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A New Class of Nitrosoureas. IX.[1] Synthesis and Antitumor Activity of 3-Substituted 1-(2-Chloroethyl)-3-(methyl α-D-glucopyranosid-6-yl or methyl 2-acetamido-2-deoxy-α-D-glucopyranosid-6-yl)-1-nitrosoureas

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A series of eight 3,3-disubstituted nitrosoureas (IVa—h) having the nitrosoureido group at the C-6 position of methyl glucopyranoside or methyl 2-acetamido-2-deoxy-glucopyranoside was prepared and tested for antitumor activities. Heating of the 6-*O*-*p*-tolylsulfonyl derivatives (I and II) with various alkylamines followed by reaction with 2-chloroethyl isocyanate gave the corresponding ureas (IIIa—h), which were nitrosated with nitrogen tetroxide to give IVa—h in high yields. The nitrosoureas (IVa—h) were significantly less active than the other positional isomers with respect to the nitrosoureido group prepared previously. Compounds IVa—h appear to be activated by a γ hydroxyl group at the C-4 position. The rate of activation, however, proved to be much slower than those of the C-1 or C-3 positional isomers having a β hydroxyl group. The structure–activity relationships of the positional isomers are discussed in the light of this difference in the rate of activation.

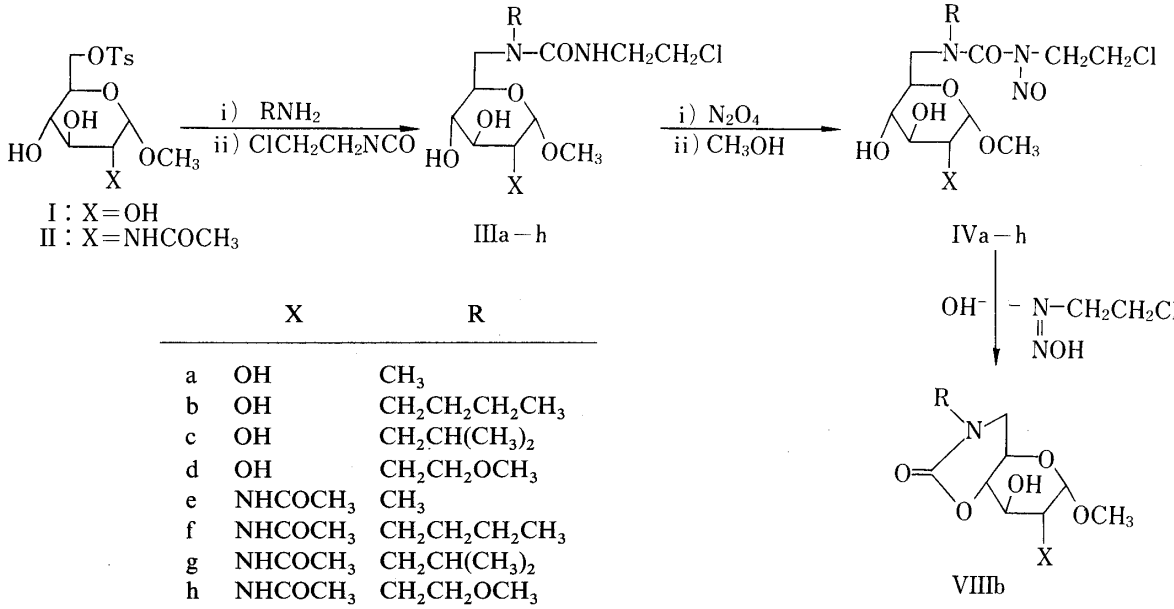
Keywords——chloroethyl nitrosourea; 3,3-disubstituted nitrosourea; methyl glucopyranoside derivative; antitumor activitiy; leukemia L1210; 1-(2-chloroethyl)-3-(α-D-glucopyranosyl)-1-nitrosourea; 2-[3-(2-chloroethyl)-3-nitrosoureido]-2-deoxy-D-glucopyranose

In previous papers, we have reported the synthesis and potent antitumor activity of various kinds of sugar derivatives of 3,3-disubstituted 1-(2-chloroethyl)-1-nitrosoureas, in which the nitrosoureido group is attached to the C-1 position of glucose,[2] or the C-2,[3] or C-3[4] position of methyl glucopyranoside. These nitrosoureas proved to be activated by attack of the β hydroxyl group of the sugar moiety on the carbonyl group to give cyclic carbamate and chloroethyl diazohydroxide without generation of the isocyanate. The structure–activity relationships (SAR) of these positional isomers were discussed. Our studies on the SAR of the positional isomers have now been extended to the nitrosoureas possessing the nitrosoureido group at the C-6 position of the methyl glucopyranoside or methyl 2-acetamido-2-deoxy-glucopyranoside moiety. These nitrosoureas are expected to be activated by the intramolecular participation of the γ hydroxyl group at the C-4 position of the sugar moiety. We describe here the synthesis and antitumor activity of 3-substituted 1-(2-chloroethyl)-3-(methyl α-D-glucopyranosid-6-yl or methyl 2-acetamido-2-deoxy-α-D-glucopyranosid-6-yl)-1-nitrosoureas. The relationships between antitumor activity and the rate of activation are also discussed in comparison with those of the positional isomers.

Synthesis of Nitrosoureas and Discussion

The nitrosoureas (IVa—h) possessing a methyl glucopyranoside or methyl 2-acetamido-2-deoxy-glucopyranoside moiety were prepared *via* the sequence outlined in Chart 1.

Various alkylamines were heated with methyl 6-*O*-*p*-tolylsulfonyl-α-D-glucopyranoside



	X	R
a	OH	CH_3
b	OH	$CH_2CH_2CH_2CH_3$
c	OH	$CH_2CH(CH_3)_2$
d	OH	$CH_2CH_2OCH_3$
e	$NHCOCH_3$	CH_3
f	$NHCOCH_3$	$CH_2CH_2CH_2CH_3$
g	$NHCOCH_3$	$CH_2CH(CH_3)_2$
h	$NHCOCH_3$	$CH_2CH_2OCH_3$

Chart 1

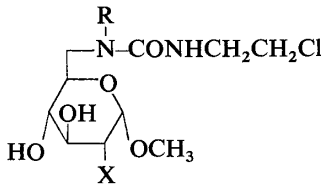
(I)[5] or methyl 6-*O*-*p*-tolylsulfonyl-2-acetamido-2-deoxy-α-D-glucopyranoside (II),[6] and the crude amino derivatives were allowed to react with 2-chloroethyl isocyanate, because the isolation of the amino derivatives in a pure form was difficult. The resulting urea derivatives (III) could be purified by column chromatography. Thus, in a typical procedure, a mixture of I and methanolic methylamine solution was heated in a sealed tube at 110 °C for 10 h and concentrated to dryness. The residue was allowed to react with 2-chloroethyl isocyanate in methanol. The urea (IIIa) was obtained in 57% yield as an amorphous powder after purification by silica gel chromatography and showed infrared (IR) signals due to the ureido group at 1625 and 1550 cm^{-1}, and nuclear magnetic resonance (NMR) signals at δ 2.84 (s, NCH_3), 3.23 (s, OCH_3), 4.54 (d, J=3 Hz, H-1), and 6.49 (br, NH). Therefore, IIIa was determined to be 1-(2-chloroethyl)-3-methyl-3-(methyl α-D-glucopyranosid-6-yl)urea. Eight 3-substituted 1-(2-chloroethyl)-3-(methyl α-D-glucopyranosid-6-yl or methyl 2-acetamido-2-deoxy-α-D-glucopyranosid-6-yl)ureas (IIIa—h) were thus obtained and their physical data are listed in Table I. They are unstable amorphous powders (IIIa—d) or caramels (IIIe—h) and have no definite melting points.

The nitrosation of the ureas (IIIa—h) was carried out by the use of dinitrogen tetroxide as described in our previous paper.[2] Four equivalents of dinitrogen tetroxide was introduced into a mixture of the urea (IIIa) and anhydrous sodium acetate in tetrahydrofuran, and then methanol was added to decompose the nitrous ester groups in the glucopyranoside moiety. After purification by silica gel chromatography, the nitrosourea (IVa) was obtained in 62% yield. It showed the IR signal due to the nitrosoureido group at 1700 cm^{-1} and NMR signals due to NCH_3, OCH_3, and β-anomeric protons at δ 3.13, 3.23, and 4.53 (d, J=3.4 Hz), respectively. Thus, IVa was determined to be 1-(2-chloroethyl)-3-methyl-3-(methyl α-D-glucopyranosid-6-yl)-1-nitrosourea. The yields and the physical data for the nitrosoureas (IVa—h) thus obtained are listed in Table II. They are unstable yellow amorphous powders.

In the previous papers[2,7] we demonstrated that 3,3-disubstituted 1-(2-chloroethyl)-1-nitrosoureas (V) having a β hydroxyl group on a glycopyranosyl moiety are activated non-enzymatically by attack of the hydroxyl group on the carbonyl group to give the five-membered cyclic carbamate (VI) and chloroethyl diazohydroxide (VII) without generation of the isocyanate (Chart 2).

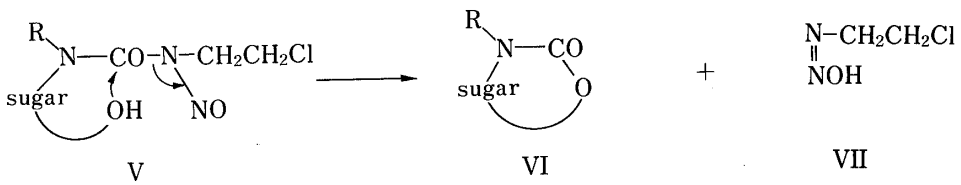
The nitrosoureas (IVa—h) prepared in the present study possess a γ hydroxyl group at

TABLE I. Properties of 3-Substituted 1-(2-Chloroethyl)-3-(methyl α-D-glucopyranosid-6-yl or methyl 2-acetamido-2-deoxy-α-D-glucopyranosid-6-yl)ureas



Compound No.	R	X	$[\alpha]_D$ (c, °C) in methanol	Yield (%)
IIIa	CH_3	OH	+52.3 (1.1, 21)	57
IIIb	$CH_2CH_2CH_2CH_3$	OH	+53.6 (1.1, 21)	75
IIIc	$CH_2CH(CH_3)_2$	OH	+57.2 (1.2, 21)	72
IIId	$CH_2CH_2OCH_3$	OH	+44.6 (1.2, 22)	66
IIIe	CH_3	NHAc	+73.9 (1.1, 22)	65
IIIf	$CH_2CH_2CH_2CH_3$	NHAc	+70.0 (1.1, 23)	73
IIIg	$CH_2CH(CH_3)_2$	NHAc	+76.4 (1.2, 23)	75
IIIh	$CH_2CH_2OCH_3$	NHAc	+68.2 (1.2, 23)	70

Compound No.	IR ν_{max}^{Nujol} (cm^{-1})	NMR δ (ppm) (J=Hz) (in d_6-DMSO–D_2O)
IIIa	3350 (br), 1625, 1550, 1050, 1010	2.84 (3H, s, NCH_3), 4.54 (1H, d, J=3, H-1), 3.23 (3H, s, OCH_3), 6.49 (1H, br, NH)
IIIb	3360 (br), 1635, 1540, 1050, 1010	0.9—1.7 (7H, m, $CH_2CH_2CH_3$), 3.23 (3H, s, OCH_3), 4.53 (1H, d, J=3, H-1), 6.42 (1H, br, NH)
IIIc	3360 (br), 1640, 1540, 1050, 1005	0.95 (6H, dd, J=6.4, $CH(CH_3)_2$), 3.32 (3H, s, OCH_3), 4.62 (1H, d, J=3, H-1), 6.41 (1H, br, NH)
IIId	3310 (br), 1610, 1525, 1025	3.23 (6H, s, $OCH_3 \times 2$), 4.56 (1H, d, J=3, H-1), 6.46 (1H, br, NH)
IIIe	3330 (br), 1640, 1545, 1090, 1050	1.84 (3H, s, Ac), 2.87 (3H, s, NCH_3), 3.22 (3H, s, OCH_3), 4.55 (1H, d, J=2.7, H-1), 6.51 (1H, br, NH), 7.72 (1H, d, J=6.9, NH)
IIIf	3330 (br), 1640, 1540, 1090, 1050	0.9—1.5 (7H, m, $CH_2CH_2CH_3$), 1.83 (3H, s, Ac), 3.21 (3H, s, OCH_3), 4.55 (1H, d, J=2.4, H-1), 6.44 (1H, br, NH), 7.72 (1H, d, J=7.5, NH)
IIIg	3330 (br), 1640, 1540, 1090, 1050	0.85 (6H, d, J=6.1, $CH(CH_3)_2$), 1.81 (3H, s, Ac), 3.18 (3H, s, OCH_3), 4.54 (1H, d, J=2, H-1), 6.41 (1H, br, NH), 7.70 (1H, d, J=7.1, NH)
IIIh	3340 (br), 1650, 1540, 1085, 1055	1.83 (3H, s, Ac), 3.18 (3H, s, OCH_3), 3.21 (3H, s, OCH_3), 4.56 (1H, d, J=2.5, H-1), 6.49 (1H, br, NH), 7.70 (1H, d, J=7.1, NH)

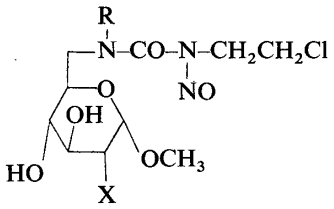


V VI VII

Chart 2

the C-4 position of sugar moieties instead of a β one and are expected to be activated in a manner similar to that shown in Chart 2. In fact, on treatment with aqueous sodium

TABLE II. Properties of 3-Substituted 1-(2-Chloroethyl)-3-(methyl α-D-glucopyranosid-6-yl or methyl 2-acetamido-2-deoxy-α-D-glucopyranosid-6-yl)-1-nitrosoureas[a)]



Compound No.	R	X	mp (°C) (dec.)	$[\alpha]_D$ (c, °C) in methanol	Yield (%)
IVa	CH_3	OH	60	+76.8 (1.0, 22)	62
IVb	$CH_2CH_2CH_2CH_3$	OH	58	+97.9 (1.0, 22)	68
IVc	$CH_2CH(CH_3)_2$	OH	75	+98.3 (1.0, 22)	70
IVd	$CH_2CH_2OCH_3$	OH	56	+100.0 (0.9, 22)	67
IVe	CH_3	NHAc	73	+118.5 (1.0, 23)	67
IVf	$CH_2CH_2CH_2CH_3$	NHAc	82	+83.8 (1.1, 23)	72
IVg	$CH_2CH(CH_3)_2$	NHAc	70	+104.0 (1.0, 23)	68
IVh	$CH_2CH_2OCH_3$	NHAc	68	+104.7 (1.0, 23)	63

Compound No.	IR ν_{max}^{Nujol} (cm^{-1})	NMR δ (ppm) (J=Hz) (in d_6-DMSO–D_2O)
IVa	3420 (OH), 1700 (CO), 1075, 1050, 1010	3.13 (3H, s, NCH_3), 3.23 (3H, s, OCH_3), 4.53 (1H, d, J=3.4, H-1)
IVb	3400 (OH), 1695 (CO), 1075, 1050, 1010	0.9—1.7 (7H, m, $CH_2CH_2CH_3$), 3.22 (3H, s, OCH_3), 4.50 (1H, d, J=2.7, H-1)
IVc	3390 (OH), 1690 (CO), 1080, 1060, 1010	0.99 (6H, d, J=6.4, $CH(CH_3)_2$), 3.33 (3H, s, OCH_3), 4.50 (1H, d, J=3, H-1)
IVd	3380 (OH), 1685 (CO), 1080, 1050, 1010	3.23 (6H, s, $OCH_3 \times 2$), 4.51 (1H, d, J=2.7, H-1)
IVe	3350 (br, OH, NH), 1700, 1660 (CO), 1545 (NHCO), 1080, 1055	1.83 (3H, s, Ac), 3.13 (3H, s, NCH_3), 3.20 (3H, s, OCH_3), 4.53 (1H, d, J=2.7, H-1), 7.67 (1H, d, J=7.5, NH)
IVf	3380 (br, OH, NH), 1690, 1660 (CO), 1540 (NHCO), 1085, 1055	0.9—1.8 (7H, m, $CH_2CH_2CH_3$), 1.83 (3H, s, Ac), 3.20 (3H, s, OCH_3), 4.53 (1H, d, J=3.2, H-1), 7.70 (1H, d, J=7.9, NH)
IVg	3360 (br, OH, NH), 1695, 1660 (CO), 1550 (NHCO), 1085, 1050	0.90 (6H, d, J=6.3, $CH(CH_3)_2$), 1.83 (3H, s, Ac), 3.21 (3H, s, OCH_3), 4.52 (1H, d, J=3.0, H-1), 7.68 (1H, d, J=6.9, NH)
IVh	3360 (br, OH, NH), 1695, 1660 (CO), 1545 (NHCO), 1085, 1050	1.83 (3H, s, Ac), 3.21 (3H, s, OCH_3), 3.27 (3H, s, OCH_3), 4.54 (1H, d, J=3.0, H-1), 7.71 (1H, d, J=6.7, NH)

a) Elemental analyses of these compounds gave unsatisfactory results since these compounds are unstable amorphous powders including solvents (especially ethyl acetate) tightly.

bicarbonate solution, IVb readily decomposed to give colorless crystals (VIIIb), mp 124 °C, in high yield. Compound VIIIb showed the characteristic IR absorption band at 1690 cm^{-1} due to a six-membered cyclic carbamate and NMR signals due to the *n*-butyl group at 0.9—1.7, the methoxyl group at δ 3.33, and the anomeric proton at δ 4.64. The mass spectrum (MS) exhibited the molecular ion peak at *m/e* 275. The structure of VIIIb was thus determined to be methyl 6-*n*-butylamino-6-deoxy-α-D-glucopyranoside 4,6-carbamate from these spectroscopic

data together with elemental analysis (see Chart 1). The rate of activation of IVb having a γ hydroxyl group, however, proved to be considerably slower than that of other positional isomers having a β hydroxyl group. For instance, complete decomposition of IVb to the six-membered cyclic carbamate (VIIIb) in aqueous sodium bicarbonate solution took 90 min, whereas 1-(2-chloroethyl)-3-isobutyl-3-(methyl α-D-glucopyranosid-3-yl)-1-nitrosourea (IXc)[4] and 1-(2-chloroethyl)-3-isobutyl-3-β-D-glucopyranosyl-1-nitrosourea (X)[2] were decomposed completely under the same conditions to give the five-membered cyclic carbamates in only 6 and 10 min, respectively (see "Experimental"). This difference in the rate of activation appears to greatly influence the antitumor activity (see below).

Antitumor Activities of Nitrosoureas and Discussion

The nitrosoureas (IVa—h) were tested for antitumor activities against leukemia L1210 and Ehrlich ascites carcinoma by the methods described in the previous paper.[2] The results are summarized in Table III together with the comparative data for positive controls; GANU[8] and DCNU.[9] The data for the positional isomers (IXa—d)[4] in which the nitrosoureido group is attached to the C-3 position of the glucopyranoside moiety are also included for comparison. All the nitrosoureas prepared in the present study were active against both leukemia L1210 and Ehrlich ascites carcinoma. Among them, the nitrosoureas

Table III. Antitumor Activities of Nitrosoureas

Compd. No.	Anti-L1210 activity[a]				Anti-Ehrlich activity[b]		
	ILS_{30}[c] (mg/kg/d × 5)	OD[d] (mg/kg/d × 5)	ILS_{max} (%)	Therapeutic[e] ratio	MED[f] (mg/kg/d × 5)	MTD[g] (mg/kg/d × 5)	Therapeutic[h] ratio
GANU	0.8	6.25	198.6	7.8	0.39	12.5	32
DCNU	1.4	12.5	240.0	8.9	0.78	12.5	16
IVa	15.0	400	751.7[i]	26.7	6.25	400	64
IVb	70.0	400	142.9	5.9	25	400	16
IVc	35.0	400	135.6	11.8	25	400	16
IVd	10.0	200	371.4	20.0	3.12	200	64
IVe	12.0	200	757.1[i]	16.7	6.25	200	32
IVf	30.0	200	180.0	6.7	25.0	200	8
IVg	40.0	400	110.0	10.0	12.5	400	32
IVh	15.0	200	225.7	13.3	12.5	200	16
IXa[j]	0.26	12.5	614.3[i]	48.1	0.39	25	64
IXb[k]	0.65	12.5	745.1[i]	38.5	0.78	50	64
IXc[l]	0.67	25	597.7[i]	18.7	0.195	25	128
IXd[m]	0.75	12.5	344.0	33.3	0.195	25	128

a) Anti-leukemic activity on L1210 in mice; leukemic cells (10^5) were inoculated *i.p.* into male BDF_1 mice and *i.p.* administration of test compound was begun 24 h after the inoculation and performed once daily for 5 d.
b) Growth-inhibitory effect on Ehrlich ascites tumor cells in mice; the ascites cells (10^6) were inoculated *i.p.* into female ICR mice and *i.p.* administration of test compound was begun 24 h after the inoculation and performed once daily for 5 d.
c) Daily dose providing a 30% increase in life-span over the control. $ILS(\%) = (T/C - 1) \times 100$.
d) Optimal dose: the daily dose providing the maximum increase in life-span.
e) Therapeutic ratio = OD/ILS_{30}.
f) Minimum effective dose: the minimum dose which shows 100% inhibition of the growth of the tumor.
g) Maximum tolerated dose: the maximum dose which shows 100% inhibition of the growth of the tumor without causing the death of mice.
h) Therapeutic ratio = MTD/MED.
i) All treated mice survived for more than sixty days.
j) 3-Methyl-(2-chloroethyl)-3-(methyl α-D-glucopyranosid-3-yl)-1-nitrosourea.
k) 3-*n*-Butyl-(2-chloroethyl)-3-(methyl α-D-glucopyranosid-3-yl)-1-nitrosourea.
l) 3-Isobutyl-(2-chloroethyl)-3-(methyl α-D-glucopyranosid-3-yl)-1-nitrosourea.
m) 3-(2-Methoxyethyl)-(2-chloroethyl)-3-(methyl α-D-glucopyranosid-3-yl)-1-nitrosourea.

(IVa and IVe) having a methyl substituent on the N-3 atom showed activity superior to those of the two positive controls and they gave sixty-day survivors against leukemia L1210 at the optimal dose. In general, however, the antitumor activities of the nitrosoureas (IVa—h) were not significant as compared with those of the positional isomers (IXa—d). As shown in Table III, compounds (IVa—h) having a γ hydroxyl group exhibit very weak activity (very large values of ILS_{30} and MED) and weak toxicity (large values of OD and MTD) as compared with those of the positional isomers (IXa—d) having a β hydroxyl group. This is probably due to the difference in their rates of activation described above. As a result, facile activation by a β hydroxyl group appears to be necessary for high antitumor activity in this class of compounds.

Experimental

IR spectra were recorded with a Hitachi IR-215 spectrometer, and NMR spectra with a JEOL PMX-60 spectrometer using tetramethylsilan (TMS) as an internal standard in d_6-DMSO. The optical rotations were measured in a 0.5 dm tube with a Jasco DIP-180 polarimeter. Column chromatography was carried out on Merck silica gel 60. Thin layer chromatography (TLC) was performed on Merck silica gel 60 F254 TLC plates and 30% sulfuric acid was used as the spray reagent. Organic solutions were generally concentrated by evaporation *in vacuo* below 40 °C.

General Procedure for the Preparation of 3-Substituted 1-(2-Chloroethyl)-3-(methyl α-D-glucopyranosid-6-yl or methyl 2-acetamido-2-deoxy-α-D-glucopyranosid-6-yl)ureas (IIIa—h)——A mixture of 1.74 g (5 mmol) of methyl 6-*O*-*p*-tolylsulfonyl-α-D-glucopyranoside (I)[5] or 1.95 g (5 mmol) of methyl 6-*O*-*p*-tolylsulfonyl-2-acetamido-2-deoxy-α-D-glucopyranoside (II),[6] 50 mmol of an alkylamine, and 10 ml of ethanol (or methanol) was heated in a sealed tube at 110 °C for 10 h, then concentrated. The residue was dissolved in 30 ml of methanol, and 1.05 g (10 mmol) of 2-chloroethyl isocyanate was added to the solution under cooling. After being stirred at room temperature for 30 min, the mixture was concentrated. The residue was chromatographed on silica gel (solvent: ethyl acetate–chloroform–methanol). The ureas thus obtained were unstable amorphous powders (IIIa—d) or caramels (IIIe—h), and the yields and physical properties are listed in Table I.

General Procedure for the Preparation of 3-Substituted 1-(2-Chloroethyl)-3-(methyl α-D-glucopyranosid-6-yl or methyl-2-acetamido-2-deoxy-α-D-glucopyranosid-6-yl)-1-nitrosoureas (IVa—h)——The urea (10 mmol) was dissolved in 40 ml of tetrahydrofuran (THF) and then anhydrous sodium acetate (40 mmol for IIIa—d or 30 mmol for IIIe—h) was added. Dinitrogen tetroxide (45 mmol for IIIa—d or 35 mmol for IIIe—h) was introduced into the mixture at −5 °C for 10 min under stirring. After 10 min, 7 ml of methanol was added to the mixture, and the whole was stirred at the same temperature for 10 min. Cold ethyl acetate (40 ml), anhydrous sodium acetate (30 mmol), and 10 ml of water were then added at −5 °C. The whole was stirred vigorously for 10 min and the pH of the mixture was confirmed to be about 5. After filtration, the organic layer was collected, dried, filtered, and concentrated. The residue was purified by silica gel chromatography (solvent: ethyl acetate–benzene–methanol). The nitrosoureas (IVa—h) thus obtained were usually unstable yellow amorphous powders, and the yields and physical properties are listed in Table II.

Decomposition of the Nitrosoureas (IVb, IXc, and X) in Sodium Bicarbonate Solution——The nitrosourea (IVb) (1.0 g) was dissolved in 30 ml of saturated sodium bicarbonate solution at room temperature and the mixture was stirred. The degree of decomposition of IVb was monitored by TLC. Complete decomposition was observed after 90 min. The mixture was saturated with ammonium sulfate and extracted twice with a mixture of ethyl acetate and THF (1 : 4). The organic layer was dried over $MgSO_4$ and concentrated. The residual colorless caramel, which gave only a single spot on TLC, was purified by short column chromatography using silica gel to give methyl 6-*n*-butylamino-6-deoxy-α-D-glucopyranoside 4,6-carbamate (VIIIb) in 91.5% yield as colorless crystals, mp 124 °C (dec.) $[\alpha]_D^{21}$ +8.3° (c=1.0, methanol). IR ν_{max}^{Nujol} cm^{-1}: 3400, 3300, 1690, 1080, 1050. MS *m/e*: 275 (M^+). NMR (in d_6-DMSO–D_2O): 0.9—1.7 (7H, m, $CH_2CH_2CH_3$), 3.33 (3H, s, OCH_3), 4.64 (1H, d, J=3.1 Hz, H-1), 5.00 (1H, d, J=5.8 Hz, C_2–OH), 5.32 (1H, d, J=3.5 Hz, C_3–OH). *Anal.* Calcd for $C_{12}H_{21}NO_6$: C, 52.36; H, 7.64; N, 5.09. Found: C, 52.18; H, 7.72; N, 5.02.

The nitrosourea (IXc)[4] decomposed completely in 6 min under the same conditions to give the five-membered cyclic carbamate (XI) in 93% yield as a colorless oil, which showed a single spot on TLC. Its NMR spectrum, however, showed two kinds of anomeric and methoxyl protons. XI was considered to be a mixture of methyl 3-isobutylamino-3-deoxy-α-D-glucopyranoside 2,3-carbamate and 3,4-carbamate in an equal ratio. IR ν_{max}^{Nujol} cm^{-1}: 3400, 1740, 1055, 1020. NMR (in d_6-DMSO–D_2O) δ: 0.91 (6H, d, J=6 Hz, $CH(C\underline{H}_3)_2$), 1.8—2.25 (1H, m, –C<u>H</u>≺), 3.36 (s, OCH_3), 3.41 (s, OCH_3), 4.72 (d, J=2 Hz, H-1), 4.86 (1H, t, J=5.8 Hz, C_6–OH), 5.10 (d, J=2.1 Hz, H-1), 5.33 (d, J=6.2 Hz, C_2–OH), 5.53 (d, J=6 Hz, C_4–OH). MS *m/e*: 275 (M^+, Calcd for $C_{12}H_{21}NO_6$), 244 ($M^+ - 31$ (OCH_3)),

232 ($M^+ - 43$ ($CH(CH_3)_2$)).

The nitrosourea (X)[2] decomposed similarly in 10 min to give 1-isobutylamino-1-deoxy-α-D-glucopyranoside 1,2-carbamate[2] in 93% yield.

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References and Notes

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