and XIIa (about 3:1) separated. Two additional crystallizations from the same solution yielded XIa (0.03 g), mp 370° dec, identical with the sample described above.

Separation by ion-exchange chromatography on Dowex 1-X8 in the acetate form was carried out as follows.[10] Dowex 1-X8 chloride (200–400 mesh) was washed several times with water to remove fines. The well-settled resin was cycled successively with 10-column volumes each of 1 *M* sodium carbonate solution, water, 2 *M* acetic acid, and finally with water, ensuring that the effluent did not show appreciable absorption in the ultraviolet. The resin was filtered and stored moist at 5°. A slurry of this resin (20 ml) was transferred with water into a column (50 × 1 cm) and washed with 50 ml of 0.02 *M* ammonium acetate buffer solution, pH 9.6. A solution of XIa and XIIa (10 mg) was dissolved in this ammonium acetate buffer solution and placed on the column. Elution was then carried out with ammonium acetate buffer solutions of decreasing pH. The ultraviolet spectrum of each 10-ml eluate was checked for its contents. Effluents from elution with ammonium acetate buffer solutions (50 ml) of pH 7.5, 6.5, and 6.0 did not contain either required isomer, but with a buffer solution of pH 5.8, an effluent (60 ml) with characteristic maxima at 244 and 284 mμ was obtained. Evaporation of these fractions to about 2 ml yielded XIIa (3 mg), mp 328–330° dec.

Continued elution of the column with the same ammonium acetate buffer (pH 5.8) solution (60 ml) gave mixtures of XIa and XIIb (λ_{max} 248–254 mμ) followed by fractions showing λ_{max} 255 mμ, characteristic of XIa. This isomer was taken off the column more efficiently by an ammonium acetate buffer solution pH 4.5 (50 ml) and then pH 3.5 (50 ml) and finally by 0.1 *N* acetate acid. All fractions with λ_{max} 255 mμ were combined and concentrated to about 5 ml to give pure XIa (5 mg), mp 370° dec.

2,4,6-Trimethyl-2H-pyrazolo[4,3-*d*]pyrimidine-5,7(4H,6H)-dione (XIIc).—Reduction of XIIa (0.2 g) as described for VIb was followed except for one modification. It was essential to increase the pH and thus the acidic filtrate was treated with sodium acetate trihydrate until the pH reached 4. On cooling at 5° for 15 hr, XIIb (0.1 g, 55%) separated: mp 400–410° dec; λ_{max} 283 mμ (log ε 3.74); $\nu_{C=O}$ 1740 and 1705 cm^{-1}; nmr signals in $(CH_3)_2SO$, δ 7.66 (pyrazole proton) and 3.98 (NCH_3).

This product (0.08 g) was methylated by the method described for VIc, to produce XIIc (0.06 g): mp 259–261°; λ_{max} 288 mμ (log ε 3.73); $\nu_{C=O}$ 1720, other bands at 1665, 1625, and 1540 cm^{-1}; lit.[8,13] mp 261–263°, λ_{max}^{MeOH} 288 mμ (log ε 3.74). Its nmr spectrum in $(CH_3)_2SO$ exhibited resonance at δ 7.99 (pyrazole proton), 4.01, 3.33, and 3.25 (NCH_3 groups) and correspondingly in $CDCl_3$ at δ 7.32, 4.07, 3.47, 3.43.

The Thermal Cleavage of 1-Carbamoyl- and 1-Thiocarbamoylpyrazole Derivatives

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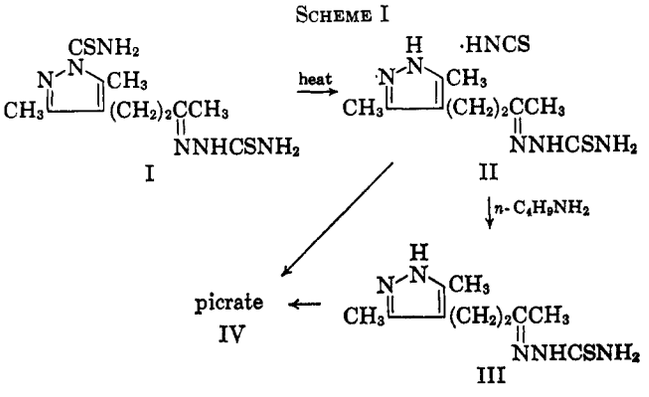
1-Thiocarbamoylpyrazoles undergo thermal decomposition with formation of thiocyanate salts while 1-N-methylthiocarbamoylpyrazoles decompose to yield methyl isothiocyanate and N^1-unsubstituted pyrazoles. Under more vigorous conditions 1-carbamoylpyrazoles also yield N^1-unsubstituted pyrazoles and cyanic acid which trimerizes to cyanuric acid.

In the course of a program of synthesis aimed at relating chemical structure and antitumor activity in a series of pyrazole derivatives it became necessary to examine the thermal cleavage of 1-carbamoyl- and 1-thiocarbamoylpyrazole derivatives. It is well known that 1-acylpyrazoles are readily cleaved with formation of N^1-unsubstituted derivatives together with products which arise from the substituents on the nitrogen atom. Scott and his co-workers[2] have described the aminolysis of 1-carbamoyl- and 1-thiocarbamoyl-3,5-dimethylpyrazole with formation of, among other products, substituted ureides and 3,5-dimethylpyrazole. Ried and Schleimer[3] have found that the cyanoacetyl residue is removed from 1-cyanoacetyl-3,5-dimethylpyrazole by treatment with amines in refluxing benzene while Ried and Konigstein[4] have reported a method of preparing aldehydes by the hydrogenolysis of 1-acylpyrazoles with lithium aluminum hydride. However the thermal cleavage of carbamoyl- and thiocarbamoylpyrazole derivatives has not been recorded.

The work described herein arose as a result of an examination of the pyrazole thiosemicarbazone (I) obtained by treatment of 3-acetyl-2,6-heptanedione with thiosemicarbazide. This compound on drying at 100° for a short period underwent a facile transformation yielding a product which, on the basis of elemental analysis and infrared examination, was shown to be the thiocyanate salt II (Scheme I). This salt on treatment with hydrazine hydrate in ethanolic solution yielded, among other products, thiosemicarbazide while treatment with *n*-butylamine yielded the base III. Further evidence in favor of structure II was obtained by conversion to a picrate which was identical with the picrate obtained from III.

SCHEME I



The thermal splitting of 1-thiocarbamoylpyrazoles with formation of the corresponding thiocyanate salts has now been found to be a more general reaction. The presence of the salt was established by infrared examination and elemental analysis while in a number of cases the thiocyanic acid has been displaced by picric

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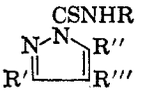
(2) F. L. Scott, D. G. O'Donovan, M. R. Kennedy, and J. Reilly, *J. Org. Chem.*, **22**, 820 (1957).

(3) W. Ried and B. Schleimer, *Angew. Chem.*, **70**, 164 (1958).

(4) W. Ried and F. J. Konigstein, *ibid.*, **70**, 165 (1958).

acid and the picrates characterized by analysis and where applicable by melting point and mixture melting point determinations with authentic samples.

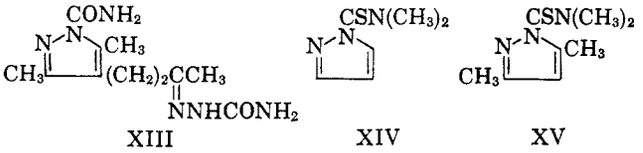


V, R = R‴ = H; R′ = R″ = CH_3
VI, R = H; R′ = R″ = CH_3; R‴ = $(CH_2)_2COCH_3$
VII, R = R″ = R‴ = H; R′ = CH_3
VIII, R = R′ = R″ = R‴ = H
IX, R = R′ = R″ = CH_3; R‴ = $(CH_2)_2C(CH_3)$=NNHCSNHCH$_3$
X, R = R′ = R″ = CH_3; R‴ = $(CH_2)_2COCH_3$
XI, R = CH_3; R′ = R″ = R‴ = H
XII, R = R′ = CH_3; R″ = R‴ = H

3,5-Dimethyl-1-thiocarbamoylpyrazole (V) is a particularly unstable material which, in solution, undergoes transformation to the thiocyanate salt of 3,5-dimethylpyrazole with extreme ease. On heating in the solid state the salt is also formed in high yield while on storage it undergoes gradual decomposition again with salt formation. The pyrazole VI is also smoothly converted to the thiocyanate salt on heating at 100° for a short period but a much longer time at the same temperature is required to effect transformation of VII. In the case of VIII conversion to the thiocyanate could not be effected below 155–160°. These results suggest that the ease of salt formation is to some extent dependent on the degree of substitution in the pyrazole nucleus.

1-N-methylthiocarbamoylpyrazoles, although somewhat more stable than their thiocarbamoyl analogs, are also thermolabile yielding methyl isothiocyanate and N[1]-unsubstituted pyrazoles. With these derivatives heating was carried out under reduced pressure and in two cases, *i.e.*, with IX and X, the methyl isothiocyanate was isolated and characterized by melting point and infrared determinations. However, with more volatile pyrazoles separation of the methyl isothiocyanate was not achieved owing to the formation of azeotropic mixtures. Such mixtures were obtained from XI and XII. Furthermore the infrared spectra of these mixtures revealed the presence of the isothiocyanate only when the spectra were taken immediately after distillation. If the spectra were taken after the lapse of a 24-hr period, absorption in the 4.5- to 4.8-μ region was very weak or nonexistent indicating that the reverse reaction, *i.e.*, condensation of the methyl isothiocyanate and the N[1]-unsubstituted pyrazole, took place at room temperature. It was subsequently found that an equimolar mixture of 3-methylpyrazole[5] and methyl isothiocyanate behaved like the above mixtures and yielded the condensation product XII in high yield. Other 1-unsubstituted pyrazoles have also been condensed with methyl isothiocyanate. Staab and Walther[6] have described the analogous condensation of imidazole with isothiocyanates to yield thiocarbamoylimidazoles.

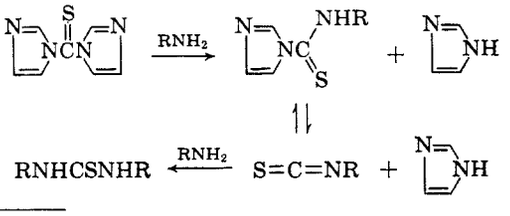
It is of interest that 1-carbamoylpyrazoles are significantly more thermostable than their sulfur analogs. Thus, in contrast to I, XIII is recovered unchanged after 24 hr at 95–100°. Higher temperatures and occasionally longer periods of heating are required to effect cleavage of the carbamoyl residue, the products obtained being the N[1]-unsubstituted pyrazole and cyanuric acid formed by trimerization of the cyanic acid. In benzene solution they also tend to undergo decarbamoylation but again at a slower rate than the sulfur compounds. After 32 hr in refluxing benzene 1-carbamoyl-3,5-dimethylpyrazole is converted to 3,5-dimethylpyrazole to an extent of 50%, whereas V is completely decomposed after 4 hr under the same conditions.



XIII XIV XV

With regard to the mechanism of these reactions it is clear that these 1-substituted pyrazoles undergo thermal decomposition with direct elimination of thiocyanic acid, cyanic acid, or methyl isothiocyanate. The pyrazoles XIV and XV are not thermolabile. It is of interest that in their aminolysis experiments with 1-carbamoyl- and 1-thiocarbamoylpyrazole derivatives Scott and his co-workers encountered a number of products, *e.g.*, cyclohexylammonium thiocyanate from the treatment of 3,5-dimethyl-1-thiocarbamoylpyrazole with cyclohexylamine in ethanolic solution, which clearly suggested that direct elimination mechanisms were involved. These workers, however, proposed[2,7] an alternative mechanism whereby the base becomes attached to the amide function, the adduct then being cleaved with liberation of the ureide and the N[1]-unsubstituted pyrazole. The formation of products such as ammonium thiocyanates was considered to be due to an initial ethanolysis of the thiocarbamoylpyrazole to ethylthionourethan followed by elimination of thiocyanate ion from the latter substance. It now appears probable that the aminolytic cleavage of the carbamoyl and thiocarbamoyl residues was accompanied by thermal cleavage with liberation of cyanic and thiocyanic acids, respectively. Furthermore, it is also unnecessary to postulate the formation of ethylthionourethan as an intermediate in the formation of ammonium thiocyanates. Cyclohexylammonium thiocyanate is formed in high yield by treatment of 3,5-dimethyl-1-thiocarbamoylpyrazole with cyclohexylamine in refluxing benzene.

It is also of interest that a closely related series of compounds, *i.e.*, 1-carbamoylimidazoles, shows a strong tendency to dissociate in solution with formation of isocyanates and imidazole[8] while isothiocyanates are analogously obtained from the sulfur derivatives.[6] Furthermore when N,N′-thiocarbamoyldiimidazoles are treated with primary amines in a molar ratio of 1:2 quantitative yields of thioureas are obtained, whereas secondary amines yield 1-thiocarbamoylimidazoles in-



(5) W. Franke and R. Kraft, *Chem. Ber.*, **86**, 797 (1953).
(6) H. A. Staab and G. Walther, *Ann.*, **657**, 104 (1962).
(7) F. L. Scott, *J. Org. Chem.*, **22**, 1568 (1957).
(8) H. A. Staab and W. Benz, *Ann.*, **648**, 72 (1961).

dicating that thiourea formation also occurs *via* an intermediate isothiocyanate.[6]

The pyrazoles employed in the present investigation have been synthesized by the reaction of 1,3-diketones with the appropriate semicarbazide or thiosemicarbazide. 1,1,3,3-Tetraethoxypropane was employed in the synthesis of 1-carbamoyl- and 1-thiocarbamoylpyrazole.[9] This tetraacetal also yielded pyrazole derivatives with N^4-methylthiosemicarbazide and N^4-dimethylthiosemicarbazide despite the statement to the contrary by Stanovnik and Tišler.[10]

Experimental Section[11]

1-[3,5-Dimethyl-(1H)-1-(thiocarbamoyl)-4-pyrazolyl]butan-3-one Thiosemicarbazone (I).—A solution of 5.5 g (0.06 mole) of thiosemicarbazide in 100 ml of 50% aqueous acetic acid was cooled to 35°; 5.1 g (0.03 mole) of 3-acetyl-2,6-heptanedione was added. On keeping this overnight a colorless, crystalline material was obtained. The yield was 7.1 g (79%). This was purified by dissolution in dimethylformamide and dilution of the solution with methanol. The product was dried by washing with anhydrous ethanol, then anhydrous ether and finally in a vacuum desiccator over KOH for 48 hr. It had mp 110–112°, resolidifying and melting again at 182–184°.

Anal. Calcd for $C_{11}H_{18}N_6S_2 \cdot HCON(CH_3)_2$: C, 45.5; H, 6.8; N, 26.4; S, 17.0. Found: C, 45.3; H, 6.7; N, 26.4; S, 17.3.

Solvent-free material having essentially the same melting point was obtained by washing the product from the aqueous acetic acid with ethanol and ether and then drying in a vacuum desiccator over KOH for 120 hr.

Anal. Calcd for $C_{11}H_{18}N_6S_2$: C, 44.3; H, 6.0; N, 28.2; S, 21.5. Found: C, 44.2; H, 6.2; N, 28.0; S, 20.4.

1-[(3,5-Dimethyl-(1H)-1-(carbamoyl)-4-pyrazolyl]butan-3-one Semicarbazone (XIII).—To a solution of 4.4 g (0.04 mole) of semicarbazide hydrochloride in 80 ml of water was added 3.4 g (0.02 mole) of 3-acetyl-2,6-heptanedione followed by sufficient ethanol to give a homogeneous solution. On keeping for 12 hr this deposited 3.0 g (56.0%) of a highly insoluble material, mp 182–186°. After crystallization from dimethylformamide–ethanol it had mp 184–187° with slight softening at 170°.

Anal. Calcd for $C_{11}H_{18}N_6O_2$: C, 49.6; H, 6.8; N, 31.6. Found: C, 49.4; H, 6.8; N, 31.3.

1-(3,5-Dimethyl-(1H)-4-pyrazolyl)butan-3-one Thiosemicarbazone Thiocyanate (II).—The pyrazole thiosemicarbazone (I) was quantitatively converted to the salt by warming at 95–100° for 4 hr. It had mp 182–184° which was not altered by crystallization from methanol: λ_{max}^{Nujol} 4.8 and 4.95 μ (N=C=S$^-$).

Anal. Calcd for $C_{10}H_{17}N_5S \cdot HCNS$: C, 44.3; H, 6.0; N, 28.2; S, 21.5. Found: C, 44.6; H, 6.1; N, 27.9; S, 21.2.

Treatment of II with Hydrazine Hydrate.—A solution of 2.0 g of II in 80 ml of 95% ethanol containing 1.0 ml of hydrazine hydrate was heated under reflux for 10 min. The solvent was removed in a spin evaporator and the residue recrystallized from aqueous methanol. A crystalline material (0.3 g) was obtained which had mp 179–181°, undepressed on admixture with authentic thiosemicarbazide. This yield is not significant since there was appreciable decomposition evidenced by the evolution of H_2S.

1-(3,5-Dimethyl-(1H)-4-pyrazolyl)butan-3-one Thiosemicarbazone (III).—A solution of 1.0 g of the thiocyanate salt II in 60 ml of 95% ethanol containing 1.0 ml of *n*-butylamine was heated under reflux for 1 hr. The solution was concentrated and kept overnight at 0°. Colorless, crystalline material, mp 188–190°, was obtained. This had no absorption in the 4.7- to 5.0-μ region. The yield was 0.5 g (62.0%).

Anal. Calcd for $C_{10}H_{17}N_5S$: C, 50.4; H, 6.7; N, 29.3; S, 13.4. Found: C, 50.2; H, 7.2; N, 28.8; S, 13.5.

This compound yielded a picrate IV, mp 191–194° dec, which was identical in decomposition point, solubility, and infrared spectrum with the picrate obtained from II.

Anal. Calcd for $C_{10}H_{17}N_5S \cdot C_6H_2OH(NO_2)_3$: C, 41.1; H, 4.1; N, 24.0. Found: C, 41.0; 4.3; N, 24.1.

3,5-Dimethyl-1-(N,N-dimethylthiocarbamoyl)pyrazole (XIV).—A solution of 4.8 g (0.04 mole) of N^4-dimethylthiosemicarbazide[12,13] in 100 ml of 50% aqueous acetic acid was cooled to 35° and 4.0 g (0.04 mole) of 2,4-pentanedione was added. A golden yellow oil separated almost immediately. After keeping overnight this was extracted with methylene chloride, the extract was dried (Na_2SO_4), the solvent was removed, and the residue was distilled. The distillate, which had bp 150–158° (15 mm), solidified on cooling. The yield was 5.7 g (68%). After crystallization from petroleum ether it had mp 59–60°.

Anal. Calcd for $C_8H_{13}N_3S$: C, 52.5; H, 7.1; N, 23.0. Found: C, 52.5; H, 7.2; N, 22.6.

1-N,N-Dimethylthiocarbamoylpyrazole (XIII).—To a stirred solution of 3.6 g of N^4-dimethylthiosemicarbazide in 80 ml of water was added 6.6 g of 1,1,3,3-tetraethoxypropane. The mixture was warmed occasionally to 40° over a period of 4 hr and then stored at 5° overnight. The aqueous layer had developed a pronounced red color and a highly insoluble golden yellow solid had separated. This was removed and the filtrate was extracted twice with methylene chloride. The combined extracts were dried (Na_2SO_4), the solvent was removed, and the residue was distilled. The distillate, which was a golden yellow oil, had bp 147–154° (15 mm). It failed to crystallize and a second distillation failed to remove the yellow color. The yield was 0.9 g (19%). The other pyrazoles employed are listed in Table I.

Anal. Calcd for $C_6H_9N_3S$: C, 46.5; H, 5.8; N, 27.1. Found: C, 46.7; H, 6.2; N, 27.2.

3-Methylpyrazole Thiocyanate.—3-Methyl-1-thiocarbamoylpyrazole (VII) was heated at 95–100° for 12 hr. The resultant semisolid mass was dissolved in methanol and on keeping in a refrigerator for several days yielded a highly crystalline, faintly yellow material, mp 143–145°. The yield of recovered material was 68%. It had λ_{max}^{Nujol} 4.85 μ (N=C=S$^-$).

Anal. Calcd for $C_4H_6N_2 \cdot HCNS$: C, 42.6; H, 5.0; N, 29.8. Found: C, 42.9; H, 5.2; N, 29.3.

1-(3,5-D-methyl-(1H)-4-pyrazolyl)butan-3-one Thiocyanate.—The pyrazole, 1-[3,5-dimethyl-(1H)-1-(thiocarbamoyl)-4-pyrazolyl]butan-3-one (VI, 1.0 g) was heated at 100° for 5 hr and the product crystallized from acetone–ether. The yield was 0.84 g (84%). It had mp 123–124°, λ_{max}^{Nujol} 4.95 (N=C=S$^-$) and 5.85 μ (C=O).

Anal. Calcd for $C_9H_{14}N_2O \cdot HCNS$: C, 53.3; H, 6.7; N, 18.7. Found: C, 53.3; H, 6.8; N, 18.4.

Thermal Decomposition of 3,5-Dimethyl-1-thiocarbamoylpyrazole (V).—This compound on heating at 85–90° for 3 hr underwent complete decomposition to the salt. The product had the characteristic infrared absorption at 4.85 to 4.90 μ and on treatment with an ethanol solution of picric acid yielded 3,5-dimethylpyrazole picrate, mp 164–166°, lit.[14] mp 166–167°. The infrared spectrum of this picrate was superimposable on that of the authentic 3,5-dimethylpyrazole picrate. An identical result was obtained by heating the thiocarbamoylpyrazole in benzene or ethanolic solutions for 3 hr or by maintaining these solutions at room temperature for 72 hr. The thiocyanate salt was extremely hygroscopic and an analytically pure sample was not obtained.

Pyrazole Thiocyanate.—1-Thiocarbamoylpyrazole (VIII) was heated on a silicone bath at 155–160° for 10 min. The resultant semisolid mass had λ_{max}^{Nujol} 4.85 μ (N=C=S$^-$) and yielded a picrate, mp 156–158°, pyrazole picrate lit.[15] mp 158–159°.

Thermal Decomposition of 1-N-Methylthiocarbamoylpyrazole Derivatives. A. 3-Methyl-1-N-methylthiocarbamoylpyrazole (XII) on heating on a silicone bath at 185–190° yielded a colorless, highly lachrymatory distillate, bp 120–145°. It had λ_{max} 4.55 and 4.75 μ (N=C=S$^-$) and a considerable absorption in the 6.4- to 7.5-μ region suggestive of a pyrazole structure. It yielded a picrate, mp 140–142°. The picrate of 3-methylpyrazole has mp 142°.[16]

B. 1-N-Methylthiocarbamoylpyrazole (XI) on heating as above yielded a mixture of methyl isothiocyanate and pyrazole

(9) *Cf.* R. G. Jones, *J. Org. Chem.*, **20**, 1681 (1955).

(10) B. Stanovnik and M. Tišler, *Naturwissenschaften*, **52**, 207 (1965).

(11) Melting points were determined on a Kofler hot stage and are uncorrected. The infrared spectra, for which the author is indebted to Dr. Peter Lim and his staff, were taken on a Beckman IR-4 spectrophotometer. Petroleum ether had bp 60–110°.

(12) K. A. Jensen, *J. Prakt. Chem.*, **159**, 189 (1941).

(13) E. Lieber, C. N. Pillai, and R. D. Hites, *Can. J. Chem.*, **35**, 832 (1957).

(14) R. V. Rothenberg, *J. Prakt. Chem.*, **52**, 45 (1895).

(15) A. Luttringhaus, J. Gander, and R. Schneider, *Chem. Ber.*, **92**, 1756 (1959).

(16) I. I. Grandberg and A. N. Kost, *Zh. Obshch. Khim.*, **28**, 3071 (1958); *cf. Chem. Abstr.*, **53**, 10188*g* (1959).

TABLE I

1-THIOCARBAMOYLPYRAZOLE DERIVATIVES

Compd	Mp, °C	Yield, %	Mol formula	Calcd, %			Found, %		
				C	H	N	C	H	N
V	92–94[a] (H·COOH)	80	$C_6H_9N_3S$	46.5	5.8	27.1	46.6	6.0	26.8
VI	104–107 (MeOH)	60	$C_{10}H_{15}N_3OS$[b]	53.3	6.7	18.7	53.3	6.8	18.2
VII	137–140[c] (MeOH)	85	$C_5H_7N_3S$	42.9	5.0	29.8	42.6	5.0	29.8
VIII	140–141[d] ($CHCl_3$)	20	$C_4H_5N_3S$	...	...	33.0	...	...	32.5
IX	123–124 (MeOH)	54	$C_{13}H_{22}N_6S_2$[e]	47.9	6.7	25.8	47.7	6.9	26.0
X	82–84 (MeOH)	57	$C_{11}H_{17}N_3OS$[f]	55.2	7.1	17.6	55.0	7.3	17.5
XI	64–65 (petroleum ether)	39	$C_5H_7N_3S$[g]	42.9	5.0	29.8	42.6	5.1	29.6
XII	71–73 (MeOH)	54	$C_6H_9N_3S$[h]	46.5	5.8	27.1	46.3	6.0	26.8

[a] G. Losse, W. Hessler, and A. Barth [*Chem. Ber.*, **91**, 150 (1958)] reported mp 95–97°. [b] Obtained from equimolar proportions of thiosemicarbazide hydrochloride and 3-acetyl-2,6-heptanedione. [c] D. M. Burness [*J. Org. Chem.*, **21**, 97 (1956)] reported mp 132.5–133.5° on a slightly impure sample. [d] Stanovik and Tišler[10] reported mp 146°. [e] From N⁴-methylthiosemicarbazide and 3-acetyl-2,6-heptanedione in 2:1 molar proportions in glacial acetic acid. [f] Obtained by condensation of molar proportions of N⁴-methylthiosemicarbazide and 3-acetyl-2,6-heptanedione. [g] From N⁴-methylthiosemicarbazide hydrochloride and 1,1,3,3-tetraethoxypropane. [h] From β-ketobutyraldehyde dimethylacetal and N⁴-methylthiosemicarbazide hydrochloride.

identified by means of the infrared spectrum and the formation of pyrazole picrate, mp 157–159°.[15]

C. 1-[3,5-Dimethyl-(1H)-1-(N-methylthiocarbamoyl)-4-pyrazolyl]butan-3-one (X) was heated on a silicone bath at 135–140° for 20 min under a vacuum of 20 mm. A colorless, lachrymatory distillate was obtained which crystallized on cooling. It had mp 34–36° undepressed on admixture with authentic methyl isothiocyanate. The infrared spectra were superimposable. The residue in a distilling flask, **1-(3,5-dimethyl-(1H)-4-pyrazolyl)-butan-3-one**, crystallized from benzene–petroleum ether: mp 72–74°, λ_{max}^{Nujol} 5.85 μ (C=O).

Anal. Calcd for $C_9H_{14}N_2O$: C, 65.1; H, 8.4; N, 16.9. Found: C, 65.1; H, 8.5; N, 16.7.

D. 1-[3,5-Dimethyl-(1H)-1-(N-methylthiocarbamoyl)-4-pyrazolyl]butan-3-one N⁴-methylthiosemicarbazone (IX) on heating in same way as previous compound also yielded methyl isothiocyanate.

Thermal Decomposition of N-Carbamoylpyrazole Derivatives.—3-Methyl-1-carbamoylpyrazole was obtained by condensation of semicarbazide hydrochloride and β-ketobutyraldehyde dimethyl acetal. It had mp 126–128° with slight softening at 96°. Burness (footnote *c*, Table I) found that this compound had a double melting point, *i.e.*, partial melting at 94–96° and complete melting at 123.5–124.5°. von Auwers and Daniel[17] gave mp 127–128°. This material (1.0 g) was recovered unchanged after 24 hr at 100°. On heating in a silicone bath at 185–190° a clear melt was initially obtained. This was followed by a brisk evolution of gas and the abrupt formation of a finely divided white solid which caused violent bumping. Cautious heating was continued for a further 10 min. A small volume of methanol was then added and the insoluble material was removed. This proved to be cyanuric acid. It gave a positive Wohler's test[18] and its infrared spectrum was superimposable on that of authentic cyanuric acid.[19,20] The yield was almost quantitative. The solvent was removed from the methanolic filtrate leaving a colorless oil, bp 198–203° (760 mm). This yielded a picrate, mp 140–141°. The recorded[16] boiling point of 3-methylpyrazole is 200–202° (760 mm) while its picrate had mp 142°.[16]

Cyanuric acid and the appropriate pyrazole were also obtained in almost quantitative yield when 1-carbamoyl-3,5-dimethylpyrazole and 1-carbamoylpyrazole were similarly heated. It is of interest that the latter compound required a slightly higher bath temperature, *i.e.*, 195–200°, to effect the decomposition.

Condensation of Pyrazoles and Methyl Isothiocyanate.—A mixture of 0.5 g (0.0073 mole) of pyrazole and 0.54 g (0.0073 mole) of methyl isothiocyanate was heated gently until a clear solution was obtained. This solution had λ_{max} 4.5 to 4.7 μ (N=C=S⁻) but after 24 hr absorption in this region was barely detectable. After 72 hr the colorless oil was dissolved in petroleum ether and on cooling the solution deposited colorless glistening plates, mp 65–66°, undepressed on admixture with 1-N-methylthiocarbamoylpyrazole. The yield was 70%. Similarly prepared were 3-methyl-1-N-methylthiocarbamoylpyrazole, in 51% yield and 3,5-dimethyl-1-N-methylthiocarbamoylpyrazole which was a golden yellow oil.

Anal. Calcd for $C_7H_{11}N_3S$: N, 24.8. Found: N, 24.6.

Aminolysis of V.—A solution of 1.55 g (0.01 mole) of V in Analar benzene (40 ml) containing 0.99 g (0.01 mole) of cyclohexylamine was heated under reflux for 3 hr. On cooling and dilution with anhydrous ether a colorless, glistening material (1:3 g, 82%) was obtained. This was cyclohexylammonium thiocyanate, mp 99–100°, undepressed on admixture with an authentic sample. The infrared spectra were also identical.

Anal. Calcd for $C_7H_{14}N_2S$: C, 53.1; H, 9.0; N, 17.7; S, 20.0. Found: C, 53.2; H, 8.9; N 17.7; S, 20.3.

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