 2.0 moles of the oxidant).

Acetylation of VII with Ac_2O–pyridine at room temperature gave an acetate as colorless needles, mp 137—138° (from benzene–hexane (1:2, v/v)). NMR ($CDCl_3$) δ: 7.68 (H, singlet, 8-H), 6.88 (H, singlet, 5-H), 6.73 (H, singlet, 4-H), 4.02 (12H, singlet, OCH_3 on aromatic ring), 3.53 (3H, singlet, OCH_3 on sugar residue), 2.18, 2.08, 1.82 (9H, singlets, OAc on sugar residue).[11-13]

iii) 1-(*p*-Methoxyphenyl)-1-deoxy-β-D-glucopyranose[34] (VIII): A solution of VIII (270 mg, 10^{-3} mole) in 10^{-4}M methanolic solution of $SnCl_2 \cdot 2H_2O$ (20 ml: $SnCl_2$, 2×10^{-6} mole) was treated with an ether solution of CH_2N_2 prepared from 1.5 g of nitrosomethylurea for 3 hr at room temperature. The solvent was removed to give a mixture of four compounds, *Rf* 0.32 (main), 0.53, 0.65 and 0.76, which was recrystallized from benzene to provide colorless needles (yield: 150 mg, 54%), mp 158—159° and $[\alpha]_D^8$ +7.0° (c=0.93, MeOH). They consumed no periodate after 24 hr (VIII consumed 2.7 moles). *Anal.* Calcd. for $C_{12}H_{14}O_4(OCH_3)_2$: C, 59.14; H, 7.09; OCH_3, 21.83. Found: C, 59.17; H, 7.25; OCH_3, 21.98.

Effect of Metal Salts on Methylation of O-D-Glucopyranosides (Table I)——As stock solutions of substrates, 10^{-2}M methanolic solutions of IX, X, XI, XII, XIII and XIV were prepared, and methylation was carried out in the same manner as in C-glucoside by using stock solution of substrate (1 ml) and that of metal salt (1 ml). The reaction mixture was left stand overnight and examined by TLC.

Methylation of O-D-Glucopyranosides in the Presence of Stannous Chloride (Preparative Experiment) (Table II)——A O-D-glucopyranoside (10^{-3} mole) in 10^{-4}M solution of $SnCl_2 \cdot 2H_2O$ in MeOH (20 ml: $SnCl_2$, 2×10^{-6} mole) was methylated with ether solution (about 15 ml) of CH_2N_2 prepared from nitrosomethylurea (1.5 g) for 4 hr.

i) Phenyl α-D-Glucopyranoside (IX): The product from IX showed three spots on TLC at *Rf* 0.35 (main), 0.61 and 0.66 (trace) and was recrystallized from benzene to give chromatographically pure compound of *Rf* 0.35 as colorless needles (yield; 81%), mp 164° and $[\alpha]_D^{14}$ +109.2° (c=1.35, MeOH). *Anal.* Calcd. for $C_{12}H_{15}O_5(OCH_3)$: C, 57.77; H, 6.71; OCH_3, 11.48. Found: C, 57.44; H, 6.75; OCH_3, 11.13. It consumed no periodate after 24 hr (IX uptook 2.0 moles). The mother liquor, *Rf* 0.35, 0.61 (major) and 0.66, was evaporated and chromatographed over silica gel (10 g) using EtOAc as a solvent and the major component (*Rf* 0.61) was isolated as a syrup (yield; 18%).

The needles (*Rf* 0.35) (400 mg) was refluxed with 5% HCl (10 ml) for 2 hr and the hydrolysate was neutralized by passing through a column of Amberlite IR 45 (OH type) and concentrated *in vacuo*. The crystals separated on leaving stand for several days were collected and recrystallized from MeOH to colorless prisms (yield; 210 mg), mp 160—161°, undepressed on admixture with authentic XV,[20] mp 160—161°. Its *Rf* value, 0.58, and color (yellowish brown with *p*-anisidine·HCl and red with triphenyltetrazolium chloride) on paper were identical with those of authentic specimen, and the phenylosazone (needles from aqueous MeOH. *Anal.* Calcd. for $C_{19}H_{24}O_4N_4$: C, 61.27; H, 6.48; N, 15.05. Found: C, 61.52; H, 6.42; N, 14.98) showed mp 174—175° (decomp.), alone and on admixture with authentic sample of 3-O-methyl-D-glucose phenylosazone.[20]

The less polar syrup, *Rf* 0.61, was hydrolyzed with 5% HCl and examined by PC. The *Rf* value, 0.75, and color (reddish brown with *p*-anisidine·HCl and negative to triphenyltetrazolium chloride) were identical with those of authentic XVI prepared by unambiguous procedure.[21] The syrup (240 mg) was treated with benzaldehyde (1 ml) and $ZnCl_2$ (0.2 g) at room temperature for 48 hr to give colorless needles (from aqueous MeOH) (yield; 90 mg), mp 144—145°, $[\alpha]_D^8$ +183.3° (c=0.93, $CHCl_3$). *Anal.* Calcd. for $C_{21}H_{24}O_6$: C, 67.78; H, 6.50. Found: C, 67.25; H, 6.59. No melting point depression was observed on admixture with authentic sample of phenyl 2,3-di-O-methyl-4,6-O-benzylidene-α-D-glucopyranoside, mp 146—147°, $[\alpha]_D^{14}$ +183.8° (c=1.27, $CHCl_3$), prepared by exhaustive methylation (Kuhn method[24]) of phenyl 4,6-O-benzylidene-α-D-glucopyranoside, mp 206° (from aqueous MeOH), $[\alpha]_D^{14}$ +174.2° (c=0.46, $CHCl_3$).

ii) Methyl α-D-Glucopyranoside (X): The product from X showed several spots at *Rf* 0.35 (main), 0.57 and so on. It was chromatographed on silica gel (30 g) using EtOAc as a solvent to give two homogeneous fractions: Fr. 1 (yield; 17%: *Rf* 0.57) and Fr. 2 (yield; 74%: *Rf* 0.35).

34) Prepared from 2,3,4,6-tetra-O-acetyl-α-D-glucopyranosyl bromide and *p*-methoxyphenylmagnesium bromide according to the method of Hurd and Bonner (C.D. Hurd and W.A. Bonner, *J. Am. Chem. Soc.*, **67**, 1972 (1945)). Colorless needles (aqueous EtOH), mp 221—223°, $[\alpha]_D^8$ ±0° (c=0.88, pyridine). *Anal.* Calcd. for $C_{13}H_{18}O_6$: C, 57.77; H, 6.71. Found: C, 57.81; H, 6.80. (tetraacetate: mp 104—105°, $[\alpha]_D^9$ −24.3° (c=1.19, $CHCl_3$)).

Fr. 2 gave a benzylidene derivative as colorless needles (from aqueous MeOH), mp 146° and $[\alpha]_D^{14}$ +122.9° (c=0.83, $CHCl_3$), which is identical with the reported values,[35] mp 148—149°, $[\alpha]_D^{20}$ +122.4° ($CHCl_3$), of methyl 3-O-methyl-4,6-O-benzylidene-α-D-glucopyranoside but not with those[30b] of 2-O-methyl isomer, mp 168°, $[\alpha]_D^{17}$ +78.9° (EtOH). *Anal.* Calcd. for $C_{15}H_{20}O_6$: C, 60.80; H, 6.80. Found: C, 60.84; H, 6.85. The acid hydrolysis of Fr. 2 gave the parent sugar which was identified as XV in the same way as in i).

Fr. 1 afforded a benzylidene derivative as colorless needles (from aqueous MeOH), mp 121°, identical with authentic methyl 2,3-di-O-methyl-4,6-O-benzylidene-α-D-glucopyranoside, mp 121°, $[\alpha]_D^9$ +95.5° (c= 1.21, $CHCl_3$), prepared by unambiguous procedure.[21] Acid hydrolysis of Fr. 1 gave XVI.

iii) Phenyl β-D-Glucopyranoside (XI): The product from XI, *Rf* 0.40, 0.66 and so on, was recrystallized from benzene to give the compound of *Rf* 0.40 as colorless needles (yield; 47%). The mother liquor, *Rf* 0.40 (trace), 0.66 and others (trace), was chromatographed on silica gel (10 g) using EtOAc as solvent to give a syrup (yield; 44%) which showed one spot at *Rf* 0.66.

The above colorless needles had mp 148° and $[\alpha]_D^{14}$ −63.9° (c=1.37, MeOH), which agree with the reported values[23] of phenyl 3-O-methyl-β-D-glucopyranoside, mp 150° (corr.), $[\alpha]_D^{25}$ −65.6° (H_2O). *Anal.* Calcd. for $C_{12}H_{15}O_5(OCH_3)$: C, 57.77; H, 6.71; OCH_3, 11.48. Found: C, 57.66; H, 6.75; OCH_3, 11.65. The parent sugar released by acidic hydrolysis was identified as XV.

The syrup, *Rf* 0.66, gave on treatment with benzaldehyde and $ZnCl_2$ a derivative as colorless needles (from EtOH), mp 174—175°, $[\alpha]_D^9$ −53.2° (c=0.72, $CHCl_3$), which was identical with authentic sample of phenyl 2,3-di-O-methyl-4,6-O-benzylidene-β-D-glucopyranoside,[23] mp 177°, $[\alpha]_D^9$ −53.0° (c=1.01, $CHCl_3$). *Anal.* Calcd. for $C_{21}H_{24}O_6$: C, 67.73; H, 6.45. Found: C, 67.66; H, 6.50. Acid hydrolysis of the syrup afforded XVI.

iv) Methyl β-D-Glucopyranoside (XII): The product from XII, *Rf* 0.34, 0.59 and so on, gave, on chromatography over silica gel (30 g) using EtOAc as solvent, two fractions: Fr. 1 (yield; 48%: *Rf* 0.59); Fr. 2 (yield; 54%: *Rf* 0.34).

Fr. 2 gave, on acid hydrolysis, XV and, on treatment with benzaldehyde and $ZnCl_2$, a benzylidene derivative colorless needles (from aqueous MeOH). *Anal.* Calcd. for $C_{15}H_{20}O_6$: C, 60.80; H, 6.80. Found: C, 60.61; H, 6.97). Its physical constants, mp 171°, $[\alpha]_D^8$ −51.3° (c=1.21, $CHCl_3$), agree with the reported values,[36] mp 174°, $[\alpha]_D^{18}$ −50° ($CHCl_3$), of methyl 3-O-methyl-4,6-O-benzylidene-β-D-glucopyranoside (methyl 2-O-methyl-4,6-O-benzylidene-β-D-glucopyranoside,[37] mp 170—171°, $[\alpha]_D^{18}$ −69.2° ($CHCl_3$)).

Fr. 1 was converted to a benzylidene derivative colorless needles (from aqueous MeOH), mp 128—129°, alone and on admixture with authentic methyl 2,3-di-O-methyl-4,6-O-benzylidene-β-D-glucopyranoside,[22] mp 130—131°, $[\alpha]_D^9$ −59.3° (c= 0.84, $CHCl_3$). *Anal.* Calcd. for $C_{16}H_{22}O_6$: C, 61.92; H, 7.15. Found: C, 62.06; H, 7.08. Hydrolysis of Fr. 1 gave XVI.

v) Methyl 4,6-O-Benzylidene-α-D-glucopyranoside (XIII): The reaction mixture of XIII revealed three spots at *Rf* 0.72 (trace), 0.61 (main) and 0.52. Recrystallization from benzene–ligroin (bp 60—90°) (1:1, v/v) gave colorless needles (yield; 93%: *Rf* 0.61). The filtrate was separated over silica gel (10 g) using benzene–acetone (9:1, v/v) as solvent into three fractions: Fr. 1 (yield<1%: *Rf* 0.72); Fr. 2(yield; 4%: *Rf* 0.61); Fr. 3 (yield; 3%: *Rf* 0.52).

The colorless needles and Fr. 2 were combined and recrystallized from aqueous MeOH to give colorless needles, mp 146°, alone and on admixture with the specimen of methyl 3-O-methyl-4,6-O-benzylidene-α-D-glucopyranoside obtained in ii). $[\alpha]_D^9$ +123.2° (c=0.93, $CHCl_3$). *Anal.* Calcd. for $C_{15}H_{20}O_6$: C, 60.80; H, 6.80. Found: C, 60.72; H, 6.76. They were hydrolyzed with 5% HCl for 2 hr to give XV.

Fr. 1 was identical on TLC with methyl 2,3-di-O-methyl-4,6-O-benzylidene-α-D-glucopyranoside.[21]

Fr. 3 gave on acid hydrolysis a reducing sugar, of which *Rf* value, 0.58, and color (reddish brown with *p*-anisidine·HCl and negative to triphenyltetrazolium chloride) on PC were identical with those of 2-O-methyl-D-glucose.

vi) Methyl 4,6-O-Benzylidene-β-D-glucopyranoside (XIV): Recrystallization of the product from XIV, *Rf* 0.83 (trace), 0.72 and 0.65, from benzene–ligroin (bp 60—90°) (1:1, v/v) provided colorless needles (yield; 17%: *Rf* 0.65). The mother liquor was evaporated and subjected to column chromatography over silica gel (30 g) using benzene–acetone (9:1, v/v) as solvent, giving three fractions: Fr. 1 (yield; <1%: *Rf* 0.83); Fr. 2 (yield; 34%: *Rf* 0.72); Fr. 3 (yield; 35%: *Rf* 0.65).

The colorless needles were combined with Fr. 3 and recrystallized from benzene–ligroin (bp 60—90°) (1:1, v/v) to colorless needles, mp 170°, alone and on admixture with a specimen of methyl 3-O-methyl-4,6-O-benzylidene-β-D-glucopyranoside obtained in iv). *Anal.* Calcd. for $C_{15}H_{20}O_6$: C, 60.80; H, 6.80. Found: C, 60.77; H, 7.04. Its acid hydrolysis gave XV.

Fr. 1 was identified on TLC with methyl 2,3-di-O-methyl-4,6-O-benzylidene-β-D-glucopyranoside,[22] and Fr. 2 was recrystallized from benzene–ligroin (bp 60—90°) (1:1, v/v) to yield colorless needles, *Rf* 0.72, mp 169°, $[\alpha]_D^8$ −66.8° (c=1.12, $CHCl_3$), almost identical with the reported values,[37] mp 170—171°, $[\alpha]_D$

35) A.F. Krasso, Ek. Weiss and T. Reichstein, *Helv. Chim. Acta*, **46**, 2538 (1963).
36) H.R. Bolliger and D.A. Prins, *Helv. Chim. Acta*, **29**, 1116 (1946).
37) J.W.H. Oldham and M.A. Oldham, *J. Am. Chem. Soc.*, **61**, 1112 (1939).

$-69.2°$ ($CHCl_3$), of methyl 2-O-methyl-4,6-O-benzylidene-β-D-glucopyranoside. *Anal.* Calcd. for $C_{15}H_{20}O_6$: C, 60.80; H, 6.80. Found: C, 60.65; H, 6.72. Acid hydrolysis of the crystal provided 2-O-methyl-D-glucose (identified on PC).

Treatment of Phenyl α- (IX) and β- (XI) D-Glucopyranosides with Diazomethane in Pure Methanol—i) Phenyl α-D-Glucopyranoside (IX): A solution of IX (500 mg) in MeOH (40 ml) was treated with CH_2N_2 in ether (about 50 ml) prepared from 5 g of nitrosomethylurea. The solvent was removed, giving a residue, *Rf* 0.12 (main, IX), 0.31 and 0.35, which was recrystallized from EtOAc. IX (380 mg) was recovered as needles and the filtrate, *Rf* 0.12 (IX), 0.31, 0.35, 0.61 (trace) and 0.66 (trace), was subjected to column chromatography over silica gel (20 g) using EtOAc as solvent, providing four fractions: Fr. 1 (trace: *Rf* 0.66 and 0.61); Fr. 2 (yield; 15 mg, 3%: *Rf* 0.35); Fr. 3 (yield; 5 mg, 1%: *Rf* 0.31); Fr. 4 (yield; 75 mg: *Rf* 0.12). Fr. 2 was identical with phenyl 3-O-methyl-α-D-glucopyranoside on TLC but its acid hydrolysate showed two spots on PC, *Rf* 0.58 and 0.51 (minor). The former was identical with that of XV and the latter was presumed to be that of the monoether different from 2-, 3- and 6-O-methyl-D-glucose on the basis of its *Rf* value and color (yellowish brown by *p*-anisidine·HCl, red by triphenyltetrazolium chloride) in comparison with the authentic samples (2-O-methyl-D-glucose, *Rf* 0.58, reddish brown by *p*-anisidine·HCl, no color by triphenyltetrazolium chloride; 3-O-methyl-D-glucose, *Rf* 0.58, yellowish brown by *p*-anisidine·HCl, red by triphenyltetrazolium chloride; 6-O-methyl-D-glucose, *Rf* 0.51, reddish brown by *p*-anisidine·HCl, red by triphenyltetrazolium chloride). Crystallization of Fr. 2 from benzene gave colorless needles (yield; 10 mg, 2%), mp 163°, undepressed on admixture with the specimen of 3-methyl ether of IX. Fr. 3 was hydrolyzed and examined by PC: *Rf* 0.58 (reddish brown by *p*-anisidine·HCl, no color by triphenyltetrazolium chloride), 0.51 (reddish brown by *p*-anisidine·HCl, red by triphenyltetrazolium chloride).

ii) Phenyl β-D-Glucopyranoside (XI): In the same manner, the product from XI was separated into four fractions: Fr. 1 (trace; *Rf* 0.69 and 0.65); Fr. 2 (yield; 6%: *Rf* 0.44); Fr. 3 (yield; 2%: *Rf* 0.32 and 0.37); Fr. 4 (yield; 88%: *Rf* 0.15). The presence of 3-O-methyl ether and an unidentified product in Fr. 2 and of 2- and 6-methyl ethers in Fr. 3 was shown by PC of each acid hydrolysate.