the solid residue, dissolved in MeOH, was filtered and dried in vacuo, followed by HPLC separation (Altex columns with MeOH/H_2O (9:1) as mobile phase), to yield 1.5 mg of **2b** and 32 mg of starting compound **1b**. The high-resolution mass and ^1H NMR spectra of **2b** were identical in all respects with those of natural **2b**.

3β,11-Dihydroxy-9,11-secogorgost-5-en-9-one (1a):[4] absorption spectrum ϵ_{285} 51; CD $(\theta)_{220}$ −3350, $(\theta)_{295}$ −4800.

Isomerization of 3β,11-Dihydroxy-9,11-secogorgost-5-en-9-one (1a) to 8α-H Isomer 2a. A 50-mg sample of **1a** was treated in the same way as described above for **1b**. The final HPlC separation yielded 2 mg of **2a** (HPLC rrt 0.14 with cholesterol = 1) and 35 mg of **1a**. Absorption spectrum of **2a**: ϵ_{285} 147; CD $(\theta)_{300}$ 32 500.

Acetylation of 1b and 3b to 3β,11-Diacetoxy-24-methylene-9,11-secocholest-5-en-9-one (4b). Both **1b** and **3b** were acetylated under standard conditions (Ac_2O/py, room temperature, 2 h) to yield the same diacetate **4b**, which was purified by HPLC on Altex columns with MeOH/H_2O (95:5) as mobile phase (rrt 0.3 with cholesterol = 1): low-resolution mass spectrum, m/z (relative intensity) 454 (M^+ − HOAc, 0.5), 394 (M^+ − 2HOAc, 0.5), 359 (0.5), 232 (3), 161 (10), 120 (100); absorption spectrum ϵ_{285} 56; CD $(\theta)_{225}$ −7000, $(\theta)_{290}$ −12 000.

Acknowledgment. This work was made possible by grants from the National Institutes of Health (Nos. GM-06840 and GM-28352). The use of the 360-MHz ^1H NMR spectrometer in the Stanford Magnetic Resonance Laboratory was supported by NSF Grant No. GP-23633 and NIH Grant No. RR-00711. We thank Annemarie Wegmann and Karen Hall for mass spectral measurements and Ruth Records for running the CD spectra. Thanks are due to Prof. A. J. Weinheimer (University of Houston) for copies of spectral data of **1a**. C.B. thanks the Italian CNR for a fellowship.

Registry No. **1b**, 81419-47-8; **1c**, 85700-72-7; **1d**, 85650-23-3; **2a**, 34290-98-7; **2b**, 85700-73-8; **3b**, 85650-24-4; **3c**, 85650-25-5; **4b**, 85650-26-6.

Direct Preparation of Bromoacetaldehyde

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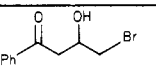
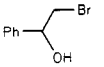
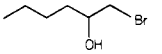
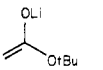
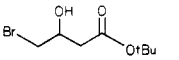
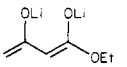
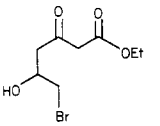
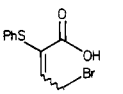
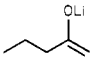
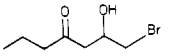
Received October 15, 1982

Halo aldehydes or their equivalents have been widely employed in heterocyclic synthesis. Such aldehydes are useful for ring-forming reactions in that they represent units with two adjacent electrophilic sites. However, the simplest representatives, bromo- or chloroacetaldehyde, have been little used because the anhydrous aldehyde is difficult to prepare. House and co-workers prepared chloroacetaldehyde by hydrolysis of the chloro acetal, trimerization, and thermal cracking of the trimer.[1] In this paper we report a preparation of bromoacetaldehyde by an ozonolysis reaction. Except for an isolated example,[2] the reaction of bromo- or chloroacetaldehyde with enolate anions has not previously been studied. We report herein the reaction of bromoacetaldehyde with various carbanions.

While Roberts[3] has observed that the ozonolysis of several allylic derivatives is complicated by undesirable side reactions, he found that allylic bromides and chlorides could be ozonized without any side reactions. We therefore examined the ozonolysis of 1,4-dichloro-2-butene and 1,4-dibromo-2-butene. In practice the cleavage of the latter compound in methylene chloride at −78 °C followed by the slow addition of triphenylphosphine afforded the highest yield. After distillation, 1 M solutions of bromoacetaldehyde in hexane can be stored for weeks without noticeable decomposition.

Table I. Reaction of Anions with Bromoacetaldehyde

anion	% yield	product
	100	
PhLi	100	
n-BuLi	60	
	82	
	85	
		
	60	

The aldehyde solution in hexane reacts with a variety of anions generated under anhydrous conditions. The results are depicted in Table I. It is interesting to note that the reaction of bromoacetaldehyde with the dianion of ethyl acetoacetate does not produce any cyclopentanone-containing products. The intramolecular alkylation of the β-keto ester anion would be a 5-endo trig-type process and should be disfavored according to Baldwin's rules.[4]

Experimental Section

Bromoacetaldehyde. A solution of 40 mmol of 1,4-dibromo-*trans*-2-butene in 60–70 mL of dry CH_2Cl_2 (over sieves or distilled from P_2O_5) was cooled to −78 °C and treated with ozone until a blue color persisted (~30 min). A nitrogen stream was passed through the solution until the blue color disappeared, giving a colorless solution. After a dried magnetic stirring bar was added to the flask, 40 mmol of triphenylphosphine was added portionwise over 1 h while the temperature was kept at −78 °C. After the addition of triphenylphosphine the solution was slowly warmed to 0 °C. An aliquot of slightly yellow solution was checked by NMR ($CDCl_3$ solvent) for the absence of ozonide. If the ozonide was still present (m, δ 3.5–4.0) stirring was continued at 0 °C until the reaction was complete. Methylene chloride was distilled at 0–5 °C (90-100 mmHg). The residue was then distilled at 1 mmHg into a receiving flask at −78 °C. As the residue became viscous, it was heated with an oil bath at ~50 °C. Distillation yielded 11.26 g (56%) of bromoacetaldehyde and methylene chloride (1:1.5). This mixture was used in the reactions described in the text. **Caution**: the aldehyde is a lachrymator, NMR ($CDCl_3$) δ 3.88 (d, J = 2.5 Hz, 2 H), 5.32 (s, CH_2Cl_2), 9.55 (t, J = 2.5 Hz, 1 H); IR (film) 1728 cm^{-1}.

General Procedure for the Reaction of Bromoacetaldehyde with Anions. To a solution of the anion at −78 °C

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prepared by the published method[5] was added an equimolar solution of bromoacetaldehyde (1 M in hexane or THF). The reaction mixture was stirred at −78 °C for 15 min. Acetic acid was added. The solution was diluted with water and extracted twice with ether. The combined organic layers were dried over sodium sulfate, filtered, and concentrated in vacuo. The reaction products were generally very clean, requiring only rapid filtration through a small amount of silica gel for purification.

4-Bromo-3-hydroxy-1-phenylbutan-1-one: IR (film) 3080, 2970, 1690, 1300, 840, 750, 685 cm^{-1}; NMR ($CDCl_3$) δ 0.10 (s, 9 H), 3.15 (d, 2 H), 3.37 (d, 2 H), 3.42 (p, 1 H), 7.35 (m, 3 H), 7.83 (m, 2 H).

(2-Bromo-1-hydroxyethyl)benzene: IR (film) 3400, 1063, 755, 700 cm^{-1}; NMR ($CDCl_3$) δ 3.5 (dd, J = 6, 7 Hz, 2 H), 4.07 (br s, 1 H), 4.77 (dd, J = 2.5, 2.5 Hz, 1 H), 7.25 (s, 5 H); high-resolution mass spectrum, C_8H_9BrO requires m/e 199.983 68, found m/e 199.98 37.

1-Bromo-2-hexanol: IR (film) 3500, 2960, 2930, 2870, 1030 cm^{-1}; NMR ($CDCl_3$) δ 0.90 (br t, 3 H), 1.43 (m, 6 H), 2.39 (br s, 1 H), 3.49 (d, 2 H), 3.63 (m, 1 H); high-resolution mass spectrum, $C_8H_{18}BrSiO$ (trimethylsilyl ether derivative − CH_3) requires m/e 237.031 03, found m/e 237.031 34.

***tert*-Butyl 4-Bromo-3-hydroxybutyrate**: IR (film) 3380, 2900, 1730 cm^{-1}; NMR ($CDCl_3$) δ 1.47 (s, 9 H), 2.53 (dd, J = 0.0, 0.5 Hz, 2 H), 3.48 (d, 2 H), 4.16 (br p, 1 H); high-resolution mass spectrm, $C_7H_{12}BrO_3$ (P − CH_3) requires m/e 222.997 48, found m/e 222.996 97.

Ethyl 6-Bromo-5-hydroxy-3-oxohexanoate: IR (film) 3460, 2980, 1735, 1715 cm^{-1}; NMR ($CDCl_3$) δ 1.26 (t, 3 H), 2.80 (d, 2 H), 3.40 (d, 2 H), 3.47 (s, 2 H), 4.13 (q superimposed on m, 4 H); high-resolution mass spectrum, $C_8H_{11}BrO_3$ (P − H_2O) requires m/e 234.989 15, found m/e 234.989 50.

1-Bromo-2-hydroxy-4-heptanone: IR (film) 3430, 2980, 1715 cm^{-1}; NMR ($CDCl_3$) δ 0.92 (br t, 3 H), 1.52 (m, 2 H), 2.48 (m, 4 H), 3.43 (dd, J = 5.5 Hz, 2 H), 4.0 (br m, 1 H); high-resolution mass spectrum, $C_4H_6BrO_2$ (P − 43) requires m/e 164.955 11, found m/e 164.954 67.

Acknowledgment. We thank the National Institutes of Health for partial support of this work.

Registry No. Bromoacetaldehyde, 17157-48-1; 1,4-dibromo-*trans*-2-butene, 821-06-7; 4-bromo-3-hydroxy-1-phenylbutan-1-one, 85565-73-7; (2-bromo-1-hydroxyethyl)benzene, 2425-28-7; 1-bromo-2-hexanol, 26818-04-2; *tert*-butyl 4-bromo-3-hydroxybutyrate, 85565-74-8; ethyl 6-bromo-5-hydroxy-3-oxahexanoate, 85565-75-9; 1-bromo-2-hydroxy-4-heptanone, 85565-76-0; $PhCOCH_2^-Li^+$, 55905-98-1; PhLi, 591-51-5; BuLi, 109-72-8; t-$BuOCOCH_2^-Li^+$, 53503-61-0; $EtOCOCH^-COCH_2^-2Li^+$, 83925-49-9; $CH_3(CH_2)_2COCH_2^-Li^+$, 85565-72-6.

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Instability of Anhydrous Tetra-*n*-alkylammonium Fluorides

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Received September 2, 1982

Quaternary ammonium fluoride salts are gaining increasing importance in chemistry as organic-soluble sources of fluoride ion.[1] Of these, tetra-*n*-butylammonium fluoride (TBAF)[2] has found widespread use as a reagent to promote various silylation/desilylation reactions, often under aprotic or anhydrous conditions.[3-12] TBAF is an extremely hygroscopic material. It has been prepared by fluoride exchange with tetra-*n*-butylammonium bromide[13] or, more commonly, by neutralization of aqueous tetra-*n*-butylammonium hydroxide with aqueous hydrogen fluoride followed by removal of water under vacuum.[3-7,14,15] It is also available commercially as the trihydrate.[16]

Because many of the literature uses of TBAF have reportedly been preceded by attempts to dry it under vacuum for extended periods at temperatures above ambient,[4,5,11,14,15] we report our observations concerning the stability of TBAF.

Results and Discussion

Our interest in studying the species formed from the interaction of various silicon compounds with fluoride ion in dichloromethane solution led us to attempt a preparation of anhydrous tetra-*n*-butylammonium fluoride. In accord with the method used by earlier workers, a sample of the trihydrate[16] was heated in a drying pistol with P_2O_5 at 77 °C (2 torr) for 15 h. Upon being cooled to 0 °C, the glassy liquid product formed white crystals which melted at 30–32 °C. Unfortunately, when this material was dissolved in dichloromethane, it did not display the reactivity toward our silicon compounds which we had expected from a source of "naked" fluoride ion.

Examination of the crystalline material in CD_2Cl_2 solution by ^1H, ^{13}C, and ^{19}F NMR spectroscopy established that this product was entirely tetra-*n*-butylammonium *bifluoride* instead of the expected anhydrous TBAF.[17-20]

In additional experiments with TBAF trihydrate at 77 °C (2 torr) we noted not only mass loss as a function of time but also changes in physical appearance as well. For example, when placed at 77 °C, the crystalline trihydrate immediately melted to a colorless liquid from which bubbles evolved. After 15 min, the liquid abruptly turned cloudy. It has lost 17.2% of its mass at this time. Examination of the sample at this stage by ^{19}F NMR spectroscopy showed it to contain both F^- and FHF^-. Continued heating of the sample caused the cloudy melt to form a yellow liquid with steady evolution of bubbles. After 3 h

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