spectrometer. Mass spectra were determined with a Hitachi Perkin-Elmer RMU 6E mass spectrometer at 70 eV. Carbon and hydrogen analyses were determined with a Perkin-Elmer Model 240 elemental analyzer at the University of Idaho.

Photolysis of 1-Keto-2-carbomethoxymethylenebenzocyclobutene[6] (1a) in Methanol Solution.—To a quartz vessel were added 139 mg (0.740 mmol) of 1-keto-2-carbomethoxymethylenebenzocyclobutene (**1a**) and 20 ml of methanol. The reaction vessel was then flushed with nitrogen and the system was closed. The solution was then irradiated at 350 nm and the reaction was monitored with gas chromatography. After 28 hr gc showed that the starting material had all reacted and the irradiation was stopped. The methanol was then removed by a rotary evaporator. The residue was dissolved in chloroform and streaked on an 8 in. × 8 in. × 1000 μ preparative thin layer plate of neutral alumina previously oven dried for 2 hr. The plate was developed with chloroform, and the main band (R_f 0.77) was removed from the plate and extracted with several portions of chloroform to give 24 mg (0.109 mmol, 15% yield) of cis and trans methyl *o*-carbomethoxycinnamate (**3** and **4**). Gas chromatography indicated that the cis:trans ratio was 85:15. Pure **3** and **4** were obtained by preparative gas chromatography using a 10 ft × 1/4 in. 5% SE-30 column at 195°.

In addition to the methyl *o*-carbomethoxycinnamates isolated, several minor bands were removed from the thin layer plate and extracted with chloroform. Solvent removal gave a total of 8 mg of material which was not characterized. The remainder of the material remained as a brown band at the origin of the thin layer plate and was also not characterized.

Photoisomerization of Methyl *o*-Carbomethoxy-*trans*-cinnamate(4).—To a quartz nmr tube was added 2 drops of methyl *o*-carbomethoxy-*trans*-cinnamate (**4**)[6] followed by several drops of deuteriochloroform with 1% tetramethylsilane. The reaction mixture was then put under a nitrogen atmosphere and sealed with an nmr cap. The mixture was then irradiated at 350 nm and the reaction was monitored with nmr. After 58 hr both nmr and gc analysis showed the solution contained a mixture of 85% cis cinnamate **3** and 15% trans cinnamate **4**.

Pure cis-cinnamate (**3**) was obtained by preparative gas chromatography using a 10 ft × 1/4 in. 5% SE-30 column at 195°. Reinjection of a small amount of the collected material indicated high (97+%) purity and that no isomerization to trans-cinnamate (**4**) had occurred on gc.

Thermal Reaction of 1-Keto-2-carbomethoxymethylenebenzocyclobutene (1a) with Methanol.—To a 10-ml flask equipped with reflux condenser, drying tube, magnetic stirrer, and heating mantle were added 25 mg of **1a** and 5 ml of methanol. Aluminum foil was wrapped around the reaction flask and condenser to prevent any light-induced reaction from occurring. The solution was then refluxed for 48 hr.

After solvent removal, gc analysis showed that the residue had a retention time identical with that of authentic 1-keto-2-carbomethoxymethylenebenzocyclobutene (**1a**). The nmr spectrum was also identical with that of authentic keto ester **1a** and, furthermore, no peaks corresponding to either cis or trans methyl *o*-carbomethoxycinnamate (**3** or **4**) were detected.

1-Hydroxy-2-carbomethoxymethylenebenzocyclobutene (8a).—To a 50-ml flask equipped with magnetic stirrer were added 150 mg (0.615 mmol) of 1-keto-2-carbomethoxymethylenebenzocyclobutene (**1a**) and 15 ml of methanol. The solution was stirred at room temperature until **1a** was dissolved and then 6 mg (0.63 meq) of sodium borohydride was added to the mixture with stirring. Stirring was continued for 0.5 hr. Dilution with water, extraction with chloroform, drying, and solvent removal gave 177 mg (0.615 mmol) of crude **8a** in a quantitative yield, as a thick, light yellow oil. Analysis by gc showed that the crude alcohol was 95+% pure and was contaminated with a slight amount of the keto ester starting material. Collection by gc using a 10 ft × 1/4 in. 10% SE-30 column at 183° gave **8a** as a light yellow viscous liquid (*Anal.* Calcd: C, 69.46; H, 5.30. Found: C, 69.65; H, 5.35%.): nmr δ 3.60 (s, 3 H), 4.10 (d, 1 H, J = 9 cps, shifted and collapsed to a singlet when H^+ was added), 5.36 (d, 1 H, J = 9 cps, collapsed to singlet when H^+ was added), 5.67 (s, 1 H), 7.16–7.38 (m, 3 H), 7.55–7.79 (m, 1 H); mass spectrum *m/e* (rel intensity) 190 (40), 175 (43), 158 (15), 131 (100), 130 (24), 103 (66), 102 (37), 77 (58), 51 (29). The ir spectrum determined from a 0.25 M solution of **8a** in carbon tetrachloride showed a broad (hydrogen bonded) hydroxyl absorption centered at 3450 cm^{-1} with a very small sharp band (nonhydrogen bonded) at 3590 cm^{-1}. In spectra determined at 0.025 and 0.0025 M, the broad band centered at 3450 cm^{-1} became much smaller and almost disappeared while the sharp band at 3590 cm^{-1} grew more intense upon dilution.

Registry No.—**1a**, 34288-39-6; **3**, 34288-40-9; **4**, 18454-56-3; **8a**, 34288-77-2.

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A New Synthesis of the 1,3-Thiazine Ring System

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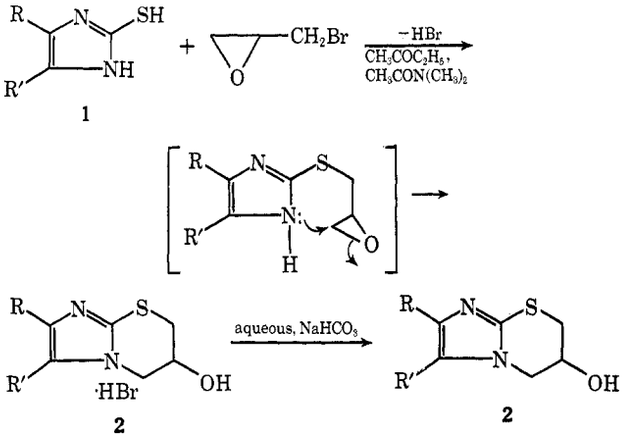
This note describes a simple synthesis of the 1,3-thiazine ring system, some derivatives of which have been shown to exhibit important physiological activity.[2] We became interested in these heterocycles while investigating the products obtained from the reaction of 2-mercaptobenzimidazole with α-halo ketones.[3] It seemed reasonable that treatment of this and related mercaptoazoles (**1**) with epoxy halides such as epibromohydrin would result in condensation followed by intramolecular cyclization to give the thiazine derivative **2** with the hydroxyl group on a ring carbon.



R = R′ = C_6H_5, H, C_4H_4, $C_2H_2N_2$

The hydroxyl functionality would be a handle for preparing numerous other potentially useful thiazines.

Treatment of 4,5-diphenyl-2-mercaptoimidazole[4a] (**1**, R = R′ = C_6H_5) with epibromohydrin in a mixture of 2-butanone and *N*,*N*-dimethylacetamide (10:1) at 85° for 2 hr gave the hydrobromide salt of **2** from which

(1) National Science Foundation Undergraduate Research Participant.

(2) For example, see R. M. Gesler and A. R. Surrey, *J. Pharmacol. Exp. Ther.*, **122**, 4 (1958); A. R. Surrey, W. G. Webb, and R. M. Gesler, *J. Amer. Chem. Soc.*, **80**, 3469 (1958); B. Loder, G. G. F. Newton, and E. P. Abraham, *Biochem. J.*, **79**, 408 (1961); J. C. Wilson, R. N. Downer, and H. E. Sheffer, *J. Heterocycl. Chem.*, **7**, 955 (1970).

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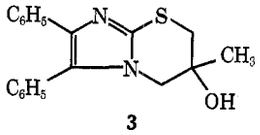
(4) (a) Aldrich Chemical Co., Milwaukee, Wis.; (b) Pfaltz and Bauer, Inc., New York, N. Y.

6-hydroxy-2,3-diphenyl-6,7-dihydro-5*H*-imidazo[2,1-*b*]-[1,3]thiazine (**2**, R = R′ = C_6H_5) could be isolated in 48% yield (based on **1**) by basification with aqueous sodium bicarbonate. Structure **2** (R = R′ = C_6H_5) was assigned on the basis of analytical data and spectral results (see Experimental Section). For instance, the infrared spectrum (KBr) of the fused thiazine showed a broad band centered at 3150 cm^{-1} for the hydrogen-bonded OH stretching vibration and an intense band at 1068 cm^{-1} due to C–O stretching. The mass spectrum gave a parent peak at *m/e* 308 with important fragment ions at *m/e* 290, 276, 264, 204, and 178. Oxidation of **2** (R = R′ = C_6H_5) with chromium trioxide in pyridine gave the corresponding ketone ($\nu_{C=O}$ 1715 cm^{-1}). A mixture of alkenes was obtained by dehydration of **2** (R = R′ = C_6H_5) with phosphorus oxychloride in pyridine.

The dihydrothiazines **2** (R, R′ = H) (23% yield), C_4H_4 (41%), and $C_2H_2N_2$ (12%) were obtained in the same manner as that described for **2** (R = R′ = C_6H_5) by the reaction of epibromohydrin with 2-mercaptoimidazole,[4b] 2-mercaptobenzimidazole,[4a] and 8-mercaptopurine,[4a] respectively. In the latter example, cyclization may occur at the 7 or 9 nitrogen and we have, thus far, been unable to distinguish between the two possible isomers.

We have used **1** (R = R′ = C_6H_5) for studying this reaction with a variety of epoxy bromides. Treatment of the mercaptoazole with the readily prepared 1-bromo-2,3-epoxy-2-methylpropane[5] and *threo*-3-bromo-1,2-epoxybutane[6] gave 6-hydroxy-6-methyl-2,3-diphenyl-6,7-dihydro-5*H*-imidazo[2,1-*b*][1,3]thiazine (**3**, 24% yield), and *erythro*-6-hydroxy-7-methyl-2,3-diphenyl-6,7-dihydro-5*H*-imidazo[2,1-*b*][1,3]thiazine (**4**, 38% yield), respectively. These heterocycles are the expected



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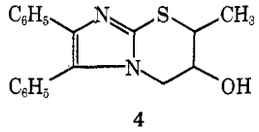

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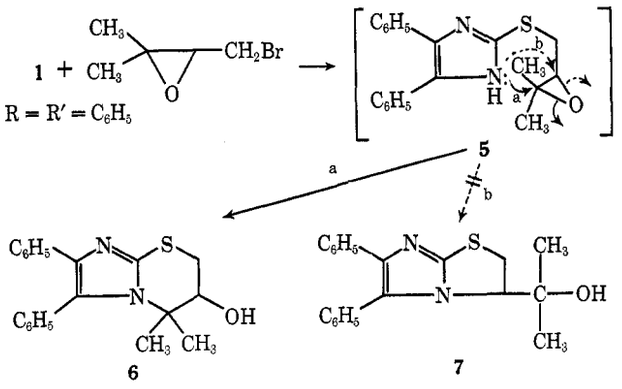
products arising from nucleophilic attack at the least substituted carbon of the epoxide ring.[7] However, use of 1-bromo-2,3-epoxy-3-methylbutane[8] as the epoxy halide gave **6** (31%) rather than the anticipated product, **7**. The nmr spectrum of the product showed a doublet at 5.75 ppm (–OH), which disappeared upon addition of trifluoroacetic acid. Oxidation of **6** with chromium trioxide in pyridine gave the corresponding ketone ($\nu_{C=O}$ at 1718 cm^{-1}). A six-membered rather than a five-membered ring intermediate has been invoked to explain the position of nucleophilic attack (at the least substituted carbon) in the reaction of glycidyl ethers with dibutylamine.[7] It is possible that the formation of a six-membered ring (leading to **6**) rather than the less favored five-membered ring intermediate (leading to **7**) is responsible for nucleophilic attack at the most substituted carbon of epoxide **5** (*i.e.*, path a rather than path b). These



examples demonstrate the ease with which one could place methyl groups at different saturated carbons of the thiazine ring by using the appropriate epoxy halide. It should be pointed out that no attempt was made to optimize yields in any of the reactions.

Experimental Section

Melting points were determined on a Fisher-Johns apparatus and are uncorrected. Elemental analyses were carried out by PCR, Inc., Gainesville, Fla. Infrared spectra were recorded on Perkin-Elmer 457 and 521 spectrophotometers; the wavelength readings were calibrated with polystyrene film. Nuclear magnetic resonance spectra were determined on a Varian A-60 spectrometer using tetramethylsilane as internal standard. Mass spectra were recorded on a MS-9 spectrometer.

General Procedure for Reaction of Mercaptoazoles and Epoxy Bromides.—The mercaptoimidazole (15.6 mmol) and the epoxy halide (15.6 mmol) were suspended in a mixture of 2-butanone (150 ml) and *N*,*N*-dimethylacetamide (15 ml) and heated to 80–95° (oil bath temperature) where the solution became clear. After 1–9 hr, the precipitated hydrobromide salt (**2**·HBr) was filtered and dried. The salt was suspended in water (250–350 ml), heated to boiling (*N*,*N*-dimethylacetamide added to bring into solution water-insoluble salts), and then basified with 5% aqueous $NaHCO_3$. The resulting white precipitate was filtered and recrystallized from either 70% aqueous ethanol or acetonitrile to give the following derivatives of **2**.

A.—**2** (R = R′ = C_6H_5) had mp 219–220°; ν_{max} (KBr) 3150 (OH, broad) and 1068 cm^{-1} (CO); nmr [dimethyl sulfoxide-d_6 (DMSO-d_6)] δ 3.25 (m, 2 H, NCH_2), 3.69 (m, 2 H, SCH_2), 4.29 (m, 1 H, CH–), 5.59 (d, 1 H, OH), and 7.02–7.41 (m, 10 H, ArH). Addition of trifluoroacetic acid resulted in disappearance of the δ 5.59 doublet. The mass spectrum gave a parent ion peak at *m/e* 308 as well as fragments at *m/e* 290, 276, 264, 204, and 178.

Anal. Calcd for $C_{18}H_{16}N_2OS$: C, 70.10; H, 5.23; N, 9.08. Found: C, 69.98; H, 4.95; N, 9.15.

B.—**2** (R = R′ = H) had mp 202–203°; ν_{max} (KBr) 3100 (OH, broad) and 1041 cm^{-1} (CO); the mass spectrum gave a parent ion peak at *m/e* 156.

Anal. Calcd for $C_6H_8N_2OS$: C, 46.13; H, 5.16; N, 17.94. Found: C, 46.16; H, 5.04; N, 18.17.

C.—**2** (R = R′ = C_4H_4) (from 2-mercaptobenzimidazole) had mp 215–217°; ν_{max} (KBr) 3090 (OH, broad) and 1042 or 1078 cm^{-1} (CO); the mass spectrum gave a parent ion peak at *m/e* 206.

Anal. Calcd for $C_{10}H_{10}N_2OS$: C, 58.22; H, 4.90; N, 13.58. Found: C, 57.95; H, 5.24; N, 13.58.

D.—**2** (R = R′ = $C_2H_2N_2$) (from 8-mercaptopurine) had mp 215–217°; ν_{max} (KBr) 3090 (OH, broad) and 1029 or 1074 cm^{-1} (CO); the mass spectrum gave a parent ion peak at *m/e* 208.

Anal. Calcd for $C_8H_8N_4OS$: C, 46.14; H, 3.87; N, 26.91. Found: C, 46.00; H, 3.87; N, 27.05.

E.—**3** had mp 218–220°; ν_{max} (KBr) 3270 (OH, broad) and 1108 cm^{-1} (CO); nmr (DMSO-d_6) δ 1.31 (s, 3 H, CH_3), 3.12 (q, 2 H, NCH_2–), 3.57 (q, 2 H, SCH_2–), 5.31 (s, 1 H, OH), and 6.80–7.62 (m, 10 H, ArH). Addition of trifluoroacetic acid resulted in disappearance of the δ 5.31 absorption. The mass spectrum gave a parent ion peak at *m/e* 322.

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Anal. Calcd for $C_{19}H_{18}N_2OS$: C, 70.78; H, 5.63; N, 8.69. Found: C, 70.29; H, 5.40; N, 8.35.

F.—**4** had mp 218–219°; ν_{max} (KBr) 3120 (OH, broad) and 1047 cm^{-1} (CO); nmr (DMSO-d_6) δ 1.00 (s, 3 H, CH_3), 3.24 (m, 2 H, NCH_2), 4.11 (m, 2 H, $CHCH_3$ and CHOH), 5.67 (d, 1 H, OH), and 7.27 (center of multiplet, 10 H, ArH). Addition of trifluoroacetic acid resulted in disappearance of the δ 5.67 doublet. The mass spectrum gave a parent ion peak at *m/e* 322.

Anal. Calcd for $C_{19}H_{18}N_2OS$: C, 70.78; H, 5.63; N, 8.69. Found: C, 71.02; H, 5.54; N, 8.53.

G.—**6** had mp 237–238°; ν_{max} (KBr) 3140 (OH, broad) and 1078 cm^{-1} (CO); nmr (DMSO-d_6) δ 1.23 (s, 3 H, CH_3), 1.31 (s, 3 H, CH_3), 3.46 (m, 2 H, SCH_2), 3.90 (broad m, 1 H, CHOH), 5.75 (d, 1 H, OH), and bands centered at 7.14 and 7.47 (m, 10 H, ArH). Addition of trifluoroacetic acid resulted in disappearance of the δ 5.75 doublet. The mass spectrum gave a parent ion peak at *m/e* 336.

Anal. Calcd for $C_{20}H_{20}N_2OS$: C, 71.39; H, 5.99; N, 8.32. Found: C, 71.19; H, 6.16; N, 8.21.

Oxidation of 2 (R = R′ = C_6H_5) and 6.—Chromic oxide (5.1 mmol) was added, in small portions, to 8 ml of a well-stirred cold pyridine solution. The alcohol (1.7 mmol) was then added and the mixture was stirred at room temperature for 12–15 hr. The reaction mixture was poured into water and the ketone was extracted with methylene chloride. The methylene chloride extract was dried (Na_2SO_4), the solvent was evaporated *in vacuo*, and the residual oil was crystallized from pentane. Recrystallization from 70% aqueous ethanol gave analytically pure product.

A.—The oxidation product from **2** (R = R′ = C_6H_5) had mp 198–200°; ν_{max} (KBr) 1715 cm^{-1} (CO).

Anal. Calcd for $C_{18}H_{14}N_2OS$: C, 70.56; H, 4.60; N, 9.14. Found: C, 70.51; H, 4.91; N, 9.40.

B.—The oxidation product from **6** had mp 192–193°; ν_{max} (KBr) 1718 cm^{-1} (CO).

Anal. Calcd for $C_{20}H_{18}N_2OS$: C, 71.83; H, 5.43; N, 8.38. Found: C, 71.89; H, 5.87; N, 8.35.

Registry No.—**2** (R = R′ = C_6H_5), 34035-39-7; **2** (R = R′ = C_6H_5) oxidation product, 34035-40-0; **2** (R = R′ = H), 34035-41-1; **2** (R = R′ = C_4H_4), 34035-42-2; **2** (R = R′ = $C_2H_2N_2$), 34035-43-3; **3**, 34035-44-4; **4**, 34035-45-5; **6**, 34035-46-6; **6** oxidation product, 34035-47-7.

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Conversion of Allylic Alcohols to Chlorides without Rearrangement

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A recent report on the conversion of allylic alcohols to their chlorides without rearrangement[1] prompts us to report similar, limited observations made some time ago. The unique properties[2] of the triphenylphosphine–carbon tetrachloride reagent suggested its potential in specific allylic alcohol–chloride conversions. When the reaction was employed using the classic isomeric α- and γ-methallyl alcohol couple, the results substantiated our hopes based on prior experience (Table I).

TABLE I
CHLORIDE COMPOSITION FROM METHALLYL ALCOHOLS USING Ph_3P-CCl_4

Alcohol	CH_3CH=$CHCH_2Cl$	CH_3CHCl-CH=CH_2
CH_3CH=$CHCH_2OH$	100	0
$CH_3CHOHCH$=CH_2	11	89

The report of Meyers demonstrated that *primary* allylic alcohols can be converted to chlorides without formation of the secondary or tertiary isomer. Our results demonstrate that not only can the primary–primary conversion be achieved specifically, but also, and perhaps more importantly, the secondary–secondary conversion can be achieved with high specificity even in a system prone toward rearrangement.

Experimental Section[3]

3-Buten-2-ol was commercial material whose glpc trace showed no contamination by its allylic isomer. **2-Buten-1-ol** was a heart cut from distillation of commercial alcohol and was also free of its allylic isomer by glpc examination. Its nmr spectrum clearly showed a mixture of cis and trans isomers. Each alcohol (0.099 g, 1.37 mmol) was dissolved in 0.5 ml of carbon tetrachloride containing 0.36 g (1.4 mmol) of triphenylphosphine and kept at ambient temperature. After 48 hr the nmr spectrum of the 2-buten-1-ol mixture showed only a small amount of unreacted alcohol and 1-chloro-2-butene. High-gain examination showed the absence of signals at 264 Hz ($CH_3CHClCH$=CH_2). Examination by glpc showed 1-chloro-2-butene as the only chloride. Similarly, the nmr spectrum of the 3-buten-2-ol mixture showed some unreacted alcohol, a multiplet at 264 Hz, and a weak doublet at 236 and 228 Hz (CH_3CH=$CHCH_2Cl$) whose integral indicated 9% of the latter chloride. Examination by glpc showed that the chlorides consisted of 89% unrearranged secondary and 11% rearranged primary allylic chloride.

To determine whether the rearranged chloride from 3-buten-2-ol was a kinetic product or resulted from post-isomerization the following experiment was performed. To 1.00 g of alcohol in 6 ml of carbon tetrachloride was added 0.9 g of triphenylphosphine. After 4 hr an aliquot was removed and examined by glpc and another 0.9 g of phosphine was added. This was repeated twice more at intervals of 16 and 8 hr. The glpc results showed the presence of 8–12% primary chloride in all cases, suggesting that the latter was a kinetically controlled product.

Registry No.—3-Buten-2-ol, 598-32-3; *cis*-2-buten-1-ol, 4088-60-2; *trans*-2-buten-1-ol, 504-61-0; 1-chloro-2-butene, 591-97-9; 3-chloro-1-butene, 563-52-0.

Acknowledgment.—This work was supported by the National Science Foundation while the author was a guest at East Tennessee State University.

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(2) R. G. Weiss and E. I. Snyder, *ibid.*, **36**, 403 (1971), and earlier work cited therein.

(3) Chloride analyses were performed on a FFAP column operated at 50°. Chemical shift data are with reference to internal TMS.