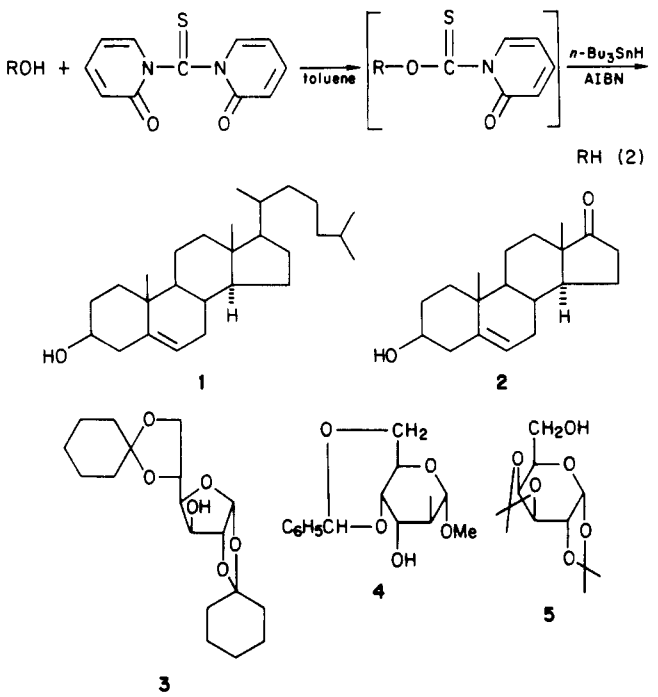

known reagents such as 1,1′-thiocarbonyldiimidazole,[12,13] 2-halopyridinium salts (Mukaiyama reagent),[14] and triphenylphosphine–diethyl azodicarboxylate (Mitsunobu reagent).[15] First, since 2-pyridone (pK_a 0.75) as the only other product formed is a neutral compound, the reactions described herein occur under essentially neutral conditions. For instance, the use of 1,1′-thiocarbonyldiimidazole produces basic imidazole (pK_a 6.95) as a byproduct, which might cause some problems in the synthesis of base-sensitive complex molecules. Second, the present method is much simpler and less laborious than the conventional methods because a byproduct, water-soluble 2-pyridone, can be completely removed by the usual aqueous workup and does not normally require chromatographic separation in most cases.[16] Third, the reagent is extremely stable even under atmospheric moisture, although 1,1′-thiocarbonyldiimidazole is hygroscopic and relatively unstable.[17] Finally, one can easily monitor the completion of the reaction by disappearance of orange color of the reagent.

Acknowledgment. We are grateful to the Korea Science and Engineering Foundation for generous support of this work.

Registry No. 1, 57-88-5; 1 (thiocarbonyl-2-pyridone), 102368-14-9; 1 (deoxygenated), 570-74-1; 2, 53-43-0; 3 (thiocarbonyl-2-pyridone), 102396-11-2; 2 (deoxygenated), 25824-80-0; 3, 23397-76-4; 3 (thiocarbonyl-2-pyridone), 102368-15-0; 3 (deoxygenated), 64503-68-0; 4, 68907-47-1; 4 (thiocarbonyl-2-pyridone), 102368-16-1; 4 (deoxygenated), 68880-90-0; 5, 4064-06-6; 5 (thiocarbonyl-2-pyridone), 102368-17-2; 5 (deoxygenated), 4026-27-1; $CH_3(CH_2)_7CH{=}NOH$, 2243-24-5; c-$C_6H_{11}CH{=}NOH$, 4715-11-1; $C_6H_5CH{=}NOH$, 932-90-1; p-$NO_2C_6H_4CH{=}NOH$, 1129-37-9; $C_6H_5NHCSNHC_6H_5$, 102-08-9; $C_6H_5NHCSNHC(CH_3)_3$, 14327-04-9; $(CH_3)_3CNHCSNHC(CH_3)_3$, 4041-95-6; c-$C_6H_{11}NHCSNH$-c-C_6H_{11}, 1212-29-9; $CH_3(CH_2)_6CSNH_2$, 5813-91-2; p-$CH_3C_6H_4CSNH_2$, 2362-62-1; p-$ClC_6H_4CSNH_2$, 2521-24-6; $C_6H_3CH_2CSNH_2$, 645-54-5; $C_6H_5CH_2NH_2$, 100-46-9; $(CH_3)_3CNH_2$, 75-64-9; $C_6H_5NH_2$, 62-53-3; p-$NO_2C_6H_4NH_2$, 100-01-6; $HOCH_2CH_2OH$, 107-21-1; $HOCH(CH_3)CH_2OH$, 57-55-6; $HOCH(CH_3)CH_2CH_2OH$, 107-88-0; $HOCH(CH_3)CH_2C(CH_3)_2OH$, 107-41-5; $CH_3(CH_2)_7CN$, 2243-27-8; c-$C_6H_{11}CN$, 766-05-2; PhCN, 100-47-0; p-$NO_2C_6H_4CN$, 619-72-7; $C_6H_5N{=}C{=}NC_6H_5$, 622-16-2; $C_6H_5N{=}C{=}NC(CH_3)_3$, 2219-34-3; $(CH_3)_3CN{=}C{=}NC(CH_3)_3$, 691-24-7; c-$C_6H_{11}N{=}C{=}N$-c-$C_6H_{11}$, 538-75-0; $CH_3(CH_2)_6CN$, 124-12-9; p-$CH_3C_6H_4CN$, 104-85-8; p-ClC_6H_4CN, 623-03-0; $C_6H_5CH_2CN$, 140-29-4; $C_6H_5CH_2N{=}C{=}S$, 622-78-6; $(CH_3)_3CN{=}C{=}S$, 590-42-1; C_6H_5NCS, 103-72-0; p-$NO_2C_6H_4N{=}C{=}S$, 2131-61-5; $\overline{OCH_2CH_2OCS}$, 20628-59-5; $\overline{OCH(CH_3)CH_2OCS}$, 13303-26-9; $\overline{OCH(CH_3)CH_2CH_2OCS}$, 56155-93-2; $\overline{OCH(CH_3)CH_2C(CH_3)_2OC}$, 102368-18-3; di-2-pyridyl thionocarbonate, 96989-50-3; 1,1′-thiocarbonyldi-2,2′-pyridone, 102368-13-8; 1,1′-thiocarbonyldiimidazole, 6160-65-2; 1-[benzyl(thiocarbonyl)]imidazole, 102368-19-4; N,N'-dibenzylthiourea, 1424-14-2.

(12) (a) Staab, H. A.; Walther, G. *Justus Liebigs Ann. Chem.* **1962**, *657*, 98. (b) Pullukat, T. J.; Urry, G. *Tetrahedron Lett.* **1967**, 1953. (c) Larsen, C.; Steliou, K.; Harpp, D. N. *J. Org. Chem.* **1978**, *43*, 337. (d) Harpp, D. N.; MacDonald, J. G. *Tetrahedron Lett.* **1983**, 4927 and references 8a and 9a therein.

(13) According to our brief study, 1,1′-thiocarbonyldiimidazole was effective for dehydration of nonanaldoxime into nonanonitrile (89%) and dehydrosulfurization of *N*-*tert*-butyl-*N*′-phenylthiourea into *N*-*tert*-butyl-*N*′-phenylcarbodiimide (82%) and 4-methylthiobenzamide into *p*-toluonitrile (82%) and was comparable to 1,1′-thiocarbonyldi-2,2′-pyridone in terms of reactivity and yield under similar conditions. However, the use of 1,1′-thiocarbonyldiimidazole as a thiocarbonyl transfer reagent did not give satisfactory results in several instances. For example, reaction of benzylamine with 1.1 equiv of commercially available 1,1′-thiocarbonyldiimidazole (90% purity from Aldrich) in methylene chloride at room temperature for 1 h gave a 38:48 mixture of benzyl isothiocyanate and 1-[benzyl(thiocarbamoyl)]imidazole along with 6% of *N*,*N*′-dibenzylthiourea. Furthermore, under the similar conditions employed using 1,1′-thiocarbonyldi-2,2′-pyridone, ethylene glycol and 1,3-butanediol were not converted into the desired cyclic thionocarbonates, yielding only several unidentified byproducts, although 2-methyl-2,4-pentanediol was converted into 4,4,6-trimethyl-1,3-dioxane-2-thione in 69% yield. Thus, it seems that the success of the cyclic thionocarbonate formation might depend on the nature of the substrates, although the reason for this observation is rather obscure.

(14) Mukaiyama, T. *Angew. Chem., Int. Ed., Engl.* **1979**, *18*, 707.

(15) Mitsunobu, O. *Synthesis* **1981**, 1.

(16) The following procedure is representative in most cases. To a solution of a substrate (2.0 mmol) in toluene (5 mL) was added 1,1′-thiocarbonyldi-2,2′-pyridone (2.0 mmol). After being stirred at 110 °C until the reaction was complete, the reaction mixture was allowed to cool to room temperature, diluted with methylene chloride (40 mL), washed with water (20 mL) and brine (20 mL), dried over anhydrous $MgSO_4$, and evaporated to dryness. The crude product was purified by distillation or recrystallization.

(17) 1,1′-Thiocarbonyldiimidazole was decomposed more than 80% upon exposure to atmospheric moisture at room temperature for 1 day and almost complete decomposition occurred after 2 days.

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The Total Synthesis of (±)-*N*-Acetylneuraminic Acid (NANA): A Remarkable Hydroxylation of a (*Z*)-Enoate

Summary: A total synthesis of the title compound was achieved. A key feature of the synthesis involved a stereospecific hydroxylation of a (*Z*)-carbomethoxyvinyl pyranoside.

Sir: *N*-Acetylneuraminic acid (Neu 5Ac = NANA (17)) was first encountered by Gottschalk[1a] upon examination of the action of influenza viruses on various mucins and later by Klenk[1b] and co-workers upon acidic hydrolysis of mucous substances. NANA is a widely encountered member of a more general class of compounds known as sialic acids, which are N- or O-acylated derivatives of

(1) (a) Gottschalk, A. *Nature (London)* **1951**, *167*, 845. (b) Klenk, E. *Z. Physiol. Chem.* **1941**, *268*, 50.

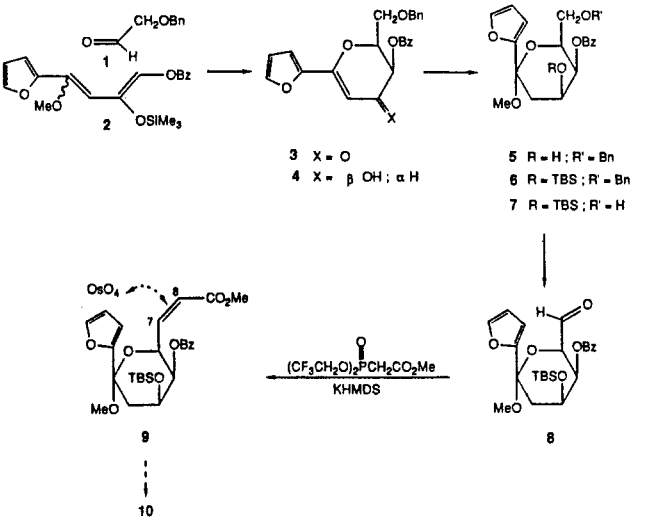
0022-3263/86/1951-2615$01.50/0

neuraminic acid.[2a,b] Sialic acids are constituents of a variety of complex carbohydrates, including polysaccharides, glycolipids, and glycoproteins. While the elucidation of the full range of roles of sialic acids is a dynamic area of biochemical research, it is already clear that these residues influence aggregation phenomena, viscosity, and agglutination. They also play a significant role in governing the recognizability of various glycoconjugates by potential biological receptors. Thus, the extent of sialidation has apparent implications at the immunological level.[3]

In the light of this diversity of properties, it would be well to gain a totally synthetic access to the sialic acids.[2b,4] In this fashion it would be possible to probe, in a systematic way, the influence of subtle structural and stereochemical changes on the biological activity of various sialyl congeners. The discovery of powerful neuraminidase or sialyltransferase inhibitors could well be of consequence.

Below we report a total synthesis of (±)-NANA (17). Aside from the obvious biological ramifications posed by NANA as a target, the research served to underscore several themes which are of broad interest in our laboratory. A key step (1 + 2 → 3) was illustrative of the use of the Lewis acid catalyzed cyclocondensation reaction of very complex dienes and aldehydes for the direct assemblage of highly functionalized pyranoids.[5] The interior substitution and stereochemistry of the pyrone was established by exploiting the rigid nature of the oxygen heterocycle (see 3 → 7). Another key feature of the synthesis was the highly stereoselective osmylation of the *cis*-enoate 9 (see 9 → 10). This transformation provides important new flexibility in achieving communication between dissymmetric pyranoside rings and stereogenic centers emerging on their side chains.[6] The last phase of the synthesis involved the introduction of an acetamido group at C_5 by distinguishing a unique alcohol at carbon center 5 for activation and displacement. This was accomplished by exploiting an O → O benzoyl migration (see 14 → 15).

Cyclocondensation of 1[7] and 2[5] (BF_3·OEt_2–toluene, −78 °C) afforded a 78% yield of a 5.1:1 mixture of cis-substituted pyrone 3 and the corresponding trans isomer (not shown). Reduction of the mixture ($NaBH_4$–$CeCl_3$, EtOH, −78 °C)[8] afforded an 80% yield of homogeneous 4,[9] which reacted with methanol in the presence of CSA to produce (82%) the masked ketoside 5. After protection (95%) of the C_4 alcohol as its TBS derivative (see compound 6), the primary alcohol was unveiled by hydrogenolysis (Pd-$(OH)_2$/C, EtOAc–MeOH).[10] Compound 7, thus obtained



in 87% yield, was oxidized (CrO_3·Py) to aldehyde 8 in 90% yield. Emmons-like condensation of 8 under the conditions of Still[11] afforded the (*Z*)-olefin 9, a substrate which was viewed as being amenable to the introduction of hydroxyl groups at carbons 7 and 8 in the required stereochemical sense.[12,13]

In the event, reaction of compound 9 with osmium tetraoxide in pyridine afforded an 87% yield of compound 10.[14] Also produced (ca. 5% yield) was an isomer, presumably differing from 10 in its configurations at carbons 7 and 8. Treatment of 10 with lithium triethylborohydride[15] in THF gave triol 11 and thence (BzCl, CH_2Cl_2, DMAP) tetrabenzoate 12.

Oxidative degradation of the furan (RuO_2–$NaIO_4$/$NaHCO_3$),[16] followed by esterification (diazomethane), gave a 90% yield of 13. As was expected, compound 14a (generated from the reaction of 13 with HF–methanol) underwent O → O benzoyl migration, thereby giving rise (62% isolated yield)[17] to compound 14b in which the benzoyloxy group is equatorial and the hydroxyl function is axial. The uniquely distinguished alcohol at C_5 in 14b was activated (MsCl, DMAP, 95%). The resultant mesylate, upon reaction with sodium azide in DMF, gave the equatorial azide (50%) 15, which, after reduction (Pd-$(OH)_2$/C)[10] and acetylation, afforded the methyl glycoside methyl ester of perbenzoyl NANA 16. The ^1H NMR (490 MHz) and IR spectra as well as chromatographic prop-

(2) (a) Schauer, R. *Adv. Carbohydr. Chem. Biochem.* **1982**, *40*, 131. (b) Schauer, R. *Sialic Acids*; Springer-Verlag: Wien and New York, 1982.

(3) Sedlacek, H. H.; Weise, M.; Lemmer, A.; Seiler, F. R. *Cancer Immunol. Immunother.* **1979**, *6*, 47.

(4) For some recent partially synthetic work in this area: Paquet, F.; Sinay, P. *Tetrahedron Lett.* **1984**, *25*, 3071. Augé, C.; David, S.; Gautheron, C. *Tetrahedron Lett.* **1984**, *25*, 4663. Augé, C.; David, S.; Gautheron, C.; Verieres, A. *Tetrahedron Lett.* **1985**, *26*, 2439.

(5) Danishefsky, S. J.; Pearson, W. H.; Segmuller, B. E. *J. Am. Chem. Soc.* **1985**, *107*, 1281.

(6) Danishefsky, S.; DeNinno, M. *Tetrahedron Lett.* **1985**, *26*, 823. Danishefsky, S. J.; DeNinno, M. P.; Phillips, G. B.; Zelle, R. E.; Lartey, P. A. *Tetrahedron*, in press.

(7) Arndt, H. C.; Carroll, S. A. *Synthesis* **1979**, 202. Due to the low yields and high expense encountered during scale-up of the literature preparation of this aldehyde, it was prepared by ozonolysis of the corresponding alkene followed by Zn/HOAc workup (yields ca. 90% on 10-g scale).

(8) Luche, J. L.; Gemal, A. L. *J. Am. Chem. Soc.* **1979**, *101*, 5848.

(9) All isolated compounds exhibited satisfactory ^1H NMR (250 or 490 MHz), IR, and mass spectral characteristics. Satisfactory elemental analyses or high-resolution mass spectra were obtained on compounds 3–7, 9, 10, and 12.

(10) Pearlman, W. M. *Tetrahedron Lett.* **1967**, *23*, 1663.

(11) Still, W. C.; Gennari, C. *Tetrahedron Lett.* **1983**, *24*, 4405.

(12) Cf., inter alia: (a) Cha, J. K.; Christ, W. J.; Kishi, Y. *Tetrahedron Lett.* **1983**, *24*, 3943. (b) Christ, W. J.; Cha, J. K.; Kishi, Y. *Tetrahedron Lett.* **1983**, *24*, 3947. (c) Stork, G.; Kahn, M. *Tetrahedron Lett.* **1983**, *24*, 3951. (d) Martin, O. R.; Szarek, W. A. *Carbohydr. Res.* **1984**, *130*, 195. (e) Danishefsky, S.; Larson, E.; Springer, J. P. *J. Am. Chem. Soc.* **1985**, *107*, 1274. (f) Brimacombe, J. S.; Hanna, R.; Bennett, F. *Carbohydr. Res.* **1985**, *135*, C17. (g) Brimacombe, J. S.; Kabir, A. K. M. S.; Taylor, I. D. *Carbohydr. Res.* **1985**, *140*, C9 and references cited therein.

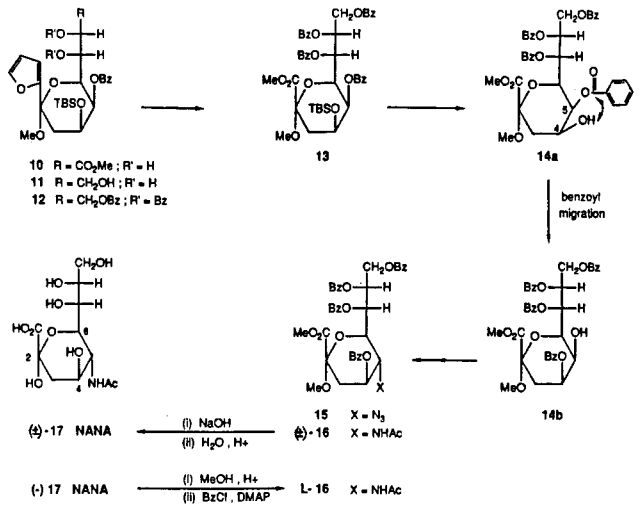
(13) An X-ray crystallographic analysis of this compound confirmed its structure. It also showed the ground-state conformation in the crystal to have an O(pyranose)–C_6–C_7–C_8 torsional angle of 161.7°. While the relevance of this finding to the reactive solution conformer is not clear, it is interesting to note that the stereochemical outcome of the osmylation reaction is well accommodated by this arrangement.

(14) An X-ray crystallographic determination on the corresponding bis(3,5-dinitrobenzoate) confirmed this structure. Details of the crystallographic measurement on this compound, as well as on compound 9, will be provided in the full paper.

(15) Brown, H. C.; Kim, S. C.; Krishnamurthy, S. *J. Org. Chem.* **1980**, *45*, 1.

(16) Carlsen, P. H. J.; Katsuki, T.; Martin, V. S.; Sharpless, K. B. *J. Org. Chem.* **1981**, *46*, 3936.

(17) The action of HF on compound 13 gives rise to a ca. 30% yield of axial alcohol and a ca. 60% yield of equatorial alcohol. The yield of 14b is increased to 62% by treating 14a with K_2CO_3/CH_2Cl_2. This reaction is complicated by the fact that the thermodynamic equilibrium lies heavily in favor of a second benzoyl migration (i.e., C_7 → C_5).



erties of (±)-16, thus obtained, were identical with those of L-16 prepared as shown.[18] Finally, (±)-16, upon saponification and acidic (Dowex) workup, afforded racemic NANA (17) whose ^{1}H NMR (490 MHz) and chromatographic properties were identical with those of authentic NANA (–)-17. The first total synthesis of NANA was thus complete.

During the course of these investigations, several other variations of C_7–C_9 functionalities were investigated with a view toward their suitability for hydroxylation. As a consequence of those studies, latitude in modifying the stereogenic centers at C_7 and C_8 is now possible. It was also found that masked furanoketosides (cf. **10–12**) are excellent substrates for simple acid catalyzed exchange reactions with other alcohols. Both of these findings augur well for the possibility of preparing novel stereoisomers and glycosides of NANA. These discoveries will be developed more fully in due course.

Acknowledgment. This work was supported by PHS Grant A116943. NMR spectra were obtained through the auspices of the Northeast Regional NSF/NMR Facility at Yale University, which was supported by NSF Chemistry Division Grant CHE 7916210.

(18) Kuhn, R.; Lutz, P.; MacDonald, D. L. *Chem. Ber.* **1966**, *99*, 611.

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Reaction of Glycals with Trifluoroacetic Anhydride and Ammonium Nitrate: A Novel Cleavage Reaction of Glycals[1]

Summary: The reaction of 3-acetylated pyranoid glycals with trifluoroacetic anhydride and ammonium nitrate followed by aqueous pH >7 workup leads to chiral (*E*)-3-acetoxy-4-formoxy-1-nitro-1-pentenes via a Grob fragmentation of the 1-*O*-(trifluoroacetyl)-3-*O*-acetyl-2-deoxy-2-nitropyranoses.

Sir: The use of carbohydrates as chiral synthons for the asymmetric synthesis of natural products is well documented.[2] Because of such interest we wish to report in this paper a facile and novel cleavage reaction of glycals that leads to chiral nitroalkenes, potentially useful chiral synthons.

Table I. Chemical Shifts (δ) and Coupling Constants ($^3J_{1,2}$)[a] of the Anomeric Protons for the 1-*O*-(Trifluoroacetyl)-2-deoxy-2-nitropyranoses 2

	δ (*J*, Hz)			
2a	6.86 (4.0)	6.74 (2.5)	6.58 (3.0)	6.26 (8.5)
2b	6.99 (1.5)	6.87 (4.0)	6.84 (4.0)	6.20 (8.5)
2c	6.98 (3.0)	6.85 (4.0)	6.82 (2.0)	6.58 (8.5)
2d	6.81 (4.0)	6.69 (2.5)	6.50 (2.5)	6.22 (8.0)
2e	6.79 (5.0)	6.74 (4.0)	6.46 (3.5)	6.14 (8.5)

[a] Determined at 360 MHz in $CDCl_3$.

The reactions at the double bond in glycals can be classified into three types: 1,2-addition,[3] substitution with allylic rearrangement (Ferrier reaction),[4] and addition with subsequent ring cleavage between C-1 and the ring oxygen. The first two types of reactions are commonplace in carbohydrate chemistry but there are very few examples of the third type of reaction.[5] Now we have discovered another ring-cleavage reaction of glycals, this time between C-1 and C-2.

Treatment of 3,4,6-tri-*O*-acetyl-D-glucal (**1a**) with trifluoroacetic anhydride and ammonium nitrate (TFAA/AN) followed by aqueous, pH >7, workup[6] gave a 90% yield of nitroalkene (*E*)-3(*R*),5-diacetoxy-4(*R*)-(formyloxy)-1-nitro-1-pentene (**3a**), as a yellow viscous oil.[7] Similarly, 3,4,6-tri-*O*-acetyl-D-galactal (**1b**)[8] and 3,4-di-*O*-acetyl-L-rhamnal (**1d**)[9] gave (*E*)-3(*S*),5-diacetoxy-4(*R*)-(formyloxy)-1-nitro-1-pentene (**3b**) and (*E*)-3(*S*)-acetoxy-4(*S*)-(formyloxy)-1-nitro-1-pentene (**3d**) in 85% and 93% yields, respectively. However, 3,4,6-tri-*O*-acetyl-D-allal

(1) Abstracted in part from the M.S. thesis of D.D., Villanova University, 1983.

(2) Hanessian, S. *The Total Synthesis of Natural Products: The Chiron Approach*; Pergamon: Oxford, 1983.

(3) Stanek, J.; Cerny, M.; Kocourek, J.; Pacak, J. *The Monosaccharides*; Academic: New York, 1963.

(4) Ferrier, R. J. In *The Carbohydrates: Chemistry and Biochemistry*; Pigman, W., Horton, D., Eds.; Academic: New York, 1980; Vol. 1B.

(5) Initially Fraser-Reid and Radatus, observed the formation of the α,β-unsaturated aldehyde, 4,6-di-*O*-acetyl-2,3-dideoxy-*aldehydo*-D-*erythro*-*trans*-hex-2-enose, in a 60% yield during the acid-catalyzed hydrolysis of 3,4,6-tri-*O*-acetyl-D-glucal; see: Fraser-Reid, B.; Radatus, B. *J. Am. Chem. Soc.* **1970**, *92*, 5288. Employing aqueous mercury(II) sulfate, Gonzalez et al. obtained a quantitative yield of the aldehyde; see: Gonzalez, F.; Lesage, S.; Perlin, A. *Carbohydr. Res.* **1975**, *42*, 267. During an attempted hydroxymercuration (aqueous mercury(II) acetate)–demercuration (sodium borohydride) a 60% yield of the aldehyde was obtained, see: Takiura, J.; Honda, S. *Carbohydr. Res.* **1973**, *29*, 477. However, oxidative cleavage of 3,4,6-tri-*O*-acetyl-D-glucal with palladium chloride in methanol with a catalytic amount of copper(II) nitrate gave a 60% yield of the saturated ester methyl 3,4,6-tri-*O*-acetyl-5-hydroxyhexanoate, see: Gouedard, M.; Gaudemer, F.; Gaudemer, A. *Bull. Soc. Chim. Fr.* **1973**, 577.

(6) A typical experimental procedure involves adding TFAA (5.0 mL, 35 mmol) to a mixture of 5 mmol of a glycal 1 and dry AN (0.48 g, 6.0 mmol). The mixture is stirred for 1 h. At this point the excess TFAA can be removed under reduced pressure and the ^{1}H NMR spectra run to demonstrate the formation of the intermediate addition products or the reaction mixture can be worked up in the following manner. The reaction mixture is diluted with 20 mL of water and extracted with dichloromethane (3 × 90 mL). The organic layer is then washed with 5% $NaHCO_3$ solution (3 × 90 mL) and saturated NaCl (30 mL), dried over $MgSO_4$, and concentrated. The resultant viscous oil can be purified by distillation under reduced pressure, (ca. 1–2 torr).

(7) Anal. Calcd for $C_{10}H_{13}NO_8$: C, 43.64; H, 4.73; N, 5.09. Found: C, 43.93; H, 4.75; N, 5.65. MS (EI), M^+ = 275; bp 181 °C (1.8 torr); ir (neat) 1735 (C=O), 1655 (C=C), 1532, 1450 cm^{-1} (NO_2); ^{1}H NMR ($CDCl_3$) δ 8.10 (s, 1 H, CHO), 7.20 (dd, 1 H, $J_{1,2}$ = 13 Hz, $J_{1,3}$ = 6 Hz, CH), 7.18 (dd, 1 H, $J_{1,2}$ = 13 *Hz*, $J_{2,3}$ = 1 Hz, $CHNO_2$), 5.72–5.82 (s, 1 H, CHOAc), 5.35–5.55 (s, 1 H, $CHCH_2$), 4.22–4.35 (s, 2 H, CH_2), 2.15 (s, 3 H, CH_3CO_2), 2.10 (s, 3 H, CH_3CO_2); ^{13}C NMR ($CDCl_3$) δ 170.29 (CH_3CO_2), 169.14 (CH_3CO_2), 159.47 (HCO_2), 142.17 (HC=), 134.15 (=$CHNO_2$), 70.37 (CH), 67.97 (CH), 61.09 (CH_2), 20.55 (CH_3).

(8) Pigman, W.; Roth, W. *Methods Carbohydr. Chem.* **1962**, *1*, 405.

(9) Pfanstiehl Laboratories, Inc., Waukegan, IL 60085.

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