This semicarbazone was shown to be different from that of 2,2,3-trimethyl-4-cyclopentenone (XII) by a depressed mixed m. p., 168–170°.

Attempts to prepare a solid oxime were unsuccessful.

As a higher-boiling fraction, 99.3 g. of the starting lactone was recovered.

2-*n*-Hexyl-2-cyclopentenone (VIII) and 2-*n*-Hexyl-4-cyclopentenone.—γ-Undecanolactone (commercial product of Givaudan–Delawanna, Inc., New York) (in two runs totaling 100.0 g., 0.54 mole) gave 25.3 g. of a mixture of ketones, b. p. 74–94° (2 mm.); $n^{20}{}_D$ 1.4728. Redistillation yielded 15.7 g. (17.5%) of 2-*n*-hexyl-2-cyclopentenone, b. p. 97–100° (5 mm.); $n^{20}{}_D$ 1.4675; sp. gr. $^{20}{}_{20}$ 0.910, *MR* calcd., 50.32; *MR* found, 50.72; ultraviolet absorption maximum 229 mμ (log ε = 2.70). The semicarbazone, recrystallized as a colorless powder from 40% ethanol, melted at 194.5–196° (reported,[9] 196°). A 4-g. lower-boiling fraction, b. p. 60–70° (5 mm.); $n^{20}{}_D$ 1.4854; ultraviolet absorption maximum 212 mμ (log ε = 2.40), yielded a semicarbazone corresponding in melting point (192–193.5°) to that of Plattner and St. Pfau[9] (m. p. 189–190°) for 2-*n*-hexyl-4-cyclopentenone. A mixture with the semicarbazone of 2-*n*-hexyl-2-cyclopentenone melted at 186–187°.

Ozonolysis of 2,2,3-Trimethyl-4-cyclopentenone (XII).—Ozone was bubbled for twelve hours through a solution of 3.3 g. (0.027 mole) of 2,2,3-trimethyl-4-cyclopentenone in 35 ml. of glacial acetic acid. The solution was then added dropwise to 25 ml. of 11% aqueous hydrogen peroxide, the mixture being agitated by a stream of air bubbles, and refluxed for two hours. The acetic acid was removed by steam distillation and the residue evaporated to a volume of approximately 5 ml. To this was added 5 ml. of concentrated nitric acid, followed by reevaporation to 5 ml., the process being repeated three times. On standing the solution then deposited platelets of trimethylsuccinic acid, weighing 0.75 g. (18%) after recrystallization from concentrated nitric acid, m. p. 147.5–149° (reported,[15] 148–149°); neutral equivalent calcd., 80.1; found, 84.6.

Anal. Calcd. for $C_7H_{12}O_4$: C, 52.49; H, 7.55. Found: C, 52.22; H, 7.81.

Distillation of 0.25 g. of the acid gave a colorless solid melting *ca.* 30° (anhydride). On standing with an equimolar amount of *p*-toluidine in benzene this deposited crystals of the mono-*p*-toluidide of trimethylsuccinic acid. Recrystallization from 95% ethanol gave colorless needles melting at 125–126° (reported,[16] 127°).

Hydrogenation of 2,2,3-Trimethyl-4-cyclopentenone (XII).—Two grams of the ketone dissolved in 8 ml. of ethanol was hydrogenated over Raney nickel at room temperature and a pressure of 1900 lb. per square inch. The reaction was stopped after five minutes when one molar equivalent of hydrogen had been absorbed (estimated by pressure drop). The catalyst was removed by filtration and the semicarbazone and oxime prepared from the alcoholic solution. The semicarbazone, recrystallized from 40% ethanol, took the form of shiny plates, m. p. 197–198° (reported,[17] 210–212°).

Anal. Calcd. for $C_9H_{17}N_3O$: C, 58.99; H, 9.35. Found: C, 58.76; H, 9.15.

A mixed m. p. with the semicarbazone of 2,2,3-trimethyl-4-cyclopentenone (XII) was depressed, 184–185°.

The oxime, recrystallized from water or aqueous ethanol as colorless needles, melted at 103–104° (reported,[18] 104°).

Anal. Calcd. for $C_8H_{15}NO$: C, 68.05; H, 10.71. Found: C, 67.45; H, 10.56.

Ultraviolet Absorption Spectra.—Miss Ruth Johnston carried out the determinations using a Beckmann Model D Spectrophotometer. The ketones were dissolved in 95% ethanol, concentration 0.006 g. per liter of solution; $\log \epsilon = \log (1/cl) \cdot \log (I_0/I)$, in which c = g./100 ml. of solution, l = 1 cm.

Summary

γ-Methyl-γ-lactones having a methylene group adjacent to the *gamma* carbon atom are converted smoothly by action of phosphorus pentoxide to 2,3-disubstituted 2-cyclopentenones. This method is not applicable, however, for the preparation of 2-cyclopentenone and 3-methyl-2-cyclopentenone.

γ,δ-Dimethyl-γ-caprolactone, when treated with phosphorus pentoxide, is converted in low yield to 2,2,3-trimethyl-4-cyclopentenone and other products.

The ultraviolet absorption spectra of substituted 2-cyclopentenones are briefly discussed.

URBANA, ILLINOIS RECEIVED SEPTEMBER 10, 1947

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(15) Auwers, *Ann.*, **292**, 142 (1896).

(16) Auwers and Umgemach, *Ber.*, **68**, 349 (1935).

(17) Blanc and Desfontaines, *Compt. rend.*, **136**, 1141 (1903).

(18) Noyes and Patterson, *Am. Chem. J.*, **27**, 427 (1902).

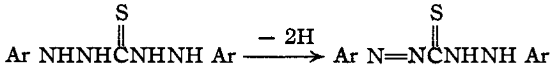
[CONTRIBUTION FROM THE DEPARTMENT OF CHEMISTRY OF THE UNIVERSITY OF ROCHESTER]

The Synthesis of Some Substituted Thiocarbazones[1]

BY D. S. TARBELL, C. W. TODD,[2a] M. C. PAULSON,[2b] E. G. LINDSTROM[2c] AND V. P. WYSTRACH[2d]

The observation[3] that thiocarbazones, especially di-(*p*-biphenyl)-thiocarbazone, were sensitive reagents for the detection of small amounts of arsenicals, led to the preparation and testing of a number of substituted thiocarbazones. The synthesis of these compounds, and their properties as arsenical detectors, are described in the present paper.

Thiocarbazones (I) are prepared by oxidation of the corresponding thiocarbazides (II) by air in alkaline solution or by hydrogen peroxide



$$\mathrm{Ar\ NHNH}\overset{\mathrm{S}}{\overset{\|}{\mathrm{C}}}\mathrm{NHNH\ Ar} \xrightarrow{-\ 2\mathrm{H}} \mathrm{Ar\ N{=}N}\overset{\mathrm{S}}{\overset{\|}{\mathrm{C}}}\mathrm{NHNH\ Ar}$$

II I

Several methods were used for the preparation of the necessary thiocarbazides in our work.

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(1) The work described in this paper was done under Contract OEM-sr-319, recommended by the National Defense Research Committee, between the Office of Scientific Research and Development, and the University of Rochester.

(2) Present address: (a) Experimental Station, E. I. du Pont de Nemours, Inc., Wilmington, Del.; (b) Research Laboratory, Grasselli Chemical Company, Cleveland, Ohio; (c) California Research Corporation, Richmond, Calif.; (d) Research Laboratory, American Cyanamid Company, Stamford, Conn.

(3) By Professor Weldon G. Brown of the University of Chicago.

(1) **The Fischer Method.**—This involves formation of the hydrazine salt of a dithiocarbazinic acid (III), which, on heating, evolves hydrogen sulfide and yields the thiocarbazide II.

$$2ArNHNH_2 + CS_2 \longrightarrow$$

$$\underset{\text{III}}{ArNHNHCS_2H \cdot H_2NHNAr} \xrightarrow{-H_2S} \text{II}$$

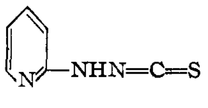
A number of hydrazines were prepared by the usual procedure of reduction of the diazonium compound with sodium sulfite[4] or stannous chloride.[5] Diazonium compounds having electron-donating groups in the ortho- or para-positions were cleaved by reduction, with the formation of the original amine or the corresponding nitrogen-free aromatic compound instead of the hydrazine. This behavior was shown by the diazonium salts from *p*-aminodimethylaniline, 2,6-dimethoxyaniline, 4-dimethylamino-1-naphthylamine, N-(*p*-aminophenyl)-morpholine, and 2-aminodiphenyl sulfide. In order to test the feasibility of a projected synthesis of *p*-dimethylaminophenylhydrazine, a model experiment was tried by treating N-magnesiobromoaniline with monochloroamine; the only product isolated was *p*-bromoaniline, identified through the mixed melting point as the acetyl derivative. Apparently the following reactions took place, instead of the desired formation of phenylhydrazine.

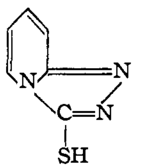
$$\begin{tikzcd} C_6H_5NHMgBr + ClNH_2 \arrow[r] & C_6H_5NHMgCl + BrNH_2 \arrow[d] \\ & p\text{-}BrC_6H_4NHMgCl + NH_3 \end{tikzcd}$$

Much variation was noted in the ability of the various arylhydrazines to react with carbon disulfide. *p*-Nitrophenylhydrazine did not react unless a base was present; in the presence of pyridine, a product was obtained which was probably *p*-$NO_2C_6H_4NHNHCS_2H \cdot C_5H_5N$, but no thiocarbazide could be obtained from it. *p*-Phenoxyphenylhydrazine did not react normally; the thiocarbazide; if formed, apparently was unstable.[6]

The reaction of thiophosgene with arylhydrazines to form thiocarbazides was also used in a few cases, but it did not offer any advantage over carbon disulfide.[7]

2-Pyridylhydrazine and carbon disulfide gave a compound at first believed to have the structure IV, but it was later found to be V, which had been previously prepared from 2-pyridylhydrazine and potassium trithiocarbonate.[8]

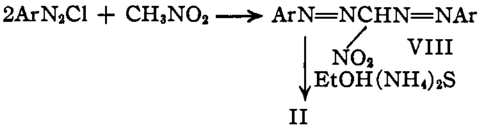

IV


V

In the second stage of the reaction between carbon disulfide and the hydrazine (III → II), long-continued heating after the evolution of hydrogen sulfide has stopped may lead to formation of a thiosemicarbazide from the thiocarbazide III by disproportionation. Thus, when 2-methylthiolphenylhydrazine VI was treated with carbon disulfide and heated overnight on the steam-bath, the thiosemicarbazide VII was the only product isolated. When the heating was limited to about an hour, the thiocarbazide was obtained as usual.

$$\underset{\text{VI}}{o\text{-}CH_3SC_6H_4NHNH_2} \qquad \underset{\text{VII}}{o\text{-}CH_3SC_6H_4NHNHCSNH_2}$$

(2) **The Bamberger Nitroformazyl Method.**[9]—This method avoids the preparation of the hydrazines, and although it requires careful attention to detail and some practice, is usually better than the Fischer method. It involves the coupling of two moles of diazonium compound with sodionitromethane, followed by reduction of the resulting nitroformazyl VIII with ethanolic ammonium sulfide:



$$2ArN_2Cl + CH_3NO_2 \longrightarrow \underset{\text{VIII}}{ArN{=}N\underset{NO_2}{C}HN{=}NAr} \xrightarrow{EtOH(NH_4)_2S} \text{II}$$

A modified procedure, due to Professor N. L. Drake,[9a] in which the *p*H of the diazonium solution is brought to 6 before adding the sodionitromethane, has been found very useful.

A number of trials runs showed that the procedure could be modified further with advantage by carrying out the coupling reaction in an acetate buffer containing 40% acetic acid at a *p*H of about 4.5; nitromethane itself was found to couple just as well as the sodio derivative under these conditions,[10] since the sodio derivative would obviously revert to nitromethane at this *p*H in an acetate buffer. The mechanism of the coupling reaction can be represented as[11]

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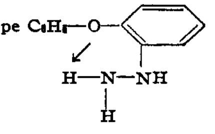
[4] "Organic Syntheses," Coll. Vol. I, 2nd ed., p. 442.

[5] Graebe and Rateanu, *Ann.*, **279**, 267 (1894).

[6] It may be noted that *o*-phenoxyphenylhydrazine is stable indefinitely, while the *p*-compound is stable for only a few hours; this may be due to chelation of the type C_6H_5—O—



[7] Thiophosgene is much more readily prepared by the method given in Sartori, "The War Gases," D. Van Nostrand Co., New York, N. Y., 1939, p. 213, than by the "Organic Syntheses" method Coll. Vol. 1, 2nd ed., p. 506).

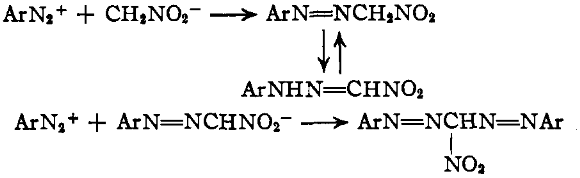
[8] Mills and Schindler, *J. Chem. Soc.*, **123**, 321 (1923).

[9] Bamberger, *Ber.*, **33**, 2043 (1900); **27**, 155 (1894); *Ann.*, **446**, 260 (1926).

[9a] Private communication from Professor N. L. Drake, University of Maryland.

[10] This procedure is based in part on Bamberger's work (ref. 9); a somewhat similar procedure has been published by Hubbard and Scott, THIS JOURNAL, **65**, 2390 (1943).

[11] Coupling of diazonium compounds with phenols and aromatic amines involves the diazonium ion, and the phenoxide ion or the free amine, respectively (Bartlett and Wistar, THIS JOURNAL, **63**, 413 (1941)).



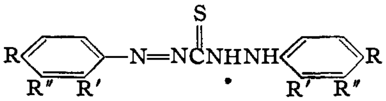
$$\begin{gathered} ArN_2^+ + CH_2NO_2^- \longrightarrow ArN{=}NCH_2NO_2 \\ \downarrow\uparrow \\ ArNHN{=}CHNO_2 \\ ArN_2^+ + ArN{=}NCHNO_2^- \longrightarrow ArN{=}N\underset{NO_2}{\underset{|}{C}}HN{=}NAr \end{gathered}$$

2-Aminodiphenyl sulfide yielded a nitroformazyl by this procedure, but it was unsuccessful with 2-aminofluorene and 4-aminostilbene. The suggestion that the reaction involves the anion in each step is supported by our observation that the phenylmethylhydrazone of nitroformaldehyde, $C_6H_5N(CH_3)N{=}CHNO_2$, which is insoluble in alkali, does not couple with benzenediazonium chloride in an acetate buffer or in glacial acetic acid.

The compound $C_6H_5NHN{=}CHNO_2$, in contrast, is readily soluble in dilute alkali, and couples so rapidly with a diazonium compound to form the nitroformazyl, as above, that it can be isolated from the reaction mixture only with difficulty.

TABLE I

THIOCARBAZONES PREPARED



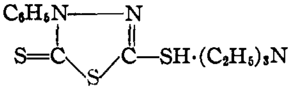
Compound[a]	Method[b]	M. p., °C.	Formula	Analyses, % Calcd. C	H	Found C	H
R′ = OC_6H_5(IX)	1, 2a, 2b	167–168 dec.	$C_{25}H_{20}N_4SO_2$	68.18	4.55	67.69	4.59
R′ = OCH_3(X)	1	186 dec.	$C_{15}H_{16}N_4SO_2$	56.96	5.06	56.88	4.88
R′ = OC_2H_5(XI)	2a	170 dec.	$C_{18}H_{24}N_4SO_3$[c]	57.50	6.38	57.72	6.23
R = OC_6H_5(XII)	2a	145 dec.	$C_{25}H_{20}N_4SO_2$	68.18	4.55	68.44	4.95
R′ = C_6H_5(XIII)	2a	154 dec.	$C_{25}H_{20}N_4S$	73.53	4.90	73.11	4.60
R″ = C_6H_5(XIV)	2a	151.5 dec.	$C_{25}H_{20}N_4S$	73.55	4.90	73.55	5.28
R′ = *p*-$CH_3OC_6H_4O$(XV)	2a	153 dec.	$C_{27}H_{24}N_4SO_4$	64.80	4.80	64.25	4.97
R′ = SC_6H_5(XVI)	2b	131–133 dec.	$C_{25}H_{20}N_4S_3$	63.52	4.27	63.12	4.44
R′ = SCH_3(XVII)	1	145–146	$C_{15}H_{16}N_4S_3$	51.7	4.6	51.6	4.4
R = C_6H_5, R′ = OC_6H_5(XVIII)	2a	159–161 dec.	$C_{37}H_{28}N_4SO_2$	74.98	4.76	75.12	4.84
R = C_6H_5, R′ = SC_6H_5(XIX)	2a	147–149 dec.	$C_{37}H_{28}N_4S_3$	71.13	4.52	70.43	3.40

[a] R, R′, R″ = H, unless otherwise indicated. [b] 1 = Fischer method; 2a = nitroformazyl (Drake); 2b = nitroformazyl in acetate buffer. [c] Calculated for one molecule of methanol of crystallization.

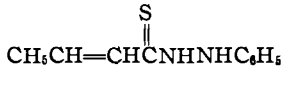
The thiocarbazones obtained in fairly pure form are indicated in Table I; compounds whose preparation in pure form failed are listed in Table II. The *p*-acetyl and *p*-benzoyl derivatives listed in Table II apparently are unstable because they oxidize very readily to the carbodiazone type, $ArN{=}N\overset{S}{\overset{\|}{C}}N{=}NAr$, in which there is a more extended conjugated system. In order to prevent this oxidation to the diazone type, which seemed to be one cause of the instability of the thiocarbazones when used as detecting agents, much time was spent in attempts to make a methyl substituted thiocarbazone (XX), which should be stable to oxidation of this type. Compound XX should

$C_6H_5N(CH_3(NHCSN{=}NC_6H_5$ XX $C_6H_5NHN{=}C{=}S$ XXI

be obtained, after oxidation, from α-methylphenylhydrazine and compound XXI, but the latter does not seem to have been reported, and an attempt to prepare it from phenylhydrazine, carbon disulfide and triethylamine yielded instead the triethylamine salt of phenyldithiadiazolonmercaptan XXII; the structure of this product is proved by



XXII



$$CH_6CH{=}CH\overset{S}{\overset{\|}{C}}NHNHC_6H_5$$

XXIII

its formation from potassium phenyldithiadiazolonmercaptide and triethylamine. The interaction of $C_6H_5NHNHCSSH$ and $C_6H_5N(CH_3)NH_2$, which should yield XX, after oxidation, was also unsuccessful.

The preparation of cinnamic thiophenylhydrazide[12] XXIII was undertaken because of its simi-

TABLE II

THIOCARBAZONES WHOSE PREPARATION WAS ATTEMPTED

Parent amine	Method	Remarks
p-Aminoacetophenone	2a	Thiocarbazide unstable
p-Aminobenzophenone	2a	Thiocarbazide unstable
2,6-Dimethoxyaniline	1, 2a	Thiocarbazone unstable, thiosemicarbazide isolated
2-Aminofluorene	1, 2a, 2b	
2-Aminodibenzofuran	1	Oxidation to thiocarbazone failed
o-Fluoroaniline	2a	Not obtained analytically pure
2-Amino-5-methylbenzenesulfonic acid	2a	Thiocarbazone apparently obtained, but could not be isolated from aqueous solution
4-Aminostilbene	1, 2a, 2b	
2-Aminothiazole	2a	Diazonium solution unstable
2-Aminopyridine	1	Ring closure occurred
2-(*p*-Aminophenyl)-naphthalene	2b	Not obtained pure

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[12] Suggested by Dr. Donald E. Pearson.

larity to the thiocarbazone structure. It could not be obtained by the action of phosphorus pentasulfide on cinnamic phenylhydrazide, and the imido chloride of the phenylhydrazide could not be obtained. Another approach, through styrylnitromethane and the nitroformazyl $C_6H_5CH{=}CHCH(NO_2)N{=}NC_6H_5$ was not successful, although styrylnitromethane was apparently obtained from cinnamyl bromide and silver nitrite in acetonitrile solution, and a red product, presumably the nitroformazyl, was obtained by treatment of this with benzenediazonium chloride.

The thiocarbazones listed in Table I were tested as arsenical detectors and the *o*-phenoxy derivative (IX) was found the most promising, considering stability, sensitivity, sharpness of color change and ease of synthesis.

Experimental Part[13]

2-Aminodiphenyl Ether.—Reduction of 78 g. of 2-nitrodiphenyl ether (in three batches) with hydrogen and Raney nickel in alcohol yielded 51.0 g. (78%) of the amine, m. p. 45.5–47°, and a second crop of 9.5 g., m. p. 43–47° (total 94%). Zinc dust and calcium chloride in ethanol gave a 68% yield of the amine from the nitro compound.[14]

2-Phenoxyphenylhydrazine.—Twenty-five grams of the above amine was diazotized, the excess nitrous acid destroyed with sulfamic acid, and 107 g. of stannous chloride in 107 cc. of concentrated hydrochloric acid added. After stirring one hour, the complex tin salt was removed and treated with 77 g. of sodium hydroxide dissolved in 650 cc. of water. The precipitate was treated with 500 cc. of water and 20 cc. of concentrated hydrochloric acid, warmed until solution was effected and cooled to obtain the hydrazine hydrochloride, which melted with decomposition at 171°. The hydrochloride was dissolved in warm water, treated with hydrogen sulfide and filtered; the hydrazine was obtained as a white precipitate, which after recrystallization from alcohol, had the m. p. 152–154°, yield, 12 g. (45%).

Anal. Calcd. for $C_{12}H_{12}N_2O$: C, 72.00; H, 6.00. Found: C, 72.33; H, 6.10. The benzal derivative melts at 129–130.5°.

The m. p. of the hydrazine is surprisingly high, compared to the *para* isomer, which melts at 52°, and is very unstable.

2-Nitro-4′-methoxydiphenyl Ether.[15]—The potassium salt of hydroquinone monomethyl ether (6.2 g.) was prepared in ethanol, the solvent removed and 7.9 g. of *o*-nitrochlorobenzene added: the temperature was brought to 160° for one hour, the mixture cooled and poured into dilute alkali. The product (8.6 g., 70%) melted, after crystallization from ethanol, at 74–74.5°.

2-Nitrodiphenyl Sulfide.—The procedure of Cullinane and Davis[16] was improved as follows: To a mixture of thiophenol (33 g.), 39 g. of sodium carbonate and 120 cc. of water was added a solution of 47.1 g. of *o*-chloronitrobenzene in 150 cc. of hot ethanol. The mixture was stirred and warmed on the steam-bath for four hours, then poured in 500 cc. of cold water, filtered and washed with water. Recrystallization from 200 cc. of ethanol yielded 61 g. (87%) of bright yellow crystals, m. p. 78–80°. The reported value[16] is 82°.

2-Aminodiphenyl Sulfide.—This compound was obtained by reduction of the nitro compound, and also by the following procedure. 2-Chloroacetanilide (20 g.) and a few tenths of a gram of copper powder were added to a solution prepared by dissolving 13.2 g. of potassium hydroxide and 26 g. of thiophenol in 40 cc. of *n*-butanol with heating. The solvent was removed, the residue heated rapidly and held at 280–300° (inside temperature) for fifteen minutes. The cooled melt, which had darkened considerably, was taken up in hot benzene and 10% sodium hydroxide solution; the two layers were filtered with suction and separated. The benzene layer was evaporated, and the crude acetyl compound hydrolyzed with hydrochloric acid and ethanol. The amine was distilled at 154–160° (3 mm.), and 11 g. (46%) of material, m. p. 33°, obtained. The reported[16] m. p. is 35°.

4-Amino-3-phenoxybiphenyl.—3-Bromo-4-acetaminobiphenyl[17] (3 g.) and 0.1 g. of copper powder were added to the potassium salt from 10 g. of phenol, and the melt heated for thirty minutes at 180°. When worked up as above, 2.9 g. of crude 2-acetamino-5-phenyldiphenyl ether was obtained, which after six recrystallizations from dilute alcohol melted at 166–167°. The free amine obtained by hydrolysis melted at 100.5–101.5° after three recrystallizations from alcohol.

Anal. Calcd. for $C_{18}H_{15}NO$: C, 82.74; H, 5.79. Found: C, 83.12; H, 5.79.

In a second preparation, the crude acetaminodiphenyl ether was hydrolyzed to the free amine directly, which was obtained in 50% yield by vacuum distillation, m. p. 94–99°. After one crystallization from alcohol, it melted at 99–101°.

4-Amino-3-thiophenoxybiphenyl.—3-Chloro-4-acetaminobiphenyl (20 g.), 20 cc. of thiophenol, 9 g. of potassium hydroxide, 30 cc. of *n*-butanol and a small amount of copper powder were heated at 260–280° for one hour. The reaction mixture was worked up as usual, yielding 13 g. (59%) of the free amine, m. p. 68–70°.

Anal. Calcd. for $C_{18}H_{15}NS$: C, 77.94; H, 5.45. Found: C, 77.87; H, 5.41.

The acetyl derivative melted at 132–134.5°. When the bromoacetaminobiphenyl was used instead of the chloro compound, a 66% yield was obtained.

2-Pyridylhydrazine.—This was prepared more conveniently from 2-bromopyridine than from the chloro compound,[18] and was obtained in 57% yield by heating the halogen derivative with 85% hydrazine hydrate at 125° for twenty-four hours.

3-Mercaptopyrido(2,1-c)-*s*-triazole.[19]—2-Pyridylhydrazine (5 g.) was added to 12 cc. of carbon disulfide in 40 cc. of chloroform. A precipitate was formed, and the mixture refluxed on the steam-bath for twenty hours, with the evolution of hydrogen sulfide. The crystals present were isolated, weighed 6.10 g. (88%), and melted at 209–210°. The product is insoluble in benzene and dioxane, but is soluble in methanol and dilute sodium hydroxide.[20]

Anal. Calcd. for $C_6H_6N_2S$: C, 47.7; H, 3.3; mol. wt., 151. Found: C, 48.1; H, 3.4; mol. wt. (Rast), 165.

This compound was also obtained by action of thiophosgene on 2-pyridylhydrazine.

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[13] Analyses by Robert Bauman.

[14] *Cf.* Suter, This Journal, **51**, 2583 (1929); the reported m. p. is 44–45°.

[15] *Cf.* Henley, *J. Chem. Soc.*, 1222 (1930); Mole and Turner, *ibid.*, 1720 (1939). The m. p. is reported as 75–76.5°.

[16] Cullinane and Davis, *Rec. trav. chim.*, **55**, 881 (1936).

[17] The preparation of this compound, which involves the separation of the constant melting mixture of 3-bromo-4-acetaminobiphenyl and 3,4′-dibromo-4-acetaminobiphenyl obtained as one of the products in the bromination of 4-acetaminobiphenyl (Kenyon and Robinson, *J. Chem. Soc.*, 3050 (1926); Case and Sloviter, This Journal, **59**, 2381 (1937)) is laborious and unsatisfactory. The amine was acetylated and the acetyl derivative purified by recrystallization from dilute alcohol. The yield of fairly pure 3-bromo-4-acetaminobiphenyl, m. p. 158–159° (literature 161°), varied from 8 to 15% based on 4-acetaminobiphenyl. The 3-chloro 4-acetaminobiphenyl was readily obtained by chlorination of 4-acetaminobiphenyl (Scarborough and Waters, *J. Chem. Soc.*, 557 (1926).

[18] *Cf.* Fargher and Furness, *ibid.*, **107**, 688 (1915); Weissberger and Porter, This Journal, **66**, 1849 (1944).

[19] Ring Index numbering.

[20] Mills and Schindler report this compound as melting at 205–206°, and their other properties agree with those of our material.

Thiocarbazone Preparations by the Fischer Method.—The preparation of *di-(2-methoxyphenyl)-thiocarbazone (X)* is typical of the procedures followed. 2-Methoxyphenylhydrazine (10 g.), 50 cc. of alcohol and 5 g. of carbon disulfide were refluxed on the steam-bath until hydrogen sulfide ceased to be liberated. The thiocarbazide was not isolated, but was treated directly in solution after cooling with enough 10% ethanolic potassium hydroxide to give a clear red color; the solution was allowed to stand with air bubbling through for about five minutes, and was acidified with 1 *N* sulfuric acid. The thiocarbazone was obtained as a black powder, and was isolated by filtration with thorough washing. In the alternate procedure, the alcoholic solution of the thiocarbazide was cooled and treated with 5 cc. of 30% hydrogen peroxide, allowed to stand five minutes, with stirring, and the product was washed with water and cold methanol.

Recrystallization of the thiocarbazone proved difficult. The best method found was to dissolve the substance in the minimum volume of chloroform, filter and precipitate by adding half the volume of methanol. The product formed a finely crystalline material, copper bronze in color. The m. p. and analysis are given in Table I.

Thiocarbazones by the Modified Nitroformazyl Procedure; Di-(2-phenoxyphenyl)-thiocarbazone.—2-Aminodiphenyl ether (b. p. 187–188° (30 mm.)) was dissolved in 160 cc. of concentrated hydrochloric acid and 270 cc. of water. The cold solution was diazotized by adding 23 g. of sodium nitrite in 135 cc. of water. After one hour the excess nitrous acid was removed with sulfamic acid, the solution was filtered through a sintered glass funnel and washed with 50 cc. of water. The solution was poured into 1430 g. of sodium acetate trihydrate in 725 cc. of glacial acetic acid, and stirred at room temperature for fifteen minutes, at which point most of the sodium acetate had dissolved; 25 cc. of nitromethane was added in one portion and the mixture stirred for five hours. The nitroformazyl precipitated rapidly, and the mixture was an almost solid mass after two hours; the product was collected, washed thoroughly with water and twice with alcohol. The nitroformazyl had not dried completely after standing several days on paper towels, and was reduced directly.

Reduction to the Thiocarbazide.—The nitroformazyl was added in one portion to 750 cc. of alcohol saturated with ammonium hydrosulfide. The color of the mixture changed from red to cream in thirty minutes; after stirring one hour, the slurry was poured into 2 liters of cold water, filtered, washed thoroughly with water and air dried on paper towels. It was not completely dry after two days.

Oxidation to the Thiocarbazone.—The thiocarbazide was dissolved in 2 liters of warm alcohol containing 35 g. of potassium hydroxide, and the calculated amount of 3% hydrogen peroxide (175 cc.) added. The mixture was heated almost to boiling on a hot plate, allowed to stand for fifteen minutes, then cooled in an ice-bath. When the temperature had reached 5°, the solution was filtered, and acidified with 100 cc. of concentrated hydrochloric acid. The precipitated thiocarbazone was filtered, and washed thoroughly with water and twice with methanol. The product was bronze colored and microcrystalline, m. p. 162–163.5° with dec., wt. 48 g. after air drying. For purification, it was dissolved in 500 cc. of hot chloroform, filtered and 800 cc. of hot methanol was added to the hot solution. Beautiful bronze crystals were obtained, m. p. 167–167.5° with decomposition (very slow heating), yield 39.5 g. (thoroughly air dried, or 58% based on amine).

Preparation of Diphenylthiocarbazone (Dithizone).—Dithizone was prepared by essentially the same method; 30 g. of clean nitroformazyl, m. p. 146–147°, was obtained from 37 g. of aniline. The sodium acetate and then the acetic acid were added directly to the diazonium solution. The coupling with the nitromethane proceeded quite slowly in the resulting 25% acetic acid solution with acetate–acetic acid ratio of 0.24.

A second preparation was run in the same manner but with an acetate–acetic acid ratio of 0.65. The reaction proceeded more rapidly; after two hours 200 cc. of water was added (changing the acetic acid concentration from 24 to 19%) because the reaction mixture had become too thick to stir. The thiocarbazone obtained from the usual oxidation step was quite pure without the final crystallization, as it melted sharply at 165–166°.

Interaction of Phenylhydrazine, Carbon Disulfide and Triethylamine.—To 15 g. of triethylamine and 25 g. of carbon disulfide in 50 cc. of chloroform was added dropwise 10.8 g. of phenylhydrazine. The mixture was heated on the steam-bath for five hours, causing evolution of hydrogen sulfide. After cooling, the mixture was subjected to steam distillation, and the residue crystallized, giving 18.6 g., m. p. 87–89°. Two crystallizations from benzene raised the m. p. to 91.5–92.5°. This product was shown to be the triethylamine salt of phenyldithiadiazolonmercaptan XXII by analysis, and by preparation from potassium phenyldithiadiazolonmercaptide[21] and triethylamine.

Anal. Calcd. for $C_{14}H_{21}N_3S_3$: C, 51.5; H, 6.4. Found: C, 51.9; H, 6.4.

2-Methylthiolphenylthiosemicarbazide (VII).—A mixture of 2-methylthiolphenylhydrazine and carbon disulfide in ethanol was refluxed overnight on the steam-bath. After the solvent was removed, the residue was treated with benzene and a white crystalline product was obtained, which, after two recrystallizations from xylene, melted at 172–173° with decomposition. Two recrystallizations from acetic acid did not change the m. p. or the percentage composition.

Anal. Calcd. for $C_8H_{11}N_3S_2$: C, 45.1; H, 5.2. Found: C, 45.3; H, 5.2.

When the heating with carbon disulfide was limited to an hour, the disproportionation did not occur, and the thiocarbazide and the thiocarbazone (XVII) were obtained.

Summary

A number of new substituted diarylthiocarbazones have been prepared, and several compounds obtained incidental to the work have been described. A modification of the Bamberger nitroformazyl procedure, consisting of coupling the diazonium compound with nitromethane in dilute acetic acid containing acetate ion, has been found useful.

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[21] Dubsky and Trtilek, *Z. anal. Chem.*, **96**, 412 (1934); Busch, *Ber.*, **27**, 2510 (1894).