(dd, $J$ = 8.3, 3.1 Hz, 1 H), 7.07 (d, $J$ = 3.1 Hz, 1 H), 7.22 (m, 6 H), 7.43 (d, $J$ = 8.7 Hz, 1 H).

**Preparation of 11.** Adduct **10** (290 mg, 0.48 mmol), 2,6-di-*tert*-butylphenol (a few crystals), and $Pd(PPh_3)_4$ (28 mg) were refluxed in 25 mL of toluene for 4.5 h, and the solvent was removed under reduced pressure. The residue was chromatographed on a 2-mm Chromatotron plate with 3:1 hexanes/ethyl acetate as eluent to afford 45% of **11**. Oxidation of **9** with PDC gave the ketone **2c**. $^1H$ NMR of **11**: $\delta$ 2.50 (m, 1 H), 3.79 (s, 3 H), 3.79 (s, 3 H), 5.42 (m, 1 H), 6.36 (s, 1 H), 6.89 (m, 2 H), 7.2-7.6 (m, 6 H); $^{13}C$ NMR $\delta$ 55.4, 75.3, 107.0, 117.3, 117.6, 123.1, 127.0, 127.5, 128.6, 135.7, 137.2, 143.1, 152.6, 161.2.

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**Registry No.** **1a**, 134419-76-4; **1b**, 134419-77-5; **1c**, 134419-78-6; **2a**, 134419-79-7; **2b**, 134419-81-1; **2c**, 134419-83-3; **3a**, 134419-80-0; **3b**, 134419-82-2; **3c**, 134419-84-4; **6**, 134419-90-2; **7**, 134419-85-5; **8**, 134419-86-6; **9**, 134419-87-7; **10**, 134419-88-8; **11**, 134419-89-9; phenylacetylene, 536-74-3; 2-bromo-5-methoxybenzaldehyde, 7507-86-0; 5-methoxy-2-bromobenzoic acid, 22921-68-2; 2-bromobenzoic acid, 88-65-3; 2-bromobenzoyl chloride, 7154-66-7; 6-bromo-3,4-(methylenedioxy)benzoyl chloride, 55171-62-5; 2-bromobenzaldehyde, 6630-33-7.

**Supplementary Material Available:** $^1H$ NMR spectra for compounds **2a-c**, **3a-c**, and **11** (12 pages). Ordering information is given on any current masthead page.

## Studies on the Reactivity of Bicyclomycin 3′-*O*-Methanesulfonate. A Novel Ring-Expansion Transformation

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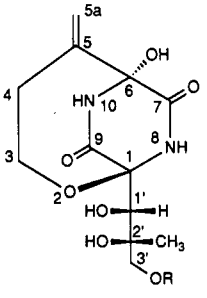
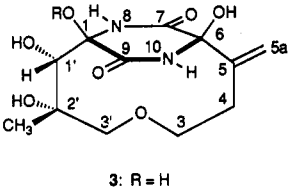
A series of fascinating transformations and rearrangements has been described for the clinically useful antibiotic[1] bicyclomycin (**1**) and derivatives under a variety of



**1**: R = H
**2**: R = $SO_2CH_3$
**4**: R = $C(O)NHCH_2CH_3$



**3**: R = H
**10**: R = $CH_3$

conditions.[2-4] In this paper, we report that bicyclomycin

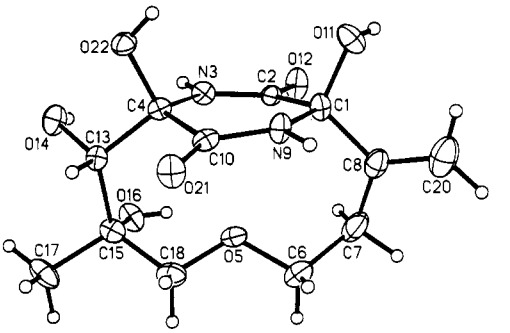
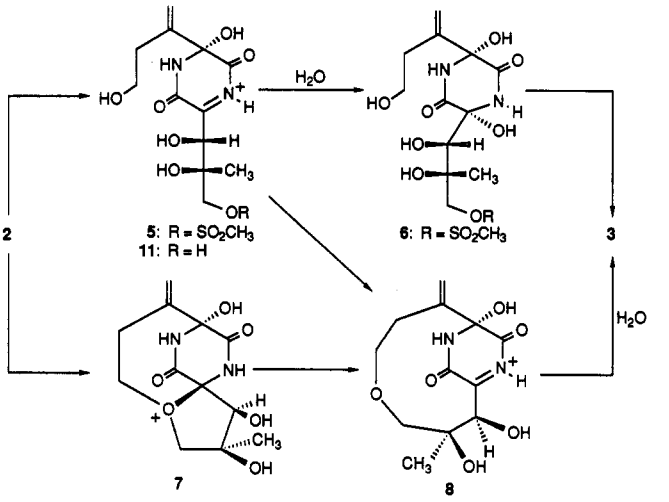


**Figure 1.** View of compound **3** with atom-labeling scheme. The non-hydrogen atoms are shown as 40% equiprobability envelopes and hydrogens as spheres of arbitrary diameter.

**Scheme I. Proposed Pathways for the Conversion of Compound 2 to Compound 3**



3′-*O*-methanesulfonate[5] (**2**) is stereospecifically converted in $H_2O$ to the ring-expanded adduct **3**, a compound that is isomeric with the natural product.

Bicyclomycin 3′-*O*-methanesulfonate (**2**) was prepared according to the procedure of Muller and co-workers.[5] Addition of **2** to an unbuffered aqueous solution led to the gradual reduction of the pH of the solution from 6.5 to 2.0 and the formation of **3** (24 h). Identification of **3** was accomplished with the aid of $^1H$ and $^{13}C$ NMR and FAB mass spectroscopy and was verified by X-ray crystallographic analysis. Distinctive signals noted for **3** in the $^1H$ NMR spectrum include the two doublets ($J$ = 9.0 Hz) at $\delta$ 3.03 and 3.13 for the diastereotopic C(3′) methylene protons and in the $^{13}C$ NMR spectrum the resonances at $\delta$ 80.57 and 80.91 for the C(1) and C(6) carbons. In the solid state, the expanded ring in **3** adopts a staggered conformation in which the ether oxygen atom is directed toward the center of the 2,5-piperazinedione ring system (Figure 1). The six-membered ring in **3** is noticeably flatter than that determined for either **1**[6] or the corresponding 3′-*O*-ethyl carbamate derivative **4**[7] (i.e., the sum of endocyclic torsion angle moduli for the six-membered ring in **4** is 150.3°, while it is 63.4° in **3**). This perturbation is attributed to the expanded ring system present in **3**. The X-ray structure for **3** also reveals that the relative configuration at C(6) in this adduct is the same as in **1** and

(1) (a) Reynolds, E. F. *Martindale, The Extra Pharmacopoeia*, 29th ed.; The Pharmaceutical Press: London, 1989; p 138. (b) DuPont, H. L.; Ericsson, C. D.; Reves, R. R.; Galindo, E. *Rev. Infect. Dis.* **1986**, *8* (Suppl 2), S 217. (c) DuPont, H. L.; Ericsson, C. D.; Johnson, P. C.; Cabada, F. J. *Ibid.* **1986**, *8*, (Suppl. 2), S 167.

(2) Maag, H.; Blount, J. F.; Coffen, D. L.; Steppe, T. V.; Wong, F. *J. Am. Chem. Soc.* **1978**, *100*, 6786.

(3) (a) Abuzar, S.; Kohn, H. *J. Am. Chem. Soc.* **1988**, *110*, 4089. (b) Abuzar, S.; Kohn, H. *Ibid.* **1989**, *111*, 4895. (c) Abuzar, S.; Kohn, H. *J. Org. Chem.* **1989**, *54*, 4000. (d) Abuzar, S.; Kohn, H. *J. Am. Chem. Soc.* **1990**, *112*, 3114.

(4) Wacker, O.; Kump, W.; Muller, B. W. *Tetrahedron Lett.* **1983**, *24*, 5607.

(5) Muller, B. W.; Zak, O.; Kump, W.; Tosch, W.; Wacker, O. *J. Antibiot.* **1979**, *32*, 689.

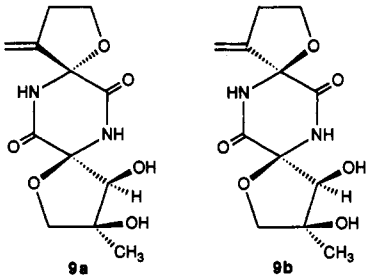
(6) Tokuma, Y.; Koda, S.; Miyoshi, T.; Morimoto, Y. *Bull. Chem. Soc. Jpn.* **1974**, *47*, 18.

(7) Kohn, H.; Abuzar, S.; Korp, J. D.; Zektzer, A. S.; Martin, G. E. *J. Heterocycl. Chem.* **1988**, *25*, 1511.

0022-3263/91/1956-5462$02.50/0 

4, while the C(1) configuration in 3 is inverted from that determined for bicyclomycin and the 3′-*O*-ethyl carbamate derivative 4.[8]

Several pathways for the conversion of 2 to 3 can be envisioned (Scheme I). These processes are distinguished by the mechanism of the ether bond formation step at C(3) and C(3′) in 2. In two of the pathways outlined (i.e., 2 → 5 → 6 → 3, 2 → 5 → 8 → 3) cleavage of the C(1)–O(2) bond to give iminium 5 precedes ether bond formation. This process is reminiscent of the mechanism[9] proposed for the acid-catalyzed dehydrative rearrangement of bicyclomycin (0.1 N $HClO_4$, 100 °C, 15 min) to give the bis-spiro adducts 9a and 9b.[2]




9a 9b

Alternatively, 3 may have been generated by the direct displacement of the C(3′)-*O*-methanesulfonate group by the O(2) ring oxygen atom[10] to give 7, followed by cleavage of the C(1)–O(2) bond and attack by $H_2O$. In agreement with all these pathways, dissolution of 2 in MeOH led to the production of the corresponding C(1)-methyl ether 10.[11] Attempts to provide evidence for the intermediacy of 5 in the reaction process by detecting (NMR spectroscopy), trapping (i.e., addition of $NaN_3$), or reducing (i.e., $NaBH_3CN$) the corresponding putative iminium ion 11 from 1 in acidic aqueous or methanolic solutions were unsuccessful. Finally, in several of the routes depicted in Scheme I formation of 3 is envisioned to proceed through the ring iminium intermediate 8. Support for the feasibility of generating this species was gained by the conversion of 3 to 10 in MeOH containing 1 equiv of $MeSO_3H$ and the corresponding production of 3 from 10 in aqueous $MeSO_3H$.

The reactivity of 3 versus 1[12] with thiols was examined. Previously, we reported that bicyclomycin reacted with sulfur nucleophiles in THF–$H_2O$ (3:1) mixtures to give a variety of rearranged, ring-closed, and ring-opened compounds in which the *exo*-methylene group in 1 was modified.[3a,c,d,13] The precise product was dependent upon the "pH" of the medium. Moreover, analysis of the corresponding reaction profiles for bicyclomycin derivatives in which the C(1)-triol moiety was partially altered prompted us to suggest that select hydrogen bonding interactions between the triol group and the 2,5-piperazinedione ring may have facilitated the bicyclomycin activation and binding processes.[3d,14] The X-ray crystallographic data for 3 indicates that these interactions are not possible in the expanded ring system 3. Treatment of 3 with EtSH (16 equiv) in THF–$H_2O$ (3:1) mixtures maintained between "pH" 6.8 and 12.5 (24 h) led to the recovery of starting material in each case.[15] These results are consistent with the hypothesis that the C(1)-triol moiety plays an important role in bicyclomycin-modification processes.[16]

## Experimental Section

**General Procedures.** Melting points are uncorrected. $^1H$ and $^{13}C$ NMR spectra were obtained at 300 and 75 MHz, respectively. pH measurements of aqueous and aqueous organic solutions were determined on a Radiometer pHM26 meter using a Radiometer G202 glass electrode.

The reactants were of the best commercial grade available and were used without further purification unless noted. THF was distilled from $Na^0$ and benzophenone prior to use. Silica gel (Merck, grade 60, 230–400 mesh, 60 Å) for flash chromatography was purchased from Aldrich Chemical Co. TLC and preparative TLC were run on silica gel GHLF microscope slides (2.5 × 10 cm; Analtech No. 21521). Visualization was performed either by charring with an ethanolic phosphomolybdic acid solution or a UV lamp.

**Bicyclomycin 3′-*O*-Methanesulfonate (2).** The title compound was prepared according to the procedure reported by Muller and co-workers[5] with slight modification. A solution of bicyclomycin (150 mg, 0.50 mmol) in anhydrous pyridine (2.0 mL) was stirred and cooled at −10 °C as $CH_3SO_2Cl$ (148 mg, 1.30 mmol) was added. The temperature was maintained at 0 °C (2 h). The reaction mixture was filtered, and the solvent was removed in vacuo. The residue was taken up in MeOH and subjected to flash chromatography on $SiO_2$ eluting with MeOH–$CHCl_3$ (1:9). A pale yellow solid was obtained after drying overnight under vacuum: yield 117 mg (61%); $R_f$ 0.55 (1:4 MeOH–$CHCl_3$); mp 138–142 °C dec (lit.[5] mp 151–153 °C); $^1H$ NMR ($CD_3OD$) δ 1.40 (s, 3 H, C(2′)$CH_3$), 2.58–2.68 (m, 2 H, C(4)$H_2$), 3.08 (s, 3 H, $SO_2CH_3$), 3.80–3.90 (m, 2 H, C(3)$H_2$), 4.08 (s, 1 H, C(1′)H), 4.25 (d, 1 H, C(3′)*H*H′, $J$ = 9.9 Hz), 4.32 (d, 1 H, C(3′) H*H*′, $J$ = 9.9 Hz), 5.13 (s, 1 H, C(5a)*H*H′), 5.56 (s, 1 H, C(5a)H*H*′); $^{13}C$ NMR ($CD_3OD$) δ 23.67 (C(2′)$CH_3$), 36.66 (C(4)), 37.30 ($SO_2CH_3$), 65.73 (C(3)), 71.41 (C(1′)), 75.74 (C(3′)), 76.93 (C(2′)), 82.96 (C(6)), 89.71 (C(1)), 116.96 (C(5)), 149.51 (C(5a)), 168.35 (C(7) or C(9)), 172.48 (C(9) or C(7)); the $^{13}C$ NMR assignments were confirmed by the APT and the heteronuclear correlation experiments.

**(1*R*,2*S*,3*S*,9*R*)-1,2,3,9-Tetrahydroxy-3-methyl-8-methylene-5-oxa-10,12-diazabicyclo[7.2.2]tridecane-11,13-dione (3).**[18] A solution of 2 (100 mg, 0.26 mmol) in $H_2O$ (1.0 mL) was stirred at rt (24 h) as the pH decreased from 6.5 to 2.0. TLC analysis (1:4 MeOH–$CHCl_3$) prior to workup indicated the presence of one major product and a small amount of 1. The solution was neutralized with dilute aqueous NaOH and concentrated in vacuo. The residue was taken up in MeOH and purified by preparative TLC using MeOH–$CHCl_3$ (1:4) as the eluant to give 3: yield 31.2 mg (40%); $R_f$ 0.40 (1:4 MeOH–$CHCl_3$); mp 190–194 °C dec; $[\alpha]^{25}_D$ = +33.3 ($c$ = 0.5, MeOH); IR (KBr) 1670 (br) $cm^{-1}$; $^1H$ NMR (DMSO-$d_6$) δ 1.05 (s, 3 H, C(2′)$CH_3$), 2.37–2.41 (m, 2 H, C(4)$H_2$), 3.03 (d, 1 H, C(3′)*H*H′, $J$ = 9.0 Hz), 3.13 (d, 1 H, C(3′)H*H*′, $J$ = 9.0 Hz), 3.19–3.30 (m, 2 H, C(3)$H_2$), 3.76 (d, 1 H, C(1′)H, $J$ = 6.0 Hz), 3.94 (s, 1 H), 4.98 (s, 1 H, C(5a)*H*H′), 5.02 (d, 1 H, C(1′)OH, $J$ = 6.0 Hz), 5.41 (s, 1 H, C(5a)H*H*′), 5.97 (s, 1 H), 6.22 (s, 1 H), 7.50 (s, 1 H), 8.44 (s, 1 H); absorptions at δ 3.94, 5.02, 5.97, 6.22, 7.50, and 8.44 were shown

(8) There is an extensive hydrogen bonding system in the crystal lattice for 3 involving one $H_2O$ molecule of solvation per molecule of 3. This $H_2O$ is very tightly bound, since it takes several days to evacuate at rt after the sample is removed from the mother liquor.

(9) Kohn, H.; Abuzar, S. *J. Org. Chem.* **1989**, *53*, 2769.

(10) For examples of related neighboring group participation transformations, see: Allred, E. L.; Winstein, S. *J. Am. Chem. Soc.* **1967**, *89*, 3991, 3998, 4008, 4012 and references cited therein.

(11) The observed spectral properties do not rule out the isomeric C(6)-methyl ether.

(12) Someya, A.; Iseki, M.; Tanaka, N. *J. Antibiot.* **1979**, *32*, 402.

(13) Kohn, H.; Abuzar, S. *J. Am. Chem. Soc.* **1988**, *110*, 3661.

(14) For a related discussion concerning the minimum structural requirements needed for the NaSMe modification of 1 under basic conditions, see: (a) Williams, R. M.; Tomizawa, K.; Armstrong, R. W.; Dung, J.-S. *J. Am. Chem. Soc.* **1985**, *107*, 6419. (b) Williams, R. M.; Tomizawa, K.; Armstrong, R. W.; Dung, J.-S. *Ibid.* **1987**, *109*, 4028.

(15) Treatment of an aqueous solution of 3 with NaSMe (1 equiv) at pH 12.5 (rt, 5 days) led to the production of two adducts (TLC analysis) that decomposed upon attempted isolation.

(16) Studies on the reactivity of bicyclomycin model compounds in which the terminal double bond was not incorporated within a bicyclic ring network demonstrated that modification of the double bond proceeded rapidly at these "pH" values.[17]

(17) Kohn, H.; Oh, Y. S. Unpublished results.

(18) Compound names were generated (Dr. P. M. Giles, Chemical Abstracts Nomenclature Service, Columbus, OH) according to IUPAC guidelines. The numbering system employed by us, however, conforms to the conventional numbering system used for bicyclomycin.

to be $D_2O$ exchangeable, and the $^1H$ NMR assignments were confirmed using the COSY experiment; $^{13}C$ NMR (DMSO-$d_6$) $\delta$ 25.05 (C(2')$CH_3$), 34.29 (C(4)), 66.97 (C(3)), 71.25 (C(3')), 73.42 (C(2')), 76.42 (C(1')), 80.57 (C(6) or C(1)), 80.91 (C(1) or C(6)), 114.38 (C(5a)), 145.03 (C(5)), 165.63 (C(7) or C(9)), 165.83 (C(9) or C(7)); the $^{13}C$ NMR assignments were confirmed using the APT experiment; MS (+FAB) 303 $[M + 1]^+$; $M_r$ (+FAB) 303.119 22 $[M + 1]^+$ (calcd for $C_{12}H_{18}N_2O_7$ 303.119 27).

**(1*R*,2*S*,3*S*,9*R*)-2,3,9-Trihydroxy-1-methoxy-3-methyl-8-methylene-5-oxa-10,12-diazabicyclo[7.2.2]tridecane-11,13-dione (10).**[18] A solution of **2** (25 mg, 0.07 mmol) in MeOH (1.0 mL) was stirred at rt (48 h). The solvent was removed in vacuo and the residue was taken up in a minimum amount of MeOH. Preparative TLC (1:3 MeOH–$CH_2Cl_2$) afforded compound **10** as a colorless solid: yield 8.1 mg (36%); mp 215–218 °C dec; $R_f$ 0.65 (1:3 MeOH–$CH_2Cl_2$); IR (KBr) 1675 (br) $cm^{-1}$; $^1H$ NMR (DMSO-$d_6$) $\delta$ 1.05 (s, 3 H, C(2')$CH_3$), 2.38–2.45 (m, 2 H, C(4)$H_2$), 2.99 (d, 1 H, C(3')*H*H', $J$ = 9.0 Hz), 3.17 (d, 1 H, C(3')H*H'*, $J$ = 9.0 Hz), 3.22 (s, 3 H, $OCH_3$), 3.30–3.50 (m, 2 H, C(3)$H_2$), 3.77 (s, 1 H, C(1')H), 5.06 (s, 1 H, C(5a)*H*H'), 5.42 (s, 1 H, C(5a)H*H'*), 7.39 (s, 1 H), 8.76 (s, 1 H); the remaining exchangeable protons were not detected; $^{13}C$ NMR (DMSO-$d_6$) $\delta$ 25.07 (C(2')$CH_3$), 34.26 (C(4)), 49.64 ($OCH_3$), 66.86 (C(3)), 70.81 (C(3')), 72.62 (C(2')), 76.51 (C(1')), 80.70 (C(6)), 85.48 (C(1)), 115.11 (C(5a)), 145.81 (C(5)), 163.19 (C(7) or C(9)), 166.53 (C(9) or C(7)); the $^{13}C$ NMR assignments were confirmed using the APT experiment; MS (-FAB) 315 $[M - H]^-$.

**Hydrolysis of 10.** $CH_3SO_3H$ (0.2 $\mu$L, 3 $\mu$mol) was added to an aqueous solution (0.4 mL) of **10** (1 mg, 3 $\mu$mol) and stirred at rt (6 h). The solution (pH ~2) was neutralized with dilute aqueous KOH and the solvent removed in vacuo. TLC analysis of the reaction prior to workup showed only the presence of **3**. The residue was triturated with MeOH and filtered and the solvent removed: yield 0.8 mg (84%); $R_f$ 0.40 (1:4 MeOH–$CHCl_3$); $^1H$ NMR (DMSO-$d_6$) $\delta$ 1.05 (s, 3 H, C(2')$CH_3$), 2.38–2.43 (m, 2 H, C(4)$H_2$), 3.02 (d, 1 H, C(3')*H*H', $J$ = 9.1 Hz), 3.10 (d, 1 H, C(3')H*H'*, $J$ = 9.1 Hz), 3.20–3.30 (m, 2 H, C(3)$H_2$), 3.80 (s, 1 H, C(1')H), 4.99 (s, 1 H, C(5a)*H*H'), 5.40 (s, 1 H, C(5a)H*H'*), 7.50 (s, 1 H), 8.40 (s, 1 H); the remaining exchangeable protons were not detected.

**Methanolysis of 3.** $CH_3SO_3H$ (1 $\mu$L, 15 $\mu$mol) was added to a MeOH solution (1 mL) of **3** (5 mg, 17 $\mu$mol) and stirred at rt (45 min). TLC analysis of the reaction prior to workup showed the presence of **10** and two additional, unidentified minor compounds. The solvent was removed in vacuo, and the residue was immediately subjected to preparative TLC (1:4 MeOH–$CHCl_3$): yield 1.8 mg (33%); $R_f$ 0.65 (1:3 MeOH–$CH_2Cl_2$); $^1H$ NMR (DMSO-$d_6$) $\delta$ 1.05 (s, 3 H, C(2')$CH_3$), 2.37–2.46 (m, 2 H, C(4)$H_2$), 2.95 (d, 1 H, C(3')*H*H', $J$ = 9.0 Hz), 3.14 (d, 1 H, C(3')H*H'*, $J$ = 9.0 Hz), 3.21 (s, 3 H, $OCH_3$), 3.30–3.50 (m, 2 H, C(3)$H_2$), 3.78 (s, 1 H, C(1')H), 5.04 (s, 1 H, C(5a)*H*H'), 5.43 (s, 1 H, C(5a)H*H'*), 7.32 (s, 1 H), 8.65 (s, 1 H); the remaining exchangeable protons were not detected; $^{13}C$ NMR (DMSO-$d_6$) $\delta$ 25.02 (C(2')$CH_3$), 34.21 (C(4)), 49.58 ($OCH_3$), 66.83 (C(3)), 70.78 (C(3')), 72.57 (C(2')), 76.49 (C(1')), 80.68 (C(6)), 85.46 (C(1)), 115.06 (C(5a)), 145.79 (C(5)), 163.12 (C(7) or C(9)), 166.47 (C(9) or C(7)).

**Reaction of Compound 3 with Ethanethiol.** A solution of **3** (3.0 mg, 0.01 mmol) and EtSH (12 $\mu$L, 0.16 mmol) in a THF–$H_2O$ (3:1; 0.3 mL, "pH" 6.8) mixture was degassed with Ar (3 min) and then capped. After the "pH" of the solution was maintained (24 h) at 6.8, then at 10.2 (24 h), and finally at 12.5 (24 h), no reaction was observed (TLC analysis).

**Acknowledgment.** We thank the National Institutes of Health (Grant No. GM37934) and the Robert A. Welch Foundation (Grant No. E-607) for their support of this research. Special thanks are given to Dr. James D. Korp (University of Houston) for determining the X-ray structure of **3** and Dr. Simon Gaskell and Ralph Orkiszewski (Baylor College of Medicine) for obtaining the mass spectral results. We also express our appreciation to Dr. K. Inokuchi and the Fujisawa Pharmaceutical Co., Ltd., Japan, for providing us with a gift of bicyclomycin.

**Registry No.** **1**, 38129-37-2; **2**, 71993-96-9; **3**, 134757-71-4; **3**·$H_2O$, 134875-89-1; **10**, 134757-72-5.

**Supplementary Material Available:** Tables 1–6 giving a complete listing of data collection and processing parameters, atomic coordinates and equivalent isotropic displacement parameters, bond lengths, bond angles, hydrogen-bonding parameters (7 pages). Ordering information is given on any current masthead page.

## Use of Tetrabutylammonium Fluoride as a Facile Deprotecting Reagent for 4-Nitrobenzyl, 2,2,2-Trichloroethyl, and Phenacyl Esters of Amino Acids

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*Roger Adams Laboratory, University of Illinois, Urbana, Illinois 61801*

*Received February 8, 1991*

A 4-nitrobenzyl (Nbn) ester has better stability than a Bn ester against the acidic conditions used for removal of amino acid and peptide protecting groups and has been recommended for the protection of Glu and Asp side chains in solid-phase peptide synthesis.[1] Several methods to cleave the Nbn ester, such as $Na_2S$,[2] zinc,[3] or $Na_2S_2O_4$[4] reduction, have been reported besides catalytic hydrogenolysis and Birch reduction.

It is sometimes difficult to remove the yellow byproducts resulting from polymerization of the aromatic amine generated by reductive cleavages. Alkaline hydrolysis avoids this problem but lacks selectivity relative to other esters, except *t*-Bu esters, and is apt to cause racemization. In the course of our study on a total synthesis of nodularin[5] and microcystins,[6] we have found that $Bu_4NF$ selectively cleaves Nbn esters of amino acids and is a useful reagent for this transformation.

$Bu_4NF$ has been widely used for deprotecting silyl ethers and esters since it was introduced for this purpose.[7] This reagent is also used in peptide syntheses as a reagent for the removal of protecting groups labile to hard bases, such as Tmse,[8] Teoc,[9] Fmoc,[10-12] and Ppt[12,13] groups and as a

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(2) (a) Lammert, S. R.; Ellis, A. I.; Chauvette, R. R.; Kukolja, S. *J. Org. Chem.* **1978**, *43*, 1243–1244. (b) Huber, D.; Andermann, G.; Leclerc, G. *Tetrahedron Lett.* **1988**, *29*, 635–638.

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