The sulfonamides (XXXVI), (XXXIX), (XLI), (XLII) were prepared from XXIV, XIV, XX, XXIX, according to the following procedure, without isolating the intermediate N^4-acetates.

Preparation of N^1-(2-Methyl(or phenyl)-3-oxo-2,3-dihydro-4-pyridazinyl)sulfanilamides——The N^4-acetylsulfonamide was dissolved in ten times the amount of 10% NaOH solution and the solution was refluxed for 1 hr. The filtered solution was acidified with HCl to pH 4.0. The precipitated sulfonamide was collected, washed and dried. Yield, quantitative. The product was purified by recrystallization from MeOH or EtOH.

The authors express their deep gratitude to Prof. Emeritus E. Ochiai of the University of Tokyo for his kind encouragements throughout the course of the present work. They are also indebted to Mr. A. Murano for the measurement of infrared and ultraviolet spectra, to Mr. M. Chikada for his cooperation in this work, and to Mr. K. Iwai, Mr. N. Nishimura and Miss M. Fujita for the elementary analysis.

Summary

Five kinds of N^1-(2-methyl-3-oxo-2,3-dihydro-4(or 5)-pyridazinyl)sulfanilamides were prepared starting from chloromaleic anhydride. In addition, three kinds of N^1-(2-methyl(or phenyl)-3-oxo-2,3-dihydro-4(or 5)-pyridazinyl)sulfanilamides were also prepared.

It is of interest that of these sulfonamides prepared, those substituted with the sulfanilamide group at 4-position of pyridazine nucleus have shown marked activities *in vitro*.

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149. Takenari Nakagome, Atsuko Misaki,*1 and Atsushi Murano*2 : Synthesis of Pyridazine Derivatives. XIV.*3 On the Methylation of 4-Amino-3(2*H*)pyridazinone Derivatives.*4

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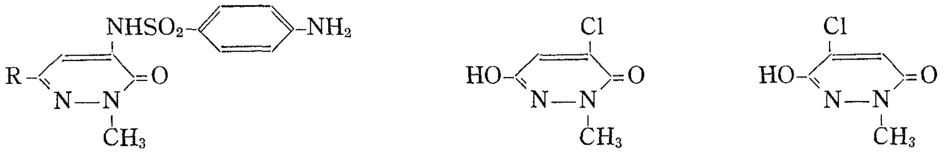
In Part XIII*3 of this series, we have described the preparation of a series of N^1-(2-methyl-3-oxo-6-substituted-2,3-dihydro-4-pyridazinyl)sulfanilamides (Chart 1, A~D), and the intermediates required in their synthesis from chloromaleic anhydride. Some of these sulfonamides showed marked promise as chemotherapeutic agents.



A : R=H B : $R=CH_3$

C : R=Cl D : $R=OCH_3$

E

F

Chart 1.

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*3 Part XIII. T. Nakagome, A. Misaki, T. Komatsu : This Bulletin, **14**, 1082 (1966).

*4 A part of this work was presented at the 85th Annual Meeting of the Pharmaceutical Society of Japan at Tokushima, Oct. 28, 1965.

The essential step in the synthesis of these compounds except for B was the condensation of chloromaleic anhydride with methylhydrazine to form 2-methyl-4-chloro-6-hydroxy-3(2*H*)-pyridazinone (E) and 2-methyl-5-chloro-6-hydroxy-3(2*H*)-pyridazinone (F) in 1:1 ratio. Compound (E) was converted into the foregoing sulfonamides after several further transformations. The formation of an equal amount of the 5-chloro compound in this step, however, made the foregoing method of preparation unsatisfactory from the industrial point of view. It became desirable, therefore, to find and develop a more advantageous method for preparing these sulfonamides. The present paper describes the results of methylation of 4-amino-6-substituted-3(2*H*)pyridazinones which was expected as a possible alternatve method of preparation of 2-methyl-4-amino-6-substituted-3(2*H*)pyridazinones, essential intermediates for the desired sulfonamides.

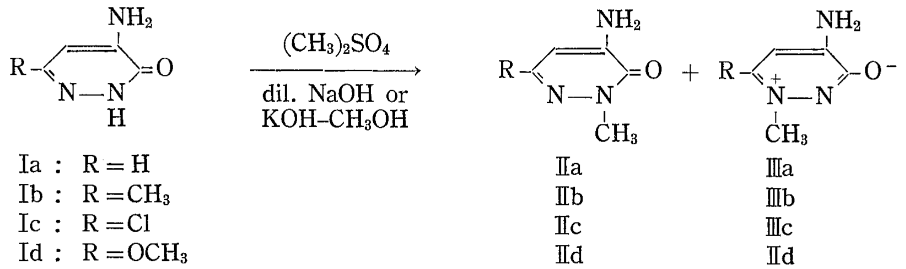


Chart 2.

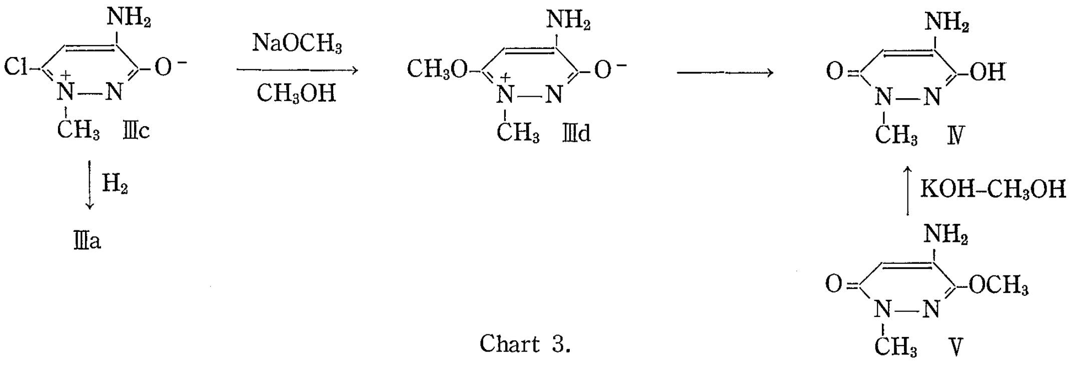


Chart 3.

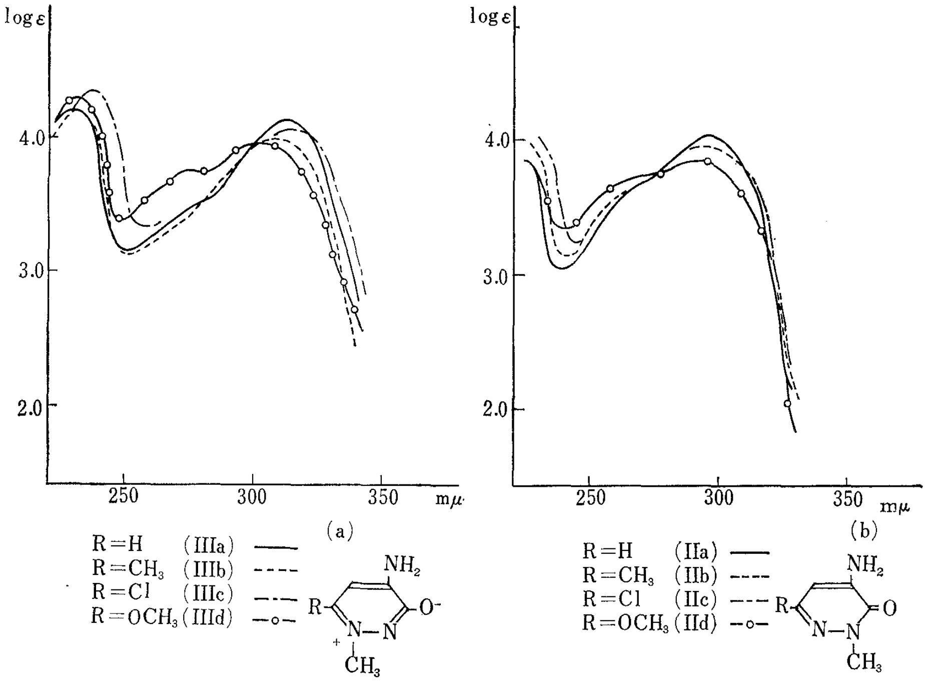
Table I. Reaction of 4-Amino-3(2*H*)pyridazinones with Dimethyl Sulfate

R	Starting material (0.04 mole)	Procedure employed	Product: Pyridazinone: p.p.t. from aq. solution (g.)	from $CHCl_3$ ext. (g.)	from MeOH ext.[a] (g.)	total (g.) (%)	Betaine g. (%)	Recovered starting material g. (%)
H	Ia	A		1.25	1.11	2.36 (47.2)	2.3 (46)	
CH_3	Ib	A	2.6	1.05	0.77	4.42 (80)	0.77 (14)	
Cl	Ic	A	4.45	0.57		5.0 (78.7)	0.74 (11.5)	
		B	4.9	0.19		5.1 (79.5)	0.36 (5.7) (IIId)	0.1 (1.7)
OCH_3	Id	A	4.7	0.41		5.11 (82)	0.41 (6.6)	0.28 (5)

[a] Determined by spectrophotometric method after separation by TLC.

4-Amino-(Ia)1), 4-amino-6-methyl-(Ib),2) 4-amino-6-chloro-(Ic),1) and 4-amino-6-methoxy-3(2*H*)pyridazinones (Id),3) employed as starting materials, were prepared according to the procedures previously reported. Methylation reaction was effected by adding dimethyl sulfate with cooling to a solution of 4-amino-6-substituted-3(2*H*)pyridazinone dissolved in aqueous 2*N* NaOH solution. Each of the reaction mixture indicated two spots on a thin-layer chromatogram[*5] (TLC), together with a spot of the starting material in some instances. Spots which were found along the solvent front were agreed with those of 2-methyl-4-amino-6-substituted-3(2*H*)pyridazinones. Additional spots moved only a short distance. This suggests that they are compounds of high polarity.

After the produced 2-methyl-4-amino-6-substituted-3(2*H*)pyridazinone was removed by filtration or extraction with chloroform, the aqueous solution was evaporated to dryness and the residue was extracted with methanol. The methanolic extract was then submitted to column chromatography and by this procedure the anhydro bases of 1-methyl-3-hydroxy-4-amino- (Ⅲa), -6-methyl- (Ⅲb), -6-chloro-3(2*H*)pyridazinone (Ⅲc) were separated. In the case of methylation of Ia and Ib a considerable amount of 2-methyl compounds (Ⅱa and Ⅱb) was obtained from the initial eluate. Although the



Pyridazinone	Ⅱa	295 (4.04)	Ⅱb	294.5 (4.01)	Ⅱc	298 (4.01)
	Ⅱd	289.5 (3.89)				
Betaine	Ⅲa	228.5 (4.20)	311 (4.13)	Ⅲb	230 (4.19)	307 (4.03)
	Ⅲc	235 (4.35)	313 (4.08)			
	Ⅲd	230.5 (4.30)	276 (4.75)			
		304 (3.98)				

Fig. 1. Ultraviolet Spectra (in MeOH)

a) Betaines (Ⅲa), (Ⅲb), (Ⅲc), (Ⅲd)
b) Pyridazinones (Ⅱa), (Ⅱb), (Ⅱc), (Ⅱd)

[*5] TLC : Silica Gel G plate, $CHCl_3$-MeOH (1:1) solvent, detected by I_2 vapor.

1) T. Kuraishi : This Bulletin, **6**, 331 (1958).

2) Part Ⅵ. T. Nakagome, T. Hayama, T. Komatsu, Y. Eda : Yakugaku Zasshi, **82**, 1103 (1962).

3) Part Ⅺ. T. Nakagome, A. Kobayashi, A. Misaki, T. Komatsu, T. Mori, S. Nakanishi : This Bulletin, **14**, 1065 (1966).

corresponding 6-methoxy betaine failed to be isolated, its presence was confirmed by comparison of ultraviolet absorption spectrum and behaviors on TLC with those of the sample (IIId) prepared from IIIc by treatment with sodium methoxide.

The constitutions of these betaines were established as follows. First the constitution of the anhydro base of 1-methyl-3-hydroxy-4-amino-6-chloropyridazinium hydroxide (IIIc) was proved by its derivation into 2-methyl-5-amino-6-hydroxy-3(2*H*)-pyridazinone (IV) which was obtained from 1-methyl-3-methoxy-4-amino-6(1*H*)pyridazinone (V) by an analogous reaction to that by which 2-methyl-4-amino-6-methoxy-3(2*H*)-pyridazinone (IId), isomeric with V, was transformed into 2-methyl-4-amino-6-hydroxy-3(2*H*)pyridazinone, as described in earlier paper.*3 The chlorine atom of IIIc was so susceptible to substitution by catalytic reduction over palladium on charcoal and was replaced by a methoxy group on warming (IIIc) with methanolic potassium hydroxide for a short minutes, 1-methyl-3-hydroxy-4-amino (IIIa) and -6-methoxypyridazine betaine (IIId) being produced respectively. Further heating of IIId with methanolic potassium hydroxide gave 1-methyl-3-hydroxy-4-amino-6(1*H*)pyridazinone (IV) which was identified by mixed melting point determination and comparison of IR spectra with the compound (IV) prepared from V. 6-Methyl derivative (IIIb) was analogously assumed to possess the similar structure, as shown in Chart 2, although no synthetic proof have been made. The assumption was substantiated by comparison of the ultraviolet absorption spectrum of IIIc with spectra of the other betaines (IIIa, b, d) (Fig. 1).

Of the possible tautomeric forms for these 1-methyl derivatives (III), their solubility in water and reactivity of 6-substituents can reasonably be explained by the zwitterionic ones, represented in Chart 2.

In order to determine quantitatively the amount of II and III produced in each of the four reactions (a～d), the methanolic extract from each of these reactions was subjected to TLC, which caused the separation of II from III. The pyridazinone (II) and the betaines (III) were then removed from TLC plate and each was placed in a standard volume of methanol and the amount of II and III present determined by ultraviolet spectrophotometry. The results are given in Table I, from which it is observed that methylation of unsubstituted 4-amino-3(2*H*)pyridazinone (Ia) yields 2-methyl (IIa) and 1-methyl (IIIa) derivatives in equal quantities, and that the yields of the betaines sharply decreases as the size of the substituent at the 6-position becomes larger in the following order: $H \rightarrow CH_3 \rightarrow Cl \rightarrow OCH_3$. Duffin and Kendall[4] studied quaternization of 3,6-disubstituted pyridazines and showed that activating influence of adjacent substituents was in the following order; $CH_3 > H > Cl > SCH_3 > C_6H_5 > OCH_3$. The order of H and CH_3 is reversed in the present methylation of 4-amino-3(2*H*)-pyridazinone derivatives. The pronounced steric effects of the 6-substituents were observed in our experiments, as already known in quaternization of various heteroaromatic compounds[5].

Attempts were made to repress the formation of the 6-chloro betaine (IIIc) in the reaction, but no satisfactory results were obtained. In one instance where methylating reagent was replaced by methanolic potassium hydroxide, the expected 6-chloro betaine was fully transformed into 6-methoxy betaine. This might be ascribed to the reactivity of the chlorine atom of IIIc.

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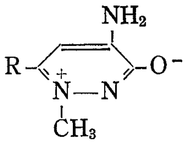
4) C.F. Duffin, J.D. Kendall: J. Chem. Soc., **1959**, 3789.

5) A.R. Katritzky, A.J. Boulton, J.M. Lagowski: "Advances in Heterocyclic Chemistry," Vol. III, 1 (1964). Academic Press, New York and London.

Table II.



Comp. No.	R	Appearance	m.p. (°C)	Formulae	Analysis Calcd. C	H	N	Found C	H	N
IIIa	H	colorless prisms	246	$C_5H_7ON_3$	47.99	5.64	33.58	47.85	5.81	33.27
IIIb	CH_3	colorless prisms	281～282	$C_6H_9ON_3 \cdot 1/2H_2O$	50.25	6.50	29.30	49.95	6.85	29.22
picrate		yellow prisms	243.5	$C_{12}H_{12}O_8N_6$	39.14	3.22	22.82	39.33	3.59	22.89
IIIc	Cl	colorless leaflets	>300	$C_5H_5ON_3Cl$	37.63	3.79	26.33	38.16	4.01	26.34
hydrochloride		colorless prisms	237～238 (decomp.)	$C_5H_7ON_3Cl_2$	30.63	3.60	21.44	29.95	3.85	20.62
IIId	OCH_3	colorless prisms	194～195	$C_6H_9O_2N_3$	46.44	5.85	27.08	46.92	5.88	26.35

Table III. Thin-layer chromatography (Silica Gel G plate, detected by I_2 vapor)

Compound	Rf-value System 1	System 2	System 3	System 4
Ic	0.59			
Id	0.47	0.46		
IIa		0.54		
IIb				0.76
IIc	0.63	0.63		
IId	0.57	0.67		
IIIa		0.02		
IIIb				0.45
IIIc	0	0.12	0.51	
IIId	0	0.13	0.33	0.40

System 1: AcOEt System 2: $CHCl_3$-MeOH (9:1)
System 3: $CHCl_3$-MeOH (1:1) System 4: $CHCl_3$-MeOH-AcOH (7:3:0.05)

Experimental[*6]

1) **Methylation of 4-Amino-6-substituted-3(2*H*)pyridazinone (I)**——A) General procedure. To a stirred solution of 4-amino-6-substituted-3(2*H*)pyridazinone (0.04 mole) in 52 ml. of *N* NaOH (in the case of Ic and Id, further 40～60 ml. of water was added) was added dropwise 5.5 g. (0.04 × 1.1 mole) of dimethyl sulfate, the temperature being kept below 10° with cooling. After stirring was continued for 2.5 hr., the deposited crystals were filtered, washed with water and dried, giving 2-methyl compound (II). Extraction of the filtrate with $CHCl_3$, evaporation of the dried extract and recrystallization of the residue from AcOEt furnished the second crop of II. In the case of Ia, no precipitate was found to be separated. The reaction mixture was directly extracted with $CHCl_3$.

The aqueous layer was then adjusted to pH 7 with HCl, the starting material being recovered by filtration.

The neutral aqueous solution was evaporated to dryness and the residue was dissolved in MeOH to remove the insoluble material (Na monomethylsulfate) by filtration. The resulting methanolic solution was used for isolation or determination of II and III in subsequent experiments.

[*6] All melting points are uncorrected. Infrared and ultraviolet spectra were respectively measured with a Shimadzu IR Infrared Spectrophotometer and a Shimadzu RS-27 Recording Spectrophotometer.

B) To a stirred solution of 4-amino-6-substituted-3(2*H*)pyridazinone (I) (0.04 mole) in 50 ml. of MeOH containing 7.3 g. of KOH (purity 85%) was added 5.5 g. (0.04 × 1.1 mole) of dimethyl sulfate below 10° and the resulting solution was stirred for 5 hr. The inorganic salt which separated out was filtered off, and the filtrate was evaporated to dryness at an atmospheric pressure. Addition of water (70 ml.) to the residue separated 2-methyl compound as colorless crystals which were collected by filtration. The filtrate was worked up as described in procedure (A).

2) **Isolation of the Anhydro Base of 1-Methyl-3-hydroxy-4-amino-6-chloropyridazinium Hydroxide (IIIc)**——The methanolic solution of Ⅲc (Experiment (1-A)) from 20 g. of Ic was poured on an alumina column (4.4 × 31 cm.) for chromatography. The column was eluted successively with 9:1 and 1:1 mixture of $CHCl_3$ and MeOH. Each eluate was checked by TLC (Table Ⅲ). The fractions which showed a spot on TLC at 0.63 ($CHCl_3$-MeOH(9:1), Table Ⅲ) were combined and the solvent was evaporated leaving 1.55 g. of crude Ⅱc which was recrystallized from AcOEt to give 0.92 g. (4%) of colorless needles, melting at 144～145° alone or on admixture with an authentic sample of Ⅱc. The following fractions which showed a spot at 0.12 gave the betaine (Ⅲc) on evaporation of the solvent. Recrystallization from MeOH formed colorless leaflets, m.p. >300°, Yield 0.7 g. (3.2%).

3) **Catalytic Reduction of IIIc**——A mixture of 0.6 g. of Ⅲc, 0.6 g. of 5% Pd-C and 20 ml. of 1/2*N* NaOH was shaken with hydrogen at an atmospheric pressure. After removal of the catalyst the solution was adjusted to pH 6.5 with dilute HCl and evaporated to dryness. The dried residue was extracted with boiling abs. EtOH, and the extract was filtered while being hot. The filtrate, after charcoal treatment, concentrated to a small volume. The crystals which separated out were collected and recrystallized from EtOH, giving 0.26 g. of Ⅲa, colorless prisms, m.p. 246°. Concentration of mother liquor gave 0.065 g. of an additional crop, m.p. 243～246°; total 0.325 g. (70%).

4) **Reaction of the Anhydro Base of 1-Methyl-3-hydroxy-4-amino-6-chloropyridazinium Hydroxide (IIIc)**——In a methanolic solution of 1.1 times the calculated amount of $NaOCH_3$ was dissolved 0.5 g. (0.00313 mole) of Ⅲc and the solution was refluxed for 10 min. The deposited crystals (NaCl) were filtered off, the filtrate was adjusted to pH 7 with HCl and evaporated. The residue was dissolved in MeOH, poured on an alumina column for chromatography. Elution with 9:1, then 8:2 and 1:1 mixture of $CHCl_3$ and MeOH afforded crystalline (Ⅲd), which was recrystallized from MeOH-ether giving colorless prisms, m.p. 194～195°. Yield, quantitative.

5) **Identification of IIId**——Five ml. of the methanolic solution (20 ml.) of the betaine (Exp. (1-A)) was streaked in line on a thin-layer chromatoplate (20 × 20 cm.), which was prepared from Silica Gel G (Merck Co.) at a thickness of 0.5 mm., and developed by the ascending technique using 6:4 mixture of $CHCl_3$ and MeOH as the solvent. Ⅲd zone, checked by detection with I_2 vapor, was scraped out and extracted with MeOH. The similar treatments were repeated with a mixture of MeOH-$CHCl_3$-AcOH(7:3:0.05), and then with a mixture of $CHCl_3$-MeOH(6:4) on a plate at a thickness of 0.25 mm. of the adsorbent. The resulting methanolic solution was found to contain Ⅲd which was identified by comparison of Rf values with those of a sample of Ⅲd prepared from Ⅲc in solvent systems shown as follows.

Solvent System	Sample from Exp. (4)	Sample from Exp. (5)	Mixtures of both samples
MeOH-$CHCl_3$-AcOH(7:3:0.05)	0.40	0.40	
MeOH-$CHCl_3$-ether-AcOH(7:4:1:0.05)	0.37	0.37	0.37
MeOH-ether-AcOH(8:2:0.05)	0.39	0.39	0.39

6) **Isolation of the Anhydro Base of 1-Methyl-3-hydroxy-4-aminopyridazinium Hydroxide (IIIa)**——The methanolic solution of Ⅲa was chromatographed on alumina (4.4 × 30 cm.) in a similar way as for Ⅲc. The initial fraction afforded 0.99 g. (20%) of Ⅱa which was recrystallized from AcOEt to give 0.85 g. (17%) of colorless rhombs, m.p. 173～175°, and 0.06 g. (1.2%) of the second crop, m.p. 171～172°. The second fraction afforded 0.65 g. (13%) of the betaine (Ⅲa) as colorless prisms, m.p. 245°, after recrystallization from EtOH. No melting point depression was observed when admixed with a sample prepared by the previous method (Exp. (3)), and the IR spectra of the two samples were identical.

7) **Isolation of the Anhydro Base of 1-Methyl-3-hydroxy-4-amino-6-methylpyridazinium Hydroxide (IIIb)**——The methanolic solution of Ⅲb from 13 g. of Ib was chromatographed as described above. The fraction eluted with $CHCl_3$ afforded 1.2 g. of crude Ⅱb, which was recrystallized from AcOEt to give 0.98 g. (6.8%) of pale yellow scales, m.p. 139～142°, undepressed on admixture with an authentic specimen. Further elution with 9:1 and 7:3 mixture of $CHCl_3$ and MeOH yielded 0.56 g. of crude Ⅲb, m.p. 262～264°. Recrystallization from EtOH gave colorless prisms of m.p. 285～285.5°, yield 0.37 g. (4.9%). Picrate, yellow prisms (from MeOH), m.p. 243.5°.

8) **1-Methyl-3-hydroxy-4-amino-6(1*H*)pyridazinone (IV)**——i) A solution of 0.5 g. of Ⅲc in 20 ml. of MeOH containing 0.9 g. of KOH was heated under reflux for 20 hr. The solution was adjusted to pH 3

with 2*N* HCl, concentrated *in vacuo* and water was added. The crystals which separated were collected and recrystallized from water with charcoal treatment giving 0.17 g. (38.4%) of colorless needles and 0.05 g. (total yield 50%) of a second crop, m.p. 246～247°. *Anal.* Calcd. for $C_5H_7ON_3 \cdot 2H_2O$: C, 33.90; H, 6.26; N, 23.72. Found : C, 34.28; H, 6.17; N, 24.07. The water of crystallization was eliminated after drying at 120～130° in vacuum and the anhydrous material melted at 252～253°. *Anal.* Calcd. for $C_5H_7ON_3$: C, 42.55; H, 5.00; N, 29.78. Found : C, 43.19; H, 5.32; N, 29.79.

ii) A solution of 2 g. of 1-methyl-3-methoxy-4-amino-6(1*H*)pyridazinone (Ⅴ) and 3.6 g. of KOH (purity 85%) in 30 ml. of MeOH was heated in an autoclave at 155～160° for 10 hr. The solvent was removed by distillation, and the residue was taken up in small quantity of water and separated were collected and recrystallized repeatedly from water giving 1.51 g. (80%) of Ⅳ, m.p. 245～246°, and 0.13 g. (7%) of the second crop, m.p. 243.5～246°, both as colorless needles. Further recrystallization raised m.p. to 246～247°, undepressed when admixed with a sample prepared from Ⅲd. The IR spectra of the two samples were also identical.

The authors express their deep gratitude to Prof. Emeritus E. Ochiai of the University of Tokyo for his kind encouragements throughout the course of the present work. They are also indebted to Mr. M. Chikada and T. Kobayashi for their cooperation in this work, and to Mr. K. Iwai, Mr. N. Nishimura and Miss. M. Fujita for the elementary analysis.

Summary

4-Amino-3(2*H*)pyridazinone derivatives (Ⅰa～Ⅰd) were methylated with dimethyl sulfate in aqueous sodium hydroxide solution, yielding 2-methyl compounds (Ⅱa～Ⅱd) and zwitterionic 1-methyl compounds (Ⅲa～Ⅲd). The position of the methyl group of these products (Ⅱ and Ⅲ) was unambiguously determined. The ratio of formation of both Ⅱ and Ⅲ in the methylation has been found to be markedly influenced by the substituent at adjacent 6-position.

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UDC 547.924.07

150. Ken'ichi Takeda, Taichiro Komeno, Shoichi Ishihara, and Hikaru Itani : Bile Acids and Steroids. XXXIV. Thiosteroids. (19).[*1] 6α- and 6β-Thiocyanatoprogesterone and Related Compounds.

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A number of recently disclosed studies on steroidal 6-substituted 4-en-3-ones by means of NMR (nuclear magnetic resonance) spectroscopy and ORD (optical rotatory dispersion) measurements[1] prompted us to prepare 4-en-3-one substituted at C-6 with a pseudohalogen, especially a thiocyanato group, because the question has arisen whether or not the sign of the n-π^* Cotton effect of 6β-thiocyanato-4-en-3-one is

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