Carbohydrate Research, 126 (1984) 81–90
Elsevier Science Publishers B.V., Amsterdam – Printed in The Netherlands

REACTION OF ETHYL 2-AMINO-4,6-*O*-BENZYLIDENE-2-DEOXY-D-GLUCONATE WITH ACETYLENIC ESTERS

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(Received July 18th, 1983; accepted for publication, August 11th, 1983)

ABSTRACT

Ethyl 2-amino-4,6-*O*-benzylidene-2-deoxy-D-gluconate adds to acetylenic esters to give sugar enaminones. The following acetylene derivatives have been employed: methyl propiolate, ethyl phenylpropiolate, and dimethyl acetylenedicarboxylate (**6**). With compound **6**, the reaction leads to a mixture of the expected enaminone and the isomeric oxazolidine derivative. The structures and configurations of the new compounds were studied by spectroscopic and chemical methods.

INTRODUCTION

Aliphatic primary amines add to acetylenic esters, for example, to dimethyl acetylenedicarboxylate (DMADC) or to methyl propiolate (acetylenecarboxylate), to give [1,2] the corresponding enaminones, as follows.

$$R^1\text{-}NH_2 + R^2\text{-}C{\equiv}C\text{-}CO_2R^3 \rightarrow R^1\text{-}NH\text{-}C(R^2){=}CH\text{-}CO_2R^3$$

Some monosaccharide enamino esters have also been described[3,4] as adducts of 2-amino-2-deoxy-D-glucose or glycosylamines to DMADC. However, attempts[3,4] to achieve reaction of these amino sugars with methyl propiolate were unsuccessful. The interest of these carbohydrate enaminones is mainly as *N*-protected amino sugars[5–7], because the enamine group is stable, but it can readily be eliminated. We now report on the preparation of several enaminones by addition of ethyl 2-amino-4,6-*O*-benzylidene-2-deoxy-D-gluconate (**1**) to some acetylenic esters. Other enaminones of **1** and of 2-amino-2-deoxy-D-gluconic acid have been obtained[8,9] by reaction of these substances with β-dicarbonyl compounds.

0008-6215/84/$ 03.00

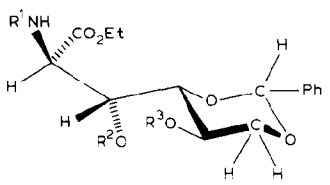
RESULTS AND DISCUSSION

The starting compound **1** was prepared from its hydrochloride[10], and characterized by acetylation to give **2**.

In the reaction of **1** with methyl propiolate (**4**), a mixture of products (probably the *Z*- and *E*-enaminones) is first formed (as evidenced by t.l.c.), from which only the last (**7**) crystallized in high yield. The acetylation of **7** led to a *cis-trans* mixture of diacetates, but again only the *E* isomer (**8**) could be isolated. The *Z* isomers slowly appear as a result of *cis-trans* equilibration in ethanolic or chloroform solutions of **7** or **8**, respectively. The isomerization can be readily observed in the case of **8** by ^{1}H-n.m.r. spectroscopy.

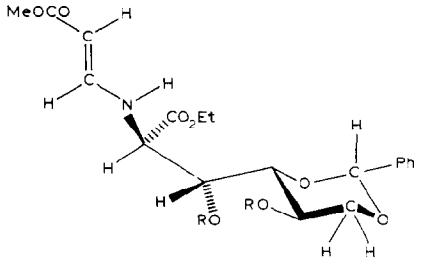
On the other hand, t.l.c. of the reaction mixture of **1** and ethyl phenylpropiolate (**5**) showed that only one new product had been formed, and its concentration remained unchanged after 15 days, but in contrast to the preceding reaction, no *cis-trans* equilibrium was detected. The new product, having a *Z*-enaminone type of structure (**9**), was isolated in poor yield (8%) by column chromatography. Acetylation of **9** under the usual conditions afforded the diacetate **10**.

In the case of the reaction of **1** with DMADC (**6**), a mixture of the oxazolidine derivative **11** and the *Z*-enaminone **13** is formed. Between these isomers **11** and **13** there exists an equilibrium that is almost entirely shifted towards **11**

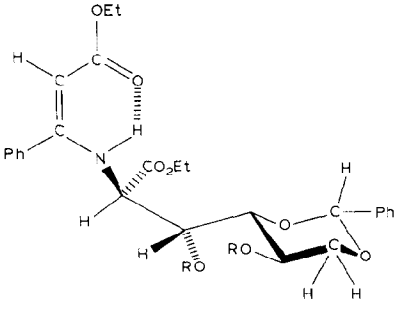


	R^1	R^2	R^3
	H	H	H
2	Ac	Ac	Ac
3	Ac	H	Ac

	R^1	R^2
4	Me	H
5	Et	Ph
6	Me	CO_2Me



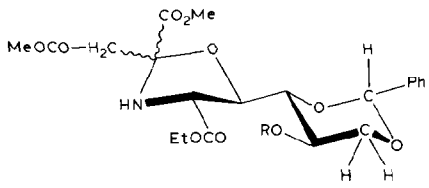
7 R = H
8 R = Ac



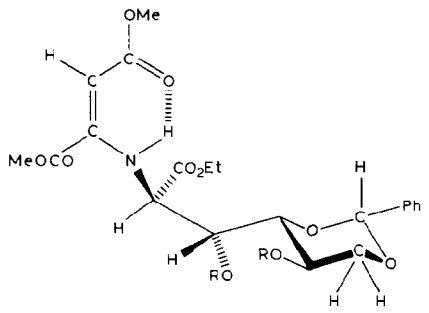
9 R = H
10 R = Ac

at room temperature in ethanol or chloroform. The two compounds were separated by preparative t.l.c. In solution, **13** rapidly affords a mixture of the two, whereas **11** stays unchanged. These facts show that the oxazolidine **11** is more stable than the isomeric enaminone **13** under the aforementioned conditions. Other amino sugars add[3,4] to DMADC, yielding stable enaminones without formation of the oxazolidine ring.

Conventional acetylation of **11** afforded the monoacetyl derivative **12**. However, treatment of **11**, the mixture of **11** and **13**, or the monoacetate **12** (R_F 0.45) with acetic anhydride in pyridine during six days, in the presence of 4-(dimethylamino)pyridine as a catalyst[11], produced the di-*O*-acetylated enaminone **14**



11 R = H
12 R = Ac



13 R = H
14 R = Ac

(R_F 0.6) in equilibrium with another product (R_F 0.4), probably its *E* isomer. The compound initially formed is that having R_F 0.4, but it gradually and entirely isomerizes to **14**. This behavior agrees with that observed[2] in analogous reactions. On the other hand, **14** slowly decomposes in solution, with simultaneous $O \rightarrow N$ acetyl migration, to give ethyl 2-acetamido-5-*O*-acetyl-4,6-*O*-benzylidene-2-deoxy-D-gluconate (**3**).

The structures and configurations of the new compounds are in agreement with the analytical and spectroscopic data. Thus, in the ^{1}H-n.m.r. spectra of **7** and **8** (see Table I), both the coupling constant between the alkenic protons (*J* 13.0 Hz) and the range (δ 4.60–4.95) in which their signals appear demonstrate[1] the *E* con-

TABLE I

^{1}H-CHEMICAL SHIFTS (δ) AND COUPLING CONSTANTS (J, Hz) FOR COMPOUNDS **1–3** AND **7–14** AT 90[a] AND 220[b] MHz

Compound	*H-2*[c]	*H-3*	*H-4*	*H-5*	*H-6e*	*H-6'a*	*OH*	*OAc*	*NAc*	*NH*	*H-1'*	*H-2'*	*R-C-1'*	*R-C-2'*[d]
1[e]	3 77d $J_{2,3}$ ~4 0	4 19t $J_{3,4}$ ~4 0	3 73dd $J_{4,5}$ ~10 0	3 92td $J_{5,6}$ ~5 0 $J_{5,6'}$ ~10 0	4 29dd $J_{6,6'}$ ~10 0	3 56t	3 1–3 5m (2 H)	—	—	3 1–3 5m (2 H)	—	—	—	—
2[e]	4 98dd $J_{2,NH}$ ~8 6 $J_{2,3}$ ~4 1	5 52dd $J_{3,4}$ ~2 4	4 10dd $J_{4,5}$ ~9 7	4 85td $J_{5,6}$ ~4 9 $J_{5,6'}$ ~9 7	4 35dd $J_{6,6'}$ ~9 7	3 59t	—	2 04s (3 H) 2 07s (3 H)	1 75s (3 H)	6 30d (1 H)	—	—	—	—
3[e]	4 68dd $J_{2,NH}$ ~8 0 $J_{2,3}$ ~7 0	← 3 8–4 3 (2 H) →		5 05td $J_{5,6}$ ~5 0 $J_{5,6'}$ ~10 0 $J_{4,5}$ ~10 0	4 47dd $J_{6,6'}$ ~10 0	3 62t	3 00d $J_{3,OH}$ ~8 0	2 11s (3 H)	1 89s (3 H)	6 30d (1 H)	—	—	—	—
7[f]	←			3 1–4 4m (8 H)				—	—	5 20t (1 H)	7 2–7 6m (1 H)	4 60d J ~13 0	—	3 52s (3 H)
8[e]	4 1–4 4m $J_{2,NH}$ ~9 5 $J_{2,3}$ ~7 0	5 34dd $J_{3,4}$ ~2 2	4 02dd $J_{4,5}$ ~9 8	5 00td $J_{5,6}$ ~4 8 $J_{5,6'}$ ~9 8	4 40dd $J_{6,6'}$ ~9 8	3 62t	—	2 04s (3 H) 2 10s (3 H)	—	5 15t (1 H) $J_{1',NH}$ ~9 5	7 3–7 6m (1 H)	4 95d J ~13 0	—	3 63s (3 H)
9[e]	←			3 1–4 5m (8 H)				—	—	9 00d $J_{2,NH}$ ~10 0	—	4 78s	0 9–1 4m (3 H) 4 1–4 8m (2 H)	[d]
10[e]	4 1–4 8m $J_{2,3}$ ~8 0 $J_{2,NH}$ ~11 0	5 48dd $J_{3,4}$ ~2 0	4 08dd $J_{4,5}$ ~10 0	4 90td $J_{5,6}$ ~5 0 $J_{5,6'}$ ~10 0	4 1–4 8m $J_{6,6'}$ ~10 0	3 58t	—	2 04s (3 H) 2 14s (3 H)	—	8 82d	—	4 74s	0 9–1 4m (3 H) 4 1–4 8m (2 H)	[d]
11[e]	←			3 3–4 6m[g] (7 H)				—	—	[g] (1 H)	—	3 05s[h] (2 H)	←3 50s/3 70s[h]→ (3 H) (3 H)	
12[e]	4 48d $J_{2,3}$ ~7 3	4 28dd $J_{3,4}$ ~2 2	3 94dd $J_{4,5}$ ~9 8	5 09td $J_{5,6}$ ~4 9 $J_{5,6}$ ~9 8	4 55dd $J_{6,6'}$ ~9 8	3 58t	—	2 10s (3 H)	—	3 70s[i] (1 H)	—	2 98d[h] (1 H) 3 10d J_{gem} ~17 1	←3 40s/3 70s[h]→ (3 H) (3 H)	
13[e,f]										8 70d $J_{2,NH}$ ~8 0		5 38s		
14[f]	5 12dd $J_{2,NH}$ ~9 6 $J_{2,3}$ ~6 0	5 43dd $J_{3,4}$ ~2.0	4 12dd $J_{4,5}$ ~10 0	4 93td $J_{5,6}$ ~5 0 $J_{5,6'}$ ~10 0	4 39dd $J_{6,6'}$ ~10 0	3 58t	—	2 03s (3 H) 2 08s (3 H)	—	8 58d	—	5 32s	←3 66s/3 72s→ (3 H) (3H)	

[a]Spectra of **3, 7, 9–11, 13,** and **14**. [b]Spectra of **1, 2, 8,** and **12**. [c]All the spectra also show signals for ethyl ester protons on C-1 (δ 1.18–1.35t for 3 H, 4.0–4.3q for 2 H) and for benzylidene group protons (δ 5.42–5.55s for the benzylic proton, 7.2–7.6m for the aromatic protons). [d]The signals for the phenyl group protons on C-2' of **9** and **10** appear overlapped with the multiplet of the benzylidene aromatic protons (total intensity 10 H). [e]In $CDCl_3$. [f]In $(CD_3)_2SO$. [g]The signal for the NH proton is also included in the complex multiplet at δ 3.3–4.6 (total intensity 8 H). [h]Non-systematic numbering for C-1' (bonded to N) and C-2', to keep the analogy with the other compounds. [i]Overlapped with the singlet of a methyl ester group (total intensity 4 H). [j]Data extracted from the spectrum of **11–13** mixture.

TABLE II

^{13}C-CHEMICAL SHIFTS[a] AND MULTIPLICITIES[b] FOR COMPOUND **12** IN $CDCl_3$ AT 20.5 MHz

δ	*Assignment*
170.6s	ester carbonyl
169.7s	ester carbonyl
169.6s	ester carbonyl
169.3s	ester carbonyl
137.3s	*ipso*-C of phenyl
128.9d	*para*-C of phenyl
128.0d	*ortho*-C of phenyl (2 ×)
126.3d	*meta*-C of phenyl (2 ×)
101.1d	benzylic carbon
95.7s	oxazolidine C-2
78.3d, 77.4d	oxazolidine C-4 and C-5
67.8t	ethyl ester CH_2
64.1d, 61.6d	C-4 and C-5 of sugar moiety
60.0t	C-6 of sugar moiety
52.2q	methyl ester
51.7q	methyl ester
40.9t	methylene carbon bonded to carbonyl of methyl ester
20.6q	acetate methyl
14.1q	ethyl ester CH_3

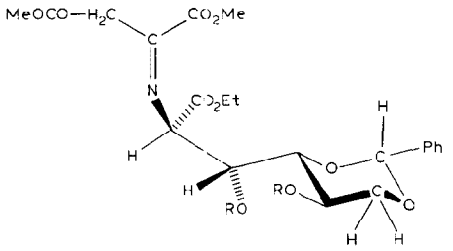
[a]Relative to the signal of internal Me_4Si. [b]In "off-resonance" experiment (d, doublet; q, quadruplet; s, singlet; and t, triplet).

figuration of the double bond, and this is corroborated by the high-field position of the free-NH signal (δ 5.20 or 5.15). However, the *Z* isomer of **8** was detected in solutions of pure **8** after several days, as additional signals arose at δ 4.58 (H-2′, doublet, *J* 8.8 Hz), 6.54 (H-1′, double doublet, $J_{1',2'}$ 8.8, $J_{1',NH}$ 12.0 Hz), and 8.05 (NH, broad triplet), all of them in positions typical[1] of a chelated, *Z* form.

For the enaminones **9** and **10**, we propose the *Z* configuration having the intramolecularly bound amino hydrogen atom, as formulated, on the basis of the positions of the vinyl proton signal (4.78 and 4.74 p.p.m., respectively; calculated by the Pascual–Meier–Simon rule[12]: 5.02 p.p.m.), and of the chelated amino proton signal (9.00 and 8.82 p.p.m.).

In the cases of **11** and **12**, the presence of the oxazolidine ring was shown by several observations. First, in their ^{1}H-n.m.r. spectra, no signal appeared for a vinyl proton, as an enaminone structure would require; instead, a singlet for two protons appeared at δ 3.05 (**11**) (or two close doublets for the AB system of two diastereotopic protons, at δ 2.98 and 3.10, in the spectrum of **12**), suggesting a methylene group α to an ester group. This feature is also possible in an iminic structure, such as **15** or **16**, but it was discarded on the basis of the absence of a C=N band in the i.r. spectra of these compounds, and especially by the ^{13}C-n.m.r. spectrum of **12** (see Table II), in which the singlet at δ 95.7 is assigned to the

oxazolidine C-2 (ring numbering), whereas the signal for the iminic carbon atom in the alternative structure **16** should appear[13] in the range of 145–170 p.p.m. In a recent study on the isomerization observed in the acetylation of certain sugar oximes, Furneaux[14] attributed the signals at ~152–155 p.p.m. to the iminic carbon atom of the acyclic oxime, and the signals at ~82–93 p.p.m. to the anomeric carbon atom (between *N* and *O* in these cases) of the cyclic form.



15 R = H
16 R = Ac

The formation of **11** probably occurs by internal addition of the hydroxyl group on C-3 to the iminic double bond, N=C, of **15**, considered the less stable tautomer (but present in the equilibrium) of the enaminone **13** first formed, although **15** could not be detected chromatographically. A similar, ring–chain tautomerism has been described, for example[15], between *N*-(2-hydroxyalkyl)-nitrones and *N*-hydroxyoxazolidines.

EXPERIMENTAL

General methods. — Solutions were evaporated *in vacuo* at <40°. Melting points were determined with a Gallenkamp apparatus and are uncorrected. Optical rotations were measured with a Perkin–Elmer 141 (10-cm cell). T.l.c. was performed on silica gel (Merck GF_{254}) with 10:1 benzene–methanol and detection with u.v. light and iodine vapor. Preparative t.l.c. was conducted on silica gel (Merck PF_{254}) with 10:1 benzene–methanol. Column chromatography was performed on silica gel (Merck No. 60; 63–200 μm) with 20:1 benzene–methanol. I.r. spectra were recorded, for KBr discs, with a Perkin–Elmer 399 grating spectrophotometer. U.v. spectra were recorded with a Pye–Unicam SP8-250 spectrophotometer. ^{1}H-N.m.r. spectra (220 and 90 MHz) were respectively recorded at 35.5° with a Perkin–Elmer R-34 and R-32 spectrometer (locked on the signal of internal Me_4Si), and coupling constants were directly measured from spectra; the spectral assignments were confirmed by double-resonance experiments. The ^{13}C-n.m.r. spectrum was recorded with a Bruker VP-80 spectrometer.

*Ethyl 2-amino-4,6-*O*-benzylidene-2-deoxy-*D*-gluconate* (**1**). — Triethylamine (4.0 mL) was added to a stirred suspension of ethyl 2-amino-4,6-*O*-benzylidene-2-

deoxy-D-gluconate hydrochloride[10] (5.0 g, 14.4 mmol) in anhydrous benzene (200 mL), and the mixture was stirred for 15 min at room temperature. The solid was filtered off, and the filtrate was evaporated, to yield **1** (4.45 g, 99%); m.p. 101–102° (from benzene), $[\alpha]_D^{20}$ −6.4°, $[\alpha]_{578}^{20}$ −6.8°, $[\alpha]_{546}^{20}$ −8.0°, $[\alpha]_{436}^{20}$ −14.4°, $[\alpha]_{365}^{20}$ −27.4° (*c* 0.5, chloroform); ν_{max} 1715 cm^{-1} (ester C=O); for ^{1}H-n.m.r. data, see Table I.

Anal Calc. for $C_{15}H_{21}NO_6$: C, 57.87; H, 6.80; N, 4.50. Found: C, 58.07; H, 7.10; N, 4.44.

*Ethyl 2-acetamido-3,5-di-*O*-acetyl-4,6-*O*-benzylidene-2-deoxy-*D*-gluconate* (**2**). — A solution of **1** (0.7 g, 2.25 mmol) in pyridine (7 mL) was treated with acetic anhydride (4.5 mL) overnight at ~0°, and then poured into ice–water (140 mL). The mixture was extracted with chloroform (3 × 50 mL), and the extracts were combined, washed successively with M HCl, aqueous sodium hydrogencarbonate, and water, dried (sodium sulfate), and evaporated. The resulting syrup was treated with ether–light petroleum, to give **2** (0.8 g, 81%); m.p. 108–109° (from ether-light petroleum), $[\alpha]_D^{20}$ −19.6°, $[\alpha]_{578}^{20}$ −20°, $[\alpha]_{546}^{20}$ −22.8°, $[\alpha]_{436}^{20}$ −38.2°, $[\alpha]_{365}^{20}$ −58° (*c* 0.5, chloroform); ν_{max} 3350 (NH), 1735, 1730, 1710 (ethyl ester C=O plus acetate), and 1665 cm^{-1} (amide I); for ^{1}H-n.m.r. data, see Table I.

Anal. Calc. for $C_{21}H_{27}NO_9$: C, 57.92; H, 6.22; N, 3.20. Found: C, 57.63; H, 6.50; N, 2.88.

*Ethyl 4,6-*O*-benzylidene-2-deoxy-2-[(*E*)-(2-methoxycarbonylvinyl)amino]-D-gluconate* (**7**). — Methyl propiolate (**4**) (1.35 mL, 15.2 mmol) was added to a solution of the amino ester **1** (4.72 g, 15.2 mmol) in ethanol (50 mL). The solution was kept for 24 h at room temperature, and then evaporated under diminished pressure, to yield **7** (4.72 g, 79%); m.p. 155–156° (from ethanol), $[\alpha]_D^{20}$ −6.4°, $[\alpha]_{578}^{20}$ −5.8°, $[\alpha]_{546}^{20}$ −6.0°, $[\alpha]_{436}^{20}$ −2.0°, $[\alpha]_{365}^{20}$ +16° (*c* 0.5, pyridine); λ_{max}^{MeOH} 268 nm (ε_{mM} 24.20); ν_{max} 3250 (NH), 1710 (non-conjugated ester C=O), 1675 (conjugated ester C=O), and 1610 cm^{-1} (coupled NH-C=C system); for ^{1}H-n.m.r. data, see Table I.

Anal. Calc. for $C_{19}H_{25}NO_8$: C, 57.71; H, 6.23; N, 3.54. Found: C, 57.47; H, 6.51; N, 3.59.

*Ethyl 3,5-di-*O*-acetyl-4,6-*O*-benzylidene-2-deoxy-2-[(*E*)-(2-methoxycarbonylvinyl)amino]-D-gluconate* (**8**). — A solution of **7** (1.0 g, 2.53 mmol) in pyridine (10 mL) was treated with acetic anhydride (7.5 mL) for 2 h at ~0°, and then poured into ice–water (200 mL), to yield **8** (0.95 g, 79%); m.p. 126–127° (from ether), $[\alpha]_D^{20}$ +27.0°, $[\alpha]_{578}^{20}$ +28.6°, $[\alpha]_{546}^{20}$ +34.6°, $[\alpha]_{436}^{20}$ +79.2°, $[\alpha]_{365}^{20}$ +174° (*c* 0.5, chloroform); λ_{max}^{MeOH} 268 nm (ε_{mM} 19.20); ν_{max} 3250 (NH), 1735, 1725 (ethyl ester C=O plus acetate), 1675 (methyl ester C=O), and 1605 cm^{-1} (NH-C=C); for ^{1}H-n.m.r. data, see Table I.

Anal. Calc. for $C_{23}H_{29}NO_{10}$: C, 57.61; H, 6.09; N, 2.92. Found: C, 57.43; H, 6.19; N, 2.84.

*Ethyl 4,6-*O*-benzylidene-2-deoxy-2-[(*Z*)-(2-ethoxycarbonyl-1-phenylvinyl)amino]-D-gluconate* (**9**). — A solution of amino ester **1** (3.4 g, 10.9 mmol) in

ethanol (80 mL) was treated with ethyl phenylpropiolate (**5**) (1.8 mL, 10.9 mmol). The solution was kept for 15 d at room temperature, and then evaporated *in vacuo*. The resulting syrup was purified by chromatography on a column of silica gel with 20:1 benzene–ethanol as the eluant, helped[16] by an overpressure of nitrogen, to give amorphous **9** (0.4 g, 8%); R_F 0.45; $[\alpha]_D^{20}$ +17.4°, $[\alpha]_{578}^{20}$ +19.4°, $[\alpha]_{546}^{20}$ +22.6°, $[\alpha]_{436}^{20}$ +43.8°, $[\alpha]_{365}^{20}$ +72.2° (*c* 0.5, chloroform); λ_{max}^{MeOH} 230 and 293 nm (ε_{mM} 5.60 and 11.00); ν_{max} 1730 (ester C=O), 1645, 1600, and 1585 cm^{-1} (coupled NH-C=C-C=O system); for ^{1}H-n.m.r. data, see Table I.

*Ethyl 3,5-di-*O*-acetyl-4,6-*O*-benzylidene-2-deoxy-2-[(Z)-(2-ethoxycarbonyl-1-phenylvinyl)amino]-*D*-gluconate* (**10**). — Conventional treatment of amorphous **9** (0.4 g, 0.82 mmol) with acetic anhydride (4 mL) in pyridine (4 mL) yielded **10** (0.4 g, 86%); m.p. 92–94° (from ethanol), $[\alpha]_D^{20}$ +54.7°, $[\alpha]_{578}^{20}$ +58.2°, $[\alpha]_{546}^{20}$ +67.5°, $[\alpha]_{436}^{20}$ +138°, $[\alpha]_{365}^{20}$ +277° (*c* 0.44, chloroform); λ_{max}^{MeOH} 228 and 291 nm (ε_{mM} 7.80 and 15.00); ν_{max} 3260 (NH), 1735 (non-conjugated ethyl ester C=O plus acetate), 1645, 1600, and 1585 cm^{-1} (NH-C=C-C=O); for ^{1}H-n.m.r. data, see Table I.

Anal. Calc. for $C_{30}H_{35}NO_{10}$: C, 63.25; H, 6.19; N, 2.45. Found: C, 63.08; H, 6.34; N, 2.33.

*Methyl (4*R*,5*R*)-5-(1,3-*O*-benzylidene-*D*-erythro-glycerol-1-yl)-4-(ethoxycarbonyl)-2-(methoxycarbonyl)oxazolidin-2-yl acetate* (**11**). — DMADC (**6**; 1.2 mL, 9.6 mmol) was added to a solution of the amino ester **1** (3.0 g, 9.6 mmol) in ethanol (50 mL). The solution was kept for 10 min at room temperature, and evaporated, and the resulting syrup crystallized from ethyl acetate–light petroleum, to yield a mixture (3 g) of **11** and **13**, which was recrystallized from methanol to give **11** (2.44 g, 56%); m.p. 121–123° (from methanol), $[\alpha]_D^{20}$ −4.6°, $[\alpha]_{578}^{20}$ −4.6°, $[\alpha]_{546}^{20}$ −5.2°, $[\alpha]_{436}^{20}$ −5.4°, $[\alpha]_{365}^{20}$ −4.0° (*c* 0.5, chloroform); ν_{max} 3440 (OH), 3290 (NH), 1760, 1745, and 1720 cm^{-1} (ester C=O); for ^{1}H-n.m.r. data, see Table I.

Anal. Calc. for $C_{21}H_{27}NO_{10}$: C, 55.62; H, 6.00; N, 3.08. Found: C, 55.52; H, 6.07; N, 2.91.

Acid hydrolysis of **11**. — A suspension of **11** (1.38 g, 3.0 mmol) in 0.1M hydrochloric acid (36.7 mL, 3.67 mmol) was heated for 2 h at 100°, cooled, and extracted with ether (4 × 15 mL). (*a*) The aqueous phase was evaporated *in vacuo* to give 2-amino-2-deoxy-D-gluconic acid (0.43 g, 74%), m.p. 250° (dec.) (from ethanol), identified by comparison of its chromatographic mobility (t.l.c.), i.r. spectrum, and mixed m.p. with those of an authentic sample. (*b*) The extracts were combined, dried (Na_2SO_4), and evaporated to a syrup which, on treatment with ethanol, yielded dimethyl oxalacetate (0.34 g, 70%), identified by its i.r. spectrum and mixed m.p. with an authentic sample. The mother liquors contained benzaldehyde, which was characterized as its phenylhydrazone.

*Methyl (4*R*,5*R*)-5-(2-*O*-acetyl-1,3-*O*-benzylidene-*D*-erythro-glycerol-1-yl)-4-(ethoxycarbonyl)-2-(methoxycarbonyl)oxazolidin-2-yl acetate* (**12**). — Acetic anhydride (5 mL) was added to a solution of **11** (1.1 g, 2.42 mmol) in pyridine (10 mL), and the mixture was kept for 24 h at 0°. The solution was then poured into ice–water (200 mL), to yield **12** (1.09 g, 91%); m.p. 108–110° (from ethanol), $[\alpha]_D^{20}$

$-23.7°$, $[\alpha]_{578}^{20}$ $-24.1°$, $[\alpha]_{546}^{20}$ $-27.3°$ $[\alpha]_{436}^{20}$ $-42.0°$, $[\alpha]_{365}^{20}$ $-57.1°$ (*c* 0.56, chloroform); ν_{max} 3290 (NH), 1750, 1730, and 1720 cm^{-1} (ester C=O); for ^{1}H-n.m.r. data, see Table I and for ^{13}C-n.m.r. data, see Table II.

Anal. Calc. for $C_{23}H_{29}NO_{11}$: C, 55.75; H, 5.89; N, 2.82. Found: C, 56.06; H, 5.92; N, 2.98.

*Ethyl 3,5-di-*O*-acetyl-4,6-*O*-benzylidene-2-deoxy-2-[(Z)-(1,2-dimethoxycarbonylvinyl)amino]-*D*-gluconate* (**14**). — A solution of **11** (0.5 g, 1.1 mmol) and 4-(dimethylamino)pyridine (0.05 g, 0.41 mmol) in pyridine (3 mL) was treated with acetic anhydride (3 mL). The mixture was kept for 6 d at room temperature, poured into ice–water, and extracted with chloroform (3 × 10 mL). The extracts were combined, washed successively with M HCl, aqueous sodium hydrogencarbonate, and water, and dried (Na_2SO_4). Isolation of the desired product **14** (R_F 0.60) was achieved by preparative t.l.c. with 10:1 benzene–methanol (yield: 0.3 g, 51%); m.p. 80–82° (from ethanol), $[\alpha]_D^{20}$ $+21.2°$, $[\alpha]_{578}^{20}$ $+22.0°$, $[\alpha]_{546}^{20}$ $+26.8°$, $[\alpha]_{436}^{20}$ $+56.8°$ (*c* 0.5, chloroform); λ_{max}^{MeOH} 307 nm (ε_{mM} 10.96); ν_{max} 3250 (NH), 1750, 1730 (non-conjugated ester C=O), 1660 (conjugated ester C=O), and 1605 cm^{-1} (NH-C=C); for ^{1}H-n.m.r. data, see Table I.

Anal. Calc. for $C_{25}H_{31}NO_{12}$: C, 55.86; H, 5.81; N, 2.60. Found: C, 56.12; H, 6.12; N, 2.71.

The mixture of **11** and **13** can also be transformed, under the same conditions, into **14**. Similarly, **12** affords **14**.

When solutions of **14** were stored for some days at room temperature, it readily decomposed, to give **3**, m.p. 145–147°, $[\alpha]_D^{20}$ $-63.2°$, $[\alpha]_{578}^{20}$ $-65.4°$, $[\alpha]_{546}^{20}$ $-74.8°$, $[\alpha]_{436}^{20}$ $-128.0°$, $[\alpha]_{365}^{20}$ $-202.6°$ (*c* 0.5, chloroform); ν_{max} 3360–3320 (NH), 1715 (ester C=O), and 1620 cm^{-1} (amide band I); for ^{1}H-n.m.r. data, see Table I.

Anal. Calc. for $C_{19}H_{25}NO_8$: C, 57.71; H, 6.37; N, 3.54. Found: C, 57.46; H, 6.51; N, 3.35.

ACKNOWLEDGMENTS

The authors thank the Instituto de Química Orgánica General (C.S.I.C., Madrid) for the ^{13}C-n.m.r. spectrum and the microanalyses, Dr. P. Tyson of Sheffield University (England) for recording the 220-MHz, ^{1}H-n.m.r. spectra, and Professor A. Gómez Sánchez for various suggestions during the discussion of results.

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