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Studies on Indole Derivatives. XVI.[1] Synthesis of Indoxyl Derivatives. (2).[1] Reactions of 1-Acetyl-3-indolinone with Ketenethioacetal Derivatives

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Reaction of 1-acetyl-3-indolinone (1-acetylindoxyl) and ketenethioacetals, in the presence of sodium hydride, afforded 2-vinylindole derivatives (II, X) substituted with a methylthio group, accompanied with (3H)-pyrrolo[1,2-*a*]indol-3-one derivative (III). Treatment of II with hydrochloric acid or triethylamine gave cyclized products, pyrano-[3,2-*b*]indole derivatives and (3H)-pyrrolo[1,2-*a*]indol-3-one derivatives.

Infrared studies by Holt[3] have led to the conclusion that 1-acetyl-3-indolinone (1) exists entirely as the ketonic tautomer in preference to the enolic 1-acetyl-3-hydroxyindole structure. Derivatives of 3-indolinone are expected to be especially reactive to base-catalyzed reactions since abstraction of a proton from the neutral ketone is favored by the additional resonance energy of the aromatic enolate. The expectation of high reactivity at α-position is borne out by considerable chemical evidences. While base-catalyzed alkylation of 3-indolinone with methyl sulfate gives 3-methoxyindole, alkylation with excess methyl iodide gives 2,2-dimethylindolin-3-one.[4] The ketonic character of indoxyl is shown in reactions involving the condensation of active methylene group with carbonyl group of aromatic aldehydes or of ketonic acid which condense easily to yield indogenides.[5] Julian[6] summarized the early work on base-catalyzed alkylation and condensation reactions of 3-indolinone and derivatives.

It is well known that methylthio group in ketenethioacetal derivatives (a, b) undergo rapid substitution with some nucleophilic reagents to give the corresponding substitution products. We have reported earlier that the reaction of oxidole[7] and indole[8,9] derivatives with some ketenethioacetals afford 2-methylthio-2-(3-oxindolyl)acrylic acid and 3-(2-cyano-1-methylthiovinyl)indole derivatives in the presence of sodium hydride as a base. The present paper deals with the reaction between 1-acetyl-3-indolinone and some ketenethioacetals as electrophilic reagents, together with cyclization of the reaction products.

Reaction of 1-acetyl-3-indolinone (I) with methyl 1-cyano-2,2-bismethylthioacrylate (a) occured in the presence of 1 mole of sodium hydride or 2 moles of potassium carbonate and 1-acetyl-2-(2-cyano-2-methoxycarbonyl-1-methylthiovinyl)-3-hyroxyindole (II) was obtained as yellow crystals, mp 160—161°, in 80% yield. The infrared (IR) spectrum of II showed the absorptions at 3240 cm^{-1} due to hydroxyl group, at 2210 cm^{-1} due to cyano group, and at 1710 cm^{-1} due to carbonyl group. When excess of sodium hydride was used,

1) Part XV: Y. Tominaga, C. Tamura, T. Hata, S. Sato, R. Natsuki, Y. Matsuda, and G. Kobayashi, *Chem. Pharm. Bull.* (Tokyo), **21**, 1651 (1973).
2) Location: *1-14 Bunkyo-machi, Nagasaki, 852, Japan.*
3) S.J. Holt, A.E. Kellie, D.G. Osullivan, and P.W. Sadler, *J. Chem. Soc.*, **1958**, 1217.
4) A. Etienne, *Bull. Soc. Chim. France*, **1948**, 651.
5) A. Baeyer, *Chem. Ber.*, **16**, 2196 (1883); A.G. Perkin and F. Thomas, *J. Chem. Soc.*, **95**, 795 (1909).
6) P.L. Julian, E.W. Meyer, and H.C. Printy, "Heterocyclic Compounds," (ed, R.C. Elderfield), Vol. 3, 186, John Wiley, New York, 1952.
7) G. Kobayashi, S. Furukawa, Y. Matsuda, M. Nakamura, and R. Natsuki, *Yakugaku Zasshi*, **87**, 1044 (1967).
8) G. Kobayashi, S. Furukawa, Y. Matsuda, and Y. Washida, *Chem. Pharm. Bull.* (Tokyo), **15**, 1871 (1967).
9) G. Kobayashi, Y. Matsuda, R. Natsuki, and Y. Tominaga, *Yakugaku Zasshi*, **92**, 1468 (1972).

the above reaction did not give II, but afforded a yellow product, mp 305°, in 90% yield. This product is soluble in 10% sodium hydroxide solution and elemental analysis corresponded to $C_{13}H_8O_2N_2S$ (*m/e* 256). The IR spectrum of III showed the absorptions at 3200 cm^{-1} due to OH, a cyano band at 2210 cm^{-1}, and a carbonyl band at 1710 cm^{-1}. The ultraviolet (UV) spectrum of III revealed maxima at 253 (ε=4.26) and 342 mμ (ε=3.96) and the nuclear magnetic resonance (NMR) spectrum of III exhibited three-proton singlet at 3.12 ppm assingnable to a methyl proton of methylthio group. From these spectroscopic data and elemental analysis, this compound, III, was found to be a cyclized product, 2-cyano-9-hydroxy-1-methylthio-(3H)-pyrrolo[1,2-*a*]indol-3-one (III).

Heating of compound II at 180—200° gave 5-acetyl-3-cyano-4-methylthiopyrano[3,2-*b*]-indol-2-one (IV) in a good yield. Deacetylation of IV with 10% hydrochloric acid gave a yellow crystalline powder (V), $C_{13}H_8O_2N_2S$ (*m/e* 256), mp 288°, in 80% yield. The IR spectrum of IV showed absorptions at 3250 tm^{-1} due to NH, cyano band at 2210 cm^{-1}, and a carbonyl band of α-pyrone ring system at 1660 cm^{-1}. Its UV spectrum revealed maxima at 256 (ε=3.95), 325 (ε=4.10), and 385 mμ (ε=4.22), which are similar to 3-cyano-4-methylthiopyrano[2,3-*b*]indol-2-one.[7] These results supported the fact that formula III is the correct structure. V was also obtained by treatment of II with 10% hydrchloric acid in methanol under refluxing.

Treatment of II with 10% hydrochloric acid in methanol at room temperature did not give V, but gave a crystalline powder (VI), which was explained by the addition of methanol to the triple bond of cyano group. Thus, the structure of VI which has an iminoether, was indicated by its NMR spectrum, which revealed the newly appeared methoxyl signal at 3.69 ppm (3H, singlet, OCH_3). The IR spectrum of V did not show the absorption of a cyano group at 2240 cm^{-1} present in II, and its UV spectrum was similar to that of the parent compound (II). The NMR and IR spectra of II and VI are shown in Fig. 1 and 2. Hydrosis of VI with hydrochloric acid in methanol under refluxing gave a red crystalline powder (VII),

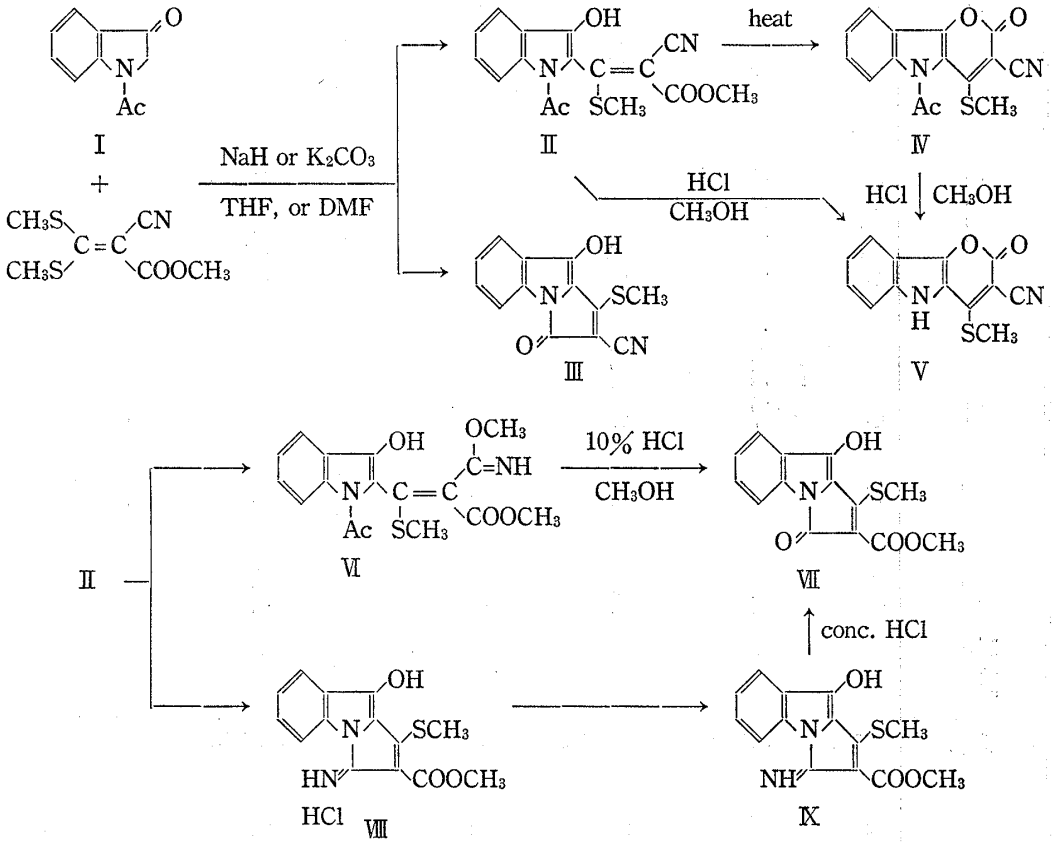
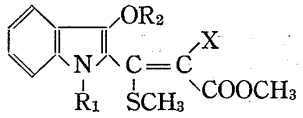


Chart 1

TABLE I.



	mp (°C)	Yield (%)	R_1	R_2	X	Formula	Analysis (%) Calcd. C	Calcd. H	Calcd. N	Found C	Found H	Found N		NMP ppm	IR(KBr) cm^{-1}	UV λ_{max}^{EtOH} mμ (log ε)
II	160–161	95	Ac[a]	H	CN	$C_{16}H_{14}O_4N_2S$	58.18	4.27	8.48	57.72	4.42	8.34	©	C-CH_3 2.30 (O); SCH_3 2.60; OCH_3 3.90	OH 3240; CN 2240; CO 1690, 1622	321 (4.20)
VI	199–200	65	Ac[a]	H	$-\overset{OCH_3}{\underset{}{C}}=NH$	$C_{17}H_{18}O_5N_2O$	56.35	5.01	7.73	56.67	5.04	7.37	Ⓟ	C-CH_3 1.96 (O); SCH_3 3.07; OCH_3 3.69, 4.16	NH 3450; OH 3240; CO 1700, 1660	242 ([b]); 280 ( ); 309 ( )
X	154–155	35	Ac[a]	H	$COOCH_3$	$C_{17}H_{17}O_6NS$	56.20	4.72	3.86	55.63	4.61	4.29	©	C-CH_3 2.30 (O); SCH_3 2.42; OCH_3 3.85, 3.92	CO 1720, 1685	290 (4.35); 306 (4.36)
XII	176–177	95	Ac[a]	[c]Ts	CN	$C_{23}H_{20}O_6N_2S_2$	57.02	4.16	5.78	57.09	4.10	5.52	Ⓟ	C_6H_5-CH_3 2.15; C-CH_3 2.30 (O); SCH_3 2.74; OCH_3 3.50	CN 2220; CO 1715	230 (4.50); 270 (4.14); 330 (4.17)
XIII	184–185	60	H	[c]Ts	CN	$C_{21}H_{18}O_5N_2S_2$	56.17	3.86	5.96	56.22	3.91	5.72	Ⓟ	C_6H_5-CH_3 2.22; SCH_3 2.25; OCH_3 3.70	NH 3390; CN 2220; CO 1730	263 (4.09); 342 (4.18)
XV	183–184	90	Ac[a]	Ac[a]	CN	$C_{18}H_{16}O_5N_2S$	58.42	4.33	7.12	58.42	4.33	7.52	©	C-CH_3 2.15 (O); SCH_3 2.46; OCH_3 2.85, 3.94	CN 2220; CO 1760, 1700, 1610	242 (4.28); 265 (4.16); 326 (4.26)
XVII	166–167	65	Ac[a]	$-CH_3$	CN	$C_{17}H_{16}O_4N_2S$	59.30	4.68	8.14	59.54	4.88	7.61	Ⓟ	C-CH_3 2.09 (O); SCH_3 2.78; OCH_3 3.72, 4.15	CN 2220; CO 1700	245 (4.12); 280 (3.99); 324 (4.14)

a) Ac=$-\overset{O}{\overset{\|}{C}}-CH_3$,

b) Concentration is known because of being insoluble.

c) Ts=*p*-toluensulfonyl © : $CDCl_3$, Ⓟ : pyridine

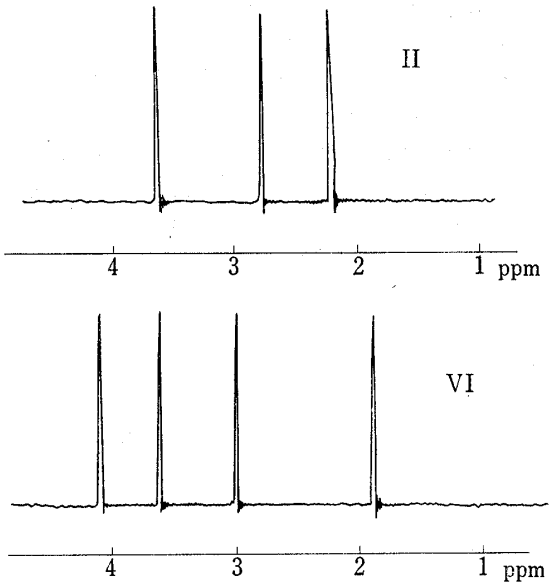


Fig. 1. Nuclear Magnetic Resonance Spectra of II and VI in Pyridine

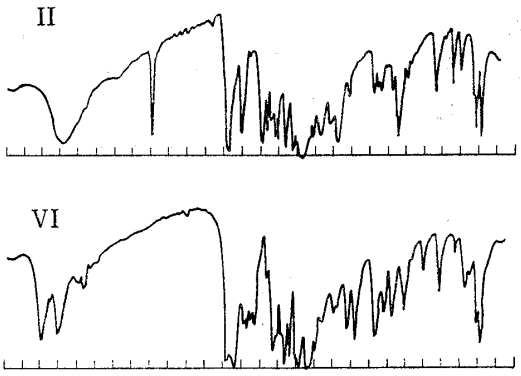


Fig. 2. Infrared Spectra of II and VI

which possesses properties similar to those of III. The structure of 9-hydroxy-2-methoxycarbonyl-1-methylthio-(3H)-pyrrolo[1,2-*a*]indol-3-one was assigned to III on the basis of elemental analysis and UV, IR, and NMR spectral analysis. Physical properties of VII are shown in Table I.

Treatment of II with dry hydrogen chloride gas in methanol and benzene solution gave red needless (VII), mp>300°, which was a hydrochloride. Refluxing of VIII in methanol resulted in dehydrochlorination to form 9-hydroxy-4-imino-3-methoxycarbonyl-1-methylthio-(3H)-pyrrolo[1,2-*a*]indole (IX). The IR spectrum of IX showed absorptions at 3440 cm^{-1} attributed to an imino group, at 3280 cm^{-1} for a hydroxyl group, and at 1670 cm^{-1} for a carbonyl group of methoxycarbonyl group. The NMR spectrum (in pyridine) of IX showed two singlet peaks of methyl protons at 3.22 ppm (3H, singlet, $-SCH_3$) and 3.85 ppm (3H, singlet, $COOCH_3$). Hydrolysis of IX with hydrochloric acid in methanol under refluxing gave the same product the (VII). The IR and UV spectra agreed with those of VII obtained by above reaction, too.

In a similar manner, the reaction of I with methyl 1-methoxycarbonyl-2,2-bismethylthioacrylate in the presence of sodium hydride in the anhydrous tetrahydrofuran (THF), followed by treatment with 10% aquous hydrochloric acid. afforded two compounds X and VII. The first reaction product (X), obtained in 25% yield, melted at 157° and had empirical formula, $C_{17}H_{17}O_6NS$. The UV spectrum of X was similar to that of the corresponding II.

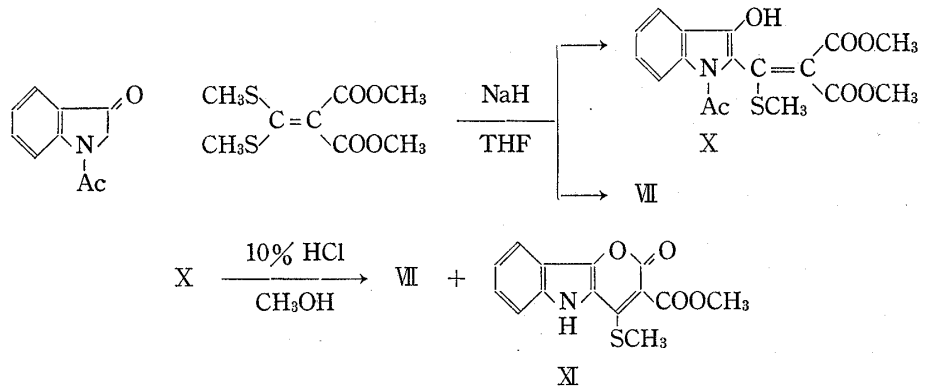


Chart 2

Physical properties of X are shown in Table II. The latter product, obtained in 45% yield, did not melt below 300°, and agreed with VII in IR and UV spectra.

Treatment of X with dilute hydrochloric acid gave two products, VII, in 30% yield, and light yellow crystals (XI) in 30% yield. The latter product melted at 244° and had an empirical formula, $C_{14}H_{11}O_4NS$. Its UV spectrum showed an absorption maximum similar to that of V and its NMR spectrum (in pyridine) had peaks at 2.57 ppm (3H, singlet, SCH_3) and 3.90 ppm (3H, singlet, $COOCH_3$). From these spectral data and elemental analysis, 3-methoxycarbonyl-4-methylthiopyrano[3,2-*b*]indol-2-one was assigned to this compound (XI).

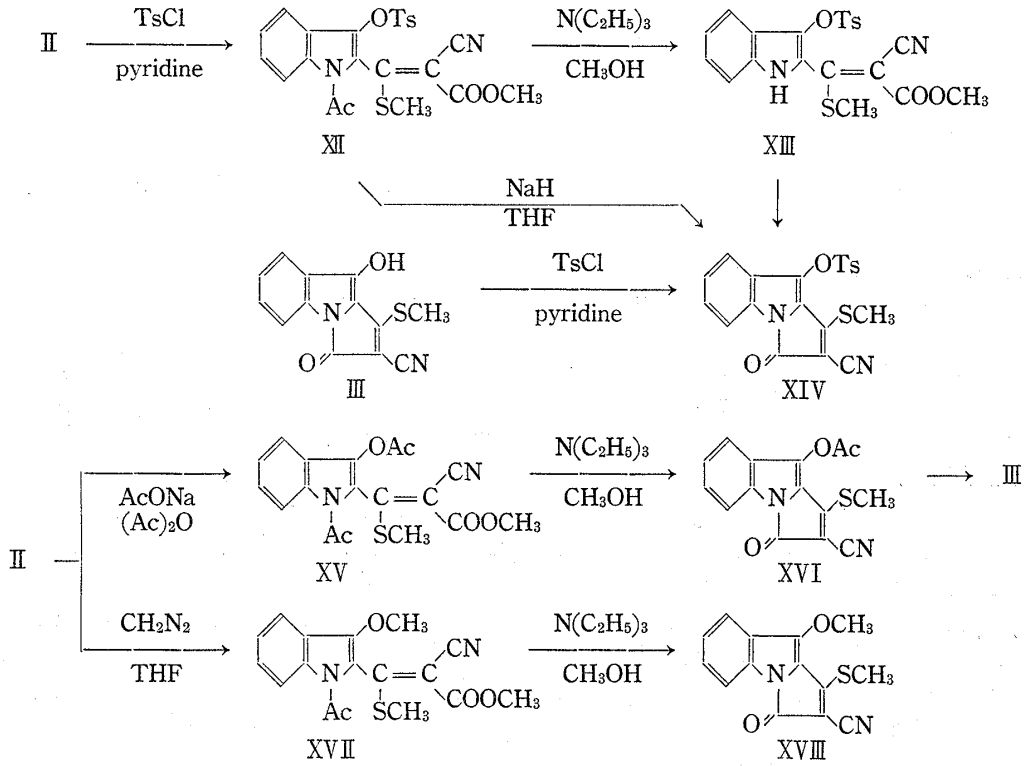


Chart 3

Because condensation reaction of II yielded two products of (3H)-pyrrolo[1,5-*a*]indoles and pyrano[3,2-*b*]indol-2-one, synthesis of pyrano[3,2-*b*]indole had to be carried out on a compound in which the hydroxyl group was protected. Reaction of II with *p*-tosyl chloride in pyridine gave 1-acetyl-2-(2-cyano-2-methoxycarbonyl-1-methylthiovinyl)-3-(*p*-toluenesulfonyloxy)indole (XII). Treatment of XII with triethylamine gave a deacetylated compound, 2-(2-cyano-2-methoxycarbonyl-1-methylthiovinyl)-3-(*p*-toluenesulfonyloxyl)indole (XIII) and further continued treatment with triethylamine gave 2-cyano-1-methylthio-9-(*p*-toluenesulfonyloxy)-(3H)-pyrrolo[1,2-*a*]indol-3-one (XIV). This compound XIV was also obtain by treatment of XII with sodium hydride in THF and tosylation of III in pyridine.

In a similar manner, II reacted with diazomethane and acetic anhydride to give the

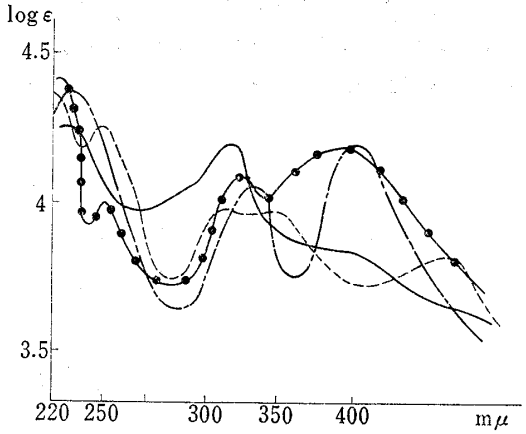
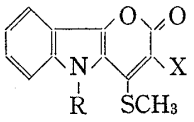


Fig. 3. Ultraviolet Spectra of II, III, V, and XVIII

II: —— III: ——
V: —●— XVIII: ——

corresponding methylated compound (XVI) and the acetylated compound (XV), and then the above treatment of these compounds (XVI and XV) with triethylamine or sodium hydride gave the corresponding deacetylated compound (III), but not 9-acetoxy-2-cyano-1-methylthio-(3H)-pyrrolo[1,5-*a*]indole-3-one and 2-cyano-9-methoxy-1-methylthio-(3H)-pyrrolo-[1,5-*a*]indol-3-one (XVII). Physical properties of these compounds are shown in Table II and III.

TABLE II.



	mp (°C)	Yield (%)	R	X	Formula
IV	255—256	85	$-C-CH_3$ (=O)	CN	$C_{15}H_{10}O_3N_2S$
V	287—288	80	H	CN	$C_{13}H_8O_4N_2S$
XI	243—244	35	H	$COOCH_3$	$C_{14}H_{11}O_4NS$

	Analysis (%) Calcd. C	H	N	Found C	H	N	NMR ppm (pyridine)	IR (KBr) cm^{-1}		UV λ_{max}^{EtOH} $m\mu$ (log ε)
IV	60.40	3.38	9.39	59.72	3.36	9.50	—	C N C O	2220 1705 1610	268 ([a]) 398 ( )
V	60.94	3.15	10.93	60.82	3.08	11.02	SCH_3 3.00	N H C N C O	3250 2220 1660	256 (3.97) 325 (4.10) 385 (4.22)
XI	58.18	3.83	4.84	58.04	3.68	4.44	SCH_3 2.57 OCH_3 3.90	N H C O	3330 1725 1670	255 (4.18) 380 (4.26)

a) Concentration is known because of being insoluble.

Experimental

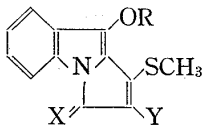
1-Acetyl-2-(2-cyano-2-methoxycarbonyl-1-methylthiovinyl)-3-hydroxyindole (II)——To a suspension of 0.48 g (0.01 mole) of NaH in mineral oil in 100 ml of absolute THF was added 1.75 g (0.01 mole) of 1-acetyl-3-indolinone and 2.03 g (0.01 mole) of methyl 1-cyano-2,2-bismethylthioacrylate. The reaction mixture was refluxed for 2 hr. After the solvent was evaporated, 100 ml of ice-water was added to its residue and stirred until all the solid dissolved. The solvent was acidified with 10% HCl solution, the precipitate washed with MeOH, collected by filtration, and recrystallized from MeOH–benzene to a yellow crystals. The result is shown in Table I.

2-Cyano-9-hydroxy-1-methylthio-(3H)-pyrrolo[1,2-*a*]indol-3-one (III)——a) To a suspension of 0.96 g (0.02 mole) of NaH in mineral oil in 100 ml of absolute THF 1.7 5g (0.01 mole) of 1-acetyl-3-indolinone and 2.03 g (0.01 mole) of methyl 1-cyano-2,2-bismethylthioacrylate were added. After refluxing for 4 hr, the solvent was evaporated. The residue was added with 100 ml of water and stirred until all of the solid dissolved. The solvent was acidified with aqueous 10% HCl, the precipitate was collected by filtration, and recrystallized from Methylcellosolve. The result is shown in Table III.

b) To a suspension of 0.96 g of NaH in mineral oil in 100 ml of THF 3.3 g (0.01 mole) of II was added and the reaction mixture was refluxed for 1 hr. After removal of the solvent, the residue was dissolved in ice-water and acidified with dil. HCl. The separated crystalline mass was collected by filtration and recrystallized from Methylcelosolve in high yields such as 70—80%.

5-Acetyl-3-cyano-4-methylthiopyrano[3,2-*b*]indol-2-one (IV)——The compound II was heated at 200° for 2 hr, during which period this compound was dissolved once, and then this compound occured to make solid when the reaction completed nearly. The resulting solid was treated with a small amount of MeOH

TABLE III.



	mp (°C)	Yield (%)	R	X	Y	Formula	Analysis (%) Calcd. C	H	N	Found C	H	N	NMR ppm	IR (KBr) cm^{-1}	UVλ_{max}^{EtOH} mμ (log ε)
Ⅲ	305	75	H	O	CN	$C_{13}H_8O_2N_2S$	60.94	3.15	10.93	60.95	3.09	10.36	Ⓟ SCH_3 3.12	O H 3100 C N 2218 C O 1700	253 (4.26) 342 (3.96)
Ⅶ	267	85	H	O	$COOCH_3$	$C_{14}H_{11}O_4NS$	58.13	3.83	4.84	58.52	3.91	4.34	Ⓟ SCH_3 3.32 OCH_3 3.80	O H 3000 | 3400 C O 1660 | 1600	230 (^{a}) 255 ( ) 460 ( )
Ⅸ	225	85	H	NH	$COOCH_3$	$C_{14}H_{12}O_3N_2S$	58.33	4.20	9.72	58.30	4.31	9.08	Ⓟ SCH_3 3.22 OCH_3 3.85	N H 3440 O H 3280 C O 1670 1610	259 (4.60) 420 (4.10)
XIV	216	65	Ts^b	O	CN	$C_{17}H_{14}O_4N_2S$	58.54	3.44	6.89	58.14	3.29	6.90	Ⓒ ϕ-CH_3 2.50 SCH_3 2.95	C N 2220 C O 1720	224 (^{a}) 342 ( ) 388 ( )
XVⅢ	202	75	CH_3	O	CN	$C_{14}H_{10}O_2NS$	62.22	3.73	10.37	62.51	3.88	10.20	Ⓒ SCH_3 3.00 OCH_3 4.42	C N 2220 C O 1710	235 (4.35) 308 (4.20) 319 (4.23) 358 (4.20)

a) Concentration is known because of being insoluble.
b) Ts=*p*-toluen sulfonyl
c) Ⓟ: pyridine, Ⓒ: $CDCl_3$

at a room temperature. The separated solid was collected filtration and recrystallized from Methylcellosolve. The result is shown in Table II.

3-Cyano-4-methylthiopyrano[3,2-*b*]indol-2-one (V)——a) To a solution of 1.5 g of IV in Methylcellosolve 10% aq. HCl was added. The reaction mixture was refluxed at 150° for 1 hr in an oil bath. When cooled, the precipitate was collected by filtration, washed with MeOH, and recrystallized with Methylcellosolve to give deacetylated product in 70% yield. The result is shown in Table II.

b) To a solution of 1.5 g of II in 30 ml of MeOH and 10 ml of benzene 10% HCl was added. The mixture was in a water bath for 2 hr. The solution was evaporated to dryness and the dark yellow residue was recrystallized from Methylcellosolve to give the compound V.

1-Acetyl-3-hydroxy-2-(2-methoxyiminomethyl-2-methoxycarbonyl-1-methylthiovinyl)indole (VI)——To a solution of 1.5 g of II in MeOH 10 ml of 10% HCl was added and the mixture was allowed to stand at room temperature for 100 hr. The white precipitate products were collected on a fiter, washed with water, and recrystallized from MeOH. The result is shown in Table I.

Treatment of VI with Hydrochloric Acid——To a solution of 1.6 g of VI in 50 ml of MeOH 5 ml of 10% HCl was added and the reaction mixture was refluxed for 1 hr. When cooled, the precipitate was collected on a filter, washed with water, and recrystallized from benzene and MeOH to a red crystalline powder. This product was proved to be 9-hydroxy-2-methoxycarbonyl-1-methylthio-(3H)-pyrrolo[1,2-*a*]indol-3-one (VII). The result is shown in Table II.

Treatment of II with Conc. Hydrochloric Acid——To a solution of 1.5 g of II in 30 ml of MeOH and 20 ml of benzene HCl gas for 20 min at the rate to keep the temperature below 50°. The precipitate was collected by filtration and recrystallized twice from MeOH to red needless (VIII), mp 300°, in a good yield.

9-Hydroxy-3-imino-2-methoxycarbonyl-1-methylthio-(3H)-pyrrolo[1,2-*a*]indole (IX)——To a solution of 1 g of VIII in 30 ml of MeOH 0.5 ml of triethylamine was added, the reaction mixture was refluxed for 1 hr, and the solvent was evaporated. The residue was poured into water, the precipitate was collected by filtration, and recrystallized from MeOH to yellow needles. The result is shown in Table III.

Treatment of IX with Hydrochloric Acid——To a solution of 1 g of IX in 30 ml of dioxan 2 ml of conc. HCl was added and the reaction mixture was refluxed in an oil bath for 30 min. The solvent was evaporated in vacuum and 30 ml of 10% K_2CO_3 solution was added. The precipitated red crystals were collected by filtration and washed with water and a little MeOH. Recrystallization from benzene and MeOH gave VII as red needles.

Reaction of 1-Acetyl-3-indolinone with Methyl 1-Methoxycarbonyl-2,2-bimethylthioacrylate——To a suspension of 0.45 g (0.0095 mole) of NaH in mineral oil in 100 ml of absolute THF 1.75 g (0.01 mole) of 1-acetyl-3-indolinone and 2.36 g (0.01 mole) of methyl 1-methoxycarbonyl-2,2-bismethylthioacrylate were added, and the reaction mixture was refluxed for 2 hr. After the solvent was evaporated, 100 ml of ice-water was added to this residue and the mixture stirred until all of the solid dissolved. The solution was acidified with 10% HCl and the resultant precipitate was collected by filtration. This precipitate was suspended in hot CH_2Cl_2, and the undissolved solid was collected by filtration, and washed with additional CH_2Cl_2. The organic filtrate was dried over Na_2SO_4, and evaporation of the solvent and addition of 5 ml of MeOH to the residue gave 0.5 g of X as a white solid, mp 170°. Recrystallization from MeOH gave 1-acetyl-2-(2,2-bismethoxycarbonyl-1-methylthiovinyl)-3-hydroxyindole (X) as white crystals. The result is shown in Table I. The solid (2 g) undissolved in CH_2Cl_2 was recrystallized from benzene and MeOH to red needles, mp 154—155°, which was found to be VII.

Treatment of X with Hydrochloric Acid——To a solution of 2 g of X in 50 ml of MeOH 10% HCl solution was added the reaction mixture was treated as described above for the reaction of I with methyl 1-methoxycarbonyl-2,2-bismethylthioacrylate. This reaction afforded two products, VII in 30% yield and XI as yellow crystals in 30% yield.

1-Acetyl-2-(2-cyano-2-methoxycarbonyl-1-methylthiovinyl)-3-(*p*-toluenesulfonyloxy)indole (XII)——To a solution of 1.5 g (0.01 mole) of II in 30 ml of pyridine 3 g (0.015 mole) of *p*-tosyl chloride. After stirring the reaction mixture for 30 min at room temperature, the resultant mixture was poured into ice-water, and the solid was collected by filtration. The solid was washed thoroughly with water and recrystallized from MeOH to white needles. The result is shown in Table I.

Treatment of XII with Triethylamine——To a solution of 1 g of XII in 50 ml of MeOH 0.5 ml of triethylamine was added and the mixture was heated under reflux for 2 hr. Evaporation of the solvent and recrystallization of the residue from MeOH gave two products; yellow and red crystals. The first product was 2-(2-cyano-2-methoxycarbonyl-2-methylthiovinyl)-3-(*p*-toluenesulfonyloxy)indole (XIII), mp 216°, in 60% yield, and the second product, 2-cyano-1-methylthio-9-(*p*-toluenesulfonyloxy)-(3H)-pyrrolo[1,2-*a*]indol-3-one (XIV), mp 216°, in 10% yield. These products were separate by recrystallization from MeOH. These results are shown in Tables I and III.

2-Cyano-1-methylthio-9-(*p*-toluenesulfonyloxy)-(3H)-pyrrolo[1,2-*a*]indol-3-one (XIV)——a) A mixture of 0.48 g of NaH and 1.5 g of II in absolute THF was heated under reflux for 2 hr. After the solvent was evaporated, the residue was poured into 50 ml of ice-water and acidified with 10% HCl solution. The precipitated red needles were collected on a filter and recrystallized from MeOH and benzene in 80% yield.

b) Preparation of XIV from III: To a solution of 1.5 g of III in 20 ml of pyridine 1.5 g of *p*-tosyl chloride was added in small portions over a 15 min period. After the reaction mixture was stirred for 30 min, the precipitated red crystals were collected by filtration and recrystallized from MeOH and benzene in 60% yield.

1-Acetyl-3-actoxy-2-(2-cyano-2-methoxycarbonyl-1-methylthiovinyl)indole (XV)——A solution of 1.6 g II in 30 ml of Ac_2O 1 g of NaOAc was added with stirring, and the reaction mixture was stirred at 70° for 30 min. When cooled, the reaction mixture was poured into-water, the solid that precipitated was collected on a filter, washed water, and recrystallized from MeOH to 1.4 g of XV as white needles. The result is shown in Table I.

Treatment of XV with Sodium Hydride——A mixture of 0.5 g NaH and 1.5 g of XV in absolute THF was heated under reflux for 2 hr. After removal of the solvent, the residue was poured into 50 ml of ice-water and acidified with 10% HCl solution. The precipitated yellow crystals were collected on a filter and recrystallized from Methylcellosolve. This product was found to be III.

1-Acetyl-2-(2-cyano-2-methoxycarbonyl-1-methylthiovinyl)-3-methoxyindole (XVII)——To the ether solution of diazomethane (large excess), 1 g of II in ether and THF (20 ml) was added. After standing overnight, the solvent was evaporated and the residue was crystallized from benzene mixed with a small amount of petr. benzine, giving XVII as colorless crystals, mp 166—167°, in 65% yield.

2-Cyano-9-methoxy-1-methylthio-(3H)-pyrrolo[1,2-*a*]indol-3-one (XVIII)——To a solution of 1 g of XVII in 50 ml of MeOH 0.5 ml of triethylamine was added and the mixture then heated under refluxing for 2 hr. Evaporation of the solvent and recrystallization of the residue from MeOH gave yellow needles. The result is shown in Table I.

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