dl-**Laurolenic Acid** (2).—Following the procedure of Eschenmoser, *et al.*,[19] 0.3469 g. (0.002 mole) of methyl laurolenate (95–97% pure) was boiled under reflux with 2.4739 g. (0.013 mole) of lithium iodide trihydrate[22] in 40 ml. of 2,4,6-collidine. After 8 hr. the mixture was cooled and poured into a mixture of ether–chloroform (2:1) and ice-cold 0.5 *N* hydrochloric acid; the acid phase was washed thoroughly with 2:1 ether–chloroform. The combined organic solutions were washed with 2 *N* hydrochloric acid until collidine was completely removed, dried over sodium sulfate, and evaporated to leave 0.3350 g. (100%) of crude laurolenic acid as a dark liquid. Distillation afforded the pure *dl*-acid: b.p. 75° (0.7 mm.); $n^{27}\text{D}$ 1.4717; $\lambda_{\max}^{\text{CHCl}_3}$ 2.8 (broad), 5.9 μ; n.m.r. (CCl_4) τ 8.38 (broad peak, 6 protons) and 8.77 (s).

Anal. Calcd. for $C_9H_{14}O_2$: C, 70.10; H, 9.15. Found (M): C, 70.34; H, 8.70.

Infrared and n.m.r. spectra of this sample were identical with those of material derived from *d*-α-bromocamphoric anhydride by the procedure of Aschan.[2] Spectra of the naturally derived methyl ester, prepared from the acid with diazomethane, were identical with the synthetic ester described above.

Bromo Lactone of *dl*-**Laurolenic Acid** (12).—To 0.2156 g. (0.0014 mole) of *dl*-laurolenic acid, b.p. 75° (0.7 mm.), in 2 ml. of chloroform was added 0.2156 g. (0.0014 mole) of bromine in 0.5 ml. of chloroform. After 1 hr. the solvent was evaporated under nitrogen to leave 0.3642 g. (89%) of a semisolid. This was taken up in 25 ml. of ether and washed with 35 ml. of 15% sodium carbonate solution, the ether solution was dried over sodium sulfate, and ether was evaporated to afford 0.2759 g. (69%) of colorless pointed needles which tended to turn black on standing. Sublimation gave a pure *dl*-bromo lactone (12) as white rosettes: m.p. 193–194°; $\lambda_{\max}^{\text{CHCl}_3}$ 5.58 μ; n.m.r. τ ($CDCl_3$) 8.38 (s), 8.50 (s), and 8.77 (s).

Anal. Calcd. for $C_9H_{13}BrO_2$: C, 46.36; H, 5.62; Br, 34.28. Found (B): C, 46.70; H, 5.65; Br, 34.10.

Infrared and n.m.r. spectra of this sample were identical with those of authentic *d*-bromo lactone, m.p. 193–194° (lit. m.p. 187°,[2,9] 194°[23]), prepared in the same manner from *d*-laurolenic acid.

Amide of *dl*-**Laurolenic Acid**.—The procedure is a modification of that of Noyes and Burke.[9] To 0.0776 g. (0.00050 mole) of ice-cold *dl*-laurolenic acid, b.p. 75° (0.7 mm.), was added 0.105 g. (0.00050 mole) of phosphorous pentachloride. After the vigorous reaction had subsided, 2–3 ml. of 30–60° petroleum ether followed by 3–4 ml. of ammonium hydroxide were added and the mixture was allowed to stand at room temperature for 1.5–2 hr. The mixture was extracted with ether and the ether solution was dried over sodium sulfate. Removal of ether afforded 0.0451 g. (58%) of a white solid which was sublimed to yield white needles of the amide: m.p. 71–72°; $\lambda_{\max}^{\text{CHCl}_3}$ 2.83, 2.92, 5.98, 6.01, 6.36 μ; n.m.r. ($CDCl_3$) τ 8.33 (broad), 8.42 (broad), and 8.77 (s).

Anal. Calcd. for $C_9H_{15}NO$: C, 70.55; H, 9.87; N, 9.14. Found (B): C, 70.27; H, 9.65; N, 9.35.

Infrared and n.m.r. spectra of this sample were identical with those of an authentic sample of *d*-laurolenamide, m.p. 71–72° (lit.[2,9] m.p. 71–72°), prepared in the same manner.

Acknowledgment.—We are grateful to the National Science Foundation for a grant (GB-1606) in partial support of this work, and to the agencies mentioned in footnote 1 for scholarship support.

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[22] Anhydrous lithium iodide served equally well.

[23] G. S. Skinner, *J. Am. Chem. Soc.*, **45**, 1498 (1923).

The Synthesis of N-Benzylthieno[2,3-*b*]pyrrole[1,2]

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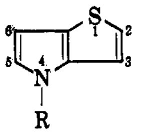
Received July 1, 1964

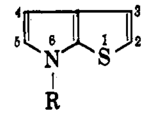
The synthesis of N-benzylthieno[2,3-*b*]pyrrole has been accomplished. Thiocyanation of diethyl 1-benzylpyrrole-3,4-dicarboxylate with thiocyanogen chloride gave diethyl 1-benzyl-2-thiocyanopyrrole-3,4-dicarboxylate. The thiocyanopyrrole was converted by reduction with sodium borohydride and alkylation with ethyl bromoacetate to ethyl (1-benzyl-3,4-dicarbethoxy-2-pyrrolylthio)acetate. Dieckmann ring closure of the pyrrolylthioacetate furnished diethyl 6-benzylthieno[2,3-*b*]pyrrole-2,4-dicarboxylate. The thienopyrrole diester was converted by hydrolysis, decarboxylation, and reduction to 6-benzylthieno[2,3-*b*]pyrrole-4-carboxylic acid. The thienopyrrole acid underwent decarboxylation at 200–220° in an evacuated, sealed tube to give N-benzylthieno[2,3-*b*]pyrrole.

Interest in the synthesis of isoteres of indole has led to the preparation of thieno[3,2-*b*]pyrrole (I)[4] and its N-benzyl derivative II.[5] The isomeric thieno[2,3-*b*]pyrrole (III) is not known. The synthesis of the N-benzyl analog of III, 6-benzylthieno[2,3-*b*]pyrrole (IV), has now been accomplished and is described herein.

Diethyl 1-benzylpyrrole-3,4-dicarboxylate (V) was prepared by the condensation of diethyl 1-formyl-2-diethoxymethylsuccinate[6] with benzylamine according to the procedure of Kornfeld and Jones.[6] Hydrolysis of the pyrrole diester V gave the known diacid.[7] The pyrrole diester V was converted by thiocyanation with thiocyanogen chloride[8] in acetic acid to the thiocyanopyrrole VI. The infrared spectrum of VI had a band at 2160 cm.$^{-1}$ due to the thiocyano group, while the n.m.r. spectrum showed the ethyl ester groups to be nonequivalent, establishing that substitution had occurred in the pyrrole ring.



I, R = H
II, R = $CH_2C_6H_5$



III, R = H
IV, R = $CH_2C_6H_5$

Lithium aluminum hydride is known to reduce thiocyanates to mercaptans.[9] It was found that sodium borohydride also effects this reaction. The thiocyanopyrrole VI was converted to the pyrrolylthioacetate VII by reduction of the thiocyano group with sodium borohydride followed by alkylation of the resulting thiol anion with ethyl bromoacetate. The n.m.r. spectrum was in accord with the proposed structure; in

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[1] Abstracted from a portion of the thesis submitted by R. K. Olsen to the Graduate College of the University of Illinois in partial fulfillment of the requirements for the degree of Doctor of Philosophy, Oct. 1964.

[2] Supported in part by a research grant (C 3969-Bio) from the National Cancer Institute, U. S. Public Health Service.

[3] National Science Foundation Fellow, 1962-1963. U. S. Public Health Service Fellow, 1963-1964.

[4] D. S. Matteson and H. R. Snyder, *J. Org. Chem.*, **22**, 1500 (1957).

[5] A. D. Josey, R. J. Tuite, and H. R. Snyder, *J. Am. Chem. Soc.*, **82**, 1597 (1960).

[6] E. C. Kornfeld and R. G. Jones, *J. Org. Chem.*, **19**, 1671 (1954).

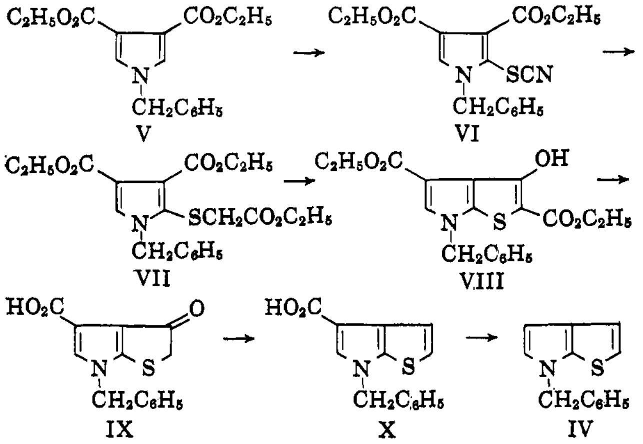
[7] L. Mandell and W. A. Blanchard, *J. Am. Chem. Soc.*, **79**, 6198 (1957).

[8] R. G. R. Bacon and R. G. Guy, *J. Chem. Soc.*, 318 (1960).

[9] J. Strating and H. J. Backer, *Rec. trav. chim.*, **69**, 638 (1950).

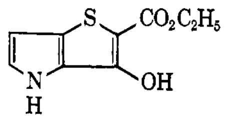
particular, the thiomethylene protons appeared as a singlet at τ 6.45.

The pyrrolylthioacetate VII underwent Diekmann ring closure when heated at reflux with sodium hydride in benzene to furnish diethyl 6-benzyl-3-hydroxythieno-[2,3-*b*]pyrrole-2,4-dicarboxylate (VIII). The spectral data are in agreement with the structural assignment. The infrared spectrum shows hydroxyl absorption at 3200 cm.$^{-1}$, while the carbonyl region has two bands at 1695 and 1652 cm.$^{-1}$. The analogous thieno[3,2-*b*]-pyrrole XI has a band at 1642 cm.$^{-1}$ in its infrared spectrum.[10] The n.m.r. spectrum of VIII in deuteriochloroform has a sharp singlet at τ -0.43 assigned to the hydroxyl proton. The hydroxyl proton in XI appears at -0.77 which is in the same region as the corresponding peak in the spectrum of methyl salicylate.[10] The remainder of the n.m.r. spectrum was also consistent with the structure VIII, showing a singlet at τ 2.52 assigned to the 5-hydrogen, a multiplet at 2.74 due to the phenyl group, a singlet at 4.95 for the two benzyl hydrogens, and multiplets at 5.68 and 8.65 assigned to the ethyl ester hydrogens. The thienopyrrole VIII exists in solution as the monomer as was shown by a molecular weight determination. This is in contrast to the thieno[3,2-*b*]pyrrole XI and its N-carbethoxy derivative, both of which exist as dimers.[10]

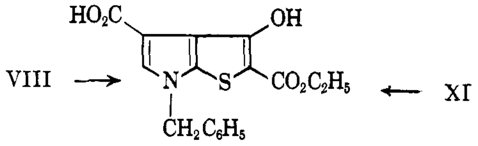


When the thienopyrrole diester VIII was dissolved in concentrated sulfuric acid and allowed to stand at room temperature for 18 hr., hydrolysis and decarboxylation occurred to give the keto acid IX. The infrared spectrum had two bands in the carbonyl region at 1725 and 1635 cm.$^{-1}$. The n.m.r. spectrum of IX in dimethyl sulfoxide showed the 5-hydrogen as a singlet at τ 2.15, the phenyl hydrogens as a singlet at 2.65, and the benzylic and methylene hydrogens as singlets at 4.83 and 5.79, respectively.

That no rearrangement had occurred during the reaction of the thienopyrrole diester VIII in concentrated sulfuric acid was established by the subsequent conversion of the keto acid IX to a compound isomeric with the known N-benzylthieno[3,2-*b*]pyrrole (II). Further evidence was obtained by conversion of the keto acid IX to the monoacid–monoester XII by carbethoxylation with diethyl carbonate and sodium ethoxide.[10] The same monoacid–monoester was obtained from the thienopyrrole diester VIII upon basic hydrolysis.



IX



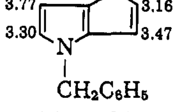
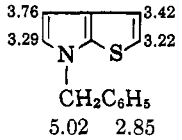
XII

Sodium borohydride reduction of the keto acid IX gave N-benzylthieno[2,3-*b*]pyrrole-4-carboxylic acid (X). The infrared spectrum of the thienopyrrole acid X had only one band in the carbonyl region at 1655 cm.$^{-1}$. In the n.m.r. spectrum in deuteriochloroform the 3-hydrogen appeared as a doublet (J = 5.5 c.p.s.) at τ 3.06, the 5-hydrogen as a singlet at 2.30, while the 2-hydrogen occurred at 2.57 with half of the doublet lying under the phenyl multiplet at 2.67. The remaining peaks at τ -0.60 and 4.83 were assigned to the hydroxyl and benzyl hydrogens, respectively.

The thienopyrrole acid X was decarboxylated by heating at 200–220° in an evacuated, sealed tube[11] to give N-benzylthieno[2,3-*b*]pyrrole (IV). The thienopyrrole IV exists as a clear liquid and appears to be stable to light and air. The infrared spectrum of IV has no absorption in the carbonyl region. The n.m.r. spectrum provides convincing evidence for the structural assignment. The phenyl peak occurs as a multiplet at τ 2.85, the thienopyrrole ring protons occur in a complex pattern from 3.22 to 3.76, and the benzyl hydrogens occur as a singlet at 5.02. When the aromatic region of the n.m.r. spectrum is expanded, it is possible to assign the chemical shifts and coupling constants of the thienopyrrole hydrogens. These assignments are listed in Table 1.

TABLE 1

VALUES OF THE CHEMICAL SHIFTS AND COUPLING CONSTANTS OF THE TWO ISOMERIC N-BENZYLTHIENOPYRROLES

	
4.95 2.85	5.02 2.85
J_{23} = 5.3 c.p.s.	J_{23} = 5.4 c.ps.
J_{56} = 3.0 c.p.s.	J_{45} = 3.0 c.p.s.
J_{25} = 1.3 c.p.s.	J_{35} = 1.0 c.p.s.
J_{36} = 0.6 c.p.s.	$J_{24} \cong 0$

The physical properties of the two isomeric N-benzylthienopyrroles differ enough to establish their nonidentity. The thienopyrrole IV exists as a liquid, while II is a solid melting at 48–51°.[5] The infrared spectra (10% in chloroform) of the two isomers are different. The n.m.r. spectra (15% in carbon disulfide), while similar, differed enough so as to leave no doubt of their nonidentity (Table 1).

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[10] W. Carpenter and H. R. Snyder, *J. Am. Chem. Soc.*, **82**, 2592 (1960).

[11] H. R. Snyder, L. A. Carpino, J. F. Zack, Jr., and J. F. Mills, *ibid.*, **79**, 2556 (1957).

Experimental[12]

Diethyl 1-Benzylpyrrole-3,4-dicarboxylate (V).—Freshly prepared diethyl 1-formyl-2-diethoxymethylsuccinate[6] (31.2 g., 0.103 mole) was dissolved in 25 ml. of absolute ether in a 100-ml., round-bottomed flask. A solution of benzylamine (11.1 g., 0.104 mole) in 10 ml. of absolute ethanol was added in small portions. The reaction mixture was allowed to stand at room temperature for 15 min. with occasional swirling. The solvent was removed under reduced pressure on a steam bath and the viscous oil which remained was allowed to cool. The oil was added to 34 ml. of cooled, concentrated sulfuric acid at a rate so as to maintain the temperature between 40–45°. The mixture was allowed to stand for 5 min. at 40° and then poured onto an excess of crushed ice. The yellow organic layer which separated was extracted with three portions of methylene chloride. The combined extracts were washed once each with 10% sodium bicarbonate and water, and were dried over magnesium sulfate. The drying agent was filtered and the solvent was removed under vacuum on a steam bath. The yellow liquid obtained was distilled as follows. Low-boiling material (b.p. 100–105°) was distilled through a 6-in. Vigreux column. When the temperature of the Wood's metal bath, which was used as the source of heat, had reached 240°, it was removed and the distillation pot was allowed to cool. The Vigreux column and water condenser were replaced with a Claisen head, adapter, and receiving flask. The distillation was continued and the dark yellow, viscous liquid boiling at 200–215° (0.5 mm.) was collected (14.7 g., 48%). Further purification by chromatography of the oil on a short column of neutral alumina and elution with methylene chloride appeared to improve the quality of the thiocyanation product in the next step. Spectral data: $\nu_{\max}^{\text{Nujol}}$ 1710, 765, and 710 cm.$^{-1}$; n.m.r. (CCl_4) τ 2.8 (multiplet, aromatic protons), 5.18 (singlet, benzylic protons), and 5.86 and 8.77 (quartet and triplet, ethyl group protons); $\lambda_{\max}$ 250 mμ (ϵ 9030), $\lambda_{\min}$ 230 mμ (ϵ 6540).

1-Benzylpyrrole-3,4-dicarboxylic Acid.—The pyrrole diester V (0.44 g., 1.8 mmoles) in a solution of 85% potassium hydroxide (0.4 g., 10 mmoles) in 4.5 ml. of water and 4 ml. of ethanol was stirred at room temperature for 18 hr. The ester was initially insoluble, but dissolved during the course of the reaction. The clear, yellow solution was acidified with 1:1 hydrochloric acid, whereupon a gelatinous, white solid formed. The mixture was cooled in a refrigerator for 1.5 hr., filtered, washed with water, and air dried. There was obtained 0.29 g. (81%) of a white solid, m.p. 204–209° dec. An analytical sample was prepared by four recrystallizations from methanol–water, m.p. 212–214° (lit.[7] m.p. 216–218° dec.[7]).

Anal. Calcd. for $C_{13}H_{11}NO_4$: C, 63.66; H, 4.52; N, 5.71. Found: C, 63.50; H, 4.54; N, 5.81.

Diethyl 1-Benzyl-2-thiocyanopyrrole-3,4-dicarboxylate (VI).—A solution of thiocyanogen chloride[8] was prepared by adding potassium thiocyanate (5.22 g., 53.7 mmoles) in one portion to a solution of chlorine (3.7 g., 52 mmoles) in 300 ml. of acetic acid (dried by refluxing with a few milliliters of acetic anhydride) and stirring for 0.5 hr. at room temperature. Diethyl 1-benzylpyrrole-3,4-dicarboxylate (V, 14.7 g., 49 mmoles) in 20 ml. of acetic acid was added in one portion and the reaction mixture was stirred at room temperature for 10 hr. The yellow solution containing dispersed potassium chloride was poured into 1500 ml. of cold water. The mixture was allowed to stand in the refrigerator overnight; the solid was filtered, washed with water, and allowed to air dry. There was obtained 14.5 g. (83%) of crude product, m.p. 66–70°. The solid was dissolved in an excess of ether and treated with Darco, the volume was reduced, and the solution was cooled in a refrigerator. There was obtained 10.8 g. (62%) of yellow crystals, m.p. 72.5–75°. Spectral data: $\nu_{\max}^{\text{KBr}}$ 2160, 1715, and 1695 cm.$^{-1}$; n.m.r. (CCl_4) τ 2.70 (multiplet, aromatic protons), 4.72 (singlet, benzylic protons), and 5.73 and 8.70 (multiplets, ethyl group protons). An analytical sample was prepared by two more recrystallizations from ether, m.p.. 73–75°.

Anal. Calcd. for $C_{18}H_{18}N_2O_4S$: C, 60.32; H, 5.06; N, 7.82. Found: C, 60.32; H, 5.23; N, 8.05.

Ethyl (1-Benzyl-3,4-dicarbethoxy-2-pyrrolylthio)acetate (VII).—The reaction was carried out in a well-ventilated hood. Diethyl 1-benzyl-2-thiocyanopyrrole-3,4-dicarboxylate (VI, 8.8 g., 24.5 mmoles) was dissolved in 130 ml. of absolute ethanol under nitrogen. Sodium borohydride (1.02 g., 26.4 mmoles) was added in portions over a period of 10 min. The solution changed color from yellow to red during the addition. A liquid was observed to reflux in the condenser during the addition of the sodium borohydride; hydrogen cyanide boils at 26°. The reaction mixture was stirred at room temperature for 10 min. and then heated at gentle reflux for 15 min. To the cooled reaction mixture was added over a period of 1 min. a solution of 85% potassium hydroxide (1.6 g., 24.9 mmoles) in 30 ml. of absolute ethanol. After stirring about 1 min., a solution of ethyl bromoacetate (4.58 g., 27.0 mmoles) in 12 ml. of absolute ethanol was added dropwise to the reaction mixture. Potassium bromide rapidly precipitated. The mixture was stirred for 15 min. and then was heated at gentle reflux for 45 min. It was then allowed to cool and was stirred for 3 hr. A solution of 300 ml. of saturated sodium chloride solution and 100 ml. of water was added and the mixture was extracted with seven 200-ml. portions of pentane. The combined pentane extracts were dried over magnesium sulfate and concentrated. The light yellow oil that was obtained was taken up in methylene chloride and transferred to a 50-ml., round-bottomed flask. The methylene chloride was removed on a steam bath. The oil that remained was heated on a steam bath under reduced pressure for 45 min. to remove low-boiling materials. The yellow oil obtained (9.7 g., 94%) was pure enough to be used in the subsequent reaction. Spectral data: $\nu_{\max}^{CHCl_3}$ 1710 cm.$^{-1}$; n.m.r. ($CDCl_3$) τ 2.7 (multiplet, aromatic protons), 4.63 (singlet, benzylic protons), 6.45 (singlet, thiomethylene protons), and 5.75 and 8.70 (multiplets, ethyl group protons).

Diethyl 6-Benzyl-3-hydroxythieno[2,3-*b*]pyrrole-2,4-dicarboxylate (VIII).—To a stirred suspension of sodium hydride (1.28 g. of a 52% dispersion in mineral oil, 27.8 mmoles) in 75 ml. of benzene under nitrogen was added over a period of 20 min. a solution of the pyrrolylthioacetate VII (10.6 g., 25.3 mmoles) in 30 ml. of benzene. The reaction mixture was stirred at room temperature for 20 min. and then heated under gentle reflux for 4 hr. To the red-brown mixture was added dropwise 50 ml. of 5 *M* sulfuric acid. The aqueous phase was extracted with three portions of benzene, and the combined benzene extracts were dried over magnesium sulfate. Filtration and concentration under reduced pressure yielded 8.8 g. of crude, yellow solid. One recrystallization from 95% ethanol gave 7.6 g. (81%) of tan crystals, m.p. 111–114°. An analytical sample was prepared by three recrystallizations from benzene–petroleum ether (b.p. 30–60°), m.p. 114.5–115°. Ultraviolet spectrum: $\lambda_{\max}$ 298 mμ (ϵ 17,100) and 262 mμ (ϵ 8400), $\lambda_{\min}$ 276 mμ (ϵ 7000) and 235 mμ (ϵ 4430).

Anal. Calcd. for $C_{19}H_{19}NO_5S$: C, 61.10; H, 5.13; N, 3.75. Found: C, 61.24; H, 5.11; N, 3.66.

6-Benzyl-3-oxo-2H,3H-thieno[2,3-*b*]pyrrole-4-carboxylic Acid (IX).—The thienopyrrole diester VIII (1.103 g., 2.95 mmoles) was dissolved in 8 ml. of concentrated sulfuric acid and the reaction mixture was allowed to stand for 18 hr. The acid solution was added dropwise to a vigorously stirred mixture of 120 ml. of ice and water. A pink solid formed immediately when the acid solution was added. The mixture was cooled for 0.5 hr. in an ice bath. The solid was filtered on a hard-surfaced filter paper (no. 50) and washed with cold water. The sticky solid was transferred to a flask and recrystallized twice from 95% ethanol. There was obtained 0.342 g. (43%) of tan crystals, m.p. 178–180°. The filtrate from the first recrystallization yielded an orange solid (63 mg.), which after one recrystallization from chloroform melted at 188–190°. The n.m.r. spectrum of this material showed the presence of an ethyl ester group. An analytical sample of the keto acid IX was prepared by two recrystallizations from 95% ethanol, m.p. 181–182°. Ultraviolet spectrum: $\lambda_{\max}$ 322 mμ (ϵ 6180) and 238 mμ (ϵ 8100), $\lambda_{\min}$ 277 mμ (ϵ 728) and 226 mμ (ϵ 5460).

Anal. Calcd. for $C_{14}H_{11}NO_3S$: C, 61.52; H, 4.06; N, 5.12. Found: C, 61.59; H, 4.06; N, 4.99.

6-Benzyl-2-carbethoxy-3-hydroxythieno[2,3-*b*]pyrrole-4-carboxylic Acid (XII).—The thienopyrrole diester VIII (0.576 g., 1.55 mmoles) was heated at reflux for 3 hr. in a solution of 6.7 ml. of 0.25 *M* potassium hydroxide (1.67 mmoles), 5.5 ml. of

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[12] All melting points are uncorrected. The spectra were determined by Mr. D. H. Johnson and his associates. The infrared spectra were determined with either a Perkin-Elmer Model 21 or a Perkin-Elmer Model 521 spectrometer. All n.m.r. spectra were measured with a Varian A-60 high-resolution spectrometer. The chemical shifts are expressed in τ-units relative to tetramethylsilane as an internal standard. The ultraviolet spectra were determined with a Cary Model 14M spectrometer with 95% ethanol as solvent. The microanalyses were performed by Mr. Josef Nemeth and his associates.

water, and 11 ml. of ethanol. While the reaction mixture was still hot, about one-half of the solvent was removed under reduced pressure. Upon cooling, a pink solid (59 mg.) formed and was collected by filtration. This solid was taken up in ethanol, a few drops of 1:1 hydrochloric acid were added to dissolve the solid (a potassium salt), and the solution was cooled to give recovered diester VIII. The cooled filtrate was acidified to pH 5 with 85% phosphoric acid, whereupon a yellow solid precipitated. The solid was filtered, washed with water, and dried in a vacuum desiccator over Drierite. There was obtained 0.442 g. of a pink solid. The solid was taken up in 95% ethanol containing 10 drops of 1:1 hydrochloric acid, heated until most of the solid had dissolved, and filtered, and the volume was concentrated. Upon cooling, 0.386 g. of yellow crystals formed, m.p. 195–200°. The yield was 82% based on the diester VIII consumed. The use of a sixfold excess of base gave the same acid. An analytical sample was prepared by two recrystallizations from 95% ethanol, m.p. 197–199°.

Anal. Calcd. for $C_{17}H_{15}NO_5S$: C, 59.12; H, 4.38; N, 4.06. Found: C, 59.06; H, 4.22; N, 4.04.

Carbethoxylation of 6-Benzyl-3-oxo-2H,3H-thieno[2,3-*b*]pyrrole-4-carboxylic Acid (IX).—The keto acid IX (96 mg., 0.36 mmole) was heated under a nitrogen atmosphere in 12 ml. of diethyl carbonate. After 2 ml. of diethyl carbonate had been distilled, a solution of sodium ethoxide (1.06 mmoles) in 3 ml. of absolute ethanol was added. Eight milliliters of condensate was collected by slow distillation over a period of 1.5 hr. The reaction mixture was cooled under a stream of nitrogen. To the mixture was added 5 ml. of water and 5 ml. of methylene chloride. The aqueous phase was acidified with 1:1 hydrochloric acid and extracted with methylene chloride. The methylene chloride extract yielded some orange solid. The solid was recrystallized from 95% ethanol to give recovered keto acid IX, m.p. 177–180°. The infrared spectrum was superimposable upon that of an authentic sample of IX. The mother liquor yielded a few milligrams of the monoacid–monoester XII. The material was recrystallized twice from ethanol and once from chloroform, m.p. 192–197°. The identity of the material with XII was established by a mixture melting point and by comparison of the infrared spectra.

6-Benzylthieno[2,3-*b*]pyrrole-4-carboxylic Acid (X).—The keto acid IX (0.178 g., 0.65 mmole) was suspended in 10 ml. of absolute ethanol. The ethanolic suspension was flushed out with nitrogen. Sodium borohydride (78.5 mg., 2.1 mmoles) was added in portions to the suspension over a period of about 45 min. When the evolution of gas had ceased, the flask was filled with nitrogen, stoppered, and allowed to stand for 16 hr. The reaction mixture was gently warmed on a steam bath for 25 min., 10 mg. of sodium borohydride was added, and the mixture was warmed for 20 min. Upon cooling, the mixture was poured into a solution of 30 ml. of cold water and 0.38 ml. of glacial acetic acid. The aqueous phase was extracted with four portions of methylene chloride. The combined methylene chloride extracts were washed once with saturated sodium chloride solution and dried over magnesium sulfate. The drying agent was filtered and the solvent was removed under reduced pressure on a steam bath. An oil was obtained which slowly solidified upon cooling under a stream of nitrogen. There was obtained 0.162 g. of tan crystals. A n.m.r. spectrum of this material indicated that about 10% of unreduced keto acid IX was present. Two recrystallizations from methylene chloride–benzene gave 0.115 g. (75%) of tan crystals, m.p. 158–160°. Ultraviolet spectrum: λ_{max} 267 mμ (ϵ 14,500) and 232 mμ (ϵ 9900), λ_{min} 243 mμ (ϵ 7900) and 223 mμ (ϵ 9360). An analytical sample was prepared by two recrystallizations from methylene chloride, m.p. 161–162°.

Anal. Calcd. for $C_{14}H_{11}NO_2S$: C, 65.36; H, 4.31; N, 5.44. Found: C, 65.12; H, 4.19; N, 5.40.

6-Benzylthieno[2,3-*b*]pyrrole (IV).—The thienopyrrole acid X (82 mg., 0.32 mmole) was placed in a 30 mm. × 15 cm. tube whch had a break-seal side arm near the neck of the tube. The acid was dissolved in methylene chloride and the tube was rotated at an angle while the solvent was evaporated under a stream of nitrogen to cause the acid to be deposited as a thin layer on the lower inside surface of the tube. The tube was evacuated for 45 min. on a vacuum line at 10^{-4} mm. and sealed.[13] The portion of the tube which contained the solid was immersed in an oil bath heated at 200° and the temperature was raised to 220° over a period of 60 min. and held at this temperature for 30 min. Upon cooling, the tube contained some yellow oil in the bottom and some clear oil on the sides. The carbon dioxide formed was measured on the vacuum line and was determined to be 0.22 mmole (69%). The tube was rinsed with carbon disulfide. The carbon disulfide solution was evaporated on a steam bath to give a light yellow oil. The oil was heated at 80° (0.1 mm.) in a sublimation apparatus. A clear liquid (35 mg., 52%) collected on the cold finger. Analysis and n.m.r. measurements (described in the introduction) indicated the liquid to be pure 6-benzylthieno[2,3-*b*]pyrrole. Ultraviolet spectrum (95% EtOH): λ_{max} 250 mμ (ϵ 9800), shoulder, increasing absorption from 245 to 210 mμ. The isomer[5] II has λ_{max} 267 mμ (ϵ 12,000) and 334 mμ (ϵ 1320), λ_{min} 237 mμ (ϵ 5625).

Anal. Calcd. for $C_{13}H_{11}NS$: C, 73.19; H, 5.28; N, 6.56. Found: C, 73.12; H, 5.38; N, 6.76.

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(13) Appreciation is expressed to Professor R. F. Nystrom for assistance in carrying out this reaction.

The Formation of Methyl Thio Ethers in the Reaction of Thiocyanates with Methanol[1,2]

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Received August 10, 1964

The reaction of diethyl 1-benzyl-2-thiocyanopyrrole-3,4-dicarboxylate with aqueous methanolic potassium hydroxide in the presence of ethyl bromoacetate gives diethyl 1-benzyl-2-methylthiopyrrole-3,4-dicarboxylate instead of the expected product, ethyl (1-benzyl-3,4-dicarbethoxy-2-pyrrolylthio)acetate. The methyl thio ether was also the major product when the reaction was carried out in the absence of ethyl bromoacetate. The scope of this unusual alkylation reaction is investigated. Methyl 2-thiocyanobenzoate and methyl 4-thiocyanobenzoate each give the corresponding methyl thio ether in approximately 50% yield upon treatment with aqueous methanolic potassium hydroxide. Under the same reaction conditions, no thio ether is formed from either thiocyanomesitylene or *n*-butyl thiocyanate.

In the course of another investigation[4] the surprising observation was made that replacement of the cyano group by methyl occurred when the thiocyanopyrrole I was treated with aqueous methanolic potassium hydroxide and ethyl bromoacetate. The reaction was carried out in the anticipation that the thiocyano group of I would be hydrolyzed to the thiol, the anion

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(1) Abstracted from a portion of the thesis submitted by R. K. Olsen to the Graduate College of the University of Illinois in partial fulfillment of the requirements for the degree of Doctor of Philosophy, Oct. 1964.

(2) Supported in part by a research grant (C 3969-Bio) from the National Cancer Institute, U. S. Public Health Service.

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(4) R. K. Olsen and H. R. Snyder, *J. Org. Chem.*, **29**, 184 (1964).