Synthesis and desulfurization–decarboxylation of cyclic thionocarbonates of glycerol 1-ethers

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SUMMARY A method is described for the synthesis of cyclic thionocarbonates of 1-*O*-alkyl glycerols in quantitative yield. These derivatives of glycerol ethers can be quantitated by UV absorbance, analyzed by gas–liquid chromatography, or quantitatively converted to allyl alkyl ethers for gas-chromatographic analysis.

SUPPLEMENTARY KEY WORDS UV absorbance · gas–liquid · thin-layer · chromatography · mass spectroscopy · allyl alkyl ethers · cyclic carbonate

The synthesis of allyl alkyl ethers from *O*-alkyl glycerol dimesylates using the analogous procedure for the preparation of allyl esters (1) was recently described (2). The allyl alkyl ethers were stable, nonpolar derivatives which were readily separated and purified by preparative GLC. We report here the synthesis of thionocarbonates of alkyl glycerols in quantitative yield and an alternative synthesis of allyl alkyl ethers from these derivatives (Fig. 1). Cyclic thionocarbonate derivatives of 1(3)-alkyl glycerols have several useful properties. As shown in this paper, they may be quantitated by their UV absorbance and analyzed by GLC.

Materials. Batyl alcohol, chimyl alcohol, and selachyl alcohol were kindly supplied by Dr. W. Chalmers (Western Chemical Industries, Ltd., Vancouver, Canada). Trimethyl phosphite, commercial imidazole, dichloromethane (Spectrograde) and thiophosgene were purchased from Matheson, Coleman and Bell, Cincinnati, Ohio. *N*,*N*′-Carbonyldiimidazole was purchased from Aldrich Chemical Co., Milwaukee, Wis. Linde molecular sieves (13X and 3A) were purchased from Union Carbide Co., Cleveland, Ohio.

Imidazole was decolorized with activated charcoal (Darco), recrystallized in benzene, and dried under vacuum at 35°C (mp 90°C). Benzene was slurried with 13X molecular sieve (200 g/liter). After 48 hr, benzene was decanted, refluxed with calcium hydride (100 g/liter), and distilled at 80°C. Trimethyl phosphite was slurried with 3A molecular sieve (200 g/liter). After 48 hr, trimethyl phosphite was decanted and distilled at 108–109°C.

Thiocarbonyldiimidazole. Thiocarbonyldiimidazole was prepared from imidazole and thiophosgene by the method of Horton and Turner (3).

Cyclic Thionocarbonates. In a modification of the Staab and Walther synthesis (4), about 500 mg of *O*-alkyl glycerol dissolved in 250 ml of anhydrous benzene and 10–15 mg of sodium dissolved in 5 ml of absolute methanol were refluxed under nitrogen. 500 mg of thiocarbonyldiimidazole was dissolved in 60 ml of benzene and added dropwise through a pressure-equilibrated dropping funnel over a period of 1 hr to the solution under reflux. We added sufficient additional thiocarbonyldiimidazole to maintain the yellow color of the solution throughout a 6 hr reflux period. The product was concentrated, dissolved in 150 ml of ether, transferred to a separatory funnel, and washed twice with 200 ml of water. The ether phase was then filtered through anhydrous sodium sulfate and concentrated. Thin-layer chromatography (TLC) on a Silica Gel H plate developed with hexane–ether–ethanol 50:50:3 (v/v) showed a cyclic thionocarbonate (R_f 0.40) and no unreacted *O*-alkyl glycerol (R_f 0.22). An unidentified spot (R_f 0.16) appeared with iodine vapor but the spot disappeared on charring with H_2SO_4. This spot was also found on TLC when a reagent blank was refluxed for 6 hr.

The thionocarbonate was eluted from a 20 g Unisil column with 150 ml of hexane–ether 85:15 and showed only one spot on TLC. 500 mg of batyl alcohol yielded 544 mg of purified thionocarbonate (97.5% yield). When sodium methoxide was omitted from the reaction mixture, the crude product contained an unidentified component with an R_f value on TLC between that of alkyl

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Abbreviations: GLC, gas–liquid chromatography; TLC, thin-layer chromatography.

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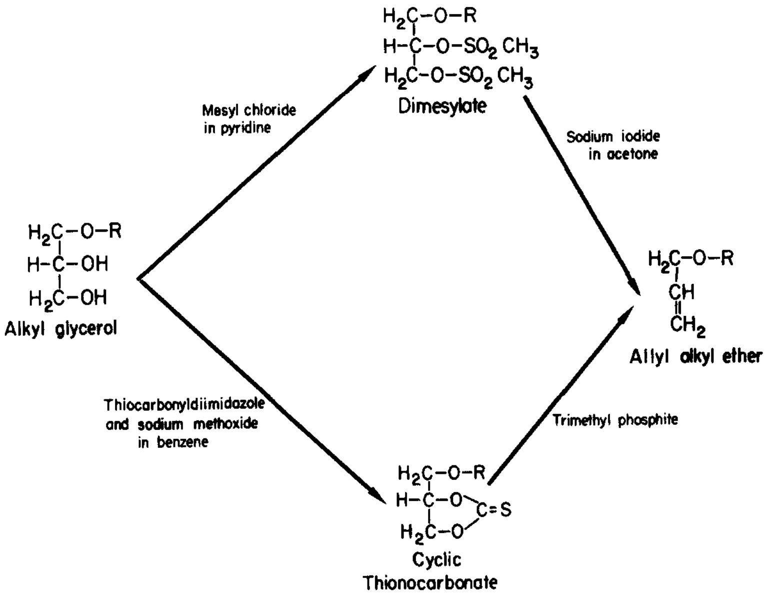

FIG. 1. Synthesis of allyl alkyl ethers from alkyl glycerols.

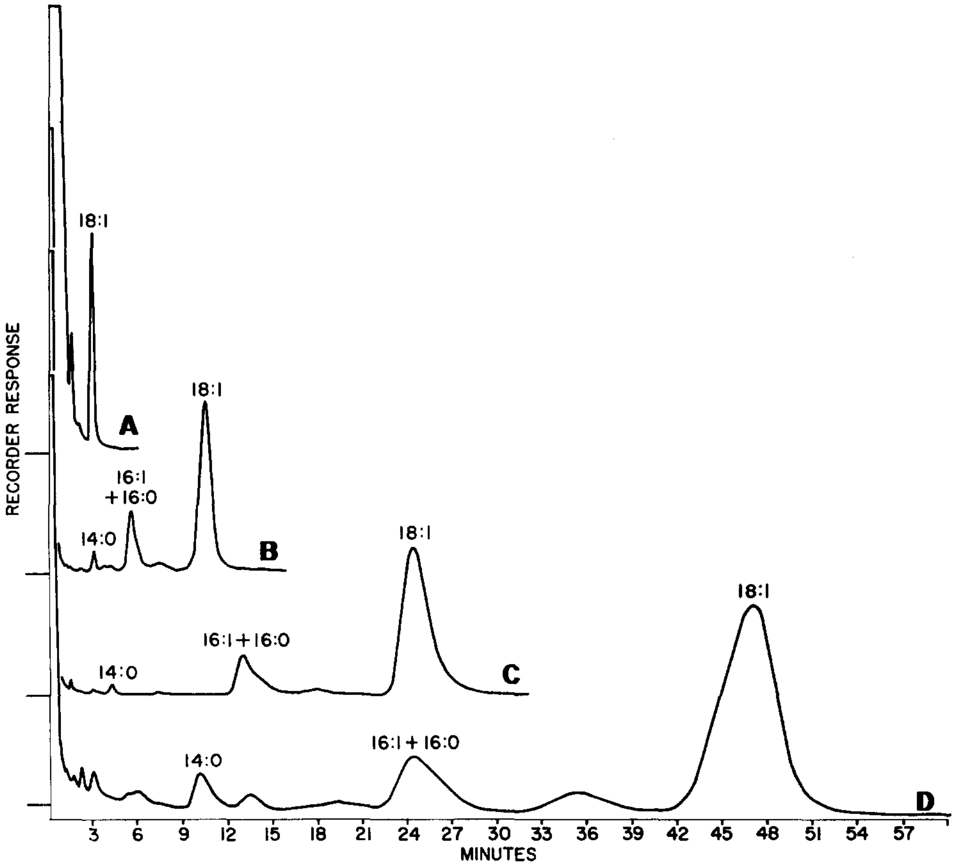

FIG. 2. GLC analyses of derivatives prepared from selachyl alcohol: *A*, allyl alkyl ethers; *B*, isopropylidenes; *C*, cyclic carbonates; *D*, cyclic thionocarbonates. The Aerograph 1200 was used with a 5-ft (150 cm) stainless steel column, $^1/_8$ inch (3 mm) O.D., containing 5% SE-30 (methylpolysiloxy gum) on 60–80 mesh Chromosorb W. Operating temperatures were: injector, 270°C; column, 200°C; detector, 310°C. Helium was the carrier gas and the flow rate was 30 ml/min.

glycerol and cyclic thionocarbonate. This component was not eluted from the Unisil column and the purified cyclic thionocarbonate was obtained in 50–70% yield.

In small-scale preparations, 1 mg of alkyl glycerol dissolved in 20 ml of benzene, 0.01 ml of a sodium methoxide solution (20 mg of sodium dissolved in 5 ml of methanol), and 20 mg of thiocarbonyldiimidazole were mixed and refluxed under nitrogen. After 1 hr, 10 mg of thiocarbonyldiimidazole was added and the mixture was then refluxed for an additional 5 hr. No unreacted alkyl glycerol or other component except a spot from the reagent blank was found on TLC.

Cyclic Carbonates. *O*-alkyl glycerols were converted to cyclic carbonates by the method of Staab (5), except that yields were improved by refluxing equal amounts of imidazole and *N,N'*-carbonyldiimidazole with the alkyl glycerol. Carbonates had the same properties as thionocarbonates on TLC and Unisil columns.

Isopropylidene Derivatives. *O*-alkyl glycerols were converted to isopropylidenes by the method of Hanahan, Ekholm, and Jackson (6).

Allyl Alkyl Ethers. Cyclic thionocarbonates were converted to allyl alkyl ethers by desulfurization–decarboxylation as described by Corey and Winter (7). The crude allyl alkyl ether was dissolved in hexane and placed on a Unisil column. Pure allyl alkyl ether was eluted with 100 ml of hexane–ether 95:5; traces of trimethyl phosphite remained on the column. 125 mg of cyclic thionocarbonate from purified selachyl alcohol yielded 100 mg of allyl alkyl ether (99% yield).

Results and Discussion. Cyclic thionocarbonates were synthesized in high yields from *O*-alkyl glycerols when sodium methoxide was added to the reaction mixture. When sodium methoxide was omitted from the reaction mixture, small amounts of unreacted alkyl glycerol and an unknown product were found in addition to the cyclic thionocarbonate on TLC. Allyl alkyl ethers were synthesized in high yields from cyclic thionocarbonates by desulfurization–decarboxylation with trimethyl phosphite. Cyclic carbonates did not yield allyl alkyl ethers by this reaction.

Cyclic thionocarbonates showed an IR absorption indicative of the thionocarbonyl group (8), λ_{max} in CCl_4 7.73 μm, and no hydroxyl group absorption. Cyclic thionocarbonates absorbed in the ultraviolet, λ_{max} in ethanol, 235 nm. Pure alkyl glycerols were not available for quantitation; however, the molar extinction at 235 nm of the thionocarbonate prepared from batyl alcohol (over 90% octadecyl glycerol) was 17,700 (calculated as octadecylglyceryl thionocarbonate). Cyclic carbonates had no UV absorption.

Mass spectral data were obtained using an AEI MS-902 mass spectrometer. The source temperature was 250°C and the ionizing voltage was 70 ev. The mass spectrum of octadecylglyceryl thionocarbonate was consistent with the proposed elemental composition. The molecular ion, m/e 386, had a low intensity. Identification of the molecular ion was facilitated by the occurrence of low intensity peaks at $(M–1)^+$ and $(M–2)^+$ which indicated labile hydrogen atoms. Three characteristic peaks in the high mass region $(M–33)^+$, $(M–61)^+$, and $(M–80)^+$ may have resulted from the loss of SH, COSH, and CO_2SH_2, respectively. Negative ion spectra (9) showed a small molecular ion, m/e 386, in the high mass region and two prominent ions in the low mass region which were identified as sulfur, m/e 32, and the thionocarbonate group, m/e 76.

GLC tracings for allyl alkyl ethers (*A*), isopropylidenes (*B*), cyclic carbonates (*C*), and thionocarbonates (*D*) are reproduced in Fig. 2. Cyclic thionocarbonates are potentially useful derivatives for GLC since the identification of these derivatives in nanogram amounts is possible with either an electron capture detector or a flame photometric detector.

Since cyclic thionocarbonates are synthesized in an alkaline solution, the preparation of cyclic thionocarbonates from both alkyl and alk-1'-enyl glycerols may be feasible. Indeed, Gigg and Gigg (10) have prepared cyclic carbonates of both alkyl and alk-1'-enyl glycerols.

We are indebted to Dr. Melvin S. Newman for suggestions and to Dr. Ralph C. Doughery for mass spectroscopy.

This investigation was supported in part by Grant GM-09506 from the National Institute of General Medical Sciences, Grant HE-11897 from the National Heart Institute, and a postdoctoral fellowship (Dr. Panganamala) from the Central Ohio Heart Association.

Manuscript received 11 February 1969; accepted 24 April 1969.

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