[CONTRIBUTION FROM THE SAMUEL C. HOOKER LABORATORY OF THE DEPARTMENT OF CHEMISTRY OF WAYNE UNIVERSITY]

Studies in Organic Sulfur Compounds. VII.[1] Lithium Aluminum Hydride Reduction of Xanthates to Mercaptans. Synthesis of Substituted β-Mercaptoethanols

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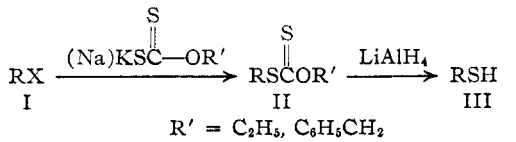
Xanthates are reducible in excellent yields to mercaptans by means of lithium aluminum hydride. This procedure offers a facile two-step sequence to substituted β-mercaptoethanols from α-halo-ketones, acids or alcohols involving reaction with potassium (or sodium) ethyl- or benzylxanthate, followed by reduction of both the carbonyl and xanthate functions with lithium aluminum hydride. The resulting β-mercaptoethanols have been characterized as hemithioketals by condensation (using zinc chloride) with various ketones.

The observation[3] that ketones react with β-mercaptoethanol to form hemithioketals which regenerate the parent ketone upon desulfurization with Raney nickel is of considerable practical and theoretical interest especially as it applies to the mechanism of the desulfurization process now under study in our laboratory. In our preceding article[1] there were investigated various procedures for the condensation of ketones with β-mercaptoethanol or γ-mercaptopropanol and a number of hemithioketals, required for desulfurization, were synthesized. From a mechanistic standpoint, it was crucial to determine the fate not only of the carbonyl portion but also of the β-mercaptoethanol moiety after desulfurization and it was necessary, therefore, to synthesize β-mercaptoethanols with appropriate substituents. The choice of the substituent depended on two factors: (a) groups which increase the molecular weight in order to simplify the isolation and characterization of the desulfurization product; (b) substituents which would result in the stabilization (*e.g.*, benzyl free radicals) of any free radicals formed during the desulfurization[4] of such hemithioketals and which might actually affect the nature of the resulting products. The present paper is concerned with the synthesis and characterization of such β-mercaptoethanols which have not been described previously in the literature.

The majority of the conventional mercaptan syntheses[5] did not appear suitable for our purposes because of the strongly alkaline conditions employed in all of them. This objection also applied to the decomposition[5] of xanthates, but in view of the ease[6] with which the latter can be synthesized it appeared worthwhile to investigate the use of reagents other than alkali; reduction with lithium aluminum hydride proved to be the method of choice.



All of the xanthates (II) employed in the present investigation were prepared by the interaction of potassium ethyl xanthate or sodium benzyl xanthate with the appropriate halide (I) in acetone solution. In the majority of instances (Table I), it was possible to obtain pure xanthates by either distillation or crystallization, but this was not essential, and at times not even desirable, in order to obtain optimum yields of mercaptan. The reduction with lithium aluminum hydride, first studied with the model benzyl (II, R = $C_6H_5CH_2$) and β-phenethyl (II, R = $C_6H_5CH_2CH_2$) ethyl xanthates, proceeded in excellent yield to furnish benzyl and β-phenethyl mercaptan, respectively. That the method is equally applicable to aryl xanthates was

TABLE I

Xanthate (R—S—C(=S)—OR′) R	R′	Yield, %	Physical constants	Empirical formula	Carbon, % Calcd.	Carbon, % Found	Hydrogen, % Calcd.	Hydrogen, % Found
$C_6H_5CH_2$	C_2H_5	70	B.p. 145–147° (4 mm.) $n^{30}D$ 1.5952	$C_{10}H_{12}OS_2$	56.60	56.14	5.70	5.66
$C_6H_5CH_2CH_2$	C_2H_5	83	B.p. 166–169 (3.5 mm.)	$C_{11}H_{14}OS_2$	58.40	58.06	6.24	6.20
$C_6H_5COCH_2$	$C_6H_5CH_2$[a]	75	M.p. 76–76.5	$C_{16}H_{14}O_2S_2$	63.57	63.44	4.67	4.76
$C_6H_5COCHC_6H_5$	$C_6H_5CH_2$[b,c]	60	M.p. 128–129	$C_{22}H_{18}O_2S_2$	69.83	69.55	4.80	4.88
$C_6H_5CH_2COCH_2$	$C_6H_5CH_2$	66	M.p. 77–78	$C_{17}H_{16}O_2S_2$	64.55	64.50	5.10	5.07
$C_6H_5CHCOOH$	C_2H_5[d]	71	M.p. 90–90.5	$C_{11}H_{12}O_3S_2$	51.56	51.38	4.72	4.65

[a] 2,4-Dinitrophenylhydrazone (orange-red), m.p. 180–181°. *Anal.* Calcd for $C_{22}H_{18}N_4O_5S_2$: C, 54.77; H, 3.76. Found: C, 54.62; H, 3.47. [b] S. V. Zhuravlev (*J. Appl. Chem. USSR.*, **23**, 1165 (1950); *C. A.*, **46**, 10107 (1952)) reported m.p. 63–64°. [c] 2,4-Dinitrophenylhydrazone, m.p. 170–172°. *Anal.* Calcd. for $C_{28}H_{22}N_4O_5S_2$: C, 60.21; H, 3.97. Found: C, 60.31; H, 4.15. [d] This compound has been described earlier (m.p. 91–92°) by A. Fredga, *Arkiv. Kemi, Mineral. Geol.*, **24B**, No. 15, 8 pp. (1947), but only a neutral equivalent was given.

(1) Paper VI, C. Djerassi and M. Gorman, THIS JOURNAL, **75**, 3704 (1953).

(2) Pfizer Predoctorate Research Fellow in Organic Chemistry, 1953–1954.

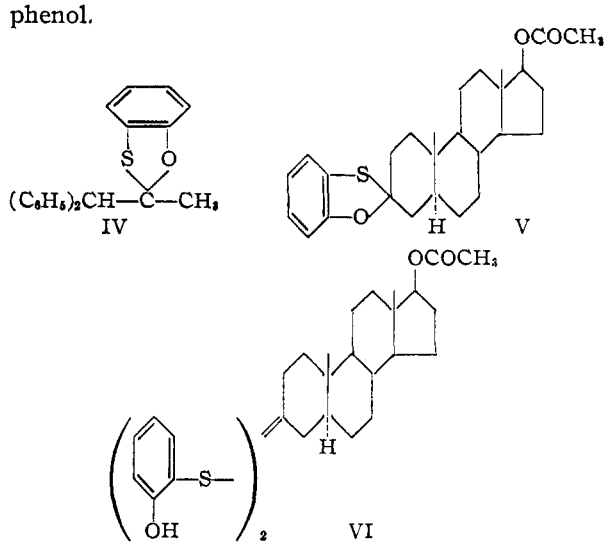
(3) J. Romo, G. Rosenkranz and C. Djerassi, THIS JOURNAL, **73**, 4961 (1951).

(4) The desulfurization of sulfides appears to proceed by a free radical mechanism (*inter alia*, W. A. Bonner, *ibid.*, **74**, 1034 (1952)); H. Hauptmann, B. Wladislaw, L. L. Nazario and W. F. Walter, *Ann.*, **576**, 45 (1952)).

(5) *Cf.* R. Connor in H. Gilman's "Organic Chemistry," John Wiley and Sons, Inc., New York, N. Y., 1943, Vol. I, pp. 841–844; R. B. Wagner and H. D. Zook, "Synthetic Organic Chemistry," John Wiley and Sons, Inc., New York, N. Y., 1953, chapter 31.

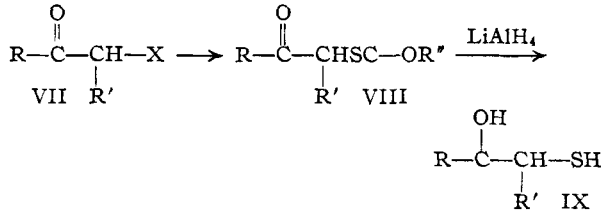
(6) *Inter alia*, (a) G. Bulmer and F. G. Mann, *J. Chem. Soc.*, 666 (1945); (b) D. Lefort and G. Hugel, *Bull. soc. chim. France*, 172 (1952).

demonstrated by the conversion of *o*-aminophenol *via* the ethyl xanthate to *o*-mercaptophenol in 64% over-all yield without isolation of intermediates. Crystalline hemithioketals (IV and V) were obtained in the condensation of *o*-mercaptophenol with both 1,1-diphenylacetone and dihydrotestosterone acetate; in the latter case an appreciable amount of the corresponding thioketal VI also was isolated and its structure was proved by desulfurization to androstan-17β-ol acetate and phenol.



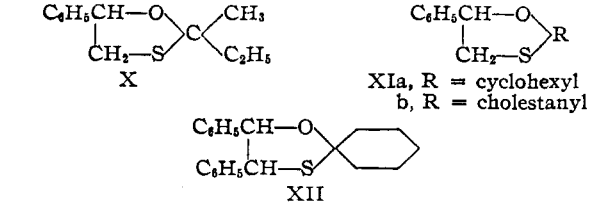
IV V VI

This new mercaptan synthesis appears to be particularly suitable for the preparation of β-mercaptoethanols from α-haloketones



VII VIII IX

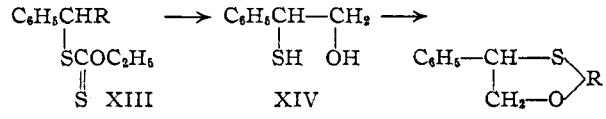
Thus phenacyl bromide (VII, R = C_6H_5, R′ = H, X = Br) upon treatment with potassium ethylxanthate followed by reduction with lithium aluminum hydride furnished 1-phenyl-2-mercaptoethanol (IX, R = C_6H_5, R′ = H) in 87% over-all yield. The liquid mercaptan was converted to the hemithioketals X, XIa, XIb with ethyl methyl ketone, cyclohexanone and cholestan-3-one, since such substances were required for desulfurization studies in order to determine whether C–O cleavage might actually be favored over C–S cleavage due to the activating influence of the phenyl substituents.



X XIa, R = cyclohexyl b, R = cholestanyl XII

An interesting case is 1,2-diphenyl-2-mercaptoethanol (IX, R = R′ = C_6H_5) since this substance can exist as two diastereoisomers and indeed 82% of a mixture of both isomers was obtained in the lithium aluminum hydride reduction of desyl benzylxanthate (VIII, R = R′ = C_6H_5, R″ = $C_6H_5CH_2$). One isomer[7] could be separated as a crystalline solid and evidence for the presence of the other isomer was adduced by the formation of two isomeric hemithioketals with cyclohexanone depending upon whether the crystalline mercaptoethanol or the mother liquors were employed. The availability of two diastereoisomeric hemithioketals should prove useful in certain desulfurization studies.

For comparison purposes, it was necessary to synthesize 2-phenyl-2-mercaptoethanol (XIV) since the corresponding hemithioketal XV would represent a case in which desulfurization would lead to an intermediate free radical stabilized by the presence of the phenyl group. The mercaptoethanol XIV, prepared by lithium aluminum hydride reduction of either phenylacetic acid 1-ethyl xanthate (XIII, R = COOH) or in poorer yield from the corresponding phenethyl alcohol ester (XIII, R = CH_2OOCH or $CH_2OOCC_6H_3(NO_2)_2$), was condensed with cholestan-3-one yielding the crystalline hemithioketal XV.



XIII XIV XV R = 3-cholestanyl

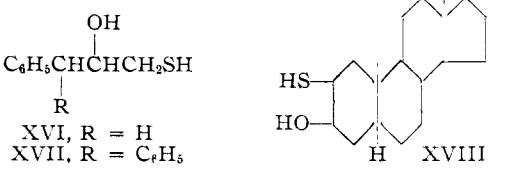
By means of the same general methods, 1-phenyl-3-mercaptopropanol-2 (XVI), 1,1-diphenyl-3-mercaptopropanol-2 (XVII)[8] and 2β-mercaptocholestan-3β-ol (XVIII)[9] were synthesized. As illustrated in the experimental portion, all of these mercaptoethanols were condensed with ketones to furnish hemithioketals, which should prove very useful in the projected desulfurization studies since in view of their size and structure, both cleavage products should be amenable to easy separation and identification. The Raney nickel desulfurizations of the hemithioketals described in this and the preceding[1] communication are now

(7) It does not appear possible to employ Cram's "Rule of Steric Control of Asymmetric Induction," (*cf.* D. J. Cram, Abstracts, 13th National Organic Chemistry Symposium, Ann Arbor, Mich., June 15, 1953) to predict the stereochemistry of the products since not enough is known about the effective size of the xanthate grouping *vs.* a phenyl group or about which group (xanthate or carbonyl) is reduced first by lithium aluminum hydride.

(8) C. L. Stevens and C. T. Lenk (*J. Org. Chem.*, **19**, 538 (1954)) have observed that methanolysis of 1,1-diphenyl-3-bromopropanone-2 results in rearrangement to yield the same methoxy derivative obtained from 1,1-diphenyl-1-bromopropanone-2. It appears quite unlikely, that such a rearrangement occurred in the reaction of sodium benzylxanthate with 1,1-diphenyl-3-bromopropanone-2, since the resulting mercaptan XVII (after lithium aluminum hydride reduction of the xanthate) was a crystalline solid, while no crystalline material could be isolated in the analogous reaction sequence with 1,1-diphenyl-1-bromopropanone-2.

(9) The tentative assignment of configuration follows from the following reasoning. Reaction of 2α-bromocholestan-3-one with potassium ethyl xanthate presumably proceeds with inversion to yield the corresponding 2β-substituted xanthate. Since cholestan-3-one *per se* yields almost exclusively cholestan-3β-ol upon reduction with lithium aluminum hydride, an additional 2β-substituent should not affect the steric course of the reduction. Such assignment is based on the tacit assumption that no equilibration occurred after formation of the xanthate.

in progress and will be reported in a forthcoming article.



XVI, R = H
XVII, R = C_6H_5

XVIII

Experimental[10]

Preparation of Xanthates (Table I). (a) Benzylxanthates.—To a solution of 23 g. of sodium in 500 cc. of benzyl alcohol was added over a period of 30 minutes 60 cc. of carbon disulfide while maintaining the temperature below 20°. This solution of sodium benzylxanthate was then used directly in the xanthate preparations.

In a typical run, one-fifth of the above solution (corresponding to 0.2 mole) was diluted with 200 cc. of acetone, and 40 g. (0.2 mole) of phenacyl bromide was added dropwise with stirring over a period of 20 minutes while keeping the temperature below 10°. The mixture was then stirred for an additional hour (without cooling), chloroform was added, the solution was washed well with water, dried and the solvent was removed *in vacuo*.

(b) Ethylxanthates.—To 56 g. of β-phenethyl bromide in 100 cc. of acetone was added dropwise with good agitation a solution of commercial potassium ethylxanthate (48.3 g.) in 1 l. of acetone over a period of 1 hour. After filtration of sodium bromide and removal of acetone, the reaction mixture was processed as above.

In instances where the xanthates could be purified by crystallization or distillation, pertinent data are listed in Table I, the yields referring to pure material. In a number of cases, the xanthates represented undistillable liquids (not listed in Table I) and these were reduced directly with lithium aluminum hydride to the mercaptans. In fact, the isolation and purification of the intermediate had no effect on the yield of the final mercaptan.

Lithium Aluminum Hydride Reduction of Xanthates.—The following procedure is typical: A solution of 33.9 g. of β-phenethyl ethylxanthate in 100 cc. of anhydrous ether was added dropwise with good stirring over a period of 30 minutes to a suspension of 8 g. of lithium aluminum hydride in 150 cc. of ether. After refluxing for 4 hours, acetone was added to destroy the excess reagent followed by the addition of 6 *N* sulfuric acid. The ether layer was separated and extracted several times with 10% potassium hydroxide solution. The alkaline extracts were combined, acidified with hydrochloric acid, the mercaptan was extracted with ether and the organic layer was washed, dried over sodium sulfate and evaporated. Distillation at 55 mm. afforded 18.5 g. (88%) of β-phenethyl mercaptan, b.p. 133–140°; 2,4-dinitrophenyl β-phenethyl sulfide,[11] m.p. 88–89°. Similar reduction of benzyl ethylxanthate or benzyl benzylxanthate (the latter without isolation of the intermediate) furnished benzyl mercaptan in over 80% yield.

1-Phenyl-2-mercaptoethanol (IX, R = C_6H_5, R′ = H).—This mercaptan was obtained in 85% yield upon reduction of phenacyl benzylxanthate (Table I) by the above described method. The following procedure illustrates the synthesis of this mercaptoethanol without isolation of intermediates. A solution of 34 g. of potassium ethylxanthate in 600 cc. of acetone was added slowly (below 10°) to 40 g. of phenacyl bromide in 100 cc. of acetone. Filtration and evaporation of the solvent left a viscous oil which was dried for 30 minutes at 60° *in vacuo*, and then reduced in ether solution by refluxing in an atmosphere of nitrogen overnight with 16 g. of lithium aluminum hydride. After working up in the usual manner, including extraction with alkali, the product was distilled under reduced pressure; yield 27 g. (87% over-all), b.p. 93–95° (3 mm.) or 125–126° (5 mm.), $n^{20}D$ 1.5816.

Anal. Calcd. for $C_8H_{10}OS$: C, 62.32; H, 6.54; S, 20.76 Found: C, 62.23; H, 6.71; S, 20.58.

2-Ethyl-2-methyl-5-phenyl-1,3-oxathiolane (X).—The zinc chloride procedure[3] proved to be most satisfactory for the preparation of hemithioketals with substituted β-mercaptoethanols.

A mixture of 3 g. of 1-phenyl-2-mercaptoethanol, 3 g. of freshly fused zinc chloride, 3 g. of anhydrous sodium sulfate and 8 cc. of ethyl methyl ketone was kept at room temperature in an atmosphere of nitrogen for 24 hours. Addition of chloroform, followed by washing with dilute ammonium hydroxide, water, drying and evaporation left a solid residue which was crystallized from methylene chloride–acetone; yield 1.3 g., m.p. 104–105°.

Anal. Calcd. for $C_{12}H_{16}OS$: C, 69.21; H, 7.74. Found: C, 68.86; H, 7.68.

5-Phenyl-1-oxa-4-thiaspiro[4,5]decane (XIa).—1-Phenyl-2-mercaptoethanol (2.0 g.) and cyclohexanone (5.0 cc.) were condensed by the zinc chloride procedure (48 hours) furnishing 2.21 g. of colorless crystals with m.p. 36–37° after crystallization from methanol–acetone.

Anal. Calcd. for $C_{14}H_{18}OS$: C, 71.77; H, 7.74. Found: C, 72.02; H, 7.88.

Spiro-(5-phenyl-1,3-oxathiolane-2,3′-cholestane) (XIb).—Cholestan-3-one (1.0 g.) was condensed with 2.0 g. of 1-phenyl-2-mercaptoethanol in the presence of 10 cc. of dioxane; 0.51 g. of one pure diastereoisomer with m.p. 164–166°, $[\alpha]^{25}D$ +45.7°, was obtained by crystallization from chloroform–methanol.

Anal. Calcd. for $C_{35}H_{54}OS$: C, 80.41; H, 10.41. Found: C, 80.91; H, 10.57.

1,2-Diphenyl-2-mercaptoethanol (IX, R = R′ = C_6H_5).—Desyl benzylxanthate (Table I) (30.2 g.) was reduced in the usual manner with lithium aluminum hydride (12 g. in 300 cc. of ether) except that the xanthate was dissolved in 200 cc. of ethylene glycol dimethyl ether. The crude product (15 g., 82%, m.p. 45–50°), once recrystallized from hexane, was obviously a mixture of the two possible diastereoisomers (Found: C, 72.81; H, 6.16). Repeated recrystallization from hexane furnished 6.2 g. (34%) of colorless crystals of one pure isomer with m.p. 76.5–77.5°.

Anal. Calcd. for $C_{14}H_{14}OS$: C, 73.02; H, 6.13. Found: C, 72.79; H, 6.16.

The other isomer, present in the mother liquors represented a viscous oil (b.p. 150–155° (0.04 mm.)) which could not be crystallized even after chromatography on silica gel, but it could be characterized as the hemithioketal of cyclohexanone (see below).

2,3-Diphenyl-1-oxa-4-thiaspiro[4,5]decane (XII).—The crystalline (m.p. 77°) isomer of 1,2-diphenyl-2-mercaptoethanol (4.0 g.) was condensed with 10 cc. of cyclohexanone yielding 3.75 g. (87%) of hemithioketal with m.p. 84–87°. The analytical sample was prepared by chromatography on alumina (eluted with petroleum ether–benzene, 9:1) and recrystallization from methanol; large prisms, m.p. 93–94°.

Anal. Calcd. for $C_{20}H_{22}OS$: C, 77.39; H, 7.14. Found: C, 77.40; H, 7.27.

Similar condensation of 0.8 g. of the oily isomer with cyclohexanone followed by crystallization from methanol furnished 0.43 g. of crystals with m.p. 98–99°, depressed to 78–85° upon admixture with the isomeric hemithioketal. The infrared spectra of the two isomers showed marked differences in the 9–12 μ region.

Anal. Found: C, 77.26; H, 7.15.

1-Phenyl-3-mercaptopropanol-2 (XVI).—Lithium aluminum hydride reduction of 1-phenylacetone 3-ethylxanthate (Table I) gave in 75% yield 1-phenyl-3-mercaptopropanol-2, b.p. 84–87° (0.3 mm.), $n^{22}D$ 1.5692.

Anal. Calcd. for $C_9H_{12}OS$: C, 64.27; H, 7.19. Found: C, 64.54; H, 7.43.

The mercaptan was characterized as the hemithioketal (**spiro-(5-benzyl-1,3-oxathiolane-2,3′-cholestane)**) of cholestan-3-one using 0.5 g. of the ketone and 0.45 g. of mercaptan; yield 0.23 g., m.p. 149–150° (ether–acetone), $[\alpha]^{25}D$ +25.3°. No attempt was made to isolate the other possible diastereoisomer.

Anal. Calcd. for $C_{36}H_{56}OS$: C, 80.55; H, 10.52. Found: C, 80.61; H, 10.37.

(10) Melting points or boiling points are uncorrected. All rotations were determined in chloroform solution. The microanalyses were carried out by Miss Phyllis Tocco (Wayne University) and by Geller Laboratories, Hackensack, N. J.

(11) R. W. Bost, J. O. Turner and R. D. Norton, THIS JOURNAL, **54**, 1985 (1932), report m.p. 88–89°.

2-Phenyl-2-mercaptoethanol (XIV). (a) From Phenylacetic Acid 1-Ethylxanthate (XIII, R = COOH).—This xanthate (Table I) was prepared by adding slowly (below 25°) 8.16 g. of α-chlorophenylacetic acid to a mixture of 9.12 g. of potassium ethylxanthate, 3.95 g. of sodium bicarbonate and 25 cc. of water and keeping the resulting mixture at 10° for 3 days. The crystalline xanthate (Table I) (4.0 g.) was reduced with lithium aluminum hydride yielding 1.67 g. (70%) of the mercaptan with b.p. 90–103° (1.6 mm.). An analytical sample was prepared by redistillation: b.p. 95–97° (1.5 mm.), solidifies on long cooling (m.p. 25–27°), d^{25}_4 1.1388, $n^{25}D$ 1.5851; M_D (calcd.) 44.76, M_D (obs.) 45.38.

Anal. Calcd. for $C_8H_{10}OS$: C, 62.32; H, 6.54. Found: C, 62.50; H, 6.86.

(b) **From α-Bromophenethyl Alcohol Esters.**—α-Bromophenethyl 3,5-dinitrobenzoate[12] (7.92 g.) and potassium ethyl xanthate (3.27 g.) in 75 cc. of acetone were refluxed for 30 minutes. The solution was filtered, the acetone was removed and the residual xanthate (XIII, R = $CH_2OOCC_6H_3(NO_2)_2$), was reduced with lithium aluminum hydride for 3 hours furnishing 39% of the mercaptan with b.p. 94–99° (1.6 mm.). No improvement (33%) was observed when the reaction was performed with the corresponding formate.[12]

Spiro-(4-phenyl-1,3-oxathiolane-2,3′-cholestane) (XV).—The condensation of cholestan-3-one (0.9 g.) and 2-phenyl-2-mercaptoethanol (2.0 g.) was carried out with 1 g. of sodium sulfate and 1 g. of zinc chloride in the presence of dioxane (5 cc.). Crystallization from acetone–methanol yielded 0.25 g. of the hemithioketal with m.p. 148–157°, raised to m.p. 158–160°, $[\alpha]^{22}D$ +12.8°, on recrystallization from acetone. No attempt was made to isolate the other diastereoisomer from the mother liquors (0.72 g., m.p. 76–93°).

Anal. Calcd. for $C_{35}H_{54}OS$: C, 80.41; H, 10.41; S, 6.12. Found: C, 80.41; H, 10.70; S, 6.13.

Cholestan-3-one-2-ethylxanthate.—The xanthate was prepared in the usual manner from 2.0 g. of 2α-bromocholestan-3-one and 0.72 g. of potassium ethylxanthate in 75 cc. of acetone for 2 hours at 25°. Crystallization from pentane gave 1.6 g. of product, m.p. 110–116°, usable for the next step; repeated recrystallization from pentane led to the analytical sample, m.p. 116.5–118°, $[\alpha]^{25}D$ −64.5°.

Anal. Calcd. for $C_{30}H_{50}O_2S_2$: C, 71.11; H, 9.95. Found: C, 71.02; H, 9.88.

2β-Mercaptocholestan-3β-ol (XVIII).—Reduction of 2.2 g. of the above xanthate with 2.0 g. of lithium aluminum hydride (14 hours) yielded 1.9 g. of mercaptan, m.p. 118–121°. Recrystallization from methanol–acetone led to the analytical sample with m.p. 122–124°, $[\alpha]^{25}D$ +10.6°.

Anal. Calcd. for $C_{27}H_{48}OS$: C, 77.09; H, 11.50. Found: C, 76.91; H, 11.36.

The corresponding **hemithioketal** with cyclohexanone was isolated in 75% yield, m.p. 161–163° (from methylene chloride–acetone), $[\alpha]^{25}D$ +65°.

Anal. Calcd. for $C_{33}H_{56}OS$: C, 79.14; H, 11.27. Found: C, 78.65; H, 11.36.

o-Mercaptophenol.—o-Aminophenol (54 g., Eastman practical grade), 300 cc. of water, 300 g. of ice and 125 cc. of hydrochloric acid was diazotized with 35 g. of sodium nitrite in 340 cc. of water at 0°. The diazonium salt solution was added slowly to 480 g. of potassium ethylxanthate in 375 cc. of water kept at 75°. After standing overnight, the xanthate was extracted with ether, dried, the ether was evaporated and the resulting dark red oil was reduced in an atmosphere of nitrogen with 38 g. of lithium aluminum hydride in ether solution (14 hours). Distillation of the product yielded 40 g. (64% over-all) of o-mercaptophenol, b.p. 88–90 (8 mm.), $n^{20}D$ 1.6058. The conventional decomposition of the xanthate is not reproducible (30–70%).[13]

Anal. Calcd. for C_6H_6OS: C, 57.14; H, 4.80. Found: C, 56.92; H, 5.08.

The 2,4-dinitrophenyl sulfide formed bright yellow crystals, m.p. 124–126° after recrystallization from dilute ethanol.

Anal. Calcd. for $C_{12}H_8N_2O_5S$: C, 49.32; H, 2.76. Found: C, 48.70; H, 2.94.

2-Ethyl-2-methyl-1,3-benzoxathiole.—The condensation of o-mercaptophenol and ethyl methyl ketone was carried out by the standard zinc chloride procedure (2 days); yield 67%, b.p. 77–78° (2 mm.). Greenwood and Stevenson[13] prepared this substance by the hydrogen chloride method and report b.p. 85° (3 mm.).

Anal. Calcd. for $C_{10}H_{12}OS$: C, 66.65; H, 6.71. Found: C, 66.36; H, 6.97.

2-Diphenylmethyl-2-methyl-1,3-benzoxathiole (IV).—This hemithioketal of 1,1-diphenylacetone and o-mercaptophenol was formed in 71% yield, m.p. 78–80° after recrystallization from dilute ethanol.

Anal. Calcd. for $C_{21}H_{18}OS$: C, 79.22; H, 5.70. Found: C, 79.34; H, 5.62.

Condensation of o-Mercaptophenol with Androstan-17β-ol-3-one Acetate (Dihydrotestosterone Acetate).—Dihydrotestosterone acetate (3.0 g.) in 5 cc. of dioxane was allowed to stand at room temperature for 2 days with 5.0 g. of o-mercaptophenol, 3.0 g. of anhydrous sodium sulfate and 3.0 g. of freshly fused zinc chloride. The crude material (3.9 g., m.p. 175–183°) was chromatographed on 60 g. of neutral alumina. Elution with pentane–ether (1:1) and recrystallization from acetone–methanol furnished 1.13 g. of the **hemithioketal, spiro-(1,3-benzoxathiole-2,3′-androstan-17′β-ol 17′-acetate) (V)**, m.p. 214–216°, $[\alpha]^{25}D$ +19°.

Anal. Calcd. for $C_{27}H_{36}O_3S$: C, 73.60; H, 8.24. Found: C, 73.77; H, 8.35.

Further elution with chloroform led to material which in contrast to the above hemithioketal showed a strong infrared hydroxyl band. Recrystallization from acetone–methanol gave 2.5 g. of the **o-hydroxyphenylthioketal of dihydrotestosterone acetate (VI)**, m.p. 186–188°, $[\alpha]^{25}D$ +15°.

Anal. Calcd. for $C_{33}H_{42}O_4S_2$: C, 69.94; H, 7.47. Found: C, 70.31; H, 7.43.

The structure of this thioketal VI was proved by desulfurization (0.2 g. refluxed with 2 g. of W-4 Raney nickel in ethanol solution (50 cc.) for 7 hours) in 67% yield to androstan-17β-ol acetate (m.p. 70–72°) and comparison (infrared and mixture melting point) with an authentic sample.[14] Phenol also was isolated and identified as the tribromo derivative.

1,1-Diphenyl-3-mercaptopropanol-2 (XVII).—1,1-Diphenyl-3-bromopropanone-2[8] (20.3 g.) in 100 cc. of acetone was treated in the standard manner (2 hours, room temperature) with 14.4 g. of sodium benzylxanthate. The crude xanthate (25 g.) was reduced directly with 8.5 g. of lithium aluminum hydride in ether solution for 24 hours and the base-soluble product was recrystallized from hexane and from dilute methanol yielding 12.1 g. of the desired mercaptan with m.p. 70–71°.

Anal. Calcd. for $C_{15}H_{16}OS$: C, 73.75; H, 6.60. Found: C, 73.68; H, 6.65.

2-Diphenylmethyl-1-oxa-4-thiaspiro[4,5]decane.—The condensation of 1.0 g. of 1,1-diphenyl-3-mercaptopropanol-2 (XVII) with 10 cc. of cyclohexanone was carried out in the customary manner (2 days, room temperature) with 1.0 g. each of zinc chloride and sodium sulfate. Crystallization from ether–methanol followed by recrystallization from methanol furnished 1.03 g. of the hemithioketal with m.p. 96–97°.

Anal. Calcd. for $C_{21}H_{24}OS$: C, 77.75; H, 7.46. Found: C, 78.00; H, 7.53.

DETROIT, MICHIGAN

(12) R. E. Buckles and J. E. Maurer, *J. Org. Chem.*, **18**, 1585 (1953), report a 50% yield, m.p. 112–113°. By carrying out the bromination by their procedure but employing a reaction vessel with a quartz window, the yield of bromo ester, m.p. 110–112°, was raised to 91%.

(13) D. Greenwood and H. A. Stevenson, *J. Chem. Soc.*, 1514 (1953); P. Friedlander and F. Mauthner, *Z. Farben Textilchem.*, **3**, 333 (1904).

(14) G. Rosenkranz, St. Kaufmann and J. Romo, THIS JOURNAL, **71**, 3689 (1949).