glacial acetic acid. The precipitate was collected and treated with 10 ml. of 1*N* potassium hydroxide and the solution heated to boiling. The solid formed on cooling was recrystallized from water to give 0.53 g. (47%) of white needles which decomposed at 327–330°.

Method C. A mixture of 0.5 g. of 2-amino-3,5-dicyano-6-chloropyridine[8] in 25 ml. of 1*N* potassium hydroxide was refluxed until the solid dissolved. Method B was then followed to give 0.47 g. (71%).

Anal. Calcd. for $C_7H_7N_4O_3K$: C, 35.87; H, 3.01; N, 23.92. Found: C, 35.84; H, 2.84; N, 23.82.

7-Ethoxy-4-hydroxy-6-cyanopyrido(2,3-d)pyridine. Three grams (0.015 mole) of 2-amino-5-cyano-6-ethoxy-3-pyridinecarboxamide in 25 g. formamide was heated to 160–170° and maintained at this temperature for 2 hr. The compound slowly went into solution. Upon cooling, crystals formed which were filtered and washed with water. The filtrate was cooled to 5° in an ice bath and a second crop was obtained. Then the combined crops were shaken for a few minutes with 100 ml. of 0.1*N* potassium hydroxide and 50 ml. of water. The solution was filtered and the filtrate acidified with glacial acetic acid to yield 2.1 g. (67%) of a yellow powder which decomposed at 260–270°. An analytical sample was obtained by recrystallizing from dimethylformamide-water, m.p. 274–275°.

Anal. Calcd. for $C_{10}H_8N_4O_2$: C, 55.55; H, 3.73; N, 25.92; C_2H_5O, 20.85. Found: C, 55.50; H, 3.97; N, 25.93; C_2H_5O, 21.02.

2-Methylthio-4-amino-5-cyanopyrimidine. A solution of 8.0 g. of sodium hydroxide in 20 ml. of water was added to a mixture of 27.8 g. (0.100 mole) of 2-methyl-2-thiopseudourea sulfate in 100 ml. of acetone. Ethoxymethylenemalononitrile (24.4 g., 0.200 mole) in 150 ml. acetone was then added. After stirring for 2 hr. 200 ml. water was added; a precipitate formed. After standing for 12 hr. the precipitate was collected, washed with cold water, and recrystallized from alcohol-water to give 21.5 g. (65%) of fine white needles, m.p. 240–241°.

Anal. Calcd. for $C_6H_6N_4S$: C, 43.35; H, 3.64; N, 33.71. Found: C, 43.53; H, 3.54; N, 33.67.

2-Ethylthio-4-amino-5-cyanopyrimidine. A solution of 8.0 g. of sodium hydroxide in 20 ml. water was added to a mixture of 31.0 g. (0.100 mole) of 2-ethyl-2-thiopseudourea sulfate and 100 ml. of acetone. Ethoxymethylenemalononitrile (24.4 g., 0.200 mole) in 150 ml. of acetone was then added. The mixture was allowed to stand 12 hr. The precipitate was filtered, washed with cold water, and recrystallized from alcohol-water to give 25.0 g. (70%) of fine white needles, m.p. 140° [lit. m.p. 141° (16.5%),[4] 147° (56%)].[11]

4-Amino-2-benzylthio-5-cyanopyrimidine. Ten grams (0.08 mole) of ethoxymethylenemalononitrile in 50 ml. of acetone was added slowly, with stirring, to a solution of 16.6 g. (0.080 mole) of 2-benzyl-2-thiopseudourea hydrochloride and 3.3 g. of sodium hydroxide in 50 ml. water. After all the ethoxymethylenemalononitrile solution had been added, the mixture was stirred for 0.5 hr. Then 100 ml. of water was added and the mixture cooled overnight in the refrigerator. The solid was then filtered and washed with water. Recrystallization from alcohol-water gave 15.5 g. (72%) of yellow needles, m.p. 174–176° (lit.[11] 86%, m.p. 171°).

4-Amino-2-thio-5-cyanopyrimidine. Ethoxymethylenemalononitrile (10 g., 0.080 mole) was added slowly to 7.0 g. (0.09 mole) of thiourea in a mixture of 70 ml. of water, 50 ml. of acetone, and 3.3 g. of sodium hydroxide. The solution was stirred for 0.5 hr. and 250 ml. of water added. The solution was acidified with glacial acetic acid and placed in the refrigerator overnight. A precipitate formed which was collected by filtration, washed with water, and dried. The yield of crude was 1.5 g. (12%). The infrared spectrum of this product was identical with that of 4-amino-2-thio-5-cyanopyrimidine prepared in an 85% yield by a method similar to that of Suter and Habicht.[11]

BUFFALO, N. Y.

(11) H. Suter and E. Habicht, U. S. Patent 2,698,326, December 1954.

[CONTRIBUTION FROM THE DEPARTMENT OF CHEMISTRY, COLLEGE OF PHARMACY, UNIVERSITY OF ILLINOIS]

Addition of Thiourea to 2- and 4-Vinylpyridines[1]

LUDWIG BAUER AND LIBERO A. GARDELLA, JR.

Received April 26, 1960

The acid-catalyzed addition of thiourea to 2- and 4-vinylpyridines readily afforded *S*-[2-(2- and 4-pyridinium)ethyl]-isothiuronium salts, II and IV, in excellent yields. In a cognate experiment, 2-methyl-5-vinylpyridine did not add thiourea. A mechanism is postulated to explain these phenomena. The isothiuronium salts, II and IV, were characterized by the corresponding thiols, disulfides and sulfonic acids.

Among the numerous nucleophilic reagents which have been added to the β-carbon of the side chain of 2- and 4-vinylpyridine are hydrogen cyanide,[2a] active methylene compounds (ketones,[2b] malonic esters,[2a] phenylacetonitriles,[2c] nitroalkanes[2d]), indole,[2f] imides,[2g] amides,[2c] amines[2c,2e] and phosphite esters.[2h] To establish a carbon-sulfur bond at the β-carbon of the vinyl side chain, mercaptans[3] and sodium bisulfite[2a] have been treated to form the corresponding 2-(2- and 4-pyridyl)ethyl sulfides and

(1) This work was sponsored by the Office of the Surgeon General, U. S. Army, Contract DA-49-193-MD-2047. This assistance is gratefully acknowledged.

(2) (a) W. E. Doering and R. A. N. Weil, *J. Am. Chem. Soc.*, 69, 2461 (1947); (b) V. Boekelheide and J. H. Mason, *J. Am. Chem. Soc.*, 73, 2356 (1951); R. Levine and M. H. Wilt, *J. Am. Chem. Soc.*, 74, 342 (1952) and 75, 1368 (1953); G. Magnus and R. Levine, *J. Org. Chem.*, 22, 270 (1957); (c) G. Magnus and R. Levine, *J. Am. Chem. Soc.*, 78, 4127 (1956); (d) E. Profft, *Chem. Techn.*, 8, 705 (1956); (e) A. P. Phillips, *J. Am. Chem. Soc.*, 78, 4441 (1956) and literature cited therein; E. Profft, *Chem. Ber.*, 90, 1738 (1957); 91, 958 (1958); (f) A. P. Gray and W. L. Archer, *J. Am. Chem. Soc.*, 79, 3554 (1957); (g) A. P. Gray, W. L. Archer, E. E. Spinner, and C. J. Cavallito, *J. Am. Chem. Soc.*, 79, 3805 (1957); S. L. Shapiro, I. M. Rose, E. Roskin, and L. Freedman, *J. Am. Chem. Soc.*, 80, 1648 (1958); (h) E. Maruszewska-Wieczorkowska and J. Michalski, *J. Org. Chem.*, 23, 1886 (1958).

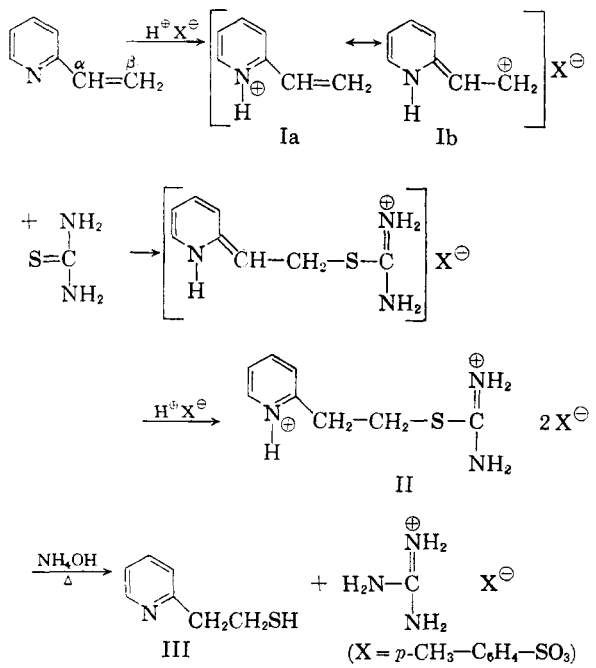
(3) W. H. Vinton, U. S. Patent 2,607,776, August 1952; *Chem. Abstr.*, 47, 6989 (1953).

2-(2- and 4-pyridyl)ethanesulfonic acids respectively.

We wish to report the facile acid catalyzed addition of thiourea to 2- and 4-vinylpyridines to afford in excellent yield *S*-[2-(2- and 4-pyridinium) ethyl]isothiuronium salts.

Experimentally, the best acid catalysts for this reaction were found to be sulfonic acids, although dry hydrogen chloride or hydrogen bromide promoted the addition very well. However, the isothiuronium chlorides and bromides were difficult to purify and for this reason sulfonic acids were used almost exclusively for this work.

Usually, nucleophilic addition to 2- and 4-vinylpyridines is base-catalyzed. Actually, in an acid medium the presence of the 2- and 4-vinylpyridinium ion should enhance nucleophilic attack at the β-carbon of the side chain because of the electron-attracting nature of the positively charged ring nitrogen atom. Furthermore, such nucleophilic attack on the 2- and 4-vinylpyridinium ion leads to favorable transition state structure in which the ring nitrogen atom is uncharged. This mechanism explains the facile acid-catalyzed addition of thiourea to 2- and 4-vinylpyridine and is illustrated for the addition of thiourea to 2-vinylpyridine, or rather, to the 2-vinylpyridinium ion, Ia, Ib:

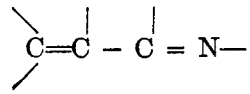


The isothiuronium salts were readily cleaved by hot concentrated ammonium hydroxide to 2-(2- and 4-pyridyl)ethanethiols. When the isothiuronium *p*-toluenesulfonates were decomposed by ammonia, guanidinium *p*-toluenesulfonate was isolated as a by-product of the reaction. In this way, *S*-[2-(2-pyridinium)ethyl]isothiuronium *p*-toluenesulfonate, II, afforded III (82%) and guanidinium *p*-toluenesulfonate (88.5% yield). The aminothiol, III, was also prepared from 2-(2-pyridyl)ethanol by the conventional synthesis.[4] This method consisted of refluxing the alcohol with 48% hydrobromic acid and thiourea for twenty-four hours to form the isothiuronium bromide, which was not isolated but immediately hydrolyzed by hot alkali to III. However, the yield was only 48% while the yields of III from the addition of thiourea to 2-vinylpyridine were consistently above 70%. Furthermore, the addition of thiourea to 2- and 4-vinylpyridines was complete after one hour reflux in ethanol. The synthesis of III is also described in the patent literature[3] and involves the addition of thiolacetic acid to 2-vinylpyridine and subsequent hydrolysis of the thiolester to III in a 23% overall yield.

Oxidation of the hydrochloride of the thiol, III, with hot concentrated nitric acid yielded the known 2-(2-pyridyl)ethanesulfonic acid.[2a] This again establishes the structure of III and hence the attachment of thiourea to the β-carbon of the side chain. Milder oxidation III with hydrogen peroxide in hydrochloric acid solution afforded 2-(2-pyridyl)-ethyl disulfide.

In contrast to the facile addition of thiourea to 2- and 4-vinylpyridine, 2-methyl-5-vinylpyridine (a typical 3-vinylpyridine derivative) failed to react with thiourea under *identical* experimental conditions used for 2- and 4-vinylpyridine. The only crystalline product isolated from the reaction mixture was thiourea *p*-toluenesulfonate in 73% yield. This substantiated the mechanism proposed above for the addition to 2- and 4-vinylpyridine. Nucleophilic attack at the β-carbon of the 3-vinyl side chain, would not be facilitated by resonance interaction with the protonated ring nitrogen atom.

It is intended to extend the acid-catalyzed addition of thiourea to systems of the type:



EXPERIMENTAL[5]

Starting materials. 2-Vinylpyridine (Reilly Coal Tar and Chemicals, Indianapolis, Ind.) was distilled, b.p. 68.5° (23 mm.), $n_D^{25°}$ 1.5455. 4-Vinylpyridine (also from Reilly) was distilled, b.p. 76° (21 mm.), $n_D^{25°}$ 1.5440. 2-Methyl-5-vinylpyridine (Monomer-Polymer Laboratories, the Borden Company, Chemical Division, Philadelphia, Pa.) was purified by vacuum distillation, b.p. 77° (13 mm.). Methanesulfonic acid was purchased from the Aldrich Chemical Co., Inc., Milwaukee, Wisc.

S-[2-(2-Pyridinium)ethyl]isothiuronium dichloride. A slow stream of hydrogen chloride gas was bubbled through a refluxing mixture of thiourea (3.8 g., 0.05 mole), and freshly distilled 2-vinylpyridine (5.25 g., 0.05 mole) in

(4) For examples of the synthesis of mercaptans from alcohols, see H. Kotod, *Org. Syntheses*, **35**, 66 (1955); Z. E. Heweihi, *Chem. Ber.*, **86**, 781 (1953).

(5) The melting points are uncorrected. The analyses were carried out by either Micro-Tech Laboratories, Skokie, Ill., Dr. Kurt Eder, Geneva, Switzerland, or by Drs. Weiler and Strauss, Oxford, England. The infrared spectra were determined with Beckman spectrophotometer, Model IR-4.

ethanol (50 ml.) for 1 hr. The reaction mixture was cooled in an ice bath and allowed to crystallize. The colorless crystals were filtered, washed with cold ethanol-ether (1:1), and dried *in vacuo* over sulfuric acid and sodium hydroxide pellets. The salt weighed 12.58 g. (99%) and melted at 208°. Recrystallization from absolute methanol-acetone did not raise the melting point.

Anal. Calcd. for $C_8H_{13}N_3SCl_2$ (254.2): C, 37.80; H, 5.15; N, 16.53. Found: C, 37.81; H, 5.25; N, 16.28.

S-[2-(2-Pyridinium)ethyl]isothiuronium bis-p-toluenesulfonate. *p*-Toluenesulfonic acid monohydrate (20.9 g., 0.11 mole) was dissolved in absolute ethanol (50 ml.) and to this solution was added thiourea (3.8 g.; 0.05 mole) and freshly distilled 2-vinylpyridine (5.25 g.; 0.05 mole). The reaction mixture was refluxed for 1 hr. on a steam bath, then half the solvent was removed *in vacuo*. Dry ether (30 ml.) was added and product allowed to crystallize. The mixture was cooled in an ice bath and the colorless crystals were filtered, washed with cold ethanol-ether (1:1), and dried. The salt weighed 24.08 g. (92%) and melted at 178°. Recrystallization from ethanol did not raise the melting point.

Anal. Calcd. for $C_{22}H_{27}N_3O_6S_3$ (525.7): C, 50.27; H, 5.18; N, 8.00. Found: C, 50.26; H, 5.45; N, 8.27.

2-(2-Pyridyl)ethanethiol. A solution of *S*-[2-(2-pyridinium)-ethyl]isothiouronium bis-*p*-toluenesulfonate (97.25 g.) was dissolved in concd. ammonium hydroxide solution (200 ml.) and water (50 ml.) and the mixture was heated on the steam bath for 0.5 hr. The solution was cooled and 50 ml. of chloroform was added. At this stage guanidinium *p*-toluenesulfonate separated. The crystals were filtered, washed with chloroform and dried. They weighed 41 g. (88.5%) and melted at 230–232°.[6] The filtrate was then extracted with chloroform (eight portions of 35 ml. each). The chloroform extract was distilled and the mercaptan obtained as a colorless oil, 21.0 g. (82.0% based on the isothiuronium salt), b.p. 137–138° (46 mm.), $n_D^{20°}$ 1.5570. It was redistilled for analysis, b.p. 57–58° (0.15 mm.), $n_D^{27°}$ 1.5581. The boiling point reported in the literature[3] is 94° (7 mm.).

Anal. Calcd. for C_7H_9NS (139.2): C, 60.39; H, 6.52; N, 10.06. Found: C, 60.31; H, 6.59; N, 10.01.

The mercaptan turned yellow within a day and after standing for a week decomposed to a brown and very viscous liquid.

The *picrate* crystallized from ethanol in yellow needles, m.p. 89°.

Anal. Calcd. for $C_{13}H_{12}N_4O_7S$ (368.3): N, 15.22. Found: N, 15.27.

The *hydrochloride*, m.p. 98–99° (in a sealed tube), was recrystallized from isopropyl alcohol. The crystals were exceedingly hygroscopic.

Anal. Calcd. for $C_7H_{10}NSCl$ (175.7): C, 47.86; H, 5.74; N, 7.97. Found: C, 47.48; H, 5.80; N, 8.29.

2-(2-Pyridinium)ethanethiol chloride from 2-(2-pyridyl)-ethanol. A solution of 2-(2-pyridyl)ethanol (12.3 g.; 0.1 mole), thiourea (7.6 g.; 0.1 mole), and 48% hydrobromic acid (37.1 g., 0.22 mole) was refluxed at 165° for 24 hr. The solution was allowed to stand for 48 hr. Half the solvent was removed *in vacuo* and acetone (20 ml.) was added to aid crystallization. The crystals which formed upon cooling were filtered and washed with cold 1:1 acetone-ethanol. These crystals were then dissolved in concd. ammonium hydroxide solution (100 ml.) and the solution heated on a steam bath for 0.5 hr. The solution was extracted with chloroform (eight 35-ml. portions). The chloroform solution was distilled and the mercaptan collected in the fraction which boiled at 120–125° (18 mm.). The aminothiol was immediately dissolved in dry ether and anhydrous hydrogen chloride was passed through this solution. The hydrochloride so formed was filtered and washed with dry ether. The crystals weighed 8.37 g. (48%), m.p. 98–99°, and were identical with the salt prepared above from 2-vinylpyridine.

2-(2-Pyridyl)ethyl disulfide. 2-(2-Pyridyl)ethanethiol (2.75 g., 0.02 mole) was dissolved in 100 ml. of 0.1*N* hydrochloric acid and treated with 3 ml. of 30% hydrogen peroxide (Superoxol) in water (20 ml.). The solution was stirred for 0.5 hr. The solvent was then evaporated *in vacuo* and the residue treated with 10% sodium carbonate solution until the solution was basic. An oil separated which was extracted with chloroform (six 35-ml. portions). The chloroform was removed by distillation. The gummy residue was extracted with hot ligroin (b.p. 60–90°). On cooling colorless needles separated, m.p. 74°, unchanged on recrystallization from the same solvent.

Anal. Calcd. for $C_{14}H_{16}N_2S_2$ (276.4): C, 60.83; H, 5.83; N, 9.95. Found: C, 60.89; H, 5.67; N, 9.80.

2-(2-Pyridyl)ethanesulfonic acid. Concentrated nitric acid (50 ml.) was added to 2-(2-pyridinium)ethanethiol chloride (3.0 g., 0.017 mole) and a vigorous reaction ensued. The reaction mixture turned deep red-brown while fumes of oxides of nitrogen were evolved. The solution was heated on the steambath until a colorless solution was obtained. Most of the solvent was removed *in vacuo* and acetone was added until the solution became opalescent. The crystals, which formed on standing were filtered, washed with cold acetone, and recrystallized from hot 90% ethanol. The sulfonic acid weighed 2.85 g. (90%) and melted at 263° with gas evolution.

The melting point, mixed melting point, and infrared spectra agreed with a sample of 2-(2-pyridyl)ethanesulfonic acid synthesized according to the method of Doering and Weil.[3a]

S-[2-(4-Pyridinium)ethyl]isothiuronium bis-p-toluenesulfonate. By a process similar to that used for 2-vinylpyridine 4-vinylpyridine gave 23.65 g. (90.1%) of the salt, m.p. 201–202°.

Anal. Calcd. for $C_{22}H_{27}N_3O_6S_3$ (525.7): C, 50.27; H, 5.18; N, 8.00. Found: C, 50.20; H, 5.43; N, 7.99.

S-[2-(4-Pyridinium)ethyl]isothiuronium bismethanesulfonate. When methanesulfonic acid was used, this salt was obtained in 84.5%, m.p. 170–171° (from methanol).

Anal. Calcd. for $C_{10}H_{19}N_3O_6S_3$ (373.5): C, 32.16; H, 5.13; N, 11.25. Found: C, 32.31; H, 5.09; N, 11.22.

2-(4-Pyridyl)ethanethiol. Using the same procedure as above, 4-vinylpyridine was treated with thiourea (both in 0.05 molar quantities) and *p*-toluenesulfonic acid monohydrate (0.11 mole) and the salt was not isolated but was converted [as described for 2-(2-pyridyl)ethanethiol] to the mercaptan which distilled as a colorless oil, b.p. 92° (0.2 mm.), $n_D^{29°}$ 1.5651. It weighed 4.5 g. and this represents a 64.8% yield based on 4-vinylpyridine. It is imperative to distil this amino mercaptan at the lowest possible pressure. Over-heating on distillation frequently caused decomposition of the mercaptan.

The mercaptan turned yellow within a day, and on standing for a week the liquid was brown and very viscous.

Anal. Calcd. for C_7H_9NS (139.2): C, 60.39; H, 6.52; N, 10.06. Found: C, 60.22; H, 6.40; N, 9.87.

The *hydrochloride* (from 2-propanol) melted at 189°, resolidified and remelted at 250° (with dec.).

Anal. Calcd. for $C_7H_{10}NSCl$ (175.7): C, 47.86; H, 5.74; N, 7.97. Found: C, 47.48; H, 5.76; N, 7.96.

2-(4-Pyridinium)ethyl disulfide dichloride. 2-(Pyridinium)-ethanethiol chloride (7.0 g.; 0.04 mole) was dissolved in 0.1*N* hydrochloric acid (100 ml.) and hydrogen peroxide (30%, 6 ml.) in water (40 ml.) was added and the solution was stirred for 2.0 hr. Half the solvent was removed *in vacuo* and 10% sodium carbonate was added until the solution was alkaline. A yellow oil separated which was extracted with pure ether (six 35-ml. portions). The ethereal solution was dried (sodium sulfate) and the most of the solvent was distilled. Dry hydrogen chloride gas was bubbled through the residual ethereal solution, and a yellowish gum

(6) This salt did not depress the melting point of an authentic sample. It also had an infrared spectra identical with that of a sample prepared from guanidine and *p*-toluene sulfonic acid.

formed which crystallized upon standing. The crystals were filtered and washed with cold dry ether. The salt weighed 3.95 g. (67.1%). Recrystallization from absolute ethanol raised the melting point to 199–200° (with dec.) with darkening at 185°.

Anal. Calcd. for $C_{14}H_{18}N_2S_2Cl_2$ (349.4): C, 48.13; H, 5.19; N, 8.02. Found: C, 48.24; H, 5.34; N, 8.11.

The *picrate* crystallized from 80% ethanol, m.p. 166° (with dec.).

Anal. Calcd. for $C_{26}H_{22}N_8O_{14}S_2$ (734.6): N, 15.25. Found: N, 15.44.

2-(4-Pyridyl)ethanesulfonic acid. Oxidation of 2-(4-pyridium)ethanethiol chloride in a manner similar to that described above for 2-(2-pyridinium)ethanethiol chloride afforded the acid (91%) which was identical with that in the literature.[5a]

Thiourea p-toluenesulfonate. A mixture of thiourea (1.52 g.; 0.02 mole) and *p*-toluenesulfonic acid monohydrate (3.8 g.; 0.02 mole) was boiled in ethanol (25 ml.) until a solution was obtained. On cooling, the crystals which formed were filtered and washed with cold ethanol. The crystals weighed 4.76 g. (96%), m.p. 173–174°. Recrystallization from ethanol did not raise the melting point. Mixedm elting point with thiourea (m.p. 180–181°) was depressed to 137–152° (with dec.).

Anal. Calcd. for $C_8H_{12}N_2O_3S_2$ (248.3): N, 11.23. Found: N, 11.22.

CHICAGO 12, ILL.

[CONTRIBUTION FROM THE ORGANIC CHEMISTRY LABORATORY, PIONEERING RESEARCH DIVISION, QUARTERMASTER RESEARCH AND ENGINEERING CENTER, U. S. ARMY]

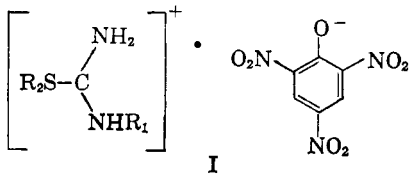
Isothiuronium, Alkylthioöxazolinium, and Alkylthiothiazolinium Picrates[1]

LOUIS LONG, JR., RICHARD C. CLAPP, FRANK H. BISSETT, AND TORSTEN HASSELSTROM

Received February 22, 1960

N-Substituted *S*-alkylisothiuronium picrates are shown to be useful derivatives in the identification of *N*-substituted thioureas derived from naturally occurring isothiocyanates, and a series of twenty-four picrates has been prepared. The procedure has been adapted to micro techniques. Conditions for the alkylation of 2-thioöxazolidones and for the preparation of a similar picrate derivative from (−)-5-vinyl-2-thioöxazolidone (goitrin) are described. The infrared spectra of the compounds are reported, and certain features are discussed.

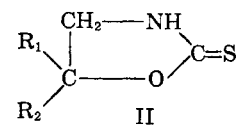
During an investigation of the naturally occurring isothiocyanates in certain plants, an attempt was made to find a derivative that would be useful in the separation and identification of substituted thioureas obtained from the isothiocyanates. The use of *S*-alkylisothiuronium picrates to identify alkyl halides has been described.[2] It is reported in the present paper that *N*-substituted *S*-alkylisothiuronium picrates (I) also constitute satisfactory



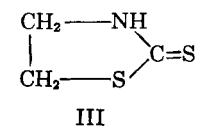
I

derivatives for *N*-substituted thioureas. The yield of picrates obtained (85–90%), their high molecular weight, their low solubility, and their crystallinity, as demonstrated in several instances by well-defined x-ray diffraction patterns,[3] favored the use of these derivatives in the isolation and identification of micro quantities.[4]

Since a derivative to assist in the identification of (—)-5-vinyl-2-thioöxazolidone (IIc), a goitrogenic compound isolated from *Brassica* seeds[5] and found to be present in micro quantities in cabbage,[6] was also desired, the preparation of a similar derivative from this compound was investigated. Hopkins[7] has reported that 5,5-dimethyl-2-thioöxazolidone (IIb) "does not combine with methyl iodide under ordinary conditions, nor does it form a picrate." However, the alkylation of 2-thiothiazolidone (III) with methyl iodide under alkaline[8] and neutral[9] conditions and the formation of a picrate from the resulting 2-methylthio-2-thiazoline have been described. Model experiments with 2-thiothiazolidone and 2-thioöxazolidone (IIa) dem-



II



III

a. $R_1 = R_2 = H$
b. $R_1 = R_2 = CH_3$
c. $R_1 = CH_2{=}CH$, $R_2 = H$

(1) Presented at the 136th National Meeting of the American Chemical Society, Atlantic City, N. J., September 1959.

(2) (a) E. L. Brown and N. Campbell, *J. Chem. Soc.*, 1699 (1937); (b) W. J. Levy and N. Campbell, *J. Chem. Soc.*, 1442 (1939); (c) L. Schotte, *Arkiv Kemi*, 5, 11 (1952).

(3) We are indebted to Dr. G. Susich and Mr. A. King of this Laboratory for the x-ray diffraction patterns.

(4) R. C. Clapp, L. Long, Jr., G. P. Dateo, F. H. Bissett, and T. Hasselstrom, *J. Am. Chem. Soc.*, 81, 6278 (1959).

(5) E. B. Astwood, M. A. Greer, and M. G. Ettlinger, *J. Biol. Chem.*, 181, 121 (1949).

(6) (a) M. R. Altamura, L. Long, Jr., and T. Hasselstrom, *J. Biol. Chem.*, 234, 1847 (1959); (b) A. I. Virtanen, M. Kreula, and M. Kiesvaara, *Acta Chem. Scand.*, 12, 580 (1958).

(7) C. Y. Hopkins, *Can. J. Research*, 16B, 341 (1938).

(8) S. Gabriel, *Ber.*, 22, 1139 (1889).

(9) A. F. McKay, D. J. Whittingham, and M.-E. Kreling, *J. Am. Chem. Soc.*, 80, 3339 (1958).