rose gradually from 46 to 109°. The crude product was poured into water, the clear solution was acidified with concentrated hydrochloric acid, the oily product was separated, and the aqueous layer was extracted with two 100-ml. portions of ether. Distillation afforded 3.5 g. of a forerun, b.p. 62–90° (0.1 mm.), which partially solidified and consisted mainly of recovered crotonic acid, and 62.5 g. (99%) of product.[49,50]

dl-**3-Phenylthiobutyric Acid.**—To a mixture of 17.2 g. (0.2 mole) of crotonic acid and 20.2 g. (0.2 mole) of triethylamine there was added with stirring 22.0 g. (0.2 mole) of thiophenol. An exothermic reaction took place, the temperature rose rapidly to 65°, remained there for about 10 min., and then dropped. The mixture was heated for 10 min. at 115°; a small sample of the reaction mixture was completely soluble in water. The usual work-up afforded on distillation 38.5 g. (98.1%) of colorless viscous liquid product.

3-*t*-Octylthiopropionic Acid.—A mixture of 29.2 g. (0.2 mole) of *t*-octanethiol (technical grade, mixture of isomers), 20.2 g. (0.2 mole) of triethylamine, and 14.4 g. (0.2 mole) of acrylic acid was refluxed for 16 hr., then worked up in the usual way.[51] Distillation afforded 42.5 g. (97.5%) of colorless product.

Acknowledgment.—The n.m.r. spectra were run and interpreted by Dr. Martin W. Dietrich.

(49) M. H. Palomaa and T. Kaski [*Suomen Kemistilehti*, **19B**, 85 (1946); *Chem. Abstr.*, **41**, 5453 (1947)] made the analogous propionic acid.

(50) L. J. Desha and G. H. Denny, Jr. (thesis, Washington and Lee University, 1950, cited in E. E. Reid, "Organic Chemistry of Bivalent Sulfur," Vol. III, Chemical Publishing Co., Inc., New York, N. Y., 1960, p. 208) reported the corresponding propionic acid.

(51) The triethylamine salts of the higher *t*-alkylthiopropionic acids tend to form gels in water.

Aminocyanopyrazoles

C. L. DICKINSON, J. K. WILLIAMS, AND B. C. MCKUSICK

Contribution No. 901 from the Central Research Department, Experimental Station, E. I. du Pont de Nemours and Company, Wilmington, Delaware

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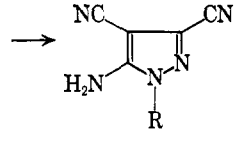
Tetracyanoethylene reacts with monosubstituted hydrazines and hydrazides to give 5-amino-3,4-dicyanopyrazoles. A number of pyrazoles have been prepared from a variety of cyanoethylenes that contain replaceable groups.

The synthesis of aminopyrazoles from cyanoethylenes containing a replaceable group on the 2-position and hydrazine or substituted hydrazines has been reported.[1] In these cases, the group replaced was alkoxy, amino, or alkylthio. We have applied this method to a number of cyanoethylenes in which the leaving group is cyano, sulfonyl, or chloro. In these cases, the reaction conditions are very mild, and hydrazides work as well as or better than hydrazines.

Tetracyanoethylene reacts with hydrazine to give the highly colored acid, 1,1,2,5,6,6-hexacyano-3,4-diazahexadiene.[2] We have now found that the reaction of monosubstituted hydrazines and hydrazides with tetracyanoethylene gives 5-amino-3,4-dicyanopyrazoles in excellent yields. The facile reaction takes place at or below room temperature.

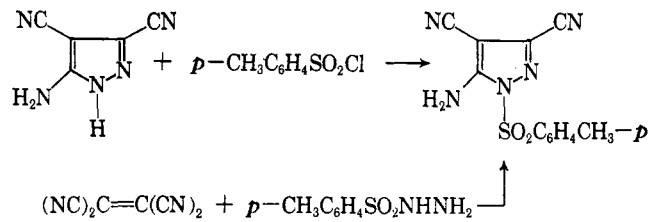
$$(NC)_2C{=}C(CN)_2 + RNHNH_2 \longrightarrow [(NC)_2C{=}C(CN)NHNHR]$$



The initial step involves replacement of a cyano group to give a tricyanovinylhydrazine intermediate, which then cyclizes to the aminodicyanopyrazole. With semicarbazide, the reaction was run in water, and a yellow color characteristic of tricyanovinylamines appeared in an early stage of the reaction. A white crystalline product slowly separated, and the yellow color diminished in intensity as more product formed. Since substituted hydrazines react much faster, the stages of reaction are not so evident.

Since initial attack on tetracyanoethylene by arylhydrazines or hydrazides would be expected to be by the unsubstituted nitrogen, the product from cyclization would be expected to be the 3-amino isomer rather than the 5-amino isomer. The product from methylhydrazine should be the 5-amino isomer, however, since the nitrogen to which the methyl group is attached is the more nucleophilic.

Although 5-amino-3,4-dicyanopyrazole cannot be prepared from hydrazine and tetracyanoethylene directly, it is readily available from 5-amino-3,4-dicyano-1-carbamoylpyrazole by hydrolysis in boiling water. A number of 1-substituted derivatives of 5-amino-3,4-dicyanopyrazole can be prepared by acylation, alkylation, or reaction with isocyanates. By the action of *p*-toluenesulfonyl chloride, dimethylcarbamoyl chloride, or isocyanic acid on 5-amino-3,4-dicyanopyrazole, we were able to prepare compounds identical with those from the reaction of tetracyanoethylene with *p*-toluenesulfonyl hydrazide, 4,4-dimethylsemicarbazide, or semicarbazide. Alkylation with dimethylsulfate gave two isomers. The lower melting isomer, obtained in lower yield, was identical with that from methyl-



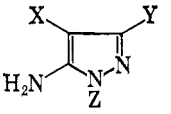
hydrazine and tetracyanoethylene. That the major product from methylation would be expected to be the 5-amino isomer by analogy with the acylation experiments is consistent with the assignments of the 3-amino structure to the methylhydrazine–tetracyanoethylene product.

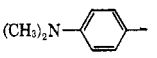
(1) (a) W. J. Middleton and V. A. Engelhardt, *J. Am. Chem. Soc.*, **80**, 2829 (1958); (b) R. A. Carboni, D. D. Coffman, and E. G. Howard, *ibid.*, **80**, 2838 (1958); (c) R. K. Robins, *ibid.*, **78**, 784 (1956); (d) R. Gomper and W. Töpfl, *Ber.*, **95**, 2881 (1962); (e) E. C. Taylor and K. S. Hartke, *J. Am. Chem. Soc.*, **81**, 2452 (1963).

(2) W. J. Middleton, E. L. Little, D. D. Coffman, and V. A. Engelhardt, *ibid.*, **80**, 2795 (1958).

TABLE I

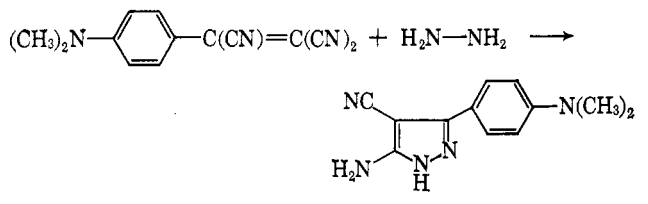
5-AMINOPYRAZOLES



X	Y	Z	Method	Q[d]	Reaction solvent
CN	CN	CH_3	A, B	CN	H_2C
CN	CN	C_6H_5	A	CN	C_2H_5OH
CN	CN	p-$O_2NC_6H_5$	A	CN	C_2H_5OH
CN	CN	CH_3CO	A	CN	H_2O
CN	CN	C_6H_5CO	A	CN	H_2O
			B		C_4H_8O
CN	CN	p-$CH_3C_6H_4SO_2$	A	CN	C_2H_5OH
			B		C_4H_8O
CN	CN	$BrCH_2CO$	B		C_4H_8O
CN	CN	$CONH_2$	A	CN	H_2O
			B		C_4H_8O
CN	CN	$CSNH_2$[a]	A	CN	DMF
CN	CN	$CONHCH_3$[b]	B		C_4H_8O
CN	CN	$CONHC_2H_5$[b]	B		C_4H_8O
CN	CN	$CONHC_4H_9$	B		$CH_3CO_2C_2H_5$
CN	CN	$CONHC_6H_5$	B		C_4H_8O
CN	CN	$CON(CH_3)_2$	A	CN	C_2H_5OH
			B		C_4H_8O
CN	CN	$CON(C_2H_5)_2$	B		C_4H_8O
CN	CN	$(CONHCH_2CH_2CH_2-)_2$	B		C_4H_8O
CN	CN	$CONHCH_2CO_2C_2H_5$	B		C_4H_8O
CN	CN	$CO_2C_2H_5$	B		C_4H_8O
CN	CN	$SO_2N(CH_3)_2$[c]	B		C_4H_8O
$CH_3C_6H_4SO_2$	CN	$CH_3C_6H_4SO_2$	A	$CH_3C_6H_4SO_2$	$HCON(CH_3)_2$
$CH_3C_6H_4SO_2$	CN	$CONH_2$	B		C_4H_8O
			C		CH_3CO_2H
$CH_3C_6H_4SO_2$	CN	$CON(CH_3)_2$	B		C_4H_8O
			C		CH_3CO_2H
CH_3SO_2	CN	$CONH_2$	C		CH_3CO_2H
CH_3SO_2	CN	$CON(CH_3)_2$	C		CH_3CO_2H
$C_6H_5SO_2$	CN	$CONH_2$	C		CH_3CO_2H
CN	CH_3SO_2	$CONH_2$	B		C_4H_8O
CN	H	$CONH_2$[a]	A	OC_2H_5	C_2H_5OH
CN	CH_3	$CONH_2$	A	OC_2H_5	C_2H_5OH
CN	C_6H_5	$CONH_2$[a]	A	OCH_3	C_2H_5OH
CN		$CONH_2$	B		C_4H_8O
CN		$CONH_2$	B		C_4H_8O
CN	CH_2CN	$CONH_2$	B		C_4H_8O
CN	SCH_3	$CONH_2$	A	SCH_3	C_2H_5OH
CN	OCH_2CH_3	$CONH_2$	A	OC_2H_5	C_2H_5OH
CN	Cl	$SO_2C_6H_4CH_3$	A	Cl	C_4H_8O
CN	C_6H_5	C_6H_5	A	OCH_3	C_2H_5OH

[a] This compound was prepared by Dr. L. M. Ellis. [b] This compound was prepared by Dr. W. Wayne. [c] This compound was pre-

Hydrazine reacted readily with 2-tricyanovinyl-1-methylpyrrole and p-tricyanovinyl-N,N-dimethylaniline, but these compounds are much less reactive than tetracyanoethylene. 5-Amino-4-cyano-3-(p-N,N-dimethylaminophenyl)pyrazole was easily carbamylated with isocyanic acid.



Other cyanoethylenes that we used were 1,1-dichloro-2,2-dicyanoethylene, 1,1-bis(methylmercapto)-2,2-dicyanoethylene,[1d] and 1,2-bis(p-toluenesulfonyl)-1,2-dicyanoethylene. In the latter case, the reaction could be run by combining sodium p-toluenesulfinate, dichlorofumaronitrile, and a hydrazide.[3] Presumably,

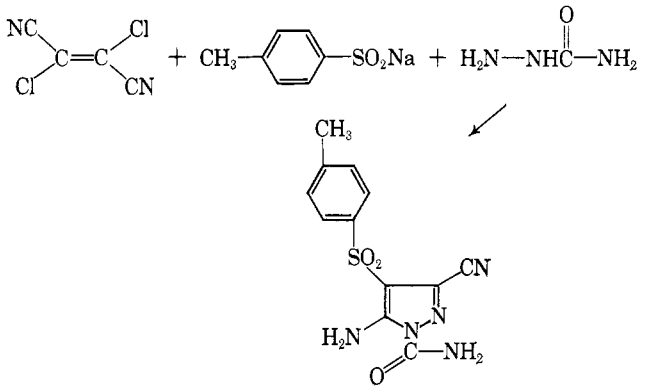
(3) We are indebted to Dr. E. L. Martin for suggesting this modification.

Recrystallization solvent	M.p., °C.	Yield, %	Empirical formula	Carbon, % Calcd.	Carbon, % Found	Hydrogen, % Calcd.	Hydrogen, % Found
H_2O	131.5–133	25	$C_6H_5N_5$	49.0	49.2	3.4	3.4
C_2H_5OH	195 dec.	58	$C_{11}H_7N_5$	63.2	63.3	3.4	3.5
C_2H_5OH	252–253	82	$C_{11}H_6N_6O_2$	52.0	52.1	2.4	2.6
CH_3CO_2H	203–207	68	$C_7H_5N_5O$	48.0	48.0	3.0	3.1
CH_3CO_2H	>200 dec.	68	$C_{12}H_7N_5O$	60.8	60.5	3.0	3.1
C_2H_5OH	214.5–216	87	$C_{12}H_9N_5SO_2$	50.2	50.4	3.1	3.3
CH_3CO_2H	210–211.5	35	$C_7H_4N_5OBr$	33.0	32.8	1.6	2.0
$C_4H_8O_2$ (dioxane)	>240 dec.	93	$C_6H_4N_6O$	40.9	41.4	2.3	2.4
CH_3OH	dec.	35	$C_6H_4N_6S$	*f*			
C_4H_8O	>280	60	$C_7H_6N_6O$	44.2	44.5	3.2	3.3
C_4H_8O	234–235 dec.	53	$C_8H_8N_6O$	47.0	47.2	4.0	4.1
$CH_3CO_2C_2H_5$	188–189	70	$C_{10}H_{12}N_6O$	51.7	52.0	5.2	5.6
$CH_3CO_2C_2H_5$	223–224	63	$C_{12}H_8N_6O$	57.2	57.5	3.2	3.4
$C_4H_8O_2$	227–228	80	$C_8H_8N_6O$	47.1	47.1	3.9	4.0
		70					
C_2H_5OH	170–173	66	$C_{10}H_{12}N_6O$	51.7	52.0	5.2	5.1
$HCON(CH_3)_2$–C_2H_5OH	>300	82	$C_{18}H_{18}N_{12}O_2$	49.8	49.8	4.1	4.4
C_6H_6–C_4H_8O	200.5–201	70	$C_{10}H_{10}N_6O_3$	45.8	45.8	3.8	3.8
$CH_3CO_2C_2H_5$	207–208	90	$C_8H_7N_5O_2$	47.3	47.5	3.4	3.7
C_2H_5OH	166–168	50	$C_7H_8N_6SO_2$	*e*			
C_2H_5OH	207.5–209	60	$C_{18}H_{16}N_4F_4S$	51.9	52.0	3.8	4.0
$CH_3CO_2C_2H_5$	191–192.5	52	$C_{12}H_{11}N_5O_3S$	47.2	47.6	3.6	3.5
		59					
$CH_3CO_2C_2H_5$	163–164	30	$C_{14}H_{15}N_5O_3S$	50.4	50.1	4.5	4.8
		56					
CH_3CN	203–204	72	$C_6H_7N_5O_3S$	31.4	32.0	3.1	3.2
$CH_3CO_2C_2H_5$	186–187	40	$C_8H_{11}N_5O_3S$	37.4	37.2	4.3	4.2
CH_3CN	194–195	50	$C_{11}H_9N_5SO_3$	45.4	45.4	3.1	3.1
CH_3CN	190–193	90	$C_6H_7N_5O_3S$	31.4	31.4	3.1	3.0
	253 dec.	20	$C_5H_5N_5O$	39.7	40.0	3.3	3.5
CH_3CN	206 dec.	30	$C_6H_7N_5O$	43.6	44.0	4.3	4.0
	200–201	70	$C_{11}H_9N_5O$	58.1	58.1	4.0	4.1
$HCON(CH_3)_2$–C_2H_5OH	220–222	79	$C_{13}H_{14}N_6O$	57.8	58.0	5.2	5.3
$CH_3CO_2C_2H_5$	187–188	82	$C_{10}H_{10}N_6O$	52.2	52.4	4.3	4.6
$HCON(CH_3)_2$–CH_3CO_2H	>300	78	$C_7H_6N_6O$	44.2	44.4	3.2	3.4
CH_3CN	214.5–215	68	$C_6H_7N_5SO$	36.5	36.6	3.6	3.5
CH_3CN	214–215	30	$C_7H_9N_5O_2$	43.1	43.3	4.6	4.6
$CH_3CO_2C_2H_5$	190–192	90	$C_{11}H_9N_4SO_2Cl$	44.6	44.6	3.0	3.4
	172–173	80	$C_{16}H_{12}N_4$	73.8	73.5	4.6	4.7

pared by Dr. E. W. Bousquet. [d] In the precursor NCC(X)=C(Y)Q. [e] Calcd.: S, 13.3; N, 35.0. Found: S, 12.9; N, 35.3. [f] Calcd.: S, 16.7. Found: S, 16.9.

the sulfinate reacted first with the dichlorofumaronitrile and the resulting ethylene reacted further with the hydrazide to give the pyrazole. (see p. 1918, col. 1).

The amino group of the dicyanoaminopyrazoles is not basic, for it cannot be titrated with perchloric acid in glacial acetic acid. 5-Amino-3,4-dicyanopyrazole is weakly acidic (pK_a = 7). The amino group can be diazotized with nitrosylsulfuric acid. The resulting diazonium group has been replaced with hydrogen and chlorine, but in the latter case one of the nitrile groups was hydrolyzed to an amide group. The amino group of 5-amino-3,4-dicyano-1-phenylpyrazole was condensed with *p*-dimethylaminobenzaldehyde to give a stable, yellow anil. Acetylation of 5-amino-3 4-dicyano-1-carbamoylpyrazole with acetic anhydride gave 3-acetamido-4,5-dicyanopyrazole. The carbamoyl group was probably intact during the acetylation, but was cleaved in the work-up with water even under acidic conditions. The 1-carbamoyl derivative of 3-acetamido-4,5-dicyanopyrazole was not obtained when that compound was treated with isocyanic acid in tetrahydrofuran.



Another example of the 1-carbamoyl group serving as a protective function and being subsequently cleaved is found in the oxidation of 5-amino-4-cyano-3-methylthio-1-carbamoylpyrazole to 5-amino-4-cyano-3-methylsulfonylpyrazole with hydrogen peroxide in glacial acetic acid.

Both nitrile groups of 5-amino-3,4-dicyanopyrazole may be hydrolyzed to amide groups by dissolving the compound in concentrated sulfuric acid and then pouring the solution into water. A more convenient synthesis is to use the 1-carboxamide directly.

The synthesis of pyrazolo[2,3-*a*]pyrimidines is readily carried out by condensation of 5-amino-3,4-dicyanopyrazole with ethyl acetoacetate or acetylacetone. This reaction has been reported previously for 3(5)-aminopyrazoles.[1a,e]

Experimental[4]

N-Substituted 5-Aminopyrazoles (Table I). Method A.—The hydrazine or hydrazide is dissolved in a suitable solvent, such as ethanol or water, and the cyanoolefin is added with stirring. Reactive olefins such as tetracyanoethylene react at room temperature with hydrazides, and with hydrazines the reaction mixture is cooled in ice. In a typical experiment, 12.8 g. (0.10 mole) of tetracyanoethylene was added to a solution of 18.6 g. (0.10 mole) of tosylhydrazide in 200 ml. of ethanol. This mixture was cooled in ice and stirred for 1 hr. and then boiled on a steam bath for 15 min. The solution was cooled, and the white crystalline precipitate of 5-amino-3,4-dicyano-1-tosylpyrazole was collected and washed with alcohol, yield 25.0 g. (87%), m.p. 211–213°. It was recrystallized from alcohol to give 21.5 g., m.p. 214.5–216°.

Method B.—A pyrazole unsubstituted on the nitrogen is treated with an acyl halide or an isocyanate in a nonreactive solvent, such as ethyl acetate or tetrahydrofuran. In a typical experiment, a solution of 10.0 g. of 5-amino-3,4-dicyanopyrazole and 9.0 g. of phenyl isocyanate in 100 ml. of tetrahydrofuran was heated under reflux for 2 hr. and then evaporated to dryness. The residue of 5-amino-3,4-dicyanopyrazole-1-carboxanilide was recrystallized from ethyl acetate, yield 11.9 g. (63%), m.p. 223–224°.

Method C.—Dichlorofumaronitrile and the appropriate hydrazide in acetic acid is treated with a sodium sulfinate. In a typical experiment, a mixture of 14.7 g. (0.10 mole) of dichlorofumaronitrile, 16.4 g. (0.10 mole) of sodium benzenesulfinate, 7.5 g. (0.1 mole) of semicarbazide, and 100 ml. of glacial acetic acid was stirred overnight and then diluted with 200 ml. of water. The precipitate of 5-amino-4-benzenesulfonyl-1-carbamyl-3-cyanopyrazole was collected and recrystallized from acetonitrile, yield 14.5 g. (50%), m.p. 194–195°.

5-Amino-3,4-dicyanopyrazole.—5-Amino-1-carbamoyl-3,4-dicyanopyrazole (160 g., 0.91 mole) was added in portions with occasional stirring to 1.5 l. of boiling water in a 4-l. beaker. This must be done carefully since carbon dioxide is evolved and foaming occurs. Boiling was continued for 5 min. after the final addition, and the reaction mixture was allowed to cool. The precipitate was collected and recrystallized from water, yield 73.5 g. (60%), m.p. *ca.* 260° dec.

Anal. Calcd. for $C_5H_3N_5$: C, 45.1; H, 2.3; N, 52.6. Found: C, 45.7; H, 2.1; N, 52.3.

5-Amino-4-cyano-3[2-(1-methylpyrrolo)]pyrazole.—Hydrazine hydrate (8.5 g.) was added to 29.0 g. of 2-tricyanovinyl-1-methylpyrrole in 200 ml. of ethanol, and the resulting solution was heated under reflux for 2 hr. The solution was then concentrated to 100 ml., and the precipitate of 5-amino-4-cyano-3-[2-(1-methylpyrrolo)]pyrazole was collected, yield 13.9 g. (46%). After recrystallization from ethanol, the melting point was 209–210°.

Anal. Calcd. for $C_9H_9N_5$: C, 57.8; H, 4.8; N, 37.4. Found: C, 57.9; H, 5.0; N, 37.6.

5-Amino-4-cyano-3-(*p*-dimethylaminophenyl)pyrazole.—Hydrazine hydrate (8.0 g.) was added to a solution of 33.3 g. of *p*-tricyanovinyl-N,N-dimethylaniline in 100 ml. of dimethylformamide, whereupon the magenta solution changed to yellow-orange. After 10 min., the solution was diluted with 250 ml. of water and the 5-amino-4-cyano-3-(*p*-dimethylaminophenyl)-pyrazole was collected and recrystallized from ethanol, yield 22.4 g. (67%), m.p. 193–196°.

Anal. Calcd. for $C_{12}H_{13}N_5$: C, 63.4; H, 5.7; N, 30.8. Found: C, 63.2; H, 5.6; N, 30.8.

3,4-Dicyano-5-*p*-dimethylaminobenzylimino-1-phenylpyrazole.—A solution of 8.0 g. (0.038 mole) of 5-amino-3,4-dicyano-1-phenylpyrazole, 5.5 g. (0.037 mole) of *p*-dimethylaminobenzaldehyde, and 0.5 g. of *p*-toluenesulfonic acid in 20 ml. of dimethylformamide was heated on a steam bath for 1 hr., cooled, and diluted with 80 ml. of ethanol. The bright yellow precipitate of 3,4-dicyano-5-*p*-dimethylaminobenzylimino-1-phenylpyrazole was collected, yield 7.9 g., m.p. 194.5–196.0°. A sample was recrystallized from ethanol for analysis.

Anal. Calcd. for $C_{20}H_{16}N_6O$: C, 70.6; H, 4.7. Found: C, 70.3; H, 4.6.

3-Methylsulfonyl-4-cyano-5-aminopyrazole.—A mixture of 149 g. of 1-carbamyl-3-methylthio-4-cyano-5-aminopyrazole, 1 l. of glacial acetic acid, and 210 g. of 30% hydrogen peroxide was heated under reflux for 2 hr. and then allowed to stand at room temperature for 11 hr. The clear amber solution was seeded and cooled in ice for 0.5 hr. The solid that crystallized was collected to give 91 g. (64.5%) of crude, yellow 3-methylsulfonyl-4-cyano-5-aminopyrazole. Recrystallization of 86 g. of this crude product from water ("Darco") gave 78 g. of pale, tan needles, m.p. 200–203°, with softening at 131°.

A sample prepared for analysis by two additional crystallizations from water melted at 200–202.5° after drying at 100° (0.2 mm.) for 18 hr.

Anal. Calcd. for $C_5H_6N_4SO_2$: C, 32.3; H, 3.2; N, 30.1. Found: C, 32.32; H, 3.3; N, 29.9.

5-Acetamido-3,4-dicyanopyrazole.—A mixture of 10.0 g. of 5-amino-1-carbamyl-3,4-dicyanopyrazole, 40 ml. of acetic anhydride, and 5 ml. of pyridine was heated on a hot plate until a solution was obtained. The solution was then poured into 400 ml. of ice water and stirred until all of the acetic anhydride had reacted. The precipitate of 5-acetamido-3,4-dicyanopyrazole was collected and recrystallized from ethanol, yield 6.0 g. (60%), m.p. 250° dec.

Anal. Calcd. for $C_7H_5N_5O$: C, 48.0; H, 2.9. Found: C, 48.0; H, 3.1.

5-Aminopyrazole-3,4-dicarboxamide.—3-Amino-4,5-dicyanopyrazole (20 g.) was added carefully to 88 ml. of concentrated sulfuric acid in small portions so that the evolution of carbon dioxide was not too vigorous. The resulting solution was stirred overnight and then poured into 500 ml. of ice-water. The precipitate was collected, suspended in 200 ml. of water, made alkaline with 10% sodium hydroxide, and acidified with 5% hydrochloric acid. The 5-aminopyrazole-3,4-dicarboxamide was collected and recrystallized from water, yield 15.5 g. (81%), m.p. >300°.

2,3-Dicyano-5,7-dimethylpyrazolo[2,3-*a*]pyrimidine.—A mixture of 26.6 g. (0.20 mole) of 5-amino-3,4-dicyanopyrazole, 50 ml. of 2,4-pentanedione, and 0.5 g. of *p*-toluenesulfonic acid was heated at 150–155° for 5 hr. The mixture was cooled and diluted with 100 ml. of ethanol. The precipitate of 2,3-dicyano-5,7-methylpyrazolo[2,3-*a*]pyrimidine was collected, yield 32.3 g. (82%). It was recrystallized from ethanol to give 23.7 g., m.p. 186–188°.

(4) (a) C. L. Dickinson and W. J. Middleton, U. S. Patent 2,998,419 (1961); (b) C. L. Dickinson and B. C. McKusick, U. S. Patent 2,998,426 (1961).

Anal. Calcd. for $C_{10}H_7N_5$: C, 60.9; H, 3.6; N, 35.5. Found: C, 60.3; H, 3.6; N, 35.2.

2,3-Dicyano-7-hydroxy-5-methylpyrazole[2,3-*a*]pyrimidine.—A solution of 13.0 g. of 5-amino-3,4-dicyanopyrazole in 56 ml. of ethyl acetoacetate was heated at 150–160° until no more vapor was evolved. The mixture was then cooled and diluted with 100 ml. of ethanol, and the 2,3-dicyano-7-hydroxy-5-methylpyrazolo-[2,3-*a*]pyrimidine was collected, yield 13.3 g. (71%), m.p. >300°. An analytical sample was prepared by recrystallization from dimethylformamide–acetic acid.

Anal. Calcd. for $C_9H_5N_5O$: C, 54.3; H, 2.5; N, 35.2. Found: C, 54.4; H, 2.7; N, 35.0.

3-Chloro-4(5)-cyano-5(4)-carbamylpyrazole.—Sodium nitrite (14.0 g.) was added to 100 ml. of concentrated sulfuric acid, and the resulting mixture was heated with stirring at 70° until solution was complete. The solution was then cooled in ice and a suspension of 24 g. of 5-amino-3,4-dicyanopyrazole in 280 ml. of glacial acetic acid was added while the temperature was kept eblow 20°. After the mixture had been stirred for 30 min., a solution of 20 g. of cuprous chloride in 200 ml. of concentrated hydrochloric acid was added slowly. The resulting solution was stirred for an additional hour and diluted with 1 l. of water; the resulting solution was extracted with three 300-ml. portions of ethyl acetate. The ethyl acetate extracts were combined, washed with water, dried over magnesium sulfate, and evaporated to dryness. The yield of chloroamide after recrystallization from water was 7.4 g., m.p. 233–235°.

Anal. Calcd. for $C_5H_3N_4OCl$: C, 35.2; H, 1.7; N, 32.8; Cl, 20.8. Found: C, 35.1; H, 1.5; N, 32.8; Cl, 20.7.

3,4-Dicyanopyrazole.—The diazotization was carried out exactly as in the preparation of the chlorocyanopyrazolecarboxamide except that one-fourth the quantities were used. The solution of the diazonium compound was slowly added to 100 ml. of ethanol that contained 0.50 g. of copper sulfate and had been preheated to 60°. The resulting solution was boiled for 30 min., diluted with 400 ml. of water, and extracted with three 150-ml. portions of ethyl acetate. The ethyl acetate extracts were combined, dried over magnesium sulfate, and evaporated to dryness to give 3.1 g. of tan solid. The 3,4-dicyanopyrazole was difficult to purify further, and an analytical sample was prepared by recrystallization one time each from water and benzene and then by sublimation. After repeating this process, the melting point was 196–197°.

Anal. Calcd. for $C_5H_2N_4$: C, 50.8; H, 1.7; N, 47.5. Found: C, 50.9; H, 1.8; N, 47.4.

5(3)-Amino-3(5), 4-dicyano-1-methylpyrazole.—To a solution of 11.5 g. of sodium hydroxide in 50 ml. of water was added 33.3 g. of 5-amino-3,4-dicyanopyrazole, and 42 g. of dimethyl sulfate immediately after the pyrazole had dissolved. After 15 min., the solid that formed was collected and washed with water, yield 22.5 g. The filtrate deposited more solid upon standing and this (B) was collected, yield 5.5 g., m.p. 110–120°. The 22.5-g. sample was heated with 100 ml. of ethanol and filtered hot to remove the undissolved solid. This solid (18.0 g.) melted at 243–245° and the melting point was unchanged after recrystallization from dioxane.

Anal. Calcd. for $C_6H_3N_5$: C, 49.0; H, 3.4; N, 47.6. Found: C, 49.2; H, 3.6; N, 47.3.

B was recrystallized several times from ethanol and the melting point was raised to 128–130°. A mixture melting point determination with the tetracyanoethylene–methylhydrazine product (Table I) showed no depression of the melting point.

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The Synthesis of 1*H*,3*H*-Thieno[3,4-*c*]thiophene[1,2]

HANS WYNBERG AND D. J. ZWANENBURG[3]

Department of Organic Chemistry, The University, Groningen, Holland

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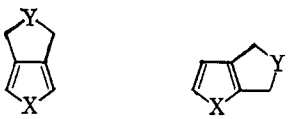
In order to study the effect of ring strain (Mills–Nixon effect) on the properties of five-membered heteroaromatics, the title compound, I, has been synthesized using a highly improved thiophene ring synthesis.

Although the Mills–Nixon[4] or ring-strain effect in indane derivatives recently[5,6] has been shown to be of little actual importance in changing the properties of the benzene ring, it seemed reasonable to expect a much larger effect by fusing the five-membered ring to a five-membered heterocyclic system. One fundamental question which might be resolved and which has received conflicting answers[6,7] thus far concerns in essence the bond order of the bond common to both rings.

To investigate the chemical and physical properties of some five-membered heteroaromatic systems fused to five-membered (or four-membered) rings, the synthesis of several compounds of type I and II has been undertaken.



I II

X = S, O, NR
Y = S, SO_2, NR, CR_2, O

This paper describes the synthesis of two compounds of type I, namely, 1*H*,3*H*-thieno[3,4-*c*]thiophene (I, X = Y = sulfur) and a derivative of 1*H*,3*H*-thieno-[3,4-*c*]thiophene 2,2-dioxide (I, X = S; Y = SO_2) by the reaction sequence outlined in eq. 1.

The reaction between biacetyl and diethyl thiodiacetate has been described[8] but furnished in our hands under the reaction conditions specified a nearly intractable tar. The desired diester could not be isolated, although 10–20% yields of the dibasic acid (IIIe) were realized. We discovered recently, however, in other work in progress in this laboratory,[9] that the reaction of α-diketones with glutaric ester analogs to furnish furans, thiophenes, and pyrroles[10]

(1) Part I of a series of papers entitled "Steric effects in heterocyclic systems."

(2) Presented in part at the 145th National Meeting of the American Chemical Society, New York, N. Y., Sept., 1963.

(3) Predoctoral Fellow of the Netherlands Organization for Pure Scientific Research (Z. W. O.).

(4) W. H. Mills and I. G. Nixon, *J. Chem. Soc.*, 2510 (1930).

(5) L. d'Albis, *Chim. Mod.*, **5**, 209 (1960); *Chem. Abstr.*, **55**, 17,585 (1961).

(6) J. P. Wibaut, *J. chim. phys.*, **53**, 111 (1956).

(7) H. C. Longuet-Higgins and C. A. Coulson, *Trans. Faraday Soc.*, **42**, 756 (1946).

(8) R. Seka, *Ber.*, **58**, 1783 (1925); D. M. Smith, R. Blanchfield, J. L. Thompson, and G. A. Grant, *Can. J. Chem.*, **35**, 156 (1957).

(9) H. Wynberg and H. J. Kooreman, in preparation.

(10) D. E. Wolf and K. Folkers, *Org. Reactions*, **6**, 435 (1951).